Update of the SoLID Cerenkov detector for PVDIS: CSI coated GEM option August, 03, 2011

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Outline

- Update of the detector layout

- Update of the simulation details

- Results

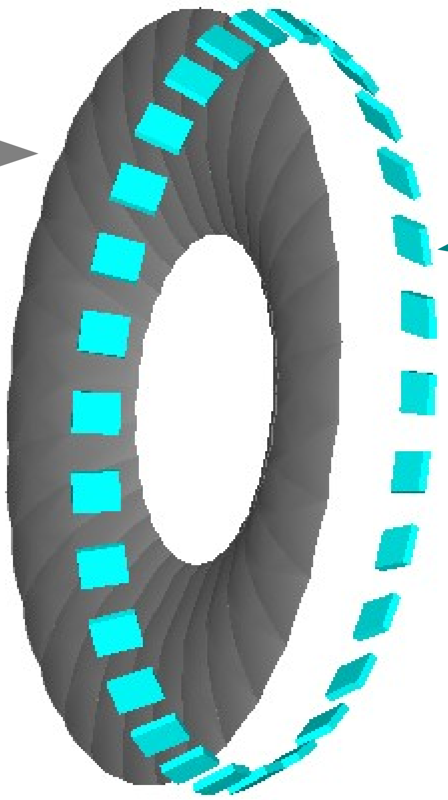
- Summary, prospectives

Update of the detector layout

Similar to what existed before, but some dimensions have changed:

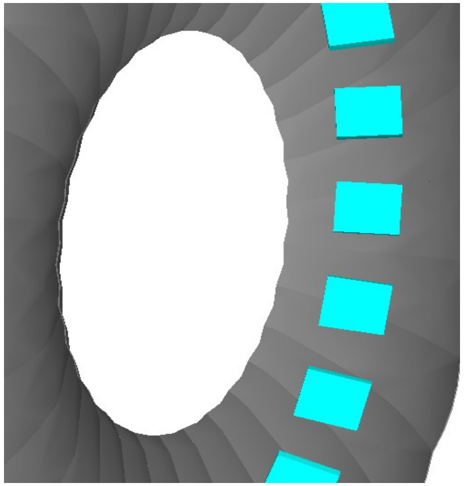
Mirrors:
"Coverage" from 19 to 37 degrees (relative to the center of the hall)
Note: there curvature radius is different from the mirrors in the PMT option

No Winston cones



Observer position:
210 cm away from beamline
240 cm downstream the center of the hall

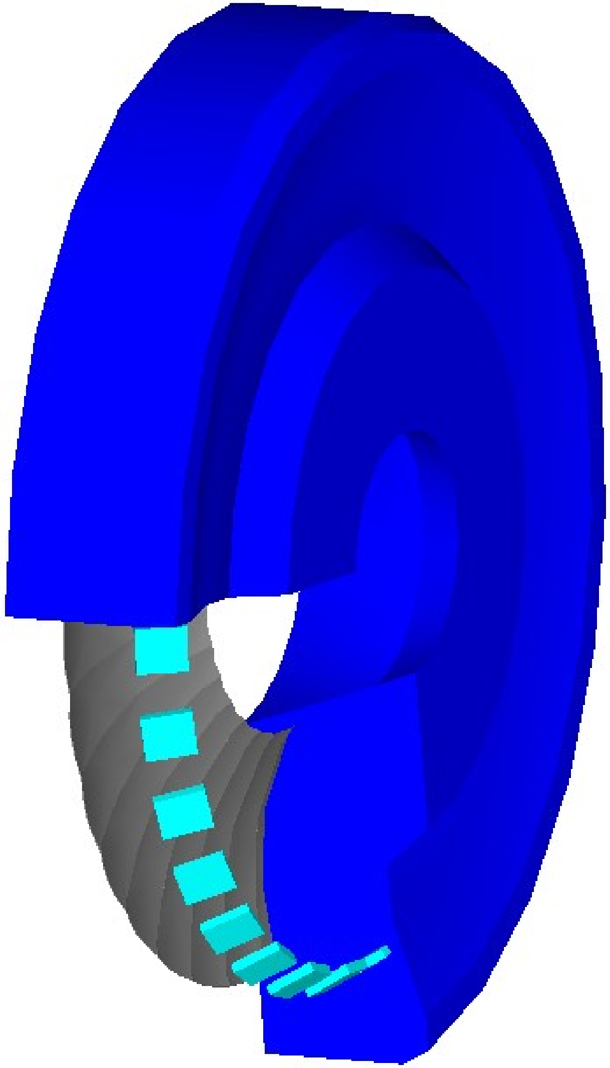
CSI coated GEM from PHENIX:
$23 \times 27\ cm^2$
"long" dimension along z
"short" along phi

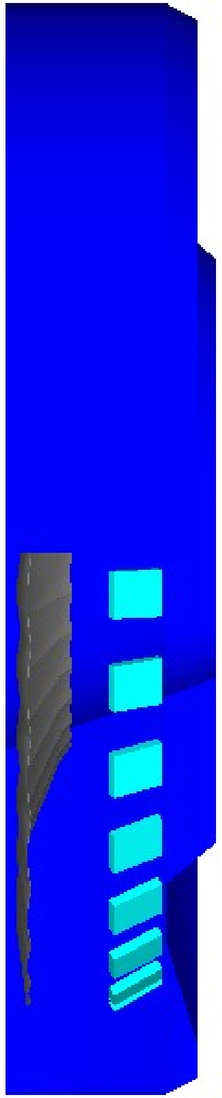


Note: use of CF_4 is mandatory (C_4F_{10} is a quencher for GEMs)

