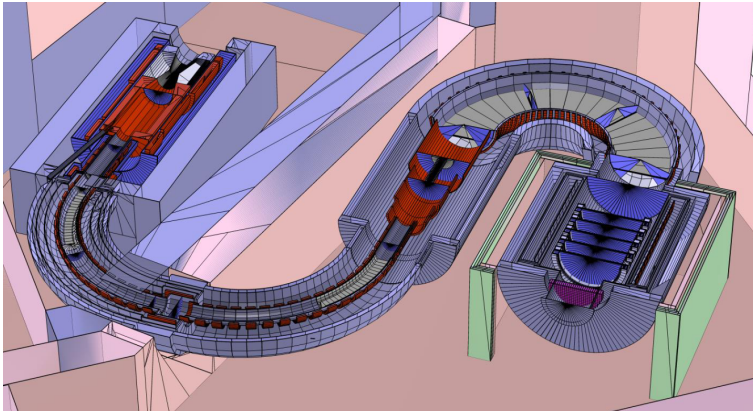
COMET: A Search for $\mu - e$ conversion

David Vico Benet



Layout of the COMET experiment [1]

$\mu - e$ Conversion

- Predictions for $\mu - e$ conversion are $\sim \mathcal{O}(\mathbf{10^{-54}})$ [2, 3]

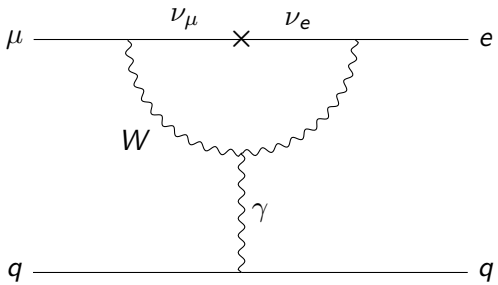


Figure 1: Diagram of $\mu N \to eN$ [4]

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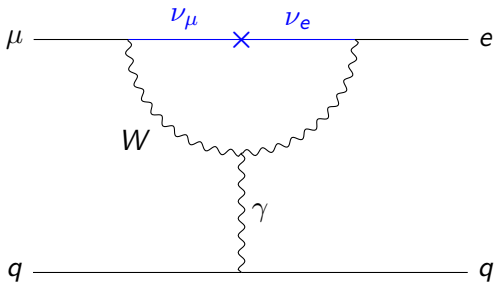

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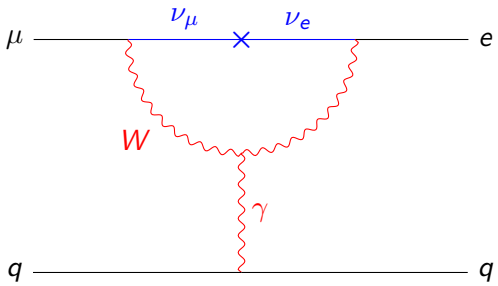

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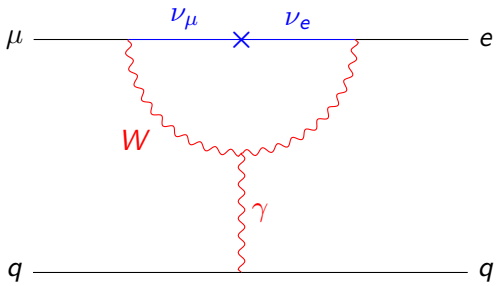
- Any signal constitutes new physics with charged lepton flavour violation (cLFV)!



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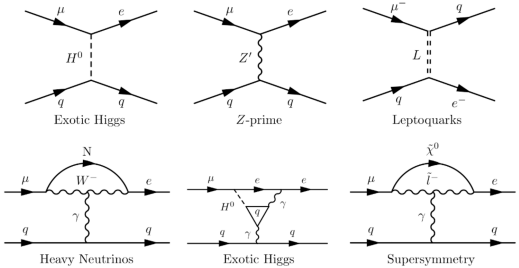

Figure 2: Diagrams of potential New Physics contributions [7]

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- Sensitive to both photonic and non-photonic contributions unlike $\mu \to e\gamma$ [6]
- The ratio $\mathcal{B}(\mu N \to eN)/\mathcal{B}(\mu \to e\gamma)$ powerful in distinguishing NP scenarios

