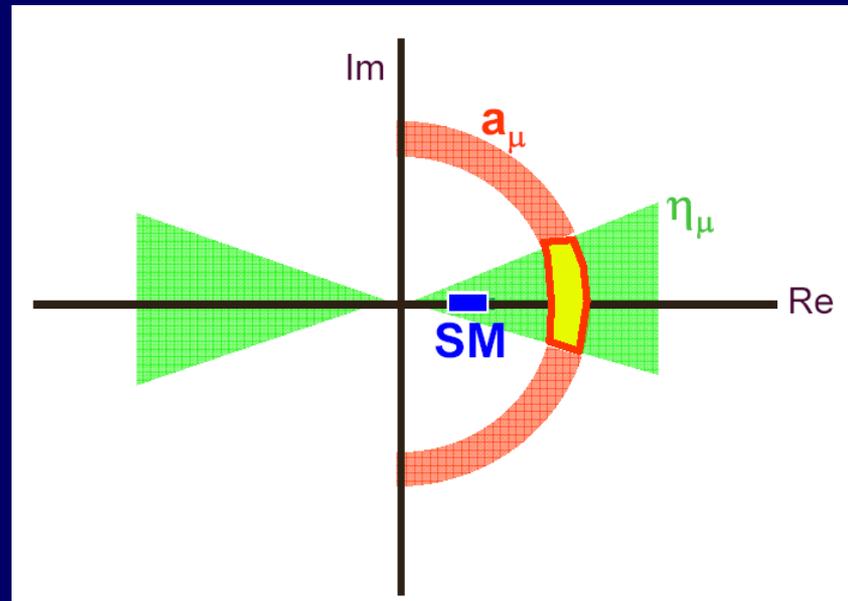


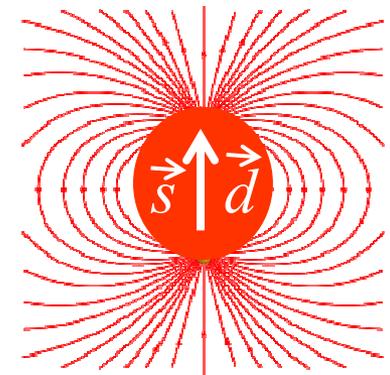
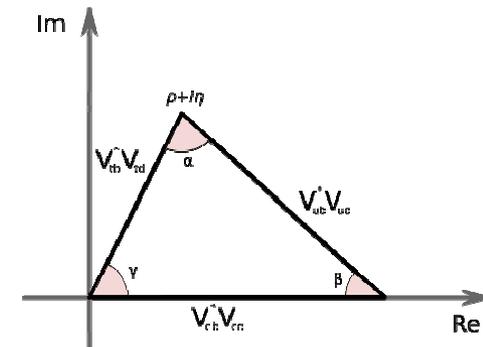
A Parasitic search for a muon EDM to 10^{-21} e-cm using an in-vacuo tracking system



