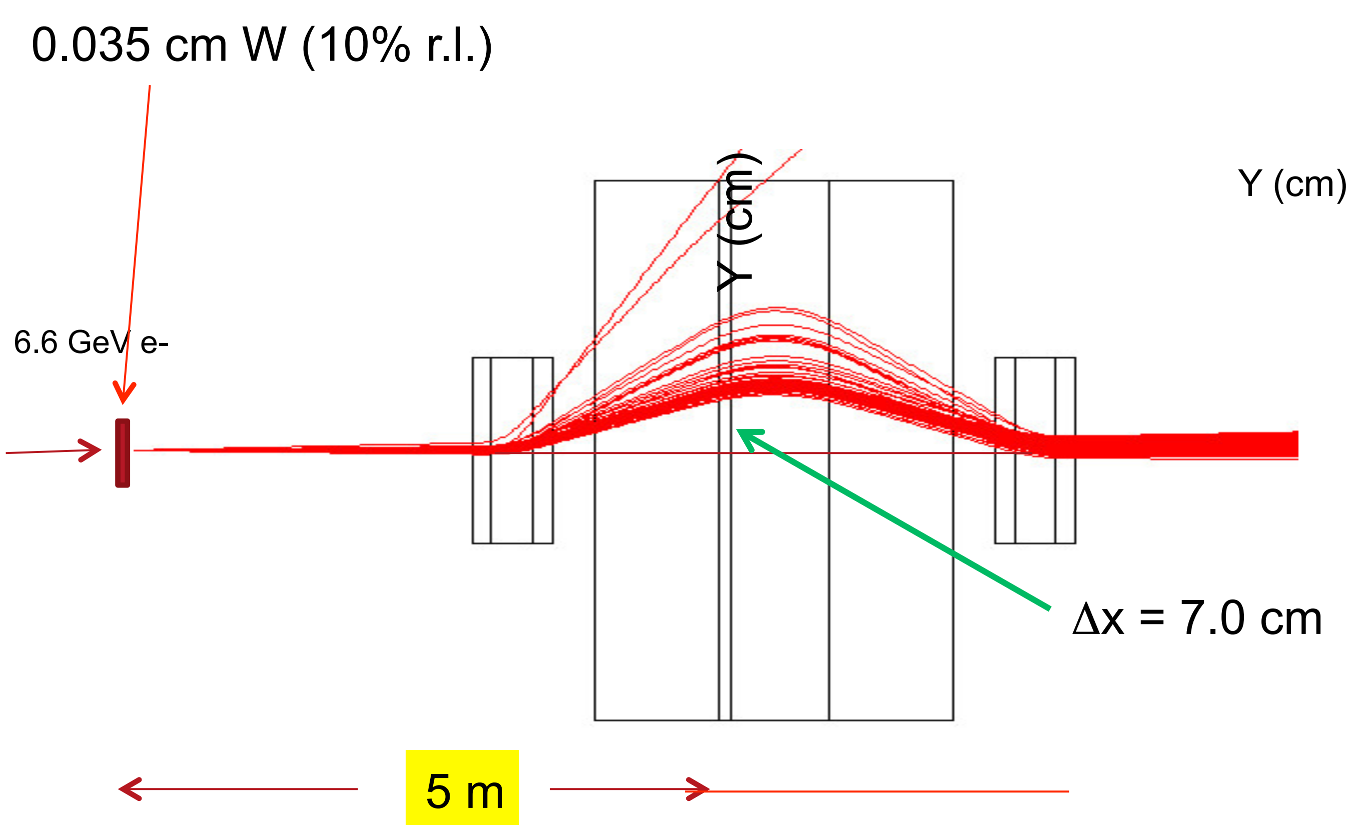
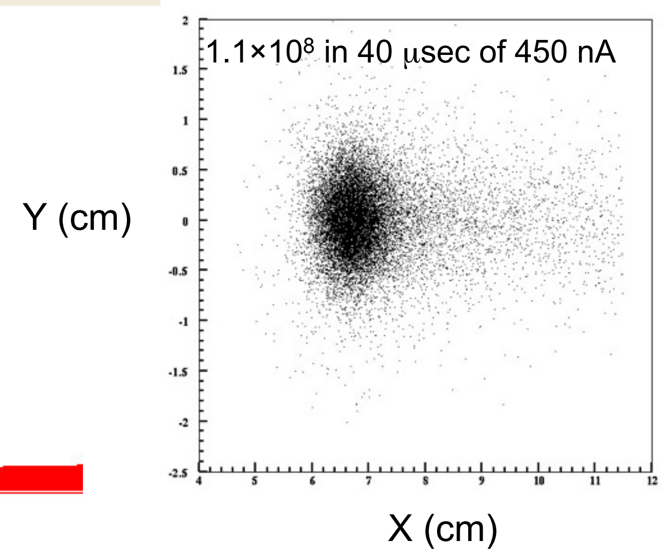
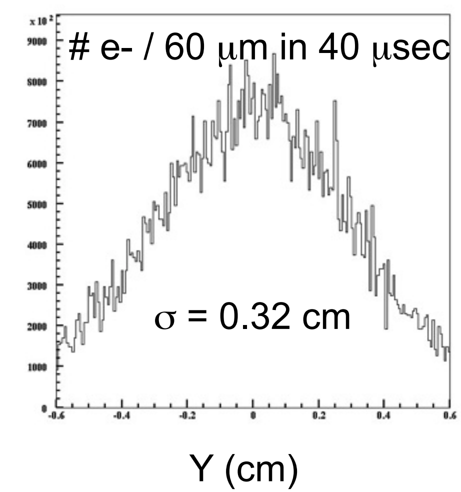
Acute SVT Sensor Damage Test Beam

Pelle

Background: Collimator Scattering (Takashi)







Expect maximum of 8×10^5 electrons/ strip / 40usec

Spot size is ~0.32cm width

No time evolution – static for 40usec for this example (?)

