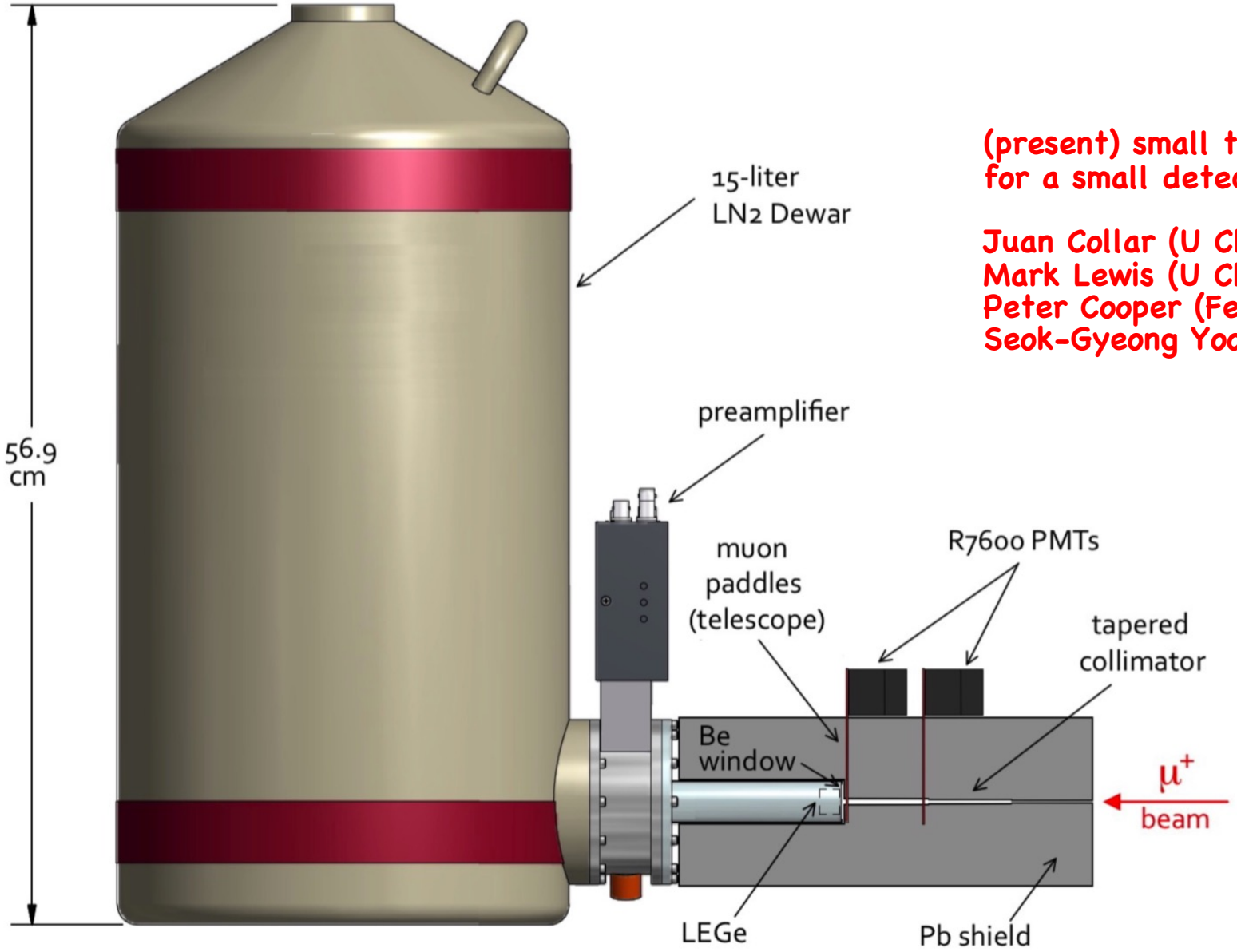
X-lent:

A Search for Two-Body Antimuon Decay Near Its Kinematic Limit



(present) small team
for a small detector:

Juan Collar (U Chicago/DIPC)
Mark Lewis (U Chicago/DIPC)
Peter Cooper (Fermilab)
Seok-Gyeong Yoon (U Chicago)

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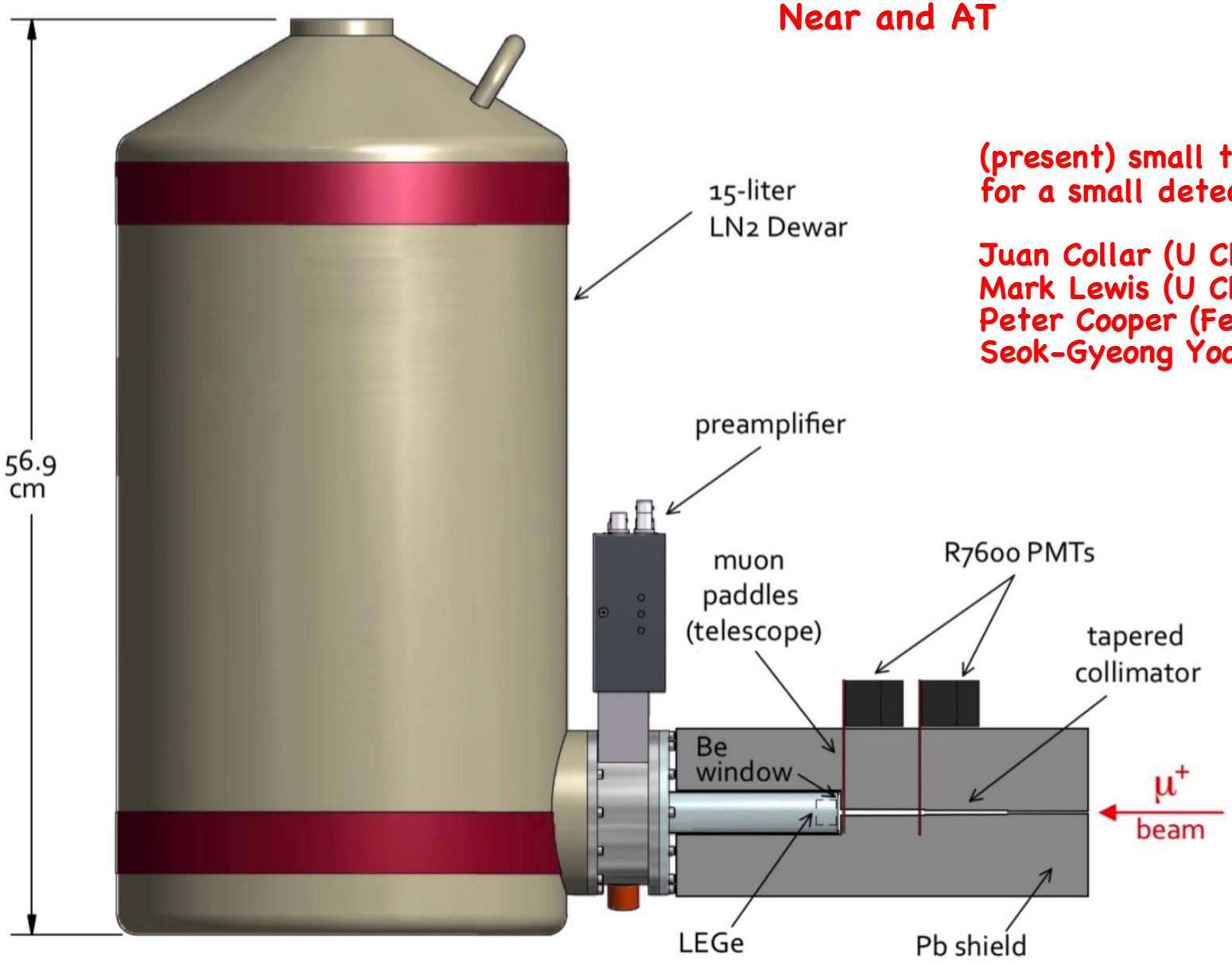
A Search for Two-Body Antimuon Decay ~~Near~~ Its Kinematic Limit

Near and AT



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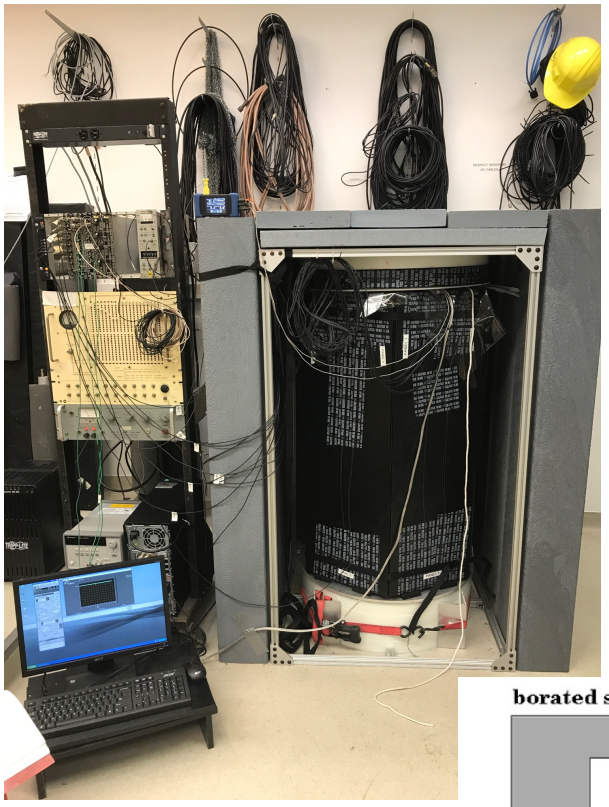
Convoluted path to this proposal...



