Software WP: status of simulation

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Introduction

WP4 includes two areas:

- Development of simulation for
  - TB module
    - Response study for optimisation of module construction
    - Evolve simulation of optical response in order to optimise the comparison of TB data to MC
    - Work being performed at present on electron data from TB2021
  - 4π geometry
    - Develop calibration for single particles and jets
    - On that basis develop physics studies leveraging the performance of the detector
- Development of machine learning techniques for analysis
  - → See Stefano Giagu

HiDRa module simulation

Construction technique same as for TB2021: build simulation as smooth evolution of TB2021 one (DREMTubes, Pezzotti et al.):

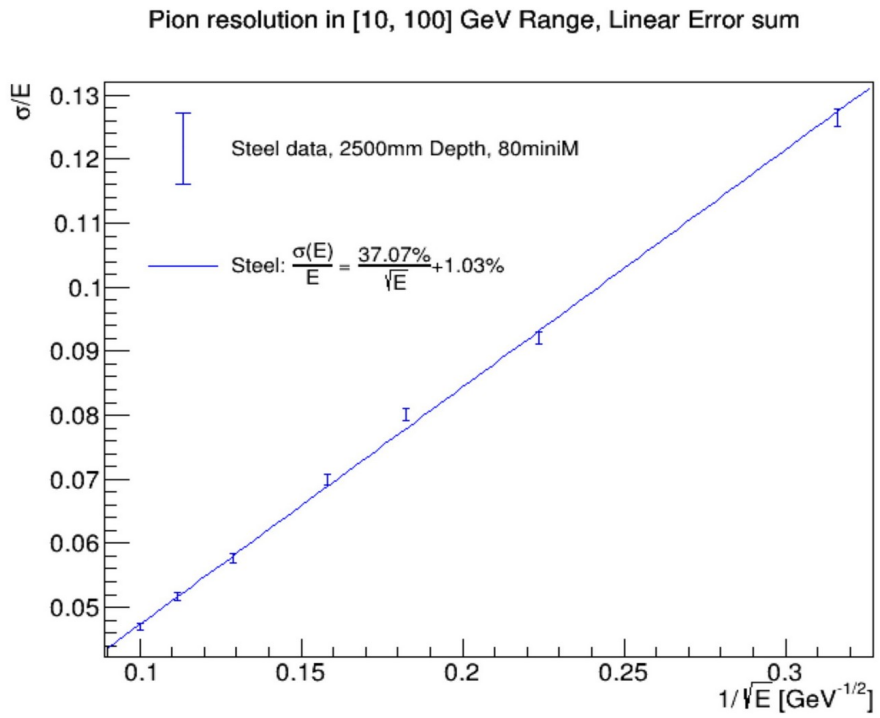
- Preserve all comparison work being done on TB2021
- Allow reverting to TB2021 transparently

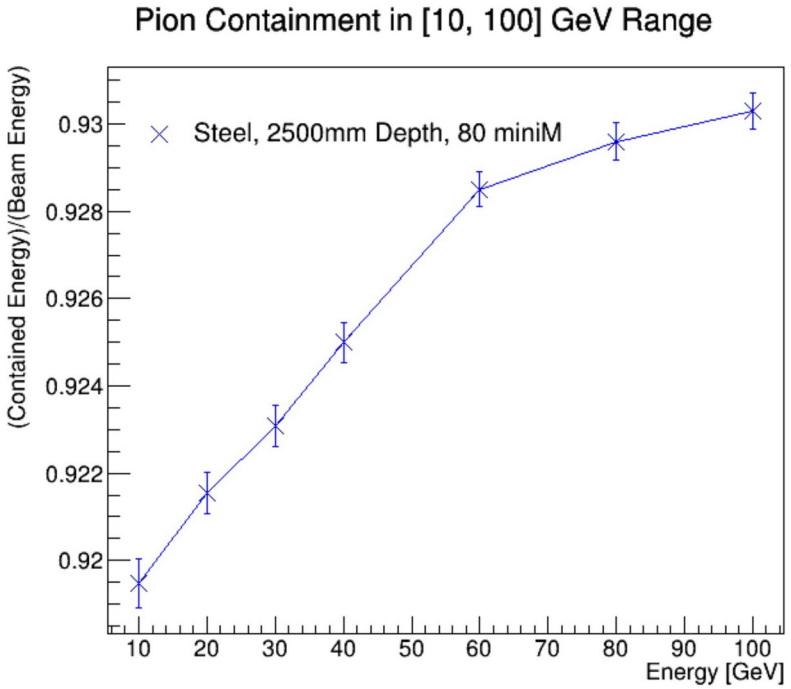
Status:

- New git organisation DRCalo created to collect software for the project
- Implementation of basic 80 module geometry in repository https://github.com/DRCalo/HidraSim and fully validated
- No modification to readout part wrt DREMtubes
- Heavily used in the last two months to understand hadronic performance of proposed module (A. Pareti)

Some results of performance studies

A. Pareti





Various length and module geometries studied to asses dependence of performance on energy containment

Ongoing study comparing brass and steel

Soon full presentation by Andrea at DR meeting

Working plans for next months

Testbeam module:

