Progress Report and Update on Mu2e

R. Bernstein
for the Mu2e Collaboration
5 March 2009

Collaboration

- Boston University
- BNL
- UC Berkeley
- FNAL: *since last PAC, seven new FNAL staff* **D. Glenzinski, P.J. Limon, S. Nagaitsev, P. Shanahan, M. Syphers, R. Tschirhart, V. Rusu**
- Idaho State University
- UC Irvine
- University of Illinois at Urbana-Champaign
- INFN/Università di Pisa
- INR Moscow
- U Mass Amherst
- Muons, Inc
- City University of New York
- Northwestern University
- Rice University
- Syracuse University
- University of Virginia

Progress Since Last PAC

General Issues and Answers to Questions

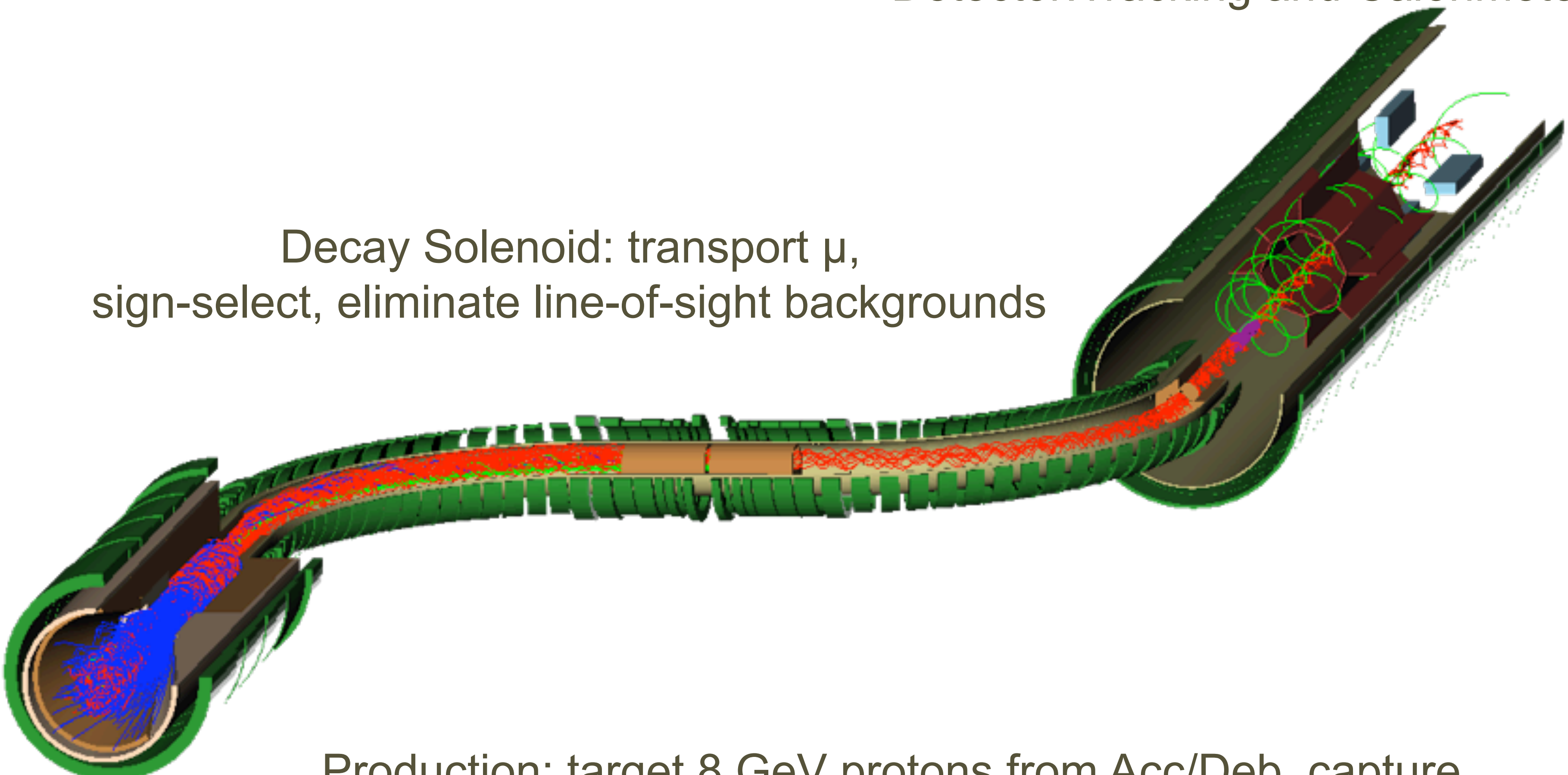
- Task Force/Working Group/Study Groups on:
  - Magnet Options
  - Background
  - Accelerator
- Software Framework for new simulations
  - Replace old, FORTRAN code from MECO
- PSI Measurement of
  - Particle emission after muon capture
- Civil Construction
  - Changed location of building, significant simplification
- Mu2e/COMET Workshop
  - Exploring areas of common interest: MOU signed
- Cost Range for CD-0
  - White Paper explaining R&D requests sent to DOE

Answers to PAC Questions

Question	PAC Page	This talk	Slide Number
Physics Case	1	Talks at FNAL underway to make case: Extreme Beam for Hisano, upcoming Kuno, de Gouvea joins collaboration	
Advance Magnet Schedule	2	Magnet Working Group, US-Japan Agreement work	7–9
Staff Project Office	3	FNAL working on this over all new Projects	35
Cost Range	4	Done for CD-0	33-34
Work with AD	5	Accelerator Working Group	23–27
Performance of D/A at high current	6	Accelerator Working Group	23–27
D/A Abort	7	Accelerator Working Group	23–27
Physical Space for Monitoring and Repair	8	Civil Construction Group, iterated design	32
Trim of Solenoids	9	Magnet Working Group	7-9
Thermal Neutrons	10	Background Working Group	13
D/A Losses	11	Accelerator Working Group	23-27
Extraction intensity limit	12	Accelerator Working Group	23
D/A Aperture Restriction	13	Accelerator Working Group	23-27
Involve vendors, Forward-fund solenoids	14	US-Japan, Magnet Working Group	7–9
Abandon Forward Muons	15	Magnet Working Group	7–9
Gradient of Production Solenoid	16	Magnet Working Group	7–9
Monte Carlo	17	Framework/GMC Monte Carlo	11–12
Downstream Electron Calorimetry	18	Background Task Force	11–12
Trigger/DAQ	19	Must understand calorimetry, need MC	11–12

