Mercury Jet Studies

Tristan Davenne
Rutherford Appleton Laboratory

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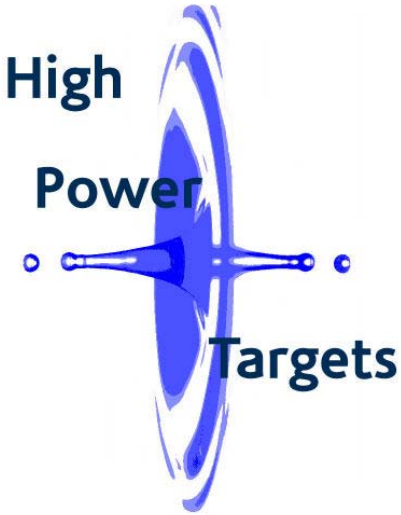


Instantaneous Energy Deposition

Result of ‘instantaneous’ energy deposition

1. Increase in temperature causes pressure rise (analagous to Youngs Modulus linear relationship between stress and strain)

$$P = K\alpha\Delta T$$

2. Strain energy is built up in the fluid due to compression (area under graph)

$$E = \frac{K}{2}\left(\alpha\Delta T\right)^2 \qquad \text{per unit volume}$$

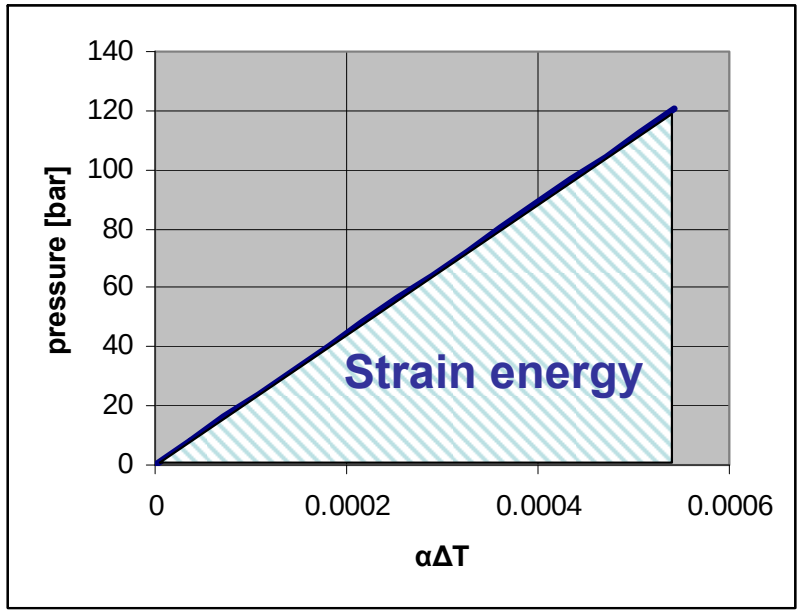
Ref (Sievers & Pugnat)

3. Strain energy will be released as kinetic energy

$$\frac{K}{2}\left(\alpha\Delta T\right)^2 = \frac{1}{2}\rho v^2 \qquad \text{so}$$