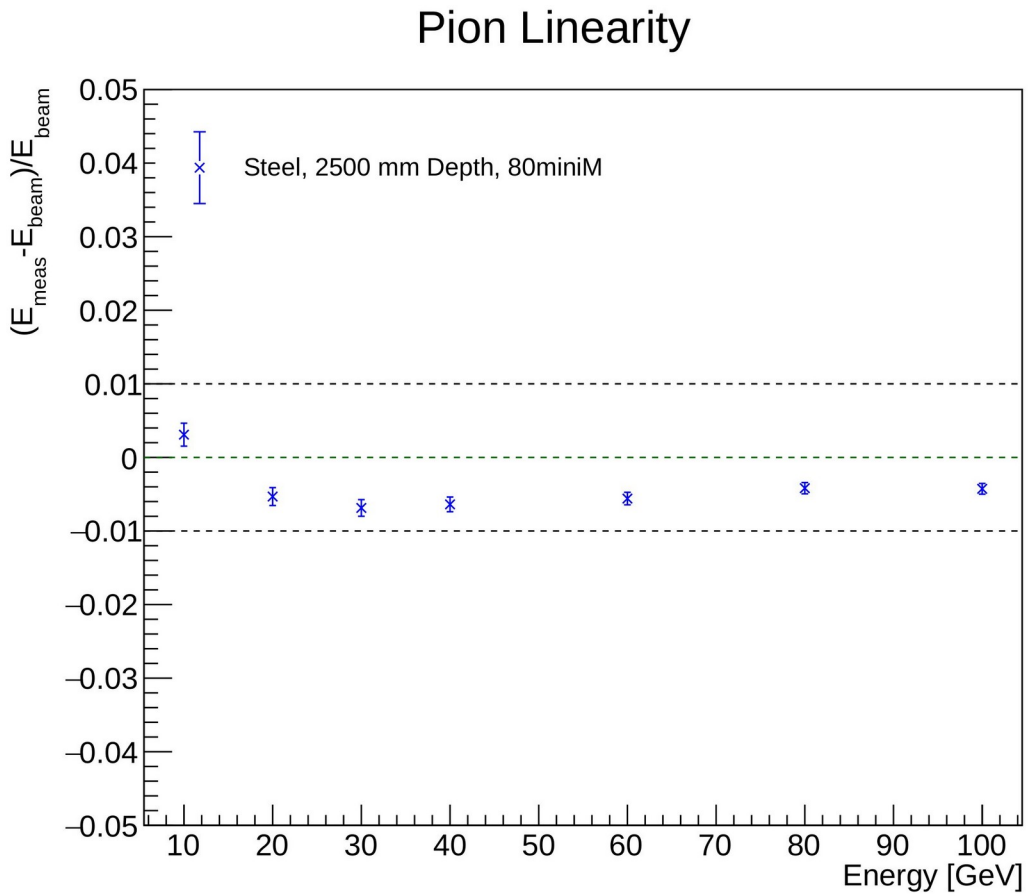
- Conclude the performance optimisation studies with present code
- Ongoing work on improving quality and flexibility of code (with E. Proserpio and L. Pezzotti)
- Based on ongoing work on understanding difference in cerenkov response on TB2021 (GP, L. Pezzotti) revise the simulation of light propagation in fibers
- Adapt the output to official FCC software

4π Simulation:

- Start from existing code from L. Pezzotti
- First step: modify sampling fraction
- Second step: implement capillary geometry

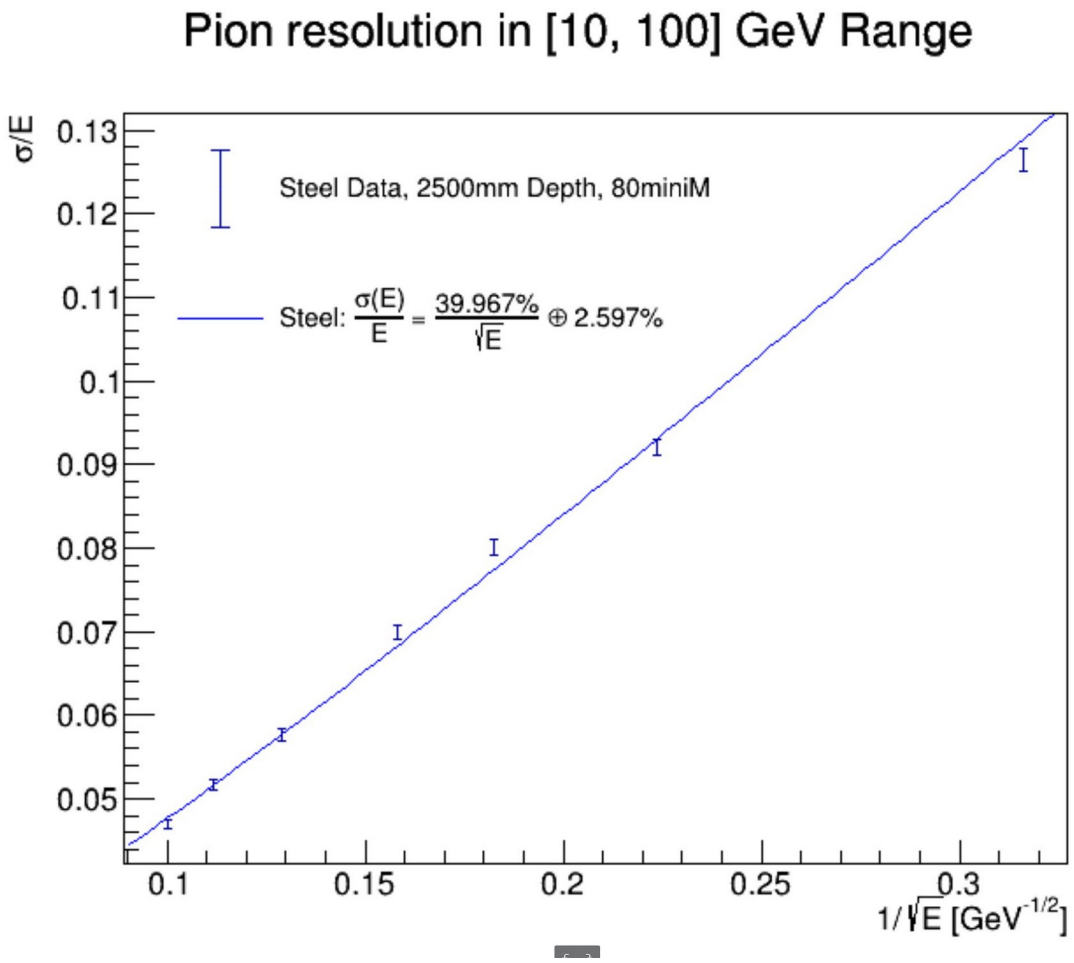
Backup

Linearity



DR χ factor calculated as reconstructing the correct energy of 40 GeV pions on large module with minimal lateral leakage

Resolution


Pion resolution in [10, 100] GeV Range
σ/E
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
Steel Data, 2500mm Depth, 80miniM
Steel: σ(E)/E = 39.967%/√E ⊕ 2.597%
0.1
0.15
0.2
0.25
0.3
1/√E [GeV^-1/2]

