

II. AUTORIDADES Y PERSONAL**B. Oposiciones y concursos**

UNIVERSIDADES

4981 *Resolución de 5 de mayo de 2020, de la **Universidad Autónoma de Madrid**, por la que se convoca **concurso de acceso a plazas de cuerpos docentes universitarios**.*

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Número de plazas y categoría: 1. Catedrático/a de Universidad. Área de conocimiento: Física Teórica. Departamento: Física Teórica. Procedencia: OEP-2019 (promoción interna). **UAM2020-P431CU**. Actividades a realizar por quien obtenga la plaza: Docencia en las asignaturas del área que imparte el Departamento e investigación en Experimentación en Física de Altas Energías.

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6.3.1 Los concursos de acceso se compondrán de una **única prueba** en la que se valorará el historial académico, docente e investigador de los candidatos, así como su proyecto docente e investigador, y en la que, en sesión pública, se contrastarán sus capacidades para la exposición y debate en la correspondiente materia o especialidad. Los candidatos dispondrán de un máximo de noventa minutos para su exposición y el debate con la Comisión de Acceso podrá extenderse hasta un máximo de tres horas.

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RESUMEN LIBRE DEL CURRÍCULUM

- académico - **docente**
 - Docencia, Gestión
 - Un Proyecto Docente
- académico - **científico / Proyecto**

académico - **docente**

- Trayectoria
 - 89/90 Profesor Titular Interino
 - 1991 → Profesor Titular
 - 2013: Acreditado CU

○ Docencia:

- Actividades Docentes
 - Primer Ciclo: Física General (físicos, matemáticos), Mecánica Clásica (fís., químicos), Variable Compleja (fís.)
 - Segundo Ciclo: Técnicas Experimentales III (3º Físicas), Estadística (4º Físicas), Electrodinámica Clásica (4º Fís.)
 - Tercer Ciclo: “Fundamentos Experimentales del Modelo Estándar” (5 créditos)
- Otros: 1999 → 2003 Coordinador Sócrates / Erasmus (et al.): responsable de la actividad académica en universidades extranjeras de 42 estudiantes de la U.A.M.
- Dirección de Tesis Doctorales:

Nine PhD. Thesis Supervised. Those thesis fully covering detector instrumentation and physics data analyses. Most of those former students held now high responsibility positions at industry or research centers.

1. *Estudio de la producción de mesones con extrañeza y encanto en colisiones e+p en HERA con el detector ZEUS*; Juan Pablo Fernández Ramos; UAM January 1998. Extraordinary PhD. Price UAM. Current Position: “Investigador titular” at CIEMAT
2. *Procesos difractivos duros en la dispersión e+p inelástica en HERA*; Jose María Hernández Calama; UAM, February 1998. CP: Head of the Basic Research’s Scientific Computation Unit, CIEMAT.
3. *Two different cases of calorimetry in High Energy Physics: the ATLAS liquid argon electromagnetic end cap and the ZEUS Forward Plug Calorimeter*; Gastón García López; UAM abril 2000. CP: Deputy Director, ALBA Synchrotron Light Source. Now: CMAM-UAM, Director
4. *Sobre algunos aspectos del diseño y construcción del calorímetro electromagnético de argón líquido del experimento ATLAS*; Pablo A. Romero González; UAM octubre 2000. CP: Project Head, Engineering Department, CESA S.A.
5. *Charm Electroproduction at HERA*; Ignacio Redondo Fernández; UAM July 2001. Extraordinary Ph.D. Price UAM. CP: “IT” at CIEMAT. At CERN since LHC startup in 2009; Technical Coordinator of the Drift Tubes Muon Detector of CMS.
6. *Measurement of D Mesons Production in Deep Inelastic Scattering at HERA*; Manuel Zambrana Ramírez; UAM octubre 2007.
7. *Dark Matter Searches in the Gamma-ray Sky with the Fermi-LAT Space Telescope* [co-dirección C. Muñoz]; Germán A. Gómez Vargas; UAM October 2013.
8. *Neutrino Physics in Present and Future Kamioka Water Cherenkov Detectors with Neutron Tagging*; P. Fernández Menéndez; UAM 2017/03. Recognized Outstanding Ph.D. Research; Springer Theses. CP: PD at IFIC, CERN based, proto-DUNE.
9. *Radioactivity Contamination in neutrino Experimental Physics: the Cases of NEXT and Super-Kamiokande Experiments*; Javier Pérez Pérez; UAM September 2017. CP: Postdoctoral researcher at the Jagiellonian University in Kraków, Gr. Zuzel group

○ Gestión:

- Julio 2012 a Junio 2014: Secretario académico Departamento de Física Teórica de la U. A. M.
- Julio 2014 a Junio 2019: Director del Departamento de Física Teórica de la U. A. M.

Highligts:

- *Conseguida la “Estabilidad” del Master de Física Teórica (selección del Coordinador)*
- *Un Beatriz-Galindo para el Departamento (D. García Cerdeño)*

- Un **Proyecto docente**: Curso de Probabilidad, Estadística, Medidas y Comprobación de Hipótesis

RACIONAL:

Se observa entre los estudiantes de Ciencias, y entre muchos sus profesores, un desconocimiento grande del significado, estimación y tratamiento matemático de conceptos tan básicos e importantes como el error de una medida, pruebas de hipótesis etc.

En muchos de los actuales planes de estudio de la Facultad de Ciencias de la UAM estos asuntos se han relegado a introducciones “para salir del paso” impartidas al comienzo de las distintas asignaturas de Laboratorio de la Carrera. Al no ser parte principal de su temario se convierten en breves, incompletas y en muchos casos incorrectas prescripciones para el tratamiento e interpretación de los resultados de las medidas a realizar, en vez de base teórica a partir de la cual sacar conclusiones científicas, con base matemática, de ellas.

El curso se propone para paliar este grave déficit en la formación de nuestros estudiantes. Sus pilares son:

- Estudio de la probabilidad y estadística desde un punto de vista de base matemática de los procesos de medida y contraste de hipótesis
- La Gaussianidad de la naturaleza, e.d. la Gaussianidad de los sucesos que son consecuencia a su vez de un número muy grande de procesos simétricos.
- Los intervalos de probabilidad como resultado último de los procesos de medida y contraste de hipótesis.

académico - científico / **Proyecto**

Líneas de Investigación [orden ~ cronológico] I

DESY [1985 – 1987] e^+e^- , $\sqrt{s}=14-45$ GeV; experimento TASSO en PETRA

[Publicaciones] Fenomenología: 1, Análisis: 29 [1505 citas]

- Fragmentación; g-jets, b-jets
- Tests de QCD perturbativa y medidas de α_s en e^+e^-

SLAC [1987 - 1989] e^+e^- , $\sqrt{s}= 29,100$ GeV; experimento MARKII en el SLC

[Publicaciones] Instrumentación: 4, Análisis: 19 [1204 citas]

- Medida $e^+e^- \rightarrow$ hadrons ($\sqrt{s}= 29$ GeV); extracción de α_s
- Medida de la resonancia del boson Z en e^+e^-
- Desarrollo del primer detector de vértices de silicio con lectura VLSI para un colisionador

UAM - DESY [1990 – 2010] ep, $\sqrt{s}=300$ GeV; experimento ZEUS en HERA

[Publicaciones] Instrumentación: 3, Análisis: 196 [18678 citas]

- Optimización diseño del calorímetro de ZEUS, extensions
- Constr. y pruebas del “Forward Tracking Detector” de ZEUS
- Medida de la sección eficaz DIS; Difracción y QCD-p
- Tests de QCD-p vía producción de “charm”

Líneas de Investigación [orden ~ cronológico] II

UAM - CERN [1995 – 2007] pp, $\sqrt{s}=14000$ GeV; experiment **ATLAS** en el **LHC**

[Publicaciones] Instrumentación: 18, Análisis: 298 [61600 citas]

- Diseño, construcción y pruebas del **Calorímetro Electromagnético** de **ATLAS** para el **LHC**
- Preparación **búsqueda Higgs** masa intermedia

UAM - FNAL [visitor *CIEMAT* 2004 – 2011] pp, $\sqrt{s}=2000$ GeV

[Publicaciones] Análisis: 3 [443 citas]

- Propiedades **hadrones b**; Violación **CP** en sector **b**

UAM [coll. INFN – Roma2, 2008 - 2013]; Búsqueda de Materia Oscura con **Telescopio Espacial Fermi-LAT**

- Centro Galáctico; Anisotropías

UAM - Kamioka Observatory [2008 →]; Experimento **Super-Kamiokande**

[Publicaciones] Instrumentación: 2, Análisis: 34 [2732 citas]

- I+D en métodos de identificación de neutrones en experimentos Agua-Cherenkov
- Medida de precisión matriz mezcla leptónica
- Desintegración del Protón

UAM - Laboratorio Subterráneo de Canfranc, LSC [2008 →]; Experimento **SuperkGd-lsc**

- Medidas de radio-pureza con detectors de Germanio de muy bajo fondo

Líneas de Investigación [orden ~ cronológico] III

UAM [2008 →]; NNN, Fenomenología de ν_s , proyectos Laguna y Laguna-LBNO,

[Publicaciones] Viabilidad, Fenomenología etc.: 4 [54 citas]

- Estrategía de la física de neutrinos en las próximas décadas; Tecnología óptima
- Infraestructura subterránea, operación; estudio de viabilidad del LSC para alojar el experimento

UAM – LSC [2011 →]; Experimento NEXT; desintegración Beta Doble Sin Neutrinos.

[Publicaciones] Instrumentación: 34 [970 citas]

- Medida de radio-pureza con detectores HPGe de todos sus materiales. Impacto.

UAM – Kamioka Observatory [2012 →]; Proyecto / Experimento Hyper- Kamiokande

[Publicaciones] Instrumentación, Viabilidad etc.: 5 [730 citas]

- Desarrollo general del diseño y del Proyecto; construcción de una participación española
- Cubiertas de los PMTs para abortar reacción en cadena en caso de implosión

UAM - Kamioka Observatory [2016 →]; Experimento T2K

[Publicaciones] Análisis: 13 [342 citas]

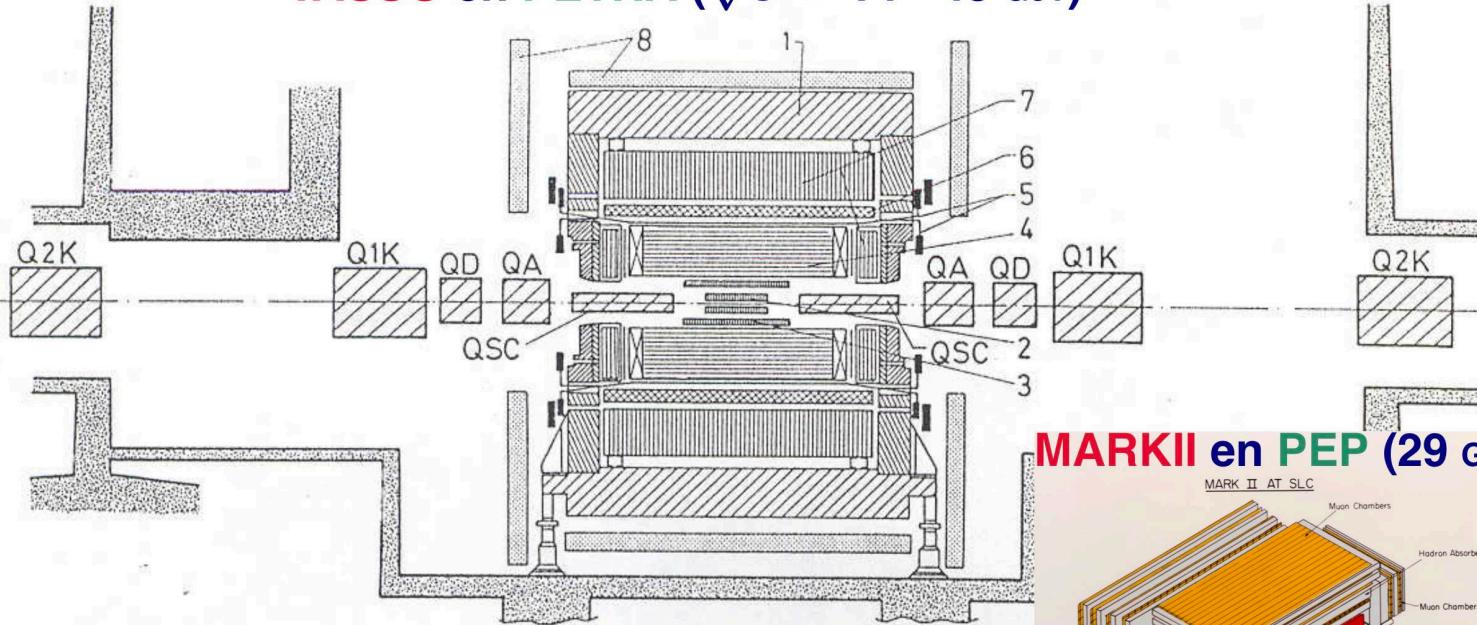
- Violación de la simetría Carga-Paridad en el sector leptónico

1. Laboratorio DESY (Hamburgo) [1985-1987]: interacciones e^+e^- de 14 a 45 GeV e.c.m. con detector TASSO

- Fragmentación
- Test de QCD

Estudios de QCD en e^+e^-

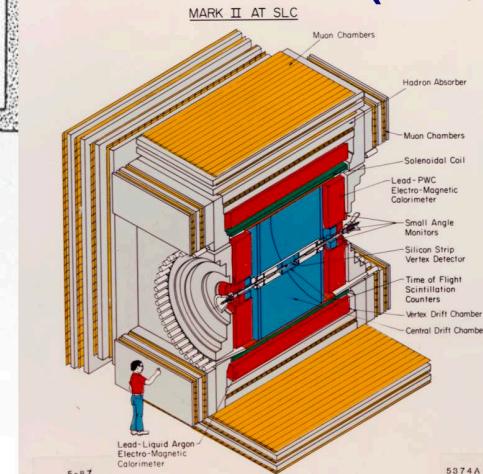
TASSO en PETRA ($\sqrt{s} = 14 - 45$ GeV)



Cut along beam

- | | |
|------------------------|------------------|
| 1 Magnet yoke | 6 Coil |
| 2 Vertex detector | 7 LA calorimeter |
| 3 Proportional chamber | 8 Muon chamber |
| 4 Drift chamber | |
| 5 TOF counter | |

MARKII en PEP (29 GeV)



5-87

5374 A 1

1. Laboratorio DESY [1985-1987]: e^+e^- , 14 a 45 GeV e.c.m. con detector TASSO

○ Test de QCD perturbativa y medidas de la constante de acoplo fuerte (α_s) en e^+e^-

QCD en e^+e^- TASSO; Z.Phys.C36,349(1987)

Asimetría en las Correlaciones de Energía

$$\bullet \frac{1}{\sigma} \frac{d\Sigma^C}{d\cos\chi} = \frac{1}{\sigma} \sum_{i,j} \int \frac{\sigma}{d\epsilon_i d\epsilon_j d\cos\chi} \epsilon_i \epsilon_j d\epsilon_i d\epsilon_j$$

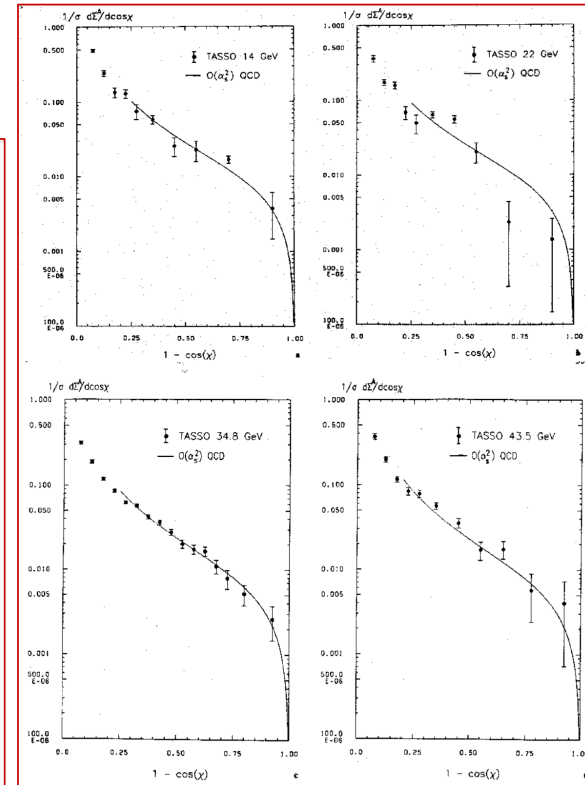
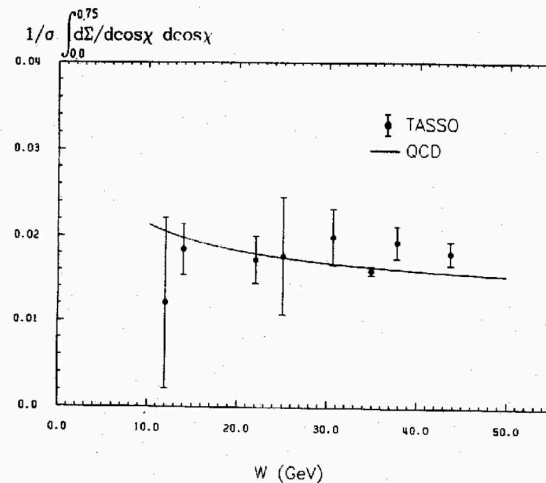
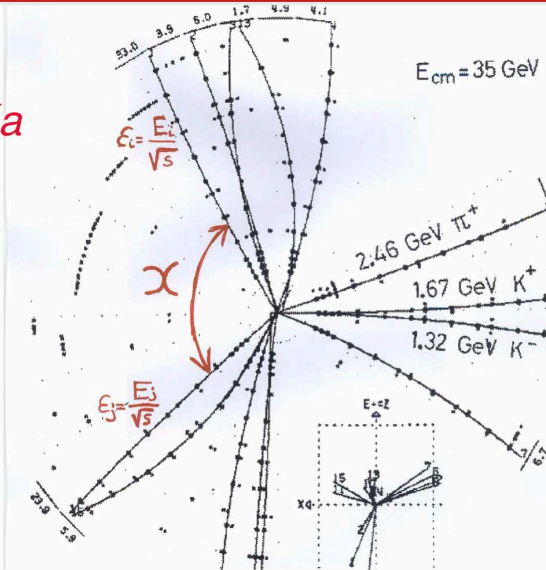
$\epsilon_i = E_i/\sqrt{s}$; E_i ener. partícula i
 χ ángulo entre parts. i y j

● **Su Asimetría**

$$\frac{1}{\sigma} \frac{d\Sigma^A}{d\cos\chi} = \frac{d\Sigma^C(\pi-\chi)}{d\cos\chi} - \frac{d\Sigma^C(\chi)}{d\cos\chi}$$

- calculada a $O(\alpha_s^2)$
- convergencia rápida
- poco sensitiva a fragmentación

⇒ variable excelente para probar **QCD** y medir α_s



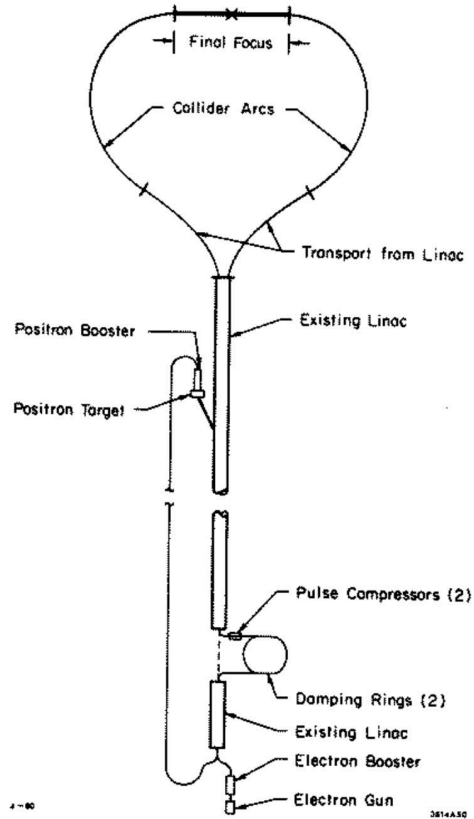
Method	A_{MS} (GeV)	α_s at 44 GeV
$O(\alpha_s^2)$ QCD fitted to data at 14, 22, 34.8 and 43.5 GeV	0.125 ± 0.025	$0.123 \pm 0.004 \pm 0.011$
$O(\alpha_s^2)$ QCD + Ali et al. fragmentation fitted to data at 43.5 GeV	0.165 ± 0.028	$0.129 \pm 0.004 \pm 0.011$
$O(\alpha_s^2)$ QCD + Lund fragmentation fitted to data at 43.5 GeV	0.305 ± 0.045	$0.143 \pm 0.005 \pm 0.012$

