Near Detector Concepts and Simulation Overview

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3rd DUNE ND workshop

CERN, November 6-7, 2017

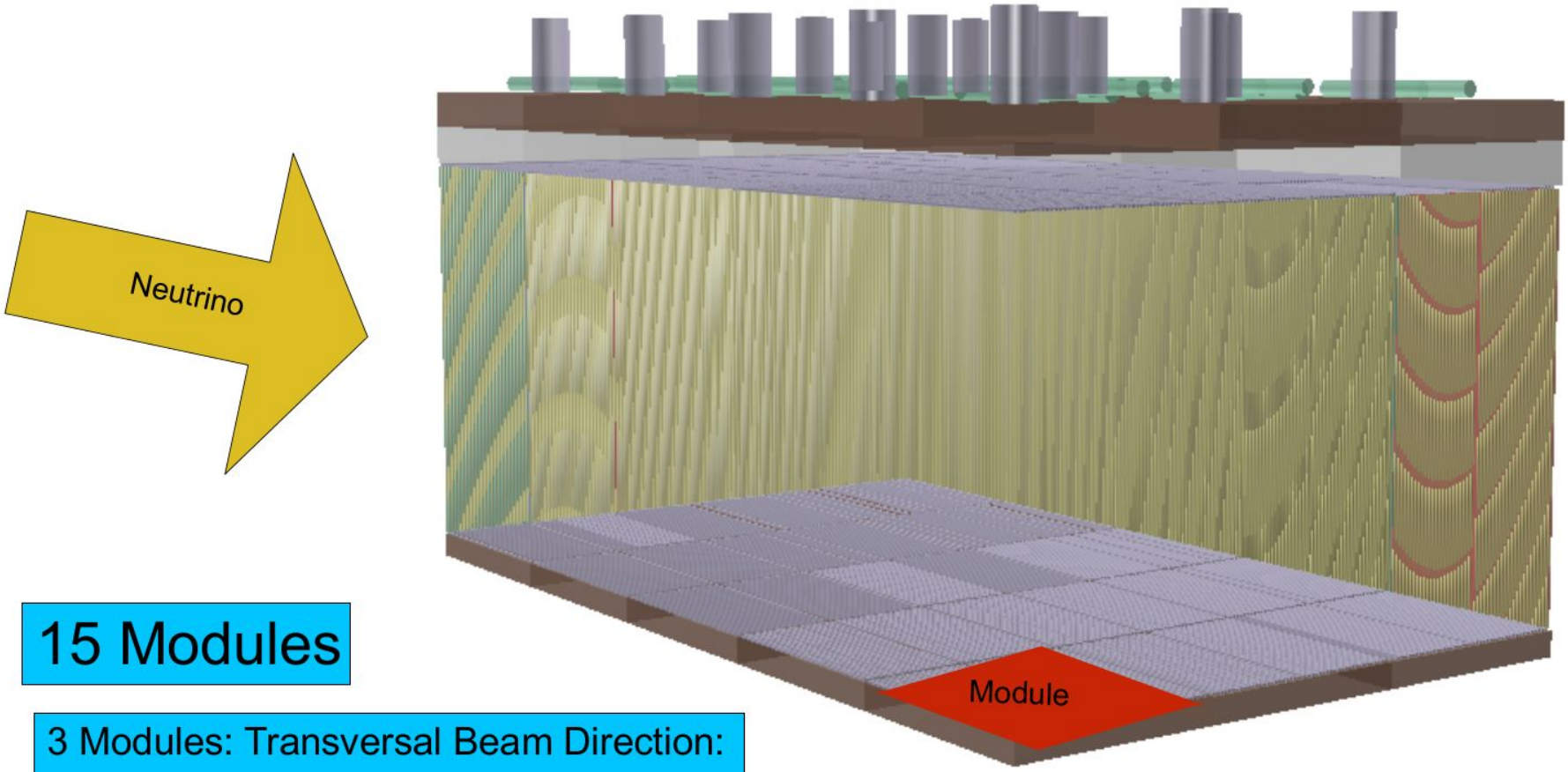
WILLIAM & MARY

CHARTERED 1693

Overview

- Near Detector Concepts & Geometries
  - ArgonCube
  - Iron dipole concept: STT, GArTPC, 3DST
  - KLOE
- Integrated concepts
- Simulation Overview
- Some events for fun

ArgonCube

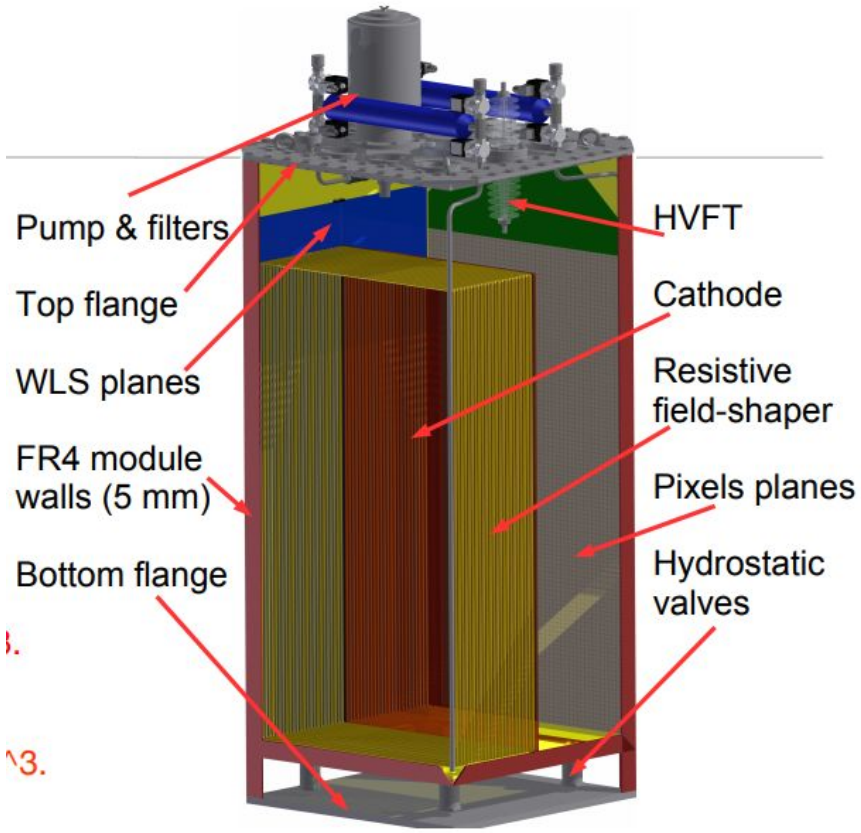


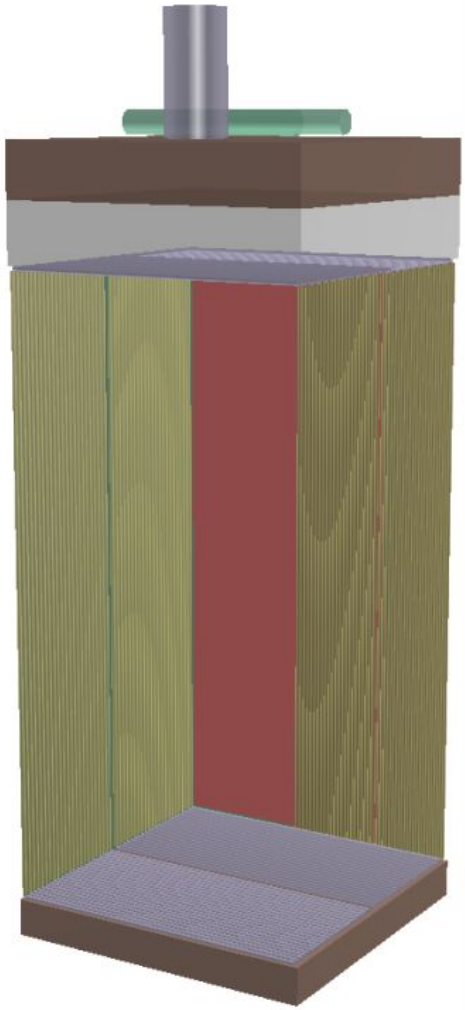
15 Modules

3 Modules: Transversal Beam Direction:
5 Modules: Beam Direction

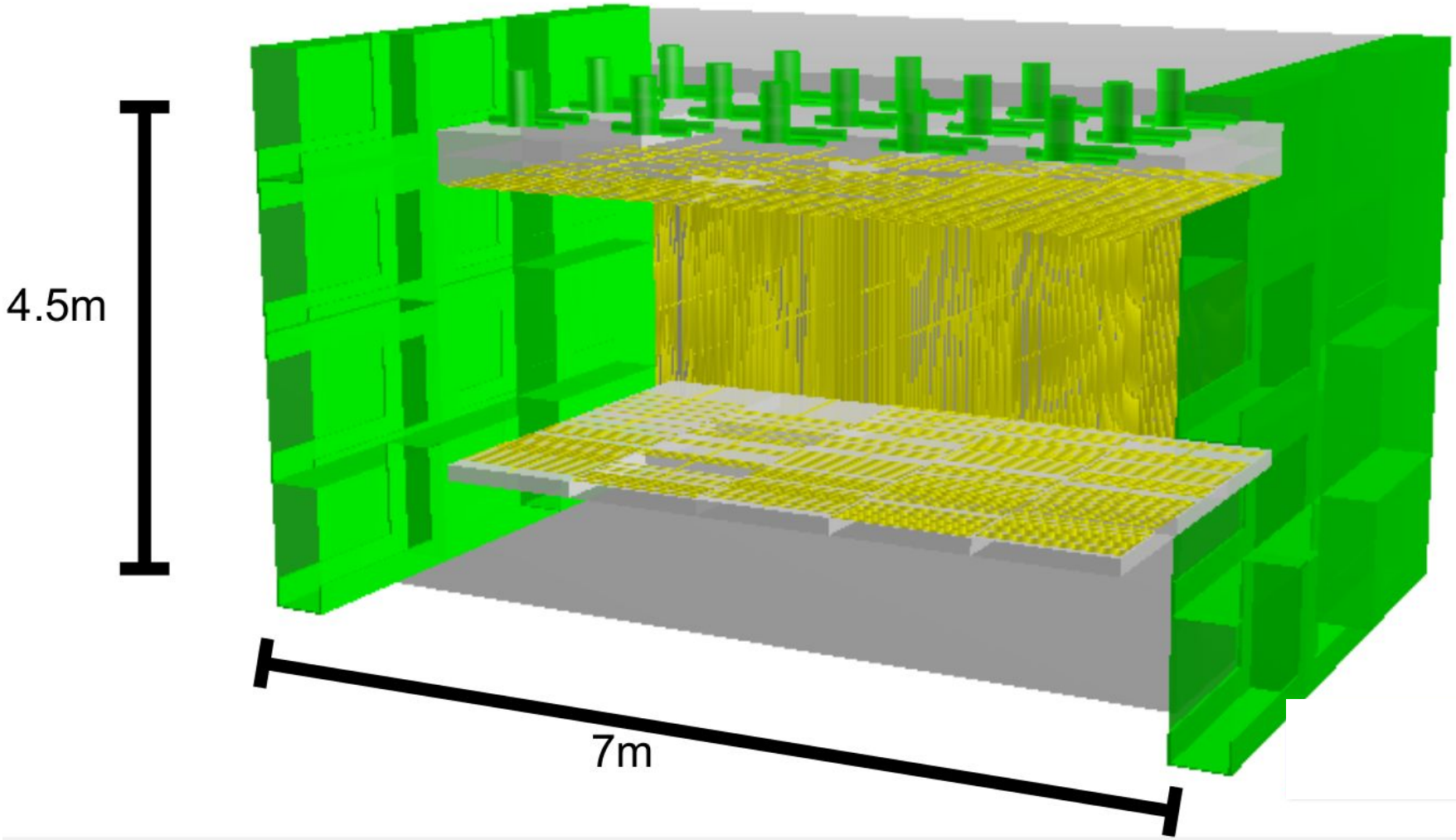
Credit:
Jose Palomino

ArgonCube

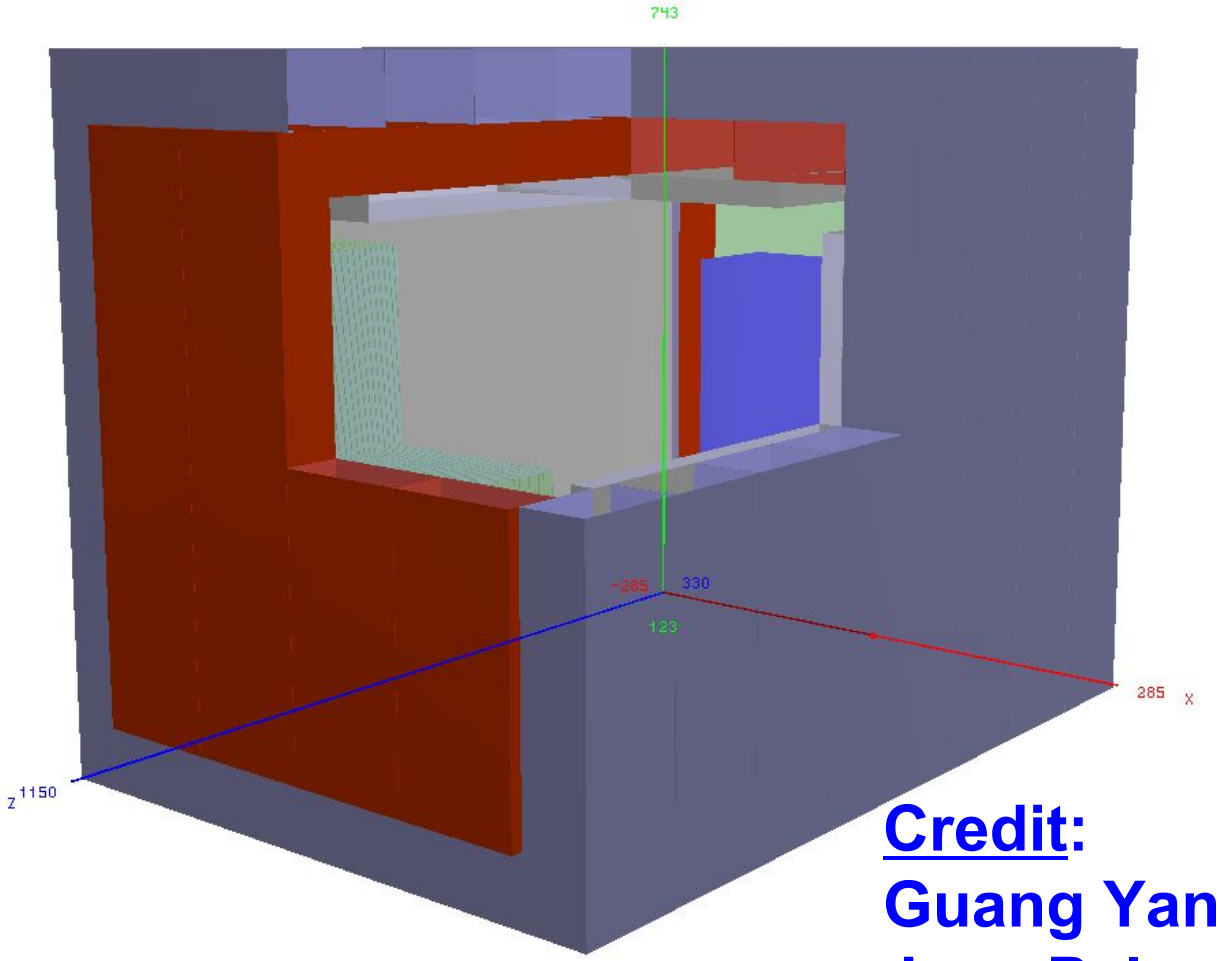

Pump & filters
Top flange
WLS planes
FR4 module walls (5 mm)
Bottom flange
HVFT
Cathode
Resistive field-shaper
Pixels planes
Hydrostatic valves



