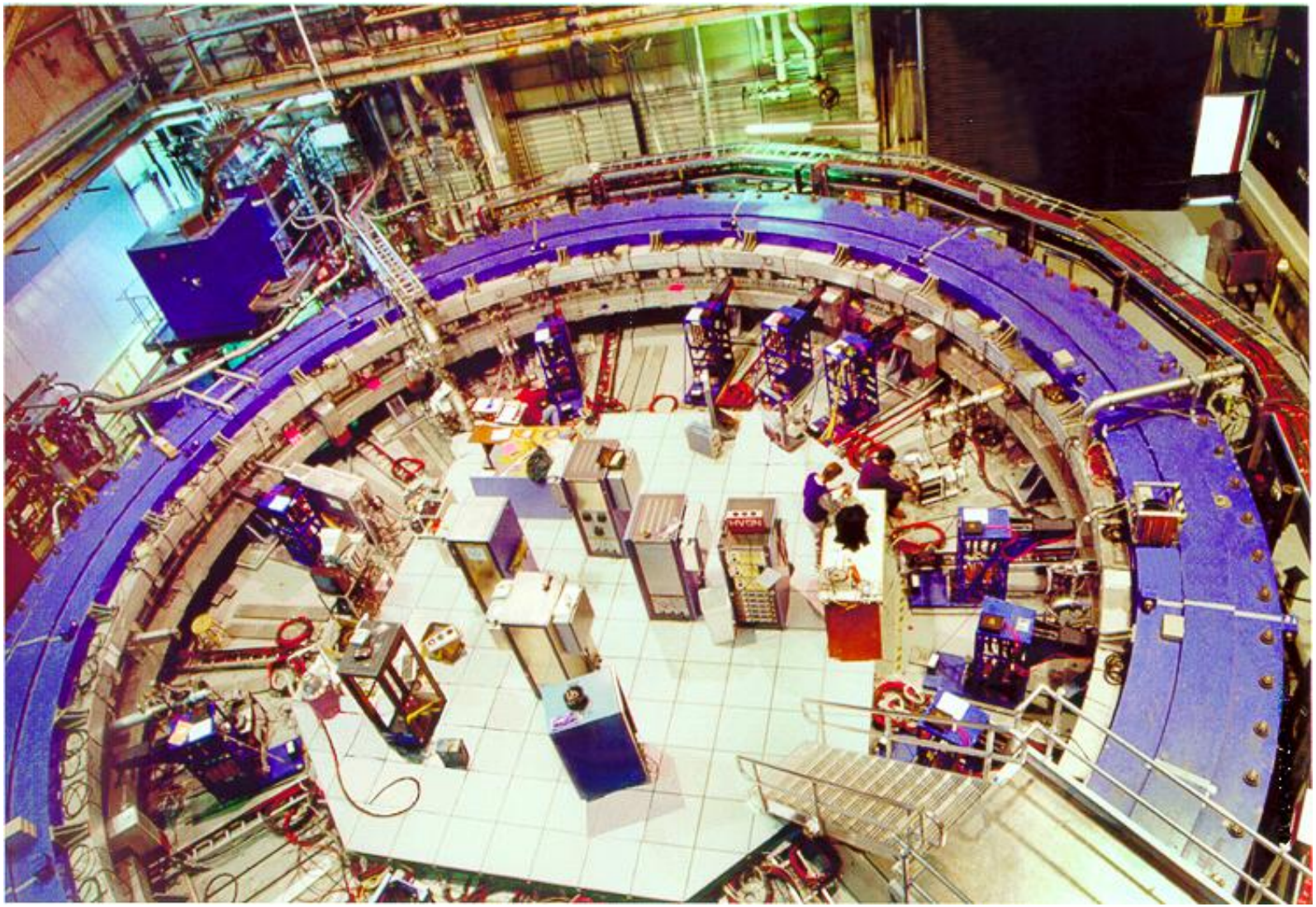
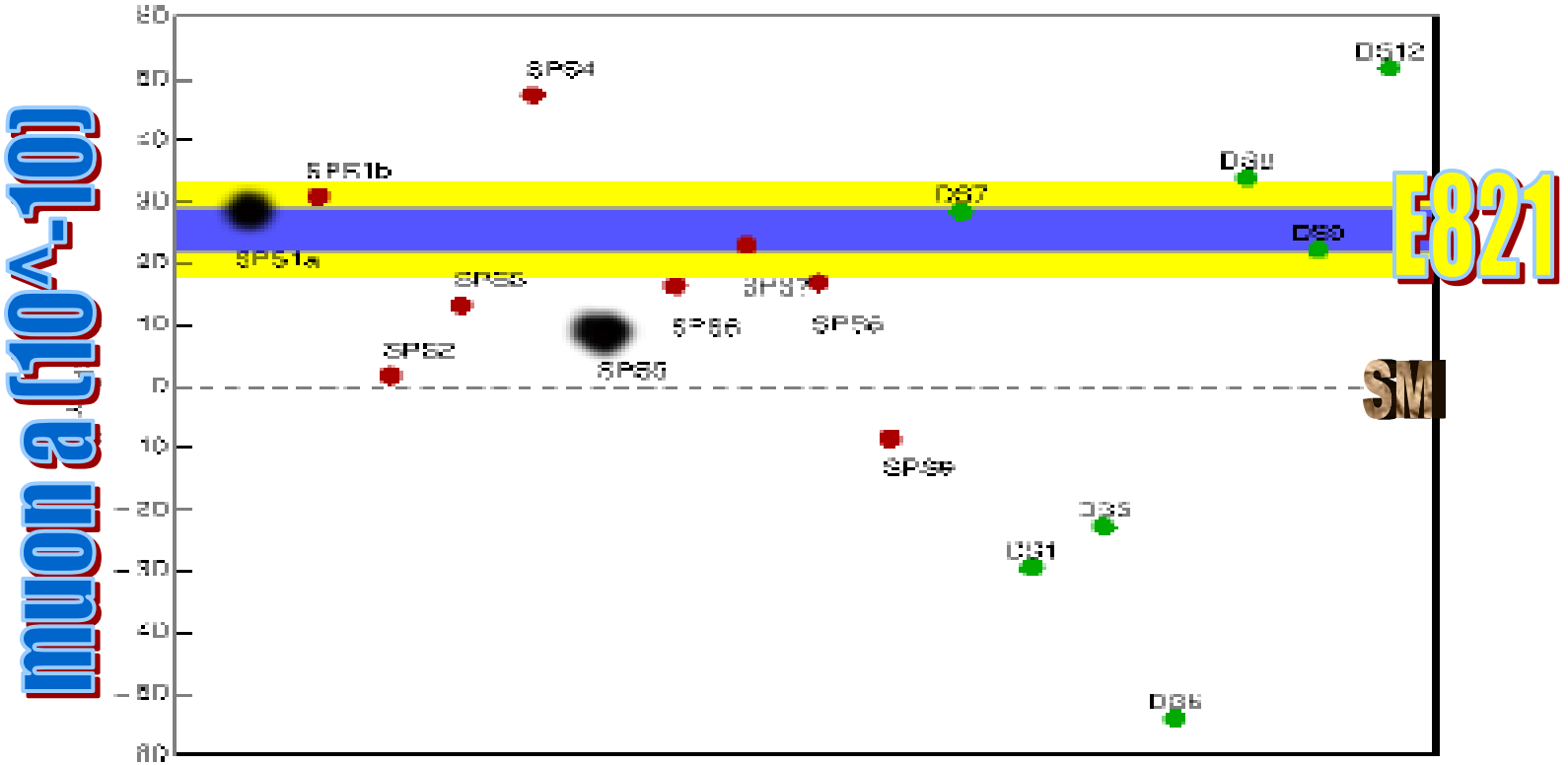
BNL Responsibilities in New Muon g-2 and Mu2e Experiments at FNAL

