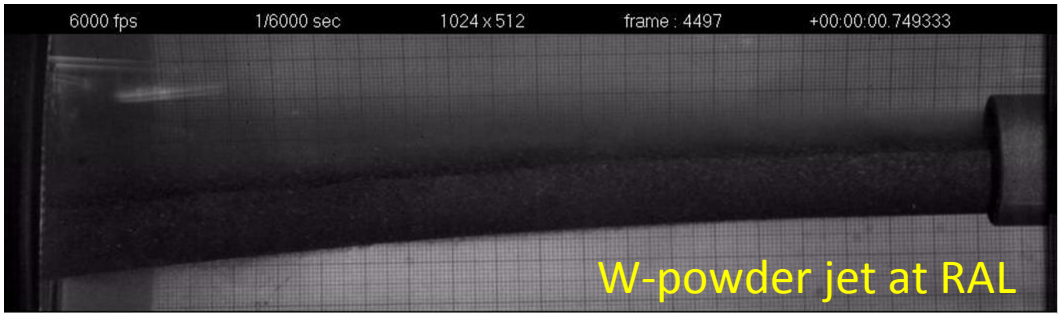
Feasibility Experiment for a High Power Fragmented Solid Target in the HiRadMat Facility at CERN



N. Charitonidis [CERN/EPFL], I. Efthymiopoulos [CERN], O. Caretta, T. Davenne, C. Densham, P. Loveridge [RAL] , L. Rivkin [EPFL/PSI]

4d High Power Targetry Workshop
Malmoe – May 2-6, 2011

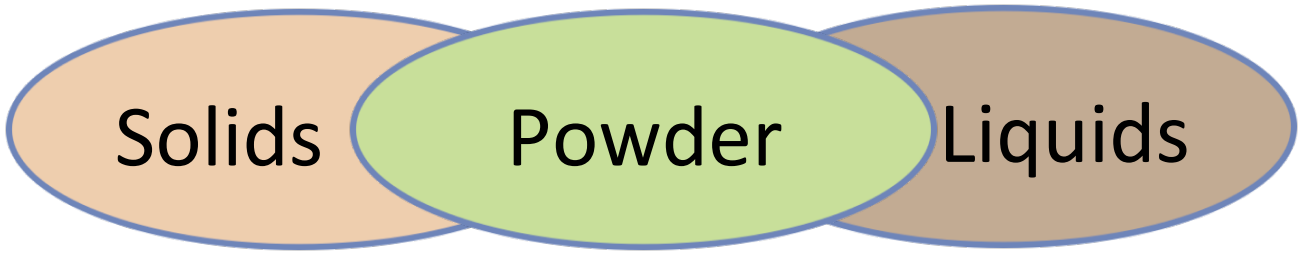
Outline

- Motivation - Scientific goals
- Experimental layout
- Diagnostics
- Planning – next steps
- Summary

Powder experiment - Motivation

- Granular targets have been proposed since long as alternatives to liquid metals for High-Power targetry
  - P. Sievers, P.Pugnat, et. al. …..

- Recent work by the RAL group on fluidized tungsten powder has given promising results and is under study as alternative high-power target to liquid Hg for a NF or MC



  - Talk of O. Caretta …. → this workshop!

- **It is about time to do a test !!!!**

Motivation

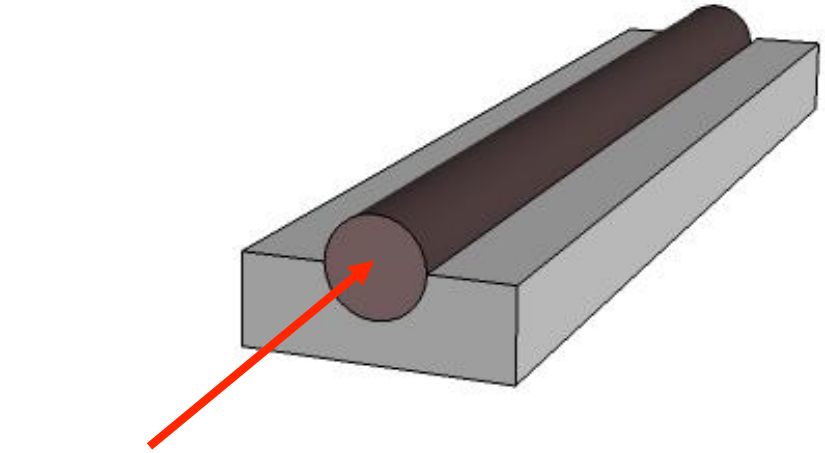
- Main **scientific goals**:
- 1. Possible **disruption** of the powder
- 2. Possible **melting** of the beads
- 3.Evaluation of the shock wave caused by the temperature increase
- 4. Temperature increase for assessing the possible cooling needed for such a target

Powder experiment in HiRadMat @ SPS

- Proposal (CERN – RAL collaboration) to test a **static** tungsten powder target on **similar conditions** as in a future application in a NF