ArgonCube



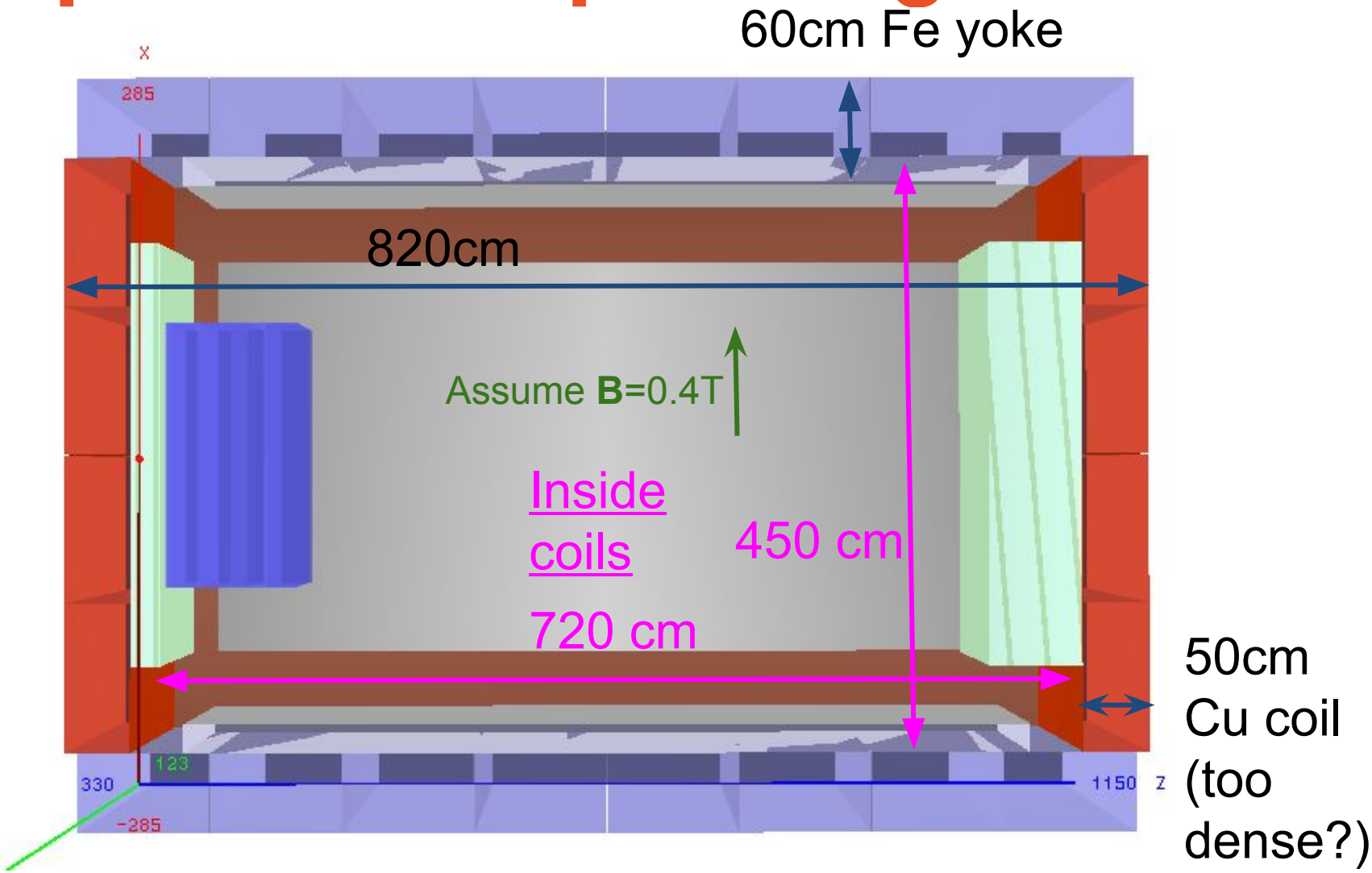
Dipole Concept



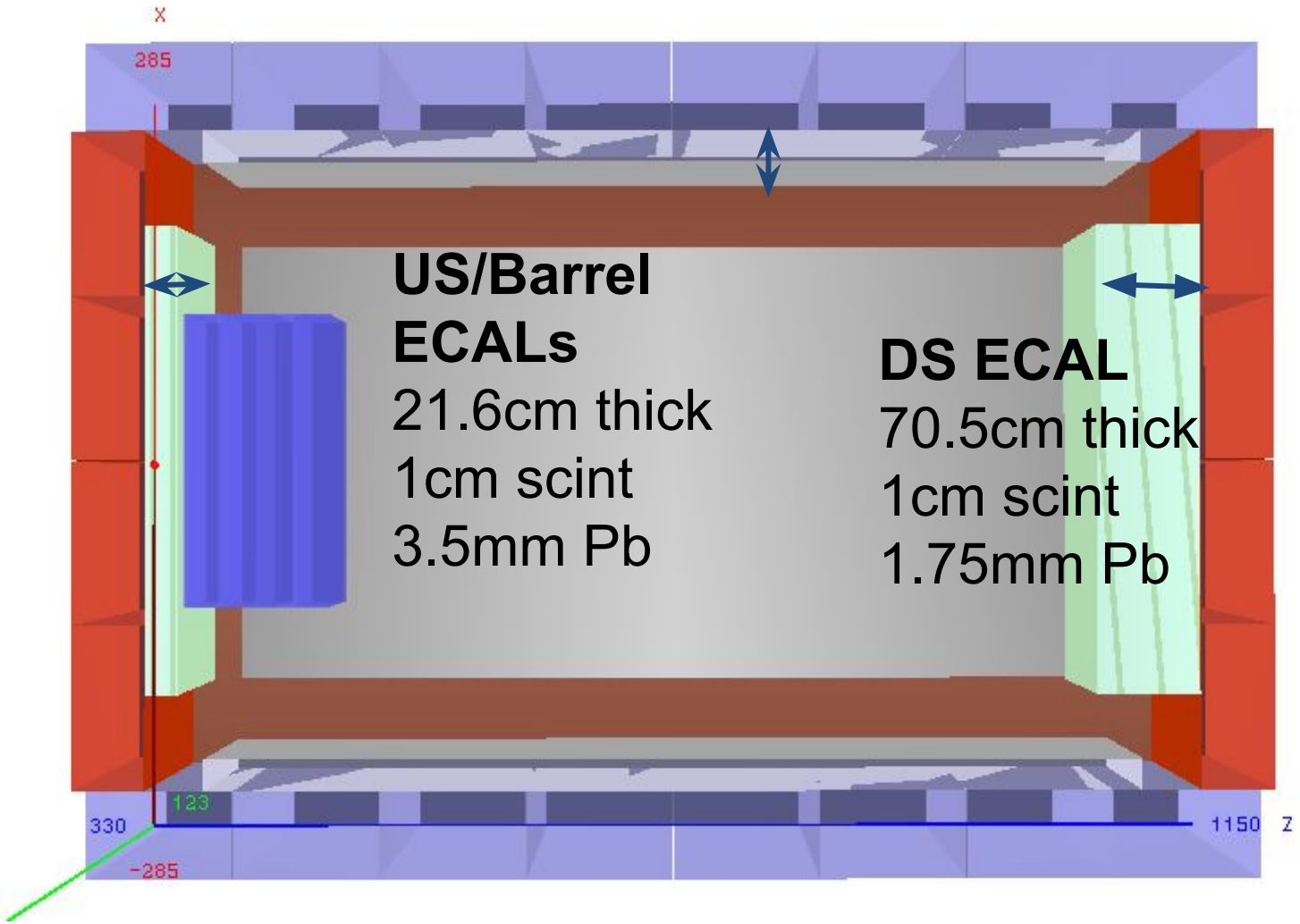
- Closely follows DUNE TDR reference design
- UA1-like warm dipole
- Coils inside of an iron yoke
- Field along x
- US,DS and Barrel ECALs
- Muon system in yoke (not shown)