W. Morse - BNL

BNL E821 Muon g-2 Storage Ring



Precision vs. Energy Frontier
SUSY Benchmarks



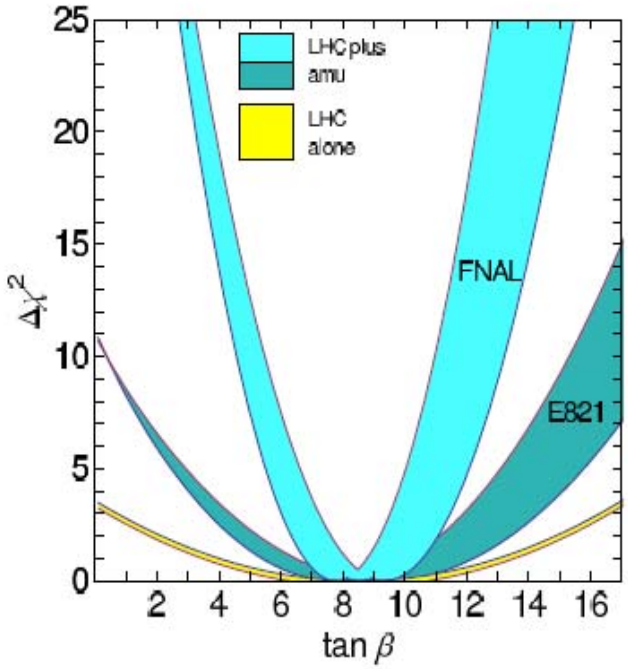
SPS benchmark points

LHC Inverse Problem ($300fb^{-1}$)

can't be distinguished at LHC
[Sfitter: Adam, Kneur, Lafaye, Plehn, Rauch, Zerwas '10]

Dominik Stockinger 3/18/11

SUSY $\tan\beta = v_2/v_1$



$\tan\beta = \frac{v_2}{v_1}$
central for understanding EWSB

LHC: $(\tan\beta)^{\mathrm{LHC,masses}} = 10 \pm 4.5$ bad
[Sfitter: Lafaye, Plehn, Rauch, Zerwas '08, assume SPS1a]

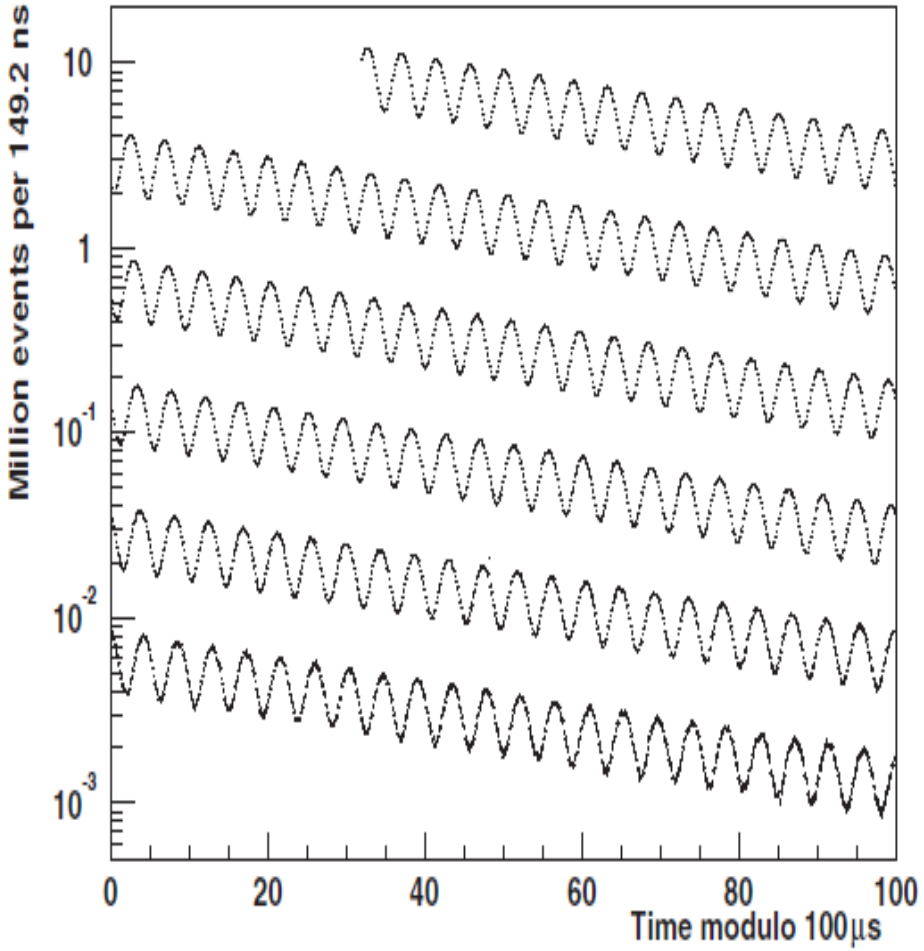
a_μ improves $\tan\beta$ considerably

vision: test universality of $\tan\beta$, like for $\cos\theta_W = \frac{M_W}{M_Z}$ in the SM:

$$(t_\beta)^{a_\mu} = (t_\beta)^{\mathrm{LHC,masses}} = (t_\beta)^{H} = (t_\beta)^{b}?$$

