Si Sensor Damage Test Beam

Pelle (w/ input from others obviously)

Introduction

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Real experts from UCSC gave talk in SVT meeting:

- https://confluence.slac.stanford.edu/display/hpsg/08.27.2013+Weekly
- Look there for additional details

Two components

- Readout chip damage (won't talk about it here; should be ok…)
- Breakdown of sensor strip implant capacitor

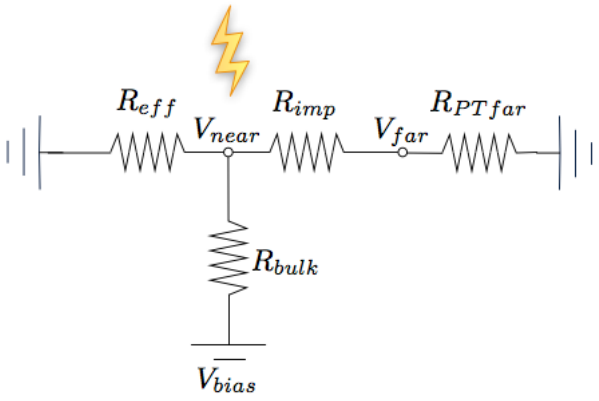
Spoiler

- Atlas studies show it's very hard to test behavior (beam loss scenarios are hard to produce in test)
- Vulnerability depends on *exact* details and specifications of the sensor
  - Bias "network", bias voltage, di-electric specifications on sensor, punch-through structures, implant resistance, etc.
- Vulnerability depends on *exact* charge deposition details:
  - Total charge, time evolution, spatial distribution, etc.

Implant Capacitor Damage

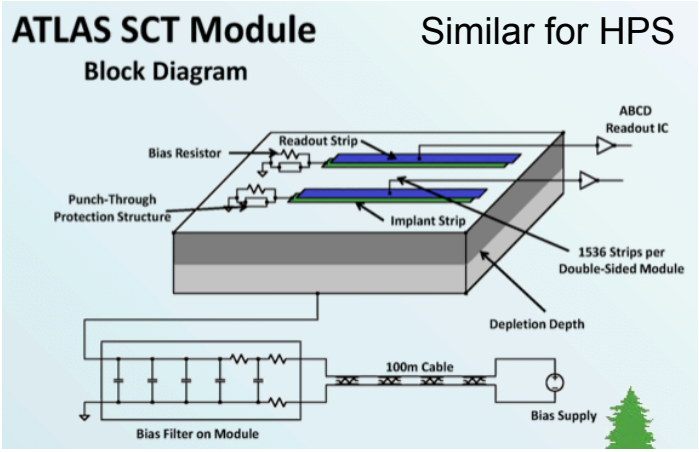
Large voltage on implant strip can permanently damage the coupling capacitor (rated for ~100V)

Operating at very high voltages (up to 1kV) increases risks



Large voltages on implant can occur if large charge deposition creates “ohmic path” in bulk (field breakdown)

- Implant voltage then depends on exact sensor design of:
  - Punch-through protection (on both sides)
  - Bias resistor
  - Strip implant resistance (incl. strip length)
  - Surface treatment and detailed geometry
- In addition, bias network will have an important impact on the circuit (may drop bias voltage which protects the implant voltage (depends on RC))



Implant Capacitor Damage (Atlas simulation)

