Mercury Target Tests at ISOLDE

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http://home.cern.ch/afabich/docs/NFWGJan2002.pdf

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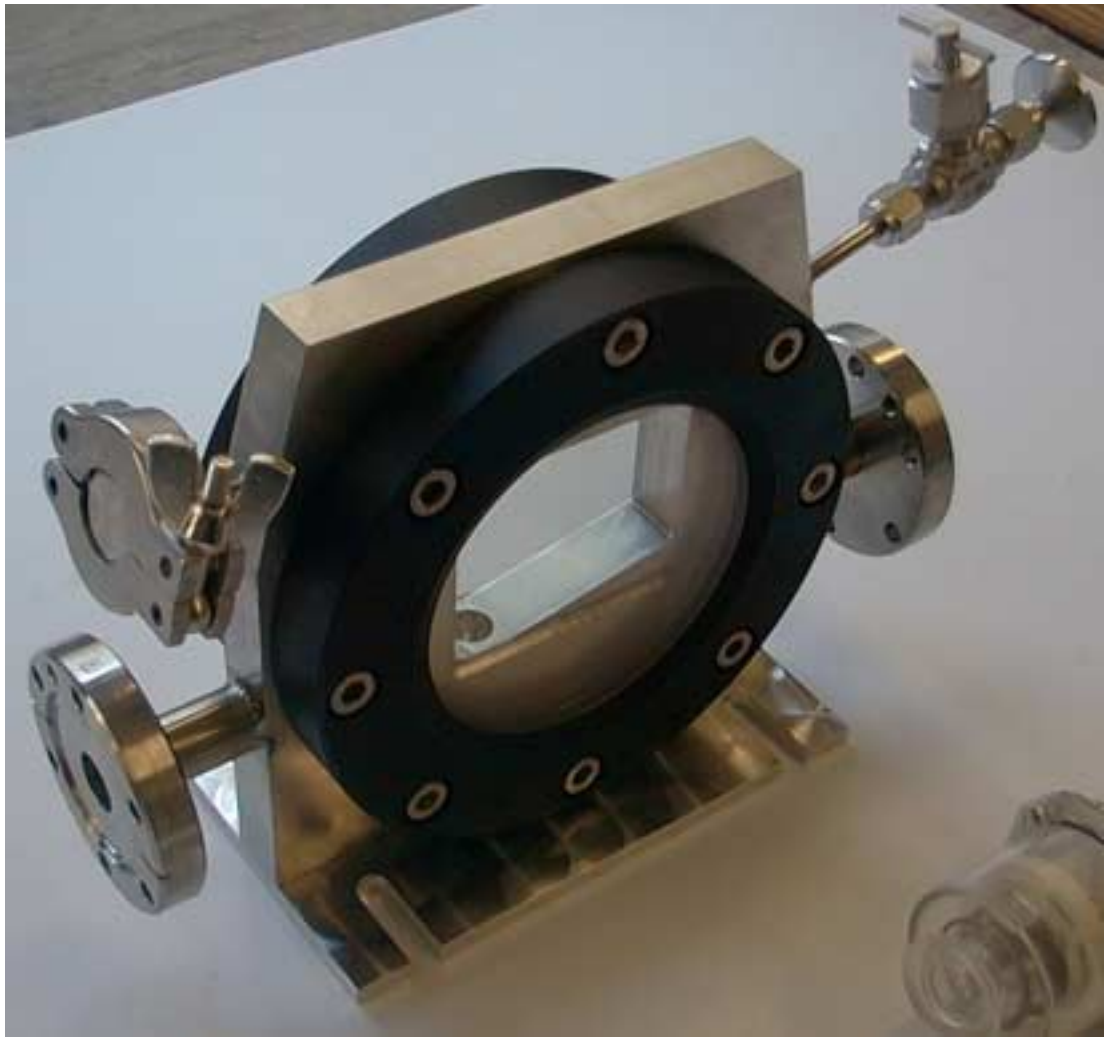
- Purpose
- Experimental setup
- Read-out and evaluation
- Scaling laws
- conclusion

