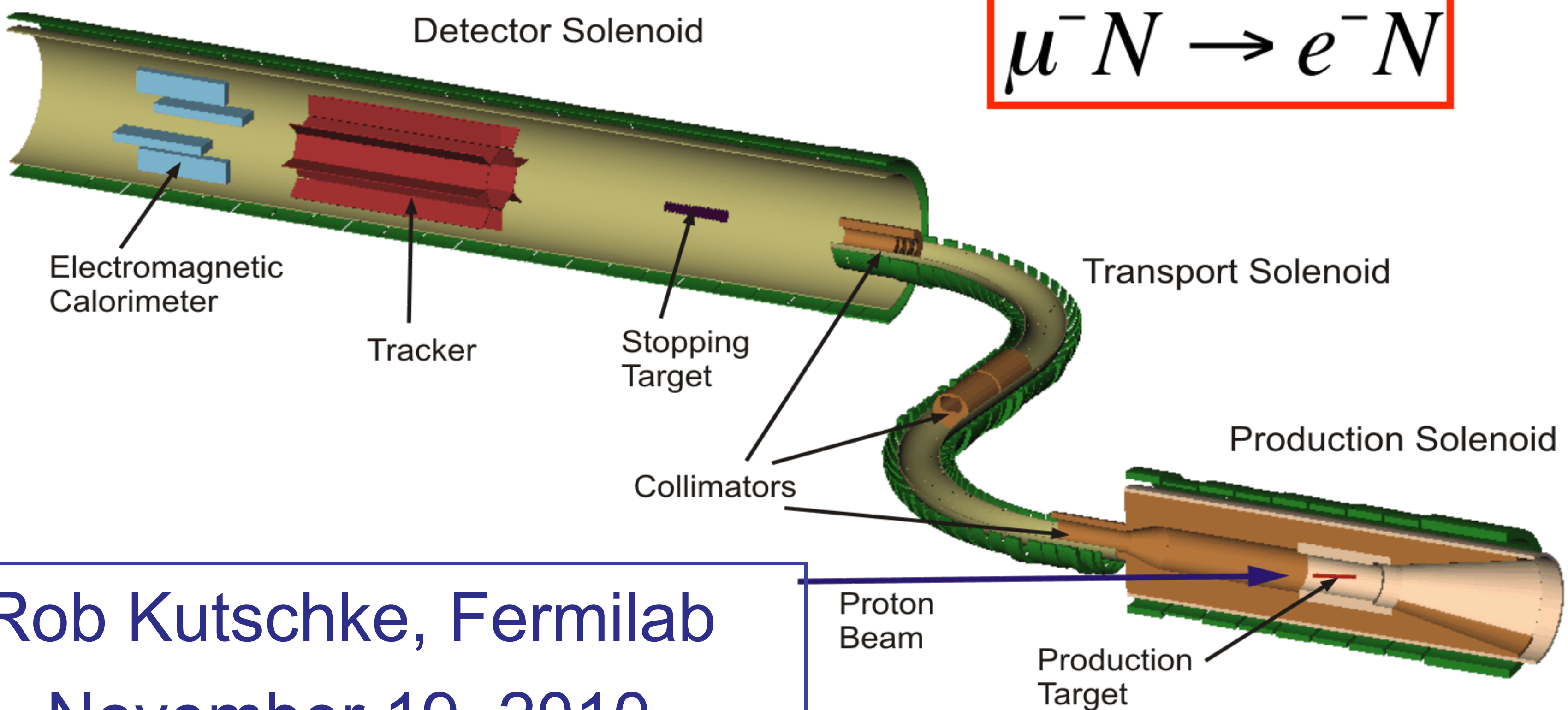
Mu2e-doc-1196-v2

The Mu2e Experiment at Fermilab

$$\mu^- N \rightarrow e^- N$$



Rob Kutschke, Fermilab

November 19, 2010

(Cornel Journal Club)

http://mu2e.fnal.gov

The Mu2e Collaboration

~100 Collaborators

Both HEP and Nuclear Physics groups.

Boston University
Brookhaven National Laboratory
University of California, Berkeley
University of California, Irvine
City University of New York
Fermilab
Idaho State University
University of Illinois, Urbana-Champaign

Institute for Nuclear Research, Moscow, Russia
JINR, Dubna, Russia
Los Alamos National Laboratory
Northwestern University
INFN Frascati
INFN Pisa,
Università di Pisa, Pisa, Italy
INFN Lecce, Università del Salento, Italy

Rice University
Syracuse University
University of Virginia
College of William and Mary

Opportunities remain for University groups.

Outline

- What is μ to e conversion? Why look for it?
- Cartoon of the experimental method.
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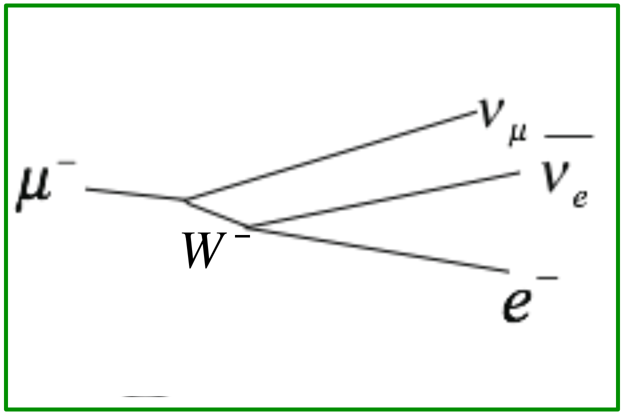
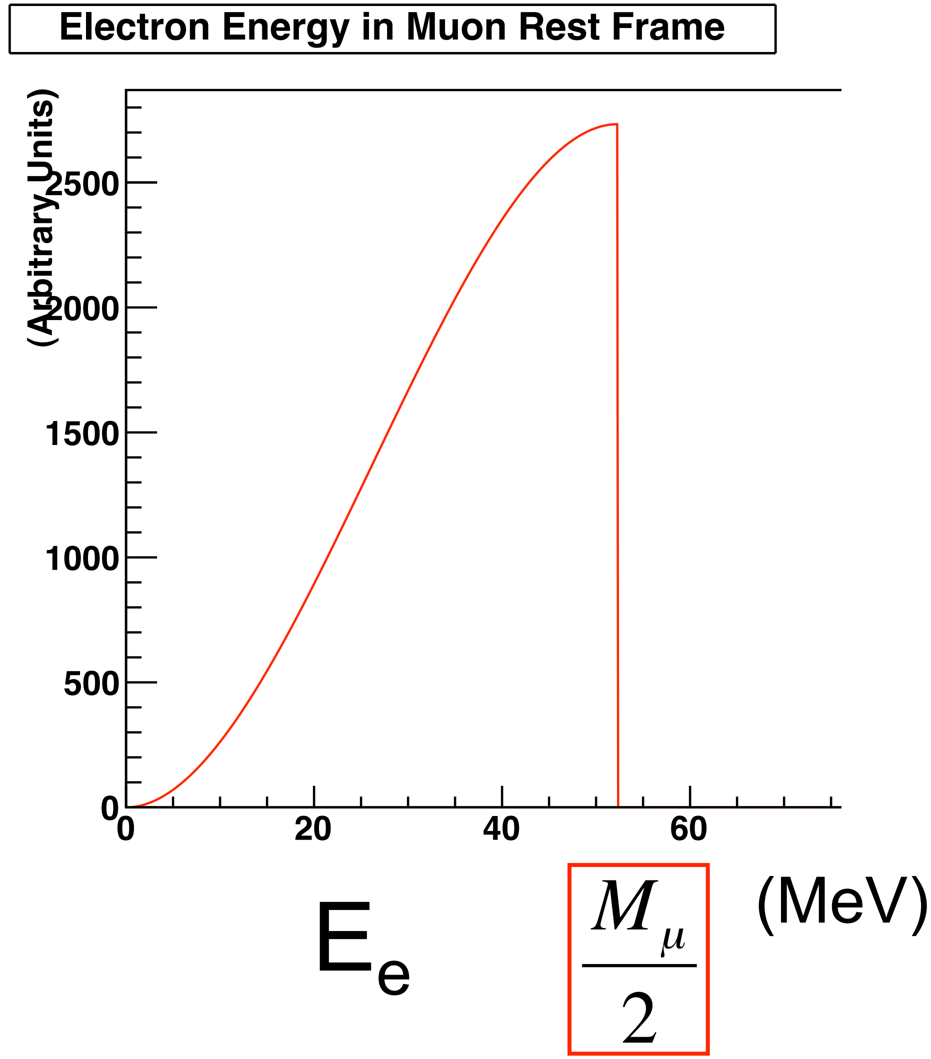
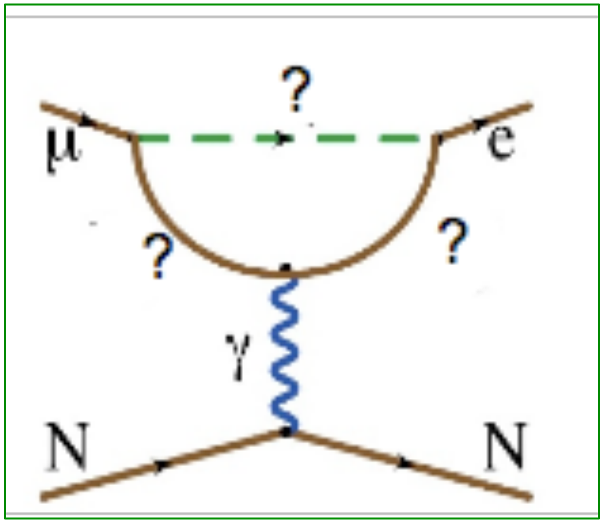
- The Project X era.
- Conclusions.

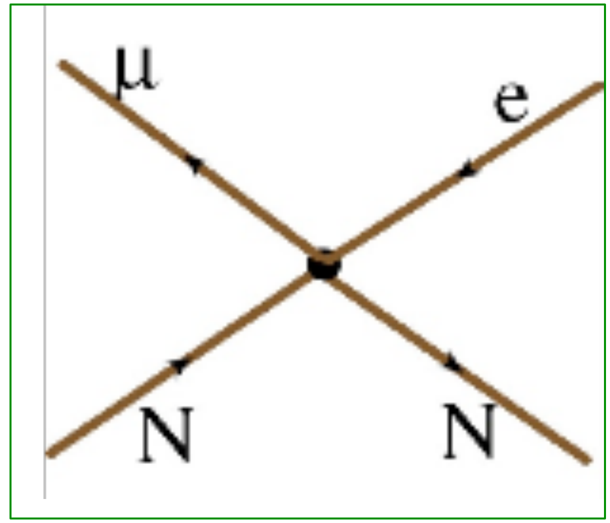
Decay of a Free Muon

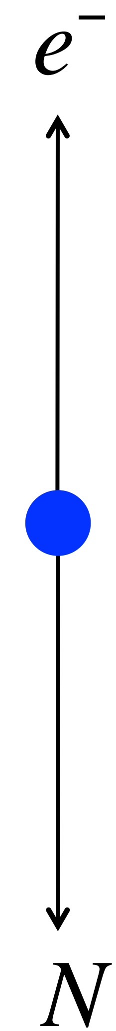




$$\mu^- N \rightarrow e^- N$$



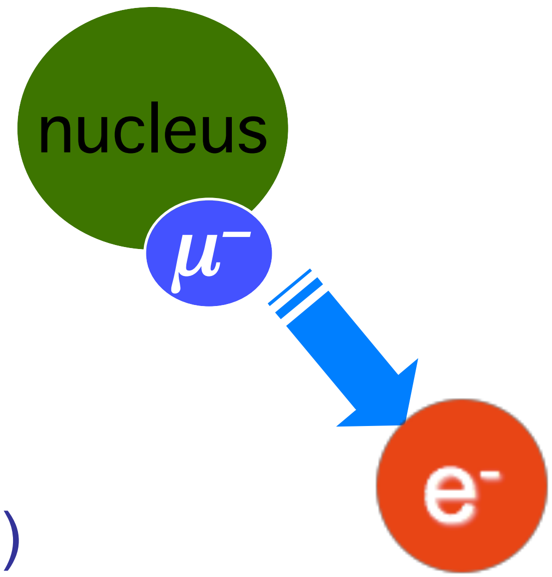




- Initial state: muonic atom at rest in lab.
- No neutrinos in the final state
- Coherent = intact nucleus; gamma coupling proportional to Z.
- Standard Model rate is non-zero! But is immeasurably low.
- Many scenarios with new physics predict measurable rates.
- Sensitive to New Physics with masses up to O(10,000 TeV).

$$\mu^- N \to e^- N$$

- Single mono-energetic electron.
  - Energy $O(M_\mu)$.
  - Depends on Z of target.
- Recoiling nucleus (not observed).
  - Coherent: nucleus stays intact.
- Charged Lepton Flavor Violation (CLFV)
- Related decays:



$$\mu \to e\gamma \quad \mu \to e^+e^-e^+ \quad K_L^0 \to \mu e \quad B^0 \to \mu e$$

$$\tau \to \mu\gamma \quad \tau \to \mu^+\mu^-\mu^+ \quad D^+ \to \mu^+\mu^+\mu^-$$

A Word of Caution

$$\mu^- \rightarrow e^- \gamma$$

- The MEG Collaboration is doing that experiment.
- See their web site:

  http://meg.web.psi.ch
- Or check SPIRES for publications by the MEGA Collaboration.

Why Do Mu2e?

- Access physics beyond the Standard Model (SM).
  - Precision measurements and searches for ultra-rare processes complement direct searches at the highest available energies.
- Negligible standard model backgrounds.
  - Wide discovery window.
  - Any non-zero observation is evidence for physics beyond SM.
- Violates conservation of lepton family number.
  - Already observed in neutrino sector.
  - Addresses the puzzle of generations.
  - Strength (or absence) of particular CLFV signals can help remove ambiguities from new physics signals seen elsewhere.

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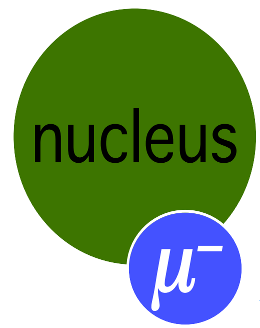
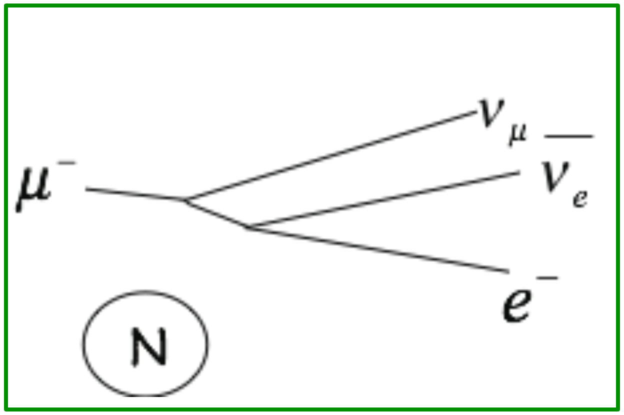
Mu2e in A Few Pages

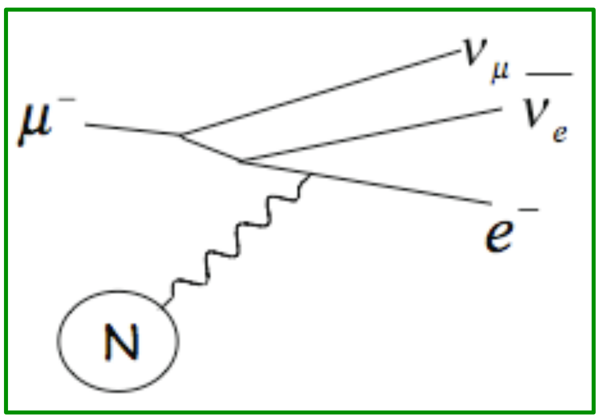
- Make muonic Al.
- Watch it decay:
  - Muon decay in orbit: ≈40%
    - Continuous E_e spectrum.
  - Muon capture on nucleus: ≈60%
    - Nuclear breakup: 2n, 2γ, 0.1 p
  - Signal:
    - Mono-energetic $E_e \approx 105$ MeV
    - At endpoint of continuous spectrum.
- Measure E_e spectrum.
  - Is there a bump at the endpoint?

