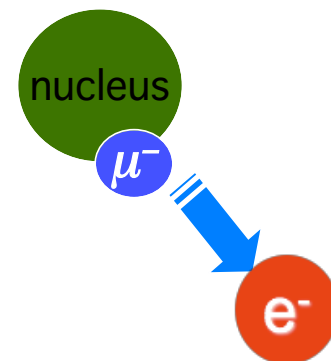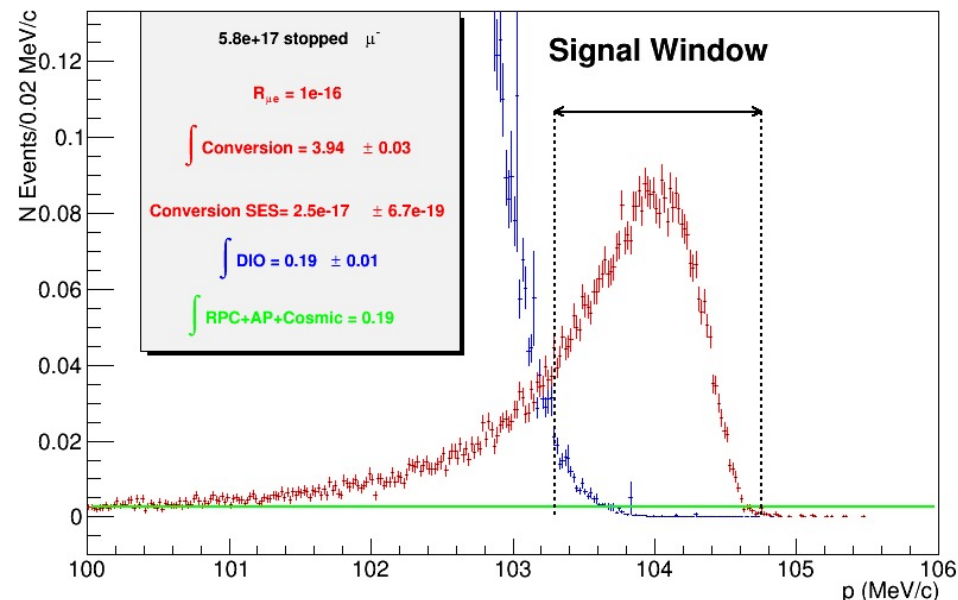# Fermilab

Mu2e Computing Status and Outlook
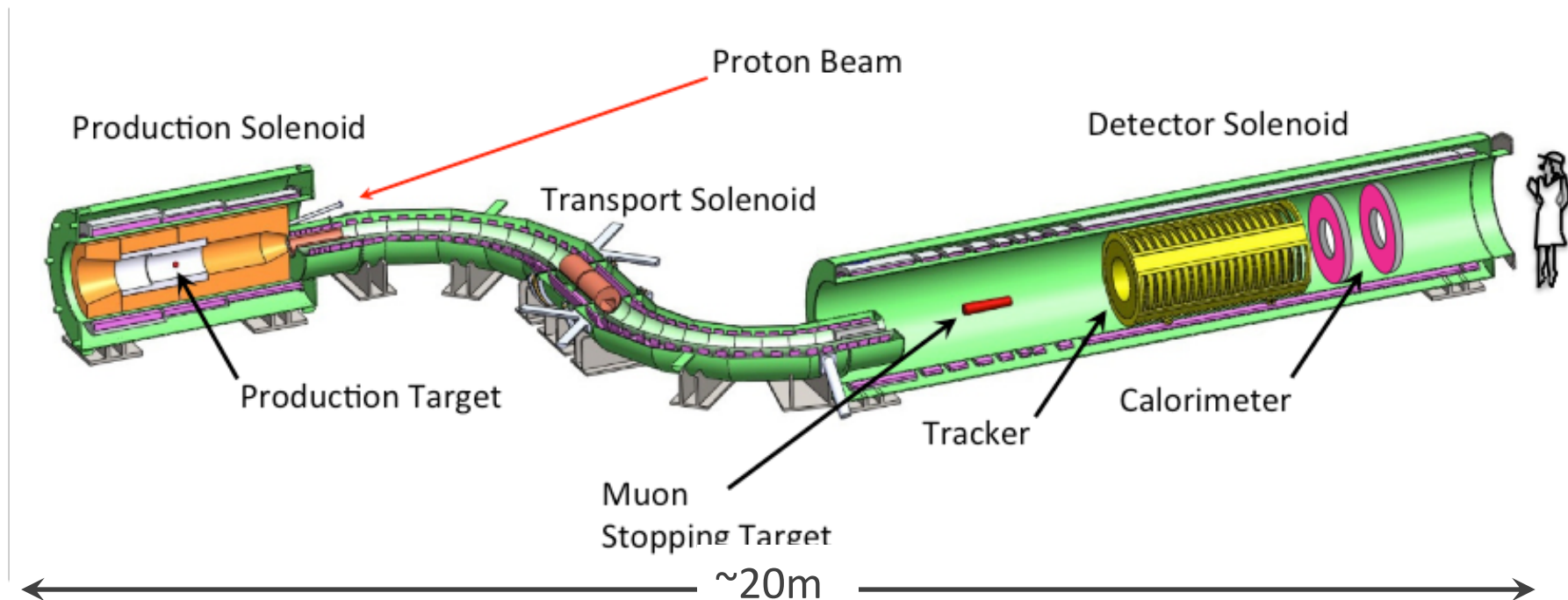
Rob Kutschke, SCD
FIFE Meeting
April 28, 2022

