Status of FARICH simulation in SpdRoot

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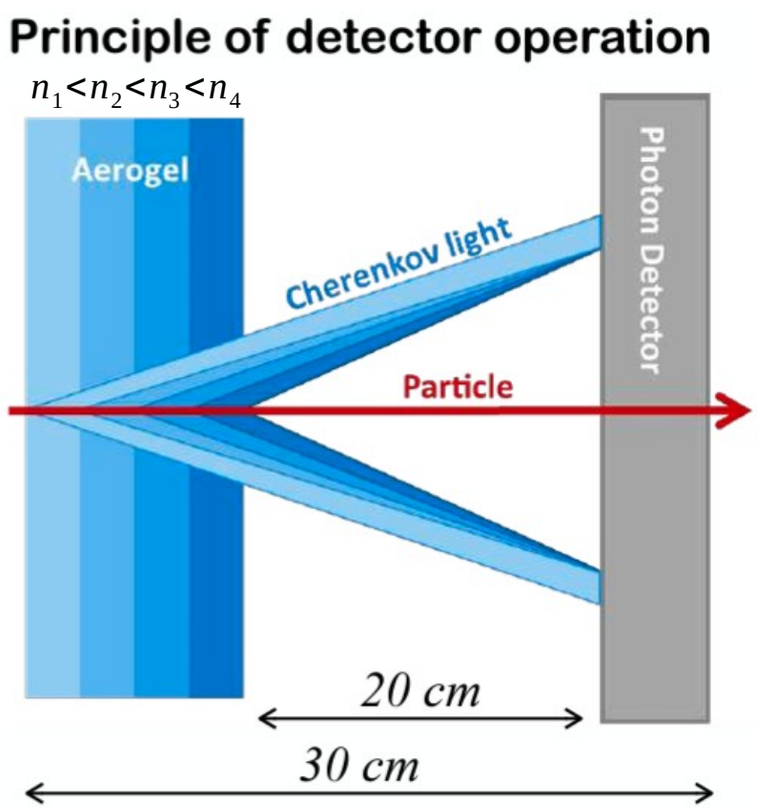
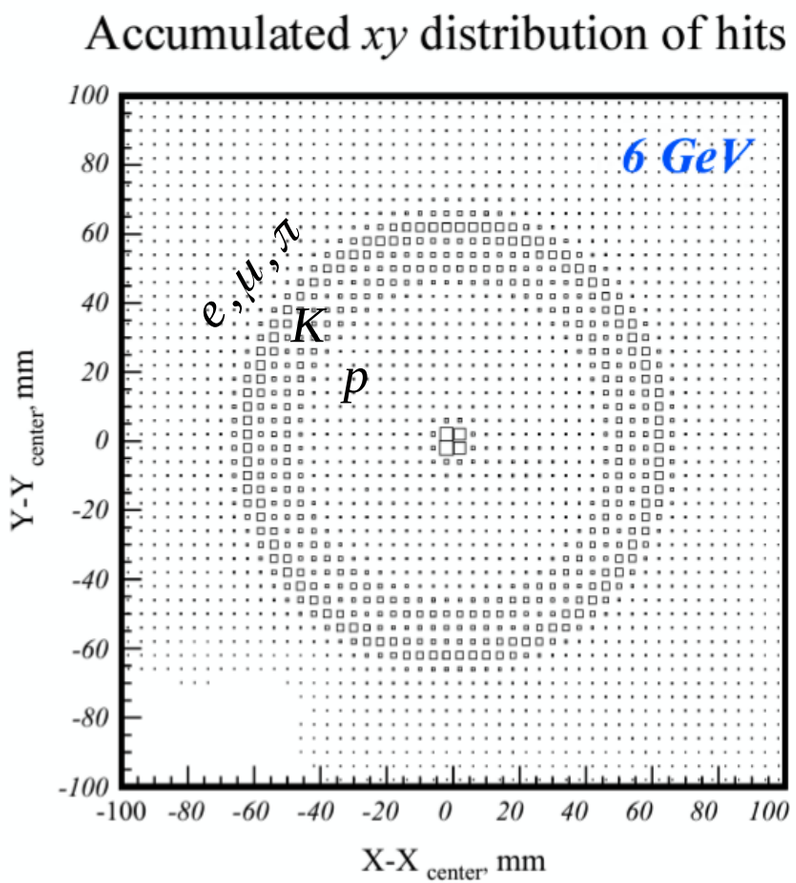
SPD Physics & MC meeting
24 January 2024

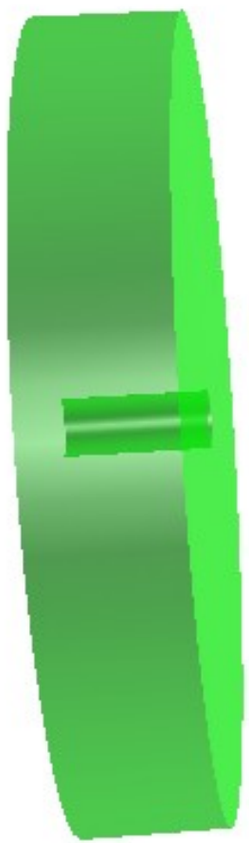
FARICH detector

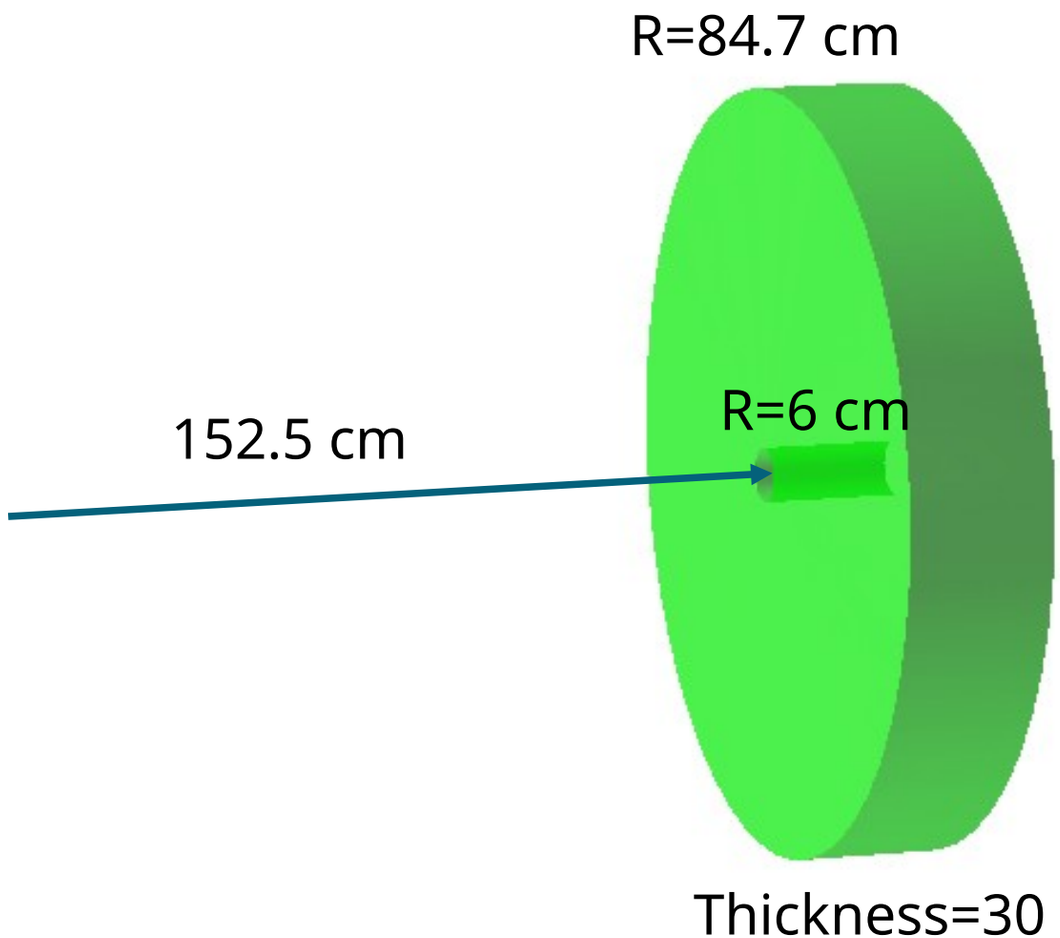
Identification of high momentum particles (p≳1.5 GeV)





