IDEA Collaboration Meeting 2019

M. Antonello
L. Pezzotti
E. Proserpio

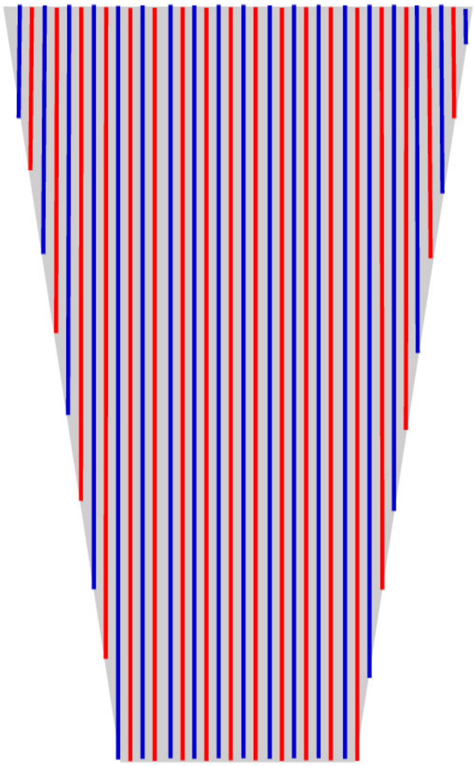
Bologna - 13.06.2019

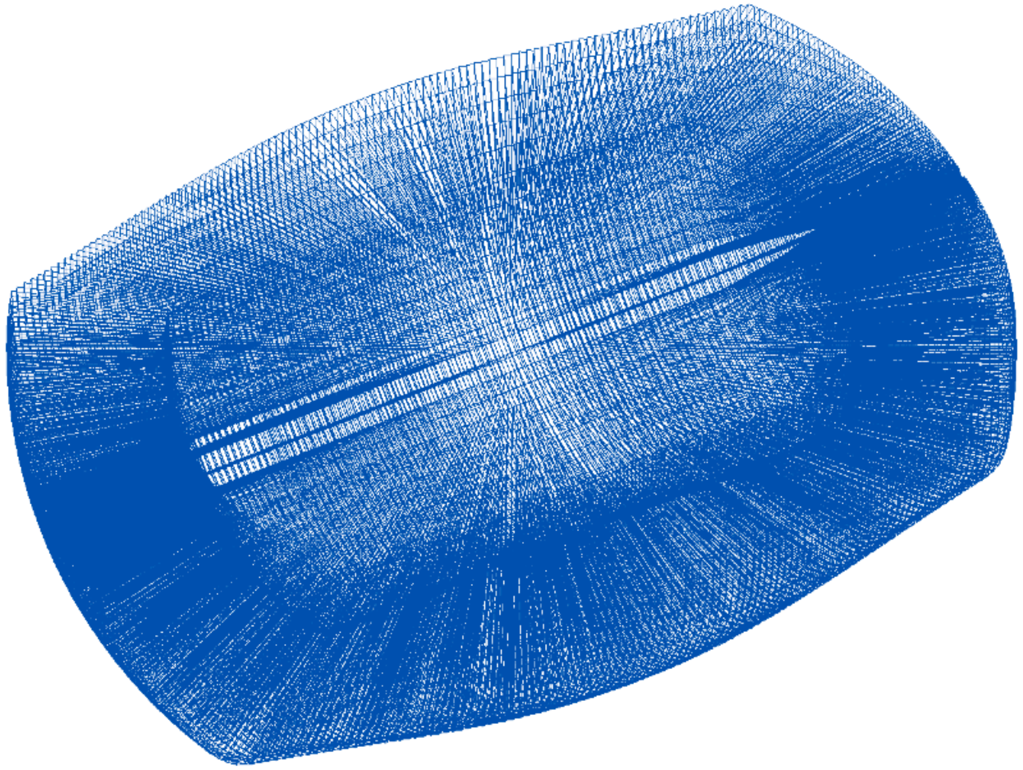
DR calorimeter full simulation geometry

The starting point

Projective layout: ***"wedge"*** geometry

- ***92*** different types of towers (wedges).
- A typical barrel has about ***4,000*** fibres with different length (to keep constant the sampling fraction).
- Barrel geometry already ***done***.





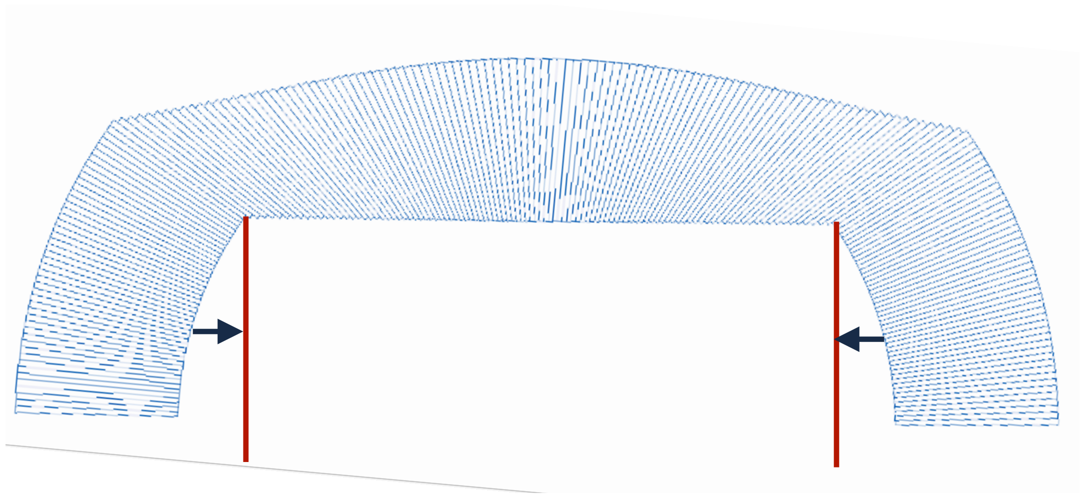
The old endcap geometry

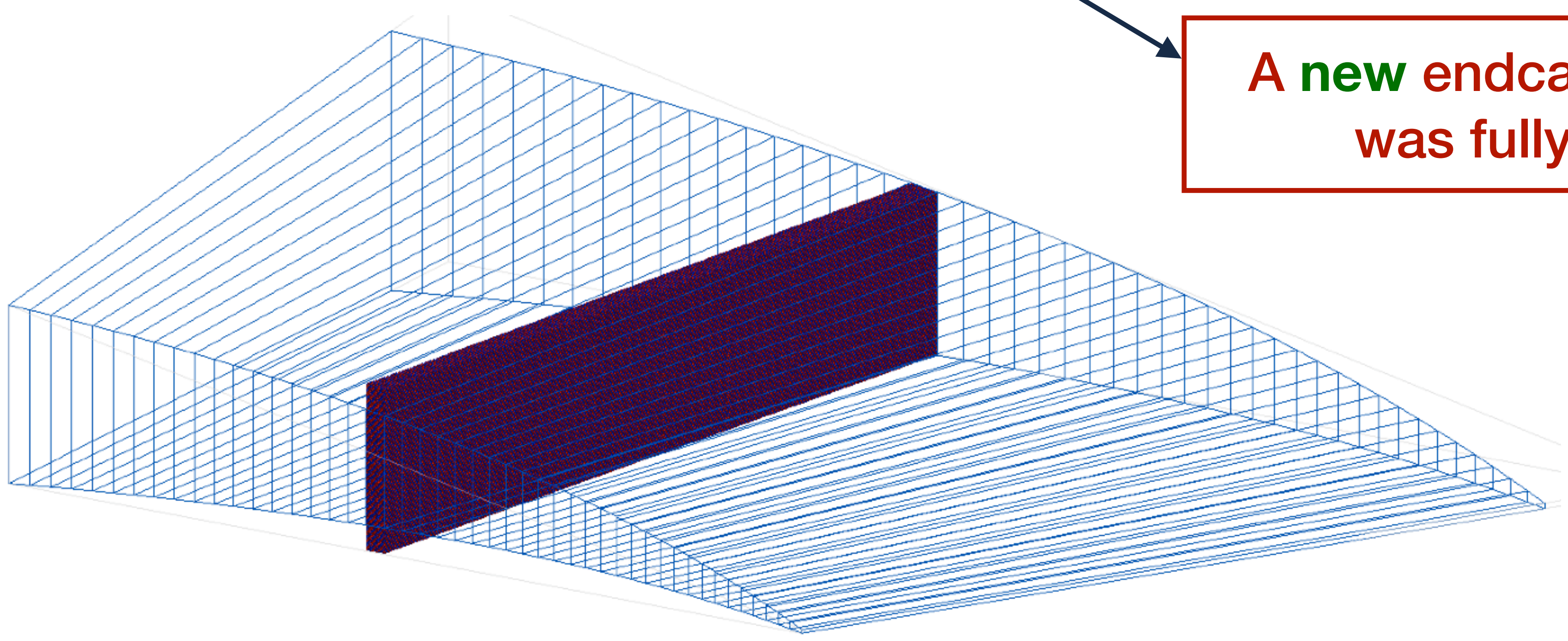
Some changes (and corrections) have been required:

- ***Straighten*** inner faces of the endcap.
- Tower angles are ***hardcoded values.***
- ***Fibre by fibre*** information not easily available.
- ***Issues*** with placement of fibres:

  Don't fit their mother volume (tower).

  In some towers ***too few fibres.***



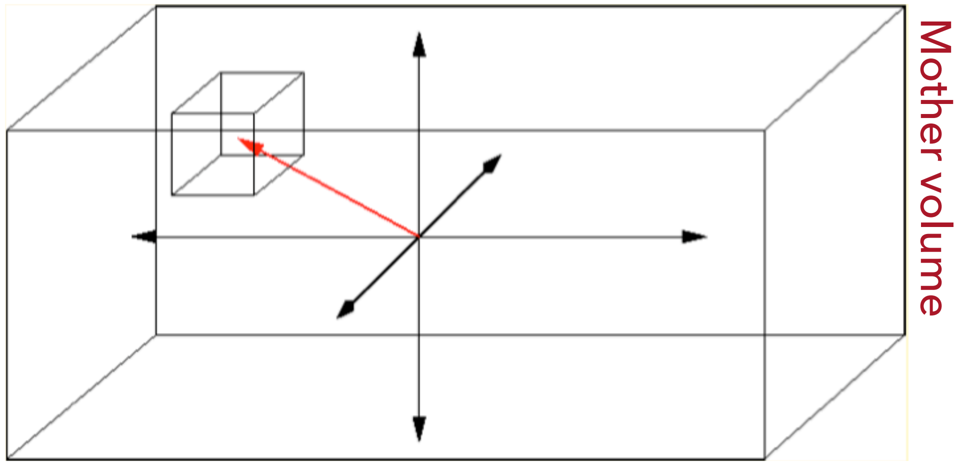


A new endcap geometry was fully rebuild

Geant4 Geometrical hierarchy

In Geant4 every volume (***daughter*** volume) has to be placed in a proper “holder” (***mother*** volume).

- A volume is placed in its mother volume:
  - Position and rotation are described with respect to the ***local coordinate*** system of the mother volume.
  - The origin of the mother's local coordinate system is at the center of the mother volume.
  - Daughter volumes ***cannot exceed*** the mother volume boundaries.
- One or more daughter volumes can be placed to a mother volume.



In our simulation: World —> Slice —> Tower —> Fibres cladding —> Fibres core.

The new endcap geometry

The old geometry adopted ***G4Trap class*** to create the slices mother volume for the towers but it was not possible to solve the endcap issues using that class.

