Intro & News

MuCol RM1 Meeting - 20/10/22

M. Bauce - INFN Roma

News

- Muon Collider Collaboration Meeting - CERN, 11-14/10/22: https://indico.cern.ch/event/1175126/
  - Agenda molto fitta, molte discussioni
- Meeting Muon Collider Italia - proposta
  - Tentativo per 19-21 dicembre a TO/LNF/??
  - https://doodle.com/meeting/participate/id/avoN2yMb
- Missioni fino a fine 2022
  - vanno aperte entro venerdì per avere una stima finale dei costi accurata

More News

- Residuo fondi 2022:
  - RD_MUCOL: qualche k€ tra missioni e materiale non inventariatile
  - DOT.GR1: cospicui residui (consumo/inventariabili), richiesta da presentare a brevissimo
- Il prossimo il 3/11/22: https://agenda.infn.it/event/32938/

Dal Muon Collaboration Meeting

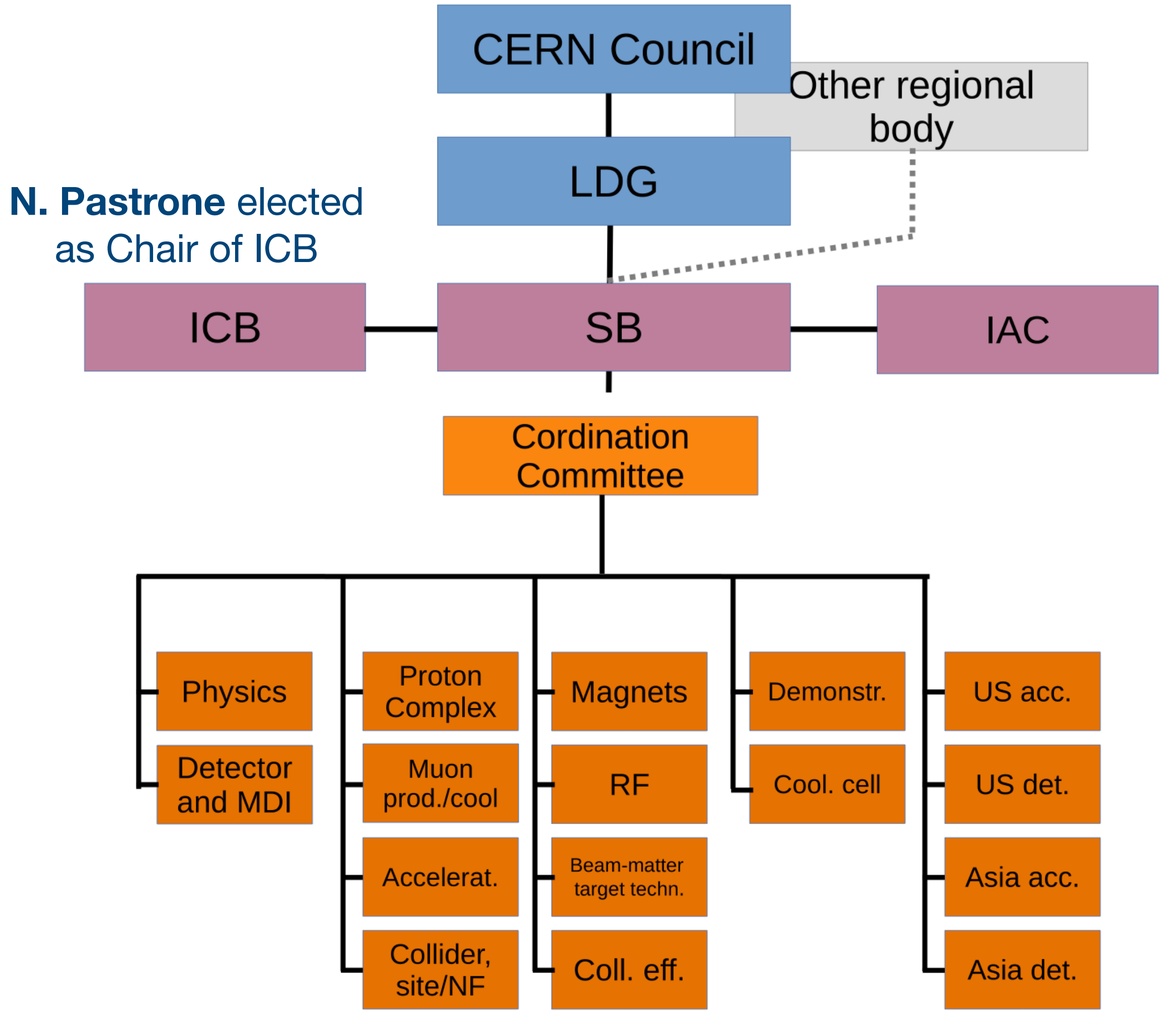
Muon Collider Collab. Meeting

- 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

Main elements of the governance structure

Formal organization

- **International Collaboration Board (ICB)**
  - First meeting today
- **Steering Board (SB)** (links to LDG, CERN Council, major FA, strategy …)
  - Chair Steinar Stapnes
- **Coordination committee**
  - Study Leader Daniel Schulte, deputies: Andrea Wulzer, Donatella Lucchesi, Chris Rogers, to be endorsed by the ICB
  - The members are already working