Either explicit discussion or that group is working on that issue

Detector and Solenoid



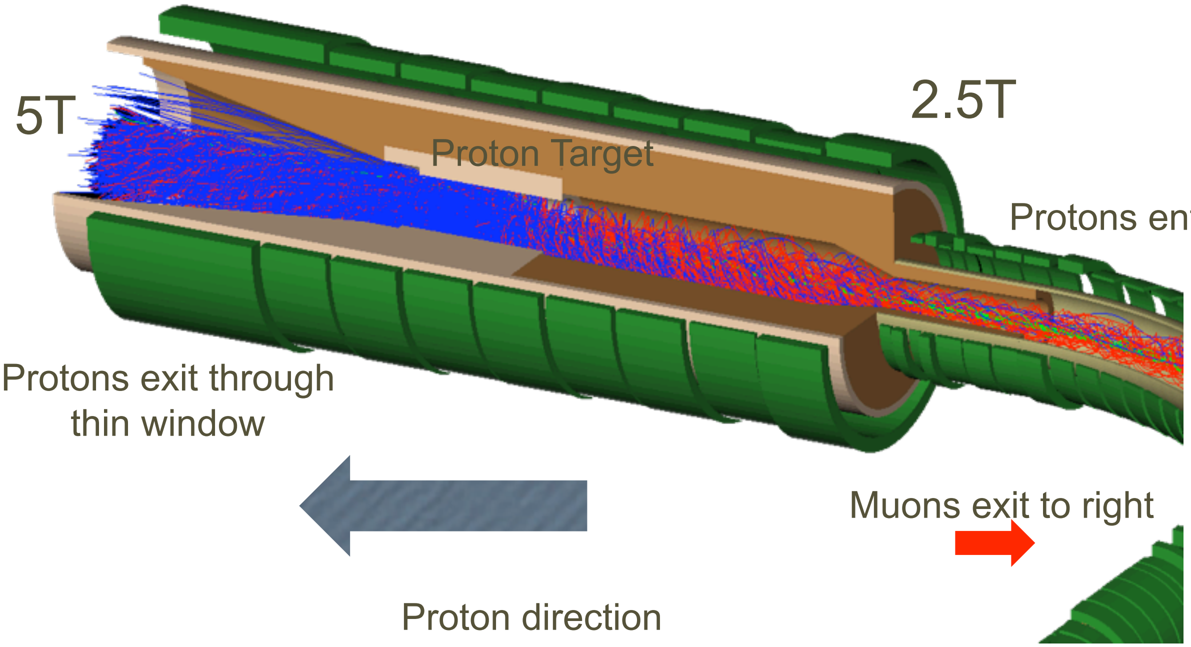
Detector:Tracking and Calorimeter

Decay Solenoid: transport μ, sign-select, eliminate line-of-sight backgrounds

Production: target 8 GeV protons from Acc/Deb, capture π and create μ from π decay

Production Solenoid

π's are captured, spiral around, and decay: Graded 5→2.5T field serves as magnetic mirror



- Issues: is this optimized?
  - Is it worth recapturing pions headed in initial proton direction? Understand number of stopped muons vs technical complexity and cost
  - Location of target? Field gradient?

Solenoid System

- Update MIT CDR from MECO
  - Many original members moved to General Atomics
  - Consulting contract with General Atomics signed last week
  - Will get most advanced version of MECO baseline design
- Re-optimizing Production Solenoid
  - Loss of SSC Cable opens many options
    - Changes in Technology and Industry
    - Applied for funding under US-Japan to prototype

      Al-stabilized, NbTi cable that is more common now
      - Understand implications of changing from MECO Cu-stabiliized, SSC-type cable
  - Re-optimize for FNAL vs. BNL
    - *can trade flux vs. running time vs. cost vs. technical complexity at FNAL's superior machine*

Formed Magnet Working Group

Nov PAC:
1) Can we advance the schedule?
2) Abandon forward pions/mirror?
3) Gradient on Production Solenoids
4) Involve vendors at R&D stage

- Systematically explore options
  - What are technical advantages/disadvantages?
  - What are cost/schedule/risk drivers?

Abandon forward pions

	Design Type	Peak field	Stabilizer	Possible advantage	Possible Disadvantage
1	Meco Baseline	5	Cu	MIT CDR completed and favorably reviewed	Massive busy coils, some concerns about reliability; nuclear heating requires pool boiling cryostat
2	Meco No Mirror	>3*	Cu	Shorter coil length, target spray downstream of solenoids: less nuclear heating; possibly lower field	Loss of mirror pions, may want 5 T anyway
3	Meco High Current	5	Cu	smaller coil profile:less energy deposit, lower inductance→easier Quench protection	higher current, same field==>higher forces
4	Meco No Mirror High Current	>3*	Cu	Best of 2 and 3	Problems of 2 and 3
5	Meco Baseline AL	5	Al	1) less nuclear materia→less heatingl 2) might be able to do continuous wind or 1-2 layers	Conductor may be expensive; not presently being made anywhere
6	Meco No Mirror, AL	>3*	Al	best of 2 and 5	Problems of 2 and 5
7	Meco Cable in Conduit	5	Al or Cu	improved and simplier cooling, eliminates pool boiling cryostat	Possible high internal pressures during quench, have to learn new technology
8	Comet Baseline	5	Al	like "6" but field gradient issue	Same concerns about conductor price and availability

FNAL: M. Lamm, R. Coleman,A. Zlobin, Va. Kashikhin , Vl. Kashikhin, E. Barzi, S. Feher, J. Tompkins, R. Yamada and Jim Miller, BU

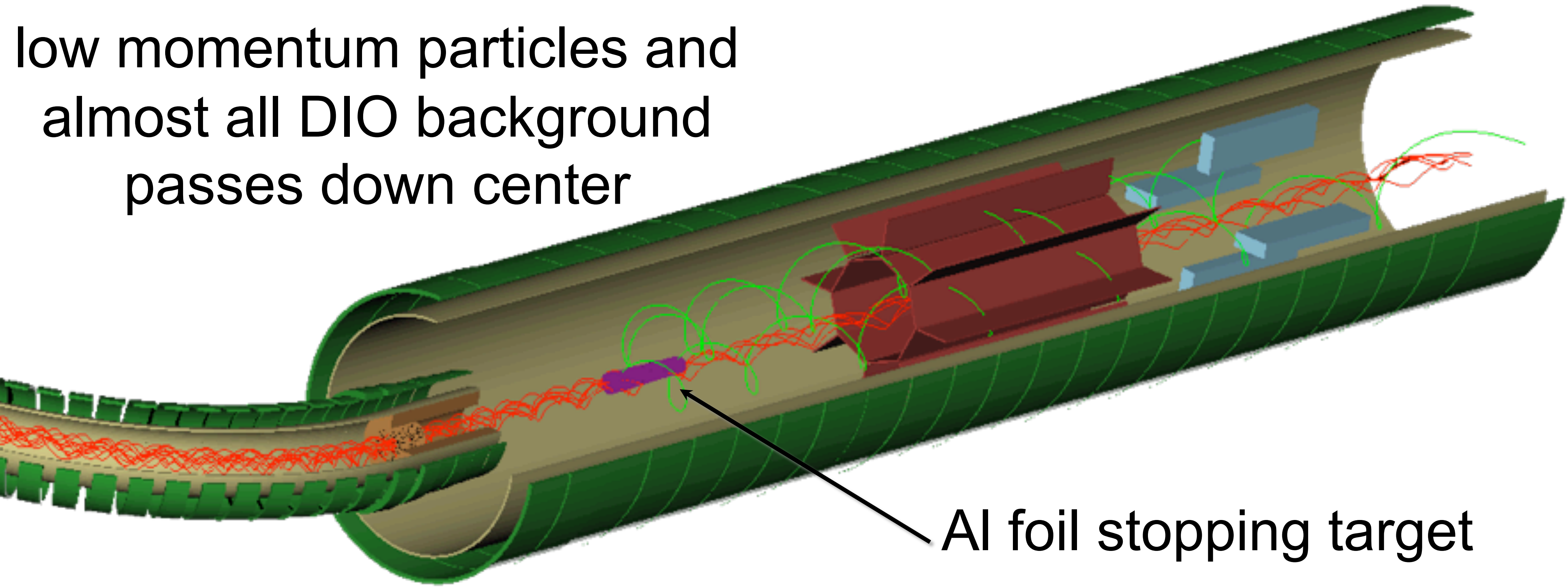
US-Japan R&D

- From US-Japan MOU: (translation)
  - Superconducting solenoid: We aim to developing aluminum-stabilized conductor that is optimized to achieve the 5T pion capture solenoids for Mu2E or COMET. The other conductors such as Nb3Al, Nb3Sn, MgB2 will be also studied for future upgrades.
- Hoping for ~$125K in joint request between solenoids and extinction system
  - Order conductor in Japan, FNAL does design work
  - Will increase request to ~$200K next year for prototype solenoid
- Meeting of Japanese committee 3-4 March, so no answer yet…

Detector Solenoid

octagonal tracker surrounding central region:
radius of helix proportional to momentum

low momentum particles and almost all DIO background passes down center



Al foil stopping target

signal events pass *through* octagon of tracker and produce hits

Background Progress

PAC:

1. Is there R&D that you can do that would increase the reliability of the background simulations and estimates?
2. Are there experimental measurements which could be done to give greater confidence in the background estimates?"

