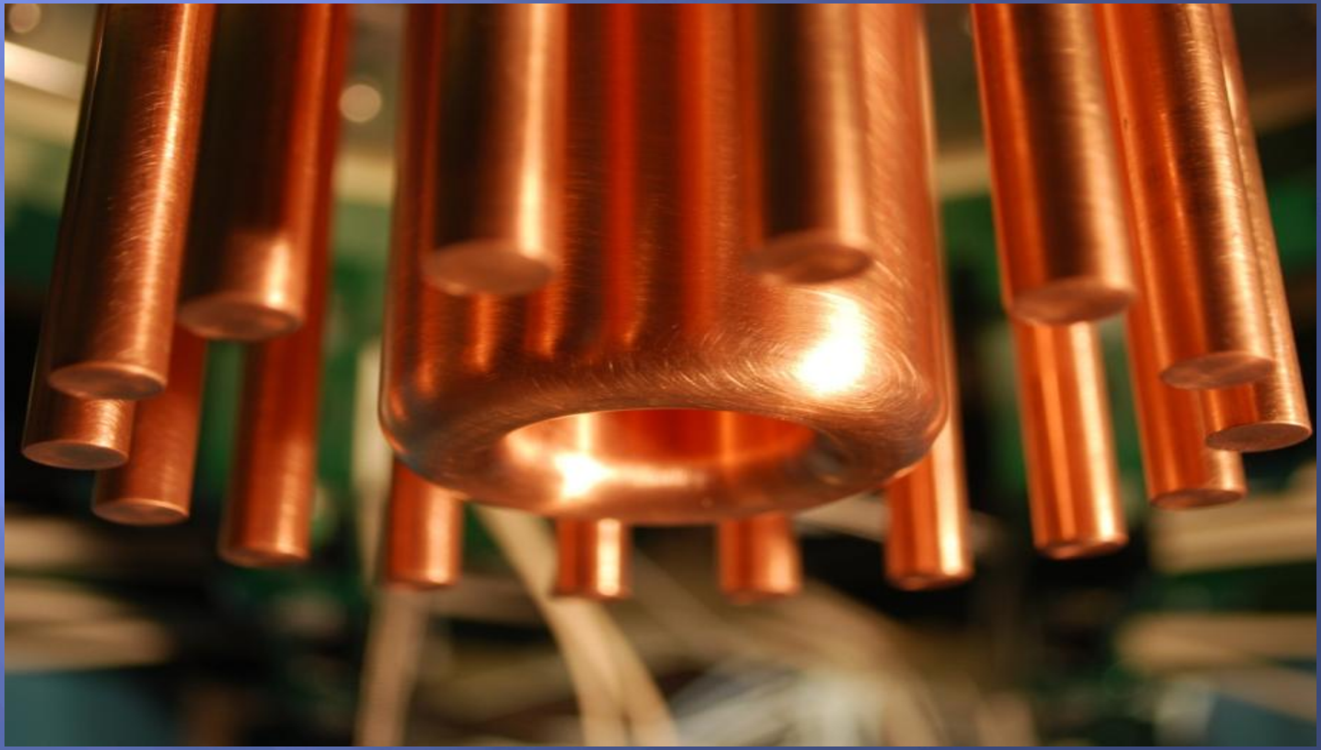
Aneutronic Fusion with a Dense Plasma Focus Device Results and Plans