FARICH in SpdRoot: current status

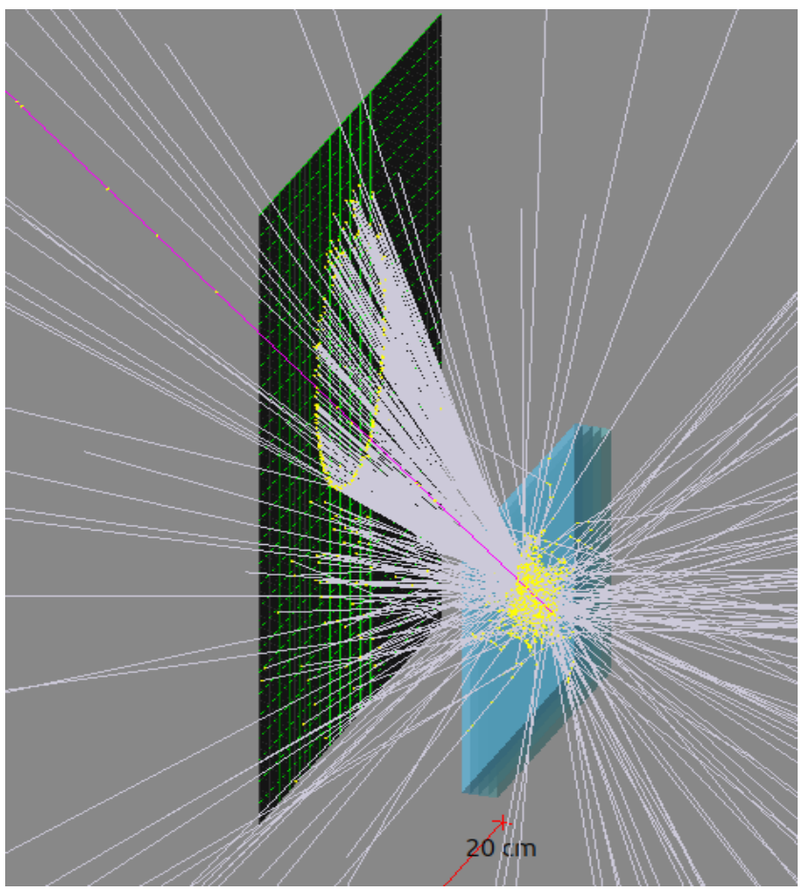


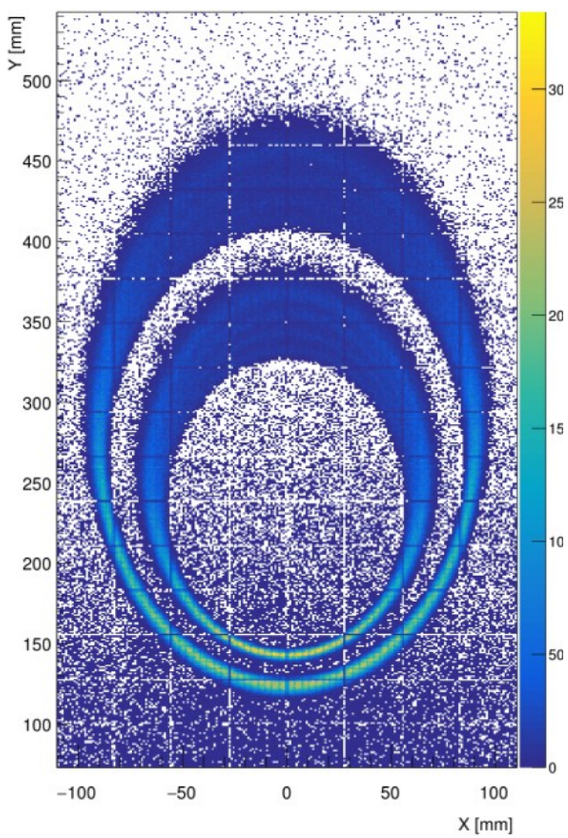


FARICH in GEANT4

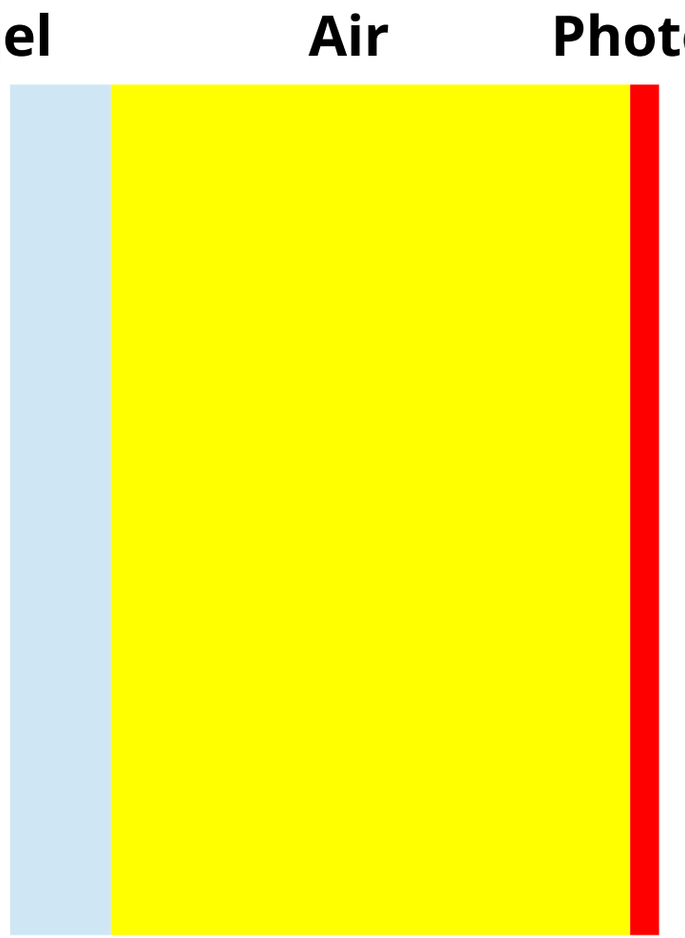
Based on stand-alone GEANT4 based simulation program from team Budker Institute of Nuclear Physics, Novosibirsk