- Calculation
  - Resurrect FORTRAN/ GEANT3 MECO calculations:
  - Document MECO Code:

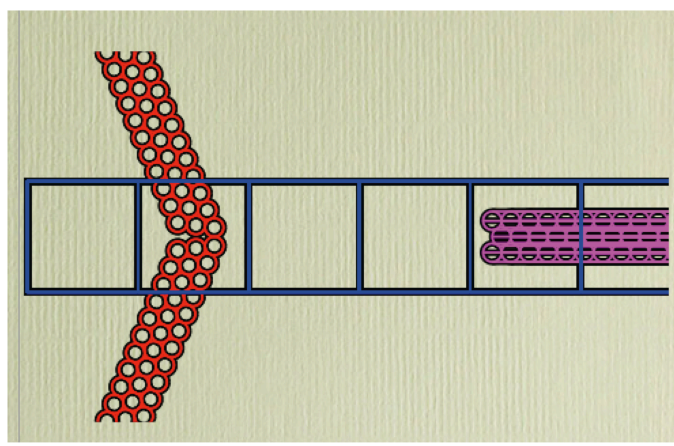
  1) Provide a better understanding of MECO calculations
  2) Provide benchmarks for new calculations
     - Hired V. Tumakov as contractor on Monday 3/2. Vlad is an expert on the relevant MECO code:
       - will regenerate key noise and background files.
       - make them work on the FNAL clusters
       - document them for Mu2e.

Building Computing Infrastructure

- CD has built new software framework based on CMS
  - Supported by CD: FNAL institutional commitment
    - CD is offering the framework to other experiments
  - Have learned to use this framework with a toy detector
  - Integration with GEANT4 in progress (by end of March)
- Will use modern resources, e.g. the grid
  - This will provide a dramatic increase in computing power. While we cannot simulate ~10^{18} DIO's, want to use modern tools to increase sample sizes for background estimates

R. Kutschke

Geometry of Tracker, Calorimeter, and Stopping Target In G4; Can swim tracks through field and create hits



Formed Background Task Force

Glenzinski, Norman, Tschirhart

Charge:

- delineate known background mechanisms,
- develop an associated risk analysis
- provide recommendations to mitigate these risks to the experiment.

Background Delineation

- Dominant Sources of Background:

1. Tail of the DIO distribution.
2. Radiative decay processes that generate high energy electrons.
   - Radiative pions: $\pi\ N \rightarrow \gamma N^*$, $\gamma \rightarrow e^+ e^-$ near signal region
3. High energy electrons and muons from upstream processes.
4. Cosmic Rays that produce electrons or extra hits
5. Rate-driven mechanisms that prevent the detector from identifying 1-4.
6. Mechanisms that affect the understanding of the momentum scale and resolution function of the spectrometer.

Background Risks: Classification and Mitigation

- Beam and Intensity Related:
  - Imperfect Extinction
  - Instantaneous rate effects
    - Pileup, tracking failures at high multiplicity

  Mitigated by detector design, measurements of extinction quality, and measurements of detector response vs. rate

- Irreducible with measurable parameters/handles
  - Proton/Neutron ejection from nuclei that stop muons
  - Cosmic Ray Flux
  - Post-extinction, remaining radiative π sample

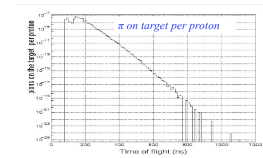
  Mitigated by external measurements and/or data, off-spill measurements of CR rate, measurements varying gate timing

- Irreducible
  - Real Physics backgrounds (DIO at endpoint, Radiative μ capture)

  Mitigated by calibration and resolution studies

Some Strategies to Measure Backgrounds…

- Three Sample Strategies:
  - Time into Gate (radiative π, 23 nsec lifetime) *TIG*
  - Vary Extinction Quality
    - e.g., Phase of AC Dipoles relative to gate
  - Vary Number and Location of Stopping Target Foils



Use ensemble of measurements to understand backgrounds

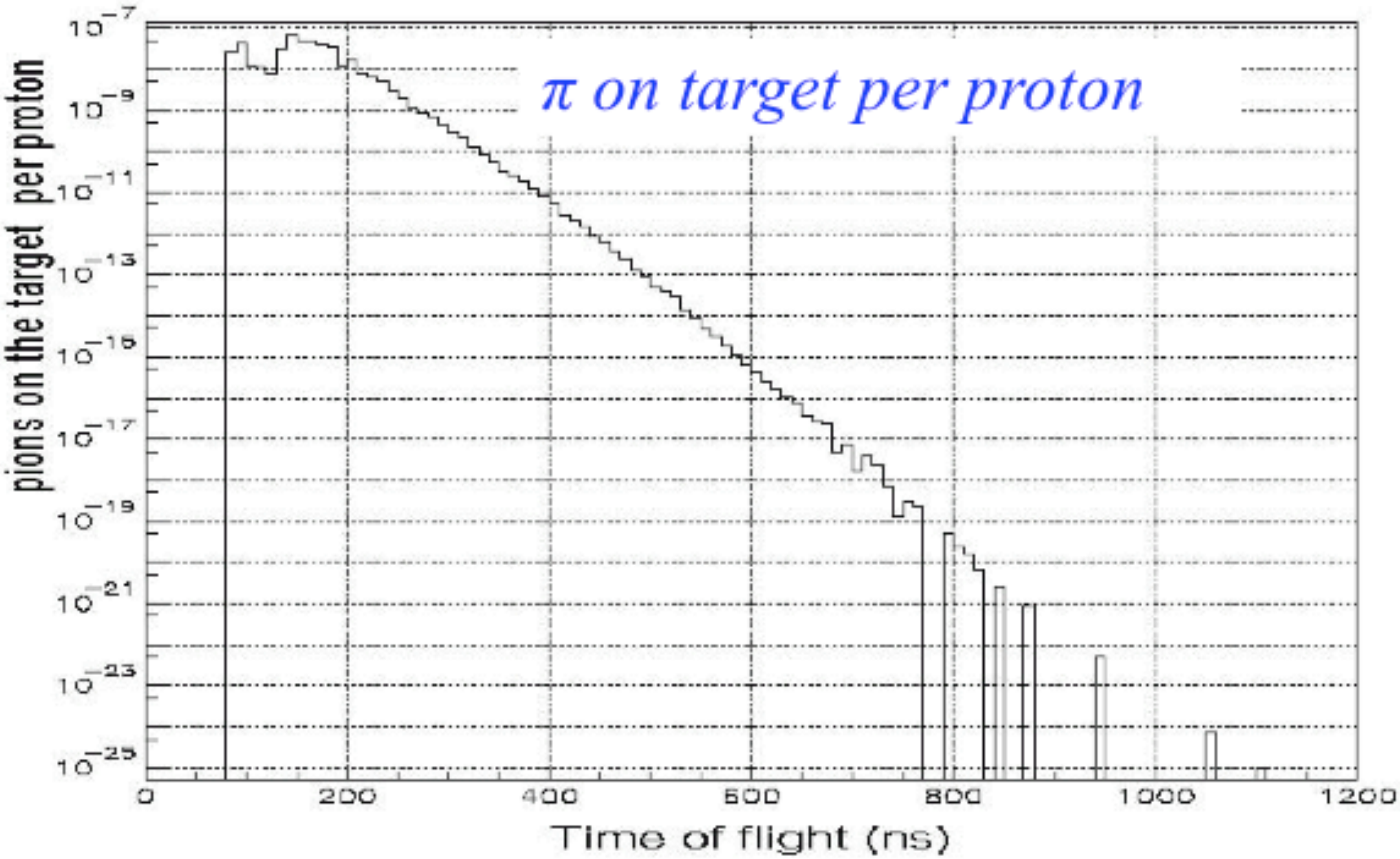
- Total Background =

DIO [early TIG probes catastrophic misreconstructions]

