The **Experimental H.E.P. Group** of the **"Universidad Autónoma de Madrid[a]"**

http://hepexp.ft.uam.es

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Outline

- Dates and People

⇒ The ZEUS experiment

⇒ The GRID project: Distributed Computing for the LHC

⇒ The ATLAS experiment: Construction of the Liquid Argon Electromagnetic Calorimeter

[a]RECFA Meeting. Barcelona, March 2003

Brief History of the HEP-EXP UAM Group

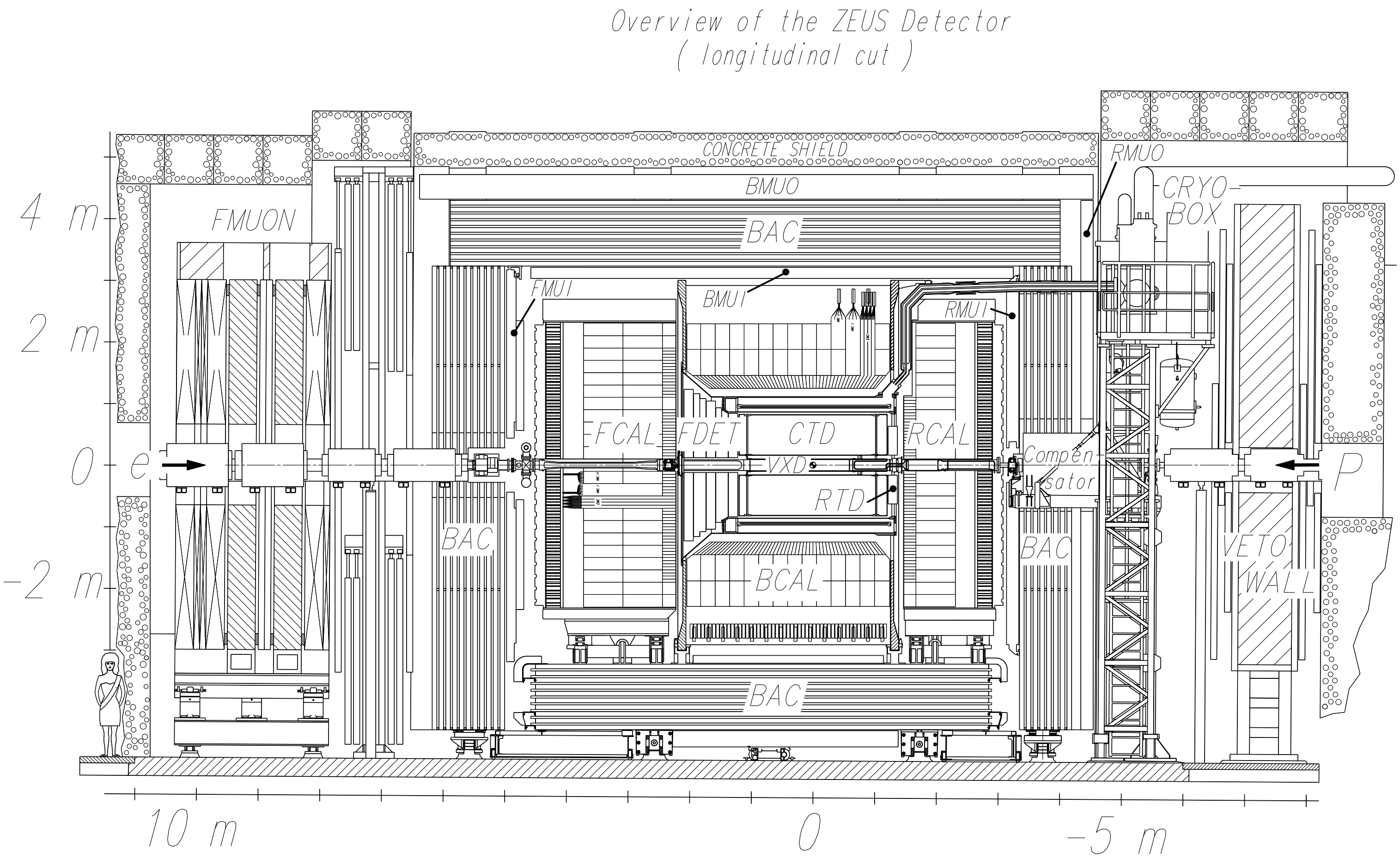
1984	Group formation
1984 - 1989	TASSO experiment at PETRA (DESY): *data taking and physics analysis*
1985 - 1991	ZEUS experiment at HERA (DESY): *R& D, construction and preparation of physics*
1992 $\Rightarrow$	ZEUS experiment: *data taking, physics analysis and upgrades*
1995 $\Rightarrow$	ATLAS experiment at LHC (CERN): *R& D, construction and preparation of physics*
2001 $\Rightarrow$	GRID - Distributed Computing for the LHC: *R& D*

Members of the Group

Name	Position	ZEUS	ATLAS	GRID
F. Barreiro	C.U.	•	•	•
L. Labarga	T.U.	•	•	•
J. del Peso	T.U.	•	•	•
J. Terrón	T.U.	•	•	•
C. Glasman	RyC	•		
E. Tassi	T.U.I.	•	•	
C. Oliver	C. Madrid F.		•	
S. Rodier	P. Ayudante		•	
M. Vázquez	Min. Sci. F.	•		
M. Zambrana	Min. Sci. F.	•		
R. García	Computing E.			•
J.J. Pardo	Computing E.			•
J. Setien	Mechanical E.		•	
F. Gallardo	Technician (P)	•	•	•
S. López	Technician		•	
D. Ruiz	Technician		•	

The ZEUS Experiment

Hardware Contributions (Mechanics)



- Wave Length Shifter light guides and their Mechanical Case-supports for the first sampling (of 2) of the F & R Had. Calorimeters: *2 x 2K pcs.*
- Wireing of the Forward Tracking Detector (consisting of 3 x 3 planar drift chambers): *4.5K sense wires + 5.3K potential wires*
- Internal support aluminum structures for the FTD
- Lead plates with precission drilled holes for the Forward Plug Calorimeter

Hardware Contributions (Electronics)

Front-end for the Forward Calorimeter

- PM bases for the whole FCAL: *4.3 K pcs.*
- CAMAC HV controlers: *20 boards*
- VME HV controlers: *250 boards*
- HV distribution boards: *500 boards*
- Data distribution boards: *500 boards*

For other components

- Shaper-Amplifiers for the **H**adron **E**lectron **S**eparator (hybrid technology): *10K pcs.*
- Analog boards (for housing shapers + pipelienes + buffers + their services) for the HES: *400 boards*
- Analog boards for the Small angle Rear Tracking Detector: *50 boards*

Hardware Contributions to ZEUS; Summary

In cost:	$\approx$ **1.5 MEuros**
In percentage	$\approx$ **2 %** of total ZEUS

Instrumentation papers by UAM-HEP members during the ZEUS R&D, Construction and Upgrade phases (I)

Calorimetry

1 Monte Carlo study of the light yield, uniformity of response and energy resolution of electromagnetic calorimeters with fiber read-out. *L.A. Labarga and E. Ros*; **Nucl. Inst. Meth. A249** (1986) 228.

2 Tests results for an electromagnetic calorimeter with fiber read-out; *F. Barreiro, B. Loehr, E. Ros and S. Weissenrieder*; *Nucl. Inst. Meth.* **A254** (1987) 26-34.

3 An electromagnetic calorimeter with scintillator strips and WLS readout; *F. Barreiro, J. del Peso, L. Labarga, B. Löhr, J. Mata and E. Ros*; *Nucl. Inst. and Meth.* **A257** (1987) 145-154.

4 Experimental study of Uranium Plastic Scintillator Calorimeters; *G. d'Agostini et al.*; *Nucl. Inst. and Meth.* **A274** (1989) 134-144.

5 Response of a Uranium-Scintillator calorimeter to electrons, pions and protons in the momentum range 0.5-10 GeV/c; *A. Andresen et al.*; *Nucl. Inst. and Meth.* **A290** (1990) 95-180.

6 Construction and beam tests of the ZEUS forward and rear calorimeter; *A. Andresen et al.*; *Nucl. Inst. and Meth.* **A309** (1991) 101-142.

7 The ZEUS Forward Plug Calorimeter with Lead-Scintillator Plates and WLS Fibers Readout; *G. García, J. del Peso et al.*; *Nucl. Inst. and Methods* **A450** (2000) 235.

Tracking Chambers

8 Design, construction and test results of the ZEUS forward tracking detector;*B. Bock et al.*; *Nucl. Inst. and Meth.* **A344** (1994) 335-349.

9 Beam Test of Silicon Strips Sensors for the ZEUS Micro Vertex Detector; *I. Redondo et al.*; Accepted for publication by *Nucl. Inst. and Methods A. e-Print Archive: hep-ex/0212037*

Electronics et al.

10 Design and performance of a 10 MHz CMOS analog pipeline; *W. Buttler et al.*; *Nucl. Inst. and Meth.* **A227** (1989) 217-221.

11 Design and implementation of a high precision readout system for the ZEUS calorimetr; *A. Caldwell et al.*; *Nucl. Inst. and Meth.* **A321** (1992) 52.

12 Measurement of the time development of particle showers in a uranium scintillator calorimeter; *A. Caldwell. L. Hervas, J.A. Parsons, F. Sciulli, W. Sippach, L. Way*; *Nucl. Inst. and Meth.* **A330** (1993) 389-404.

13 Running experience with the ZEUS Calorimeter; *L. Hervas*; *IEEE Trans. Nucl. Sci.* **41.4** (1994) 830-834.

ZEUS Publications by UAM-HEP members

Jet Production and QCD

1 *Observation of hard scattering in photoproduction at HERA. Phys. Lett.* **B297** (1992) 404-416.

2 *Observation of two-jet production in deep inelastic scattering at HERA. Phys. Lett.* **B306** (1993) 158-172.

3 *Observation of direct processes in photoproduction at HERA. Phys. Lett.* **B322** (1994) 287-300.

4 *Inclusive jet differential cross sections in photoproduction at HERA. Phys. Lett.* **B342** (1995) 417-432.

5 *Dijet Angular Distributions in Resolved and Direct Photoproduction at HERA. Phys. Lett.* **B384** (1996) 401-413

6 *Measurement of Jet Shapes in Photoproduction at HERA Eur. Phys. J.* **C2** (1998) 1, 61-75

7 *High-ET Inclusive Jet Cross Sections in Photoproduction at HERA. Eur. Phys. J.* **C4** (1998) 4, 591-606

8 *Measurement of Jet Shapes in High Q^2 Deep Inelastic Scattering at HERA. Eur. Phys. J.* **C8** (1999) 3, 367-380

9 *Measurement of dijet production in NC DIS at high Q^2 and determination of α_s. Phys. Lett.* **B507** (2001) 70-88

10 *Dijet production in NC DIS at HERA. Eur. Phys. J.* **C23** (2002) 1, 13-27

11 *High-mass dijet cross sections in photoproduction at HERA* *Phys. Lett.* **B531** (2002) 9-27

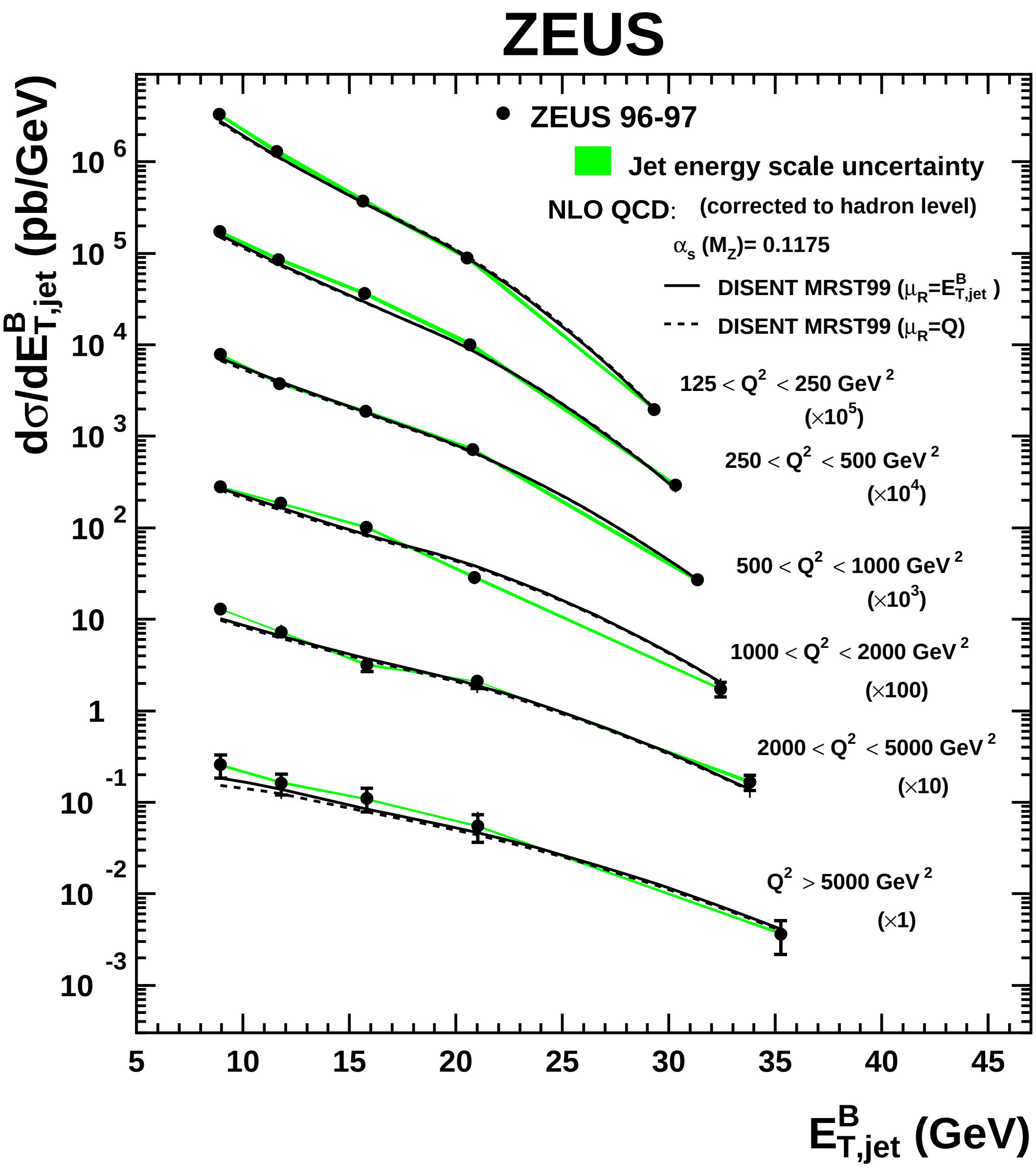
12 *Inclusive jet cross sections in the Breit frame in NC DIS at HERA and determination of* α_s. *Phys. Lett.* **B547** (2002) 164-180

13 *Study of the azimuthal asymmety of jets in NC DIS at HERA.* *Phys. Lett.* **B551** (2003) 3-4

14 *Measurement of subjet multiplicities in NC DIS at HERA and determination of* α_s. DESY 02-217, Submitted to Phys. Lett.
.

