ND-GAr lite: Current status and plans.

DUNE ND General Meeting

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DESY
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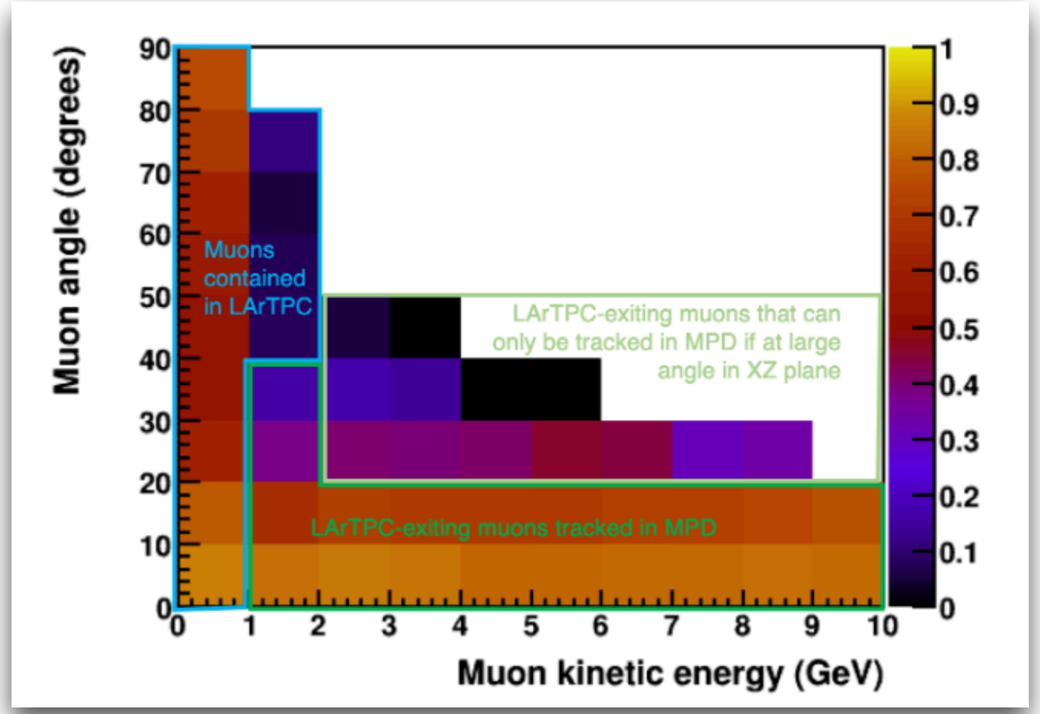
HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

DESY.

ND-GAr lite requirements.

What does it need to do?

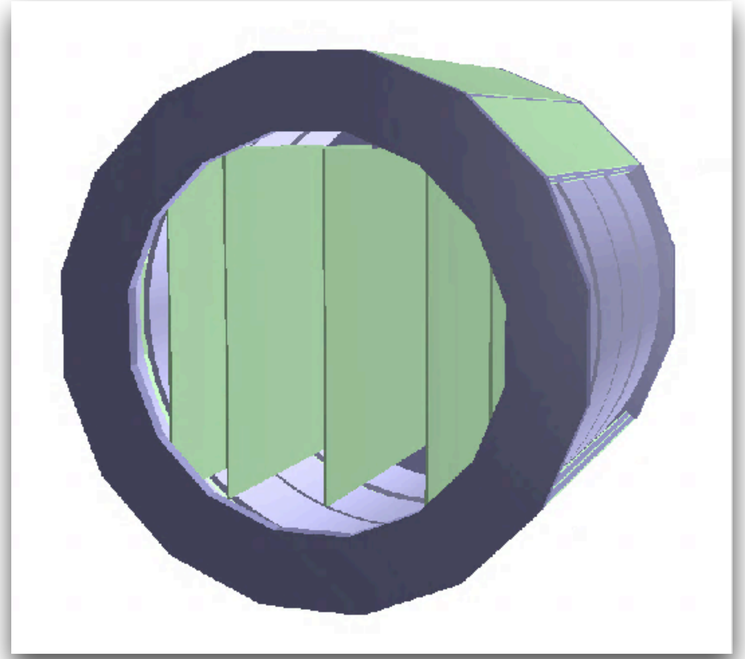
- Needs to be able to fulfil physics goals of DUNE in the first 3 years
  - Need to measure muon momentum exiting the LAr -> recover acceptance
  - Precision needed
    - 3-4% momentum resolution (core) and 10% tails (RMS)

