Dal Muon Collaboration Meeting

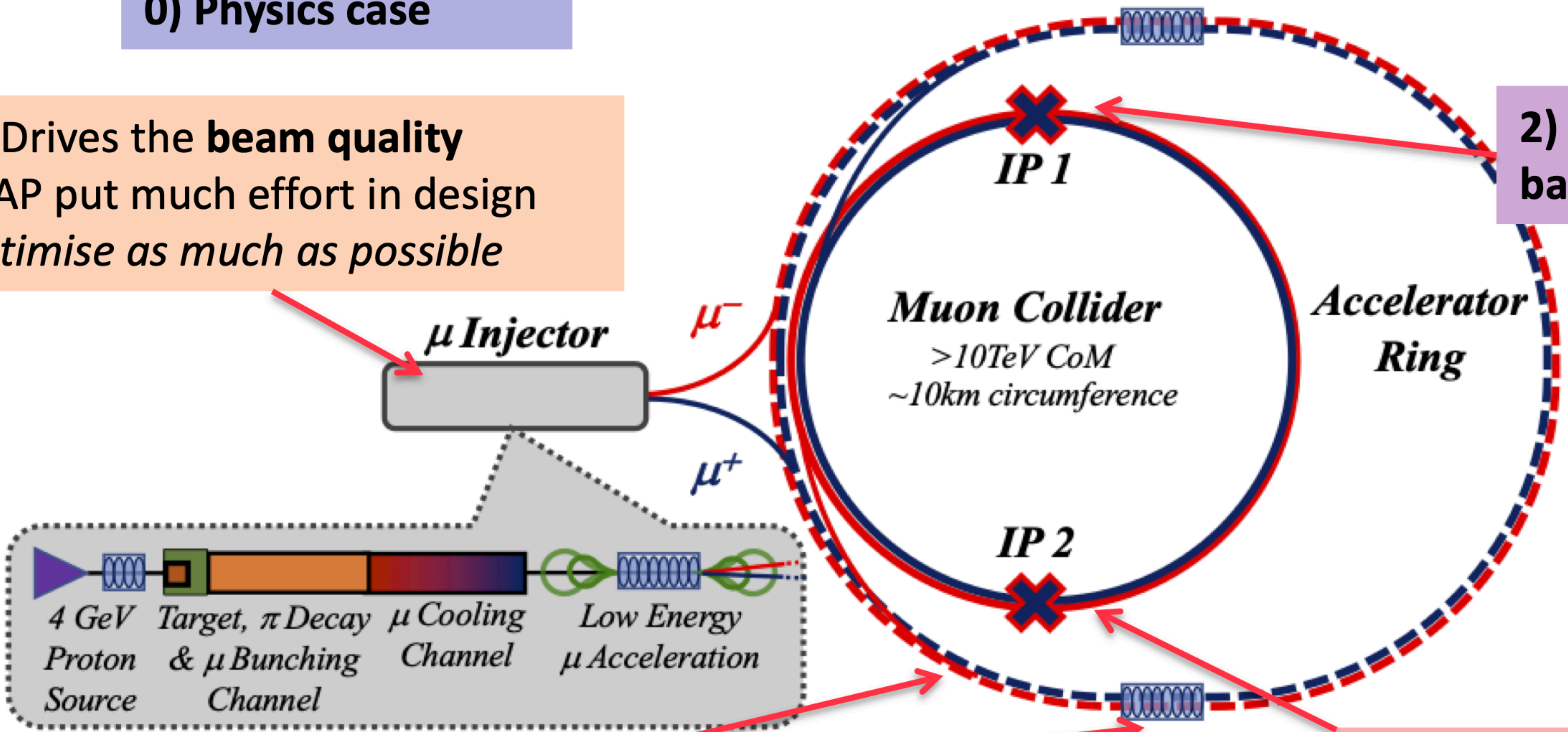
Muon Collider Collab. Meeting

- Relevant talks (in a non-complete list, in non-obvious order):
  - Design study overview from D. Schulte
  - Overview of different Working Groups
  - Physics and Phenomenology by F. Maltoni
  - Detector Design by S. Jindariani
  - Rectilinear Colling by C. Rogers
  - Layout of the facility by C. Rogers
  - Final Cooling by B. Stechauner
  - Cooling Windows/absorbers by J.A. Ferreira
  - All about BIB by F. Collamati

Key Challenges

0) Physics case

4) Drives the **beam quality**
MAP put much effort in design
optimise as much as possible