Update of the detector layout

Compatibility of this setup has been checked: OK





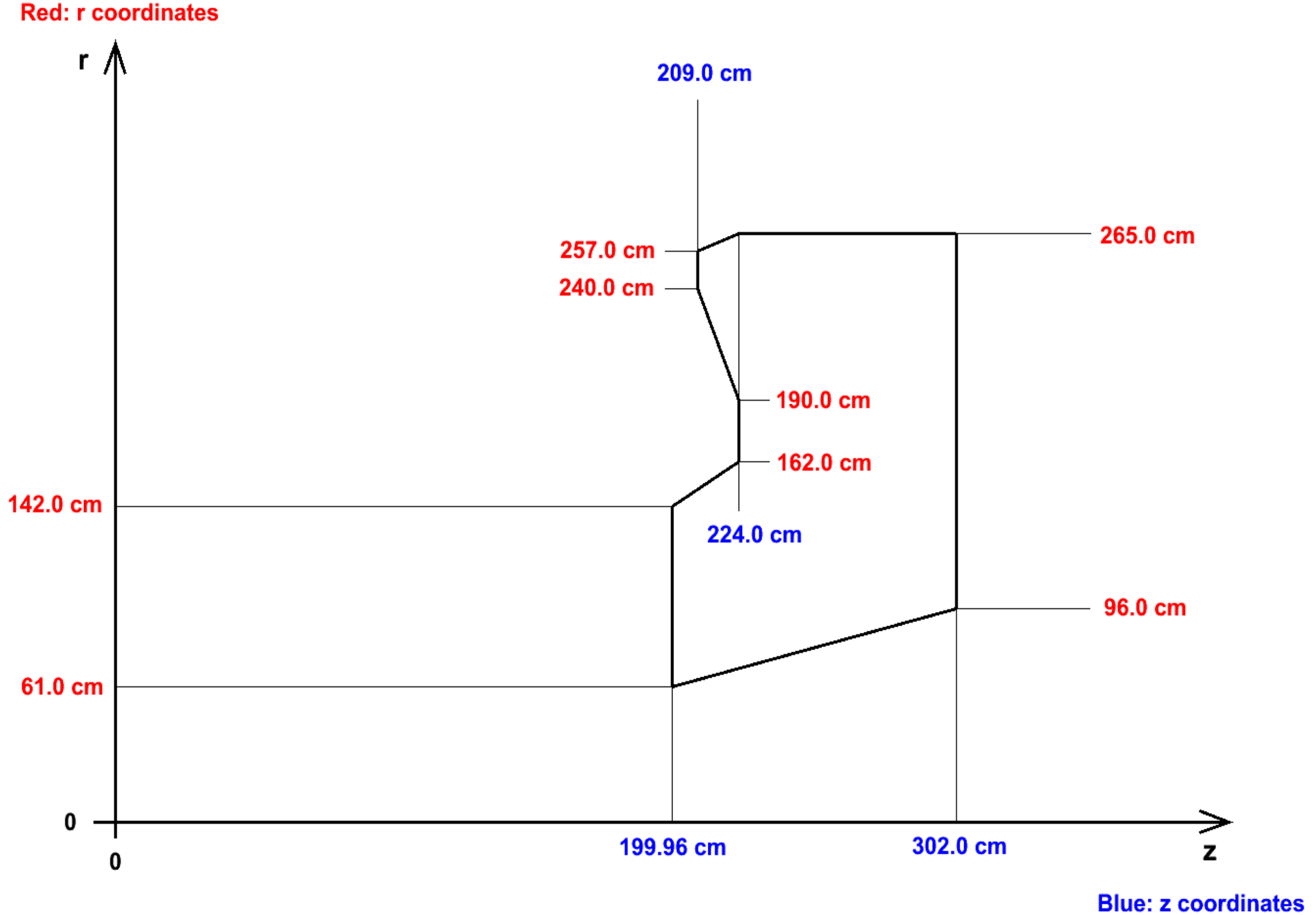
Update of the detector layout

“Big” issue to be expected: until now, we assumed we would get the BaBar solenoid to design our tank:
We may not get the BaBar solenoid, but the CLEO solenoid instead...
(Actually need to clarify that... heard about CLEO, but would it be CDF for instance ?)

The issue is: ...

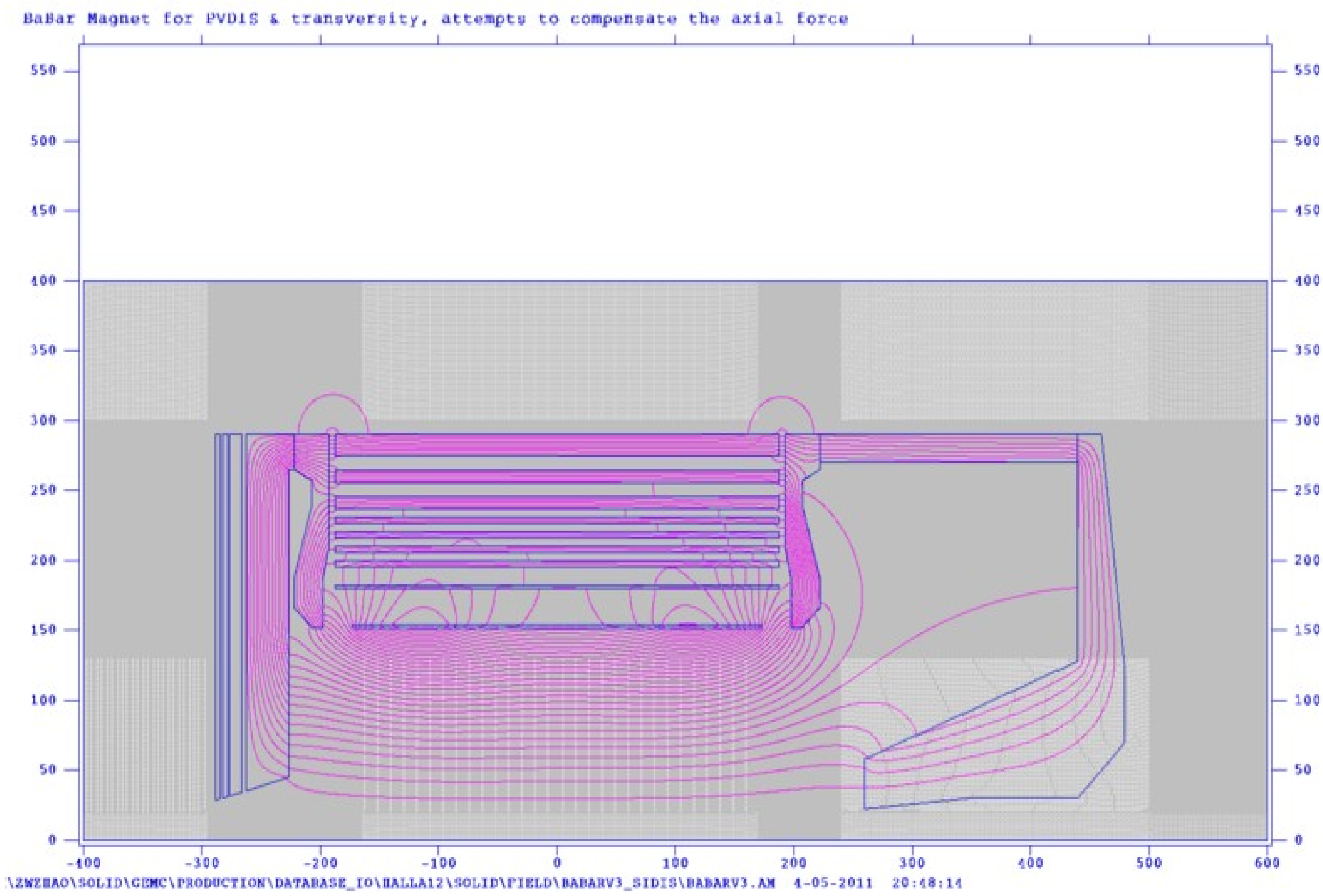
Update of the detector layout

The gas tank is pretty big...



