

WG5 questions and plans: “Neutrinos beyond PMNS”

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Proposal from Alain and Kobayashi-san



WG5, 'Neutrinos Beyond PMNS'

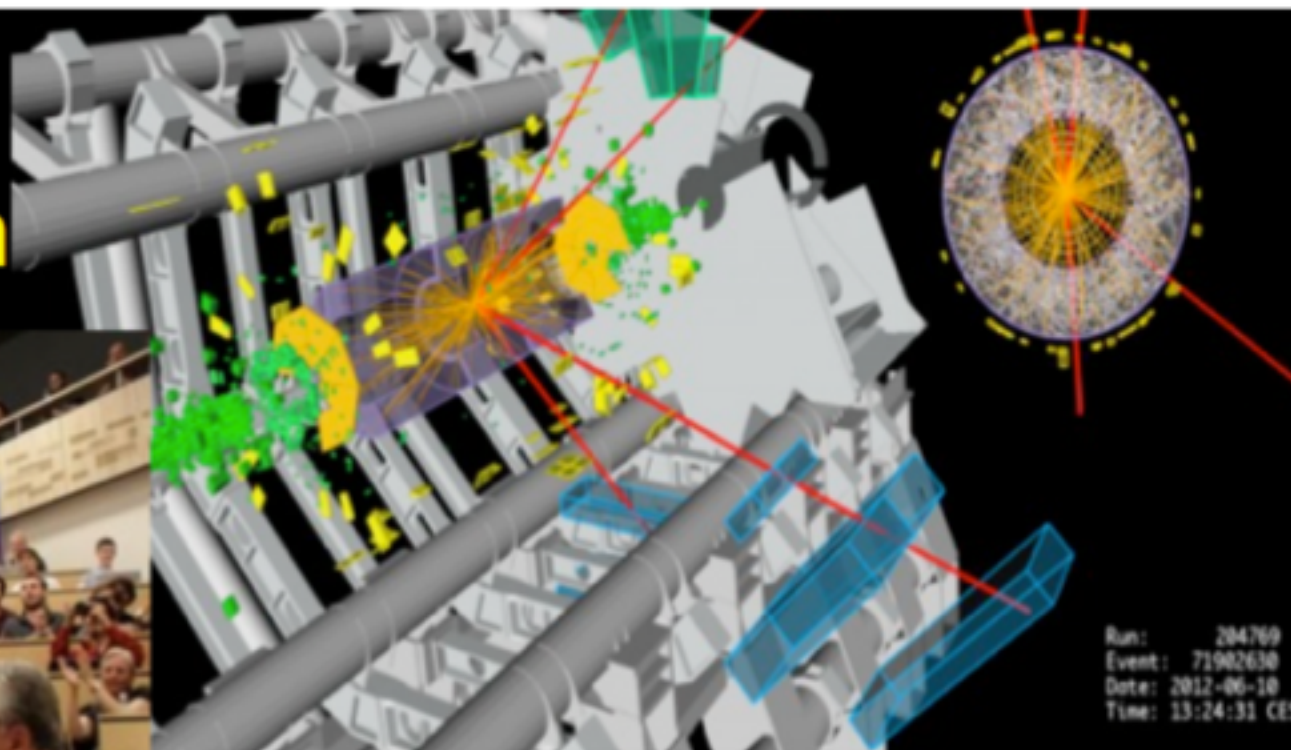
TOPICS and QUESTIONS *could* cover the following :

- general discussion, motivation and, possibly, rationalization of models beyond PMNS
- experimental searches for right handed neutrinos
 - nuclear decays and galactic emissions (no emphasis)
 - short baseline oscillations
 - observation of neutral decays in beam dump experiments and neutrino beams
 - observation in e-e- colliders (W-W- final state)
 - observation in Z and Higgs factories
 - observation at hadron colliders LHC, HL-LHC and SppC and FCC-hh
 - unification of interpretation framework
- other beyond PMNS, NSI, etc.

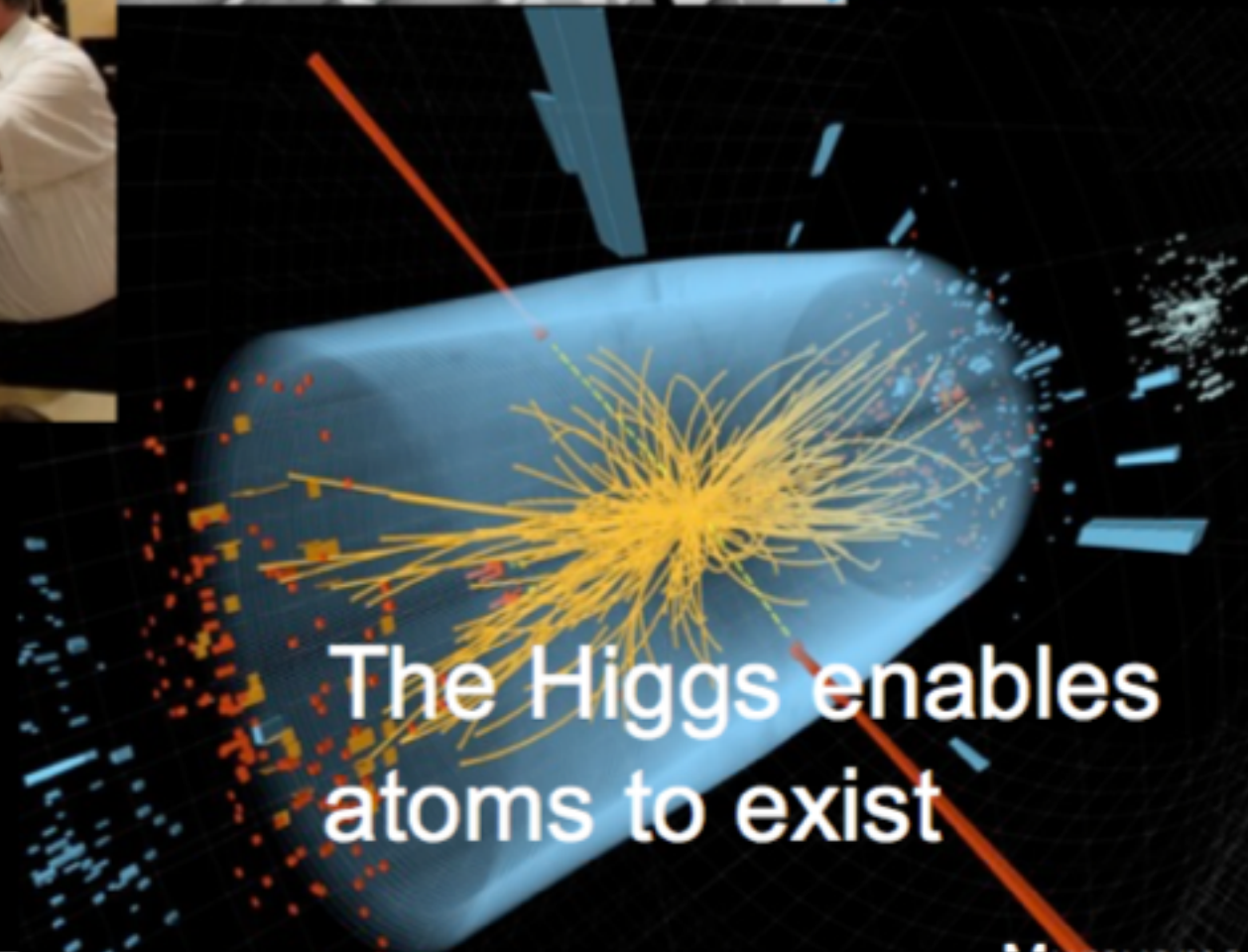
Indeed emerging picture in HEP more and more supporting WG5-like studies (as Alain pointed out also in his plenary talk this morning)

...a few slides stolen from I.Shipsey's (thanks!) summary talk at ICHEP (I was not there...) follow

2012.7.4 discovery of Higgs boson



theory : 1964
design : 1984
construction : 1998



The Higgs enables
atoms to exist

However...