Brendan Casey, Fermilab
For the New $(g-2)_\mu$ Collaboration

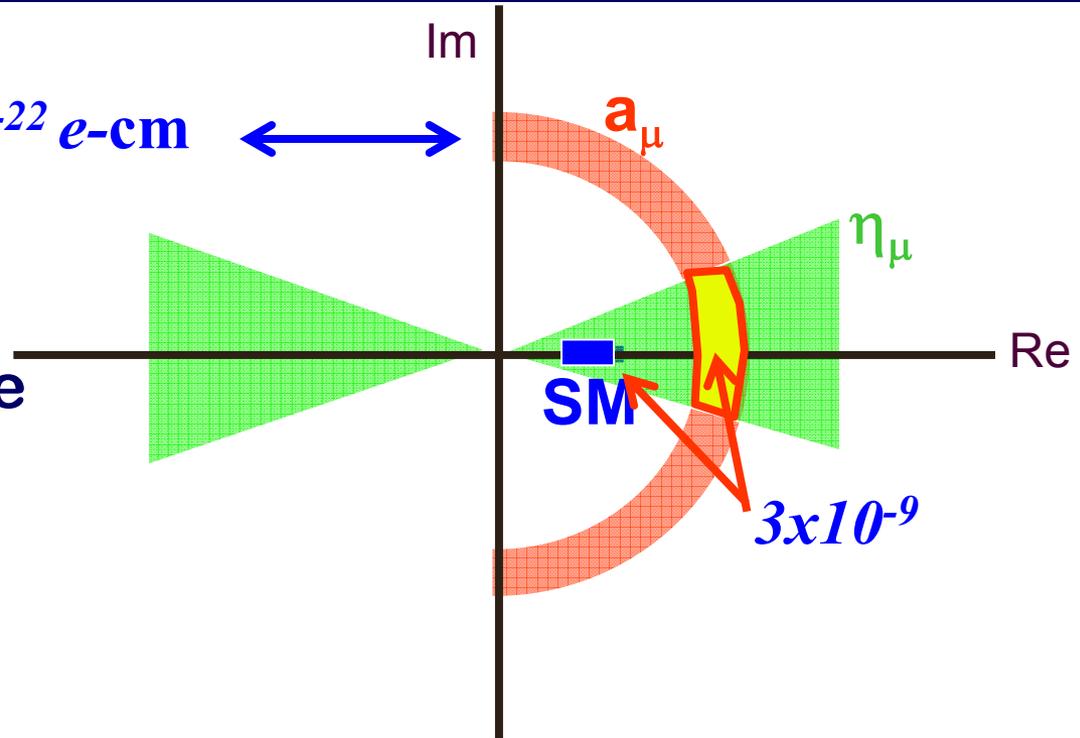
A UNIVERSE WITH MATTER

- Differences between matter and antimatter interactions allowed a small amount of matter to escape annihilation in the early universe
 - $(4-6) \times 10^{-11}$ baryon to photon ratio
- Observed CP violation in neutral meson mixing and decay only partially explains this
 - From CKM: $< 6 \times 10^{-27}$ baryons/photon
 - Huet, Sather PRD51 379 (1995)
- New effects needed. A small permanent electric dipole moment (EDM) of elementary particles is a good candidate.
 - Violates P and T



MUON EDM EXPECTATIONS

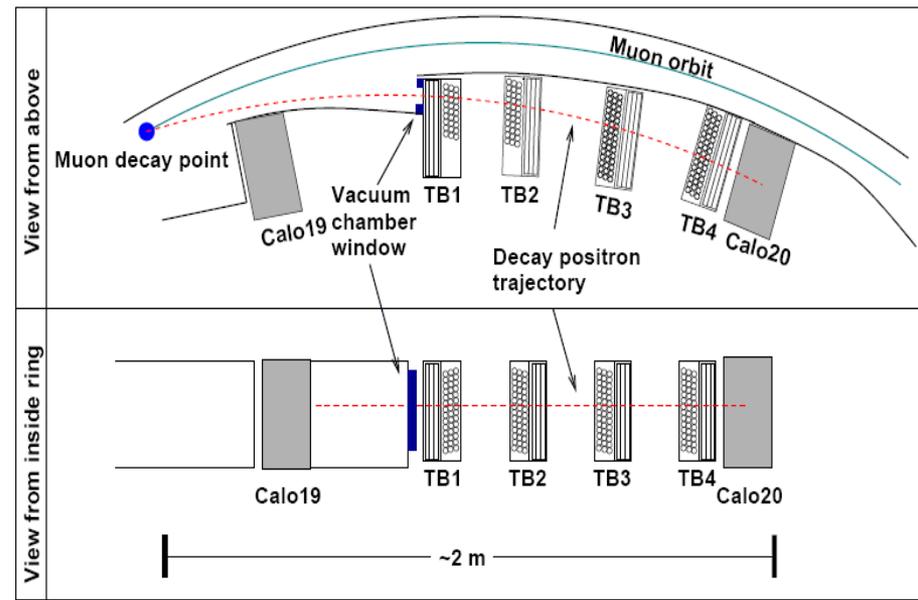
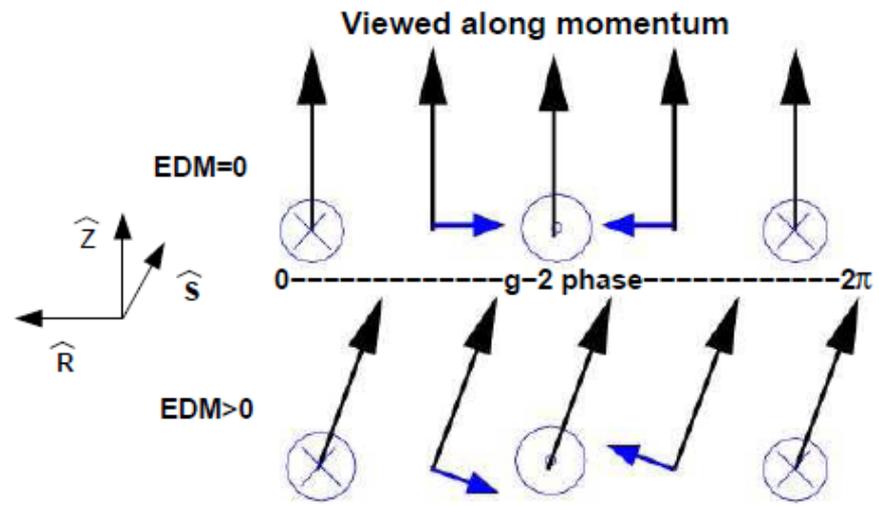
$$d_\mu < 3 \times 10^{-22} \text{ e-cm}$$