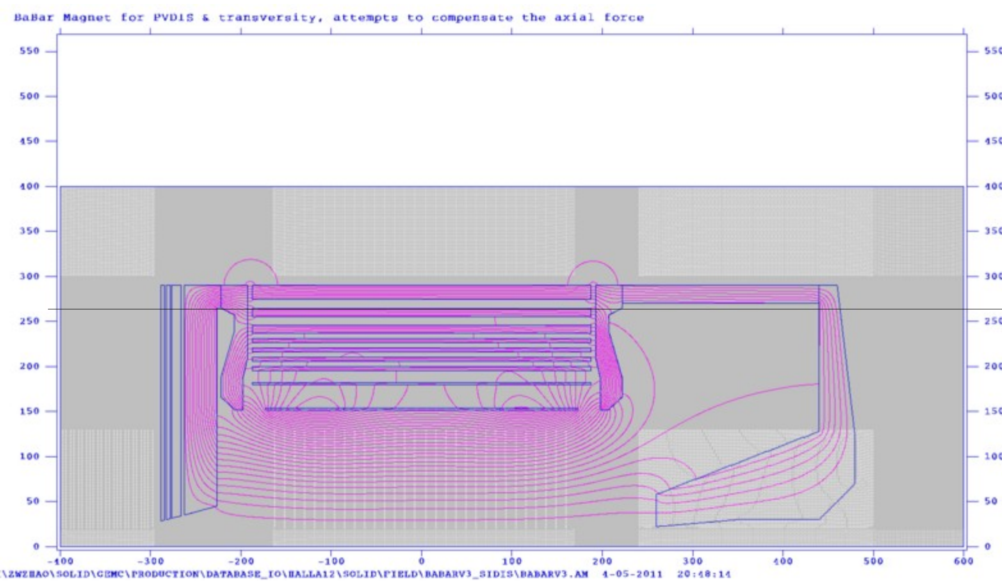
Update of the detector layout

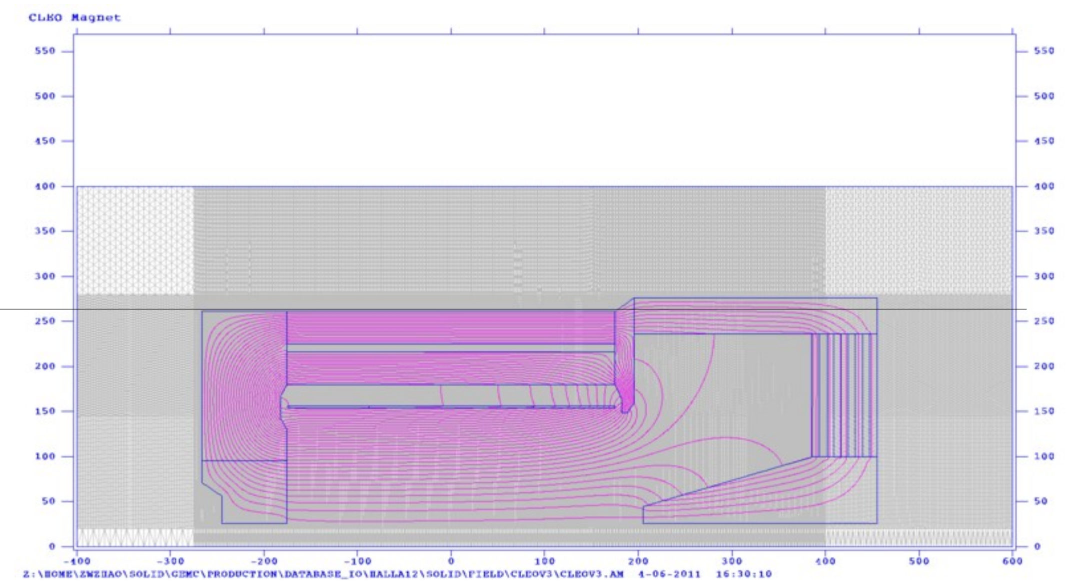
... but the BaBar magnet yoke is pretty capacious



Update of the detector layout

which is not (yet) the case of the CLEO magnet yoke !



