Designing an Aerogel Beamline Cherenkov Detector (ABCD) for LArIAT

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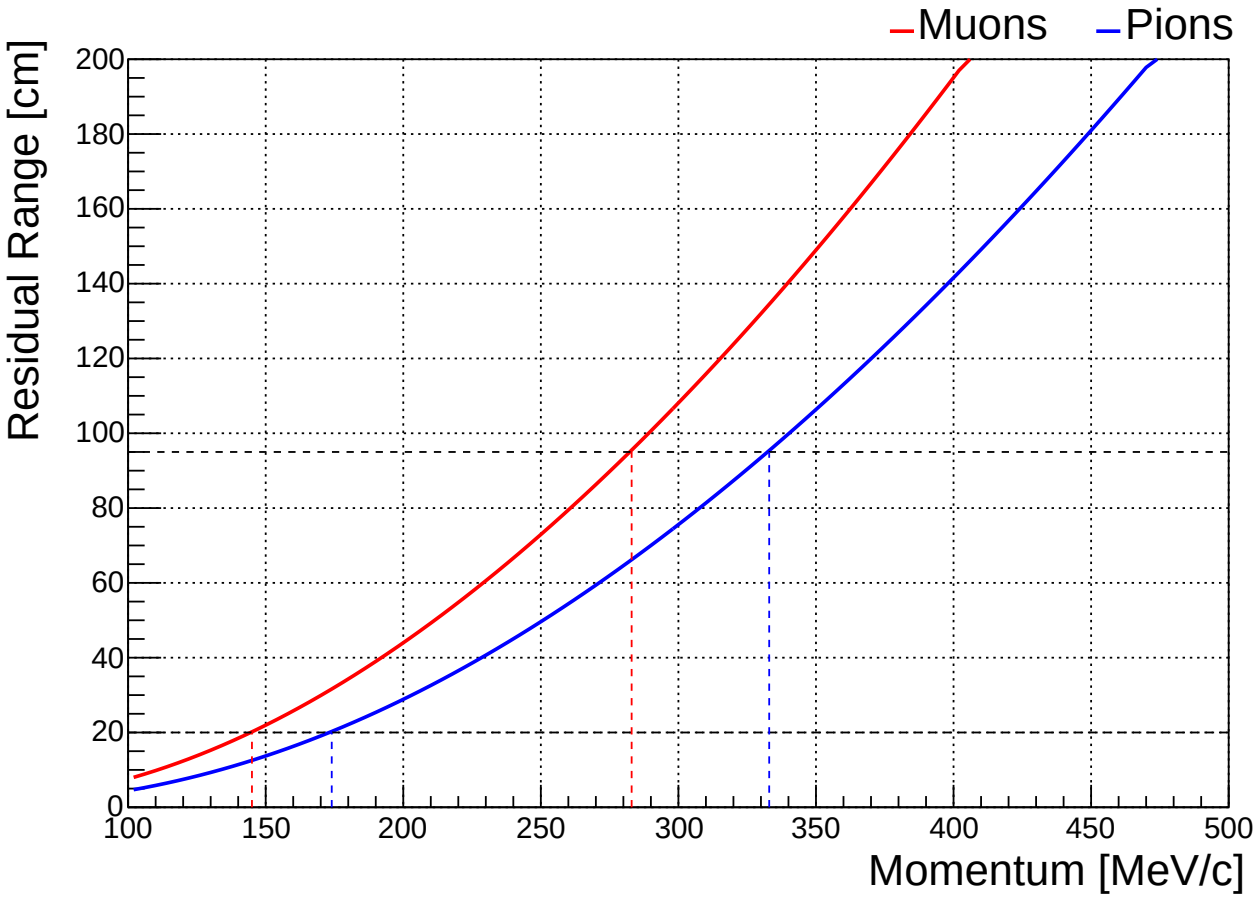
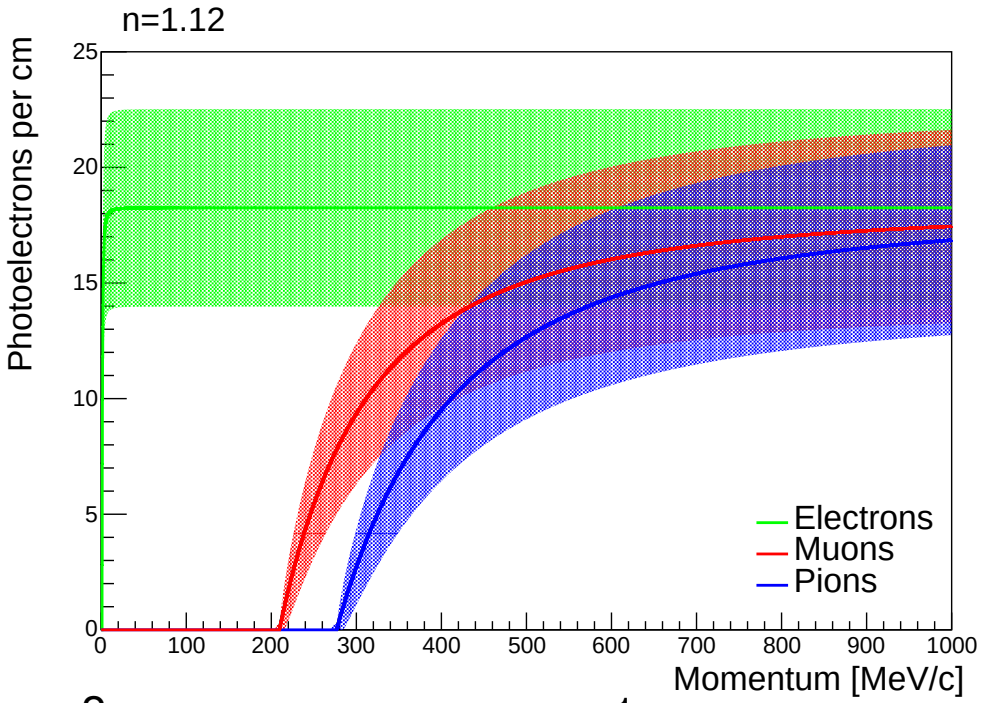
Motivation