Are the SVT modules safe for this type of accident?

SVT Module Damage

Two major concerns

- Readout chip damage
- Breakdown of sensor strip implant capacitor

Atlas study by our Santa Cruz colleagues:
https://confluence.slac.stanford.edu/display/hpsg/08.27.2013+Weekly

Predicting vulnerability for our sensors is hard

- Depends on exact sensor geometry and bias network
- Exact beam loss scenario is also important: how many strips get hit simultaneously, time evolution, etc.

Conclusion is that we cannot say we are safe

➔ Test susceptibility using beam test

NLCTA (Next Linear Collider Test Accelerator)

NLCTA provides good match for out purpose

- R&D accelerator: beam availability, flexibility
- High enough intensity

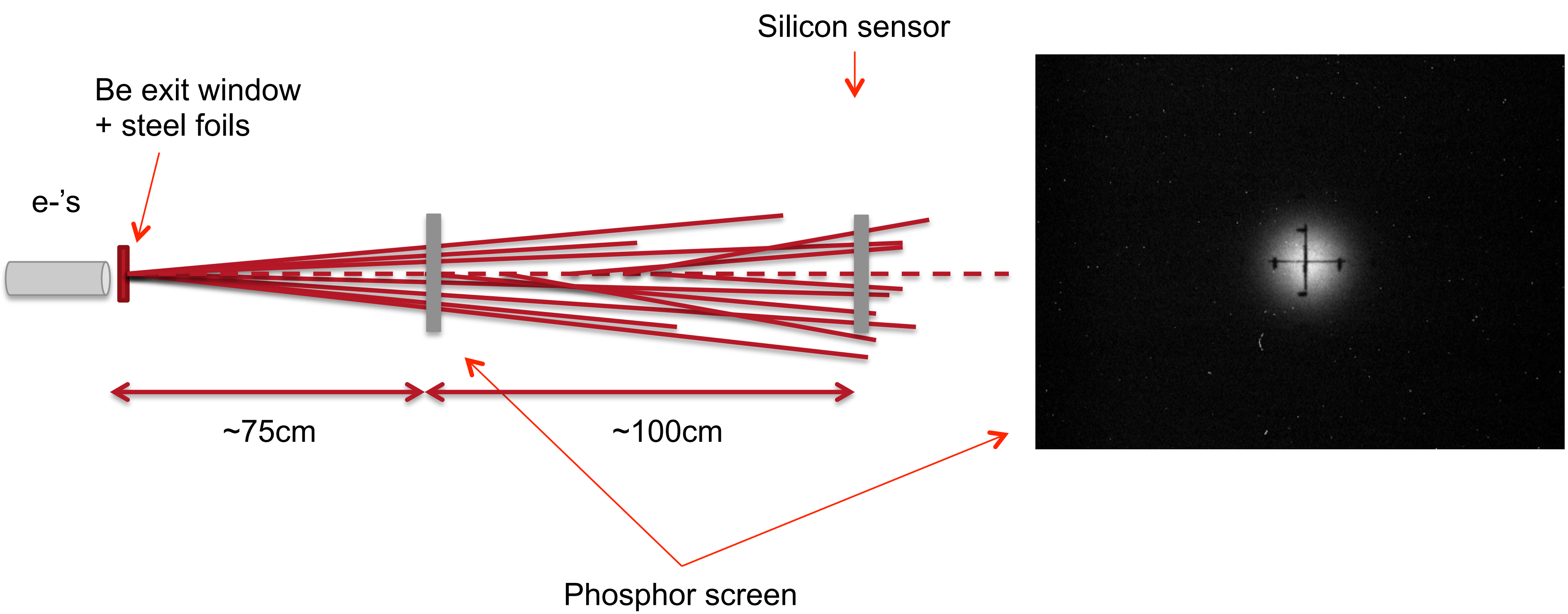
	NLCTA
Beam Type	e^-
Beam energy (MeV) (range)	120 60, 80-120
Repetition Rate (Hz) (range)	10 1-10
Bunch Intensity ($\times 10^8$) (range)	1.2 0.06-12
Bunch Length (σ,μm) (range)	60
Beam Spot size (σ,μm) (range)	150 100-300

