York R&D relevant to ISS upgrade

David Jenkins, 16th August 2022

Novel µRWELL tests: York Long Chamber

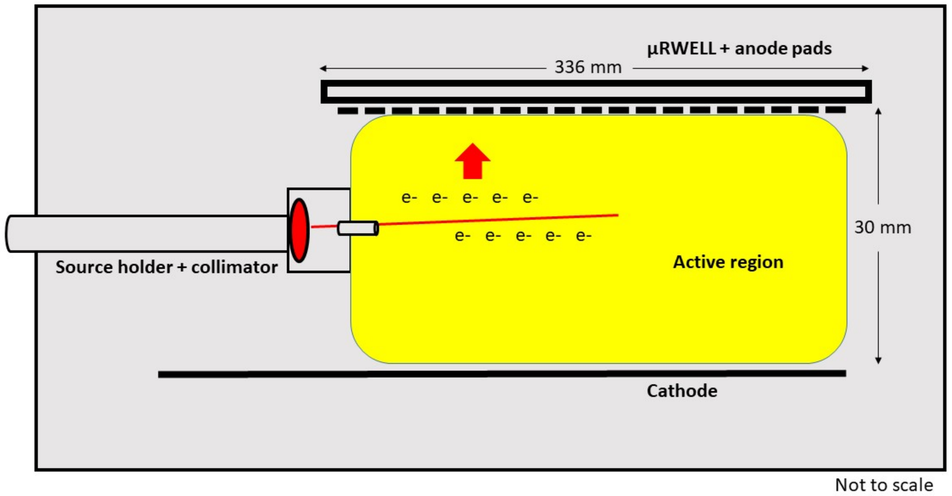

Fig 1. York Long Chamber schematic

Fig 2. µRWELL with 60 anode pads on the back (York Long Chamber)

- York Long Chamber: Time projection chamber (TPC) with planar geometry
- Detector dimensions: 150mm x 480mm x 120mm
- Distance between cathode and µRWELL surface (drift gap): 30mm
- µRWELL active area dimensions: 35mm x 251.85mm ; µRWELL overall dimensions: 336mm x 80mm; Foil thickness: 0.2mm
- Anode is segmented into 60 pads of width 4.2 mm
- Designed to test MPGDs and electronics for **TACTIC** (TRIUMF Annular Chamber for Tracking and Identification of Charged particles)

<u>Goals:</u>

- Gain measurement in different gases (Ar:CH4, He:CO2, isobutane). High gas gain (~10^3) is required in order to detect light reaction products (alphas and protons). Single GEM gas gain was too low for this purpose.
- Estimation of lateral structural gain variation is required to improve energy calibration.

