Estimate of Flying Wire Sensitivity to Channeled Beam

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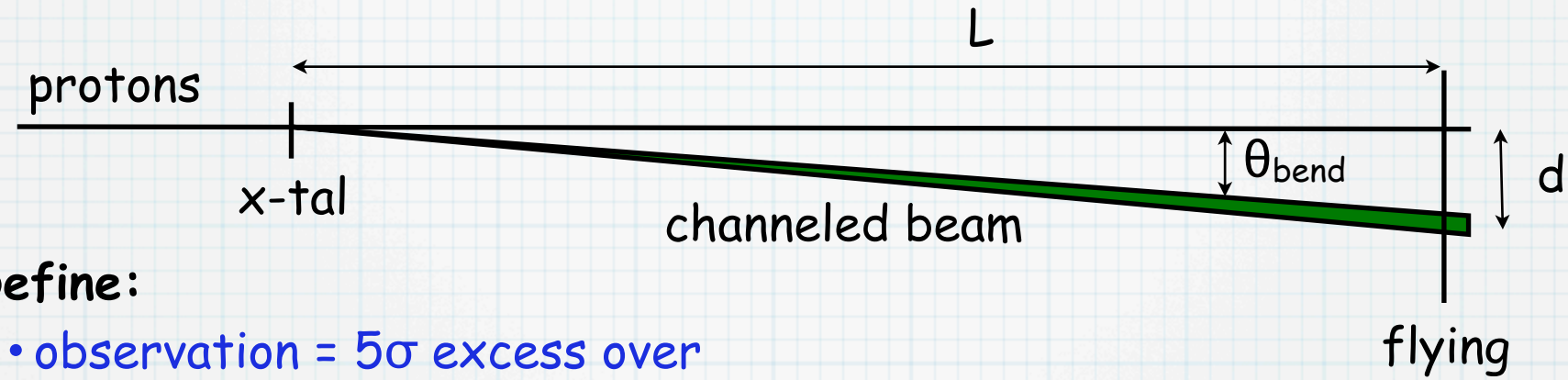
2/25/09

Sensitivity Calculation



Define:

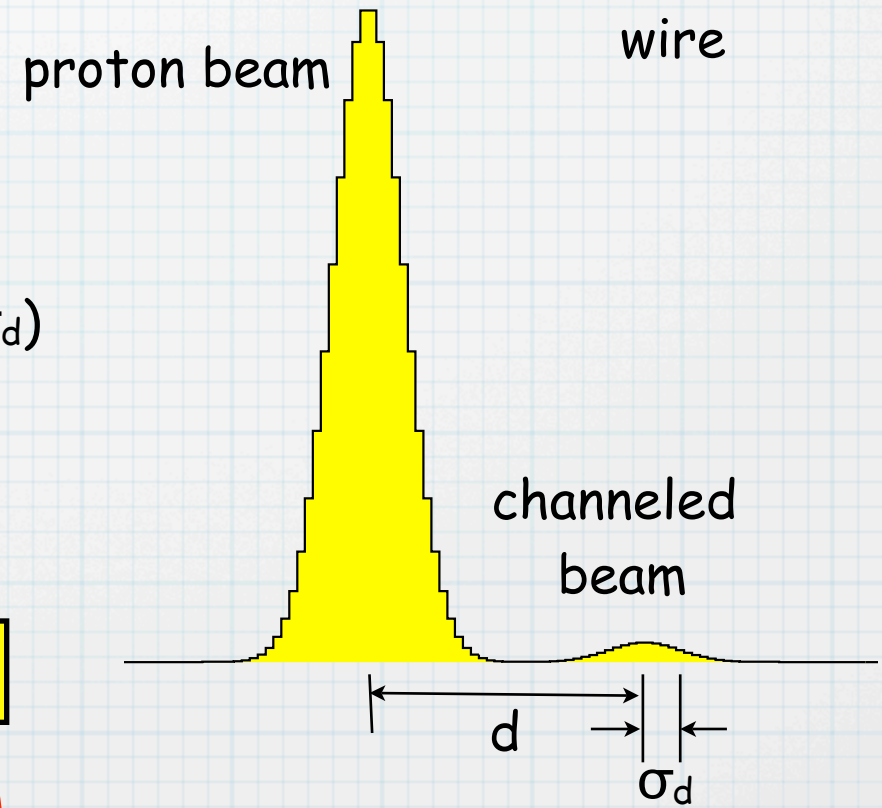
- observation = 5σ excess over background. $s \geq 5\sigma_b$
- signal (s) = area under peak
- background (b) = "noise"