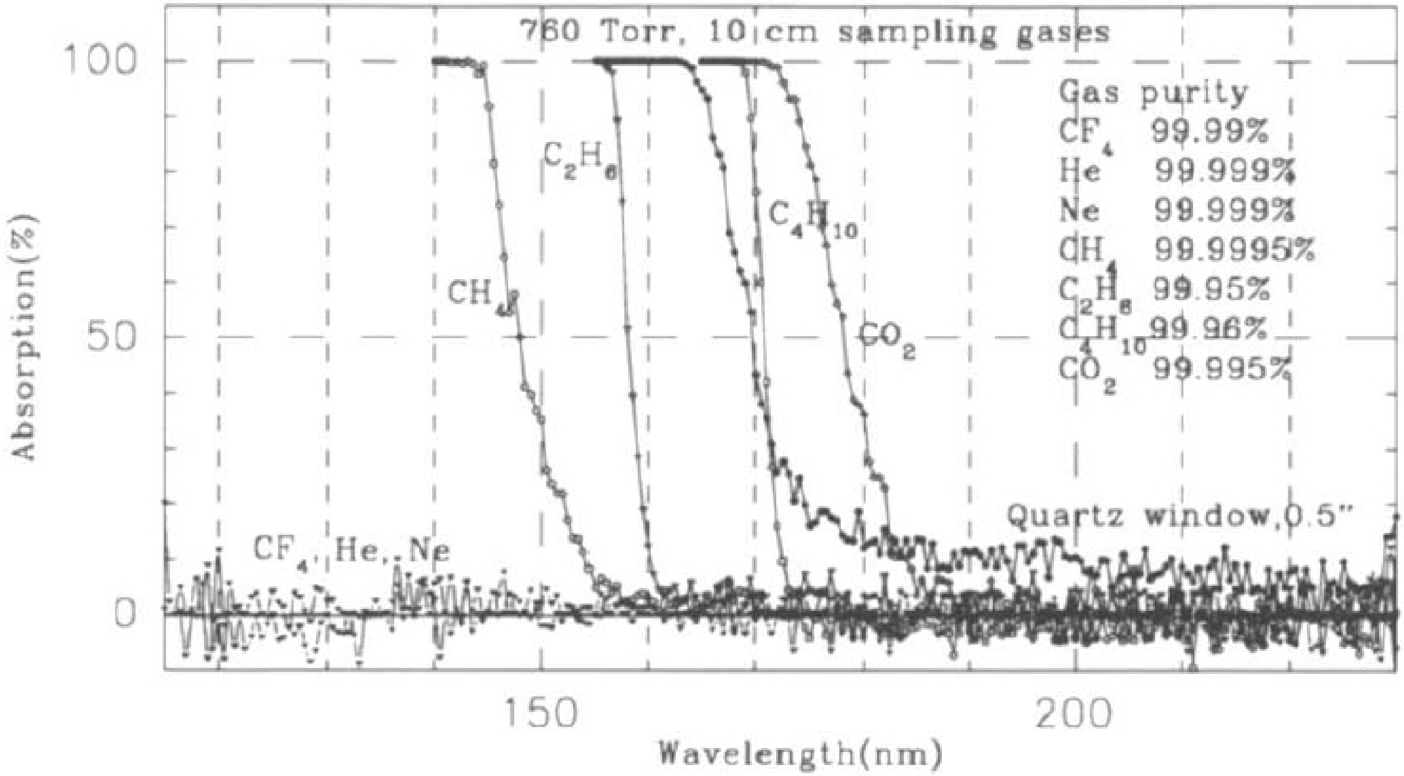


This implies:

1) a need precise dimensions of the CLEO yoke to “redesign” the gas tank
2) OR a new design for the CLEO end cap yoke which would imply a new field map

Update of the simulation details

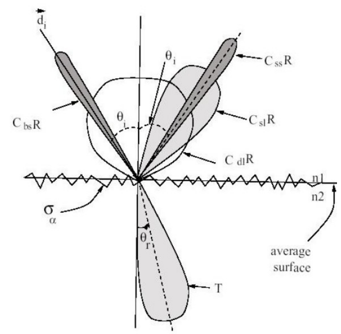
Need to set the absorption length for CF4 (but transmission is close to 100 % anyway)



[C. Lu, K.T. Mc Donald, NIM A 343, (1994), pp 135-151]

Update of the simulation details

Started to set up realistic surfaces in the GEANT 4 simulation: Mirrors surfaces include reflectivities, various types of reflections, and the layer of MgF_2 coating, necessary to preserve reflectivities at short wavelengths



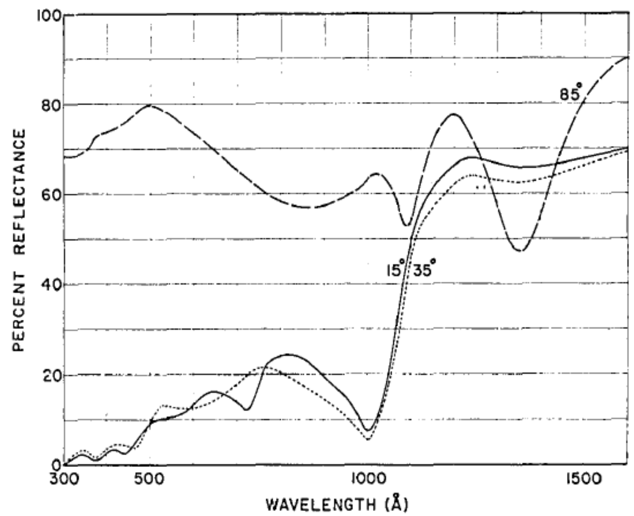
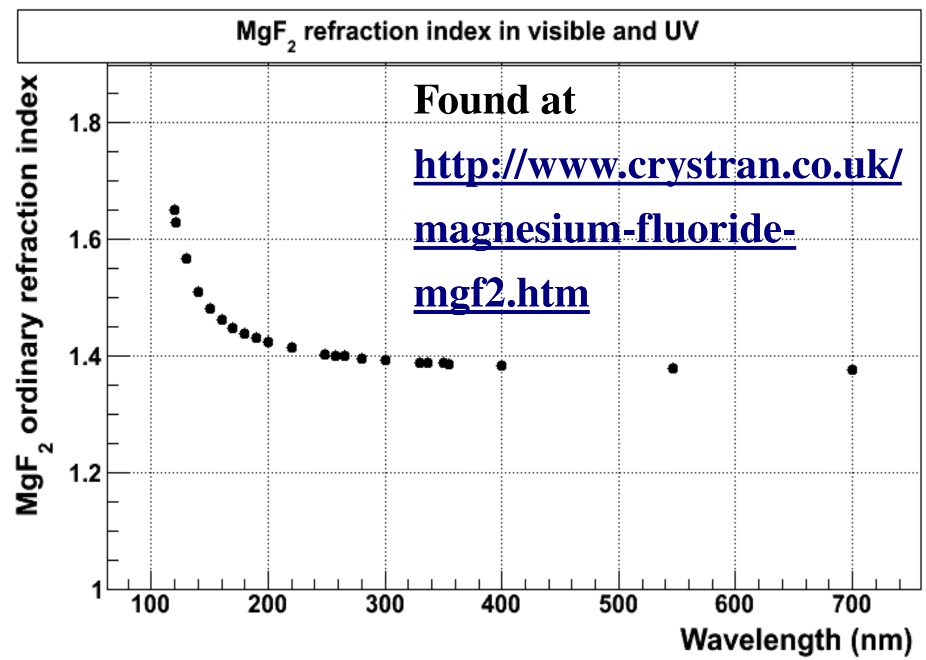


Fig. 1. Measured reflectance of an Al + MgF_2 mirror from 300 Å to 1500 Å. The MgF_2 thickness is 150 Å.