2. Laboratorio SLAC (Palo Alto, California, EEUU) [1987-1989]: e^+e^- , e.c.m.= 29 y 100 GeV, detector MARKII

- Medida de la
- Medida de los
- Desarrollo de

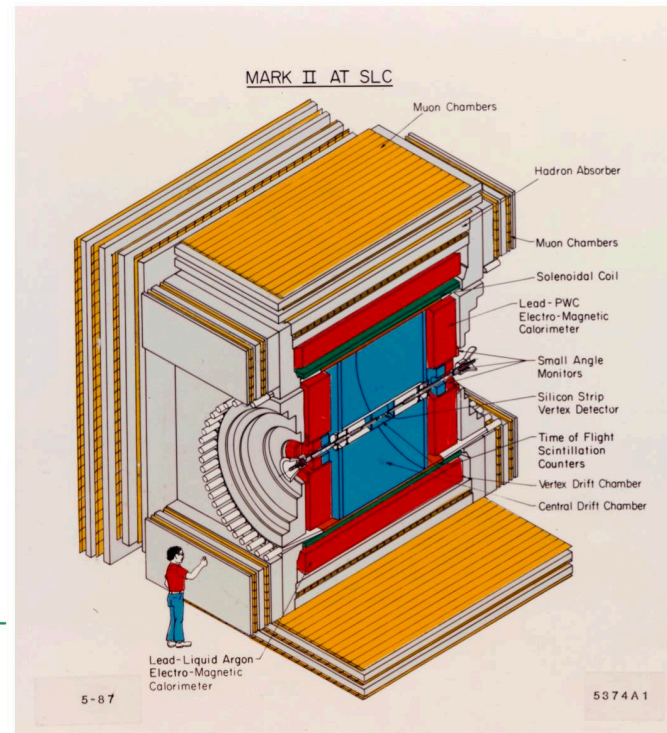
EW en e^+e^- : Resonancia del Bosón Z

SLC (Stanford Linear Collider) $\sqrt{s} \approx 92$ GeV



Es el primer colisionador lineal e^+e^-
¿ ... quizás también el último ?

con MARKII



ector SSVD de MARKII

2. Laboratorio SLAC (Palo Alto, California, EEUU) [1987-1989]: e^+e^- , e.c.m.= 29 y 100 GeV, detector **MARKII**

- o Medida de la **sección eficaz de producción hadrónica** en e^+e^- con e.c.m.= 29 GeV y **extracción de α_s**

QCD en e^+e^- :

MARKII; Phys.Rev.D43,34(1990)

Medida de precisión de $\sigma_h(e^+e^- \rightarrow \gamma, Z \rightarrow \text{hadrones})$

$$R(s) \equiv \frac{\sigma_h^0(e^+e^- \rightarrow \gamma, Z^0 \rightarrow \text{hadrons})}{\sigma_\mu^0(e^+e^- \rightarrow \gamma \rightarrow \mu^+\mu^-)}$$

$$= N_c \sum_q \left[Q_q^2 - \frac{\sqrt{2} G_F}{16\pi\alpha} Q_q v_e v_q \frac{2s}{(s/m_Z^2 - 1) + [\Gamma_Z^2/(s - m_Z^2)]} + \frac{G_F^2}{128\pi^2\alpha^2} (v_q^2 + a_q^2)(v_e^2 + a_e^2) \frac{s^2}{(s/m_Z^2 - 1)^2 + (\Gamma_Z^2/m_Z^2)} \right]$$

$$\times \left[1 + \frac{\alpha_s(s)}{\pi} + C_2 \left[\frac{\alpha_s(s)}{\pi} \right]^2 + C_3 \left[\frac{\alpha_s(s)}{\pi} \right]^3 + \dots \right],$$

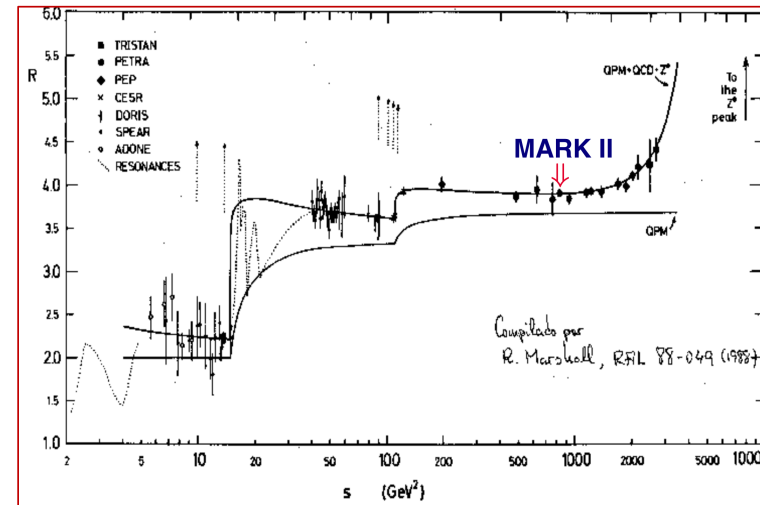
TABLE VIII. Summary of the systematic errors for R.

Quantity	Value	Statistical	Systematic
N_h	7340	1.2%	1.7%
$\epsilon_h(1 + \delta_h)$	0.8432		0.4%
$\mathcal{L}(\text{pb}^{-1})$	21.52		1.3%
QED correction $> \mathcal{O}(\alpha^3)$			0.4%
R value	3.92	1.2%	2.2%

Medida de dos magnitudes fundamentales de QCD:

N_c (no. de colores)= 3

$\alpha_s(29^2 \text{ GeV}^2) = 0.150 \pm 0.074$



2. Laboratorio SLAC (Palo Alto, California, EEUU) [1987-1989]: e^+e^- , e.c.m.= 29 y 100 GeV, detector MARKII

o Medida de los parámetros de la resonancia del bosón Z en e^+e^-

Measurements of Z-Boson Resonance Parameters in e^+e^- Annihilation

G. S. Abrams,⁽¹⁾ C. E. Adolphsen,⁽²⁾ D. Averill,⁽⁴⁾ J. Ballam,⁽³⁾ B. C. Barish,⁽⁵⁾ T. Barklow,

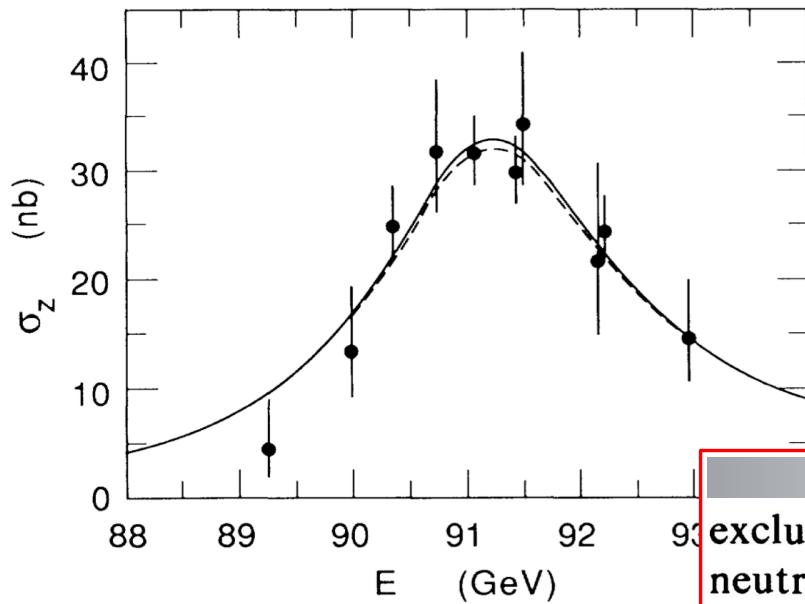
$$\sigma_Z(E) = \frac{12\pi}{m_Z^2} \frac{s\Gamma_e\Gamma_f}{(s - m_Z^2)^2 + s^2\Gamma^2/m_Z^2} [1 + \delta(E)]$$

W. T. Ford,⁽³⁾ C. Fordham,⁽³⁾ R. Frey,⁽³⁾ D. Fujino,⁽³⁾ K. K. Gan,⁽³⁾ E. Gero,⁽³⁾ G. G. H. Harter,⁽³⁾ T. Glanzman,⁽³⁾ G. Goldhaber,⁽¹⁾ J. J. Gomez Cadenas,⁽²⁾ G. Gratta,⁽²⁾ G. Grindhar,⁽³⁾ P. Grosse-Wiesmann,⁽³⁾ G. Hanson,⁽³⁾ R. Harr,⁽¹⁾ B. Harral,⁽⁶⁾ F. A. Harris,⁽⁸⁾ C. M. Ha

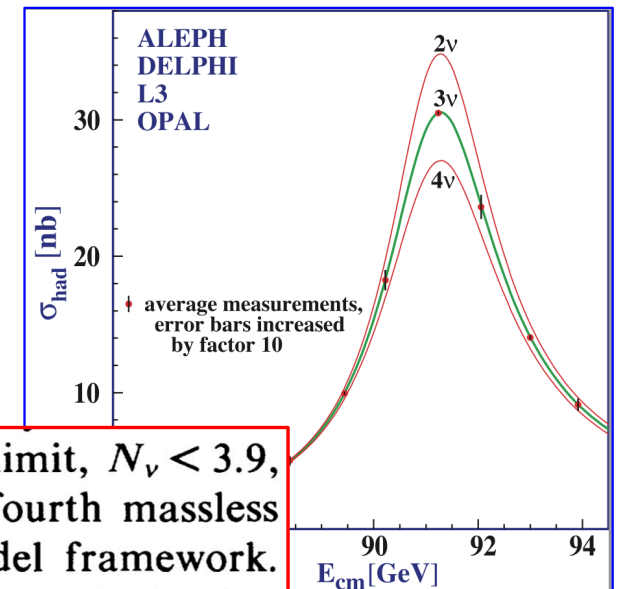
⁽³⁾ T. Himel,⁽³⁾ D. A. Hinshaw,⁽³⁾ J. Jacobsen,⁽³⁾ J. A. Jaros,⁽³⁾ C. K. Jung,⁽³⁾ Koetke,⁽³⁾ S. Komamiya,⁽³⁾ W. Koska,⁽⁷⁾ L. Labarga,⁽²⁾ A. J. Lankford,⁽³⁾ R. R. C. Lou,⁽⁴⁾ V. Lüth,⁽³⁾ J. A. McKenna,⁽⁵⁾

TABLE II. Z resonance parameters. The three fits are described in the text.

Fit	m_Z (GeV/c ²)	N_ν	Γ (GeV)	σ_0 (nb)
1	91.14 ± 0.12
2	91.14 ± 0.12	2.8 ± 0.6
3	91.14 ± 0.12	...	2.42 ^{+0.45} _{-0.35}	45 ± 4



The 95%-C.L. limit, $N_\nu < 3.9$, excludes to this level the presence of a fourth massless neutrino species within the standard-model framework.



2. Laboratorio SLAC (Palo Alto, California, EEUU) [1987-1989]: e^+e^- , e.c.m.= 29 y 100 GeV, detector MARKII

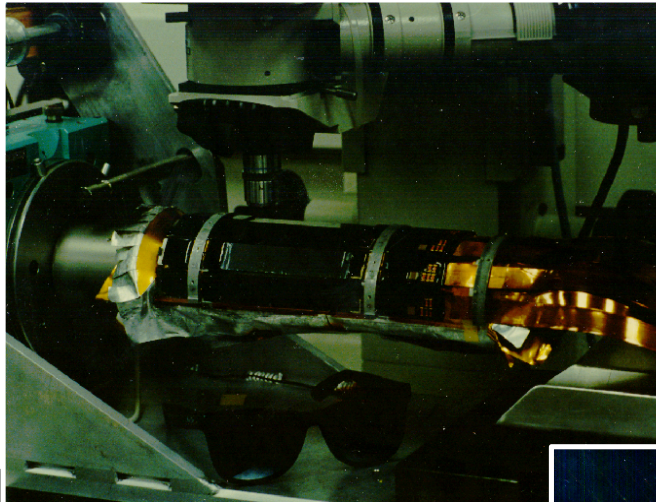
- Desarrollo del primer detector de vértices de silicio con lectura VLSI para un colisionador de partículas: el sub-detector SSVD de MARKII

El SLC y la física de b 's

- A $\sqrt{s} = m_Z$, $\sigma(e^+e^- \rightarrow \text{hadrons})$ enorme; en ME $\Gamma_{bb} \sim 0.2$
 - producción copiosa de pares bb
 - La vida media del b es larga: $c\tau \sim 400\mu\text{m}$
 - identificación por vértices secundarios
 - Entre las peculiaridades del SLC está la 2 diminuta sección transversal del haz: $\approx 3 \cdot 3\mu\text{m}$
 - buena localización del vértice primario
 - el reducido radio del tubo del haz: $\approx 25\text{mm}$
 - mínima distorsión por “Multiple Coulomb Scattering”
- escenario ideal para un detector de vértices de alta resolución

2. Laboratorio SLAC (Palo Alto, California, EEUU) [1987-1989]: e^+e^- , e.c.m.= 29 y 100 GeV, detector MARKII

- Desarrollo del primer detector de vértices de silicio con lectura VLSI para un colisionador de partículas: **el sub-detector SSVD de MARKII**



Nuclear Instruments and Methods in Physics Research A313 (1992) 63-102
North-Holland

The Mark II silicon strip vertex detector *

C. Adolphsen, R.G. Jacobsen and V. Lüth

Stanford Linear Accelerator Center, Stanford University, Stanford, CA 94309, USA

G. Gratta¹, L. Labarga², A.M. Litke, A.S. Schwarz³, M. Turala⁴ and C. Zaccardelli⁵

Santa Cruz Institute for Particle Physics, University of California, Santa Cruz, CA 95064, USA

A. Breakstone, C.J. Kenney and S. Rankin
University of Hawaii, Honolulu, HI 96822, USA

B.A. Barnett, P. Dauncey⁶, D.C. ...
Johns Hopkins University, Baltimore, MD 21218

NUCLEAR
INSTRUMENTS
& METHODS
IN PHYSICS
RESEARCH

VOLUME 67, NUMBER 24

PHYSICAL REVIEW LETTERS

9 DECEMBER 1991

Measurement of the $b\bar{b}$ Fraction in Hadronic Z^0 Decays with Precision Vertex Detectors

R. G. Jacobsen,⁽¹⁾ D. S. Koetke,⁽¹⁾ C. E. Adolphsen,⁽¹⁾ D. Fujino,⁽¹⁾ B. A. Schumm,⁽²⁾ S. R. Wagner,⁽¹⁾ J. P. Alexander,⁽¹⁾ D. Averill,⁽³⁾ B. C. Barish,⁽⁴⁾ T. Barklow,⁽¹⁾ B. A. Barnett,⁽⁵⁾ D. Blockus,⁽³⁾ A. Boyarski,⁽¹⁾ B. Brabson,⁽³⁾ A. Breakstone,⁽⁶⁾ F. Bulos,⁽¹⁾ P. R. Burchat,⁽⁷⁾ D. L. Burke,⁽¹⁾ R. J. Cence,⁽⁶⁾ J. Chapman,⁽⁸⁾ M. Chmeissani,⁽⁸⁾ D. Cords,⁽¹⁾ D. P. Coupal,⁽¹⁾ P. Dauncey,⁽⁵⁾ H. C. DeStaeblcr,⁽¹⁾ J. M. Dorfan,⁽¹⁾ P. S. Drell,⁽²⁾ D. C. Dreuer,⁽⁵⁾ D. Durrett,⁽⁹⁾ R. Elia,⁽¹⁾ G. J. Feldman,⁽¹⁾ R. C. Field,⁽¹⁾ W. T. Ford,⁽⁹⁾ C. Fordham,⁽¹⁾ R. Frey,⁽⁸⁾ K. K. Gan,⁽¹⁾ E. Gero,⁽⁸⁾ G. Gidal,⁽²⁾ T. Glanzman,⁽¹⁾ G. Goldhaber,⁽²⁾ J. J. Gomez Cadenas,⁽⁷⁾ G. Gratta,⁽⁷⁾ G. Hanson,⁽³⁾ R. Harr,⁽²⁾ B. Harral,⁽⁵⁾ F. A. Harris,⁽⁶⁾ K. Hayes,⁽¹⁾ C. Hearty,⁽²⁾ C. A. Heusch,⁽⁷⁾ M. D. Hildreth,⁽¹⁾ T. Himel,⁽¹⁾ D. A. Hinshaw,⁽⁹⁾ S. J. Hong,⁽⁸⁾ D. Hutchinson,⁽¹⁾ J. Hylen,⁽⁵⁾ W. R. Innes,⁽¹⁾ J. A. Jaros,⁽¹⁾ C. K. Jung,⁽¹⁾ J. A. Kadyk,⁽²⁾ C. Kenney,⁽⁶⁾ M. King,⁽⁷⁾ S. Komamiya,⁽¹⁾ ...

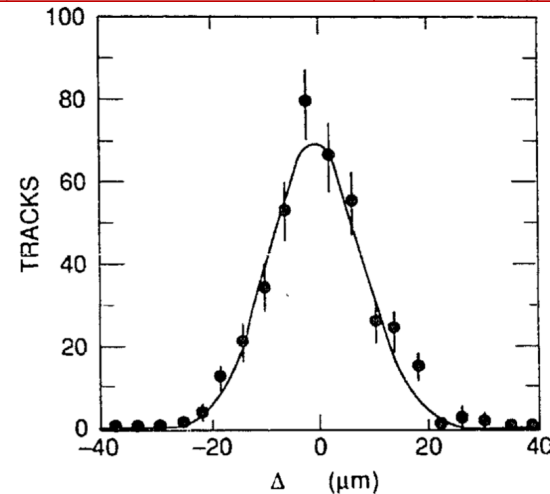
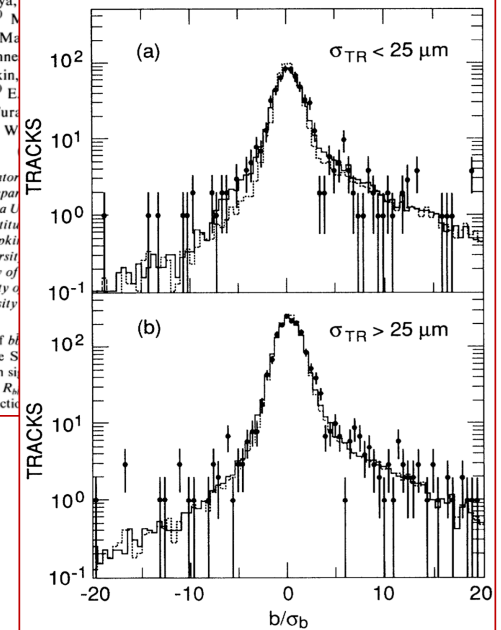
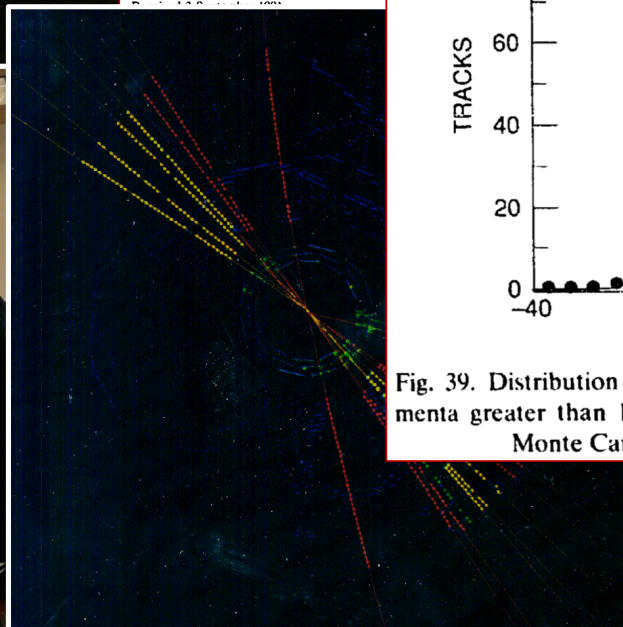
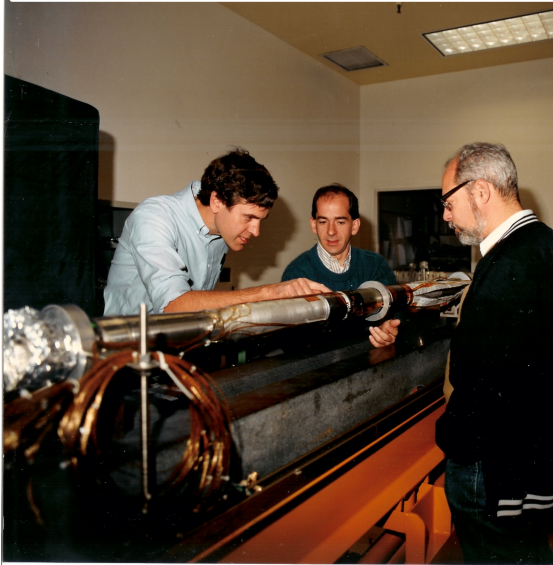


Fig. 39. Distribution of the variable Δ for tracks with momenta greater than 1 GeV/c. The data are compared to a Monte Carlo simulation (smooth curve).