Wrong time constant; but short pulse is more dangerous

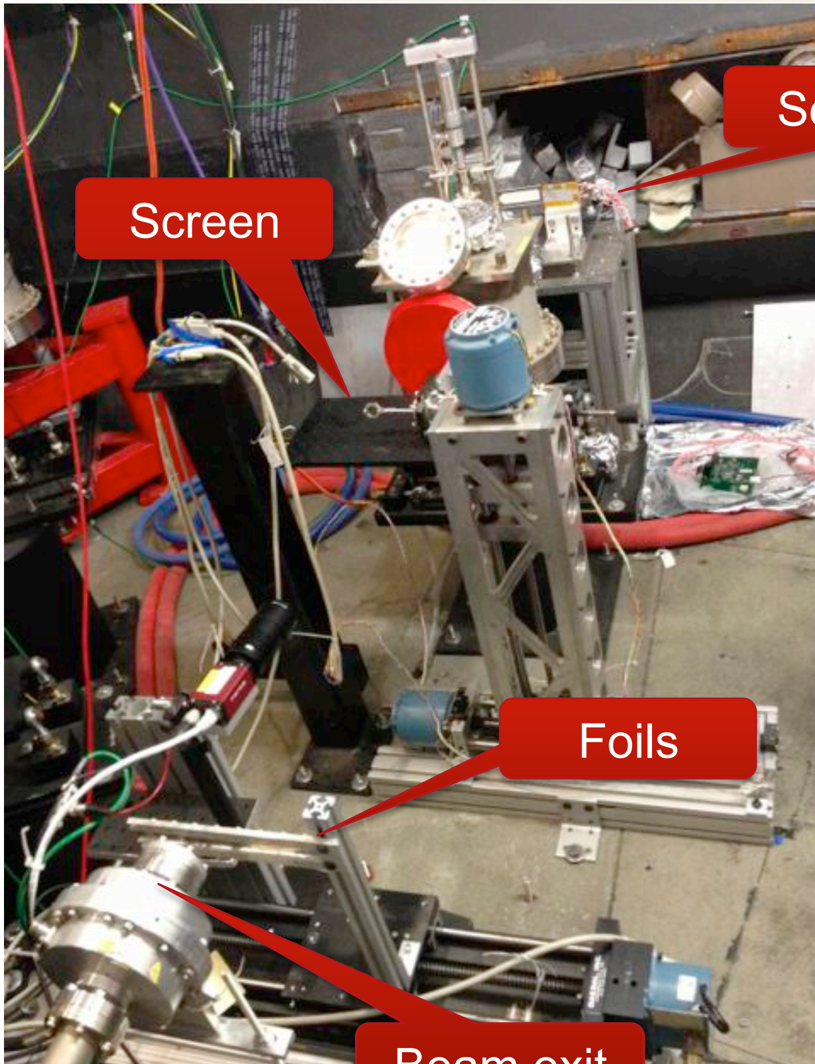
Use scattering in foils and air to vary intensity

X-ray contribution is relatively small

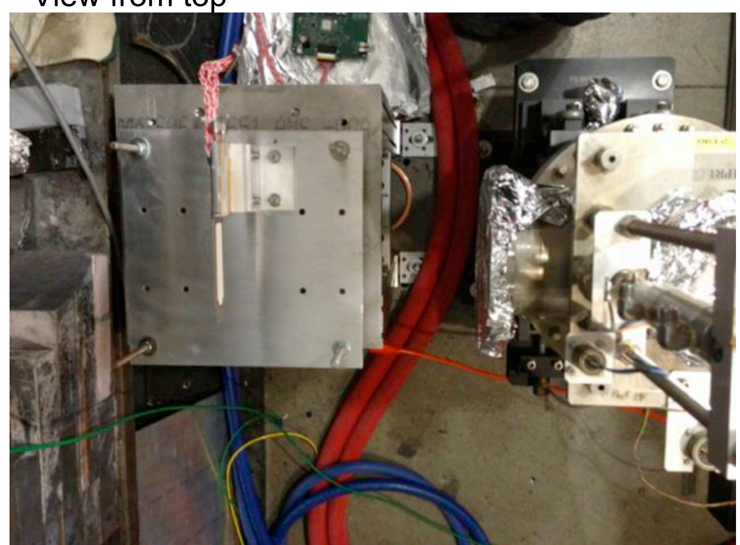
Setup


Silicon sensor
Be exit window
+ steel foils
e-'s
~75cm
~100cm
Phosphor screen

Setup



View from top



NLCTA Simulation

Setup

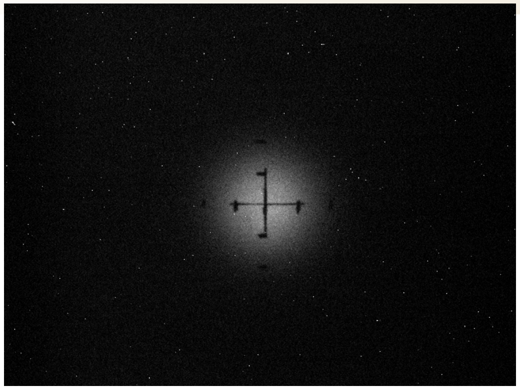
- 120 MeV electron beam
- 150um beam spot (estimate)
- 50um Be window, steel foils 25um thick
- 1” aperture not included (no real effect since spot is small)

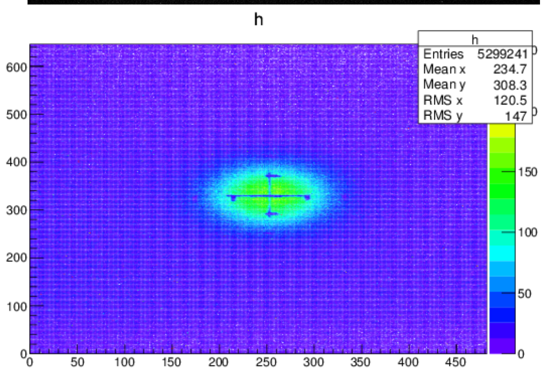
“Gaussian” approximation

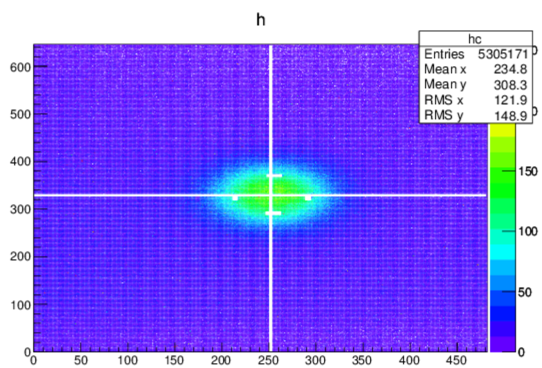
- Core multiple scattering description
- Foils and window on same “z”-position
- The effect from scattering in air is taken into account