Lawrenceville Plasma Physics

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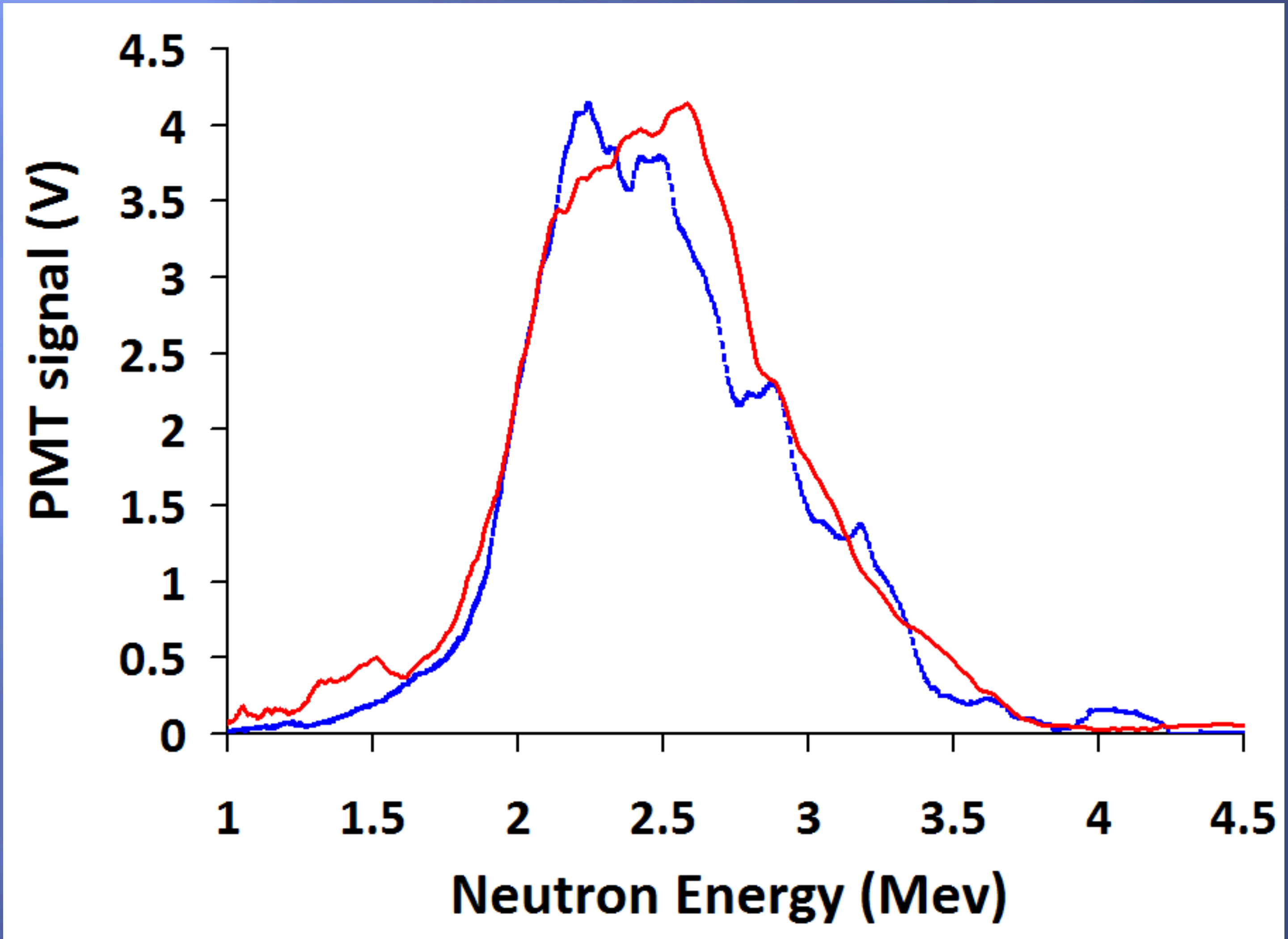
Focus-Fusion-1

8-Capacitor Configuration

Stored energy	43-60kJ
Capacitor potential	35-40 kV
Capacitance	75 μF
Peak current	1.2 MA
Pressure	10-30 torr

Key Feature: Small electrodes for MA DPF
(5 cm cathode, 2.8 cm anode)

Ion energy of 160 keV



Low Anisotropy Rules Out Beam as Main Source of Neutrons

- 0 degree detector <0.3% of neutrons
- 12 degree <4.5% of neutron
- For unconfined beam-plasmoid expect anisotropy of 2.6, measure 1.25 so <23% of neutrons
- So >70% from confined ions

Duration & Density

- From neutron TOF, images: duration~ 10 ns
- 30 ion orbits, 200x Alfven time
- From $1.7x10^{11}$neutron yield, volume:

Density ~ $8x10^{19}$/cc

Neutron calibration-thanks to PPPL

How do we get it so hot?