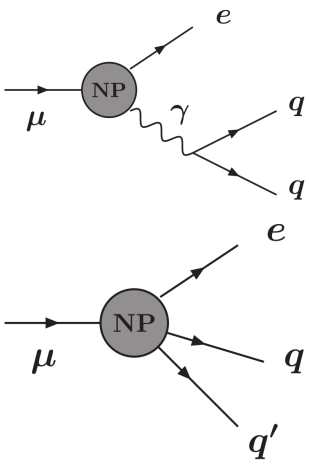

Figure 3: Schematic of potential New Physics contributions [6]

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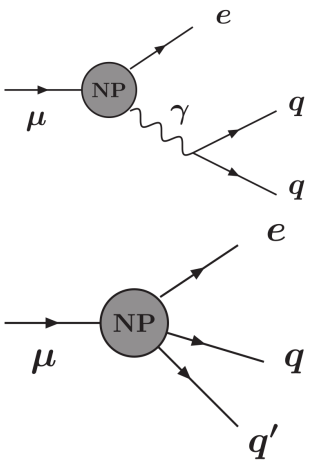
- The ratio $\mathcal{B}(\mu N \to eN)/\mathcal{B}(\mu \to e\gamma)$ powerful in distinguishing NP scenarios
- $\mu \to e\gamma$ limited by photon resolution

$\implies$ $\mu N \to eN$ natural next step for LFV experiments



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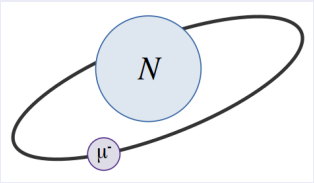

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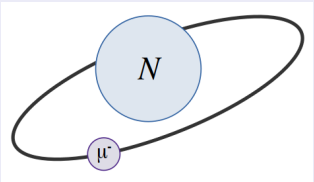

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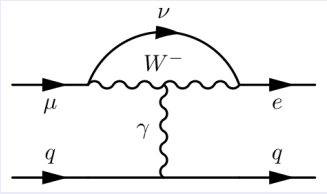

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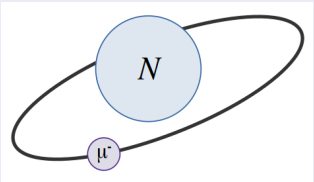

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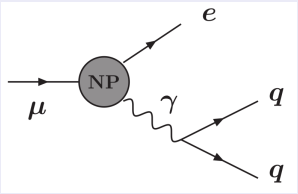

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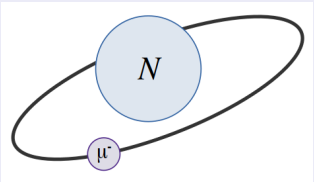

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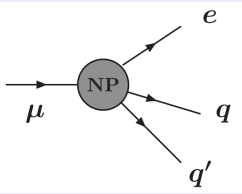

Sensitivity to New Physics

Great probe for [*insert your favourite cLFV BSM theory*]

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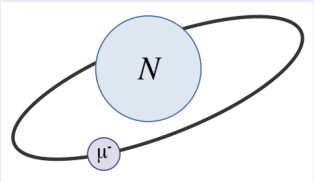

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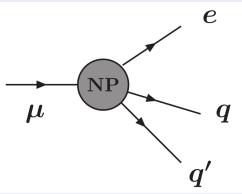

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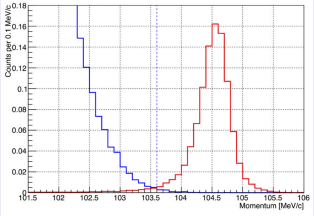
Monoenergetic e^- Signal [4]



- 2-body eN final state

$\Longrightarrow$ Defined e^- energy

COMET Experiment

- Experiment at J-PARC, Japan
- **CO**herent **M**uon to **E**lectron **T**ransition (**COMET**)

Figure 4: COMET - wait no

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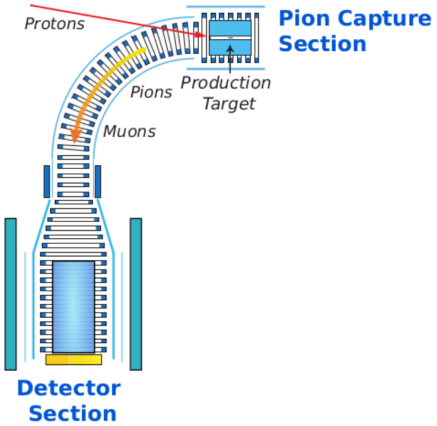

