Valencian Invisibles

UVEG-IFIC

CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

Institute for Particle and Nuclear Physics

~130 experimentalists
~90 theorists

- Phenomenology
- Nuclear theory
- Astroparticle, Cosmology
- Gravity and string theory

- LHC-ATLAS
- T2K, MiniBOONE, NEXT
- Antares, Km^3 , Auger
- FAIR

Invisibles (Theory)

Seniors:

- G. Baremboim
- A. Donini
- P. Hernández
- O. Mena
- S. Palomares-Ruiz
- C. Peña-Garay
- N. Rius
- R. Ruiz de Austri

Postdocs

- S. Agarwalla
- T. Li
- J. Racker
- A Vincent (Invisibles ESR)

Students:

- E. Giusarma
- J. Herrero
- M. Peña-Jimenez
- F. Villaescusa
- M. Cerdà

Invisibles (Exp)

Seniors:

- A. Cervera
- J. Gómez-Cadenas
- M. Sorel

Postdocs

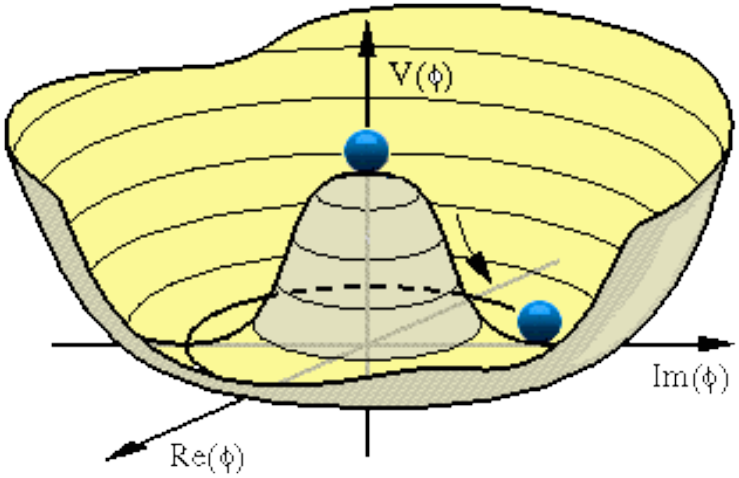
- I. Liubarsky
- P. Ferrario

Students:

- L. Escudero
- J. Martín-Albo
- L. Monfregola
- F. Monrabal
- M. Nebot
- D. Lorca
- L. Serra….

The mass puzzle

Structure of the SM vacuum ?

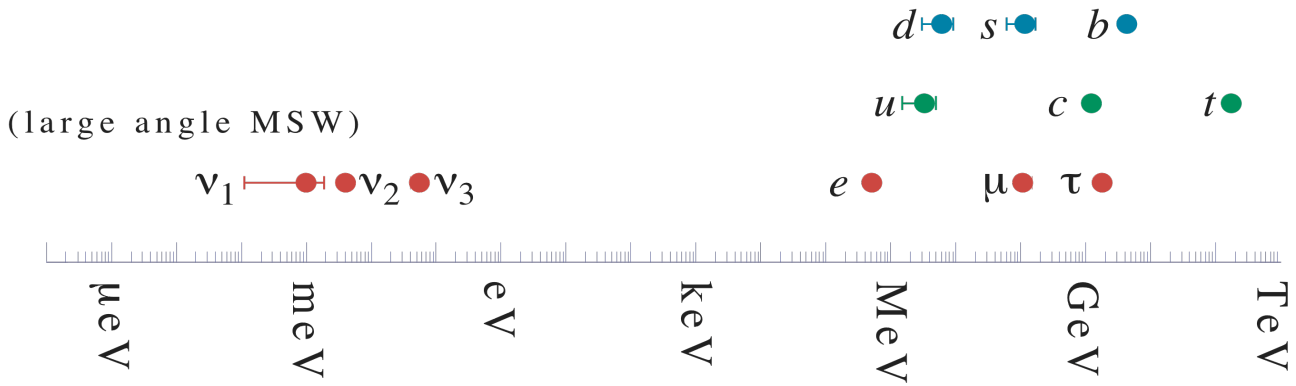


Hierarchy problem ?

