Cerenkov Detector for SANE

presented by

Seonho Choi

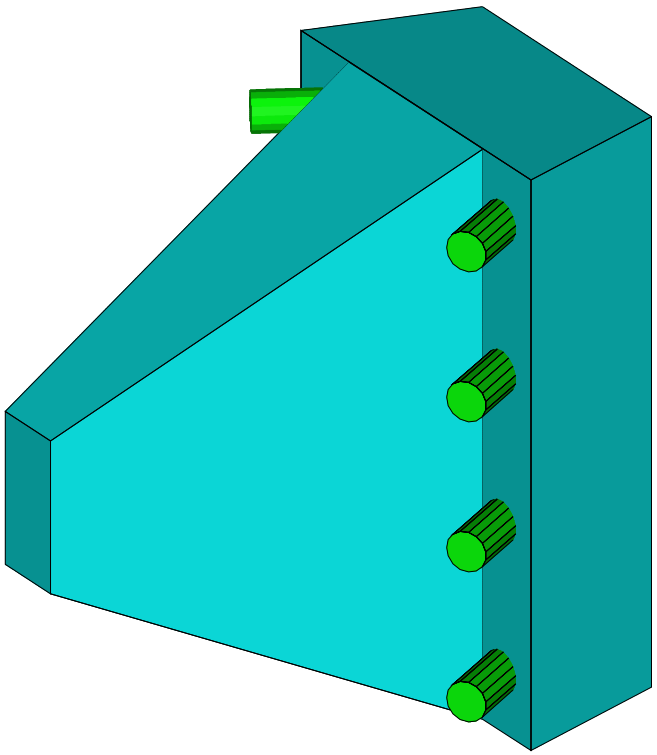
Temple University

SANE Collaboration
March 26, 2004

Overview

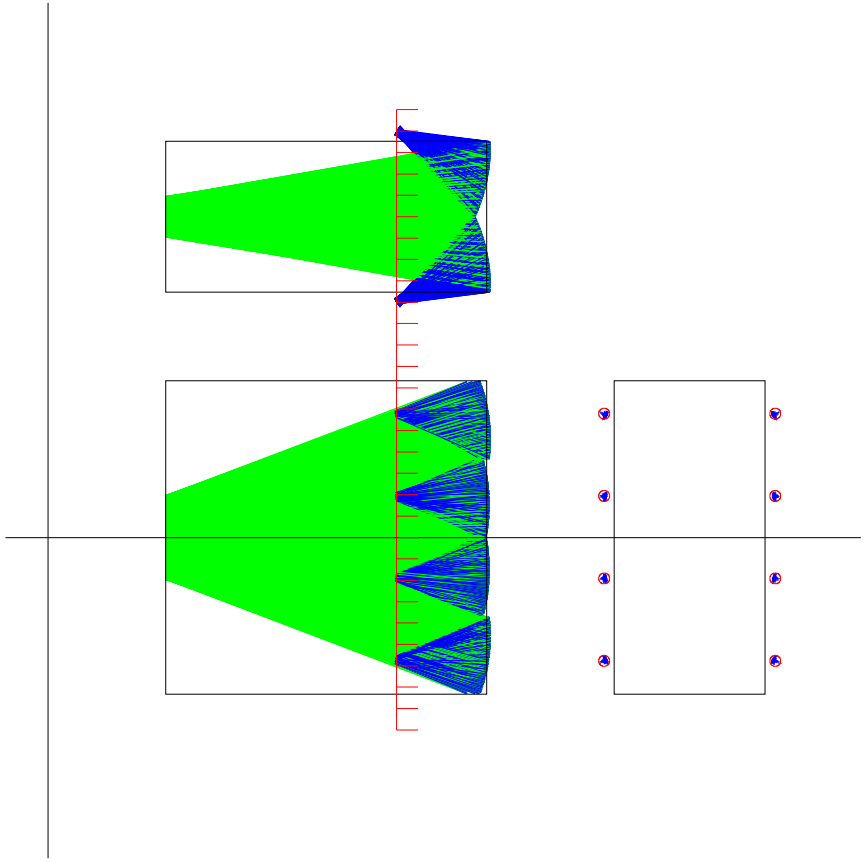
- Goal
  - High electron detection efficiency
  - Pion rejection of at least 1000:1
  - Consideration of strong target magnetic field
  - Insensitivity to beam background events
- Design parameters
  - Operation at about atmospheric pressure (slightly over pressure)
  - Radiator: dry nitrogen at 20°C, n=1.000279
  - Pion momentum threshold: 5.9 GeV
  - Electron momentum threshold: 21.6 MeV

