The Mu2e Experiment at Fermilab

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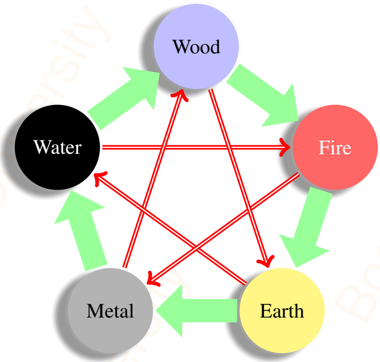
Outline

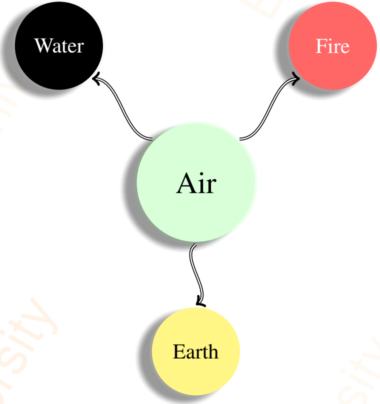
Outline

What is the World Made of?

Wu Xing (700 BC)



Anaximander (610 BC-546 BC)



Periodic table

Dmitri Mendeleev (1834-1907)

Periodic Table of Chemical Elements

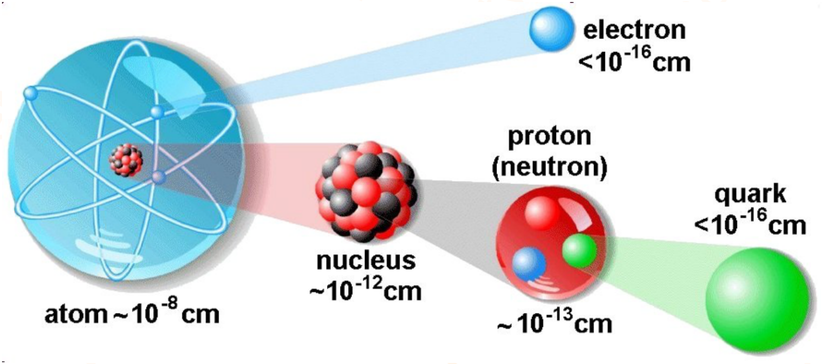
	1 IA	2 IIA	3 IIIA	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 1.0079 H Hydrogen																	2 4.0025 He Helium
2	3 6.941 Li Lithium	4 9.0122 Be Beryllium											5 10.811 B Boron	6 12.011 C Carbon	7 14.007 N Nitrogen	8 15.999 O Oxygen	9 18.998 F Flourine	10 20.180 Ne Neon
3	11 22.990 Na Sodium	12 24.305 Mg Magnesium											13 26.982 Al Aluminium	14 28.086 Si Silicon	15 30.974 P Phosphorus	16 32.065 S Sulphur	17 35.453 Cl Chlorine	18 39.948 Ar Argon
4	19 39.098 K Potassium	20 40.078 Ca Calcium	21 44.956 Sc Scandium	22 47.867 Ti Titanium	23 50.942 V Vanadium	24 51.996 Cr Chromium	25 54.938 Mn Manganese	26 55.845 Fe Iron	27 58.933 Co Cobalt	28 58.693 Ni Nickel	29 63.546 Cu Copper	30 65.39 Zn Zinc	31 69.723 Ga Gallium	32 72.64 Ge Germanium	33 74.922 As Arsenic	34 78.96 Se Selenium	35 79.904 Br Bromine	36 83.8 Kr Krypton
5	37 85.468 Rb Rubidium	38 87.62 Sr Strontium	39 88.906 Y Yttrium	40 91.224 Zr Zirconium	41 92.906 Nb Niobium	42 95.94 Mo Molybdenum	43 96 Tc Technetium	44 101.07 Ru Ruthenium	45 102.91 Rh Rhodium	46 106.42 Pd Palladium	47 107.87 Ag Silver	48 112.41 Cd Cadmium	49 114.82 In Indium	50 118.71 Sn Tin	51 121.76 Sb Antimony	52 127.6 Te Tellurium	53 126.9 I Iodine	54 131.29 Xe Xenon
6	55 132.91 Cs Caesium	56 137.33 Ba Barium	57-71 La-Lu Lanthanide	72 178.49 Hf Halfnium	73 180.95 Ta Tantalum	74 183.84 W Tungsten	75 186.21 Re Rhenium	76 190.23 Os Osmium	77 192.22 Ir Iridium	78 195.08 Pt Platinum	79 196.97 Au Gold	80 200.59 Hg Mercury	81 204.38 Tl Thallium	82 207.2 Pb Lead	83 208.98 Bi Bismuth	84 209 Po Polonium	85 210 At Astatine	86 222 Rn Radon
7	87 223 Fr Francium	88 226 Ra Radium	89-103 Ac-Lr Actinide	104 261 Rf Rutherfordium	105 262 Db Dubnium	106 266 Sg Seabörgium	107 264 Bh Bohrium	108 277 Hs Hassium	109 268 Mt Meitnerium	110 281 Ds Darmstadtium	111 280 Rg Roentgenium	112 285 Uub Ununbium	113 284 Uut Ununtrium	114 289 Uuq Ununquadium	115 288 Uup Ununpentium	116 293 Uuh Ununhexium	117 292 Uus Ununseptium	118 294 Uuo Ununoctium
				57 138.91 La Lanthanum	58 140.12 Ce Cerium	59 140.91 Pr Praseodymium	60 144.24 Nd Neodymium	61 145 Pm Promethium	62 150.36 Sm Samarium	63 151.96 Eu Europium	64 157.25 Gd Gadolinium	65 158.93 Tb Terbium	66 162.50 Dy Dysprosium	67 164.93 Ho Holmium	68 167.26 Er Erbium	69 168.93 Tm Thulium	70 173.04 Yb Ytterbium	71 174.97 Lu Lutetium
				89 227 Ac Actinium	90 232.04 Th Thorium	91 231.04 Pa Protactinium	92 238.03 U Uranium	93 237 Np Neptunium	94 244 Pu Plutonium	95 243 Am Americium	96 247 Cm Curium	97 247 Bk Berkelium	98 251 Cf Californium	99 252 Es Einsteinium	100 257 Fm Fermium	101 258 Md Mendelevium	102 259 No Nobelium	103 262 Lr Lawrencium

- Alkali Metal
- Alkaline Earth Metal
- Metal
- Metalloid
- Non-metal
- Halogen
- Noble Gas
- Lanthanide/Actinide

