

Precision Science Strategic Planning Workshop

March 23, 2018

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Charge from Scientific Advisory Committee

Brief working group charge

Considering the particular field of your working group, facilitate discussion and seek input from working group participants in answering the following questions:

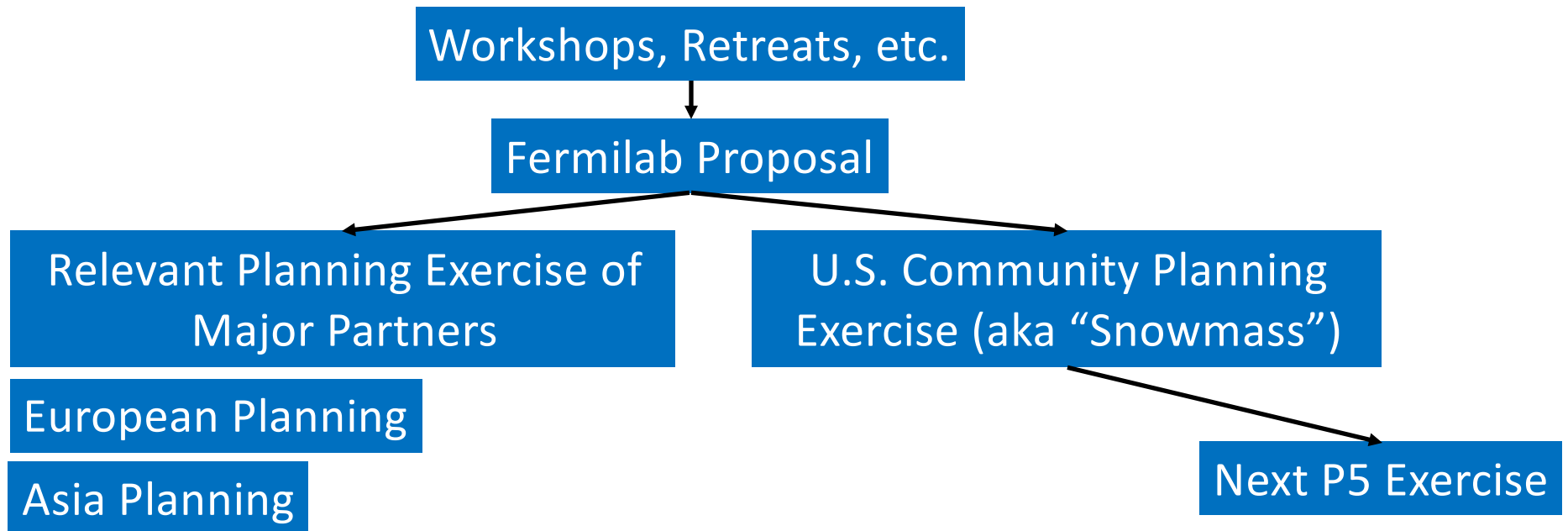
- What are the interests of the Fermilab scientists for the decade or so following 2026?
- How do we give our input to both the US community planning and the European Strategy Group?
- What is the post-retreat plan for working with US, European, and other partners to give our input?

Considerations in answering these questions:

- Build on the written report from the preceding retreat
- Consider both activities at Fermilab, and activities elsewhere in which Fermilab should be involved.
- Please be optimistic, but realistic, in your assessment of the likely scale of available funding.
- Please outline, in broad terms, any developments in terms of facility construction/upgrade, R&D, new physics knowledge decision points etc. that your suggested activity will require.
- Consider everything necessary to perform the experiment or other activity proposed. For example, if you suggest an experiment, you should also consider the accelerator, computing, and so on required to perform the experiment.
- Consider how we should approach coordinating with your community within the US, and the European community to provide input into the EPPSU process (CERN/European strategic planning update, which expects scientific input later this calendar year.)
 - This will need the involvement of the wider US community
 - Exactly how this works may be different for different working groups

