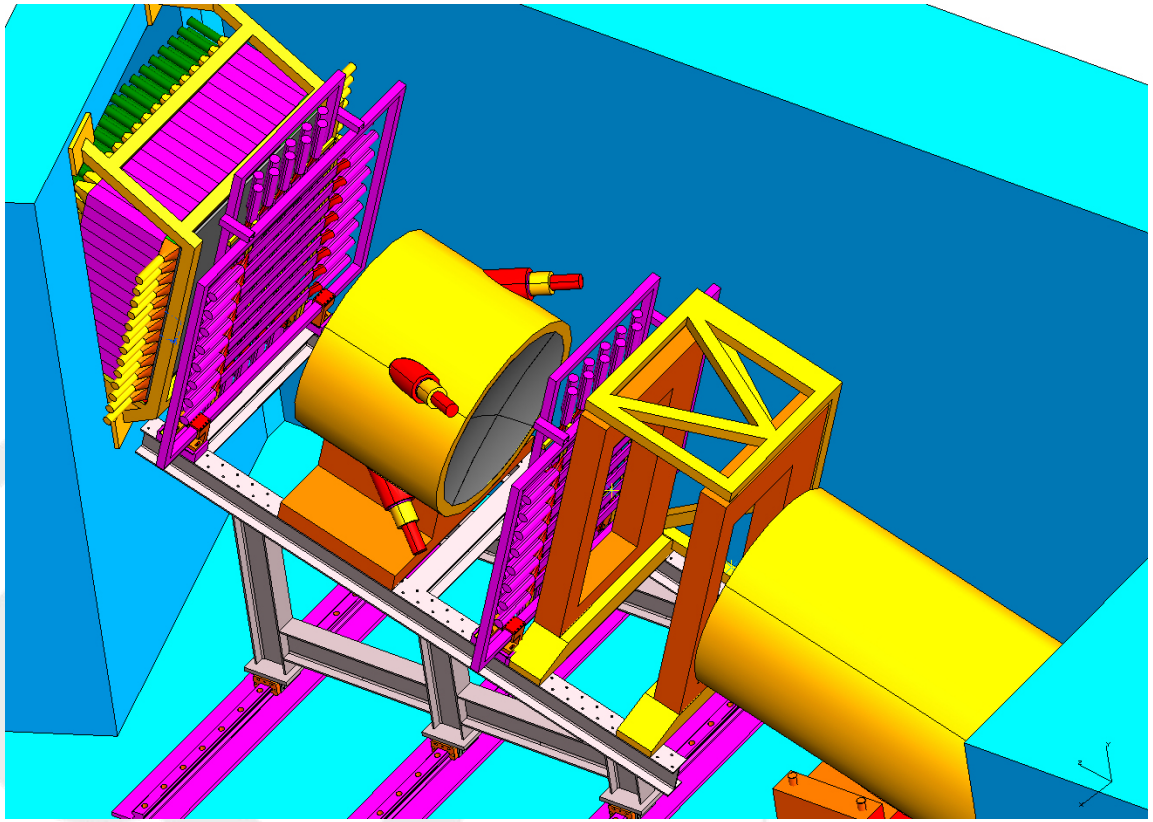
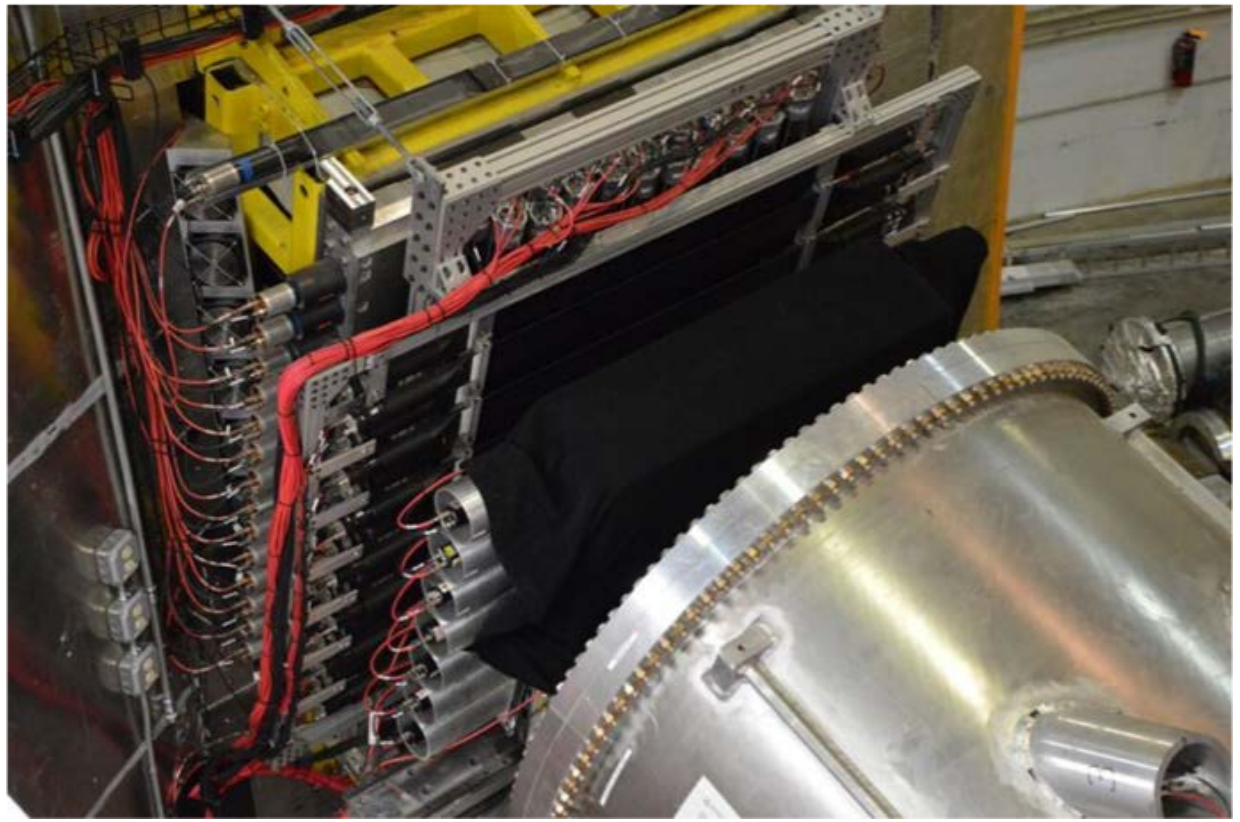
Quartz Bar Hodoscope – 32 x ET9814WB PMTs Photon Detection Efficiency Validation





C. Zorn, JLAB Radiation Detection and Imaging Group

ET9814WB – Photon Detection Efficiency Measurement

- Vendor ET provided complete scan in UV-VIS (200-700 nm) for all PMTs
- As alternative, verified performance by using ***pulsed method*** to measure actual ***photon detection efficiency (PDE)*** at **340 nm** (as per purchase requisition spec)
- This will take into account ***photoelectron collection efficiency*** and ***QE*** of PMT
- **Initial Specs in Purchase Order:**
  - *At λ=340nm - QE ≥ 25% for all PMTs and at least 22 have QE ≥ 30%*
  - *All PMTS must have Gain ≥ 0.4 x 10^7 at HV = 1.9 kV*

Measure Photodetection Efficiency (PDE)