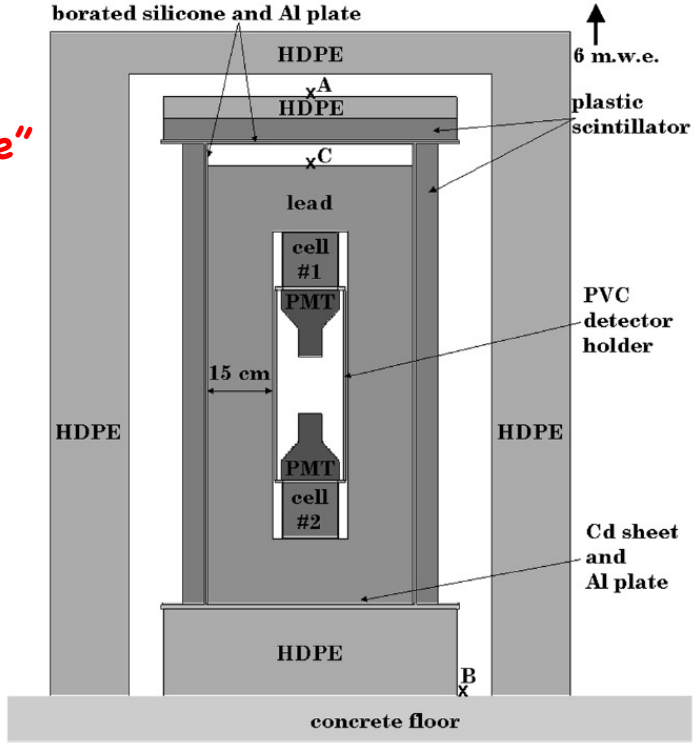
classic "muon telescope"
(w/ amusing tweaks)

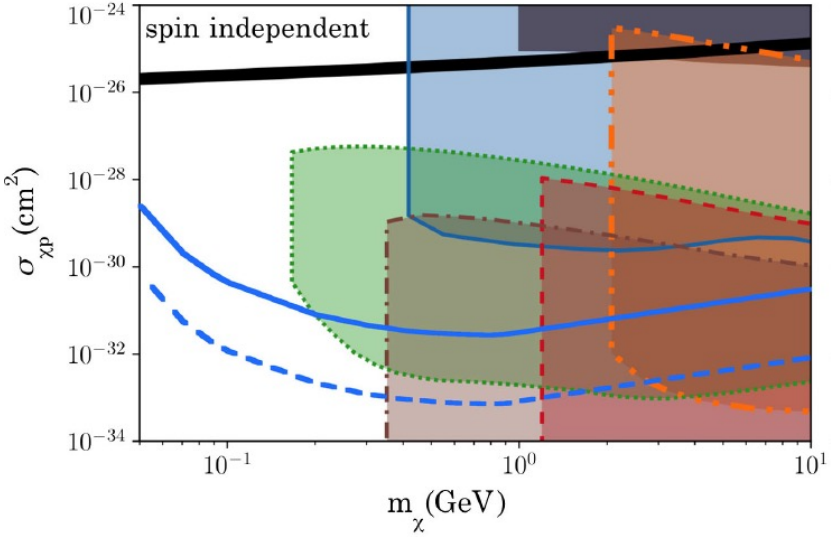
junk recycling...

PHYSICAL REVIEW D **98,** 023005 (2018)

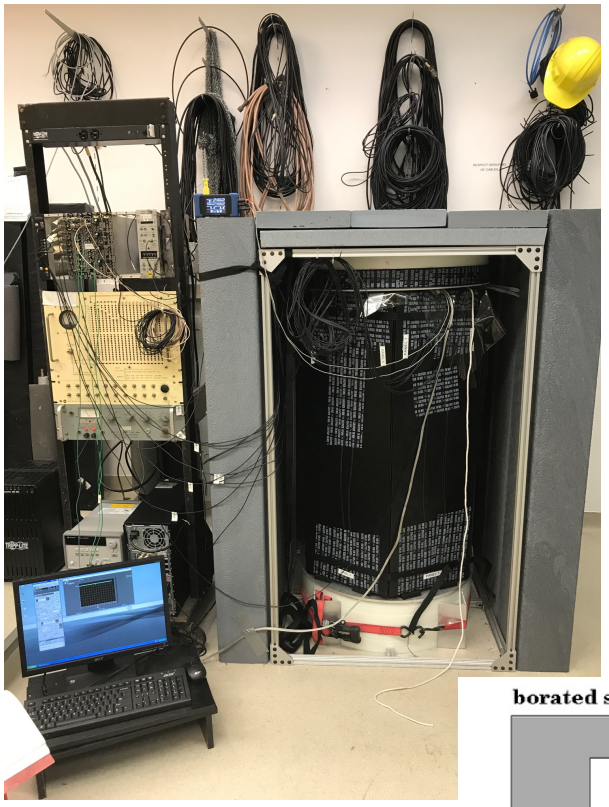
Search for a nonrelativistic component in the spectrum of cosmic rays at Earth

J. I. Collar*





one thing leads to another...



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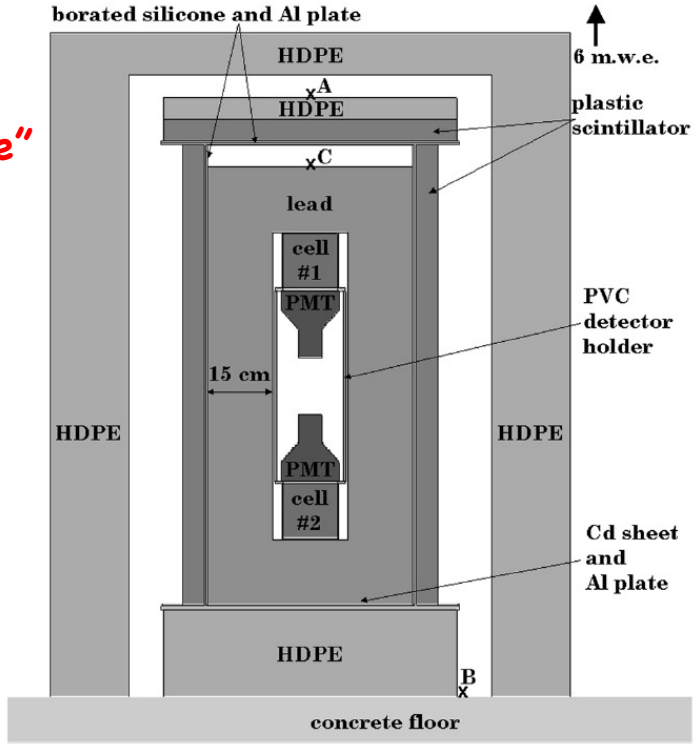
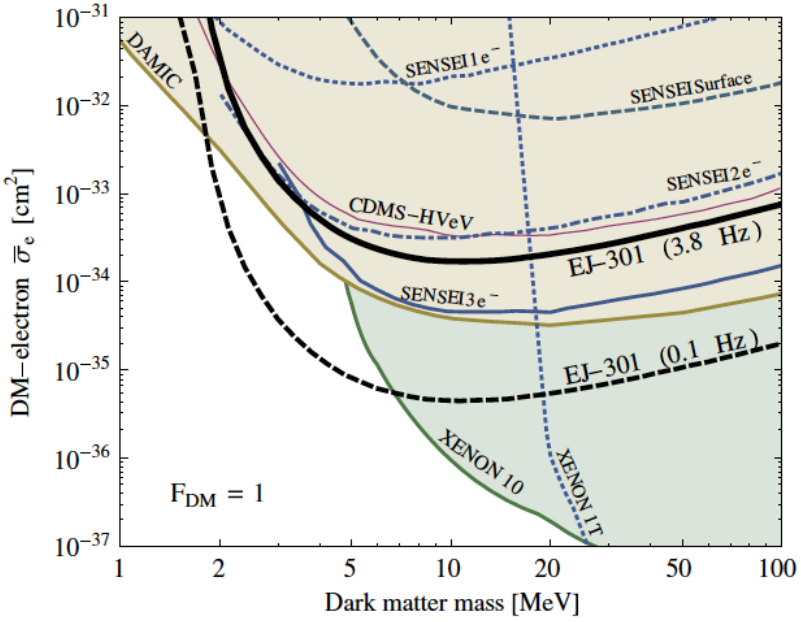


additional low-mass DM limits...

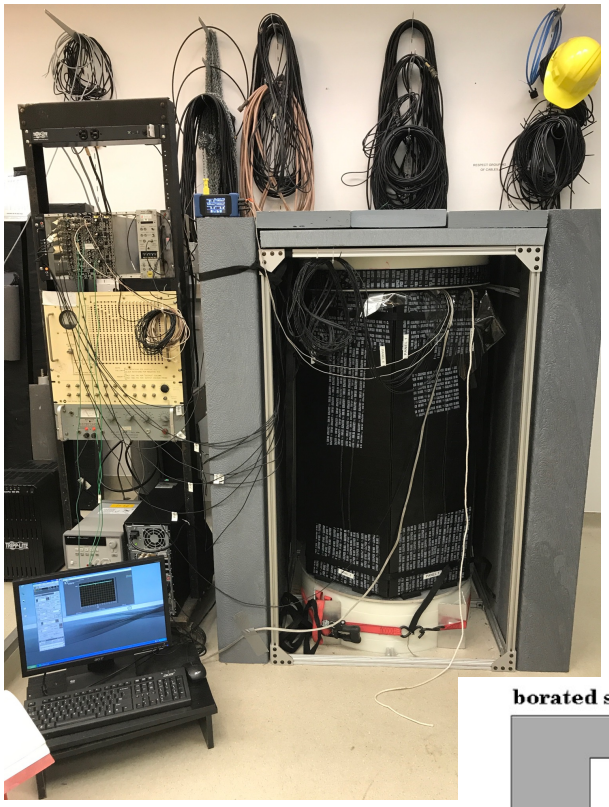
PHYSICAL REVIEW D **101,** 056001 (2020)

Dark matter-electron scattering from aromatic organic targets

Carlos Blanco,[1,2,*] J. I. Collar,[1,2,†] Yonatan Kahn,[3,‡] and Benjamin Lillard[3,§]



one thing leads to another...



