Irradiation Scanning System

suitable for silicon & passive materials (with cooling)

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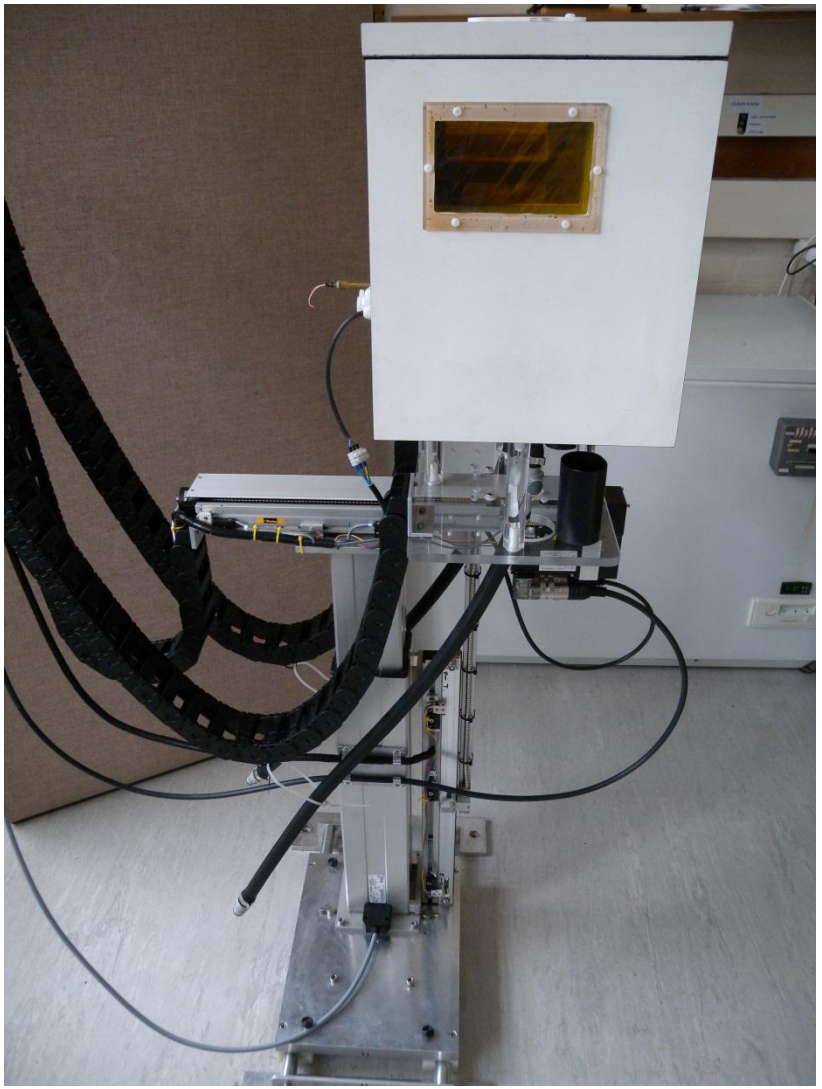

21st RD50 Workshop
CERN 16th Nov 2012

Richard French

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Irradiation using a MC40 Cyclotron

