Beam Instrumentation Issues for the MERIT Experiment

Outline

- Experiment layout
- Beam Instrumentation
- Beam envelop
  - Limits
  - Issues to consider

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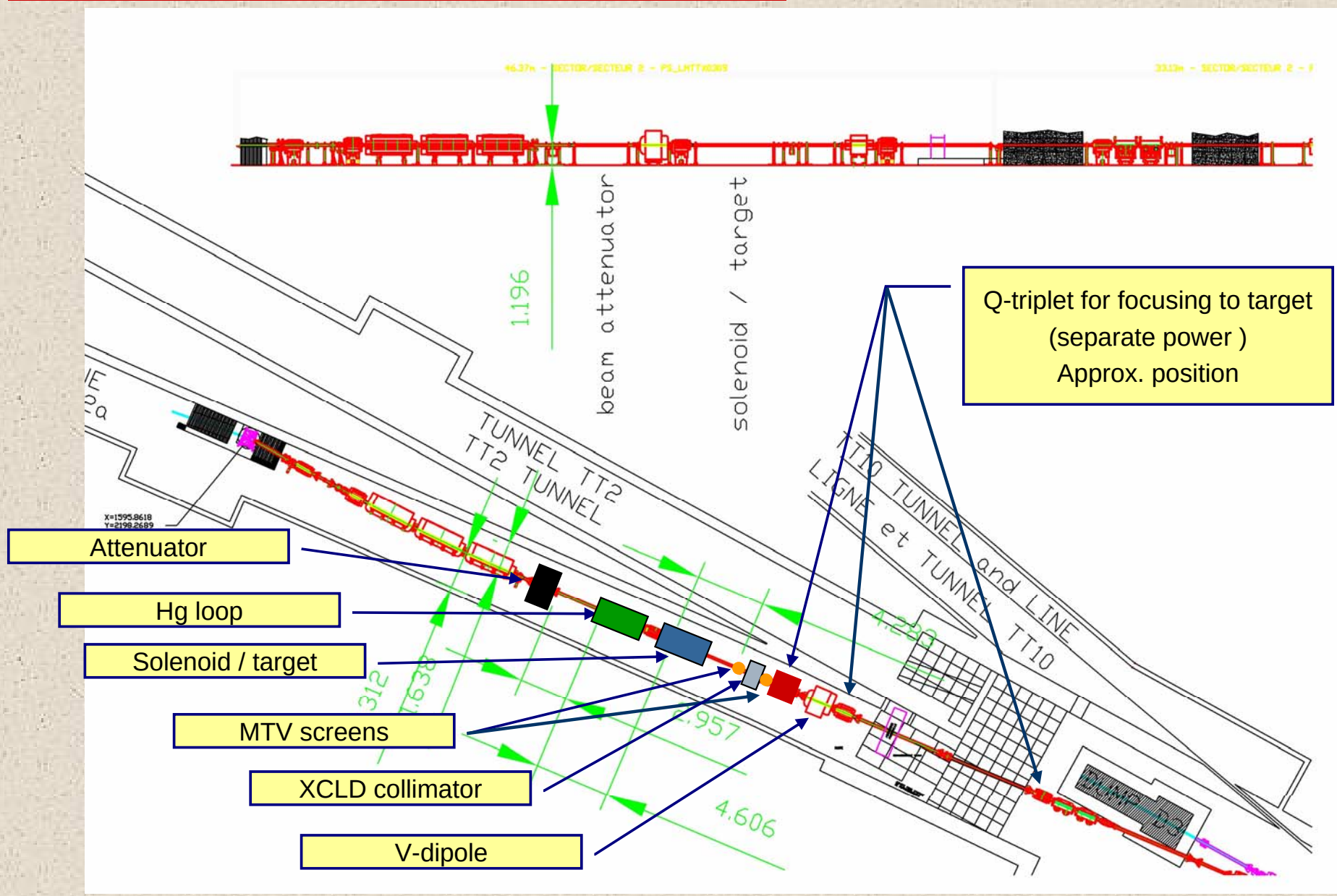
VRVS Meeting
CERN – December 6, 2005

Layout - beam elements (1/2)