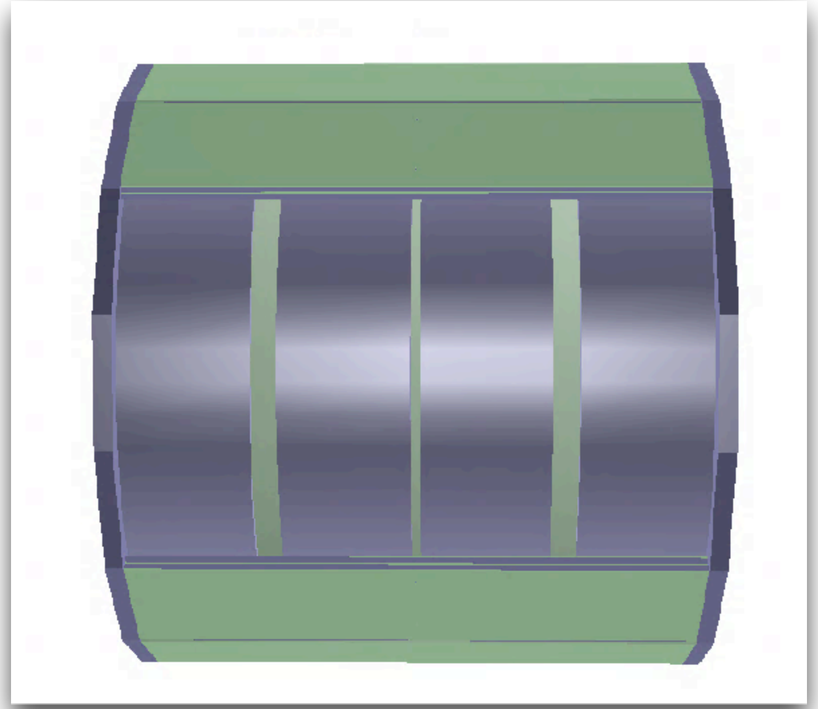


ND-GAr lite design.

What does it look like?

- The ND-GAr lite is based on the full ND-GAr without the ECAL/TPC
  - Uses the SPY design magnet
    - 10 cm Al solenoid
    - Iron return yoke ~15 cm
    - Open window in front of the LAr
    - 7 m in diameter
- Can integrate a muon system id inside the yoke
- Inside, 5 large scintillator planes (6 m x 5 m) of 4 cm thickness
  - Segmented Minerva-like (triangle shaped strips with fiber 4 cm base/2 cm high) - crossed in X/Y
  - Placement of the planes to be optimised for tracking

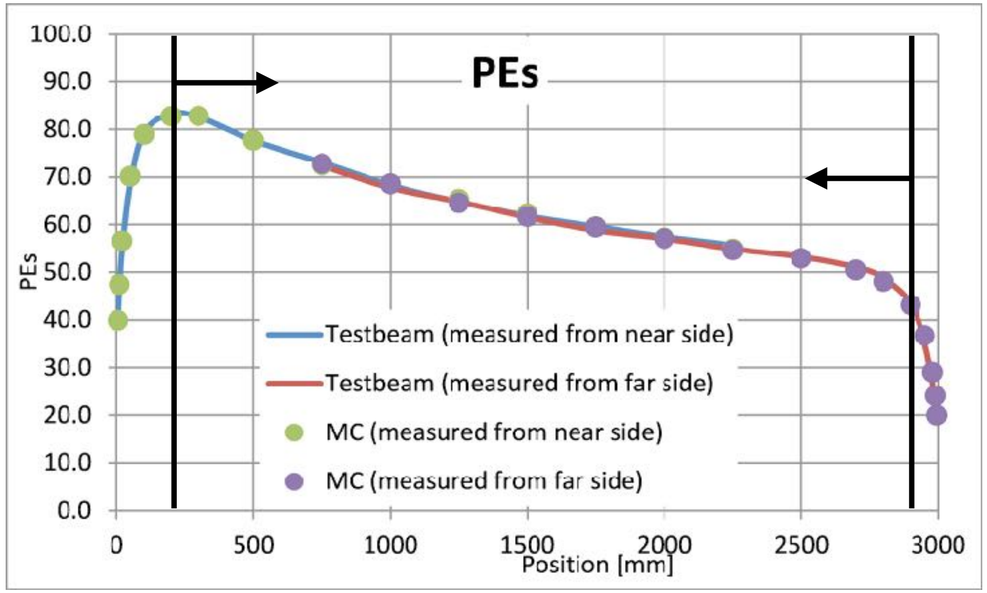




ND-GAr lite: Pattern recognition.

How to do tracking?