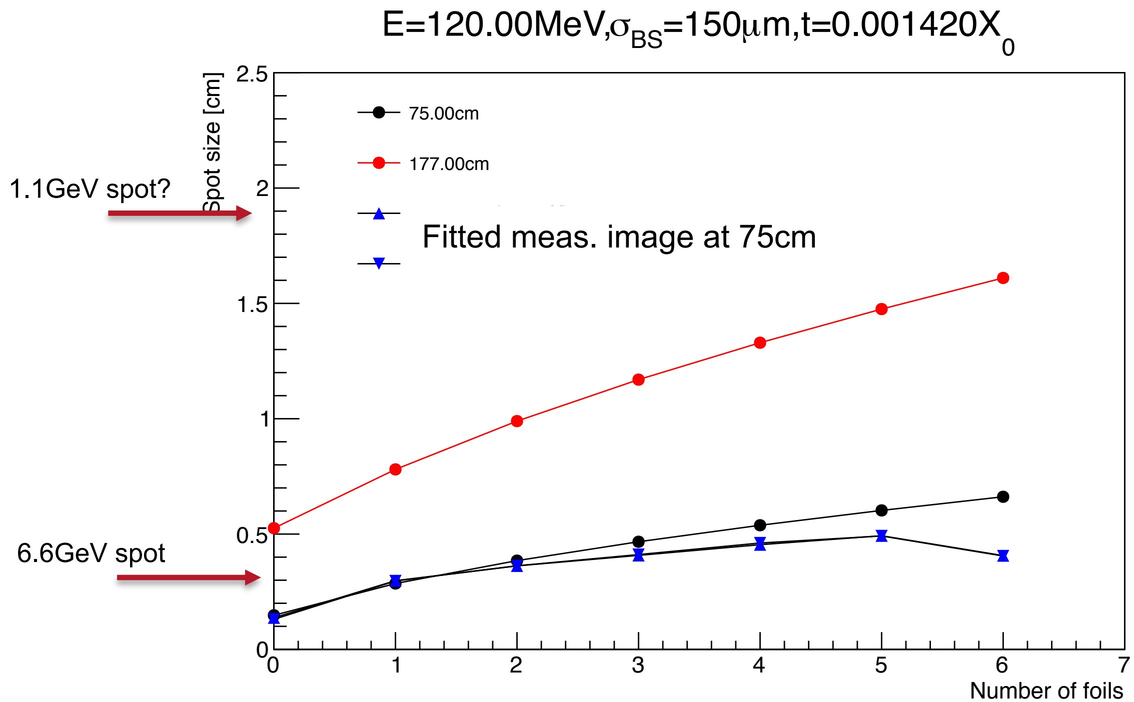
Cross-check with full EGS5 simulation

Estimated and Measured Beam Spot









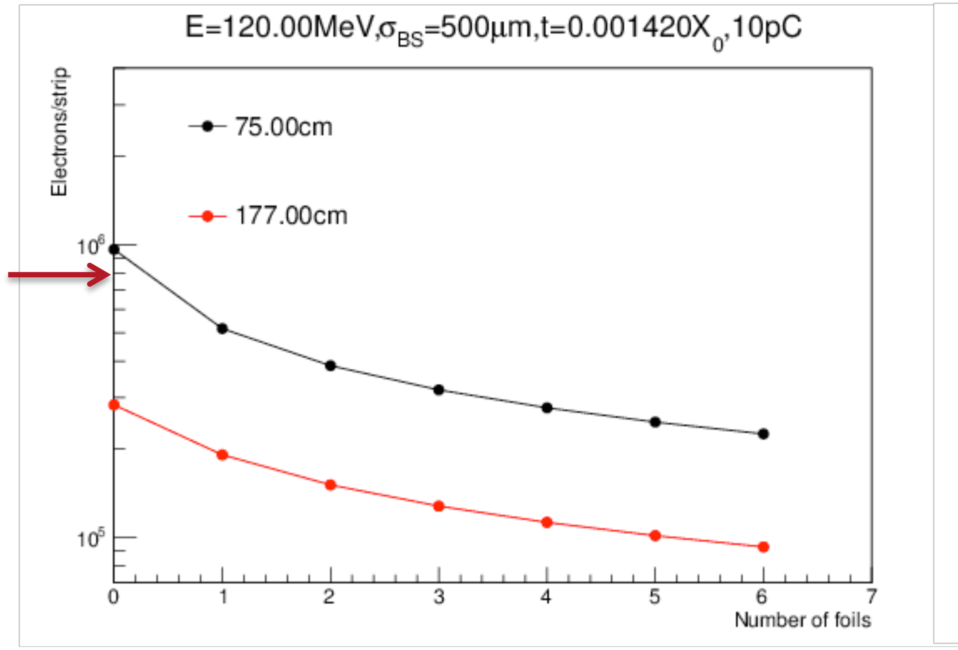
Agreement to measured within 20% up to 5 foils; not sure what happened at 6 foils

