WP8.3.3

Status of Cold Boxes & Irradiation of Si sensors

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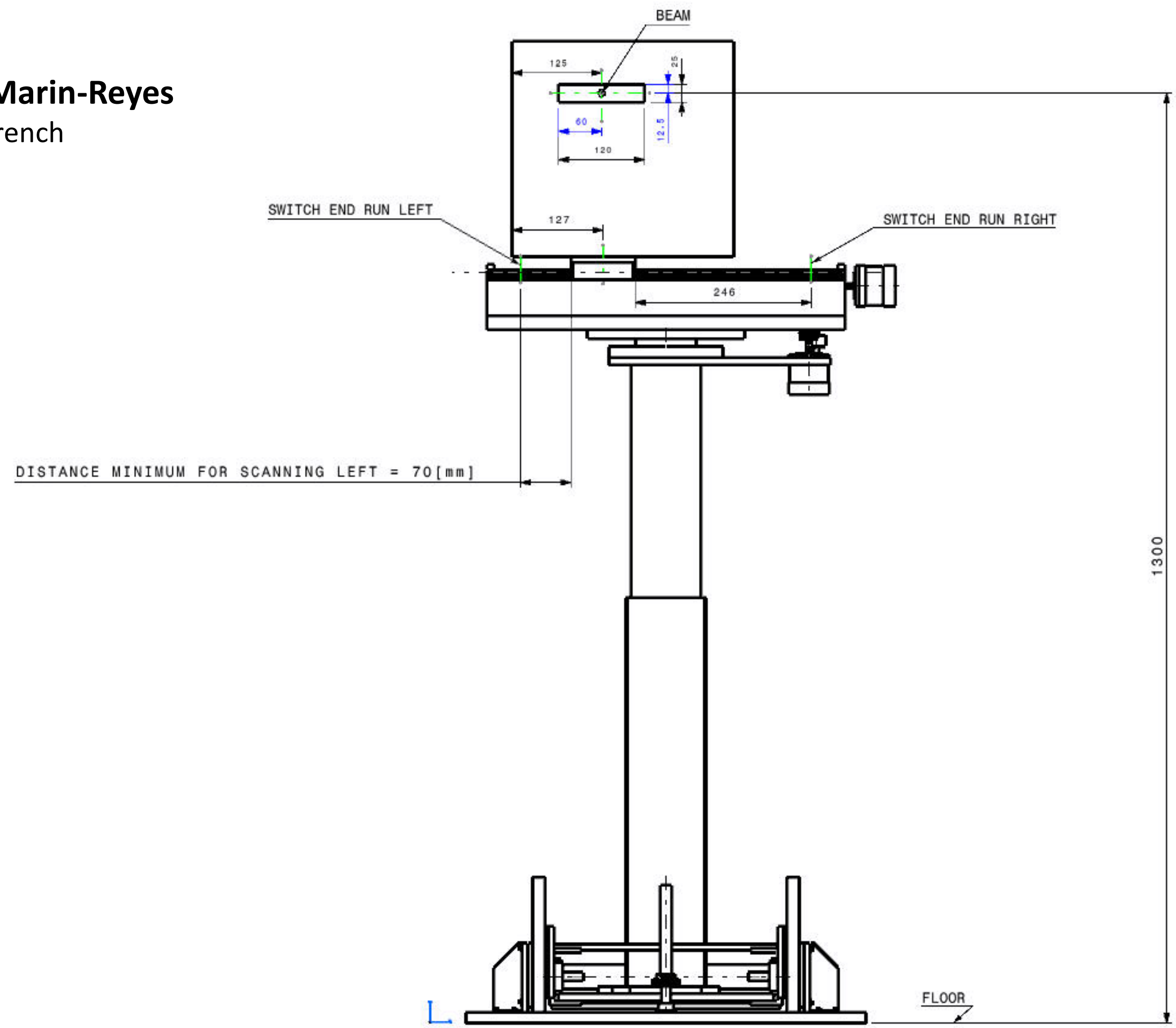

Task 8.3. – Upgrade of PS proton and mixed-field irradiation facilities at CERN

- **Task leader: Michael Moll (CERN)**
- Objectives:
  - Improvement of existing irradiation facilities at CERN PS
  - Elaboration and evaluation of upgrade scenarios
  - Design and test of common infrastructure for the facility
- Sub-tasks and participants
  - 8.3.1. Improvement of existing irradiation facilities and evaluation of upgrade scenarios
    CERN
  - **8.3.2/3 Common infrastructure for the facilities**
    CERN, UNILIV, USFD - (Irradiation tables and boxes)
    VU - (Radiation monitoring system)
- 2 milestones and 2 deliverables:

Task Overview

MS31	**Installation of new equipment**	**CERN(1)**	**m26** **March 2013**	**Movable irradiation tables operational (Task 8.3.2)** CERN, UK
MS35	**Installation of infrastructure**	**(34)**	**m37** **Feb. 2014**	**Cold boxes and Fluence monitoring system operational (Task 8.3.3)** CERN, UK, VU

D8.4	**Upgrade scenarios for irradiation lines: Design study on new or upgraded irradiation facilities at CERN based on slow extracted proton beams. Containing a proton and – if feasible – a mixed field irradiation facility.**	[month 37] **Feb. 2014**	Task 8.3.1 CERN
D8.10	**Commissioning of new facility equipment: Report on commissioning of shuttle systems, movable irradiation tables with cold boxes and a fluence monitoring system based on a microwave absorption technique in silicon.**	[month 48] **January 2015**	Task 8..3.2 CERN, UK, VU

Scanning tables for PS IRRAD

Maurice Glaser
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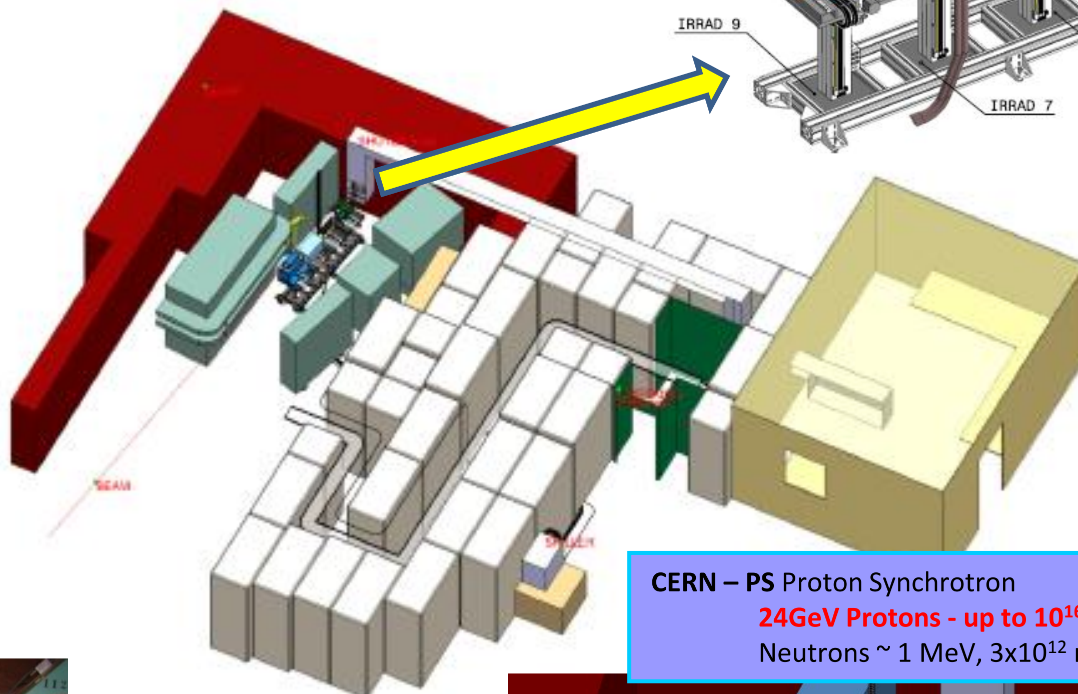
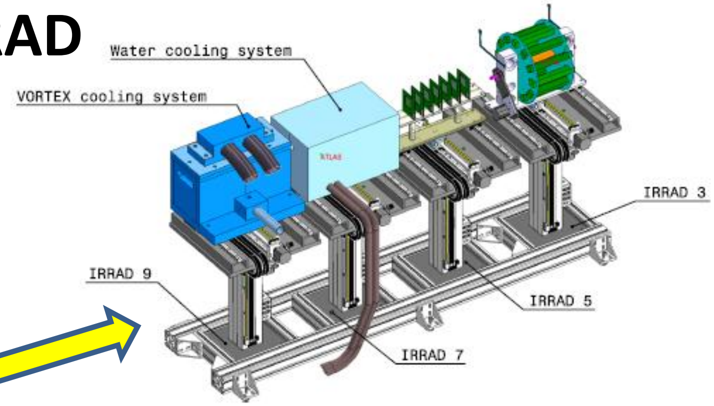
Michael Moll