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(w/ amusing tweaks)

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PHYSICAL REVIEW D **98,** 023005 (2018)

Search for a nonrelativistic component in the spectrum of cosmic rays at Earth

J. I. Collar*

high-mass DM limits...

PHYSICAL REVIEW D **103,** 023019 (2021)

New experimental constraints in a new landscape for composite dark matter

Christopher V. Cappiello[1,2,*] J. I. Collar[3,†] and John F. Beacom[1,2,4,‡]

additional low-mass DM limits...

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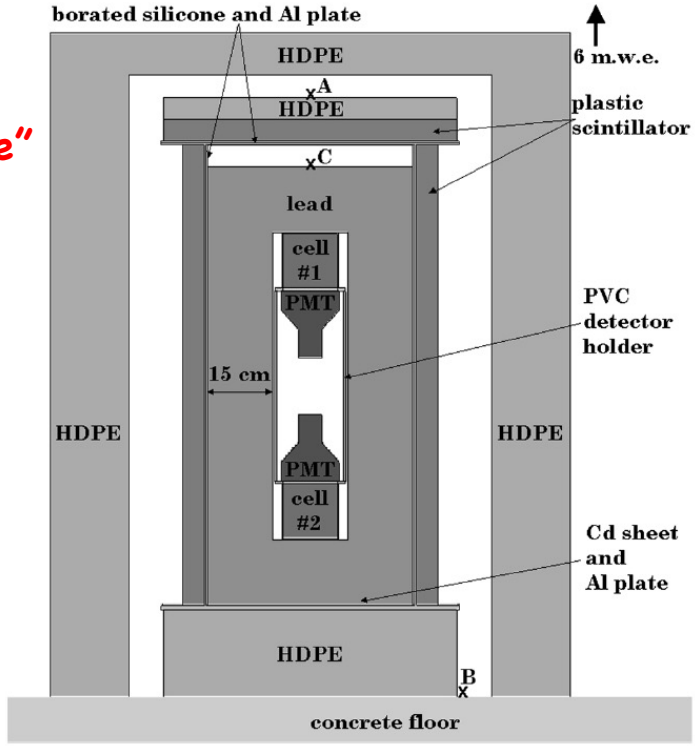
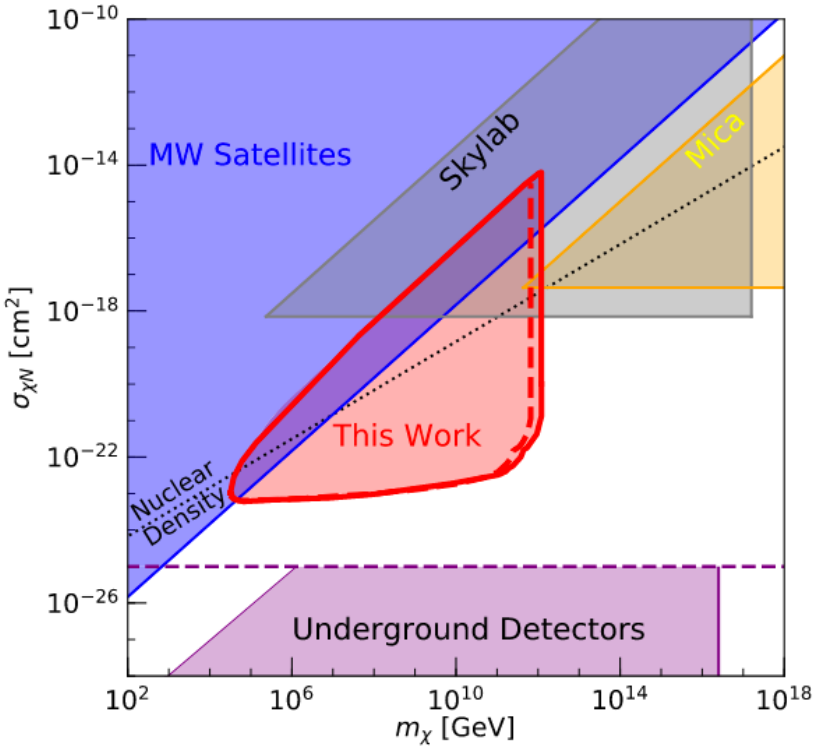
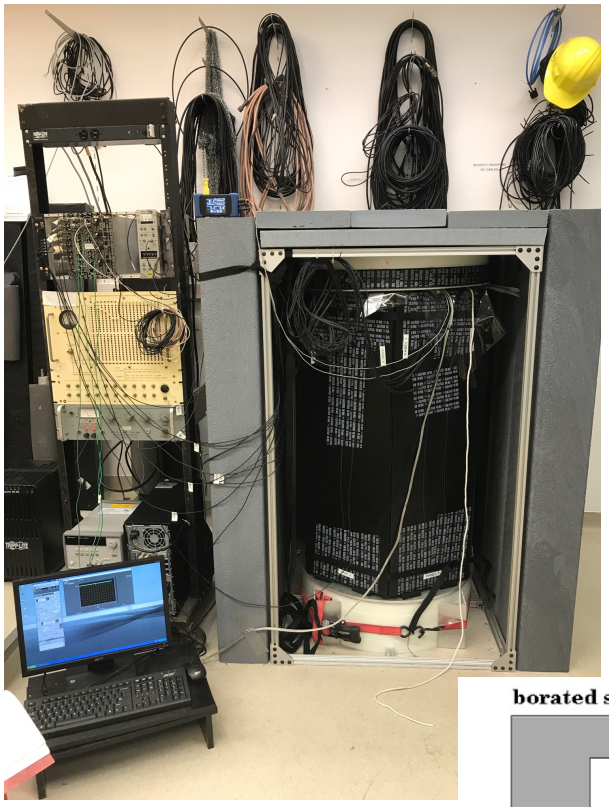




one thing leads to another…



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(w/ amusing tweaks)

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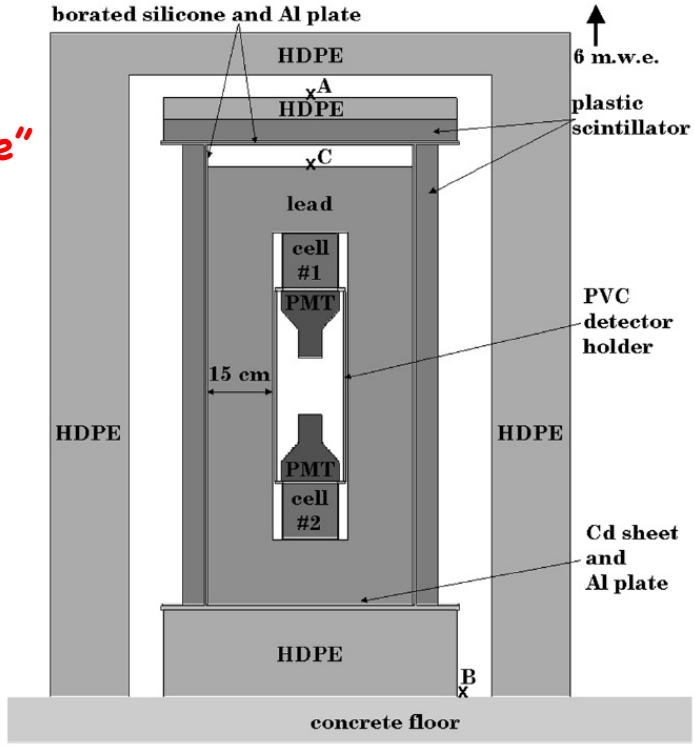
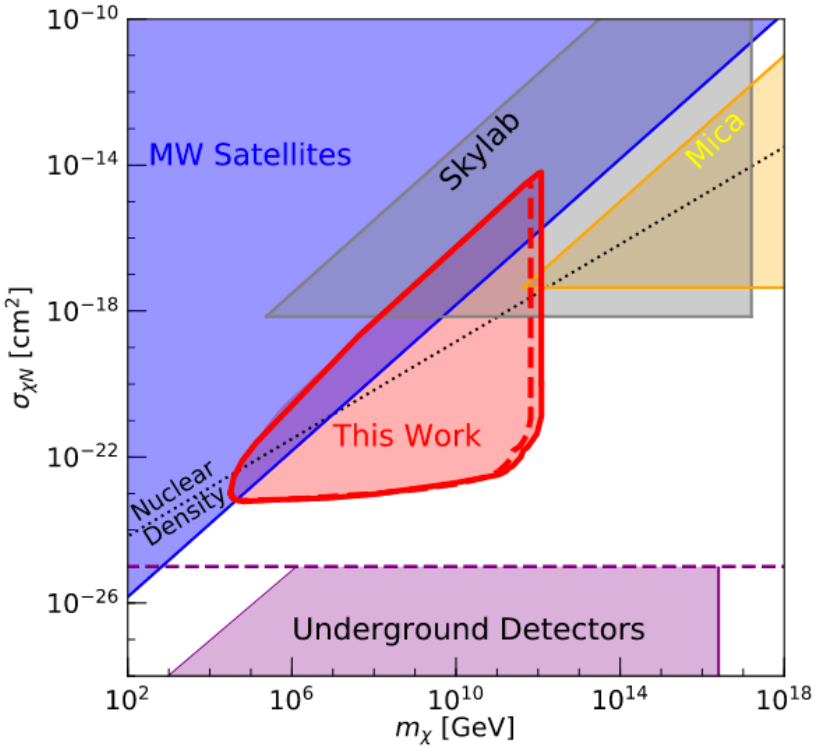
byproduct of background ruminations…

PHYSICAL REVIEW D **103,** 052007 (2021)

Search for a cosmologically relevant boson in muon decay

J. I. Collar*





one thing leads to another...