Credit:
Guang Yang
Jose Palomino

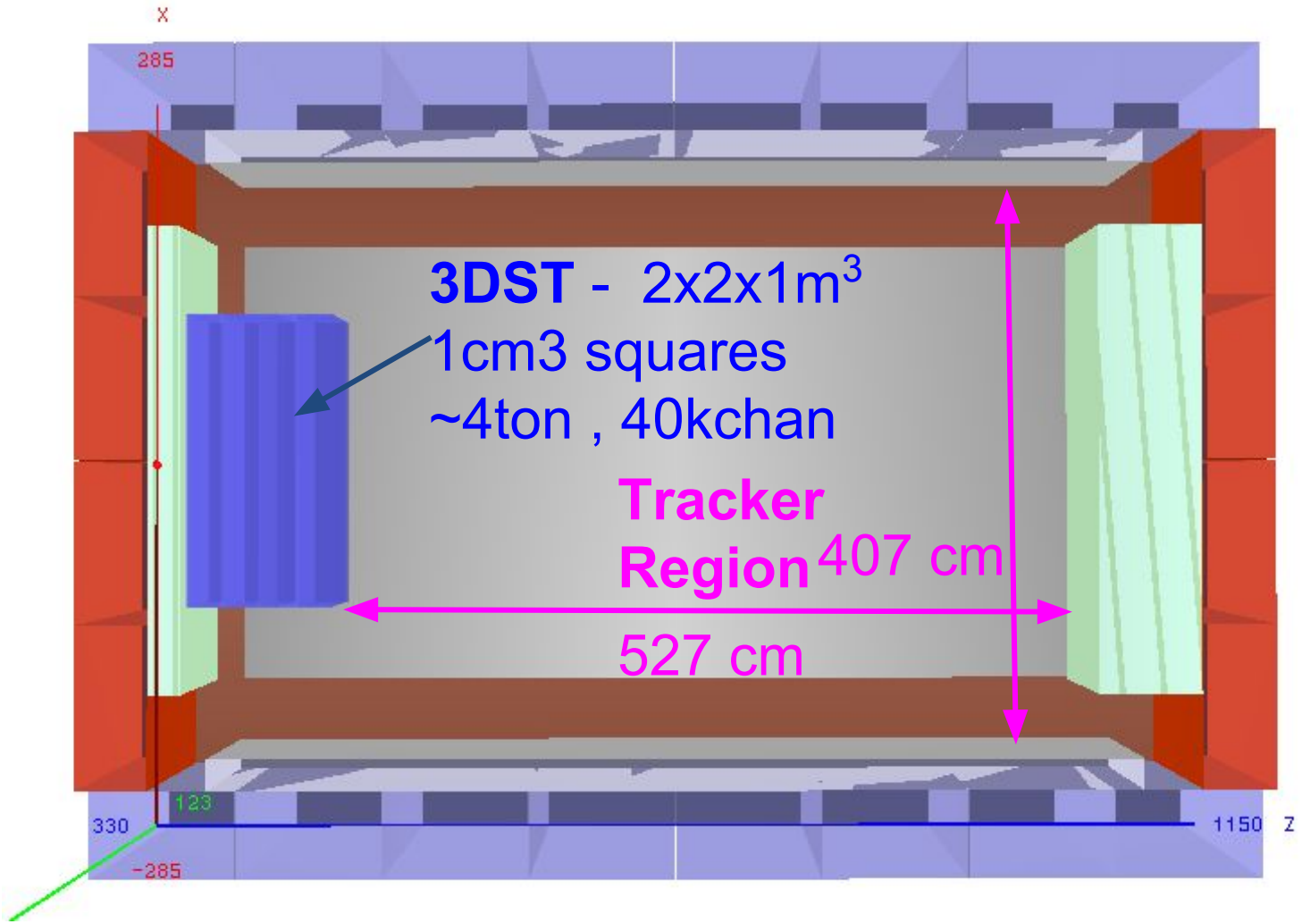
Dipole Concept - Magnet



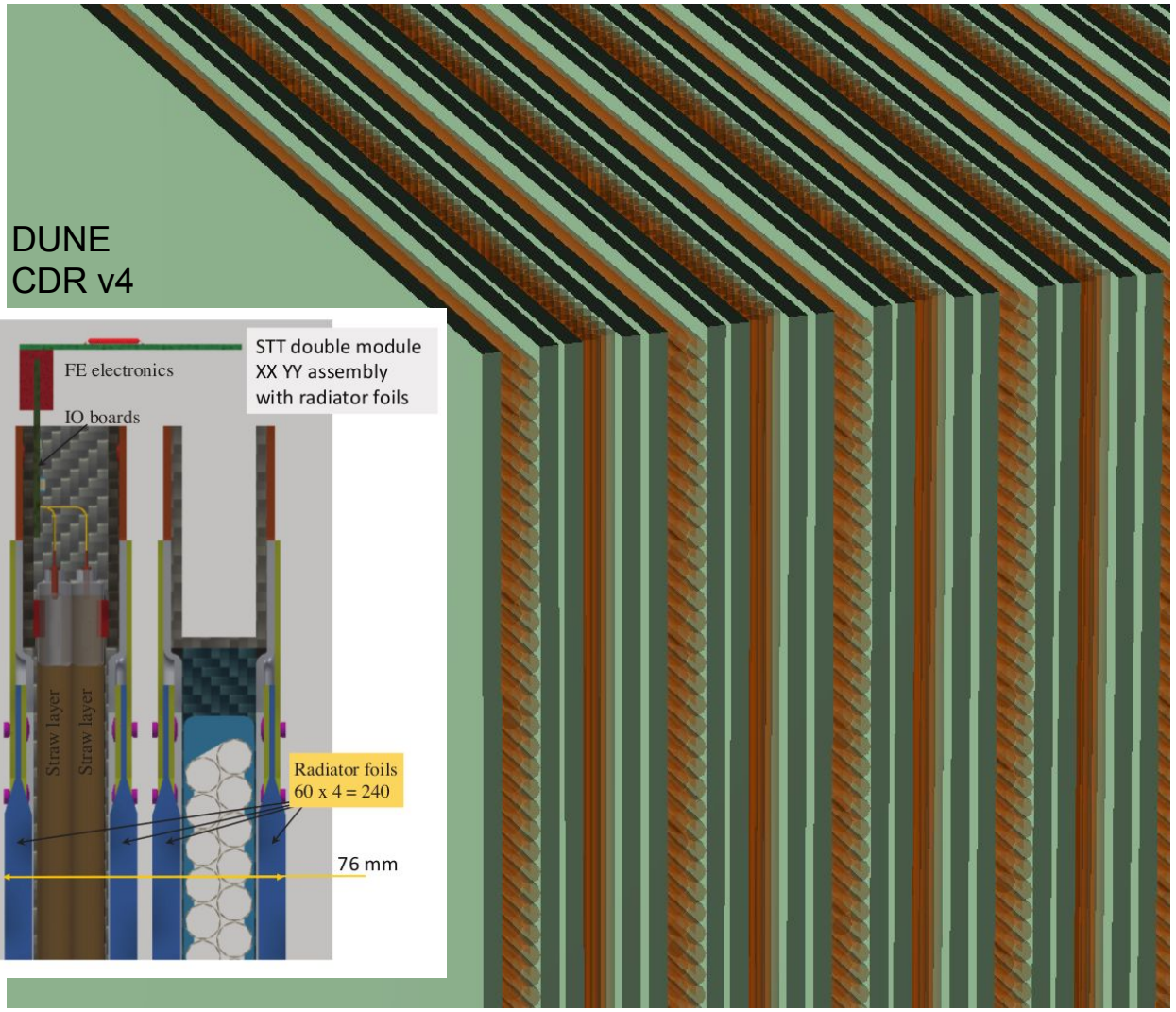
Dipole Concept - ECALs



Dipole Outer Detectors

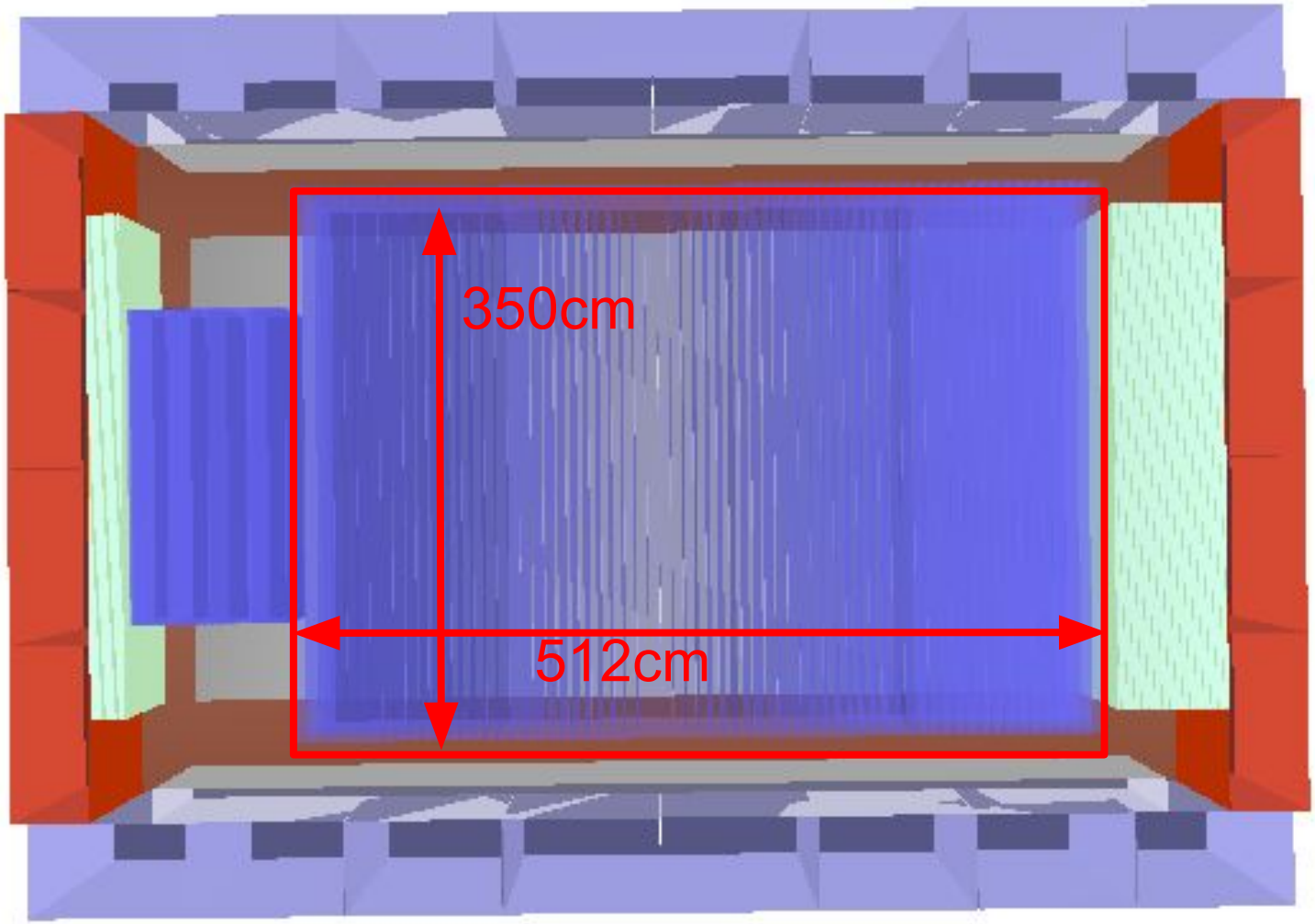


Straw Tube Tracker



- **Replicates the CDR reference design**
- **Straws**: d=1cm, 70um Kapton, two layers XX or YY
- **Radiators (R)** =9mm thick radiators, 0.16g/cc mix of air and polypropylene
- **Double module** consists of RXXR RYYR
- **Module width** = 7.5cm
- **Module pitch**=8cm

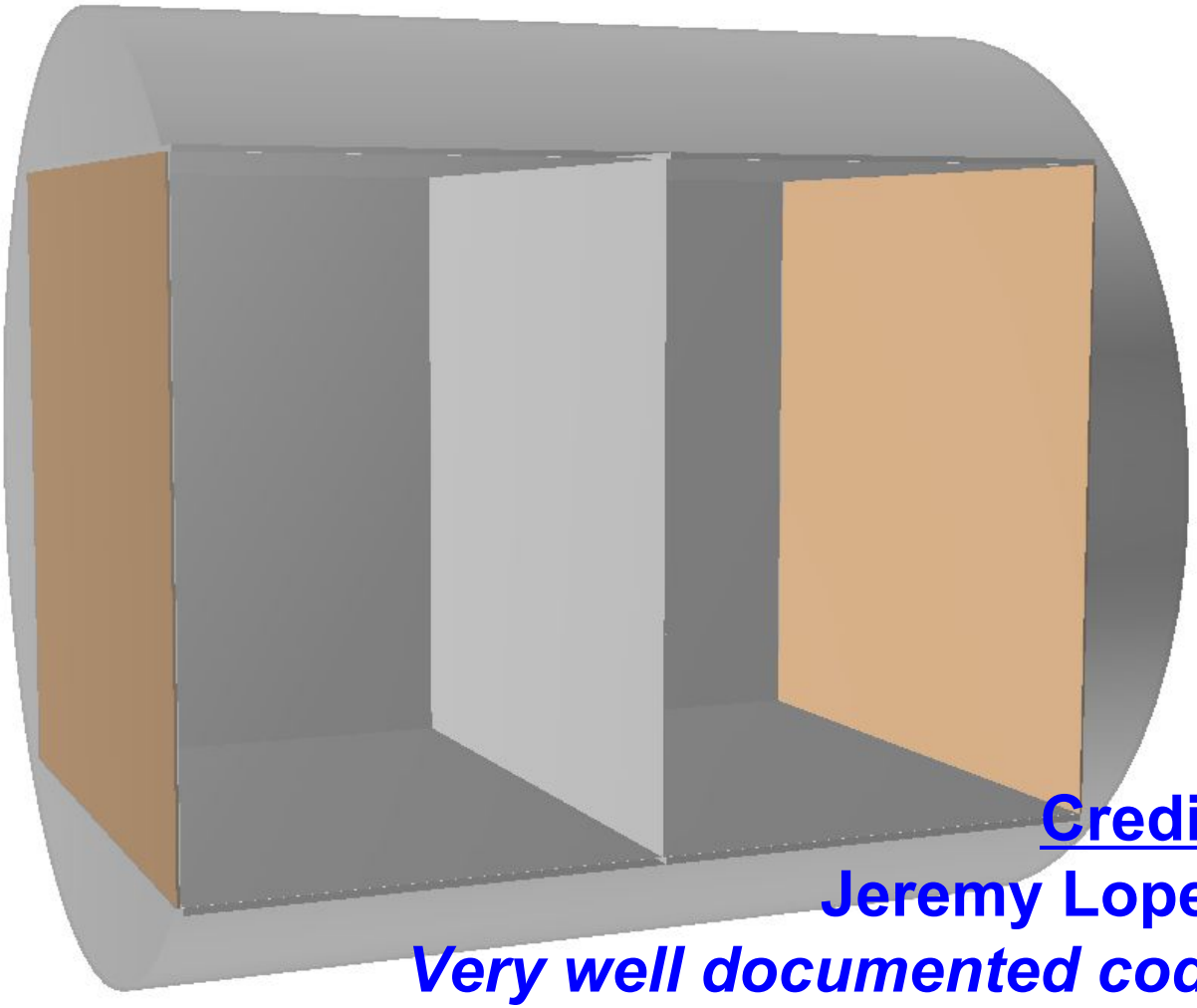
Dipole with STT



64 double modules
Each with 1398 straws
89.5k straws in total

5.4 ton = 0.58 interactions /spill

GArTPC @ 10 atm



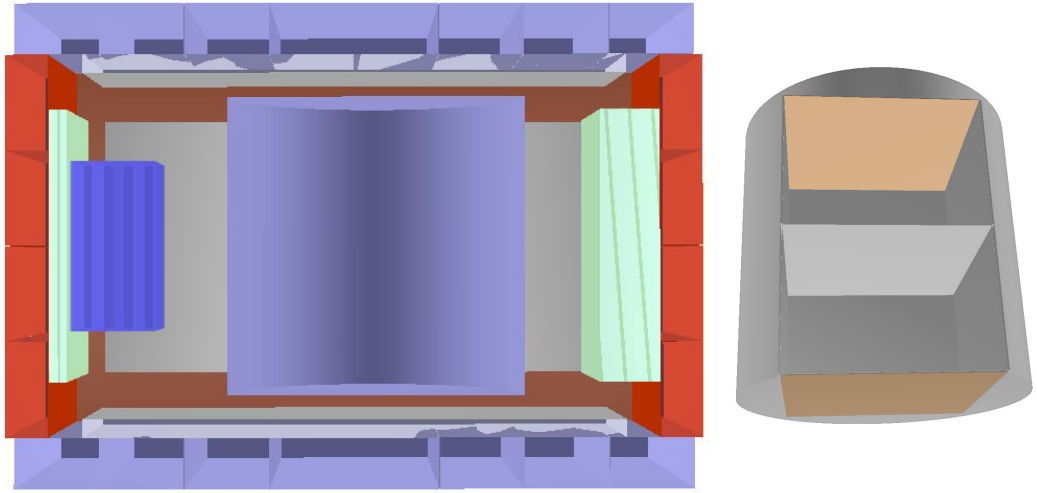
Credit:
Jeremy Lopez
Very well documented code

- **Based on ALICE**
- **Vessel** 1cm thick steel cylinder
- **Gas:** 10 atm Ar (9atm) CO_2 (1atm)
- **Central Cathode** Nomex honeycomb with Mylar skin, 6mm thick
- **Readout Anodes** 5mm FR4 with 1.5 cm Al frame
- **Field cage** 21 cm Nomex, Tedlar, Kevlar
- **E** = 400 V/cm, 2.7cm/us (ALICE spec)

