SoLID Heavy Gas Cherenkov Update

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University of Regina

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NSERC CRSNG

FRN: SAPIN-2016-00031

Zhiwen Zhao
Chao Gu
Duke UNIVERSITY

Klaus Dehmelt
STONY BROOK UNIVERSITY

SoLID Collaboration Meeting. December 2, 2016.

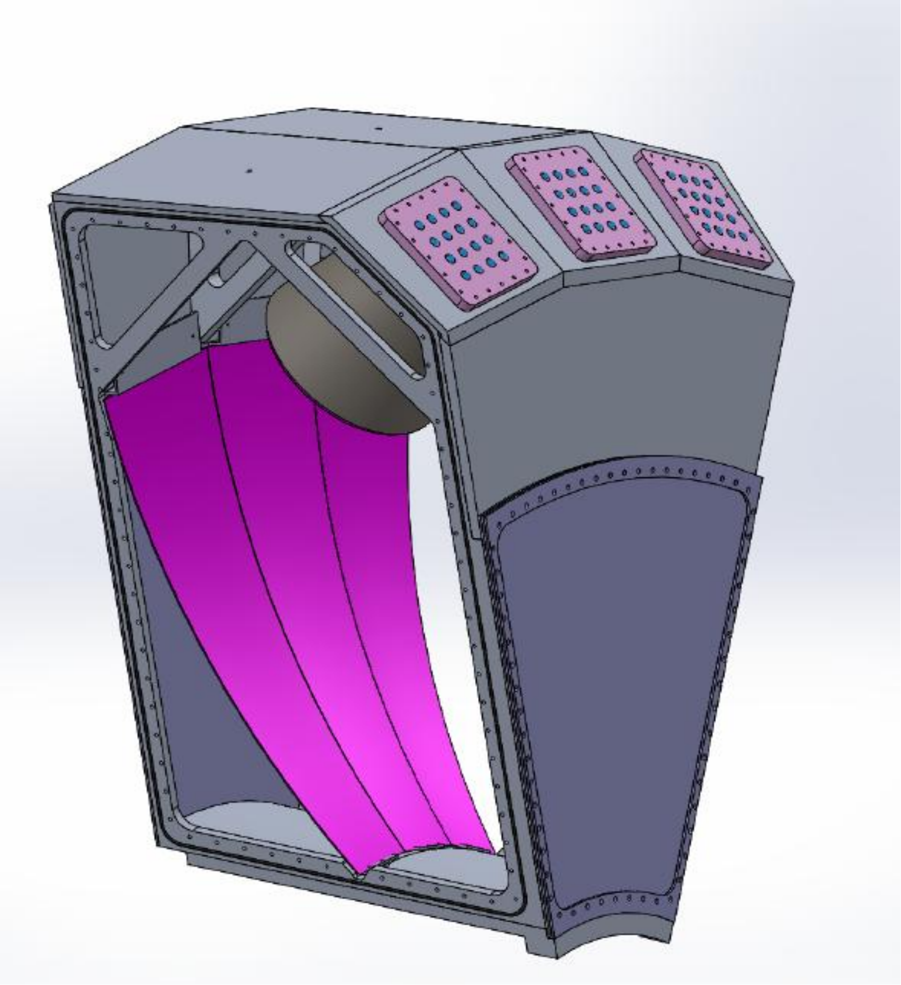
Planned HGC Prototyping Studies

Garth Huber, huberg@uregina.ca

C$100k grants from CFI & Fedoruk allow us to construct one SoLID HGC module for testing.

Questions to be addressed:

- Enclosure deformation at 1.5 atm operating pressure (investigate design and metal alloy options).
- Performance of the O-ring seals against adjacent units.
- Performance of thin entrance window in terms of light and gas tightness (test several options).
- Optical performance.



Conceptual design by Gary Swift, Duke U.

Progress since August 2016 meeting

HGC Entrance Window Pressure Tests

- We constructed a jig to test the CLAS-12 LTCC window material (1.5mil Tedlar-3mil PET-1.5mil Tedlar) under SoLID HGC operating conditions.
- One full-size entrance window was tested on the jig, material provided by Maurizio Ungaro.
- Air was slowly pumped to 0.5atm overpressure, and the window deformation measured.
- The pressure was maintained 24hrs and after observing no further deformation, the window was deflated and then the pressure raised until failure.

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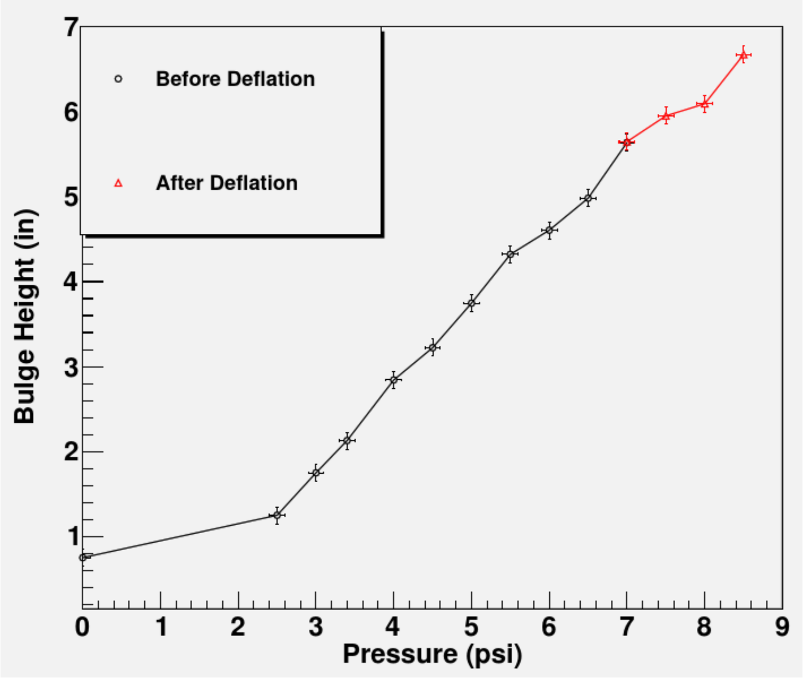
HGC Entrance Window Test

Despite the fact that the vendor (Madico) quotes this material as rated for 6 atm continuous performance, we observed:

- Very unacceptable window deformation, nearly 6” at 0.5 atm overpressure.
- Window failure occurred at only 8.6psi overpressure, well below any satisfactory safety margin.
- A full test report is available upon request.
- **We need a clarification on the maximum window deflection allowed by SoLID space requirements.**



We are investigating other window material options, including a kevlar-mylar material used for high performance sailboat sails recommended by Dave Meekins.

