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Title: Active Interrogation of Sensitive Nuclear Material Using Laser Driven Neutron Beams

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Roth, Markus

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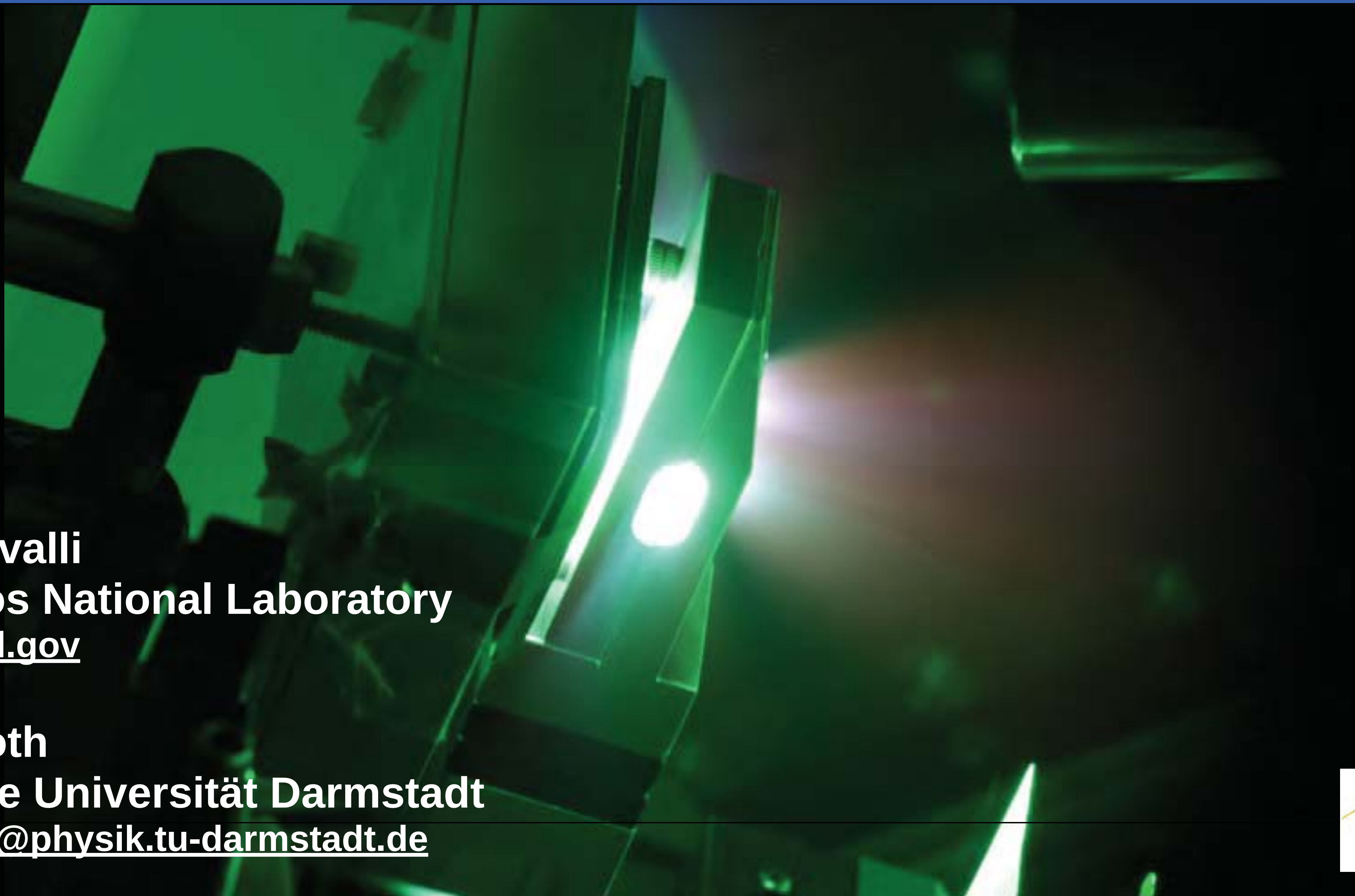
Active interrogation of sensitive nuclear material using laser driven neutron beams



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Active interrogation system to detect special nuclear material

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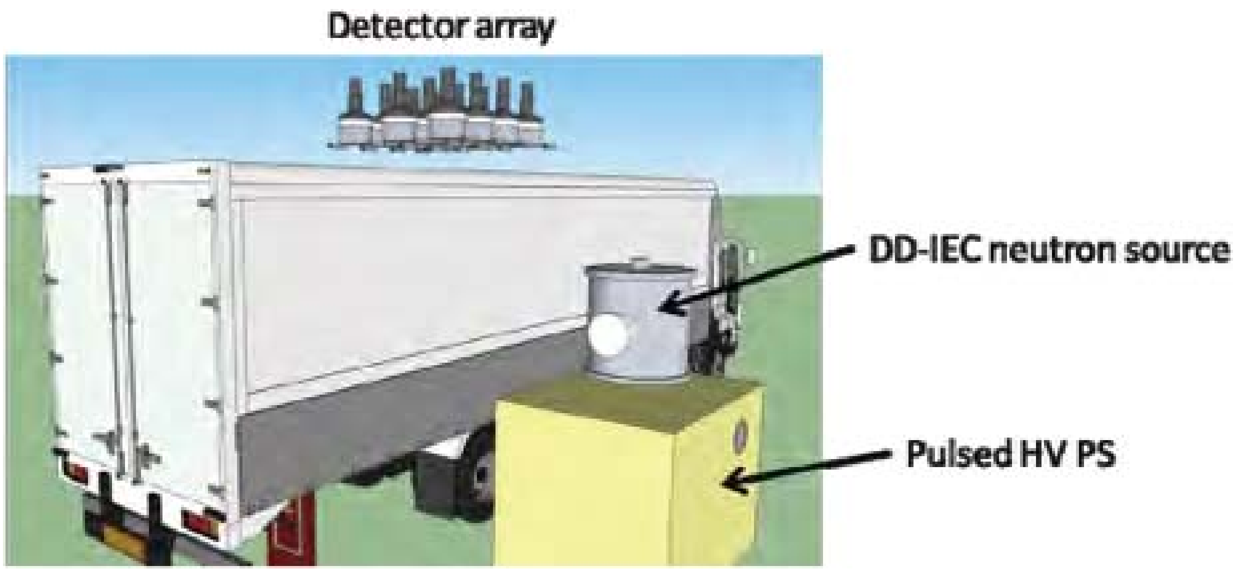
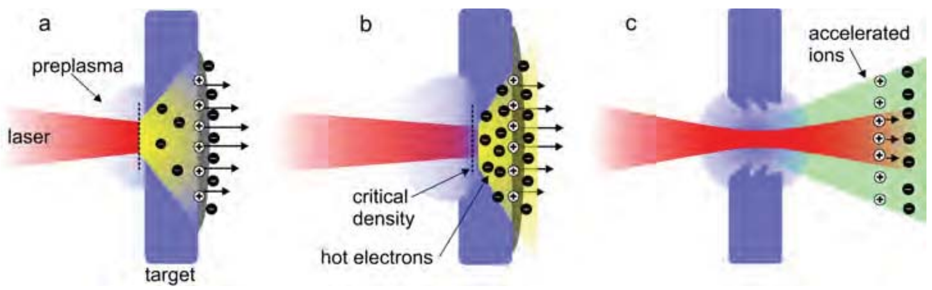


Figure from Masuda et al., IEA Kyoto

Need: Fast, movable, operationally safe neutron source featuring energy tunable, and high intensity directional neutron production

Investigation of the viability of a laser-driven neutron source for active interrogation

Since two years we have a new laser driven neutron source available, based on RT



a) Target Normal Sheath Acceleration (TNSA) phase
b) Intermediate phase
c) Laser Breakout Afterburner (BOA) phase

Short but High intensity neutron production, which equals high throughput and high signal-to-noise

• Energy tunable, which gives an advantage for interrogation of variable types and thickness of shielding

•Directionality; increases signal for the interrogation while helping the safety of the operators

