Effect of smaller gas TPC on LAr muon acceptance

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Motivation & goals

- Space in the ND hall is very tightly constrained
- Reducing the size of any detector could have significant cost savings
- MPD serves two separate, important purposes:
  - Muon spectrometer for LAr
  - Its own ν-Ar physics program
- This talk describes the impact of changing the dimensions of the HPgTPC on the performance as a muon spectrometer

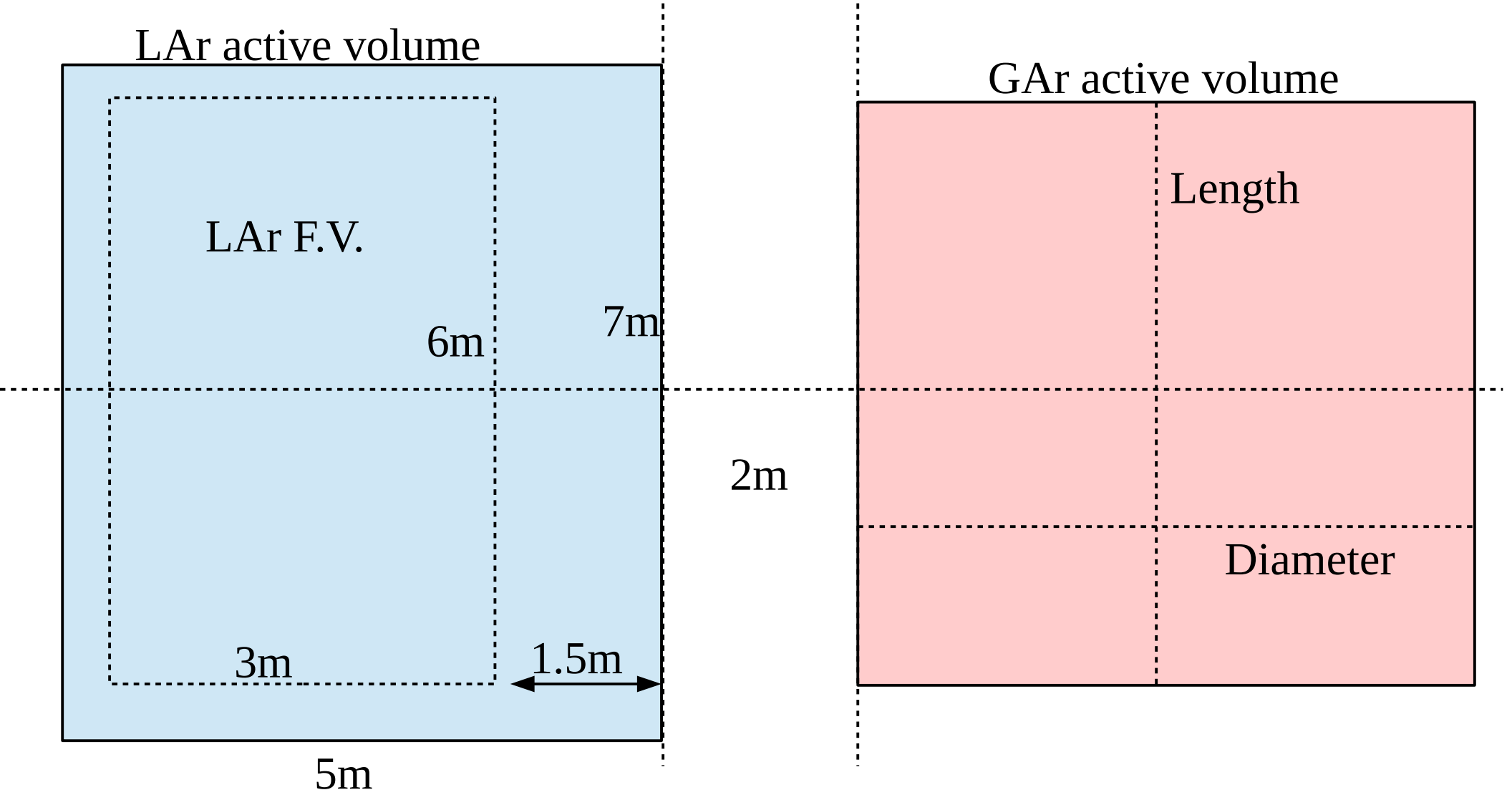
Conclusions, in advance

- For LAr muon acceptance, gas TPC should match the size of the LAr, i.e. >3m diameter and ~7m length
- Minimum dimensions are ~3m diameter and ~5m length; smaller dimensions adversely impact LAr analysis
- The gain in LAr acceptance going from 3m → 5m active HPgTPC diameter is minimal – reducing the diameter from 5m → 3.5m or 4m has no negative impact on the LAr analysis

