Use Of Plasma Window For Enhanced Ion Beam Transmission From Vacuum To Air

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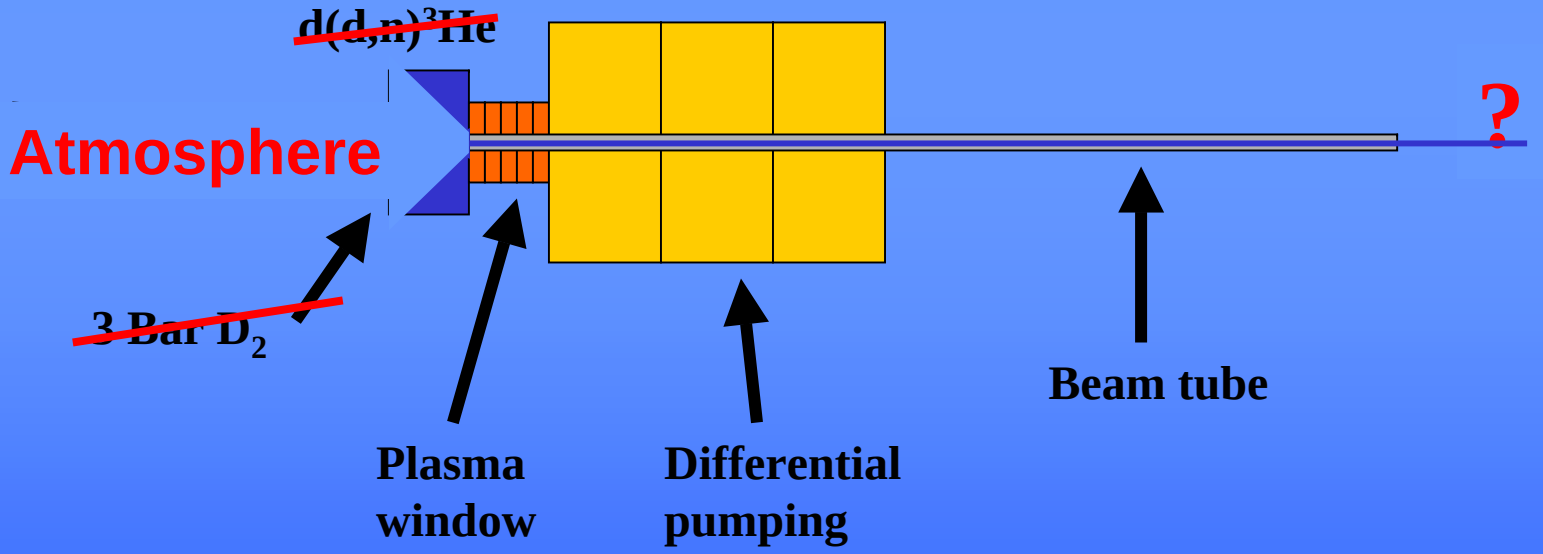
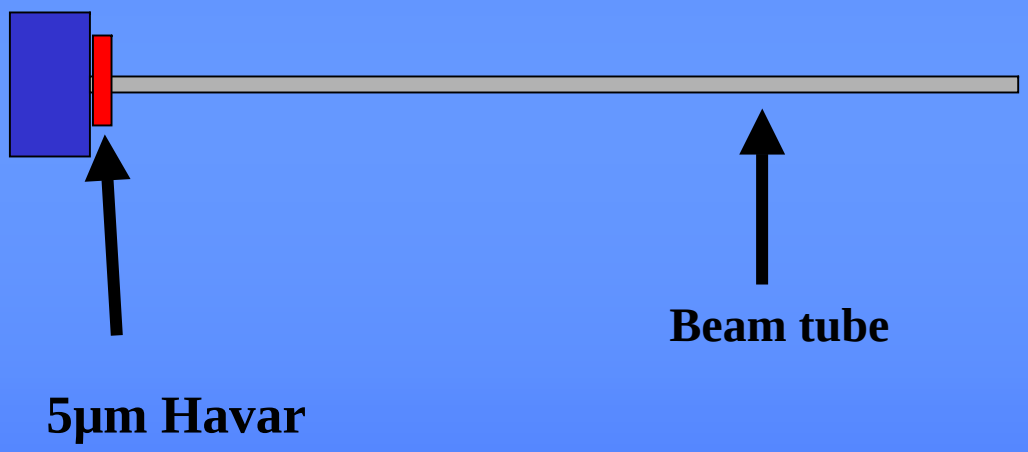
Objective

Primary objective is to be able to support a ***3 Bar*** deuterium gas target using a plasma window with an aperture diameter of ***5 mm***.