•Can be made in a feasible size for a movable/ transportable source

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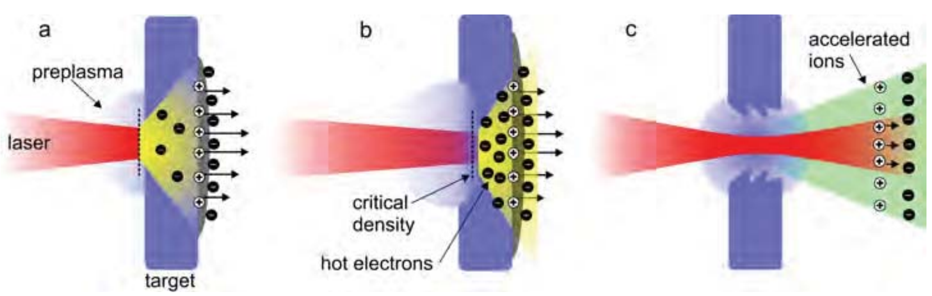

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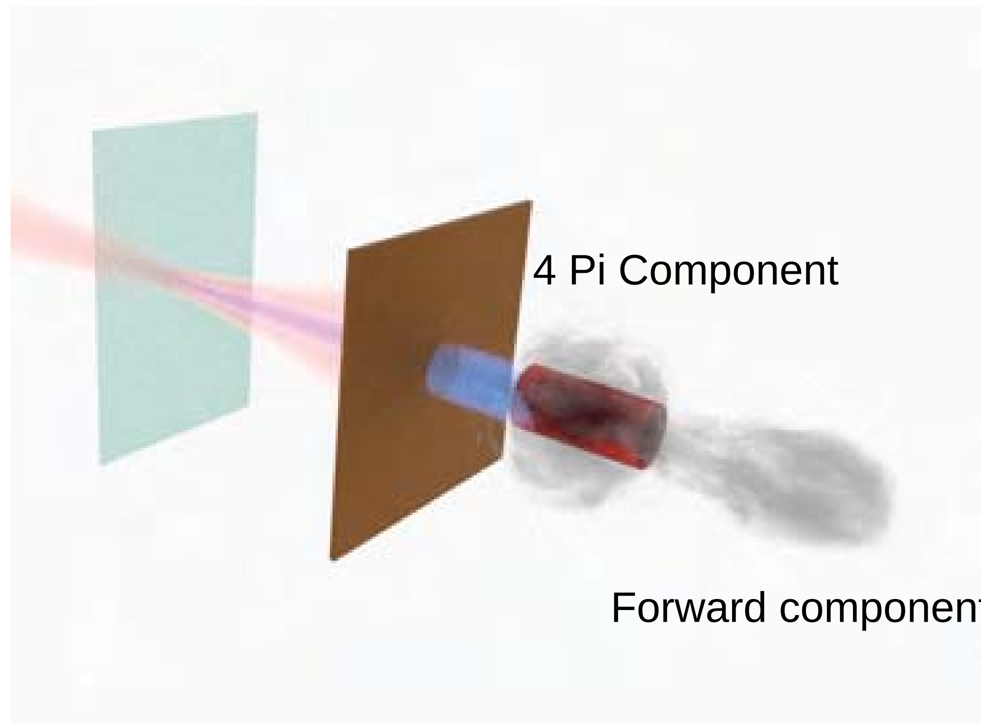

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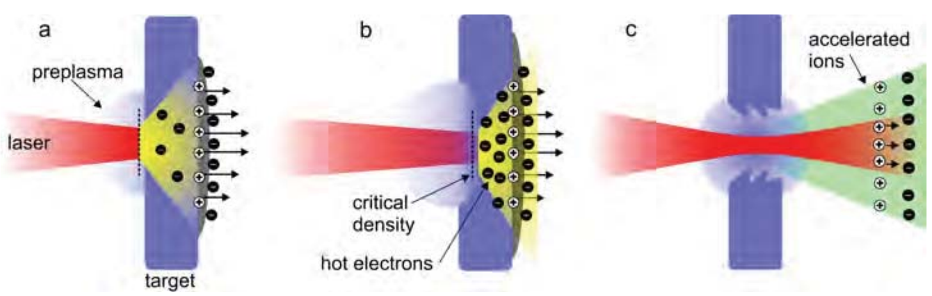

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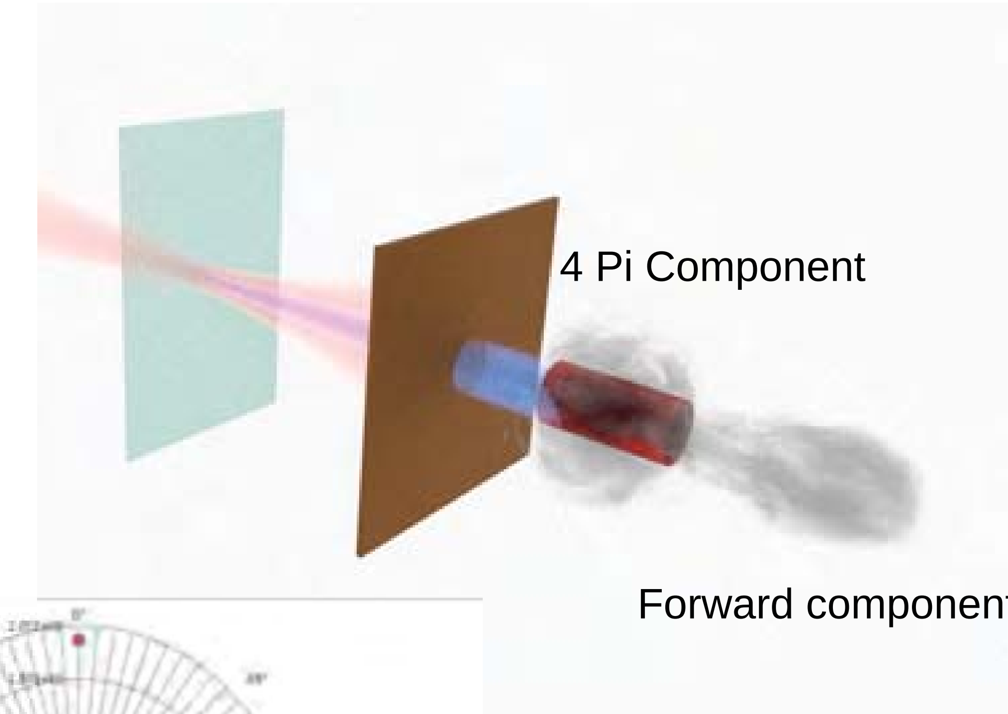

