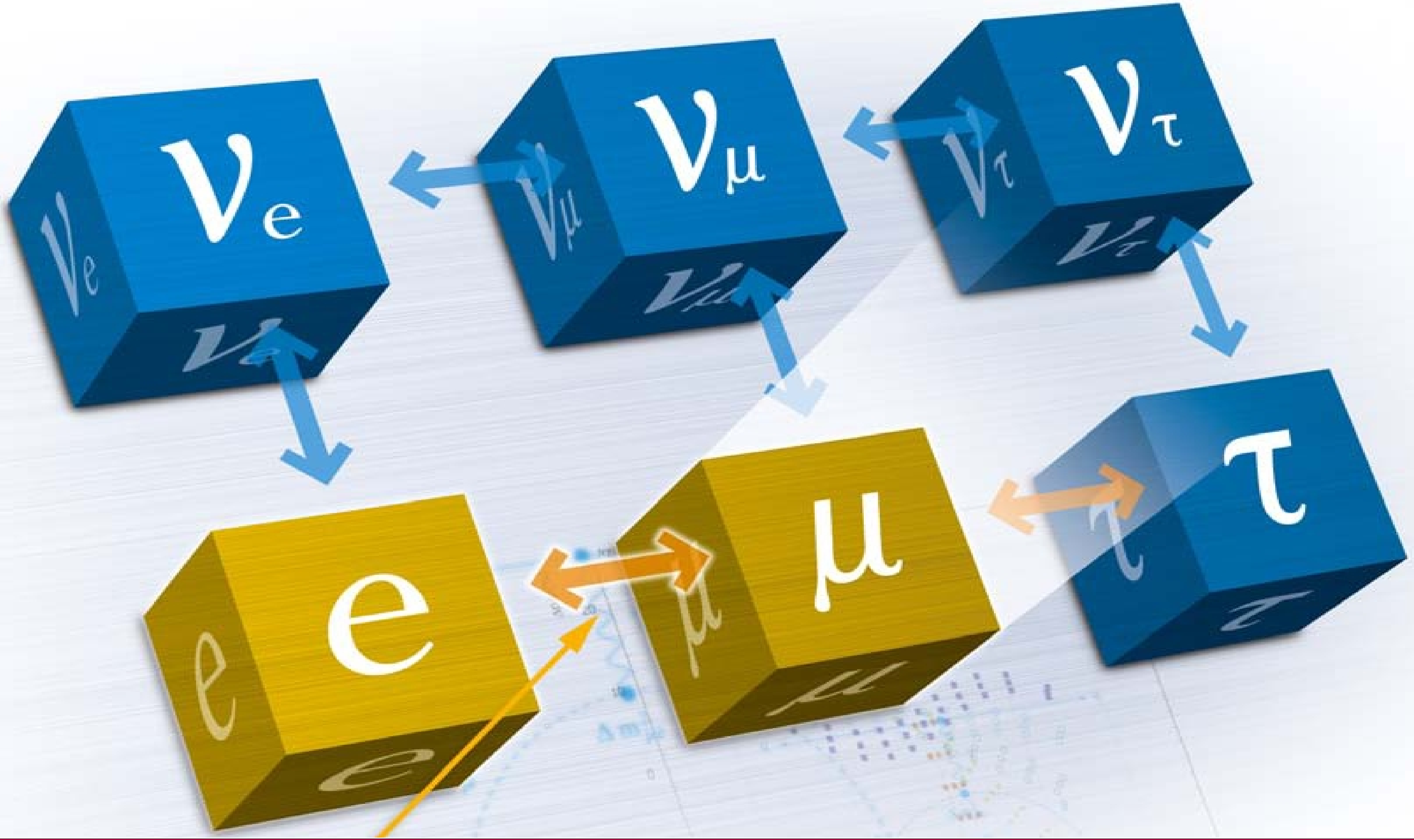
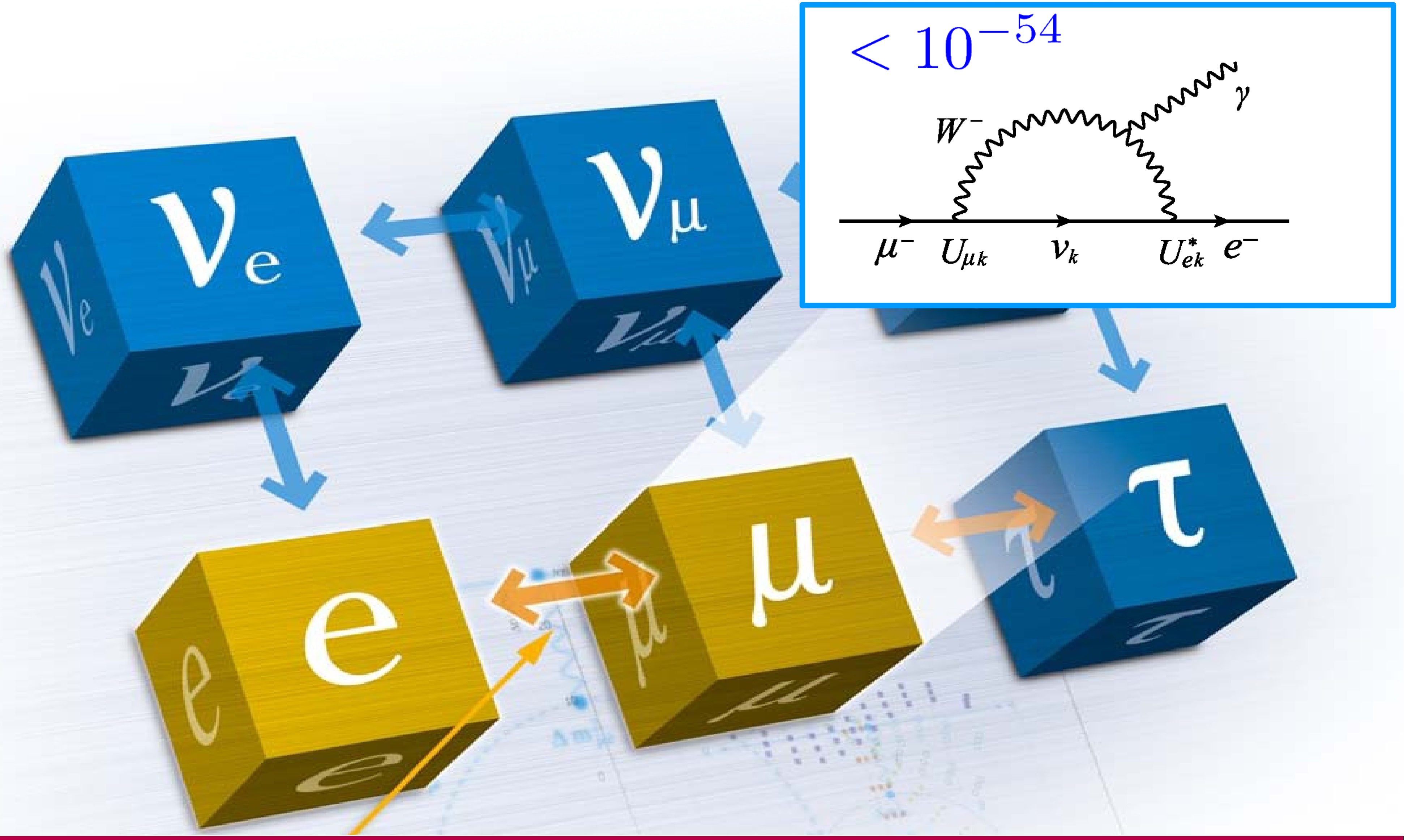
COherent Muon to Electron Transition



COMET?