$$\sigma_b = 4\sigma_d \frac{\sigma_{pedestal}}{\sqrt{N_{meas}}}$$ (+/- 2σ_d)

$$4\sigma_d = N_{meas}\delta x_{meas}$$

$$\sigma_d = L \cdot \tan\theta_c \approx L \cdot \theta_c$$

$$\boxed{s \geq 10\sigma_{pedestal}\sqrt{\delta x_{meas} L \theta_c}}$$



Need $\sigma_{pedestal}$ in units of protons/mm

Flying Wire Sensitivity Analysis

Overview

- **Low Gain counter:**
  - 'Processed data' converted to dN/dx using C:FBIPNG bunch-by-bunch for each pass through the beam
- **High Gain Counter:**
  - Raw data converted to 'processed data'
  - 'Processed data' converted to dN/dx using calibrated low gain counter data (only consider the tails of the peak)
  - Pedestal RMS from high gain counter used to assess sensitivity.

Store: 6021, fly 1207267033 (4/3/2008 18:57) last HEP fly

Low Gain Counter Calibration

$dN/dx_i = S*(D_i - P)$

Pedestal (P):

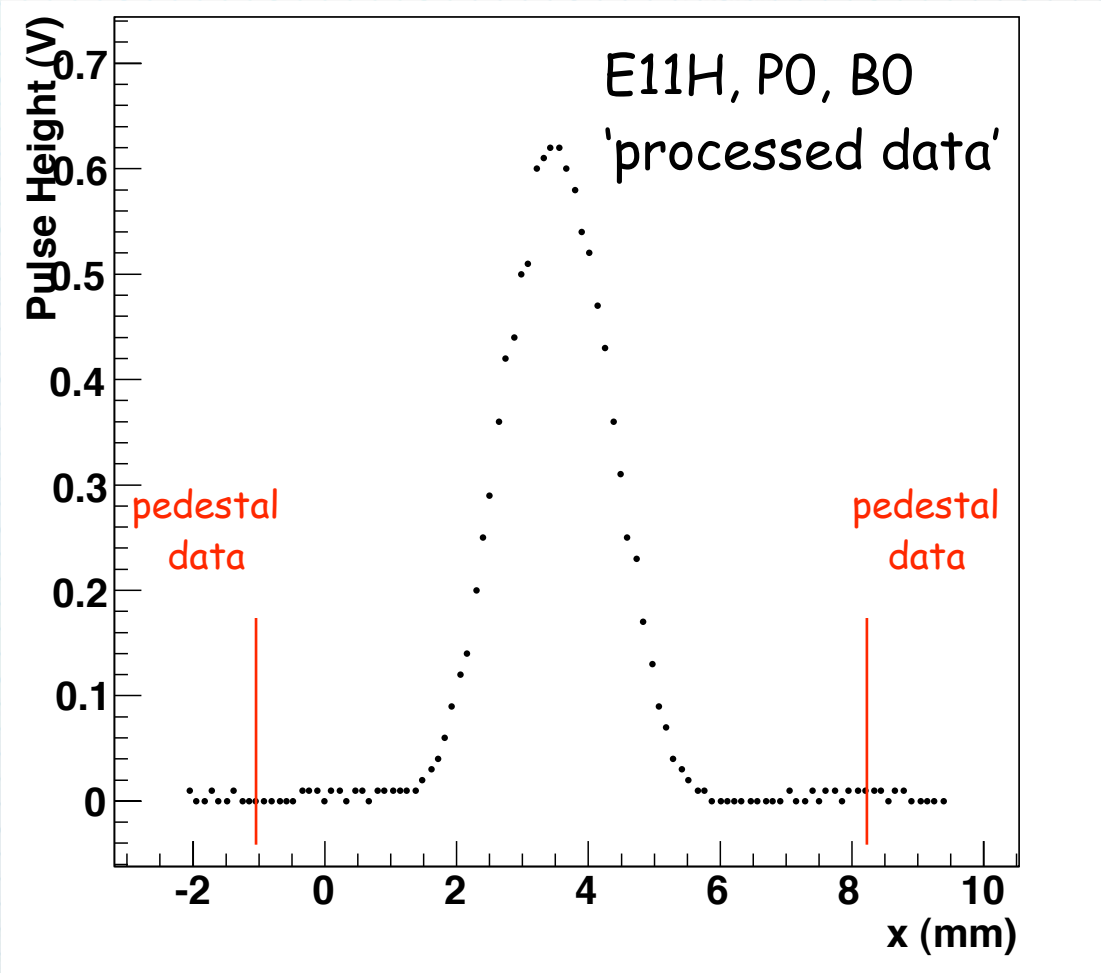
- Calculate using 1st & last 10 points (far from peak)
- Subtract from data

