NPS anode current studies
Status update

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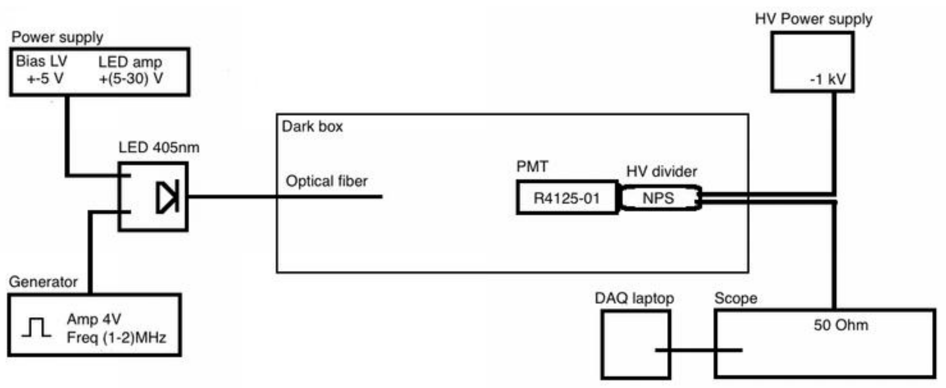
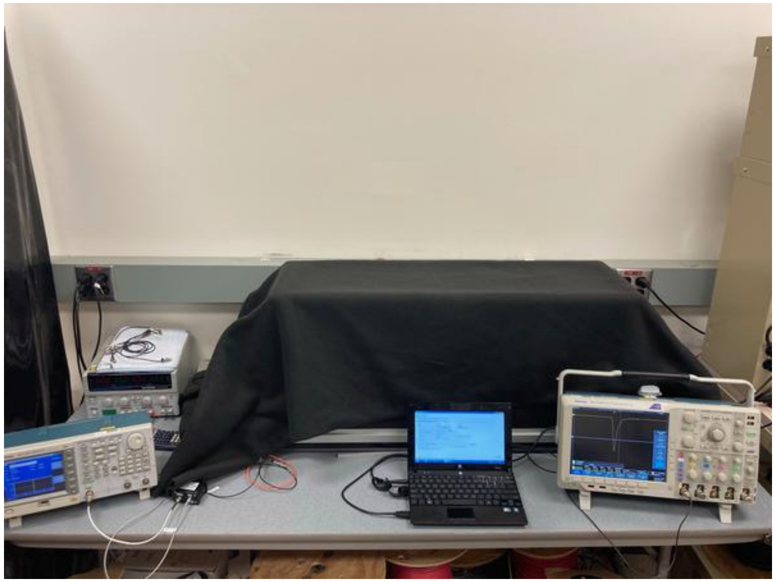
NPS meeting April 1 2021

Action items:

- Determine the PMT gain reduction value by shortening the dynods
- Measure pulse peak amplitude and pulse charge for different applied HV (800-1000 V) and different versions of PMT HV base
    - Hamamatsu
    - NPS Original
    - NPS Bypassed
    - NPS Dynode 10-A
    - NPS Dynode 9-10-A
    - NPS Dynode 9-10-A + NPS preamp with 3 versions of the gain



