

# 3D Sensor Proton Irradiation

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(most drawings and sketches from Chris)

# Introduction:

Goal: irradiate sensors up to  $1 \times 10^{16}$  p/cm<sup>2</sup>.

Two main issues:

- 1) FE-I3 chips designed to hold up to  $1 \times 10^{15}$  p/cm<sup>2</sup>. How to irradiate to higher levels (needed for sensor)?
- 2) sensors irradiated under bias and cooled (between -10 and -40 C).

Options:

- 1) irradiate bare sensors and bump bond afterwards:

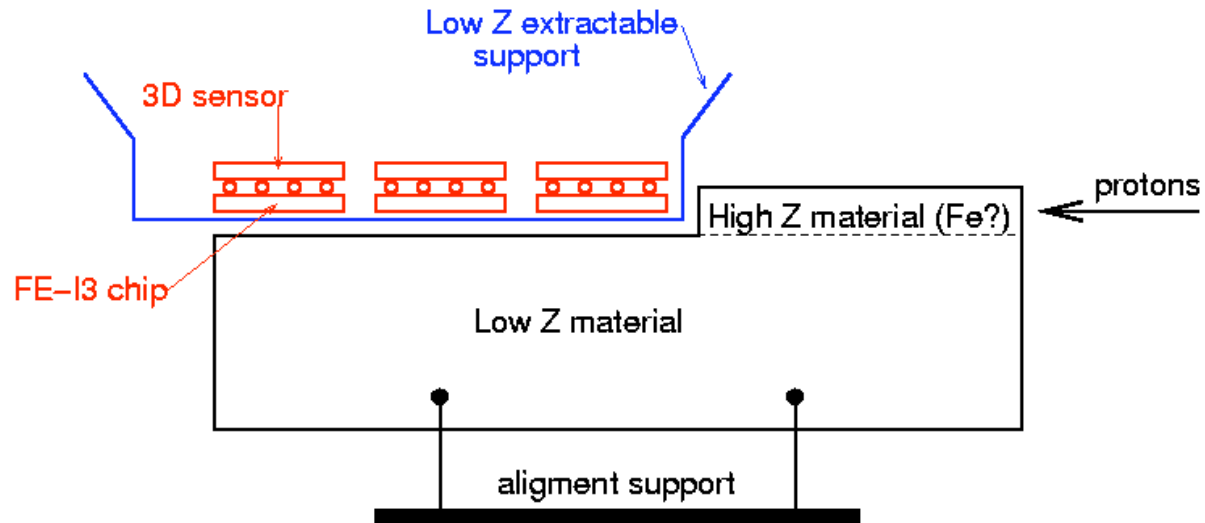
we are exploring room temperature bump bonding, no solution yet (regular bump bonding at >100 C, large effect on annealing, so cold bump bonding required)

Risky procedure: bonding yield?... if only 3 or 4 irradiated sensors?

- 2) irradiate assemblies, but shield FE chip: some ideas (see next slides).
- 3) irradiate up to several  $10^{15}$  p/cm<sup>2</sup>.

# Assembly irradiation with shielded FE-I3 ... with regular assemblies

Original idea... but given up on it.



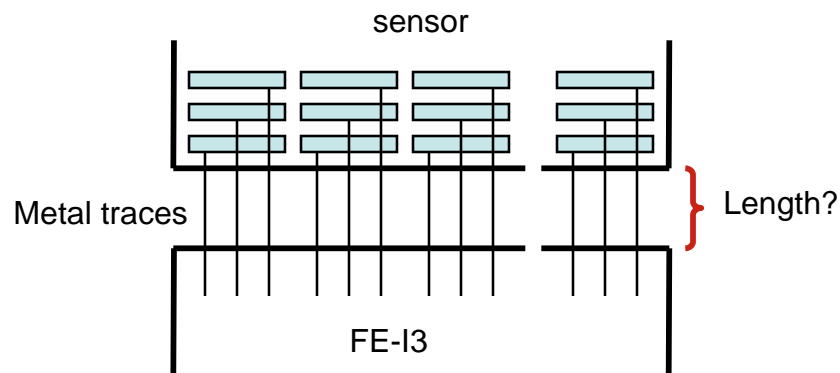
Main problem is alignment.... not a feasible solution

# Assembly irradiation with shielded FE-I3

## ... with modified assemblies

Currently the option that seems the most promising:

stagger bonding of sensor and chip with long traces: some number of rows with no chip behind



How many rows: depends on trace density

Capacitance?