GOAL

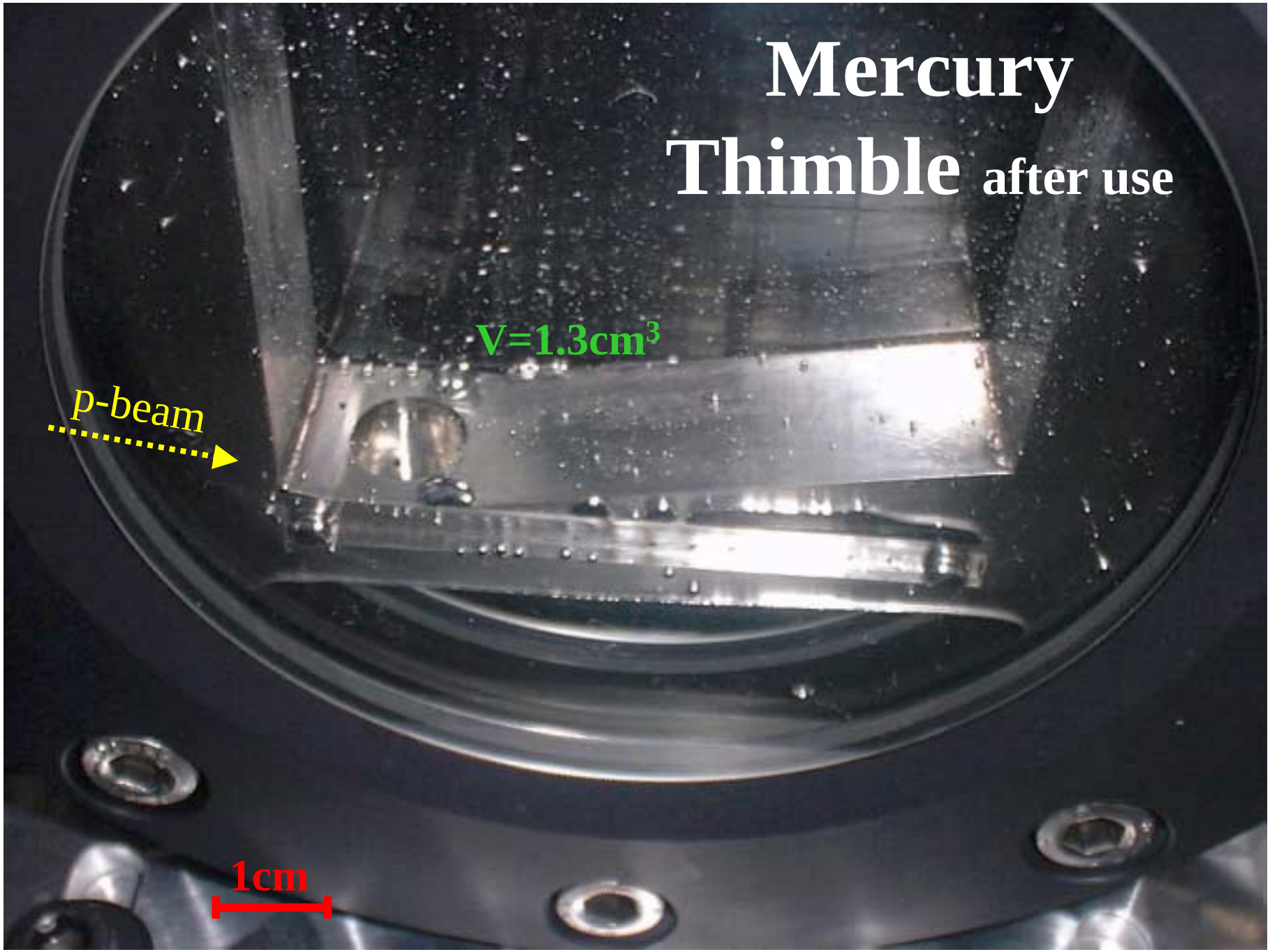
- feasibility of liquid metal option for high power proton beam targets
  - surface velocities
  - impact of cavitation voids on particle production

Target setup

- ISOLDE GPS
- steel frame
  - with mercury thimble
  - viewing windows
- optical read-out by high-speed camera
  - 8000 frames/s



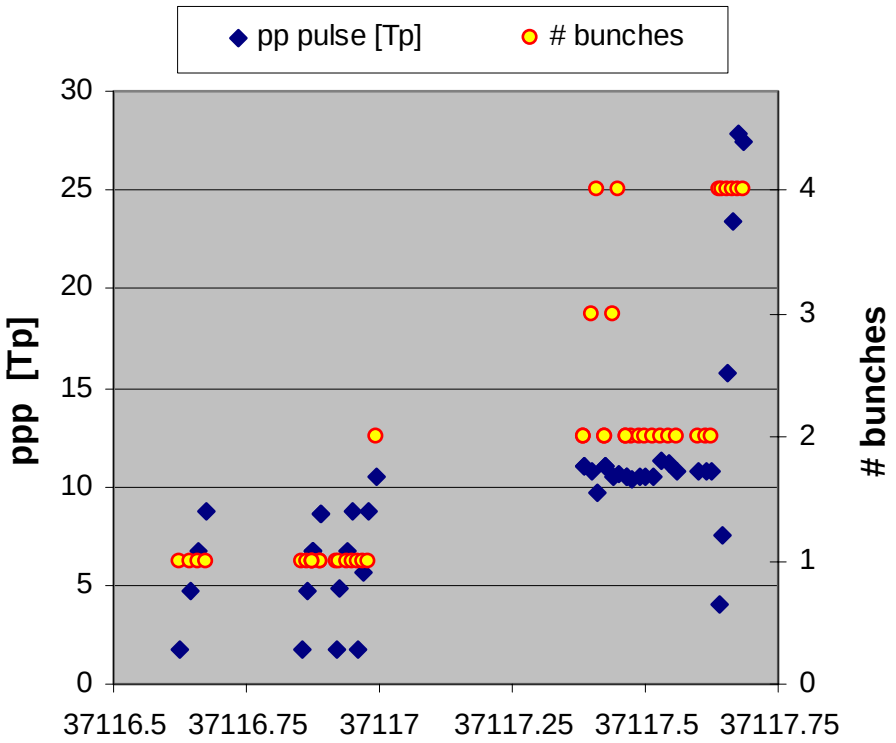
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Mercury
Thimble after use
V=1.3cm3
p-beam
1cm

