SHMS Heavy Gas Čerenkov
June 2009 Update

Garth Huber & Paul Selles

UNIVERSITY OF REGINA

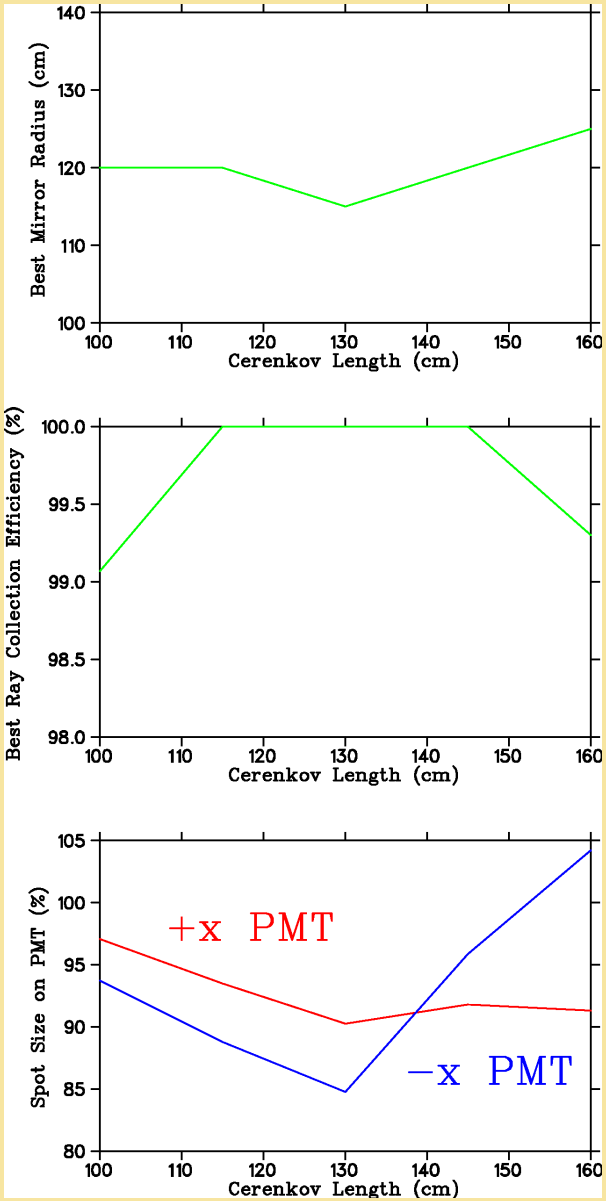
SHMS Detector Working Group Meeting. June 24, 2009.

Progress since Feb/09 Update

- **2D Ray Trace studies completed.**
  - Iterated over many mirror radii, mirror and PMT placements to determine optimal configuration.
  - Thanks to WestGrid high performance computing center in Vancouver for the necessary computing resources.
- **3D simulations using Geant4 in progress.**
  - Initial results will be shown.
- Met with Jan Soukup, Detector Physicist/Engineer at the University of Alberta.
  - Pressure vessel and entrance/exit window engineering studies to be underway soon.
  - Confirmed availability of 5 axis CNC machine for mirror mount fabrication.

Conclusions from 2D Ray Trace Study

- Optimal Mirror r=115-125cm for all detector lengths studied.
- Good collection efficiency obtained for L=115-145cm detectors.
  - Best to worst: L=130,115,145,100,160cm.
- Typically more difficult to focus light onto *+x* PMT than *–x* PMT
- **L=130cm detector with r=115cm mirrors** has best overall performance.