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HGC vessel prototyping

- **A small wooden mock-up of the prototype enclosure has been constructed to better understand the various fabrication issues before we start cutting metal.**
- In the conceptual design by Gary Swift (Duke), there are a lot of beveled edges between the three segments making up the top of the enclosure, and where the PMTs mount.
- We can save some costs in the final assembly if we reduce the amount of fancy machine-work required, such as by replacing some parts by rolled aluminum plate, or by casting certain parts.
- This will also improve the mechanical rigidity of the structure, and reduce the number of potential pressure leakage points.

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HGC vessel design considerations

It will be very helpful to our prototyping if we can have at least approximate answers to the following questions:

1. Can the HGC be assembled as a single unit and then installed in the magnet, or must it be split into two halves (and sealed) vertically, in situ?
   - The first option might simplify the vessel design.
2. How the HGC mounts to the magnet structure, e.g. via rails at top and bottom.
   - Is there any additional mechanical stress that must be accounted for?
3. Can the structure of the shell be increased in the exit area (more 'spokes') so the back window panels can be smaller and thinner?
4. Can the detector width be increased in Z (beam direction), by 2" to 4" to provide clearance for window bulge and an externally accessed mating flange for the halves (or segments)?

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HGC prototyping

- We have purchased 50 uncoated LHCb-type mirror samples and drop shipped them to Stony Brook for aluminization testing.
- We have also provided one reference mirror used as part of our Hall C SHMS HGC work, for calibration of the Stony Brook setup.
- **Funds remaining: about C$85k.**

University of Regina

P.O. Number: P0065619

This Order Number must appear on all Labels, Documents and Communication pertaining to this Order.

BILL TO: FINANCIAL SERVICES, UNIVERSITY OF REGINA
3737 WASCANA PARKWAY
REGINA, SASKATCHEWAN, CANADA S4S 0A2

SHIP TO: UNIVERSITY OF REGINA
CENTRAL RECEIVING, MAINTENANCE BUILDING
3737 WASCANA PARKWAY
REGINA, SASK., CANADA S4S 0A2

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VENDOR 520 7339306
Composite Mirror Applications Inc.
1638 S. Research Loop
Tucson AZ
85710

ITEM	QUANTITY	U/M	DESCRIPTION	UNIT PRICE	EXTENSION
1	1	Lot	Produce 50 flat uncoated CFRP mirror samples (coupons are 55.8mm in diameter) Optical quality based on LHCb type mirrors	$6,623.00	$6,623.00

DROP SHIP TO: KLAUS DEHMELT
STONY BROOK UNIVERSITY
DEPARTMENT OF PHYSICS AND ASTRONOMY
STONY BROOK, NY 11794-3800

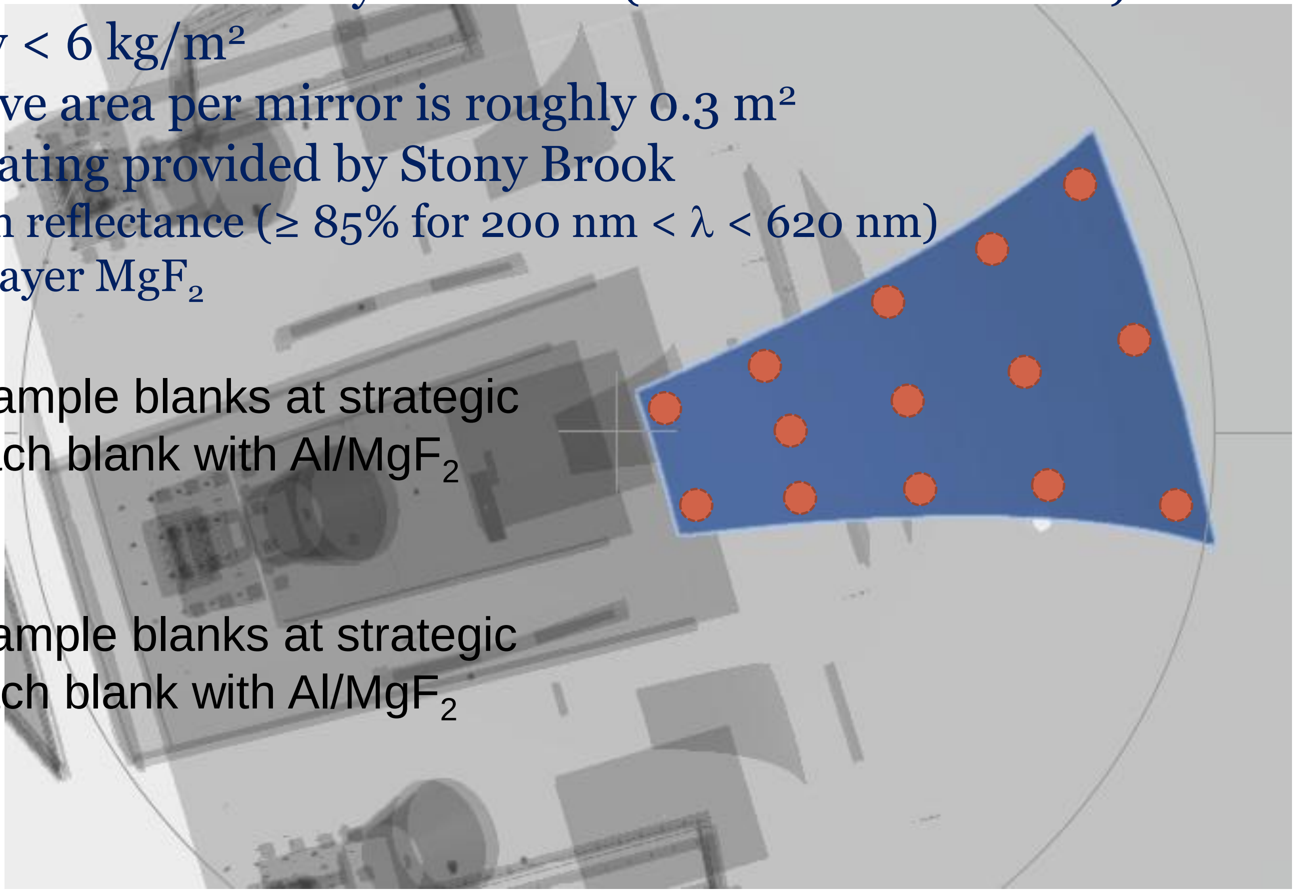
As per Quote Number: 16-Q-RT079A, dated October 11, 2016
Reference Documents: Email correspondence from Z.Zhao, G. Huber

