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# **SoLID PVDIS Cherenkov detector**

**May, 10, 2012**

# Outline

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- > Purpose
- > Design status
- > Performances, FOM
- > Costs estimation

# Purpose

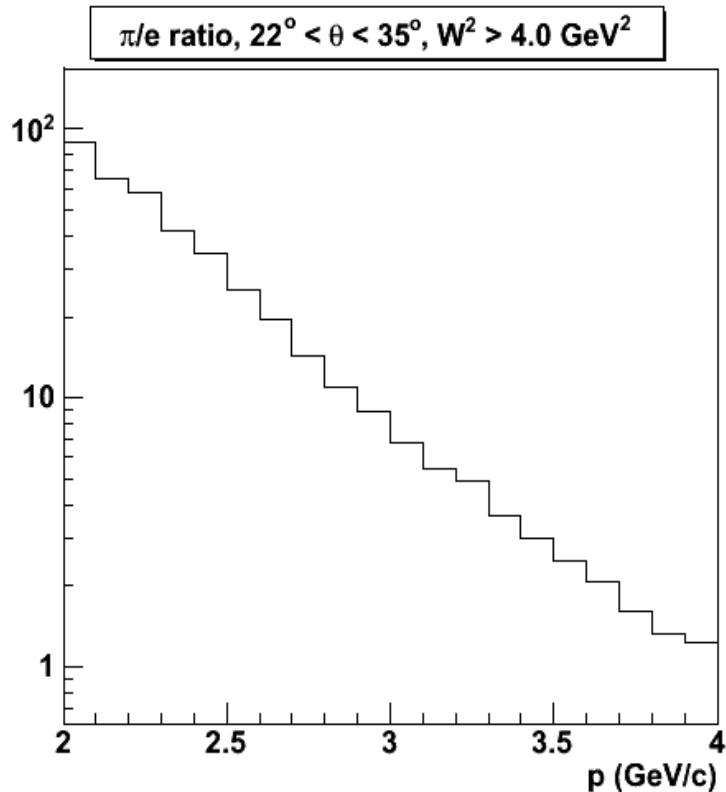
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Electron identification and pion rejection for the PVDIS experiment in SoLID.

According to PVDIS proposal:  $\pi/e < 1\%$  after Calo+Cher selection.

Pion rejection rate from the Calo: 100/1.

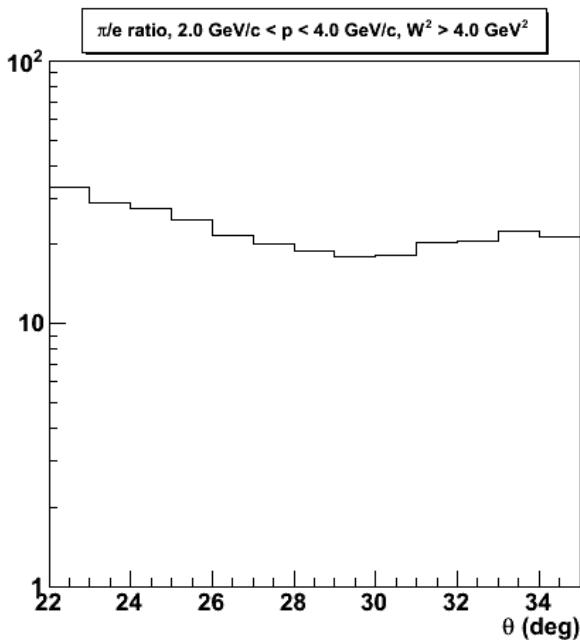
$\pi/e$  ratio as function of the momentum (courtesy from Seamus):



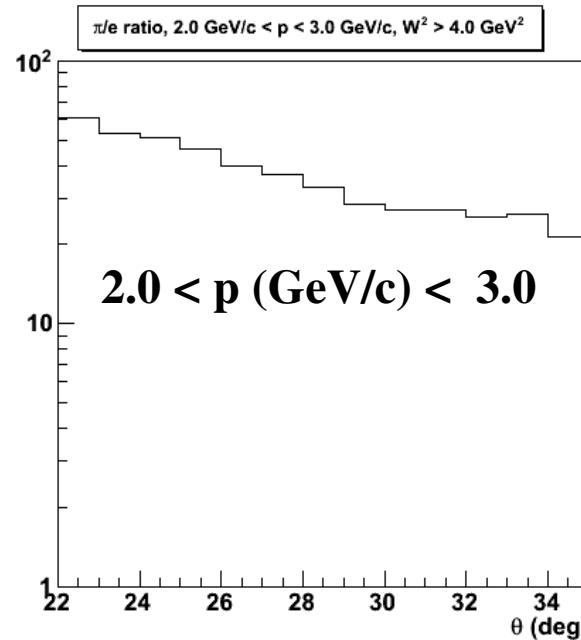
→ Cherenkov needed from 2 to 4 GeV/c (previously assumed Cherenkov was needed from 2 to 3 GeV/c)  
Hopefully a small design adjustment.

# Purpose

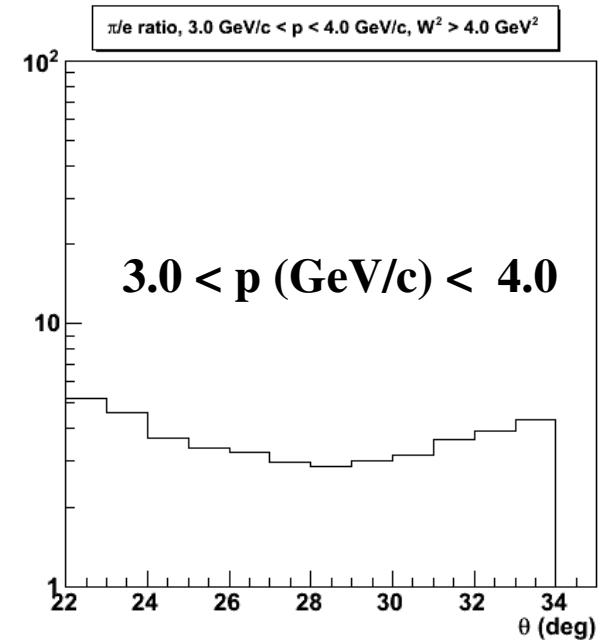
$\pi/e$  ratio as function of the angle (courtesy from Seamus):



- Somewhat shallow dependence on the angle;



Needed rejection rate:  
~100/1.

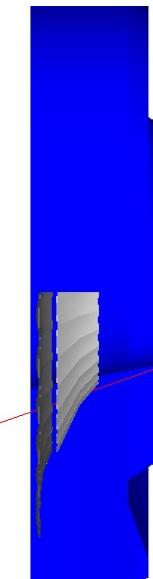


Needed rejection rate:  
~10/1.

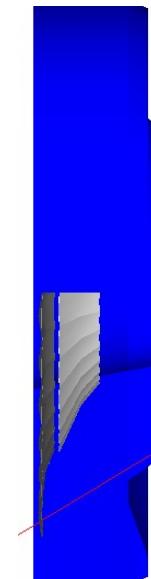
# Design status

- Still using BaBar field map;

- Tank dimensions tweaked;



22 deg,  
+30 cm



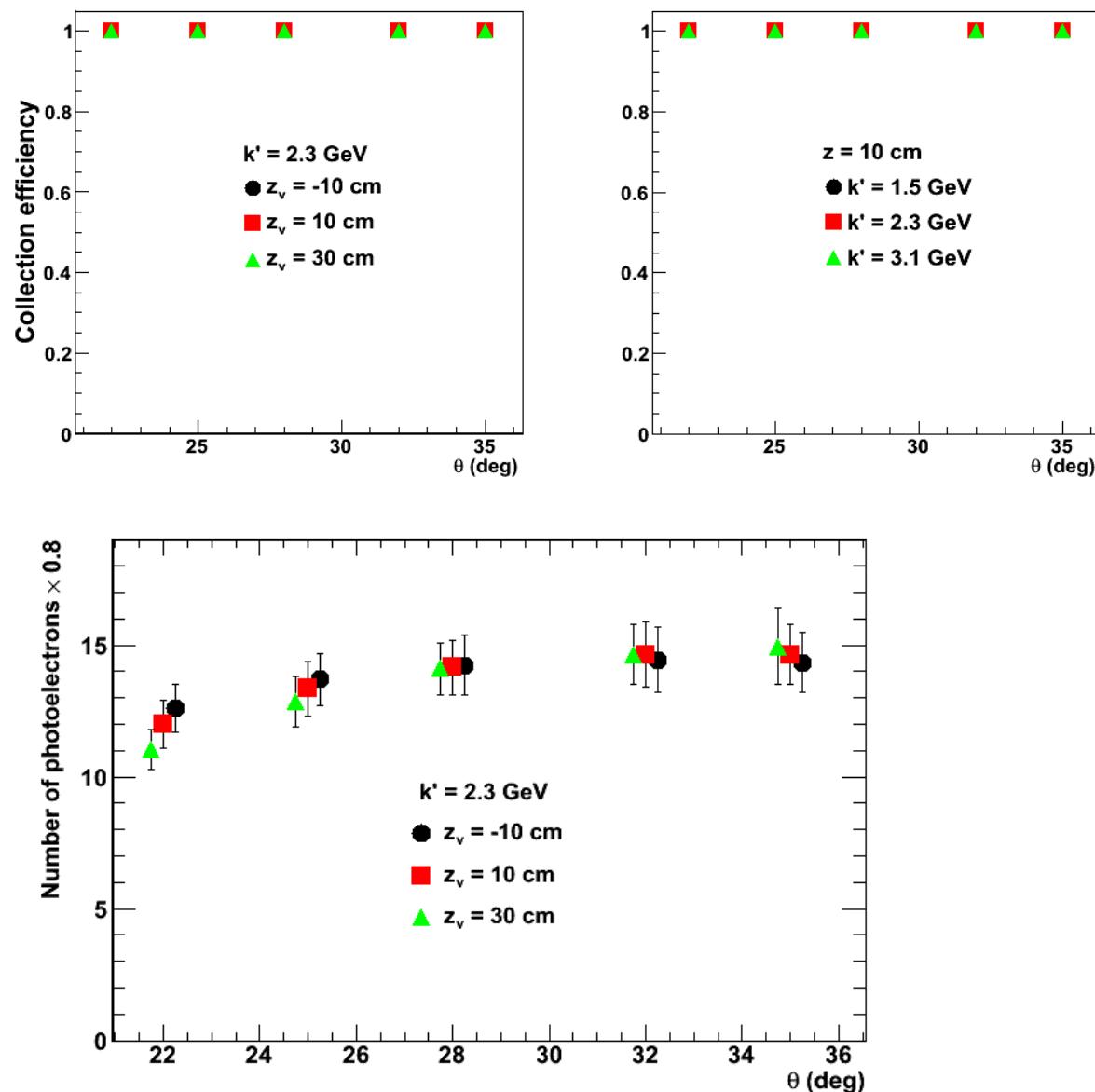
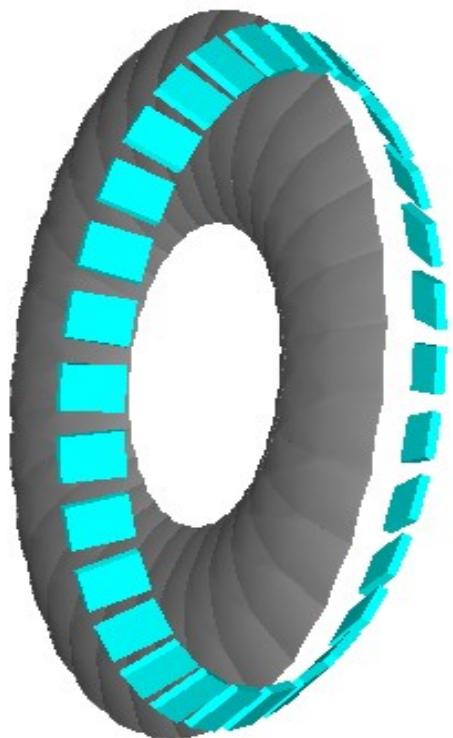
35 deg,  
-10 cm

- For GEM option: no major changes ;

- For PMT option: use a  $\text{C}_4\text{F}_8\text{O}$  (60%) /  $\text{CO}_2$  (40%) gas mixture (to raise pion threshold to 3 GeV) at 1 atm (previously considered pure  $\text{C}_4\text{F}_8\text{O}$  at 0.75 atm...)