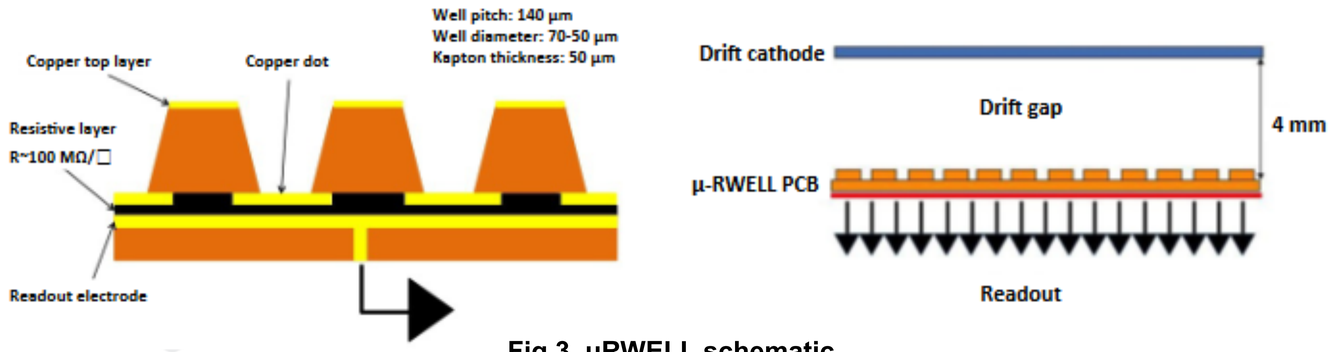

Fig 3. µRWELL schematic
Ref: G. Bencivenni et al 2015 JINST 10 P02008

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