Fast Neutron Detection with MITPC at Fermilab

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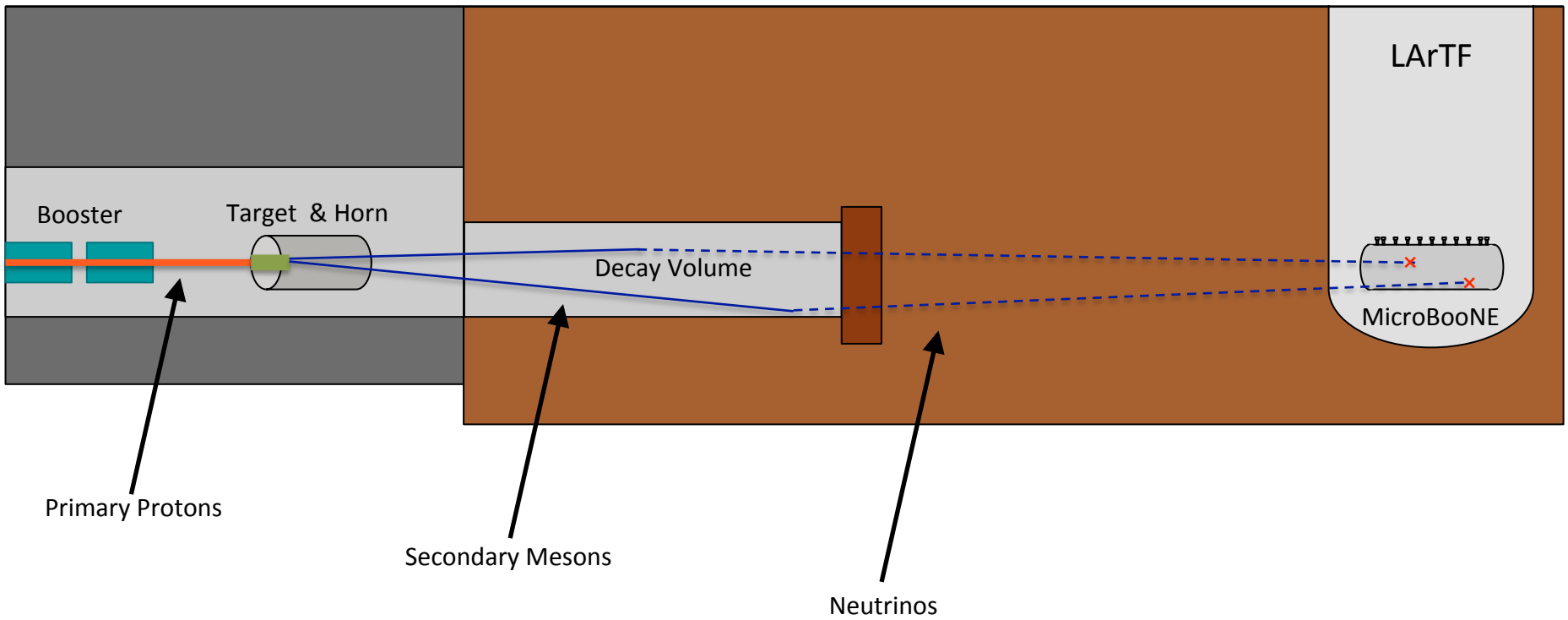
New Perspectives

June 8, 2015

Booster Neutrino Beamline



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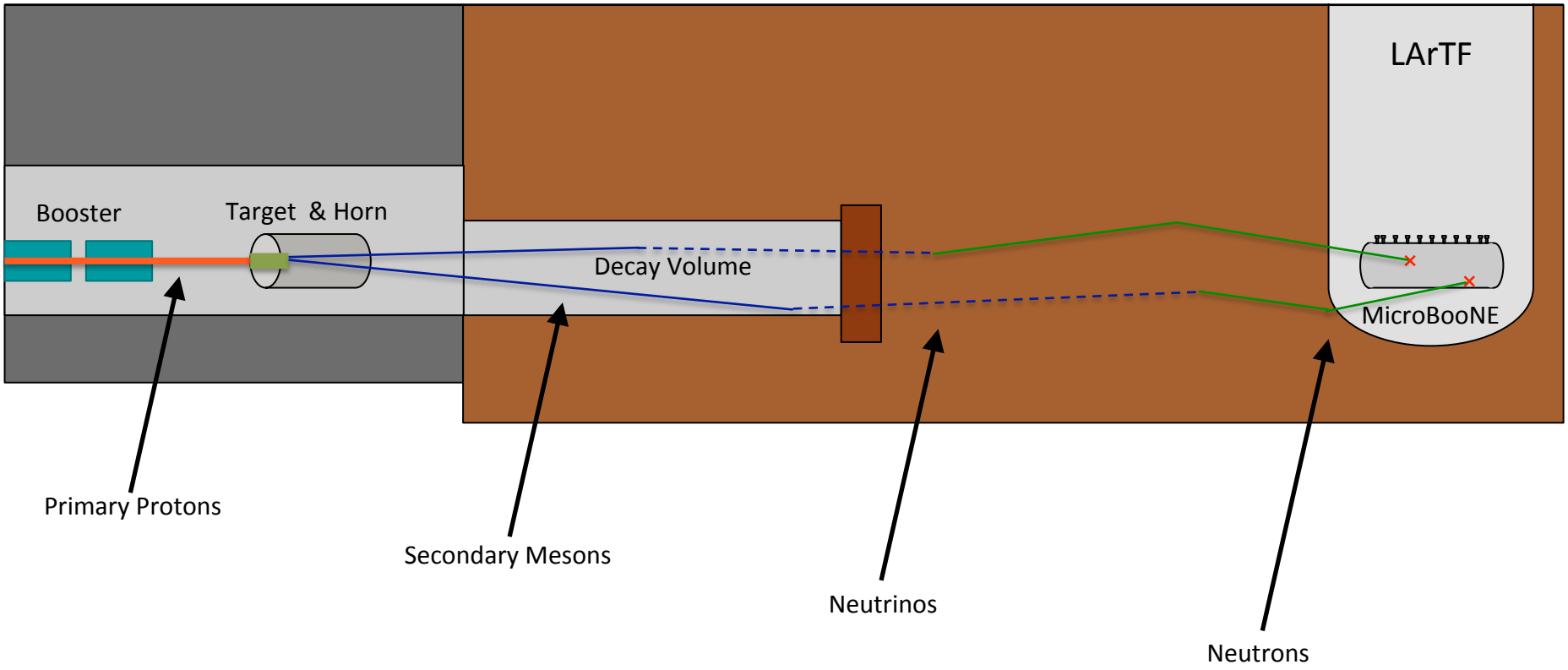

