Cherenkov detector for PVDIS

SoLID Collaboration Meeting

October, 14, 2011

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Outline

- Status of the detector design:
  - -> with PMTs option
  - -> with CsI coated GEMs option

- Detector costs estimation

- Plan for GEM test in Hall A

- Summary and prospectives

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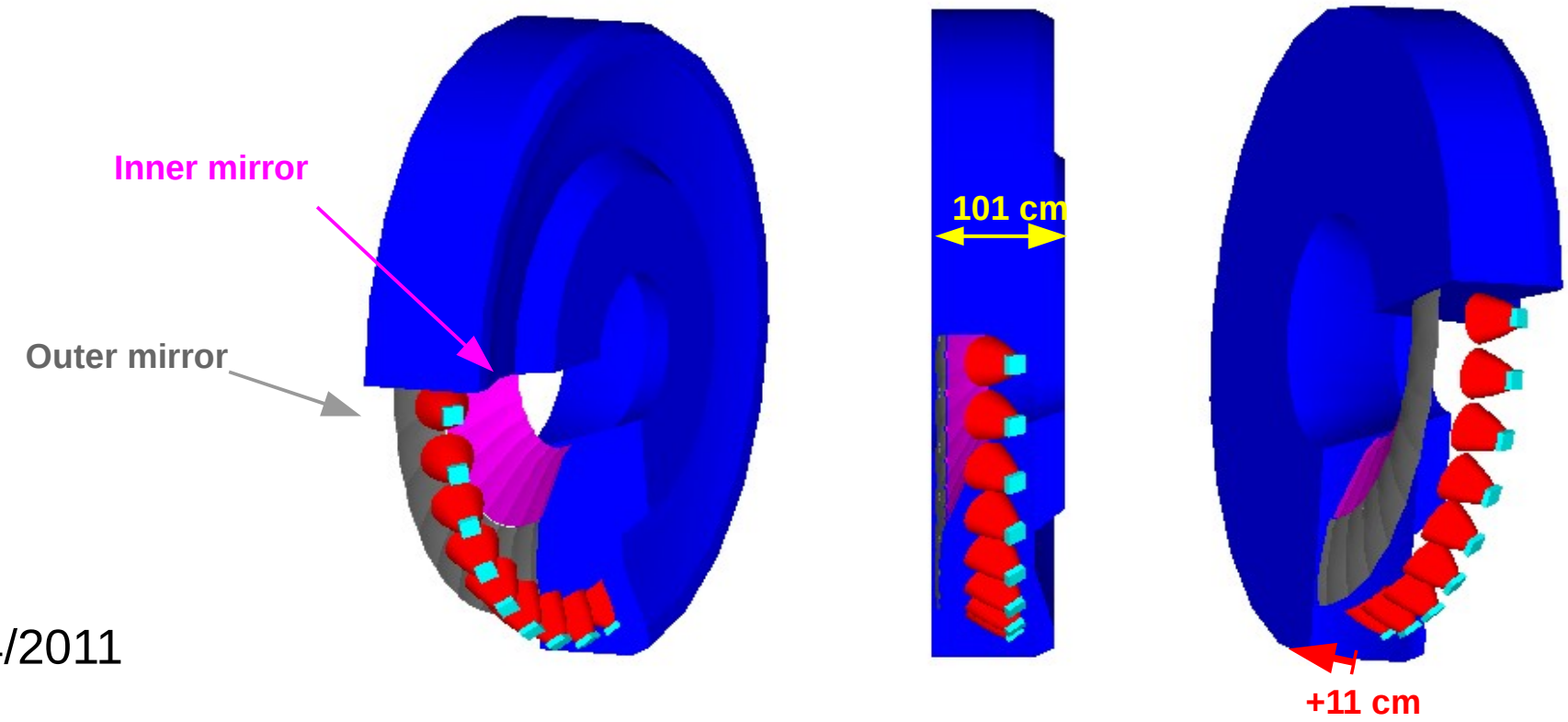
Status of the design: basic design

Changes on the basic design from the last collaboration meeting:

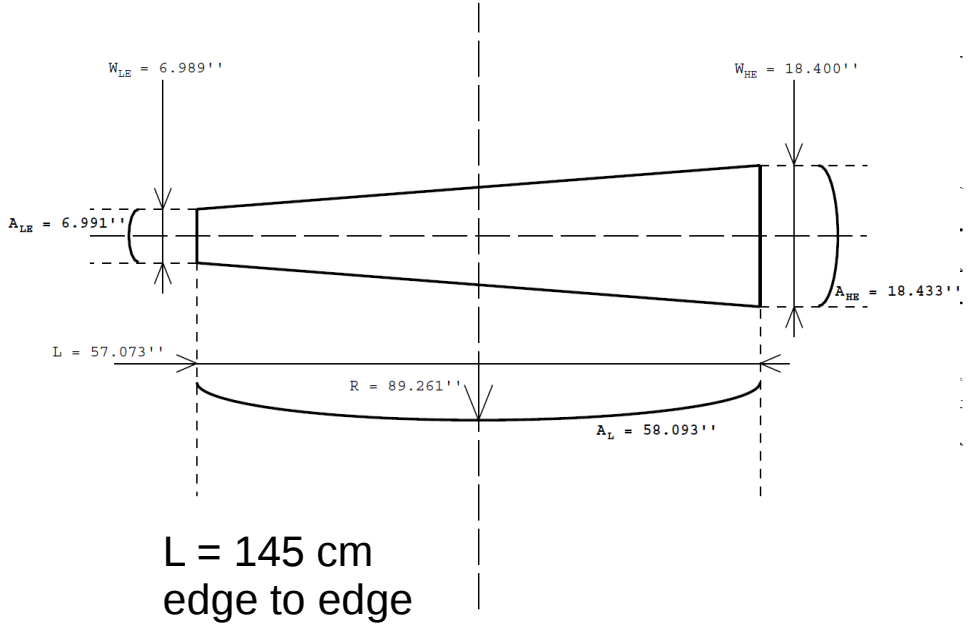
- The tank length for PVDIS Cherenkov has been extended by 11 cm downstream the target compared to the proposal (101 cm instead of 90)
- Mirrors will be split in two:



Status of the design: details about mirrors

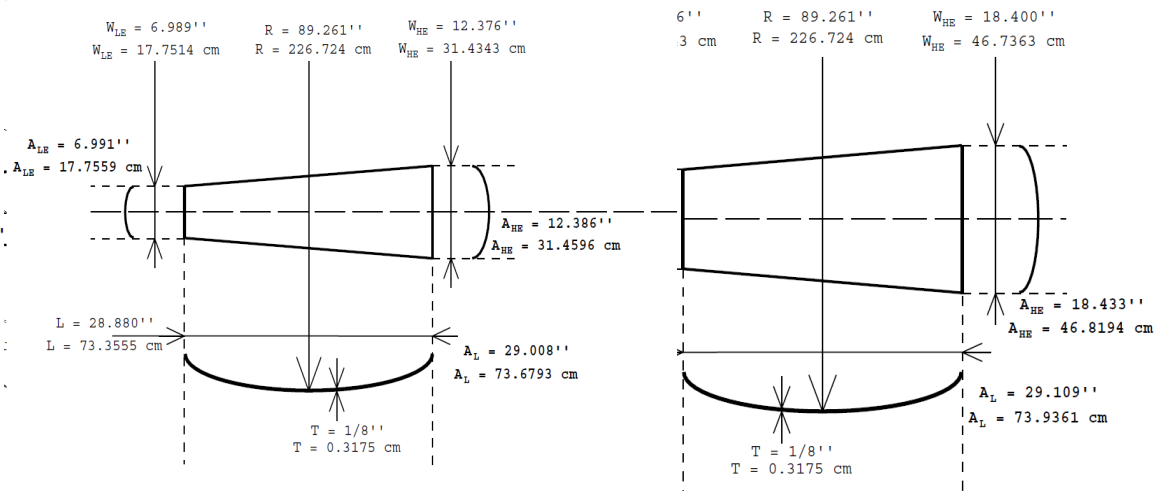
Mirrors split in two: constraint given by the glass substrate manufacturer AND the mirror evaporator from CERN (diameter 90 cm)

First design sent to the glass manufacturer for a quote request and to the mirror coating expert at CERN



L = 145 cm
edge to edge

Second design sent to the glass manufacturer for a quote request and to the mirror coating expert at CERN
=> NOT final design , but close to...



