Muon Accelerator Program: Overview & Directions

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Fermilab

Outline

- Introduction
- Organizational Thrusts
- R&D Effort
- Snowmass Process
- Concluding Remarks

INTRODUCTION

Welcome

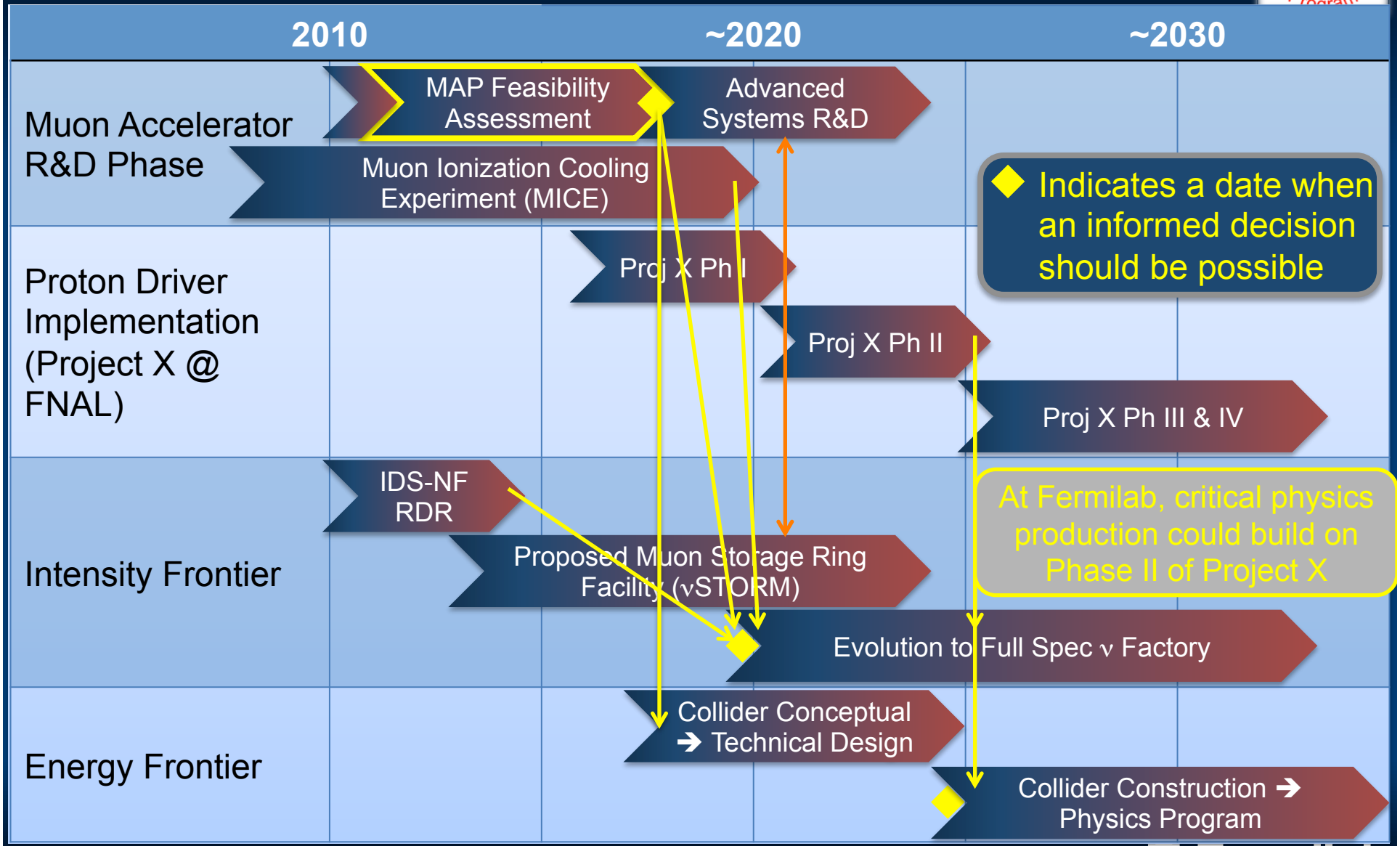
- Today is a joint MAP and MICE day
  - Welcome to all!
  - I hope that today provides an opportunity for both groups to mingle and enhance connections
- I would like to say thanks in advance to Alan Bross and Pavel Snopok who handled the local organization along with:
  - The Fermilab Conference Office
    - Cynthia Sazama
    - Suzanne Weber

MAP's Near Term Picture

Significant program reorganization over the last year:

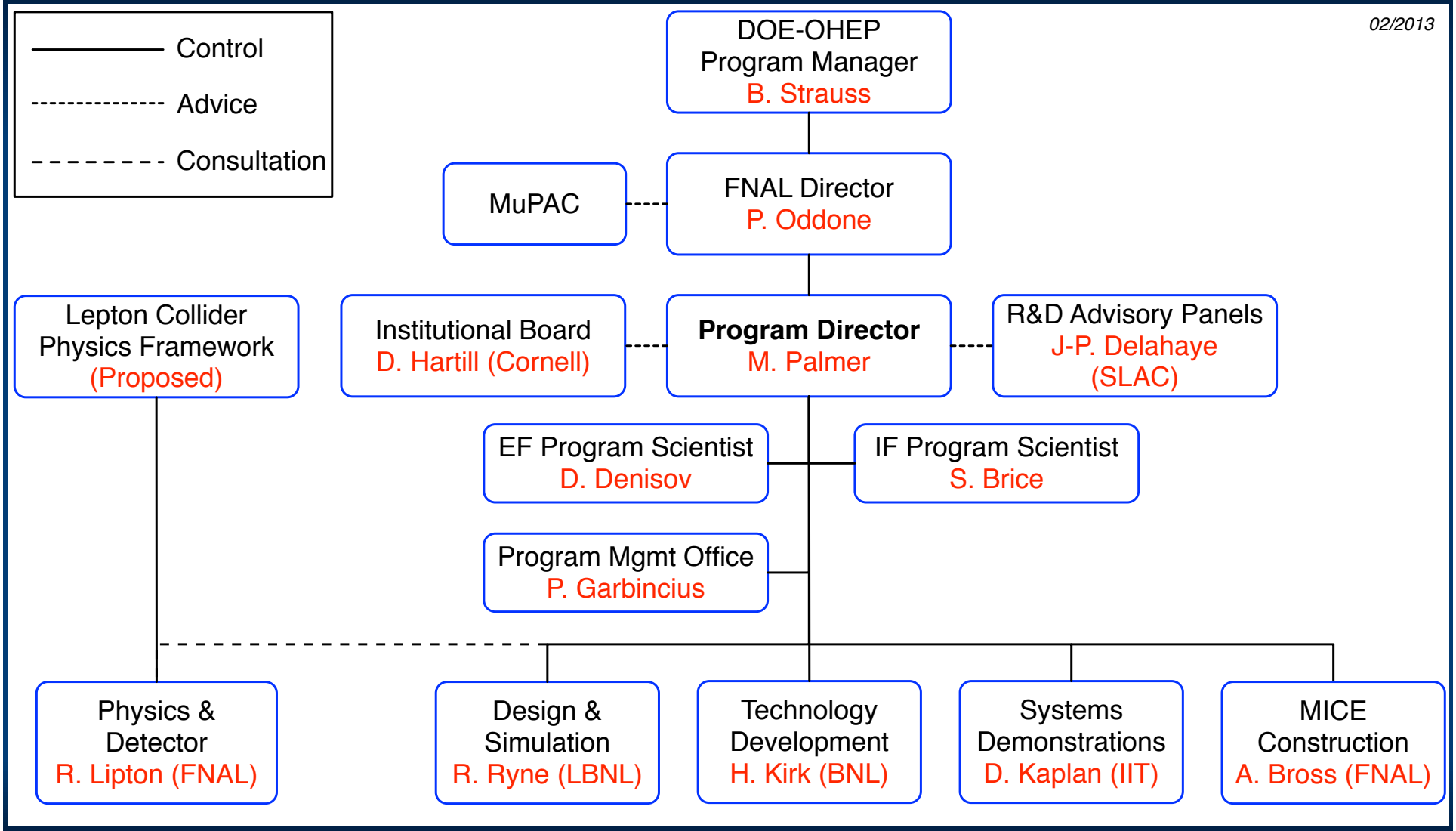
- ***Project-like reorganization of the program***
  - Updated Program Management Plan
  - Implementation of project planning/tracking tools
  - Development of a more detailed Program Execution Plan
  - Detailed assessment of likely costs and schedules
- ***Major Requirements of the Feasibility Assessment***
  - Initial Baseline Selection Process
  - Technology Demonstrations
  - MICE Construction Sub-Project ⇨ Successful Experimental Effort
  - Long-term planning
    - MASS
    - 6DICE
- Some things have gone smoothly. And some less so…