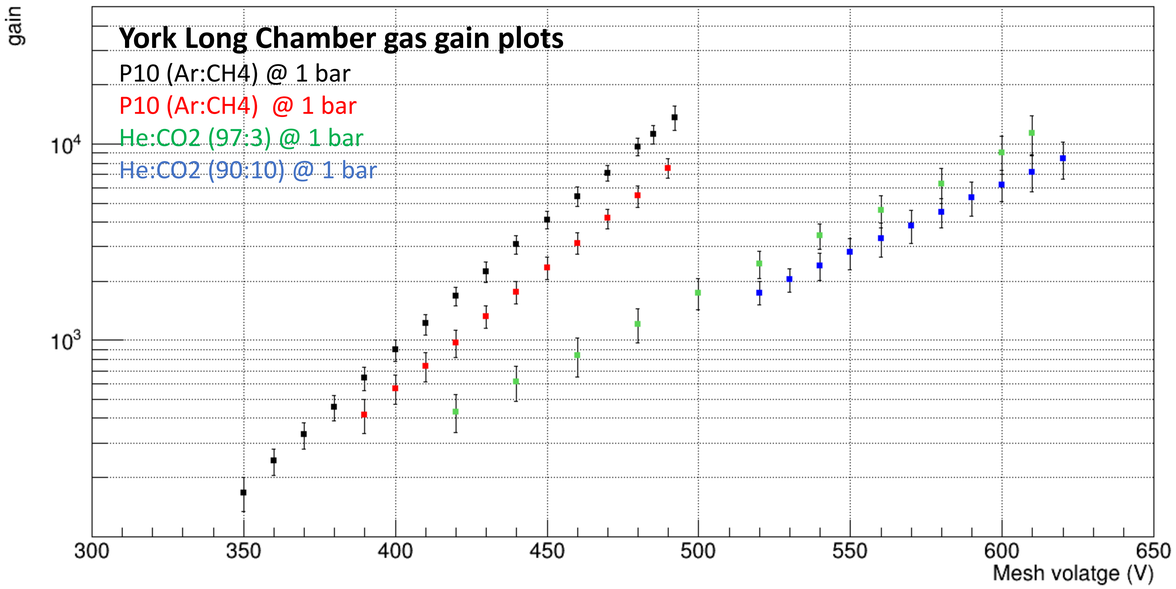
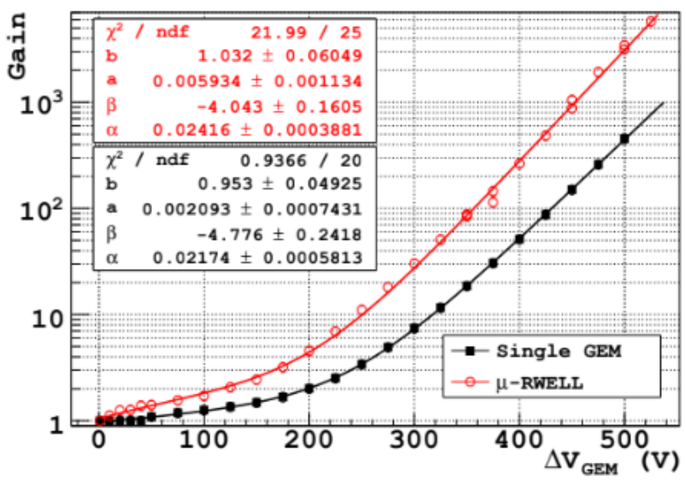
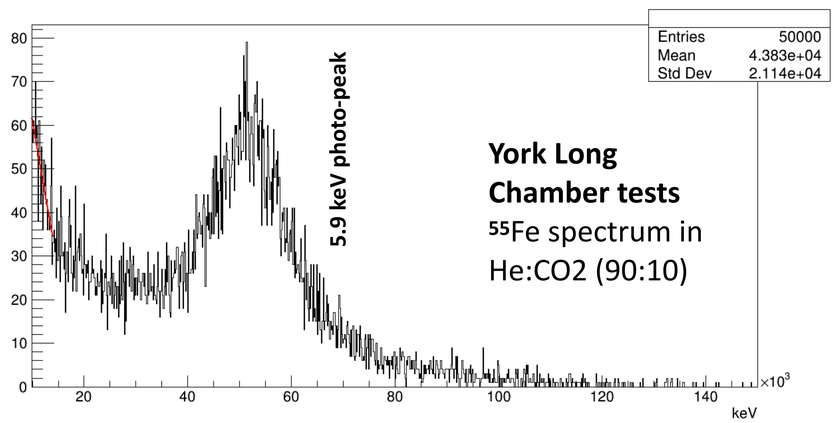
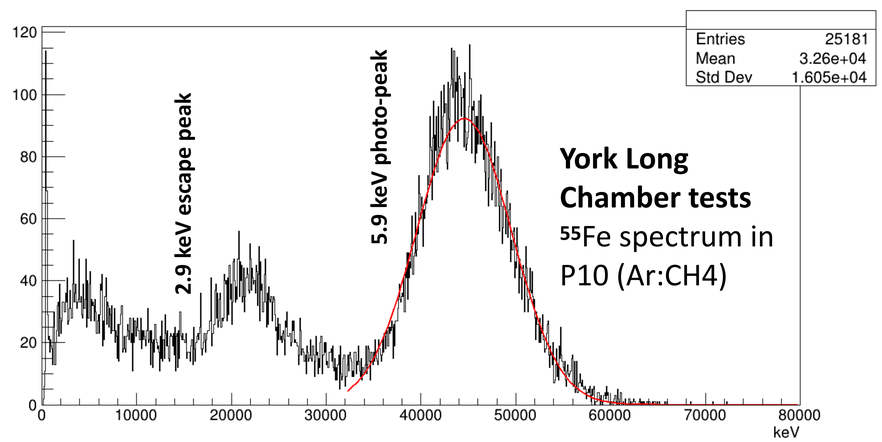