Protons vs. Mercury

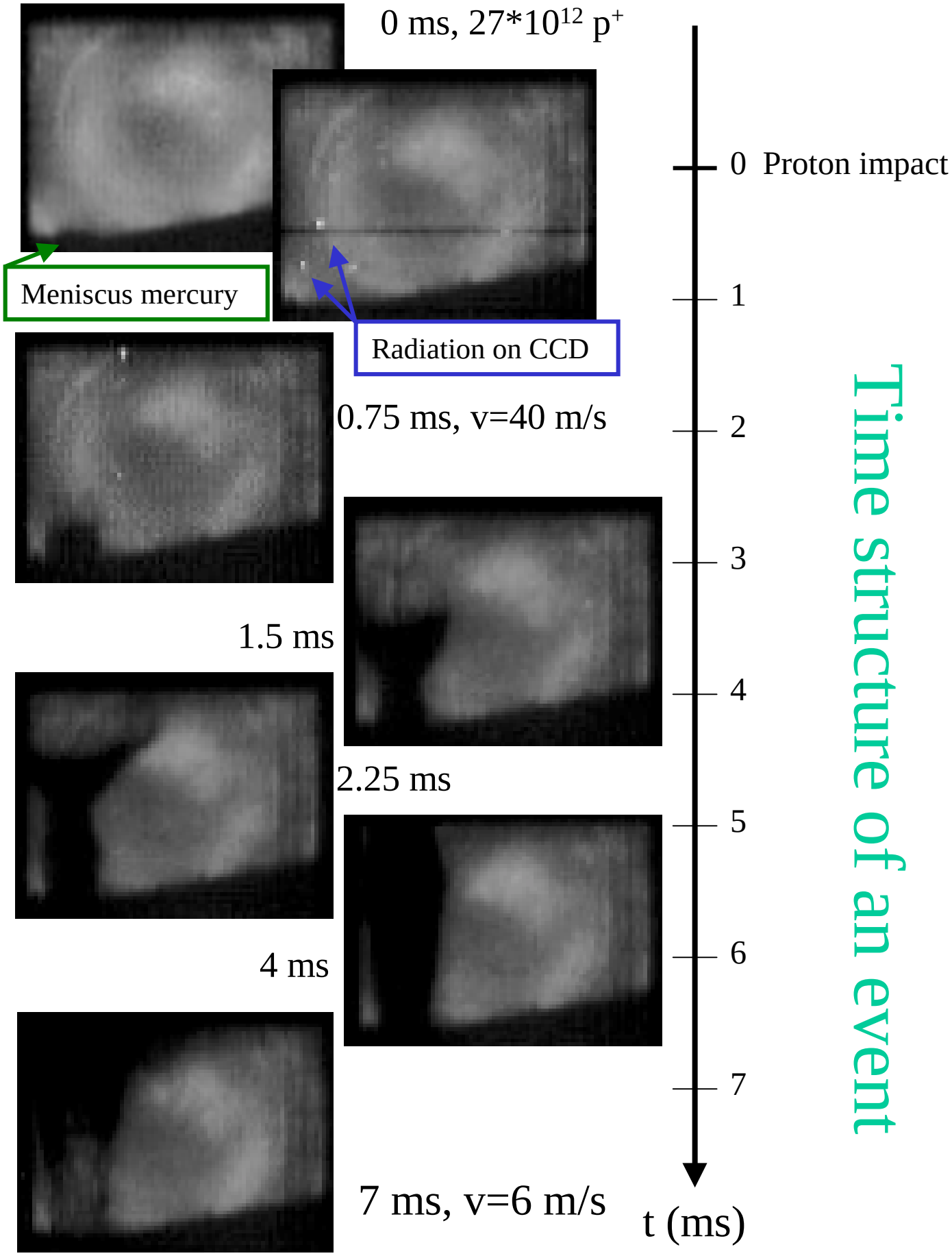
ISOLDE GPS, Aug. 2001

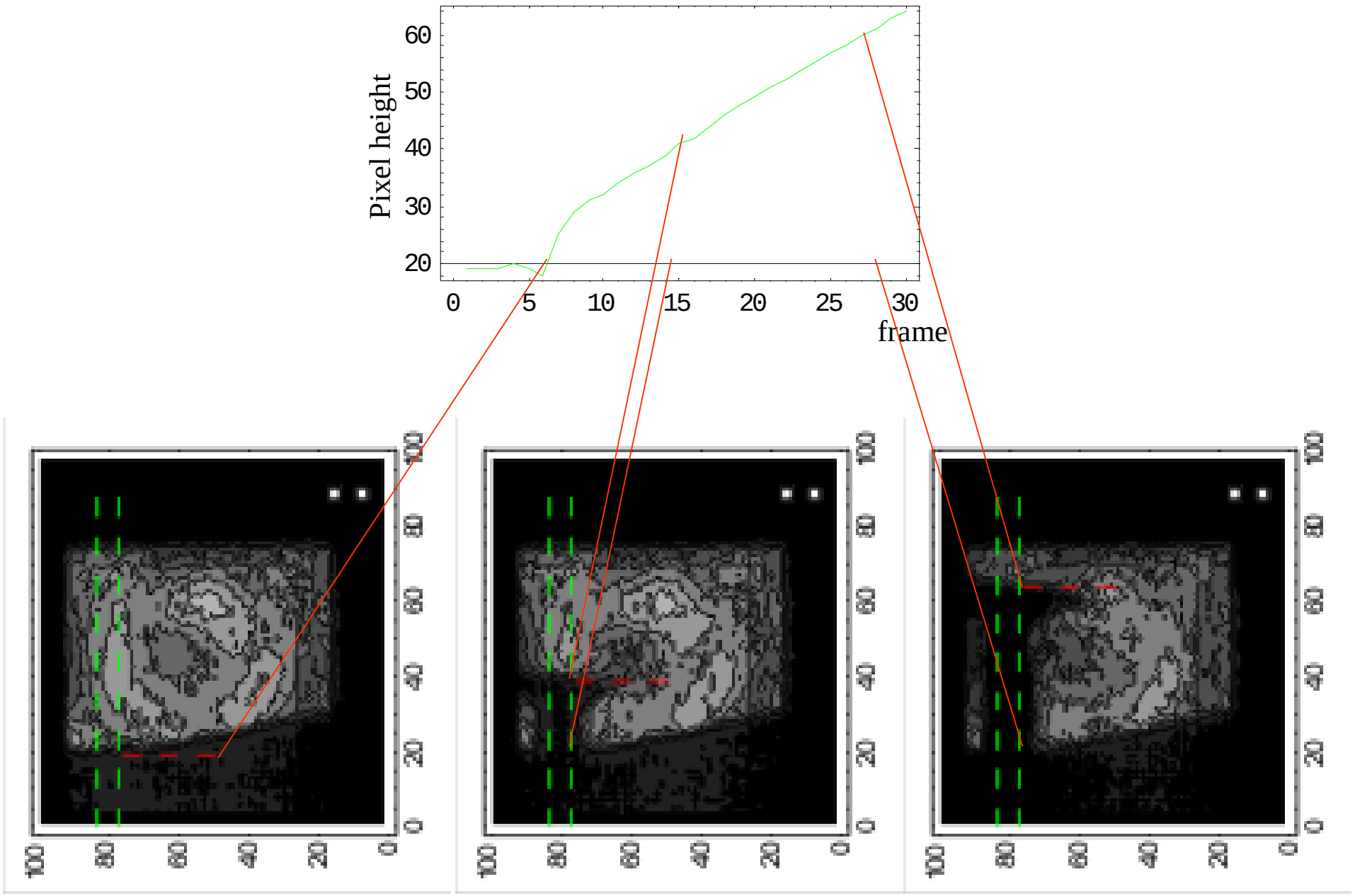
40 single pulse events at 1.4 GeV



PSB (NuFACT CERN)