Thanks to *A.Yu. Barnyakova, V.S. Bobrovnikov*





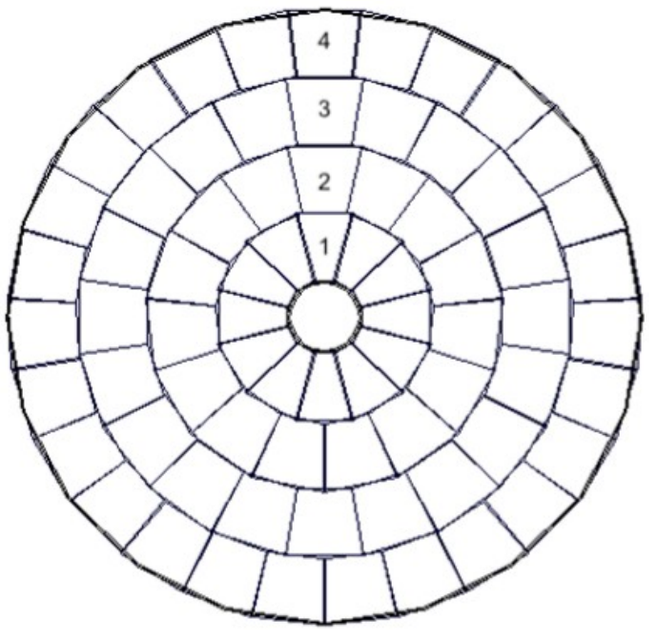
FARICH in SpdRoot



36 mm 200 mm 0.17 mm **=236,17**

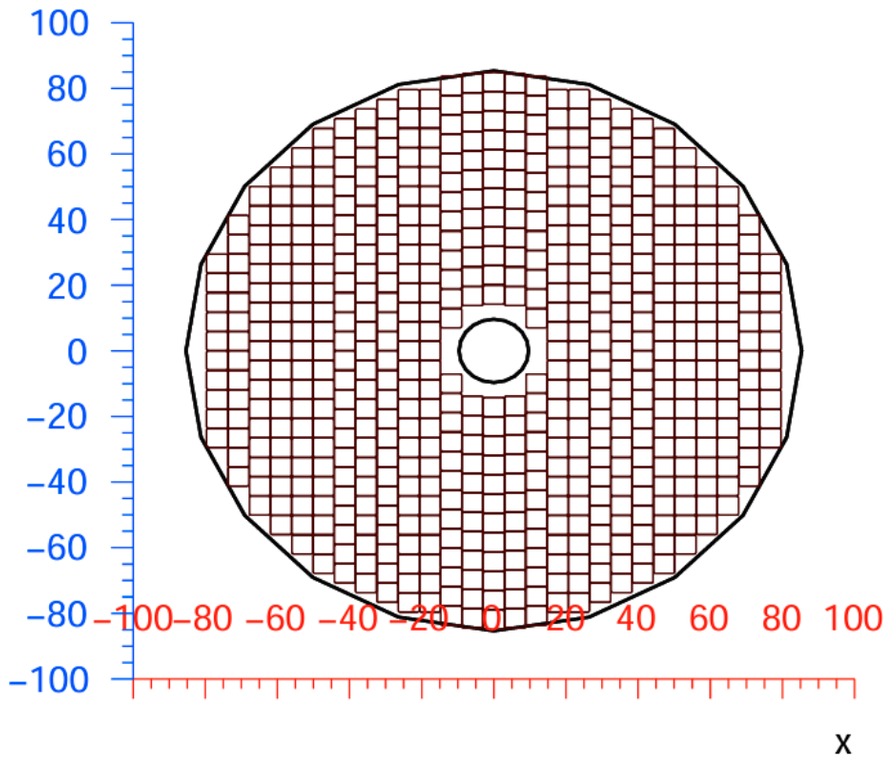
FARICH in SpdRoot: geometry

Aerogel



n(400)=1.0370, 7.00 mm
n(400)=1.0410, 10.00 mm
n(400)=1.0430, 9.00 mm
n(400)=1.0470, 10.00 mm

Photon detector



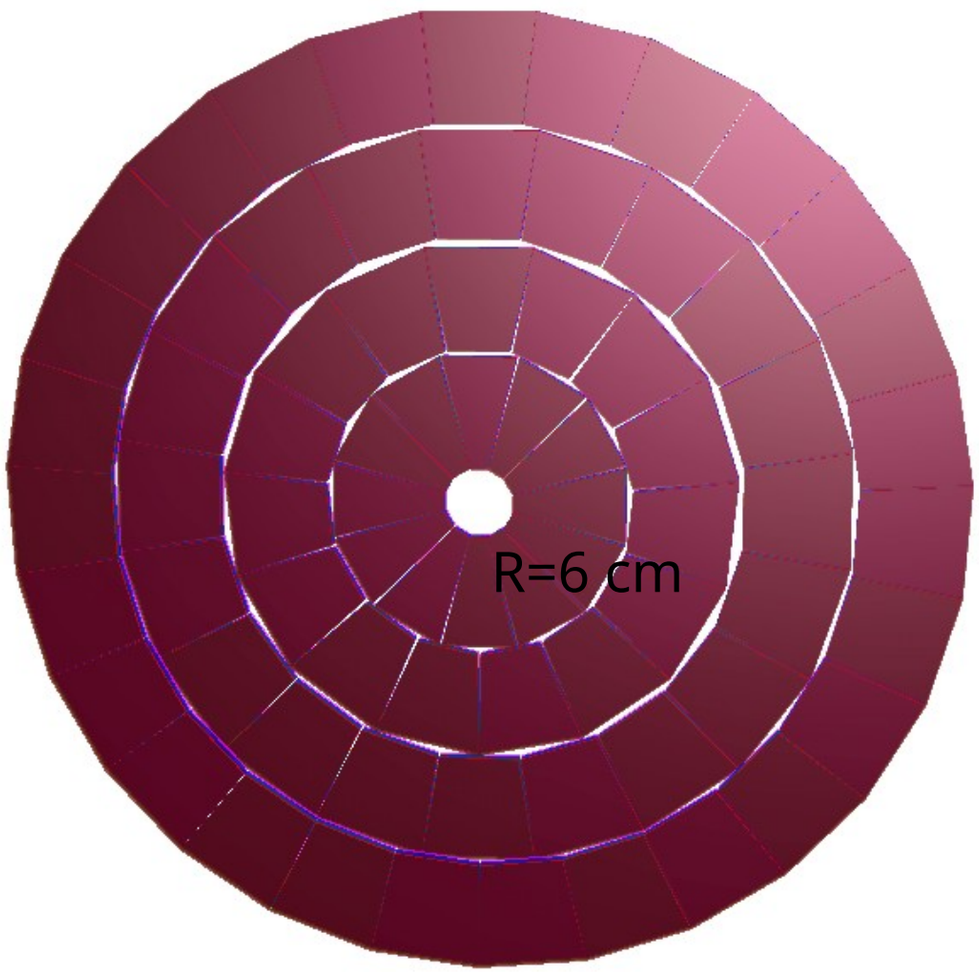
MCP PMT N6021

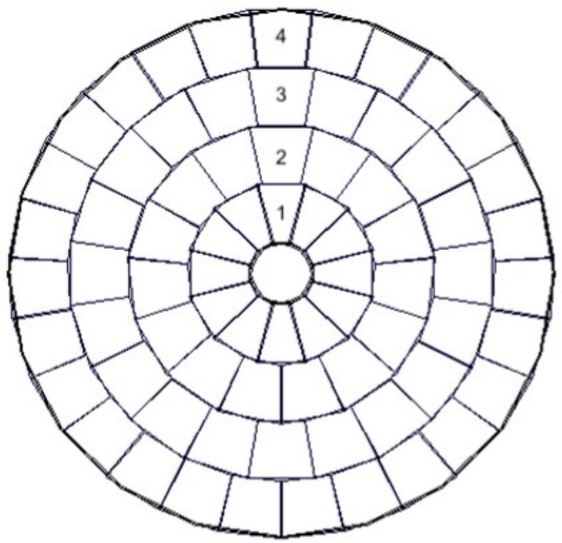
- lateral size 51×51 mm^2.
- 8×8 pixels with size 5.8×5.8 mm ^{2}

