Plans for CRV Studies Using Test Beams and Neutrons

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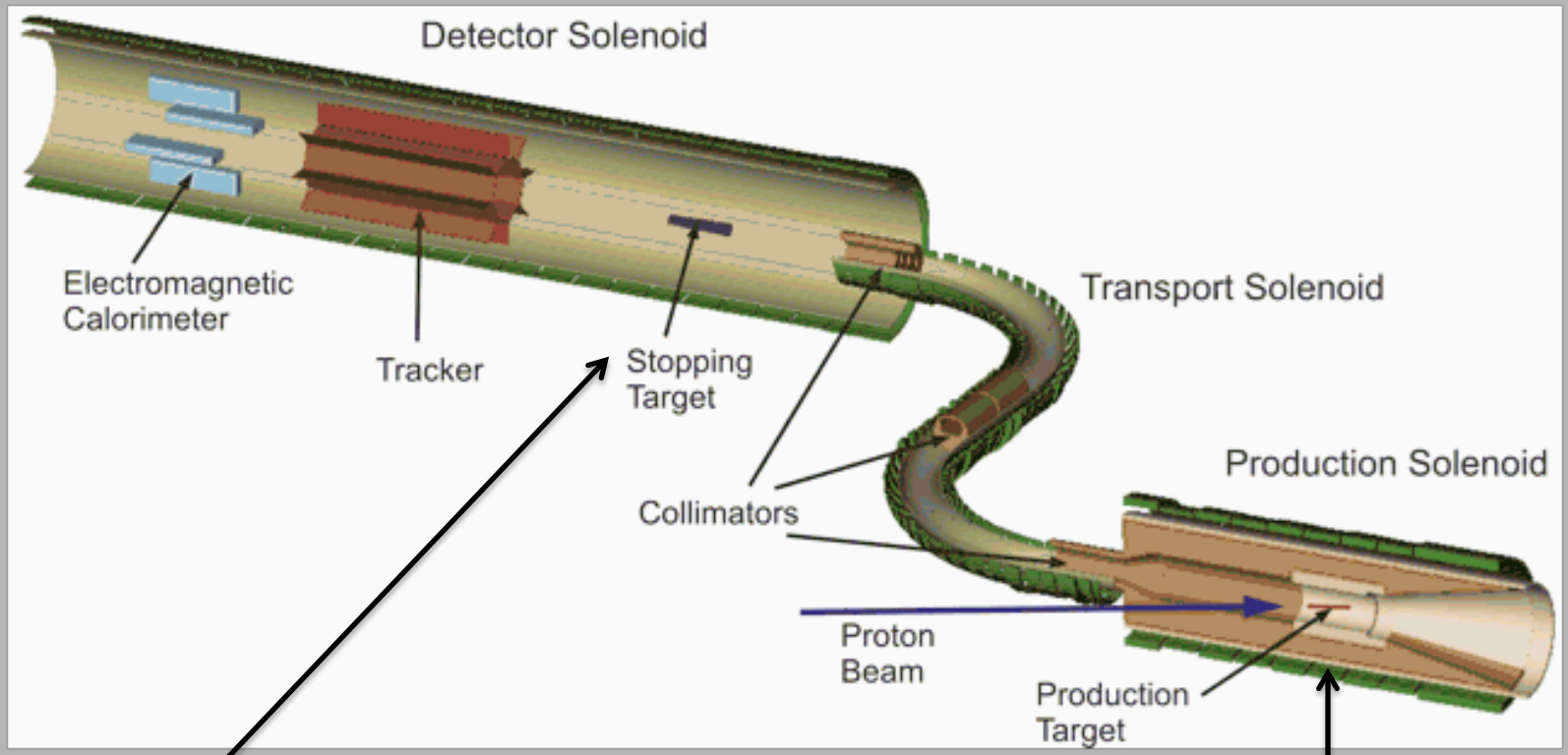
Outline

- Studies of Neutron sensitivity
- Plans for new test-stand for neutron studies
- Proposal for a test beam program

Introduction

- Neutron flux in mu2e cavern has not yet been simulated but is expected to be high.
  → Rick Coleman is looking into simulating this.
- Two components:
  - Thermal neutrons: $E < 0.5$ eV
  - Fast neutrons: $E > 1$ MeV
- Question: Are we sure these neutrons won't cause a significant source of background in the CRV?
- Goal:
  - Understand the sensitivity of the plastic scintillator used in the CRV test stand to neutrons.
  - Minimize this background through detector design or differences in signal shapes

Neutrons and the CRV



Fast Neutrons from the stopping target may pass through the shielding and solenoid to the CRV.

