MuCol Introduction

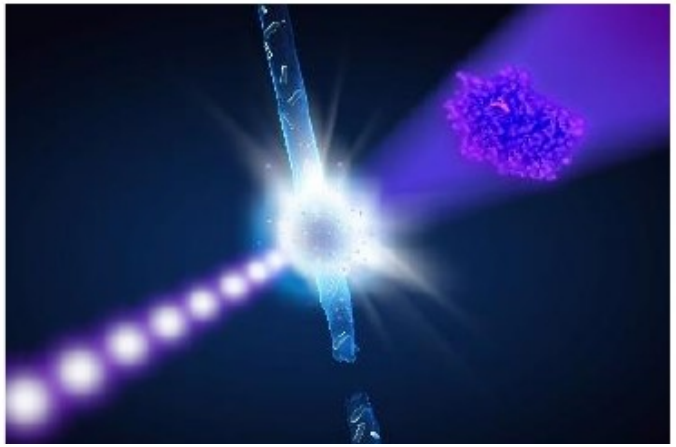
D. Schulte

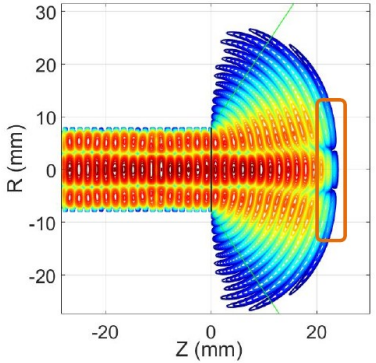
Funded by the European Union under
Grant Agreement n. 101094300

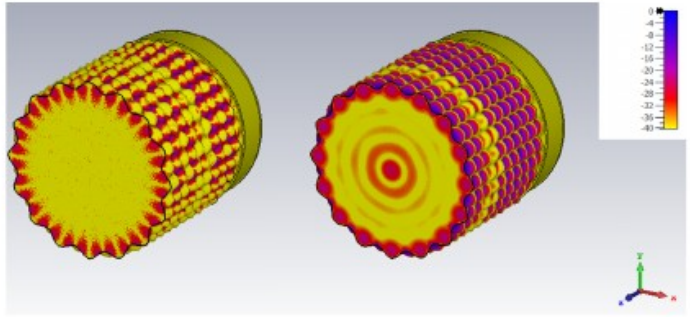
CERN
March 2023

Prof. Adrian Cross

International MUON Collider Collaboration

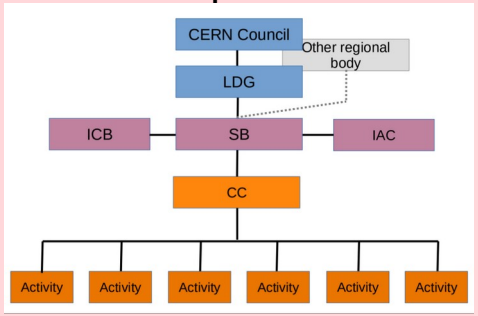






Muon Collider Community

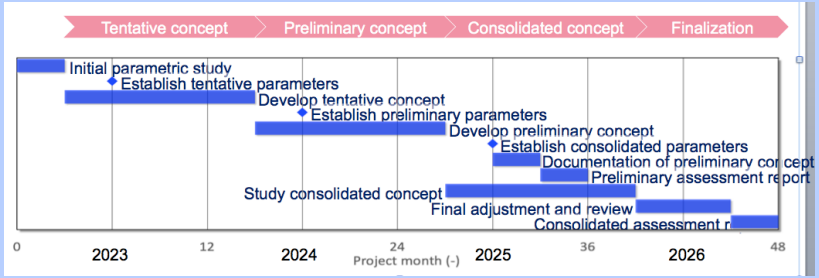
Formed **collaboration** to implement and R&D Roadmap for CERN Council



50+ partner institutions
30+ already signed formal agreement

EU Design Study just started, 32 partners, O(3+4 MEUR)

(EU+Switzerland+UK and partners)



Plan to apply in 2024 for **HORIZON-INFRA-2024-TECH**
Goal: prepare experimental programme, e.g. **demonstrator, prototypes, …**

