Hyper-K Geometry for WCSim

Peter Gumplinger - TRIUMF
Simulation Software Support Scientist
Geant4 Collaboration - Author of optical Module

Abstract: This talk describes the implementation details of a Geant4 geometry model for the baseline design of the Hyper-K detector.

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Baseline Design - Salient Features

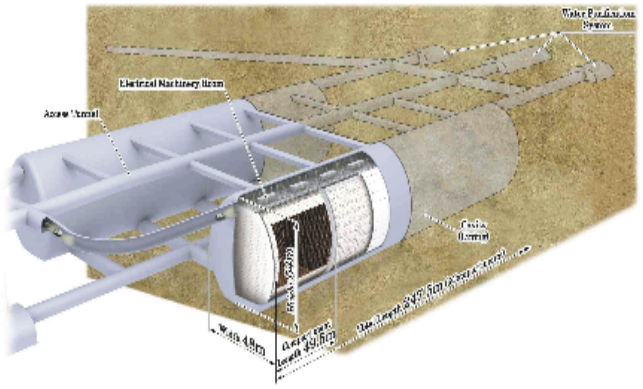


FIG. 1. Schematic view of the Hyper-Kamiokande detector.

- 2 separate caverns
- *egg-shape* cross section
- 5 optical separated compartments per cavern
- Compartment optically separated into 3 regions: inner, outer, and middle/dead space

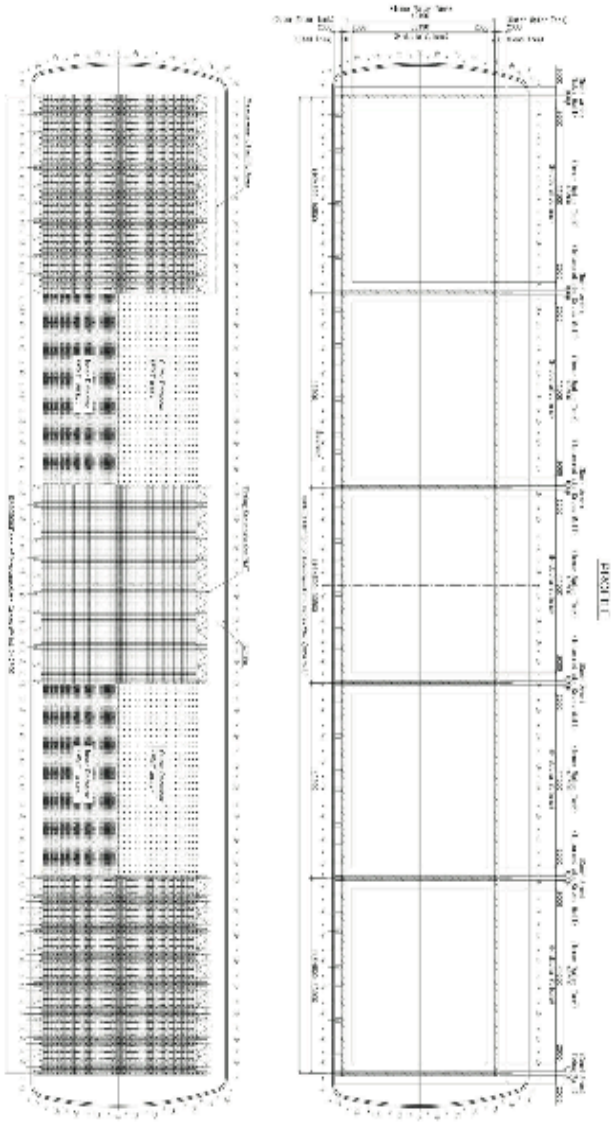
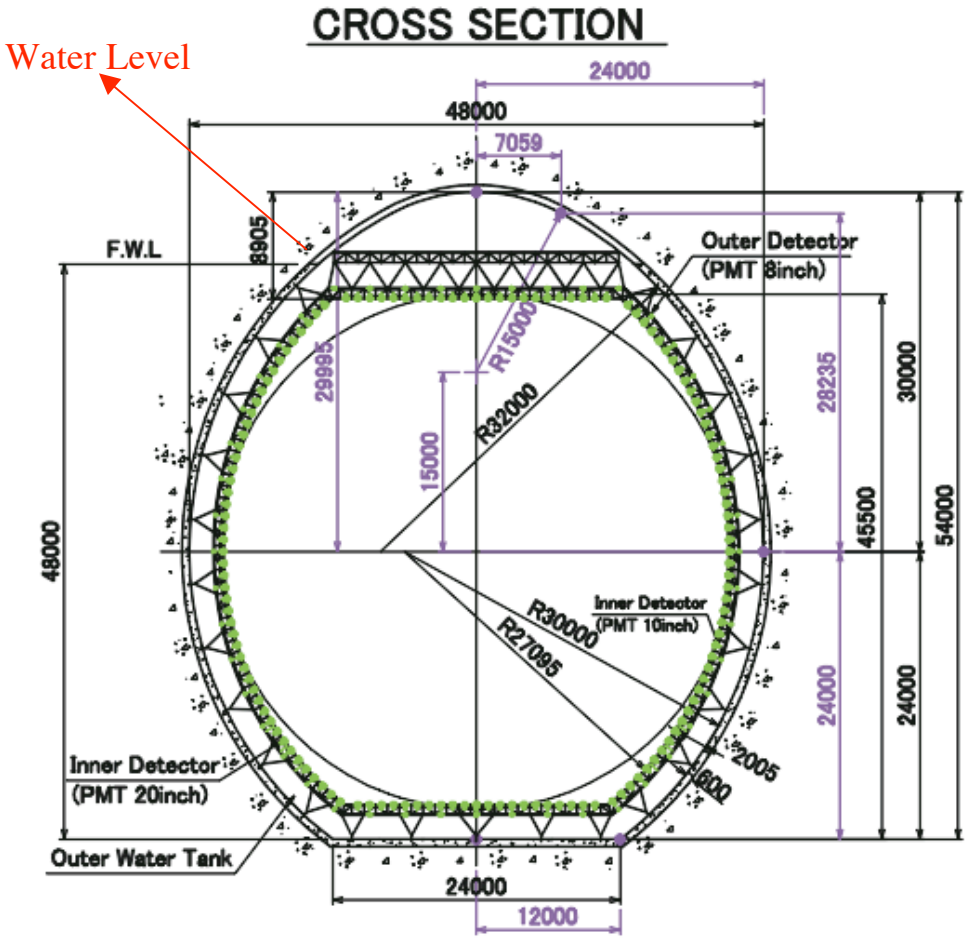