Neutrons from proton beam on production target will bounce around the hall and surround the CRV in a thermal Neutron bath. Low energy at CRV?

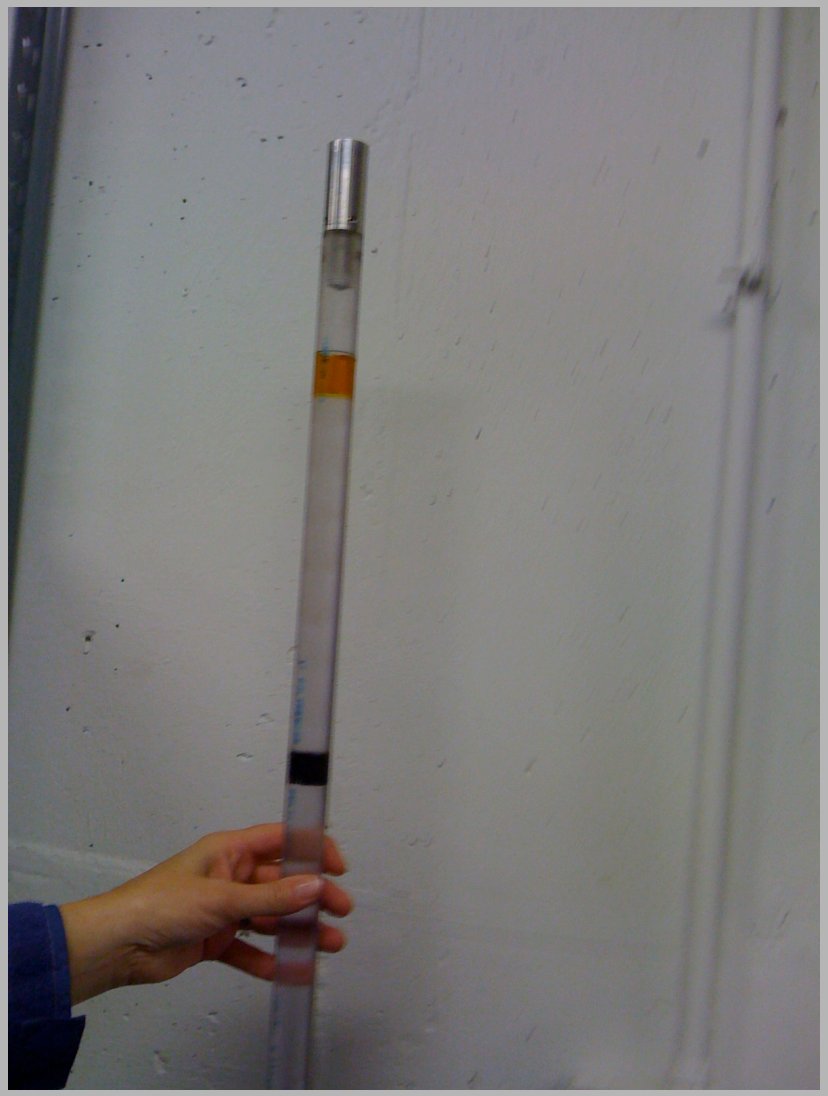
Sources of Neutrons?

