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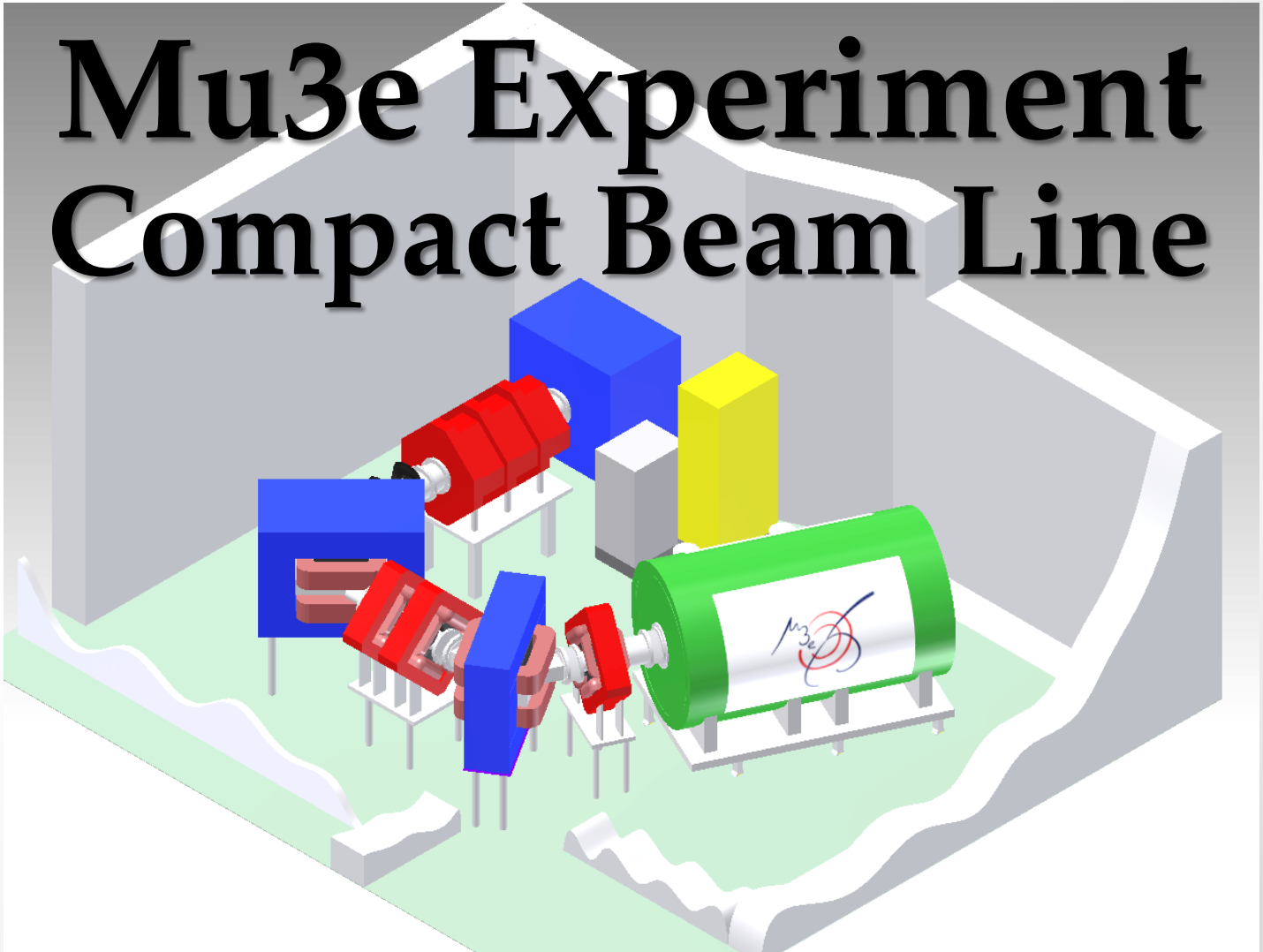
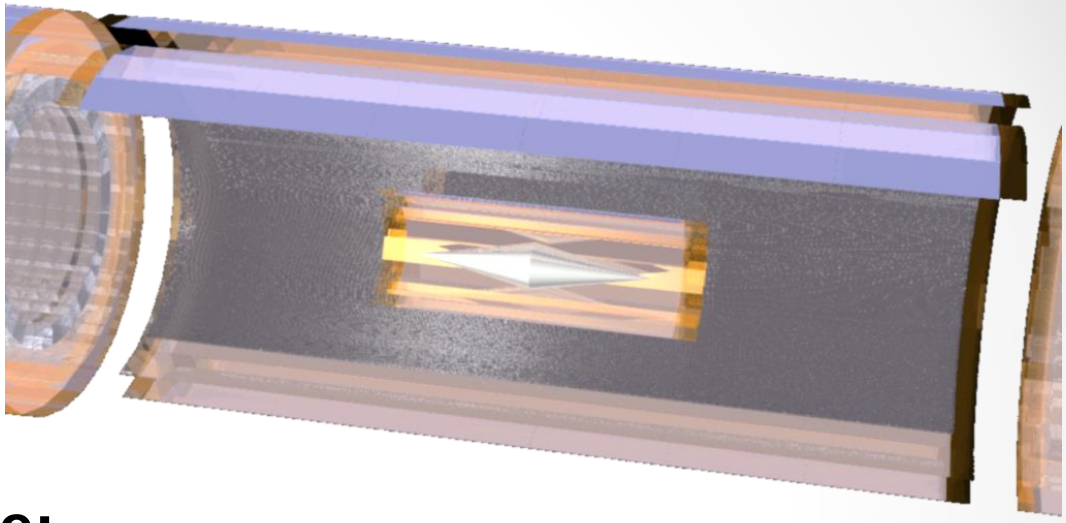
Mu3e Experiment
Compact Beam Line

