Thoughts on TASD Near Detector

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Issues to be Discussed

- Goals of the Near Detector
- Possible Design
- Issue of Rates
- Cost Estimate

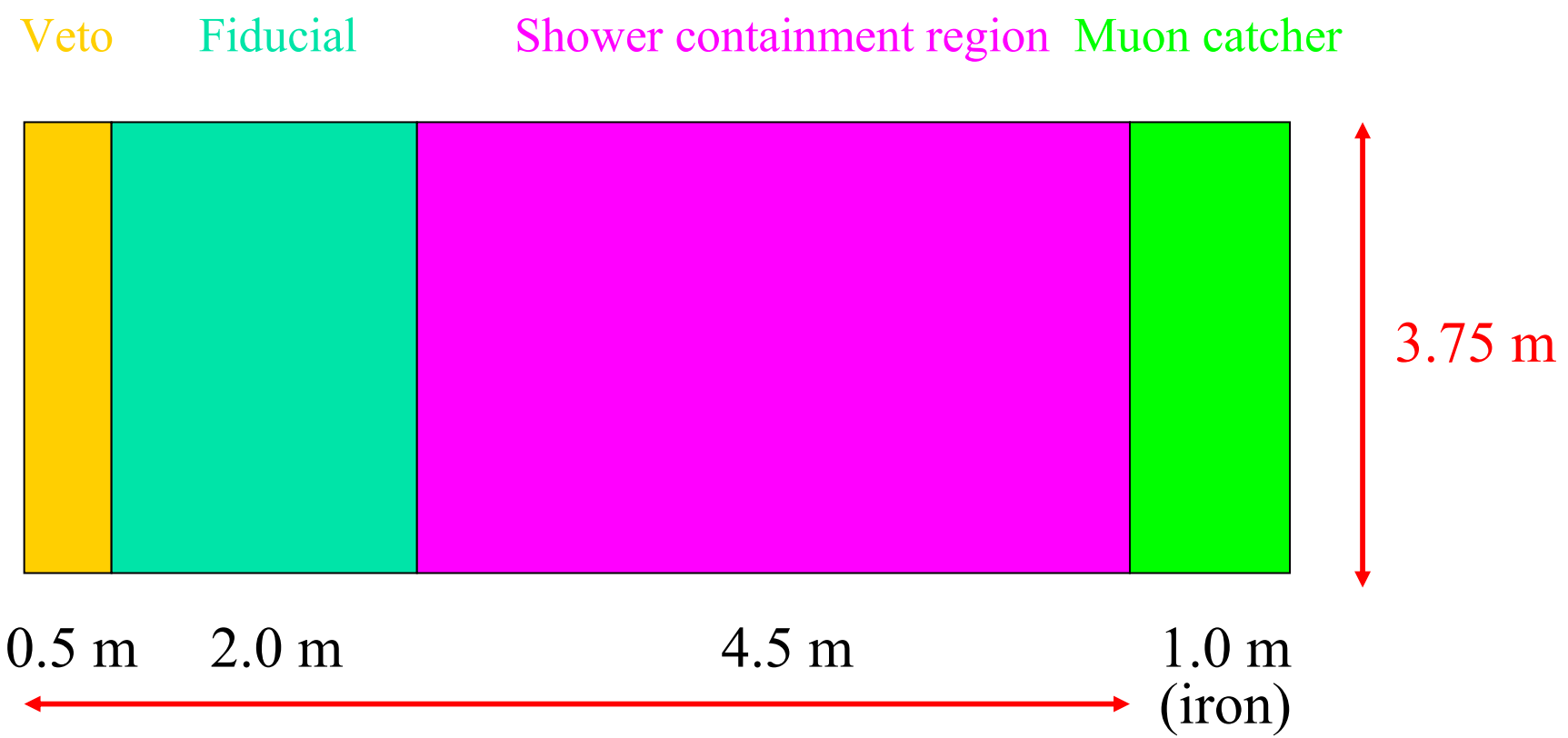
Goals for the Near Detector

- Reproduce structure (granularity,material) of the Far Detector
- Spectrum of the beam should be as close to that of the Far Detector as possible
- Should be able to measure the relevant part of the neutrino spectrum
- Number of events should be significantly higher (~100 times) than in the Far Detector
- Number of pileup events should be negligible (no additional significant systematic error introduced)