+ ($\gamma \rightarrow e^+e^-$ mostly from π^-) [TIG, use positrons in the data]
+ μ^-, e^- scattering in target
+ μ^-, e^- misses target [vary stopping target mass (# foils)]]
+ Very late particles [TIG studies]
+ Cosmic Rays [measured with ample off-spill time]

- Spoil Extinction and/or Change TIG in controlled ways to understand radiative π contribution or other backgrounds

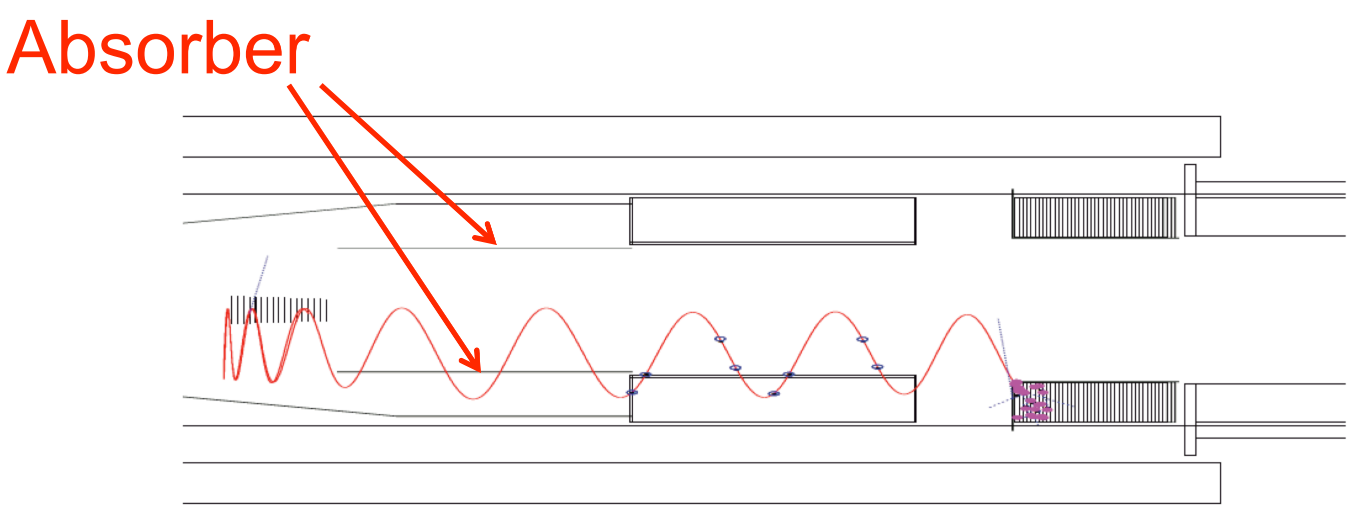
Time into Gate



Can get many more pions for study by looking earlier than 700 nsec

Background Measurements!!

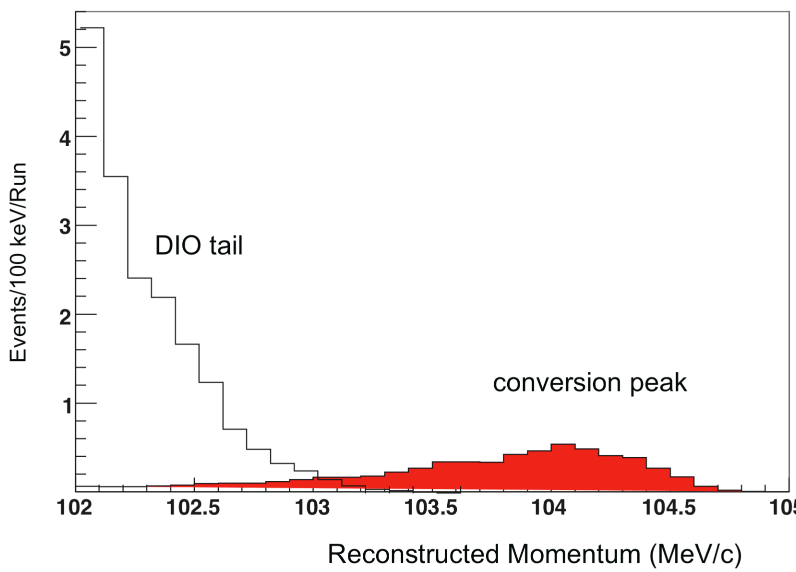
- Measuring Backgrounds: one important case:
  - Proton absorber
    - About 0.1 protons ejected per stopped muon in our Al stopping target; this proton is highly ionizing and can deaden straws
    - MECO used a proton absorber of CH_2 to reduce the number of protons to an acceptable level:



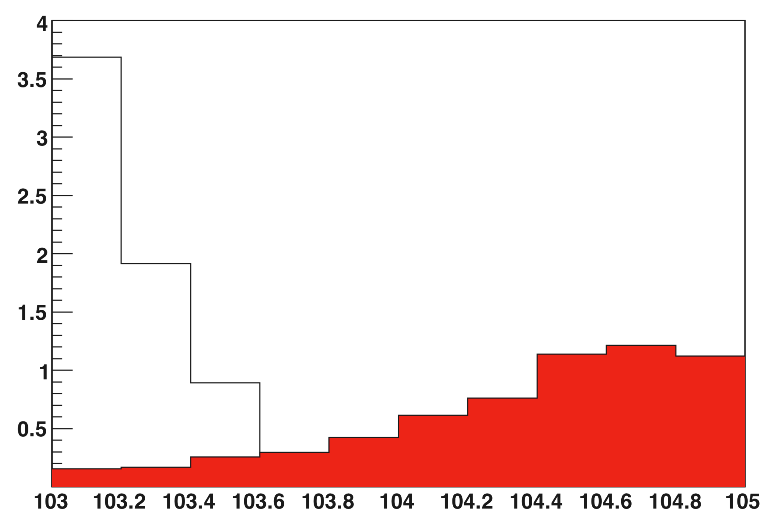
But conversion electron passes through the absorber!

Backgrounds and Measurements

- But the proton absorber has a cost: energy loss
  - *Signal-to-noise worsens: S/√B goes from 8 to 5.5 @ $R_{\mu e}$ = 10^{-16}*
- Proton rate estimates range from 0.04 to ~0.1, design is for 0.1 (this is conservative)
- Nor is the momentum distribution well-known, inferred from Si
- Should be able to decrease thickness if we can achieve lower instantaneous rates at FNAL vs BNL; the absorber issue is connected to various beam delivery schemes under consideration



