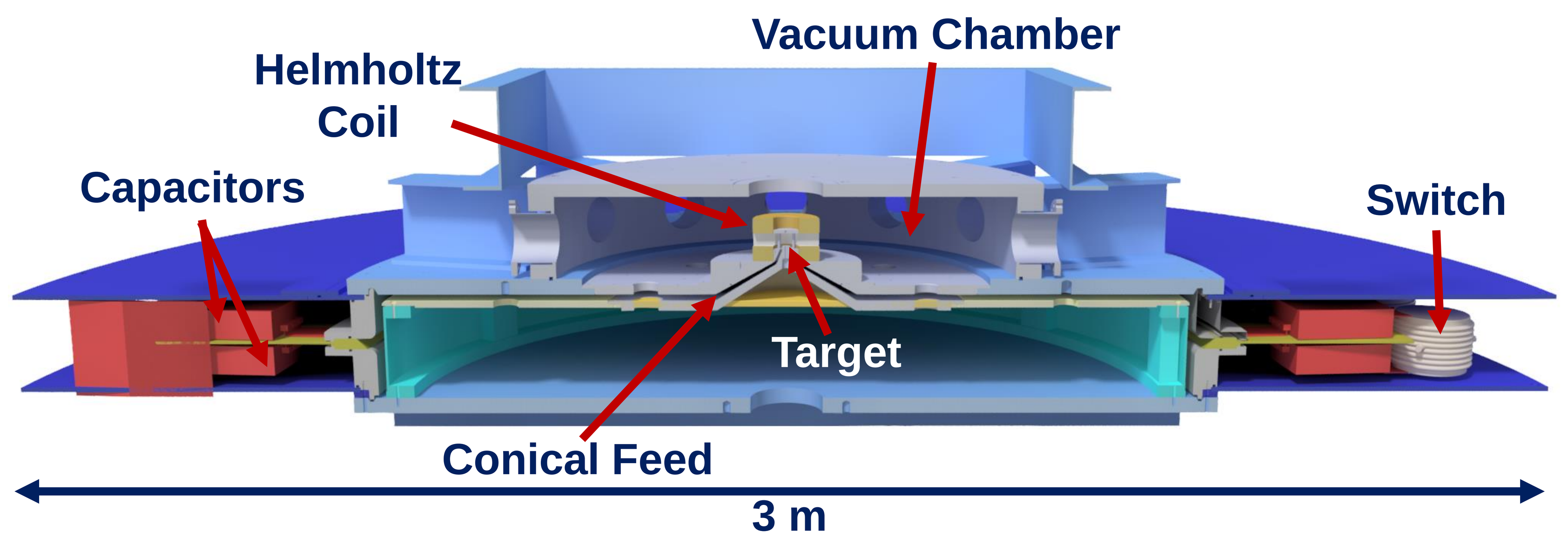
Pulsed-power magnetized jets for laboratory astrophysics at MAIZE

Raul Melean, Rachel Young, Sallee Klein, Trevor Smith, George Dowhan, Paul C Campbell, Nicholas Jordan, Ryan McBride, Carolyn Kuranz.

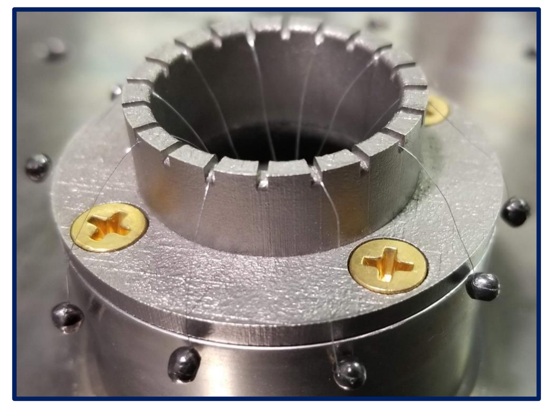
Center for Laboratory Astrophysics & Plasma; Pulsed Power and Microwave Laboratory