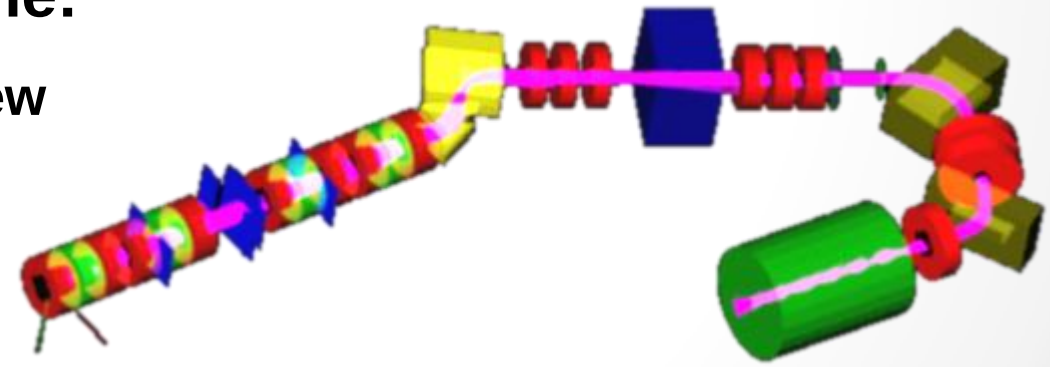


Outline

- **Mu3e:**
  - **CLFV**
  - **Signal**
  - **The detector**



- **Compact Beam Line:**
  - **Beam Line Overview**
  - **Full Beamline**
  - **Short Version**

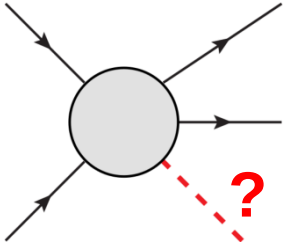


- **Conclusions**

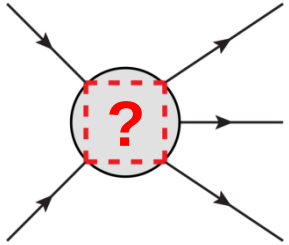
CLFV decay $\mu^+ \rightarrow e^+ e^- e^+$

- **Search for BSM physics**

High energy frontier

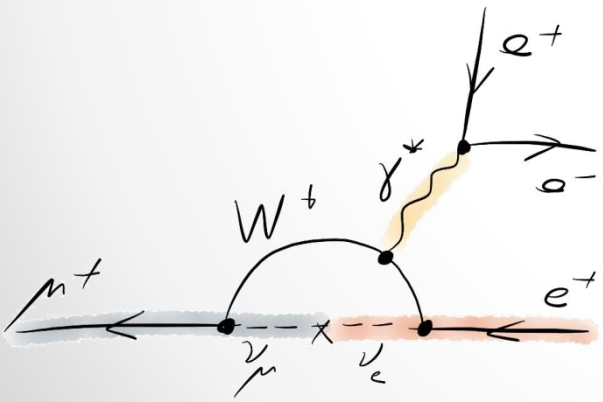


High intensity frontier

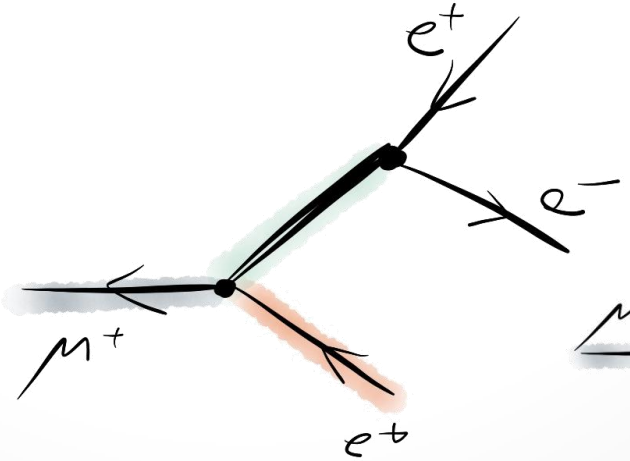


- $\mu^+ \rightarrow e^+ e^- e^+$

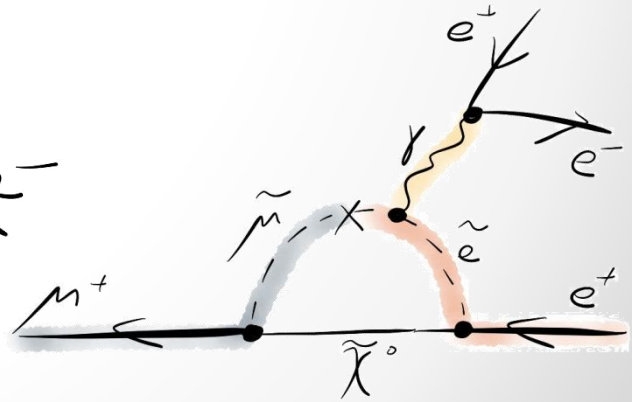
Neutrino mixing (SM)



Tree Level



SUSY



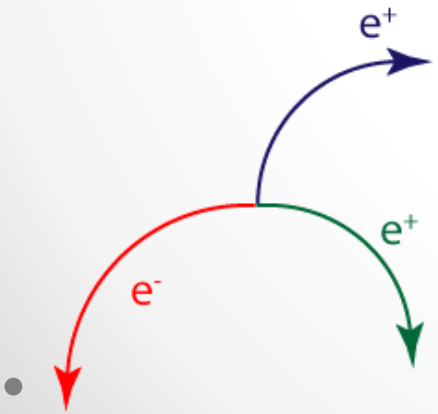
Experimental signature of $\mu^+ \rightarrow e^+ e^- e^+$