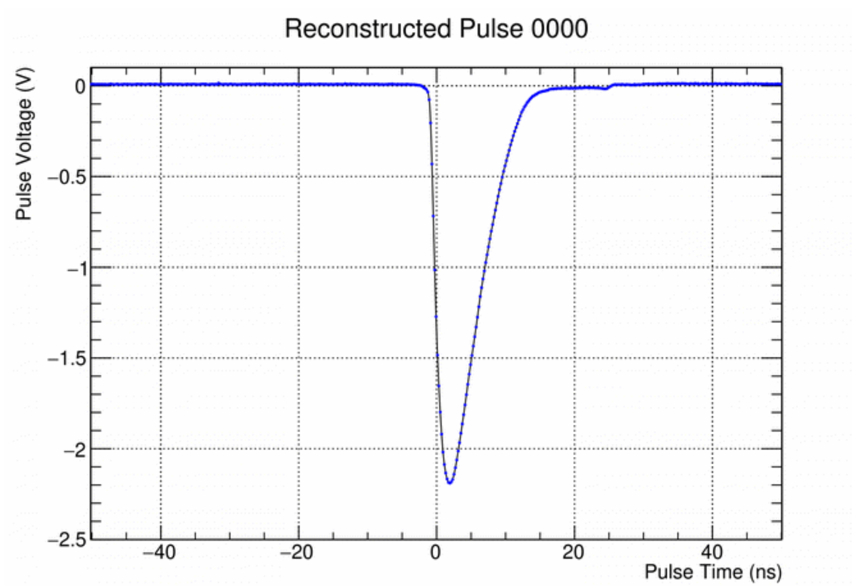


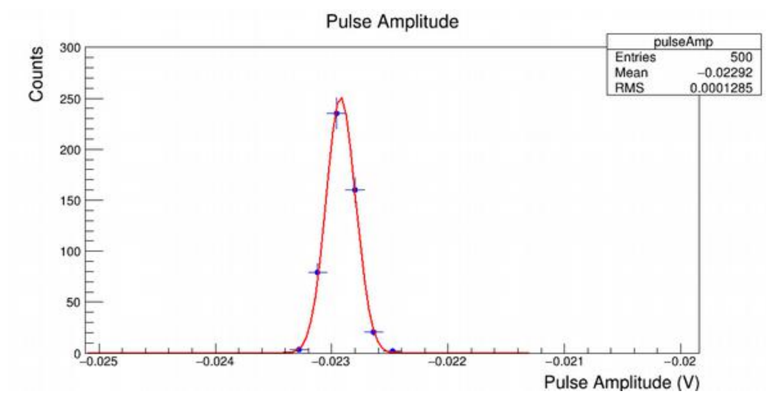
Setup configuration:

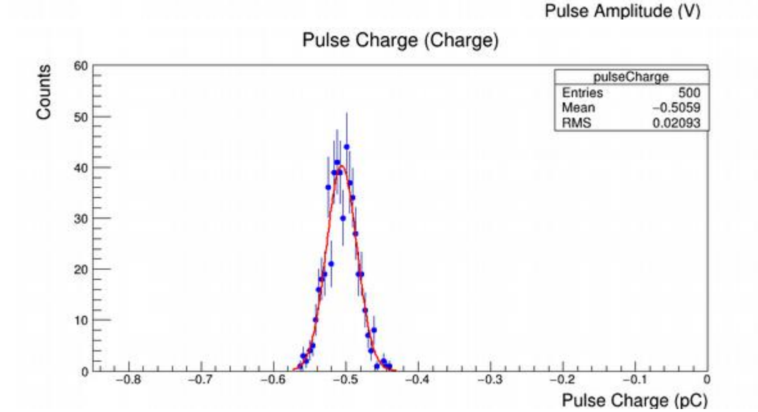
- LED intensity correspond to ~1 GeV dE/dx in PWO crystal coupled with R4125 PMT
- LED frequency 1kHz
- DAQ using scope

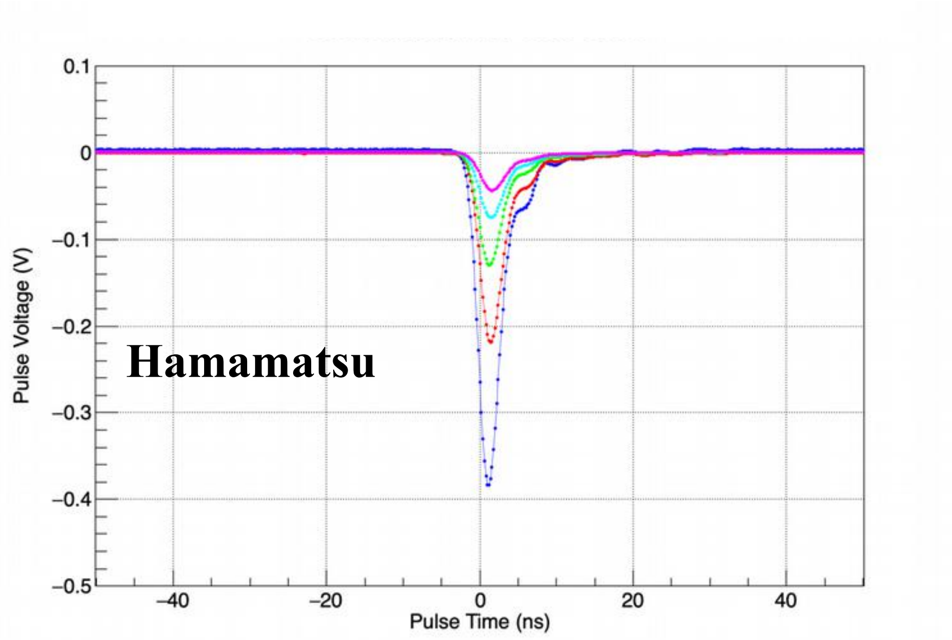
Data analysis:

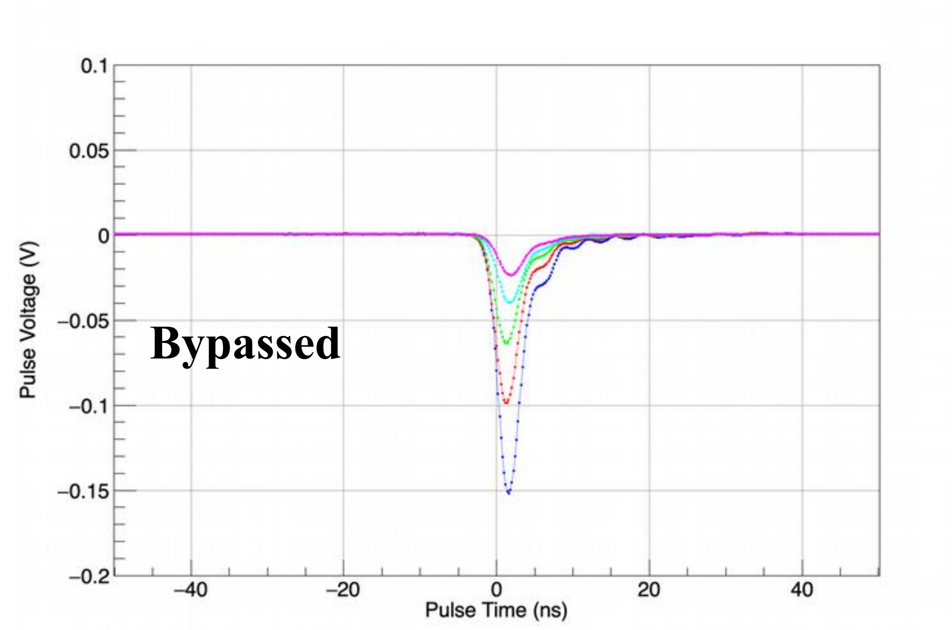
- Acquired 500 waveforms for each setting, one waveform is average over 512 pulses
- Pulse by pulse pedestal calculation using average over first 50 samples (5ns)
- Pedestal subtracted pulse peak maximum and charge calculated for each waveform
- Average pulse peak and charge calculated by Gauss fit mean value