$$PDE = \frac{N_{pe}^{d}}{N_{ph}}$$

Mean number of detected photons / Mean number of received photons

$$N_{pe}^{d} = \mu_{pe}^{100\%}$$

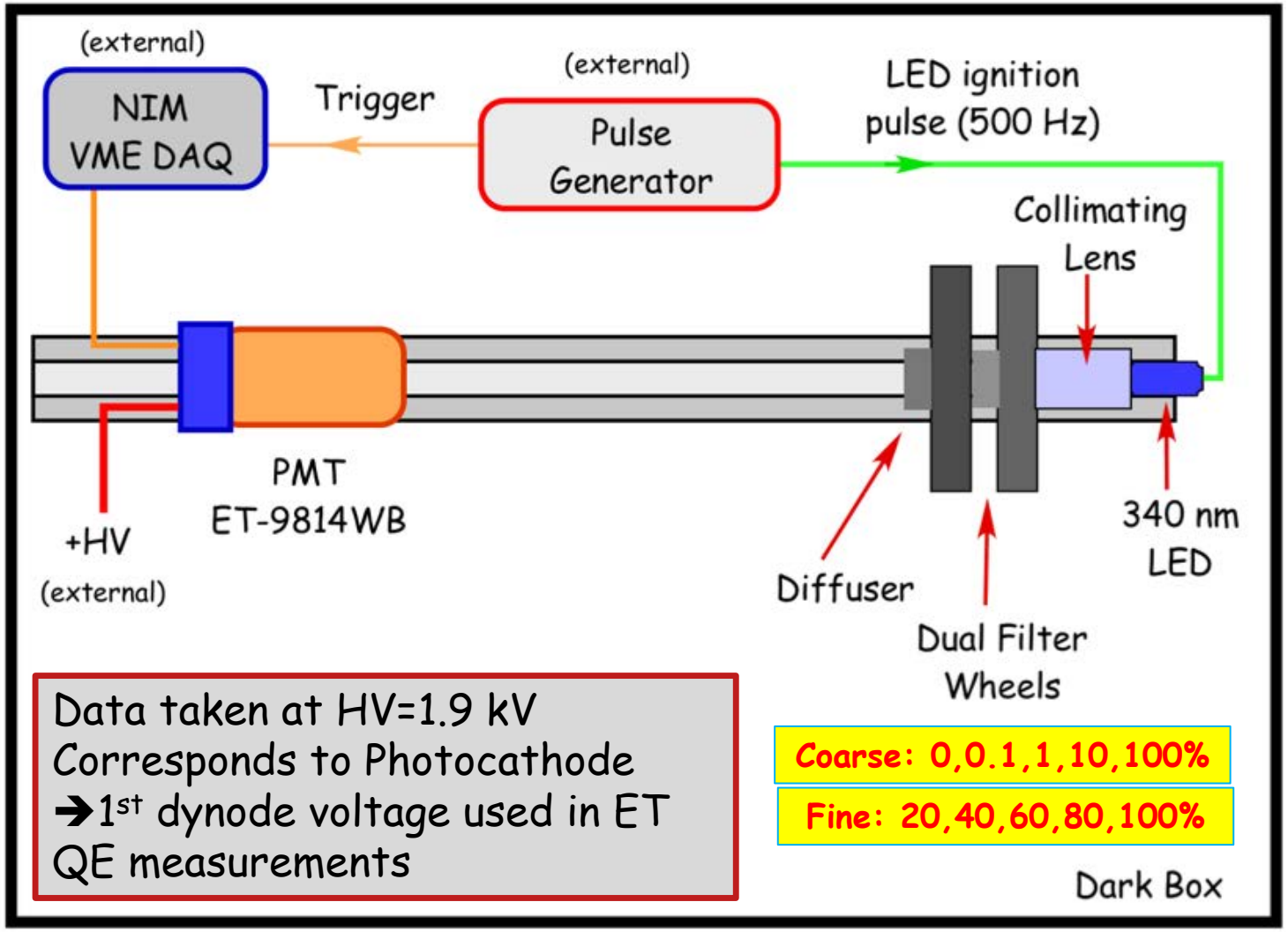
Mean photoelectron count scaled to 100% (full) intensity

$$N_{ph} = I_{ph} \bullet \mathrm{A}_{pmt}$$

Calibrated intensity [photons / mm^2]

Photosensitive area of PMT (Vendor spec)

PDE measurement setup

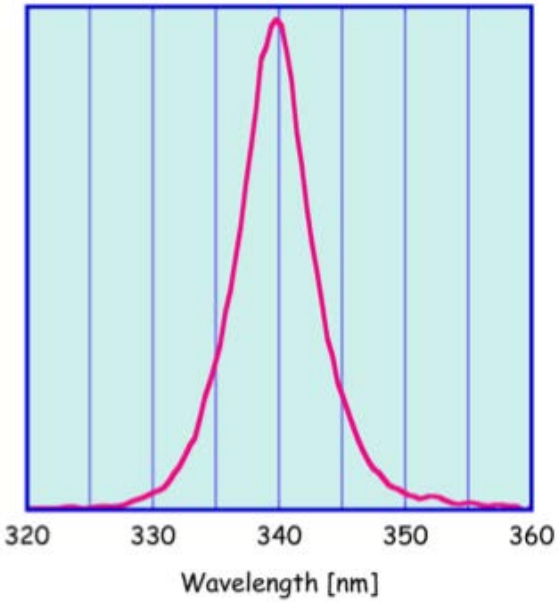


Data taken at HV=1.9 kV
Corresponds to Photocathode
➔1st dynode voltage used in ET
QE measurements

Coarse: 0,0.1,1,10,100%

Fine: 20,40,60,80,100%

Thorlabs 340 nm LED



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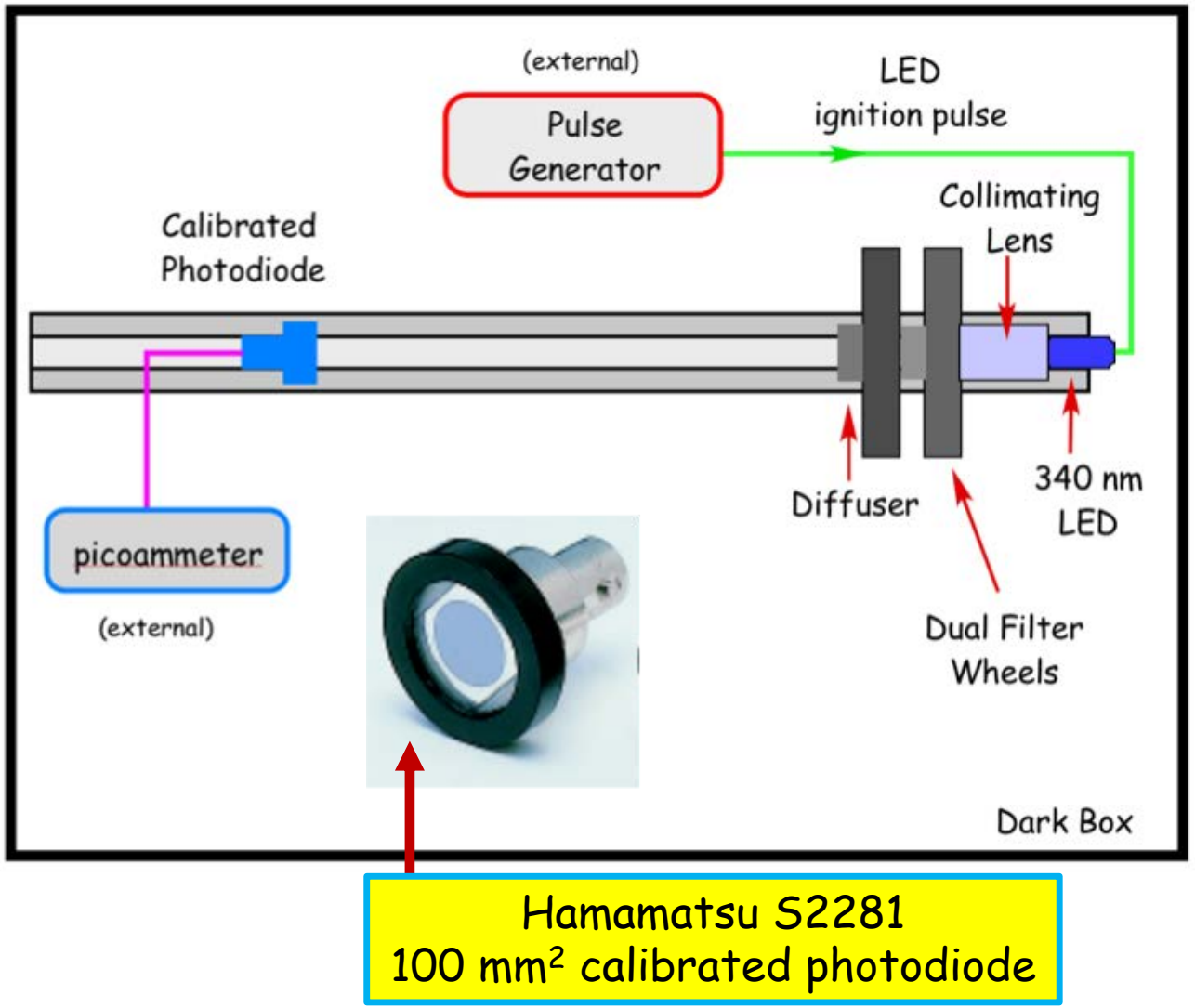
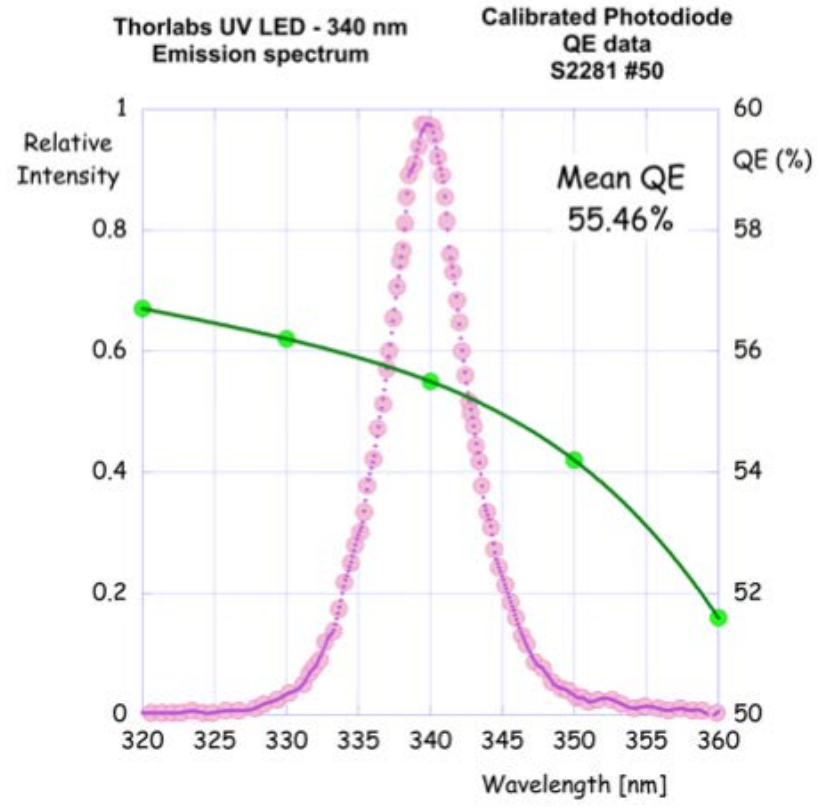
Photon intensity calibration