US Snowmass has **strong support**

- to contribute to R&D
- as a collider in the US

Now P5 and EPP2024 are ongoing
Planning potential contributions

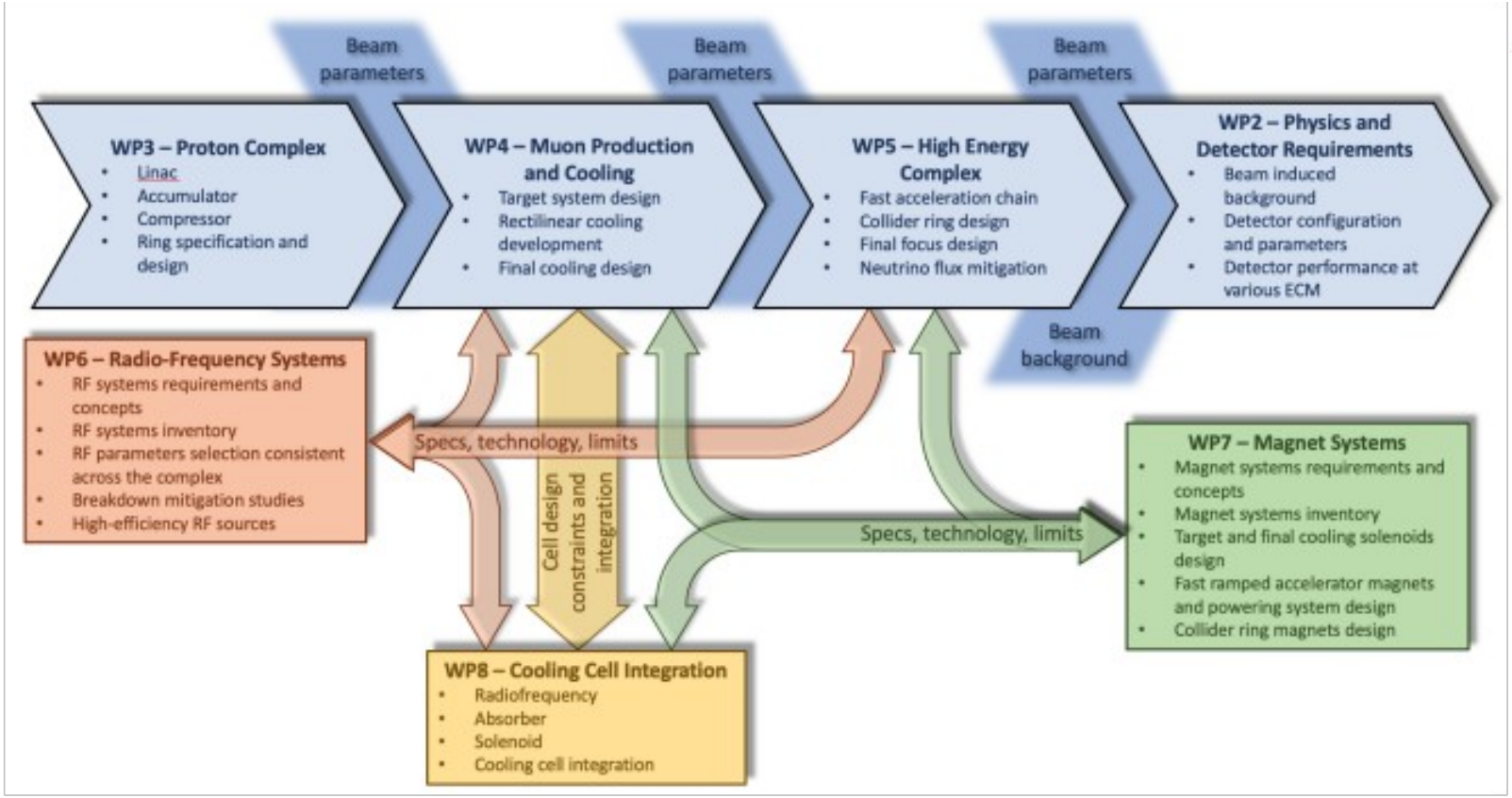
MuCol Partners

IEIO	CERN*
FR	CEA-IRFU*
	CNRS-LNCMI
DE	DESY*
	Technical University of Darmstadt*
	University of Rostock*
	KIT
IT	INFN*
	INFN, Univ. Milano*
	INFN, Univ. Padova*
	INFN, Univ. Pavia
	INFN, Univ. Bologna
	ENEA
PT	LIP*
SE	ESS*
	University of Uppsala*