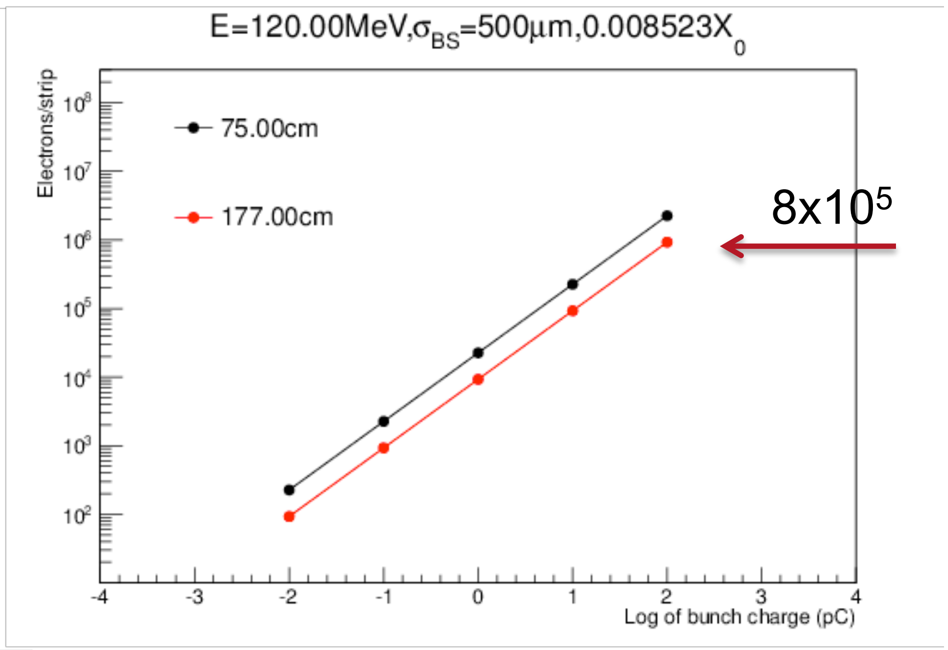
EGS agree to within 20-50% with this simulation…

At 177cm; probing ~1.1GeV spot size…

Estimated Hit Density per Strip

Scan orders of magnitude using beam current





Measurements and Runs

Start at a safe level

- Beam energy: 120MeV, 10Hz,
- Start at 180V bias voltage on sensor and ~1pC bunch charge (no measurement below that)
- Use 6 foils

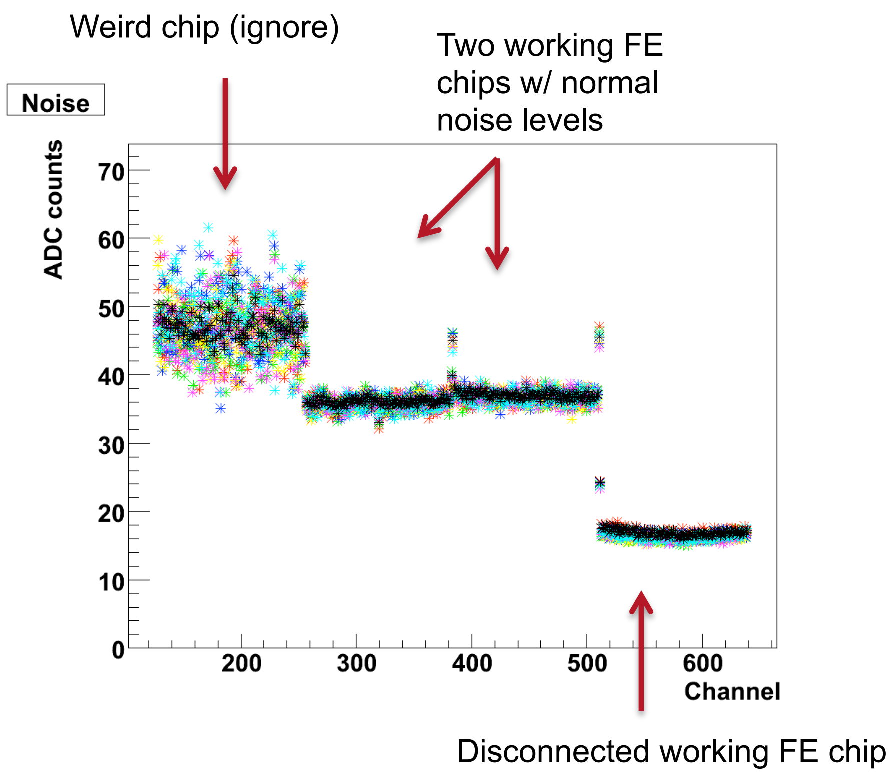
Then scan bias voltage and beam current

For each setting of bias voltage and beam current:

- 30s-60s of exposure to beam at each setting of bias voltage and bunch charge
- Run baseline (~pedestal run)
- Go back to 180V and run baseline
- Monitor leakage current

Time	Bunch charge (pC)	ADC1	Bias (V)
~11:00	~0.001	-	180
11:36	1.0	0.002	180
	1.0	0.002	250
	1.0	0.002	350
	1	0.002	400
	1	0.002	500
12:00	10	0.01	180
	10	0.01	350
	10	0.01	500
	100	0.135	180
	100	0.135	250
	100	0.135	350