The Muon Accelerator Program Timeline

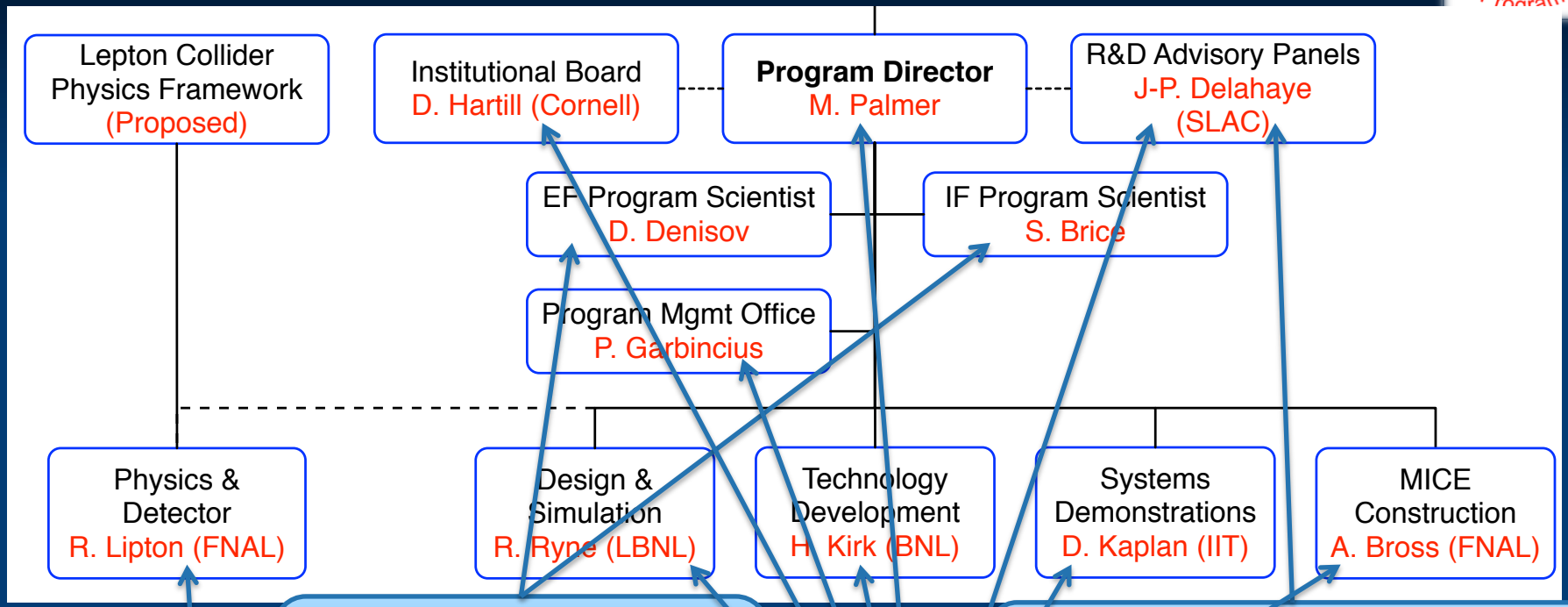


ORGANIZATIONAL THRUSTS

MAP Top Level Organization



Updated Management Plan



Program Scientists:
- Strategic Connections with Community
- Program Feedback

Advisory Panels:
- Program Guidance (eg, MASS)
- Technology and Baseline Reviews

Physics and Detector:
- Operational Connection to Physics & Detector Group
- Close Coordination

Executive Committee:
- Overall Program Coordination
- Program Strategy
- Central Planning and Tracking

New Elements in the Program

Fermilab has appointed Program Scientists to support MAP

- **Steve Brice** will help coordinate the strategic connections of MAP to the Intensity Frontier physics effort
- **Dmitri Denisov** will help coordinate the strategic connections of MAP to the Energy Frontier physics effort
- They have an important role to play as we move through the Snowmass and P5 process…