CC Members

Physics	Andrea Wulzer
Detector and MDI	Donatella Lucchesi

Protons	Natalia Milas
Muon production and cooling	Chris Rogers
Muon acceleration	Antoine Chance
Collider	Christian Carli

Magnets	Luca Bottura
RF	Alexej Grudiev
Beam-matter int. target systems	Anton Lechner
Collective effects	Elias Metral

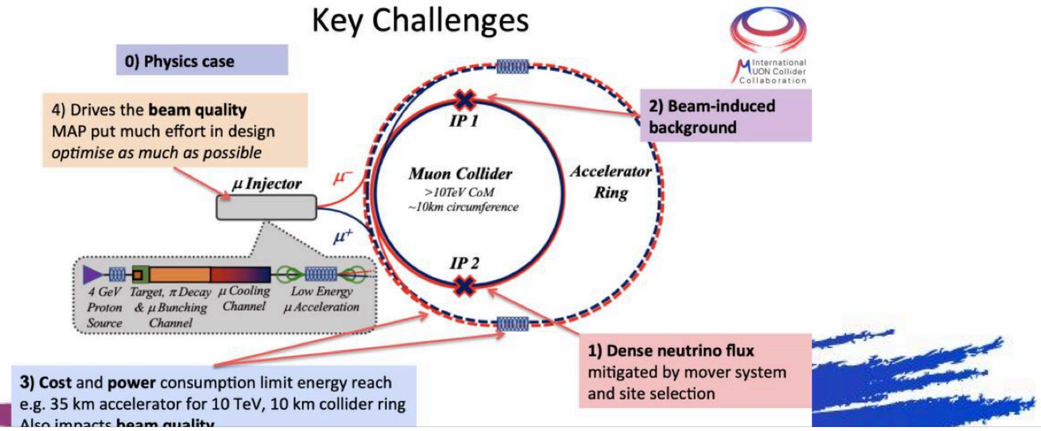
Cooling cell design	to be filled after EU decision
Demonstrator	Roberto Losito

US (detector)	Sergo Jindariani
US (accelerator)	Mark Palmer
Asia (China)	Jingyu Tang
Asia (Japan)	tbd

EU Design Study WP leaders:

EU RF WP	Claude Marchand
Cooling cell	Lucio Rossi

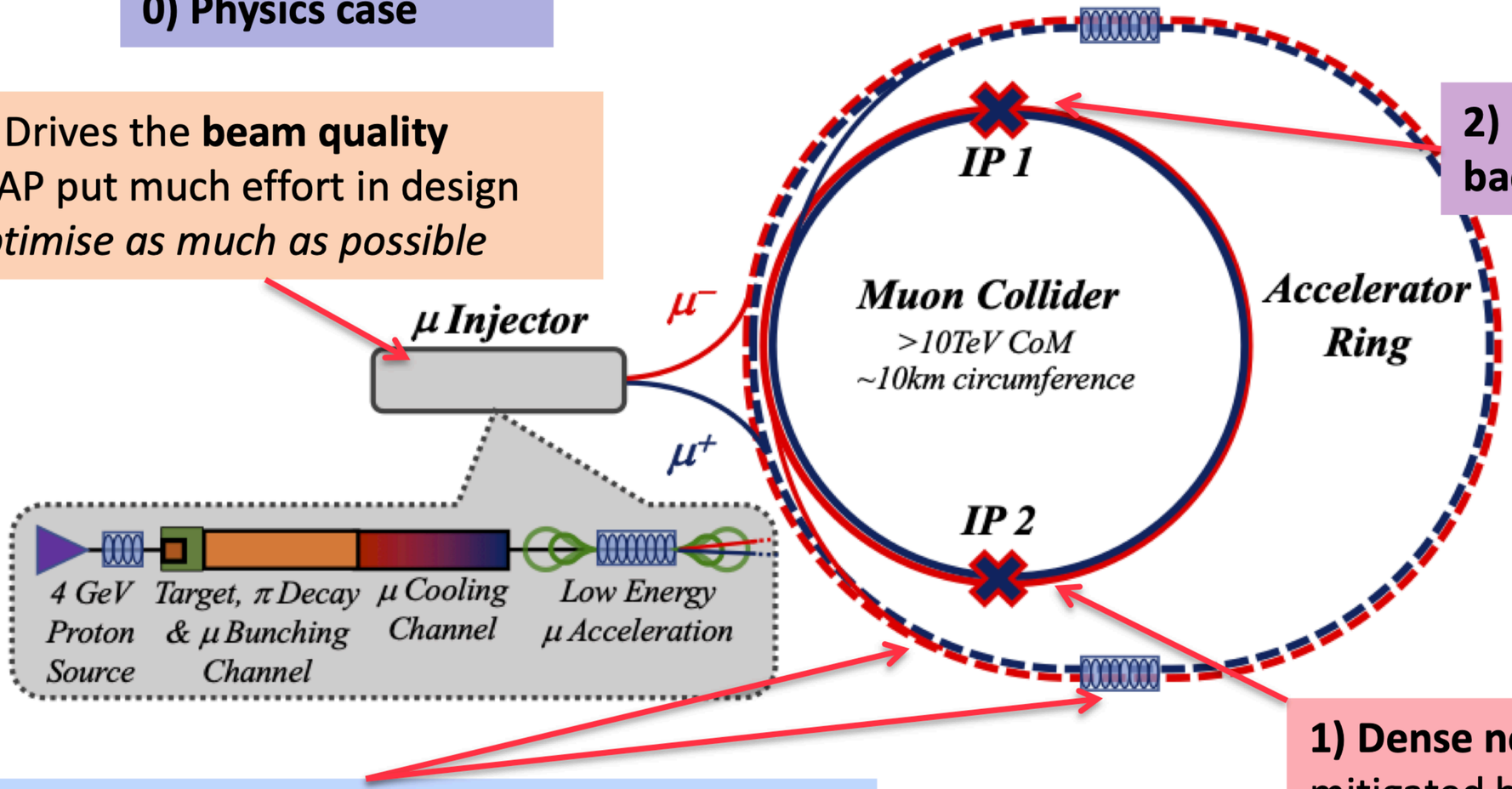
Proposal for deputies (to be endorsed by ICB):
Andrea Wulzer, Donatella Lucchesi, Chris Rogers