Physics Letters B 348 (1995) 19–28

Anomaly in the time distribution of neutrinos from a pulsed beam stop source

KARMEN Collaboration

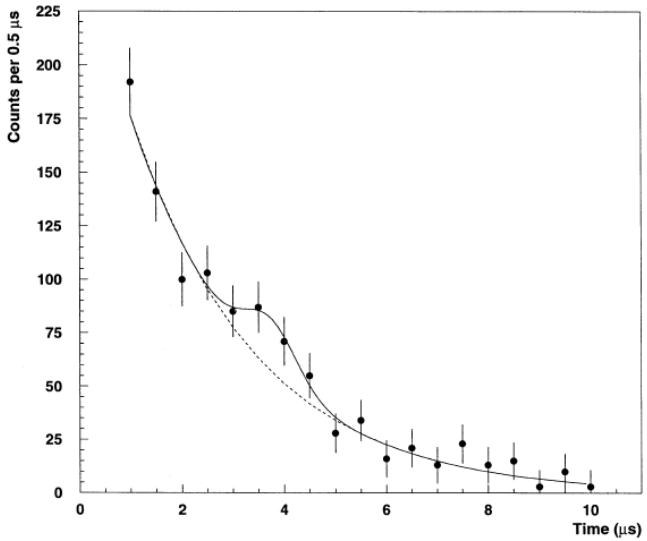


Fig. 1. Time distribution of events in the KARMEN calorimeter after the subtraction of the cosmic background.[3] The data are fitted to an exponential with the 2.2 μs decay constant on which is superimposed a Gaussian signal centered at 3.7 μs. The fit procedure results in χ^2 of 9.8 for 14 degrees of freedom.

arXiv:hep-ex/0008073v1 30 Aug 2000

Does the KARMEN time anomaly originate from a beam-correlated background?

F. Atchison, M. Daum*, P.-R. Kettle, C. Wigger

(womp-womp)

one thing leads to another…

Physics Letters B 348 (1995) 19–28

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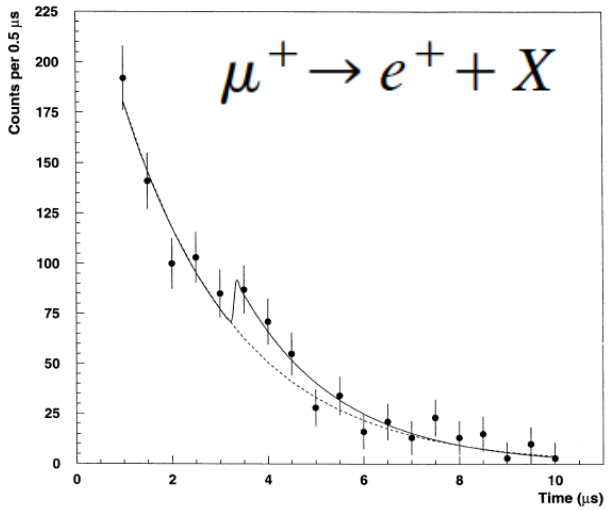


Fig. 2. Time distribution of events in the KARMEN calorimeter after the subtraction of the cosmic background.[3] The solid curves are a fit to the points by a sum of two exponentials. The first exponential describes the time distribution in the region from 1.0 to 3.3 μs and the other in the region from 3.3 to 10 μs with time constants of $(2.29 \pm 0.34)\mu s$ and $(2.1 \pm 0.6)\mu s$, respectively. The broken line corresponds to the extrapolation of the first exponential. The fit procedure results in χ^2 of 9.7 for 15 degrees of freedom.

Does the KARMEN time anomaly originate from a beam-correlated background?

F. Atchison, M. Daum*, P.-R. Kettle, C. Wigger

(womp-womp)

Physics Letters B 434 (1998) 163–168

Exotic muon decays and the KARMEN anomaly

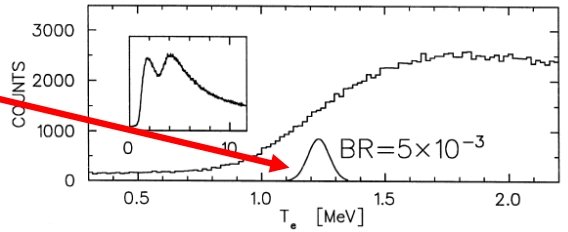
S.N. Gninenko [1], N.V. Krasnikov [2]

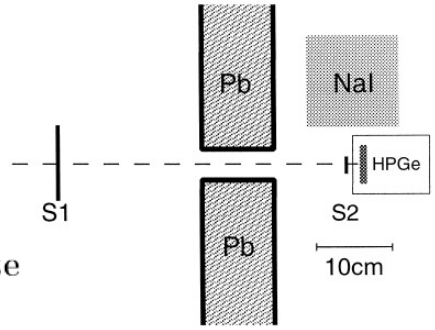
Physics Letters B 446 (1999) 363–367

Search for exotic muon decays [1]

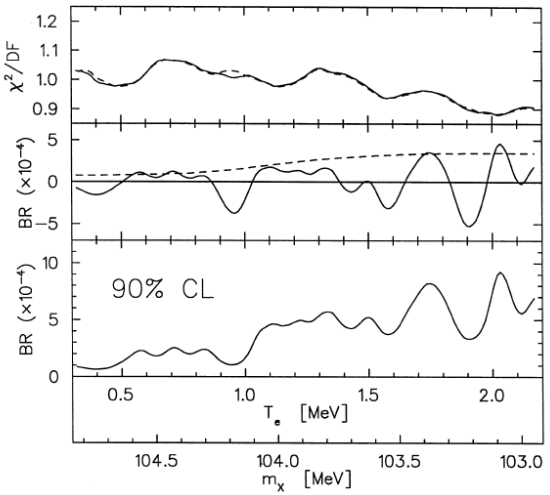
R. Bilger [a,2], K. Föhl [b], H. Clement [a], M. Cröni [a], A. Erhardt [a], R. Meier [a], J. Pätzold [a], G.J. Wagner [a]

THIS
(but much skinnier!)



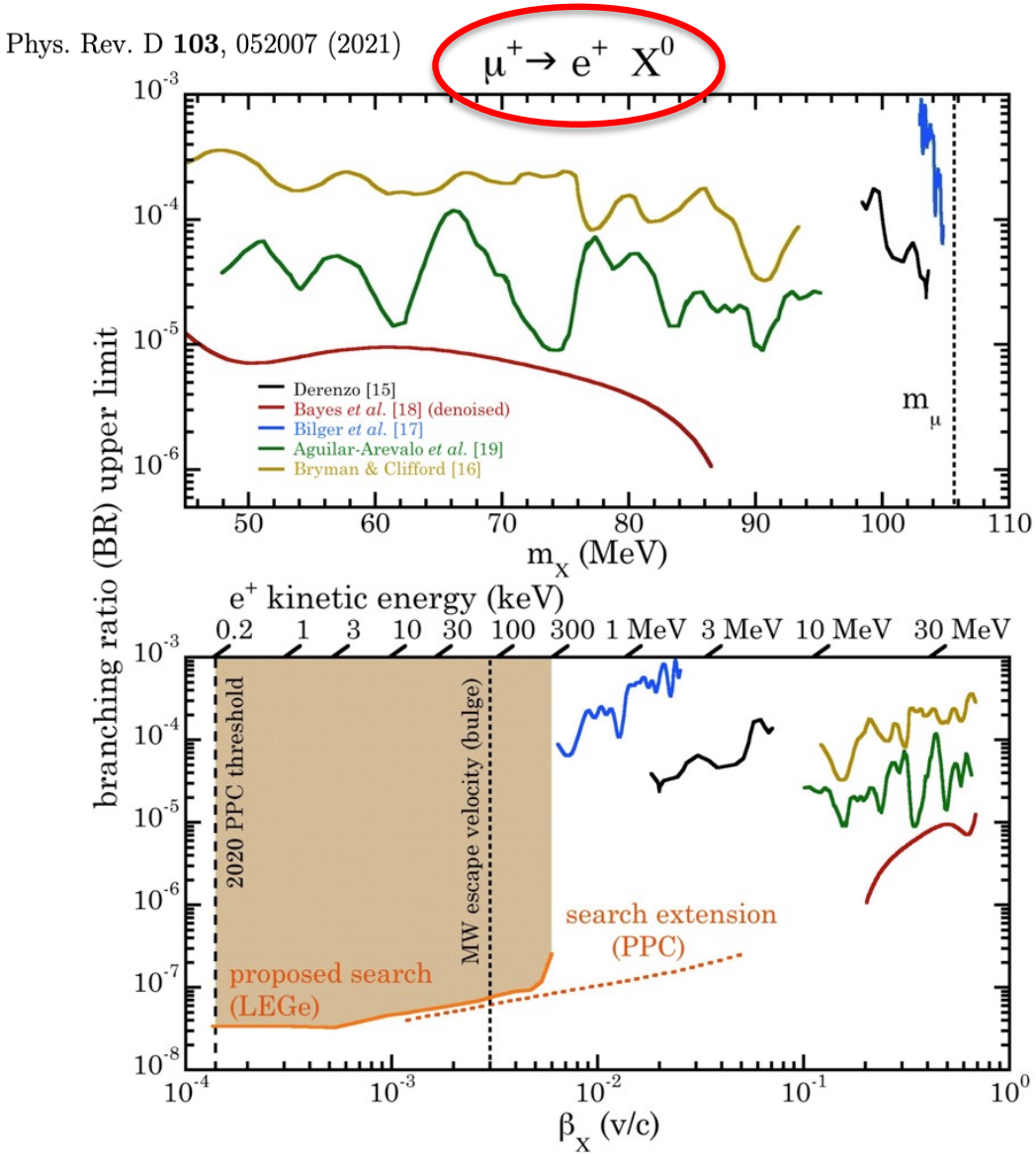


"Germanium beam-dump"
PSI MuE4 circa 1999



A different motivation

(isn't CLFV enough?)