Run 2 SUSY Searches

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: August 2016

ATLAS Preliminary

$\sqrt{s} = 7, 8, 13 \text{ TeV}$

| Model | e, μ, τ, γ | Jets | E_T^{miss} | $\int \mathcal{L} d\sqrt{s} [\text{fb}^{-1}]$ | Mass limit | $\sqrt{s} = 7, 8 \text{ TeV}$ | $\sqrt{s} = 13 \text{ TeV}$ | Reference |
|--|---|---------------------|---------------------|---|---------------|-------------------------------|---|--|
| Inclusive Searches | | | | | | | | |
| MSUGRA/CMSSM | 0-3 e, μ, τ | 2-10 jets/3 b | Yes | 20.3 | 2.2 | 1.85 TeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1507.0525 |
| $\tilde{g} \rightarrow q\bar{q}$ | 0 | 2-6 jets | Yes | 13.3 | 2 | 1.35 TeV | $m_0 = 300 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | ATLAS-CONF-2016-076 |
| $\tilde{g} \rightarrow q\bar{q}$ (compressed) | 0 | 1-3 jets | Yes | 3.2 | 2 | 608 GeV | $m_0 = 300 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1504.07773 |
| $\tilde{g} \rightarrow q\bar{q}$ | 0 | 2-6 jets | Yes | 13.3 | 2 | 1.35 TeV | $m_0 = 300 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | ATLAS-CONF-2016-076 |
| $\tilde{g} \rightarrow q\bar{q} + \tilde{g} \rightarrow q\bar{q}$ | 0 | 2-6 jets | Yes | 13.3 | 2 | 1.35 TeV | $m_0 = 300 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | ATLAS-CONF-2016-076 |
| $\tilde{g} \rightarrow q\bar{q} + \tilde{g} \rightarrow q\bar{q}$ | 3 e, μ | 4 jets | - | 13.2 | 2 | 1.7 TeV | $m_0 = 300 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | ATLAS-CONF-2016-037 |
| $\tilde{g} \rightarrow q\bar{q} + \tilde{g} \rightarrow q\bar{q}$ | 2 e, μ (SS) | 0-3 jets | Yes | 13.2 | 2 | 1.8 TeV | $m_0 = 300 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | ATLAS-CONF-2016-037 |
| GMSB (if NLSP) | 1-2 $e + 0-1 \tau$ | 0-2 jets | Yes | 3.2 | 2 | 2.8 TeV | $m_0 = 300 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1507.0525 |
| GGM (bino NLSP) | 2 γ | - | Yes | 3.2 | 2 | 1.85 TeV | $m_0 = 300 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1506.05130 |
| GGM (higgsino-bino NLSP) | 7 | 1 b | Yes | 20.3 | 2 | 1.37 TeV | $m_0 = 300 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1507.05483 |
| GGM (higgsino-bino NLSP) | 7 | 2 jets | Yes | 13.3 | 2 | 1.8 TeV | $m_0 = 300 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | ATLAS-CONF-2016-086 |
| GGM (higgsino NLSP) | 2 e, μ (Z) | 2 jets | Yes | 20.3 | 2 | 900 GeV | $m_0 = 300 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1503.03290 |
| Gravitino LSP | 0 | mono-jet | Yes | 20.3 | 2 | 865 GeV | $m_0 = 300 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1502.01518 |
| 3rd gen. & med. | | | | | | | | |
| $\tilde{t} \rightarrow b\bar{b}$ | 0 | 3 b | Yes | 14.8 | 2 | 1.85 TeV | $m_0 = 300 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | ATLAS-CONF-2016-052 |
| $\tilde{t} \rightarrow b\bar{b}$ | 0-1 e, μ | 3 b | Yes | 14.8 | 2 | 1.85 TeV | $m_0 = 300 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | ATLAS-CONF-2016-052 |
| $\tilde{t} \rightarrow b\bar{b}$ | 0-1 e, μ | 3 b | Yes | 20.1 | 2 | 1.37 TeV | $m_0 = 300 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1507.0500 |
| 3rd gen. squarks direct production | | | | | | | | |
| $\tilde{t}_1 \tilde{t}_1^* \rightarrow b\bar{b}$ | 0 | 2 b | Yes | 3.2 | \tilde{t}_1 | 840 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1506.08772 |
| $\tilde{t}_1 \tilde{t}_1^* \rightarrow b\bar{b}$ | 2 e, μ (SS) | 1 b | Yes | 13.2 | \tilde{t}_1 | 325-685 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | ATLAS-CONF-2016-037 |
| $\tilde{t}_1 \tilde{t}_1^* \rightarrow b\bar{b}$ | 0-2 e, μ | 1-2 b | Yes | 4.7/13.3 | \tilde{t}_1 | 170 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1209.2152, ATLAS-CONF-2016-077 |
| $\tilde{t}_1 \tilde{t}_1^* \rightarrow W\bar{W}^* \text{ or } Z\bar{Z}^*$ | 0-2 e, μ | 0-2 jets/1-2 b | Yes | 4.7/13.3 | \tilde{t}_1 | 90-198 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1506.08616, ATLAS-CONF-2016-077 |
| $\tilde{t}_1 \tilde{t}_1^* \rightarrow b\bar{b}$ | 0 | mono-jet | Yes | 3.2 | \tilde{t}_1 | 90-323 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1504.07773 |
| $\tilde{t}_1 \tilde{t}_1^* \rightarrow b\bar{b}$ | 2 e, μ (Z) | 1 b | Yes | 20.3 | \tilde{t}_1 | 130-600 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1503.03290 |
| $\tilde{t}_1 \tilde{t}_1^* \rightarrow b\bar{b} + Z$ | 3 e, μ (Z) | 1 b | Yes | 13.3 | \tilde{t}_1 | 290-700 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | ATLAS-CONF-2016-036 |
| $\tilde{t}_1 \tilde{t}_1^* \rightarrow b\bar{b} + b$ | 1 e, μ | 6 jets + 2 b | Yes | 20.3 | \tilde{t}_1 | 320-620 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1506.08616 |
| EW direct | | | | | | | | |
| $\tilde{g} \tilde{g} \rightarrow \tilde{g} \tilde{g}$ | 2 e, μ | 0 | Yes | 20.3 | \tilde{g} | 90-335 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1403.5294 |
| $\tilde{g} \tilde{g} \rightarrow \tilde{g} \tilde{g}$ | 2 e, μ | 0 | Yes | 20.3 | \tilde{g} | 140-475 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1403.5294 |
| $\tilde{g} \tilde{g} \rightarrow \tilde{g} \tilde{g}$ | 2 e | - | Yes | 20.3 | \tilde{g} | 355 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1407.0350 |
| $\tilde{g} \tilde{g} \rightarrow \tilde{g} \tilde{g}$ | 3 e, μ | 0 | Yes | 20.3 | \tilde{g} | 715 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1402.7029 |
| $\tilde{g} \tilde{g} \rightarrow \tilde{g} \tilde{g}$ | 2-3 e, μ | 0-2 jets | Yes | 20.3 | \tilde{g} | 425 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1403.5294, 1402.7029 |
| $\tilde{g} \tilde{g} \rightarrow \tilde{g} \tilde{g}$ | e, μ, τ | 0-2 b | Yes | 20.3 | \tilde{g} | 270 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1501.07110 |
| $\tilde{g} \tilde{g} \rightarrow \tilde{g} \tilde{g}$ | 4 e, μ | 0 | Yes | 20.3 | \tilde{g} | 635 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1403.5086 |
| GGM (bino NLSP) weak prod. | 1 $e, \mu + \gamma$ | - | Yes | 20.3 | \tilde{g} | 115-270 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1507.05483 |
| GGM (bino NLSP) weak prod. | 2 γ | - | Yes | 20.3 | \tilde{g} | 595 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1507.05483 |
| Long-lived particles | | | | | | | | |
| Direct $\tilde{t}_1 \tilde{t}_1^* \rightarrow b\bar{b}$ prod., long-lived \tilde{t}_1 | Disapp. 9% | 1 jet | Yes | 20.3 | \tilde{t}_1 | 270 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1310.3675 |
| Direct $\tilde{t}_1 \tilde{t}_1^* \rightarrow b\bar{b}$ prod., long-lived \tilde{t}_1 | dE/dx 9% | - | Yes | 18.4 | \tilde{t}_1 | 495 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1506.05332 |
| Stable, stopped \tilde{t}_1 R-hadron | 0 | 1-5 jets | Yes | 27.9 | \tilde{t}_1 | 850 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1310.3684 |
| Stable \tilde{t}_1 R-hadron | 9% | - | - | 3.2 | \tilde{t}_1 | 1.58 TeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1506.05129 |
| Metastable \tilde{t}_1 R-hadron | dE/dx 9% | - | - | 3.2 | \tilde{t}_1 | 1.37 TeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1504.04520 |
| GMSB, stable $\tilde{t}_1 \rightarrow t\bar{t} + \tilde{t}_1 \rightarrow t\bar{t} + \tilde{t}_1$ | 1-2 μ | - | - | 19.1 | \tilde{t}_1 | 537 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1411.6795 |
| GMSB, $\tilde{t}_1 \rightarrow t\bar{t}$, long-lived \tilde{t}_1 | 2 γ | - | Yes | 20.3 | \tilde{t}_1 | 440 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1409.5542 |
| $\tilde{g} \tilde{g} \rightarrow \tilde{g} \tilde{g}$ | displ. $\tilde{t}_1 \tilde{t}_1^* \rightarrow t\bar{t}$ | - | - | 20.3 | \tilde{g} | 1.8 TeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1504.05142 |
| GGM $\tilde{g} \tilde{g} \rightarrow \tilde{g} \tilde{g}$ | displ. $\tilde{t}_1 \tilde{t}_1^* \rightarrow t\bar{t}$ | - | - | 20.3 | \tilde{g} | 1.8 TeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1504.05142 |
| RPV | | | | | | | | |
| LFV $\tilde{g} \tilde{g} \rightarrow \tilde{g} \tilde{g}$ | e, μ, τ, γ | - | - | 3.2 | \tilde{g} | 1.8 TeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1507.05079 |
| Bilinear RPV CMSSM | 2 e, μ (SS) | 0-3 b | Yes | 20.3 | \tilde{g} | 1.45 TeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1404.2500 |
| $\tilde{t}_1 \tilde{t}_1^* \rightarrow b\bar{b}$ | 4 e, μ | - | Yes | 13.3 | \tilde{t}_1 | 1.14 TeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | ATLAS-CONF-2016-075 |
| $\tilde{t}_1 \tilde{t}_1^* \rightarrow b\bar{b}$ | 3 $e, \mu + \tau$ | - | Yes | 20.3 | \tilde{t}_1 | 450 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1403.5086 |
| $\tilde{g} \tilde{g} \rightarrow \tilde{g} \tilde{g}$ | 0 | 4-5 large- R jets | - | 14.8 | \tilde{g} | 1.08 TeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | ATLAS-CONF-2016-037 |
| $\tilde{g} \tilde{g} \rightarrow \tilde{g} \tilde{g}$ | 0 | 4-5 large- R jets | - | 14.8 | \tilde{g} | 1.55 TeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | ATLAS-CONF-2016-037 |
| $\tilde{g} \tilde{g} \rightarrow \tilde{g} \tilde{g}$ | 2 e, μ (SS) | 0-3 b | Yes | 13.2 | \tilde{g} | 1.3 TeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | ATLAS-CONF-2016-037 |
| $\tilde{t}_1 \tilde{t}_1^* \rightarrow b\bar{b}$ | 0 | 2 jets + 2 b | - | 15.4 | \tilde{t}_1 | 410 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | ATLAS-CONF-2016-032, ATLAS-CONF-2016-084 |
| $\tilde{t}_1 \tilde{t}_1^* \rightarrow b\bar{b}$ | 2 e, μ | 2 b | - | 20.3 | \tilde{t}_1 | 8.4-1.8 TeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | ATLAS-CONF-2015-015 |
| Other | | | | | | | | |
| Scalar charm, $\tilde{t}_1 \rightarrow c\bar{c}$ | 0 | 2 c | Yes | 20.3 | \tilde{t}_1 | 510 GeV | $m_0 = 100 \text{ GeV}, m_{1/2} = 100 \text{ GeV}, A = 0$ | 1501.01325 |

*Only a selection of the available mass limits on new states or phenomena is shown.