Key Challenges

0) Physics case

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

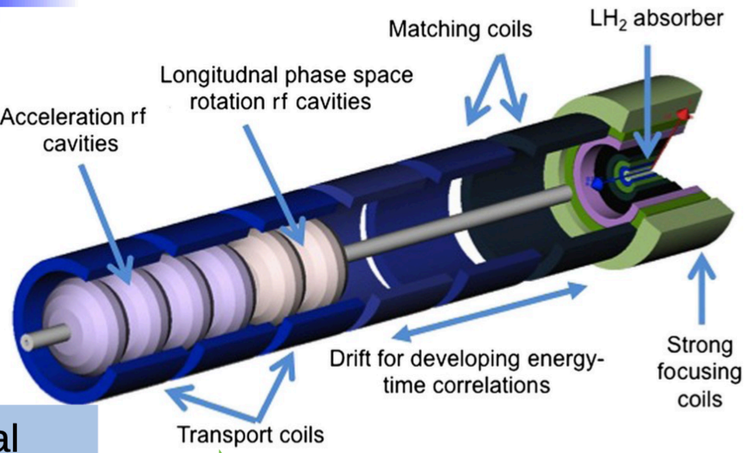


2) Beam-induced background

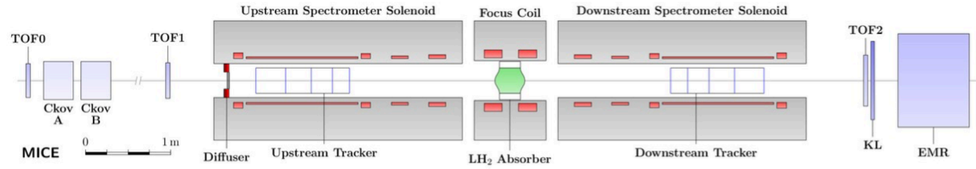
1) Dense neutrino flux
mitigated by mover system and site selection