Ben Krikler

COherent Muon to Electron Transition



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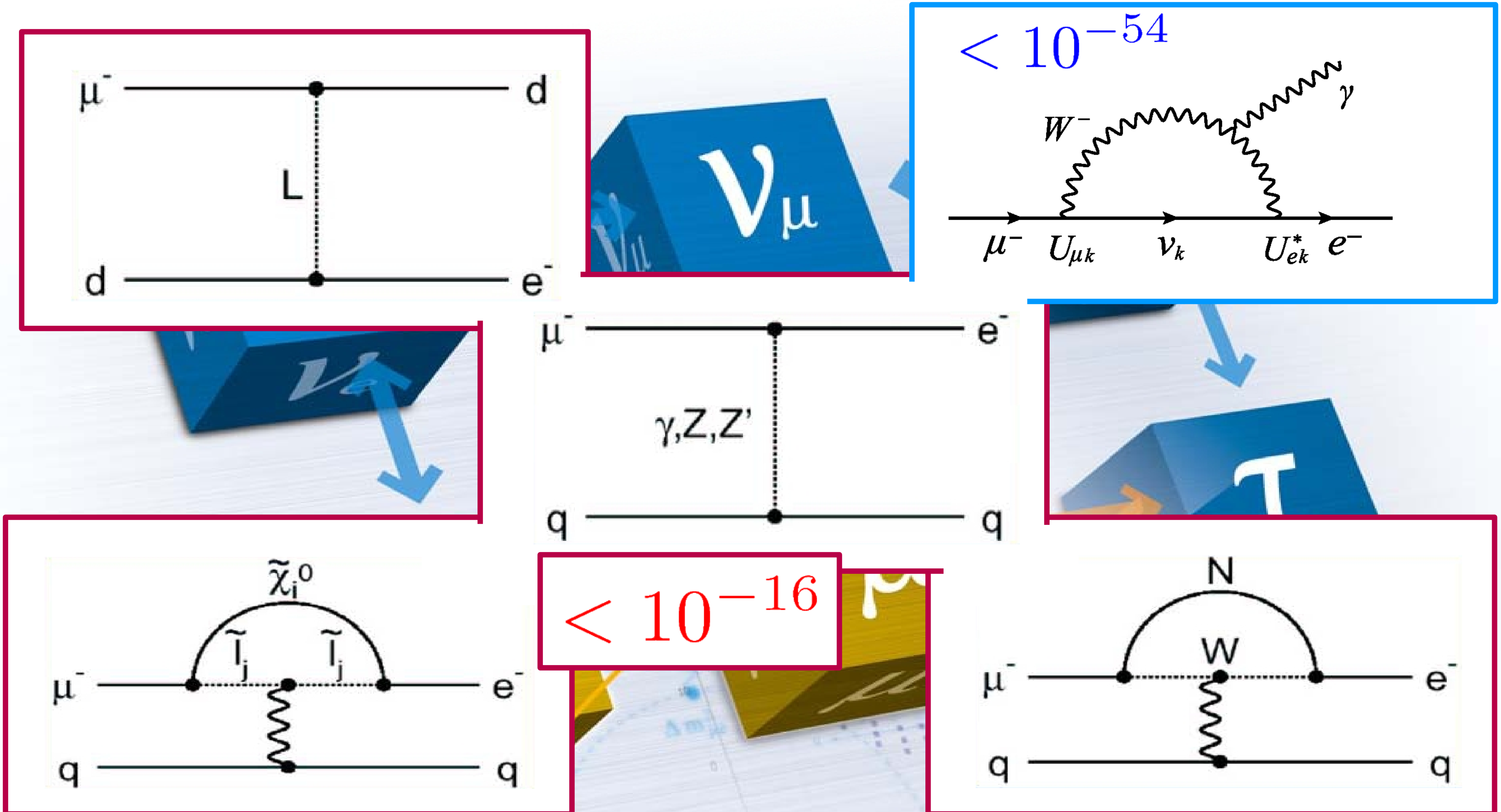
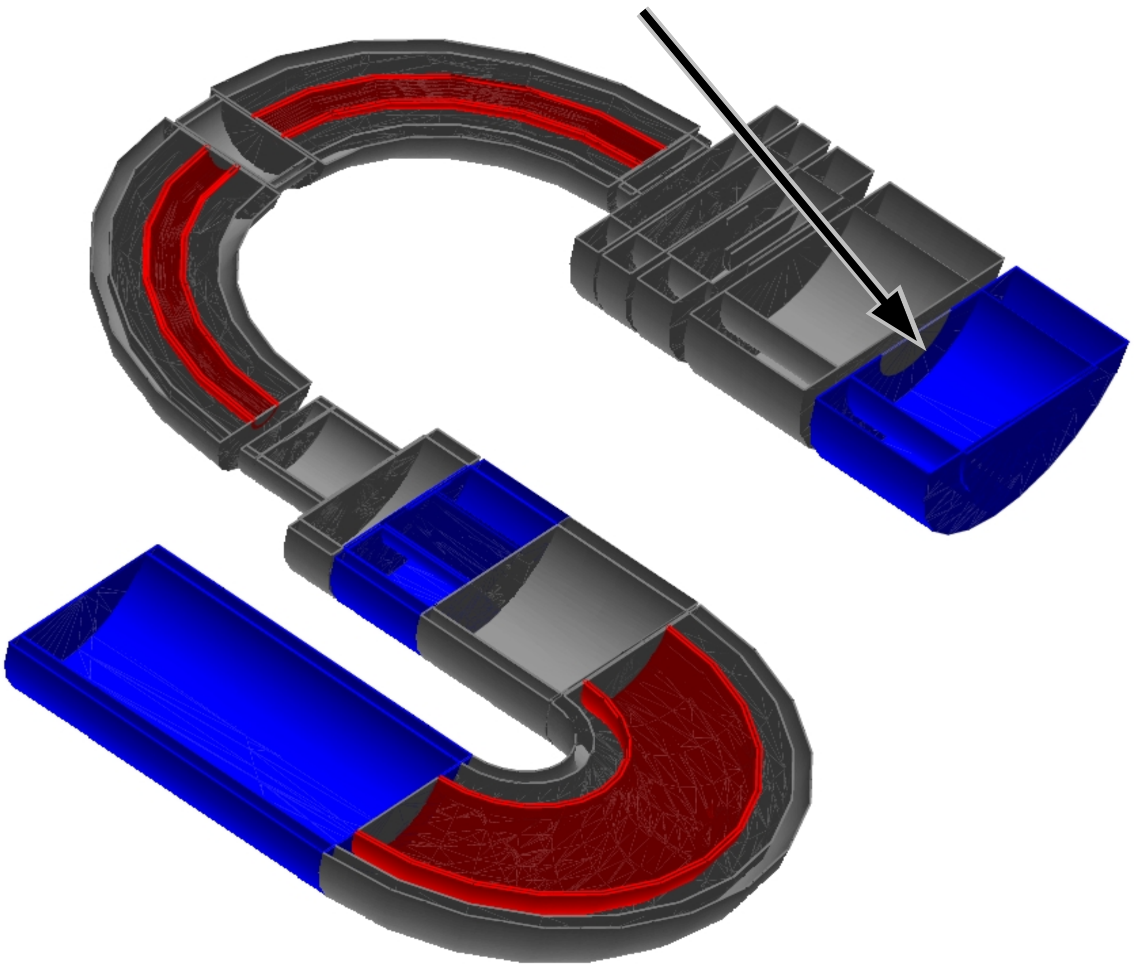
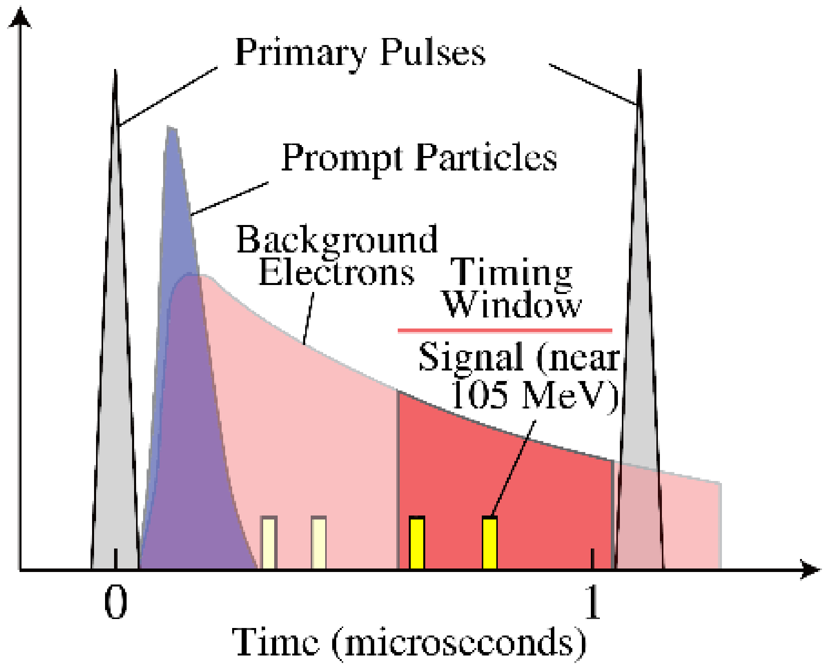


What does COMET do?

What does COMET do?

What is COMET?