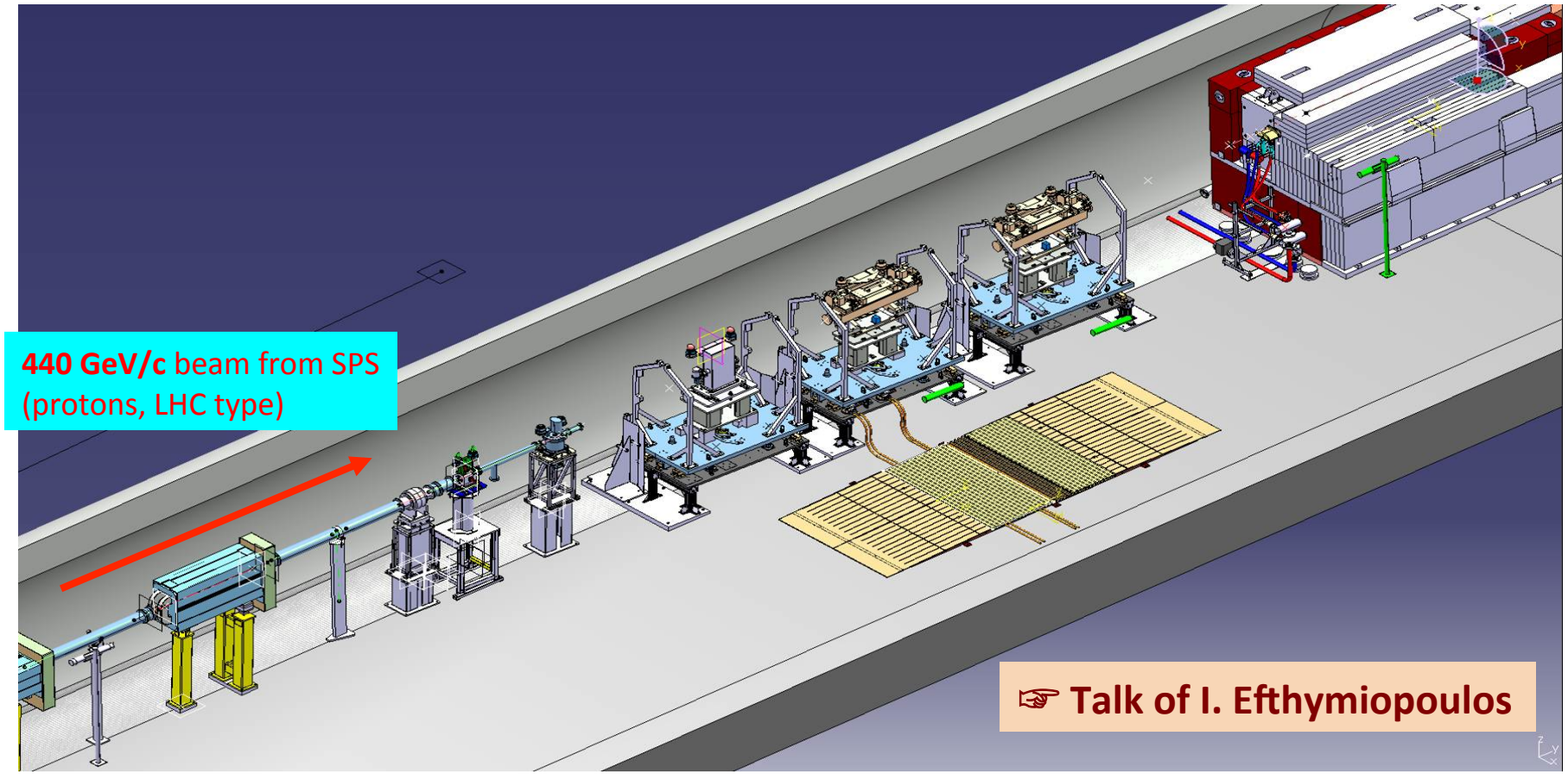
- Single pulse experiment (like MERIT)

- **Target configuration:**
  - 1(0.8) cm diameter
  - 20-30cm long (along z)



The HiRadMat Facility @ SPS

- Facility specially designed to test impact of high-intensity beam on materials
  - Designed primarily to test LHC components (collimators, etc.)