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

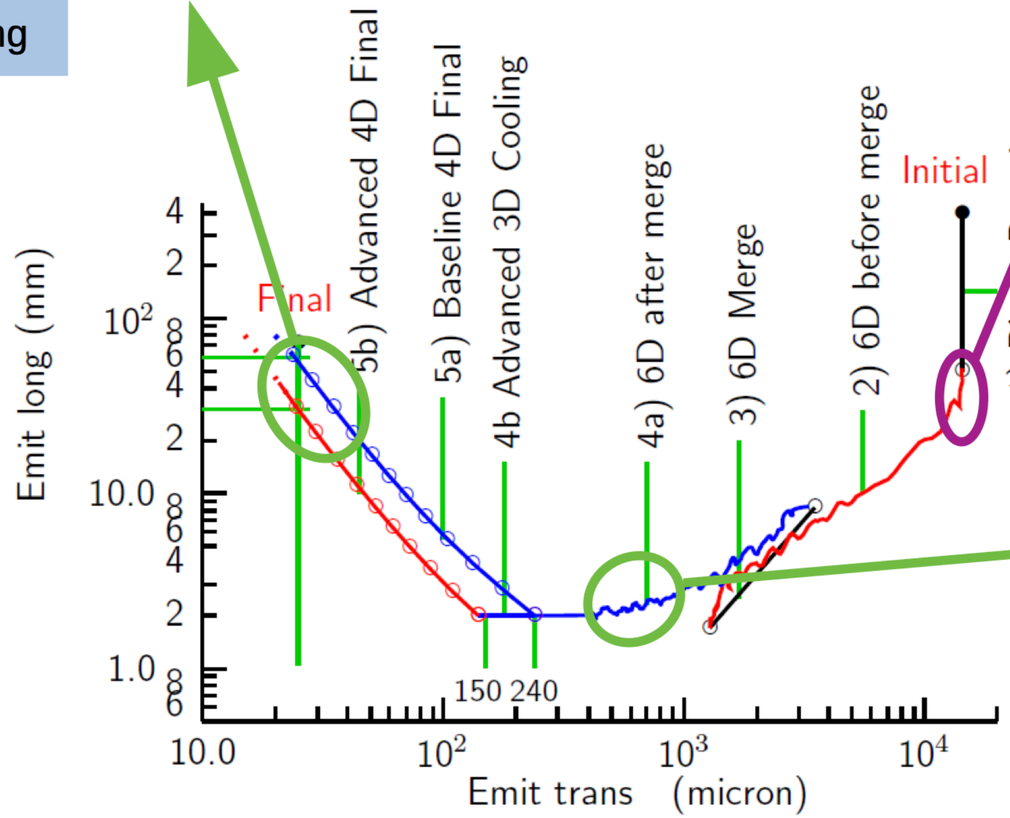
Cooling for Muon Collider



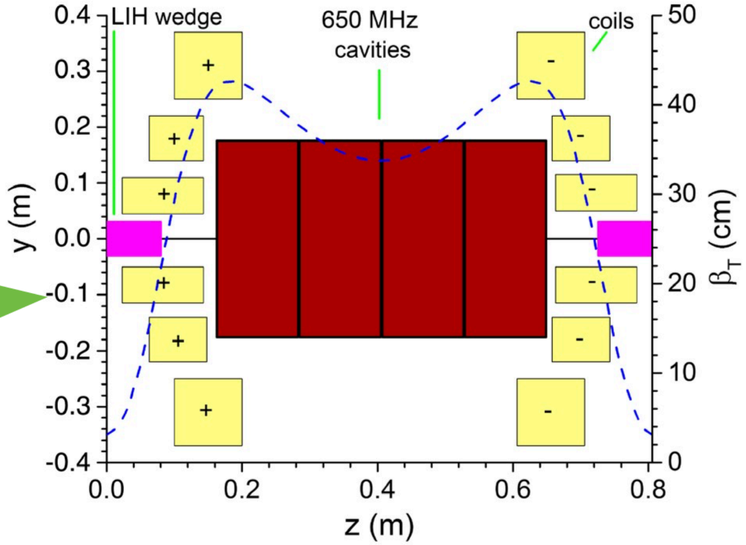
Final cooling



"MICE-like"

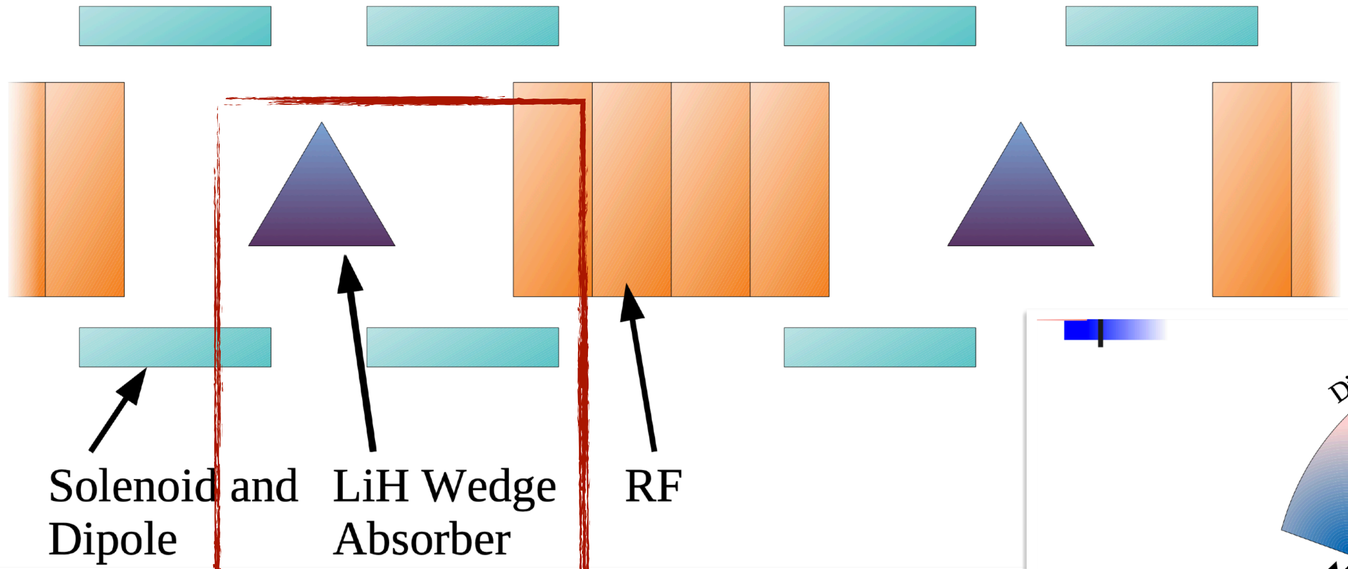


Rectilinear B (Stage B8)