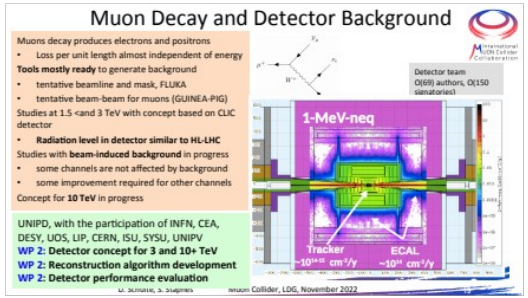
UK	UKRI (*)
	University of Lancaster (*)
	University of Southampton (*)
	University of Strathclyde
	University of Sussex (*)
	Imperial College
	Royal Holloway
	University of Huddersfield
	University of Oxford
	University of Warwick (*)
NL	University of Twente*
CH	PSI
	University of Geneva
US	Iowa State University
	BNL
China	Sun Yat-sen University

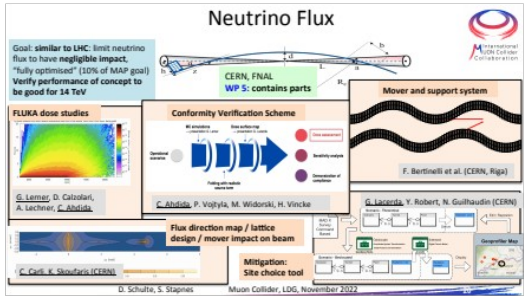
International MUON Collider Collaboration

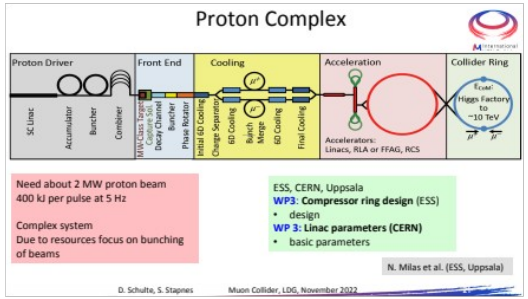
MuCol

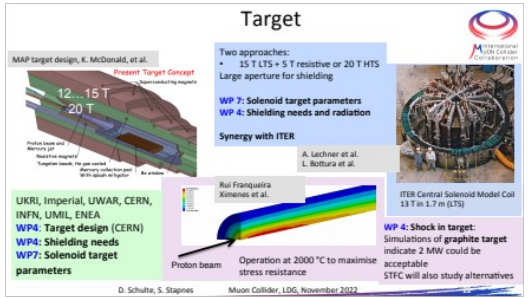

Beam parameters
Beam parameters
Beam parameters
WP3 – Proton Complex
Linac
Accumulator
Compressor
Ring specification and design
WP4 – Muon Production and Cooling
Target system design
Rectilinear cooling development
Final cooling design
WP5 – High Energy Complex
Fast acceleration chain
Collider ring design
Final focus design
Neutrino flux mitigation
WP2 – Physics and Detector Requirements
Beam induced background
Detector configuration and parameters
Detector performance at various ECM
Beam background
WP6 – Radio-Frequency Systems
RF systems requirements and concepts
RF systems inventory
RF parameters selection consistent across the complex
Breakdown mitigation studies
High-efficiency RF sources
Specs, technology, limits
Cell design constraints and integration
Specs, technology, limits
WP7 – Magnet Systems
Magnet systems requirements and concepts
Magnet systems inventory
Target and final cooling solenoids design
Fast ramped accelerator magnets and powering system design
Collider ring magnets design
WP8 – Cooling Cell Integration
Radiofrequency
Absorber
Solenoid
Cooling cell integration