Noise? Assemblies measured before/after irradiation

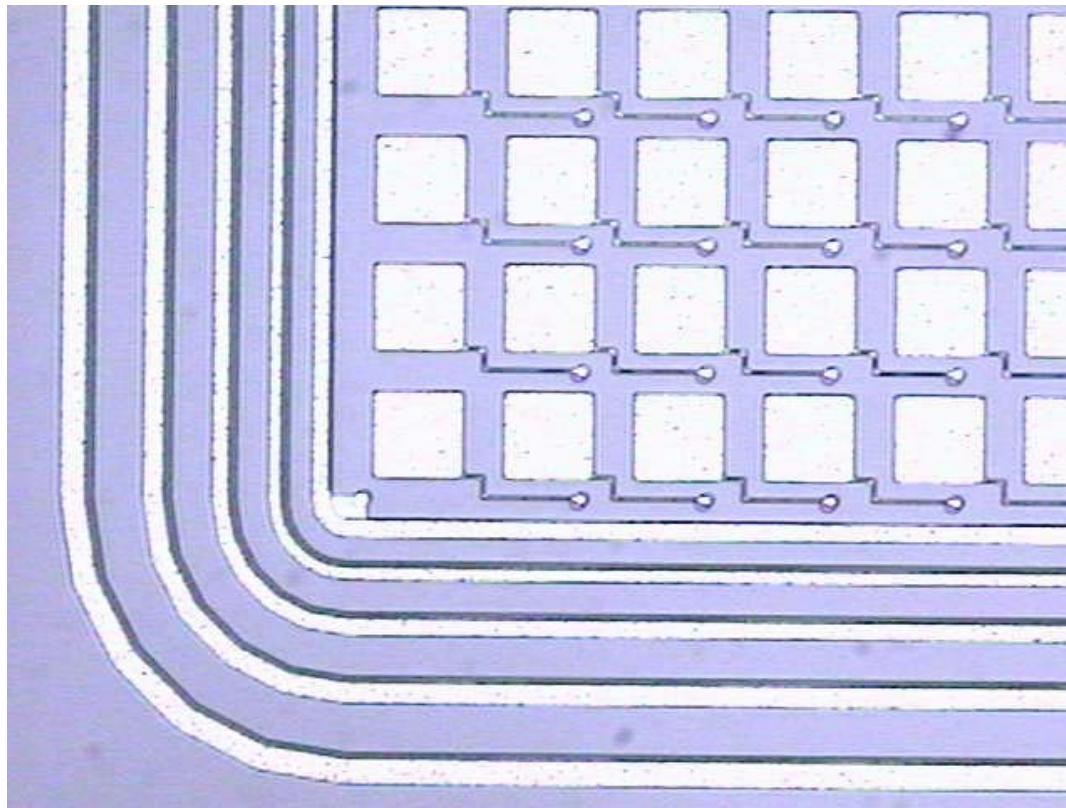
Bonding yield? Just need several assemblies

Shielding: easy to do (depends on length, which should be  $>1\text{mm}$ ).

# Assembly irradiation with shielded FE-I3

## ... with modified assemblies

Concrete demonstration of the concept: a planar sensor with bump pads shifted relative to the pixel by 300 microns