UNIVERSITY OF MICHIGAN

MAIZE Linear Transformer Driver

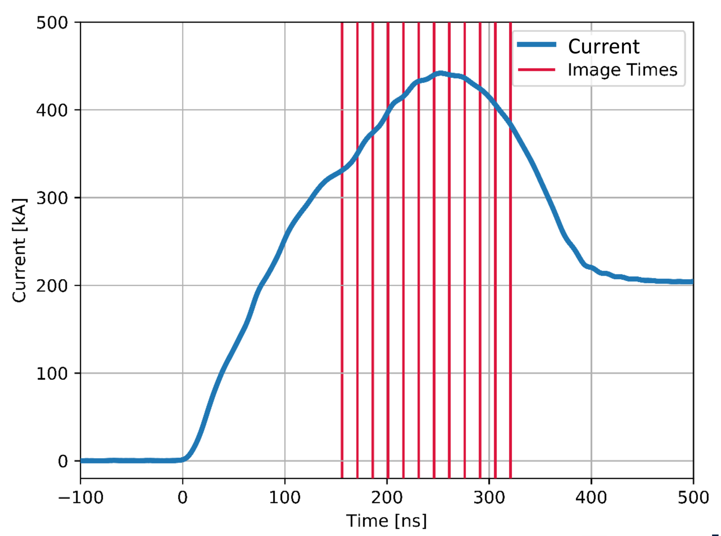


Magnetized plasma jets are created at the Michigan Accelerator for Inductive Z-Pinch Experiments (MAIZE) lab, using the Linear Transformer Driver (LTD). MAIZE can reach 1 Mega-Amp of current, with a 100 – 250 rise time.



Target
- 10 wires
- Aluminum
- 100 µm
- 37° wire angle

LTD Current Profile at ±60 kV

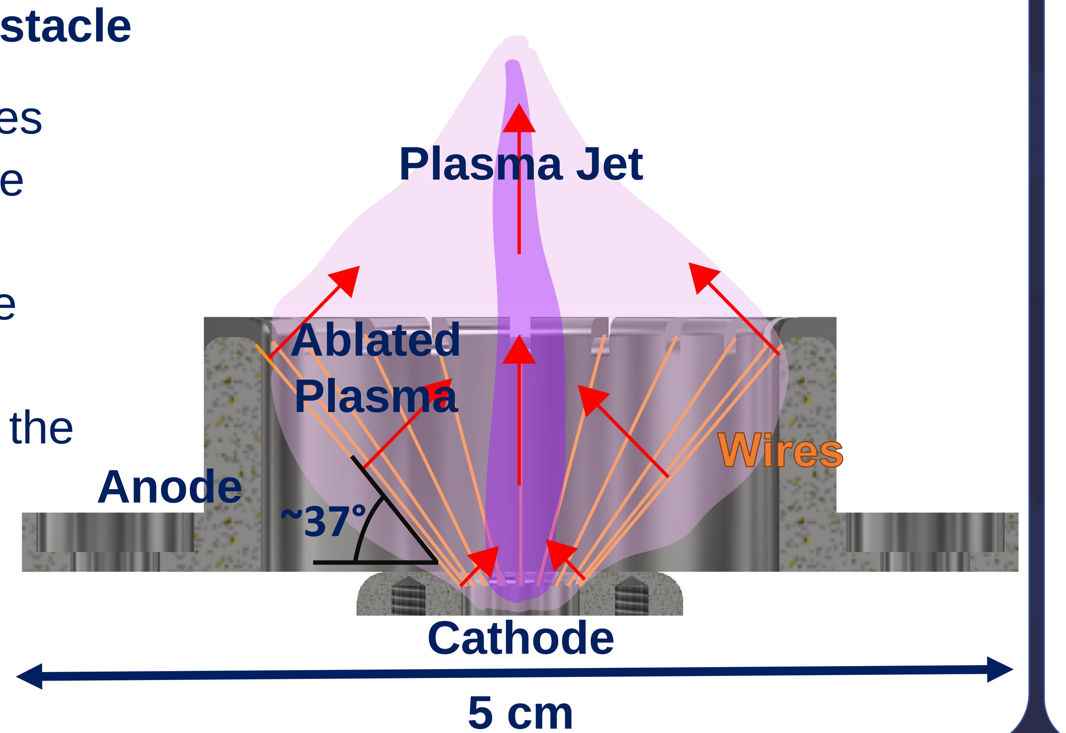


Calibrations and Diagnostics
- Self Emission: Fast Camera (up to 200,000 fps, 5 ns gate)
  - Speed of plasma flow
  - Structure of shock
- Rogowski coil and B-dots
  - Current
  - Magnetic Field

