First Ideas on the Design of the Beam Transport and the Final Focus for the NF Target

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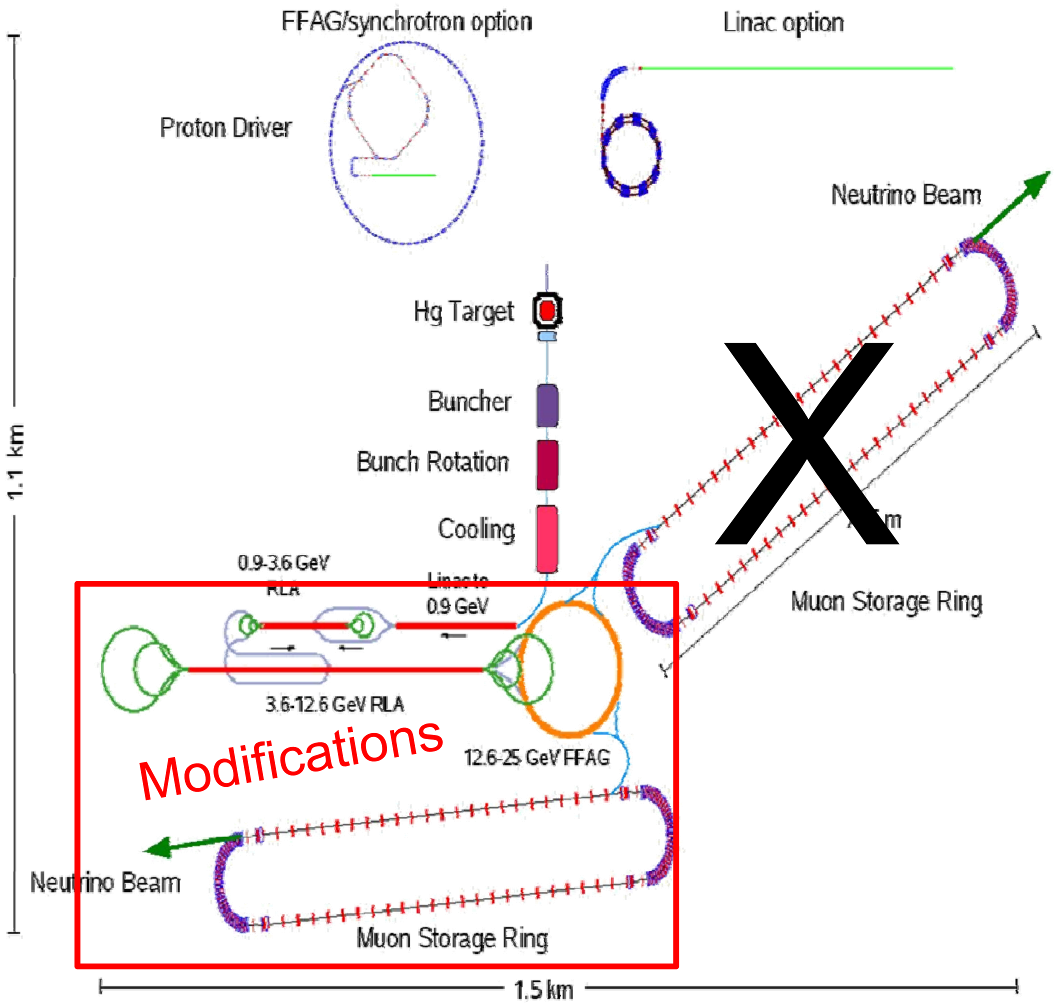
Outline

- Introduction.
- Proton Driver and Target Station.
- Choice of the initial and final conditions.
- Beam Window considerations.
- Preliminary layout.
- Towards optics.
- Summary and future plans.

Status of the Neutrino Factory Baseline after the discovery of the large θ_{13}



Effects of large θ_{13} on the baseline:

- Only one decay ring needed with reduced energy/circumference/cost.
- Modifications in the muon acceleration scheme (only 10 GeV needed).

As you can see the Proton Driver is not connected to the target, why?

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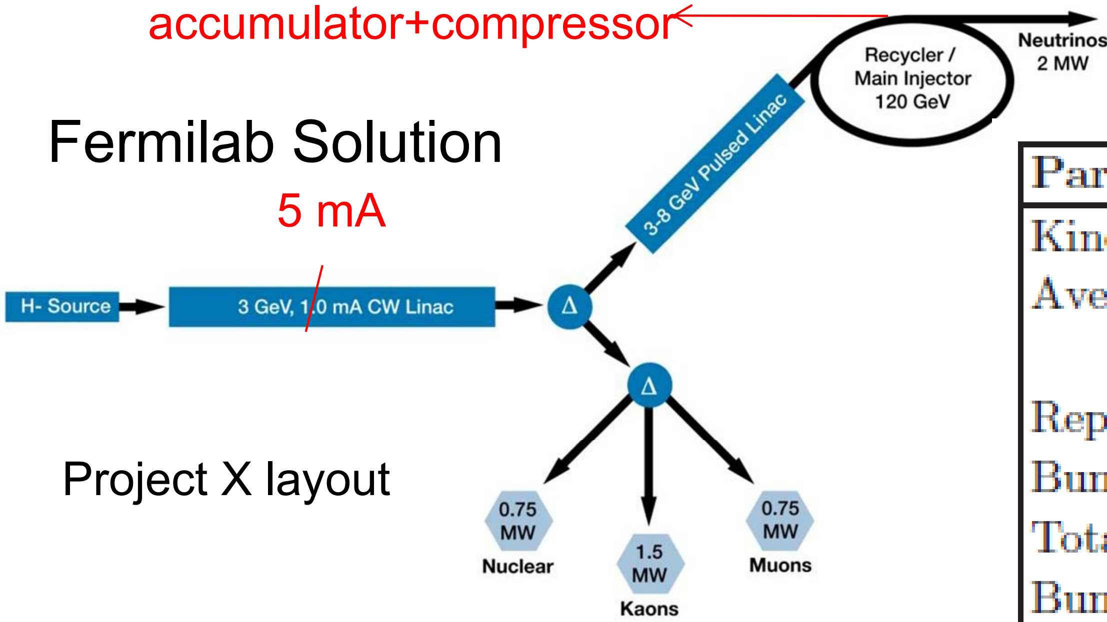
Proton Driver Solutions

