Some thoughts on CRV@AMF

CalTech Workshop

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Cosmic Rays - a dangerous background!

SINDRUM II at PSI

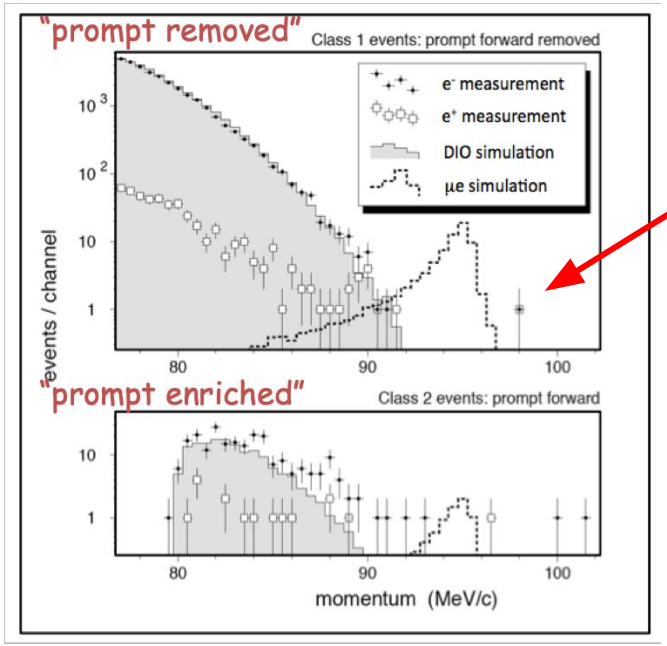
Final results on Au:

$R_{me} < 7x10^{-13}$ @ 90% CL

One candidate event past the end of the spectrum. Pion capture, cosmic ray?

Timing cut shows the contribution of prompt background (0.3 ns muon pulse separated by 20 ns)

W. Bertl et al., Eur. Phys. J. C 47, 337–346 (2006)

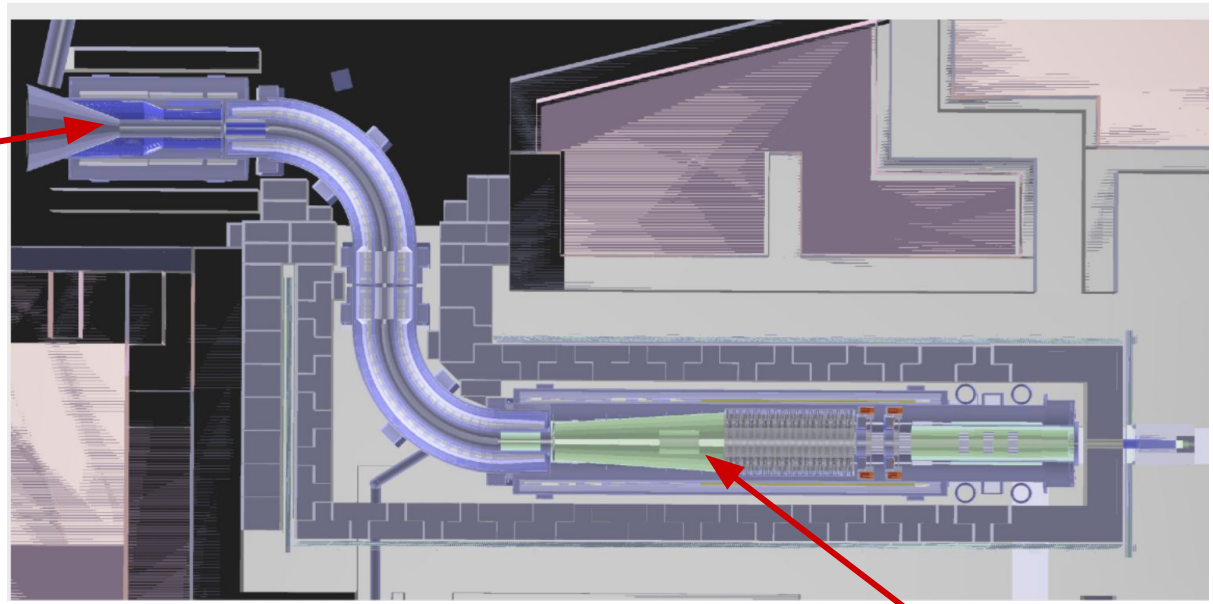


Cosmic Muon ?