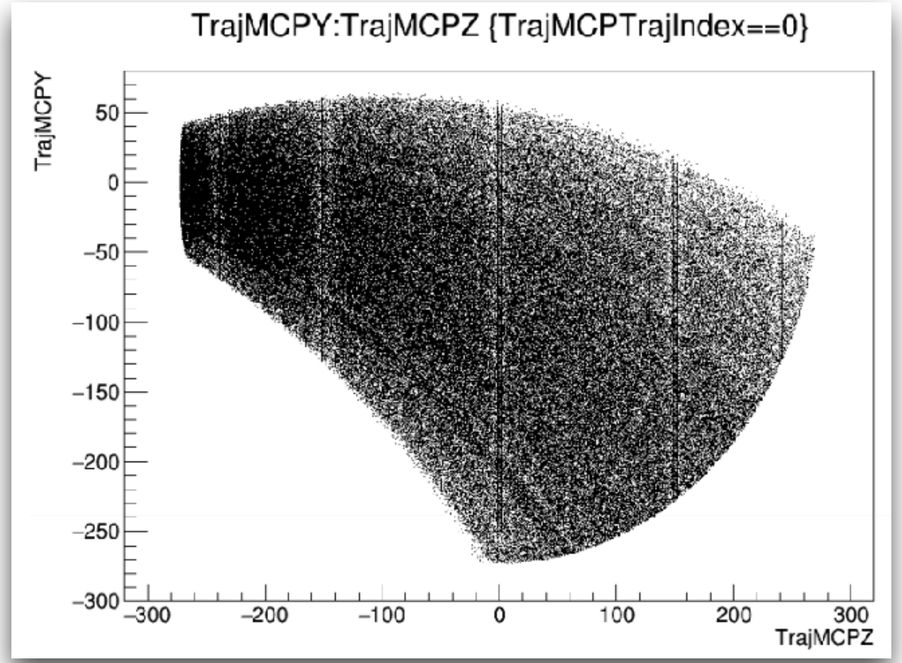
- Three hits are needed to fit a circle in the YZ plane
- Planes hits are parametrised based on
  - Point resolution < 3 mm
  - Mu2e scintillator performance
    - ~60% scale for light yield (50 pe at near end -> 25 pe at 6 m)
    - ~ 1 ns time resolution
- Find triplets of hits that have no more than one hit per plane
  - Create a candidate track and find all hits within 5 cm of the track. Pick the closest hit to the track in each plane
  - Triplet with the most added hits is chosen as the best candidate track
  - For now, only one track is found per event
- Using a circle fitter from OPAL reconstruction code
  - N. Chernov and G. Ososkov (Dubna), Comput. Phys. Commun 33, 329.

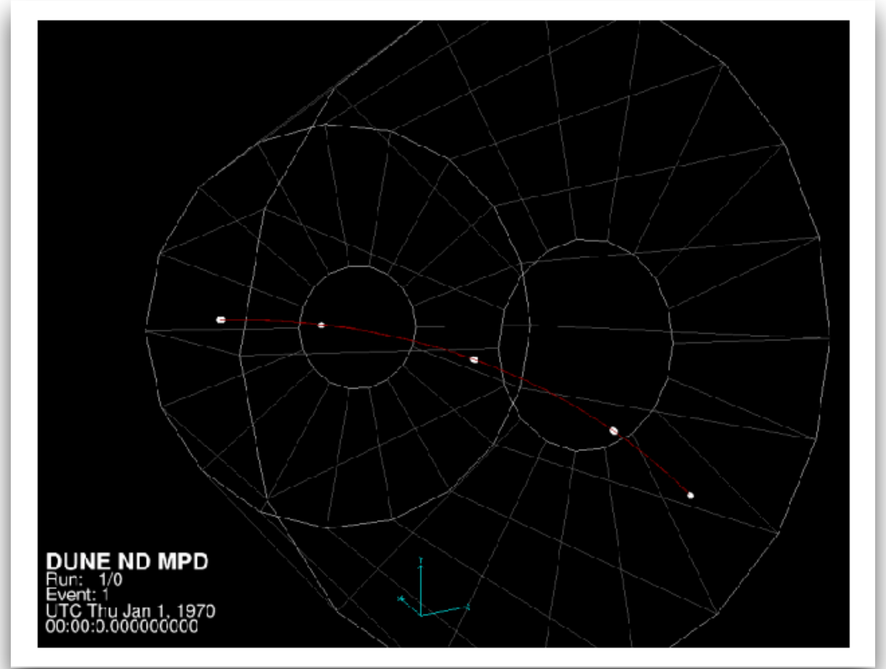


ND-GAr lite: First tests.

Reconstructing tracks

- Using a 10k sample of particle gun muons
  - 1 GeV kinetic energy (p = 1.106 GeV/c)
  - 20 degree cone
  - Shot at 6 m from the ND-GAr lite
- 95% of the muons hit at least 3 planes
- ~0.4% track are missed