Geometry definition

Hidra

```
const G4int NofmodulesX = 24;
const G4int NofmodulesY = 5;
const G4int modflag[120]={-1,-1,-1,-1,-1,-1,-1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9,-1,-1,-1,-1,-1,-1,-1,
                          -1,-1,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,-1,-1,
                          30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,
                          -1,-1,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,-1,-1,
                          -1,-1,-1,-1,-1,-1,-1,74,75,76,77,78,79,80,81,82,83,-1,-1,-1,-1,-1,-1,-1};
const G4int NoModulesSiPM=10;
const G4int SiPMMod[10]={37,38,39,40,41,42,43,44,45,46};
const G4int NofFiberscolumn = 64;
const G4int NofFibersrow = 16;
const G4int NoModulesActive=84;
const G4double moduleZ = (2500.)*mm;
const G4bool irot=true;

const G4int NoFibersTower=NofFiberscolumn*NofFibersrow/2;
```

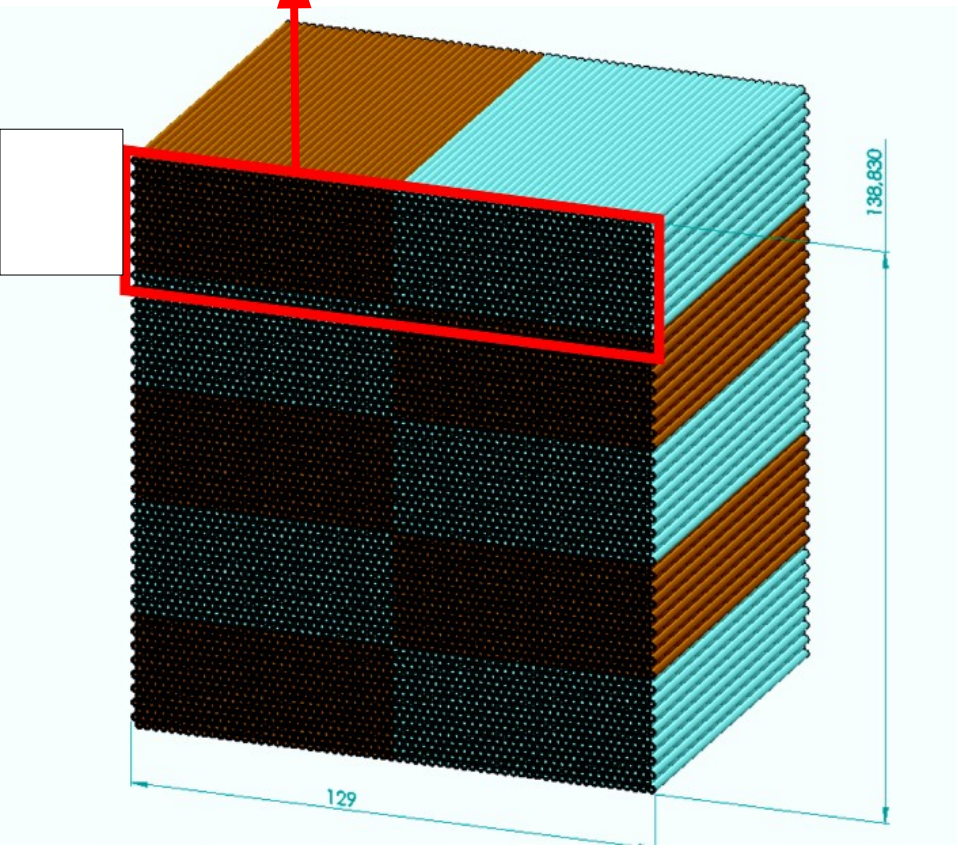
TB2021

```
const G4int NofmodulesX = 3;
const G4int NofmodulesY = 3;
const G4int modflag[9]={3,2,1,5,0,4,8,7,6};
const G4int NoModulesSiPM=1;
const G4int SiPMMod[1]={0};
const G4int NofFiberscolumn = 16;
const G4int NofFibersrow = 20;
const G4int NoModulesActive=9;
const G4double moduleZ = (1000.)*mm;
const G4bool irot=false;
```

Use for validation against TB2021

Hidra geometry (Gabriella)

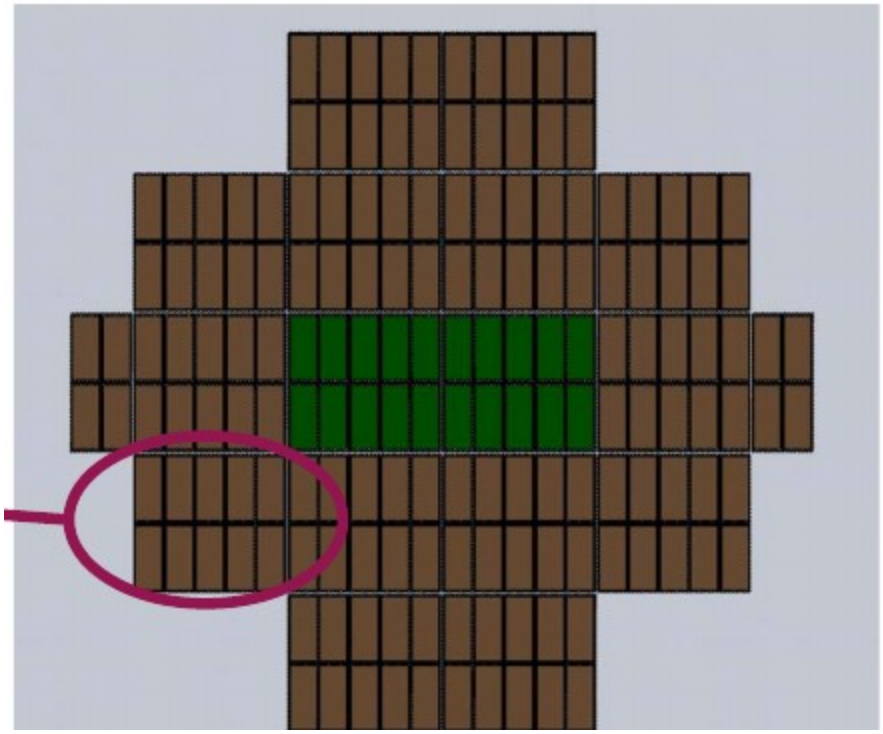
Double Mini-Module (MM):
64× 16 channels (1024 ch)
→ 512 S + 512 Č fibres