New Muon g-2 Experiment at FNAL

- Upgraded FNAL muon beamline,
- KEK inflector,
- Cornell kicker,
- BNL electric quad,
- University DAQ/ detectors.
- Statistical error 0.5ppm $\rightarrow$ 0.1ppm

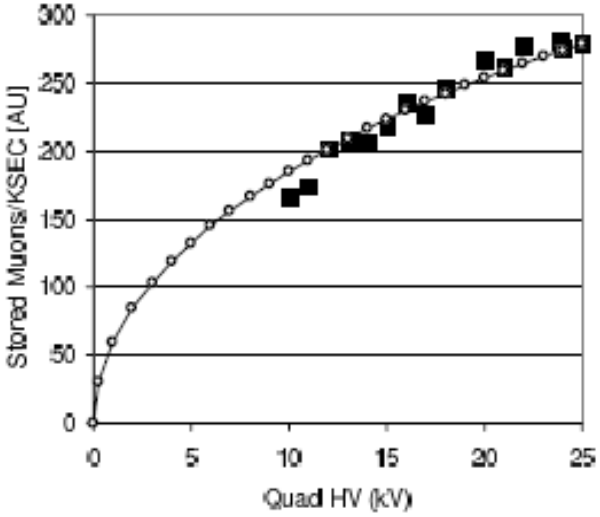


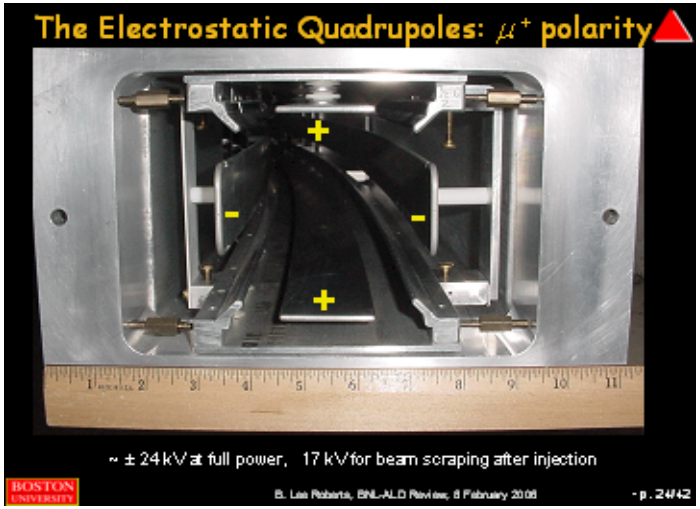
E821 Expt. Systematic Errors

Systematic Error	R01 (ppm)	
Detector Pileup	0.08	0.04 Univ
Lost Muons	0.09	0.02 BNL
Coherent Betatron Oscillation (CBO)	0.07	0.01 BNL
Detector Gain	0.12	0.02 Univ
Others	0.11	0.03 FNAL

Lost Muon and CBO Systematics

- Lost muon and CBO systematic errors depends on the electric quads.
- Lost muon were reduced in E821 by bringing the pulsed electric quad HV up asymmetrically to scrape against collimators.
- New methods being studied for the upgrade.
- CBO systematic error depends on the distance from twice the g-2 frequency: ($f_{cbo} - 2f_{g-2}$).
- This was not properly under-stood until 2000.

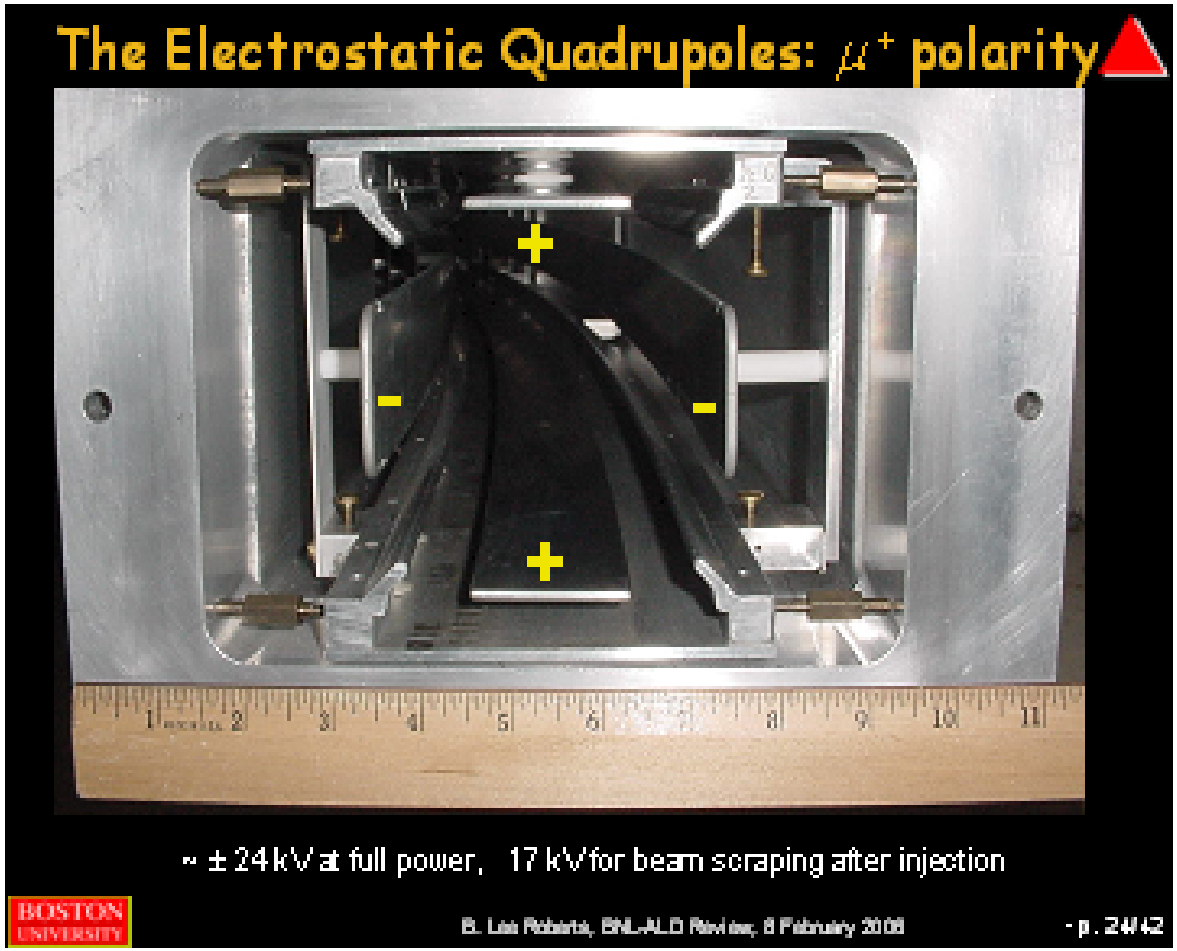




Weak Focusing Electric Quads

$$n = \frac{R_0}{c\beta B_0}\frac{\partial E_y}{\partial y}$$

$$f_{CBO} = \left(1-\sqrt{1-n}\right) f_C$$



This was a surprise: CBO Systematic Error due to "Observational Resonance"