- EDM can be seen as the imaginary part of the anomalous magnetic moment
- Current $(g-2)_\mu$ measurement constrains the muon EDM
- We can reach this with a dedicated experiment at Project X
- We propose here an intermediate step, parasitic to the new $(g-2)_\mu$ measurement, to reach 10^{-21} e-cm

EXPERIMENTAL SETUP

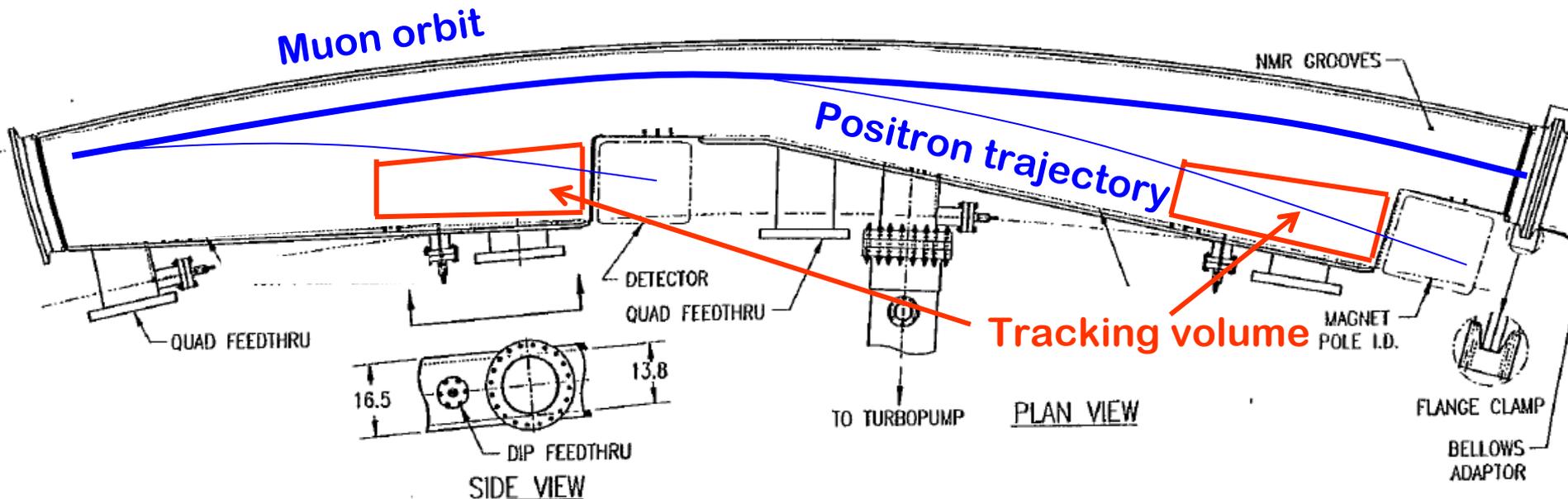
- Relativistic muon in magnetic field sees a motional electric field pointing into the ring in the muon rest frame.
- Muon EDM will tilt the precession plane
- Results in an up-down asymmetry in the positron decay angle, 90° out of phase
- Was measured using a straw tracking system in front of one calo station for the BNL $(g-2)_\mu$ experiment