- Same Vertex
- Coincidence
- Stopped muon decays

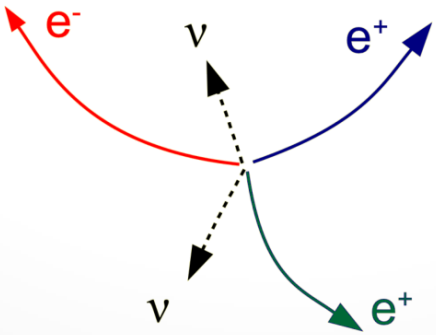
$$\sum_i \vec{p_i} = 0 \qquad \sum_i E_i = m_\mu c^2$$

- Momentum calculated from track bending radius in B-Field

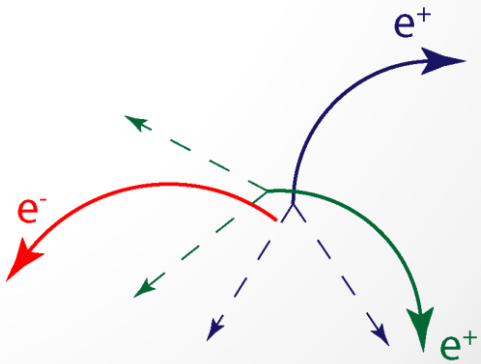
Possible signal:



Radiative decay (int. conversion):



Combinatorial background:

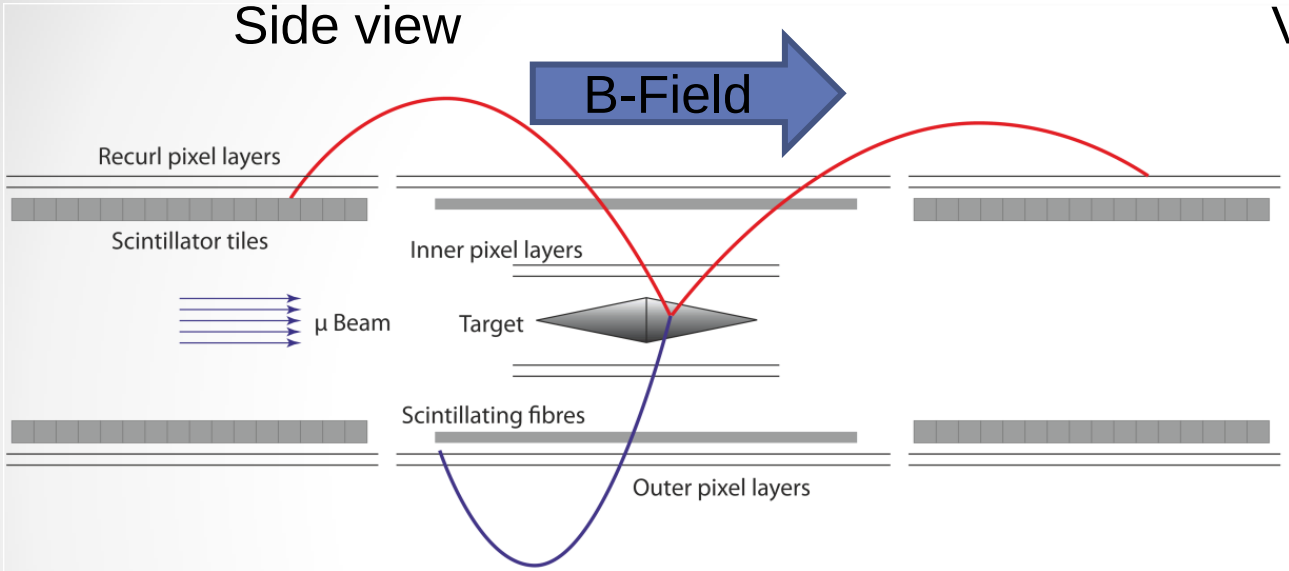


The Mu3e Experiment

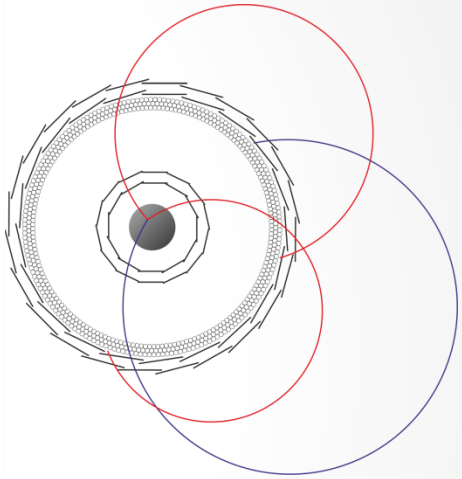
Phase I

Sensitivity of B($\mu^+ \rightarrow e^+ e^- e^+$) ~ 10^{-16}

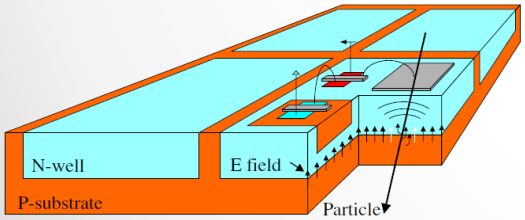
Side view



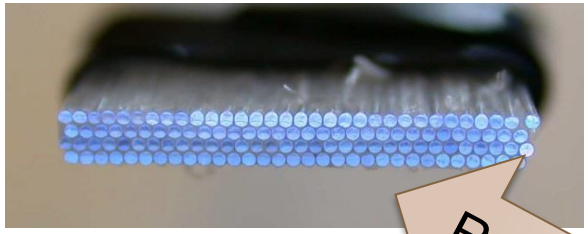
View in beam direction



Silicon pixel (HV-MAPS)