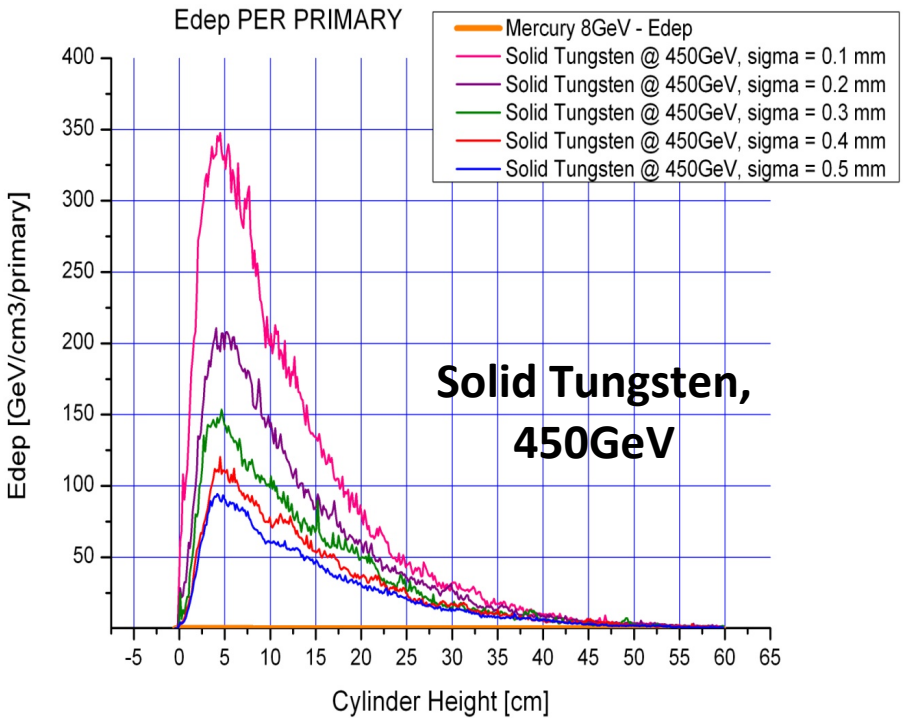


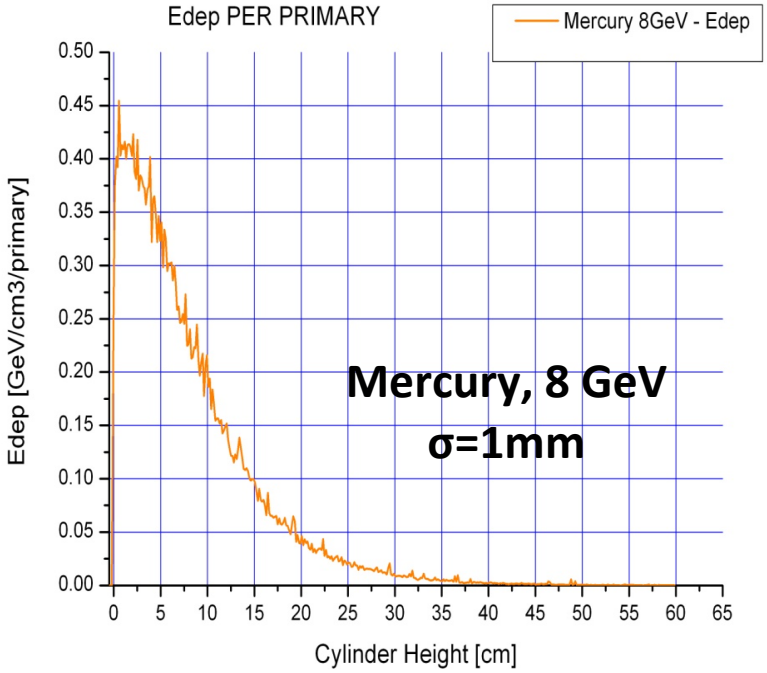
Beam parameters

- How to adjust the HiRadMat beam to match the NF parameters on target
  - Neutrino Factory beam parameters:
    - Beam energy : 8GeV
    - Beam spot size: ~1mm
    - Protons/pulse: 6.25E13 (50Hz)
  - HiRadMat beam parameters:
    - Beam energy: 450GeV
    - Beam spot size: 0.1 – 0.5 mm
    - Protons / pulse: available from 1 – 288 bunches with intensity up to 1.7E11 protons
  - Adjust HiRadMat beam to match a single pulse
    - Adjust total intensity
    - Adjust beam spot size

FLUKA Monte – Carlo simulations

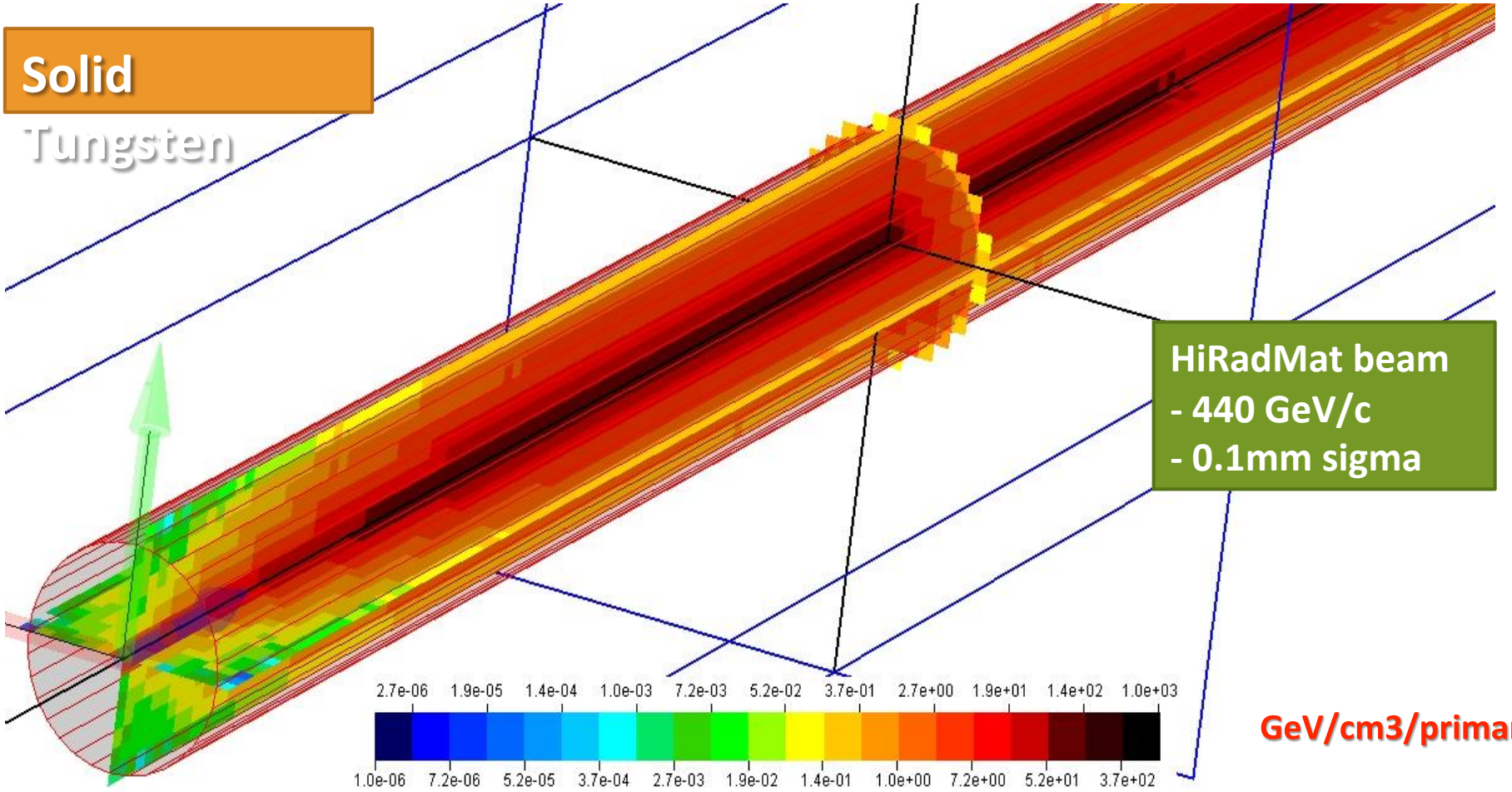
- Cylindrical geometry of 1cm diameter and 60 cm length
- Scoring: Cylindrical binning of radius: 0.05σ at the center of the cylinder (beam impact point)