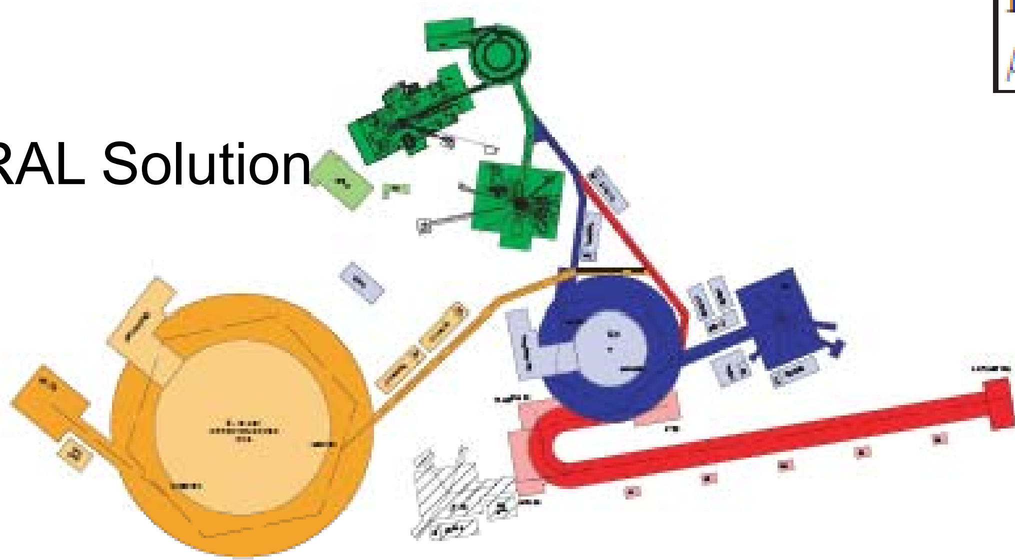
Fermilab Solution

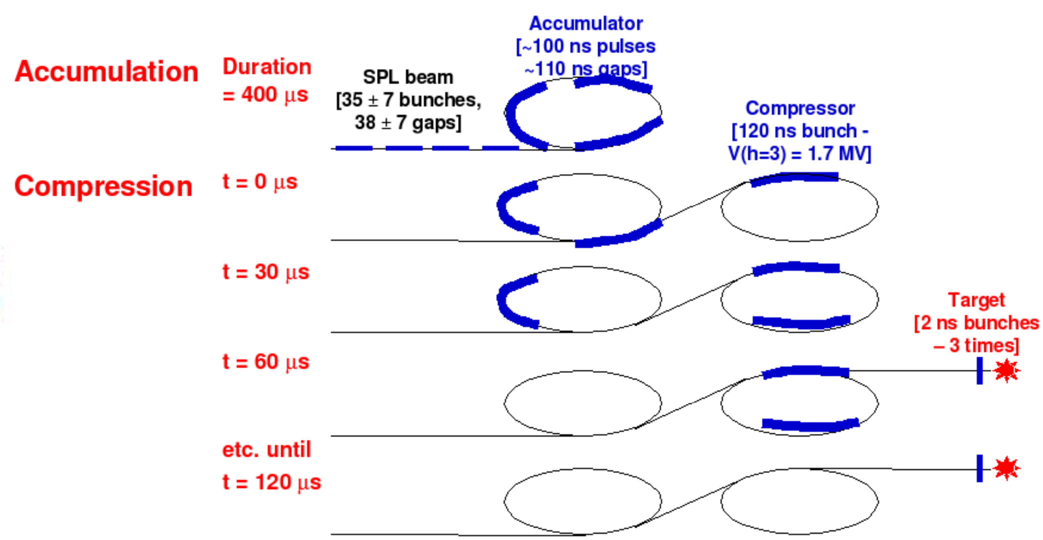


Project X layout

Parameter	Value
Kinetic energy	5–15 GeV
Average beam power	4 MW
	(3.125×10^{15} protons/s)
Repetition rate	50 Hz
Bunches per train	3
Total time for bunches	240 μs
Bunch length (rms)	1–3 ns
Beam radius	1.2 mm (rms)
Rms geometric emittance	$< 5\ \mu$m
β^* at target	≥ 30 cm

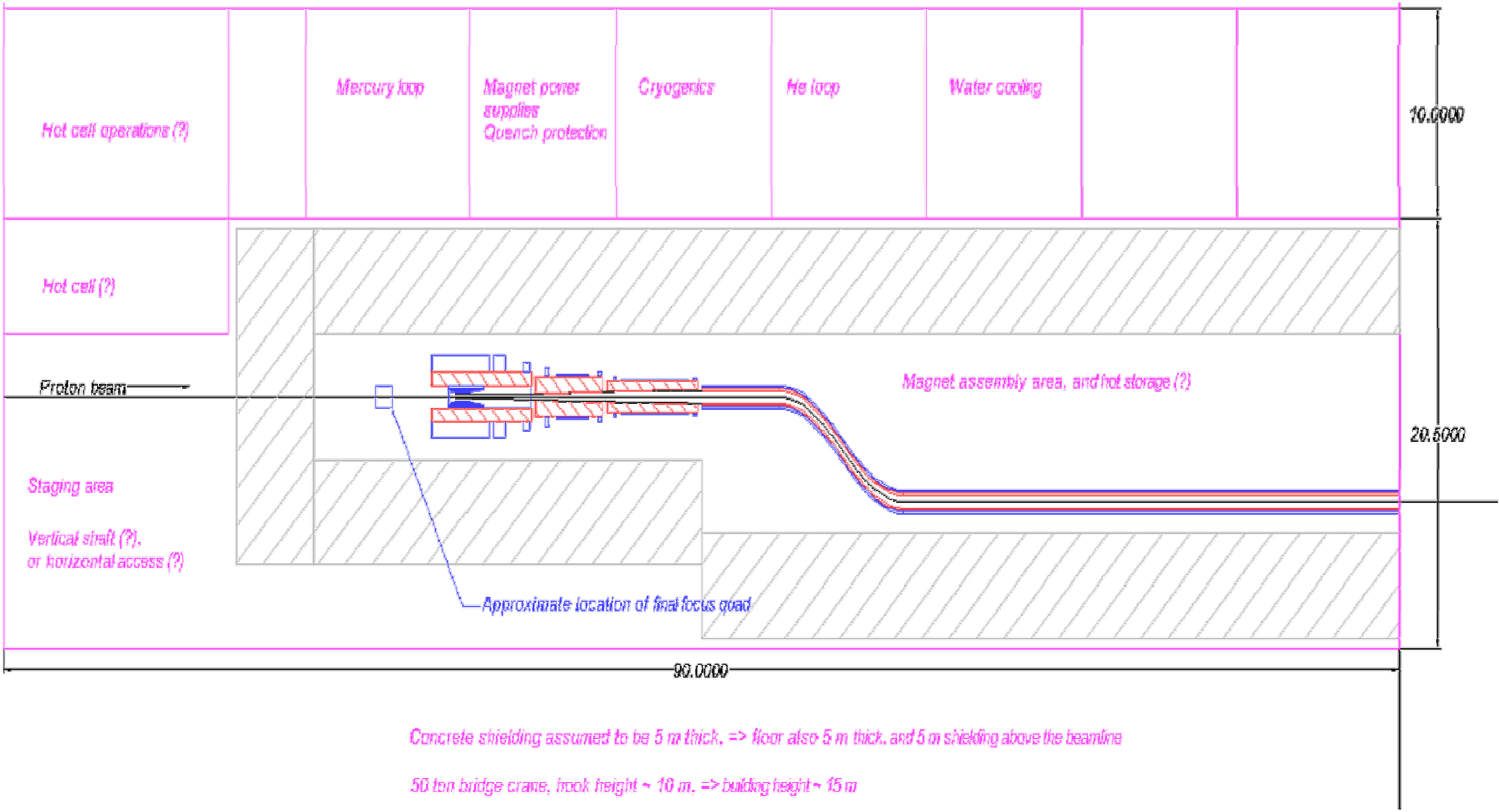
RAL Solution





CERN Solution

Status of the beam transport from PD to target (up to my knowledge)



Needs more definitions!