Gas gain plot in Ar:CO2
Ref: G. Bencivenni et al 2015 JINST 10 P02008





<u>Summary:</u>

- Gas gain and resolution studies in various gas mixtures were performed, e.g. P-10 (Ar:CH4), Ar:CO2 and He:CO2
- Sources used: Spectroscopic 3-α and Fe-55 X-ray source
- Maximum gas gain observed in Ar:CH4 and He:CO2 ~ 7×10^3
- In Ar:CO2 gas mixture, at gas gain ~ 10^3 an energy resolution of ~ 33% was estimated by fitting the main photo-peak
- Studies of "charging-up" effect, pressure and quench gas percentage dependence of gas gain have been conducted

Novel μRWELL tests: TACTIC

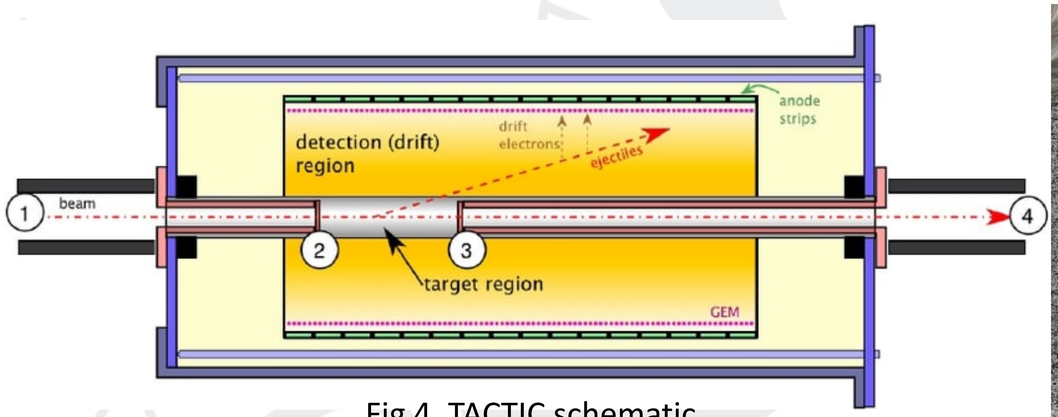


Fig 4. TACTIC schematic

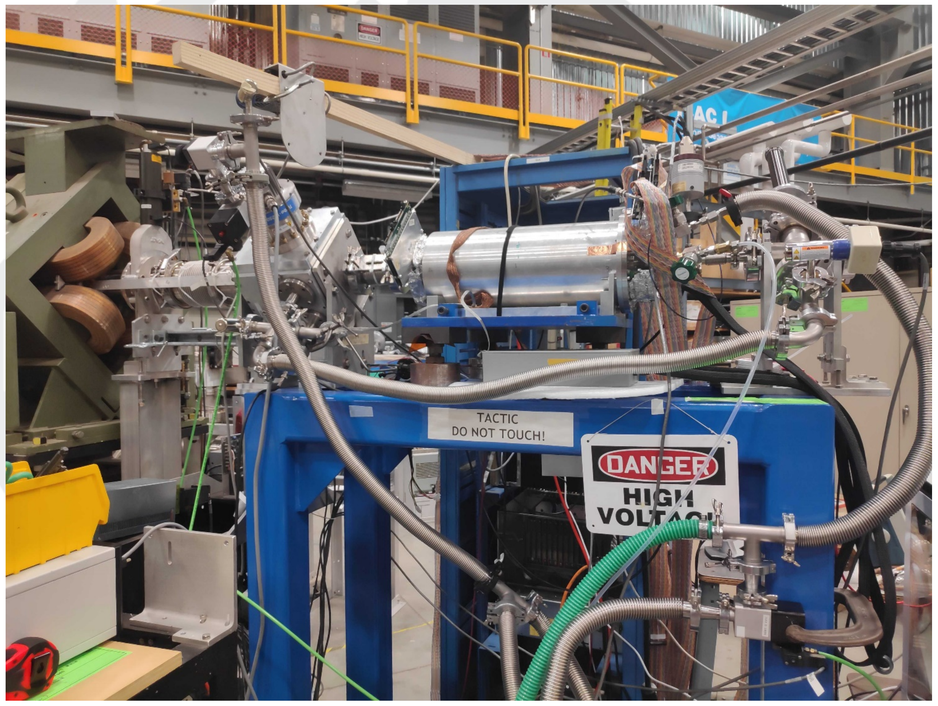


Fig 5. TACTIC during beam tests at TRIUMF (July 2022)

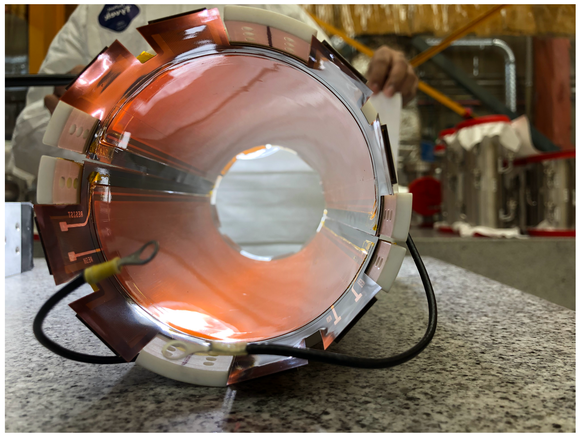


Fig 6 & 7. μRWELL in the curved geometry (TACTIC)

- TACTIC: Active-target time projection chamber (TPC) with cylindrical geometry designed to study nuclear reactions with astrophysical significance
- Aims at efficient small reaction cross-section measurements at low energies
- Uses **novel μRWELLs in a curved cylindrical geometry** as the gas amplification stage for detection of various reactions products of interest with a range of energies (tens of keV to few MeV)
- Total length of detection region (shaded yellow): 251.9 mm and radius: 53 mm
- 480 anode pads for tracking the reaction products divided into 8 sectors (60 pads/sector)
- μRWELLs are currently installed inside and stable beam tests were conducted at TRIUMF during July 2022.