conventional view

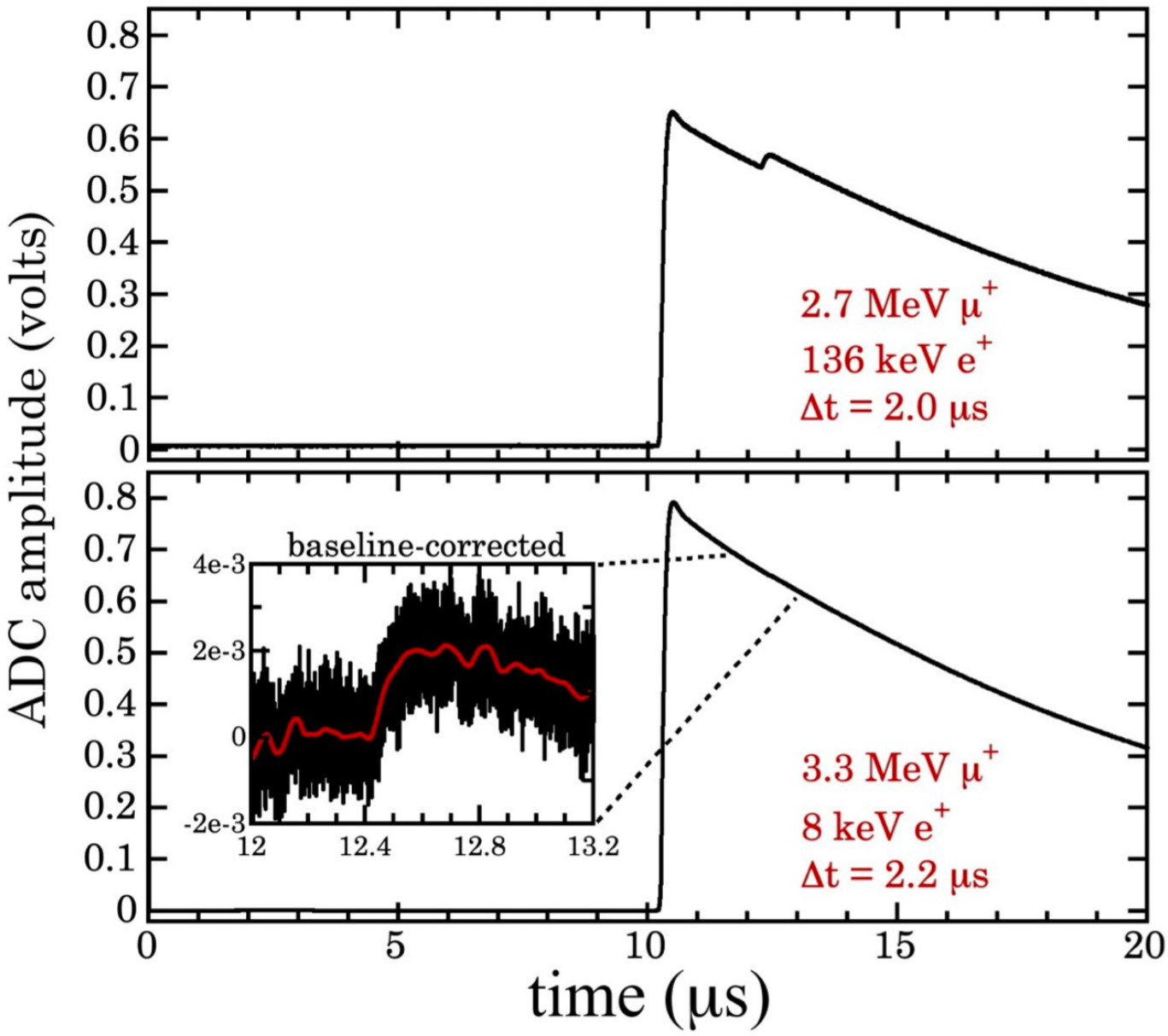
l'avant-garde

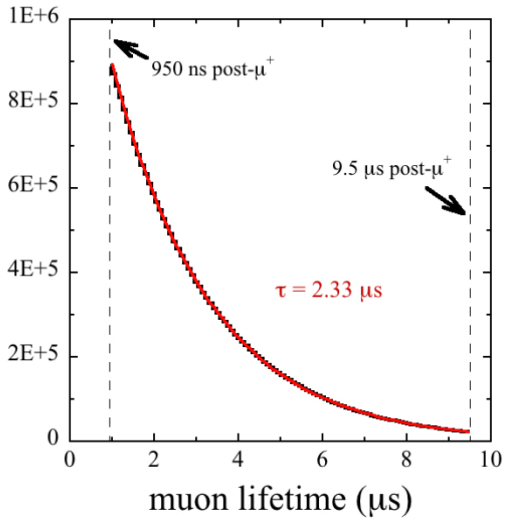
(some possible cosmological roles for a nonrelativistic X^0)

$X^0 \to e^+e^-\bar{\nu}\nu$, $X^0 \to e^+e^-\phi$

Main difficulty

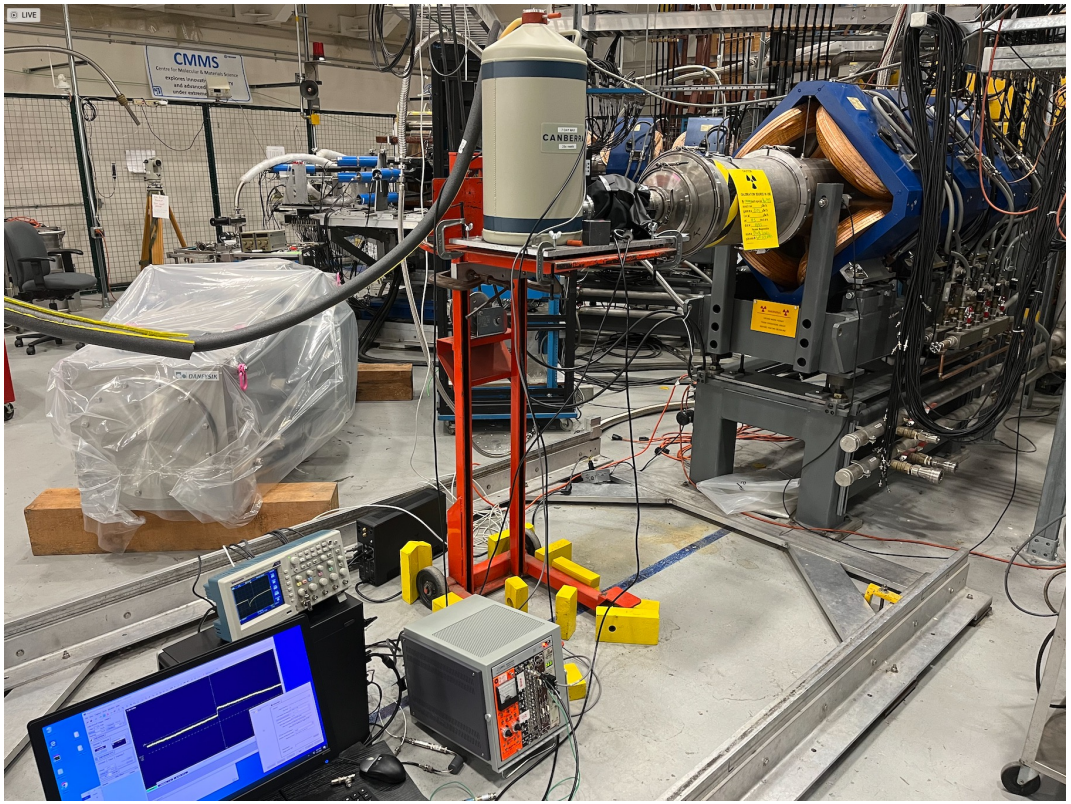
(identification of lowest possible E_{e+} a.s.a.p. after large $E_{\mu+}$)

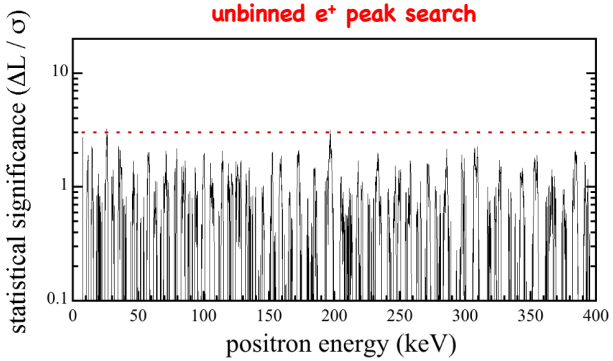




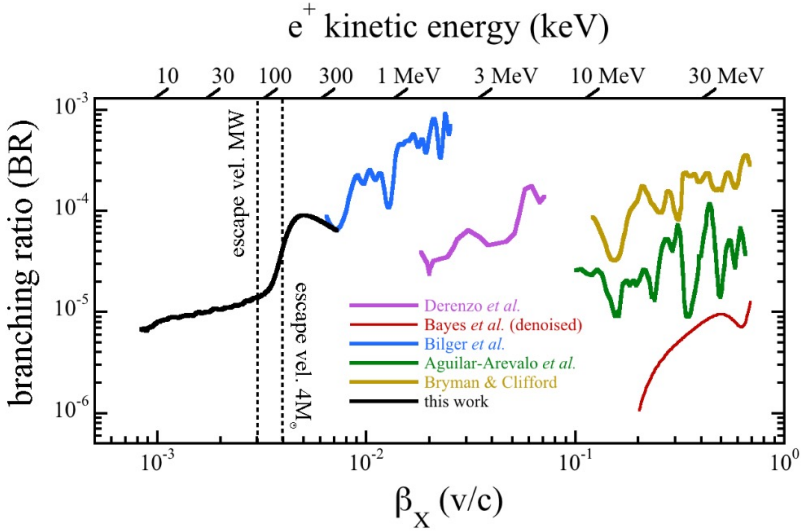
Solution is high-throughput digitization and advanced offline analysis tools