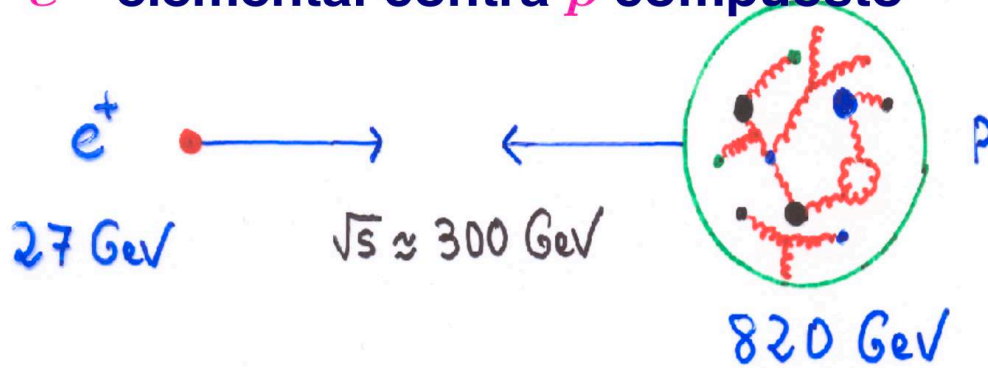
In conclusion, we have presented a method for tagging $Z^0 \rightarrow b\bar{b}$ events, based on the precise measurement of track impact parameters, which tags $Z^0 \rightarrow b\bar{b}$ events with a high efficiency of 50% and sample purity of 85%. By



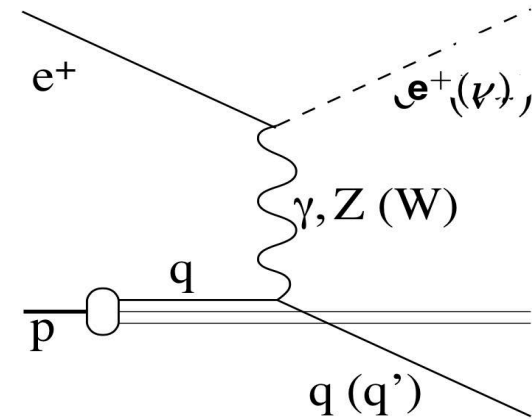
3. UAM - Laboratorio DESY [1990-2010]: interacciones **electrón protón (ep)** con e.c.m.= 300 GeV, detector **ZEUS**

QCD y EW en DIS $e^\pm p$: ZEUS en HERA

e^+ elemental contra p compuesto



Si DIS ($Q^2 \gg 0$) \rightarrow interacción **leptón-partón**



● Estructura del p , sus constituyentes y sus interacciones:

$\Rightarrow F_2(x, Q^2)$ y sus contribuciones vs. **QCD**

\Rightarrow Producción de c : el g dentro del p y **QCD**

\Rightarrow Interacción difractiva e^+p , ¿el IP dentro del p ?

● Interacción entre el e^+ y los q 's y g 's dentro del p :

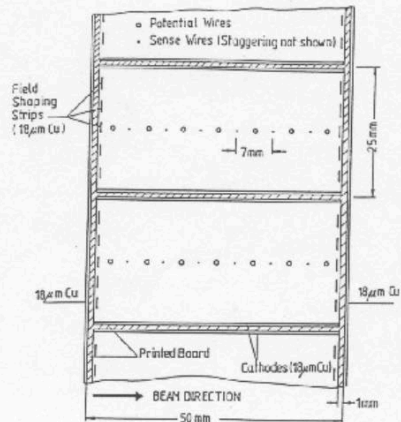
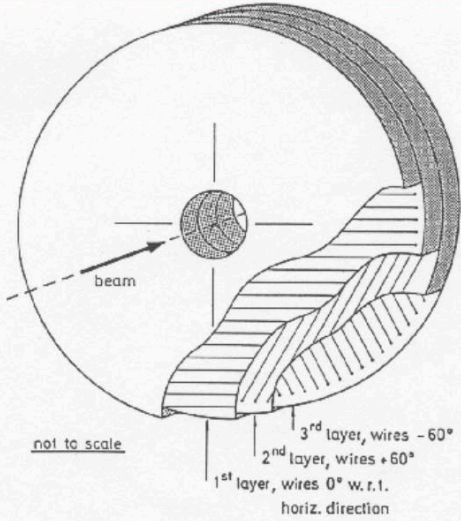
\Rightarrow **NC** y **CC** a alto Q^2 vs. **EW**

3. UAM - Laboratorio DESY [1990-2010]: interacciones electrón protón (ep) con e.c.m.= 300 GeV, detector ZEUS

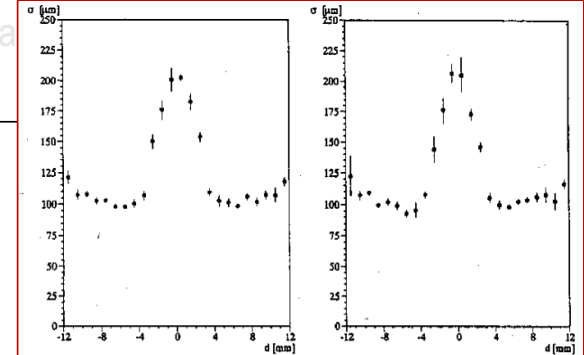
○ Optimización diseño calorímetro ZEUS y extensiones. Construcción y pruebas del sub-detector de ZEUS "Forward Tracking Detector"

El detector de trazas "hacia delante" de ZEUS: FTD

LL et al.; Nucl.Instr.Meth.A344,335(1994)



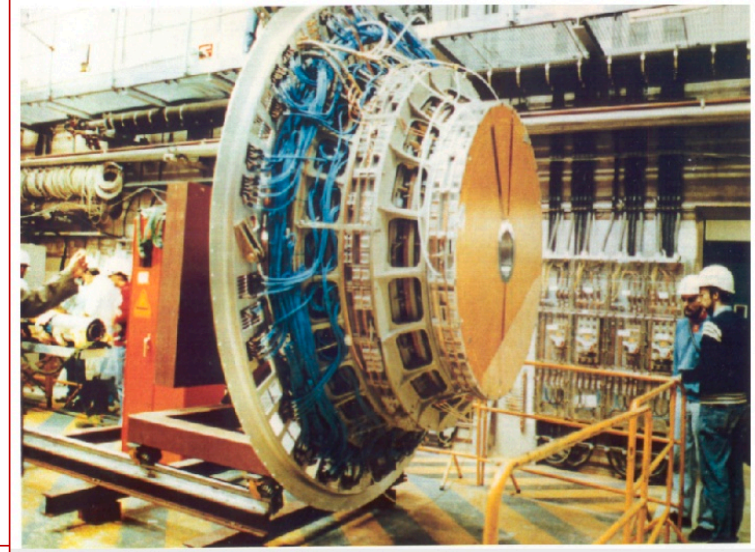
Sala
limpia
en U.A.M.



Resolución espacial de
 $\sigma(x) \approx 100\mu m$

	FTD1	FTD2	FTD3
no. hilos señal	1296	1584	1854
no. hilos pot.	1512	1848	2163
no. total hilos	10248		
no. canales salida	5778		

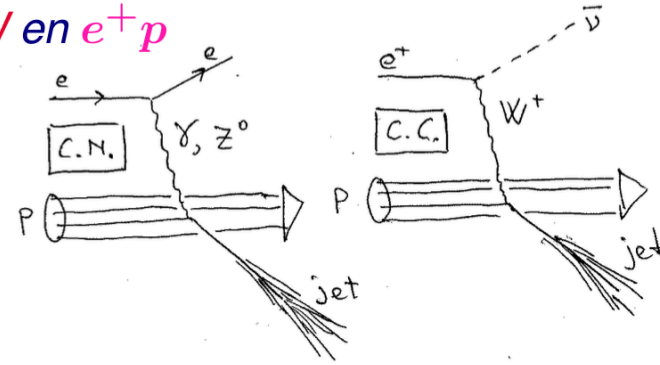
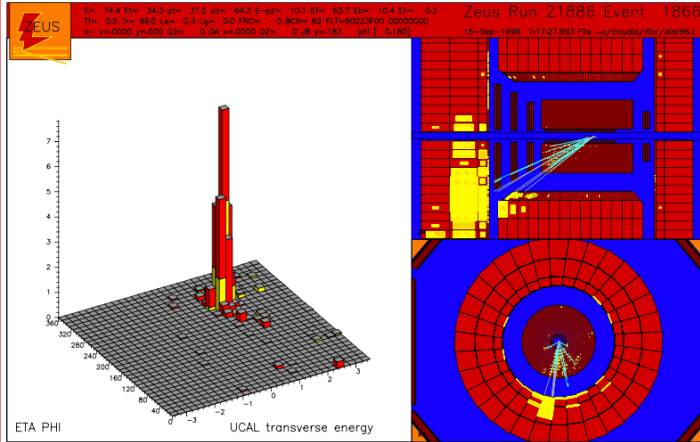
El FTD listo para ZEUS:



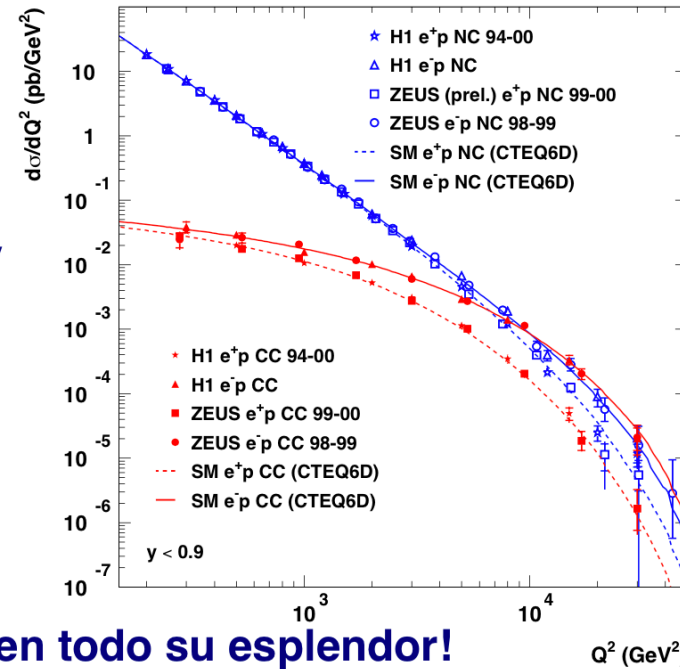
3. UAM - Laboratorio DESY [1990-2010]: interacciones electrón protón (ep) con **e.c.m.= 300 GeV**, detector **ZEUS**

- Sección eficaz profundamente inelástica ep ; Difracción y Cromodinámica Cuántica (QCD) perturbativa
- Pruebas de QCD-perturbativa

Sección eficaz de interacción e^+p : EW en e^+p



HERA

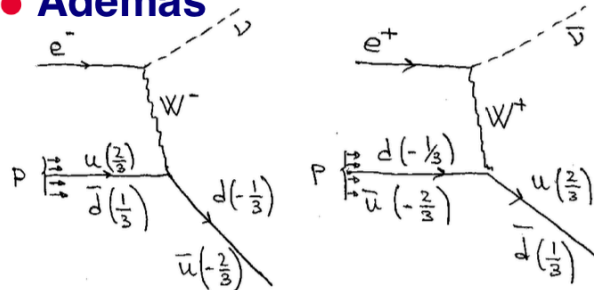


● **Por un lado:**

$$\frac{d\sigma}{dQ^2} \propto \frac{1}{(Q^2 + M_X)^2}$$

$M_\gamma = 0, M_Z \approx M_W \approx 90 \text{ GeV}$

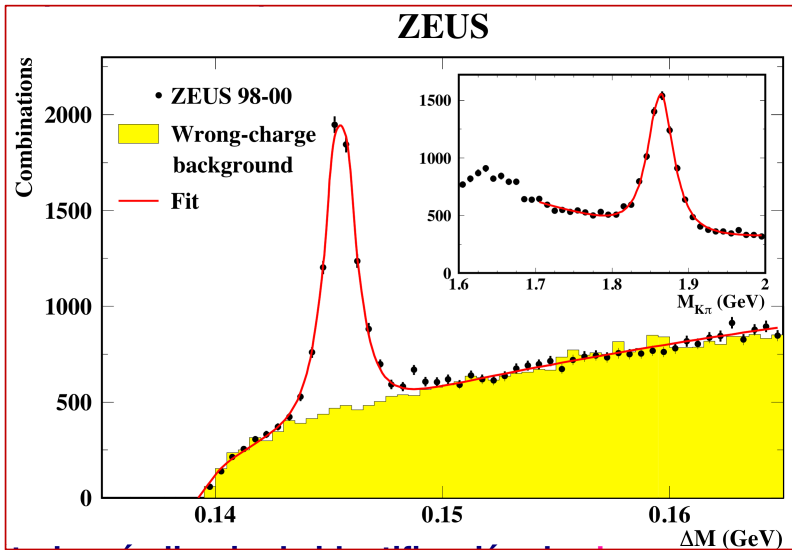
● **Además**



¡La Unificación Electro-Débil en todo su esplendor!

3. UAM - Laboratorio DESY [1990-2010]: interacciones electrón protón (ep) con e.c.m.= 300 GeV, detector **ZEUS**

- Optimización diseño calorímetro ZEUS y extensiones. Construcción y pruebas del sub-detector de ZEUS "Forward Tracking Detector"
- Sección eficaz profundamente inelástica ep; Difracción y Cromodinámica Cuántica (QCD) perturbativa
- Pruebas de QCD-perturbativa vía producción de "charm"

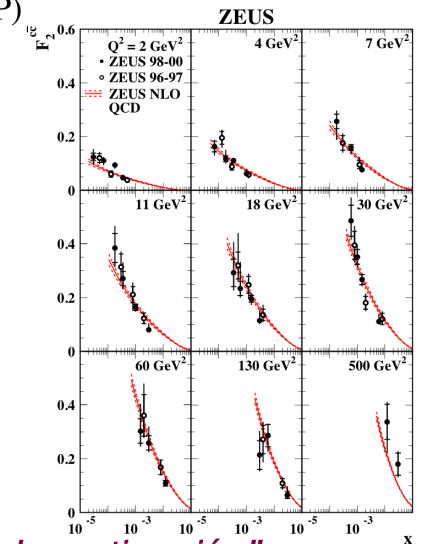
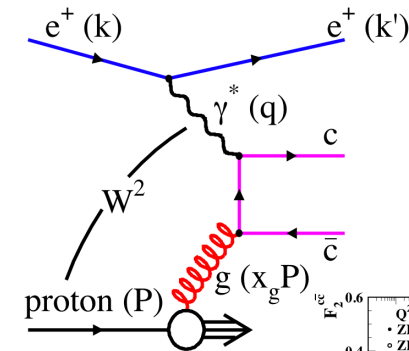
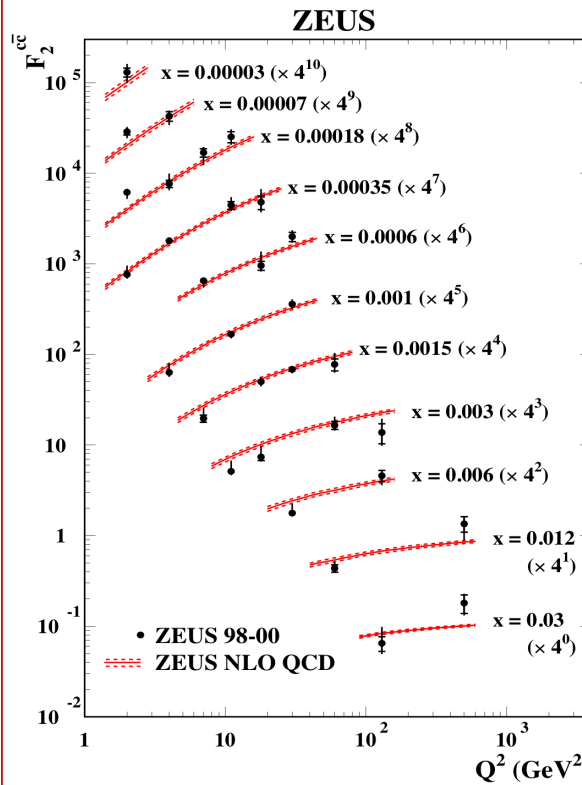


Artículo MZambran

J.P. Fernández PhD Thesis, UAM 1998
 I. Redondo, PhD Thesis, UAM 2001
 M. Zambrana, PhD Thesis, UAM 2007

QCD en e^+p : producción de charm

ZEUS; Phys.Lett.B407,402(1997)
 ZEUS; Eur.Phys.J.C12,35(2000)
 ZEUS; Phys.Rev.D69,0120004(2004)



4. UAM - CERN [1995 – 2008], interacciones protón protón (pp) con e.c.m.= 14 TeV; **experimento ATLAS en el LHC**

○ **búsqueda del bosón de Higgs del Modelo Estándar:** Diseño, construcción y pruebas del Calorímetro Electromagnético de ATLAS

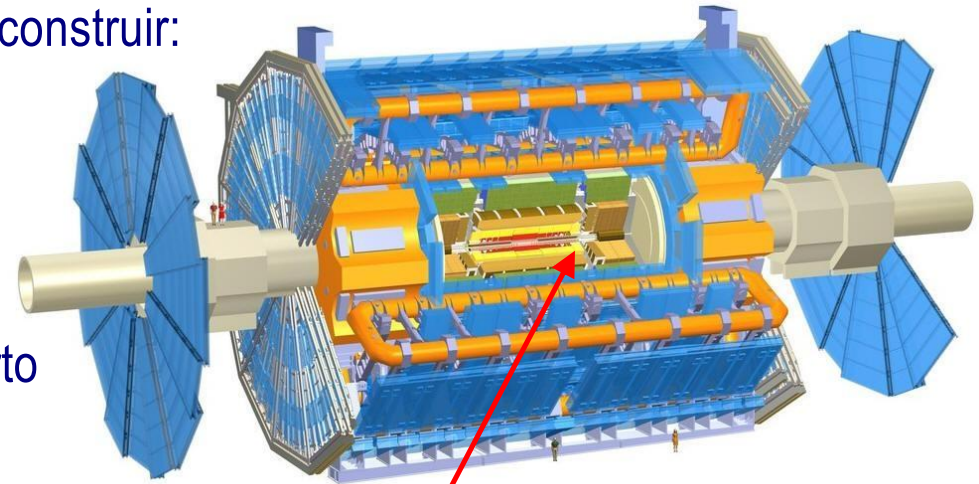
ATLAS en el LHC (pp $\sqrt{s} \approx 14$ TeV). Estudio del **origen de la masa en la escala de energía electrodébil.**

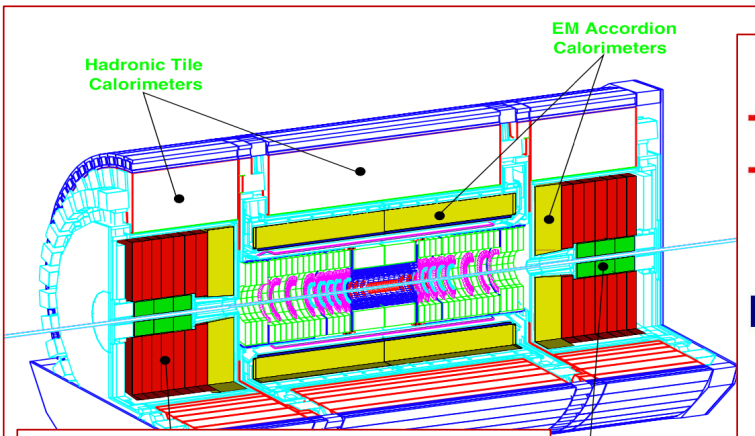
Para el **Higgs (H)** del ME el detector ha de ser capaz de reconstruir:

- 1) $H \rightarrow \gamma\gamma$; * $m_H < 150$ GeV
- 2) $H \rightarrow ZZ \rightarrow 4l$; $130\text{GeV} < m_H < 2m_Z$
- 3) $H \rightarrow ZZ \rightarrow 4l$ or $2l+2\nu$; $m_H > 2m_Z$
- 4) $H \rightarrow WW, ZZ \rightarrow l+\nu+2$ jets or $2l + 2$ jets; $m_H < 1\text{TeV}$
 - significación proporcional al rango de rapidez cubierto
 - a **alta E** se necesita $\sigma(E) < 1\% E$
... particularmente importante en 1)

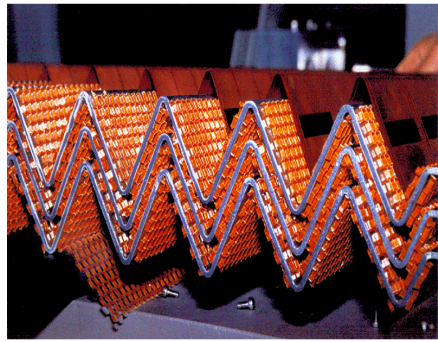
→ Se requiere una medida excepcional de γ 's y e^\pm 's a lo largo del mayor ángulo sólido posible.