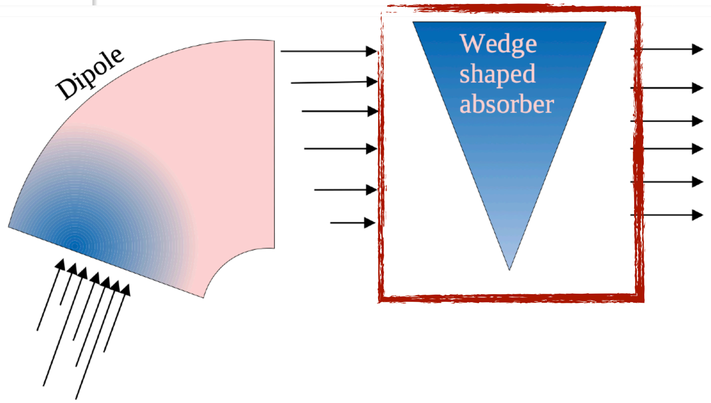
Muon Cooling

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



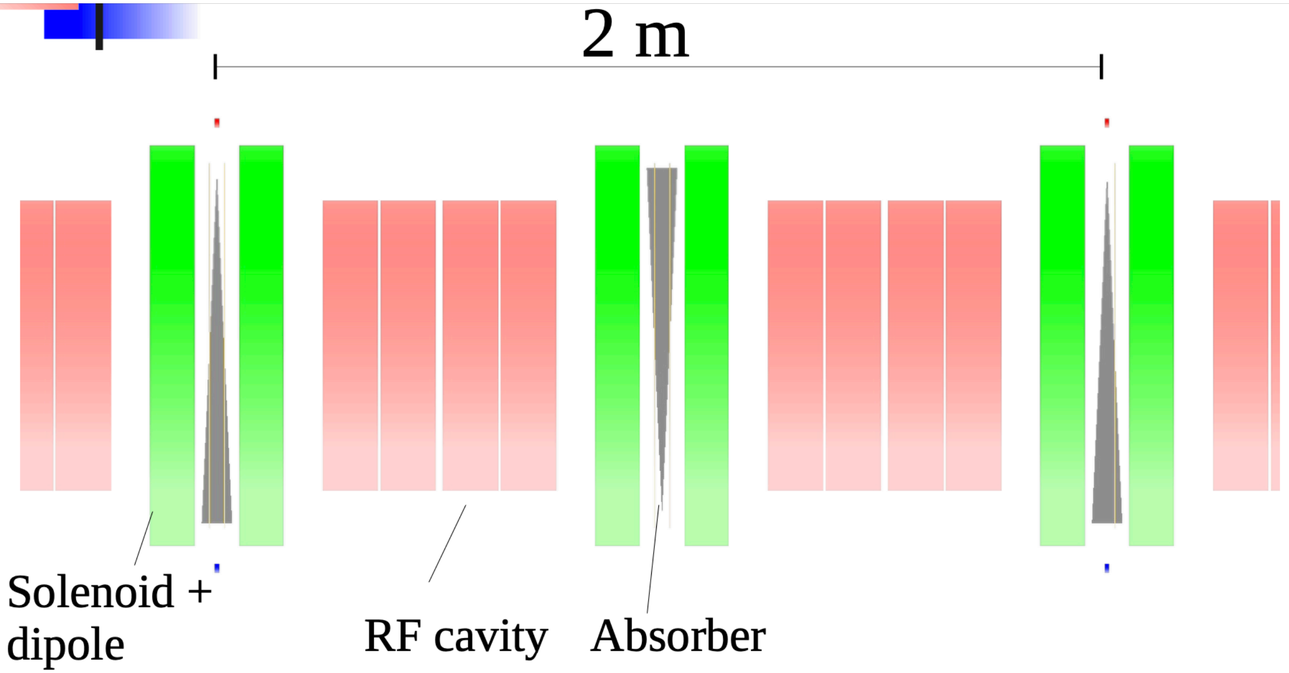
~250 MeV muons slowing down

6D Ionization Cooling

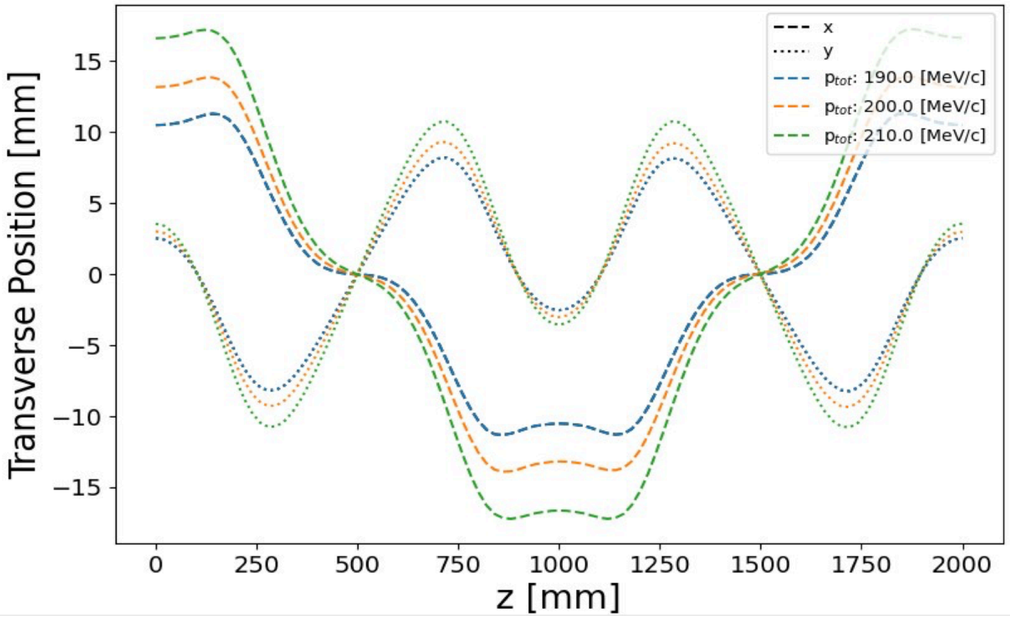


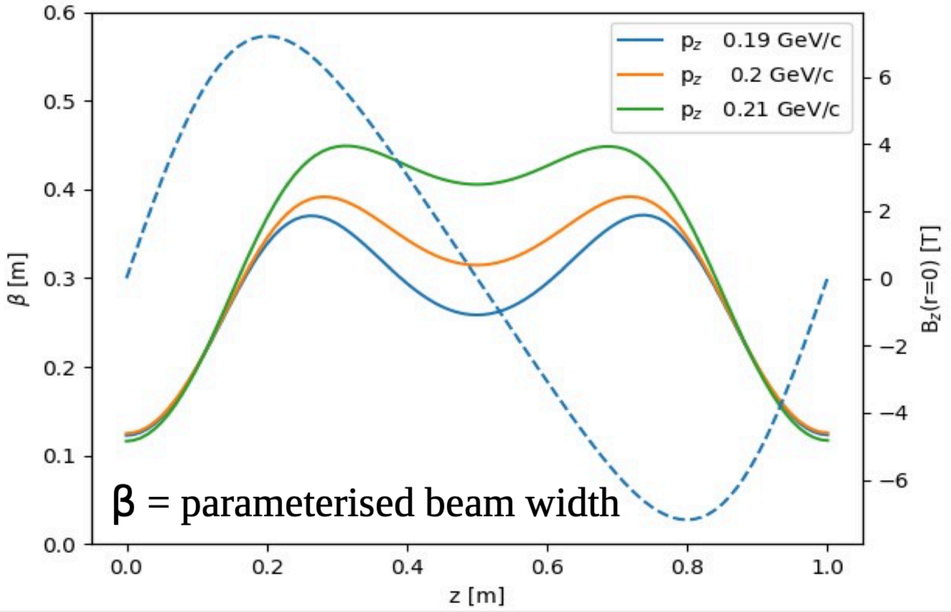
- Initial beam is narrow with some momentum spread
  - Low transverse emittance and high longitudinal emittance
- Beam follows curved trajectory in dipole
  - Higher momentum particles have higher radius trajectory
  - Beam leaves dipole wider with energy-position correlation