New endcap geometry:

- Start from the barrel slice mother volume (but volumes ***overlap*** issues).
- ***G4GenericTrap*** class used to obtain a proper new mother volume.
- ***Trigonometric corrections*** applied to reach the final geometry.
- Missing fibres ***added*** (and information extracted from them).

```
//ER
// I use the G4Generictrap class, so I define the 8 points needed
vector<G4TwoVector> vertices;
vertices.push_back( G4TwoVector(0,0));
vertices.push_back( G4TwoVector(0,0));
vertices.push_back( G4TwoVector(-innerR*tan(0.5*phi_unit),innerR));
vertices.push_back( G4TwoVector(innerR*tan(0.5*phi_unit),innerR));
vertices.push_back( G4TwoVector(0,0));
vertices.push_back( G4TwoVector(0,0));
vertices.push_back( G4TwoVector(-
(innerR+tower_height)*tan(0.5*phi_unit),innerR+tower_height));
vertices.push_back(
G4TwoVector((innerR+tower_height)*tan(0.5*phi_unit),innerR+tower_height)
);

G4GenericTrap* phiER = new G4GenericTrap( "phiER", tower_height/2.,
vertices);
G4LogicalVolume* phiERLog = new G4LogicalVolume(phiER,Air,"phiERLog");
```

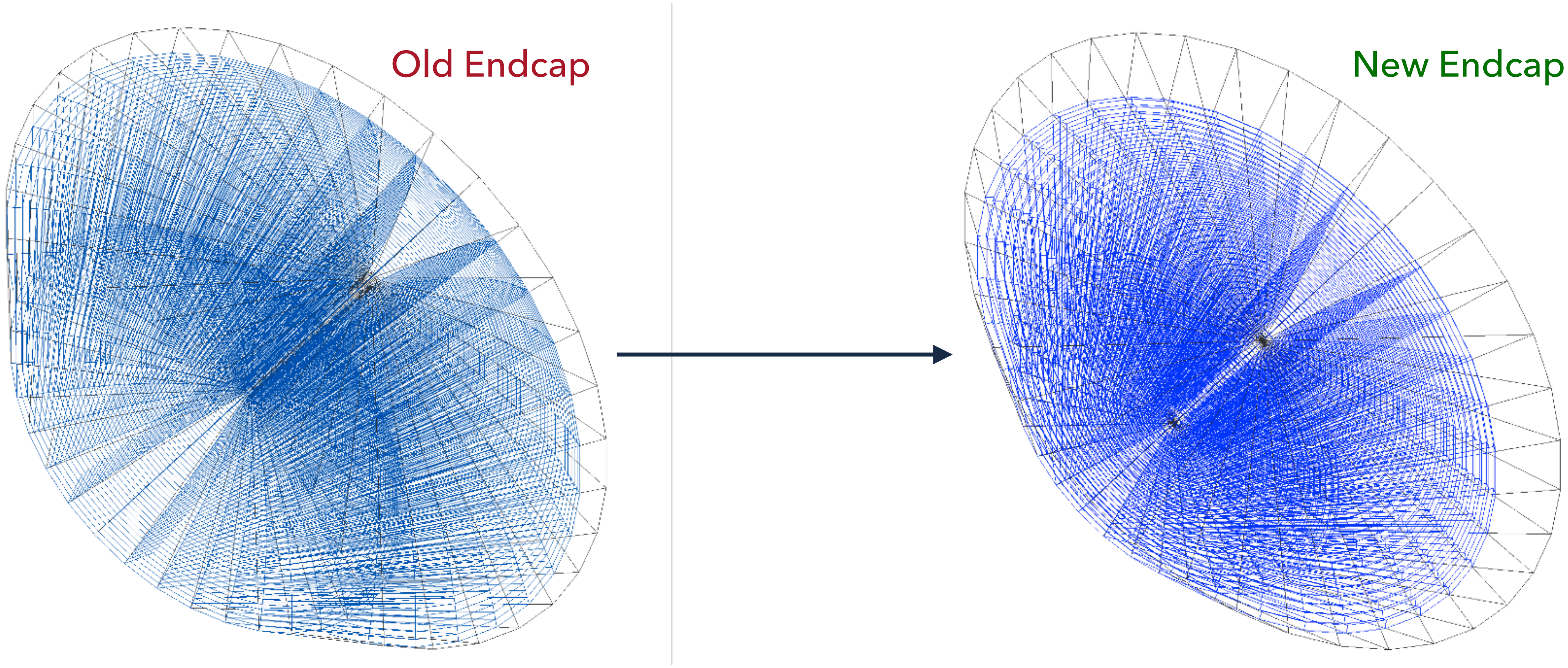
```
finnerR_new = finnerR/(cos(fthetaofcenter)-
sin(fthetaofcenter)*tan(fdeltatheta/2.));
finnerR_new2 = finnerR/(cos(fthetaofcenter2)-
sin(fthetaofcenter2)*tan(fdeltatheta2/2.));
G4double innerSide_half = finnerR_new*tan(fdeltatheta/2.);
G4double outerSide_half =
(finnerR_new+ftower_height)*tan(fdeltatheta/2.);
G4double innerSide_half2 = finnerR_new2*tan(fdeltatheta2/2.);
fTrns_Length = ftower_height/2.+finnerR_new;

fTrns_Vector =
G4ThreeVector(cos(fthetaofcenter)*fTrns_Length,0,sin(fthetaofcenter)*fTr
ns_Length);
G4double dx1=finnerR;
G4double
dxi=sin(fthetaofcenter)*finnerR_new+innerSide_half*cos(fthetaofcenter);
G4double
dxi2=sin(fthetaofcenter2)*finnerR_new2+innerSide_half2*cos(fthetaofcente
r2);
Ratio=dxi/dx1;
Ratio2=dxi2/dx1;
```

The new endcap geometry

New endcap geometry:

- Start from the barrel slice mother volume (but volumes ***overlap*** issues).
- ***G4GenericTrap*** class used to obtain a proper new mother volume.
- ***Trigonometric corrections*** applied to reach the final geometry.
- Missing fibres ***added*** (and information extracted from them).