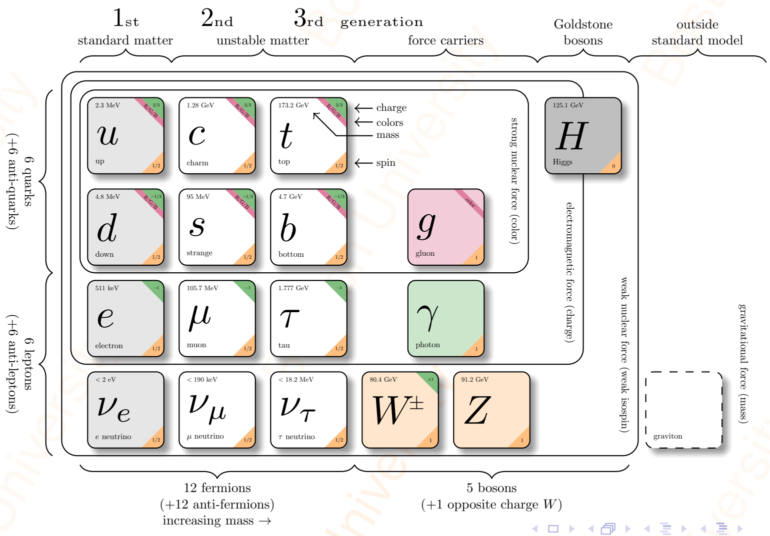
Z mass Symbol Name

man-made

Subatomic structure

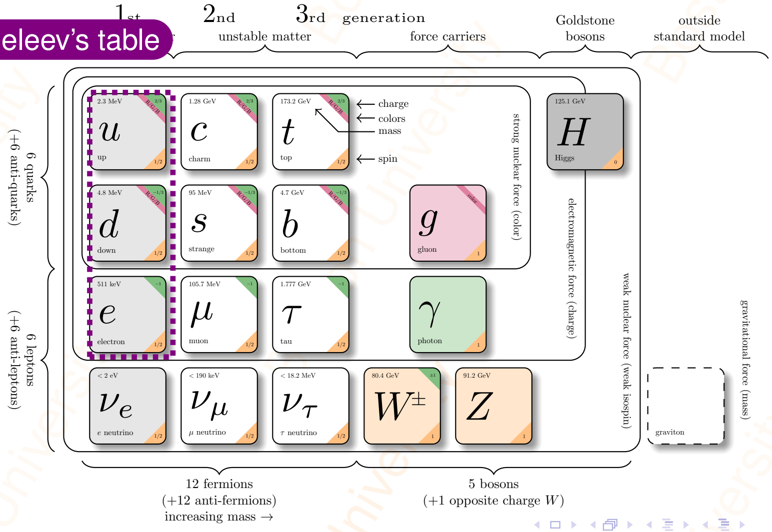


Standard Model and beyond

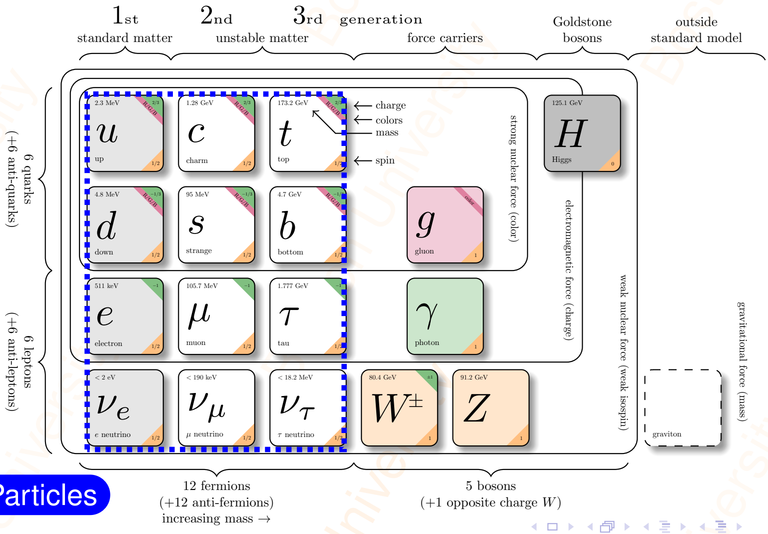


Standard Model and beyond

Mendeleev's table

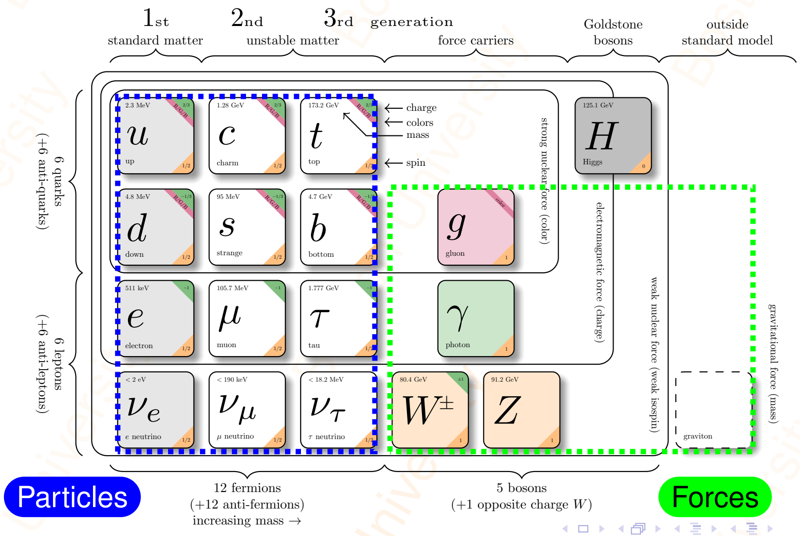


Standard Model and beyond

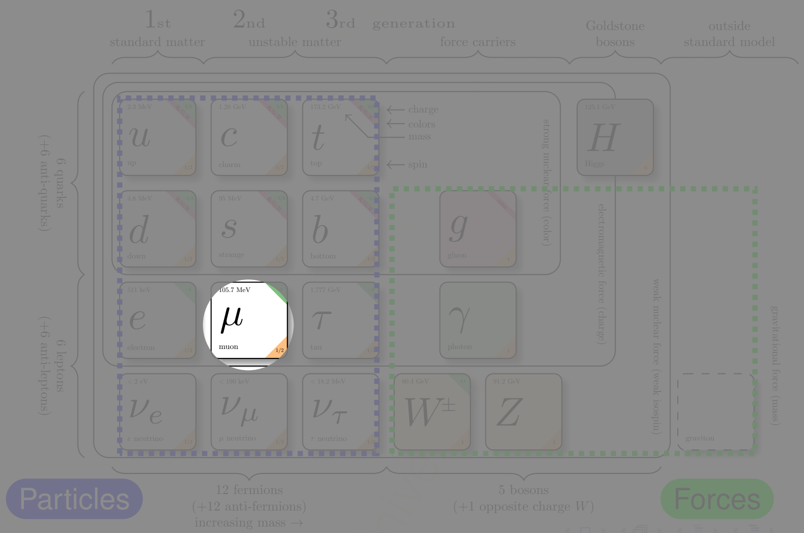


Particles

Standard Model and beyond



Standard Model and beyond



What is a Muon?

Mass	m_μ	$105.6583745 \pm 0.0000024$ MeV
Mean life	τ_μ	$2.1969811 \pm 0.0000022\ \mu\text{sec}$
Spin	s_μ	$1/2$
Magnetic moment ratio	μ_μ/μ_p	$3.183345142 \pm 0.000000071$
μ_μ anomaly	$(g_\mu - 2)/2$	$(116592089 \pm 54 \pm 33) \times 10^{-11}$
Electric dipole moment	d_μ	$(-0.1 \pm 0.9) \times 10^{-19} e \cdot \text{cm}$
Decay modes $\mu^- \rightarrow$	$e^-\nu_\mu\bar{\nu}_e$	$\approx$100%
	$e^-\nu_\mu\bar{\nu}_e\gamma$	$(6.0 \pm 0.5) \times 10^{-8}$
	$e^-\nu_\mu\bar{\nu}_e e^+e^-$	$(3.4 \pm 0.4) \times 10^{-5}$
	$e^-\nu_e\bar{\nu}_\mu$	< 1.2 %
	$e^-\gamma$	$< 4.2 \times 10^{-13}$
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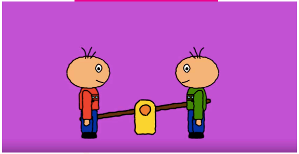
$e^\pm$ vs. $\mu^\pm$



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Well known

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Precision

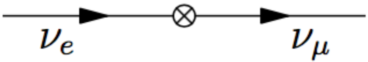
Lepton number violation (Rare decays)

Why Are Precision and Rare Important?

- Access physics beyond the Standard Model
  - Higher and Higher Energy
  - Either direct (LHC) or indirect production
  - Complimentary to the LHC experiments
- Processes that are forbidden or highly suppressed in the SM, or where the SM gives a very accurate prediction
- Observation or significant deviation
- Mu2e and Muon g-2 are two examples at Fermilab

Lepton Flavor Violation in SM

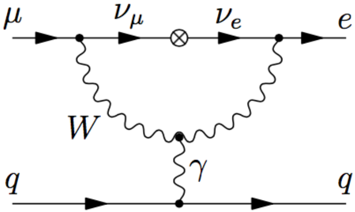
- Neutral Lepton Flavor Violation



- Not forbidden for Charged but highly suppressed

$$\frac{\Gamma_{\mu\to e\gamma}}{\Gamma_{\mu\to e\nu\nu}} \propto |\sum_i \frac{\Delta m_i^2}{m_W^2} U_{\mu i}^* U_{ei}|^2 \sim 10^{-54}$$

Lorenzo&Giovanni, arXiv:1709.00294 [hep-ph]



- However, many New Physics models predict rates $10^{-14} \sim 10^{-16}$

Sensitivity to New Physics Scale

$$\mathcal{L}_{CLFV} \sim \frac{1}{\Lambda^2}\left[\frac{1}{(1+\kappa)} m_\mu \bar{\mu}_R \sigma_{\mu\nu} e_L F^{\mu\nu} + \frac{\kappa}{(1+\kappa)} \bar{\mu}_L \gamma_\mu e_L \left(\sum_{q=u,d} \bar{q}_L \gamma^\mu q_L\right)\right]$$