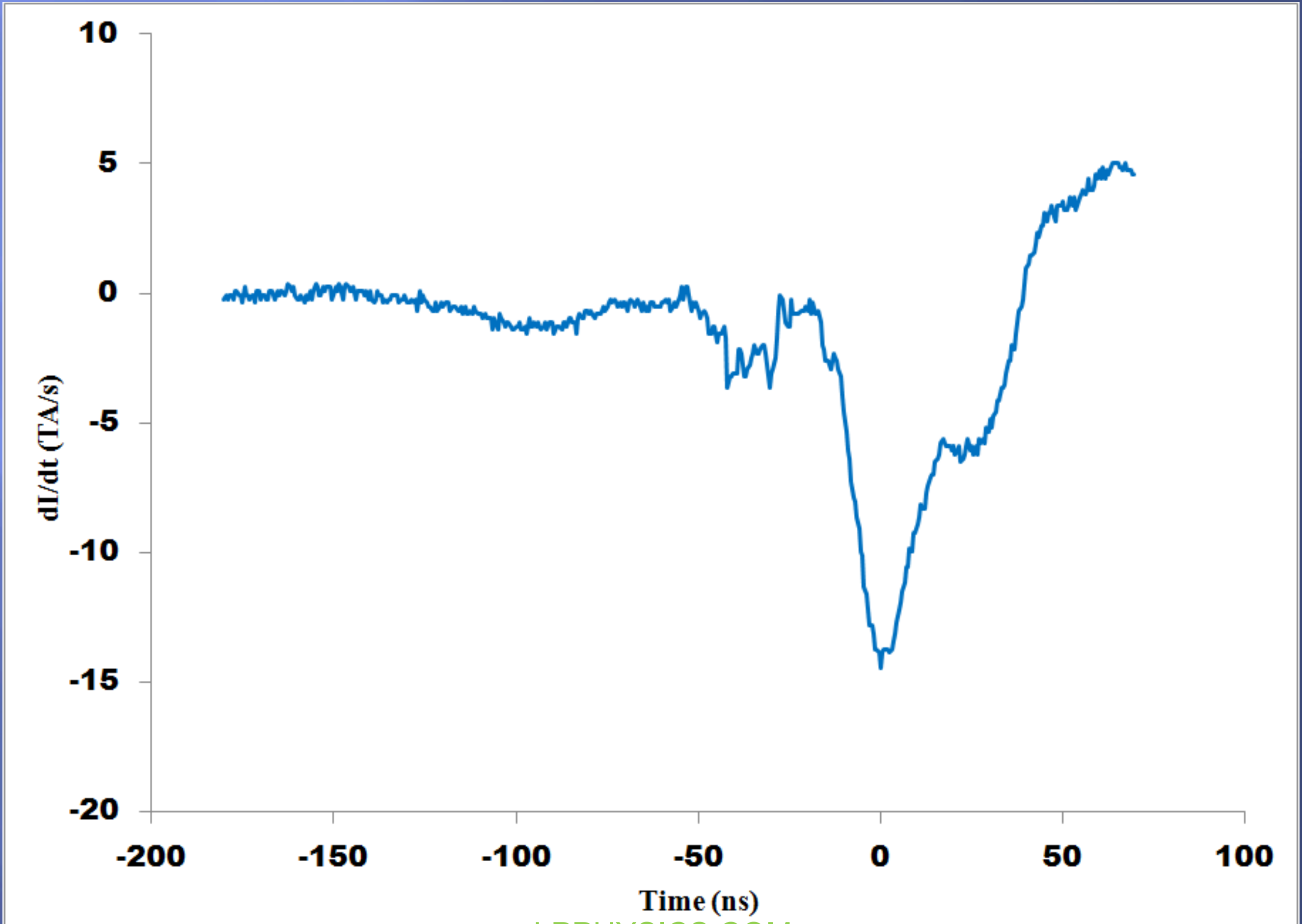
Viscous heating (Haines, Abolhasani) heats plasmoid

Theory shows $T \sim B^{0.4}$

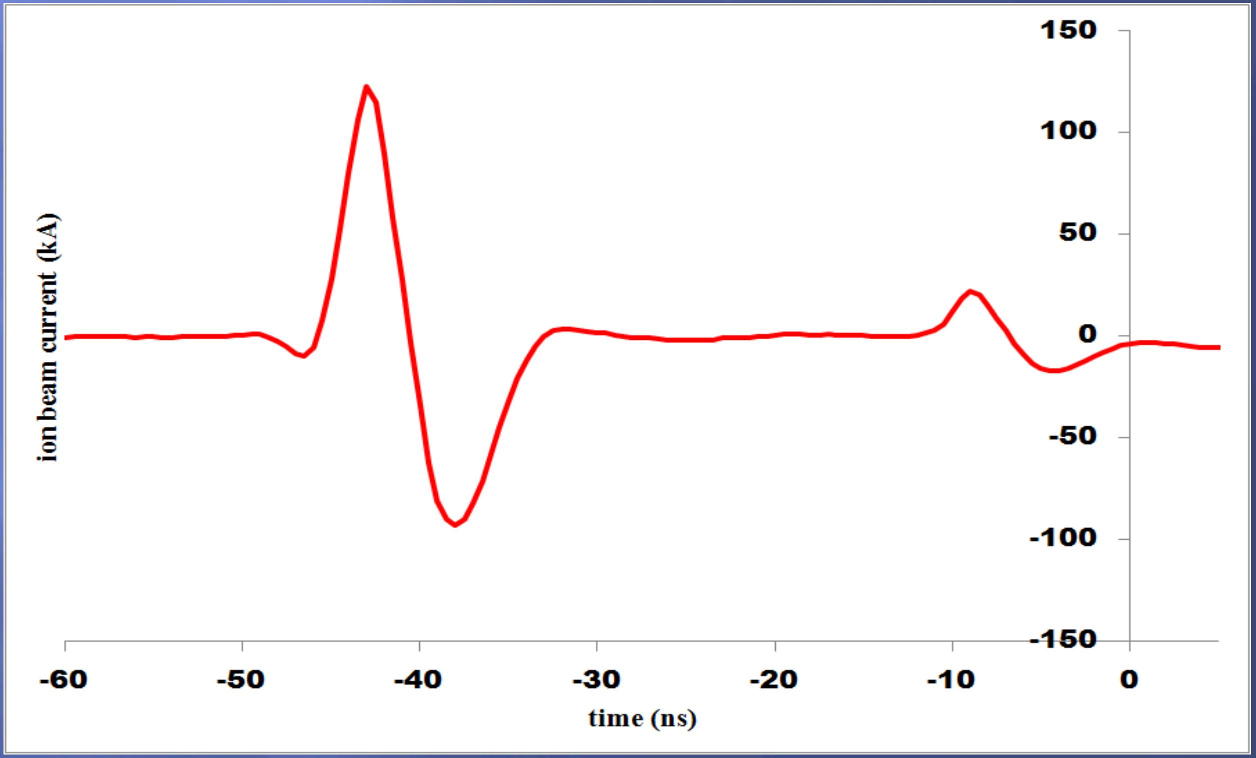
Our smaller electrode size leads to higher B