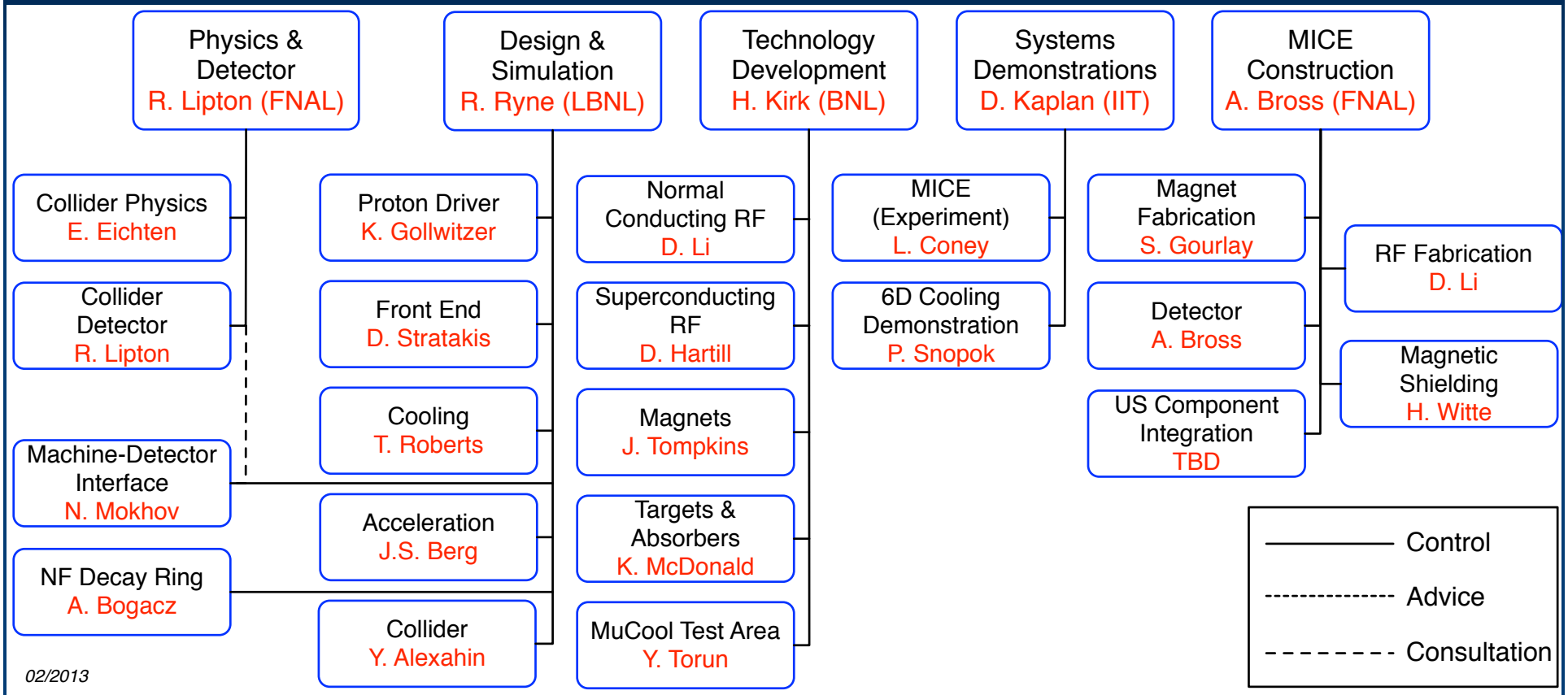
MAP R&D Advisory Panels

- **Jean-Pierre Delahaye**
- First instance is MASS, which is working towards a staging plan and is coordinating our Snowmass White Paper

MAP Program Management Office

- **Peter Garbincius**
- Program planning, budget and interfaces between institutions

MAP L1 & L2 Organization



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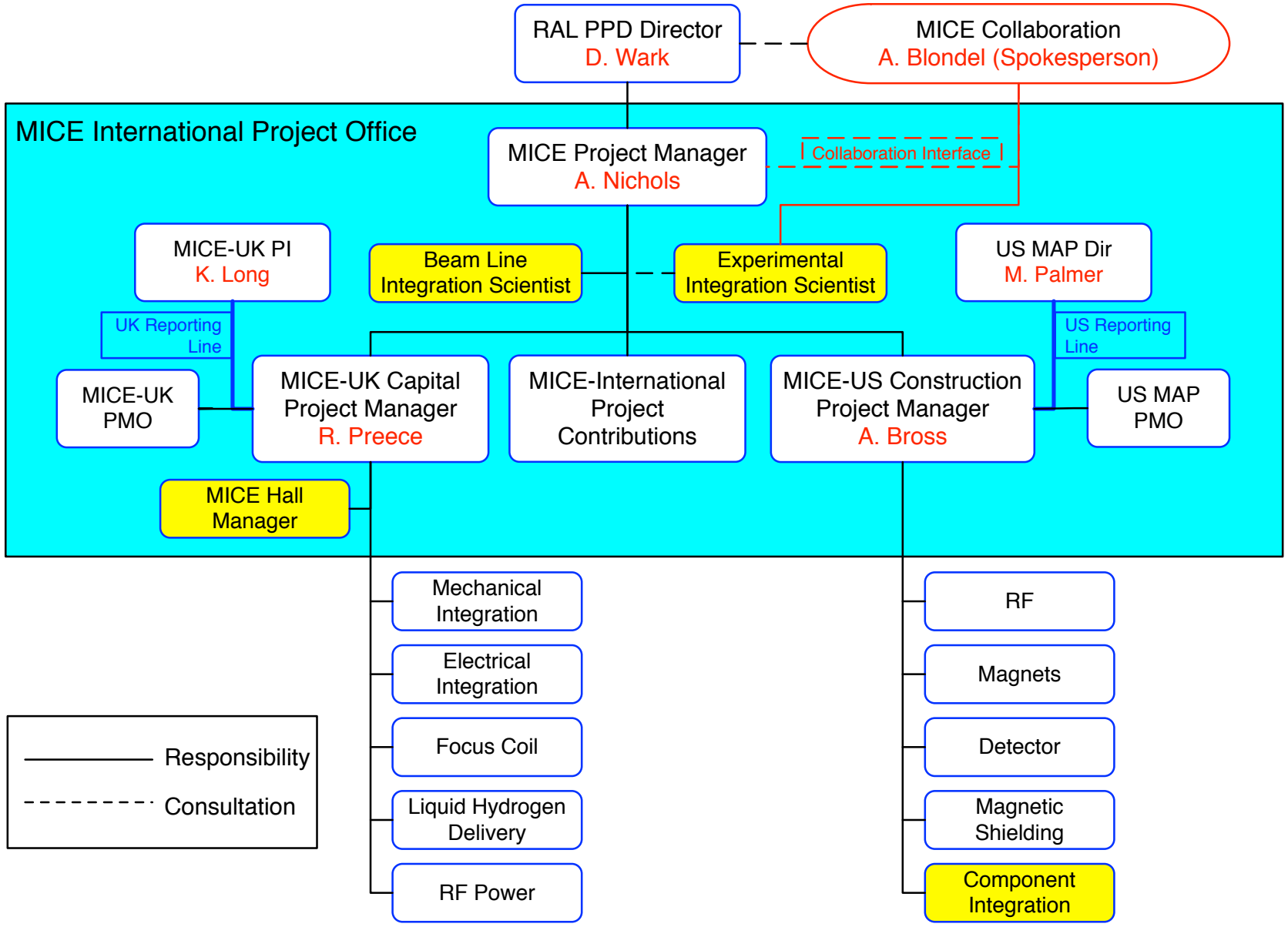
MICE International Project Team