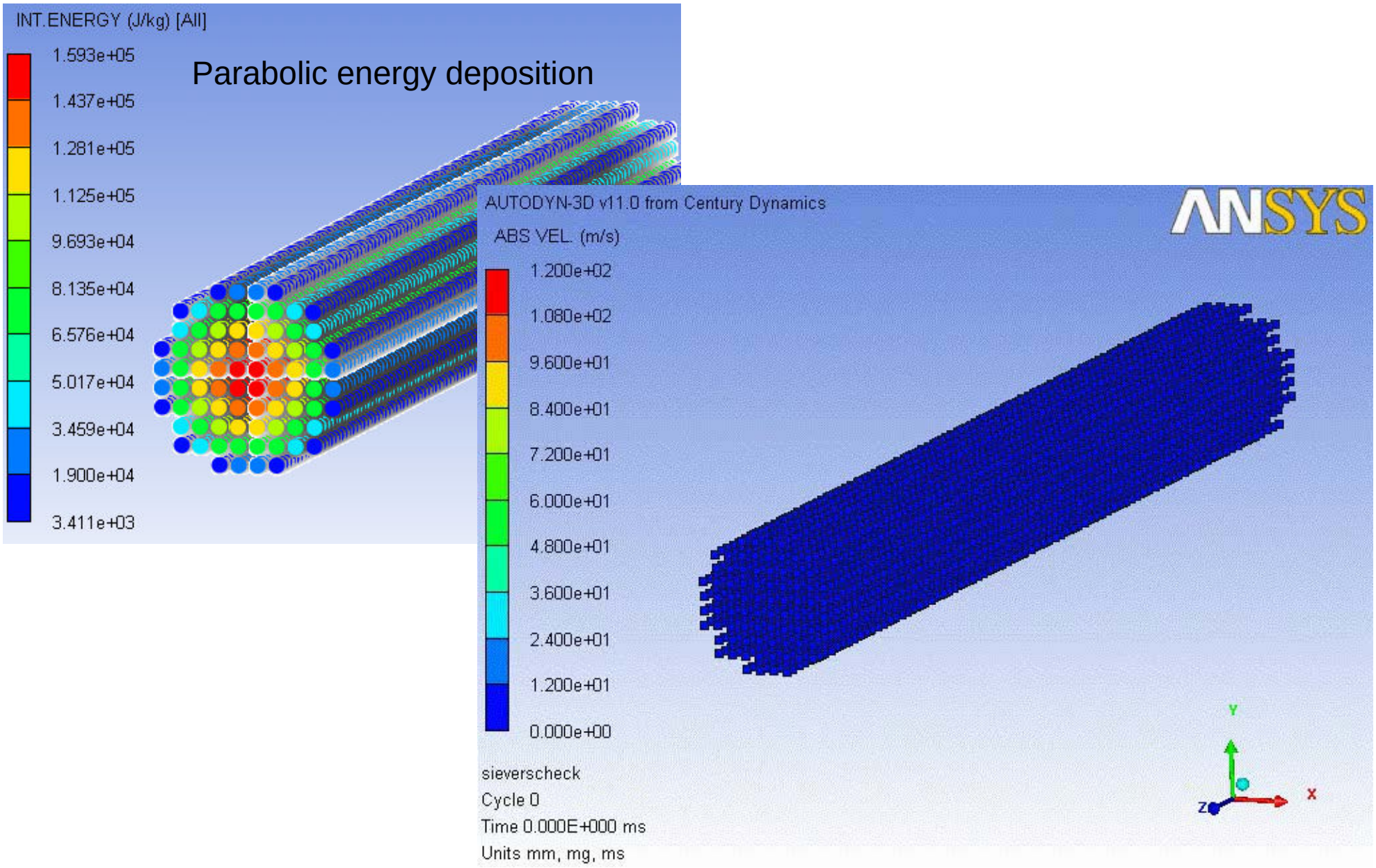
$$\alpha\Delta T \propto v$$

4. Expansion velocity is proportional to energy deposition



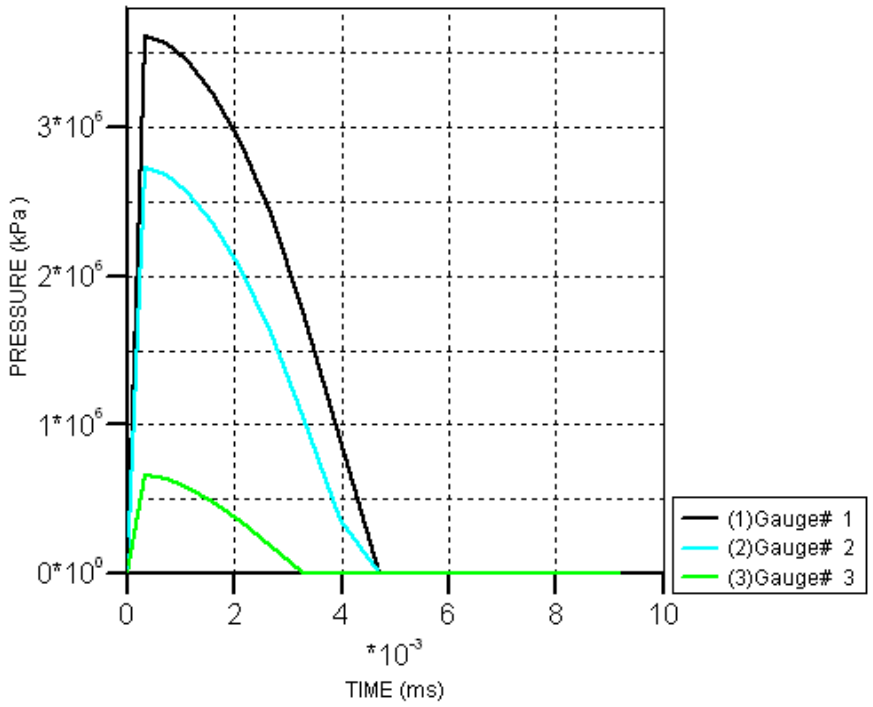
Sievers & Pugnat 2000 considered a parabolic radial energy deposition in 2cm diameter mercury target
and reported a radial velocity at surface of mercury jet due to proton beam is 36m/s

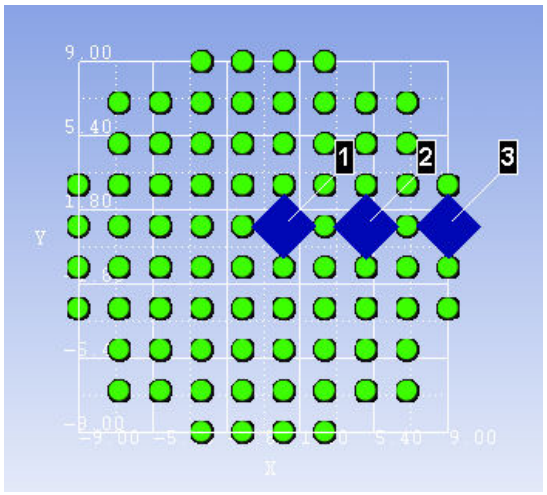
Numerical simulation of Sievers & Pugnat Result