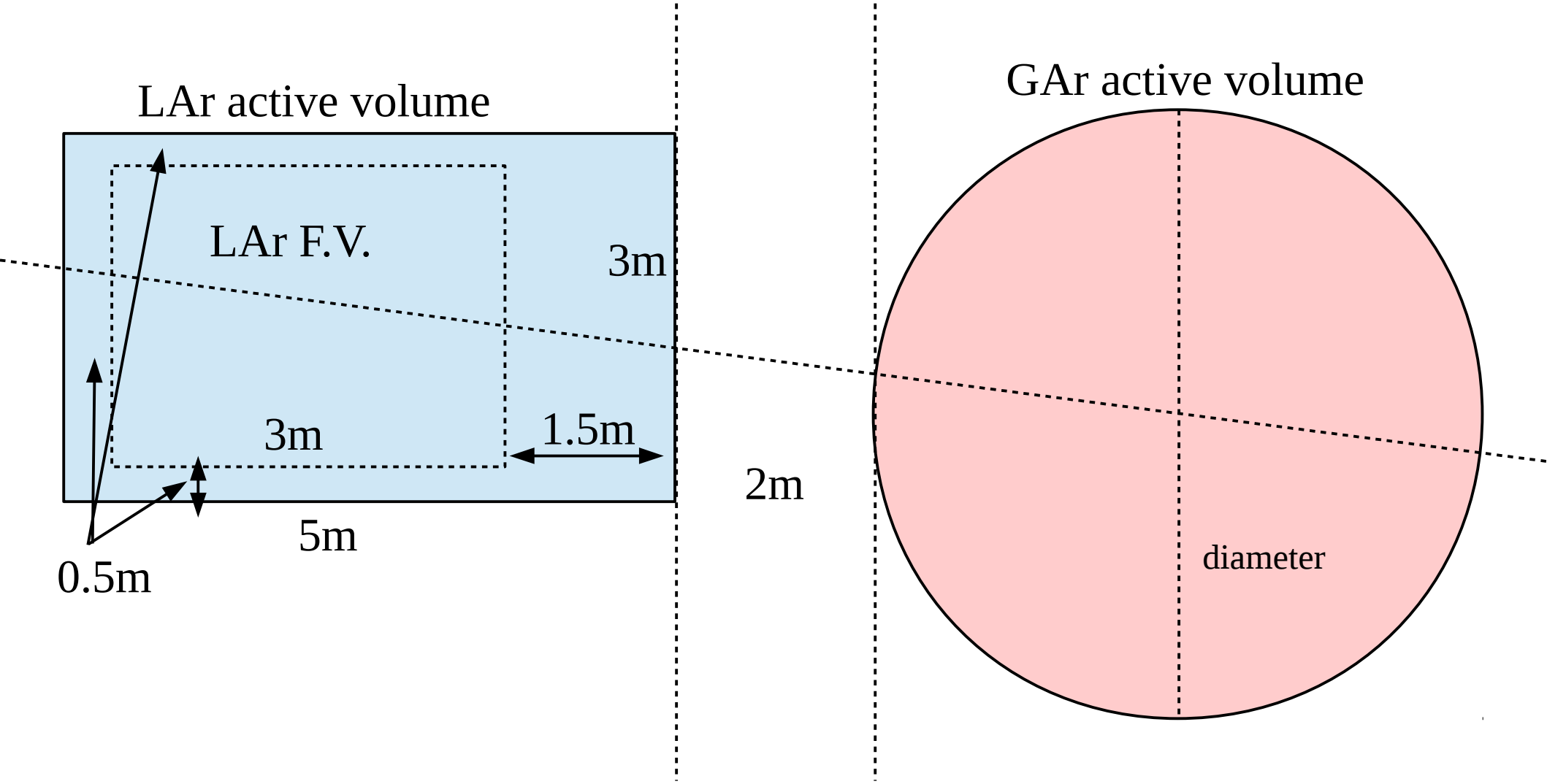
Assumptions

- LAr active volume of 7m (wide) x 3m (tall) x 5m (long ~ beam direction)
- LAr fiducial volume excludes 50cm around sides and upstream end, and 150cm on downstream end, for a total of 6m x 2m x 3m
- GAr active volume begins 2m downstream of LAr active volume – range-out in passive material is not included, only angular acceptance
- Neutrino beam axis passes through exact center of LAr and GAr active volumes
  - Alternative: both detectors sit on the floor
- Events are accepted with >1m track length in active gas TPC
- FHC ν_μ CC events only