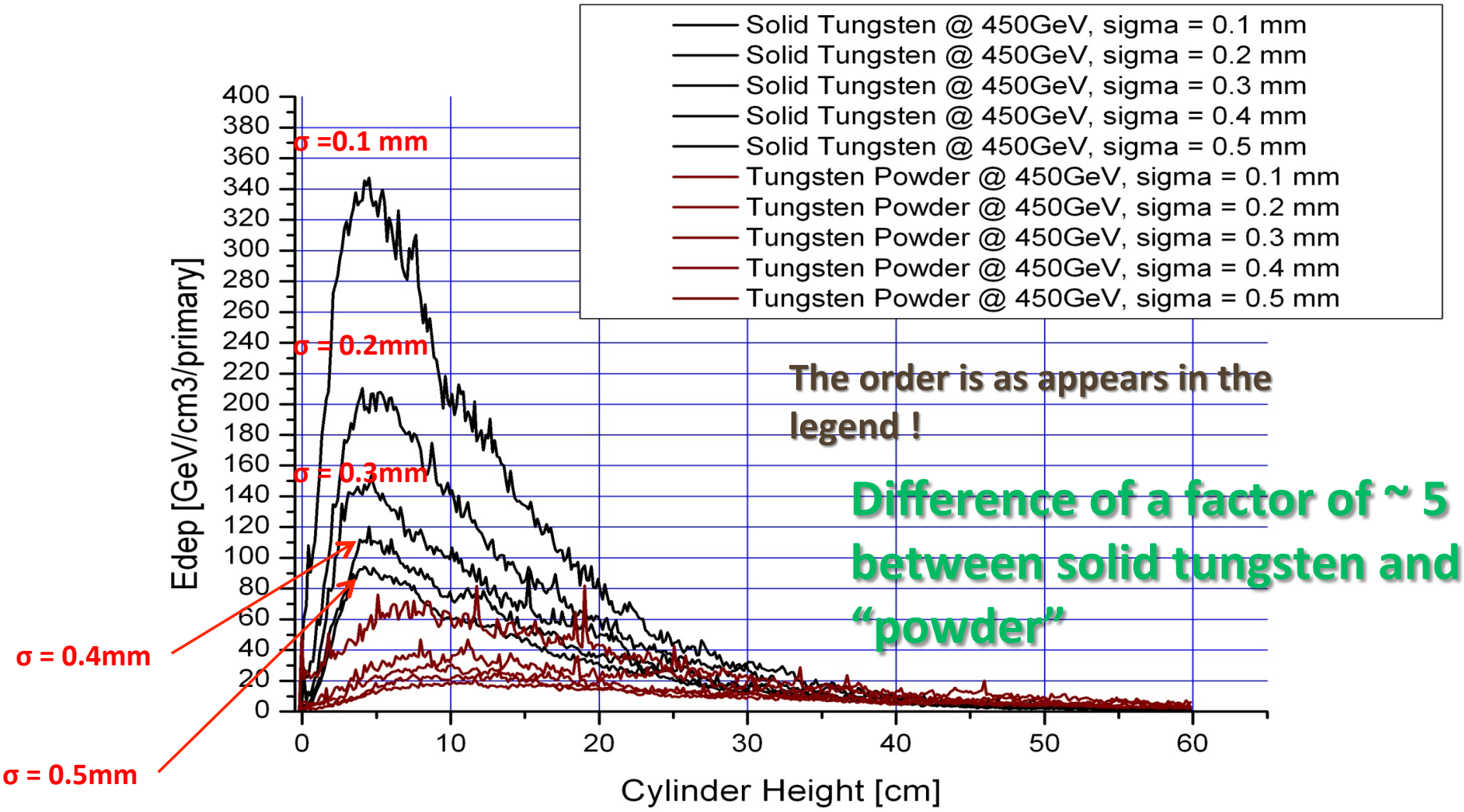


•Energy in solid W/primary @ HiRadMat ~1000-100 times greater than Hg/primary@NF

Energy Deposition – FLUKA Simulation



Solid W and W-Powder @ 450 GeV

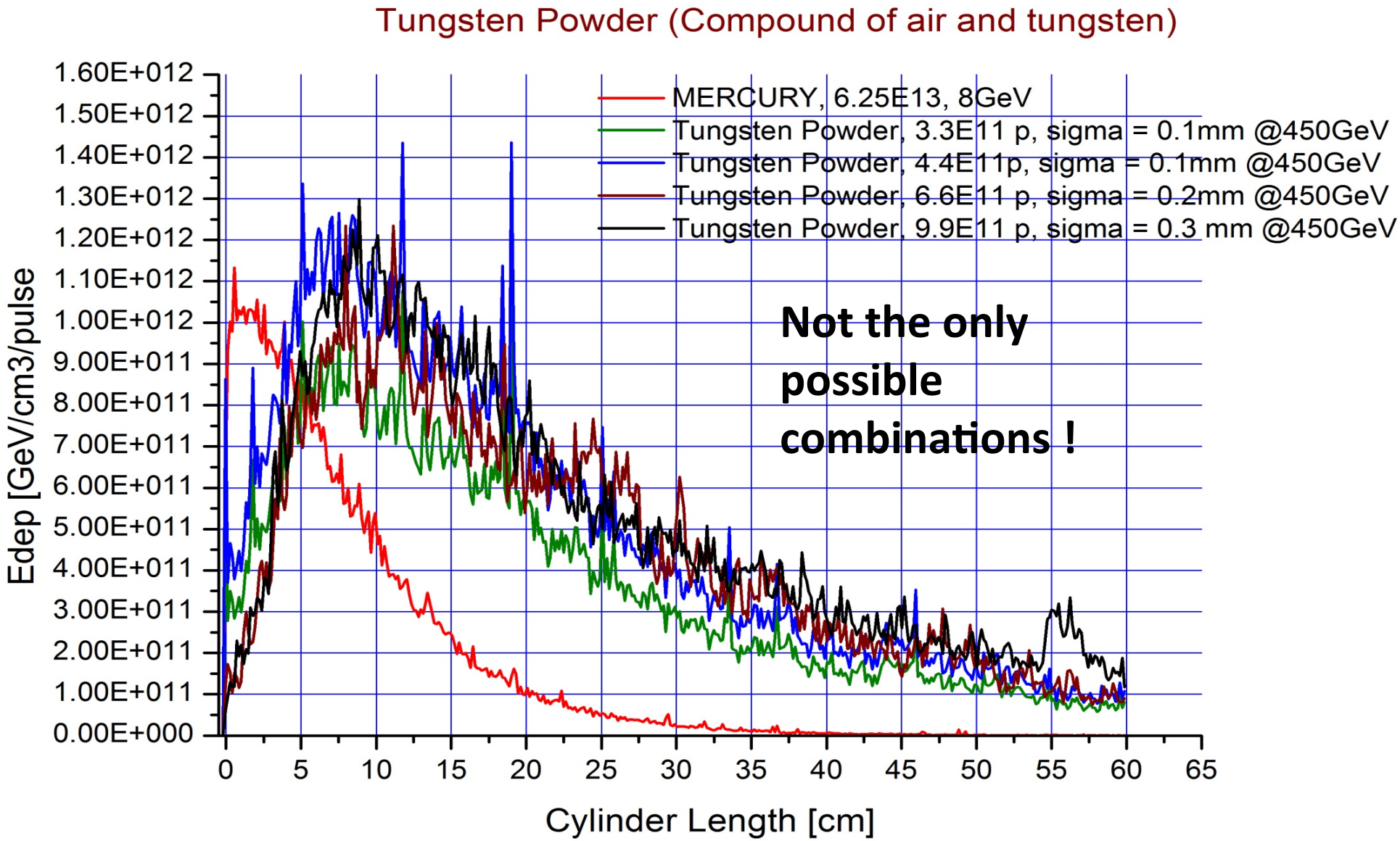


