Goals of Mu2e

• Measure the ratio of rates of muon to electron conversion to nuclear muon capture when the muon is in atomic orbit around Al nucleus

\[ R_{\mu e} = \frac{\mu^- N \rightarrow e^- N}{\mu^- N \rightarrow \text{nuclear capture}} \]

• Energy of electron, Aluminum, \(\sim 105 \text{ MeV}\)

• This is an example of charged lepton flavor violation (as yet unobserved in any charged lepton interaction)

• Goal is \( R_{\mu e} < 6 \times 10^{-17} \) at 90% CL
  – 10^4 times better than any previous measurement

• Need a pulsed, high-flux, low energy muon beam
  – Optimal pulse spacing \(\sim 2 \mu s \sim \text{few times muonic atom lifetime (0.86 } \mu s\)\)
  – Stopped muon rate \(>10^{10} \text{ Hz}\)
Mu2e Muon Beam Line

- Three superconducting solenoids in series
  - Production Solenoid (PS), 4m long x 1.5 m diam
  - Transport Solenoid (TS), 13 m long x 50 cm diam
  - Detector Solenoid (DS), 11 m long x 2 m diam
  - Warm bore, evacuated to $10^{-4}$ to $10^{-6}$ Torr

Delivers ~0.002 stopped muons per 8 GeV proton
Review Schedule

• Received CD1 June 2012
• Receive CD3a December-January 2014
  – authorizes purchase of long lead time item: superconductor for solenoids
• Currently preparing for coincident CD2/CD3 review spring-summer 2014
  – CD2: Cost, schedule, scope, baseline, TDR
  – CD3: Final or near-final design
  – Receive CD2/CD3 Late FY 2014
  – Break ground on building Oct 2014
• CD4 late FY19
Proton Source: Bird’s Eye View

Booster
Proton Source: Bird’s Eye View

Booster → Debuncher (via recycler)
Proton Source: Bird’s Eye View

Booster → Debuncher (via recycler) → Mu2e target
Accelerator

• Heat and Radiation Shield (HRS to protect superconducting coils) Design solution is near: brass plus water.

• Production target design: Radiation-cooled vs water-cooled:
  – Rad-cooled easier to support and to service with remote handling, but higher vacuum required (10^-6 torr vs 10^-1 torr)
  – If 10^-6 torr not achieved, a rad-cooled tungsten target may erode from interaction with H_2O. Possible solution: iridium-coated tungsten- Tests underway at RAL
  – Pre-conceptual design of water cooled target exists.

• Other systems progressing well (much off-project or g-2)

• Design work on the extraction septum, RF knockout kicker, spill monitor, and magnet systems is on track. Work on resonant extraction beam transport and loss models is very advanced

• Mu2e Beamline: Optic design for 80% of line is complete -- this is sufficient to fix the position of the proton target
Detectors

• Prototypes planned in summer for detector systems (Tracker, CRV, Calorimeter, Extinction Monitor)

• Tracker
  – Choice made for straws over drift chamber
  – Operation of single straws in vacuum demonstrated
  – Prototype plane of straws being developed
  – Detailed simulations show performance meets specs in realistic background overlay

J. Miller  AEM Meeting  June 3, 2013
Cosmic Ray Veto

- Surrounds Detector Solenoid- must be high efficiency
- Choice between 3 layers of scintillators or 3-4 layers of Cathode Strip chambers depends on results of large effort to understand neutron and associated induced gamma fluxes at the CRV detectors (from many sources), and necessary shielding
- High quality 4 cm x 2 cm prototype extruded scintillator successfully made and will go to test beam in fall
Extinction Monitor

- Background control: between bunch proton flux $< 10^{-10}$ in-bunch proton flux
- Downselect of pixel option over scintillator option
- Look for scattered protons from production target
- Prototype pixel detector to be tested in test beam in fall 2013
Calorimeter

- LYSO array (~2000 xtals) ~3 cm across x 11 cm long
- Downselect: Disk-shape array chosen over vane-shape
  - advantage of e+-e- detection efficiency symmetry
  - disadvantage is more susceptible to background from stop target
    - Simulations and prototyping show disks meet performance spec
- 5x5 LYSO array to be tested at Mainz tagged photon beam in Fall
- Simulations of backgrounds, resolution, efficiency, cluster-forming continuing
Solenoids: PS, TS, DS

- Prototype superconductor for solenoids is on order and being fabricated.
- Prototype coils are being built and tested.
- Current focus on the cryogenic design and buswork for all three magnets.
- Plan to complete PS and DS reference design by the end of July... go out for bids for the final design in ~October. TS a bit later.
- The change from thermal siphon to Forced flow for DS and TS is delaying the completion of the final design.

PS test coil fabricated at Toshiba 2012

Test at Fermilab w/ indirect cooling, July 2013
Stopping Target Tests: AlCap at PSI

- AlCap: Collaboration between Mu2e and COMET
  - Mu2e: U Washington, Boston U., U Houston, Lecce, PNNL, Argonne
- Muons capturing in stopping target produce n, p, γ
  - major sources of noise hits in the detectors.
  - Fluxes not well-known
  - Use stopped muon beam to measure fluxes of particles for candidate stopping target nuclei: Al, Si, Ti
- Use low energy negative muon beam line at PSI
  - One month run scheduled for Dec 2013
  - Possible additional beam time in the spring