# Numerical Simulations for Jet-Proton Interaction

**Wurigen Bo,** Roman Samulyak

*Department of Applied Mathematics and Statistics*
*Stony Brook University*
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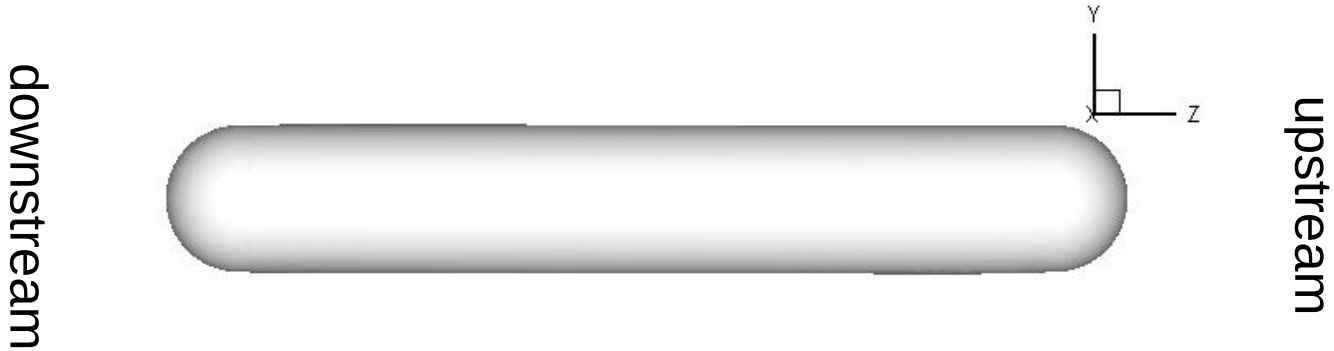
# Setup of the Simulation of the Circular Jet

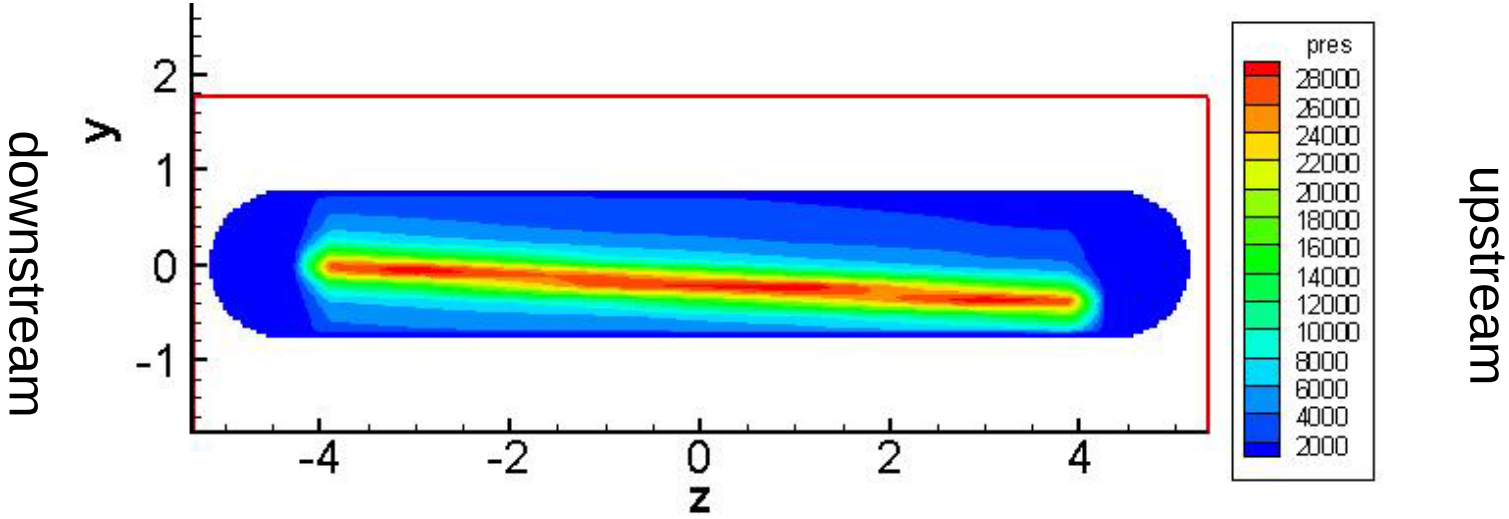
- Length of the circular jet: 8cm. Radius of the circular jet: 0.795cm.
- Mercury jet density: 13.4g/cm^3.
  Density of air outside the jet: 0.0013g/cm^3.
- Computational domain: [x, y, z]=[3.5cm, 3.5cm, 10.5cm].
  mesh: 100x100x300.
- A front tracking method is used to track the jet surface. Eulerian equations are solved numerically for both the jet and the air.
- A discrete bubble insertion algorithm is developed to model cavitation bubbles inside the jet.