Potential sources of neutrons:

- Radioactive Sources
  - Cf-252
- Neutron beam
  - Neutron Treatment Facility (NTF) at Fermilab
- Neutron Generator
  - University of Chicago has one we may be able to use

Cf-252 Source at FNAL

- Decay:
  - Alpha decay ~97%
  - Spontaneous fission (3%)
    - Emits neutron!
- Lifetime: ~2.6 years
- E_n = few MeV or less
- Fermilab source 20 years old!
  - Emits ~7.7×10^4 neutrons/sec
  - Isotropic decays



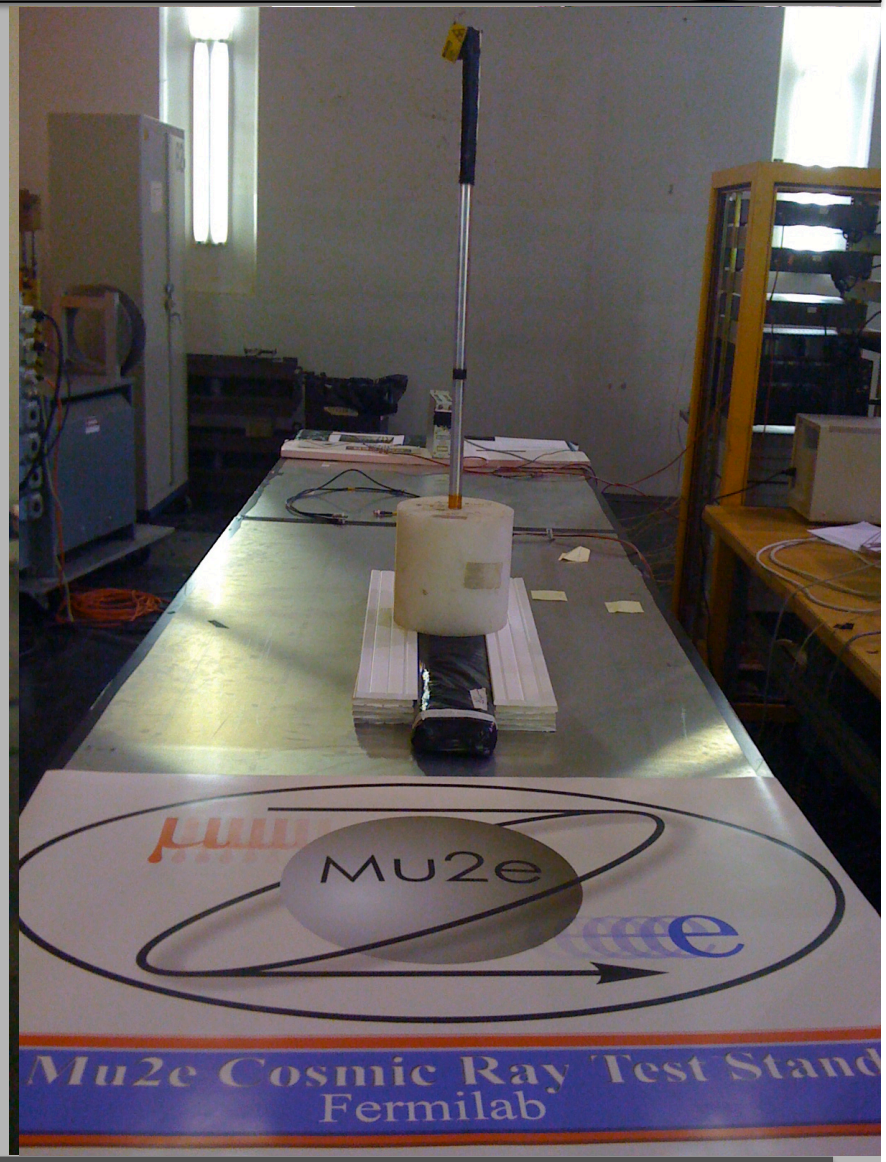
Don't abort the Tevatron!

- The CRV test stand sits in B0 just on the other side of a shielding wall from the collision hall.
- Several chipmunks are located a few feet away that can trigger a Tevatron abort!
- There was concern that the CF-252 source might cause a Tevatron abort so we had to bring it over during a down time and check to make sure it did not trigger the abort.

  → The source is quite weak and there was no noticeable effect on the chipmunks.

