A 10 minutes mini-review on the flavor problem (mixing, CP-violation)

Based on “minus 10 minutes attack”

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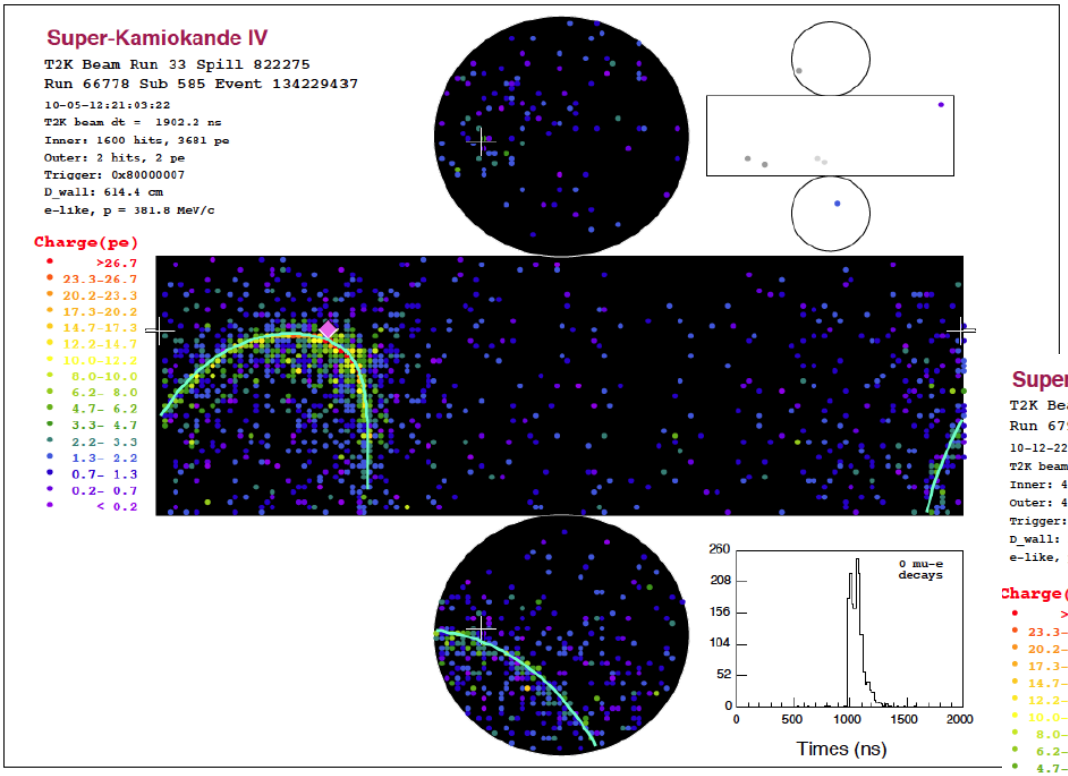
Fully biased 10 minutes counterattack

The questions which we would like to discuss include… (André and Silvia)