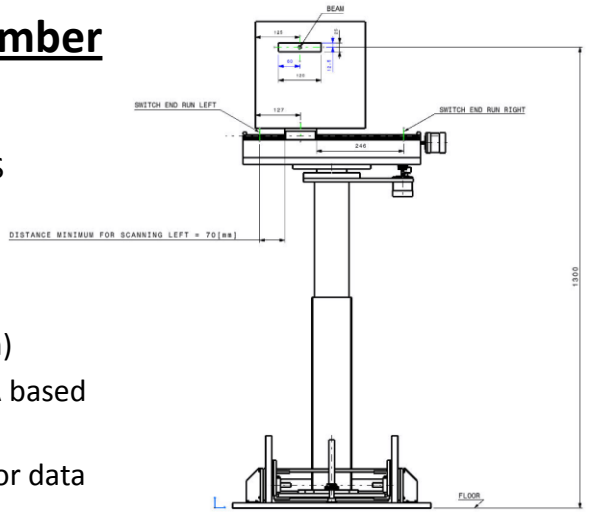
Birmingham University, UK

History & Details

- 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

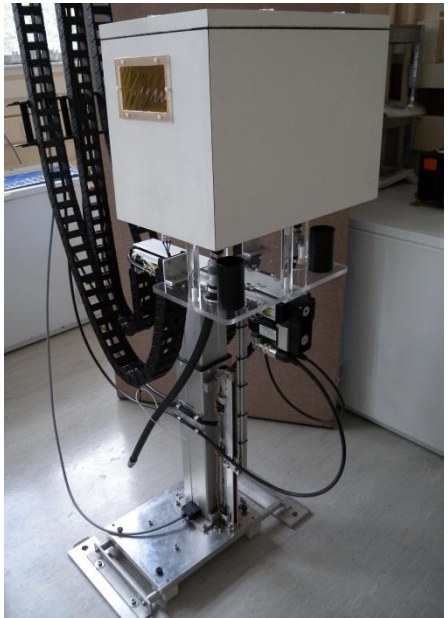
Scanning system + Thermal Chamber

- Fully portable plug & play scanning system
- Thermal chamber using similar principle to PS irradiation facility CERN (IRRAD 5)
  - -22°C minimum operating temp
  - ~ 480W heat load removal (@ -20°C).
  - Recirculate cold air (forced convection)
- 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
- Dedicated beam line for higher beam currents of >0.8uA suited to detector activities ready in November 2012
- New shielding final installation Oct 2012 to allow for high energy running (custom high density concrete blocks)
- PIN Diode/ Titanium activation foil measurements made & calibrated ok
- Fibre optical ribbon jacket Irradiation carried out for ATLAS Upgrade 2012
- Possibility of linking to EU AIDA programme for user access to this facility 2013 onwards



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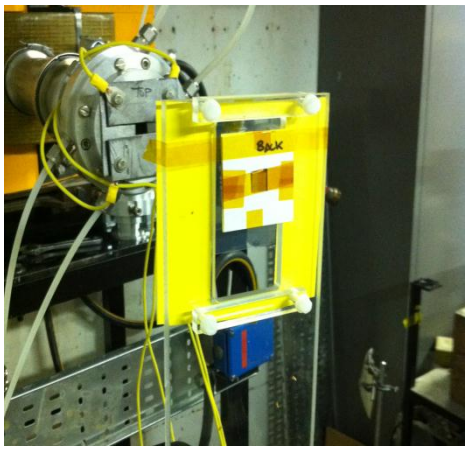
Summary of the irradiation on 14/06/11

Beam Line

- Run at a current of 0.5μA for 800 seconds to reach 2.5×10^{15} n_{eq}/cm^2
- The faraday cup was also used to give an end time (667 units)
- Both the time estimate and the faraday cup agreed with each other to within 1 second at the end of the run.

- Beam spot



- Sensors mounted in the beam line

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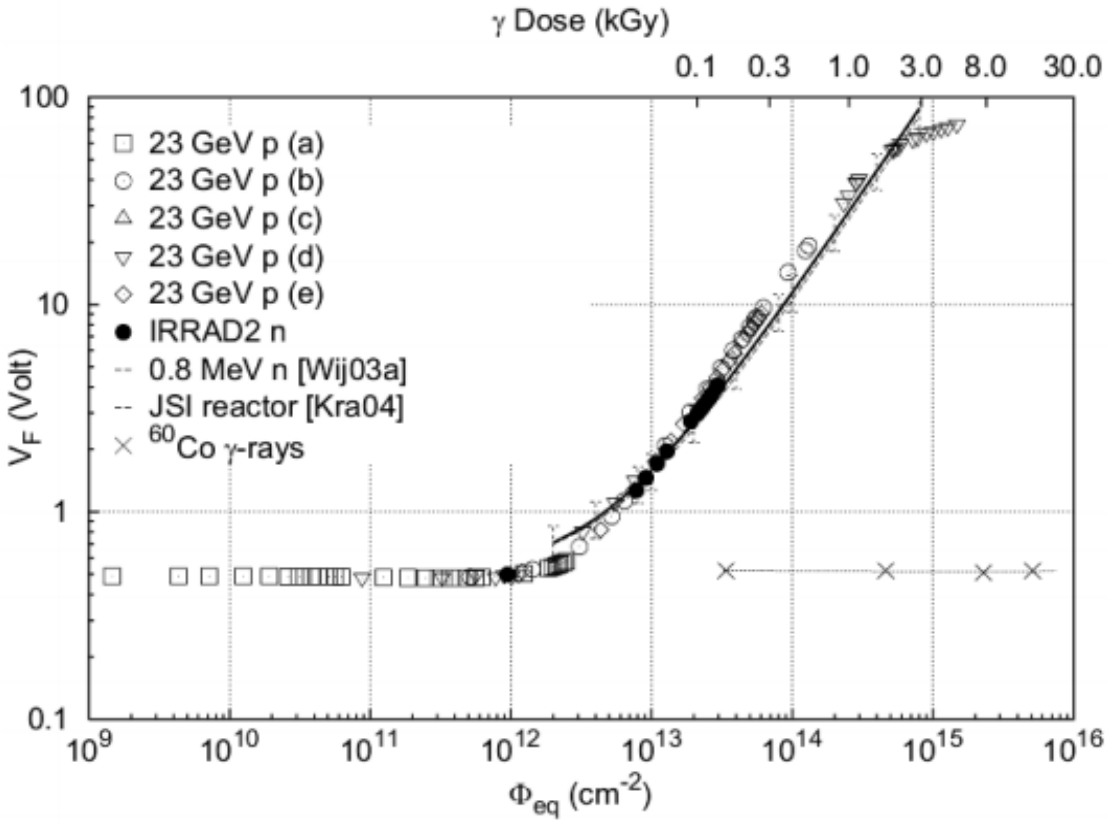
Online dosimetry