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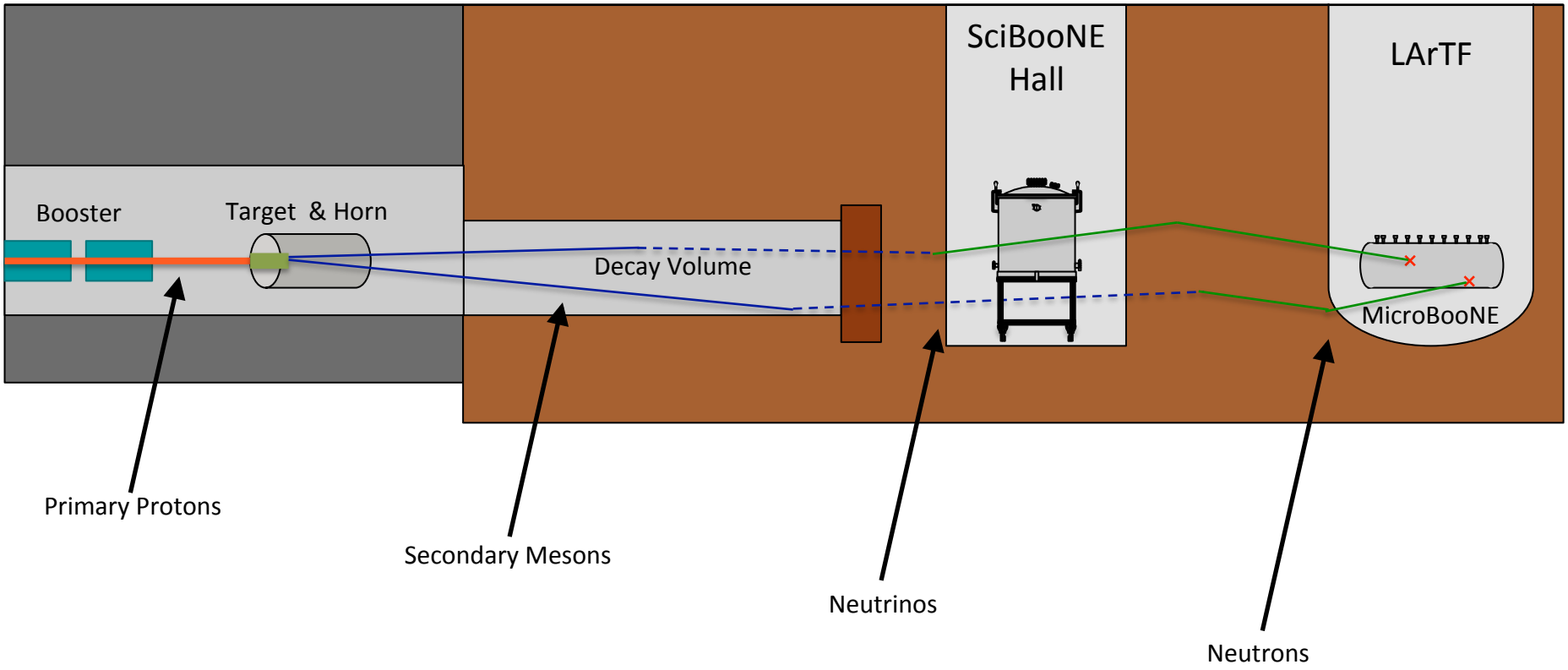
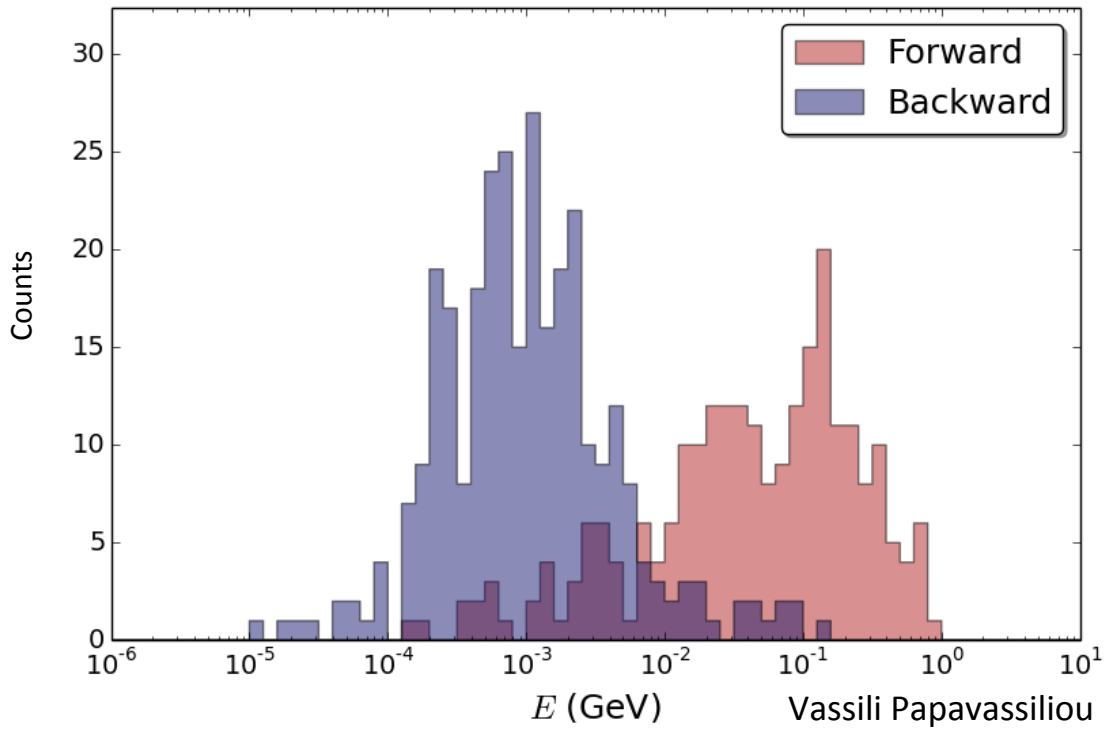


Neutron measurements useful for:

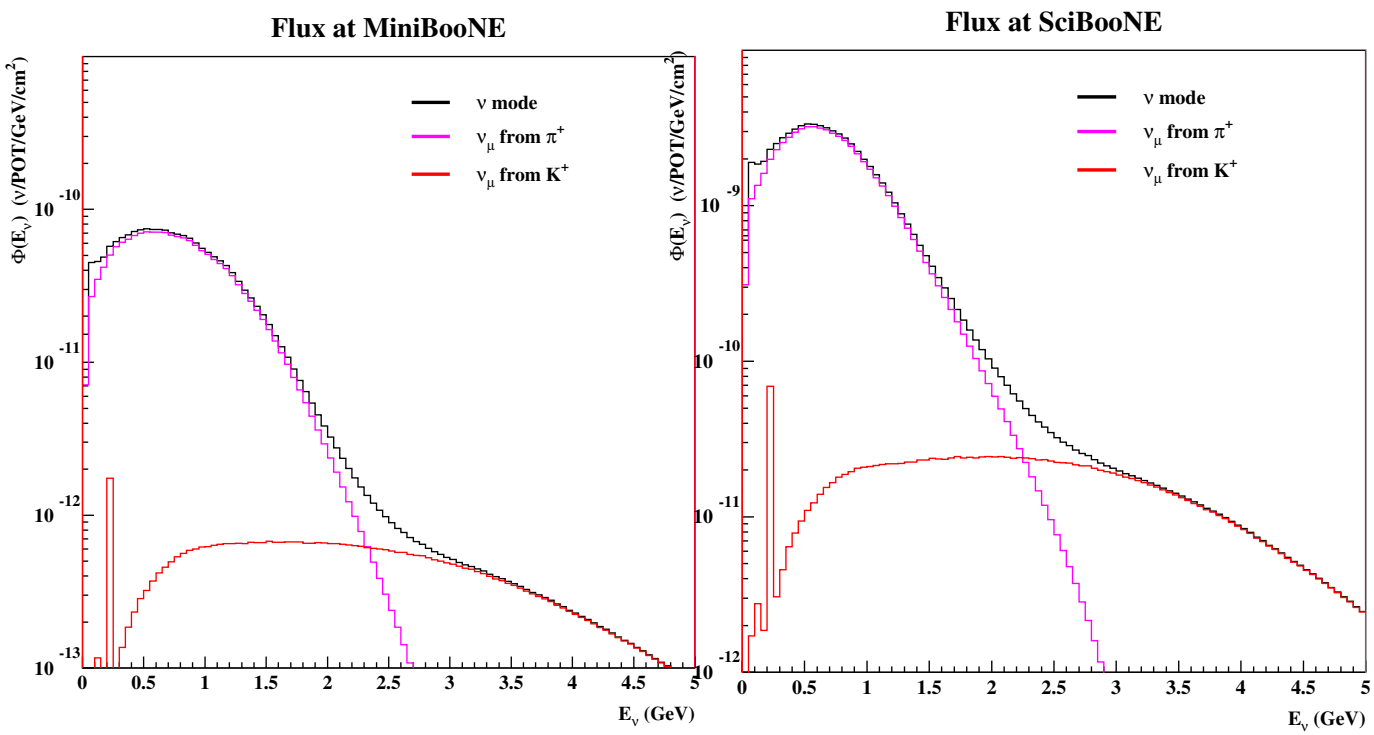
- Tuning Monte Carlo-based prediction of neutron background
- MicroBooNE studies:
  - Neutral current elastic
  - Strange quark contribution to nuclear spin
  - Neutron ID
  - Supernova neutrinos
  - ^{39}Ar
  - Nuclear de-excitation gammas
- SBND and ANNIE