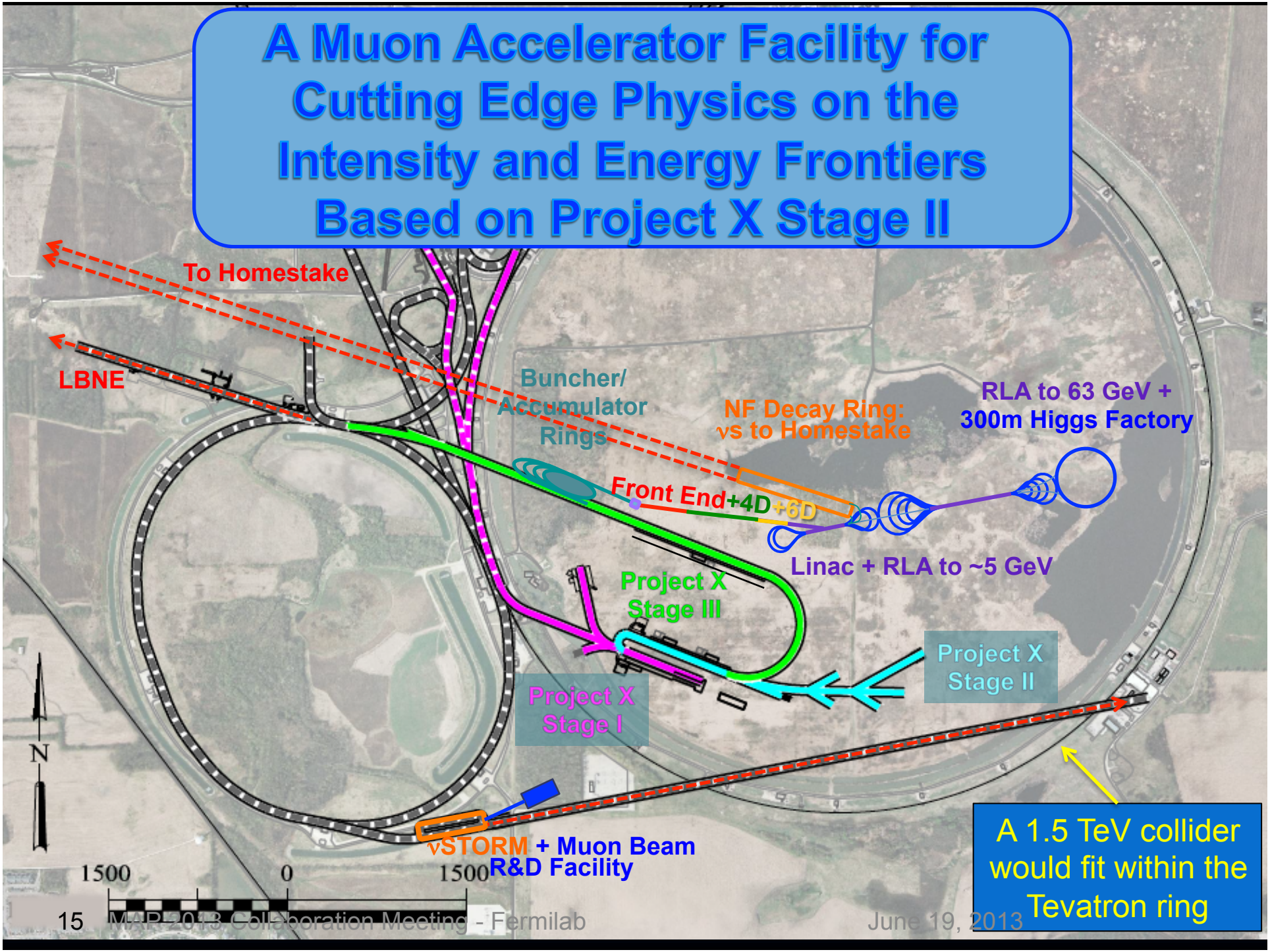
R&D EFFORT

Some Highlights of the R&D Effort

Design & Simulation	• High Performance Computing Initiative • Setting up the Initial Baseline Selection Process • New NF & MC Design Options and MC Backgrounds
Technology Development	• Expanded support for the MTA • Modular 805 MHz Cavity Effort • HTS Conductor & Magnet Development
Systems Demonstrations	• Contributions to the MICE Online, DAQ, and Analysis Efforts • 6DICE Options Study
MICE Construction	• Magnet Progress • Preparing for RF Cavity Tests in the MTA • Partial Yoke Magnetic Shielding for the Cooling Channel