Inclusive jet cross sections in the Breit frame in NC DIS at HERA and determination of α_s *Physics Letters B 547 (November 2002) 164-180*

For instance:



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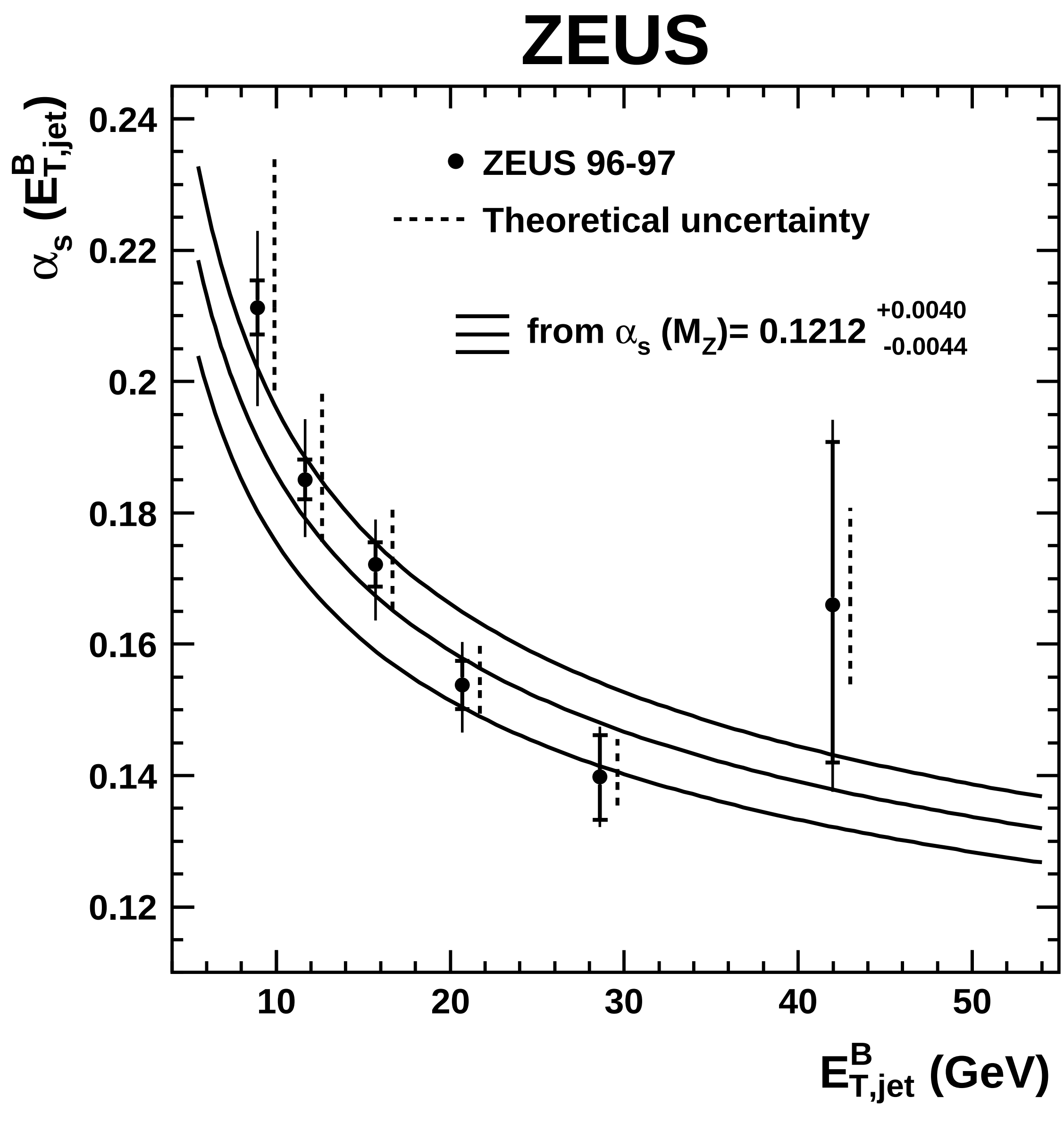
From a NLO QCD fit to dσ/dQ^2 for $Q^2 > 500$ GeV^2

$$\alpha_s(M_Z) = 0.1212 \pm 0.0017(stat.)^{+0.0023}_{-0.0031}(syst.)^{+0.0028}_{-0.0027}(th.)$$

Physics Letters B 547 (November 2002) 164-180

And also the runing of α_s



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ZEUS Publications by UAM-HEP members

Diffraction

15 *Observation of jet production in deep inelastic scattering with a large rapidity gap at HERA. Phys. Lett.* **B332** (1994) 228-243.

16 *Observation of hard scattering in photoproduction events with a large rapidity gap at HERA. Phys. Lett.* **B346** (1995) 399-414.

17 *Diffractive hard photoproduction at HERA and evidence for the gluon content of the pomeron. Phys. Lett.* **B356** (1995) 129-146.

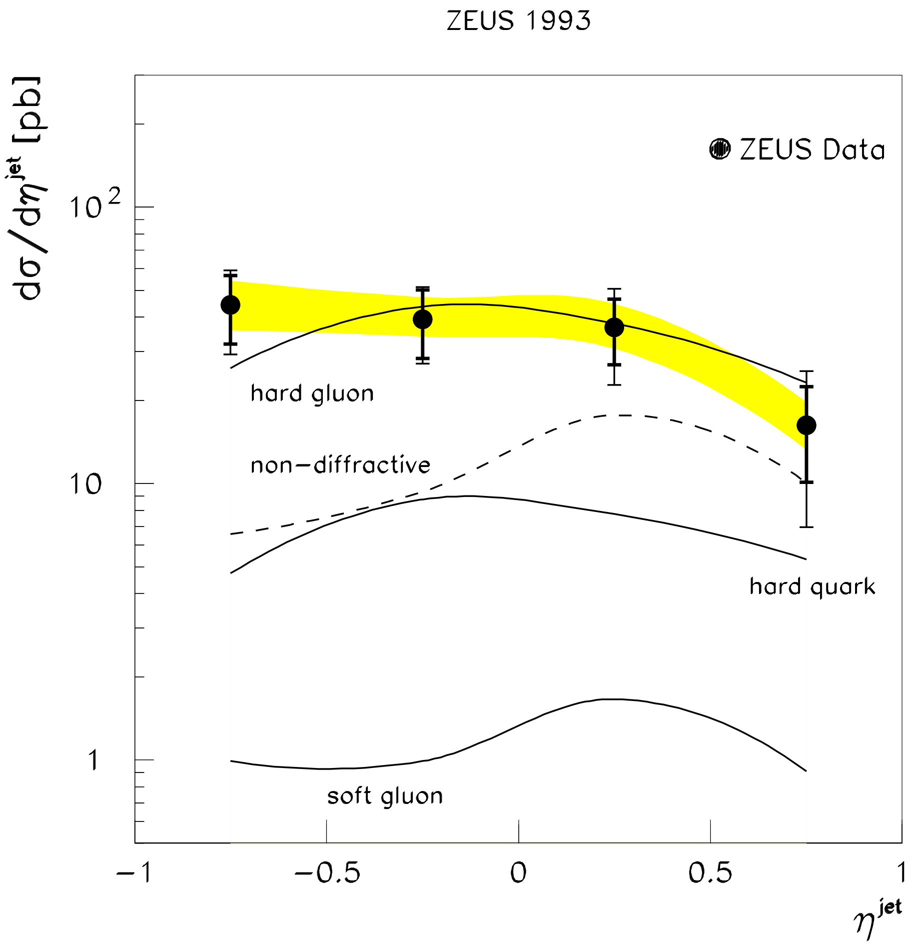
18 *Event Shape Analysis of DIS events with a LRG at HERA. Phys. Lett.* **B421** (1998) 368-384.

19 *Three-jet production in diffractive DIS at HERA. Phys. Lett.* **B516** (2001) 3-4, 273-292

20 *Difractive Dijet Cross Sections in Photoproduction at HERA. Eur. Phys. J.* **C5** (1998) 41-56

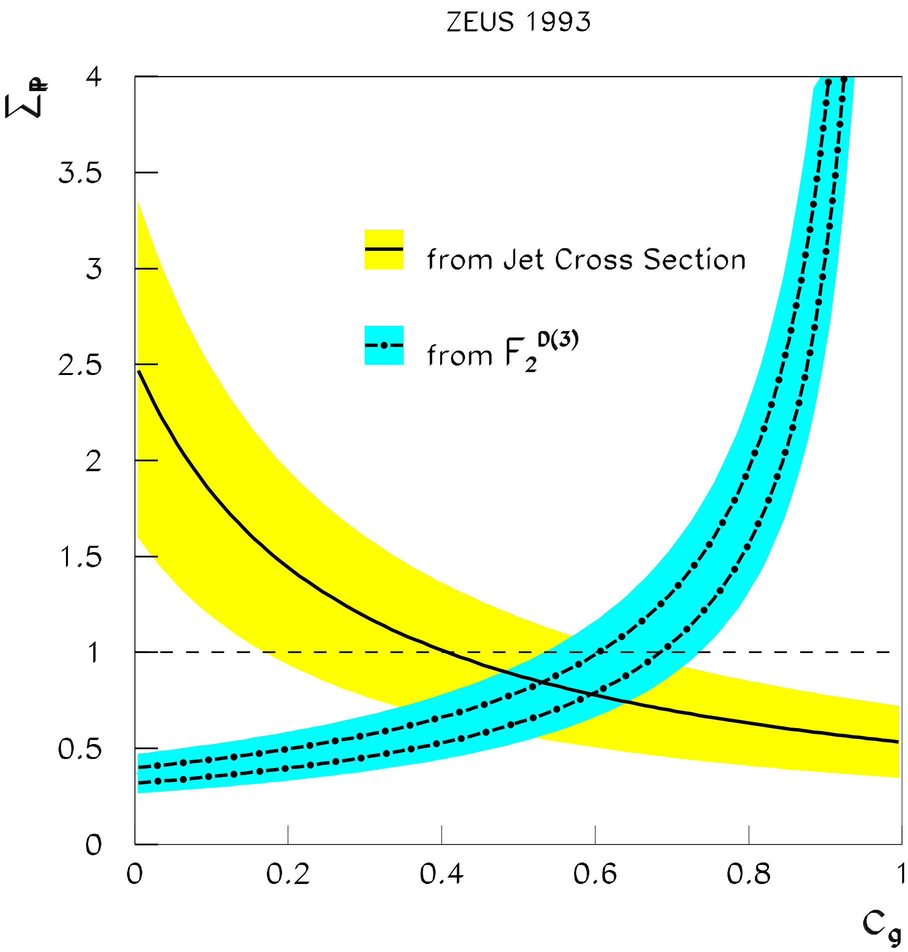
Diffractive Hard Photoproduction at HERA and Evidence for the Gluon Content of the Pomeron *Physics Letters B 356 (1995) 129-146*

Jet Cross Sections in Photoproduction with a LRG



⇒ In the framework of a factorisable difractive model, a **hard gluon** spectrum **Pomeron** is needed to describe the data.

If we combine the previous result with the measured ZEUS $\mathbf{F}_2^{D(3)}$:



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⇒ The data indicates that **30% - 80%** of the momentum of the **Pomeron** carried by partons is due to **hard gluons**

ZEUS Publications by UAM-HEP members

Heavy quarks

21 *Study of* $D^*(2010)^\pm$ *production in* ep *collisions at HERA. Phys. Lett.* **B349** (1995) 225-237.