Scale(S):

- Integrate area (A) from pedestal subtracted data
- Use C:FBIBNC[bunch] to determine scale (S)

$$A = \frac{1}{2}\sum_{i=0}^{N-1}(v_{i+1}+v_i)(x_{i+1}-x_i)$$

$$S = FBI/A$$

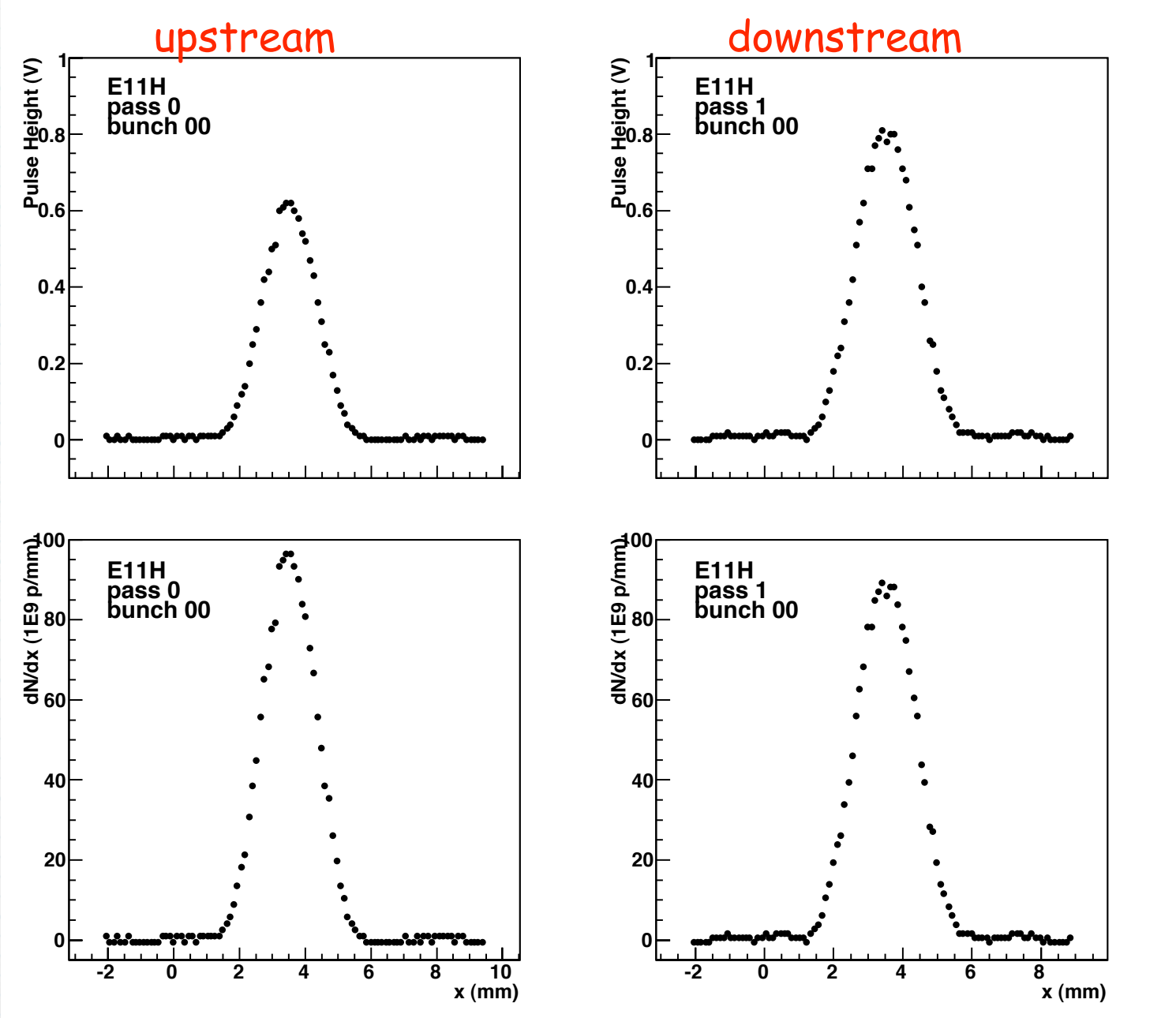


All calculations performed separately for each pass and bunch