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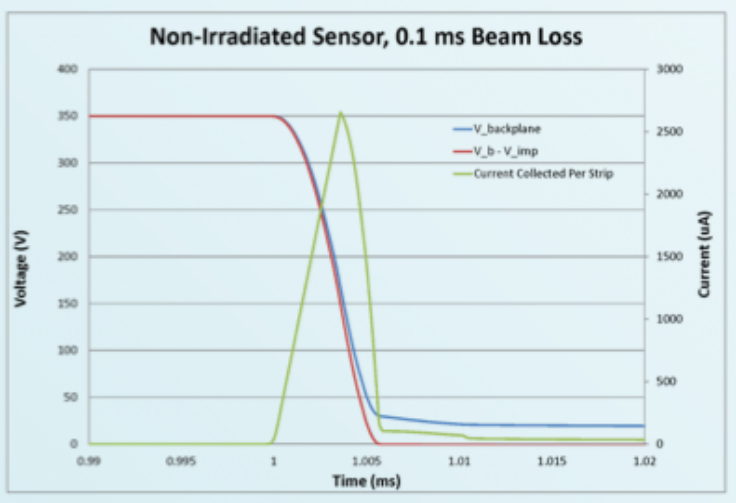
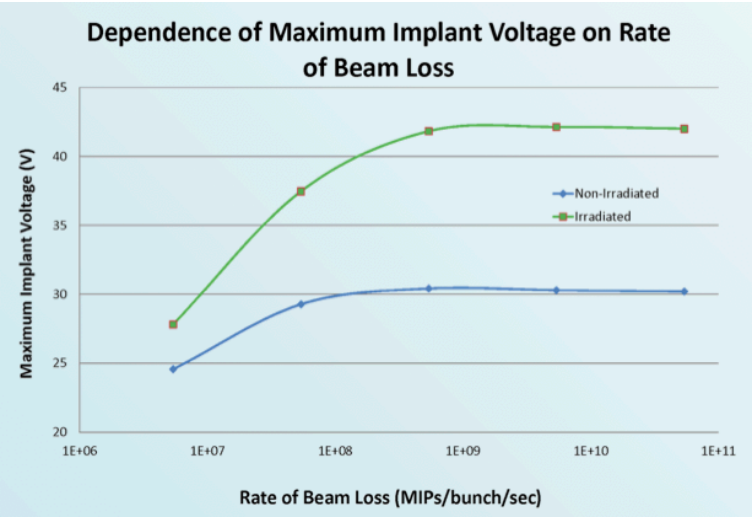
Full sensor exposure with linear beam loss (25ns “steps”)

- Peak of ~0.5×10^6 MIPs/strip/25ns





Backplane voltage drops (capacitance is depleted of charge)

Peak implant voltage is <50V

Rate of beam loss matters.

Implant Capacitor Damage (Atlas simulation)

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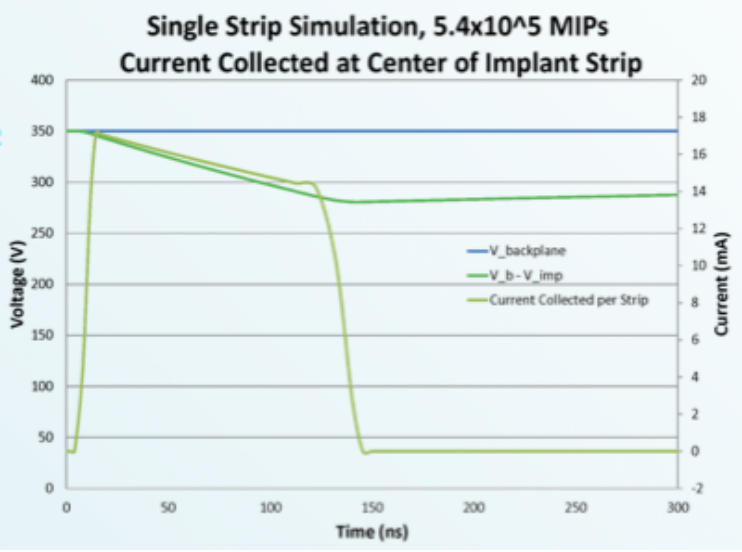
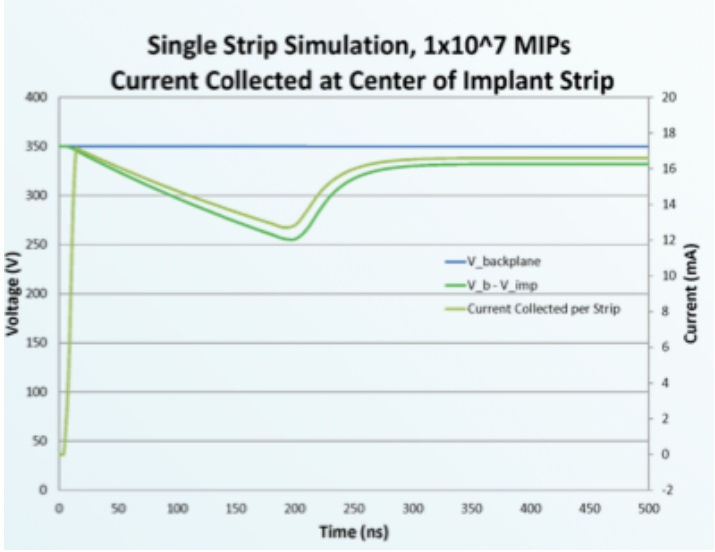
Single strip exposure to single laser pulse



$V_{implant}$>70V



$V_{implant}$>90V

Backplane voltage do not protect for single strip exposure

Spatial distribution is important

Summary (again)

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Predicting vulnerability for our sensors is hard

- Implant strip resistance not measured
- Punch through protection not measured
- Bias network would need to analyzed with different exposure scenarios

Exact beam loss scenario is important

- How many strips get hit simultaneously
- What is the time evolution (gradual exposure?)