Hamamatsu S2281
100 mm^2 calibrated photodiode



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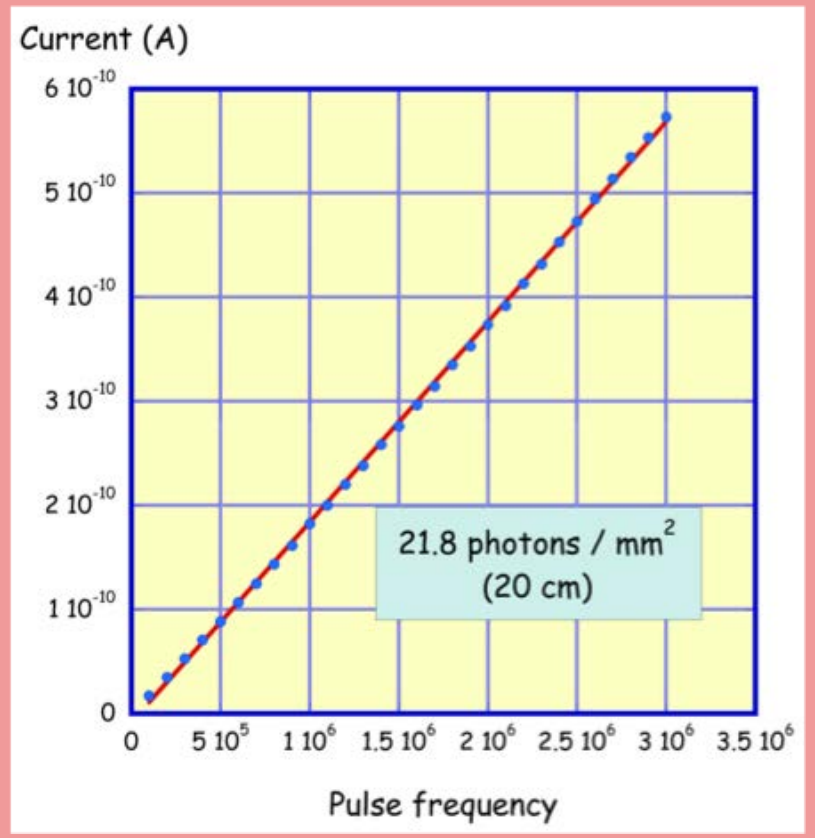
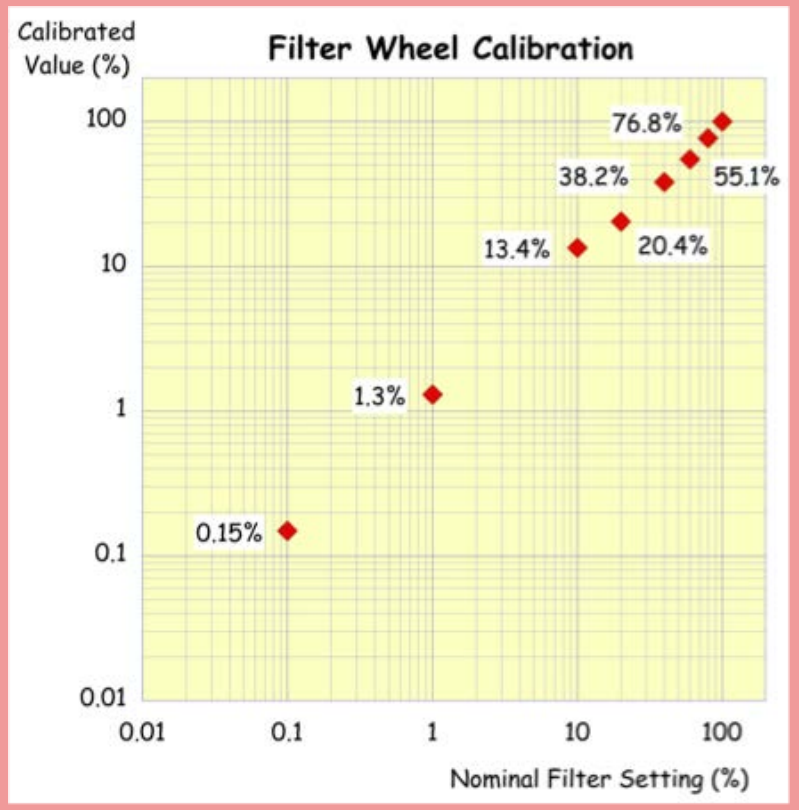
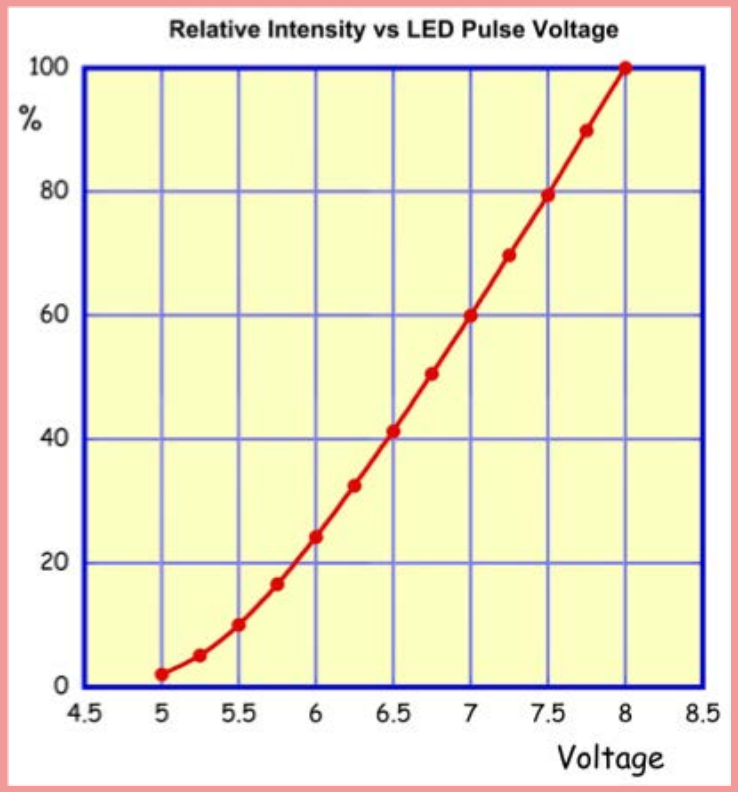
Photon Intensity Calibration and intensity Controls







