Gain, SNR and Risetime of the “Penn1” Amplifier

SNW, July 25, 2017

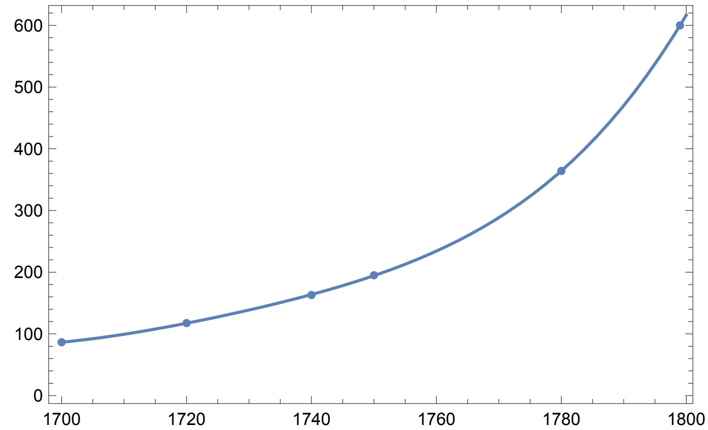
(some early results on HFS data taken within the “PICOSEC” project at SPS July5-18)

The signal from the HFS Silicon detector was calibrated using a 5.4 KeV X - Ray source and then compared to the signal seen at the same operating voltage (1800 V) and with the same front end electronics (see SNW note Feb. 21, 2017
http://physics.princeton.edu/~mcdonald/LHC/White/white_resnati_170222.pdf).
From this comparison we find that The most probable signal from a 150 GeV muon (MIP) is 5,380 e-h pairs
To find the input charge into the amplifier we use an (average) Gain curve from similar devices.
The nominal Detector capacitance for the RMD “8x8” diode is 0.79 pF/mm^2 and since the detector active area is ~9x9 we take this to ->~60 pF. However the effective capacitance is lower in the “mesh readout” capacitive coupling scheme. We estimate C_D~25 pF.

```
Gain = {{1700, 86.5}, {1720, 117.5},
  {1740, 163}, {1750, 195}, {1780, 364}, {1799, 600}}
{{1700, 86.5}, {1720, 117.5}, {1740, 163}, {1750, 195}, {1780, 364}, {1799, 600}}

lm = LinearModelFit[Gain, {x, x^2, x^3, x^4}, x]
```

FittedModel[$6.32833\times10^{7} - 146774.\,x + 127.668\,x^{2} - 0.0493609\,x^{3} + 7.15763\times10^{-6}\,x^{4}$]

```
Show[ListPlot[Gain], Plot[lm[x], {x, 1700, 1800}], Frame → True]
```



The Penn1 Detector/Amp was operated with bias voltages of 1700, 1726, 1751, 1772 in the July ' 17 testbeam.

```
HV = {1700, 1726, 1751, 1772};
```

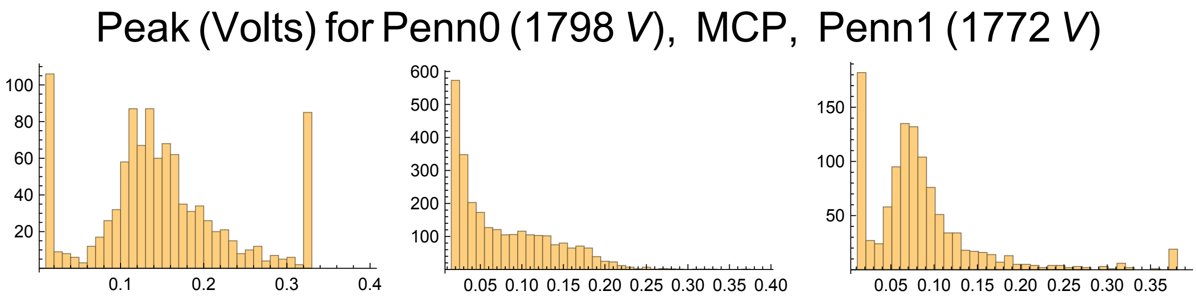
```
lm[HV[[4]]]
301.563

qmip = 5380 * 1.6 * 10^{-19} * 10^{12}
{0.0008608}
```

Signal charge vs Silicon Bias Voltage (in femtoCoulombs)

