CERN PS Irradiation plans for large area sensors

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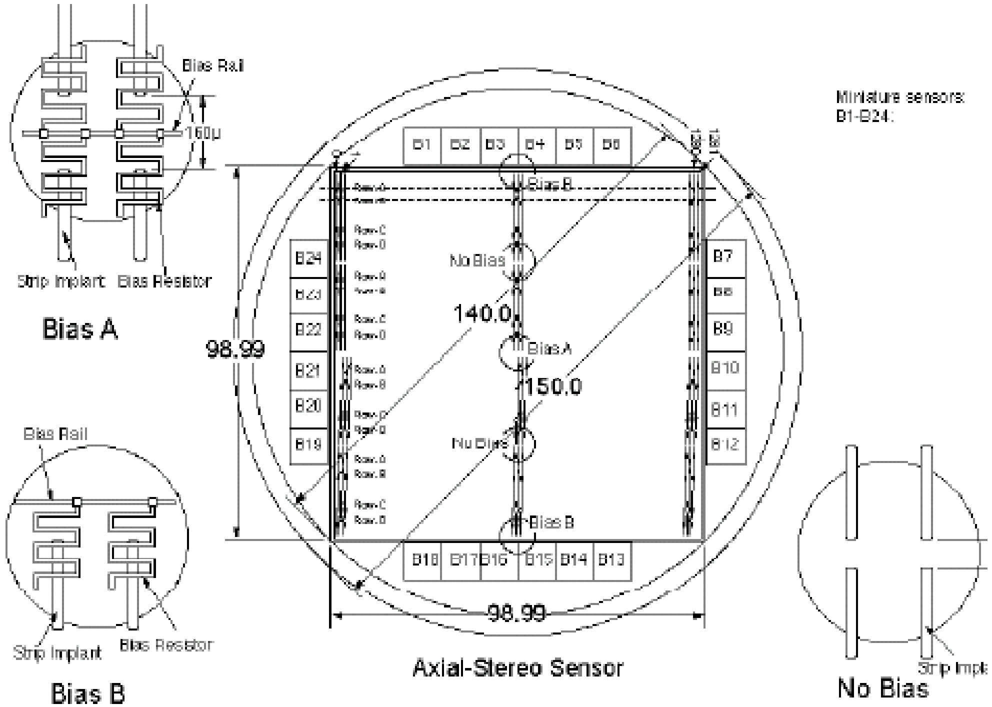
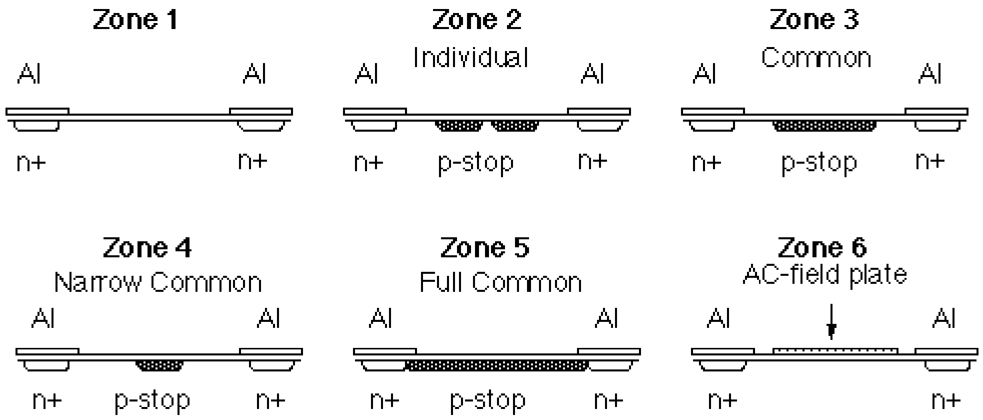
OUTLINE

- Obvious need to test large area sensors under bias and with field across the AC dielectric.
- Need to test sensors + hybrid, with probably reduced functionality of the hybrid (might be difficult to read out, but biasing and powering could be possible)
- Likely need to test other mechanical parts.