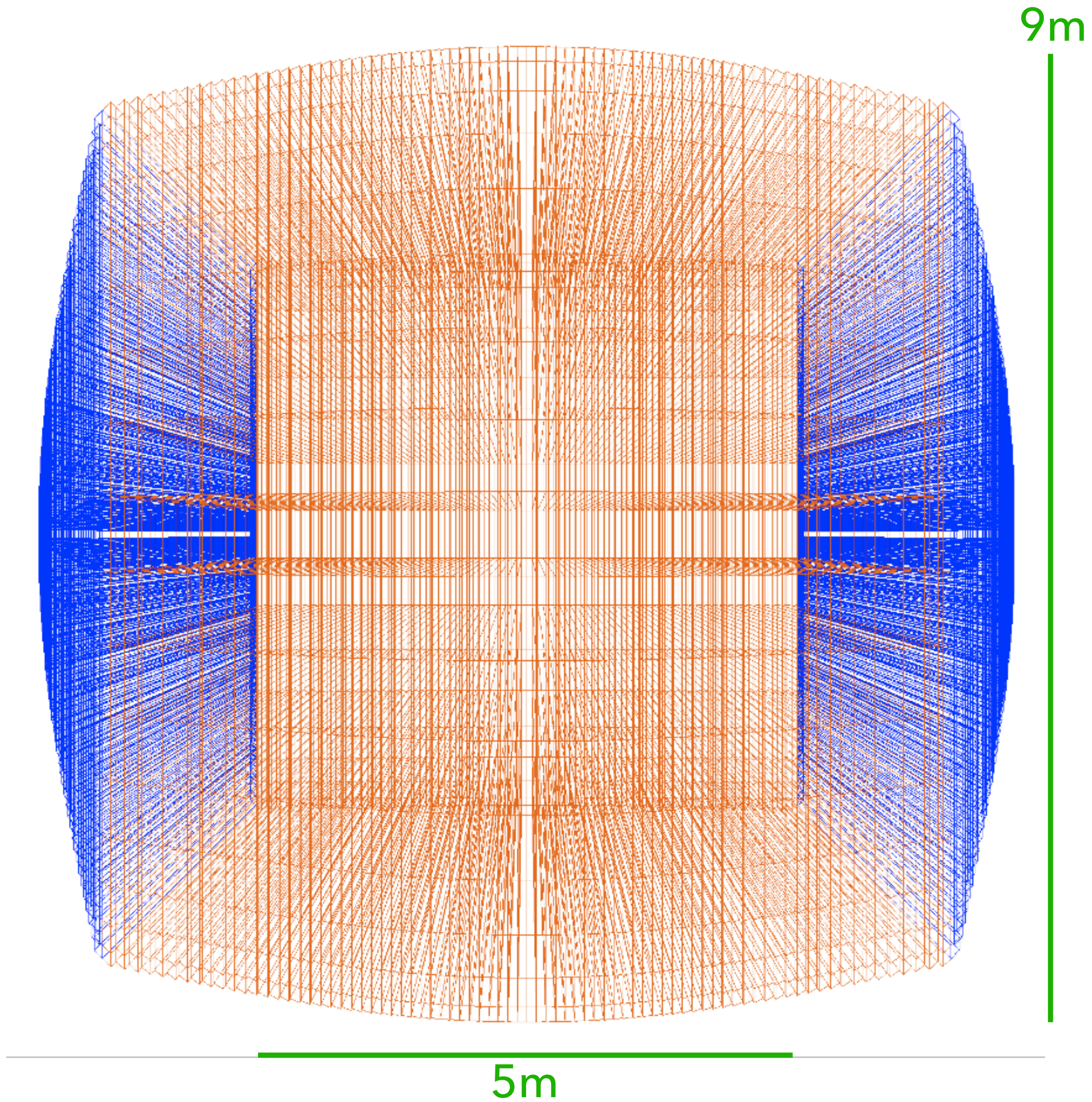


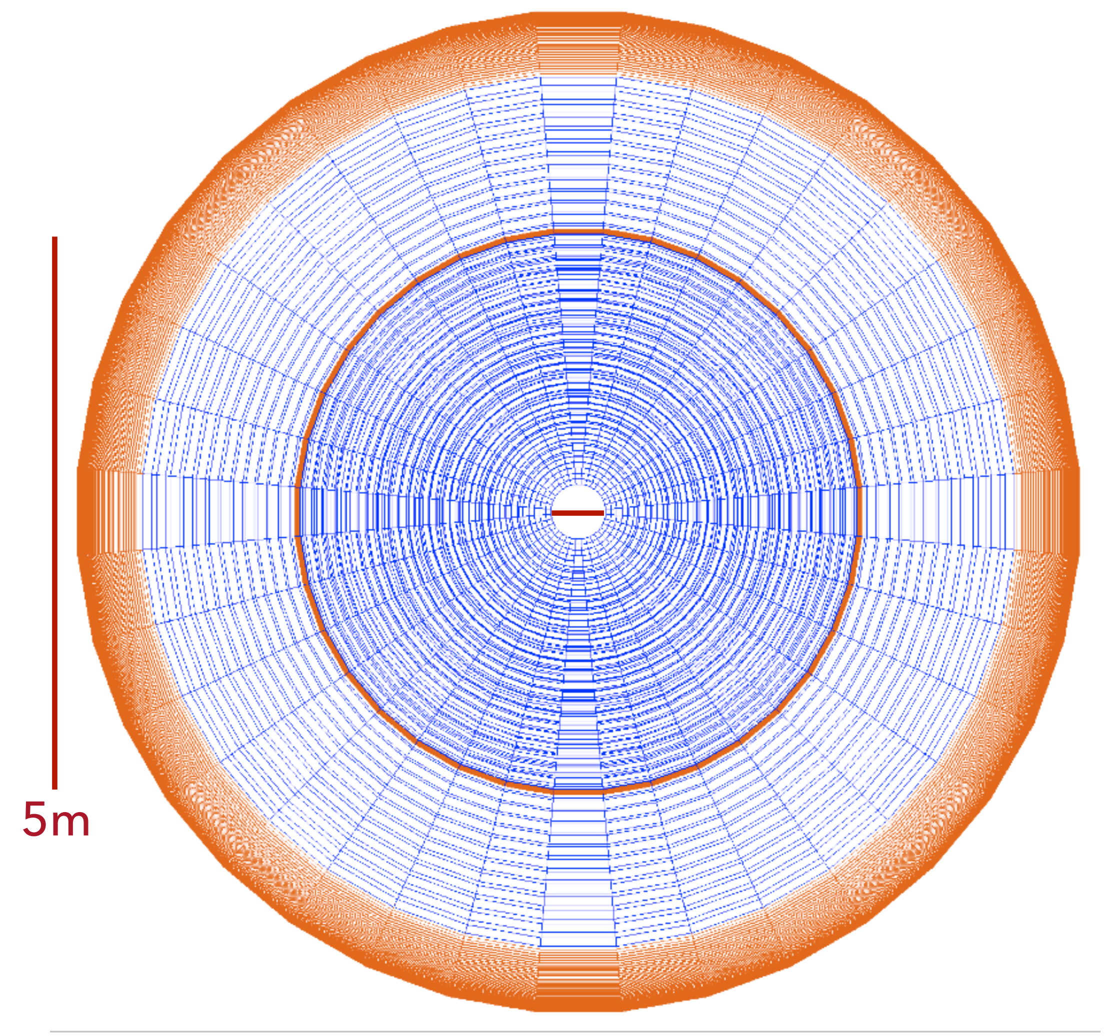
4π full geometry

Barrel: Inner length: ***5m*** - Outer diameter: ***9m.***

Endcap: Inner diameter: ***~0.5m*** - Outer diameter: ***5m.***

36 rotation around z axis (slice): ***5400*** towers (made of copper).



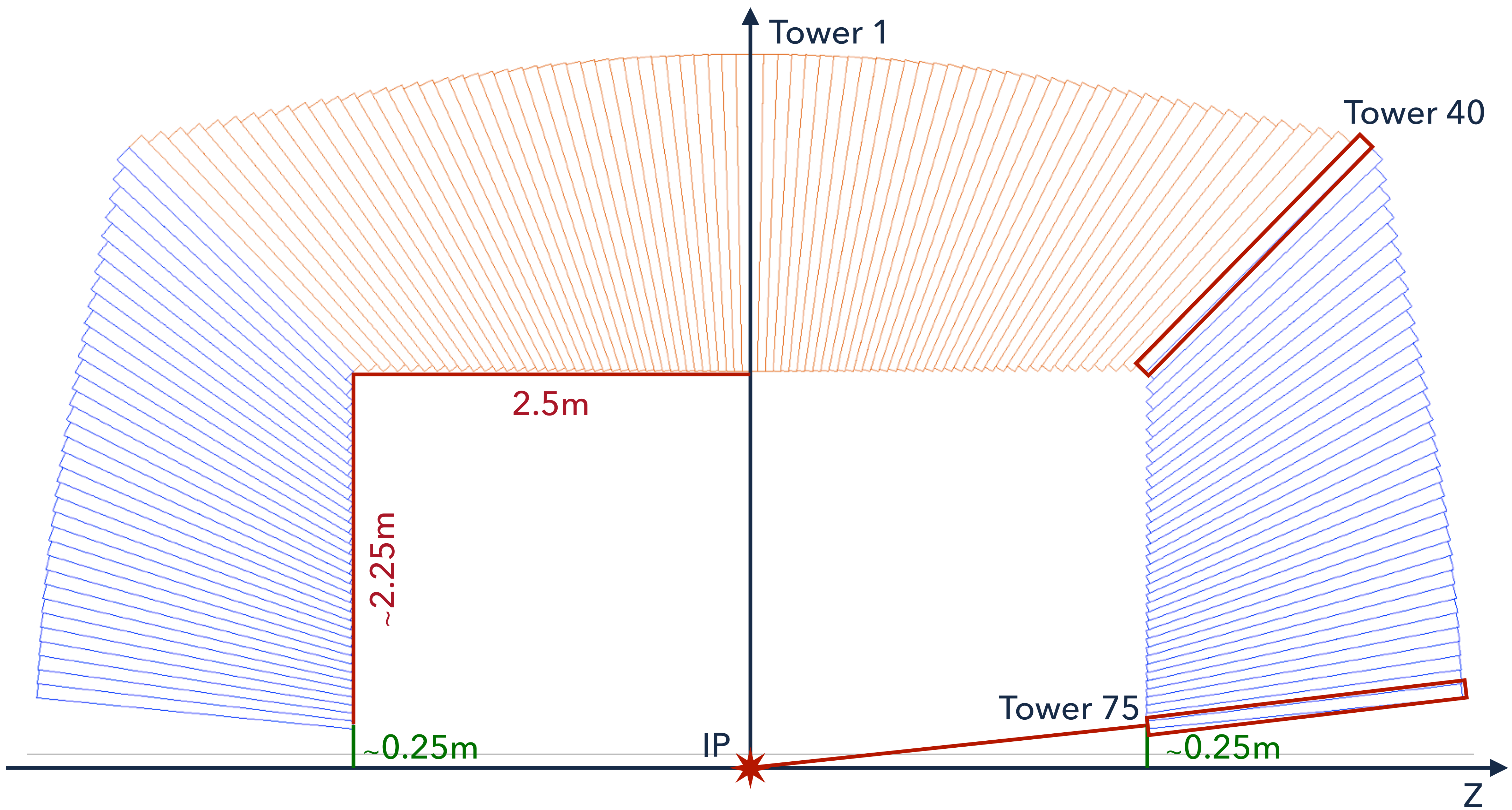


Slice details

Each ***slice*** has ***150*** towers: **Δϑ = *1.125°*** (0.0196 rad) - Tower height ***2m.***

Barrel: 40*2 = 80 towers - Inner length: 2.5m.

Endcap: 35*2 = 70 towers - Inner length: 2.25m - up to ~***0.100 rad.***

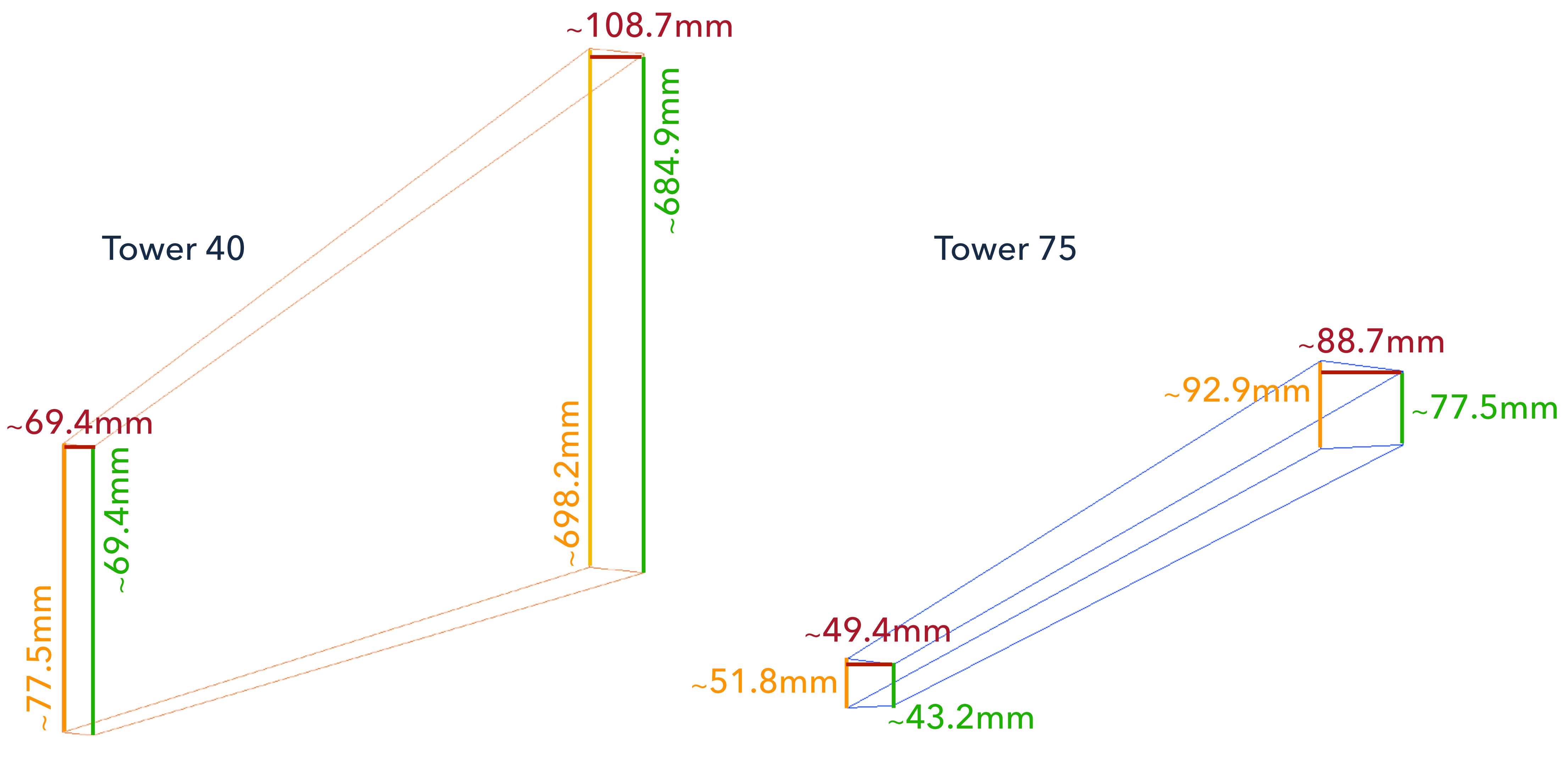


Tower details

For each half slice: 75 towers with ***different dimensions.***

Comparison between tower 40 (biggest) and 75 (smallest).

NOT TO SCALE



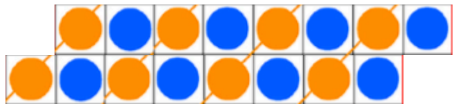
Fibres details

For both C/S fibres: 1mm diameter, 0.5mm absorber in between.