Expected neutron rate



- Neutrons through 1m x 1m area 1m upstream of MicroBooNE over 2.1-3.2 x 10^{19} POT
- MITPC would see 6-9 neutrons (on carbon) over 6.6 x 10^{20} POT (2 years)

Expected neutron rate

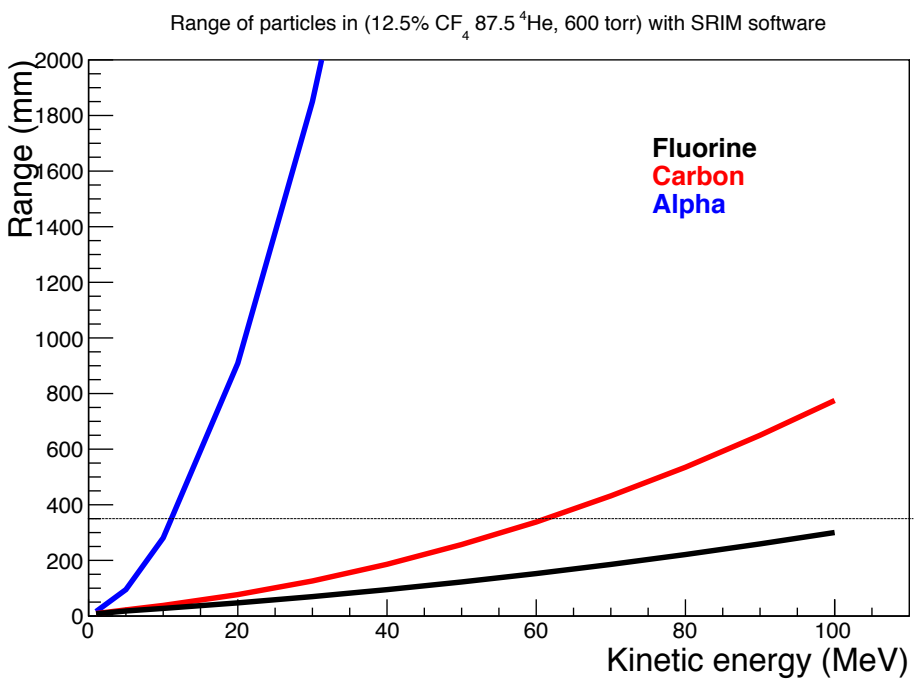


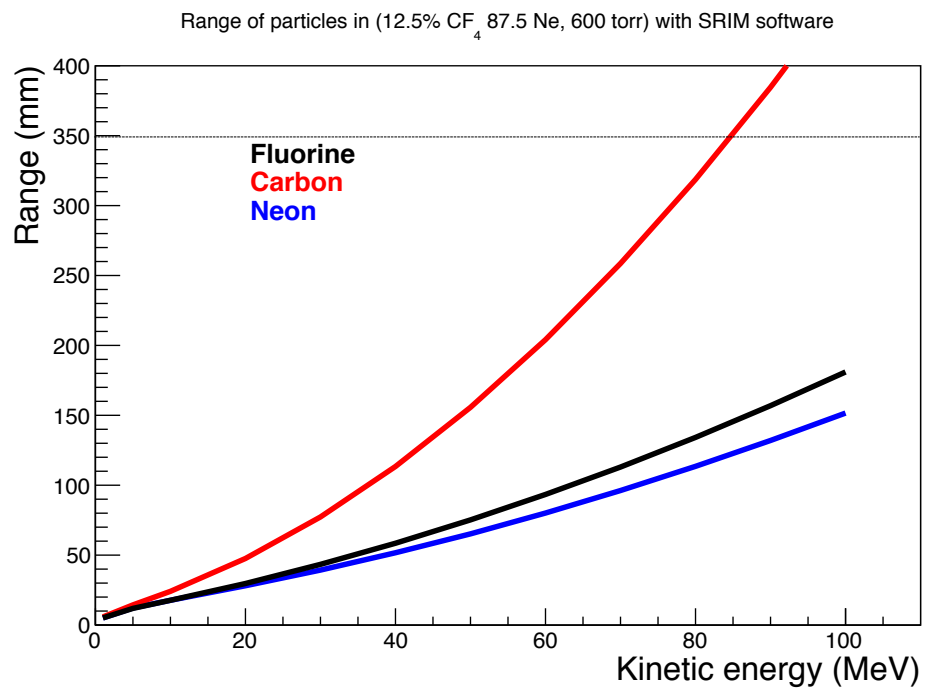
Kendall Mahn's thesis

- Neutrino flux ~60 x higher in SciBooNE Hall
- MITPC would see 300-500 neutrons over 6.6 x 10^{20} POT (2 years)

MITPC Energy Sensitivity

	Big MITPC at Double Chooz	Big MITPC at FNAL
Gas Composition	87.5% He, 12.5% CF4	87.5% Ne, 12.5% CF4
Nuclear Recoil Sensitivity	0.2-30 MeV	Over 100 MeV*