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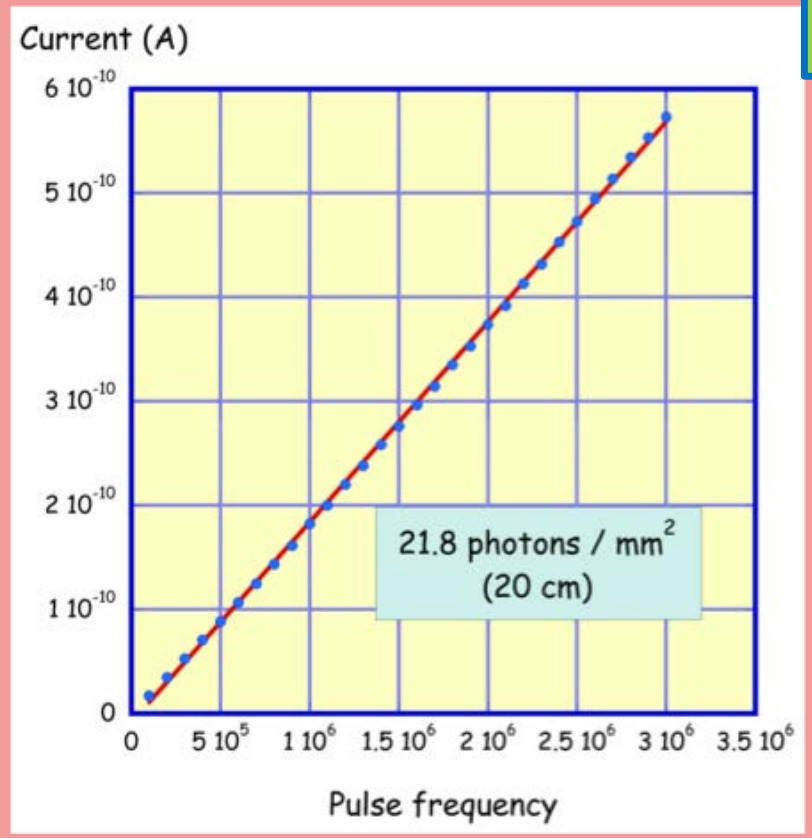
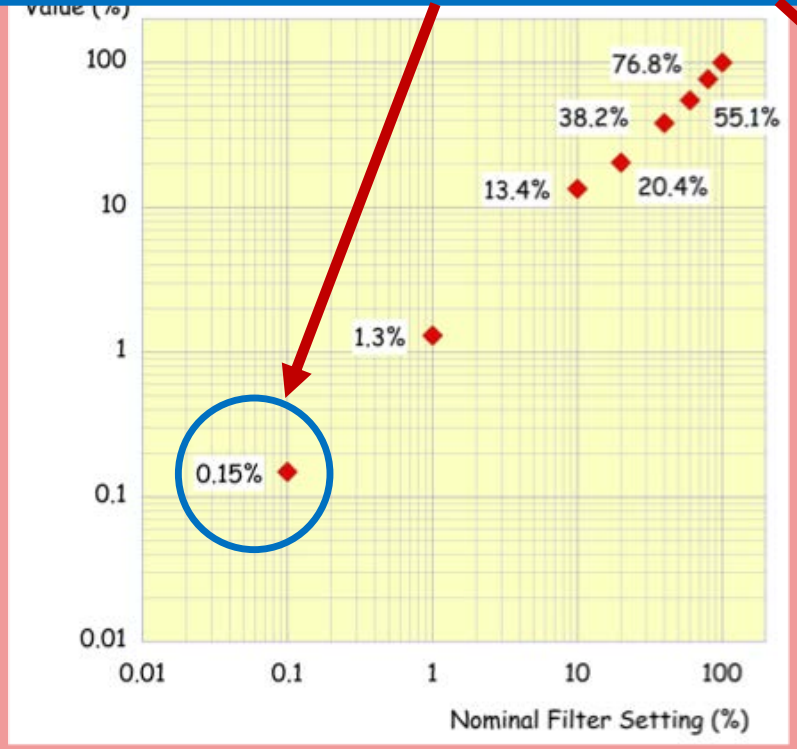
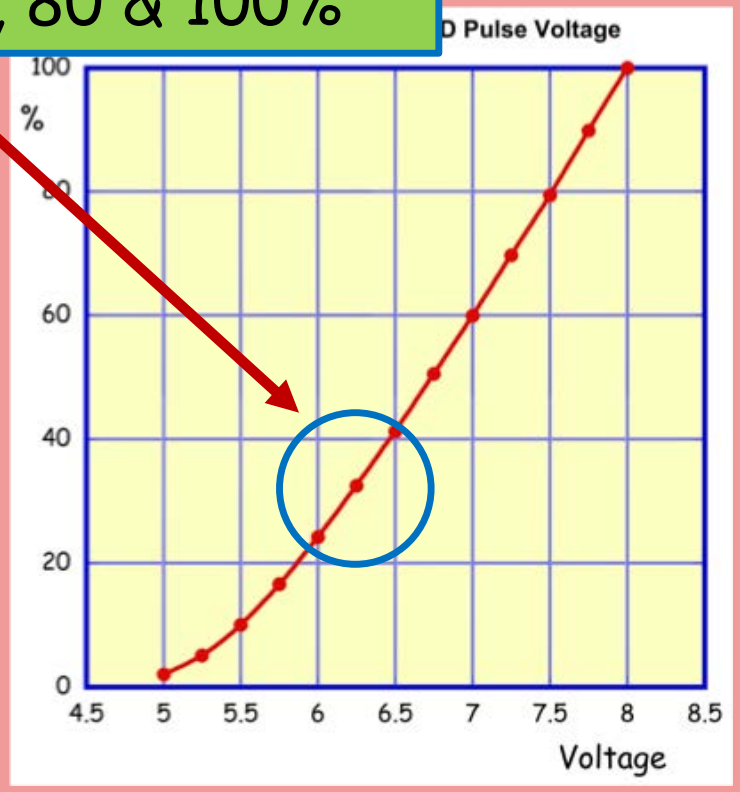
Photon Intensity Calibration and intensity Controls

Set Filter to 0.1% and LED level to 30%
Stepped through 20, 40, 60, 80 & 100%







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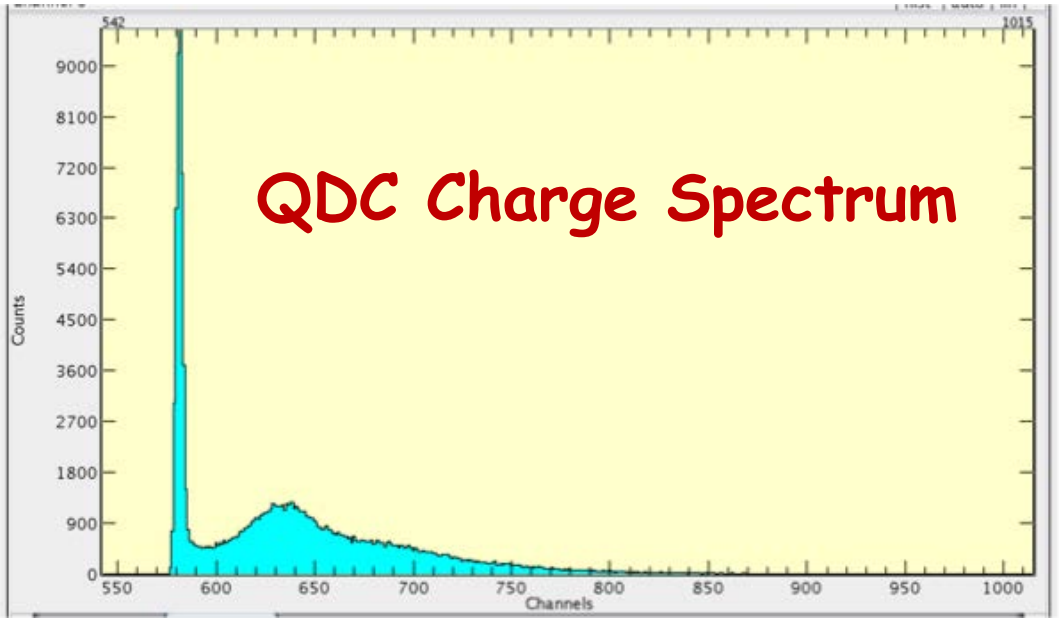
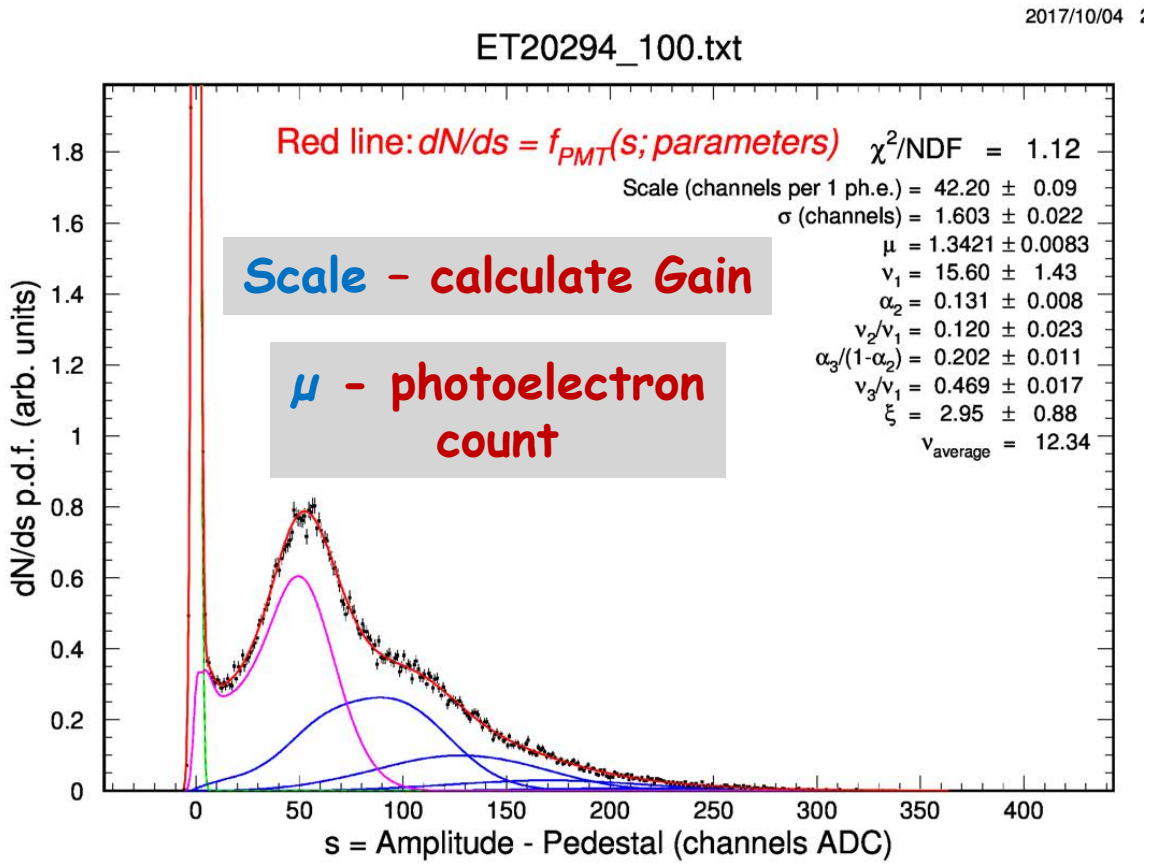
Charge Spectra analyzed via Pavel Degtiarenko's Fit Program