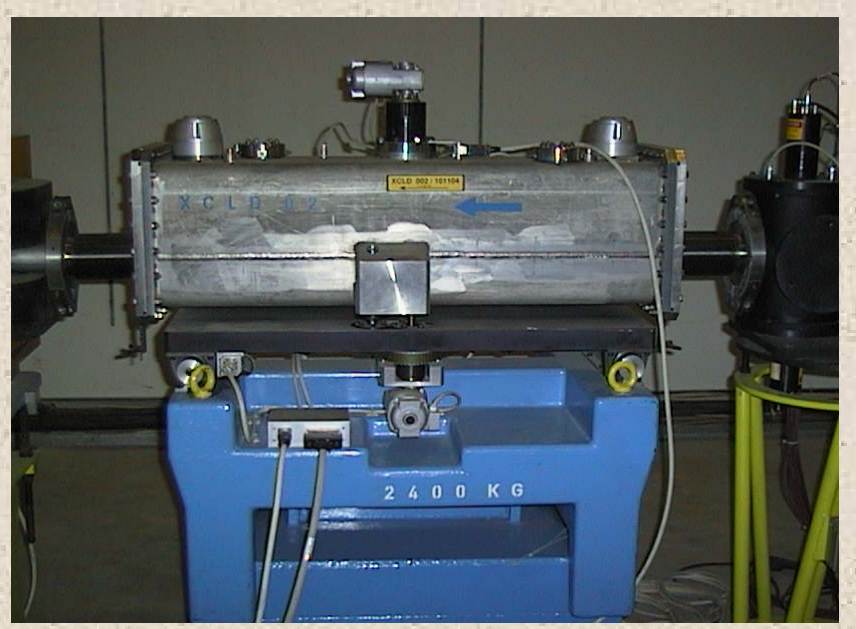


Layout - XCLD Collimator (2/2)

General description

- 100 mm x 100 mm iron block, 1.2m long
- Has a fixed hole of Ø60mm – use W inserts to reduce diameter
- Possibility to move it {x,y} in +/- 8mm range
  - Local control not a problem ; remote control quite difficult (is it needed?)

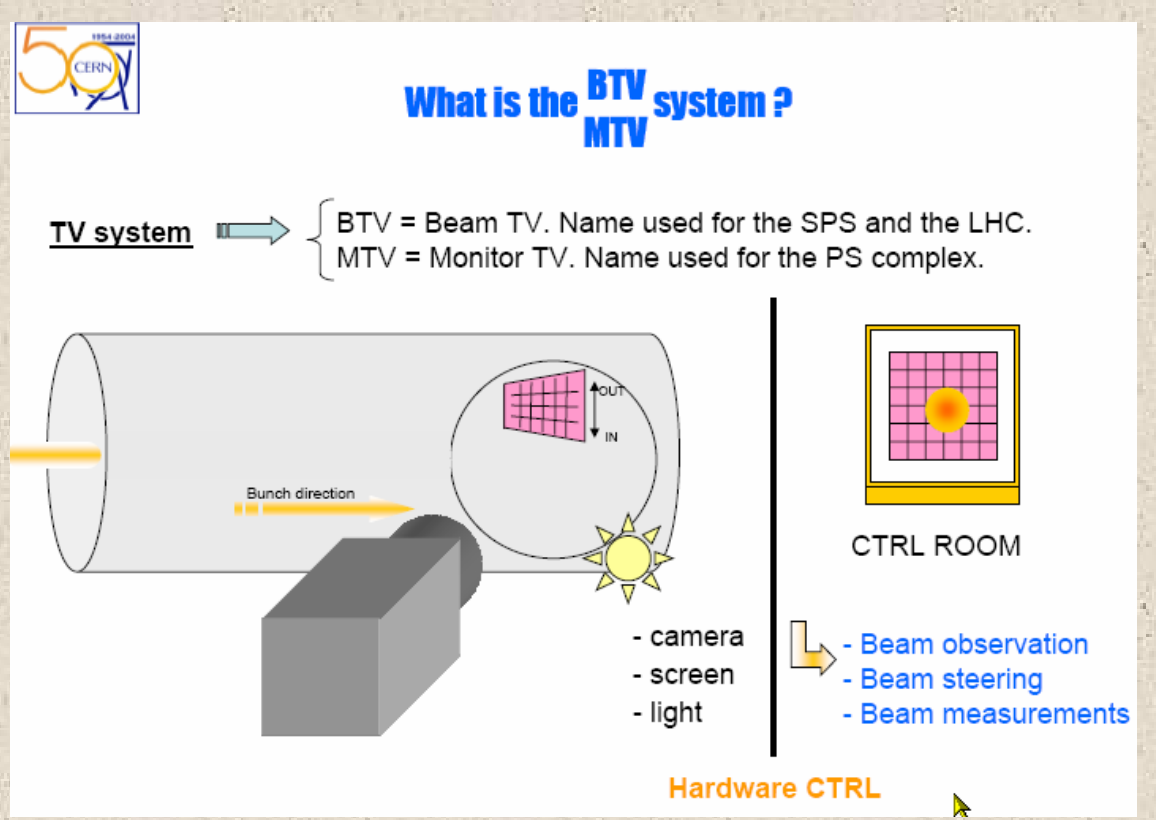
- XCLD collimator will be installed ~2m upstream of the target
  - defines beam path and protects material (primary container & windows)
  - adjust hole to Ø???mm diameter – a bit less than the beam window



