Tracker and Calorimeter in Mu2e-II

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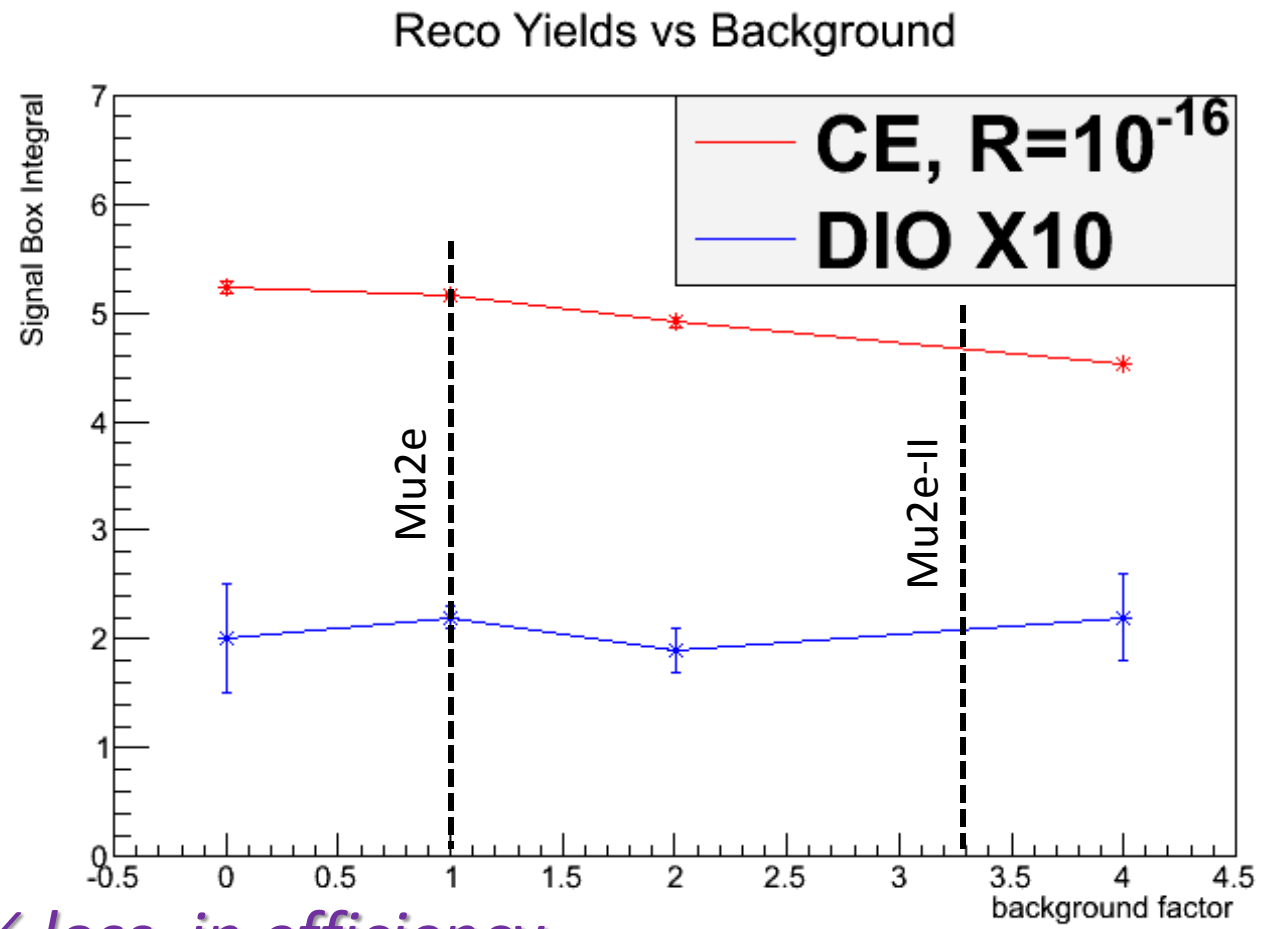
Breakdown of × 10 Rate Increase