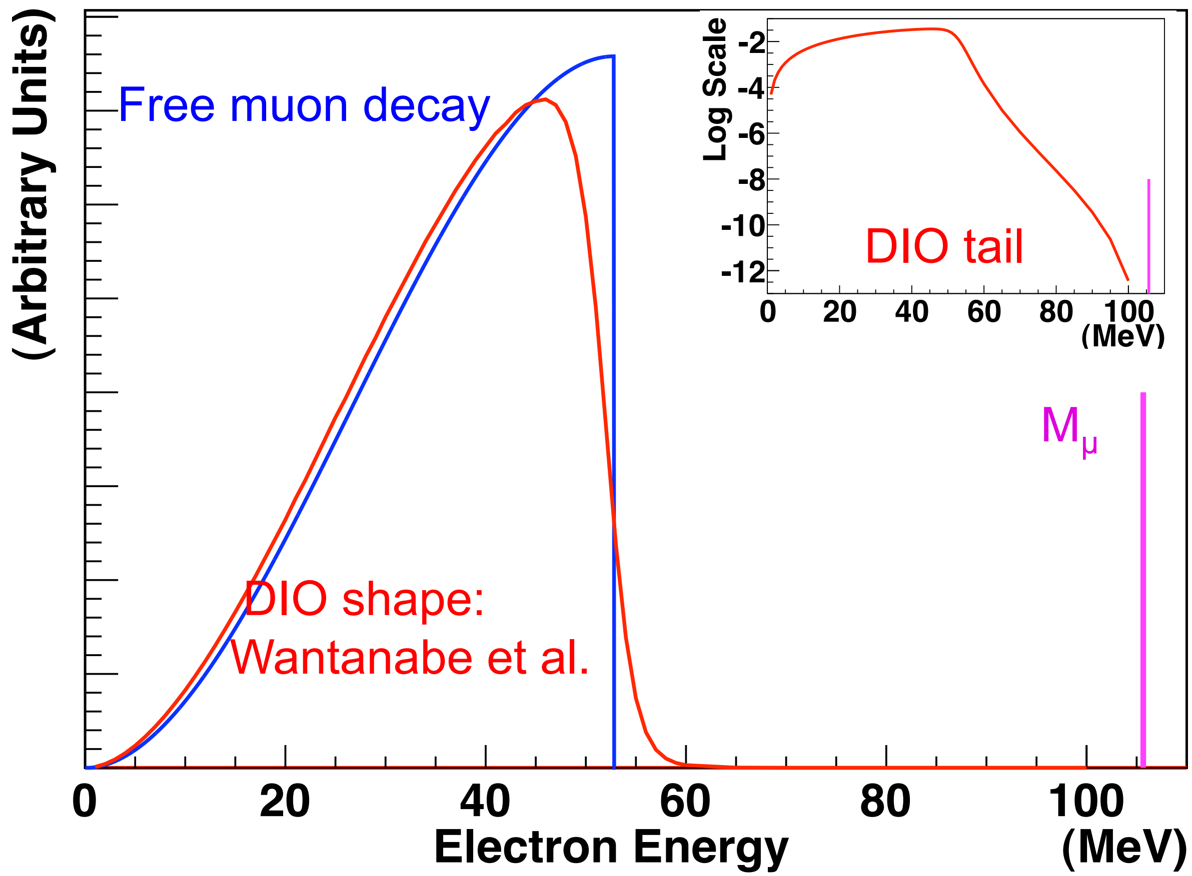


For Al:
Bohr radius ≈ 20 fm
Nuclear radius ≈ 4 fm
Lifetime: 864 ns

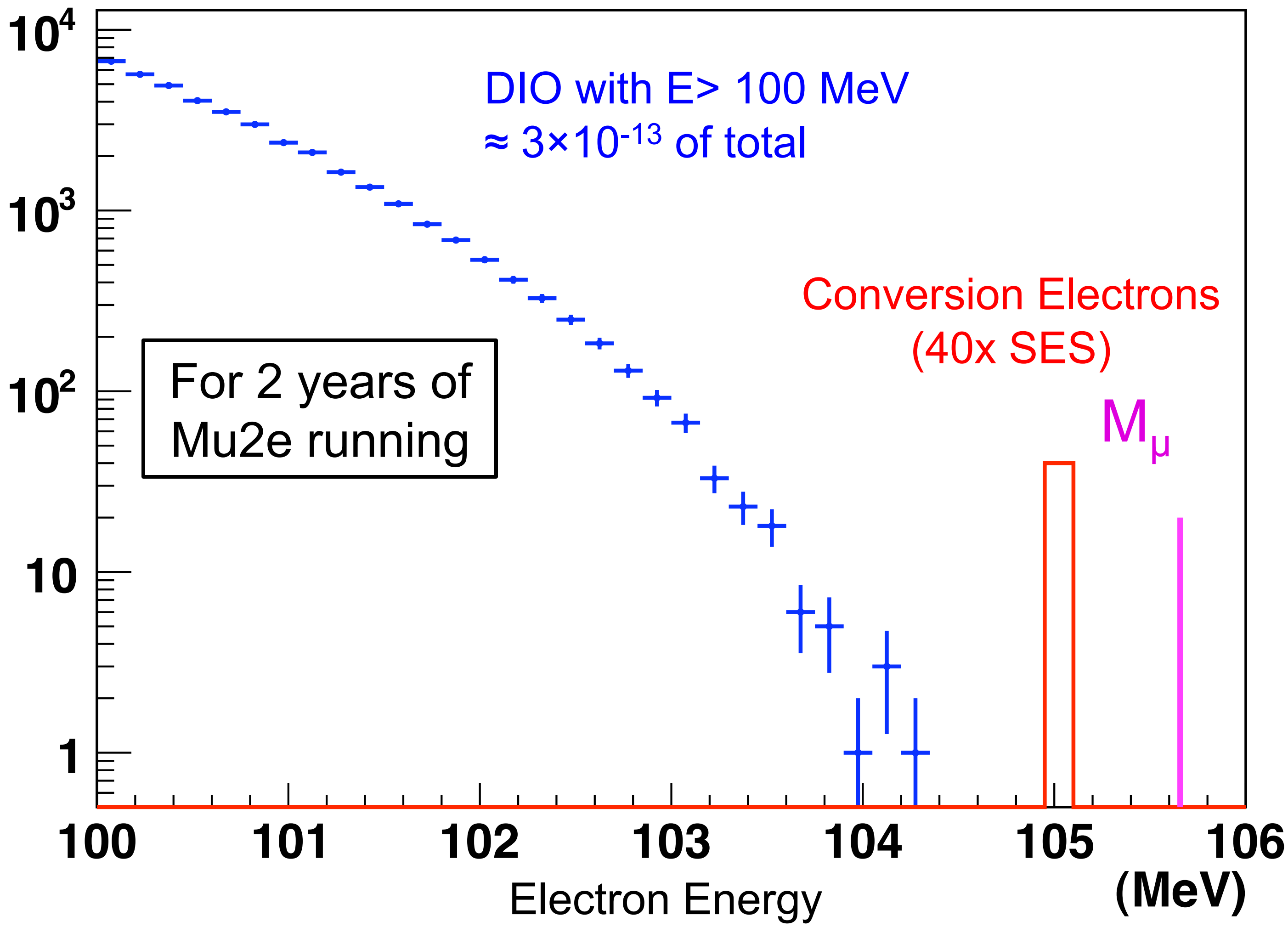
Decay-in-Orbit: Dominant Background







EndPoint in a Perfect Detector

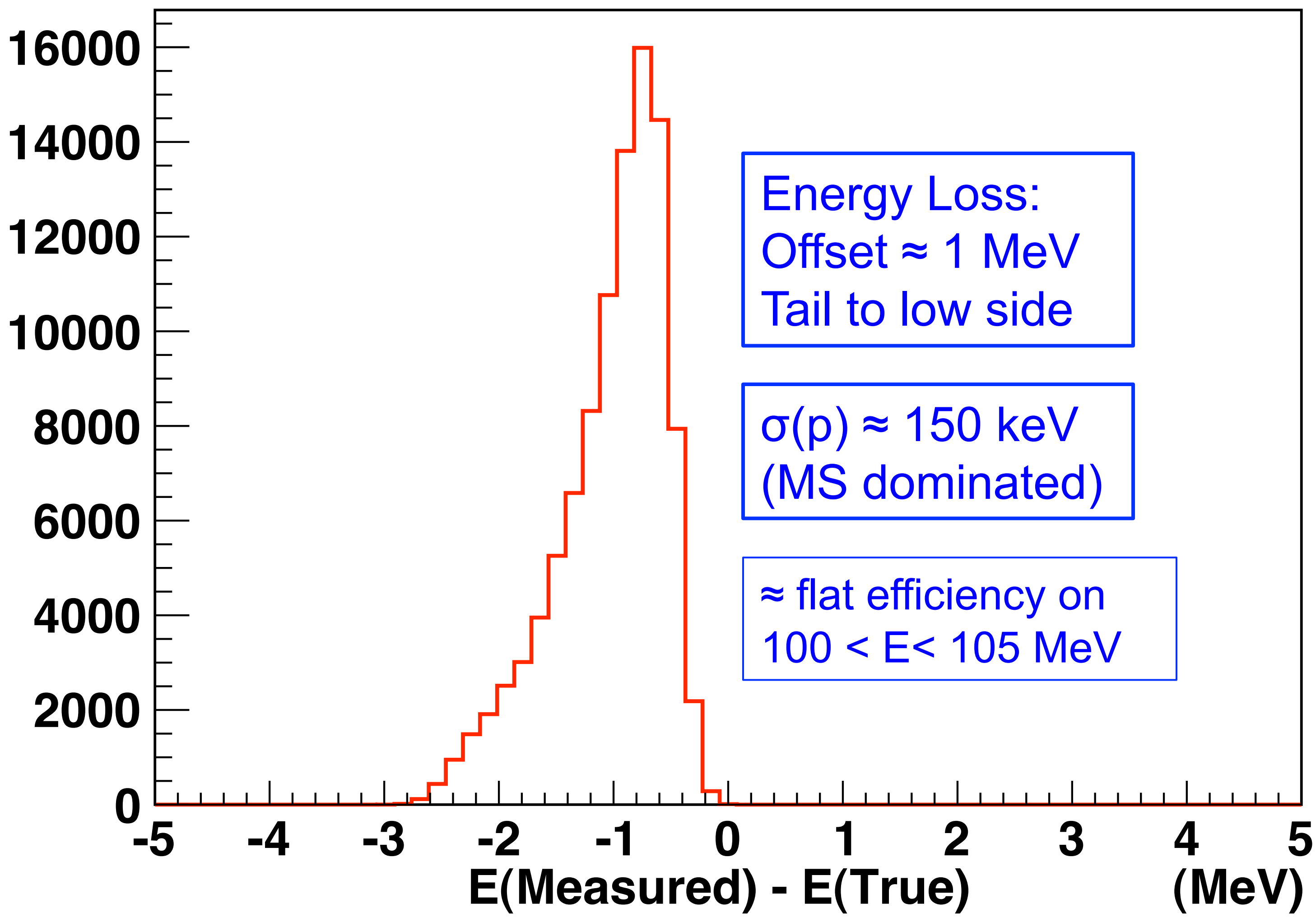


SES = Single Event Sensitivity.

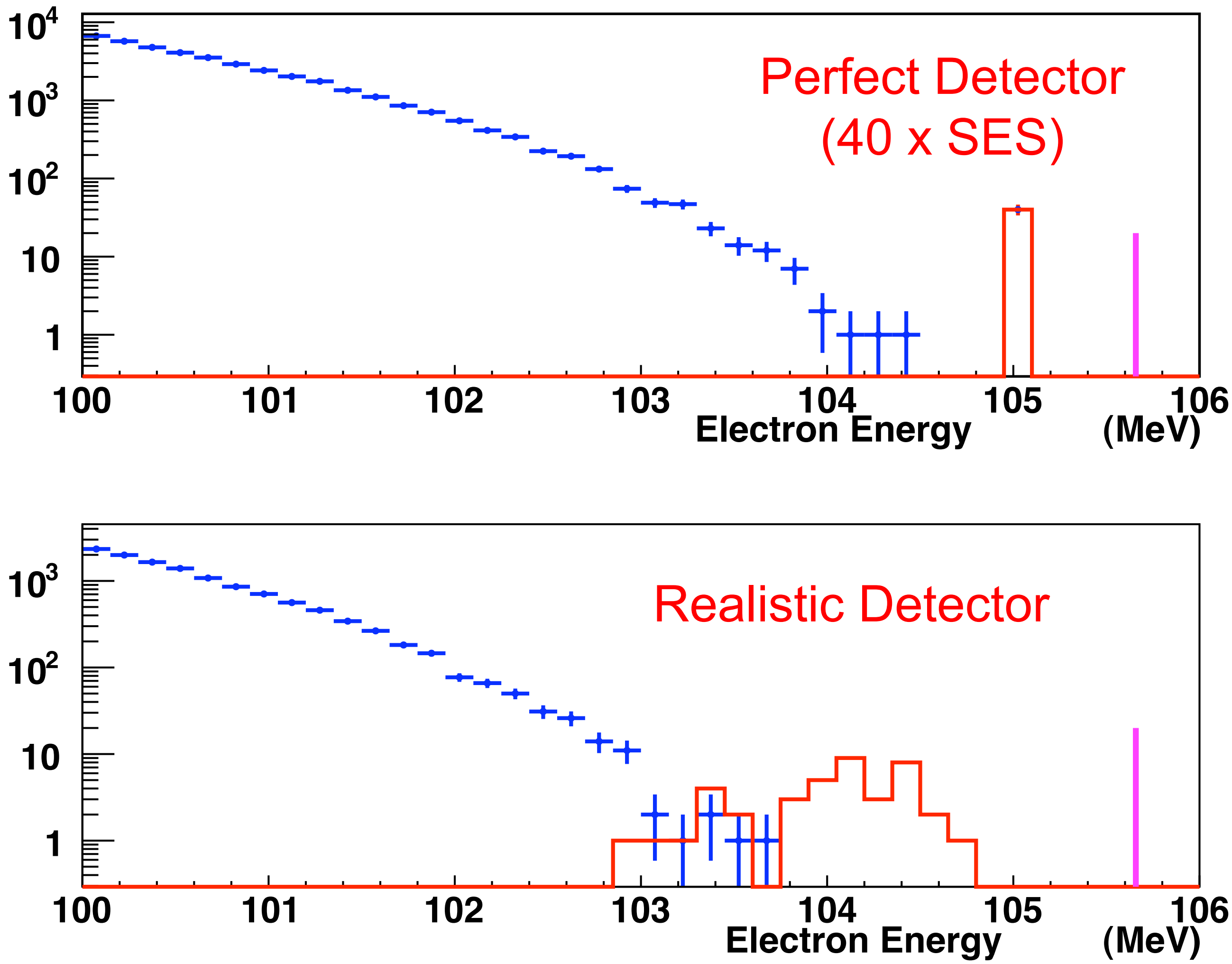
Comments On Previous Slide

- Bin size ≈ resolution
- Data points are random draw from the theory spectrum.
- Shift in signal from muon mass:
  - K shell binding energy
    - Gets bigger with bigger Z
  - Recoil of nucleus
    - Gets smaller with bigger A

Cartoon of Detector Response



Cartoon Including Detector Effects

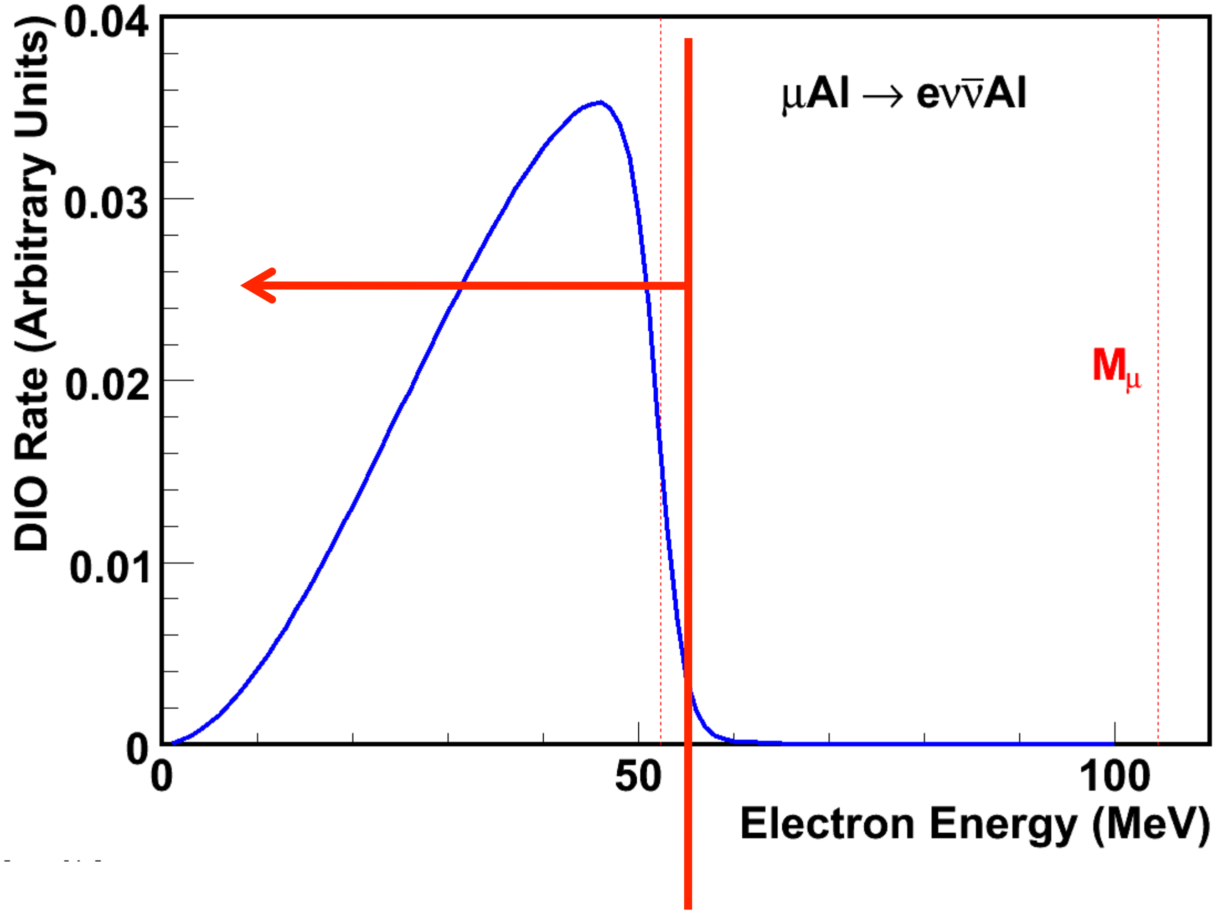


What Will We Measure?

$$R_{\mu e} = \frac{\Gamma(\mu^- + (A,Z) \to e^- + (A,Z))}{\Gamma(\mu^- + (A,Z) \to \nu_\mu + (A,Z-1))}$$

- Numerator:
  - Do we see an excess at the E_e end point?
- Denominator:
  - Normal muon capture on Al; muonic X-ray cascade.
- Sensitivity for a 2 year run (2×10^7 seconds).
  - $\approx 2.3 \times10^{-17}$ single event sensitivity.
  - $< 6 \times10^{-17}$ limit at 90% C.L.
- 10,000 × better than previous limit (SINDRUM II).

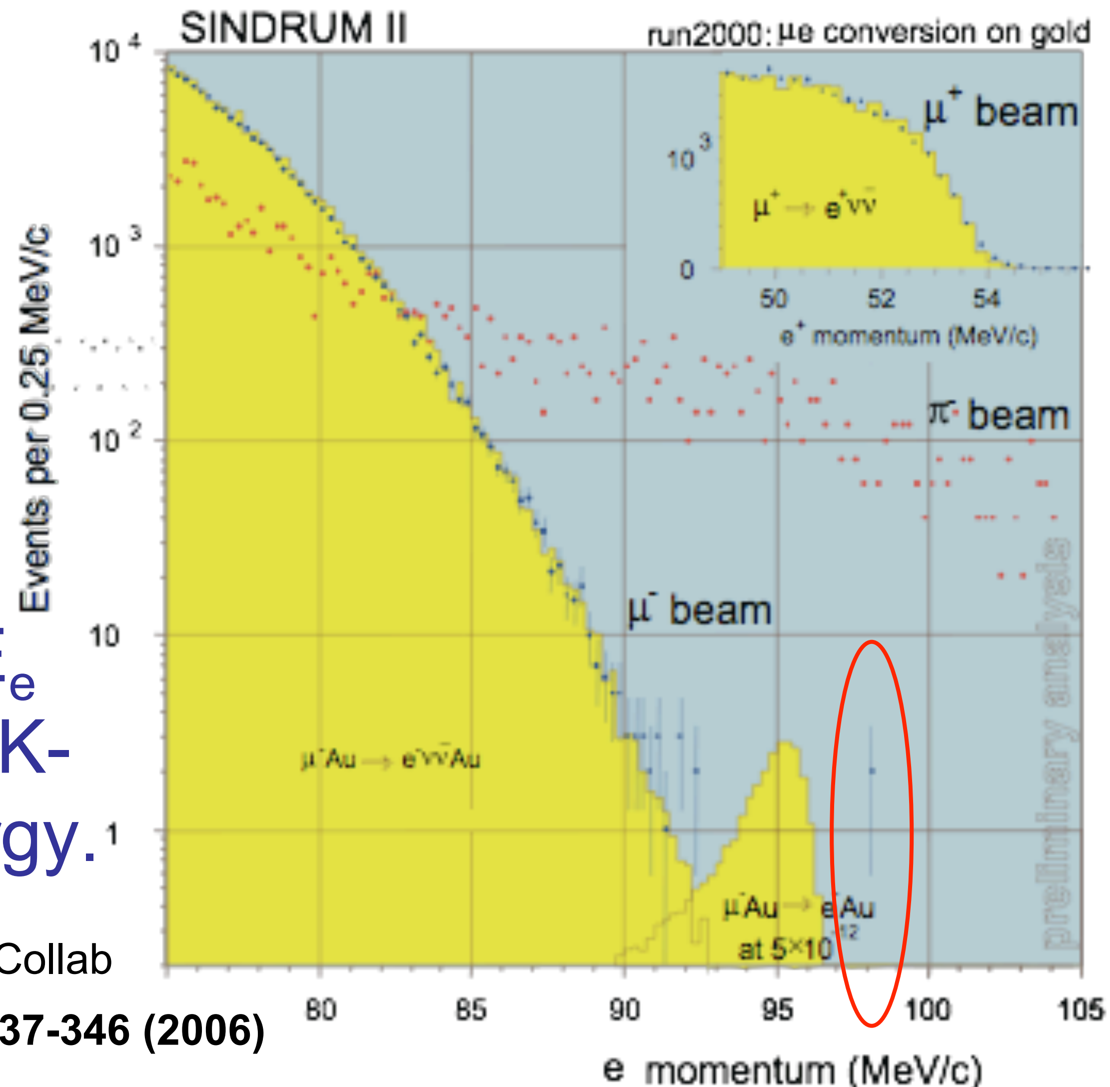
How do you measure 2.3×10^{-17} ?