Low Gain Counter Calibration

'processed data'

calibrated data



High Gain Counter Calibration

Convert raw data to 'processed data

- Associate encoder angle w/ ADC
- Convert encoder counts to position

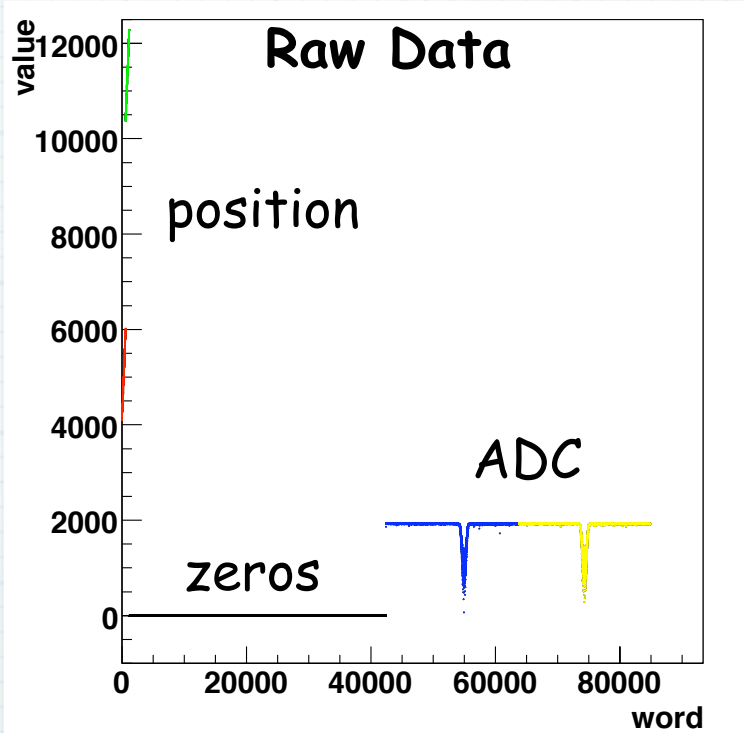
$$\theta = \theta_0 + K_E \theta_E$$
$$x = x_0 + r \sin\theta$$