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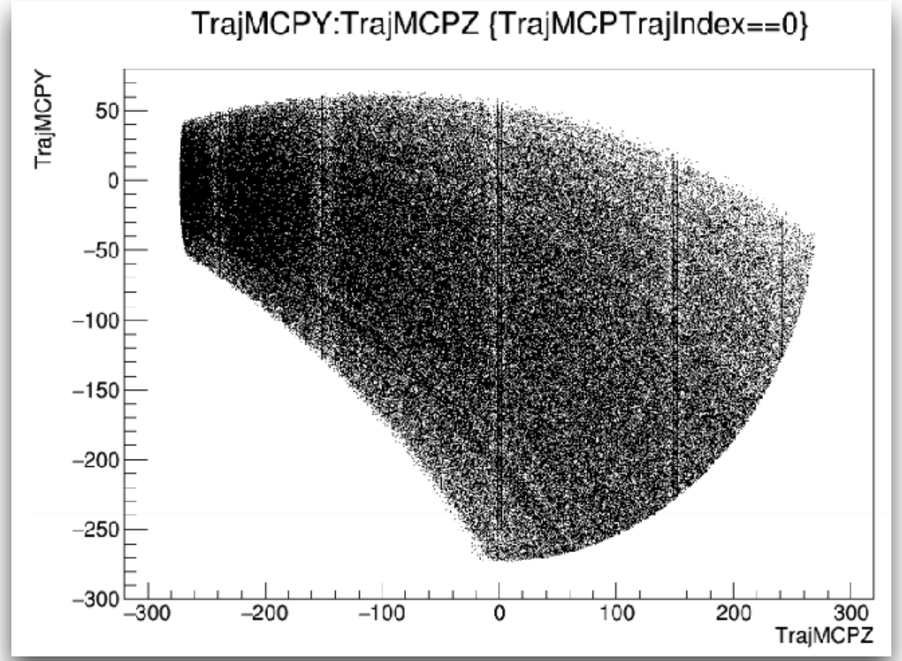
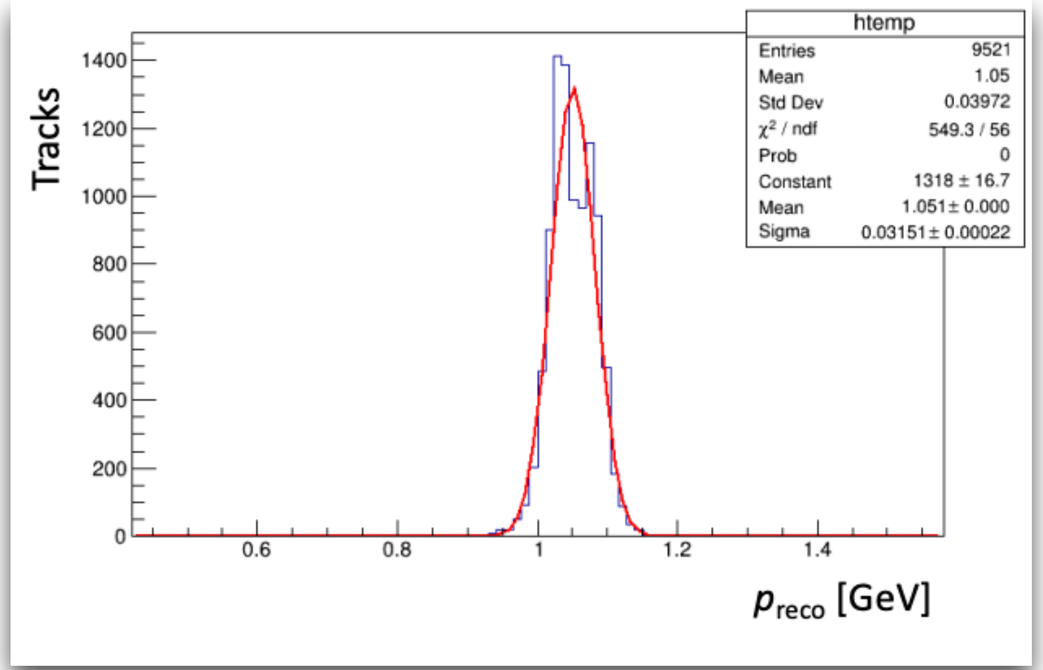
- Momentum resolution
  - Average momentum is off by 5%
  - Resolution at about 3%