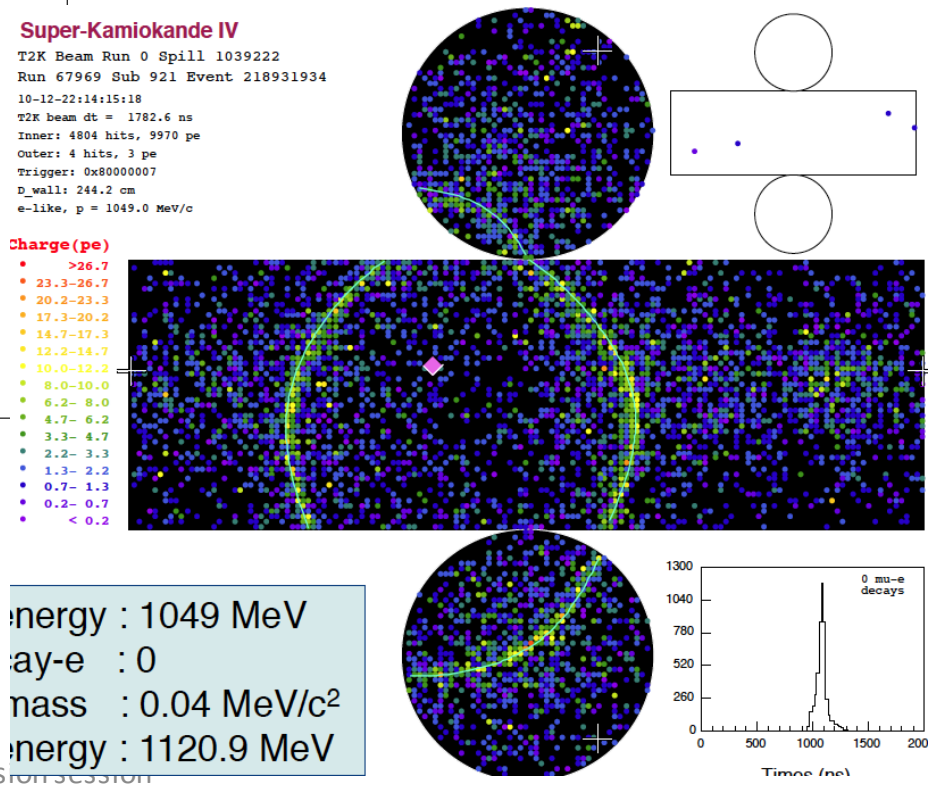
- If θ_{13} is large, what can we learn about mixing?
- Is TBM still a good guiding principle, if the large θ_{13} hints hold?
- What can we learn about beyond 3-neutrino mixing (e.g. sterile neutrinos,…) in long baseline neutrino experiments?
- What do we need in order to achieve this aim (e.g. precision, near detectors…)?

Apparently θ_{13} is large



6 events at T2K !

Released in June 15@KEK



energy : 1049 MeV
ay-e : 0
mass : 0.04 MeV/c²
energy : 1120.9 MeV

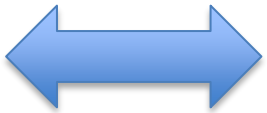
My prejudice: θ_{13} is large because …

- It is natural to expect θ_{13} large because $U_{MNS} = U^{+}V$ and other 2 angles are large
- Apparently, it is the case ⇒ T2K-6 events (I assume reactor confirms the large θ_{13})
- This argument breaks down if there is a reason for small θ_{13} ⇒ symmetry !
- But if ~ 10 degree it falls into "anarchy regime"
- My favorite interpretation of θ_{13} ~ 10 degree: no symmetry which drive $\theta_{13} << 1$

Fate of discrete symmetries

- You may ask: Are discrete symmetries for small θ_{13} still viable?
- Of course, one can "perturb" with large symmetry breaking term, but …
- We know in particle physics a symmetry which is badly broken  π vs. K meson masses, but for good reasons
- discrete symmetry can be the case if you find such reasoning

Beyond 3-neutrino mixing ?

- Unitarity NOT verified in lepton sector  quark sector 
- Unitarity violation/NSI very interesting window to new physics
- Hunting unitarity violation formulated, but in a (mildly) model-dependent way
- "Unitarity triangle" tried, but a long way
- Strategy to verify unitarity in LBL not so well known (I guess ..)  need more efforts

- Related different approach: NSI (unitarity imposed, looking for new neutrino interactions)

Steriles ?

- LSND-MiniBooNE-reactor anomaly would suggest sterile ν's
- If θ_s is large, $0.01 < \sin^2 2\theta_s < 0.1$, they can be hunt by various methods
- By 10 g ^{144}Cs source in SNO+ (if KamLAND is busy)
- By Bugey like setting at a reactor
- If Δm^2 large, by Joyo nuclear reactor @ Tokai (small core size)

If θ_s is small, $\sin^2 2\theta_s \sim 0.001$,

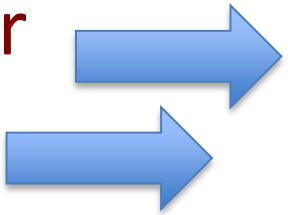
- I don't know how …
- By further run of MiniBooNE/MicroB ?
- Two ICARUS T600 detectors @ CERN-PS