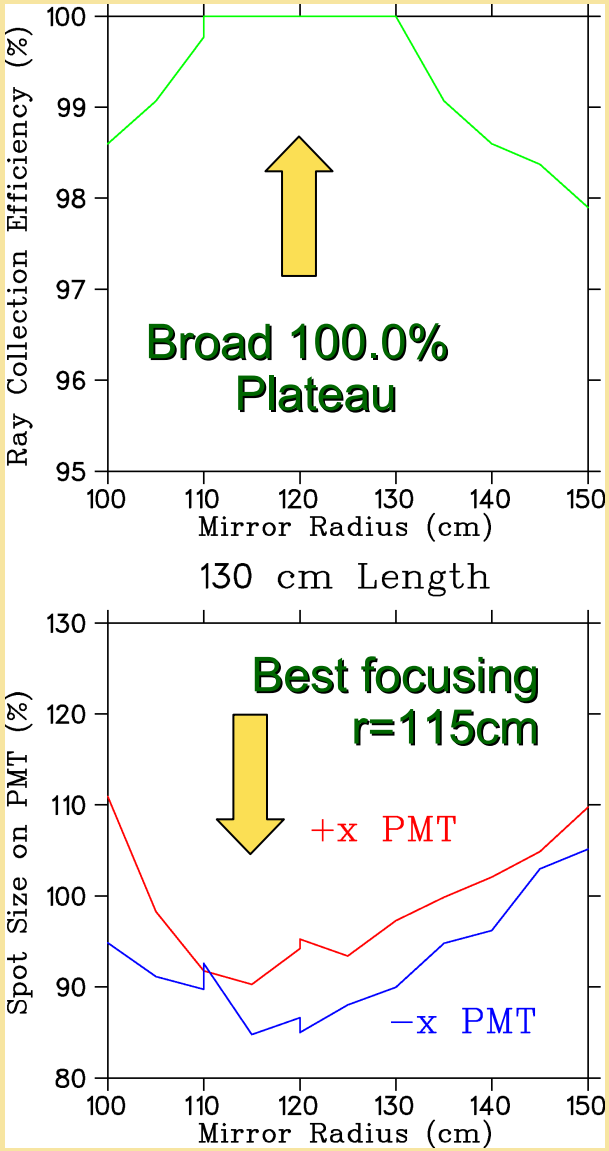


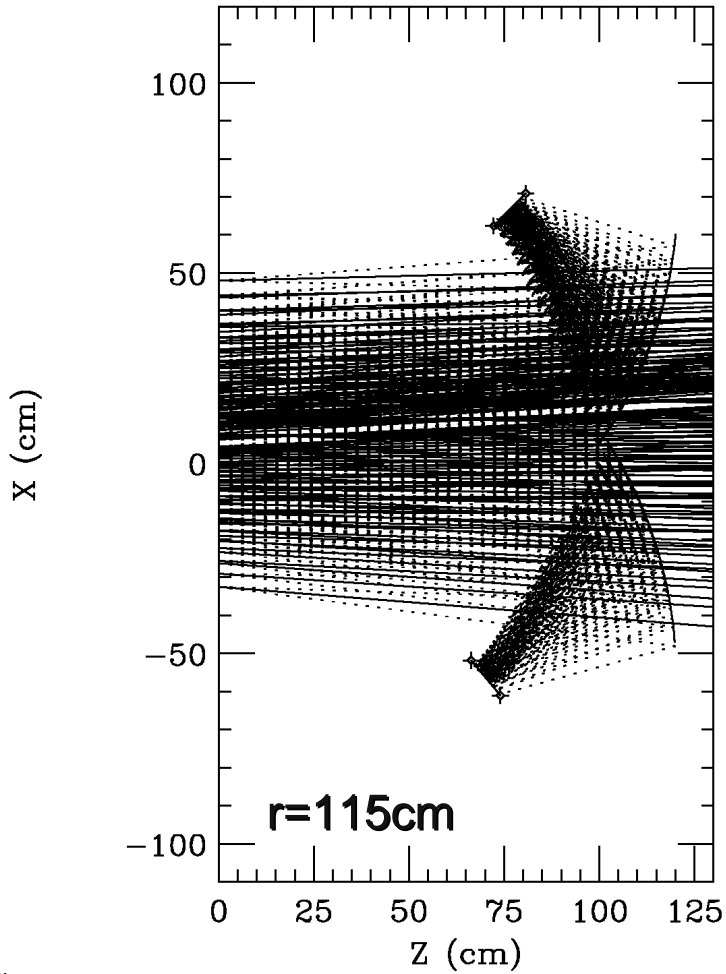
Larger # is better

Smaller # is better

Dr. Garth Huber, Dept. of Physics, Univ. of Regina, Regina, SK S4S0A2, Canada.