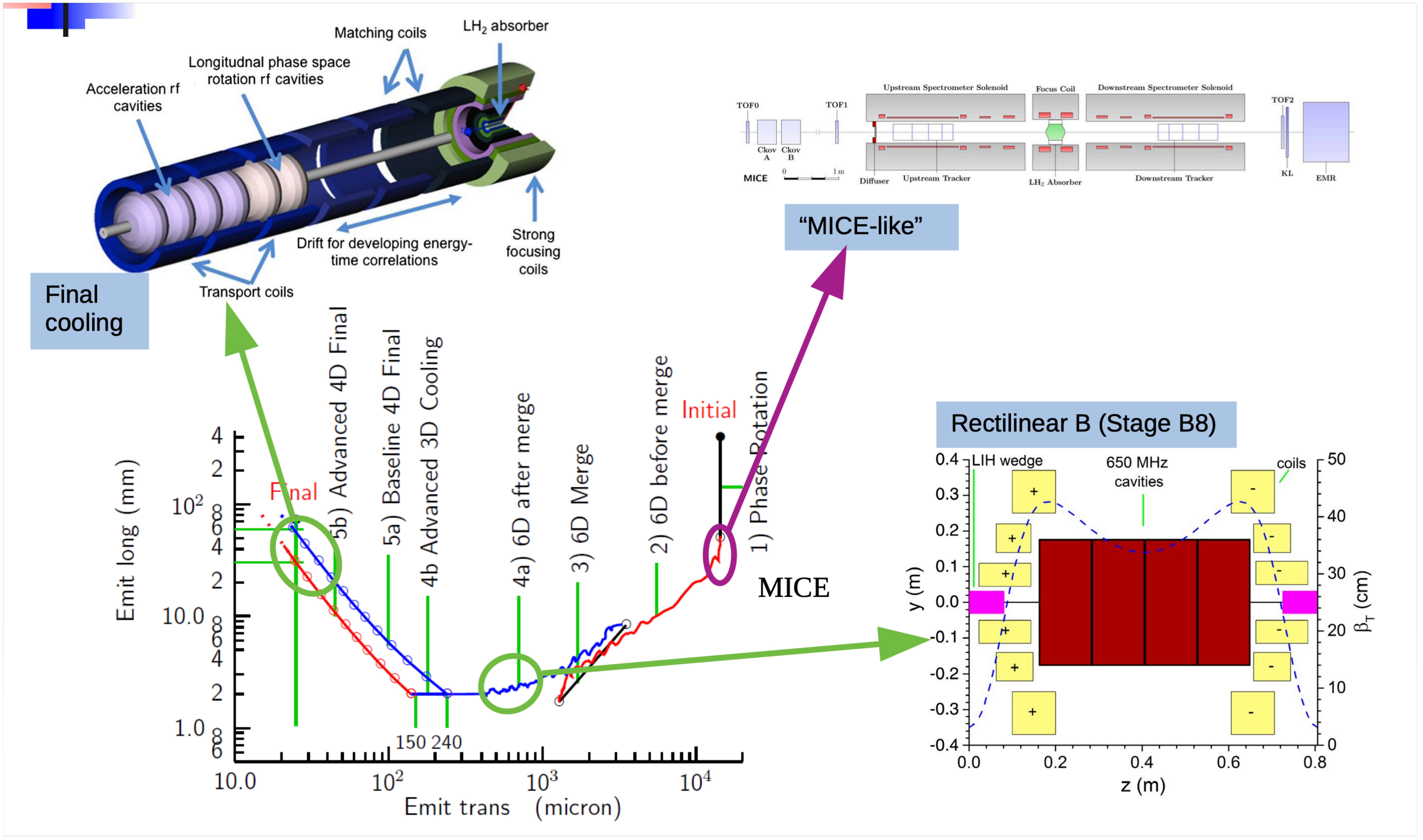


2) Beam-induced background

1) Dense neutrino flux
mitigated by mover system
and site selection

3) Cost and **power** consumption limit energy reach
e.g. 35 km accelerator for 10 TeV, 10 km collider ring
Also impacts **beam quality**