Box Design



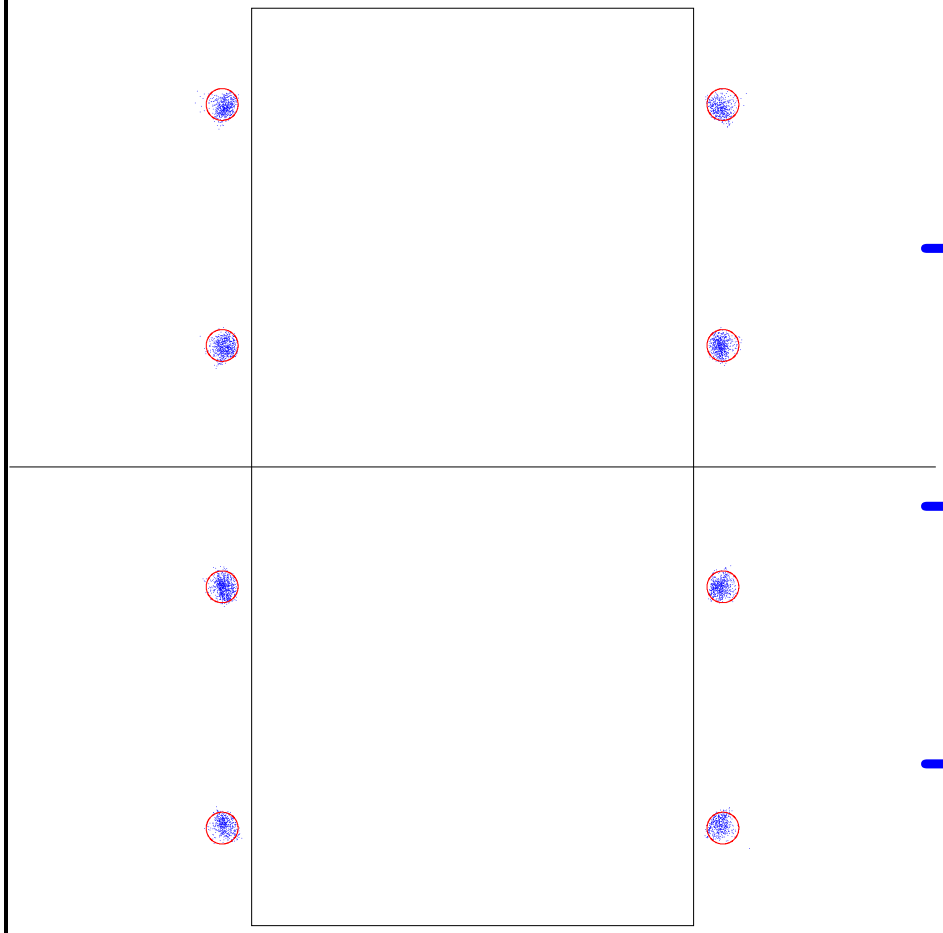
- Total radiator length: 1.5m
- 50cm from the target center
- Material
  - flat sheets of Al with frame reinforcement or
  - non-magnetic stainless steel
  - 2 in Pb wall shield for beam pipe
- Windows
  - thin front window of tedlar for light seal
  - interior polymer window for gas-tight seal

Ray Tracing



- 8 mirrors cover an area
  71 cm (H)× 147 cm (V)
- Each mirror:
  ~36cm (H) × 37cm (V)
  Tilted 11° w.r.t. the beam
- Radius of curvature: 80cm
- Phototubes
  - 2 inch tubes
  - 30° outward from central plane

Study of the Light Focusing



- Almost point-to-point focus from the target (small target field effect)
- Using 2 inch tube, full focus for the events from ±5cm box around the target
- Effective suppression of background events from outside of the target