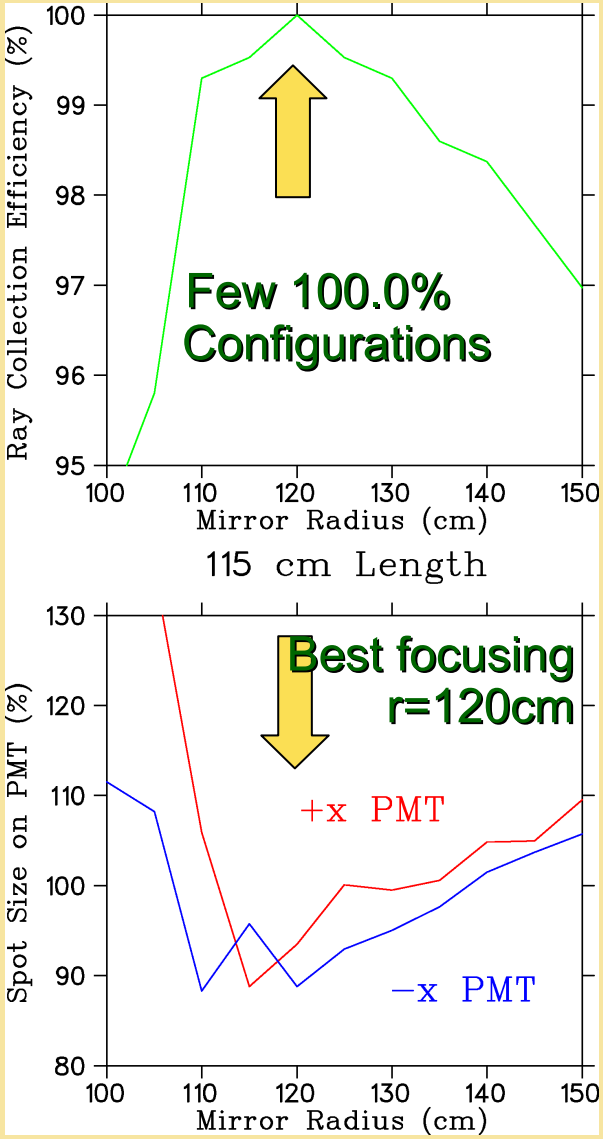
Best 2D L=130cm Configuration

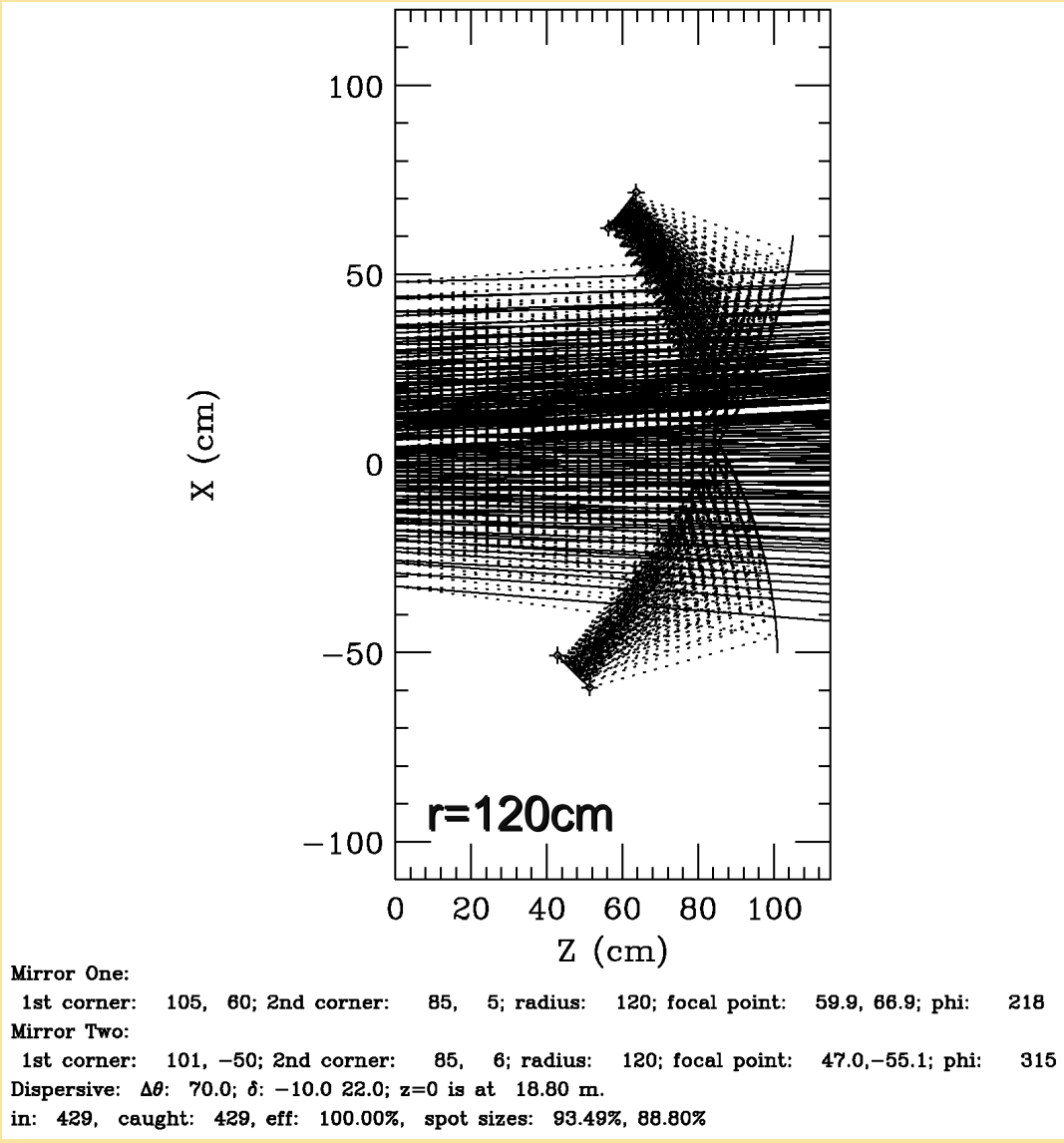




Mirror One:
1st corner: 120, 60; 2nd corner: 100, 5; radius: 115; focal point: 76.4, 66.6; phi: 224
Mirror Two:
1st corner: 120, −50; 2nd corner: 102, 6; radius: 115; focal point: 70.1,−56.5; phi: 320
Dispersive: $\Delta\theta$: 70.0; δ: −10.0 22.0; z=0 is at 18.80 m.
in: 429, caught: 429, eff: 100.00%, spot sizes: 90.26%, 84.76%