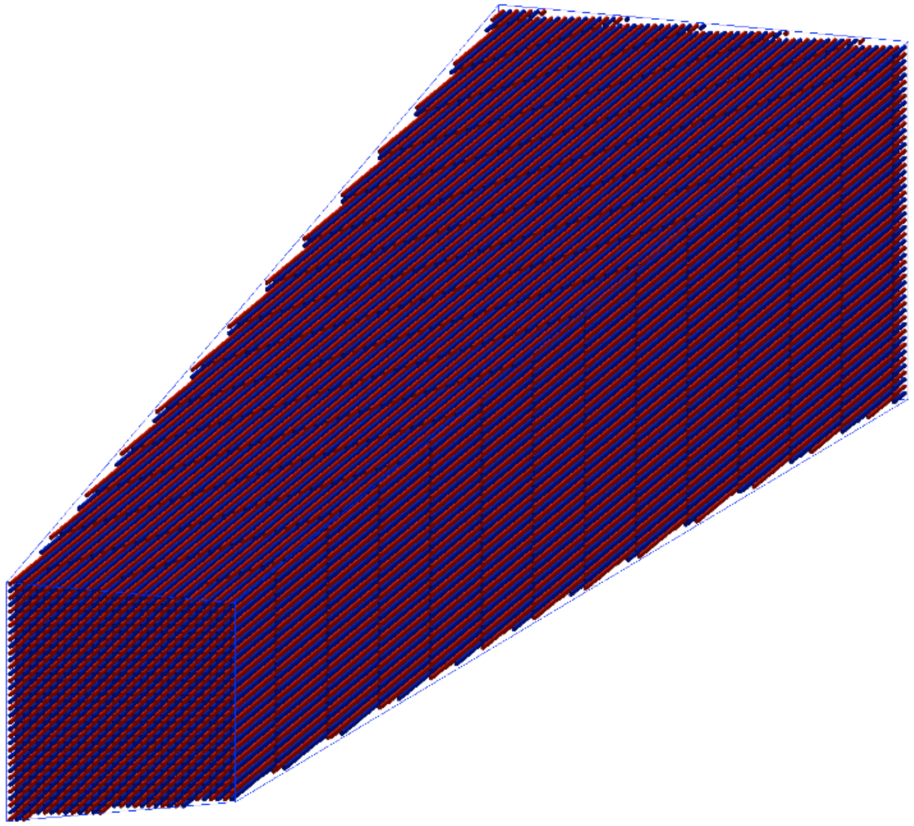
For each tower: ***different number of fibres.***

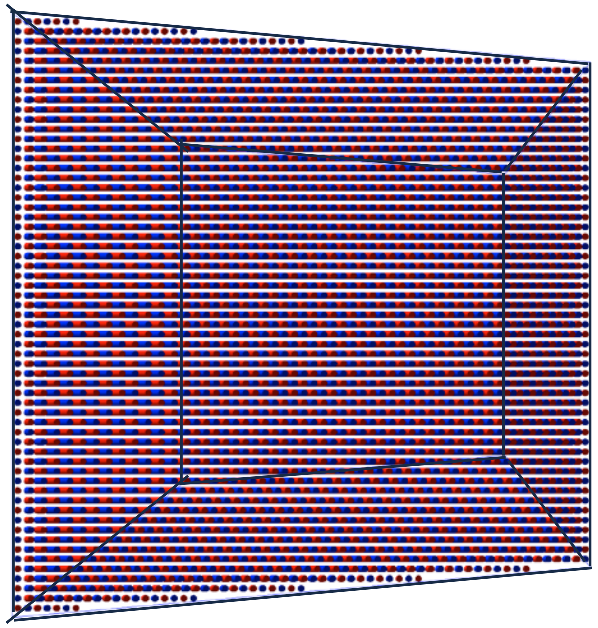
Total number of fibres: ~***131 M*** (130,729,608).

SiPM module



From **33,140** fibres (Tower 40) to **3,311** fibres (Tower 75)





Fibres details

Total number of fibres: ~***131 M*** (130,729,608).

For each tower: ***different fibre lengths.***

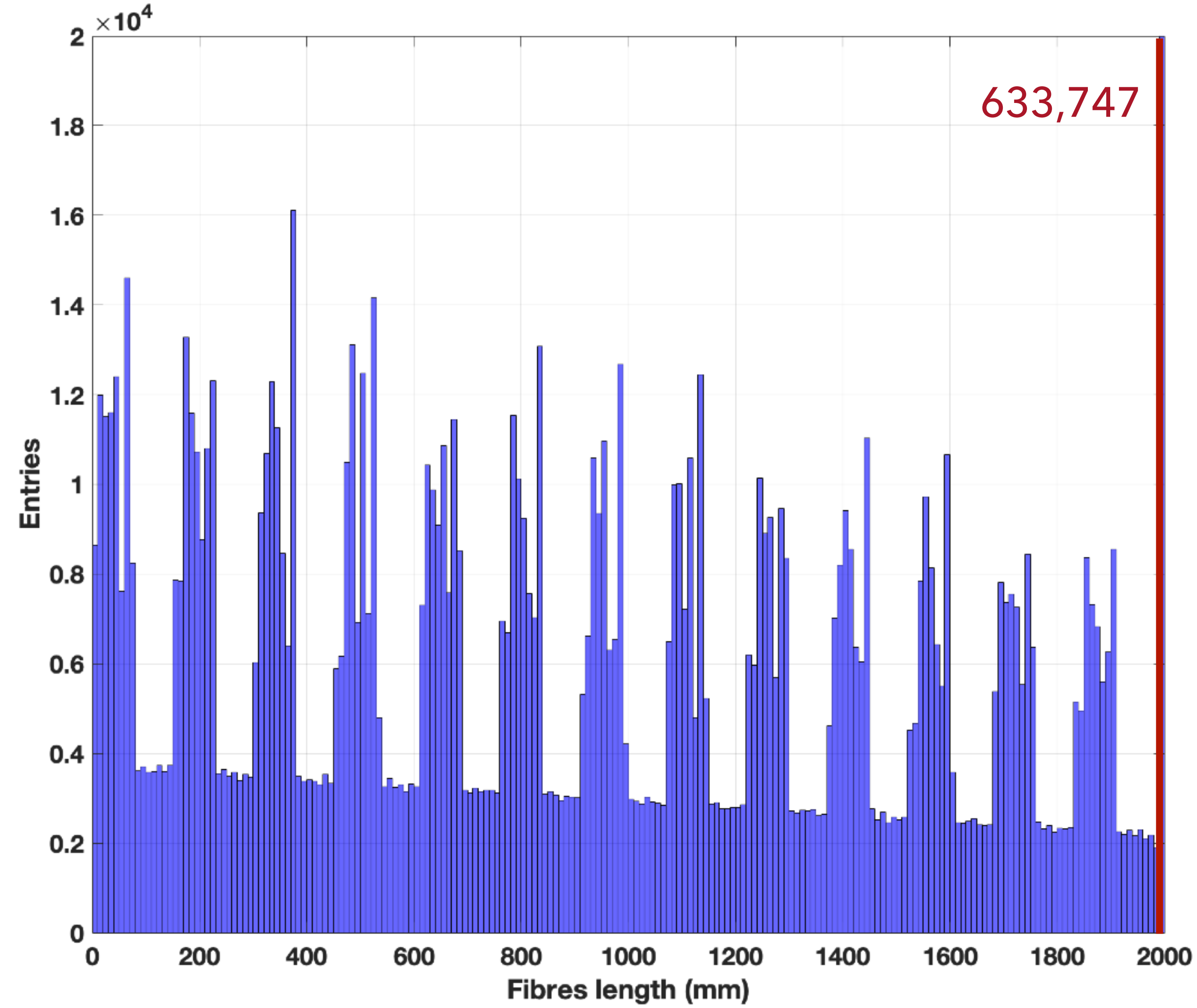
~35% are 2m long.

~38% are <1m long.

Mean length: ***~1.3 m***

Total length: ***~166,987 km***

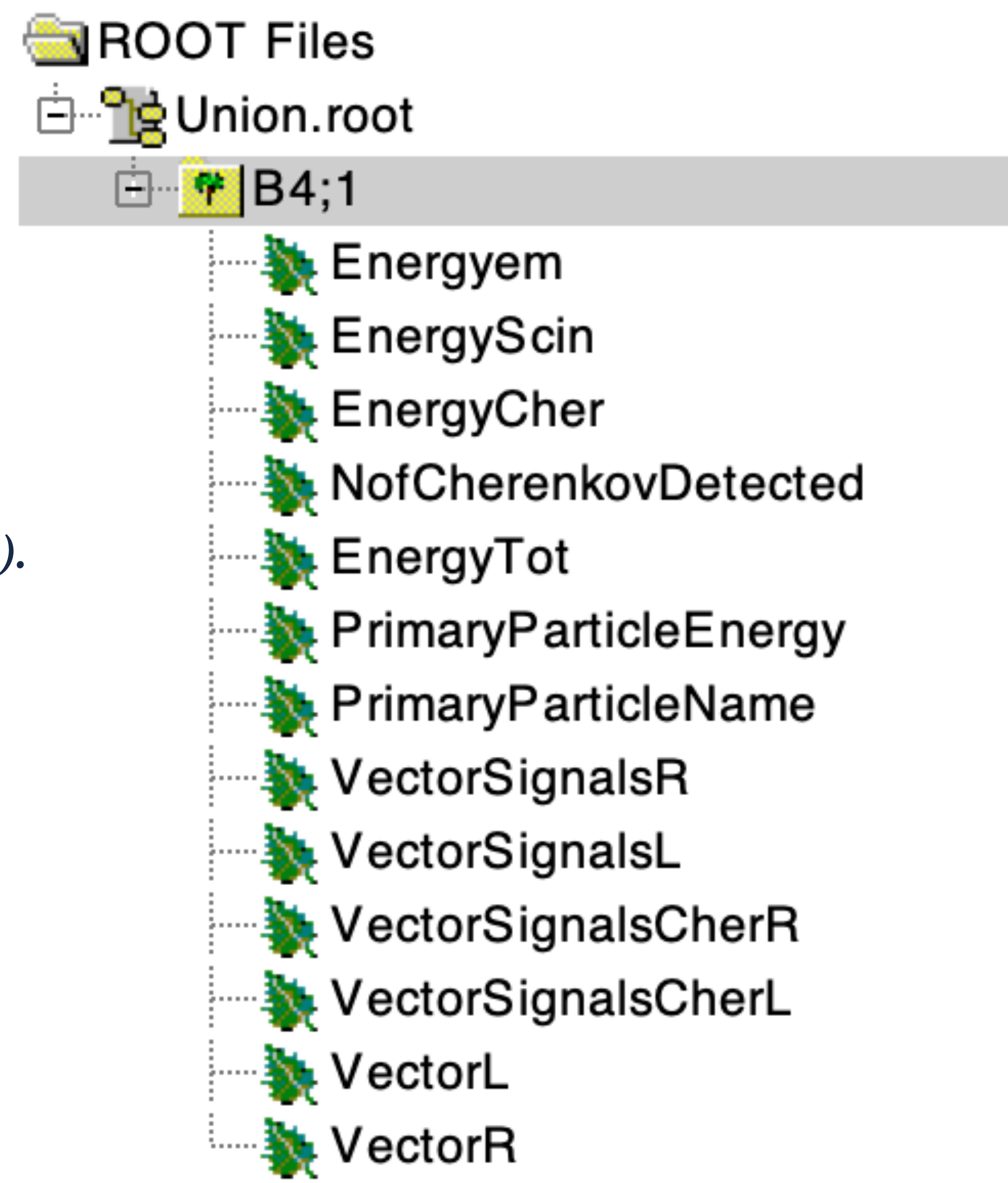
This is an "ideal world" with a constant sampling fraction



Output

The output is a root file.

All the information available for ***each tower***:



Energy of em component.

E in S fibres.

E in C fibres.

# of C photons detected (in C fibres).

Total E deposited (does not count invisibile energy).

Primary particle energy.

Primary particle name.

Vector with S fibres E deposits (R side).

Vector with S fibres E deposits (L side).

Vector with C photoelectrons in C fibres (R side).

Vector with C photoelectrons in C fibres (L side).

Vector with E deposited in towers (L side).

Vector with E deposited in towers (R side).