The order is as appears in the legend !

Difference of a factor of ~ 5 between solid tungsten and "powder"

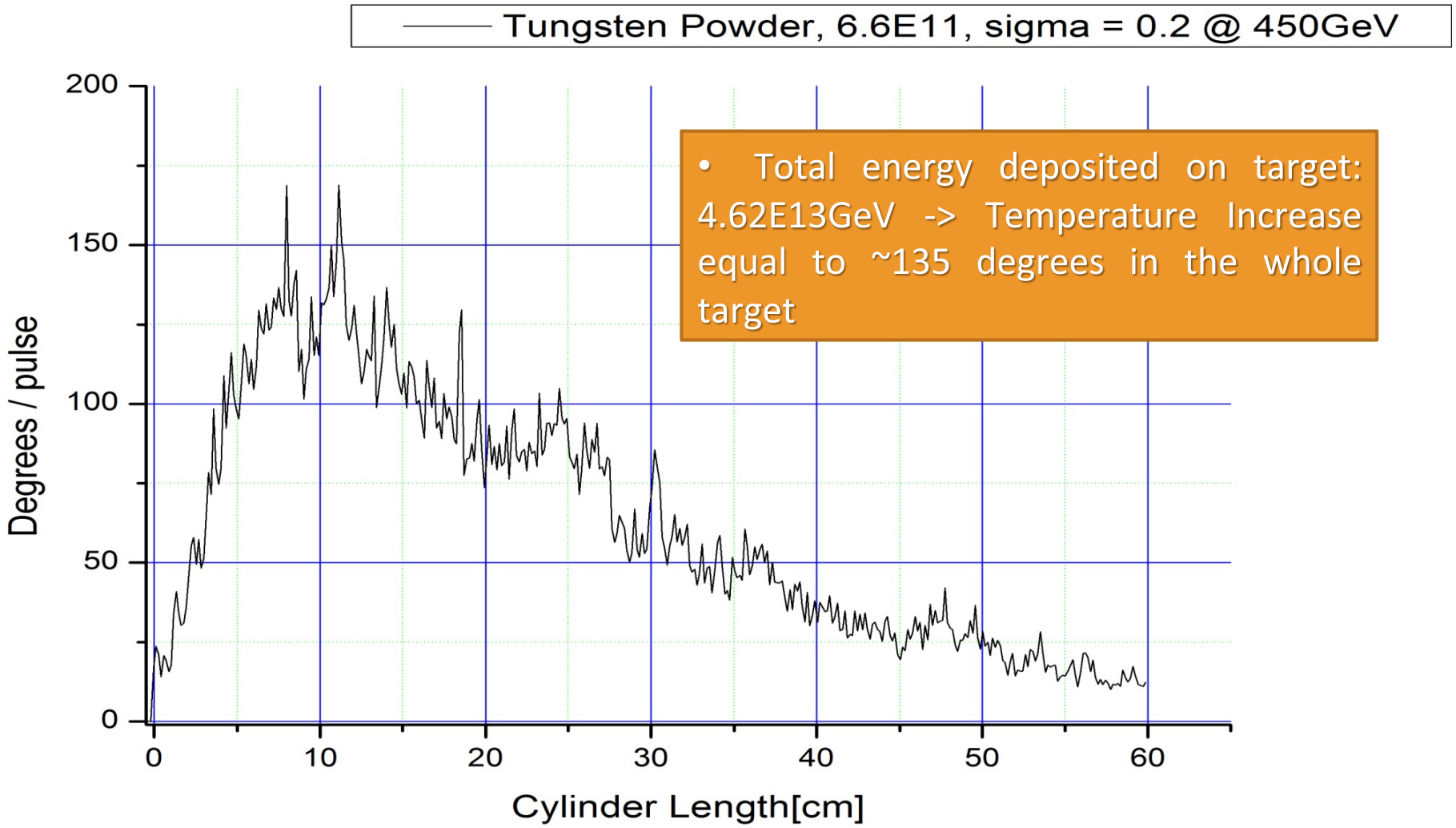
W-powder simulated as an air-tungsten compound with density 9gr/cm3