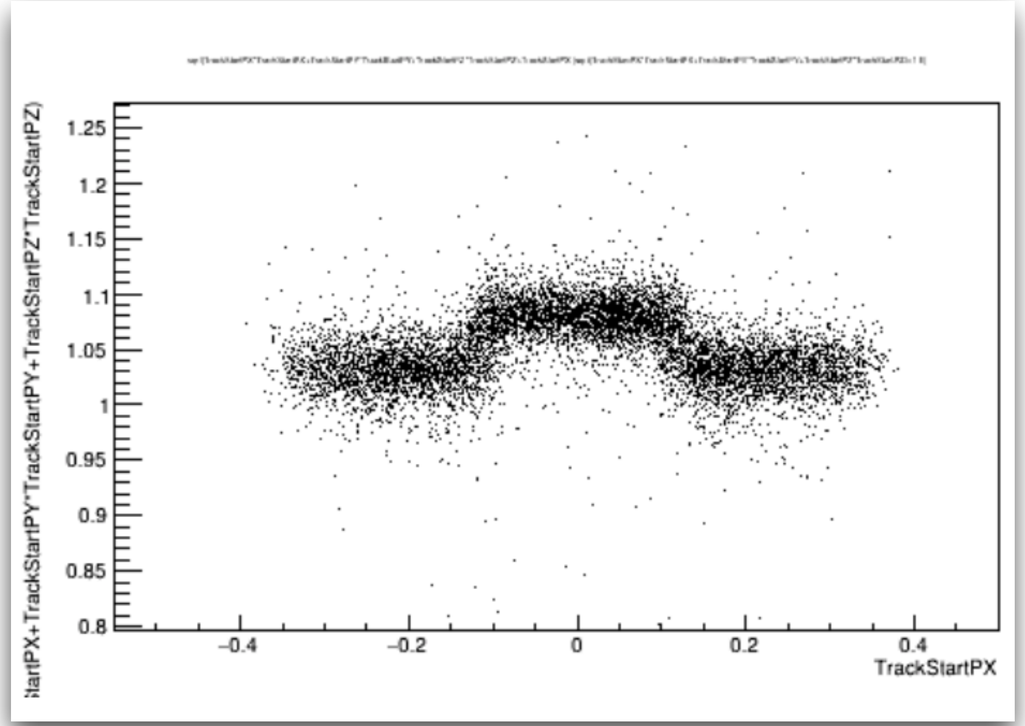




ND-GAr lite: First tests.

Understanding the bias

- Looking into more details
  - Found bias dependent of the X component
  - Look something detector geometry dependent!
- This is understood
  - -> Gap between solenoid cryostats at x = 0
  - Muons passing through the cryostats lose more energy



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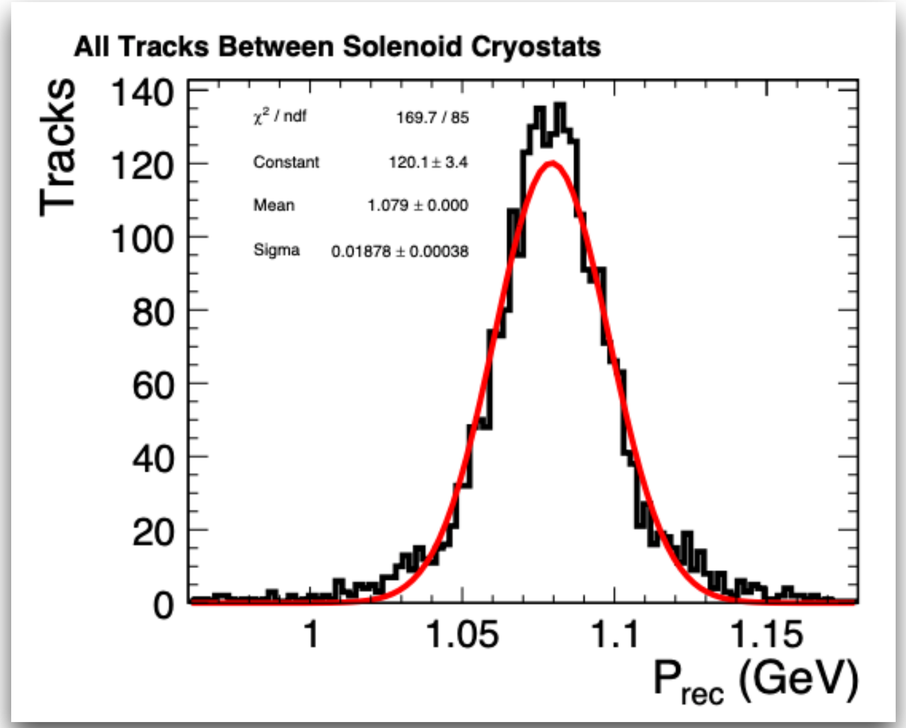
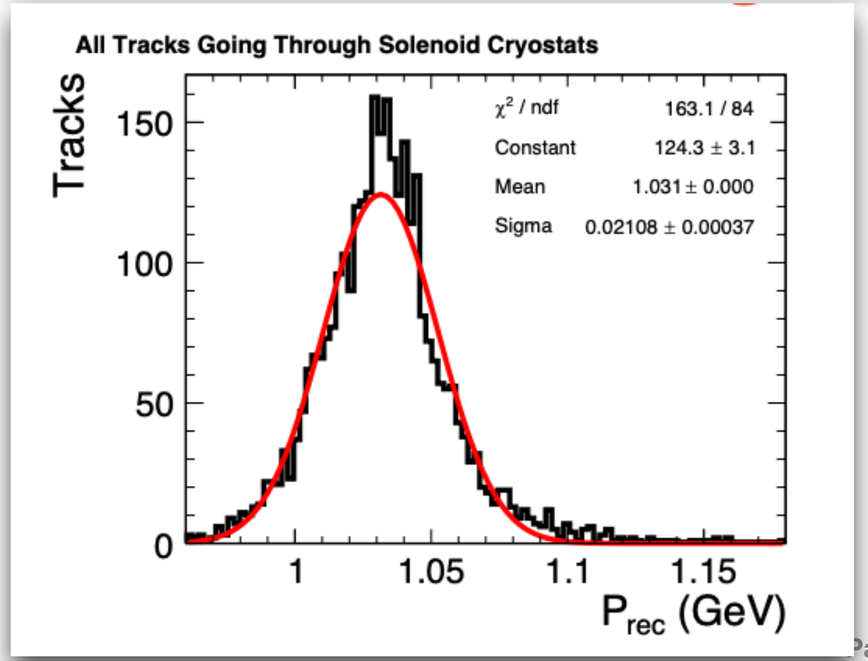
- This is understood
  - -> Gap between solenoid cryostats at x = 0
  - Muons passing through the cryostats lose more energy
- Resolution for the gap
  - 1.6% momentum resolution, bias 26 MeV
  - Bias due to energy loss in the scintillator planes
- Resolution for the cryostat
  - 2.1% momentum resolution, bias 71 MeV
  - Increase bias due to cryostat -> estimated to 40-50 MeV in 10 cm Al