22 *Neutral strange particle production in deep inelastic scattering at HERA. Z. Phys.* **C68** (1995) 29-42.

23 *Differential Cross Sections of* $D^{*\pm}$ *Photoproduction in* ep *Collisions at HERA. Phys. Lett.* **B401** (1997) 192-206

24 $D^{*\pm}$ *Production in DIS at HERA. Phys. Lett.* **B407** (1997) 402-418

25 *Charged Particles and Neutral Kaons in Photoproduced Jets at HERA. Eur. Phys. J.* **C2** (1998) 1, 77-93.

26 *Measurement of* $D^{*\pm}$ *production and the charm contribution to* F_2 *in DIS at HERA. Eur. Phys. J.* **C12** (2000) 1, 35-52

Others

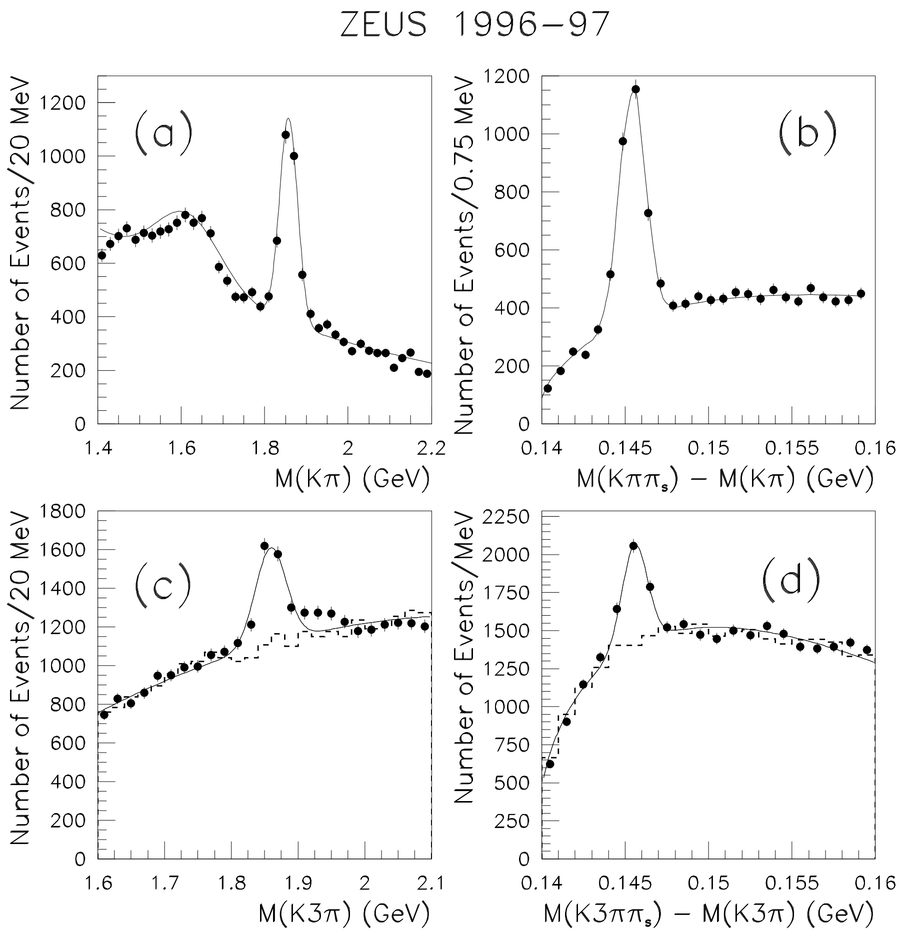
27 *Initial Study of deep inelastic scattering with ZEUS at HERA. Phys. Lett.* **B303** (1993) 183-197.

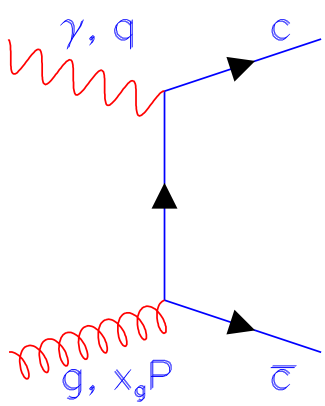
28 *Study of Charged-Current* ep *Interactions at* $Q^2 > 200$ *GeV*^{2} *with the ZEUS Detector at HERA. Z. Phys.* **C72** (1996) 47-64.

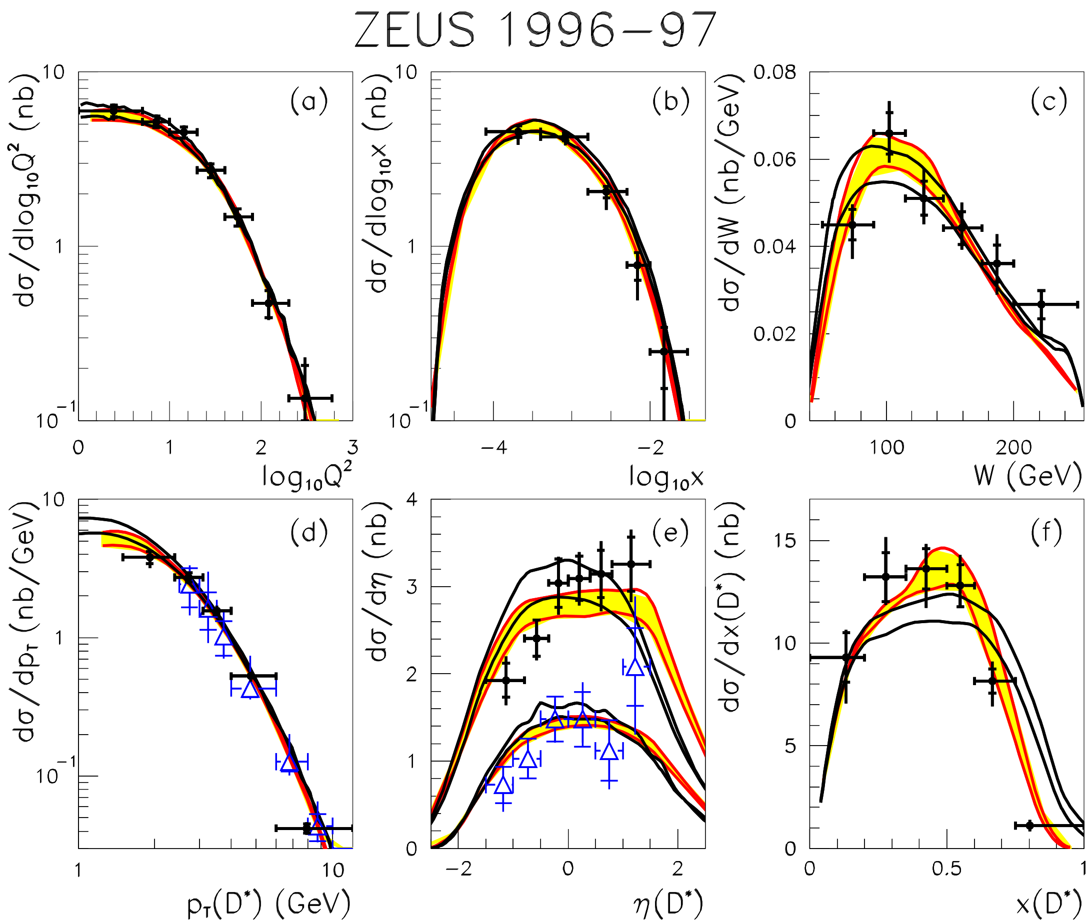
29 *Search for single-top production in ep collisions at HERA.* DESY 03-012, Submitted to Phys. Lett.

Measurement of $D^{*\pm}$ production and the charm contribution to F_2 in DIS at HERA

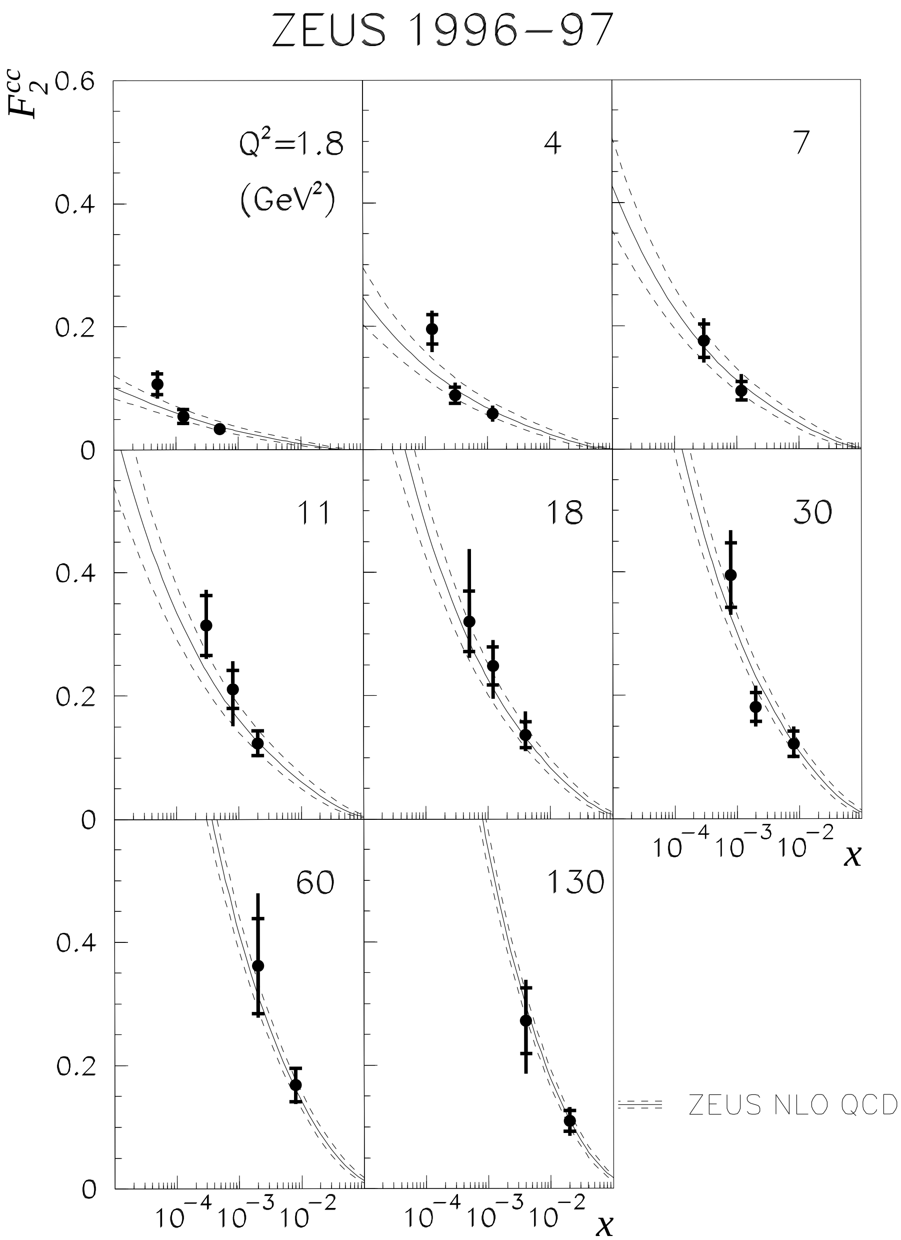
The European Physical Journal C 12 (2000) 1, 35-52







⇒ Good description by NLO QCD with a PDF extracted from F_2



⇒ Universality of the Gluon Distribution

SUMMARY of ZEUS Publications by Exp. HEP UAM members

RECFA Meeting, Madrid 1997:

Total number of publications by ZEUS: **45**

ZEUS publications by UAM-HEP members: **11**

ZEUS pubs. by UAM-HEP members (in percentage):

24 %

RECFA Meeting, Barcelona 2003:

Total number of publications by ZEUS: **124**

ZEUS publications by UAM-HEP members: **29**

ZEUS pubs. by UAM-HEP members (in percentage):

23.4 %

The GRID Project:
Distributed Computing for the LHC

Goal

1. Analyse LHC data and contribute to generation of simulated events.
2. Participate in the Data Challenge of the ATLAS experiment as a step towards the previous goal.

Carry Out

- LHC Computing Grid (LCG) in coordination with other 6 spanish institutes (LCG-ES project).