Novel µRWELL tests: TACTIC

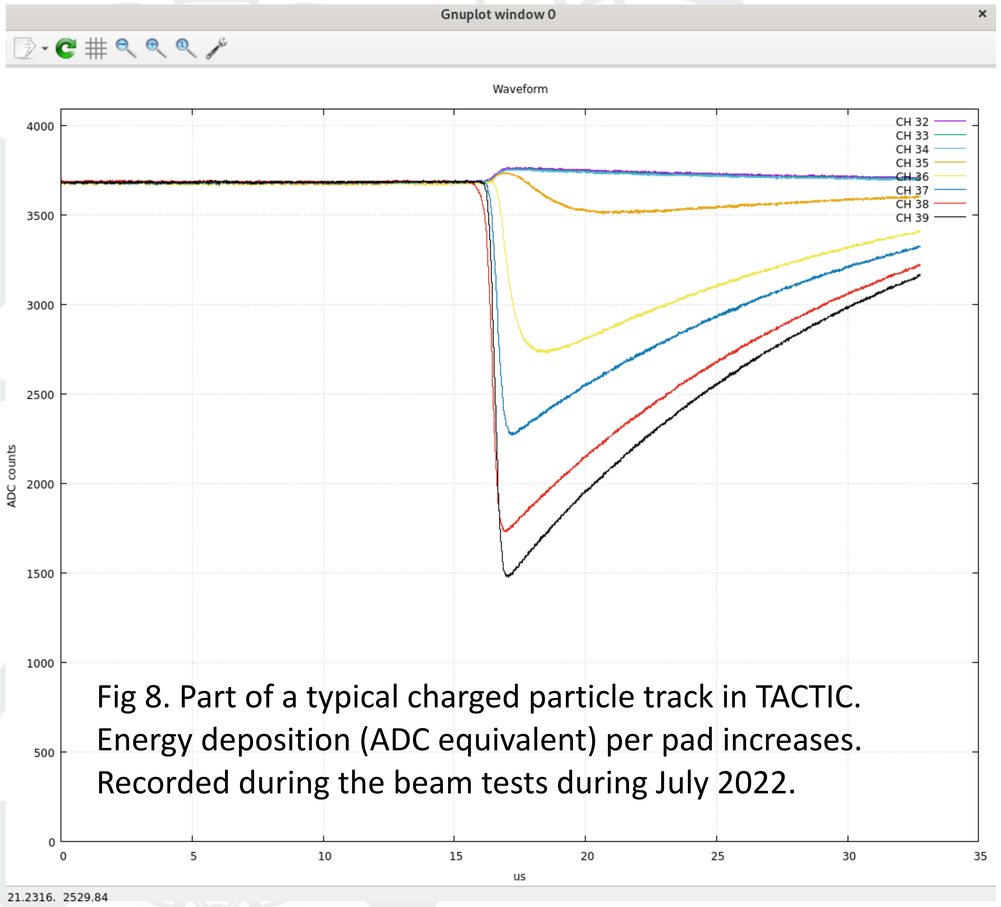
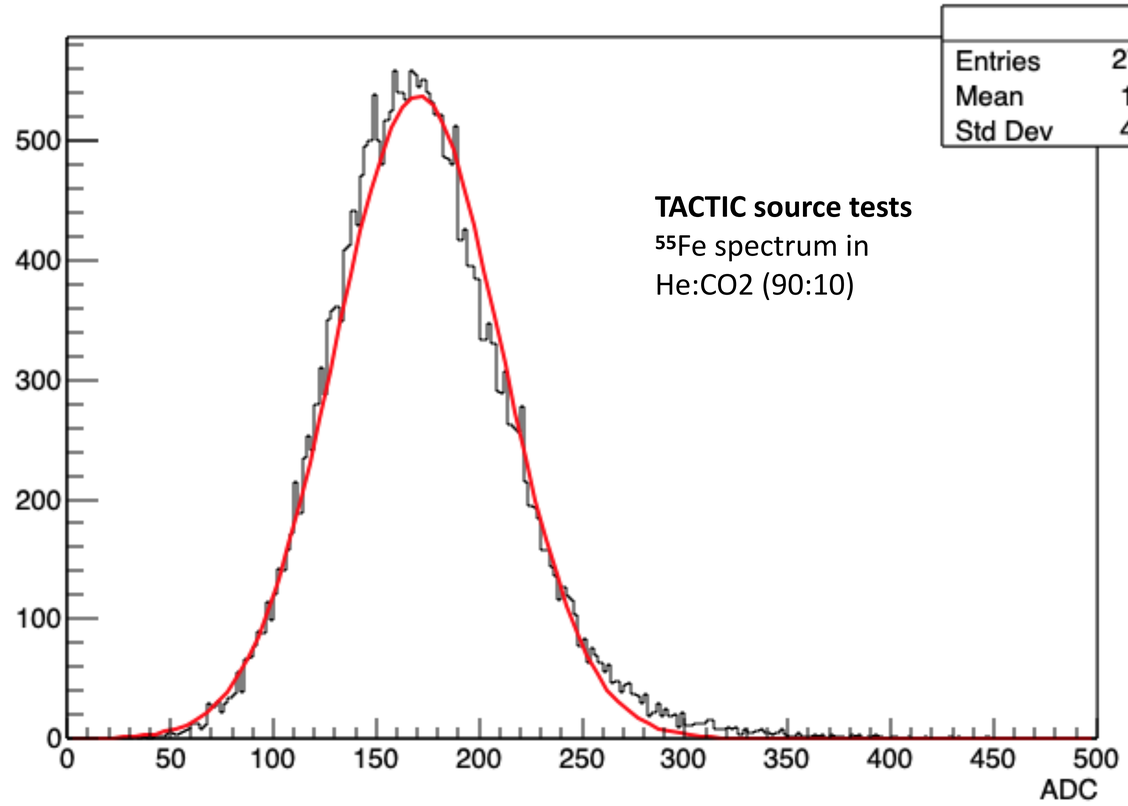


Fig 8. Part of a typical charged particle track in TACTIC. Energy deposition (ADC equivalent) per pad increases. Recorded during the beam tests during July 2022.