Workpackage Contributions

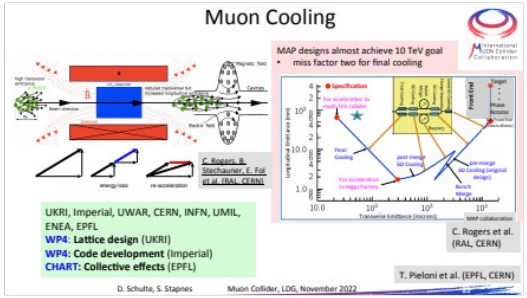


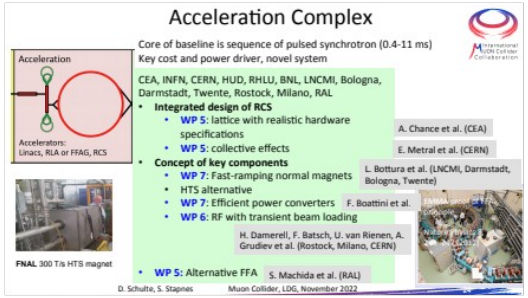


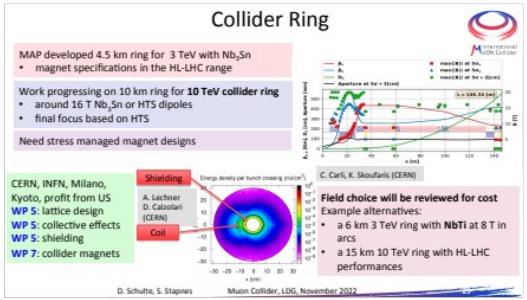


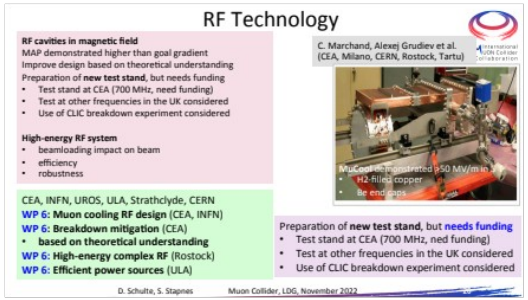


Workpackage Contributions









Workpackage Contributions

Magnet Technology

Target solenoid
- Large aperture high field, potential synergy with ITER

Highest field solenoids
- MAP demonstrated 30 T
- now magnets aim for 40+ T
- even more can be possible
- synergy with high-field research

6D cooling solenoids
- Large aperture high field, potential synergy with power generators

Collider ring magnets
- Large aperture dipoles, quadrupoles etc.

L. Bottura et al. INFN (Task Leader), CEA, CERN, LNCMI, PSI, SOTON, UNIGE and TWENTE, in collaboration with KEK and US-MDP

INFN, CERN, CEA, CNRS, KIT, PSI, SOTON, UNIBO, UNIGE, PSI, TUDa, TWENTE, in collaboration with KEK and US-MDP
WP 7: Target capture and cooling magnets (INFN)
WP 7: Fast-ramping magnets (CERN)
WP 7: Collider ring magnets (INFN)
For all: Develop realistic performance targets
Almost no budget for experiments

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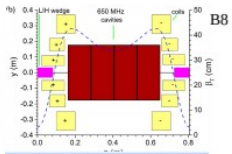
Cooling Cell Integration



Cooling cell poses engineering challenges
Timely design and prototyping is essential for test facility
Use specific designs of components that are available in the very near future

Will develop **example cooling cell**
- understand tight constraints
- additional technologies (**absorbers**, instrumentation,...)
- early preparation of **demonstrator facility**

UMIL, INFN, UKRI, CERN, Imperial
WP 8: Absorbers and windows (CERN)
WP 8: RF system (INFN)
WP 8: Solenoids (Milano)
WP 8: Performance (UKRI)
WP 8: Cooling cell integration (Milano)

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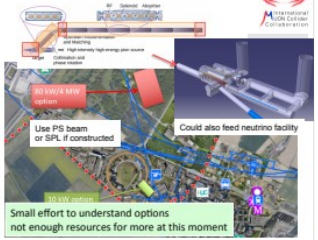
Demonstrator(s)

R&D efforts can be distributed over labs
- cooling demonstrator
- RF test stand
- module test stand
- ...