Little time separation between signal and prompt background, this becomes problematic at higher rate.

The challenge of the Mu2e CRV

Mu2e will hit target with ~10^{21} protons here. Just a few meters away from the CRV!



Mu2e will stop ~10^{18} protons here. Just a few meters away from the CRV!

Both are sources of neutrons and other particles that can leave signals in the CRV and cause **deadtime**!

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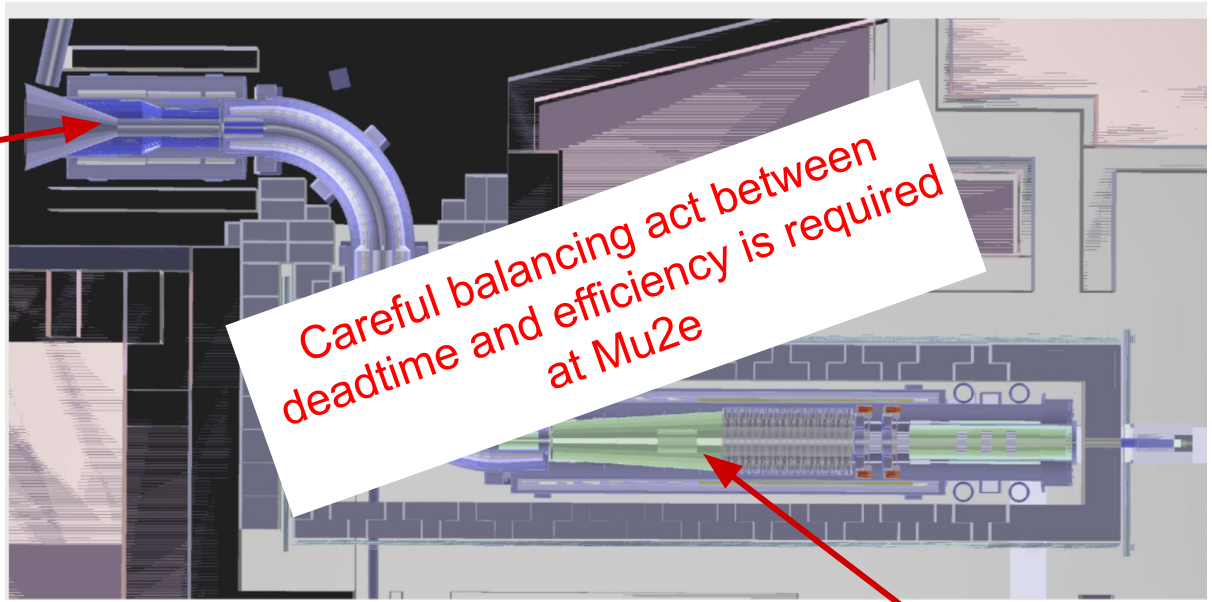

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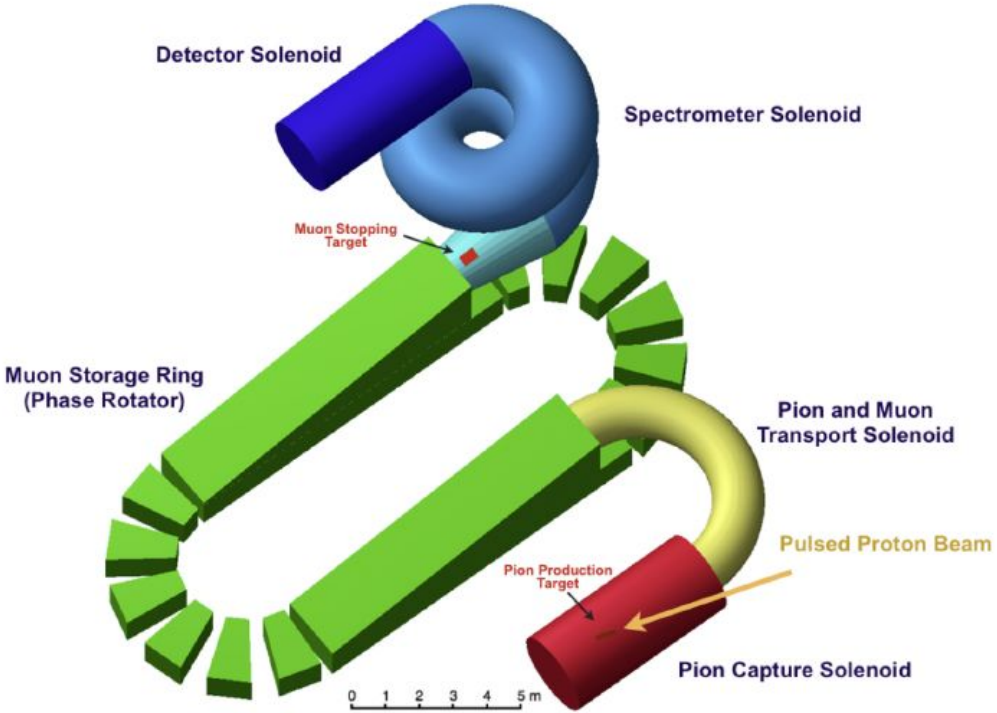
CRV may be less challenging at AMF:

From PRISM/PRIME concept:



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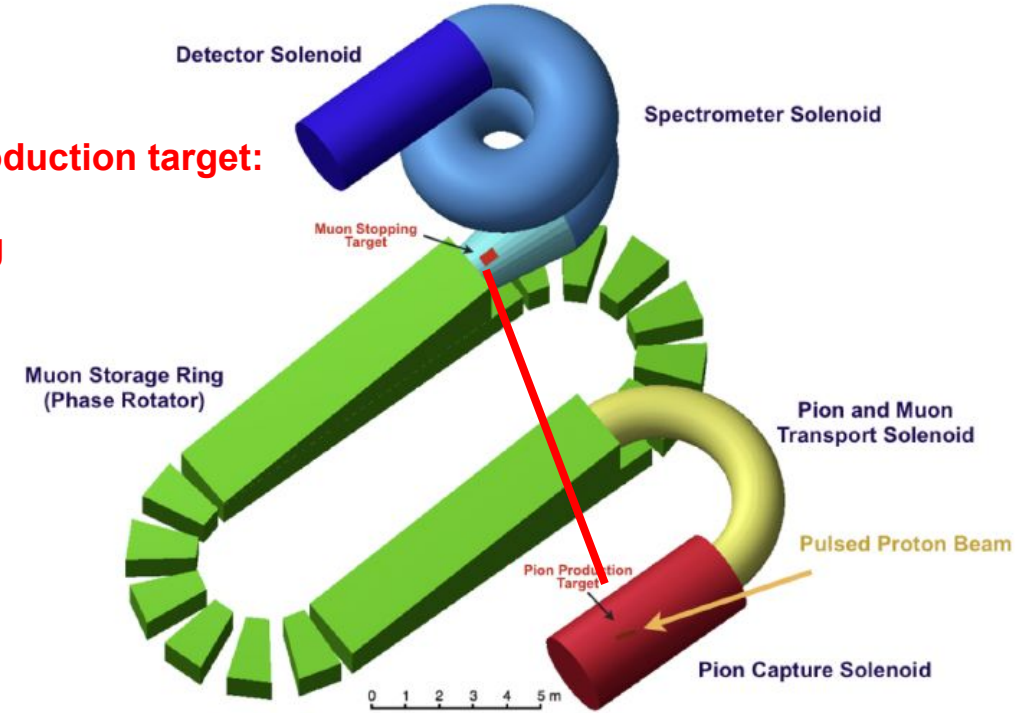
From PRISM/PRIME concept:

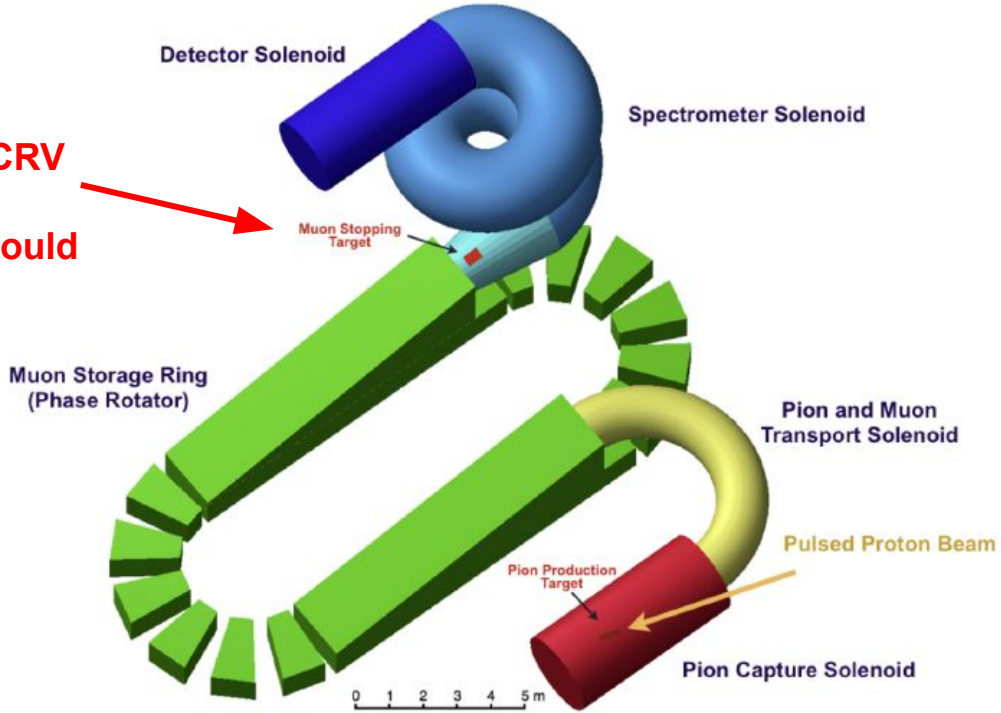
1) About 15 m from pion production target:
→ Much farther than Mu2e
→ Room for plenty of shielding



CRV may be less challenging at AMF:

From PRISM/PRIME concept:

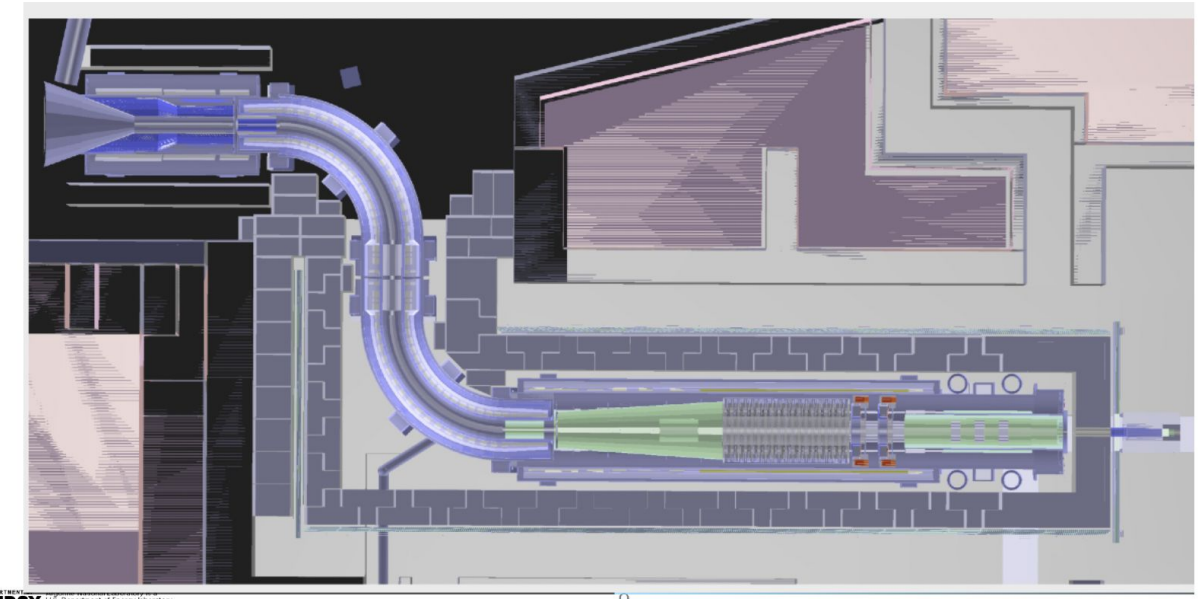
2) Assuming we can shield the CRV from the muon stopping target, background rates in the CRV should be more manageable.



