Queen's University Belfast

Recent Progress in Diagnostics Development for Laser Driven Neutron beams

Centre for Plasma Physics

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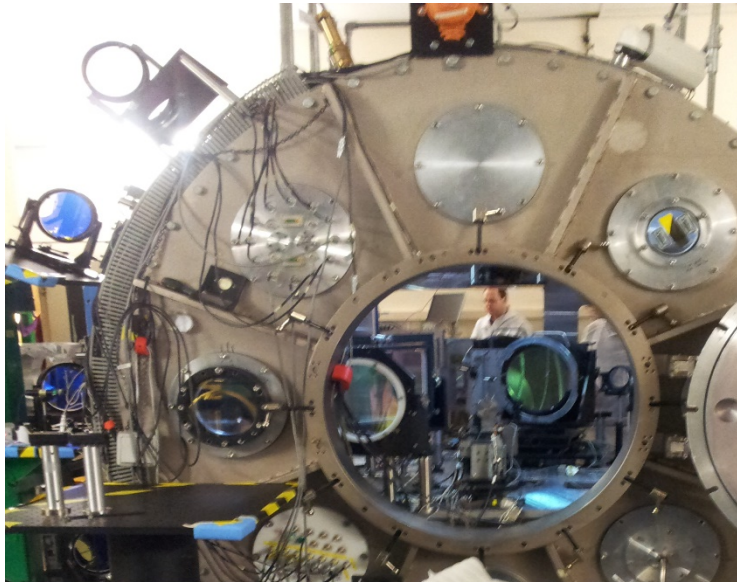

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Outline of the Talk

- Introduction
  - Laser-driven Beam mechanism
- Experimental Results
  - Fast Neutrons
    - EJ232Q Calibration
    - CR39 Track Detectors
  - Epithermal Neutrons
    - Epithermal Neutron Diagnostics
- Conclusion

Laser-driven Neutron Beam

Introduction

- Laser-driven sources offers unique advantages:
  - High brightness,
  - Directionality,
  - Short pulse,
  - Compactness.
- Sub-ns sources opens new paths in many applications:
  - Science,
  - Industry,
  - Security,
  - Healthcare.

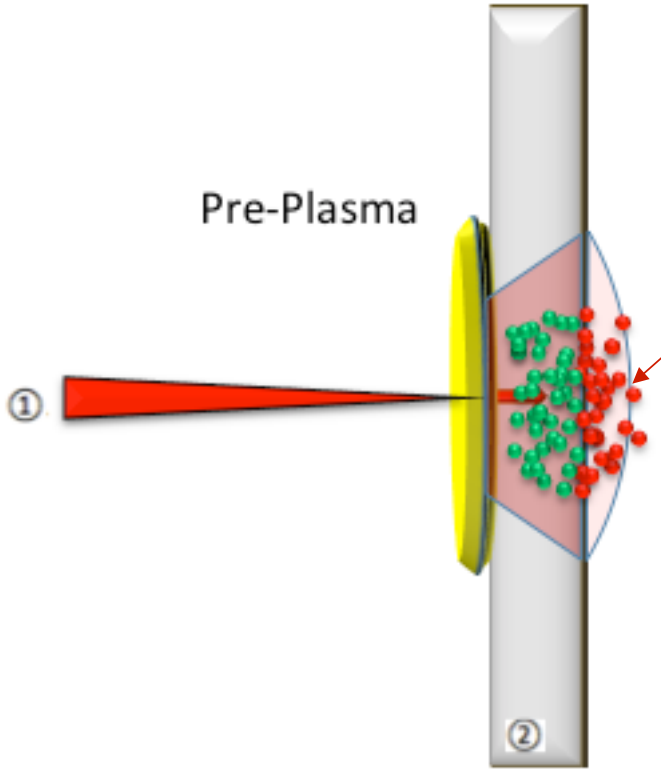
Laser Driven Neutron Beam Mechanism

The Neutron Beam

- Electron
- Ions
- Neutrons

Mechanism: Target Normal Sheath Acceleration (TNSA)