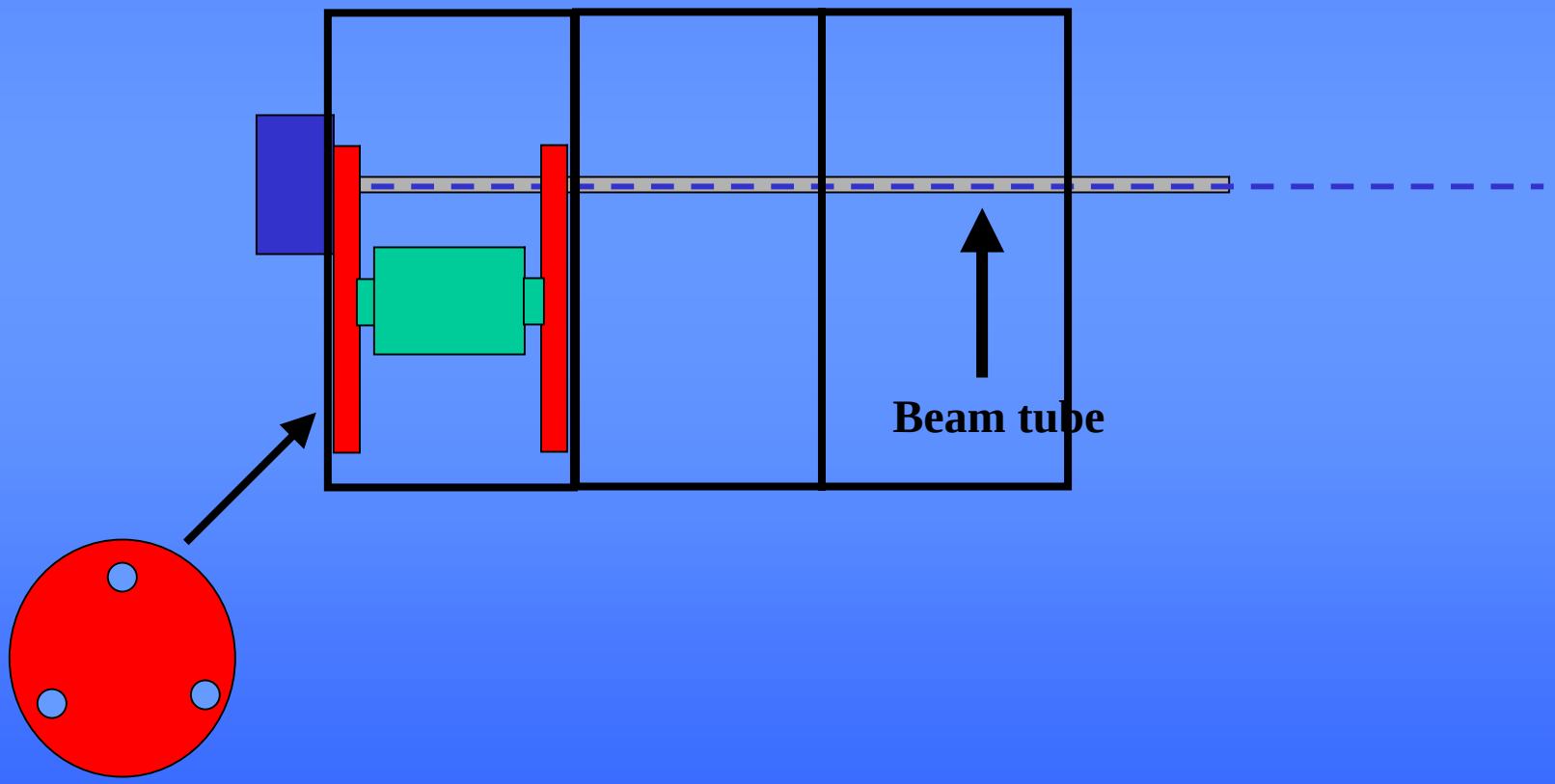
History

Thin foils



History

Spinning discs



3 Highlights of the Theory

1. Ideal gas pressure effect:

$$p = nkT,$$

=> low density of hot plasma

2. Dynamic viscosity effect:

$$Q = \frac{\pi d^2}{16\eta\ell} p_a (p_1 - p_2),$$

$$\eta = aT^{\alpha},$$

$\Rightarrow$ low flow due to high viscosity of hot plasma

3. Plasma lens effect:

$$F = q\underline{V} \times \underline{B},$$

=> additional beam focussing

The Plasma Porthole: a Windowless Vacuum-Pressure

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Beam Interactions with Materials & Atoms