Comparison with L=115cm Configuration

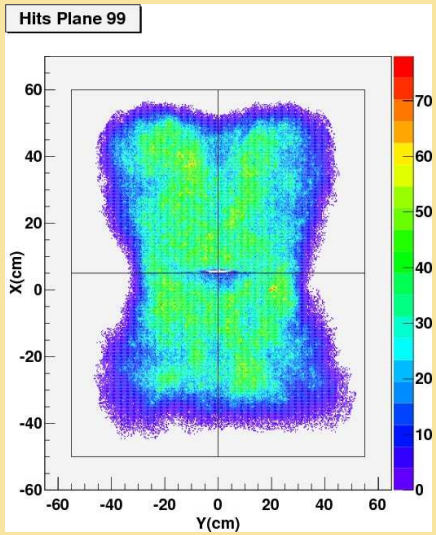


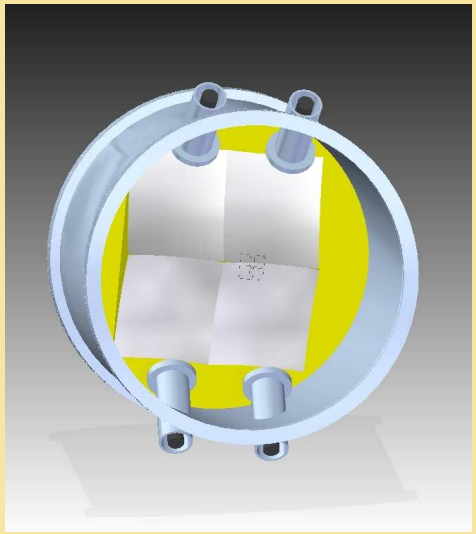


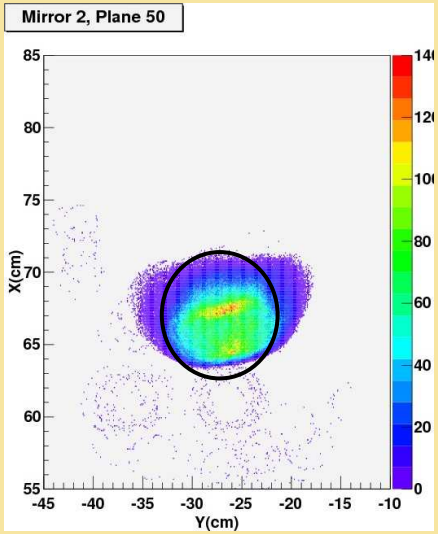
Geant4 3D Simulations

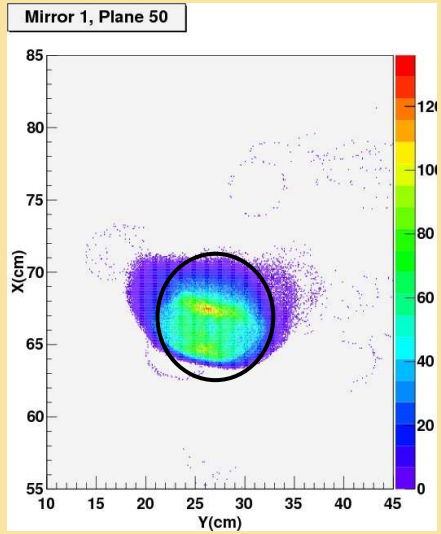
- Thanks to Vahe Mamyan for setting up the software framework. Ongoing development by Paul Selles.
- **"Best 2D" geometry is starting point for studies.**
  - All simulations make use of 5000 event SHMS white spectrum provided by Tanja Horn.
- **Good News**: 2D Raytrace studies in the dispersive plane are largely validated.
  - Differences are due to SHMS transverse plane dependence, not taken into account in 2D Raytrace studies.
- Therefore, L=130cm detector will only be considered.
  - Emphasis of Geant4 studies is final optimization of mirror/PMT configuration, taking SHMS transverse plane effects into account.