Pavel Degtiarenko, "Precision analysis of the photomultiplier response to ultra low signals", Nuclear Instr. and Methods in Physics Research, A 872 (2017) 1–15





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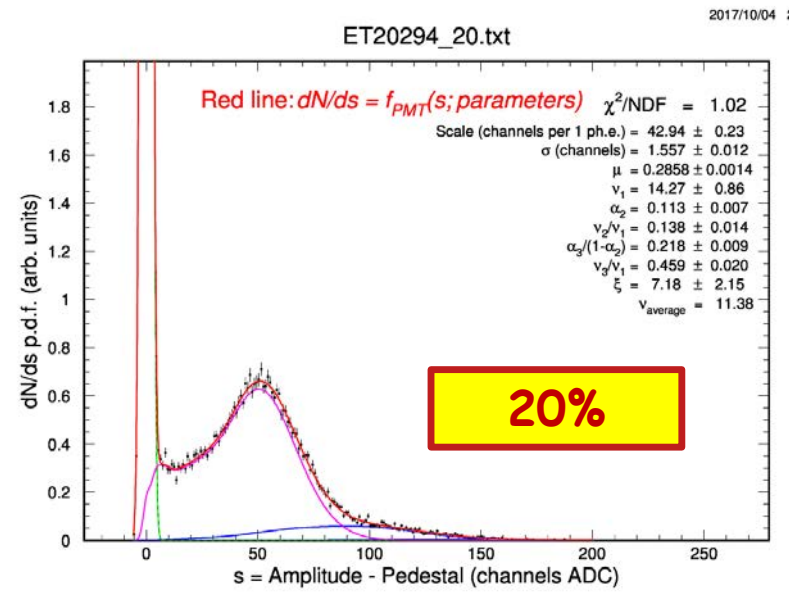
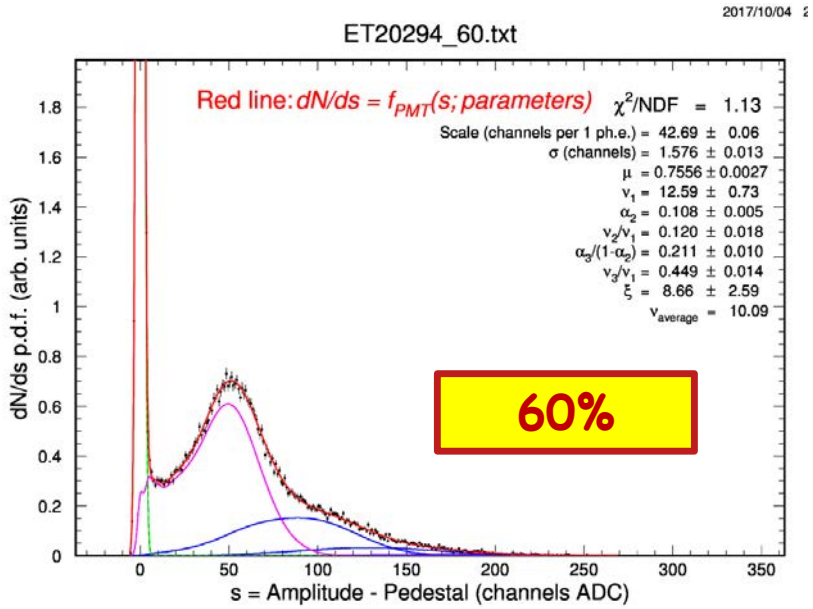
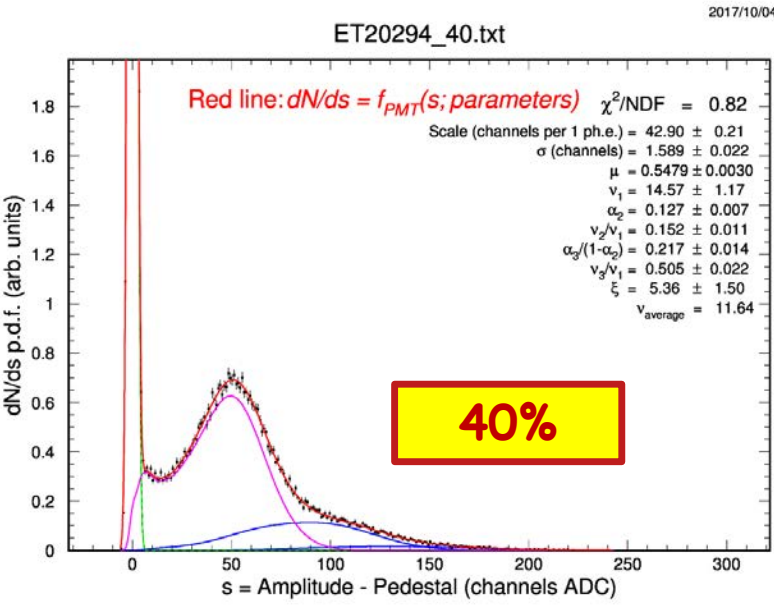
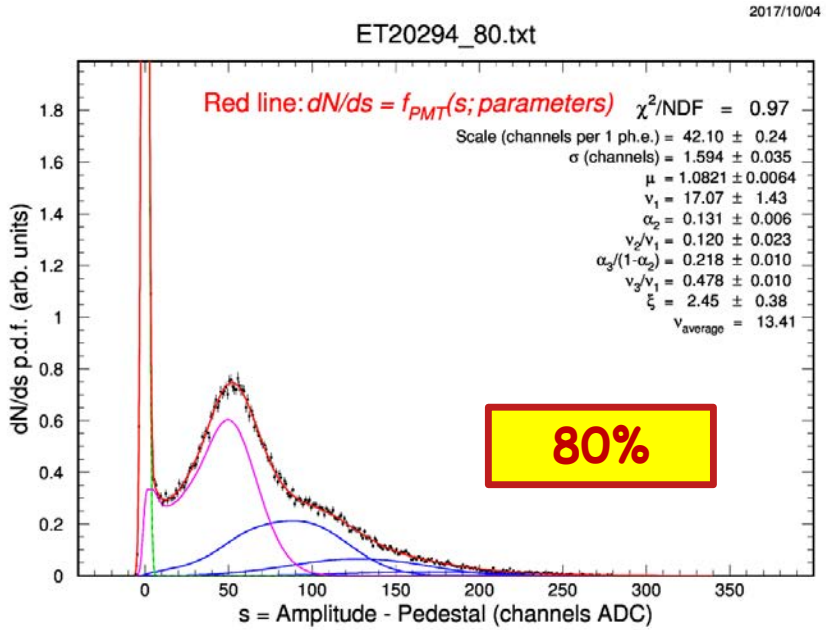
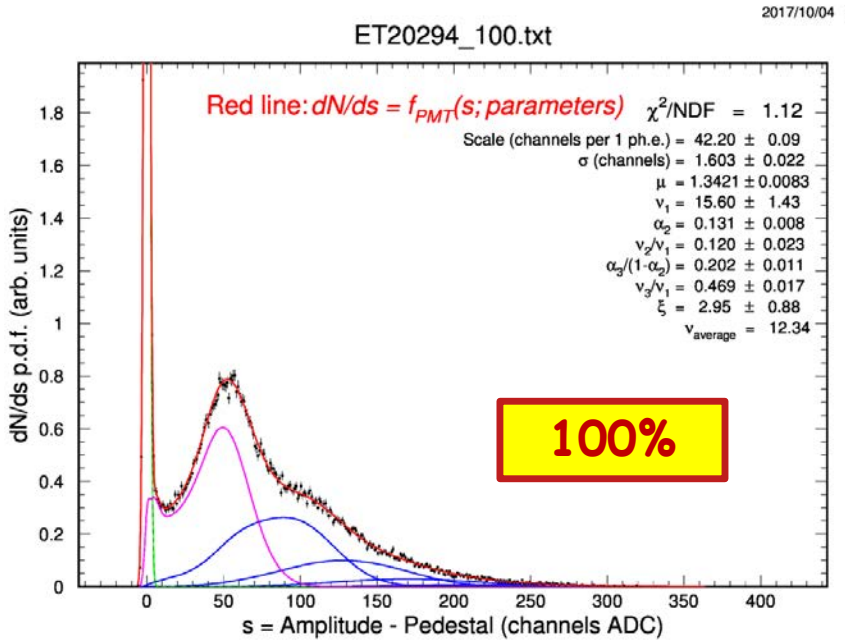
Collect Charge Spectra through 5 filter settings