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Performance of a plasma window for a high pressure differentially pumped deuterium gas target for mono-energetic fast neutron production – Preliminary results

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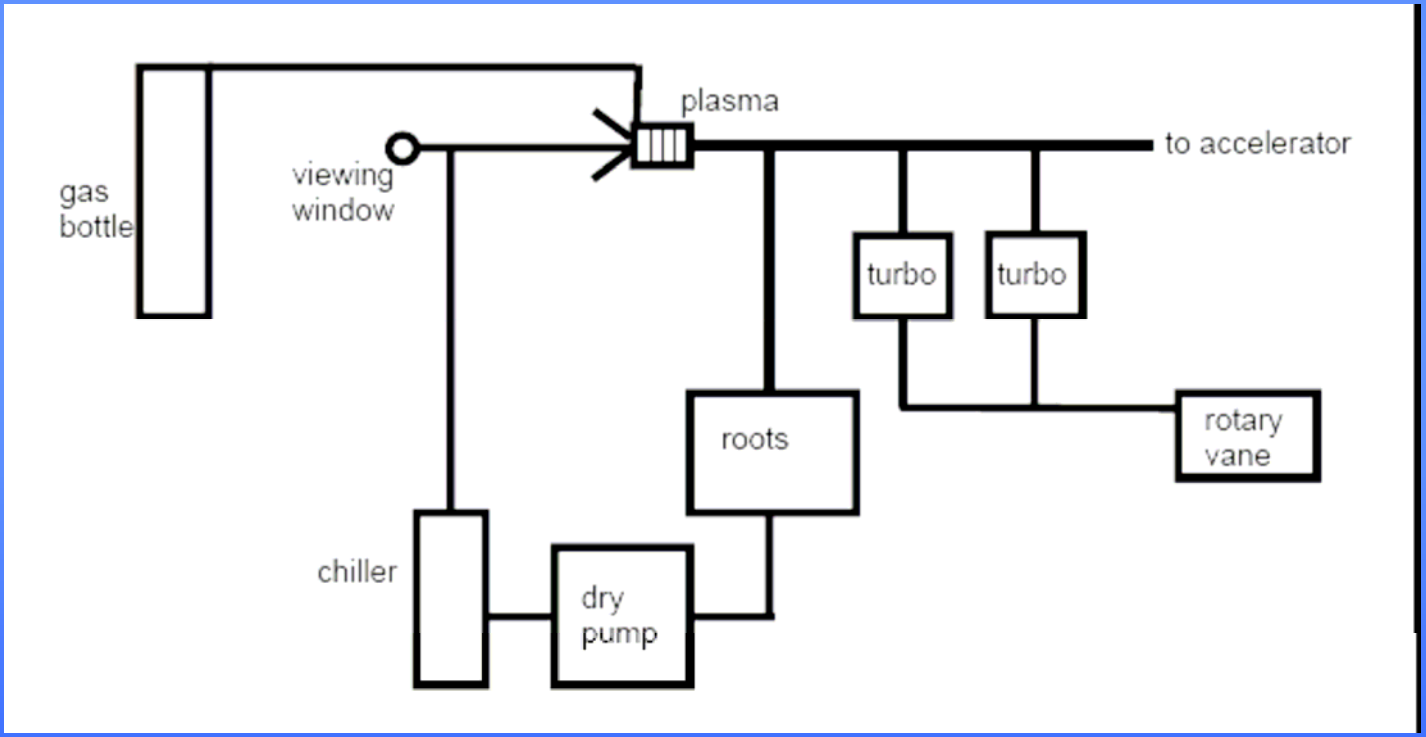
Current Work