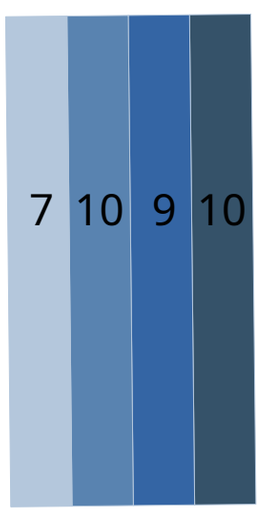
548(PMT)×64(pixels)=70144 pixels

Aerogel geometry

R=84.7 cm

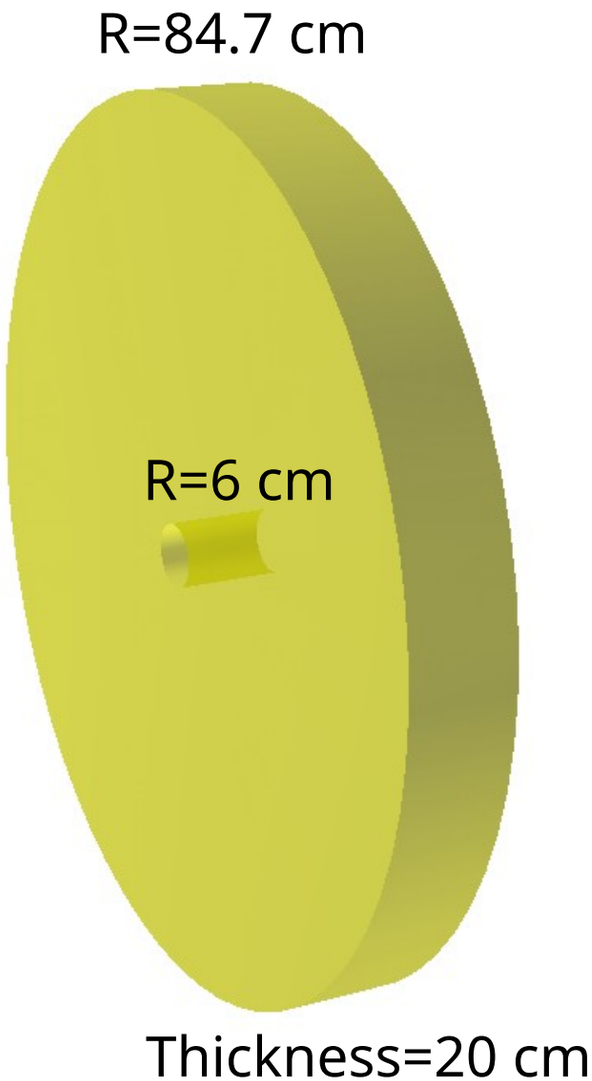




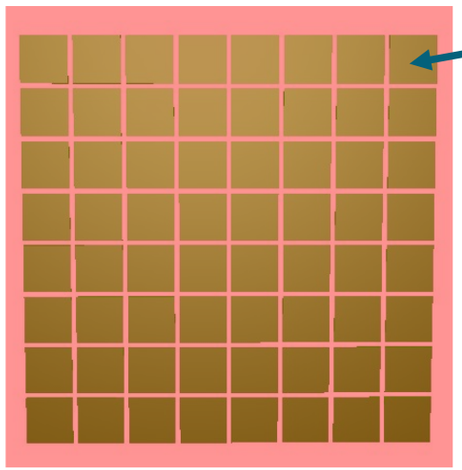


Thickness=3.6 cm

Air geometry



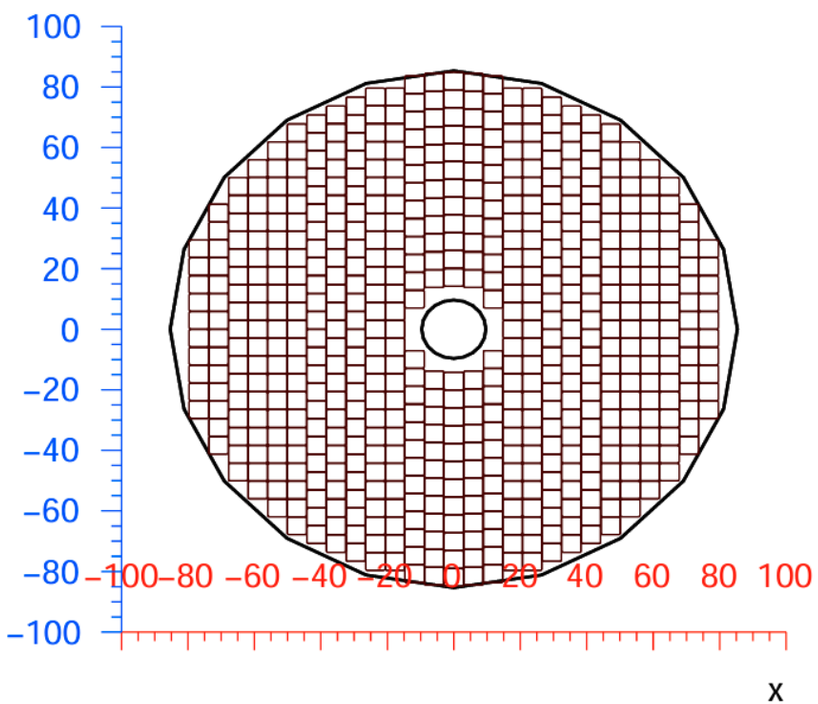
Photon detector geometry

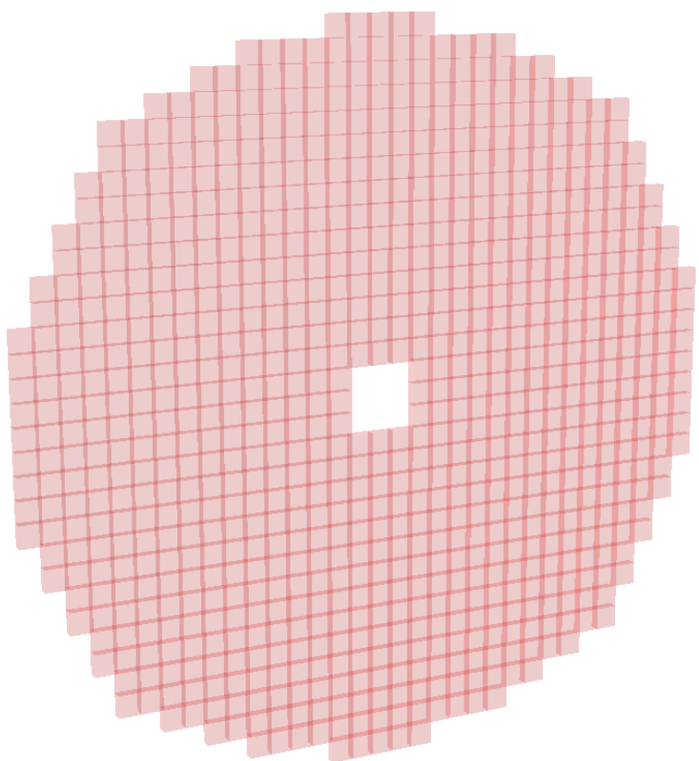


MCP PMT N6021

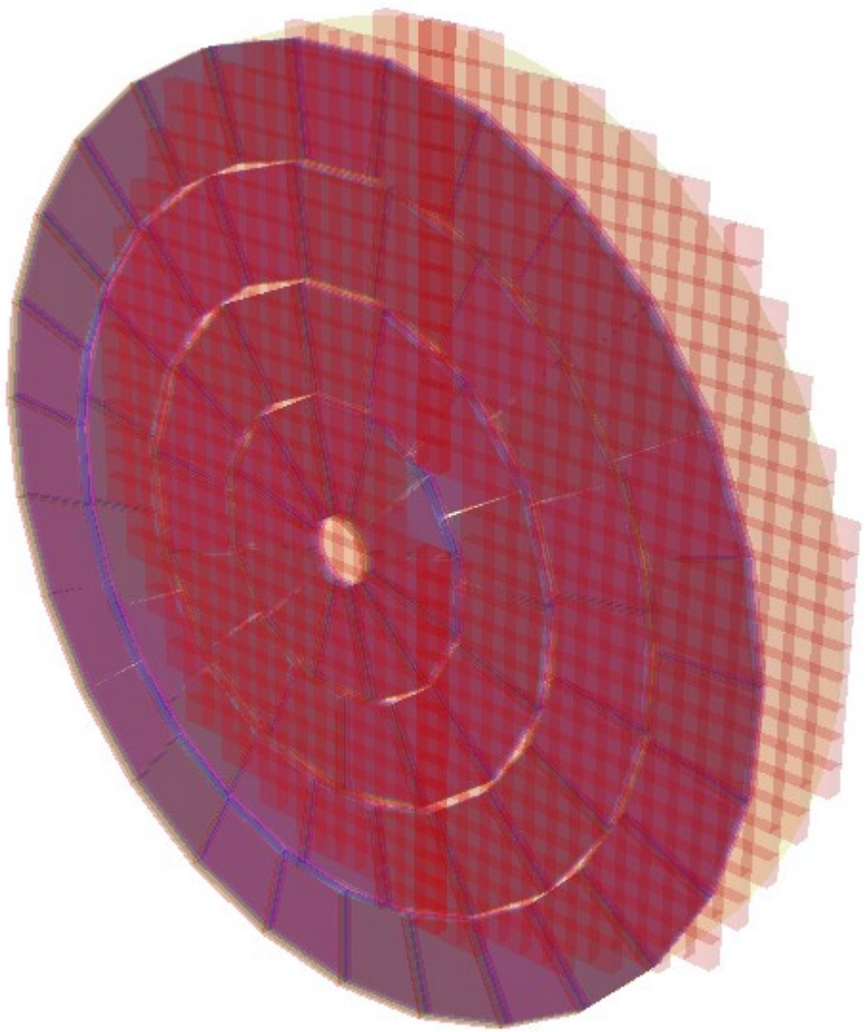
- 8×8 pixels with size 5.8×5.8 mm^2
- Lateral size 51×51 mm^2.