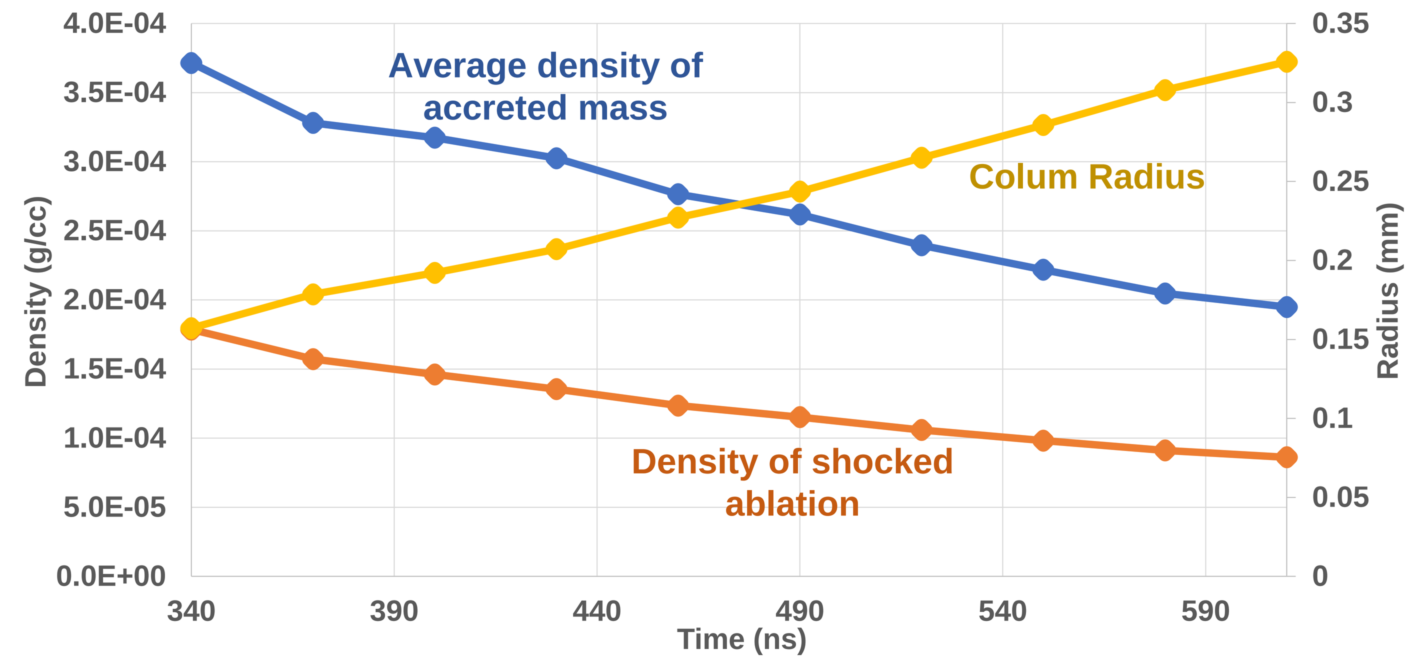
Experimental Set-Up

Conical wire array creates a plasma jet that is driven into the obstacle

- Current pulse ablates the wires
- The wires are stationary in the experiment time scale
- Ablated plasma collides in the center, creating a narrow jet
- An external B-field parallel to the jet "funnels" the plasma



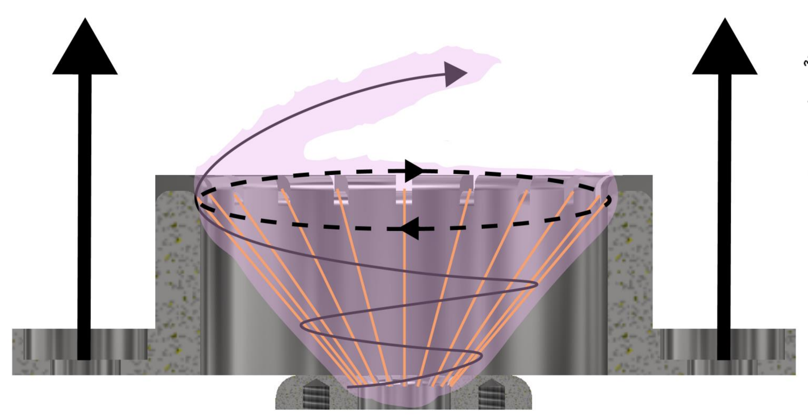
Hydrodynamics let us estimate plasma parameters

