

International  
UON Collider  
Collaboration



# Assessing the MC Technology Drivers

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# How To Systematically Assess the Muon Collider Technology Drivers

- The following slides contain an evaluation, based primarily on the MAP effort, of the technology status
- It is a proposal on how we might systematically categorize our maturity evaluation for communications both
  - Internally within the collaboration
  - Externally with the broader physics community
- Actual items and entries remain subject to feedback from the working groups carrying out the effort
  - The present version is meant to be a starting point for the broader discussion



# 4 Areas of Evaluation



- 1) Component Concept Maturity
- 2) Component Engineering Maturity
- 3) System Concept Maturity
- 4) System Engineering Maturity

# Component Concept Maturity

Category	Sub-Category	Range Min	Range Max	Value	Description
<b>Component Concept Maturity</b>	<b>Component Feasibility</b>	1	5	1	Feasibility not yet demonstrated
				2	Feasibility assessment underway
				3	Indications of feasibility but further work required
				4	Detailed feasibility being evaluated through R&D and/or design studies
				5	Feasibility established
	<b>Component R&amp;D</b>	1	5	1	Component R&D not started
				2	Component R&D underway OR similar components exist elsewhere
				3	Initial R&D complete but further R&D required OR similar components exist elsewhere
				4	Advanced component R&D underway if necessary
				5	Feasibility R&D complete or not needed (established concept)
	<b>Component Conceptual Design</b>	1	5	1	No Conceptual Design
				2	Preliminary conceptual design underway
				3	Preliminary conceptual design complete
				4	Advanced conceptual design underway
				5	Component conceptual design complete

MAP focused heavily in this area with a mandate to verify component feasibility

# Component Engineering Maturity

Category	Sub-Category	Range Min	Range Max	Value	Description
<b>Component Engineering Maturity</b>	<b>Component Engineering Concept</b>	1	5	1	No complete engineering concept for component exists
				2	Component engineering design underway OR equivalent operating device available elsewhere
				3	Component engineering design being evaluated (e.g., component prototyping underway)
				4	Engineering concept satisfies most requirements OR equivalent operating device available elsewhere
				5	Engineering concept meets all specifications or equivalent component in operation elsewhere
	<b>Component Prototyping</b>	1	5	1	Design concept not yet sufficiently mature for prototyping
				2	Sub-component development OR similar components exist elsewhere
				3	Full component prototype ready for testing or being tested OR similar components exist elsewhere
				4	Updates to component prototype being prepared for final testing
				5	Component prototype results are sufficient to finalize engineering design
	<b>Component Engineering Design</b>	1	5	1	Design concept not yet sufficiently mature for engineering design
				2	Preliminary component engineering underway OR equivalent operating device available elsewhere
				3	Preliminary engineering design exists OR equivalent operating device available elsewhere
				4	Preliminary engineering design being updated to incorporate prototyping results
				5	Component engineering design meeting all specifications complete

# System Concept Maturity

Category	Sub-Category	Range Min	Range Max	Value	Description
System Concept Maturity	System Design Concept	1	5	1	System concept not yet established
				2	Preliminary system design concept being developed
				3	Preliminary system design concept complete
				4	Full system design concept being validated
				5	System design concept complete
	System R&D	1	5	1	System R&D not started
				2	Preliminary system R&D underway OR equivalent sub-systems in operation elsewhere
				3	Preliminary system R&D complete OR equivalent sub-systems in operation elsewhere
				4	Advanced system R&D underway
				5	System R&D complete
	Sub-System Engineering Concepts	1	5	1	Sub-system engineering concepts not yet available
				2	Preliminary sub-system conceptual design underway OR equivalent sub-systems in operation elsewhere
				3	Preliminary sub-system conceptual design complete OR equivalent sub-systems in operation elsewhere
				4	Advanced sub-system conceptual design underway
				5	Sub-system conceptual design complete

MAP also focused on setting a preliminary system design concept

# System Engineering Maturity

Category	Sub-Category	Range Min	Range Max	Value	Description
System Engineering Maturity	System Interface Specification	1	5	1	System interfaces not yet defined
				2	System interfaces under development
				3	Preliminary system interfaces defined
				4	Updates being incorporated into system interfaces based on end-to-end evaluations
				5	System interface specification complete
	Sub-System Prototyping	1	5	1	Design concept not yet sufficiently mature for prototyping
				2	Sub-system development OR equivalent sub-systems in operation elsewhere
				3	Full sub-system prototype ready for testing or being tested OR equivalent sub-systems in operation elsewhere
				4	Updates to sub-system prototypes being prepared for final testing
				5	Sub-system prototype results are sufficient to finalize engineering design
	Full System Engineering Design	1	5	1	Design concept not yet sufficiently mature for engineering design
				2	Preliminary system engineering underway OR equivalent system operating elsewhere
				3	Preliminary engineering design complete
				4	Preliminary engineering design being updated to incorporate detailed system evaluations
				5	System design meeting all specifications complete