The first source test

- Took several 4-hour calibration runs to check stability of rate
  - → Rate stable to a few %
- Ran with source in 2 configurations:
  - Directly on trigger paddle
  - Separated from trigger paddle by ~3” of plastic



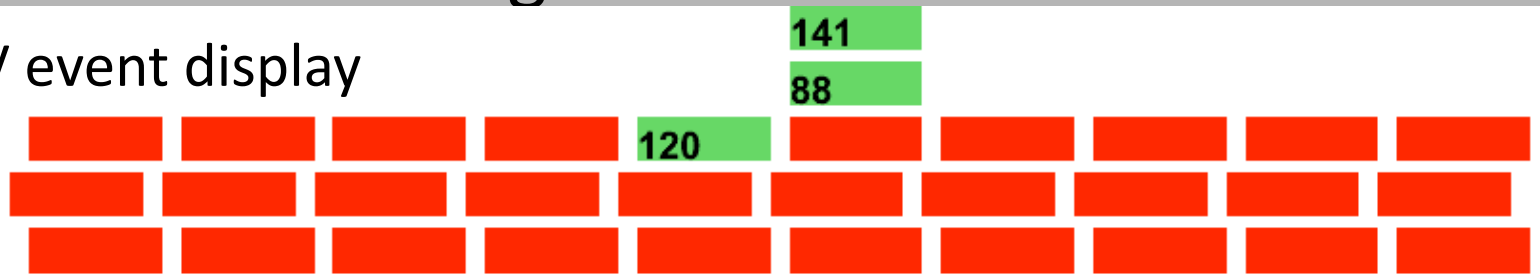
The idea

- See if the trigger rate is affected by the pressence of the source.
- If so, what do the “new” events look like in the CRV?

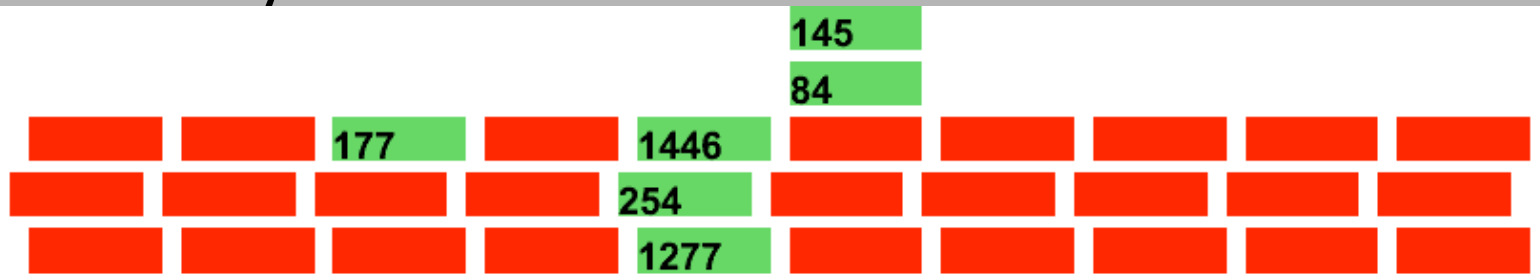
The Result

- Huge rate compared to cosmic rate!
  - Directly on trigger: rate ~10x higher (65% empty)
  - 3” of plastic: rate ~2.5x higher (55% empty)
- Seem to be a large fraction of events like this:

CRV event display



- Cosmic ray events look like this:



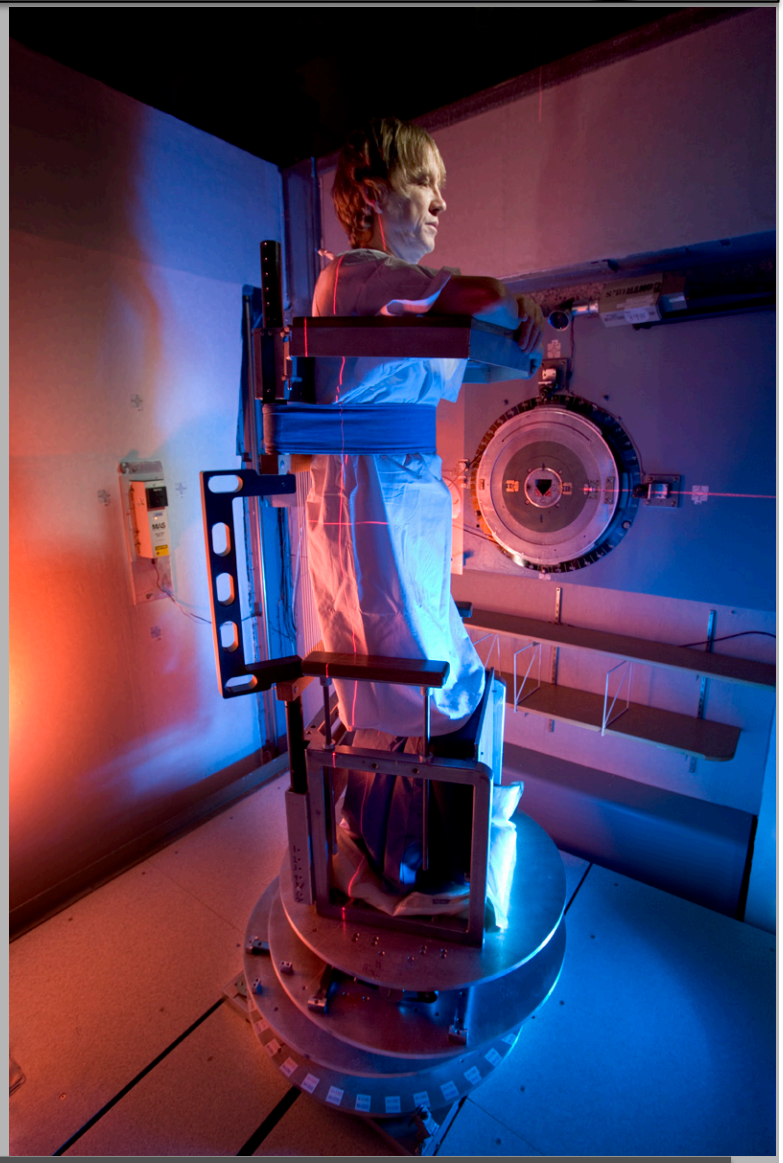
- Amy Allen (IMSA) is working to quantify this effect and understand this data

The Results cont…

- Not conclusive:
  - Branching fraction of CF-252 for neutrons is only 3%
  - Other 97% is alpha decay: α's, e-'s, γ's ?
- Planned studies:
  - Introduce metal plates one at a time between source and trigger to see if we can remove contamination
    → Amy's Senior thesis project on this (High School!)
  - Problem: will no longer know the neutron flux
- Need to consider other options…

NTF

- Pure neutron beam (<1% γ's)
- Energy is a continuom
  - E_n<~20 MeV
- Bunches pulsed at 15Hz
- About 1M neutons per pulse
- 10^12 p -> ~ 10^6 n
- Two options:
  - Place detector in treatment room (Fast neutrons)
  - Place detector on other side of shielding wall (thermal)
- Eric Ramberg and Tim Kroc are happy to have us do these studies.