$$|d_{\mu^+}| < 3.2 \times 10^{-19} \text{ (e} \cdot \text{cm) (95\% C.L.)}$$

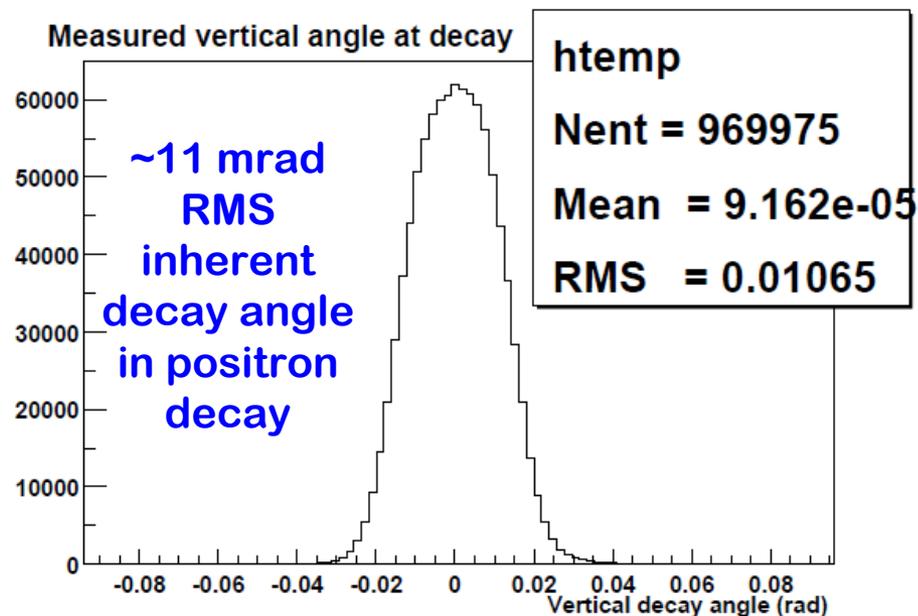
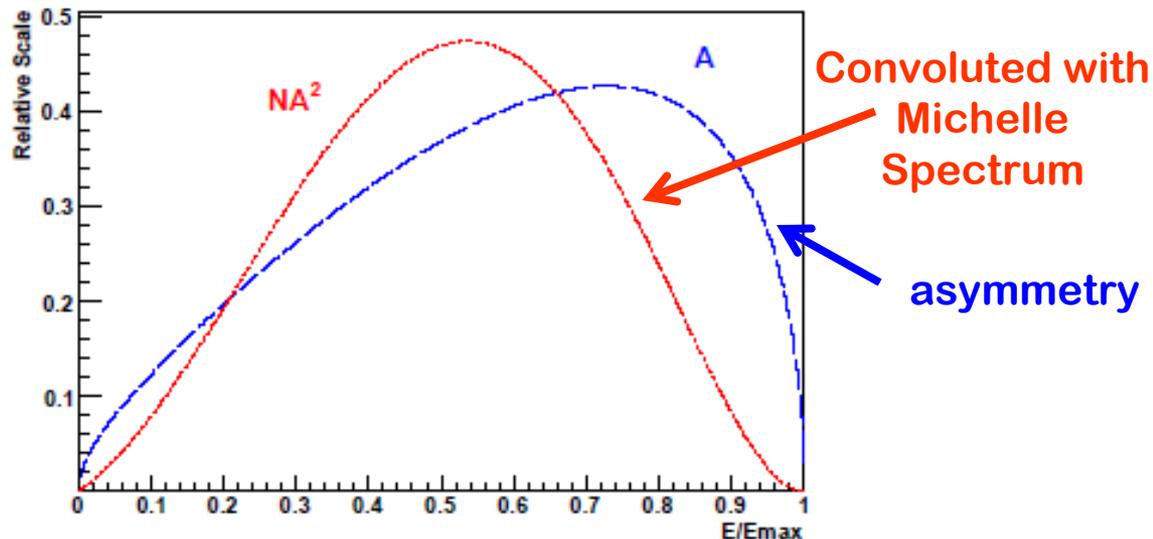
PROPOSED UPDATE