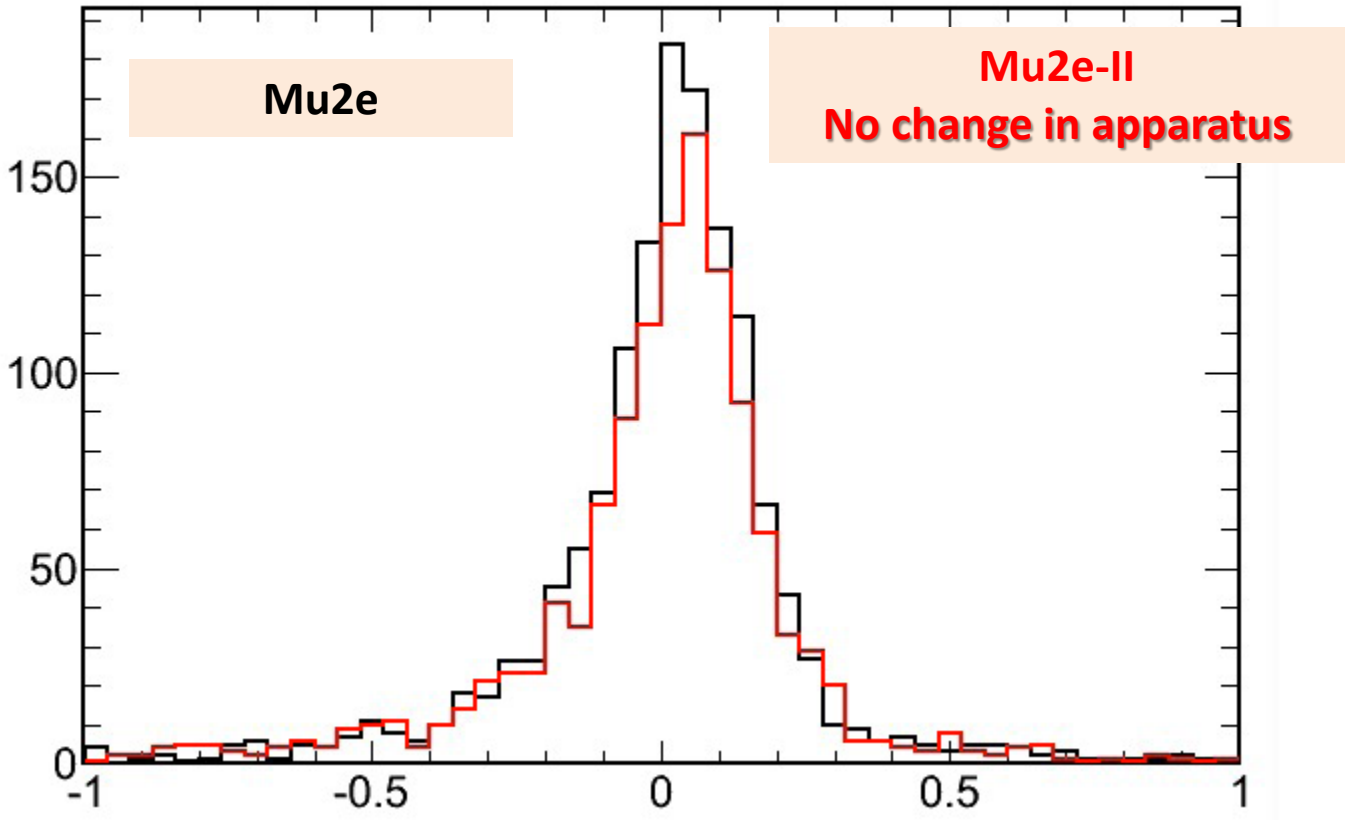
- ×3 instantaneous rate
  - Affects performance directly (higher occupancy)
  - Can study via simulations
    Already studied up to ×4 background rates as part of understanding mu2e robustness
- ×3 duty factor
  - No direct affect on performance
  - Concern is radiation damage (aging)