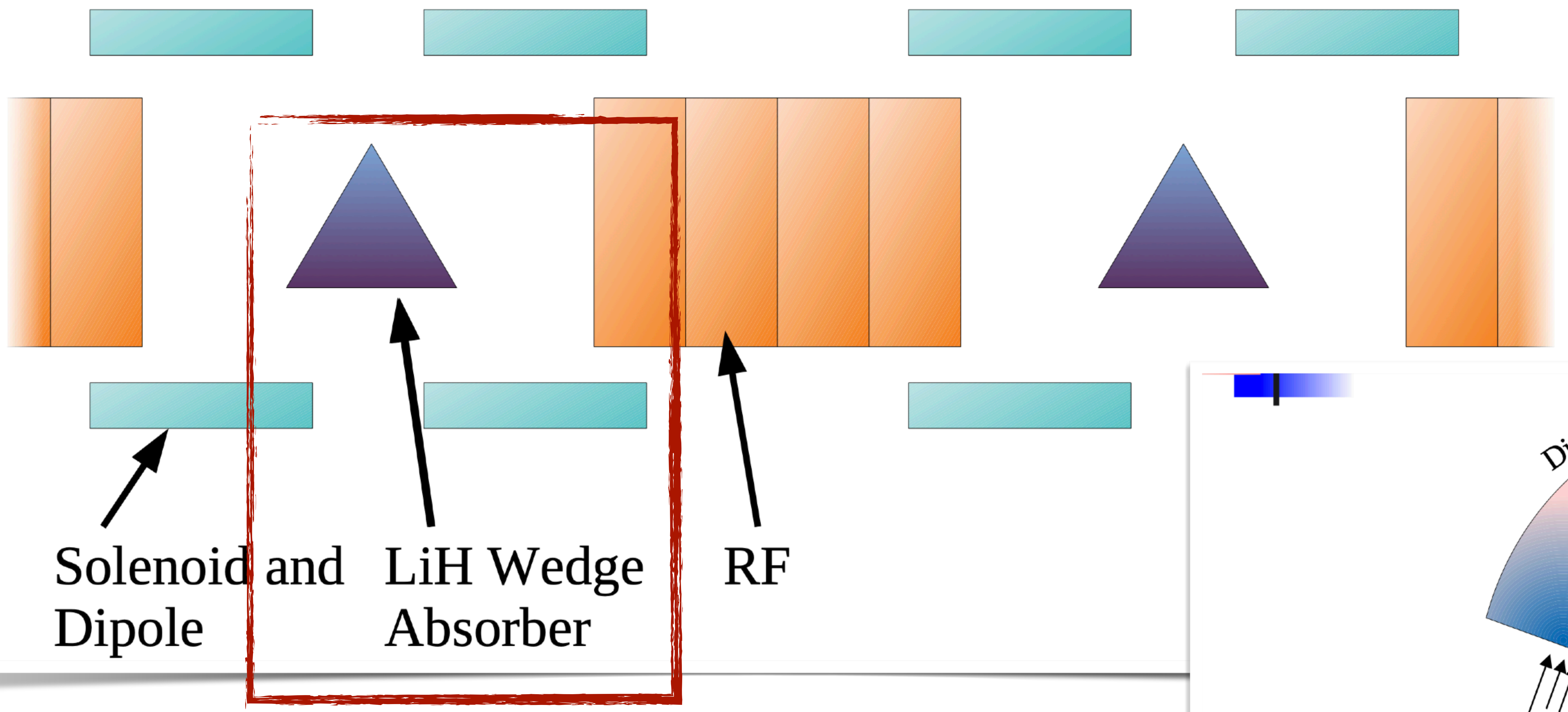
Cooling for Muon Collider



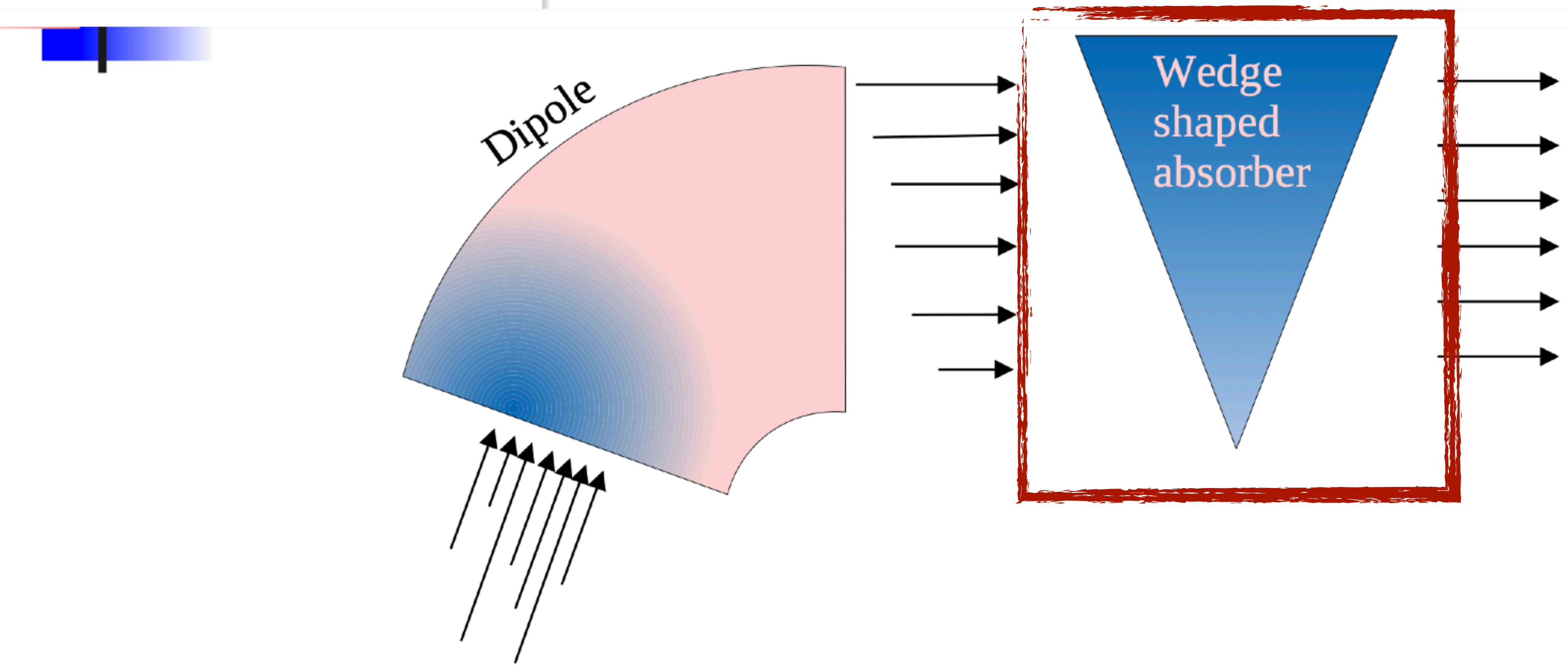
Muon Cooling

- Rectilinear cooling channel
  - Aim to reduce transverse and longitudinal emittance
- Reminder:

~250 MeV muons slowing down

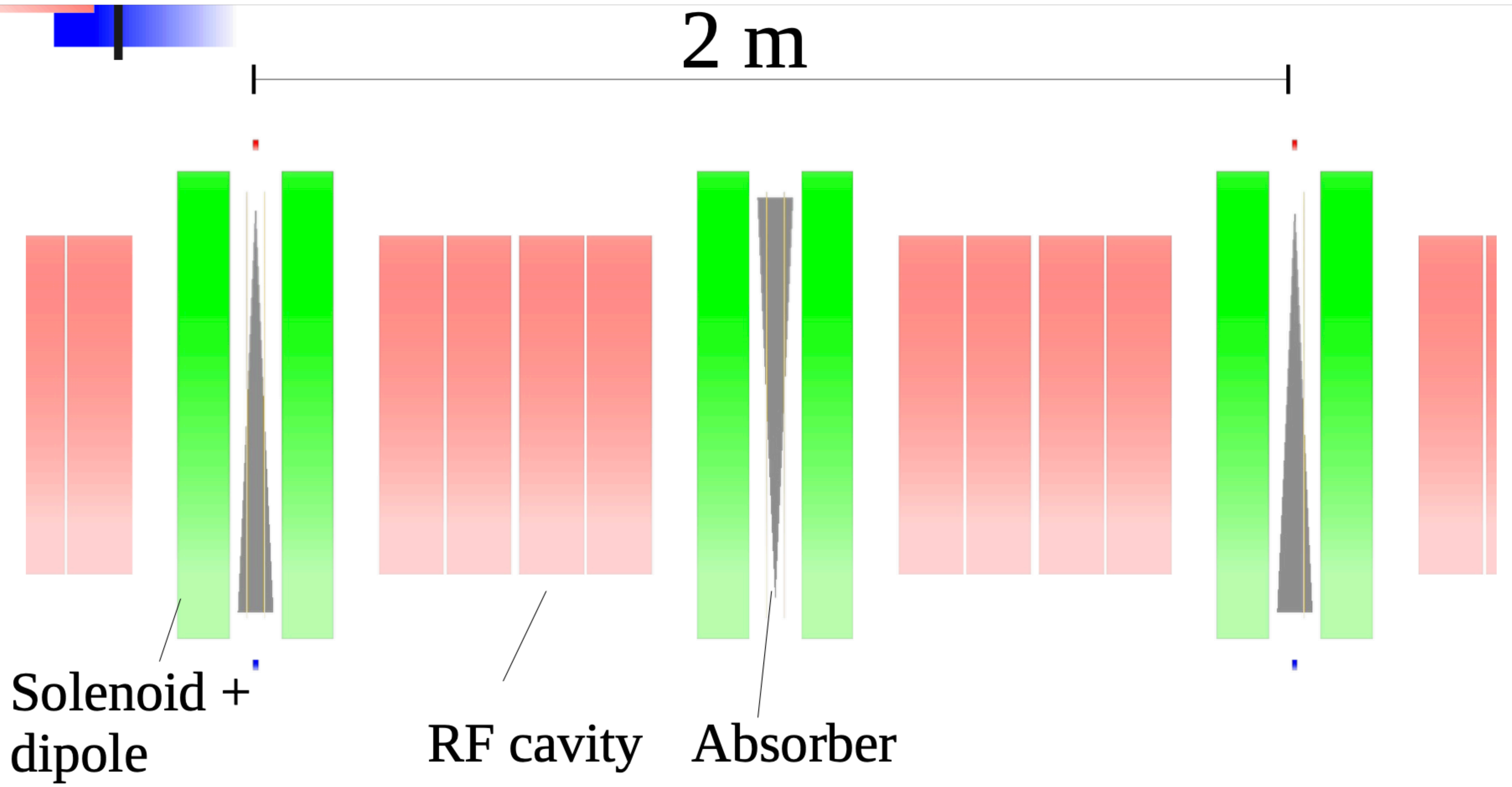


6D Ionization Cooling

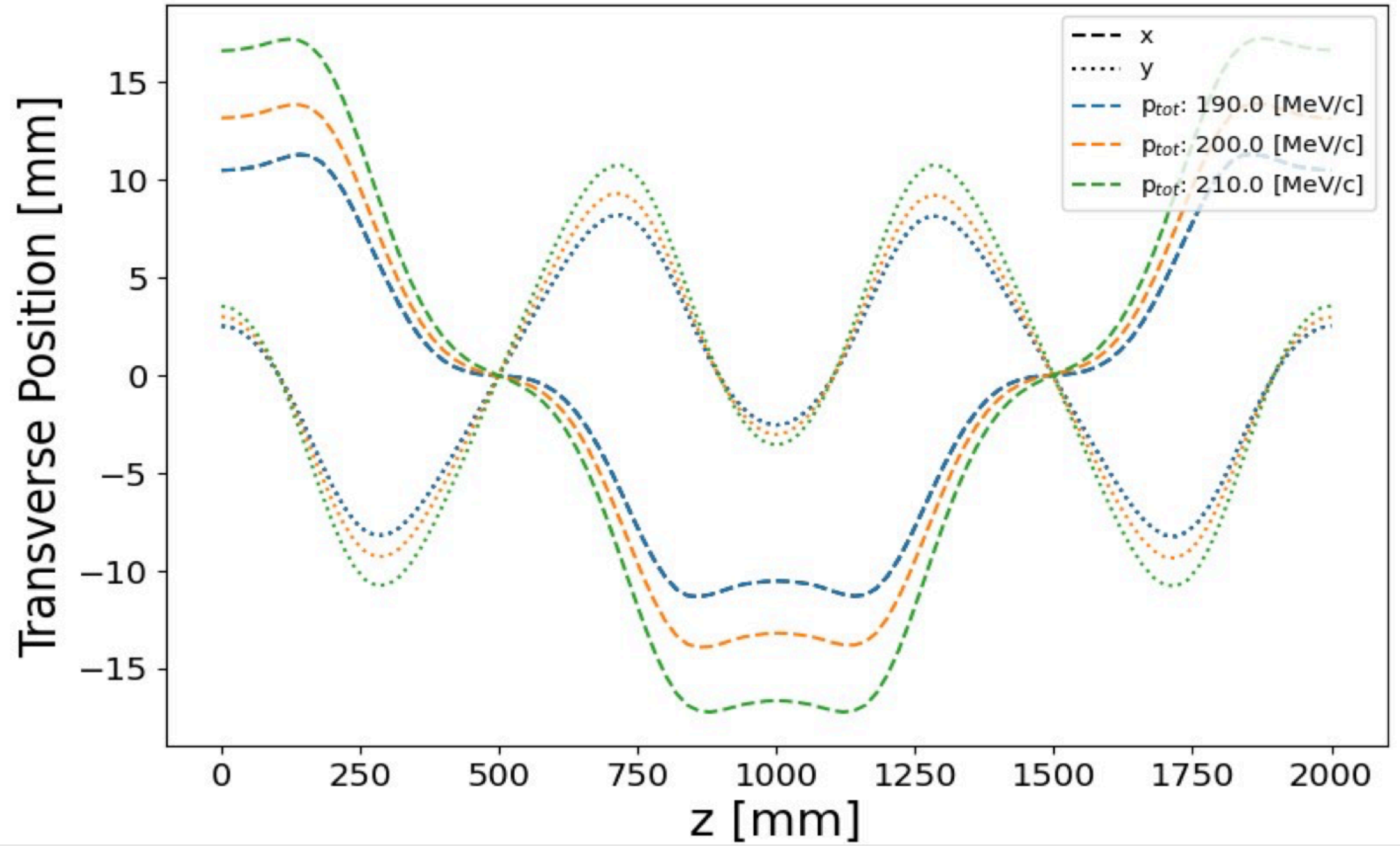


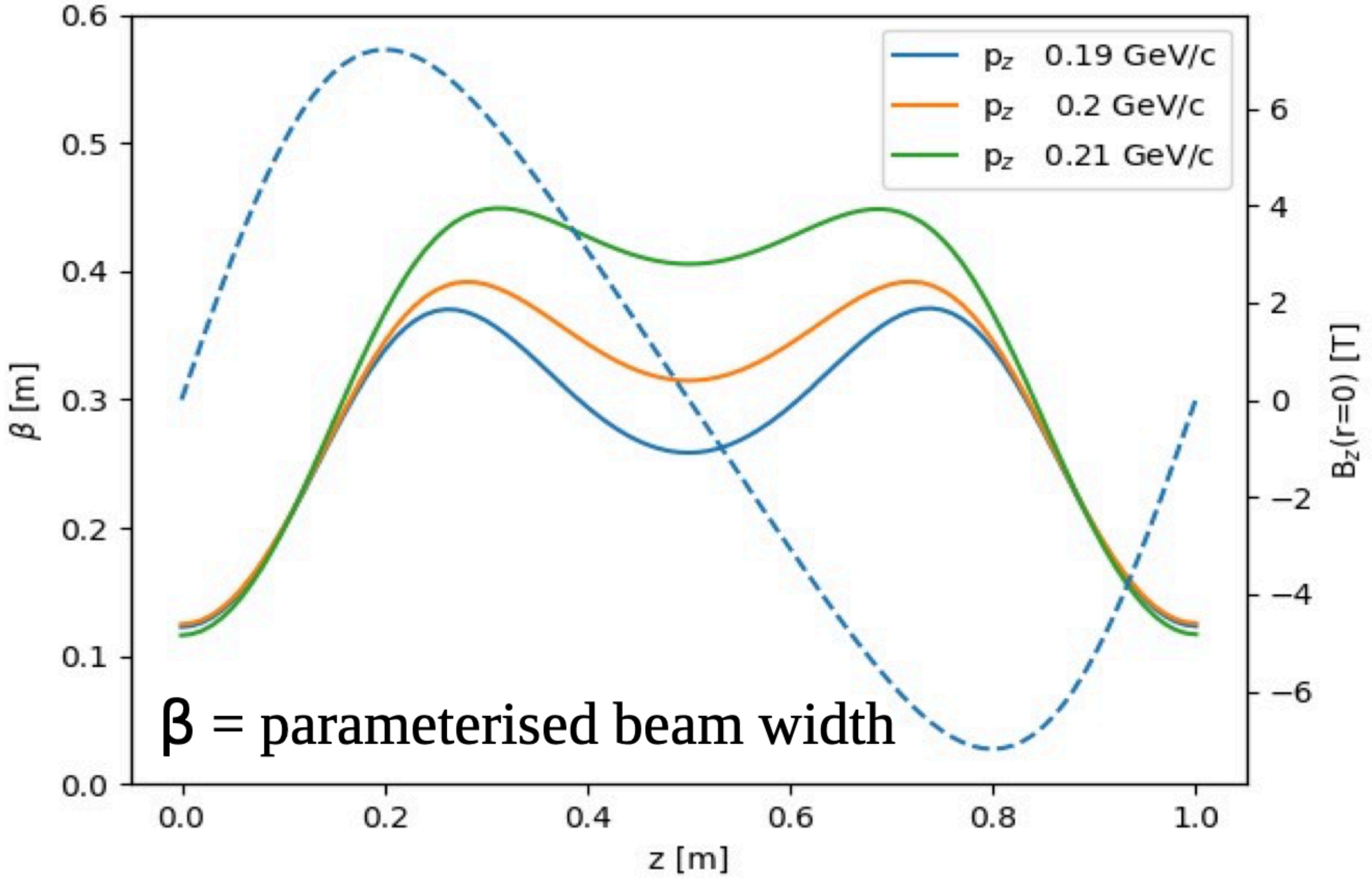
- Initial beam is narrow with some momentum spread
  - Low transverse emittance and high longitudinal emittance
- Beam follows curved trajectory in dipole
  - Higher momentum particles have higher radius trajectory
  - Beam leaves dipole wider with energy-position correlation
- Beam goes through wedge shaped absorber
  - Beam leaves wider without energy-position correlation
  - High transverse emittance and low longitudinal emittance