- **How can we measure stopped muons and pions at LArIAT?**
  - Given simple assumptions, muons should stop within the LAr TPC with p<280 MeV and pions with p<330 MeV.
  - R Acciarri *et al* 2013 *JINST* 8 P08005 (Thanks to Bruce B.)
    - `http://iopscience.iop.org/1748-0221/8/08/P08005`



Motivation (continued)

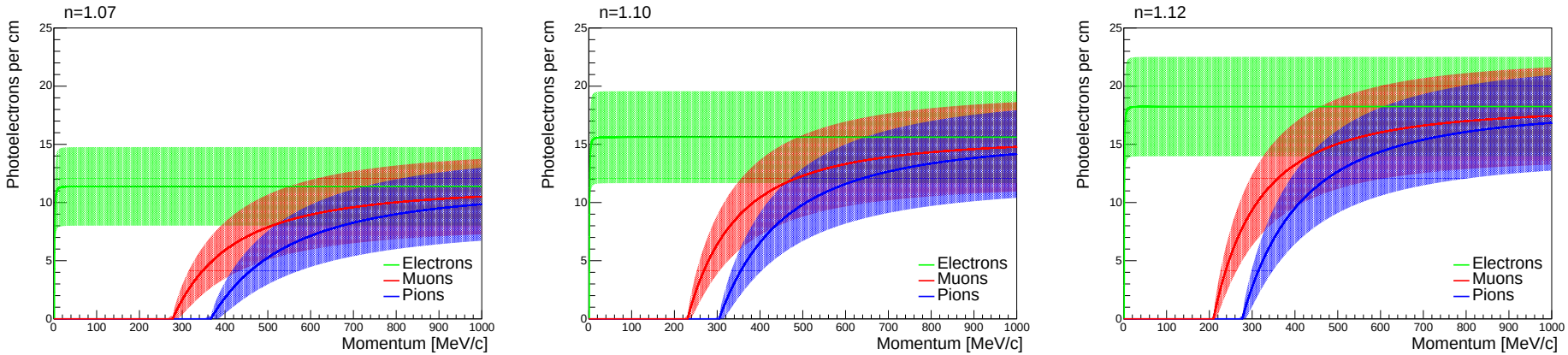
- **How can we seperate stopped muons and pions at LArIAT?**
  - Can't use a muon range stack since these muons will be stopping in the LAr TPC.
  - Time of Flight (ToF) can be difficult since muon and pion masses only differ by 30%
  - What about a material with a small index of refraction (Aerogel)?