Could also have synergies
- booster for light sources (e.g. ESRF) or proton therapy?

For cooling demonstrator look for an existing proton beam with significant power

Different sites are being considered
- CERN, FNAL, ESS are being discussed
- J-PARC also interesting as option



Small effort to understand options not enough resources for more at this moment

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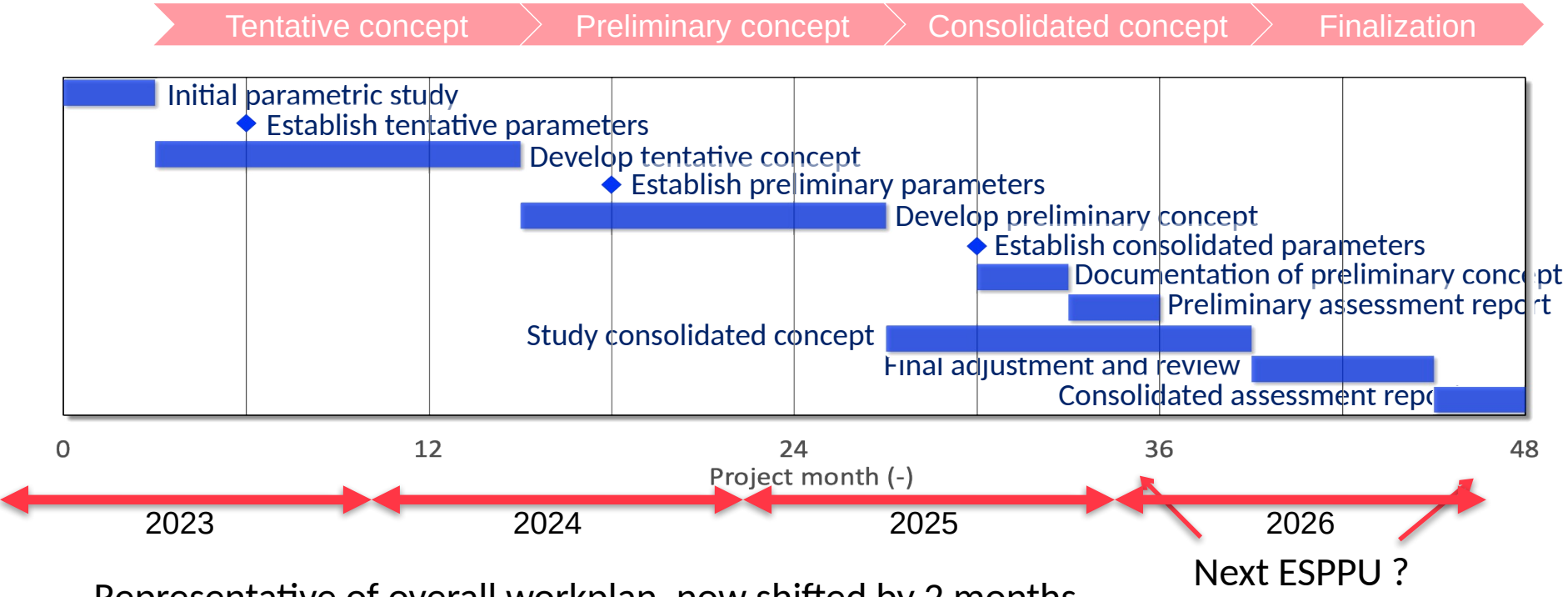
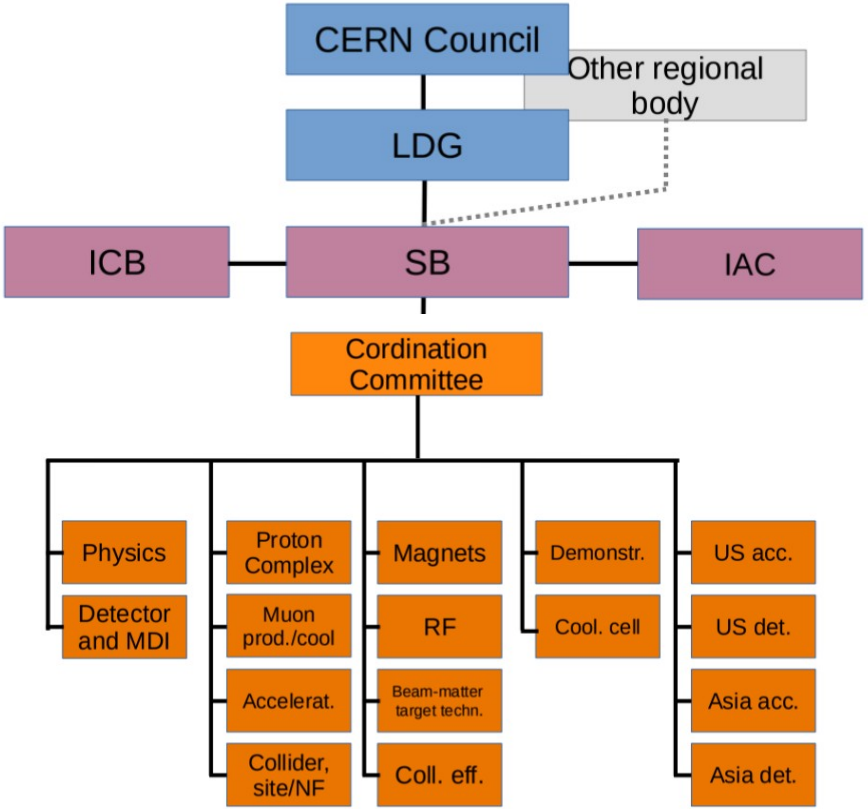
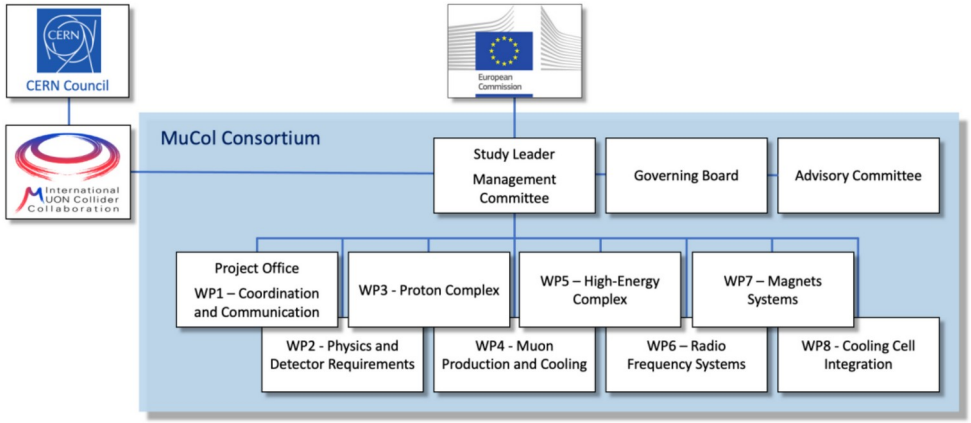
MuCol Timeline