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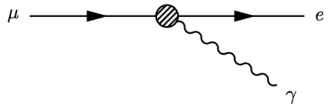
Loop



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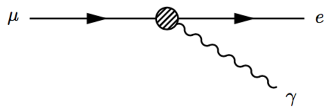
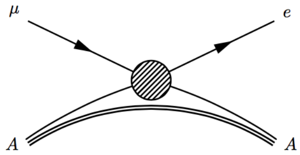
Loop

Contact





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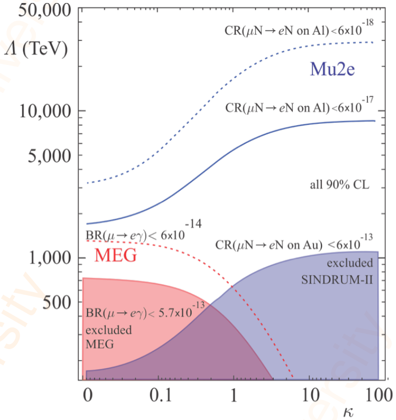
Loop

Contact

κ: relative contribution of the two terms

Λ: the effective mass scale of New Physics



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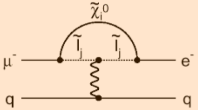
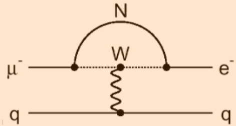
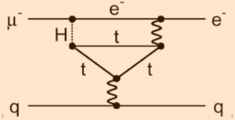
Mediate both $\mu^+ \to e^+\gamma$ and $\mu^- N \to e^- N$



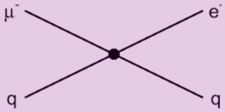
Supersymmetry



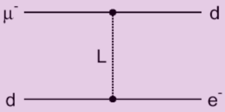
Heavy neutrino



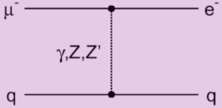
Two Higgs doublets



Compositeness



Leptoquarks



New heavy bosons/ anomalous couplings

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

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

- $\mu \to e\gamma$:
  - Sensitive to small κ
  - Coincidence between electron and photon
  - Combinatoric background for high intensity beam
  - MEG
- $\mu^- N \to e^- N$:
  - Sensitive to all κ
  - Single mono-energetic electron
  - COMET and Mu2e

Stopping Target

- Sensitivity to $B(\mu \to e)$ increases as Z $\Uparrow$

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- $\mu^- + ^A_Z X \to ^A_{Z-1} Y + \nu_\mu + \gamma$
  - Pair production of $\gamma \to e^+e^-$ when $E_\gamma \sim E_{e^-}$
  - Require $\Delta_M = m(Y) - m(X) > 0$

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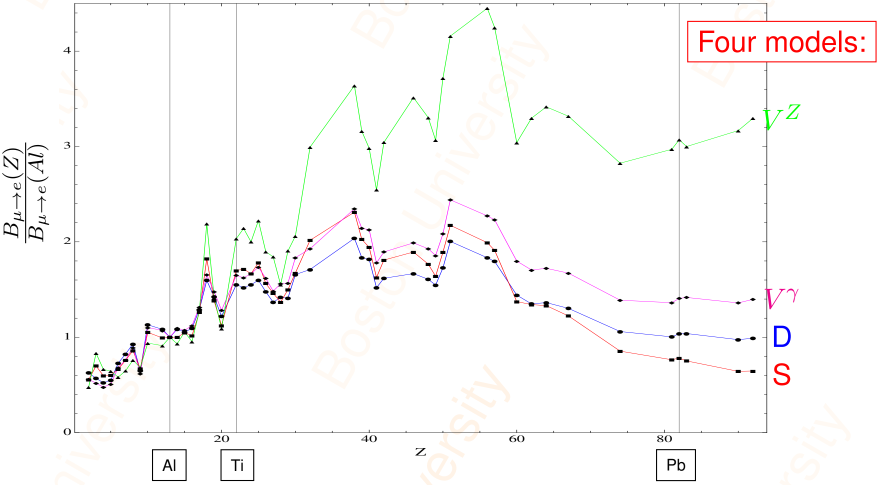
- Chemically stable and readily purified
- Aluminum is the final choice: $\tau = 864$ ns, $\Delta_M = 2.6$ MeV

Target dependence of $\mu \to e$ rate



V. Cirigliano, R. Kitano, Y. Okada, P. Tuzon., arXiv:0904.0957 [hep-ph]; Phys. Rev. D80 (2009) 013002

Outline

Muon beams

high current	medium energy	cyclotrons and continuous
lower current	high energy	synchrotrons and pulsed

PSI

TRIUMF

Fermilab

J-PARC

Muon beams

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PSI

TRIUMF

Fermilab

J-PARC

Muon Campus @ Fermilab

Muon Campus @ Fermilab

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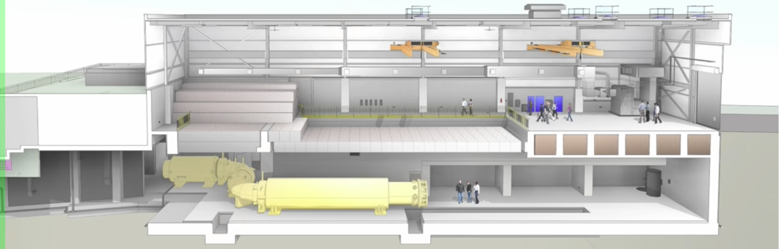
Mu2e Collaboration

6 Countries, 39 Institutions, 228 Collaborators

US:
-Argonne
-Boston
-Brookhaven
-CalTech
-Cornell
-Duke
-Fermilab
-Houston
-Illinois
-James Madison
-Kansas
-LBNL
-Lewis
-Louisville
-Minnesota
-New York
-Northern Illinois
-Northwestern
-Purdue
-South Alabama
-Virginia
-UC, Berkeley
-UC, Davis
-UC, Irvine
-Washington
-Yale



China-Sun Yat-Sen
Germany-Dresden
Russia-Dubna
-Novosibirsk
-Protvino
-Moscow

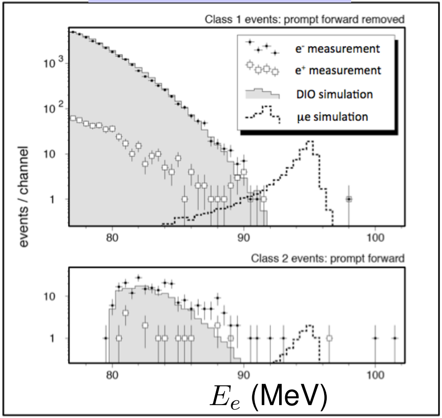
England:
-Liverpool
-Manchester
-UCL

Italy:
-INFN
—LNF Frascati
—Genova
—Pisa
—Lecce

Present and Future

- SINDRUM II: $R_{\mu e} = \frac{\mu^- + Au \to e^- + Au}{\mu^- + Au \to \text{capture}}$
  - 1 MW beam, 10^7 muon/s
  - Well described by MIO/DIO
  - No signal is found
  - e^- & e^+ beyond signal
  - $R_{\mu e} < 7 \times 10^{13}$
- Mu2e aims 10^4 times better:
  - S.E.S.=2.5×10^{-17}
  - Discovery: $R_{\mu e} > 2 \times 10^{-16}$
  - 10^{18} stopped muons
  - 10^{20} protons on target

SINDRUMII @ PSI

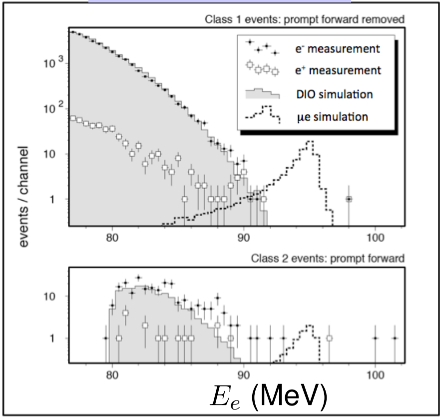


W. Bertl et al., Eur. Phys. J. C 47, 337-346 (2006)

Present and Future

- SINDRUM II: $R_{\mu e} = \frac{\mu^- + Au \to e^- + Au}{\mu^- + Au \to \text{capture}}$
  - 1 MW beam, 10^7 muon/s
  - Well described by MIO/DIO
  - No signal is found
  - e^- & e^+ beyond signal
  - $R_{\mu e} < 7 \times 10^{13}$
- Mu2e aims 10^4 times better:
  - S.E.S.=2.5×10^{-17}
  - Discovery: $R_{\mu e} > 2 \times 10^{-16}$
  - 10^{18} stopped muons
  - 10^{20} protons on target