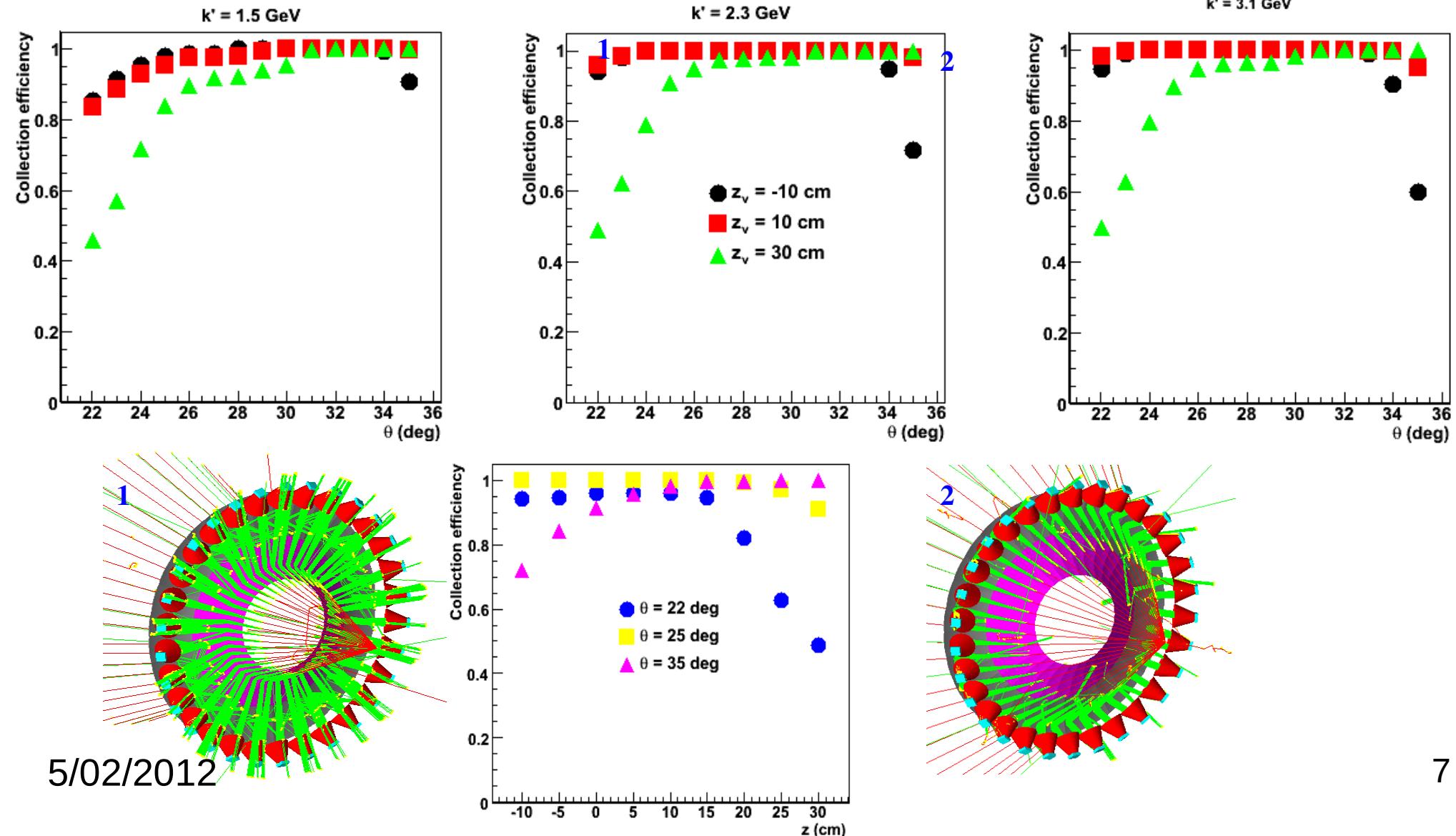
# Performances: GEM option

Performances:



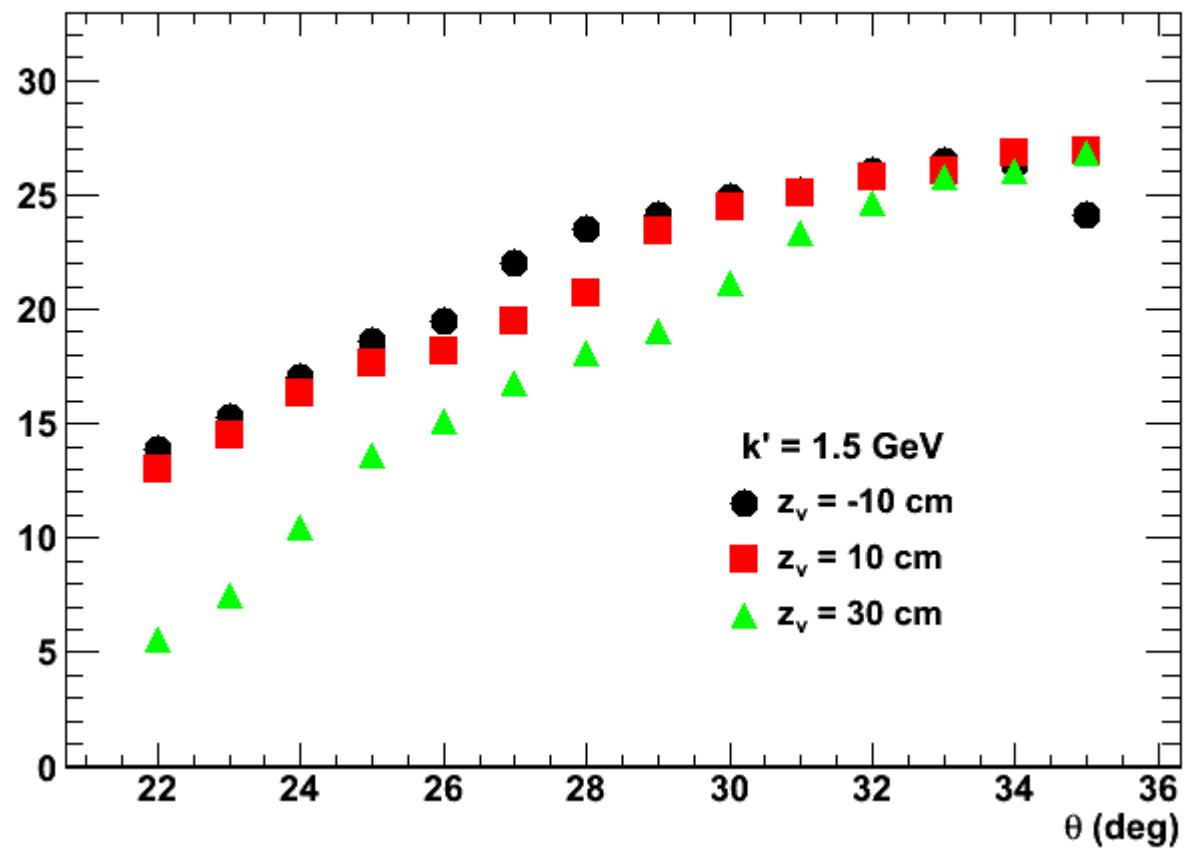
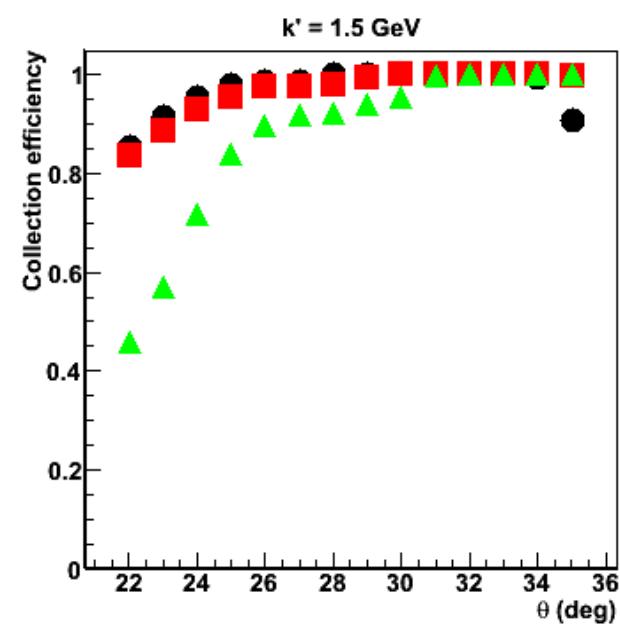
# PMT option

- 3x3 PMT array: performances:



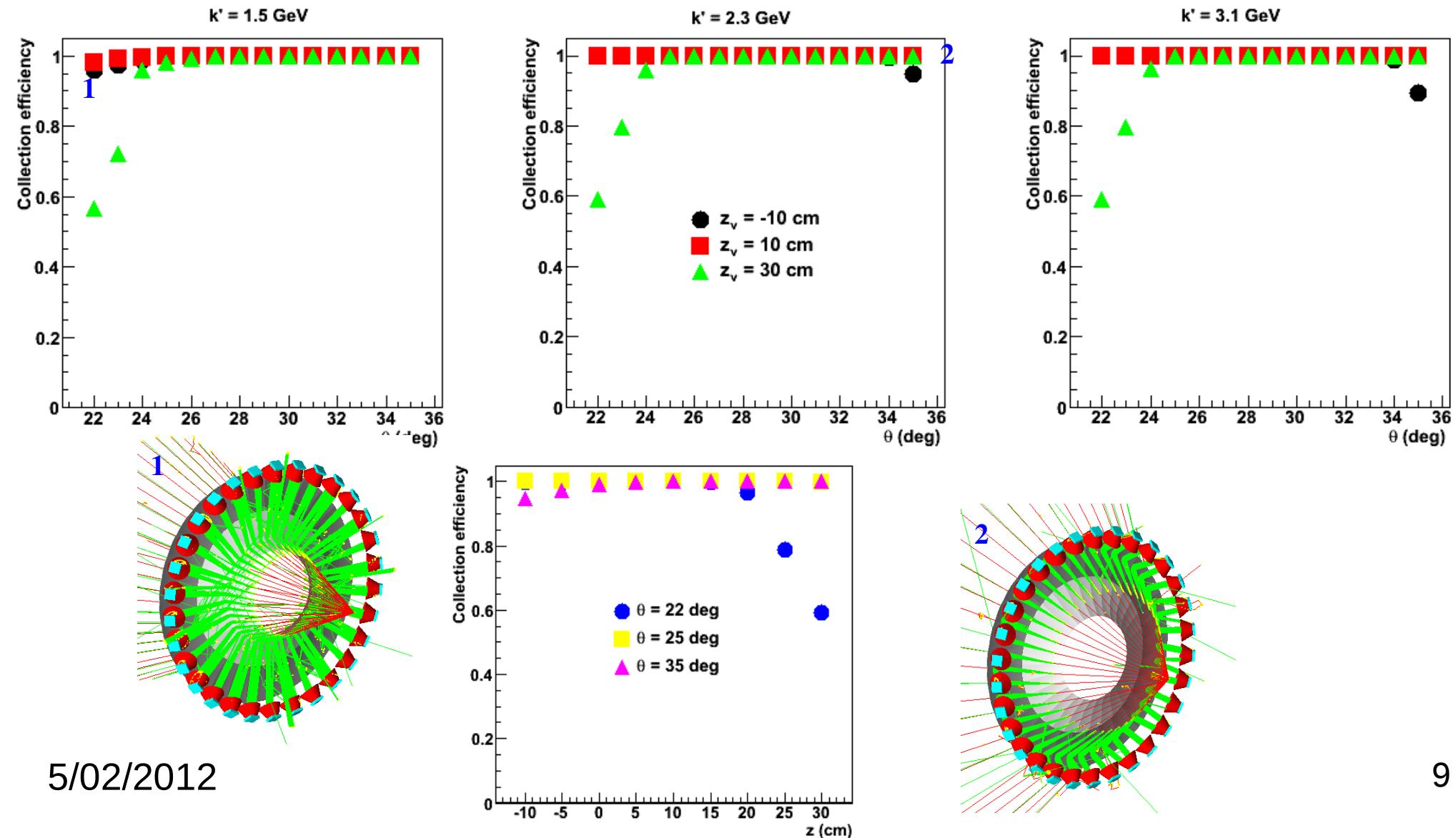
# PMT option

- 3x3 PMT array: performances:



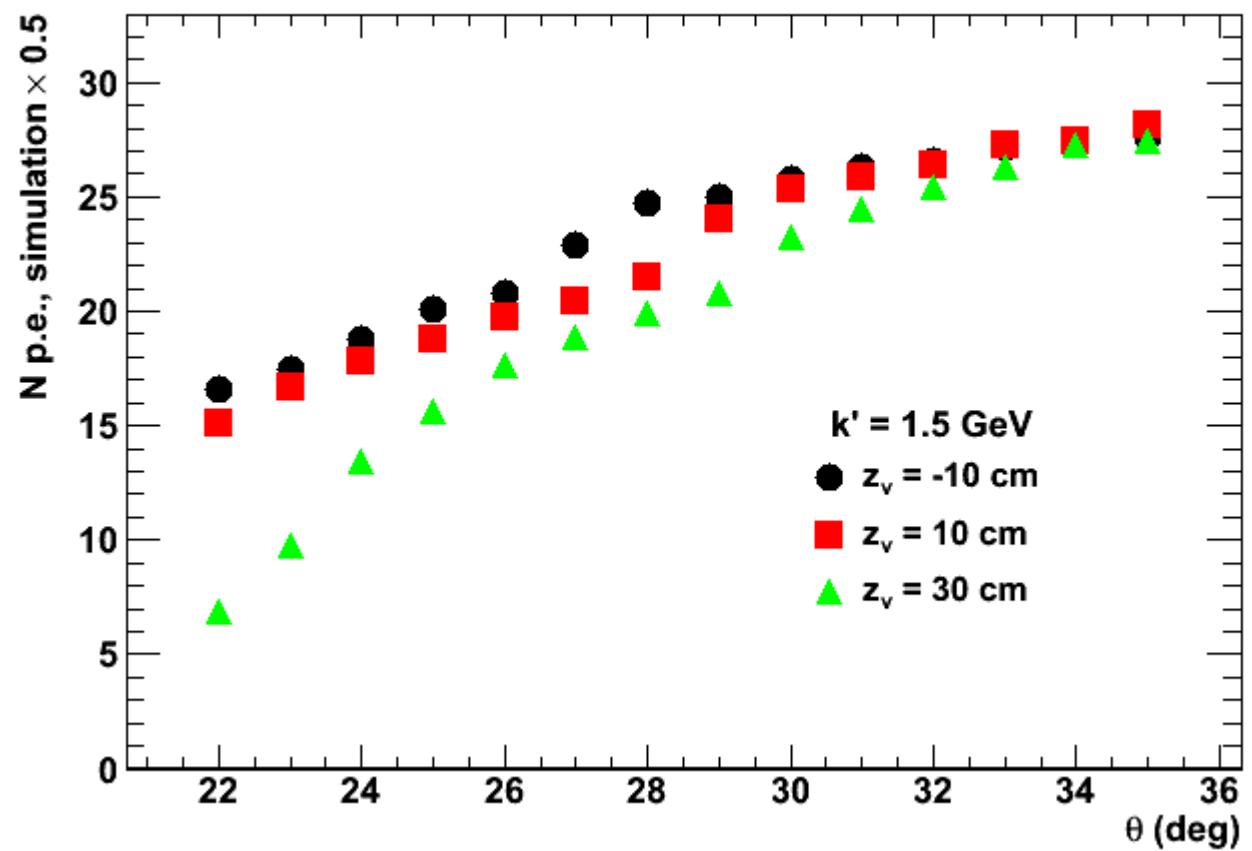
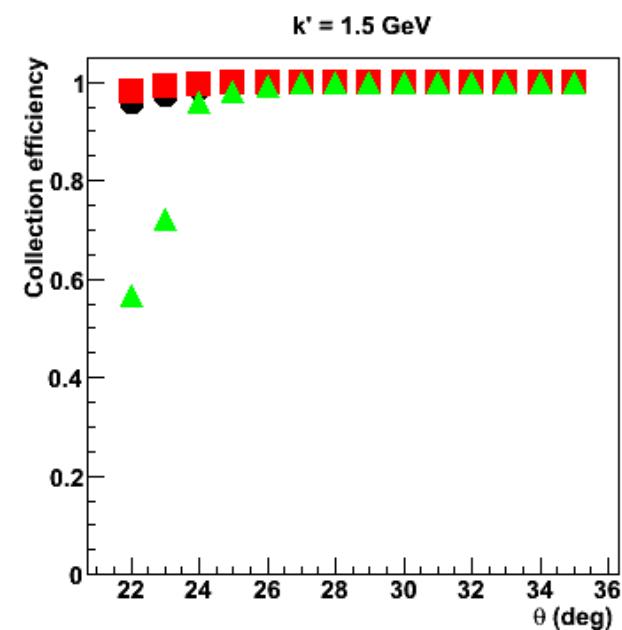
# PMT option

- 4x4 PMT array: performances:



# PMT option

- 4x4 PMT array: performances:

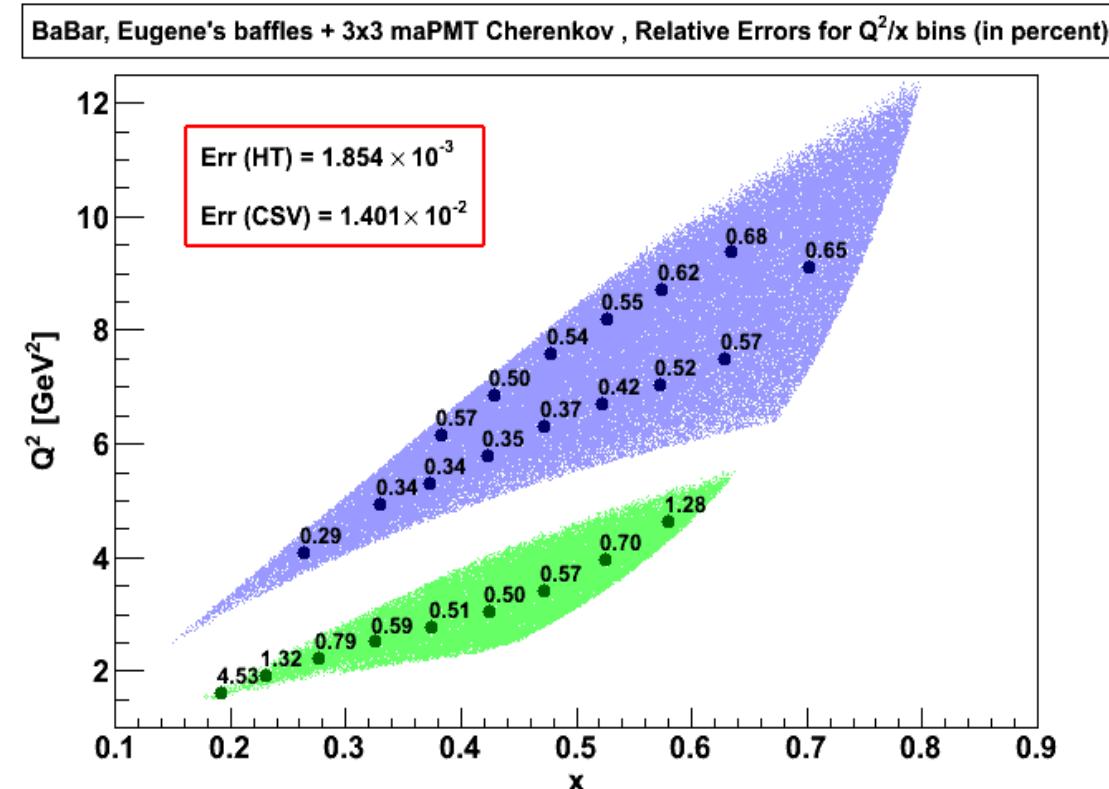


# Figure of Merit

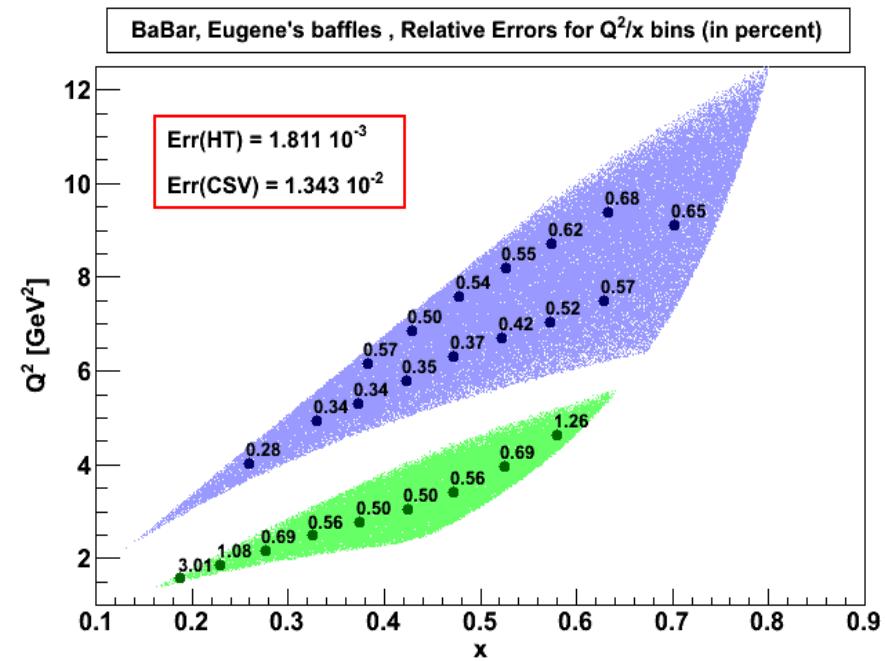
Figure-of-Merit assuming:

- 5 pe threshold (reject 95 % of a 1 p.e signal ~ pions at 3 GeV/c):
- rejection from Cherenkov not needed above 3.0 GeV/c

9 H8500C maPMTs per sector



FOM: Baffles only

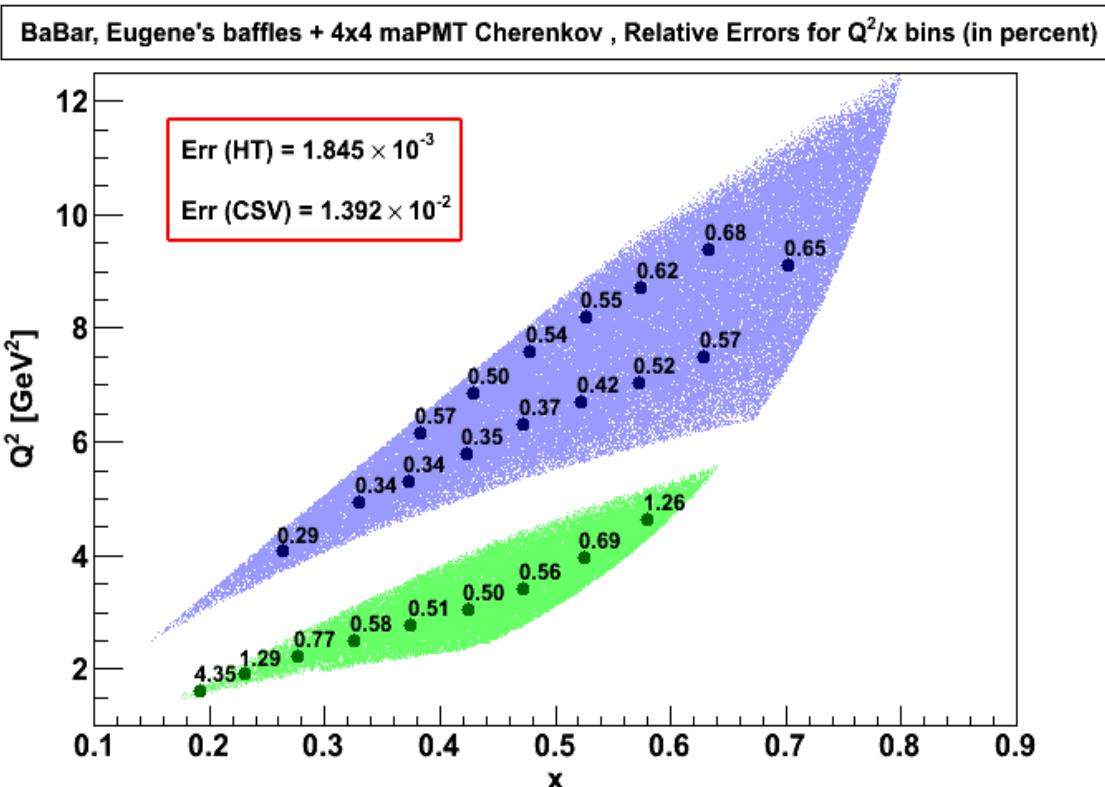


# Figure of Merit

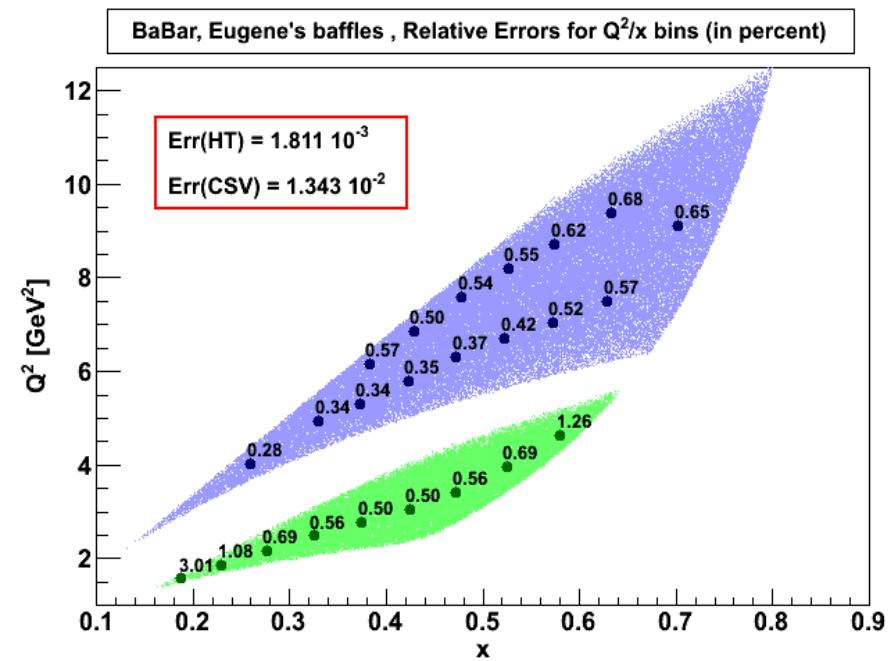
Figure-of-Merit assuming:

- 5 pe threshold (reject 95 % of a 1 p.e signal ~ pions at 3 GeV/c):
- rejection from Cherenkov not needed above 3.0 GeV/c

16 H8500C maPMTs per sector



FOM: Baffles only



# Costs estimation

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- requested and obtained quotes to Rayotek Scientific, Inc. for GEM option mirrors blanks;

|  |   |    |           |           |
|--|---|----|-----------|-----------|
| FABRICATE BACK DETECTOR AND FORWARD DETECTOR MIRRORS PER CUSTOMER DWGS., MADE BY MOLDING 2mm BOROSILICATE SHEET GLASS (SCHOTT BOROFLOAT) |   |    |           |           |
| 1  | FORWARD DETECTOR                            | 32 | 1,350.00  | 43,200.00 |
| 2  | BACK DETECTOR                               | 32 | 1,260.00  | 40,320.00 |
| 3  | NRE, MOLD, & TOOLING (DUE AT TIME OF ORDER) | 1  | 66,500.00 | 66,500.00 |

- also requested quotes to the same company for PMT option mirror blanks (asked separately – did not received yet, but should come soon);

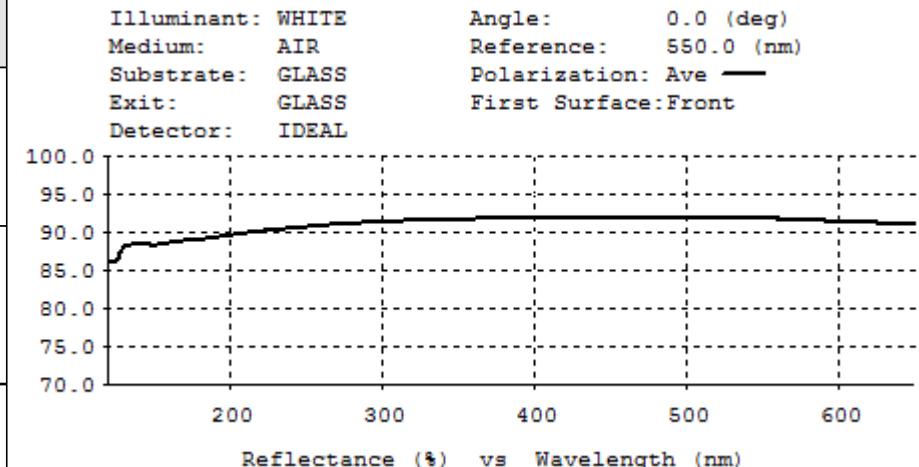
# Costs estimation

- requested a quote for mirror coating to Cascade Optical Co.

| P/N DESCRIPTION  | COATING SPEC  | QTY  | Prep& Setup Per Lot | Lot Charge | DELIVERY Wks           |
|--|---|------|---------------------|------------|------------------------|
| <a href="#"><u>Mirror_BackDetector_Dimensions</u></a><br>40.988" length x 16.9668"<br>C.A. allow within 1" of any edge | Coat one side with protected Al<br>MgF2 10nm of protection<br>Rav >85% 193-650nm<br>A.O.I. = 0° | 1 ea | \$200 ea            | \$700      | First Batch starts 2-3 |
| <a href="#"><u>Mirror_Split_Outer_Dimensions</u></a><br>31.007" length x 18.219"<br>C.A. allow within 1" of any edge   |   | 1 ea | \$150 ea            | \$700      | First Batch starts 2-3 |
| <a href="#"><u>Mirror_Split_Inner_Dimensions</u></a><br>29.7518" length x 12.2666"<br>C.A. allow within 1" of any edge |   | 1 ea | \$150 ea            | \$700      | First Batch starts 2-3 |

Our spectrophotometer is only capable of measuring down to 193nm  
Delivery time for all 32 units for each mirror T.B.D.

Theoretical Curve for 10nm of MgF2 over Al Actual coating may vary..Test run will be performed prior to mirror deposition. A reduction in MgF2 thickness may be necessary



Predicted performance

Costs: total \$ 18100

- we may want to look a little bit more into it...

# TODO

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- Design adjustments to extend the useful momentum range of the Cherenkov (hopefully no *major* changes);
- Completing the costs estimation.