- If confirmed (unitarity violation/sterile) revolution in particle physics 

Good time for experimenta lists

With large θ_{13} things are easier for EVERYBODY

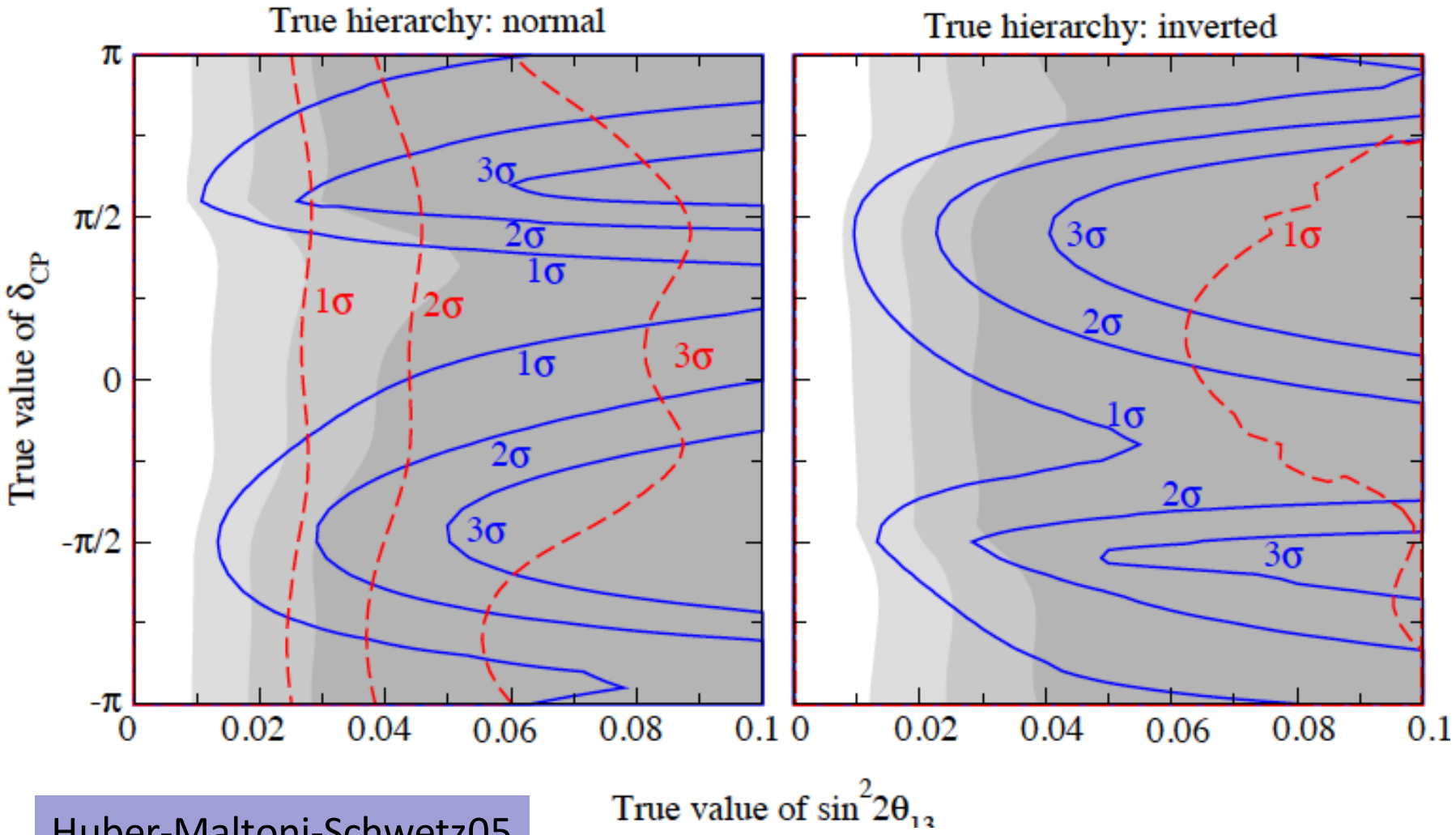
How large is δ ?

- If no symmetry is behind U_{MNS} δ need not be constrained to be small
- In fact, no symmetry is known (I guess) to drive δ to 0 or π, apart from CP symmetry itself
- It is broken in quark sector to exist in lepton sector  no reason δ must be order unity

What do we need in order to achieve our goal ?

