INTERNATIONAL YEAR OF LIGHT 2015

Queen's University Belfast

High-Power Laser-driven Neutron Sources

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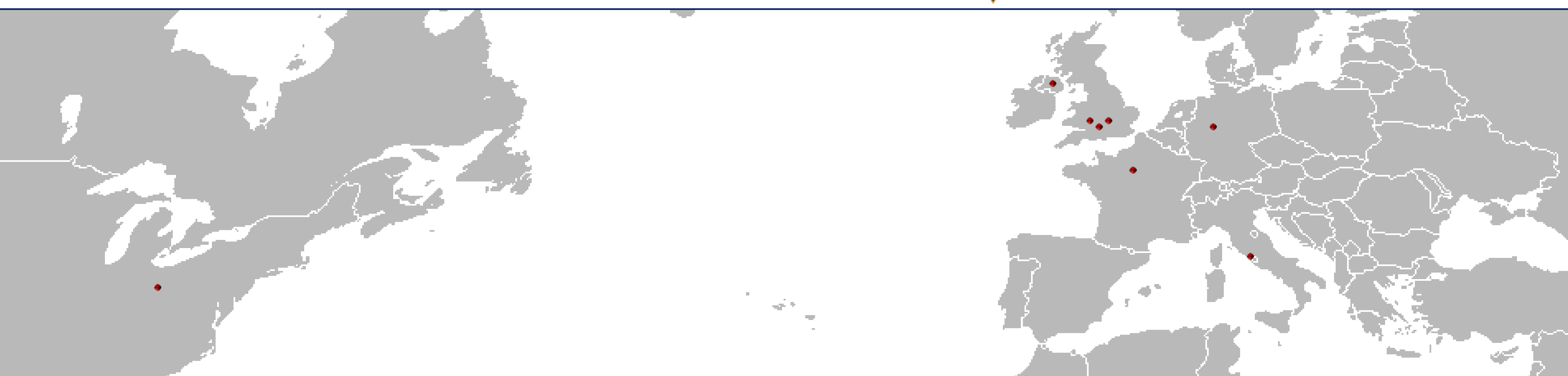


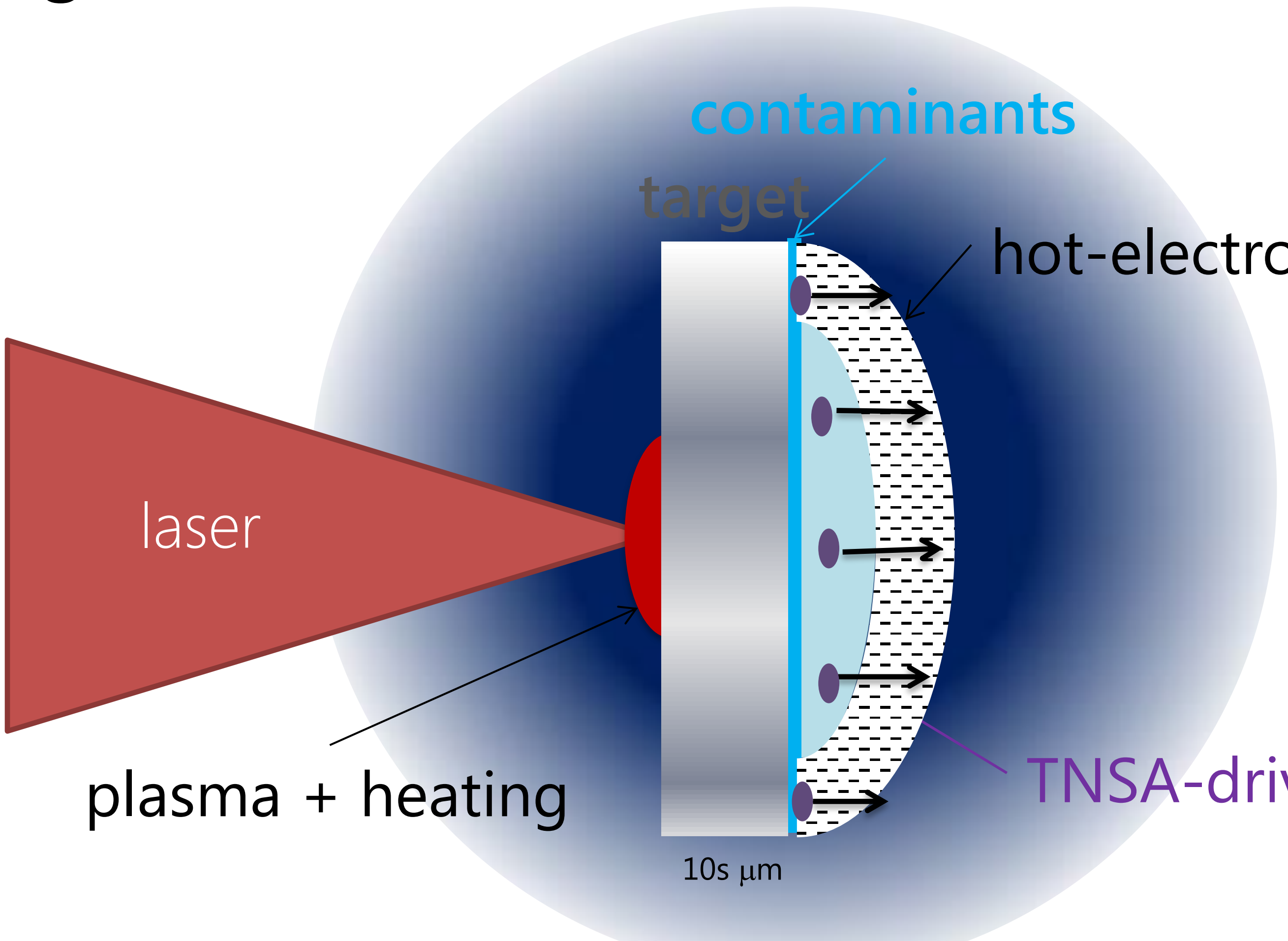
Outlook

- Laser-driven neutron generation
  - Target Normal Sheath Acceleration
  - Radiation Pressure
- Applications
  - Fast-neutron imaging
  - Moderation