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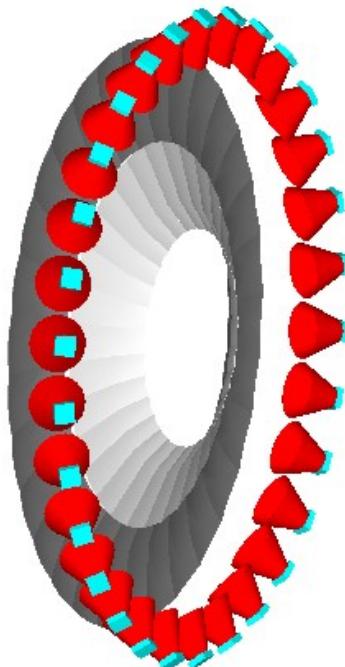
# **Back-up**

# Design status

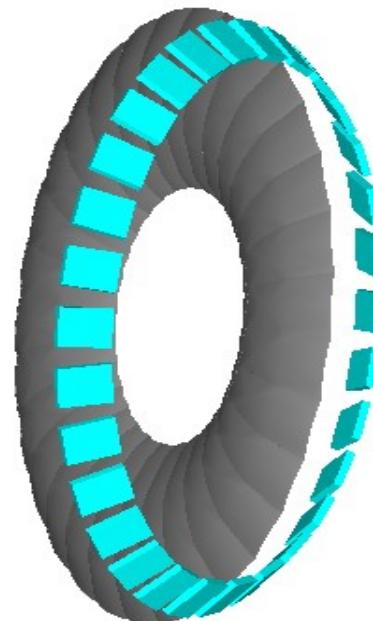
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- Still using BaBar field map;
- Basic layout:  $2\pi$  coverage, divided in 30 sectors, each with one observer, and one mirror;
- two options for observer: array of maPMT H8500C (hamamatsu) with straight cones, **or** CsI coated GEM option;

maPMT  
option



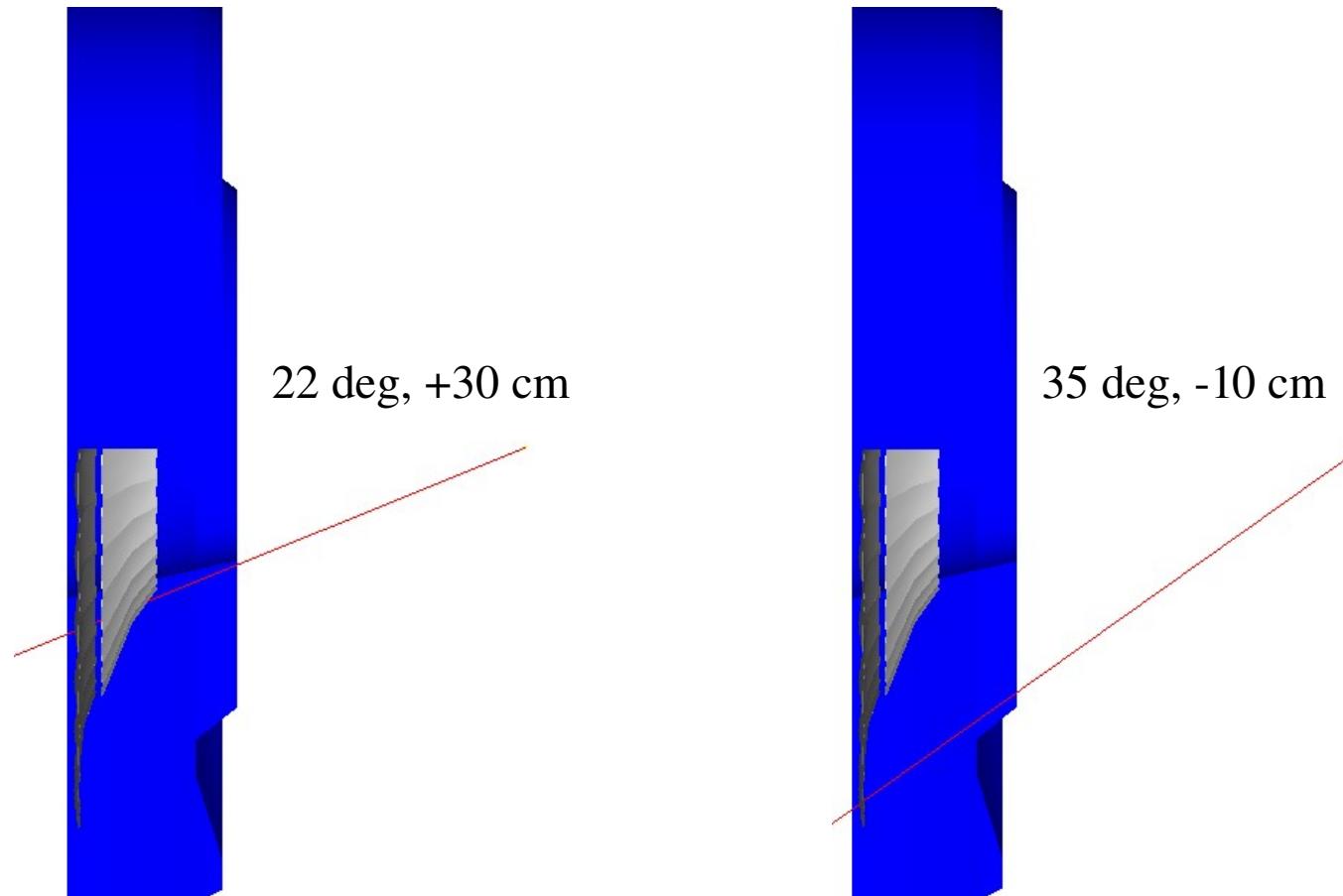
GEM option



# Design status

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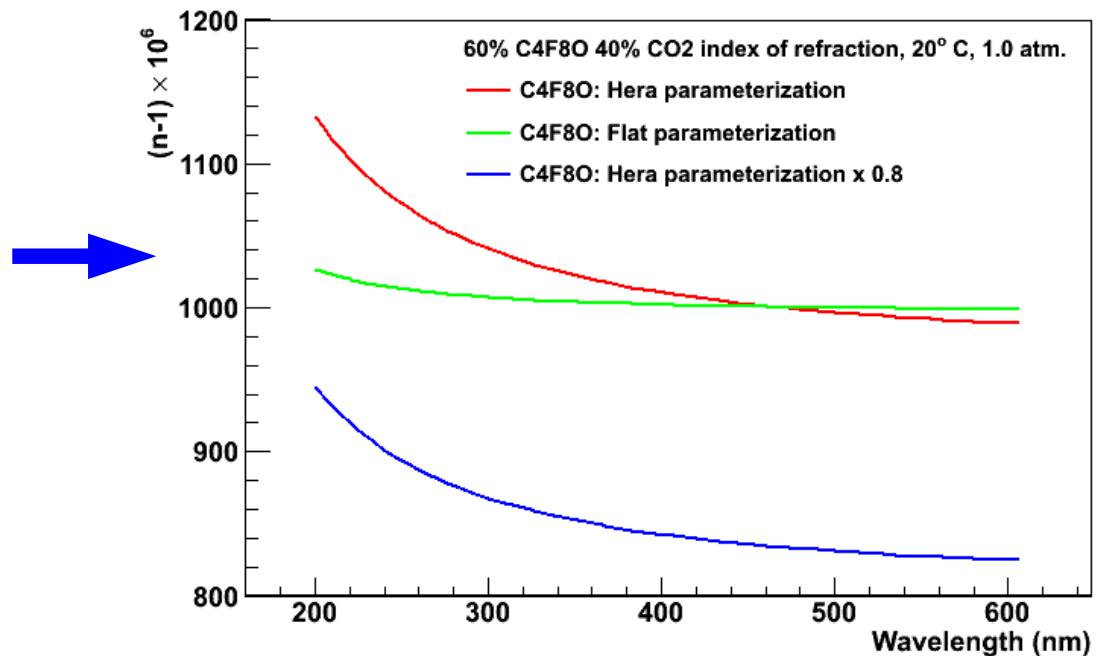
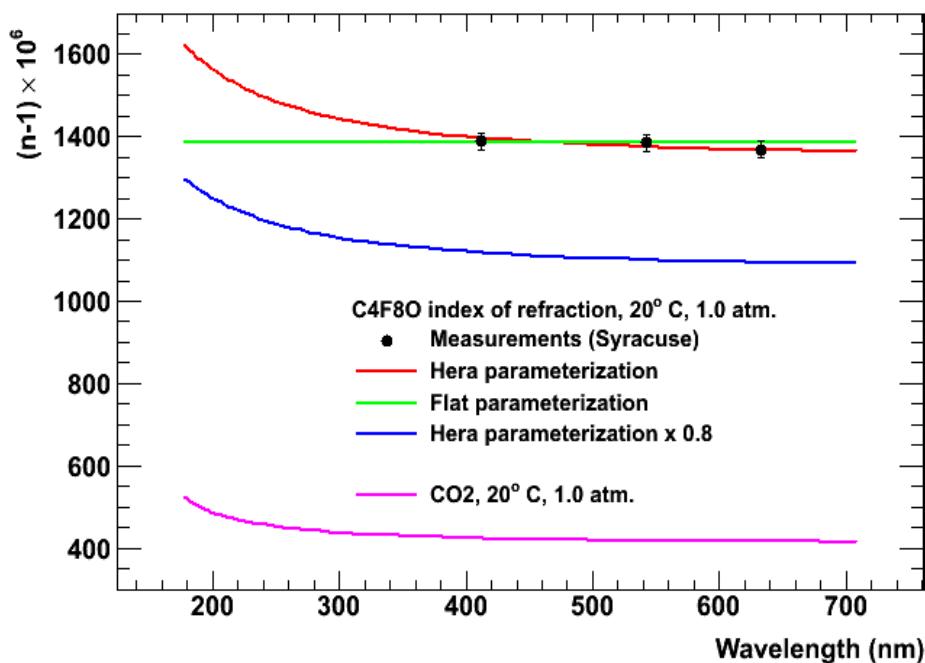
- Tank dimensions tweaked;



# Design status

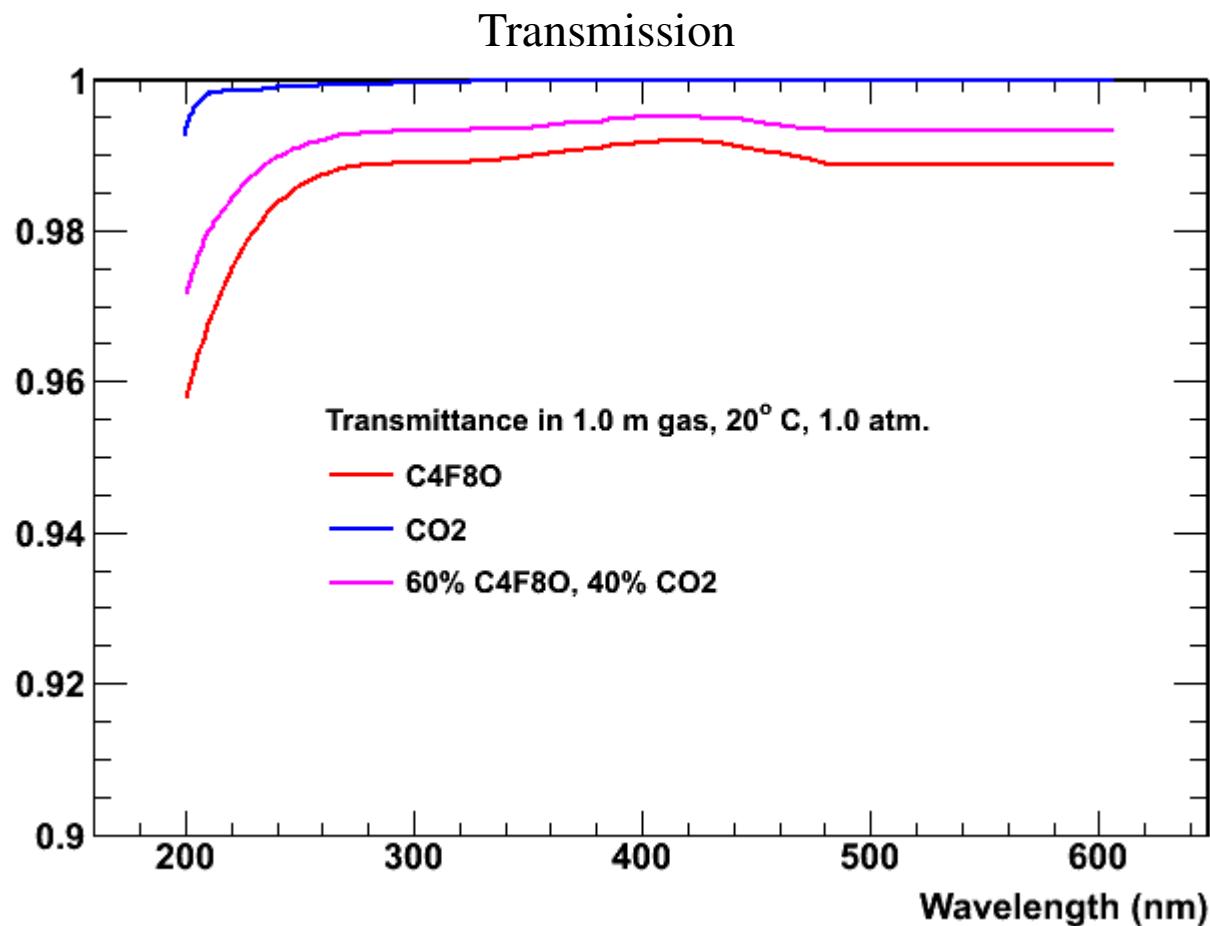
- PMT: use a  $\text{C}_4\text{F}_8\text{O}$  (60%) /  $\text{CO}_2$  (40%) gas mixture (to raise pion threshold to 3 GeV) at 1 atm (previously considered pure  $\text{C}_4\text{F}_8\text{O}$  at 0.75 atm...).