Tracker Efficiency



<5% loss in efficiency

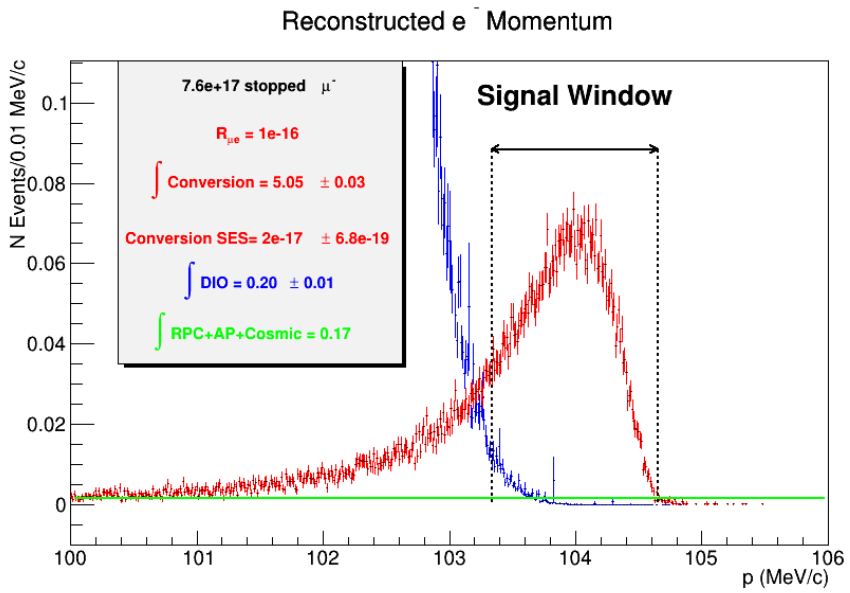
Tracker Resolution



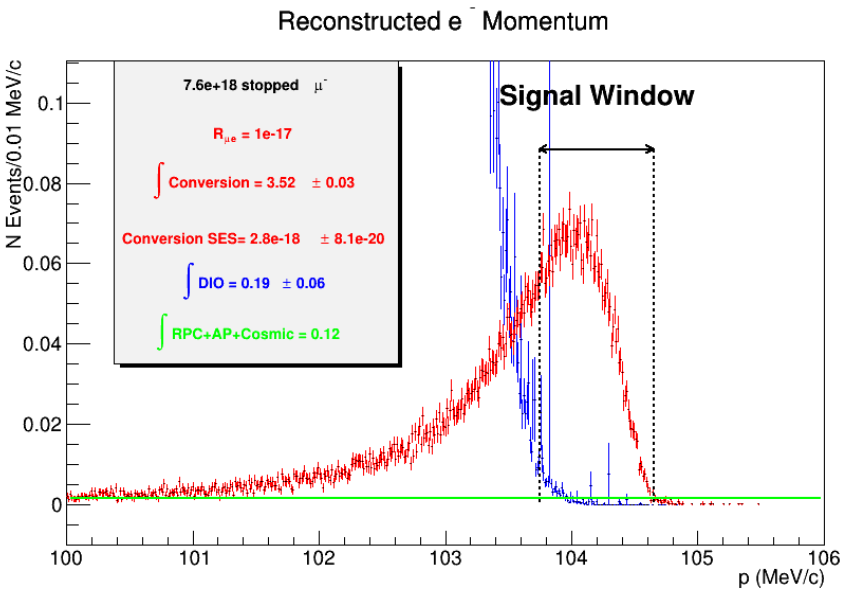
*Loose cuts … **not** resolution used for most analysis*

Key point: No significant change

Tracker Performance



Standard Mu2e



Mu2e-II

No change in apparatus

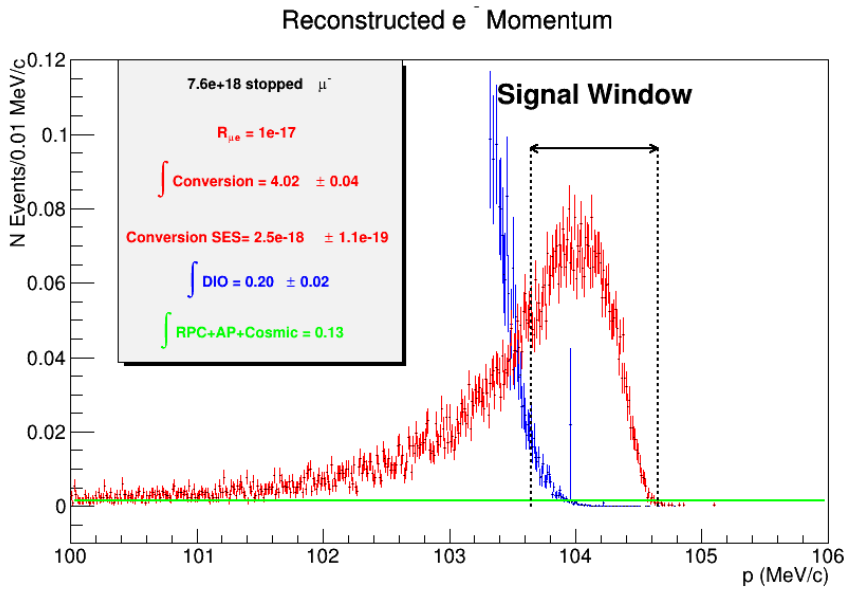
Window set to keep background at 0.2 events

SES: $2.0 \cdot 10^{-17} \rightarrow 2.8 \cdot 10^{-18}$

×7 … not quite ×10 … in sensitivity

Rebuild Tracker?