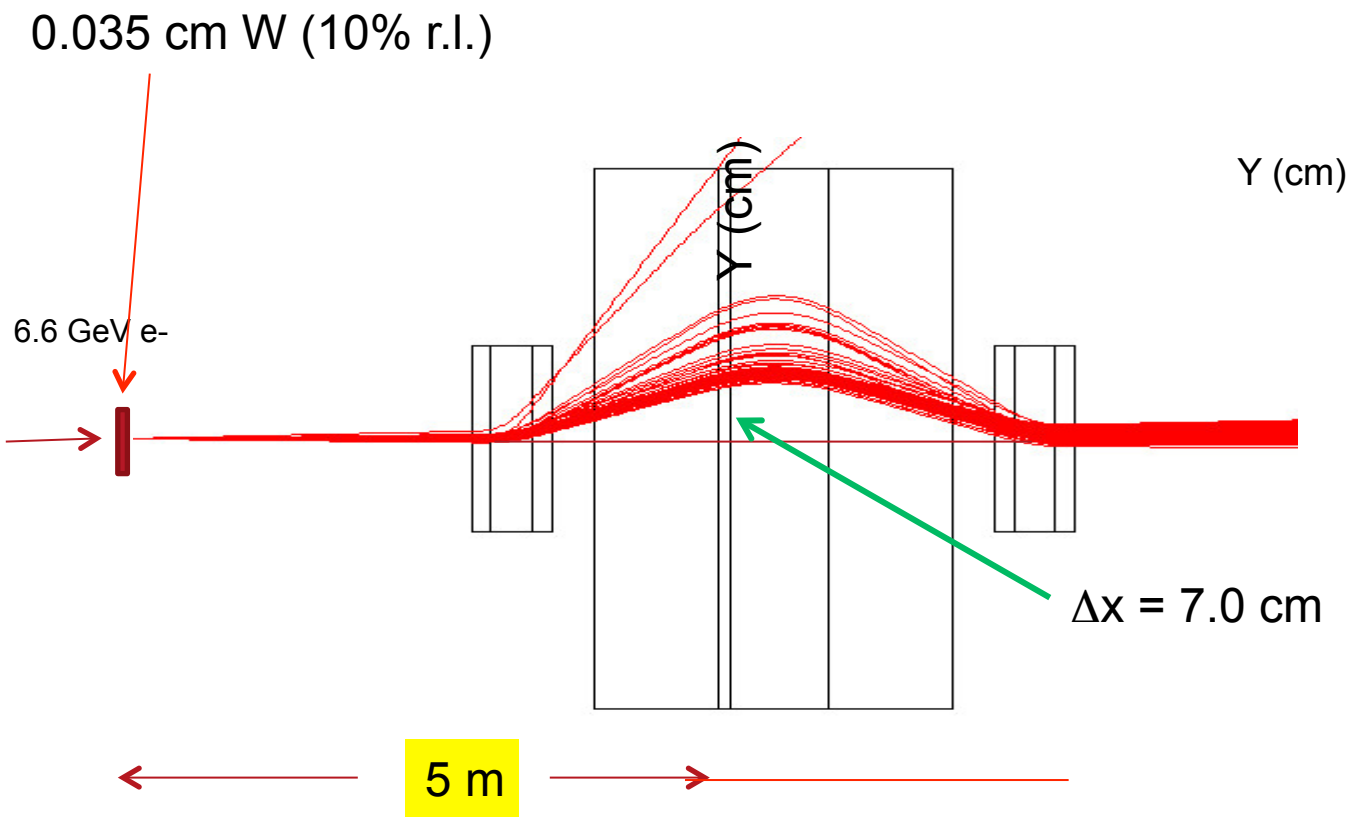
Conclusion is that we cannot say we are safe

