MUon collider STrategy network - MUST

Nadia Pastrone INFN-Torino
for the MUST team
INFN - CERN (+BINP) – CEA – IJCLAB – KIT – PSI – UKRI
(USA not beneficiary)

Task 5.1

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It will serve as the common ground for a growing international muon-collider collaboration

MUST will support to establish an international collaboration and develop an optimized R&D roadmap towards a future muon collider, including the definition of optimum test facilities and possible intermediate steps

Web page:
http://muoncollider.web.cern.ch
Mailing lists to subscribe:
Login at: https://e-groups.cern.ch
search for "muoncollider"
i.e. -FACILITY@cern.ch

International Muon Collider Collaboration
Project Leader: *Daniel Schulte*

Accelerator R&D Roadmap
Bright Muon Beams and Muon Colliders

Panel members: **D. Schulte**,(Chair), M. Palmer (Co-Chair), T. Arndtl, A. Chancé, J. P. Delahaye, A.Faus-Golfe, S.Gilardoni, P.Lebrun, K.Long, E.Métral, N.Pastrone, L.Quettier, T.Raubenheimeru, C.Rogers, M.Seidel, D.Stratakis, A.Yamamoto
Associated members: A. Grudiev, R. Losito, D. Lucchesi

- Detailed review and plan forward prepared by the international Roadmap panel
- Community was involved: 3 Community Meetings (May-July-October)

  ➔ https://indico.cern.ch/category/14577/
- MUST can now play a crucial role to consolidate the community and to disseminate infos
  - **MS15:** International workshop on muon source design **M18** ➔ *Report*
  - **MS16:** International workshop to define R&D plans **M36** ➔ *Report*
  - **D5.1:** International collaboration plans towards a multi-TeV muon collider **M46**

Community Meeting - WG

Radio-Frequency (RF): *Alexej Grudiev (CERN), Jean-Pierre Delahaye (CERN retiree), Derun Li (LBNL), Akira Yamamoto (KEK)*
Magnets: *Lionel Quettier (CEA), Toru Ogitsu (KEK), Soren Prestemon (LBNL), Sasha Zlobin (FNAL), Emanuela Barzi (FNAL)*
High-Energy Complex (HEC): *Antoine Chance (CEA), J. Scott Berg (BNL), Alex Bogacz (JLAB), Christian Carli (CERN), Angeles Faus-Golfe (IJCLab), Eliana Gianfelice-Wendt (FNAL), Shinji Machida (RAL)*
Muon Production and Cooling (MPC): *Chris Rogers (RAL), Marco Calviani (CERN), Chris Densham (RAL), Diktys Stratakis (FNAL), Akira Sato (Osaka University), Katsuya Yonehara (FNAL)*
Proton Complex (PC): *Simone Gilardoni (CERN), Hannes Bartosik (CERN), Frank Gerigk (CERN), Natalia Milas (ESS)*
Beam Dynamics (BD): *Elias Metral (CERN), Tor Raubenheimer (SLAC and Stanford University), Rob Ryne (LBNL)*
Radiation Protection (RP): *Claudia Ahdida (CERN)*
Parameters, Power and Cost (PPC): *Daniel Schulte (CERN), Mark Palmer (BNL), Philippe Lebrun (CERN retiree and ESI), Mike Seidel (PSI), Vladimir Shiltsev (FNAL), Jingyu Tang (IHEP)*
Machine Detector Interface (MDI): *Donatella Lucchesi (University of Padova and INFN), Christian Carli (CERN), Anton Lechner (CERN), Nicolai Mokhov (FNAL), Nadia Pastrone (INFN), Sergo R Jindariani (FNAL)*
Synergy: *Kenneth Long (Imperial College), Roger Ruber (Uppsala University), Koichiro Shimomura (KEK)*
Test Facility (TF): *Roberto Losito (CERN), Alan Bross (FNAL), Tord Ekelof (Uppsala University)*

Physics & Detector:
Donatella Lucchesi *(University of Padova and INFN)*

WG 1: **Physics Potential:** Andrea Wulzer (EPFL&CERN) et al.
WG 2: **Detector performance (with several focus areas)**
WG 3: **Detector R&D and Software & Computing development**