- BPW32 measurements (F. Ravotti's PhD Thesis)

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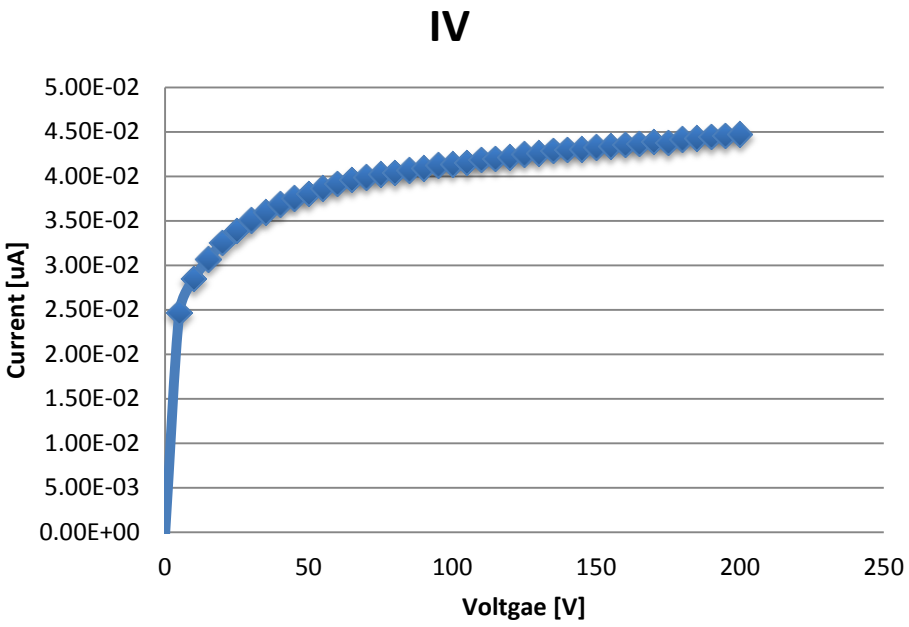
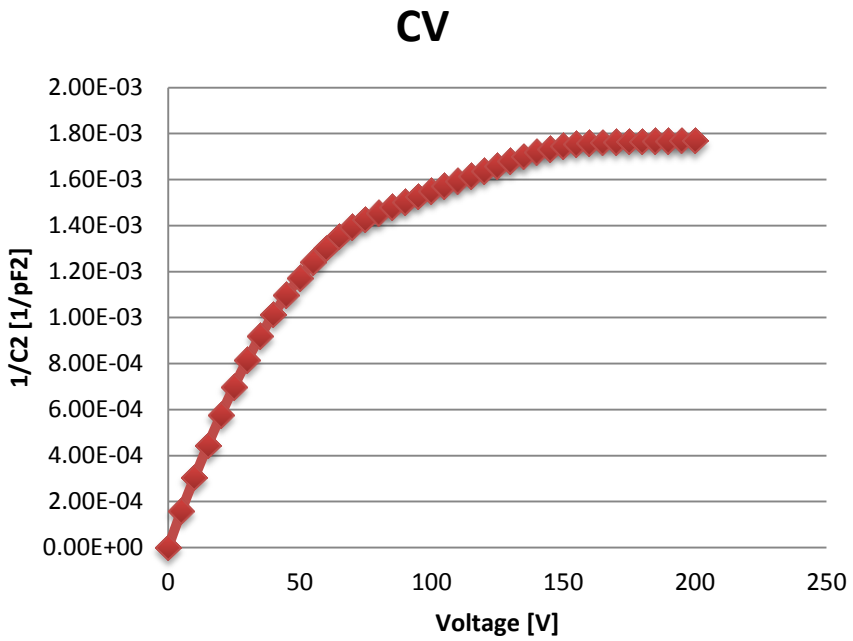
Foils and Sensors

Four 300µm thick ATLAS07 mini sensors (1 × 1cm2) were placed in the beam

- VPX73814-W148 BZ5-P11 (Back)
- VPX73814-W146 BZ6-P12
- VPX73814-W146 BZ5-P23
- VPX73814-W148 BZ6-P24 (Front)