Proposed Basic Structure

- Transverse dimensions: 3 32-cell modules, 3.75 m
- Logitudinally there are 4 components (1st 3 parts totally active):
  - Veto region, 0.5 m long
  - Interaction region, 2.0 m long
  - Hadron catcher region, 4.5 m long
  - Muon catcher region, 1 m long (iron plates interspersed with scintillator modules)

Proposed architecture



Fiducial region rates

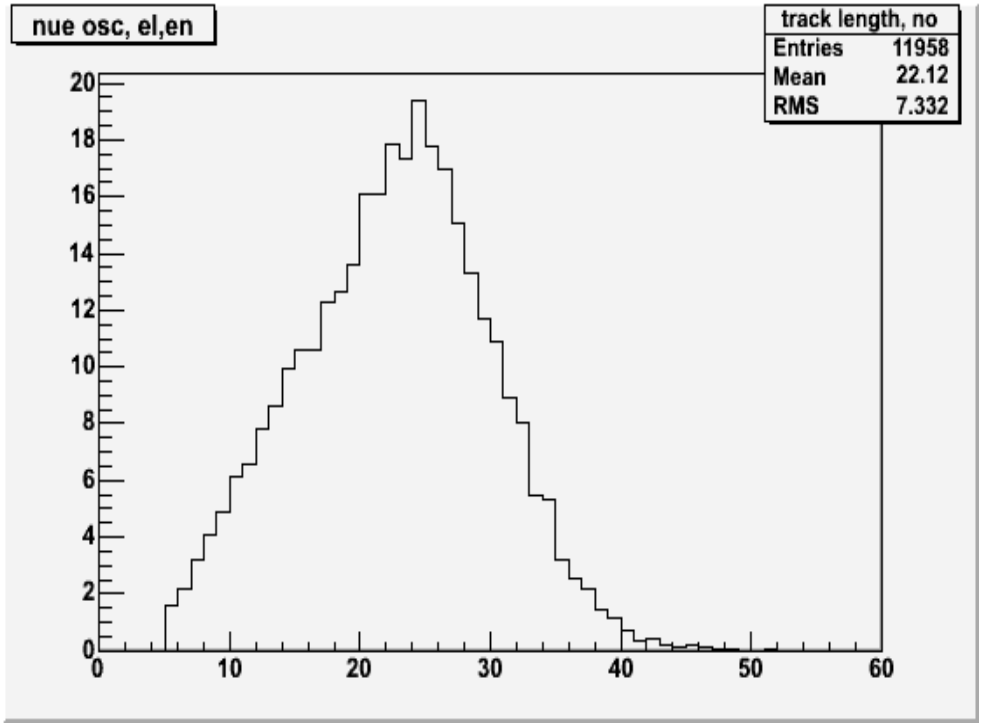
- Only central 2.5 m (in x and y) would be used for accepted events
- This gives 2.5 x 2.5 x 2 m =12.5 m^3, ie 10.75 tons in fiducial volume
- The raw event rate in that region will be:

  (10.75/25000) x 10^6 ~ 400 times FD

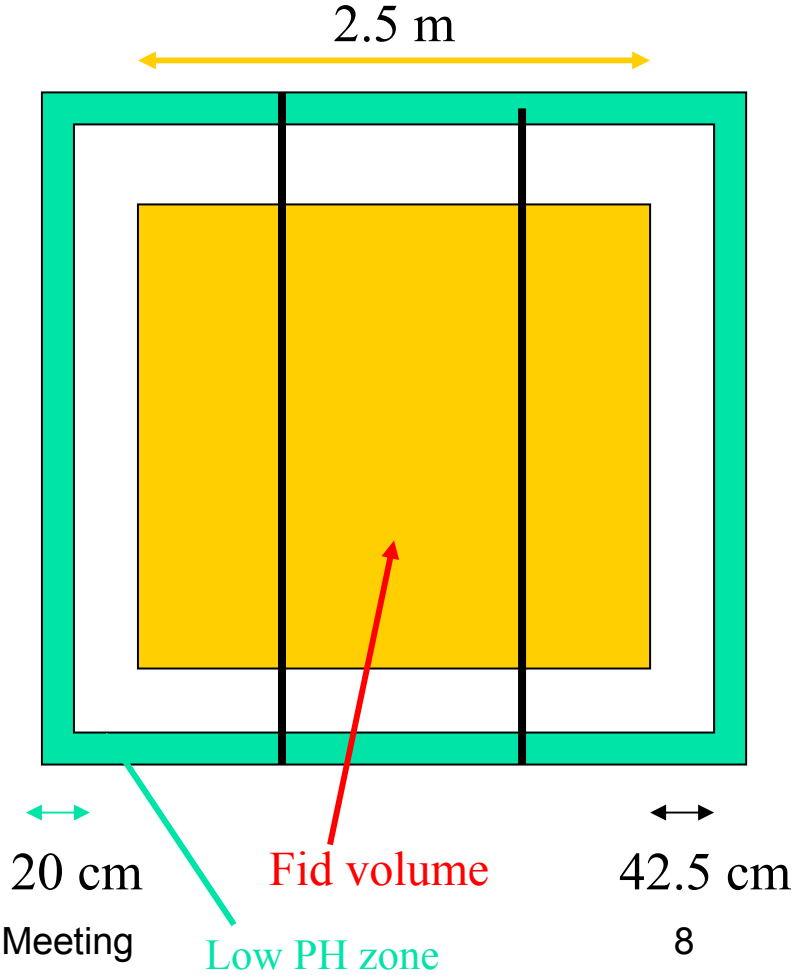
Containment issues

- The ν_e events in the accepted energy band have maximum length of 45 planes in each projection (90 total), ie 4.4 m.
- The length of the iron muon catcher (~ 1m) is chosen so as to contain all ν_μ's in the region of interest
- Accepted events will be required to have small energy deposition (<5%) in the outer 20cm region of the detector
- That gives a loss of only 4% of good events

Electron length, fiducial area



Electron length in each projection in planes



Pileup Issues

- The total mass of totally active region is 79 t
- Assuming 200 days/yr with 100% running efficiency and 0.5 Hz rate, this gives 0.9 evts/pulse in the detector
- Steel would contribute another 1.3 evts/pulse
- Assuming 500 ns time bin (FD electronics specs for NOνA) and 8.5 μs spill, that would give 6 (13) % event overlap probability in time

How to mitigate it?

- Assuming same cell structure and fiber diameter in ND as in FD, we will have ~3 times more light in ND
- That means that higher noise rate can be tolerated and thus sampling time can be made shorter, noise α $t^{1/2}$
- Decreasing multiple event / time bucket rate in active part of ND to 1-2% means that one can just reject pulses with more than one event in a time bucket, if they can be identified as such

Additional electronics/detectors

- One could put “fast” (a la MINOS ND) electronics on every 20’th plane in place of standard ones
- This would be sufficient to identify presence of more than one event in a time bucket and thus allow one to reject that pulse in an unbiased manner
- Alternatively, additional detector might be put in every 20’th plane with ganged fast electronics
- The choice is an issue of physics preference as well as value engineering
- Events with in-time signals in veto region (eg due to rock muons) would also be rejected

Rough Cost Estimate

- Following costs are based on Far Detector unit cost (unburdened) where available:
  - Fiber - 9.5 m/cell - $0.62/m $109K
  - Extrusions - 579 @ $142 $ 82K
  - Liquid scintillator - 92 t @ $1191/t $110K
  - Standard electronics @11.37/channel $211K
- Other costs (rough estimate)
  - Fast electronics - $200/channel $195K
  - Data acquisition $ 50K
  - Steel - 110t - $1K/t $110K
  - Installation $100K

Costs (ctd)

- The total unburdened cost from the Table on the preceding slide add up to $967K
- The assumption is made that most of the startup costs will have been already included in Far Detector costs
- To be conservative, we should probably double this cost to allow for overhead and contingency, giving a cost of ~$2M

Conclusion

- The straw man design presented appears to be able to perform the functions required of the Near Detector in TASD
- One should be able to build and install this detector for ~$2M
- Lot of these ideas can probably be carried over to the baseline design
- The fraction of fast electronics there would be higher but total amount probably the same