Demonstration using surface antimuons @ TRIUMF's M20
(using off-the-shelf commercial detector)





C.M. Lewis, Ph.D. dissertation 2023 (APS Tanaka prize 2024)
https://browse.arxiv.org/abs/2310.01314



PHYSICAL REVIEW LETTERS **131,** 241802 (2023)

Search for a Nonrelativistic Boson in Two-Body Antimuon Decay

J. I. Collar,[1,2,*] P. S. Cooper,[3,†] and C. M. Lewis[1,2,‡]

Excellent sensitivity due to:

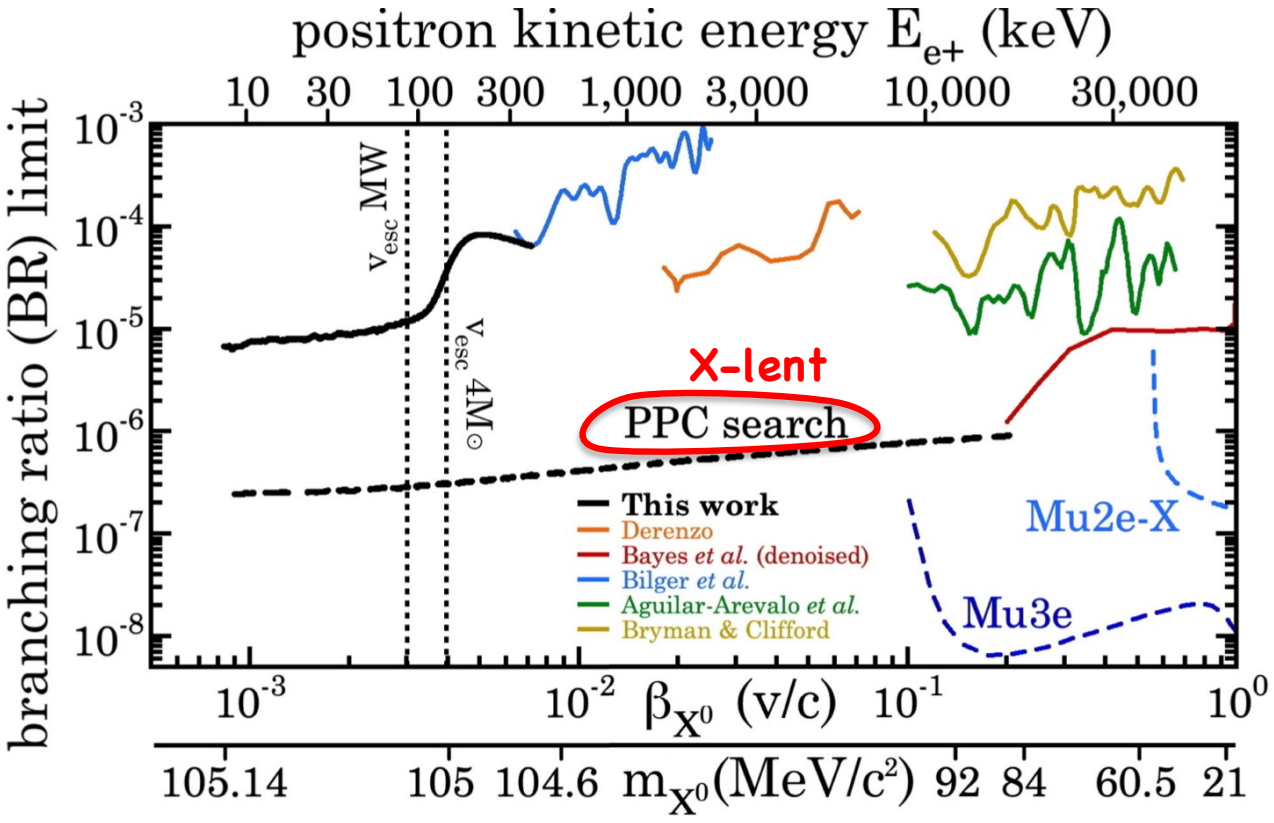
1) low-mass detector (2g)
2) Small fraction of Michel e+ at low-energy
3) Superb detector energy resolution

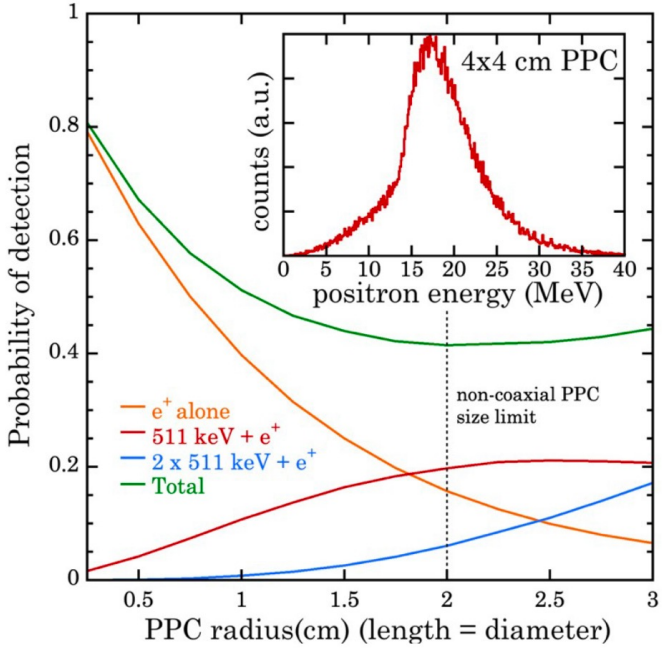
However, still limited due to:

1) digitization noise from available DAQ
2) short exposure (magnet issues)
3) predicted e+ escape bckg in a small detector

X-lent: final search at PSI

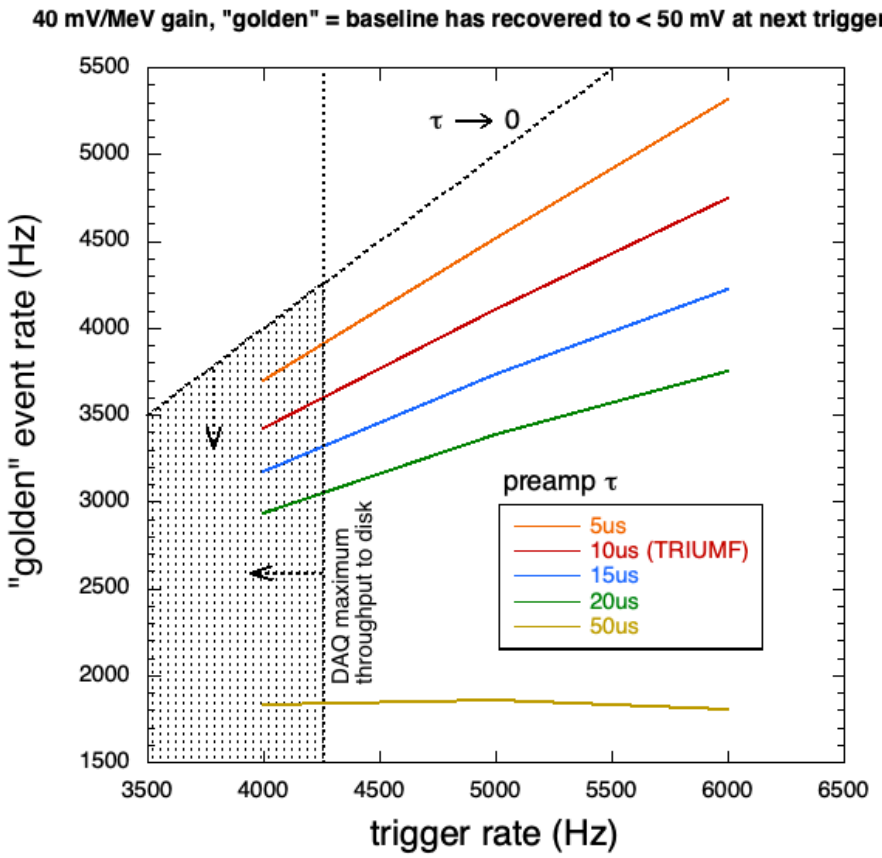
(*ad hoc* optimized PPC detector, 98 MeV/c cloud μ^+)