Representative of overall workplan, now shifted by 2 months

IMCC and MuCol Organisation





Collaboration Board (ICB) and **Governing Board (GB)**

Steering Board (SB) is unique

Coordination Committee (CC) and **Management Committee (MC)**

International Advisory Committee and **Advisory Committee**

MuCol and Collaboration Integration

Main executive body of MuCol is Management Committee (MC)

- a subset of the Coordination Committee of the collaboration (CC)

Foresee to have all meetings combined

- e.g. annual meeting, CC+MC, ICB+GB
- may need some specific effort to document meetings for MuCol

Dissemination and publication of reports should be synchronised

- Task in MuCol to ensure quality and publication of reports
- Can in part rely on existing Conference Preparation Team
- Need to define clear procedures

Propose that MuCol Governing Board agrees to rely on International Advisory Committee of IMCC

- Steering Board will propose a composition

Coordination Committee 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, **Claude Marchand**
Beam-matter int. target systems	Anton Lechner
Collective effects	Elias Metral

Cooling cell design	**Lucio Rossi**
Demonstrator	**Roberto Losito**

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

The proposed MuCol WP coordinators are CC members

essentially all activities are integrated in MuCol

MoC/MuCol Partners

IEIO	**CERN***
FR	**CEA-IRFU***
	CNRS-LNCMI
DE	DESY*
	Technical University of Darmstadt*
	University of Rostock*
	KIT
IT	**INFN***
	INFN, Univ., Polit. Torino
	INFN, Univ. Milano*
	INFN, Univ. Padova*
	INFN, Univ. Pavia
	INFN, Univ. Bologna
	INFN Trieste
	INFN, Univ. Bari
	INFN, Univ. Roma 1
	ENEA
PT	***LIP****

UK	**RAL+**
	University of Lancaster
	University of Southampton
	University of Strathclyde
	University of Sussex
	Imperial College London+
	Royal Holloway
	University of Huddersfield
	University of Oxford
	University of Warwick
	University of Durham+
SE	**ESS***
	University of Uppsala*
NL	**University of Twente*+**
EST	***Tartu University***
LAT	**Riga Technical Univers.**
AU	**HEPHY**
	TU Wien

FI	**Tampere University**
ES	**I3M+**
	ICMAB
CH	**PSI**
	University of Geneva+
	EPFL
BE	***Louvain***
IT	**INFN Frascati**
	INFN, Univ. Ferrara
	INFN, Univ. Roma 3
	INFN Legnaro
	INFN, Univ. Milano Bicocca
	INFN Genova
	INFN Laboratori del Sud
	INFN Napoli
	INFN Catania

Blue: MuCol Participant
* MuCol beneficiary
+ new MoC signatory

US	**Iowa State University**
	Wisconsin-Madison
	Pittsburg University
	Florida State U.
	U. of Tennesse
	Old Dominion U.+
	BNL
China	***Sun Yat-sen University***
	IHEP
	Peking University
India	***CHEP***
Korea	**KNU+**

US	FNAL
	LBL
	JLAB
	Chicago
Japan	Akira Yamamoto, Akira Sato, T. Ogitsu

US Snowmass

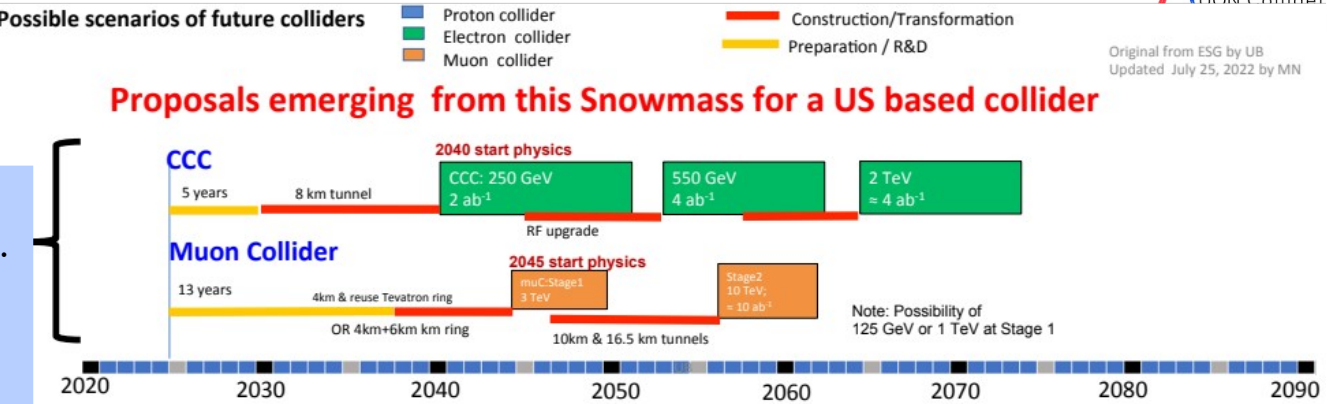
Strong interest in the US community in muon collider
- want funding for **R&D**
- like to **host a muon collider**