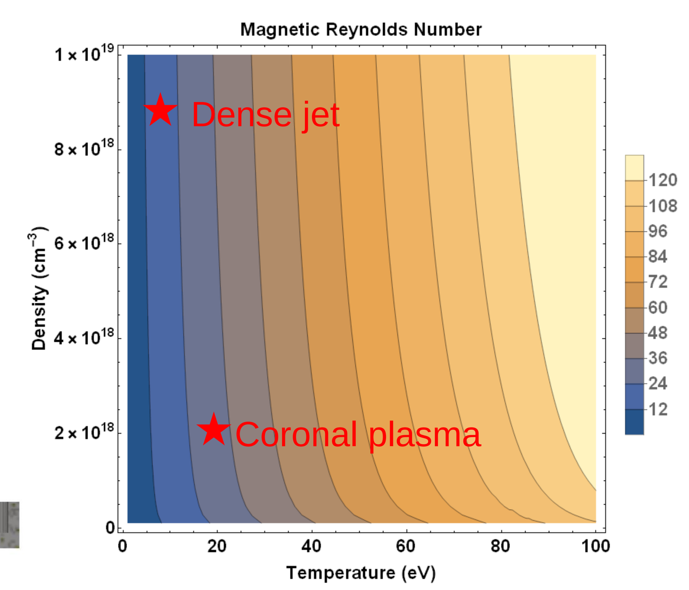


- **Mass accretion rate from MHD rocket model***
- **Average density from mass conservation**
- **Increase in density from shock conditions**
- **Early shock on the axis creates the inner jet**
- **Shock on the coronal plasma creates a layer of "streamers"**
- **The optically thin plasma does not absorb significant radiation**
- **Rapid radiative cooling increases the density by 10-100**

*Lebedev, et al. (2001). *Effect of discrete wires on the implosion dynamics of wire array Z pinches*.

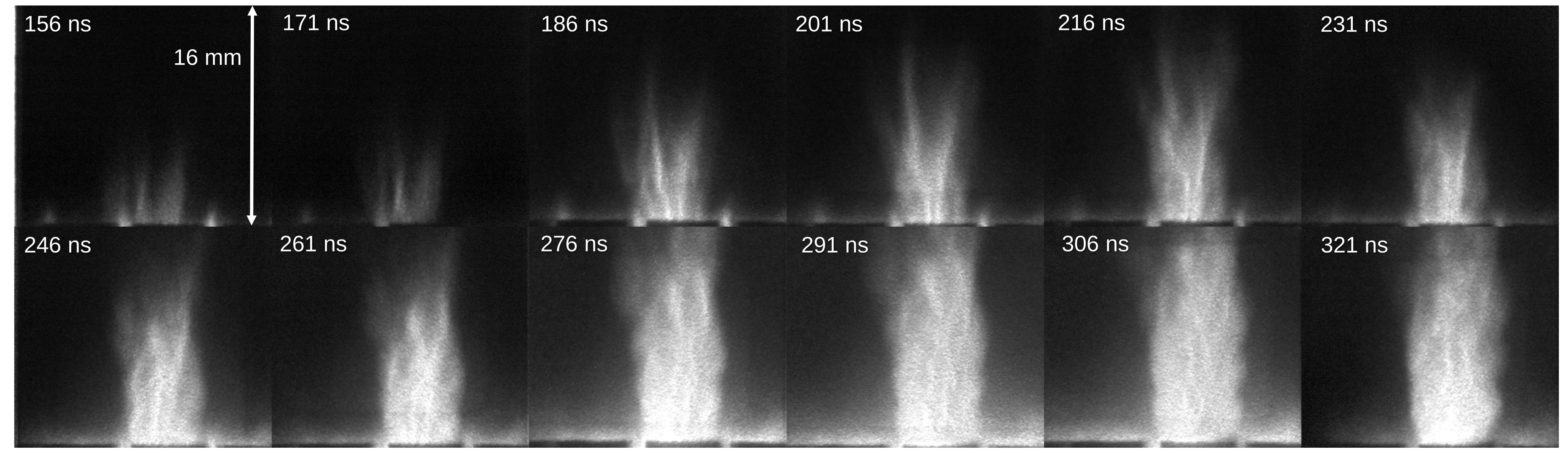
Adding an external B-field creates tension in the frozen field