⇒ Un calorímetro **Electro Magnético** de muestreo con **Argón Líquido** como material ionizable y una geometría **acordeón** con una **uniformidad geométrica y eléctrica extrema**





**Geometría Acordeón:
nulo volumen inactivo**



Absorbentes: clave para $\sigma(E)/E$

- **plomo** protegido y rigidizado por **acero**
- **espesor plomo/Absorber AE (A)**
1.7/2.4 (2.2/2.9) mm

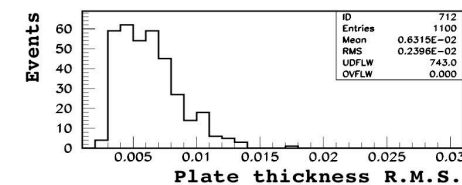
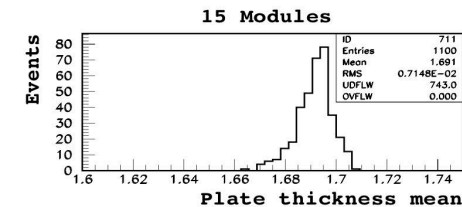
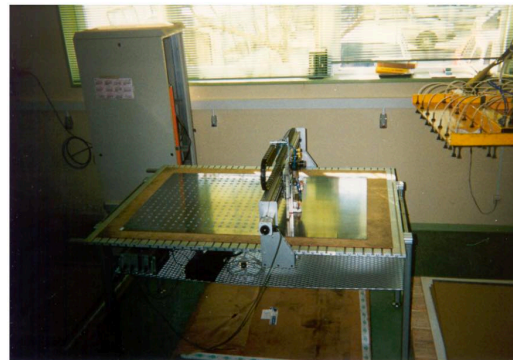
Para que $b_{mec} \leq 0.3\%$:

- **espesor plomo uniforme al 1% $\Rightarrow 17\mu m$ ($22\mu m$) RMS en AE (A)**
- **“espesor” ArgL uniforme al 3% \Rightarrow geometría absorbentes reproducible en $\approx 150\mu m$ RMS**

Planchas de *plomo* laminadas en fundición \approx estándar midiendo y corrigiendo su espesor en tiempo real con dispositivo de rayos X

Rohr GmbH, Krefeld (Alemania)

Medida con U.S. en UAM

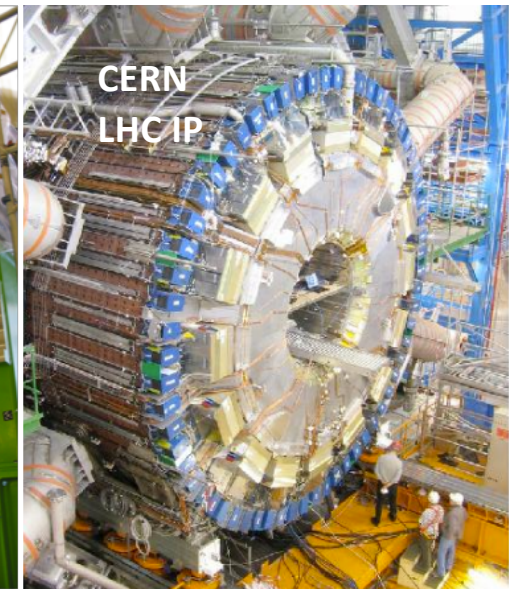
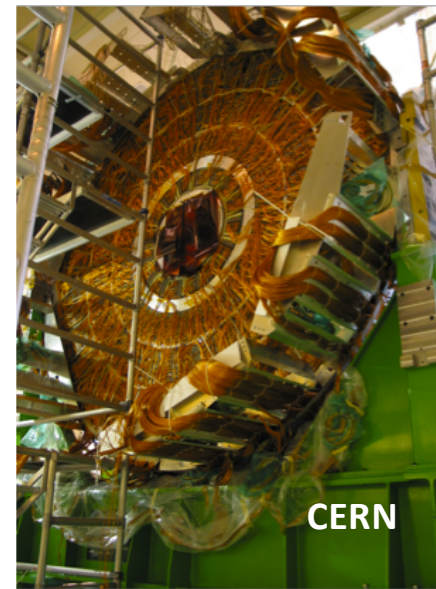


**Uniformidad
en espesor
 $< 9\mu m$ RMS**

Discovering the Higgs particle: ATLAS Electro-magnetic End-Cap Calorimeter construction in Spain



- G.García, PhD Thesis, UAM 2000
- P. Romero, PhD Thesis, UAM 2000
- Nucl.Instrum.Meth. A344(1994)39
- Nucl.Instrum.Meth.A389(1997)398
- Nucl. Inst. and Meth. A418(1998)513
- Nucl.Instrum.Meth. A500(2003)178
- Nucl.Instrum.Meth.A550:96-115,2005
- Nucl.Instrum.Meth.A582:429-455,
2007 JINST 3:P06002,2008



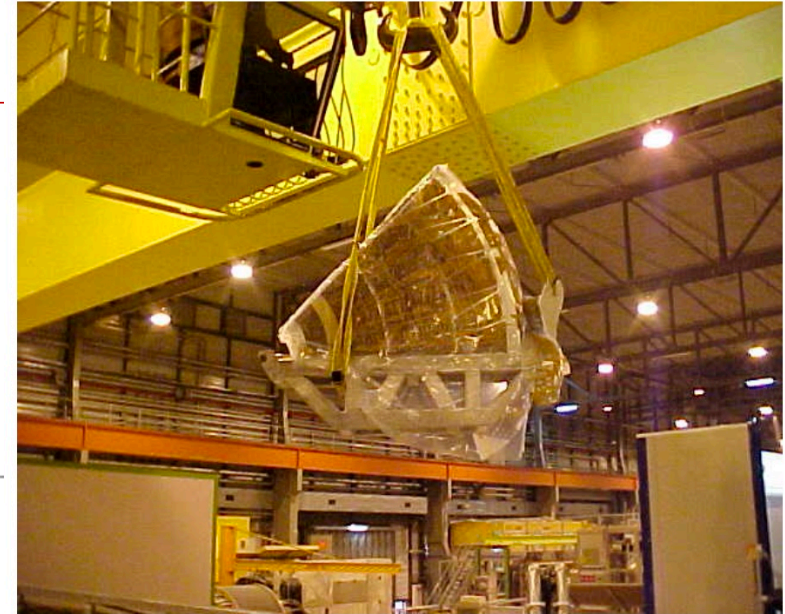
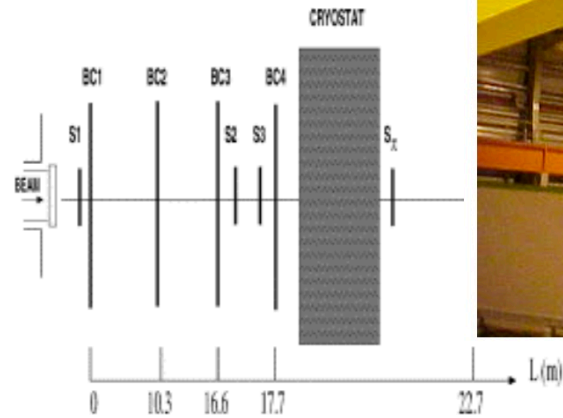
Discovering the Higgs particle: ATLAS Electro-magnetic End-Cap Calorimeter construction in Spain; testing

Programa de *Pruebas* en el *CERN* (criostato NA31, línea H6)

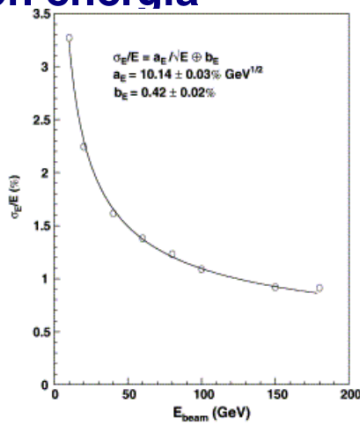
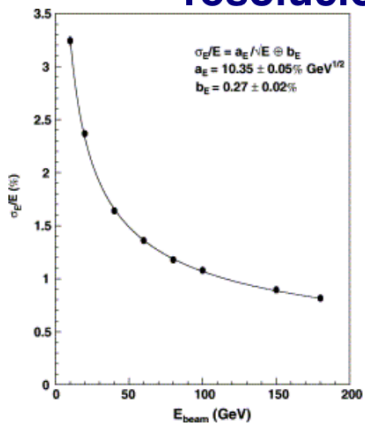
1) “en frío” (todos los módulos)

- Inyección de carga
- Calibración: cálculo de ganancias
- Comportamiento con Alto Voltaje

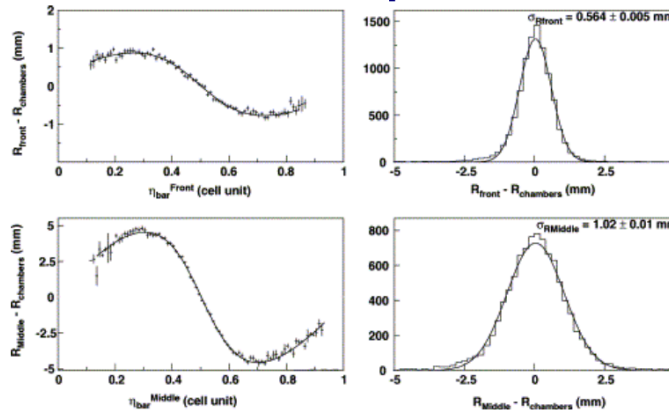
2) con haces de e^\pm 's de 10 a 200 GeV (3 módulos y 2 prototipos)



resolución energía



reconstrucción posición





Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC[☆]

ATLAS Collaboration^{*}

This paper is dedicated to the memory of our ATLAS colleagues who did not live to see the full impact and significance of their contributions to the experiment.

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 Editor: W.-D. Schlatter

ABSTRACT

A search for the Standard Model Higgs boson in proton–proton collisions with the ATLAS detector at the LHC is presented. The datasets used correspond to integrated luminosities of approximately 4.8 fb^{-1} collected at $\sqrt{s} = 7 \text{ TeV}$ in 2011 and 5.8 fb^{-1} at $\sqrt{s} = 8 \text{ TeV}$ in 2012. Individual searches in the channels $H \rightarrow ZZ^{(*)} \rightarrow 4\ell$, $H \rightarrow \gamma\gamma$ and $H \rightarrow WW^{(*)} \rightarrow e\nu\mu\nu$ in the 8 TeV data are combined with previously published results of searches for $H \rightarrow ZZ^{(*)} \rightarrow 4\ell$ and $H \rightarrow \gamma\gamma$ channels in the 7 TeV data and results from improved analyses of the $H \rightarrow ZZ^{(*)} \rightarrow 4\ell$ and $H \rightarrow \gamma\gamma$ channels in the 7 TeV data. Clear evidence for the production of a neutral boson with a measured mass of $126.0 \pm 0.4 \text{ (stat)} \pm 0.4 \text{ (sys)} \text{ GeV}$ is presented. This observation, which has a significance of 5.9 standard deviations, corresponding to a background fluctuation probability of 1.7×10^{-9} , is compatible with the production and decay of the Standard Model Higgs boson.

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1. Introduction

The Standard Model (SM) of particle physics [1–4] has been

120–135 GeV; using the existing LHC constraints, the observed local significances for $m_H = 125 \text{ GeV}$ are 2.7σ for CDF [14], 1.1σ for DØ [15] and 2.8σ for their combination [16].

[129] ATLAS Collaboration, JHEP (2012), in press, arXiv:1206.5971 [hep-ex].

[141] C.N. Yang, Phys. Rev. 77 (1950) 242.

ATLAS Collaboration

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H. Kurasnige¹⁶, M. Kurata¹³⁰, Y.A. Kurochkin¹³⁰, V. Kus¹⁴⁰, E.S. Kuwertz¹⁷⁷, M. Kuze¹³⁰, J. Kvita¹⁷⁶, R. Kwee¹⁶, A. La Rosa⁴⁹, L. La Rotonda^{37a,37b}, L. Labarga⁸⁰, J. Labbe⁵, S. Lablak^{135a}, C. Lacasta¹⁶⁷, F. Lacava^{132a,132b}, I. Lacey²⁹, H. Lacker¹⁶, D. Lacour⁷⁸, V.R. Lacuesta¹⁶⁷, E. Ladvain⁶⁴, R. Lafave⁵

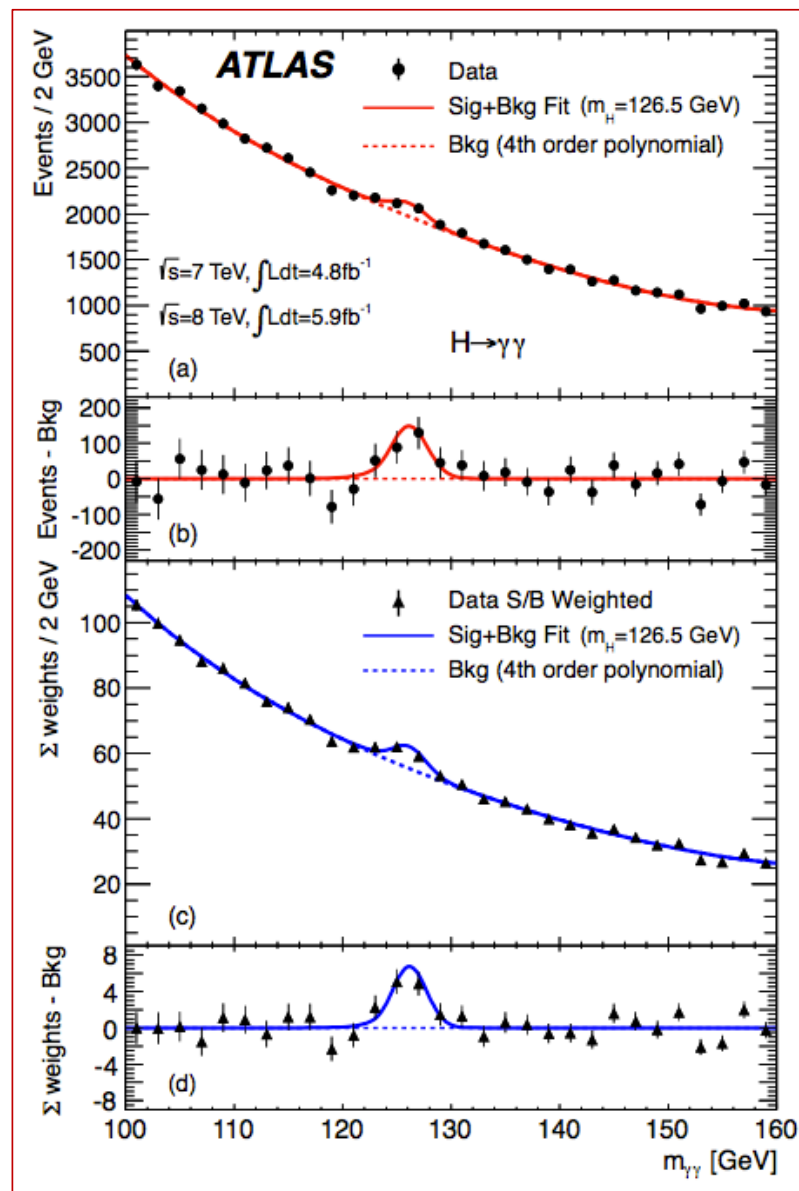
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⁷⁹ Fysiska institutionen, Lunds universitet, Lund, Sweden

⁸⁰ Departamento de Física Teórica C-15, Universidad Autónoma de Madrid, Madrid, Spain

⁸¹ Institut für Physik, Universität Mainz, Mainz, Germany

⁸² School of Physics and Astronomy, University of Manchester, Manchester, United Kingdom



5. UAM – Fermilab (Chicago) ("CIEMAT visitor") [2004 - 2011]: protón -antiprotón con e.c.m.= 2 TeV, detector CDF

- Medida de propiedades de hadrones "b"
- Violación de la simetría Carga Paridad en sector "b"

6. UAM [2008 - 2013] ("INFN Roma-2 collaborator"); Búsqueda de Materia Oscura con Telescopio Espacial Fermi-LAT

- Centro Galáctico
- Anisotropías **G. Gómez Vargas, PhD Thesis, UAM 2013** (*C. Muñoz co-dir*)

7. UAM - Kamioka Observatory (Kamioka, Japón) [2008 →]: **Exp. Super-Kamiokande (SK)**

- Métodos de identificación de neutrones en experimentos Agua-Cherenkov

Super-Kamiokande: superb physics thanks to **water-cherenkov technique**

- discovery of ν oscillations in the atmospheric sector
- key in the understanding of the solar- ν problem
-
- evidence for the appearance of atmospheric ν_{τ}
- first indication of terrestrial matter effects on solar- ν

most stringent limits on:

- nucleon decay
- WIMP-type Dark Matter from indirect search
- **D**iffuse **S**upernova **N**eutrino **B**ackground

Probably our main involvement: Superk-Gd (former GADZOOKS!): go further with **high efficiency neutron tagging**

- adding a 0.2 % by mass of a Gd compound, $Gd_2(SO_4)_3$, to SK water, the majority of final state **neutrons** produced in the interactions (90% captured \times 90% reconstructed) will, after thermalized, be **captured** by **Gd** after $\sim 30 \mu s$ and detected through the 8 MeV γ ray cascade from its de-excitation Beacom and Vagins PRL93,171101 (2004)



7. UAM - Kamioka Observatory (Kamioka, Japón) [2008 →]: Exp. Super-Kamiokande (SK)

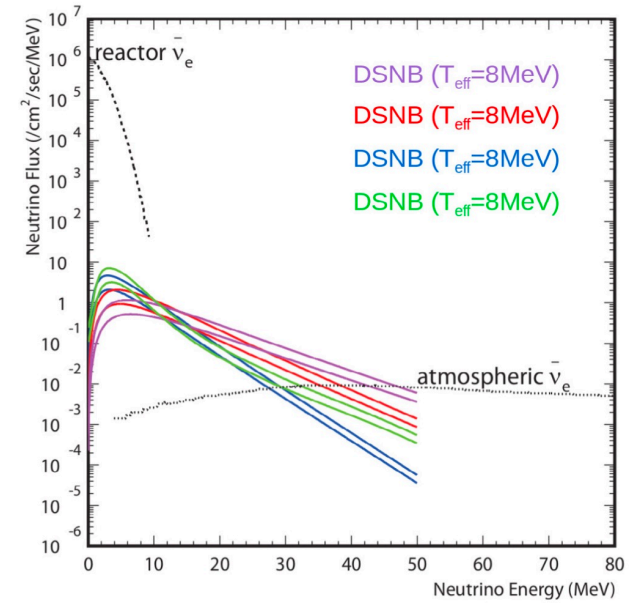
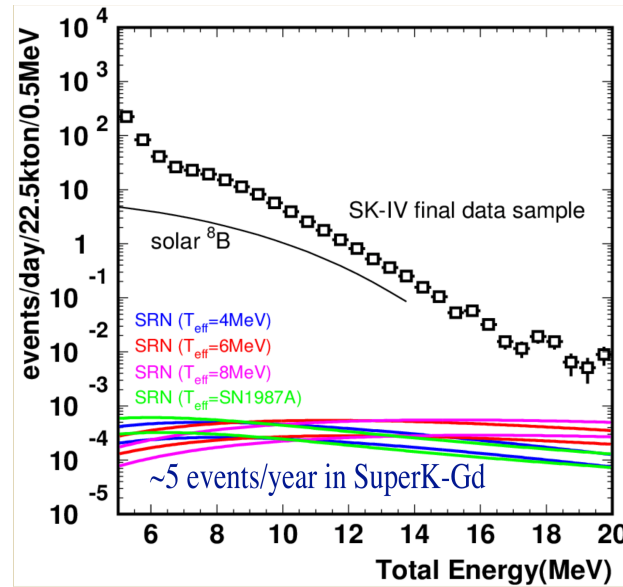
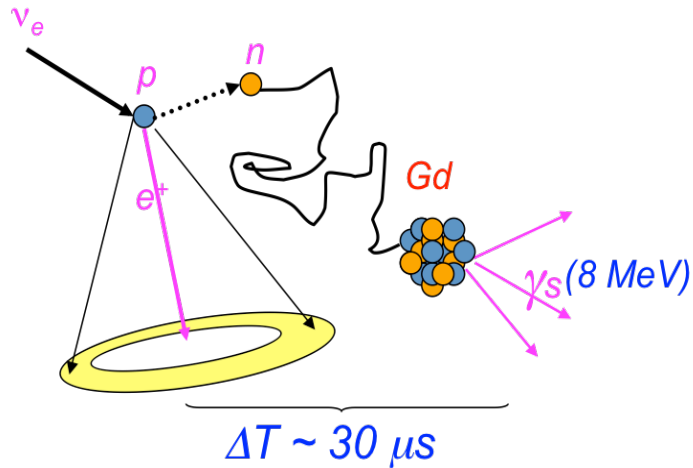
- Métodos de **identificación de neutrones en experimentos Agua-Cherenkov**

P. Fernández, PhD. Thesis, UAM 2017
 L. Labarga PoS [HQL 2016] 007
 L. Labarga PoS [EPS-HEP2017] 118

Superk-Gd: high efficiency neutron tagging by dissolving Gd in SK water

anti-neutrino tagging by inverse β reaction

discovering **DSNB** from the very much reduced background

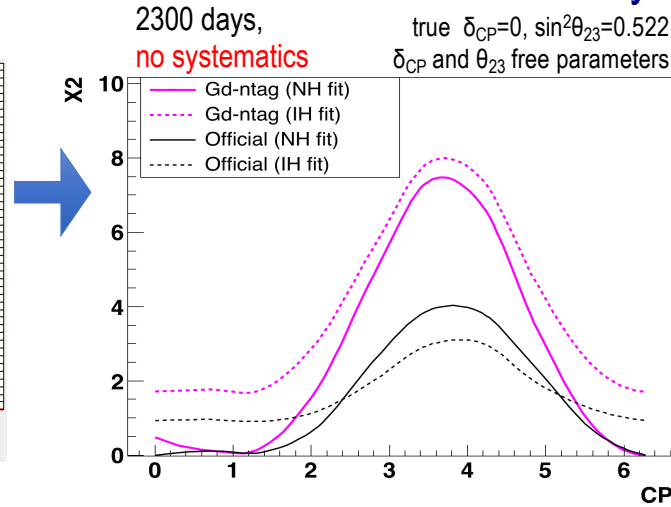
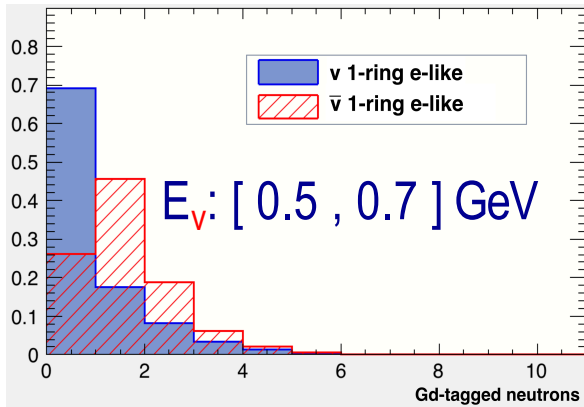


- Supernova early warning from Si burning ν_s ; Particle discrimination in Supernova burst measurement
- high precision solar- ν_s elements from reactor ν_s (if available)

7. UAM - Kamioka Observatory (Kamioka, Japón) [2008 →]: Exp. Super-Kamiokande (SK)

- Métodos de **identificación de neutrones en experimentos Agua-Cherenkov**

ν oscillation analysis: neutrino / anti-neutrino discrimination by neutron counting