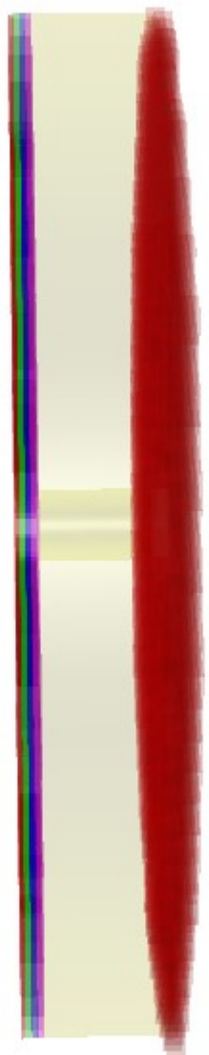
548(PMT)×64(pixels)=70144 pixels





SpdRoot: FARICH geometry





Settings Geant

SpdRoot

spdroot/gconfig/g4config.C

```
TG4RunConfiguration *runConfiguration =
    new TG4RunConfiguration("geomRoot",
                            "QGSP_FTFP_BERT+optical",
                            "stepLimiter+specialCuts+specialControls+stackPopper",
                            false);
```

spdroot/gconfig/g4config.in

```
/process/optical/wls/setTimeProfile delta
/process/optical/cerenkov/setMaxPhotons 300
/process/optical/cerenkov/setMaxBetaChange 10.0
/process/optical/cerenkov/setTrackSecondariesFirst  true
```

GEANT4

farich_sim.cc

```
G4OpticalPhysics* opticalPhysics = new G4OpticalPhysics();
opticalPhysics->SetWLSTimeProfile("delta");
opticalPhysics->SetScintillationYieldFactor(1.0);
opticalPhysics->SetScintillationExcitationRatio(0.0);
opticalPhysics->SetMaxNumPhotonsPerStep(300);
opticalPhysics->SetMaxBetaChangePerStep(10.0);
opticalPhysics->SetTrackSecondariesFirst(kCerenkov, true);
opticalPhysics->SetTrackSecondariesFirst(kScintillation, true);
```

- Set the step size to limit the number of photons produced (on average) to a given value (an integer N)

  /process/optical/cerenkov/setMaxPhotons N

- Set the maximum change in β=v/c in a step, expressed in percent.

  /process/optical/cerenkov/setMaxBetaChange X.X

- Specify whether to track secondaries produced in the step before continuing with primary.

  /process/optical/cerenkov/setTrackSecondariesFirst true

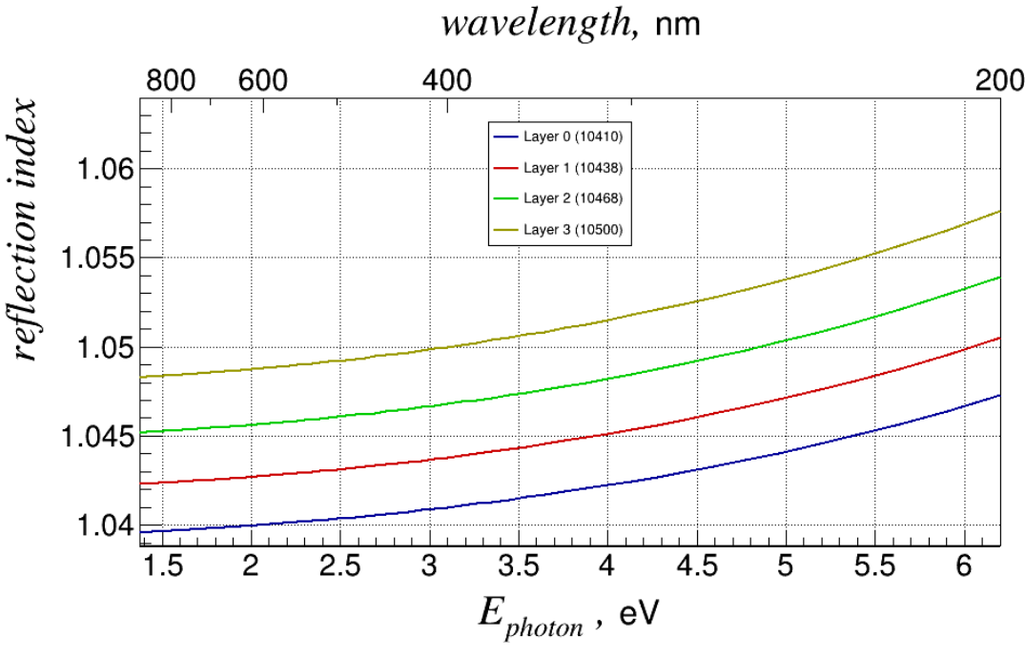
Settings Geant

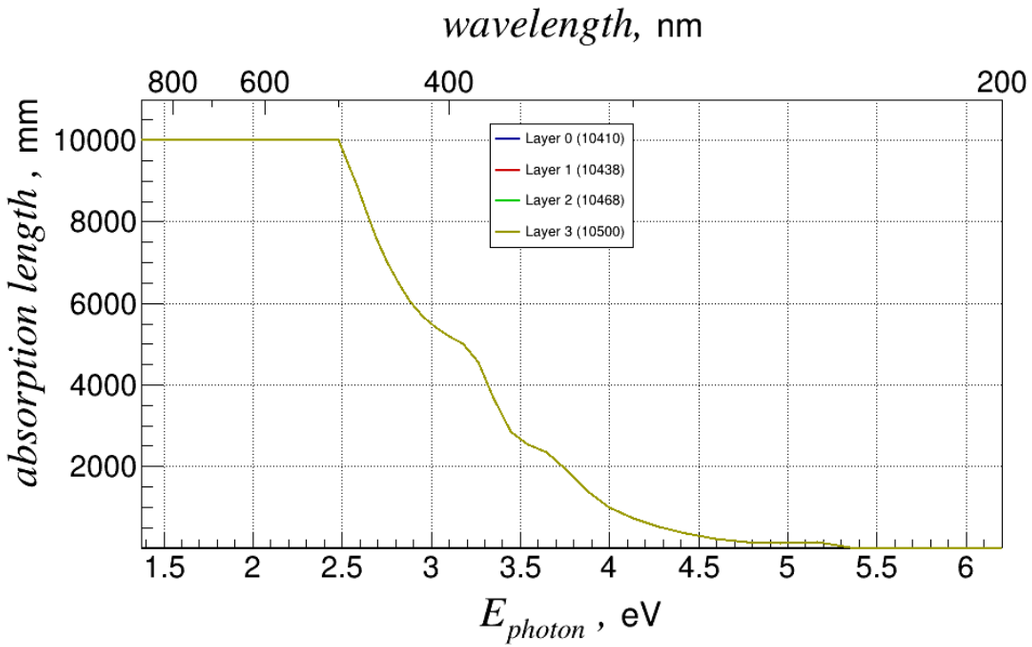
SpdRoot

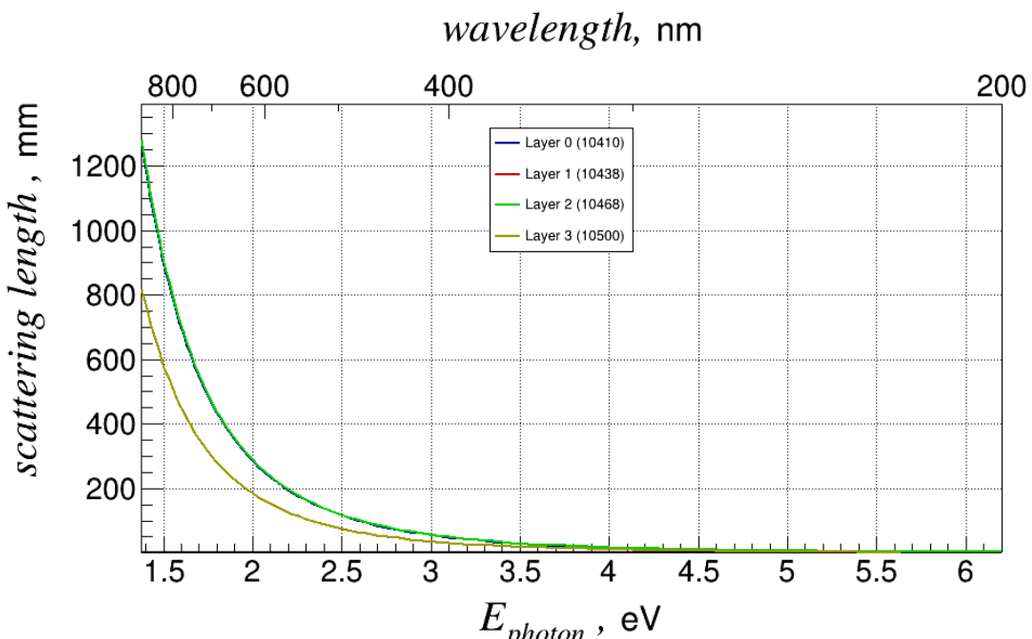
spdroot/gconfig/g4config.in

```
/process/optical/processActivation Cerenkov true
/process/optical/processActivation Scintillation false
/process/optical/processActivation OpAbsorption false
/process/optical/processActivation OpRayleigh false
/process/optical/processActivation OpMieHG false
/process/optical/processActivation OpBoundary true
# улетает за границу если поставить false
/process/optical/processActivation OpWLS false
/process/optical/processActivation OWLS2 false
```

