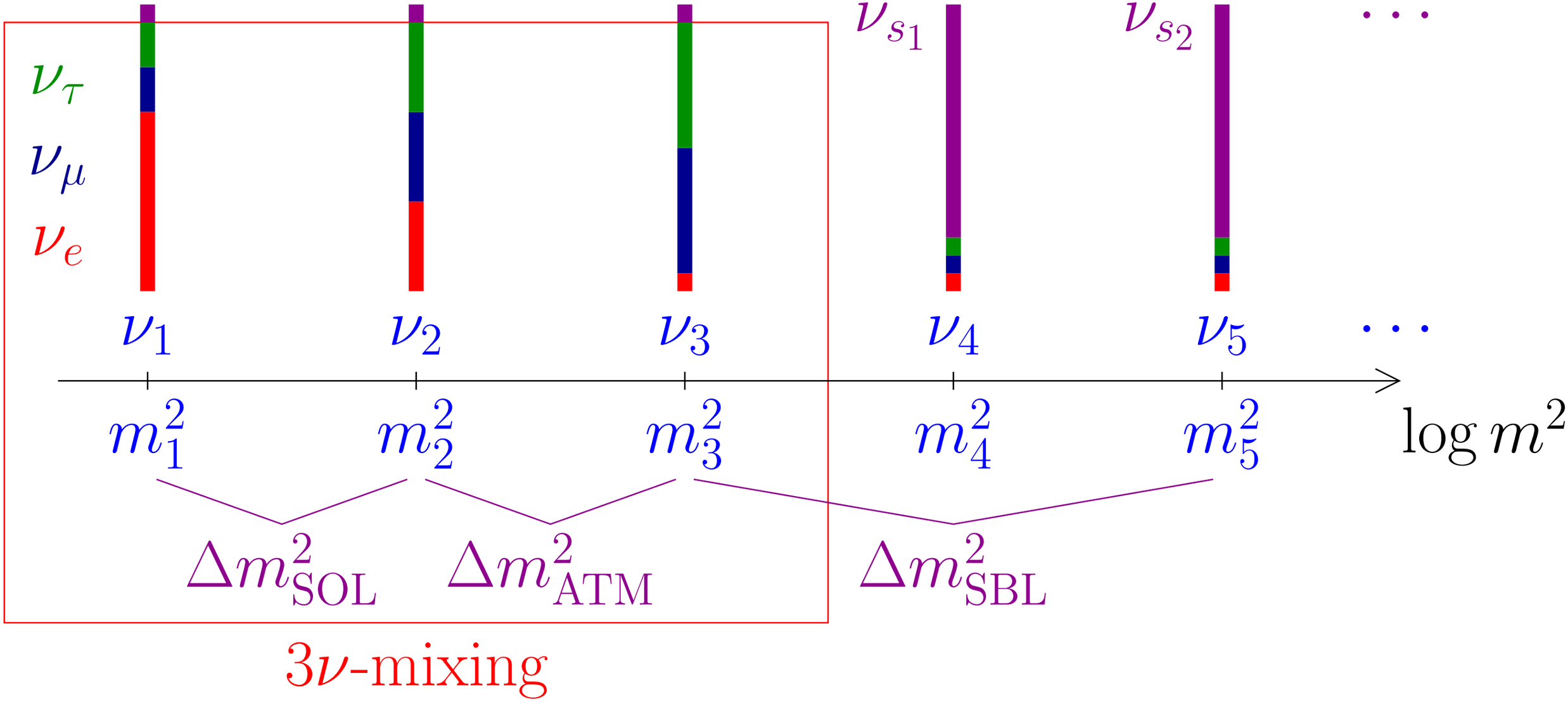
Search for eV-scale Neutrinos at a muon storage ring (VLENF)

Christopher Tunnell
JAI, Oxford

eV-scale neutrinos?

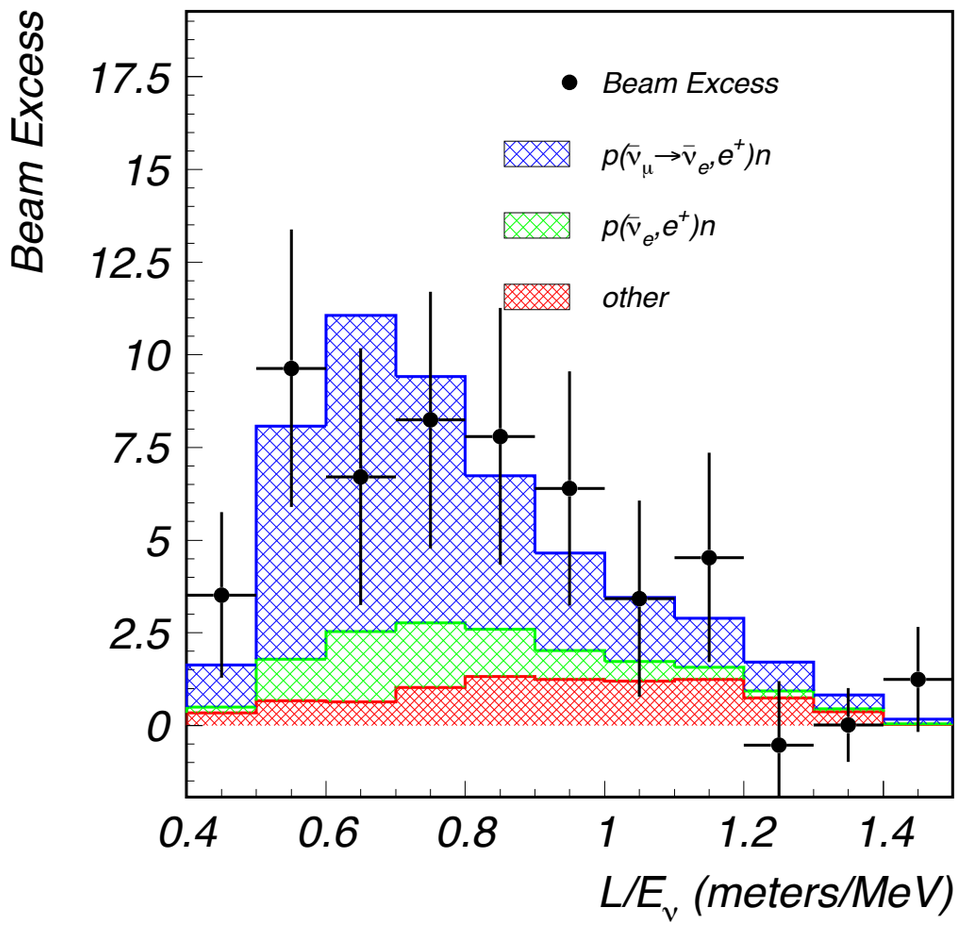
ie. "sterile"