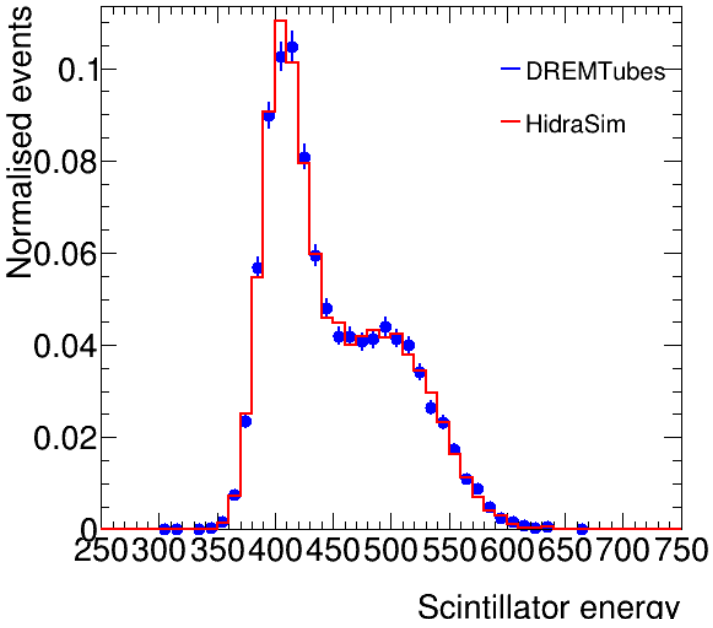
1 Module:
2 × 5 MMs = 5x1 double MM
→ 10 FEE boards
(8-channel grouping)
~ 13 × 13 × 250 cm^3

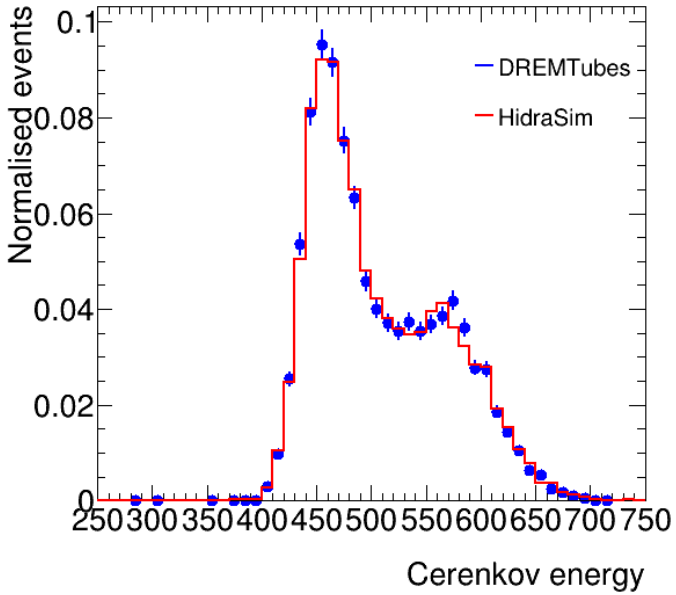
16 modules, ~ 65 x 65 x 200 cm^3

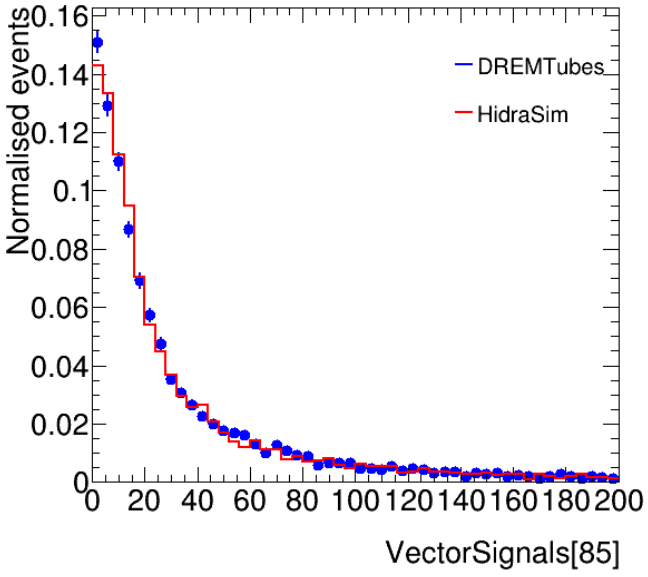
- 2 central modules with SiPMs
  → ~ 10 k SiPMs, ~ 20 FEE boards
- all others with PMTs
  → ~ 150 PMTs