① Laser Beam
② Target



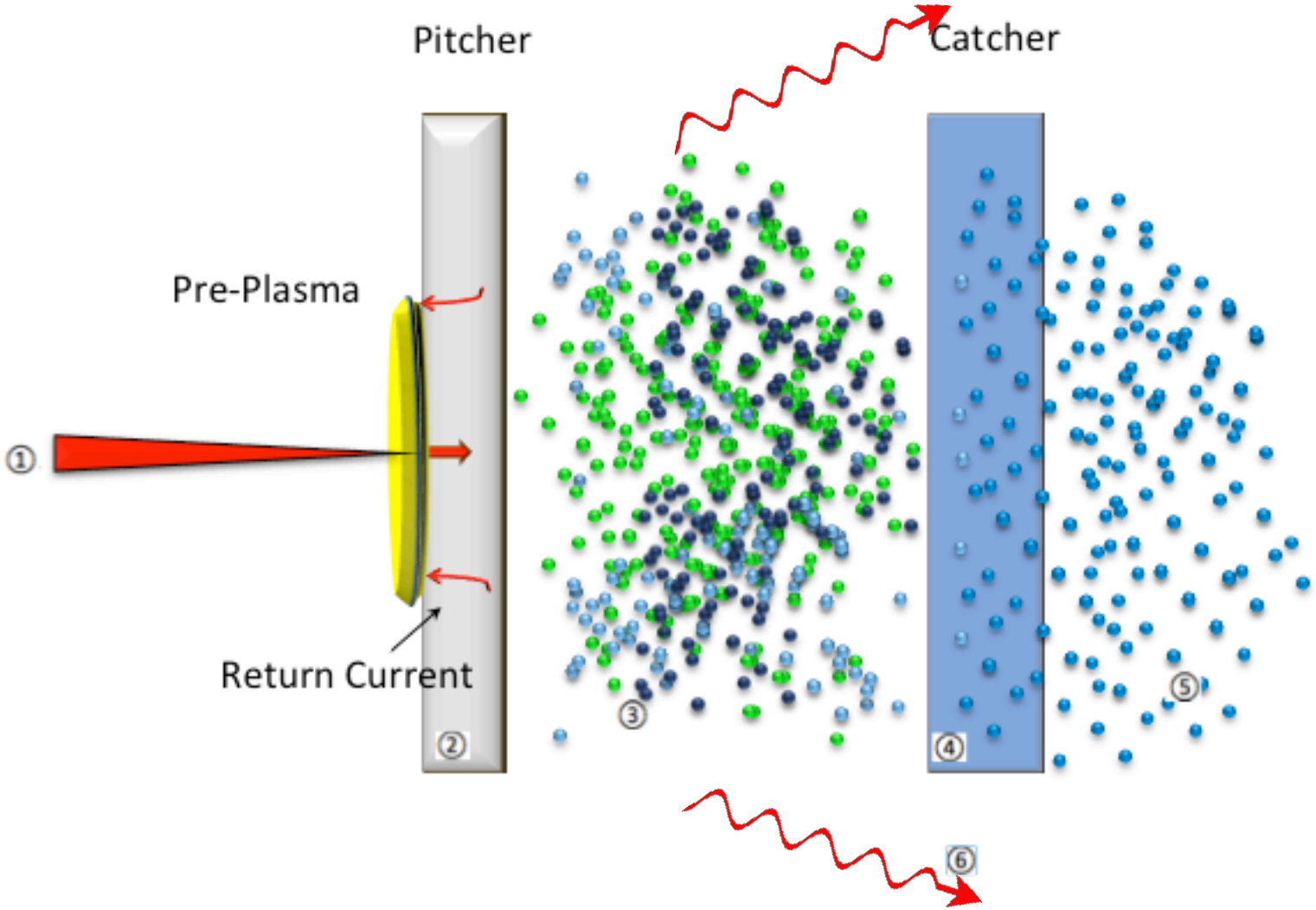
- **Laser striking a target,**
- **The ionisation of the target due to laser field oscillations creates pre-plasma at the front of the target**
- **The laser pondermotive force pushes away the electrons,**
- **Giving rise to longitudinal electric field, leading to acceleration of ions**