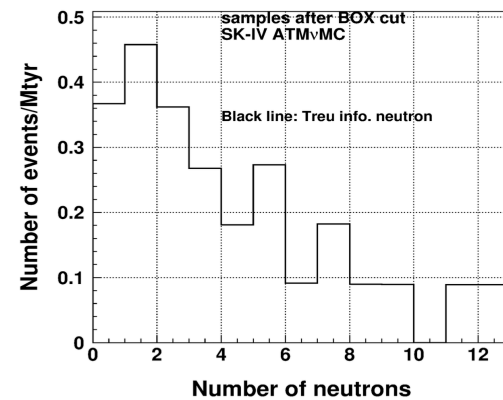
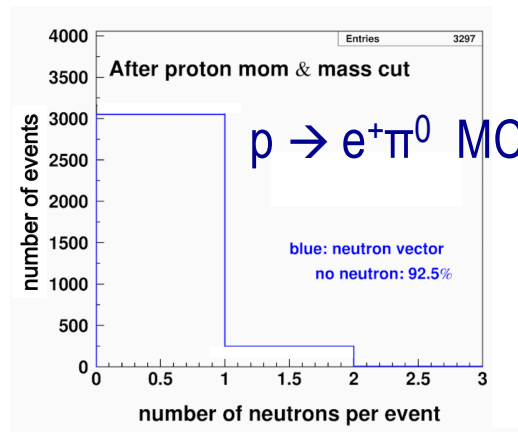


very significant increase in fraction of δ_{CP} over 90% CL

P. Fernández, PhD. Thesis, UAM 2017
 L. Labarga PoS [HQL 2016] 007
 L. Labarga PoS [EPS-HEP2017] 118

GUT searches:

- neutron veto
- background probability reduced from 44% to 9%



Atmospheric ν MC

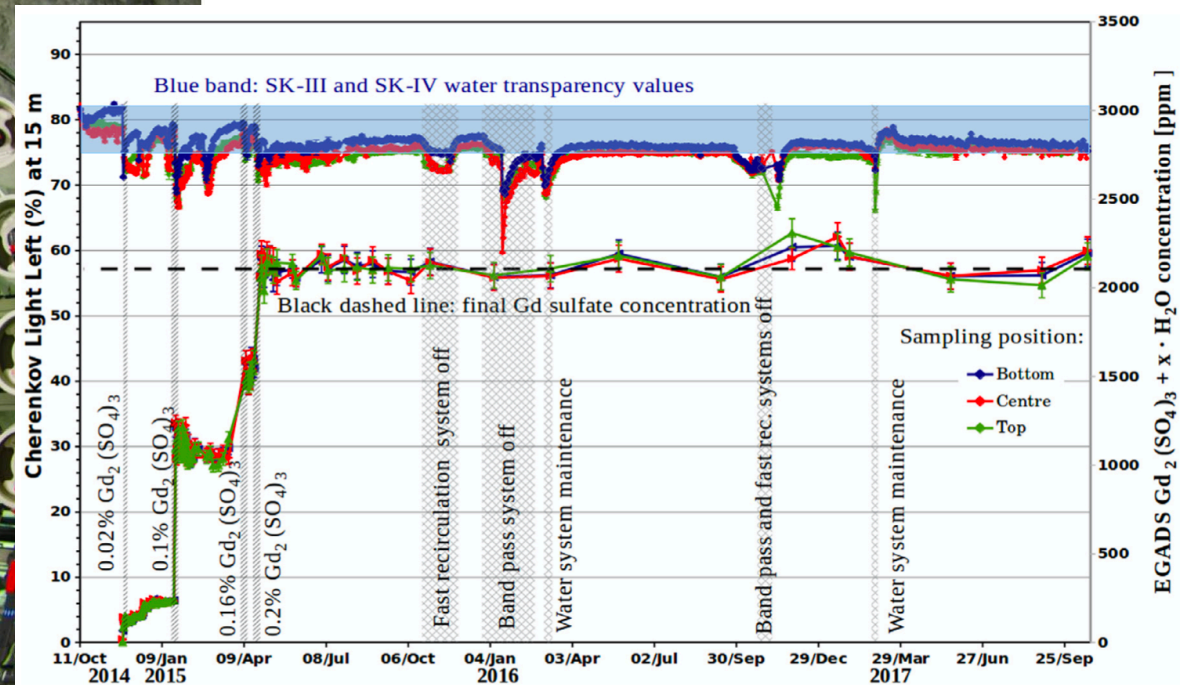
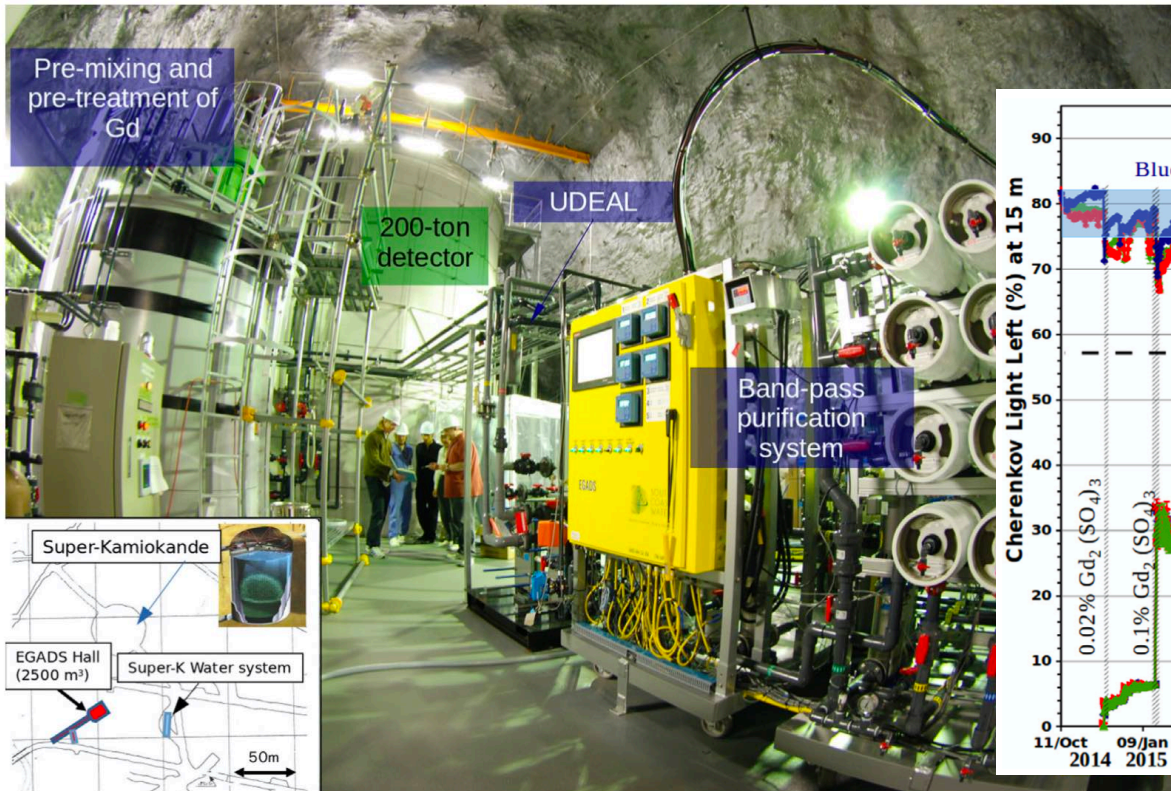
and more ...

7. UAM - Kamioka Observatory (Kamioka, Japón) [2008-]: Super-Kamiokande

- Métodos de **identificación de neutrones en experimentos Agua-Cherenkov**
- Medida de precisión de matriz de mezcla leptónica
- Desintegración del Protón



Evaluation of gadolinium's action on water Cherenkov detector systems with EGADS SK-Gd team; Nuclear Inst. and Methods in Physics Research, A 959 (2020) 163549



8. UAM – Kamioka Observatory -Laboratorio Subterráneo de Canfranc (LSC) [2008 →]:

- Exp. SuperKGd (LSC-EXP-006-2009). **Medida de radio pureza con detectores HPGe** de los materiales relevantes en SK. Impacto.

Radioactivity Contamination at $Gd_2(SO_4)_3$ very seriously assessed

[source of severe background signals all along the Fiducial Volume]

Typical activities of salts in the market:

SuperK-Gd Physics based requirements

Radioactive chain	Part of the chain	mBq/kg	SRN (mBq/kg)	Solar ν (mBq/kg)
^{238}U	^{238}U	50	< 5	-
	^{226}Ra	5	-	< 0.5
^{232}Th	^{228}Ra	10	-	< 0.05
	^{228}Th	100	-	< 0.05
^{235}U	^{235}U	32	-	< 3
	$^{227}Ac / ^{227}Th$	300	-	< 3

P. Fernández, PhD. Thesis, UAM 2017
 J. Pérez, PhD. Thesis, UAM 2017
 L. Labarga TMEX-2018-WCP



- Superk-Gd can not afford those amounts of RI; **approaches to reduce them**
 - ✓ by ourselves from received batches [processing through resins]
 - ✓ Cooperative development of pure salts with chemical Co.
- Key screening work done at the **Canfranc Underground Laboratory** under [LSC-EXP-06-2009] SupeKGd: “*Very low background measurements of radioactivity contaminations for the upgrade of the Super-Kamiokande experiment for neutron tagging by dissolving Gadolinium in its water*”

8. UAM – Kamioka Observatory -Laboratorio Subterráneo de Canfranc (LSC) [2008 →]:

- Exp. SuperKGd (LSC-EXP-006-2009). **Medida de radio pureza** con detectores HPGe de los materiales relevantes en SK. Impacto.

[EXP-06-2009] measurements corresponding to the ~14 tons currently being injected in Super-Kamiokande:

SuperK-Gd T1 sample overview (l.u. 20200623)

#	Raw mat. Comp.		Lab.	Status / comments	Ge, main chains (mBq/kg 95% c.l.)						Ge, other (mBq/kg 95% c.l.)					batch #	
					238U▲	238U▼	232Th▲	232Th▼	235U▲	235U▼	40K	138La	176Lu	134Cs	137Cs		
					upper	lower	upper	lower	upper	lower							
				requirement =>	< 5	< 0.5	< 0.05	0.05	< 30	< 30							
190302	713	714	Canfranc	ge-Asterix, at HADES	< 9.8	< 0.32	< 0.35	< 0.29	< 0.42	< 0.92	< 1.6	0.26±0.1	< 0.21	< 0.09	< 0.09	190302	
				HADES	< 105	< 8.6	< 3.3	< 3.6	< 5.6	< 10.4	< 8.8	< 1.66	< 2.47	-	< 0.93		
190303	714	612	Canfranc	ge-Asterix	< 8.4	< 0.3	< 0.44	< 0.29	< 0.39	< 0.81	< 1.5	0.45±0.09	0.16±0.12	< 0.08	< 0.09	190303	
190304	612		Canfranc	at HADES, tbm at ge-Asterix												190304	
				HADES	< 88	< 7.7	< 2.6	< 3.3	< 5.0	< 9.5	< 10	1.34±0.96	< 1.28	-	< 1.26		
190305	612		Canfranc	ge-Asterix	< 9.0	< 0.34	< 0.36	< 0.30	< 0.41	< 0.90	< 1.6	0.5 ± 0.1	0.14±0.13	< 0.09	< 0.12	190305	
190601	627	840	Canfranc	ge-Asterix	< 10.2	< 0.52	< 0.35	< 0.41	< 0.50	< 1.36	< 1.9	< 0.16	1.3±0.1	< 0.10	< 0.11	190601	
			Kamioka	RaEmporeDisk	-	< 0.32	< 0.39	< 0.34	-	-	-	-	-	-	-		
190602	627	840	Canfranc	ge-Tobazo	< 29	< 0.49	< 1.64	< 0.82	< 0.76	< 1.85	< 2.1	< 0.21	1.6±0.2	< 0.17	< 0.14	190602	
			Kamioka	RaEmporeDisk	-	< 0.28	< 1.01	< 0.28	-	-	-	-	-	-	-		
190603	627	840	841	Canfranc	Ge-Anayet	< 26	< 0.45	< 1.03	< 0.76	< 0.58	< 2.02	< 1.58	< 0.18	1.7±0.1	< 0.15	< 0.12	190603
190607	912		Canfranc	ge-Oroel	< 7.2	< 0.30	< 0.79	< 0.42	< 0.30	< 0.96	< 1.59	< 0.18	< 0.13	< 0.12	< 0.09	190607	
190608	912		Canfranc	ge-Asterix	< 8.8	< 0.53	< 0.43	< 0.35	< 0.40	< 0.88	< 1.50	< 0.14	< 0.25	< 0.08	< 0.09	190608	
			Kamioka	RaEmporeDisk		< 0.49	< 0.43	< 0.55									
190702	912		Canfranc	ge-Oroel	< 11.0	< 0.45	< 1.11	< 0.50	< 0.37	2.4±0.9	< 1.5	< 0.20	0.23±0.13	< 0.12	< 0.11	190702	
			Kamioka	5kg/12.7d	< 9.4	< 0.57	< 0.97	< 0.26	< 2.6	< 1.4	-	-	< 0.44	-	-		
190703	912	913	Canfranc	ge-Asterix	< 8.4	< 0.35	< 0.51	< 0.50	< 0.45	1.8±1.0	< 1.7	< 0.20	0.5±0.1	< 0.10	< 0.10	190703	
190801	913	914	Canfranc	ge-Anayet	< 28	0.39±0.32	< 1.5	< 0.77	< 0.80	< 1.17	< 1.44	< 0.18	2.7±0.2	< 0.23	< 0.18	190801	
190803	914		Canfranc	ge-Asterix	< 7	< 0.31	0.39±0.21	0.55±0.22	< 0.36	< 0.74	< 1.4	< 0.09	3.5±0.1	< 0.08	< 0.07	190803	
190805	914		Canfranc	ge-Oroel	< 8.4	0.25±0.23	0.53±0.39	0.60±0.36	< 0.40	< 0.89	< 1.12	< 0.09	9.4±0.1	< 0.10	< 0.08	190805	
190901	917		Canfranc	ge-Asterix	< 6.85	< 0.27	0.48±0.23	0.34±0.24	< 0.42	< 1.09	< 1.31	< 0.13	4.9±0.1	< 0.09	< 0.12	190901	
190903	917		Canfranc	under meas. ge-Asterix	< 8.9	< 0.37	0.59±0.28	0.35±0.28	< 0.54	< 1.7	< 1.5	< 0.14	4.9±0.1	< 0.10	< 0.09	190903	
					238U▲	238U▼	232Th▲	232Th▼	235U▲	235U▼	40K	138La	176Lu	134Cs	137Cs		

8. UAM – Kamioka Observatory -Laboratorio Subterráneo de Canfranc (LSC) [2008 →]:

- Exp. SuperKGd (LSC-EXP-006-2009). Medida de radio pureza con detectores HPGe de los materiales relevantes en SK. Impacto.

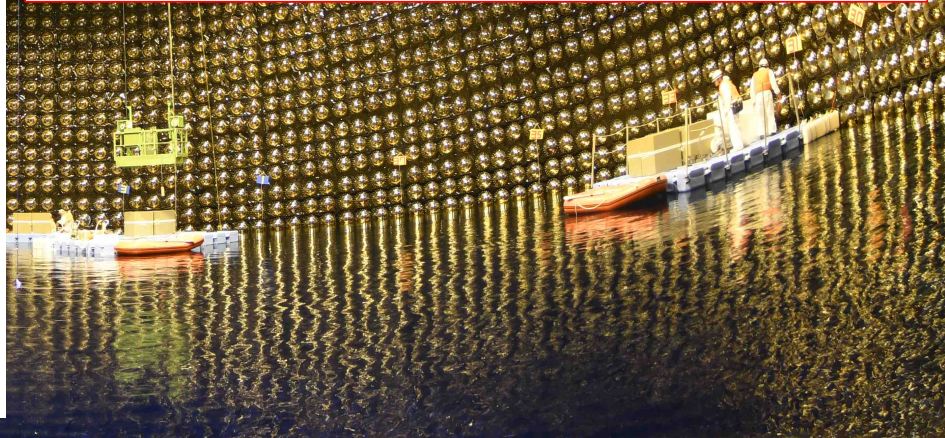
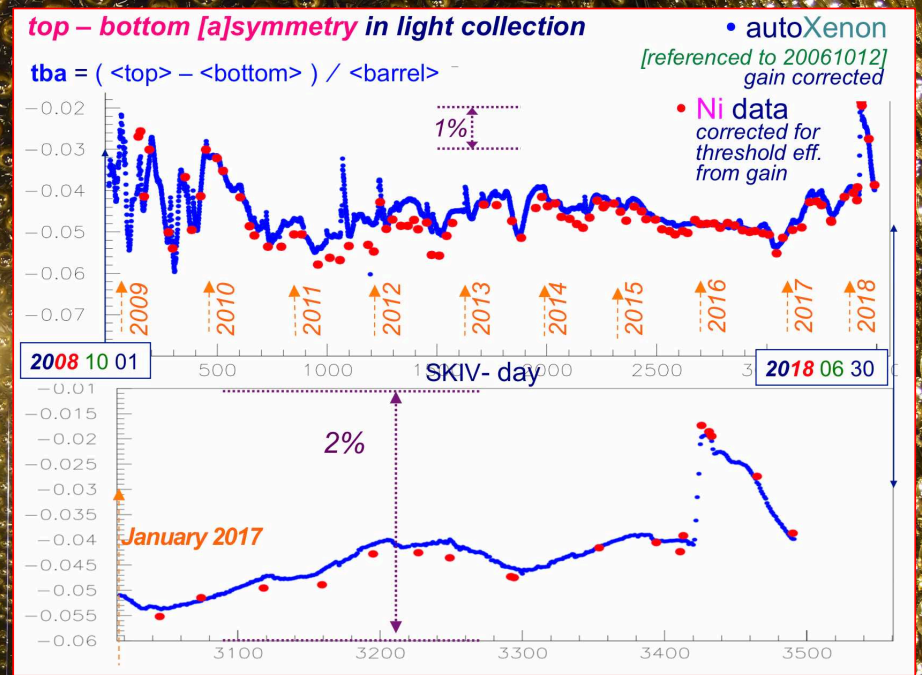
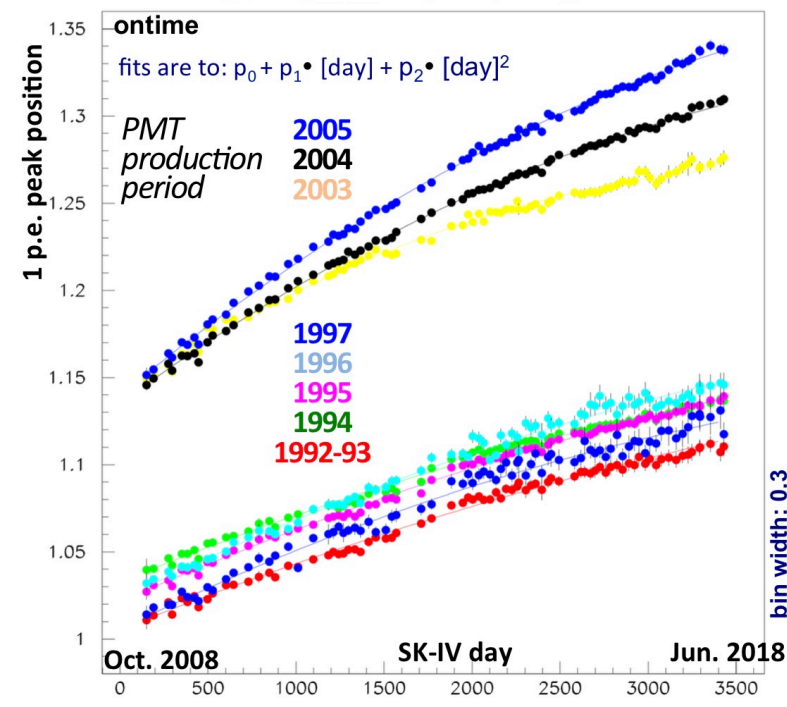
- Some information about the ICPMS meas. at UAM: From every sample, a few grams subsample is extracted and sent to the UAM where ICPMS measurements of Ce, Eu and La were made. Ce and Eu are dangerous because of light emission (particularly Ce), La is a nice element to cross-check the Ge measurement.

batch #	ICPMS				
	Ce	Ce	La	Eu	Eu
	ppb	ppb	ppm	ppm	ppm
	UAM	Kamioka	UAM	UAM	Kamioka
	< 50	< 50			
190302	23±1	23.5±1.0	0.56±0.02	0.78±0.02	
190303	12±1	10.4±1.2	0.90±0.05	0.74±0.02	
190304	12±1	10.8±0.7	0.99±0.04	0.56±0.02	
190305	11±1	11.7±0.3	0.93±0.03	0.44±0.02	
190601	tbd	30.0±1.0	tbd		
190602	36±1	33.7±1.3	0.17±0.01	1.51±0.05	1.4
190603	tbd	30.2±0.4	tbd		
190607	8±1	10.1±0.1	0.12±0.01	0.59±0.02	
190608	8±1	13.8±1.0	0.08±0.03	0.65±0.02	
190702	12±1	12.1±0.7	0.12±0.01	0.61±0.02	
190703	14±1	9.7±0.6	0.14±0.01	0.69±0.02	
	Ce	Ce	La	Eu	Eu
	ppb	ppb	ppm	ppm	ppm
	UAM	KO	UAM	UAM	KO

Quite a lot of learning from our UAM colleagues

SK: calibrations, detector evolution, etc.