SES: $2.5 \cdot 10^{-18}$

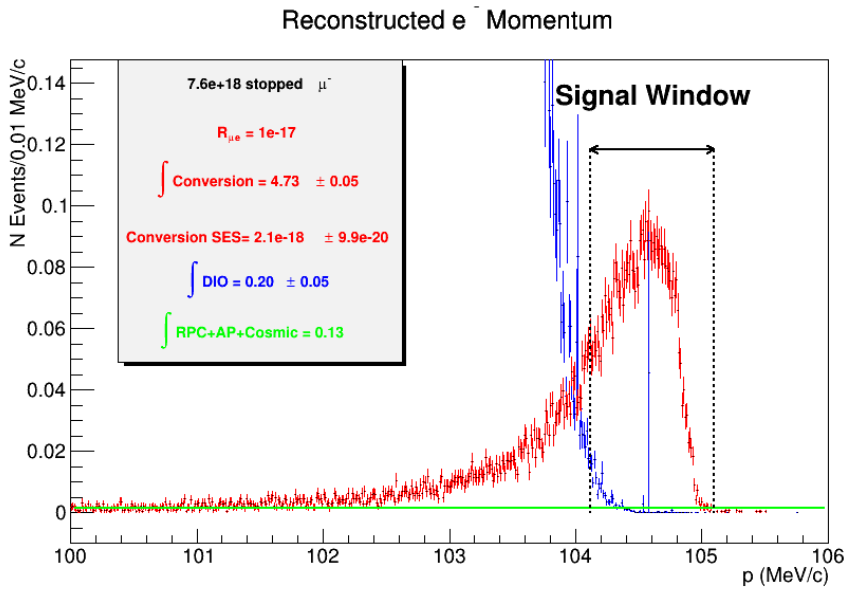


- Straws: 15μm → 8μm
- Target: Unchanged
- PA: nominal
- 1.5× electron rate
  - Not 3× … less mass → Fewer conversions
  - Fewer δ-rays
- 3× proton rate

Minor gain on it's own

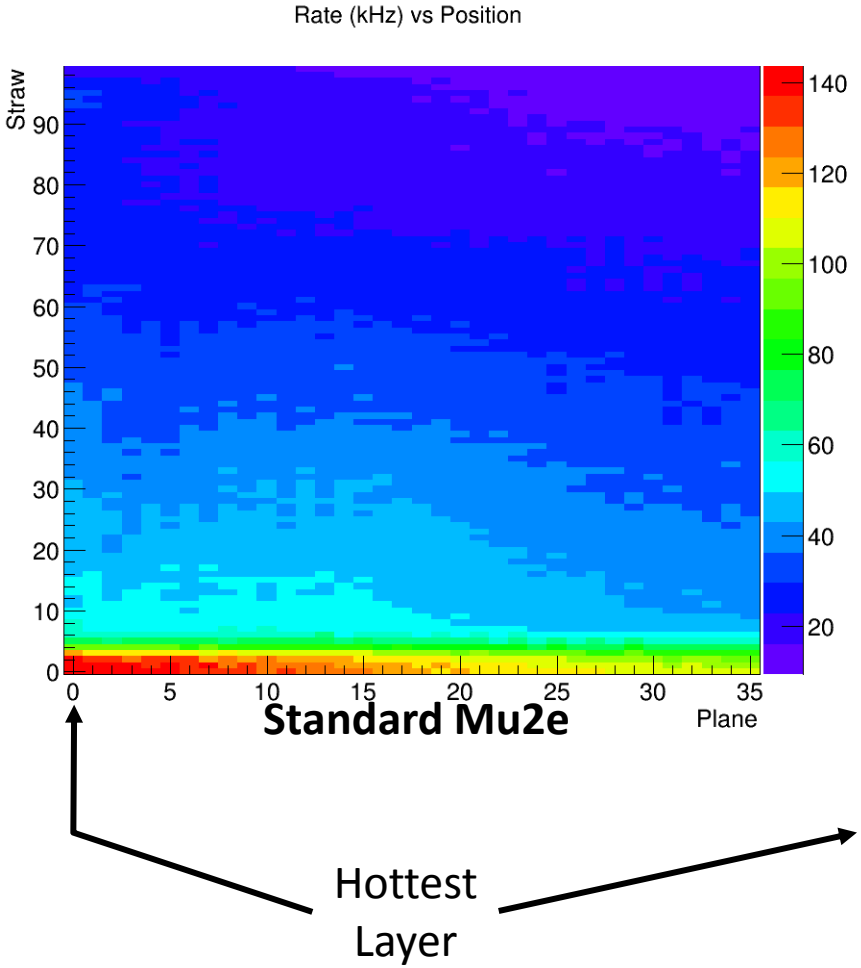
Rebuild Tracker?