# Energy Deposition at the Initial Time

- Sergei's result for 24Gev, 10TP beam is used as the external energy deposition in the jet.
- Sergei gives energy deposition  for the 1m jet, we use a 8cm segment in our simulation.
- The beam parameters:

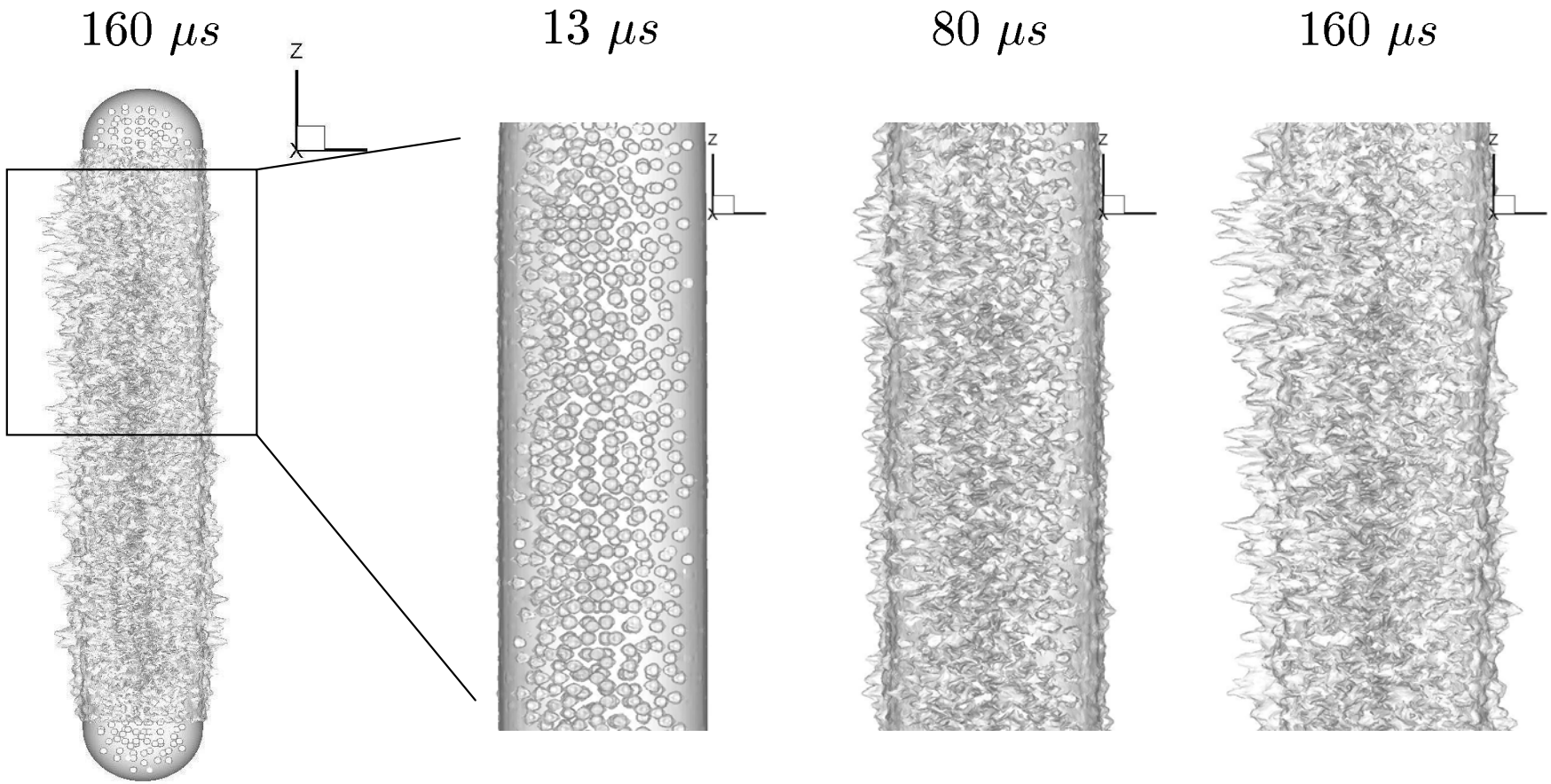
$$\sigma_x = 0.13394\text{cm}\ \sigma_y = 0.07894\text{cm}$$