- Example of an IV measurement, pre-irradiation
- Example of a CV curve, pre-irradiation

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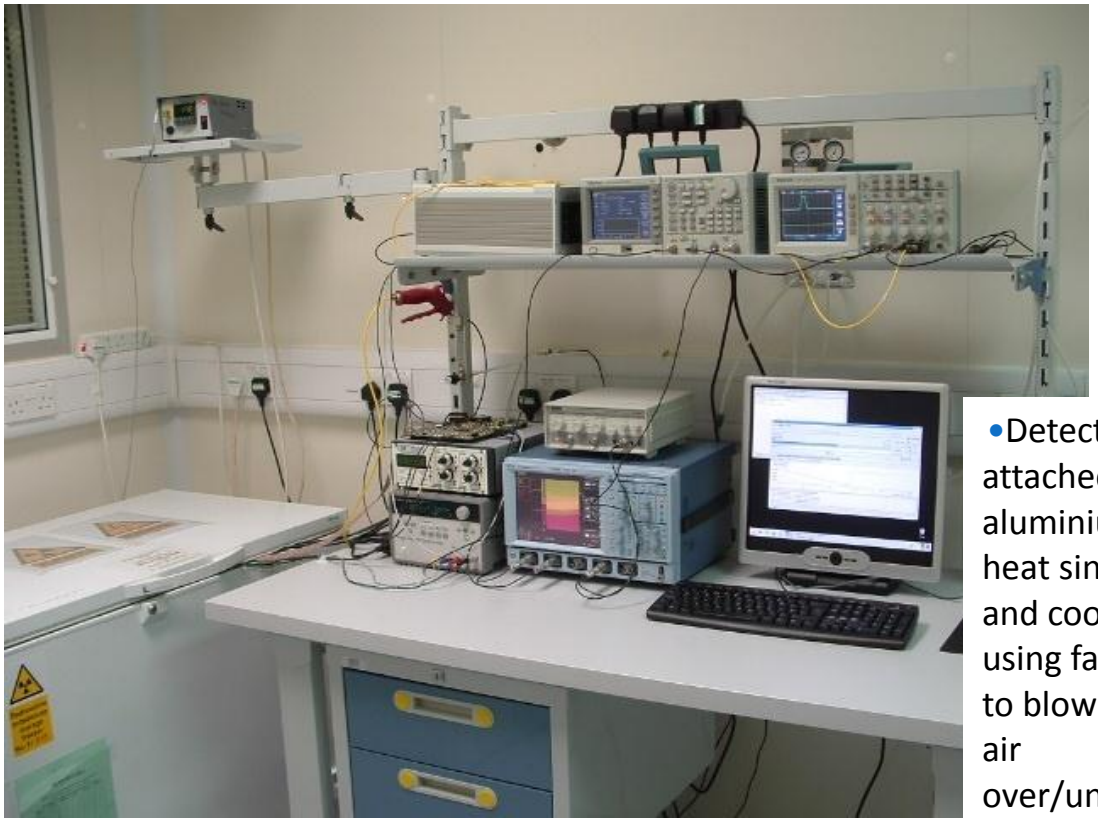
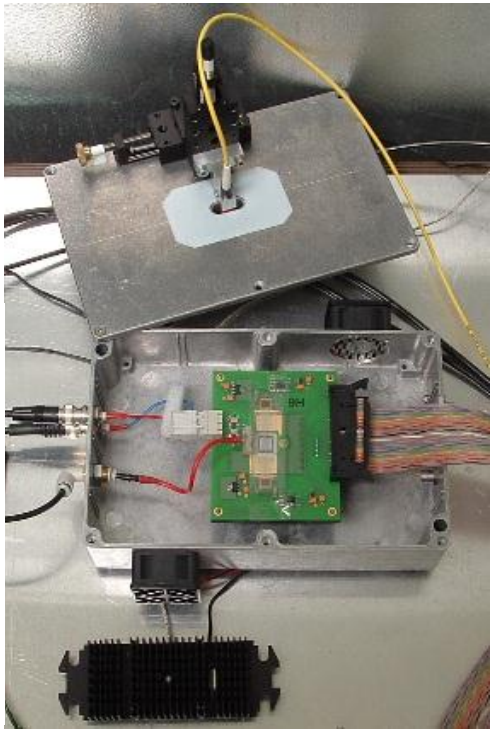
Alibava Setup

- Analogue readout based on the Beetle V1.5 chip(40 MHz readout speed)



- Detector attached to aluminium heat sink and cooled using fans to blow cold air over/under detector
- Cooling down to - 45 deg.C (ElCold EL11LT), 1deg.C hysteresis loop