At higher currents, electron beam causes wave heating as well

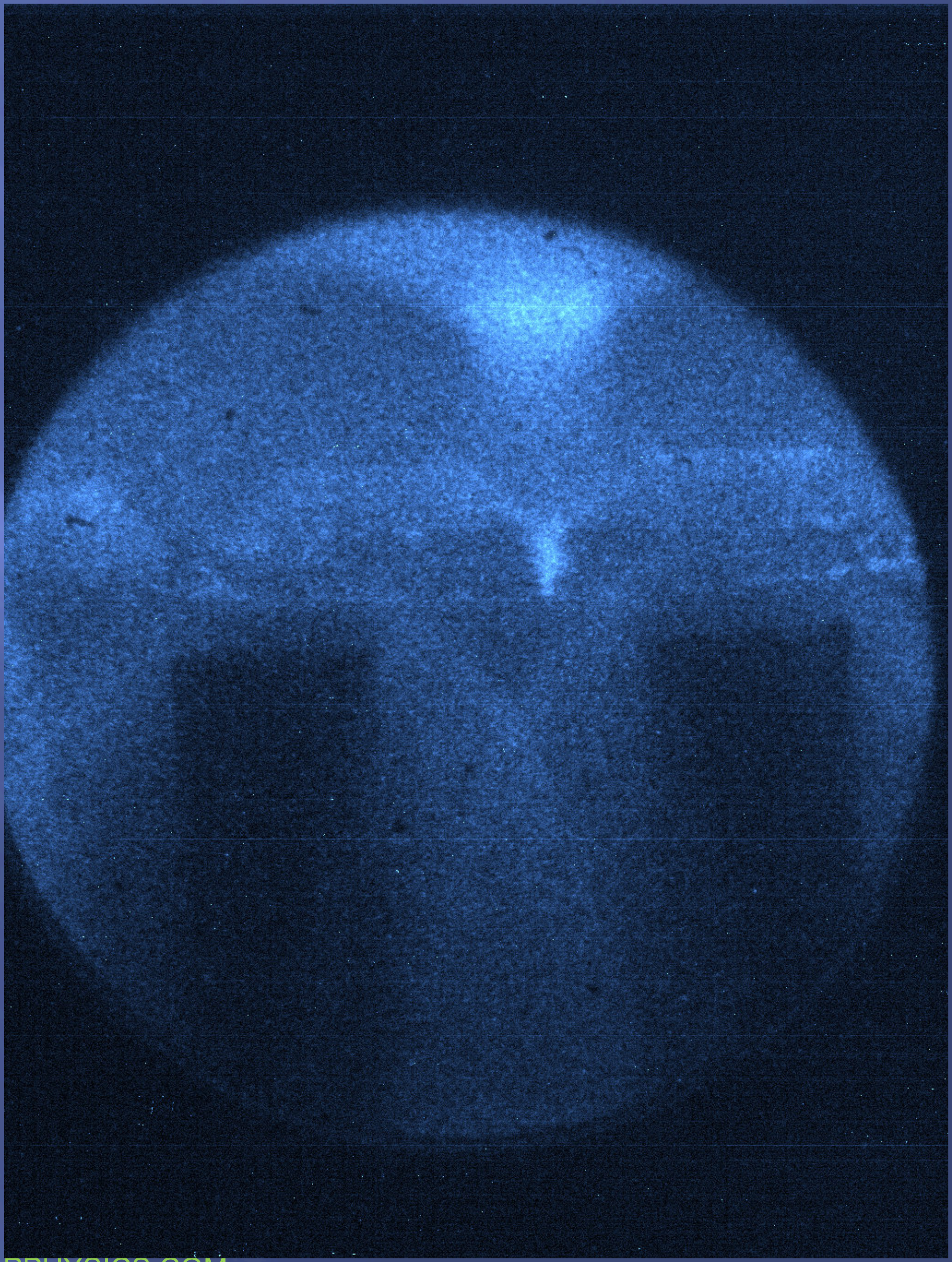
Hurdles to Higher Density: Early Beam



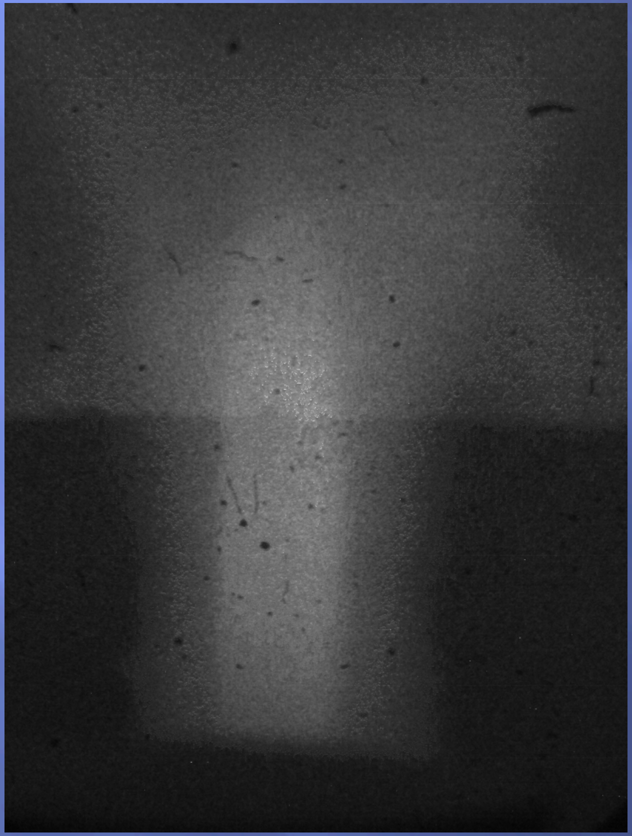
2kJ Ion Beam Is Emitted 30-50 ns before Pinch