SES: $2.1 \cdot 10^{-18}$

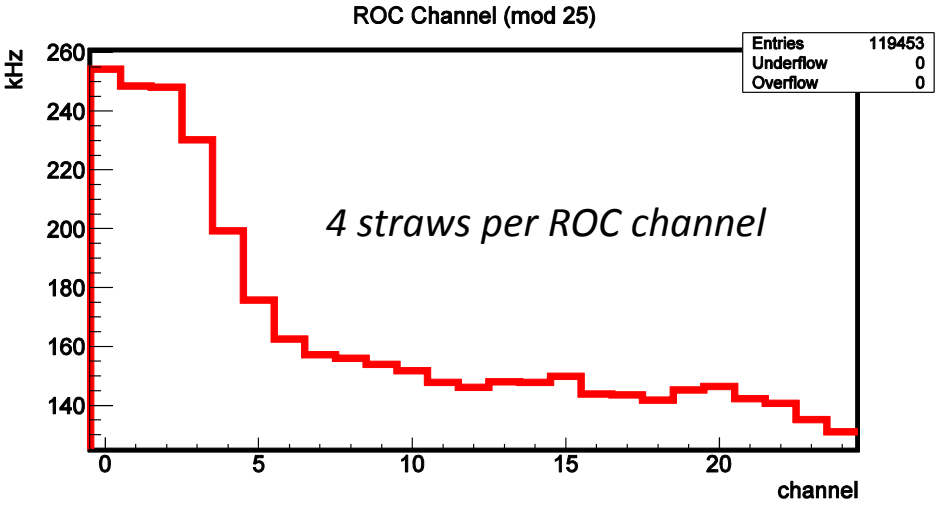


- Straws: 15μm → 8μm
- Target: Unchanged
- PA: ¼ nominal
- 1.5× electron rate
- ***6× proton rate***
  - Can we tolerate this?
  - Back to this later

Tracker Front End (FE) & Readout Controller (ROC)