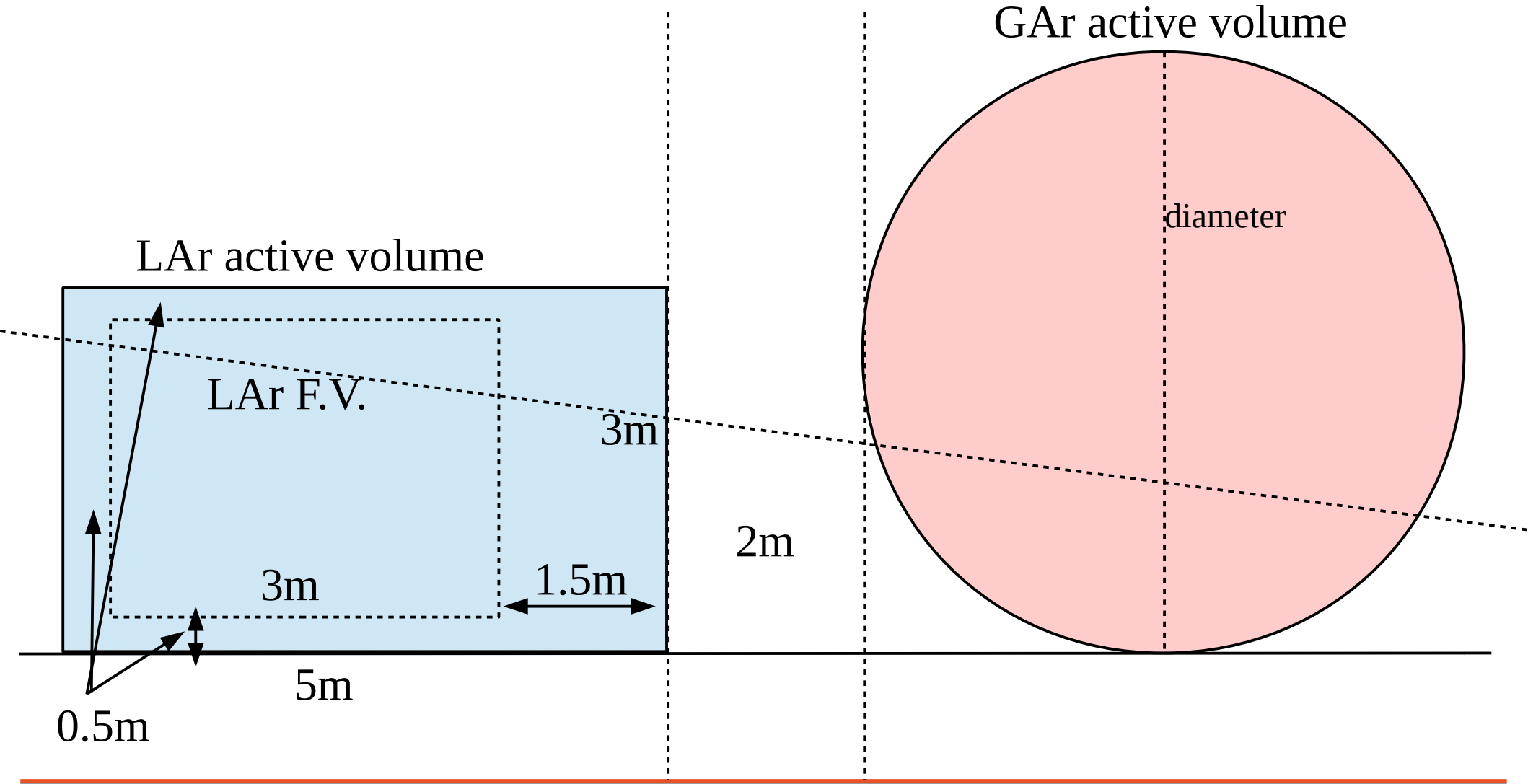
Cartoon: top view



Cartoon: side view



Alternative: everything on the floor