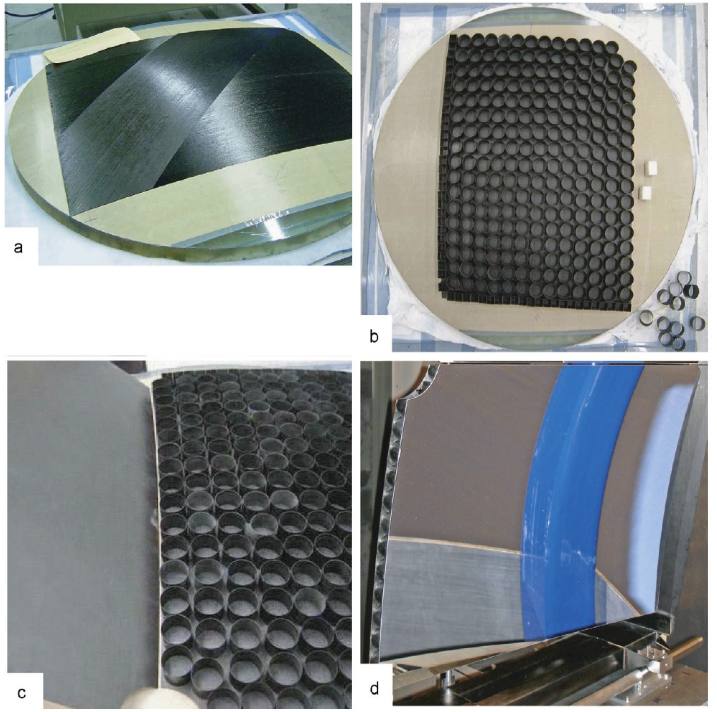
L < 75 cm
edge to edge

Status of the design: details about mirrors

Mirrors split in two:

- "Challenge" to hold them in a stable configuration... two choices: Go for lightweight mirrors such as LHCb RICH1 mirrors (request for a quote has not been done yet) OR sacrifice some phase space if first option price is prohibitive.

- Advantage: we can use two different mirror curvatures for improved detector performances at a reduced price, at least if PMTs are used for light detection.



Pics from NIMA 593 pp 624-637 (2008)
Company: Composite Mirrors Applications

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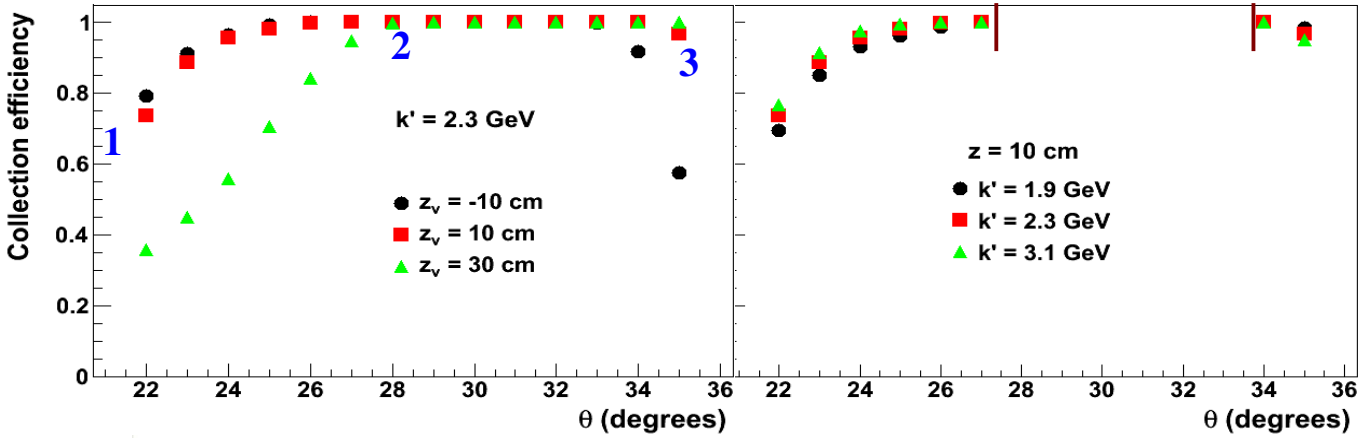
Detector design: Performances for PMT option

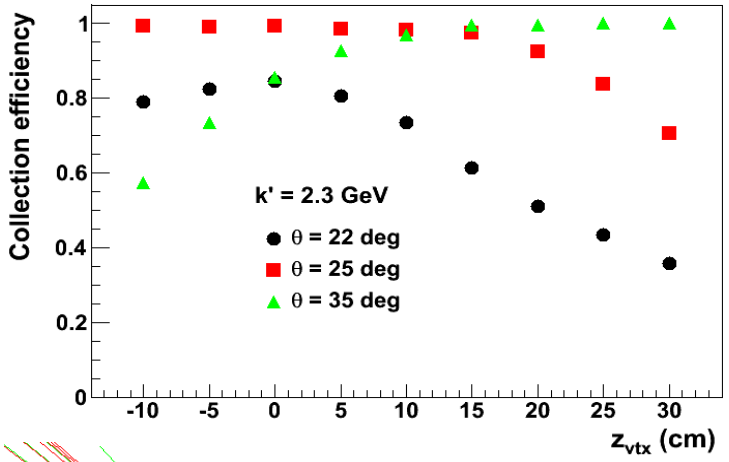
Limitations due to the wide kinematic range and the constraints on the PMT position

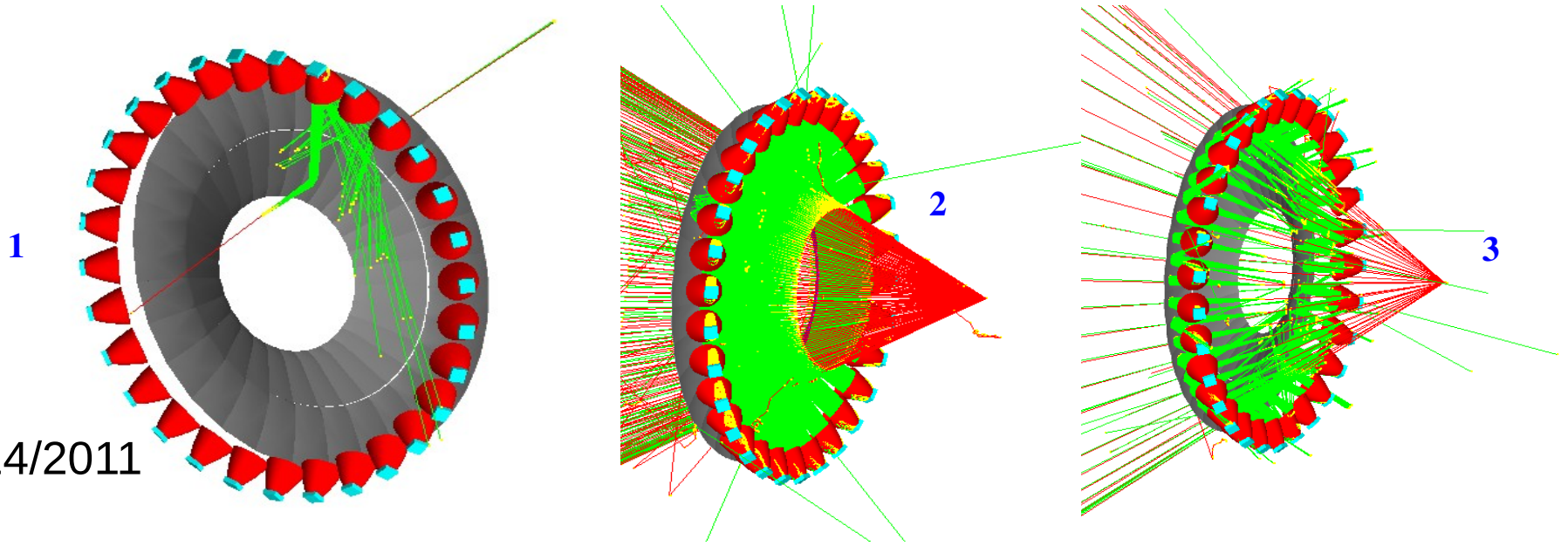
Collection efficiency: 9 H8500C MaPMTs per sector