Key Challenges of the facility

- **Focus on two energy ranges:**

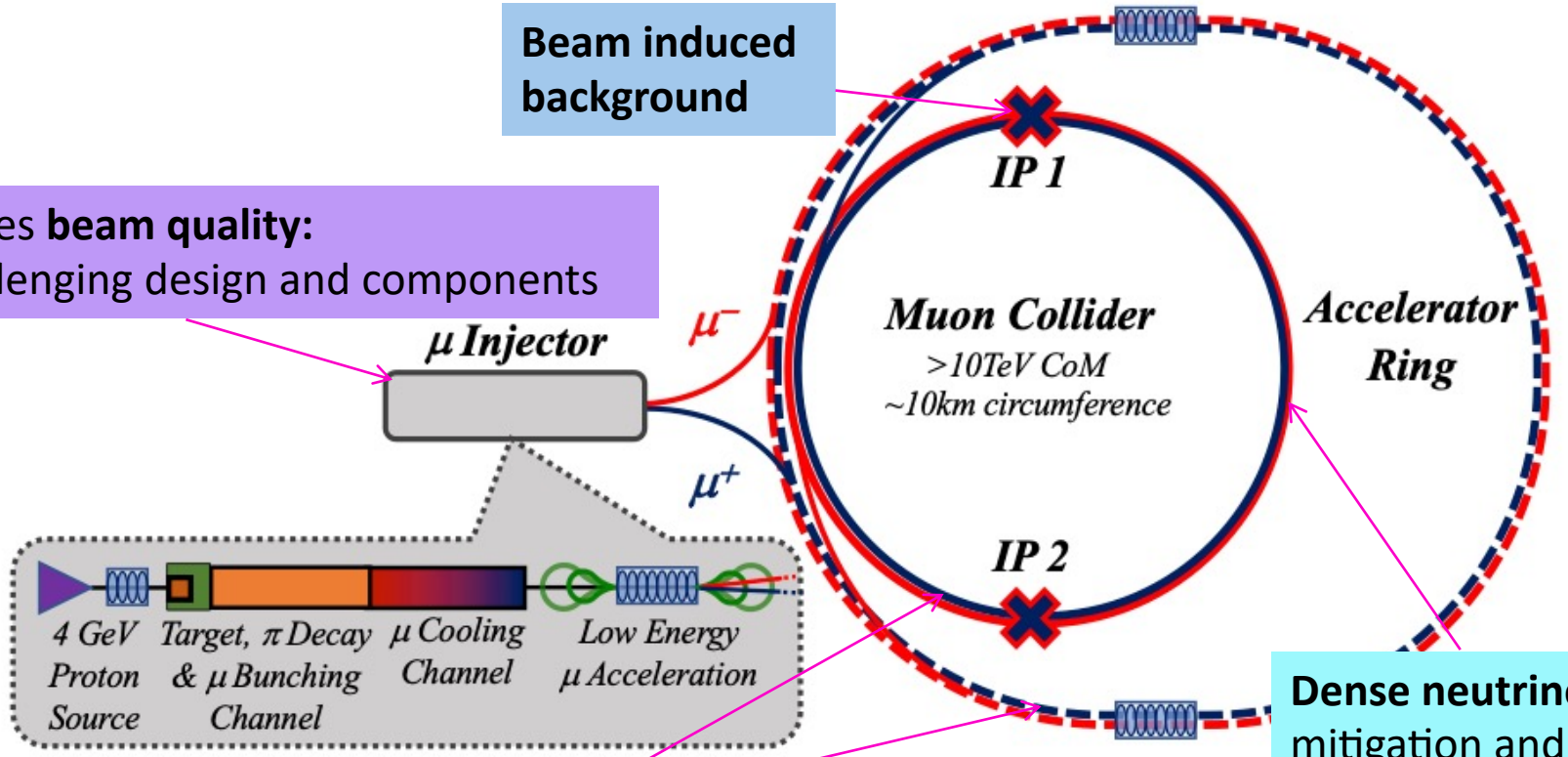
– **3 TeV** technology ready for construction in 10-20 years

– **10+ TeV** with more advanced technology

$\sqrt{s}$	$\int \mathcal{L} dt$
3 TeV	1 ab^{-1}
10 TeV	10 ab^{-1}
14 TeV	20 ab^{-1}

Beam induced background

Drives **beam quality:** challenging design and components



Dense neutrino flux mitigation and site

Cost and **power** consumption drivers, limit energy reach
e.g. 30 km accelerator for 10/14 TeV, 10/14 km collider ring