Choosing gas for MITPC @ FNAL

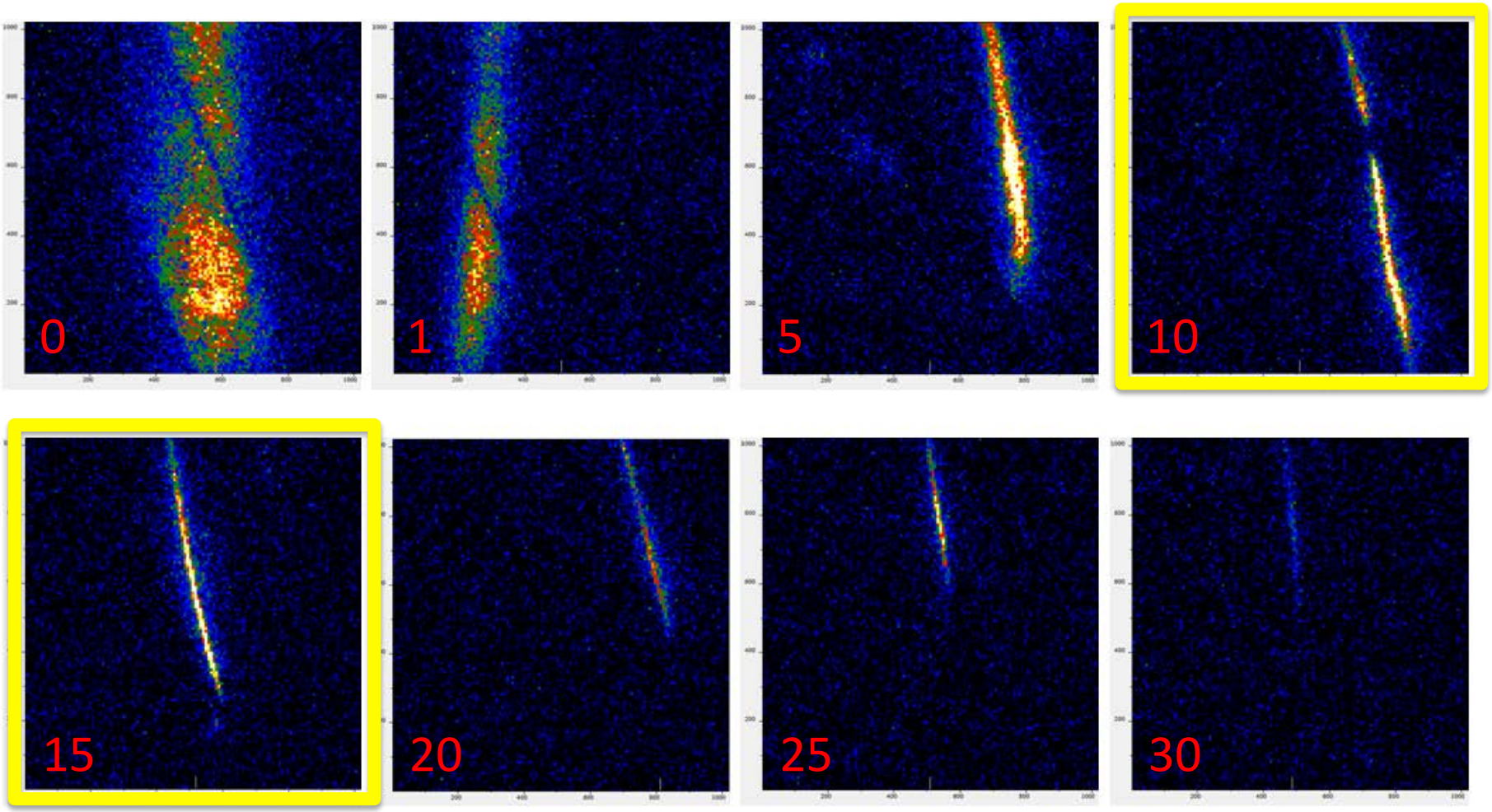
Parameters:

- Composition
  - CF_4, He, Ne
- Pressure
- Optical system

Want:	Test?	Calculate?
• Sufficient stopping power		✔
• Sufficient gain	✔	
• Low diffusion	✔	✔

Diffusion with Xe & CF4

80 torr Xe with xyz torr CF4



Hidefumi Tomita's Thesis

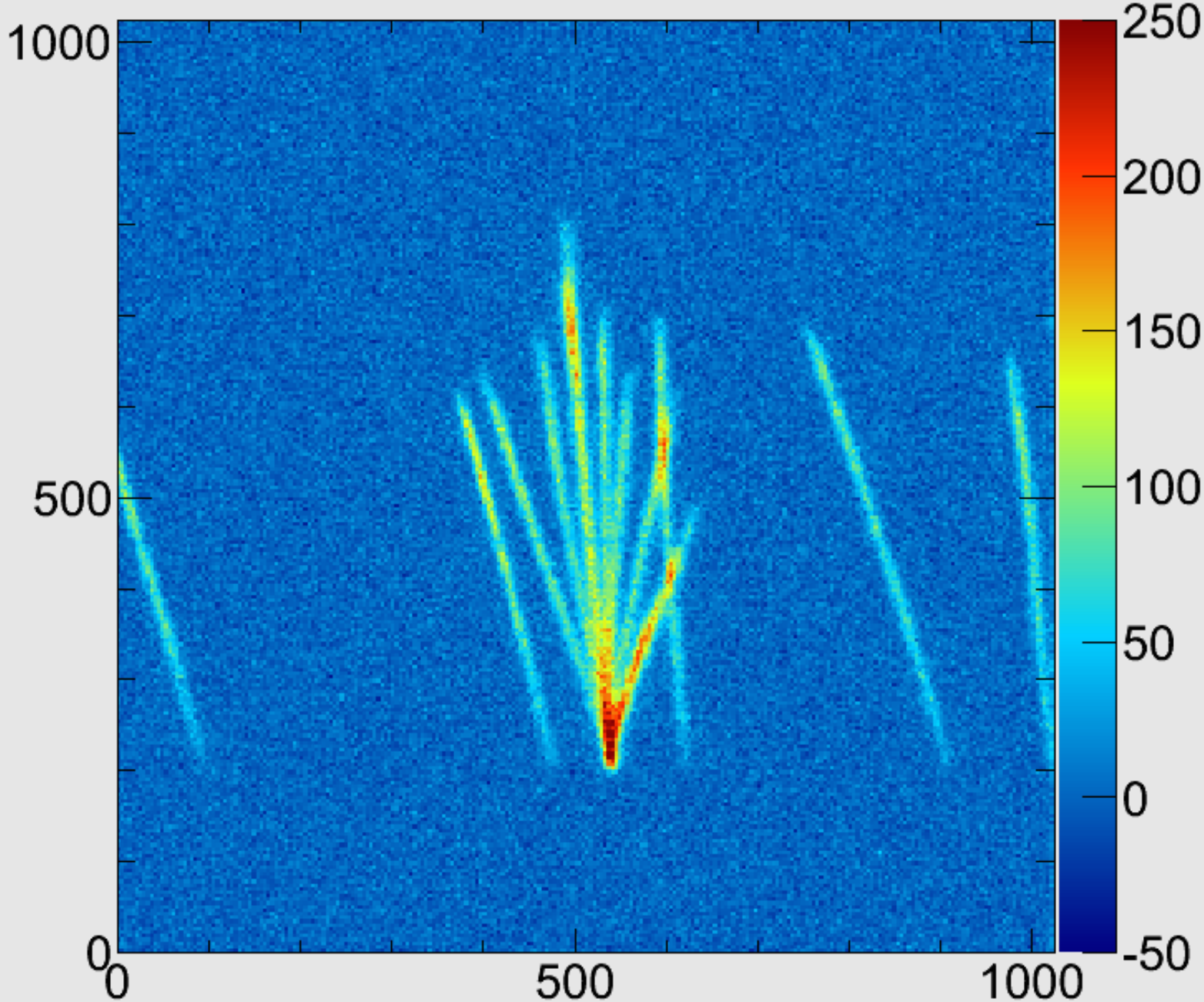
Electron diffusion in noble gases

Kinetic parameters of electrons
in noble gases in an electric field of 75 V/cm.