100% efficiency
No discrepancy

Without mirror splitting, 16 such PMTs were necessary to achieve similar performances



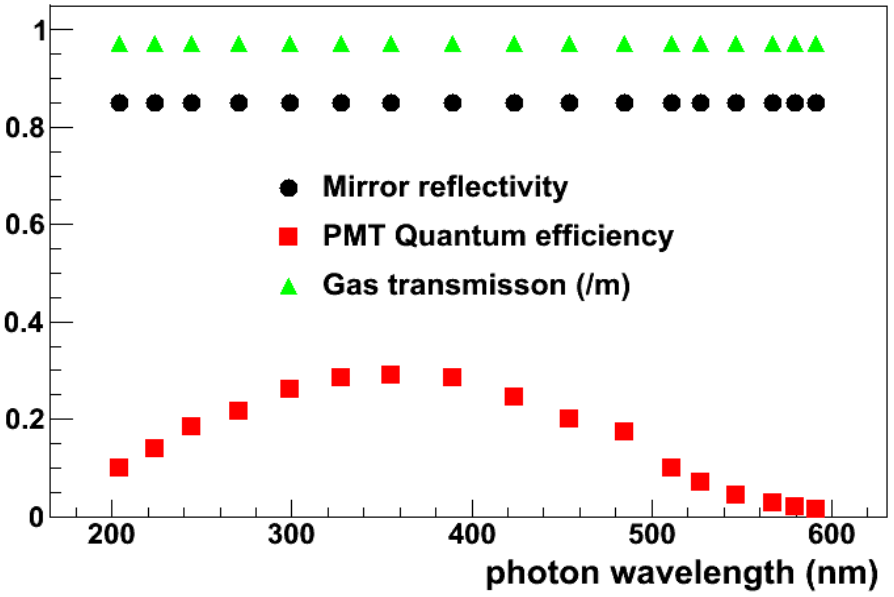


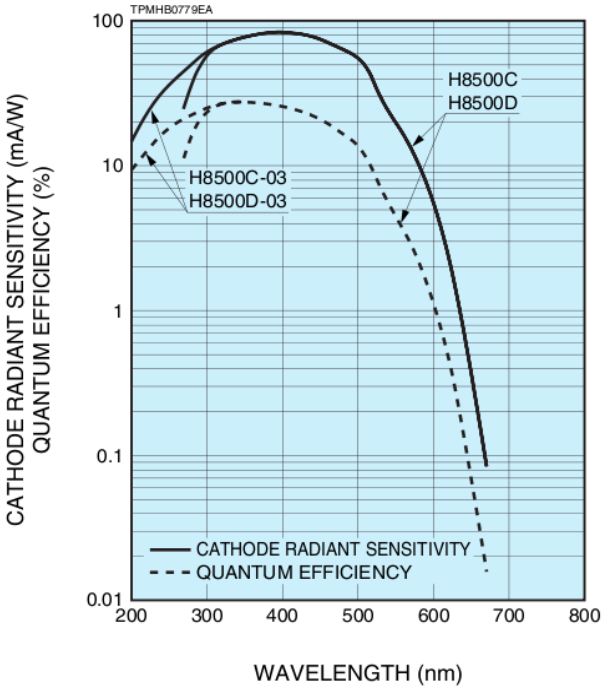


Detector design: Performances for PMT option

Number of photoelectrons: Simulation details (more details in Simona's talk):

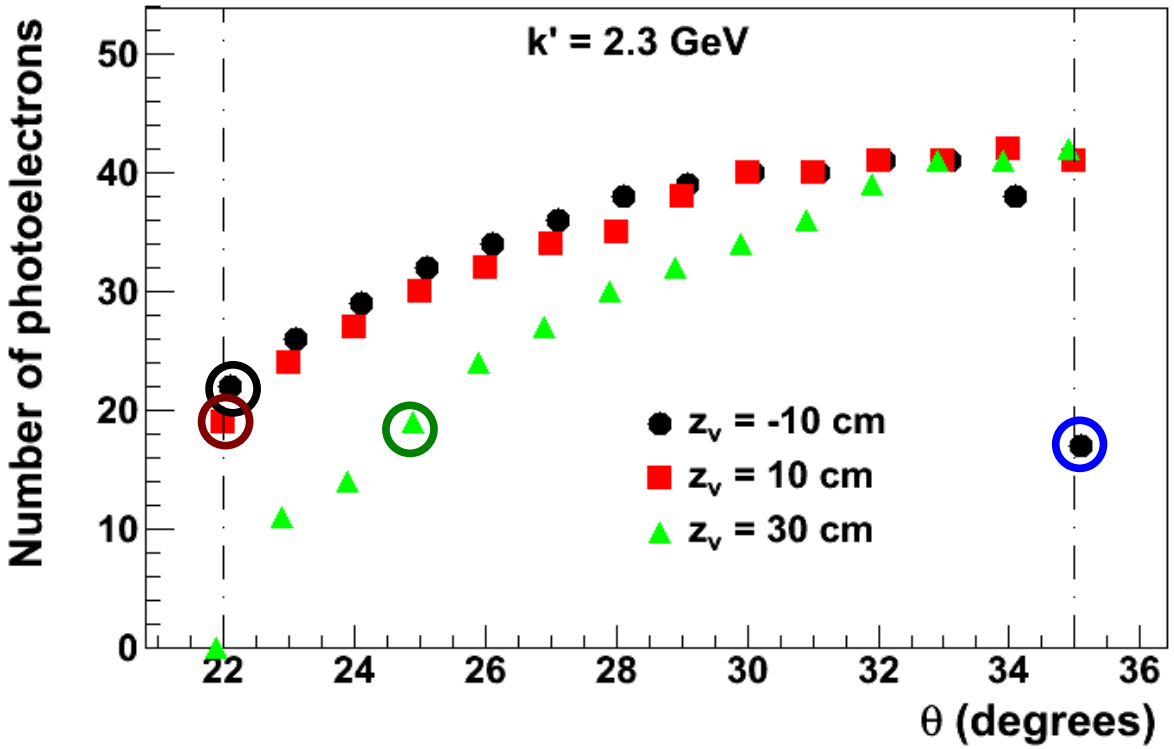
- gas used: C_4F_{10} (used as a "reference gas", since we do not have on hand precise data about C_4F_8O). Absorption length extracted and extrapolated over the useful photon wavelength wave from Compass data **[P. Abbon *et al.*, NIMA 577, pp 455-518 (2005)]**;
- PMT efficiency: injected actual efficiency data from Hamamatsu;
- Mirror reflectivities set to 0.85 over the photon wavelength range;
- "Realistic" surfaces implemented, at least for the PMT window;
- another factor 0.7 is applied for various effects (dead area, etc...);



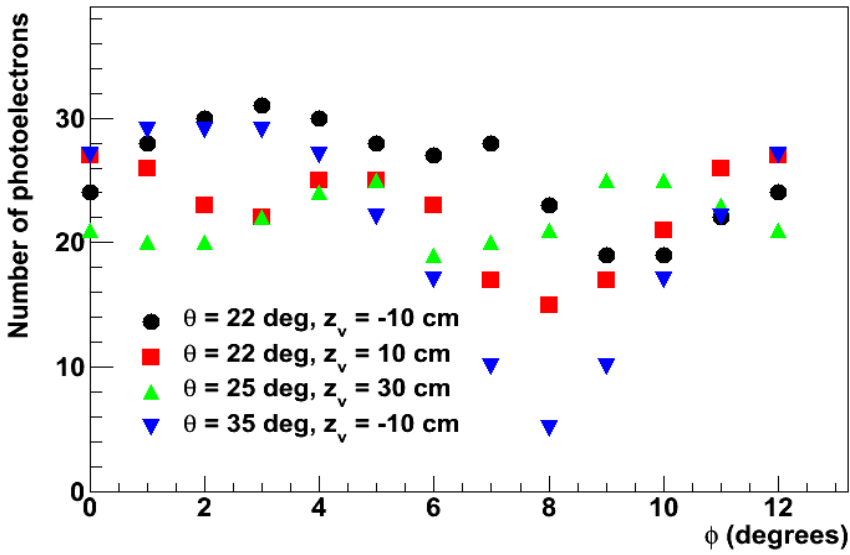


Detector design: Performances for PMT option

Number of photoelectrons:



When "critically" low because of the collection, may want to check the phi-dependence of the number of photoelectrons.