Flavour Puzzle ?

Cosmological constant ?

The flavour mess



PMNS

$$|U|_{3\sigma} = \begin{pmatrix} 0.77 \to 0.86 & 0.50 \to 0.63 & 0.0 \to 0.22 \\ 0.22 \to 0.56 & 0.44 \to 0.73 & 0.57 \to 0.80 \\ 0.21 \to 0.55 & 0.40 \to 0.71 & 0.59 \to 0.82 \end{pmatrix}$$

Gonzalez-Garcia, Maltoni

CKM

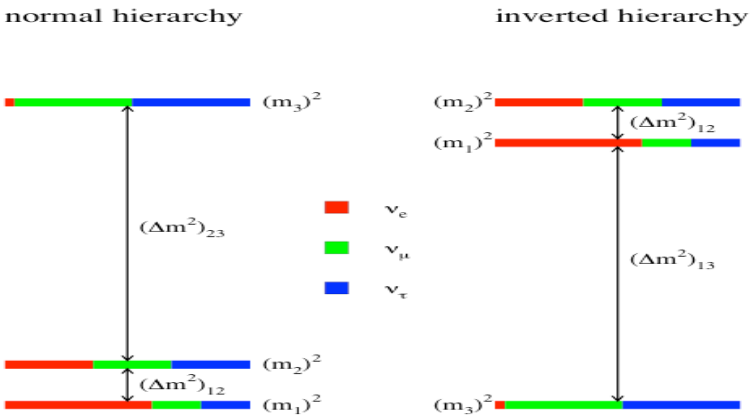
$$V_{CKM} = \begin{pmatrix} 0.97383(24) & 0.2272(10) & 3.96(9) \times 10^{-3} \\ 0.2271(10) & 0.97296(24) & 42.21^{+0.10}_{-0.80} \times 10^{-3} \\ 8.14^{+0.32}_{-0.64} \times 10^{-3} & 41.61^{+0.12}_{-0.78} \times 10^{-3} & 0.999100^{+0.000034}_{-0.000004} \end{pmatrix}$$

PDG 2007

Why three of each ? Why ν so light ? Where do the numbers come from ?
CKM vs PMNS? Majorana nature of ν ? Are there more matter fields ?

Neutrino Physics in the νSM

Objectives: measurement of neutrino masses and mixing matrix & new physics searches in present and future neutrino experiments



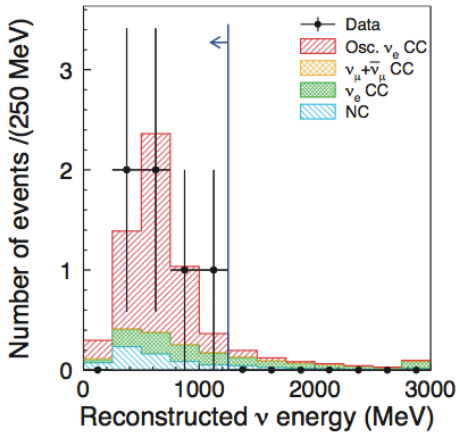
θ_{13} measured !!

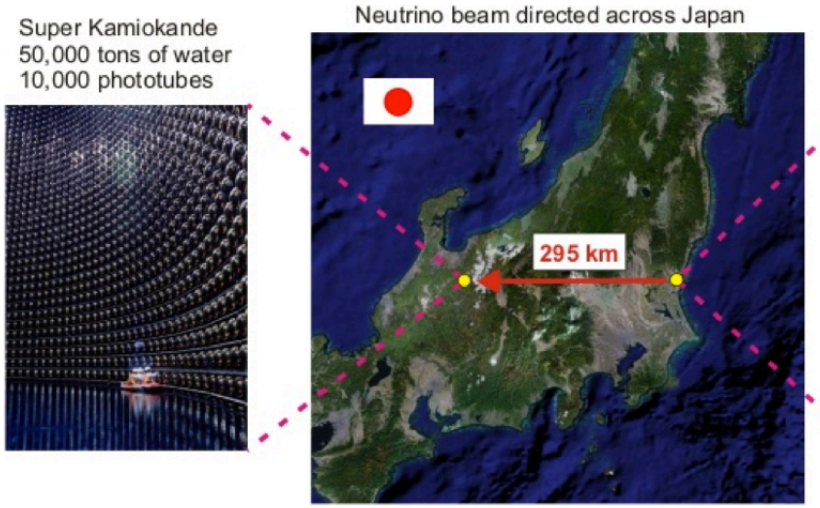
Masses	Angles	CP-phases
$m_1^2 < m_2^2, m_3^2$	$\theta_{12}, \theta_{23}, \theta_{13}$	$\delta, \alpha_1, \alpha_2$