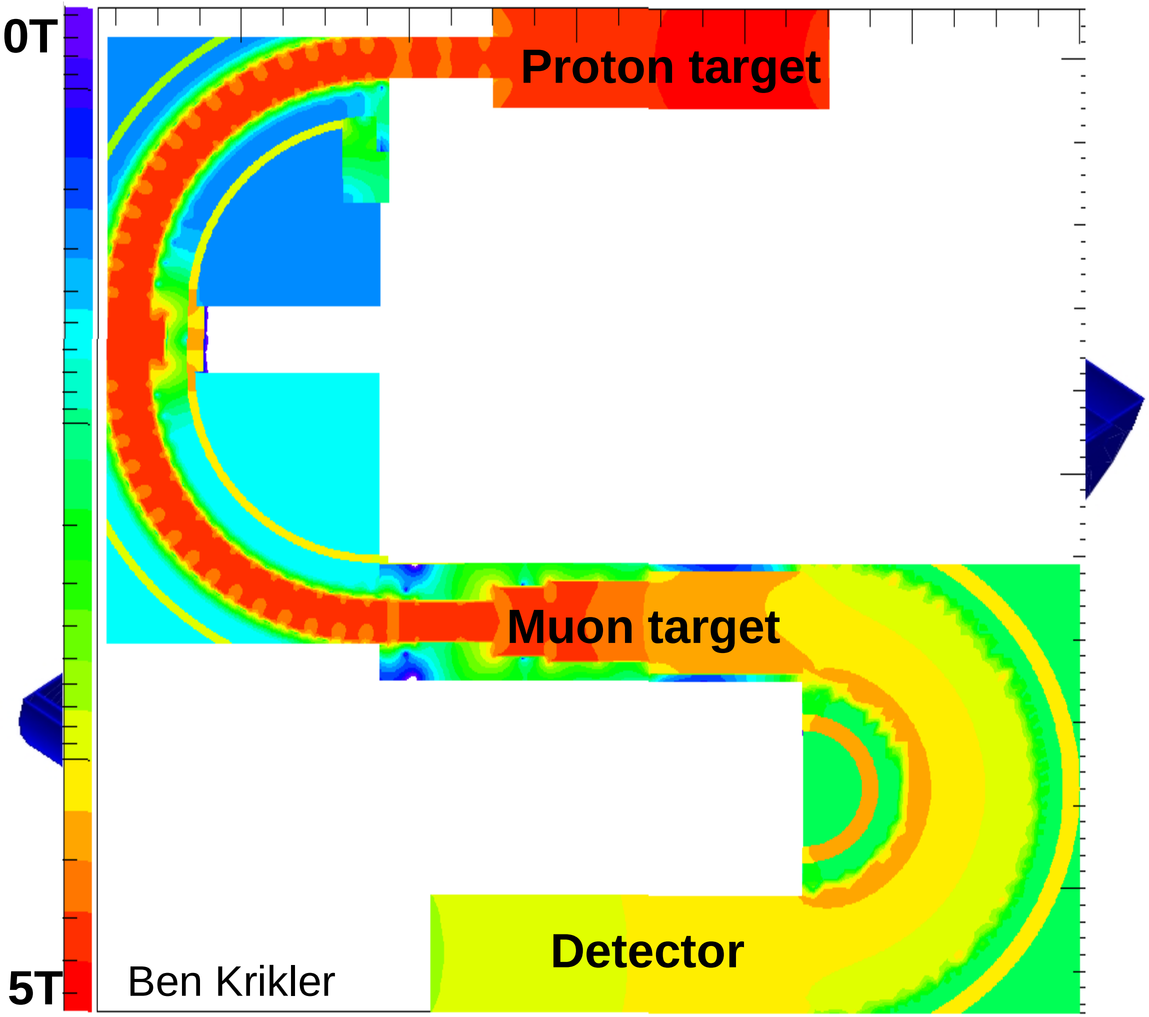


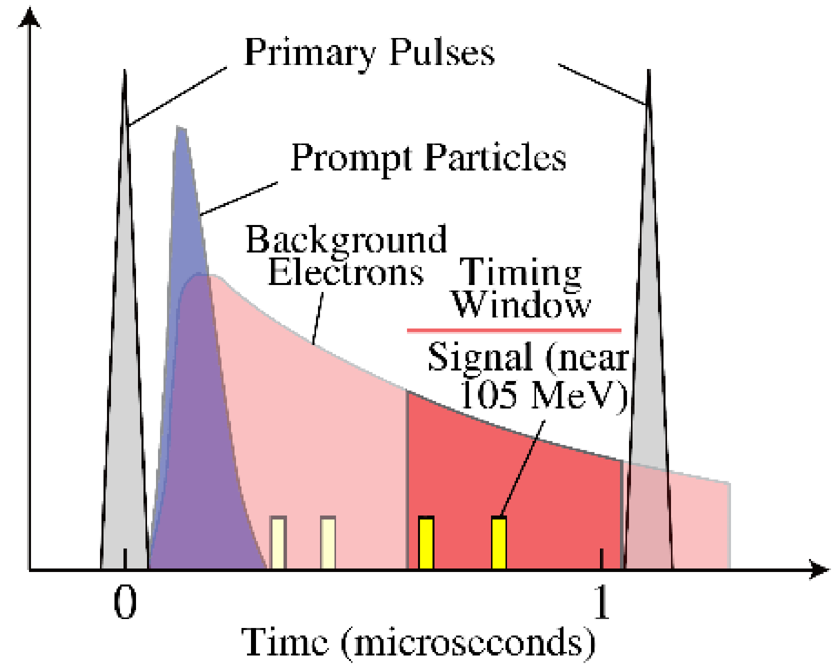
1) 8 GeV proton beam, 100 ns

Sensitivity per event (Phase-II):

$$3 \times 10^{-17}$$

What is COMET?





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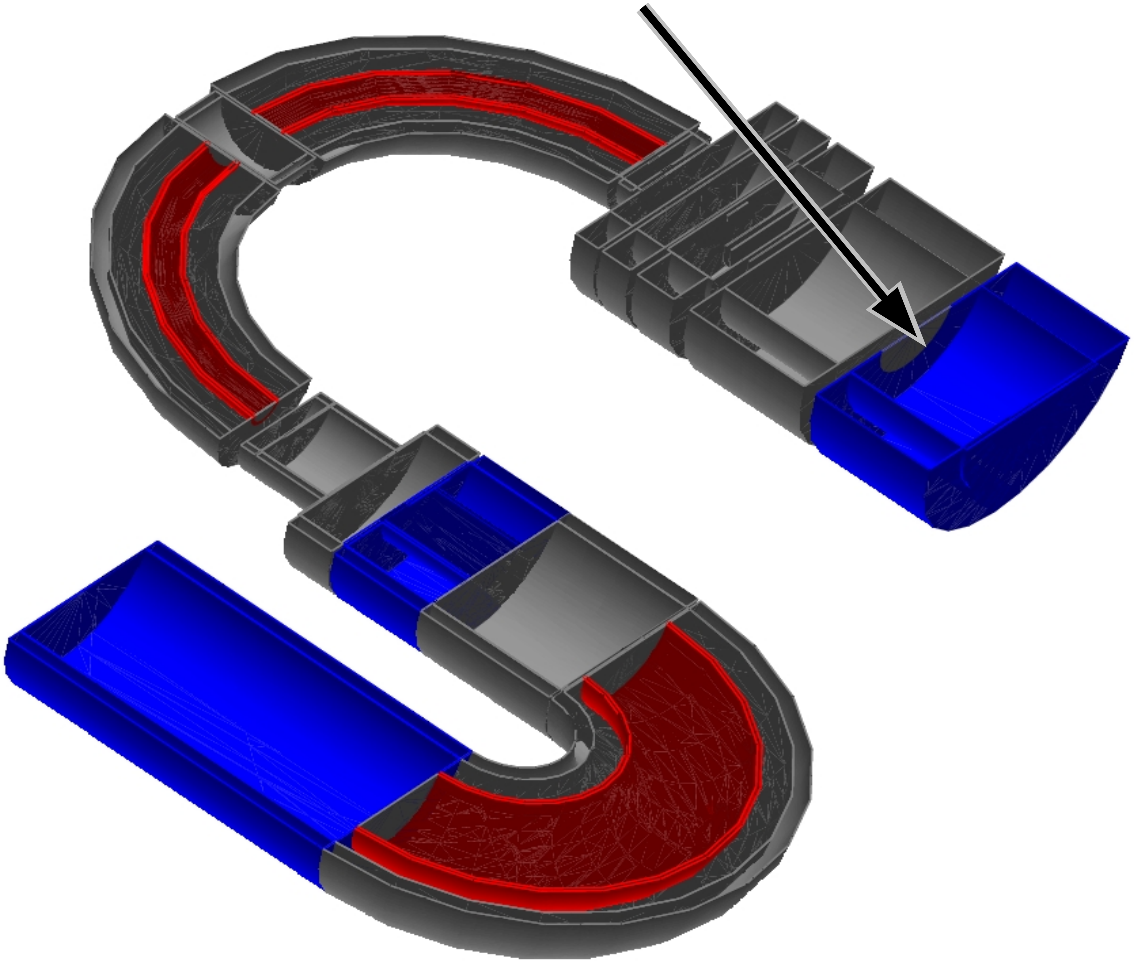