=> No acceptance loss in phi at low angles

=> ~15/20 % acceptance loss at one single point at highest angle.

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Detector design: Performances for GEM option

Two choices for CsI coated GEM option:

- if possible recycle the GEMs used by PHENIX for its Hadron Blind Detector (unless they are not available or too “old”) => photon detector size is a constraint;

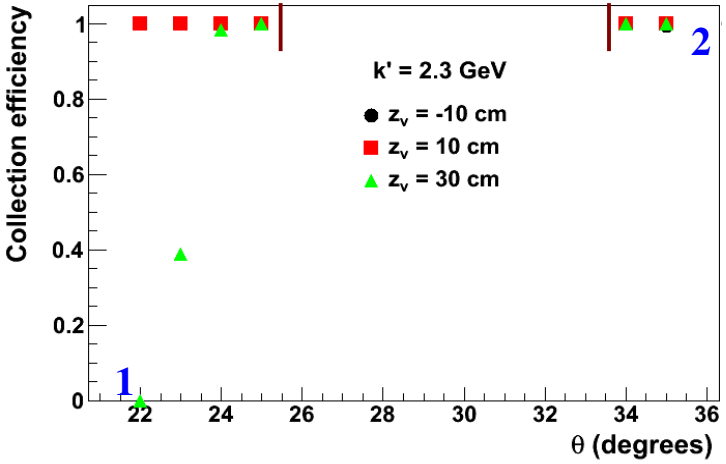
- have new ones manufactured => we can decide which size we need to have a perfect efficiency;

- In the case of GEMs, it is not worth having two mirrors with two curvature radii.

Detector design: Performances for GEM option

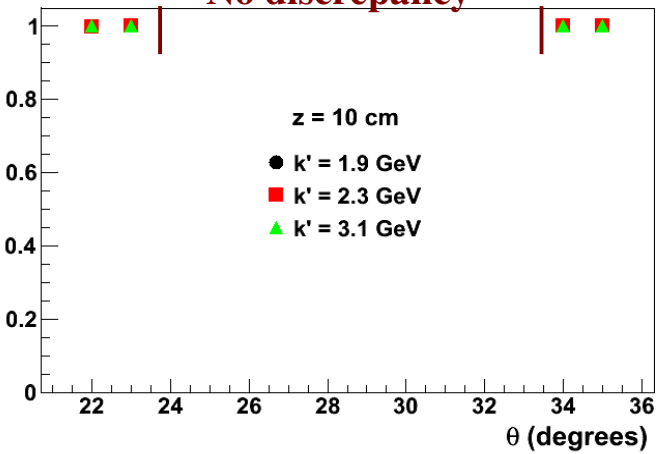
Collection efficiency for CsI coated GEMs with PHENIX size:

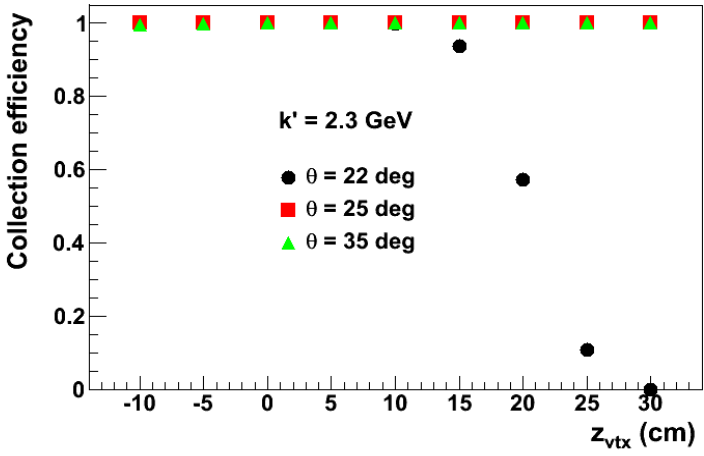
100% efficiency

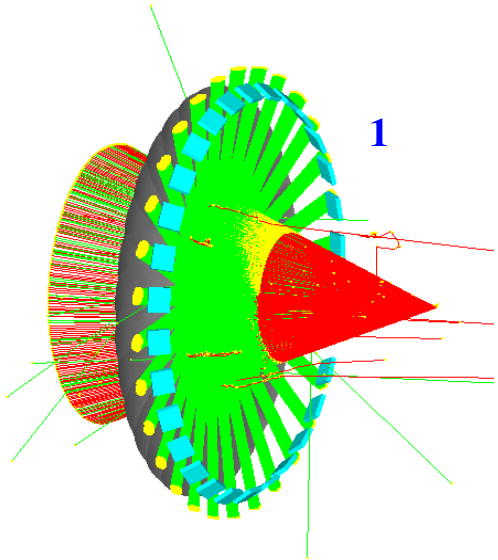


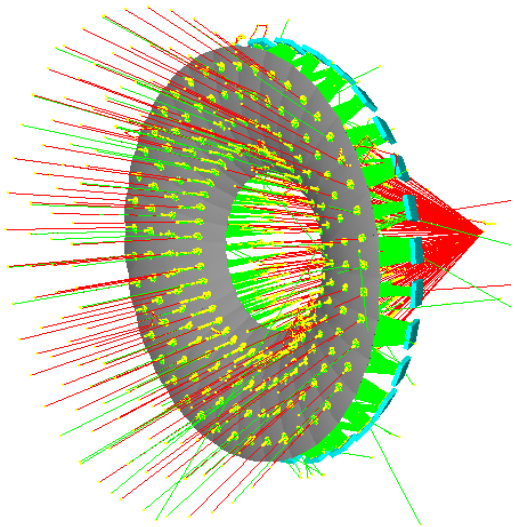
100% efficiency

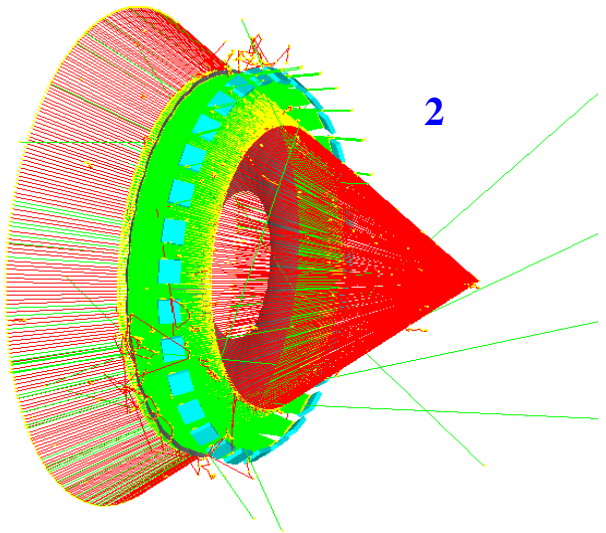
No discrepancy











Detector design: Performances for GEM option

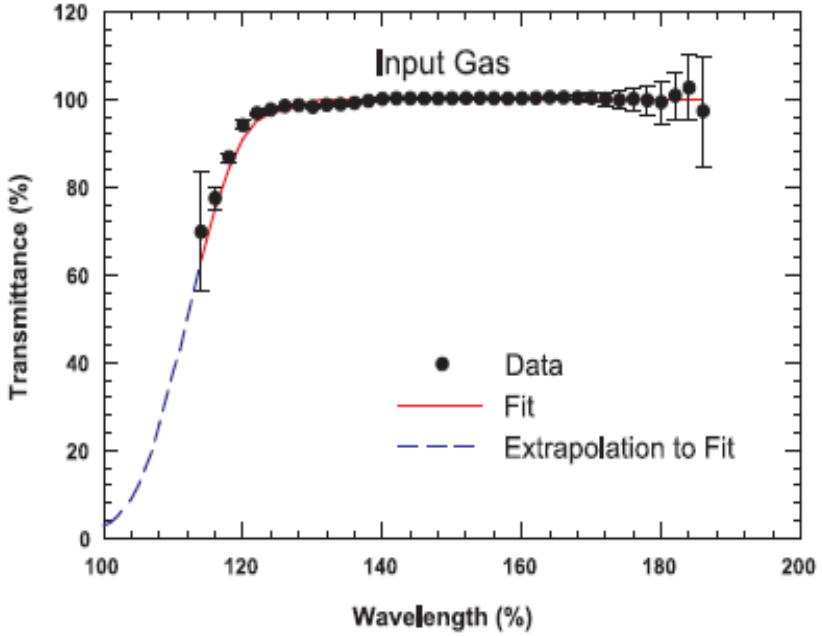
Number of photoelectrons: Simulation details (more details in Simona's talk):