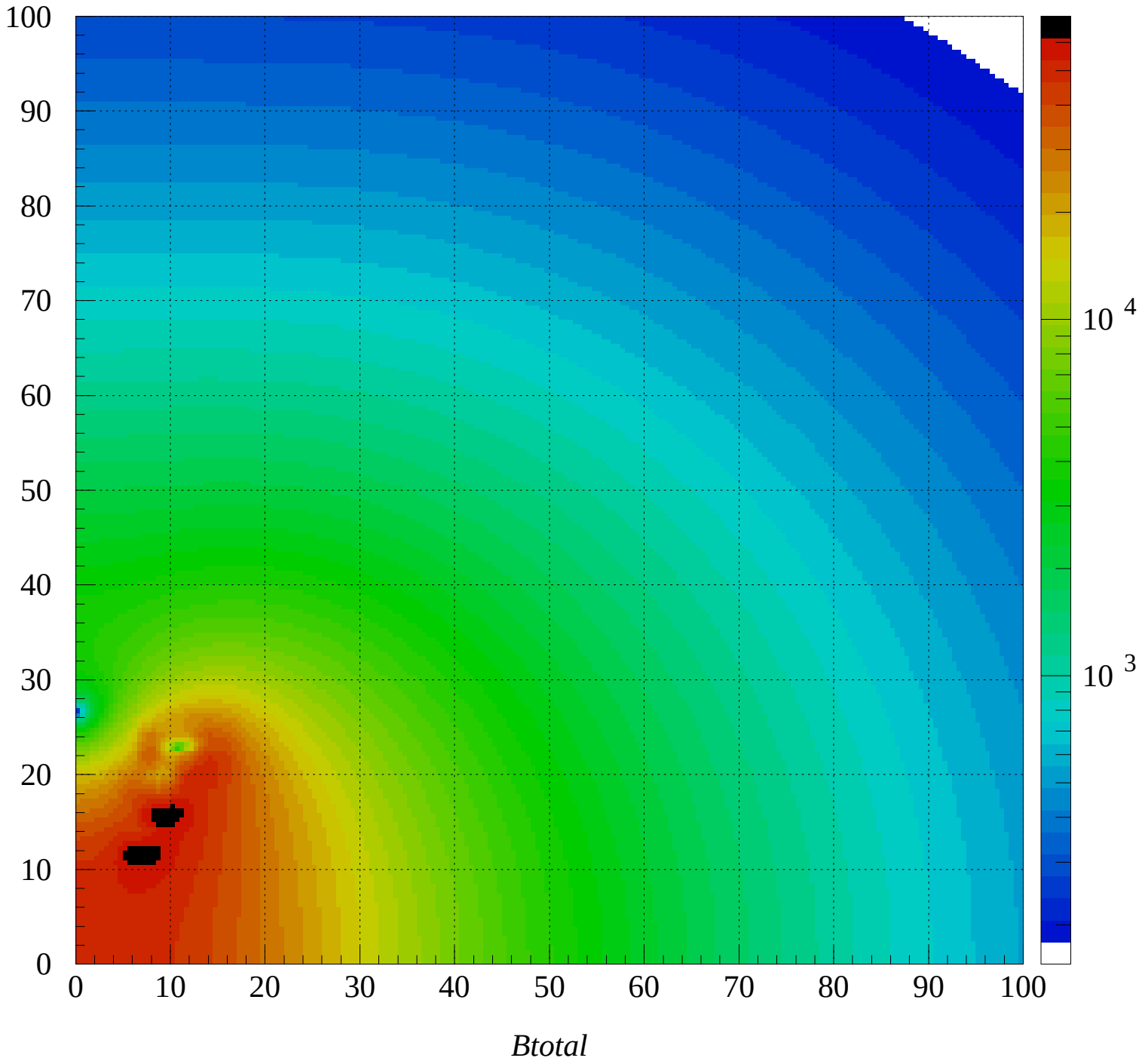
Target Field Effect

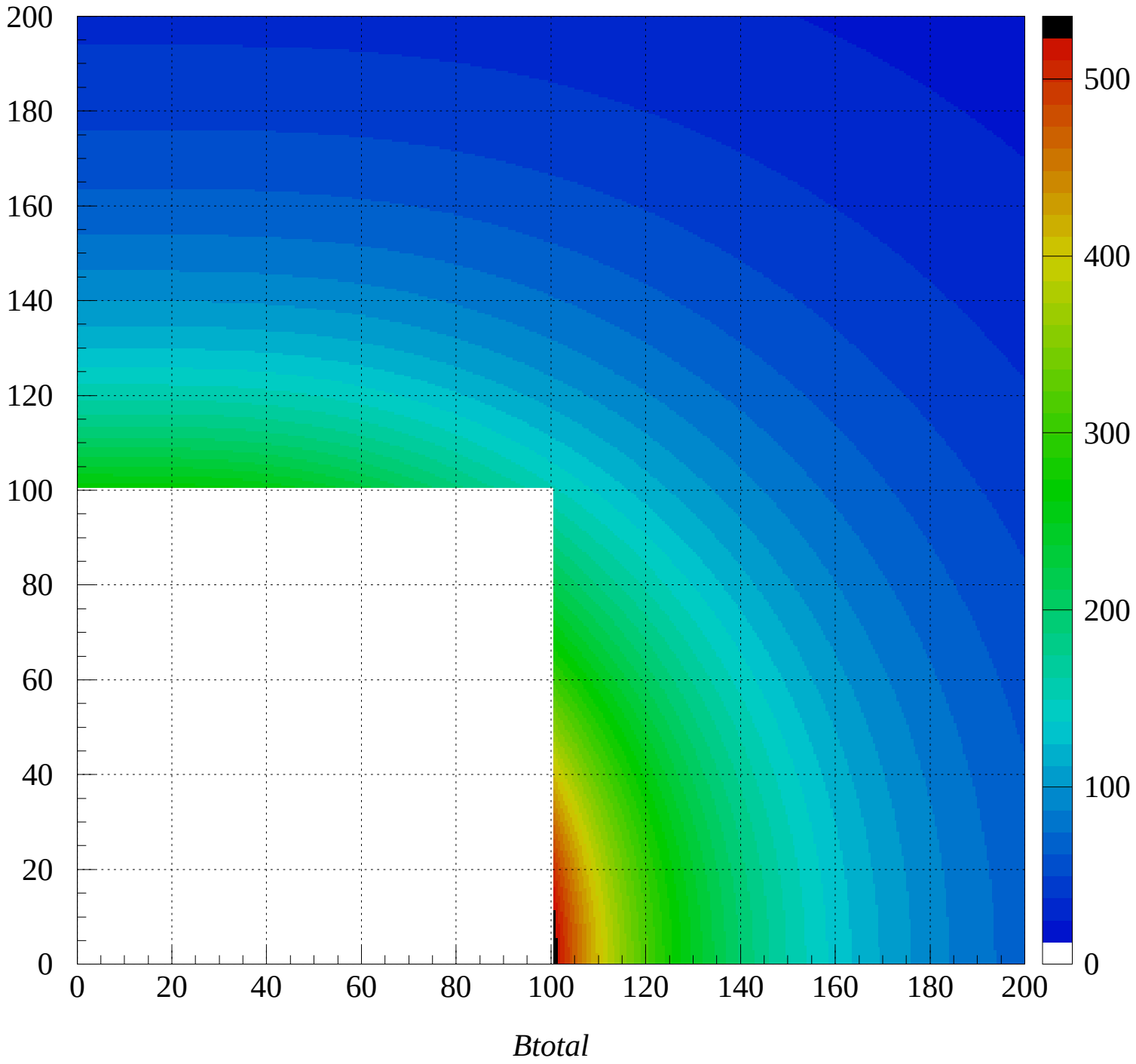
- Field map measured for ± 100 cm in z and ρ up to 100cm
- Extrapolation beyond measurement
  - Approximation of the magnet by a current loop at large distance