- pulse intensity
  1-28 10^{12} p^+ (230 10^{12} p+)
- pulse length
  0.6-8 μs (3.2 μs)
- height scan
- spot size (Gaussian)
  σ=1.2-3.5 mm (7.5 mm)
- Average beam density
  1.3-8.5 p^+/mm^2 (1.3 p^+/mm^2)


0 ms, 27*10^12 p+
Meniscus mercury
Radiation on CCD
0.75 ms, v=40 m/s
1.5 ms
2.25 ms
4 ms
7 ms, v=6 m/s
0 Proton impact
1
2
3
4
5
6
7
t (ms)
Time structure of an event


Pixel height
60
50
40
30
20
0
5
10
15
20
25
30
frame

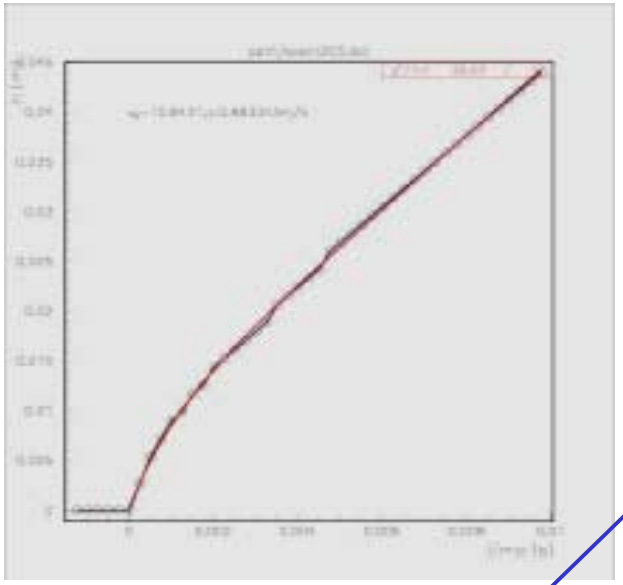
Explosion Velocity

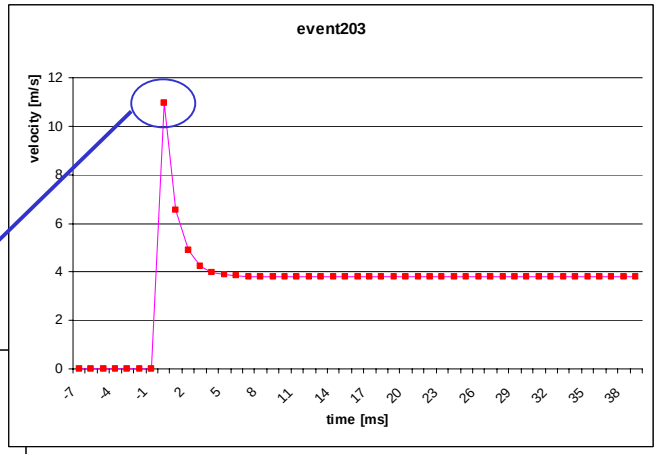
Initial velocity

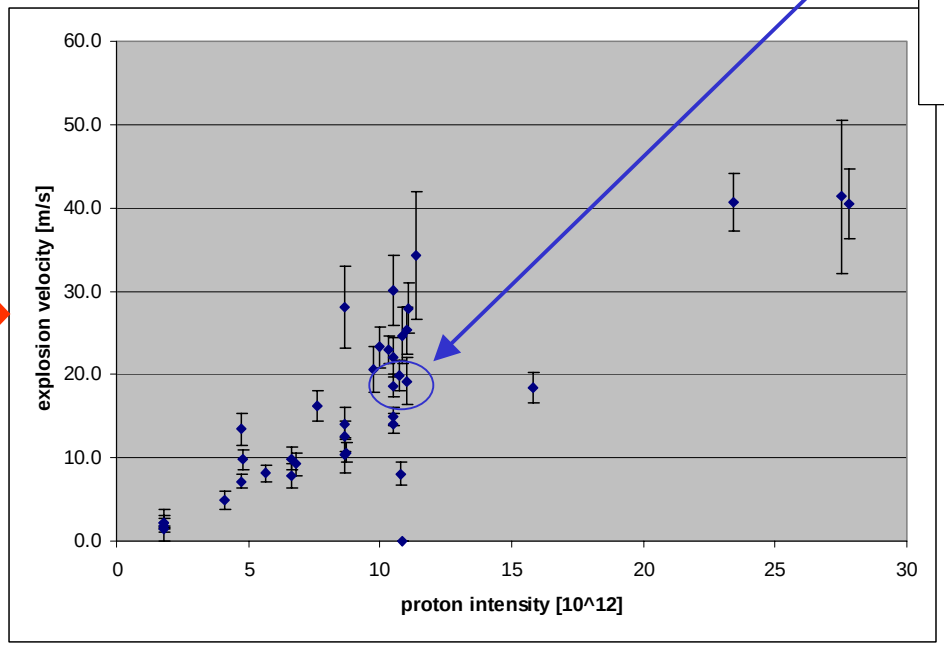
-gravity

-drag force
(Argon 1 bar)

