Mu2e CD-2 Replies to Questions

R. Ray/D. Glenzinski

7/9/2014

Fraction of Collab. involved in Project?

- There are 145 active collaborators
  - 42 of them have official roles within the project
    (e.g. L2/L3/L4 manager, role in project office)
  - An additional 49 of them provide effort to the project
    - Test beams, R&D efforts, simulations, internal reviews, etc.

Stability of Requirements

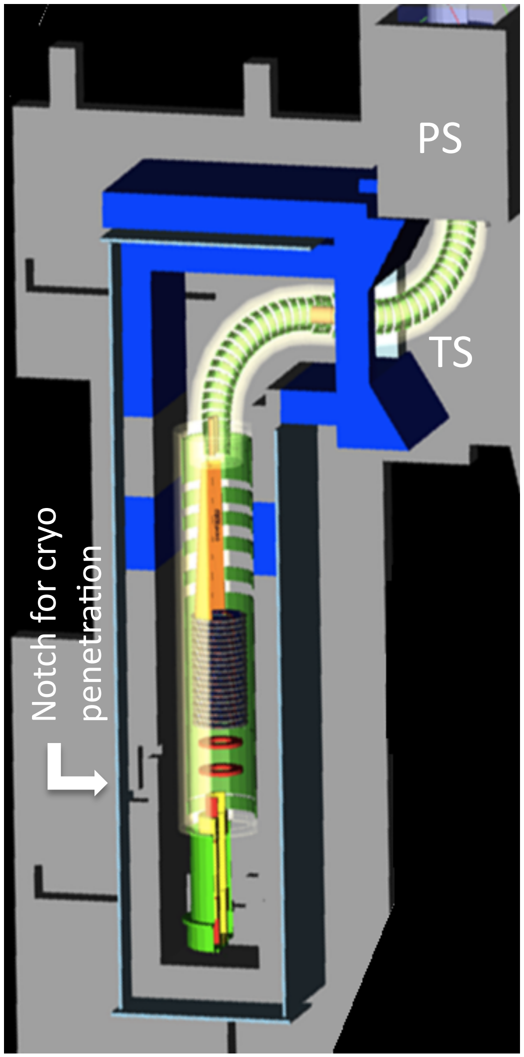
- We have 30 requirements documents.
- All of them have been updated in the last 6 months.
- Most all the updates addressed editorial issues to improve clarity and internal consistency
  - **the fundamental requirements for most systems have been unchanged since CD-1**
- Since CD-1 there have been two things that have given rise to significant changes to requirements
  - Realization that W oxidizes rapidly if hot unless vacuum is good (vacuum spec in PS region changed $10^{-1} \rightarrow 10^{-5}$ torr)
  - Realization that neutron flux at CRV can be a significant source of deadtime due to false vetos (CRV, shielding)

Stability of Requirements

- We've known about these changes for >1y and have been developing a design to meet the new requirements for quite some time.

- NB. We recognized the possibility that the neutron rates at the CRV may require additional resources back at CD-1
  - Established the Neutron Working Group in July 2012 (1 month after CD-1 review)
  - Spent ~1 yr developing a shielding plan that
    - Effectively mitigates neutron rates, is cost effective, can be installed, allows adequate room for CRV maintenance
  - We spent ~$5M to mitigate this risk, all of which was identified and accurately estimated in the CD-1 risk register.

Stability of Requirements



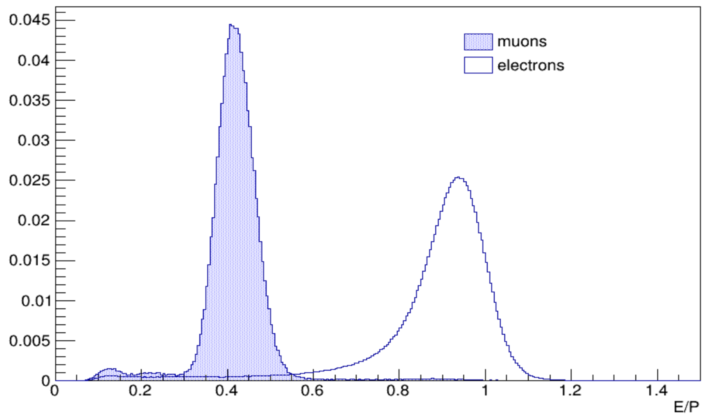
- The shielding plan that's in the RLS
  - Is the result of a ~year long simulation effort (v14)
  - Meets our requirements and gives a 2-8% veto deadtime depending on model and CRV hit threshold
- Simulation efforts moving forward are aimed at optimization, primarily to reduce cost
  - We're confident building is appropriately sized