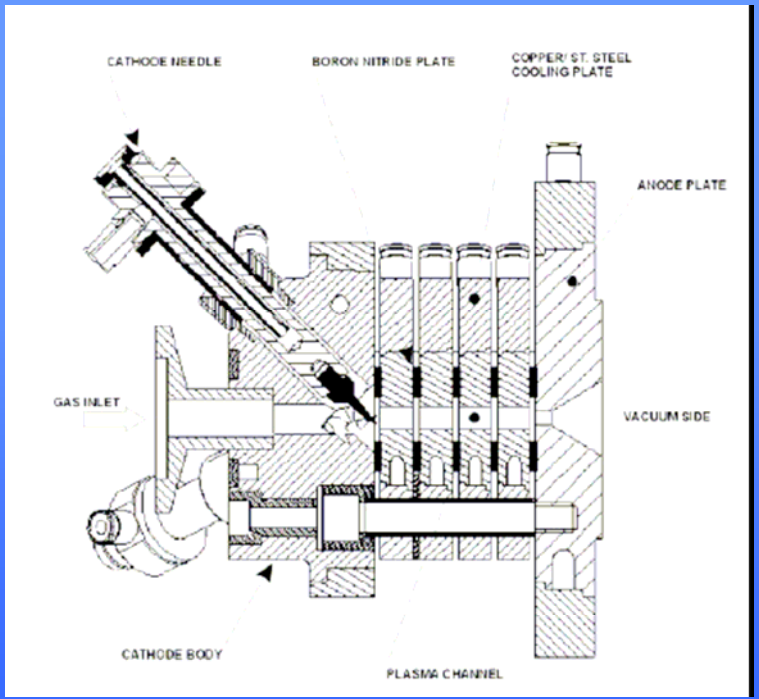
- Reconstruction of vacuum system



Current Work

- Reconstruction of electrical system
  50kW power supply with resistor bank and shunt

- Reconstruction of plasma arc components



Current Work

- Visit to Ady Hershcovitch in the USA to work on his experimental setup (which was on an electron beam rather than an ion beam)

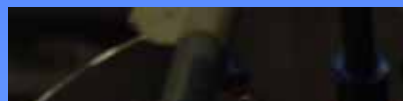
- Testing of limits of our plasma window (often until burnout) and making appropriate design changes