NEUTRON GENERATION

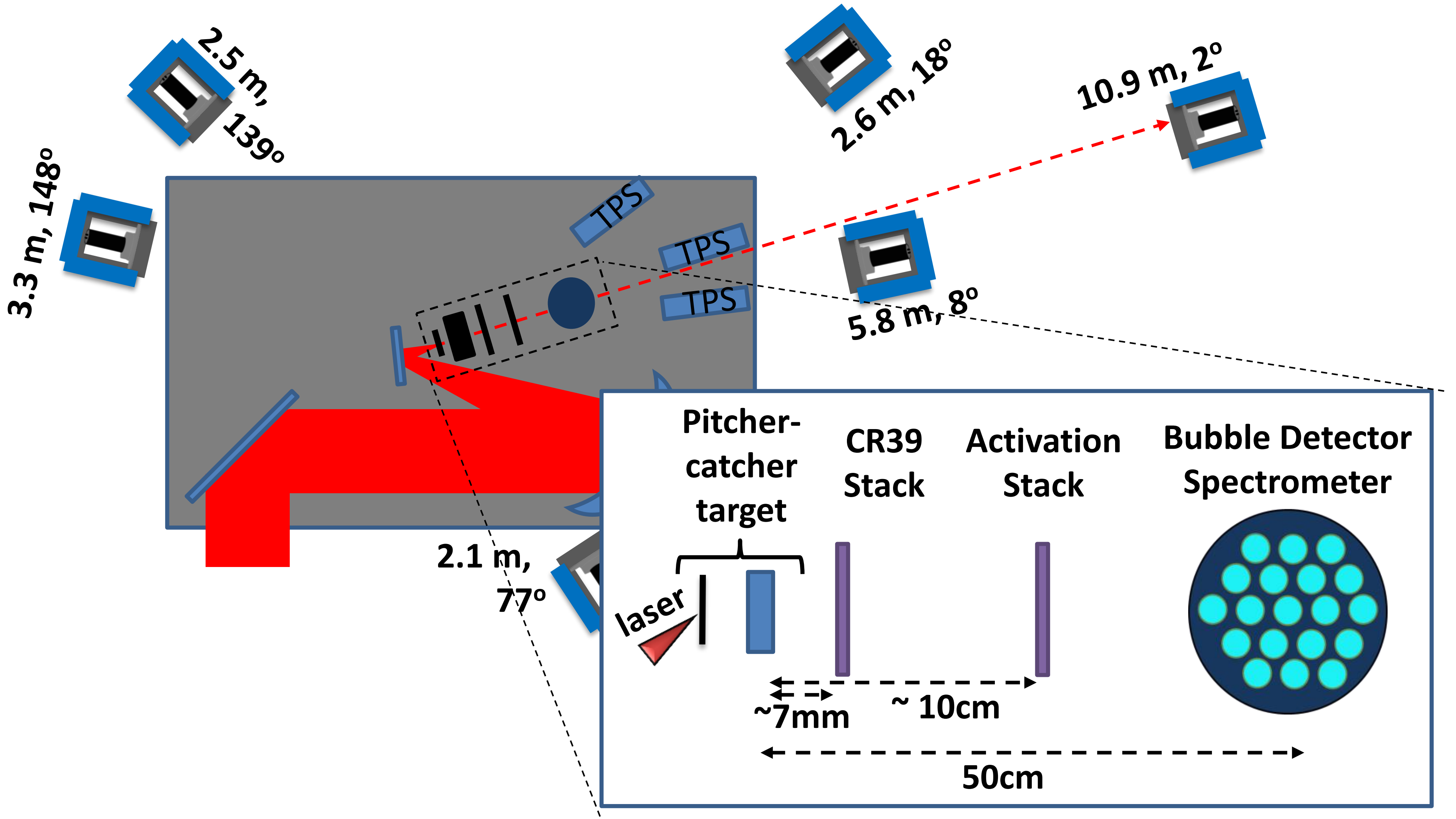
TNSA. Theory

- Target Normal Sheath Acceleration

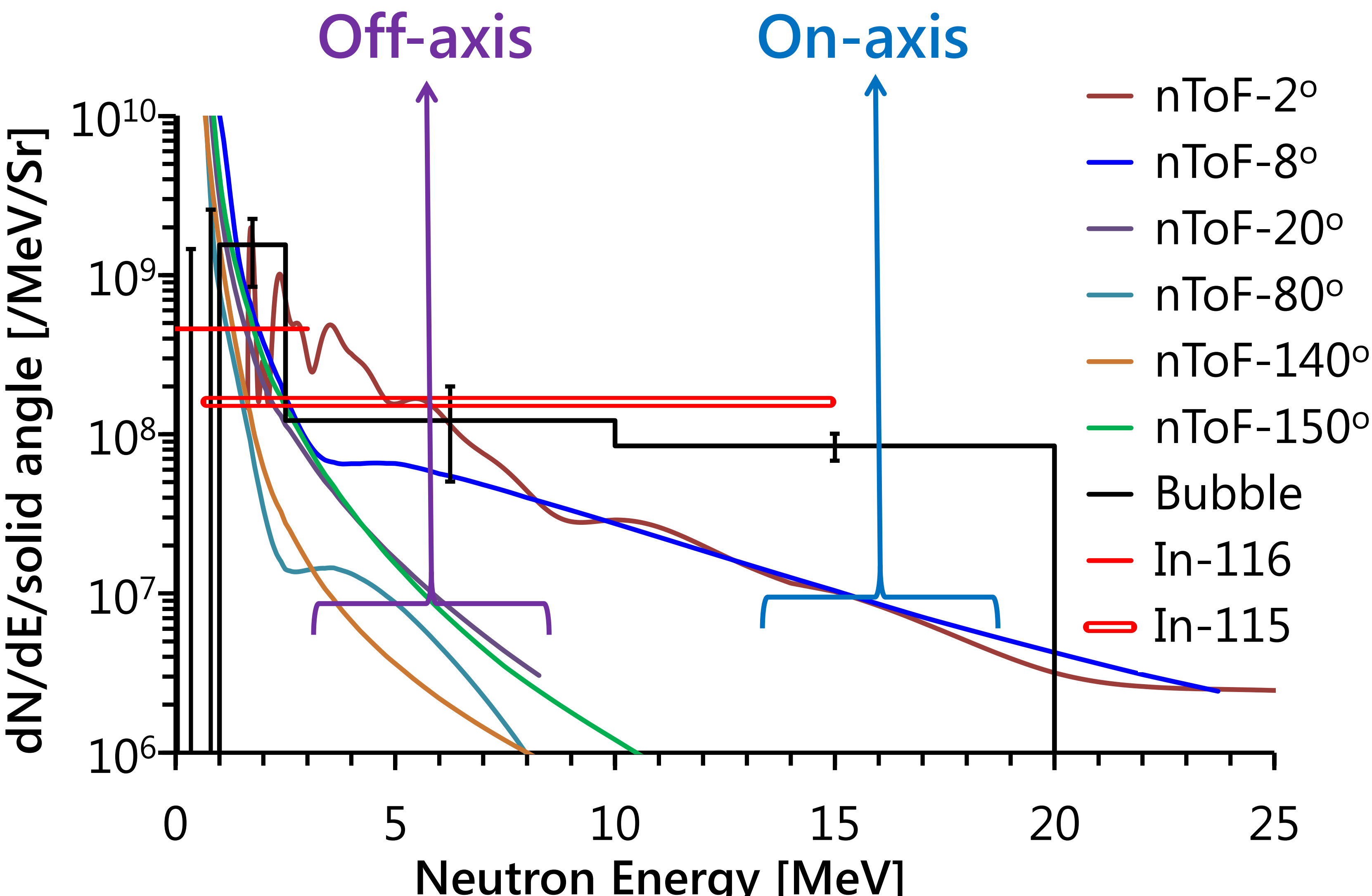


+ Low-flux, isotropic neutron emission