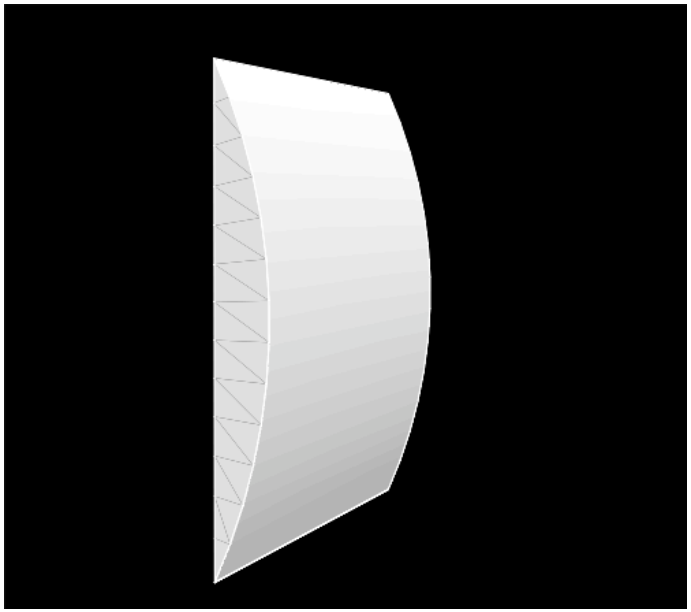
FIG. 8. Profile of the Hyper-K detector. The left panel shows PMT arrays and the support structure for the inner and outer detectors. The right panel shows segmentation of the detector. Each quasi-cylindrical tank lying horizontally is segmented by intermediate walls into five sub-detectors.



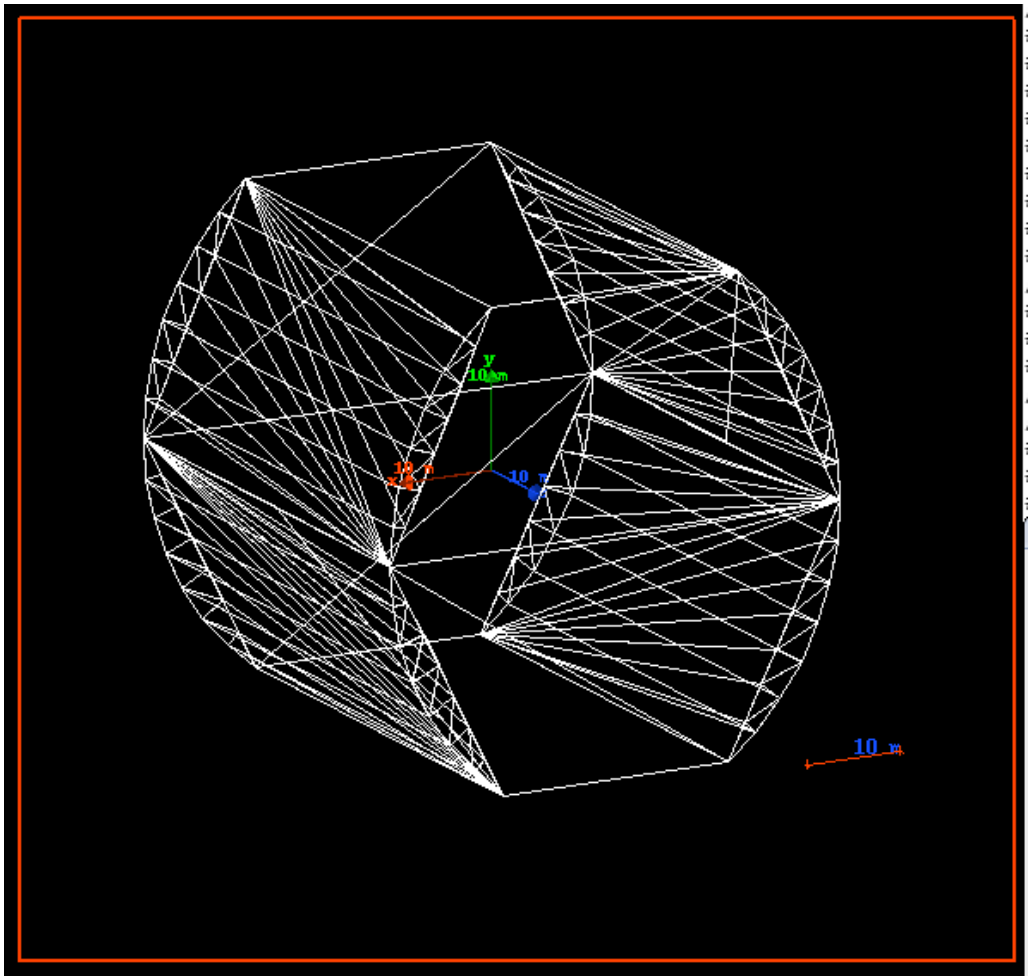
Cavern Cross Section

- R_Top > R_Bottom
- Centre_Top != Centre_Bot
- PMTs facing to/away from centre of curvature
- Side: **inner PMT on equator**
- End: inner PMT on horizontal line

Water Tank



Slice == G4SubtractionSolid(G4Tub - G4Box)



Construct Half (top or bottom):