First production 3axis scanning table with cold box (above). Scanning table and rail system installed in beam line (below)

Proposed layout of IRRAD area

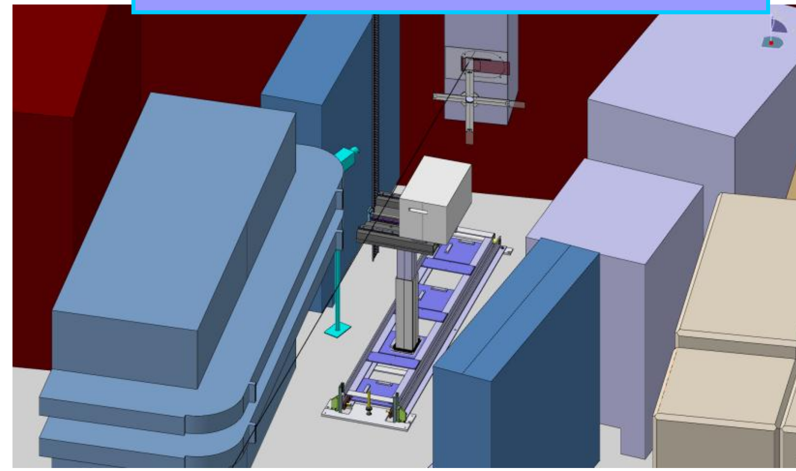




CERN – PS Proton Synchrotron
24GeV Protons - up to 10^{16} cm^{-2}
Neutrons ~ 1 MeV, $3x10^{12}$ n/hour/cm2

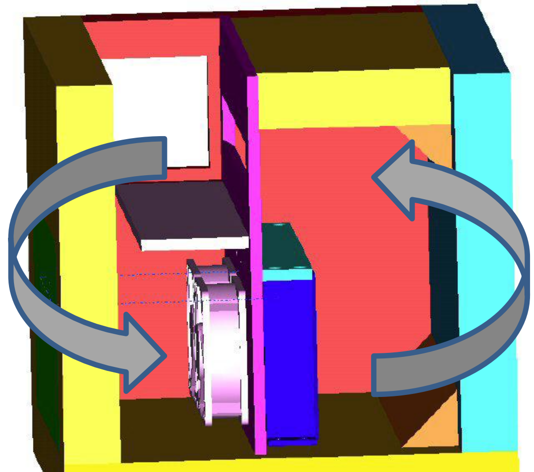
CATIA models (above) of IRRAD area with thermal box and scanning installed.

CATIA model of first installation on beam-line with rail system (right).



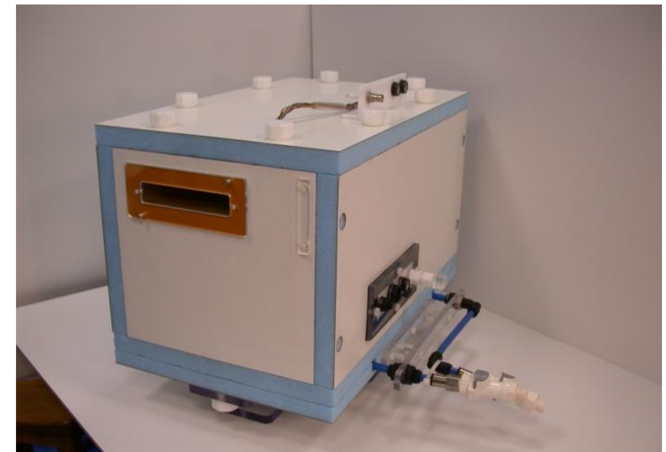
Cold box design

Chilled N_2 circulated by AC powered fans in thermally insulating box through HEX cooled by Glycol. All radiation hard materials and components Concept designed by Sheffield. New design & manufacture at QMUL/Sheffield.