- Signal generation with 370 Mbq 90Sr fast beta source for charge collection & sharing studies



- Scintilator/s placed under/ontop daughter board for single or coincidence trigger

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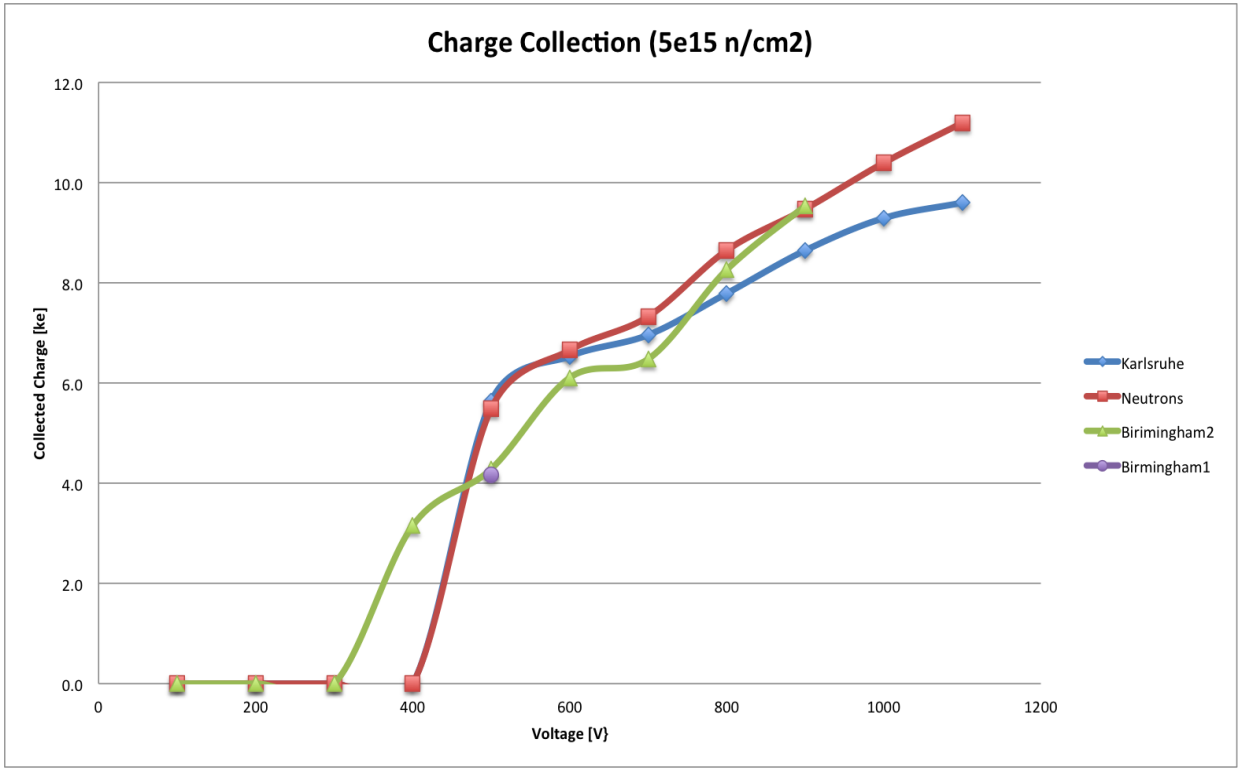
Charge Collection



- CCE measurements

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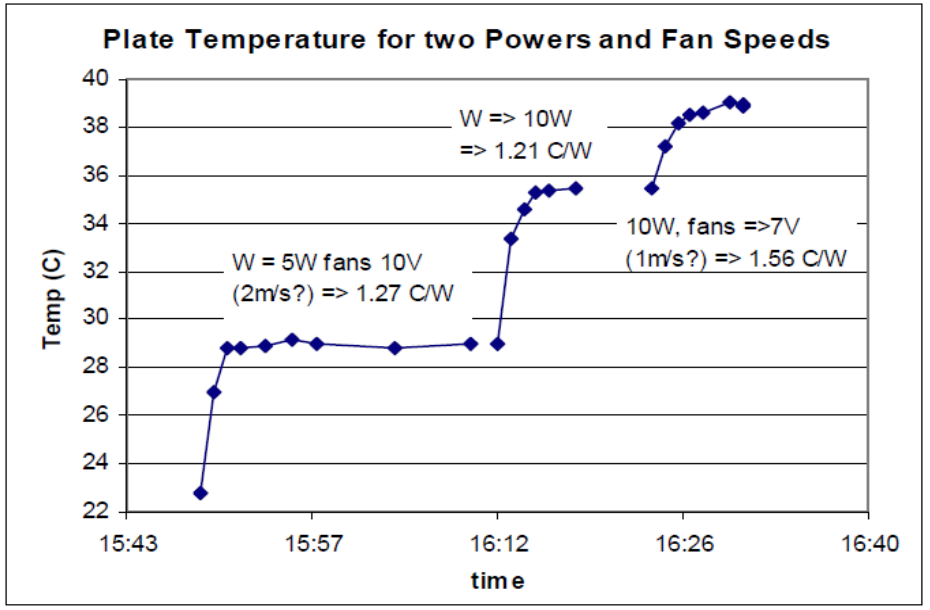
Chamber cooling performance