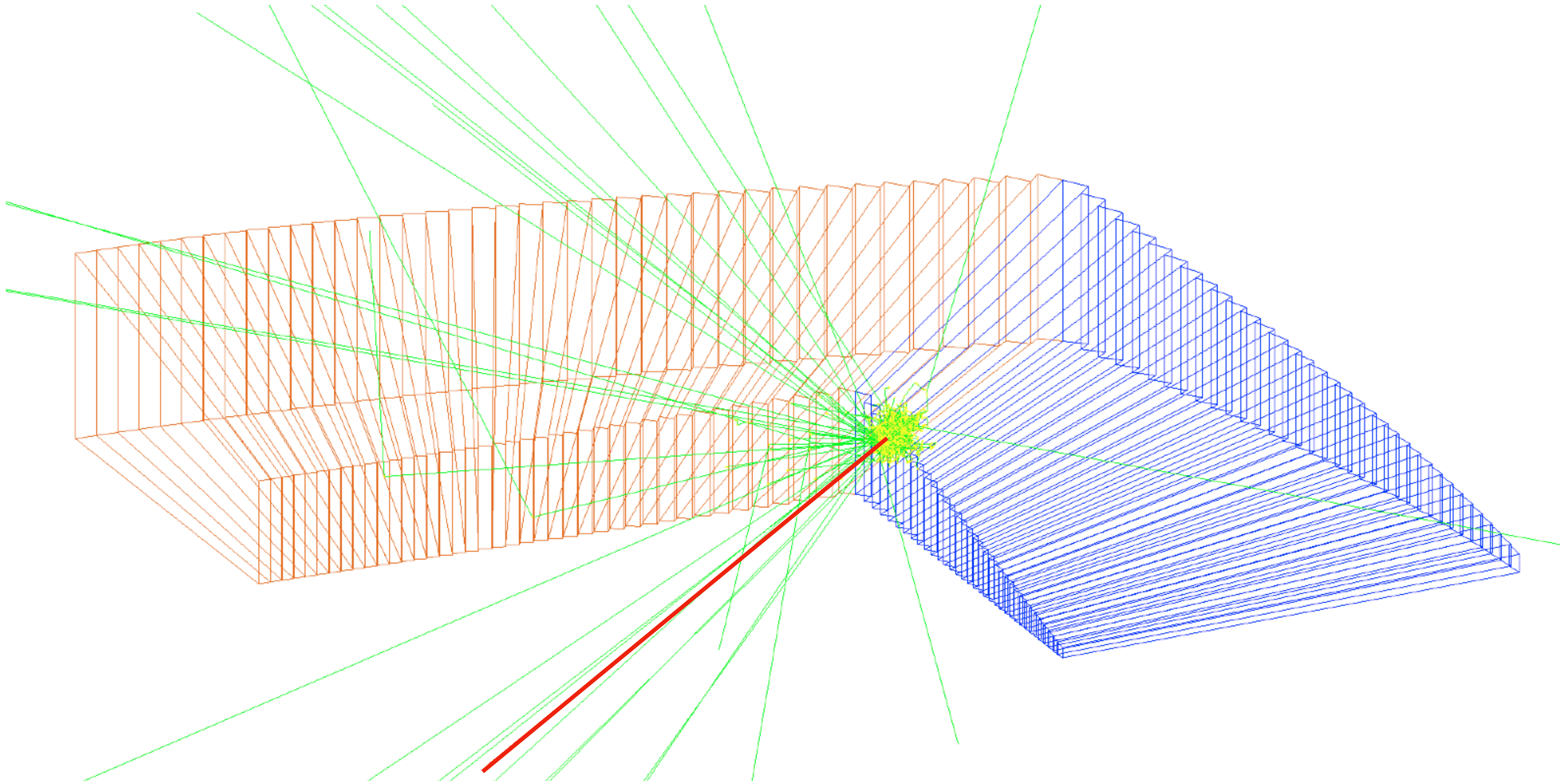
Towers calibration

Each tower of a tested half right slice was calibrated (75 total):

40 GeV e- impinging @ the center of the tower inner face (3000 events).

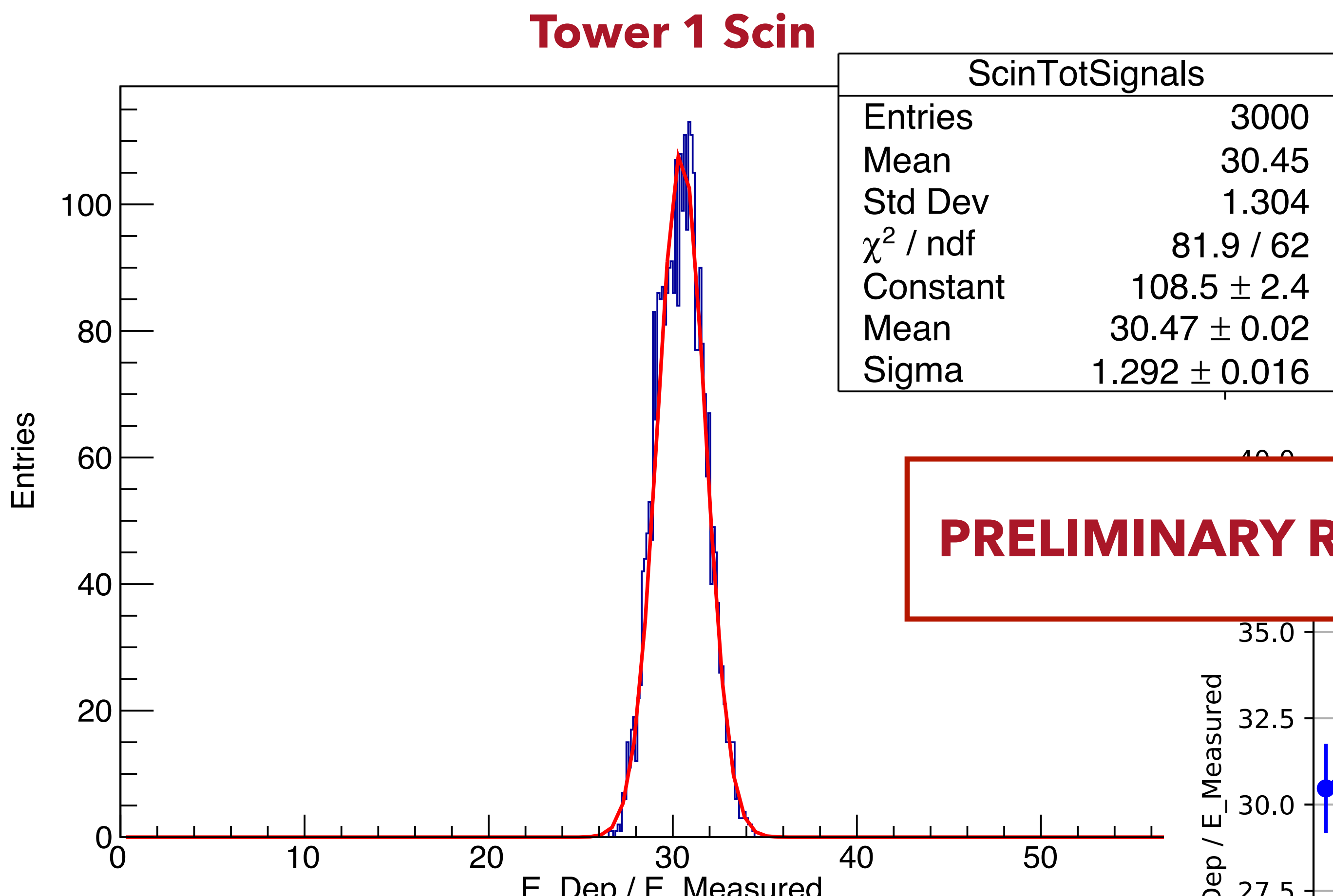
$\Delta\phi$ = +*1.5*° and **$\Delta\vartheta$** = +*1.0*° rotation applied to avoid channeling effects.

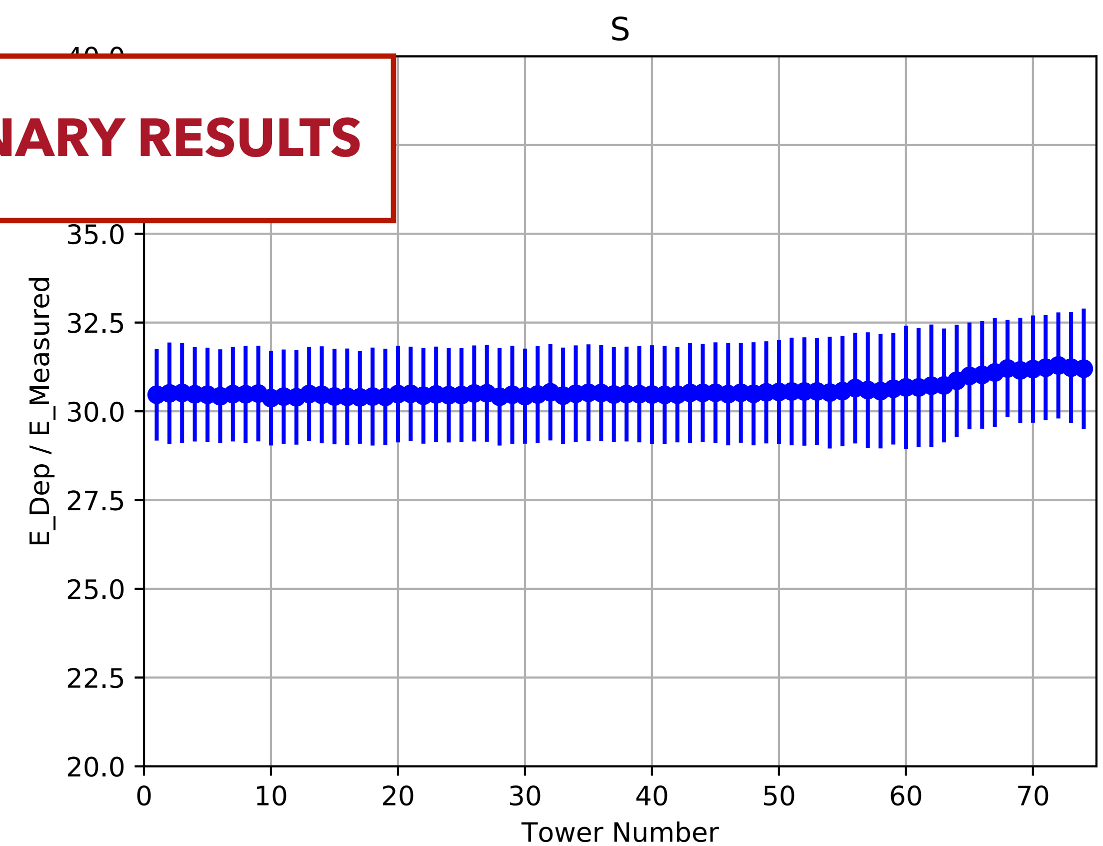
G4GeneralParticleSource used (with radius 1.0 cm and std 0.2 cm).



Towers calibration

Scintillation signal: ratio between E deposited in the tower (E_Dep) and E deposited in the relative S fibres (E_measured).