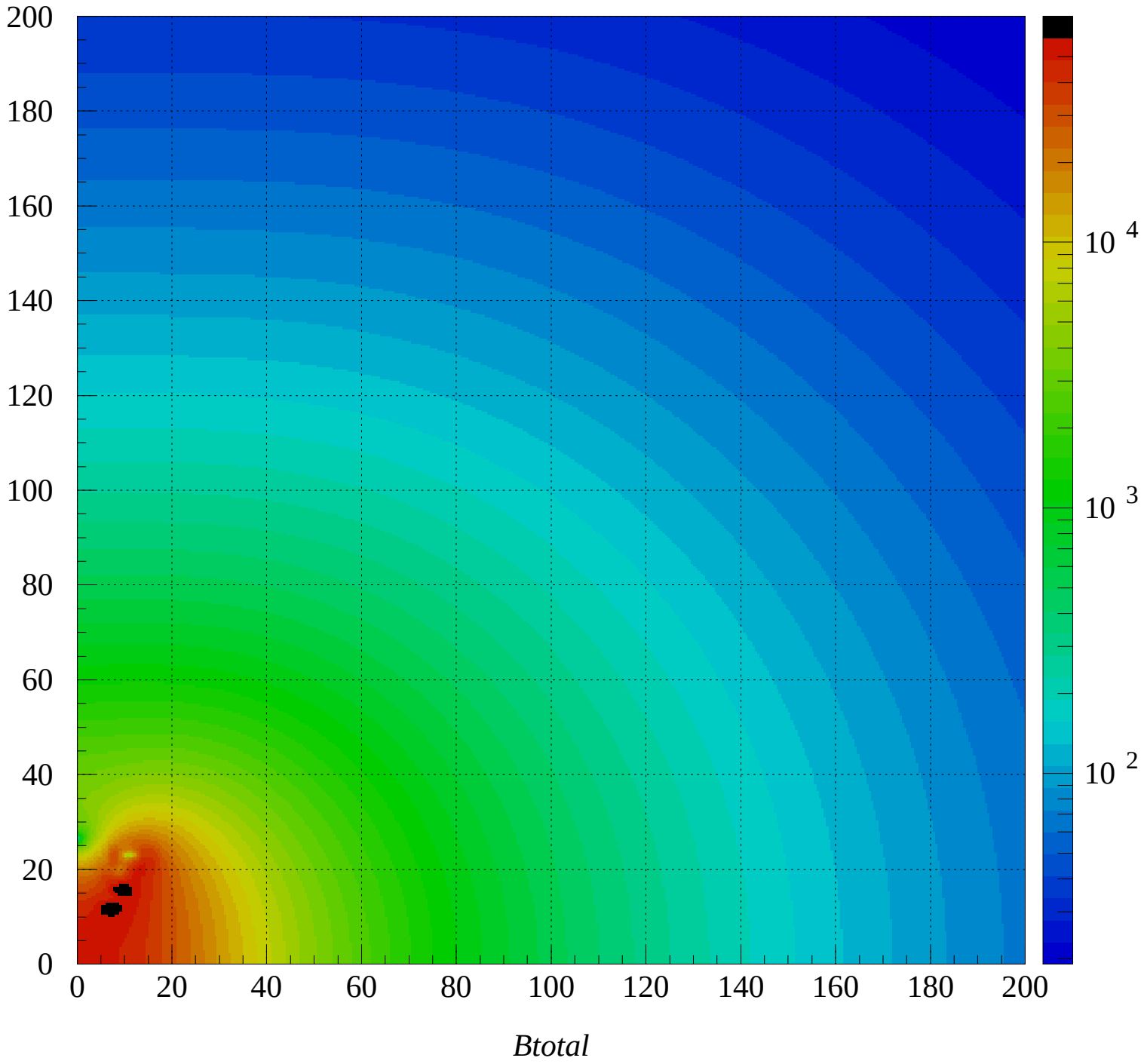
$$B_r(r,\theta) = \frac{\mu_0 I}{2}\frac{a^2}{r^3}\left[P_1 - \frac{3}{2}\left(\frac{a}{r}\right)^2 P_3 + \frac{15}{8}\left(\frac{a}{r}\right)^4 P_5 - \frac{35}{16}\left(\frac{a}{r}\right)^6 P_7 + \cdots\right]$$