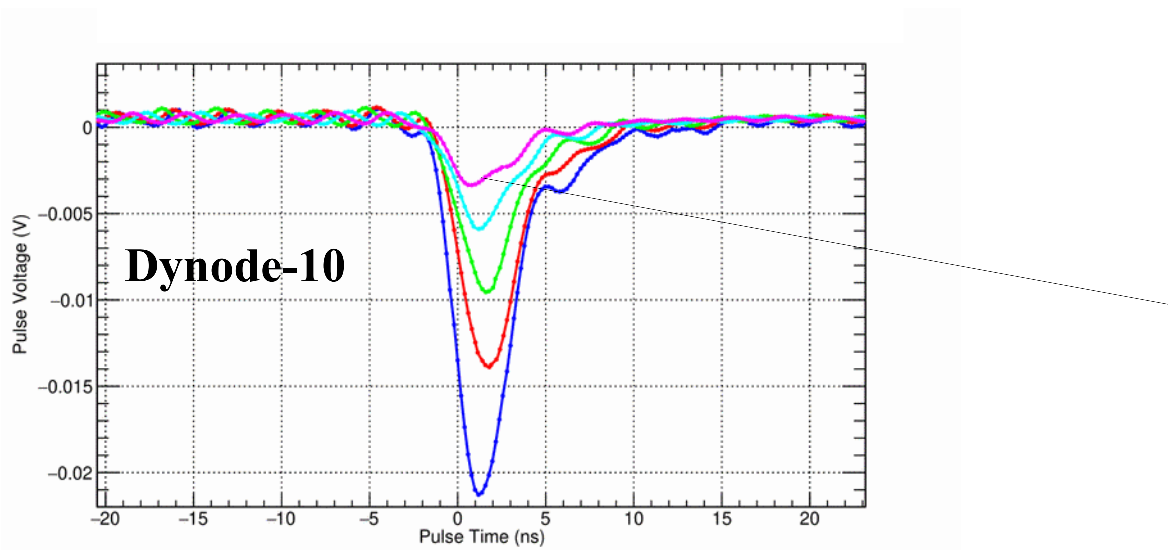


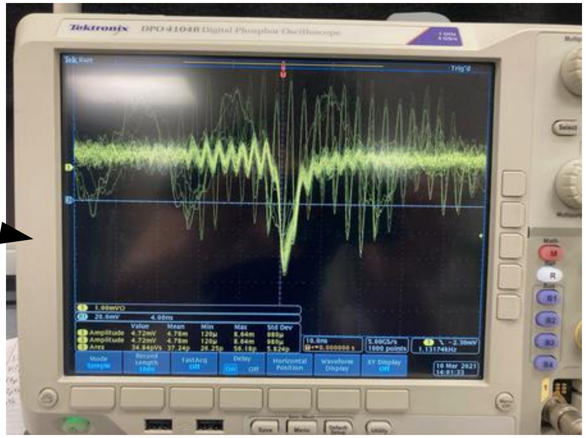




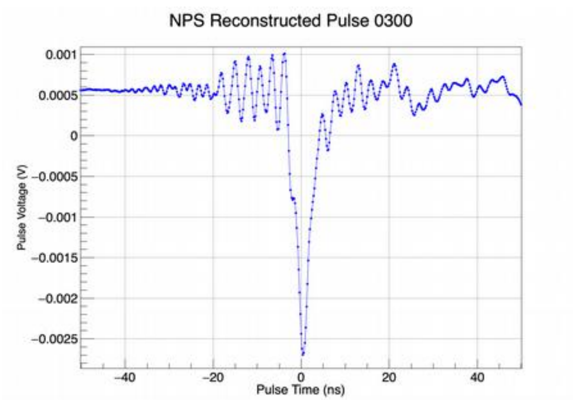

Hamamatsu
Pulse Voltage (V)
Pulse Time (ns)

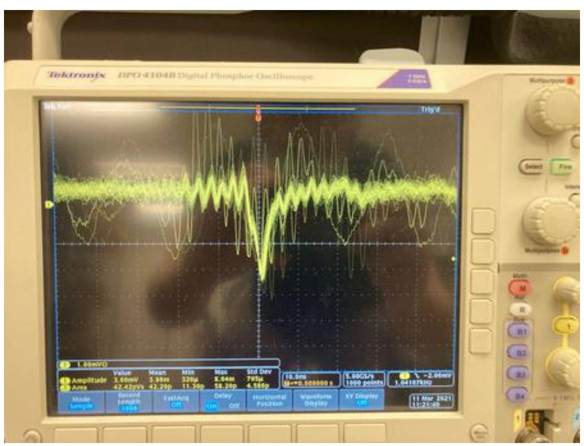

Bypassed
Pulse Voltage (V)
Pulse Time (ns)


Dynode-10
Pulse Voltage (V)
Pulse Time (ns)