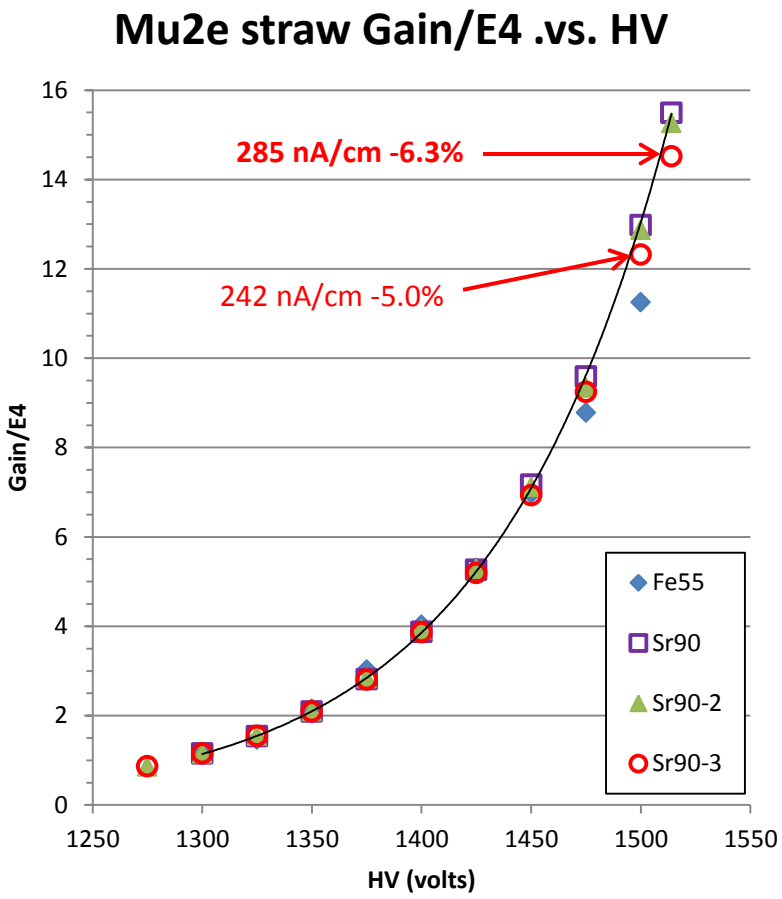


- FE → ROC
  - 4 straws
  - Max 250kHz @ 100bits/hit 25Mb/sec for Mu2e
  - 75Mb/sec (Mu2e-II)
  - FE can move 200Mb/sec



Tracker Space Charge

- 76µs ion drift time
- Long compared to micro-bunch spacing
  - Can emulate with source
- Short compared to macro-bunch spacing
  - ×3 in current density
- 70 nA/cm → 210nA/cm
- Gain loss <5%



Tracker Aging

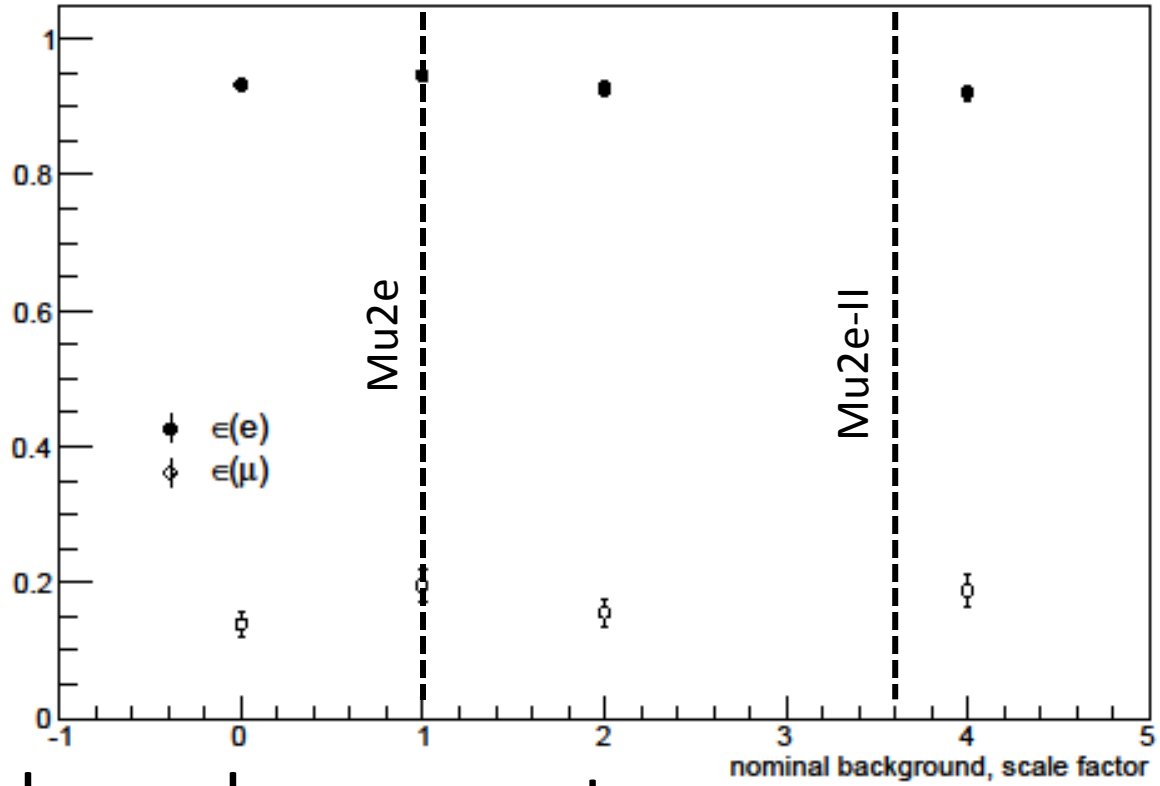
- No observable gain loss or other aging issues up to 0.9C/cm
  - Expected dose in Mu2e with nominal proton absorber
- Testing to 9C/cm requires hotter sources
  - May be available from our collaborators