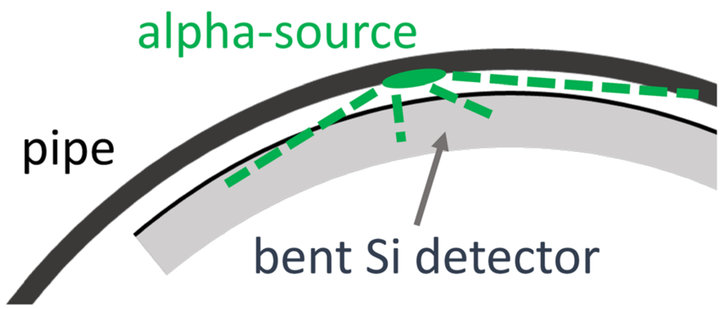


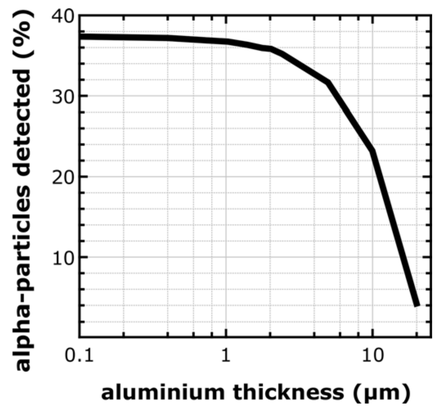
TACTIC source tests
^{55}Fe spectrum in He:CO2 (90:10)

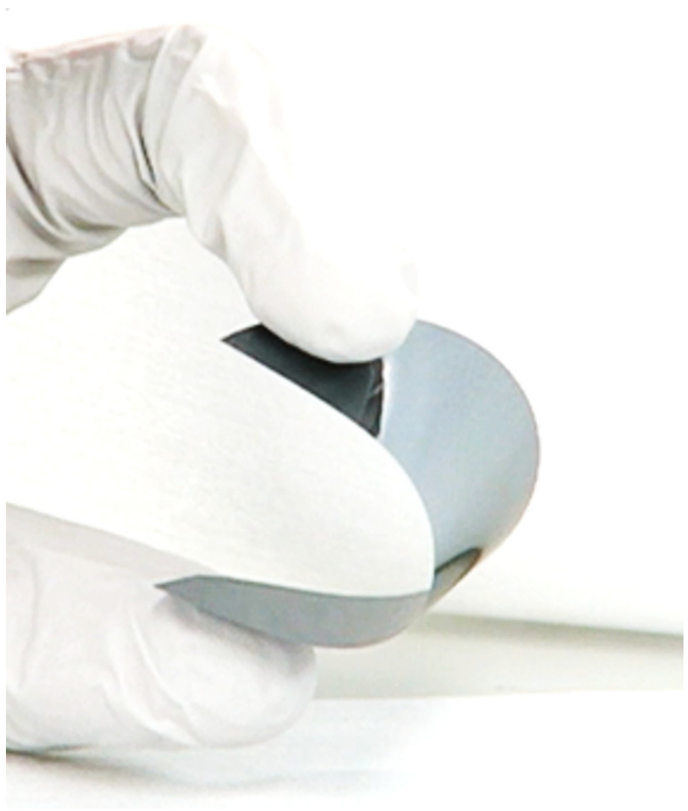
Summary

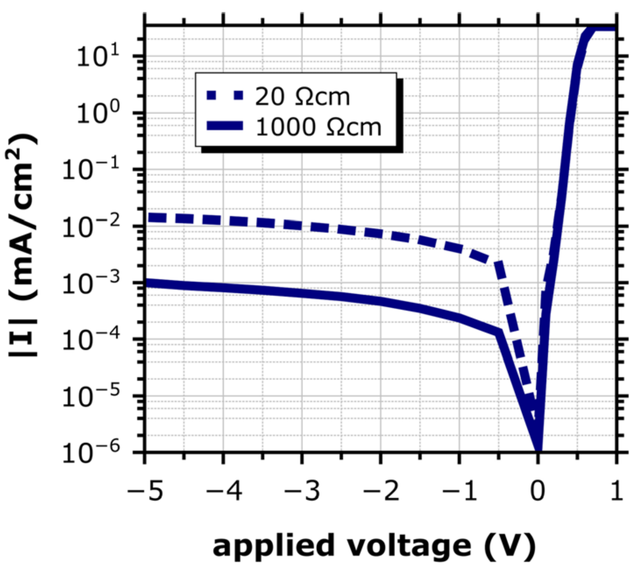
- Gains in the order of ~ $7x10^3$ was measured in Ar:CH4 and He:CO2 gas mixtures.
- Resolution study was performed by using Fe-55 source. A resolution of ~ 32% @FWHM in He:CO2 gas mixture was achieved.
- Preliminary charging-up effect study was performed in He:CO2 gas mixture. Detailed study will be performed in the future using stable beam in curved geometry.
- μRWELL GEMs are installed inside TACTIC. First μRWELL studies in a curved cylindrical geometry are being performed.