Dummy silicon heater tests using 100mm^2
Aluminium plates with Kapton film heaters

- Chiller cooling the heated plate gives :
- 10W Sensor at -7C + Integrated hybrid => need to cool gas (N_2)to -22C
- Chiller cooling heated plate gives DT ~ 1.5C/W => 1W sensor at -7C => cool the N_2 to -8.5 C
- 3x ATLAS Upgrade 250nm strip sensors 100mm^2 + hybrids, 2 fans at 10w, 12m of cooling circuit, 800w chiller power.
  Sensors 3 x 1W + Hybrid: 10W
  Fans: 10W
  Ambient conduction (DT=35C): ~20W (estd.)
  => sub-total for HEX: ~30 – 40W (*tested - ok! G.Beck et al 2009)*
- Conduction through insulation (2 x 6m) ~ 100W
- => total load for circulating chiller to remove ~ =< 150W or 50W per sensor



CONCLUSIONS

- Thermal chamber and chiller have more than enough head room to cool multiple sensors (powered)
- Temperature losses through transfer lines will be a problem if length exceeds 20m, loss per m is more dramatic the longer the length…….

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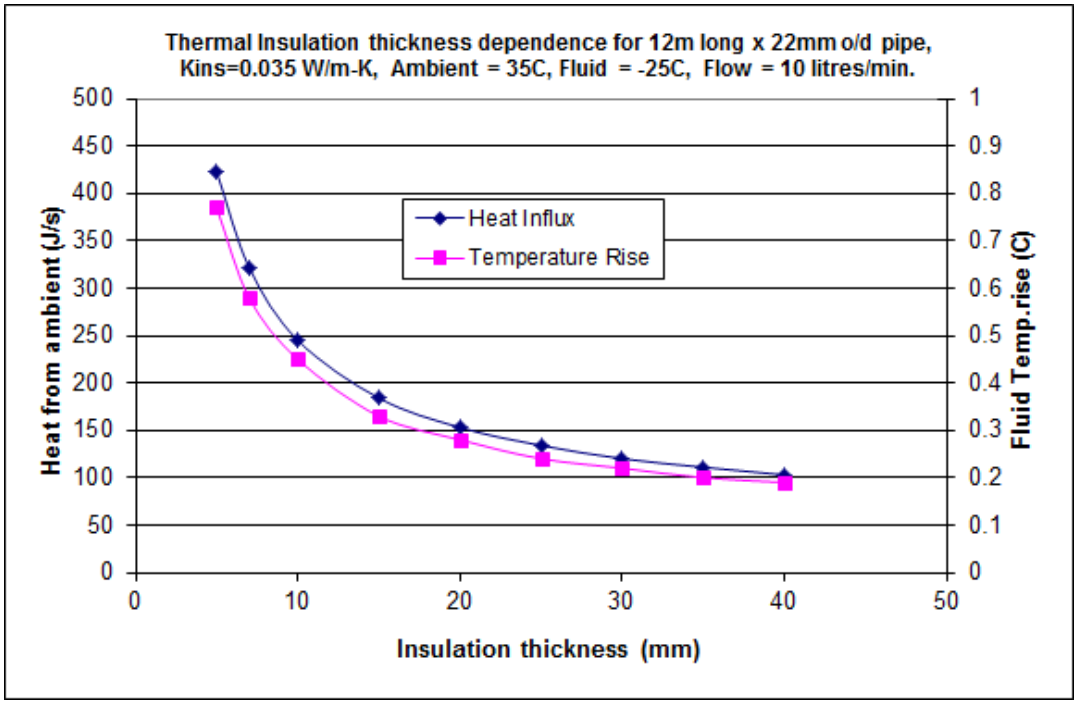
Transfer line cooling tests



Properties	Values
Material	Foamed nitrile rubber
Max. Surface Temperature	+105°C
Max. Temperature for Flat Surface	+85°C
Min. Surface Temperature	-200°C*
Thermal Conductivity at 0°C	0.034 W/(m · K)
Thermal Conductivity at +20°C	0.036 W/(m · K)
Thermal Conductivity at +40°C	0.038 W/(m · K)