Make a detector that is blind to most of the DIO spectrum.
Curl them up in a 1 T magnetic field.

Previous Best Experiment

- SINDRUM II
- $R_{\mu e} < 6.1\times10^{-13}$ @90% CL
- 2 events in signal region
- Au target: lower E_e endpoint than Al, K-shell binding energy.



HEP 2001 W. Bertl – SINDRUM II Collab

W. Bertl et al, Eur. Phys. J. C **47, 337-346 (2006)**

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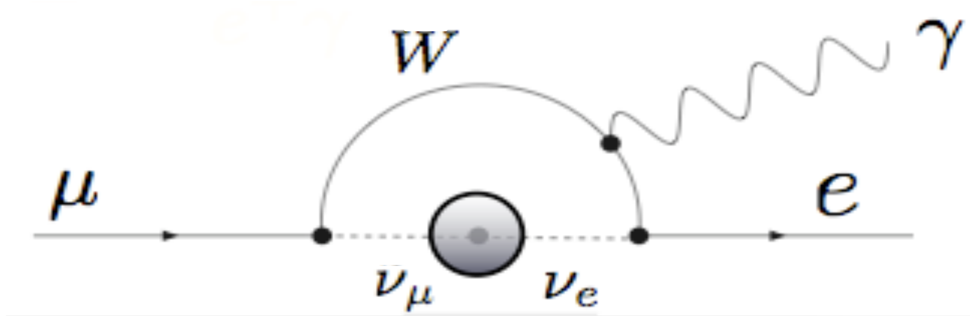
Rates in the Standard Model

- With massive neutrinos, non-zero rate in SM.
- Too small to observe.



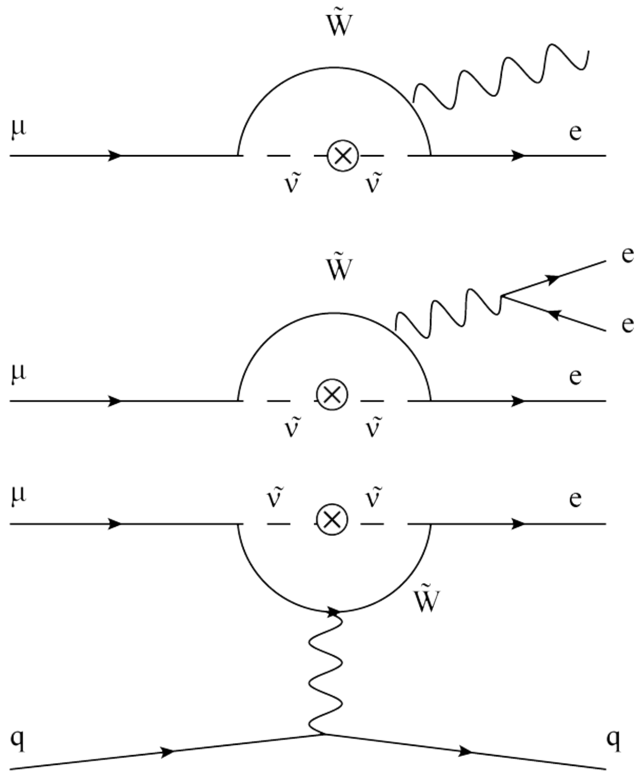
$$\mathrm{BR}(\mu \to e\gamma) = \frac{3\alpha}{32\pi}\left|\sum_{i=2,3} U^*_{\mu i} U_{ei} \frac{\Delta m^2_{1i}}{M^2_W}\right|^2 < 10^{-54}$$

CLFV in Muon Decays

$$\mu^- \rightarrow e^- \gamma$$

$$\mu^- \rightarrow e^- e^+ e^-$$

$$\mu^- N \rightarrow e^- N$$

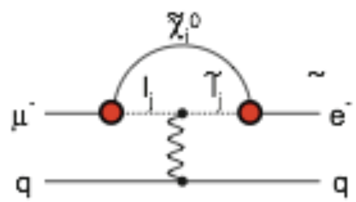


- Loops shown with SUSY; also works with heavy ν.
- If loops dominate over contact terms, then rates follow ≈ 400: 2: 1
- Contact terms do not produce μ➔eγ; so conversion can dominate over μ➔eγ .

Contributions to μe Conversion

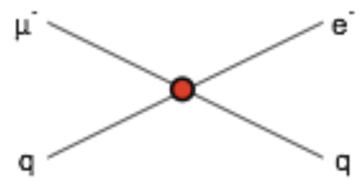
Supersymmetry

rate ~ 10^{-15}



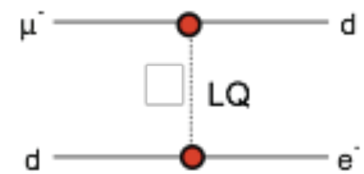
Compositeness

Λ_c ~ 3000 TeV



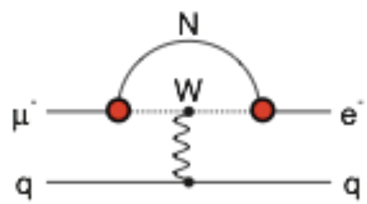
Leptoquark

$M_{LQ} = 3000\ (\lambda_{\mu d}\lambda_{ed})^{1/2}$ TeV/c^2



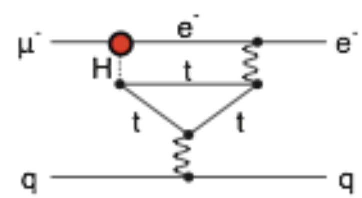
Heavy Neutrinos

$|U_{\mu N}U_{eN}|^2 \sim 8\times10^{-13}$



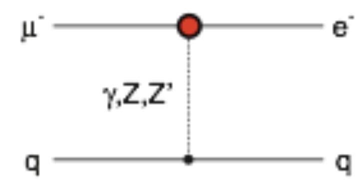
Second Higgs Doublet

$g(H_{\mu e}) \sim 10^{-4} g(H_{\mu\mu})$



Heavy Z' Anomal. Z Coupling

$M_{Z'}$ = 3000 TeV/c^2



Sensitive to mass scales up to O(10,000 TeV)!

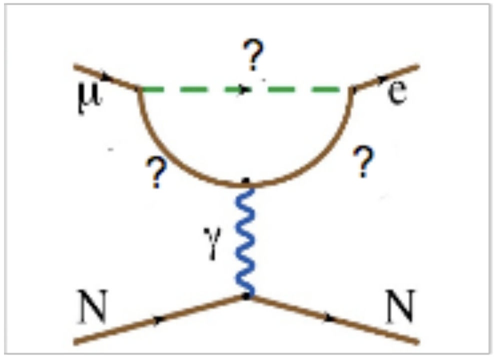
Do not contribute to μ→eγ

See Flavour physics of leptons and dipole moments, arXiv:0801.1826

Parameterizing CLFV

$$L_{\mathrm{CLFV}} = \frac{m_\mu}{(\kappa+1)\Lambda^2}\bar{\mu}_R\sigma_{\mu\nu}e_L F^{\mu\nu} + \frac{\kappa}{(1+\kappa)\Lambda^2}\bar{\mu}_L\gamma_\mu e_L(\bar{u}_L\gamma^\mu u_L + \bar{d}_L\gamma^\mu d_L)$$

Loops

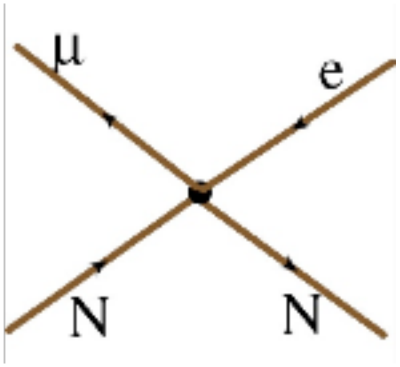


Contributes to μ→eγ

SUSY and massive neutrinos

Dominates if κ<<1

Contact terms



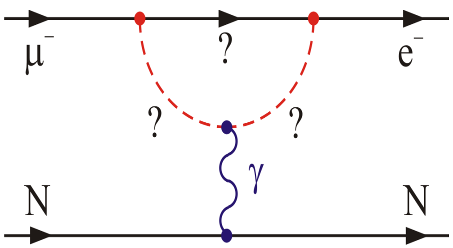
Does not produce μ→eγ

Exchange of a heavy particle

Dominates if κ>>1

Sensitivity to High Mass Scales

Loops



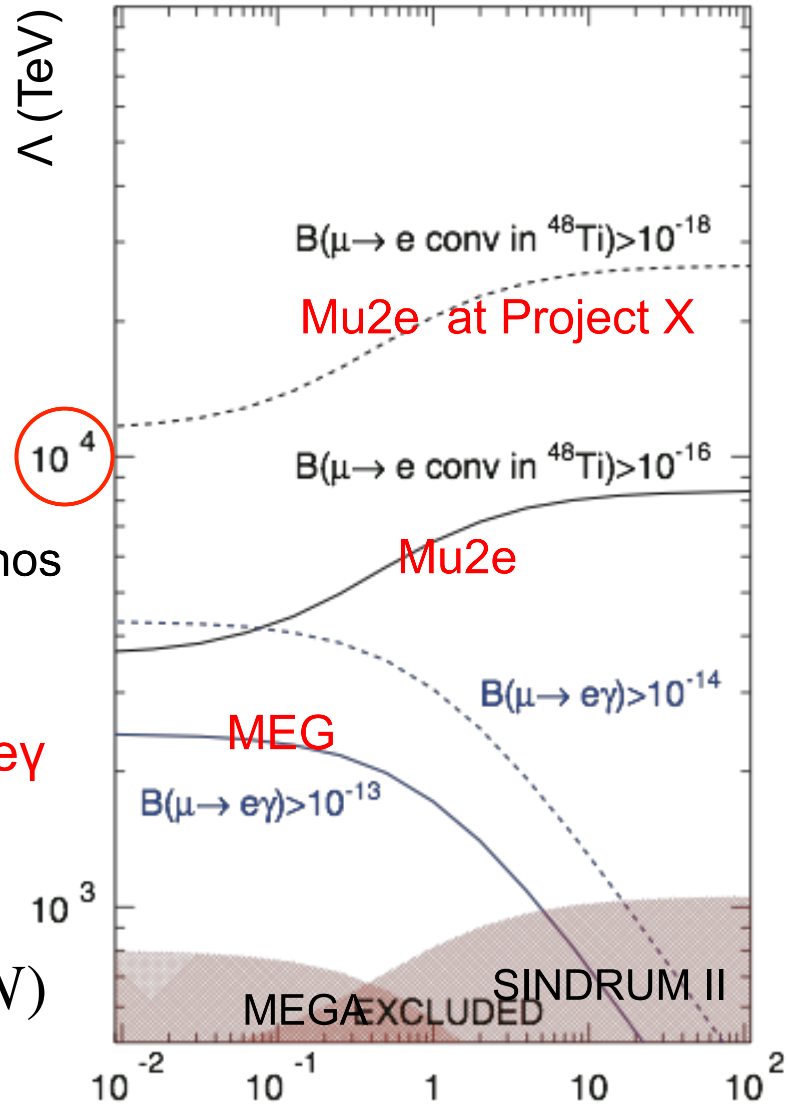
SUSY; massive neutrinos

Dominates if κ<<1

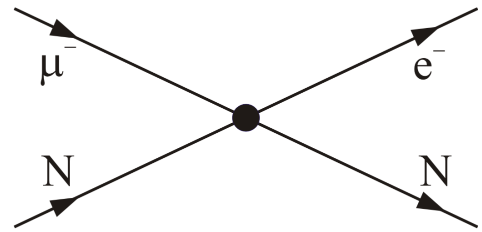
Contributes to μ→eγ

$$\Gamma(\mu \to e\gamma)$$

$$\approx 300\ \Gamma(\mu N \to eN)$$



Contact terms



Exchange of a new massive particle

Dominates if κ>>1

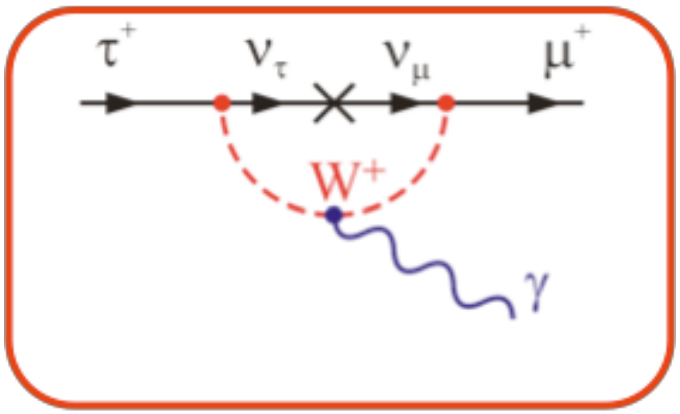
Does not produce μ→eγ

$$\Gamma(\mu N \to eN)$$

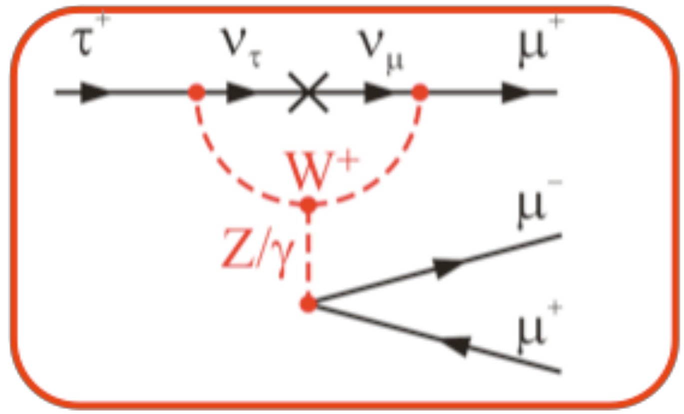
$$>> \Gamma(\mu \to e\gamma)$$

CLFV in Tau Decays

Lee, Shrock
Phys.Rev.D16:1444,1977



SM ~ 10^{-40}



SM ~ 10^{-14}

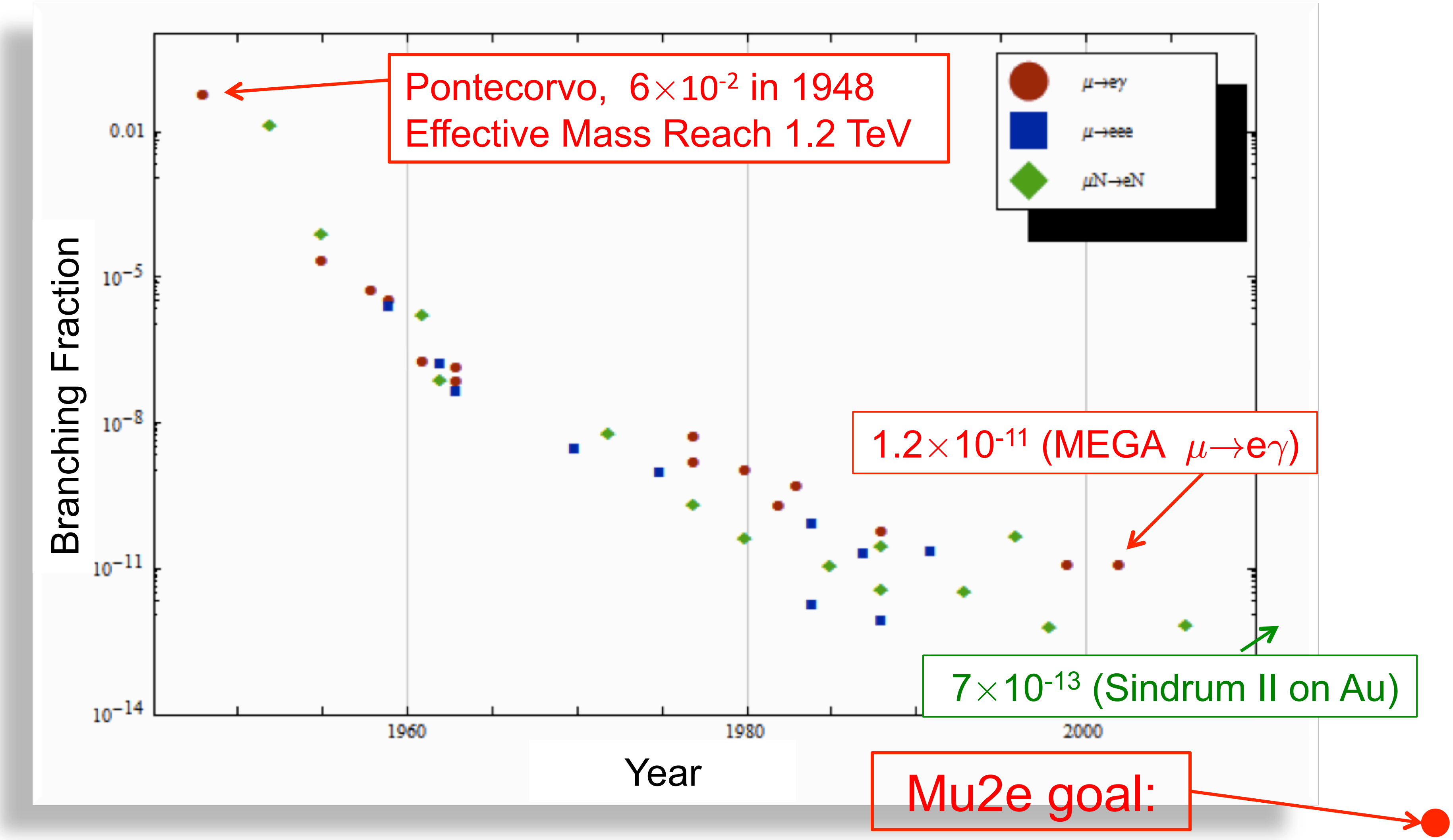
Pham, hep-ph/9810484

Beyond SM Rates higher than for muon decay; milder GIM suppression.

But only O(10^9 tau/year) at B factories, compared to 10^{11} muon/s at Mu2e/COMET.

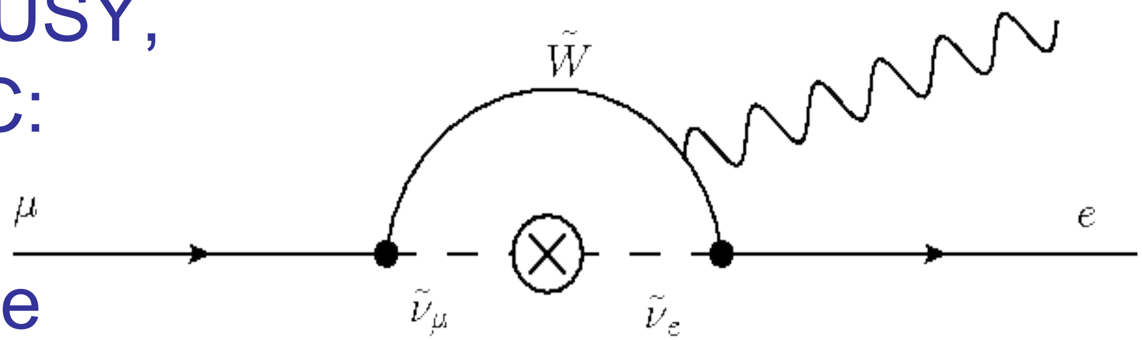
- BaBar/Belle/CLEO working on CLFV in tau decay.
- Also in B and D decay.

History of μ LFV Measurements



LFV and SUSY at the LHC

- For low energy SUSY, accessible at LHC: Rμe ≈ O(10^{-15})
- At Mu2e this same physics gives, for a 2 year run:
  - ≈ O(40) events on a background of ≈ 0.5 events.