Index of refraction

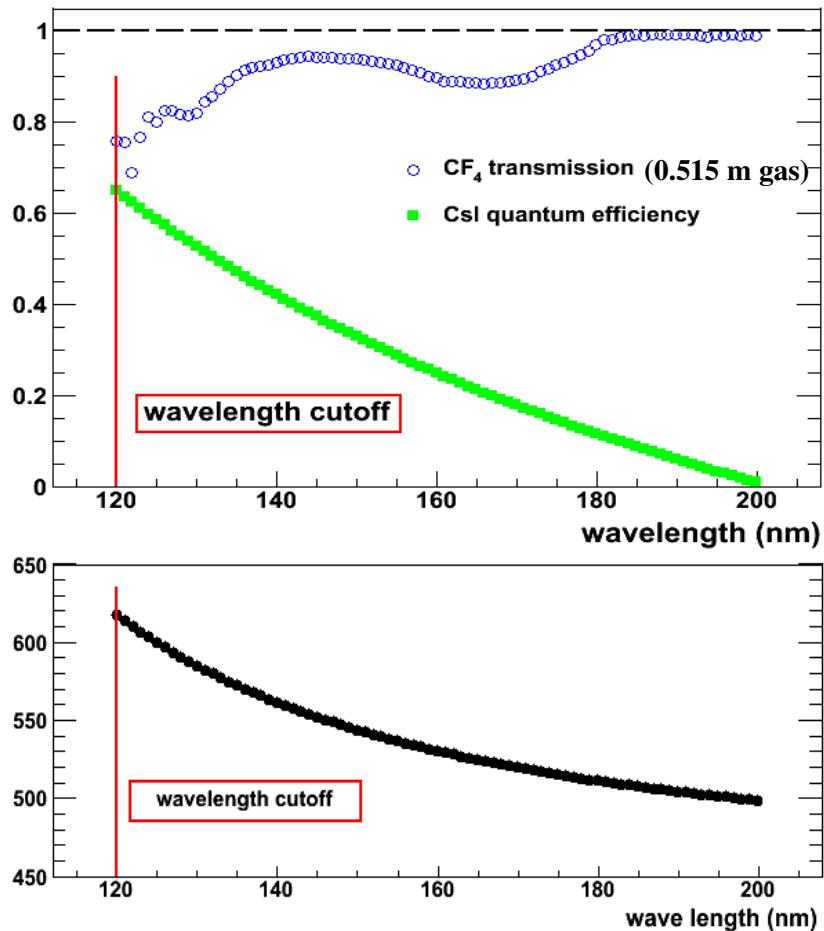


# Design status

- PMT: use a  $\text{C}_4\text{F}_8\text{O}$  (60%) /  $\text{CO}_2$  (40%) gas mixture (to raise pion threshold to 3 GeV) at 1 atm (previously considered pure  $\text{C}_4\text{F}_8\text{O}$  at 0.75 atm...).



# Detector design: Performances for GEM option



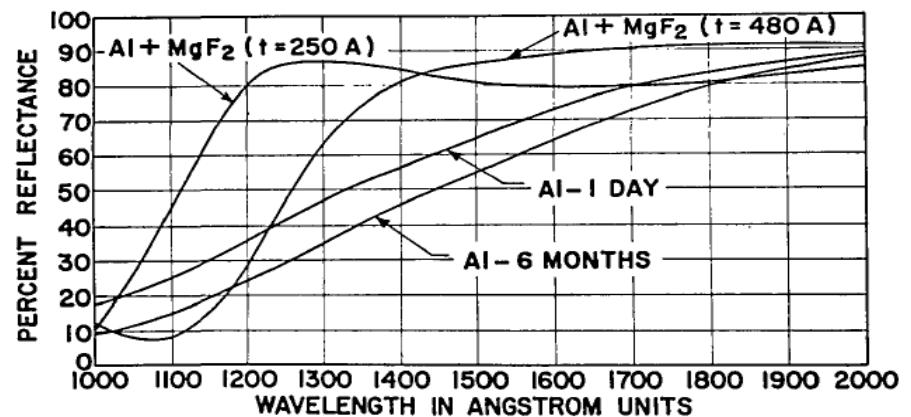
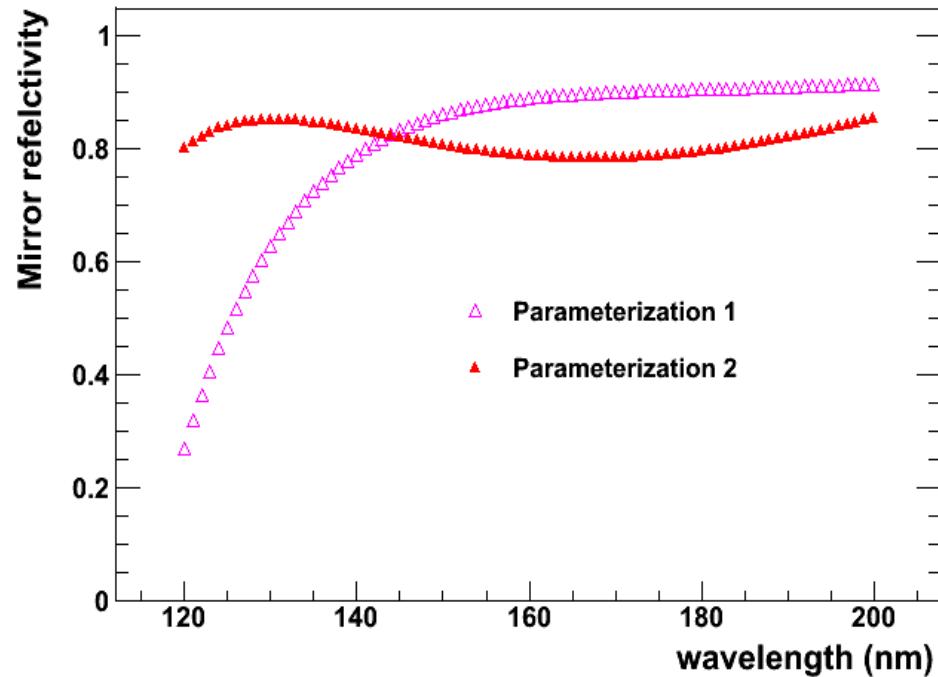
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|                                      |       |
|--------------------------------------|-------|
| Optical transparency of mesh         | 88.5% |
| Optical transparency of photocathode | 81%   |
| Radiator gas transparency            | 89%   |
| Transport efficiency                 | 80%   |
| Reverse bias and pad threshold       | 90%   |
| Total                                | 51%   |

A red arrow points from the "Total" row down to the text "Implemented better in G4".

Implemented better in G4.

# Detector design: Performances for GEM option

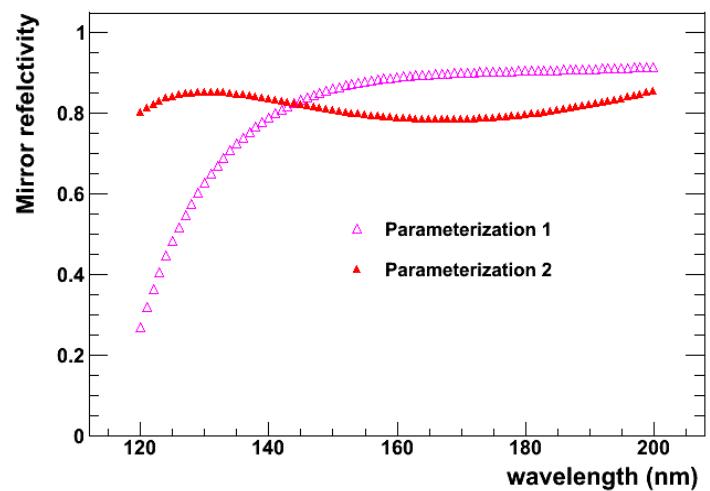
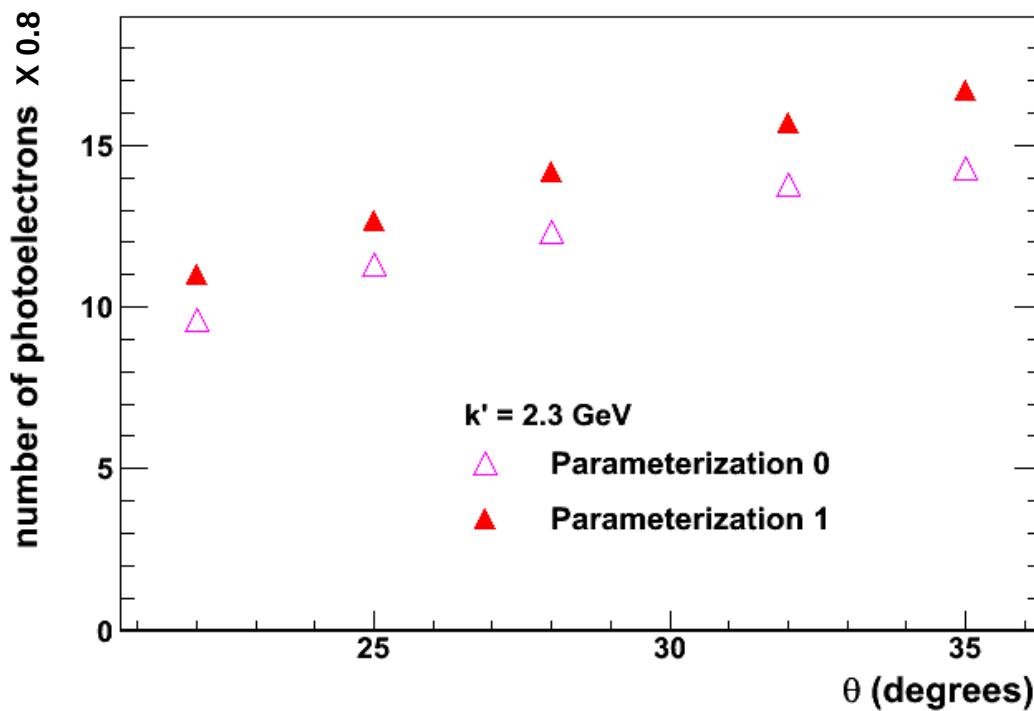