Preliminary Design



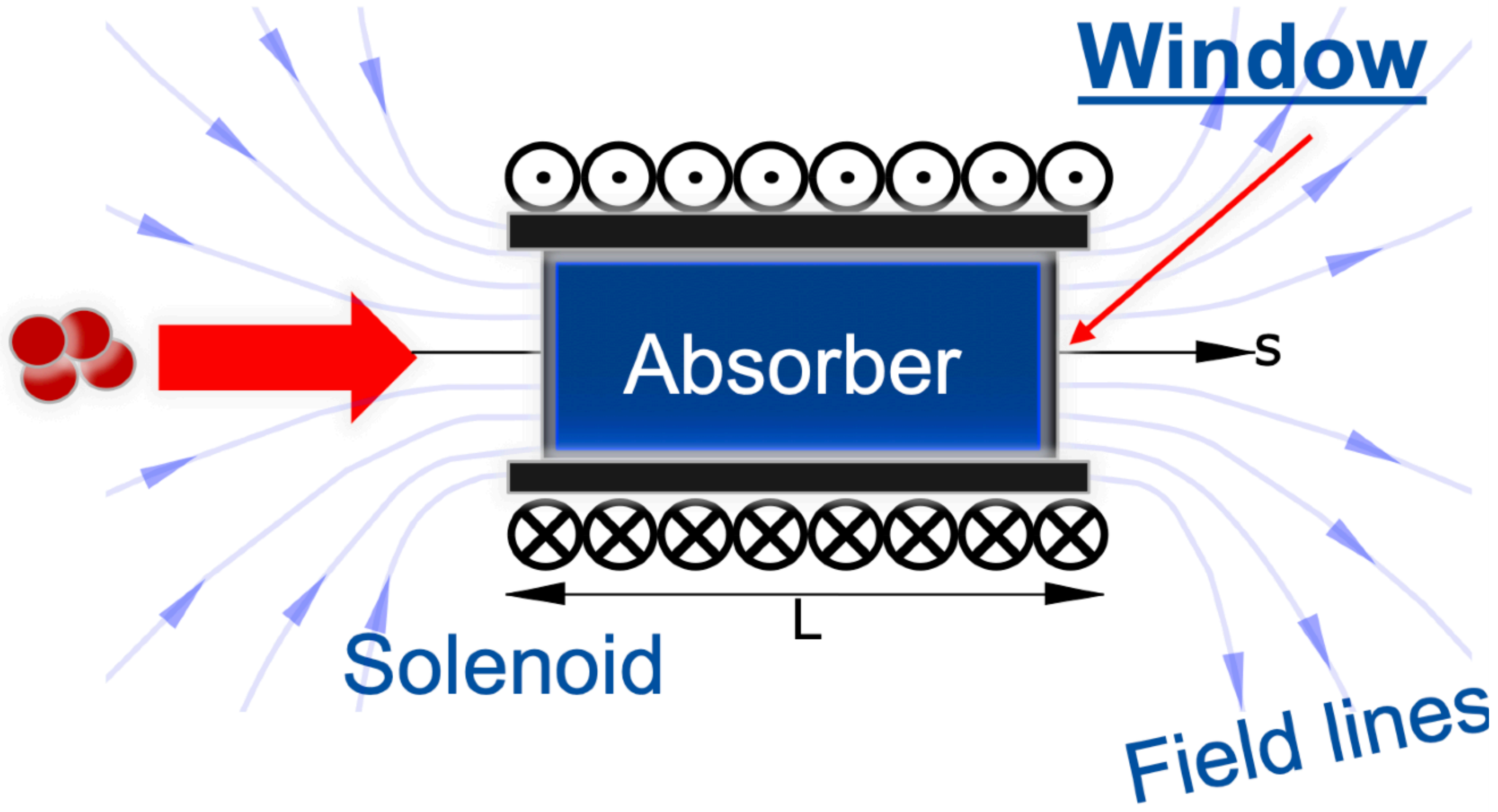
Cooling System	
Cell length	2 m
Peak solenoid field on-axis	7.2 T
Dipole field	0.2 T
Dipole length	0.1 m
RF real estate gradient	22 MV/m
RF nominal phase	20°
RF frequency	704 MHz
Wedge thickness on-axis	0.0342 m
Wedge apex angle	5°
Wedge material	LiH





Final cooling

- H_2 can be solid, liquid, gaseous, supercritical,…
- Mitigate muons-window interactions
- Requirements: low Z and thin
- Candidates: Be and Si_3N_4



Parameters:
- 20 to 5 MeV cooling
- 4e12 muons/pulse
- 5 Hz repetition rate
- σ_{RMS}=0.6 mm

Thermodynamics in liquid H_2

- $\epsilon_{\perp,N}$ reductions = storing energy in the absorber

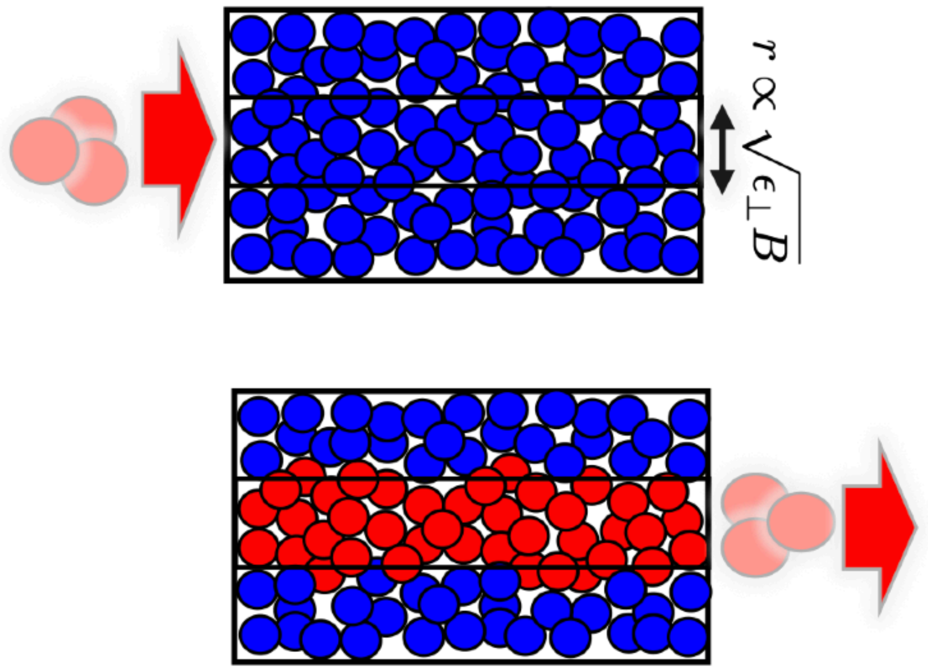
$\rho = 70\,\mathrm{kg\,m^{-3}}$ $\quad B = 50\,\mathrm{T}$

