SHMS Noble Gas Cerenkov

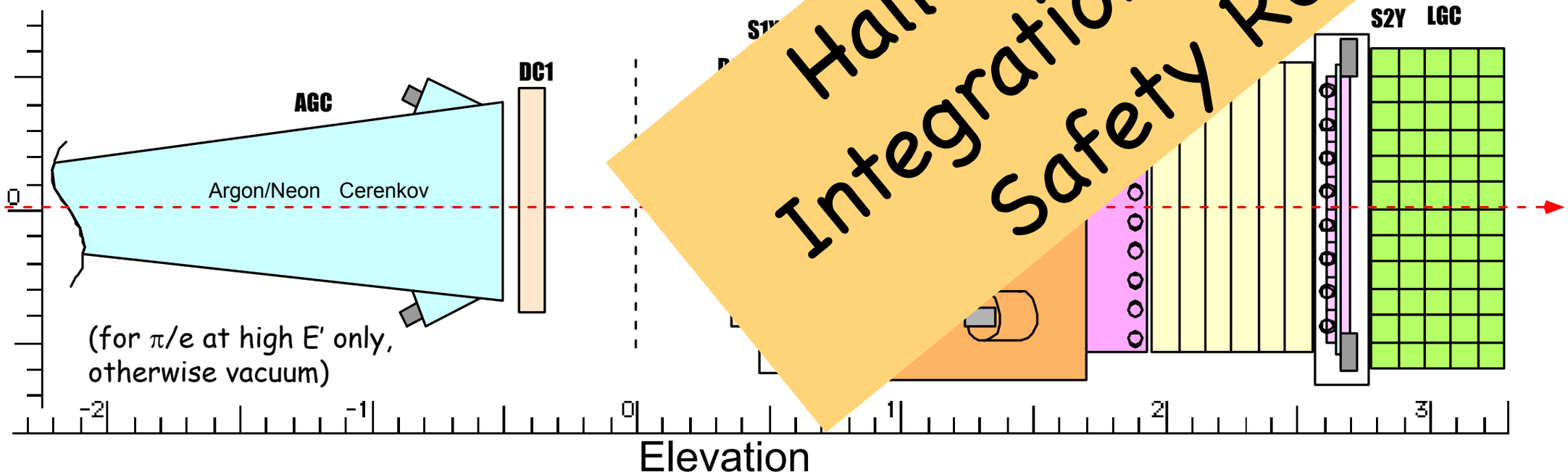
Donal Day
Mikhail Yurov

January 25, 2013

Focusing on PMT and Tank

SHMS Atmospheric Čerenkov

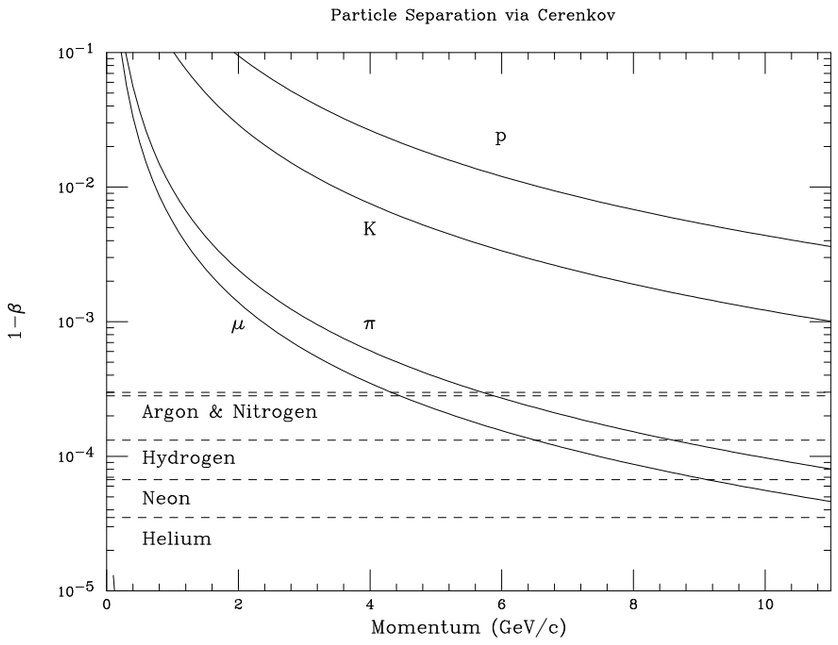
Donal Day
University of Virginia
January 22, 2008

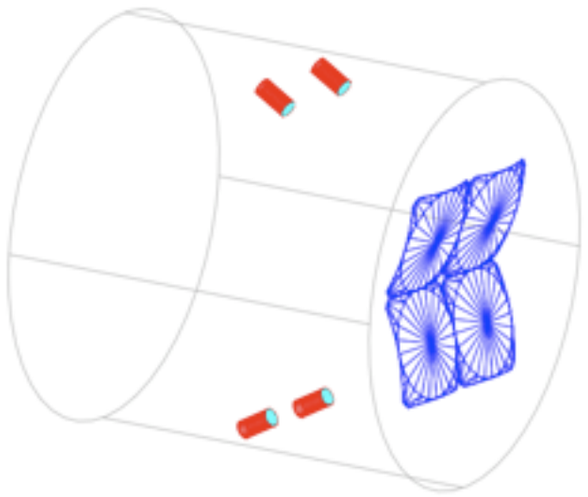


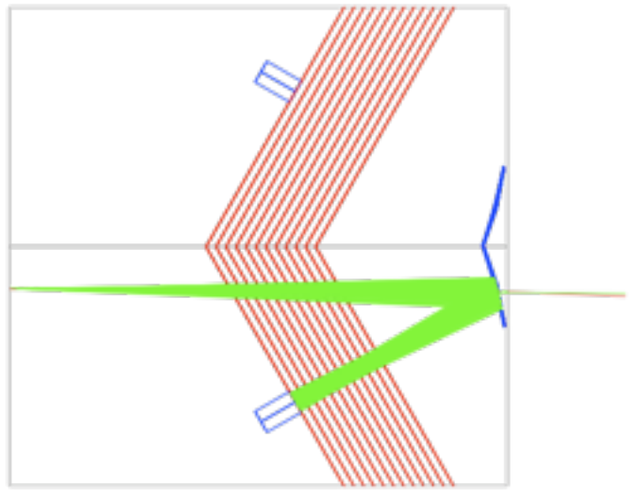
Hall C - Detector Integration Design and Safety Review

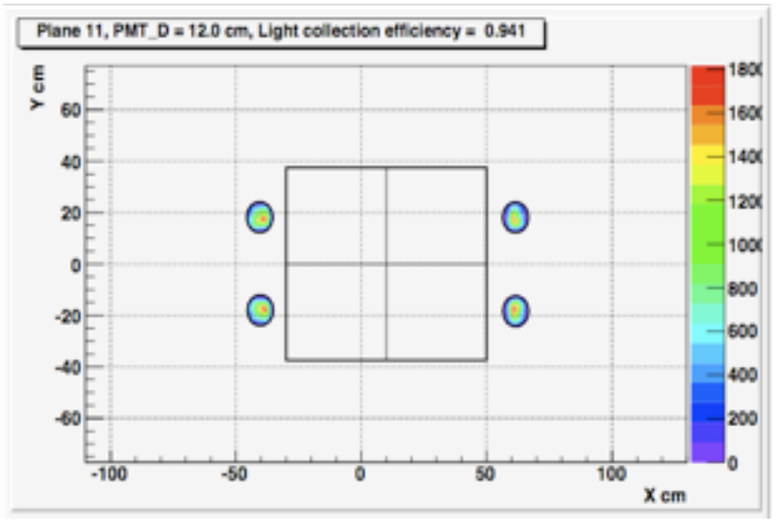
Overview

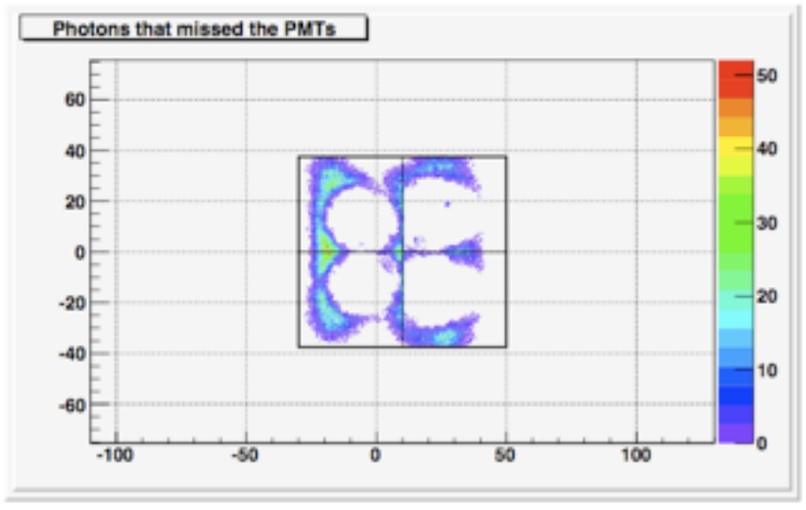
2m long active length of Argon/Neon, covering 80 by 80 cm
4 overlapping mirrors, each focusing onto a single 5 inch PMT











Full featured Geant4 simulation

Mirrors to have R = 135 (down from 155) for small spot size

43 by 43 cm to be slumped by Rayotek of San Diego, coatings by Acton Research/Princeton Optics

We predict 10 N_{pe} for worst case (Argon at 11 GeV)

Select PMT

From start our choice was Hamamatsu R1584 5-inch UV glass, coated with WLS, as we did the HMS Burle 8854

Test R1584 before and after coating to gauge the benefit (results to come)

In the meantime, pricing of R1584 went from $3500 in Nov 2009 to $4500 in March 2011 to $9300 in Jan 2012!

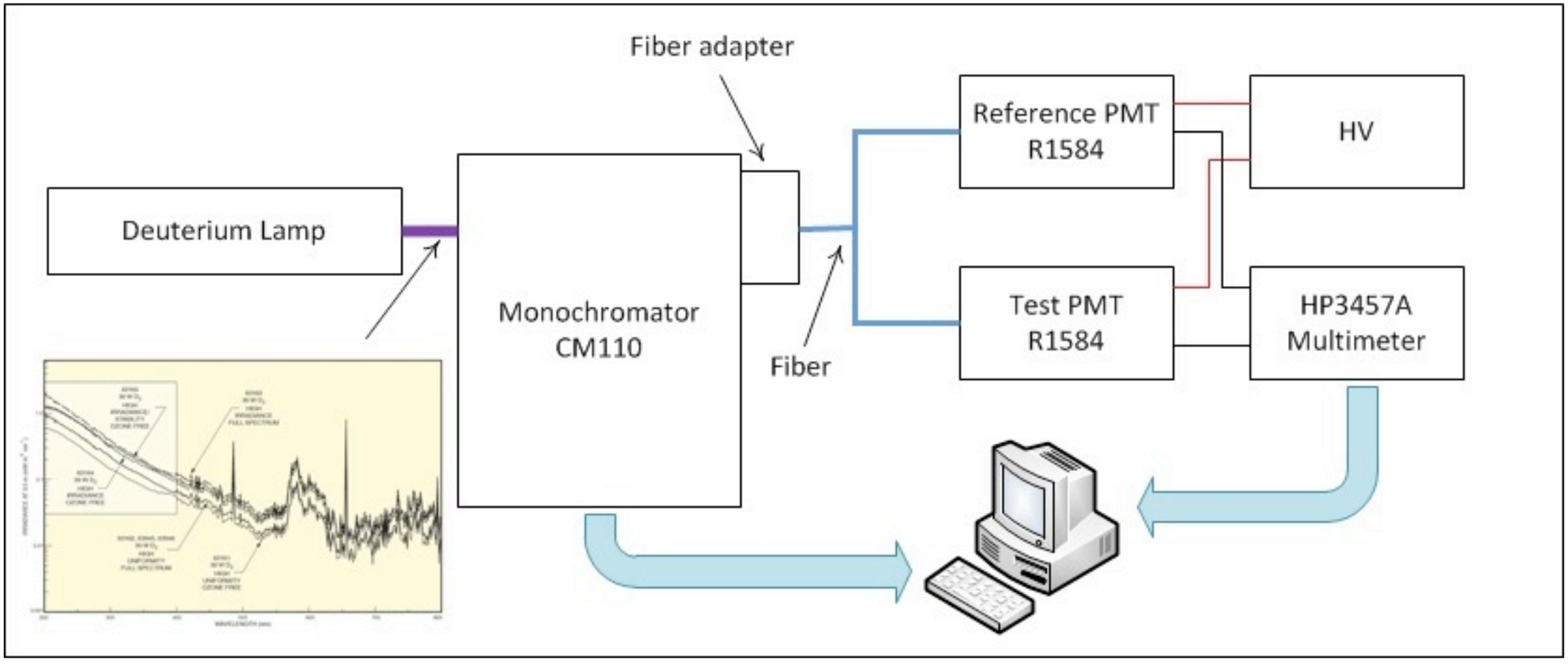
We should then consider the quartz 5-inch Electron Tube 9823QB, about $7000. We order one in August 2012, received last week (results to come)

We were asked to consider use (save $) some spare 5-inch quartz tubes used by G0

- Investigated 8 spare quartz tubes (XP4578)
  - Unproductive - tubes are faulty
    - DC discharge at anywhere between 1100 and 1500V.
    - "Good ones" show some after-pulsing at around ~500ns-- gas contamination.
- Returned to JLAB today