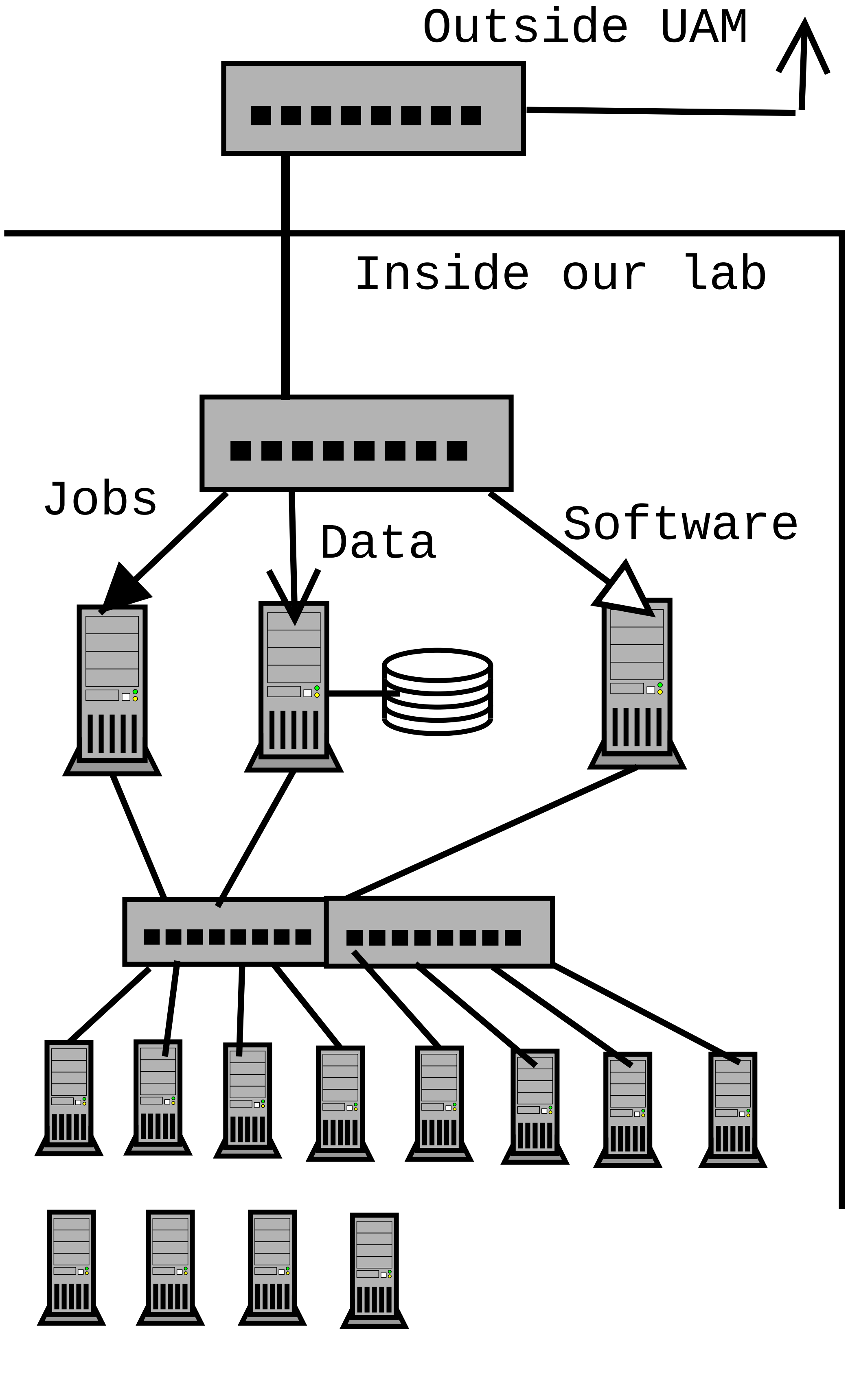
  Main tasks in the context of the LCG-ES project:

  – Coordination of a distributed computing cluster for generation of (ATLAS, CMS and LHCb) Monte Carlo events.
  – Build in our lab a PC cluster integrated in the int. grid LCG, for data analysis purposes.

- European DataGrid (EDG).

  Tasks within the EDG project:

  – Software development in the WP4 WorkPackage, "Fabric Management".
  – Test of different releases in the WP6 WorkPackage, "Testbed".



Outside UAM
Inside our lab
Jobs
Data
Software

The Beginning ...

The ATLAS Experiment

Design Construction and Test of the
Liquid Argon Electromagnetic Calorimeter

The Physics Case; its Implications

The main goal of ATLAS at the LHC is the study of the origin of mass at the electroweak energy scale. For SM Higgs boson (**H**) searches, the detector has to be sensitive to:

1. **H**$\rightarrow \gamma\gamma$; $\mathrm{m}_H < 150$ GeV.
2. **H**$\rightarrow ZZ^* \rightarrow 4l$; 130 GeV $< \mathrm{m}_H < 2\,\mathrm{m}_Z$
3. **H**$\rightarrow ZZ \rightarrow 4l$ or $2l + 2\nu$; $\mathrm{m}_H > 2\,\mathrm{m}_Z$
4. **H**$\rightarrow WW, ZZ \rightarrow l + \nu +$ 2jets or $2l + 2$ jets ; for m_H up to 1 TeV.

$\rightarrow$ In particular the significance of (1) is proportional to the rapidity range coverage.

$\rightarrow$ Also (1) needs an energy resolution well below 1% at high energy.

$\Rightarrow$ A superb measurement of γ's and $e^{\pm}$'s is required along as much solid angle as possible.

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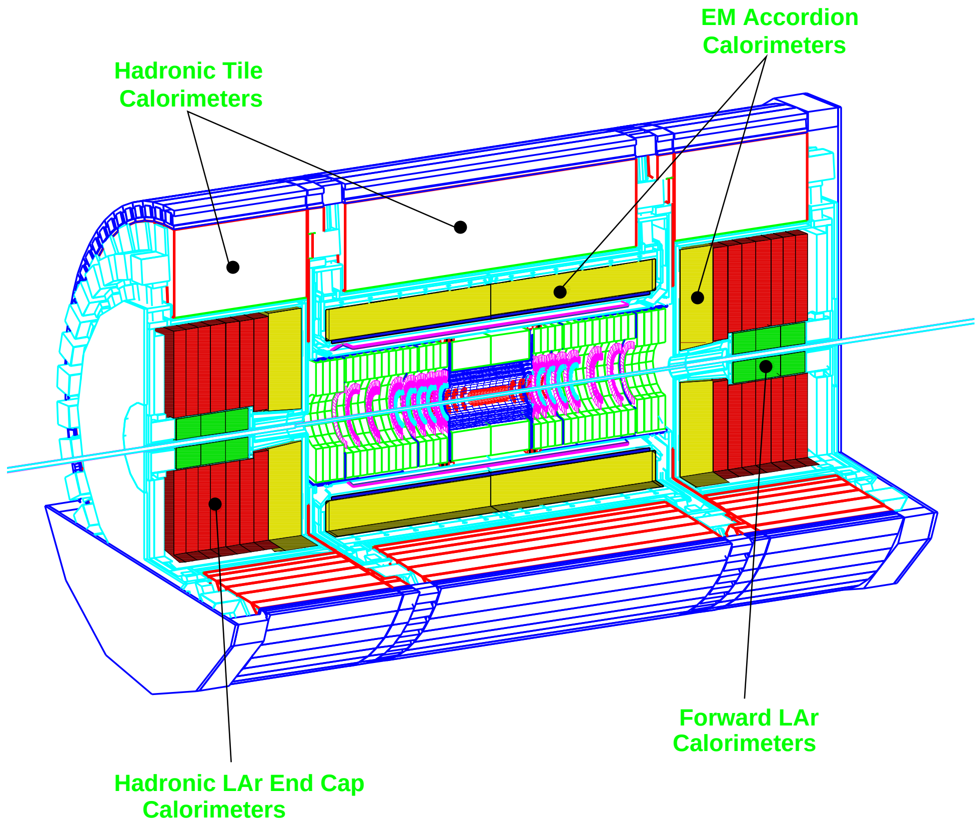
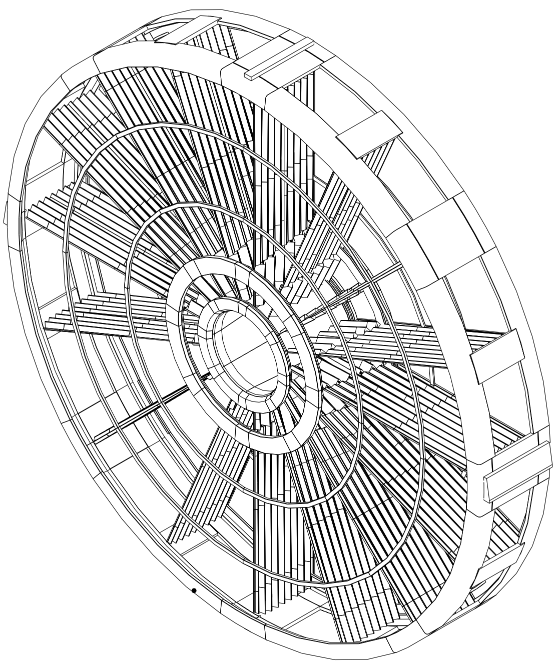
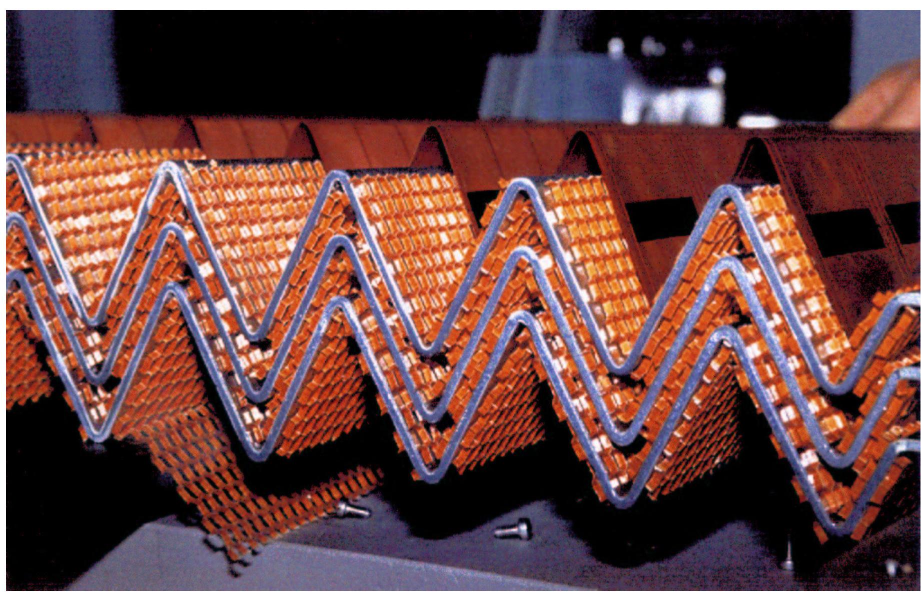
$\Longrightarrow$ EM sampling calorimetry with ionizable liquid **(LArg)** and novel **accordion** geometry with extreme geometrcal and electrical **uniformity requirements.**

The EndCap of the LArg EM Calorimter







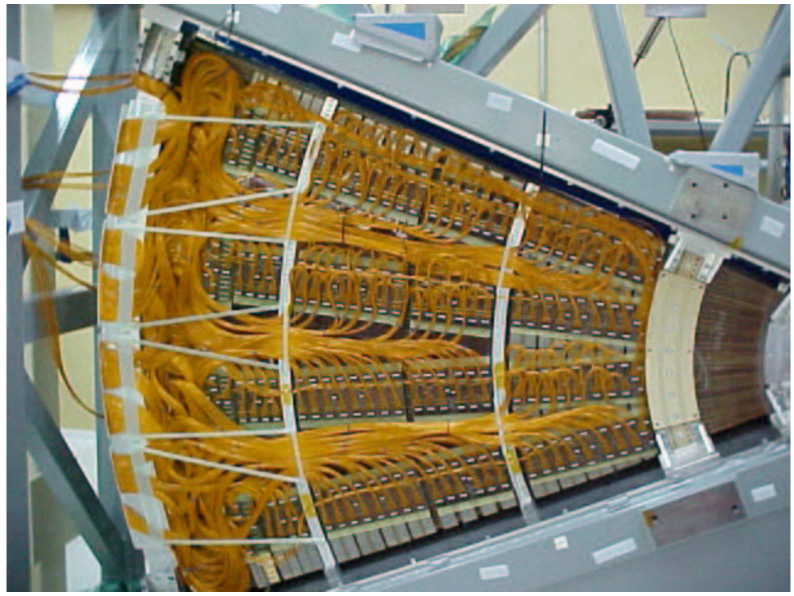
Sampling Unit : **Lead Absorber** / *Honey Comb Spacer* / Read Out Electrode / (*Honey Comb Spacer* / Read Out Electrode / **Lead Absorber** /...)

Sharing of Responsabilities

Lead Absorbers:	mostly **UAM**
Honey Comb Spacers:	mostly *CPPM*
Read-Out Electrodes:	other collaborators
Main Structure:	mostly *CPPM*
Cold Electronics:	**UAM** and *CPPM* at $\approx 50\%$
Stacking:	**UAM** and *CPPM* at $\approx 50\%$
Test Program at CERN:	**UAM** and *CPPM* at $\approx 50\%$

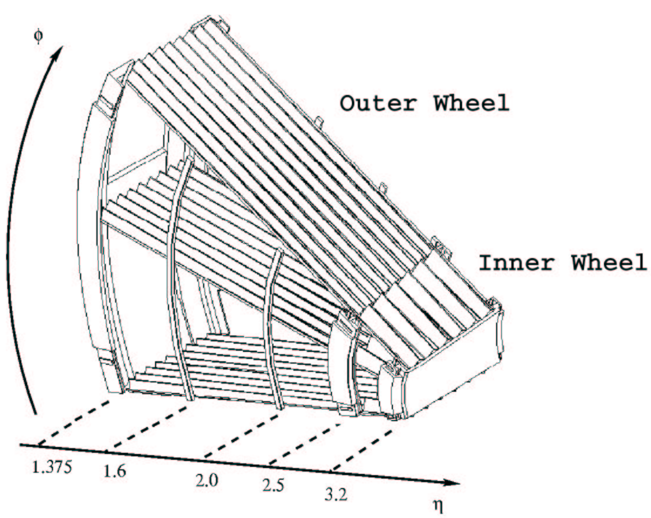
Main Particularities

Each EndCap wheel is splitted into two “sub-wheels” due to mechanical limits



- pseudorapidity ranges:
  OW: $1.375 < \eta < 2.5$
  IW: $2.5 < \eta < 3.2$
- 8 modules per EndCap

96 / 32 gaps (absorber - *spacer* - **electrode** - *spacer* - absorber) at the outer / inner “wheel” per module.