$A = 0.002\,\mathrm{kg\,m^{-3}}$ $\quad \epsilon_{\perp,N} = 25\,\mu\mathrm{m}$

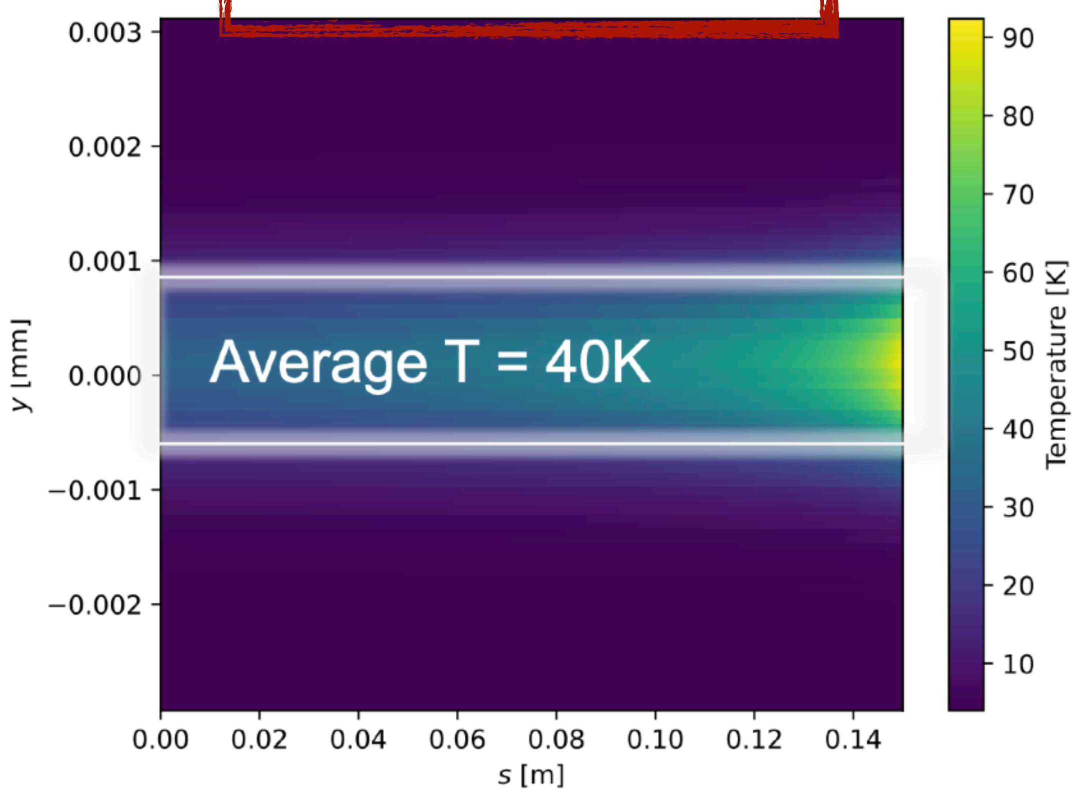
$$n = \frac{\rho V}{A}$$

$$p = \frac{nRT}{V} = \frac{\rho RT}{A}$$

$$p = \frac{70\,\mathrm{kg\,m^{-3}} \cdot 8\,\mathrm{J\,mol^{-1}\,K^{-1}} \cdot 40\,\mathrm{K}}{0.002\,\mathrm{kg\,mol^{-1}}} \approx 100\,\mathrm{bar}$$