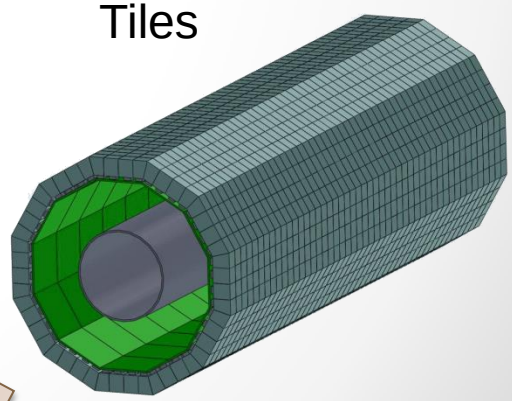


Fibres



R. Gredig

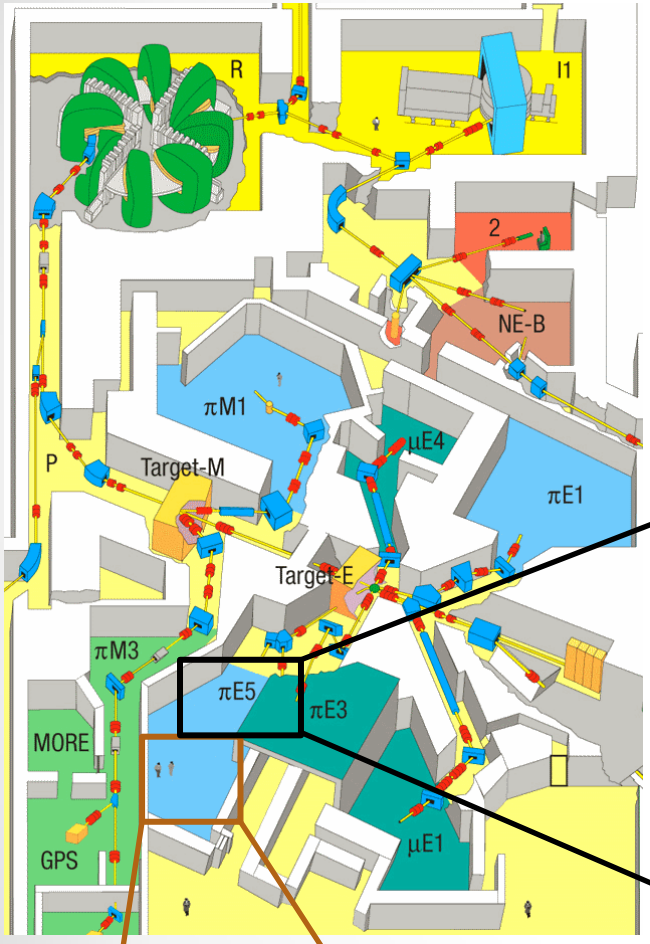
Tiles



Readout S. Corrodi

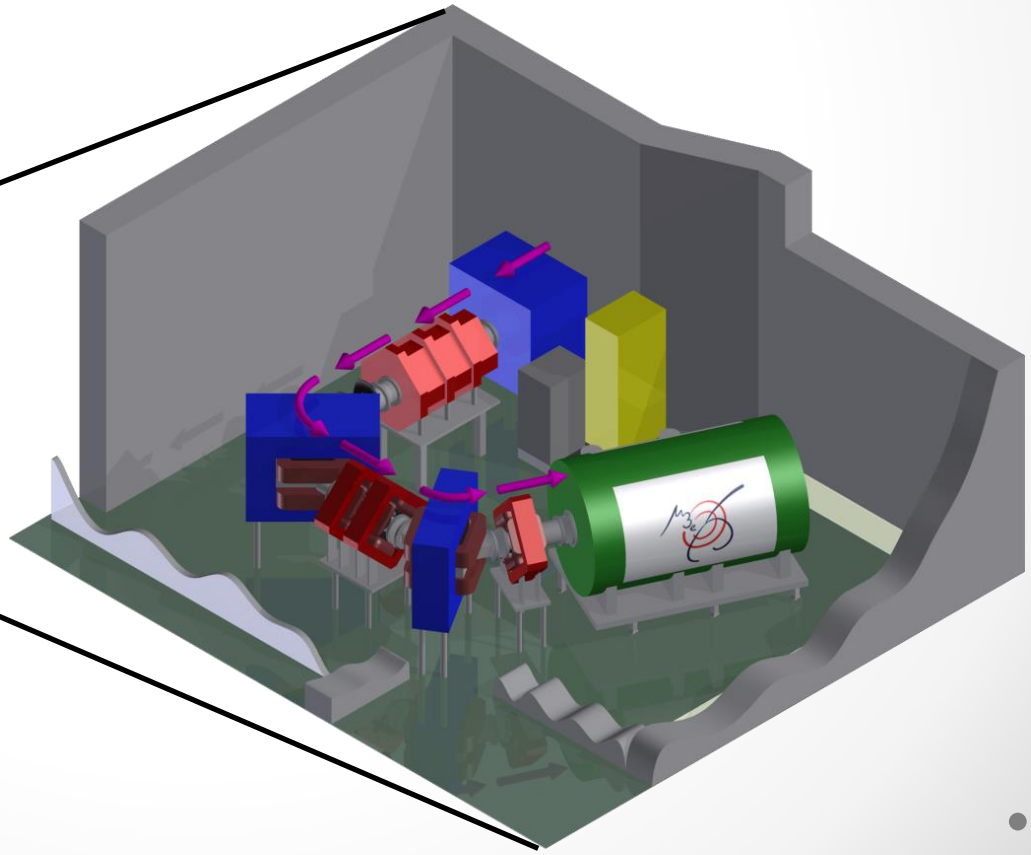
PSI - PiE5 area