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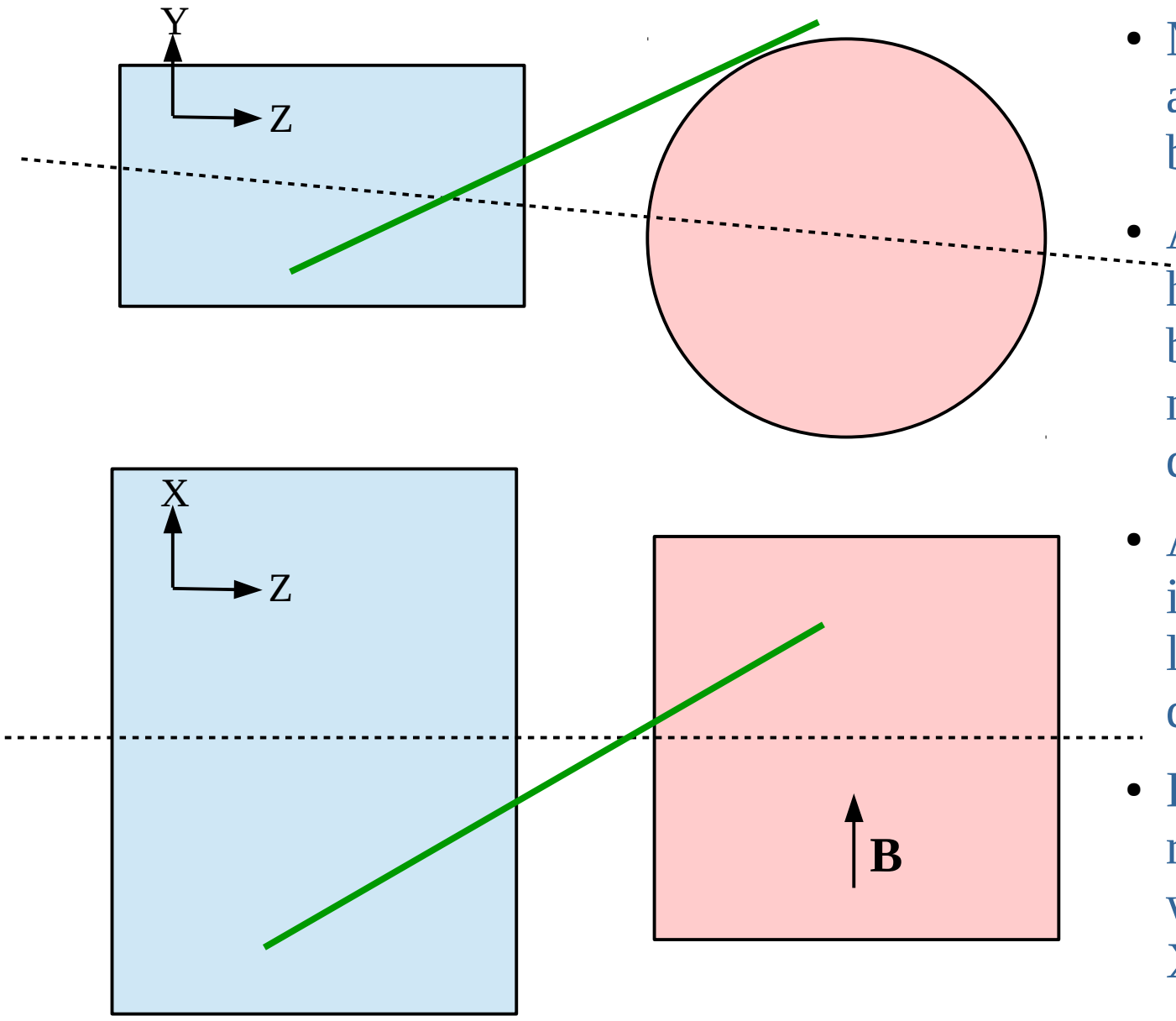
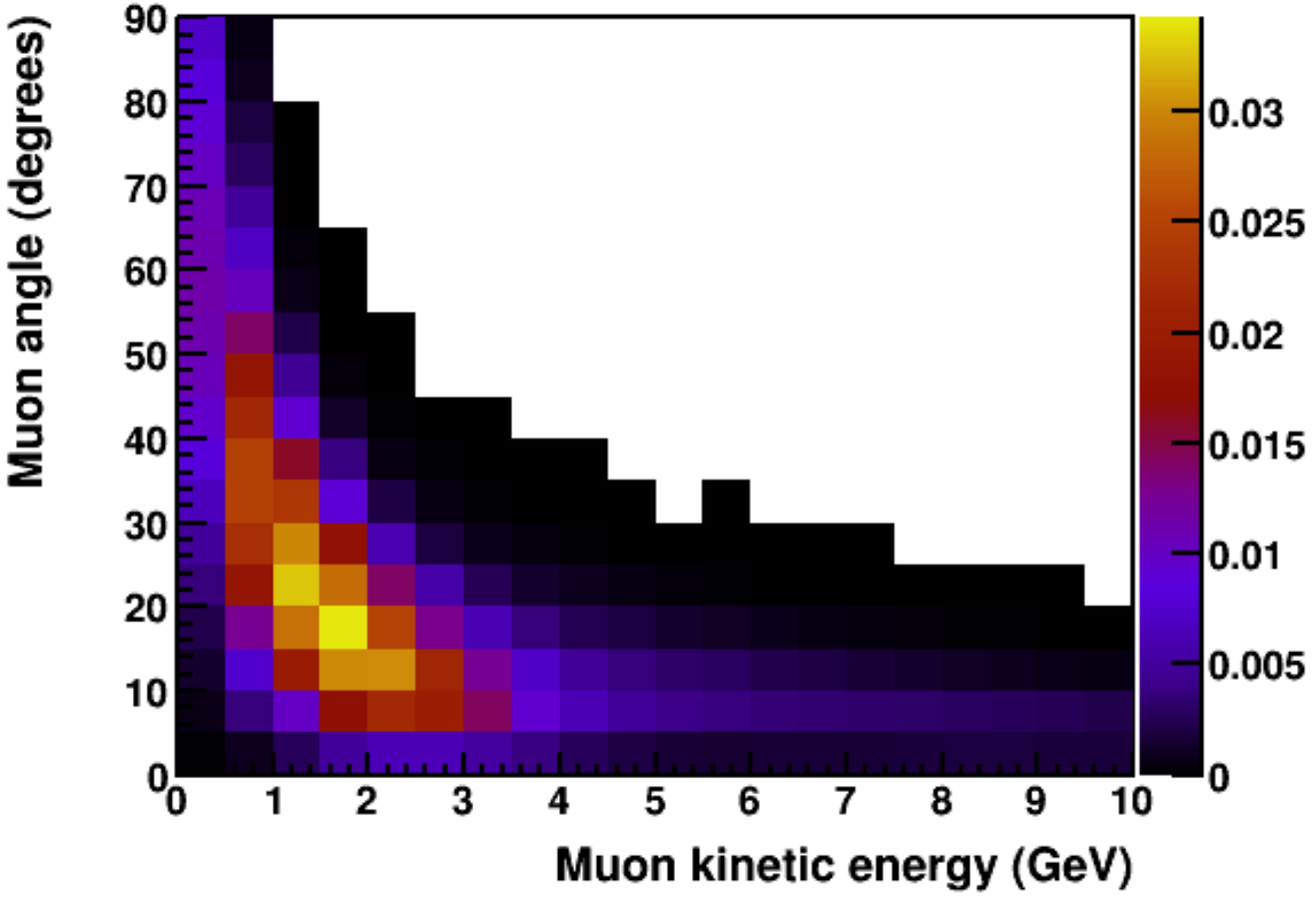
XZ and YZ angles are different