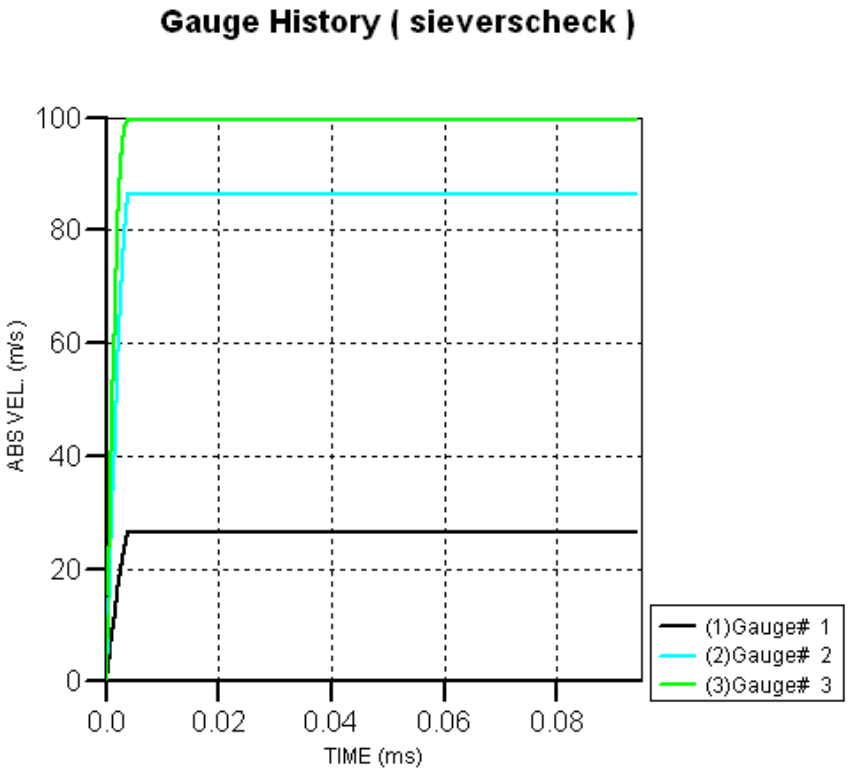
Click on image above to watch video of 2cm mercury target responding to concentric parabolic energy deposition