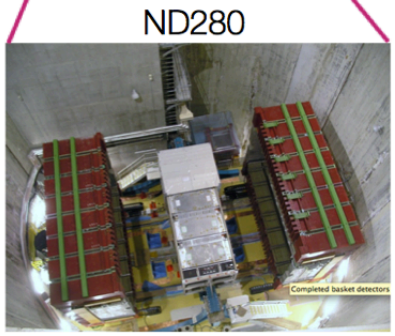
Lepton number violation ?

Daya Bay Col. arXiv: 1203.0669

Electron neutrino appearance search in a muon neutrino beam ($\nu_\mu \sim \nu_e$) to measure θ_{13}. Fundamental step prior to CP violation searches







IFIC has participated in the construction, calibration, reconstruction software and data analysis of the near detector ND280

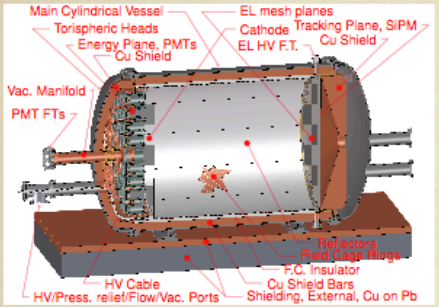
In June 2011 T2K published an indication of $\nu_\mu \sim \nu_e$ oscillations at the 2.5 sigma level. Its measurement of θ_{13} was recently confirmed by Daya-Bay (5.5 sigmas)

After the earthquake T2K resumed data taking in February 2012 and expects to confirm its previous measurement in few months

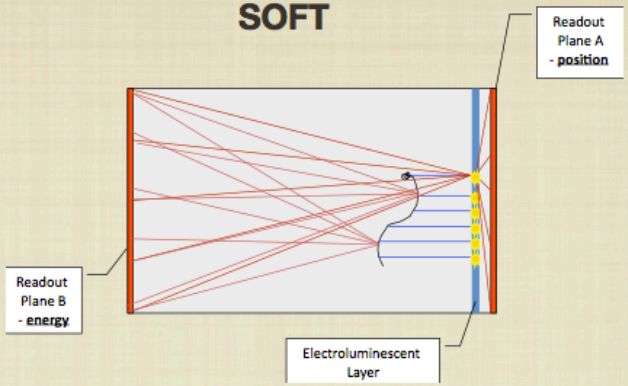
To be Majorana or not to be, that is THE question!