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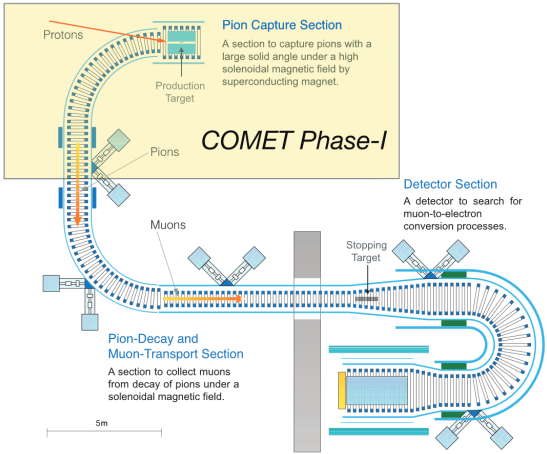

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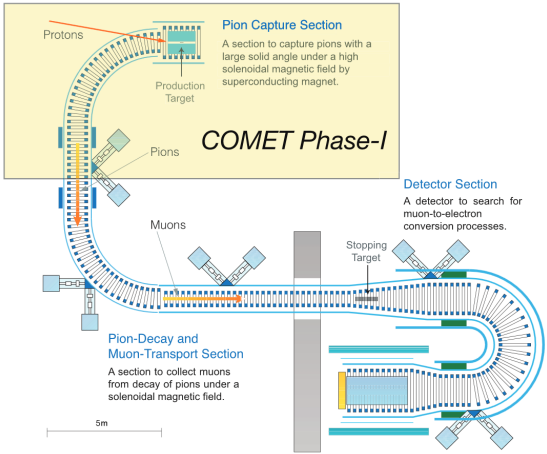
- Competitive with Mu2e - targets similar sensitivity [9]

$\rightarrow$ Greater beam intensity means COMET can reach limit in shorter data-taking period



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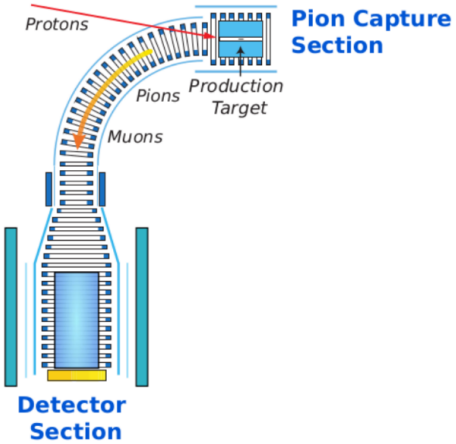

Figure 7: COMET Phase-I Layout [10]

Beam Production [3]

- Proton beam hits target, producing π
- μ beam produced from decay $\pi \rightarrow \mu\nu$

Muon Transport System [3]

- Curved Solenoid selects muons with a momentum of 40 MeV/c

Muon Stopper & Detector [6]

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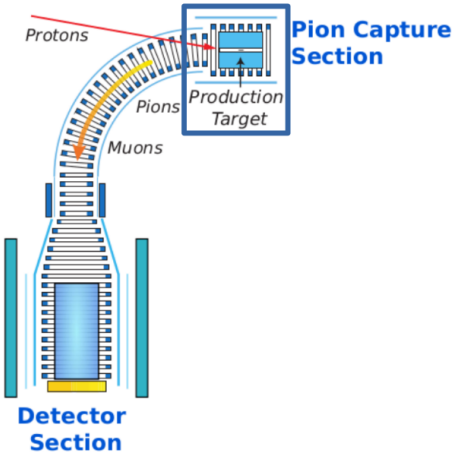

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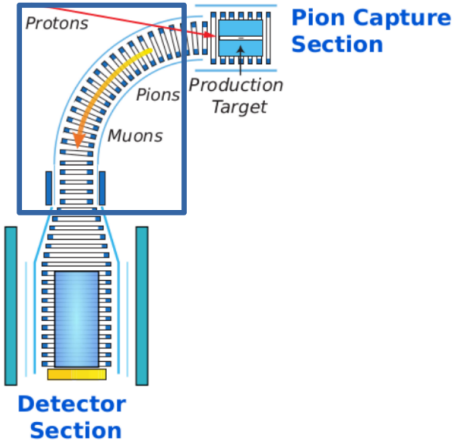