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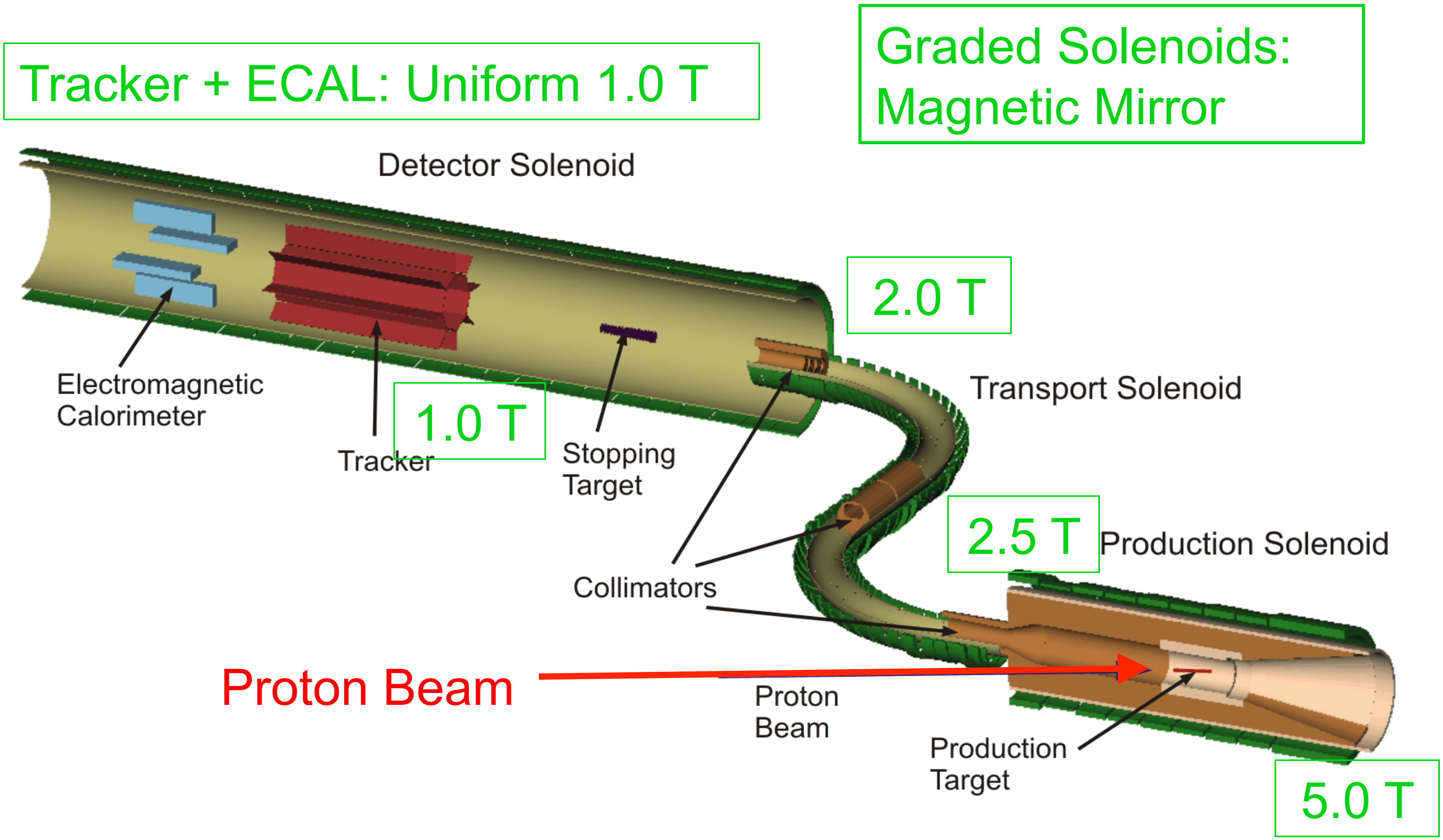
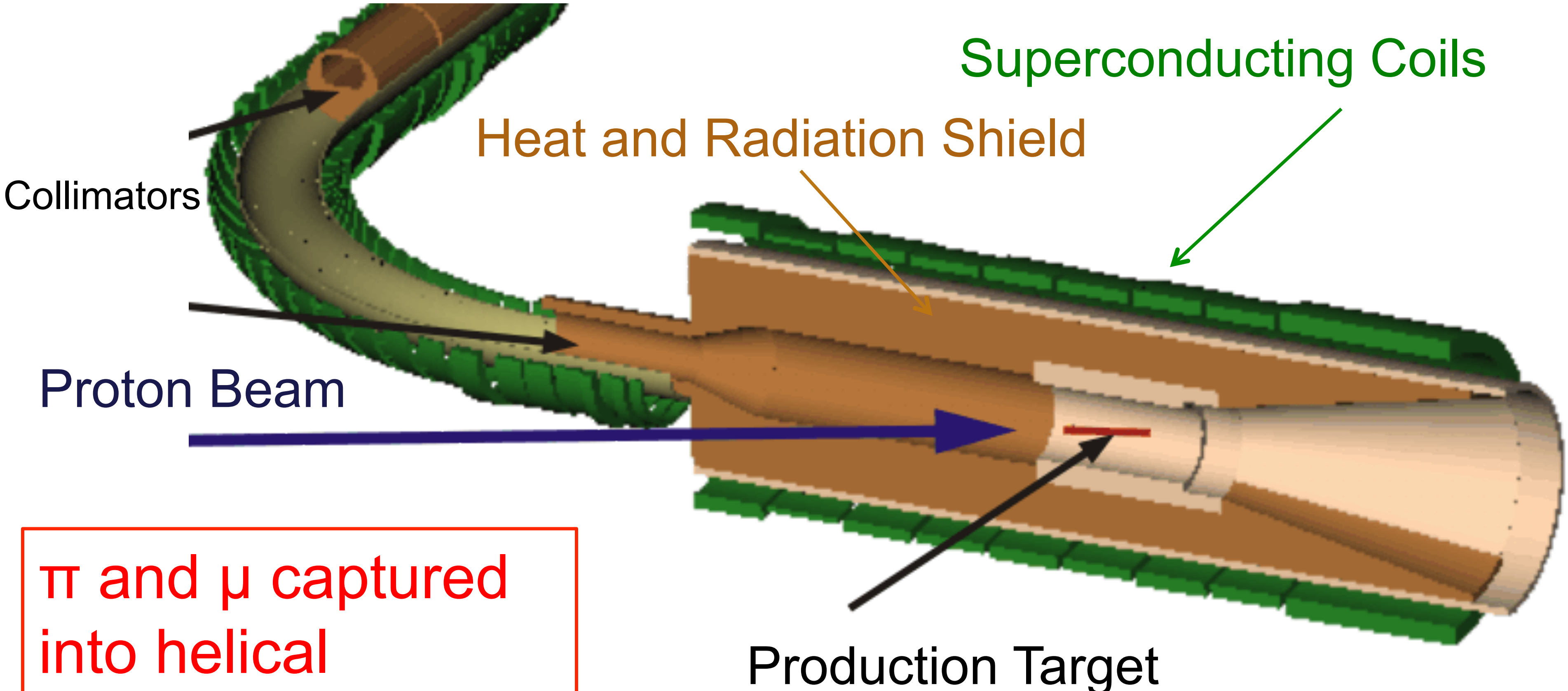
Intellectual Precursors

- 1992:
  - Collection scheme using solenoids proposed by MELC collaboration at Moscow Meson Factory.
- 1997-2005:
  - MECO proposed to run a BNL.
  - Cancelled when entire RSVP program was cancelled.
  - Mu2e design starts from MECO design.

A Back-scattered Muon Beam



Production Solenoid

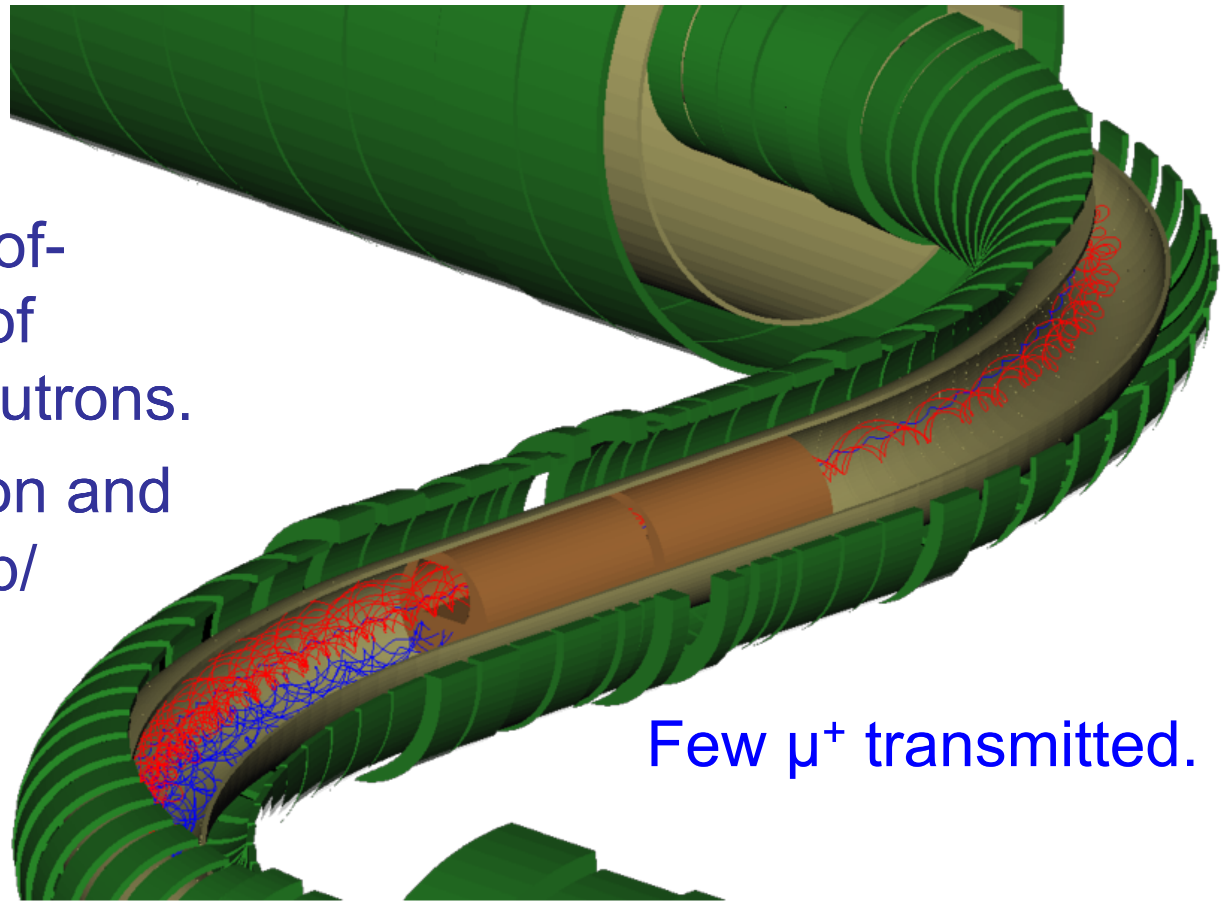


π and μ captured into helical trajectories

$$p\ Au \rightarrow \pi^{-} X \rightarrow \mu^{-} X$$

Transport Solenoid

- Curved solenoid:
  - Eliminates line-of-sight transport of photons and neutrons.
  - Negative/position and particles shift up/down.
- Collimators sign and momentum select the beam.

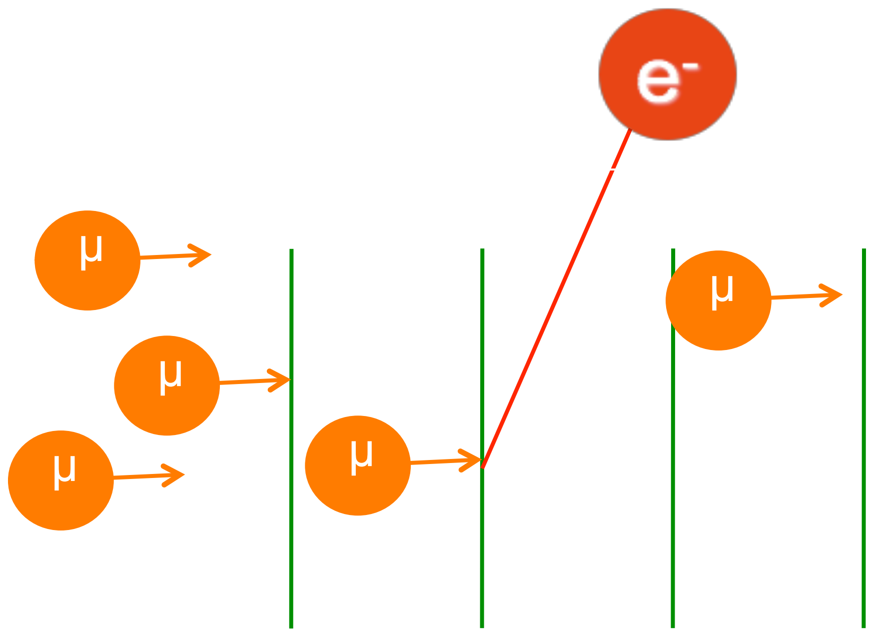


Few μ^+ transmitted.

13.1 m along axis × ~*0.25 m* radius

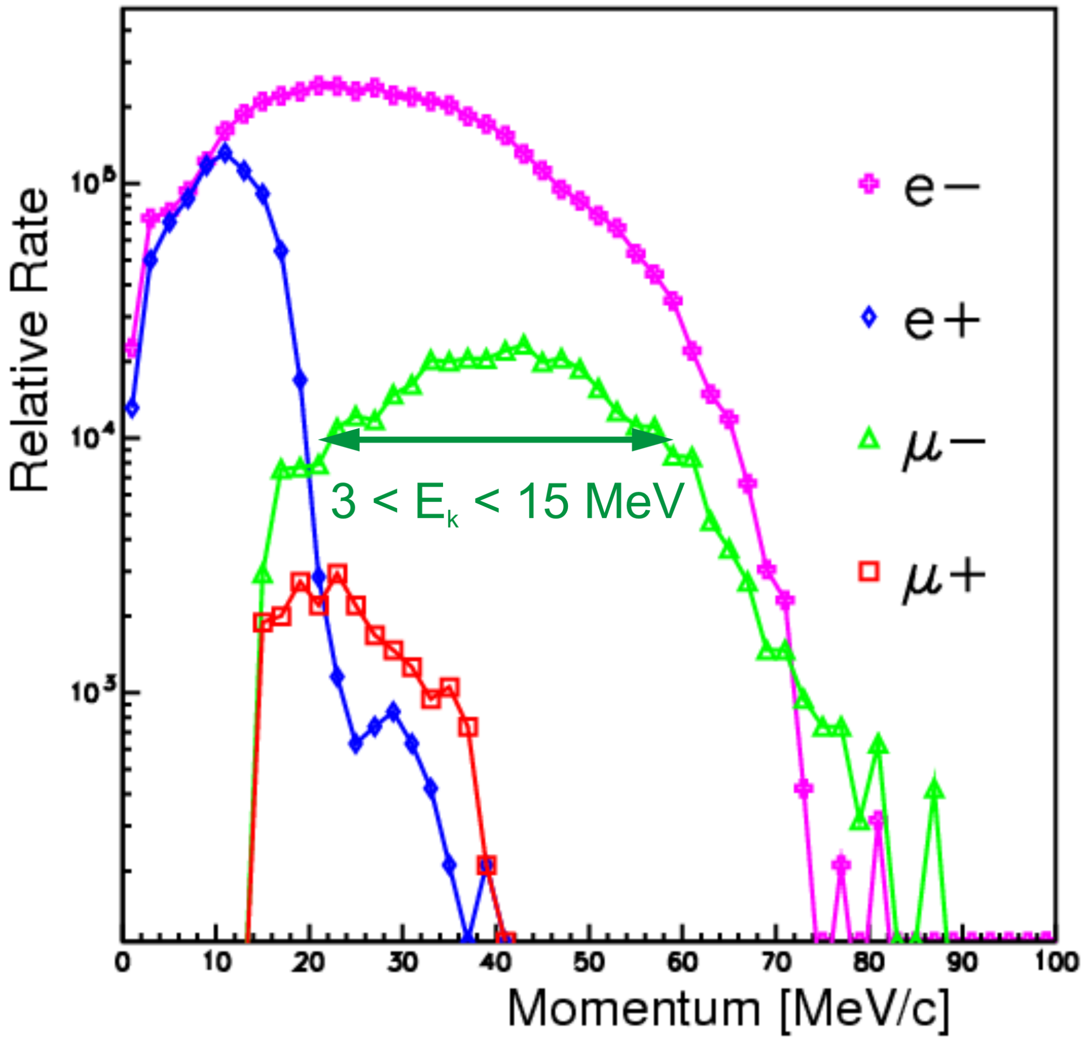
At the Stopping Target

- Pulse of low energy μ^- on thin Al foils.
- 1 stopped μ^- per 400 protons on production target.
  - X-ray cascade emitted during capture: normalization!
- Electrons pop out of foils (lifetime of 864 ns)



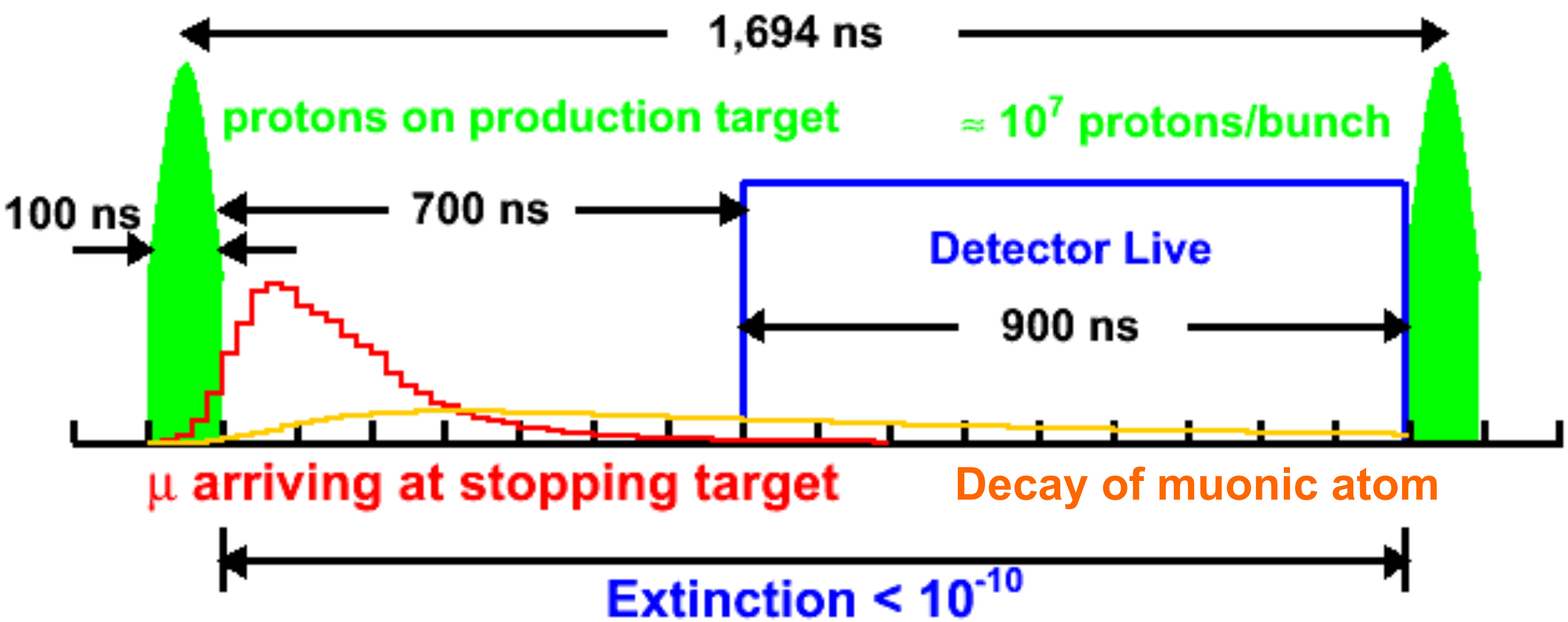
- 17 target foils
- 200 microns thick
- 5 cm spacing
- Radius:
  - ≈10. cm at upstream
  - ≈6.5 cm at downstream

Particle Content of Muon Beam



- Plus pions, which are an important source of background.