The HPK ATLAS07 mask layout



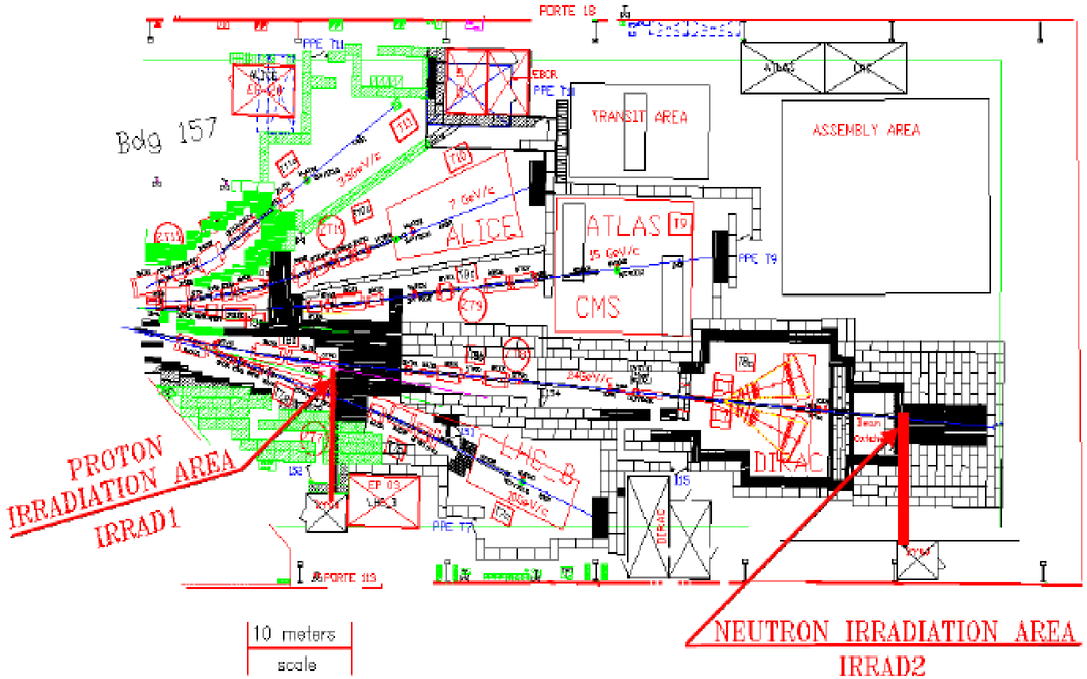


Where?

- We are well equipped for irradiating 1x1cm^2 sensors at the CERN (p), Karlsruhe (p), KEK (p), Ljubljana (n) (note, hundreds of these HPK sensors with different p-stop/spray geometries have been, are being or will shortly be irradiated).
- The dimension of the full-size samples (10x10cm^2+mounting frames + services) will not allow irradiations in the neutron facilities traditionally used. Need high energy protons to efficiently irradiate through the hybrid. CERN-PS seems to be suitable for the task, it has been used efficiently for the irradiation program of the present SCT.

CERN PS Infrastructure

- 2009 Programme will use the existing IRRAD 5 facility located in the east hall which consists of:
- Linier scanning table (X-Y parallel bedways) placed on SKF telescopic foot (Z with 700mm of adjustment).