Choices, choices

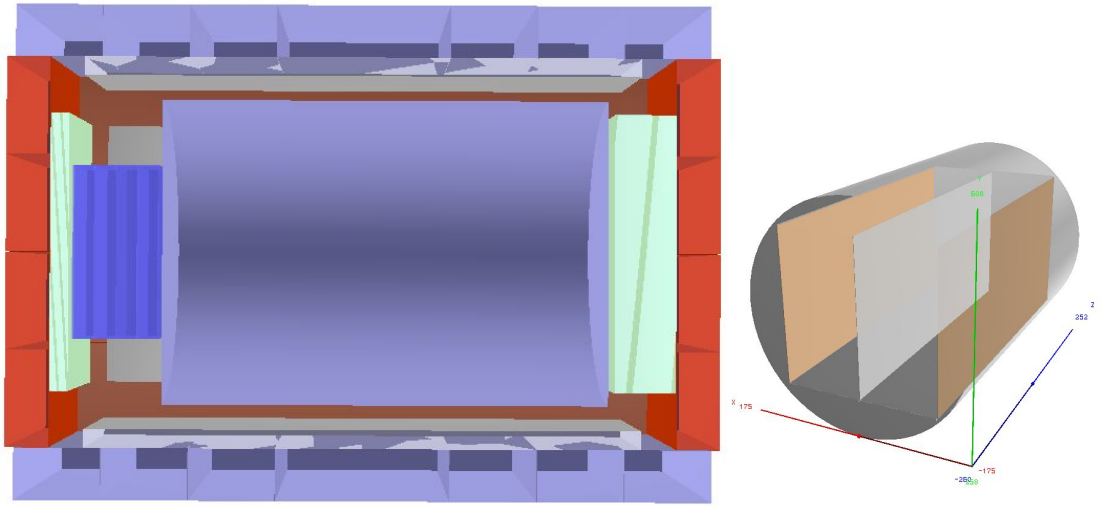
Option

A



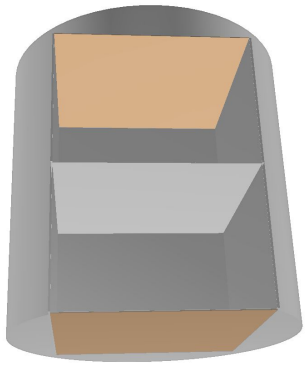
Vessel =0.64 t
TPC=⅔ Vessel
= 0.43t

B



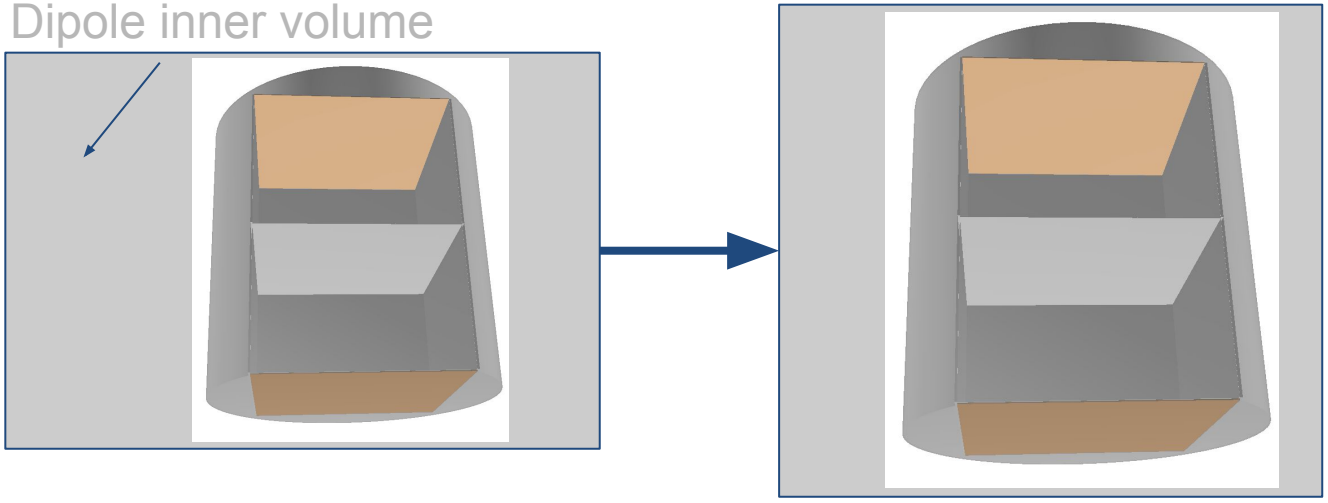
Vessel = 0.91t
TPC = 0.60 t

Square peg, round hole



Cylindrical readout gives 50% more events. Should this be the baseline?

Dipole inner volume



Consider reshaping GArTPC dipole?

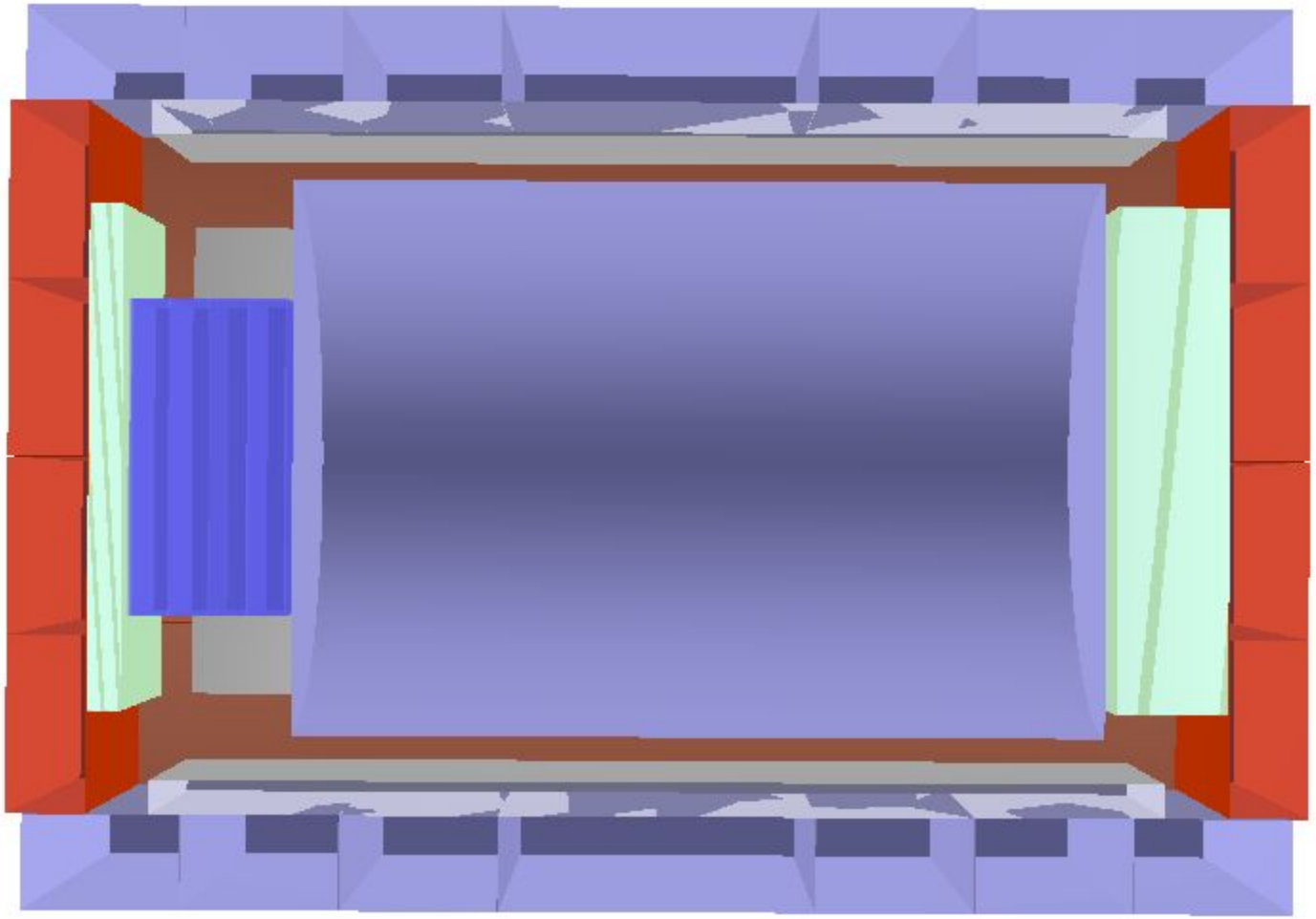
How to make "fair"?

Same energy?

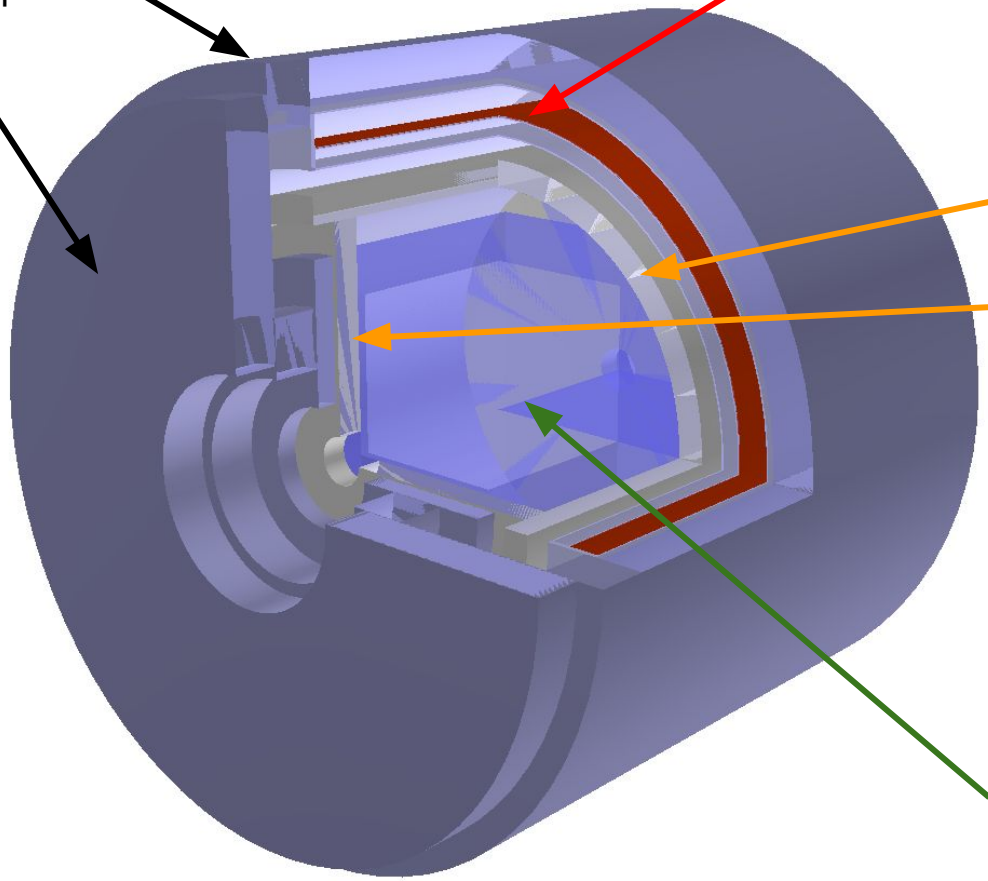
Materials?

Costing?