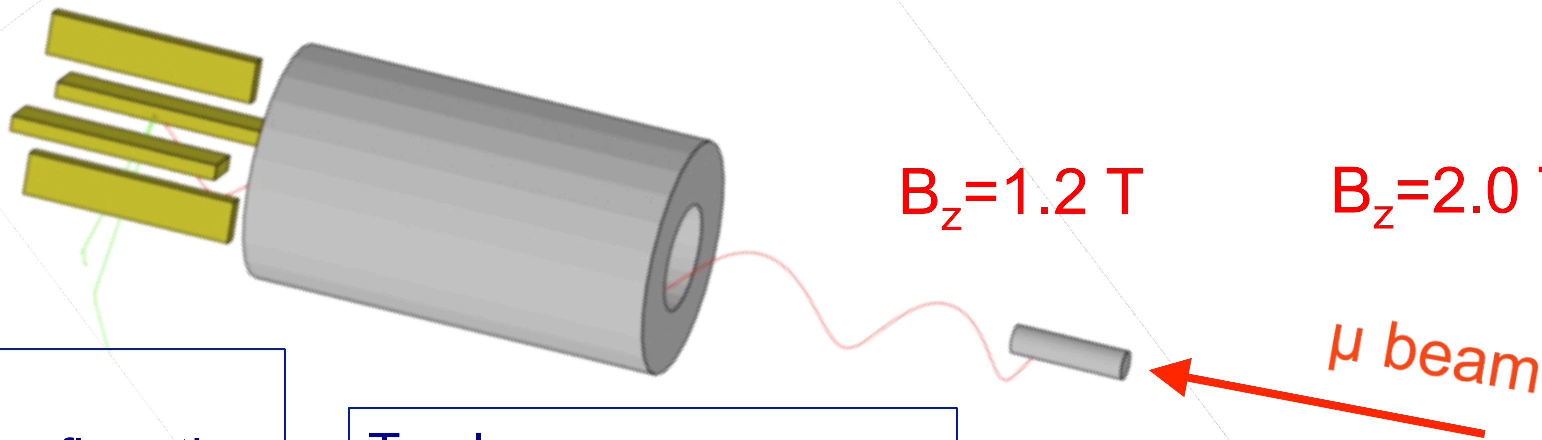
One Cycle of the Muon Beamline



- μ^- accompanied by e^-, e^+, π^-, …; prompt backgrounds
- "Extinction" required to reduce backgrounds.
  - 1 out of time proton per 10^{10} in time protons.
- Lifetime of muonic Al: 864 ns.

Detector Solenoid and Detector

B_z=1.0 T uniform field in Tracker + ECal



ECAL:
Trigger + confirmation of a real track.

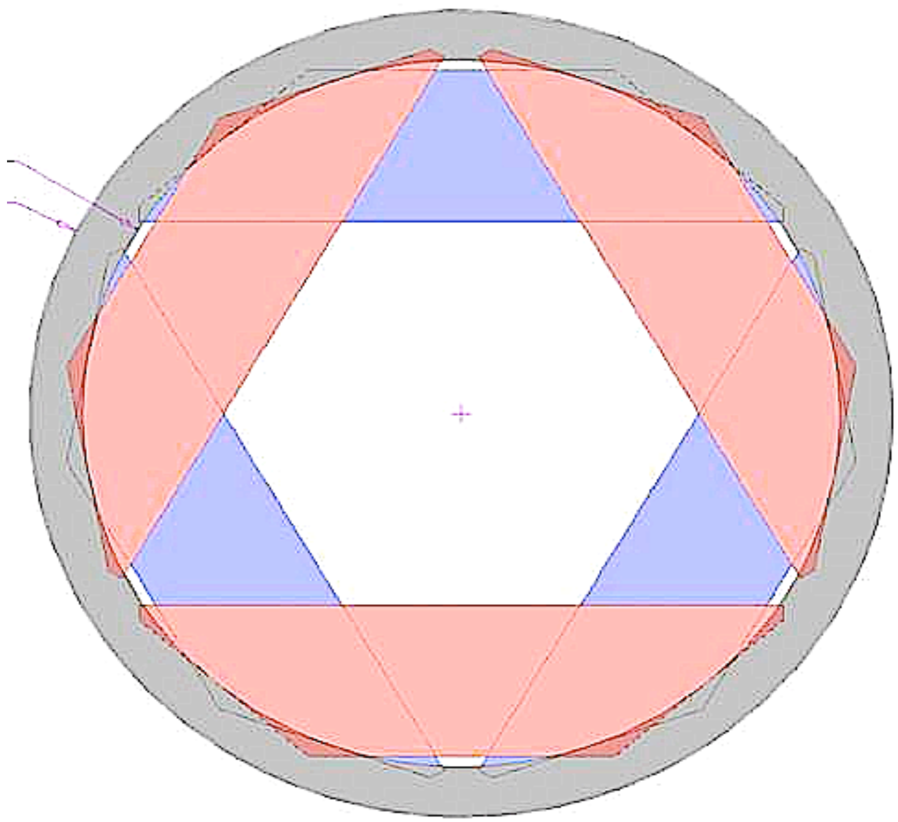
Tracker:
Precision momentum measurement:

Stopping target:
In graded field

Require:
σ(p) ≈ 150 keV at p=105 MeV

Useful tracks make 2 to 3 turns inside the tracker.

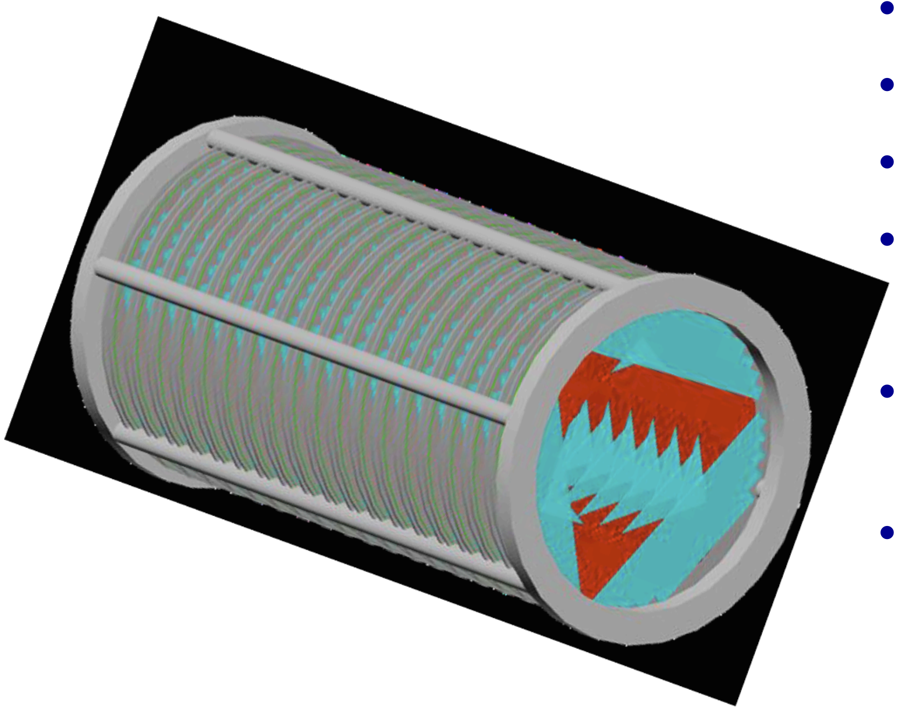
T-Tracker (T=Transverse)



Electrons spiral into the page.

- Straw planes in vacuum.
- Basic unit: plane
  - 3 panels each side
  - 2 layers per panel
  - 50 straws per layer
- Station
  - 2 planes close packed
  - 30 degree rotation
- Tracker
  - 18 Stations
- Most DIO electrons pass through central hole.

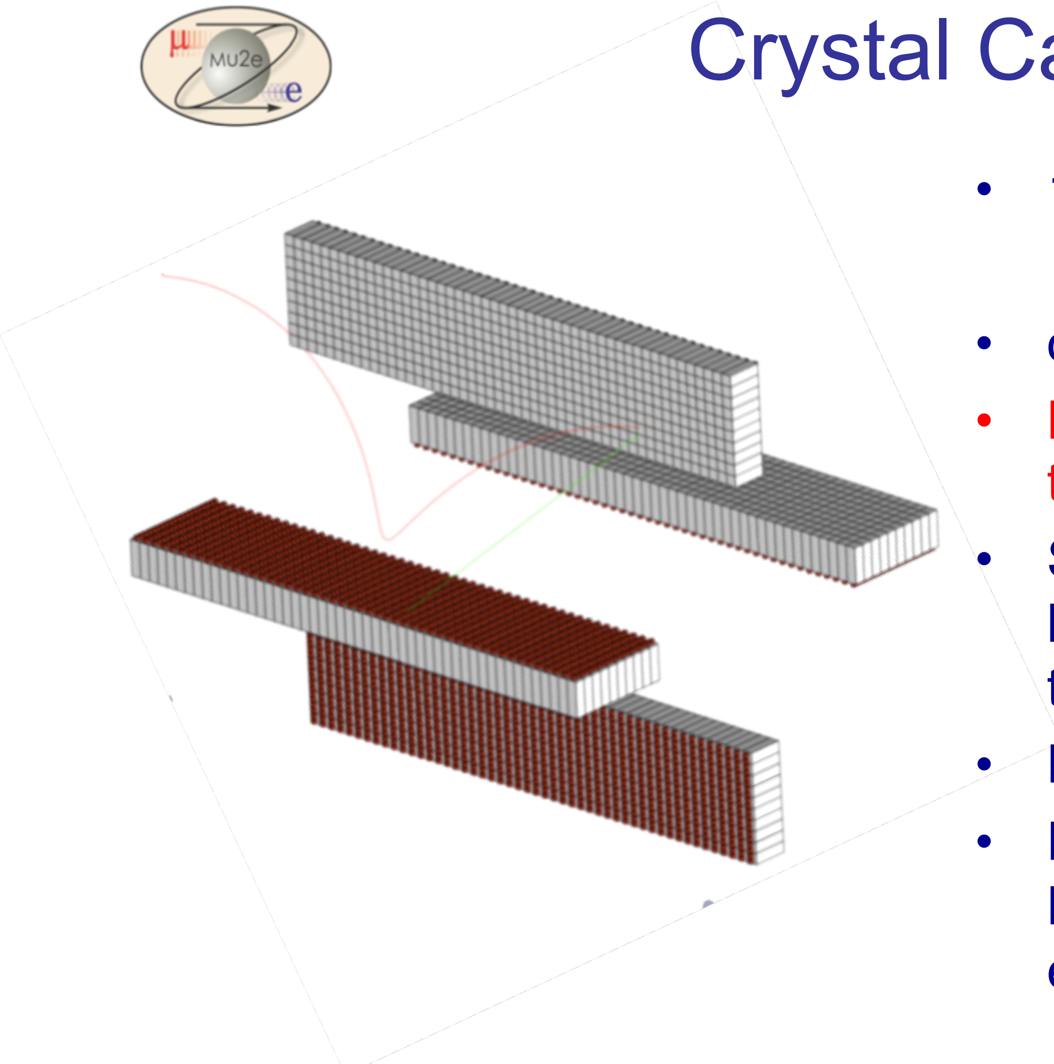
T-Tracker (T=Transverse)



- Preferred alternative.
- 70-130 cm long; 5 mm diameter.
- Rates demonstrated in KTeV.
- Possible time division
  - For pattern recognition.
- Straw ends are outside of the fiducial volume: support and readout easier.
- Issues:
  - Robust pattern recognition not yet demonstrated.
    - High priority to do so.

- Alternate tracker designs
  - L-Tracker (MECO style)
  - I-Tracker (Drift chamber)

Crystal Calorimeter



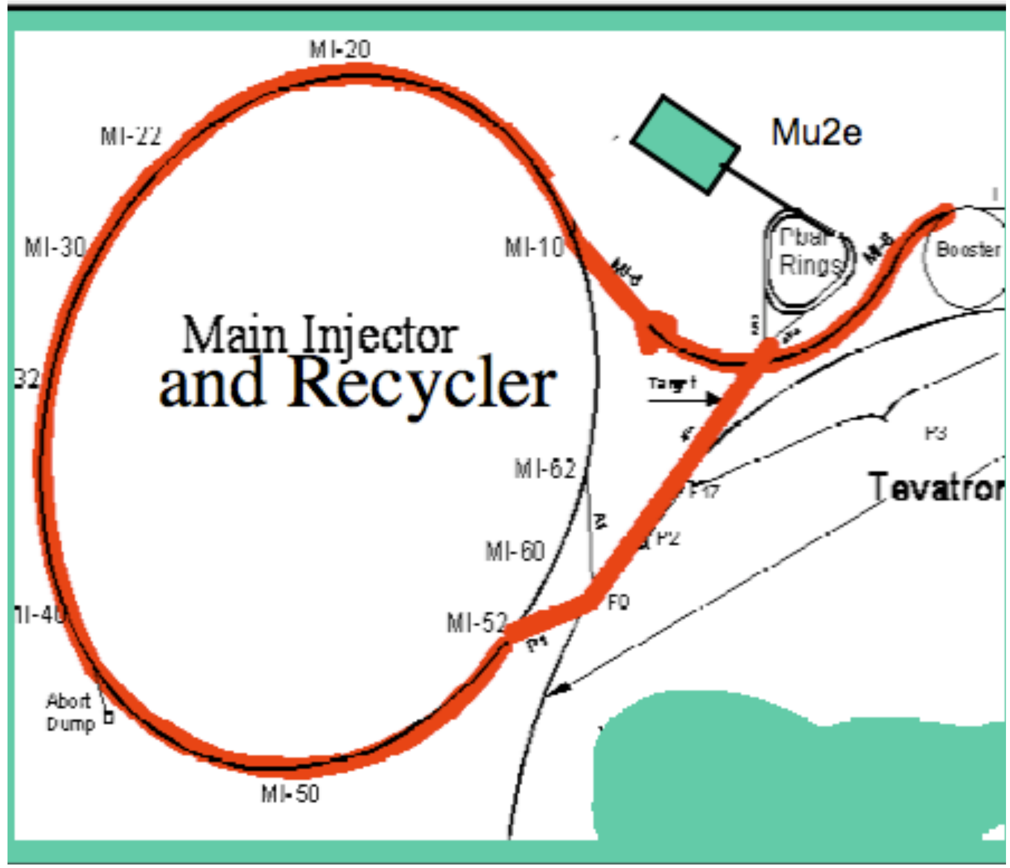
- 1024 $PbWO_4$ crystals.
  - 3.5×3.5×12 cm
- σ(E) ≈ 5 MeV at 105 MeV.
- Main job is to trigger on interesting tracks.
- Spatial match of extrapolated track will help reject badly mis-reconstructed tracks.
- Most tracks from DIO curl inside.
- Pisa and LNF groups evaluating LXe, LSO, LYSO which might provide good enough σ(E/p) to be interesting.

Other Detector Systems

- Active Cosmic Ray Veto
  - Requirement: 99.99% efficiency to veto cosmic rays.
  - 3 Layers of 1 cm thick scintillator;
    - MINOS Style WLS fiber readout.
  - Option: RPC if n flux gives high dead time.
- Muon Capture Monitor
  - One way to get at the denominator in Rμe.
  - Measure X-ray lines from muon capture on Al.
  - Ge detector located downstream of main beam dump.
  - Views target foils via tiny bore holes.

Proton Delivery and Economics

- Reuse existing Fermilab facilities with modest modifications.
- p-bar complex: 2 rings.
  - Use one ring as a “stash”.
  - Slow spill from the other.
  - 90% duty cycle slow spill.
  - Other schemes under study.
- Sharing p’s with NOVA:
  - NOVA 12/20 booster cycles.
  - Mu2e will use 6/20 cycles.



Making a stable, slow spill with a very intense proton beam is a big challenge (space charge tune shift).

Outline

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Major Backgrounds

- From stopped μ^-
  - Decay in orbit (DIO) close to end point.
    - Irreducible component.
    - Mismeasured DIOs can smear into the signal region.
  - See cartoons pages 12, 14.
- Beam related (aka “prompt”):
  - Radiative π^- capture.
  - μ^- decay in flight + scatter in target.
  - e^- scattering out of beam.
- Cosmic rays

Radiative π^- Capture

$$\pi^- N(A,Z) \rightarrow \gamma X$$

- End-point of $E\gamma$ spectrum is $m(\pi)$.
- Asymmetric conversions (internal or in material) can produce electrons at all energies up to $m(\pi)$.
  - Includes the signal region.
- The limiting background in SINDRUM II
- Mitigate using pulsed beam with excellent extinction.

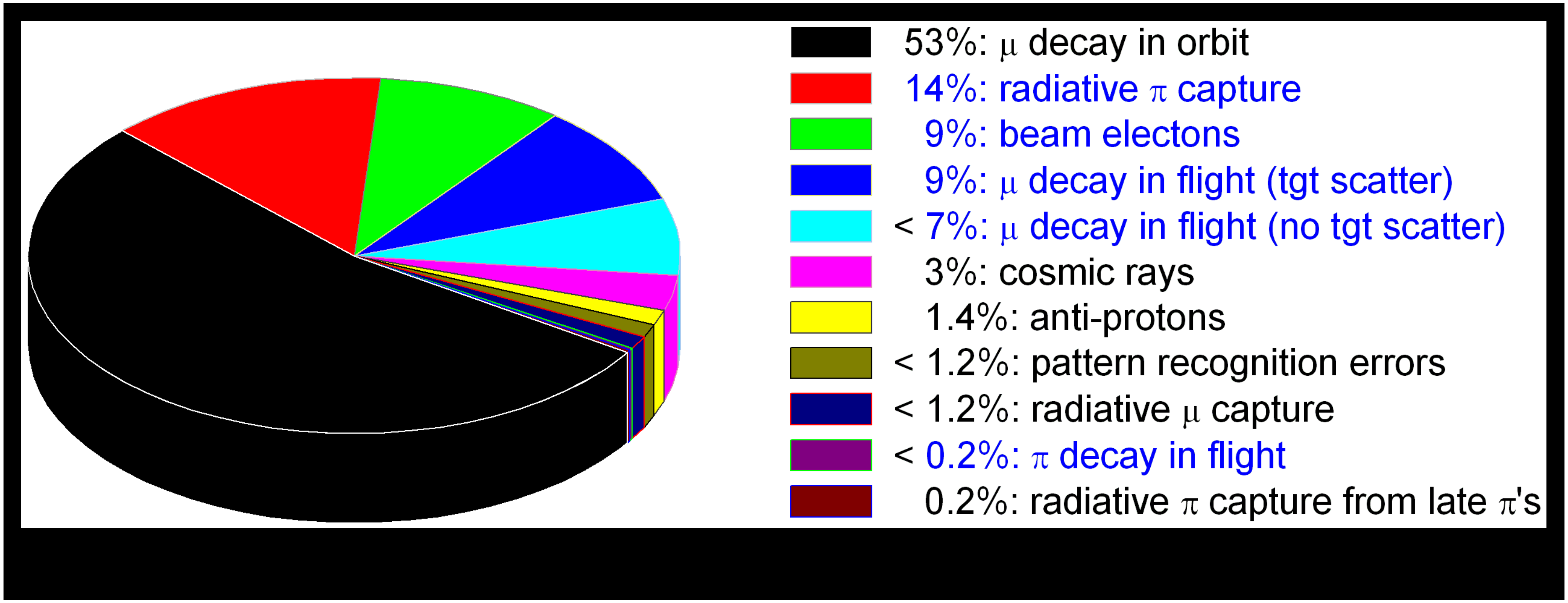
Backgrounds for 2×10^7 s Running

Source	Events	Comment
μ decay in orbit	0.225	
Radiative π^- capture*	0.063	From protons during detection time
Beam electrons*	0.036	
μ decay in flight*	0.036	With scatter in target
Cosmic ray induced	0.016	Assumes 10^{-4} veto inefficiency
Other	0.039	6 other processes
Total	0.42	

*: scales with extinction; values in table assume extinction of 10^{-10}.