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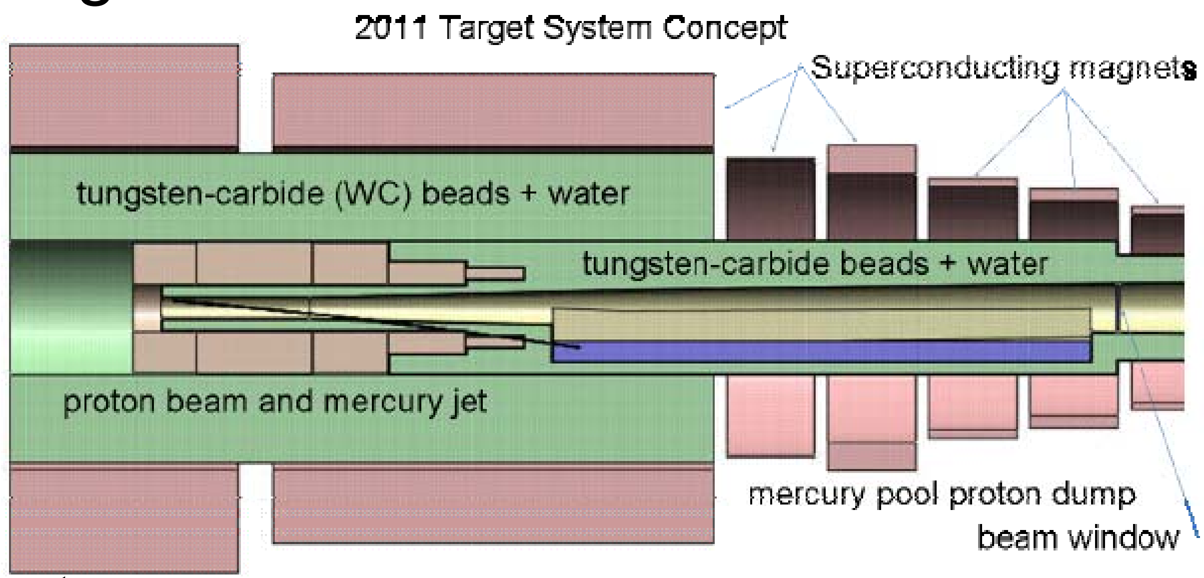
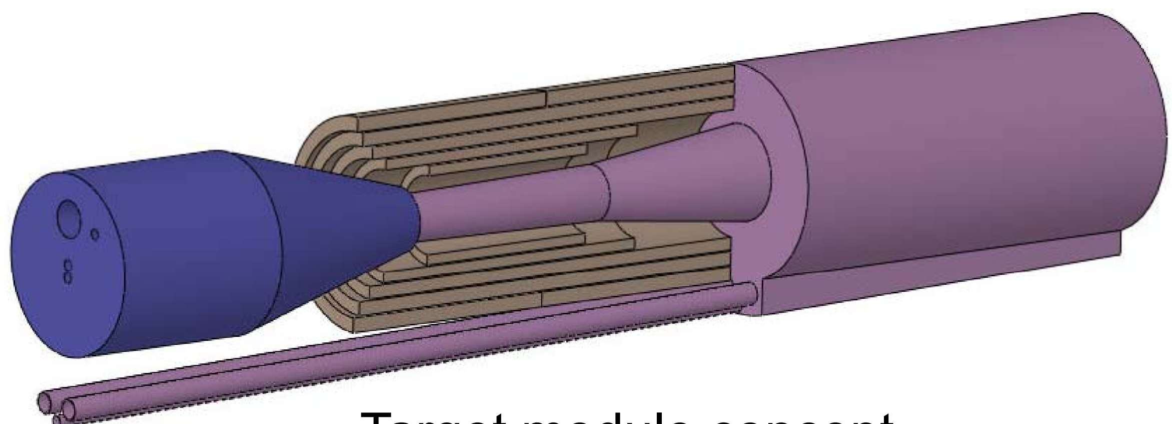
Target



- Baseline based on the Mercury jet.
- Validated by MERIT experiment at CERN.
- Alternatives include solid target options and powder jet.
- Substantial redesign in order to mitigate the energy deposition in SC coils.

Cooling system based on (WC beads+water).

- Recent new idea: Gallium target!
- To be done:
  - Final focus.
  - Beam window.
  - Beam dump.
  - and much more!



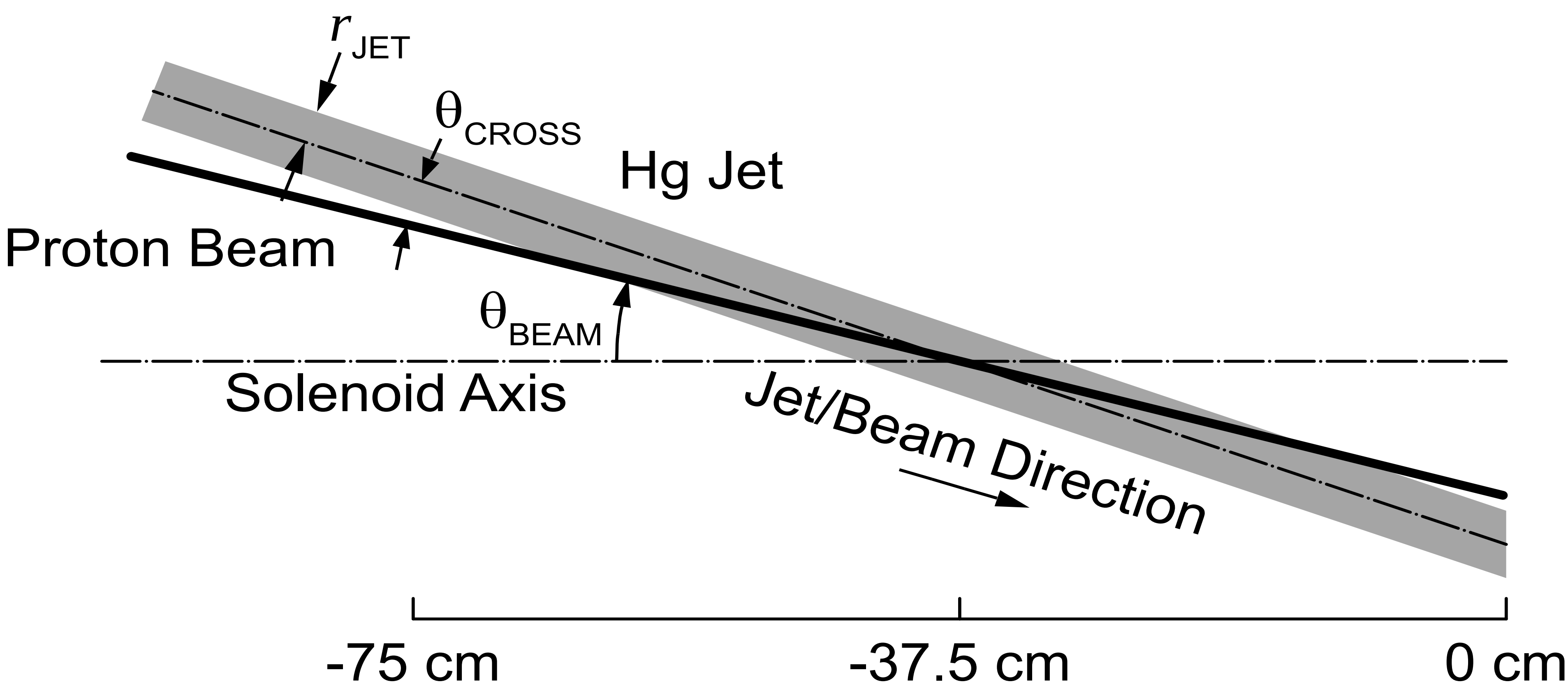
Target module concept

Target System Baseline

•**Target type**	**Free mercury jet**
•**Jet diameter**	**8 mm**
•**Jet velocity**	**20 m/s**
•**Jet/Solenoid Axis Angle**	**96 mrad**
•**Proton Beam/Solenoid Axis Angle**	**96 mrad**
•**Proton Beam/Jet Angle**	**27 mrad**
•**Capture Solenoid Field Strength**	**20 T**

From H. Kirk’s talk at IDS meeting at VT, October 2011

Jet/Solenoid/Protons geometry



The mercury jet target geometry. The proton beam and mercury jet cross at z=-37.5 cm.