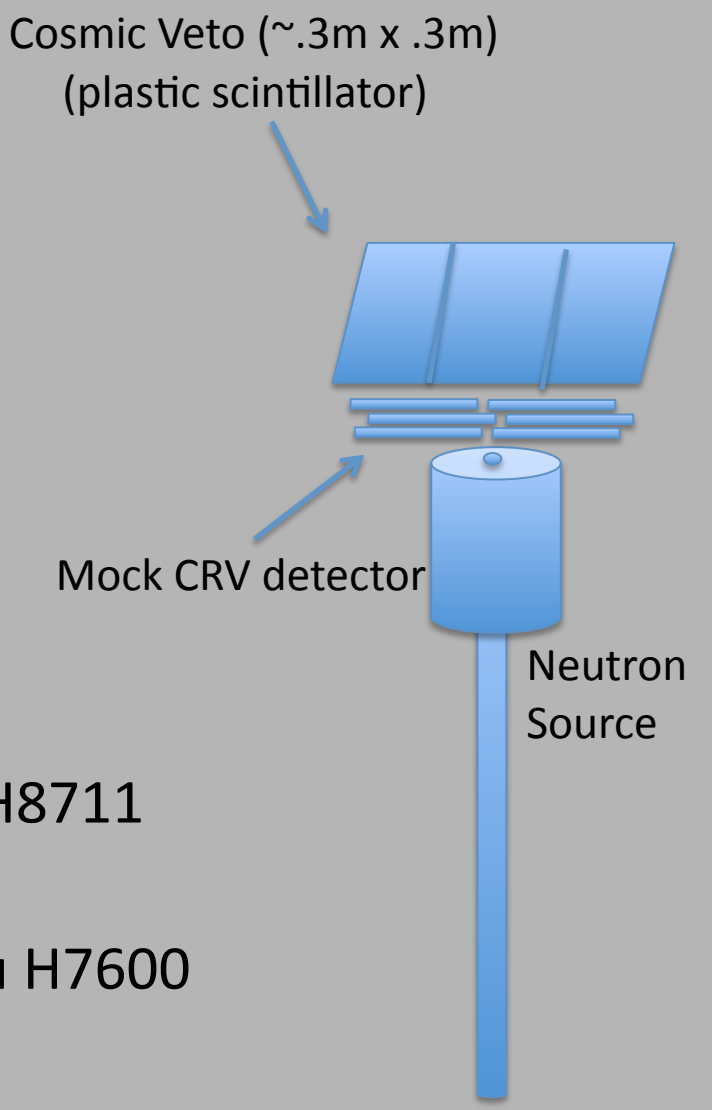


Neutron Generator

- Compact linear accelerators that produce neutrons by fusing isotopes of hydrogen together:
  - D + T → N + 4He E_n = 14.2 MeV
  - D + D → N + 3He E_n = 2.5 MeV
- About 3M neutrons /sec
- Cost ~ 60,000 $ dollars
- Very pure monochromatic neutron beam
- Juan Collar has a D+D generator at UC:
  - Target only good for 1000 hrs and his already has 850 hrs
  - Happy to let us use it
  - We went to see the setup a few weeks ago (12/16)