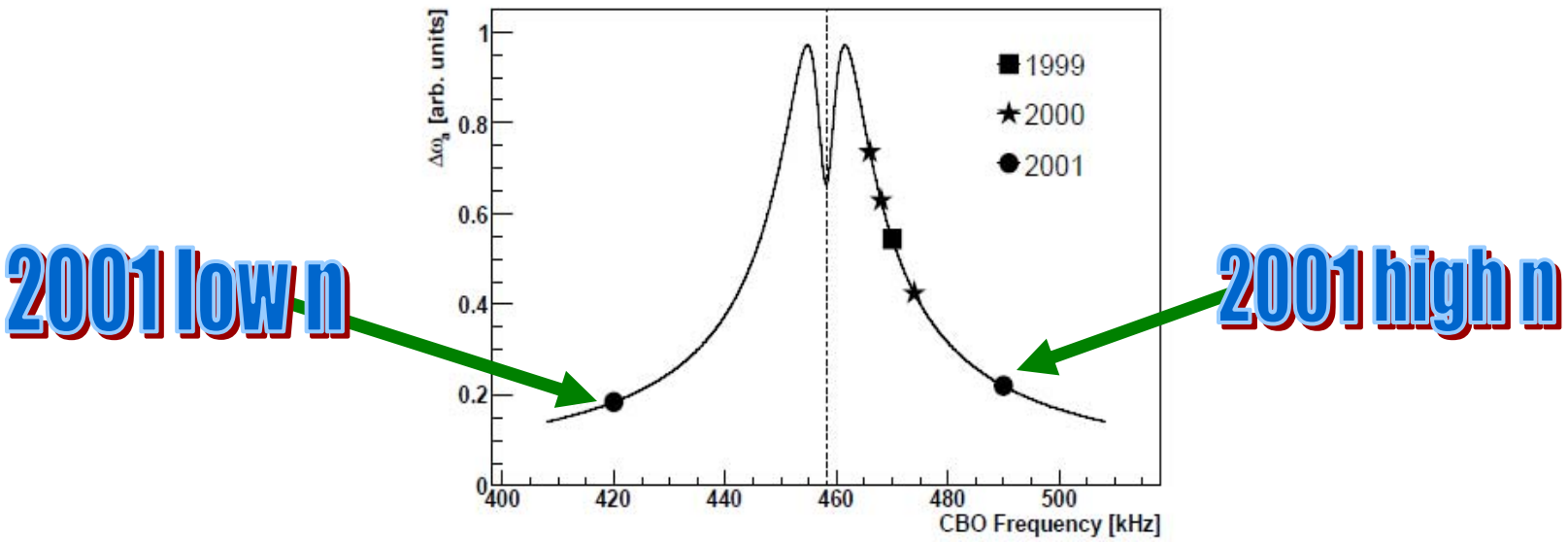


FIG. 36: The relative pull ($\Delta\omega$) versus the CBO modulation frequency *if not* addressed by the fitting function. A typical full vertical scale is several ppm; the actual scale depends on the specifics of the fit and the data set used. The R00 data were acquired under run conditions in which ω_a was very sensitive to CBO. This sensitivity was minimized in the R01 period where low- and high-n subperiods, each having CBO frequencies well below or above twice the $(g-2)$ frequency, were employed.

Increase HV to another resonance free region n≈0.18 to get f_{cbo} away from $2f_{g-2}$?

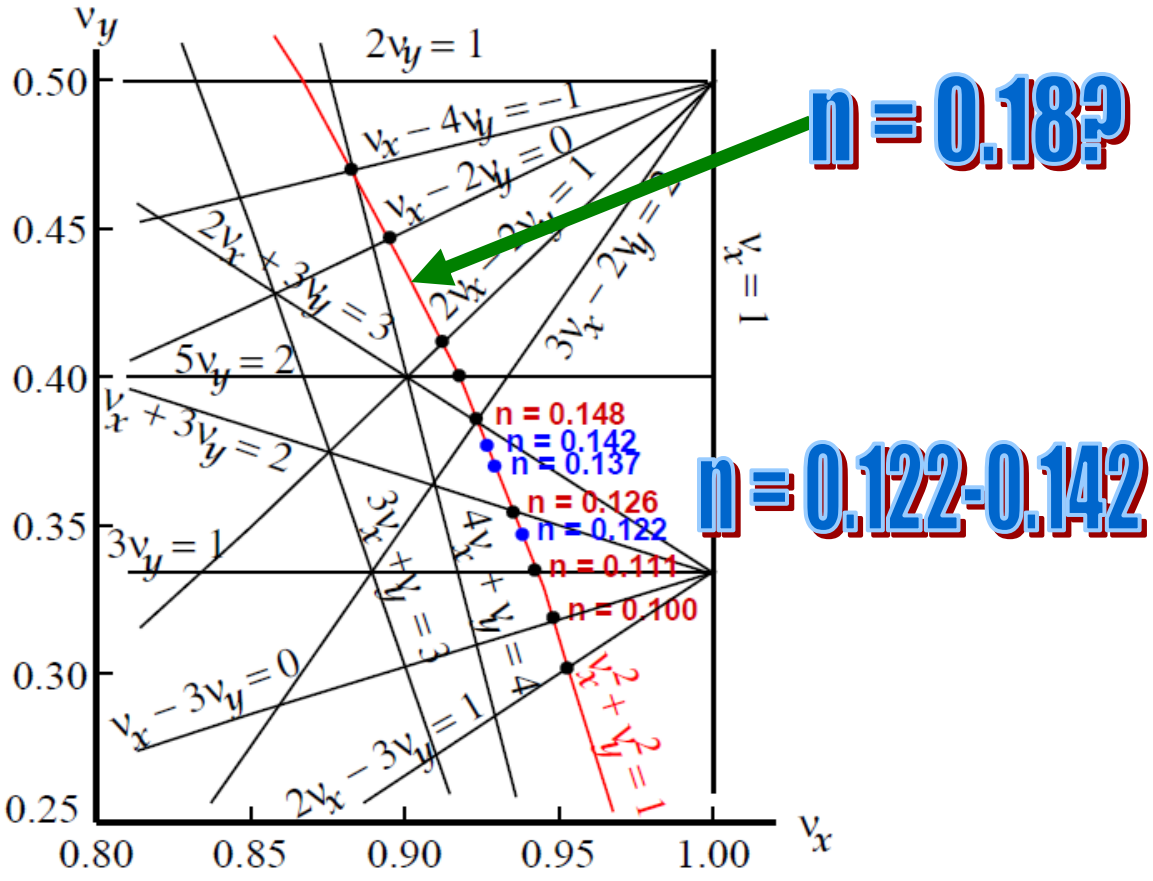
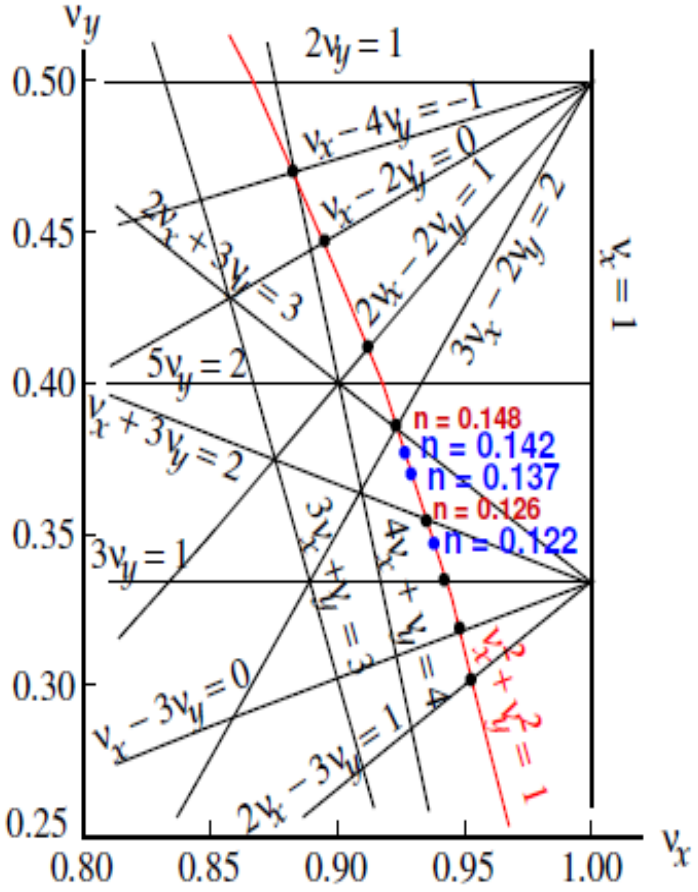