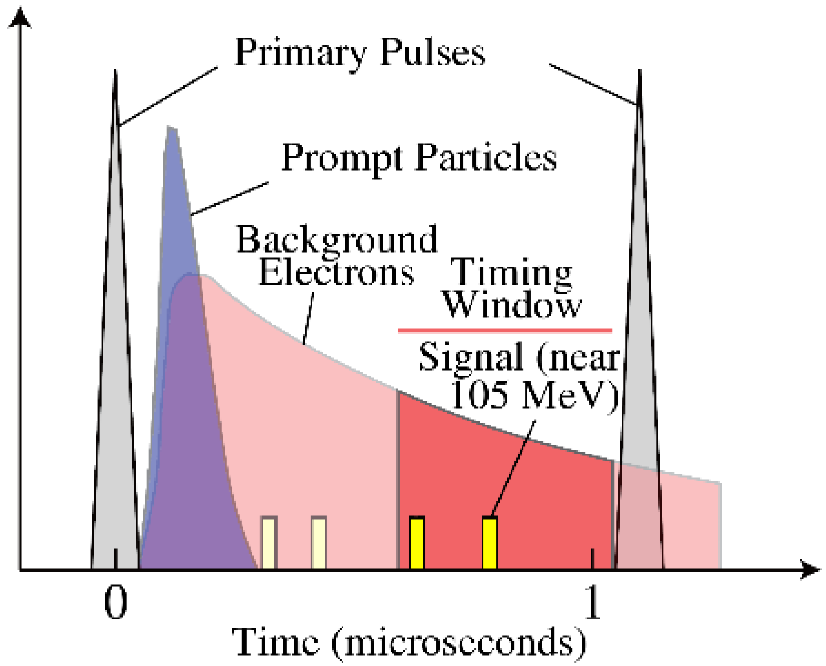

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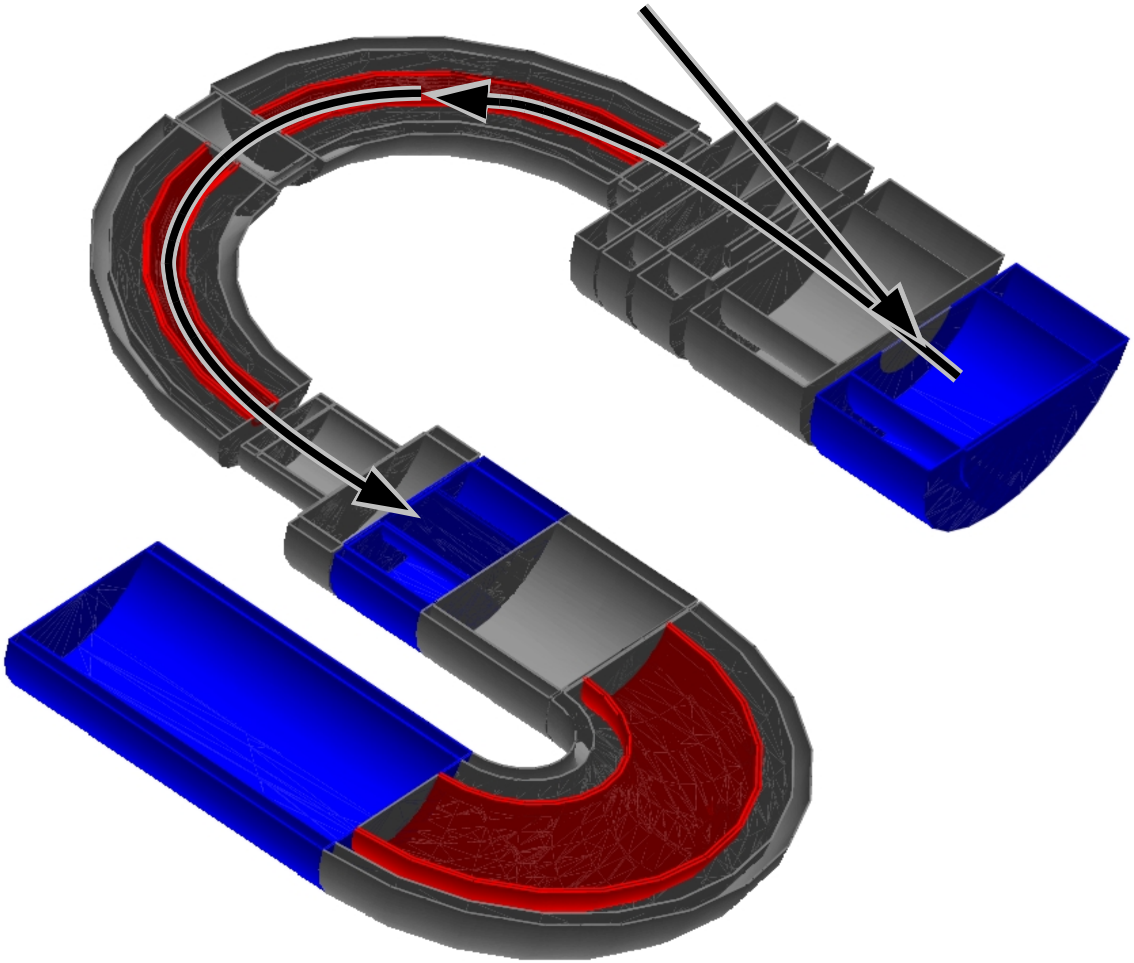
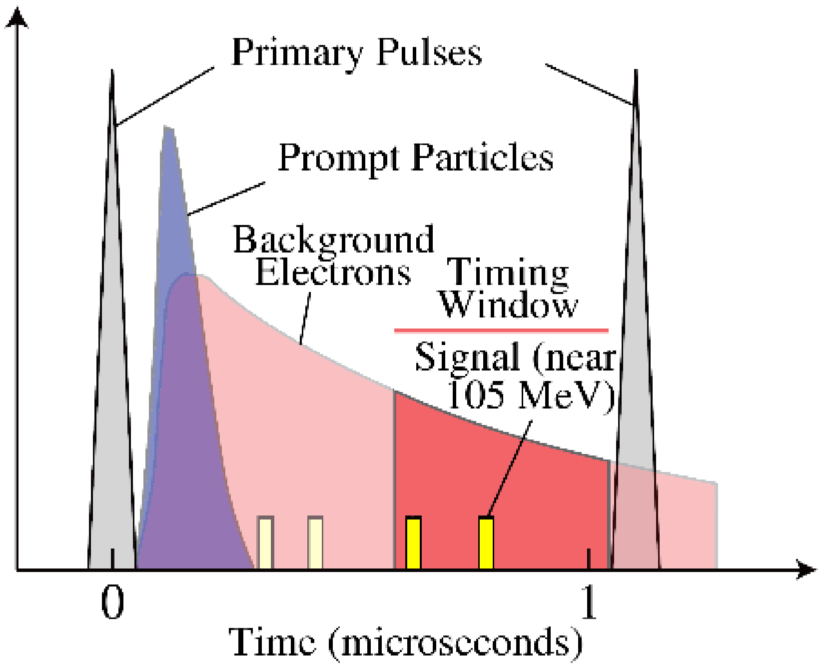


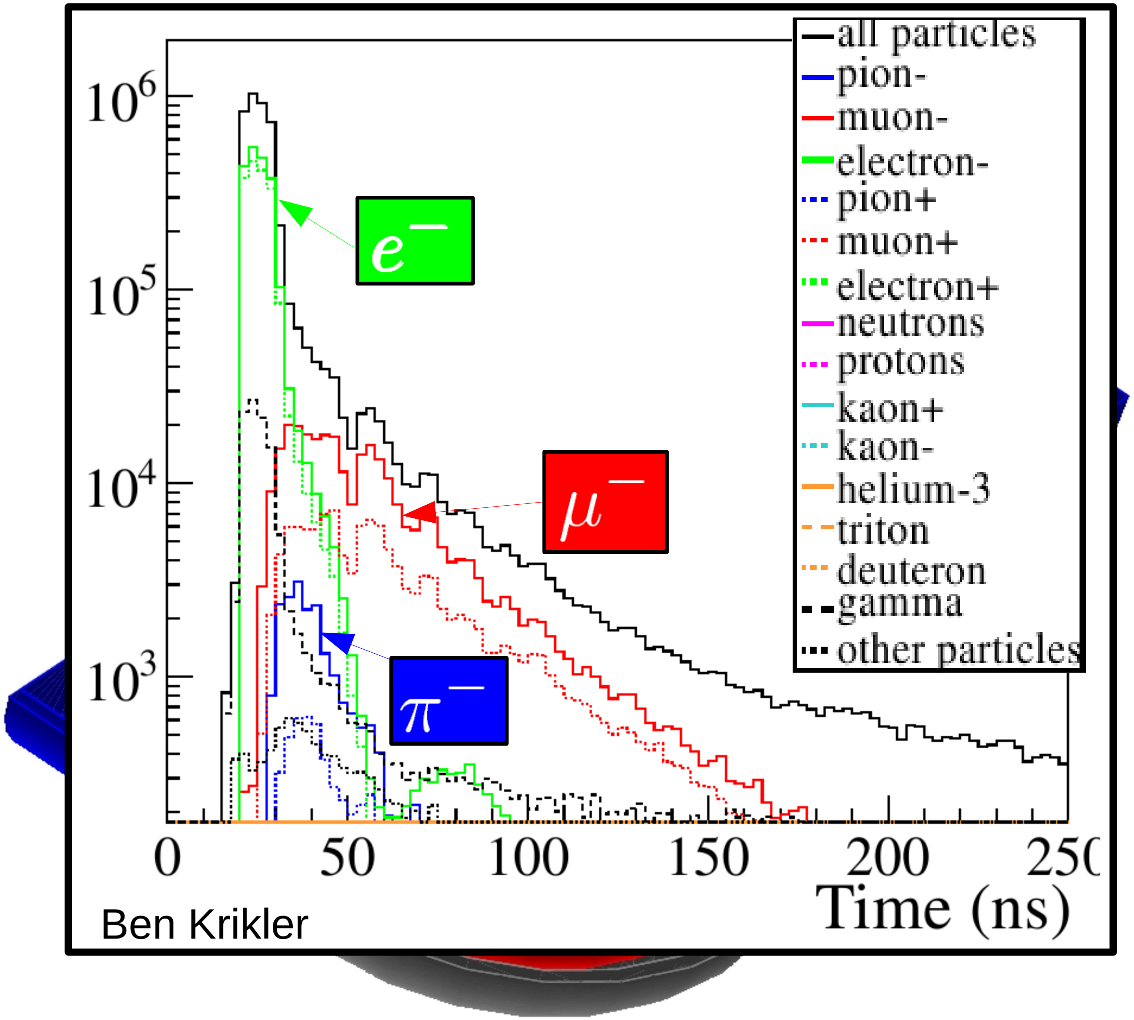


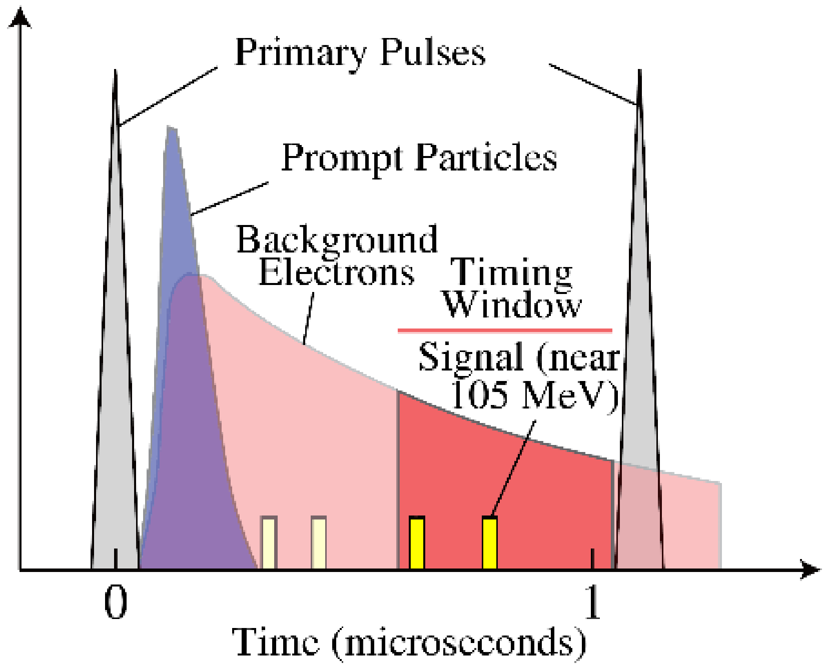
1) 8 GeV proton beam, 100 ns
2) Pions decay to muons

Sensitivity per event (Phase-II):

$$3 \times 10^{-17}$$

What is COMET?





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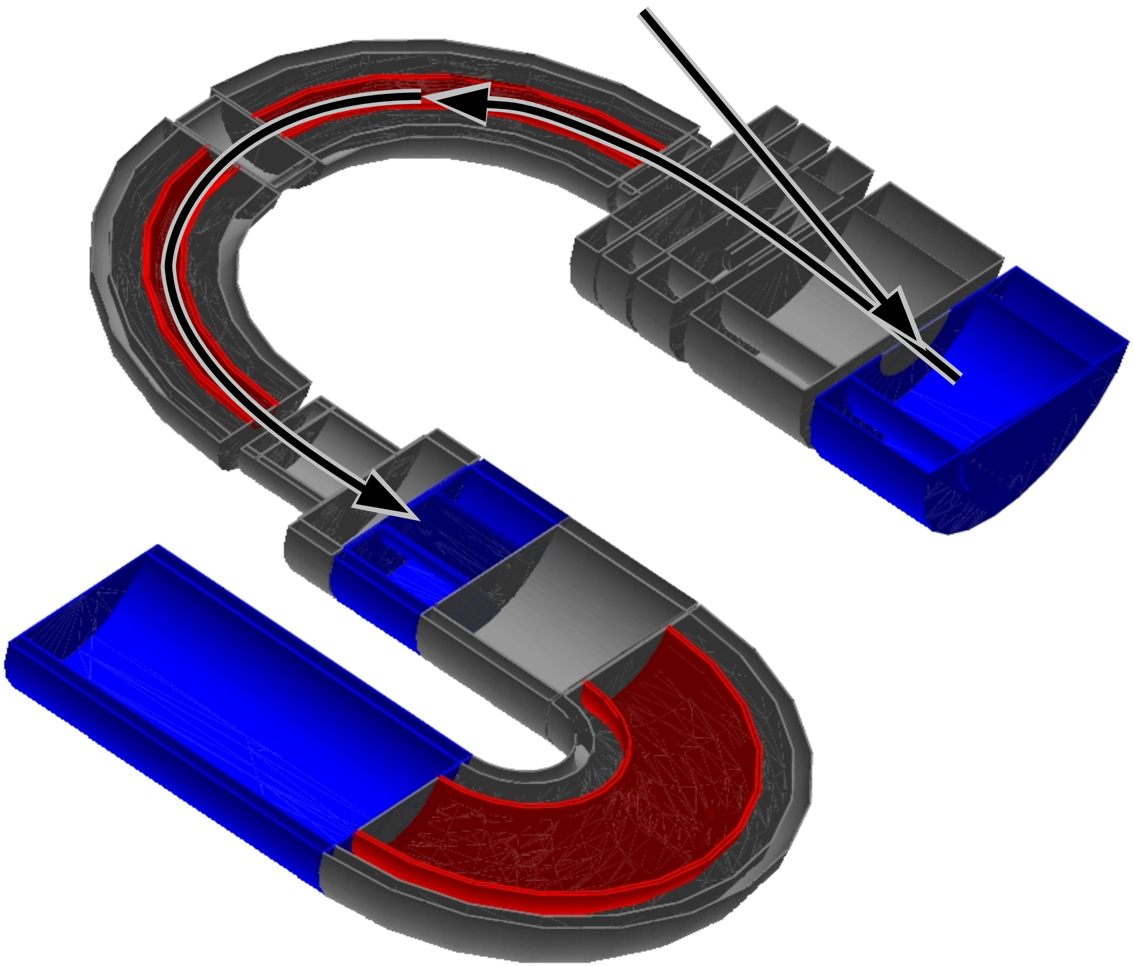