-surface tension
neglected

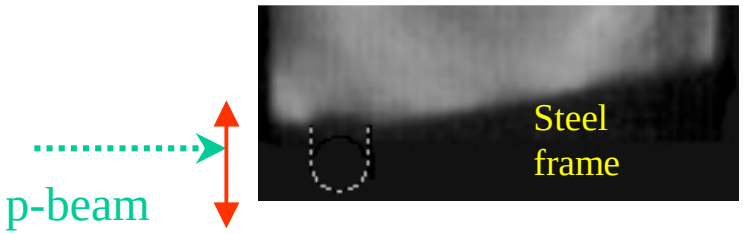


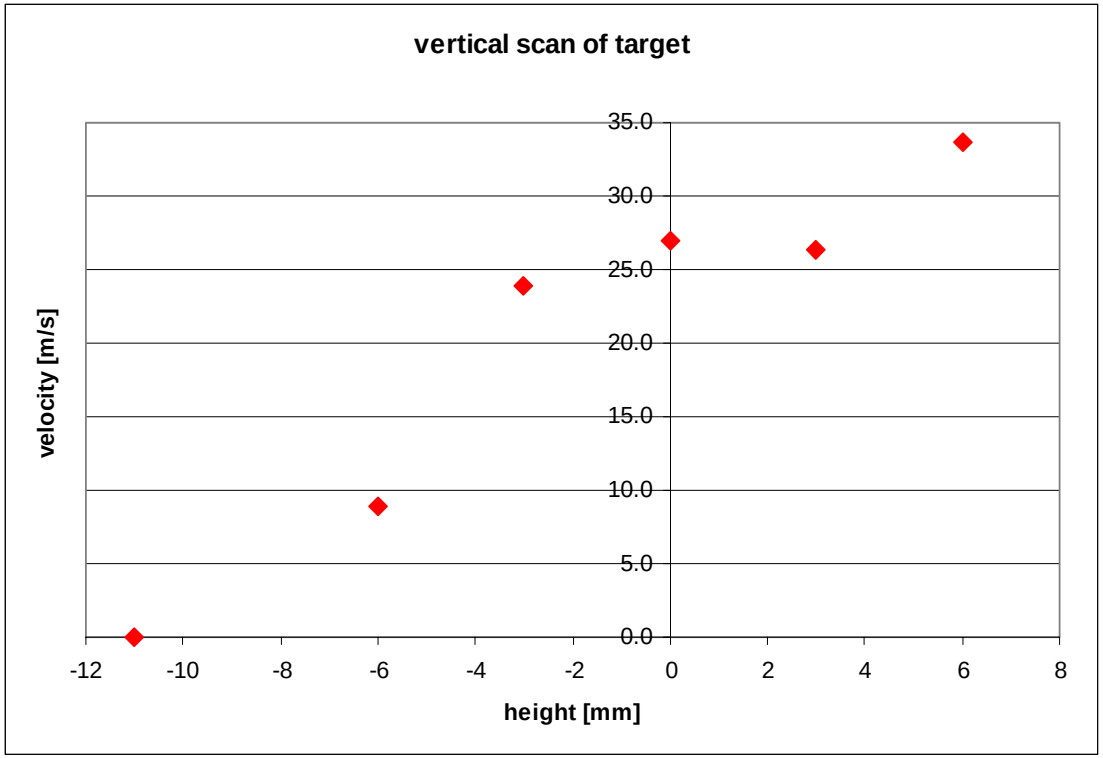




Height Scan

- Assure centering of the beam



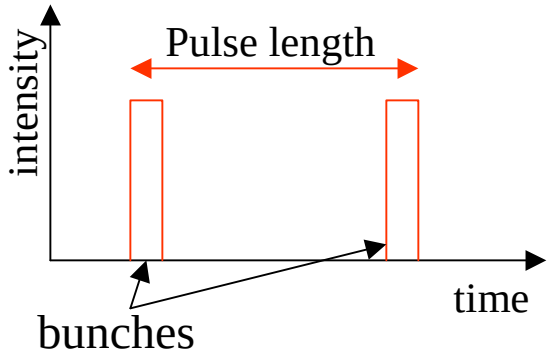


Position tested by

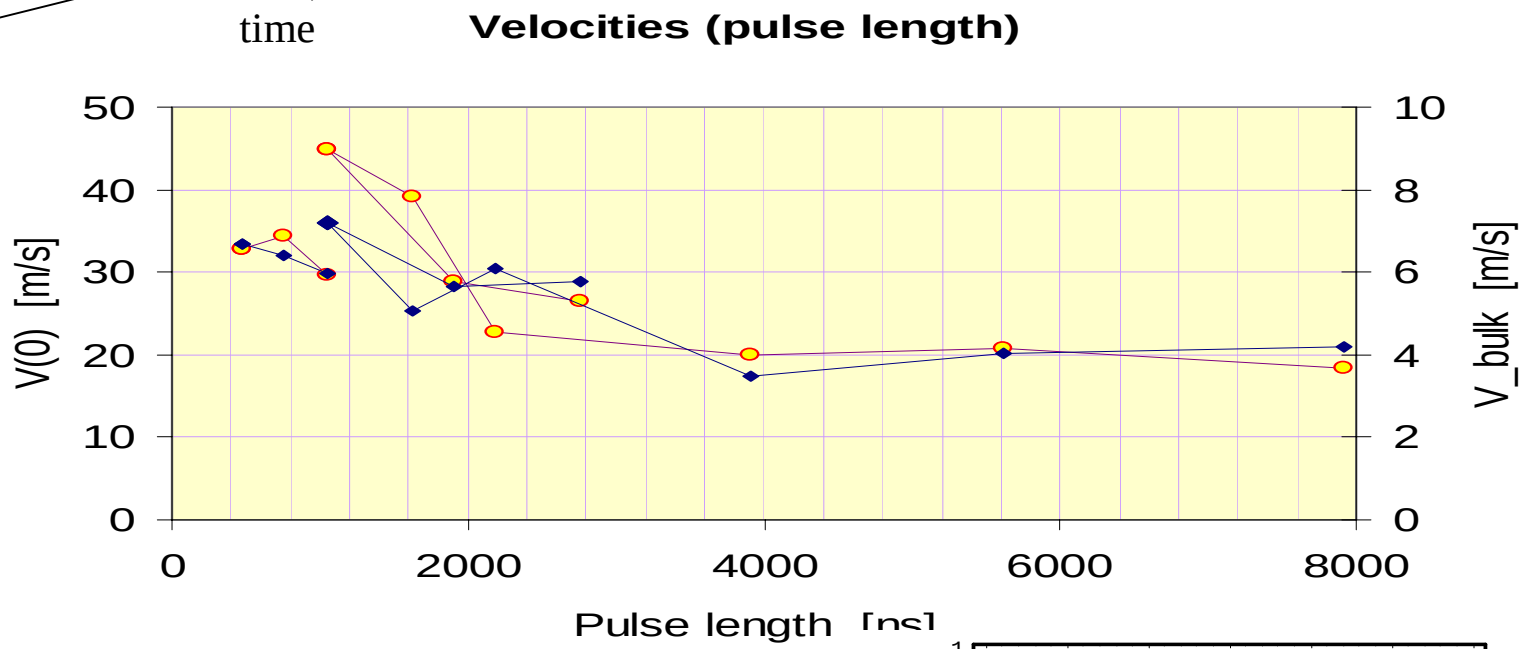
1. SEM grid
2. aluminum foil
3. beam scan on target