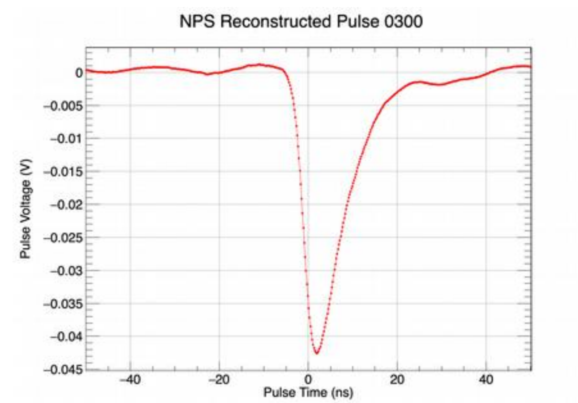

Tektronix

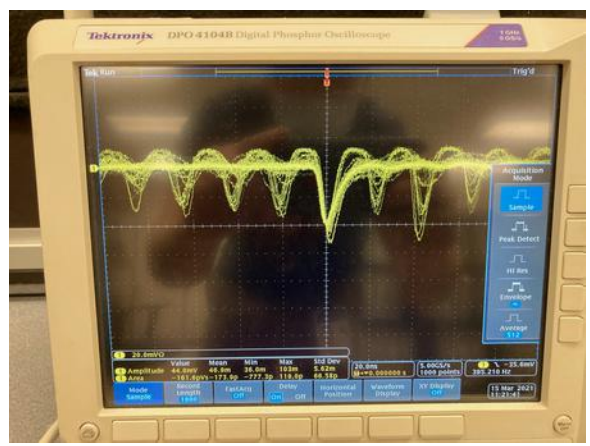
Dynode-9



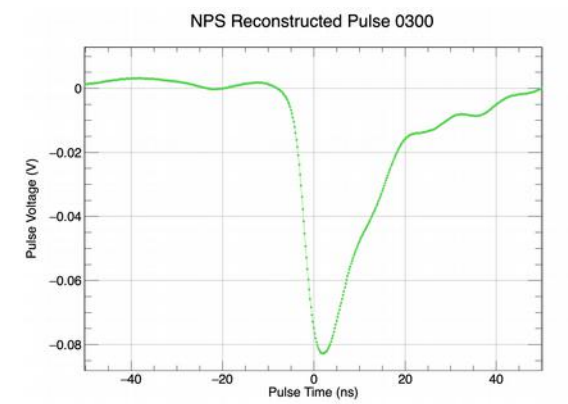


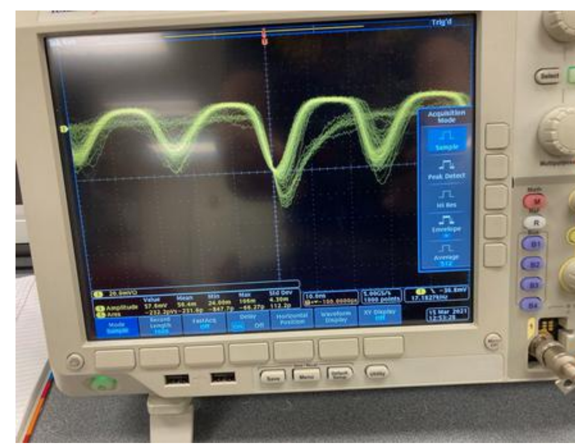
Dynode-9+PreAmp_2





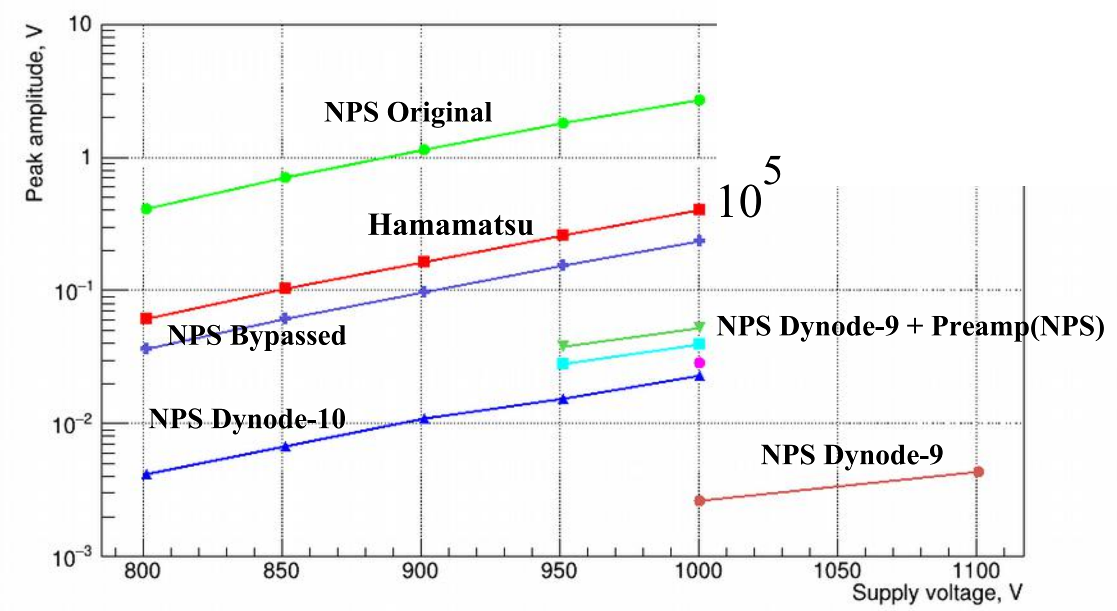
Dynode-9+PreAmp_3



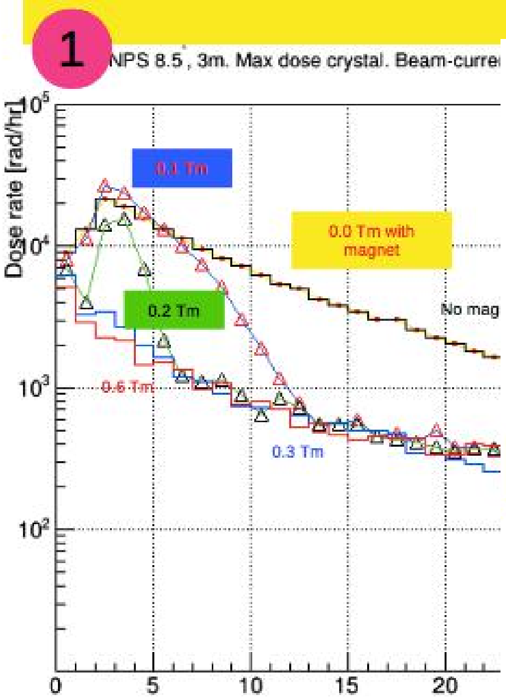