Noise @ 1pC



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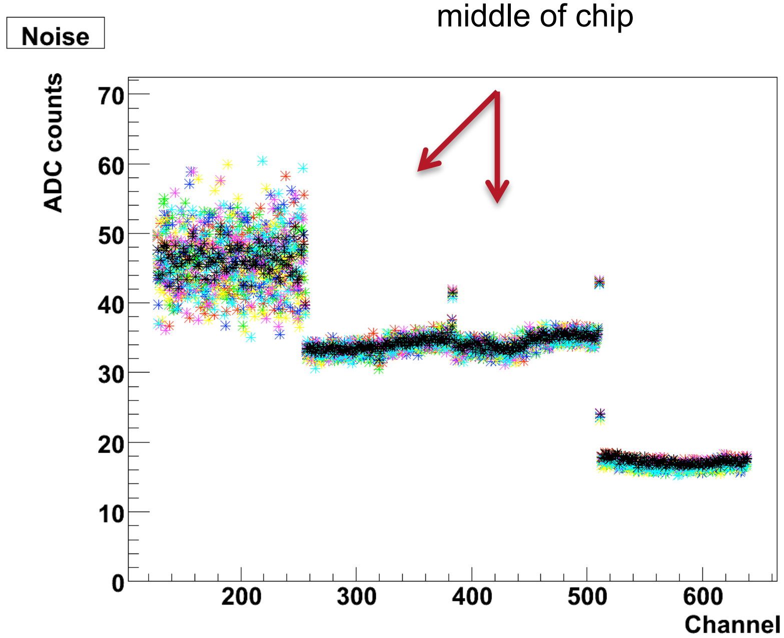
1pC and 500V: no problems

Noise @ 10pC, 350V

Note shoulder in middle of chip



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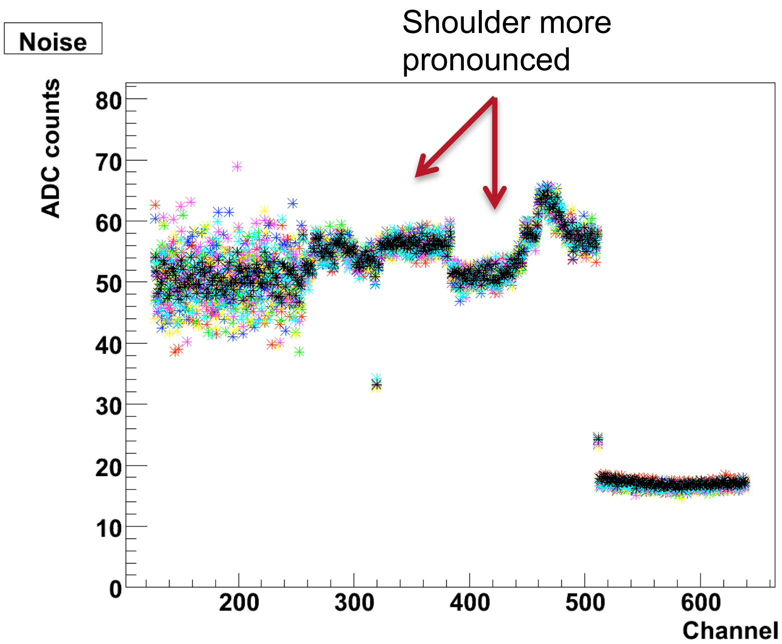
10pC and 350V: first sign of issues

Noise @ 10pC, 500V



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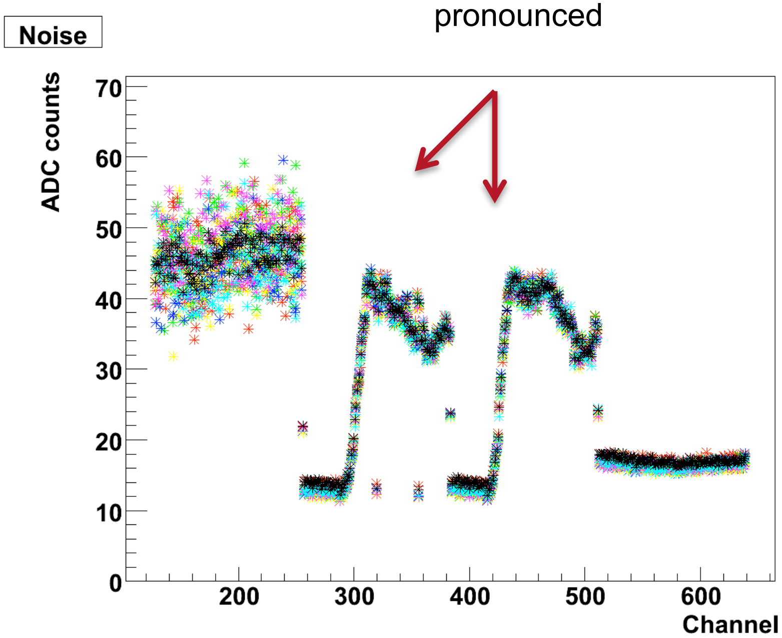
Noise @ 100pC, 180V