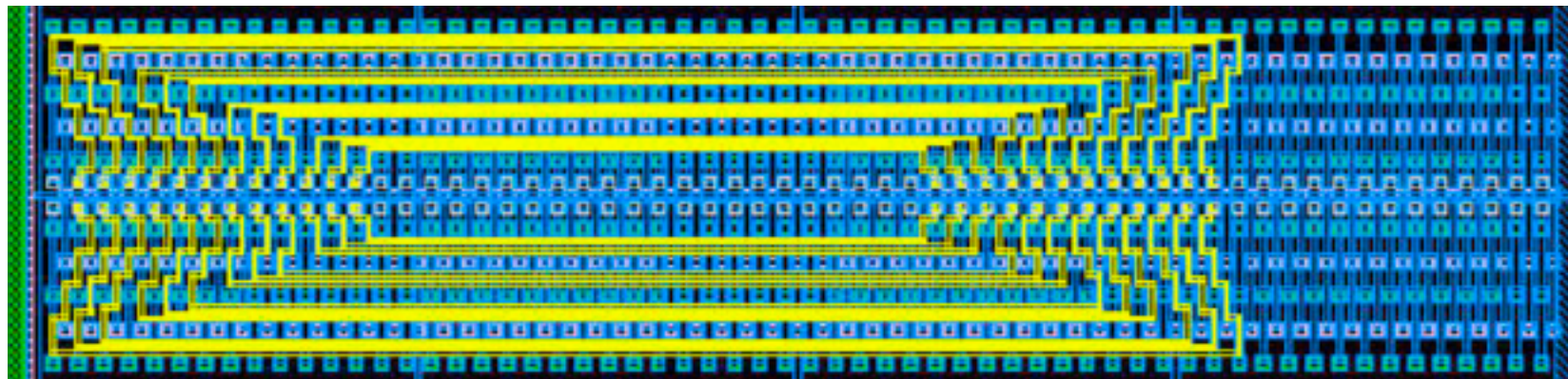


# Assembly irradiation with shielded FE-I3

## ... with modified assemblies

Application to 3D sensors: adding a second metal layer

- Existing Aluminium traces
- Second metal layer



Bumps connecting offset pixels and ASIC cells: chip covers only a fraction of the sensor area.