SINDRUMII @ PSI



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

A Clever Idea

Published in Soviet Journal of Nuclear Physics

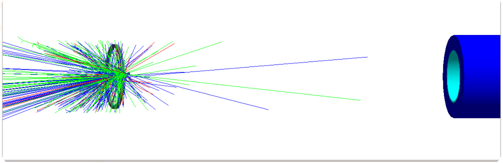
Эксперимент МЕЛС по поиску процесса $\mu^- A \to e^- A$

длагается эксперимент по поиску процесса аномальной конверсии мюонов
ах $\mu^-+(A,Z) \to e^-+(A,Z)$ на уровне $Br \simeq 10^{-16}$ с использованием
ика остановленных отрицательных мюонов с интенсивностью до 10^{11} μ^-/сек
.ирующем пучке Московской мезонной фабрики при среднем токе $\sim$ 200
настоящее время получен верхний предел на этот процесс на ядре Ti —
$\iota^-+\mathrm{Ti} \to e^-+\mathrm{Ti})/\Gamma(\mu^-$ Ti capture$) < 4\times10^{-12}$ (TRIUMF, Канада).

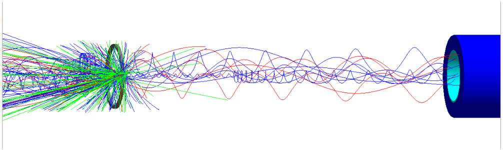
- Proposed by V. Lobashev and R. Djilkibaev in 1989
  - Utilize a pulsed proton beam
  - Use solenoids to collect muons

Increase Muon Rate

- SINDRUM II:
  - 1 MW beam
  - Stop $\sim 10^{7-8}$ muon/s

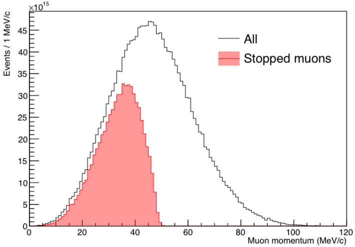


- Mu2e:
  - Use solenoid
  - Confines soft pions
  - 8 kW beam
  - Stop $\sim 10^{10}$ muon/s



Some Mu2e Numbers

- For every one second, Mu2e will
  - Send 7,000,000,000,000 protons to the Production Solenoid
  - Collect 26,000,000,000 through the Transport Solenoid
  - Stop 13,000,000,000 muons in the Detector Solenoid
- At the end: stop 1,000,000,000,000,000,000 muons



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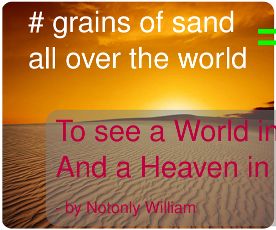
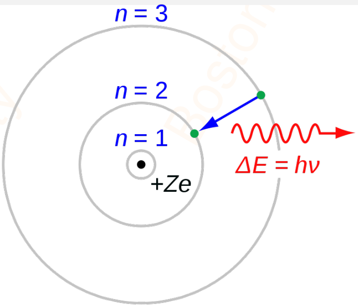


grains of sand all over the world = # atoms in a droplet

To see a World in a Drop of Water
And a Heaven in a Wild Flower

- by Notonly William

Bohr Model



Orbit radius: $r_n = \frac{n^2\hbar^2}{m_e Z k_e e^2}$

Orbit energy: $E_n = -\frac{m_e Z^2 (k_e e^2)^2}{2n^2\hbar^2}$

If replace the e^- with a μ^-:

$$\frac{E_\mu}{E_e} = \frac{m_\mu}{m_e} = 207 \text{ and } \frac{r_\mu}{r_e} = \frac{m_e}{m_\mu} = \frac{1}{207}$$

In $\mu^- + Al \to e^- + Al$:

$$E_e = m_\mu c^2 - E_{\text{binding}} - E_{\text{recoil}}^{\text{nucleus}}$$

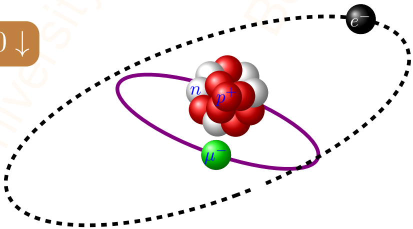
Mu2e Experiment

- Stop μ^- in Al targets

Mu2e Experiment

- Stop μ^- in Al targets
- Muonic atom is formed
  - Bohr radius: ≈ 20 fm
  - Binding energy: $\approx$ 500 keV
  - Nuclear radius: ≈ 4 fm
  - τ_{μ^-} in 1S orbit: ≈ 864 ns

$\times 200 \downarrow$



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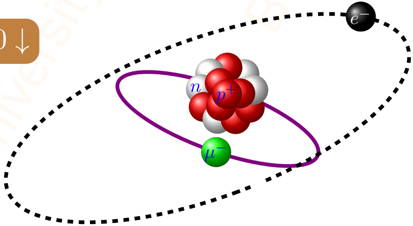

- Reactions that could happen
  - Muon decays (~40%): $\mu^- \rightarrow e^- + \bar{\nu_e} + \nu_\mu$
  - Muon captures (~60%): $\mu^- + ^{27}_{13}Al \rightarrow ^{27}_{12}Mg + \nu_\mu$
  - Muon to electron conversion: $\mu^- + ^{27}_{13}Al \rightarrow ^{27}_{13}Al + e^-$

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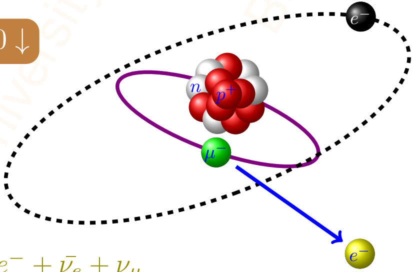

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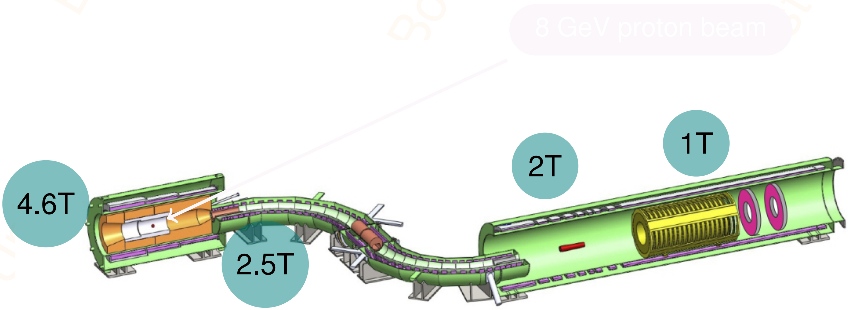
  - Muon to electron conversion: $\mu^- +^{27}_{13} Al \rightarrow^{27}_{13} Al + e^-$
- Search for 105 MeV electron

Mu2e Beamline



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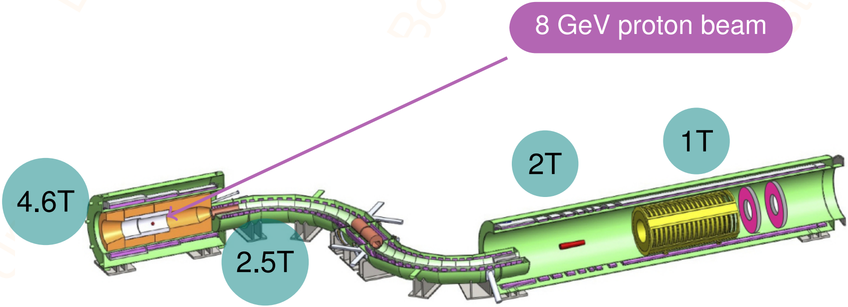
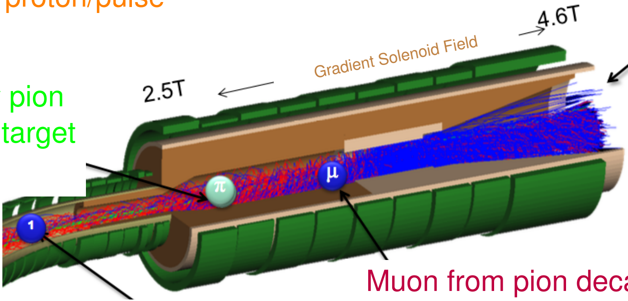