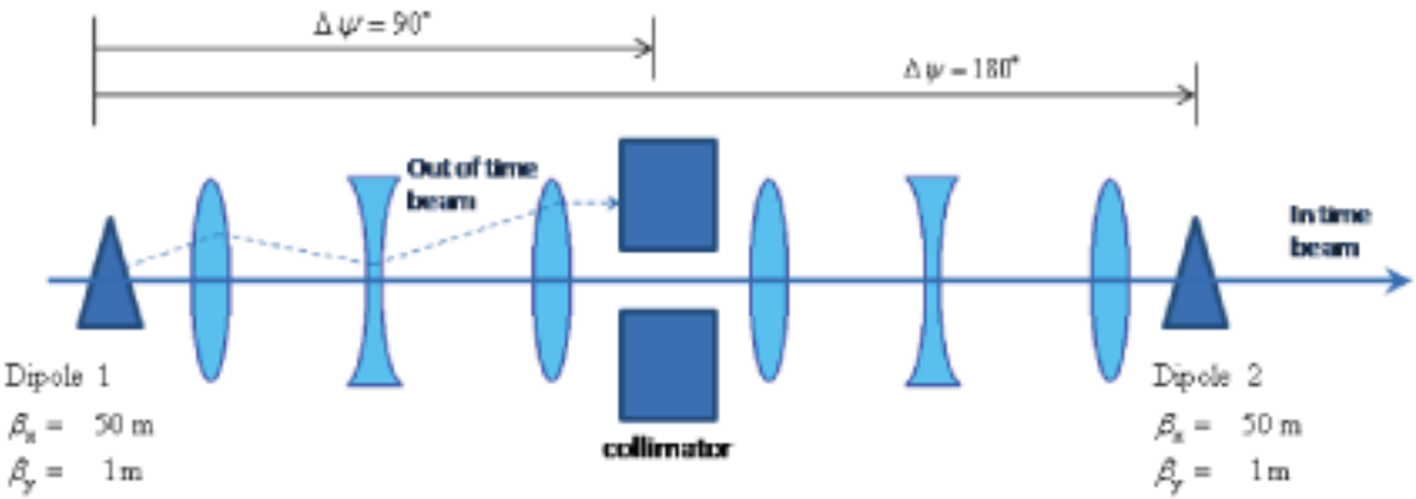
- Reduce DIO BG with excellent energy resolution, obtained by careful design of the tracker.
- Reduce next tier BGs with extinction.
- Reduce cosmic ray BG with shielding and veto.

All Estimated Backgrounds

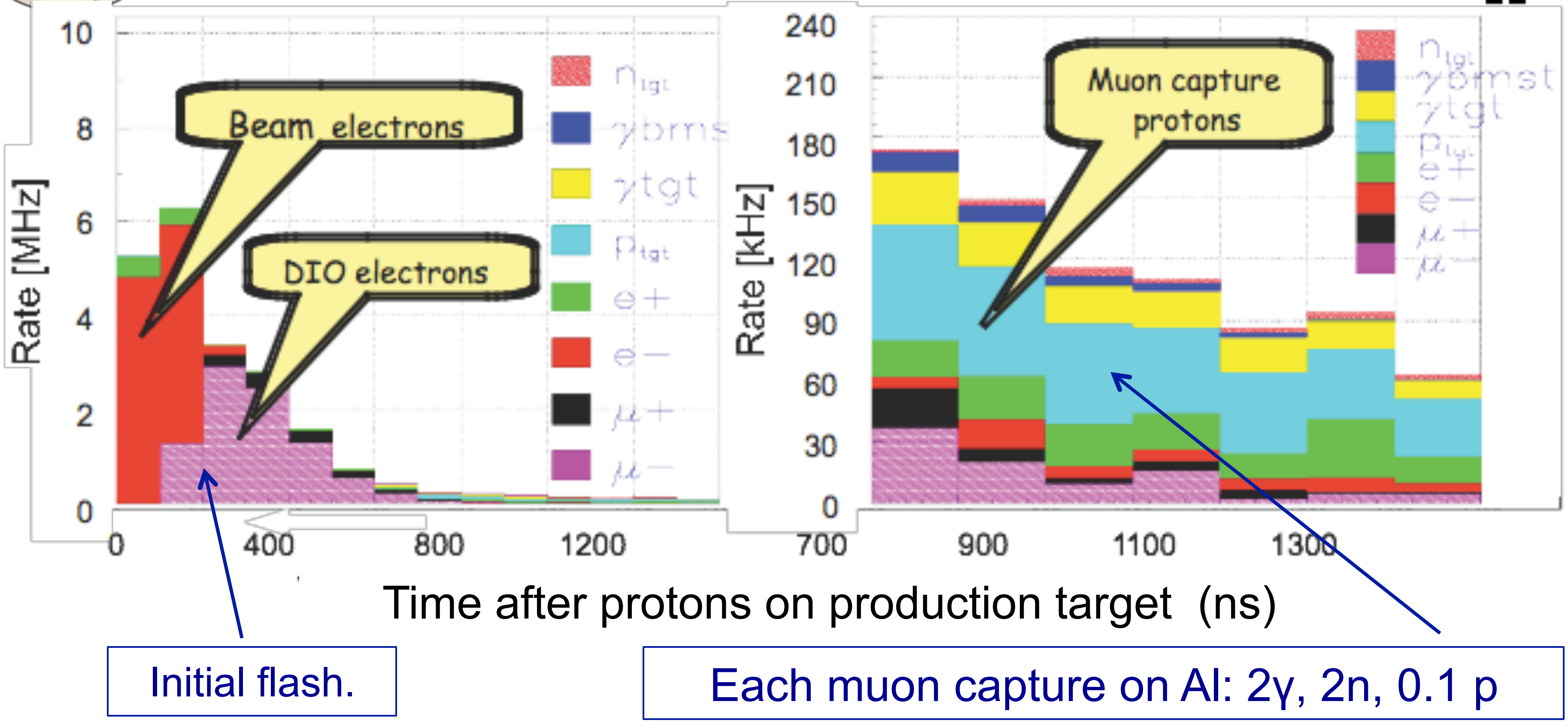


Required Extinction 10^{-10}

- Internal: 10^{-7} already demonstrated at AGS.
  - Without using all of the tricks.
  - Normal FNAL: 10^{-2} to 10^{-3}; but better has not yet been needed.
- External: in transfer-line between ring and production target.
  - Fast cycling dipole kickers and collimators.
- Monitoring techniques under study.



High Rates in the Tracker



- Option: shield p from μ capture; but shield degrades resolution.
- Must prove that tracker design will perform robustly at these rates.
- Rates in live window imply an occupancy of O(1%).

Attacking Backgrounds

- DIO: excellent momentum resolution
- Prompt: pulsed beam with high extinction
- Special runs to measure backgrounds and for calibration
  - Switch polarity: μ^+ beam.
  - Lower intensity and earlier live window.
  - Lower field, look for $\pi \rightarrow e\nu$ to get momentum scale.
  - Dedicated cosmic runs.
- Small standalone experiments
  - Learn how to measure the extinction.
  - Measure proton spectrum from μ^- capture on Al.
    - UIUC summer 2009 at PSI (ongoing).
  - Opportunities for university groups.

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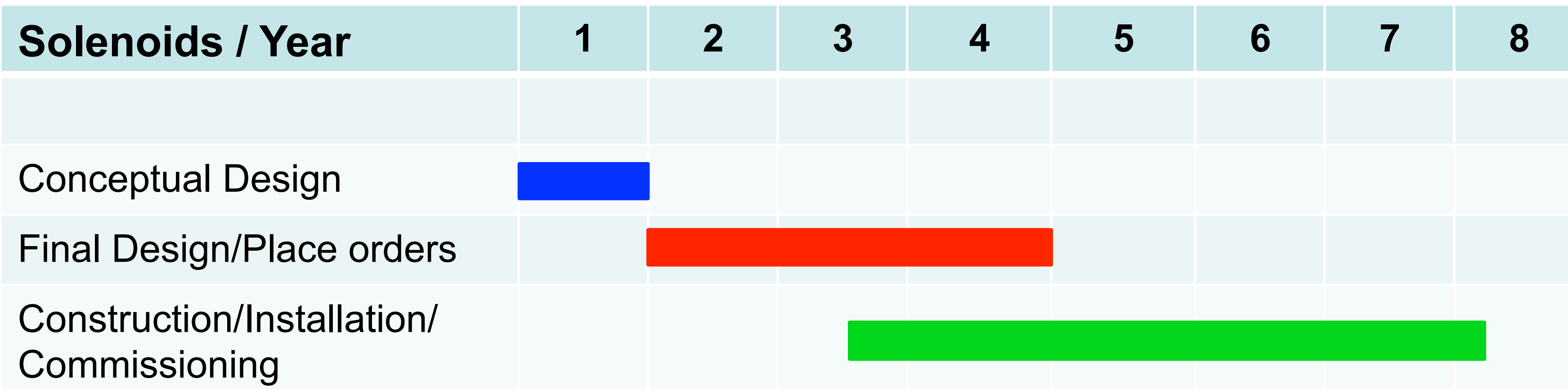
Estimated Cost and Schedule

- Estimated Total Project Cost O(M$200.).
  - Fully loaded, escalated. Overall contingency ≈50%.
- Critical path: solenoids.
  – Technically limited schedule:



- R&D going on now or soon.
  - PSI: products of μ capture on Al (more runs planned).
  - FNAL: Extinction tests; straw tests.

Fermilab 10 Year Plan

Programs / Projects	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19
Energy Frontier												
Tevatron: CDF	Operation				Data Analysis							
Tevatron: DZero	Operation				Data Analysis							
LHC: CMS			Operation									
LHC: ATLAS					Operation							
LHC Phase I Upgrade	R&D			Construction								
LHC Phase II Upgrade	R&D				Construction							
Lepton Collider	R&D					Decision	ILC	or CLIC/Muon Collider				
Intensity Frontier												
ν: SciBooNE		Data Analysis										
ν: MiniBooNE				Data Analysis								
ν: MicroBooNE	R&D	CD-0	CD-1/2	Construction					Data Analysis			
ν: MINOS					Data Analysis							
ν: MINERvA	CD-3b				Shutdown		Data Analysis					
ν: NOvA	CD-2	CD-3a	CD-3b									Data Analy
ν: Long Baseline at DUSEL			CD-0	CD-1	CD-2		CD-3a					
μ: Mu2e			CD-0	CD-1	CD-2	CD-3a						
Project X				CD-0	CD-1	CD-2		CD-3a				
Cosmic Frontier												
Dark Matter: CDMS	4 kg			15 kg					~1 ton scale detector			
Dark Matter: COUPP	2 kg		60 kg						(tech choice: CDMS, COUPP, LAr TPC, ...)			
Dark Energy: SDSS		Data Analysis										
Dark Energy: DES	CD-3a									Data Analysis		
Dark Energy: JDEM	R&D											
Cosmic Rays: Pierre Auger	South					North to be determined						
Other Facilities												
Testbeam for Detector R&D	Operation				Shutdown							
Accelerator Research at A0	Operation											
SCRF Test / Accel. Research	Construction						Operation					
Lattice QCD	Operation											

Pre Run III
Pre Election

Outline

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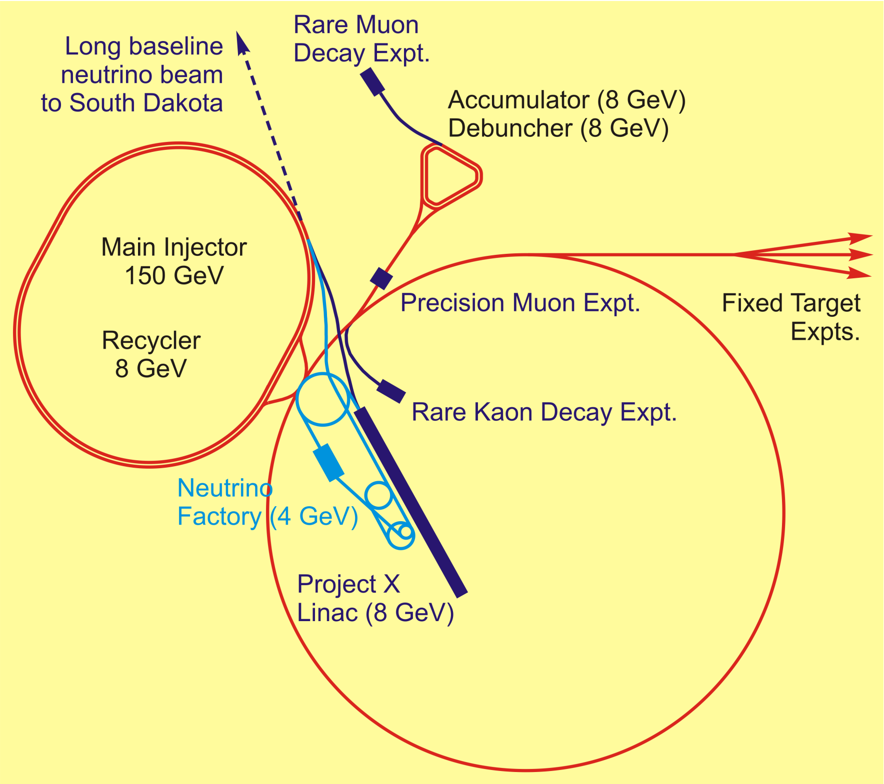
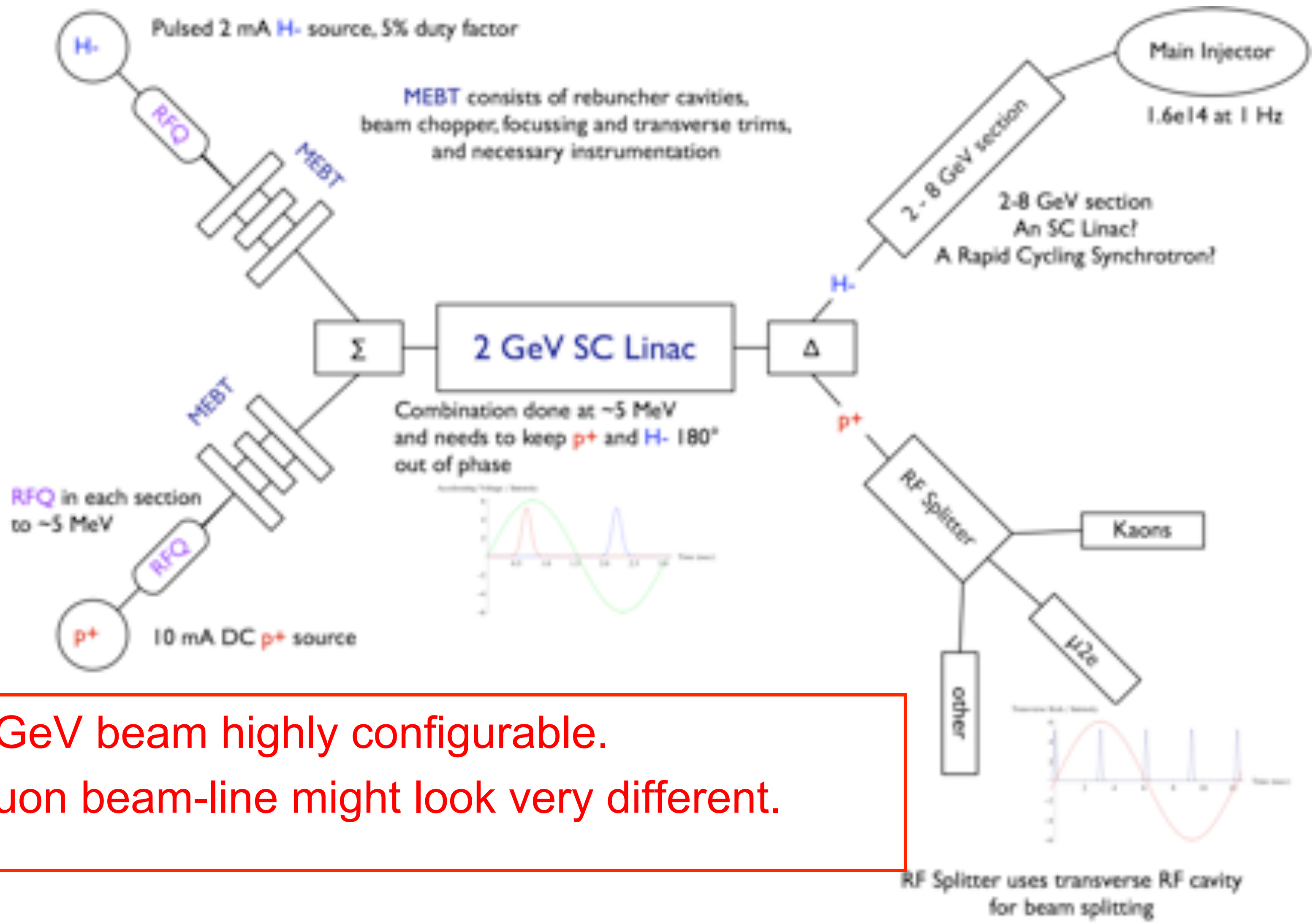
Mu2e In the Project X Era

- Project X: high intensity proton source to replace existing Booster.
  - Booster: 20 kW beam power at 8 GeV.
  - Project X: 200 kW at 8 GeV (with upgrade path to 2000 kW).
  - With corresponding upgrades at 120 GeV.
- If we have a signal:
  - Study Z dependence by changing stopping target.
  - Helps disentangle the underlying physics.
- If we have no signal:
  - Up to to 100 × Mu2e physics reach, $R_{\mu e} < 10^{-18}$.
  - First factor of ≈10 can use the same detector.



Project X ICD-2



- 2 GeV beam highly configurable.
- Muon beam-line might look very different.

Project-X Related Links

- 4th Workshop on physics with a high intensity proton source, Nov 9-10, 2009.

http://www.fnal.gov/directorate/Longrange/Steering_Public/workshop-physics-4th.html

- Muon Collider Physics workshop, Nov 10-12, 2009.

http://www.fnal.gov/directorate/Longrange/Steering_Public/workshop-muoncollider.html

- Fermilab Steering Group Report, June 2008.

http://www.fnal.gov/directorate/Longrange/Steering_Public/

Summary and Conclusions

$$\mu^- N \rightarrow e^- N$$

- Sensitivity for 2 years of running:
  - Discover new physics or $R_{\mu e} < 6 \approx 10^{-17}$ @ 90% CL.
  - Mass scales to O(10,000 TeV) are within reach.
  - 10,000 × better than previous best limit.
- Many SUSY@LHC scenarios predict $R_{\mu e} \approx 10^{-15}$,
  - Expect 40 events with < 0.5 events BG.
- Critical path is the solenoid system:
  - Planning: Construction: 2013-17; Operations 2018…
- Project X era:
  - If a signal, we can study N(A,Z) dependence.
  - If no signal, improve sensitivity up to 100 ×, $R_{\mu e} < O(10^{-18})$.
- Opportunities remain for new university groups.

