Summary of the Extinction Monitor session

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Mu2e-II workshop 2018-08-30

Outline

- Understanding PIP-II intrinsic extinction
- Extinction measurement in Mu2e-II

PIP-II intrinsic extinction

- PIP-II Injector Test (PIP2IT) is a test accelerator at FNAL
- Includes chopper to define PIP-II beam time structure
- 25 MeV H^- beam by 2020
- Measure extinction in PIP2IT to inform Mu2e-II planning
- Approach:
  - Ionize H^- in nominally empty bunches
  - Count produced electrons
    (Swept by B field: $p_{H^-} = 0.2$ GeV$/c$, $p_e = 0.1$ MeV$/c$)

PIP-II measurement R&D

- Laser system synchronized to beam timing for the ionization
- Electron energy is $\mathcal{O}(10\ \text{keV})$, hard to detect
- LDRD preproposal submitted by Myron Campbell and Monica Tecchio (U. Michigan) and Paul Derwent (Fermilab)

Other potential use

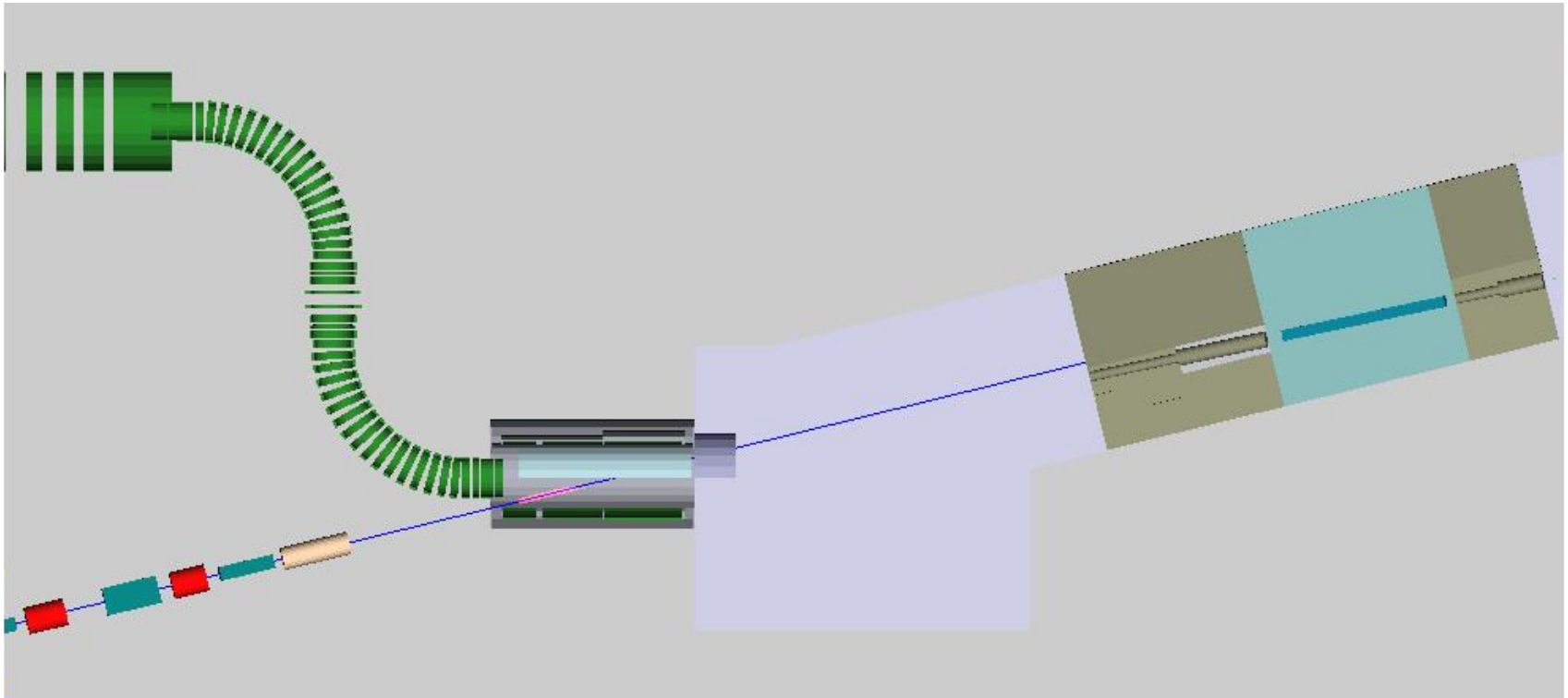
A more powerful laser can help create extinction by cleaning up "empty" H^- bunches