➤ Searches now extended to more challenging scenarios

- Electroweak production, compressed mass spectra, ...
- Can expect many more after end of 2016 data taking!

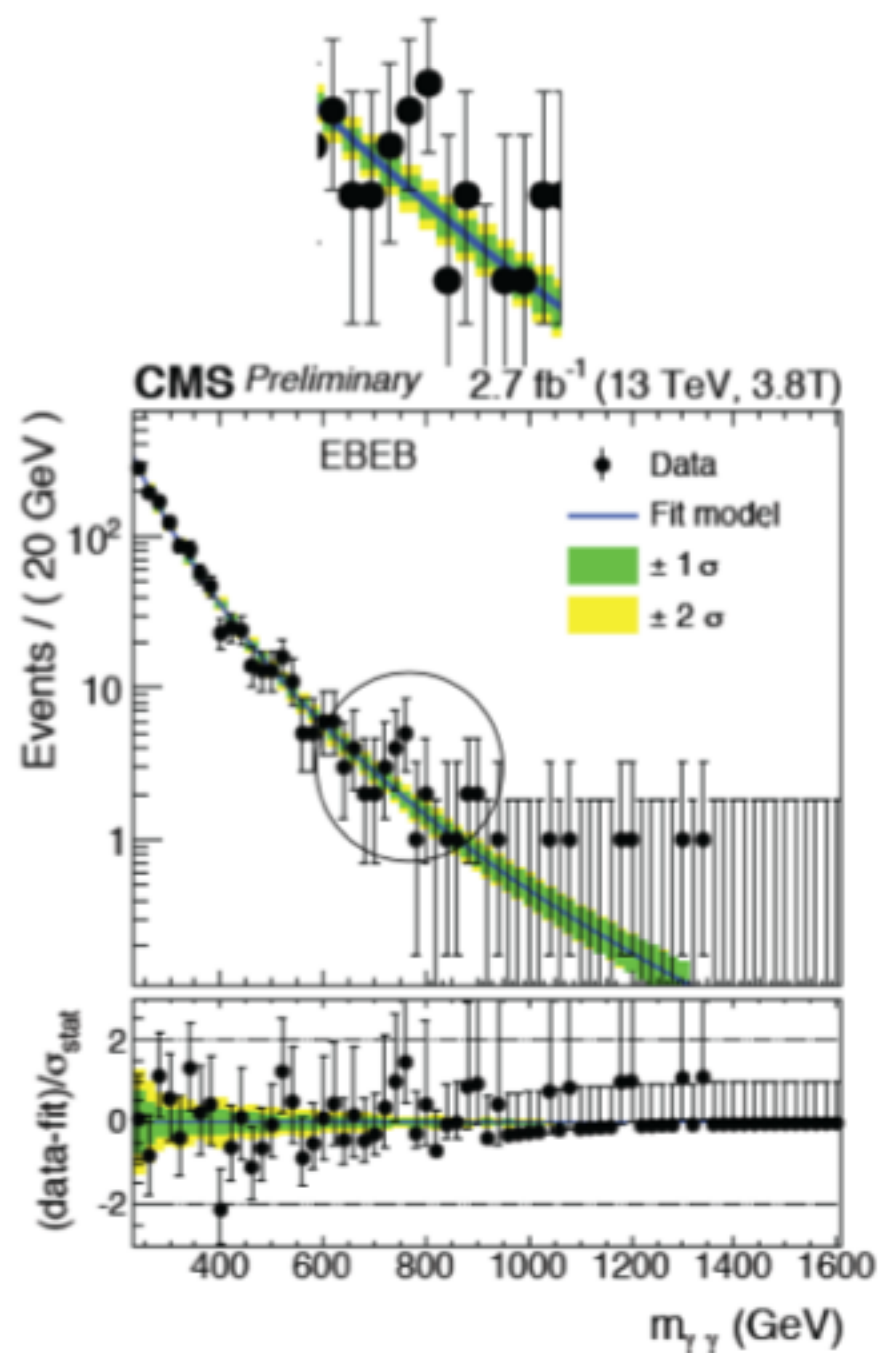
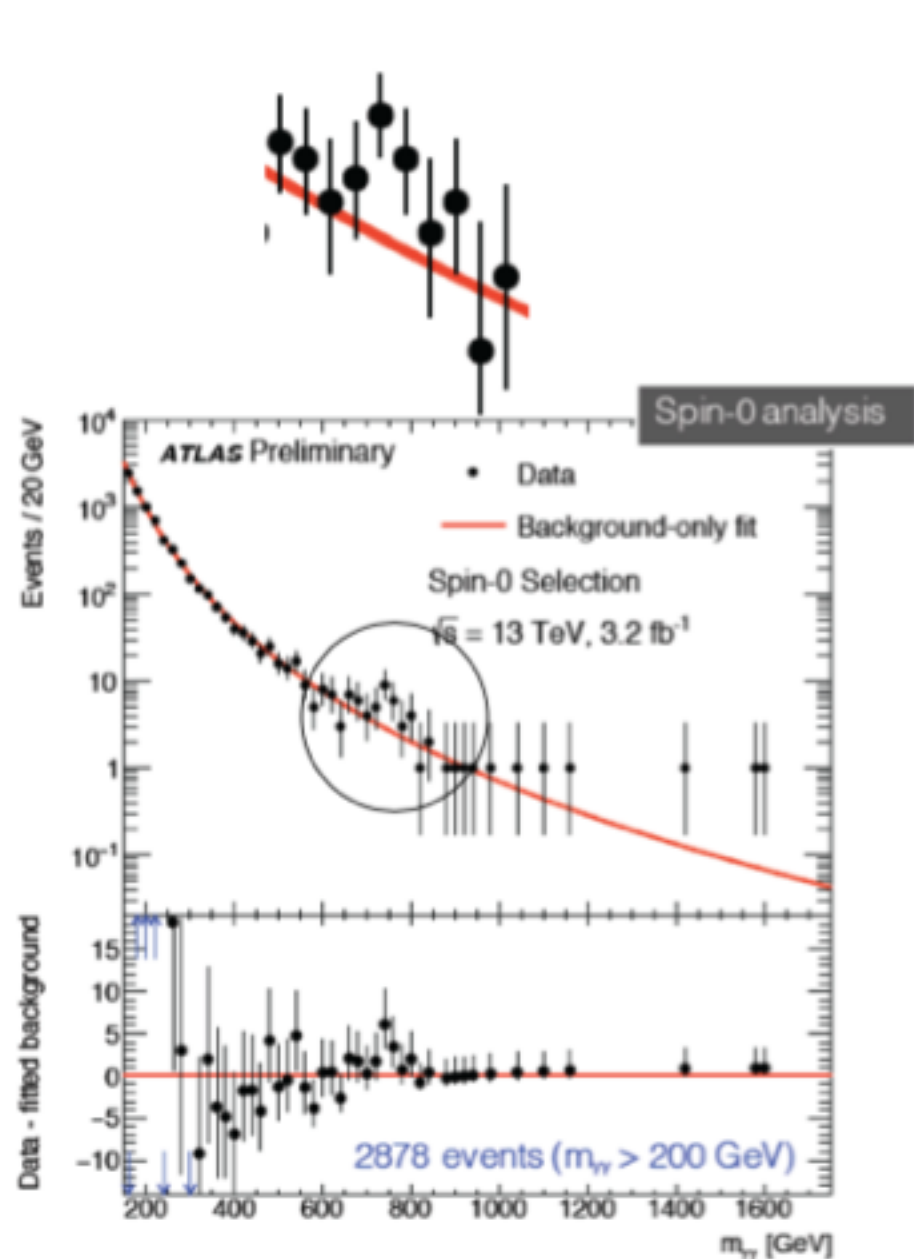
➤ Mass limits (in simplified model spectra!)

- pushed to about 1.9 TeV (gluinos) and 900 GeV (top squarks); limits on EW production even for small mass differences