- In preparation for All Scientist Retreat, 26 April 2018, the SAC has organized a set of WG leaders to help develop a Fermilab plan
- Expect April Workshop will be followed by additional discussions

Big Picture



- Current lab program finishes data-taking by 2026, after which only DUNE data taking
- Long term : Arrive at P5 with a suite of experiments with Fermilab as host or major partner
- Near term : Participate as warranted in European planning exercise

April 2017 Workshops - Reprise

Precision Science Working Group met twice

April 4th and 20th

Agenda: <https://indico.fnal.gov/categoryDisplay.py?categId=664>

Tuesday, April 4, 2017	Thursday, April 20, 2017
12:00 - 12:15 Introduction 15' Speakers: Brendan Kiburg (Fermilab), Dr. Juliana Whitmore (Fermilab)	12:30 - 12:40 Evolution of Proton Performance at FNAL 10' Speaker: Stephen Holmes (Fermilab) Material: Slides
12:15 - 12:25 g-2 (μ -run) 10' Speaker: Dr. Chris Polly (Fermilab) Material: Slides	12:40 - 12:50 Neutrino Flux Originating from Fermilab Muon Campus 10' Speaker: Dr. Diktys Stratakis (Brookhaven National Laboratory) Material: Slides
12:25 - 12:35 REDTOP 10' Speakers: Dr. Corrado Gatto (INFN), Corrado Gatto (INFN) Material: Slides	12:50 - 13:00 Accelerator Based Dark Matter Searches 10' Speakers: Andrew Whitbeck (JHU), Nhan Tran (FNAL), Dr. Gordan Krnjajic (Fermilab) Material: Slides
12:35 - 12:45 Mu2e-II 10' Speaker: Dr. Douglas Glenzinski (Fermilab) Material: Slides	13:00 - 13:10 Kaons 10' Speaker: Jonathan Lewis (Fermilab) Material: Slides
12:45 - 12:55 Proton EDM 10' Speaker: Brendan Casey (FNAL) Material: Slides	13:10 - 13:20 Precision Science - Theory 10' Speaker: Prof. Richard Hill (University of Chicago) Material: Slides
12:55 - 13:05 Transfigured Electron Double Slit Experiment (TEDSE) in IOTA 10' Speakers: Roger Dixon (Fermilab), Dr. Richard Tesarek (Fermilab) Material: Slides	13:20 - 14:10 Defining Accelerator/Detector R&D/Computing Needs 50' Material: Slides
13:05 - 13:15 A Dark Matter Search using Electron Beams 10' Speakers: Dr. Gordan Krnjajic (Fermilab), Nhan Tran (FNAL), Andrew Whitbeck (JHU) Material: Slides	

- Don't need to revisit all of this. Pursue most promising.
 - Criteria: a) Important physics, b) Leverages Fermilab strengths, c) Strong User community, d) Feasible R&D/Cost/Schedule

Our Proposed Strategy

- **Prelude**
 - μ - running for g-2 is a Program Planning decision
 - TEDSE @ IOTA is small enough to be handled internally
- **Our strategy**
 - Identify next-generation opportunities for Muon Campus experiments
 - Leverages large investment in constructing Muon Campus beam lines, detector halls, and associated infrastructure
 - Offers opportunity to continue to engage this user community
 - Consider whether other important opportunities are available
 - Participate in European planning exercise as warranted
 - Work with stakeholders to ensure we're ready for next P5 exercise

Evolution of Mu2e : Mu2e-II

- An upgrade to Mu2e that would be designed to achieve another x10 improvement in sensitivity
 - Would allow precision measurements of $R_{\mu e}$ vs stopping nuclei, or
 - Push search for BSM physics to explore new parameter space
- Work done to date
 - Feasibility Study (arXiv:1307.1168)
 - Expression of Interest (arXiv.1802.02599)
 - Workshop at ANL this past December (see P. Murat's talk later today)

Evolution of Muon g-2 : TBD

- Possibilities
 - Utilize storage ring to make dedicated muon EDM determination with at least x10 improvement in sensitivity
 - Use the MC1 detector hall and beam line to host a separate experiment
- Needs some additional thought. What resonates with the Muon g-2 collaboration?