Pressure and velocity response of 2cm diameter mercury target

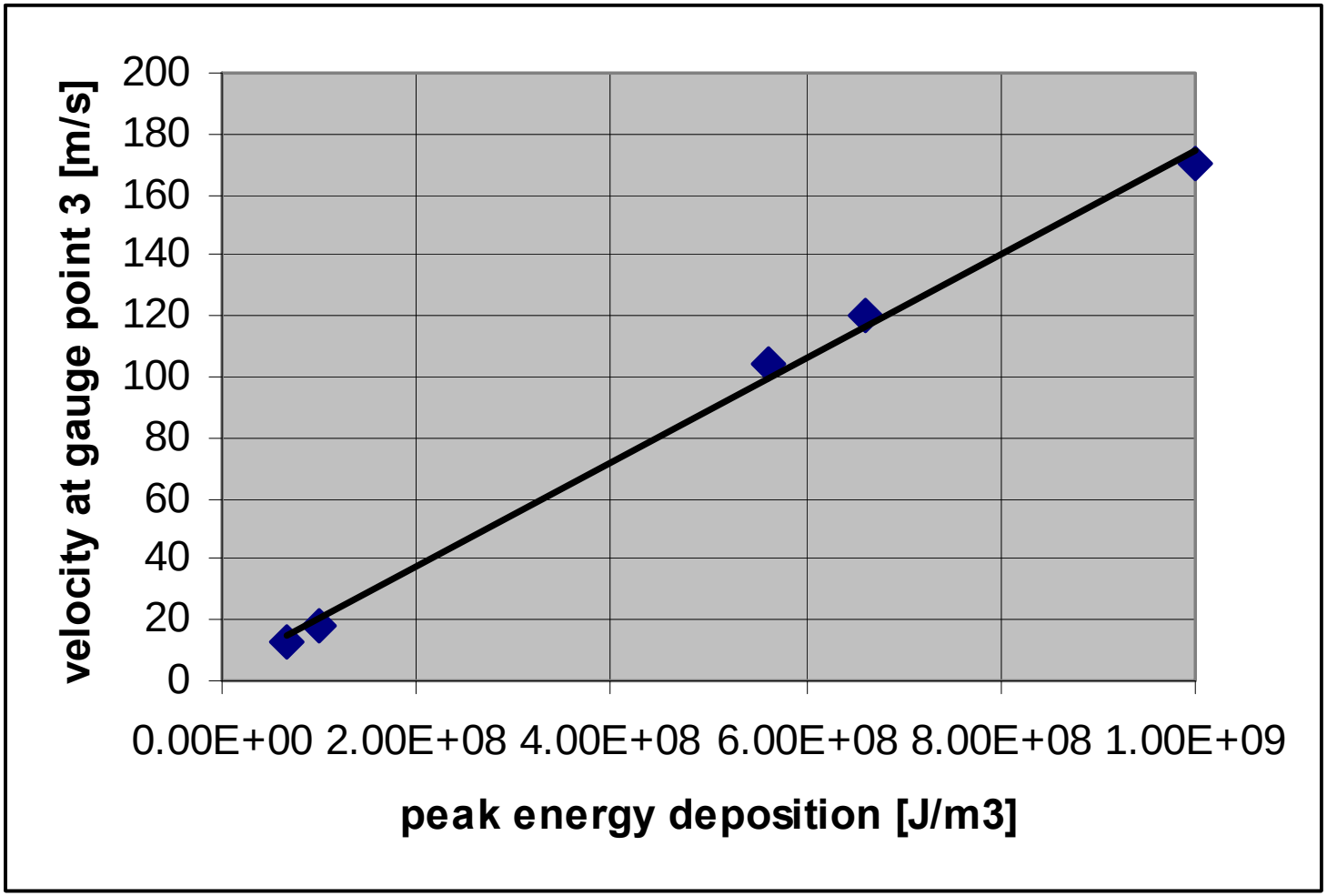




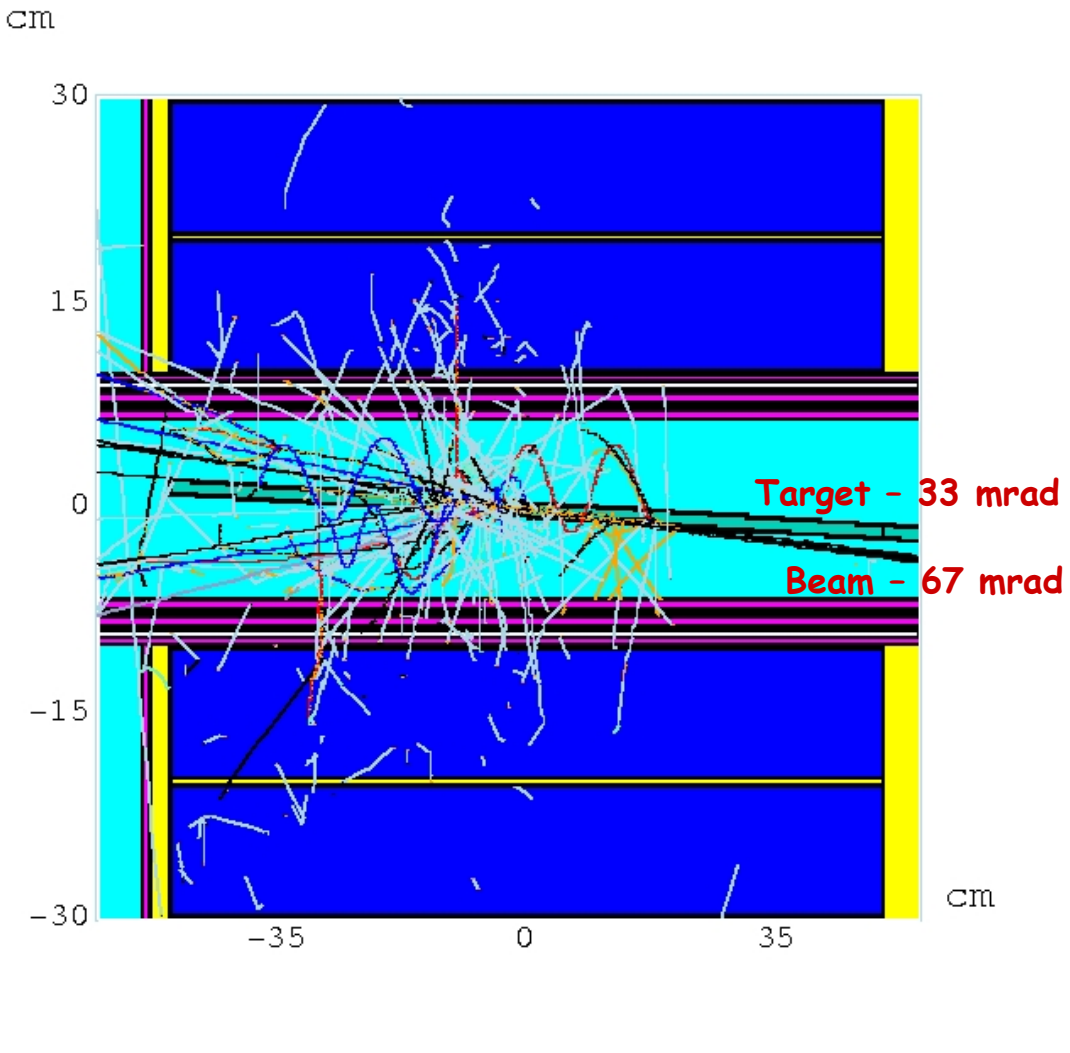
from Century Dynamics