MAP also focused on setting preliminary system-to-system interface targets

# Maturity Estimates Organized by System

- Organized by the recently proposed work package categories
  - Proton Complex
  - Muon Generation Complex
  - Muon Cooling Complex
  - High Energy Acceleration
  - Collider Ring



# Proton Complex

MC Complex	System	Component	Component Concept Maturity			Component Engineering Maturity			System Concept Maturity			System Engineering Maturity		
			Component Feasibility	Component R&D	Component Conceptual Design	Component Engineering Concept	Component Prototyping	Component Engineering Design	System Design Concept	System R&D	Sub-System Engineering Concepts	System Interface Specification	Sub-System Prototyping	Full System Engineering Design
Proton Complex	<i>H<sup>+</sup> Source</i>								3	3	3	3	3	1
	<i>LINAC</i>								3	3	3	3	3	1
	<i>Accumulator</i>								3	3	3	3	3	1
		H- Stripping	3	3	3	4	3	2						
	<i>Buncher/Compressor</i>								3	3	2	3	3	1
		RF System	4	3	3	4	3	3						
	<i>Transport to Target</i>								3	3	2	3	2	1
		Multi-Beam Trombone	4	3	3	4	3	3						
	Target Delivery Quadrupole	3	2	2	3	1	1							

# Muon Generation Complex

MC Complex	System	Component	Component Concept Maturity			Component Engineering Maturity			System Concept Maturity			System Engineering Maturity		
			Component Feasibility	Component R&D	Component Conceptual Design	Component Engineering Concept	Component Prototyping	Component Engineering Design	System Design Concept	System R&D	Sub-System Engineering Concepts	System Interface Specification	Sub-System Prototyping	Full System Engineering Design
Muon Generation Complex	<i>Production Target</i>								3	1	1	3	1	1
		Target Solenoid	3	3	2	2	1	1						
		Target	3	2	2	2	1	1						
		Target Solenoid Shielding	3	2	2	2	1	1						
		Proton Dump	2	1	1	1	1	1						
	<i>Decay Channel</i>								3	2	1	3	1	1
		Solenoid Channel	4	2	2	2	1	1						
		Chicane/Proton Dump	3	2	2	2	1	1						
	<i>Capture and Buncher</i>								3	2	1	3	1	1
		RF in Magnetic Fields	4	3	2	2	1	1						
		RF Configuration	3	2	2	2	2	2						
	<i>System Dump</i>								3	2	1	2	1	1

# Muon Cooling Complex

MC Complex	System	Component	Component Concept Maturity			Component Engineering Maturity			System Concept Maturity			System Engineering Maturity				
			Component Feasibility	Component R&D	Component Conceptual Design	Component Engineering Concept	Component Prototyping	Component Engineering Design	System Design Concept	System R&D	Sub-System Engineering Concepts	System Interface Specification	Sub-System Prototyping	Full System Engineering Design		
Muon Cooling Complex	<i>Initial Cooling</i>															
		RF in Magnetic Fields	4	3	2	2	1	1	3	2	1	3	1	1	1	1
		Cooling Cell	3	3	2	2	1	1								
	<i>Charge Separation</i>															
		RF in Magnetic Fields	4	3	2	2	1	1	2	2	1	2	1	1	1	1
		Separator Magnets	3	2	2	2	1	1								
	<i>6D Cooling - Stage 1</i>															
		RF in Magnetic Fields	4	3	2	2	1	1	3	2	1	3	1	1	1	1
		Cooling Cell	3	2	2	2	1	1								
	<i>Bunch Merge</i>															
									3	2	1	3	1	1	1	1
	<i>6D Cooling - Stage 2</i>															
		RF in Magnetic Fields	4	3	2	2	1	1	3	2	1	3	1	1	1	1
		Cooling Cell	3	2	2	2	1	1								
	<i>Final Cooling</i>															
		High Field Solenoids	4	3	2	2	1	1	3	2	1	3	1	1	1	1
		Cooling Cell	3	2	2	2	1	1								
	<i>Matching and Transfer</i>															
									2	2	1	2	1	1	1	1