Beam profile measurement (1/3)

MTV screens

- Provide information on beam spot
  - Optics should be adjusted to our beam size
- A pair of MTV screens could be installed upstream of the experiment
- Issues of concern:
  - Radiation
  - Magnetic field



Beam profile measurement (2/3)

Other possibilities:

SEM grids

- 40 um gold plated W wires / 3mm W strips
- IN/Out movement possible

- Points of concern:
  - Our beam is too small for the existing grid spacing
  - Development of a new chamber is:
    - Costly : > 50 KCHF
    - Takes time and manpower – difficult at CERN nowadays….

Wire scanners

- Would require new installation – a bit difficult
- Quite delicate object – lots of problems already using them in PS/SPS

Beam profile measurement (3/3)

Transverse beam parameters

- Position & spot size → MTV screens
- Direction → 2× MTV screens & collimator
- Divergence → not a direct measurement
  - Rely on beam simulations
  - Estimate from spot size monitors

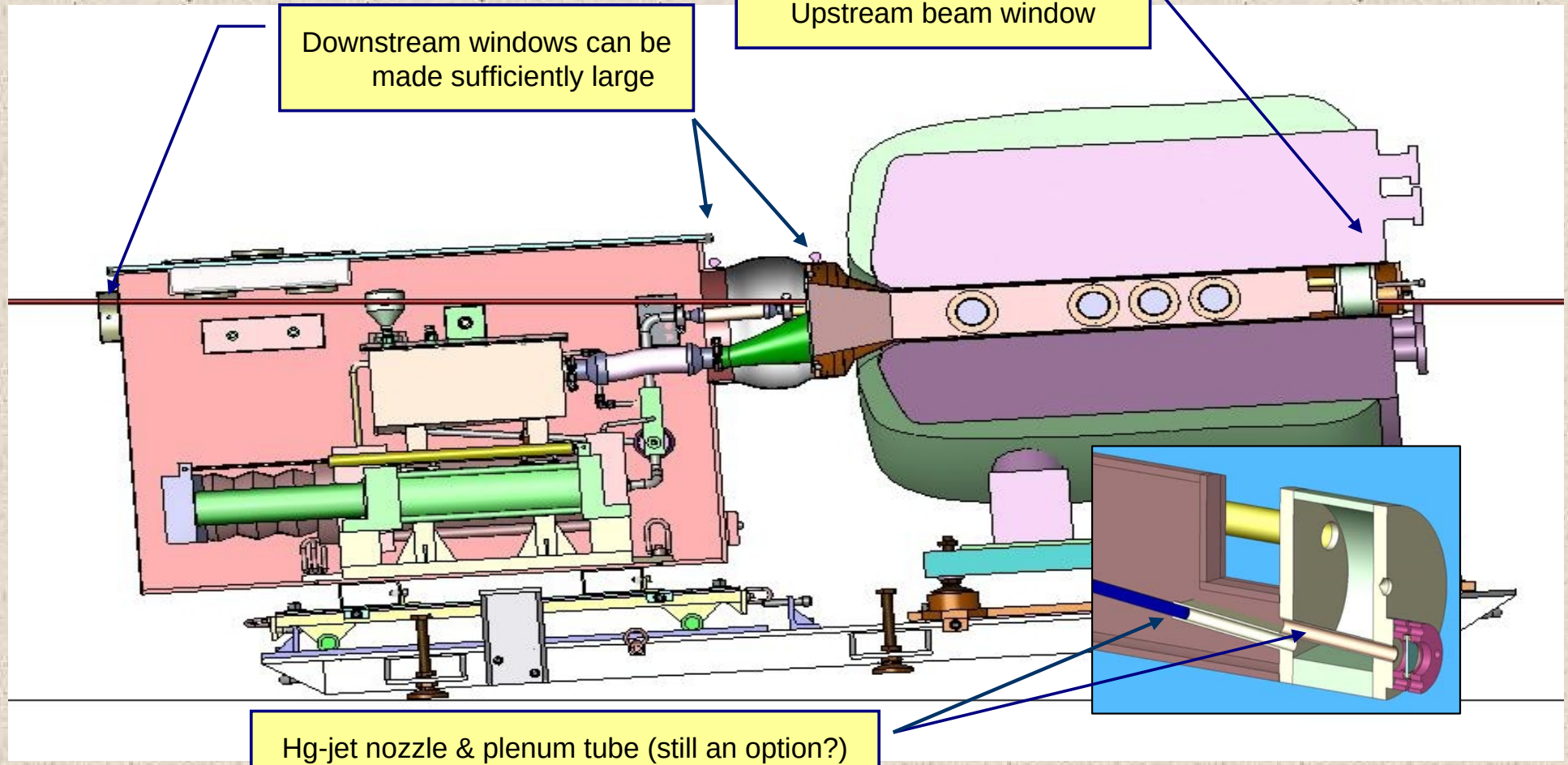