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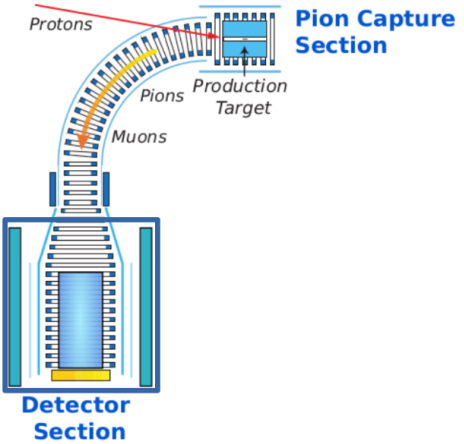

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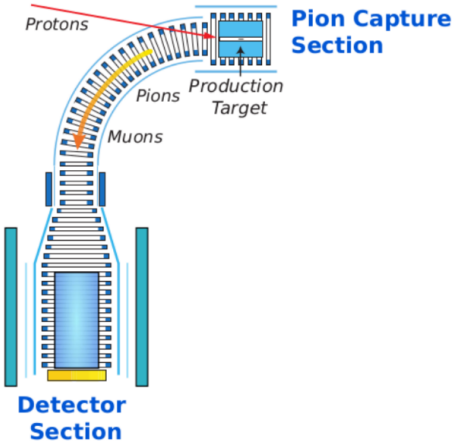

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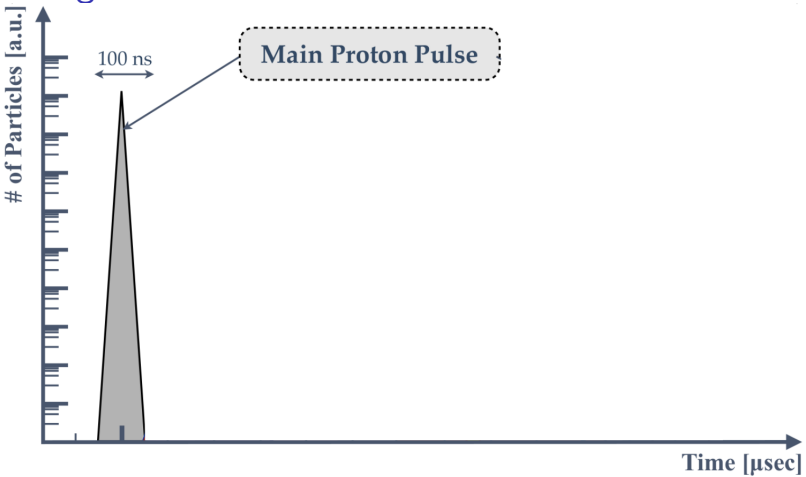

Figure 8: Time relation of the proton beam pulses, prompt background, stopped muon decay, and a signal event in the data-taking window [6, 9]

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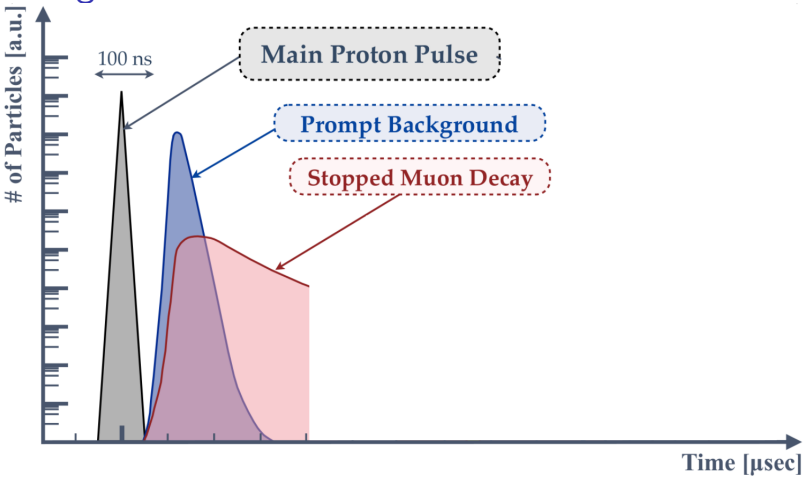