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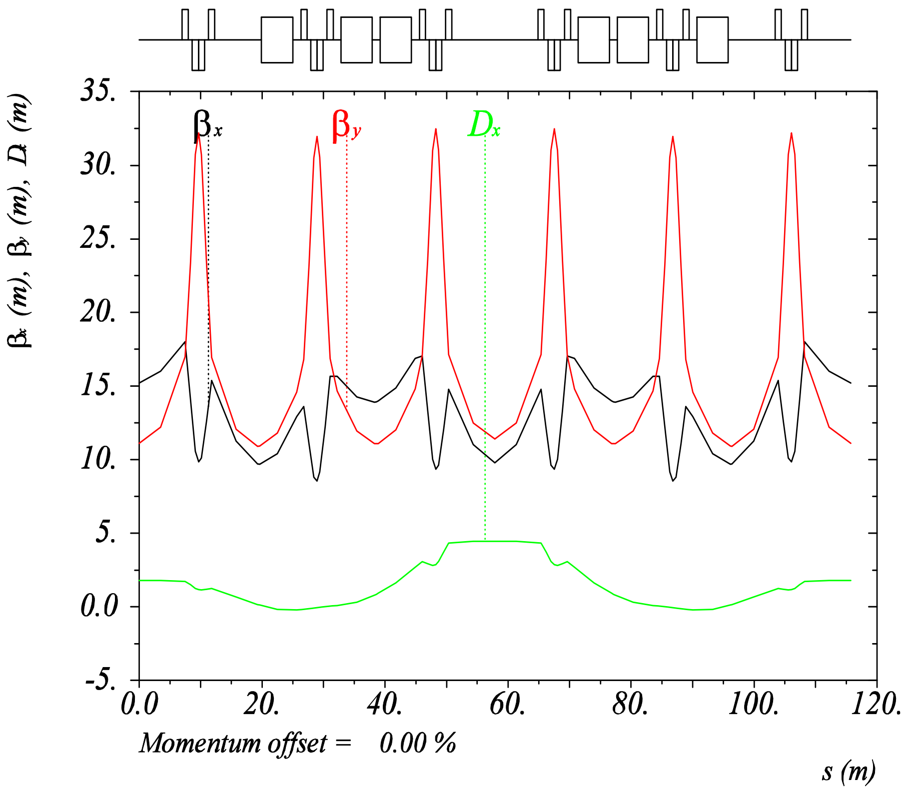
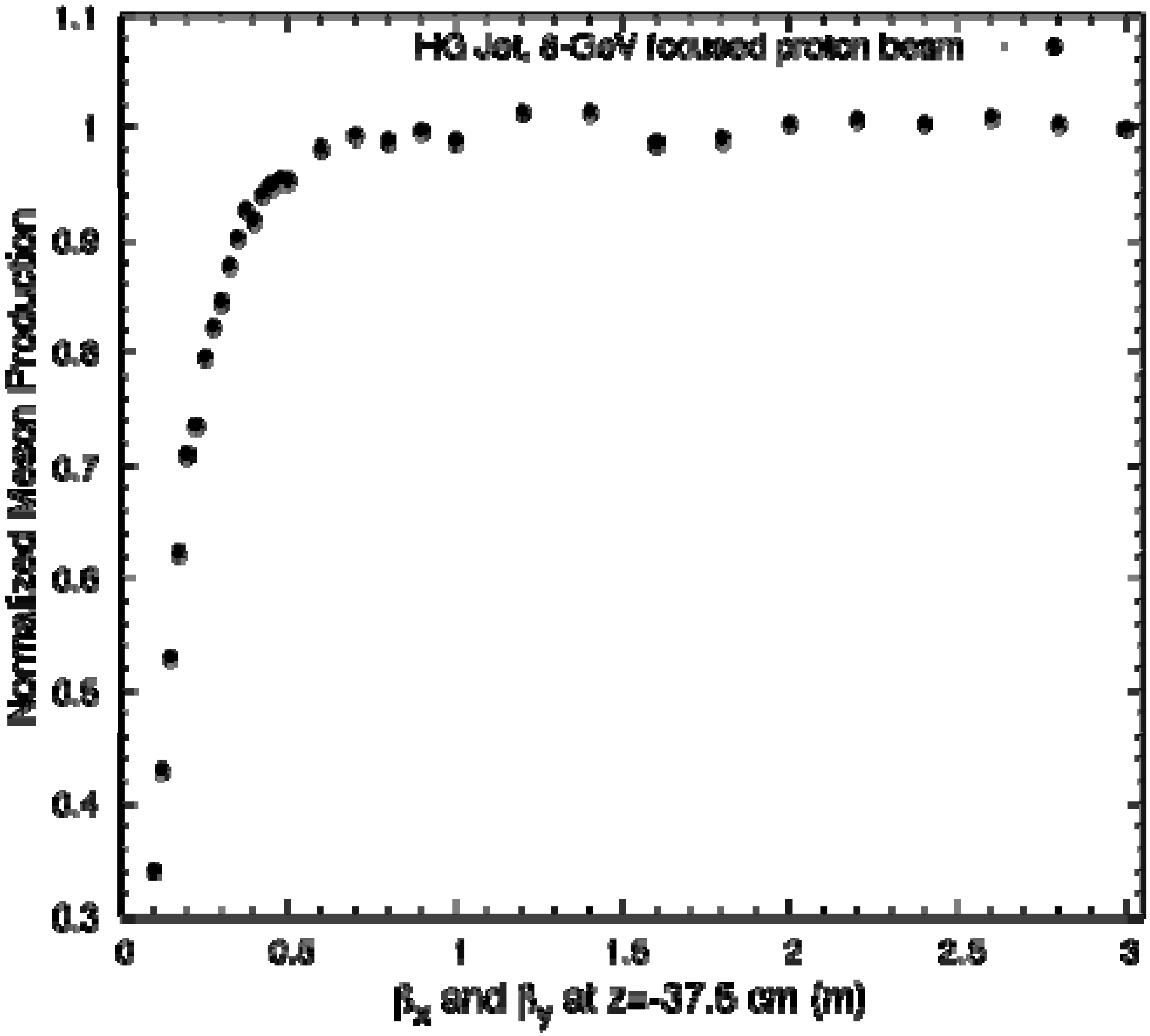
Starting condition



Parameters	Values
Circumference	694.352m
Number of Superperiods	6
Injection/Extraction Energy	3.2/9.6 GeV
Gamma transition	13.37
Harmonic number	17
RF frequency	7.149-7.311 MHz
Bunch Intensity	5.208×10^{13} protons
Number of Cavities	91
Energy gain per cavity	40.4 keV

I shall use RAL solution as an example, but any other may be used.