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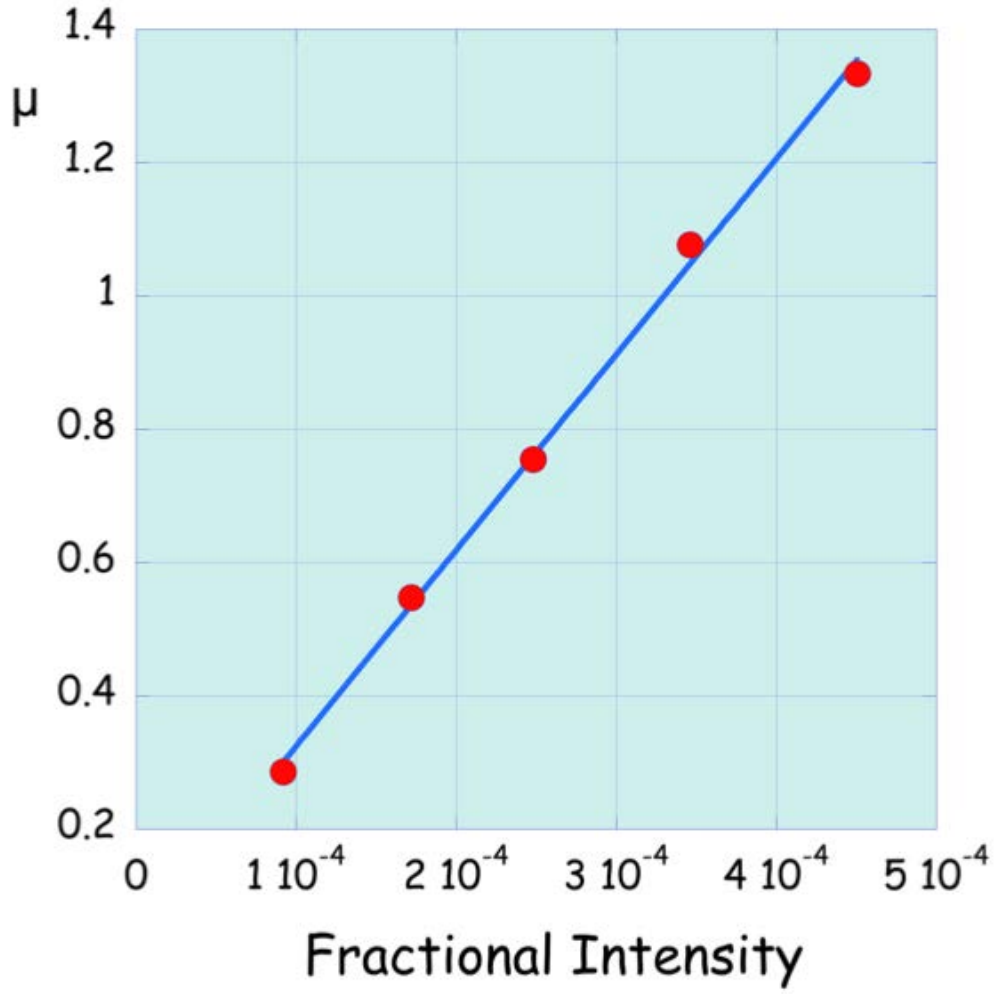
Photon Detection Efficiency (PDE)