[W. R. Hunter *et al.*, Applied Optics Vol. 10, No. 3 (1971), pp 540-544]



Found at http://www.crystran.co.uk/magnesium-fluoride-mgf2.htm

Update of the simulation details

Not really figured out how to treat GEM surfaces properly:
GEM surfaces still only include efficiencies

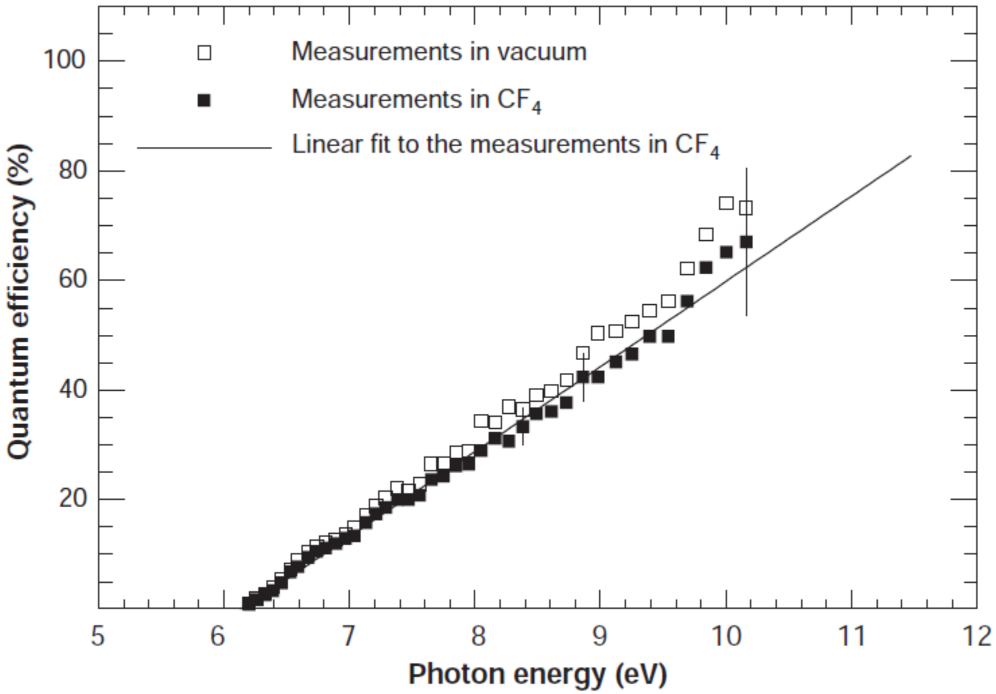
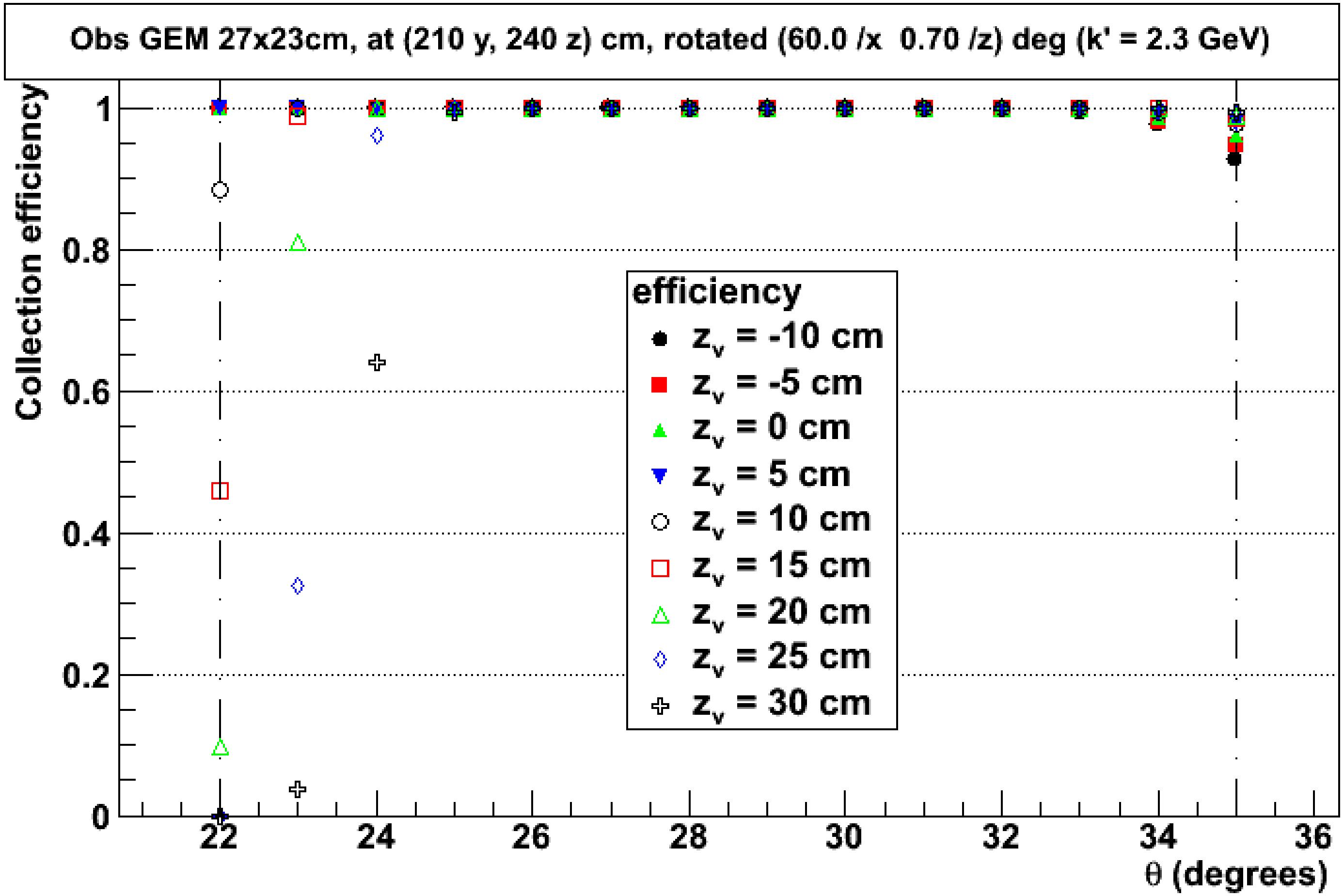


Fig. 9. Absolute quantum efficiency of CsI in vacuum and CF_4 over the bandwidth 6.2–10.3 eV.