- Main components vary along R:
  - Fold angle
  - Gap distance
  - HV settings
  - Capacitances

the Absorbers

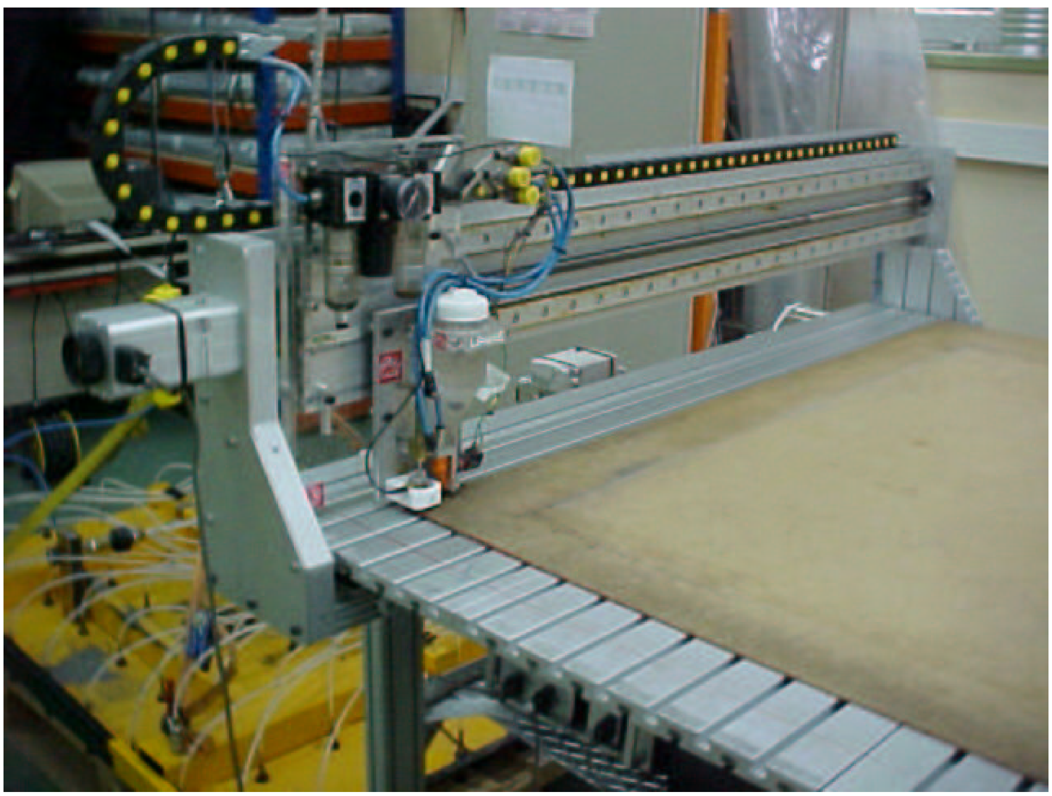
Thickness of:/at	O. W.	I. W.
Lead plates	**1.7 mm**	**2.2 mm**
Stainless steel	**0.2 mm**	
Glass-fibre prepreg adhesive	**0.15 mm**	
Absorber	**2.4 mm**	**2.9 mm**

The contribution of the non uniformities at the mechanical parts to the constant term should be kept at $\approx 0.2\%$.

- $\rightarrow$ lead thickness better than 1% (from M.C. studies) $\Rightarrow$ RMS thicknesses smaller than $17\mu m$/$22\mu m$ for OW/IW
- $\rightarrow$ LArg gap better than 3% $\Rightarrow$ absorber geometry reproducibility at the level $\approx 200\mu m/50\mu m$ for large/inner radius part

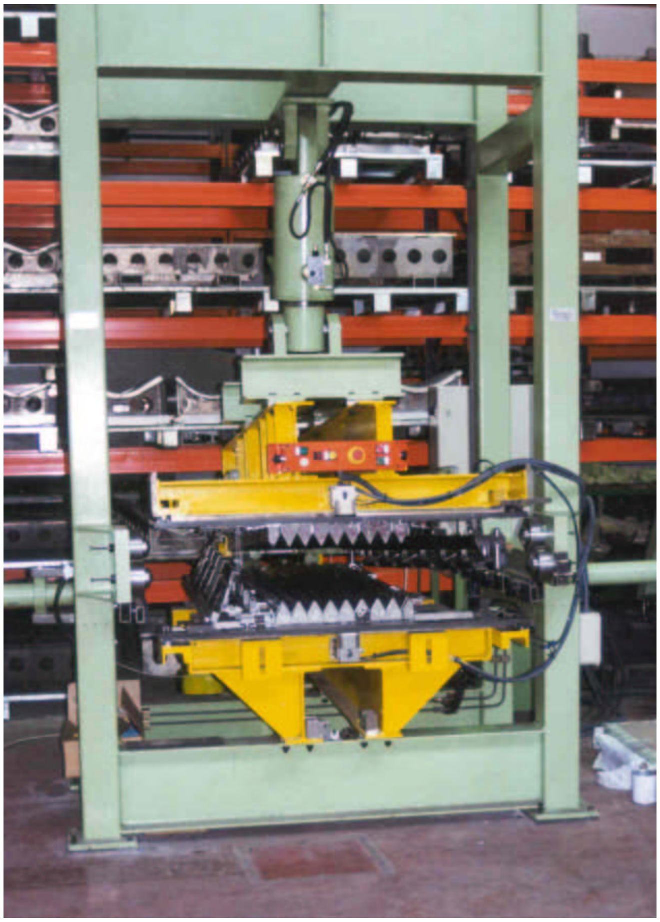
Lead plates were obtained by lamination on a $\approx$ standard foundry, with the thickness measured and corrected on -line by an X-ray absortion measurement system.

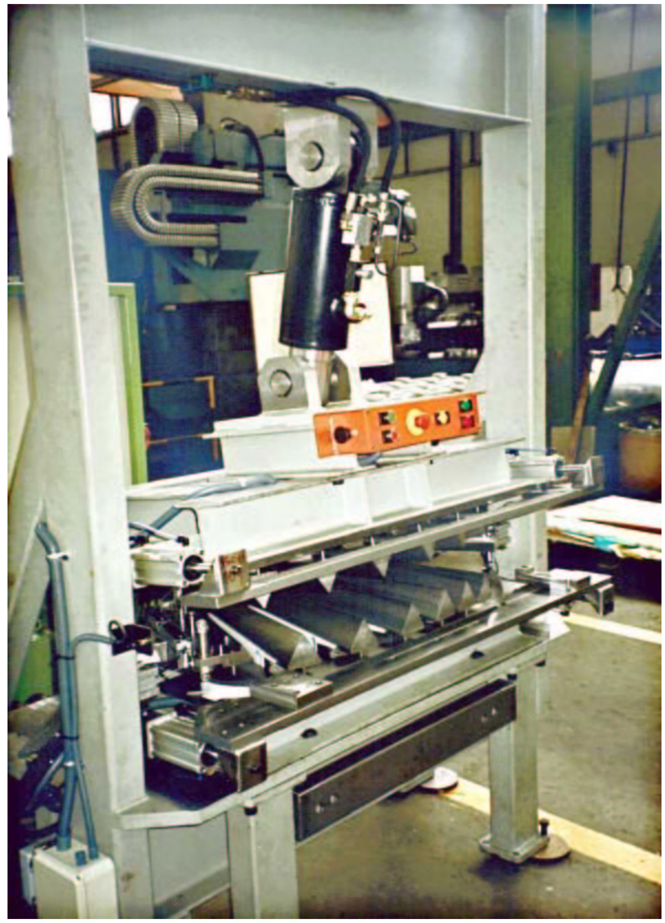
$\Rightarrow$ better than $9\mu m$ thickness uniformity **achieved**



The Absorber Fabrication[a]

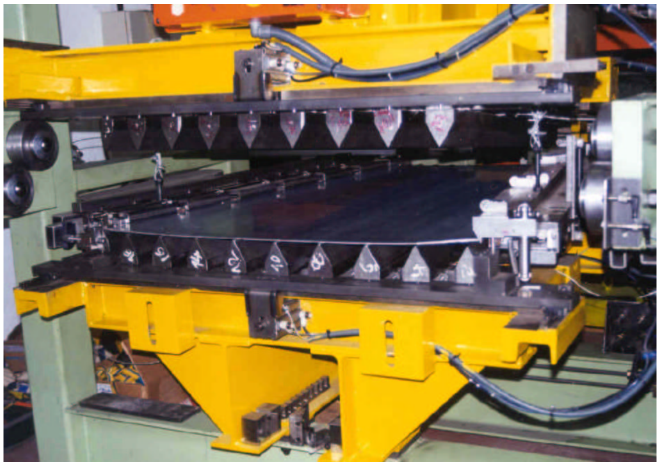
Flat Sandwich Bending:

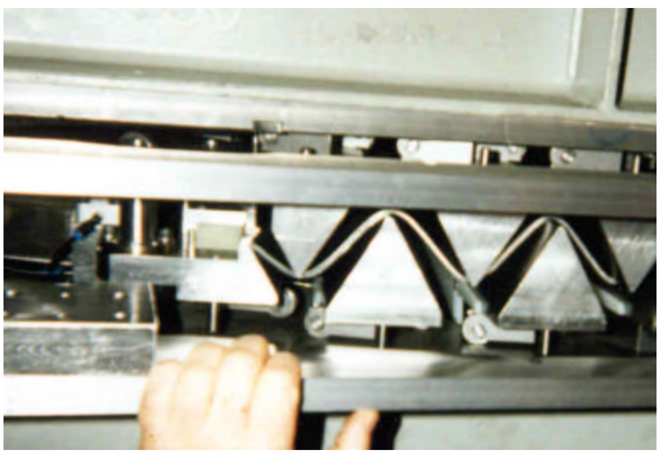




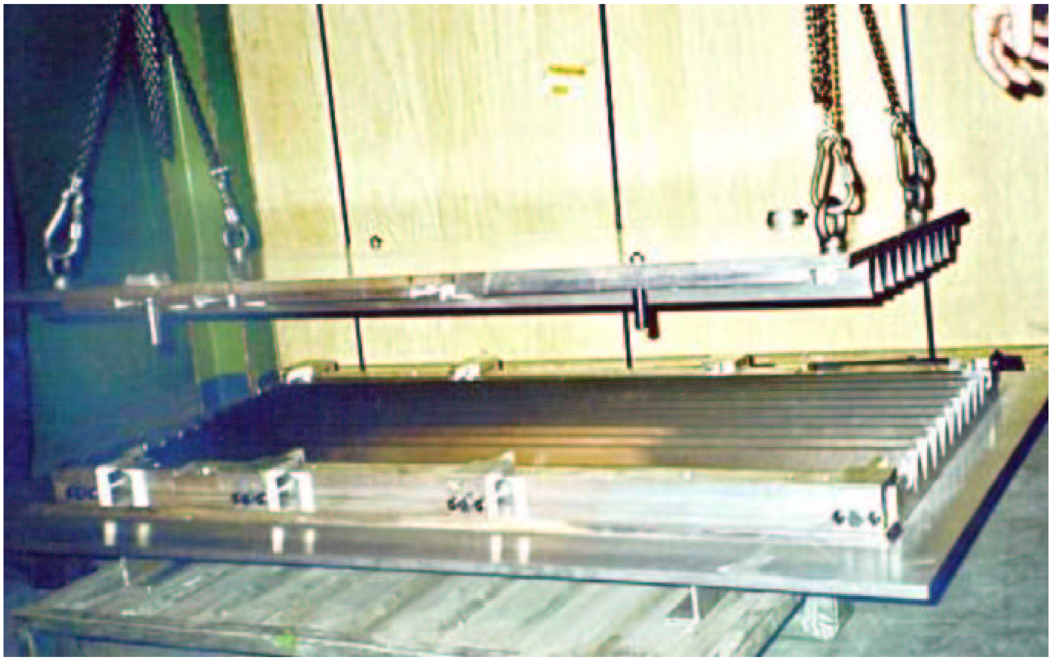
Mechanical tolerances at the **150** μm level (over distances of **2** m)

[a]Tooling manufacturated by Talleres Aratz S.A.; absorber fabrication itself by Fibertecnic S.A.. Both companies are located at Vitoria (Spain).