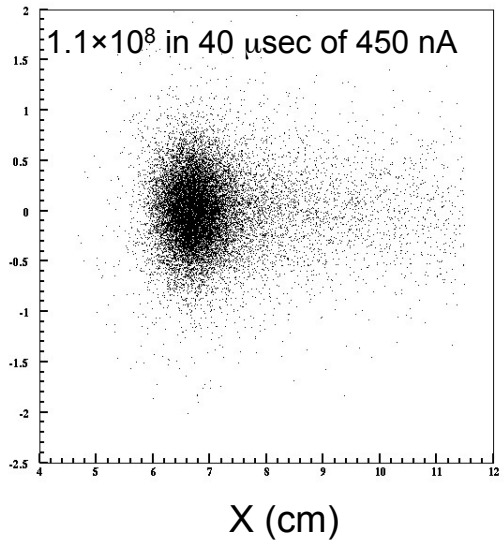
- Experts guess that most likely we are more vulnerable than Atlas (worse PTP distance, longer strips, potentially larger implant resistance)

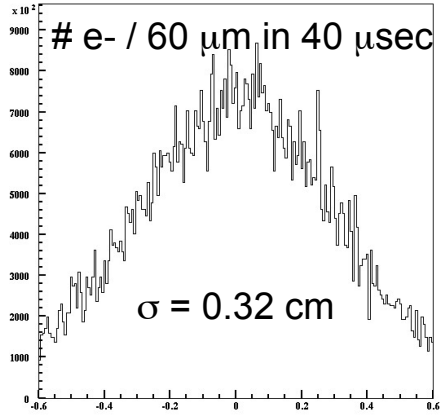
➔ We need to test our susceptibility

Looking at beam tests – these are only at the idea stage yet.
Who will help?

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 (?)

SLAC NLCTA (Next Linear Collider Test Accelerator)

Propose to use NLCTA

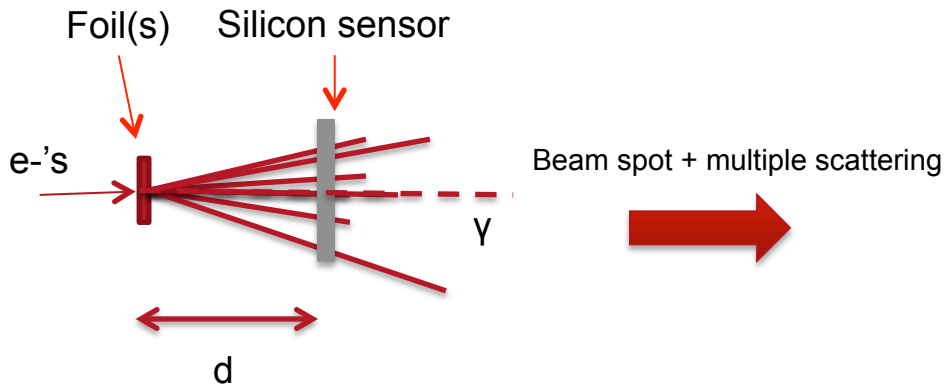
- Beam available this fall
- Tests in parallel to other experiments
- High enough intensity
- Much higher dQ/dt -> worst case scenario
- Easy access and setup

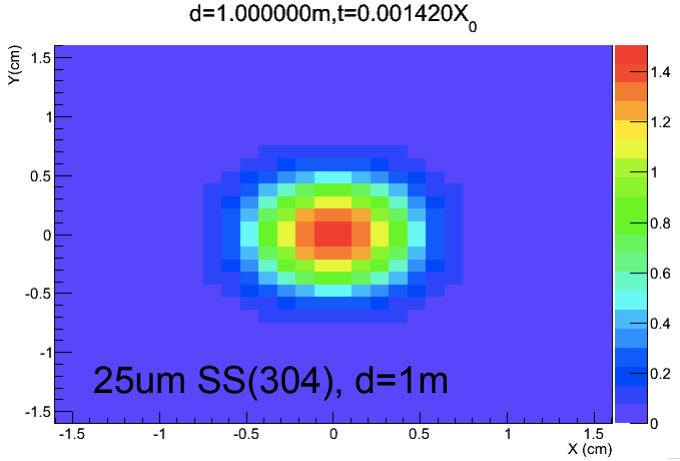
Vary intensity

- Foil thickness and # foils
- Distance from foil

X-ray contribution should be small

	NLCTA
Beam Type	e^-
Beam energy (MeV) (range)	120 60, 80-120
Repetition Rate (Hz) (range)	10 1-10
Bunch Intensity (E8) (range)	1.2 0.06-12
Bunch Length (s , mm) (range)	60
Beam Spot size ((s , mm) (range)	150 100-300
Comments/Notes	