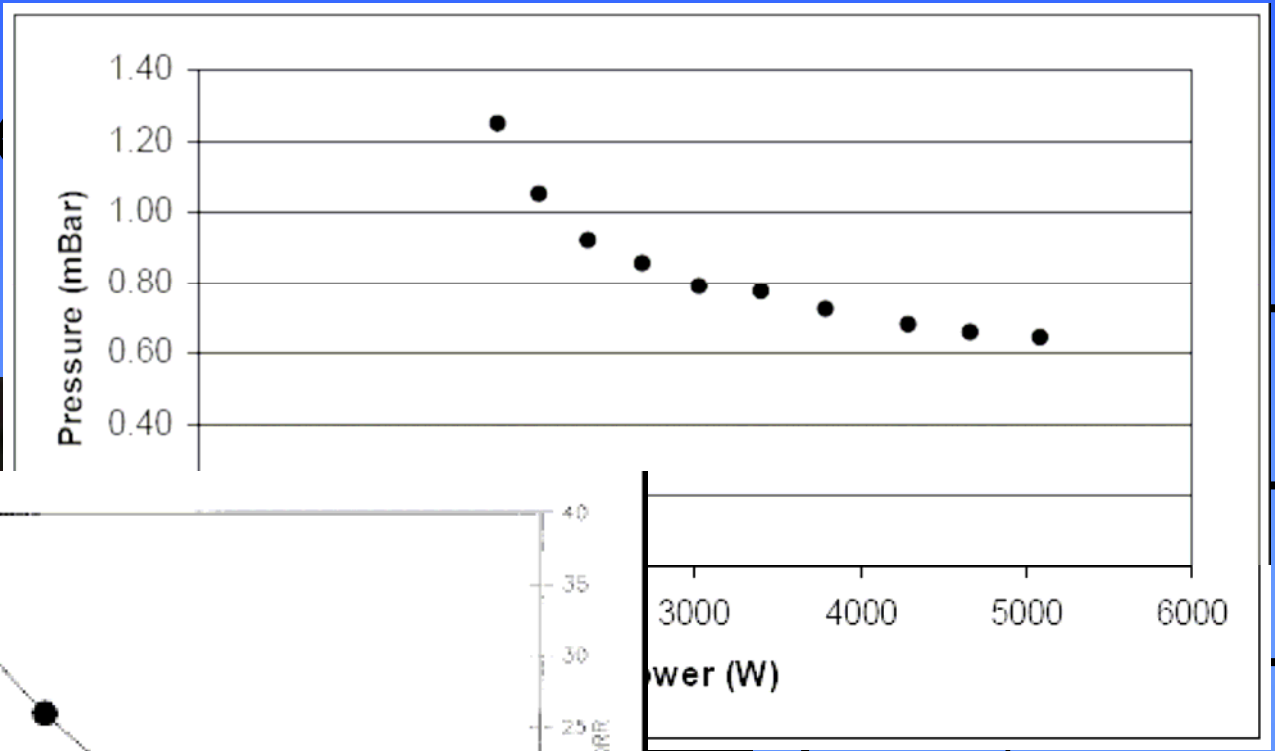
Experimental Results

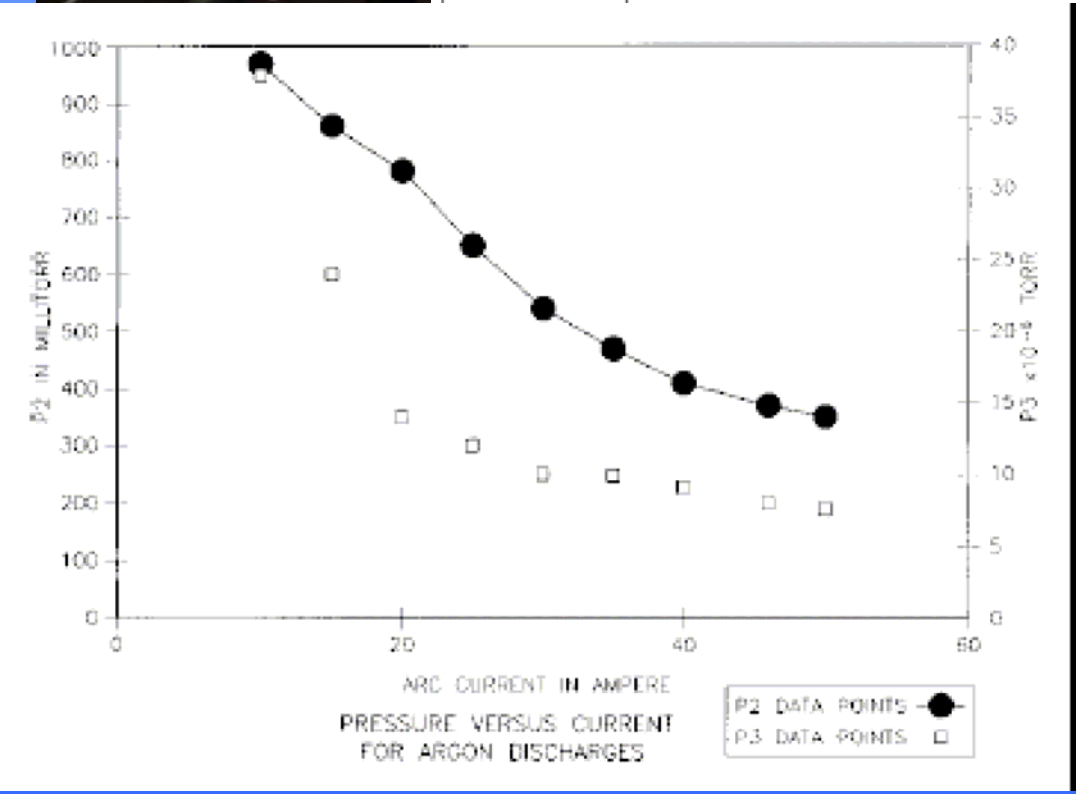
1. Vacuum to Atmosphere experiments
2. Gas cell experiments (comparison to previous work)
3. New cathode design