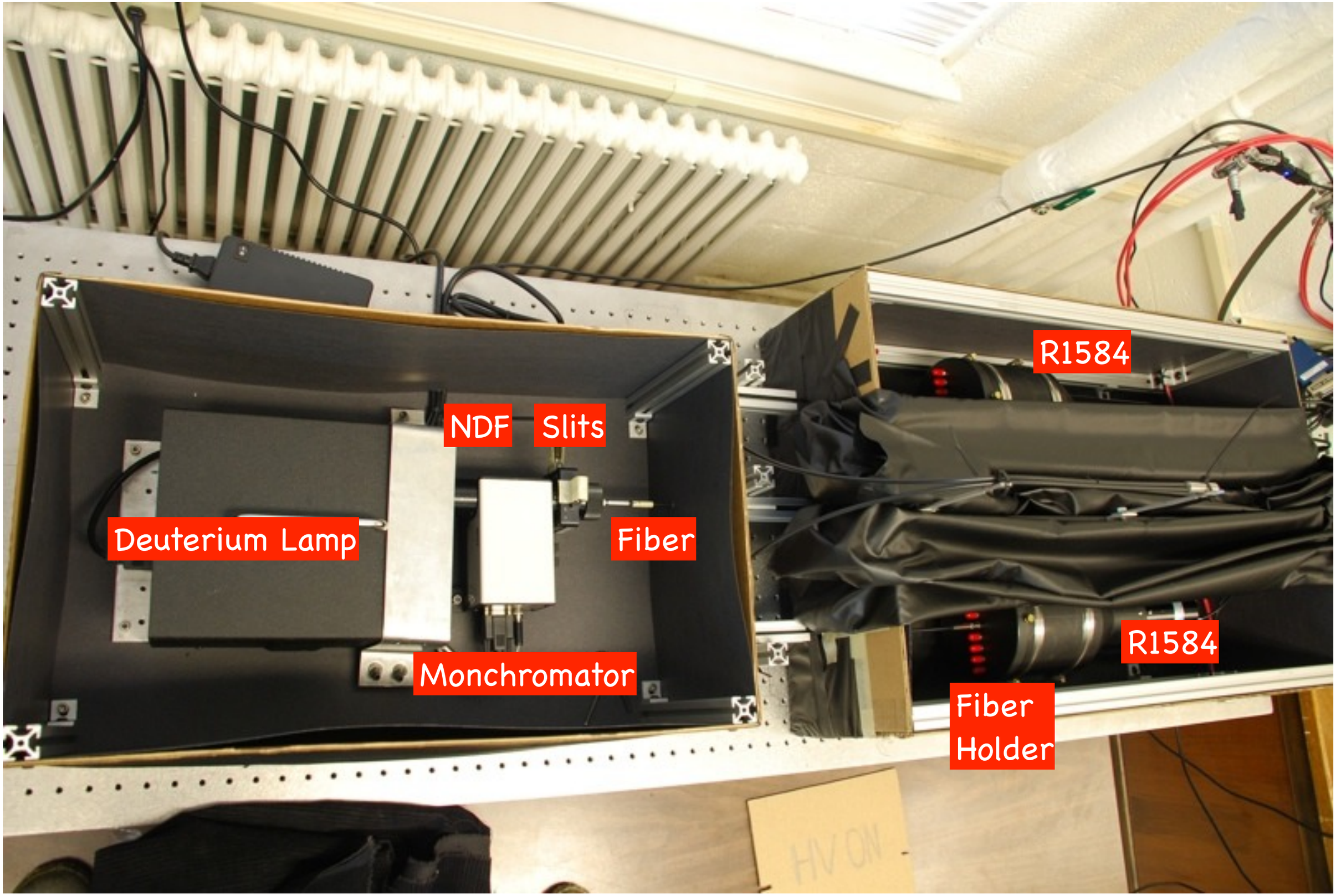
PMT testing Setup

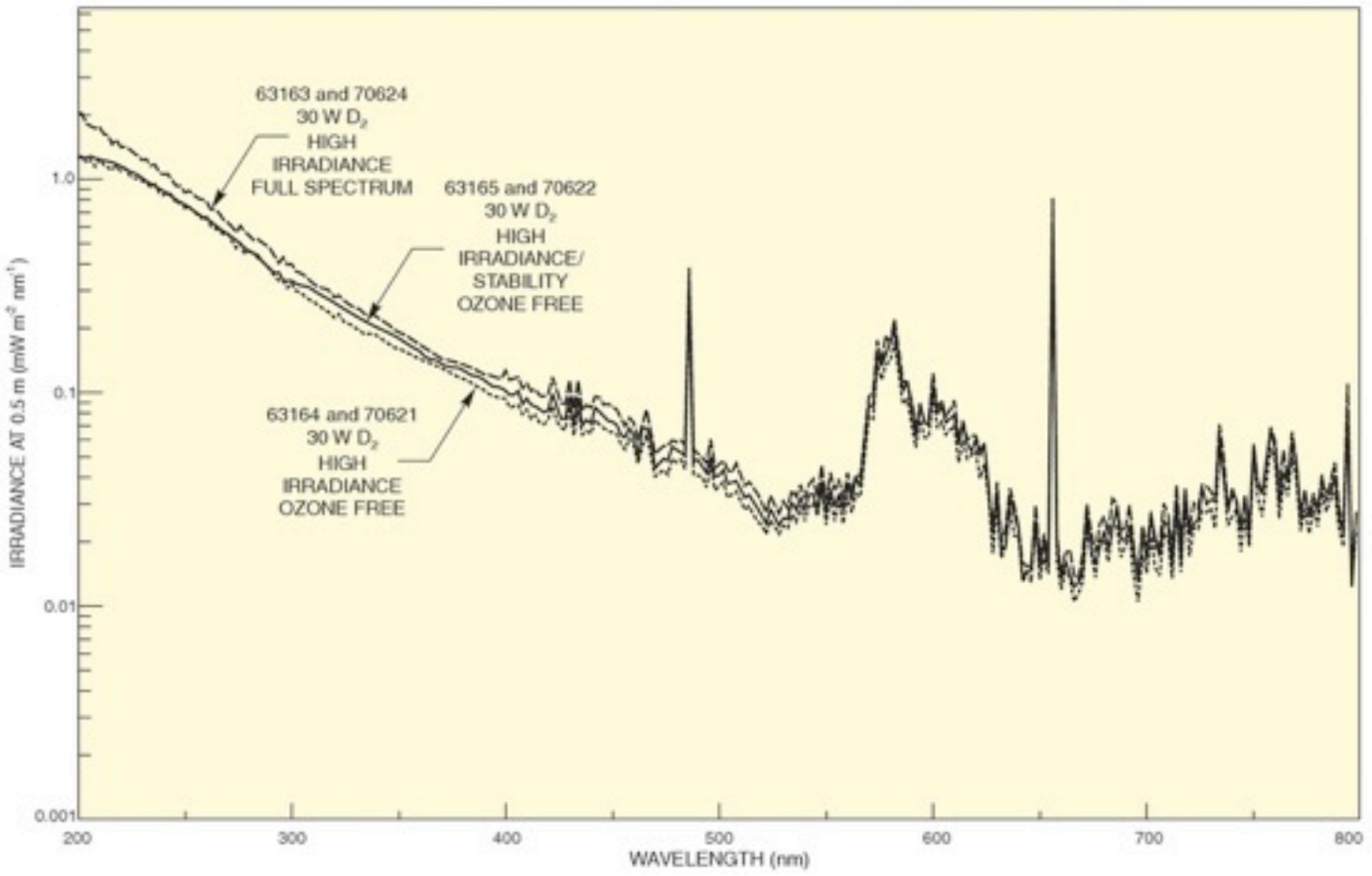
- Setup a testing system to estimate PMT spectral response before and after coating
- Photocathode relative sensitivity tests. We make measurements before and after coating.



Issues: lamp lifetime, reproducibility, intensity is function of wavelength

Test Setup


NDF
Slits
Deuterium Lamp
Fiber
Monchromator
R1584
R1584
Fiber
Holder
HV ON

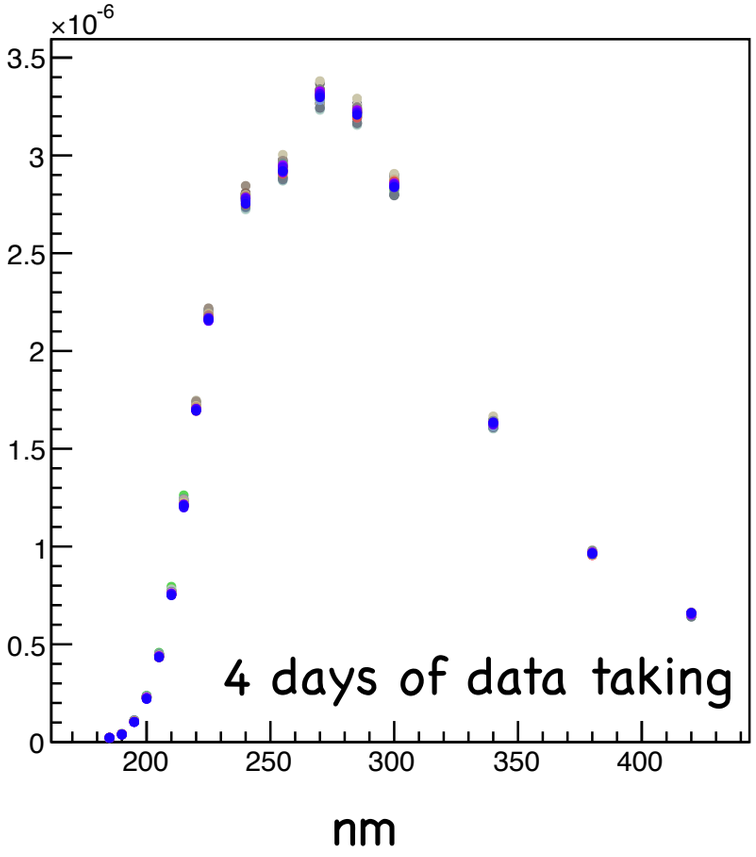


$$I_t = I_0 \times e^{-ct}$$

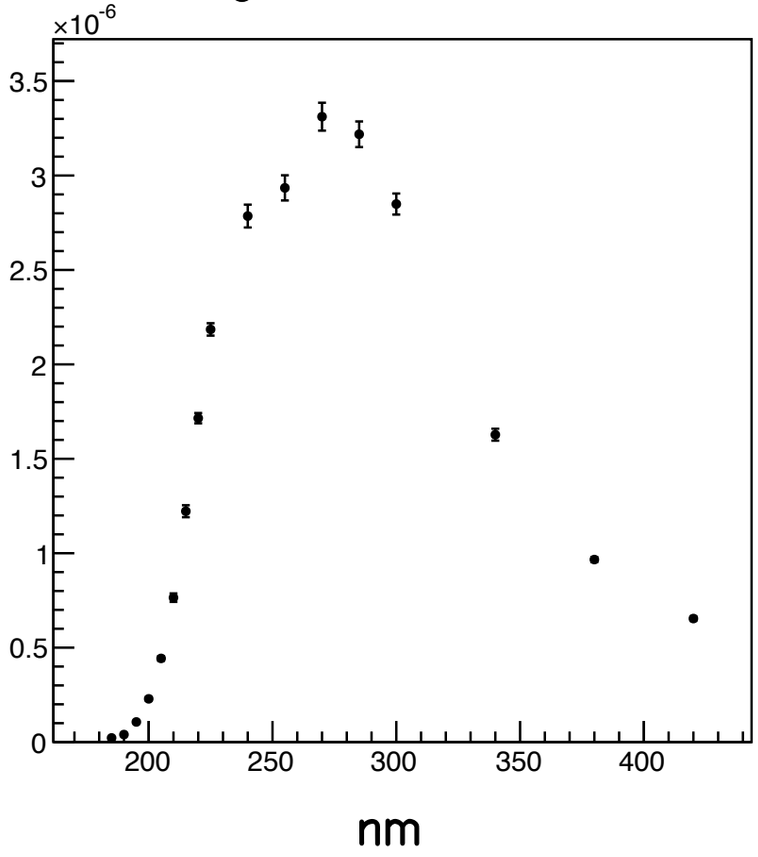
Typical lifetime = 1000 hours

Estimate maximum uncertainty of measurements: Lamp and PMT warm up, lamp degradation