MASS	• A Fermilab Staging Plan
	  • Possibility of Launching a Facility on Project X Stage II (2020's)
	  • Truly a 2 Frontier Plan

A Muon Accelerator Facility for Cutting Edge Physics on the Intensity and Energy Frontiers Based on Project X Stage II



How Could the Staged NF to Homestake Perform?

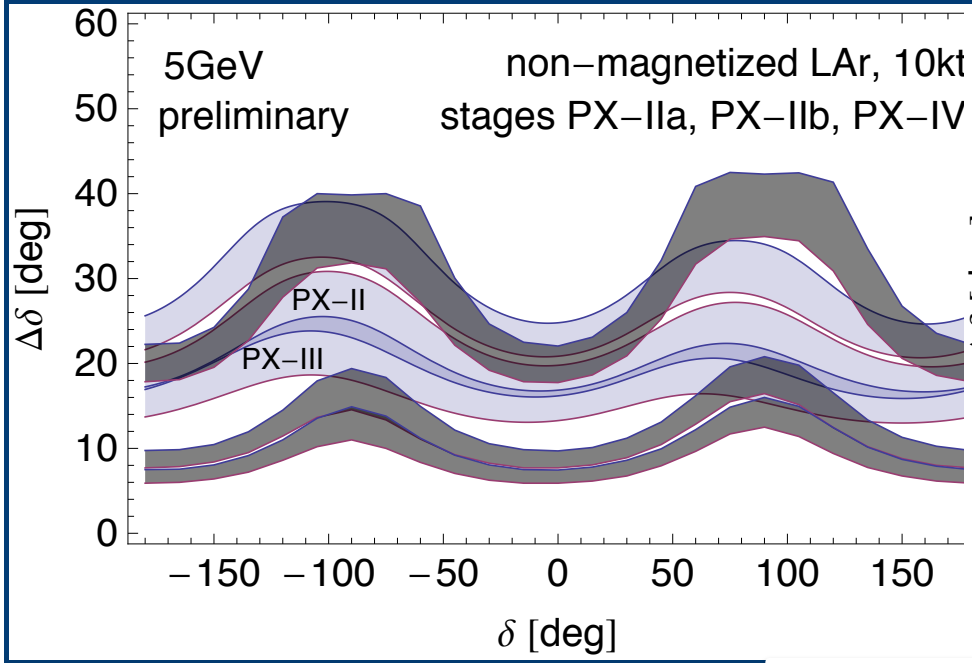
What if we send beam to LBNE?

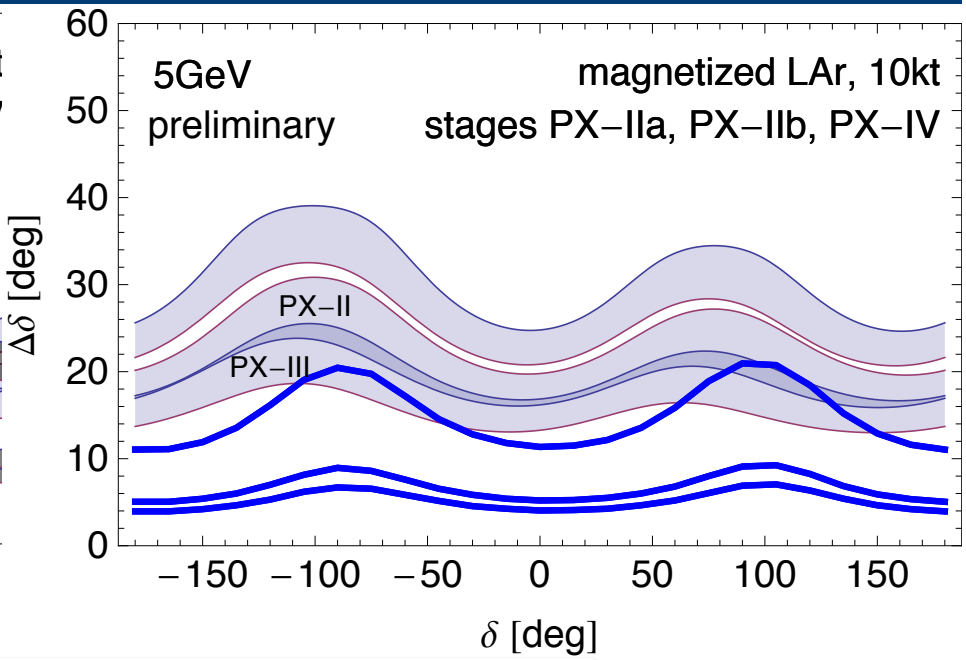
1 MW, no muon cooling

⇨ 3 MW, w/cooling

⇨ 4 MW, w/cooling

What if we were able to have a magnetized LAr detector?