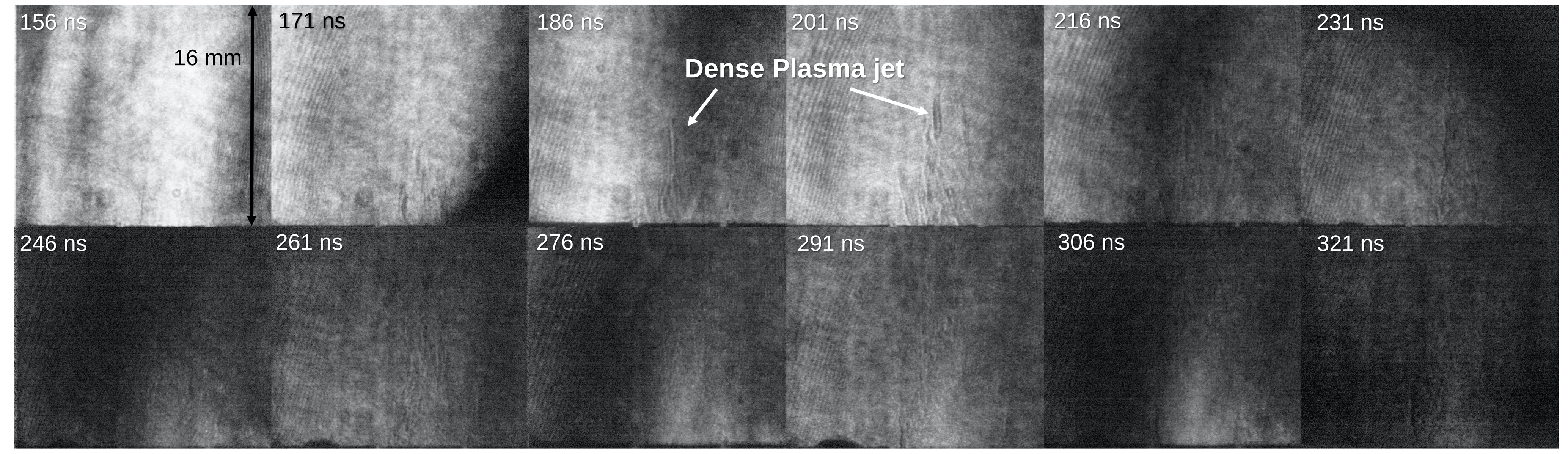


- **The field is frozen in and advected by the plasma**
- **The cold wires are more resistive than the plasma**
- **The plasma is flung out by the combination of magnetic tension and magnetic pressure (total $\vec{J} \times \vec{B}$ force)**