FIG. 18: The tune plane showing resonance lines. Three of the n values used to run the experiment, 0.122, 0.137, 0.142, are indicated on the arc of the circle defined as $v_x^2+v_y^2 = 1$. They do not intersect any of the resonance lines, contrary to nearby tunes, which are also shown on the arc.

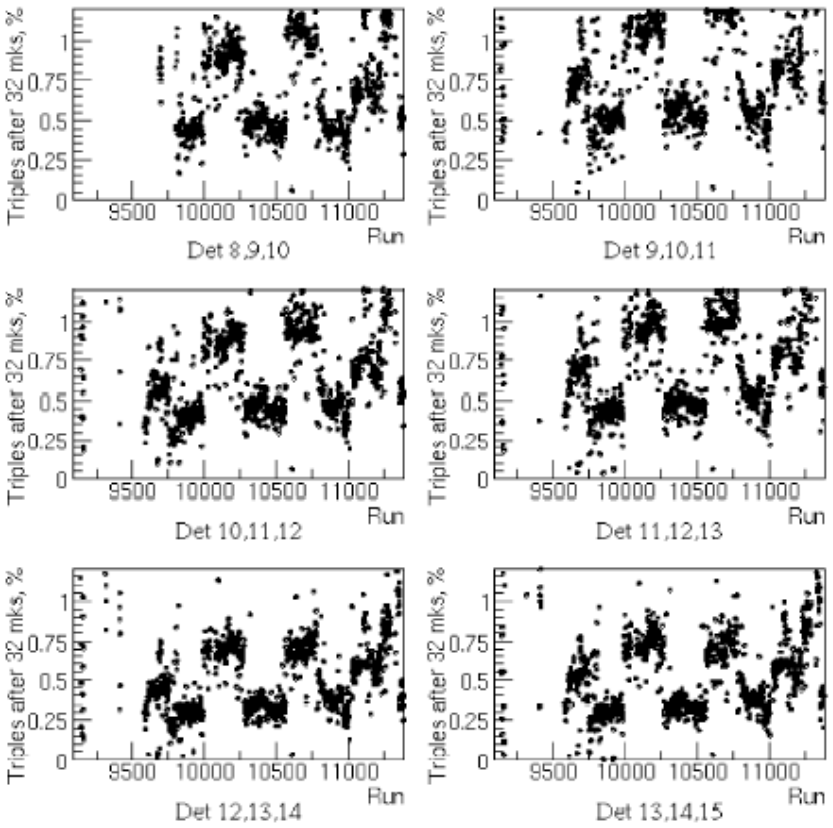
What n Value Should We Use at FNAL?

- New Muon g-2 Note, W. M. and Y. Semertzidis (2011).
- Quad HV = 24KV $\rightarrow$ 32KV.
- Issue is trapped electrons in the E×B field.
- CBO systematic 0.07ppm $\rightarrow$ 0.01ppm.
- Very far from twice g-2 frequency.



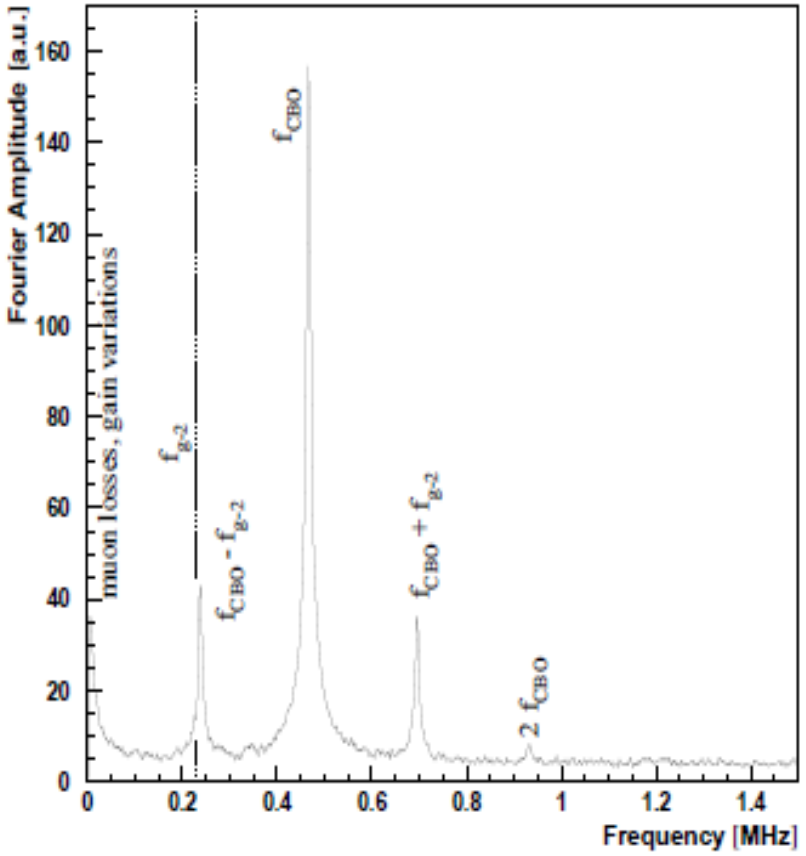
Muon losses 2.5x higher for E821 2001R low n compared to high n!