standard



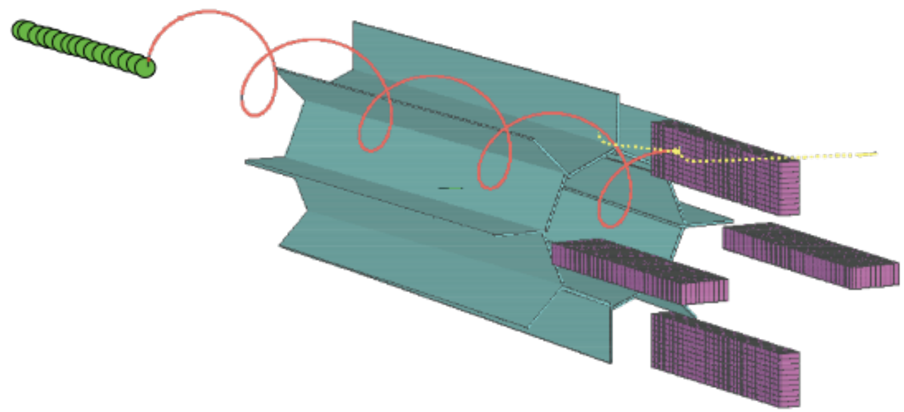
no-absorber

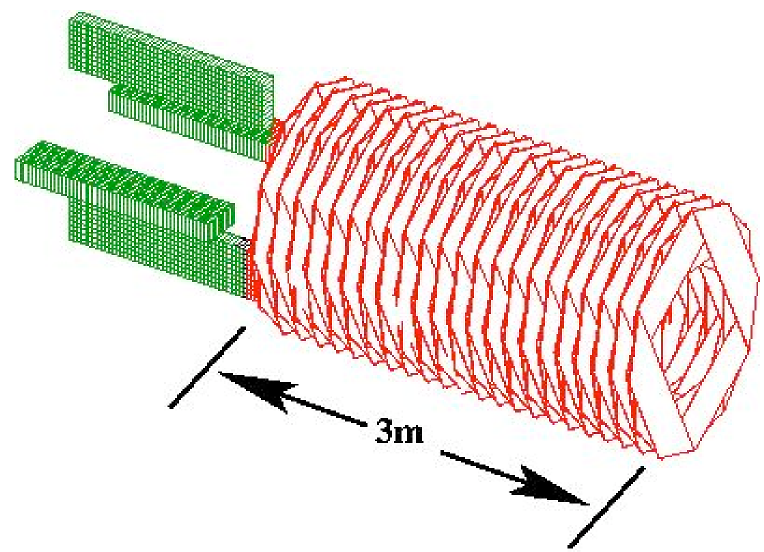
Background Measurements

- So let's measure this rate:
  - Useful Input for Mu2e optimization,
    - Al/Ti comparison also interesting
  - Charged particle emission (rate, spectrum and composition) relevant for Mu2e not measured, estimates based on theoretical extrapolations
  - Additional measurements of neutrons, radiative muon capture and radiative pion capture being investigated
  - Collaboration gains experience in low energy muon physics, trains students in small scale experiment
- Investigating measurement at PSI
  - Design concept, beamline exist and we can piggyback off MuLan/MuCap (Mu2e's Urbana/BU are on expt)
  - Working through when this can be done, pushing for this summer: P. Kammel (UIUC), K. Kumar(UMass Amherst), V. Rusu (FNAL), J. Phillips (BU), H. Miyadera (LANL)?, Yoshi Kuno (Osaka)?

Tracker

- Two Alternatives currently under consideration:
- L-Tracker
  - MECO baseline
  - 2.6 m × 0.5 cm long straws along muon beam direction
- T-Tracker
  - 0.7-1 m× 0.5 cm long straws transverse to muon beam direction





Tracker

- L vs. T:
  - L harder to build but easier to analyze
- Therefore prototype L
  - If L works, no need to prototype T
  - If L doesn't work, will have solved many of T problems along the way (e.g., straw leakage in vacuum)
- Need to prototype full-size octant
  - MECO did prototyping at smaller scale, not definitive
  - People working: Marj Corcoran, Hogan Nguyen, John Krider, Bill Molzon, Russ Rucinski , Aseet Muhkerjee, Bob Wagner
  - Rucinski assigned 20%, plans to come up with conceptual design
- *Want to build a mechanical prototype this summer*

Accelerator Issues

- How do we get beam from Booster to Recycler to Acc/Deb?
  - Can use Recycler, Accumulator, and Debuncher in different ways: which is optimal?
    - Define "optimal"
    - *Trading space charge vs. instantaneous rate in detector*
    - *Many options being explored and "phase space" being mapped out*
      - *Significant work done since proposal, and excellent FNAL group actively engaged*
- Resonant Extraction:
  - studies have begun of 1/3-integer vs. 1/2-integer
  - gearing up to study space charge effects
  - requirements and expectations for the slow spill feedback circuit will be developed
- Radiation Safety:
  - Need careful analysis of safeguards for running high intensity beams in the antiproton enclosures. Design and cost passive and active safety measures. This needs to start *SOON*

Accelerator Organization

- Group has weekly meetings:

MU2E-BEAM membership

amundson@FNAL.GOV	Jim Amundson
ankenbrandt@FNAL.GOV	Chuck Ankenbrandt
rhbob@FNAL.GOV	Robert Bernstein
cbhat@FNAL.GOV	Chandra Bhat
broemmel@FNAL.GOV	Dan Broemmelsiek
coleman@FNAL.GOV	Rick Coleman
fritzd@FNAL.GOV	Fritz DeJongh
drozhdin@BPMAIL.FNAL.GOV	Alexandr Drozhdin
dukes@BEAUTY1.PHYS.VIRGINIA.EDU	Craig Dukes
sgeer@FNAL.GOV	Steve Geer
g-gollin@UIUC.EDU	George Gollin
dej@FNAL.GOV	David Johnson
cjj@FNAL.GOV	Carol Johnstone
JJohnstone@FNAL.GOV	John Johnstone
kahn@BNL.GOV	Stephen Kahn
kobilarc@FNAL.GOV	Thomas Kobilarcik
yury@PHYSICS.BERKELEY.EDU	Yury Komolensky
PJLIMON@FNAL.GOV	Peter Limon
maclachlan@FNAL.GOV	Jim MacLachlan
marshw@FNAL.GOV	Bill Marsh
martens@FNAL.GOV	Mike Martens
MICHELOTTI@FNAL.GOV	Leo Michelotti
mokhov@FNAL.GOV	Nikolai Mokhov
nsergei@FNAL.GOV	Sergei Nagaitsev
neuffer@FNAL.GOV	David Neuffer
ng@FNAL.GOV	Bill Ng
ostiguy@FNAL.GOV	Francois Ostiguy
popovic@FNAL.GOV	Milorad Popovic
prebys@FNAL.GOV	Eric Prebys
rray@FNAL.GOV	Ron Ray
tjrob@FNAL.GOV	Tom Roberts
shiltsev@FNAL.GOV	Vladimir Shiltsev
spentz@FNAL.GOV	Panagiotis Spentzouris
syphers@FNAL.GOV	Mike Syphers
werkema@FNAL.GOV	Steve Werkema
yamin@BNL.GOV	Peter Yamin
yonehara@FNAL.GOV	Katsuya Yonehara
yosh@FNAL.GOV	Cary Yoshikawa
zwaska@FNAL.GOV	Bob Zwaska

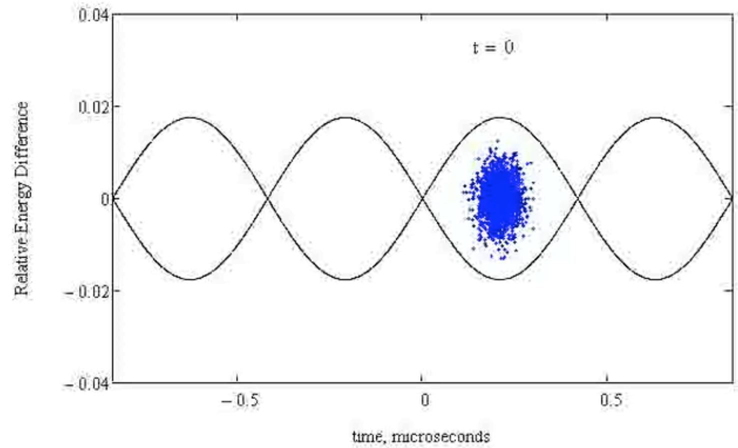
*
* Total number of users subscribed to the list: 39
* Total number of local host users on the list: 0

Typically 15 people/week attend

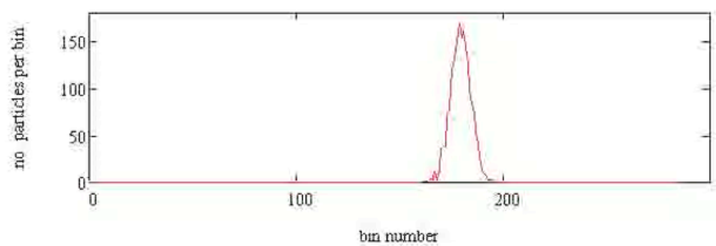
- And is putting together a WBS, so it can think coherently about issues and interplay