Mu3e phase I



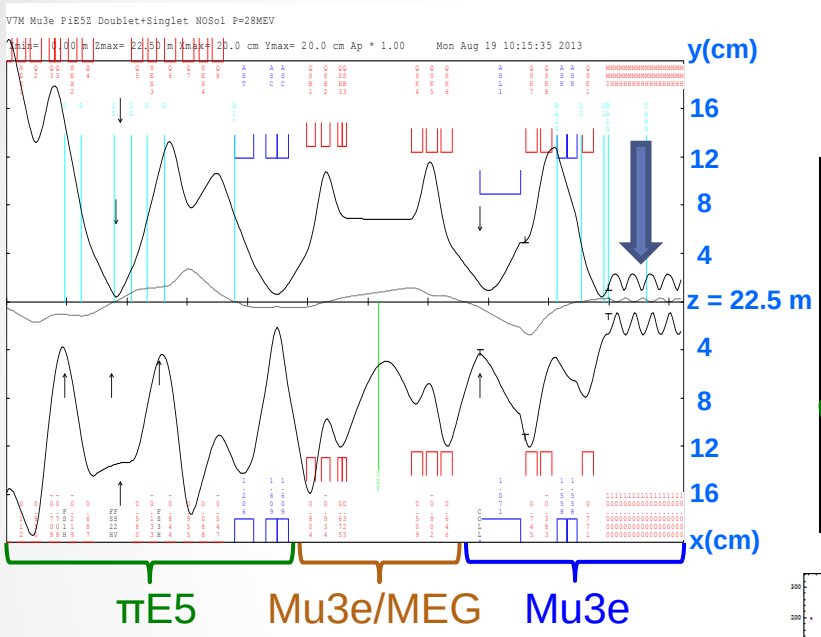
- Graphite Production Target
- Surface muons 28 MeV/c
- Flux at PiE5 ~ 10^8 μ^+/s
- Limited Space / MEG → Compact solution