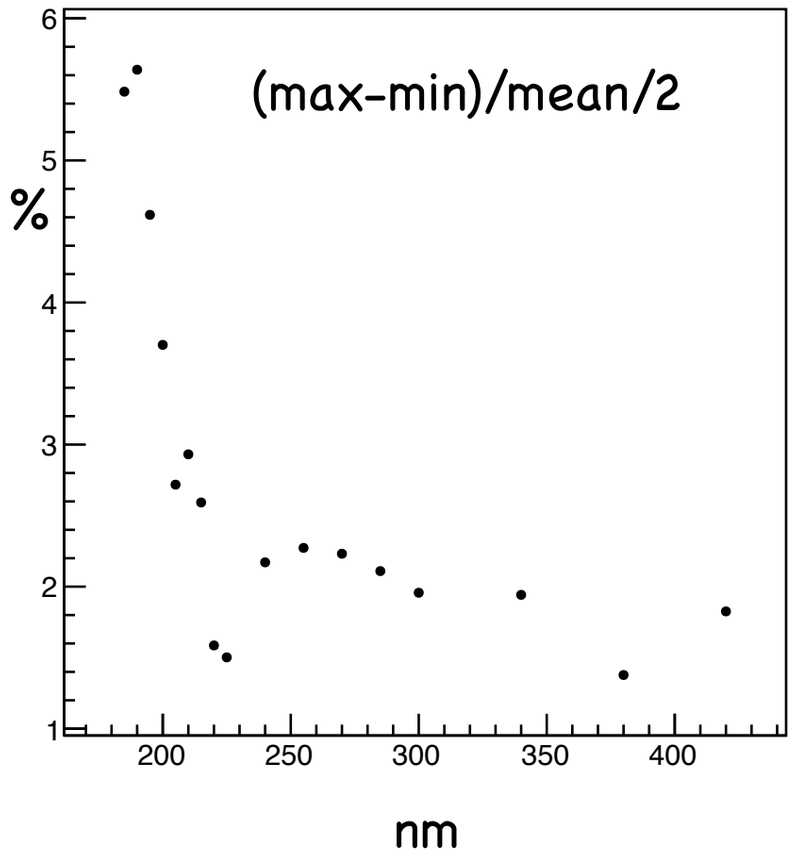
Reference PMT



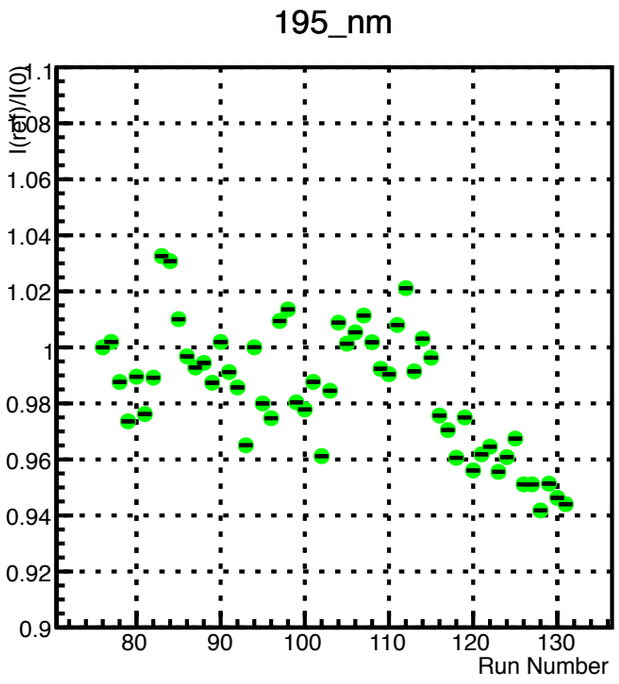
Averaged Ref PMT for all runs

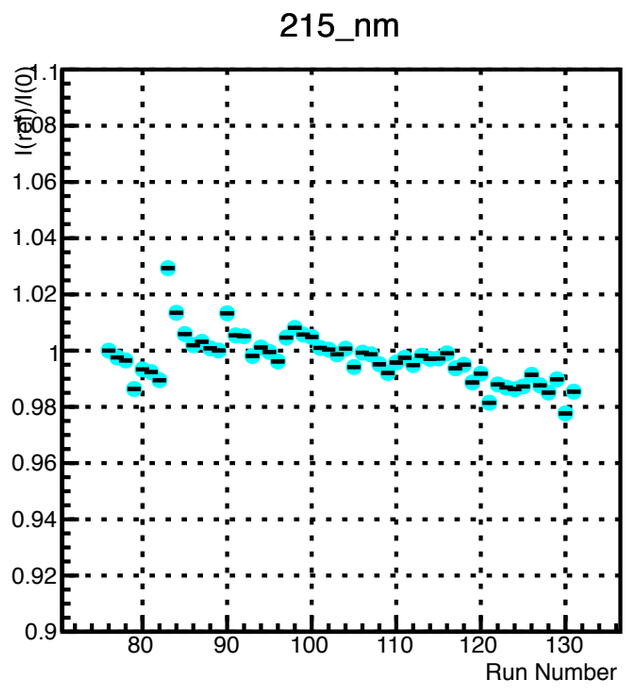


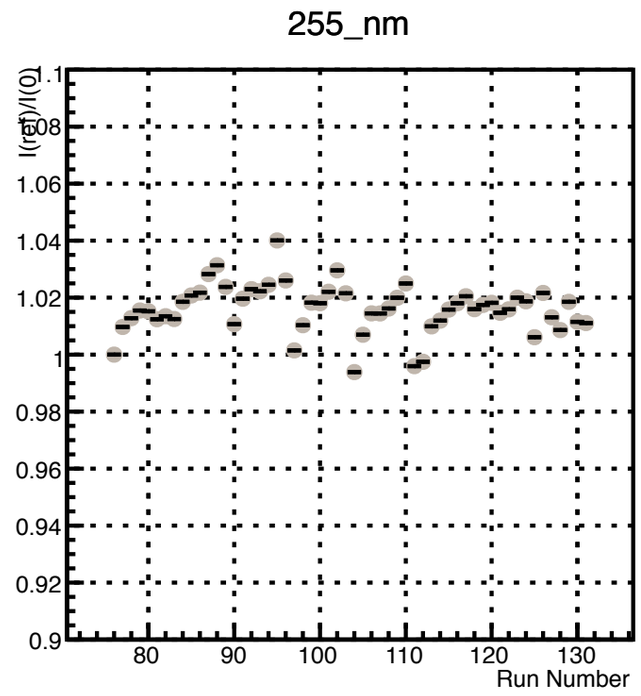
Max Relative Uncertainty for Warm-up

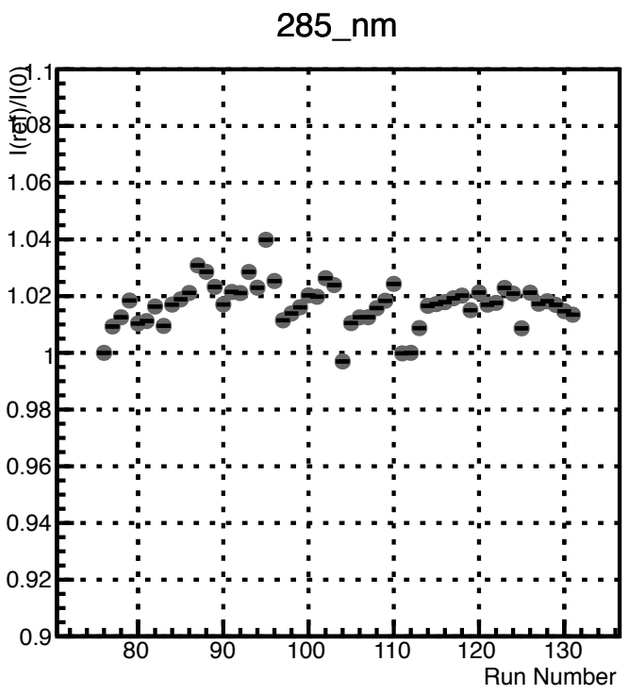


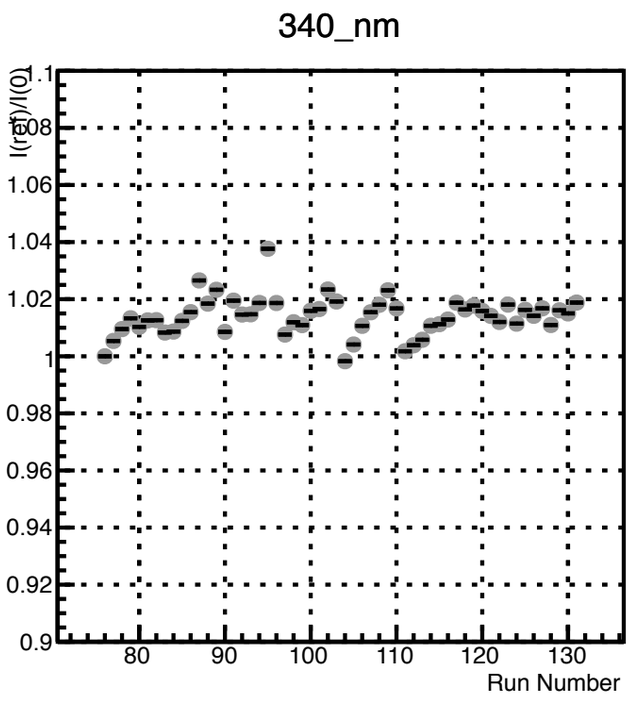
I_{ref}/I_{ref}(1st run)

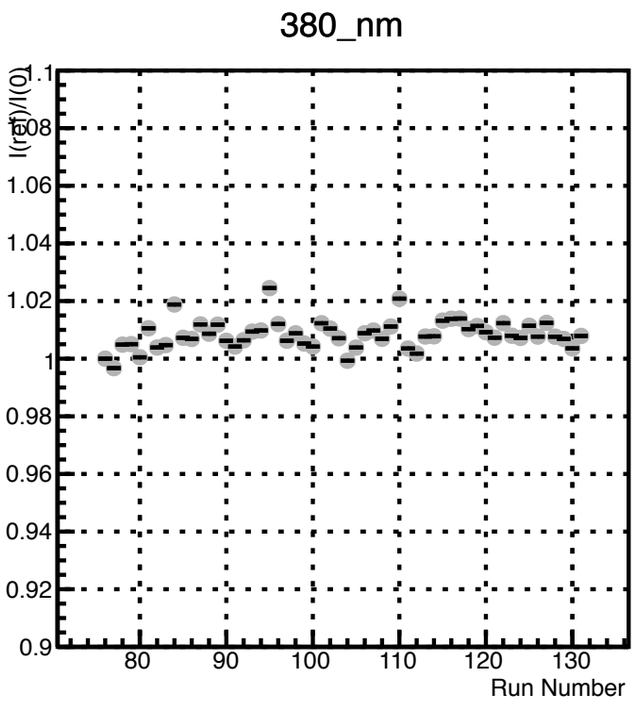






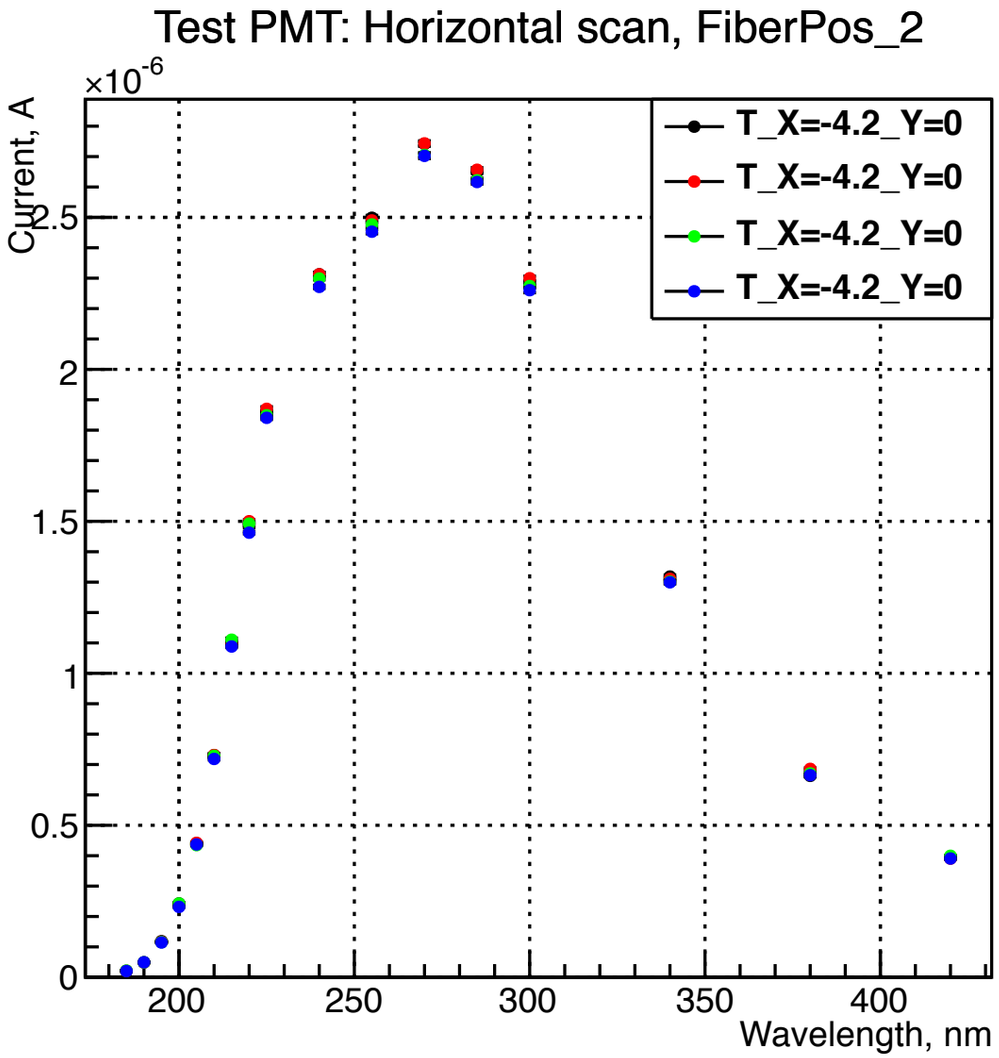


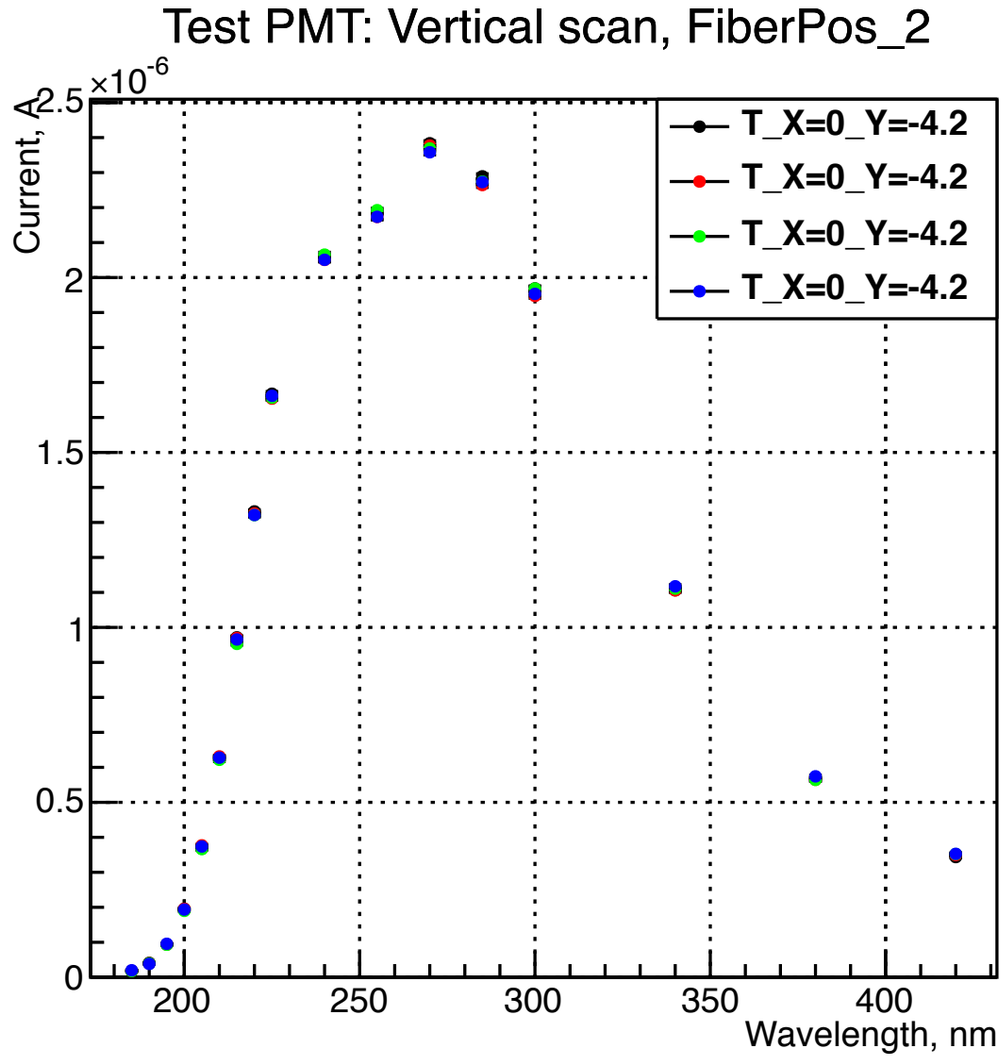




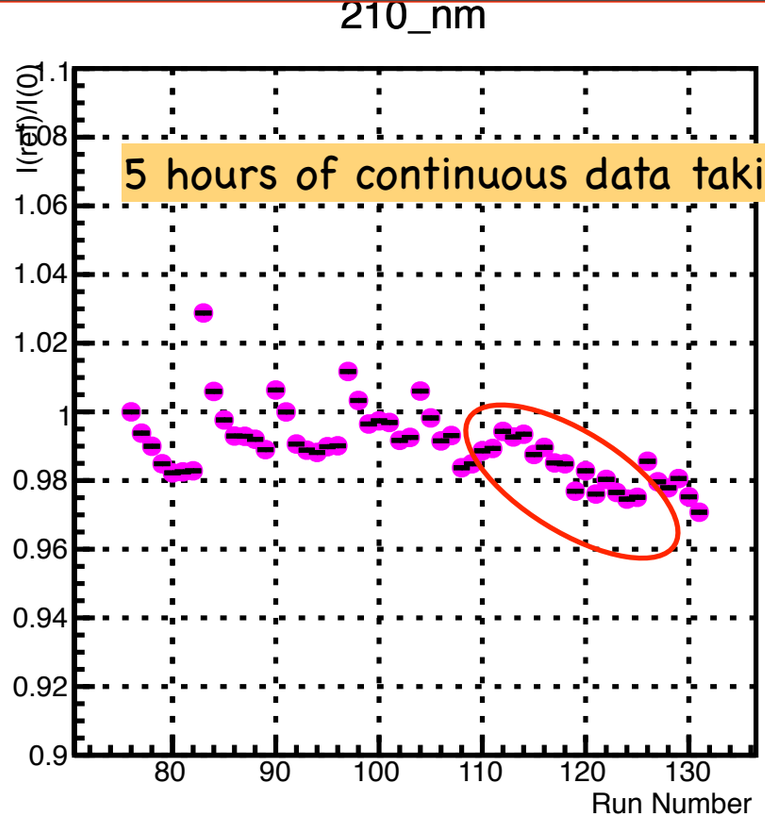
Turn on/off lamp, turn on/off PMT, over several days