Extinction (Sources)

- Extinction: Require protons-out-of-bucket/protons-in-bucket < 10^{-9}
- Investigating processes that can generate energy or phase errors, causing particles to diffuse out of the RF bucket, resulting in distribution of charge along circumference
- $\Delta\varphi_{rms}$ ~ 1.0^{o}, x10 larger than typical for illustration



Momentum vs. circumference



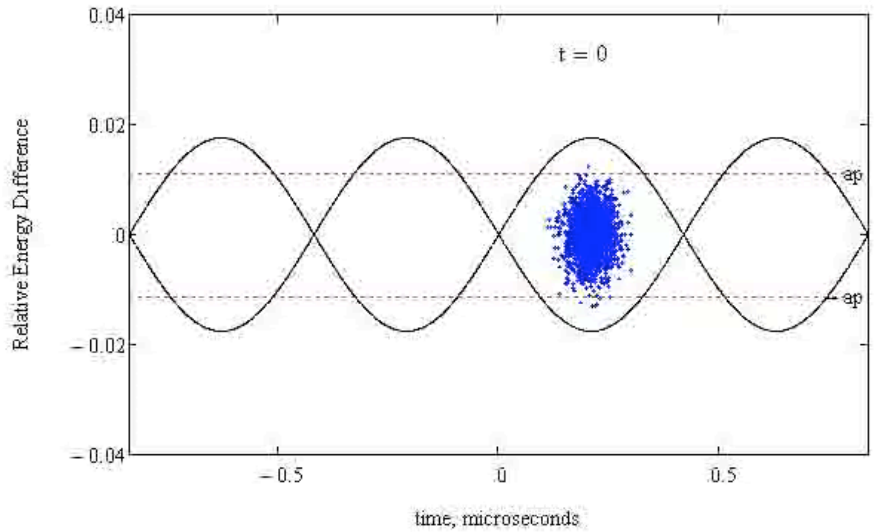
Extinction in the Rings

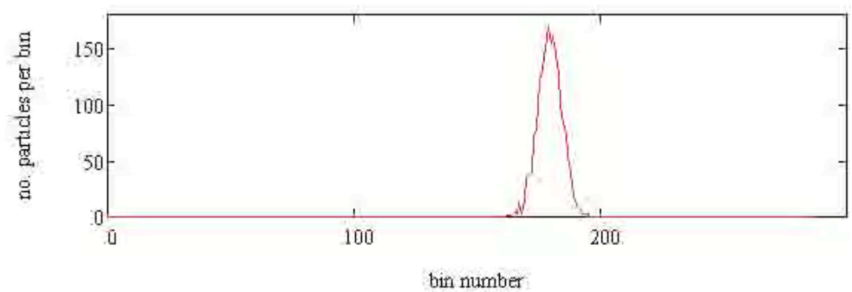
- More typical

  $\Delta\varphi_{rms} = 0.1°$

- D is the dispersion function:
  - Transverse Offset = $\Delta E/E \times D$

- Anticipate installation of collimator in region with dispersion, removing off-momentum particles:
  - Momentum scraping

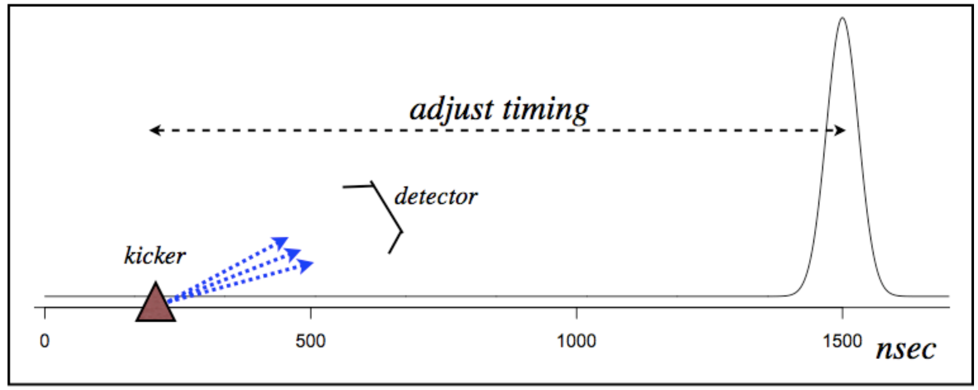




Extinction Experiment?

- Prepare beam pulse from Main Injector using its existing Barrier (broadband) RF system and 2.5 MHz system
- Send bunch to Accumulator and/or Debuncher and capture in h=4 RF bucket
- Measure distribution around circumference
  - Kick at times relative to bunch to look for particles out of the bucket
- What kickers are available?

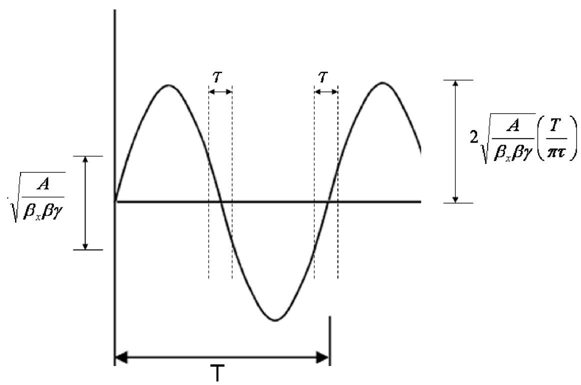
- Need to develop detector(s) to use in test
- similar (same) as used for Flying Wire systems?