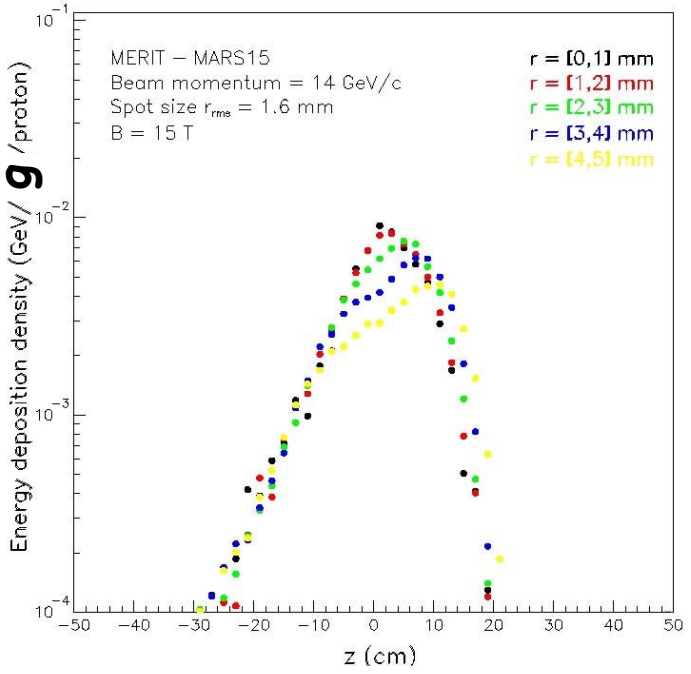


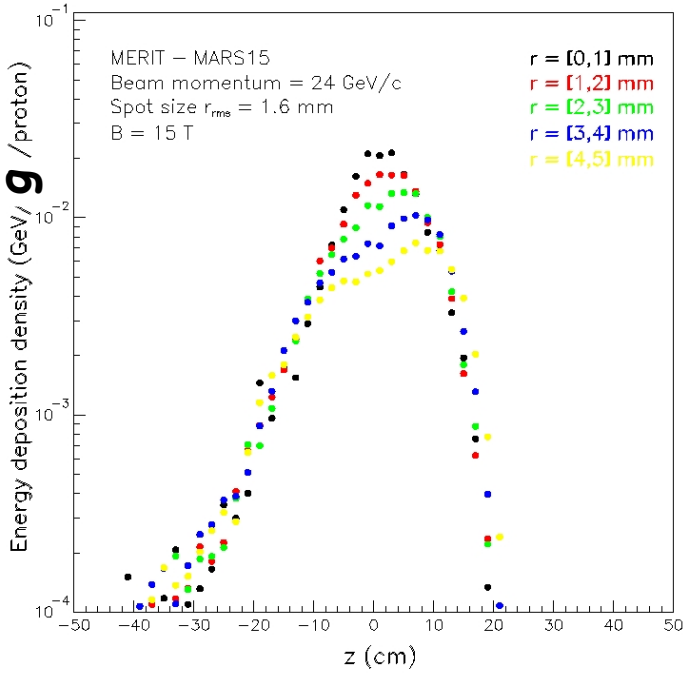
Autodyne result for peak radial velocity vs peak energy deposition