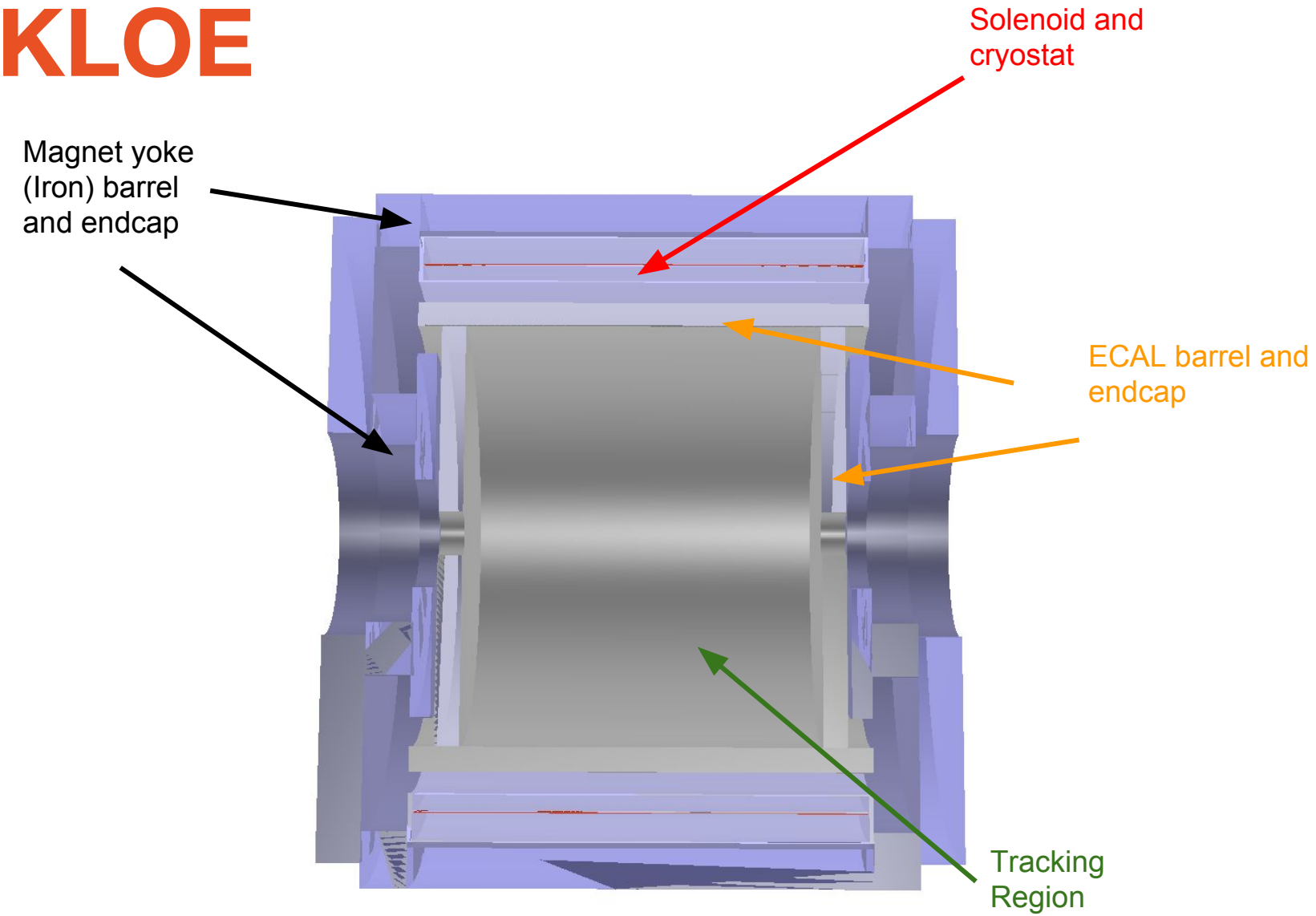
For now, Dipole + GArTPC



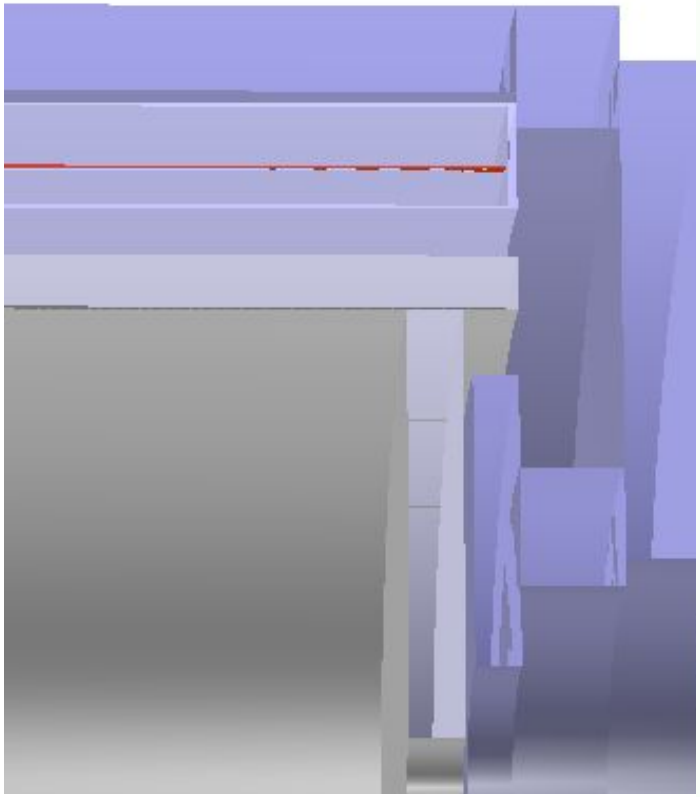
KLOE

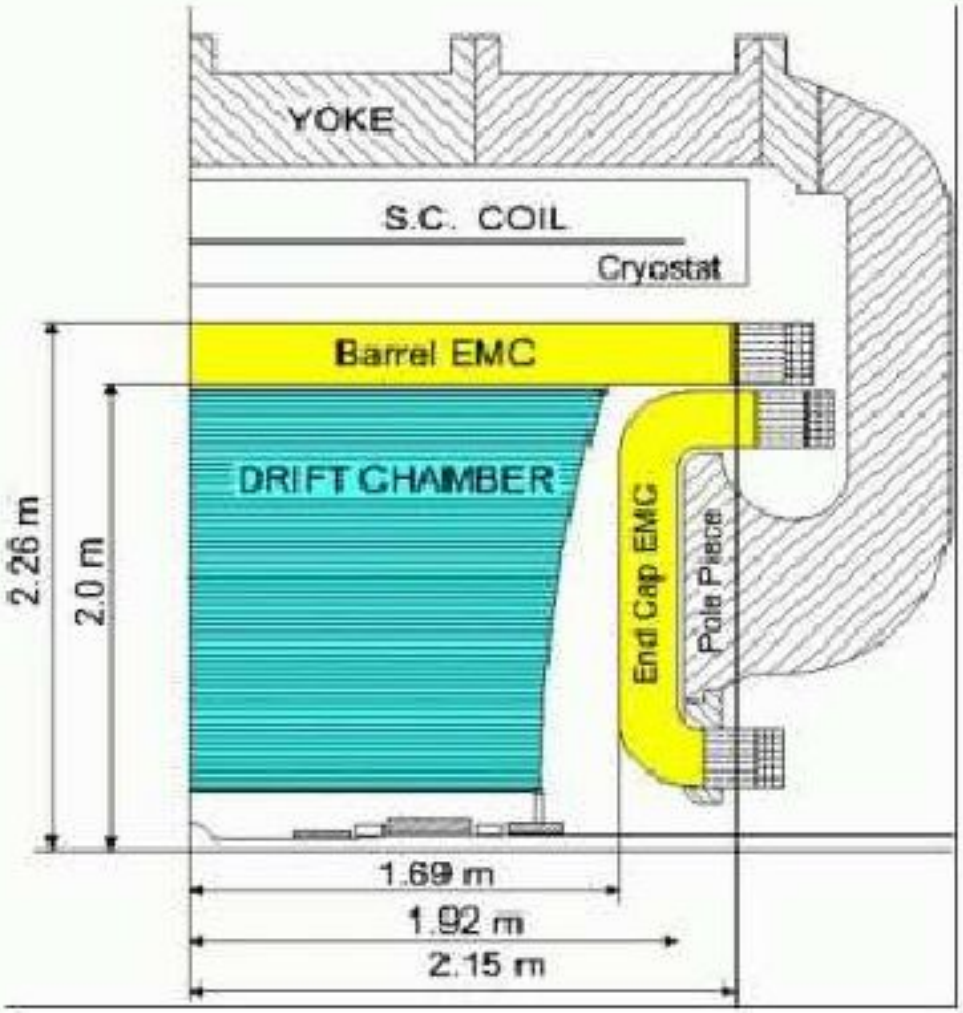

Solenoid and cryostat
Magnet yoke (Iron) barrel and endcap
ECAL barrel and endcap
Tracking Region

KLOE

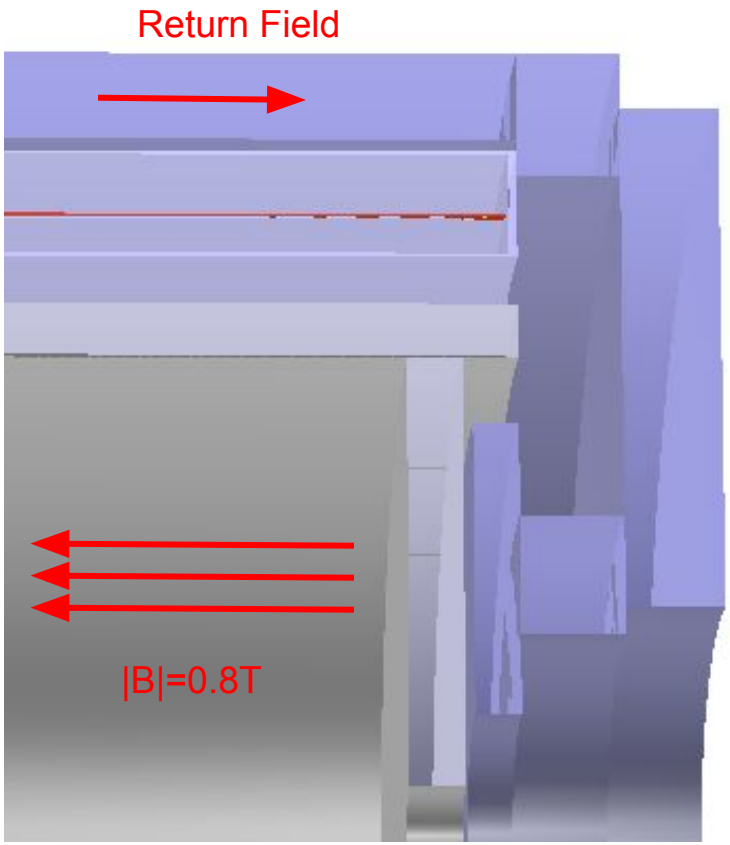

Solenoid and cryostat
Magnet yoke (Iron) barrel and endcap
ECAL barrel and endcap
Tracking Region

KLOE



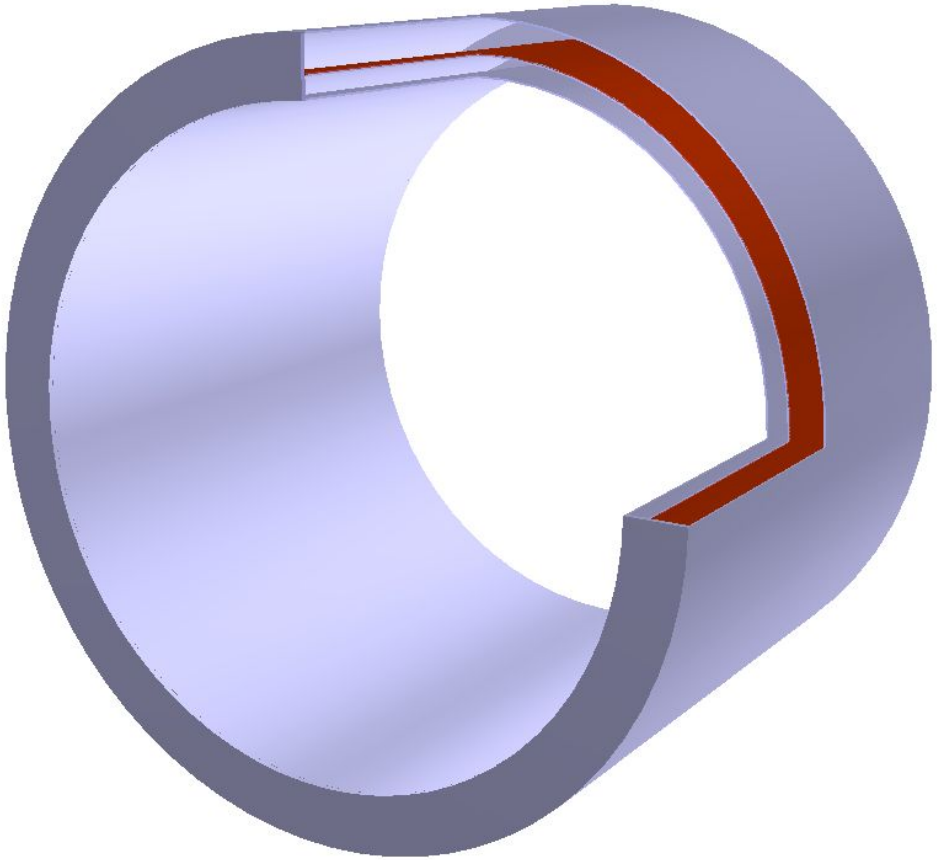

YOKE
S.C. COIL
Cryostat
Barrel EMC
DRIFT CHAMBER
End Cap EMC
Pole Piece
2.26 m
2.0 m
1.69 m
1.92 m
2.15 m

KLOE Magnetic Field



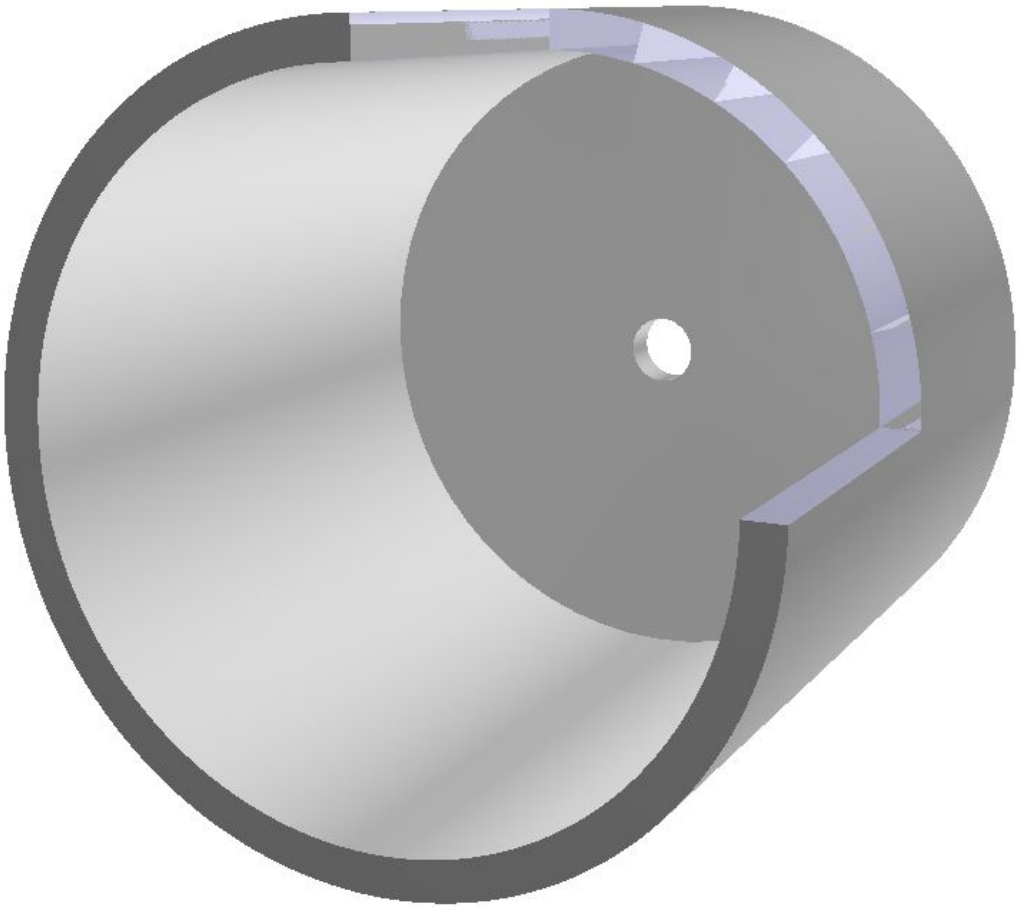
- Done crudely *at the moment*
  - DUNEGGD is useful for specifying geometry
  - Complex fields in GEANT require a geometry + algorithm
  - Thinking about how best to do this.
- Uniform 0.8T (configurable) field inside solenoid
- Return field in barrel only
  - Magnitude by ∫B.da conservation
  - Uniform
- All others zero

KLOE Solenoid



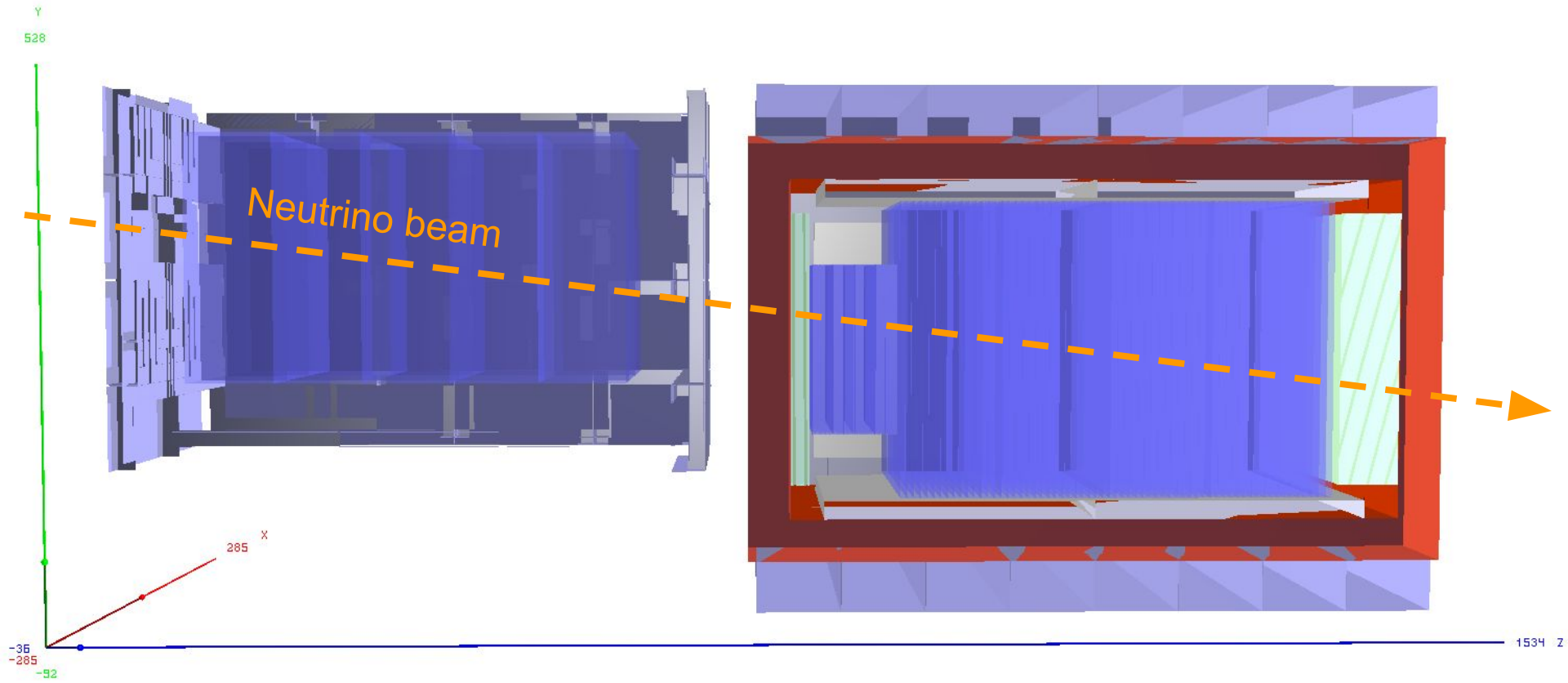
- Modeling:
- inner and outer cryostat walls+radiators
  - 12+3mm Al each
- Endcaps: 40mm Al
- Coil shell: 11mm Al
- Coil: 10mm Cu
  - Just a placeholder, need more information.