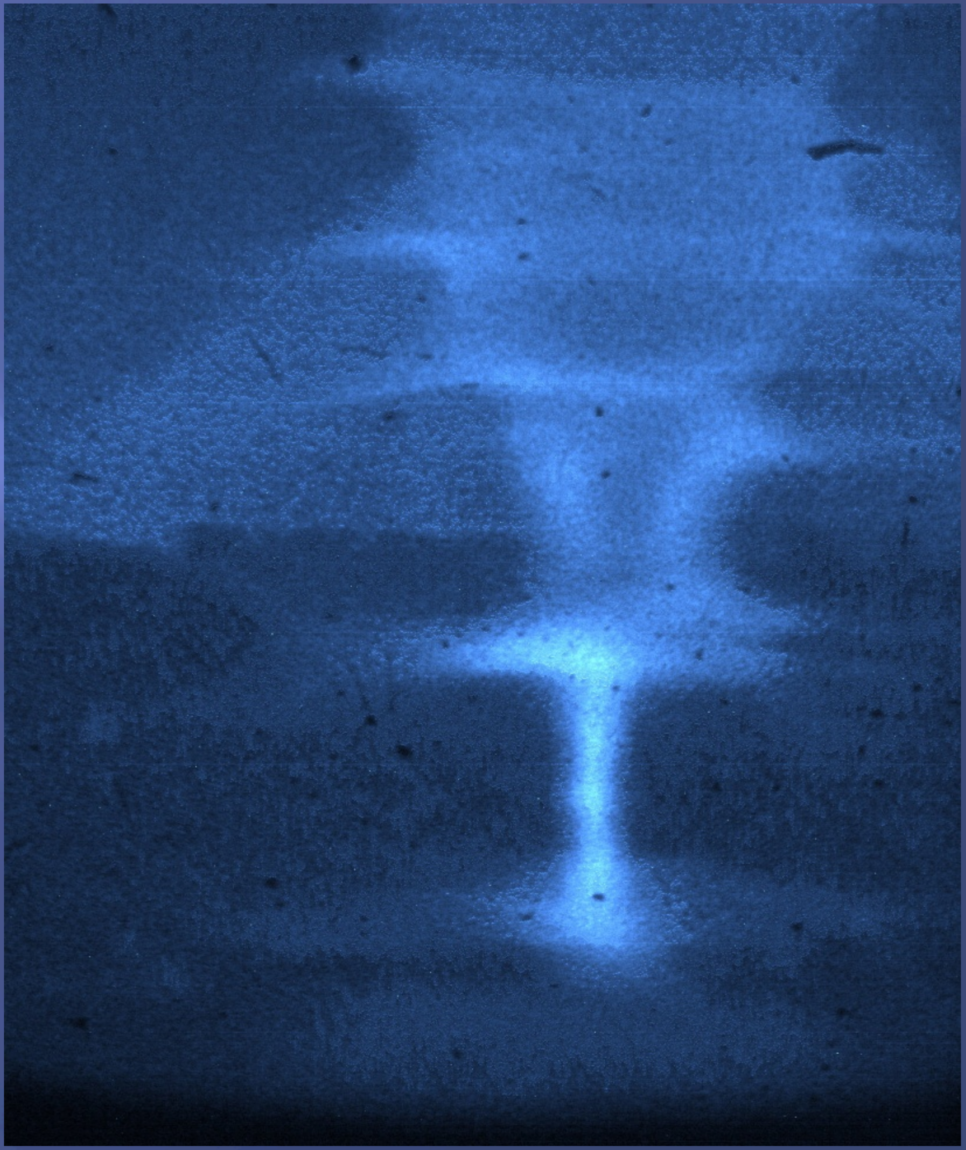
Split Sheath Causes Early Beam