For Further Information

- Mu2e home page: http://mu2e.fnal.gov
- Mu2e Document Database:
  - http://mu2e-docdb.fnal.gov/cgi-bin/DocumentDatabase
  - Mu2e Proposal: Mu2e-doc-388
  - Mu2e Conference presentations

Backup Slides

Backgrounds for 2×10^{7} s Running

Source	Events	Comment
μ decay in orbit	0.225	
Pattern Recognition Errors	<0.002	
Radiative μ capture	<0.002	
Beam electrons*	0.036	
μ decay in flight*	<0.027	without scatter in target
μ decay in flight*	0.036	with scatter in target
π- decay in flight*	<0.001	
Radiative π^- capture*	0.063	from protons during live gate
Radiateive π^- capture	0.001	from late arriving π^-
Anti-proton induced	0.006	
Cosmic ray induced	0.016	
Total	0.415	

*: scales with extinction; values in table assume extinction of 10^{-10}.

Why Can Mu2e Do Better than SINDRUM II?

- FNAL can deliver ≈1000 × proton intensity.
- Higher μ collection efficiency.
- SINDRUM II was BG limited.
  - Radiative π capture.
  - Bunched beam and excellent extinction reduce this.
  - So Mu2e can effectively use the higher proton rate.

PAUL SCHERRER INSTITUT

Background : b) pion induced

Radiative Pion Capture (RPC) : $\pi^- Au \rightarrow \gamma + Pt^*$ followed by $\gamma \rightarrow e^+ e^-$

Kinematic endpoint of photon spectrum around 130 MeV ! Branching ratio of order 2%.

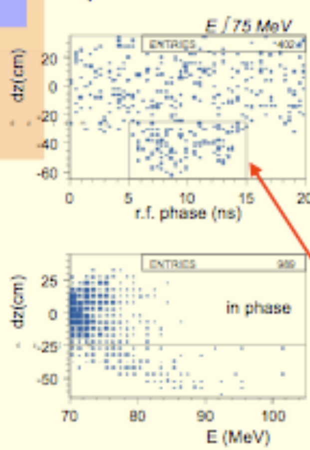
No way to distinguish an asymmetric $e^+ e^-$-pair (with little e^+ energy and e^- energy at 95 MeV) from μe !

⇨ Needs strong pion suppression : only ~ 1 pion every 5 minutes is allowed to reach gold target!

⇨ tune beamline to suppress high momentum tail

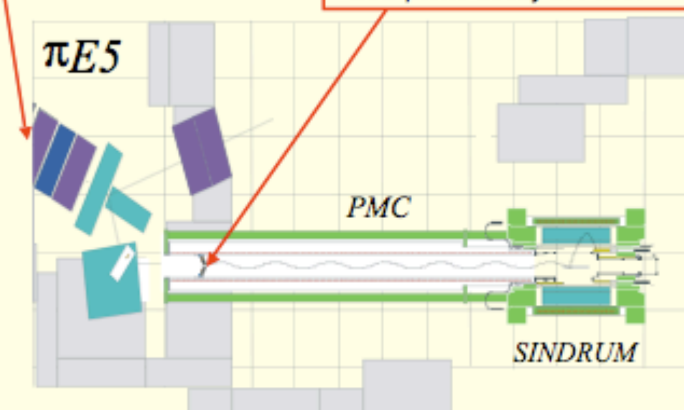
*⇨ use **degrader** 8m in front of gold target to separate μ's and π's by their different stopping power. Penetrating slow pions decay in PMC.*

positron distributions



***BUT:** Degrader is now pion stop target → e^+e^- pairs from RPC are collected by B_{PMC} and transported towards the gold target where they may scatter into spectrometer acceptance (typ. forward scattering)*

⇨ use solid angle and cyclotron phase correlation to cut.



July 14, 2001 HEP 2001 (W.Bertl - SINDRUM II collaboration)

We have CD-0!

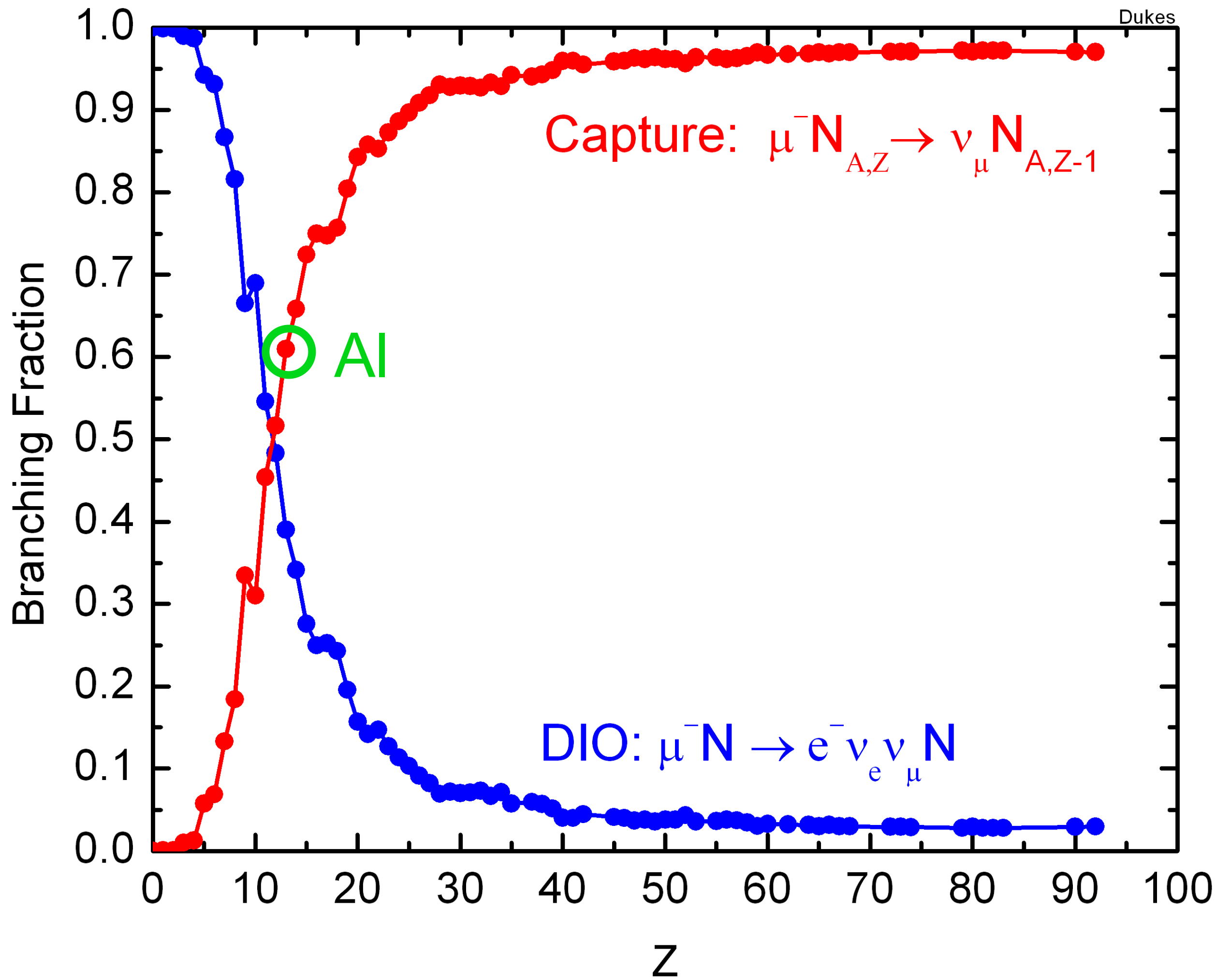
- Strongly endorsed by P5 in May 2008:
  - “The panel recommends pursuing the muon-to-electron conversion experiment …. under all budget scenarios considered by the panel.”
- Stage I Approval from Fermilab Directorate
  - November 2008.
- Critical Decision 0 (CD-0)
  - “Approval of Mission Need”
  - Received November 24, 2009.
  - This means DOE has said they want to do Mu2e.

DOE Order 413.3A

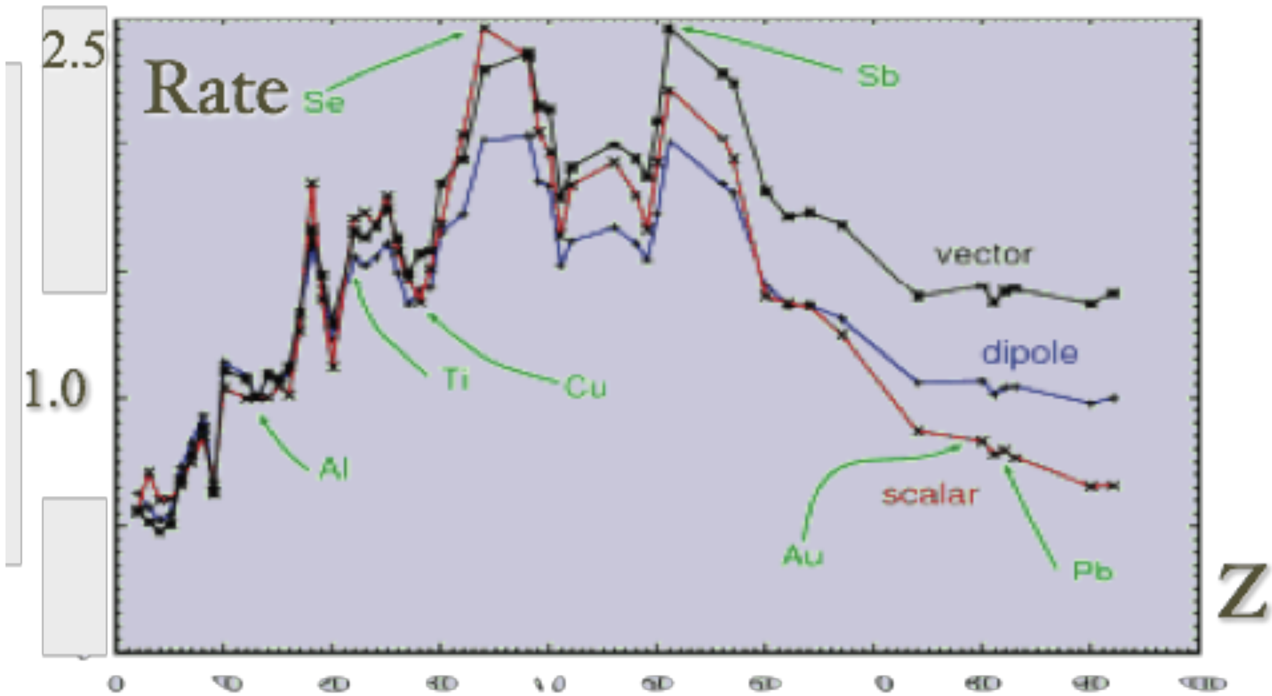
- CD-0: Approve Mission Need
  - A determination is made that there is a scientific case to pursue the project. Some of the possible alternative means of delivering the science are presented as well as a coarse estimate of the cost.
- CD-1: Approve Alternative Selection and Cost Range
  - One of the alternatives proposed in the CD-0 is selected and a credible cost range is established.
- Critical Decision 2: Approve Performance Baseline
  - The technical scope of work, the cost estimate, and the construction schedule is sufficiently well known that the project can be completed on time and within budget.
- Critical Decision 3: Approve Start of Construction
  - Engineering and design are sufficiently complete that construction, procurement, and/or fabrication can begin.
- Critical Decision 4: Approve Start of Operations
  - The project is ready to be turned over to the organization that will operate and maintain it. The criteria for this stage are defined in the Performance Baseline.

http://www.er.doe.gov/hep/project_status/index.shtml

Capture and DIO vs Z

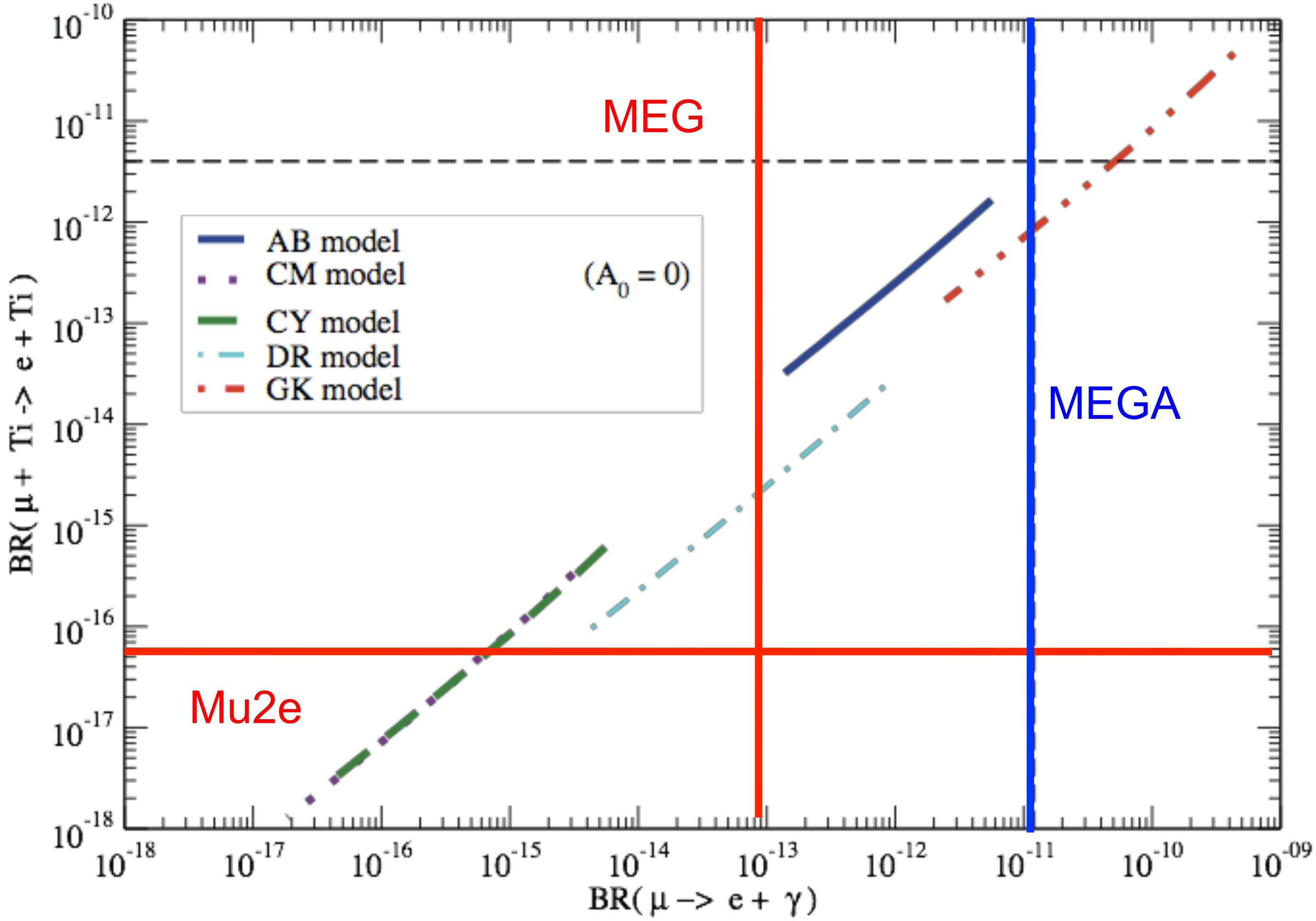


Conversion Rate, Normalized to Al



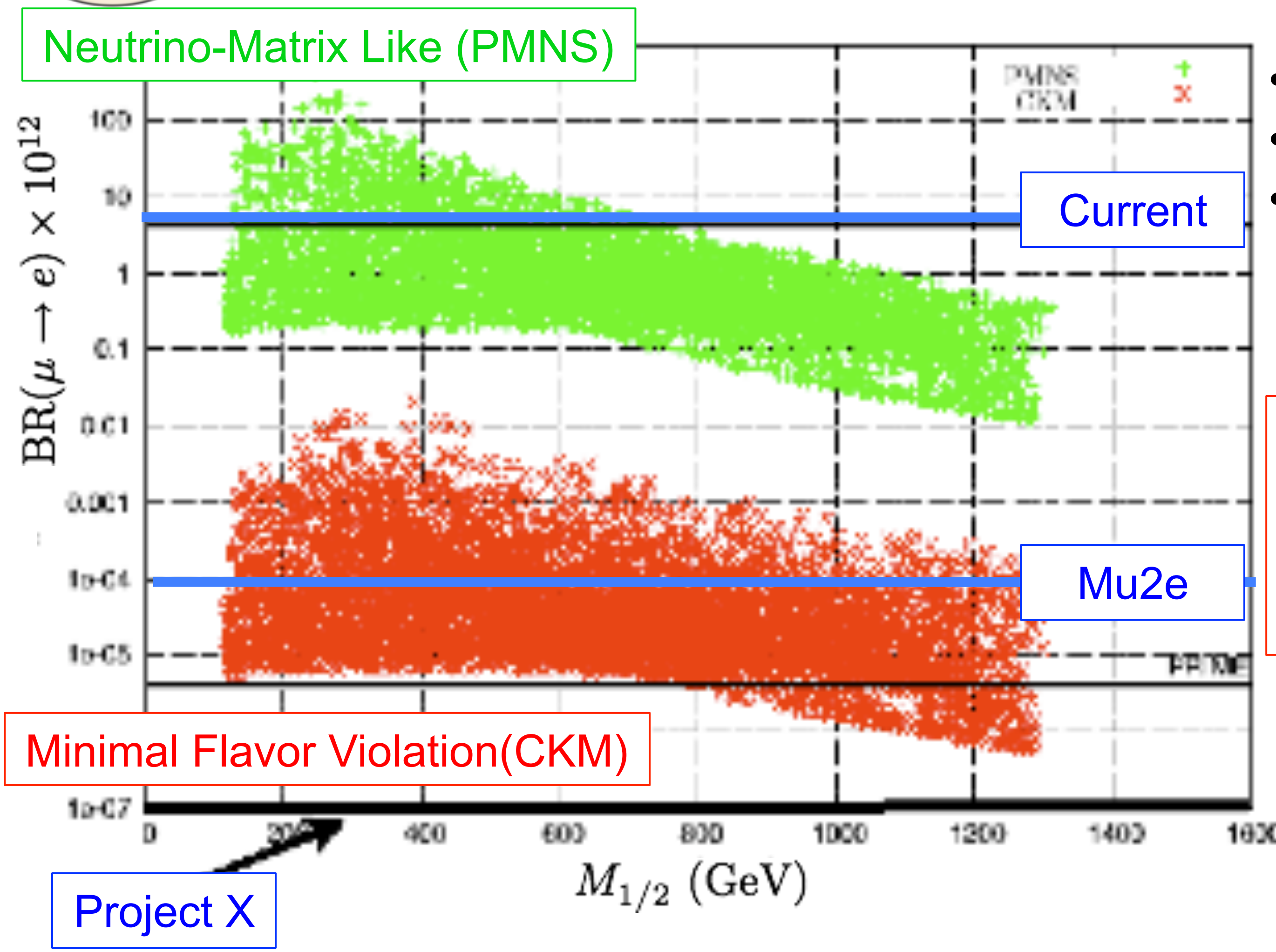
Kitano, et al., PRD 66, 096002 (2002)