Shoulder more
pronounced



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	100	0.135	180
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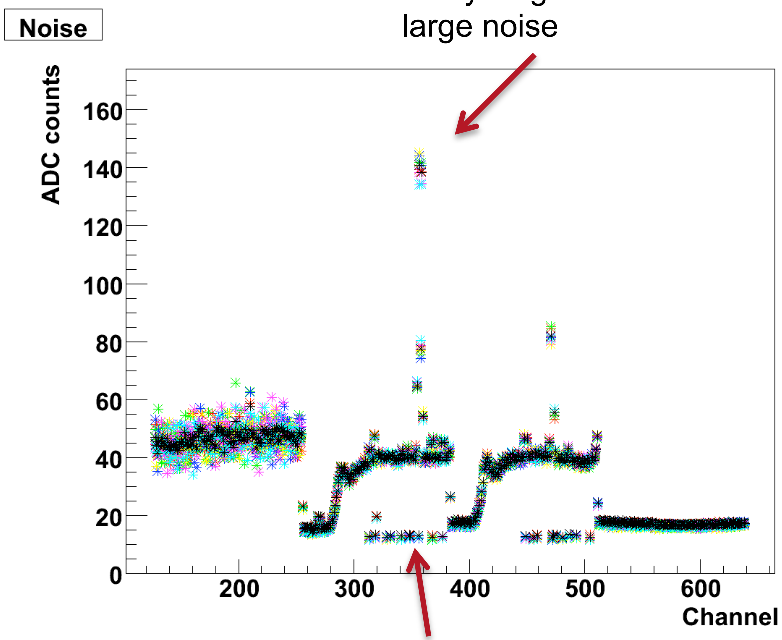
Noise @ 100pC, 350V



Many single channels with large noise

Channels almost looks like they are disconnected from sensor

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Summary of Notes, Observations, Ideas

Radiation is almost uniform on two working chips (~2cm spot); many adjacent strips will see close to the same intensity

First damage sign at 10pC (350V); roughly 10^5 e-/strip

Shoulder on noise across both FE chip channels (not seen before); increasing with higher bias and bunch charge

After 100pC and 350V, roughly 10^6 e-/strip, see many individual channels with high noise (pinholes?) and some look disconnected

Bias voltage matters: threshold in noise seen at ~210V

Disconnected chip shows no sign of issues

1 hypothesis: many adjacent pinholes may need chip to swallow large DC current which could affects the chips inner structure.

Summary

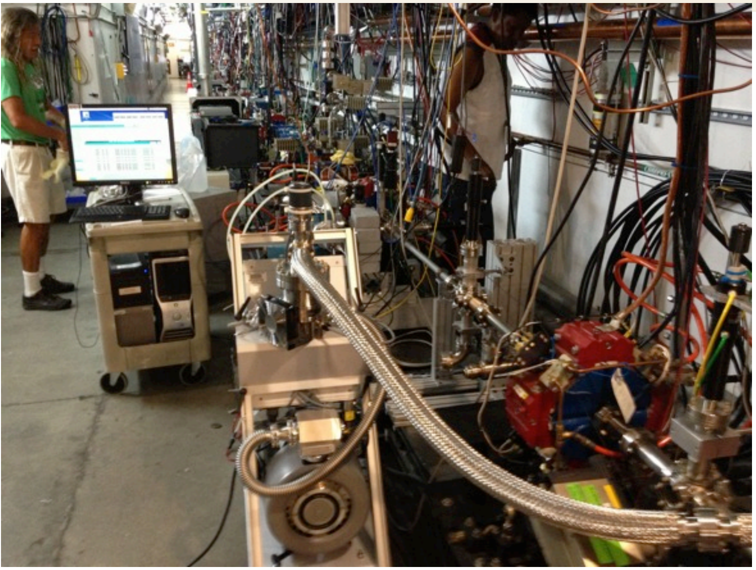
No definitive answer yet what the limits are: but we are definitely flirting with them!

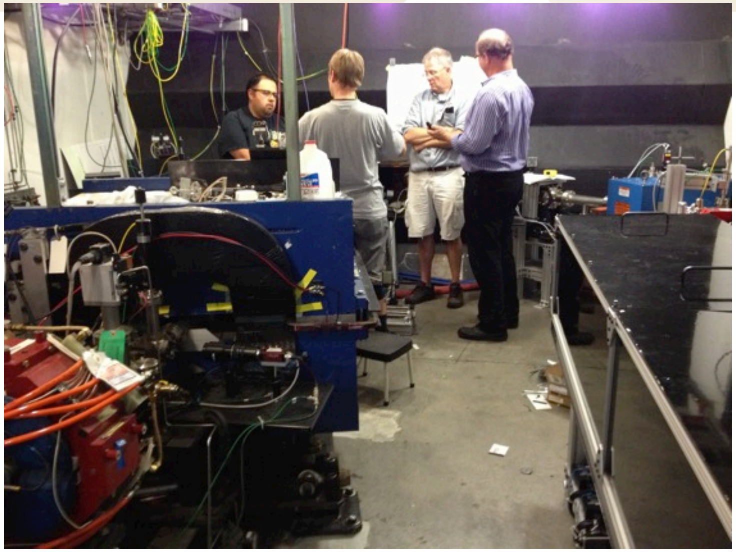
Lab tests on irradiated module should give definitive clues to understand the cause of failure