IC

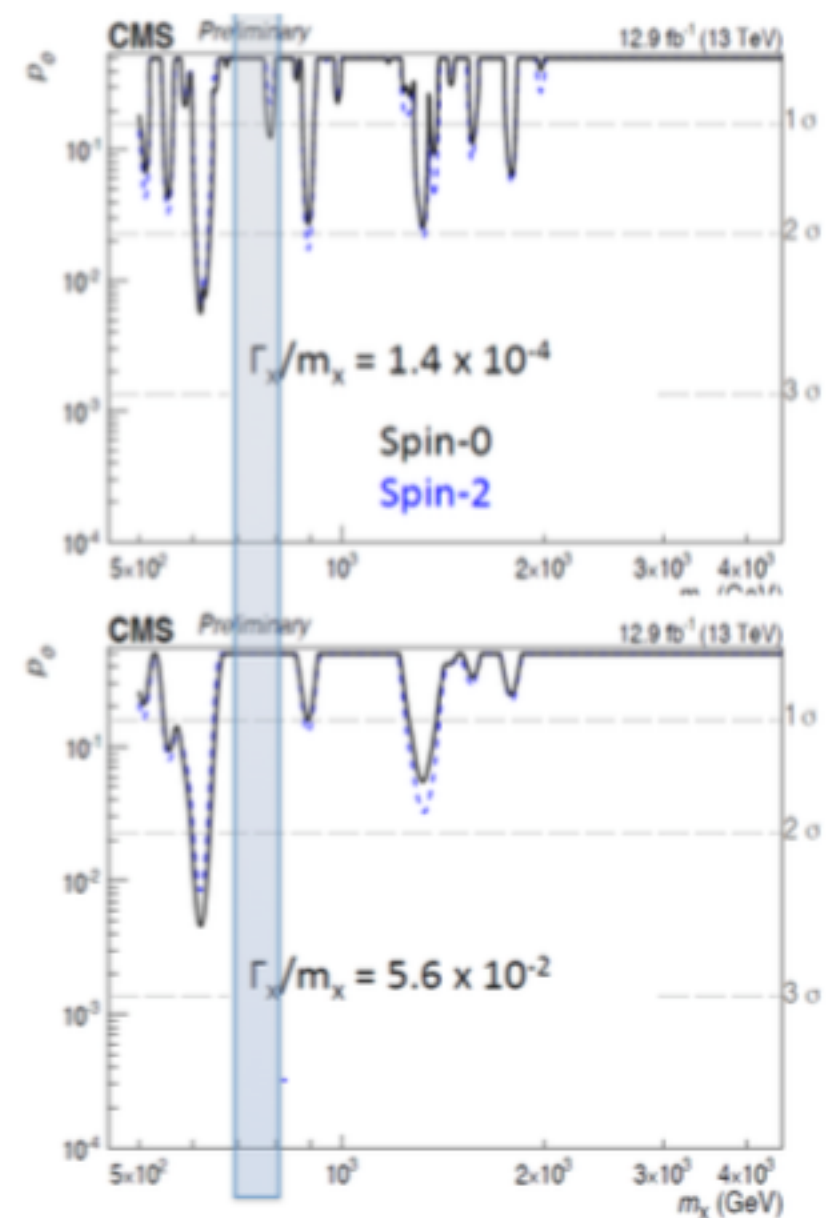
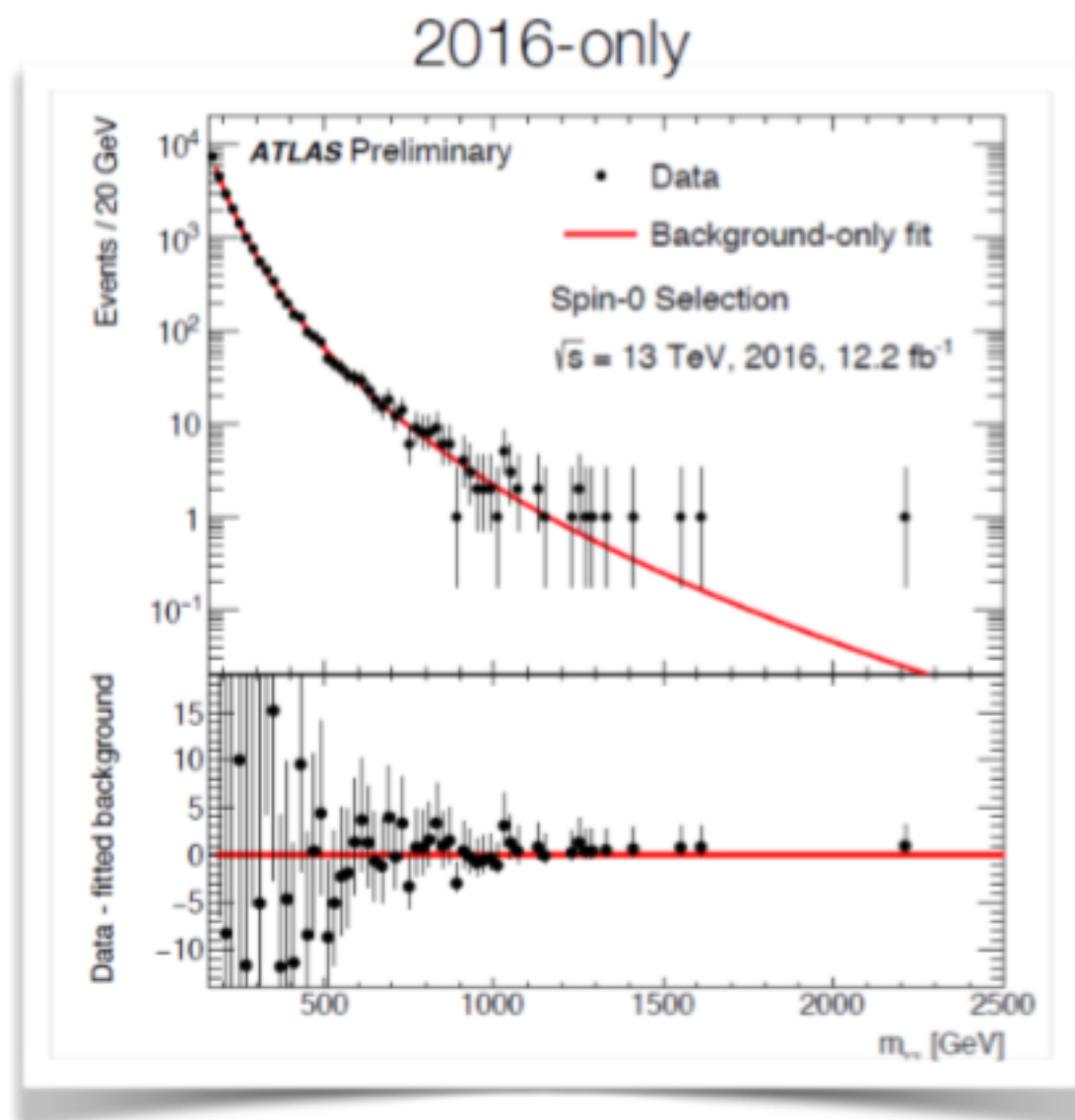
Some hopes...

ATLAS and CMS searches for di-photon resonances



not realized...

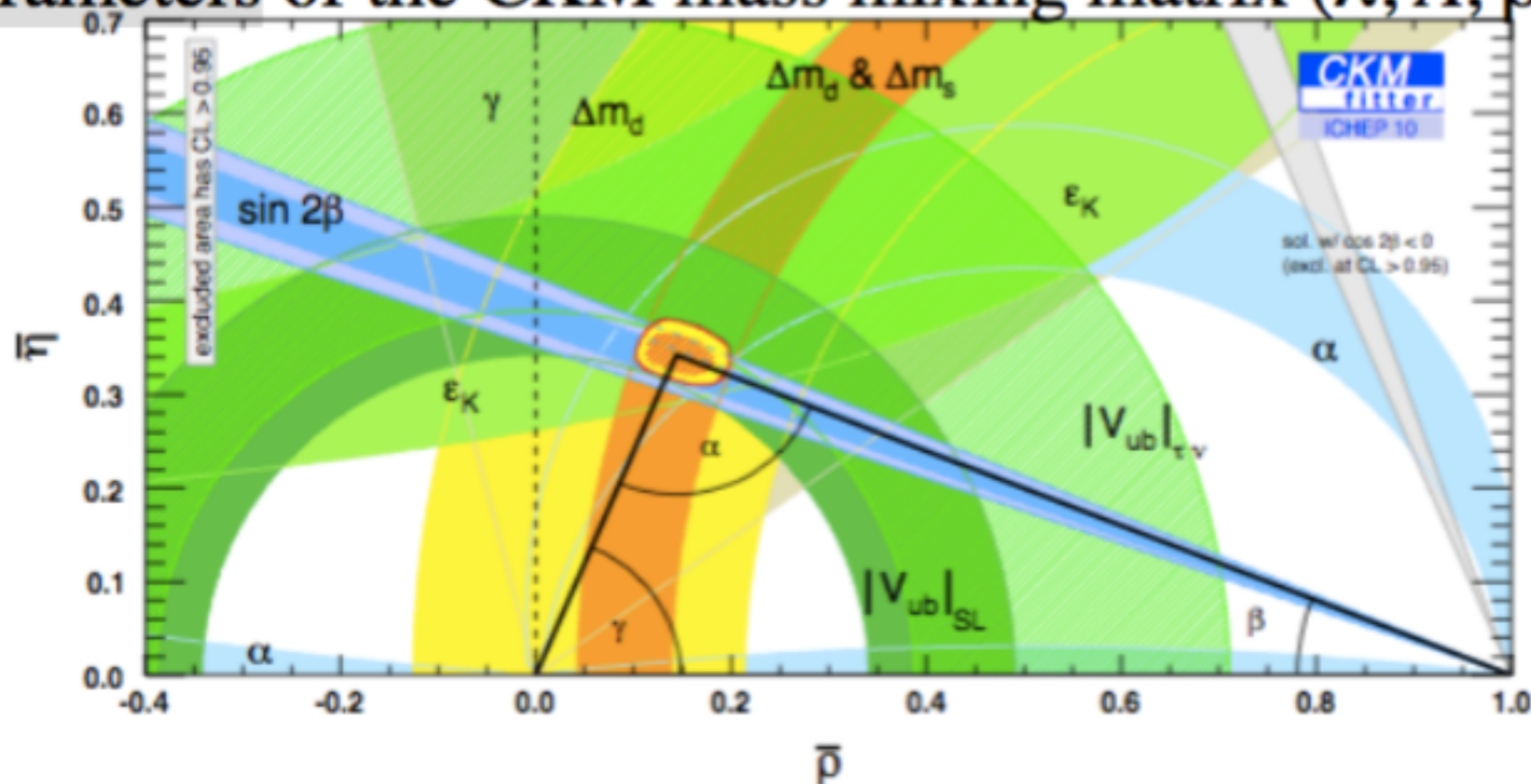
New data @ ICHEP 2016:



Quark flavor physics

Triumph of the CKM description

- All the flavour changing processes are described by the four parameters of the CKM mass mixing matrix (λ, A, ρ, η)