The Neutron Beam

Mechanism: Pitcher-Catcher Configuration

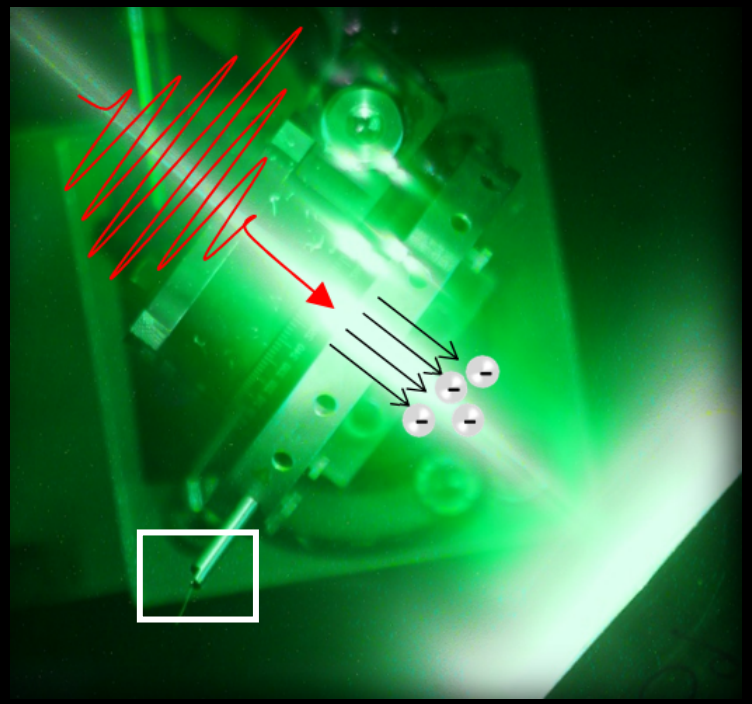
- Electron
- Ions
- Neutrons

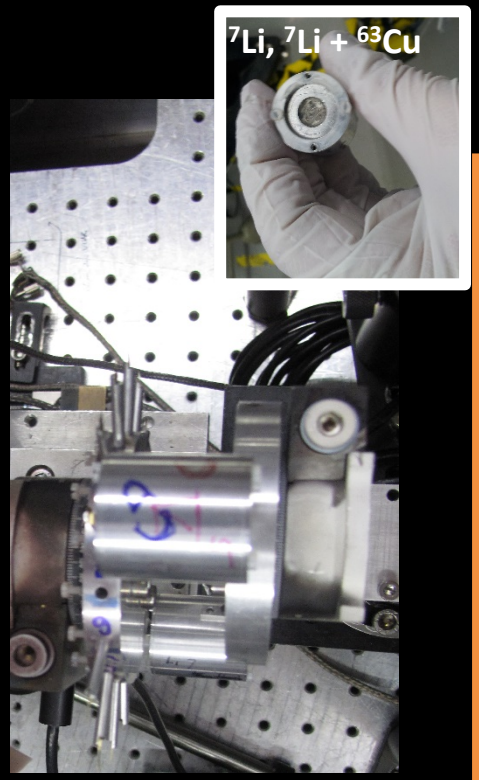
① Laser Beam
② Target
③ Ions
④ Catcher
⑤ Neutrons
⑥ γ-rays