- beam centered
- slight offset causes minor effect

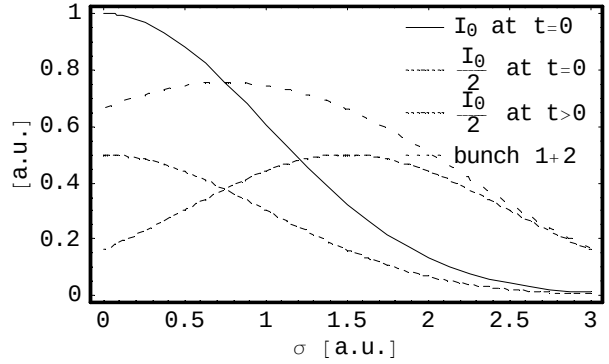
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Pulse length



- velocity drops for pulse length > 3 μs
- due to traveling pressure wave $\longrightarrow$
- can not be due to cavitation as …

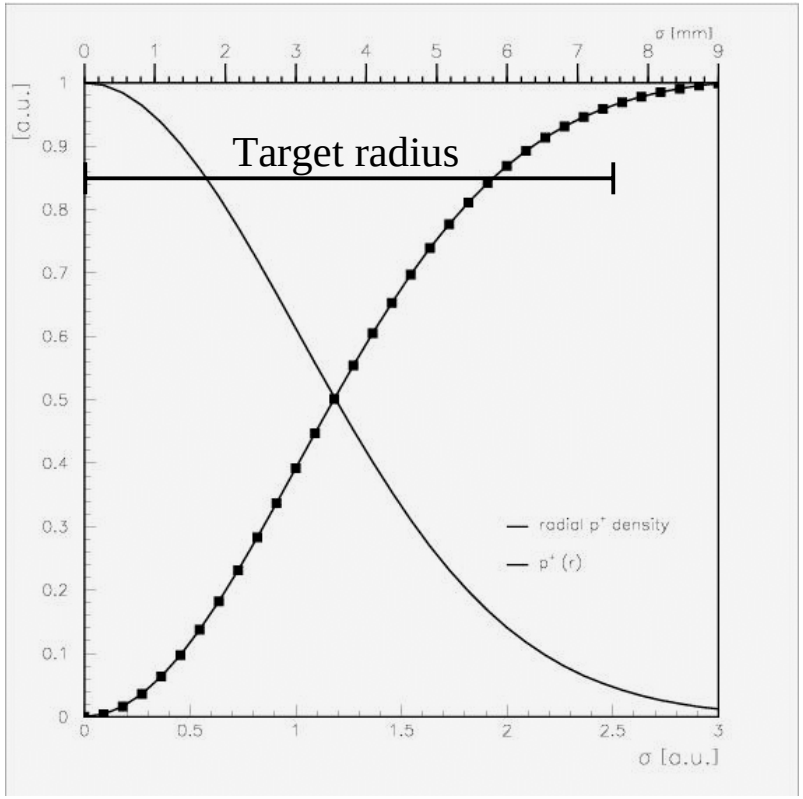