Roadmap panel conclusions

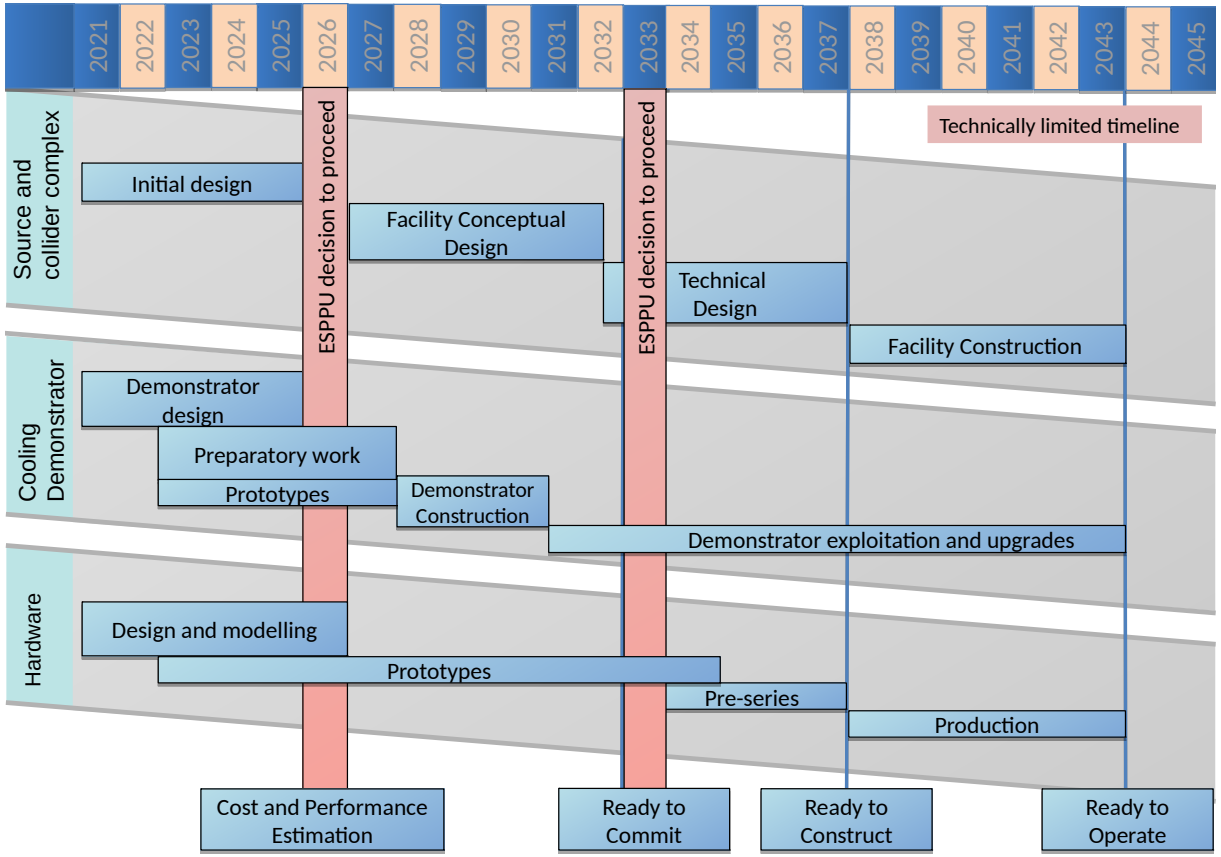
GOAL

In time for the next European Strategy for Particle Physics Update, aim to **establish whether the investment into a full CDR and a demonstrator is scientifically justified**

The panel endorsed this ambition and concludes that:

- The MC presents enormous potential for fundamental physics research at the energy frontier
- At this stage the panel did not identify any showstopper in the concept and sees strong support of the feasibility from previous studies
- It identified important R&D challenges

The panel has identified a development path that can address the major challenges and deliver a 3 TeV muon collider by 2045



Accelerator Key Challenge Areas

- Impact on the environment
  - The **neutrino flux mitigation** and its impact on the site (first concept exists)
  - The **machine induced background** impact the detector, and might limit the physics
- **High-energy systems** after the cooling (acceleration, collision, ...)
  - Fast-ramping magnet systems
  - High-field magnets (in particular for 10+ TeV)
- **High-quality muon beam production**
  - Special RF and high peak power
  - Superconducting solenoids
  - Cooling string demonstration (cooling cell engineering design, demonstrator design)
- **Full accelerator chain**
  - e.g. proton complex with H- source, compressor ring ➔ test of target material

Next steps

GOAL:

- pre-conceptual design report with cost and power scale
- test facility conceptual design
- prepared R&D programme

- **IMPORTANT** to profit from I.FAST platforms and on-going activities on R&D technology
- A plenary workshop is planned in February 2022 ➔ including **MS15**

  to better consolidate Collaboration after the Roadmap to work on Design Study and R&D
- Documents will be prepared for SnowMass March 15 2022 deadline

extras

MUST activities and goals

INFN, CERN (+BINP), CEA, IJCLAB, KIT, PSI, UKRI /STFC

- Support the effort to design a muon collider and to project and plan the required R&D
- Consolidate the community devoted to develop an international future facility
- Prepare the platform to disseminate the information (website, meetings, simulation tools)

- A Europe-wide network is essential for the development of the collider design and technology, which will serve as a common forum to coordinate with the growing international muon-collider efforts, including the US-MAP collaboration, sharing data and results.
- The muon collider requires an intense muon source, fast muon acceleration to high energies and efficient collisions to provide high luminosity:
  - The fast acceleration stage and the collider ring are critical for the collider cost, power consumption and performance, and technologies that can be developed in synergy with other future projects.
  - The decay of muons produces intense fluxes of neutrinos and electrons, sources of background in the machine and in the detector. Dedicated technology development and close collaboration between the accelerator and the detector will be needed to address this issue.
- This task will provide a platform to discuss the plans for key R&D and test facilities as well as disseminate the information on muon colliders activities.

Planning ahead

- **AMBITION**: successful implementation of an **international plan** to address all studies and key issues towards the design of a muon collider capable to reach multi-TeV collision energies with an adequate luminosity for high-precision measurements and new discoveries.
- **CHALLENGES**: establish an organized international collaboration to address key issues and plan future steps. Evaluate reuse of existing infrastructures taking into account neutrino radiation hazards. Design of needed **test facilities** to address final feasibility.

MUST will actively contribute:

- Seeking for new EU et other regions collaborators
- Network in EU & other regions: USA – ASIA - activities ongoing at SnowMass21 process
- Promote synergies with other projects/industries for technologies R&Ds