Thermal chamber to chiller system transfer line insulation performance

- Based on Armacell data & samples
- Chosen 30mm thick for optimal performance
- Box insulation is a Styrofoam sourced from Dow - laminated with 0.8mm Aluminium (grounding & shielding) and 0.2mm white Formica (light tight rad hard, dust free

TESTED OK WITH THIS 800w SYSTEM UP TO 22.5m LONG

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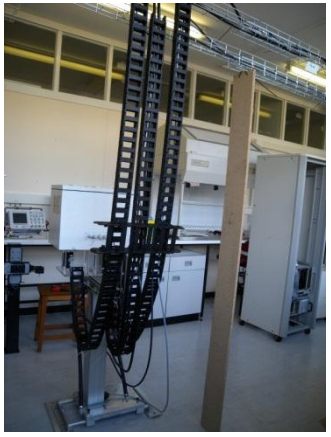
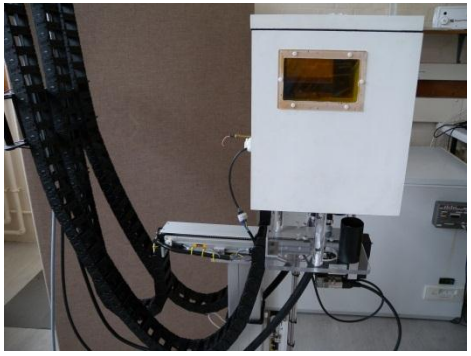
Scanning Table

Pre-configured XY-axis Cartesian Robot System

- It handles payloads up to 60 kg
- Speed: as low as 1 mm/s and as high as 360 mm/s (X-axis)
- Acceleration rates up to 20 m/s²
- Positional Accuracy ±50 µm (X-axis)
- This motion system can execute strokes up to 450 mm in X-axis, and 400 mm in Y-axis
- System driven by NI CompactRIO Real-Time controller and AKD Servo Drives with synchronized multi-axis motion using NI LabVIEW graphical programming.



- Overall unit length with a parallel mounted motor is 598mm long to reduce working space



- Motors and cables connect to the scanning table in a straightforward and simple manner.

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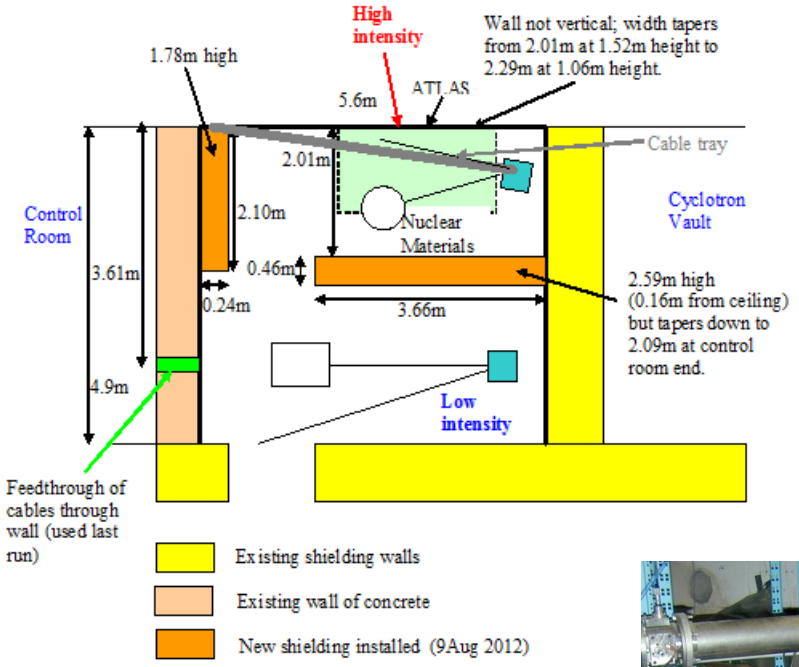
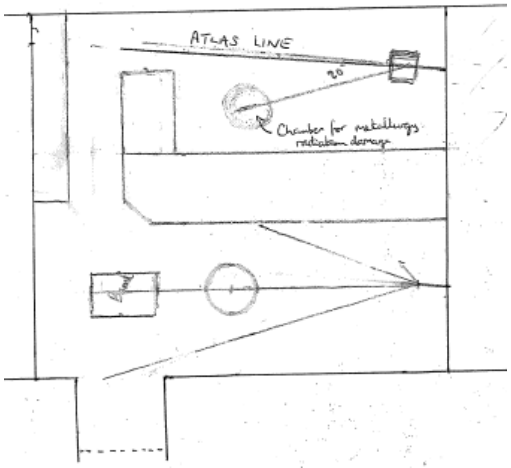
New Beam Area