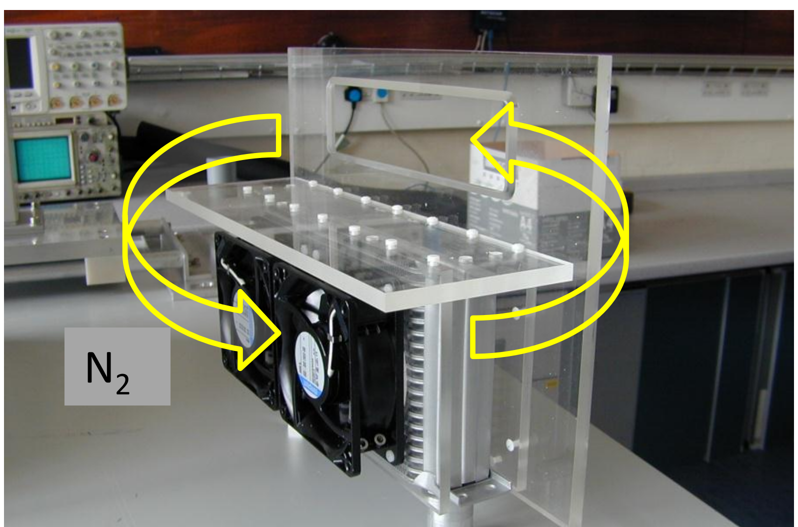


Basic CAD model of box

John Morris QMUL



First production box at QMUL



Final Fan and Heat Exchange Mounting (Sheffield)

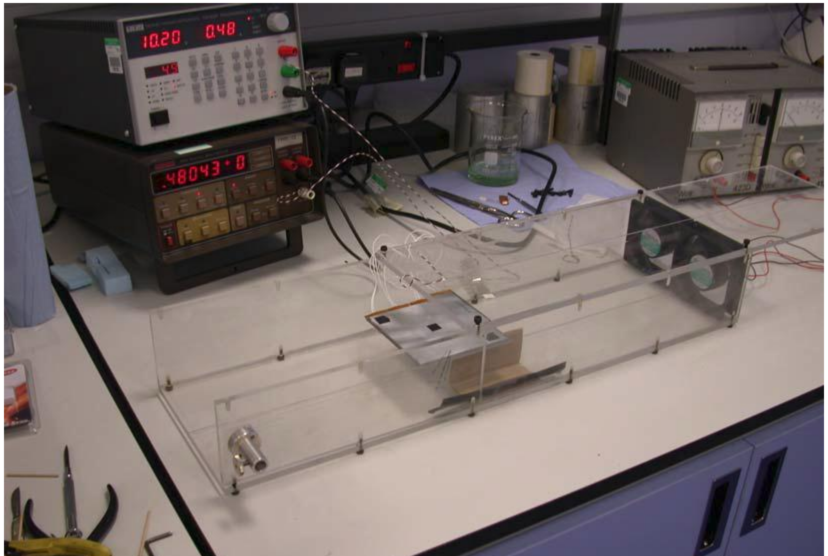
Fan + HEX in test thermal box

First box produced, tested and ready for installation (above).

Status

- 1 Box at CERN installed =ok
- 1 Box at QMUL testing
- 1 Box at Sheffield prototype