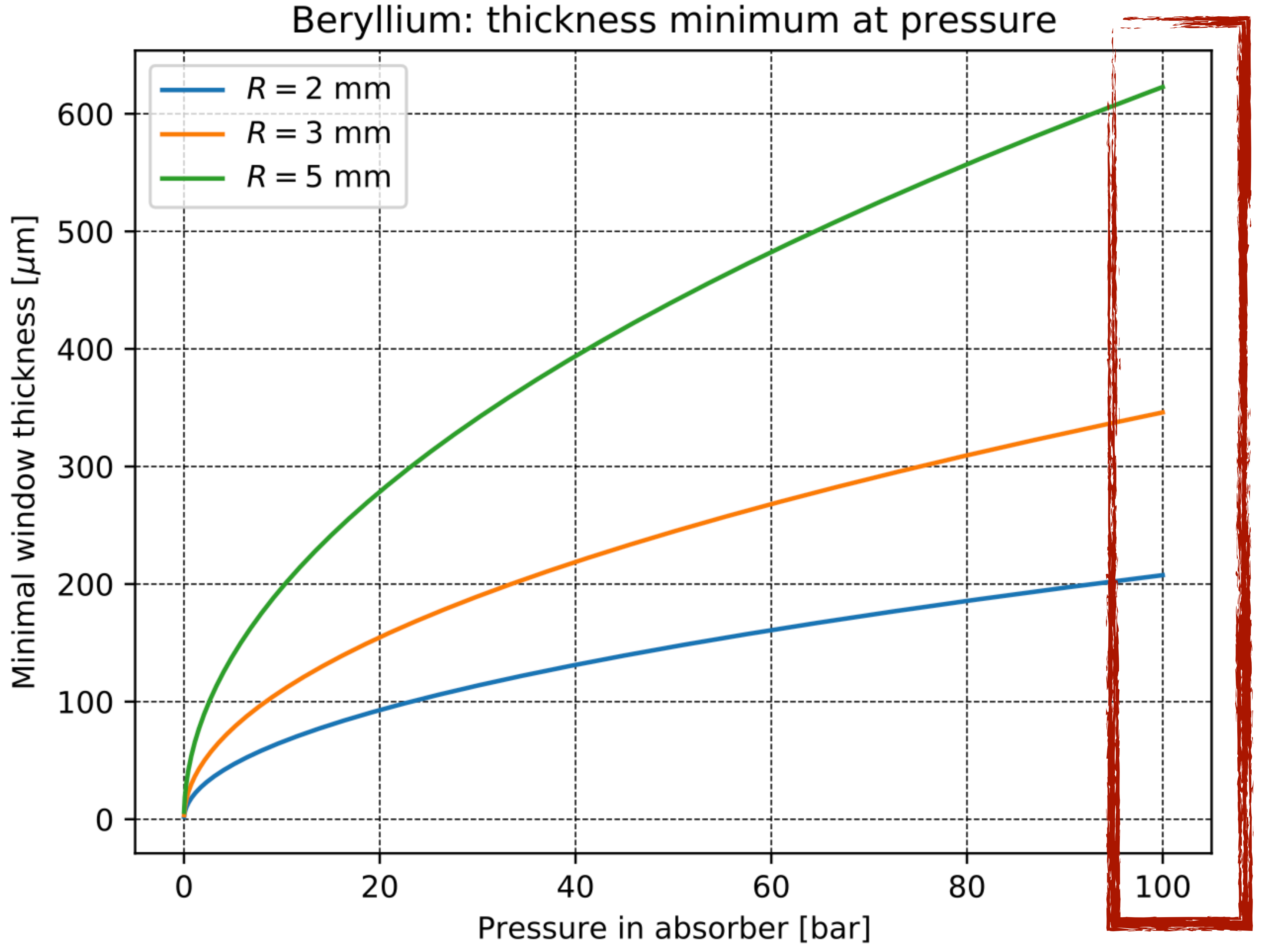
20MeV to 5Mev

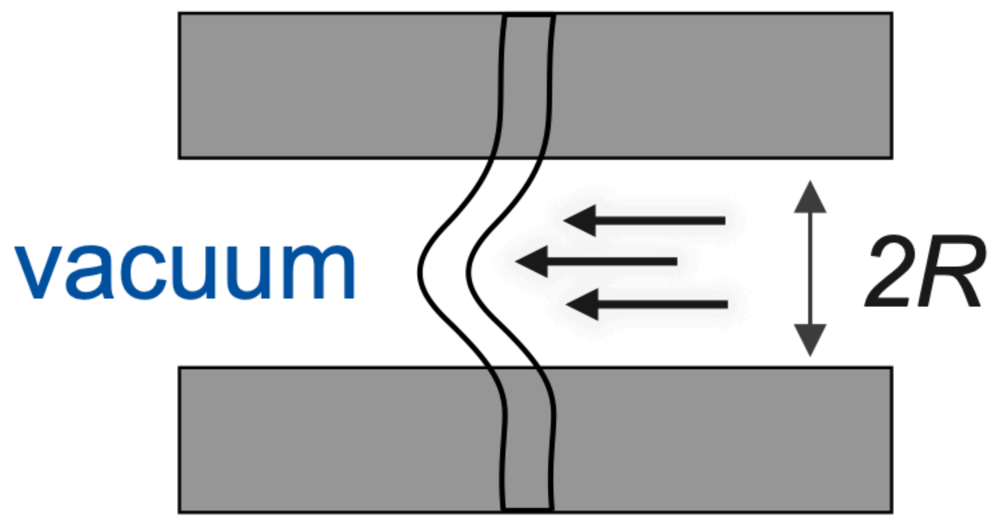


Final cooling

Minimum window thickness

~100 bar





d…window thickness [m]
p...pressure [Pa]
R...radial size [m]
ν ...Poisson's ratio
σ_{max}…Maximum yield strength [N m^{-2}]

$$\boxed{d = \sqrt{\frac{3}{8} p (1+\nu) \frac{R^2}{\sigma_{\max}}}}$$

- Thick windows influences the beam
  1. Longitudinal emittance
  2. Lifetime

Thin Windows (?)

Issue: ~1mm window stops a 5 MeV beam

Thin windows: Be

- Well known material
- As thin as 8 μm in commercial x-ray windows[3]
- Aperture 7 mm
- ΔP > 1 bar

Figure 1 Typical Assembly of Beryllium Window

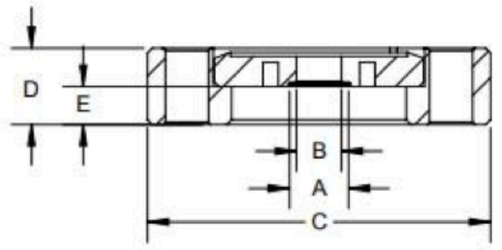


Figure 2 Conflat Flange Geometry

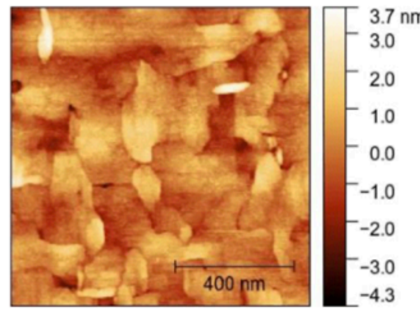
Table 1 Dimensions of Conflat Flange Options (Refer to Figure 2 above)

CF	Foil Thickness (μm)	Foil Diameter (mm) - A	Through Hole Diameter (mm) - B	CF Outer Diameter (mm) - C	CF Thickness (mm) - D	Window Height (mm) - E	Coating	Part ID
1-1/3" OD	8.0	9.2	7.0	33.8	7.2	0.5	DuraCoat Plus	DBM-08-9.2-CF1.3-P
	25.0	16.0	13.0	33.8	7.2	0.5	DuraCoat	DBM-25-16.0-CF1.3
2-1/8" OD	8.0	9.2	7.0	53.6	11.9	6.5	DuraCoat Plus	DBM-08-9.2-CF2.1-P
	25.0	16.0	13.0	53.6	11.9	6.5	DuraCoat	DBM-25-16.0-CF2.1

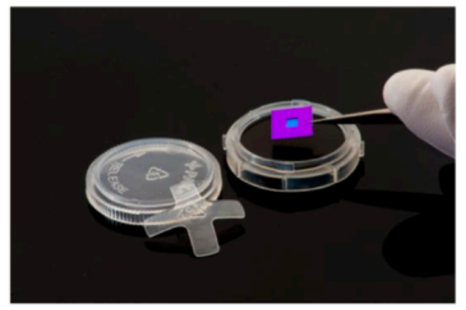
MOXTEK

Thin windows: SiC

- Thickness <1 μm
- Bulk material has excellent mechanical properties
- No many commercial suppliers [6]

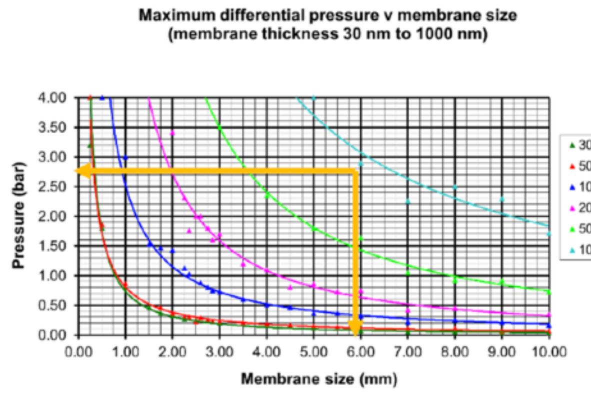


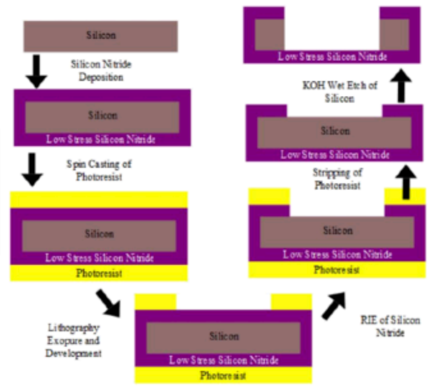
Silson

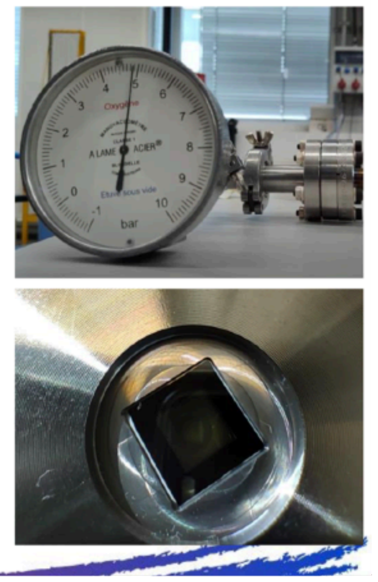


Thin windows: Si_3N_4

- Commercially available: Xray windows i.e. [4]
- Thickness <1 μm
- It can work at cryogenic temperature [11]
- Bulk material has excellent mechanical properties [5]
- 1 μm 6×6mm window → ≈5 bar pressure