PLEASE CONTACT KIMBERLY MITCHELL (SENIOR SUPPLY MANAGEMENT CONSULTANT) FOR ACCEPTANCE

Garth Huber, huberg@uregina.ca

LGC and HGC mirror

- Mirror blanks
  - Carbon Fiber Reinforced Polymer CFRP (Same as LHCb RICH)
  - Areal density < 6 kg/m^2
  - Total reflective area per mirror is roughly 0.3 m^2
  - Reflective coating provided by Stony Brook
    - Al with high reflectance ($\geq$ 85% for 200 nm < λ < 620 nm)
    - Protective layer MgF_2



- Position small sample blanks at strategic places and coat each blank with Al/MgF_2

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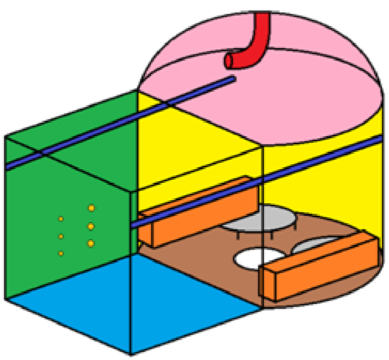
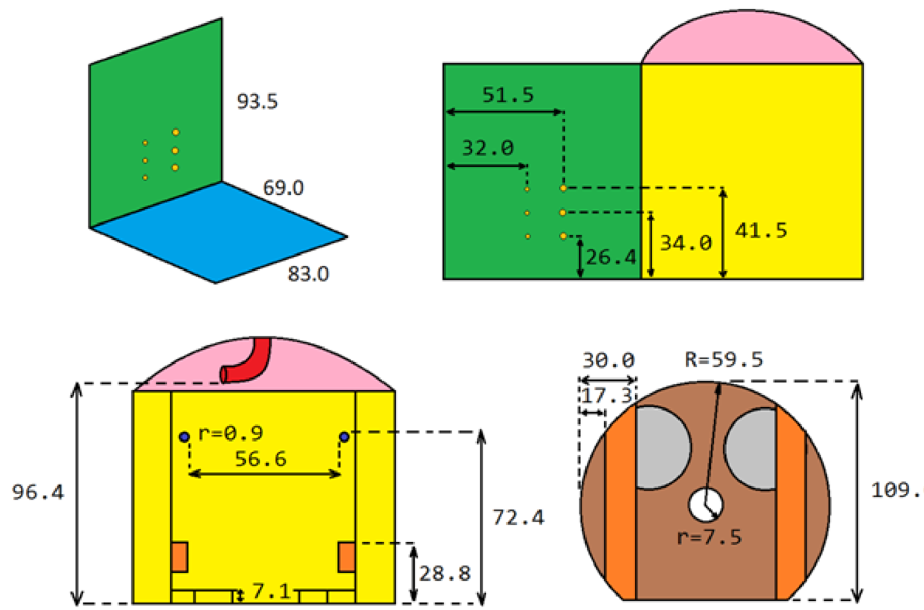
SBU Mirroring