- Hamamatsu 1kV correspond to 10^5 gain
- NPS Dynode-10 correspond to 5.78*10^3
  - noise levels tolerable

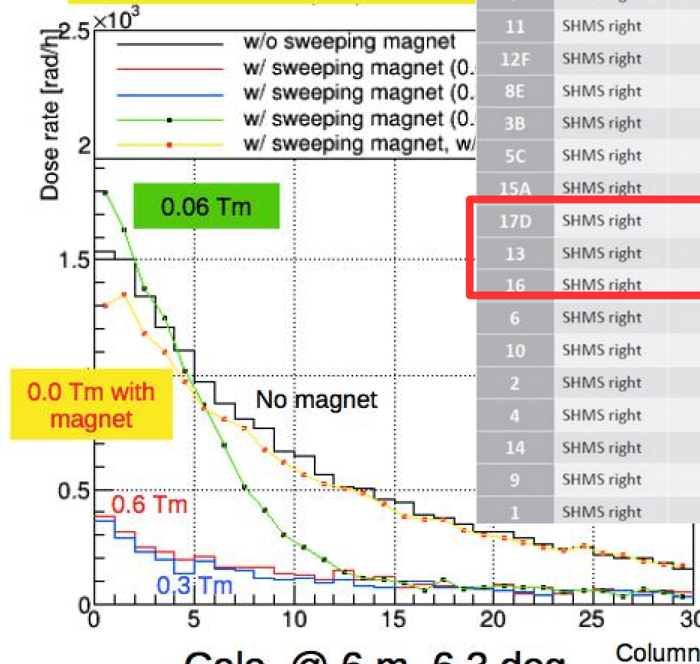
- NPS Dynode-9 correspond to 0.65*10^3
  - NPS Dynode-9
    - noise levels significant
  - NPS Dynode-9+Amp
    - max achieved Amp gain ~50
    - noise levels very large