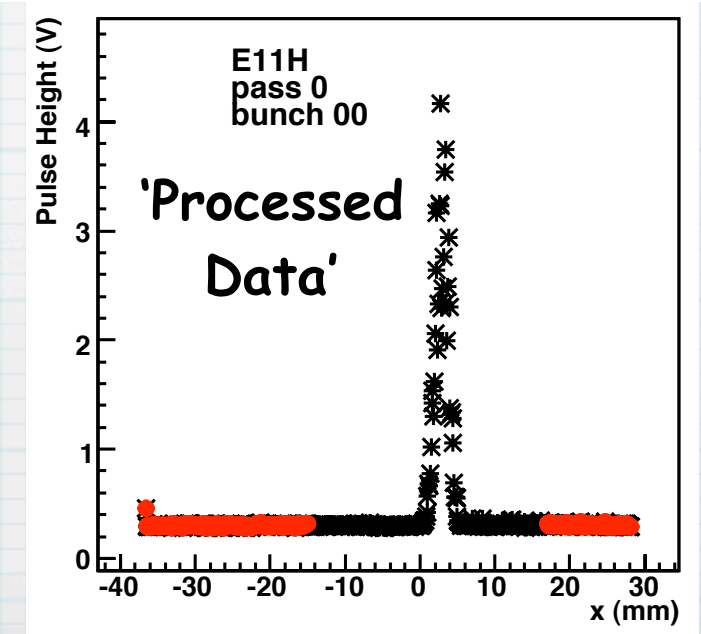
- Convert ADC to voltage

$$V = C\,(P - ADC)$$

parameter	value	units
θ_0	-1.57	radians
K_E	-0.3834	mradians/count
x_0	-36.5	mm
r	96.5	mm
C	-0.002441	V/count
P	2048	counts

Conversion constants from J. Zagel, D. Slimmer





High Gain Counter Calibration

$dN/dx_i = S*(D_i - P)$

Pedestal (P):

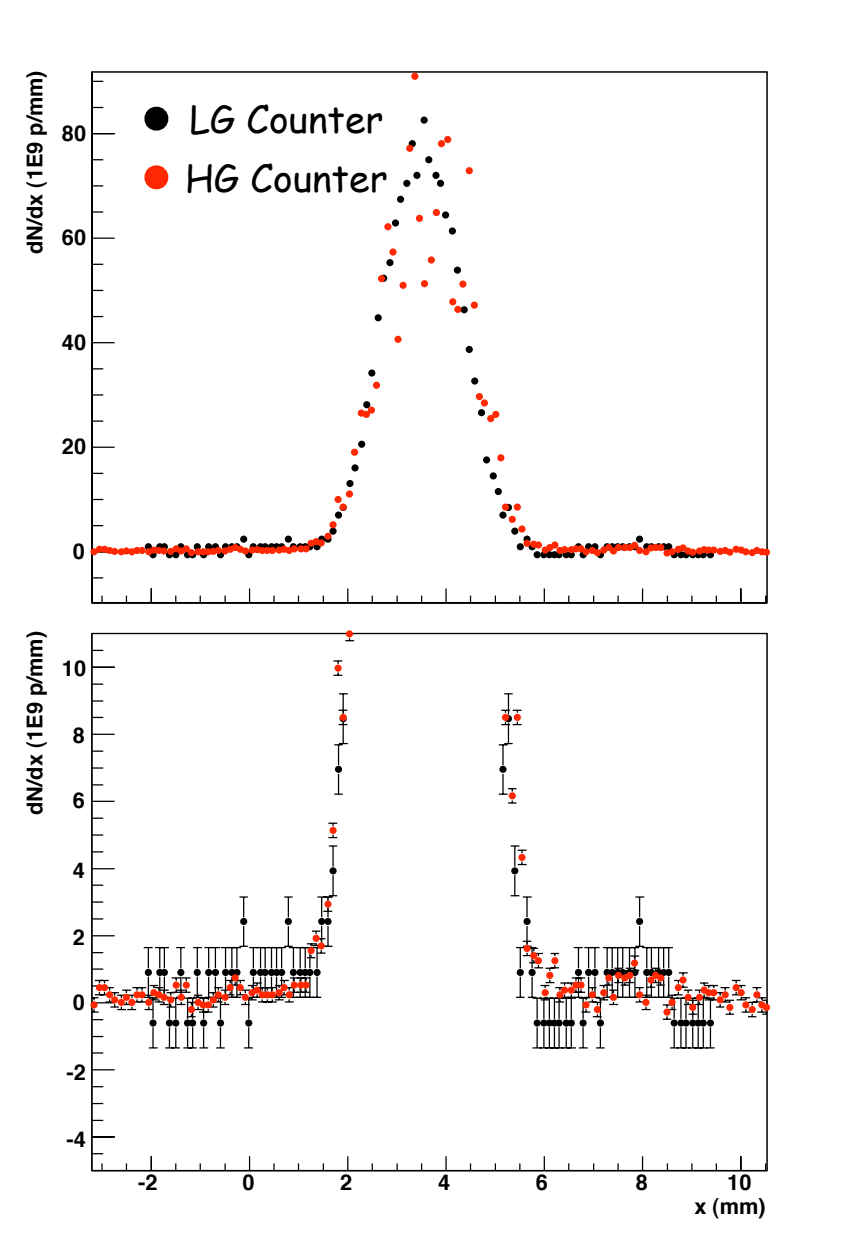
- Calculate using 1st & last 10 points (far from peak)
- Subtract from data