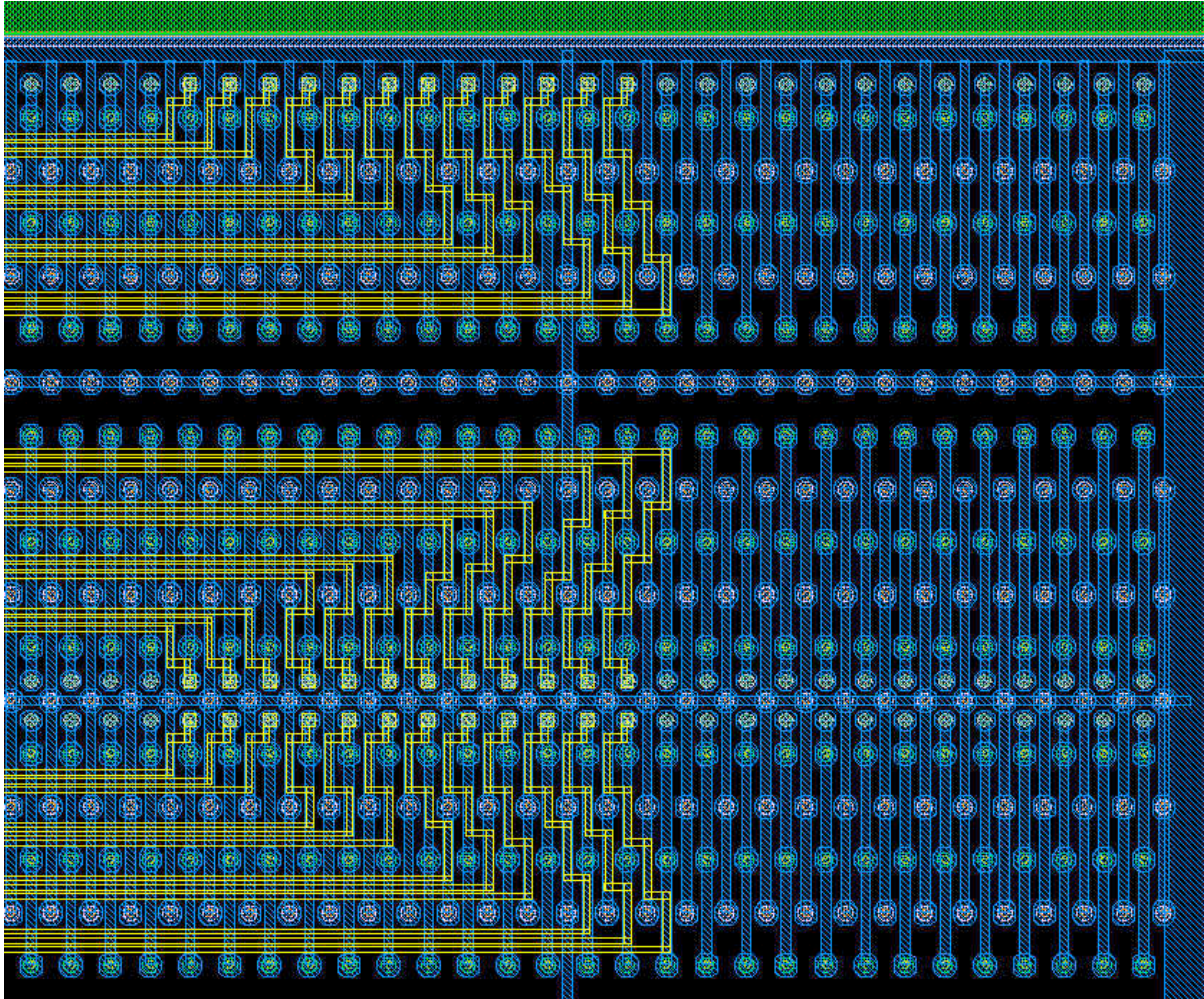
“neutral” zone~1mm

Sensor pixels to be read-out: 12 rows



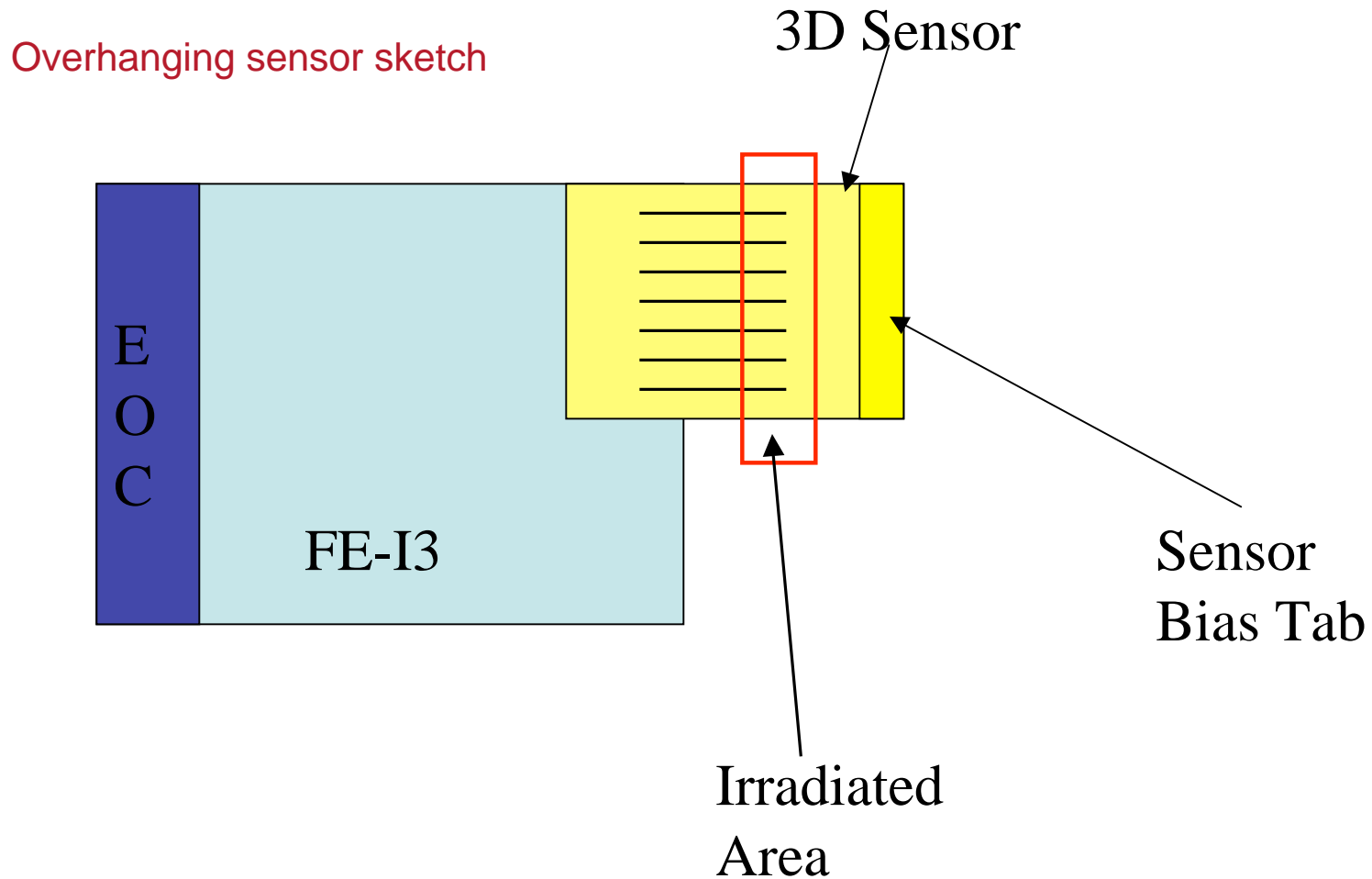
# Assembly irradiation with shielded FE-I3