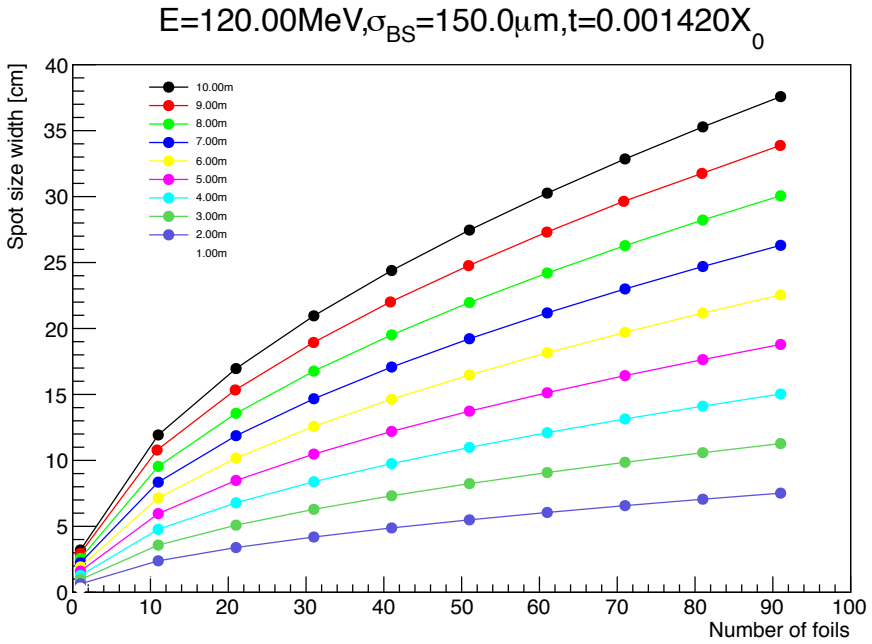


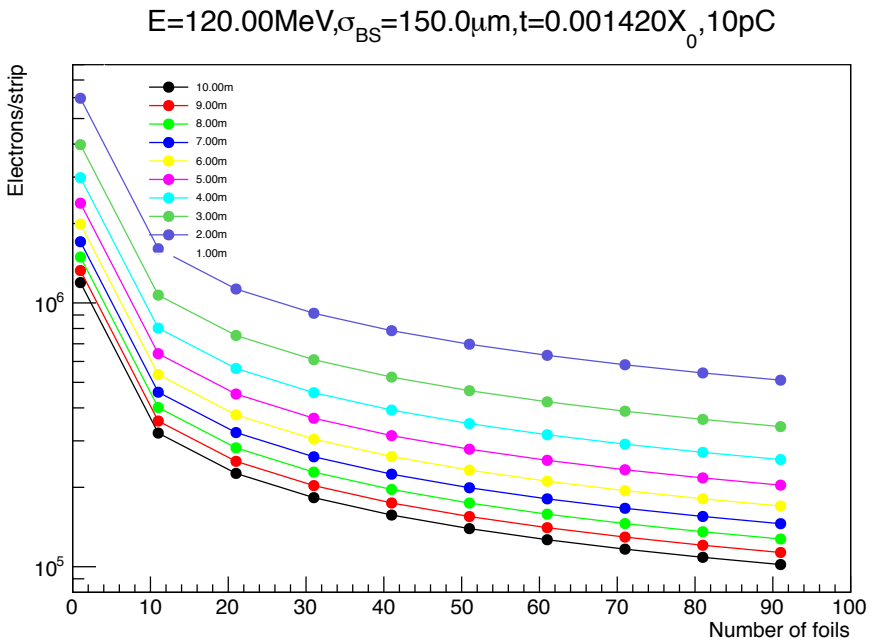


SLAC NLCTA (Next Linear Collider Test Accelerator)

Start at “safe” level and then ramp up intensity

- Would like to see where it fails (if it fails)
- Can use bias voltage setting as safety measure as well





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