KLOE ECAL

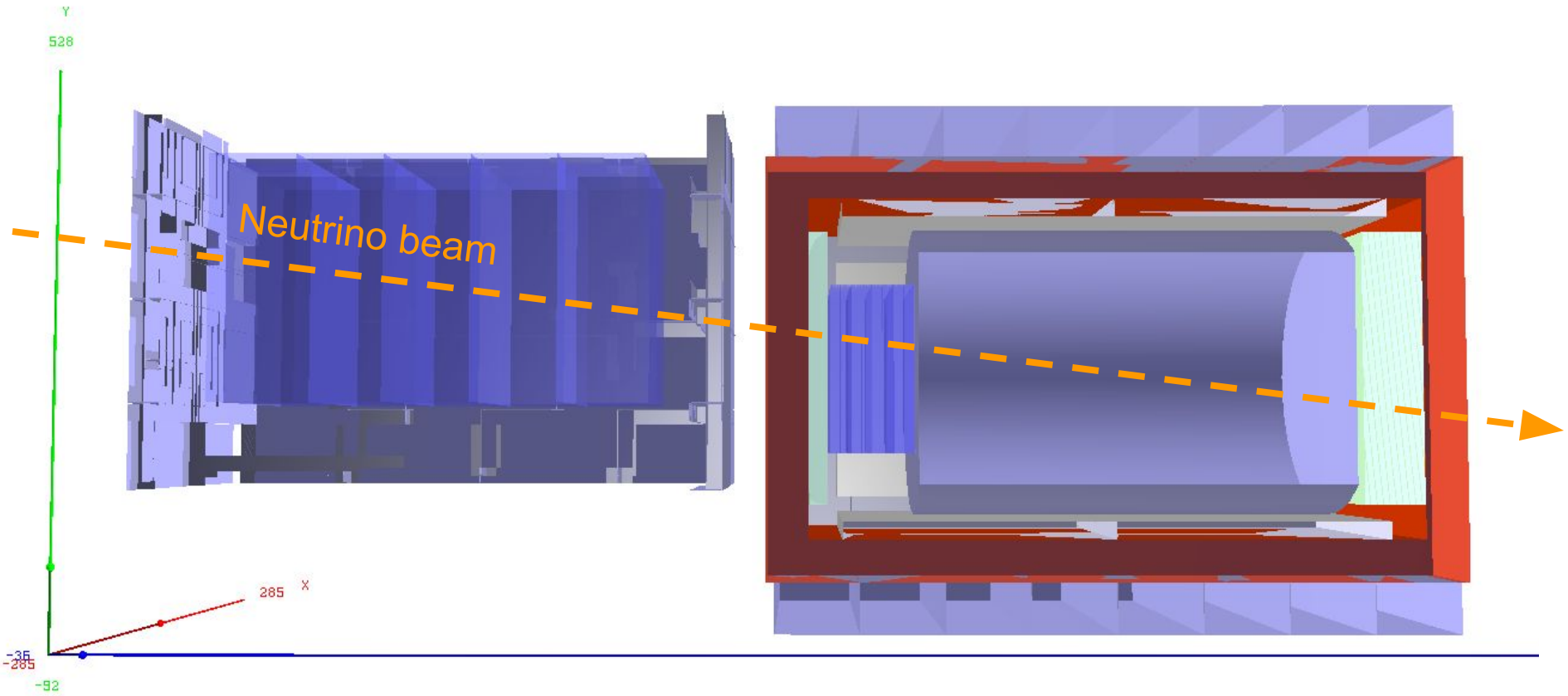


- Pb:Sci:epoxy 42:48:10%
- Segmented in 15 degree wedges around barrel
- Endcaps modeled as disks
  - Could improve
- Real life: Ends couple to multiple light guides to provide segmentation
- Readout simulation will need to segment, as in real life

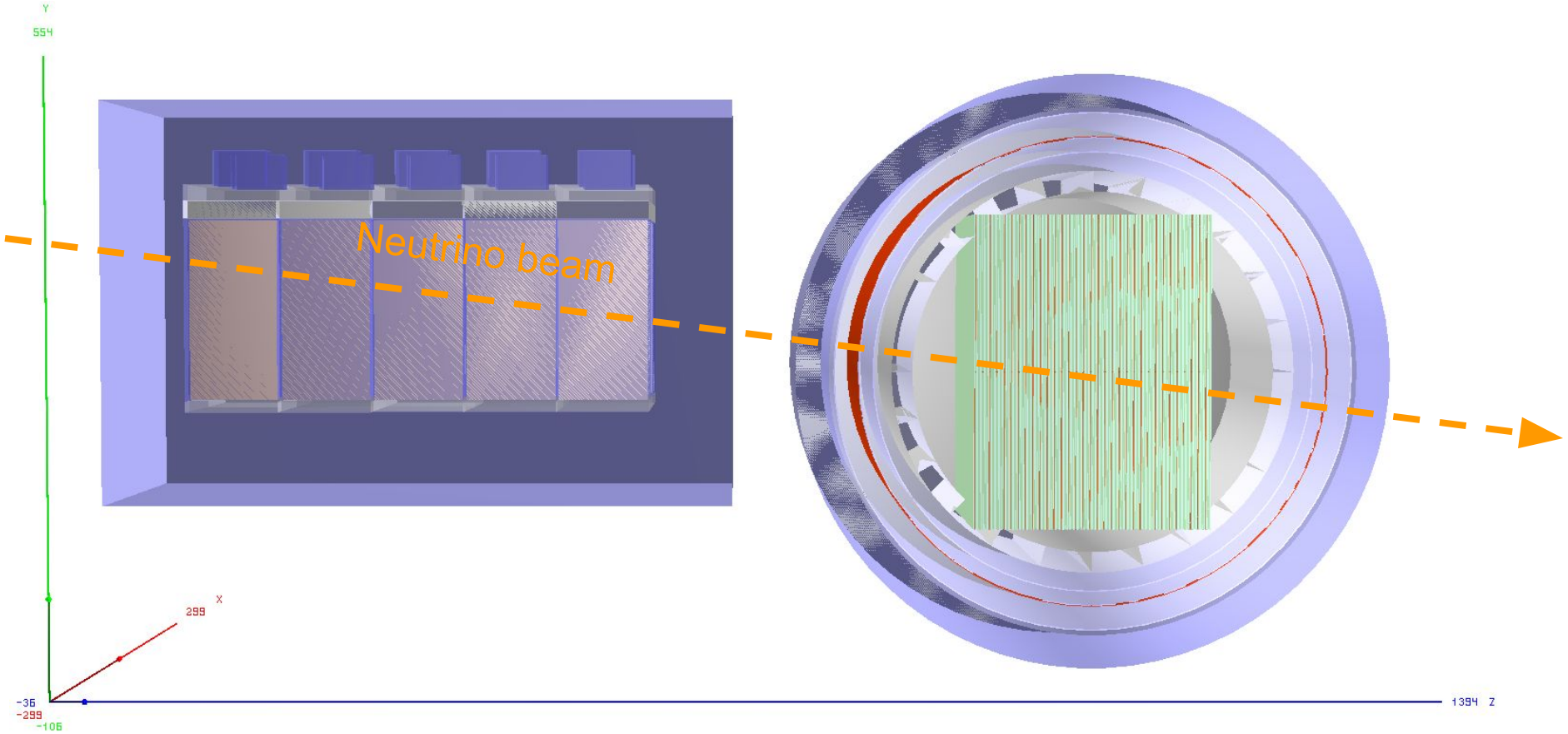
Argon Cube + dipole + STT



ArgonCube+dipole+GArTPC

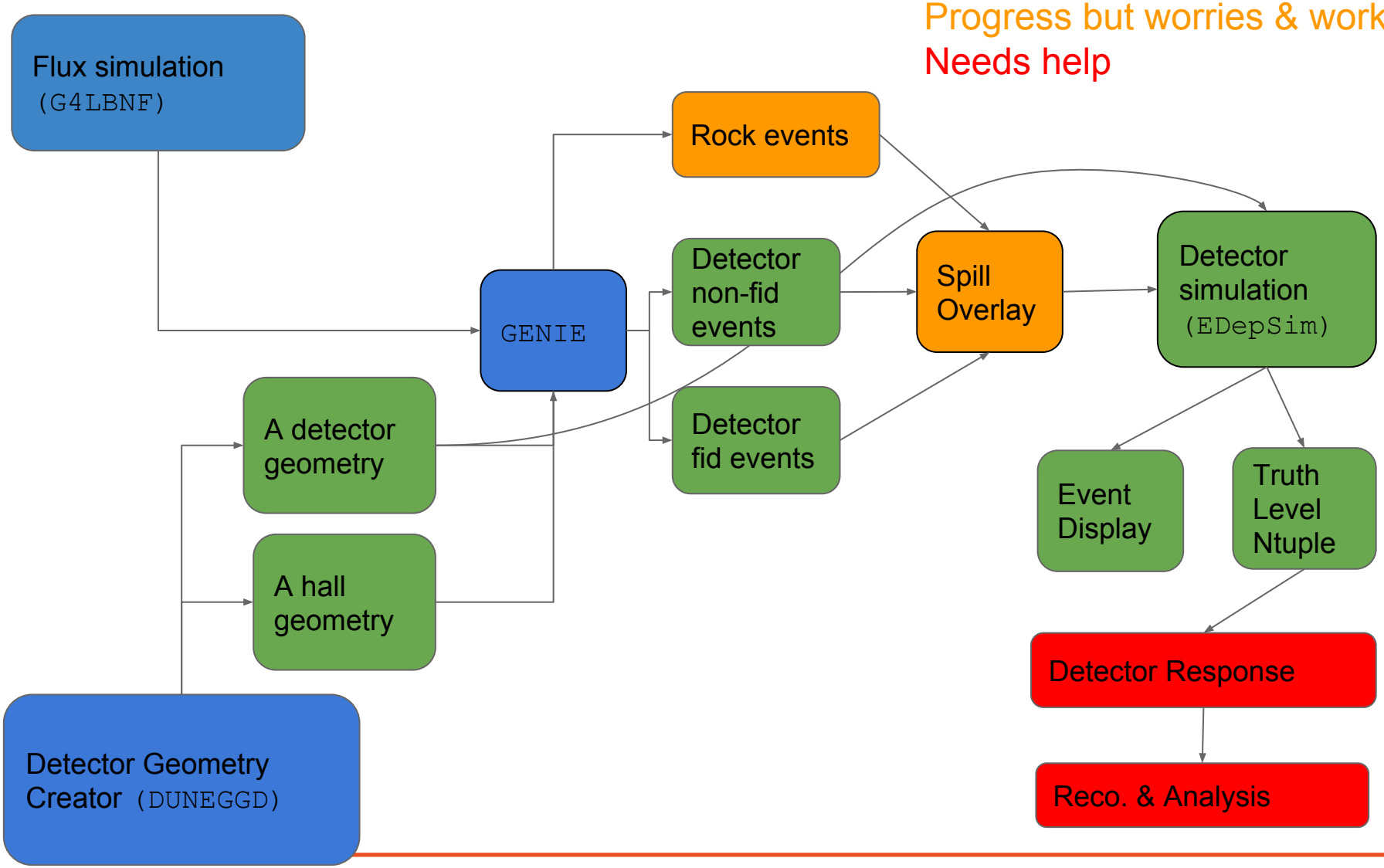


ArgonCube+KLOE+STT



Simulation Stack

Legend
Well established
Good progress
Progress but worries & work
Needs help

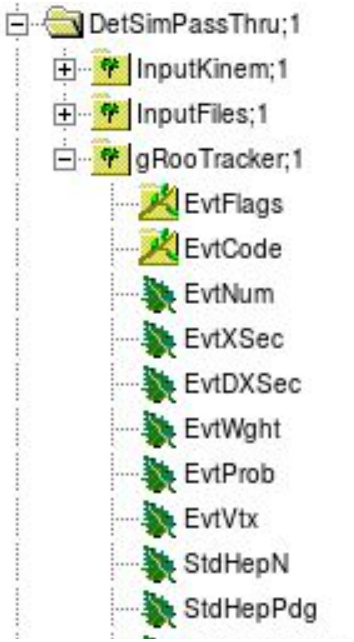


Edep-sim

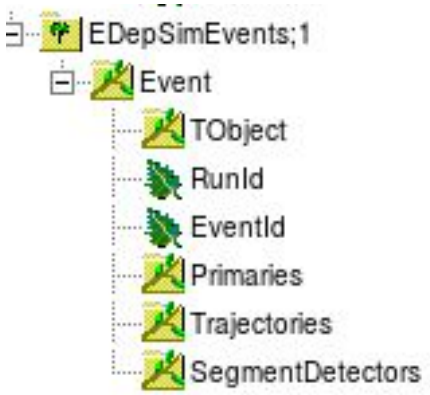
Credit:
Clark McGrew

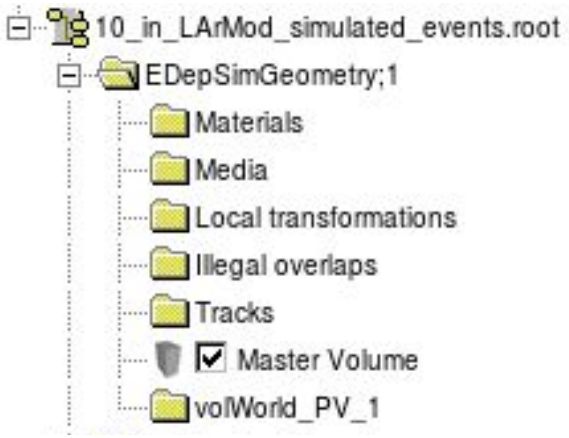
- Runs GEANT taking in GENIE interaction ntuple
- Output
  - GENIE Truth
  - Hits in sensitive detectors
  - Geometry (ROOT format)