Ex

1. Vacuum







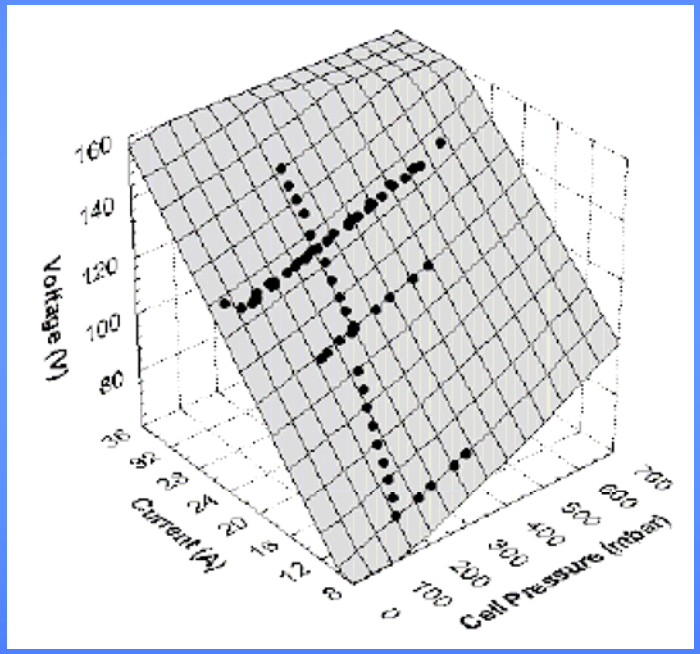
hour

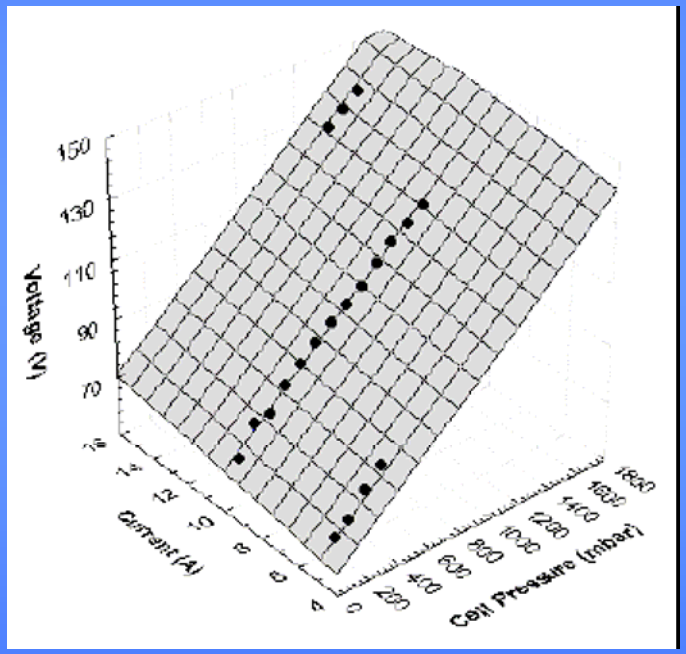
0.001 Bar in first chamber

2 MeV proton beam passed into atmosphere

Experimental Results

2. Gas cell experiments (comparison to previous work)





Max ***585 mBar*** at ***10 kW***

Max ***1500 mBar*** at ***6.3 kW***

Experimental Results

3. New cathode design

Tips can create non-uniformity

Cylindrical uniform plasma

Near-future Work…

1. Characterisation of ion beam in atmosphere
2. Implementation of a venturi system
3. Improved cooling on plasma arc
4. Experiments with the shape of the plasma channel
5. Further changes to cathode design

Applications

1. Fast Neutron Production (variable mono-energetic)
    - gold in rock (279keV line in ^{197m}Au irradiated with 2-5MeV neutrons)
    - Contaminant analysis in wool bales
    - Fast neutron radiography and tomography
2. Ion beam experiments in atmosphere (PIXE etc.)
3. Plasma-wakefield experiments
4. Electron and ion beam irradiation
5. Liquid targets
6. Internal targets
7. Solid targets
8. Electron beam welding
9. Beam recycling
10. *<insert your application here>*

Summary (stuff to remember)

1. Progress is being made in the evaluation and upgrade of the plasma window technology for use on gas targets and vacuum-atmosphere interfaces.

2. A 2 MeV proton beam has been passed into atmosphere through nothing but the plasma window. More work needs to be done into characterising this beam.

3. There are numerous applications for this technology and it is advantageous over other methods due to its capability of handling high current continuous beams.

Acknowledgements

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Thank you!