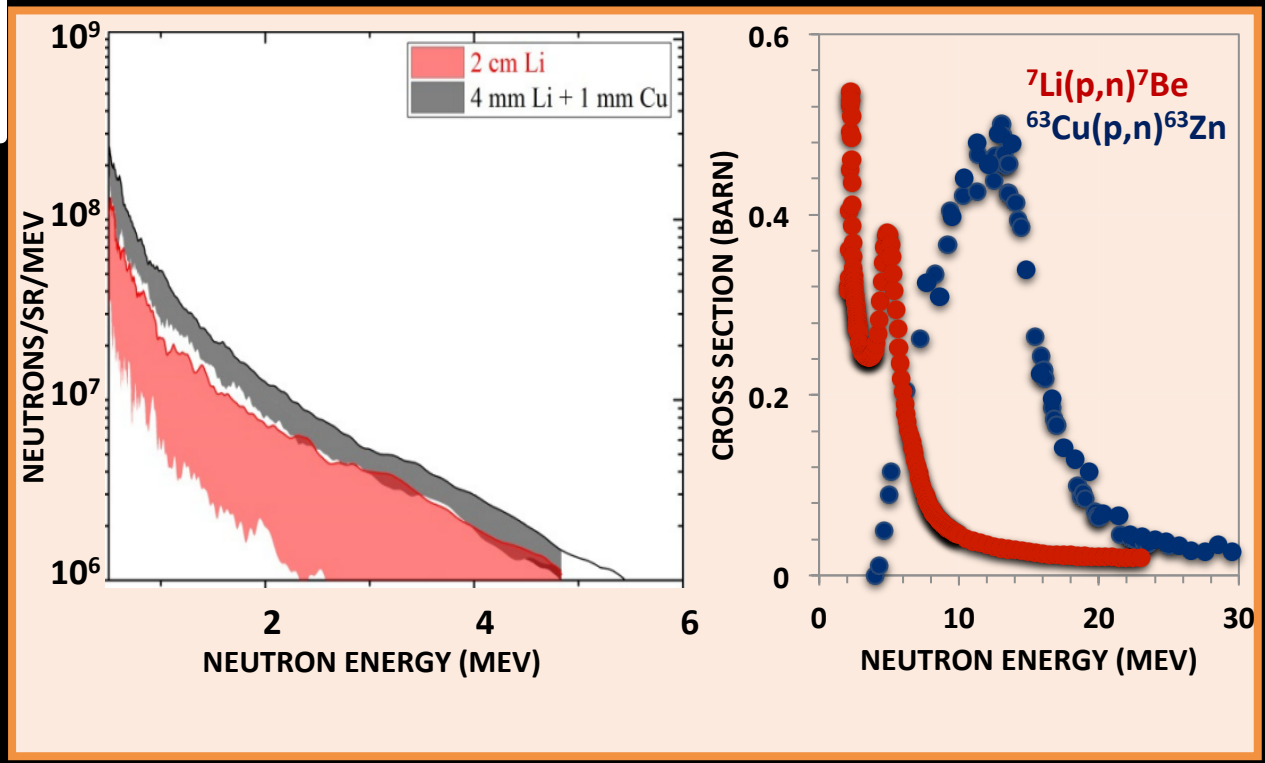
The Neutron Beam

The Experiment: Fast Neutron Beam





The 750fs FWHM laser pulse of VULCAN (Petawatt target) with energy of 100J was focused on the 50 µm Au target delivering the intensity in the range of 1-5 ×10^{20}W cm^{-2}.



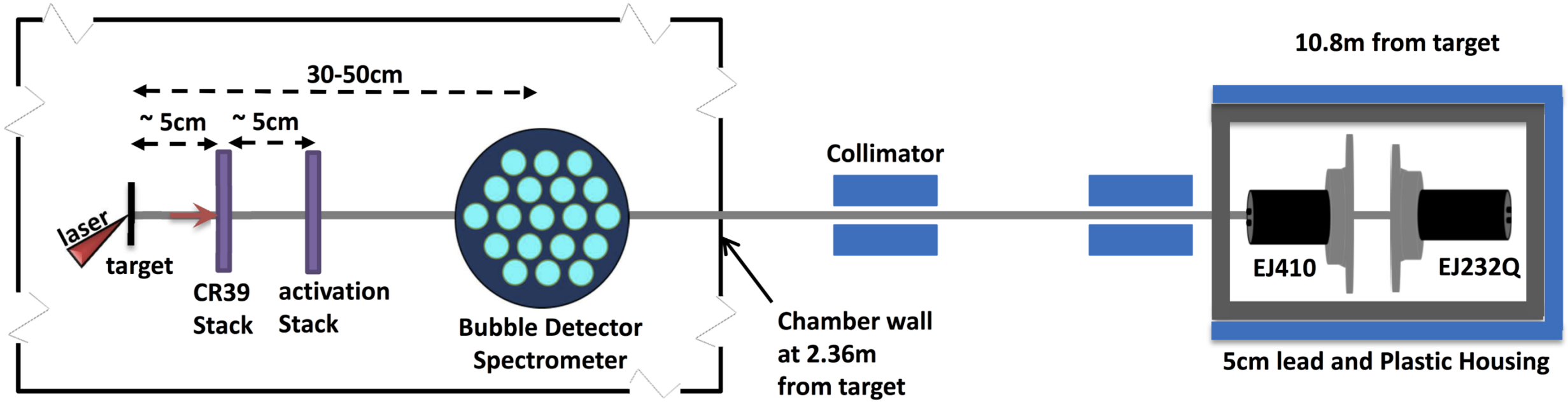
C M Brenner, S R Mirfayzi, et. al. Plasma Physics and Controlled Fusion 58.1 (2015): 014039.