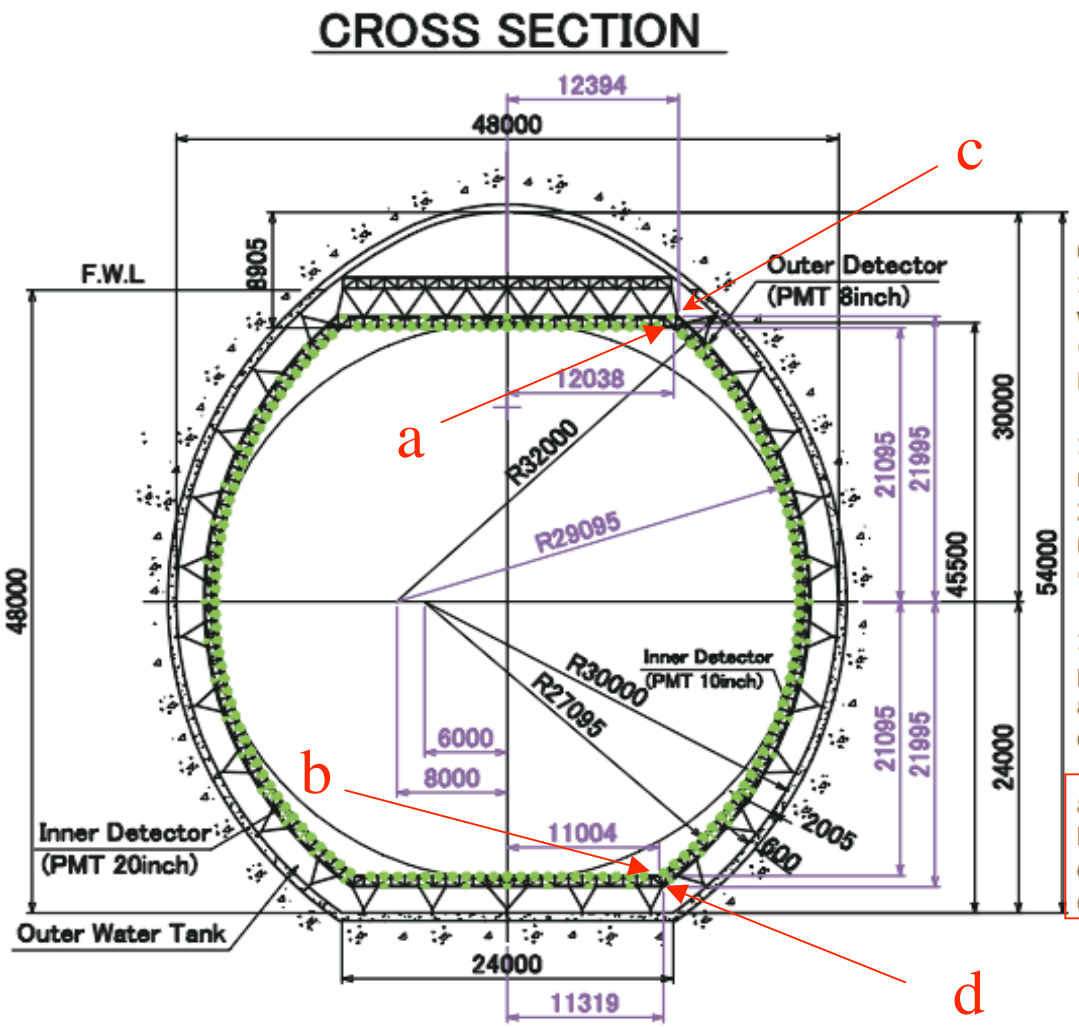
Centre == G4Trap

Union1 == G4UnionSolid(G4Trap + Slice(pos1))

Union2 == G4UnionSolid(Union1 + Slice(pos2))

WaterTank == G4UnionSolid(Top+Bottom)

Side Wall PMT Arrangement



Q1. About cross section

1-1) The center position of outer wall, denoted by A and B.
➔See figure. A (-8000,0)
B(-6000,0)

1-2) The center position and the radius in lower half is B and 27095. How about upper half (center and radius)?
➔R =29095

1-3) Where are the edge positions crossing top/bottom and barrel in the inner and outer detector (denotes a,b,c,d)?

a(12038,21095)
b(11004, -21095)
c(12394, 21995)
d(11319, -21995)

Side Wall PMT Arrangement

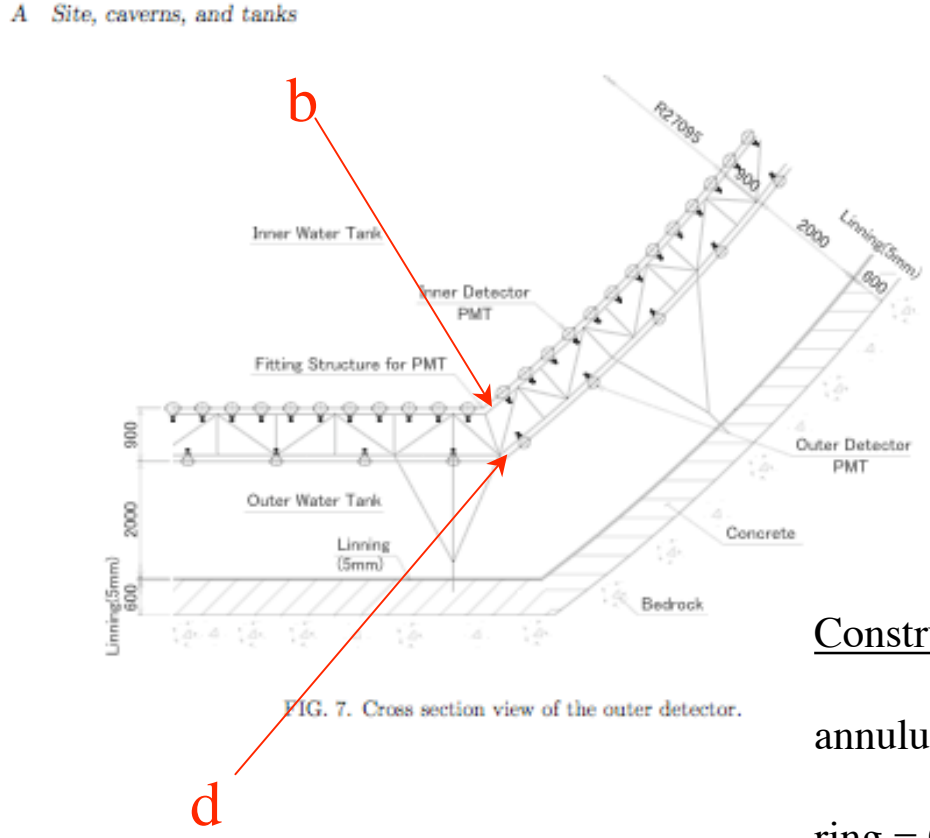


FIG. 7. Cross section view of the outer detector.