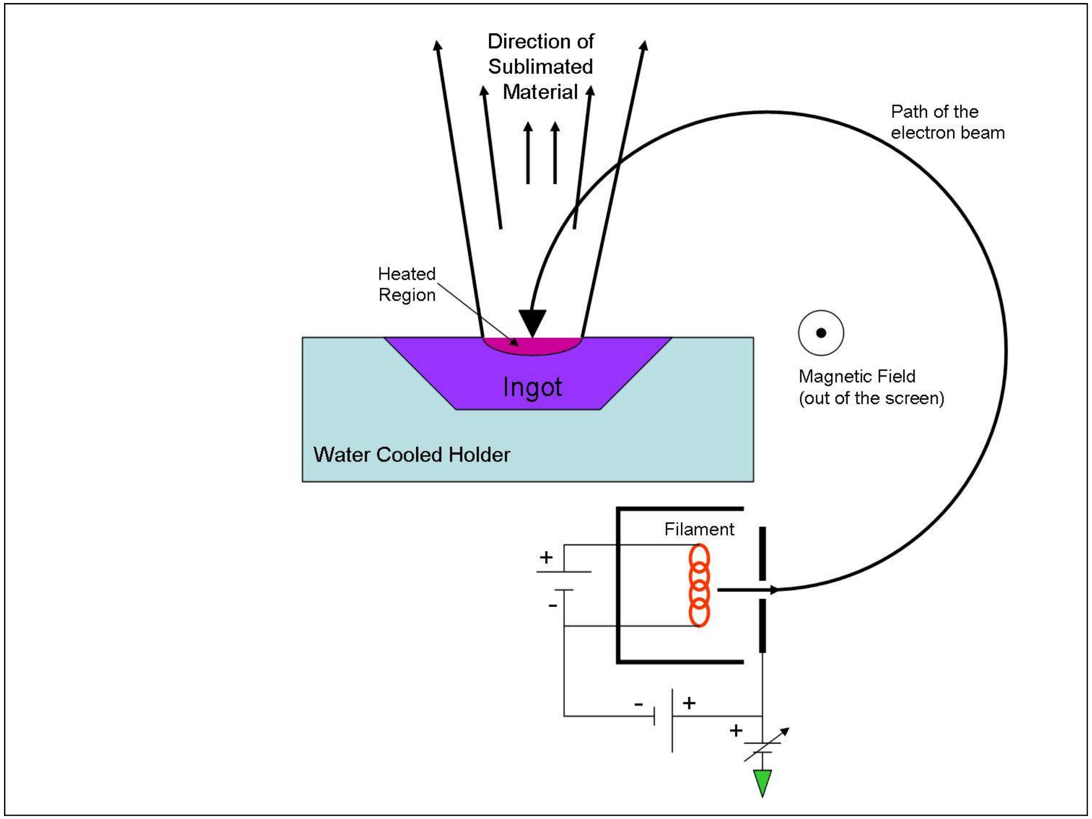
INFN Evaporator

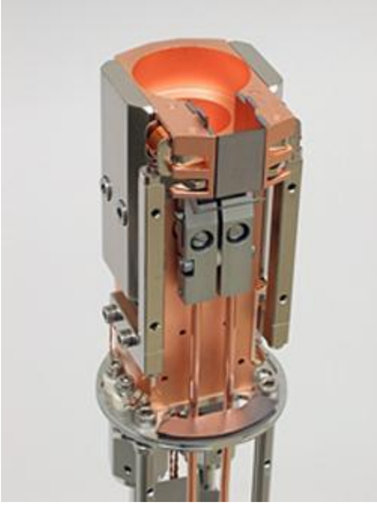
Italian Evaporator
(all in cm)





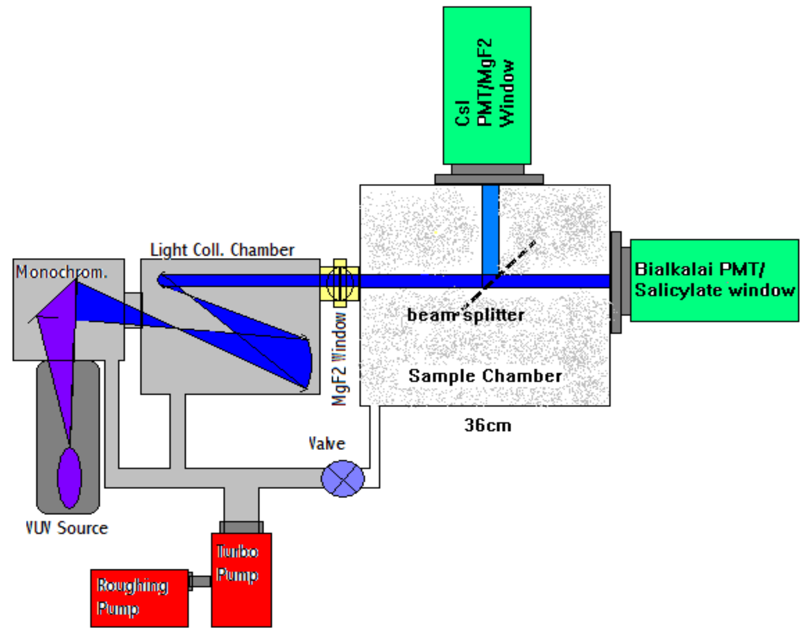
How to coat: Electron Gun





Reflectivity Measurement (relative)

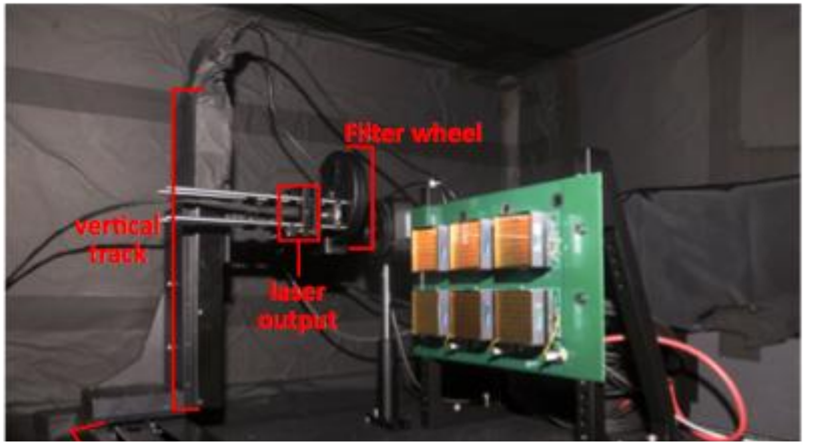
- Spectral analysis of each sample mirror