# High-Energy Acceleration



MC Complex	System	Component	Component Concept Maturity			Component Engineering Maturity			System Concept Maturity			System Engineering Maturity			
			Component Feasibility	Component R&D	Component Conceptual Design	Component Engineering Concept	Component Prototyping	Component Engineering Design	System Design Concept	System R&D	Sub-System Engineering Concepts	System Interface Specification	Sub-System Prototyping	Full System Engineering Design	
High-Energy Acceleration	LINAC (Ebeam = 1.25 GeV)								3	2	1	3	1	1	
		SRF Cryomodules	4	3	2	3	1	1							
		Beam Loading	4	2	2	3	1	1							
		Radiation Load on SRF	3	2	2	3	1	1							
	RLA 1 (Ebeam = 5 GeV)								3	2	1	3	1	1	
		SRF Cryomodules	4	3	2	3	1	1							
		Beam Loading	4	2	2	3	1	1							
		Radiation Load on SRF	3	2	2	3	1	1							
	RLA 2 (Ebeam = 63 GeV)								3	2	1	3	1	1	
		SRF Cryomodules	4	3	2	3	1	1							
		Beam Loading	4	2	2	3	1	1							
		Radiation Load on SRF	3	2	2	3	1	1							
RCS 1 (FFA less mature)		Fast Ramping Magnets	2	2	2	2	1	1	2	2	1	3	1	1	
		Fast Ramping Magnet PS	2	1	1	2	1	1							
		SRF Cryomodules	4	3	2	3	1	1							
		Beam Loading	4	2	2	3	1	1							
		Radiation Load on SRF	3	2	2	3	1	1							
Hybrid RCS 1 (FFA less mature)		Fast Ramping Magnets	2	2	2	2	1	1	2	2	1	3	1	1	
		Fast Ramping Magnet PS	2	1	1	2	1	1							
		SRF Cryomodules	4	3	2	3	1	1							
		Beam Loading	4	2	2	3	1	1							
		Radiation Load on SRF	3	2	2	3	1	1							
Hybrid RCS 2 (Ebeam=1.5 TeV) (FFA less mature)		Fast Ramping Magnets	2	2	2	2	1	1	2	2	1	3	1	1	
		Fast Ramping Magnet PS	2	1	1	2	1	1							
		SRF Cryomodules	4	3	2	3	1	1							
		Beam Loading	4	2	2	3	1	1							
		Radiation Load on SRF	3	2	2	3	1	1							
Hybrid RCS HE (Ebeam = 5 TeV) (FFA less mature)		Fast Ramping Magnets	3	2	2	2	1	1	2	2	1	3	1	1	
		Fast Ramping Magnet PS	2	1	1	2	1	1							
		SRF Cryomodules	4	3	2	3	1	1							
		Beam Loading	4	2	2	3	1	1							
		Radiation Load on SRF	3	2	2	3	1	1							

# Collider Ring

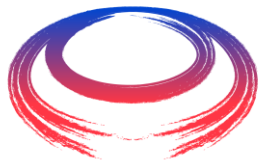
MC Complex	System	Component	Component Concept Maturity			Component Engineering Maturity			System Concept Maturity			System Engineering Maturity		
			Component Feasibility	Component R&D	Component Conceptual Design	Component Engineering Concept	Component Prototyping	Component Engineering Design	System Design Concept	System R&D	Sub-System Engineering Concepts	System Interface Specification	Sub-System Prototyping	Full System Engineering Design
Collider Ring	125 GeV	Magnet Heat Load	3	2	2	3	1	1	3	2	1	3	1	1
		Ring Magnets	3	3	3	3	3	2						
		Interaction Region Lattice	3	2	2	3	1	1						
		Machine Detector Interface	3	2	2	3	1	1						
		Detector Design	2	2	2	3	1	1						
		Neutrino Radiation	4	2	2	3	1	1						
		Energy Calibration	3	3	3	3	1	1						
	3 TeV	Magnet Heat Load	3	2	2	3	1	1	3	2	1	3	1	1
		Ring Magnets	3	3	3	3	3	2						
		Interaction Region Lattice	3	2	2	3	1	1						
		Machine Detector Interface	3	2	2	3	1	1						
		Detector Design	2	2	2	3	1	1						
		Neutrino Radiation	3	2	2	3	1	1						
		Energy Calibration	3	3	3	3	1	1						
	10 TeV	Magnet Heat Load	3	2	2	3	1	1	2	2	1	2	1	1
		Ring Magnets	2	2	2	3	3	2						
		Interaction Region Lattice	3	2	2	3	1	1						
		Machine Detector Interface	3	2	2	3	1	1						
		Detector Design	2	2	2	3	1	1						
		Neutrino Radiation	2	1	1	3	1	1						
		Energy Calibration	3	3	3	3	1	1						

# Technology Drivers

- During the next ~5 years
  - Need to significantly address the Component Concept Maturity areas
  - A low readiness level indicates a technology driver
    - This must be combined with a weighting for the level of difficulty involved
    - The list of specific components determines whether work is required
    - However, there must be a balanced approach spanning all machine systems
  - Additional criteria are probably needed
    - Estimated cost impact of specific systems
    - Estimated performance impact of specific systems
- Having a clearly communicated set of metrics will help the HEP community make good decisions

# Conclusion

- These slides contain a preliminary assessment of the technology maturity, hence starting the identification of the technology drivers that must be addressed over the next 5 years
- They structure is open for discussion
  - Modification of categories
  - More detailed inputs from the technical working groups



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*Thank you  
for your attention*