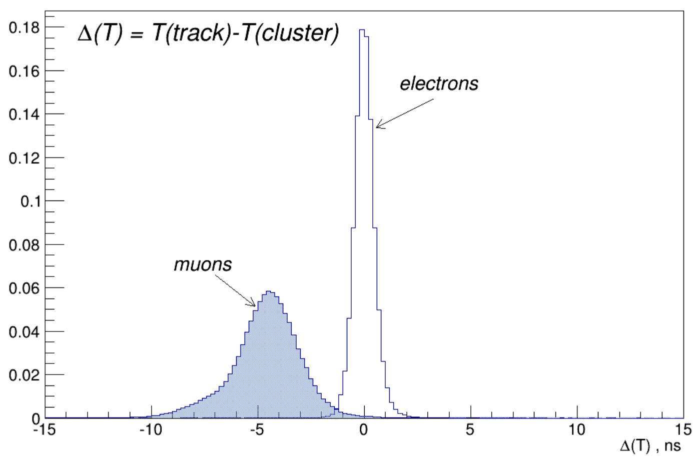
Role of the calorimeter

- The calorimeter is *essential* to reject backgrounds from muons that are reconstructed as 105 MeV/c electrons
  - Tracker-only PID
    - muon rejection: x6
    - Signal electron efficiency: 93%
  - Calorimeter PID
    - Muon rejection: x200
    - Signal electron efficiency: 96%
- The calorimeter is also important in providing
  - A fast trigger that's independent of tracker information (e.g. for collecting calibration data sets)
  - t_0 information that makes for a more robust track reconstruction algorithm as a function of occupancy

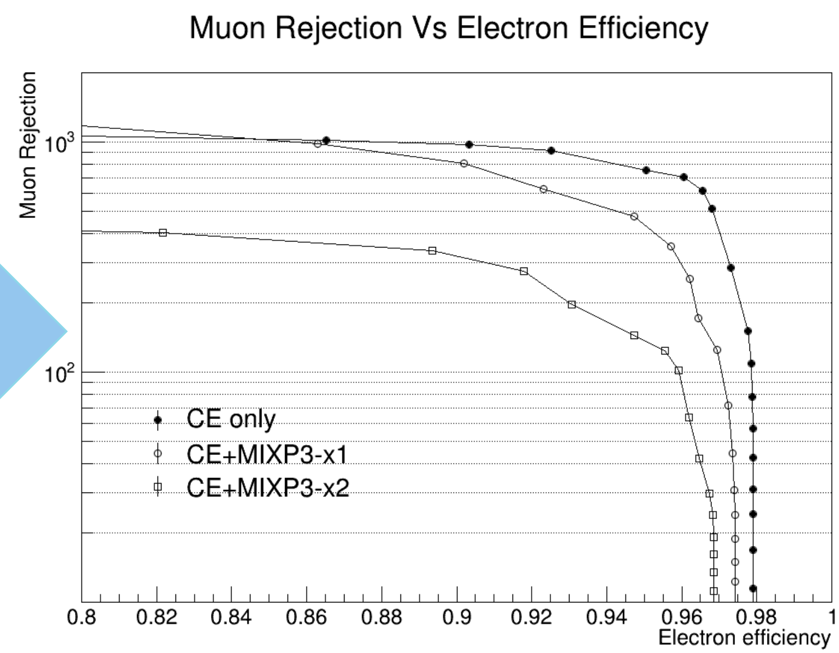
Role of the calorimeter

- At 105 MeV, only electrons are relativistic
  - TOF from tracker to calorimeter different μ & e
  - Kinetic energy of μ only ~40 MeV, E/P different for μ & e





Construct LLR



CAMs and Control Accounts

CAM	Control Account Cost (AY k$)
Ray, Ron	20,752
Werkema, Steve	8,499
Drendel, Brian	2,295
Leveling, Tony	2,182
Nagaslaev, Vladimir	5,516
Dey, Joe	2,709
Johnstone, Carol	5,740
Prebys, Eric	3,134
Coleman, Rick	10,866
Lackowski, Thomas	20,628
Lamm, Mike	10,809
Kashikhin, Vadim	14,133
Lopes, Mauricio	23,264
Buehler, Mark	15,929
Page, Tom	12,693

CAM	Control Account Cost (AY k$)
Hays, Steven L	1,487
ORRIS, DARRYL F	2,946
Brandt, Jeff	5,618
Ginther, George	19,715
Mukherjee, Aseet	4,384
Wagner, Robert	5,234
Hitlin, David G	5,444
Dukes, Craig	3,478
Pla-Dalmau, Anna	1,015
Whitmore, Juliana	766
Group, Craig	1,476
Bowden, Mark	1,535
Biery, Kurt	1,841
Rivera, Ryan	1,441
Rusu, Vadim	2,118