Longitudinal beam parameters

- Measured by pick-ups in the TT2 line upstream of MERIT
- Log values and make available the information for the MERIT collaboration
- Parameters measured:
  - Bunch length
  - Bunch spacing
  - Pulse length
  - Intensity
- What is the precision we require on all those ?

The beam envelop (1/3)

- Consider beam size : 3 sigma
- Consider possible movements: Scans or Badly steered beam

Critical points at the experiment:



The beam envelop (2/3)

Issues to consider:

- The 3σ beam shall never be closer to the beam window frame than 5 mm (??)
  - Input on window design is required – Nick?
  - Adjust the XCLD collimator opening accordingly

- Avoid interaction of the beam (3 sigma) with the nozzle
  - Optimize the nozzle size wrt movements?
  - Restrict scans to one direction

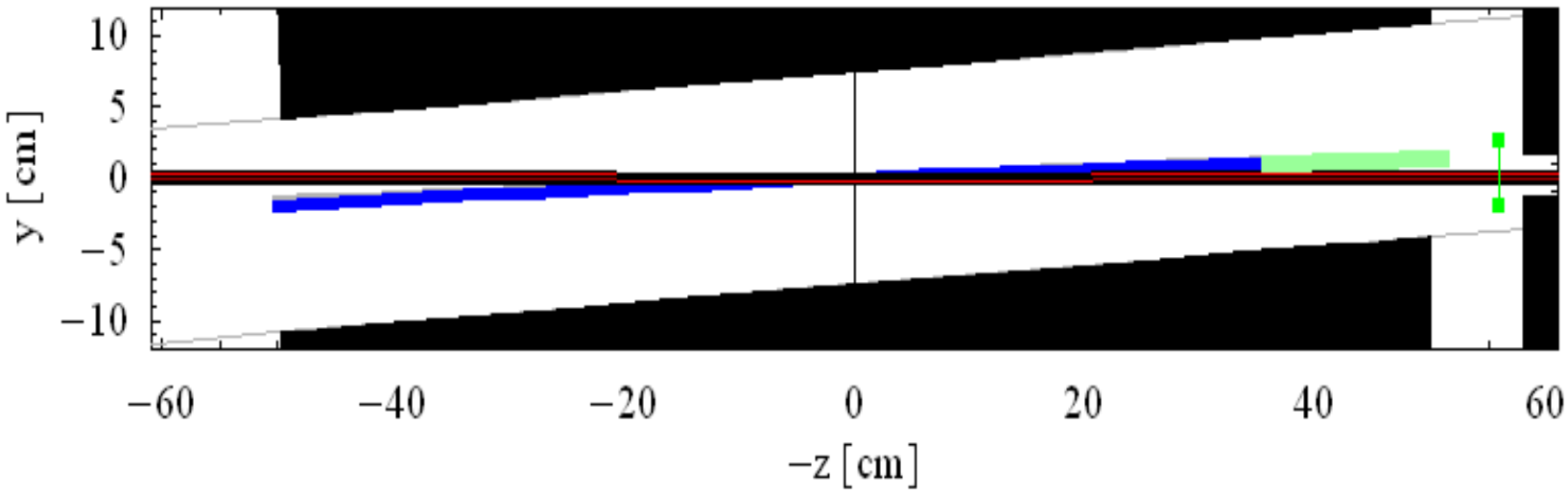
- Take into account
  - Fluctuations :
    - may need to adjust the beam spot between “major” PS configurations
  - Scans of the beam position
  - Spot size :