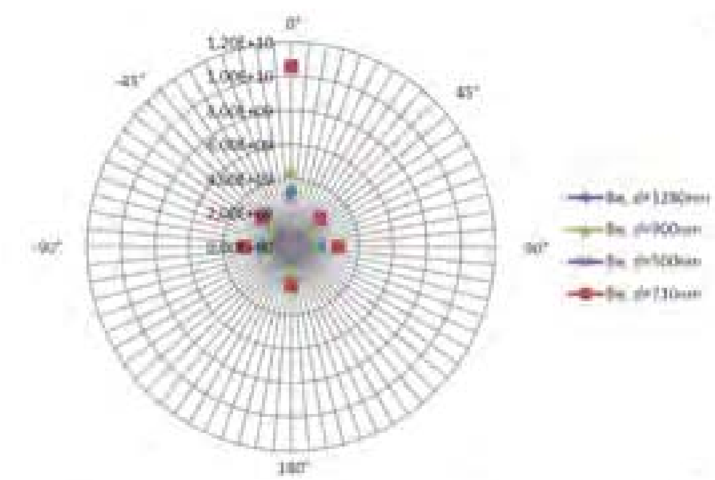

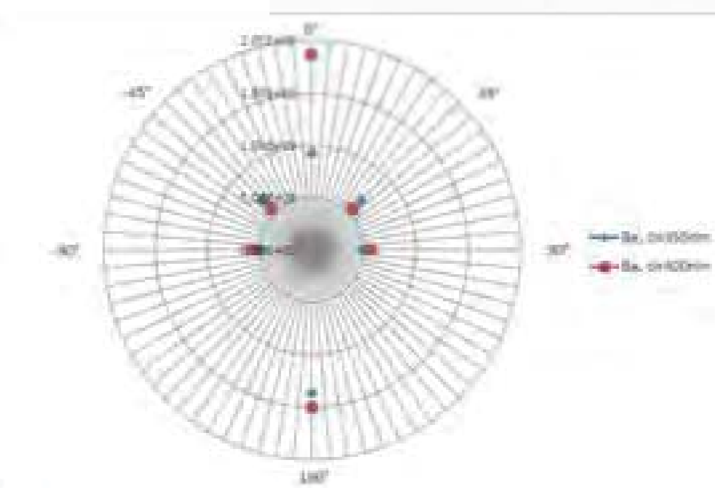

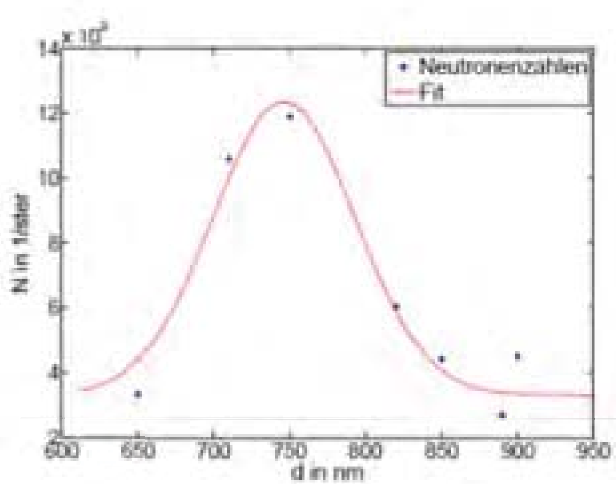

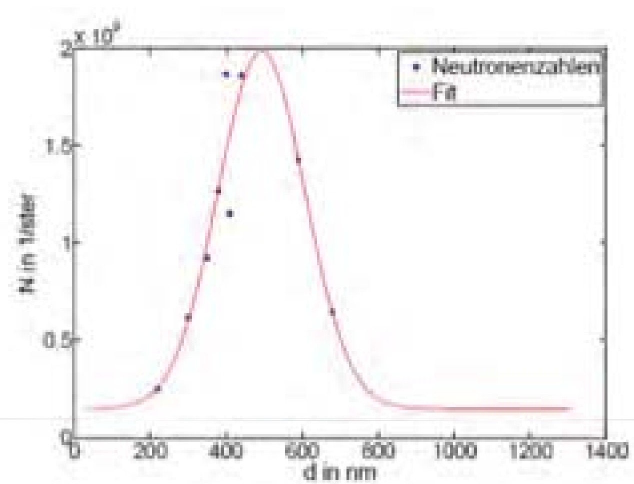

<u>Short but High intensity neutron production</u>, which equals high throughput and high signal-to-noise

- *<u>Energy tunable</u>, which gives an advantage for interrogation of variable types and thickness of shielding*
- *<u>Directionality</u>; increases signal for the interrogation while helping the safety of the operators*
- *Can be made in a <u>feasible size</u> for a movable/ transportable source*

Why neutrons?

Highly penetrating

GKSS, Geesthacht

Why neutrons?

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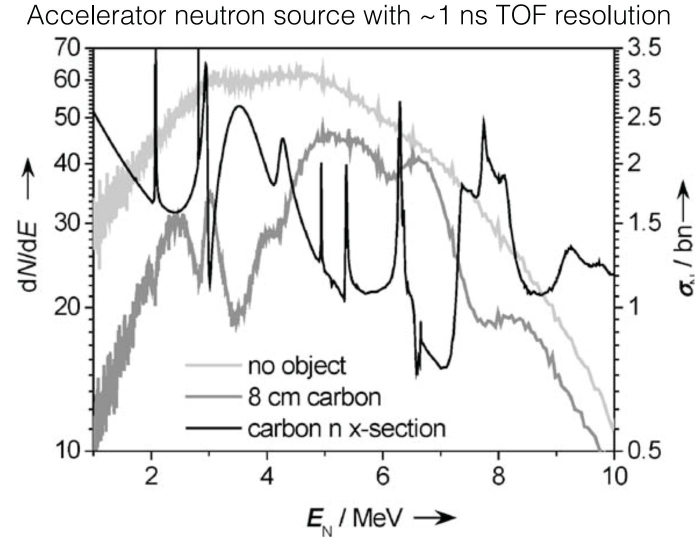
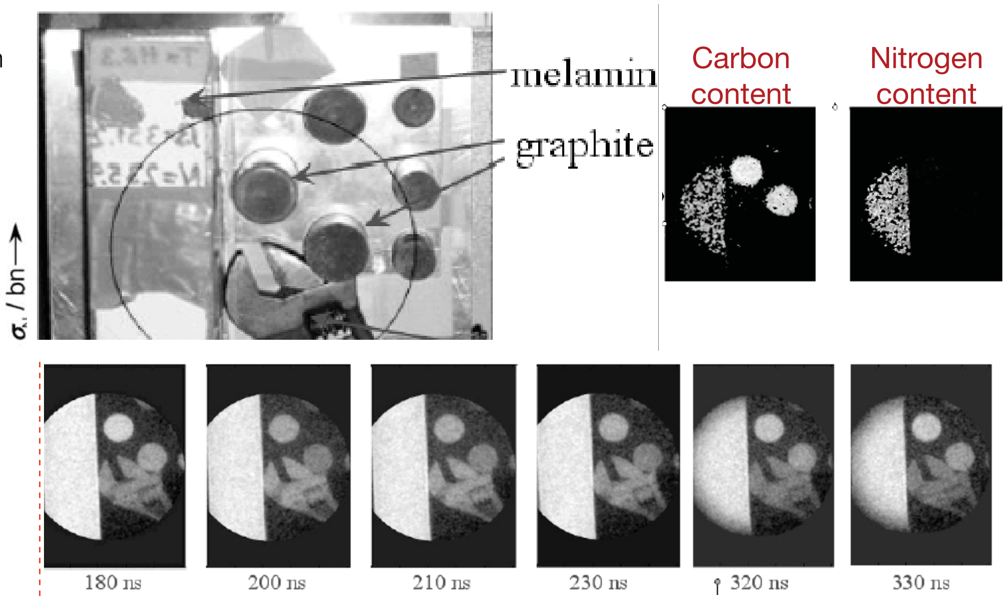
Material selective (fast neutron radiography)



Ishay Pomerantz / U. Texas



Vartsky, D. et al. Nuclear Instruments and Methods A623, 603–605 (2010)

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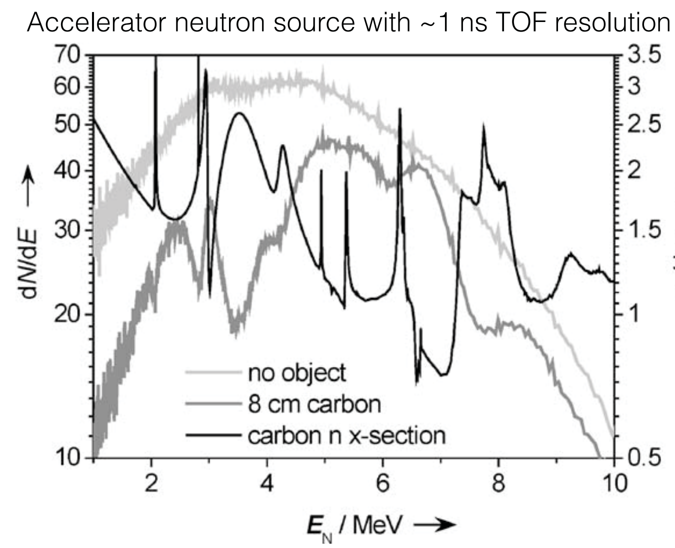

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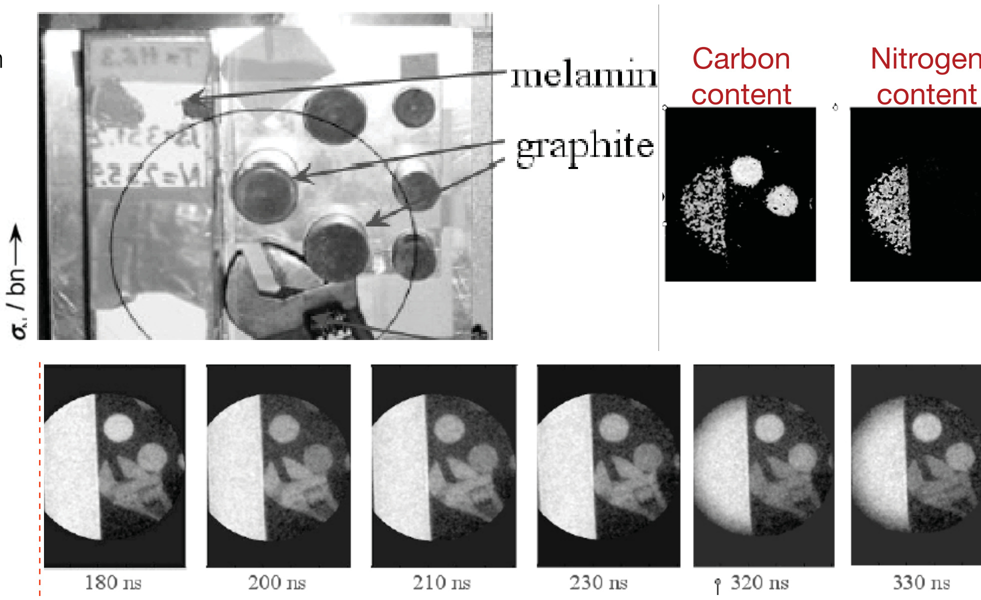

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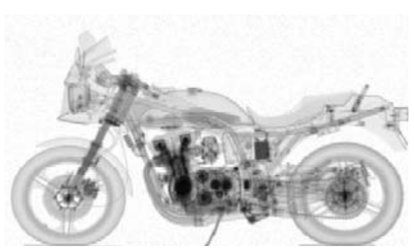
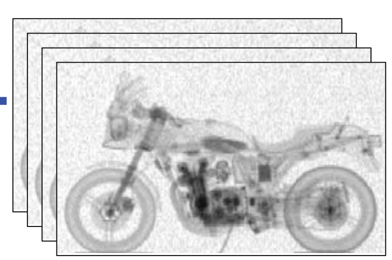
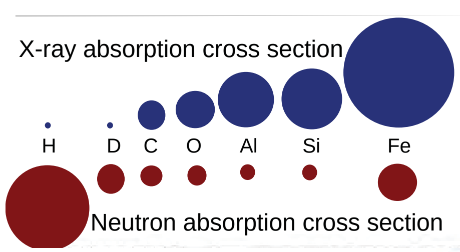
Complementary to X-rays

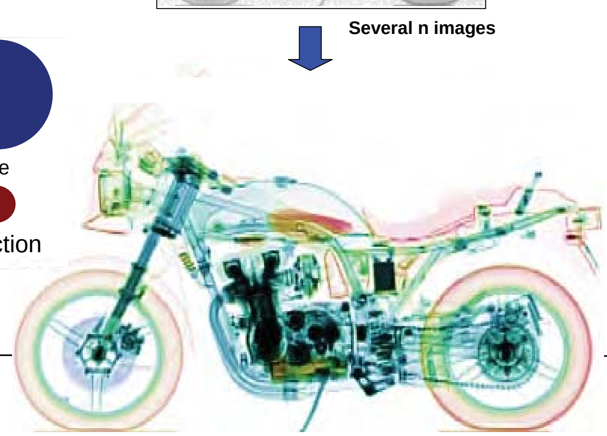


γ image



Several n images





Eberhardt, CSIRO

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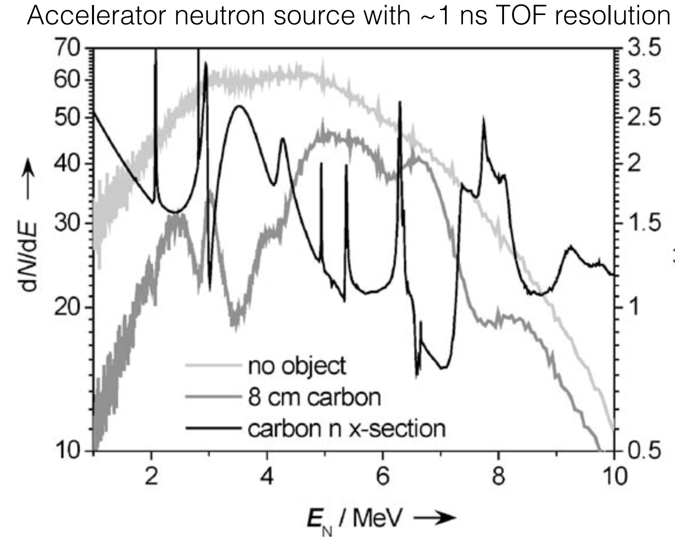
Material selective (fast neutron radiography)

Accelerator neutron source with ~1 ns TOF resolution



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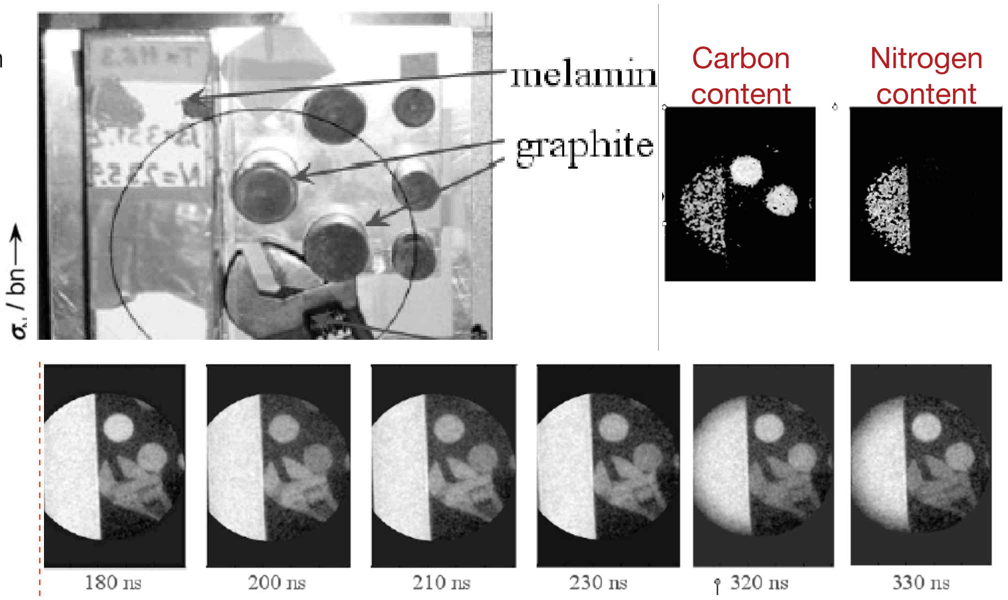

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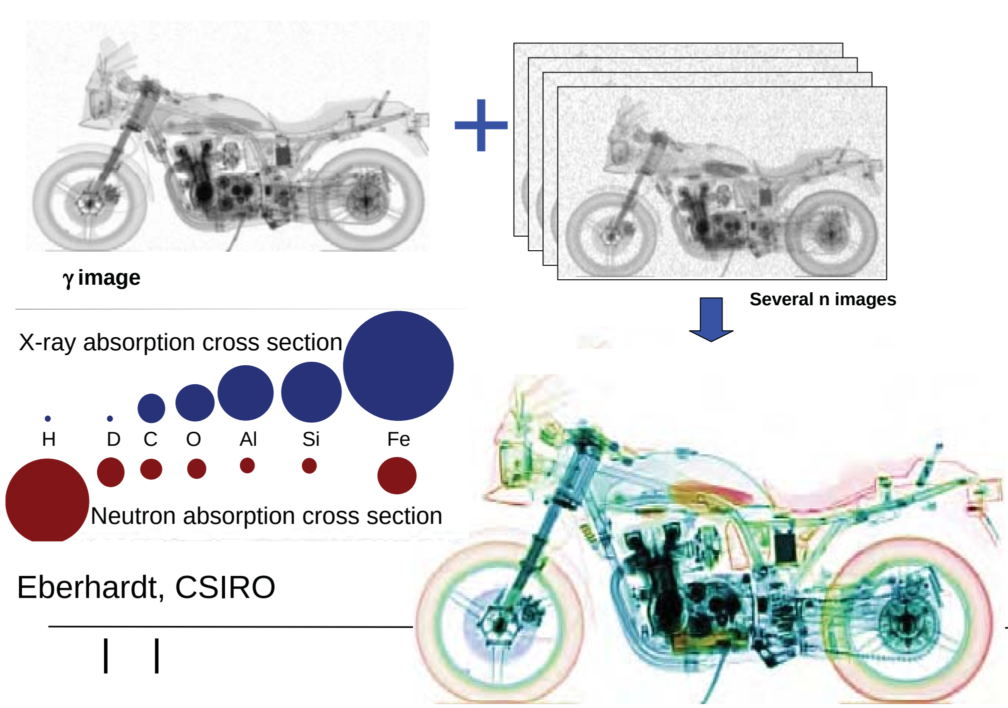
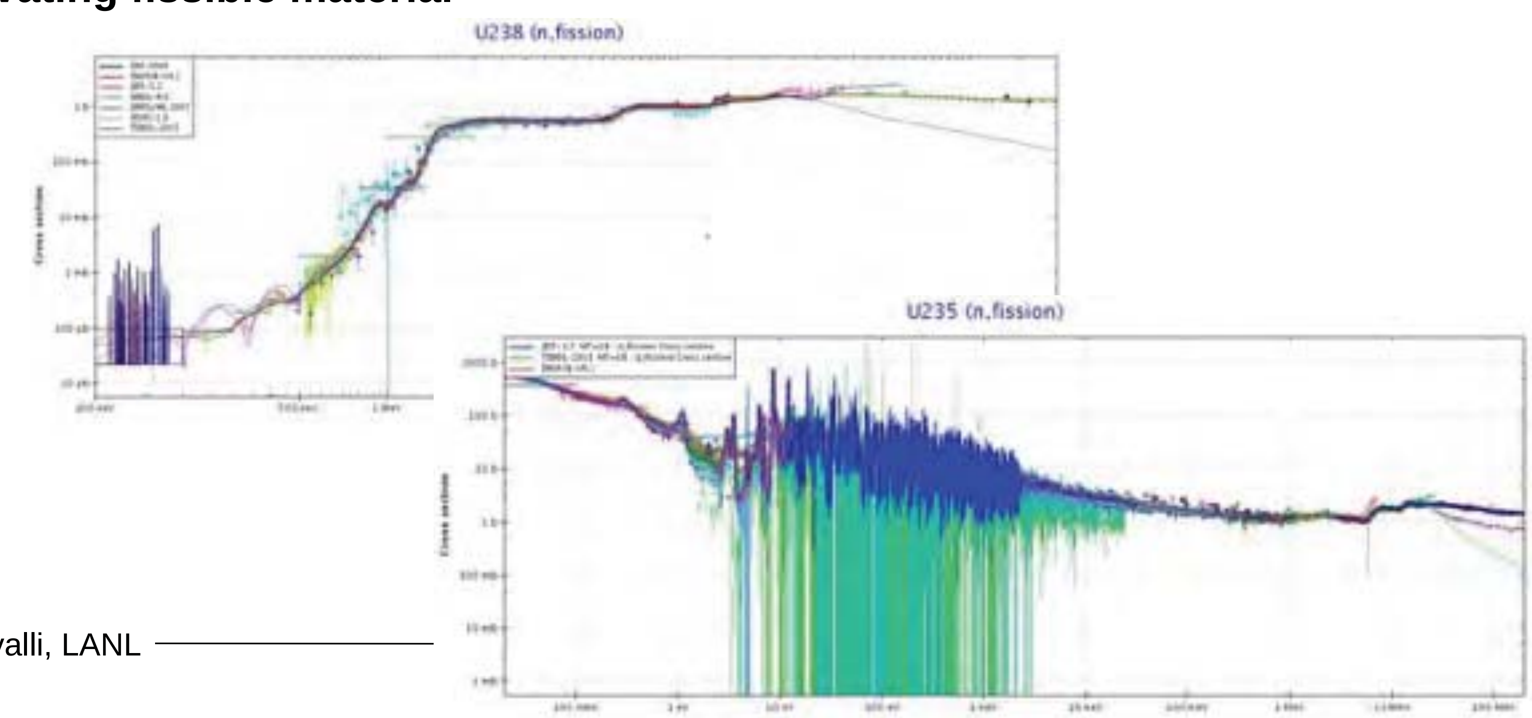


Eberhardt, CSIRO

Activating fissible material



A. Favalli, LANL

Why lasers?

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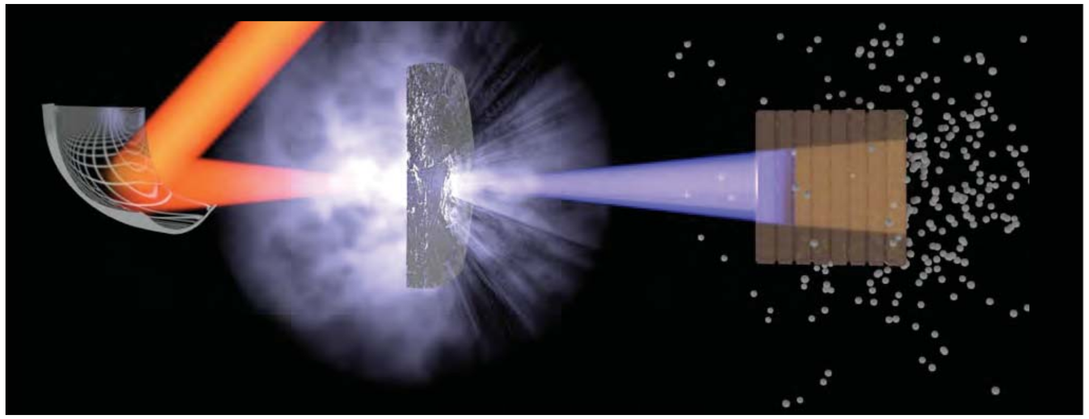
Very compact and directed source



I. Pomerantz, UT

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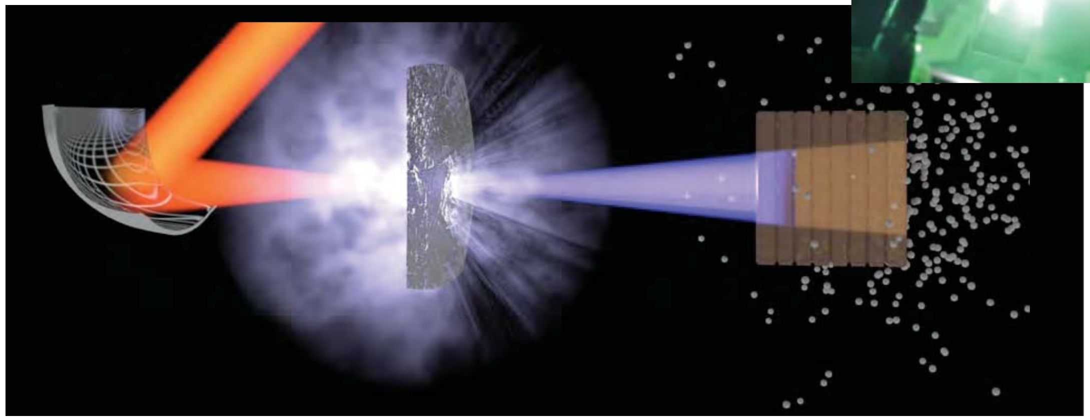

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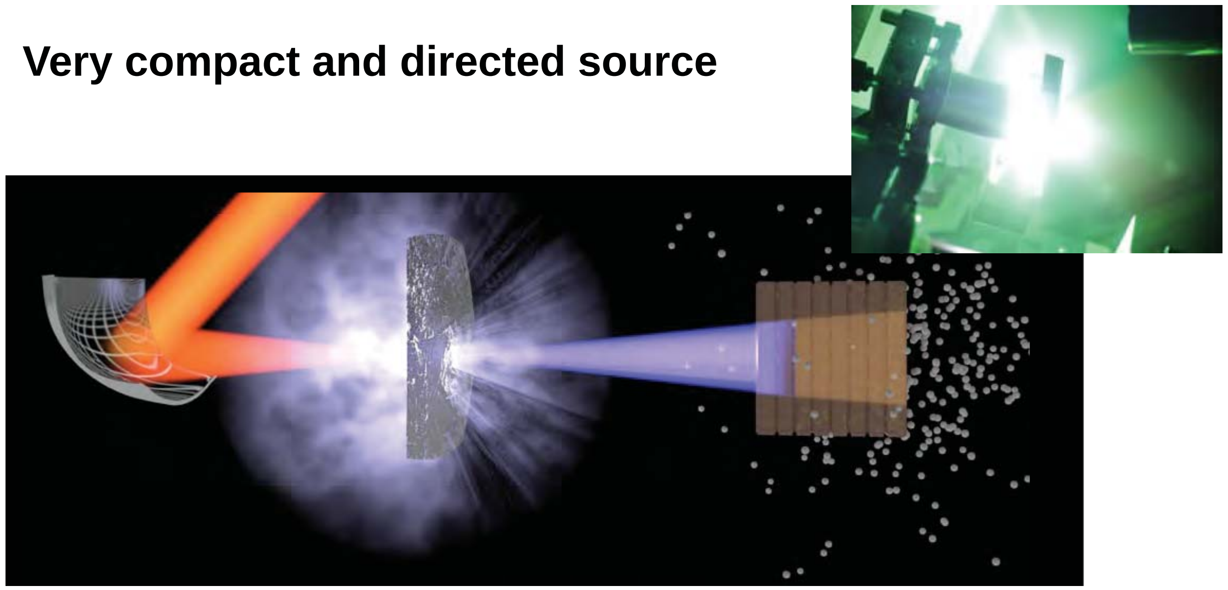
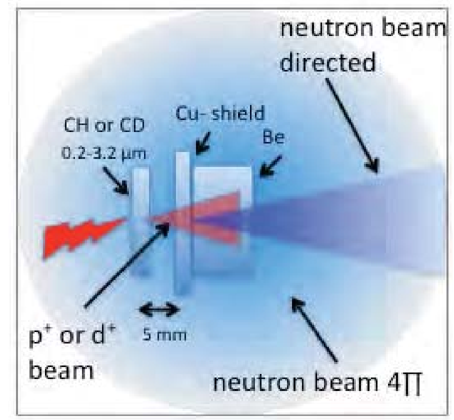
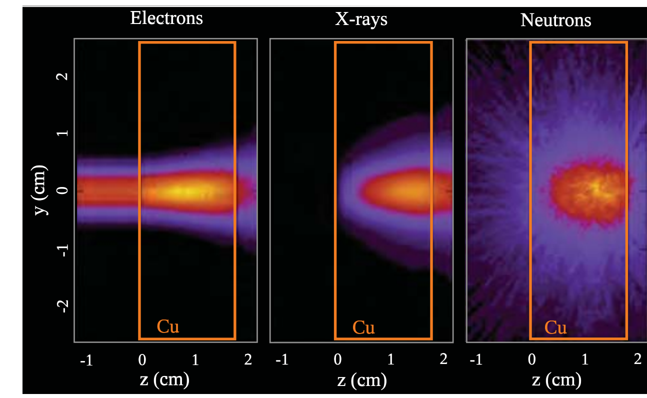


I. Pomerantz, UT

Ultra-short pulses via ion or electron production



Harder spectrum, more neutrons

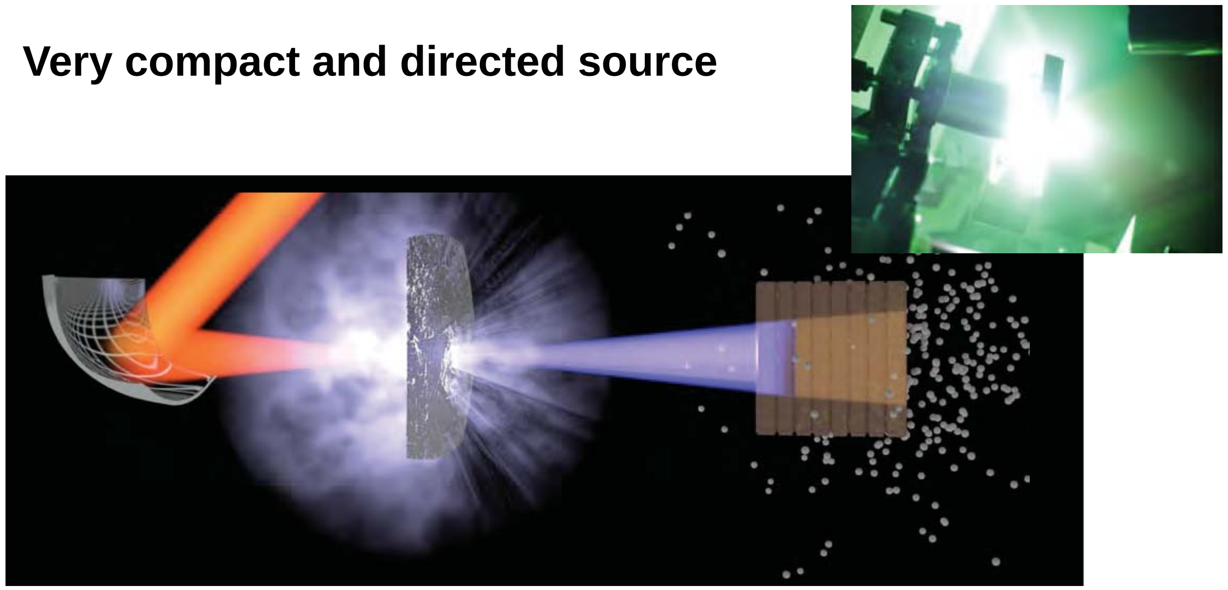


Softer spectrum

Just dial in contrast of the laser

Why lasers?

Very compact and directed source



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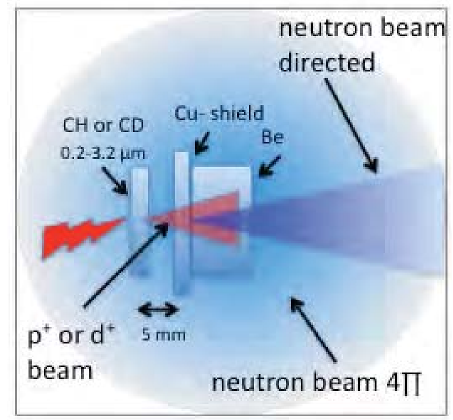

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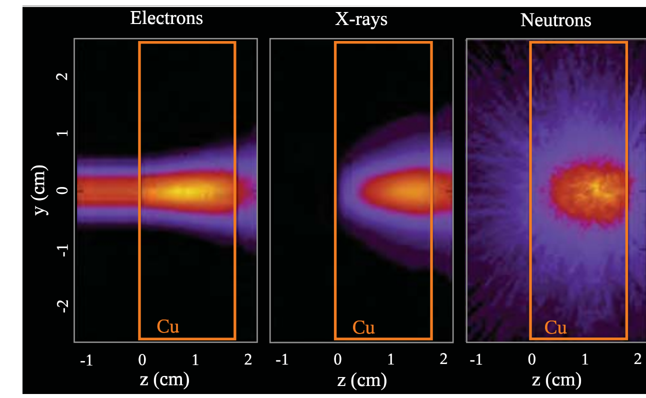
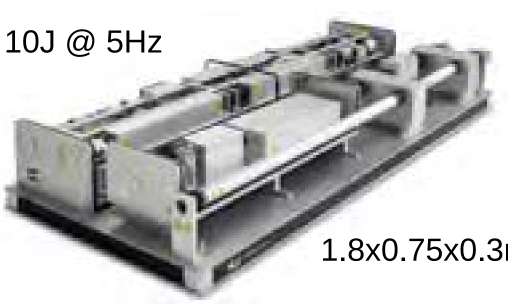


Softer spectrum

Just dial in contrast of the laser

Future drivers can be compact

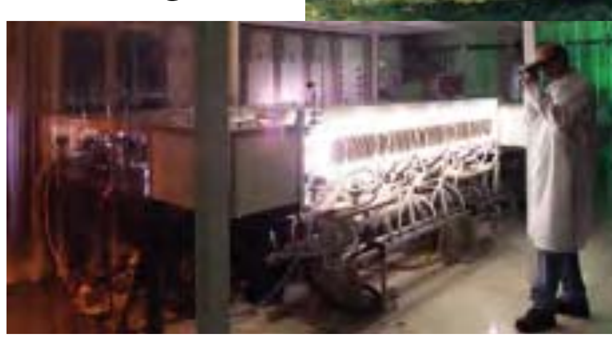
10J @ 5Hz



1.8x0.75x0.3m

Litron Lasers, UK

500J @ 20Hz



SSHCL, LLNL

compared to

Experiments in 2014 @ LANL

PI: Andrea Favalli, LANL

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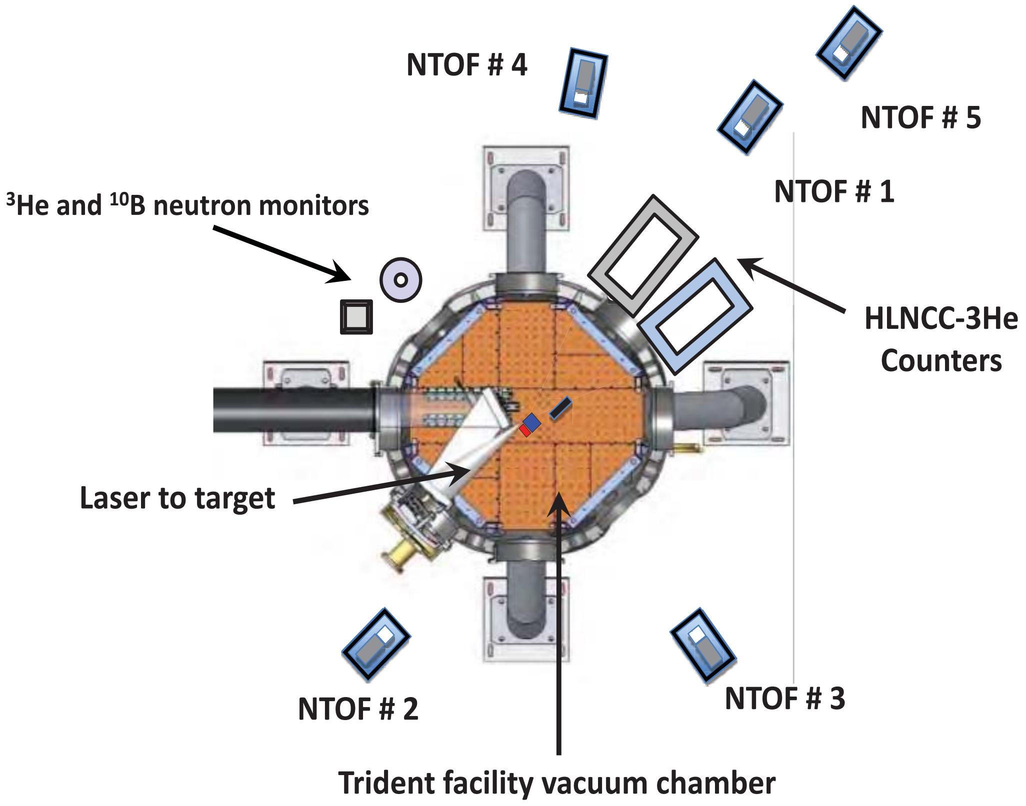
Active interrogation: identify nuclear material with a single pulse

Diagnostic for the neutron production:

- Bubble detectors (insensitive to γ's)
- nTOF: with plastic scintillator + PMT→neutron energy spectrum
- Neutron yield detectors based on ^{3}He +polyethylene (have been developed in the project specifically for the one shot measurement)



Experiments in 2014 @ LANL

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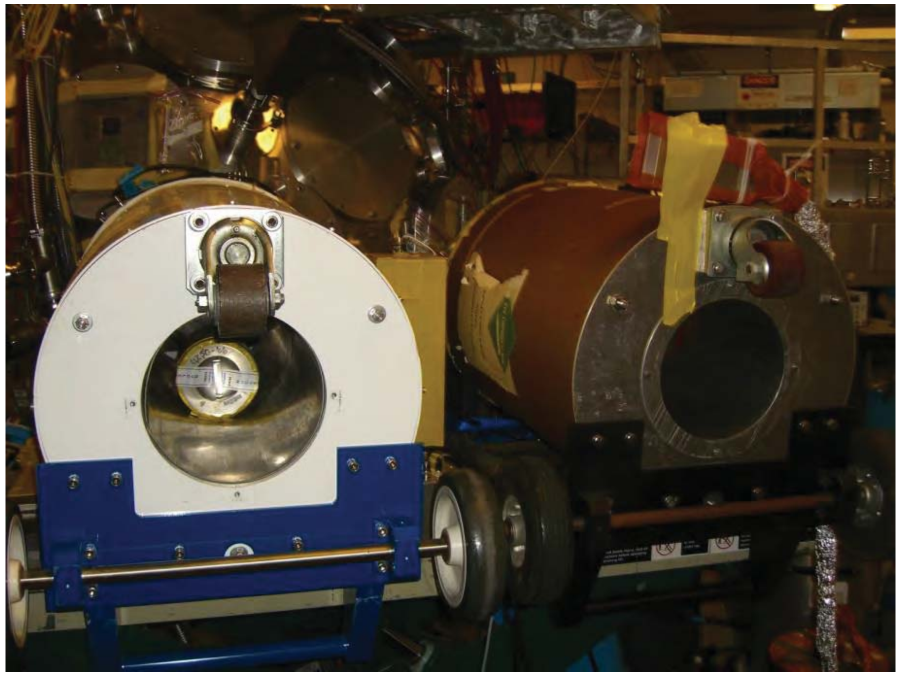
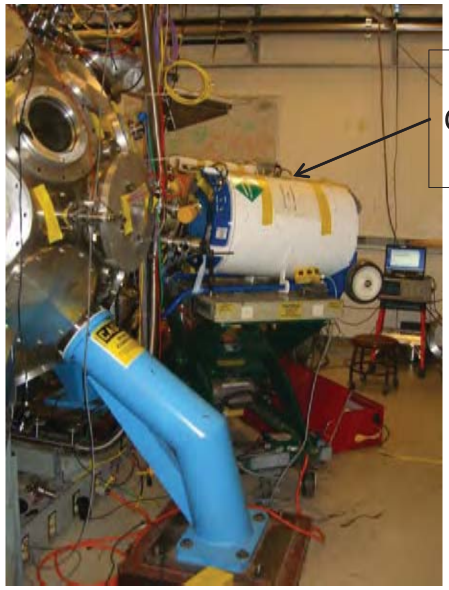
Uranium Samples

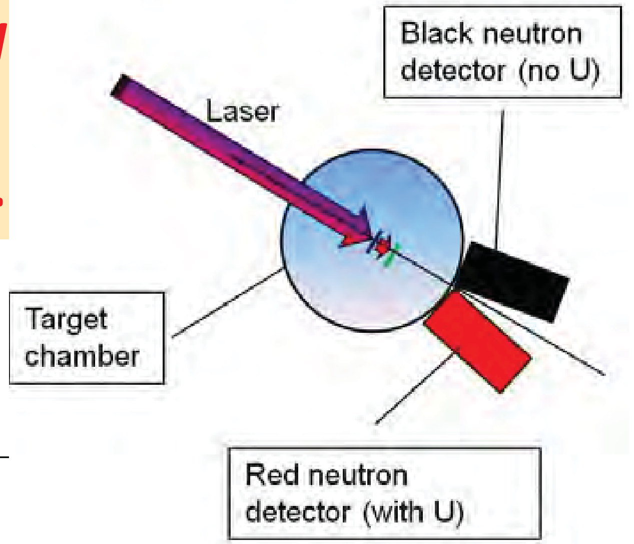




Uranium Samples tested:

- Depleted Uranium with mass up to 4.5kg
- Sample of enriched uranium up to 65%(w.t.) enrichment in ^{235}U

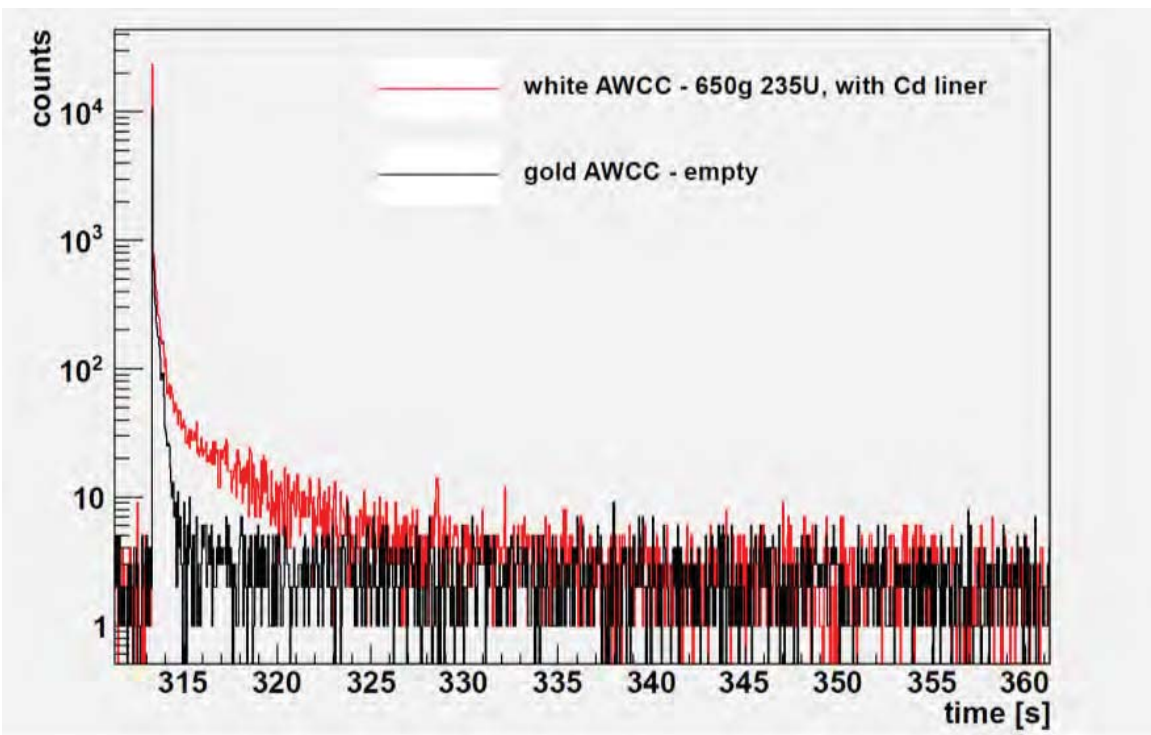
Neutron coincidence counter with single ring structure *of ^{3}He proportional detectors embedded in polyethylene*. In the *left* detector is visible the U sample.