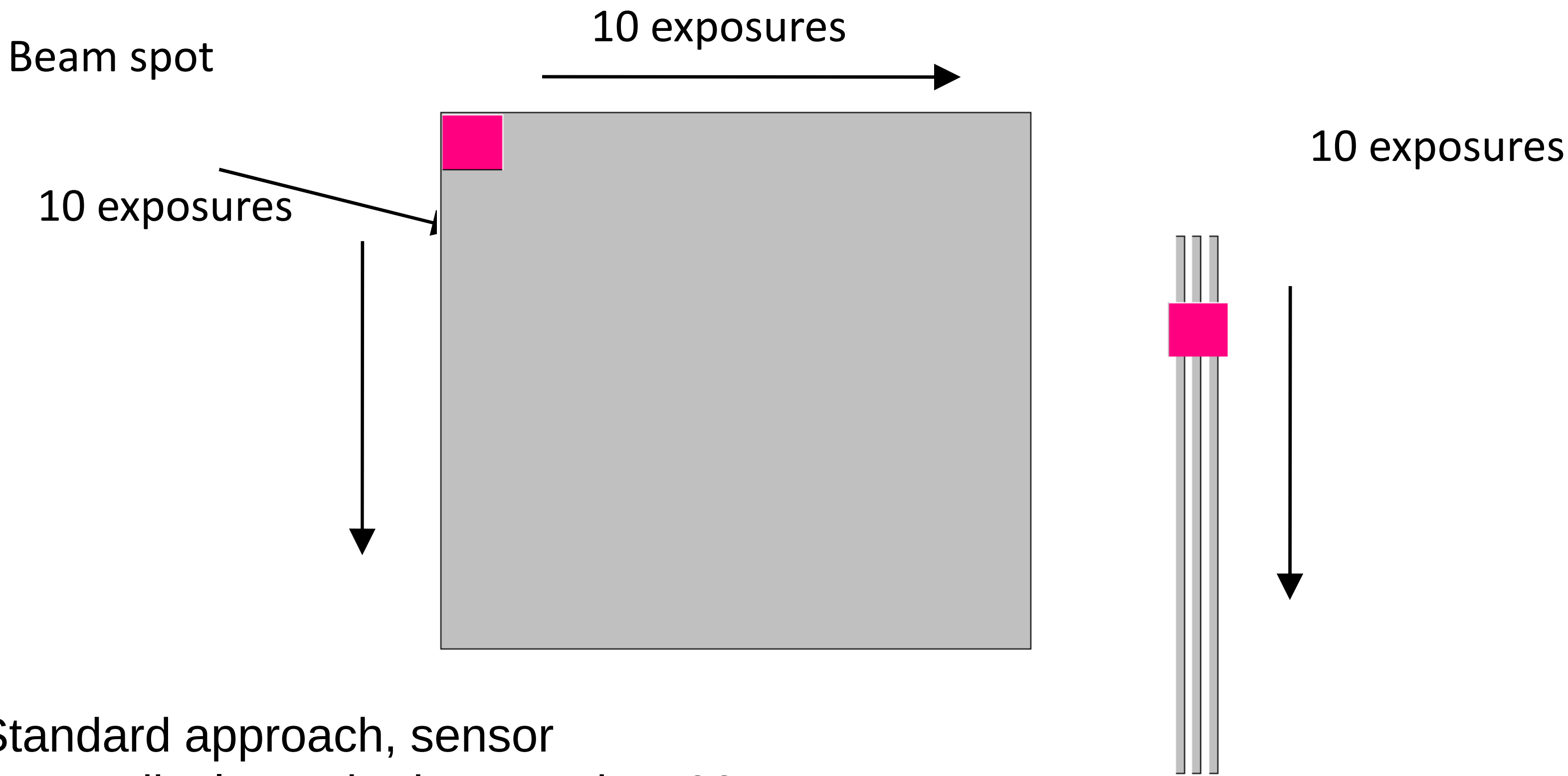


•Power from CAEN supplies and most equipment as per 1997 irradiation set up with refurbishment.

•Cables from previous programme will need replacing and redundancy adding for increased RO channels and additional switching matrixes.

  •Provision for in-line connector at 1m away from beam to enable radiation damaged cable changeover.

Problem: qualification fluence is now up to 1×10^{15} n_{eq} cm^{-2}. The devices are 10x10 cm^2, the CERN-PS flux about 1-3E13 p/hour/cm^2, with a beam spot of about 1cm^2. So, to cover the entire surface we would need 100 exposure to final dose, with an anticipated irradiation time is ~ 400-140 days!!
Need at least a factor of 10 reduction in time.



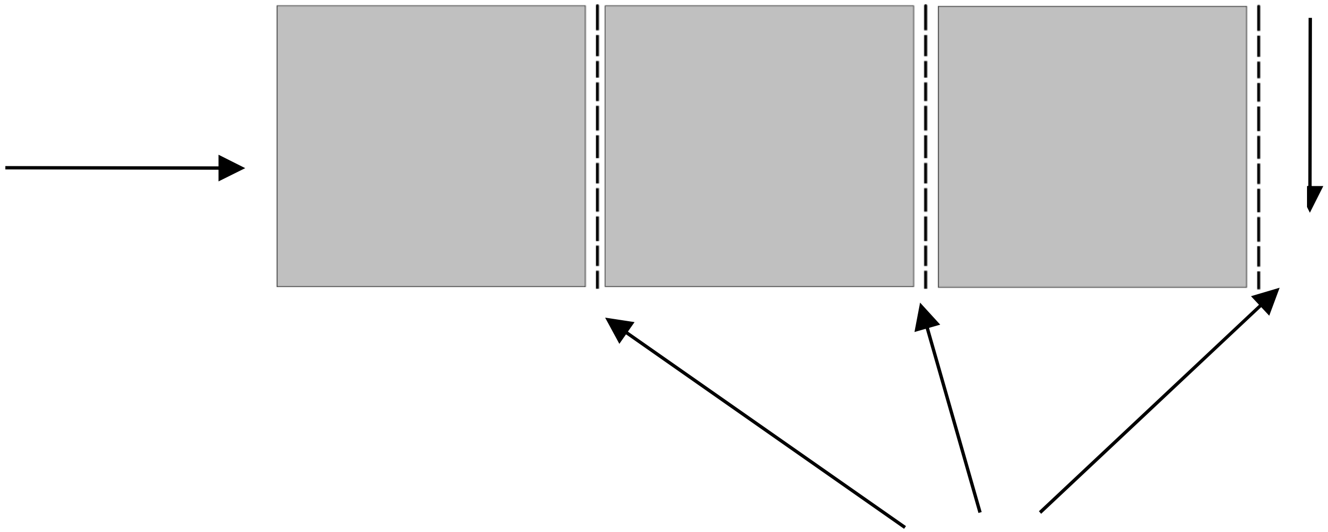
Standard approach, sensor perpendicular to the beam axis, 100 exposures.