Rebuilt Tracker

- Thinner walls
  - 8µm instead of 15µm
  - Less scattering
  - Fewer conversions & δ-rays
- Run sub-atmospheric
  - 8µm unsafe for 15psid
  - Fine for 8psid
- Side benefit: shorter ion drift time
  - Less space charge

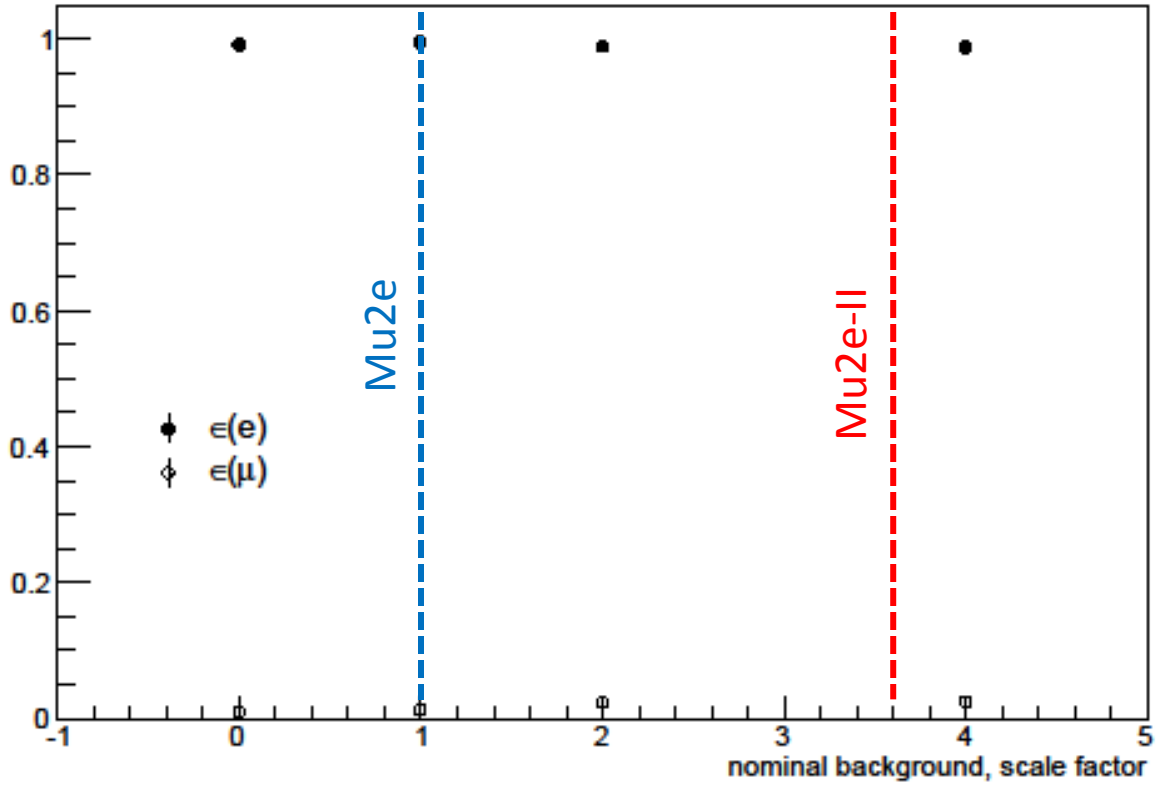
- Cannot operate at nominal gas density in air
- Harder to test
- But … by then we'll have more experience

Tracker e-μ separation (TOF, dE/dx)



