



Baseline configurations, options, power and cost C. Rossi – 15th May 2025





- Recap of the Muon Collider preliminary cost study
- What is missing
- Directions from the cost analysis
- Critical spots and possible issues at the interfaces
- Concluding remarks





# Muon Collider preliminary cost study



• The cost range for the different configurations was evaluated and compared to the Green Field scenario, where a cost for Civil Engineering of 50kCHF/m was assumed in the absence of a detailed study.







• A previous estimate was done in the frame of the Snowmass exercise in 2022, by using a multi-parameter cost model and starting from estimates provided by project proponents (B\$ in the scale below).

Project Cost (no esc., no cont.)	4	7	12	18	30	50
MC-3						
MC-10						





### Configurations



Parameter	Symbol	unit	Site independent		CERN	
			Stage 1	Stage 2	Stage 1	Stage 2
Centre-of-mass energy	$E_{\rm cm}$	TeV	3	10	3.2	7.6
Target integrated luminosity	$\int \mathcal{L}_{ ext{target}}$	$ab^{-1}$	1	10	1	10
Estimated luminosity	$\mathcal{L}_{ ext{estimated}}$	$10^{34} \mathrm{cm}^{-2} \mathrm{s}^{-1}$	1.8	17.5	0.9	7.9
Collider circumference	$C_{ m coll}$	$\mathrm{km}$	4.5	11.4	11	11
Collider arc peak field	$B_{ m arc}$	Т	11	14	4.8	11
Collider dipole technology			Nb <sub>3</sub> Sn	HTS	NbTi	Nb <sub>3</sub> Sn
						or HTS

 As for costing, we intend to stay with the CERN scenario and try to complete the cost and power analysis as much as possible before the end of 2025.





# What are we missing (machine)



- Accumulator and compressor Rings (they will be estimated in the next months)
- Muon charge separation and merging
- Final cooling (conceptual)
- SC Linac
- Collider ring : Beam dynamics and realistic magnets. Field-free length.





# What are we missing (systems)



- Decay channel shielding, solenoids ? (my figures may be incomplete)
- Final cooling RF
- RLAs magnets
- Magnet cryostats ? (for RF this was included)
- Vacuum in general (is 20kCHF/m a reasonable estimate ?)





• In the two configurations, the same technologies weigh differently on the cost uncertainty, showing the path for some risk mitigation and priorities in case of energy staging.







### The Cooling Channel challenge





• Expect changes in the beam dynamics and cavity design.

Carlo Rossi

• Modular design and standardization may help to adapt to changes



Initial and new  $E_{peak}$  copper walls - AM stages

Cell	$E_{\rm Mag}$	$e_{\mathrm{Mag}}$	Coil	$J_E$	B <sub>peak</sub>
	(MJ)	(MJ/m <sup>3</sup> )		(A/mm <sup>2</sup> )	(T)
A1	5.4	21	A1-1	57.6	5.2
A2	22.1	106.1	A2-1	149.5	11.6
A3	5.0	49.5	A3-1	131.5	10.1
A4	8.0	92.3	A4-1	193.2	13.8
<b>B</b> 1	9.1	49.8	B1-1	96.9	7.7
B2	15.6	64.2	B2-1	102.1	9.2
B3	36.9	105.9	B3-1	127.9	12.9
<b>B</b> 4	75.6	149.9	B4-1	88.5	16.1
B5	17.3	88.9	B5-1	179.6	14.7
B5			B5-2	154.0	14.7
B6	8.3	96.6	B6-1	214.4	15.3
B6			B6-2	211.5	12.0
B6			B6-3	212.7	12.4
B7	8.2	87.7	B7-1	183.3	14.7
B7			B7-2	153.9	11.1
B7			B7-3	210.3	13.2
<b>B</b> 8	8.8	92.1	B8-1	193.7	16.5
<b>B</b> 8			B8-2	202.1	15.4
<b>B</b> 8			B8-3	212.8	13.2
B9	7.5	76.5	B9-1	256.4	17.2
B9			B9-2	88.4	10.0
B9			B9-3	204.9	13.2
B10	5.0	68.6	B10-1	326.8	19.2
B10			B10-2	146.1	11.1
B10			B10-3	207.8	12.5





# The Cooling Channel challenge

- Integrate the absorbers
- Interface to cryogenics
- Alignment tolerances and strategy for alignment
  - Admissible alignment tolerances by the beam dynamics team
- Beam instrumentation
  - Preliminary layout of the required beam instrumentation by the beam dynamics team, possibly provide dynamic range and bandwidth



INFN cell demonstrator



Carlo Rossi



#### From the magnet session $\rightarrow$ Solenoids - M. Statera



• Conclude on the most appropriate metrics to apply, try to include a notion of technical risk.



# **RCS Magnets and powering**



 Cost and implications of the different options for the RCS magnet powering may affect the CE and General Infrastructure design.





### Collider Ring Combined Function Magnets





#### D. Novelli

- The large gap in the B-G plots between the requested performance (triangles) and what appears as achievable today imposes an iteration with the design team.
- New input provided to the beam physicists.



# **Concluding remarks**



- A close interaction / coordination among the design team and the WPs in charge of the technical systems is necessary for an effective progress in the selection of the most appropriate options.
- The cost and power exercise will be properly **documented** to allow the continuation of this work.
- A kind of quality assurance system concerning parameters and configurations would be beneficial in assuring consistency and tracking of the different efforts.
- Permanently **include cost and power** considerations into the facility design may help with the selection of technical options.