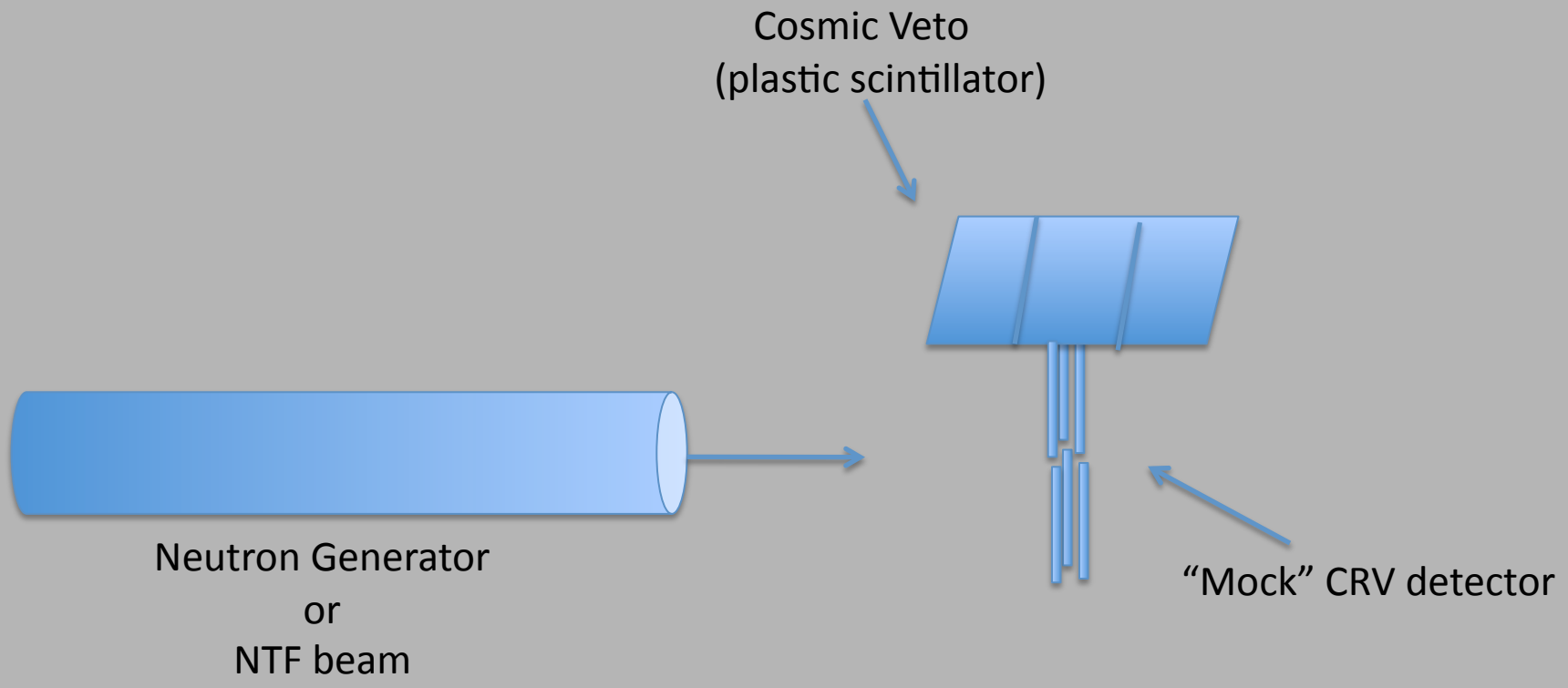
Plan for new test stand

- Constructing a simple test stand with cosmic veto for neutron sensitivity studies:
- Use plastic scintillator from same batch as CRV prototype
- Ordered:
  - WLS fiber(BCF 92):
    - 1.4 mm
    - 100m spooled
  - PMTs:
    - Hamatsu H8711 (16 ch)
    - 2 Hamatsu H7600 (2ch)



New test stand cont…

- Keep the design flexible and portable:
  - > Example: Make it possible to change orientation of the "mock" detector



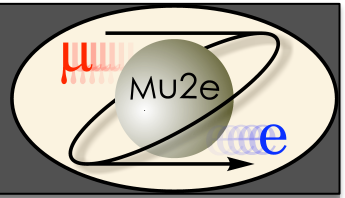
New test stand cont…

- Engineers to help with project identified
  (Carl Lindenmeyer, John Korienek + techs)
- Drawings made and materials ordered
- Construction on hold while we try to understand exactly what we need:
  - Visited UC and neutron generator
  - Visited NTF
  - Test run with neutron source
- Have the information we need now to make a plan…

Points for Discussion

- Thermal neutrons:
  - What interaction processes are we concerned about?
  - Is H(n,gamma)D the only process of concern?
    - H+n→D+gamma (2.2 MeV gamma)
    - Gamma pair produces near border between 2 scintillators
- It would help to have more specific goals:
  - Expected neutron flux?
  - Expected neutron energy distribution?

Test Beam Proposal



- Giovanni Pauletta contacted us about a proposal for using the Meson Test Beam facility at Fermilab to study plastic scintillator
- Proposal planned for ILC detector R&D
  - → Same questions we have for CRV!
  - → Similar geometries
  - (Multi-layer scintillators (5-6 m long), WLS fibers, Etc…)
- Goals:
  - Study response of different photon detectors
    - → Si Pixelated Photon Detectors (PPD)
  - Study # photo electrons for different lengths of scintillator (signal attenuation)
  - Study light loss due to PPD/fiber interface
  - Fiber's grooves v/s extruded holes
  - …

Test Beam Proposal

- Collaboration exists, but we hope to join the effort and use this R&D to improve the CRV design
- Studies should ramp up in the next few months
- We plan to help out
- How much should mu2e get involved?

  → (i.e. contribute effort, $, other resources)

Summary

- Hard to find a source of:
  - pure neutrons
  - neutrons with well-known flux
- Neutron Plans:
  - More studies with CF-252 source
  - Investigate using NTF or neutron generator:
    → Investigate rates with simple trigger paddle
  - Build dedicated test stand for improved sensitivity and portability
- Test Beam:
  - MOU/Proposal already exists to do many of the studies we were considering to improve CRV efficiency
    → We are considering helping out and taking advantage of the results