Focused Incident Proton Beam at 8 GeV (X. Ding's talk, MAP meeting, March 2012)



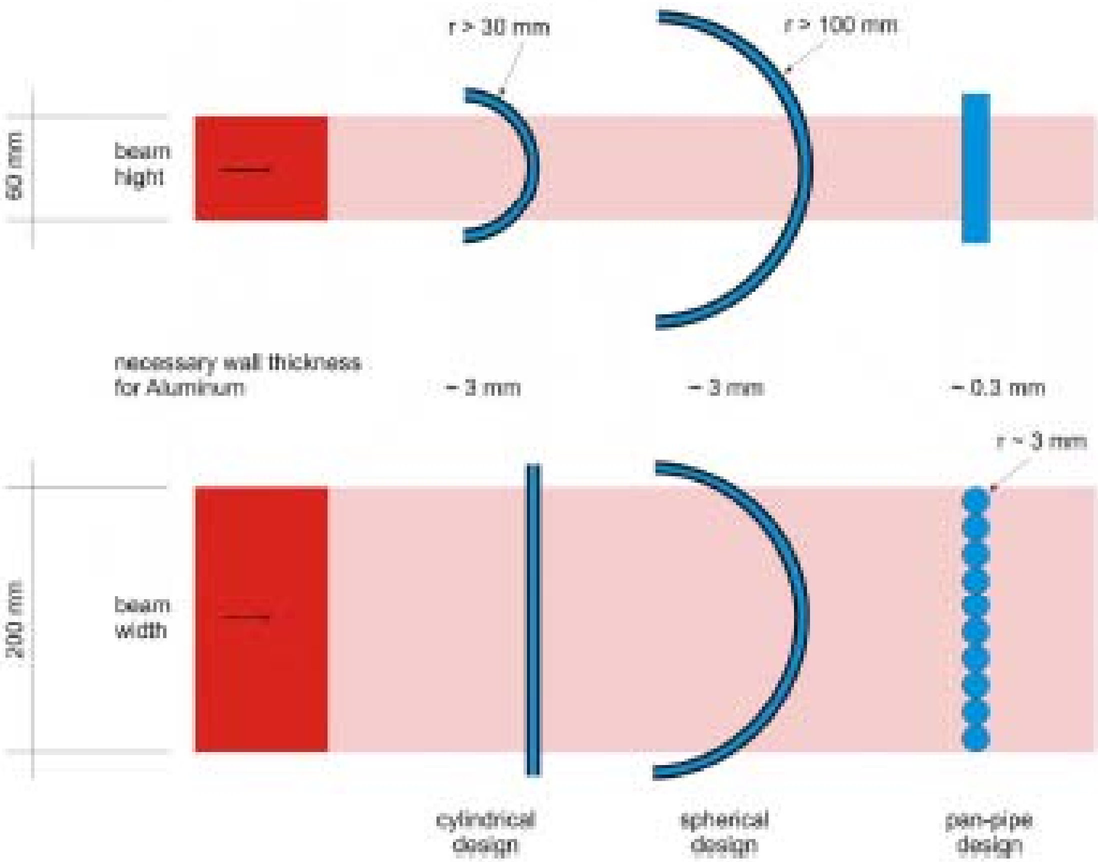
It looks, it is not good to over-focus the beam! But we should not make the beam larger then the target.

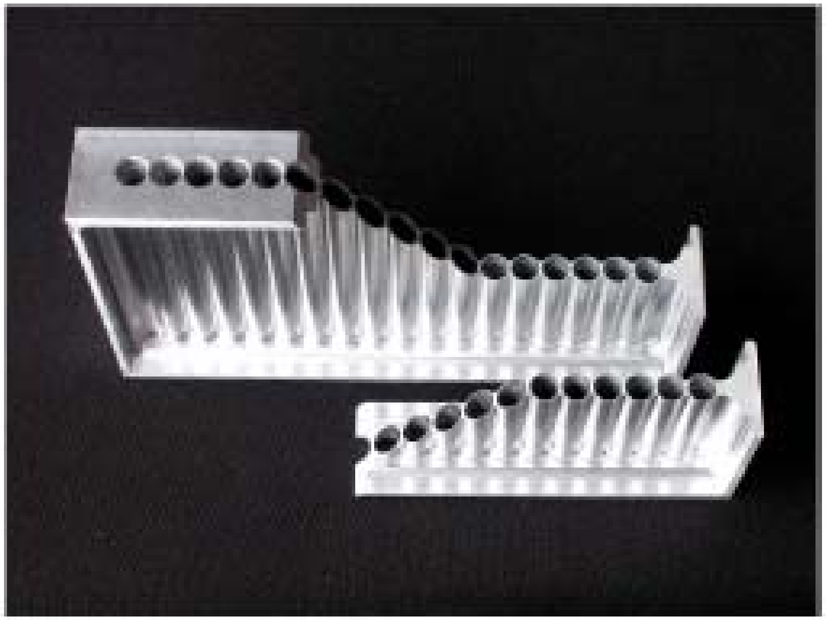
Corrent assumptions:

- $\beta^{*} = \beta_x = \beta_y = 0.65$ m,
- Geometrical rms emittance Smaller than 5 π μm.

Beam Window Design for 5 MW beam of ESS (M. Butzek's talk, May 2011)

Reduce wall thickness by reducing radius to minimize heat deposited in window





proof of manufacturing sample

Rescaling the beam power to 4 MW and assuming the round beam: beam radius is 5.5 cm . Let's take $\beta_x = \beta_y$ =~600 m (to be updated).