CD-3 Dates

- January 2015 – Extinction Monitor, Beamline
- October 2015 - PS, DS, Target Station, Tracker, DAQ
- December 2015 - TS
- April 2016 – Resonant Extraction, CRV
- November 2016 – Calorimeter
- September 2017 - Muon Beamline

Deputy Project Manager

- My Deputy Project Manager was recently elected co-Spokesperson of Mu2e
- This was a good thing…
- However, changing deputies in the run-up to a summer filled with reviews is not a good idea
- I am working with the Lab to identify a new Deputy who will take over from Doug at the end of August.

KPPs and Off-Project Installation Activities

Ron Ray
Mu2e Project Manager
7/8/2014

Key Performance Parameters (Draft)

Key Parameters	Threshold Performance	Objective Performance
Accelerator	All accelerator components in the M4 beamline upstream of the M4 diagnostic absorber, and all RF and resonant extraction components in the Delivery Ring are installed and operational at nominal voltages and currents. Fabrication of all target station components complete.	Protons are delivered to the diagnostic absorber in the M4 beamline. Proton target beam absorber installed. Heat and Radiation Shield installed inside of the Protection Solenoid. Proton target fabricated and delivered to Fermilab.
Superconducting Solenoids	The Production, Transport and Detector Solenoids have been installed in the Mu2e Detector Enclosure and are ready to be cooled and powered.	The Production, Transport and Detector Solenoids have been cooled and powered to their nominal field settings.
Detector Components	Cosmic rays are observed in the Tracker, Calorimeter and Cosmic Ray Veto after they are installed in their garage position.	Cosmic ray tracks are observed in the Tracker Calorimeter and Cosmic Ray Veto and acquired by the Data acquisition system after they are installed in the garage position.

- Still under discussion with DOE.
- Threshold parameters define minimum accepted outcome for CD-4
- Objective parameters are the desired outcome for CD-4.
- Objective parameters are fully costed in baseline.
- Cost difference between Threshold and Objective performance ~ $1M.

Off-Project Installation

- The solenoid fields are specified at the percent level. The fields must be validated to this level as part of our acceptance criteria.
- To achieve the momentum resolution required to obtain the best possible physics results, the field in the tracker region must be known to high precision.
  - High-precision, fine-grained field maps required at 100%, 70% and 50% of nominal field strength.
  - High precision map is performed off-project. Not required to satisfy KPPs
  - Will take several months.
  - Detectors cannot be installed inside DS while mapping is being performed.
  - Downstream neutron shielding/Cosmic Ray Veto Counters cannot be in the way either
    - Final insertion of detectors inside DS is off-project.

Off-Project Installation

- To optimize transmission of muons to the stopping target and to properly simulate muon transmission, the field lines in the PS and DS must be optimized and known.
  - Some adjustability of coils built into TS design
- Not necessary to satisfy KPPs.
- To map out the PS/TS field lines and to optimize transmission, a movable electron source will be placed at the location of the production target.
- Production target, pbar window, stopping target, neutron shielding, CRV cannot be in place during test.
  - Neutron shielding and CRV preclude TS coil adjustment.
  - Implies that these are all installed off-Project.

Off-Project Installation

- To summarize, once the precision measurements of the solenoid fields have been completed, the following activities remain before the apparatus is ready for beam.
  - Insertion of stopping target, proton absorber, Tracker, Calorimeter into DS
  - Installation of Stopping Target Monitor downstream of DS.
  - Installation of pbar window(s)
  - Installation of production target
  - Installation of vacuum system endcap enclosures
  - Installation of neutron shielding around TS and DS
  - Installation of CRV.
  - Installation of shield blocks in hatches
  - Commissioning of detector in vacuum.
- These activities will take > 1 year.
- Accelerator commissioning to the diagnostic beam dump can proceed in parallel with these activities.
- Operations schedule with links to project schedule developed in P6 (but not costed as part of Project)

How does size of collaboration compare with similar efforts?

- Mu2e has 145 collaborators
- Sindrum-II (previous muon-conversion experiment that holds current world's best limits, published >10y ago) had ~30 collaborators
- MEG (search for muon decaying into eg… same type of physics, but different decay mode; published in 2013, currently being upgraded for another x10 improvement, data-taking starting in 2016) has ~70 collaborators
- COMET (very similar to Mu2e, but in Japan; has same physics sensitivity goal and timescale) has ~140 collaborators