NEXT concept

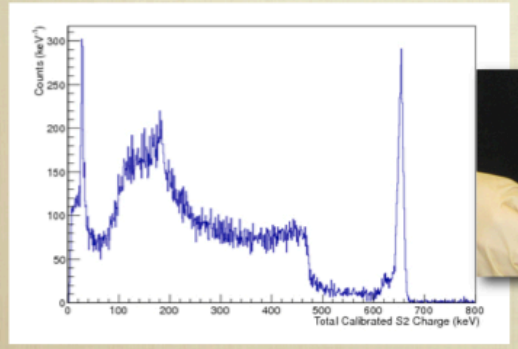
HPGXe

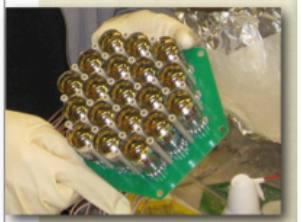


SOFT

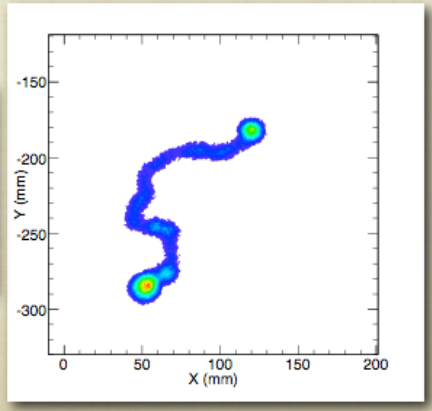


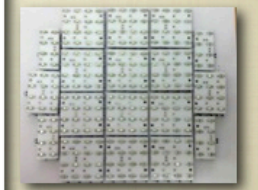
Energy resolution





Topological signature





@ Canfranc Laboratory

Neutrino Phenomenology: Future

Next step: discovery of leptonic CP violation -> T. Li's talk

(Madrid and Valencia groups leaders in this field since '98)

Comparison of achievable precision in future facilities

P. Coloma, A. Donini, E. Fernández-Martinez, P. H. arXiv: 1203.5651

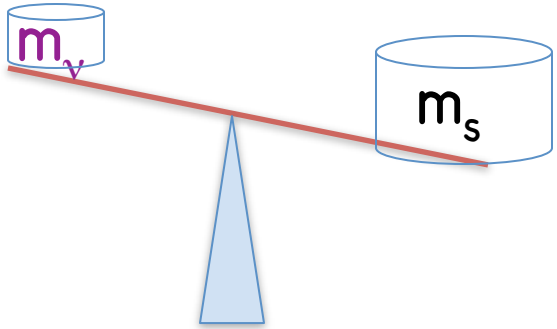
Origin of neutrino masses: extra sterile dofs ?

Most general (renormalizable) Lagrangian compatible with SM gauge symmetries:

Y: $3 \times n_R$ $\quad$ M_N: $n_R \times n_R$

Phenomenology and cosmo implications strongly depend on n_R, M_N and global symmetries (patterns in Y and M_N)

Type I seesaw: $M_N \gg Y\ v$



GUT

LHC

BAU

DM

ν osc. anomalies

CMB,LSS

Y_e

Important to understand how data breaks this Y, M_N degeneracy

Extra Light Sterile Neutrinos

-> S. Agarwalla's talk

Improve global fits: LSND+MiniBOONE, SBL reactors

Giunti, Laveder, (GL) arXiv:1107.1452

Kopp, Maltoni, Schwetz (KMS) arXiv:1103.4570

Minimal Models of this type: just 2 singlet Weyl fermions U_{ei}, $U_{\mu i}$ right ballpark!

A. Donini, P.H., J. López-Pavón, M. Maltoni, arXiv: 1106.0064

Neutrino Phenomenology Beyond SM

Extra SM generations and neutrino masses

A. Aparici, J. Herrero-García, N. Rius and A. Santamaría, arXiV:**1104.4068**

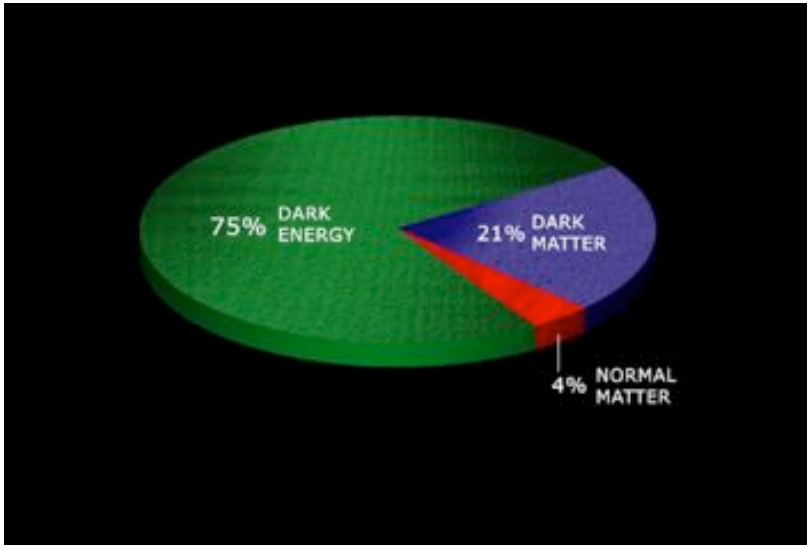
- Extra generations being tested at LHC
- Challenge: 3 very light neutrinos + 1 above LEP bound