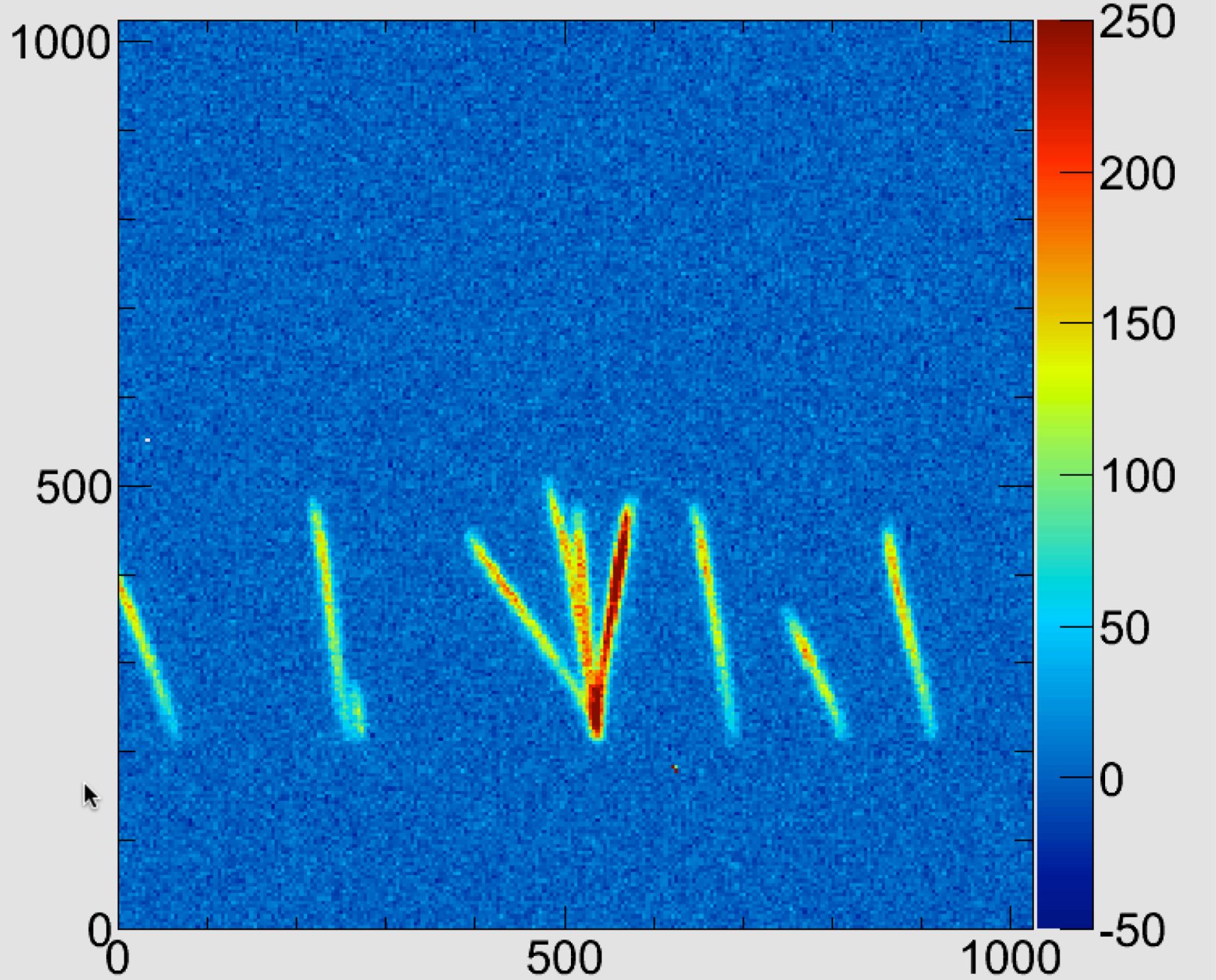
	V, 10^5 cm s^{-1}	eD_T/μ, eV
He	2.8	0.25
Ne	3.5	1
Ar	2.3	3.0
Kr	1.6	2.0
Xe	1.05	2.7

E. Aprile, et al., "Nobel Gas Detectors"

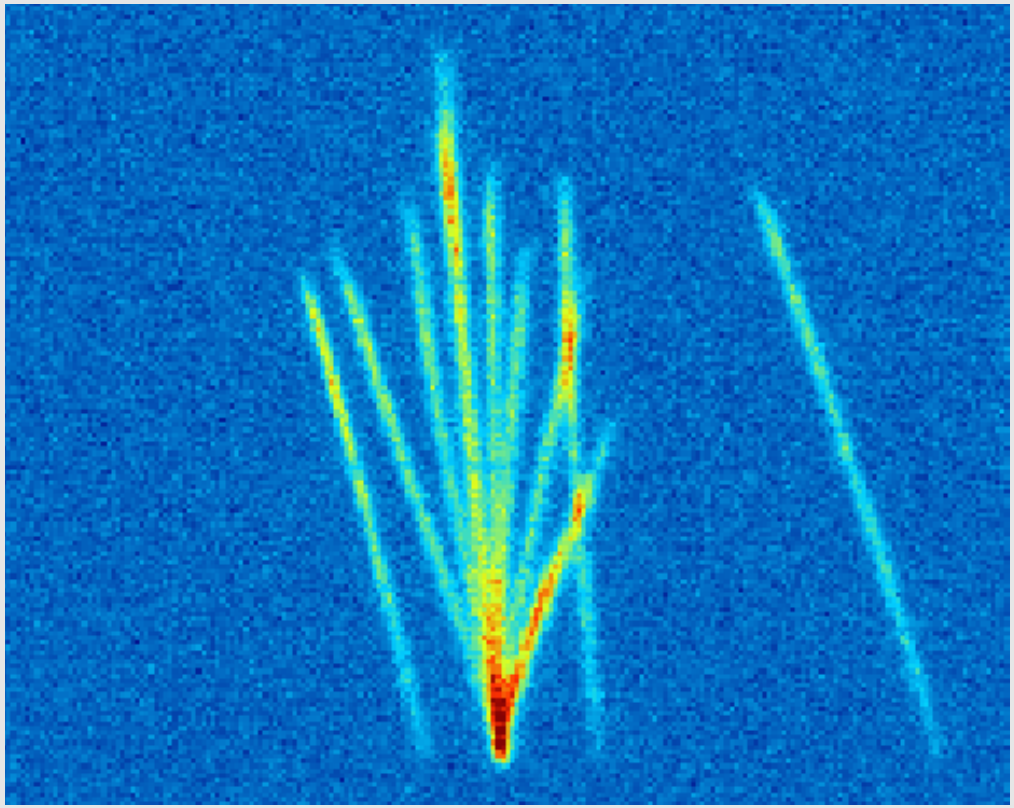
Alpha tracks in 87.5% He-4, 12.5% CF_4 (Am-241 source)