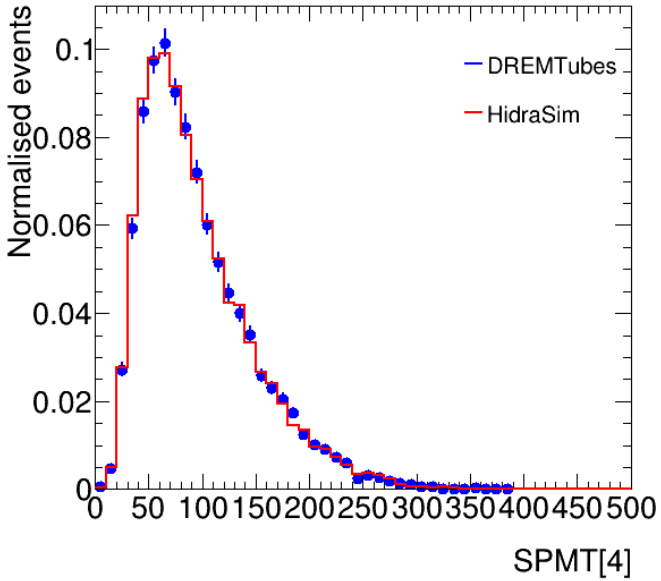


Validation



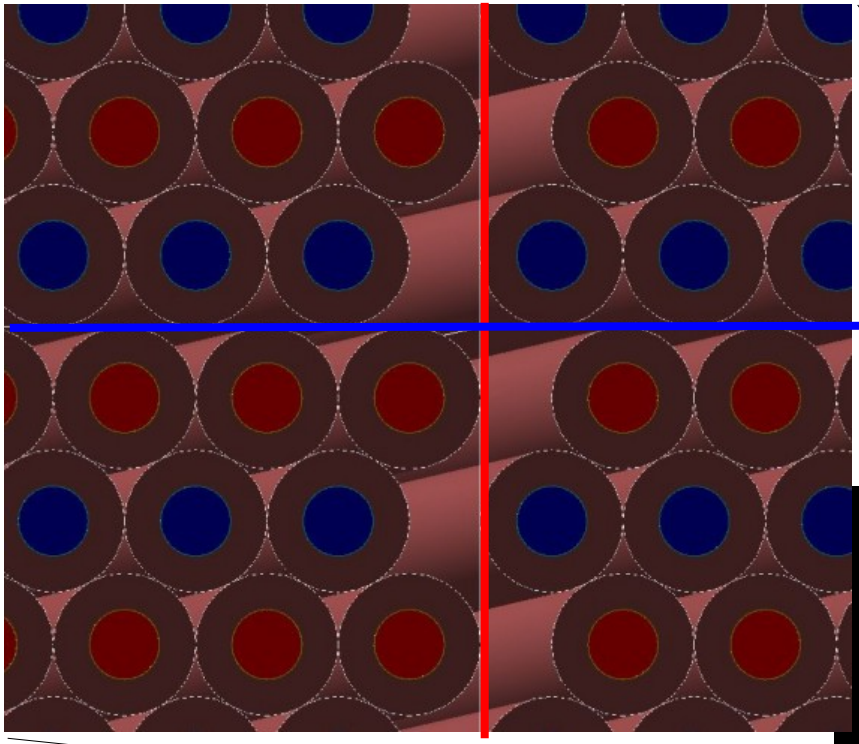


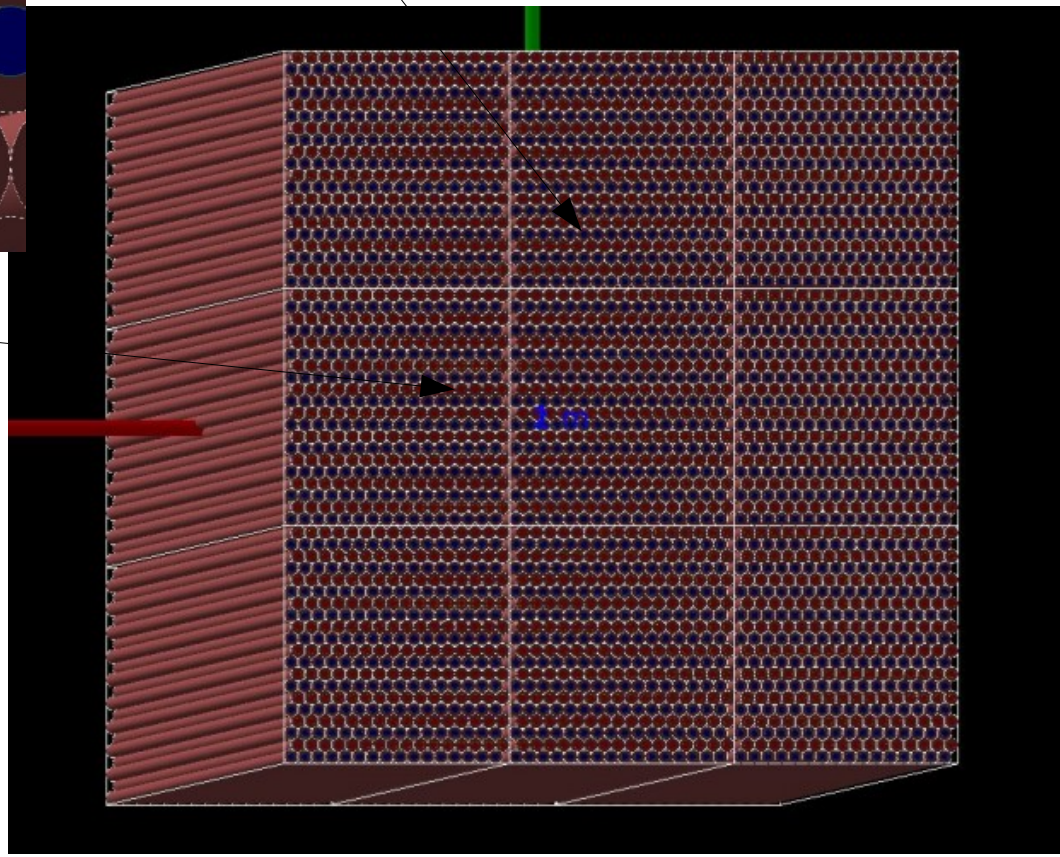




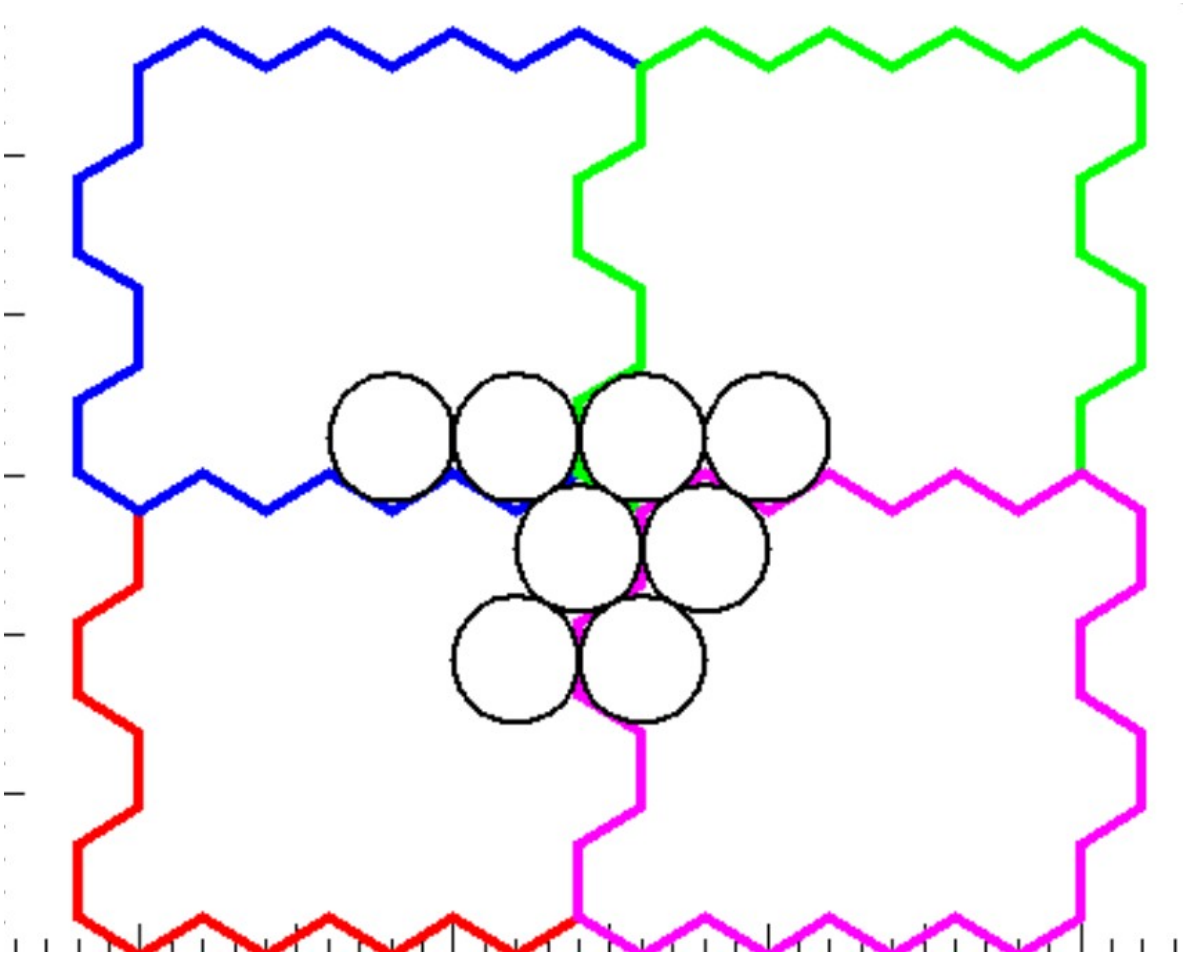
Run with 20 GeV e+
Compare raw variables from DREMTubes and HidraSim with Module-aware TB2021 geometry