Nice Feature:
Flexibly adapts to changes to the geometry



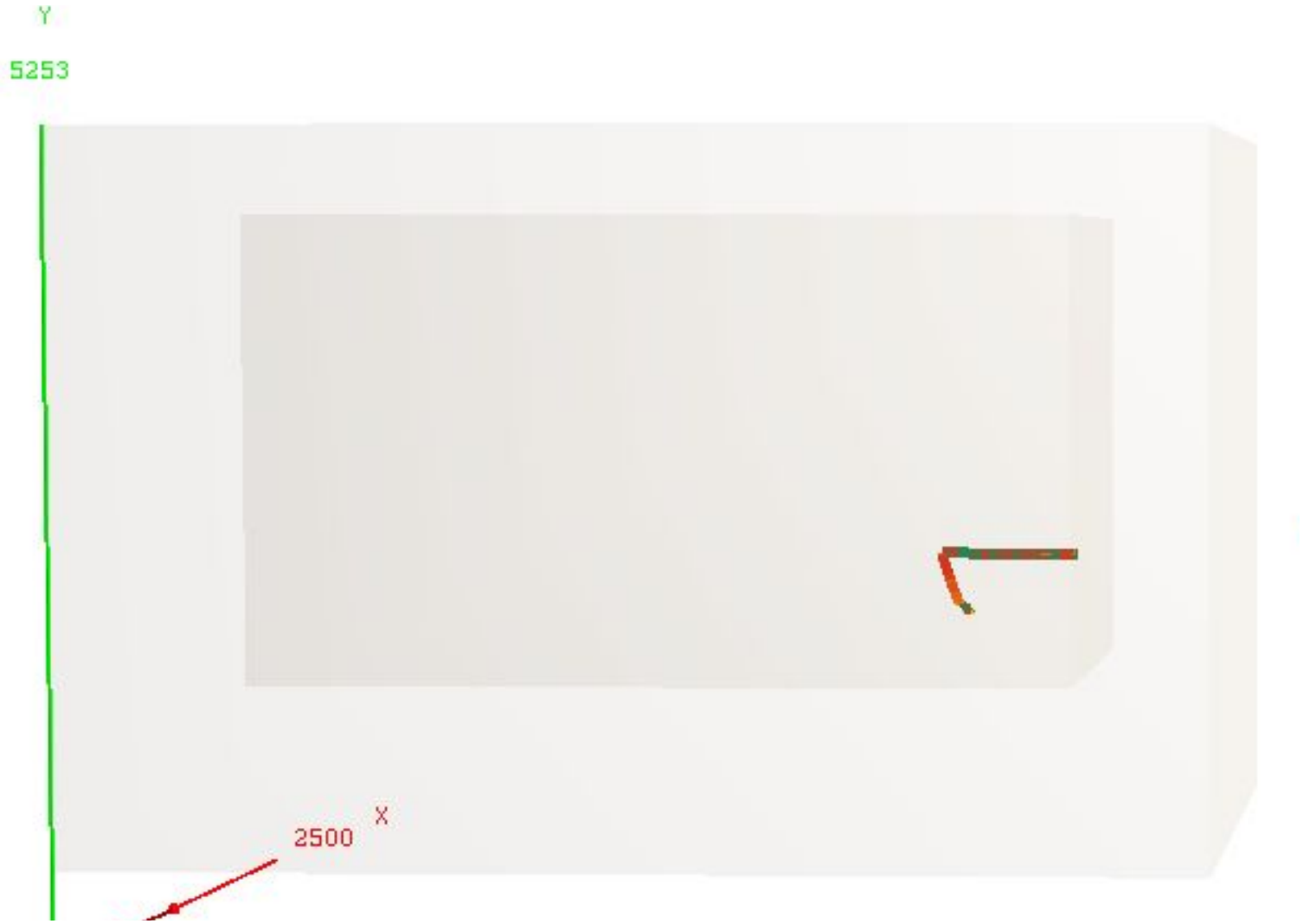
… etc



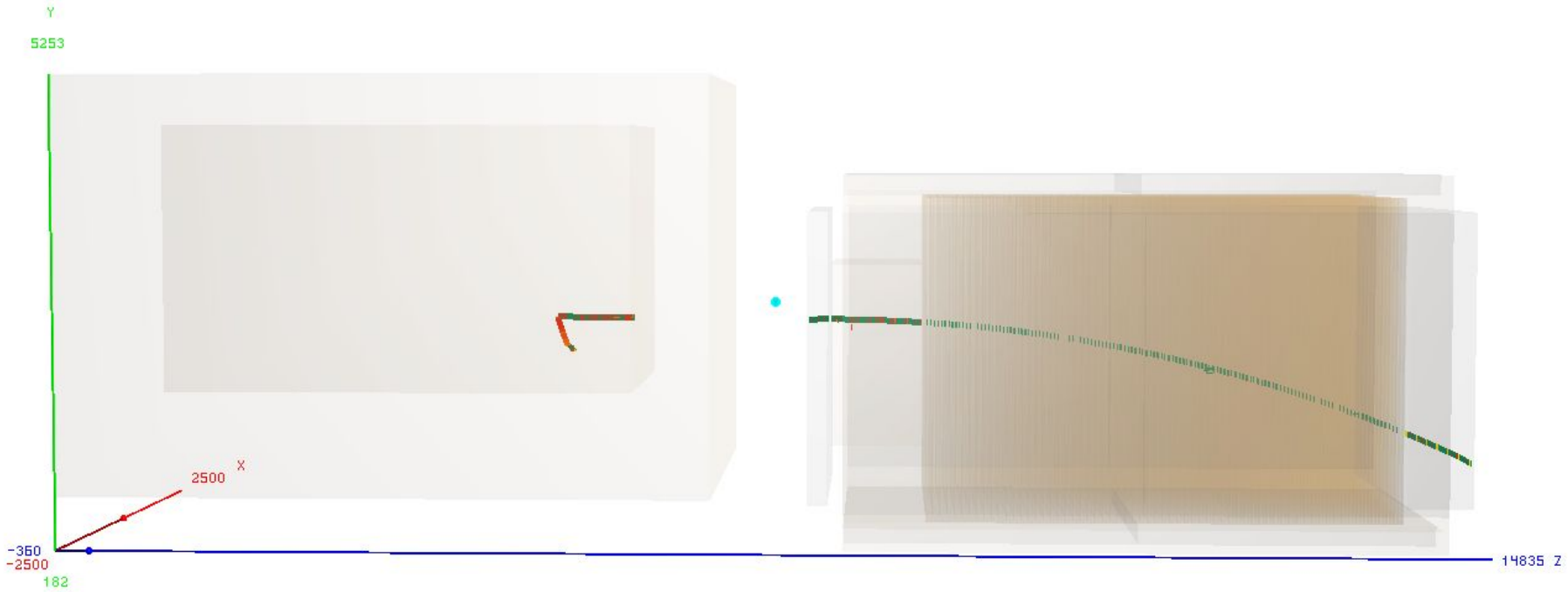


Events

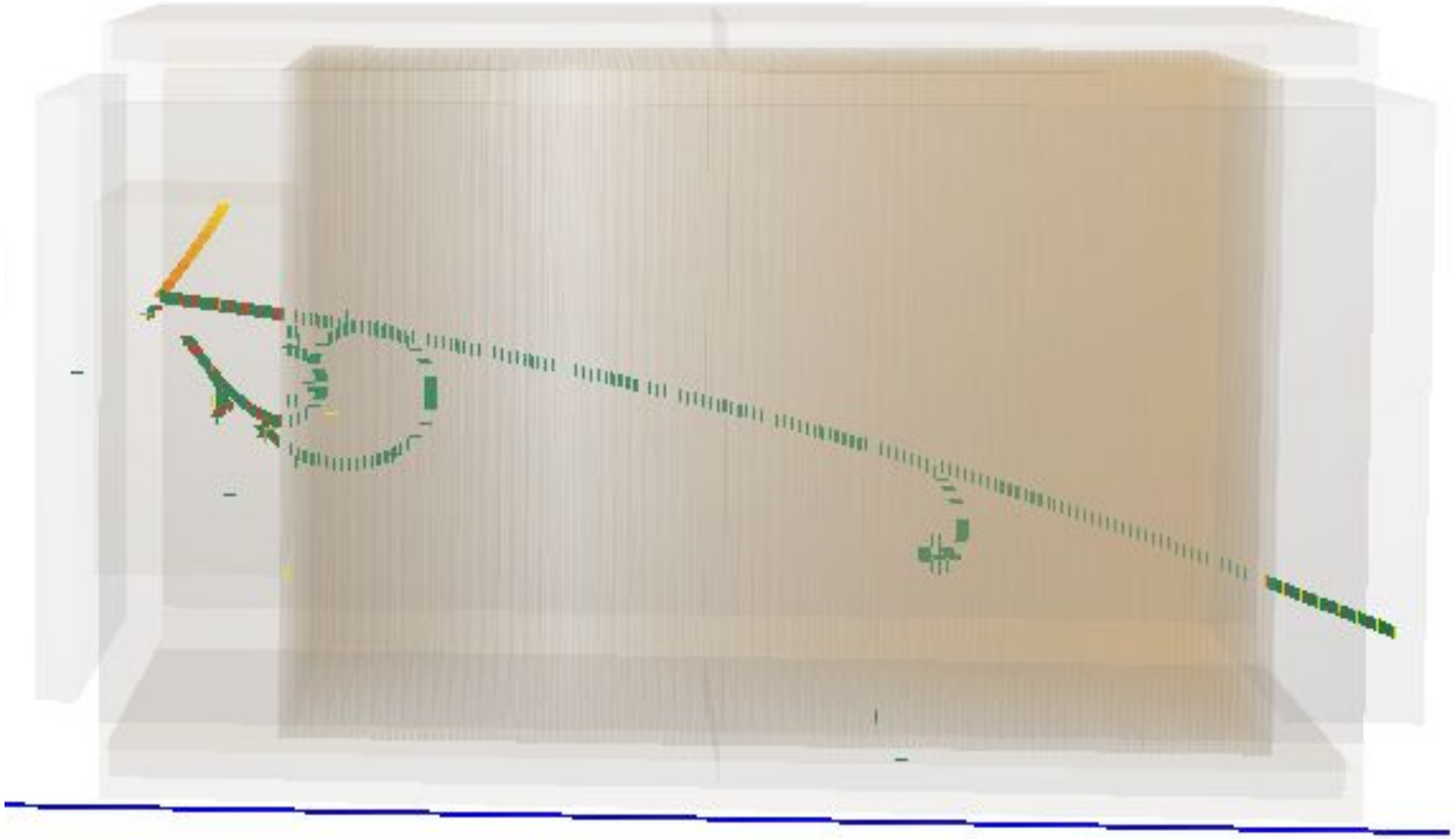
Events



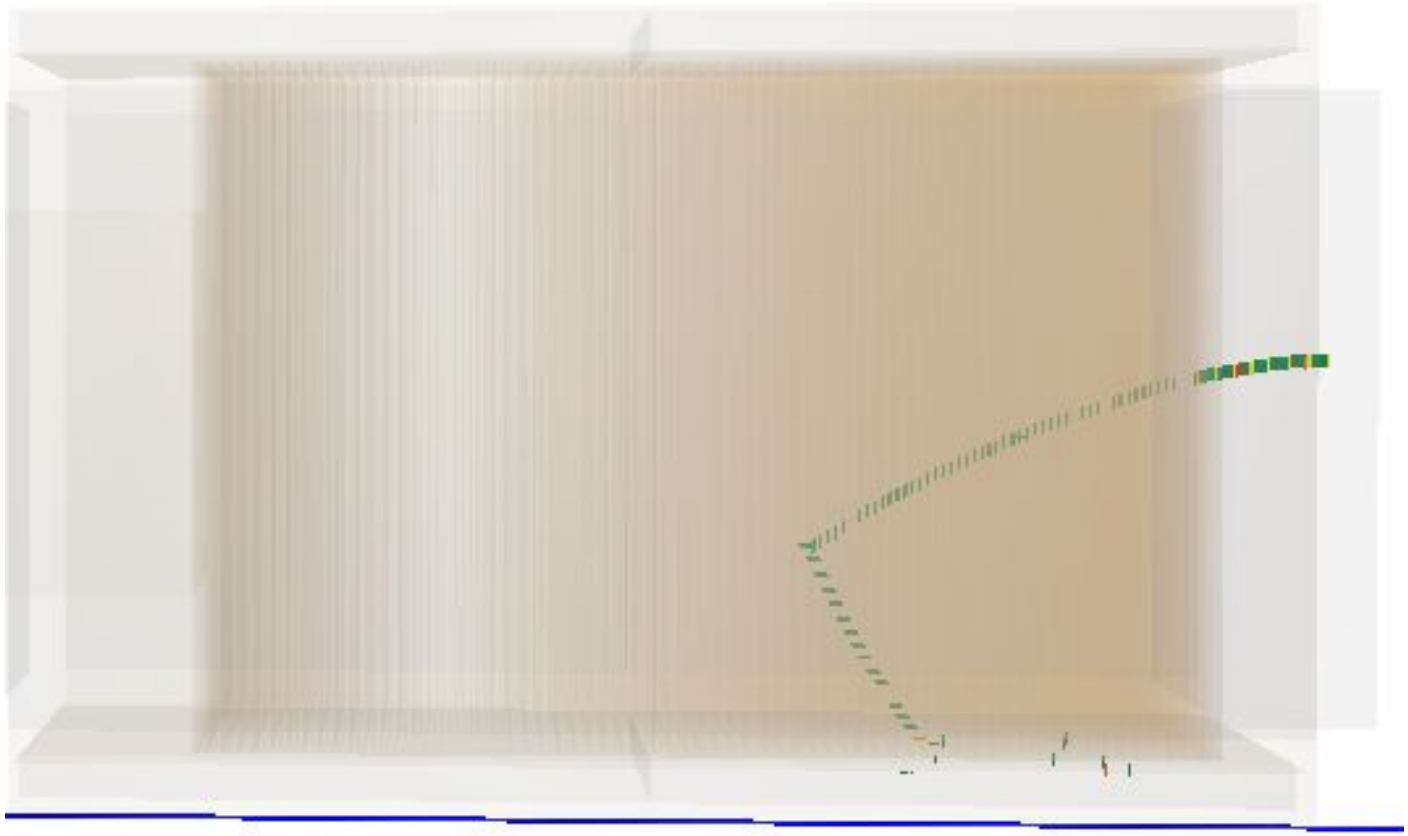
Events



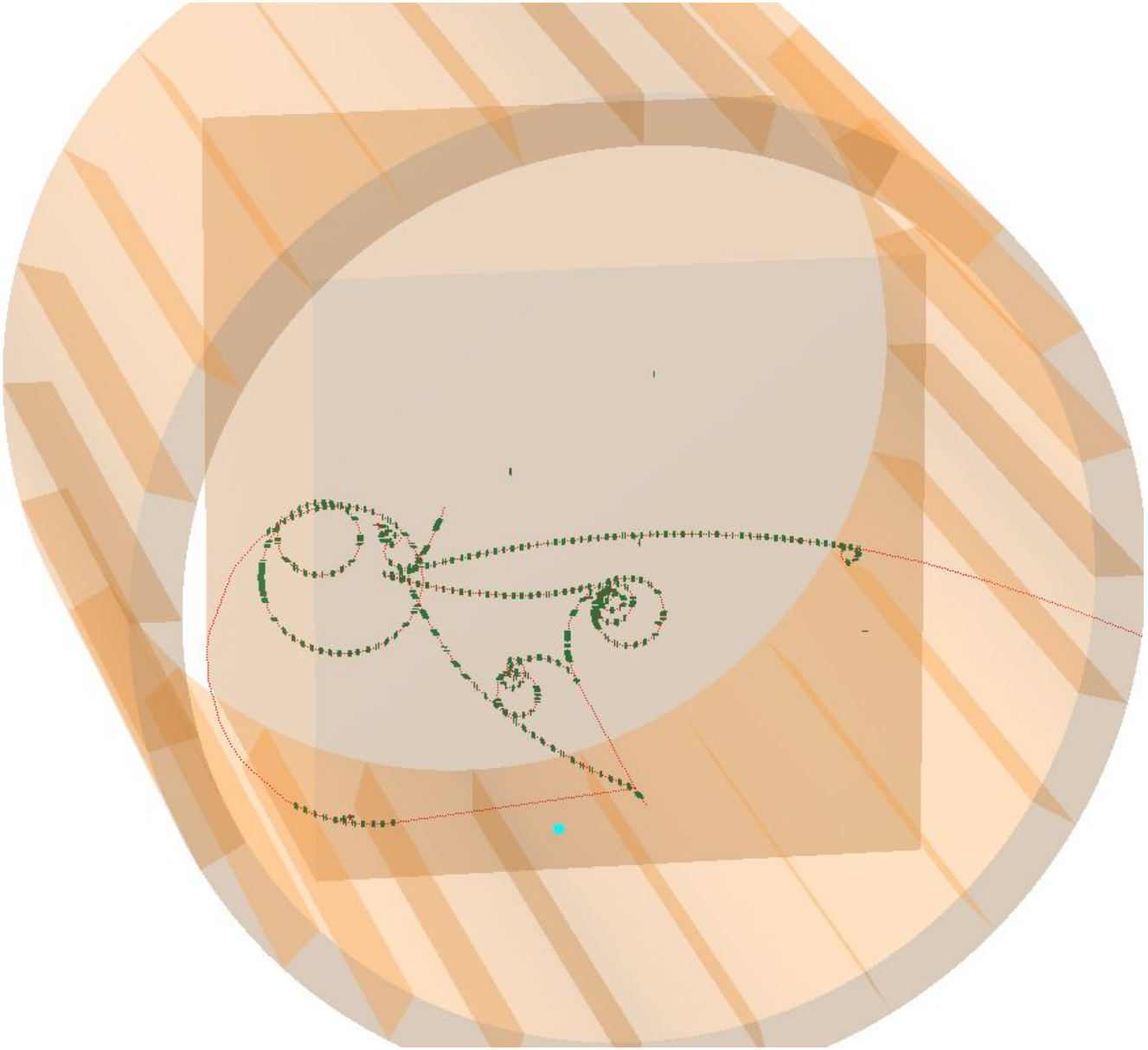
Events



Events

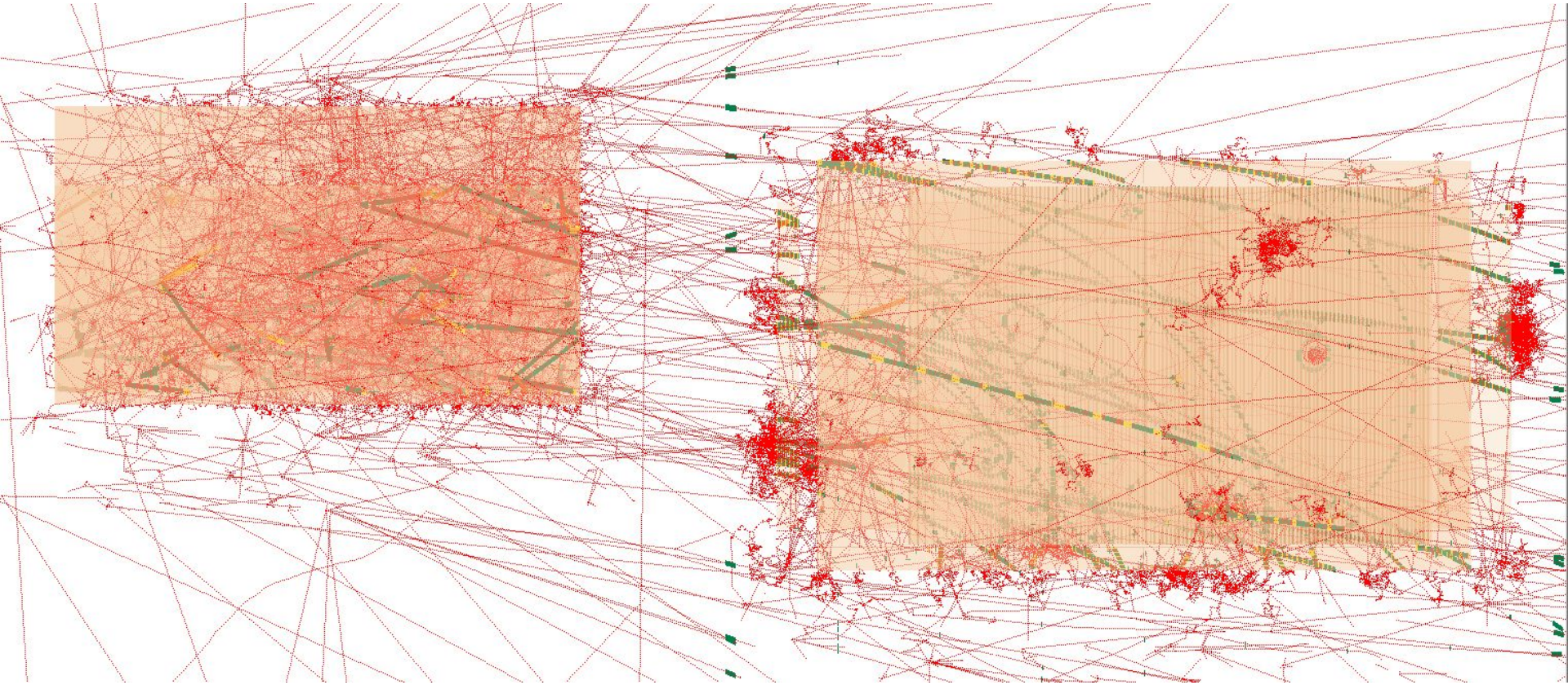


Events



One Spill

Caution: No rock interactions



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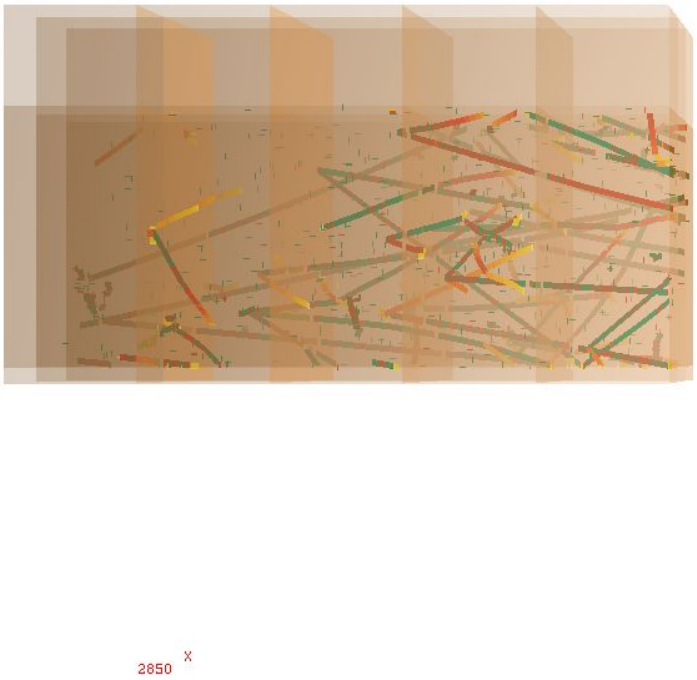

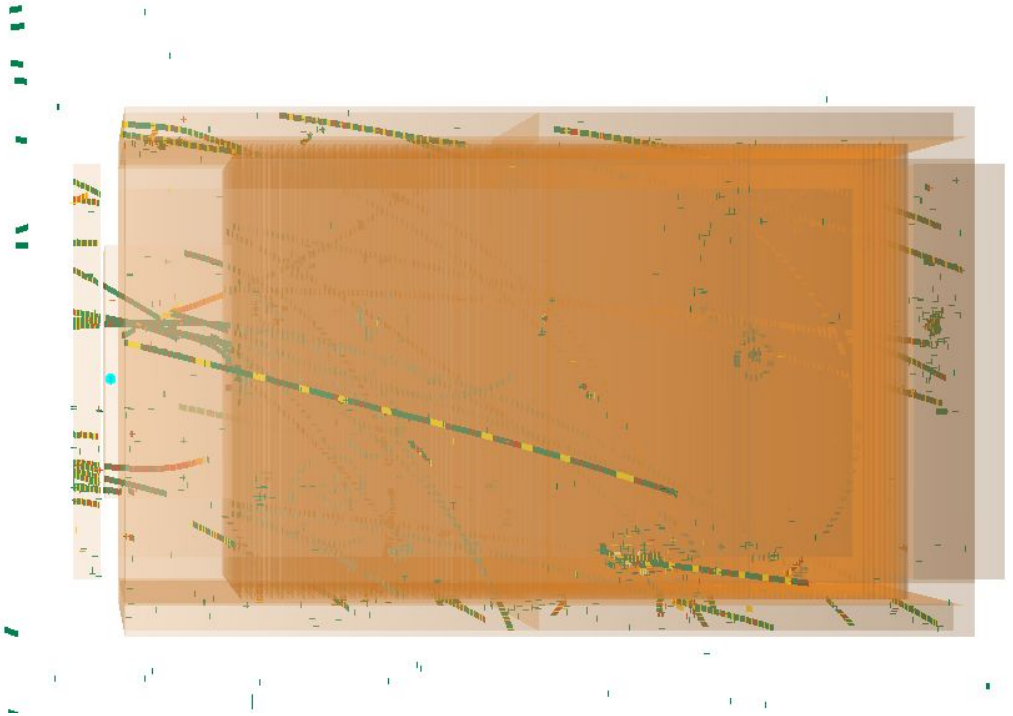

Another Spill

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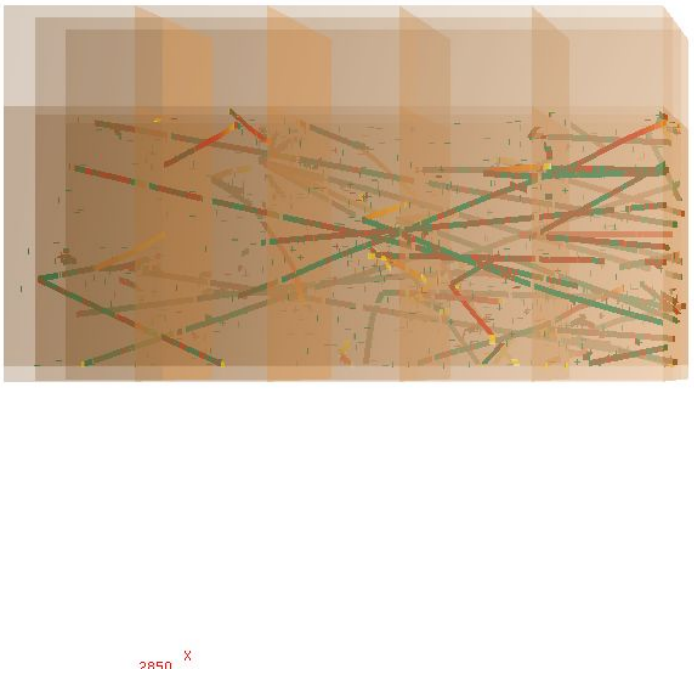