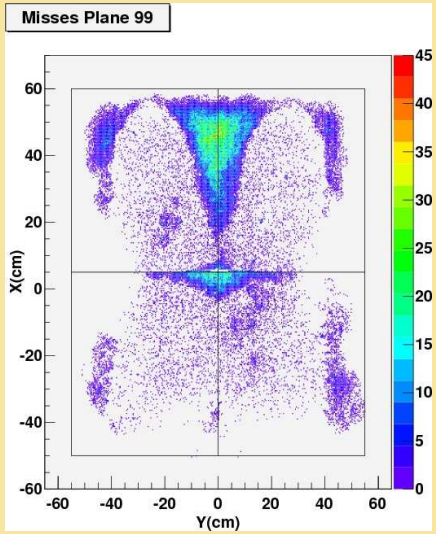
“Best 2D” Geometry



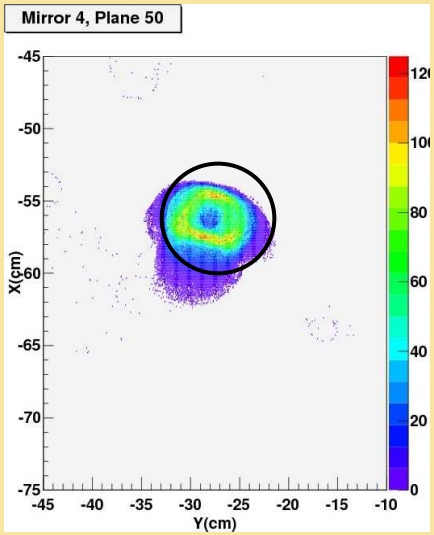


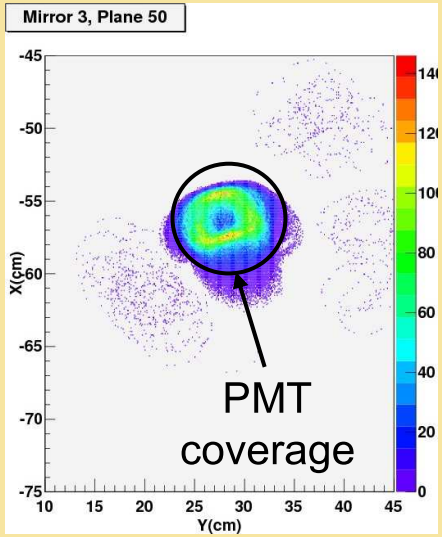






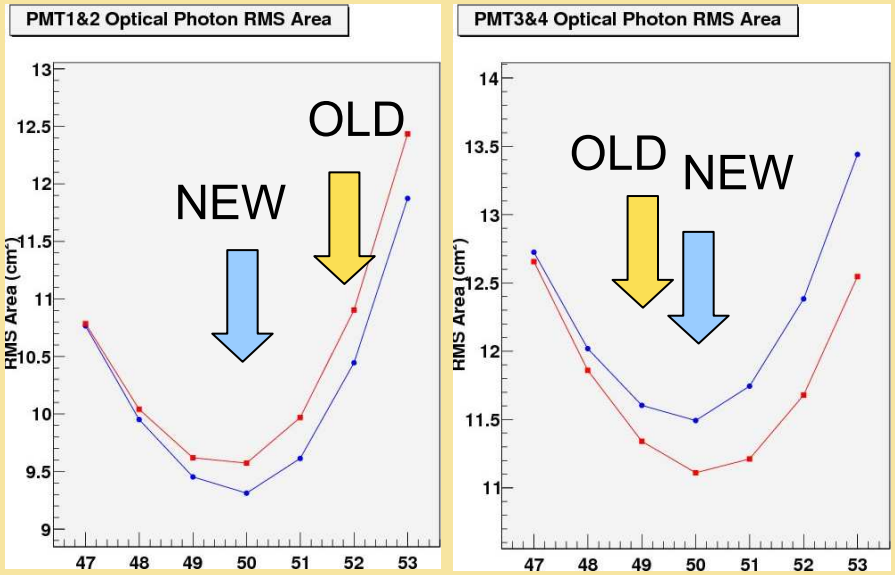
- Vertical planes through mirror centers are OK.
- PMT misses originate at mirror edges.
- Effect not in 2D.

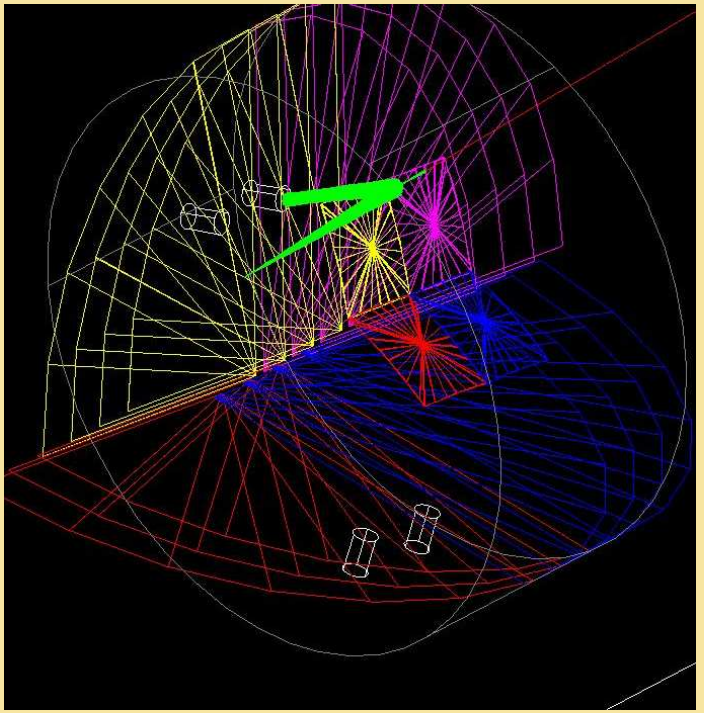




PMT Position Optimization

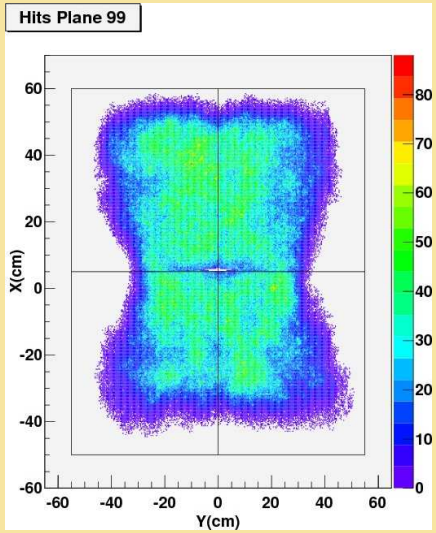
- Investigate “spot size” on planes fore and aft of nominal PMT position, determining the plane with the minimum rms area.