Other Possibilities

- **Dark sector searches using μ beams**
 - Clearly motivated if g-2 anomaly persists
 - Nhan, Gordan, and Andrew have continued to explore this (see their talk later in this workshop)
- **Other CLFV decays using μ^+ beams**
 - We will engage this community as part of the European planning exercise (see M. Lancaster's talk later in this workshop)
- **Let's think a bit more...**
 - What beam will be available in >2026 era?
 - Can we learn anything from recent CERN "Beyond Colliders" workshop? (see C. Polly's talk later in this workshop)

European Planning Exercise

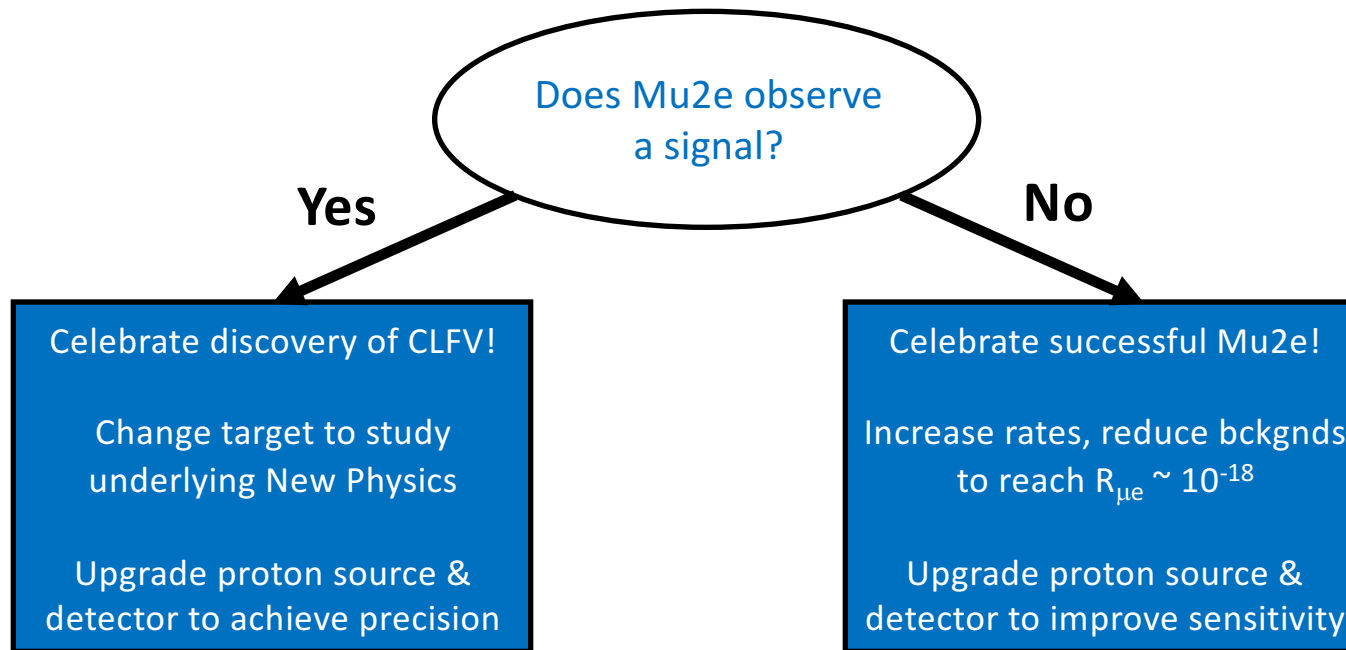
- The CERN Council has set itself the objective of updating the European Strategy for Particle Physics by May 2020.
- As input to this planning exercise they have solicited “White Papers”
 - Due 18 December 2018
 - A link to the guidelines is provided [here](#).
 - Needs to be driven by PIs from European institutions
- Any experiment that hopes to have significant European participating should consider how best to participate in this process