Z. Hodge



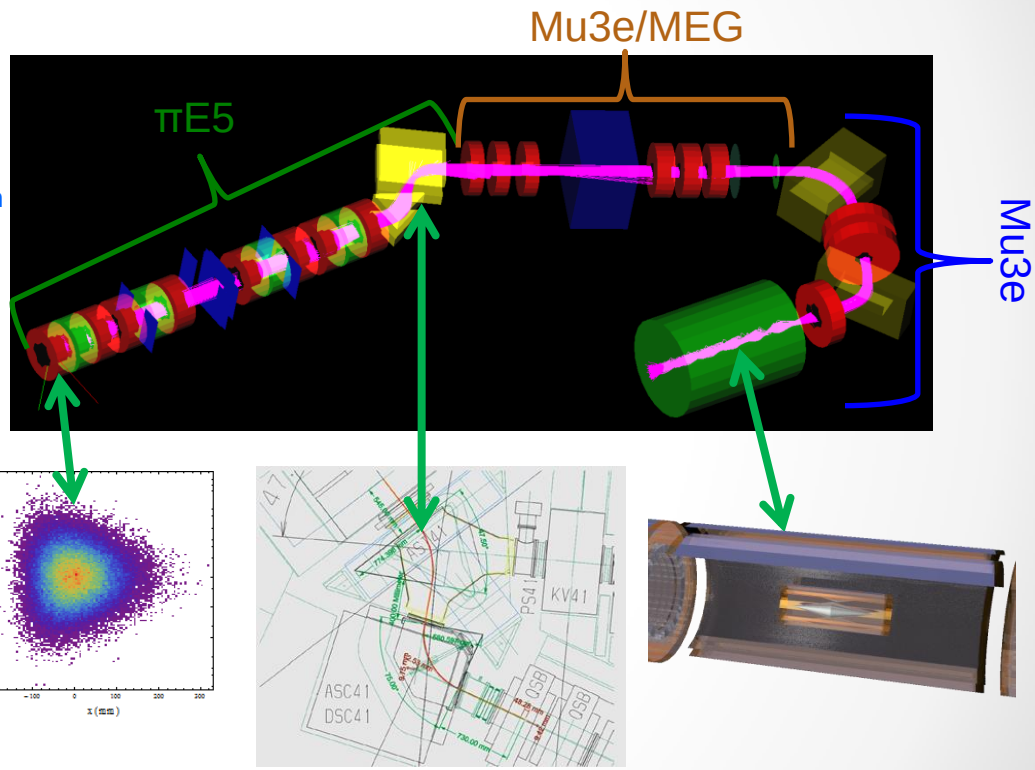
Compact Beam Line

TRANSPORT

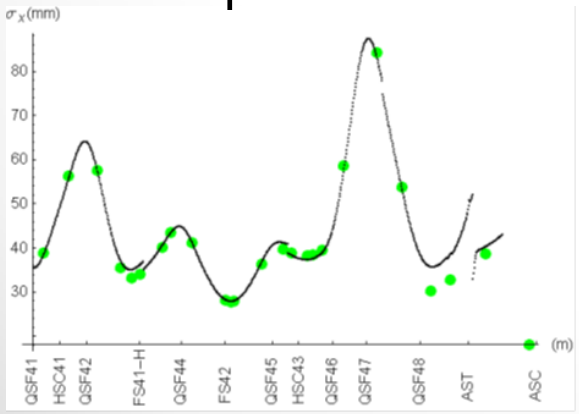


G4Beamline

Transmission to solenoid: > 70%

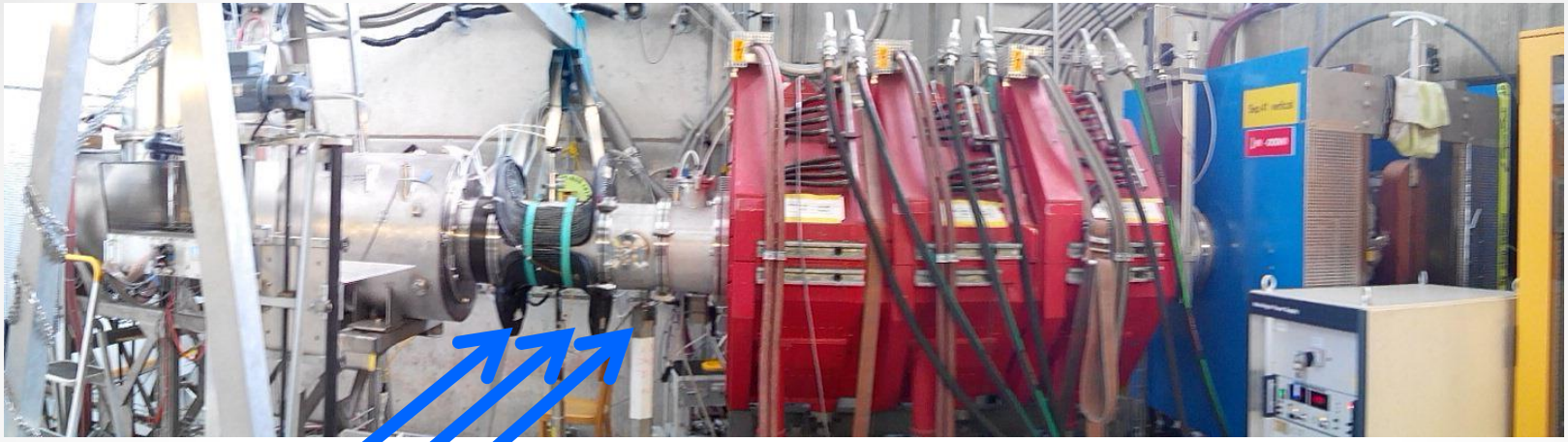


Comparison



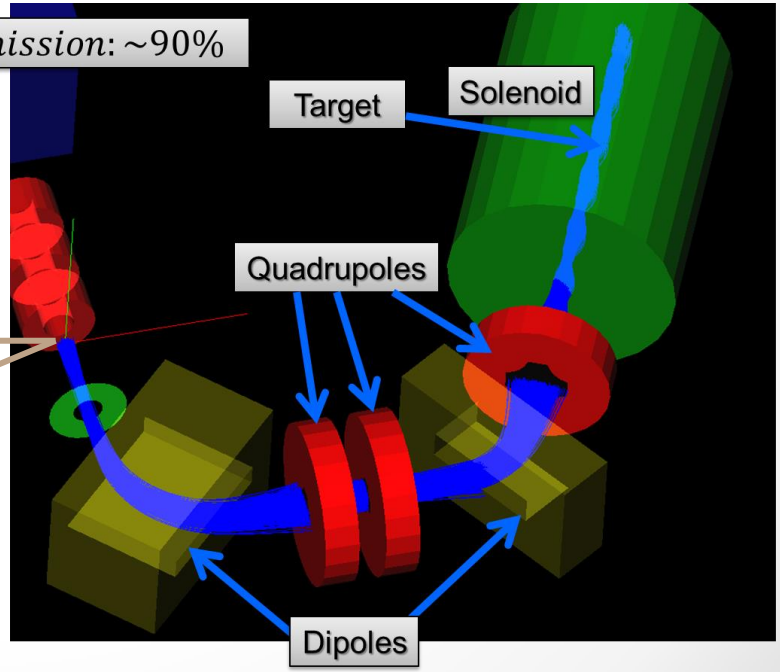
- Beam from 1st QP in PiE5 (matrix code)
- Limited space for optical elements
- Double bending required
- Fringe field overlap