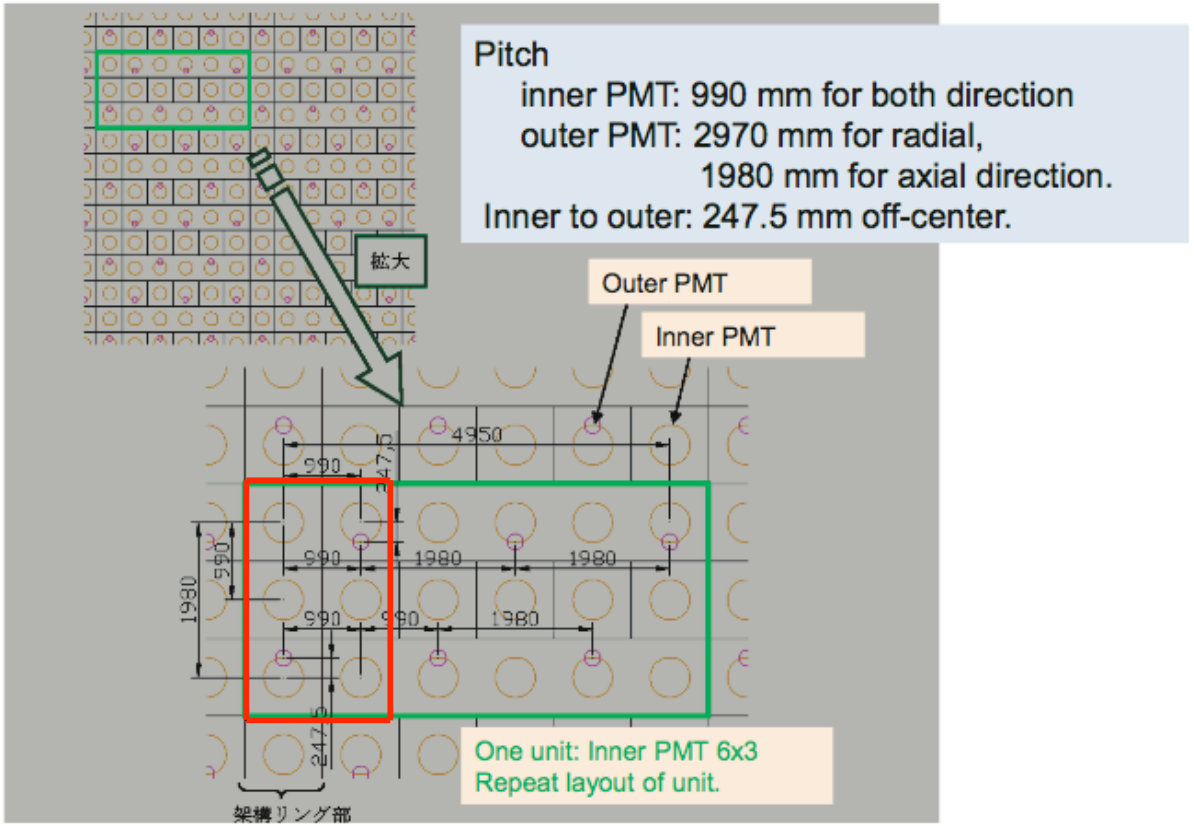
ConstructRadialPMT (inner/outer & top/bottom)

annulus = G4Tubs

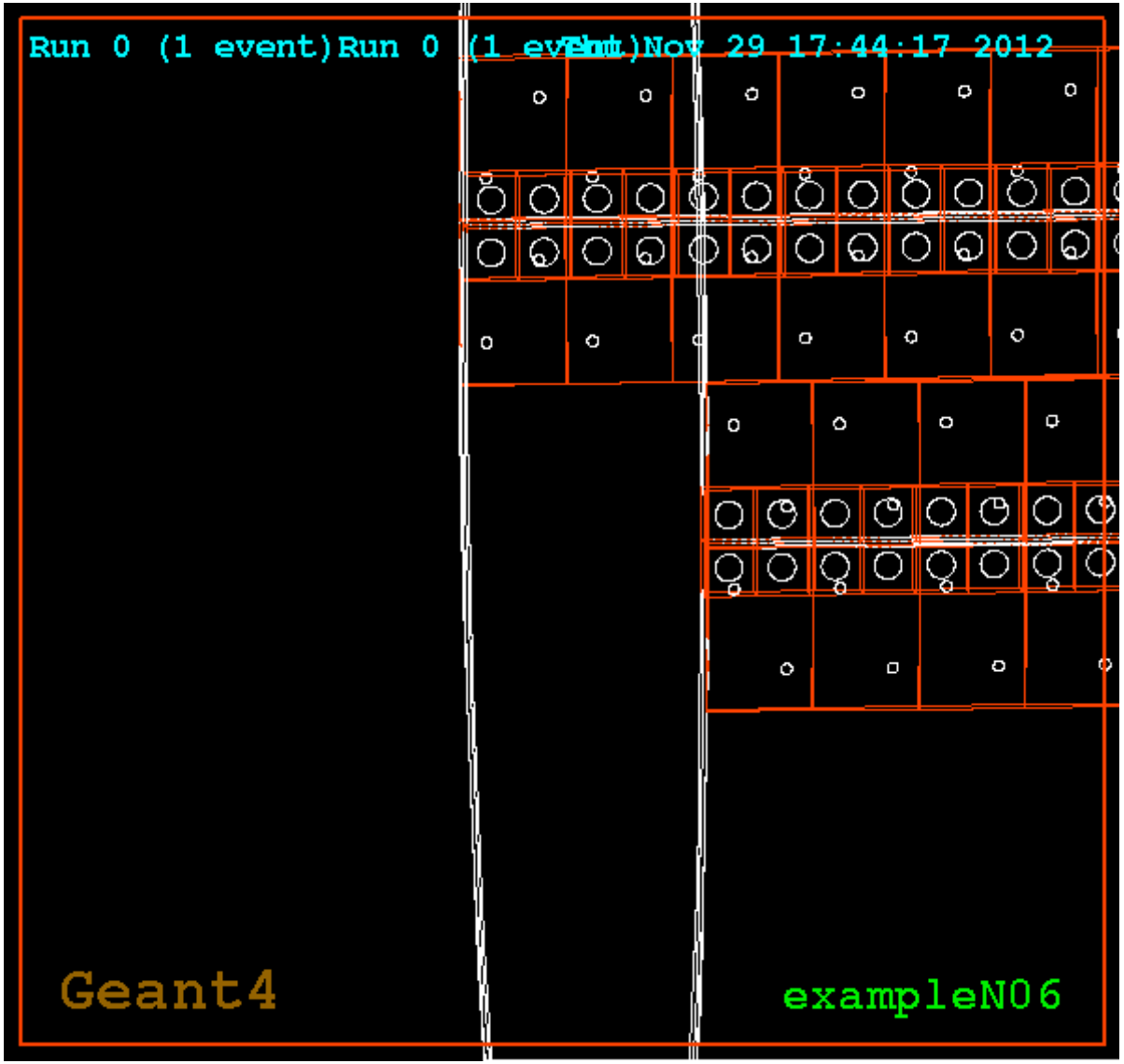
ring = G4PVReplica(annuls,kZAxis, nz, pitchZ)
cell = G4PVReplica(ring,kPhi,nphi,dphi,-phi/2)