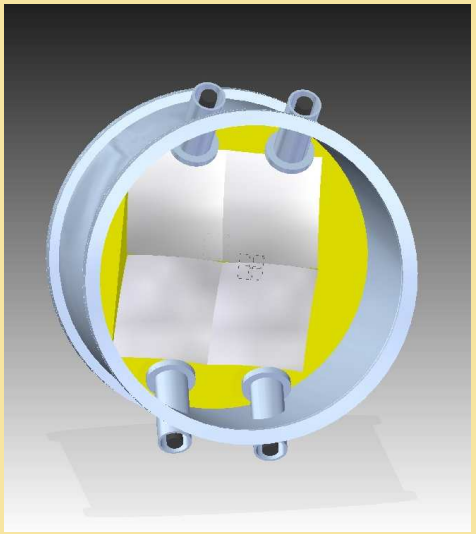


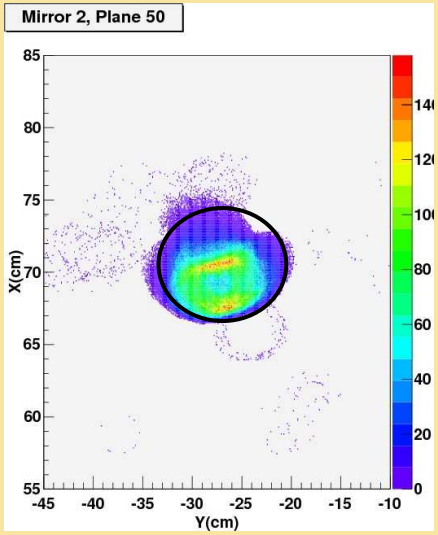


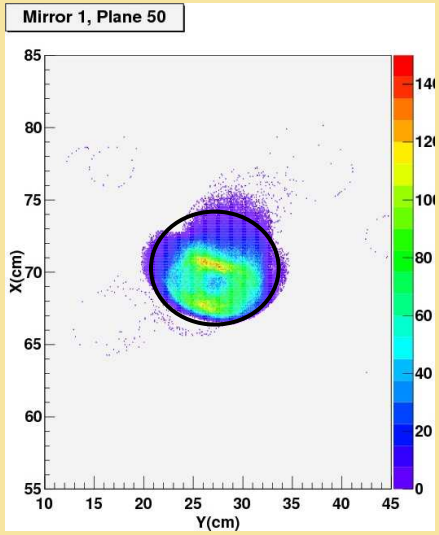
PMTs 1,2 (+*x*):
4.1cm further from mirror.
PMTs 3,4 (-*x*):
1.8cm closer to mirror.

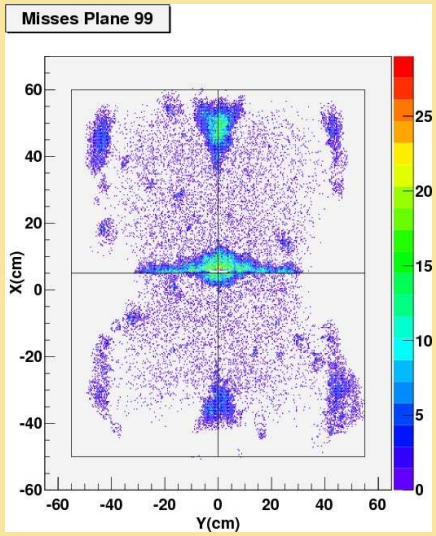
Improved PMT Positions



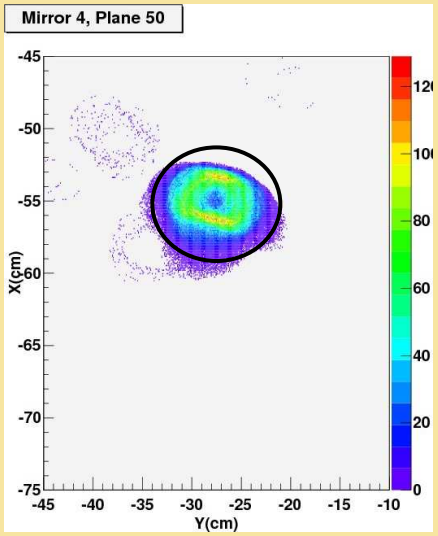


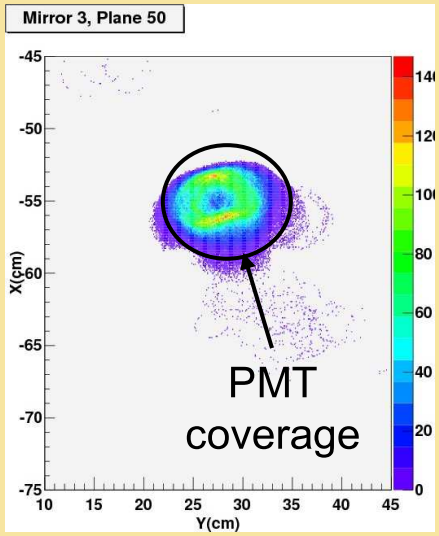






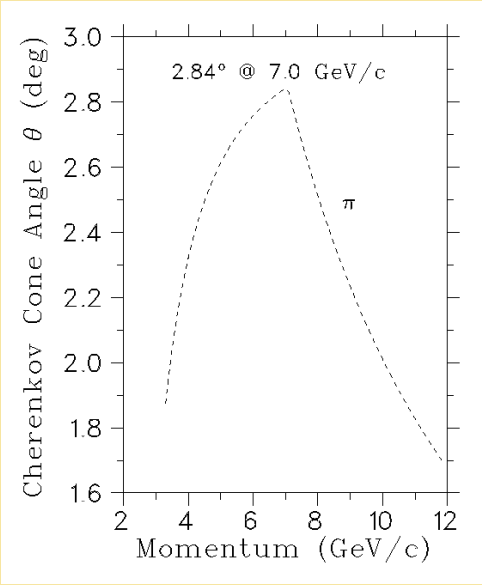
Better light collection efficiency, but still room for improvement.