Agenda

- Introduction & Charge - Doug Glenzinski
- FNAL Fluxes & CERN Physics Beyond Colliders - Chris Polly
- EU Coordination - Mark Lancaster
- Update on Muon Fixed-Target Possibilities - Nhan Tran, Gordan Krnjaic, Andrew Whitbeck
- Summary of Mu2e-II Workshop at ANL - Pasha Murat
- AOB, plans moving forward - All

Backup

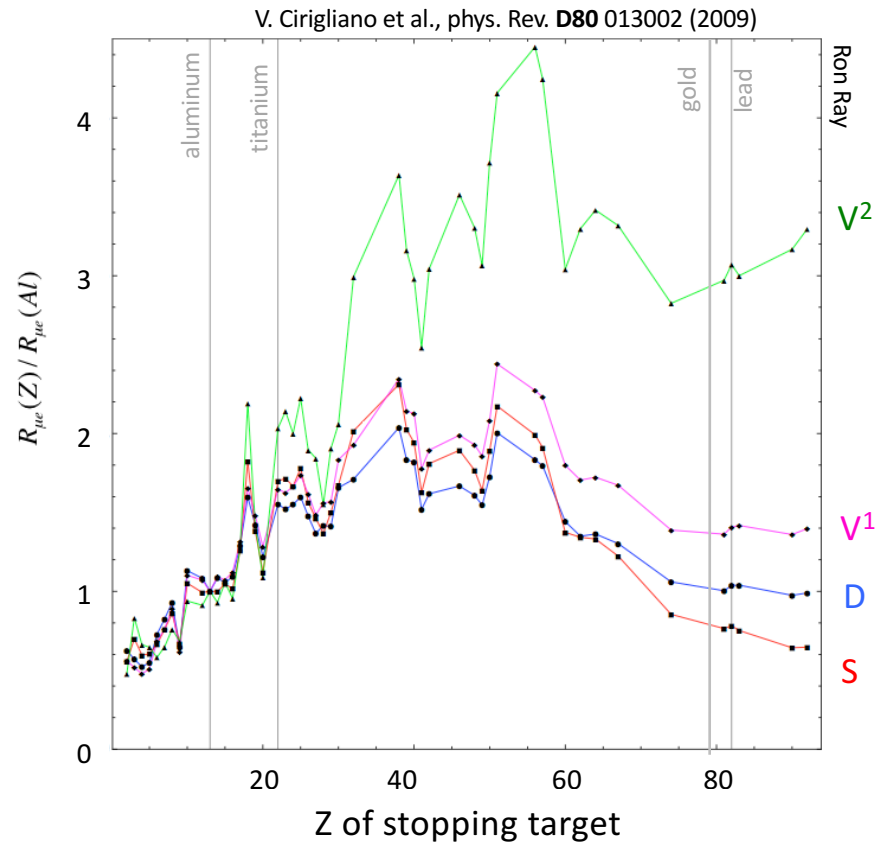
Motivation



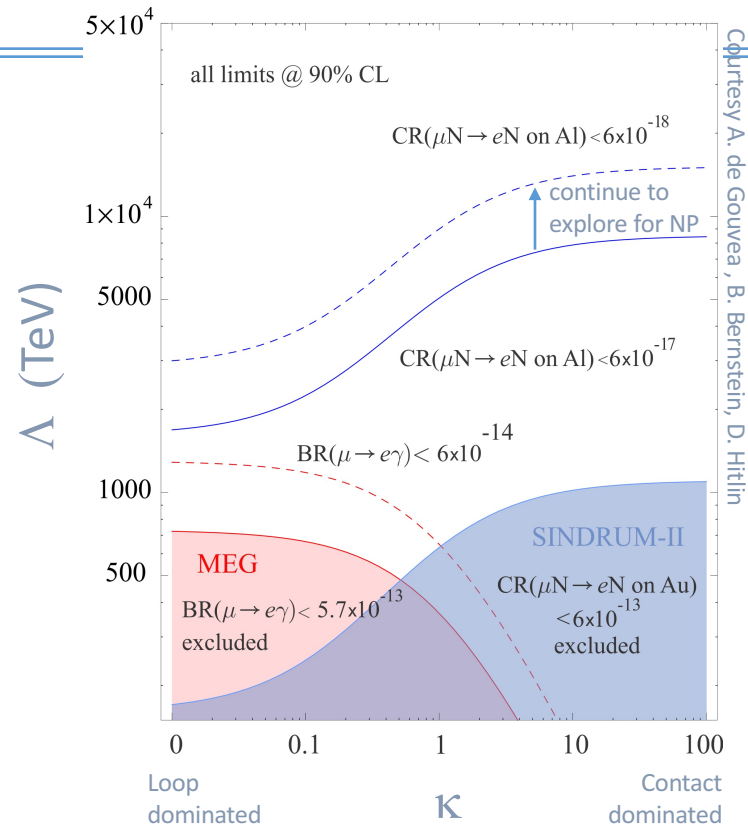
- At conclusion of Mu2e, strong motivation to upgrade proton source and detector to further pursue New Physics

Upgrade Motivation with Mu2e signal