Production Solenoid

8 GeV incident proton beam
3.9×10^7 proton/pulse

Magnetic field behaves like a mirror

Primary pion from W target



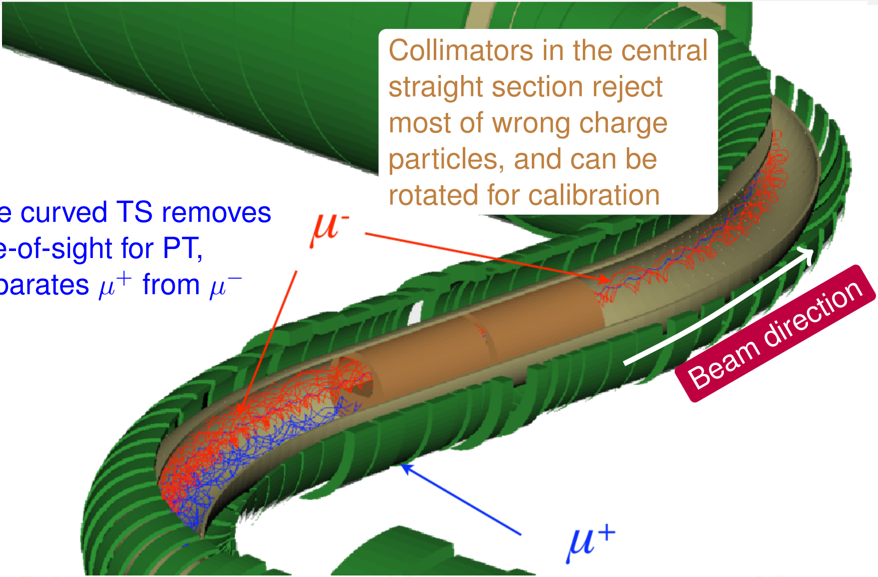
Muon from pion decays

Muon is collected into the Transport Solenoid and proceed to the Stopping Target

Transport Solenoid

The curved TS removes line-of-sight for PT, separates μ^+ from μ^-

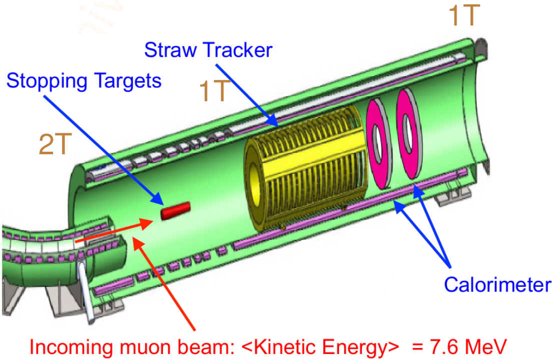
Collimators in the central straight section reject most of wrong charge particles, and can be rotated for calibration



Detector Solenoid

- Magnetic field: 2T→1T around ST
- Gradient field increases acceptance
- Stopping Target: thin foils to reduce loss of energy resolution

Flux of low energy electron from muon decay in orbit (DIO) go through the central holes of the detectors



Outline

Backgrounds for $\mu^- \to e^-$

- Radiative pion capture: $\pi N \to \gamma N^*$
- Decay in orbit: electron approach the signal energy when
  - exchanging momentum with the nucleus
  - neutrinos carry little momentum
- Delayed particles from the beamline: slowly moving particles
- Misreconstruction: better resolution, influence from detector and software

Radiative Pion Capture

$\pi^- + Al \rightarrow \gamma^{(*)} + X$

$\rightarrow e^+e^-$

Occurs promptly

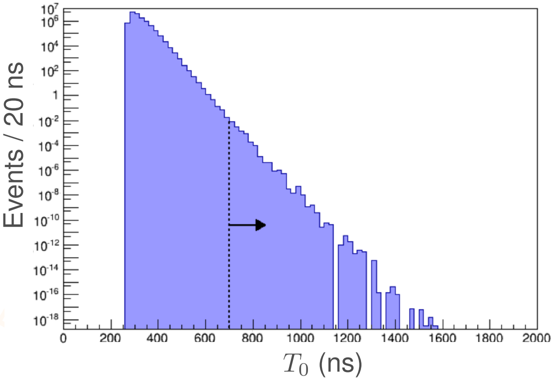
E_e up to m_π (139.6 MeV)

Pulsed proton beam

Minimize proton tail

Out-of-time protons

A delayed live gate



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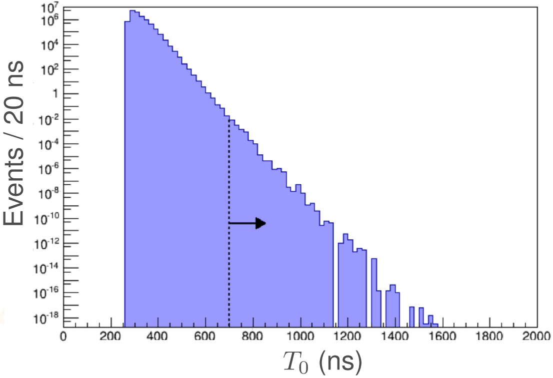
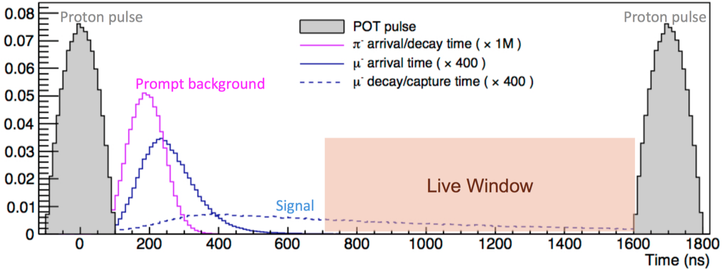


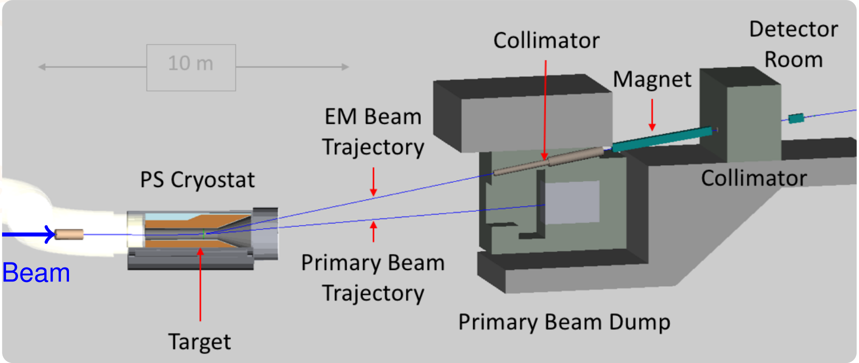
A suppression of 17 orders of magnitude

Pulsed Proton Beam

- Pulsed beam of low energy μ^-
- Stop the muons in 1S state of muonic atom
- Let prompt backgrounds go
- Measure the electron spectrum in a delayed window
- Search for the conversion electron



Extinction Monitor



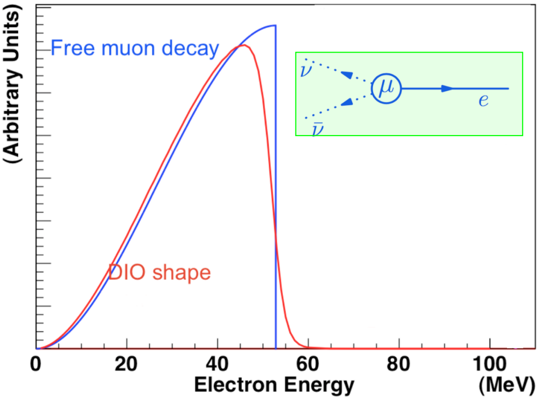
- Collimators and permanent magnet: 4.2 GeV protons or pions
- Require a precision of 10^{-10}
- Record at least 16 particles per pulse, 150k pulses/s