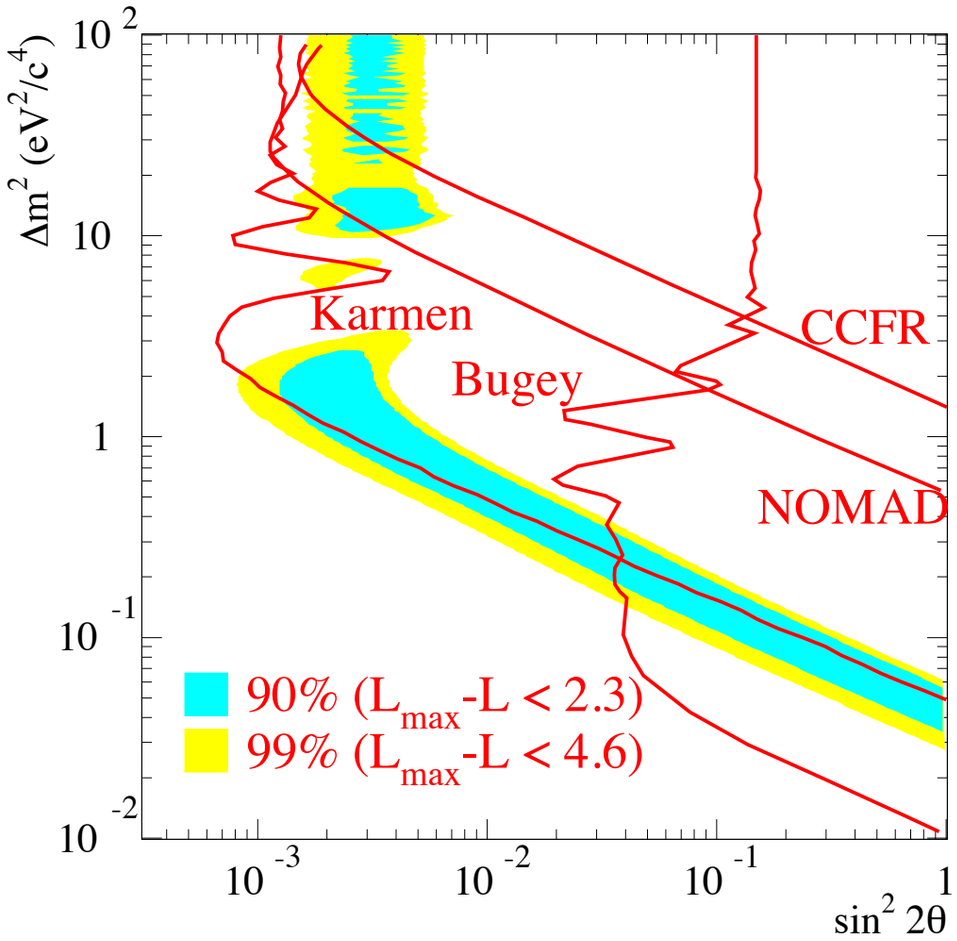


Giunti's figure

LSND "Evidence"

Anti-neutrino mode





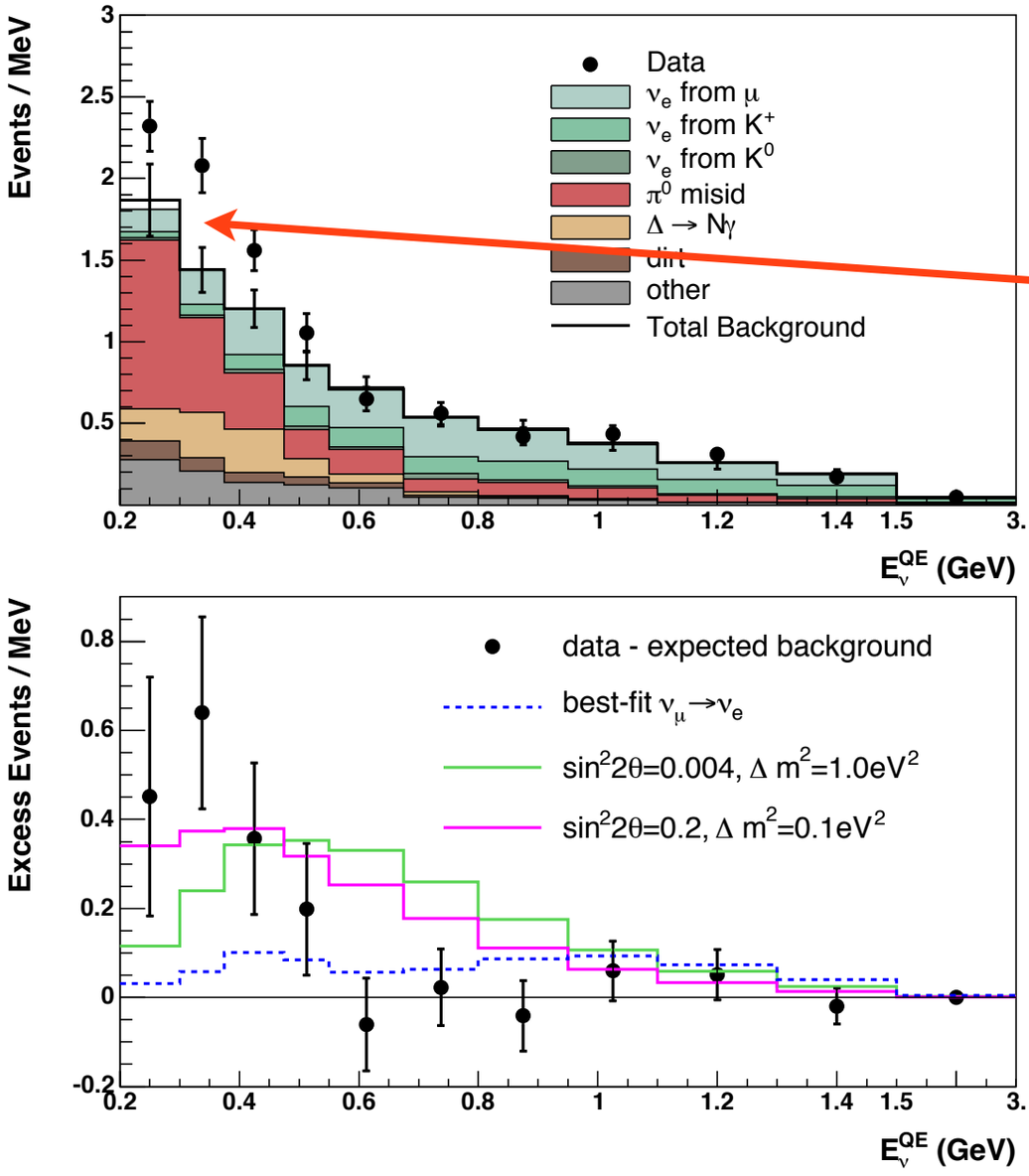
$$\mathrm{Prob}[\mu \to e] = \sin^2 2\theta \sin^2 \left(\Delta m^2 L/4E\right)$$