4 'runs' separated by arbitrary times (lamp on/off/ degradation, pmt warm up time)

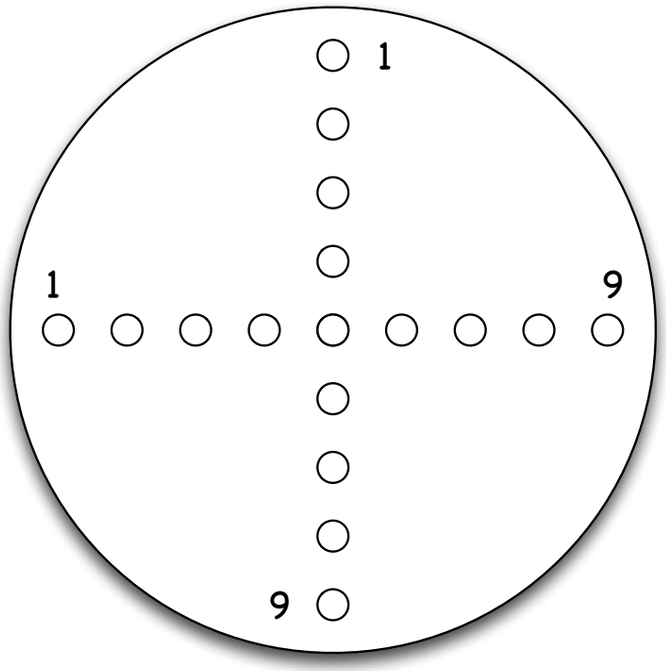


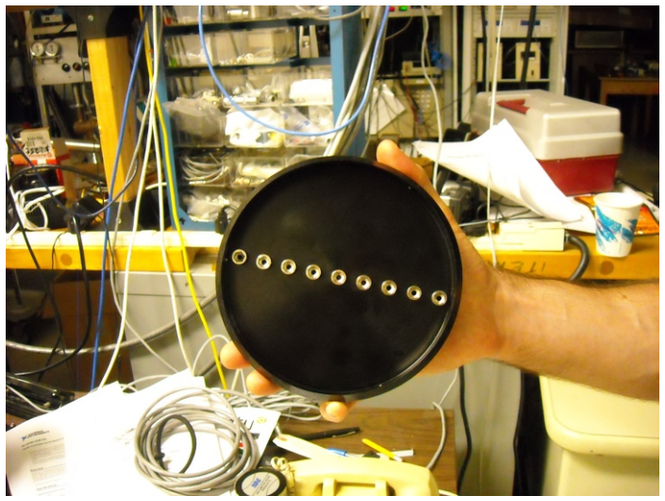


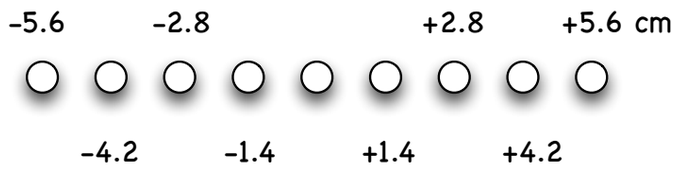
System is reproducible, lamp degradation is modest, results should be reliable