Fig. 1. Ratio of muon loss triples to electrons vs. run number from 2001 on-line analysis.



2001 Run Lost Muons

- 2.5× higher for low n! This was a surprise.
- Back of the envelope type calculations:
- Paley, Polly, Morse, Orlov, g-2 note 433 (2003).
- Orlov, Semertzidis, g-2 note 431 (2003).
- Need real simulations to understand muon losses quantitatively and simulate new scraping paradigms.

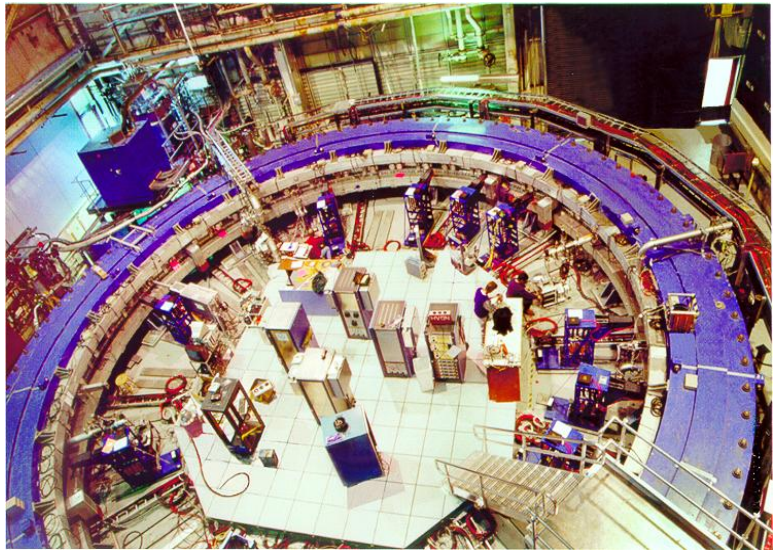


BNL Electric Quads R&D

- To refurbish the electric quadrupoles (ESQ) to be used in the Muon g-2 experiment at FNAL.
- To upgrade the ESQ to be able to run at a higher field-focusing index in order to essentially eliminate the systematic error due to CBO.
- Develop the CBO elimination scheme using RF at the CBO frequency at injection and phase shifting at the end of the beam scraping period.
- Test a full prototype and refit all the modules with the upgraded design.
- Study the beam and spin dynamics related to CBO and its influence to the g-2 result
- Study the muon losses as a function of beam scraping schemes and optimize the muon storage.
- Need two RAs.

Moving the E821 Ring to FNAL

- Significant BNL involvement.
- Large BNL/FNAL interface.
- W.M. was the E821 Resident Spokes-man, and is the BNL Coordinator for Moving the Ring.
- This week BNL/FNAL personnel start taking ring apart for R&D at Cornell (kicker), FNAL (traceback detector in vacuum chamber), and Regis College (scintillating fiber harp).
- New g-2 Collaboration Meeting at BNL July 26-29.