Alphaflex: Flexible silicon detectors for nuclear decommissioning





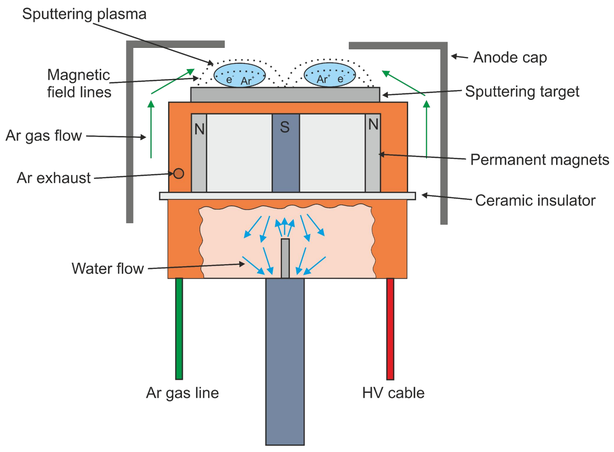




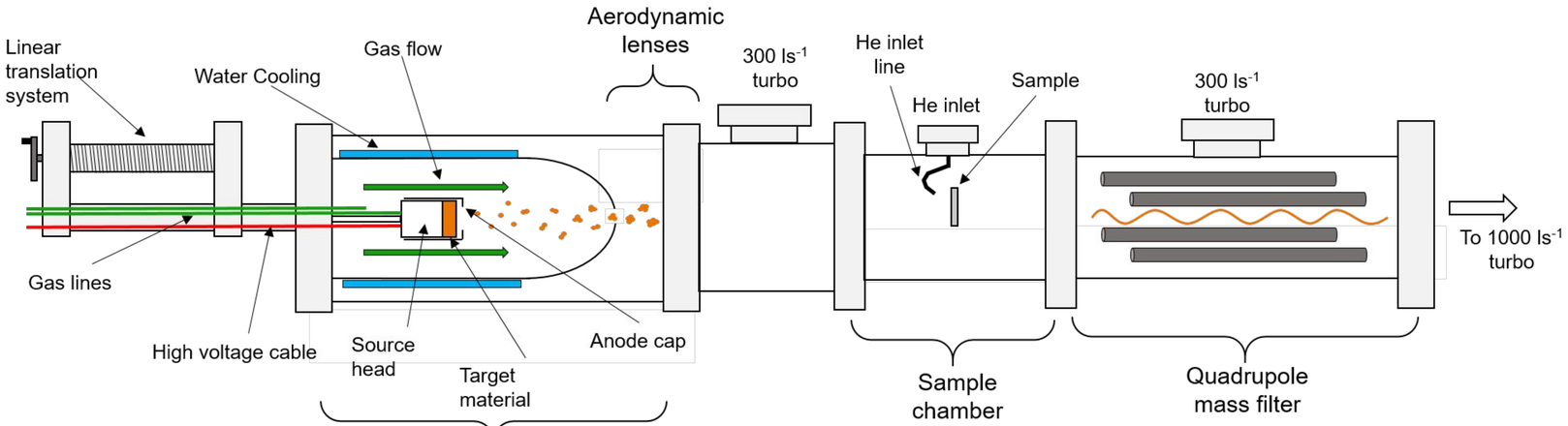
Flexible silicon for charged particle reaction studies:

Advantages:
- Can create true cylindrical geometry or other e.g. conical; tight bending radius possible
- Can strip/pixelate in same way as regular detectors
- Manufacturer in place (SINTEF) willing to produce such sensors
- Sensors could also be used to move the decommissioning project to higher TRL
- Research/industry crossover is attractive

Disadvantages:
- Limited to thickness regime of 30 - 70 um where silicon is flexible
- Still needs a prototyping phase to move to full production
- Impact on electrical properties of such sensors needs study