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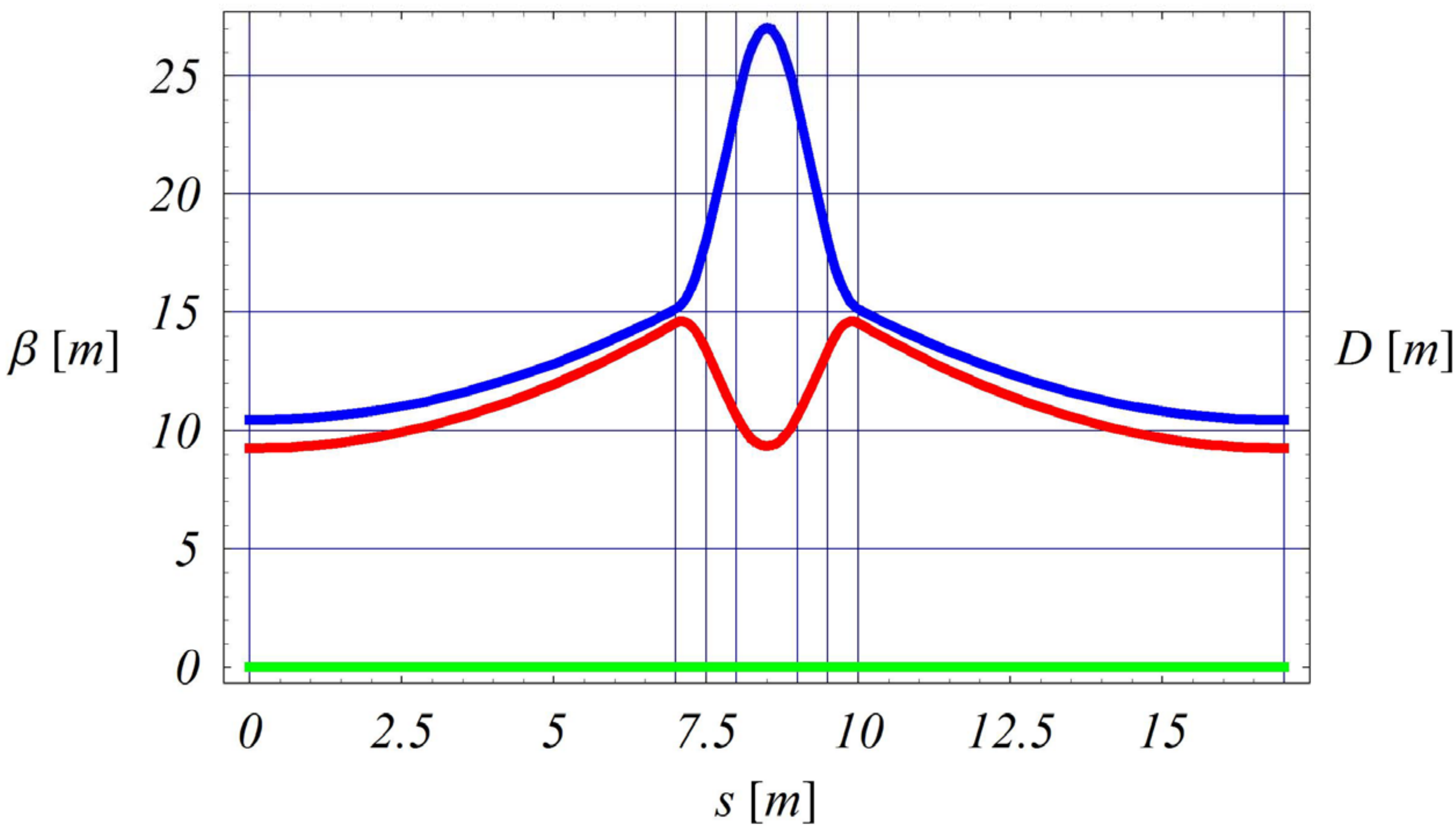
Lattice Building Blocks



Simple optical solution-triplet similar to the RCS lattice cell to be used in the Beam transport to the channel, with only exceptions of the final focus and other matching sections.

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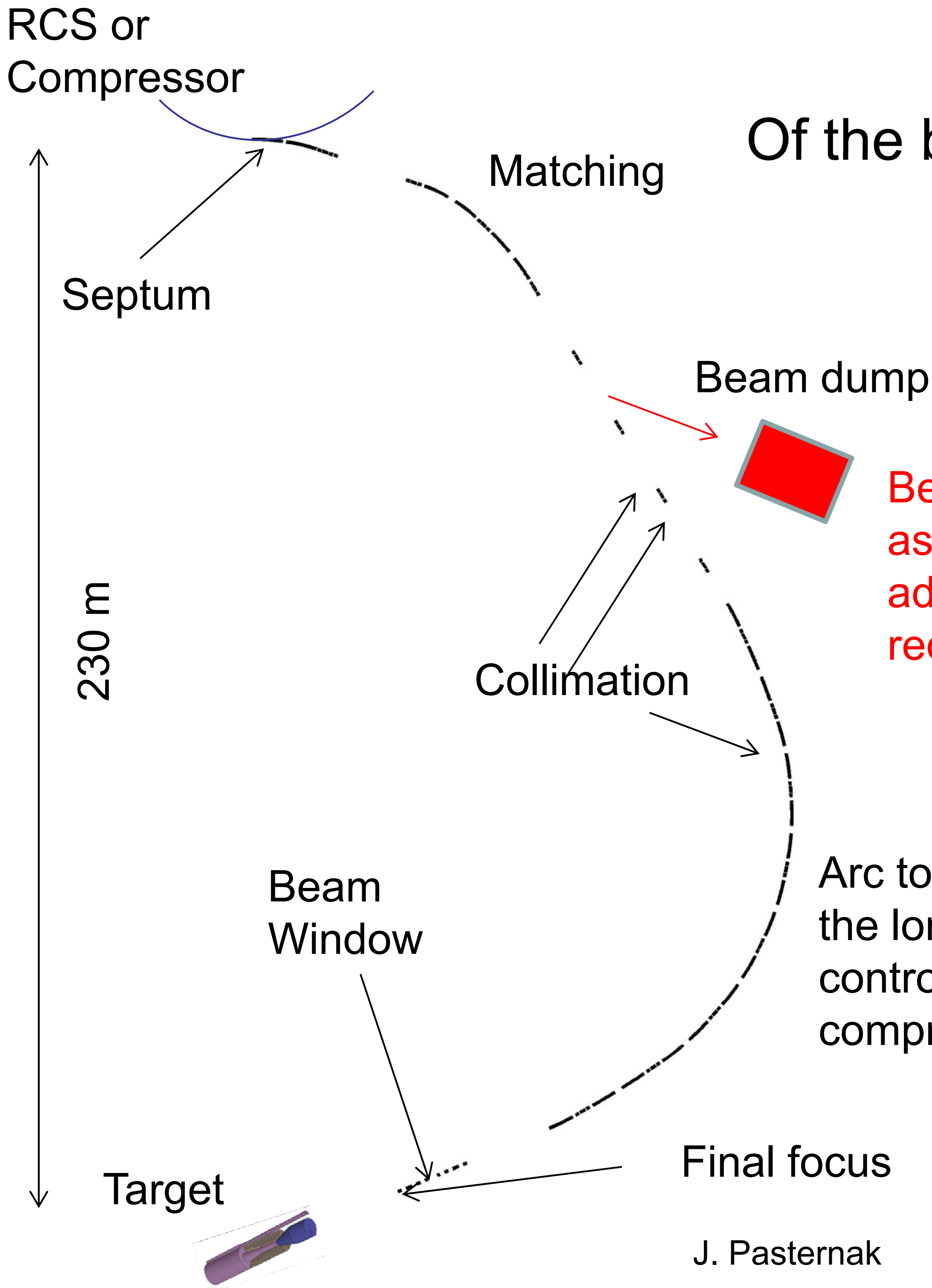
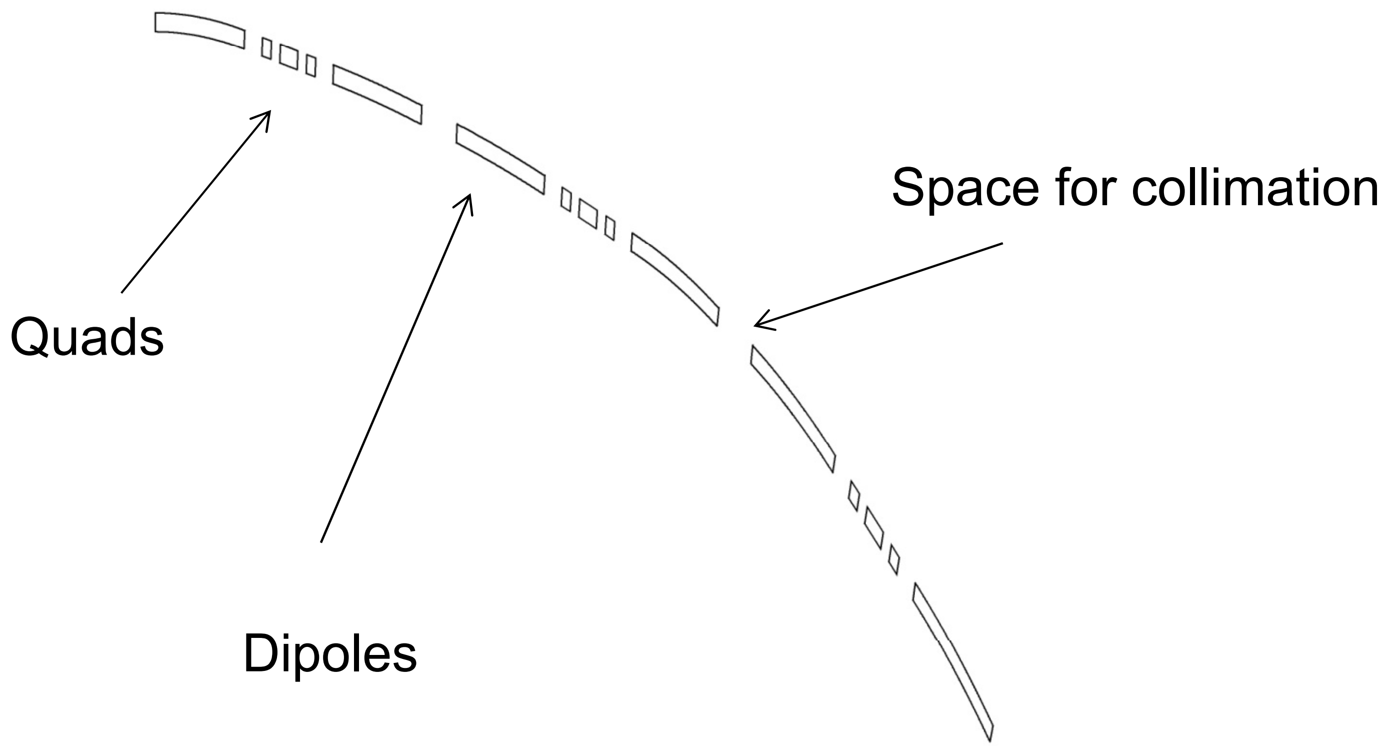
Preliminary Layout
Of the beam transport to the target