- Muon with 30 degree angle w.r.t neutrino in both panels
- Acceptance is better at high angles w.r.t. neutrino beam when the angle is mostly in the XZ plane, due to the wider LAr
- Acceptance at high angles is more sensitive to GAr length along X than diameter in YZ
- However, momentum resolution will be slightly worse for tracks with large XZ angles

Event rate distribution



- Fraction of total ν_μ CC events in each bin of energy and angle
- 40% of events are between 0.5-3 GeV and between 10-30 degrees

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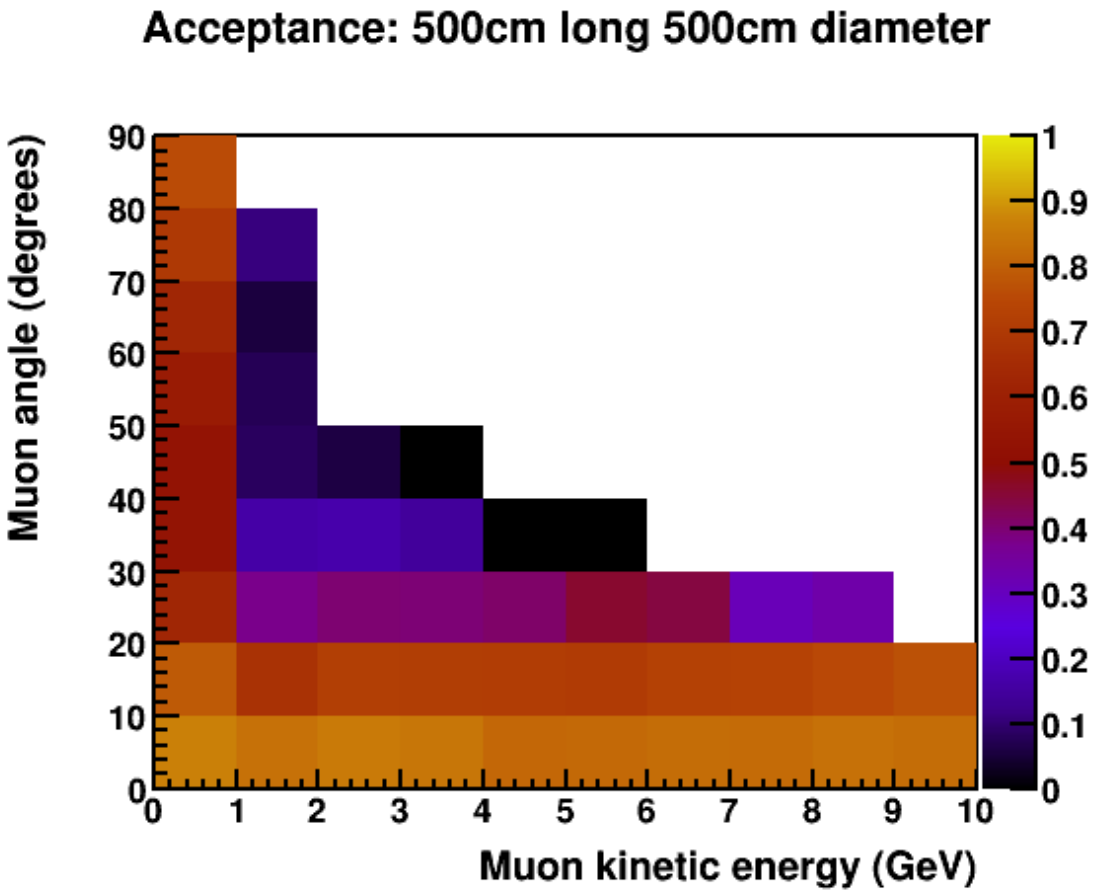
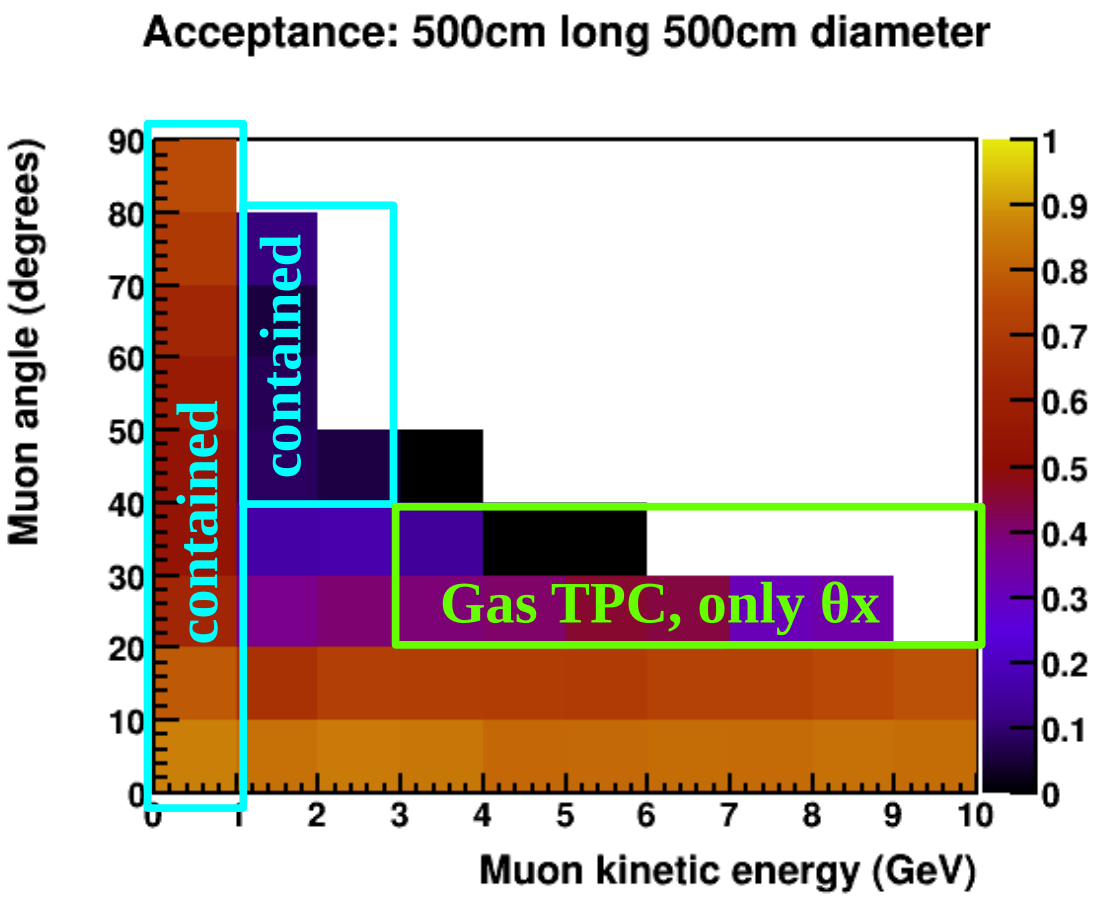
Muon acceptance: nominal