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- Particles orginating from beam dump

Stopped Muon Decays

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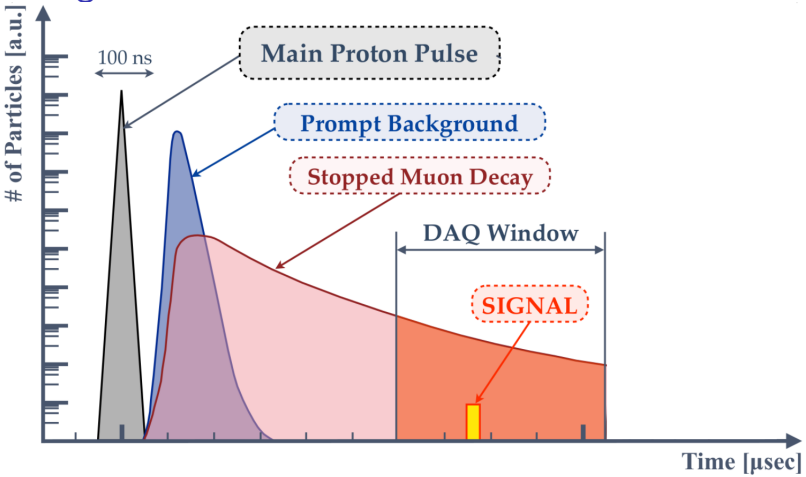

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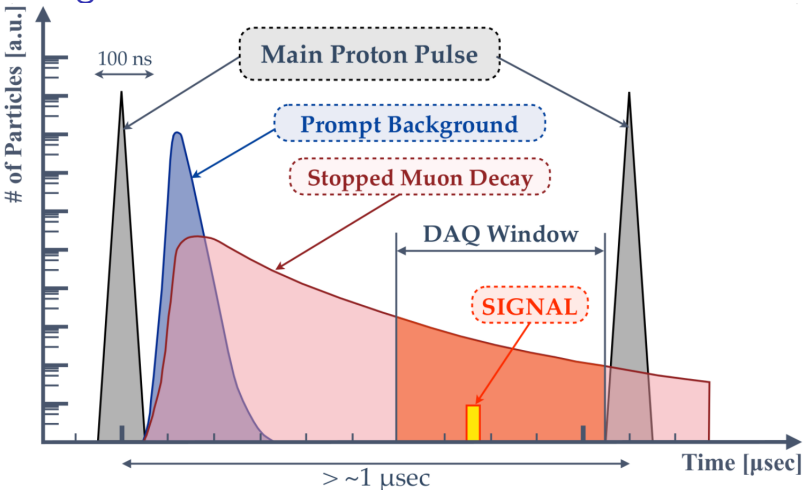

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Decays in Orbit (DIO)

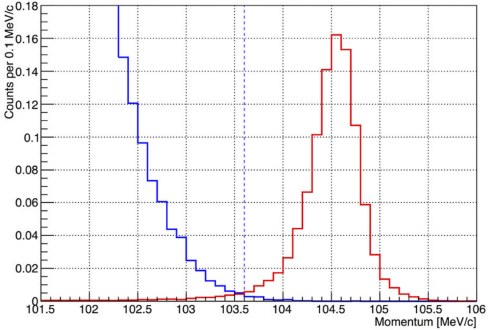

Figure 9: Signal and DIO distributions in e^- energy, for a simulated 10^{-15} $\mu - e$ signal [4]

- The captured μ can decay in orbit $\mu^- \rightarrow e^- \overline{\nu}_e \nu_\mu$
- Tail of the e^- energy distribution contaminates signal region [4]

$\rightarrow$ For $\mu - e$ below 10^{-17} this would completely hide the signal

- Conduct precise measurement of DIO energy distribution in Phase-I [6]

COMET Phase II

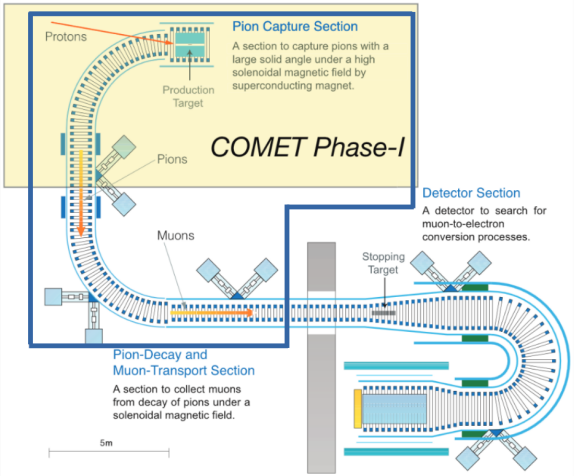

Figure 10: COMET Phase-II Layout [8]