Energy deposition at x=0 plane, the pressure unit is bar

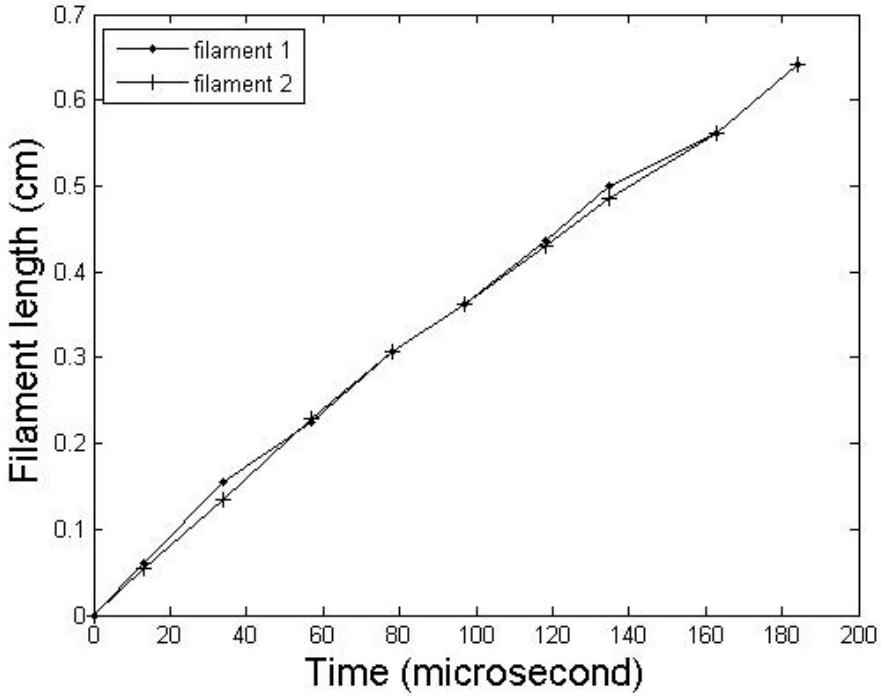
# Results from the Simulation

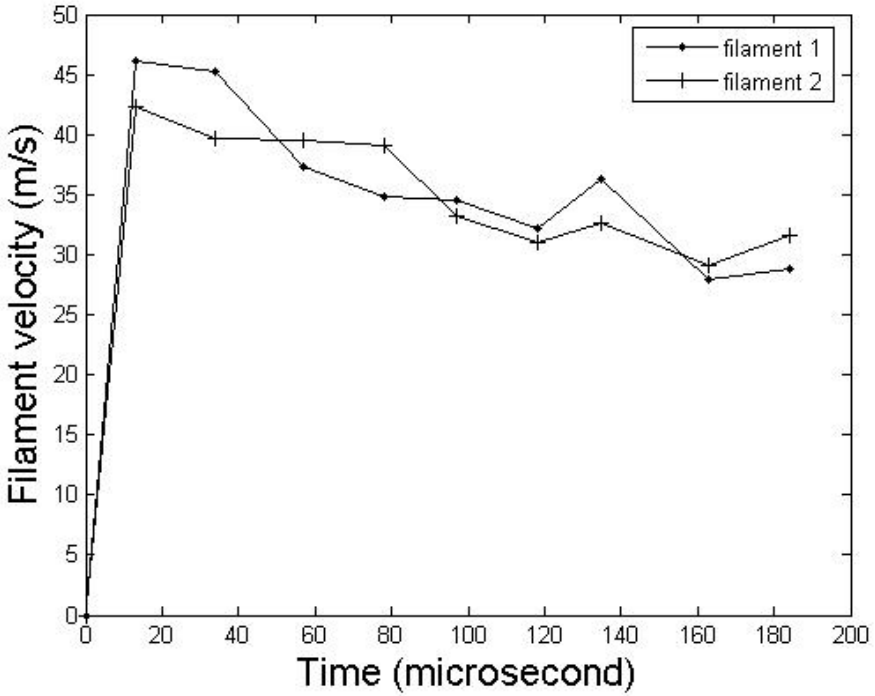
- Jet surface perturbation and its interior cavitation