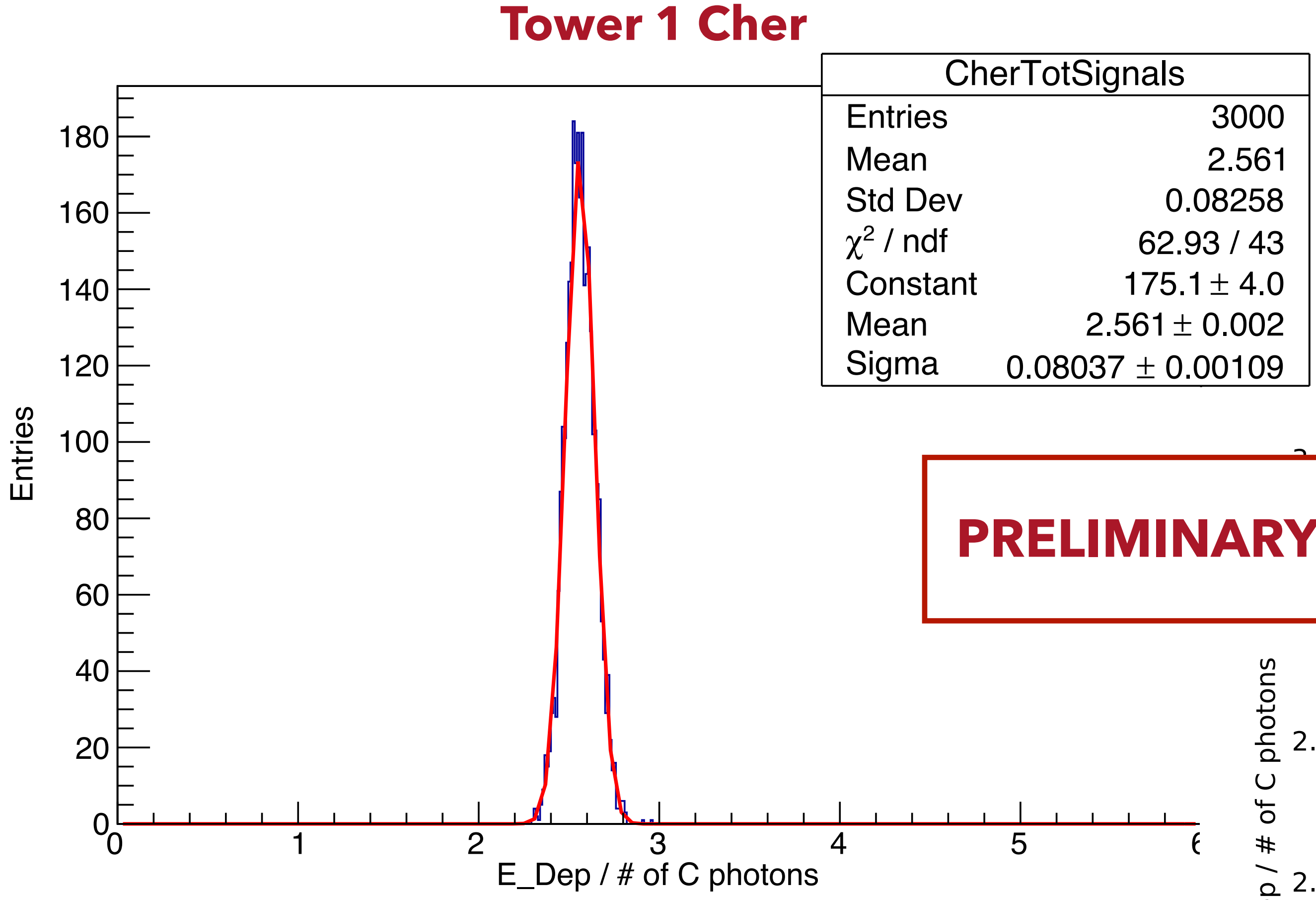


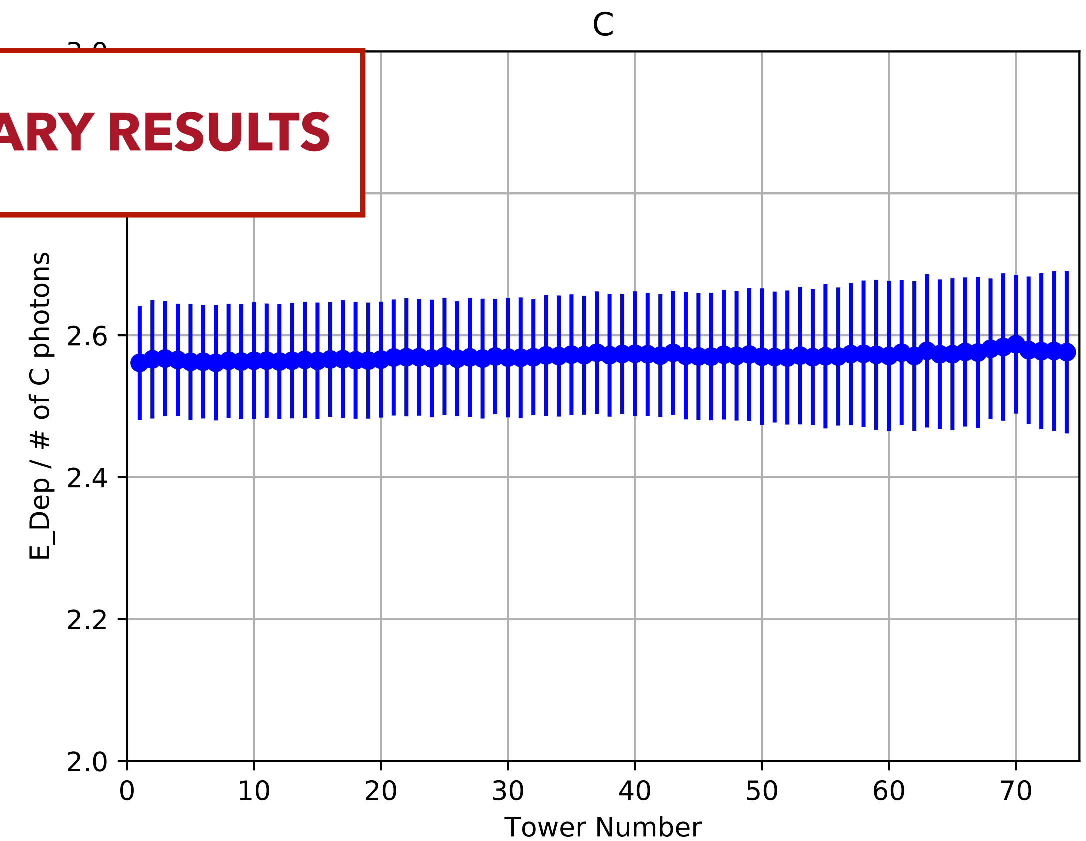
PRELIMINARY RESULTS

Birks saturation correction applied

Towers calibration

Cherenkov signal: ratio between E deposited in the tower (E_Dep) and C photons generated in the relative C fibres (# C photons).





PRELIMINARY RESULTS

C photons not yet converted in pe

Event display

It is also possible to extract a txt file.

All the information available for ***each hit fibre***:

Fibre ID: (univocally determinate by convolution of different volumes copy numbers)

E deposited in S fibre (if S fibre) or # of C photons (if C fibre).

C/S flag type.

Inner fibre tip position (x,y,z with respect to the IP).

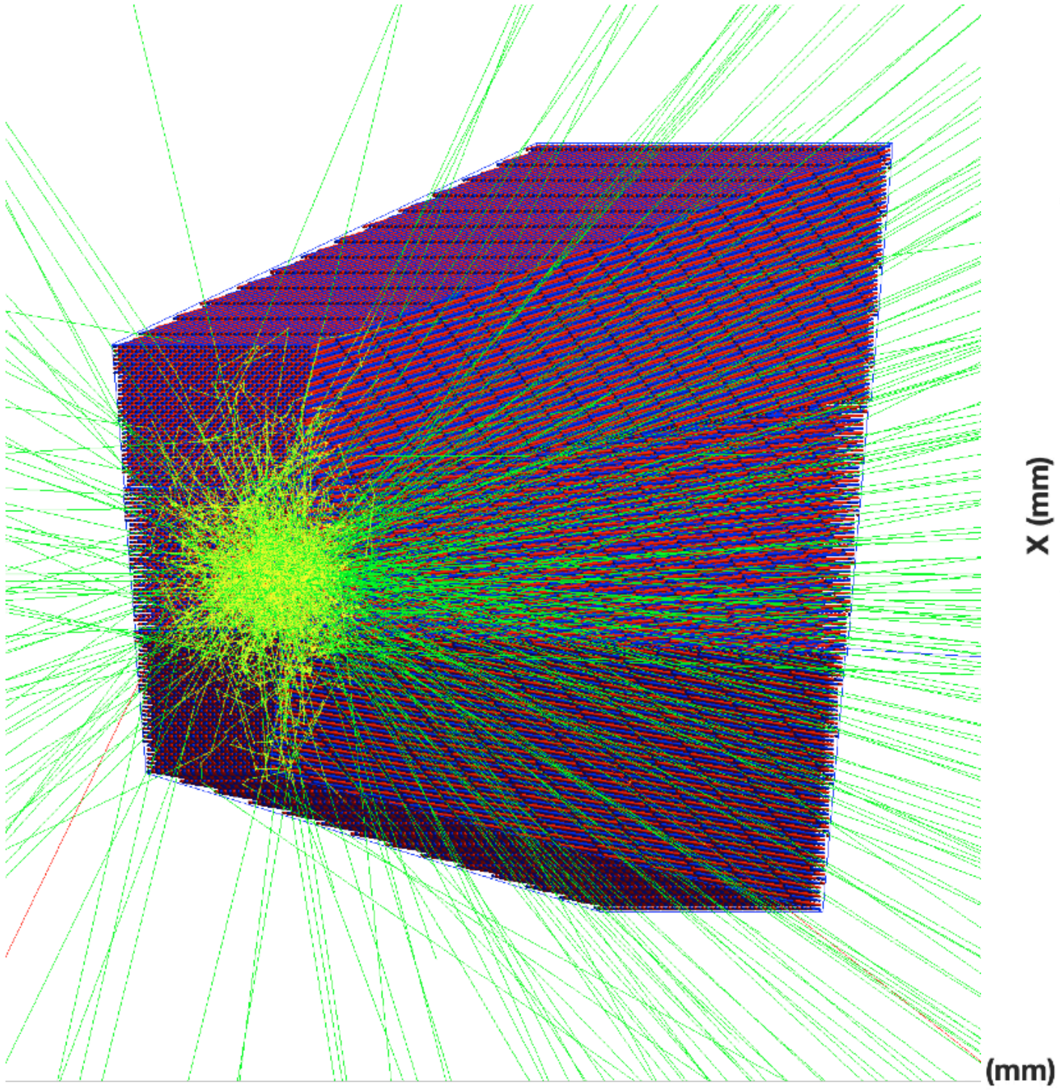
Slice and tower copy numbers.