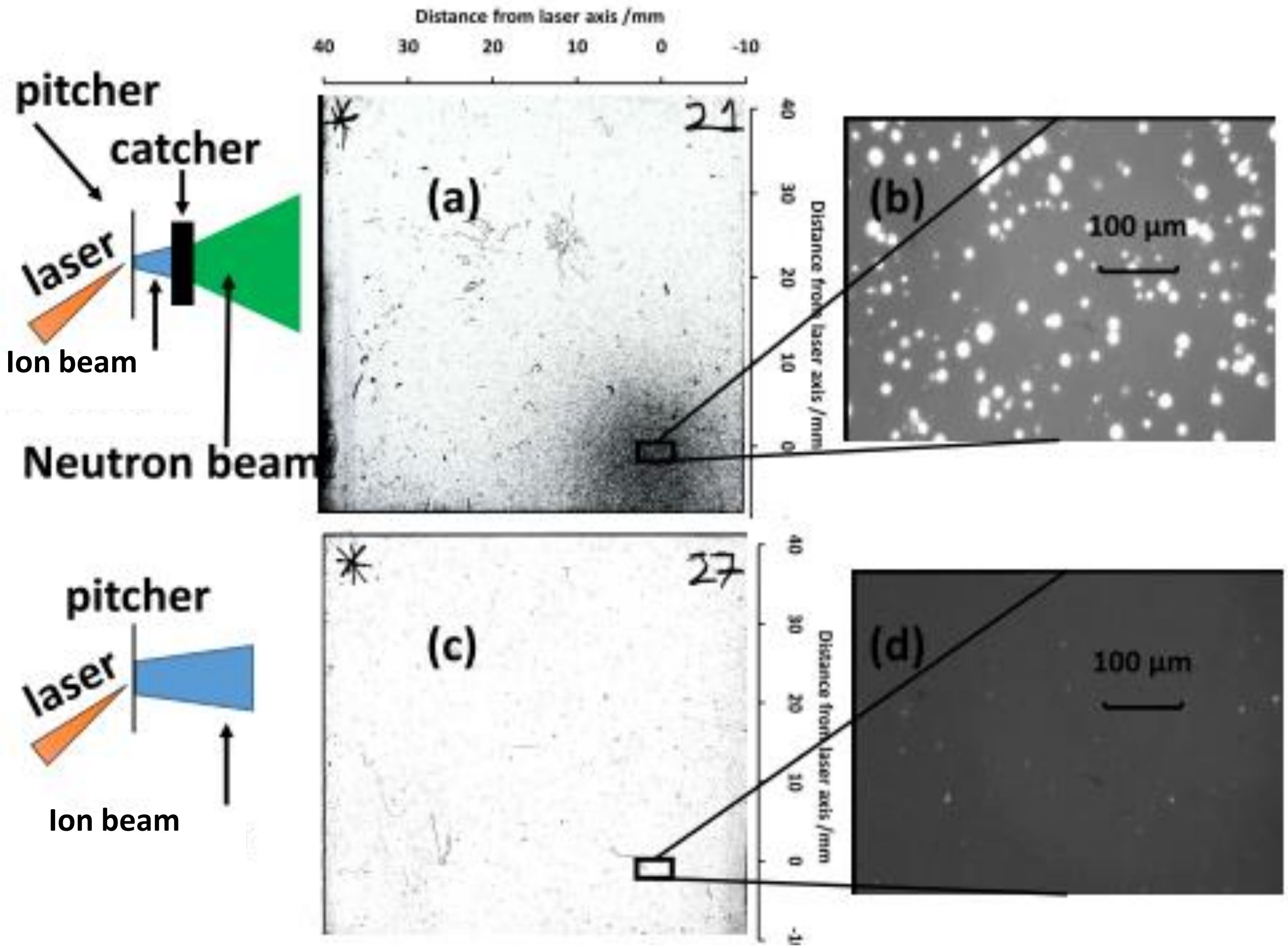
TNSA. Experimental setup



TNSA. Beamed emission

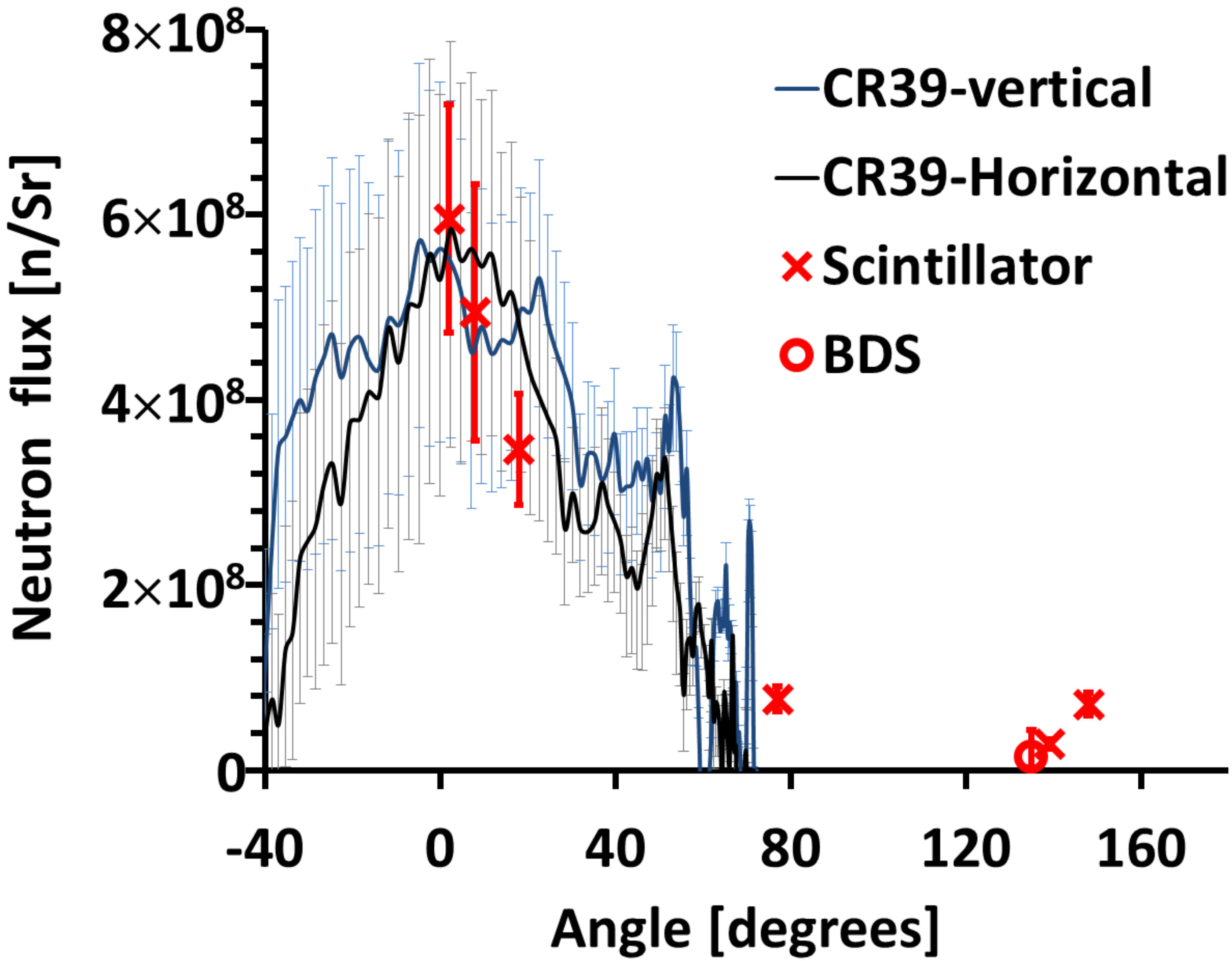


TNSA. Neutron Beam Profile



(S. Kar et al., 2015, In preparation)