L ~ 30 m, 20 MeV < E < 200 MeV

90s

arXiv:nucl-ex/9709006

Then MiniBooNe refutes LSND... sort of.



Different excess?!

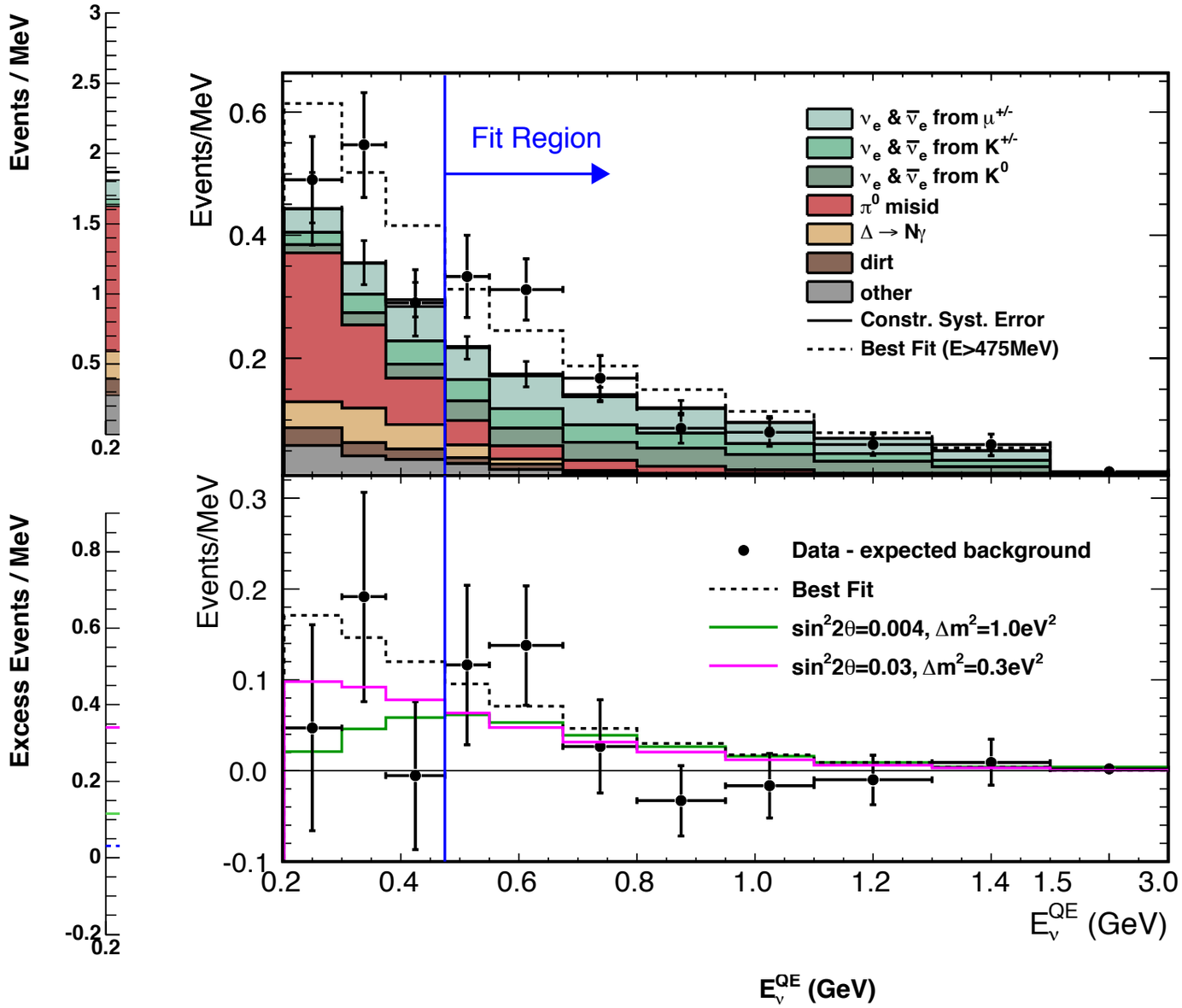
??????!!!!

Neutrino mode

00s

L ~ 541 m, 475 MeV < E < 3 GeV

MiniBooNe ~~refutes~~ LSND... sort of.



?????!!!!

Anti-Neutrino mode

Agrees with LSND?

00s

L ~ 541 m, 475 MeV < E < 3 GeV

Anomalies galore

- Reactor neutrino anomaly
- Gallium anomaly
- ...