In seesaw type models, the 4th generation ν must be Majorana

(Majorana masses for the RH neutrino generated radiatively – At two loops)

Majorana mass for the 4th generation neutrinos induce two-loop contributions to light neutrino masses

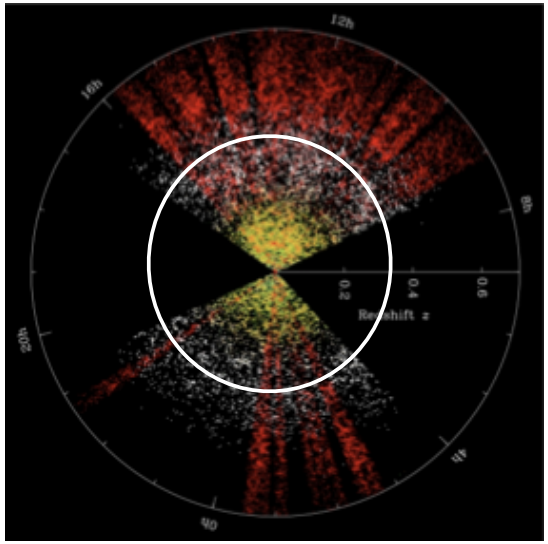
The missing energy puzzle

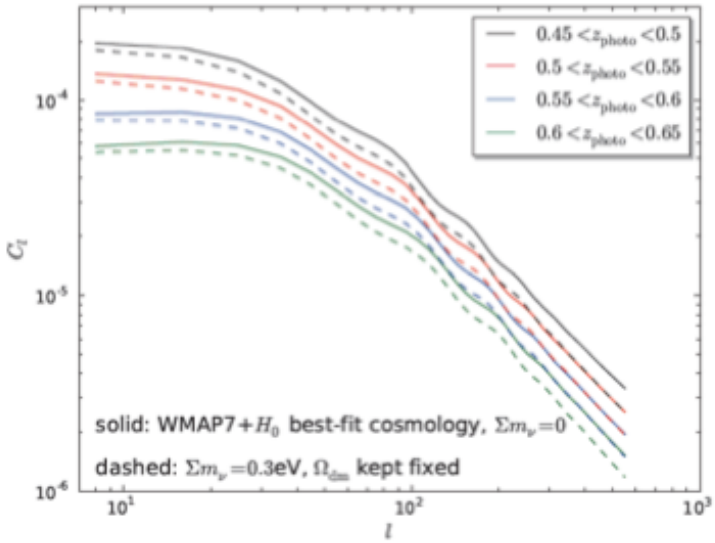


We do not understand any of the components in the SM !

Why baryons did not annihilate ? What is DM ? What is DE ?

SDSS-III: BOSS (Baryon Oscillation Spectroscopic Survey)





SDSS II main (10^5 LRGs, z<0.4)
SDSS III BOSS LRGs (2014=1.5 10^6, z<0.7 and 1.6x10^5 quasars z=2-3)

The radial (H(z)) and angular BAO signals and growth factor with unprecedent precision as function of z