- gas used: CF_4. Injected absorption data from PHENIX measurements

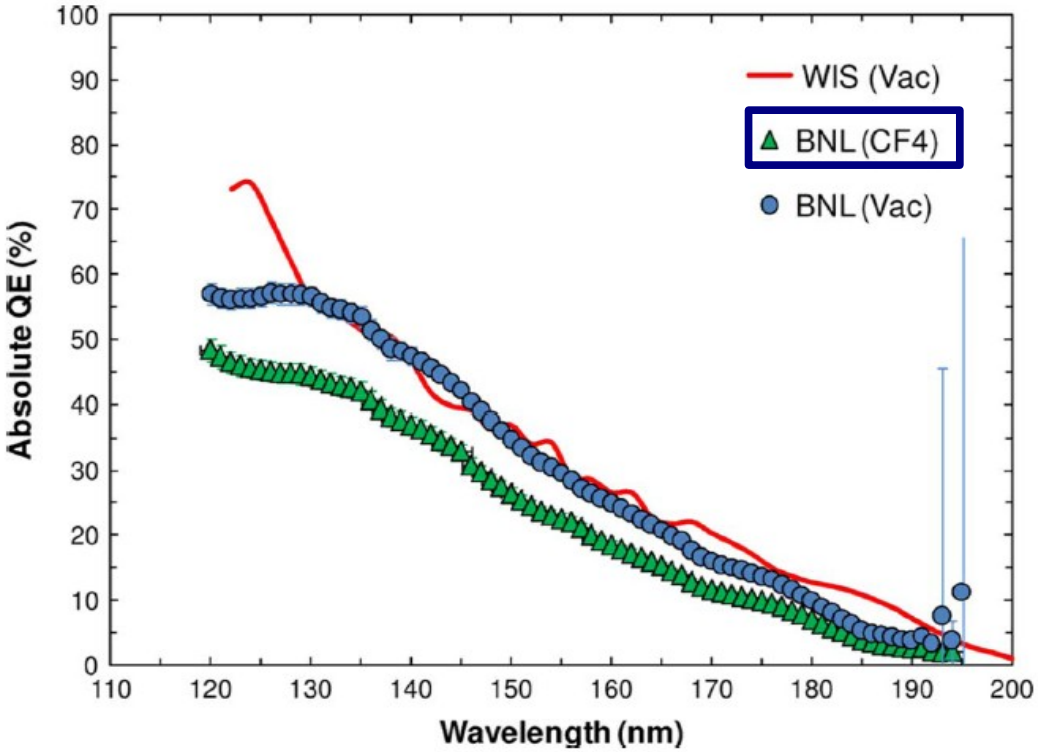
[W. Anderson *et al.*, arXiv:1103.4277 physics.ins-det (2011)];

- CsI quantum efficiency: also from PHENIX data

[B. Azmoun *et al.*, IEEE Trans. Nucl. Sci. Vol. 56 no3, pp 1544-1549 (2009)];



H_2O, O_2 < 2ppm
("pure" gas)



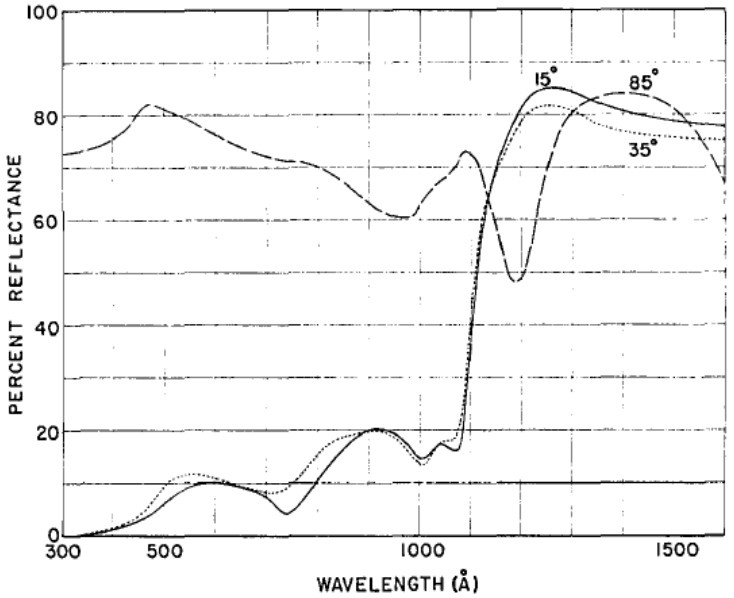
Detector design: Performances for GEM option

Number of photoelectrons: Simulation details (more details in Simona's talk):

- Mirror reflectivities from

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

- another factor 0.5 is applied for various effects (see table, from **[arXiv:1103.4277 physics.ins-det]**);

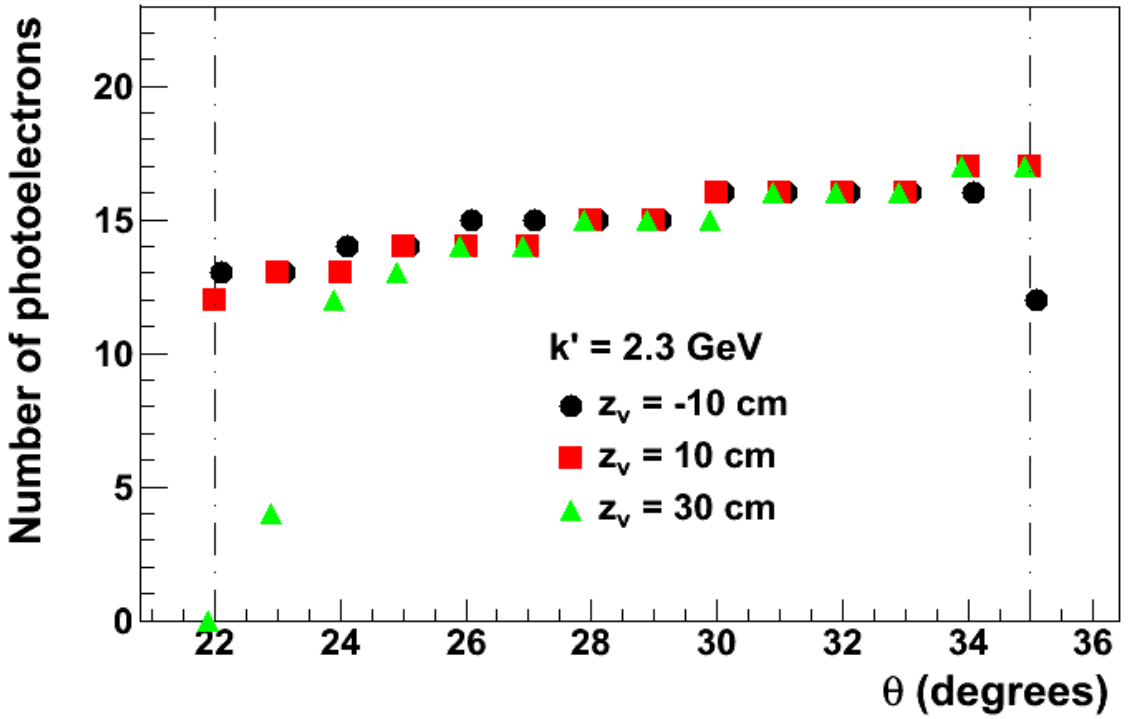


Measured reflectance of an Al + MgF_2 mirror from 300 Å to 1600 Å. The MgF_2 thickness is 250 Å.