Facts of the case

1. Nobody *knows* if LSND is correct.
2. Nobody *knows* what MiniBooNe is seeing
3. Having 4 (or more) neutrinos changes things
4. Regardless of what you think about previous experiments, an experiment could resolve this

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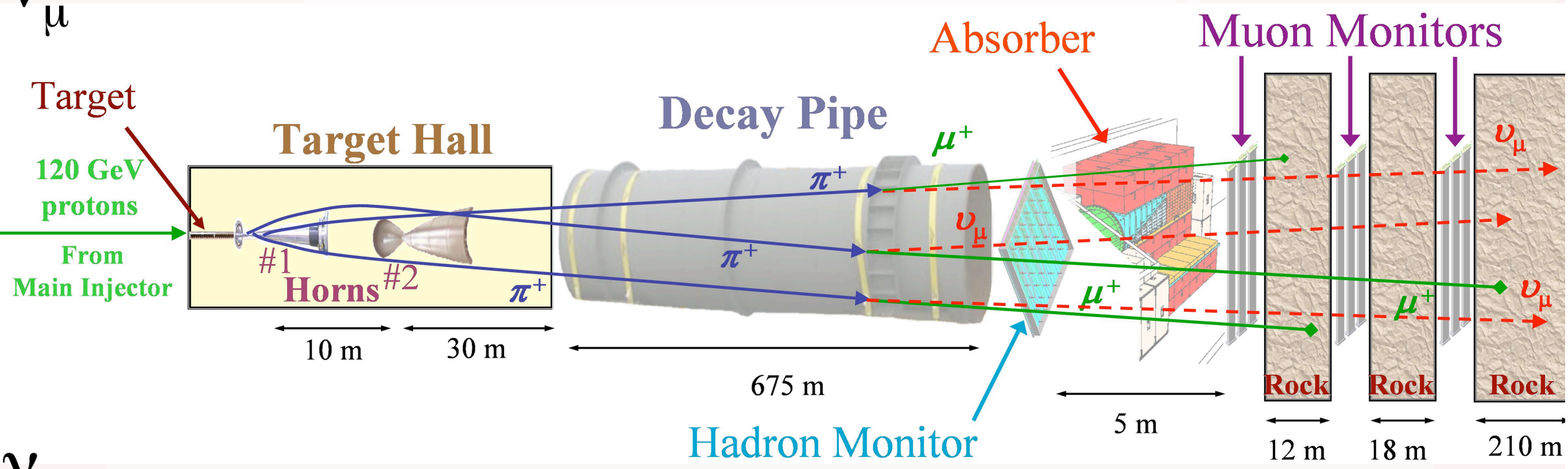
Q: What third experiment could you build to ensure you don't have to build a fourth?