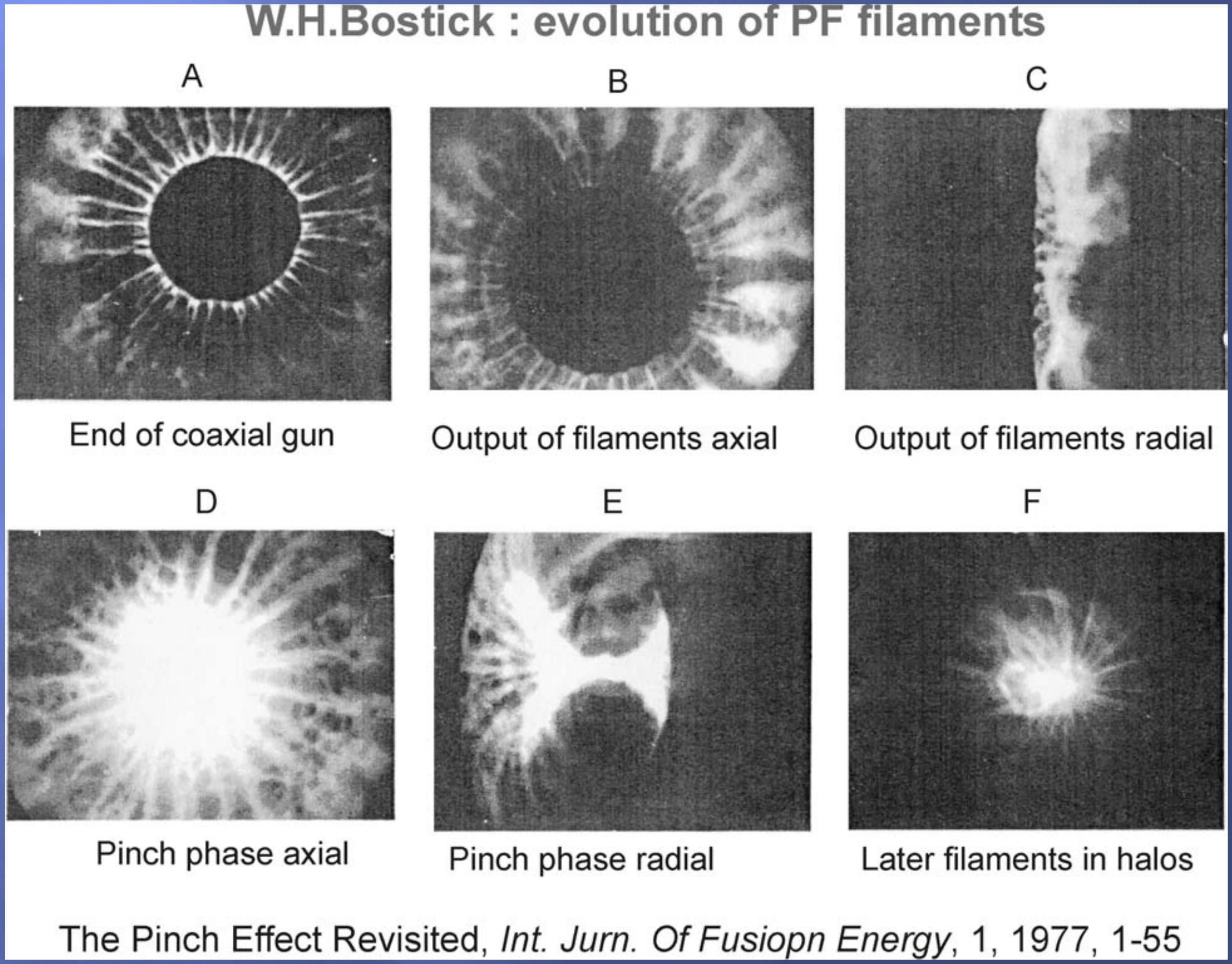
First sheath forms plasma jet—Sausage instability follows