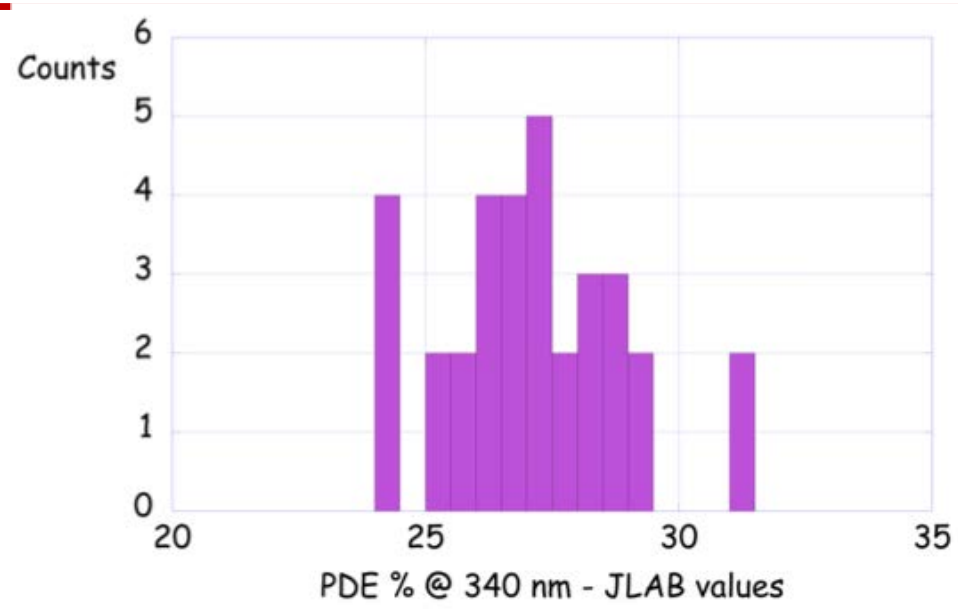
Mean Detected Photon Count

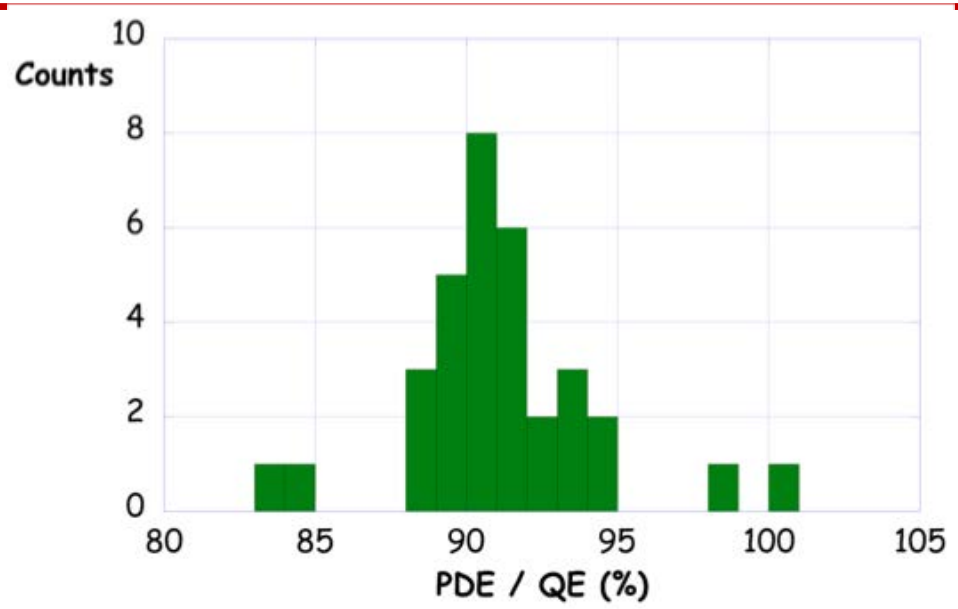


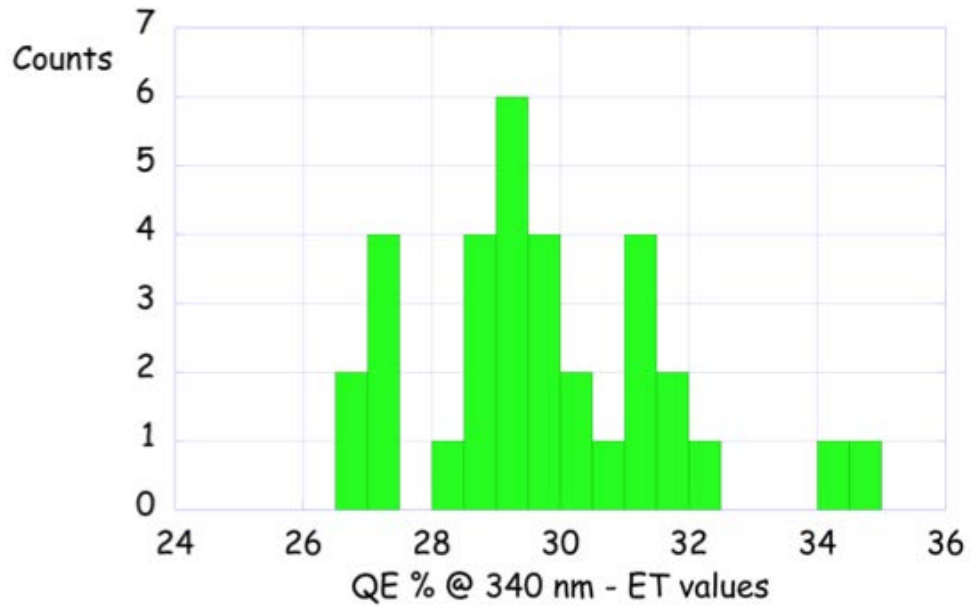
Use line fit from plot of *mean photon count* as function of *filter setting* to extrapolate to *mean detected photon count* at **full** intensity (filter setting=1)

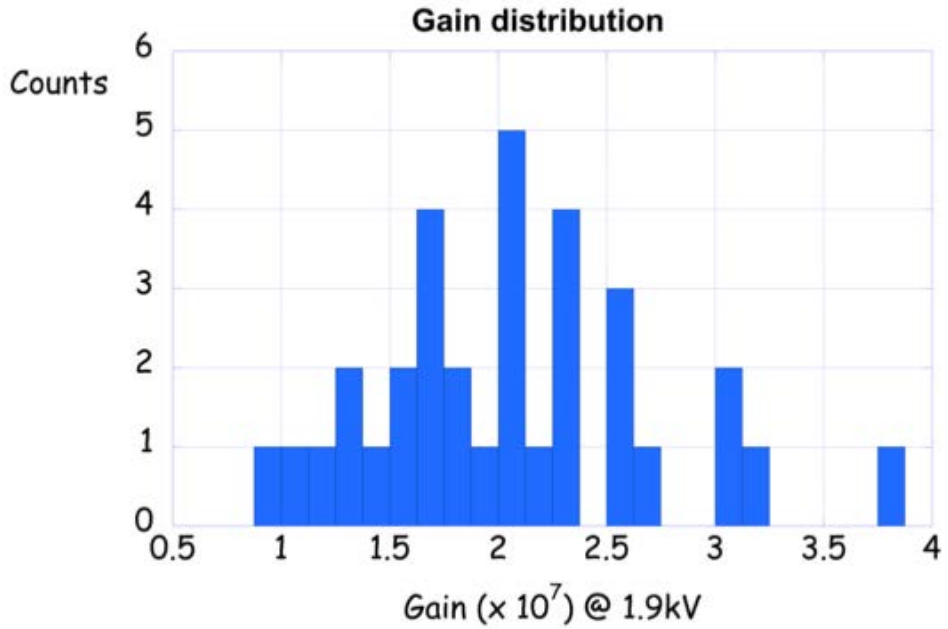
Ratio of mean detected photons to actual photon intensity gives PDE

Results


Counts
0
1
2
3
4
5
6
20
25
30
35
PDE % @ 340 nm - JLAB values

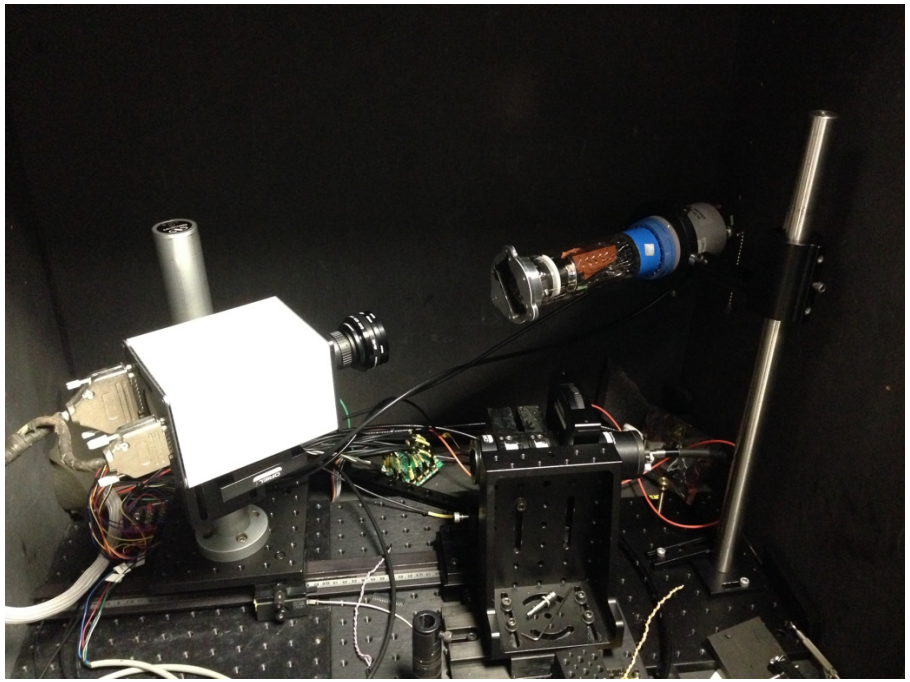

Counts
0
2
4
6
8
10
80
85
90
95
100
105
PDE / QE (%)

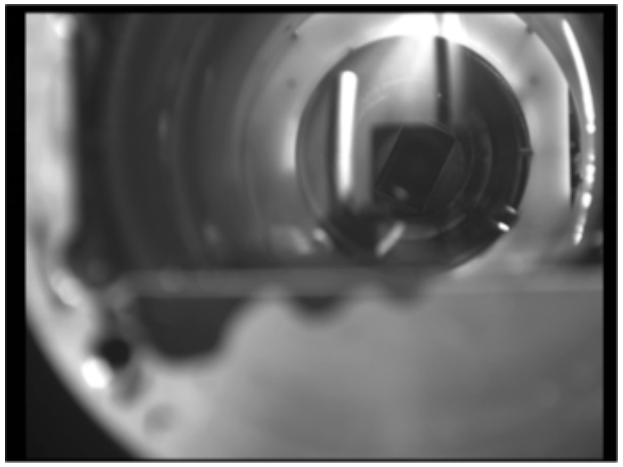

Counts
0
1
2
3
4
5
6
7
24
26
28
30
32
34
36
QE % @ 340 nm - ET values

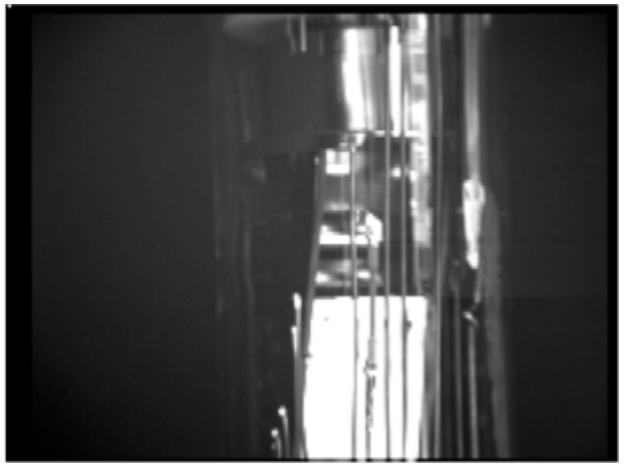

Gain distribution
Counts
0
1
2
3
4
5
6
0.5
1
1.5
2
2.5
3
3.5
4
Gain (x 10^7) @ 1.9kV