- Previous measurement based on ~10 million reconstructed positron tracks
- Tracking detectors in front of all calorimeter stations could reconstruct $\sim 10^{11}$ tracks in the new experiment
 - Factor 100 improvement in statistics
- Baseline is straw systems in the vacuum optimized for EDM measurement in front of all calorimeter stations



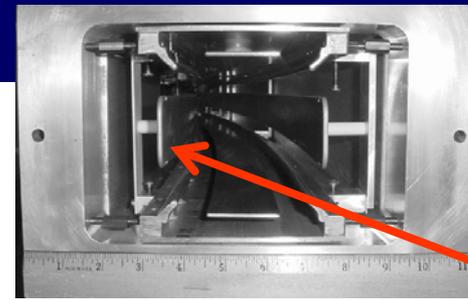
TRACKING DESIGN CONSIDERATIONS

- Effective maximum asymmetry
 - Optimize design for positron momentum near 1.5 GeV
- Inherent angular spread in decay angle
 - Sets upstream material budget: keep multiple scattering below this.
- Occupancy throughout the fill
 - Sets how early we can take data

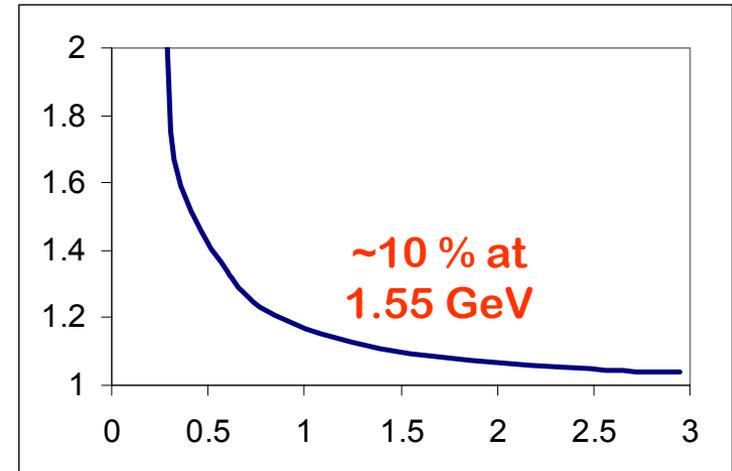


TRACKING DESIGN PROGRESS

- Calculating/simulating
 - Fermilab Geant4 and beam simulation experts helping to get ring simulation running at FNAL
- Building a team
 - Fermilab, PNPI, ...
 - Leveraging shared infrastructure with Mu2e at Fermilab
 - Leveraging infrastructure, human resources used for ATLAS straws at PNPI
 - Casey applying for Office of Science Early Career Grant to design and partially construct the system
- Resurrected a straws-in-vacuum cosmic test stand and designing prototypes
 - Very attractive to post docs analyzing Tevatron data but also looking for hardware experience



Resolution degradation due to quads



Fermilab DØ/g-2 postdoc Mandy Rominsky



Positron p (GeV)

High School physics teacher Terry Barchfeld

EDM CONCLUSIONS

- Best current knowledge indicates EDMs will be seen in experiments this decade
- To understand what we see requires a measurement of the muon EDM
- We know how to improve by 2 orders of magnitude by adding tracking stations to the new $(g-2)_\mu$ experiment
- This naturally progresses into a dedicated muon EDM experiment at Project X