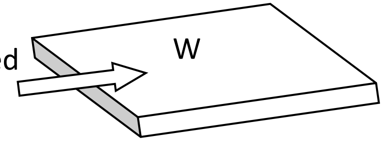
Proving the forced convection cooling

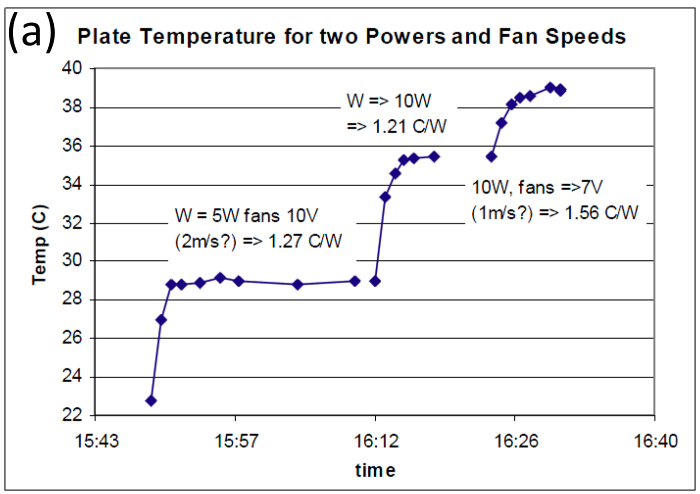


Test system built at QMUL to prove concept

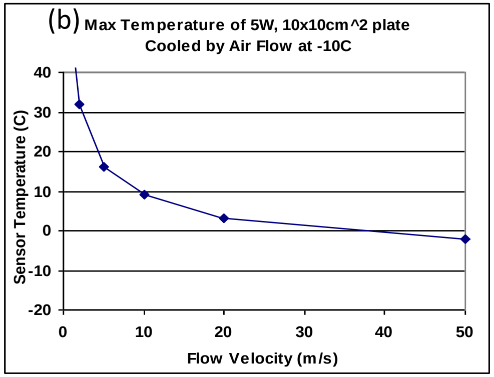
•Air (here at room temperature) is blown through a perspex duct by two 8x8 cm^2 fans.
•The cooled structure is a 10x10 cm^2 sandwich of two 0.6mm Al plates, enclosing kapton film elements providing uniform heating.
•Airflow speed (judged from injecting small fragments of Kleenex) is of order 1m/s. The lid of the duct is displaced to allow measurement of the surface temperature by a spot radiometer (3xblack squares).
•FYI: the DC fans are nominally 12V, 2W each. Note that the rise in air temperature is not measured. Production box uses higher powered AC fans.
•In general this can be estimated from: $\Delta T(gas) = W/(v.A.\rho.C_v)$.
As an example, choosing some appropriate round numbers:
W=1Watt, v = 1 m/s, A = 20cm x 5cm = 10-2 m2. ρ (NTP) = 1.2 kg/m3, Cv ~ 1 kJ/kg/K
=> ΔT(gas) ~ 0.8C, low enough (for such conditions) that the exit gas should be re-used (rather than vented).

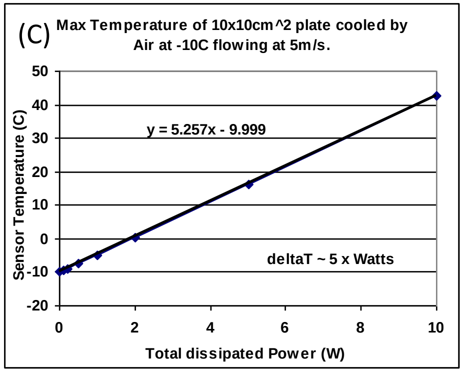
Assume that nitrogen is pre-cooled and blown across the detector surface with detectors edge-on to the beam (a)





The plots below are calculated (following a worked example from Holman [1]) for the cooling of a Flat Plate dissipating a constant heat flux by air flowing across it at a given speed and temperature.





A change in air temperature produces a similar shift in sensor temperature. However, there is a strong velocity dependence (b). The power dependence (c) is essentially linear.

[1] Heat Transfer, J.P.Holman, 8th edition, p 244.

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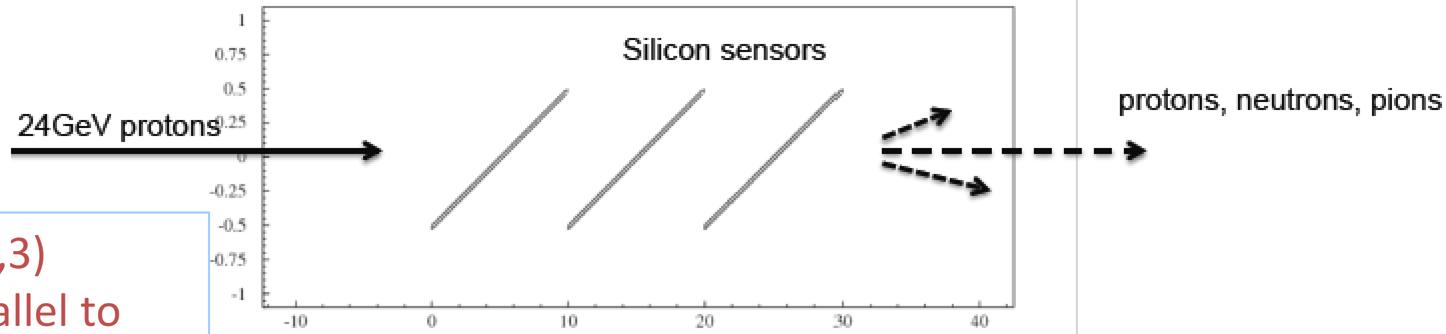
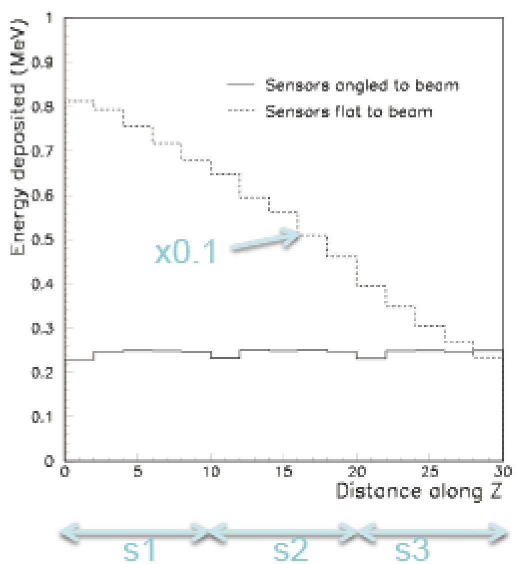
Sensor mounting simulation