Always normalize to the Reference PMT

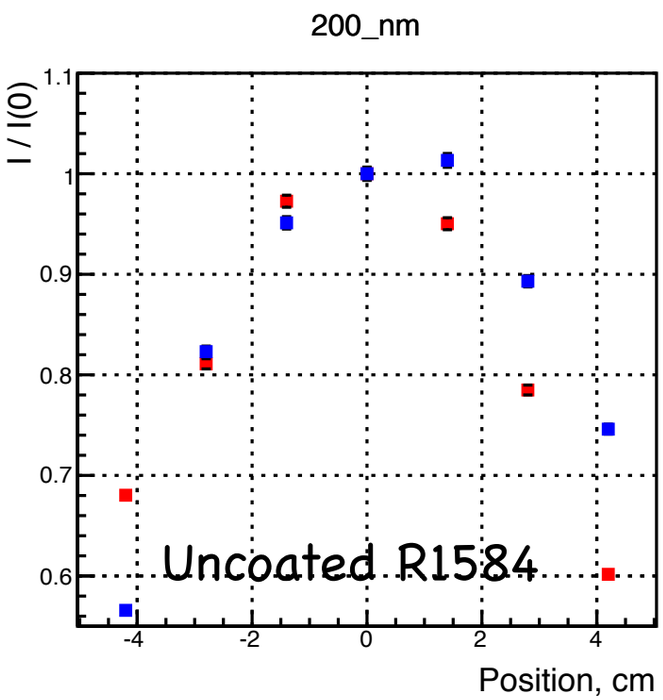


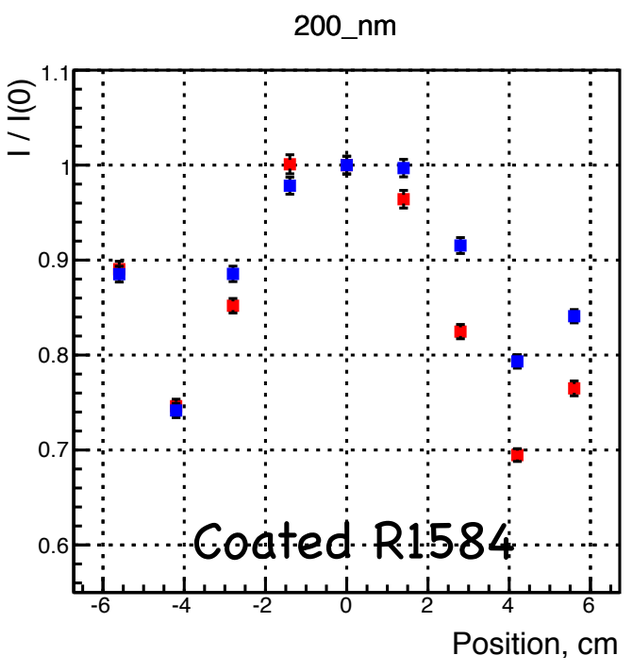


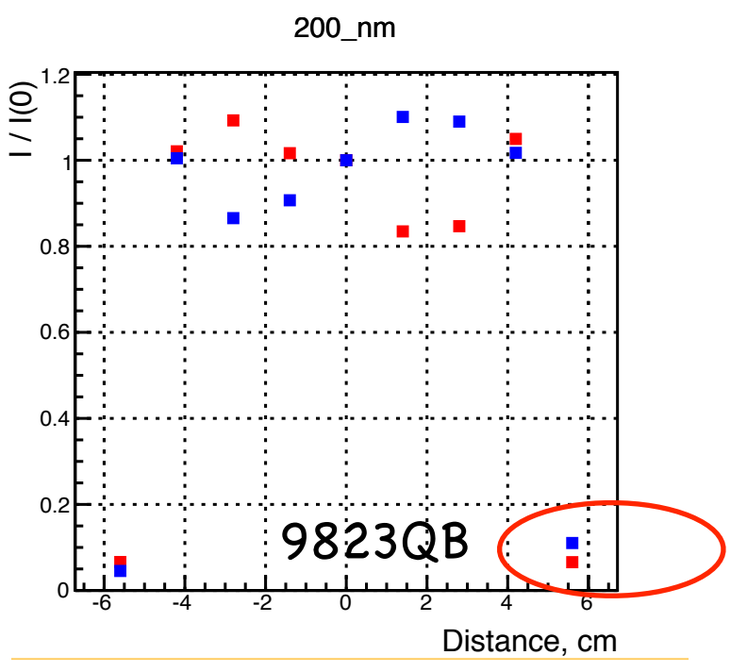


Consider the position on the face of PMT

Collection Efficiency



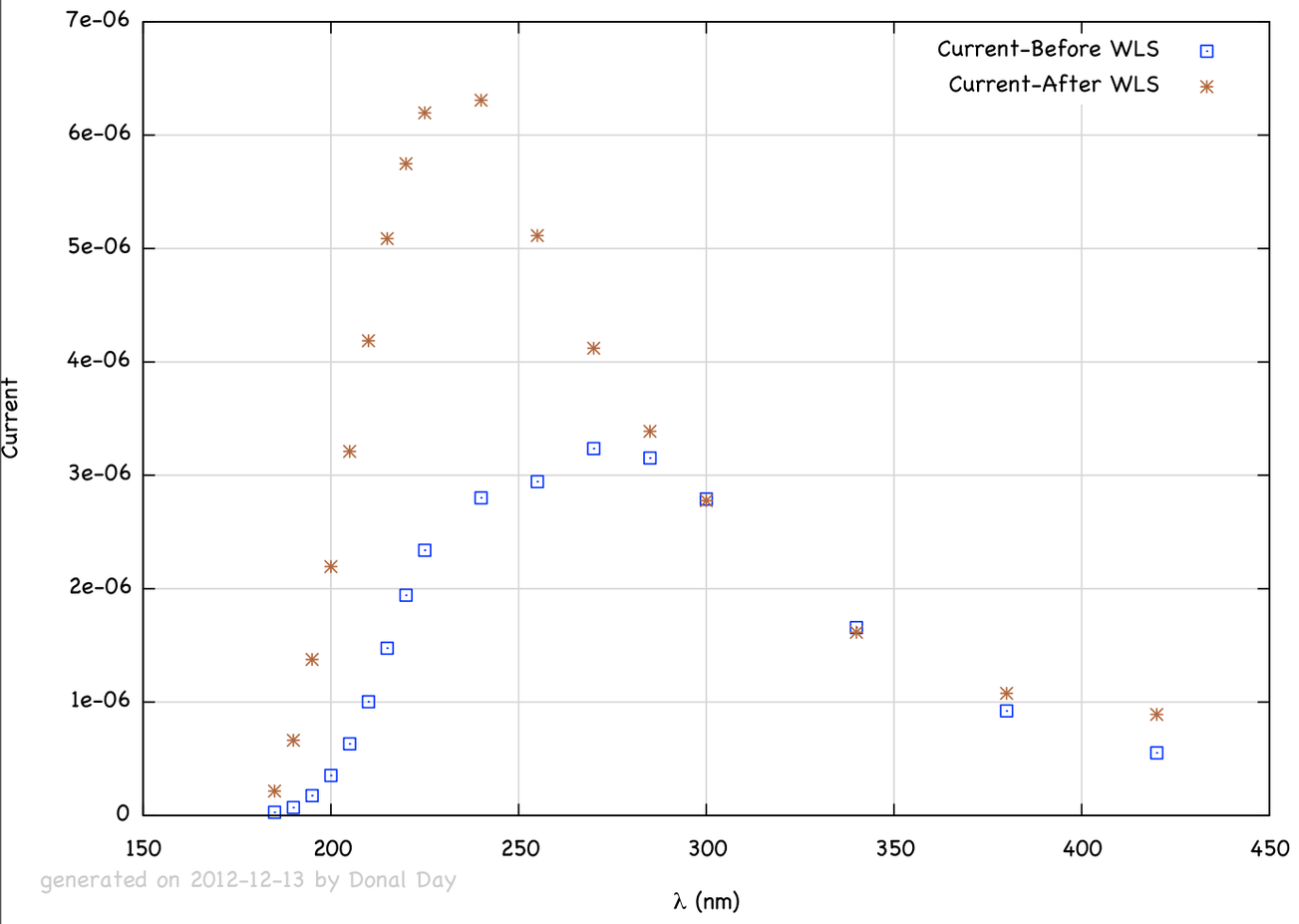


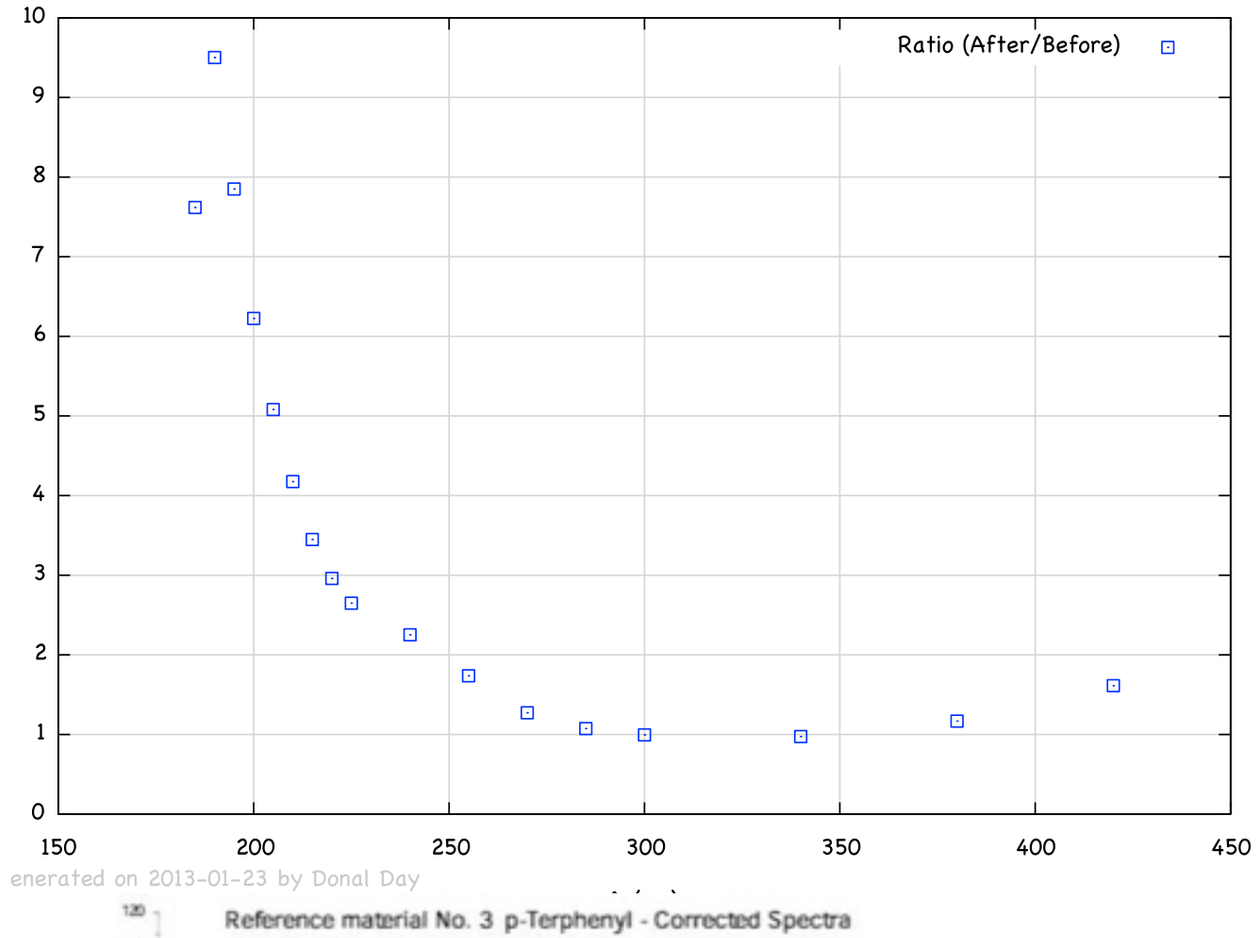


Basically independent of wavelength

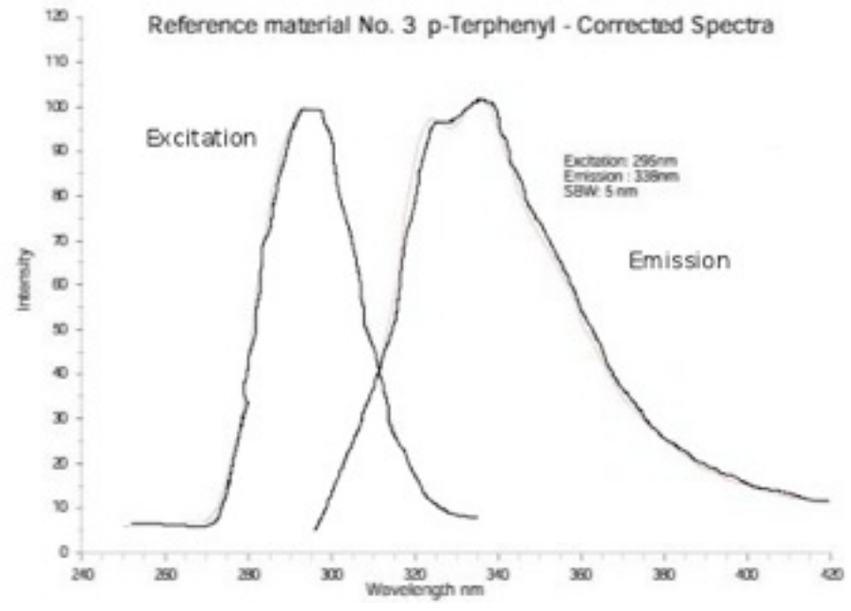
Test R1584 PMT, coated at Fermilab, no protective coating

- Characterized Hamamatsu R1584 prior to sending for WLS coating
- Returned from Fermilab, we tested R1584 coated with p-terphenyl is in 2nd week of November.





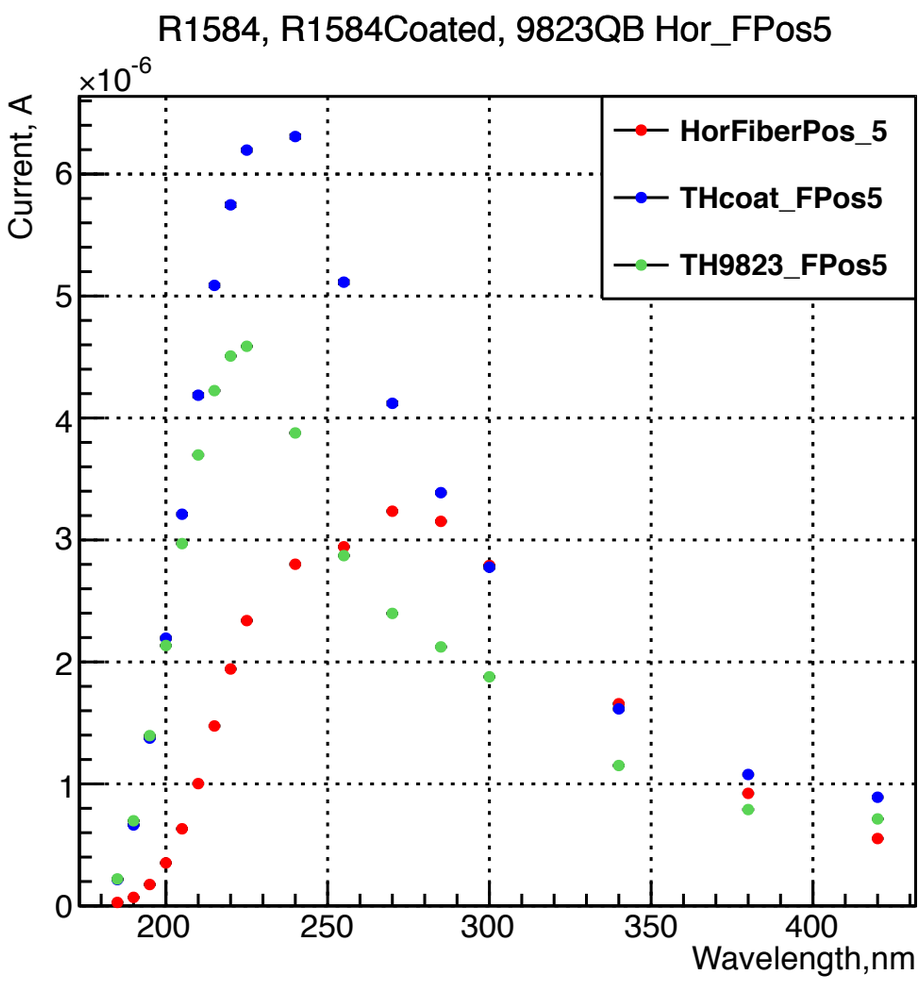
Why? the absorption of the light by p-terphenyl is fairly well peaked at about 295 nm - much diminished at 180-200 nm.



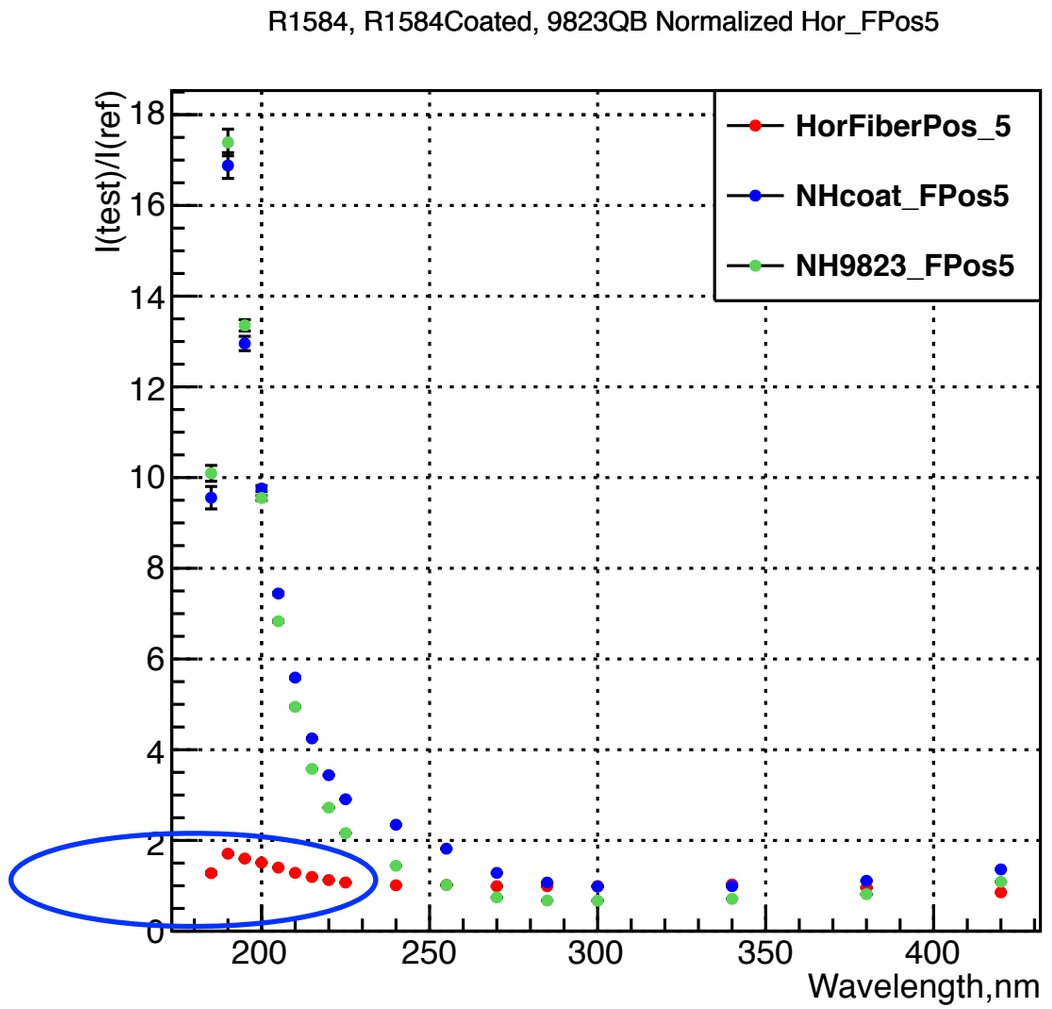
Comparison* of R1584, Coated R1584 and 9823QB

- Quartz tube (ET 9823QB) arrived last week
  - 14 stage
  - 5 inch tube
  - 110 mm active area, compared to 120 for R1584 (also 14 stage)
- Submit to same test as the R1584 in order to determine it performance relative to both uncoated and coated R1584

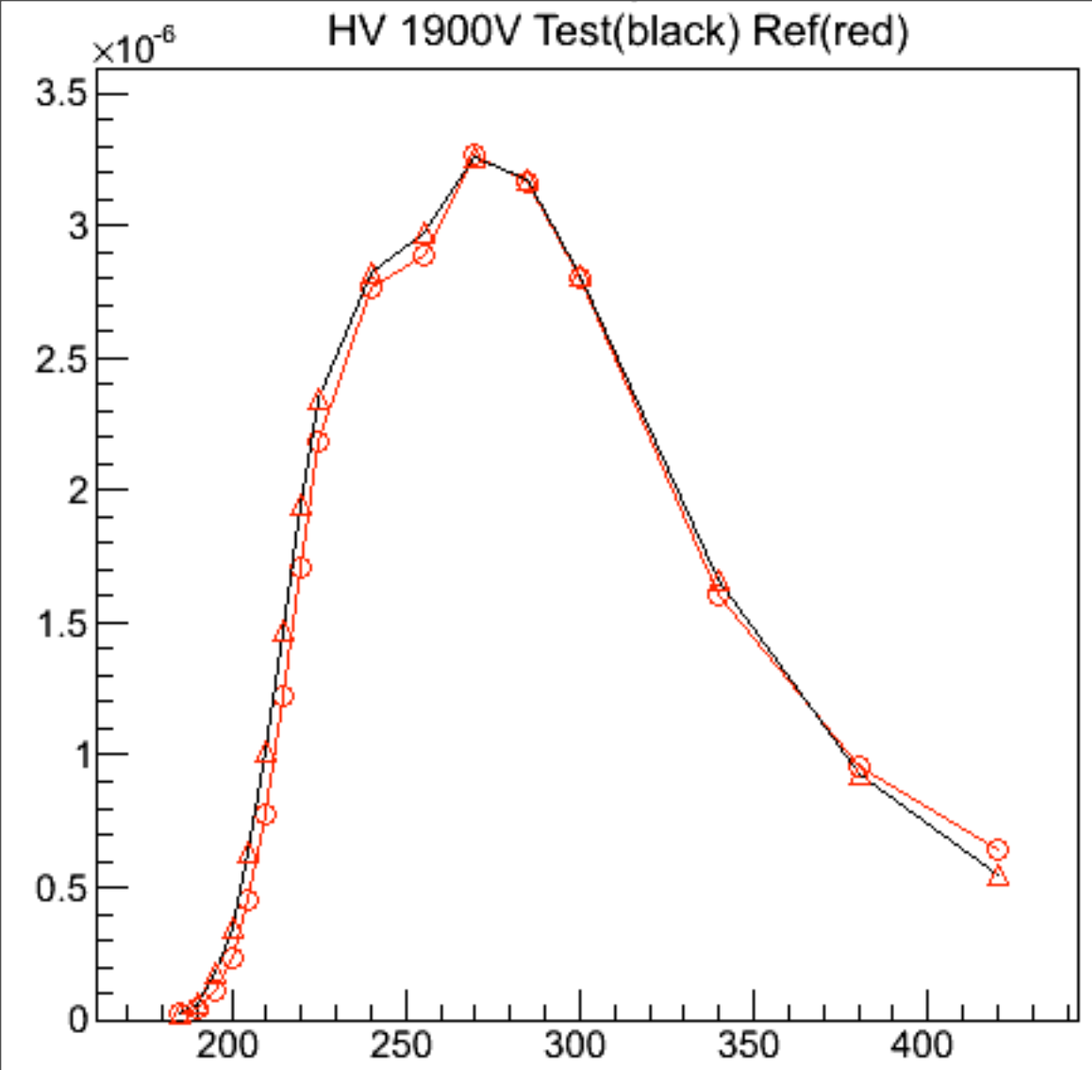
* gains not normalized but ...