[Z. Fraenkel *et al.*, "A Hadron Blind Detector for PHENIX experiment at RHIC", NIM A546 (2005), pp 466-480]

Results

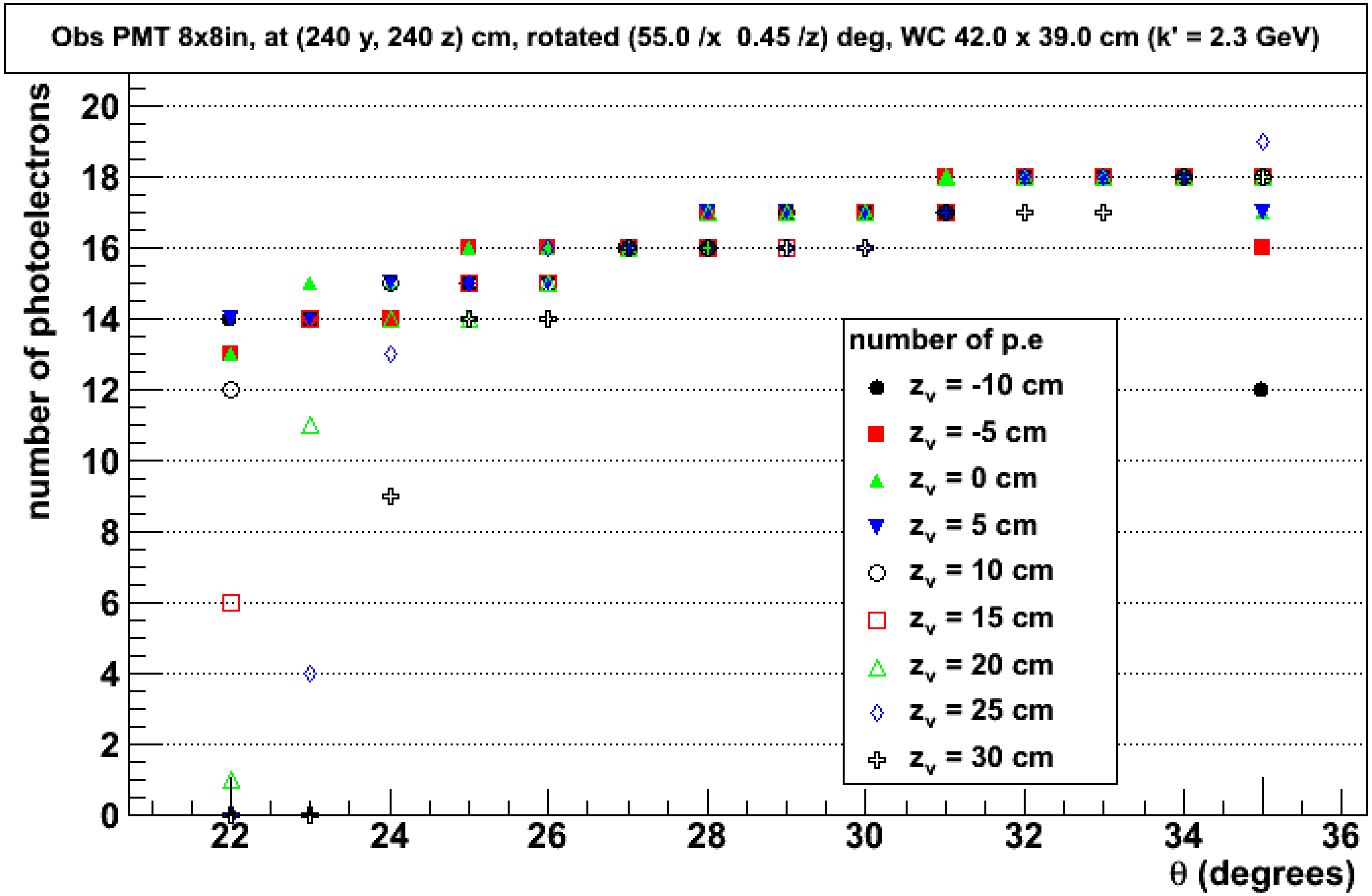
Efficiency (with perfect surfaces at 100 % reflectivity for mirrors, and 100% efficiency for PMTs). Optimized at $k' = 2.3$ GeV.



Results

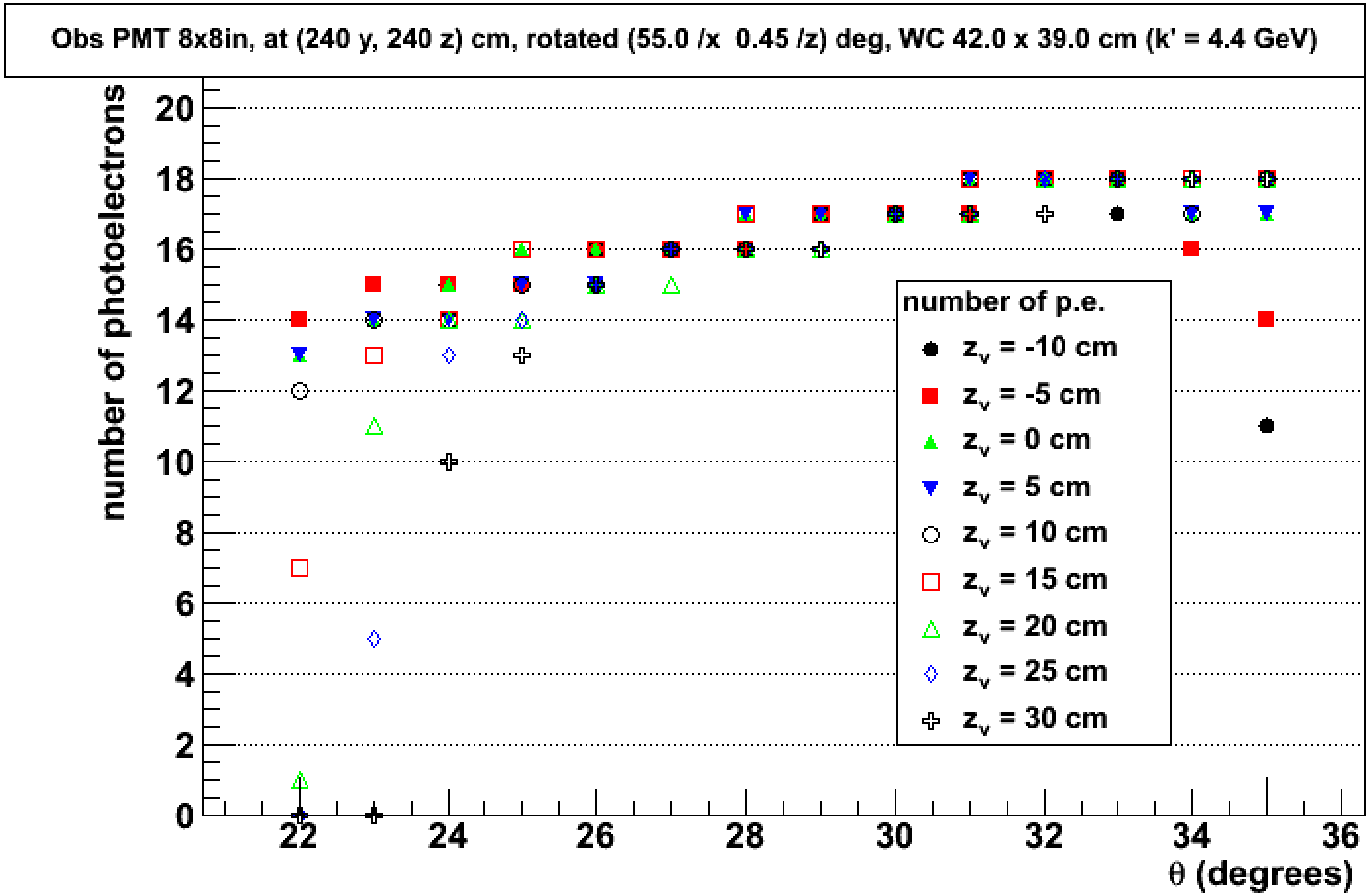
Number of photoelectrons with CF_4 (dead GEM area - holes - taken into account by a coefficient 0.54) at $k' = 2.3$ GeV.