For Mu2e, but very promising for shielding neutrons from stopping target:

SOLUTIONS/ONGOING R&D: SHIELDING

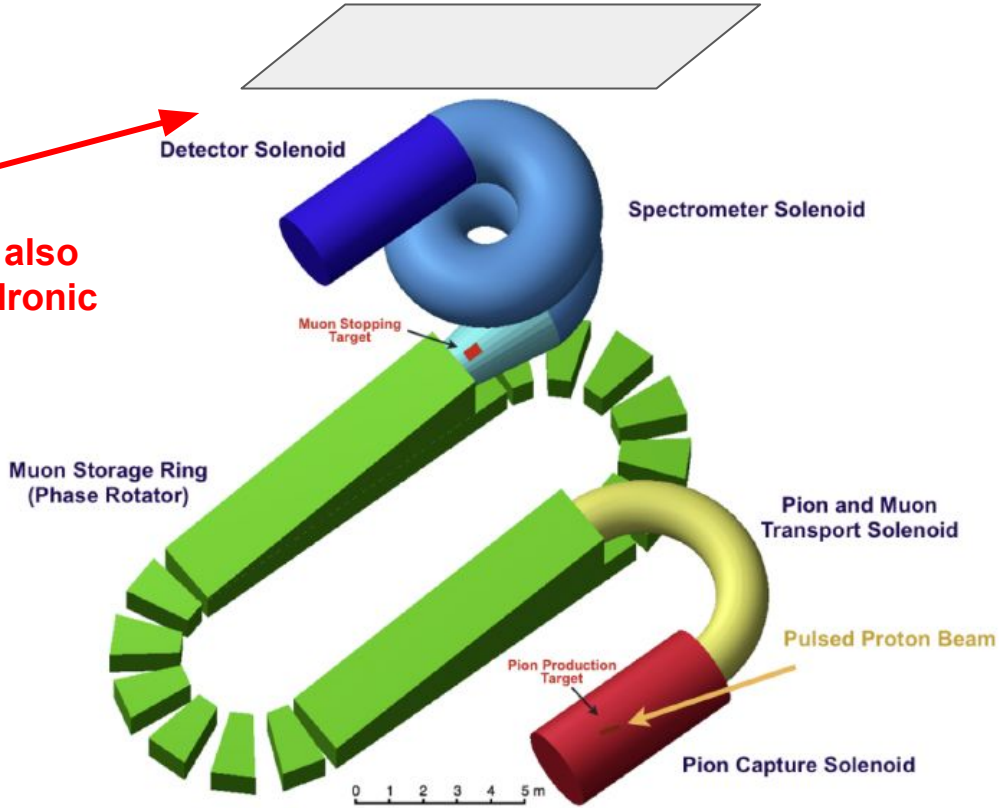
Yuri simulated high-Z (Barite) enriched with 1% Boron carbide: capture neutrons
=⊳ reduce dead time close to 0



CRV may be less challenging at AMF:

From PRISM/PRIME concept:

3) Sufficient CRV overburden is also important to shield from the hadronic component of cosmic rays.



Need to simulate!

Of course, we will need an AMF conceptual design, and simulation tools in order to understand the shielding that is needed.

Assuming, that sufficient shielding can be included in the design, I don’t expect getting to the required veto efficiency to be a limiting factor for the experiment.

Holes in the veto coverage due to penetrations are likely the limiting factor - need to be minimized to keep cosmic ray background manageable.

Summary

My feeling is that significant work on an AMF CRV isn't critical at this time. The R&D plan for Mu2e-II will explore improvements to detector design and shielding.

While creating an experiment design:

- Care must be taken to allow for significant shielding between pion production target and the CRV, as well as the muon stopping target and the CRV.
- Significant overburden is required to keep the hadronic component of the cosmic rays low.
- Penetrations to the CRV must be considered carefully.

Once design geometry exists:

- Simulations must be run to understand particle fluence at CRV
- Sheilding options can be considered
- CRV technologies can be considered

References

1. AMF Snowmass Contributed Paper (2022): https://arxiv.org/abs/2203.08278
2. Mu2e-II Snowmass Contributed Paper (2022): https://arxiv.org/abs/2203.07569
3. Mu2e-II CRV LOI
4. SINDRUM II: W. Bertl et al., Eur. Phys. J. C 47, 337–346 (2006)
5. Snowmass Summary Report: https://arxiv.org/abs/2301.06581
6. Snowmass Report of the Frontier For Rare Processes and Precision Measurements: https://arxiv.org/abs/2210.04765