TNSA. Neutron Beam Profile



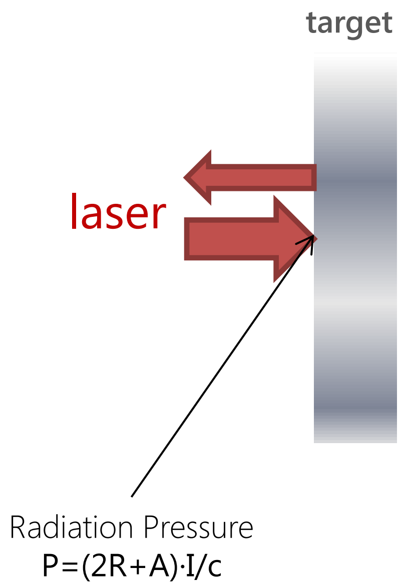
(S. Kar et al., 2015, In preparation)

BUT…

- The ion beam is formed mainly from protons, which limits the possible nuclear reactions
  - Main reaction was $d+p \rightarrow p+p+n$
- Spectrum is a MB distribution → poor efficiency to accelerate to high energies.
- Highly divergent beam, …

RPA. Theory

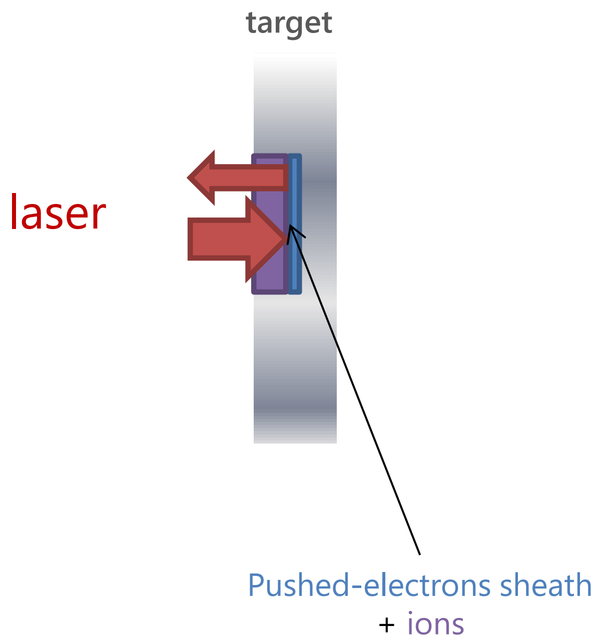
- Radiation Pressure Acceleration



Hole-Boring Ion acceleration

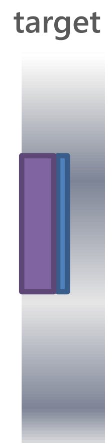
RPA. Theory

- Radiation Pressure Acceleration



RPA. Theory