The beam envelop (3/3)

Parameters to consider:

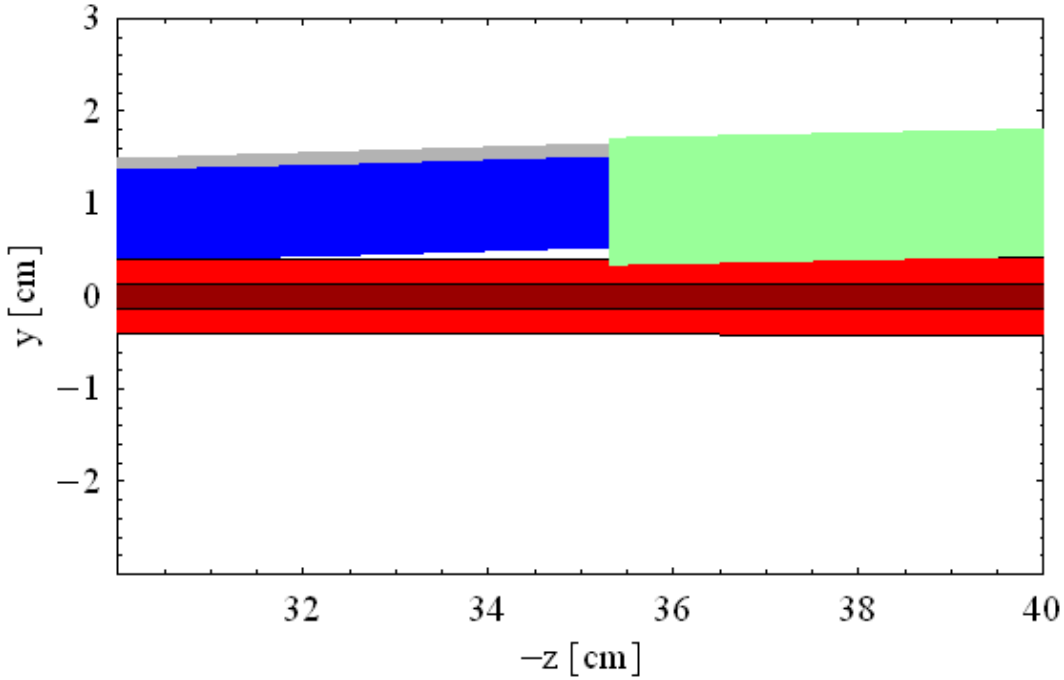
- Interaction point: x=y=z=0
- Solenoid bore: L=100 cm, D=15 cm, α=67mrad
  - Reduction of bore size by primary/secondary containment not included
- Nozzle: L=15 cm (tip to lowest point), z_{exit}=36 cm, $OD_{pipe}=D_{jet}$ + 2*0.2 cm
- Hg jet: D=1 cm, tilt= 0.033 rad (at IP), v=20 m/s (at IP)
- Proton beam: r_{rms}=0.15 cm, x'=y'=0.5 mrad, $\Delta x=\Delta y \in$ [-7,+7] mm
  - Beam scattering due to target not included, impact on downstream window only
- Beam window: ID=3.5 cm, $OD_{frame}=ID_{window}$ + 2*1 cm
- XCLD collimator: $ID=ID_{window}$ - 0.5 cm
  - Collimator opening must be smaller than frame of beam window