... with modified assemblies



# Assembly irradiation with shielded FE-I3

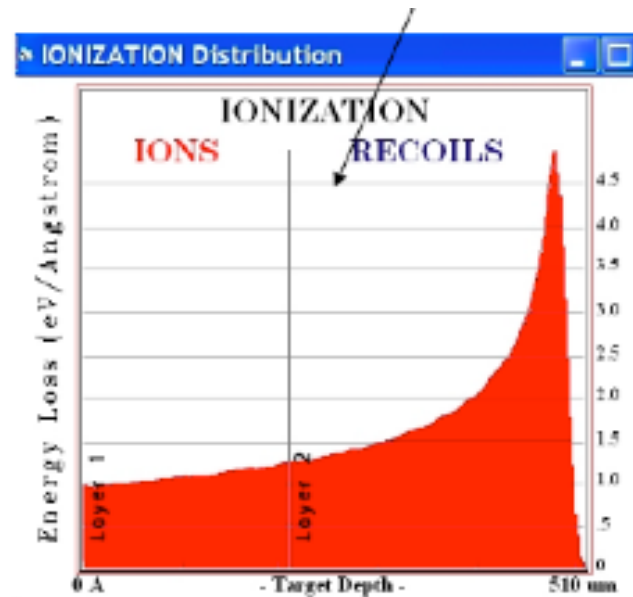
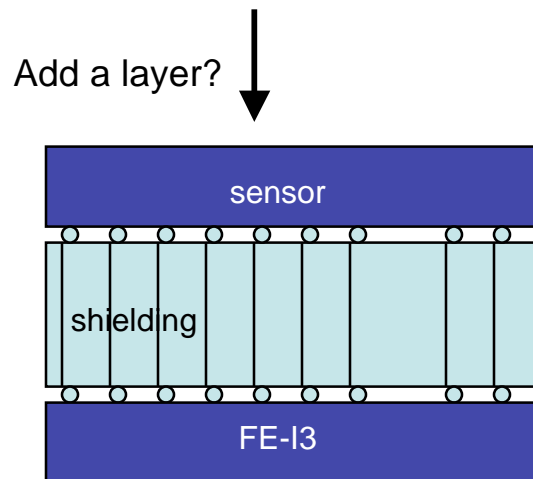
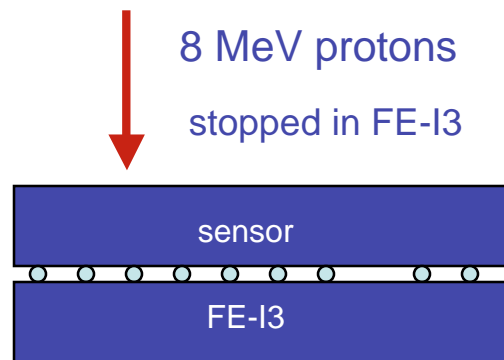
... with modified assemblies





# Assembly irradiation with shielded FE-I3

... with modified assemblies: **Another option from Steve Watts**



210  $\mu\text{m}$  sensor  
+  
300  $\mu\text{m}$  FE-I3

How running the traces through the shielding?  
Noise? Assemblies measured before/after irradiation  
Bonding yield? Just need several assemblies  
Possibly entire sensor bump bonded

# Conclusion

Investigating several options for proton irradiation at LANL

Current best options is with staggered bonding

Trying to converge soon on a reliable solution and request beam time at LANL