Mu2e in One Page

- ## Make muonic Al.

- ## Watch it decay:
  - Decay-in-orbit (DIO): 40%
    - Continuous E_e spectrum.
  - Muon capture on nucleus: 60%
    - Nuclear breakup: p, n, γ
  - Neutrino-less μ to e conversion
    - Mono-energetic $E_e \approx 105$ MeV
    - At endpoint of continuous spectrum.

- ## Measure E_e spectrum.

- ## Is there an excess at the endpoint?

- ## Quantitatively understand backgrounds

Signal Window

5.8e+17 stopped μ⁻

$R_{\mu e}$ = 1e-16

∫ Conversion = 3.94 ± 0.03

Conversion SES= 2.5e-17 ± 6.7e-19

∫ DIO = 0.19 ± 0.01

∫ RPC+AP+Cosmic = 0.19

N Events/0.02 MeV/c

p (MeV/c)

nucleus

μ⁻

e⁻

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The Mu2e Detector

- Any observation is a clear signal of new physics
  - Standard model background ~ x10^{40} less than our sensitivity
- Sensitivity ~10^4 times better than previous best experiment
- Sensitive to mass scales beyond direct production at LHC
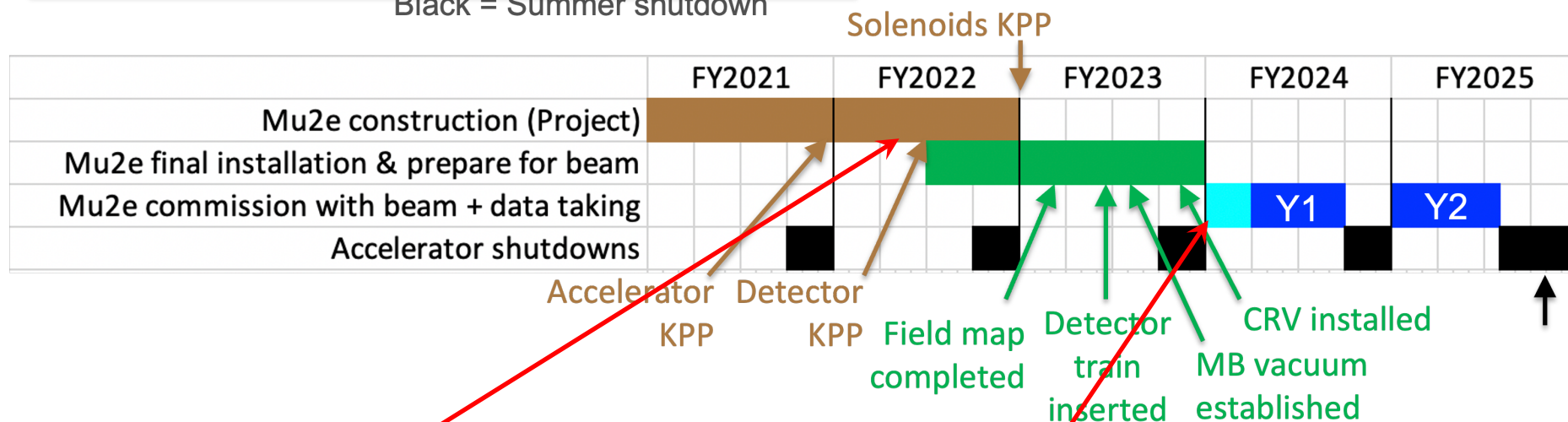
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Located on the Muon Campus

Mu2e Hall

Mu2e/Kutschke · 3/3/2022 · 🟦 Fermilab

Pre-COVID Schedule (May 2020)