Compact Beam Line – Short Version



Profile measurements
→ phase space
→ Generate new beam

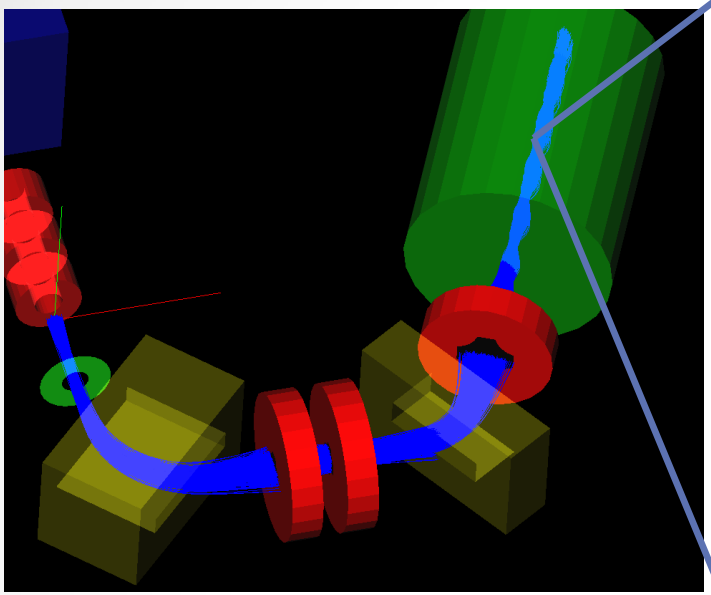
$\gtrsim 10^8 \mu^+/s$

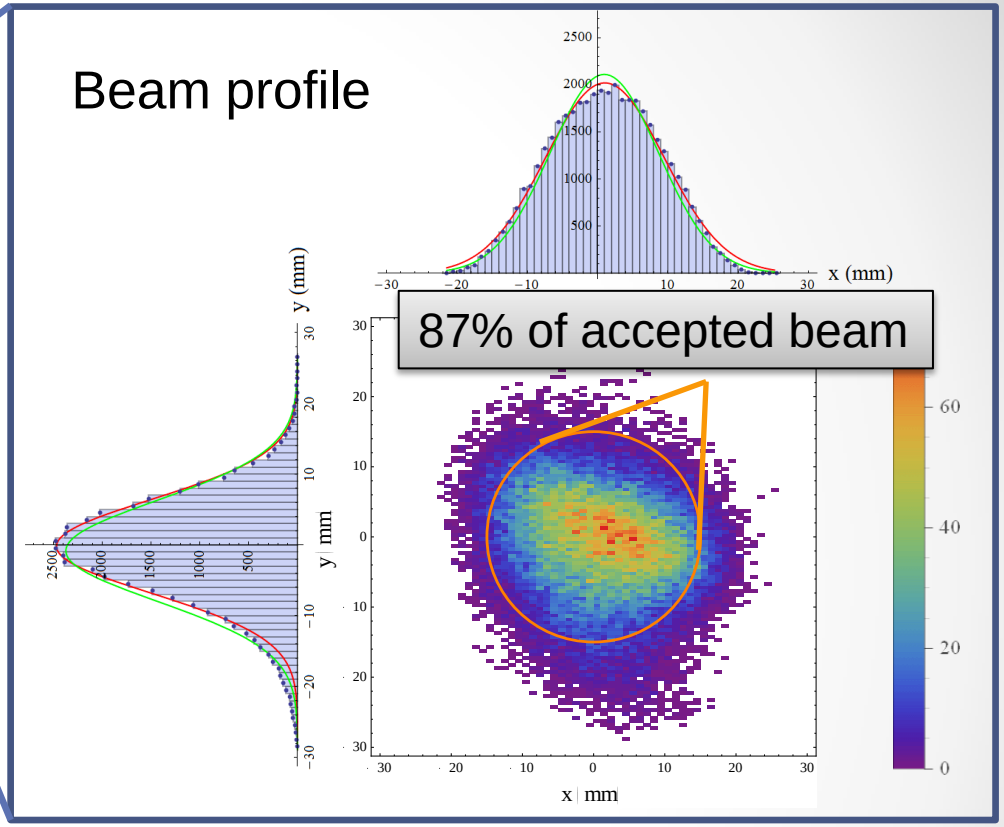


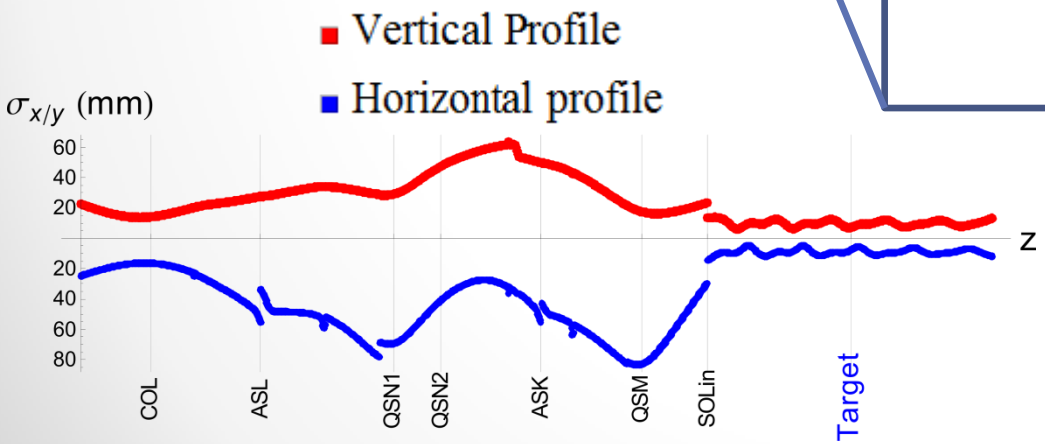
Simulation based on measurements
@ intermediate focus

[G4Beamline T. Roberts]