Scale(S):

- Match tails of beam peak to low gain data (eyeball fit)

Many problems along the way!

Too many to detail here



HG/LG Counter Sensitivity

$$s \geq 10\sigma_{pedestal}\sqrt{\delta x_{meas} L \theta_c}$$

Quantity	value	units
θ_c	10×10^{-6}	radians
L	33115	mm
δx_{meas}	0.083	mm
$\sigma_{pedestal(LG)}$	0.925	10^9 protons/mm
$\sigma_{pedestal(HG)}$	0.261	10^9 protons/mm

s_{LG} > 1.53×10^9 protons
s_{HG} > 0.43×10^9 protons

How does the sensitivity compare with expected signal size?

Interpretation

Expected lost signal size:

- Particles loss rate: ~ 1×10^6/sec (N. Mokhov)
- Bunch integration time: ~60×10^{-9}sec
- # bunches: 36
- # samples in deflected beam: ~ 20
- # particles in sample: ~ $1 \times 10^6 * 60 \times 10^{-9} * 36 * 20$ = 42 protons

High Gain Counter Sensitivity = 0.4×10^9

Need increase signal by ~10^8

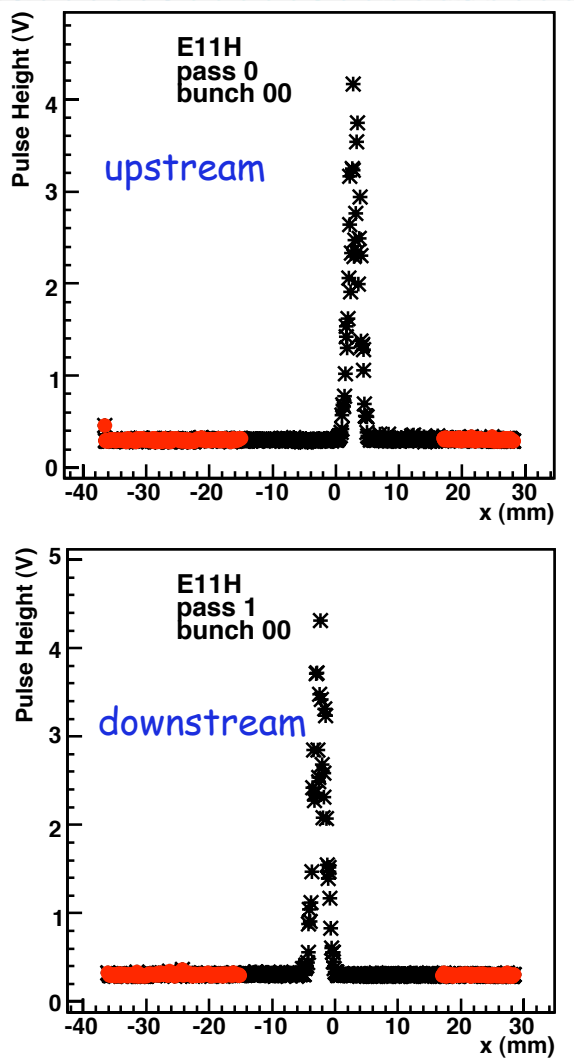
Typical "high gain" PMT has gain of ~10^6