- Weak dependence on rate
- Never very good

Combined (mostly calorimeter) e-μ separation



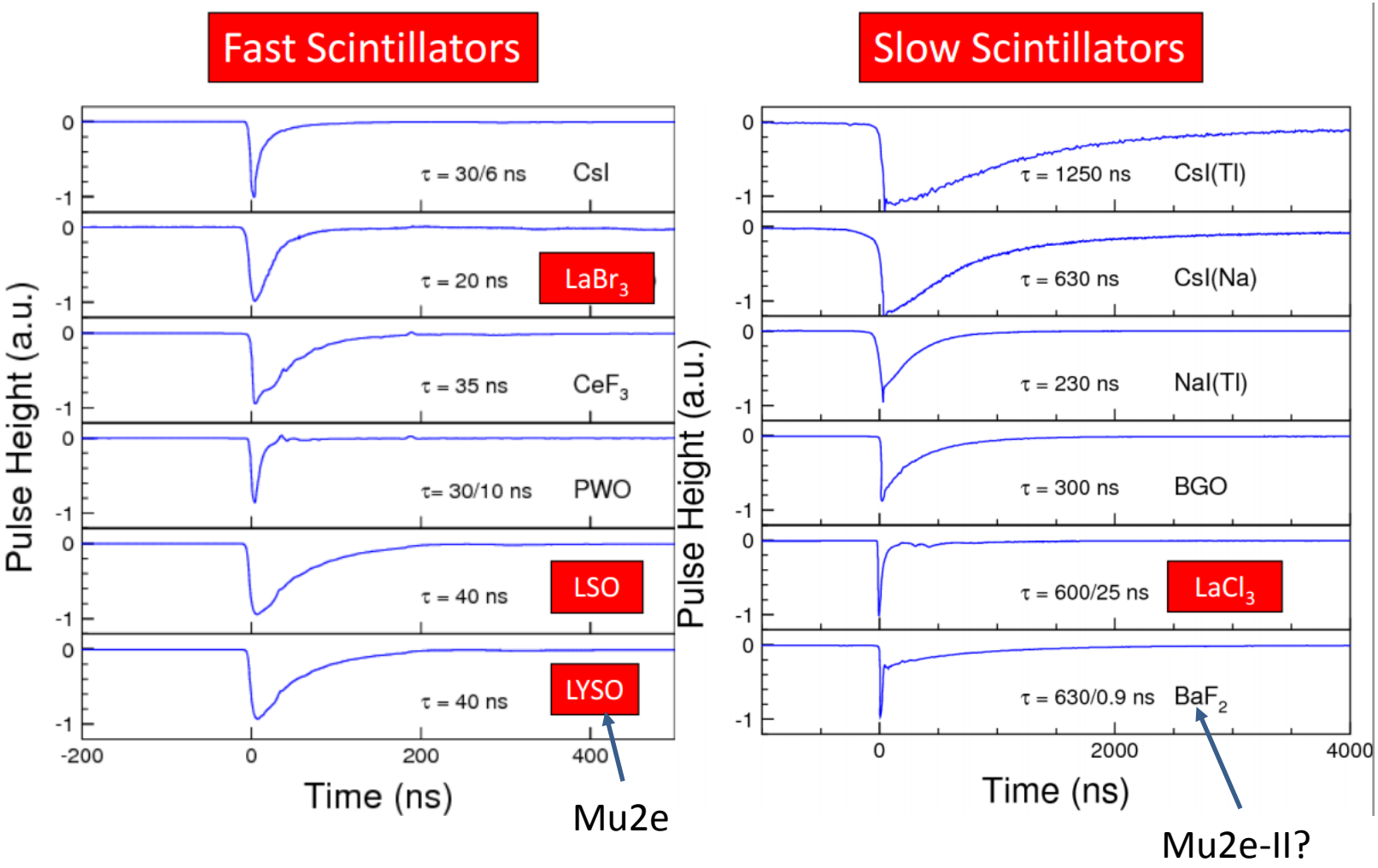
- Excellent even at high rates

Calorimeter Resolution

	Energy resolution	
Background	σ (MeV)	FHWM/2.35 (MeV)
1x	0.6 ± 0.1	1.5 ± 0.1
2x	0.6 ± 0.1	1.2 ± 0.1
4x	1.0 ± 0.2	1.4 ± 0.2

- Poor statistics … but resolution does not degrade very fast

Faster scintillator?



Conclusion

- Mu2e-II could run with the Mu2e detector
- Studies needed:
  - Extend aging tests for tracker
  - More extensive calorimeter performance versus rate studies
  - Impact of changes in PA and INA on calorimeter
- Possible improvements
  - Tracker
    - Thinner walls
    - Run sub-atmospheric
  - Calorimeter
    - Shorten integration in FE
    - Consier faster crystals, e.g the fast component of BaF_2