Muon Beam [3]

- μ beam using Phase-I curved solenoid

Muon Stopper [3]

- Aluminium target outside detector

Curved Solenoid [3]

- Serves as electron spectrometer
- Select monoenergetic signal and supress DIO background

Detector [3]

- Detector outside beam line of sight

$\rightarrow$ Reduced background $\implies \mathcal{O}(10^{-17})$ sensitivity

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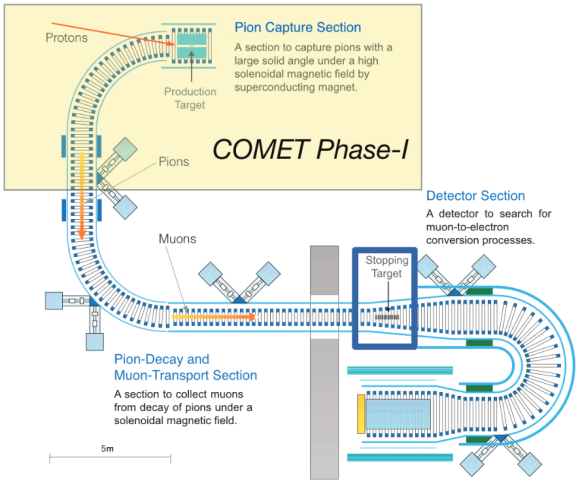

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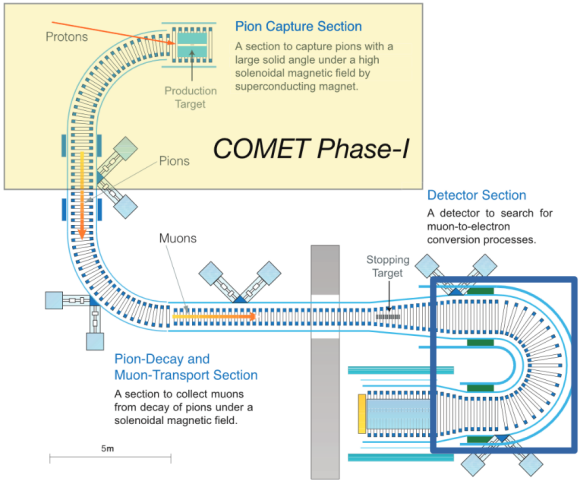

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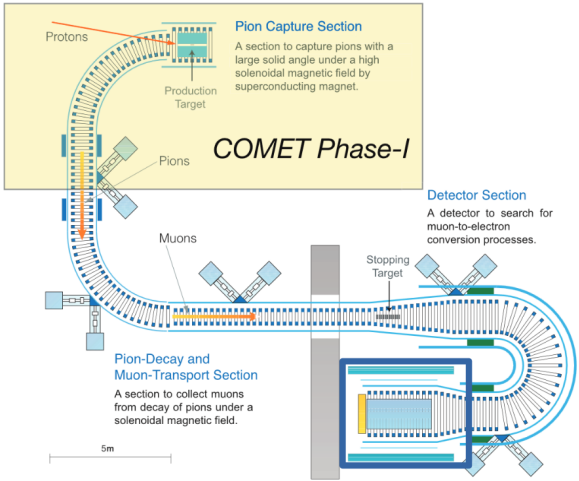

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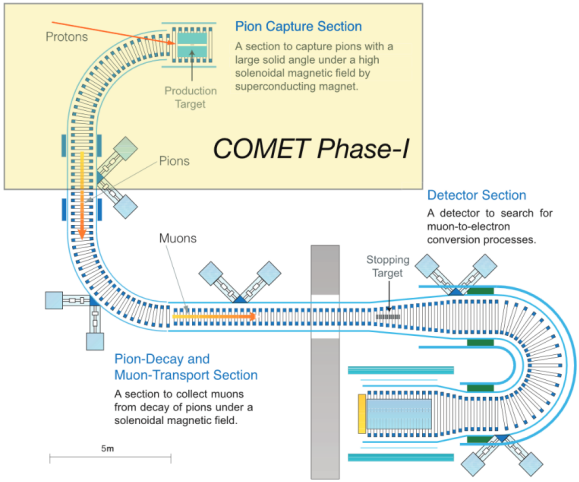

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Current Status

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  - Curved solenoid and proton beamline constructed [8, 11]

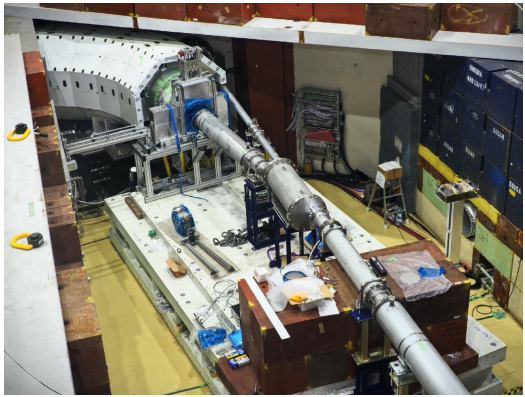

Figure 11: COMET Muon solenoid and beamline [12]

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  - Curved solenoid and proton beamline constructed [8, 11]
  - Tests of muon transport and beam profile have been performed

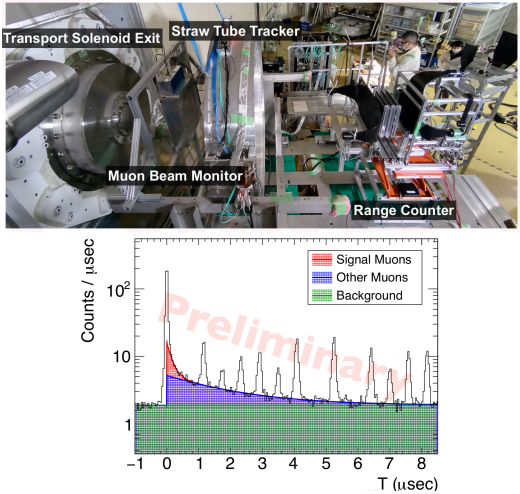

Figure 12: Detector set-up and preliminary results for beam profile tests [12]

Current Status

- Phase-I currently under construction
  - Curved solenoid and proton beamline constructed [8, 11]
  - Tests of muon transport and beam profile have been performed
  - Cylindrical tracker has been constructed and tested [11]

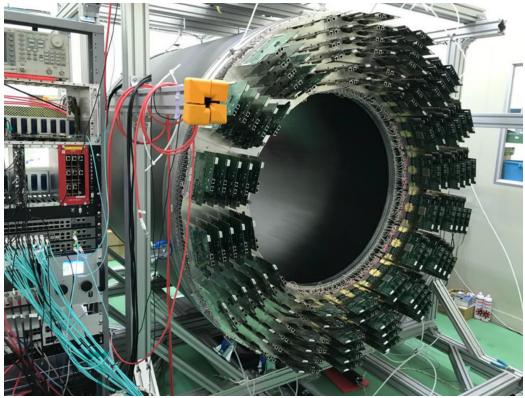

Figure 13: Phase-I cylindrical tracker [11]

Conclusions

- COMET - $\mu - e$ experiment, increasing sensitivity by 10^4
- Phase-I construction is being finalised
- Data taking is scheduled to begin within the next year! [11]
- Natural upgrade path in form of PRISM [6]
  - Use of new accelerator technology for intense muon beams
  - Further improvement by factor ~ 100

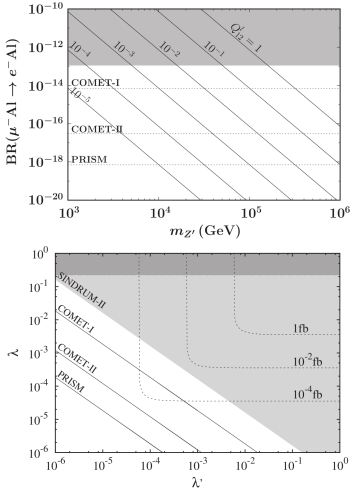

Figure 14: Bounds on BSM models with massive neutral vector bosons (top), and SUSY couplings λ, λ' (bottom) [6]

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