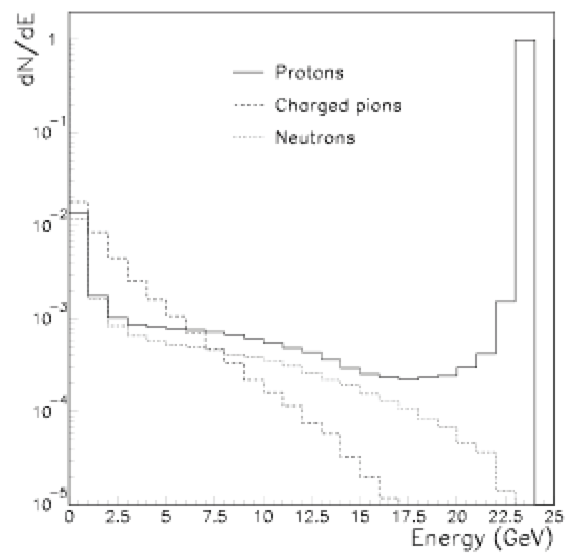
Ian Dawson, FLUKA simulations

Making large area sensors fit economically in the PS facility by tilting the sensor



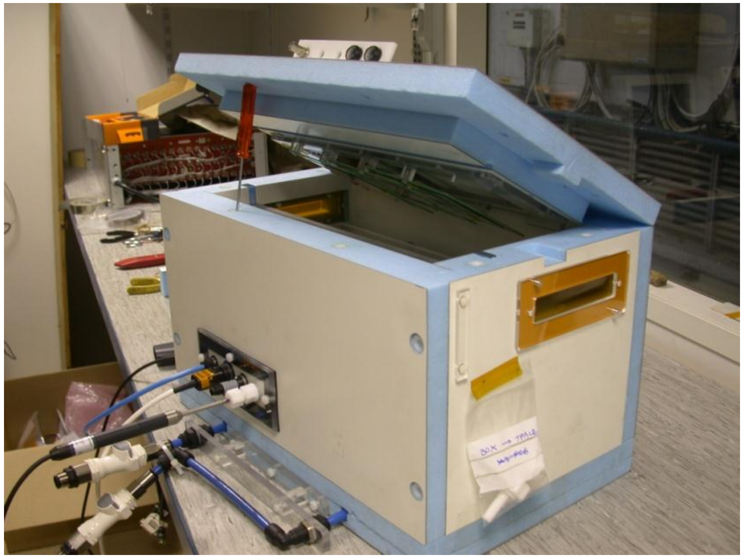
Sensors (S1,2,3) placed in parallel to beam Z axis