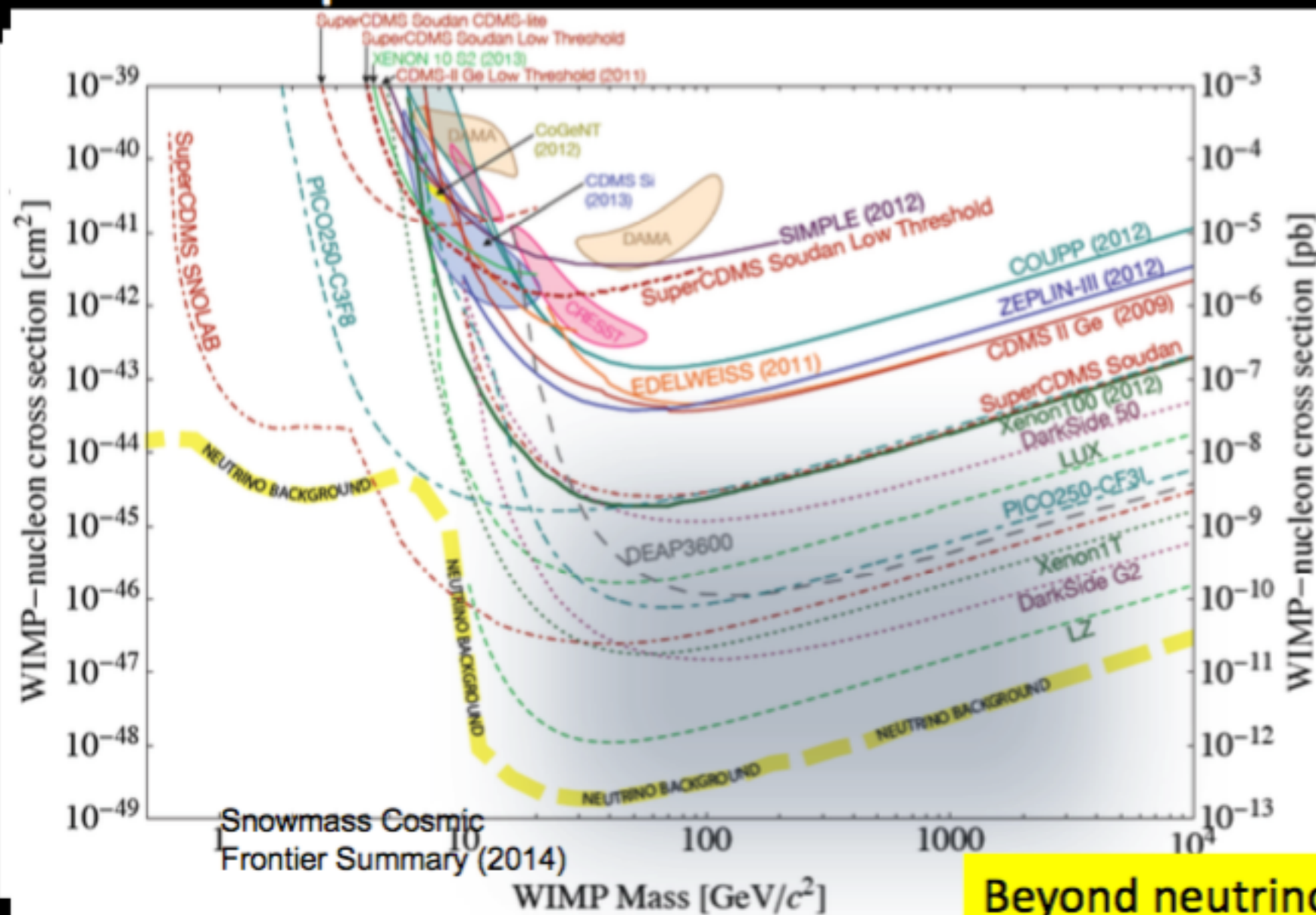


- From this plot, we know already **either new physics energy scale is \gg TeV (far beyond LHC)** or the flavour structure of new physics is very special.

ICHEP 2016 – I. Shipsey

DIRECT DETECTION: STATUS AND PROSPECTS

- Since 2010, sensitivity improved by ~ 100 (for $m \sim 100$ GeV)
- Further improvements by 2-3 orders of magnitude expected by a suite of experiments world-wide



Beyond neutrino floor
directional detection needed

ICHEP 2016 — I. Shipsey

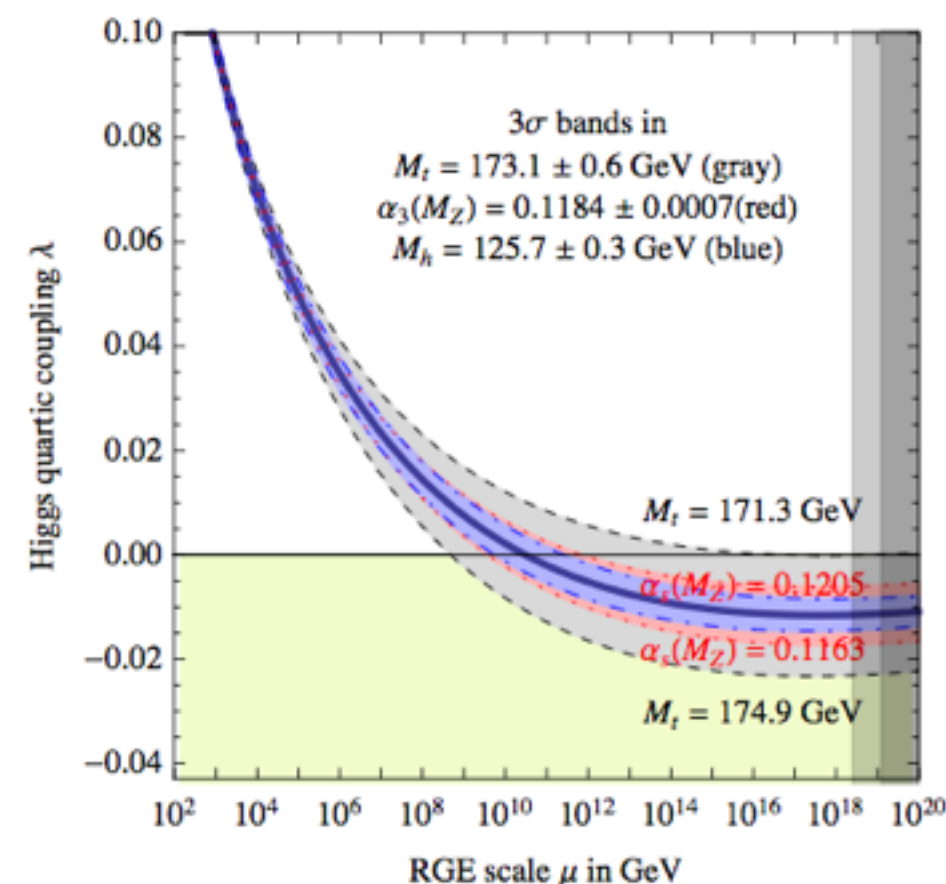
So what?

No NP anywhere! Also, naturalness is now severely challenged.

Of course we should continue all searches at LHC (and beyond), flavour, direct dark matter etc. with vigour!

Still the peculiar Higgs mass suggest that, even in absence of NP, the Universe is metastable.

SM could well be valid up to Planck scale (and we could maybe forget about fine tuning problems)



JHEP 1312 (2013) 089

But...

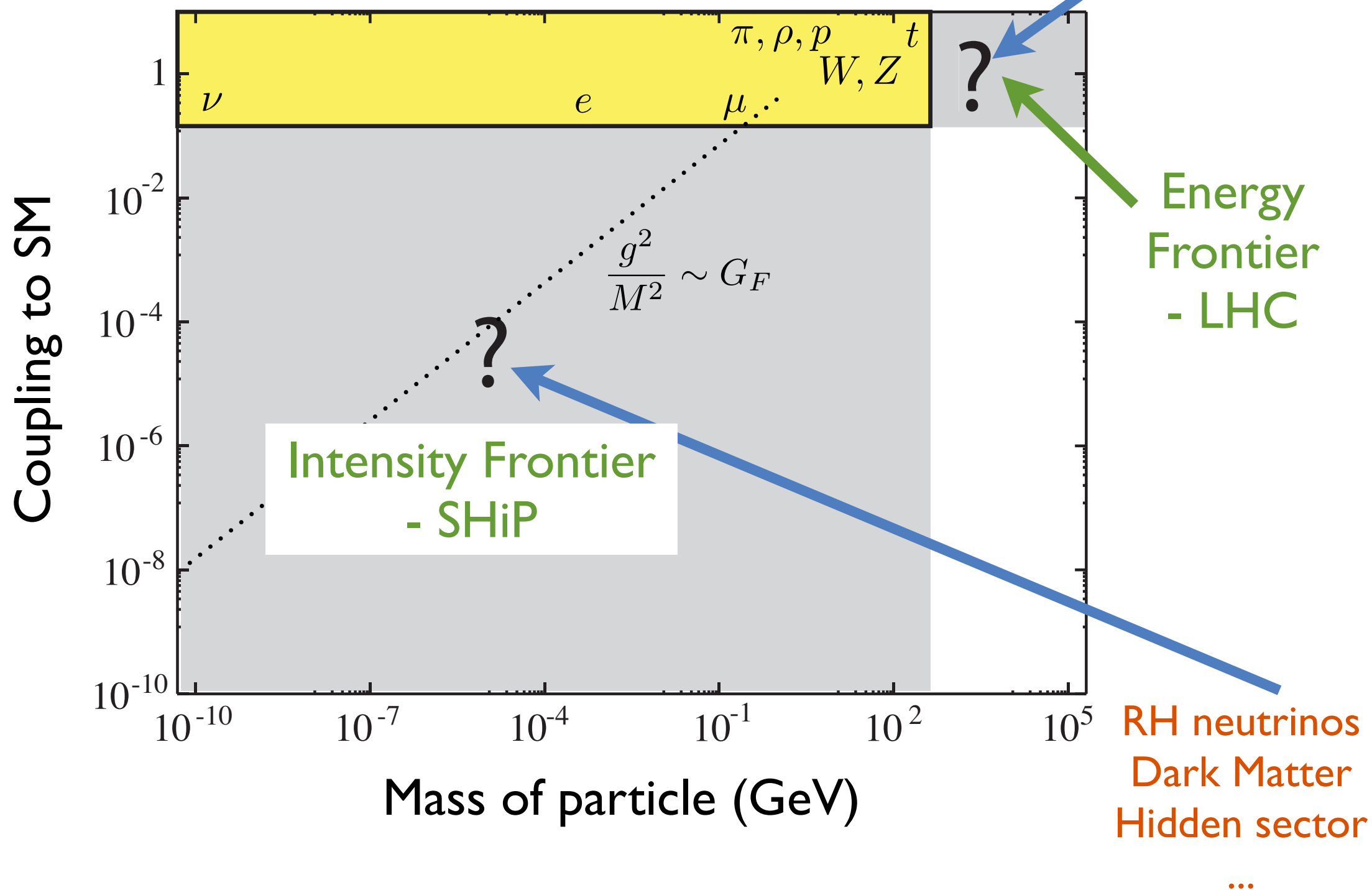
... we have at least to explain some experimental facts:

neutrino oscillations

baryogenesis

dark matter (+inflation, dark energy...)