Magnetron head

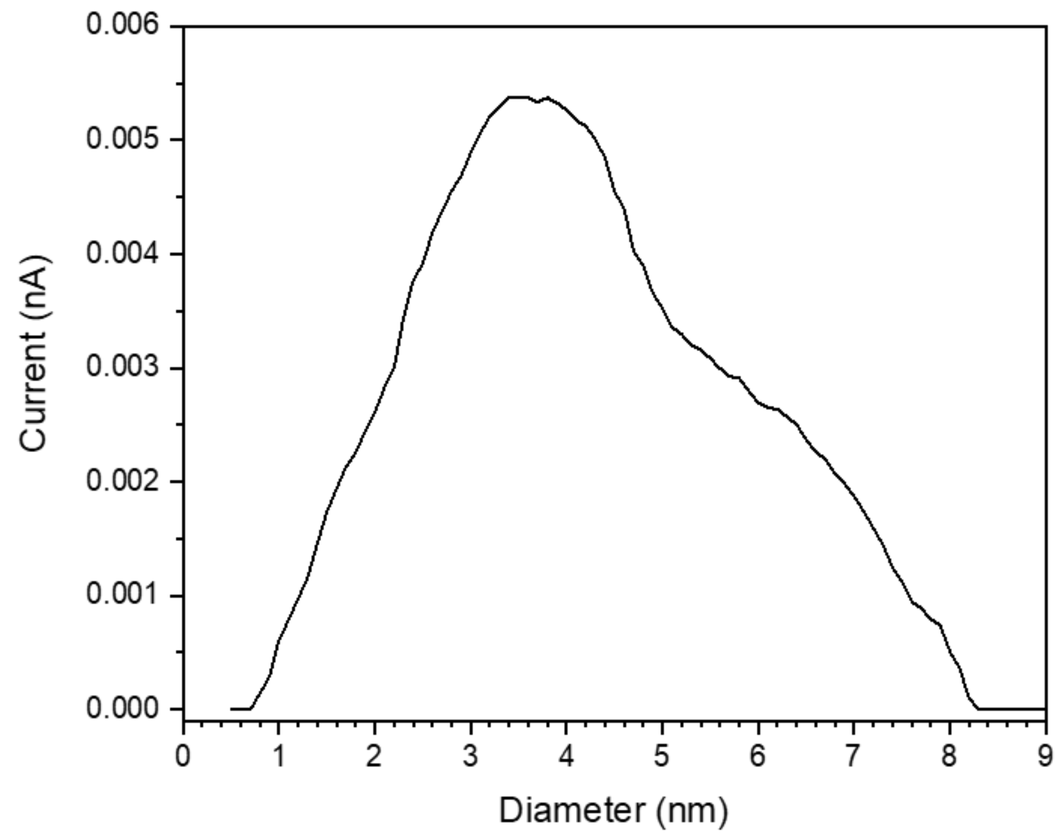


Schematic of Merlin

- Magnetron head sat in bullet shaped chamber with 5mm orifice serving as an exit aperture. Two further 5 mm flat plate apertures are placed after this and before the first pump to aerodynamically lens the beam.
- Ar gas is let in through the gas lines which then strike the plasma over the target material which is then sputtered by the plasma.
- Sample chamber contains two linear drives, the sample carousel which is a hexagonal mount for omicron style plates. Helios frames can be carbon tabbed to mount
- Quartz crystal microbalance (QCM) also on sample chamber for deposition rate monitoring.
- Quadrupole allows for mass spec to be produced in flight but this is blocked during sample deposition so no real-time monitoring is possible but this has removed the “masking” effect we had seen.
- 1000 l/s turbo allows for effective downstream pumping (also where old sample chamber was but is now just there for the pumping speed).

Sample details

- Roughly 2 microns thick Cu Nanoparticles on 1 micron Al foil
- Deposition rate ~ 1.5 nms-1 but saw as high as 3.0 nms-1
- 2 foils per sample condition of He partial pressure
    - High pressure: 1 x10-3 mbar
    - Low pressure: 1 x10-4 mbar



Polarised targets:

York NPG is collaborating with CHYM based at York

CHYM hyperpolarise molecules e.g. from parahydrogen. Interest is in high contrast in MRI

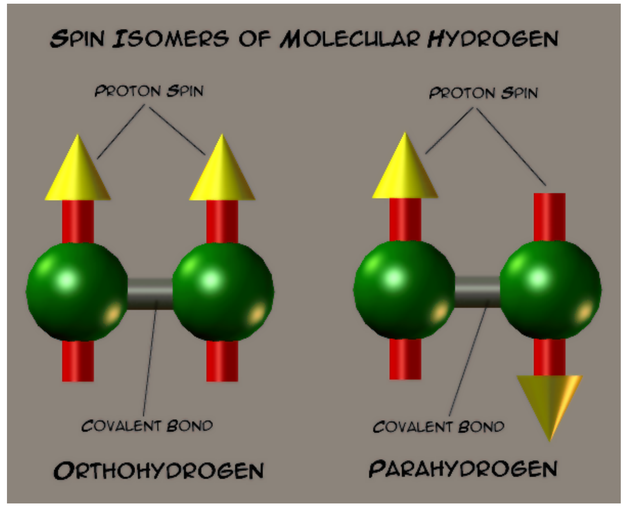
Scope to produce hyperpolarised compounds in gas/liquid phase

Dan Watts already exploring opportunities for J-Lab upgrade as does not need cryogenic LHe cooling

MRI field ideal for ensuring spin alignment

Relevant to polarised reaction studies??

Centre for Hyperpolarisation in Magnetic Resonance



Potential testbed at York:

3-T MRI magnet at YNIC available for access