Key:
Brown = Project
Green = Prep for beam

Light blue = Commission with Beam
Dark blue = Physics Data Taking
Black = Summer shutdown

Solenoids KPP

	FY2021	FY2022	FY2023	FY2024	FY2025
Mu2e construction (Project)					
Mu2e final installation & prepare for beam					
Mu2e commission with beam + data taking				Y1	Y2
Accelerator shutdowns					

Accelerator KPP   Detector KPP   Field map completed   Detector train inserted   MB vacuum established   CRV installed

- Routine cosmic ray data taking
- Q2 FY22
- First moderate volume data
  – Rough estimate: O(a few TB/day)

- Commissioning with beam
- Q1 FY24
- First high rate data
- Ramping up to 7 PB/year

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Updated Schedule

- Re-baseline review:

June 22 - 23	DOE Review
May 10 - 12	Director's Review

- I am not allowed to discuss publicly the revised schedule until it is approved by DOE.

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Computing and Software Status - 1

- Mature code base for
  - Simulations, including modeling of pileup
  - Trigger, reconstruction and physics analysis of events with perfect alignment and calibration
  - Studies of many types of backgrounds
- Several event displays including an REve based version.
- Code hosted in GitHub
  - Contributions via PR; CI using Jenkins triggered by GitHub comments
- Jenkins used for building production releases
- Nightly integration tests run on grid
- Ramping up code sanitizing
- Prototype DQM system
- Prototype system now in DAQ room; includes disk buffer.
- Reference documentation on wiki; new tutorials in development

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Computing and Software Status - 2

- Support low-rate data taking from Vertical Slice Tests, test stands and sub-assembly testing
  - Intermittent. Peaks to 10's of GB/day.
    - Store on tape; FTS (old Fermilab FTS)
    - Analyzed interactively or by grid jobs (by users)
  - First conditions data
- Mock Data Challenge MDC2020
  - Simulation campaign to produce data sets with some of the diseases of real data: mis-alignment and mis-calibration
  - Will be used to learn how to calibrate and align
  - Our first project using POMS
- Infrastructure to support the above

What's Next

- Continue support for VST, test stands etc

- Continue MDC2020
  - Ramp up efforts on alignment and calibration

- Develop infrastructure to
  - Move raw data, logs etc from Mu2e Hall to long term storage
  - Process raw data as it arrives
  - Mirror curated information from online DBs to offline DBs
    - Run configuration; run status; slow control (EPICS).
  - Move more grid workflows to POMS.
    - Some will be complex and we may need ask for new features.

- When do we move from SAM to RUCIO/Metacat?
  - We need Data Dispatcher to use POMS
  - Last we heard was mid 2023. Is this still on track?

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Moving Data from Hall to Long Term Storage

- Steady state
  - Strawman: 20 TB/day; 20k files/day
  - Peaks to 2x this (draining a backlog)
- This plus DQM, reco, calibration, simulation, analysis ….
  - O(50-100k) new SAM files per day; several operations per file.
- Prioritize which files are moved first
  - First offline jobs do nearline DQM
- We require an end-to-end checksum
  - Risk: limited disk bandwidth in counting room
- Manage free space on counting room disks and persistent dCache
- Risk: may need to split/join/reshape some files before moving to tape?
- Counting room disks are in-hand.

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An Related FTS Question

- Part of [RITM1388520](#).

- The way we have used FTS requires two copy operations
  - Copy from online to FTS dropbox
  - Copy from dropbox to tapebacked dCache

- Is there a way to avoid the double copy?
  - What do other experiments do?

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Other issues - 1

- dCache continues to be the primary culprit for job reliability
  - About once per month some of the nightly validation fails
  - In a recent campaign 5% to 10% of jobs failed
    - Automatically resubmitted by POMS
    - Net >99% complete OK without human intervention
- Jobsub management of python versions is fragile
  - setup jobsub
  - setup a Mu2e environment
  - Then jobsub often breaks due to python version issues
- We would appreciate improvements to fair use of tape drives
  - Requesting a handful of files from one tape can take days
  - Users are accessing pre-staged files to keep them in cache

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Summary

- Well established base for Software and Computing
  - Critical contributions during the CD-1 ... CD-3
- We have already started some discussions about moving raw data to long term storage, data base mirroring etc
  - Ray Culbertson is leading a lot of this
- As our requirements firm-up we will be open new discussions
- I will remind our users to follow up on open tickets
- Once our new schedule is public (guess ~July this year) we can set milestones for having our infrastructure –in-place and tested before it is needed.

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