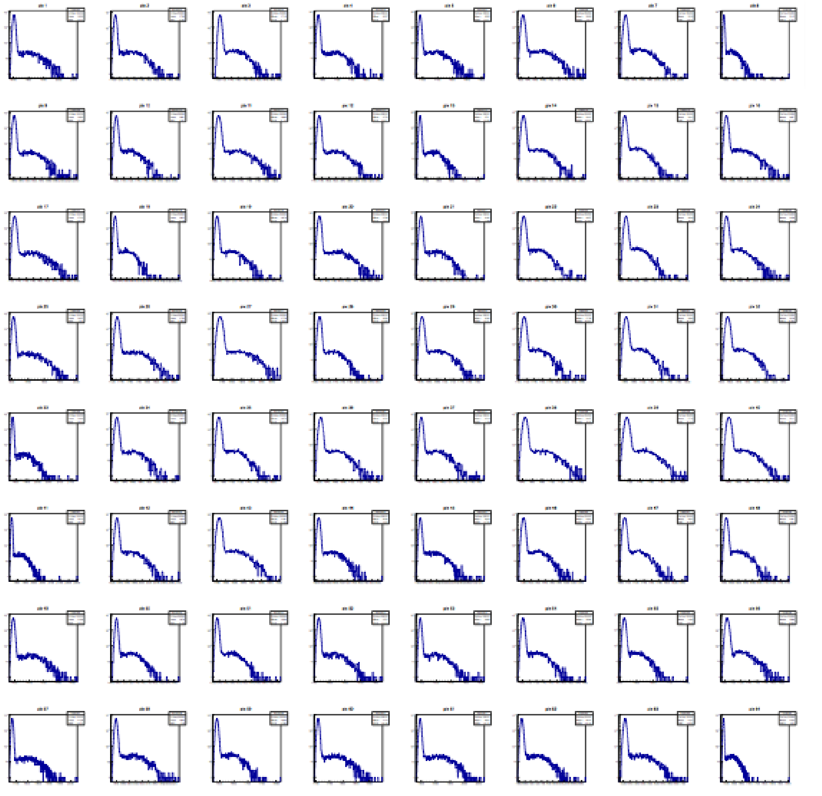


Chao Gu

MAPMT Test

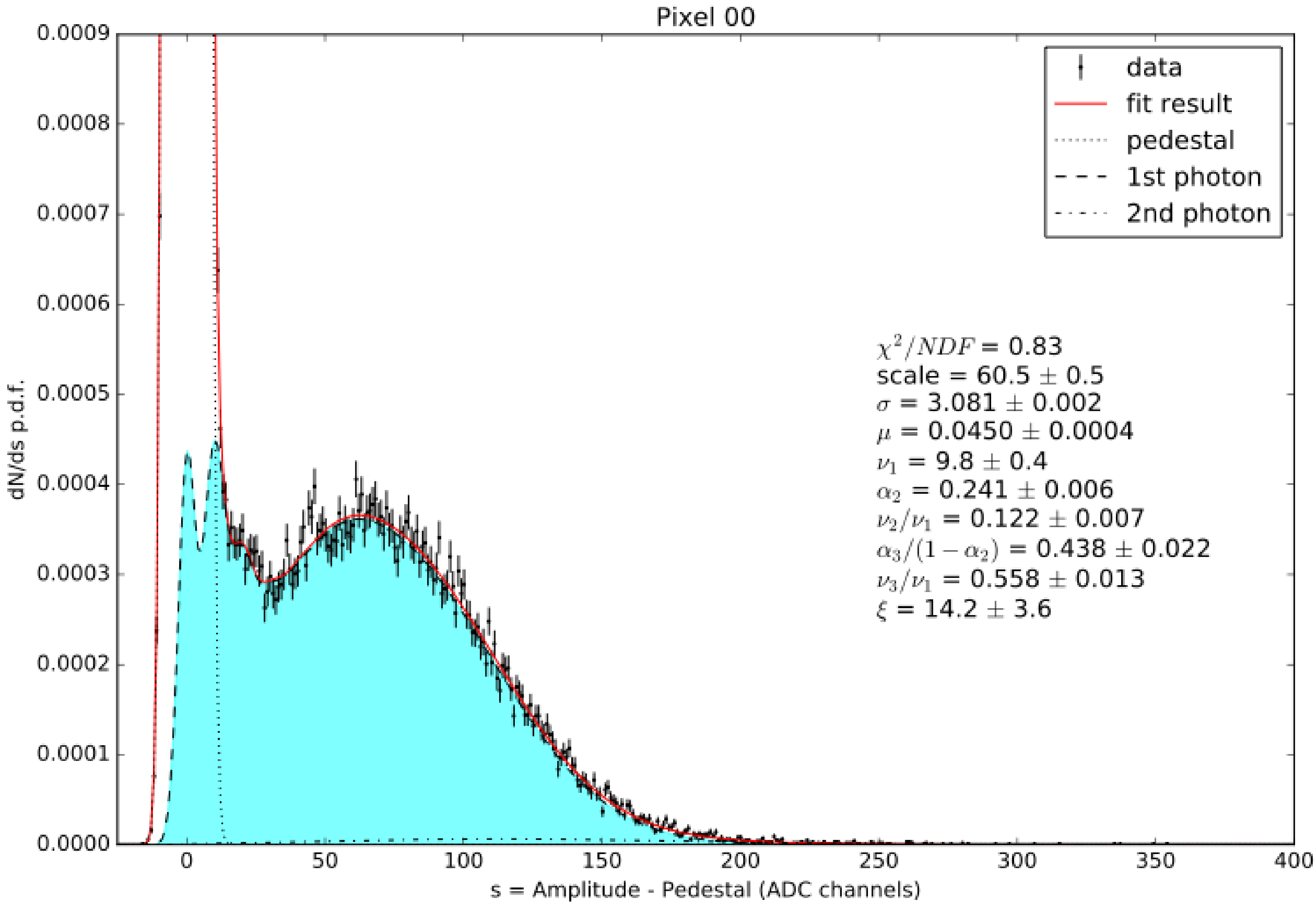
- Borrowed test platform from Hall B
- Use 470 nm laser as the light source and diffuse the light to give full coverage of the MAPMT surface
- Use filter to attenuate the laser to get single photoelectron spectrum (SPE)
- 17 MAPMTs tested and SPE fitted