- Beam goes through wedge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

Preliminary Design



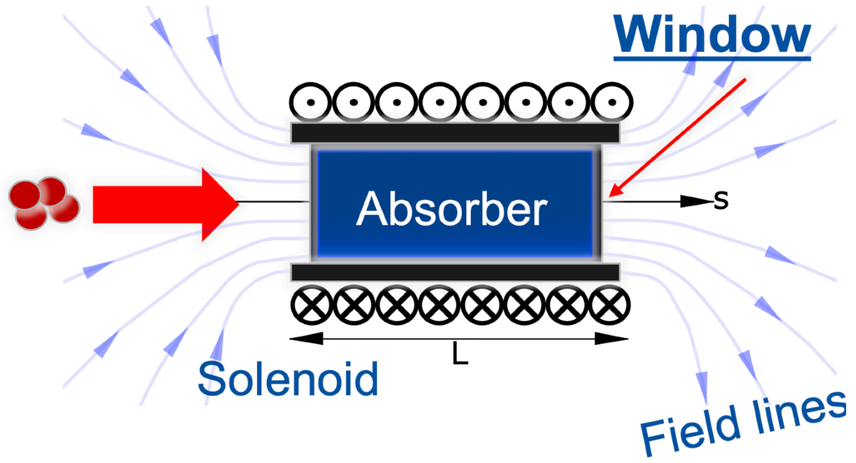
Cooling System	
Cell length	2 m
Peak solenoid field on-axis	7.2 T
Dipole field	0.2 T
Dipole length	0.1 m
RF real estate gradient	22 MV/m
RF nominal phase	20°
RF frequency	704 MHz
Wedge thickness on-axis	0.0342 m
Wedge apex angle	5°
Wedge material	LiH





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

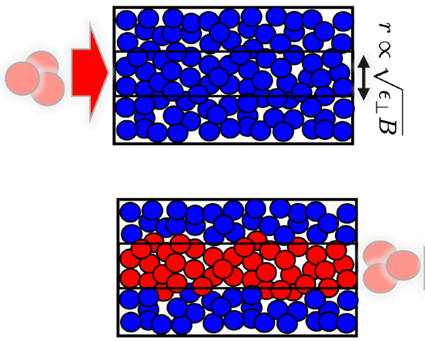
$\rho = 70\,\mathrm{kg\,m^{-3}}$ $B = 50\,\mathrm{T}$