=> Acceptable but not comfortable !



Results

Number of photoelectrons with CF_4 (dead GEM area - holes - taken into account by a coefficient 0.54) at $k' = 4.4$ GeV (detection threshold for pions). => Acceptable but not comfortable !



Results

As a cross check to those numbers of photoelectron, we compared the yield of raw number of photons produced on the path length of the electron in the gas given by GEANT 4 to the number of photons given by the integral of Frank-Tamm equation over the path computed by Mathematica (courtesy of Brad Sawatzky):

=> estimation better than 8 %

```
GEM option (CF4, n = 1.00046, 133 photons/m):
  z = 0
  theta(deg)   L_Gas(cm)    N_th    N_G4   |N_G4-N_th|/N (%)
    22.0          90.1       120     128         6.7
    35.0         115.0       152     164         7.9

PMT option (C4F10, n = 1.0015, 454 photons/m):
  z = 0
  theta(deg)   L_Gas(cm)    N_th    N_G4   |N_G4-N_th|/N (%)
    22.0          65.7       298     307         3.0
    35.0         112.3       510     481         5.7
```

Summary

- Simulation still needs little bit of refinement.

- GEM detectors from PHENIX would do the job pretty well in terms of efficiency;

- The number of photons starts to be critically low because of the mandatory use of CF_4 with CSI coated GEMs; An alternate way to do would be to use C_4F_{10} and a window to isolate the GEMs (COMPASS) but that would signify:
    * A cut-off on the shortest wavelengths, where the QE of CSI is maximal (i.e. not necessarily more photons)
    * increase of costs (several gas purifying systems, etc...)

Prospectives

TO DO

- May need to redo the optimization, regardin to the magnet we will get
- Try to get a cost estimation for the mirrors

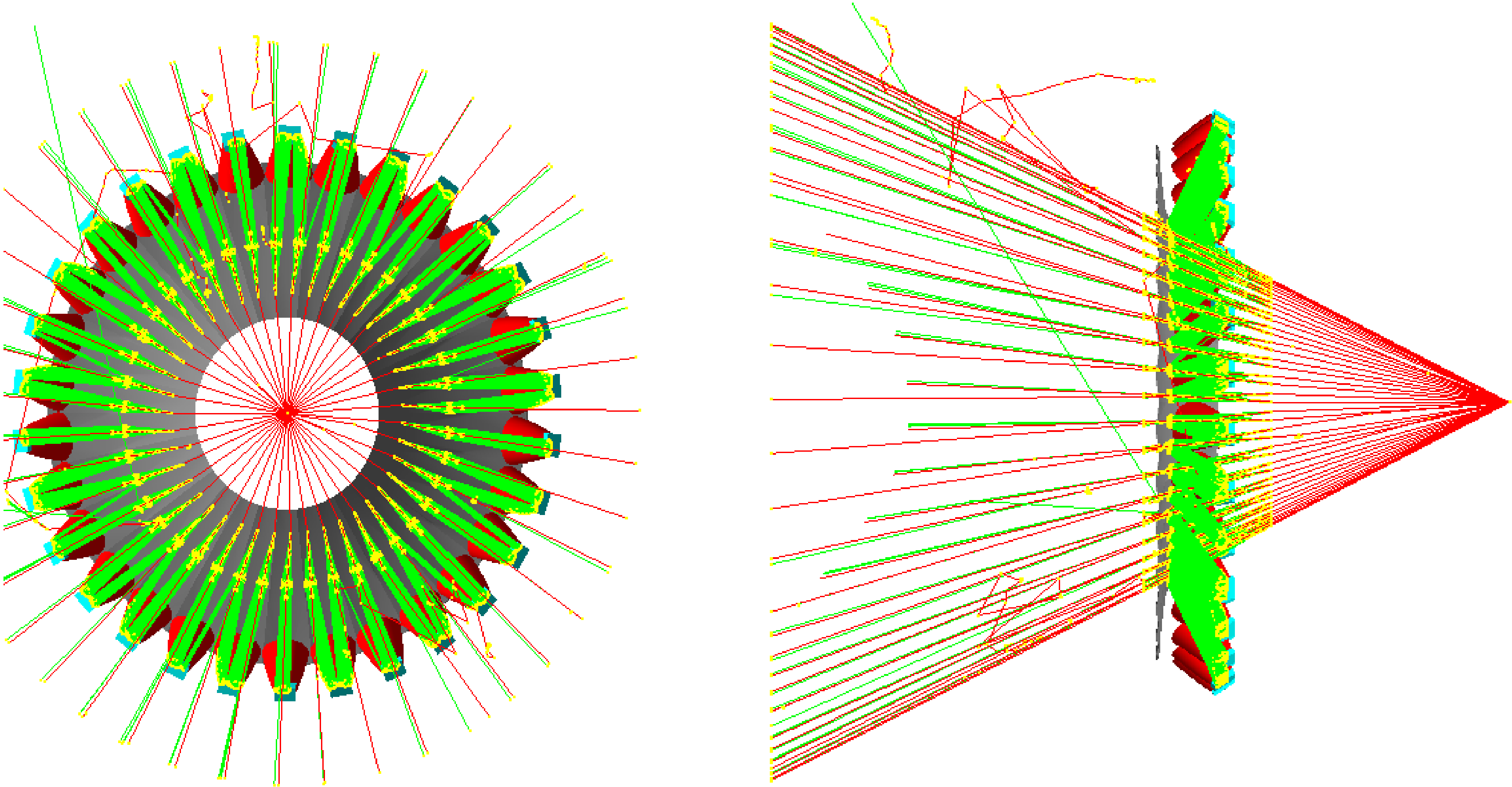
- For CSI coated GEM option:
  * Set realistic surfaces to the GEMs
  * Test the "C_4F_{10} / window alternative"
  * Start to think about a plan to test GEMs

- For PMT option:
  * still need to optimize detector with 6x6 inches PMT arrays, and set realistic surfaces to them.