EJ232Q Plastic Scintillator Calibration

The Neutron Beam

2013 Vulcan Experiment

The Experiment: Scintillators Calibration, setup

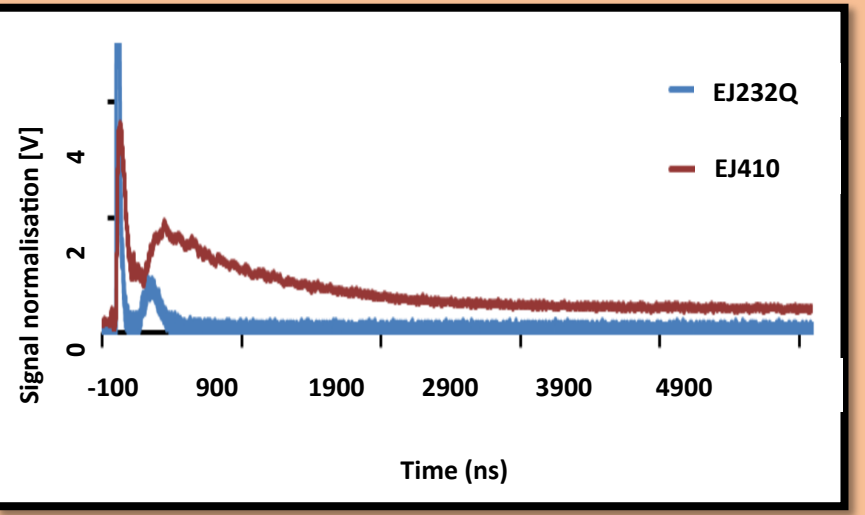


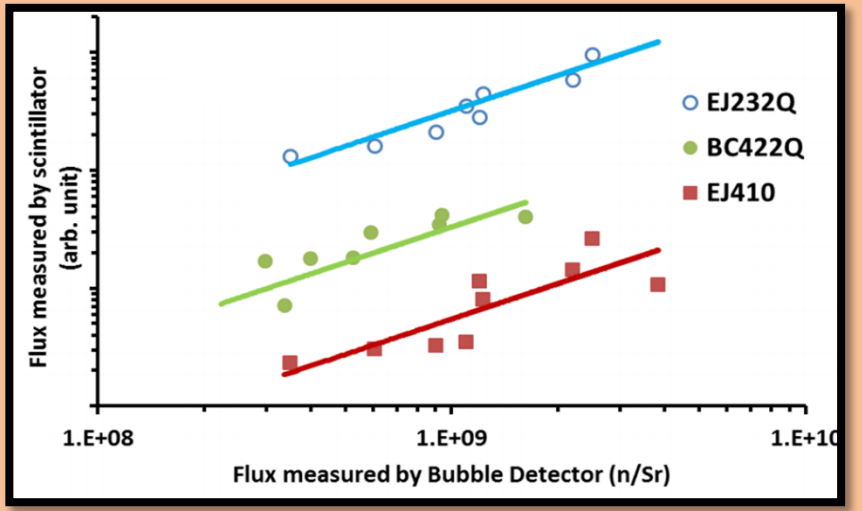
S R Mirfayzi, S. Kar, Rev. Sci. Instrum. 86, 073308 (2015).