Task forces to prepare P5 bids:
- lead by FNAL (Sergo Jindiriani, D. Stratakys)

Detector and physics

Accelerator
- Goal is 40-50 FTE, similar to Europe
- Would bring resources close to full R&D Roadmap programme

European contact members:
Chris Rogers, Federico Meloni, Donatella Lucchesi, Daniel Schulte



- **Timelines technologically limited**
- Uncertainties to be sorted out
  - Find a contact lab(s)
  - Successful R&D and feasibility demonstration for CCC and Muon Collider
  - Evaluate CCC progress in the international context, and consider proposing an ILC/CCC [ie CCC used as an upgrade of ILC] or a CCC only option in the US.

ational Cost Sharing

proposing hosting ILC in the US.

Meenakshi Narain: Energy Frontier / Large Experiments, Snowmass Community Summer Study July 17-26, 2022

US preparation for P5

Accelerator R&D Focus Areas:

- Muon source: Mary Convery (Fermilab), Jeff Eldred (Fermilab), Sergei Nagaitsev (JLAB), Eric Prebys (UC Davis)
- Machine design: Frederique Pellemoine (Fermilab), Scott Berg (BNL), Katsuya Yonehara (Fermilab)
- Magnet systems: Steve Gourlay (Fermilab), Giorgio Apollinari (Fermilab), Soren Prestemon (LBNL)
- RF systems: Sergey Belomestnykh (Fermilab), Spencer Gessner (SLAC), Tianhuan Luo (LBNL)

International Liaisons: Daniel Schulte (CERN), Chris Rogers (RAL), Donatella Lucchesi (INFN), Federico Meloni (DESY)

Detector R&D Focus Areas:

- Tracking Detectors: Maurice Garcia-Sciveres (LBNL), Tova Holmes (Tennessee)
- Calorimeter Systems: Chris Tully (Princeton), Rachel Yohay (FSU)
- Muon Detectors: Melissa Franklin (Harvard), Darien Wood (Northeastern)
- Electronics/TDAQ: Darin Acosta (Rice), Isobel Ojalvo (Princeton), Michael Begel (BNL)
- MDI+Forward Detectors: Kevin Black (Wisconsin), Karri DiPetrillo (Chicago), Nikolai Mokhov (Fermilab)
- Detector Software and Simulations: Liz Sexton-Kennedy (Fermilab), Simone Pagan Griso (LBNL)

US preparation for P5

Goal:

- US would like to participate to collaboration
- Contribution should roughly match European effort (40-50 FTE)
- European effort approaches minimal plan
  - hope to further increase it
- Equivalent US contribution would allow us to start approaching full programme
  - with some delay compared to Roadmap

Plan:

- Will install task force to prepare integration of US efforts into the collaboration
  - based on current US experts by adding several experts from collaboration
  - mandate until decision in the US
  - allows to follow developments and prepare smooth collaboration
  - will also consider other new efforts outside Europe
  - currently preparing mandate and choice of experts

MuCol Thanks

The conveners

Antoine Chance (CEA), Anton Lechner (CERN), Christian Carli (CERN), Claude Marchand (CEA), Daniel Schulte (CERN), Donatella Lucchesi (Padua, INFN), Elias Metral (CERN), Lionel Quettier (CEA), Luca Bottura (CERN), Lucio Rossi (Milano, INFN), Marco Calviani (CERN), Nadia Pastrone (Torino, INFN), Natalia Milas (ESS), Roberto Losito (CERN), Simone Gilardoni (CERN), Tord Johan Carl Ekelof (UU)

EU office: Svetlomir Stavrev, Cloe Levointourier-Vajda, Sabrina El-Yacoubi, Pablo Federico Lopez

Legal Service: Mandy Stewart, Julia Heliemann

Finance: Florence Pesce, Laura Gina Dalla Palma

Library: Alex Kohls, Sunje Dallmeier-Tiessen

All the contributors

Roberto Losito

The Europeen Commission, the UK and Switzerland

Conclusion

- MuCol is an important part of the collaboration
- Kick-started it

- Hope to further enlarge the collaboration

- New partners can still join MuCol

- Check final institute representation, not everybody replied so used default