Gray bands represent range of possible detector performance per arXiv:0805.2019

Plots courtesy of P. Huber

Plots assume 100 kt-years

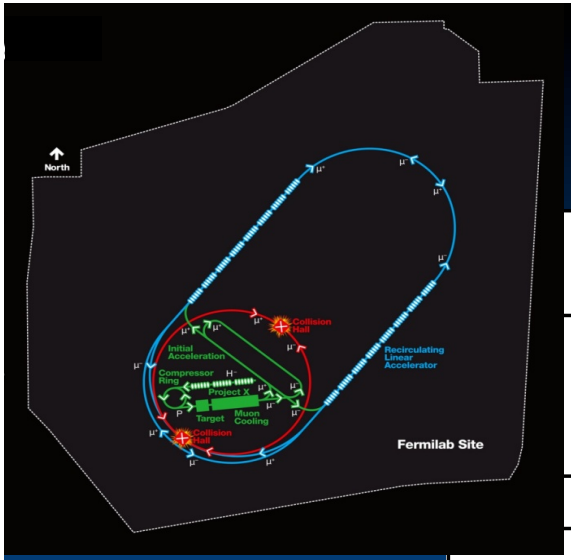
Neutrino Factory Staging (MASS)

Preliminary Staging Plan Based on Project X Phase 2

System	Parameters		Unit	NuSTORM	L3NF	NF	IDS-NF
Performance	stored μ+ or μ-/year			8×10^{17}	2×10^{20}	1.2×10^{21}	1×10^{21}
	ν_e or ν_μ* to detectors/yr			3×10^{17}	8×10^{19}	5×10^{20}	5×10^{20}
Detector	Far Detector	Type		Super-Bind*	Mag LAr	Mag LAr	Super-Bind
	Distance from ring		km	1.5	1300	1300	2000
	Mass		kT	1.3	10	30?	100
	magnetic field		T	2	0.5	0.5	1-->2 ?
	Near Detector	Type		Liquid Ar	Liquid Ar	Liquid Ar	Liquid Ar
	Distance from ring		m	50	100	100	100
	Mass		kT	0.1	1	2.7	2.7
	magnetic field		T	No	No	No	No
Neutrino Ring	Ring Momentum	P_μ	GeV/c	3.8	5	5	10
	Circumference	C	m	350	600	600	1190
	Straight section Length		m	150	235	235	470
	Arc Length		m	25	65	65	125
Acceleration	Initial Momentum		GeV/c	3.8	0.22	0.22	0.22
	single pass Linac		GeV	None	0.9?	0.9?	0.9
	4.5-pass RLA		GeV	None	0.92?	0.92?	4
	NS-FFAG Ring		GeV	None	None	None	10
	SRF frequency linac/RLA		MHz	None	325/650	325/650	201
	Number of cavities			None	50 + 26?	50 + 26?	50 + 26 + 25
	Total Arc Length		m	50	550?	550?	550 +200
Cooling				No	No	4D	4D
Proton Source	Proton Beam Power		MW	0.2	1	3	4
	Proton Beam Energy		GeV	60	3	3	10
	protons/year		1×10^{21}	0.2	41	125	25
	Repetition Frequency		Hz	1.25	70	70	50

* supports multiple detector technologies

MAP Designs for a Muon-Based Higgs Factory and Energy Frontier Collider



Muon Collider Baseline Parameters

		Higgs Factory		Multi-TeV Baselines	
Parameter	***Units***	Initial Cooling	Upgraded Cooling / Combiner		
CoM Energy	TeV	0.126	0.126	1.5	3.0
Avg. Luminosity	$10^{34}cm^{-2}s^{-1}$	0.0017	0.008	1.25	4.4
Beam Energy Spread	%	0.003	0.004	0.1	0.1
Circumference	km	0.3	0.3	2.5	4.5
No. of IPs		1	1	2	2
Repetition Rate	Hz	30	15	15	12
β^*	cm	3.3	1.7	1 (0.5-2)	0.5 (0.3-3)
No. muons/bunch	10^{12}	2	4	2	2
No. bunches/beam		1	1	1	1
Norm. Trans. Emittance, ε_{TN}	π mm-rad	0.4	0.2	0.025	0.025
Norm. Long. Emittance, ε_{LN}	π mm-rad	1	1.5	70	70
Bunch Length, σ_s	cm	5.6	6.3	1	0.5
Beam Size @ IP	μm	150	75	6	3
Beam-beam Parameter / IP		0.005	0.02	0.09	0.09
Proton Driver Power	MW	4[#]	4	4	4