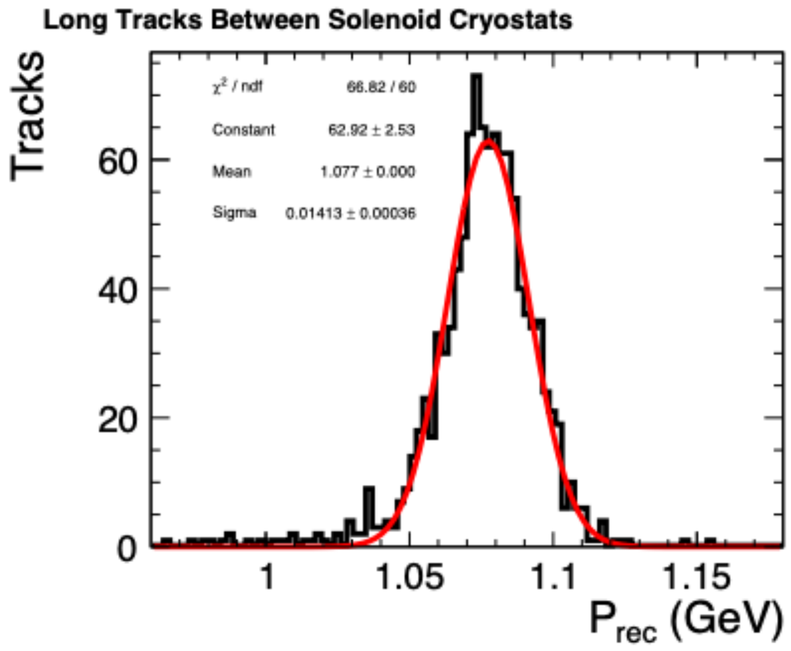


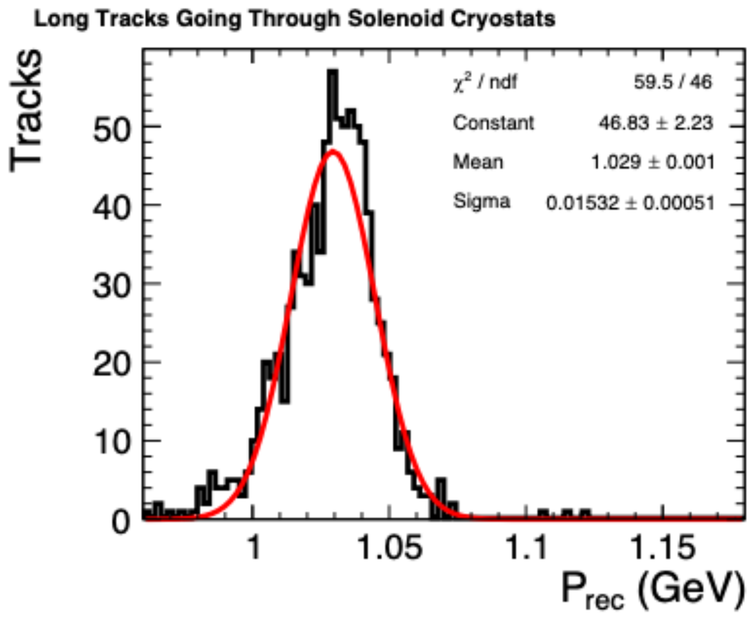


ND-GAr lite: First tests.

Resolution for long tracks (> 500 cm)

- Look at long tracks
  - Gap momentum resolution at 1.22%, bias 28 MeV
  - Cryostat momentum resolution 1.72%, bias 75 MeV
- Bias increases as expected