Silson NORCADA SiMPore

Thin windows: C

- Thickness <1 μm
- Different options: Graphenic carbon [12] or diamond [13]

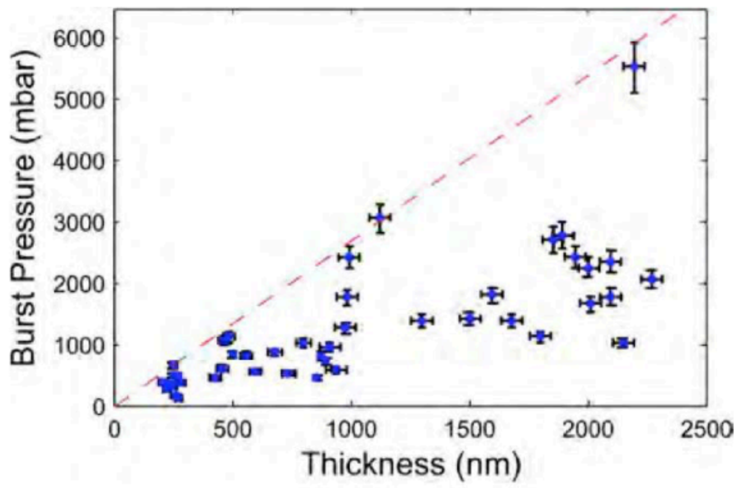


Fig. 4. Measured thickness dependent burst strength of fabricated GC transmission windows with a diameter of 7 mm.

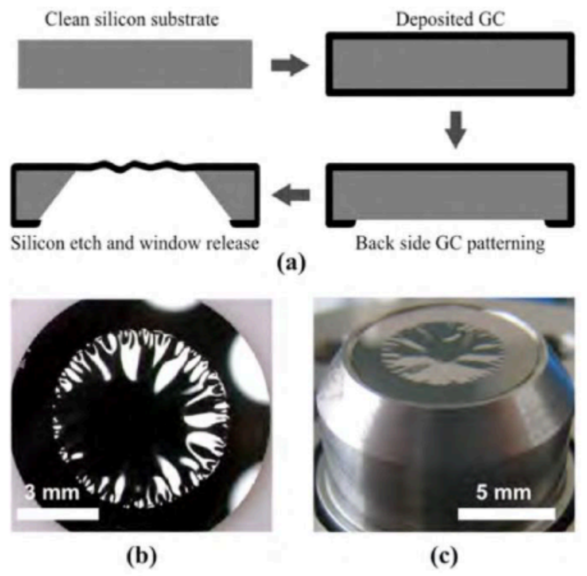


Fig. 2. (a) sketches the fabrication process of the transmission window. (b) shows a top view image of a fabricated GC window. (c) depicts a TO8 housing with a GC window glued into the top of the housing

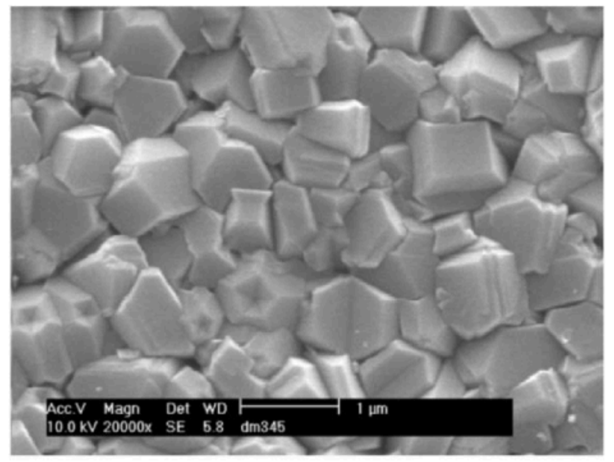
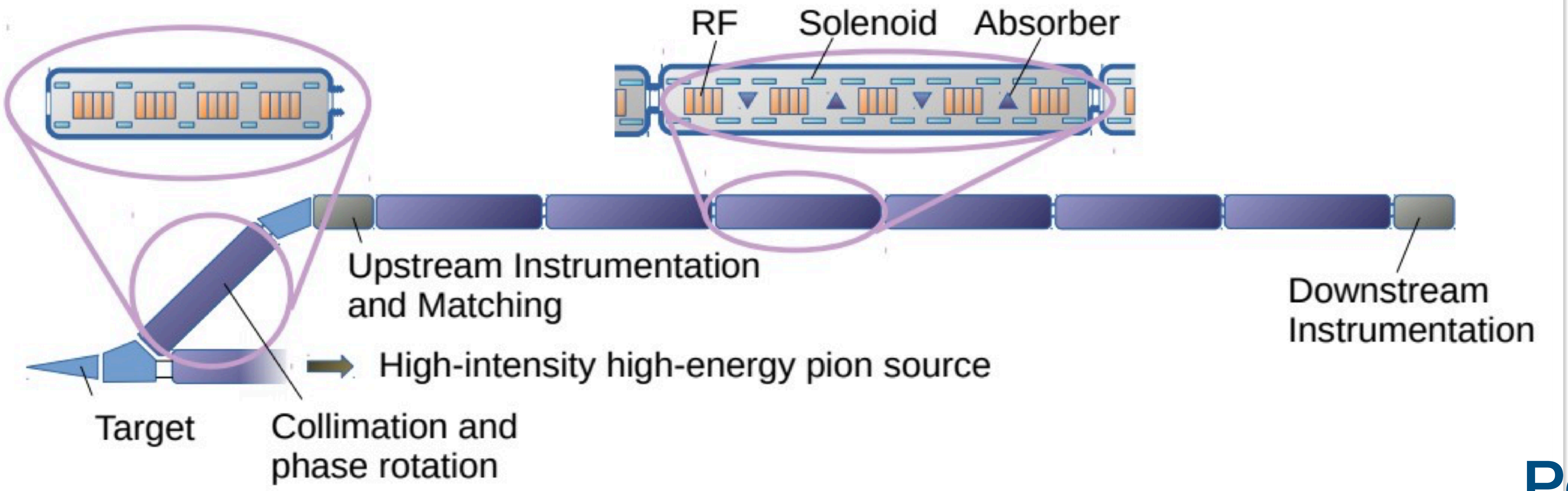


Fig. 4. SEM picture of the diamond film 345#.

Demonstrator layout



- Cooling system test Demonstrator
  - Produce pions on a target
  - Collimate +capture longitudinally
  - Characterise the incoming muons
  - Cool the muons
  - Characterise the outgoing muons

Possible CERN location