New proposal: sensor parallel to the beam axis, 10 exposures.

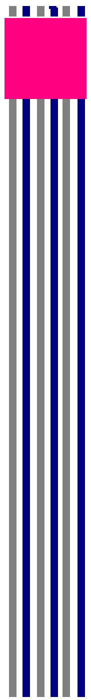
How many detectors is possible to irradiate? Lining up detectors for irradiation could be possible.

10 exposures

Beam spot



Al foils for dosimetry



To have more control on dose can also be staggered.

Evaluate dose at different positions.

Motored cool box and biasing electronics, switching matrix for measurements to be revamp/prepared.

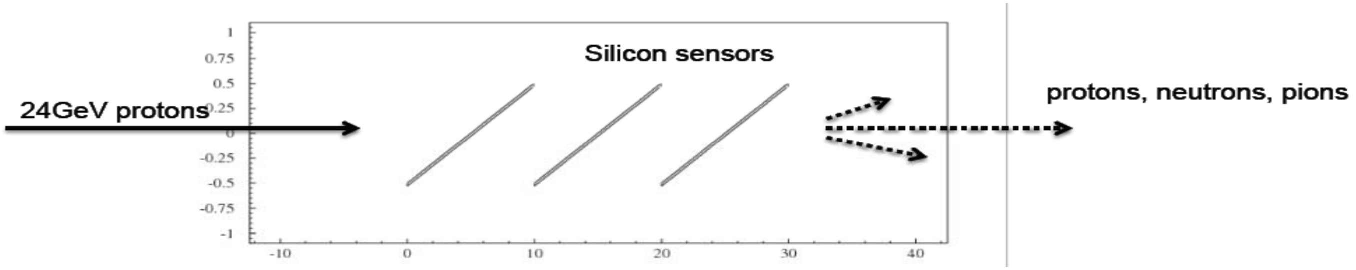
Verify radiation hardness (to SLHC fluence) of full-size sensor with surface glued hybrid

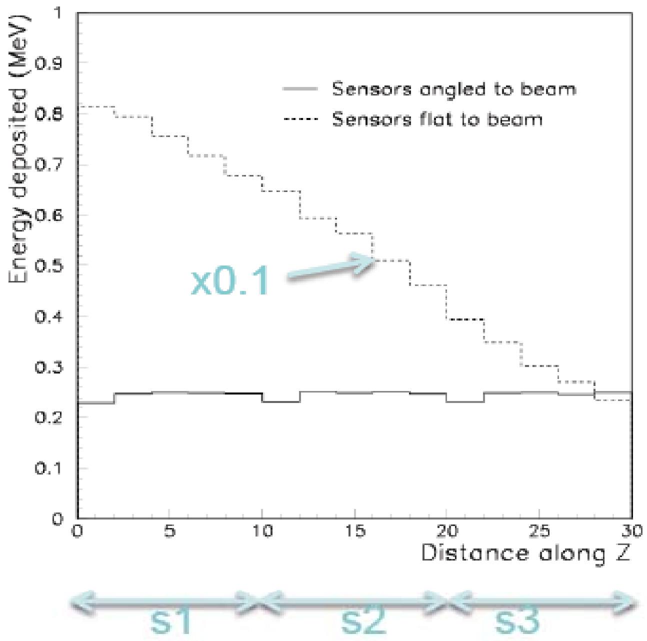
Need bias for realistic electric fields during irradiation (surface charge effects) =>