- A x10 improvement in sensitivity allows measuring $R_{\mu e}$ to $\sim 10\%$
 - Can help identify underlying New Physics operators



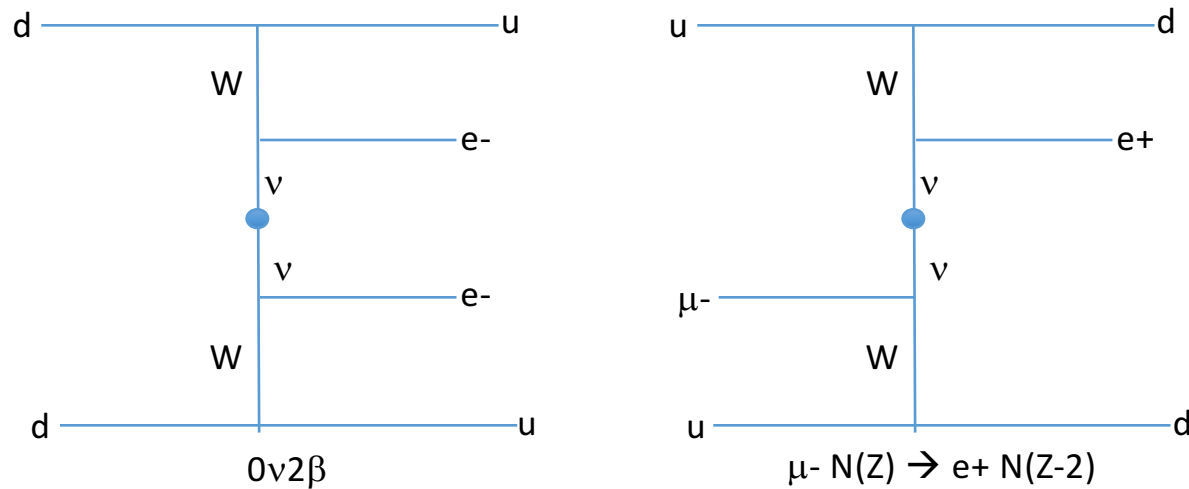
Upgrade Motivation no Mu2e signal



- A x10 improvement in sensitivity allows probing $R_{\mu e}$ to $\sim 10^{-18}$
 - will further probe New Physics parameter space

Upgrade Motivation – $\mu^- \rightarrow e^+$

(We've just begun thinking about this...)



- With increased beam intensity can also pursue a program that utilizes targets optimized for LNV $\mu^- N(Z) \rightarrow e^+ N(Z-2)$ searches (complementary to $0\nu 2\beta$)