Making a neutrino beam

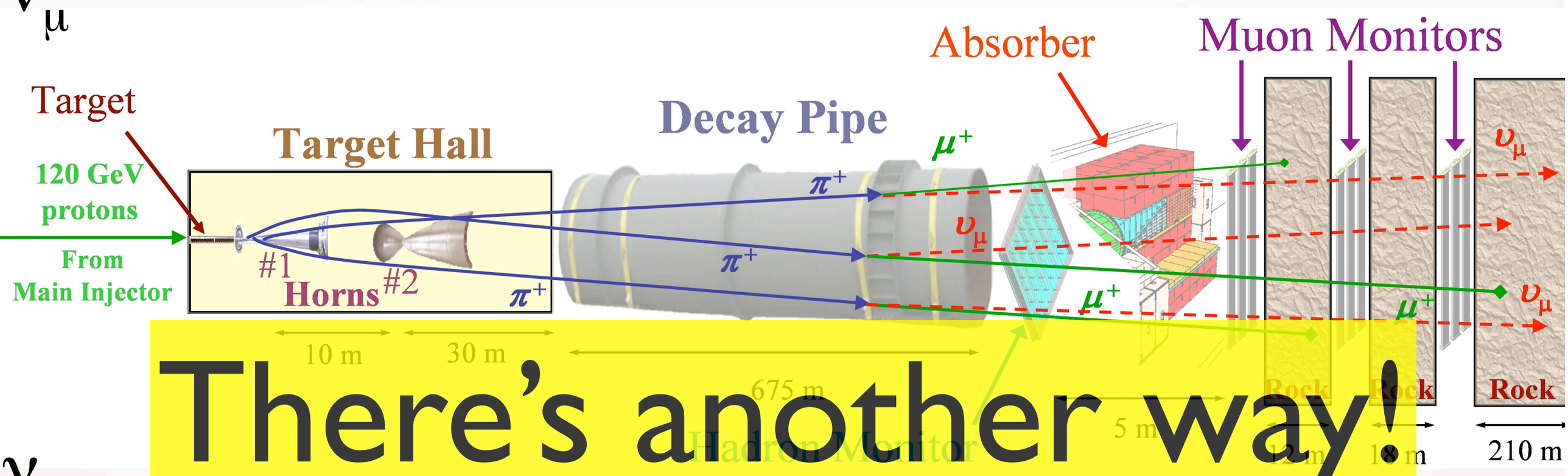
ν_μ



ν_e

Making a neutrino beam

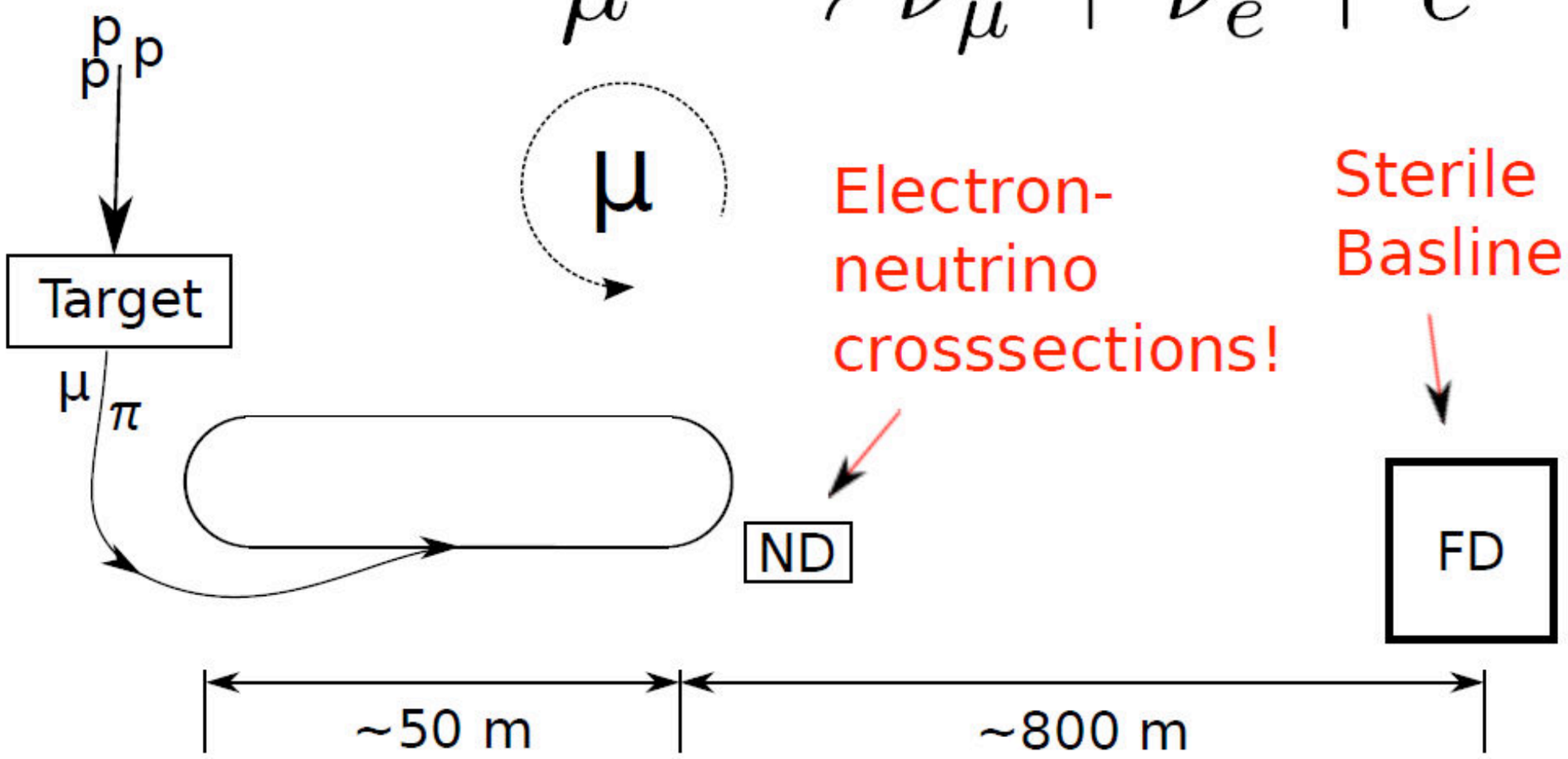
ν_μ



There's another way!

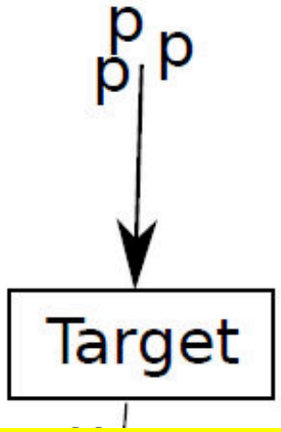
ν_e

$$\mu^+ \rightarrow \bar{\nu}_\mu + \nu_e + e^+$$



Appearance-only (though disappearance good too!)

$$Pr[e \rightarrow \mu] = 4|U_{e4}|^2|U_{\mu 4}|^2 \sin^2(\frac{\Delta m^2_{41} L}{4E})$$



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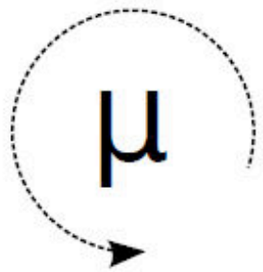
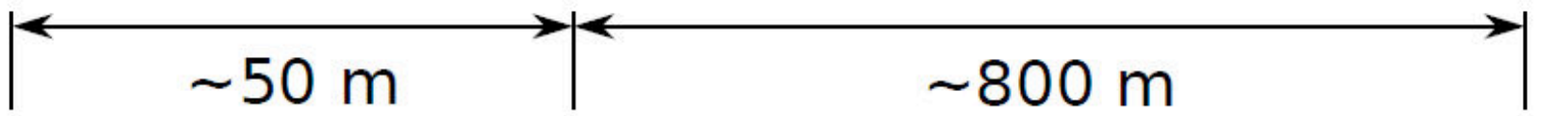


Electron-neutrino crosssections!

Sterile Basline

Muon final state! CPT invariant channel and muons easier to measure than electrons.



Appearance-only (though disappearance good too!)

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Already Proposed

Telemark 1980

DESIGN CONSIDERATIONS FOR A MUON STORAGE RING

David Neuffer
Fermi National Accelerator Laboratory*, Batavia, ILL 60510

ABSTRACT

It was noted earlier[1] that a muon (μ) storage ring can provide neutrino (ν) beams of precisely knowable flux and therefore suitable for ν oscillation experiments. In that paper it was suggested that parasitic use of the Fermilab $\bar{p}$ precooler could provide a useful μ storage ring. In this paper design possibilities for μ storage rings are explored. It is found that a low energy (~1 GeV) ring matched to a high intensity proton source (8 GeV Booster) is most practical and can provide ν beams suitable for accurate tests of ν oscillations.

Technology existed then, certainly exists now...

Also papers by Wolfenstein, Wu, Davis, Nakagawa, Bahcall, Cleveland. Great historical reads!

http://www.slac.stanford.edu/econf/C801002/

Facility

- 2 GeV FFAG ring
- Fed from 60 GeV Main Injector
- 100 kW target station -> 2e18 muons
- 800 m to 1 kt Iron sampling calorimeter (think MINOS near detector)
- Saturate the steel. SCTL from VLHC work.