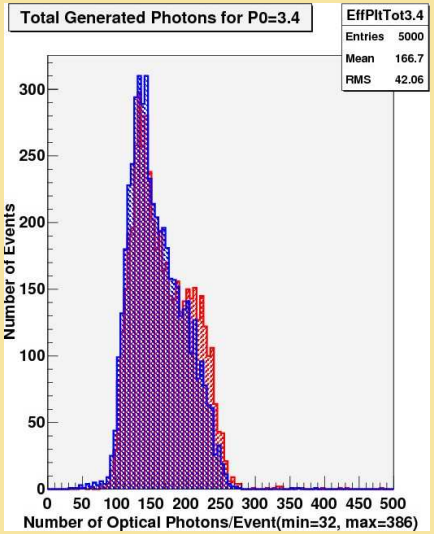


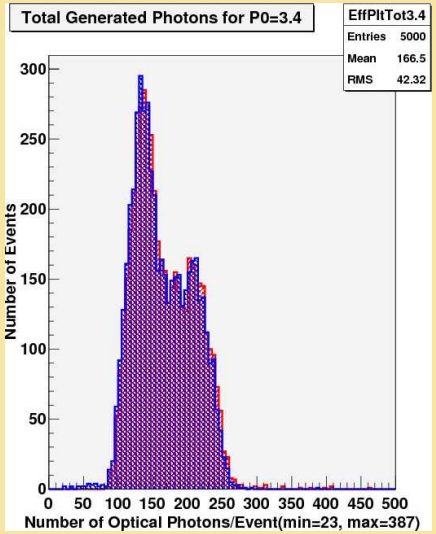
Light Collection Improvement

- More Čerenkov light at 7 GeV/c than at 3.4 GeV/c.
- Cone angle is also larger at 7 GeV/c, so harder to collect all the light rays.



Original **Improved**

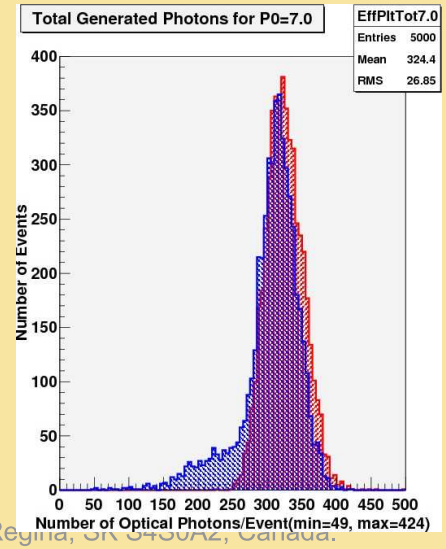


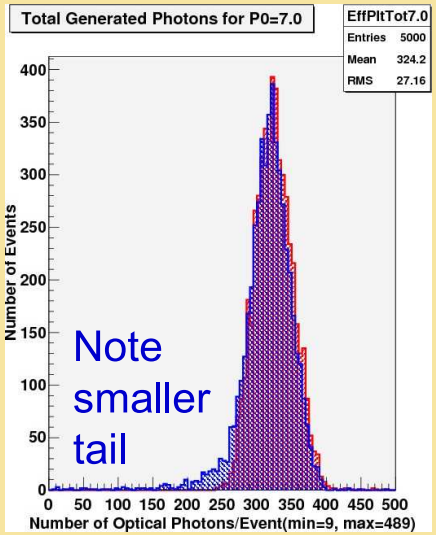


P_0=3.4 GeV/c

Red=γ's generated.

Blue=γ's hitting PMTs.