Problem with splitting into modules:
If module defined as G4 box
1 mm cracks at the boundary
not there in actual module

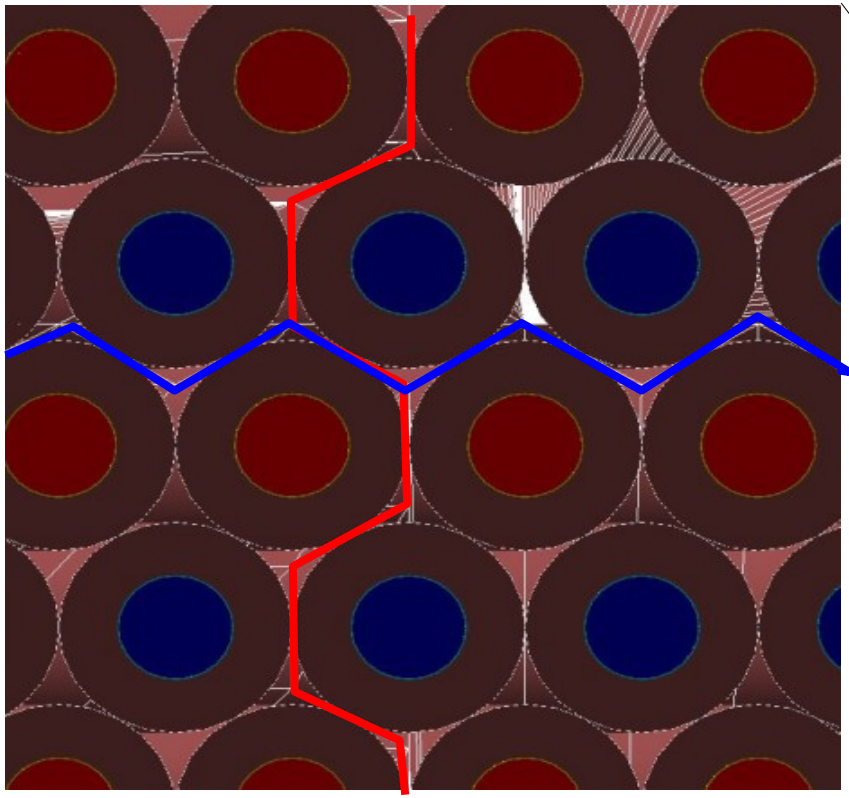


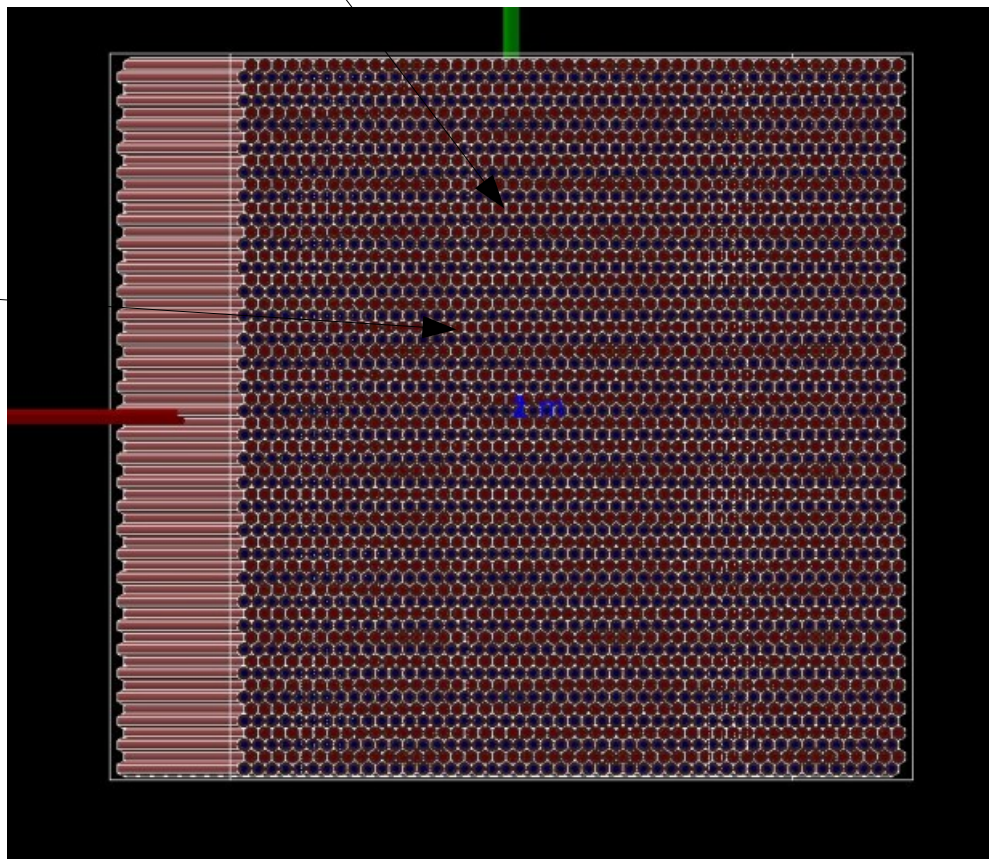


G4 has a large palette of predefined solids, but packing of tubes not available
Solution: define the boundary of each module as an hexcell polygon
In this way tubes touch each other
Build the 3-d module using G4ExtrudedSolid method