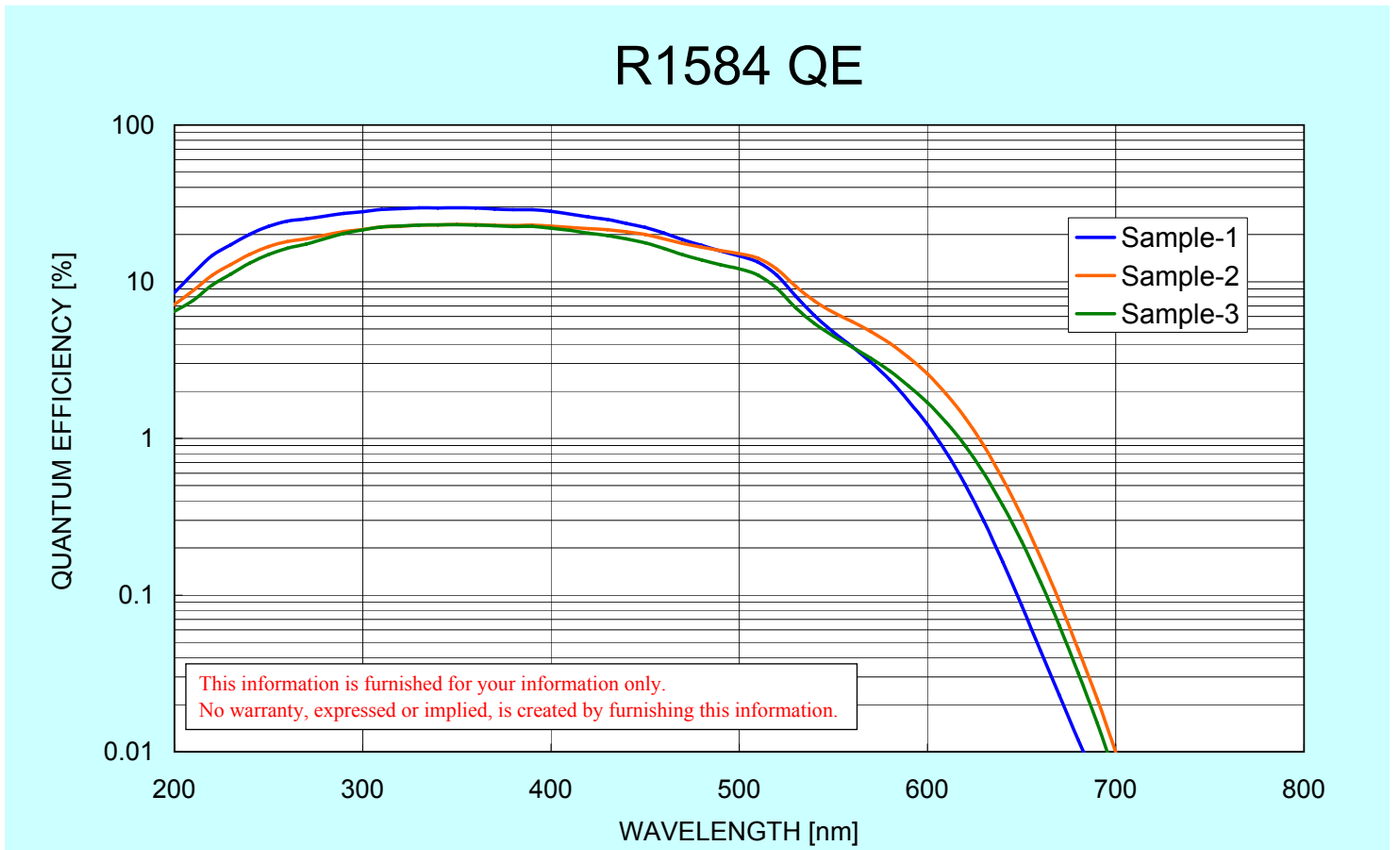


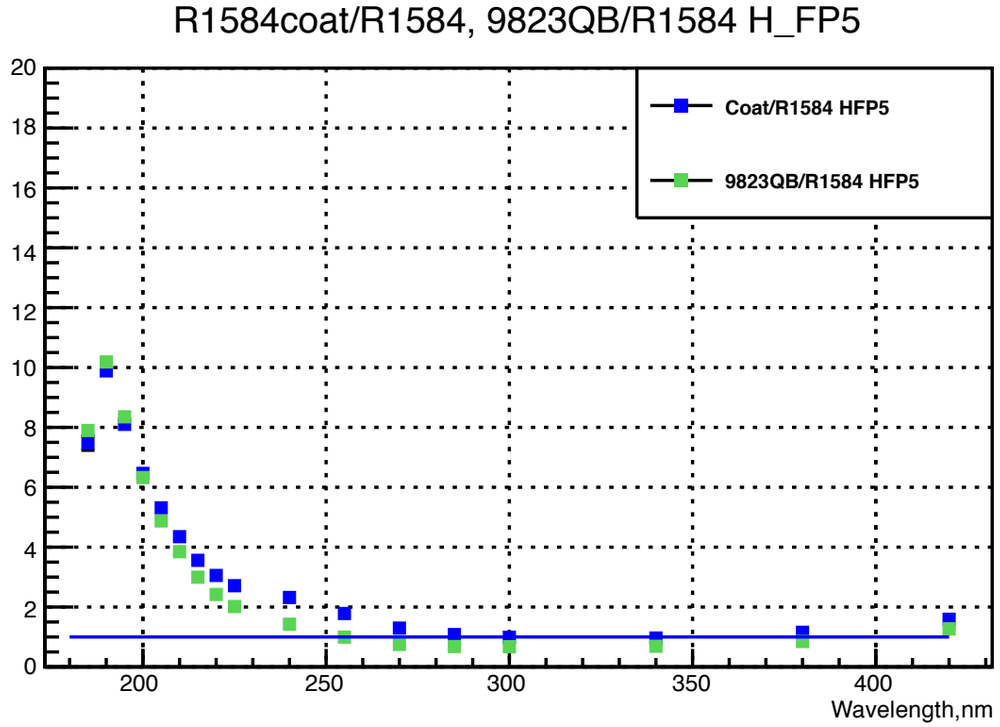
Current

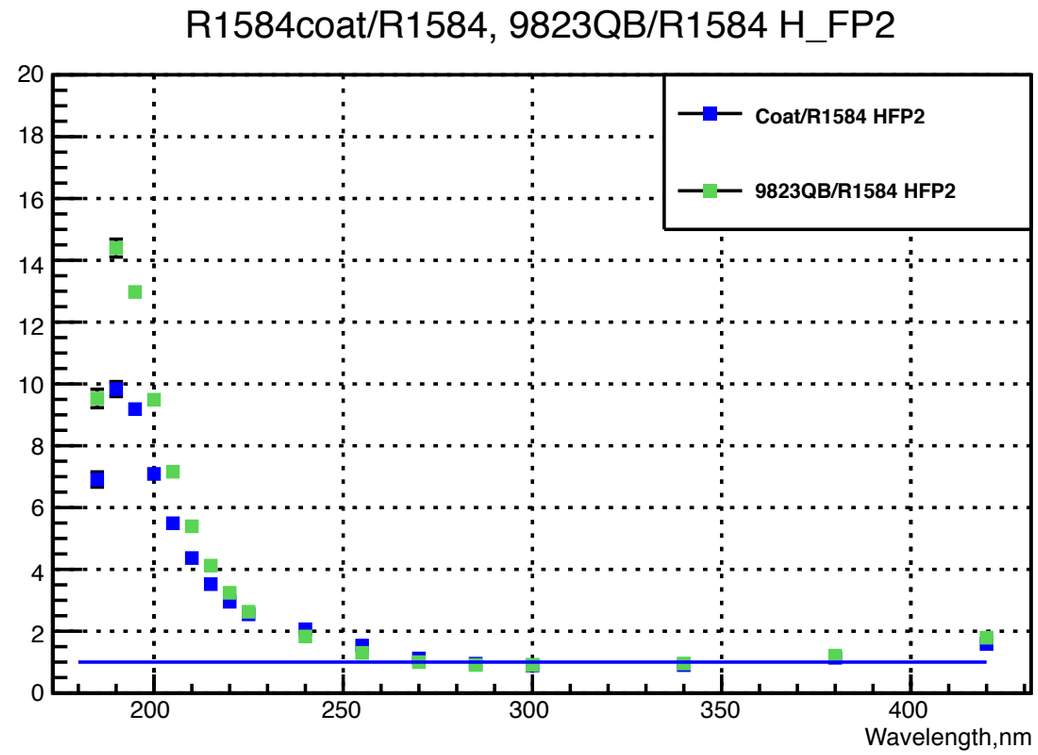


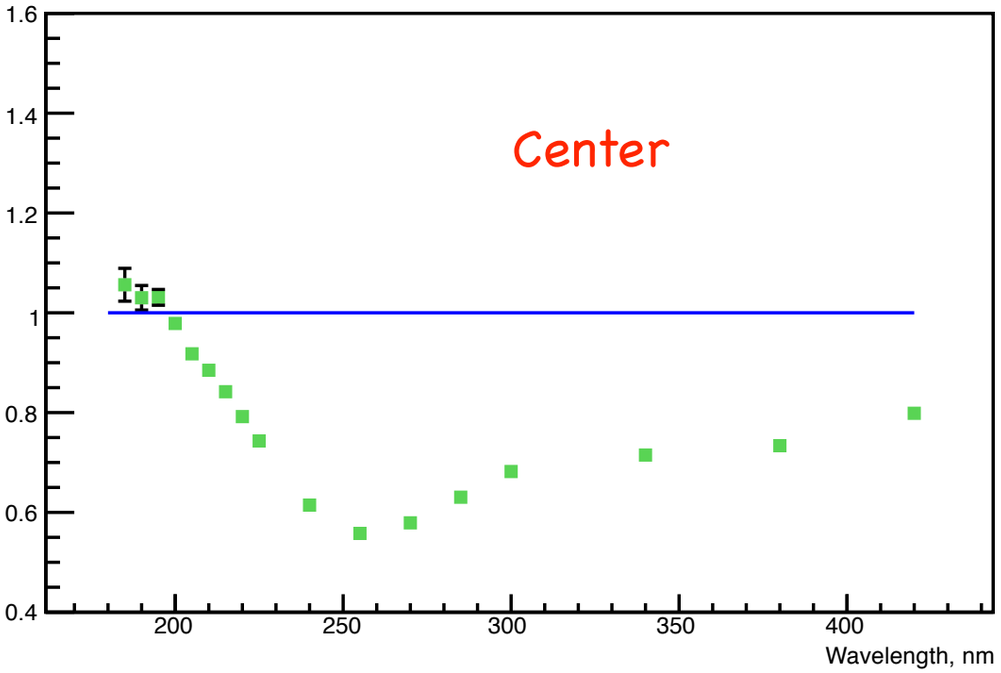
Current divided by Reference PMT

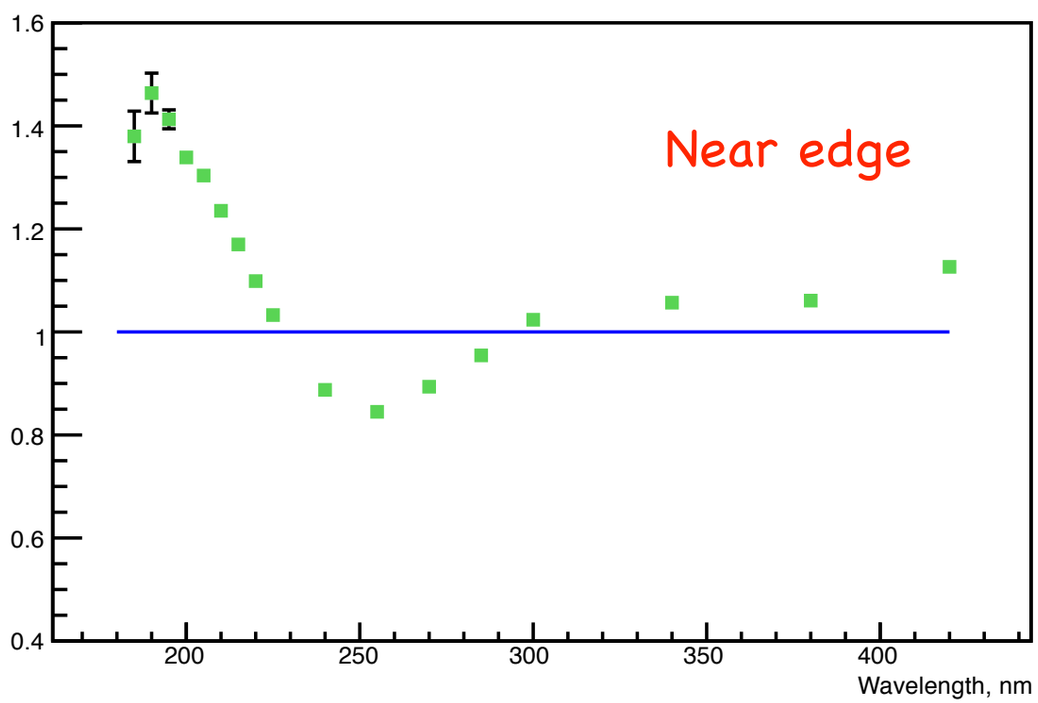

HV 1900V Test(black) Ref(red)
×10⁻⁶
3.5
3
2.5
2
1.5
1
0.5
0
200
250
300
350
400


R1584 QE
QUANTUM EFFICIENCY [%]
100
10
1
0.1
0.01
200
300
400
500
600
700
800
WAVELENGTH [nm]
Sample-1
Sample-2
Sample-3
This information is furnished for your information only.
No warranty, expressed or implied, is created by furnishing this information.
HAMAMATSU
HAMAMATSU PHOTONICS K.K. Electron Tube Division









First order conclusion is that within the variations across the face and manufacturers control of QE, WLS coated UV glass PMT competes easily with quartz

Bottom line with respect to Photoelectron Yield for NGC

$$N_e = 2\pi a\left(1-\frac{1}{\beta^2 n^2}\right)\int_{\lambda_1}^{\lambda_2}\epsilon_c(\lambda)QE(\lambda)G(\lambda)\frac{d\lambda}{\lambda^2}\int_0^L dx$$

$$= AL\left(1-\frac{1}{\beta^2 n^2}\right)$$

QE, Mirror reflectivity, gas absorption, collection efficiency

Tube	A	N_{pe}
Hamamatsu 5in (R1584) UV glass	219	5.9
Electron Tubes Quartz	349	9.4
G0 XP4578	284	7.6
Hamamatsu 5in (R1584) WLS	349	10.7

For argon, π_{thres} = 11 GeV

Others have found a factor of 2 or 3

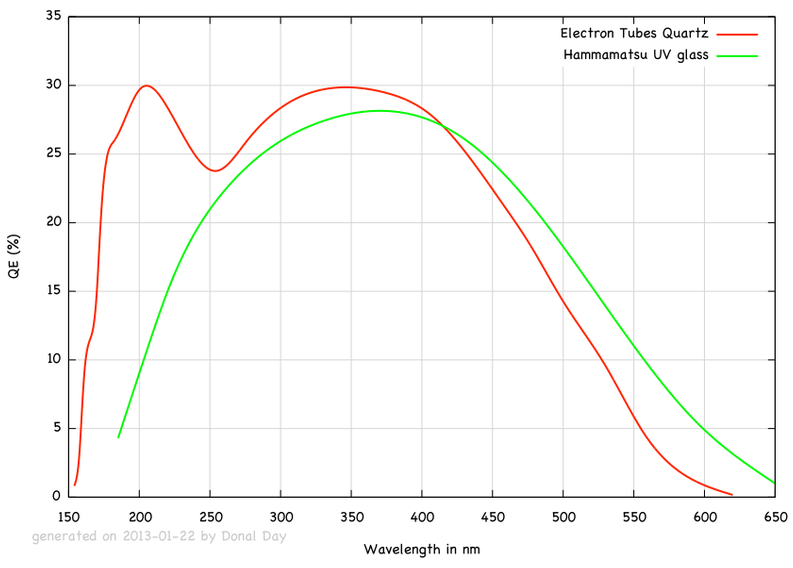
When I multiply the R1584 QE by the ratio of coated to uncoated, I get almost a factor of 2

Decision Time?