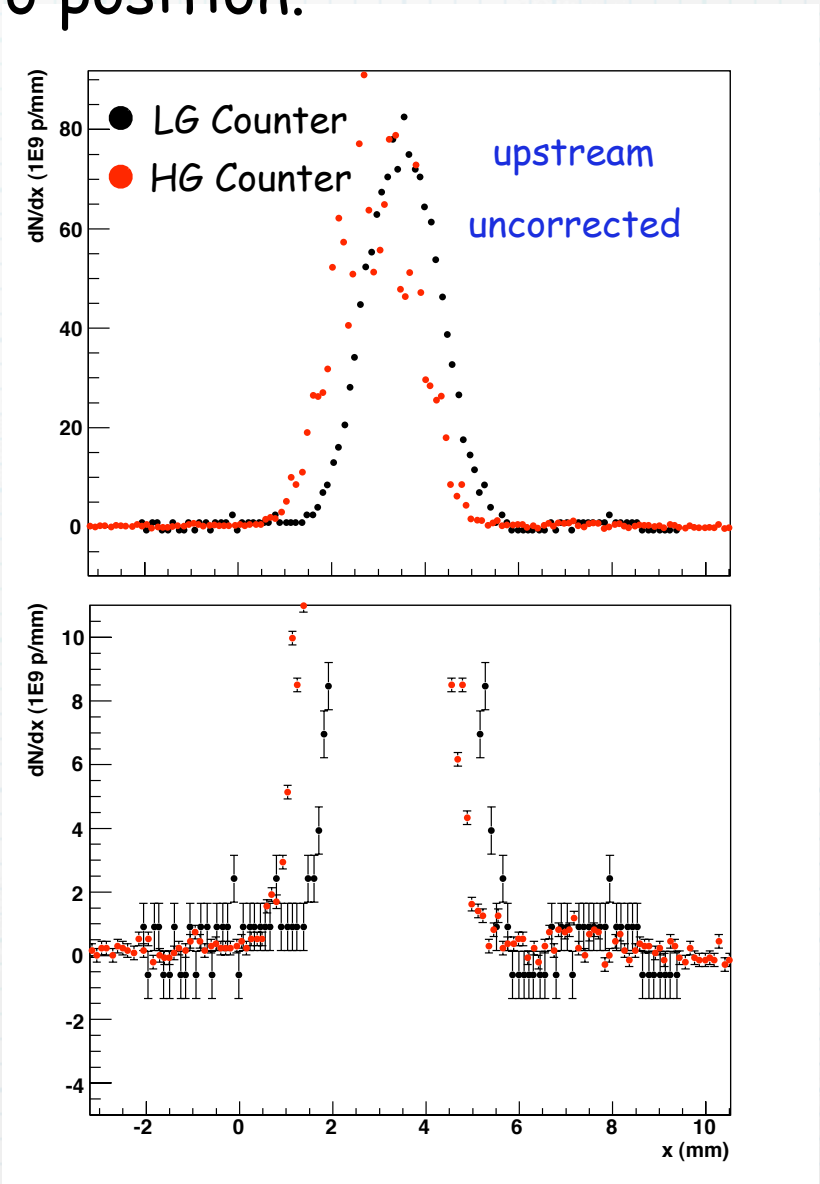
Unlikely we can use flying wires to "see" channeled beam.