Aerogel


wavelength, nm
800
600
400
200
reflection index
1.06
1.055
1.05
1.045
1.04
Layer 0 (10410)
Layer 1 (10438)
Layer 2 (10468)
Layer 3 (10500)
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
E_{photon} , eV


wavelength, nm
800
600
400
200
absorption length , mm
10000
8000
6000
4000
2000
Layer 0 (10410)
Layer 1 (10438)
Layer 2 (10468)
Layer 3 (10500)
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
E_{photon} , eV


wavelength, nm
800
600
400
200
scattering length , mm
1200
1000
800
600
400
200
Layer 0 (10410)
Layer 1 (10438)
Layer 2 (10468)
Layer 3 (10500)
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
E_{photon} , eV

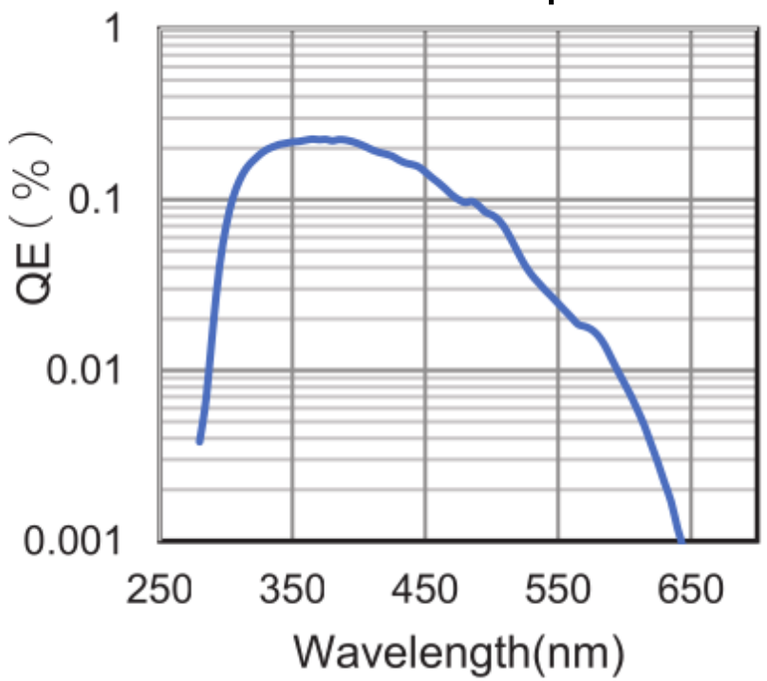
Air

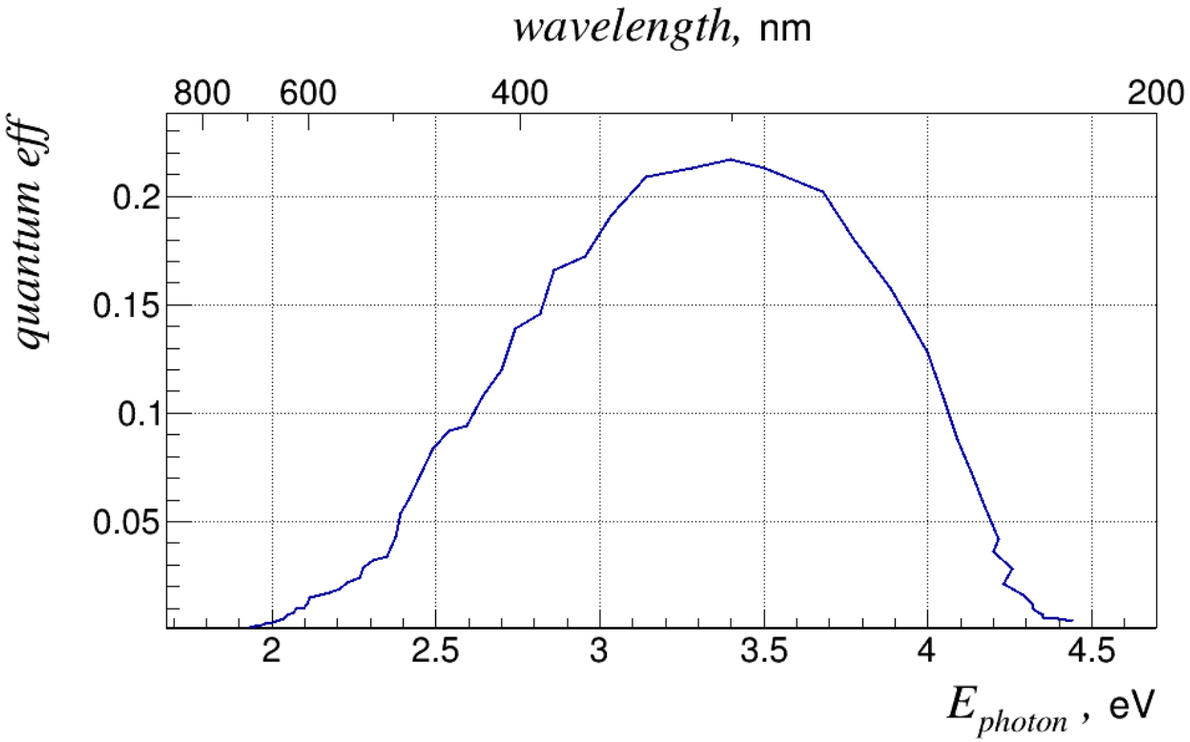
```
Int_t mId = gMC->MediumId("FARICHair");

const  int npoints = 2;

vector<Double_t> ephoton = {1.53067, 6.19921};
vector<Double_t> refInd = {1.0, 1.0};
vector<Double_t> eff = {1, 1};      You, 16 seconds ago • Uncommitted changes
vector<Double_t> absLen = {1.0e+32, 1.0e+32};

gMC->SetMaterialProperty(mId, "ABSLENGTH", npoints, &ephoton[0], &absLen[0]);
gMC->SetMaterialProperty(mId, "EFFICIENCY", npoints, &ephoton[0], &eff[0]);
gMC->SetMaterialProperty(mId, "RINDEX", npoints, &ephoton[0], &refInd[0]);
}
```