-> E. Giusarma's talk

2010 Data: 2x10^5 LRGs

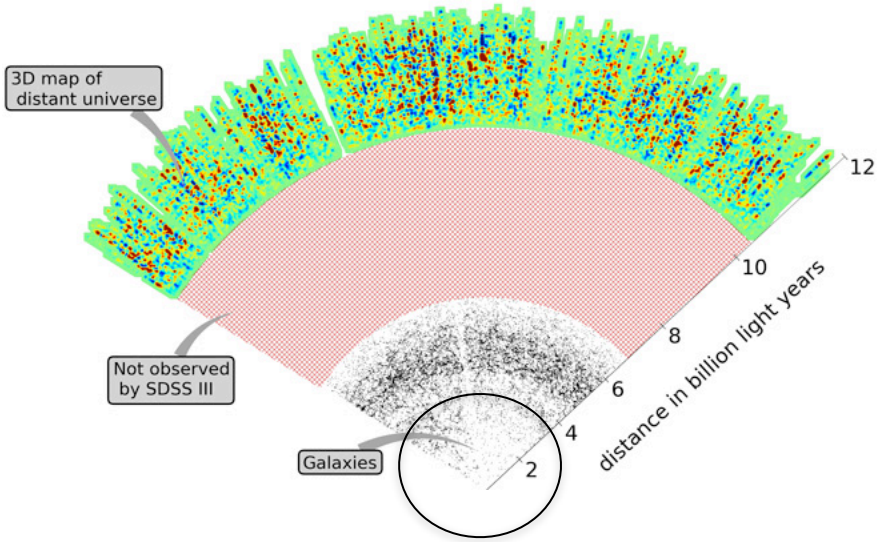
NEW NEUTRINO MASS BOUNDS FROM SLOAN DIGITAL SKY SURVEY III DATA RELEASE 8 PHOTOMETRIC LUMINOUS GALAXIES

Roland de Putter[1,2], Olga Mena[2], Elena Giusarma[2], Shirley Ho[3,4], Antonio Cuesta[5], Hee-Jong Seo[3,6], Ashley J. Ross[7], Martin White[3,8], Dmitry Bizyaev[9], Howard Brewington[9], David Kirkby[10], Elena Malanushenko[9], Viktor Malanushenko[9], Daniel Oravetz[9], Kaike Pan[9], Will J. Percival[7], Nicholas P. Ross[3], Donald P. Schneider[11,12], Alaina Shelden[9], Audrey Simmons[9], Stephanie Snedden[9]

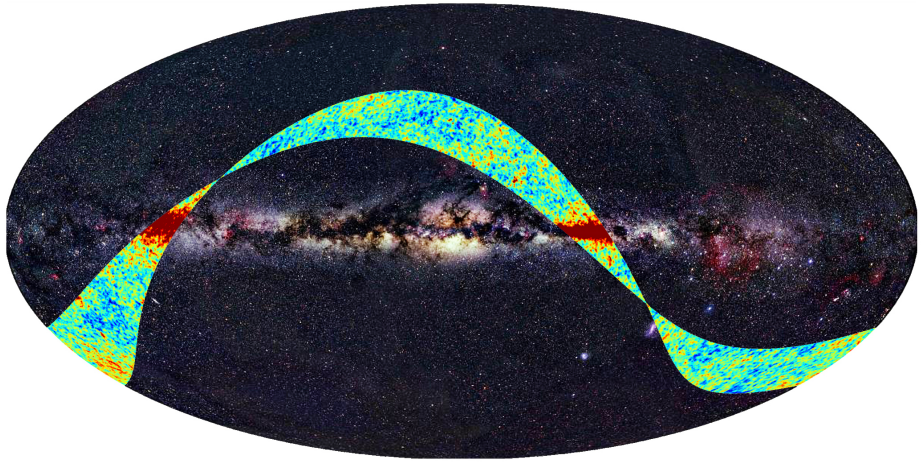
(Dated: January 11, 2012)
Draft version January 11, 2012

BOSS + Planck CMB:

Galaxy surveys: BOSS



CMB: Planck



-Einstein vs modified gravity

-Nature of dark energy (quintessence? cosmological constant?)

-Neutrino/axion mass bounds

-Non gaussianities (inflationary models)