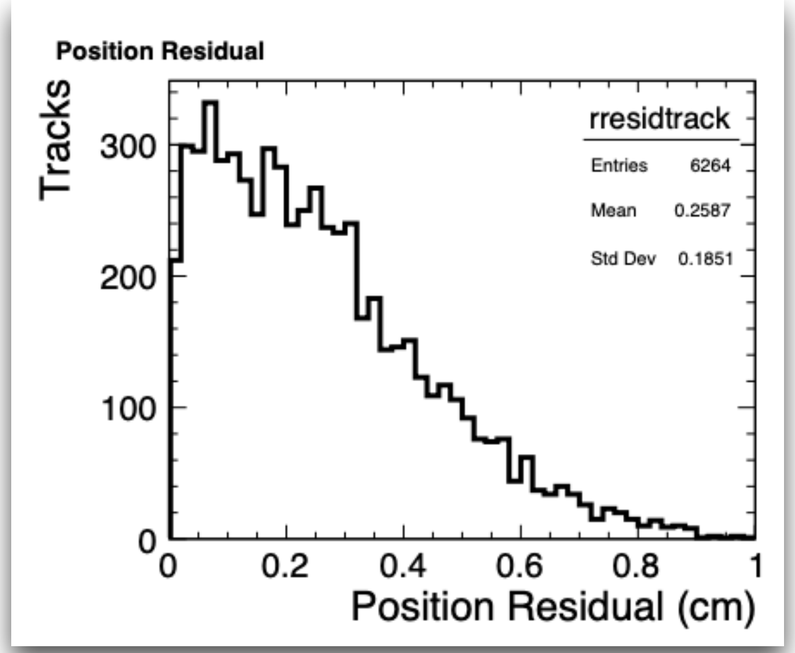


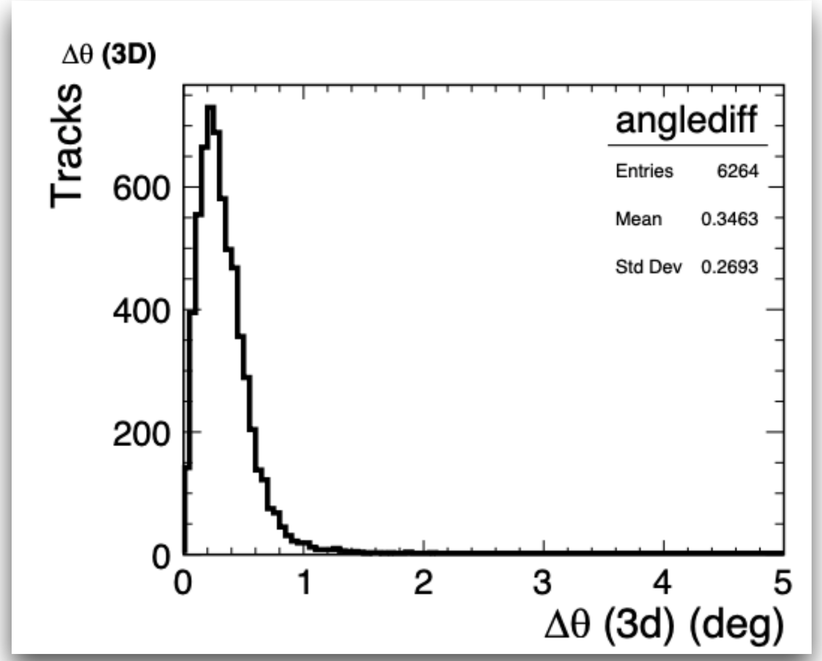


ND-GAr lite: First tests.

Position and angular resolution

- Essential to match ND-LAr tracks to ND-GAr lite tracks
- Check track from the first plane
- Compare with the MC trajectory position and direction
  - ~3 mm position resolution
  - ~0.3 degree angular resolution

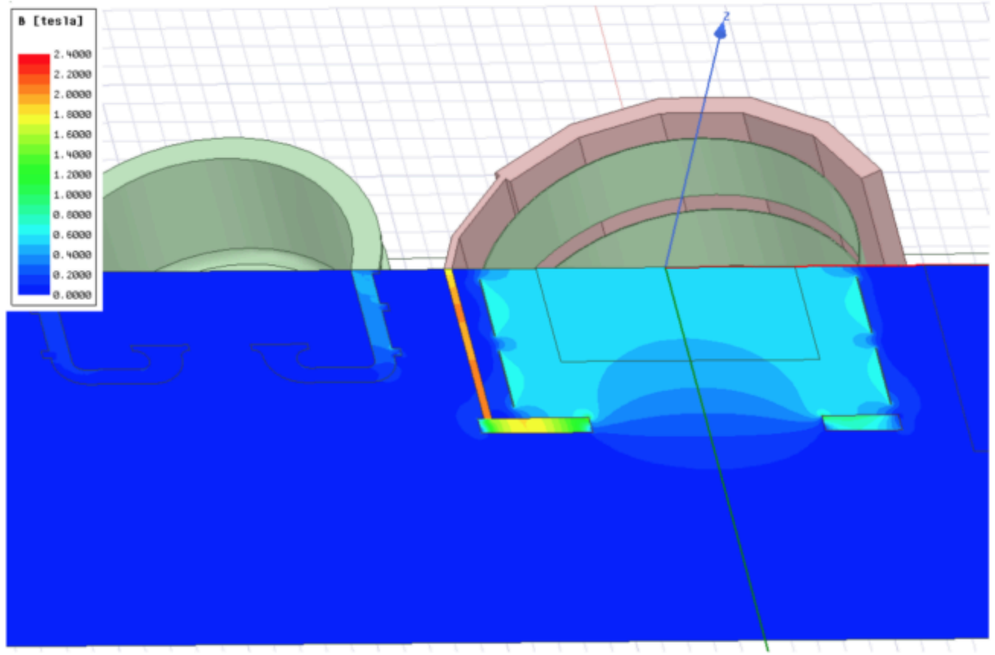




ND-GAr lite: Current software state.