Pulse characteristic	HV	Hamamatsu		NPS original		NPS Bypassed		NPS Dynode 10	
		Mean from fit	Error	Mean from fit	Error	Mean from fit	Error	Mean from fit	Error
Peak Amplitude (V)	1000	0.3998	0.00299999	2.7365	0.0174999	0.23425	0.00345	0.0230892	0.0004617
	950	0.2597	0.0011	1.806	0.00999999	0.1528	0.000999995	0.0154425	0.0003088
	900	0.1648	0.000399999	1.155	0.00699997	0.09801	0.000769999	0.0108097	0.0002179
	850	0.10245	0.00045	0.70095	0.00654998	0.060695	0.000475001	0.0067925	0.0001358
	800	0.061175	0.000305001	0.411	0.00390001	0.0361	0.00031	0.0041226	8.24E-05
Charge (pC)	1000	35.505	0.135	406.5	4	21.4	0.4	2.1375	0.04275
	950	23.94	0.0100002	260.15	2.35001	14.38	0.22	1.4869	0.029738
	900	15.7	0.04	168.7	1.4	9.4695	0.1255	1.0265	0.02053
	850	10.0505	0.000499725	105.35	1.15	6.118	0.059	0.6752	0.013504
	800	6.26	0.0109999	63.7	0.719999	3.794	0.051	0.4342	0.008684
		NPS Dynode 9		NPS Dynode 9 + PreAmp(R37=1kOhm)		NPS Dynode 9 + PreAmp(R37=2kOhm)		NPS Dynode 9 + PreAmp(R37=4.75kOhm)	
		Mean from fit	Error	Mean from fit	Error	Mean from fit	Error	Mean from fit	Error
Peak Amplitude (V)	1000	0.002635	5.27E-05	0.0288	0.000576	0.0395	0.00079	0.05216	0.0010432
	950					0.02787	0.00056	0.03776	0.0007552
	1100	0.004335	8.66E-05						
Charge (pC)	1000	0.2407	0.004814	4.4502	0.089	7.8265	0.15653	11.836	0.23672
	950					5.5825	0.11165		
	1100	0.4021	0.008043						



Calo. @ 3 m, 8.5 (50 uA)



Calo. @ 6 m, 6.3 deg (low-xB 11uA)

SETTING	NPS location	NPS angle (deg)	HMS angle (deg)	D magnet (m)	D calorimeter (m)	Magnet angle (deg)	Beam energy (GeV)	Beam current (uA)	Time (hours)
7	SHMS right	21.7	11.7	1.6	3.0	5.5	11	28.0	48
11	SHMS right	19.8		1.6	3.0	5.5	11	28.0	120
12F	SHMS right	17.2	17.84	1.6	6.0	4.0 or 5.5	11	28.0	240
8E	SHMS right	16.6	15.65	1.6	3.0	5.5	11	28.0	120
3B	SHMS right	16.2	11.7	1.6	3.0	5.5	11	28.0	96
5C	SHMS right	12.4	15.30	1.6	3.0	5.5	11	28.0	72
15A	SHMS right	10.6		1.6	4.0	4.0 or 5.5	11	50.0	24
17D	SHMS right	7.9	24.15	1.6	3.0	5.5	11	50.0	120
13	SHMS right	6.3	27.90	1.6	6.0	4.0	11	11.0	24
16	SHMS right	6.3	17.30	1.6	6.0	4.0	11	11.0	24
6	SHMS right	20.2		1.6	3.0	5.5	8.8	28.0	72
10	SHMS right	17.8		1.6	3.0	5.5	8.8	28.0	24
2	SHMS right	14.7		1.6	3.0	5.5	8.8	28.0	96
4	SHMS right	10.3		1.6	4.0	4.0 or 5.5	8.8	50.0	24
14	SHMS right	9.2		1.6	4.0	4.0 or 5.5	8.8	5.0	24
9	SHMS right	13.8		1.6	3.0	5.5	6.6	28.0	120
1	SHMS right	11.7		1.6	3.0	5.5	6.6	28.0	24