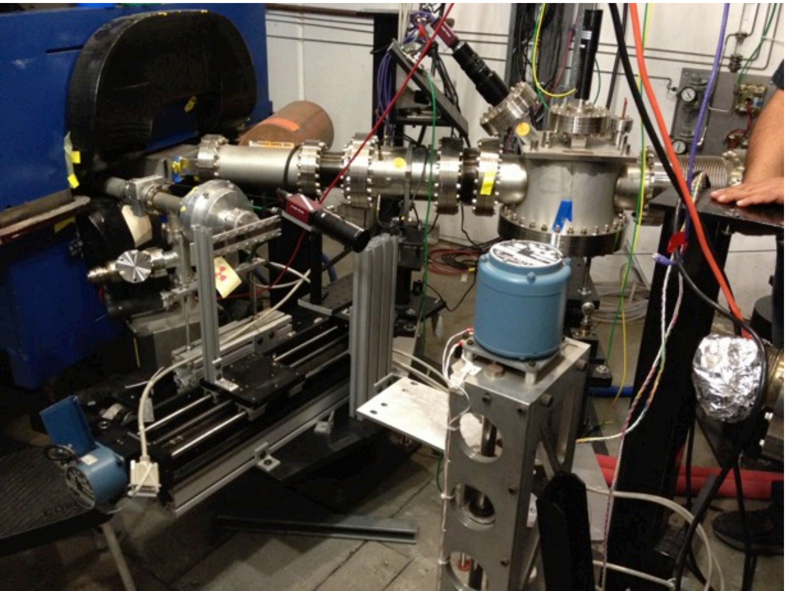
Consider the possibility of another beam test

Adapt tests/plans to new collimator studies and setups

NLCTA



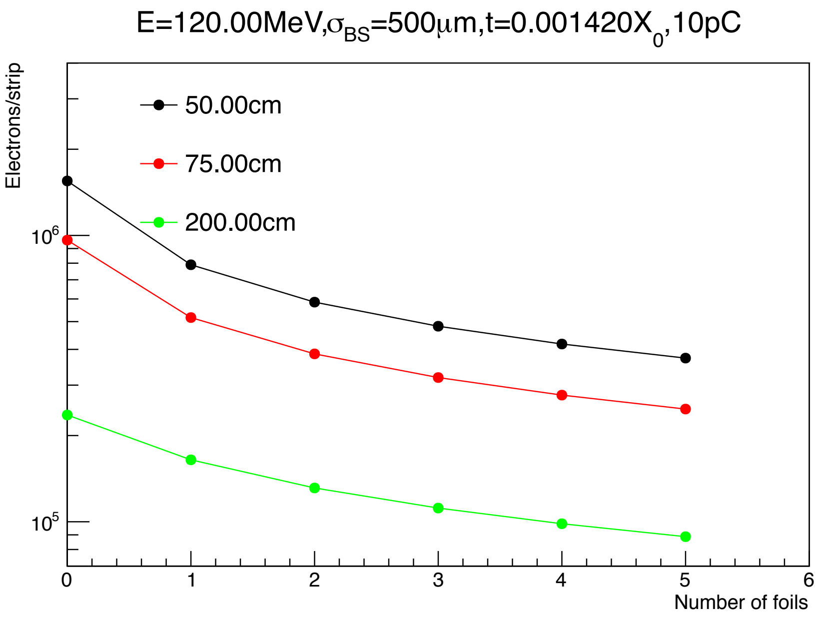


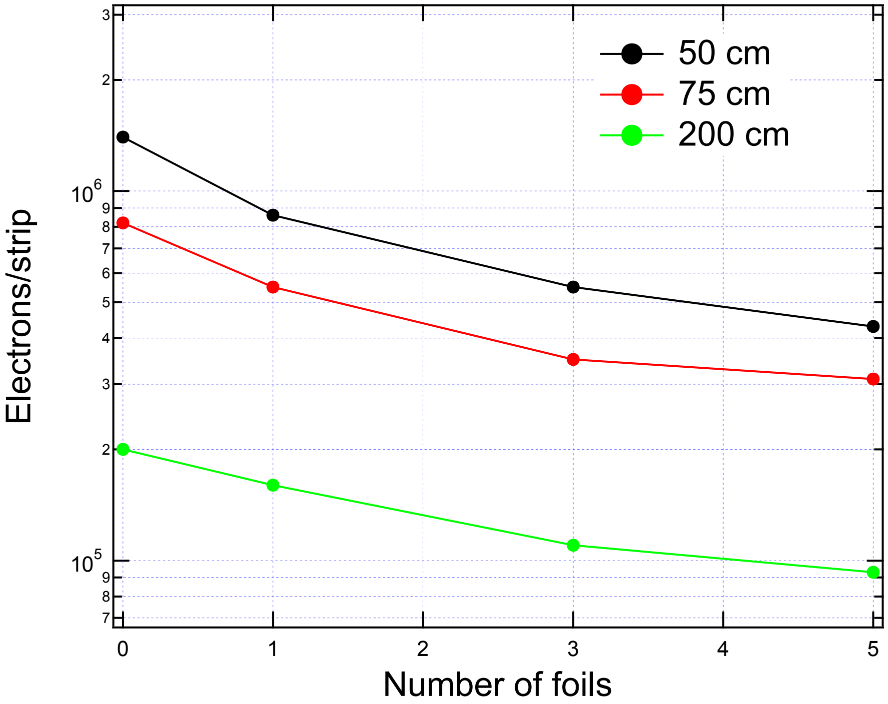


EGS5 Full simulation

SLAC

Agreement to within 20-50%





EGS5 Full simulation – X-rays

200cm Air + 5 foils