- Radiation Pressure Acceleration

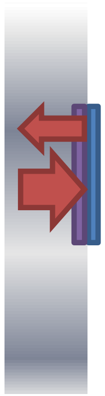


Hole-Boring Ion acceleration

RPA. Theory

- Radiation Pressure Acceleration

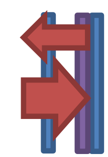
target



10s-100s nm

RPA. Theory

- Radiation Pressure Acceleration

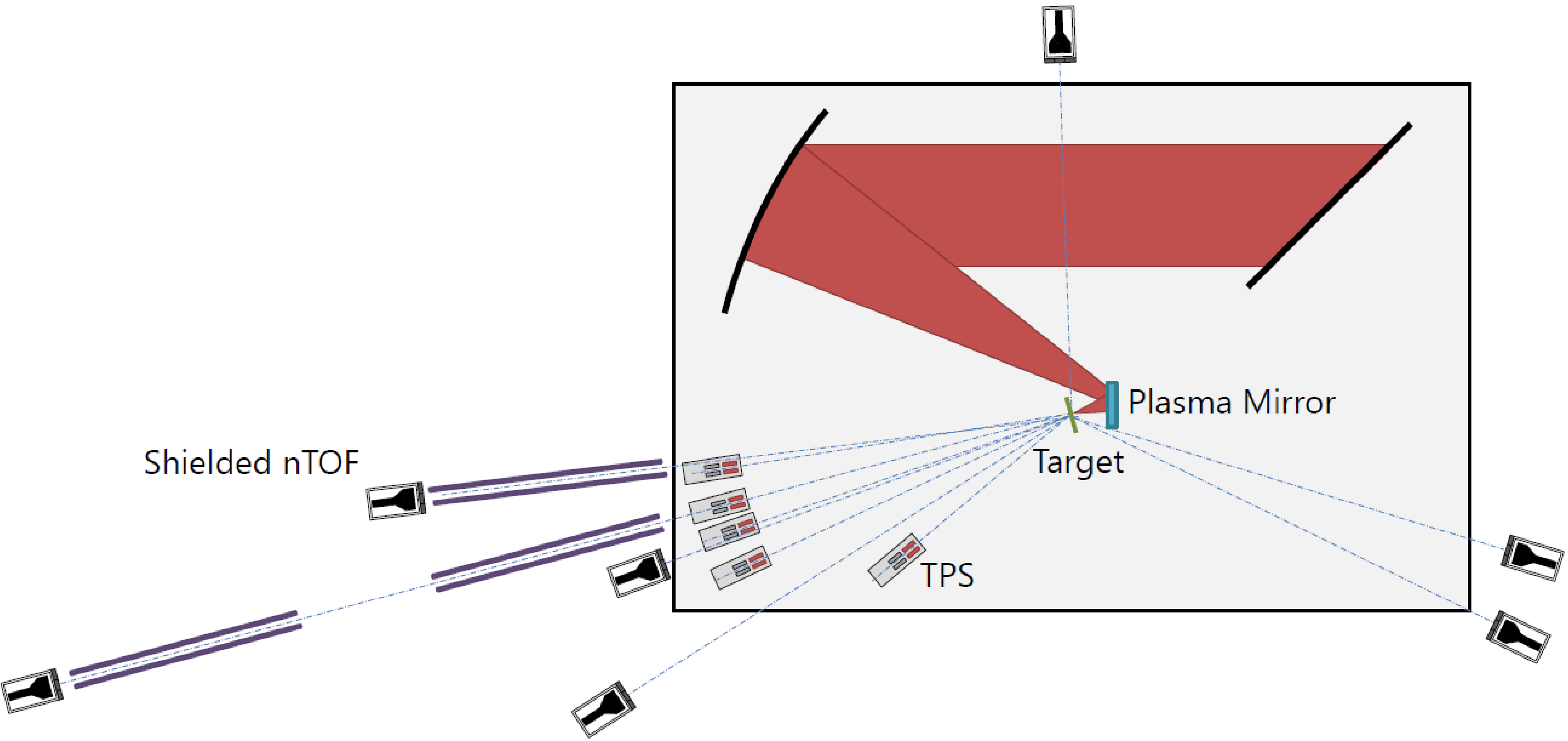


Light-Sail Ion acceleration

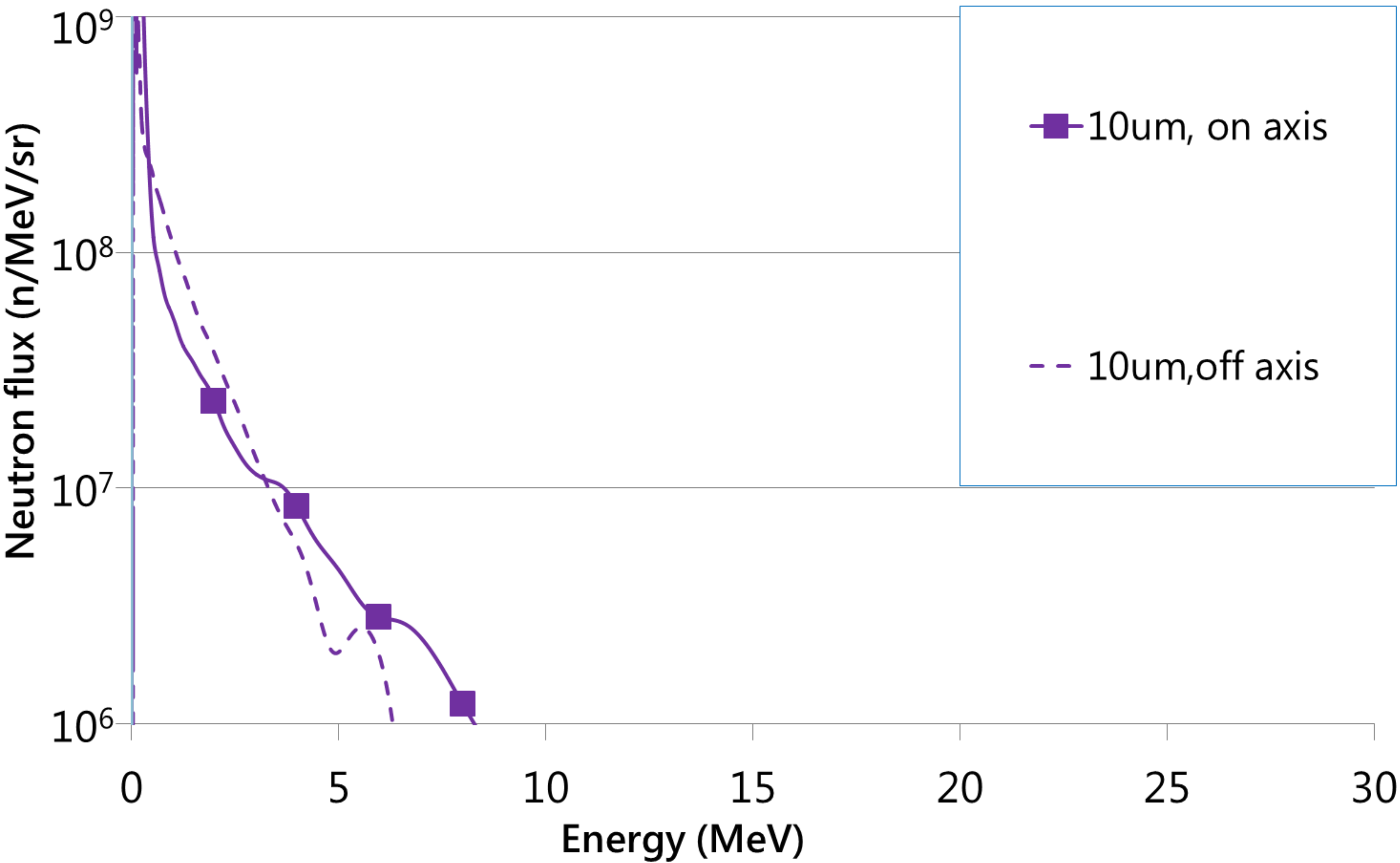
Characteristics of the source

- Quasi-monoenergetic spectrum
- Ion energy $E \propto \left(a_0^2 \tau_p / \chi\right)^{\alpha} \equiv (E_{laser}/\rho_{target} l_{target})$
- Bulk ions accelerated