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

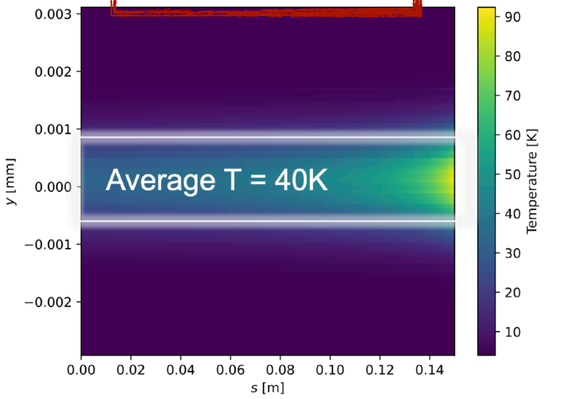
$$n = \frac{\rho V}{A}$$

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

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

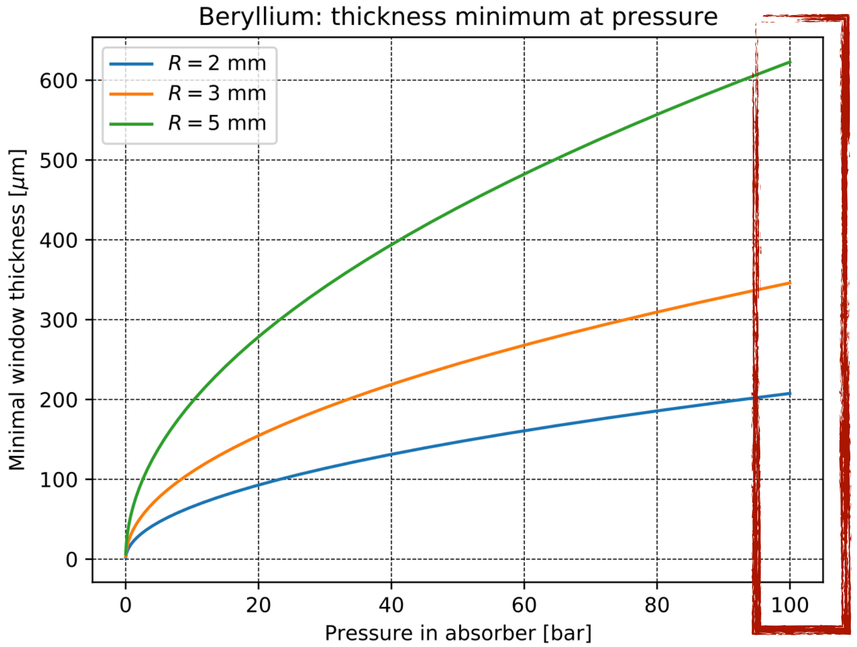


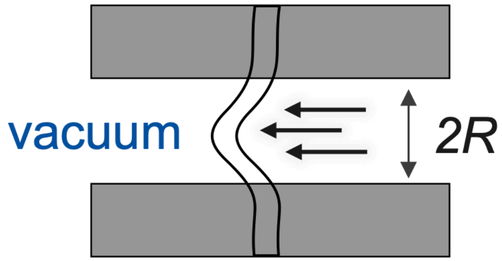
20MeV to 5Mev



Final cooling

Minimum window thickness





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

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

- 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

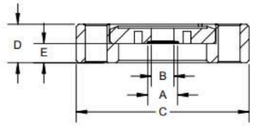


Figure 2 Conflat Flange Geometry

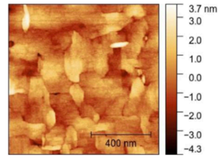
MOXTEK

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

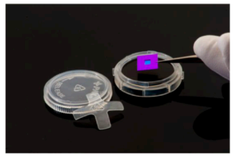
CF	Foil Thickness (μm)	Foil Diameter (mm) - A	Through Hole Diameter (mm) - B	CF Outer Diameter (mm) - C	CF Thickness (mm) - D	Window Height (mm) - E	Coating	Part ID
1-1/3" OD	8.0	9.2	7.0	33.8	7.2	0.5	DuraCoat Plus	DBM-08-9.2-CF1.3-P
	25.0	16.0	13.0	33.8	7.2	0.5	DuraCoat	DBM-25-16.0-CF1.3
2-1/8" OD	8.0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

Thin windows: SiC

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

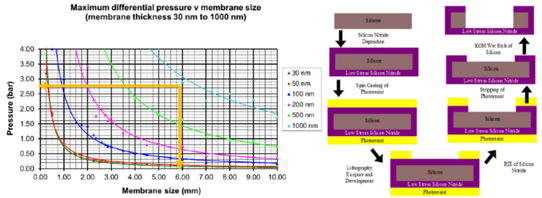


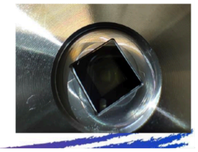
Silson



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 · epi · SiMPore

Thin windows: C

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

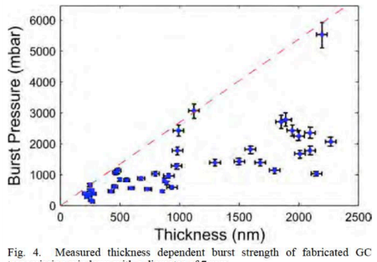


Fig. 4. Measured thickness dependent burst strength of fabricated GC transmission windows with a diameter of 7 mm.

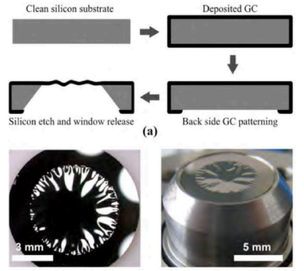


Fig. 2. (a) sketches the fabrication process of the transmission window. (b) shows a top view image of a fabricated GC window. (c) depicts a TO8 housing with a GC window glued into the top of the housing