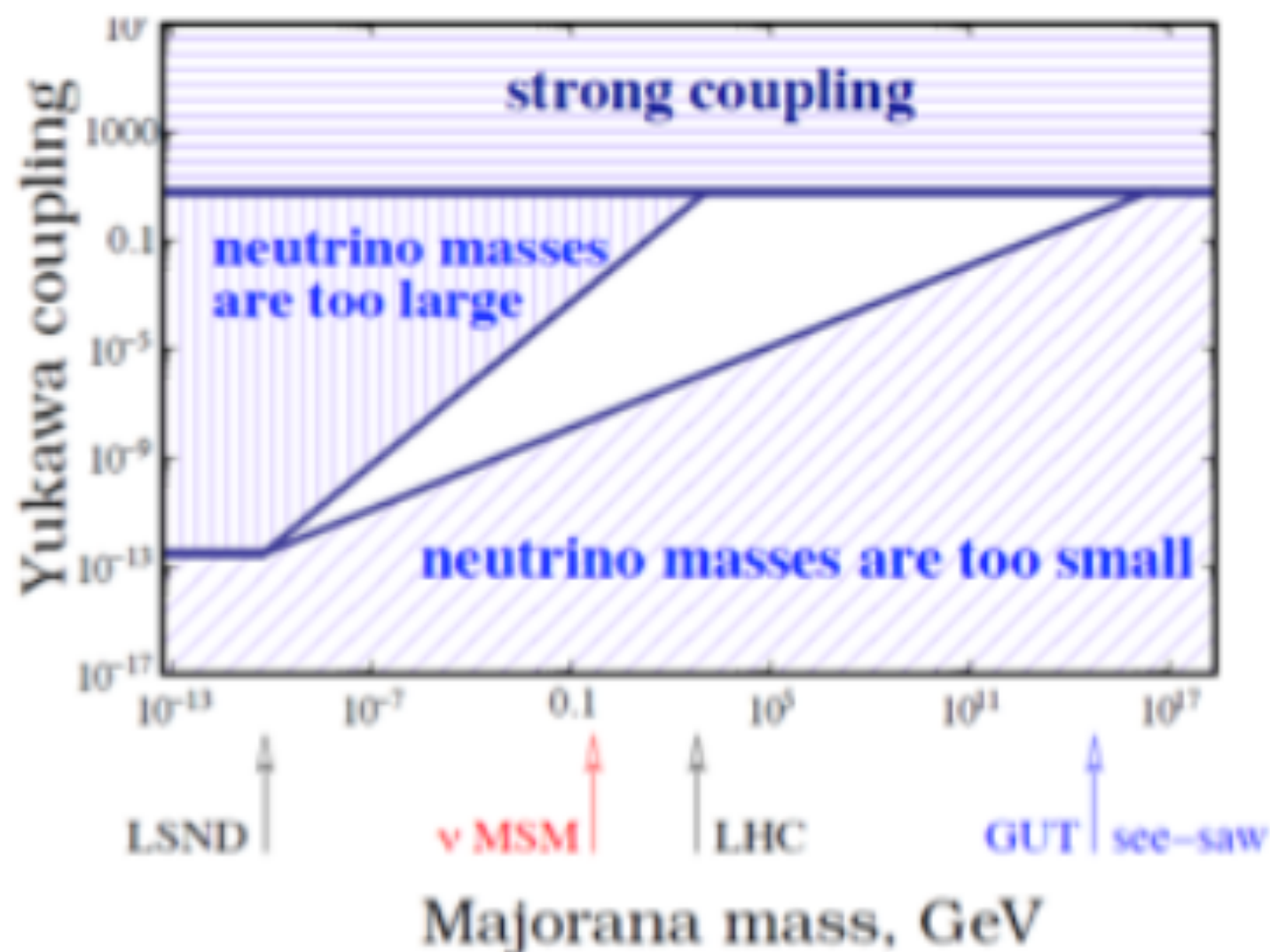
Where is the new physics?



consequences of neutrino oscillations

Where does the ν mass come from?

One remarkable possibility: see-saw mechanism (type I) with one/two/three massive and sterile Majorana-type neutrinos



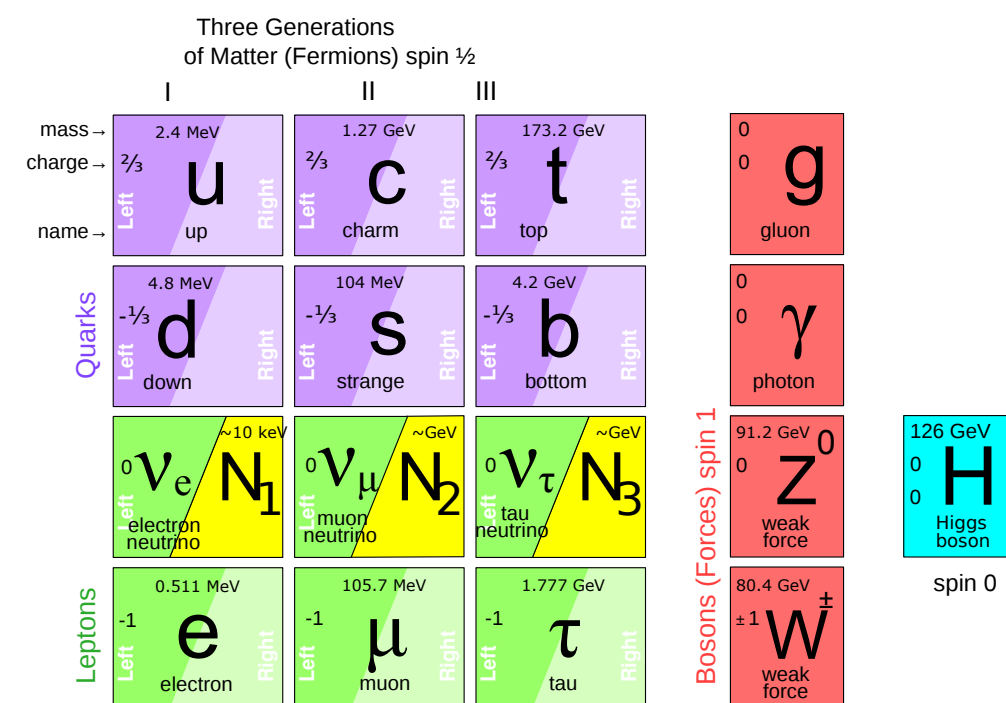
The neutrinos can come in rescue!

An example:

3 Majorana (HNL) partners of ordinary ν , with $M_N < M_W$

In a peculiar parameter space ν MSM explains:

neutrino masses (see-saw),
baryogenesis (via lepto-genesis)
and DM (N_1)!

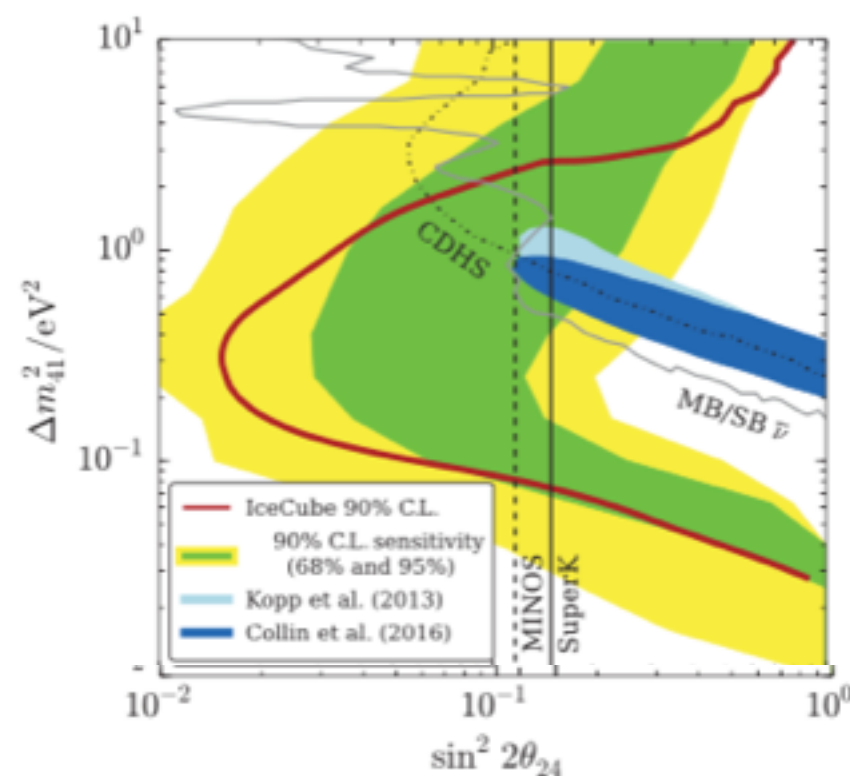


ν MSM: T.Asaka, M.Shaposhnikov PL **B620** (2005) 17
M.Shaposhnikov Nucl. Phys. B763 (2007) 49