Not quite yet. Funding only available after Oct 1.

The gains? We believe they are approximately equal. We get about the same current where the Hamamatsu and the ET tubes have equal QE's

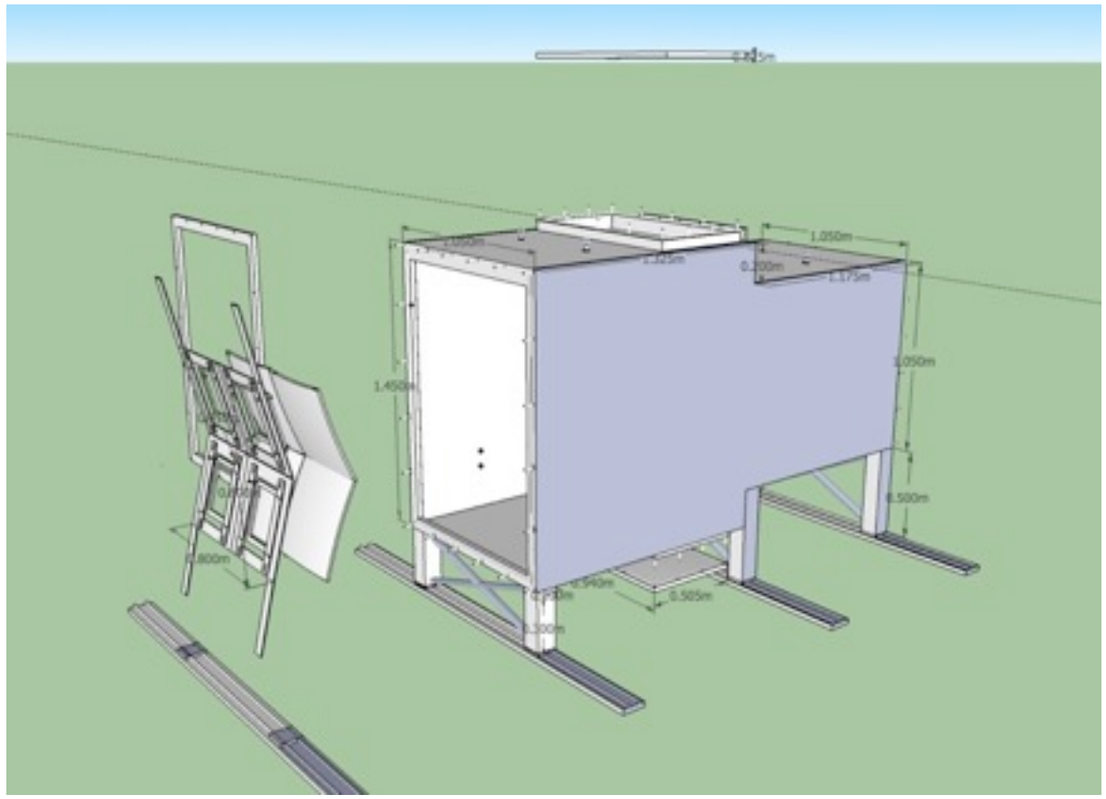
We will fix the gains to be equal and repeat

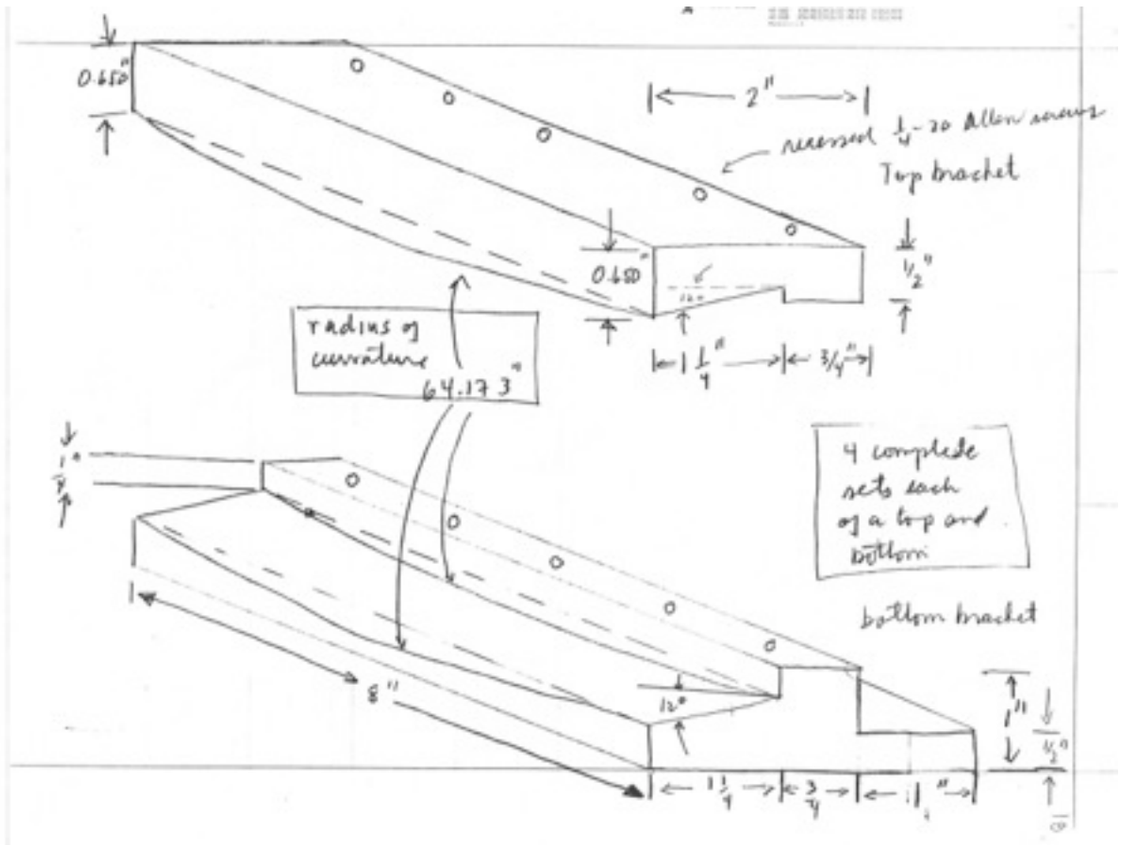


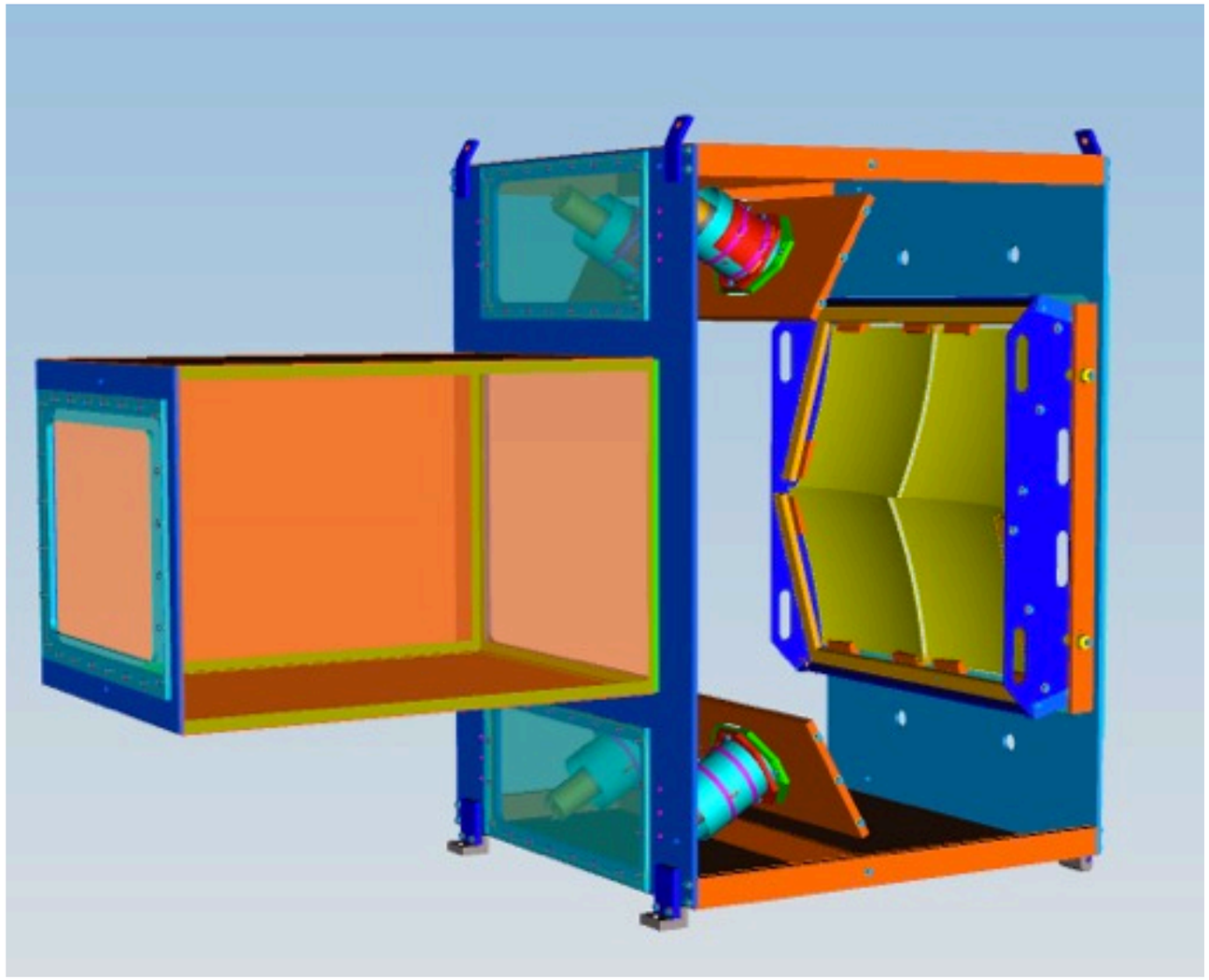
Tank Design

Decision taken long time ago to work at 1 Atm - a simple box and frame - UVa draft.

We passed our experience with HMS Cerenkov to Bert Metger who proceeding with the design