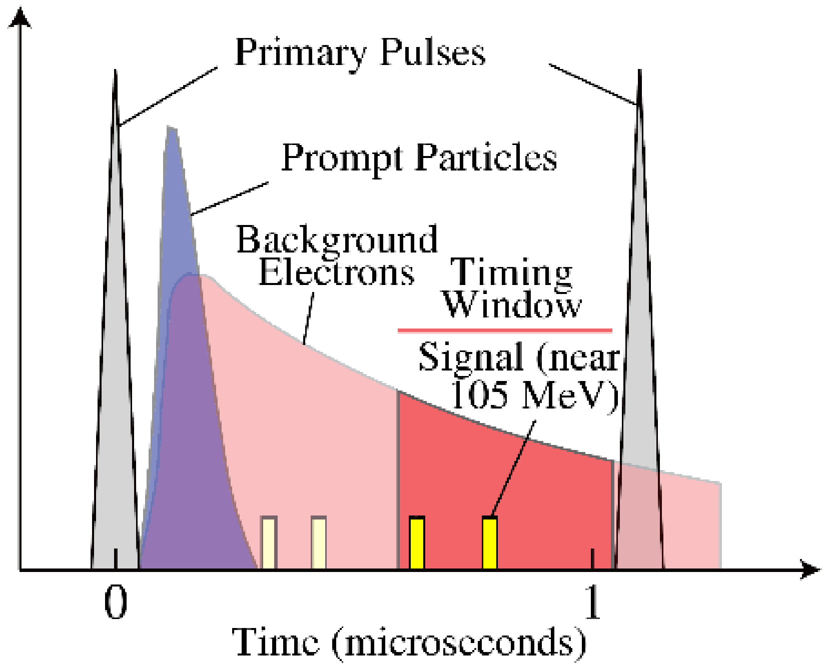

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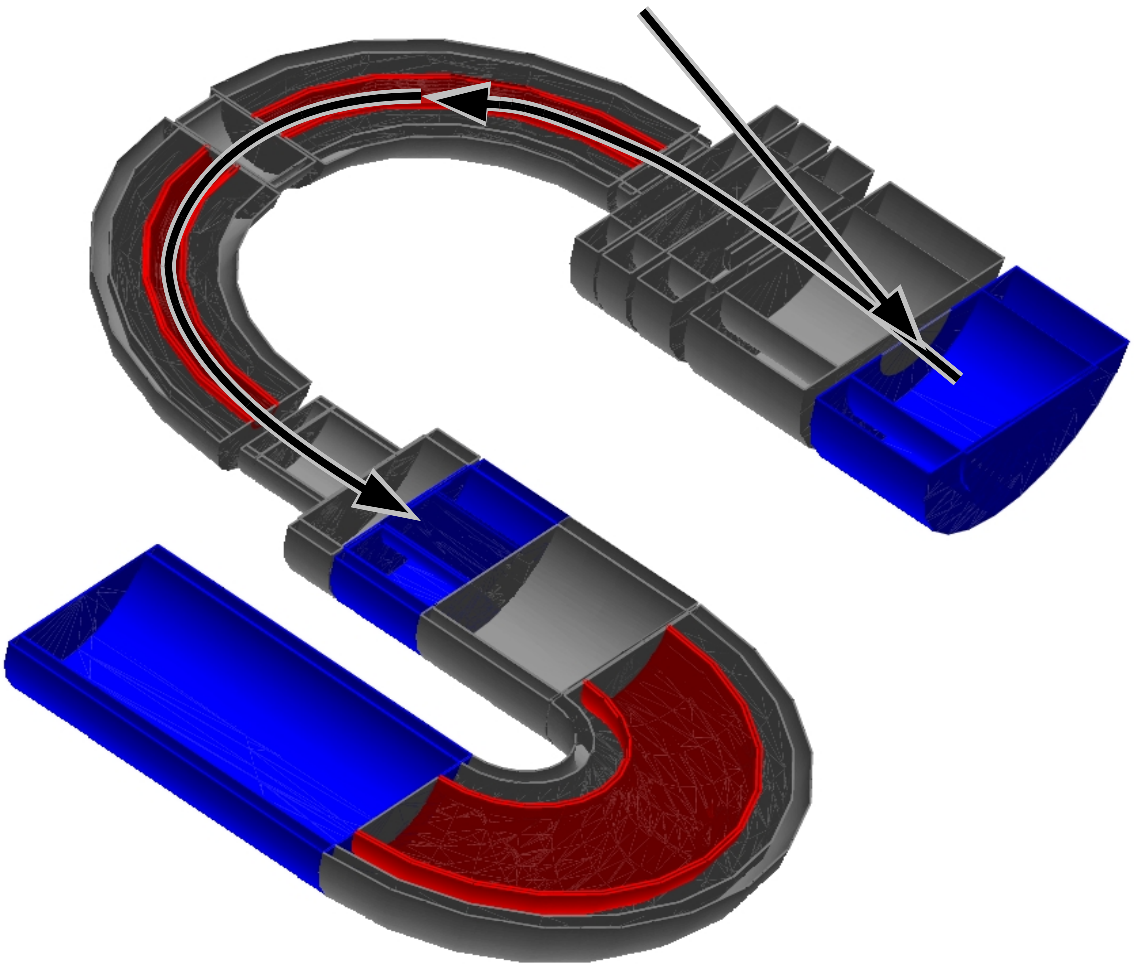
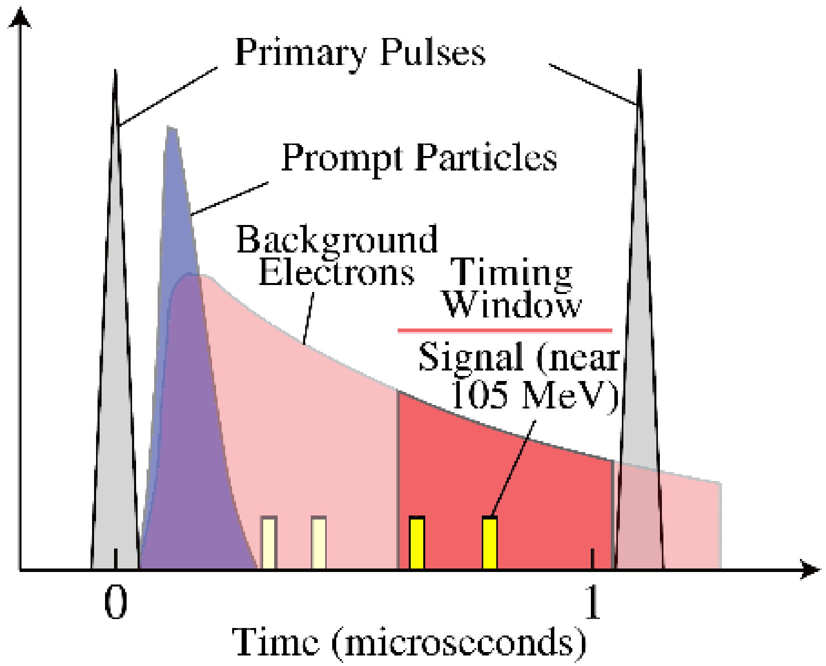