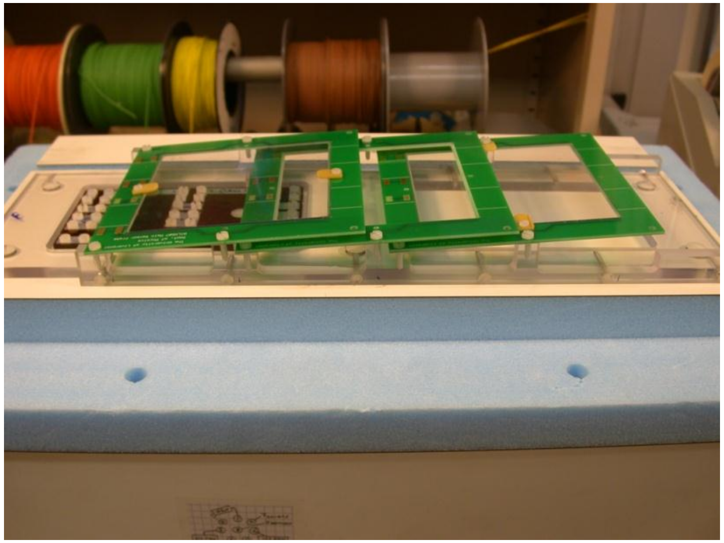


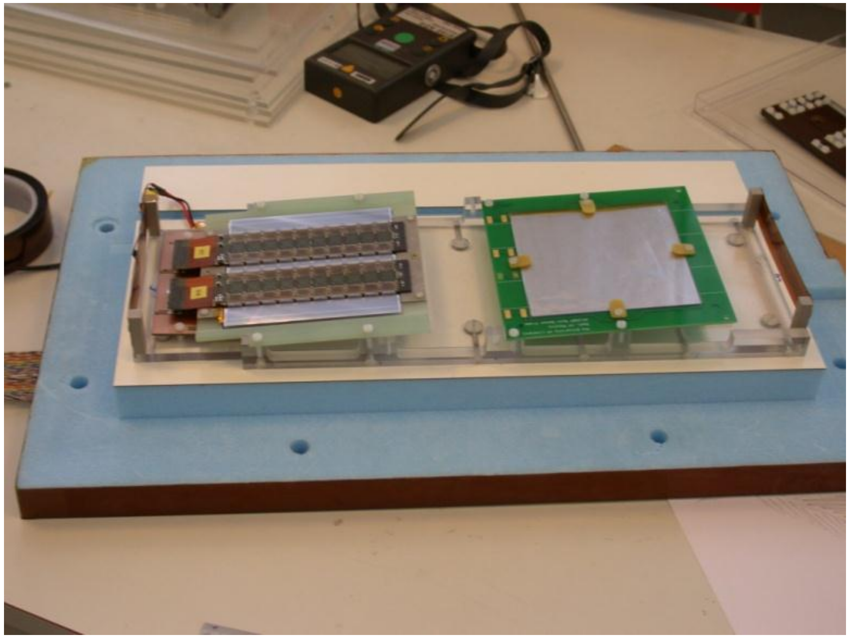
Tilted sensors effectively reduce proton path from Z=300mm =>10mm

Sensor mounting & cooling

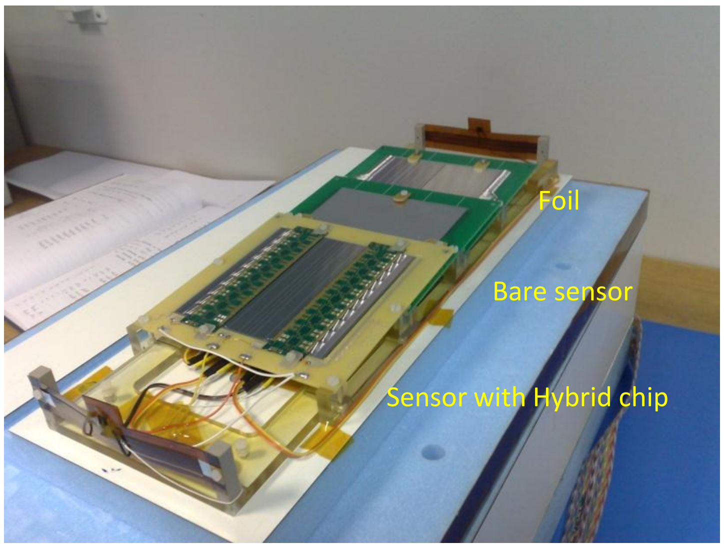


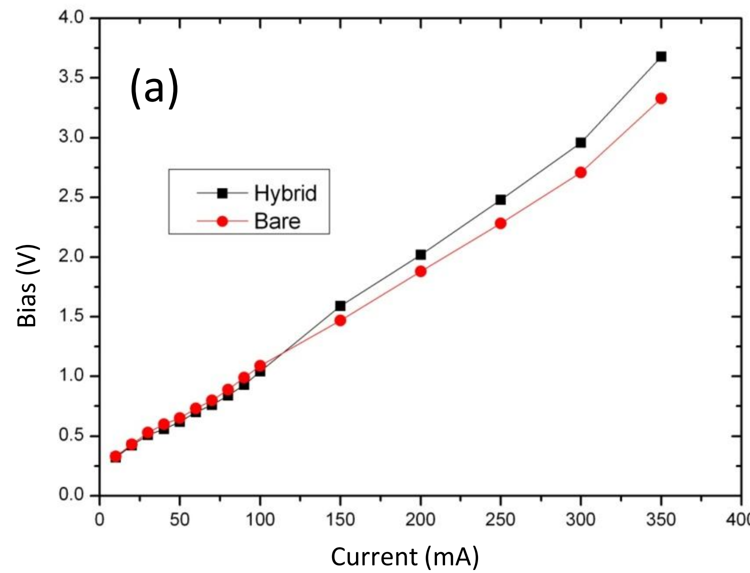
•Once sensor cooling and fluence simulation understood, mounting in the thermal box was possible.
•Activation foils and pin diodes present for Dosimietry.
•Temperature monitoring was done by existing sensors on the detector PCB.