High Gain Counter Problems

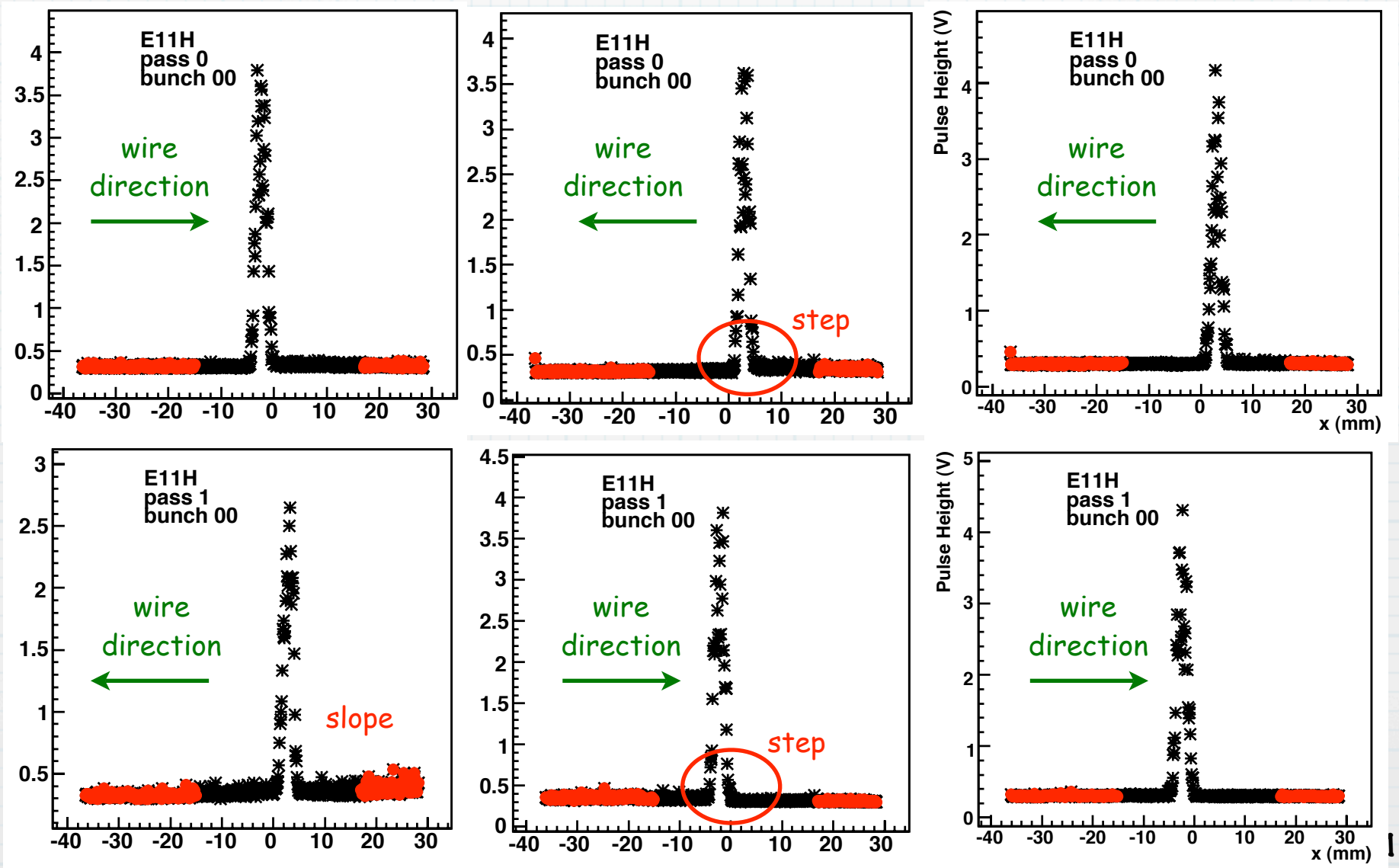
Conversion from angle encoder to position.

High Gain Counter





High Gain Counter Problems

Pedestal features (intensity dependent?)

1st "HEP" fly | 2nd "HEP" fly | last "HEP" fly