- MERIT target -
energy deposition from MARS
B = 15 T



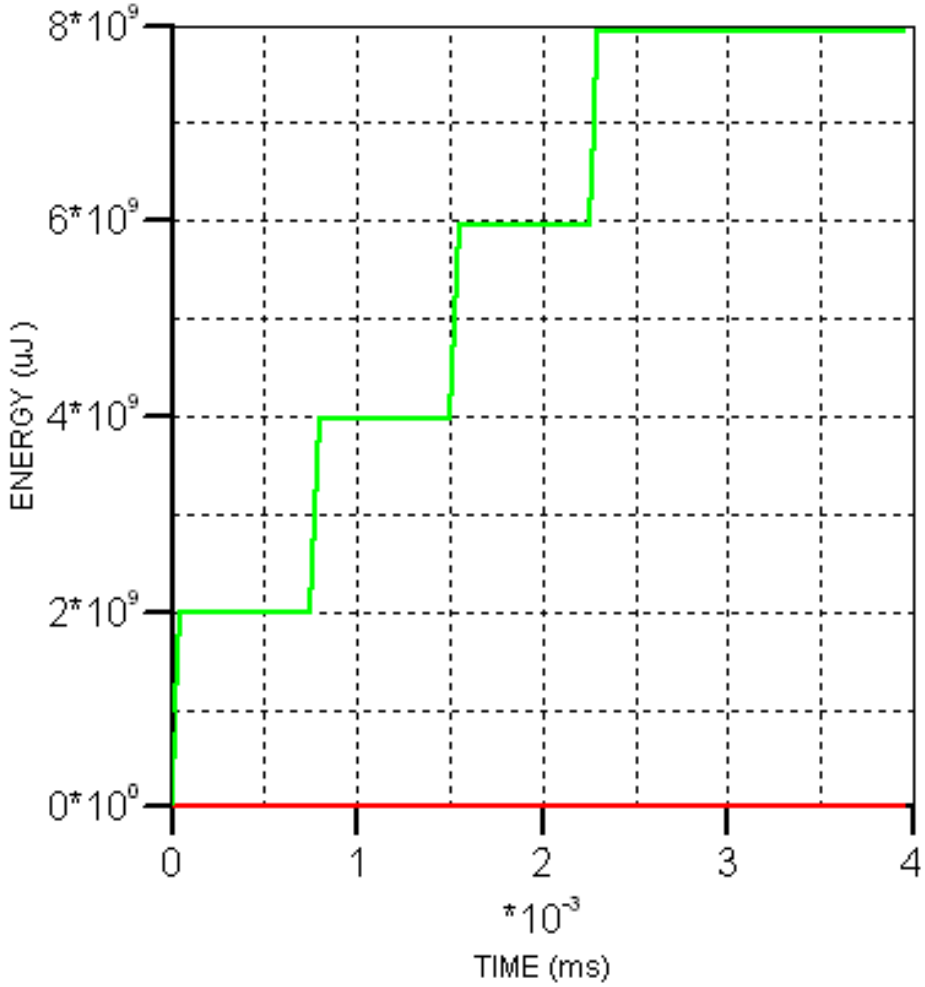




Goran Skoro

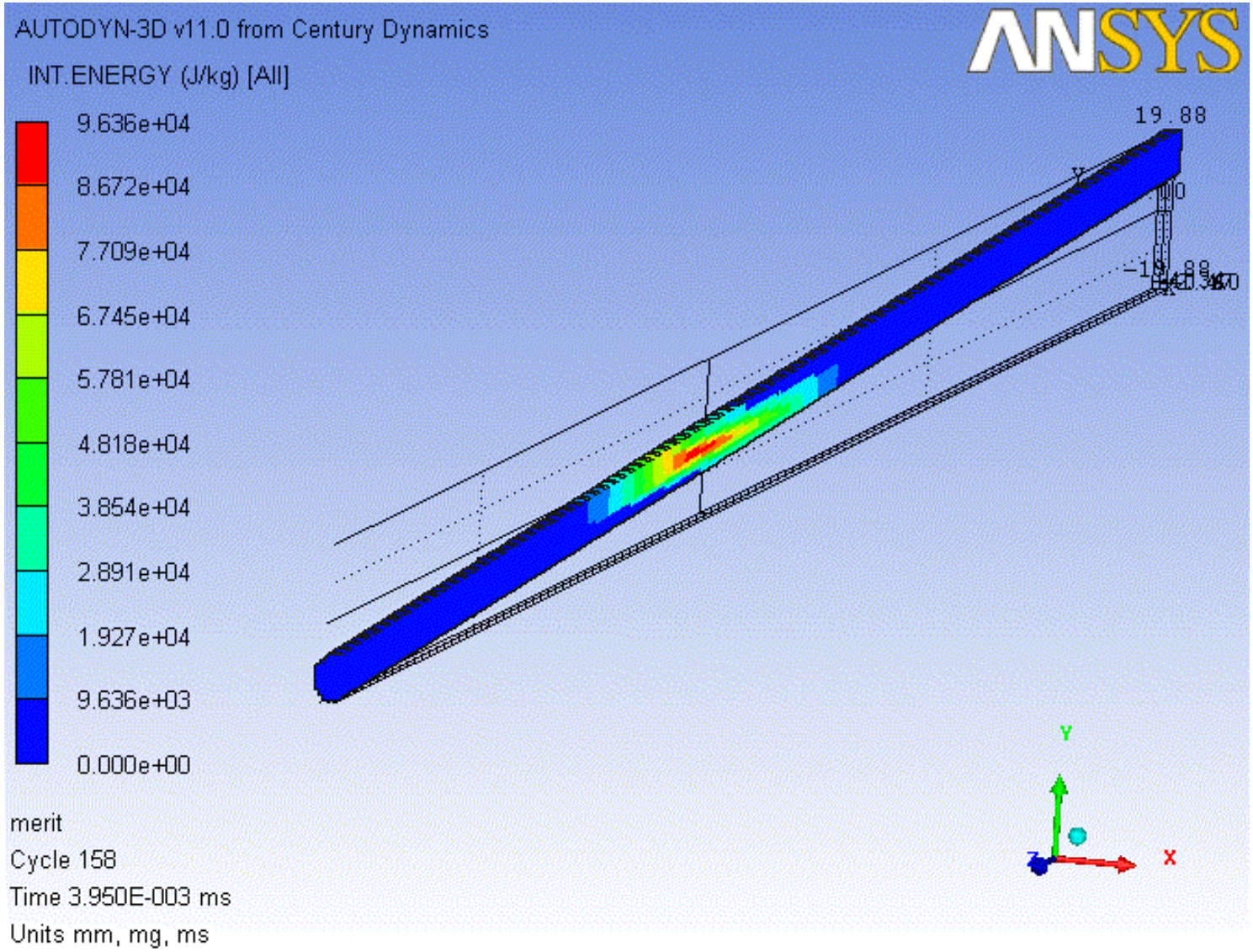
Autodyne Model of Merit Jet

beam energy = 24GeV