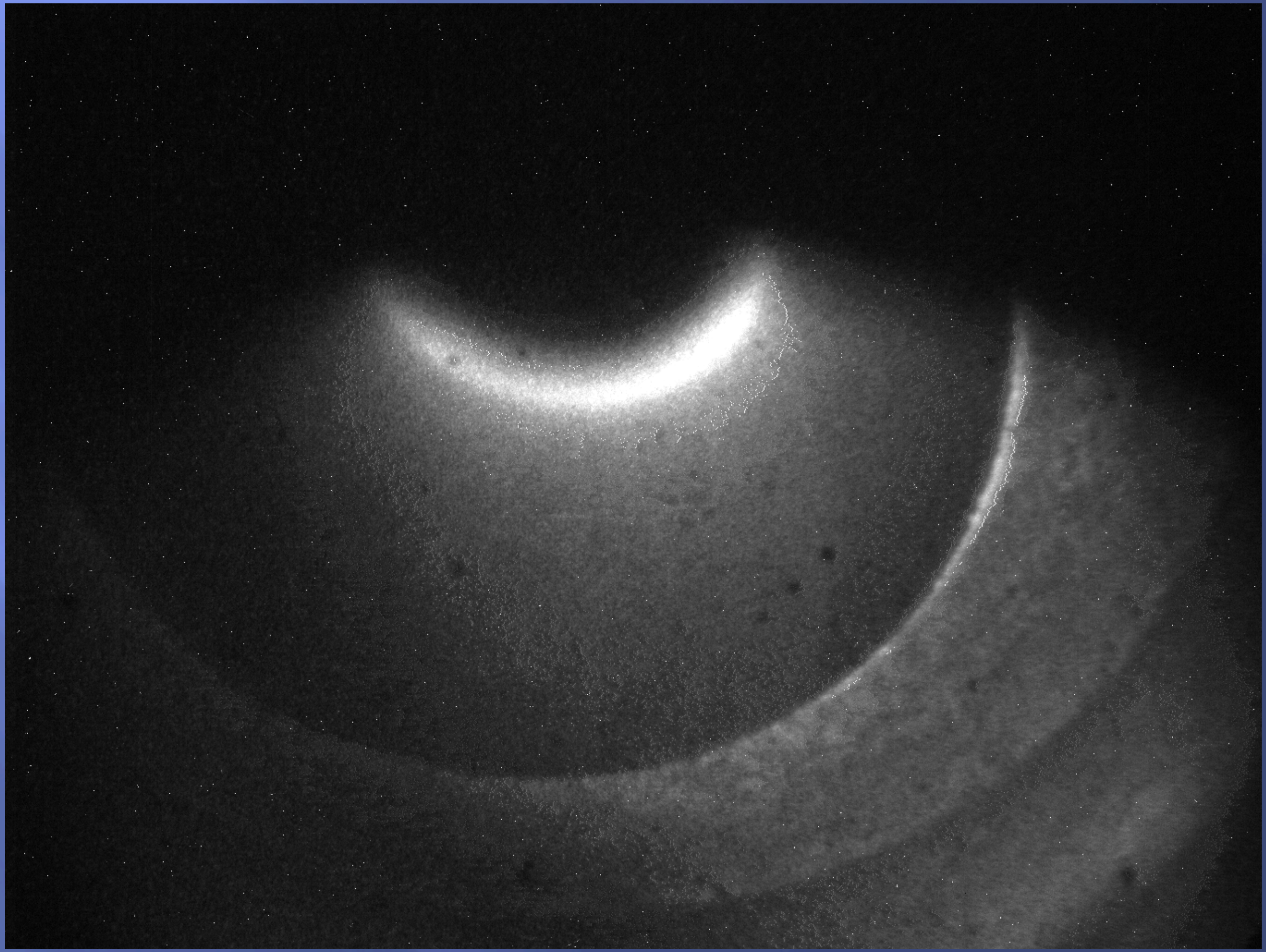
Plasmoid, 8 ns after pinch 200 micron radius