Mu2e-II beam-on-target extinction

Mu2e approach

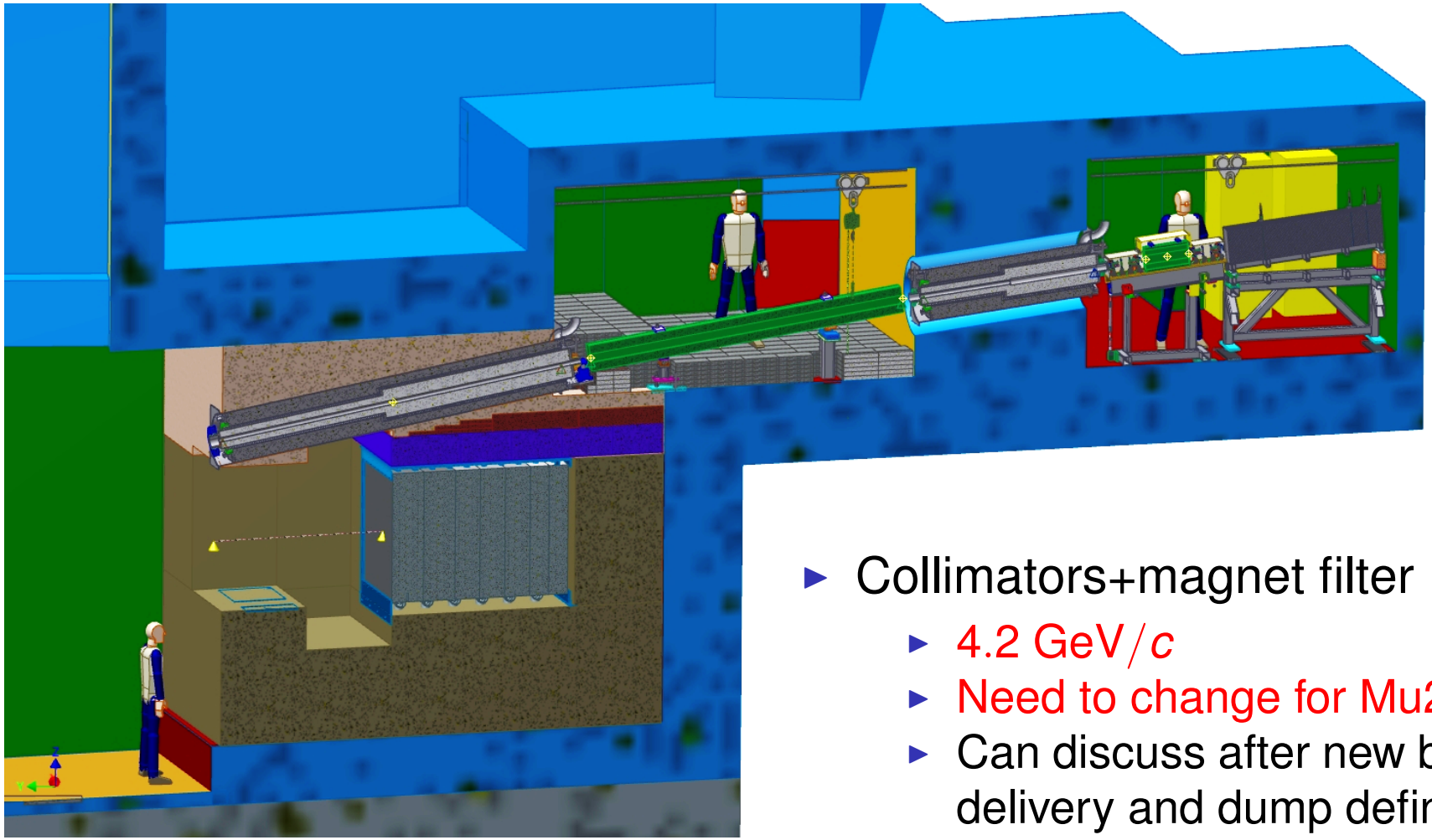
- Monitor extinction for beam on target, not elsewhere
- Shift the 10^{10} dynamic range down
  - Instead of looking at every proton, detect a small fraction of particles scattered from production target (dozens per bunch)
  - Accumulate statistics for $\mathcal{O}(10^9)$ pulses (hours) while maintaining zero background

Mu2e layout



Beam dump design and position likely to change
for 800 MeV 100 kW beam

Mu2e extinction monitor



- Collimators+magnet filter
  - 4.2 GeV/c
  - Need to change for Mu2e-II
  - Can discuss after new beam delivery and dump defined
- Pixel detector. Reuse?

Pixel performance

Backgrounds

Background $< 0.015 \pm 0.004$ (dominated by cosmic) per 1 signal out of time track for $\varepsilon = 10^{-10}$ *Mu2e docdb-2481*

- OK for 10^{-11}! (Can also add timing and momentum cuts.)
- Can handle larger flux to avoid measurement time $\times 10$

Timing

- Is 25 ns clock tick too coarse for 100 ns beam pulse? $\sigma_t = 25/\sqrt{12} = 7$ ns
- Pion transport: ≈ 20 ns smearing
  $\Longrightarrow$ no physics gain in much better timing

If we want a new detector. . .

- Mu3e HV-MAPS pixel R&D looks promising
  (see Dirk Wiedner talk at LPC on 2018-07-17)
- $81 \times 80 \mu\mathrm{m}^2$ pixels:
  about $\times$ 2 granularity
  (current: $50 \times 250 \mu\mathrm{m}^2$)
- 125 MHz sampling
  (current: 40 MHz)
  and $<$ 1 ns charge collection
- Can build larger detector to reduce measurement time