3+1 BF Event Rates

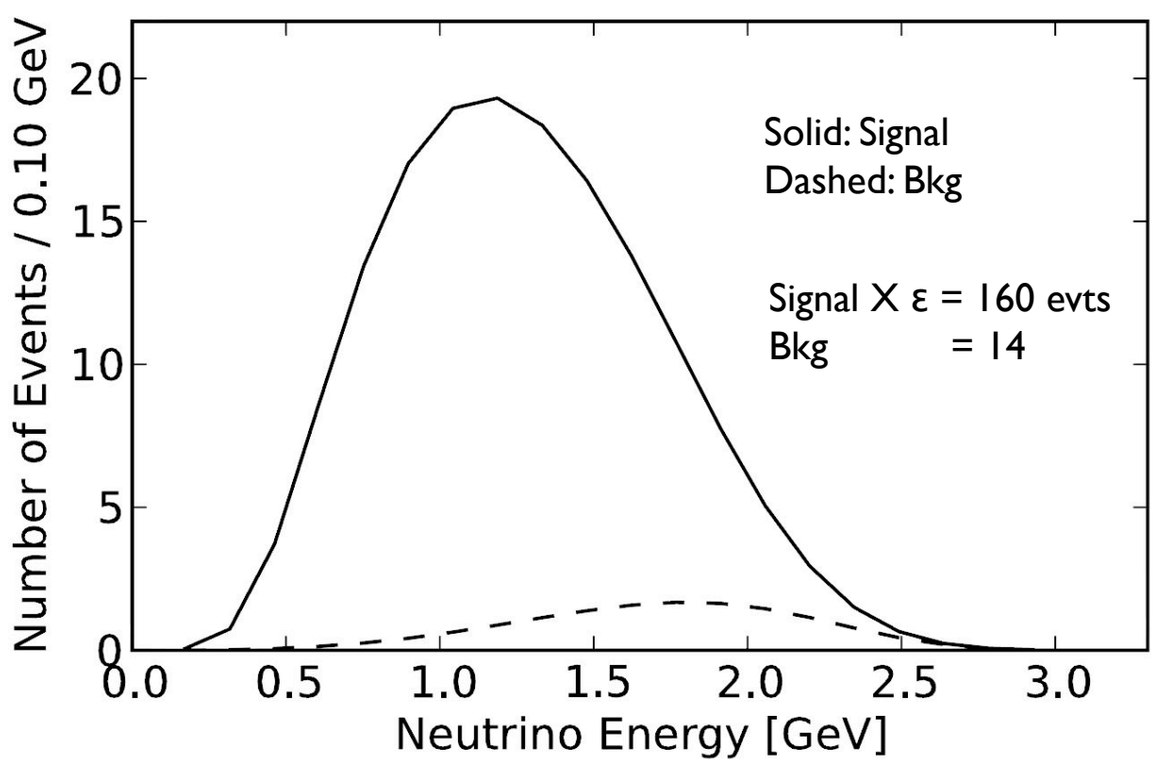
[$\bar{\nu}$-mode with stored μ^-]

Channel name	Number Events
$\bar{\nu}_e \to \bar{\nu}_\mu$ CC	77
$\nu_\mu \to \nu_\mu$ CC	234133
$\nu_\mu \to \nu_\mu$ NC	85767
$\bar{\nu}_e \to \bar{\nu}_e$ CC	79729
$\bar{\nu}_e \to \bar{\nu}_e$ NC	32916

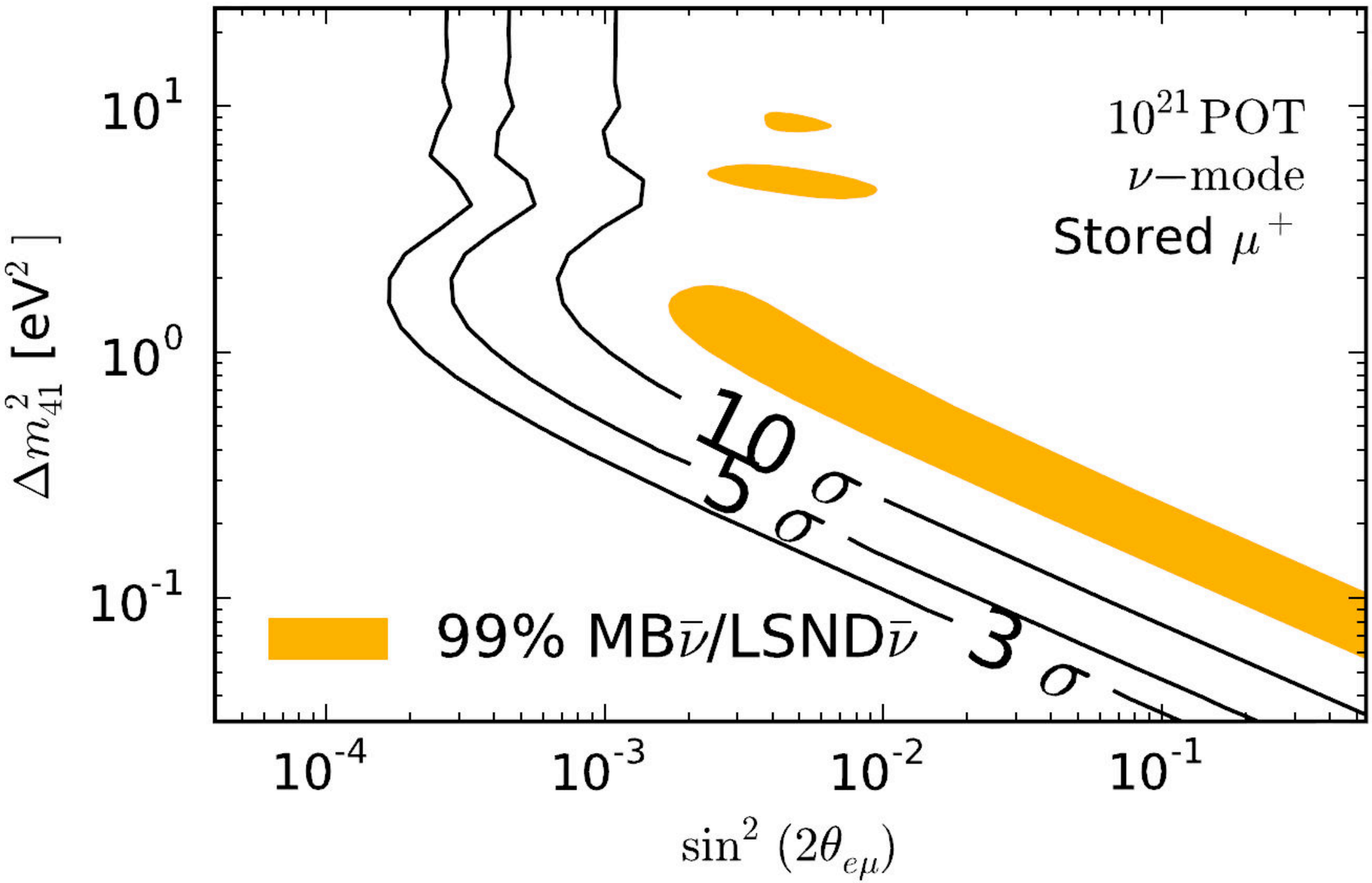
[ν-mode with stored μ^+]

Channel name	Number Events
$\nu_e \to \nu_\mu$ CC	200
$\bar{\nu}_\mu \to \bar{\nu}_\mu$ CC	99237
$\bar{\nu}_\mu \to \bar{\nu}_\mu$ NC	40329
$\nu_e \to \nu_e$ CC	196441
$\nu_e \to \nu_e$ NC	74098