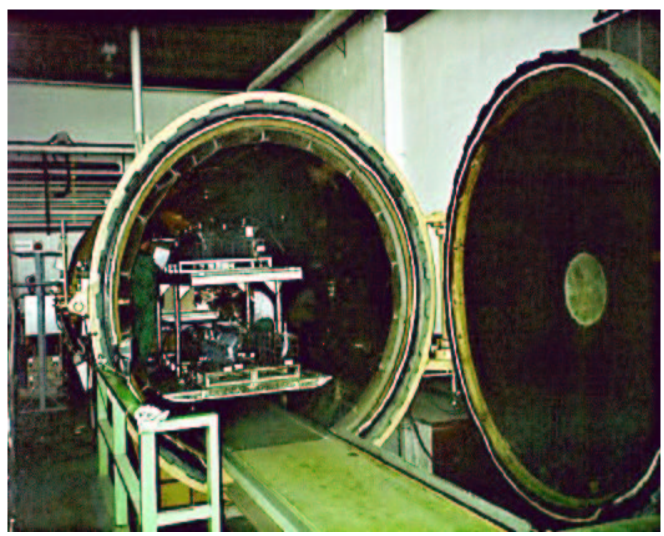




Absorber Moulding and Curing (Autoclave technique):



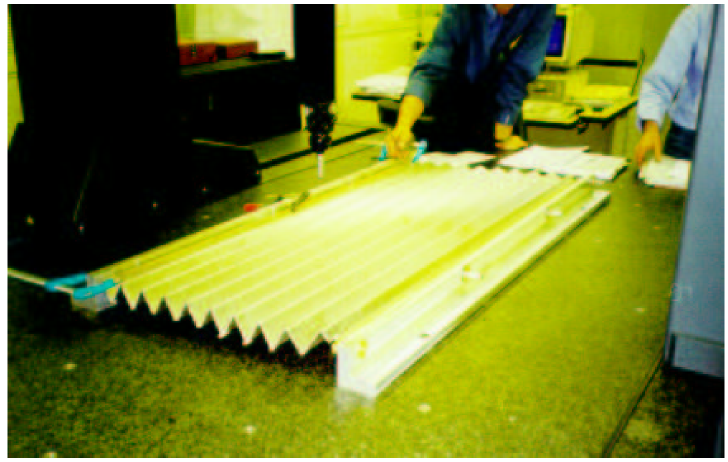
Temperature/Preasure cycle (120 ^{o}C/2.7 bars) for the pre-preg to polimerize and the absorber to get its final shape.



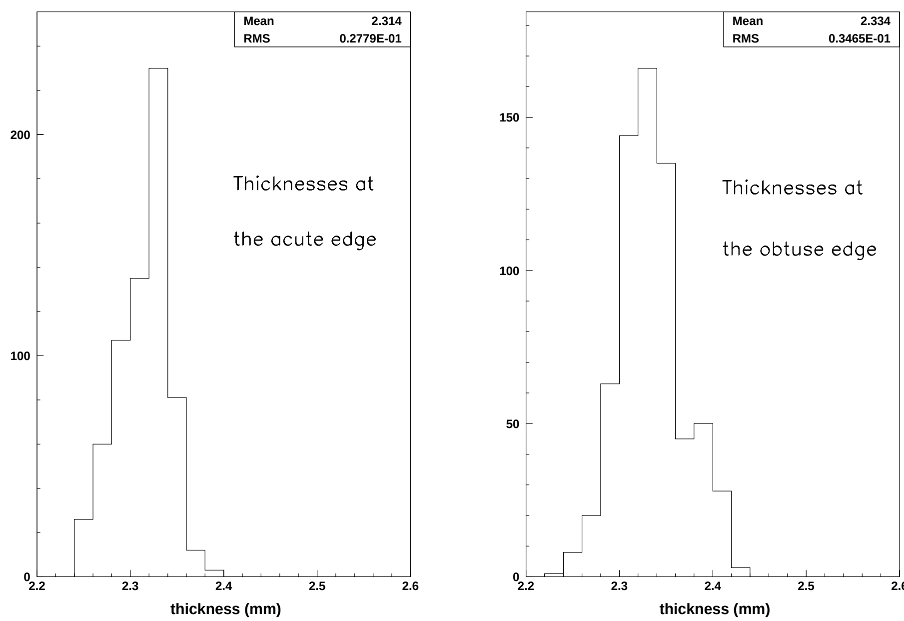
10 (4) OW (IW) absorber moulds $\Rightarrow$
Mechanical Reproducibility at the $\mathbf{40\mu m}$ level

Quality Controls on the Produced Absorber:

- Optical inspection (100%)
- Thicknesses and widths at predifined positions (100%)
- Full 3D mapping (10%)



For example, the thicknesses at the edges:



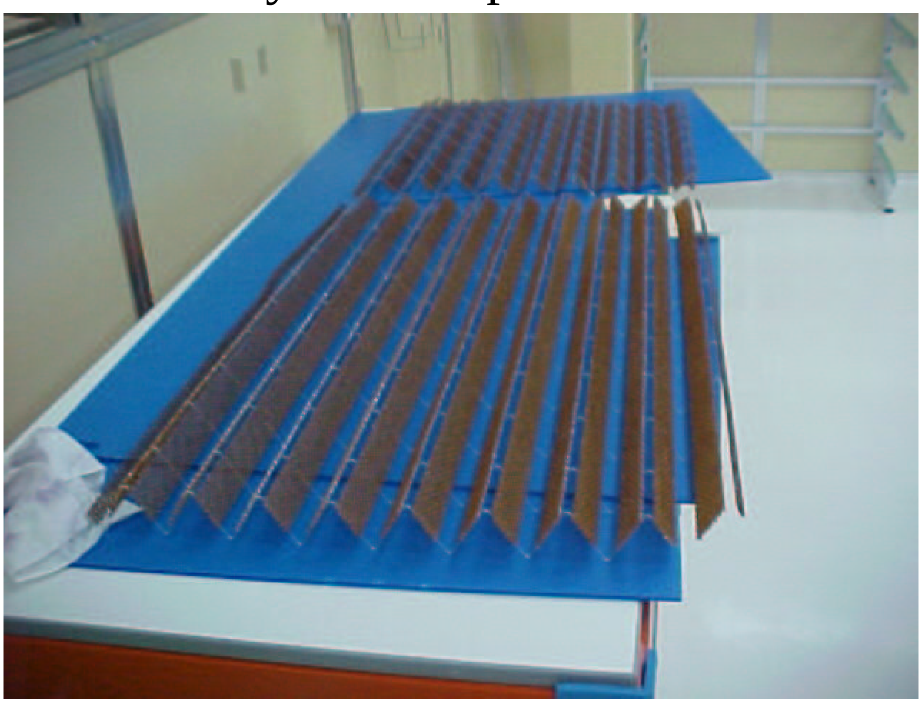
Thickness RMS	Acute edge	Obtuse Edge
obtained:	$28\mu m$	$35\mu m$
tolerances:	$110\mu m$	$36\mu m$

The prod. yield (along the whole process) is ≈ 96 %

Rest of Material for the sampling unit:

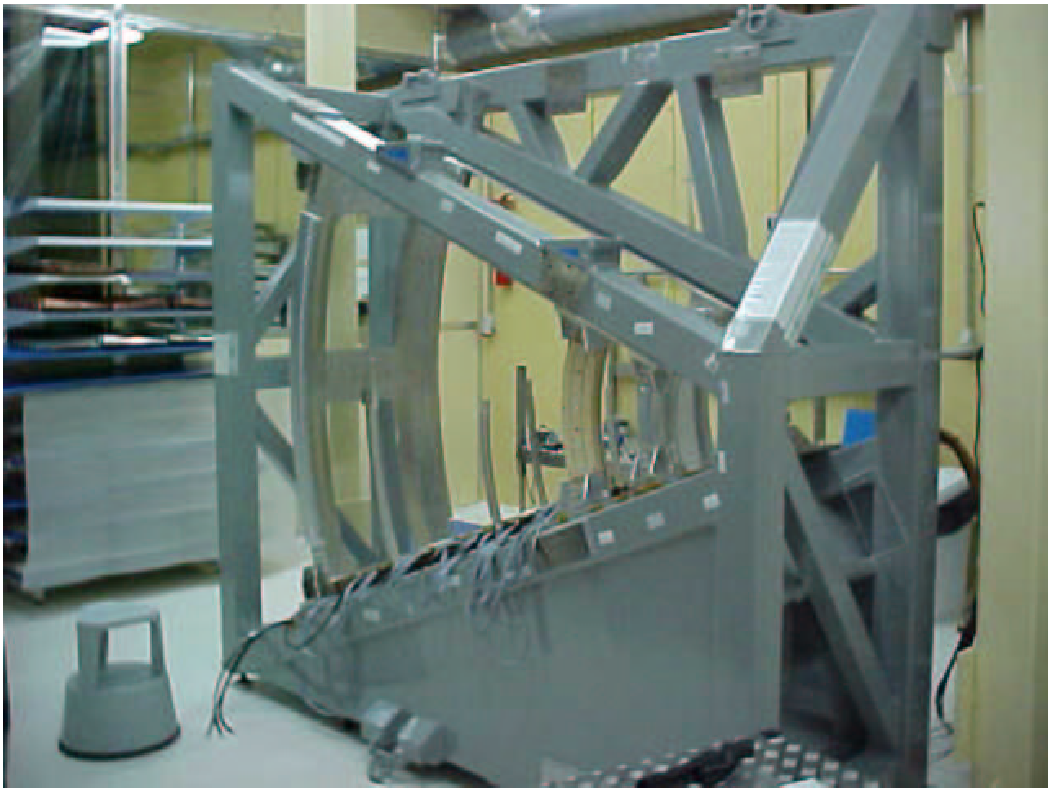
Final OW electrode fully equipped:

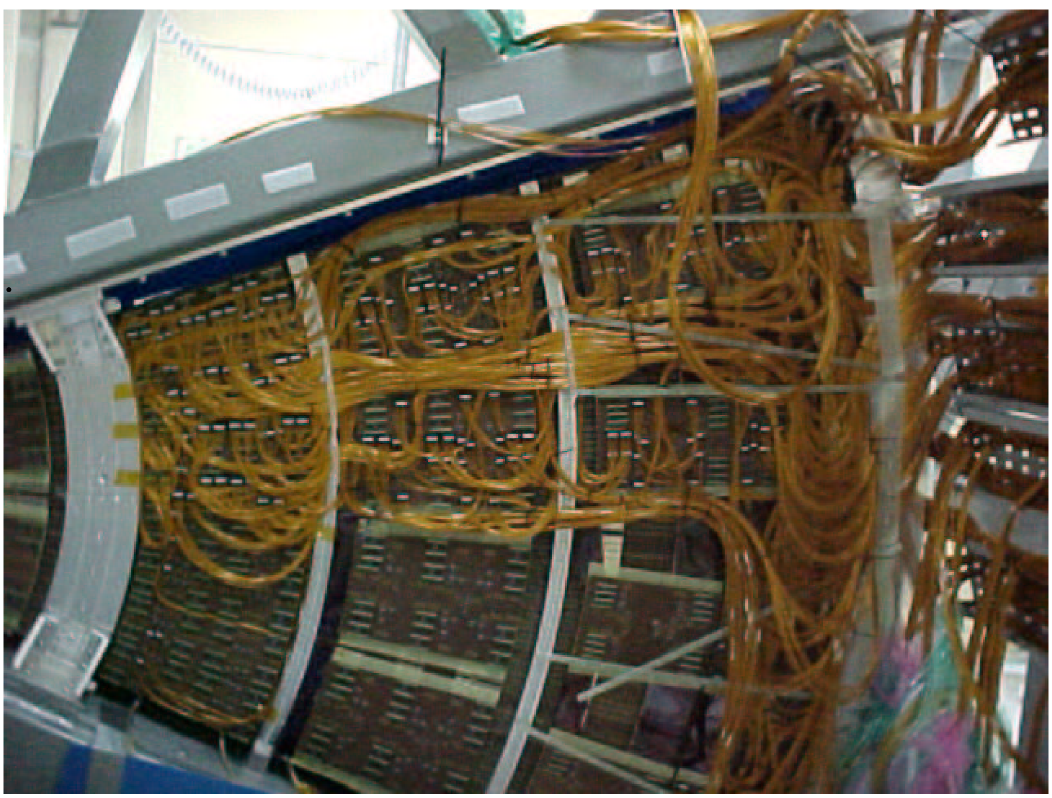
Set of Honey Comb Spacers:



Module Stacking

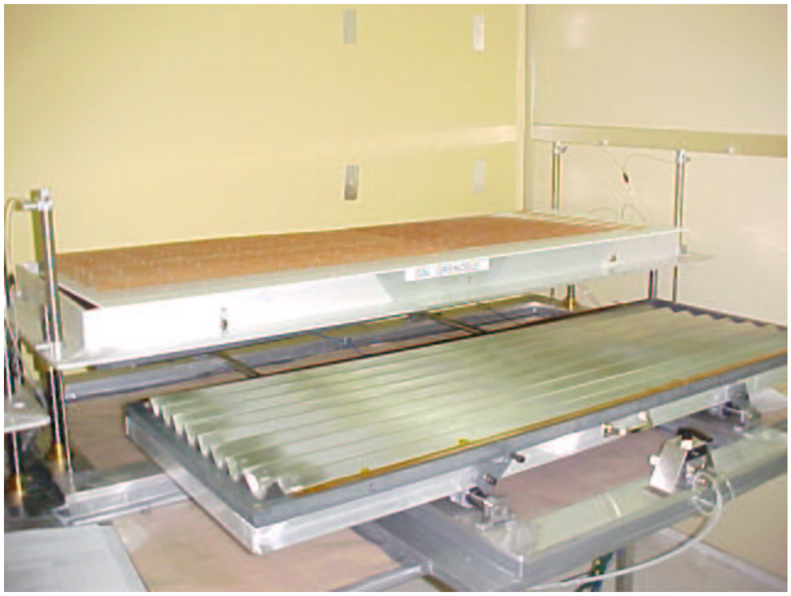
A fully equipped stacking site at UAM:





Stacking Procedure:

- last inspection and cleaning of absorber and electrode
- HV test of spacers (Voltage $\approx 1.6\times$ nominal at LArg)



- stack gap (spacers - electrode - spacers -absorber)
- bulging check/measurement i.e. relative height of each fold (severe problem at the first modules):

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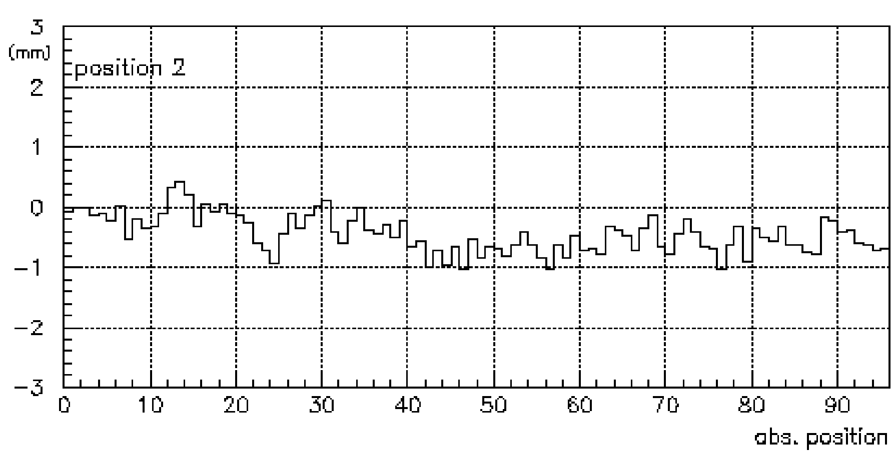
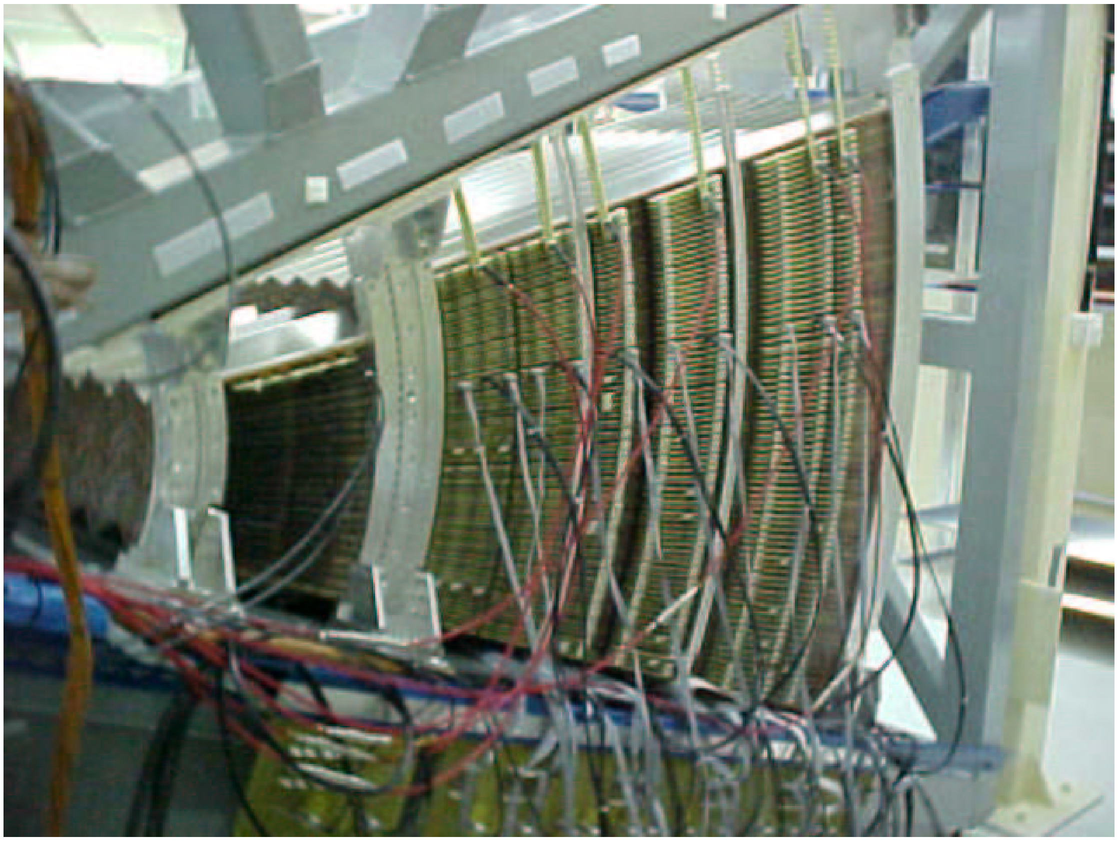


Stacking Quality Control II: HV Test Program



HV settings: those nominal at LArg (notice that the ratio between the dielectric coefficients of LArg and Air is ≈ 1.6)

- After stacking one gap (≈ 10 min.): test the stacked gap and the previous one

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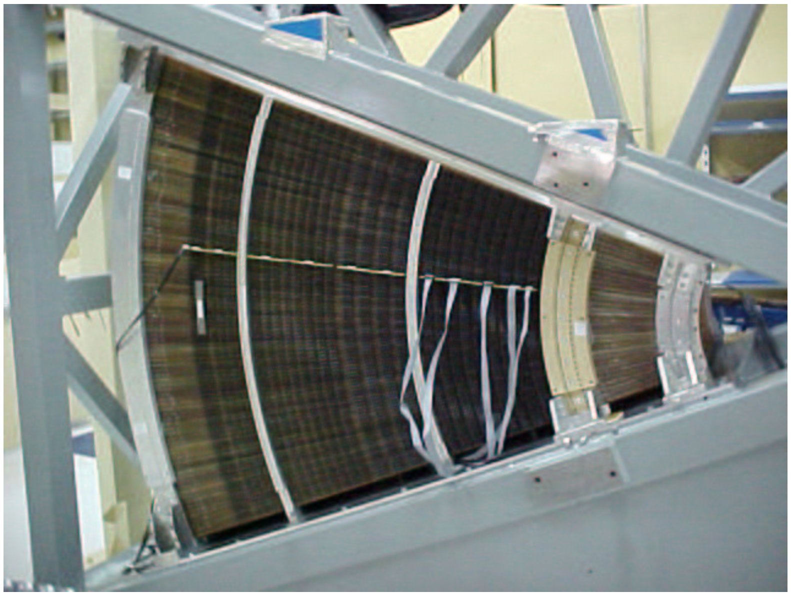
- Night test (≈ 12 hours): leave at HV the gaps stacked during the day + 2

- Week-End test (≈ 60 hours): leave at HV the gaps stacked during the week + 5

Stacking Quality Control III: Miscellanea

- Structure Deformations (4 times during the stacking of a module)

Deformations smaller than $\approx 200\mu m$; first modules showed as much as 2 mm

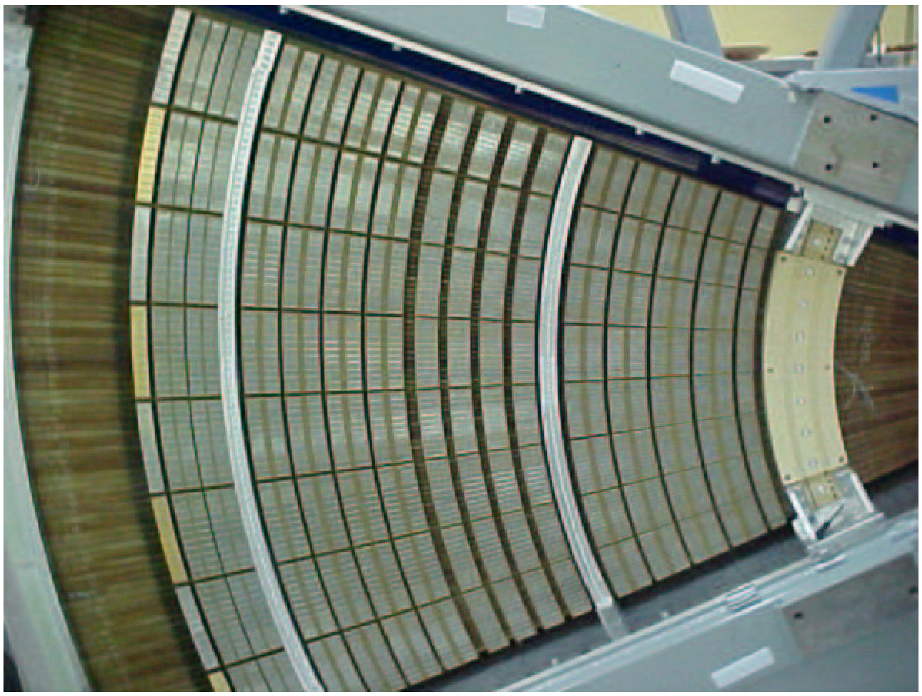


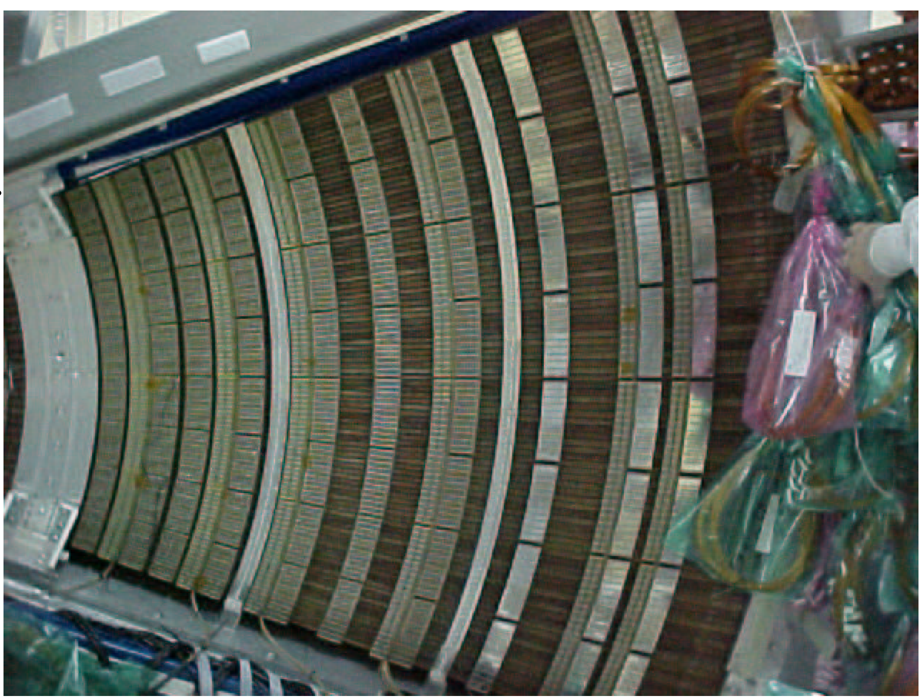
- Cell Capacitances:

  To spot any last minute failure either at the electrode or in the chain electrode - summing board - mother board

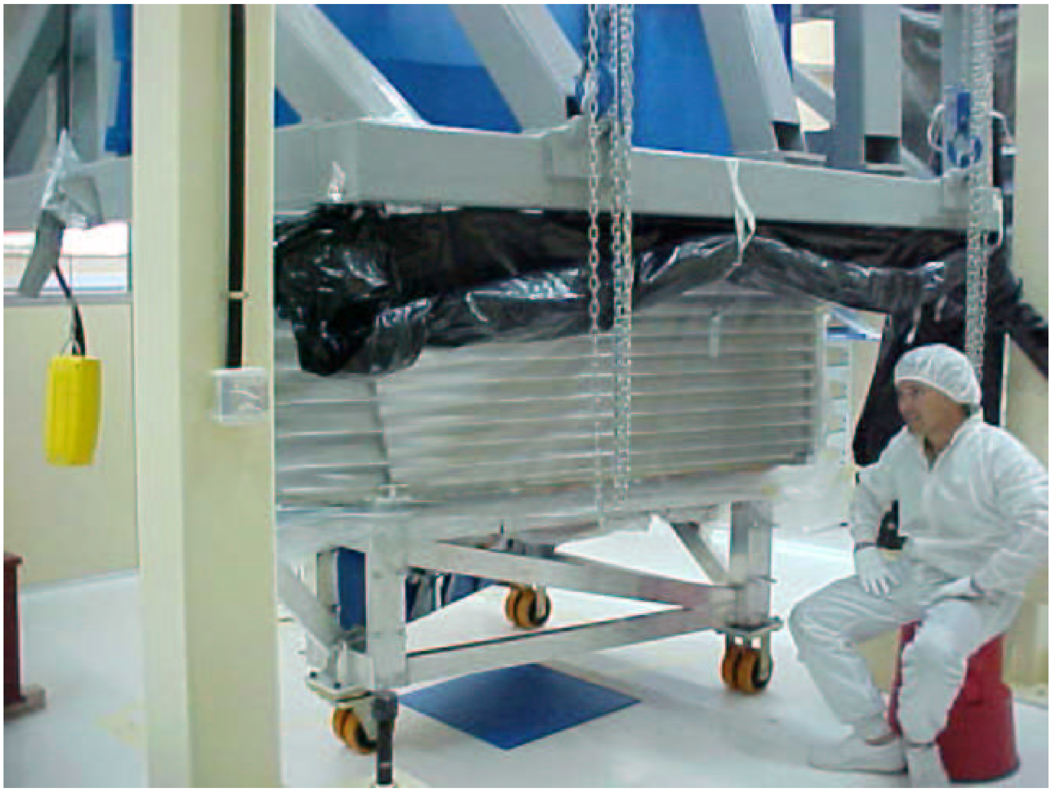
Cold Electronics

- HV Distribution Boards: **576** of **9** different types
- Summing Boards (Controlled Impedance Techinque): **3888** of **32** different types
- Test Boards: **2232** of **10** different types





Module Preparation ...