Questions and issues addressed by the WG5 this year

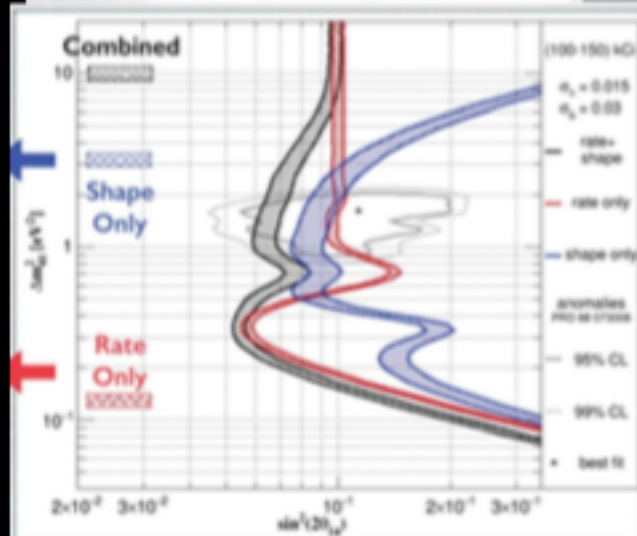
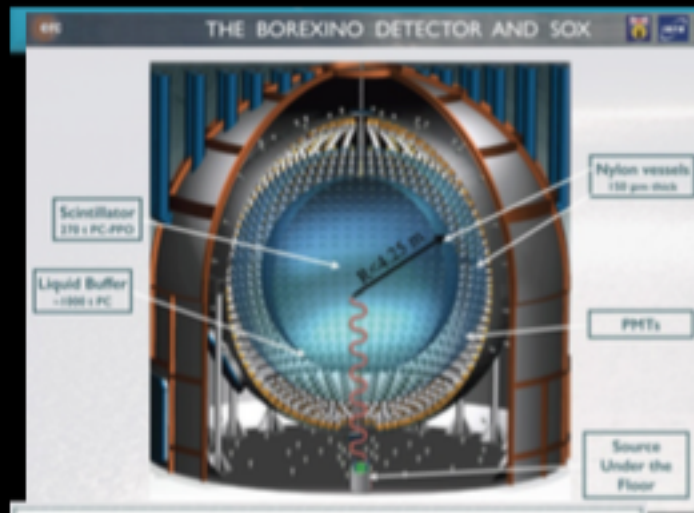
Status of PMNS matrix, unitarity and hints of a 4th neutrino. Can we test the unitarity of the PMNS matrix at neutrino oscillation experiments?

Steriles at eV: the new ICECUBE and MINOS results. how global fits include this? what models are still viable?



many coming experiments and planned!!!! what is their peculiarity? is there a rationale behind all of them?

Next Generation sterile neutrino experiments are almost ready



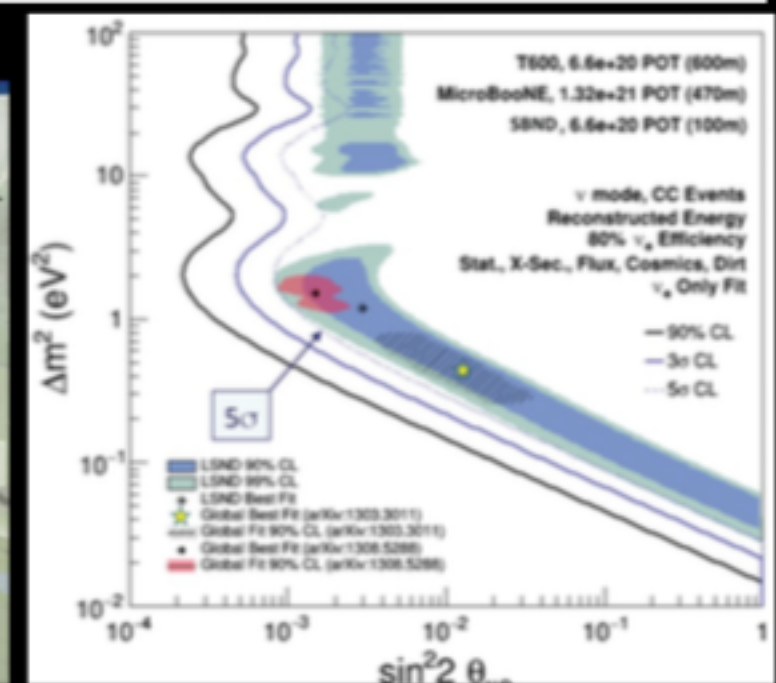
| Experiment | Reactor Power/Fuel | Overburden (mwe) | Detection Material | Segmentation | Optical Readout | Particle ID Capability |
|----------------------|------------------------------|------------------|---------------------------------------|---------------------------------|-------------------------|--------------------------------|
| DANSS (Russia) | 3000 MW LEU fuel | ~50 | Inhomogeneous PS & Gd sheets | 2D, ~5mm | WLS fibers. | Topology only |
| NEOS (South Korea) | 2800 MW LEU fuel | ~20 | Homogeneous Gd-doped LS | none | Direct double ended PMT | recoil PSD only |
| nuLat (USA) | 40 MW ²³⁵ U fuel | few | Homogeneous ⁶ Li doped PS | Quasi-3D, 5cm, 3-axis Opt. Latt | Direct PMT | Topology, recoil & capture PSD |
| Neutrino4 (Russia) | 100 MW ²³⁵ U fuel | ~10 | Homogeneous Gd-doped LS | 2D, ~10cm | Direct single ended PMT | Topology only |
| PROSPECT (USA) | 85 MW ²³⁵ U fuel | few | Homogeneous ⁶ Li-doped LS | 2D, 15cm | Direct double ended PMT | Topology, recoil & capture PSD |
| SoLid (UK Fr Bel US) | 72 MW ²³⁵ U fuel | ~10 | Inhomogeneous ⁶ LiZnS & PS | Quasi-3D, 5cm multiplex | WLS fibers | topology, capture PSD |
| Chandler (USA) | 72 MW ²³⁵ U fuel | ~10 | Inhomogeneous ⁶ LiZnS & PS | Quasi-3D, 5cm, 2-axis Opt. Latt | Direct PMT/ WLS Scint. | topology, capture PSD |
| Stereo (France) | 57 MW ²³⁵ U fuel | ~15 | Homogeneous Gd-doped LS | 1D, 25cm | Direct single ended PMT | recoil PSD |

A Proposal for a Three Detector Short-Baseline Neutrino Oscillation Program in the Fermilab Booster Neutrino Beam
Submitted FNAL PAC January 2015 arXiv:1503.01520

$$\frac{\langle L_\nu \rangle}{\langle E_\nu \rangle} \sim \frac{600 \text{ m}}{700 \text{ MeV}} \sim \mathcal{O}(1 \text{ km/GeV})$$



| Detector | Distance from BNB Target | Active LAr Mass |
|------------|--------------------------|-----------------|
| SBND | 110 m | 112 ton |
| MicroBooNE | 470 m | 87 ton |
| ICARUS | 600 m | 476 ton |



Room 1: WG1+WG5 Sterile Neutrinos

Chairperson: Walter Marcello Bonivento (INFN Cagliari)

- 10:45 11:15 - **Impact of sterile neutrinos on CP and mass hierarchy at long baselines**
Sanjib Kumar Agarwalla (Bhubaneswar University, India)
- 11:15 11:45 - **eV Scale Sterile at LBL & SBL (Exp.)**
Roxanne Guenette (University of Oxford)
- 11:45 12:15 - **eV Scale Sterile at SBL (Exp.)**
Alessandro Minotti (CEA Saclay)

Room 1: WG1+WG5 Sterile neutrinos and Unitarity of the PMNS matrix

Chairperson: Mattias Blennow (Royal Institute of Technology, Stockholm)

- 13:30 14:00 - **Results of the Search for Sterile Neutrinos with IceCube**
Ben Jones (University of Texas at Arlington)
- 14:00 14:30 - **Non-Unitarity of the PMNS matrix**
Mark Ross-Lonergan (IPPP Durham University)
- 14:30 15:00 - **Neutrino Oscillations in Matter with Direct and Indirect Unitarity Violation in the Lepton Mixing Matrix**
Shu Luo (Xiamen University)

Friday August 26th

Room 5: WG5 Neutrinos Beyond PMNS (Non Standard Interactions / Unitarity of the PMNS matrix)

Chairperson: Jordi Salvado (IFIC, Valencia)

- 15:30 16:00 - **Testing the Direct and Indirect Unitarity Violation at a Neutrino Factory**
Jian Tang (Sun Yat-Sen University, Guangzhou)

Friday August 26th

Room 4: WG4+WG5 New physics and lepton flavor violating observables

Chairperson: Michael Schmidt (The University of Sydney)

- 15:30 16:00 - **Global constraints on Seesaw neutrino mixing**
Josu Hernandez (IFT UAM, Madrid)

Thursday August 25th

What is the relation between CPV in sterile neutrino decays, CP of PMNS matrix and leptogenesis?