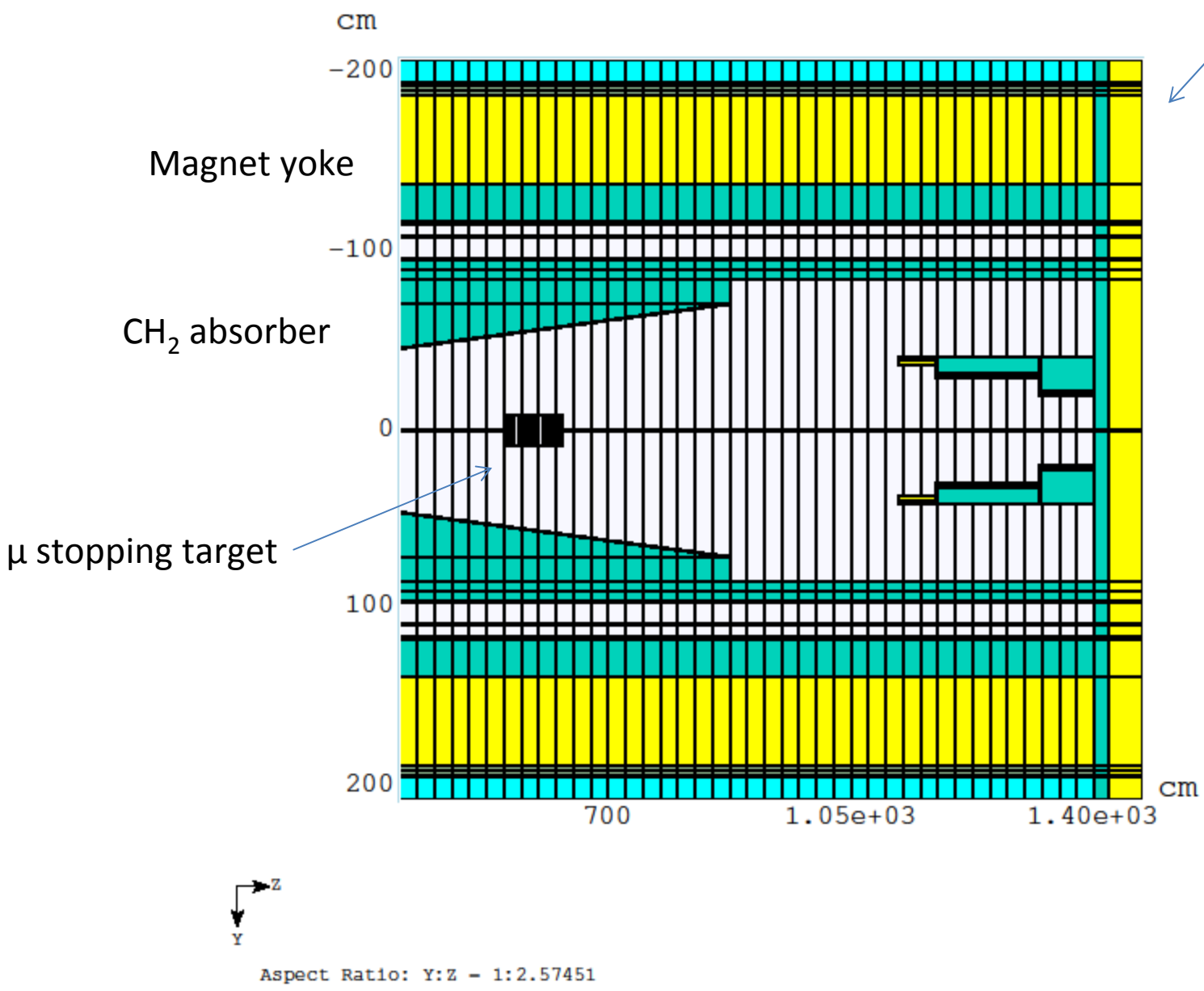
BNL People

- Quad, CBO, Lost Muon upgrade:
- WM, Y. Semertzidis, 2RAs (Physics Dept.)
- J. Benante, L. Snydstrup (CA Dept.)
- Moving the Ring:
- WM, Y. Semertzidis (Physics Dept.)
- J. Benante, D. Von Lintig, L. Snydstrup, C. Pai, M. Mapes, J. Mi, A. Pendzick, C. Pearson (CA Dept.)

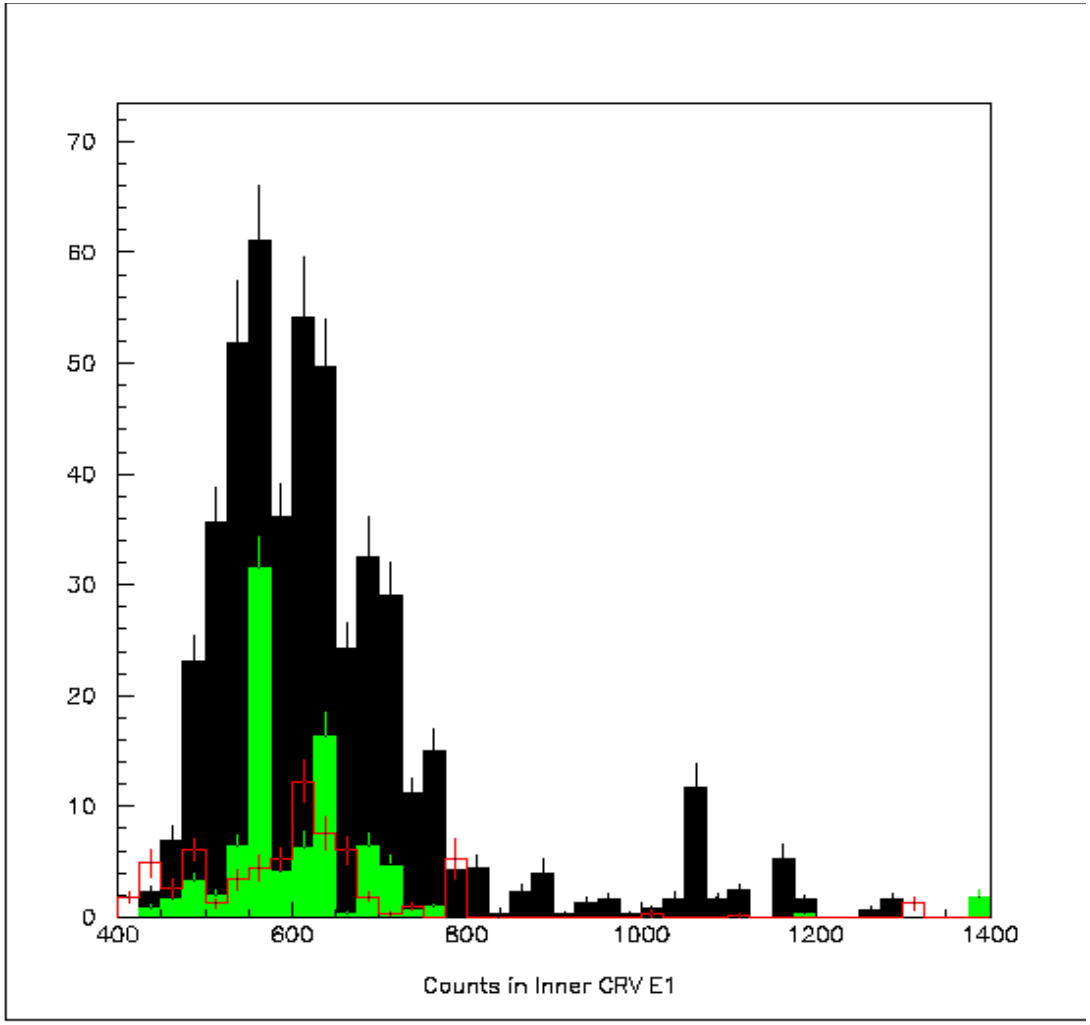
Mu2e

- ~10^{11} stopped μ/sec.
- Each stopped μ produces ~1.2 neutrons.
- Neutrons are captured on the hydrogen in the Cosmic Ray Veto (CRV) Detector.
- This may produce a background that compromises the 10^{-4} CRV detector inefficiency requirement.

BNL-MARS simulation of Mu2e experiment



Hits in CRV1: E_{dep} > 100keV



for 250K stopping μ

w/CH_2: 479 events
w/5%B in CH_2: 85 events
w/30%B in CH_2: 66 events

Mu2e

- Cathode Strip Chambers (CSCs) are effectively insensitive to neutrons.
- They may be a viable alternative to plastic scintillator for the CRV detector.
- We will ship two spare ATLAS CSCs from CERN to Fermilab for evaluation.