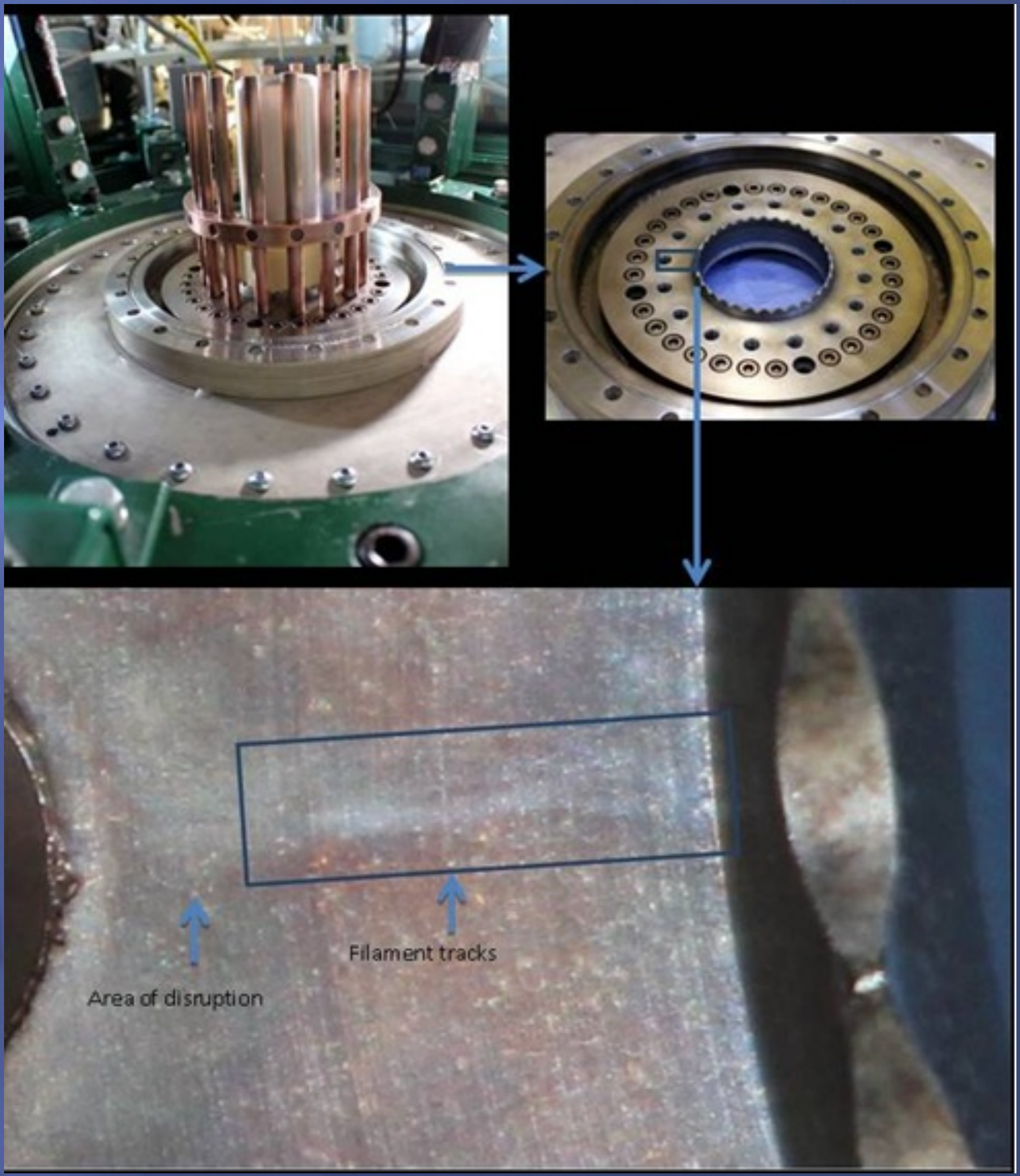
What We Should See



What we actually see

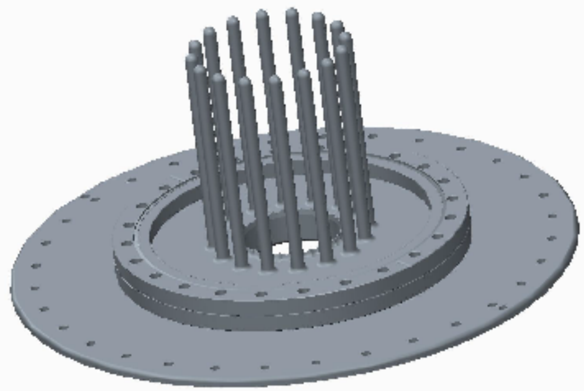


Filament Disruption by Arcing Leads to Split Sheath



Solution:

Monolithic W-Cu cathode



Path to Higher Density

- Preserve filaments to get theoretical density—8×10^{21}/cc
- Increase current to 2.8 MA, shorten electrodes--4×10^{22}/cc
- Heavier gases, mixtures, pB11--10^{24}/cc

Quantum Magnetic Field Effect

Angular momentum quantized,

Landau energy levels:

E_b = (n+1/2) ehB/mc =11.6eVB(GG)

Since maximum momentum transfer is mv, where v is relative velocity, for $mv^2/2 < E_b$ very little excitation from ground level, very little energy transfer.

E_i <(M/m) E_b

For E_i =300keV,

B>14GG for p

B>3.5GG for a

B>1.3GG for 11B

Quantum Magnetic Field Effect

New Idea:

QMFE acts only for ions moving parallel to B field—those moving perp to B will lose energy rapidly to electrons

Electrons act to "herd" ions in B direction

Ions preferentially moving along B field will have relative velocities enhanced by $3^{0.5}$

Thus effective T could be enhanced by 3

Summary

Results:

- 160 KeV confined >10 ns
- 10% energy transfer to plasmoid
- Density $8x10^{19}$/cc

Plans:

- Eliminate impurities, preserve filaments with monolithic tungsten cathode
- Concerns—will tungsten take thermal stress?