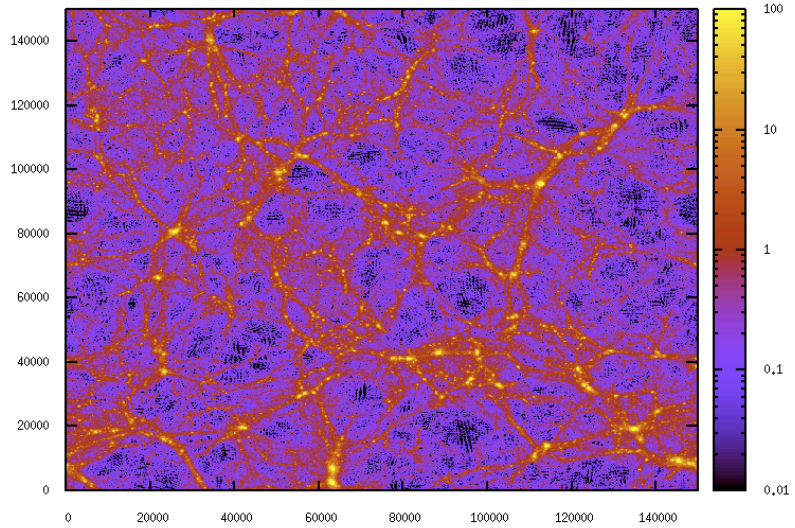
Neutrino properties from cosmology

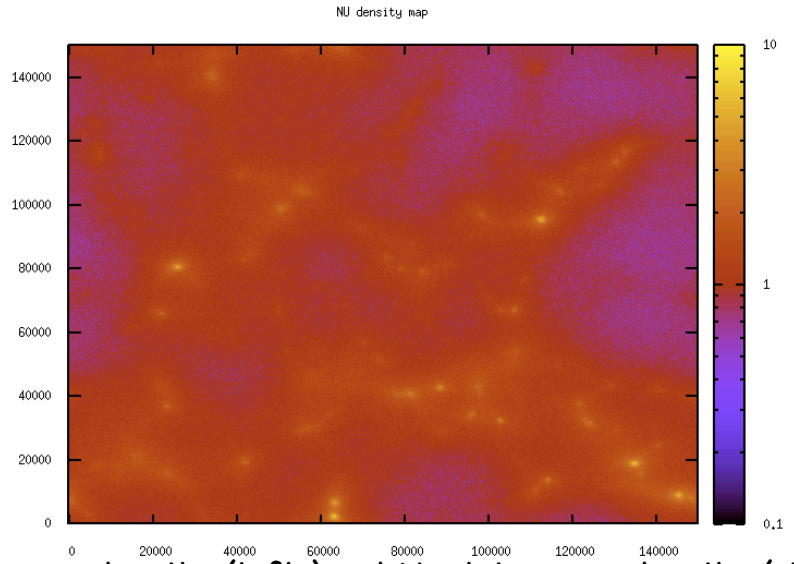
Dark matter in extra light neutrinos strongly constrained from cosmology

E. Giusarma et al, arXiv: 1102:4774

Signatures of Neutrino Masses in Large Scale Structure

S





150 Mpc/h x 150 Mpc/h x 10 Mpc/h slice, Dark Matter overdensity (left)and Neutrino overdensity (right).
Simulation: 512^3 CDM and 512^3 n (3x0.2 eV degenerate neutrinos) in 150 Mpc size Box.
Software: CAMB (linear regime)+ GADGET-3 (N-body) + SUBFIND/AMIGA (halo finder)

Can we measure the neutrino mass hierarchy in the sky? Jimenez et al, **JCAP 1005:035,2010**.
Atmospheric splitting under reach if total mass is smaller than 0.2eV. Hierarchy only if total mass < 0.12 eV.

Neutrino Halos in Clusters of Galaxies and their Weak Lensing Signature. Villaescusa-Navarro et al, **JCAP 1106:027,2011**.
Neutrino profile in the deepest potential wells (Galaxy clusters). Sensitivity to neutrino mass by stacking weak lensing profile of many cluster.

Neutrino Signatures on the High Transmission Regions of the Lyman-alpha Forest. Villaescusa-Navarro, et al, **1106.2543**
Neutrino-Dark matter ratio from voids. Neutrinos make voids smaller and denser. Number of voids is sensitive to the neutrino mass.

Baryogenesis & leptogenesis

-> J. Racker's Talk

ν astrophysics

- Solar neutrinos -> solar models
- Neutrino astrophysics
- Neutrino signals of DM,....

M.C. Gonzalez-Garcia, J. Racker and N. Rius,JHEP0911 (2009) 079

Networking already @ work

O. Mena, our most active networker