bunches in a pulse = 4
pulse duration = 2.3us
total energy deposition in mercury in a pulse = 8kJ



Autodyne Model of Merit Jet

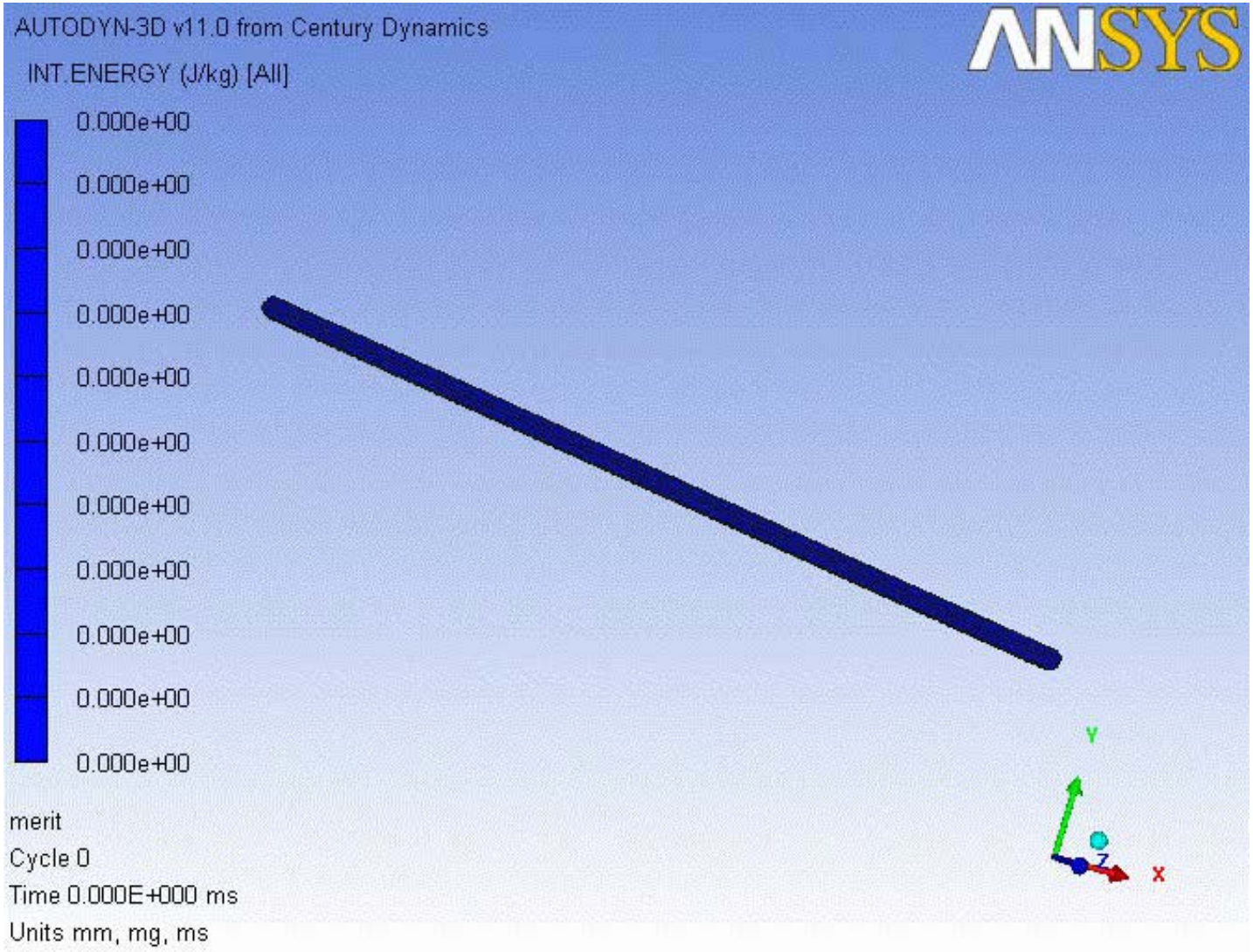
Beam at 33mrads to 10mm diameter mercury jet