Decay In Orbit

$\mu^- \rightarrow e^- \bar{\nu}_e \nu_\mu$

Michel threshold

$E_e^{\max} = (m_\mu^2 + m_e^2)/2m_\mu$



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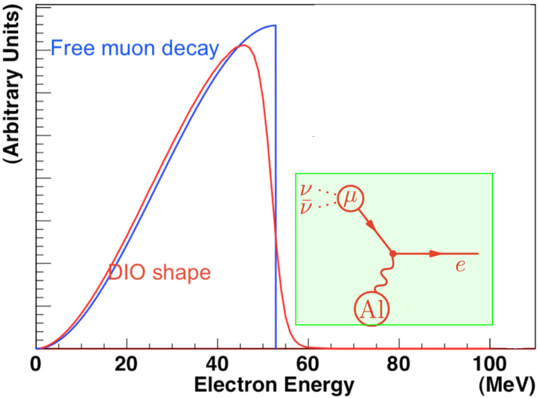
Decay in orbit

Very long tail



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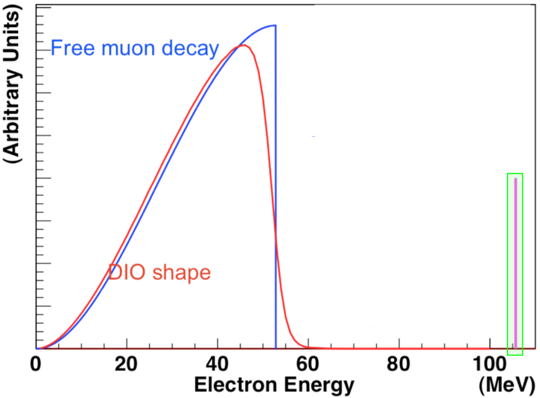
Conversion energy



Simulation of DIO

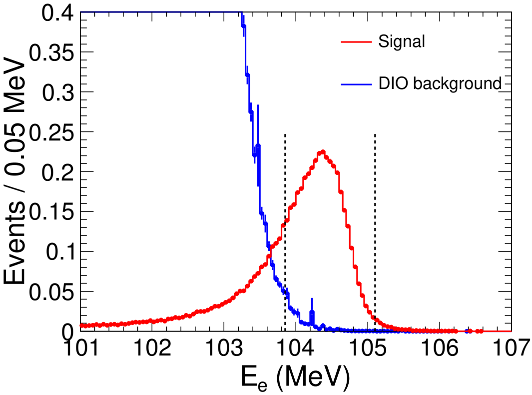
Assuming $R_{\mu e} = 10^{-16}$

With 3.6×10^{20} POT

In 103.85-105.10 MeV:

$N_S = 3.72 \pm 0.01$

$N_{BG} = 0.20 \pm 0.02$



A. Czarnecki, X. Tormo, W. Marciano, Phys. Rev. D84 (2011) 013006

Tracker Straw

- Straw technology assures the resolution
  - Low mass
  - Robust in vacuum
  - Allows single-wire failure

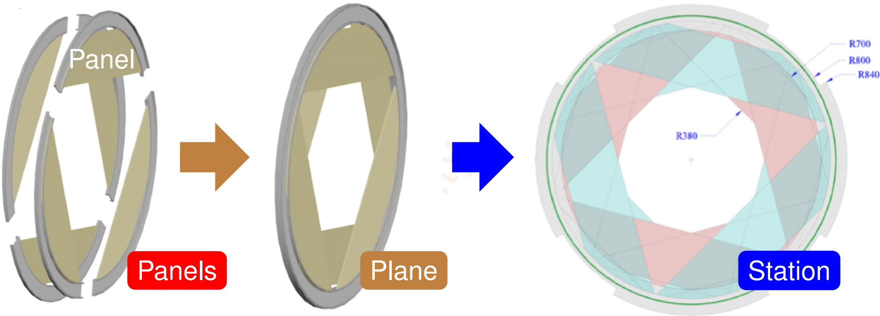
- ϕ =5 mm straw
- Spiral wound
- Walls: 12 μm Mylar + 3 μm epoxy

  + 200 Ångstrom Au + 500 Å Al
- 25 μm Au-plated W sense wire
- 33-117 cm in length
- 80/20 Ar/CO2 with HV < 1500 V

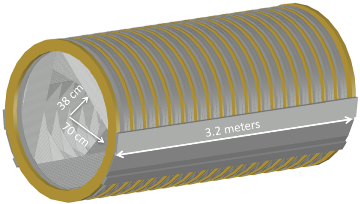
Straw Tracker

- Each self-supporting panel contains 96 straws
- Six panels assemble a plane
- Two planes for a station
- Rotation of panels and planes
- 18 stations use >20k straws in total

Momentum resolution:
$\sigma_p/p < 0.2\%$ @ 105 MeV



Signal and Background in Tracker



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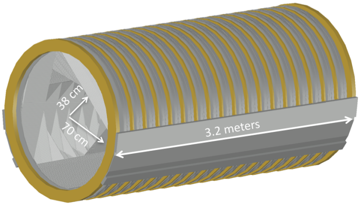

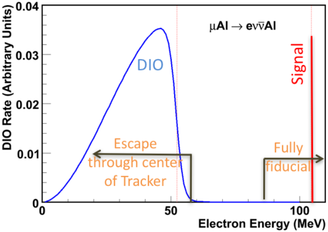

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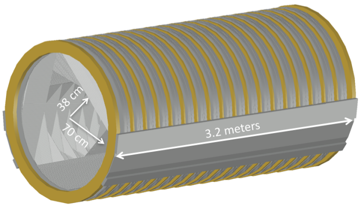
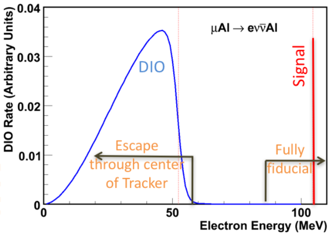
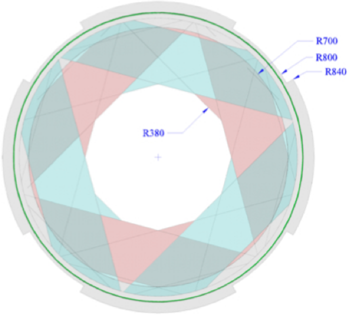




- Inner hole with radius $\sim$ 38 cm



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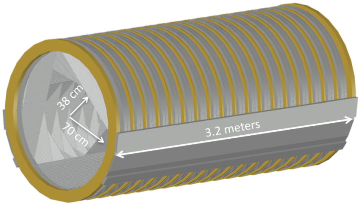
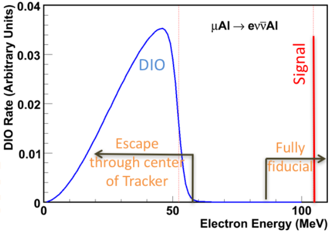
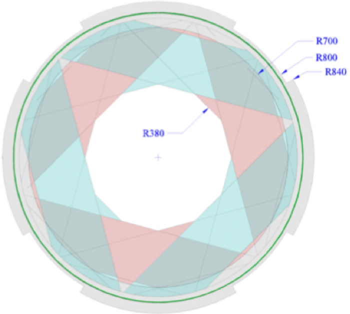




- Inner hole with radius $\sim$ 38 cm
- Blind to beam flash



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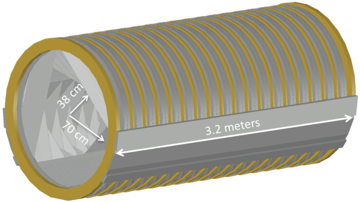
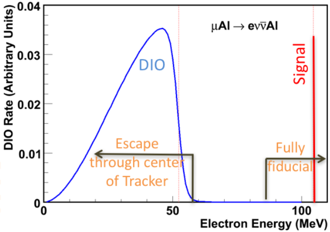
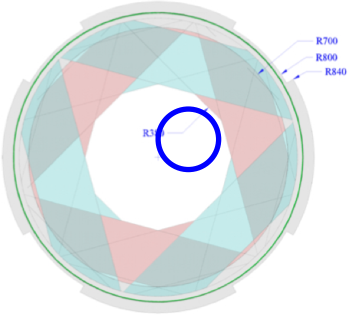
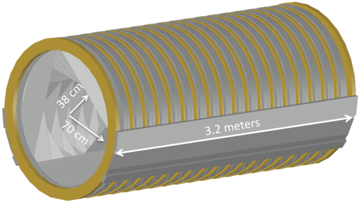