Room 5: **WG5** Neutrinos Beyond PMNS (Dark Matter / Astrophysical Neutrinos)

Chairperson: Enrique Fernandez-Martinez (UAM, Madrid)

Tuesday August 23rd

14:30 15:00

discussion lead by M.Drewes and J.Salvado

Link between steriles and LFV

Room 4: WG4+WG5 New physics and lepton flavor violating observables

Chairperson: Michael Schmidt (The University of Sydney)

16:00 16:30 - **Electric dipole moments of charged leptons with sterile fermions**
Takashi Toma (LPT, Orsay)

16:30 17:00 - **Conversions of Bound Muons: LFV from Doubly Charged Scalars**
Tanja Geib (Max Planck Institute for Physics, Munich)

Thursday August 25th

Link between steriles and $0\nu 2\beta$ relation with leptogenesis

$0\nu 2\beta$: detection? how? when will we be able to know if Dirac and Majorana? complementarity of different planned experiments

Room 5: **WG5** Neutrinos Beyond PMNS (Neutrinoless Double Beta Decay: Experiments)

Chairperson: Marco Drewes (TU Munich, Garching)

13:30 14:00 - **Searching for Neutrinoless Double Beta Decay with Bolometers (CUORE/CUPID)**
Ke Han (Shanghai Jiao Tong University)

14:00 14:30 - **The Status of NEXT**
Ben Jones (University of Texas at Arlington)

14:30 15:00 - **Search for neutrinoless-double-beta decay with EXO-nEXO**
Guofu Cao (Institute of High Energy Physics CAS, Beijing)

Thursday August 25th

Room 5: **WG5** Neutrinos Beyond PMNS (Neutrinoless Double Beta Decay: Theory)

Chairperson: Pasquale di Bari (University of Southampton)

10:45 11:15 - **Review on theoretical and experimental prospects on Neutrinoless Double Beta Decay**
Stefano Dell'Oro (INFN Gran Sasso Science Institute, L'Aquila)

11:15 11:45 - **On neutrinoless double beta decay in the nuMSM**
Hiroyuki Ishida (Shimane University, Matsue)

Thursday August 25th

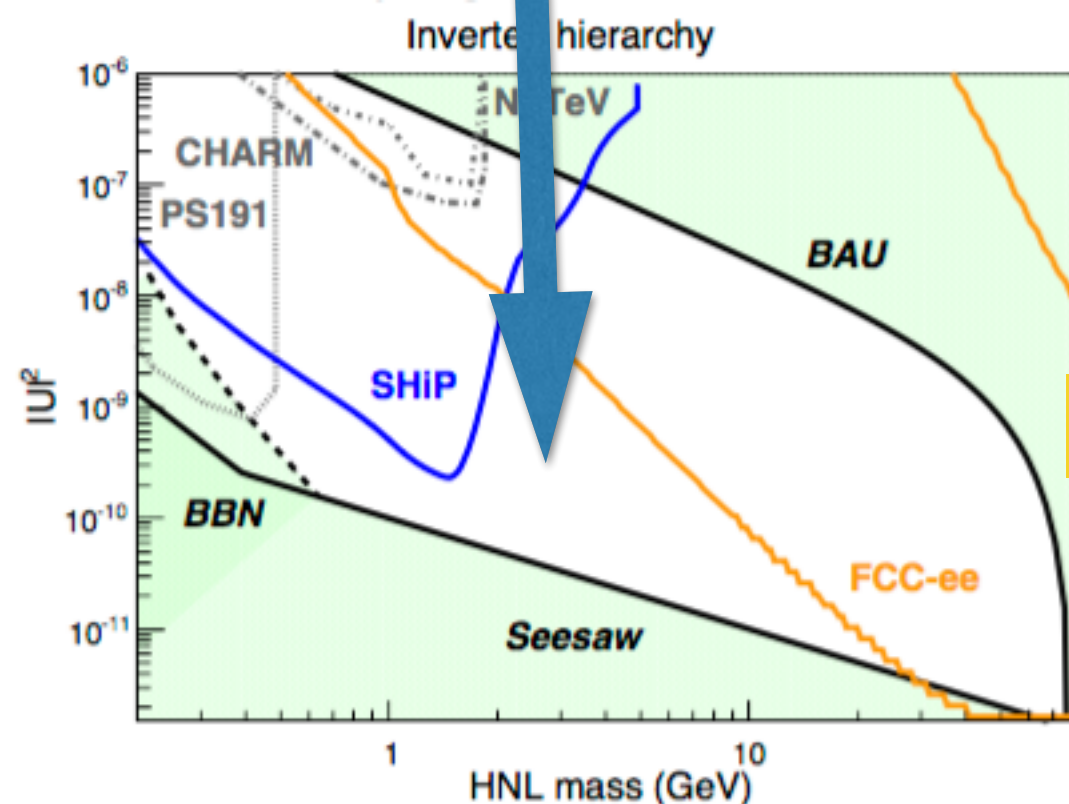
Steriles at MeV and above:

how can we improve existing limits with running or upcoming experiments?
how the new proposed projects (e.g. SHiP and FCC) fit into this picture?

Could we cover one day all the “interesting” parameter space, at least within some minimal models?

what technologies we have to push in order to do that?

What about less constrained models?



arXiv:1411.5230v2

(c) Decay length 0.01-500 cm, $10^{13} Z^0$

Room 3: WG3+WG5 New Physics and Accelerators

Chairperson: **Takahashi Nakadaira**

10:40 11:10 - **Accelerator developments for SHiP and FCC**
Linda Stoel (CERN, Geneva)

Wednesday August 24th

11:10 11:40 - **Search for massive neutrinos at LHCb and discovery potential of the FCC**
Marcin Chrzaszcz (University of Zurich)

11:40 12:10 - **Physics and Experimental Development towards IsoDAR@KamLAND**
Jose Alonso (MIT, Cambridge)

NSI in neutrino experiments:

are there any viable models that can give large NSI without entering in conflict with bounds from charged leptons?

what is the best way to probe new interactions in production, detection and propagation of neutrinos?

are neutrino oscillation experiments enough. or are there better experiments to do this?

Room 5: WG5 Neutrinos Beyond PMNS (Non Standard Interactions / Unitarity of the PMNS matrix)

Chairperson: Jordi Salvado (IFIC, Valencia)

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Friday August 26th

- 16:00 16:30 - **Will atmospheric neutrino experiment at Hyper-Kamiokande see non-standard interaction effects?**
Osamu Yasuda (Tokyo Metropolitan University, Hachioji)
- 16:30 17:00 - **Viable models for large Non-Standard neutrino interaction**
Yasaman Farzan (Institute for research in fundamental sciences, Tehran)

Room 1: WG1+WG5 Non Standard Interactions and Steriles

Chairperson: Roxanne Guenette (University of Oxford)

- 15:30 16:00 - **Non-Standard neutrino interactions at running reactor and beam-based neutrino oscillation facilities**
David Vanegas Forero (Virginia Tech, Blacksburg)
- 16:00 16:30 - **New Physics Searches at ESSnuSB**
Mattias Blennow (Royal Institute of Technology, Stockholm)
- 16:30 17:00 - **New Physics Searches at DUNE**
Kevin Kelly (Northwestern University, Evanston)

Monday August 22nd

Flavour models:

can we test flavour models by measuring the value of the CP phase? can we definitely rule out certain types of flavour models? which ones?

are there other ways to do this? what signatures should we be looking for?

Room 5: **WG5** Neutrinos Beyond PMNS (Flavor Models / Dark Matter)

Chairperson: Sanjib Agarwalla (Institute of Physics, Bhubaneswar)

10:40 11:10 - **Lepton mixing from the interplay of the alternating group A_5 and CP**
Andrea Di Iura (Università Degli Studi Roma Tre)

11:10 11:40 - **Mass limit for light flavon in neutrino flavor model**
Yusuke Shimizu (Hiroshima University)

Tuesday August 23rd

Room 5: **WG5** Neutrinos Beyond PMNS (Neutrinoless Double Beta Decay: Theory)

Chairperson: Pasquale di Bari (University of Southampton)

11:45 12:15 - **Leptonic CP Violation Predictions from Discrete Flavour Symmetry Approach**
Arsenii Titov (SISSA, Trieste)

Thursday August 25th

Dark matter/astro neutrinos:

are sterile neutrinos a viable dark matter candidate? under which conditions?
how could they be produced in the early universe? are we sensitive to a possible dark matter decay through astrophysical neutrino signals?

what other models of New Physics can give interesting signatures at Icecube?
what type of signatures should we be looking for? are there any models of New Physics that can give a sizable deviation for the flavor ratios with respect to the SM prediction?

Room 5: **WG5** Neutrinos Beyond PMNS (Flavor Models / Dark Matter)

Chairperson: Sanjib Agarwalla (Institute of Physics, Bhubaneswar)

11:40 12:10 - **Sterile Neutrino Dark Matter Production from Scalar Decay**
Michael Schmidt (University of Sydney)

Room 5: **WG5** Neutrinos Beyond PMNS (Dark Matter / Astrophysical Neutrinos)

Chairperson: Enrique Fernandez-Martinez (UAM, Madrid)

13:30 14:00 - **IceCube Events from Heavy DM decays through the Right-handed Neutrino Portal**
Yong Tang (Korea Institute for Advanced Study, Seoul)

14:00 14:30 - **New Physics in Astrophysical Neutrino Flavor**
Jordi Salvado (Instituto de Fisica Corpuscular, Valencia)

Tuesday August 23rd

All summarised by the plenaries!

Plenary Session #7: WG5 related Session

Chairperson: Sanjib Agarwalla (Institute of Physics, Bhubaneswar)

- | | |
|-------------|---|
| 08:30 08:55 | - The seesaw mechanism in neutrino oscillations Enrique Fernandez-Martinez (UAM, Madrid) |
| 08:55 09:20 | - keV sterile neutrinos: theoretical and experimental prospects Marco Drewes (TU Munich) |
| 09:20 09:45 | - Heavy neutrino searches from MeV to TeV Elena Graverini (Zurich University) |
| 09:45 10:10 | - Searches for dark sector particles at neutrino experiments Dave Mc Keen (University of Washington, Seattle) |

**Dark sector particles and dark Matter detection in neutrino experiments
(accelerators and astrophysical probes)**

do we need dedicated experiments or we can derive constraints from neutrino experiments only?