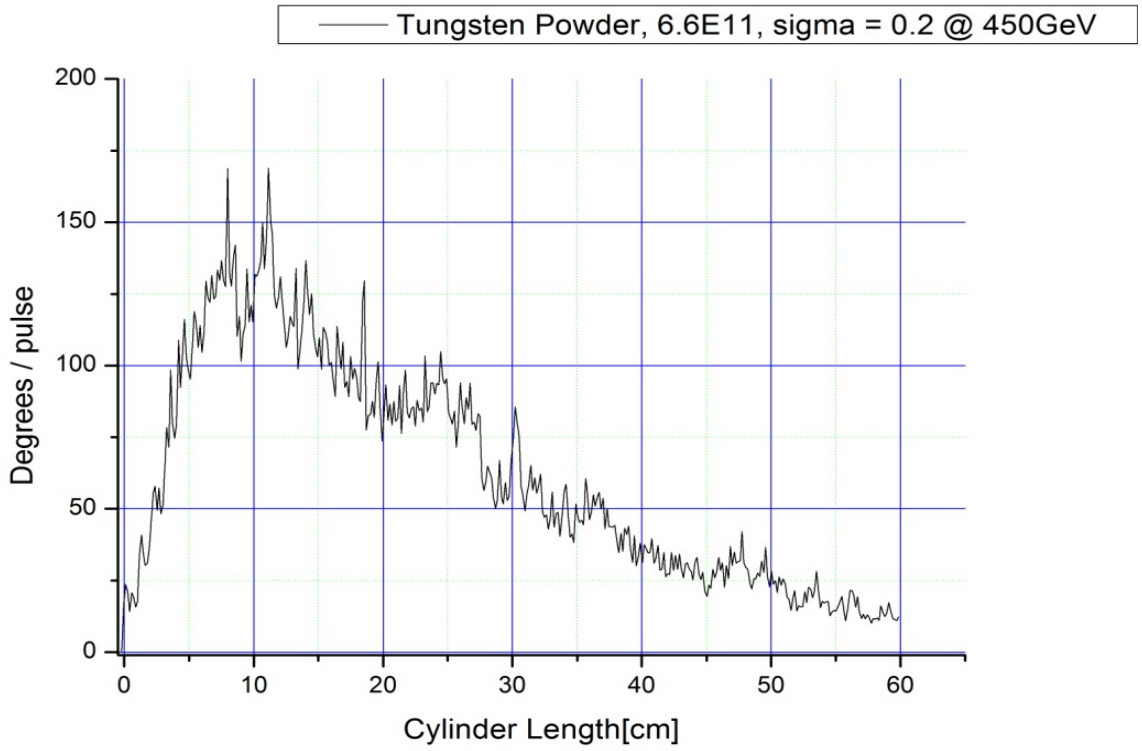
Mercury @8 GeV and W-powder @450GeV



Temperature increase in powder

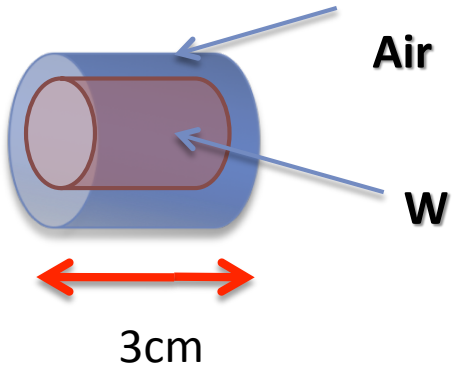
- Through the rough formula $$\Delta T = \frac{1}{\rho c}\frac{\Delta E}{\Delta V}$$





Pressure of the air:

Assuming a small cylinder of powder exactly at ~ 10 cm (max) and assuming a simple configuration:



And **assuming** that all the heat from the w-bead will transfer to the air, changing it's pressure…

$$\frac{p}{p'} = \frac{T}{T'} \Rightarrow \frac{p'}{p} = \frac{T'}{T} \Leftrightarrow p' \cong 136\,p$$

WILL THIS PRESSURE CHANGE CAUSE A DISRUPT ON THE POWDER ?

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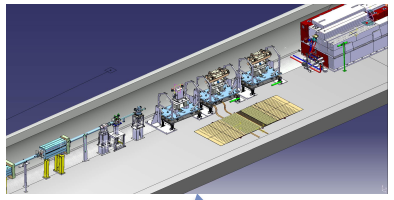
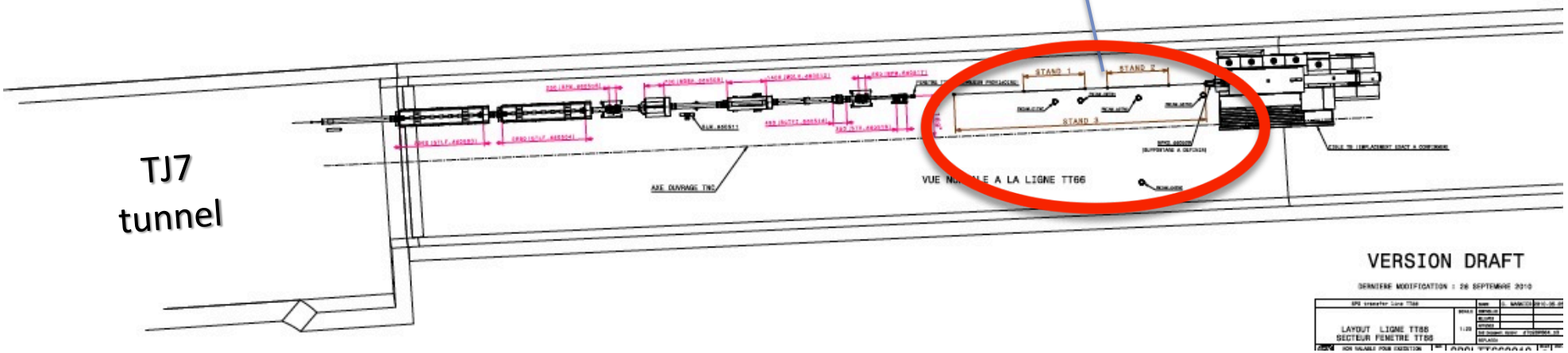
Experimental layout