[#]Could begin operation with Project X Phase 2 beam

Exquisite Energy Resolution Allows Direct Measurement of Higgs Width

Site Radiation mitigation with depth and lattice design: ≤ 10 TeV

SNOWMASS

White Papers

- Two Primary White Papers are Being Prepared
  - MAP Accelerator Capabilities
    - Produced by MASS
    - J-P. Delahaye lead editor
  - Higgs Factory
    - Report based on UCLA Muon Collider Higgs Factory Workshop
    - D. Cline and G. Hanson leading the effort
- Inputs for
  - Intensity Frontier Reports
  - Project X Reports
  - Energy Frontier Reports
  - Capabilities Frontier Reports

The Aims of the Muon Accelerator Program

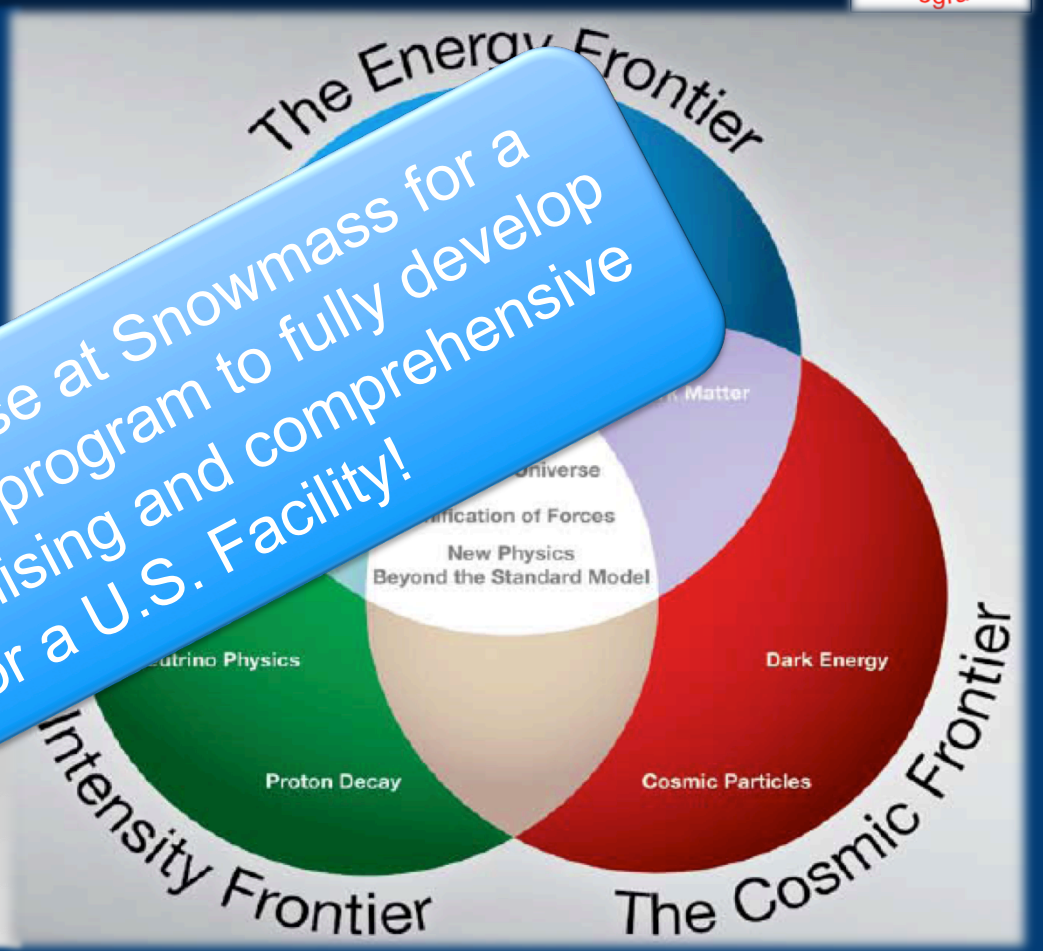
Muon accelerator R&D is focused on developing a facility that can address critical questions spanning two frontiers…

The Intensity Frontier:

with a ***Neutrino Factory*** producing well-characterized ν beams for pre… high sensitivity studies

with … reach…

*a **Higg**… border bet… frontiers*



We must make the case at Snowmass for a continued robust R&D program to fully develop one of the most promising and comprehensive options for a U.S. Facility!

The unique potential of a facility based on muon accelerators is physics reach that SPANS 2 FRONTIERS

CONCLUSION

Concluding Remarks

- The last year has seen many developments
  - Significant progress on the technology and design efforts
  - Program re-organization
  - Clear guidance on our budget profile
  - Clarification of the program goals
- However, there is a great deal of work remaining…
  - The Initial Baseline Selection
  - Integrating the Staging Plan with our D&S Effort
  - Increasing our rate of progress on technology demonstrations
  - Clearing major R&D risks from the MICE Construction Effort
- The potential of a Muon Accelerator Facility is tremendous
  - It is our responsibility to ensure that a clear assessment of the required technologies is completed in timely fashion
  - I'm looking forward to completing that process with everyone here