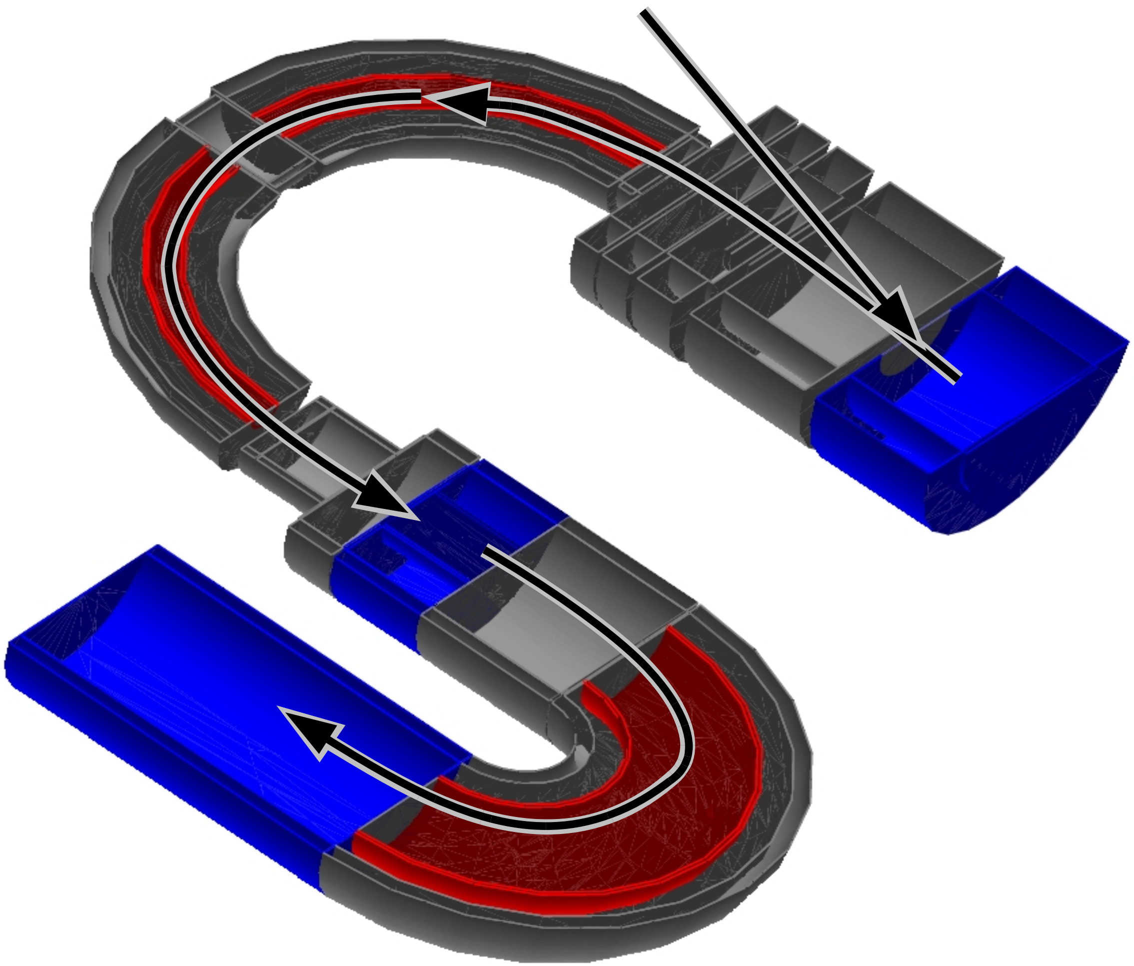


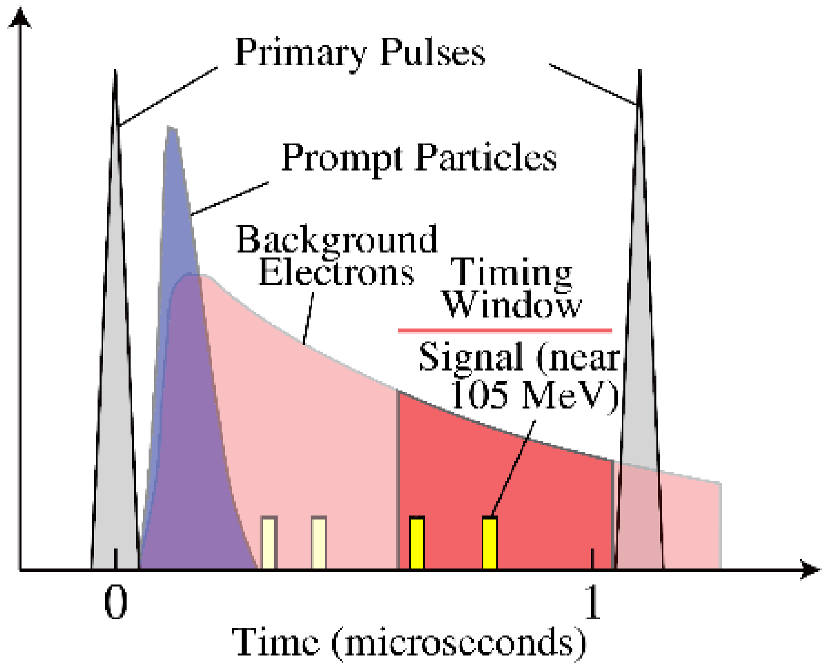
1) 8 GeV proton beam, 100 ns
2) Pions decay to muons
3) Muons hit aluminium target

Sensitivity per event (Phase-II):

$$3 \times 10^{-17}$$

What is COMET?





1) 8 GeV proton beam, 100 ns
2) Pions decay to muons
3) Muons hit aluminium target
4) Target interactions
5) Detect electrons

Sensitivity per event (Phase-II):