Sweeping m

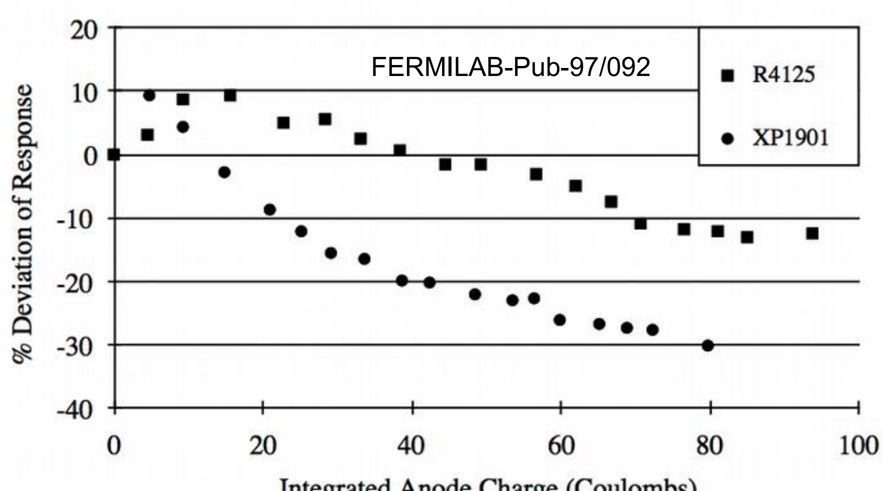


Figure 12) Change in response of an R4125 and an XP1901 PMT as a function of integrated anode charge.

Version	HV base	Gain	Int. An. Charge	Anode current
default	Bypassed (1kV)	0.5*E+05	1990 C	~(0.5-2.9) mA
1	Dynode-9 (1kV)	6.6*E+02	22.0 C	~(5-32) uA
2	Dynode-10 (1kV)	5.8*E+03	199 C	~(50-300) uA
3	Dynode-10 (950V)	3.86*E+03	133 C	~(34-201) uA
4	Dynode-10 (900V)	2.7*E+03	94.0 C	~(24-141) uA
5	Dynode-10 (850V)	1.7*E+03	58.0 C	~(15-87) uA
6	Dynode-10 (800V)	1.0*E+03	40.0 C	~(10-60) uA

- **The PMT gain reduction measured for two configurations:**
  - **Dynode 10 shortened to Anode (Gain- 5.78*10^3 for 1 kV)**
  - **Dynode 9 shortened to dynode 10 to Anode (Gain- 6.59*10^2 for 1 kV)**
- **The amplifier needed to scale PMT signal to one of fADC-250 ranges 0.5, 1.0 or 2.0 V**
- **For the extremest kinematic settings total integrated anode charge need to be < 100 Coulombs. The R4125 tube response degrading less than 15% for an integrating charge of ~100 C.**
- **Nonlinearity of the amplifier should be at the level of ~1% to not affect the resolution Note: Hamamatsu rate PMT R4125 at ~2% nonlinearity**
- **PMTs need to operate above 900 V**
- **Noise levels need to be considered**
- **Possible amplifier options:**

  1) **design new linear and low noise amplifier with external power**
     possible solutions for all versions of HV base
  2) **keep assembled dividers and add external amplifier**
     possible solution for only Dynode-10 v2,v3 and v4, need to be proved
  3) **keep the present scheme with appropriate modifications of the dividers**
     possible solution for only Dynode-10 v2,v3 and v4, need to be proved