Mu2e

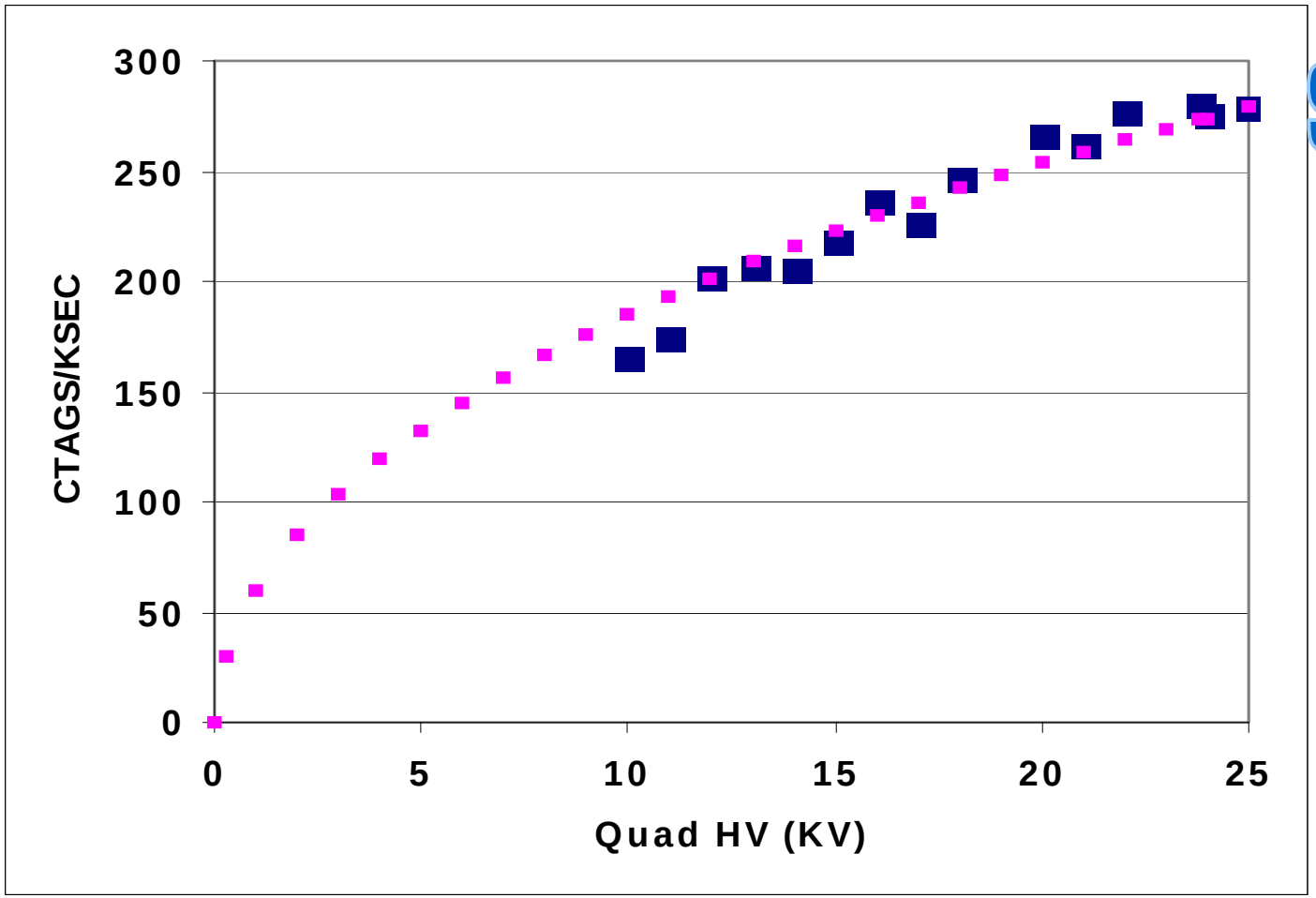
- Scintillator vs. CSC comparison /evaluation is in progress.
- CSCs have the additional potential for good spatial- and time-resolution.
- CSCs have been identified in the Mu2e CD-1 document as the preferred technology to scintillator, should scintillator not be viable due to neutron background.

Mu2e BNL People

- P. Yamin, V. Polychronakos, Y. Semertzidis (Physics Dept)

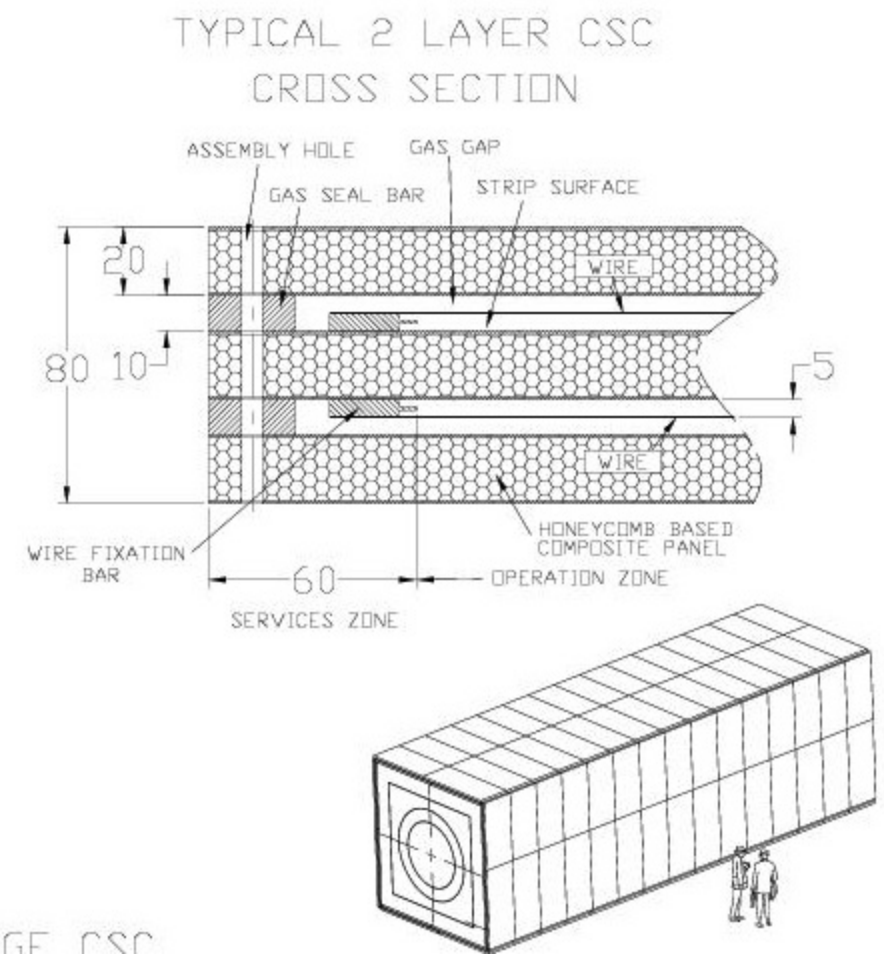
Extras

Increase ESQ HV and CBO f?



store more

CR Veto with CSC?



How would a CSC-based CR-Veto would look like?