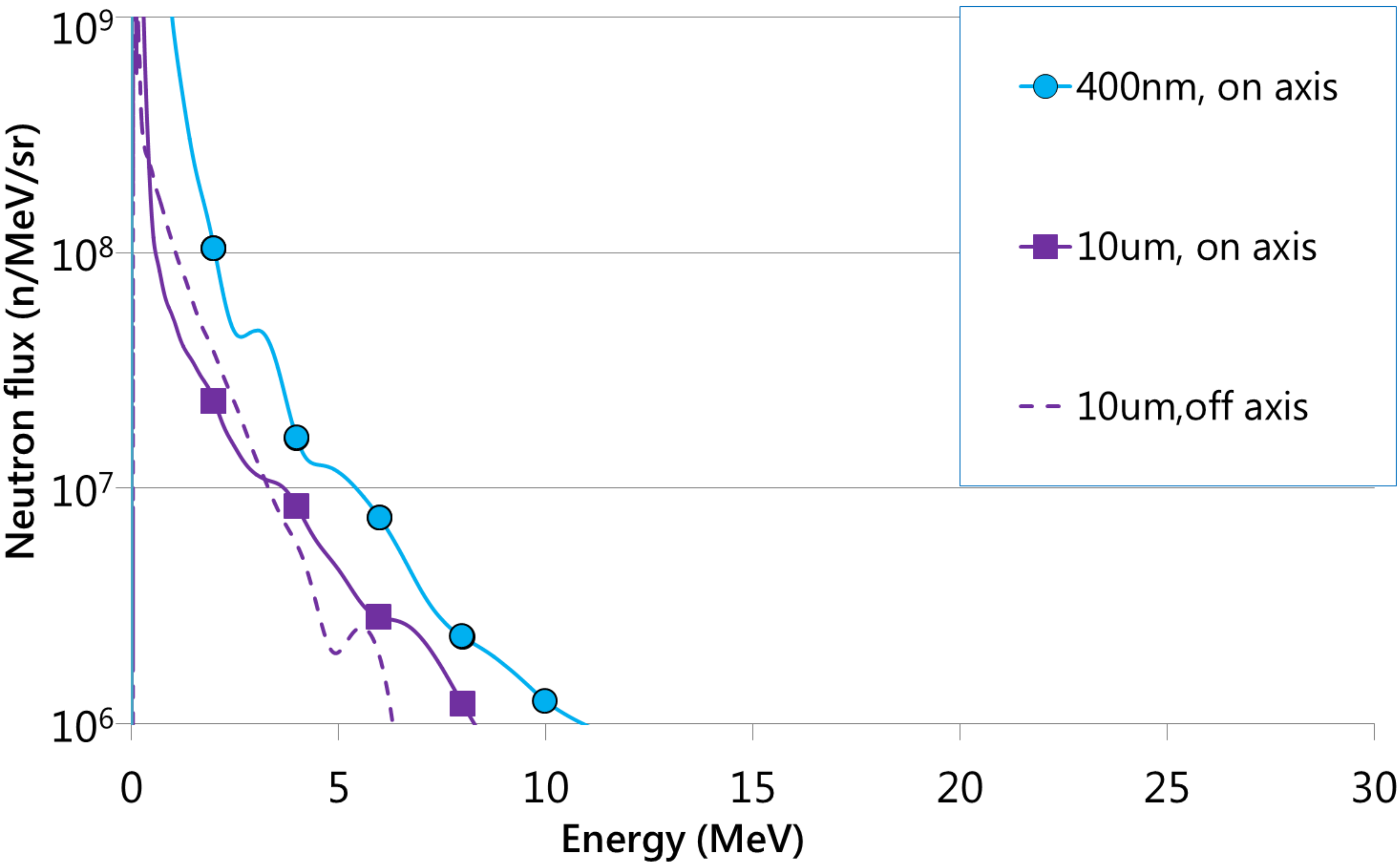
RPA. Experimental setup



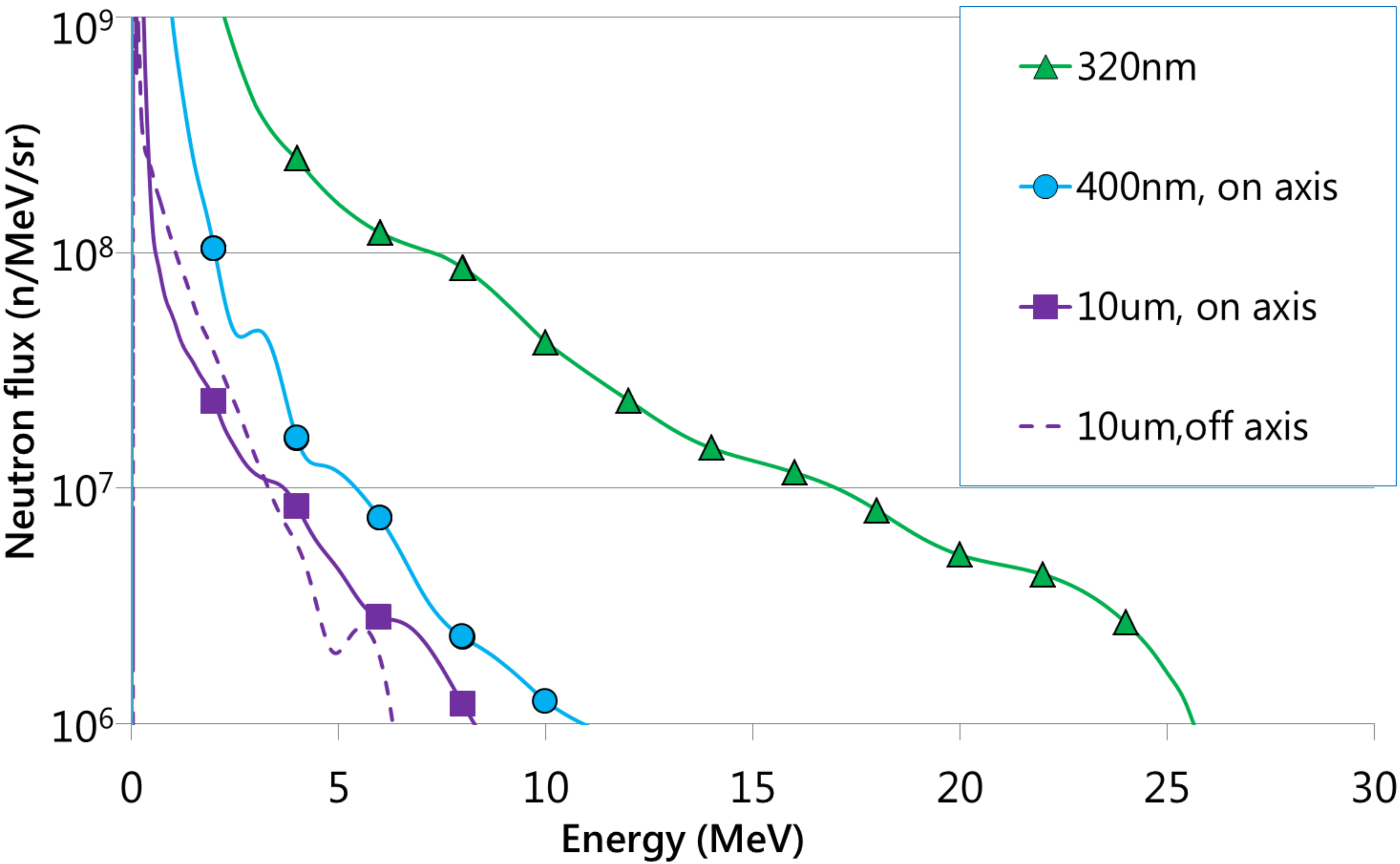
RPA. The unexpected



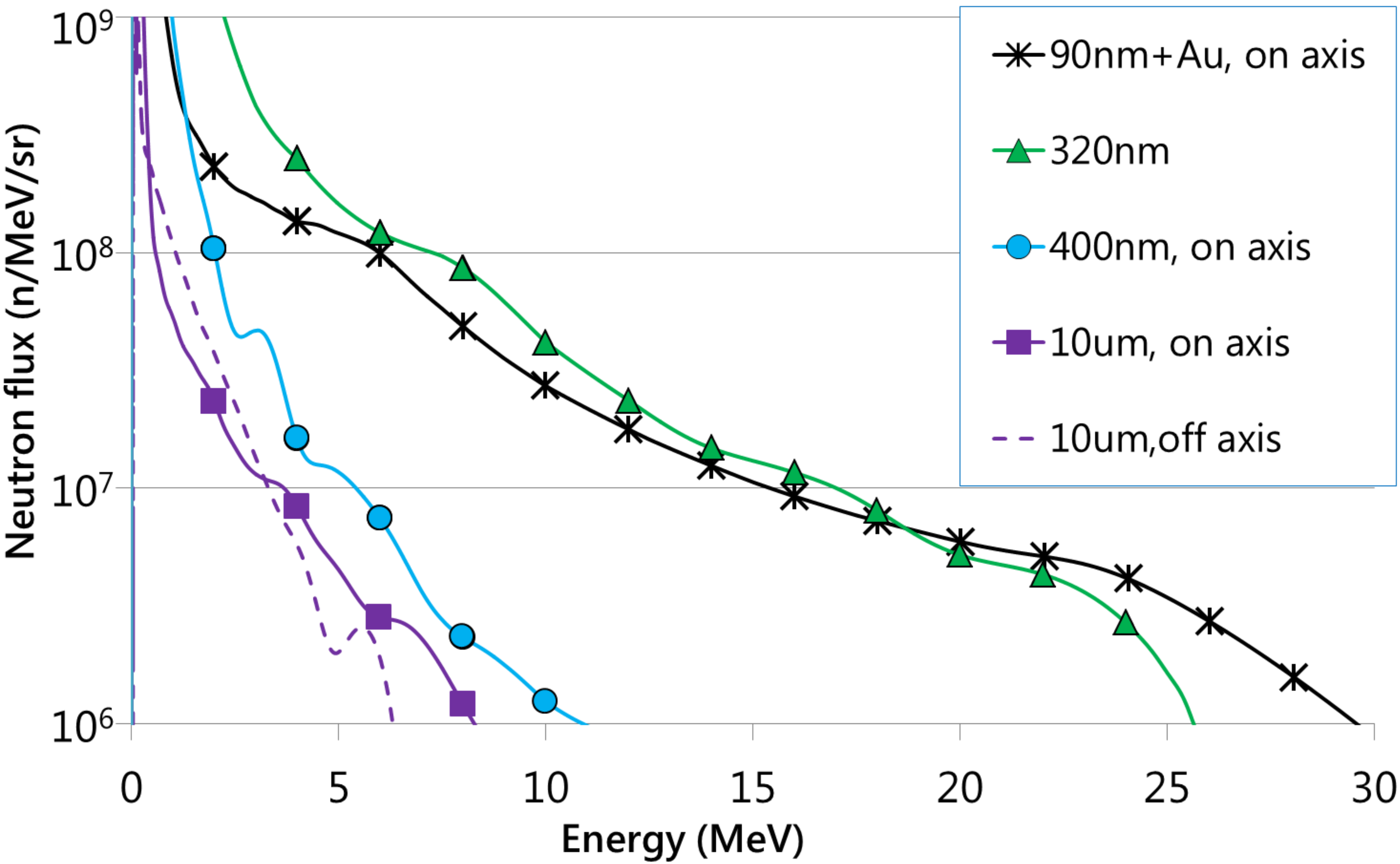
RPA. The unexpected



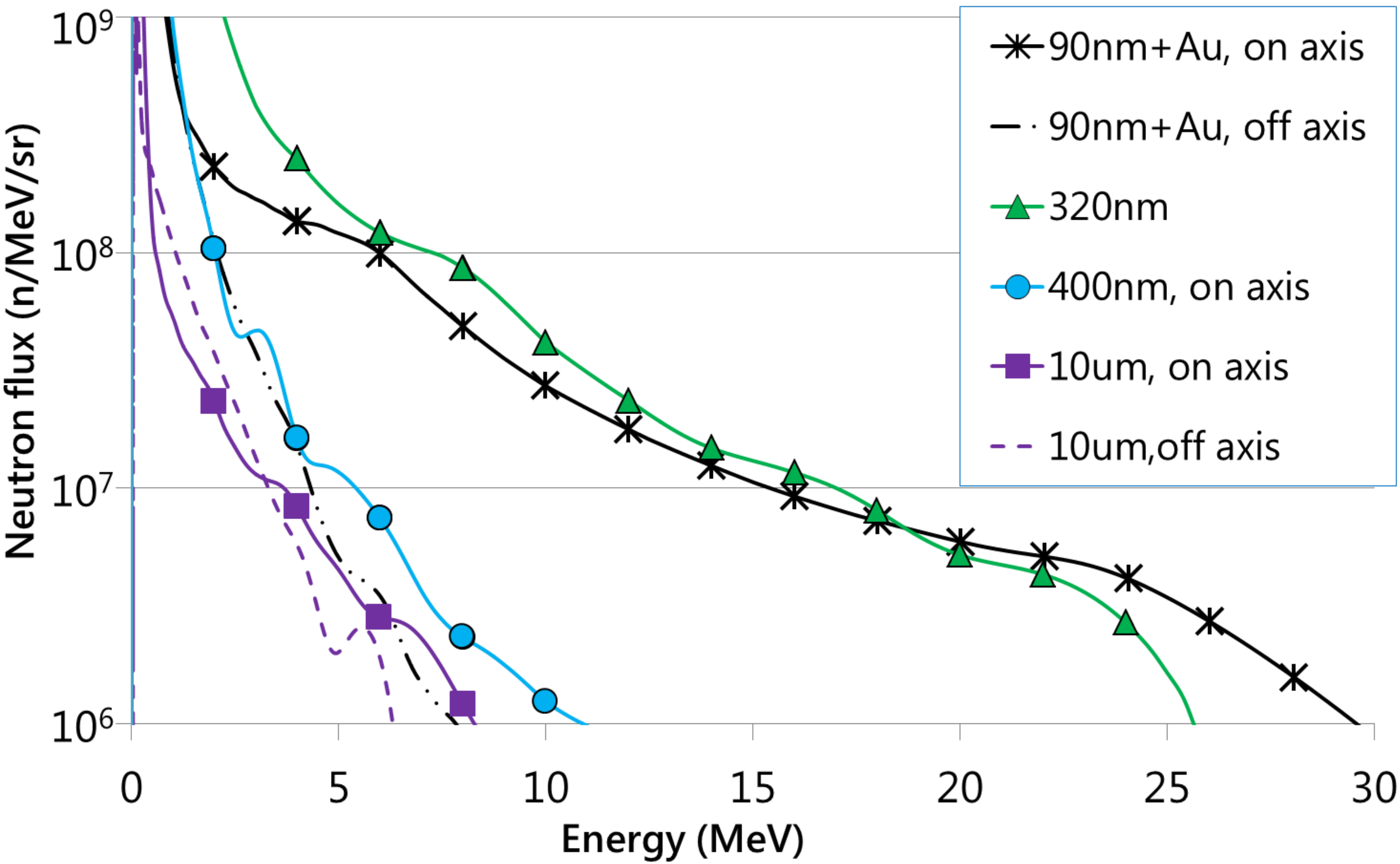
RPA. The unexpected



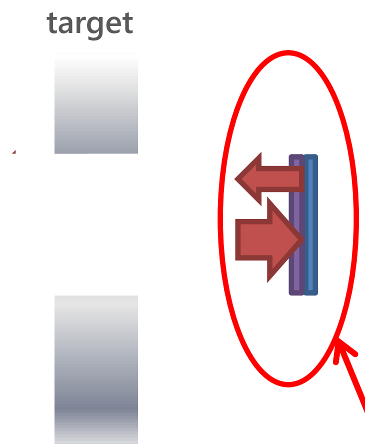
RPA. The unexpected



RPA. The unexpected



RPA. Revisited

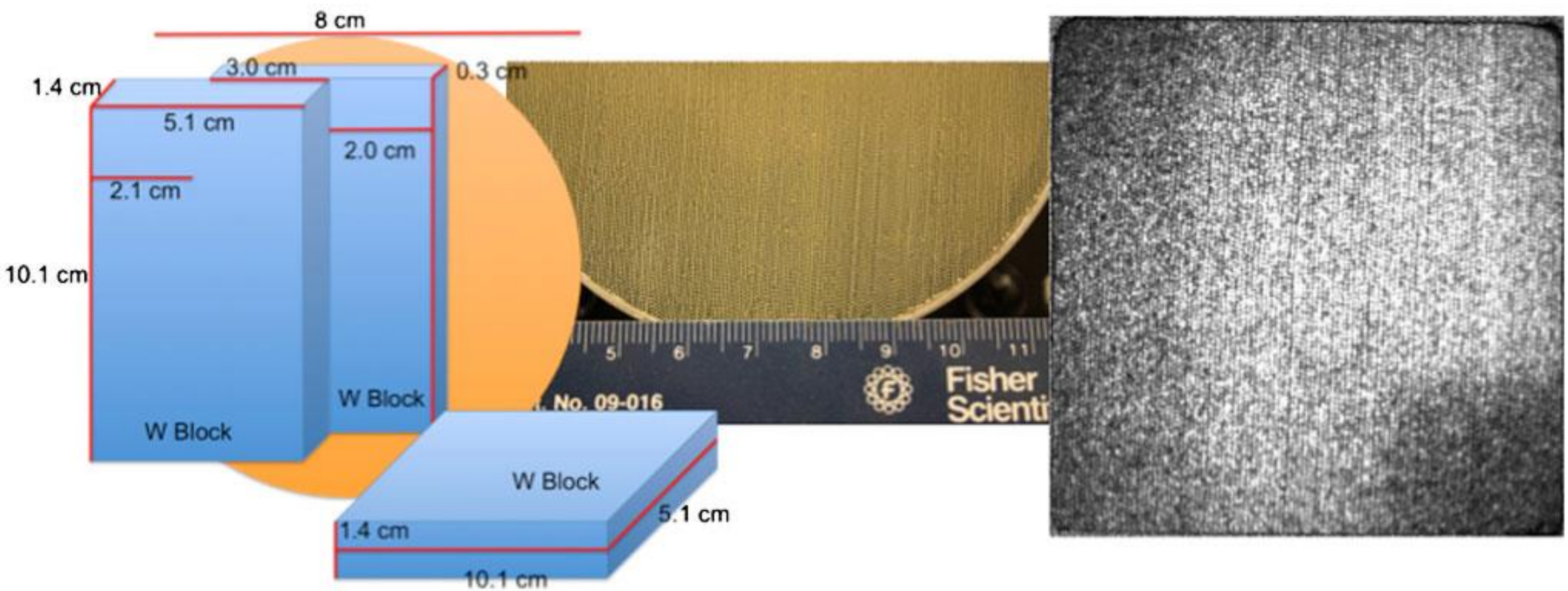