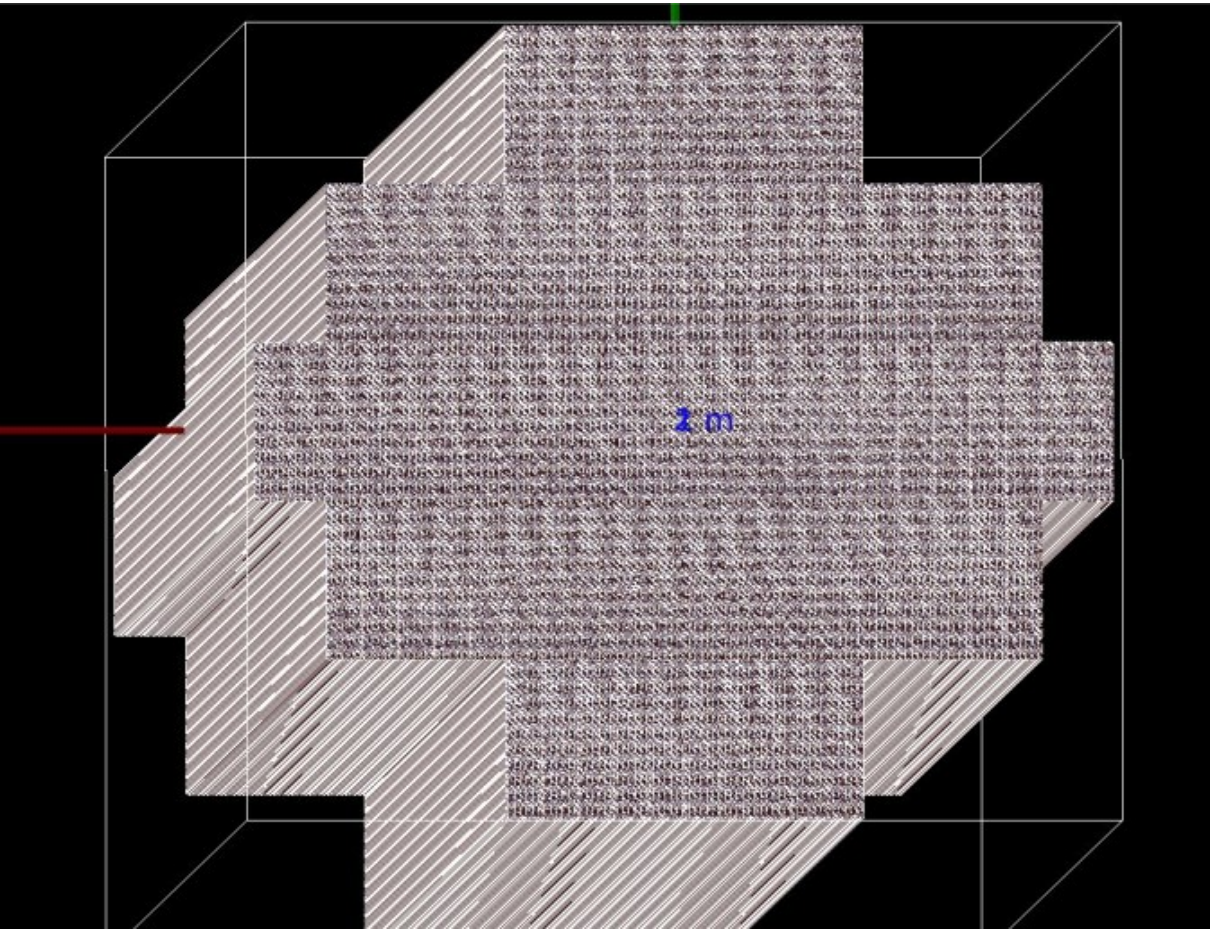


Module-aware implementation of TB2021 geometry in HidraSim





Preliminary test of whole Hidra simulation



Waiting for workshop to figure out whether modules will be wrapped in boxes, develop geometry based on assembling double minimodules

Preliminary lepton performance

Energy scan e+ from 10 to 80 GeV

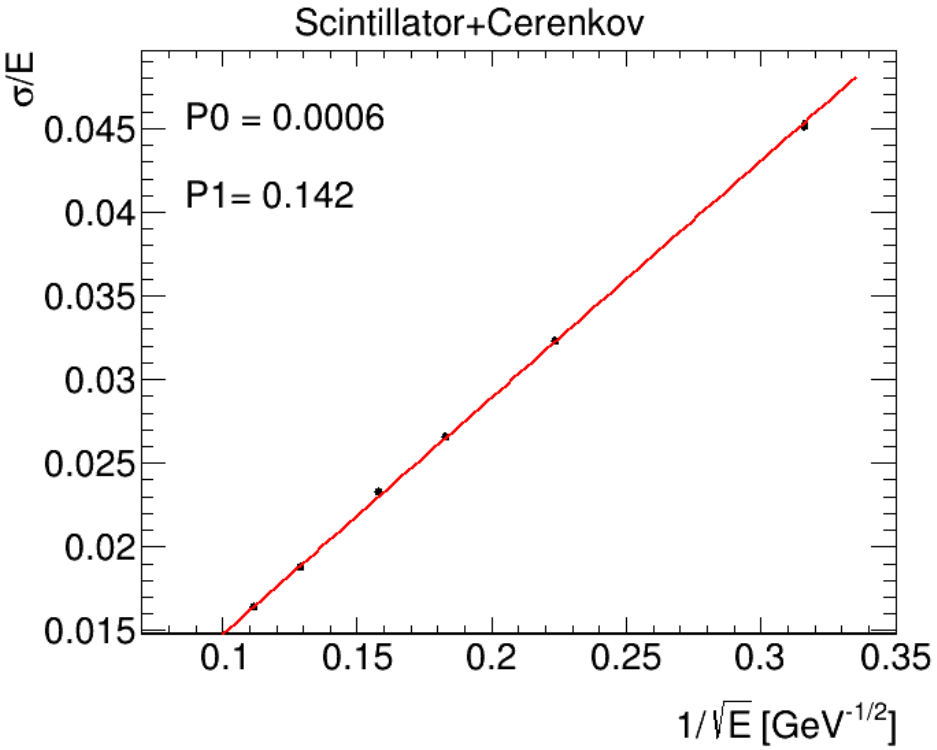
Containment 99.5%.