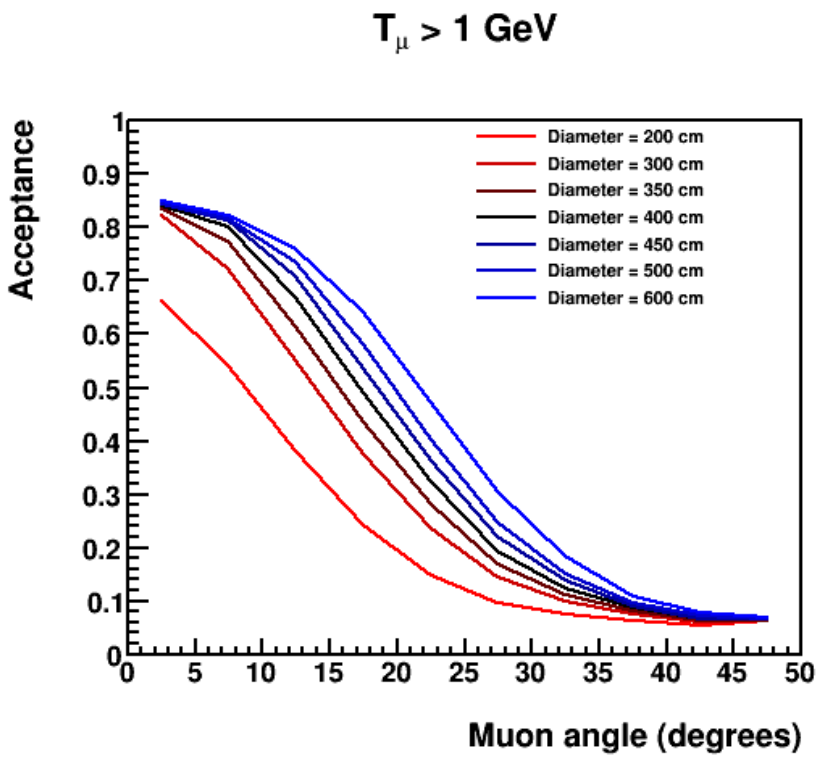
- Nominal detector considered is 5m diameter and 5m length along x direction
- Acceptance is over full LAr F.V., and is not expected to be high for events near the edges
- Hadronic side is not considered, only muon acceptance
- Contained events are included and counted as accepted for all gas TPC sizes