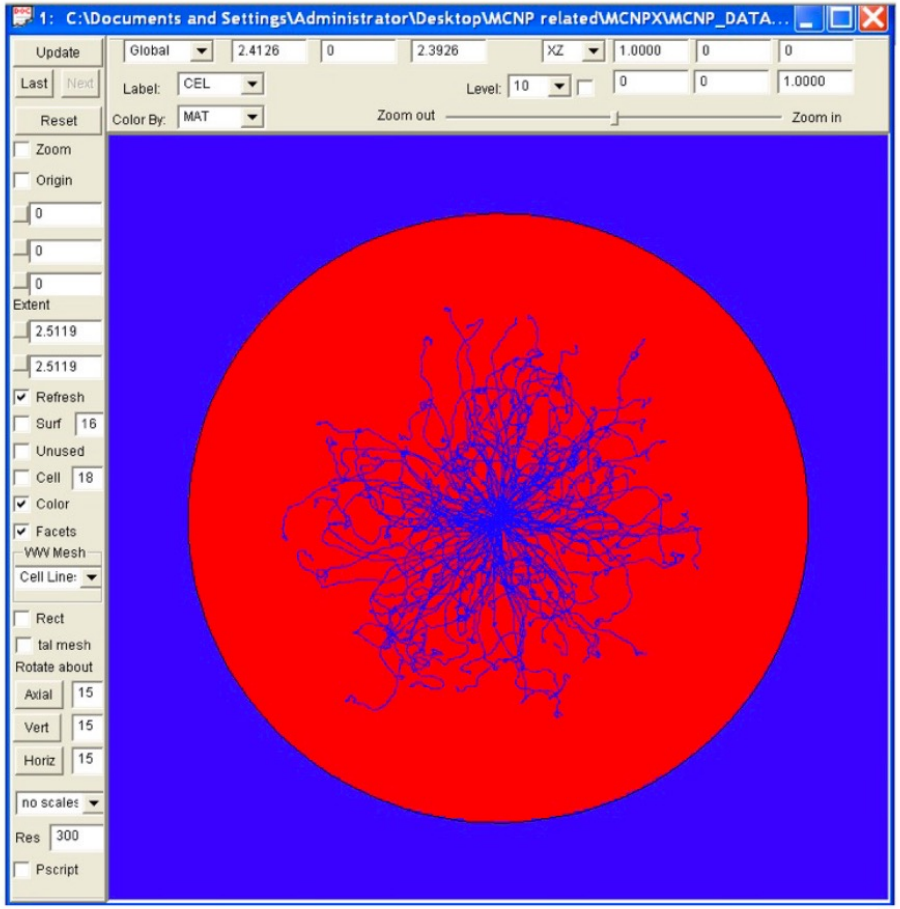




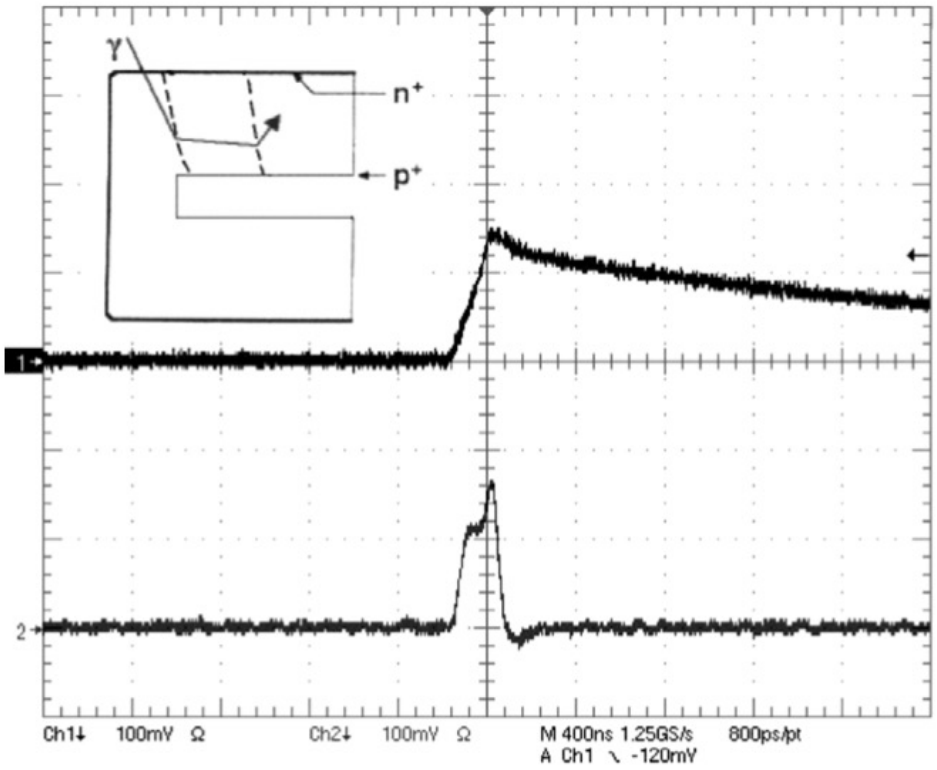
- Unique opportunity due to MuE1 planned beam test during June 2024. Presently the only beam line with required μ^+ purity and energy, anywhere. Detector completion expected March 2024.
- Conservative expectation (1,000 Hz trigger rate, aiming for ~3,500 Hz via preamplifier modifications). One-week run assumed and requested.
- Complex X_0 signature (three peaks in E_{e+} spectrum with known separation and predictable relative amplitude). Boson emission *at rest* detectable via search for 2 x 511 keV line. PSD features of PPCs can help establish a positron origin for anomalies. Anti-coincident data provide knowledge of (subtractable) environmental and beam-related backgrounds.
- Excellent complementarity in this channel with Mu3e @ PSI. Radiative losses limit us to $E_{e+} \lesssim 20$ MeV.
- Funded via US NSF PHY-2209456. Looking forward to collaboration with PSI scientists.

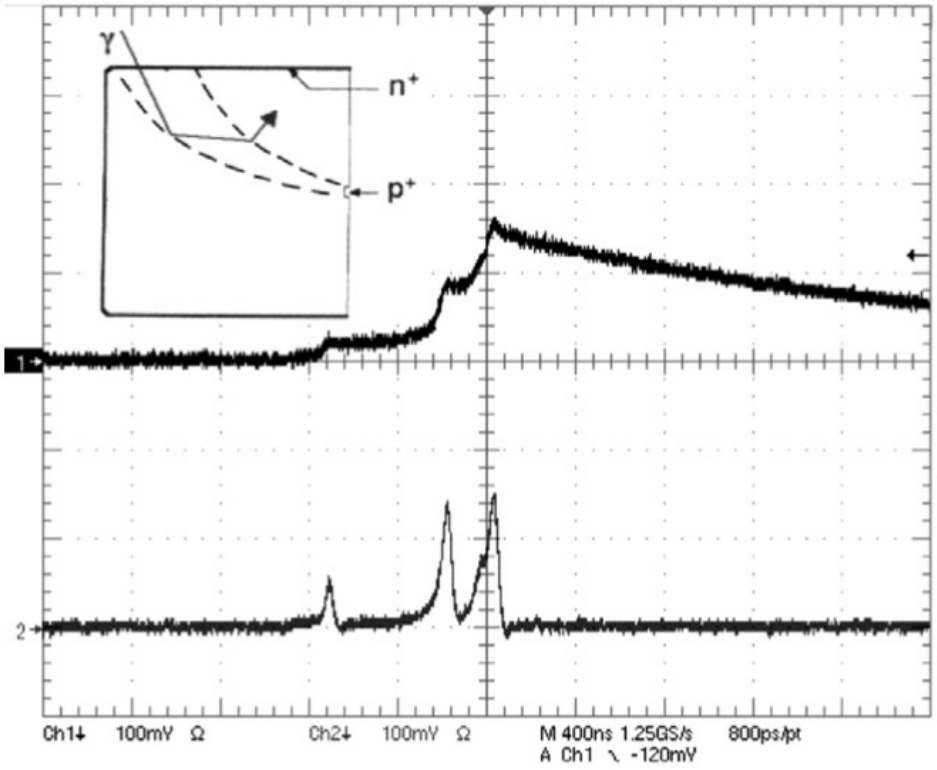
Reserve


40 mV/MeV gain, "golden" = baseline has recovered to < 50 mV at next trigger
"golden" event rate (Hz)
trigger rate (Hz)
τ → 0
DAQ maximum throughput to disk
preamp τ
5us
10us (TRIUMF)
15us
20us
50us
5500
5000
4500
4000
3500
3000
2500
2000
1500
3500
4000
4500
5000
5500
6000
6500

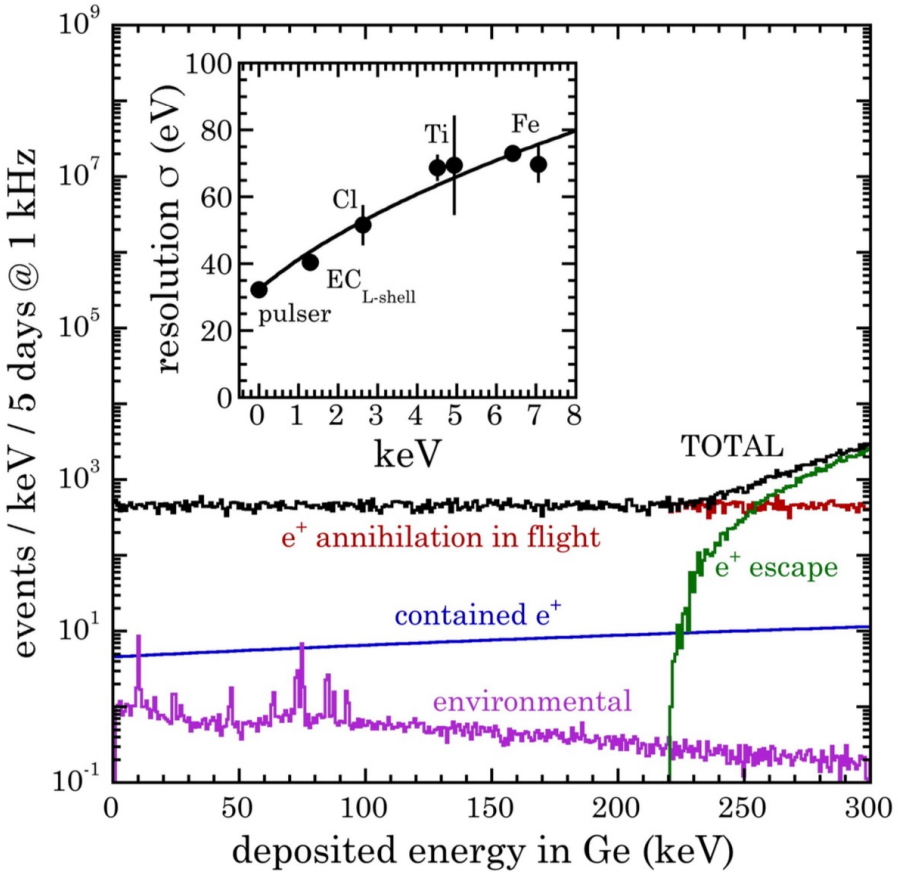

1: C:\Documents and Settings\Administrator\Desktop\MCNP related\MCNPX\MCNP_DATA...
Update
Last
Next
Reset
Zoom
Origin
Extent
Refresh
Surf
Unused
Cell
Color
Facets
Rect
Rotate about
Axial
Vert
Horiz
Pscript
Global
Label:
CEL
Color By:
MAT
Level:
Zoom out
Zoom in