$$3 \times 10^{-17}$$

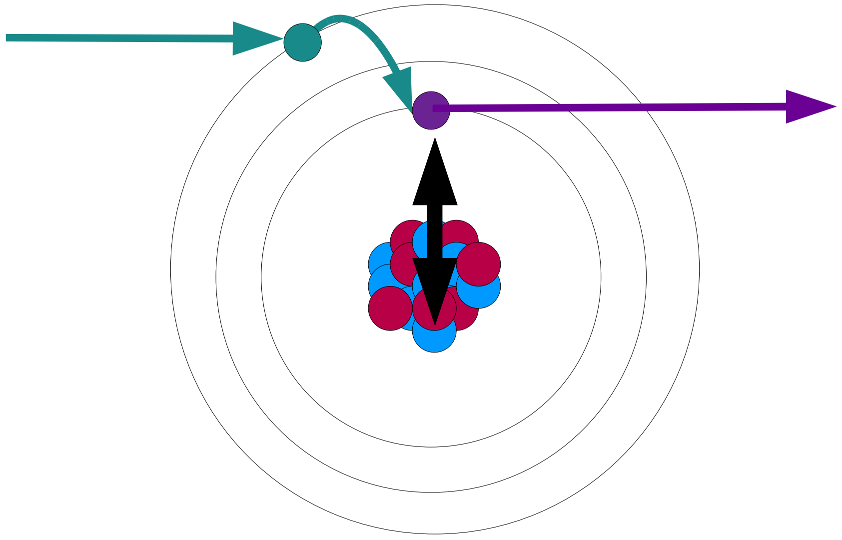
μ-e: Signal process

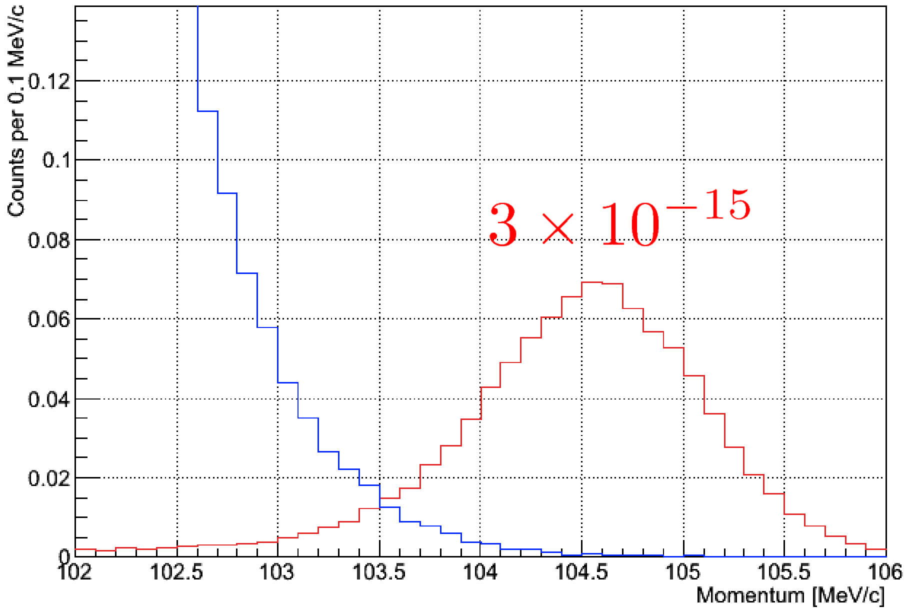
1) Create muonic atom

2) De-excitation to 1s state

3) Conversion $\mu^- + Al \rightarrow e^- + Al$

- Monoenergetic electron: $E_e = m_\mu - B_\mu - E_{rec} = 105 \text{ MeV}$

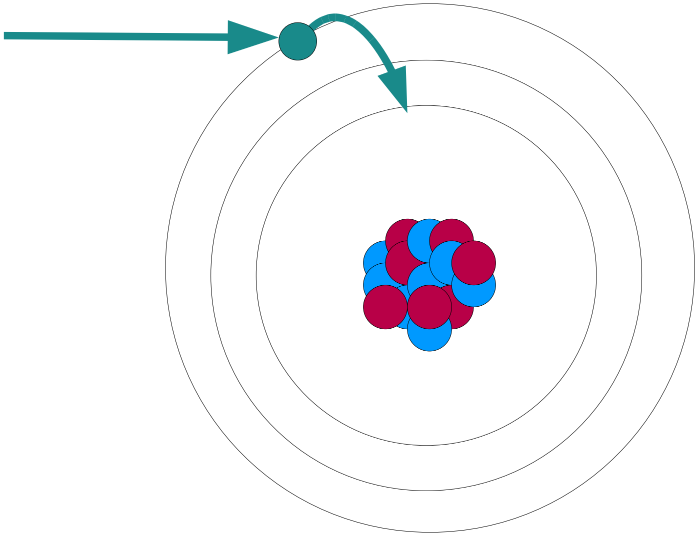


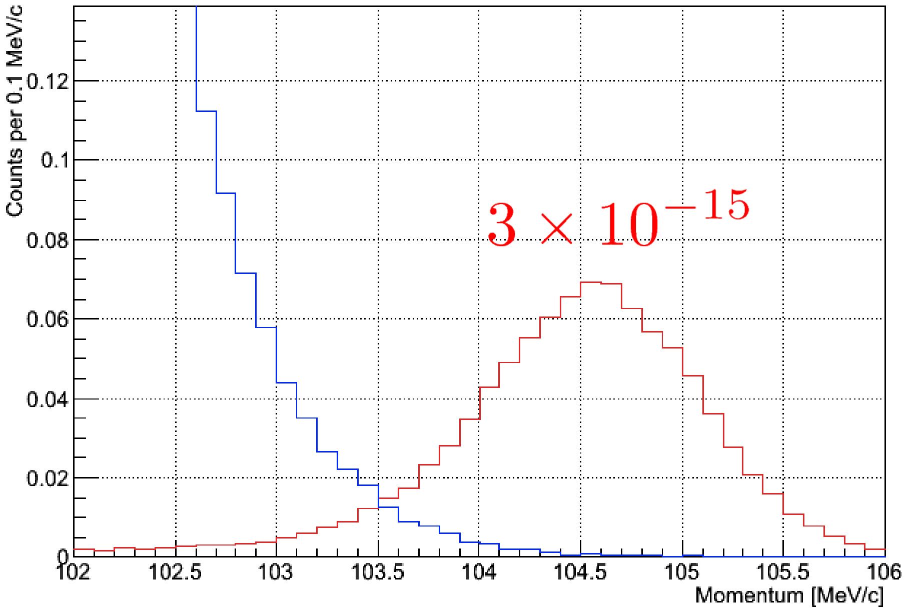


Intrinsic Background

1) Create muonic atom

2) De-excitation to 1s state



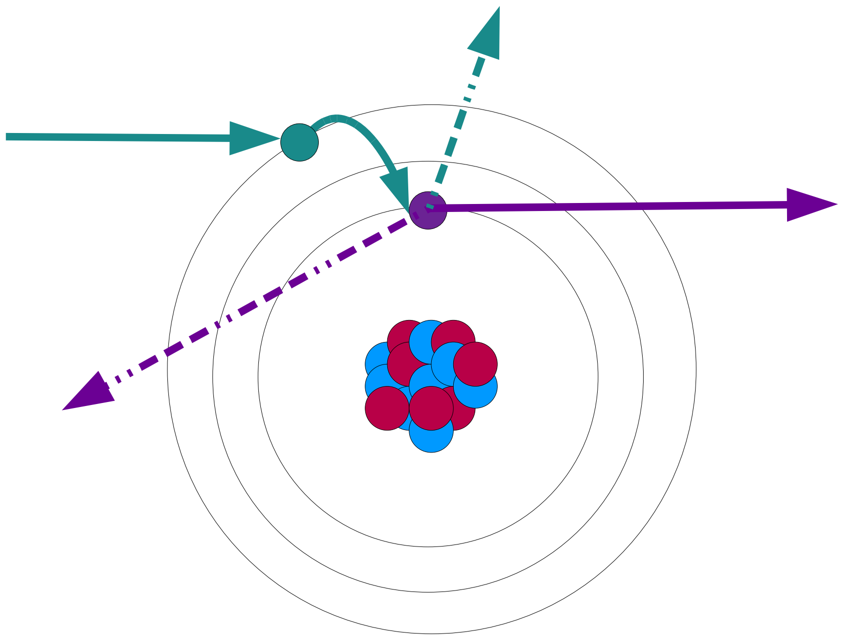


Intrinsic Background

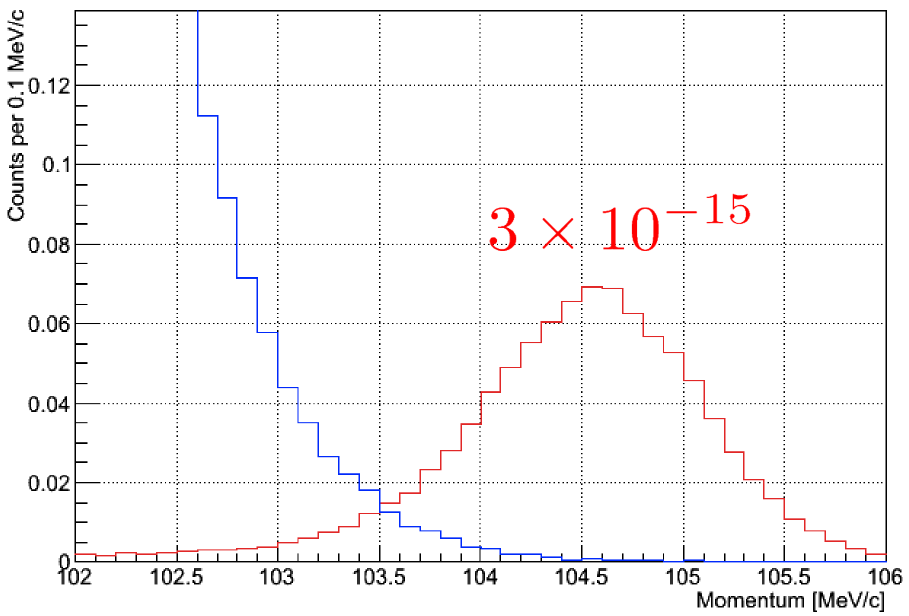
1) Create muonic atom

2) De-excitation to 1s state

3) Decay in Orbit (DIO)



$$\mu^- \rightarrow e^- + \bar{\nu}_e + \nu_\mu$$



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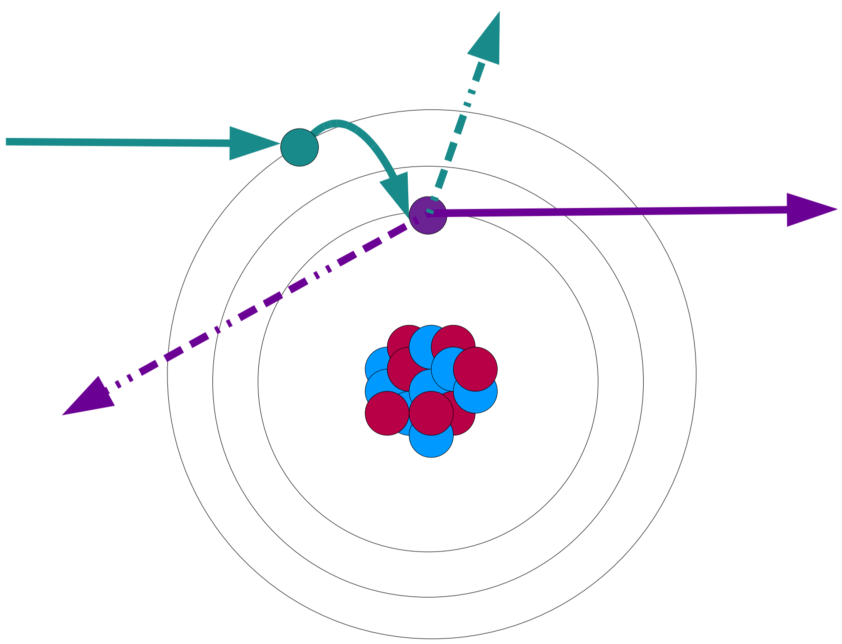

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Intrinsic Background

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2) De-excitation to 1s state
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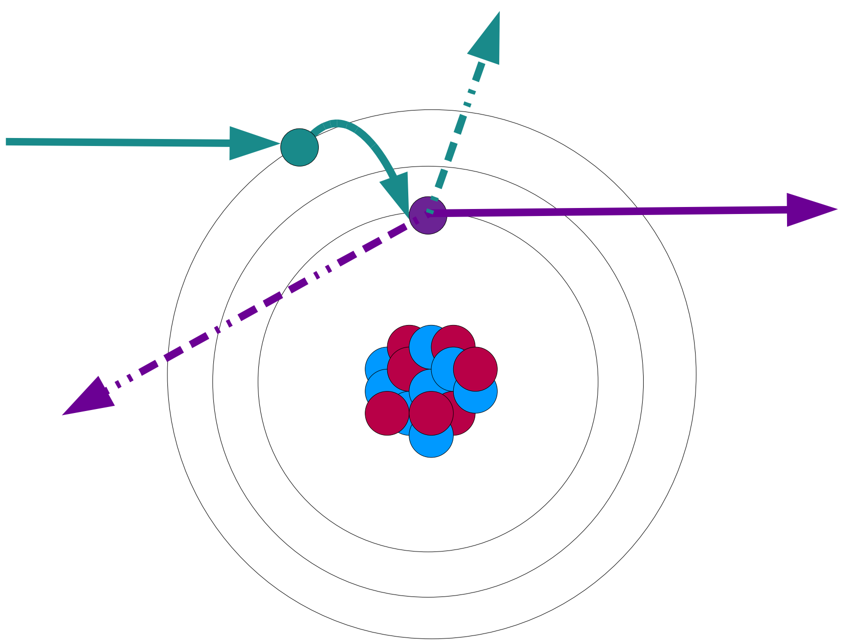
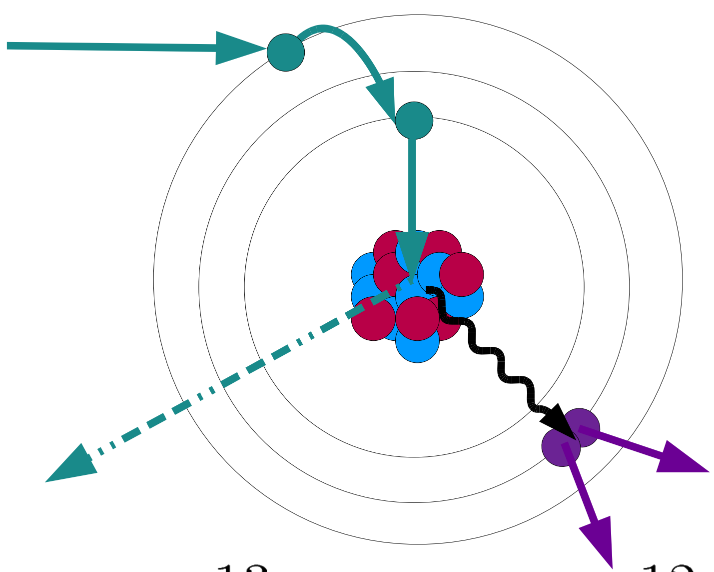


$$\mu^- \rightarrow e^- + \bar{\nu}_e + \nu_\mu$$

1) Create muonic atom
2) De-excitation to 1s state
3) Muon nuclear capture
4) Electrons from γ, n etc