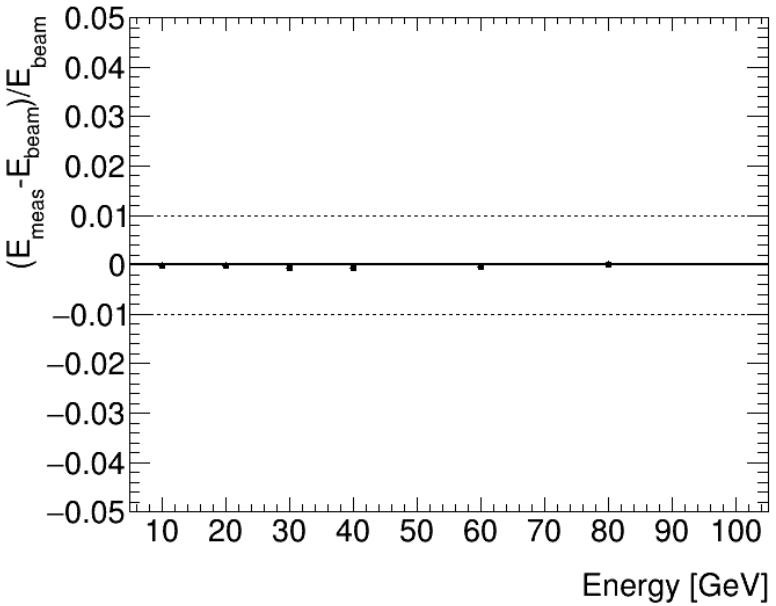
Calibrate response with same conversion factor Phe/GeV as for TB2021

Calculate energy as 1.005*0.5*(TotSci+TotCer)

TotSci(Cer): sum of scintillator (cerenkov) signal in 84 minimodules

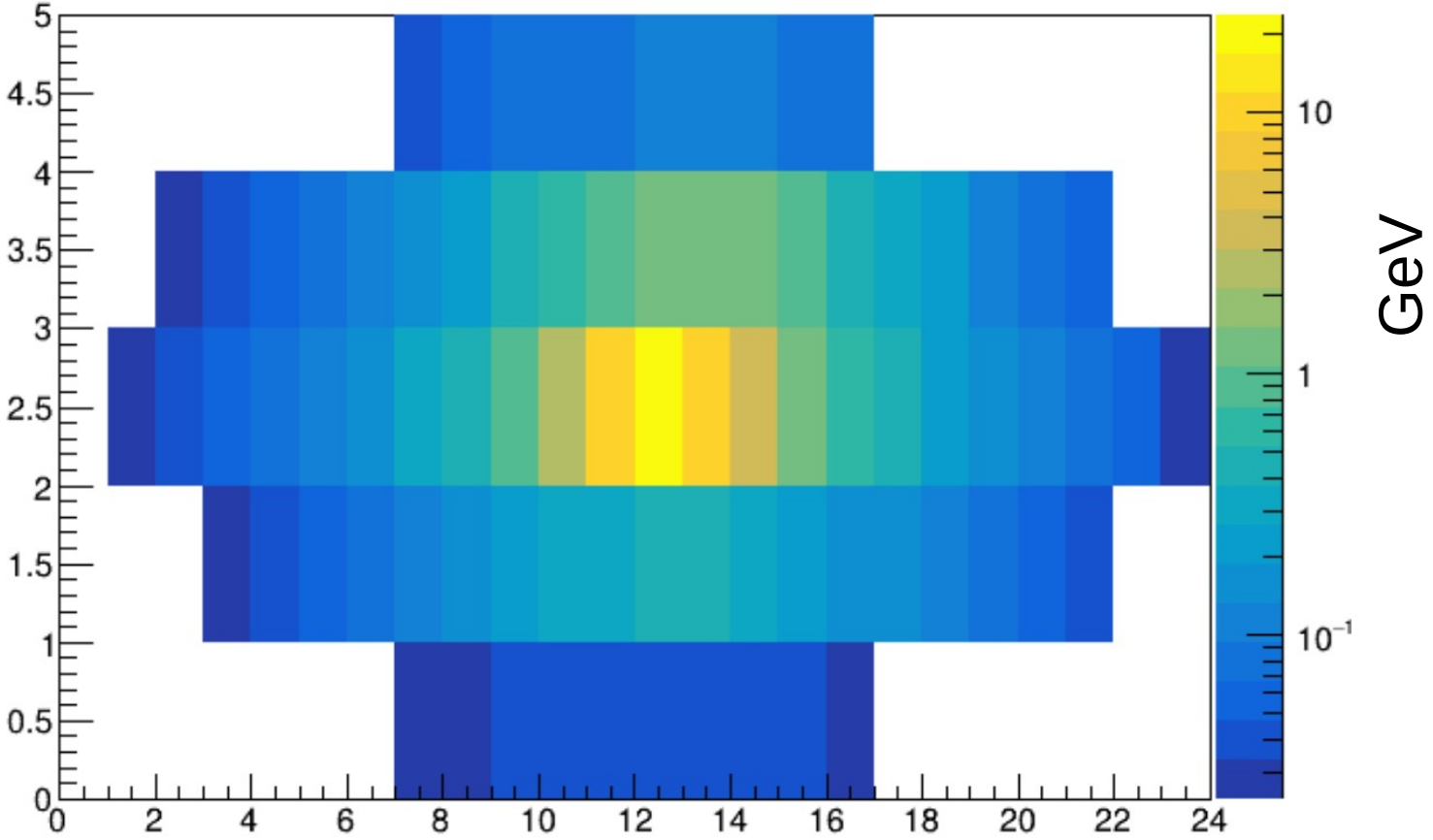
Same resolution ad for TB2021 (slightly better, better containment)





Pion response map

80 GeV π^+ impact angles 2.5 deg, 2.5 deg



Preliminary hadronic response

Apply DR formula with chi=0.43, show plot for 40 GeV π+