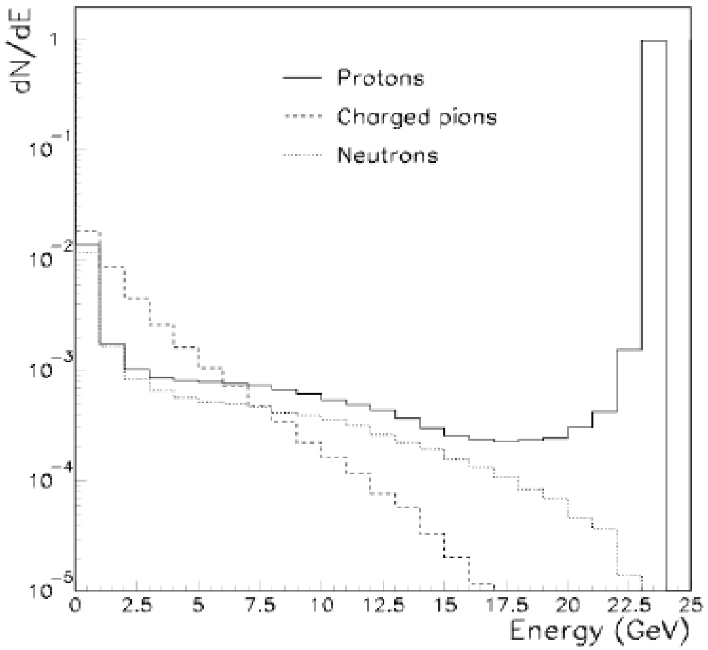
- reverse bias, ~ 200V could be sufficient.
- metal->strips: daisy-chain R/O pads + bias to ~1V.

Sensors Demountable: clamp in G10 pcb frame (+ a few wire bond connections) => minimal sensor mounting: allows removal/re-configuring post irradiation.

FLUKA sensor angle simulations







Ian Dawson

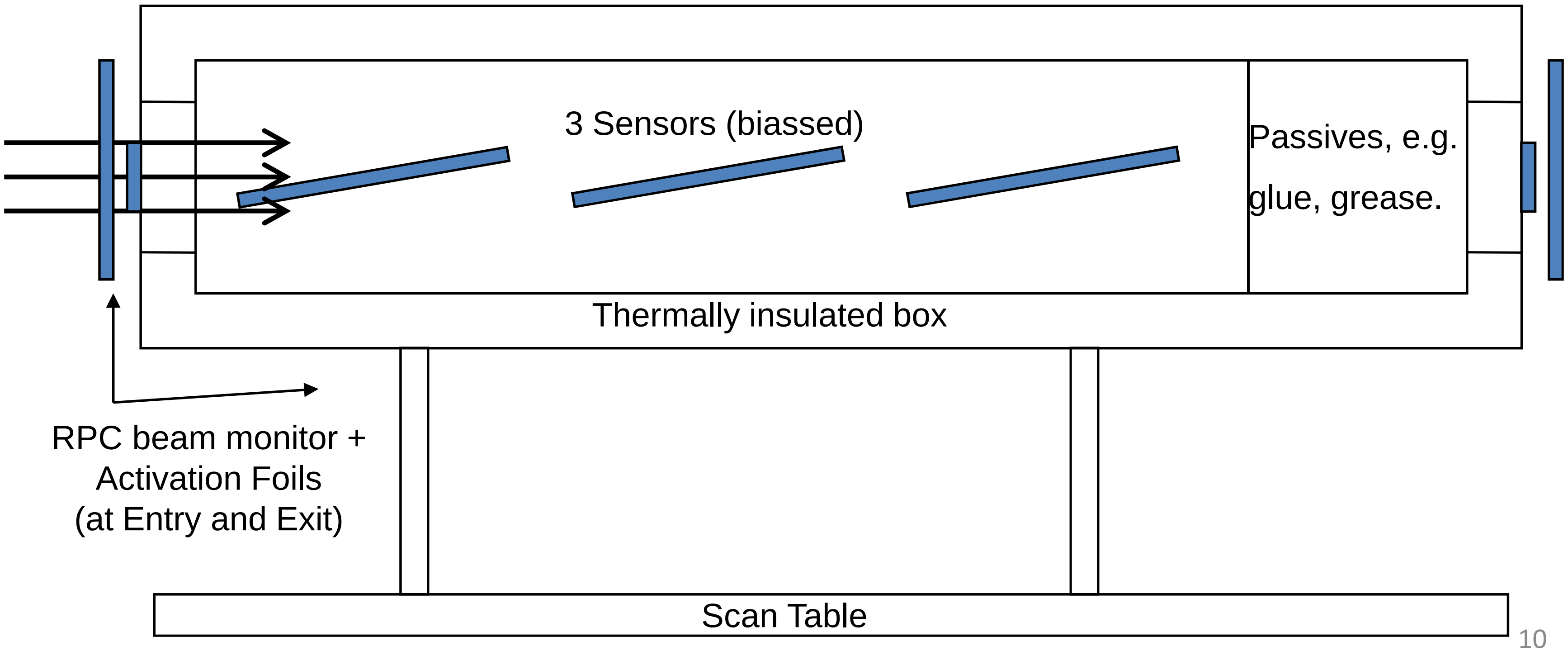
Sensors (S1,2,3) placed in parallel to beam Z axis