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dv/dt=-dP/dr

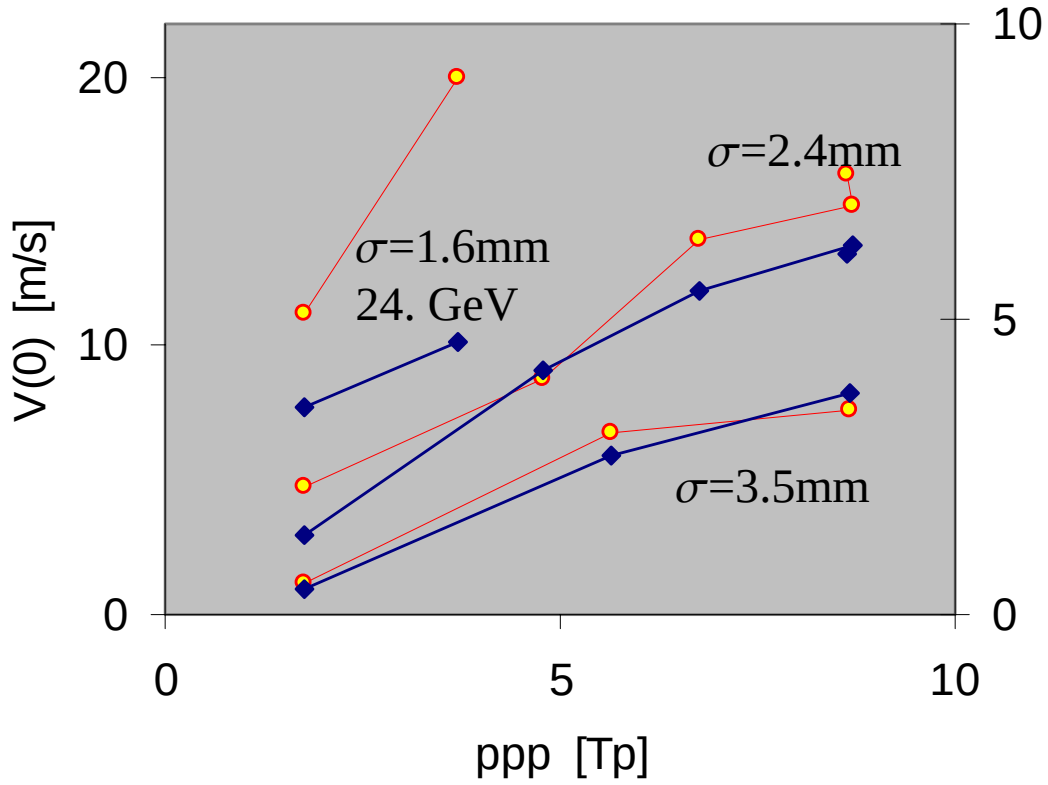
Cavitation

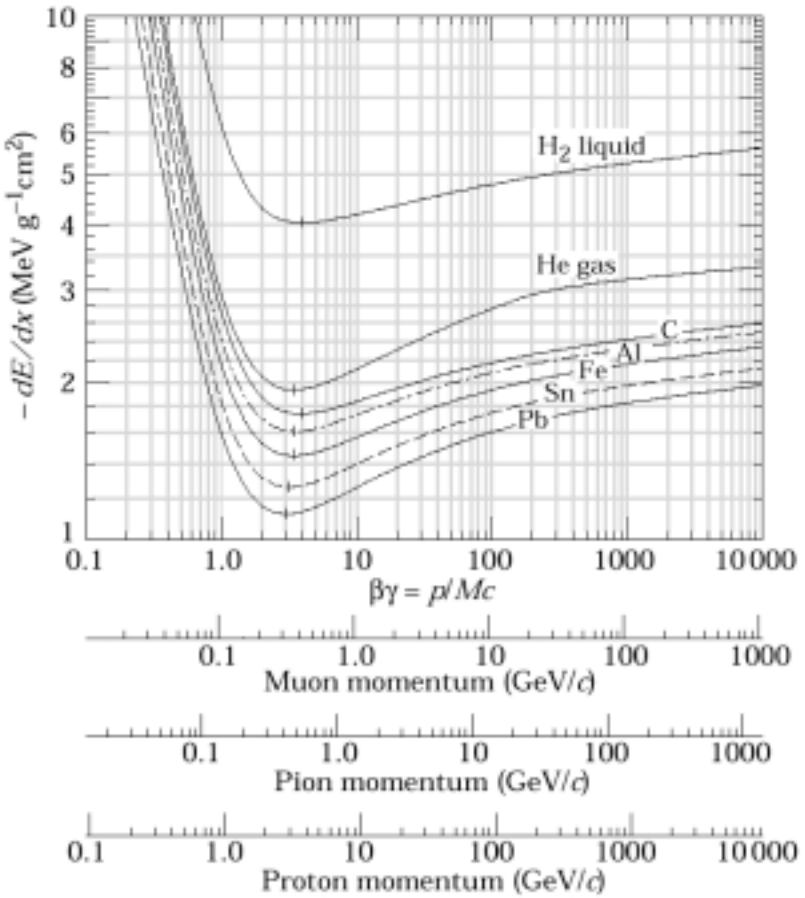
- cavitation might occur
  → reduced interaction length
- assuming cavitation in center
  → low percentage of particle interaction lost



Spot size

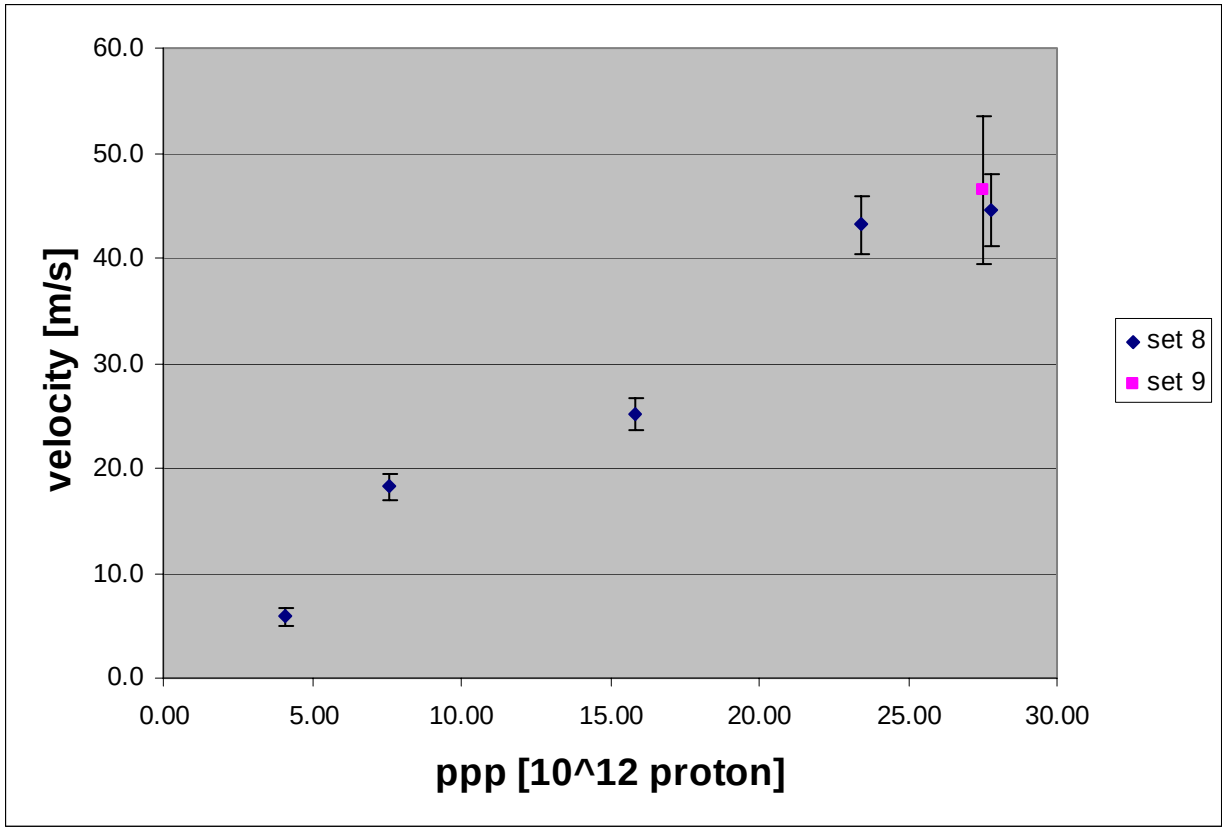
Velocities (Pulse intensity)