- Experimental Area layout

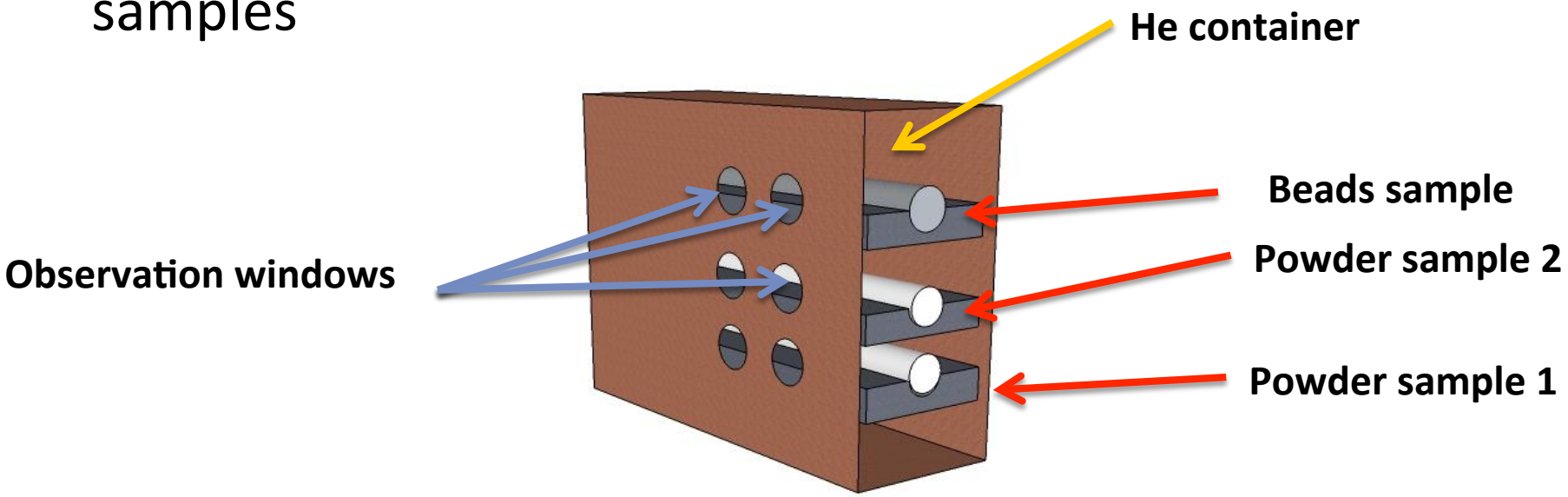




- The experimental instrumentation will be installed in TJ7 tunnel. The observation will take place through high-reflectivity mirrors.

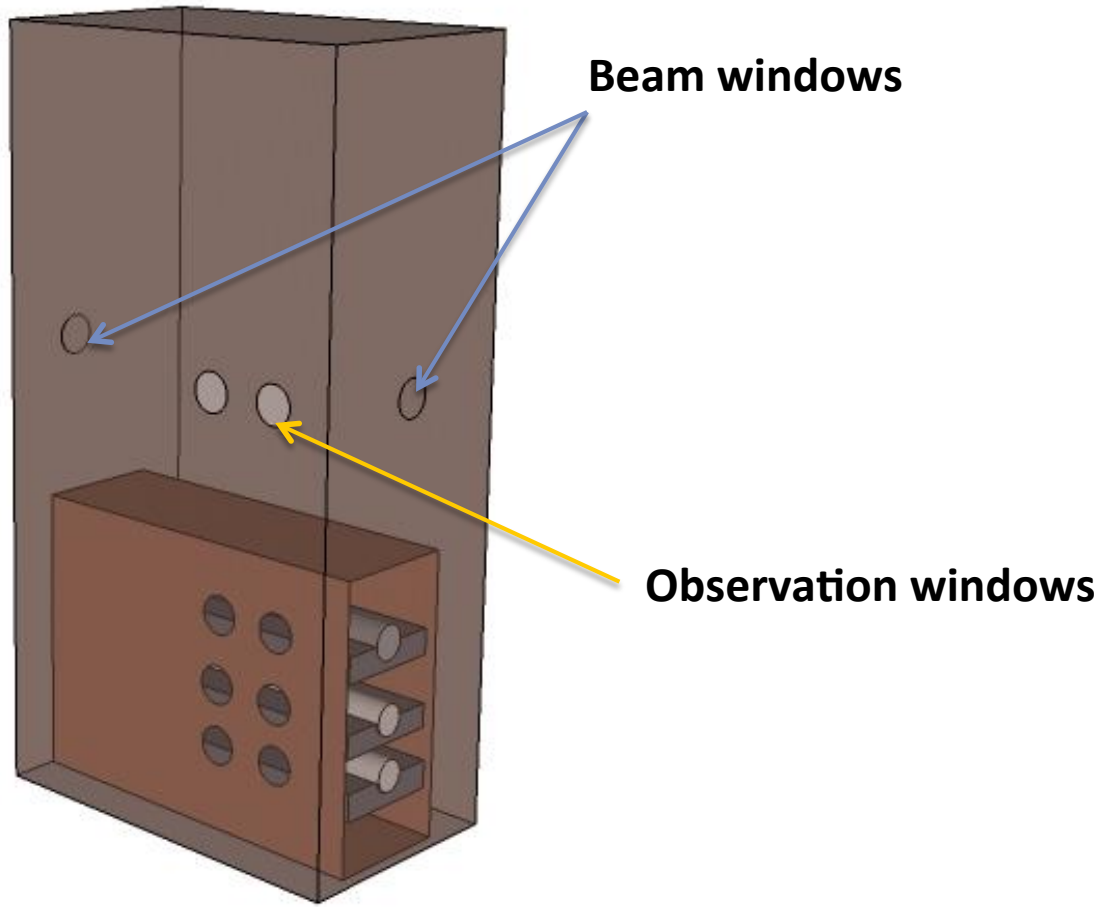
Experimental sampler

- 2 samples will be tested :
  - W-powder samples: two (basic + reserved), 1cm diameter, 30cm (tbc) long
  - W-beads : 3 mm diameter – proposed for EUROnu SB target
- A special sampler is being designed, containing the samples