Better idea would be to set the dump as a default configuration so an additional kicker system would be required to send the beam to the target.

Arc to manipulate the longitudinal dynamics via controlling eta (to maintain the bunch compression without the RF system).

Layout of the arc section, dispersion matching to one regular cell



All magnets are of a room-temperature type, with not very high fields!

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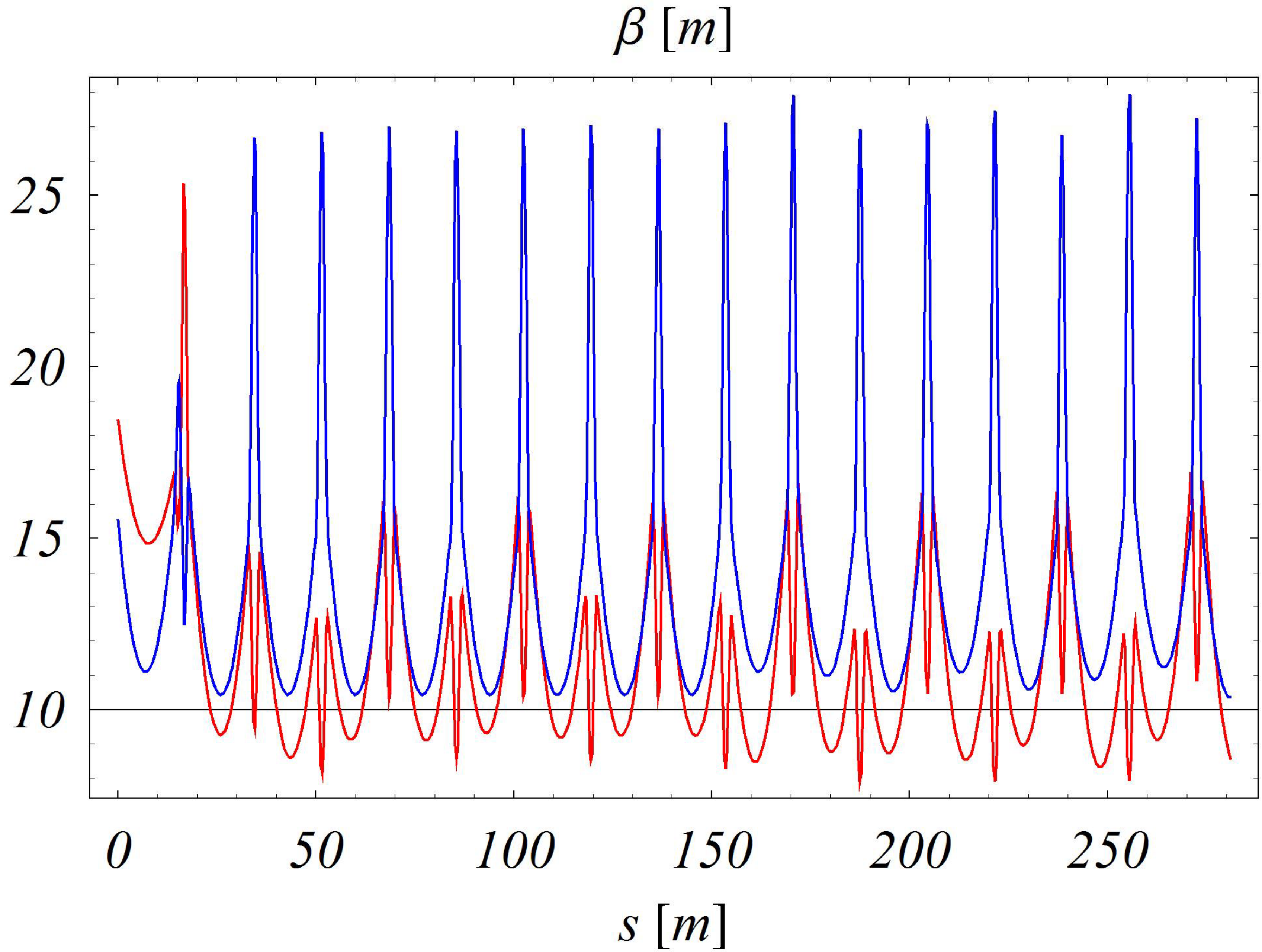
Optics from the RCS to the end of ARC
(small mismatch in horizontal plane)