SPE Analysis

Model 2: Pavel Degtiarenko, arXiv: 1608.7525

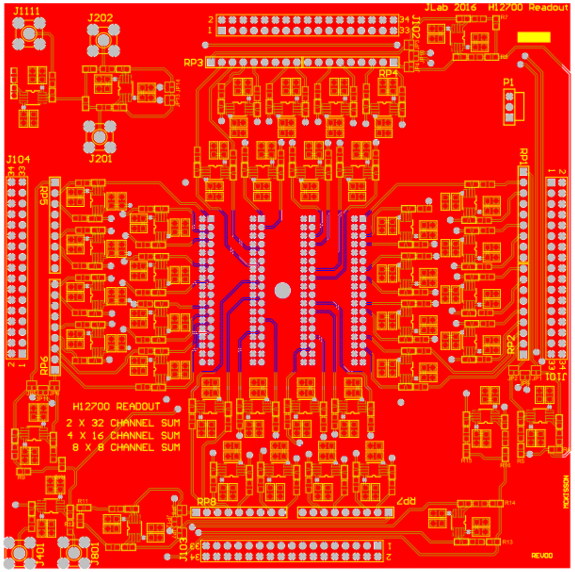


Readout board

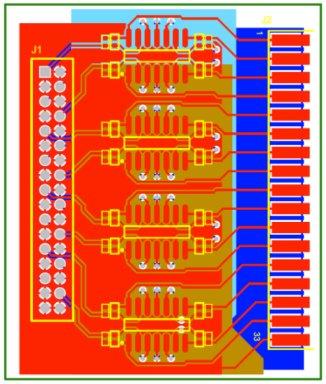
- Default(?): CLAS12 RICH MAROC3 with additional a total sum, waiting for design and sample to test
- Alternative: summing board as follows (design by Jack McKisson from detector group)

Flat test board for one MAPMT

Waiting for quote



One section of actual vertical board



PMT shielding

- Zhenyu Zhang from Wuhan U has a PhD student (Shuang Han) who could help on the project
- Solenoid ~200 Gauss could be used to test the shielding

Gas and gas system

- full system: talked to Jack, but he hasn’t had much time to work on it yet
- Small system for prototype testing: use HallC HGC gas system?