Photon detector

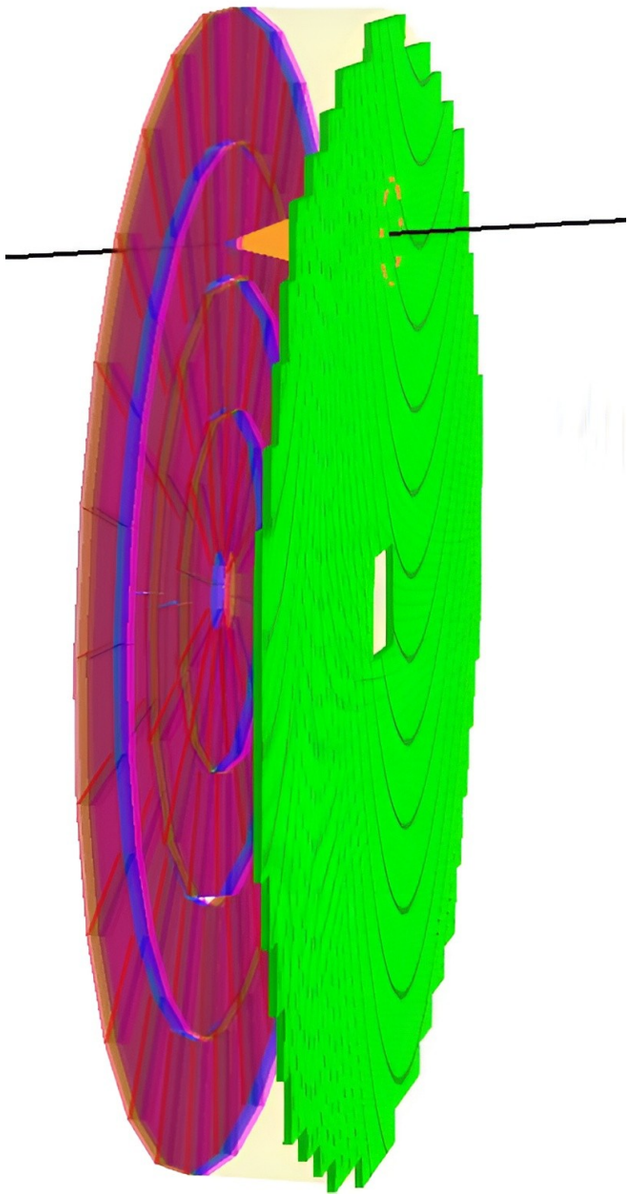
MCP PMT N6021

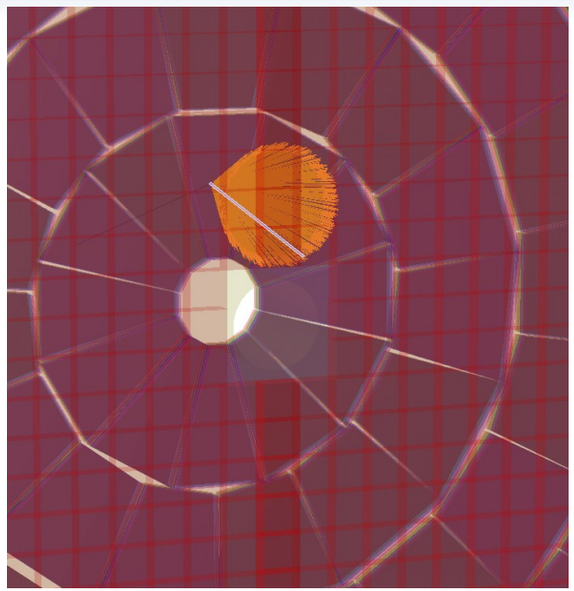
from technical specification

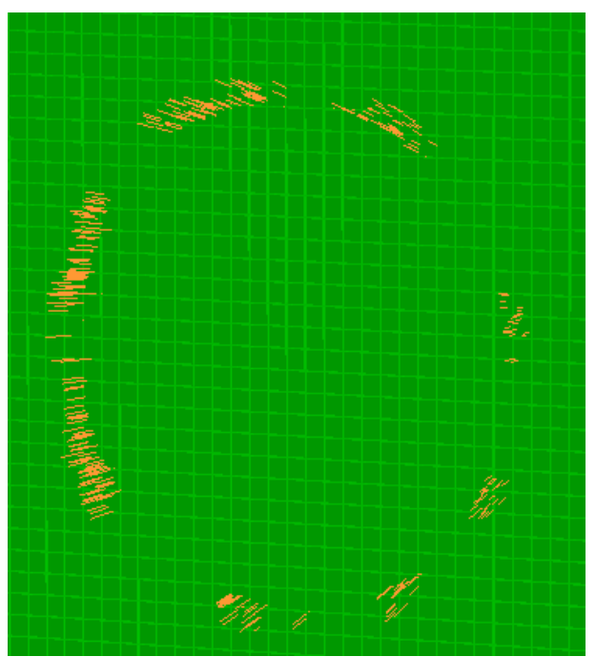




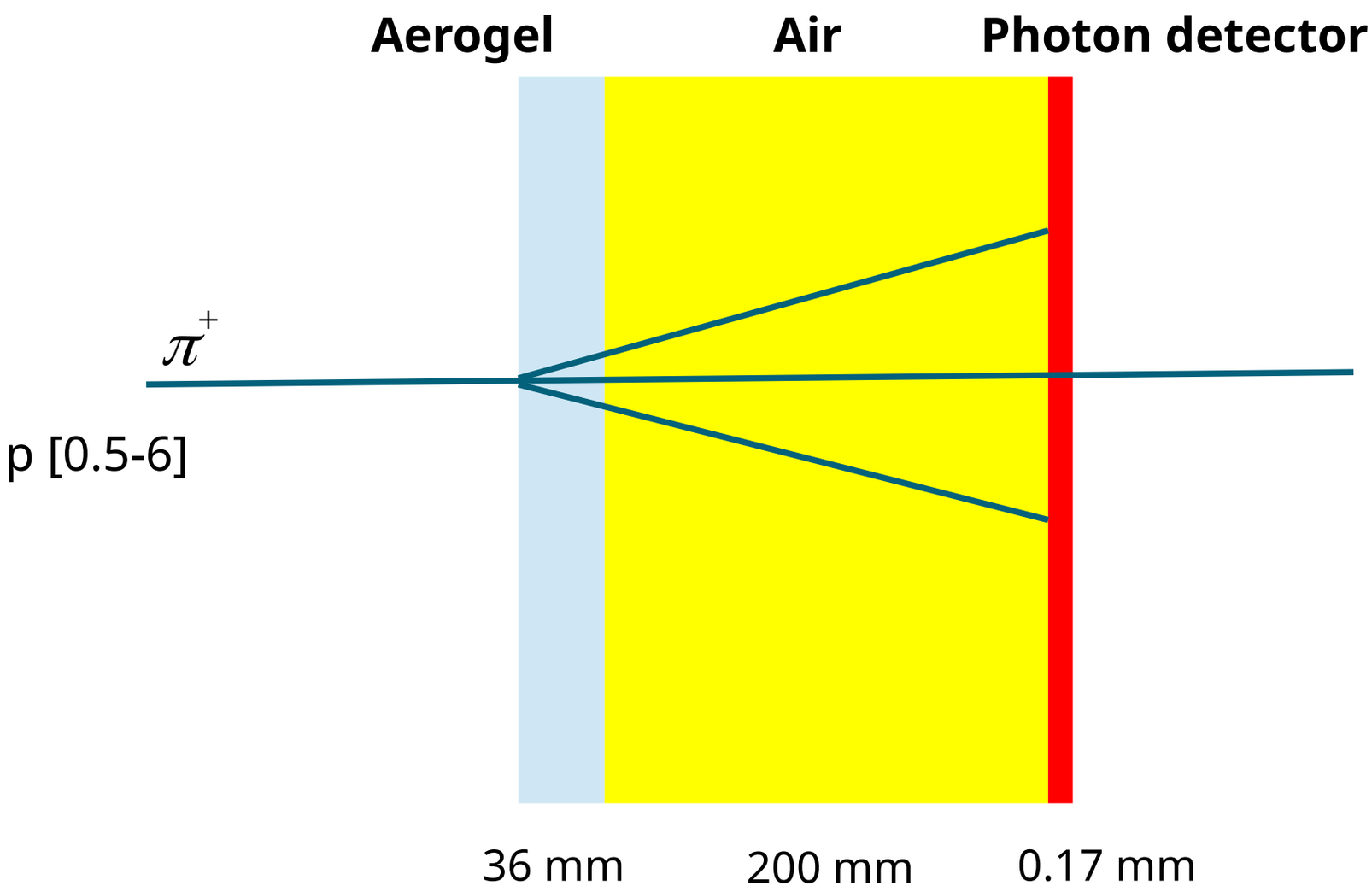
SpdRoot: FARICH







FARICH in SpdRoot



FARICH in SpdRoot: Fit

“Методы оценки параметров колец черенковского излучения в детекторе RICH для эксперимента CBM”
А. С. Айриян , В. В. Иванов , С. А. Лебедев , Г. А. Ососков , Н. И. Чернов

MINUIT
Fitting by ellipse

$$d_1 + d_2 = 2a,$$

$$d_1 = \sqrt{(x - x_{F1})^2 + (y - y_{F1})^2} \qquad d_2 = \sqrt{(x - x_{F2})^2 + (y - y_{F2})^2}$$