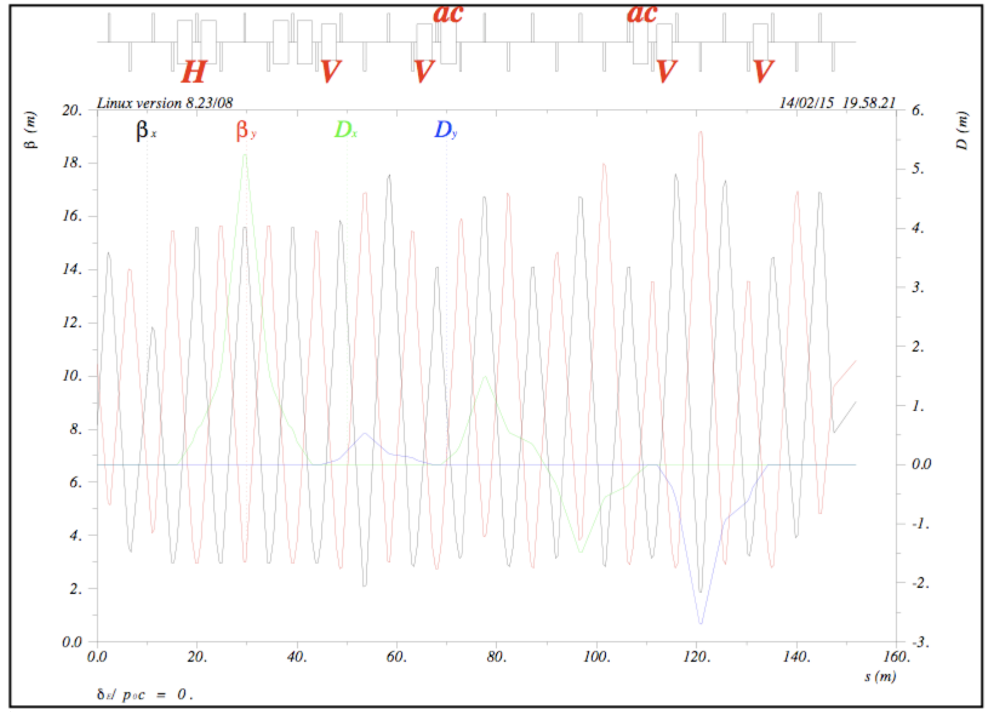


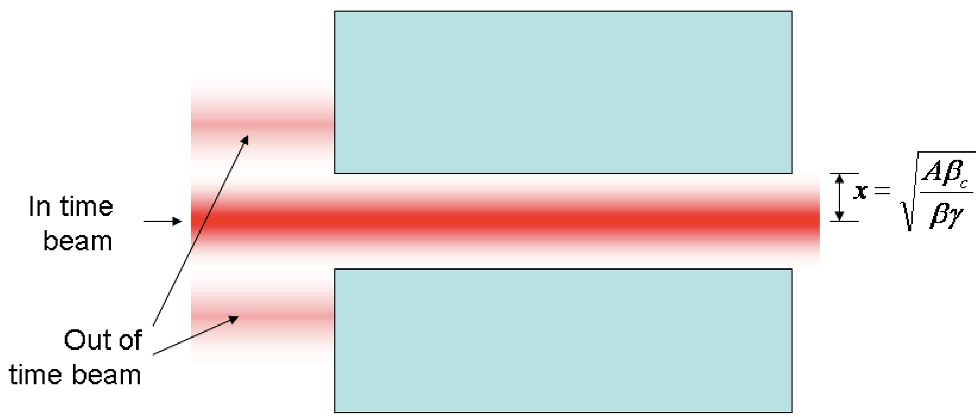
- Want to measure and understand extinction *before/while* solenoids are being built

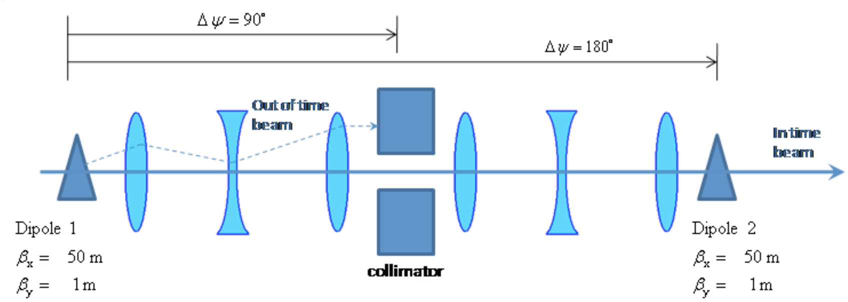
External Extinction (AC-Dipole Scheme)

- Possible change from baseline in proposal: two stage collimation









Old design, single collimator

Extinction System: AC Dipole Progress

- AC-Dipole must operate at 300 kHz so losses from eddy currents and hysteresis important: hysteresis is material, eddy currents mechanical construction
- Procured ferrites and measured magnetic properties
- Will continue prototyping this summer using US-Japan funding:
  - US: AC-Dipole
  - Japan: proton-by-proton measurement

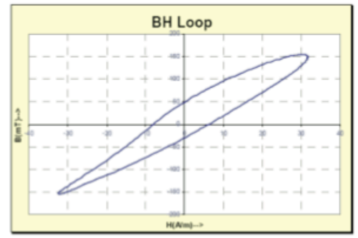


Fig.3 48499-1-2 (8W)

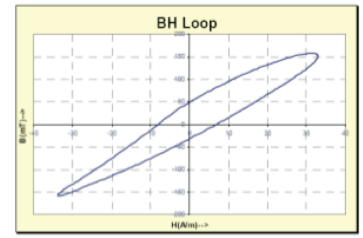


Fig.4 48499-1-1 (9W)

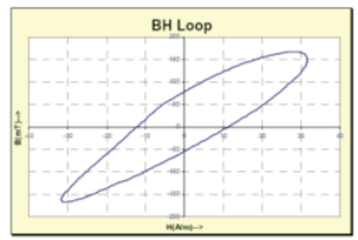


Fig. 5 48550-2 (16W)

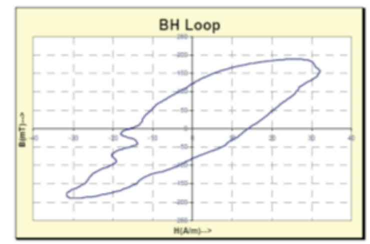


Fig. 6 48551-2 (22W)

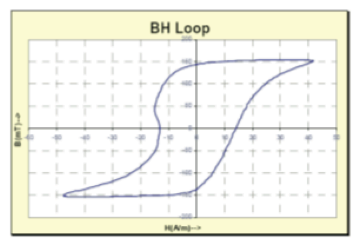


Fig. 7 48550-1 (25W)

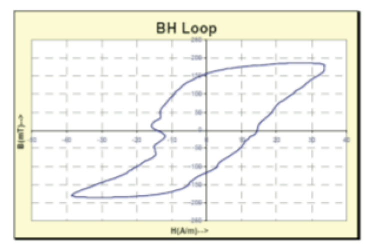
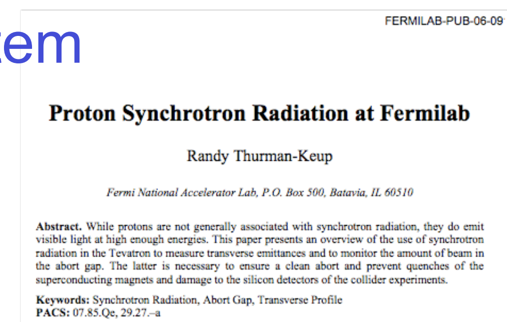


Fig. 8 48551-1 (25W)

D. Harding, Vl. Kashikin, A. Makarov, G. Velev

Extinction Measurement

- From US-Japan MOU (translation):
  - Proton extinction: (U.S side) We will perform examination of the ferrite magnetic properties and their power losses in the leads. We will construct the first physical model of the AC-Dipole magnet. The power supply system requires R&D. The system must run at precisely the correct frequency to synchronize with the beam delivery and therefore must be able to tune the circuit. We will produce a Conceptual Design Report. (Japanese side) We will develop a design of an extinction monitor using a gated PMT technique.
- Joint Effort on Gated PMT:
  - Very similar work at FNAL as part of SyncLite system
  - May lead to using MCP instead of PMT



FERMILAB-PUB-06-09

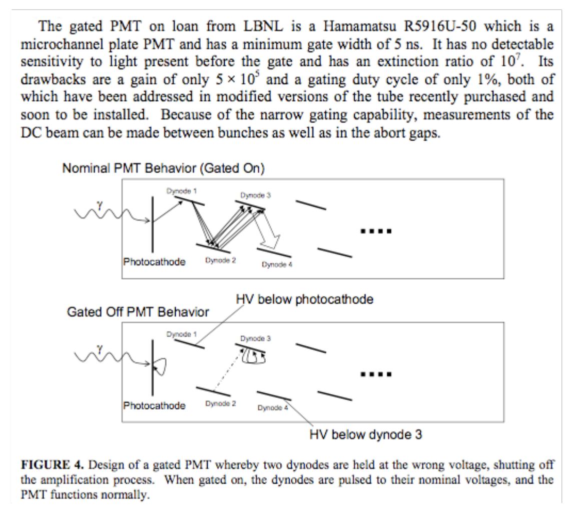
Proton Synchrotron Radiation at Fermilab

Randy Thurman-Keup

Fermi National Accelerator Lab, P.O. Box 500, Batavia, IL 60510

Abstract. While protons are not generally associated with synchrotron radiation, they do emit visible light at high enough energies. This paper presents an overview of the use of synchrotron radiation in the Tevatron to measure transverse emittances and to monitor the amount of beam in the abort gap. The latter is necessary to ensure a clean abort and prevent quenches of the superconducting magnets and damage to the silicon detectors of the collider experiments.