$$B_\theta(r,\theta) = \frac{\mu_0 I}{4}\frac{a^2}{r^3}\left[P_1^1 - \frac{3}{4}\left(\frac{a}{r}\right)^2 P_3^1 + \frac{5}{8}\left(\frac{a}{r}\right)^4 P_5^1 - \frac{35}{64}\left(\frac{a}{r}\right)^6 P_7^1 + \cdots\right]$$

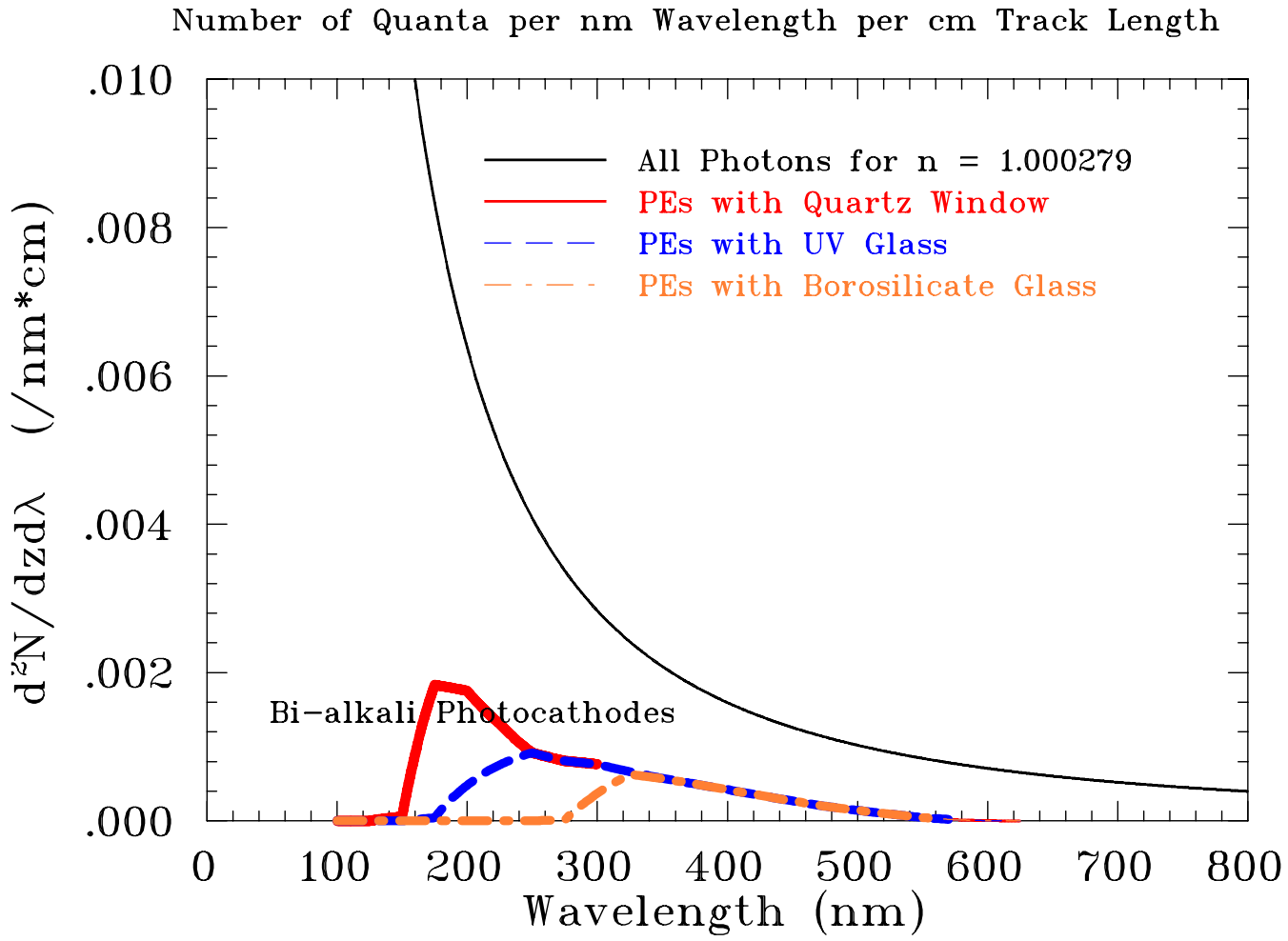
  - Parameters fitted using measured field at r >40cm
  - Residual field at the PMT's: 67 to 103 gauss
  - Need to design/test a good magnetic shield for the tubes


100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Btotal
10 4
10 3


200
180
160
140
120
100
80
60
40
20
0
0
20
40
60
80
100
120
140
160
180
200
500
400
300
200
100
0
Btotal