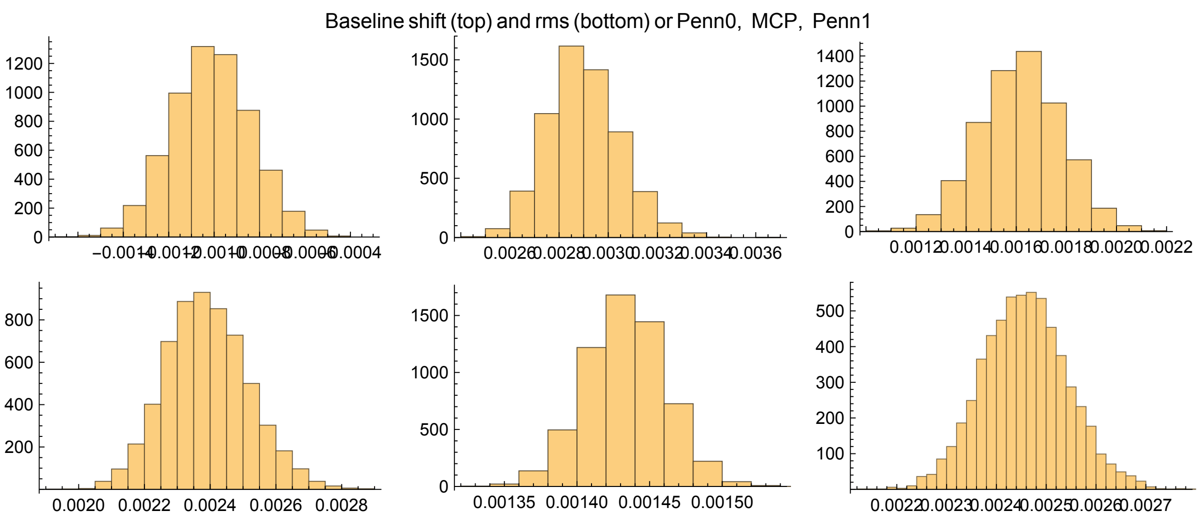
```
qin = Table[qmip * lm[HV[[i]]], {i, 4}]
{{0.074497}, {0.111649}, {0.170318}, {0.259585}}
```

Correction of Scope Signal to Penn Amp output : Since we use a second stage of 13 dB we need to divide by ~4.5 to get the correct scale of mV/fCoulomb.

Out[83]=

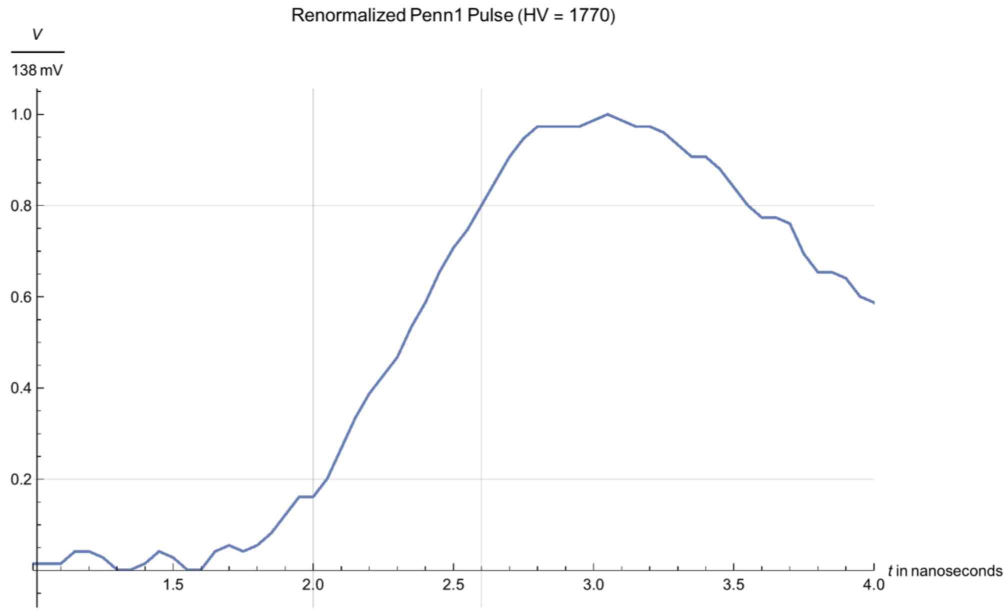


Referring to the above figure, Penn1 for an input charge of 0.26 fCoulombs produces an output of 70 mV/(4.5).
= > 60 mV per femtoCoulomb. By comparison the rms noise (at full 4 GHz bandwidth is 2.5mV/4.5~600 microVolts. See below:



More beam analysis in progress but we typically have 10 - 100 k events per run and the triggers were from a large area scintillator (2 x3cm^2) and recorded with a fast MCP - hence the poor separation of MIP from noise in the above raw plots.

So timing characteristics will follow but a peek at a typical waveform below shows major improvement in signal risetimes form the ~1.2 - 1.4 nsec we were used to.



Below are figures of the new construction techniques that led to good performance of Penn1.