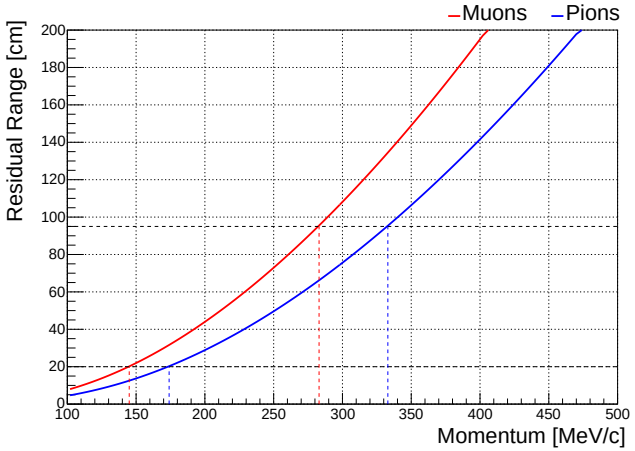
- $N_{PE} \approx 90 \times \sin^2\theta_c$ where $\cos\theta_c = \frac{1}{\beta n}$
  - i.e. p.420 of Particle Data Group, Chin. Phys. C 38, 090001 (2014)

Motivation (continued)

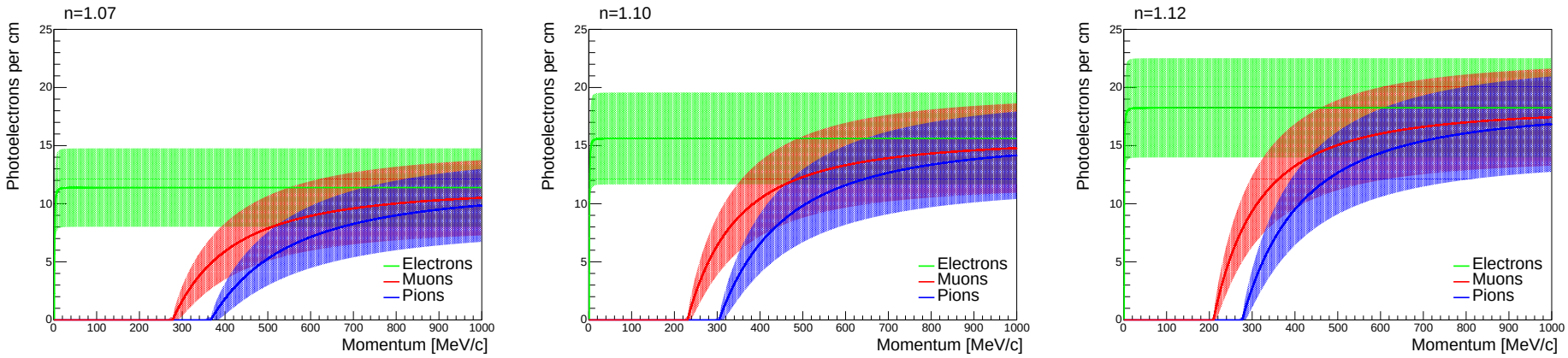
- Different indices of refraction are sensitive to different momentum ranges



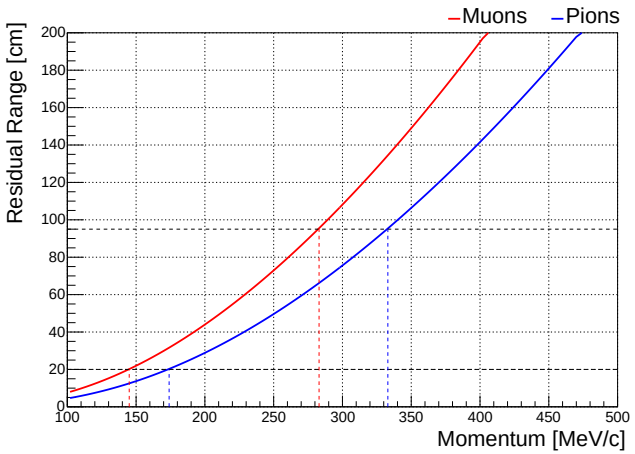
- For example, what indices of refraction are of interest to a 250-280 MeV beam of stopped muons and pions?
  - n=1.12 would 'see' muons but not pions



Motivation (continued)



- With multiple aerogels, we could create simple trigger logic:
  - Muons = (1.12) AND (1.07) ; Pions = (1.12) AND NOT (1.07)