Layout in bore vicinity



- Includes gravity, divergence and places nozzle accordingly
  - No beam scattering
- 1σ and 3σ beam indicated

Nozzle and beam



Nozzle

Beam (1 σ)

Beam (3 σ)

Hg jet

Grey indicates the “33 mrad jet”

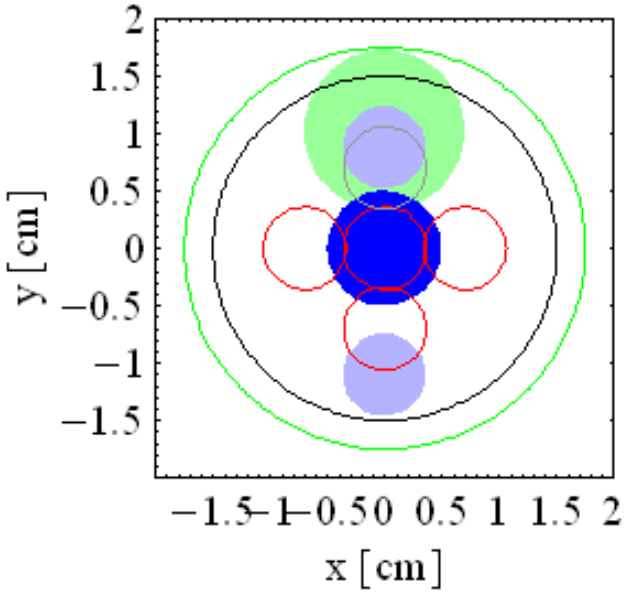
- Nozzle tip (z= -35 cm): centered at +1.03 cm, tilted by -25 mrad
- Closest approach of nozzle and 3σ beam: overlap by 0.3 mm
- Can that be considered as acceptable?

- Issues to consider:
  - it does not allow any vertical upwards scan of beam
  - any variation of spot size (or misalignment) increases overlap
    - what should we consider as the limit ?

Can the nozzle be retracted further upstream?
What is the limit?

Beam displacement

- Possibility for beam scans
  - To define window/collimator openings, the beam parameters must be fixed first.
- Window size slightly larger than collimator

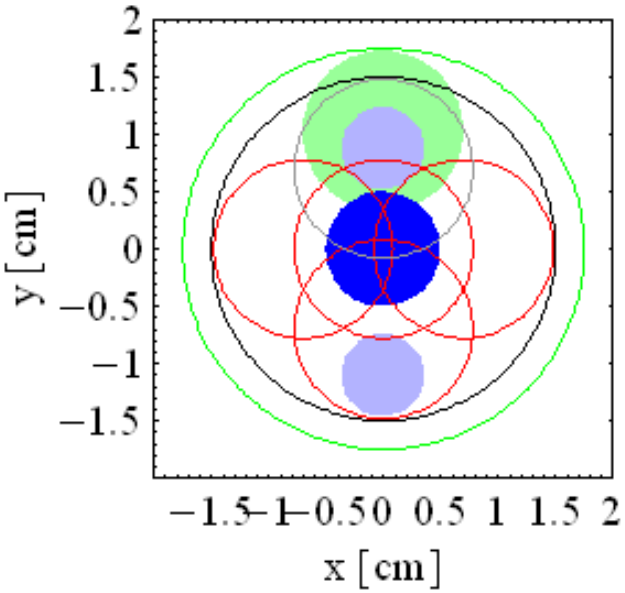


nozzle

jet z=0

3σ beam at z=0

With maximum spot size listed in pulse list



- Parameters used:
  - $ID_{collimator} \geq 3$ cm
  - $ID_{window} \geq ID+0.5cm$

Additional slides

Allow vertical displacement of the beam?

Vary the jet velocity:

- Allows to simulate irregular operation of a high power target
- Systematic study as input for simulation codes

- $v_{jet}=\infty$: Δx_{beam}= +1mm
- v_{jet}=10 m/s : Δx_{beam}= -5mm

- Configurations do not allow a lowering of the beam position