Combining Conversion and μ→eγ



C. Albright and M. Chen, arXiv:0802.4228, PRD D77:113010, 2008.

Example of SUSY in Muon LFV

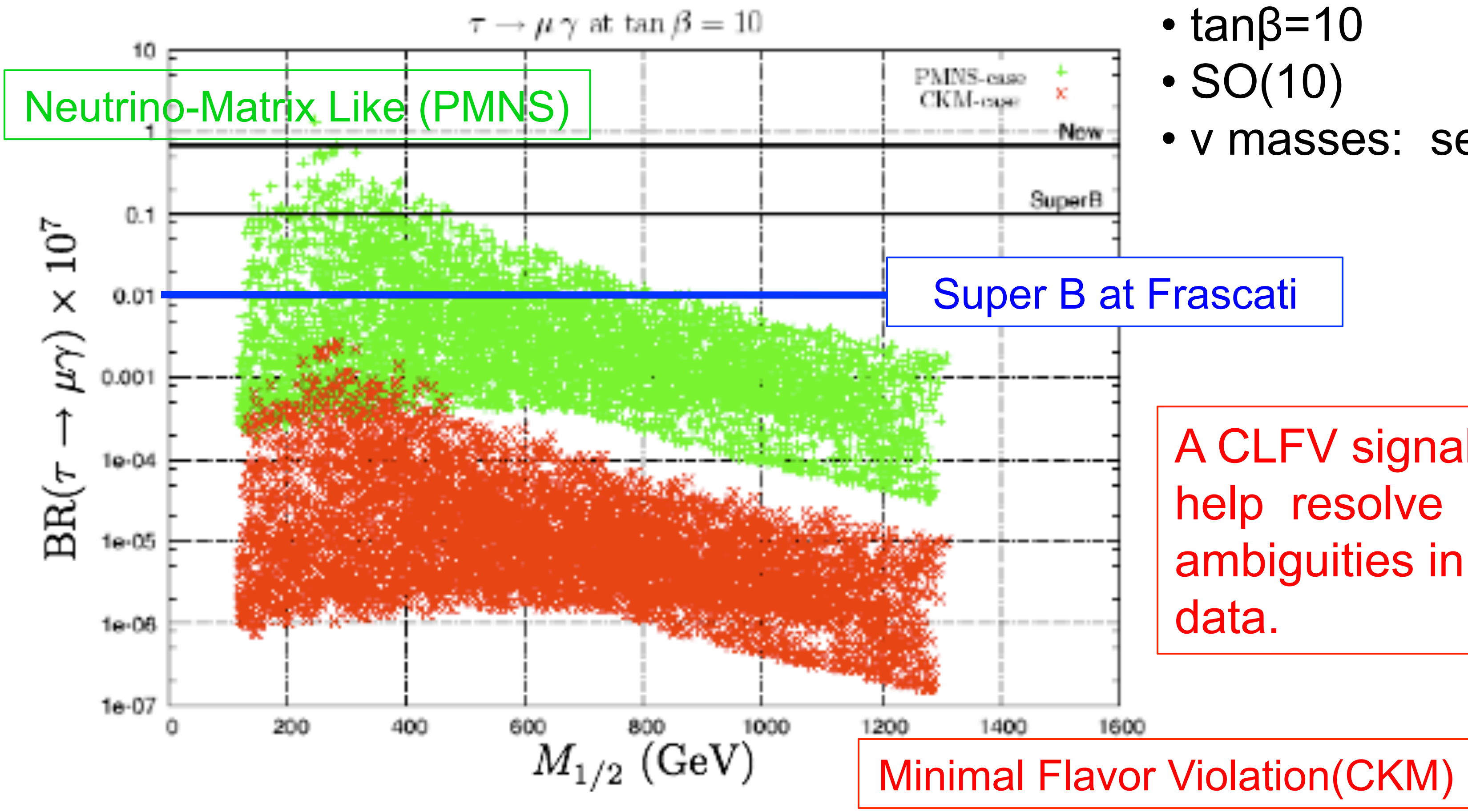


- tanβ=10
- SO(10)
- ν masses: see-saw.

A CLFV signal can help resolve ambiguities in LHC data.

L. Calibbi, A. Faccia, A. Masiero, S. Vempati hep-ph/0605139

Example of SUSY in Tau LFV



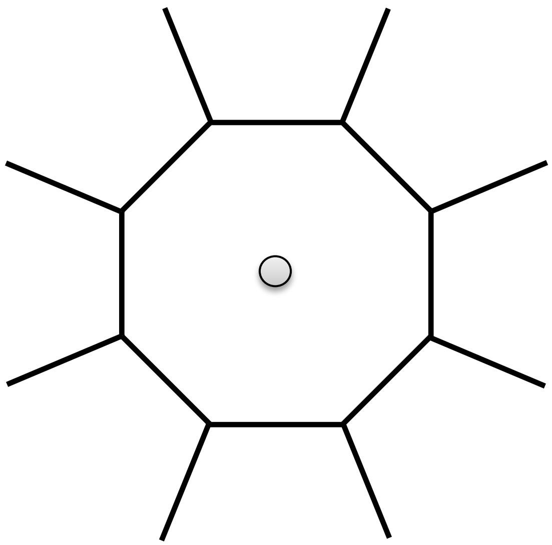
- tanβ=10
- SO(10)
- ν masses: see-saw.

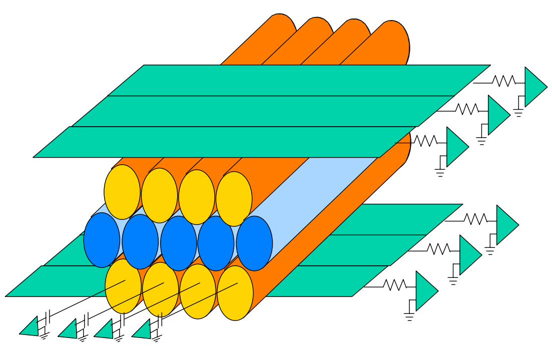
A CLFV signal can help resolve ambiguities in LHC data.

L. Calibbi, A. Faccia, A. Masiero, S. Vempati hep-ph/0605139

L-Tracker (L=Longitudinal)

XY Cross-section of LTracker



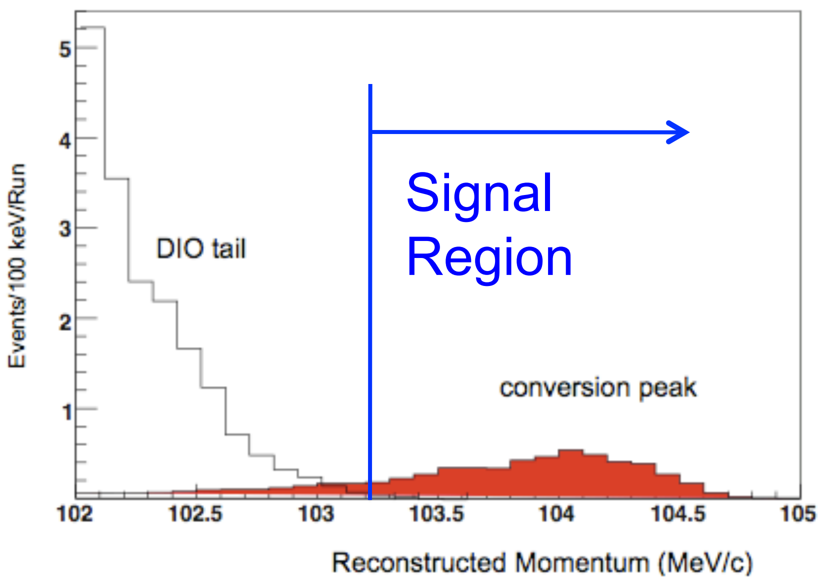


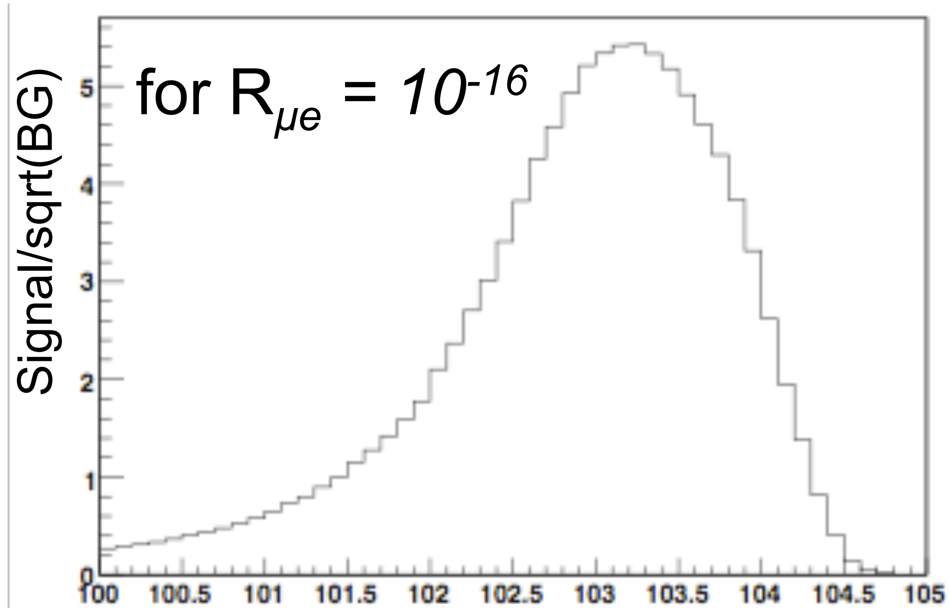
- Octagon + vanes.
- ≈ 2800 axial straws in vacuum
  - ≈ 2.6 m long; 5 mm diameter
  - 25 μm wall thickness
- 3 layers; hex close packed.
  - Resistive walls on outer layers.
  - Cathode pads for z position.
- p_T < 55 MeV curls inside octagon.
- Issues:
  - Mechanical design; especially the cathode sheets.
  - High rates on resistive straws not yet demonstrated.
  - Enough measurements/track?

I-Tracker (I=Italian)

- Proposed by group from INFN Lecce.
- KLOE style cluster counting drift chamber.
  - Axial and stereo layers.
  - Central region empty (as with L and T).
- Advantage:
  - Robust pattern rec.; many measurements per track.
- Issues:
  - Material budget in upstream endplate.
  - Rates.

Defining the Signal Region

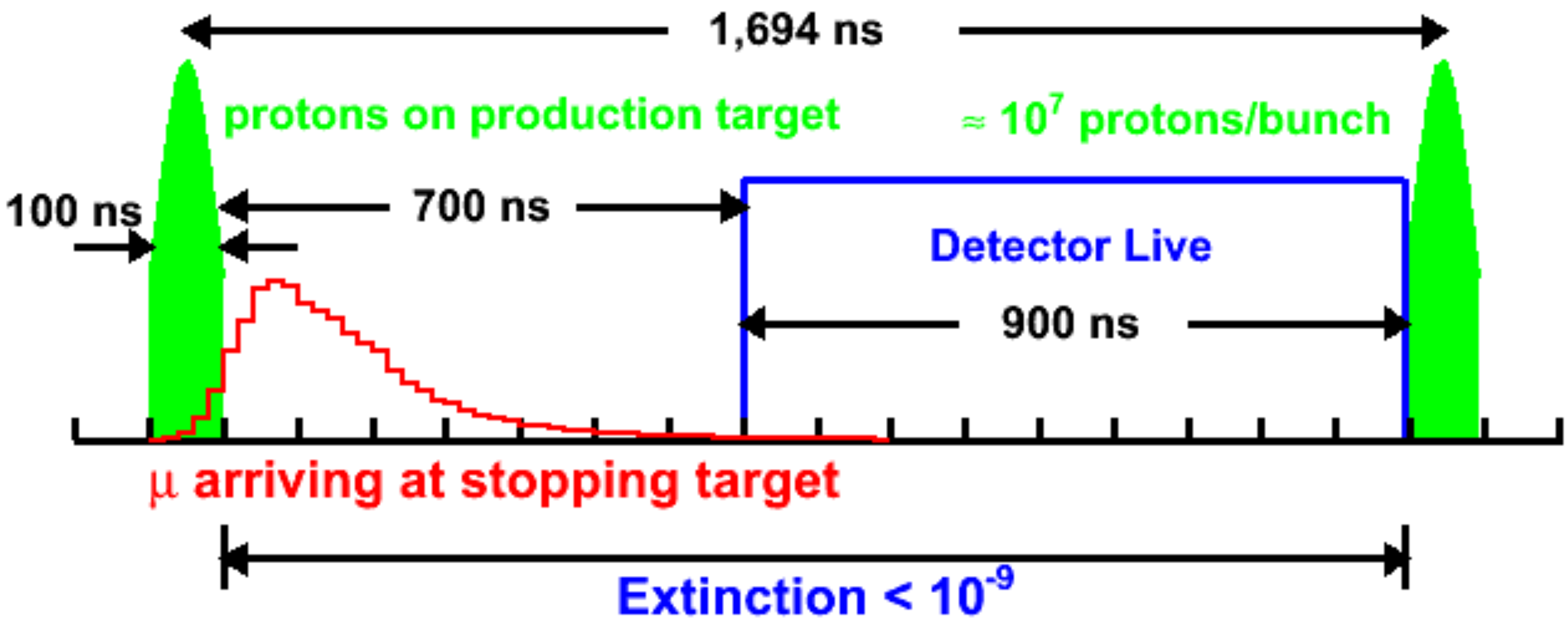




Low Edge of Signal Region

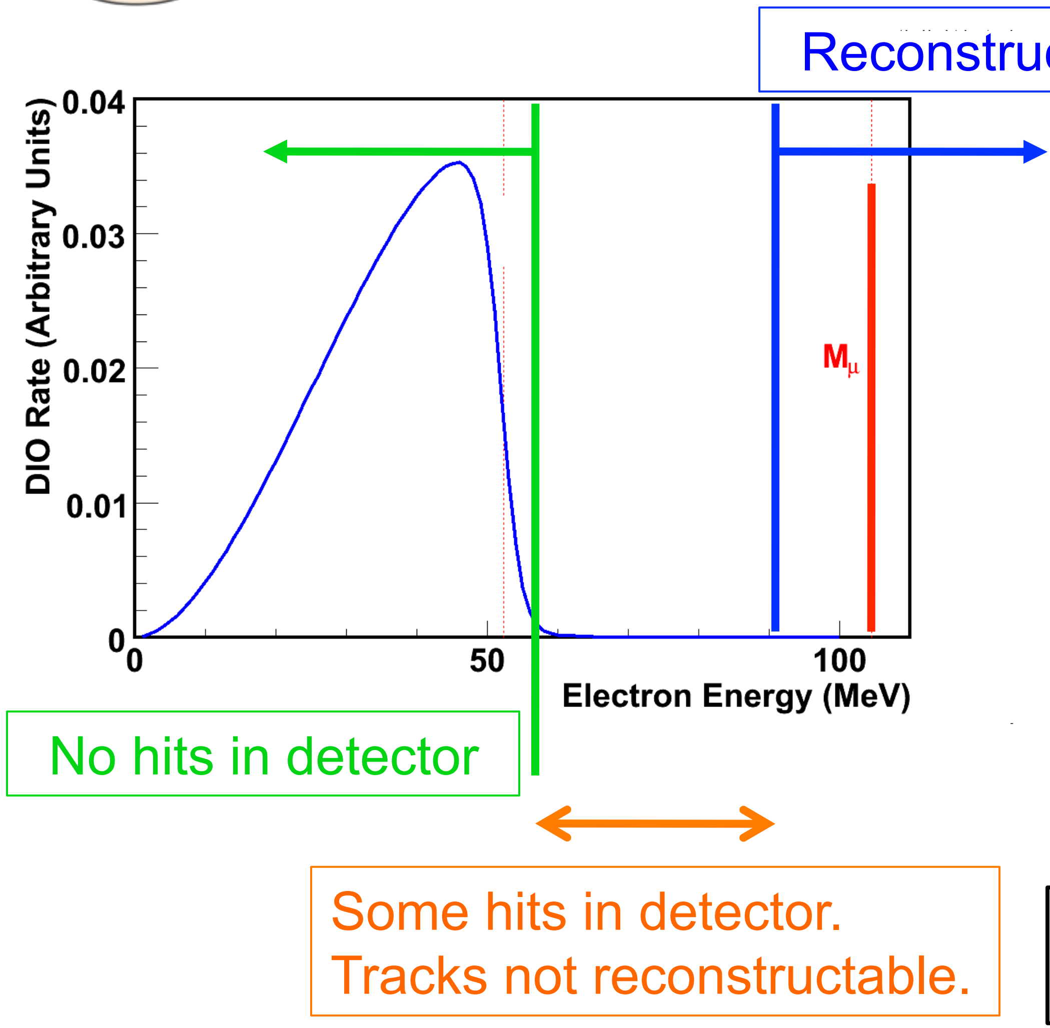
- There is an irreducible background component.
- In addition, mis-measured DIO events can be reconstructed in the signal region. Critical to understand high side tails in the momentum resolution function.

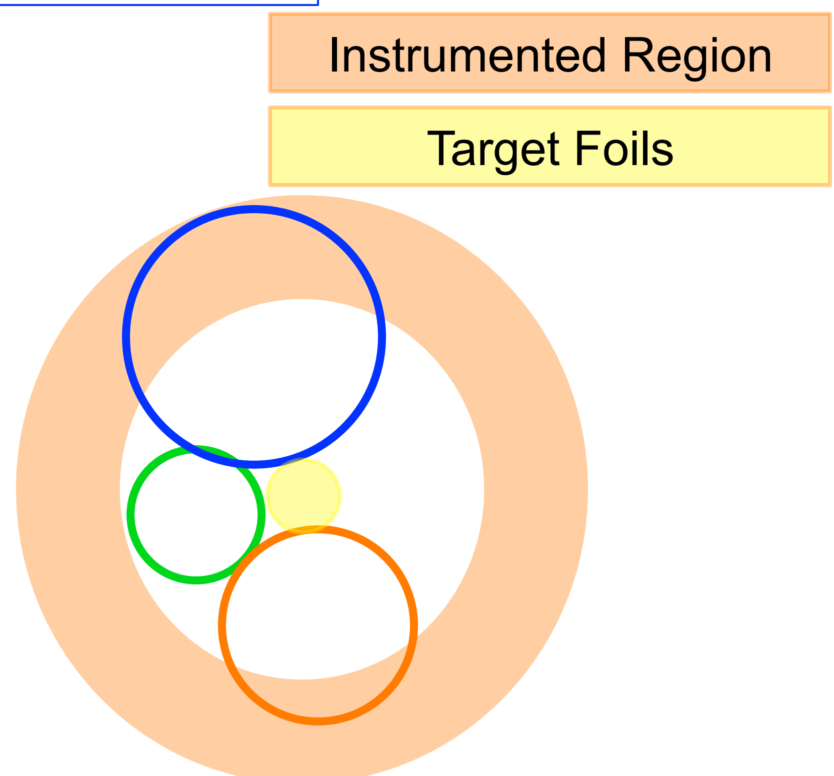
One Cycle of the Muon Beamline



- μ^- accompanied by e^-, e^+, π^-, …, which make backgrounds
- "Extinction" required to reduce backgrounds.
  - 1 out of time proton per 10^{10} in time protons.
- Lifetime of muonic Al: 864 ns.

How do you measure 2.3×10^{-17} ?





Beam's-eye view of a generic Tracker; magnetic field into the page.