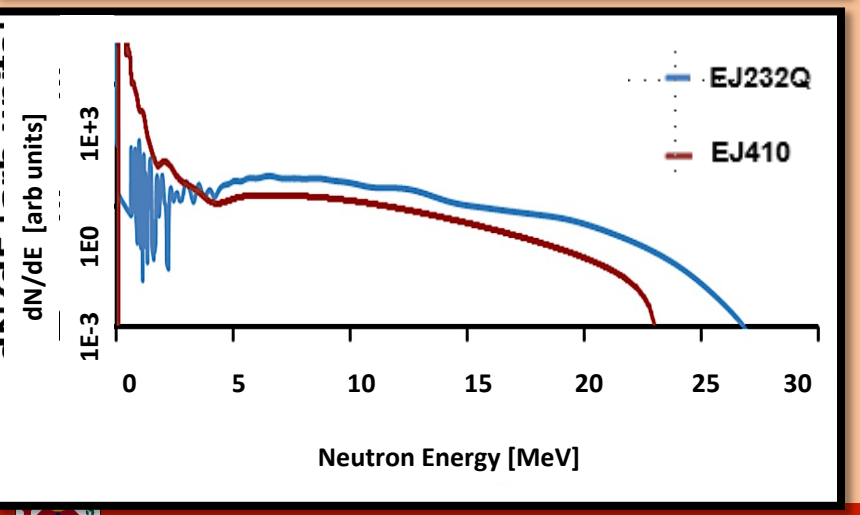
The Neutron Beam

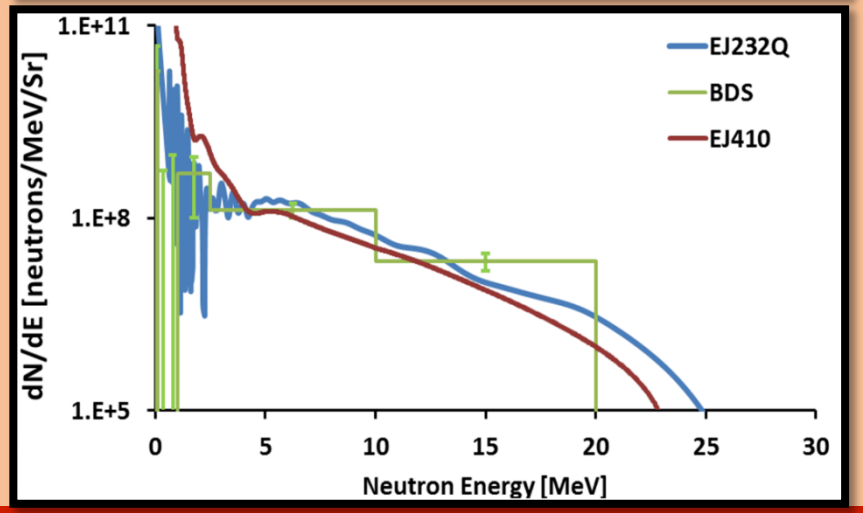
The Experiment: Scintillator Calibration