Tilted sensors effectively reduce proton path from Z=300mm =>10mm

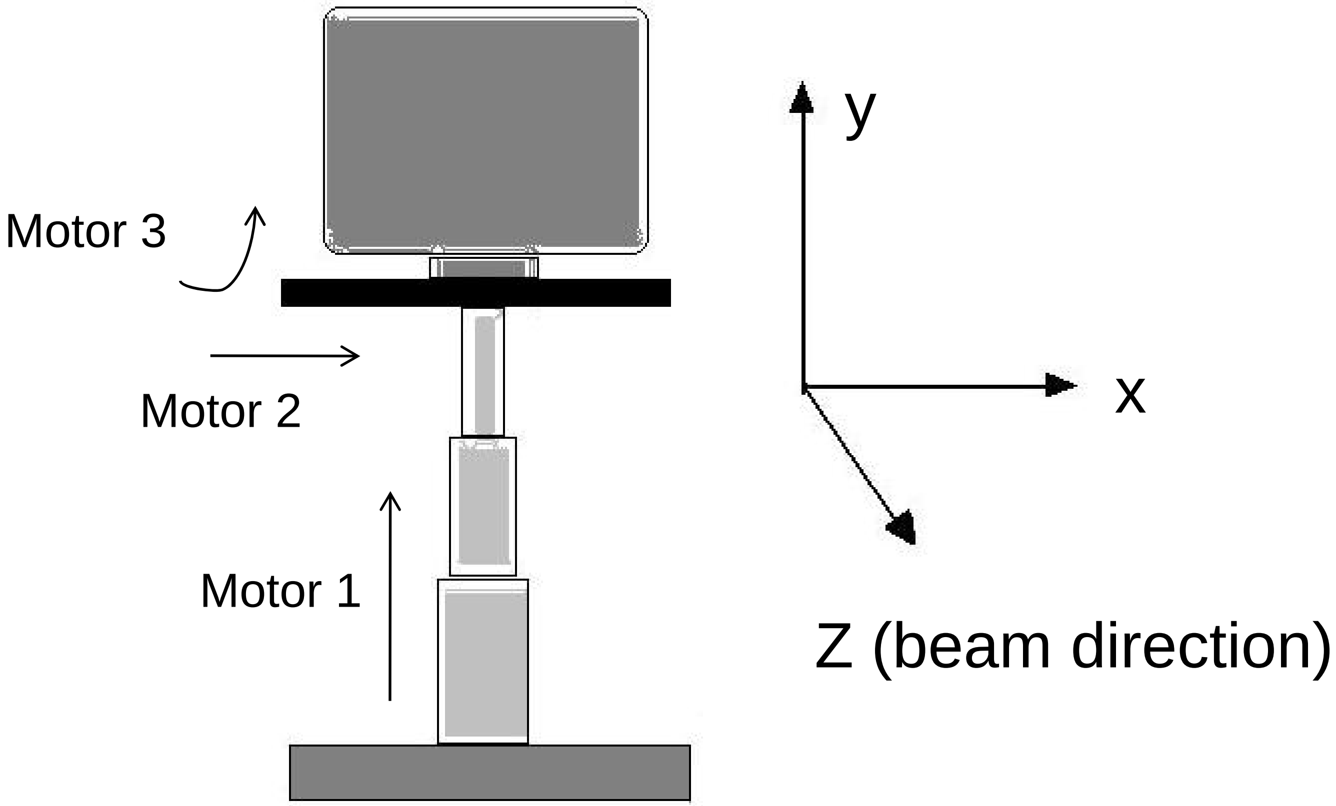
Irradiation of Full size sensors to $10^{15}/cm^2$ neq.

- T7 extracted proton beam, profile ~ 1 x 1 cm^2. Flux about 1-3E13 p/hour/cm2
- Achieve Fluence in 2 week beam period by aligning sensors parallel to beam . . .
- . . . at small angle to horizontal to reduce secondary effects but maximise use of beam.
- 50cm long table + thermally insulated box, scanned horizontally through 10cm.
- Space for maximum of three 10x10 cm^2 sensors + some passive materials.

Schematically (side view):



Three motors: 1 Foot elevator for y positioning
2 x scanning motor
3 theta angle motor for alignment to beam axis using RPC information



How to Cool Sensors?