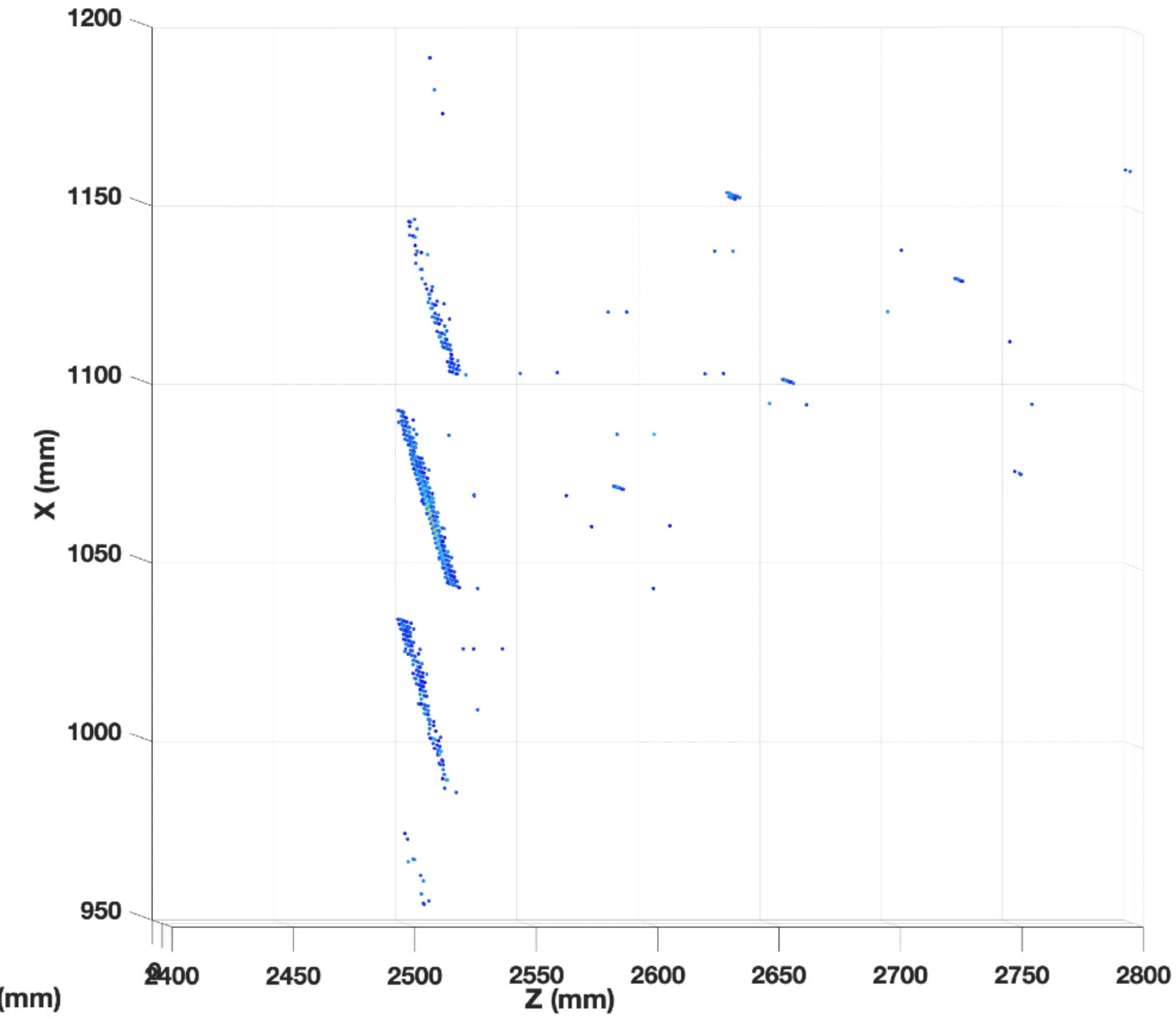
```
typedef struct FiberInfo {
    G4double F_ID, F_E, F_X, F_Y, F_Z;
    G4int F_Type, F_slice, F_tower; //C
} Fiber_Info;
```

```
inline void B4aEventAction::WriteFiber_Info(G4double FID, G4double FE, G4int FType, G4ThreeVector Fpos, G4int
    slice, G4int tower){
    int k=0;
    while (Fiber_Hits[k].F_ID!=0 && Fiber_Hits[k].F_ID!=FID){
        k++;}
    Fiber_Hits[k].F_ID = FID;
    Fiber_Hits[k].F_E += FE;
    Fiber_Hits[k].F_Type = FType;
    Fiber_Hits[k].F_X = Fpos[0];
    Fiber_Hits[k].F_Y = Fpos[1];
    Fiber_Hits[k].F_Z = Fpos[2];
    Fiber_Hits[k].F_slice = slice;
    Fiber_Hits[k].F_tower = tower;
}
```

Event display

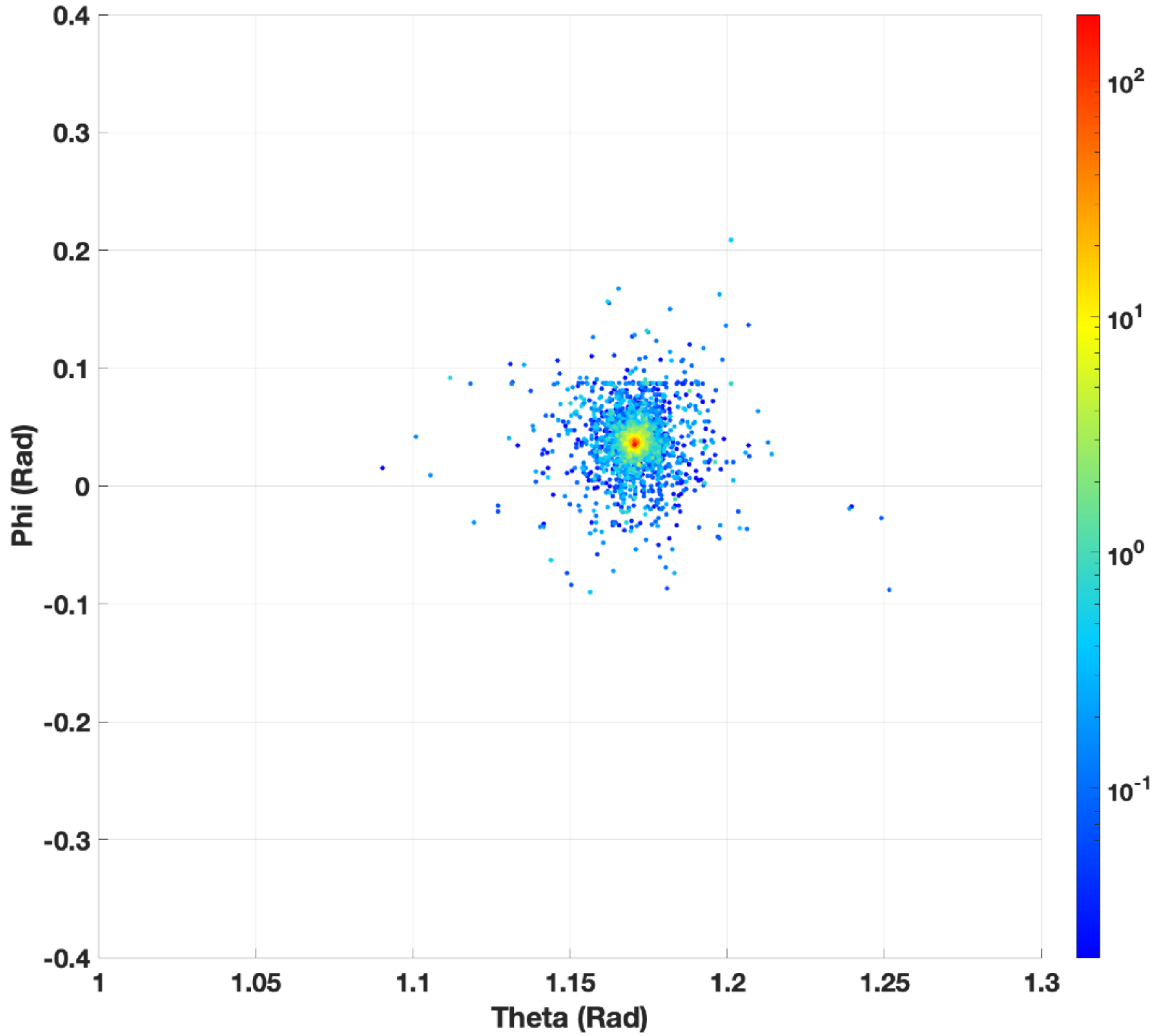
It is also possible to extract a txt file: using the inner fibre tip position and the E deposited, i.e. in the Scintillating fibres, an event display can be generated.





Event display

40 GeV e- Scintillating fibres sample

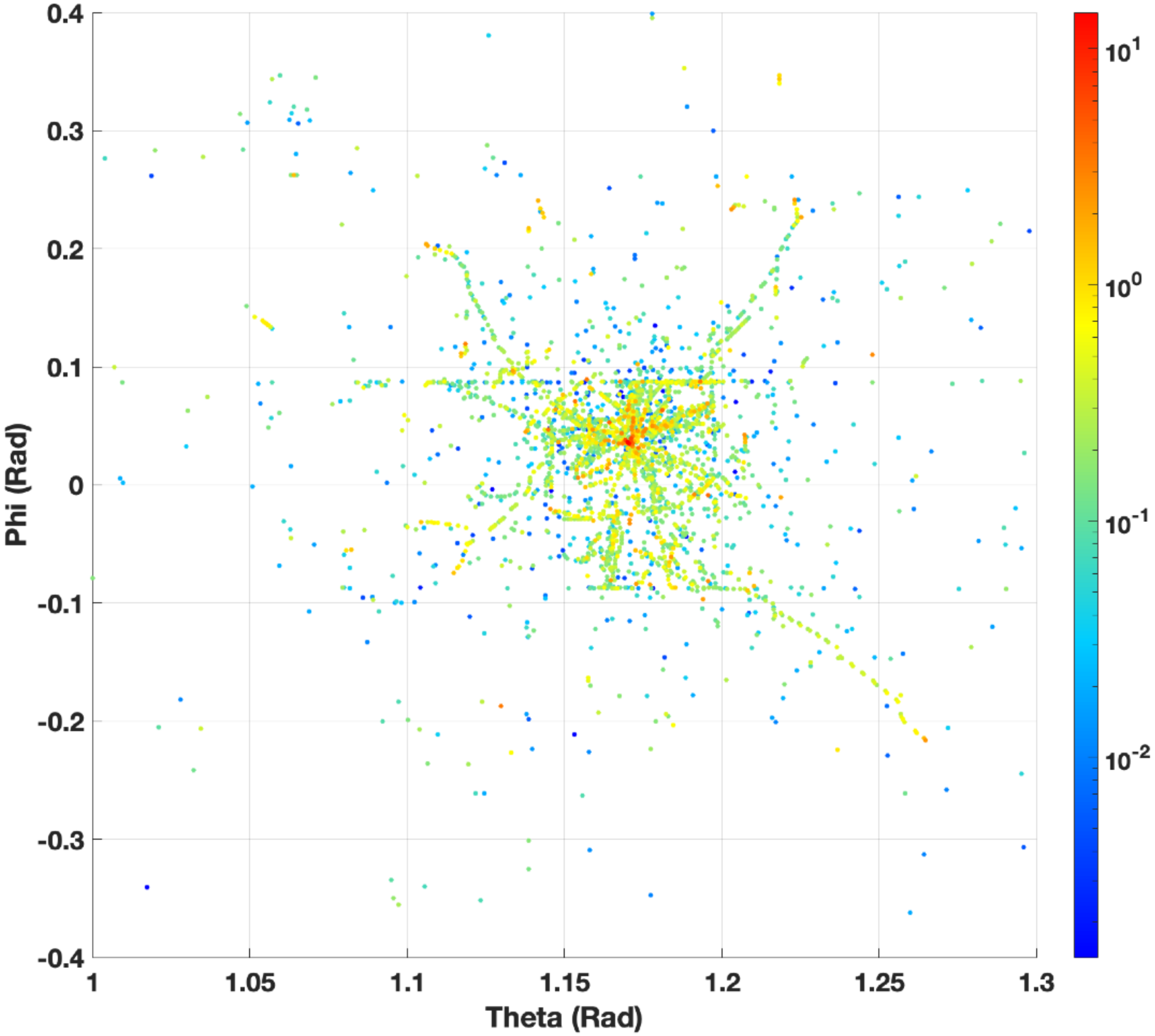


PRELIMINARY RESULTS

Particle:	*e-*
Total # of fired fibres:	**1849**
# of S fired fibres:	**1217**
# of C fired fibres:	**632**
# of fired towers:	**9**
# of fired slices:	**3**
Total S energy:	**1260 MeV**
Max S energy:	**191 MeV**
Total # of C photons:	**14343**
Max # of C photons:	**1471**