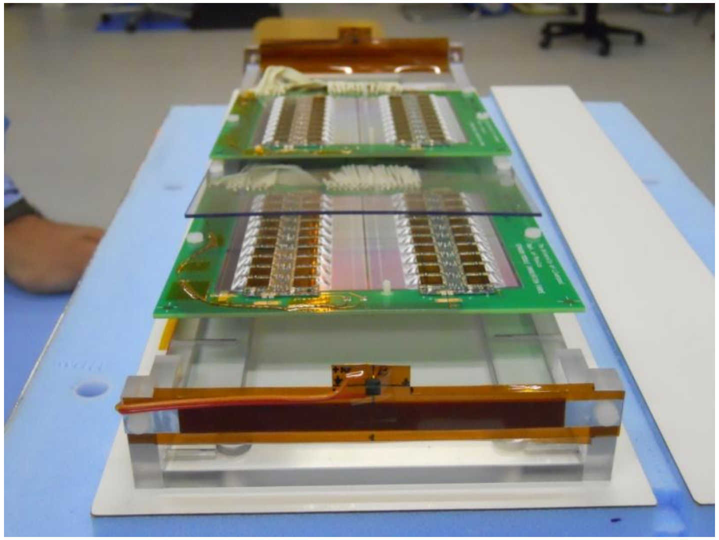
1st Sensor Irradiation

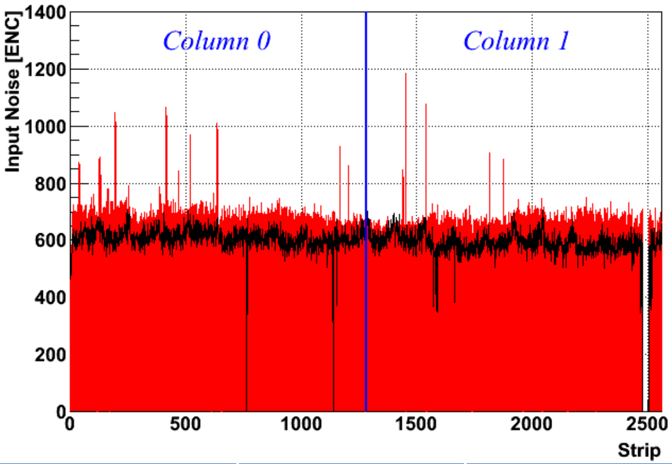




- One bare sensor and one sensor with hybrid glued on it – can the glue damage the sensor?
- Irradiated to 1.82×10^{15} p/cm^2 in the cold box on the CERN PS IRRAD scanning table
- Reverse current at the end of irradiation (a) (black with bare sensor, red with hybrid).
- Temperature on chiller at -16^{o}C
- No degradation due to gluing of the hybrid onto the sensor.

Stave module (2nd) irradiation





	Column 0	Column 1
Pre-Irrad	610	589
Post-Irrad	675	650
Difference	65	61
Expected	670	640

- Two modules irradiated (one active C.0 [powered], one passive C.1)
- They were irradiated to 1.9×10^{15} n_{eq}/cm^2 (more fluence than we would expect)
- We have a fully functional module after 1.9×10^{15} n_{eq}/cm^2

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Interest to AIDA? Irradiation using a MC40 Cyclotron Birmingham University, UK

History & Details

- Radial Ridge Cyclotron – since 2004
  - Scanditronix MC40 variable energy cyclotron
  - maximum energies
    - 40 MeV (protons or alphas)
    - 20 MeV (deuterons)
    - 53 MeV (3He)
  - Produces tracers for the Positron Imaging Centre; related research projects; 81Rb production for sale to hospitals

Scanning system + Thermal Chamber

•Fully portable plug & play scanning system

•Thermal chamber using similar principle to PS

•Readout and control system using COTS FPGA based technology

•Networked readout allowing remote access for data analysis and real-time sample performance.

Current status of facility

•2011 - Irradiations performed using 26MeV protons with a beam current of 0.4uA.

•2012 – Reconfiguring beam- line for higher beam currents of >0.8uA for faster irradiation times.

•New shielding to be installed to allow for higher energy running.

•Dedicated beam line for detector activities ready in August 2012.

•PIN Diode/ Titanium activation foil measurements underway

•Fibre optical ribbon jacket Irradiation carried out for ATLAS Upgrade.

•Possibility of linking to AIDA for other users to access this facility?

Contact R.French r.s.french@sheffield.ac.uk for information

THANK YOU