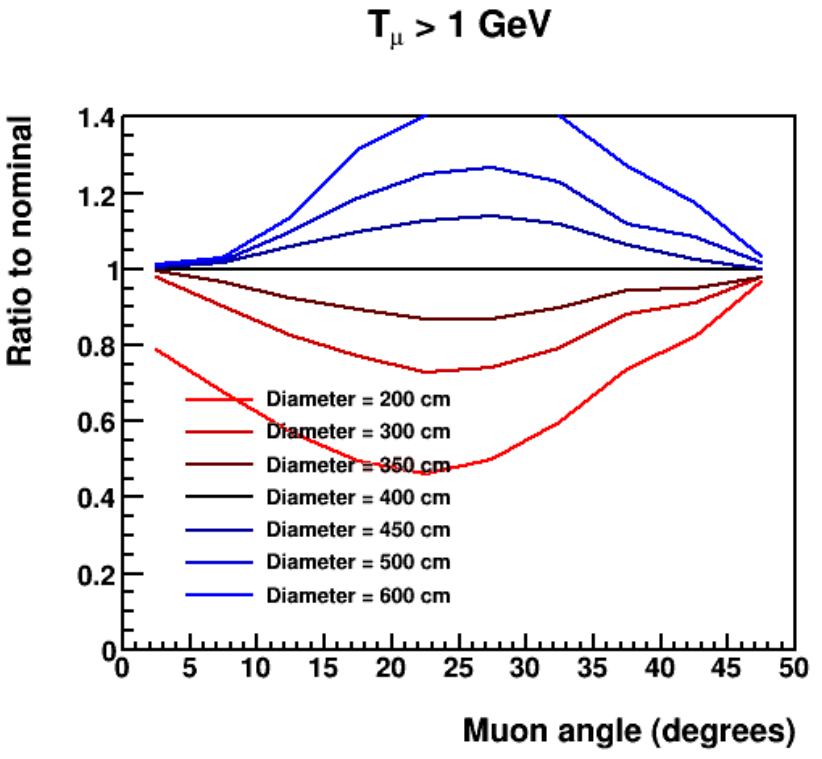
Muon acceptance: why



- Events with energy < 1 GeV are primarily contained, and don't depend on gas TPC dimensions
- Also ~2 GeV and high angles are contained
- For 20-30 degrees, match only when events have large angles in XZ plane
- Above 1 GeV, acceptance depends mostly on the angle

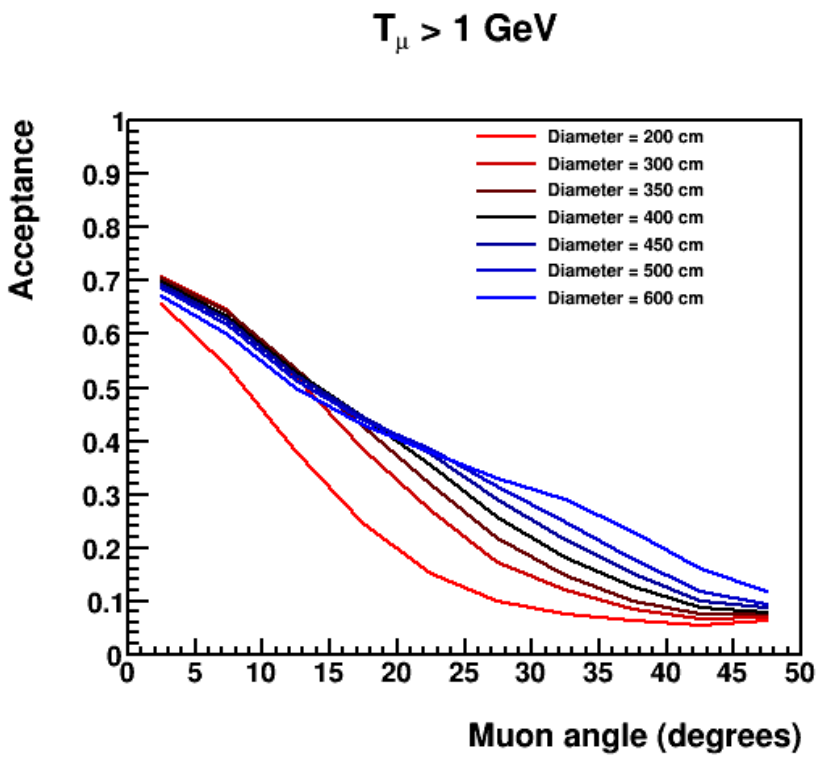
Acceptance vs diameter

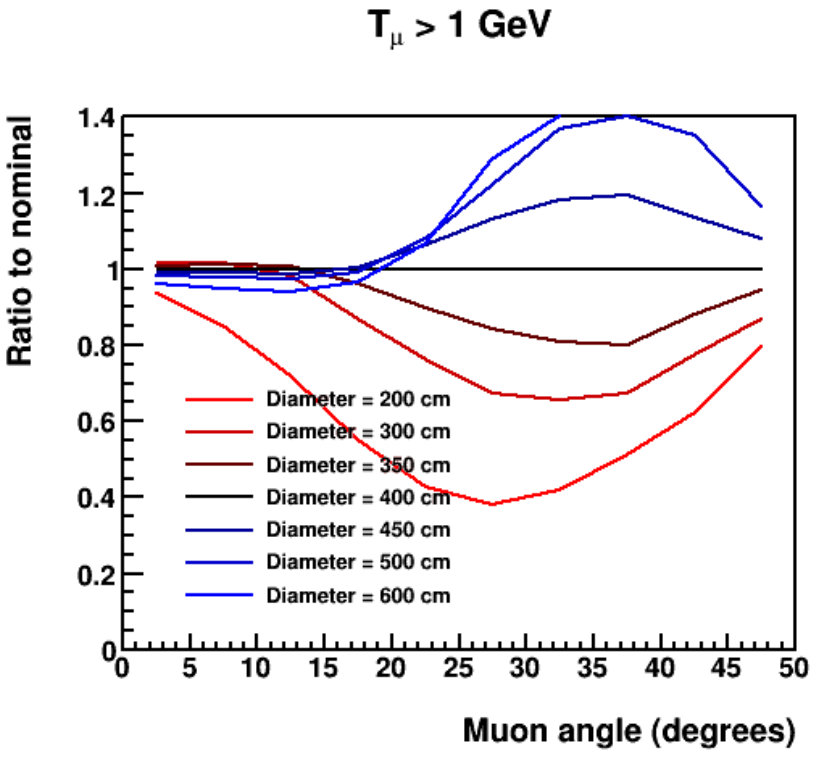




- 5m length in X direction, diameter varying between 2m and 6m
- Right plot is ratio to acceptance of 4m diameter
- Going from 4m → 5m is ~20% gain at best point