Side Wall PMT Arrangement

Position of inner and outer PMT

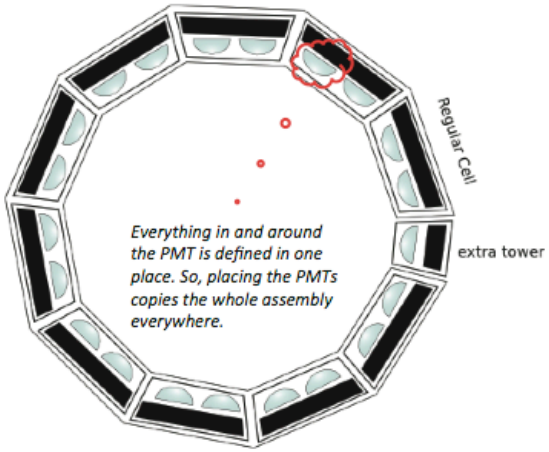


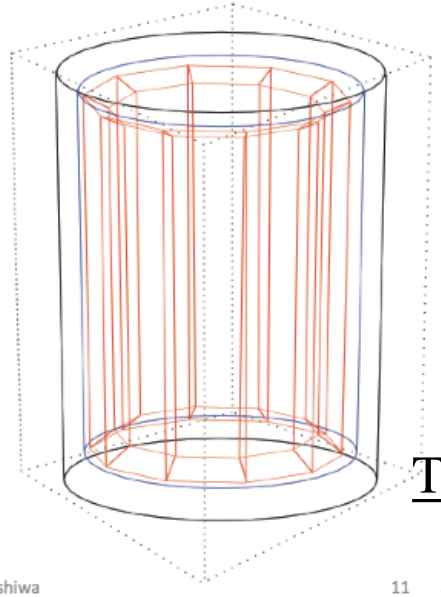
Side Wall PMT Arrangement



Side Wall PMT Arrangement

WCSim geometry details





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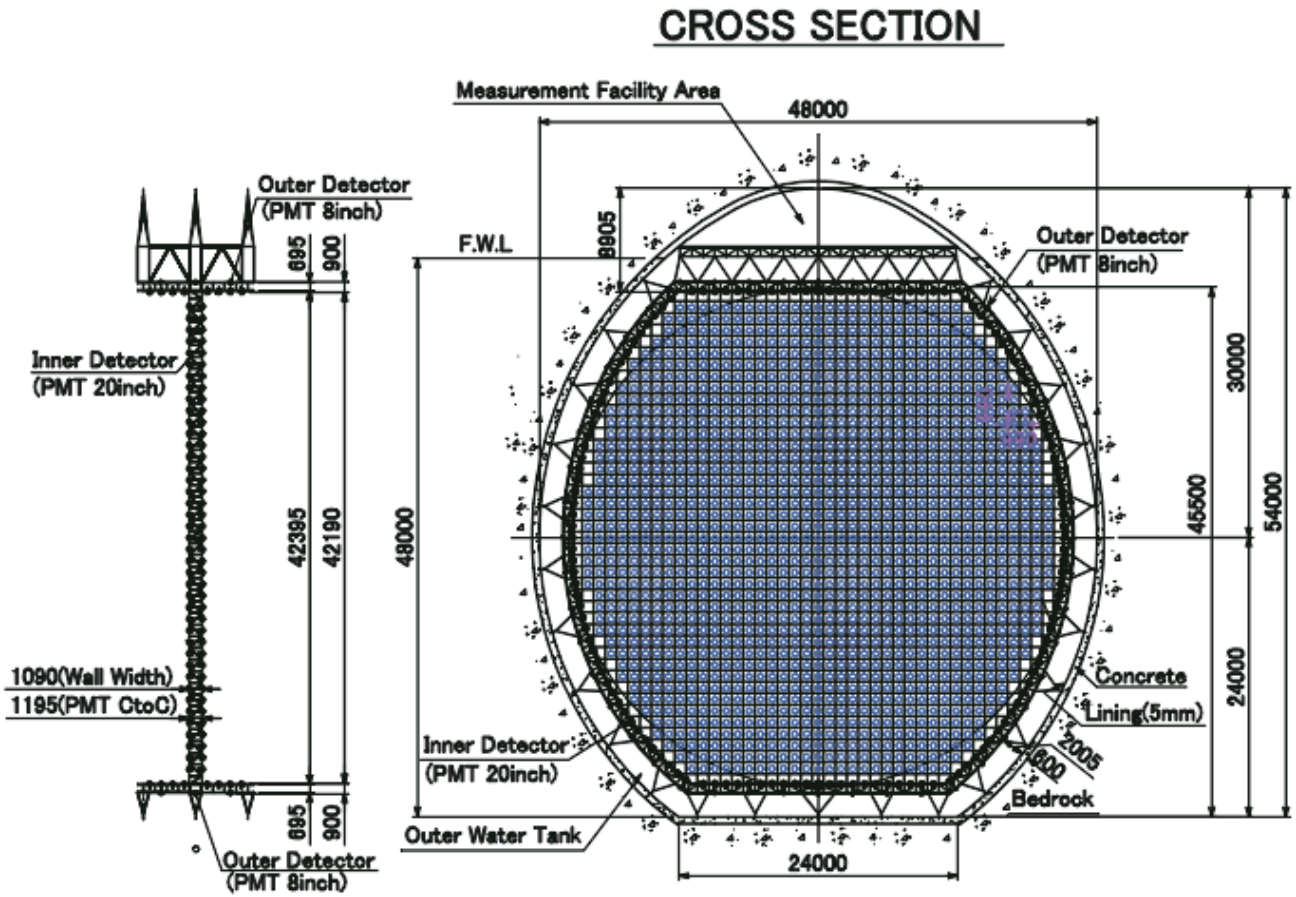
Thin walled Cylinder:

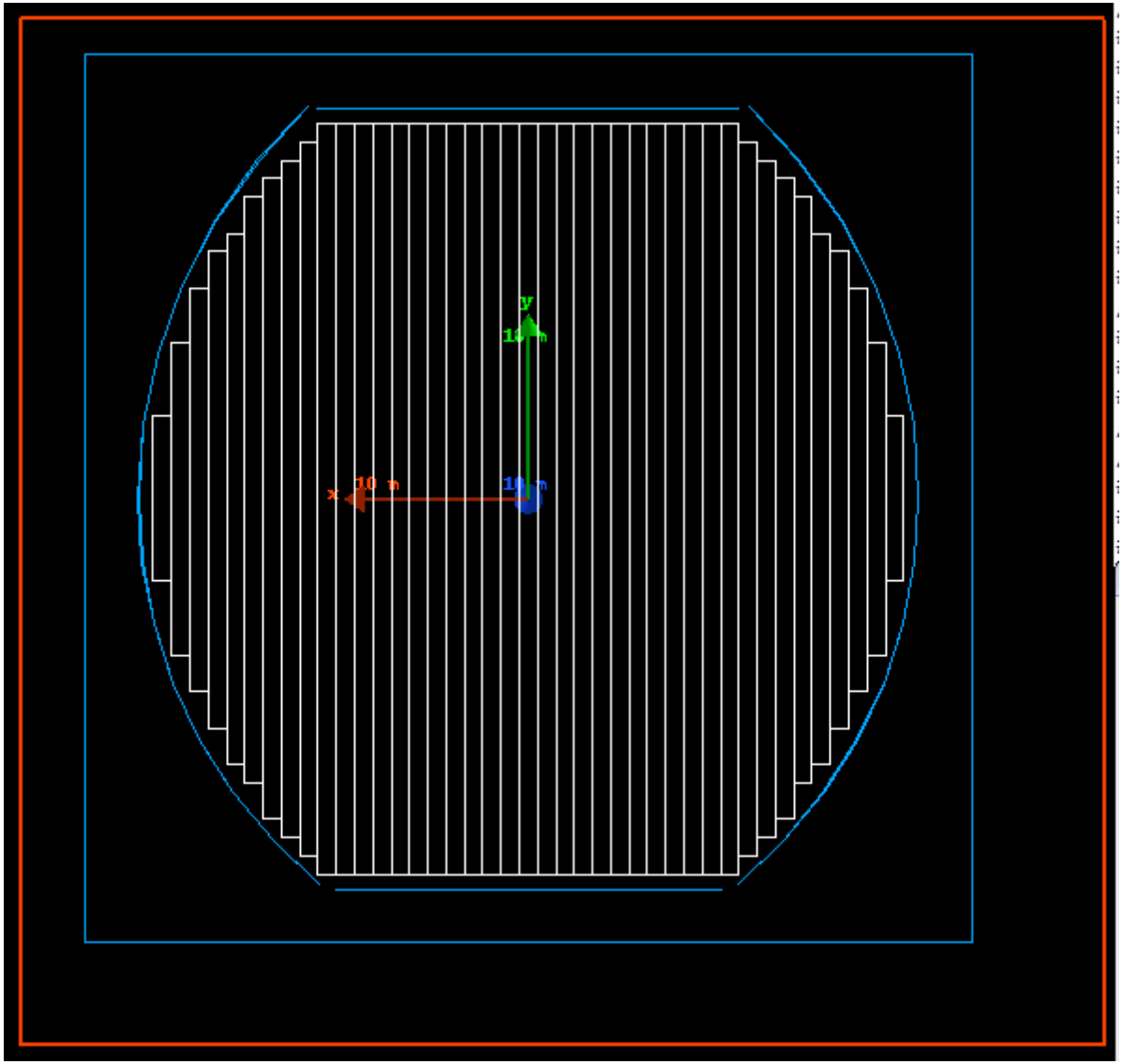
- in WCSim is rendered as a G4Polyhedra (Trapezoid)

- for HK egg shape sides rendered as phi-section replicas of G4Tubs (cylinder)