- I assume reactor confirms large θ_{13}
- Then δ
- Everything in a single "lunch box" ?
- Natural choice would be ~megaton water Cherenkov, or ~100 kt liquid Ar, under the environment of severe ν pollution → *super neutrino beams*
- Mass hierarchy ? → atmospheric ν
- Bonus: proton decay

Large θ_{13} makes things easier; mass hierarchy resolution by T2K II + atmospheric ν

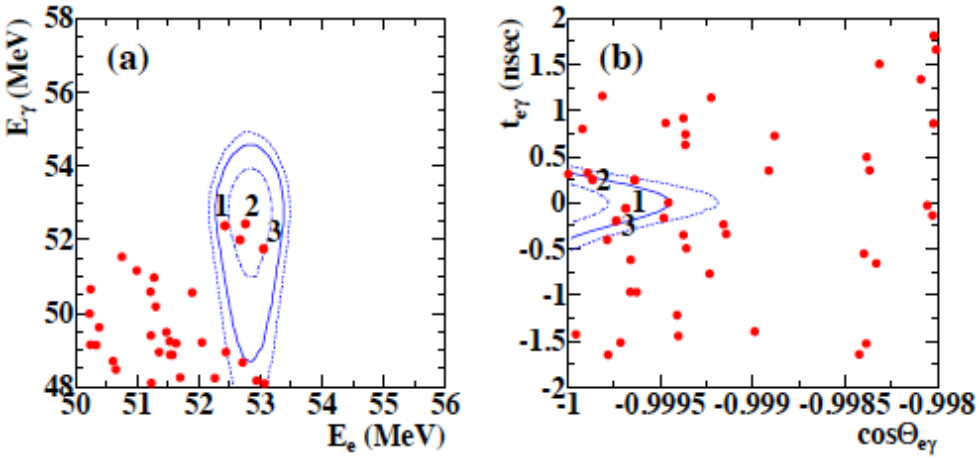


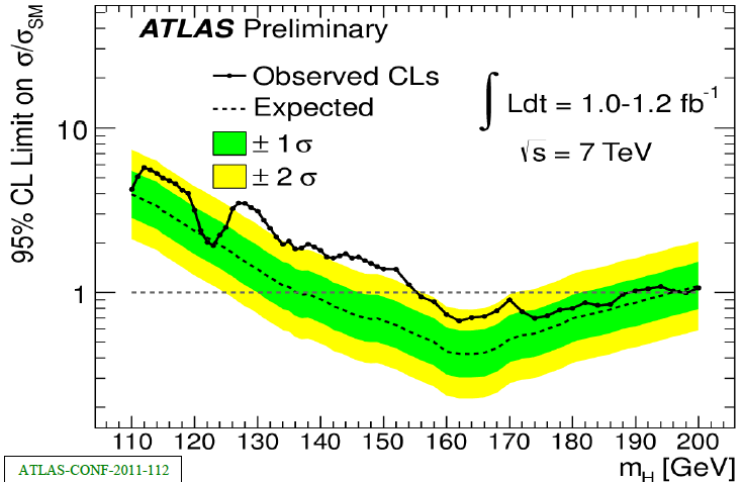
Huber-Maltoni-Schwetz05

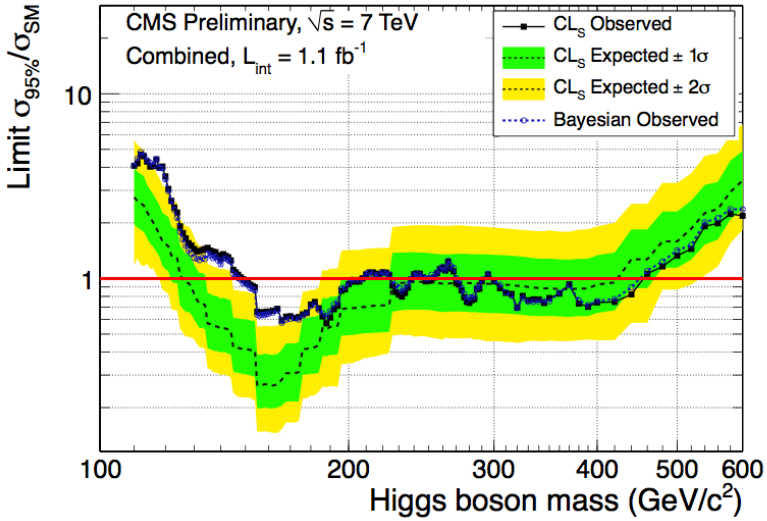
News from other (related) fields

New data from MEG:
Br(μ->eγ) < 2.4 x 10^{-12}

"Higgs" bump ?







Finally,

- I failed to address absolute ν mass: KATRIN, double beta, cosmology ..

- I want to learn about: what is the role of neutrino factory if θ_{13} = 10 degree ?