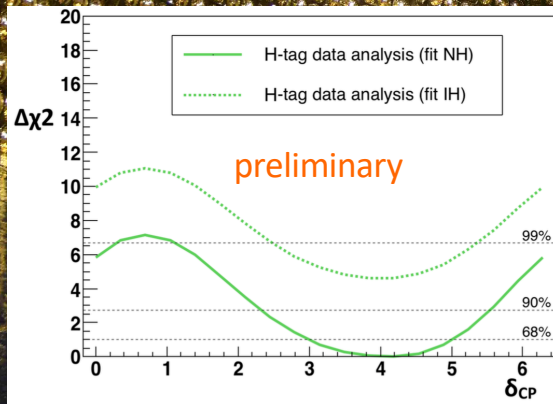
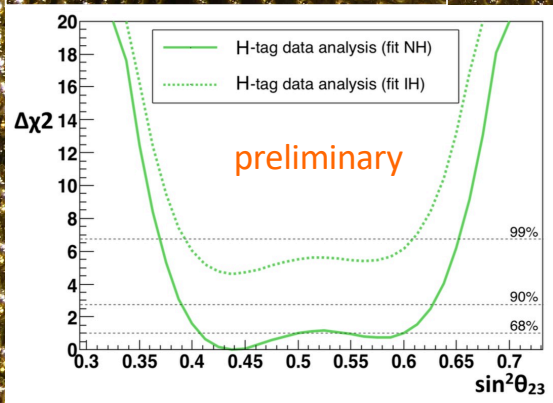
PMT-gain variation with time at different PMT groups
Nickel SK-IV data: gain [fitted 1 p.e. peak] vs. time



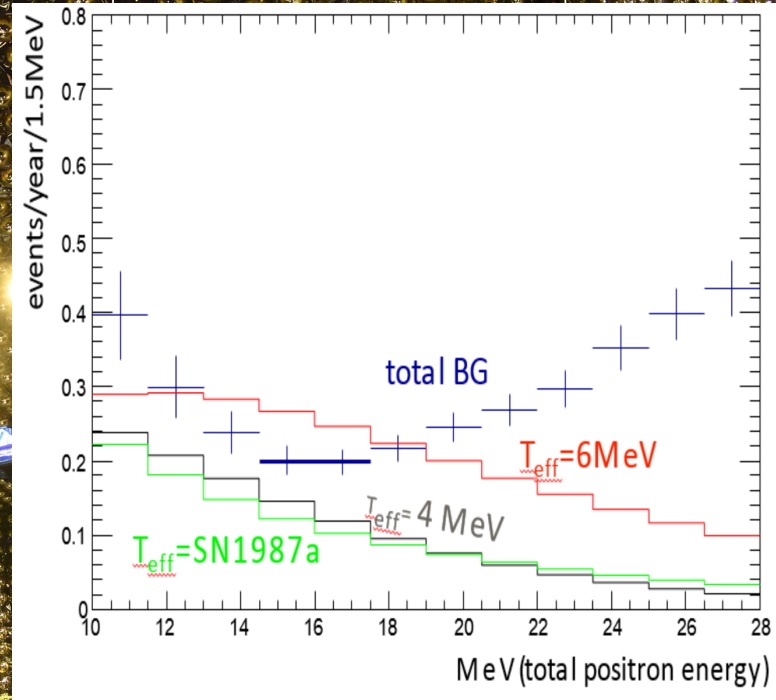
Measured in SK-IV, to be measured in SK-VI

Discovering of DSNB

oscillation analyses
with neutron-tag



P. Fernández, PhD. Thesis, UAM, 2017

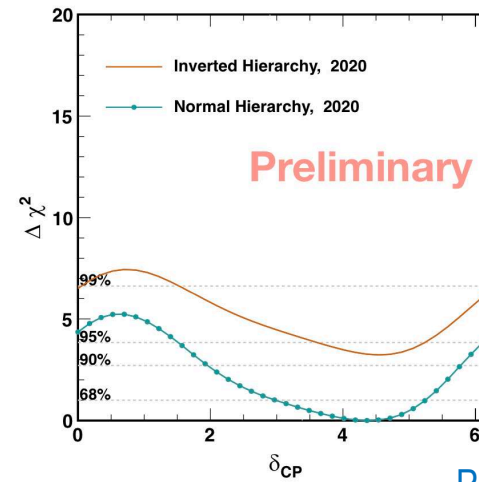
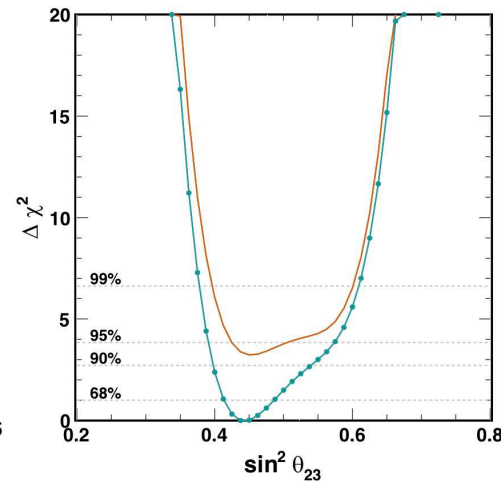
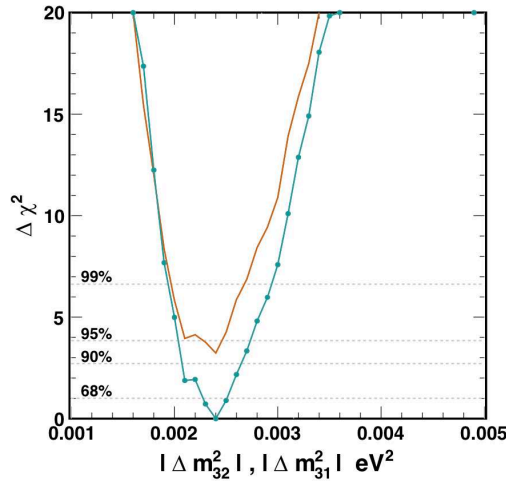


7. UAM - Kamioka Observatory (Kamioka, Japón) [2008 →]: Exp. **Super-Kamiokande (SK)**

- Medida de precisión de **matriz de mezcla leptónica**

Oscillation Parameter Measurement

SK @ Neutrino2020



Hybrid method developed by P. Fernández for SK - IV data [where electronics allows -low efficiency- neutron tagging]

P. Fernández, PhD. Thesis, UAM 2017

930 Bins	χ^2	θ_{13}	δ_{cp}	θ_{23}	$\Delta m_{23} (x10^{-3})$
SK (NH)	1037.5	0.0218	$4.36^{+0.88}_{-1.39}$	$0.44^{+0.05}_{-0.02}$	$2.40^{+0.11}_{-0.12}$
SK (IH)	1040.7	0.0218	$4.54^{+0.88}_{-1.32}$	$0.45^{+0.09}_{-0.03}$	$2.40^{+0.09}_{-0.32}$

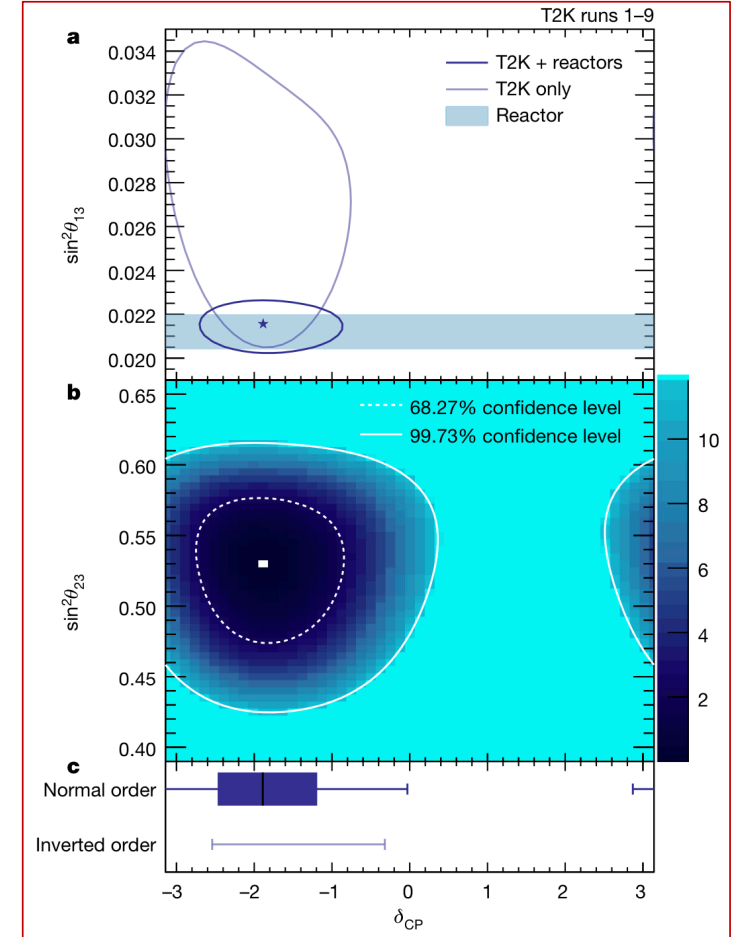
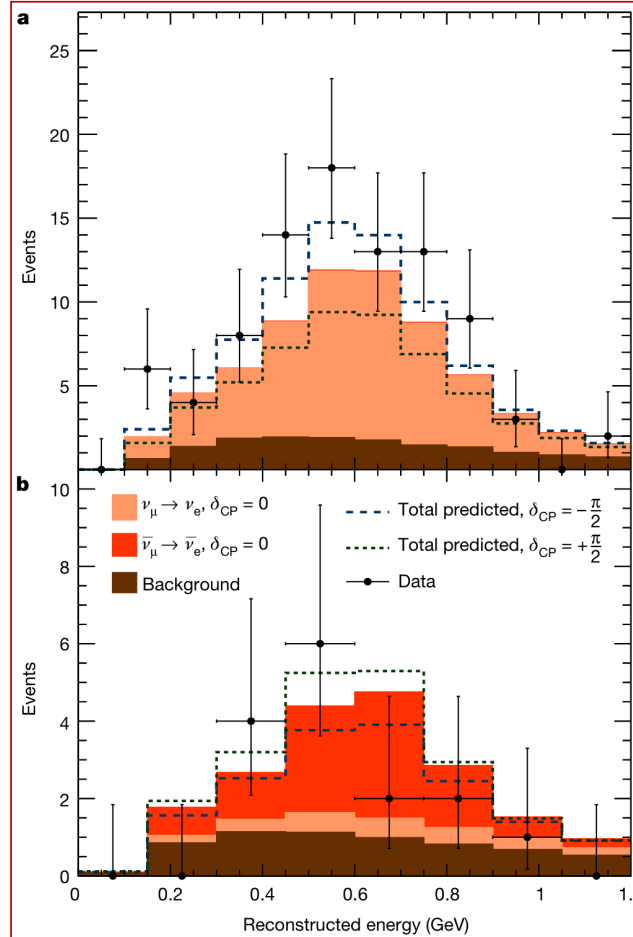
SK data disfavors Inverted Hierarchy at 71.4-90.3% CL_s (was 81.9-96.1% in 2018)

Also prefers: 1st θ_{23} octant and $\delta_{CP} \sim 3/2\pi$

12. UAM – Kamioka Observatory [2016 →]: Experimento T2K

- Violación de la simetría Carga Paridad en el sector leptónico

Constraint on the matter-antimatter symmetry-violating phase in neutrino oscillations; Nature 580 (2020) no.7803, 339



Parece que δ_{CP} no es 0 en el sector leptónico [formalmente no lo es a tres sigmas]

→ Descubrimiento y medida de precisión por HK

10. UAM - LSC [2011-]: **Experimento NEXT**; **Desintegración Doble Beta sin Neutrinos**

- Medida de radio-pureza con detectores HPGe de todos sus materiales. Impacto.

- The SuperK-Gd works performed at the LSC have, in turn, produced a fantastic synergy relationship with the Spanish-lead NEXT experiment at the LSC.
- We have performed along U. Zaragoza people and the LSC itself the complete screening campaign for the extremely high Radiopurity materials mandatory for the experiment.
- NEXT is now taking data in the so called NEXT-NEW phase prior the full phase NEXT-100. We aim for continuing the less demanding but still mandatory radio-purity works for NEXT, as well as a modest, but hopefully significant contribution to the first search for the $2\beta_{0\nu}$ process.

→ From a physics point of view it can't be better: with NEXT we complement SK, SK-Gd, and HK in exploring the very high-energy regime, totally inaccessible for colliders, in particular by searching for a heavy mass Majorana particle that might clarify the origin of the mass and the nature itself of the neutrinos.

J. Pérez, PhD. Thesis, UAM 2017

Radiopurity assessment of the energy readout for the NEXT double beta decay experiment. NEXT Coll.; 2017 JINST 12 T08003

Radiopurity Control in the NEXT-100 double beta decay experiment: procedures and initial measurements. NEXT Coll.; 2013 JINST 8 T01002

Radiopurity assessment of the tracking readout for the NEXT double beta decay experiment. NEXT Coll.; 2015 JINST 10 05 P05006

- Siempre incremento de conocimiento
 - A la espera de una Supernova cercana; extraer la máxima información possible
 - Incrementar sensibilidad análisis oscilaciones neutrinos solares, atmosféricos
 - seguir explorando “espacio de fase” GUT. por ejemplo: no se debe parar la exploración de GUTs
 - Etc. ...
 - SuperK-Gd “solo” va a descubrir DSNB → lo siguiente es medir su flujo, espectro de energía, asimetrías etc.
 - El valor tan grande de θ_{13} (medido por T2K y reactores) abre la puerta a CPV en el sistema leptónico; sus primeras medidas indican que puede ser realmente importante, lo que puede tener implicaciones muy profundas en nuestro conocimiento de la naturaleza → se necesita establecer y medir con precisión
 - Etc.
- Next generation of a Neutrino and Nucleon decay experiment
- Dos aproximaciones: DUNE “poca” masa, tecnología argón líquido; Hyper-Kamiokande: muy masivo, capaz de explorar bien astrofísica y Gran Unificación
 - Hemos apostado por Hyper-Kamiokande ¡ sin duda !

9. UAM [2008-]: Proyectos Laguna y Laguna-LBNO.

- Infraestructura subterránea, operación del detector → Estudio de viabilidad del LSC para alojar tal experimento
- Expectativas de descubrimiento y medida de la violación de la simetría Carga Paridad en el sector leptónico



FEASIBILITY STUDY FOR LARGE UNDERGROUND CAVERNS AND AUXILIARY INFRASTRUCTURE FACILITIES OF THE LAGUNA PROJECT AT THE LSC (CANFRANC, HUESCA, SPAIN)

Revision 12th May 2010

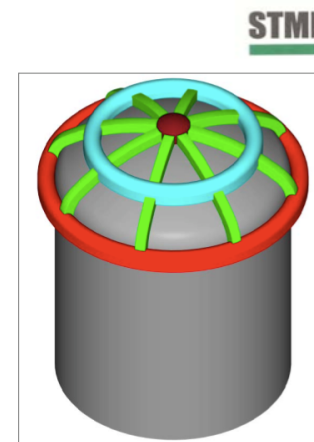
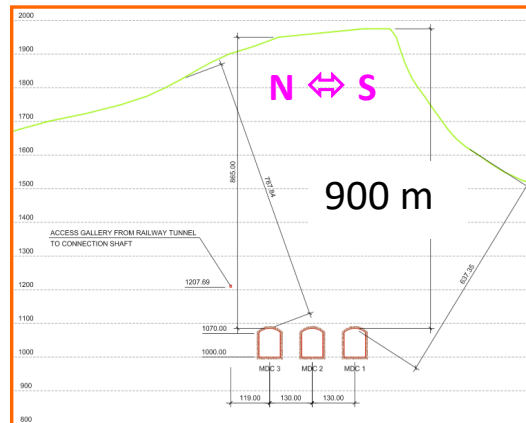
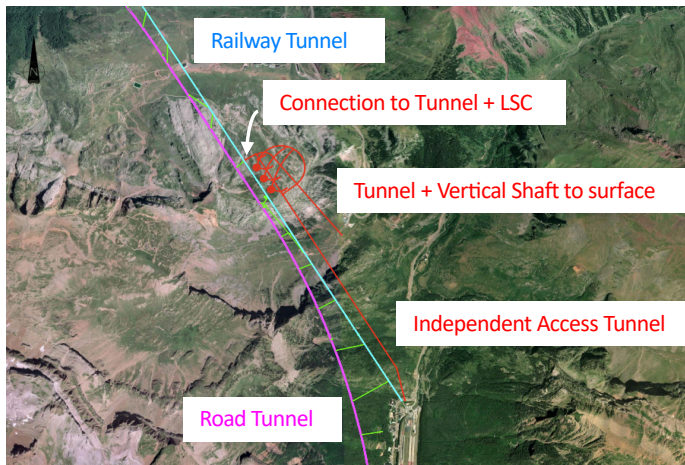


Figure 7.3-2. Perspective view of the vault system.

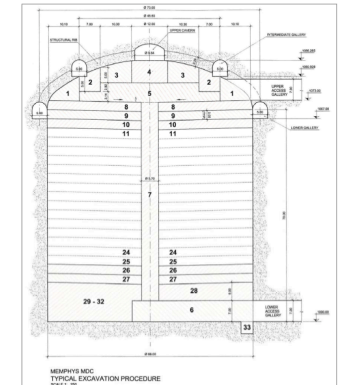
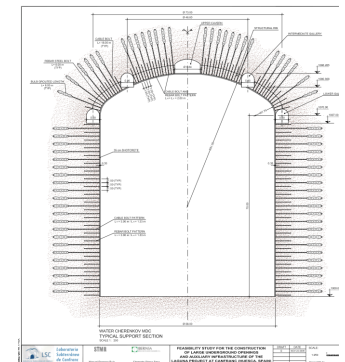
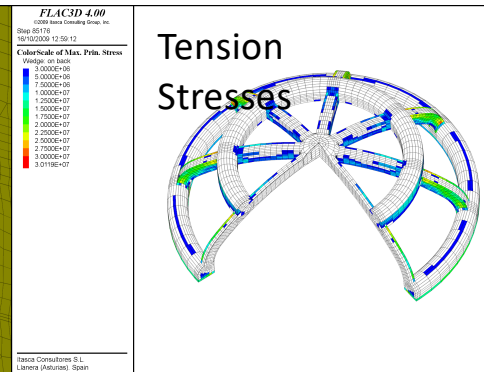
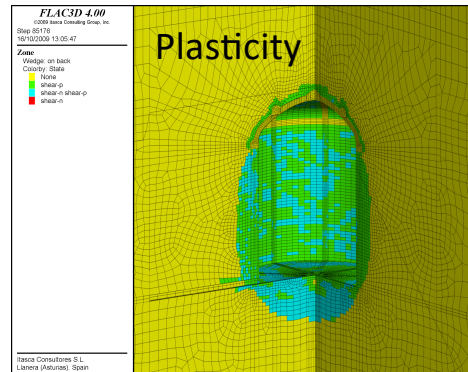
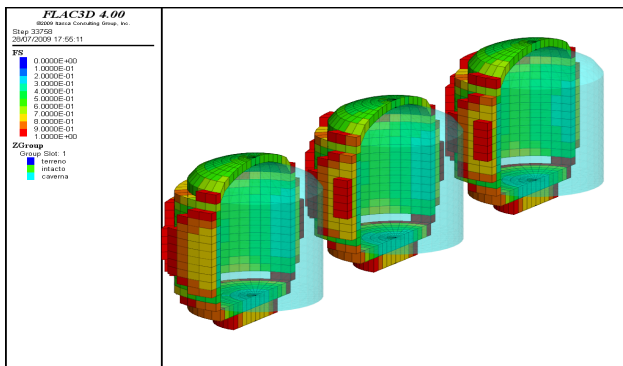


Figure 7.3-3. Excavation sequence for the MEMPHYS caverns.