End Wall PMT Arrangement



End Wall PMT Arrangement



ConstructEndWallPMT

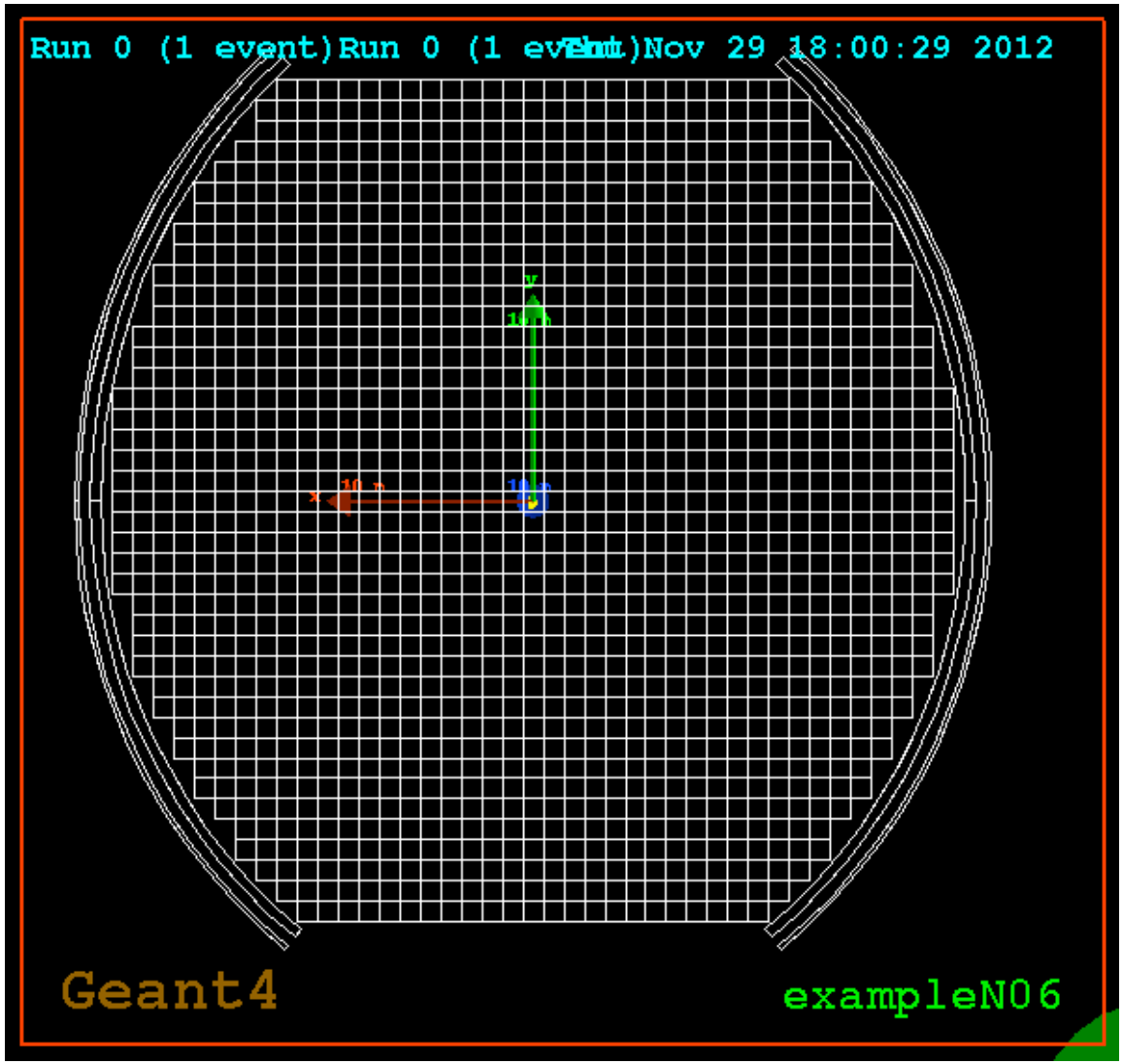
Slab (establish vertical length):

```
while(x<xmas)
  while(y<ymax)
    if(diagonal > radius_top)break
    if(diagonal > radius_bot)break;
```

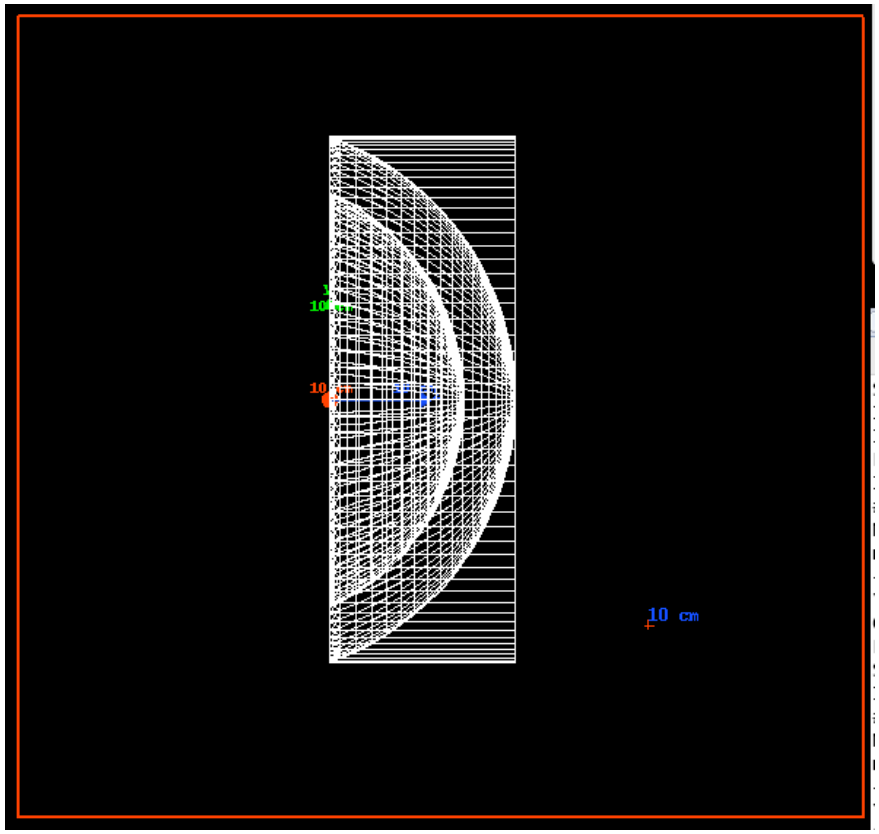
(increment pitchy)

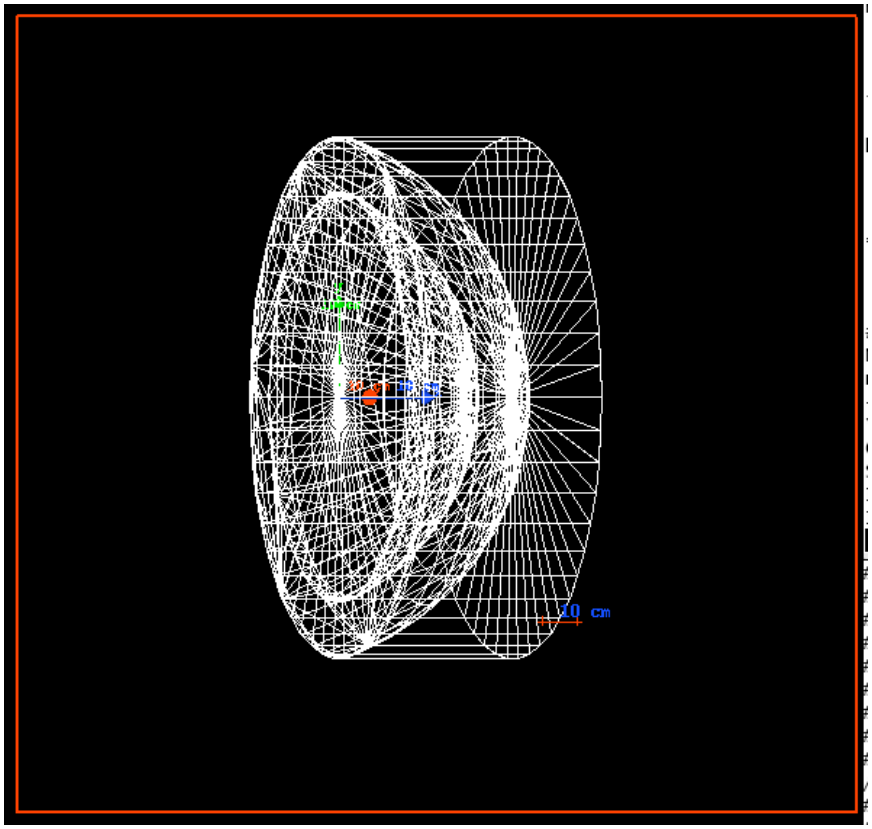
G4PVReplica(Slab,kYAxis,ny,pitchy)