Need a systematic study of the photoelectron yield wrt the mirror reflectivity

# Detector design: Performances for GEM option

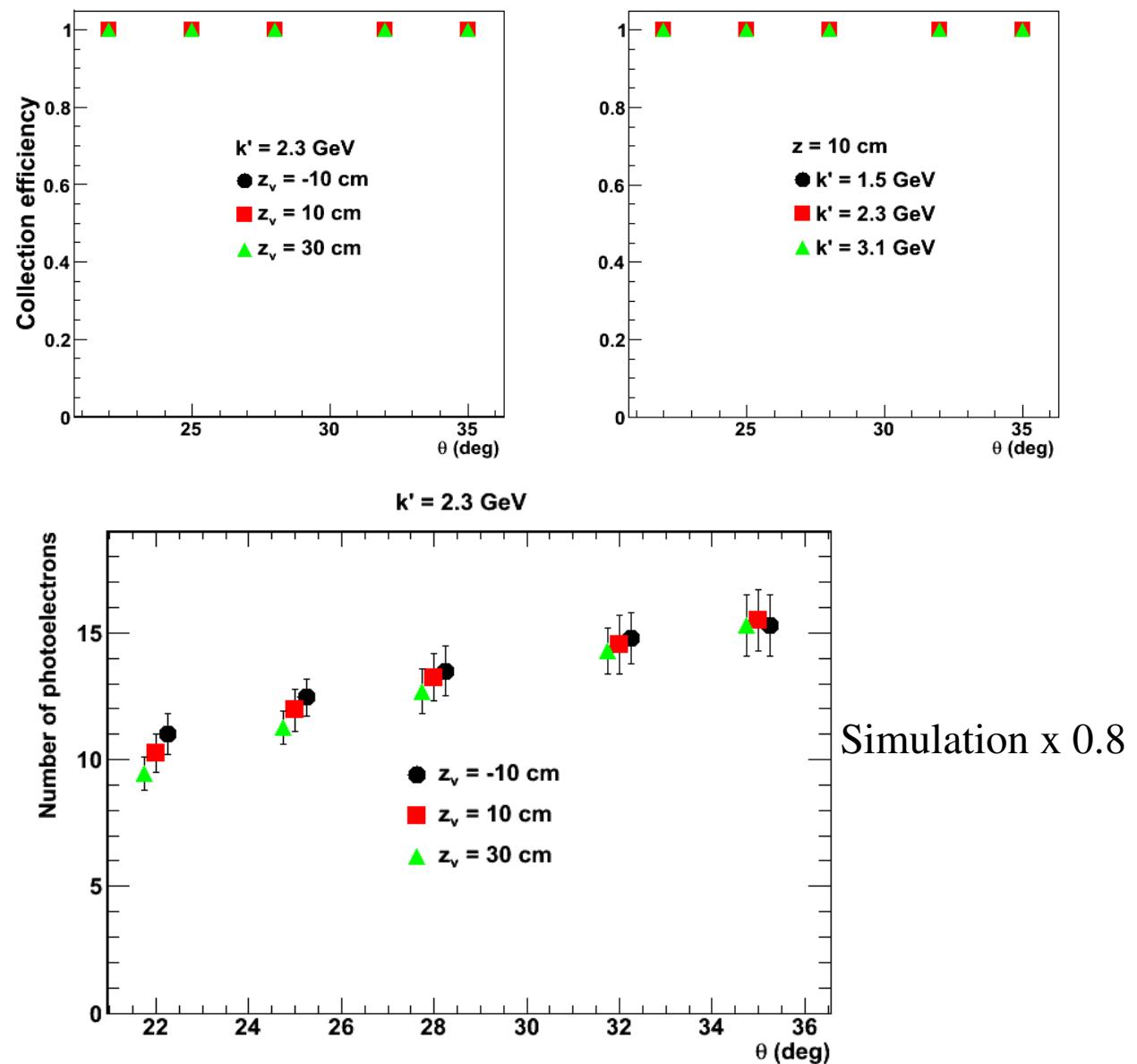
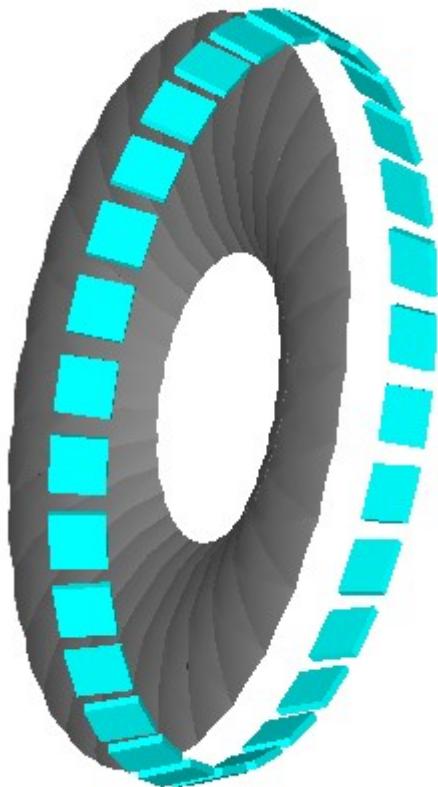
15 % discrepancy between both:

Number of photoelectrons will be taken as the average, and the error as half the discrepancy between the p.e. yield for each parameterization

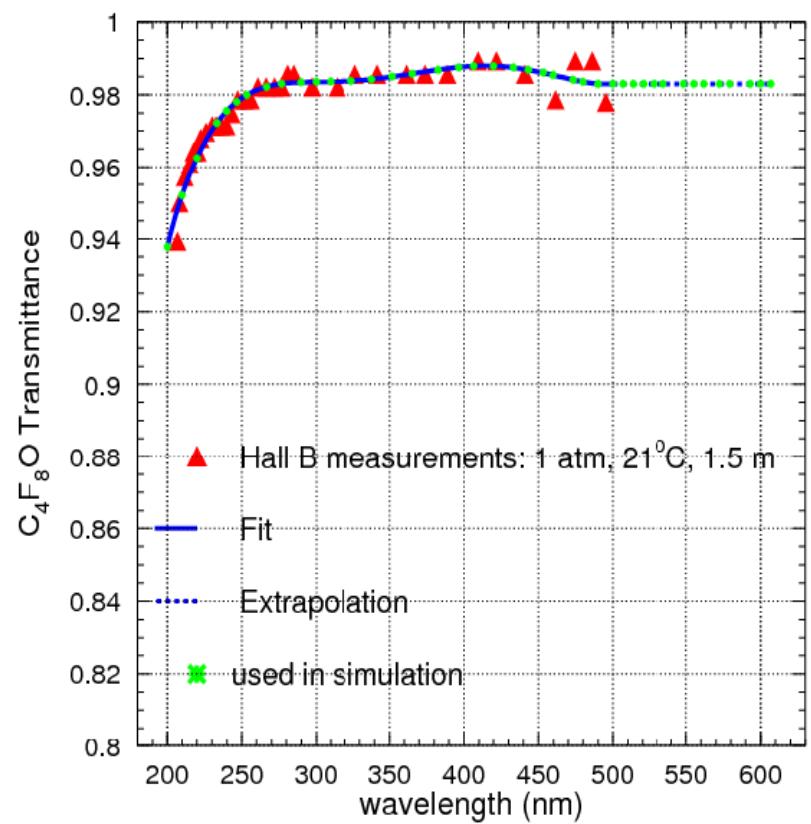
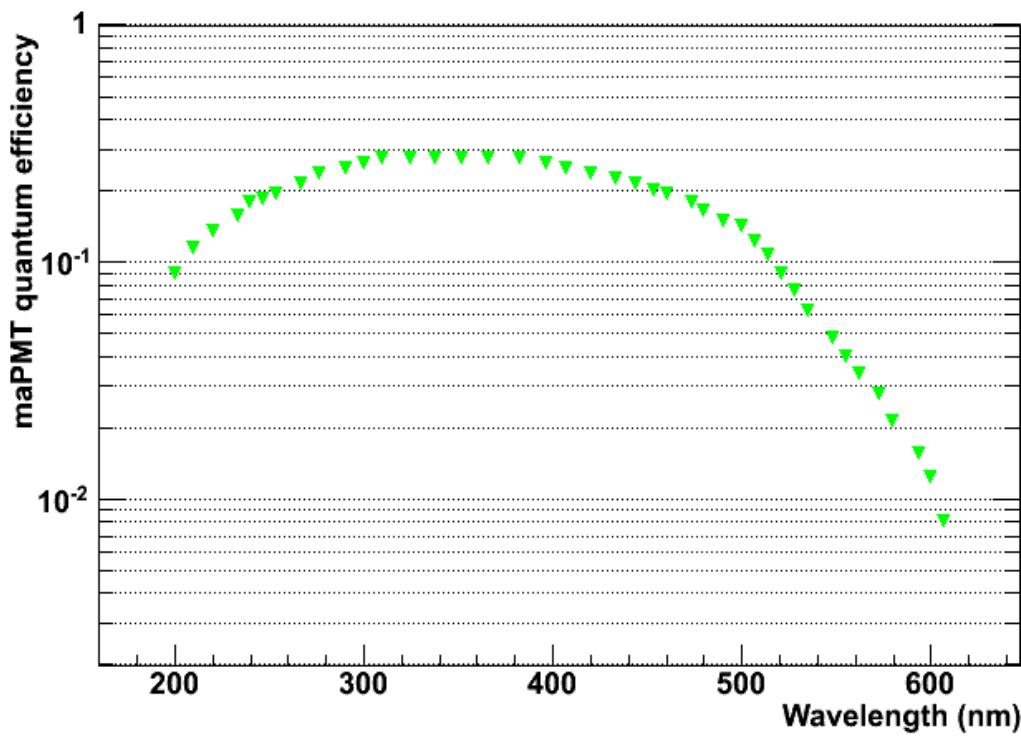


# Performances: GEM option

Performances:



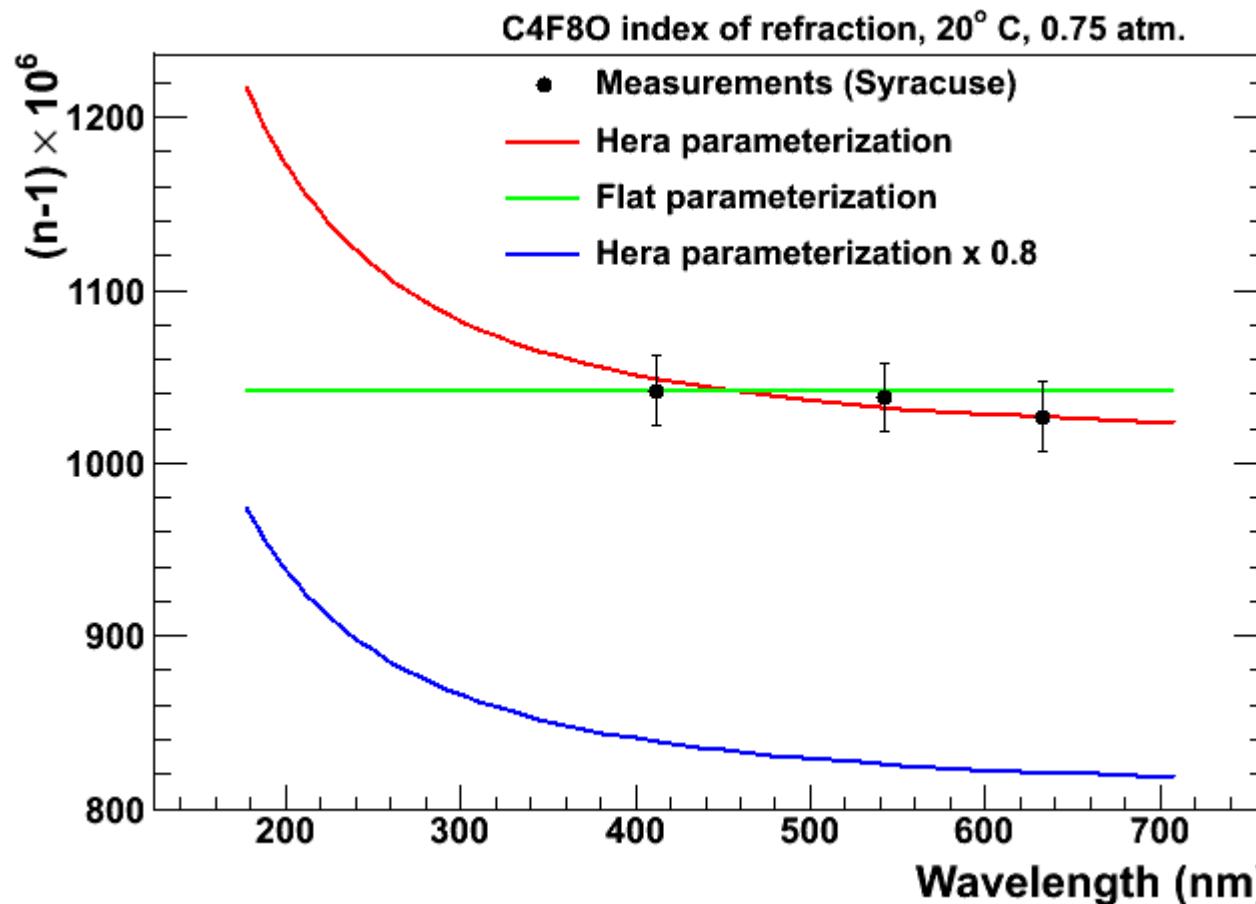
# Detector design: Simulation for PMT option



# Detector design: Simulation for PMT option

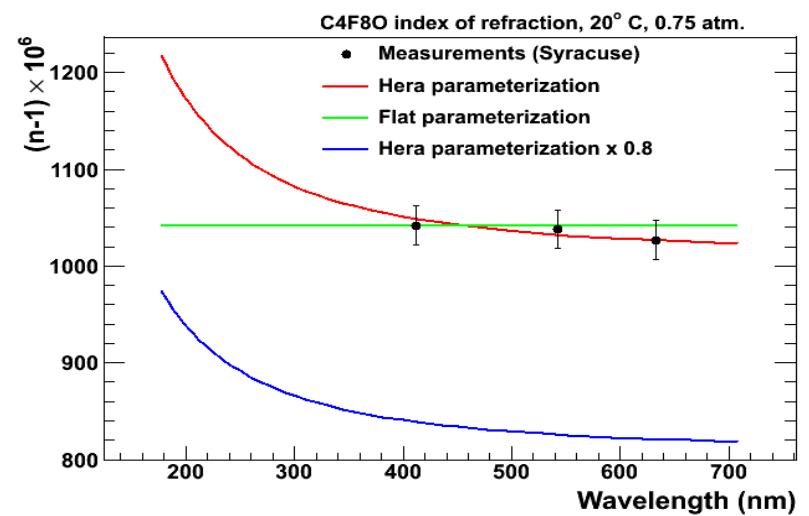
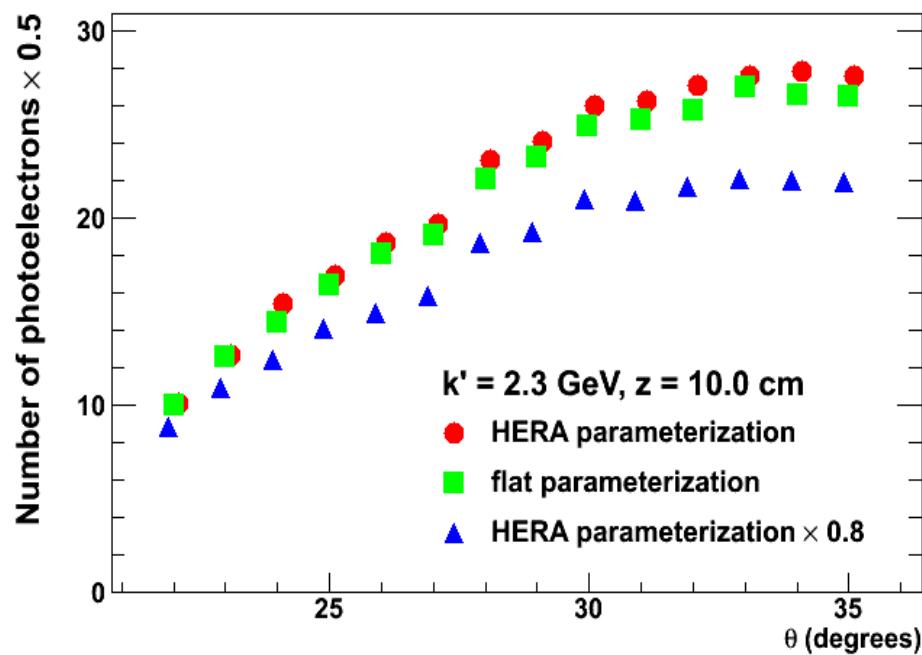
Simulation details :

Refraction index for C<sub>4</sub>F<sub>8</sub>O: very few measurement, in the visible, from Syracuse => extrapolated in UV using HERA parameterization for C<sub>4</sub>F<sub>10</sub>



# Detector design: Performances for PMT option

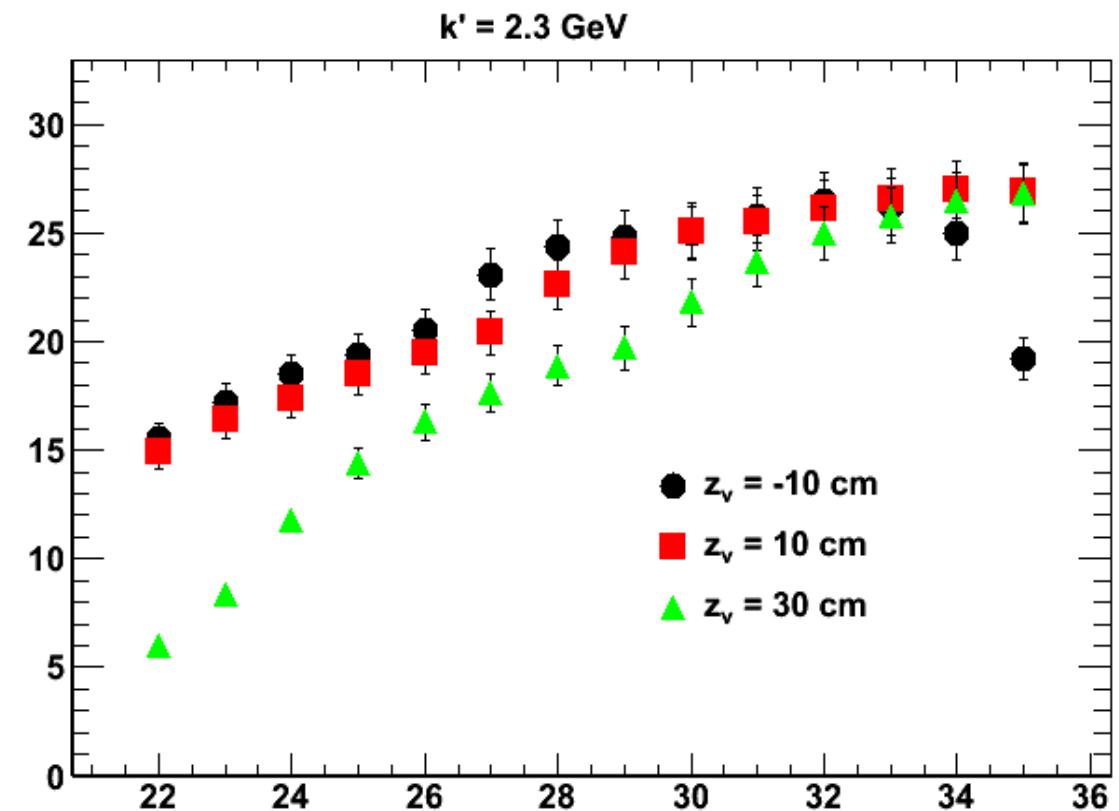
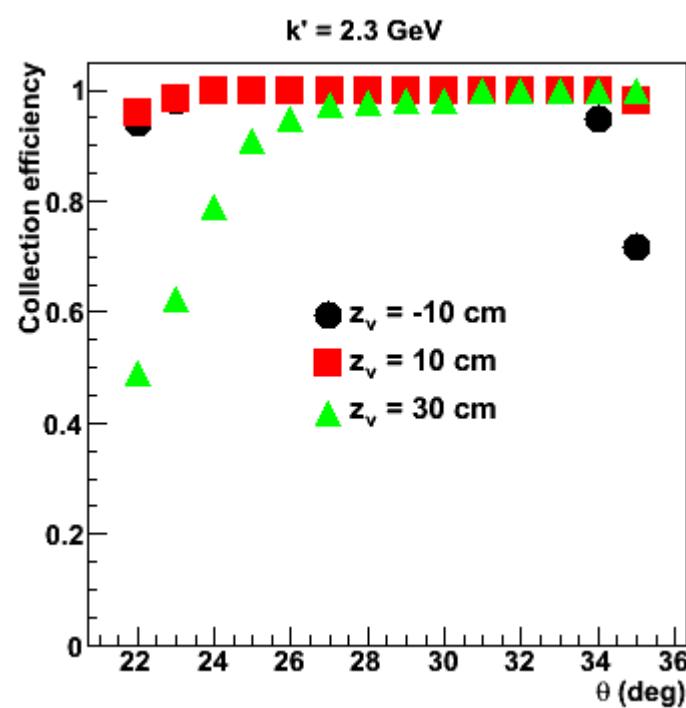
Number of photoelectrons: Systematic study with the gas refraction index:



HERA/flat parameterization: up to 5 % discrepancy      => error on p.e. yield

HERA/(HERAx0.8) parameterization: up to 20%

- 3x3 PMT array: performances:



- 4x4 PMT array: performances:

