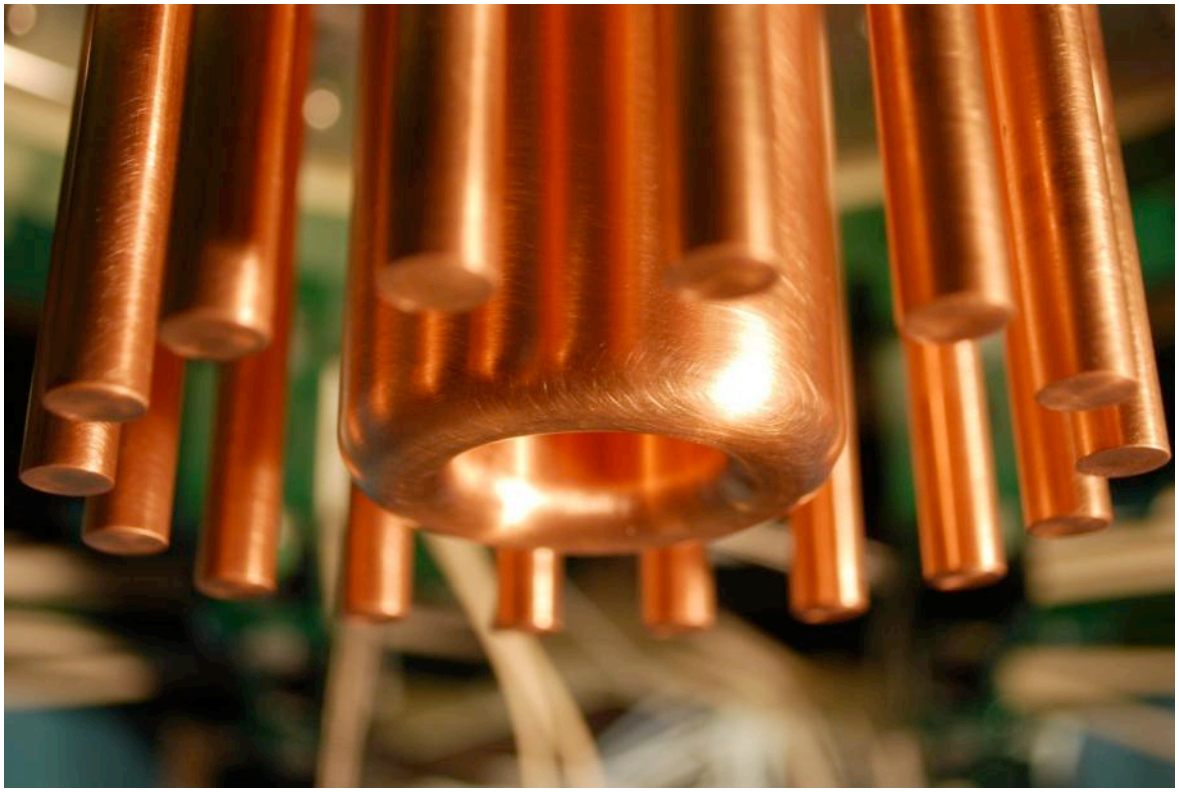
Sub-Millimeter, High-Ion-Energy Plasmoids In A Dense Plasma Focus



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Focus-Fusion-1
Dense Plasma Focus

8-capacitor configuration

Stored energy	**43 kJ**
Capacitor potential	**34 kV**
Capacitance	**75 μF**
Peak current	**0.92 MA**
Pressure	**10-16 torr**

Key Feature: Small electrodes for MA DPF

(5 cm cathode, 2.8 cm anode)

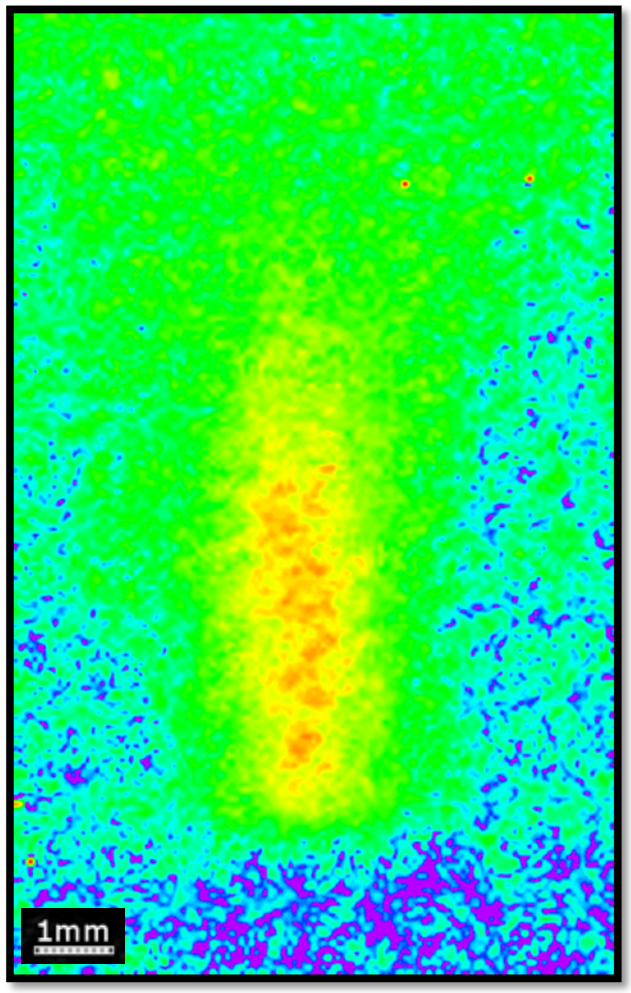
Where are the Neutrons Produced?

Up to 10^{11} DD neutrons per shot

Questions:

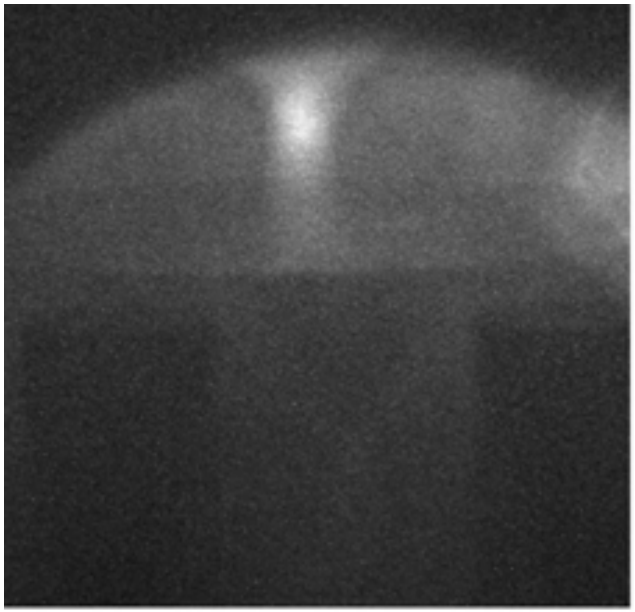
- **From confined ions in plasmoid or unconfined beam?**
- **Plasmoid: volume? Ion energy? Density? Confinement time?**

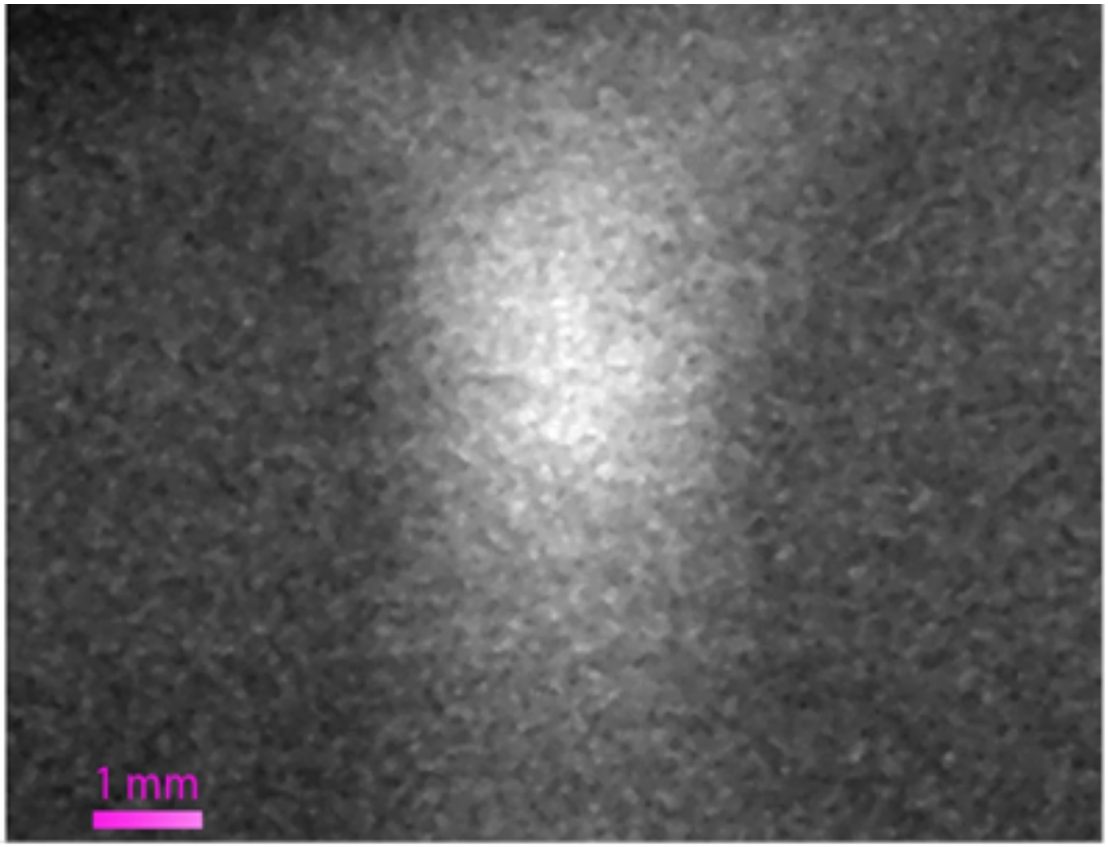
Kinking pinch
Shot 101402



200 ps exposure, 85 ns before pinch peak, 30 kV, 13 torr

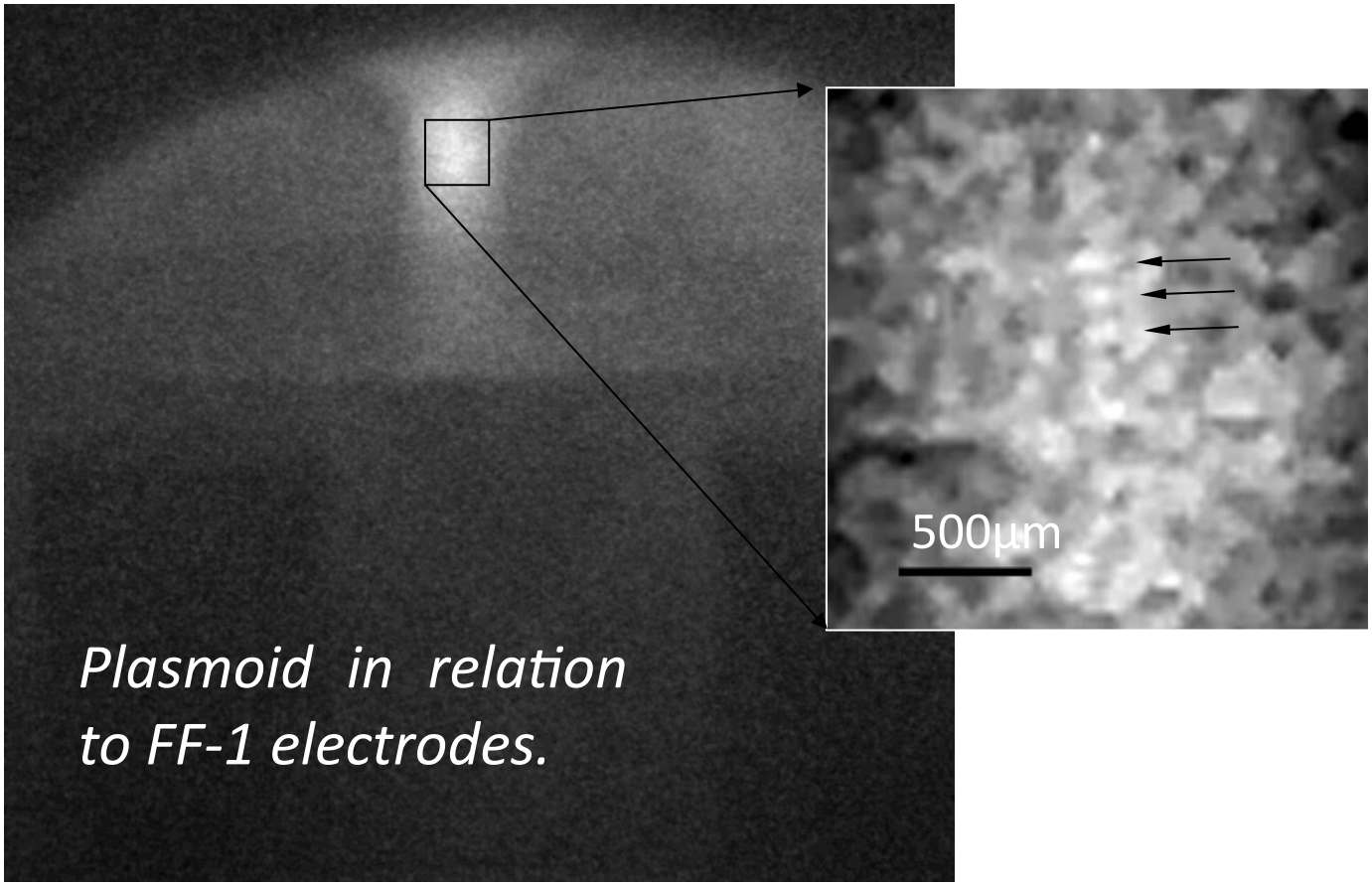
Imaging the plasmoid, shot 01241103



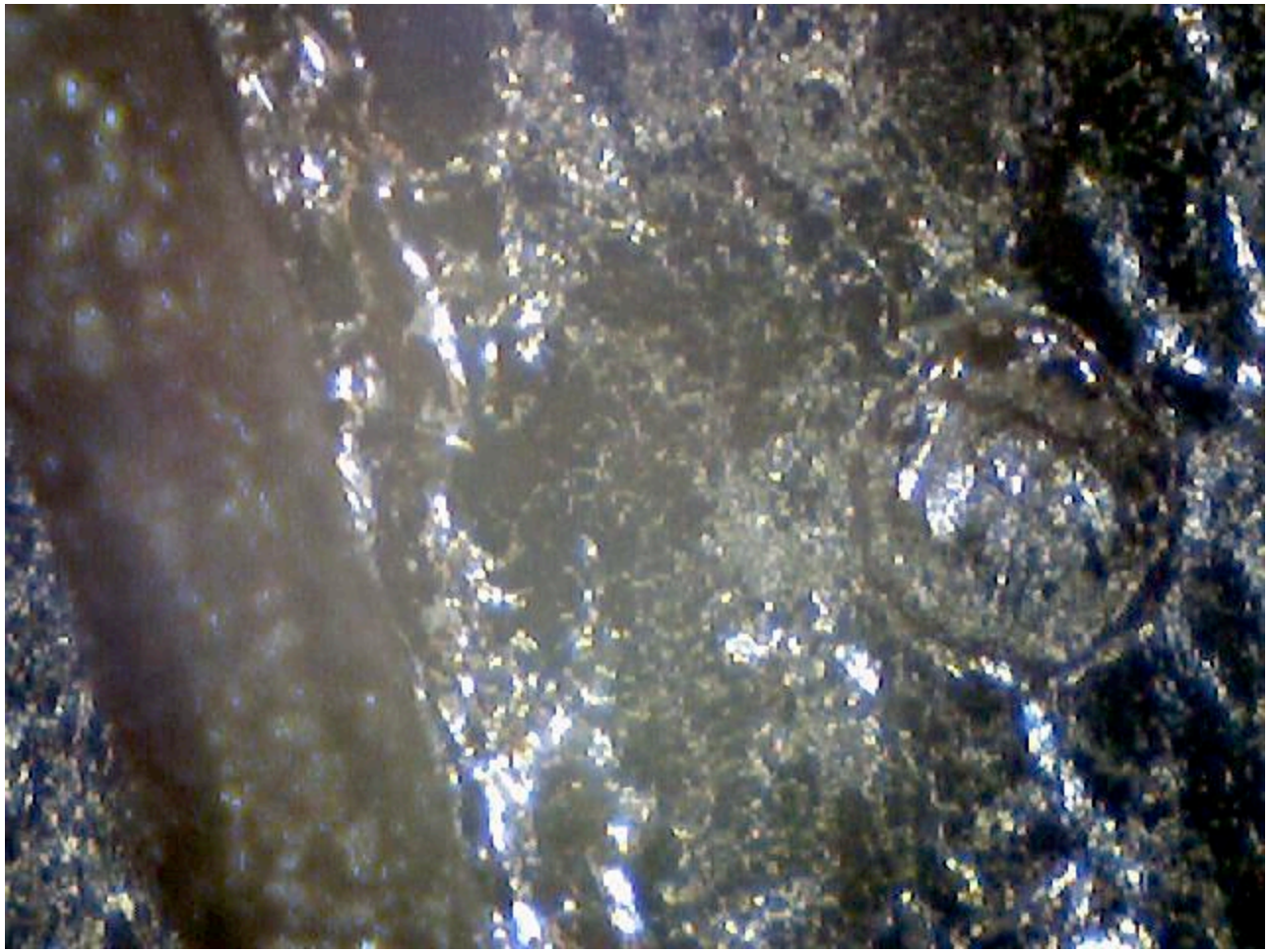


Above, plasmoid in relation to FoFu-1 electrodes. At right, close-up on plasmoid with scale bar.

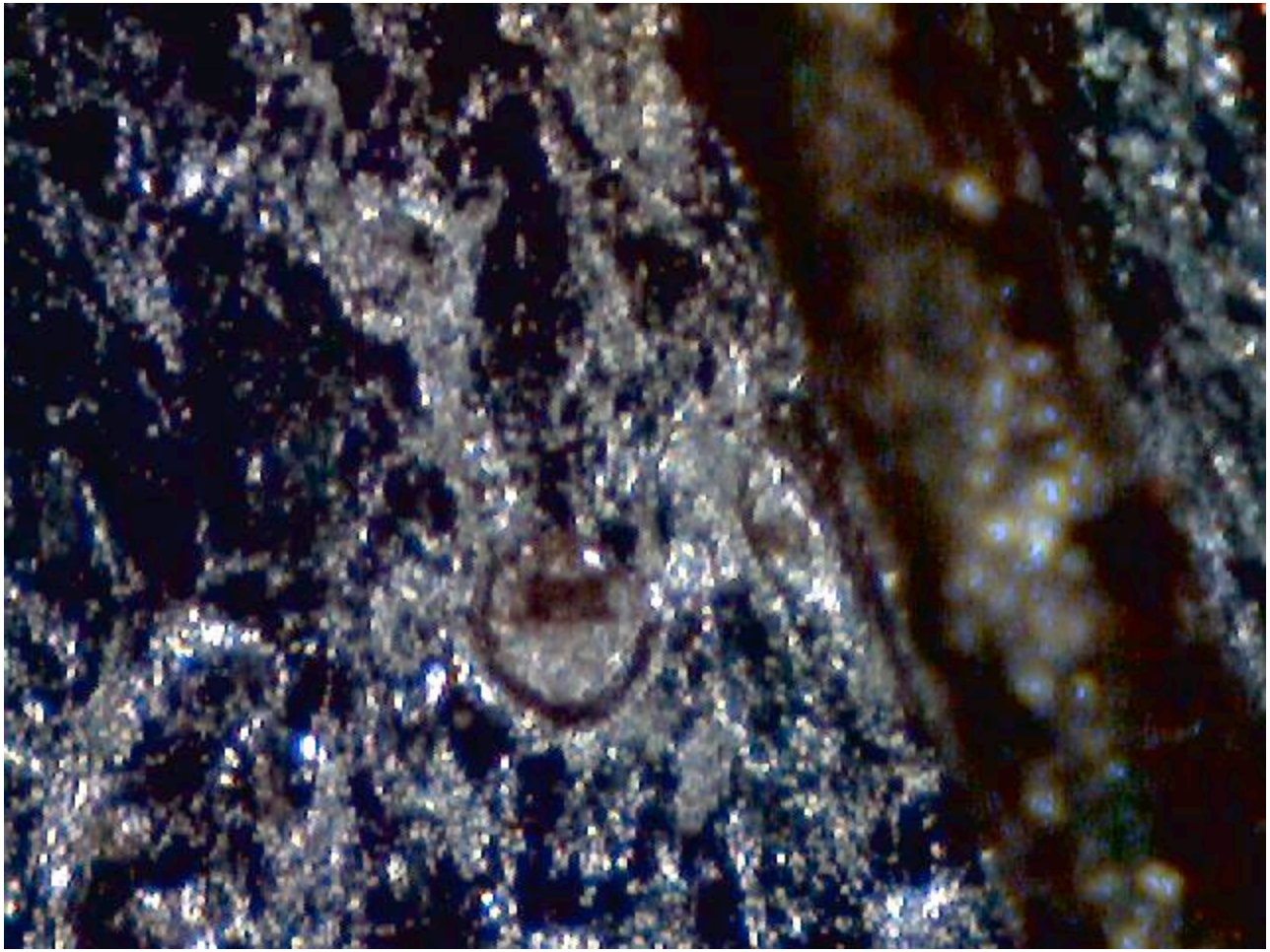
Record 30 μm resolution



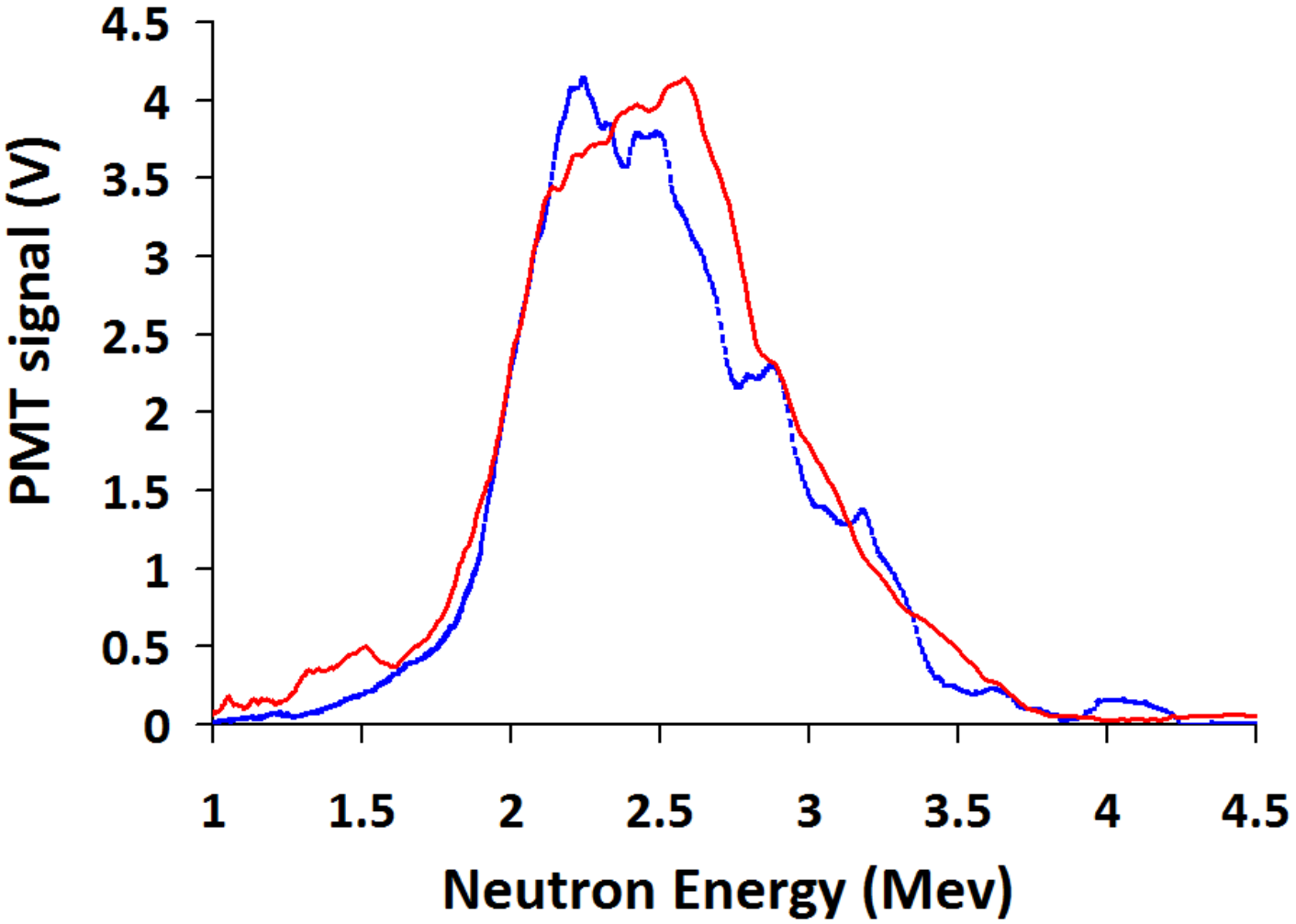
Ion Beam Filaments



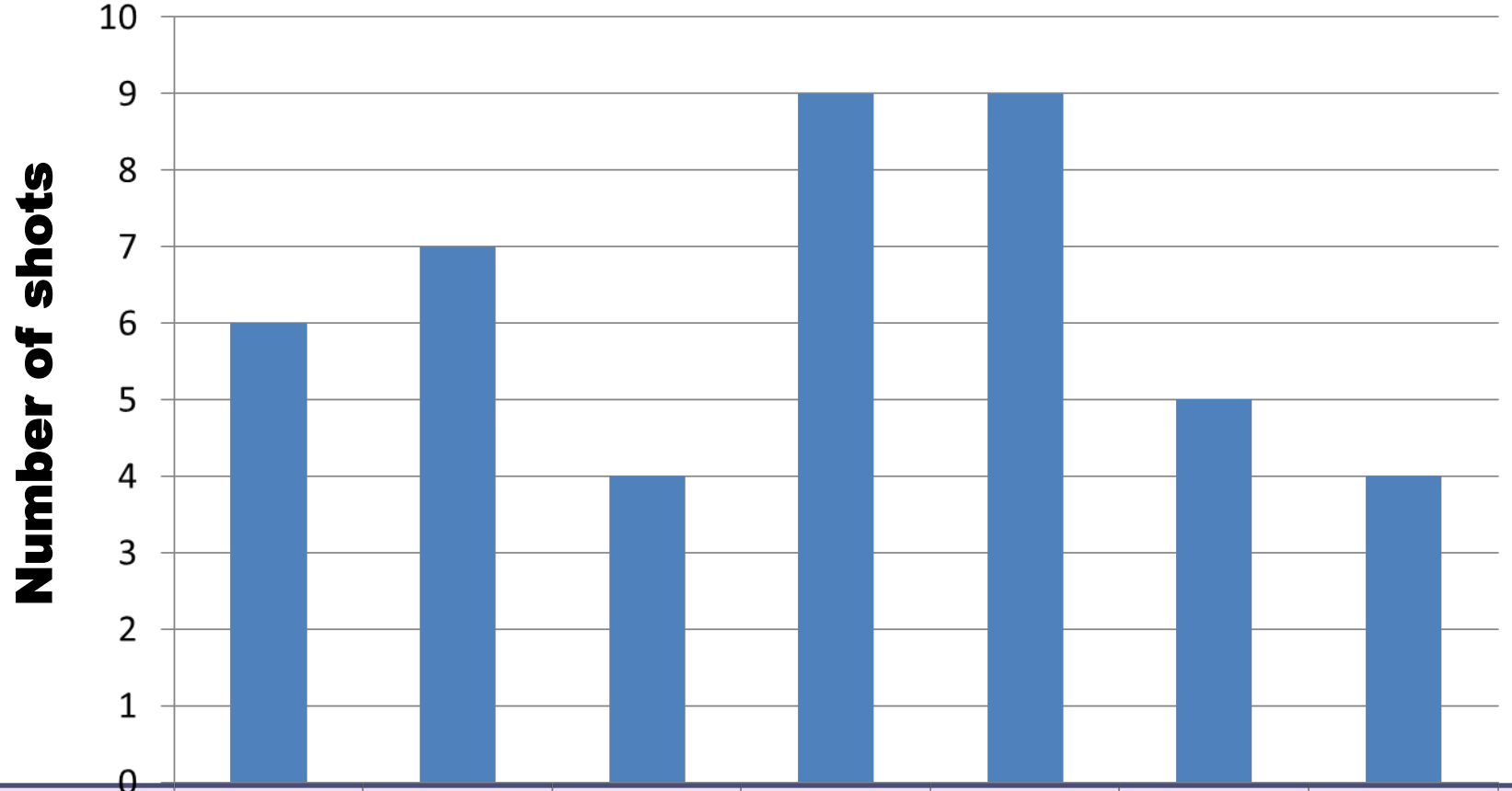
More Filaments



RECORD FWHM of 960 ± 40 keV

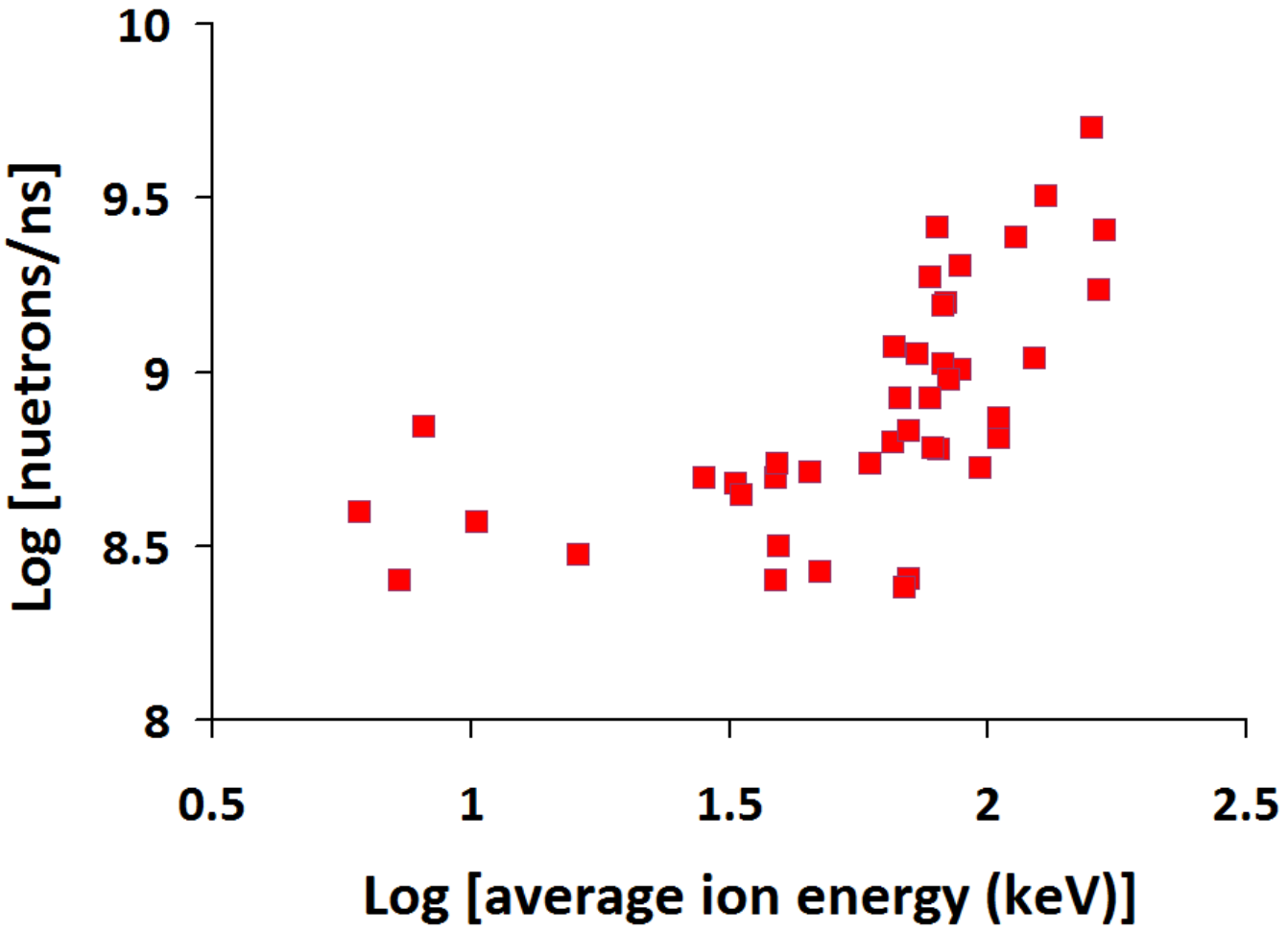


Distribution of Average Ion Energies

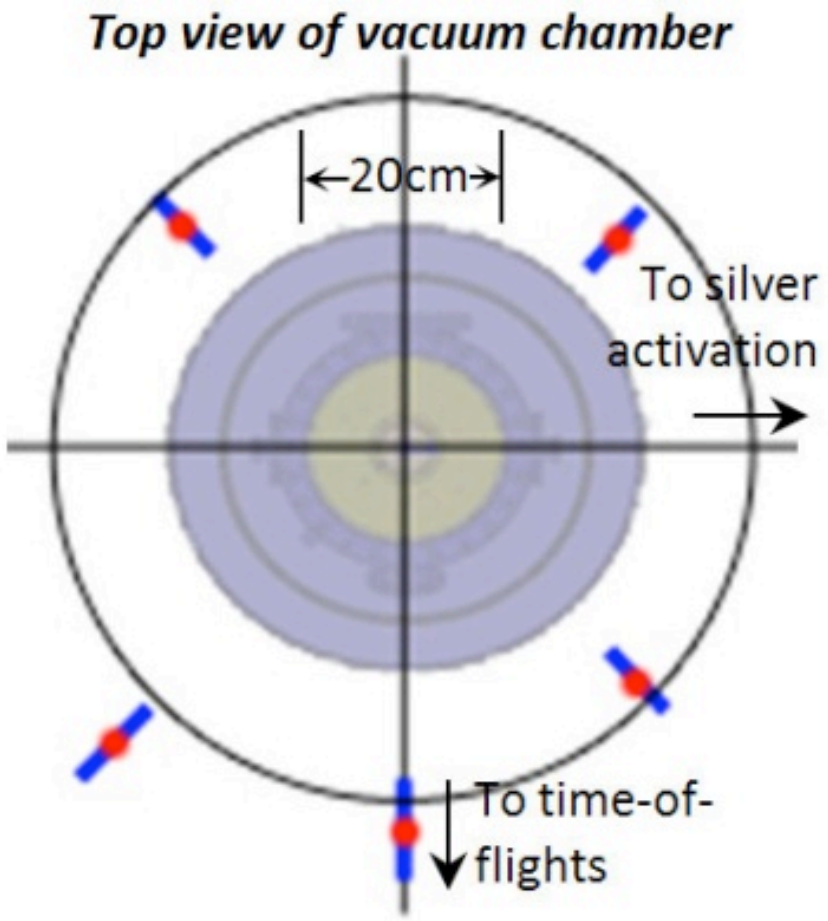


FWHM (keV)	0-320	320-450	450-560	560-650	650-720	720-880	>880
E_i (keV)	0-20	20-40	40-60	60-80	80-100	100-150	>150

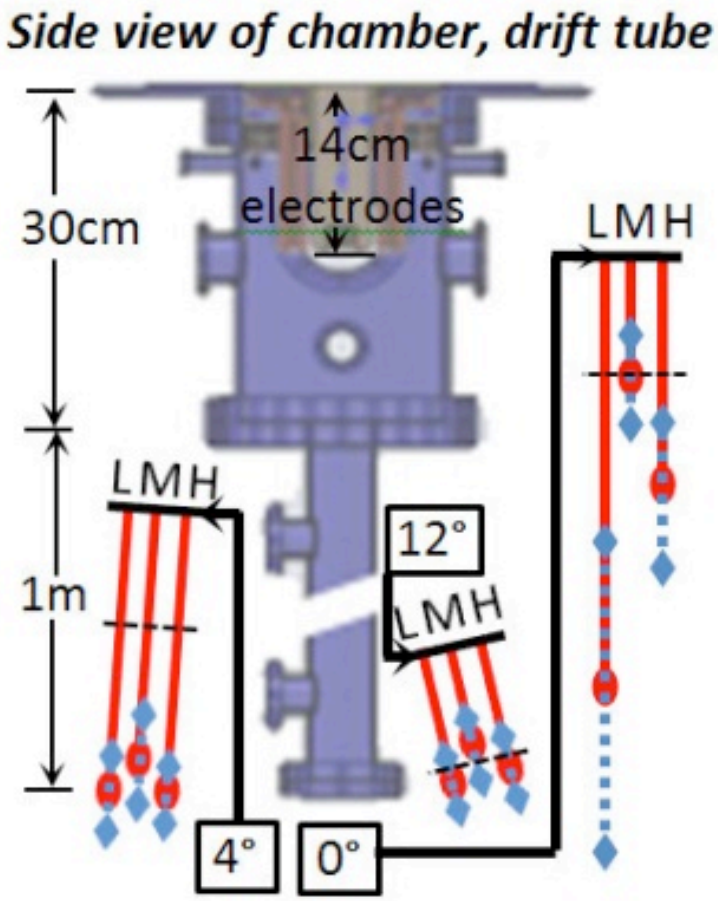
Correlation between fusion power and average ion energy



Anistropy of neutron flux



Anistropy of neutron flux



Low Anisotropy Rules Out Beam as Main Source of Neutrons

- 0 degree detector highly sensitive to beam at 128 cm, <0.3% of neutrons
- 12 degree lack of anisotropy allows beam at 16 cm only <4.5% of neutron
- Ion Beam TOF shows E~0.25-0.5 Mev
- For unconfined beam-plasmoid expect anisotropy of 2.6, measure <1.25 so <15% of neutrons

Comparison with PF-1000

- **Plasmoids 30x smaller in radius, length**
- **Much smaller anisotropy, larger plasmoid neutron production**
- **Main reason:4x smaller electrodes 16x higher density**

Conclusions

- **>80% neutrons from plasmoid**
- **$3x10^{19}$/cc<n< $5x10^{20}$/cc**
- **Radius ~ 200 μm , length~ 1.5 mm**
- **Confined ion energy E_i > 150 keV**
- **Lifetime 30-60 ns**

- **Conditions of interest for pB11**
- **Thanks to: Reece Arnott, Ivana Karamitsos for help with data reduction**