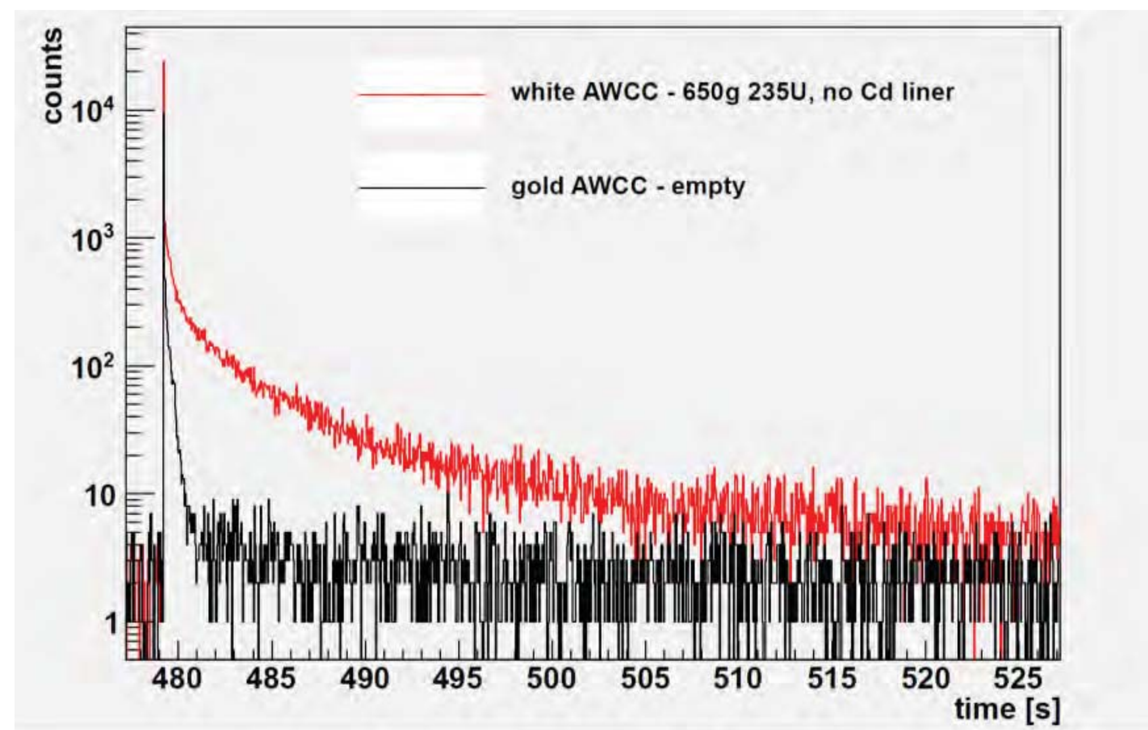


Interrogation of an enriched uranium sample

PI: Andrea Favalli, LANL

Sample: High Enriched Uranium (990 g U, of which 650g ^{235}U)





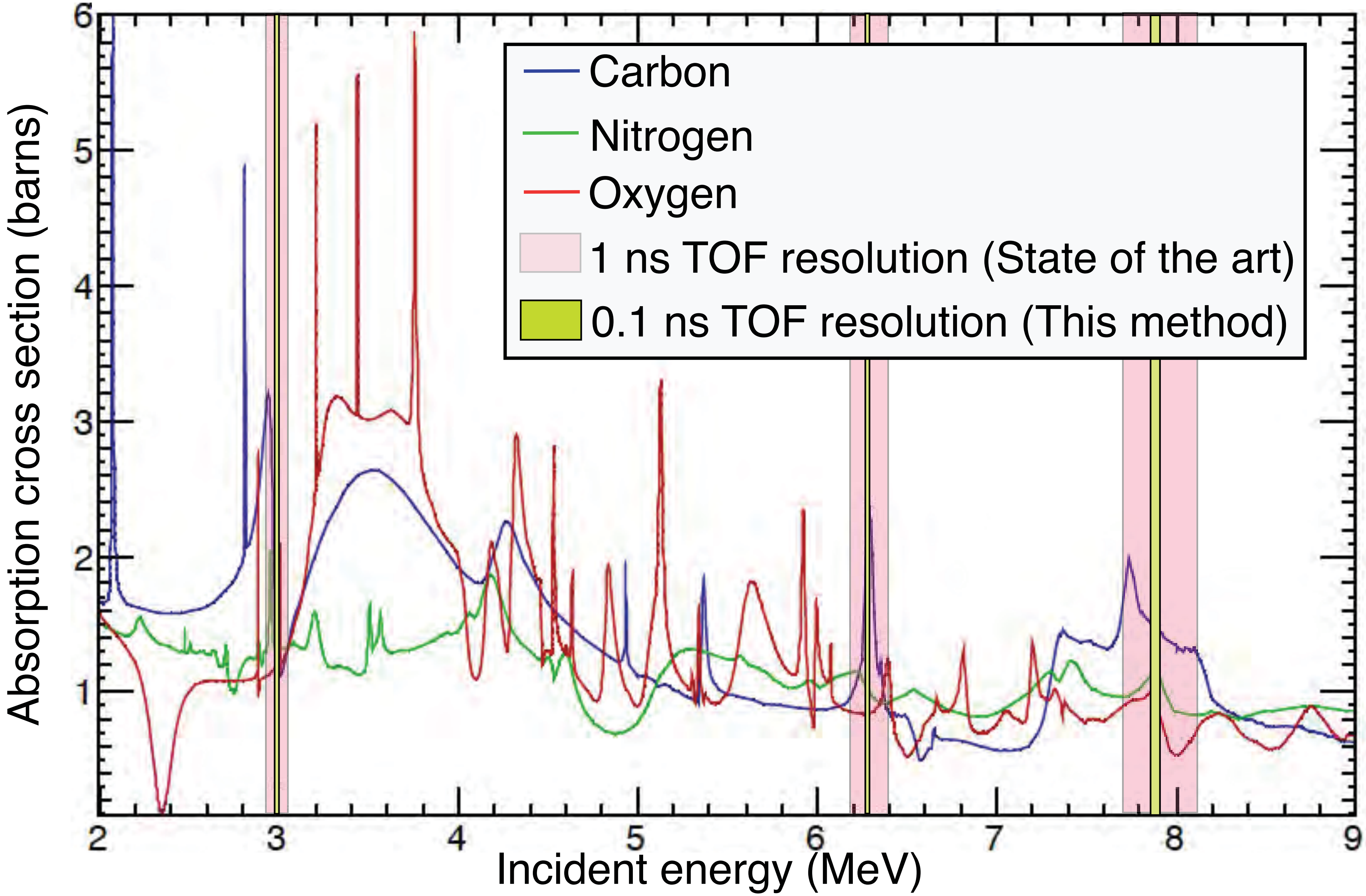
Fast Mode (*with* Cd sleeve)

Thermal Mode (*without* Cd sleeve)

Delayed Neutrons chosen as signature, these neutrons are characteristic signatures for nuclear fission (few other process yield delayed neutrons)

Prospects:
Fast Neutron Radiography

(from I. Pomerantz, PRL 113, 184801 (2014))

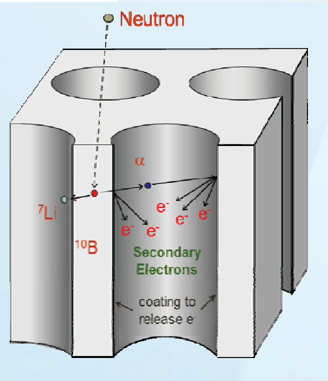


New detectors (also for FAIR)

Large area detectors are needed for cargo inspection

The price for He3 tubes has skyrocketed

New detectors are currently tested those are also dedicated for FAIR



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