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	~50%

Detector design: Performances for GEM option

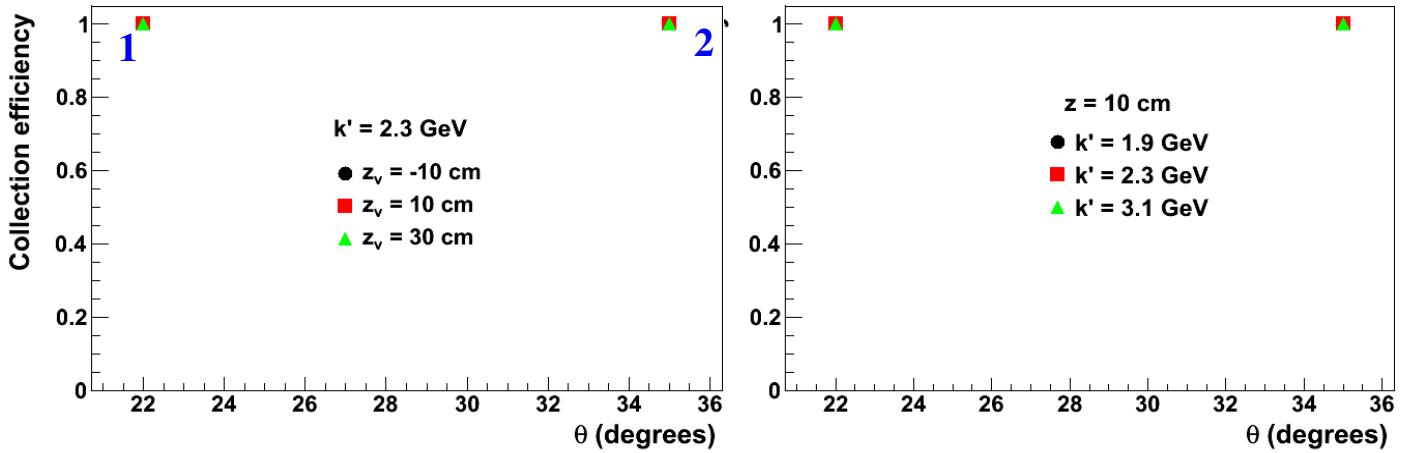
Number of photoelectrons for CsI coated GEMs with PHENIX size:

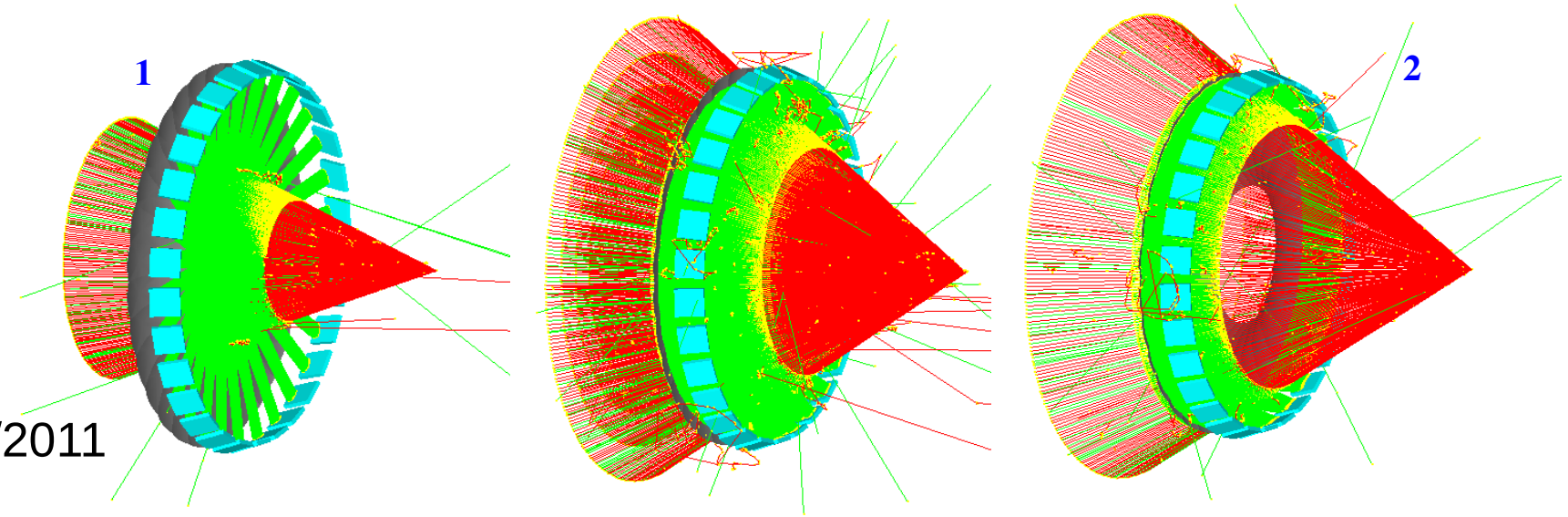


Not a lot of photoelectrons, BUT: at this stage, we think the number of photoelectrons is conservative enough so we can trust these numbers, and work with them

Detector design: Performances for GEM option

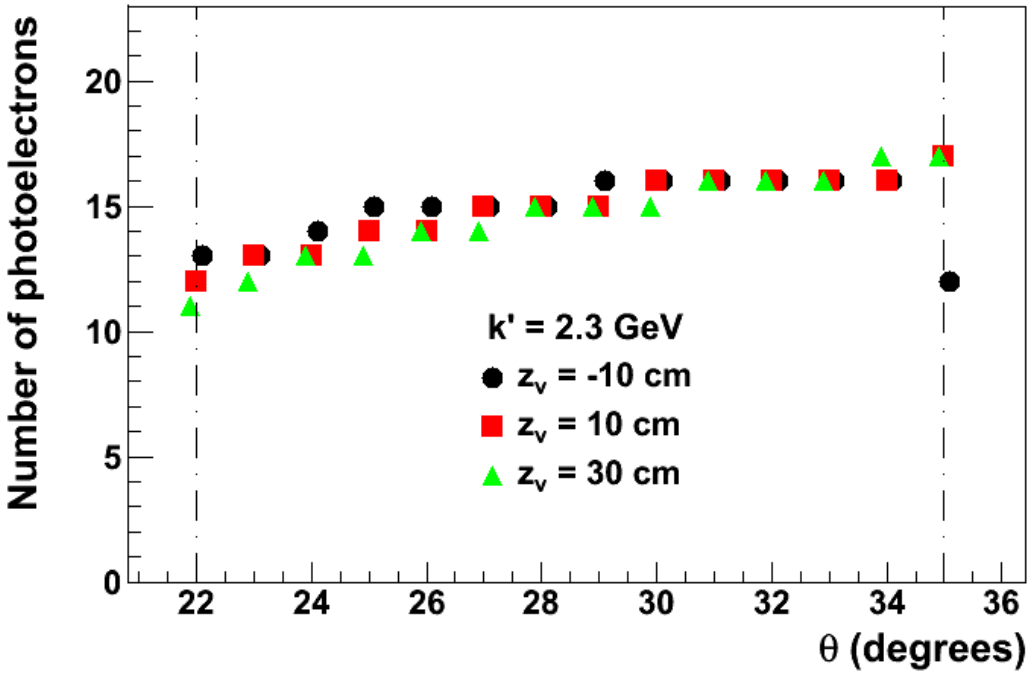
Collection efficiency for CsI coated GEMs with custom size:





Detector design: Performances for GEM option

Number of photoelectrons for CsI coated GEMs with custom size:



Number of photoelectrons similar to those obtained with PHENIX GEMs, except we are missing no acceptance.