What can we do better? What is missing?

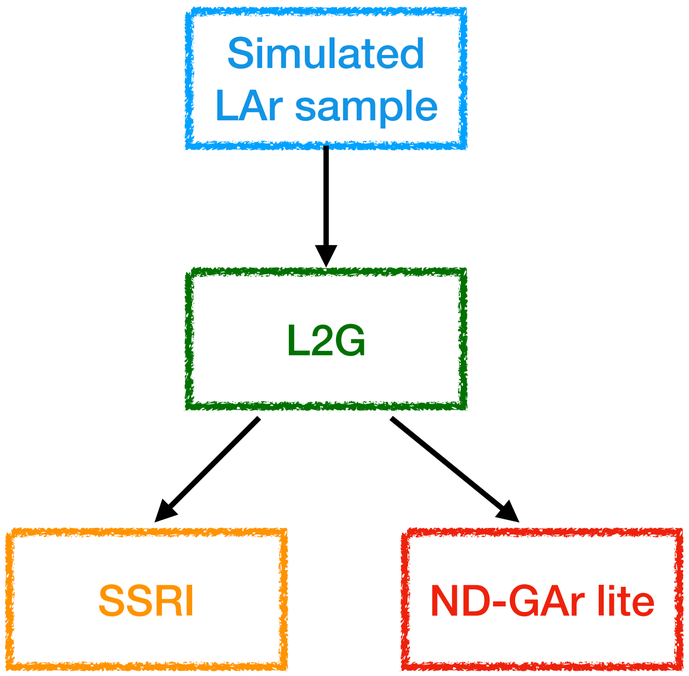
- The example above is just for testing, we need to test with a wider momentum range
- Need to put more realism in the track fitting
  - Kalman filter -> seed then step along the track, updating with new hits. Energy loss can be put in the fit
  - Minimised chi-square fit: may be better suited for such “simple” detector
- Constant B-field currently
  - Custom B-field is implemented in edep-sim/GArSoft
  - Stray field is important issue w.r.t the LAr, it may need to be mapped before installing the LAr + tracking in non-uniform field



ND-GAr lite: Current software state.

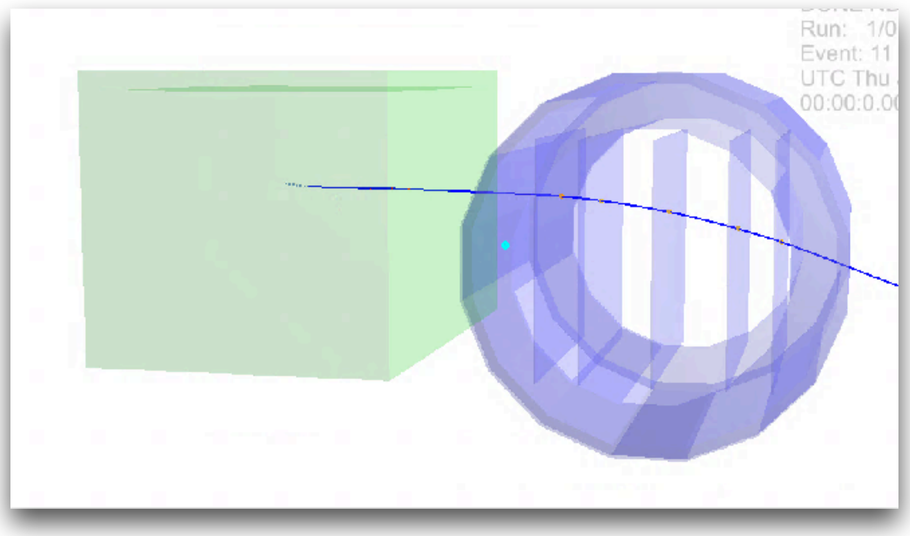
What can we do better? What is missing?

- Need to test harder the software chain
  - Strong need for LAr samples
  - Sample need to be foremost already simulated in edep-sim (could be LAr only geometry in the ND hall)
  - We can make an interface after that take outgoing particles and feed them to edep-sim with any TMS detector
    - Already working on this with Xianguo and Federico in the context of LAr + GAr (L2G)
    - Would speed up the simulation and simplify the procedure
    - B-field may need special care (but second order for now)
  - We need to use the same samples between the SSRI and ND-GAr lite to evaluate the detector performance



Next steps.

Understanding performance and limitations



- The ND-GAr lite geometry is implemented
- A first test at it shows a very good momentum resolution
- But still some work is needed
  - Proper sample of muons momenta range
  - Implement proper track fitter and take energy loss into account
  - Matching to LAr tracks -> may need some LAr reco/parametrisation?
  - Issue of the B-field: stray field in the LAr and tracking in the ND-GAr lite
- Understand the limitations of the ND-GAr lite? B-field and tracking plane optimisation
- Plans
  - Working on getting LAr samples and interface (L2G) with GArSoft (ND-GAr lite) to simplify the simulation procedure
  - Improve the fitting procedure
  - Evaluate the performance of the detector with different B-field/plane configurations