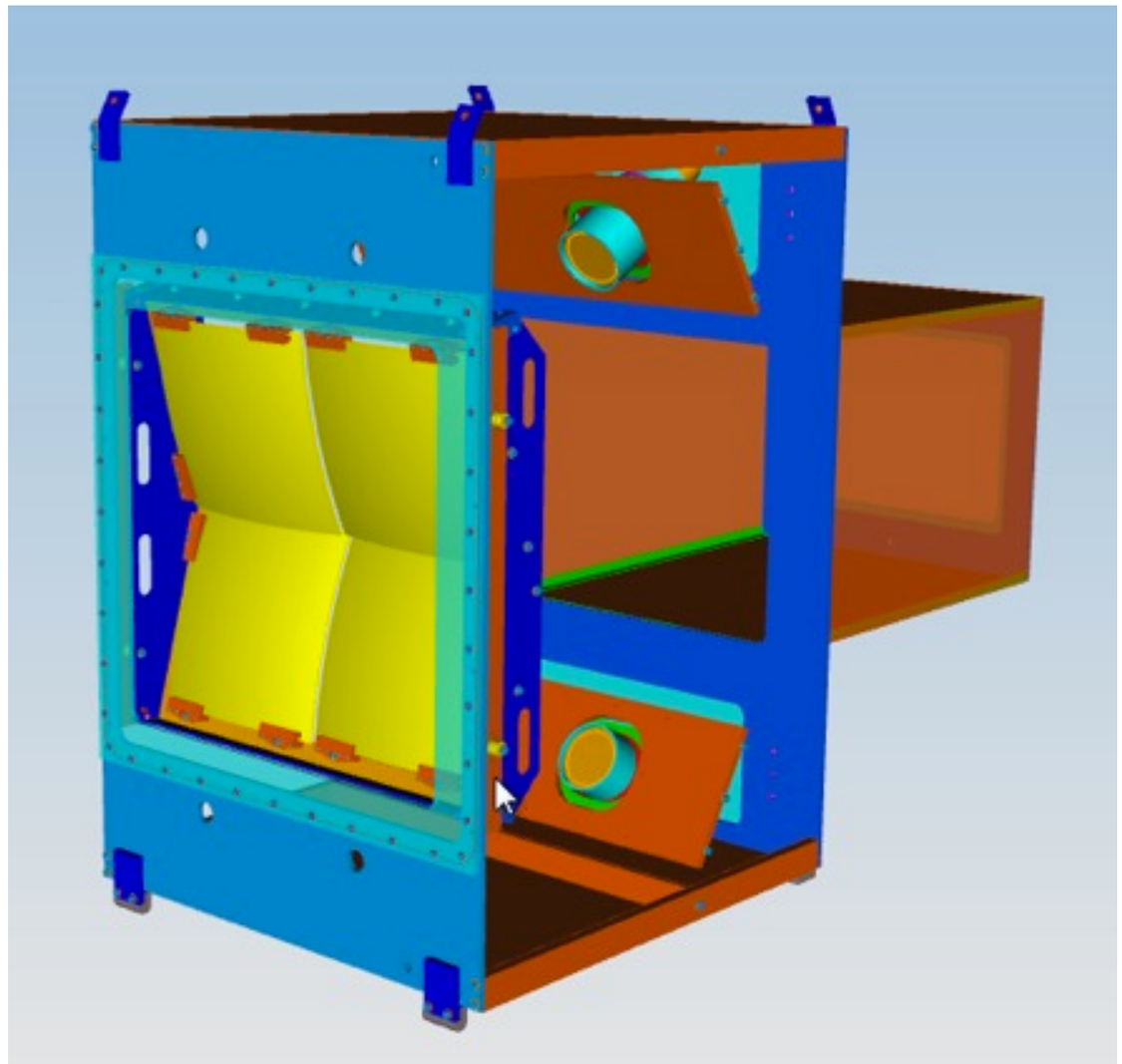






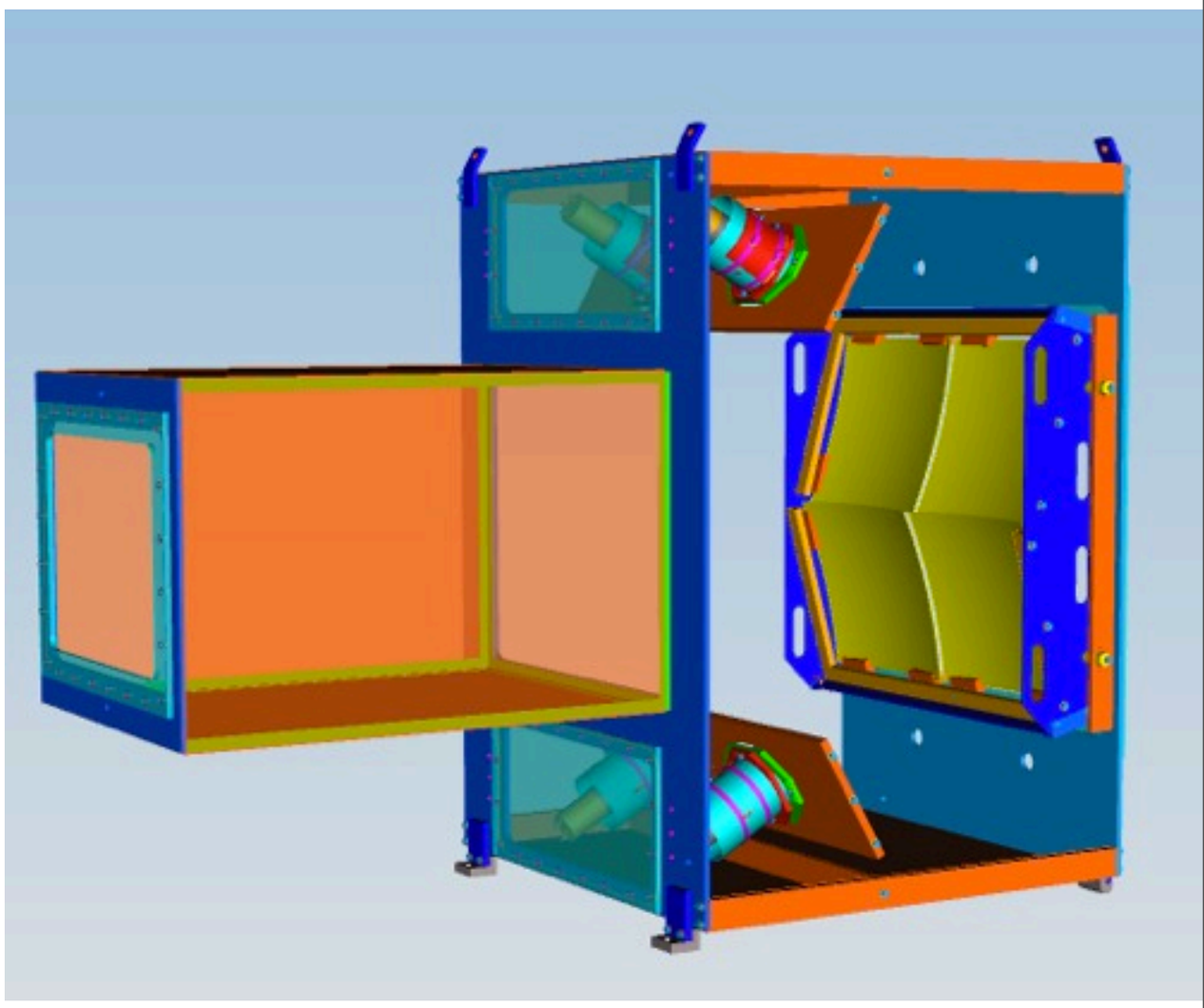
SHMS NGC tank, Jan 2013

Welded box



Few Issues

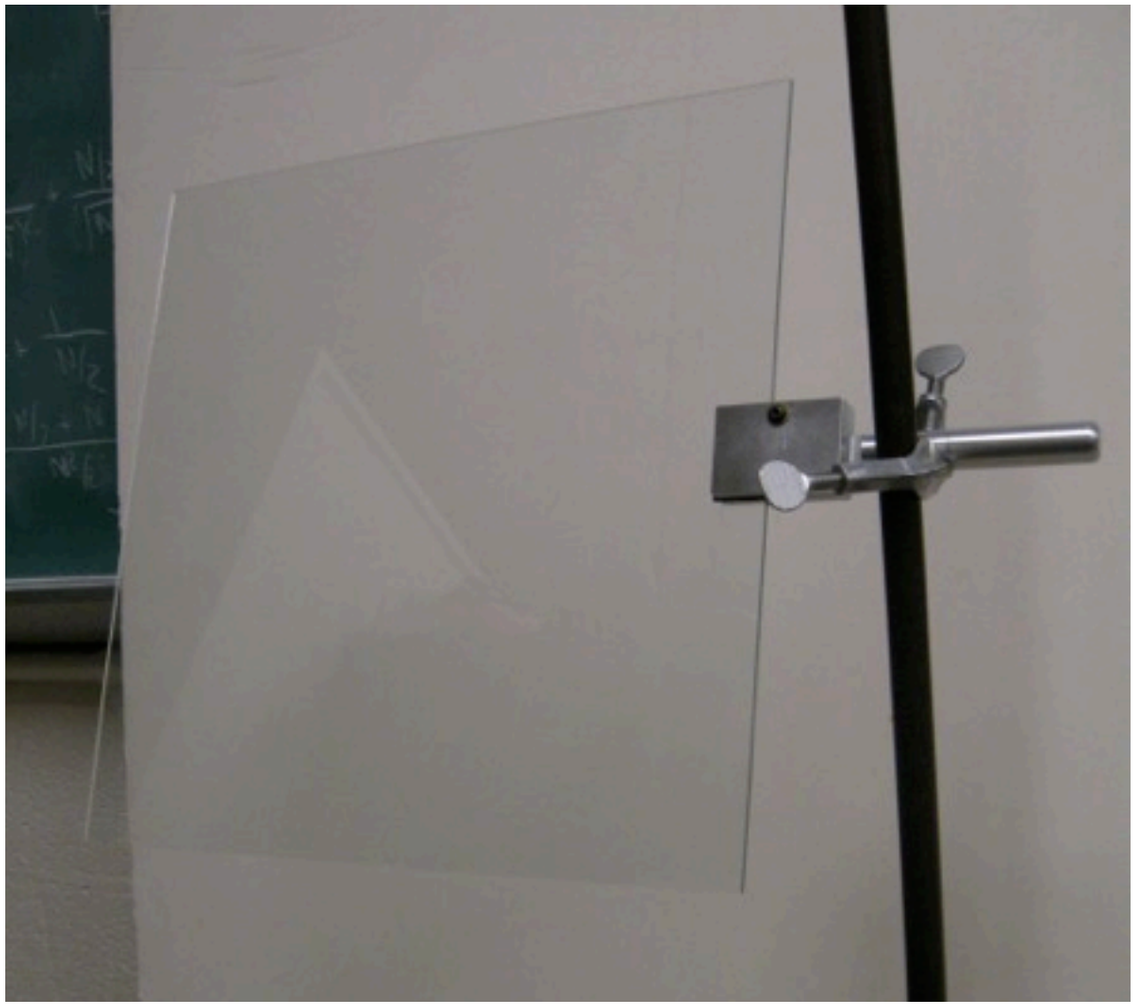
- Reduce # of mirror mounts to 2 and use neoprene pad
- Mirror tilt is not easily adjustable and limited
- Mounting mirror in master frame appears problematic
  - Need access to mirror edges to place in frame
  - Installing master frame in tank appears difficult (a handle or two?).

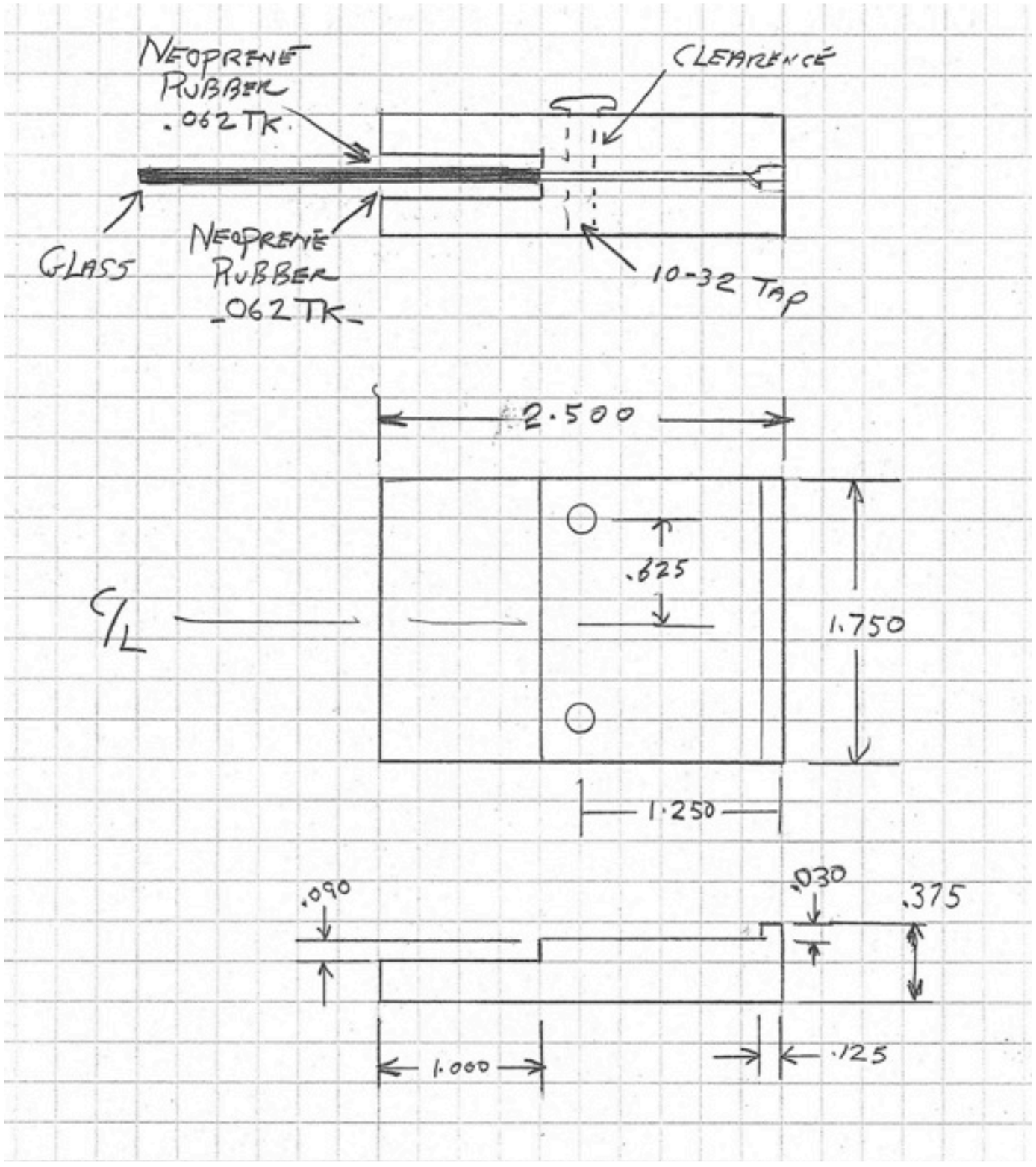


- One side of tank should be removable (to look at mirrors during alignment
- Snout of tank should be removable for mirror alignment
- Work assembly with UVa shop
- Does UVa shop welder need any certification?
- Alignment process to be detailed

Improving process

- I will hire UVa undergraduates with design experience (Solidworks and Autodesk Inventor etc) to articulate modest changes and then pass back to JLAB




NEOPRENE RUBBER .062 TK.
CLEARENCE
GLASS
NEOPRENE RUBBER .062 TK.
10-32 TAP
2.500
.625
1.750
1.250
.090
.030
.375
1.000
.125

PMT Decision

- Electron Tubes 9823B (quartz) or R1584 with WLS
  - There are different methods to apply WLS
    - Different thicknesses
    - Protective coating
      - Where to get this done?
- Economy and performance
  - No real cost saving going with R1584 and WLS, performance of ET 9823QB comparable
  - Gains, noise and timing should be evaluated
- Submit PO, anticipating delivery time (2-3 months)

Tank Design

- Tank design pretty far along (probably 90%)
- Some details have to be worked out
- Get feedback from UVa machinists on every aspect of design
  - PMT mounts, adjustment
  - Mirror mounts and adjustment
  - Converge
- Collect drawings
- Get in the queue at UVa shop.

Mirror blank order is working its way through UVa

Get mirrors coated

Spare blanks for assembly rehearsals etc.

While waiting for shop work and mirror arrival

- Write final design report
- Write procedures
  - Mirror mounting and adjustment
- Alignment procedure
- ……

Assemble and test, Fall 2013