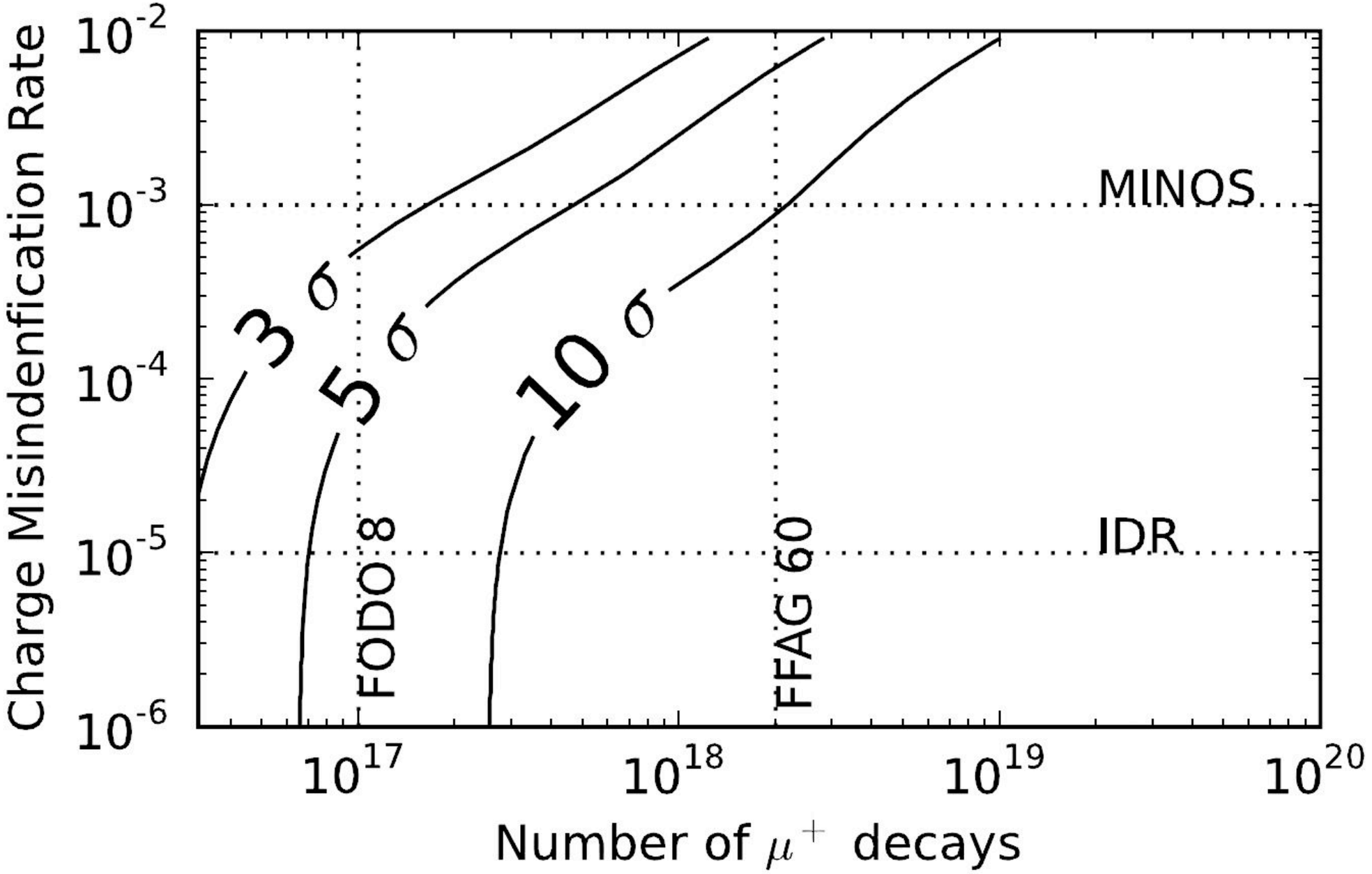
Appearance channels



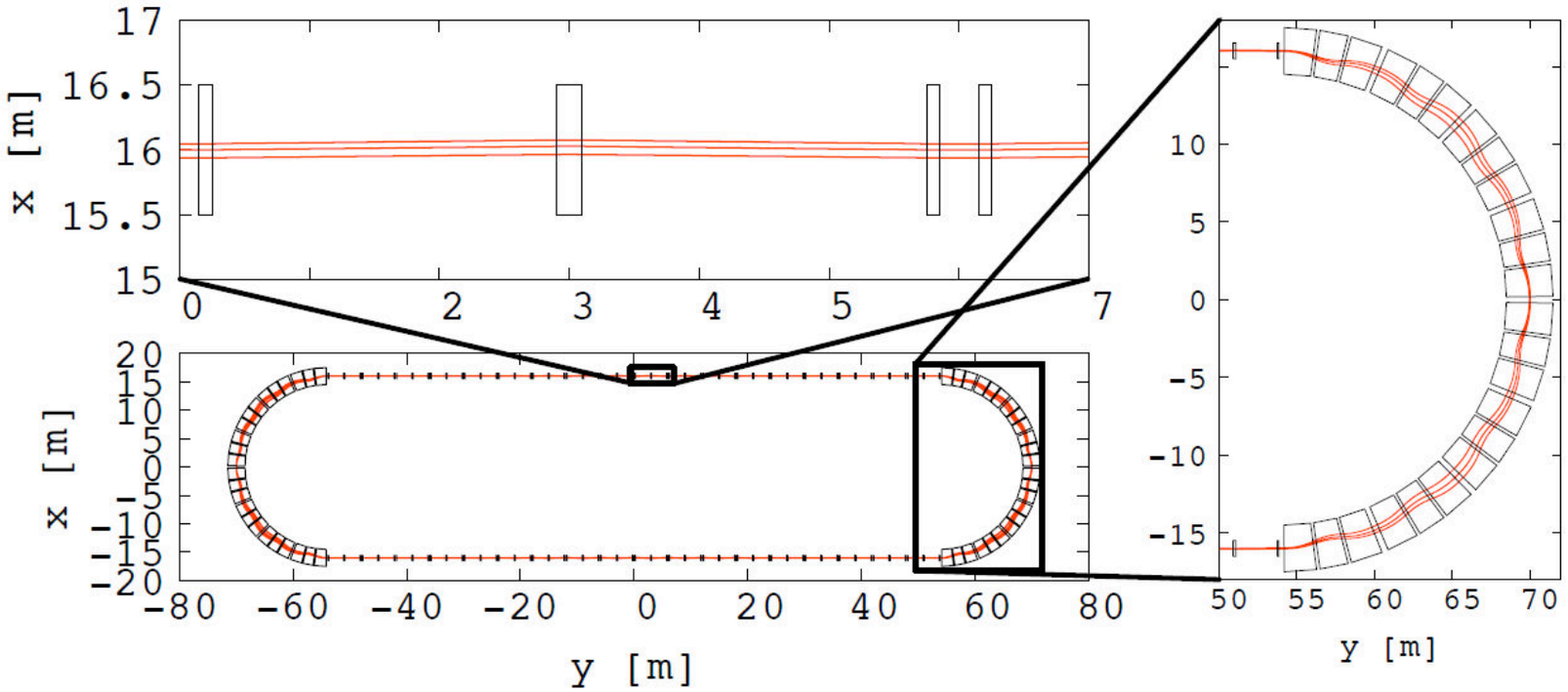
CPT(LSND) Channel



Accelerator v.s. Detector



Have drawings...



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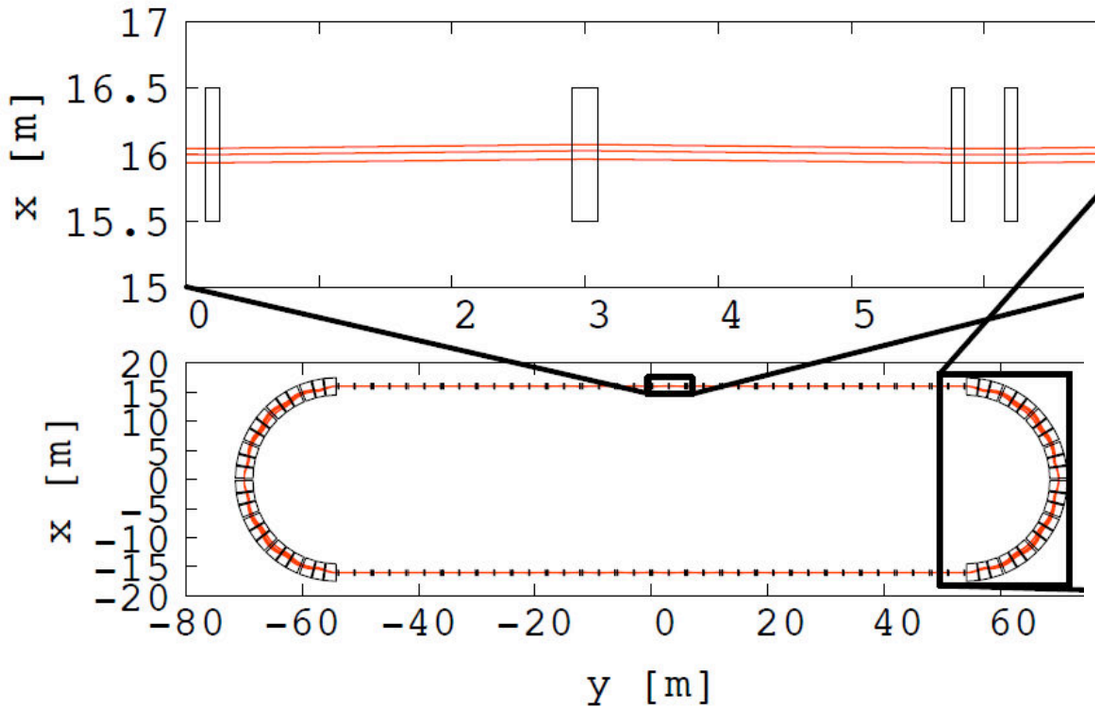

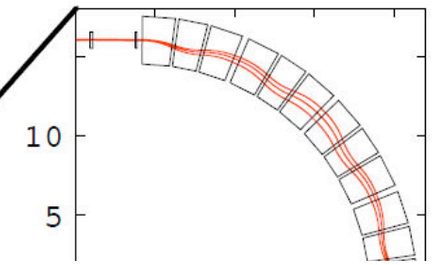