backup

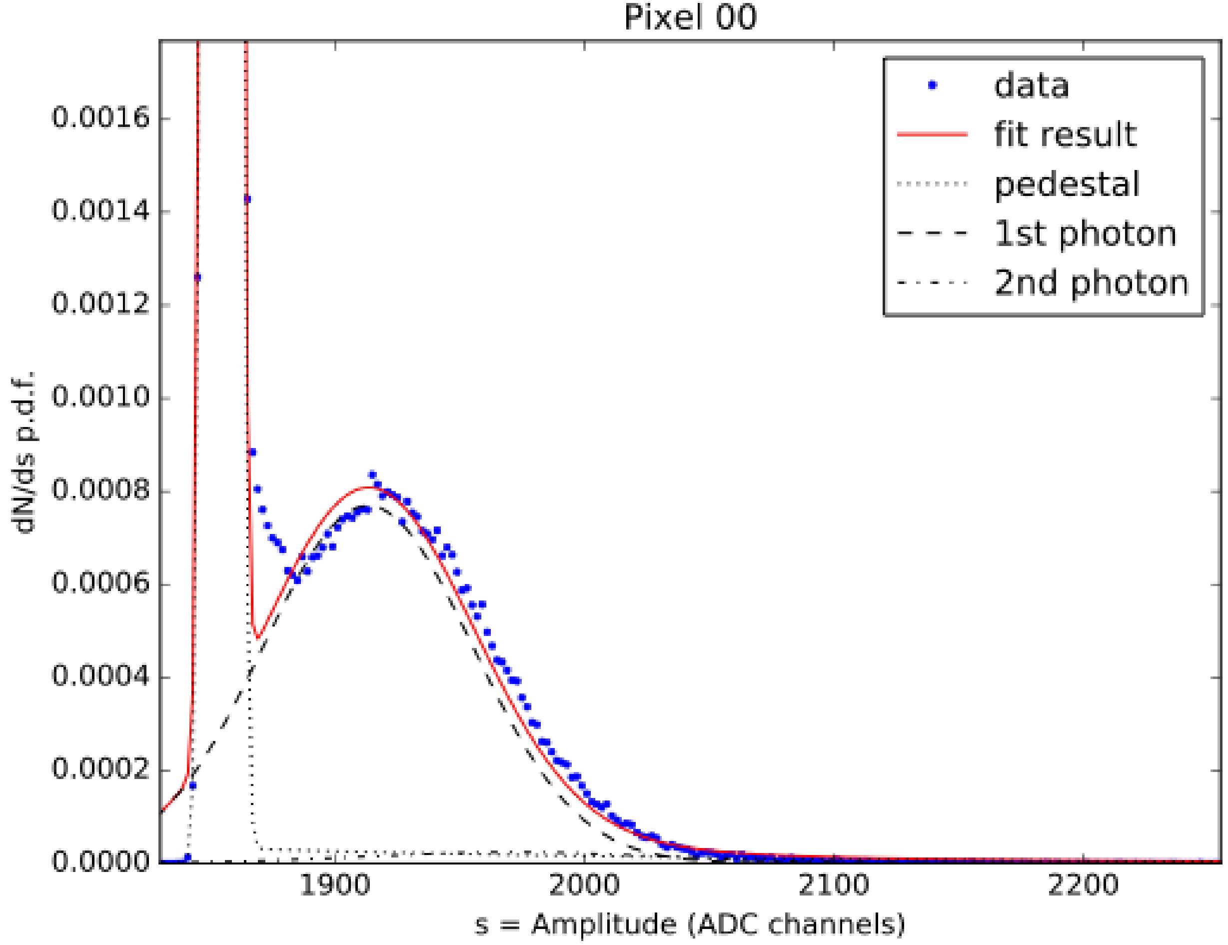
SPE Analysis

- Fit the single photoelectron spectrum:
- Model 1: E.H. Bellamy et al., NIM A 339(1994)468
  - The number of photoelectrons follows Poisson distribution
  - The response of multiplicative dynode system is approximated by a Gaussian distribution
  - The ideal spectrum is the convolution of the Poisson distribution and the Gaussian distribution
  - The realistic spectrum is the convolution of the ideal spectrum and the background charge distribution (caused by leakage current, thermoemission, etc.)

$$f(x) = P(m; \mu) \otimes G_m(x) \otimes B(x)$$

m is the number of the photoelectrons

Fit with Method 1



- Problem: during the fitting, it is found that the initial value of the fitting for each pixel need to be adjusted by hand to get a good fit result, which is time-consuming especially when we have 17*64 = 1088 channels

SPE Analysis

- Better model might help
- Model 2: Pavel Degtiarenko, arXiv: 1608.7525
  - The number of photoelectrons follows Poisson distribution
  - Multiplicative dynode system:
    - Photoelectron hitting the first dynode might knock one or more second-stage electrons: another Poisson distribution
    - The response of other dynodes are still approximated by a Gaussian distribution
  - The spectrum is the convolution of two Poisson distribution and a Gaussian distribution
  - Also considered the non-uniformity of the first dynode: assume 3 different averages for the Poisson distribution describing the first dynode

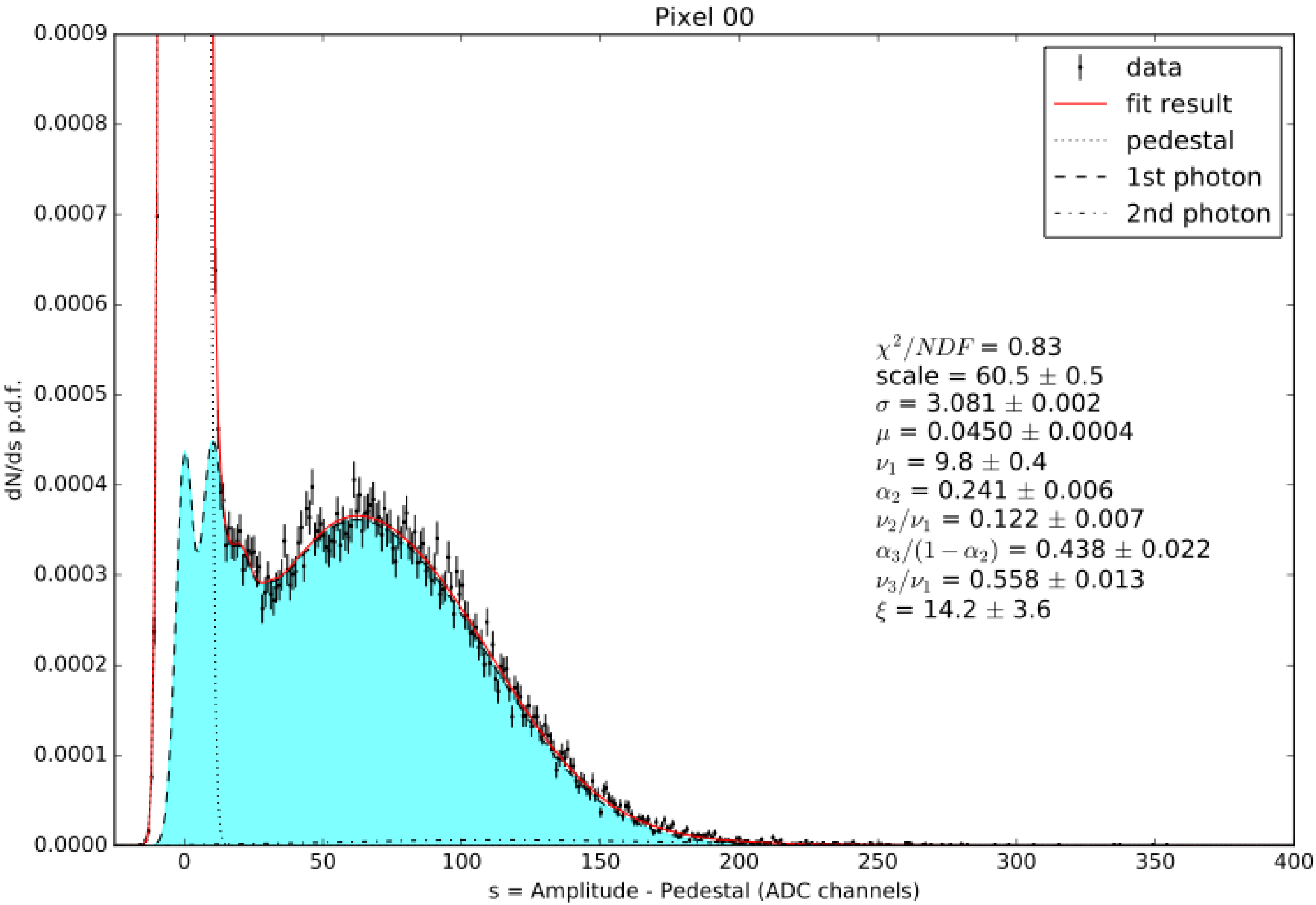
SPE Analysis

- Benefits:
  - The scale, sigma is almost identical for each high voltage setting (they depends on the gain of the PMT)
  - mu only depends on the property of the photocathode
  - nu1, alpha2, nu2, alpha3, nu3 only depends on the property of the first dynode
  - the initial value of the parameters could be determined and applied to a couple of pixels