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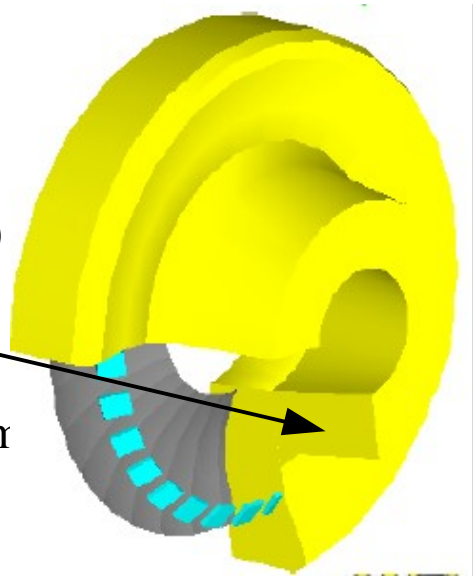
Detector costs estimations

Cost depends on the option chosen for light detection.

If the CsI coated GEM option is chosen for PVDIS/SIDIS light gas Cerenkov:

- Photon detectors (GEMs) will (of course) be shared;
- Mirrors will be shared (see Simona's talk);
- Gas system (CF_4) will be shared;
- Tank will be mostly common (exception: "nose" of the SIDIS tank)



SIDIS heavy gas Cerenkov will have its own photon detectors
(9 PMTs + cone / sector), its own mirrors, its own tank and gas systen

Detector costs estimations

Unitary costs:

- Mirrors: $130 each + $15000 tooling => $25000 total (i.e. 30+spares x 2)
  + $100000 for coating;
- PMTs: $3000 each for MaPMT H8500C;
- Cones: $1350 each for straight cones (not determined yet for winston cones);

Costs still to be determined for:

- CsI coated GEMs;
- Gas system;
- Tank;

Detector costs estimations

Summary of costs for CsI coated GEM option (without contingency):

	SIDIS light gas	PVDIS	SIDIS heavy gas
Mirrors	$25000		$25000
Mirror coating	$100000		$100000
GEMs	?		-
PMTs	-		$3000 x (30+1)x9
Cones	-		$1350 x (30+1)
Gas system	?		?
Tank	?		?

Total cost estimation for all three detectors: ~$2.15 M

Detector costs estimations

If the PMT option is chosen for PVDIS/SIDIS light gas Cerenkov:

- PMTs will be shared between PVDIS and both SIDIS detectors;
  (so far: 9 PMTs per sector for PVDIS / 4 PMTs per sector for light gas + 9 PMTs per sector for heavy gas for SIDIS + spares)
- Mirrors will be have to be distinct for all three detectors;
- Winston cones will be distinct for all three detectors as well;
- Gas system for PVDIS (C_4F_8O) will be distinct from SIDIS light gas (CO_2), but common with SIDIS heavy gas;

Detector costs estimations

Summary of costs for H8500C MaPMT option (no contingency):

	SIDIS light gas	PVDIS	SIDIS heavy gas
Mirrors	$25000	$25000	$25000
Mirror coating	$100000	$100000	$100000
PMTs	$3000 x (30+1)x4	$3000 x (30+1)x9	
Cones	$1350 x (30+1)	$1350 x (30+1)	$1350 x (30+1)
Gas system	?	?	
Tank	?		?

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Plan from GEM test in Hall A

Main goal: Have a Cherenkov detector prototype with a CsI coated GEM and a mirror that works in the JLab environment (cf. PVDIS at 5 10^{38} cm^{-2}/s^{-1}):

Tentative plan so far:

- During the break prepare to put a prototype detector that has a healthy gas volume of clean CF4, a mirror and a CsI coated GEM photon detector.;
- Work is still underway to write a run plan to be submitted to Hall A;

Note: we do not disregard doing this test in Hall C...

Plan from GEM test in Hall A

We plan to put the GEM module from Stony Brook ~ 10 meters away from the target, at large and probably low angles (if space available).

Started reconnaissance in Hall A => we will likely have the space we need on the floor, but we still need to know which angle will be clear of detectors (i.e. matter) (will check with Al Gavalya);

a support would be available for the detector to sit:
~ 170 cm tall,
able to support ~ 450 kg.

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Summary and prospectives

- The detector design for PVDIS is in good shape overall, if we except the limitations for the PMT option;

- The signal seems to be satisfactory;

- Still need to move to GEMC (official software for SoLID) -> start next week... and study the tolerances of the detector design;

- Another new technology (Large Acceptance Picosecond PhotoDetector) might be considered in the future;

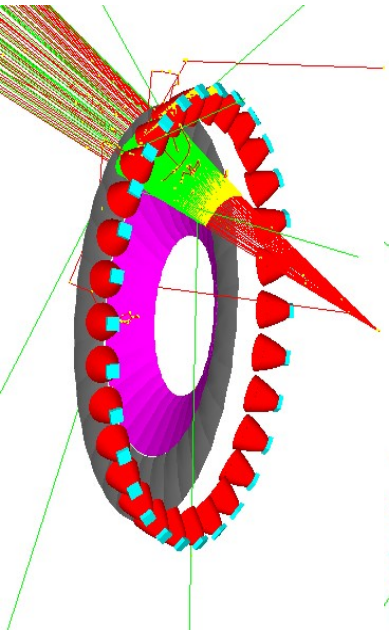
- Estimation costs are still under progress;

- Plan for tests in beam is being written and submitted soon to the Hall A collaboration;

BACK-UP

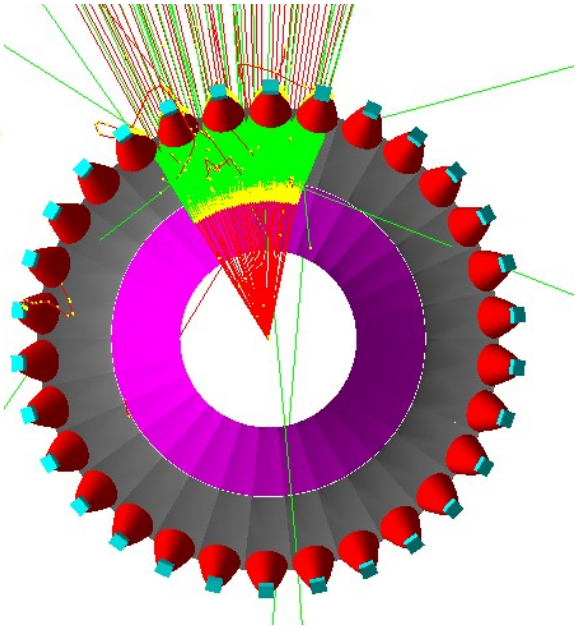
PMT limitations for PVDIS:

- cones need to be wide to maximize the collection efficiency at higher angles;
- BUT if they are too wide, bizarre reflections occur at low angle;

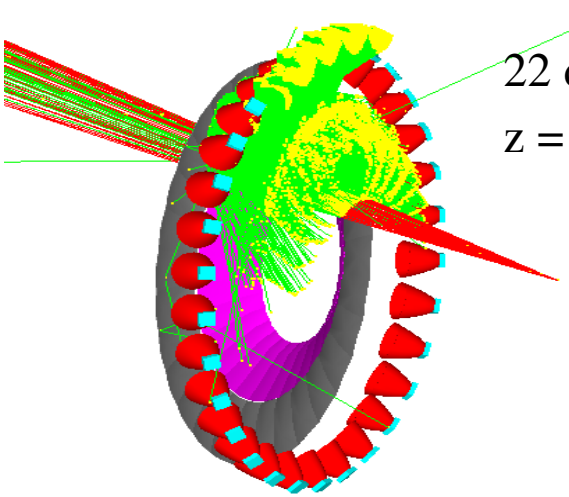


35 deg,
z = +10 cm

Setting for perfect efficiency at higher angle
(cones cannot be any narrower)



At lower angle => AWFUL
(Collection efficiency ~20%)