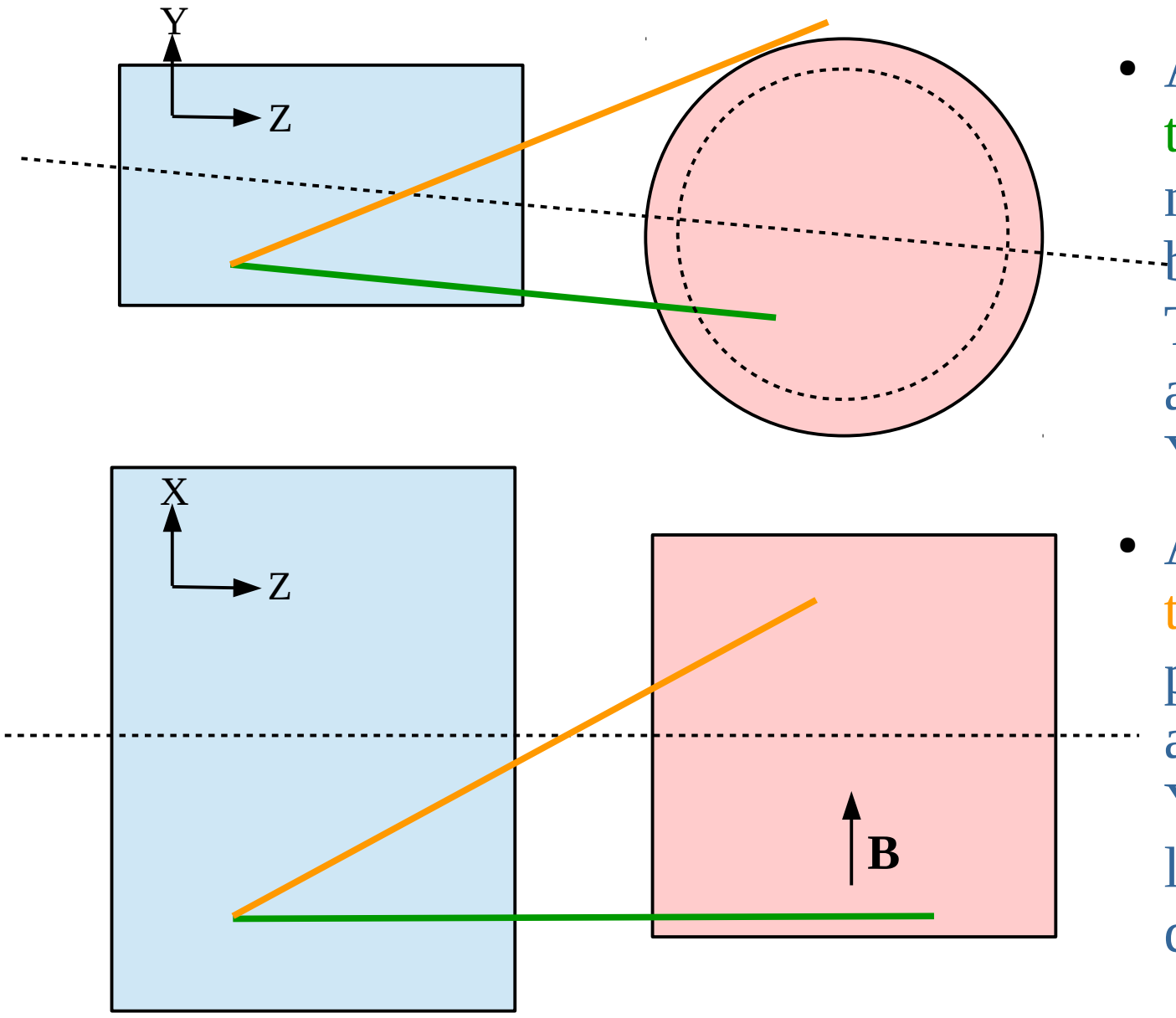
Acceptance vs diameter: floor





- 5m length in X direction, diameter varying between 2m and 6m, all assuming bottom of GAr & LAr at same height
- Worse acceptance at low angles, because forward tracks can miss HPgTPC in this configuration
- But somewhat better acceptance at very high angles

Explanation of previous slide



- At small angles (green track), acceptance does not depend on diameter because center of Gas TPC is always on axis, and LAr F.V. is small in Y compared to GAr
- At large angles (orange track), accepted events primarily have large angle in XZ rather than YZ, so acceptance is less sensitive to diameter

Conclusions, again

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