200
180
160
140
120
100
80
60
40
20
0
0
20
40
60
80
100
120
140
160
180
200
10 4
10 3
10 2
Btotal

Photoelectrons



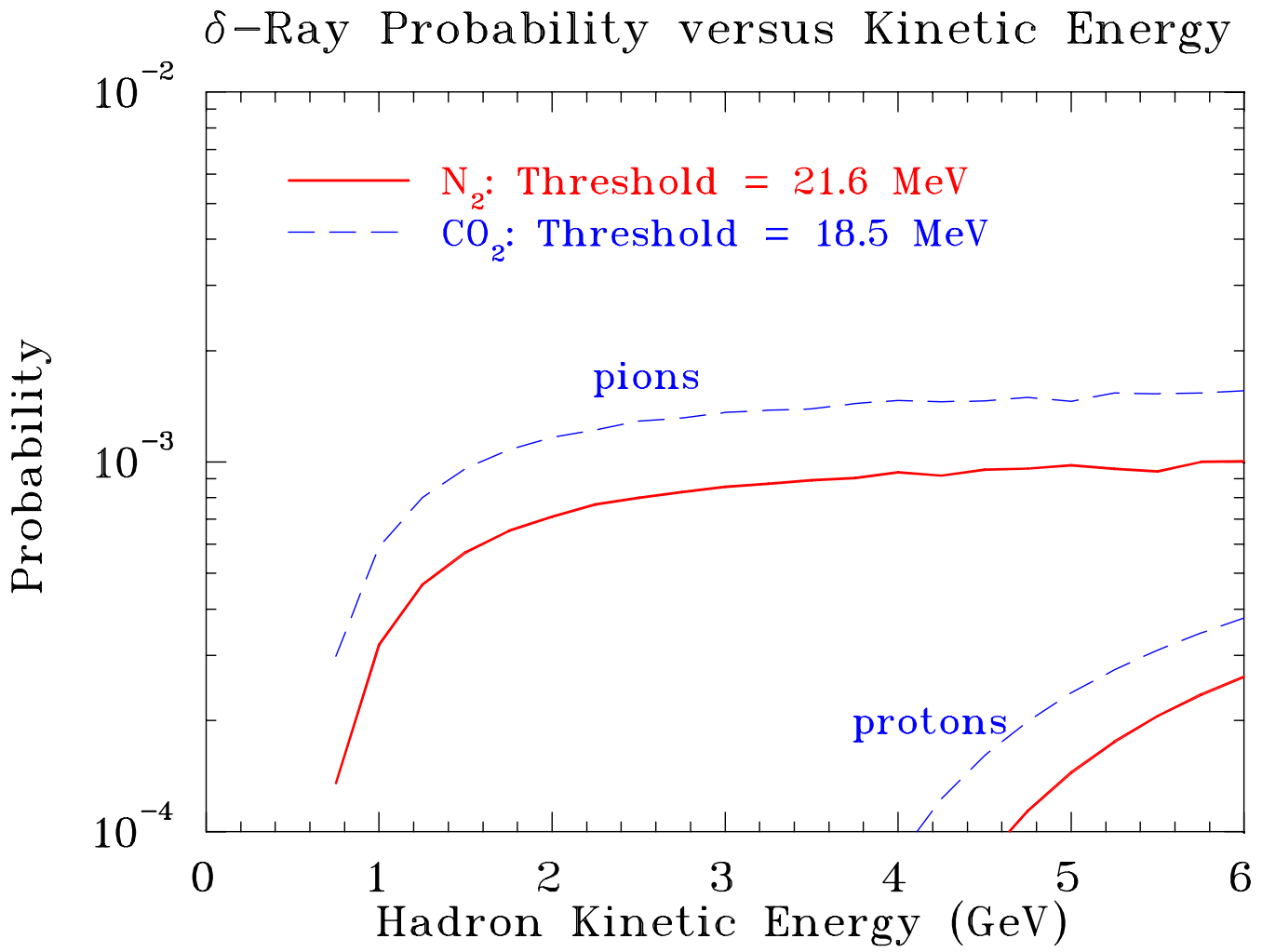
Photoelectrons(cont.)

Expected number of photo electrons for a 150 cm N_2 radiator

Window	dN/dz (cm^{-1}) (200nm - 650nm)	Naïve total pe's	Actual* total pe's
Quartz	0.199	29.9	24.2
UV Glass	0.169	25.4	20.5
Borosilicate Glass	0.0908	13.6	11.0

* Including 90% reflectivity of the mirror and 90% transmission at the gas-window interface