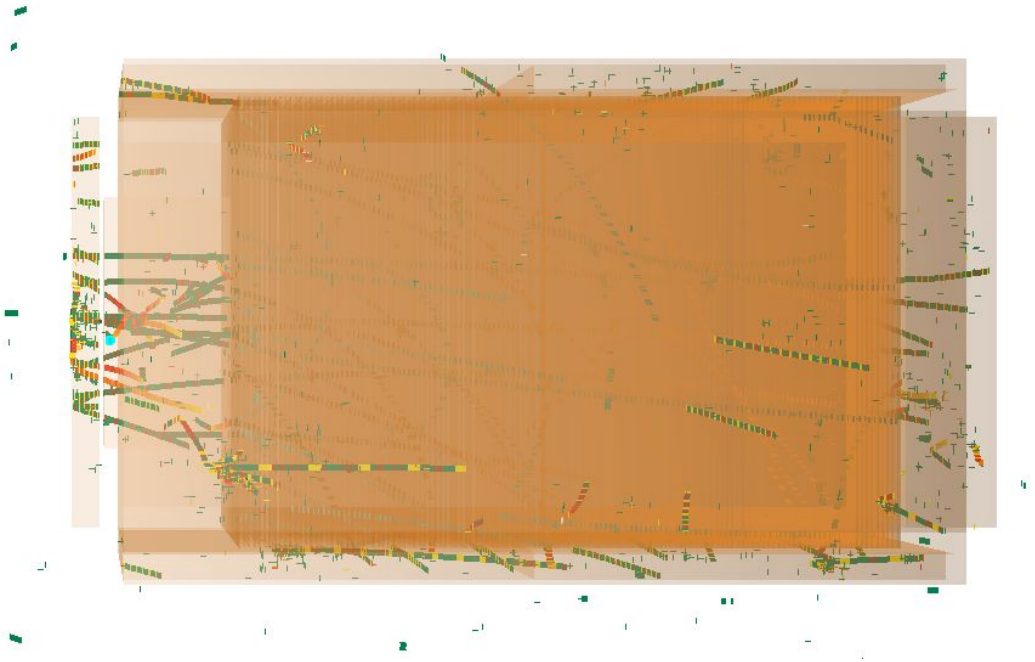

Next Steps

- Reasonable simulation at Geant hit level
  - B-field treatment is very basic
  - No transition radiation (how to? where?)
  - Add GArTPC option to KLOE
- Need to make overlays more efficient and add rock events
  - reuse of rock/non-fiducial events
  - biasing for low mass detectors
  - File size: one spill = 11Mb
- Need to do some official productions
  - Need help with this
- Need to document what we have done / are doing.
  - https://cdcvs.fnal.gov/redmine/projects/dune-neardet-design/wiki/DUNE_NearDet_Design
- We need consumers!
  - Detector response simulation can start now
  - Geant hit level studies can start now