9. UAM [2008 - 2012]: Proyectos Laguna y Laguna-LBNO.

- Infraestructura subterránea, operación del detector → Estudio de viabilidad del LSC para alojar tal experimento
- Expectativas de descubrimiento y medida de la violación de la simetría Carga Paridad en el sector leptónico

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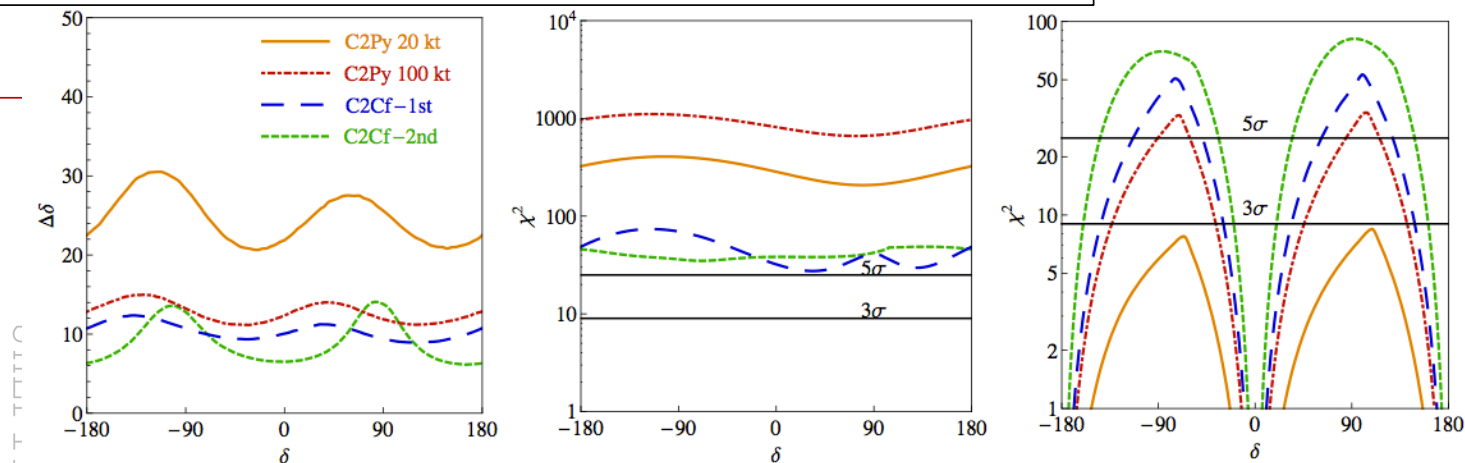
RECEIVED: June 12, 2012
 REVISED: September 10, 2012
 ACCEPTED: October 18, 2012
 PUBLISHED: November 13, 2012

Physics reach of CERN-based SuperBeam neutrino oscillation experiments

Pilar Coloma,^a Enrique Fernández-Martínez^b and Luis Labarga^c

^aCenter for Neutrino Physics, Department of Physics, Virginia Tech, Blacksburg, VA 24061, U.S.A.
^bCERN Physics Department, Theory Division, CH-1211 Geneva 23, Switzerland
^cDepartamento de Física Teórica, Universidad Autónoma de Madrid, Cantoblanco 28049 Madrid, Spain

JHEP11(2012)011



Next Generation Accelerator Neutrino Projects - Long and Short Baseline

Marco Zito, IRFU/SPP CEA-Saclay

Project	Beam power MW	Fiducial Mass kt	Baseline km	MH	CPV 90%CL, (3σ)	Physics starts	Astrophysical program	p-decay program
LBNO	0.8	20- >100	2300	Excellent	71 (44)	2023	Yes	No
T2HK	0.75	500	295	Little	86 (74)*	2023	Yes	Yes
LBNE	0.7	10	1300	OK	69 (43)	2022	No	No
Lund	5	440	365	Some	86 (70)	>2019	Yes	Yes
CERN-Canfranc	0.8-4	440	650	Some	80-88(80)	>2020	Yes	Yes

*: if mass hierarchy is known



Contribution ID : 24

A realistic next-generation nucleon decay and neutrino experiment capable to probe leptonic CP violation

Primary authors : FERNANDEZ MARTINEZ, Enrique (); LABARGA, Luis (Departam.de Física Teórica)

11. UAM – Kamioka Observatory [2012 →] Proyecto / Experimento **Hyper-Kamiokande**

- **Desarrollo general** del diseño y del Proyecto, Construcción de una participación española
- Cubiertas de los PMTs para abortar reacción en cadena en caso de implosión

P. Fernández, PhD. Thesis, UAM 2017
 L. Labarga PoS [HQL 2016] 007
 L. Labarga PoS [EPS-HEP2017] 118

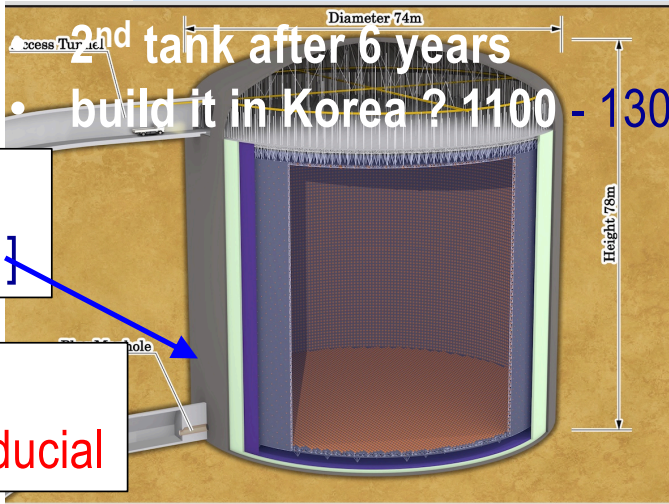
neutrino physics with water Cherenkov in Japan: A most successful experimental program

Kamiokande → Super-Kamiokande [K2K , T2K] →

- maximizes available resources → minimizes time, useless efforts ...
- maximizes experience & know-how → minimizes risks, delays, failures

→ **Hyper-Kamiokande [T2HK]**

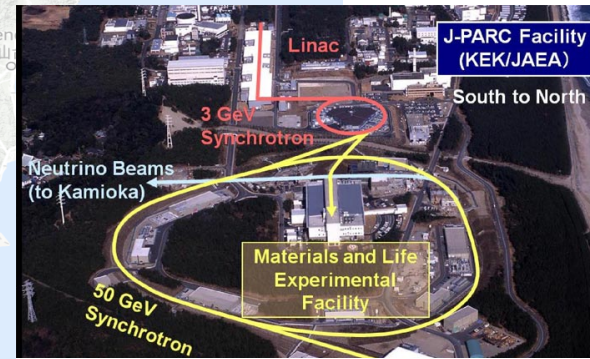
- uses Water-Cherenkov: unique technique to achieve **huge amount of instrument matter**



[1 + 1] x
 [72m H x 64m Ø]

[0.26 + 0.26] Mt
 [0.19 + 0.19] Mt fiducial

295 Km



1.3 MW, 2.5° off-axis
 narrow-band, ~600 MeV

- precise rec. of particle's energy, position, direction, type ...

11. UAM – Kamioka Observatory [2012 →] Proyecto / Experimento **Hyper-Kamiokande**

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Hyper-Kamiokande: our scientific goals

- Origin of ν mass, anti-/matter asymmetry: in less than 10 years CP violation in the lepton sector can be observed with more than 3 (5) significance for 76 (57)% of the possible values of CP. DUNE estimates: 3(5) significance for 75(50)% of the possible values of CP in 9 (12.5) years
- ν astrophysics:
 - **DSNB**: E spectrum; expected number of DSNB events by HK after 10 years observation is $\sim 70 \pm 10$ ($16 \leq E \leq 30$ MeV). If HK is loaded with Gd the number rises to ~ 300 (10- 30 MeV). DUNE estimates: 46 ± 10 events with $16 \leq E_e \leq 40$ MeV (we believe this is far an optimistic estimate), no possibility of E spectrum, the same for JUNO.
 - solar, atmospheric and supernova neutrinos: HK will be the world leading detector in the observation of solar, atmospheric and supernova neutrinos for more than two decades in the energy range from few MeV to tens of GeV.
- proton decay, Grand Unification: partial lifetimes limits (90% C.L., 10y exposure) of $0.8 \cdot 10^{35}$ y for $p \rightarrow e^+ \pi^0$, $3 \cdot 10^{34}$ y for $p \rightarrow \nu K^+$ and basically one order of magnitude improvement for other modes. DUNE: only $p \rightarrow \nu K^+$ (this is assuming 100% eff. for K^+ identification, we believe this is also too optimistic), JUNO: similar for $p \rightarrow \nu K^+$

Status of the Hyper-Kamiokande project

- The Hyper-Kamiokande project has officially started in the beginning of 2020 by receiving its first Japanese funding of 3.5 BJPY from supplementary budget for FY2019 and 0.3 BJPY from general budget for FY2020. Construction schedule: 5 years of cavern excavation + 2 years of instrumentation. Data taking is scheduled to commence in 2027.
- The Japan Proton Accelerator Research Complex (J-PARC) beam delivered to the detector is planned to be upgraded from the current 0.5 to 1.3 MW over the same time period.
- The overall budget is 64.9 BJPY (~558.7 M€) with a Japan share of 50.2 BJPY (~432.2 M€) until FY2026 for the HK main detector, and 7.3 BJPY (~62.8 M€) with a Japan share of 4.3 BJPY (~37.0 M€) until FY2026 for the J-PARC upgrade.
- The HK project has two host institutes: the University of Tokyo and KEK
- The HK proto-Collaboration consists of ~350 members from 18 countries: Armenia, Brazil, Canada, France, Germany, India, Italy, Japan, Korea, Mexico, Poland, Russia, Spain, Sweden, Switzerland, UK, Ukraine, and USA. The p-Collaboration is transitioning to a real Collaboration in which commitments of each participating institutes and countries are defined.

In Spain

- The UAM has been pushing and working actively on the project since its start. The LSC incorporated and, as the World Class laboratory that is, it has taken the lead. DIPC is already taking position
- A “Japan Spain Technical Committee for the Spanish Contribution to HK” was setup by MEXT and MICIN; its *Final Report* was submitted to both on May 24th
 - following slides provide some summary of the main conclusions/recommendations
- Hard work to spread HK Science in Spain; Promotion tour by Shiozawa, Moriyama, Ishitsuka + CPG& LL
- Prof. T. Kajita has provided invaluable help. On 20/02/2020, Minister Dr. P. Duque informed that HK is among the Science projects of the MCIN during his presentation of the general lines of MCIN to the Committee on Science, Innovation and Universities of the Spanish Congress of Deputies.

Status of Spanish Contribution to the Hyper-Kamiokande experiment.

- Based on the lead of the LSC. Currently very active the LSC and the UAM. Very important is that the LSC belongs to the map of Spanish “Singular Scientific Installation Units” of MCIN.
- In addition, other groups may be joining in the near, mid-term future, depending on agreement (common interests in neutrino physics). Centers currently interested in becoming members of HK, one way or another, sooner or later: DIPC, IGFAE / U. Santiago Compostela, U. Oviedo, IFCA / U. Cantabria
- Trying to bring more groups into this scientific enterprise

In Spain

Intended Spanish Contributions to the Hyper-Kamiokande construction:

- Design, full test and certification of the 20" Inner Detector PMT covers for chain reaction prevention from PMT implosion. The certification will proceed by a program of hydrostatic pressure tests in Spain and forced-implosion tests in Japan.
- Analysis of components and materials of the HK far detector, in terms of radiopurity, by the Canfranc Underground Laboratory;
- Production of the parts, assembly and transport to Kamioka for 20,000 of the above covers.
- Contribution to the assembly of the photodetection units (PMT inside cover) and contribution to the installation in the main structure of those units.

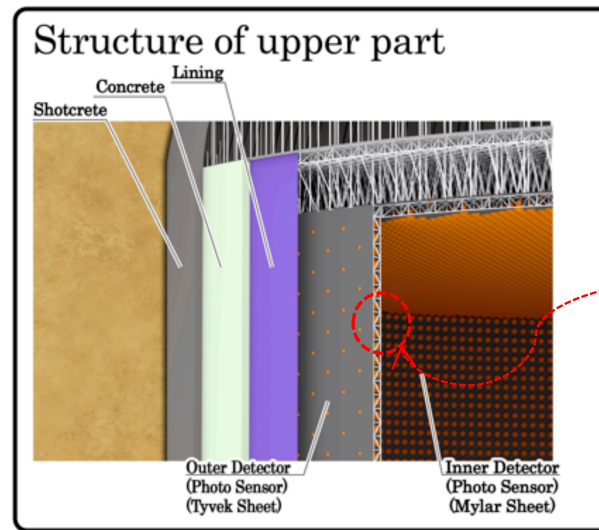
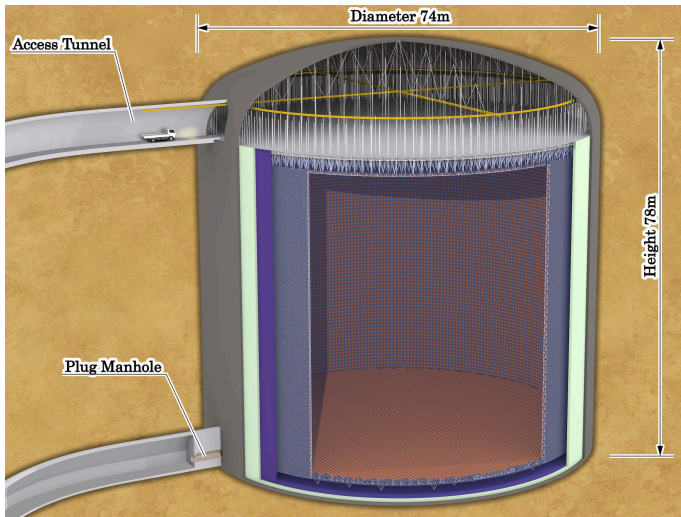
Possible additional contributions are considered if the needed conditions are met:

- Software development for Data Analysis; extensive use of AI on final state reconstructions.
- Computing and Storage by sharing Tier 2 LHC infrastructure from UAM and maybe other institutes.
- Other mechanical or electronic parts.
- Radon free air supply systems for the underground installation
- Calibration of optical properties of the covers and PMTs.

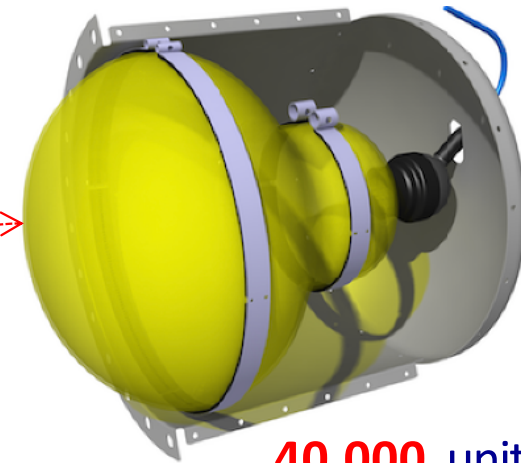
11. UAM – Kamioka Observatory [2012 →] Proyecto / Experimento **Hyper-Kamiokande**

- Desarrollo general del diseño y del Proyecto, Construcción de una participación española
- **Cubiertas de los PMTs para abortar reacción en cadena en caso de implosión**

identifying relevant parts of the experiment for suitable contributions by Spain



The basic unit of the H detector:



40.000 units at most

- photo detection system: key in HK
- problem with chain reaction after accidental implosion of one PMT: the case of SK
- need new implosion mitigation cover (SK: 40 m, HK: **70 m**)
- it is key part of the photo detection system sensor: efficiency, noise, safety etc.
- **LSC+UAM strongly contributing to it**

11. UAM – Kamioka Observatory [2012 →] Proyecto / Experimento **Hyper-Kamiokande**

- Cubiertas de los PMTs para abortar reacción en cadena en caso de implosión

former activities: works on covers for ID 20'' PMTs (up to V2.2)

in very close collaboration with
Talleres Aratz S.A.
www.talleresaratz.com

[HK-TN-01: Progress report on the Spanish cover design and testing; D. Bravo Berguño, L Labarga]

V1: first approach,
accomplished in
collaboration
with ICRR

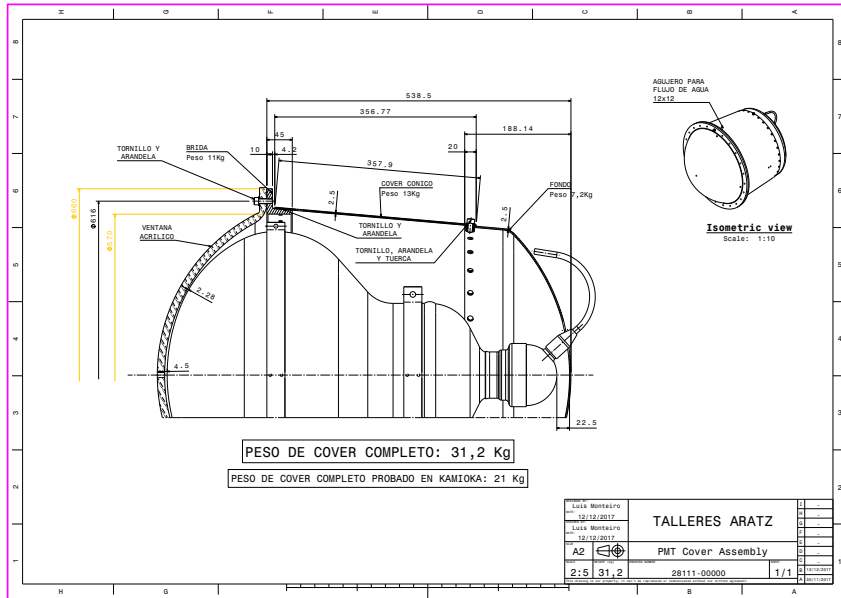


V2: new design; also hydrostatic pressure test setup in Spain. Failure of V2.0 and V2.1; but success of V2.2



→ We got already a base design for which the proof of principle has successfully worked at 60m depth
 (for previa to V2.2 see “additional material”)

V2.2 successfully tested for implosion at Hokkaido

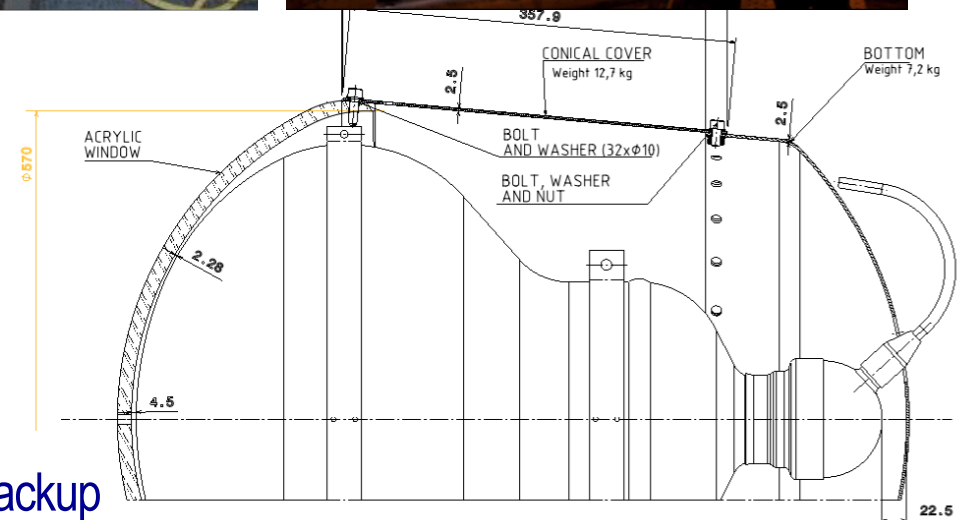


for Hyper-Kamiokande:

→ **V3**: probably the simplest, most robust, and cheapest approach

- flangeless acrylic domes
- Riveting instead of bolts and nuts

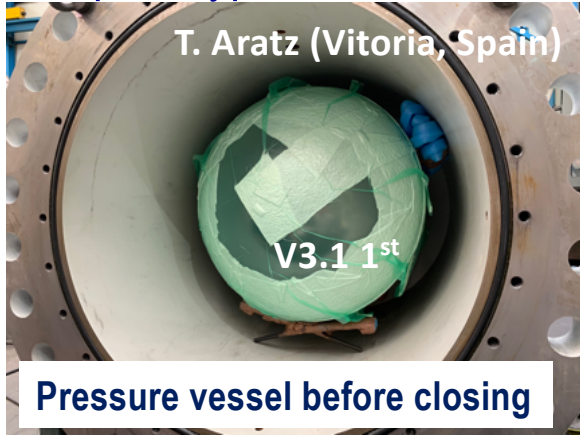
→ but keep and improve current version V2.2 (→ **V2.3**) as alive backup



11. UAM – Kamioka Observatory [2012 →] Proyecto / Experimento **Hyper-Kamiokande**

- Desarrollo general del diseño y del Proyecto, Construcción de una participación española
- **Cubiertas de los PMTs para abortar reacción en cadena en caso de implosión**

V3.1, 1st prototype sustained 9 bar



V3.1, 2nd prototype sustained 9.5 bar



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Colaboración con colegas UAM


Activities ongoing (IV):
transmittance measurements of acrylic samples by Spanish company
(by UAM colleagues/friends)

→ no UV transmitting,
discussing with company

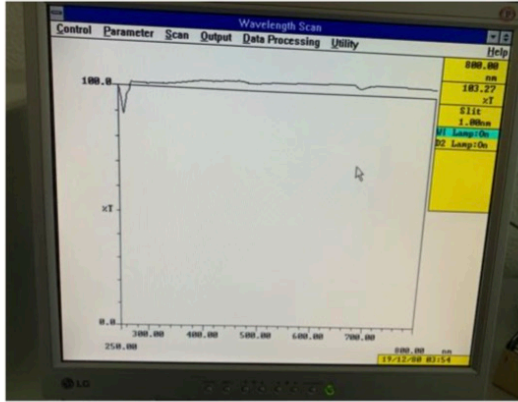
Medidas transmitancia muestras EMACRYL LL20200221



Espectrofotómetro es Hitachi U-3501



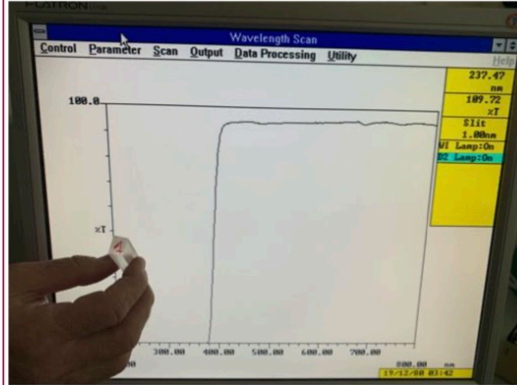
Pieza 1 es Plexiglas plástico transparente
Pieza 2 es Plexiglas plástico azul



La medida transmitancia es desde 800 a 250 nm.
La foto muestra la respuesta cuando no hay muestra (i.e. correspondiente a transmitancia 100%)

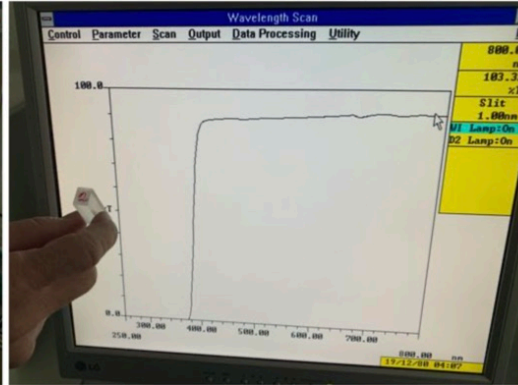
Medidas transmitancia muestras EMACRYL LL20200221