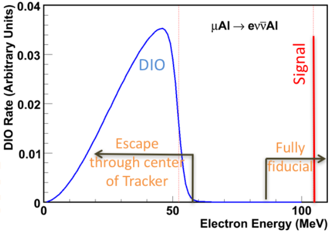




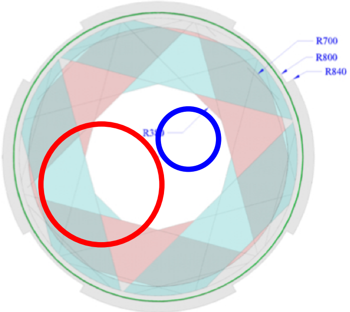
- Inner hole with radius $\sim$ 38 cm
- Blind to beam flash
- Skip most of the DIOs

Signal and Background in Tracker



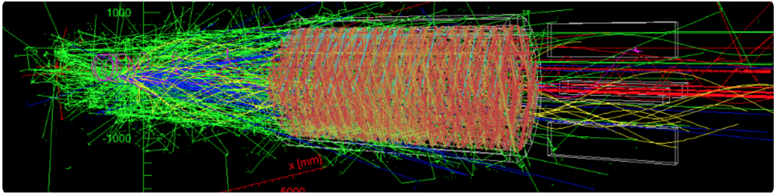


- Inner hole with radius $\sim$ 38 cm
- Blind to beam flash
- Skip most of the DIOs
- Efficient for the signal



Tracking

- To reconstruct a track from the straw hits
  - Remove noise hits
  - Pattern recognition: classify hits for particles
  - Helix fitting: reconstruct the trajectory

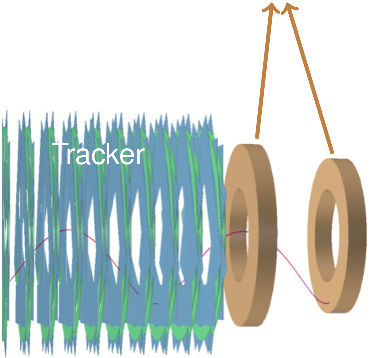


Signal electron hides in hits in the signal time window

Calorimeter

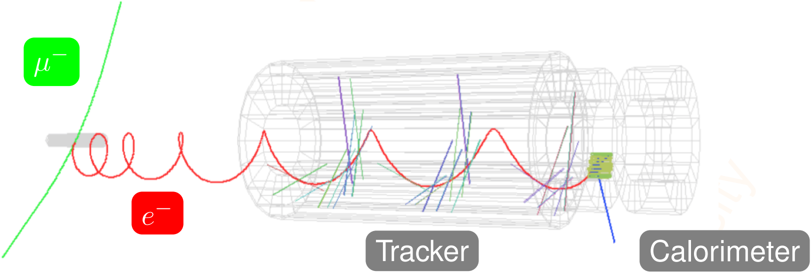
- Requirements:
  - PID to separate e/μ
  - Seed for track pattern recognition
  - Independent trigger with E_{deposit}
  - Work in 1T B field and vacuum
  - Radiation hard, $10^{12}\text{n}/\text{cm}^2$/year
- Choice: Cesium Iodide (CsI)
  - σ_E/E: 5% @ 100 MeV
  - Time resolution: 0.5 ns
  - Position resolution: 1 cm
  - $\sim$90% acceptance @ 100 MeV

Two disks separated by half λ
674 crystals/disk
each $3.4 \times 3.4 \times 20$ cm



Cosmic Ray

- Muon decay in the Detector Solenoid
- Muon interactions in the Stopping Target, absobers, detectors that produce produce electrons
- Muons that enter the Detector Solenoid being scattered and misidentified as electrons



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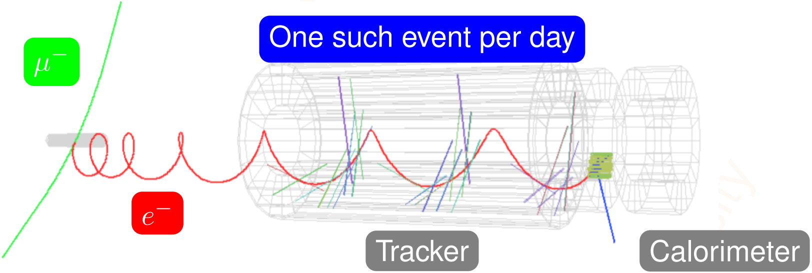
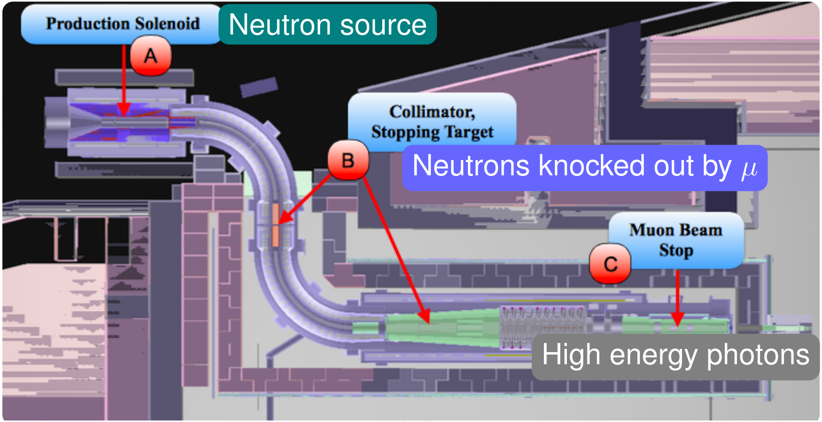


Beam Shielding

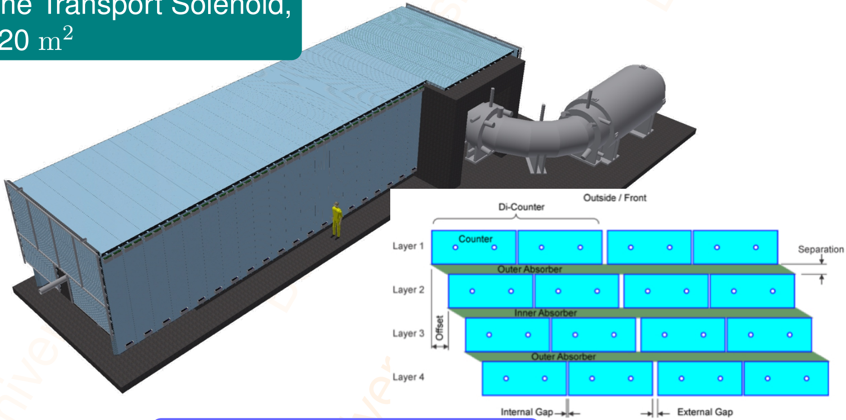
- 91 cm thick T-shaped concrete walls to shield from the beam backgrounds



Cosmic Ray Veto

Covers Detector Solenoid and part of the Transport Solenoid, about 320 m^2

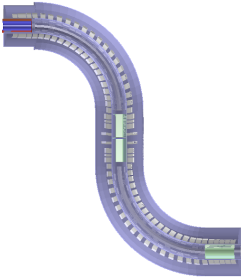
Effeciency: 99.99%



4 stacked layers of scintilator

$\bar{p}$ induced Background

- $\bar{p}$ from the 8 GeV proton beam
- Negatively charged, don't decay
- Several μs to reach the Detector Solenoid
- Annihilate on nuclei, releasing significant energy



$\bar{p}$ induced Background

- $\bar{p}$ from the 8 GeV proton beam
- Negatively charged, don't decay
- Several μs to reach the Detector Solenoid
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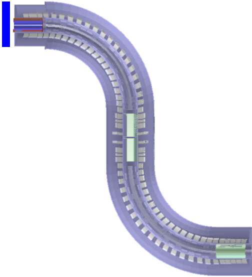
Limit the number of $\bar{p}$ reaching the Stopping Target



- In Detector Solenoid: $\bar{p} + \text{nuclei} \to \pi^0/\pi^- + X$
- π^- from the absorbers
- Cause electrons in the signal region, and needs consumption

Expected Backgrounds

Category	Source	Yields
Intrinsic	μ Decay in Orbit	0.14
	Radiative μ Capture	< 0.01
Late Arriving	Radiative π Capture	0.02
	Beam electrons	< 0.01
	μ Decay in Flight	< 0.01
	π Decay in Flight	< 0.01
Miscellaneous	Anti-proton Induced	0.04
	Cosmic Ray	0.21 ± 0.06
Total		0.41 ± 0.13