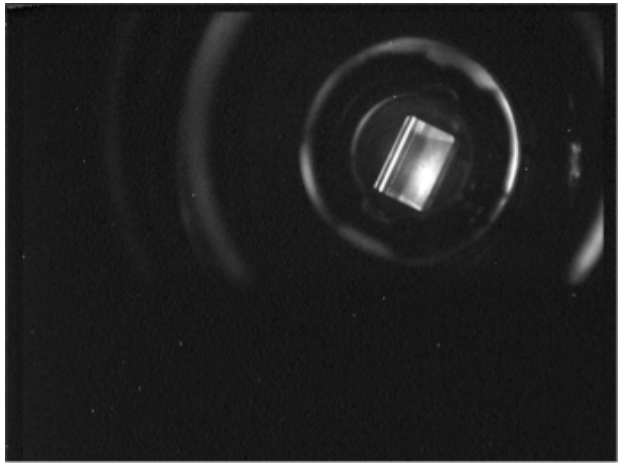
BACKUP

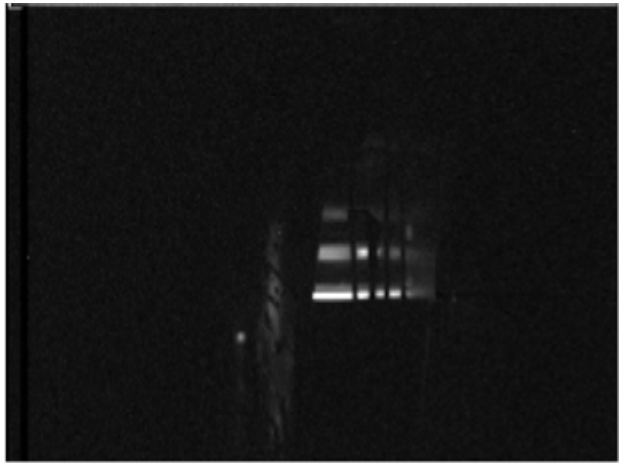
Internal luminescence activated when signal loss occurs

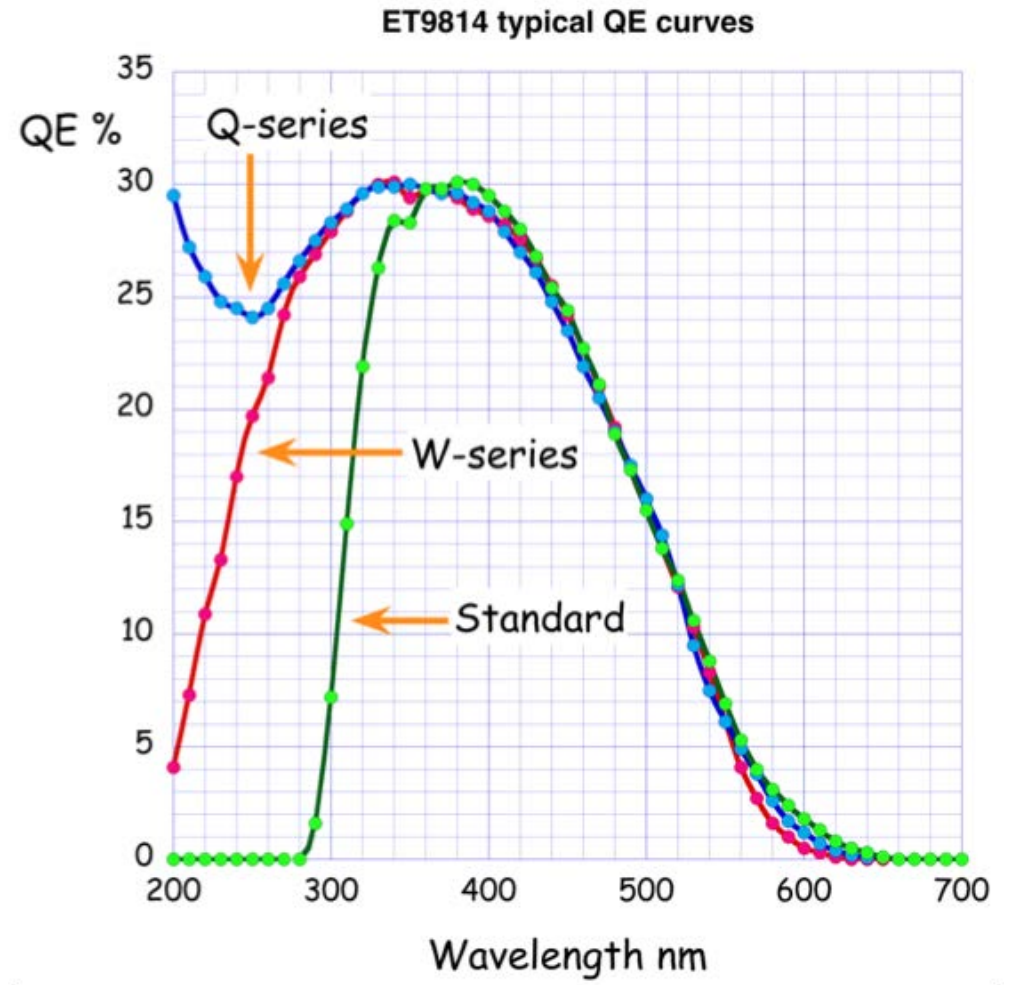
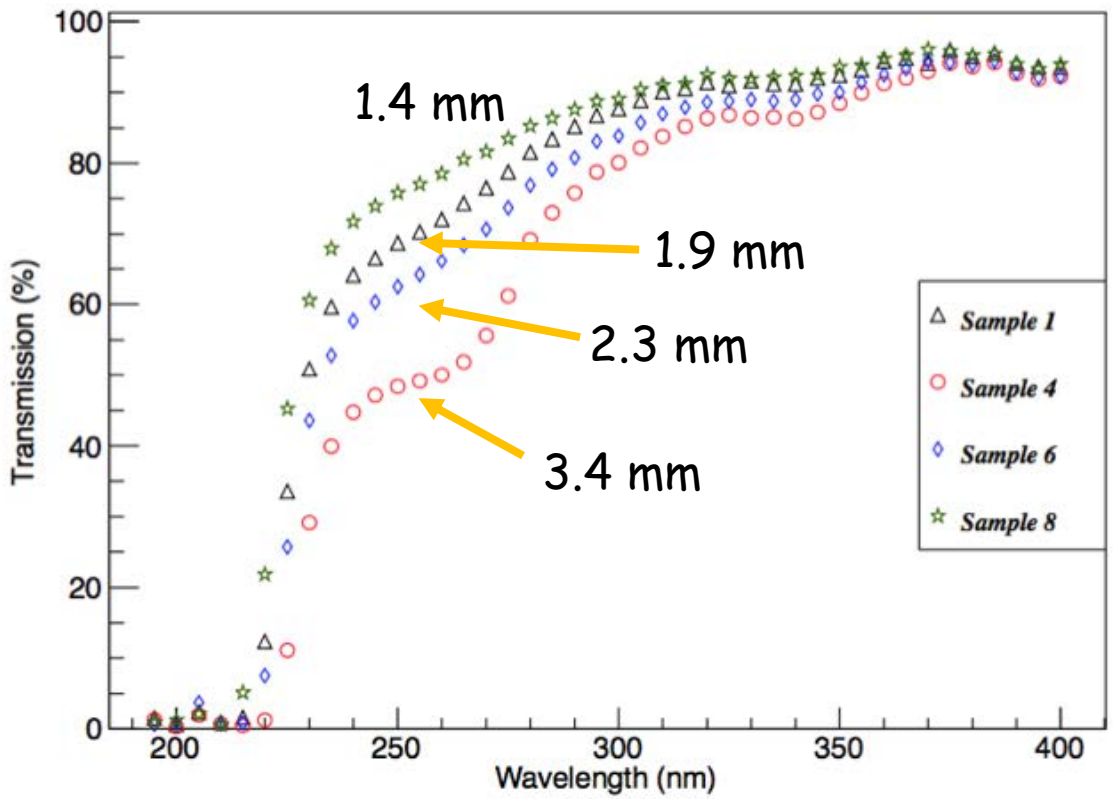










UV window / RTV615 gel pad transmission

Sample (#)	Mass (g)	Thickness (mm)	Curing Method (Temperature °C)
1	4.20 ± 0.01	1.90 ±0.07 ±0.02	Normal (25 °C)
4	7.31 ± 0.01	3.35 ±0.07 ±0.02	Normal (25 °C)
6	5.05 ± 0.01	2.30 ±0.02 ±0.02	Normal (25 °C)
7	3.20 ± 0.01	1.48 ±0.05 ±0.02	Heat (100 °C)
8	3.03 ± 0.01	1.37 ±0.02 ±0.02	Normal (25 °C)
9	7.37 ± 0.01	3.39 ±0.02 ±0.02	Heat (100 °C)