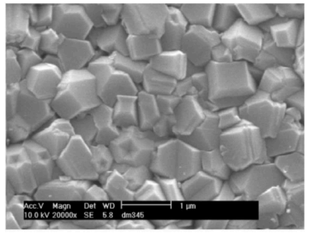
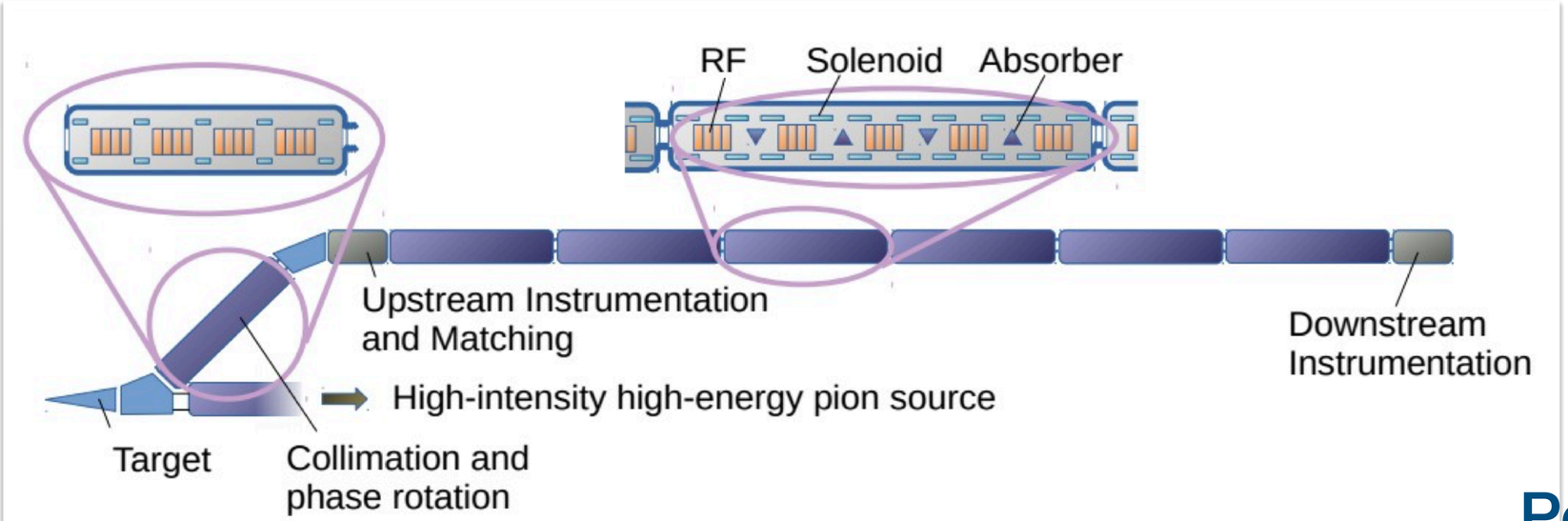


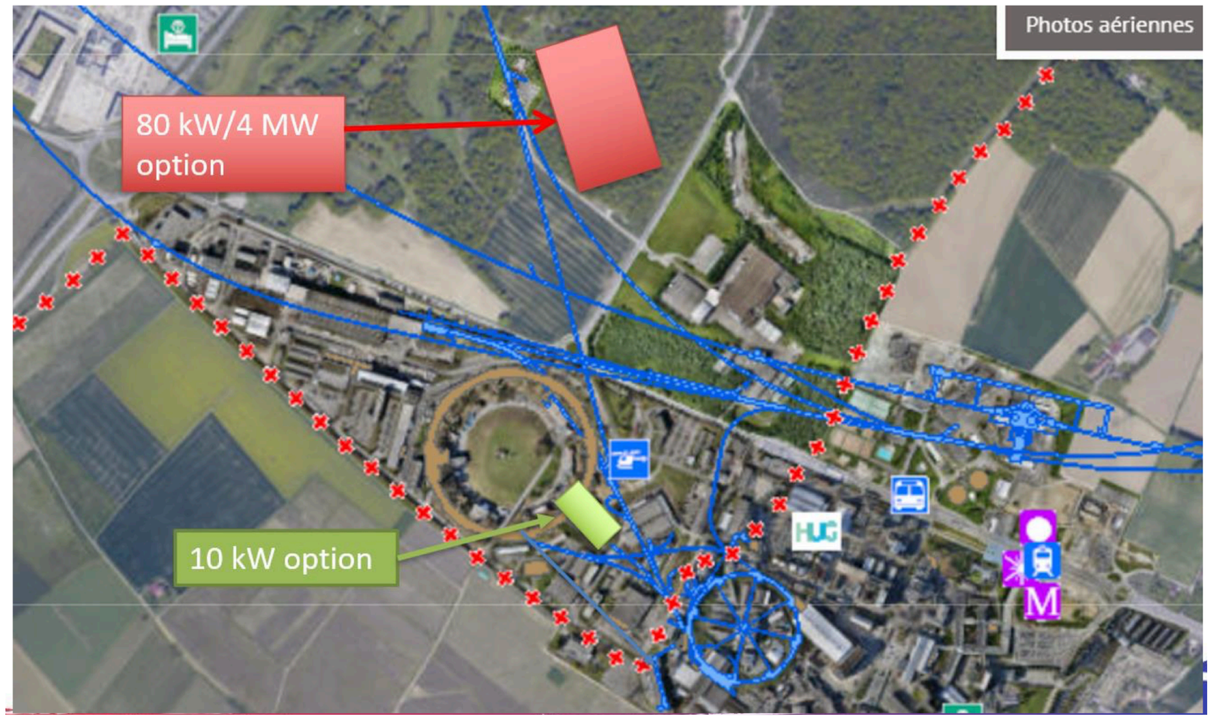
Fig. 4. SEM picture of the diamond film 345#.

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



/End

State of the Art

- Installazione camera a vuoto
  - Ilaria ha parlato con Nello, siamo a buon punto
  - Ionvacs **NON installa**, a noi manca un tavolo, va pensata/preparata location a SBAI
- Termocamera da LNF a SBAI
  - tiepido ottimismo, non imminente
- Test a SBAI
  - Come procedono?
- PRIN: idee e piani?
- AOB