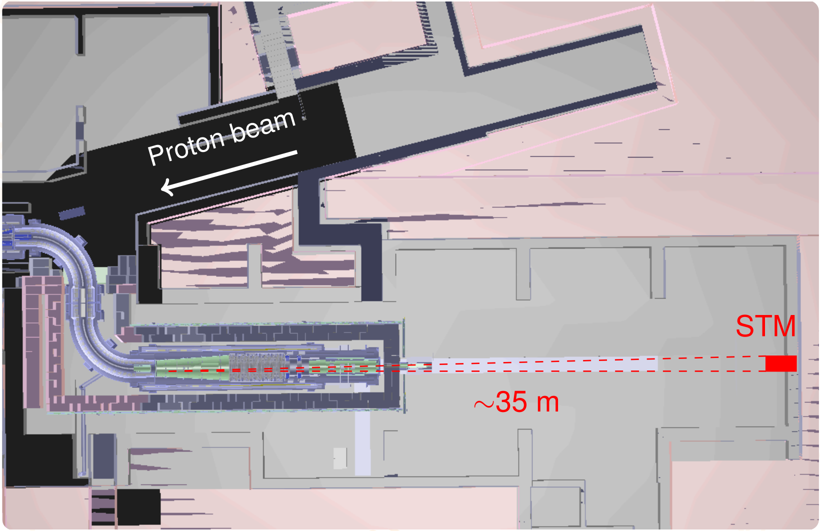
Reach a 32% uncertainty with 3-year running

Systematic Uncertainties

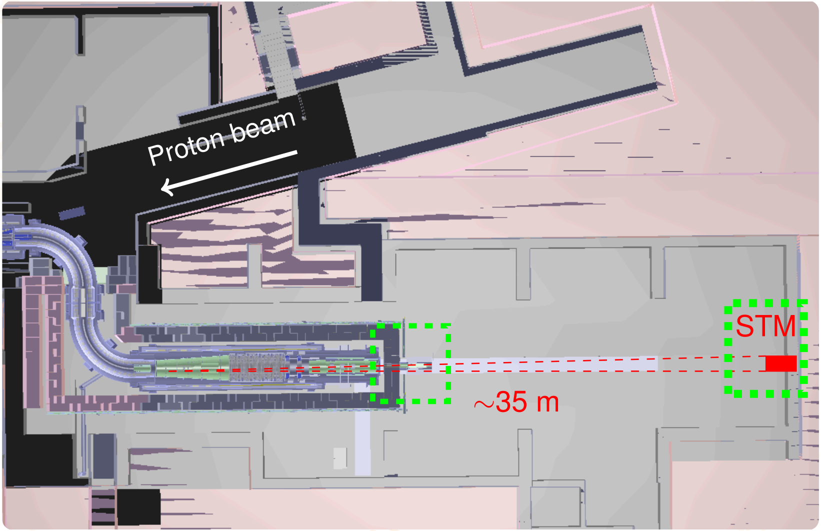
Source	Uncertainty in DIO background yield	Uncertainty in CE single-event-sensitivity (10^{-17})
MC Statistics	±0.02	±0.07
Theory	±0.04	-
Tracker Acceptance	±0.002	±0.03
Reconstruction Efficiency	±0.01	±0.15
Momentum Scale	$+0.09, -0.06$	±0.07
μ-bunch Intensity Variation	±0.007	±0.10
Beam Falsh	±0.011	±0.17
μ-capture Proton	±0.01	±0.016
μ-capture Neutron	±0.006	±0.093
μ-capture Photon	±0.002	±0.028
Out-Of-Target μ Stops	±0.004	±0.055
Degraded Tracker	-0.013	$+0.191$
Total	$+0.10, -0.08$	$+0.35, -0.29$

Outline

Stopping Target Monitor



Stopping Target Monitor



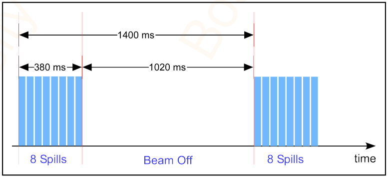
Signals for STM

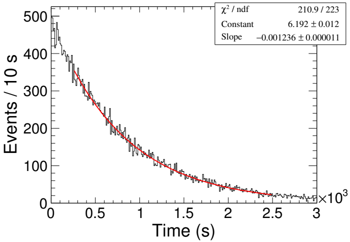
Photons emitted by muons: keV

- 347: produced immediately when muons stop
  - 2p-1s transition with 79.8(8)% rate
  - overlap with the prompt backgrounds
- 844: delayed signal
  - $\mu +^{27}_{13} Al \rightarrow^{27}_{12} Mg + \nu_\mu,\ ^{27}_{12}Mg \rightarrow^{27}_{13} Al + e^- + \bar{\nu}_e \gamma(844)$
  - 9.5 min. half-life
  - Rate at ∼9.3% of μ captures
- 1809: when muons get captured
  - $\mu +^{27}_{13} Al \rightarrow^{26}_{12} Mg^* + n + \nu_\mu,\ ^{26}_{12}Mg^* \rightarrow^{26}_{12} Mg + \gamma(1809)$
  - Rate at 31.1% of stops or at 51(5)% of captures

STM Choices

- Ge detector
  - Good time and energy resolution
  - For the prompt signal 347
- 1 sec. beam-off period:
  - Lifetime of 844 is 13.6 min.
  - Good for 844
- Lanthanum Bromide
  - Rate up to 1M Hz
  - Radiation hard
  - Worse resolution
  - Good complement to Ge





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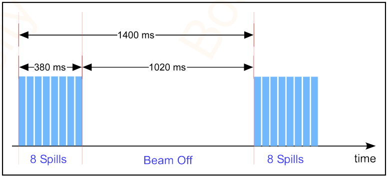
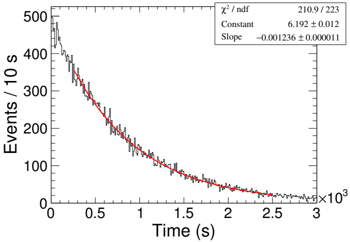
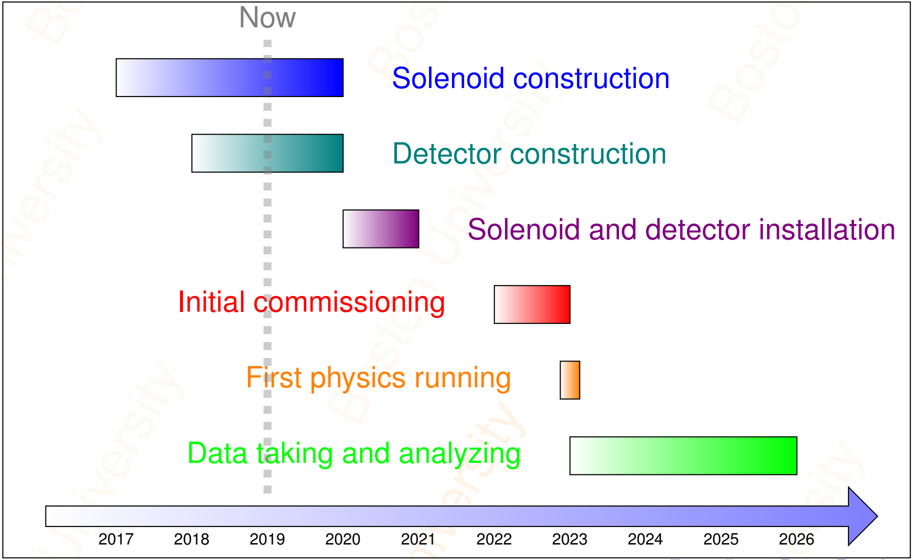
Achieve a 10% precision





Outline

Mu2e Schedule



Mu2e → Mu2e-II

- Higher sensitivity or precision
- 10 times stronger beam
- Upgrade detectors
- White paper arXiv:1307.1168
- Expression of Interest: arXiv:1802.02599

Summary

- A search for Charge Lepton Flavor Violation
  - Coherent conversion of $\mu^- \to e^-$ in the field of an Al nucleus
  - Provides discovery for $R_{\mu e} > 2 \times 10^{-16}$
- Expect 4 orders of magnitude improvement
  - World's most intense muon beam
  - Almost background free
- Data is coming in ~2023