End Wall PMT Arrangement



PMT

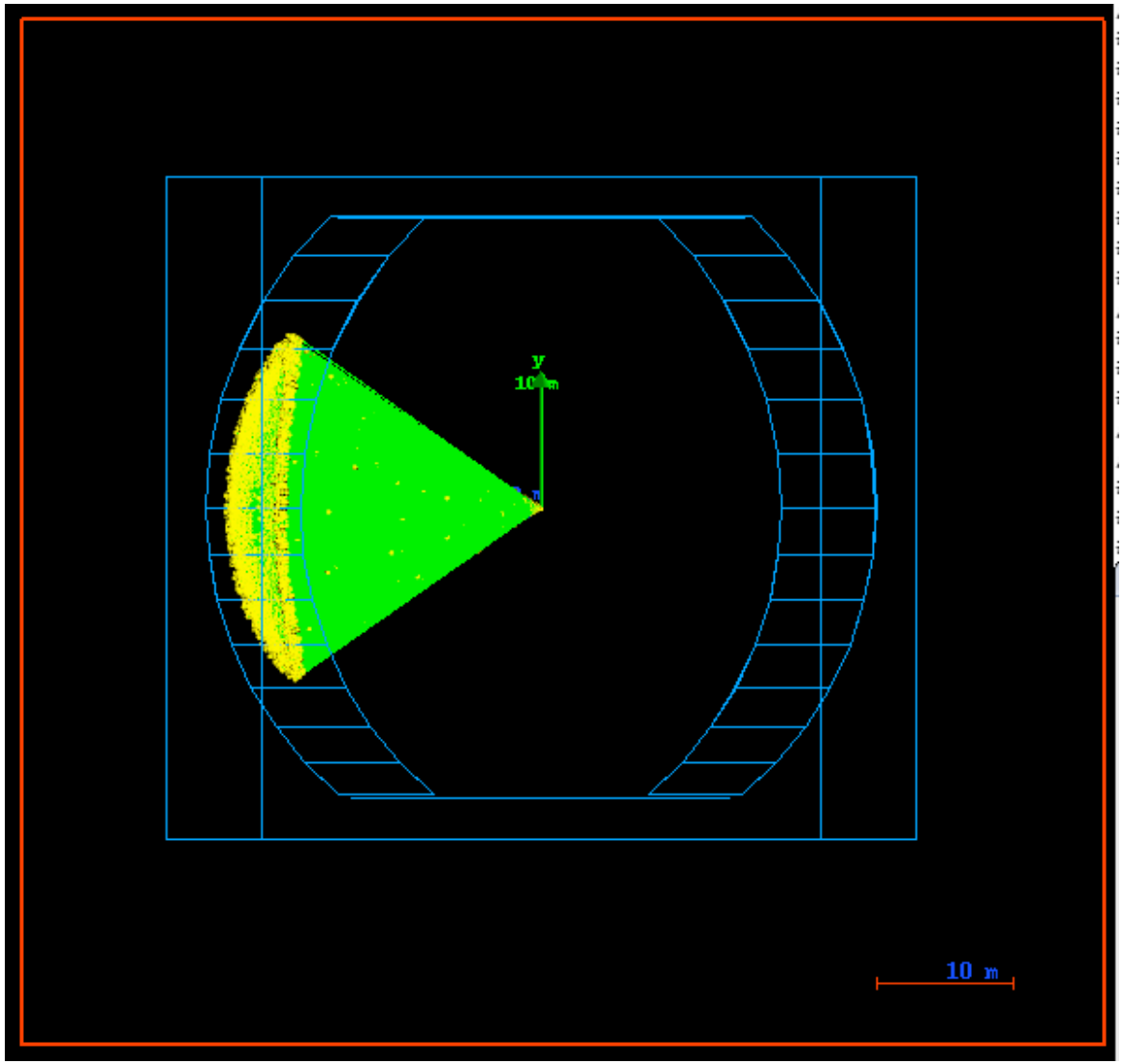




G4SensitiveDetector == logicGlassFaceWCPMT

(in WCSim) its name is expected to be "GlassFaceWCPMT"

Cerenkov Ring



Monte Carlo Tuning

Optical Properties:

Water: Refractive Index, Absorption Length, Rayleigh Scattering Length, and Mie Scattering Length

Glass: Refractive Index, Absorption Length

Cathode Surface: Reflectcivity

Black Sheet: Reflectivity, Surface Roughness

Surface: BorderSurface in WCSim / replace with SkinSurface (also for World volume) for the Black Sheet

Implementation (done)

- Geometry: Water Volume, PMT Arrangement, Black Sheet

Integration Details (not yet done - needs discussion)

- **WCSim** uses FORTRAN style “if(){…}elseif(){…}elseif(){…} and a proliferation of class data members describing all geometry options.
- change to proper C++ class inheritance: base class and derived classes for each detector geometry implementation.

Conclusion

- **A close working relationship between Monte Carlo simulation and technical design teams is desirable. In particular, to avoid non-essential design decisions that may impact computing performance. (~~*PMTs in the horizontal plane*~~)**

Next Steps

- What is the Panel layout for the Side PMTs?
- Merge with WCSim
- Run some events and analyze (Root Geometry)