Keywords: Synchrotron Radiation, Abort Gap, Transverse Profile
PACS: 07.85.Qe, 29.27.–a



The gated PMT on loan from LBNL is a Hamamatsu R5916U-50 which is a microchannel plate PMT and has a minimum gate width of 5 ns. It has no detectable sensitivity to light present before the gate and has an extinction ratio of 10^7. Its drawbacks are a gain of only 5×10^5 and a gating duty cycle of only 1%, both of which have been addressed in modified versions of the tube recently purchased and soon to be installed. Because of the narrow gating capability, measurements of the DC beam can be made between bunches as well as in the abort gaps.

FIGURE 4. Design of a gated PMT whereby two dynodes are held at the wrong voltage, shutting off the amplification process. When gated on, the dynodes are pulsed to their nominal voltages, and the PMT functions normally.

R&D Plan for Extinction: Summer 2009

- This summer:
  - Can we repair system if needed? (insulation breakdown from discharge in bubbles)
  - What do we need for power supply at 300 kHZ? Needs precise tuning for circuit
  - Understand losses from eddy currents
- For 2010:
  - Build prototype

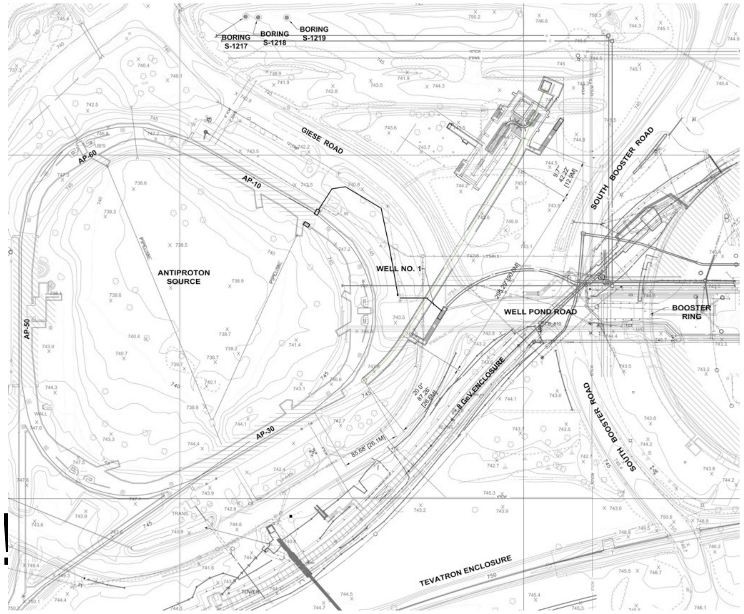
2009 (Required for Conceptual Design)	
Mechanical components and fixturing for single brick test	$ 2,000
Instrumentation and data acquisition for single brick test	15,500
Power supply tuner prototyping	15,000
2010 (Required for Prototyping)	
Components for prototype magnet modules	30,000
Tooling for magnet assembly	10,000
Components for prototype power supply	120,000
Magnet measurement instrumentation	15,000

Need to do this R&D
but are asking for US-Japan funding

Civil Construction

- Selected new site since proposal:
  - Moved extraction point from first design
    - Avoids wetlands issues
    - Existing "stub" pipe here from past: space for extraction exists
    - Not as deep
  - Smaller, simpler building
  - Includes room for staging and assembly but much more work is required to understand final requirements

T. Lackowski, Herman White



- Cost Change: \$40.7M→\$26M!!
  - preliminary

Cost and Schedule

- Cost estimate from proposal: $186M FY09 (with old building site)

  Nov PAC: Should be working with a cost range

  - includes R&D
  - Includes 50-100% contingencies depending on subproject
  - We believe this is a reasonable estimate:
    - start with MECO, include inflation
    - add FNAL estimates for accelerator and Civil
    - Increased MECO contingencies to DOE standards based on maturity of design and risk; consistent with Temple Review of MECO
- Escalated to Actual Year: $211M “Actual Year”
  - 3.5%/yr inflation
  - Funding profile based on MECO WBS modified to align tasks with CD-process milestones, and input from FESS and AD

Cost and Schedule

- CD-0: next few months; FNAL portion submitted
  - Following instructions from DOE, we generated a “range” by modifying contingency to account for low risk and high risk assumptions.
  - Instructed to define a range; we **must** stay below upper limit:
    - $178M-$240M range sent to DOE
    - The point estimate of $211M starts with MECO numbers and adds modern DOE methodology plus Civil and Accelerator Costs
      - Our Project Manager was Deputy PM for Nova, used that knowledge and experience
- CD-1:
  - we will generate a tighter range with smaller contingencies from a bottoms-up resource loaded cost and schedule (as opposed to the top-down estimate for CD-0)
- CD-2:
  - we will arrive at a baseline cost with an overall contingency in the 30 - 40% range.

Nothing has changed since proposal with the schedule: technically limited 2016

Project Office

- The Lab has worked with all of the new projects to understand their needs.
  - More sensible to look across Projects (DUSEL, Mu2e…) in an integrated way especially at this early phase
  - Requisitions are now in the pipeline to hire contract project controls personnel
  - Mu2e expects ~ 50% of a project controls person soon and a full-time person by the end of the Summer.
  - Once we get CD-0 we will need 10% of a budget officer to help us track costs. By the end of the summer we will need 50% of a budget officer to work with our project controls person.
  - We have had some informal discussions with PPD about a Project Mechanical Engineer.
- Mu2e has named three L2 Managers:
  - M. Lamm, Solenoids; M. Syphers, Accelerator; T. Lackowski, Civil Construction
  - More to follow soon

Mu2e/COMET Joint Workshop

- Looked at R&D Needs of both experiments for possible areas of collaboration
  - About two dozen talks Jan 23-24th in Berkeley
  - Discussions were wide-ranging
- Focused on Solenoids, Trackers, and Backgrounds
  - Significant overlap on production solenoid issues, and are
    - Writing joint request for US-Japan funding for prototyping (just defended, as discussed earlier)
    - Sharing/comparing code for Production Solenoid modeling
      - R. Coleman (Mu2e), A. Sato (COMET)
- *Wrote MOU between collaborations for R&D into areas of common interest; signed this week*

Mu2e and Project X

- Mu2e will be a customer!
  - Requires upgrades that will depend on what we learn
    - From building and executing the experiment
    - And the result!

- Accelerator Advisory Committee 2009 closeout report mentions Mu2e 58 times in connection with muon collider/neutrino factory, Project X, and future of FNAL complex

  http://www.fnal.gov/directorate/Fermilab_AAC/AAC_Feb_09/AAC_Closeout_Feb09_Compiled.pdf

- P5 agrees:
  - [muon-to-electron conversion] …could be the first step in a world-leading muon-decay program eventually driven by a next-generation high-intensity proton source. Development of a muon-to-electron conversion experiment should be strongly encouraged in all budget scenarios considered by the panel.

R&D Summary: next several months

- Solenoids
  - Investigation of Al/Ni-Tb technology for production solenoid
  - Hiring of General Atomics to update MECO TDR
    - Study field specs and tolerances
- Software/Simulations:
  - functioning model of detector to be benchmarked against old code
  - Built new framework for modern computing
- Tracker
  - L-tracker prototype this summer
- Extinction
  - Prototyping of AC-Dipole leads, ferrites, and power supply
  - Extinction measurement scheme in collaboration with COMET/Japan
- PSI Measurement of rates
  - Will use measurements to refine design of detector

more R&D topics in White Paper to DOE (made available to committee)

Summary and Conclusions

Lots of Progress and Planning: Preparing for CD-1

- Solenoids:
  - production solenoid group will delineate and investigate options
  - Develop conceptual design and procurement plan
- Backgrounds:
  - Active Group is classifying risk and response
  - Planning measurement of protons, neutrons, photons at PSI
- Tracker:
  - plan to construct one-octant prototype of L-tracker this summer
- Accelerator:
  - continued modeling of space charge
  - Large group working on detailed beam design
- Extinction:
  - plan to test ferrites for AC Dipole this summer