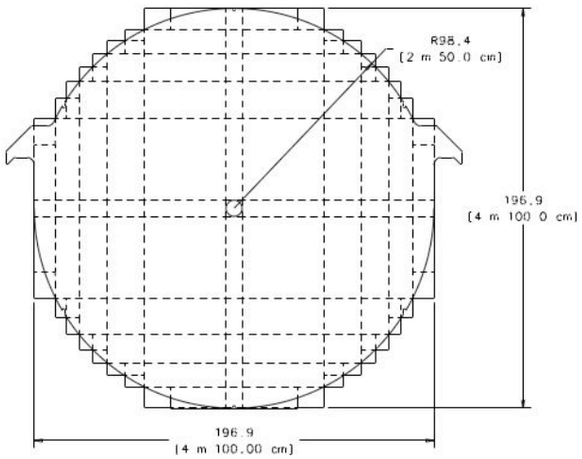

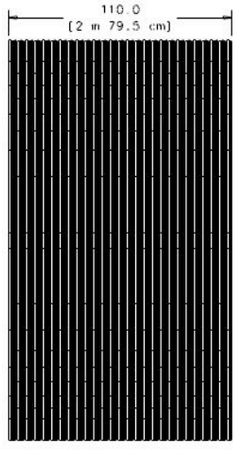

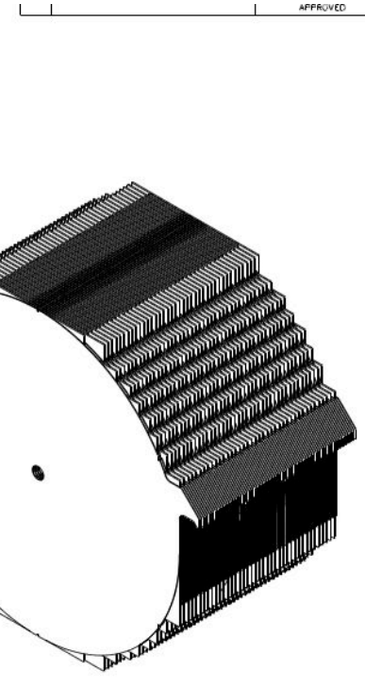

LOI in progress

Akira Sato

Conclusions

- Something weird is happening around mass splitting of an eV^2
- Shown was a way one could solve the puzzle: no new technology
- Catch me in coffee to learn more