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Intensity

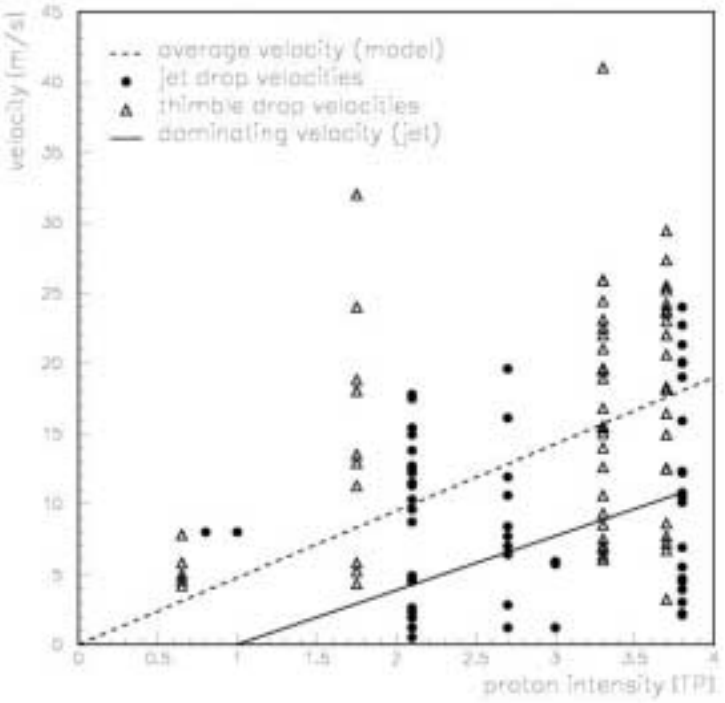


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Trough ↔ Jet

BNL events showed:

- explosion velocities of thimble 2 times higher than jet
  - due to free surface



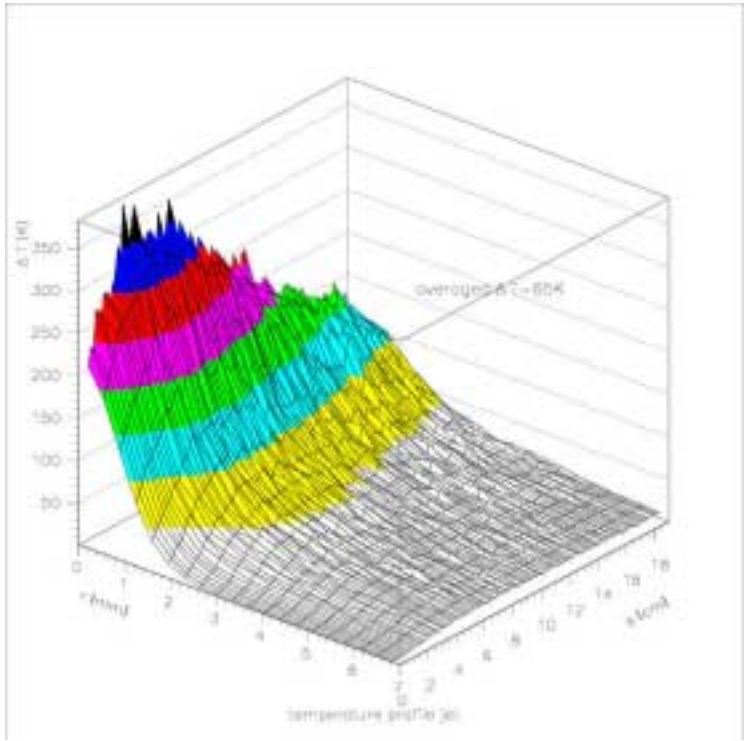
Scaling to ν-Factory

- For maximum intensity at ISOLDE: v=45 m/s
- for ν-Factory (CERN):
  - intensity 8 times higher
  - spot size 4 times larger (7.5 mm)
  - trough→jet: factor 0.5
  - jet under vacuum removes drag forces
  - pulse length: 3.2 μs → sound travels 5 mm
  - Proton energy from 1.4 GeV to 2.2 GeV: gain 0.7

⇒ Explosion velocities of 2*jet speed → 4π-explosion

4π-explosion not acceptable

- Where we can gain?
  - spot size fixed (horn dimensions)
  - 2.2 GeV: already at minimum dE/dx
  - Pulse length to an order of 100μs “solves everything”
  - Atmosphere causes drag: gain 0.7
  - Linear scaling too pessimistic



– These velocities occur only in small part of the jet

Thanks to …

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TIS-FB	J. Elorza
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