Jet Evolution

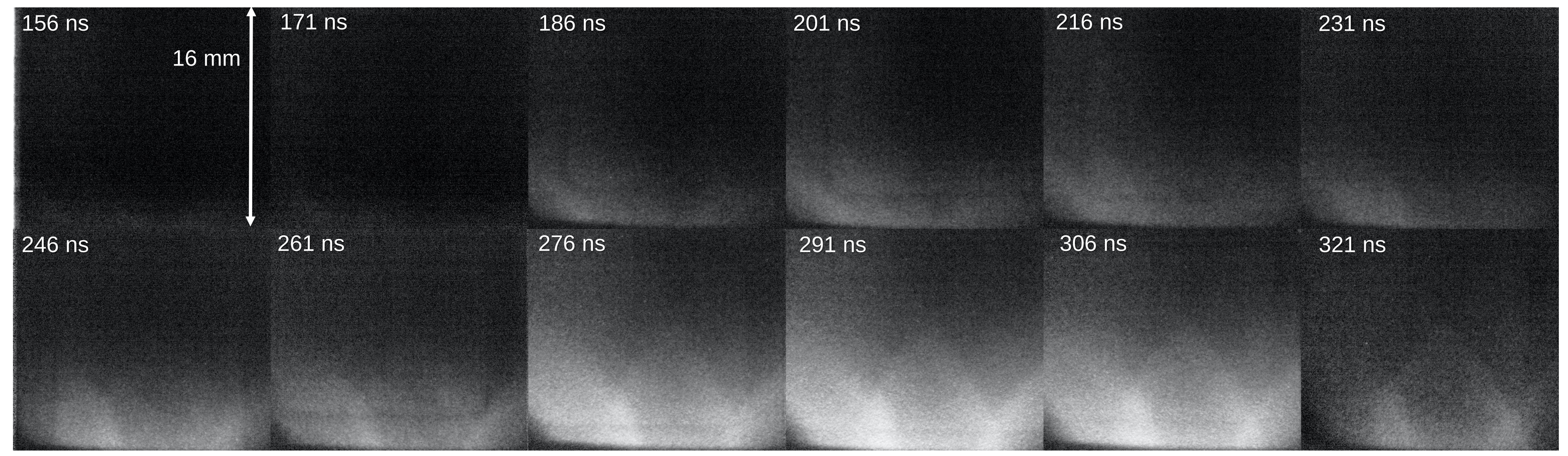


Self-emission of the jet. Streaming filaments of a hot coronal, 20 eV plasma. Estimated low density ~10^{-6} g/cc, and features a divergent cone.



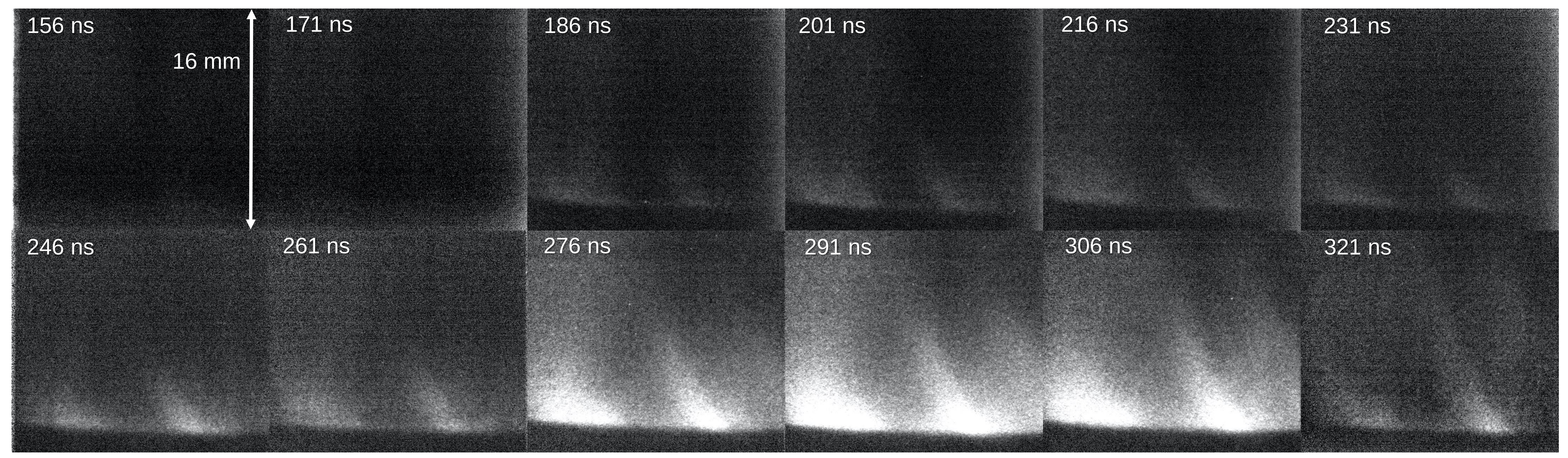
The expansion of the jet has been imaged with backlit laser shadowgraphy, making the central dense jet visible.

The jet's upward speed can be measured at around 100 km/s.



A uniform, 2 Tesla, axial field has been applied around the expanding jet. The hot corona plasma is being pushed out radially.

Further shadowgraphy is needed to evaluate the presence of the central jet.



The magnetic field is increased to 5 Tesla. The hot corona plasma is pushed further into radial strands.

Further shadowgraphy is needed to evaluate the presence of the central jet.

References

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Acknowledgments

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