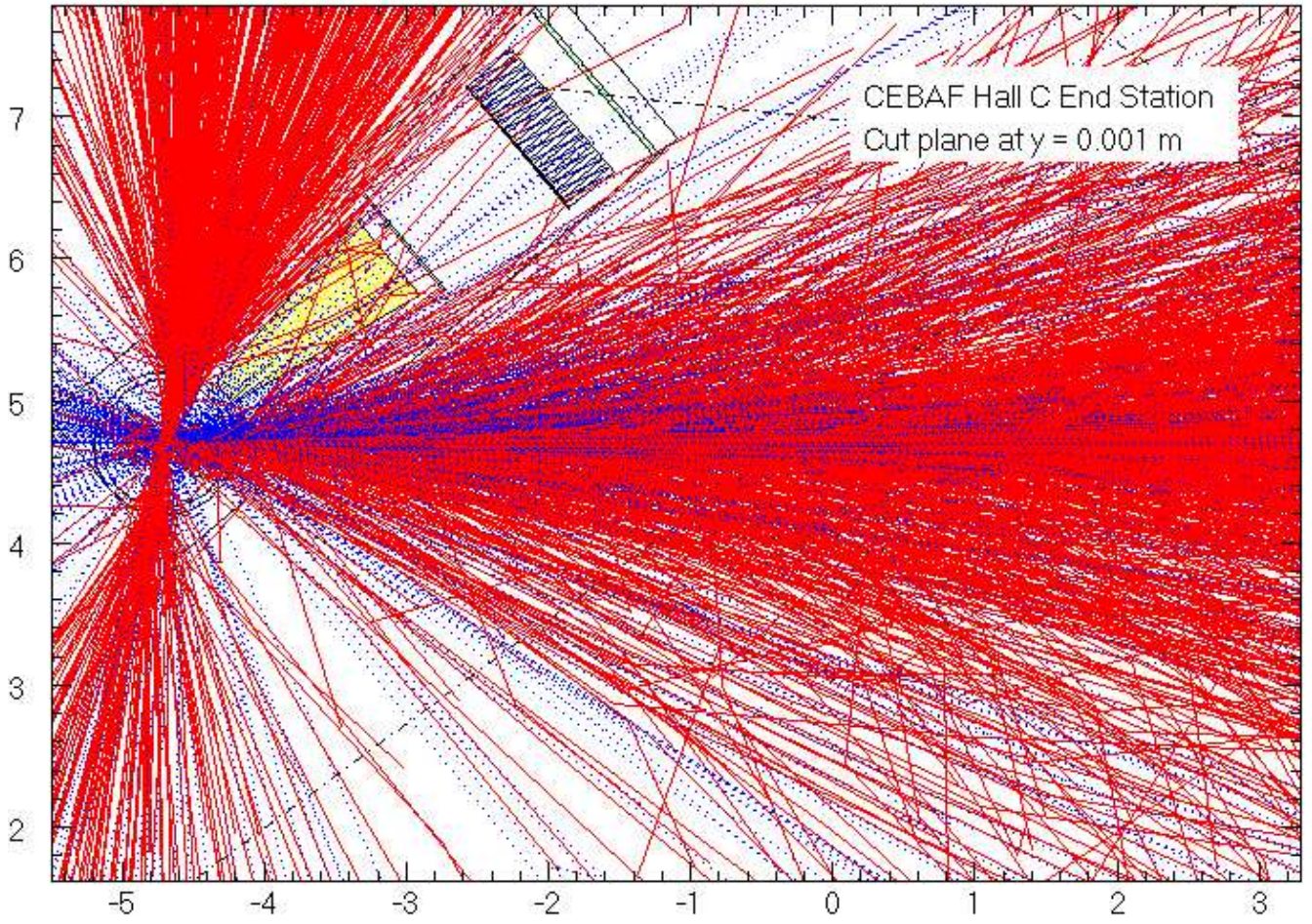
Pion Rejection



Planned Test

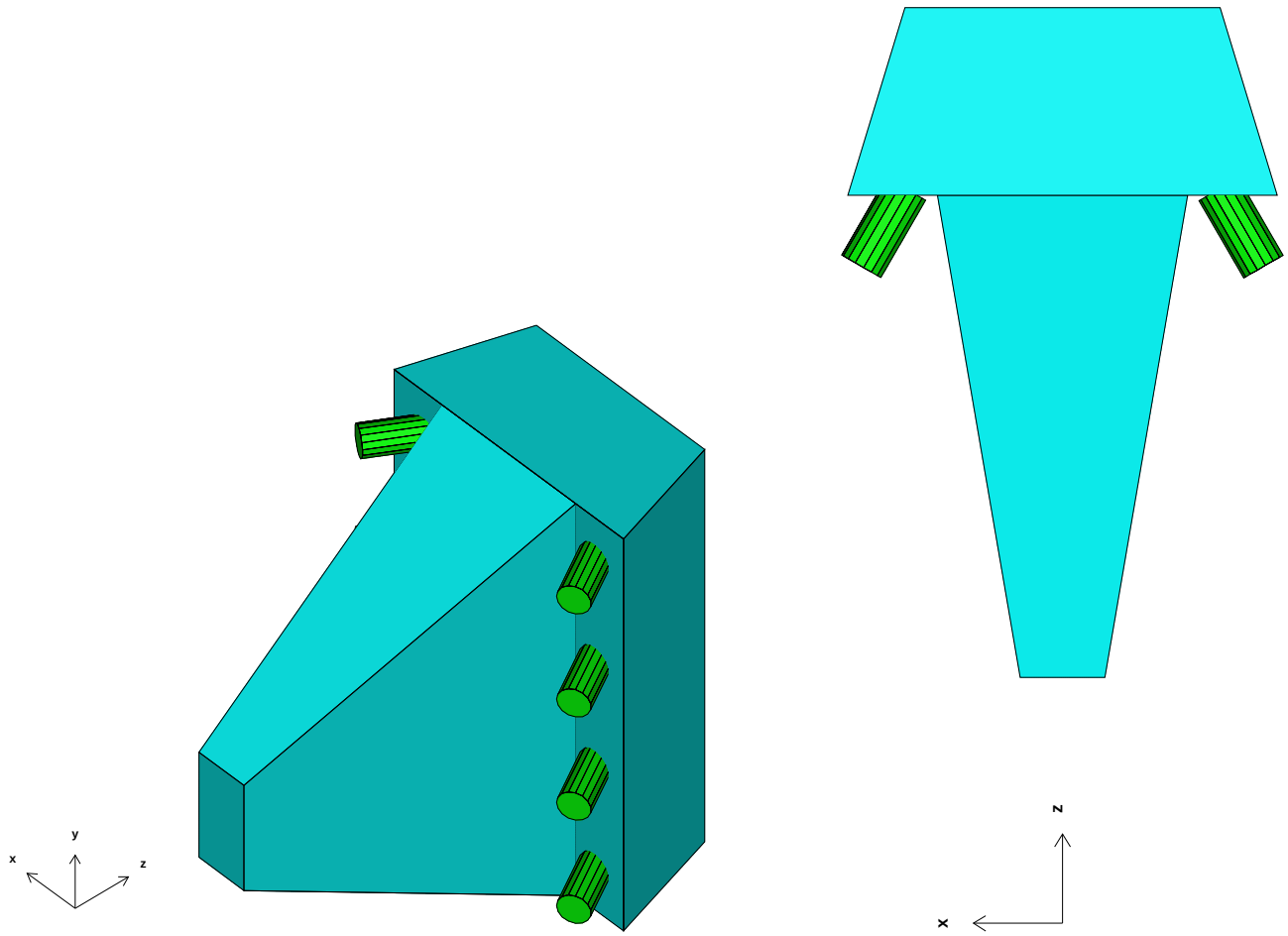
- Phase 1: using an existing tank and a mirror (A. Lukhanin and E. Kaczanowicz, Temple University)
  - : 1m long, 33cm in diameter
- In-beam test in the Hall
  - Parasite with separate DAQ
  - Check number of photo-electrons
  - Optimize the length of the radiator
- Test at UVa with target field on
  - Design/test the magnetic shield for the tubes