- Irradiated Sensor at 200V bias, will dissipate 1W if at -10C and 3W at 0C.
- Single Hybrid Finger (20 x current ABCN) dissipates ~8W clocked and ~10W (during read-out) => difficult task for gas to be chilled and blown to remove heat from a sensor + integrated hybrid.
- Conductive Cooling:
  - Would require good thermal contact to back of sensor + in-board (in-beam) coolant: similar to stave concept
  - Liquid Coolant: Note that in/close to beam Commercial Anti-Freeze subject to polymerisation!
  - Plus dry nitrogen atmosphere.

- Chilled N2 Gas
  - non-contact but inefficient (1999: problems with stability of 6W *module)*.

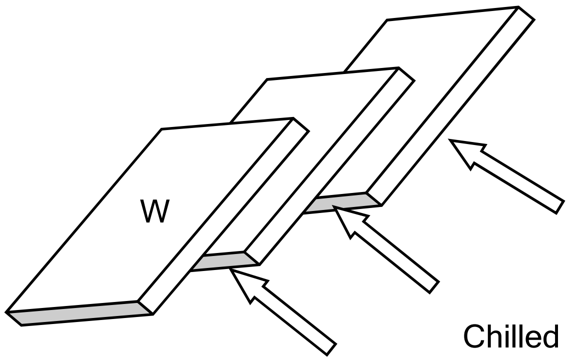
Aim for similar system, but with faster, re-cycled flow.

Some simple empirical trials (in progress) at QMUL:

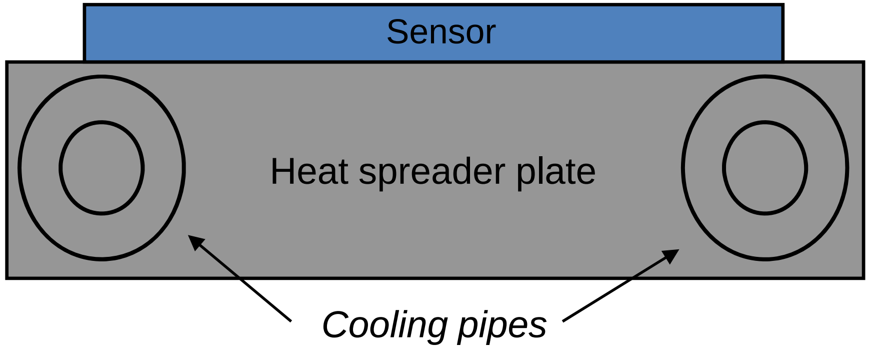
Sensor cooling!

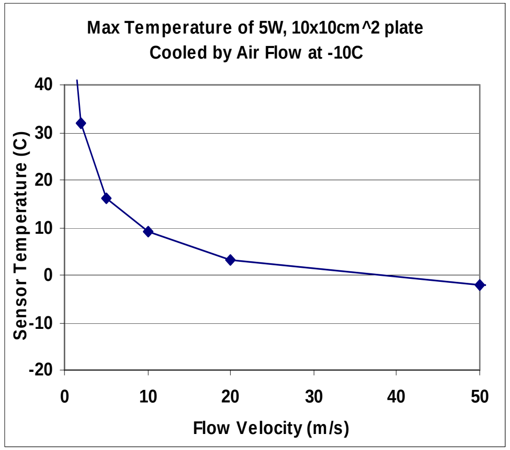
Two viable alternatives under scrutiny:

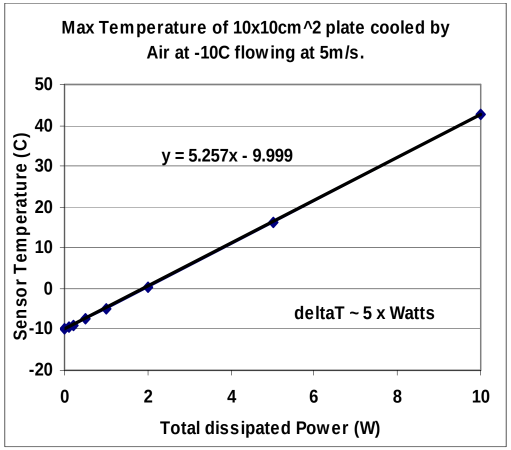
Tilted sensor used as a cooling fin, circulated cold glycol (Hakke chiller) and blown N2 previously gave ~ -10°C at box.
Can we improve the efficiency?