Autodyne Model of Merit Jet

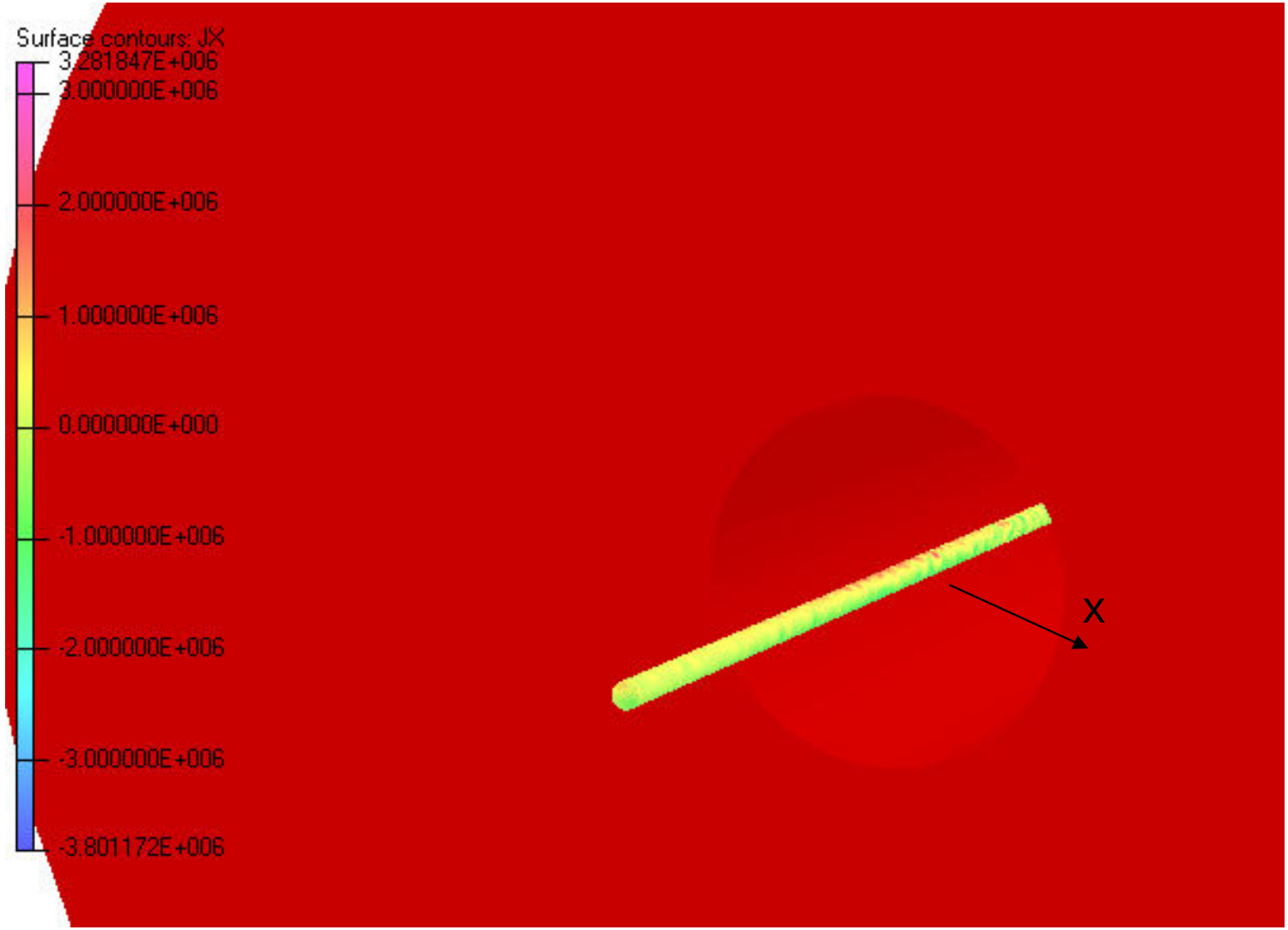
Max radial Velocity 93m/s

click on image below to watch video of mercury jet being hit by the proton beam



Influence of magnetic field

current density [A/m$^{2]}$ induced in a mercury cylinder travelling at 15m/s through a 15T solenoid, mercury conductivity 1.04x10^{6} S/m



Conclusions

- Autodyne was used to model the response of a 2cm diameter mercury target to a parabolic energy deposition. A radial velocity of order 100m/s was predicted. This compares to 36m/s predicted by Sievers & Pugnat 2000.
- The relationship between radial velocity and energy deposition can be approximated by a linear expression in the range of energy deposition of interest.
- Autodyne was used to model the MERIT experiment with no magnetic field. Data from MARS calculated by Goran Skoro was used as an input. For the case of 24GeV, 30 Terra protons per bunch the radial velocity of mercury is predicted to be 93m/s.

Proposed Aims

- Understand discrepancy between Sievers result and Autodyne result. (could be difference in input parameters)
- Calculate surface pressure on mercury jet due to 15T solenoid. (started looking at this)
- Calculate effect of magnetic field on radialy travelling lumps of mercury as a function of lump size.
- Consider possibility of combining dynamics and magnetic fields software packages.