- Phase 2: test with actual proto-type (1 mirror segment)

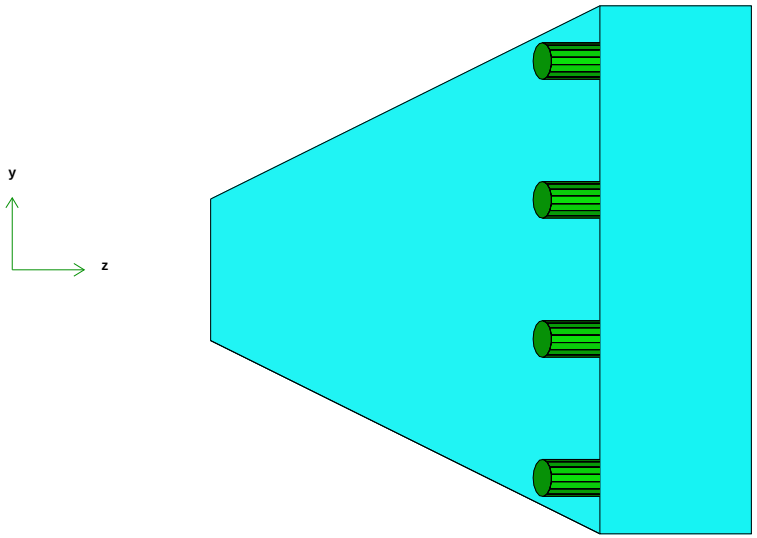
Background Simulation

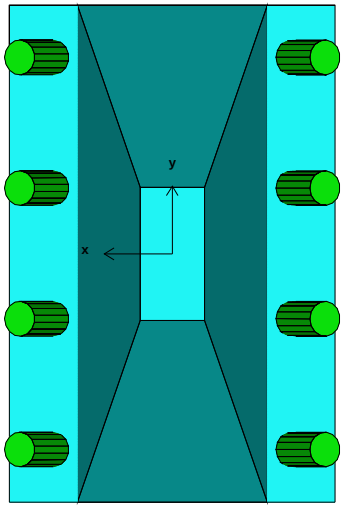


Summary

- Draft design with full ray trace finished
- Planned tests with phase 1 proto-type
- Full simulation with GEANT in progress
- Need integration of design/installation of Cerenkov and UVa target
- Finalize the design and build phase 2 proto-type
- Instrumentation proposal to DOE or NSF


y
x
z
Z
X


y
z


y
x