Event display

40 GeV π- Scintillating fibres sample

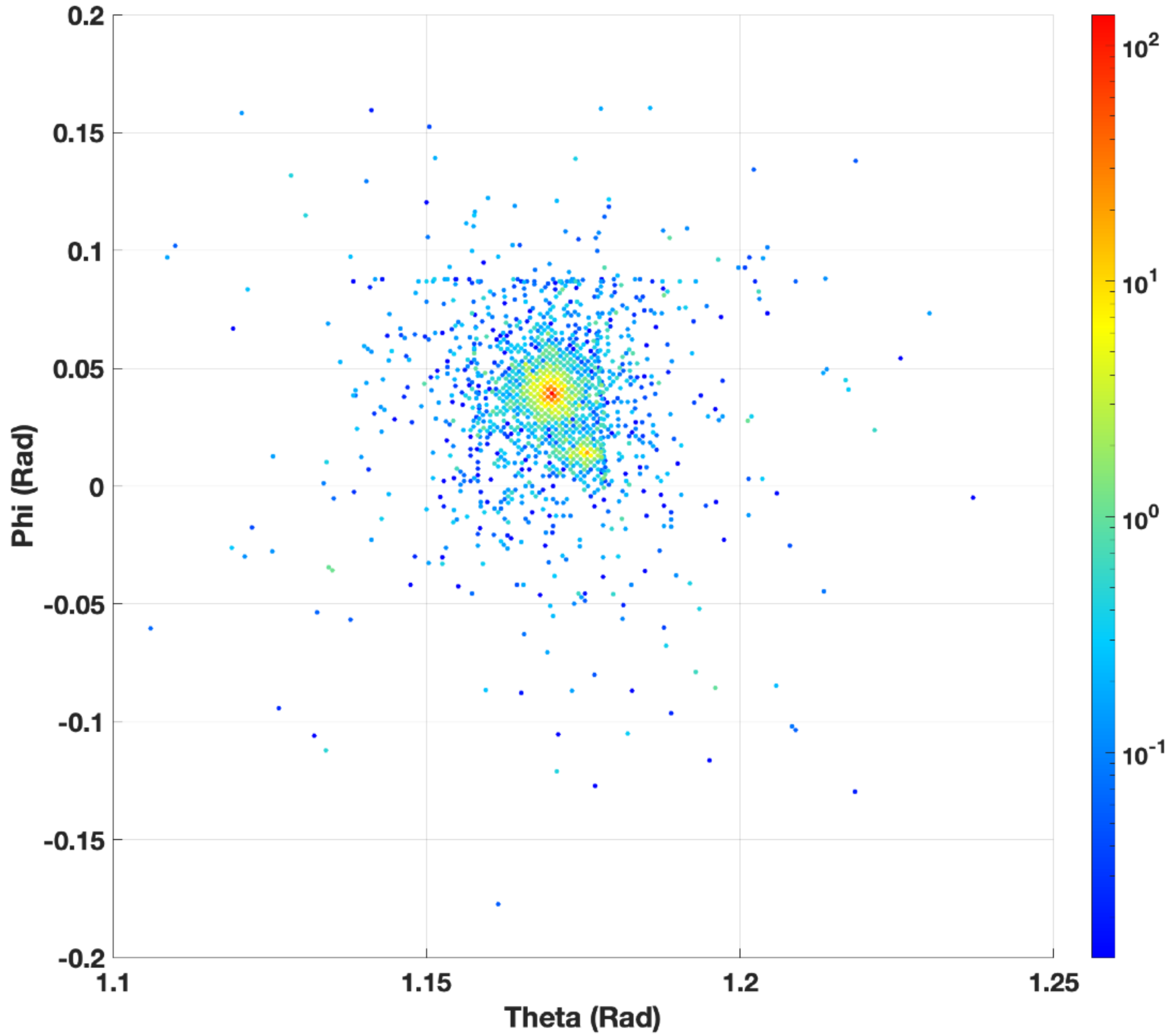


PRELIMINARY RESULTS

Particle:	π-
Total # of fired fibres:	3907
# of S fired fibres:	2746
# of C fired fibres:	1224
# of fired towers:	22
# of fired slices:	8
Total S energy:	963 MeV
Max S energy:	14 MeV
Total # of C photons:	6831
Max # of C photons:	73

Event display

40 GeV π^0 —> $\gamma\,\gamma$ Scintillating fibres sample



PRELIMINARY RESULTS

Particle:	π^0
Total # of fired fibres:	**1985**
# of S fired fibres:	**1290**
# of C fired fibres:	**695**
# of fired towers:	**10**
# of fired slices:	**3**
Total S energy:	**1193 MeV**
Max S energy:	**135 MeV**
Total # of C photons:	**14758**
Max # of C photons:	**1896**

Conclusions

What has been done:

The geometry is now fully implemented and customisable.

Data can be collected from both hit fibres and/or towers.

Other quantities can be "easily" added to the struct (if needed).

Next steps:

Improve data collection in a more efficient way (using G4Hits).

Add the PreShower detector in front of the DR calorimeter.

Add DR geometry in the common GEANT4 based framework (more in Elisa slides).

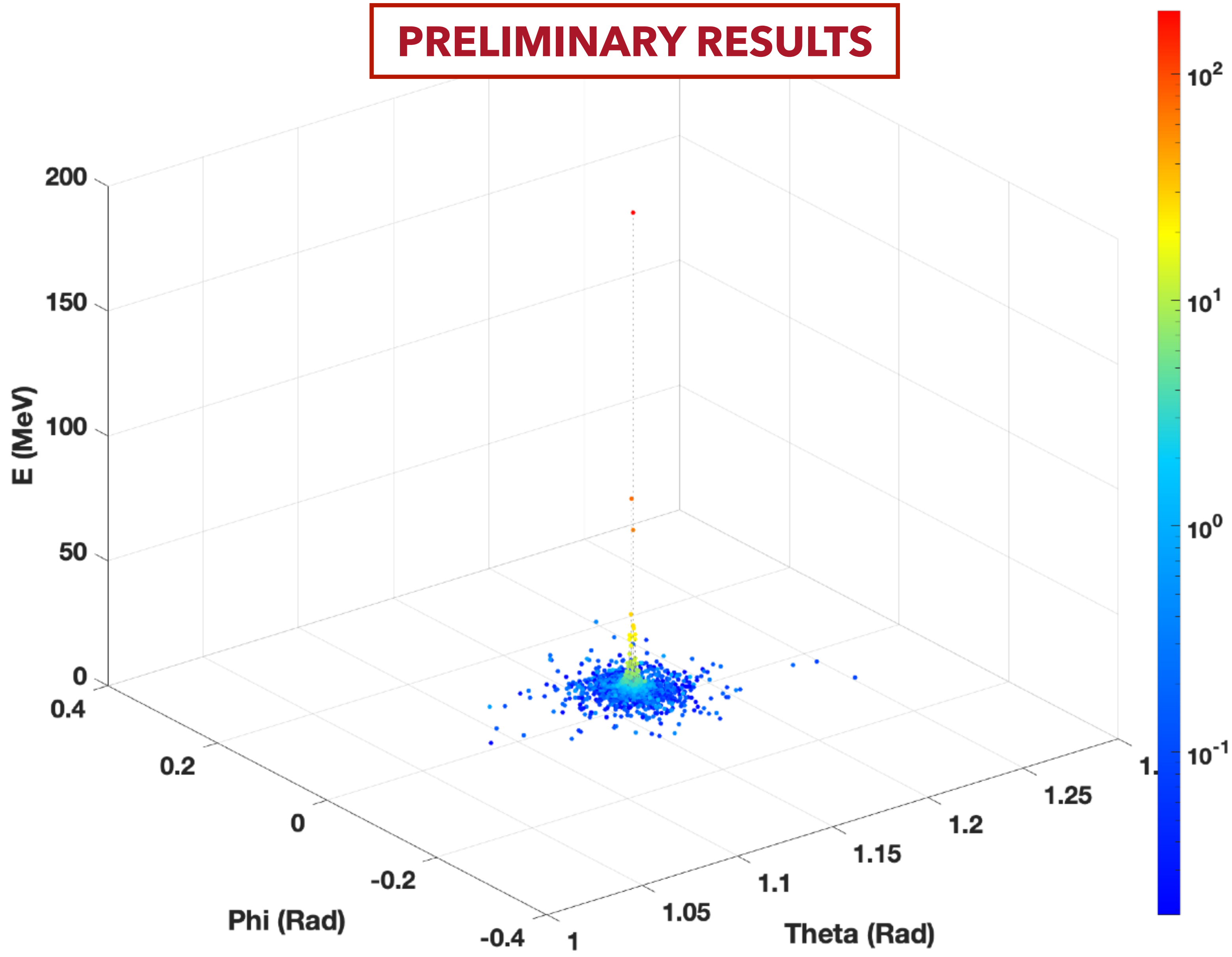
Start some preliminary validation and analysis.

Thank you

Additional Slides

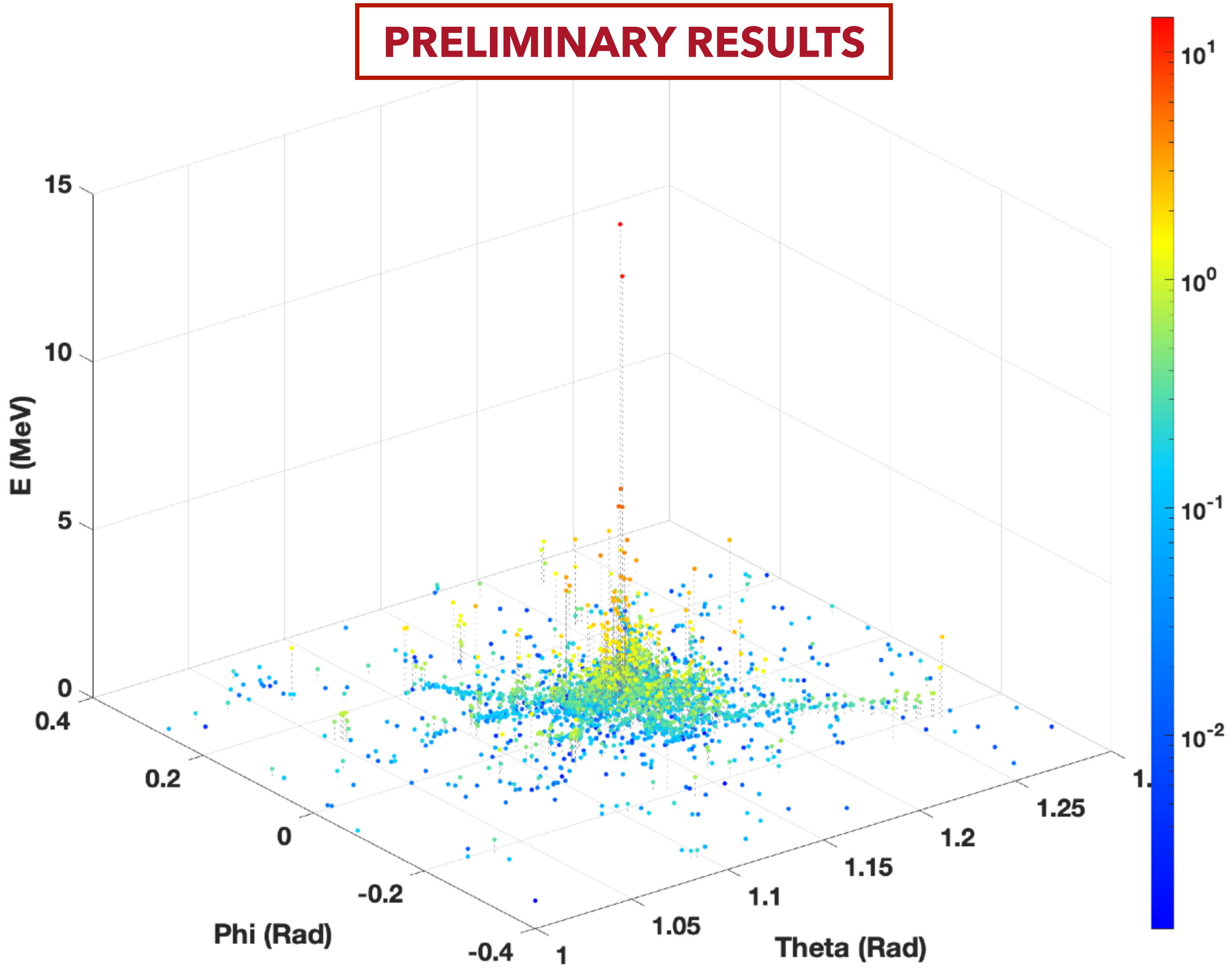
Event display

40 GeV e-



Event display

40 GeV π-



Event display

40 GeV π^0 —> $\gamma\,\gamma$

PRELIMINARY RESULTS