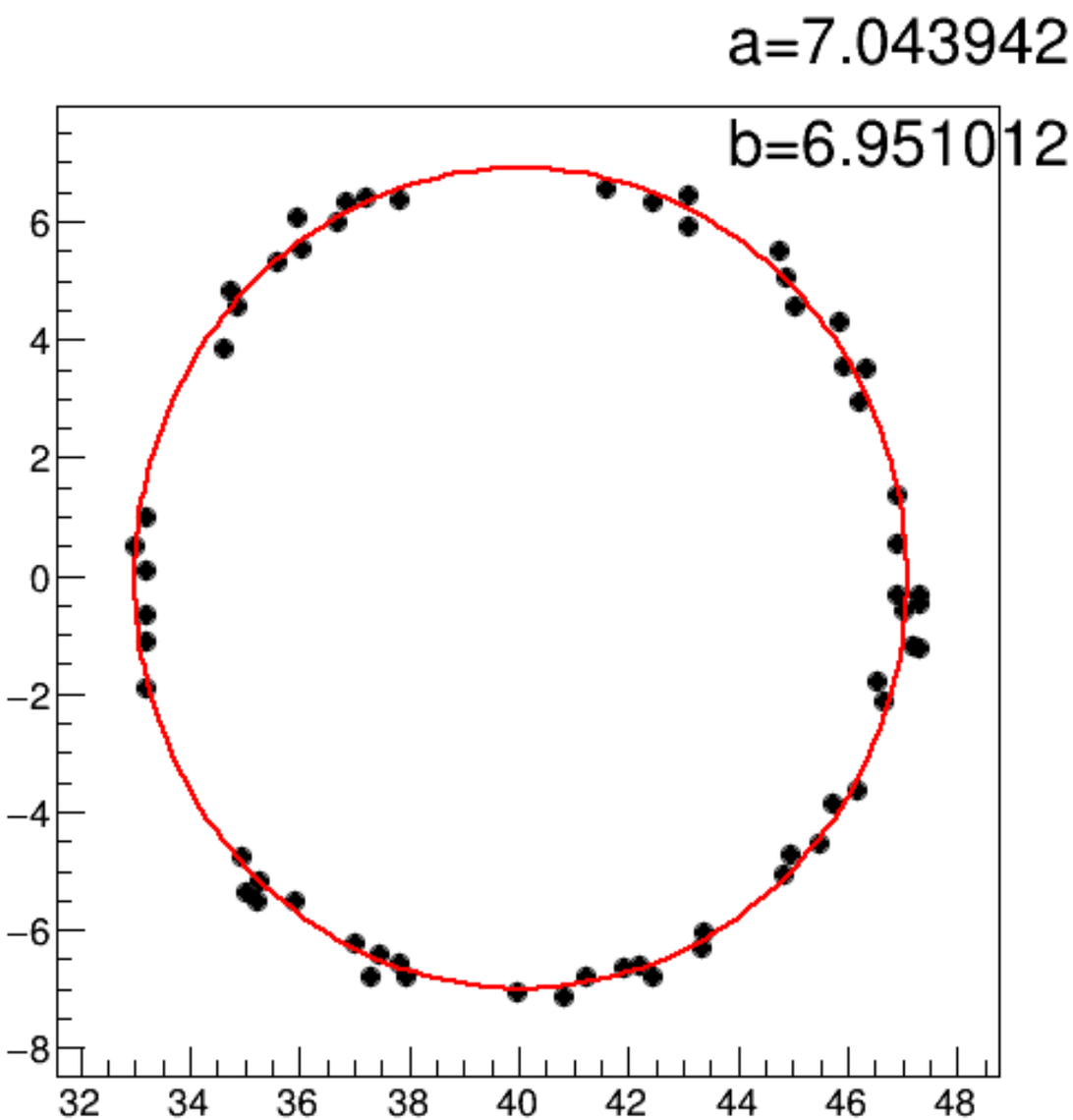
$$x_c = (x_{F_1} + x_{F_2})/2$$

$$y_c = (y_{F_1} + y_{F_2})/2$$

$$b = \sqrt{a^2 - \sqrt{(x_{F_1} - x_{F_2})^2 + (y_{F_1} - y_{F_2})^2}}$$

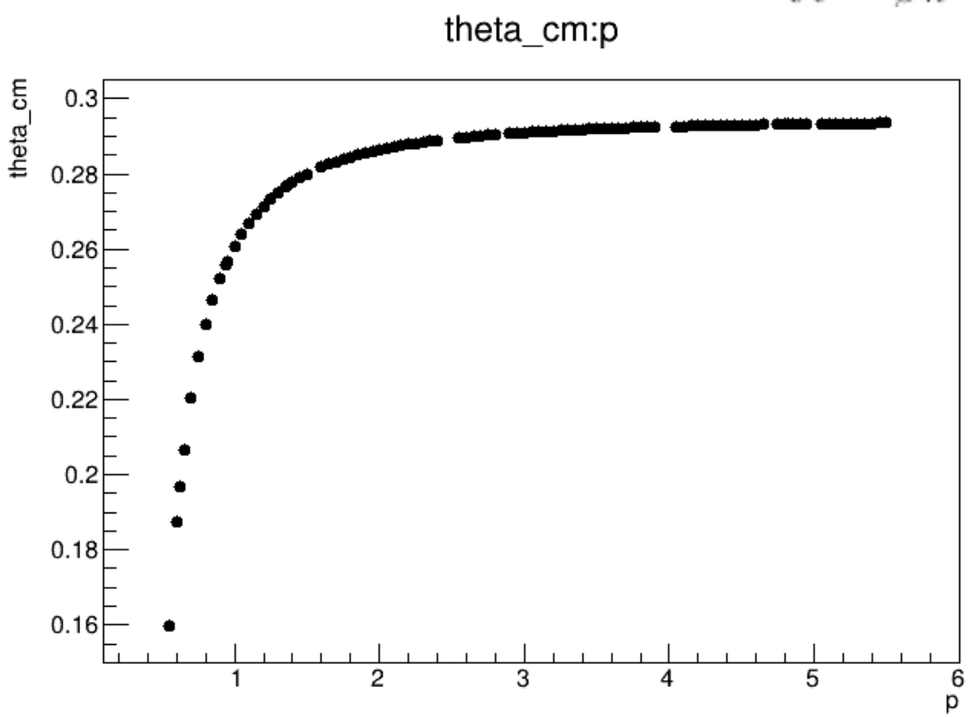
$$\varphi = \arctan\left(\frac{y_{F_1} - y_{F_2}}{x_{F_1} - x_{F_2}}\right)$$

FARICH in SpdRoot: Fit

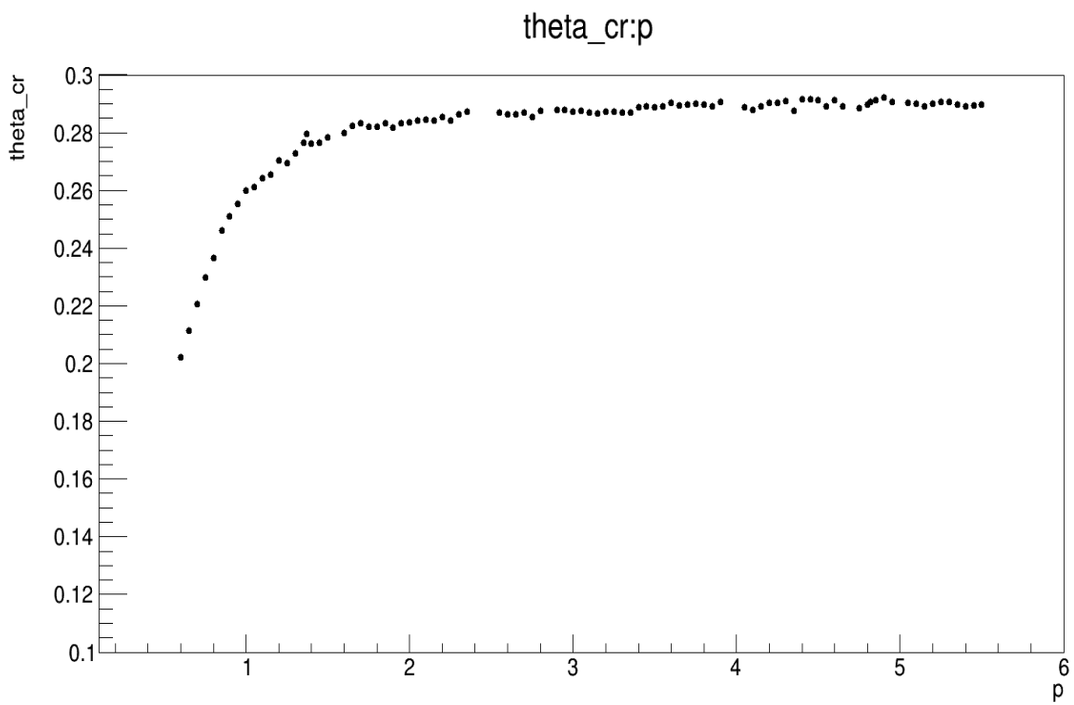


FARICH in SpdRoot: θ_c vs p

formula $$\cos\theta_c = \frac{\frac{c_0}{n}t}{vt} = \frac{1}{\beta n}.$$



From fit and geometry



Conclusion

- Geometry FARICH was described in SpdRoot.
- First results of R and θc was obtained.

Next step

- to compare the N_{ep} with Geant4.
- to implement the reconstruction of ring parameters and θc.