Table 1: List of PMT model fit parameters

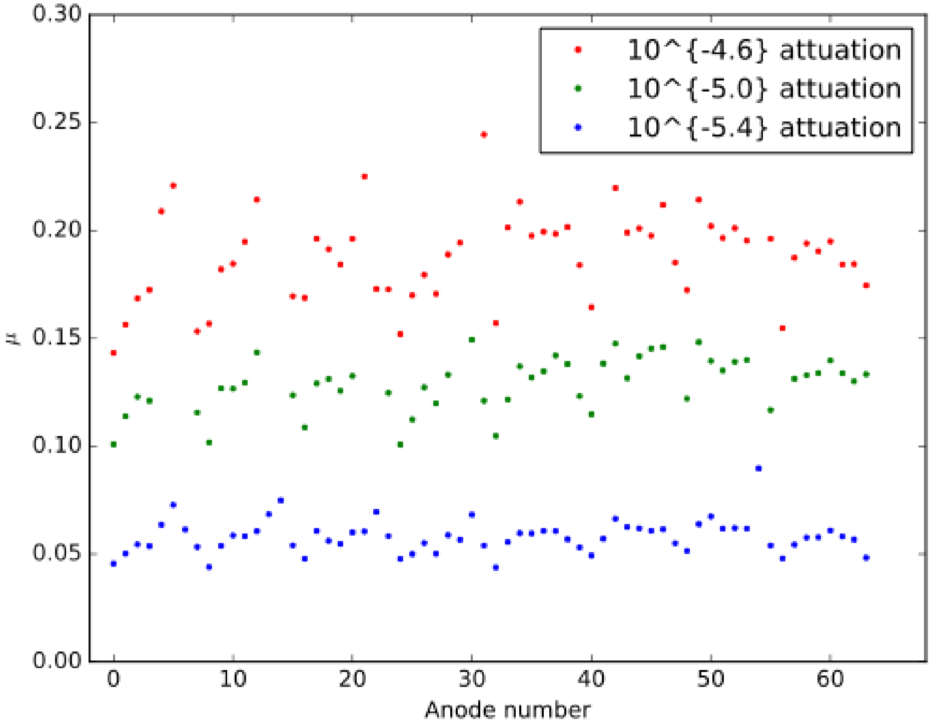
Name	Limits		Brief Description
scale	> 0	–	average amplitude of SPE signals (channels ADC)
σ	> 0	–	standard deviation of the pedestal fit (channels ADC)
μ	> 0	–	average multiplicity of photoelectrons
ν_1	> 0	–	average multiplicity of the first gain component in (24)
α_2	$[0, 1]$	–	portion of second gain component in (24)
ν_2/ν_1	$[0, 1]$	–	relative multiplicity of the second gain component in (24)
$\alpha_3/(1-\alpha_2)$	$[0, 1]$	–	relative portion of third gain component in (24)
ν_3/ν_1	$[0, 1]$	–	relative multiplicity of the third gain component in (24)
ξ	> 1	–	average multiplicity at the second dynode

SPE Analysis

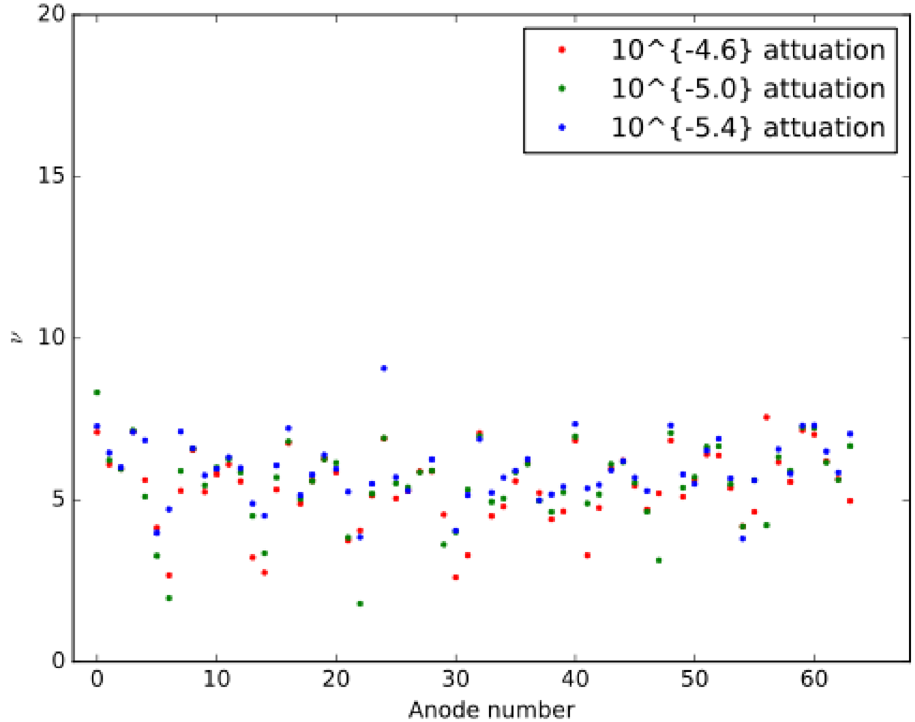


SPE Analysis

Distribution of mu for PMT HA0000



Distribution of nu for PMT HA0000



$$\nu = \nu_1(1 - \alpha_2 - \alpha_3) + \nu_2\alpha_2 + \nu_3\alpha_3$$

is the average multiplicity of one photoelectron at the first dynode (average of three Poisson distribution)