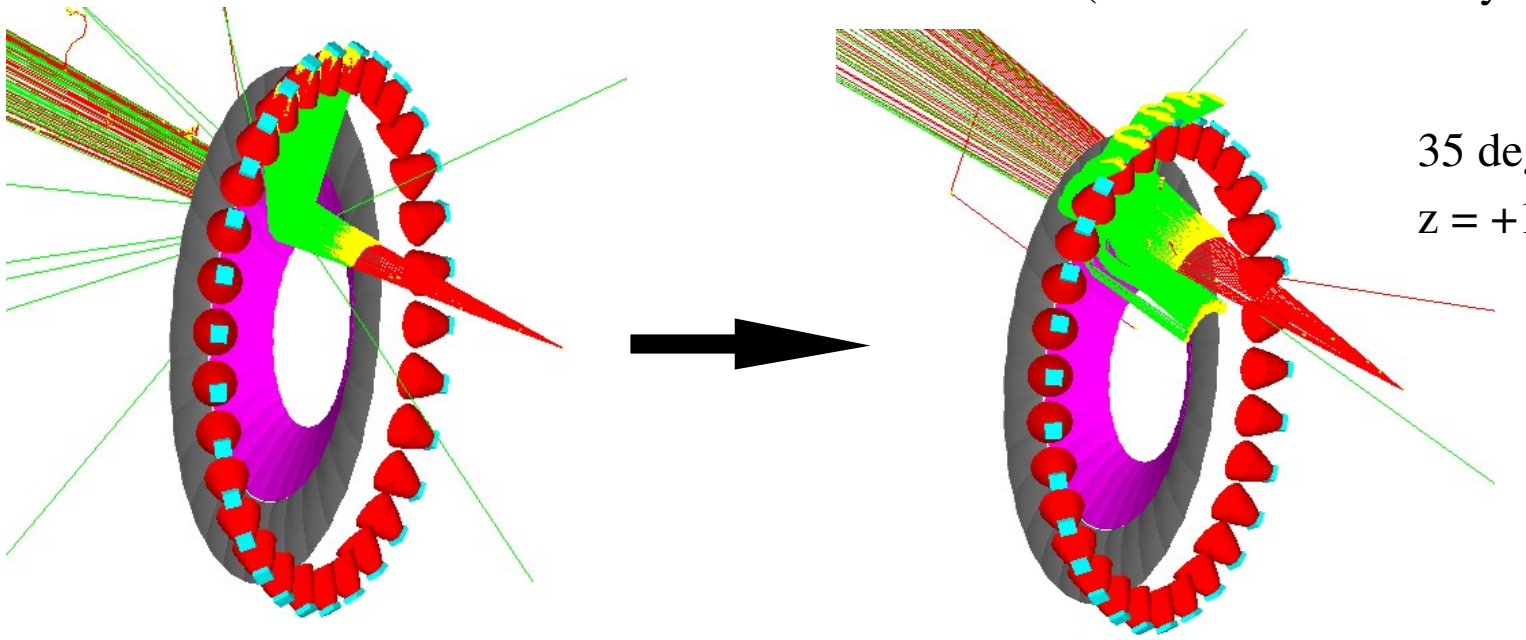


22 deg,
z = +10 cm

PMT limitations for PVDIS:

Setting for perfect efficiency at lower angle
with same cone size

Very bad at higher angle
(Collection efficiency ~67%)



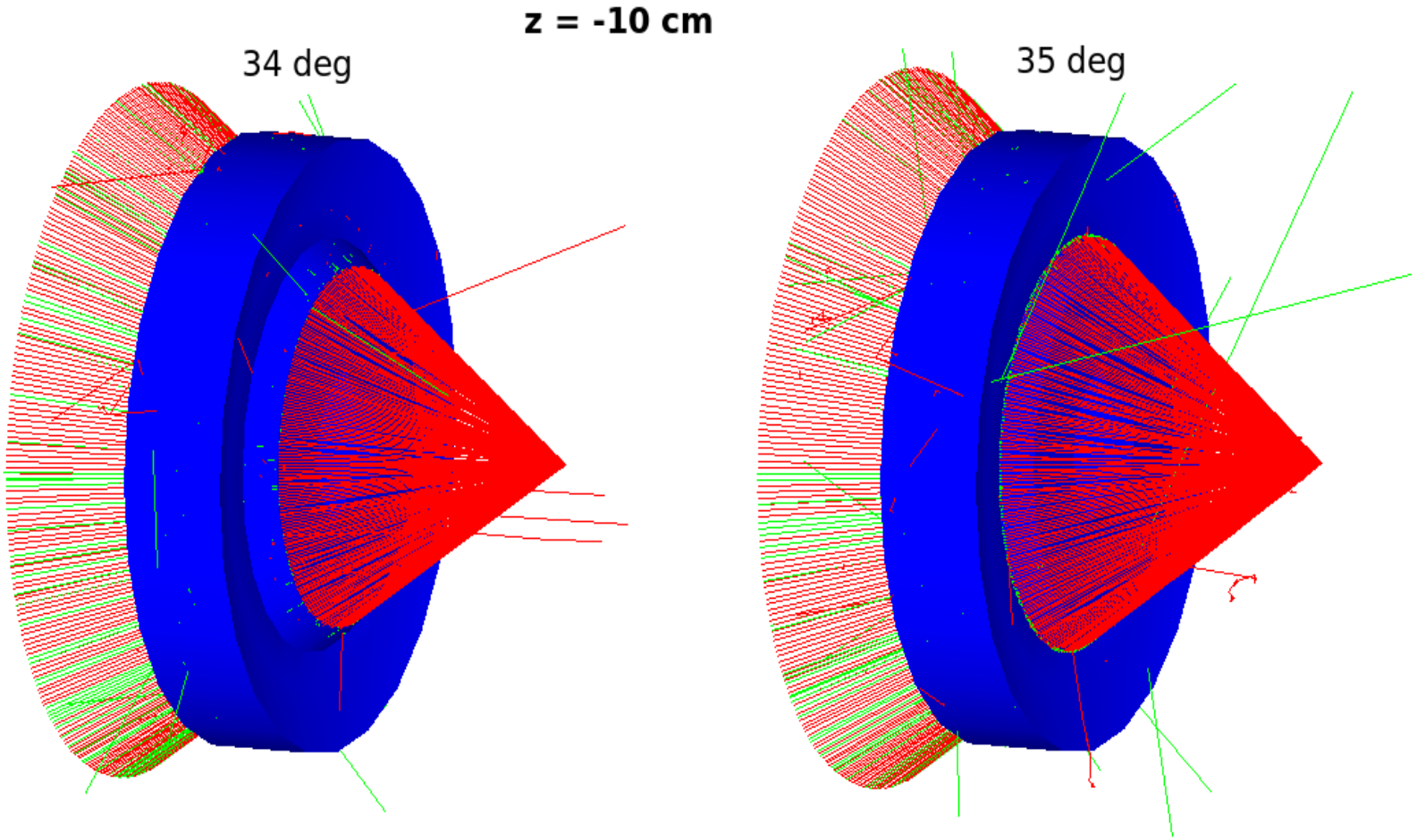
22 deg,
z = +10 cm

35 deg,
z = +10 cm

= > What should be favored ?

“Bizarre” drop of the number of photoelectrons at an edge of the acceptance.

=> Due to tank design: the “nose” is not extended enough in *r* to catch this ray.



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Fax: 765-348-3823

August 30, 2011

Temple University
Attn: Dr. Eric Fuchey

Dear Dr. Fuchey,

The following is our quote you requested.

18.4" x 28.98" x 1/8" clear glass – bent spherically to a 89.261" radius – swiped edges – bulk paper packed
The piece price based on 30 pieces is $132.60 each.

12.376" x 28.88" x 1/8" clear glass – bent spherically to a 89.261" radius – swiped edges – bulk paper packed
The piece price based on 30 pieces is $131.55 each.

The tooling charge for the above items is $15,080.00.

There is currently a 10% surcharge in effect. The above item is quoted F.O.B. Hartford City, IN. Our payment terms are 50% deposit required with order and 50% due prior to ship.

Thank you for the opportunity to quote your specialty glass requirements. If you have any questions, please feel free to contact me directly at 765-348-3100.

Sincerely,

Andrew Mair
President