BACK UP

Collection efficiencies

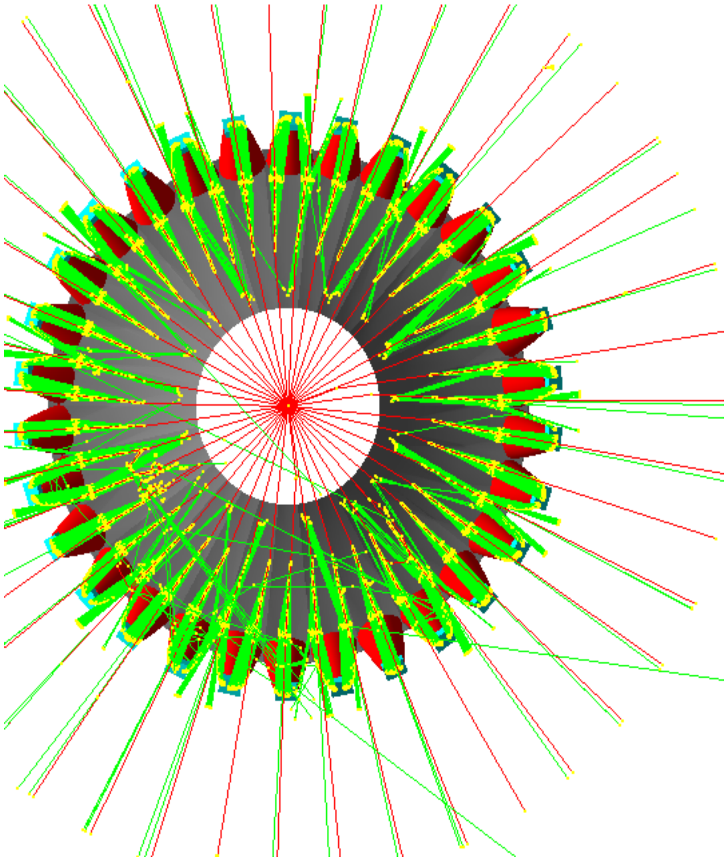
In the middle of the acceptance (z = +10 cm, θ = 29 deg)



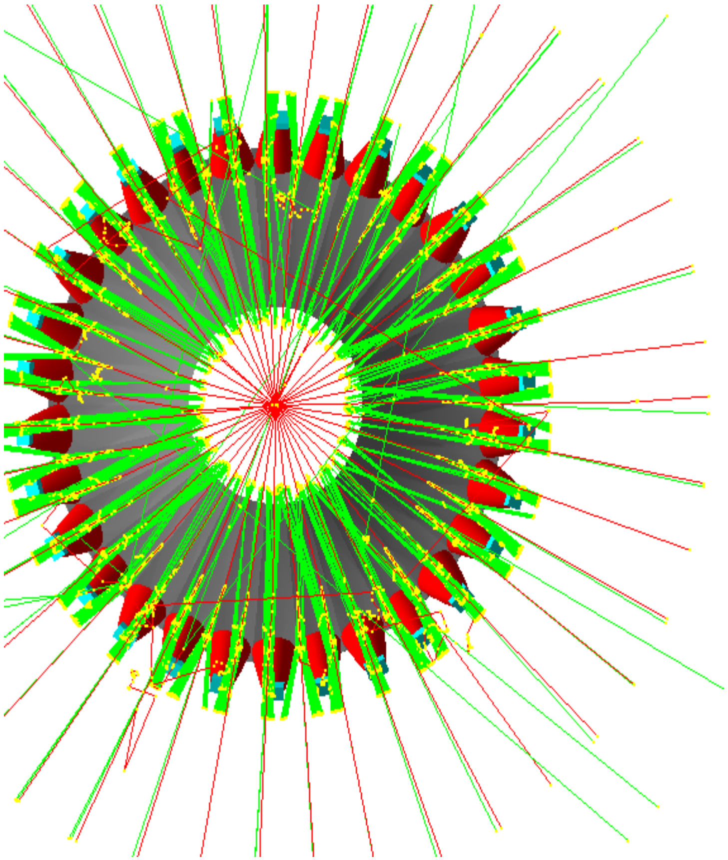
Collection efficiencies

At the higher edges of the acceptance (θ = 35 deg)

$z = +10$ cm



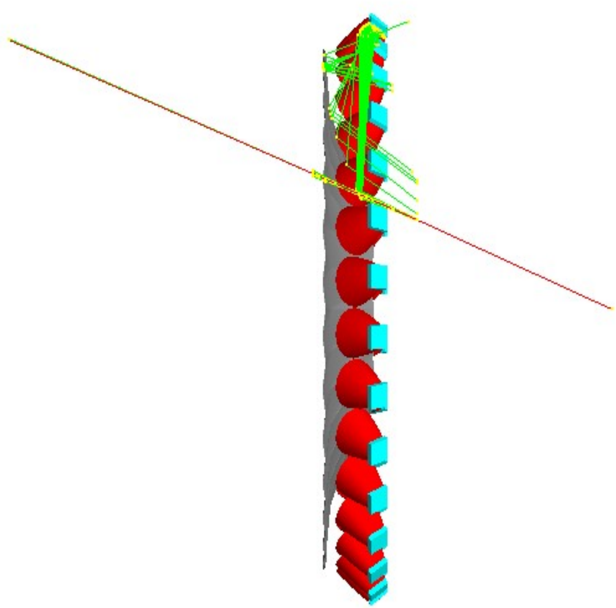
$z = +30$ cm



Collection efficiencies

At the lower edges of the acceptance (θ = 22 deg)

z = +10 cm



z = -10 cm