# Results from the Simulation

- The length and velocity of two fastest growing filaments



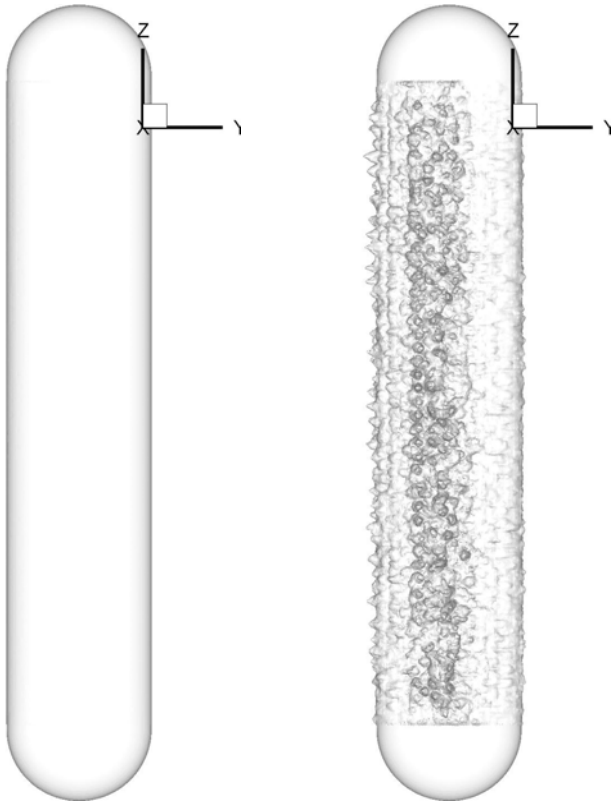
# Setup of the Simulation of the Elliptic Jet

- Length of the jet: 7cm. Vertical radius of the jet: 0.795cm, horizontal radius of the jet 0.315cm
- Mercury jet density: 13.4g/cm^3.
  Density of air outside the jet: 0.0013g/cm^3.
- Computational domain: [x, y, z]=[1.5cm, 3.0cm, 9cm].
  mesh: 60x120x360.
- Sergei's result for the elliptic jet is used. The beam parameters:

$$\sigma_x = 0.33\text{cm}\ \sigma_y = 0.27\text{cm}$$

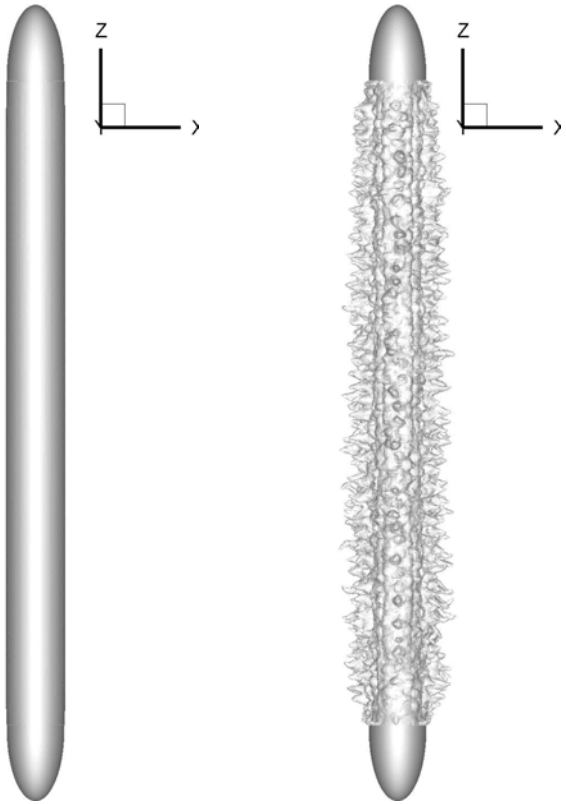
# Results from the Simulation

- Jet surface at 0 and 140 microsecond




$0\ \mu s$ $140\ \mu s$

Major axis

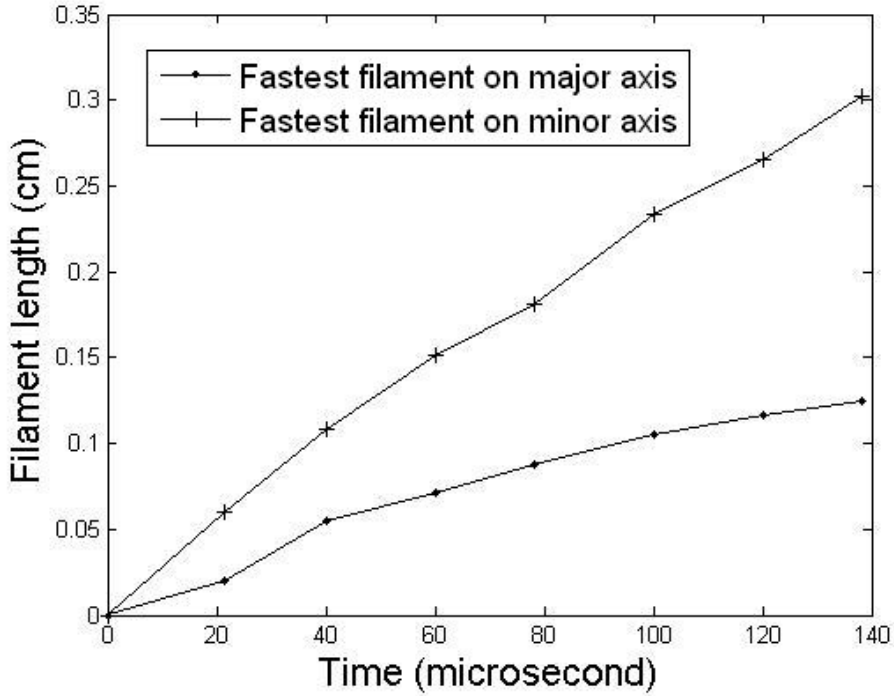


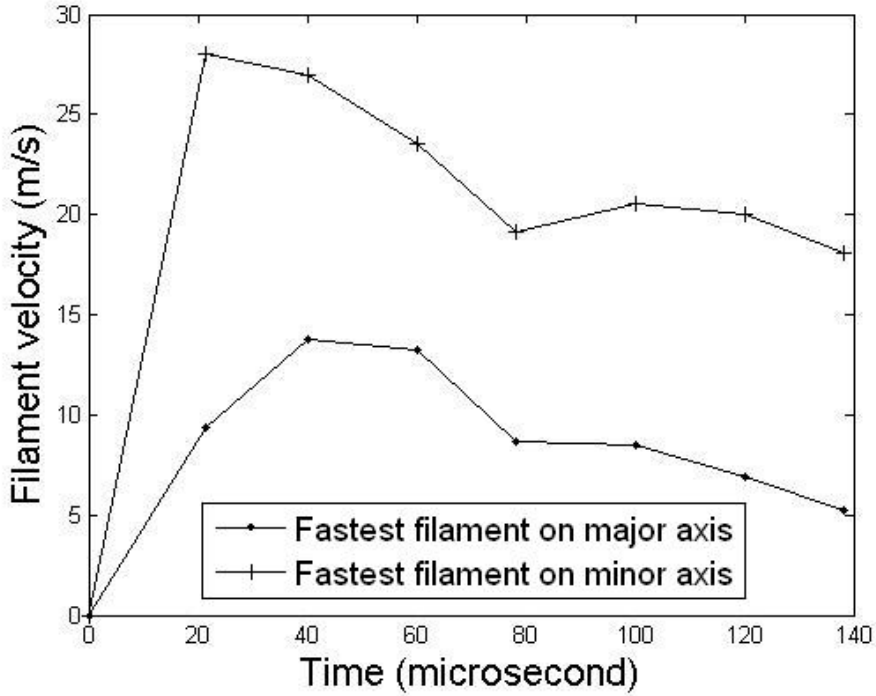

$0\ \mu s$ $140\ \mu s$

Minor axis

# Results from the Simulation

- The length and velocity of two fastest growing filaments



# Conclusions

- The expansion of the jet and the growth of the filaments on jet surface are noticed in the simulations of both circular and elliptic case. This is consistent with experimental observation.
- The filaments reach their maximal velocity when they first protrude out of the jet surface. Then the velocity decreases due to air resistance. For circular case, the average filament velocity is 35m/s.
- For elliptic jet, the filament velocity on the minor axis is much larger than that on the major axis.
- The delay of filament growth found in experiments is not observed in the simulations.