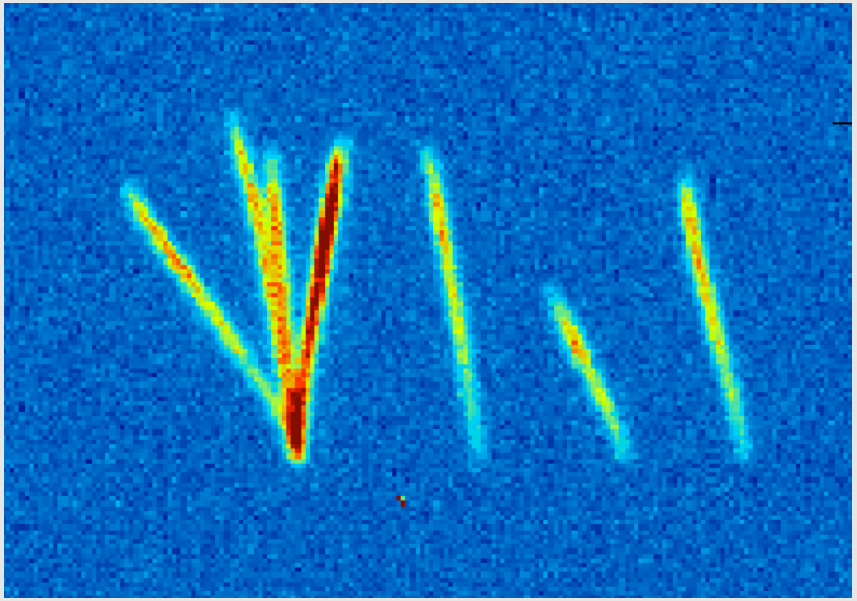
Alpha tracks in 87.5% Ne, 12.5% CF_4 (Am-241 source)