Cooled sensor mount similar to Stave







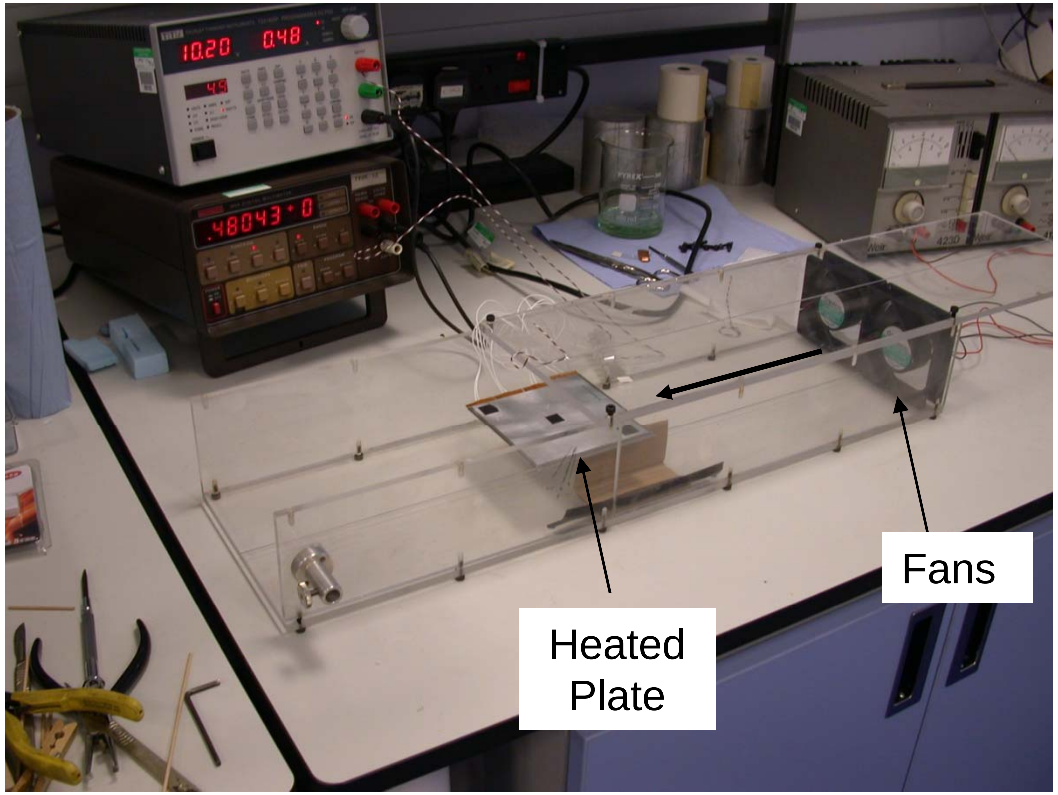
Calculating the exact cooling power required for higher energy running is not trivial.
Selection of cooling method is now a difficult choice – pitfalls with each alternative.
Speedy construction and commissioning time plus reliability throughout PS runs is the deciding factor.

Ducted Fast-Flow Gas Cooling (QMUL)

Room Temperature test!

10x10 cm^2 Aluminium sheet /Kapton heater sandwich in Duct (16cm x 8cm Perspex)

Measure air flow (hot-wire anemometer) + plate and air Temperature (radiometric).



First Look:

Fan supply: 10V

Air Speed: ~ 2.4 m/s

Max Plate Temp: ~ 1.2C/W (linear, 0-10W)

Local Increase in Air Temp ~ 2C at 10W.

<10% degradation when 2mm high frame (as pcb) added to plate.

Gas Circuit

From above: Fast Flow seems adequate for sensors (if 1.3 C/W holds at -10C).

But cannot use:

Bottled Gas => Heat Exchanger => Flow across Sensor => Vent to Surroundings.

(2m/s x 5 cm high x 40cm wide (3 sensors) => 1 Nitrogen bottle every 4 minutes!)
+ enormous cooling power from Chiller.

Investigate possibility of a nitrogen compressor in the area.

In progress at QMUL:

- Explore Sensor cooling dynamics (flow cross-section, velocity)
- Devise:
  - Gas Circulation +Top Up (to maintain acceptable Relative Humidity?)
  - Effective gas chiller: liquid chiller out of beam + Heat Exchanger close to box).

Also to be done:

Cool-box aligning software, scanning software, bias and monitoring hardware switching matrix for measurements to be revamp/prepared /software……

Timescale: April will start irradiation. Unlikely to be ready for installation then, but aim is to be in for the summer campaign!

Useful links for UK ATLAS upgrade and irradiation information

UK Wp7 Upgrade TWIKI

https://twiki.cern.ch/twiki/bin/view/Sandbox/TrackerExchange

UK WP7 Upgrade Irradiation TWIKI

https://twiki.cern.ch/twiki/bin/view/Sandbox/PSIrraditationProgramme

CERN PS homepage www.irradiation.web.cern.ch

Many thanks to all who contributed slides for this presentation!

Sheffield, QMUL, Liverpool, Lancaster, Glasgow