Medida Pieza 1 (Plexiglas plástico transparente)



Hasta ~400 nm transmitancia ~90% : ~OK
Por debajo baja rápidamente a cero : MAL

Medida Pieza 2 (Plexiglas plástico azul)



Hasta ~400 nm transmitancia ~90% : ~OK
Por debajo baja rápidamente a cero : MAL

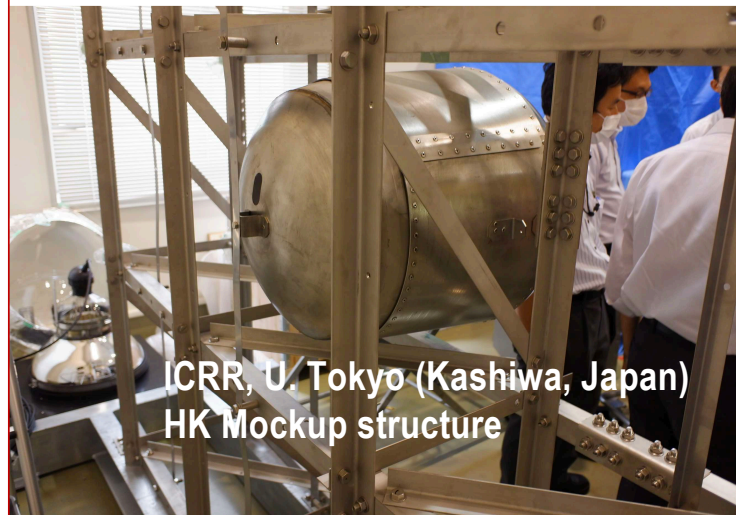
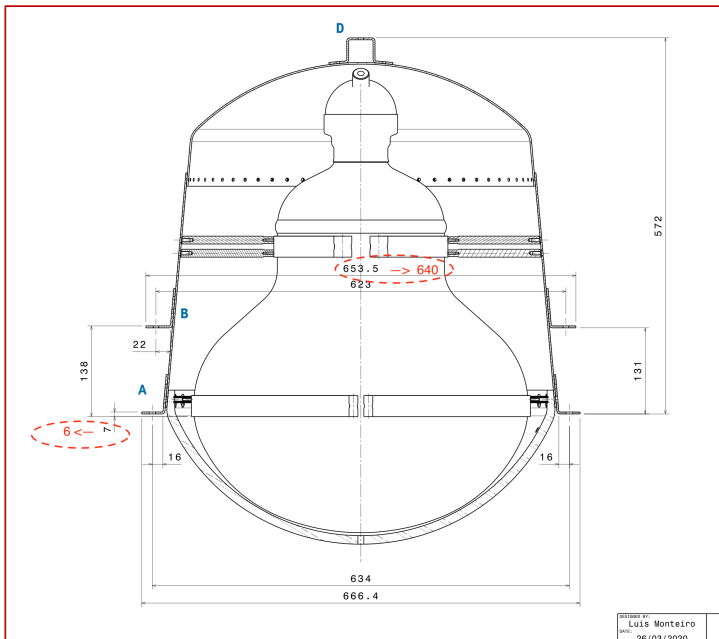
Ambas muestras **no** transmiten UV, deberían ser transparentes al ~90% hasta 300 nm, **no** se pueden usar en Hyper-Kamiokande

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Attachment Cover-to-Structure

- First iteration finished
- 1 unit of sp-cover with attachment system in place is now in Kashiwa HK mockup structure for testing



ICRR, U. Tokyo (Kashiwa, Japan)
HK Mockup structure



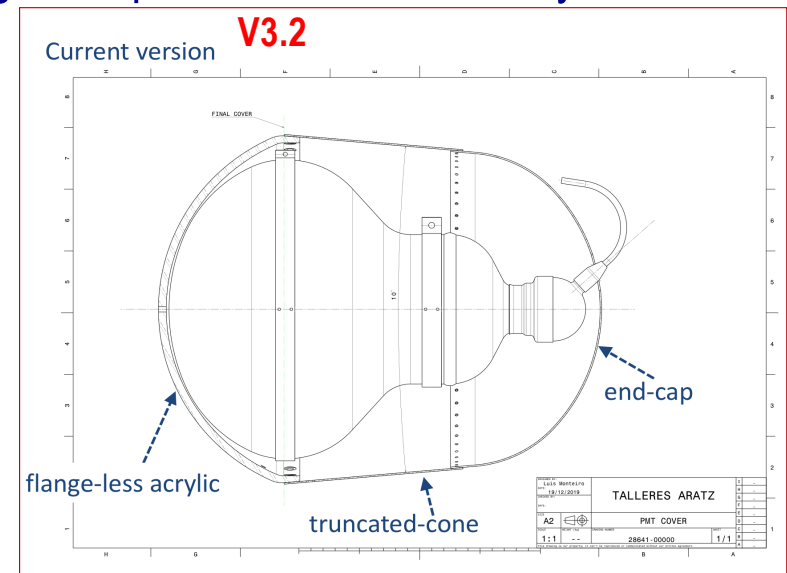
ICRR, U. Tokyo (Kashiwa, Japan)
HK Mockup structure

Overall schedule; two periods

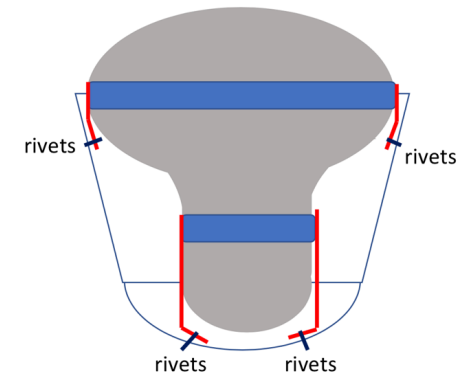
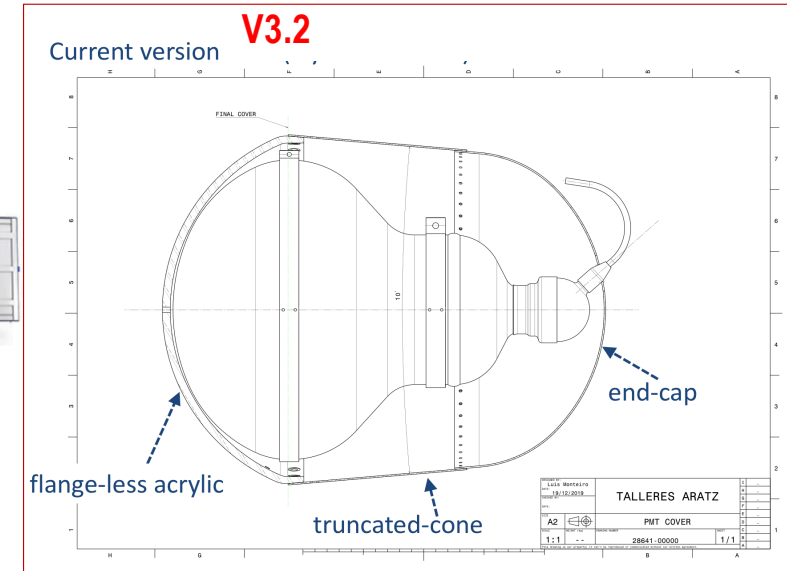
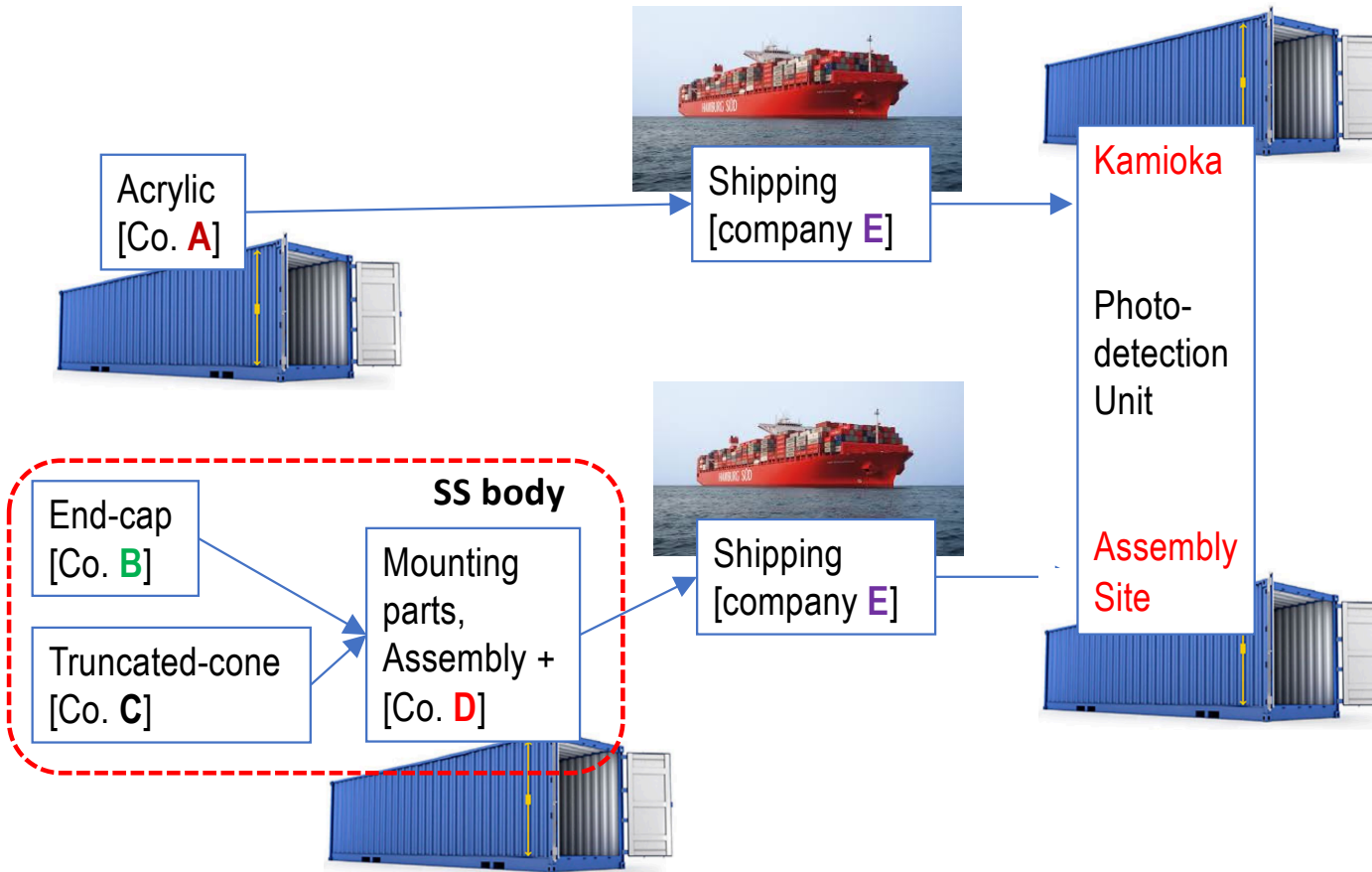
11. UAM – Kamioka Observatory [2012 →] Proyecto / Experimento **Hyper-Kamiokande**

- Desarrollo general del diseño y del Proyecto, Construcción de una participación española
- **Cubiertas de los PMTs para abortar reacción en cadena en caso de implosión**

- now → mid.-2021: finalize R&D + settle design: Test Program to qualify/certify “final” design for HK
 - Goals:
 - thorough test of prototypes with “sheet metal formed” mass produced end-caps. Final truncated-cone and acrylic designs (mass produced method). Assembly PMT-to-cover and assembly Photo-sensor unit to structure
 - Establish base materials (see also next slide)
 - define and exercise logistics for quality-control/testing, transport, storage, assembly
 - Main actions
 - Produce ~15 units V3.2 + ~5 units backup V2.3
 - Hydrostatic tests in Aratz ~February-March 2021
 - Implosion tests in Hokkaido ~April 2020
- end-2021 → 2026:
 - mass production;
 - storage / transport Spain ↔ Kamioka
 - contribution to assembly, mounting, controls, calibrations etc. in Kamioka



Current approach to mass production [logistics]



Important note: company A, and the set of companies B, C and D, do exist, have proven their capability for the job and are in excellent position to win any bid.

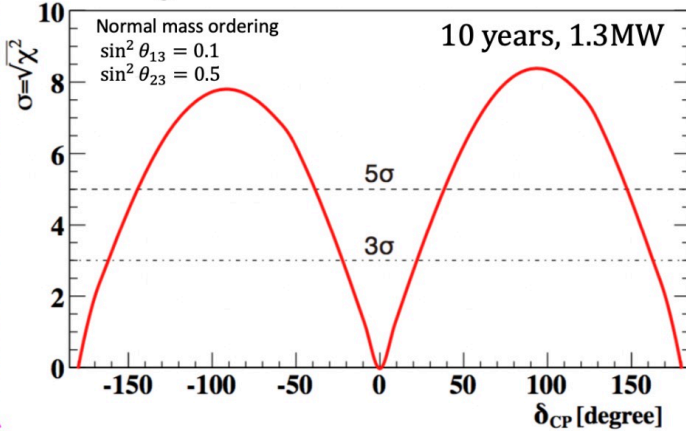
Como final

¿ que mediré, que física haré antes de jubilarme ? ¿ y como emérito ? (I)

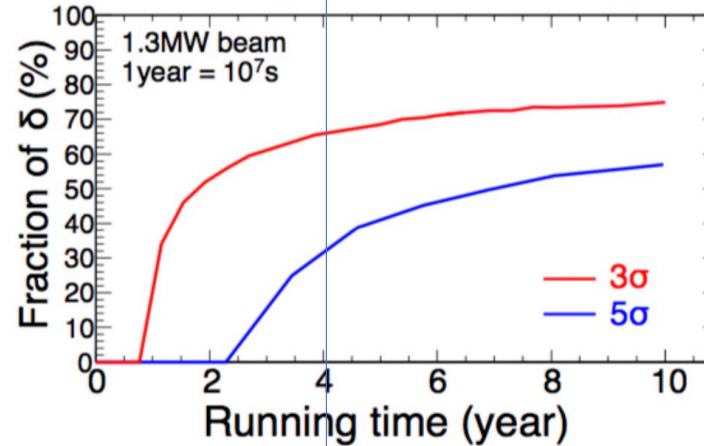
Masaki Ishitsuka @ NEUTRINO 2020

Syst. errors (T2K 2016 + improvements for Hyper-K) δ_{CP}

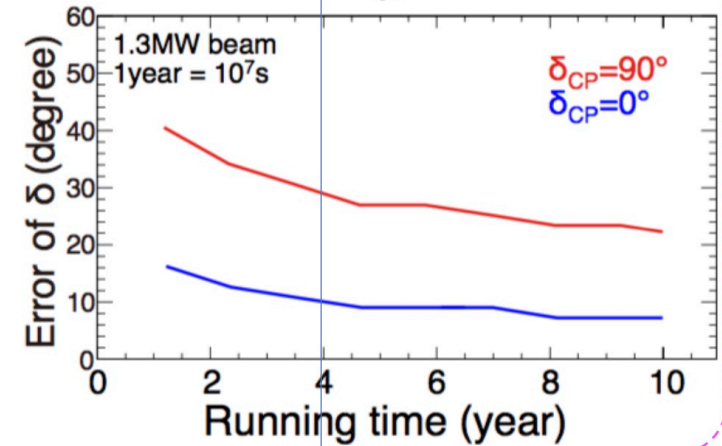
Significance to CP violation



Fraction of δ_{CP} to exclude $\sin \delta_{CP} = 0$

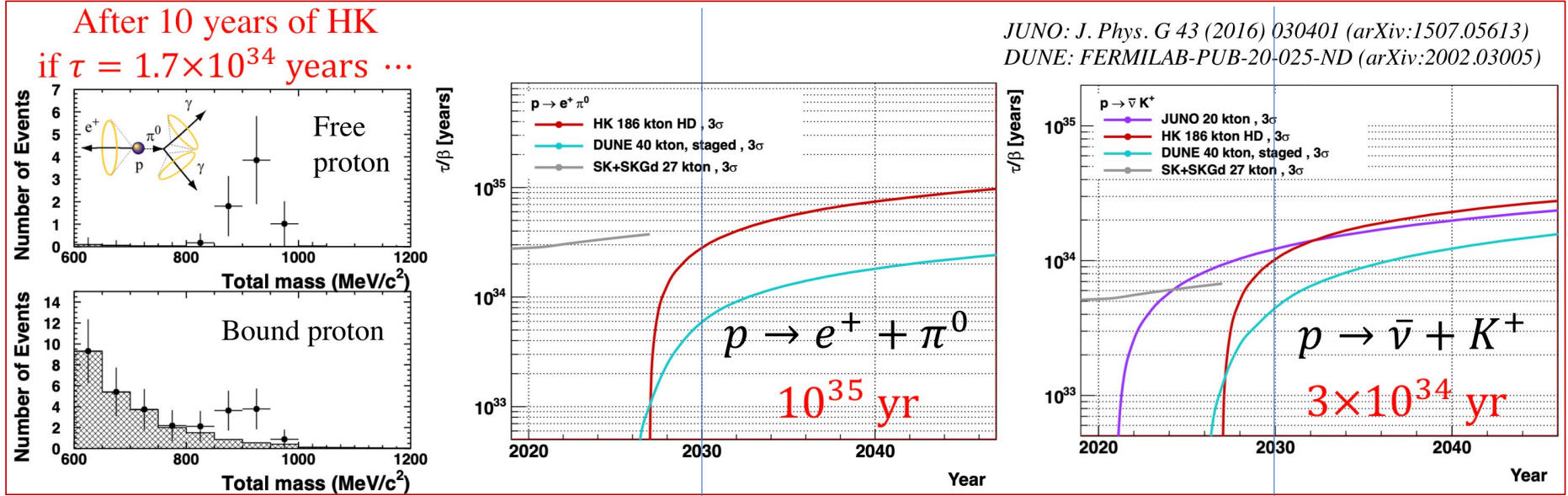
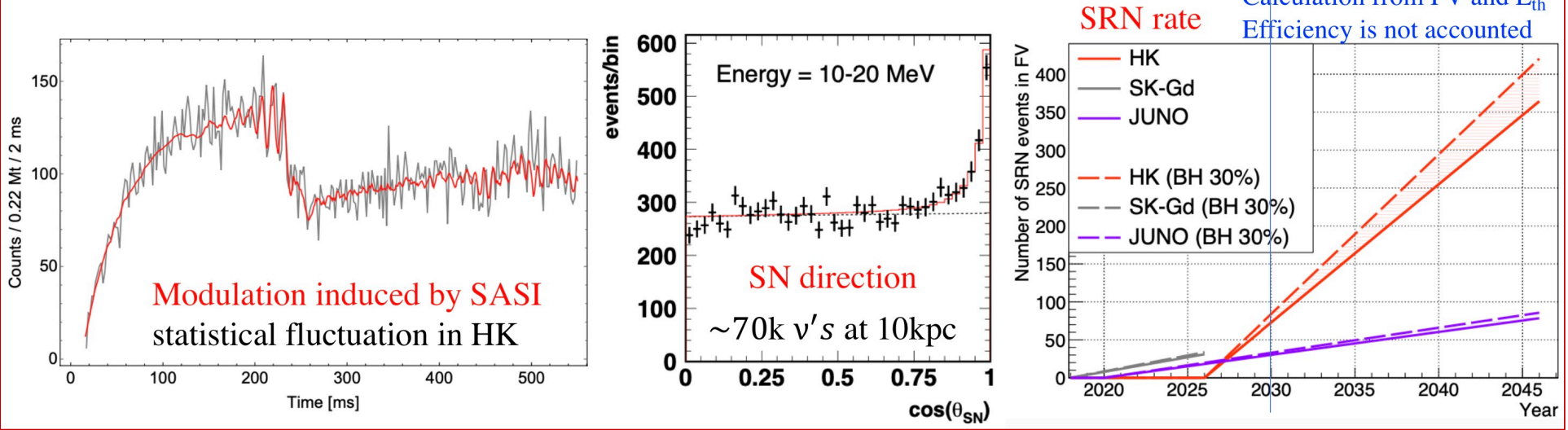


Precision of δ_{CP} measurement



¿ que mediré, que física haré antes de jubilarme ? ¿ y como emérito ? (II)

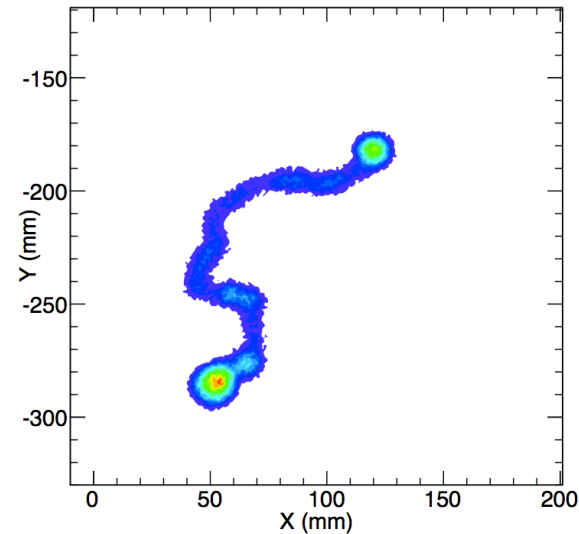
Masaki Ishitsuka @ NEUTRINO 2020



¿ que mediré, que física haré antes de jubilarme ? ¿ y como emérito ? (III)

¿ y el experimento NEXT ?

¿ descubriremos $2\beta_0v$?



Muchas gracias por vuestra paciencia y atención