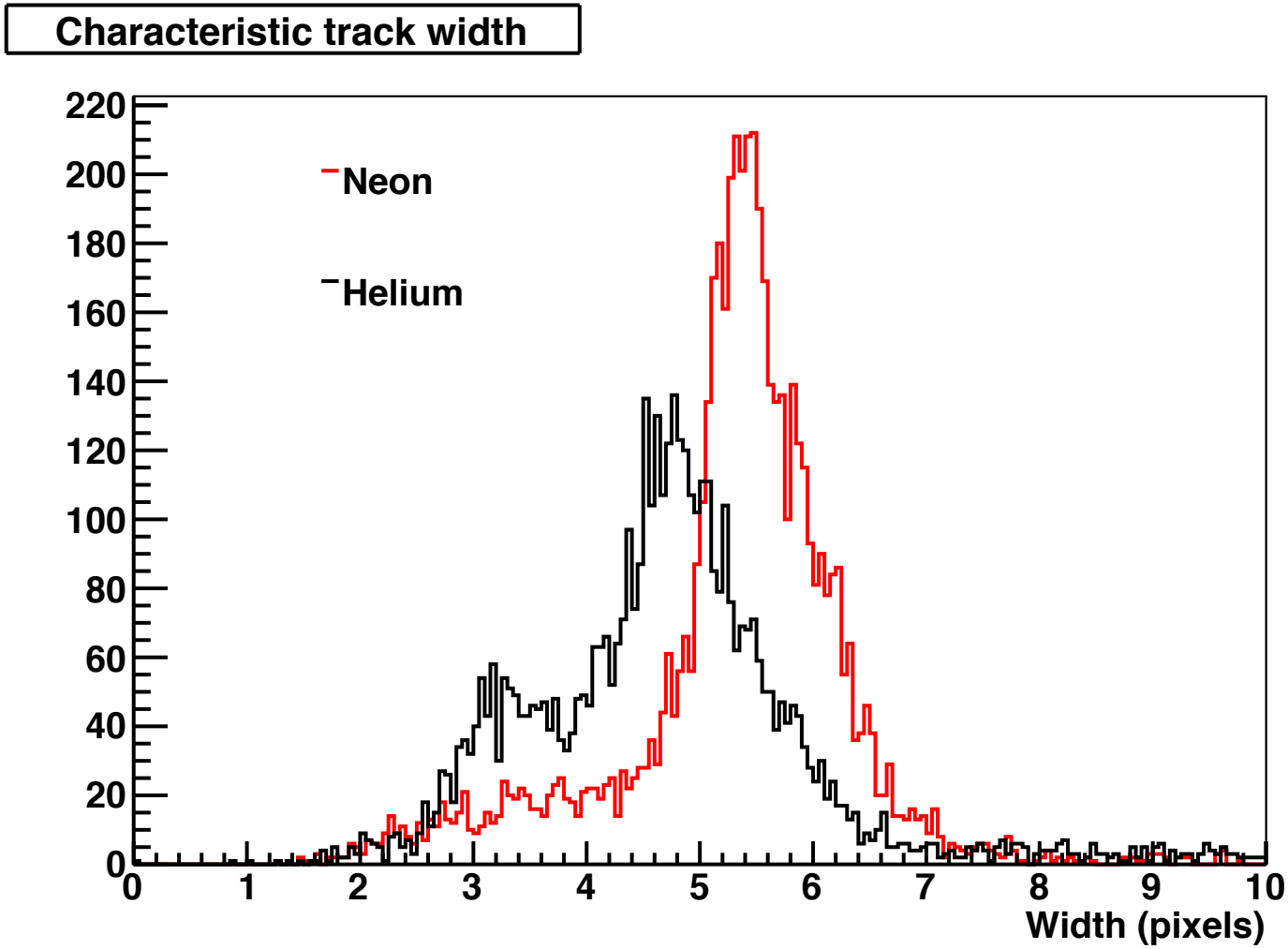
87.5% He-4,
12.5% CF_4



87.5% Ne,
12.5% CF_4



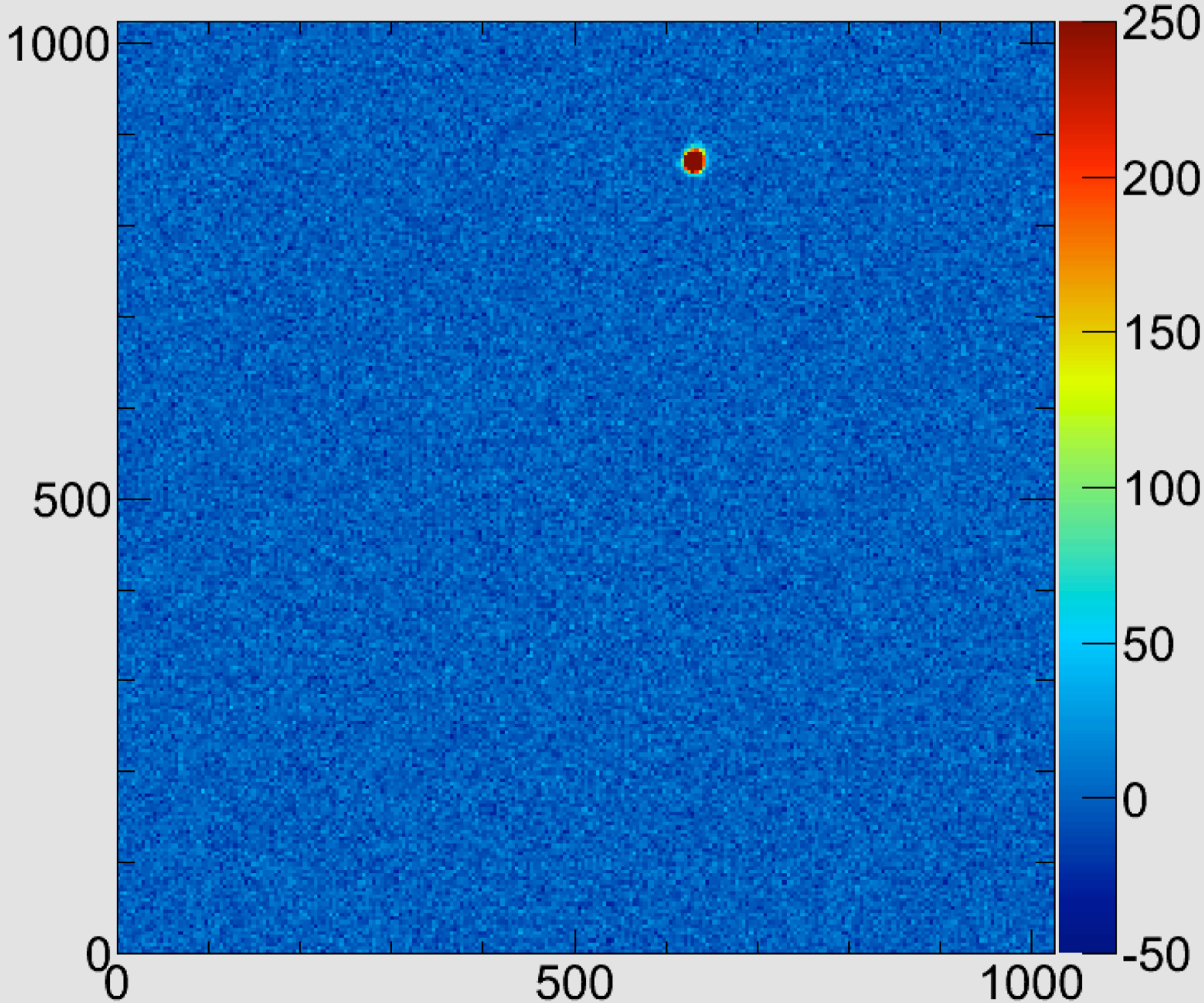
Track width as a measurement of diffusion



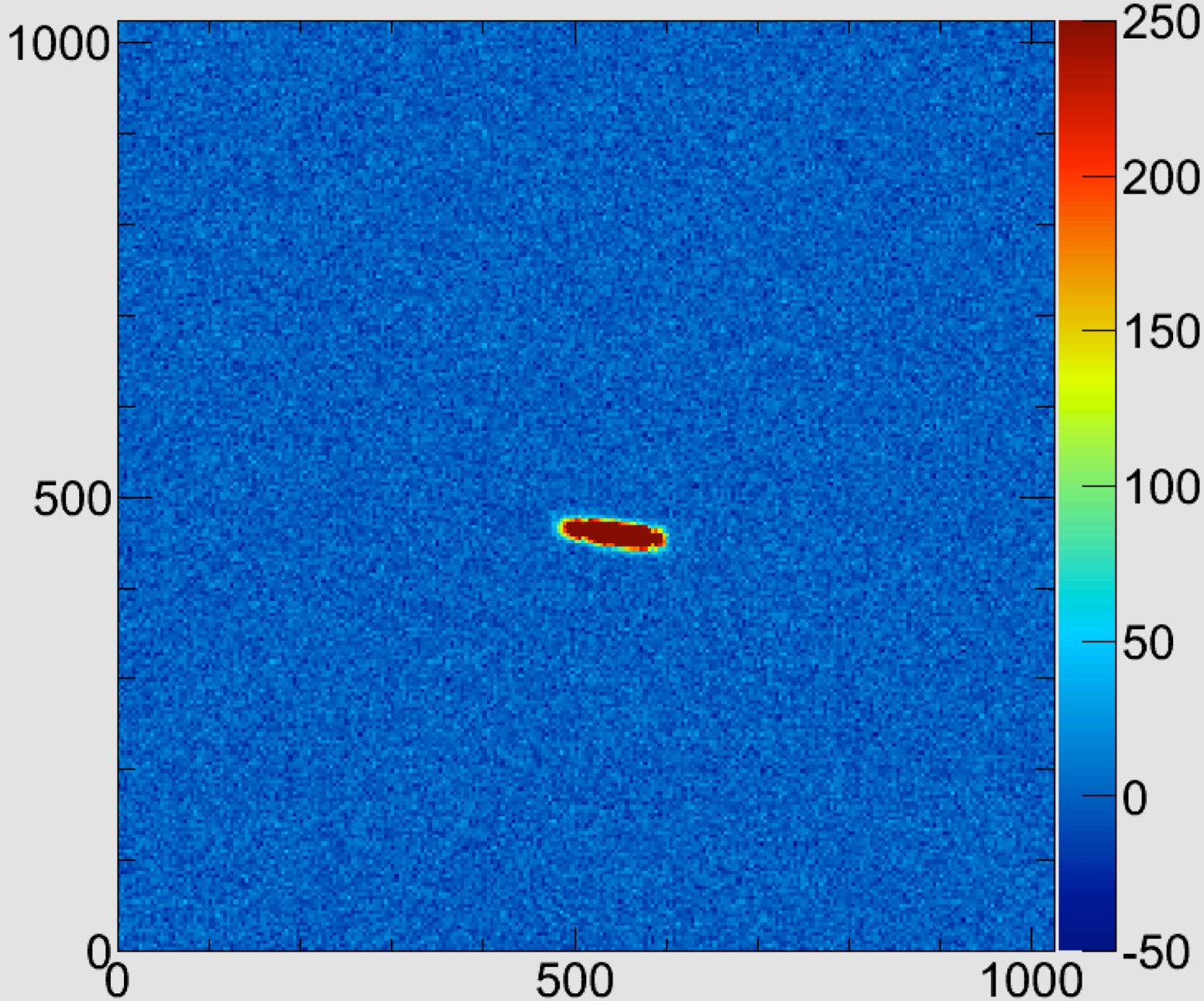
Another surprise – low spark rate

- Much lower spark rate!
  - Don't know why
  - Allows higher gain
  - More stable detector
  - Better signal-to-noise
- Neon may be interesting in directional dark matter searches
  - Tune the sensitive parameter space
  - Decrease spark rate