- If we can tune the beam such that muons escape the cryostat while pions stop, the muon range stack can also accomplish such a ‘muon veto’

Aerogel Inventory

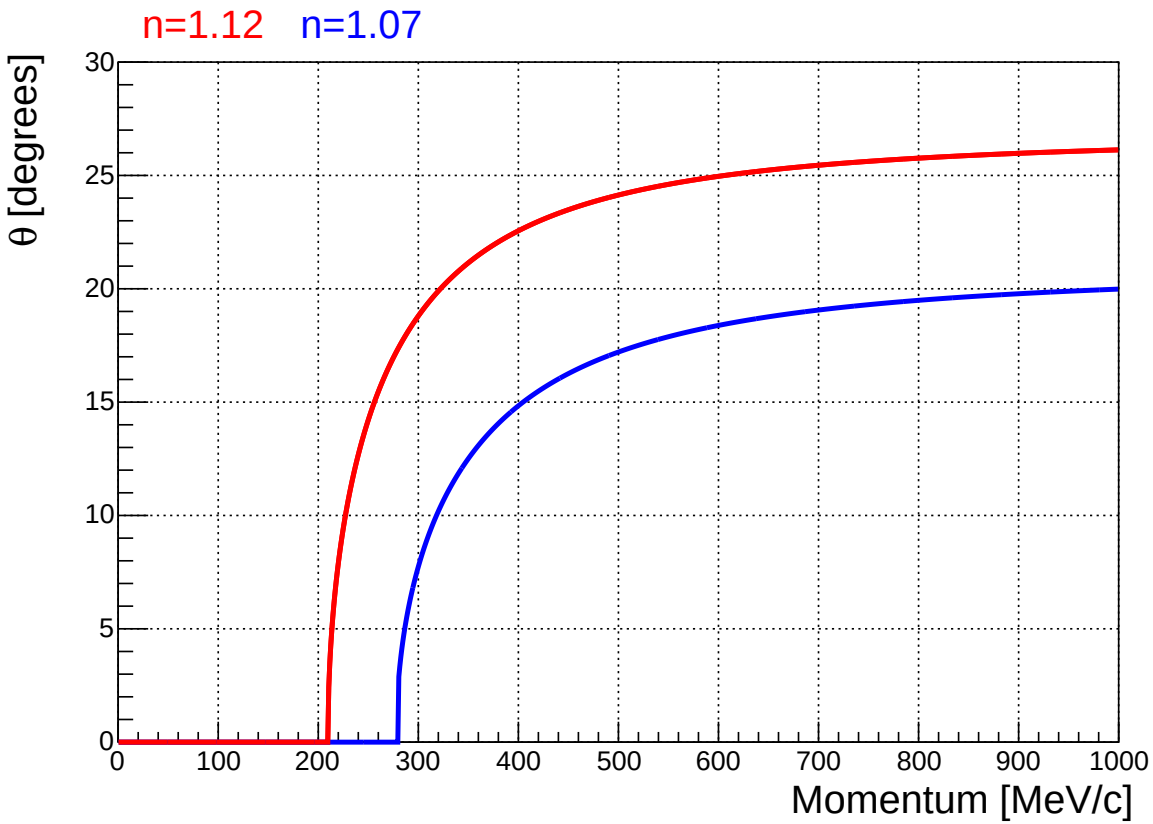
- In the UT Austin lab, we have 2 1cm thick tiles of n=1.07 (HY-80) and 2 1cm thick tiles of n=1.12 (HY-120).
  - On loan from MICE collaborators. Unable to obtain more.
- Iwai-san and Maruyama-san are sending us two more tiles of n=1.057!!!

Aerogel Inventory

- An aerogel counter of n=1.11-1.12 is *essential* to separating stopped muons and pions.
- An additional aerogel counter of smaller index could be a very nice addition.
- If PMT rise time is short enough, an aerogel counter could be tied to another beamline detector or another aerogel counter for time of flight measurements.
- An aerogel counter could also be an excellent electron trigger at momenta below both the muon and pion thresholds.

- Now we'll have Brandon Soubasis tell us about the PMT calibration and detector prototyping at the UT Austin lab...

Backup

Cherenkov Angle

- The cherenkov angle rises sharply after reaching threshold.
- below is the muon cherenkov angle as a function of momentum for two different indices of refraction