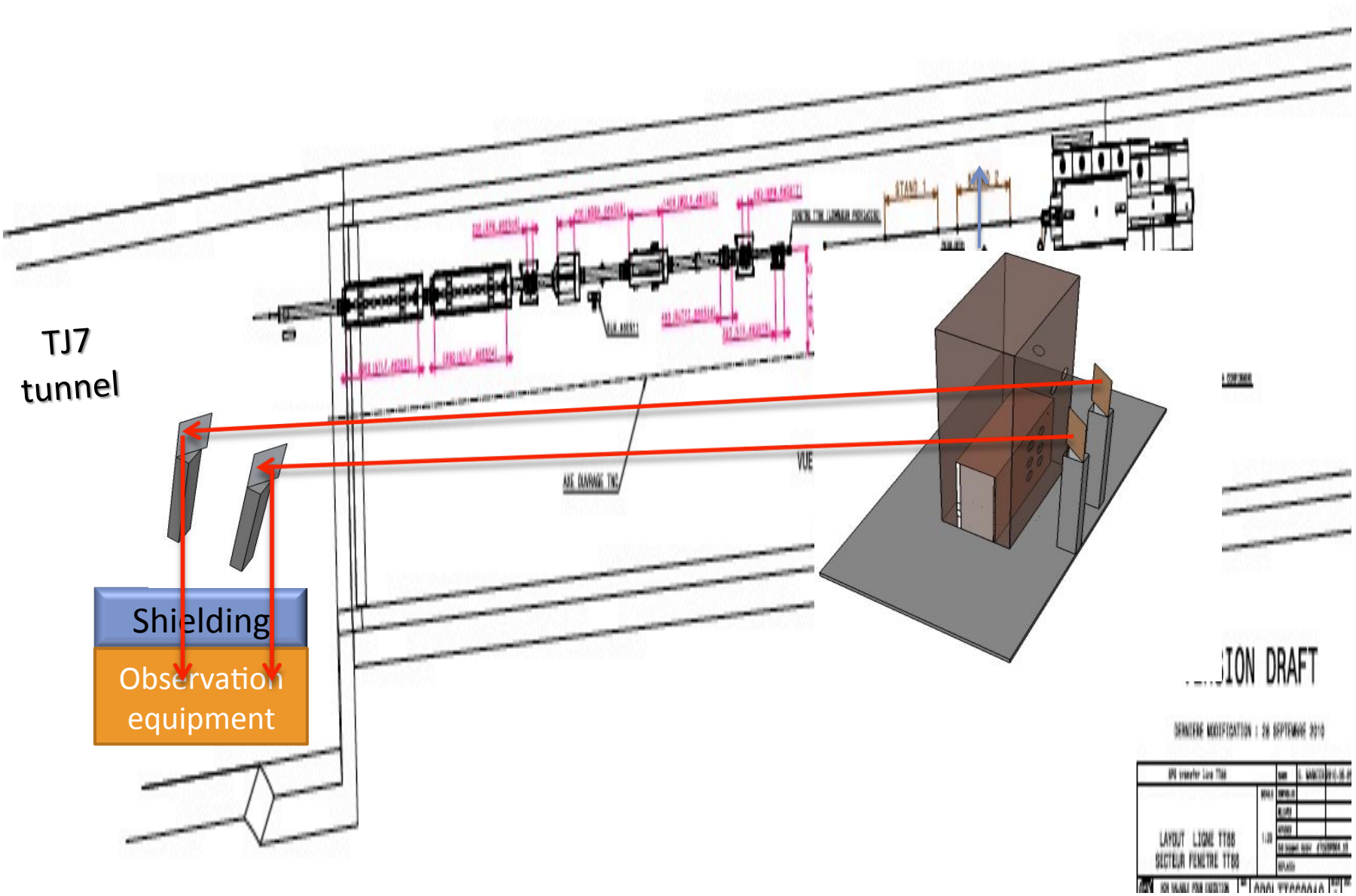


Experimental sampler

- The sampler will be aligned each time with the help of a motor with the beam line



Experimental setup



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High speed cameras

- Based on previous experience, cameras of the kHz frame speed should be enough
- Installed behind a shielding in TJ7, in order to be protected from the prompt radiation.
- A triggering system of the camera with the beam will assure the accuracy of the observation

Laser Vibrometers & Microphones

- Even if no *visible* effect is there, we have to evaluate the shock wave.

- Through the mirrors, a laser vibrometer (LVB) will be installed in order to assess the possible vibration of the containers.

- Moreover, radiation-hard microphones will record the sound of the beam impact, a well known technique used in the LHC collimators tests.

Temperature increase

- The measurement of temperature is very important but difficult task.

- A thermal camera for this purpose is being under consideration.

Post irradiation analysis

- The post irradiation analysis of the samples will reveal possible changes in the shape or the beads or in their size.

- Of course, a significant amount of cooling down time will be needed until the samples can be analyzed

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Planning

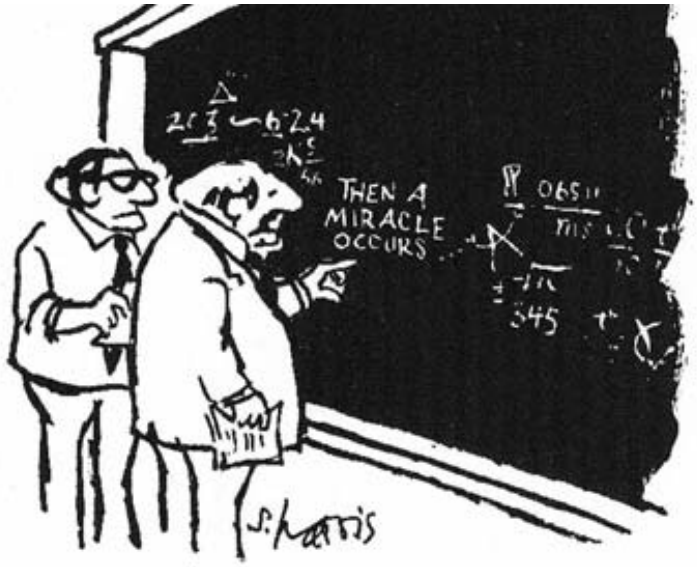
- The preparation of the experiments is dependent on the LHC technical stops
- The initial planning of this experiment is for this year's autumn, but it can also be performed at the beginning of next year.
- After the cooling down of the targets, the post-irradiation analysis in a special facility (either on CERN or elsewhere) will reveal more structural information.

Summary

- We plan to perform a feasibility experiment for fragmented solid targets in HiRadMat/SPS as possible neutrino factory targets.
- 2 samples of fragmented targets (tungsten beads and powder) will be tested
- Instrumentation based on high speed cameras, laser vibrometers, thermal cameras and microphones will be used to evaluate the result
- Post-irradiation analysis will reveal structural changes after the irradiation.

Thank you !

Thank you



"I think you should be more explicit here in step two."