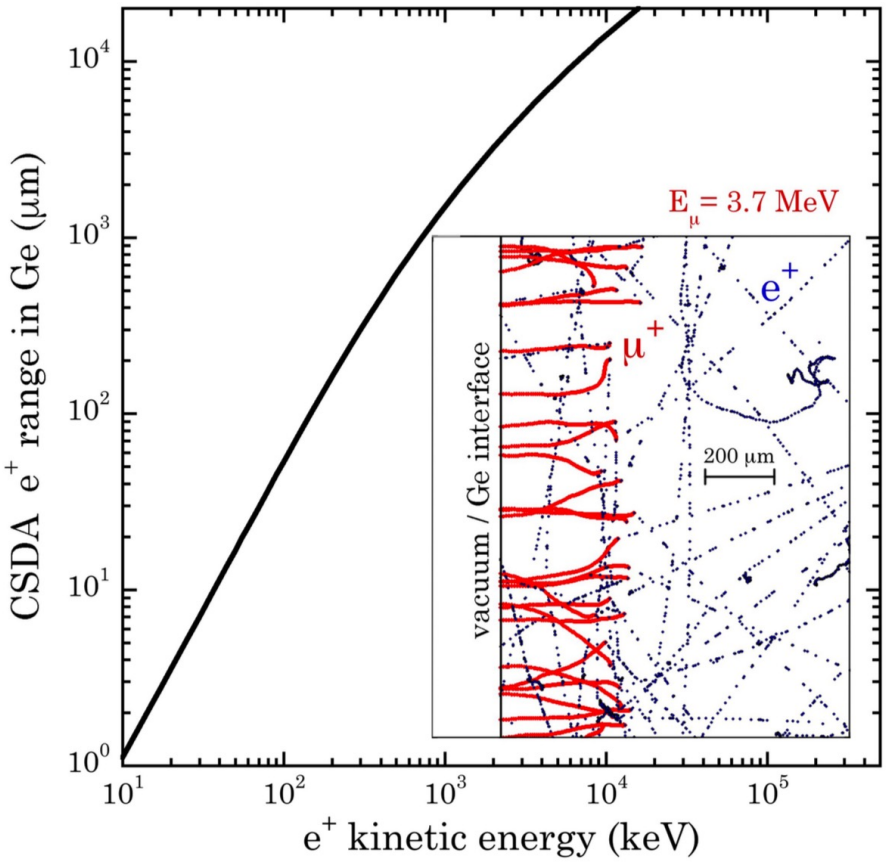
stacks.iop.org/JCAP/2007/i=09/a=009

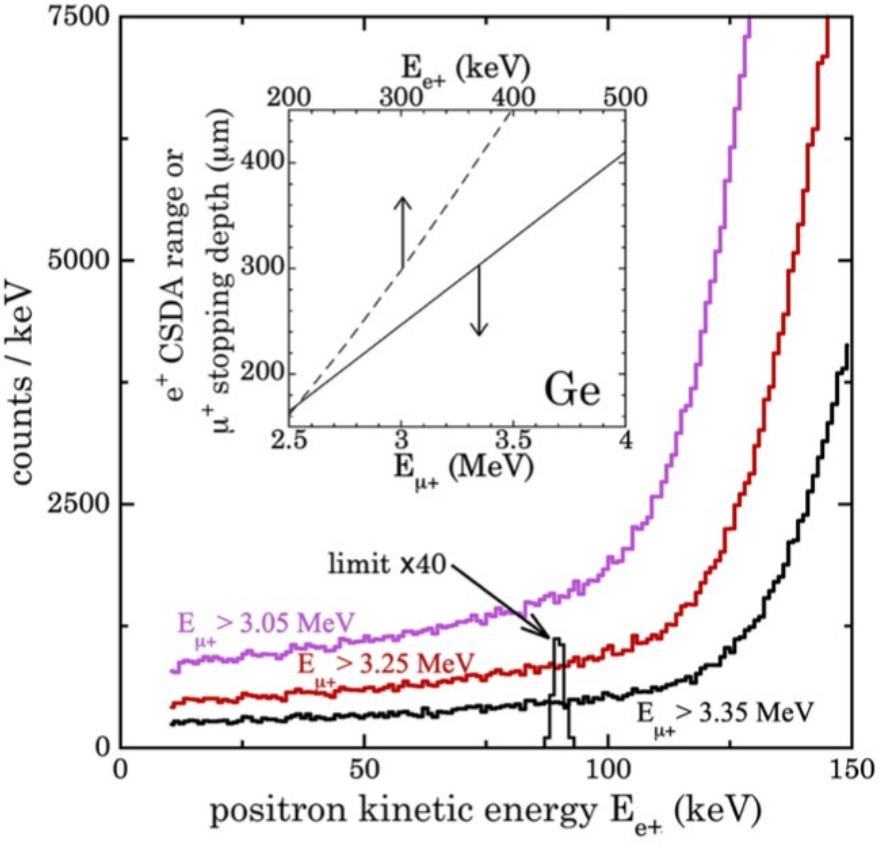


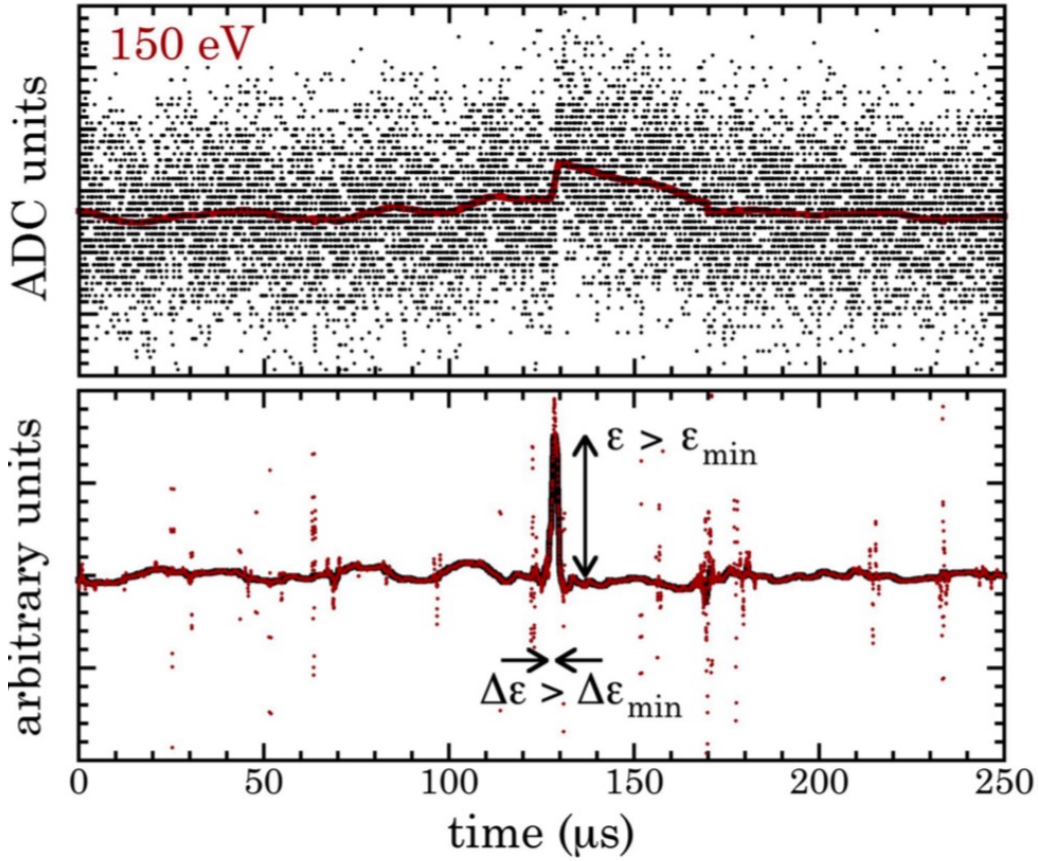


Phys. Rev. D **103**, 052007 (2021)






counts / keV
positron kinetic energy E_{e+} (keV)
limit x40
$E_{\mu+}$ > 3.05 MeV
$E_{\mu+}$ > 3.25 MeV
$E_{\mu+}$ > 3.35 MeV
e^+ CSDA range or
μ^+ stopping depth (μm)
E_{e+} (keV)
$E_{\mu+}$ (MeV)
Ge


150 eV
ADC units
arbitrary units
ε > $ε_{min}$
Δε > $Δε_{min}$
time (μs)

(see arXiv:2202.09672 and arXiv:2108.02880)