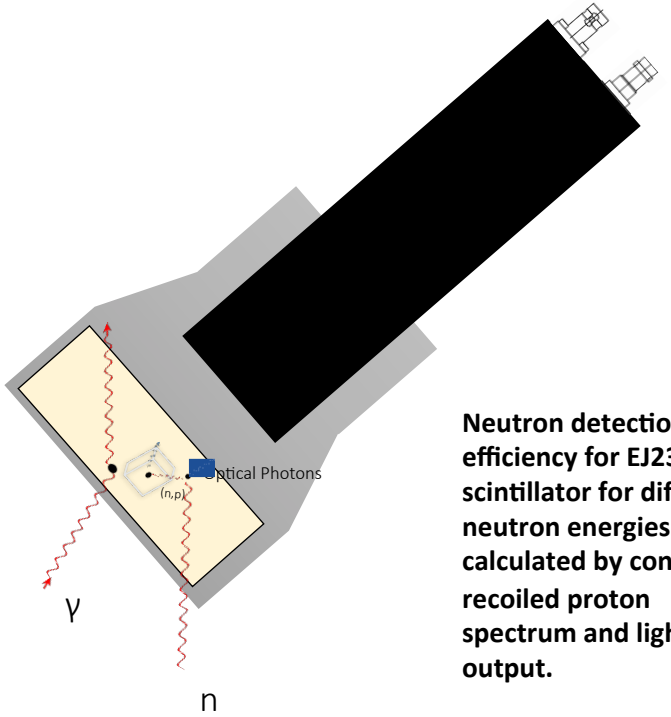
Experimental data



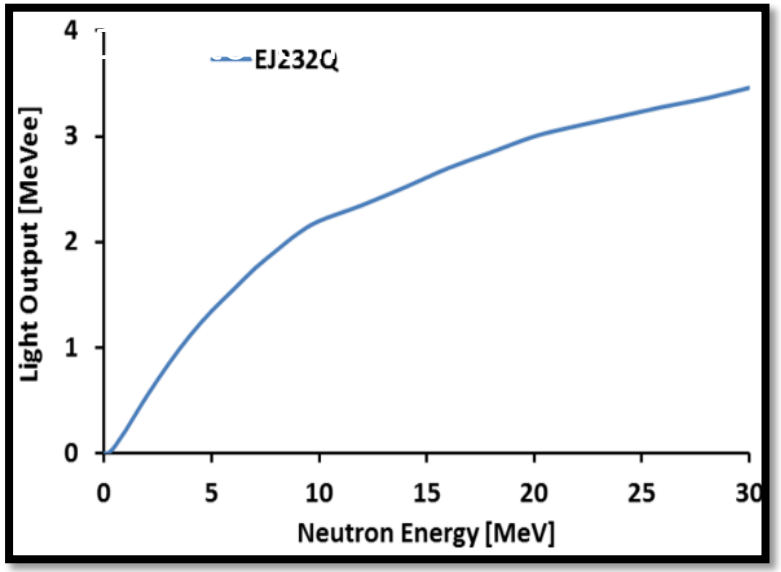








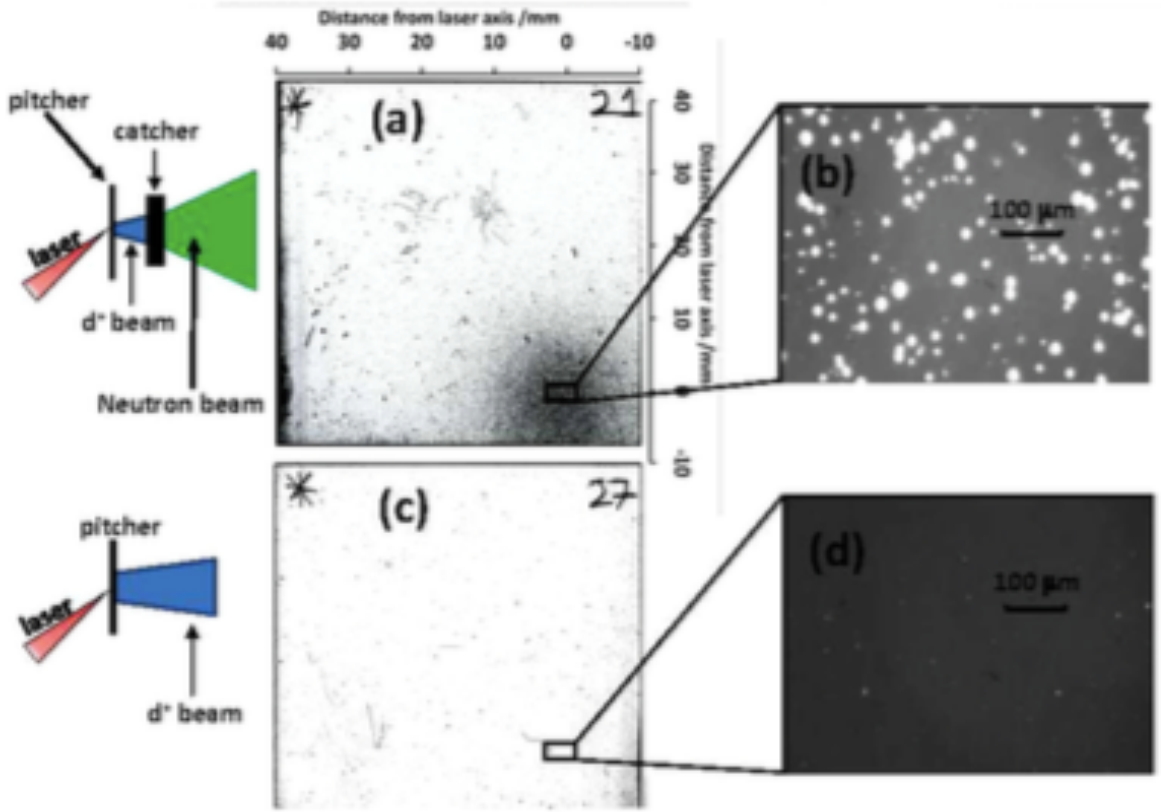
Neutron detection efficiency for EJ232Q scintillator for different neutron energies calculated by convolving recoiled proton spectrum and light output.