... and Transport to CERN

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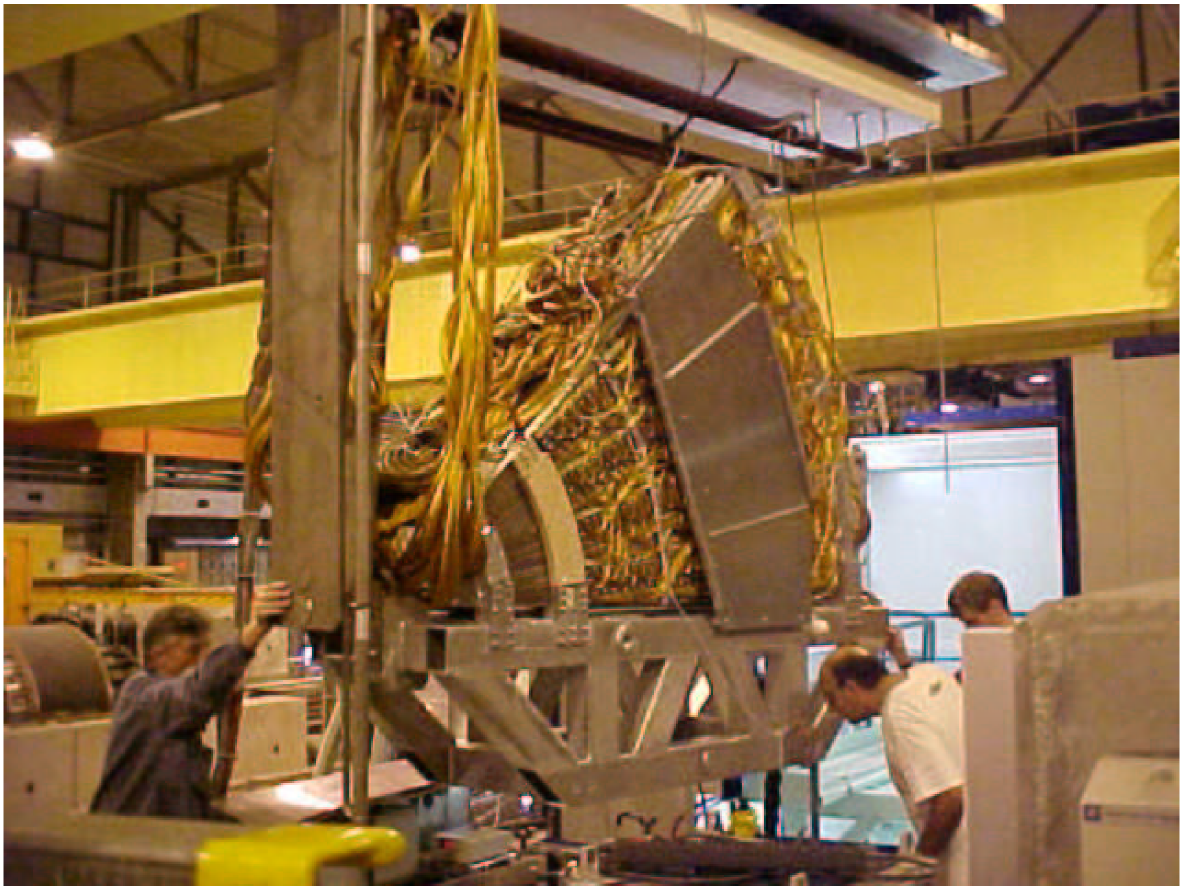
Module Testing

Cold Test Program at CERN (all modules)

we use the NA31 cryostat



- Charge Injection Resistance at Mother Board measurement: to check the MB and the signal cable continuity.

- Stand-alone calibration system to a) fully check the calibration and read-out circuitry b) cell gains

- High Voltage (at warm, at cold, at warm): HV problems that were not present at the stacking site develop (or dissapear) during the above cycle.

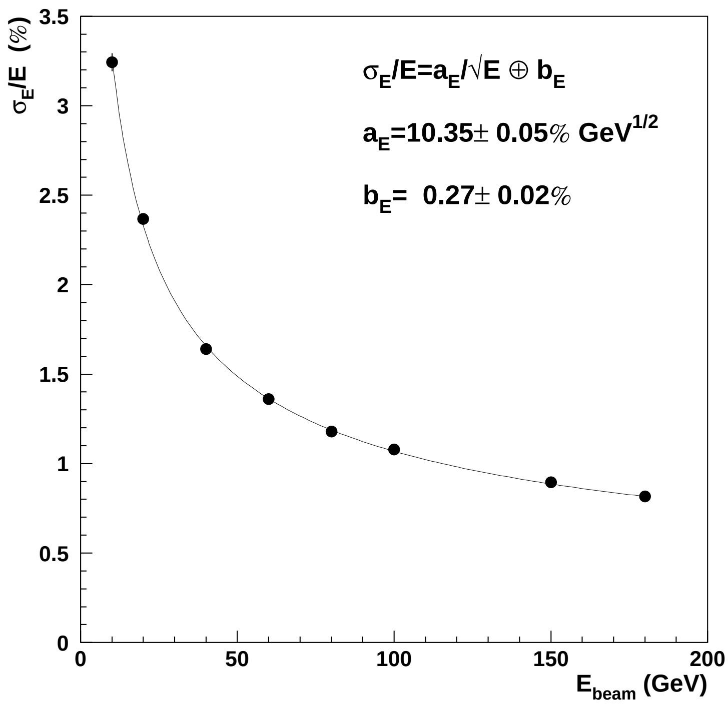
  Major concern. ⇒ The problematic electrode sectors are connected to individual spare HV lines.

Beam Test Program (20% of the modules):

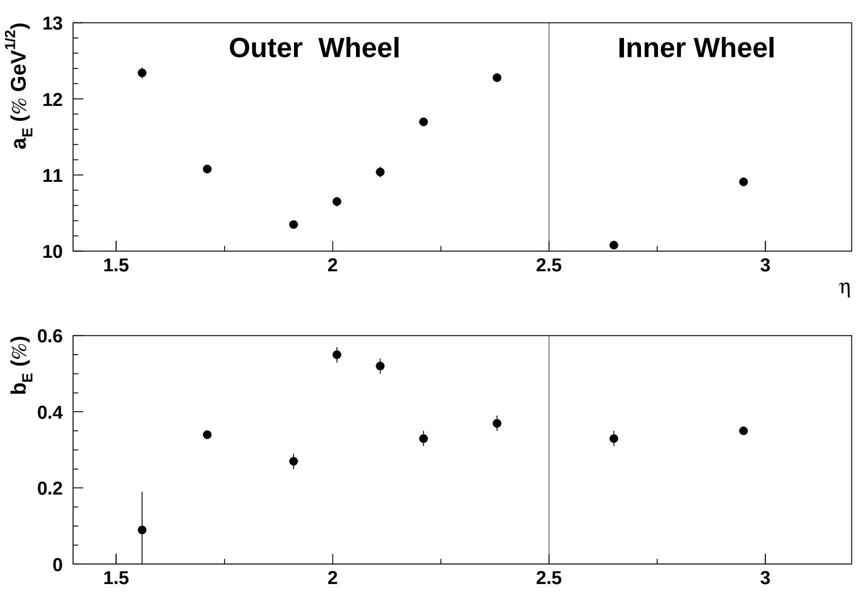
CERN H6 beam line (North Hall E.A.)

Resolution vs. Energy at Module 0. Fit to

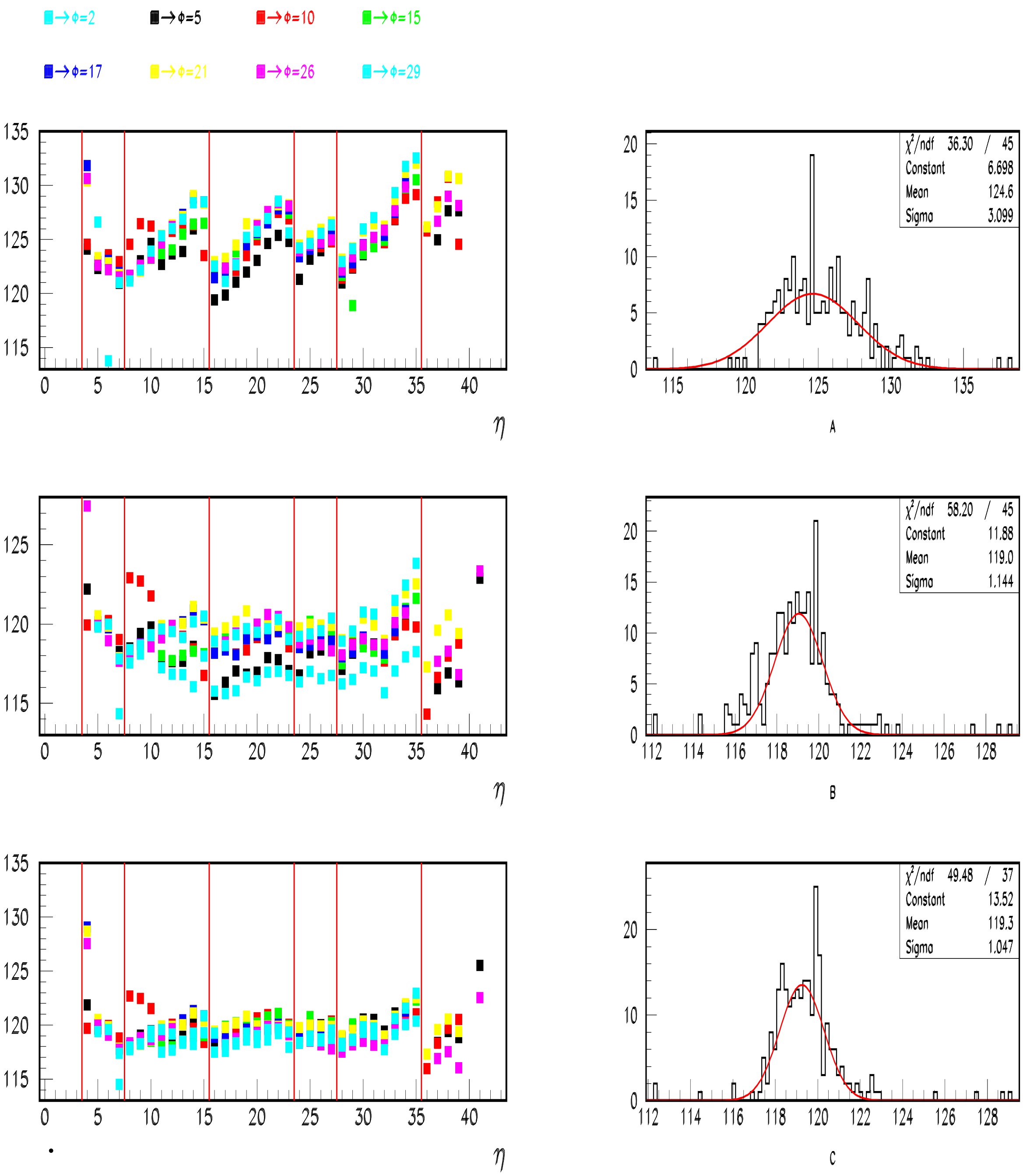
$$\frac{\sigma_E}{E} = \frac{a}{\sqrt{E}} \oplus b$$



Evolution with E of a and b terms



Production Module M05: η scans



Uniformity results (preliminary):

	no corrections	time, HV, ϕ and η	+ slope
σ/E	2.48%	0.96%	0.88%

Status

- Status of Components:
  - Structure' parts (rings etc.): ready
  - Absorbers: producing those for module no. 15
  - Electrodes: ready
  - Spacers: producing those for module no. 12
  - Cold Electronics: ready
- Status of Modules:
  - 9 modules at CERN fully tested and qualified
  - 1 module being stacked at CPPM
  - 1 module just finished at UAM to be shipped to CERN on monday
- We dont envisage new major problems on the modules
- But now comes the EndCap assembly ...