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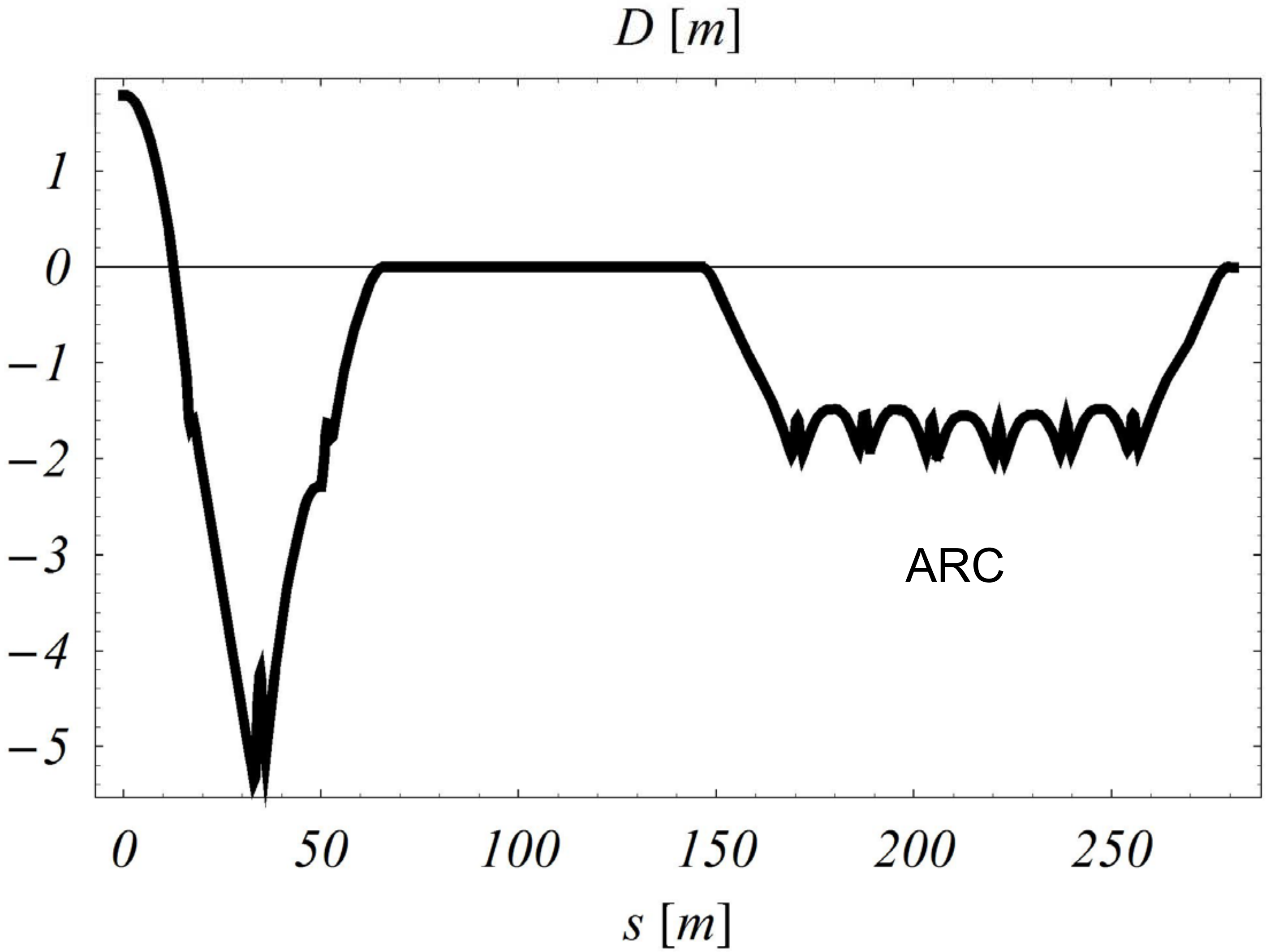
Dispersion from the RCS to the end of the Arc



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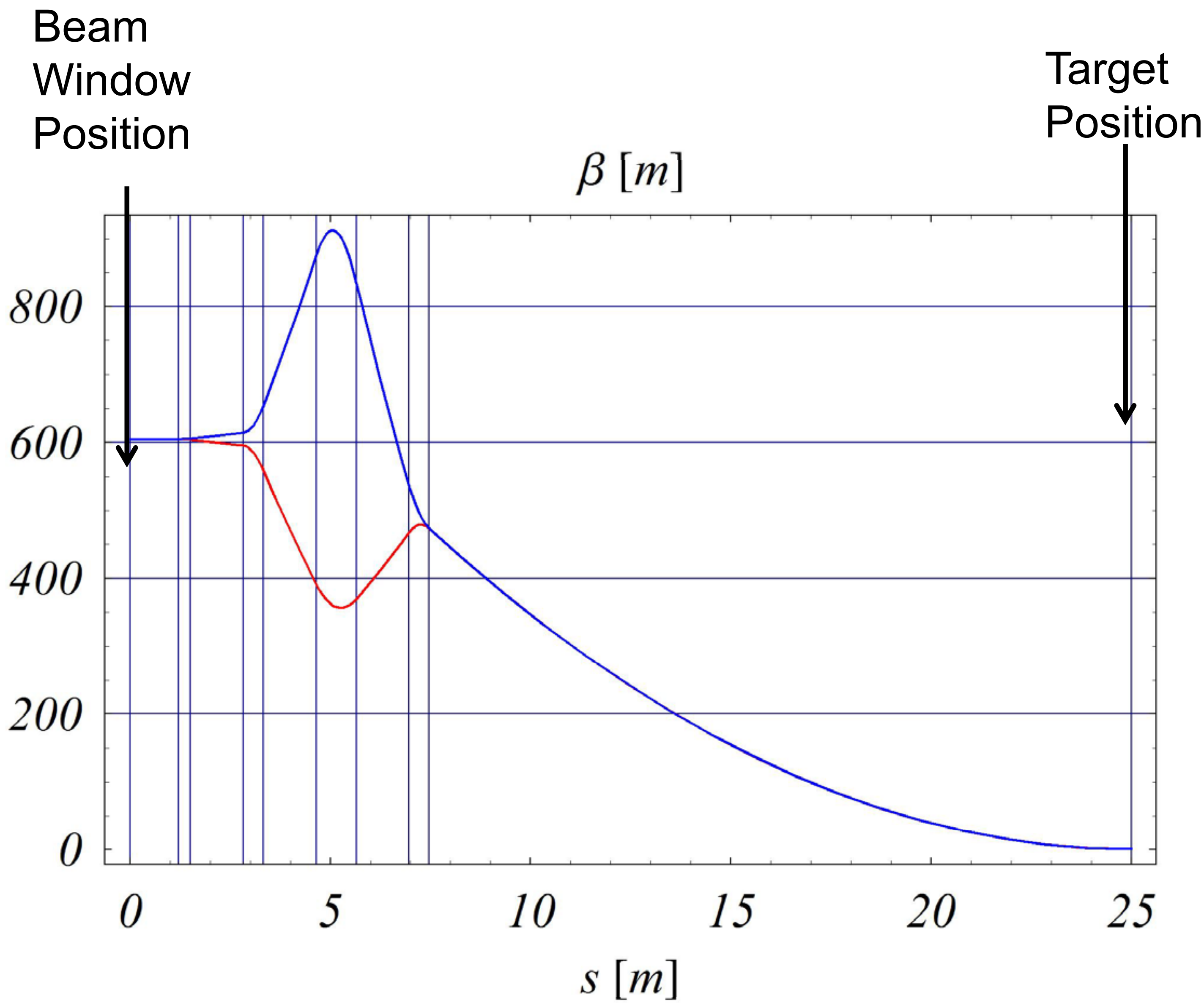
Optics in the Final Focus, for β^* of 0.65 m

(However, β^* = 0.3 m may be preferred.)



Final focus consists of 4 room-temperature quads!

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Summary

• The optics in the beam transport and the final focus is dictated by the beam sizes at the target (1.2 mm rms) and at the beam window (5.5 cm - ??).

• Space is needed for the potential emergency beam dump and the collimation.

•To maintain the bunch compression the control of eta is required, which can be done in the dedicated arc (longer for 8 GeV at the Project-X, shorter for 9.6 GeV at RAL, CERN solution still to be studied) .

• Preliminary geometry and optics has been drafted.

•Engineering of the beam window may influence the optics.

More details on the beam window would be highly desirable!