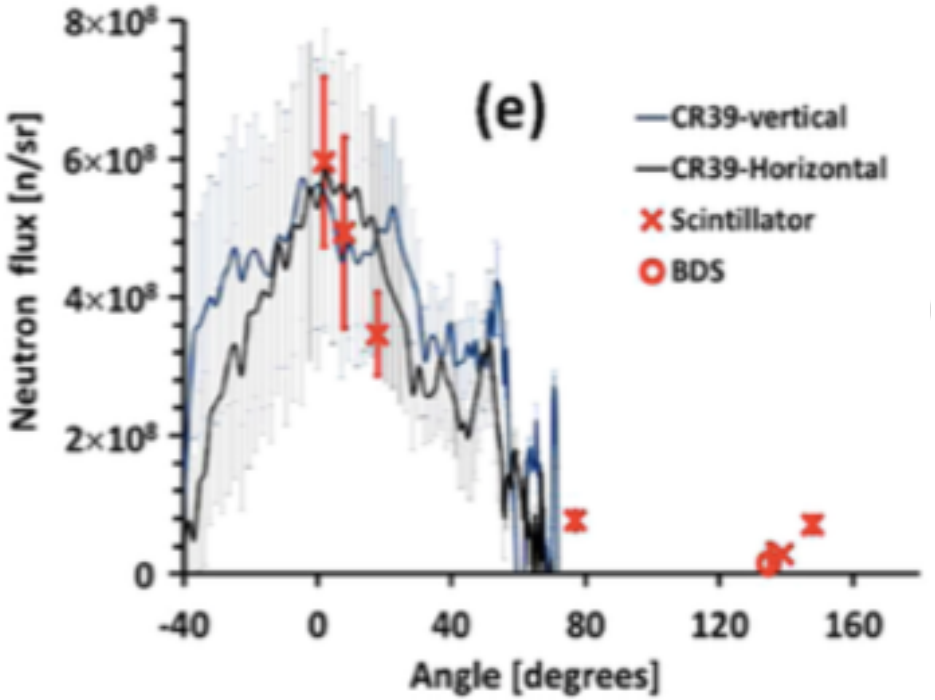


The Neutron Beam

2013 Rutherford Vulcan Experiment

The Experiment: CR39 track detectors





CR39

S. Kar et. al., Beamed neutron emission driven by laser accelerated light ions, accepted for publication

Conclusion

- The experiments were designed to assess the feasibility of Laser-driven sources with short pulses.
- There's a significant scope for improving the neutron flux further (currently 10^{10} n/sr fast flux is demonstrated).
- The current flux is adequate for many applications such as eV neutron spectroscopy, activation, BNCT in a closely coupled beamline.
- The use of plastic track detectors the beam profile can be studied.

Thank you for your attention!