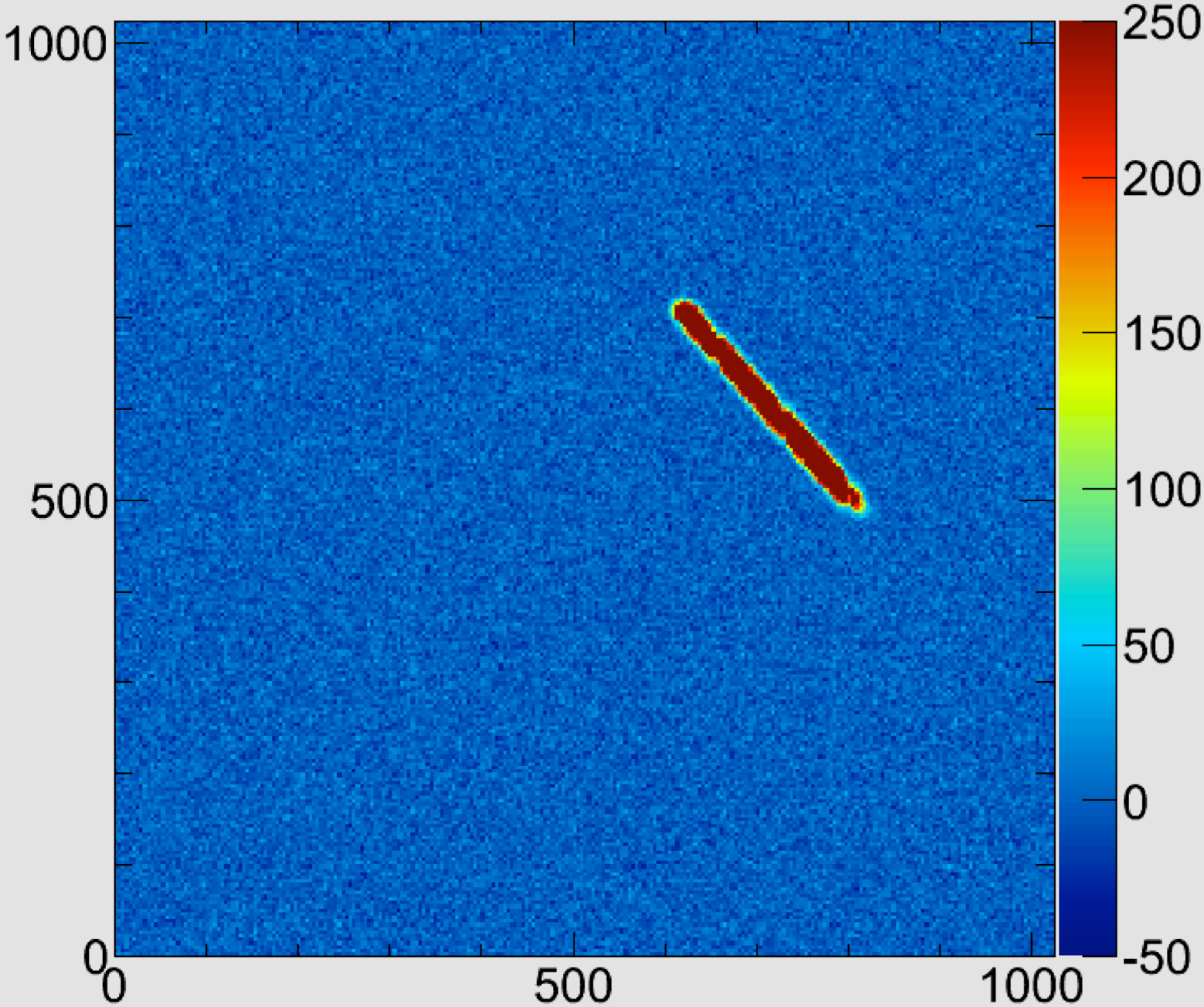
Simulated 5 MeV neutron-induced nuclear recoil (87.5% Ne, 12.5% CF_4)



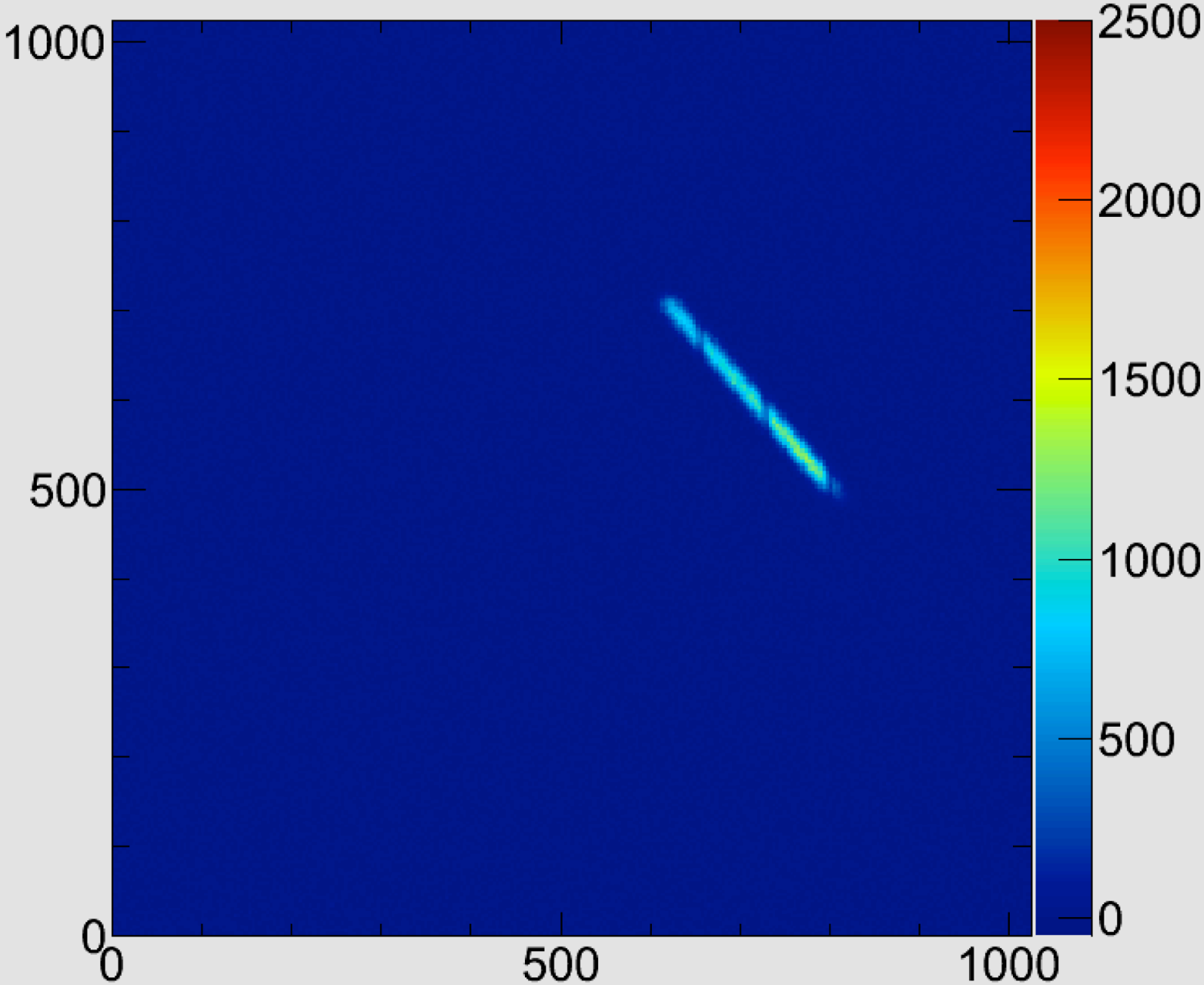
Simulated 30 MeV neutron-induced nuclear recoil (87.5% Ne, 12.5% CF_4)



Simulated 75 MeV neutron-induced nuclear recoil (87.5% Ne, 12.5% CF_4)



Simulated 75 MeV neutron-induced nuclear recoil (87.5% Ne, 12.5% CF_4)



Takeaway

- Demonstrated use of Ne/CF4 in MITPC
  - Diffusion is not a problem!
  - Low spark rate!
- Simulations look good
- Installing Big MITPC in SciBooNE hall this summer
- Stay tuned for results