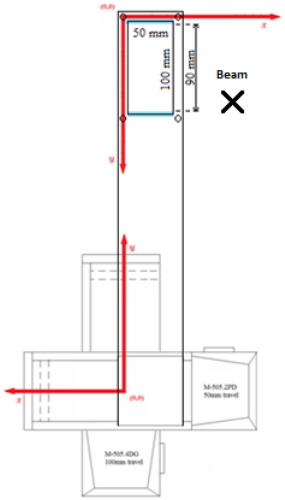
Birmingham University, UK



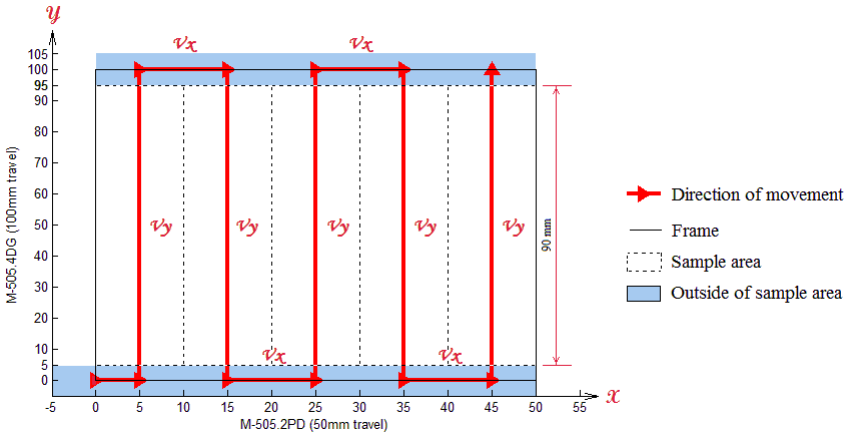


Irradiation Path Profiles

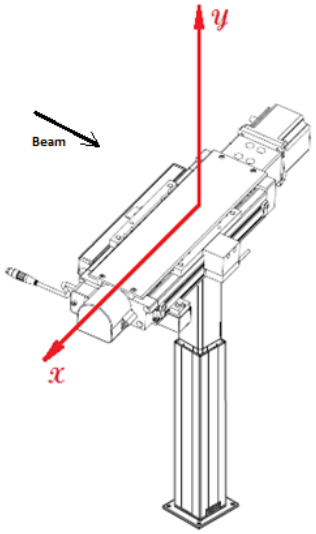
- Birmingham Irradiation (Nov 2011)



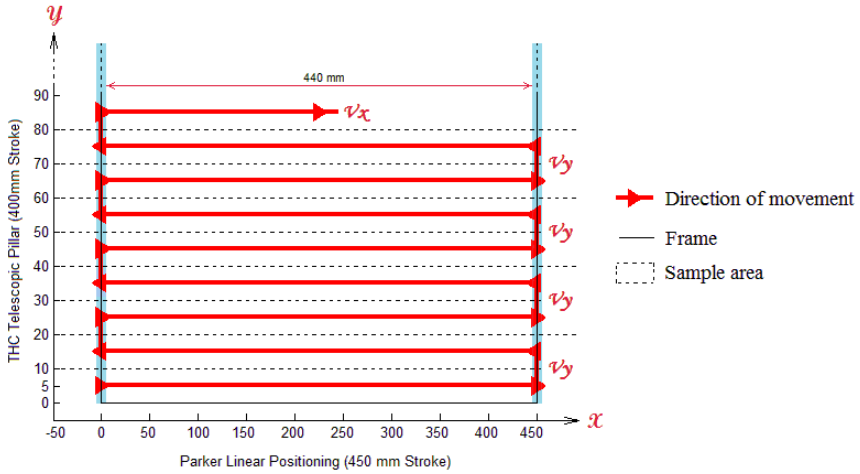
	X	Y
Stroke	50mm	100mm
Max. Speed	Variable: 0-15 mm/s	Variable: 0-15 mm/s



- New XY-axis Cartesian Robot System



	X	y
Stroke	450mm	400mm
Max. Speed	Variable: 0-360 mm/s	Fixed: 15 mm/s



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Conclusions

- The Scanditronix MC40 located at Birmingham is easily capable of providing fluences for SLHC type applications
- Has provided successful irradiations of materials (e.g. Fibre Optical cable components – support jackets)
- New high energy beam area nearly ready for operation
- Plug and play portable irradiation system design that is easy to reproduce
- Dosimetry and activation measurements now fully tested and calibrated
- Detector test facilities proven and established
- Cooling system testing shows enough headroom to prevent annealing of sensors
- Final construction 27th Nov 2012 (Additional shielding)

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THANK YOU