Highly-dense deuteron bunch travelling together long time

(A. Alejo et al., 2015, In preparation)

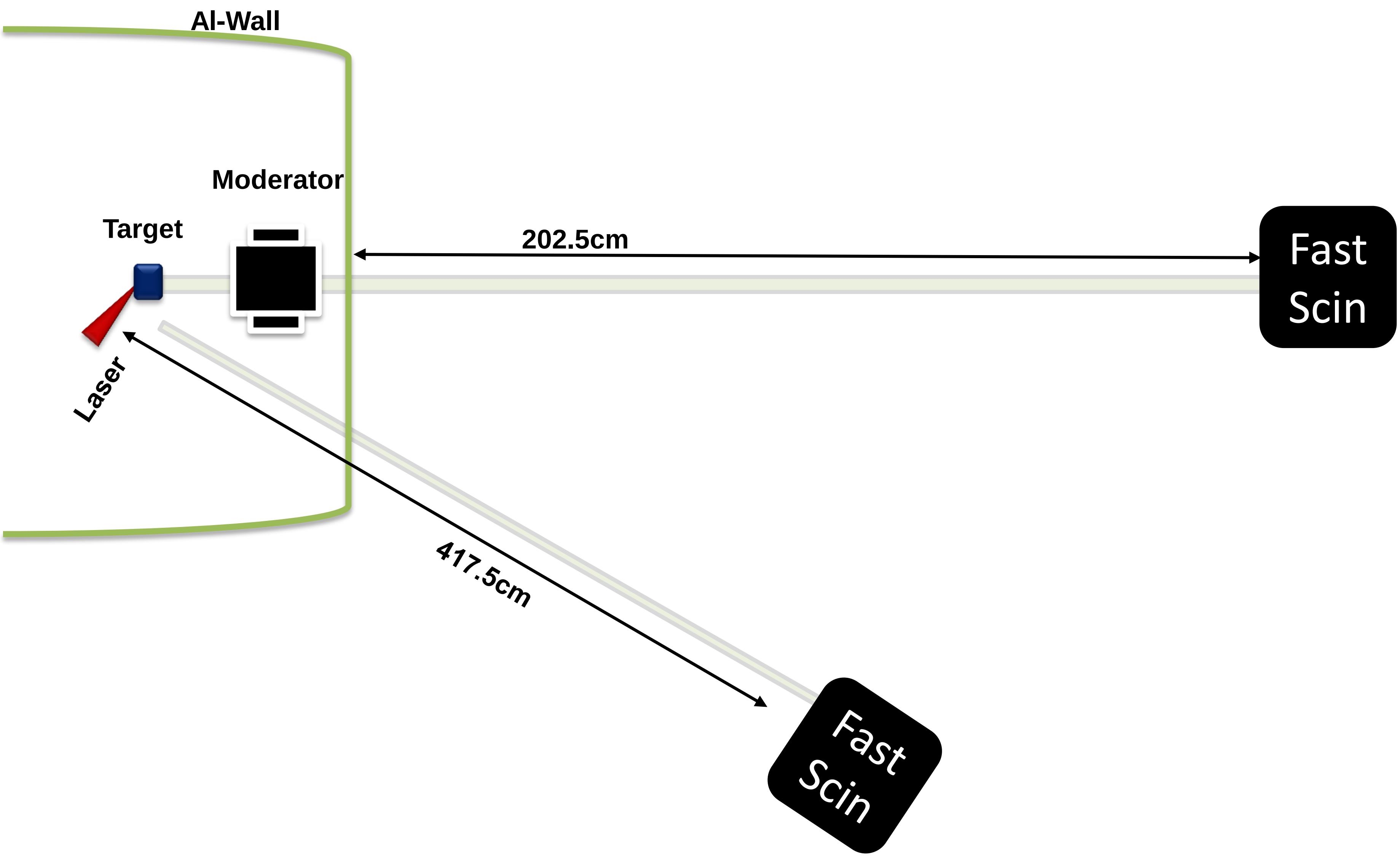
APPLICATIONS

Fast-neutron imaging



*Analysis pending, results shown are taken from M. Roth et al., PRL 110 (2013)

Moderation. Experimental Setup



Conclusions

- Laser accelerators are a good alternative for a cost-effective, compact neutron sources
- TNSA+catcher can produce a bright, directional beam of neutrons.
  - First direct observation of a laser-driven neutron beam
- RPA appears as an intrinsically good mechanism for neutron generation, even without converter
  - Flux can be further increased including a catcher
- A compact moderator could slow down MeV neutrons to eV-100 eV range

Thank you for you attention