Compact Beam Line – Short Version





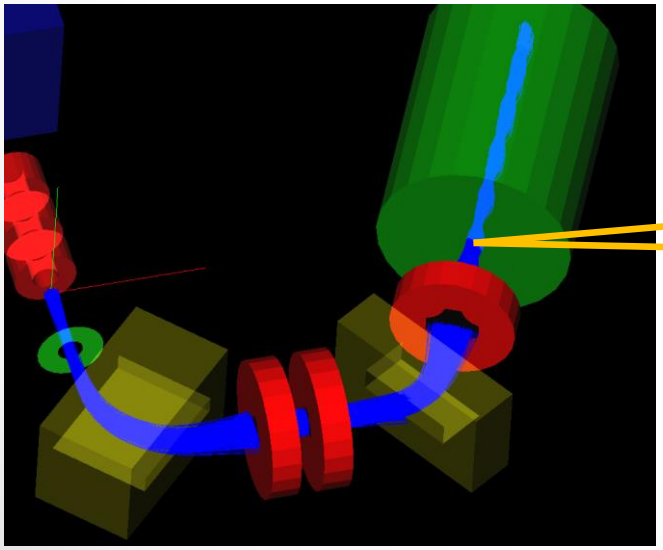


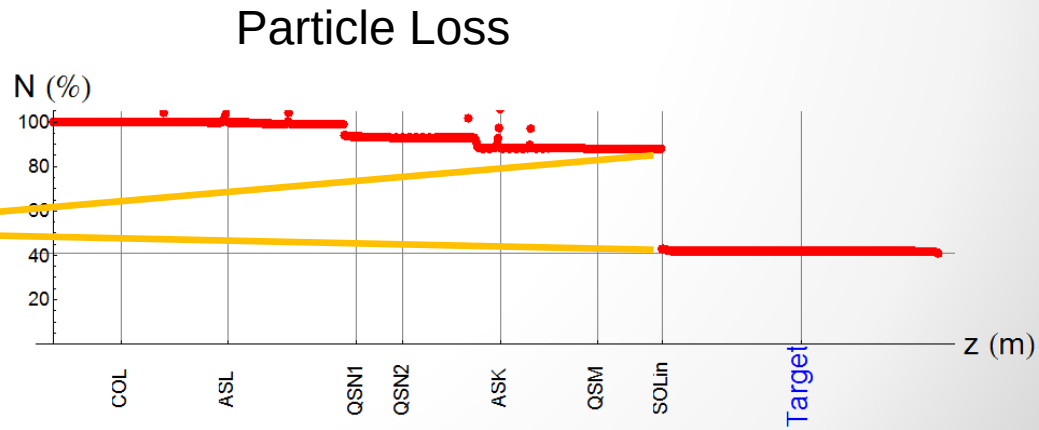
- ~90% transmission to solenoid
- Main losses governed by beam pipe & target size
  → see next slide

Compact Beam Line – Short Version

	Transmission (solenoid entrance)	On target r = 15 (beam pipe Ø=60)	On target r = 15 / 10 (without beam pipe)
Full version	70 % (1st QP PiE5)	-	-
Short version	88 % (intermediate focus)	37 %	52 %

- Can achieve ~ 90 % transmission (O $10^8 \mu^+/s$) to solenoid
- Initial experimental phase requires compact inner Si detectors
  → means target Ø ≲ 30 mm & small diameter beam tube
- Allows max. target acceptance of ~ 37 %





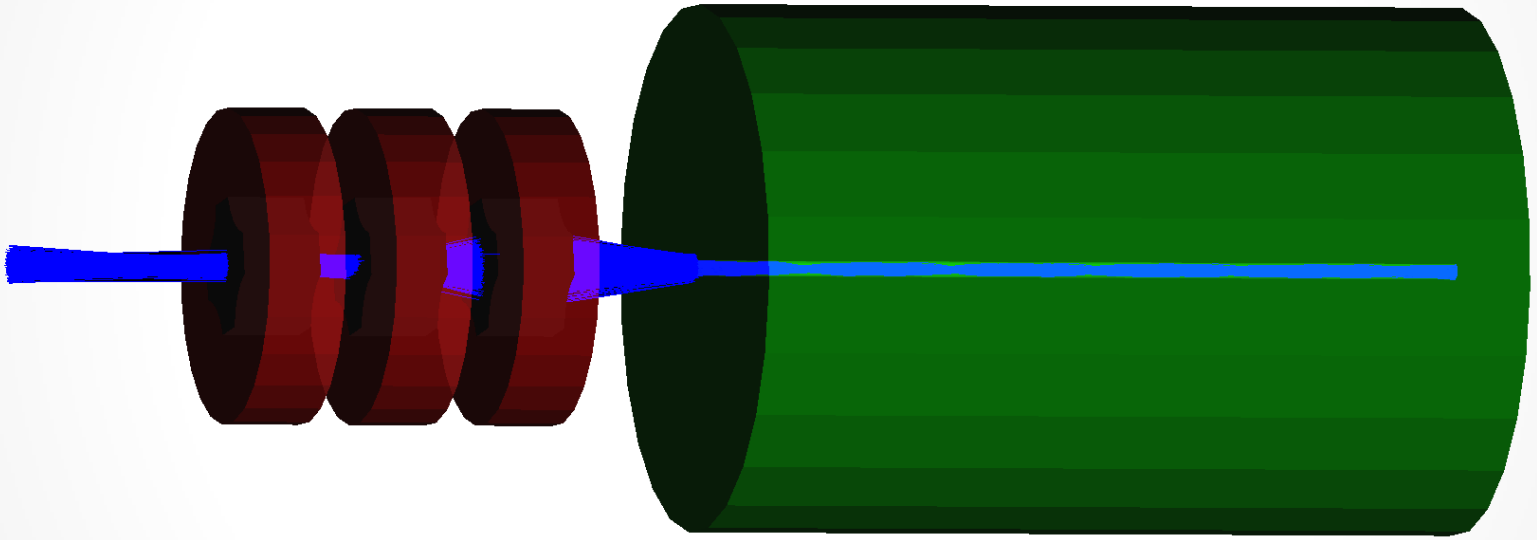
Conclusion

- **Mu3e experiment will push forward search for physics BSM with an aimed sensitivity reach of $\mathcal{O}(10^{-16})$**
- **Staged approach to experiment:**
  - **phase I → Compact Beamline**
  - **phase II → High Intensity Muon Beamline**
- **Simulation Tools TRANSPORT, TURTLE, G4BL validated**
- **Baseline solution for Beamline layout matching spatial constraints achieved**
- **Order 10^8 μ^+/s transmission to solenoid**
- **Current experimental setup → 37 % target acceptance @ 100 % stopping efficiency**
- **Beamline test setup without solenoid end 2014**

Additional Slides – max. Acceptance

Simple straight beamline allows to estimate max target acceptance

Optimize on target



→ 57 % on target @ 68 % acceptance is the optimum

Additional Slides - Optimization