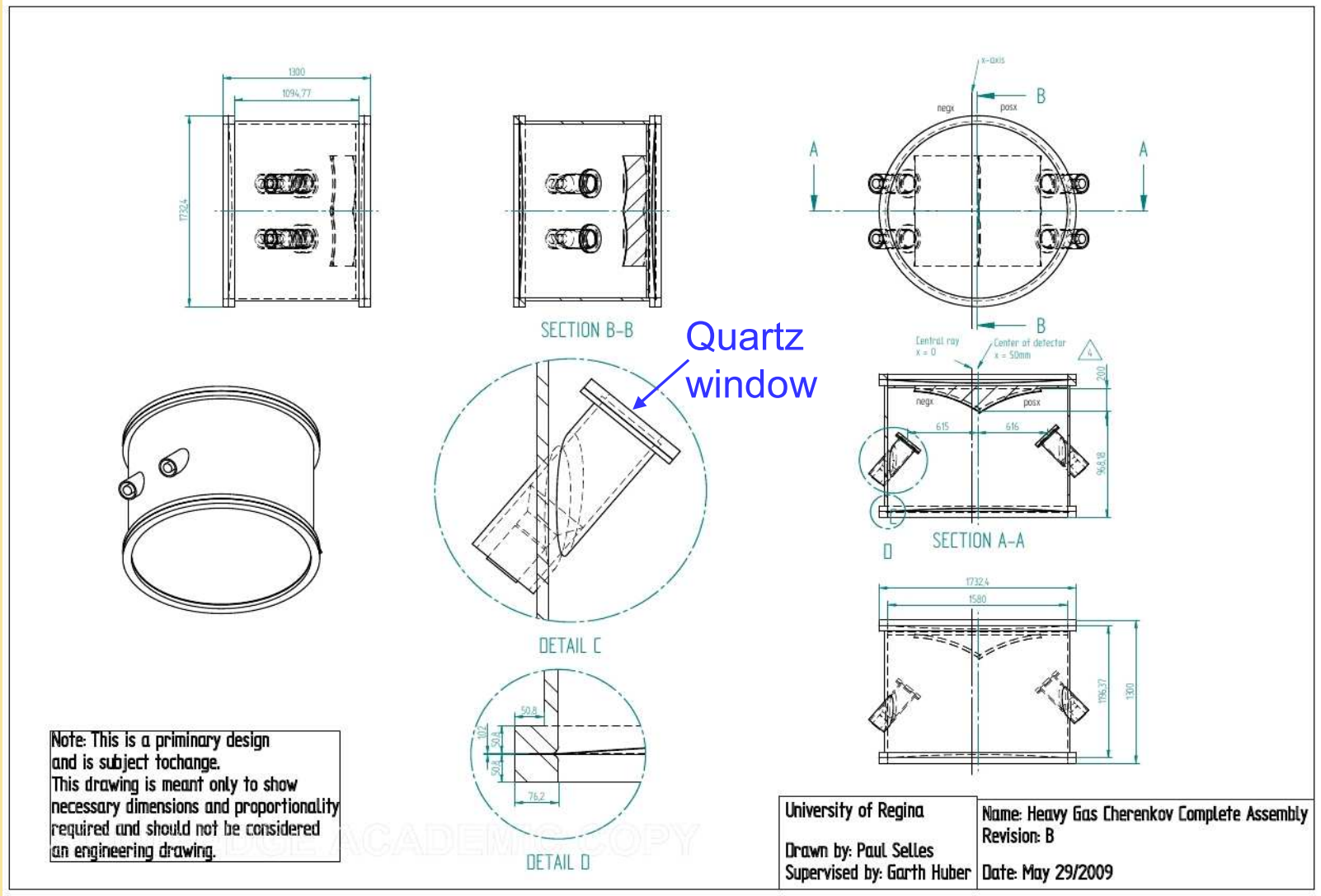
P_0=7 GeV/c

Planned Geant4 Studies

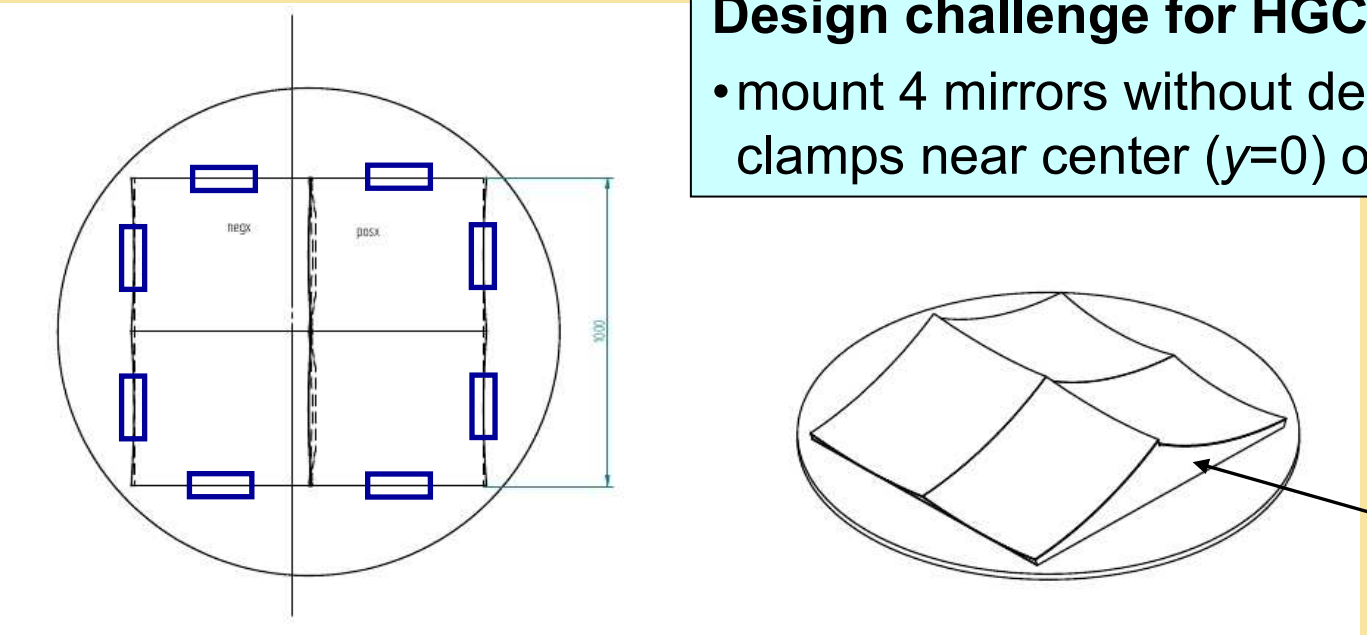
- **Continue with r=115cm spherical mirror.**
  - better understand local inefficiencies.
  - how/whether they can be overcome with improved mirror/PMT placement.
  - predict # photoelectrons at 3.4, 7.0, 11.0 GeV/c.
- **Check r=110,120cm mirror radii.**
  - 2D raytrace simulations predict slightly worse performance.
  - Is this still the case when transverse plane effects are included?
- **f=57.5cm parabolic mirror.**
  - Director's Project Review, December, 2008:

    "The question arose if allowing for non-spherical mirrors will result in better light collection."
  - Check to see if the performance improvement is worth more detailed study.

Preliminary Design Drawings



Mirror Mounting Considerations



Design challenge for HGČ and NGČ:

- mount 4 mirrors without dead spots due to clamps near center (y=0) of detector.

Base milled to exact mirror shapes.

Proposal:

- Mill a single Rohacell base to the exact shape of all 4 mirrors using CNC machine at U.Alberta.
- Glue mirrors to this base and clamp only at edges of beam envelope.

5” PMTs and Bases

- **Since our last meeting Photonis has announced their exit from the PMT market.**
  - Various alternatives have been investigated.
- **Likely Scenario:** Hamamatsu R1584 UV-glass convex head PMT.
  - Require spherical adapter to mount PMT against quartz viewport.
  - Waiting for a response from Kathryn Pritchard (Hamamatsu).
- Hamamatsu reports that Yuri Sharabian is looking for 60 5” UV-glass PMTs.
  - It might be advantageous to co-ordinate orders with Hall B.