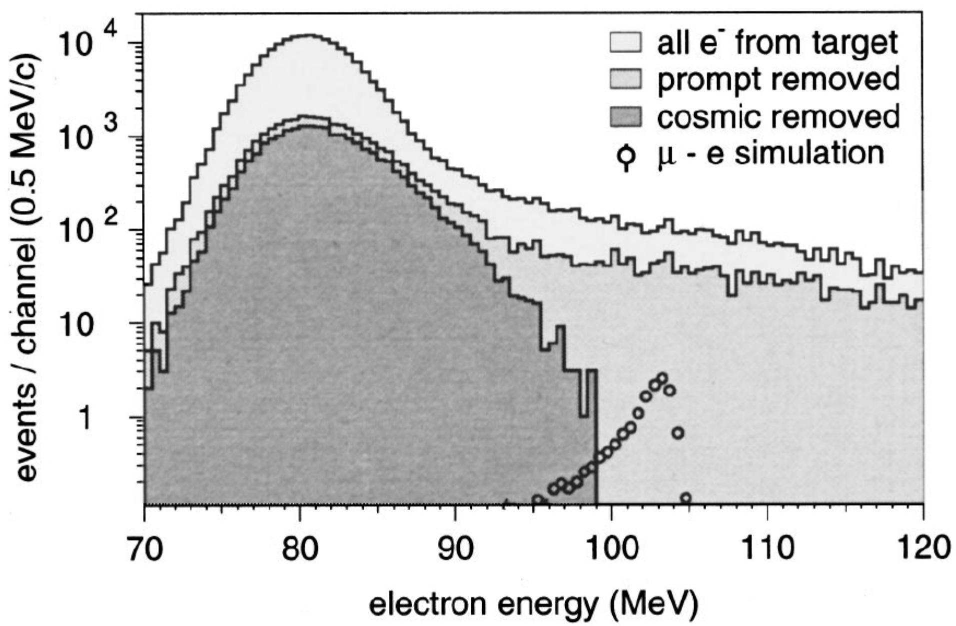


$$\mu^- + {}^{13}_{27}Al \rightarrow \nu_\mu + {}^{12}_{27}Mg$$

Backgrounds

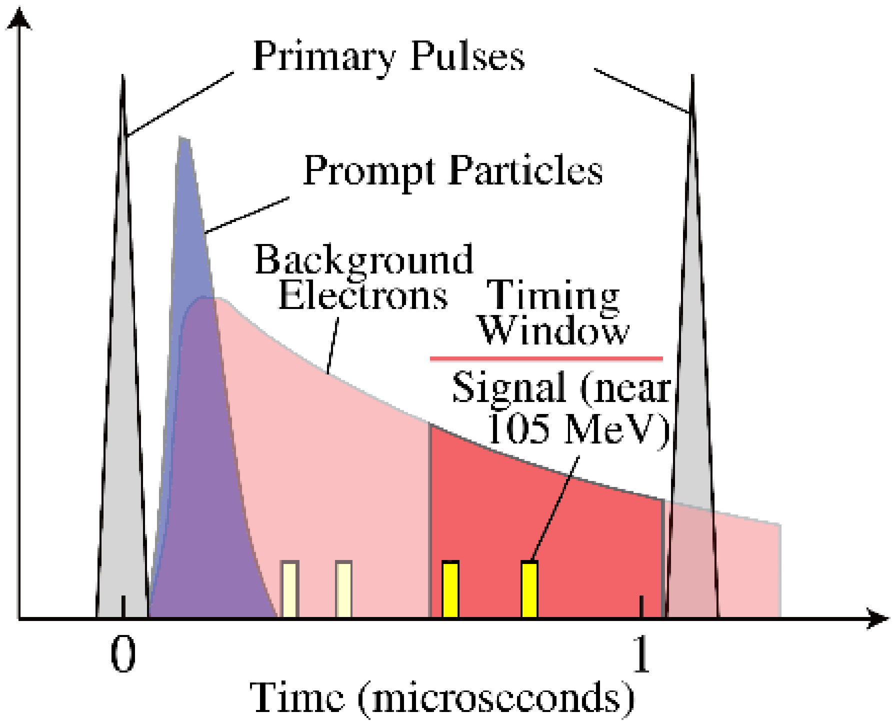
Prompt:

- Radiative π capture (RPC)
- μ/π decay in flight
- Electrons in beam
- Neutrons



Delayed:

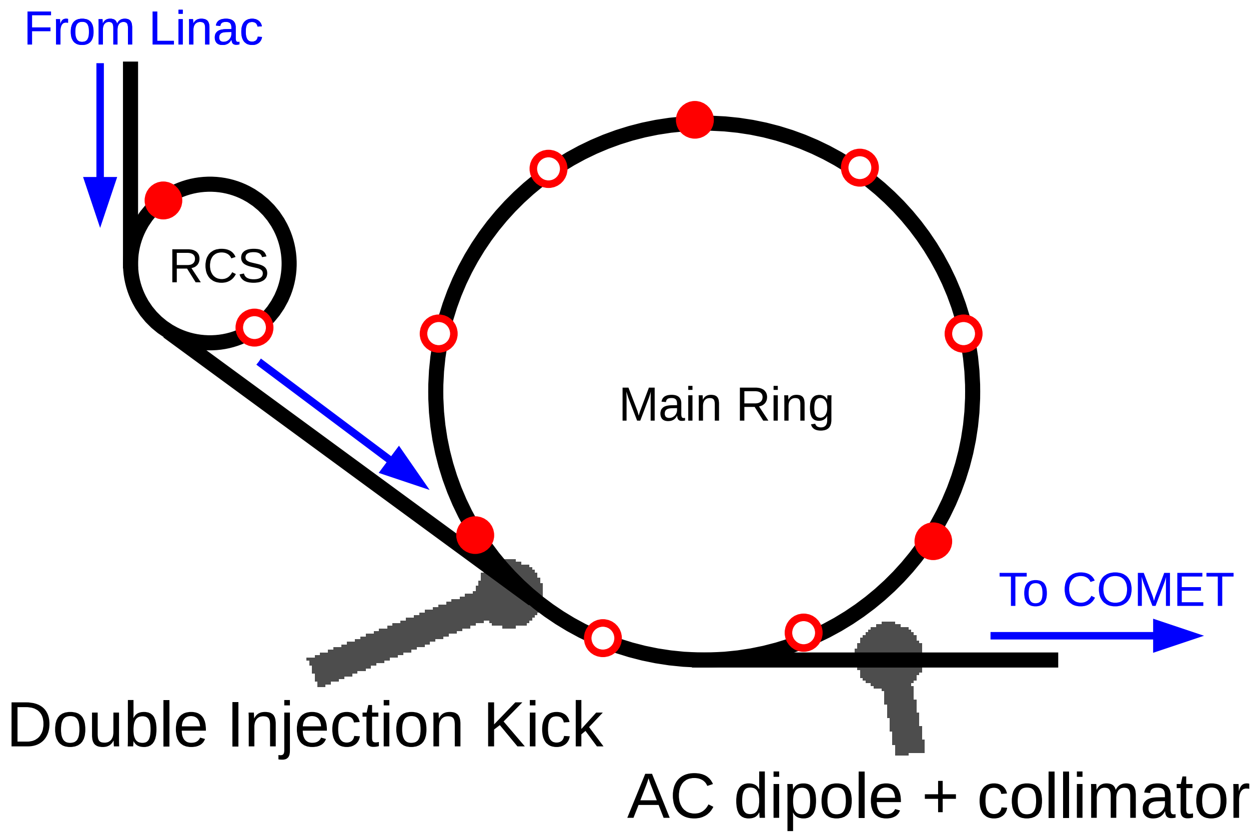
- Radiative π capture (RPC)
- Anti-protons

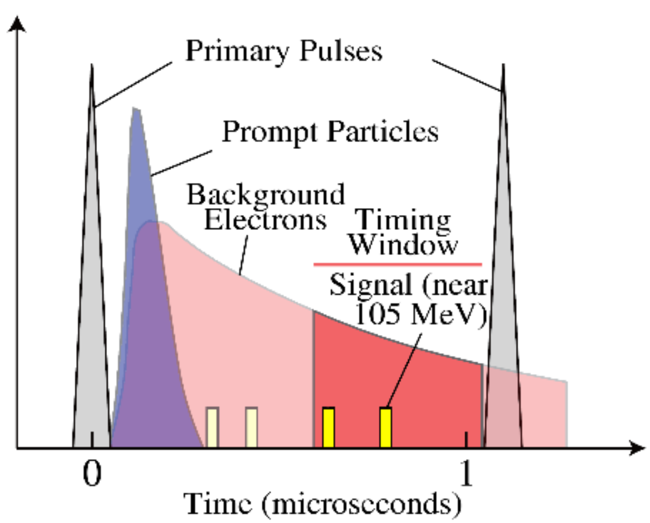


Beam Extinction

Require 10^{-9}

Linac provides 10^{-7} extinction





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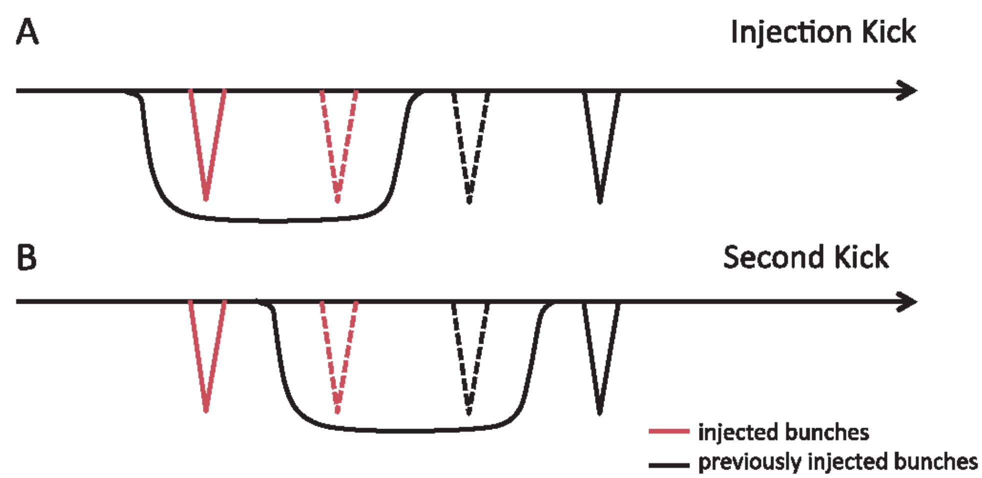

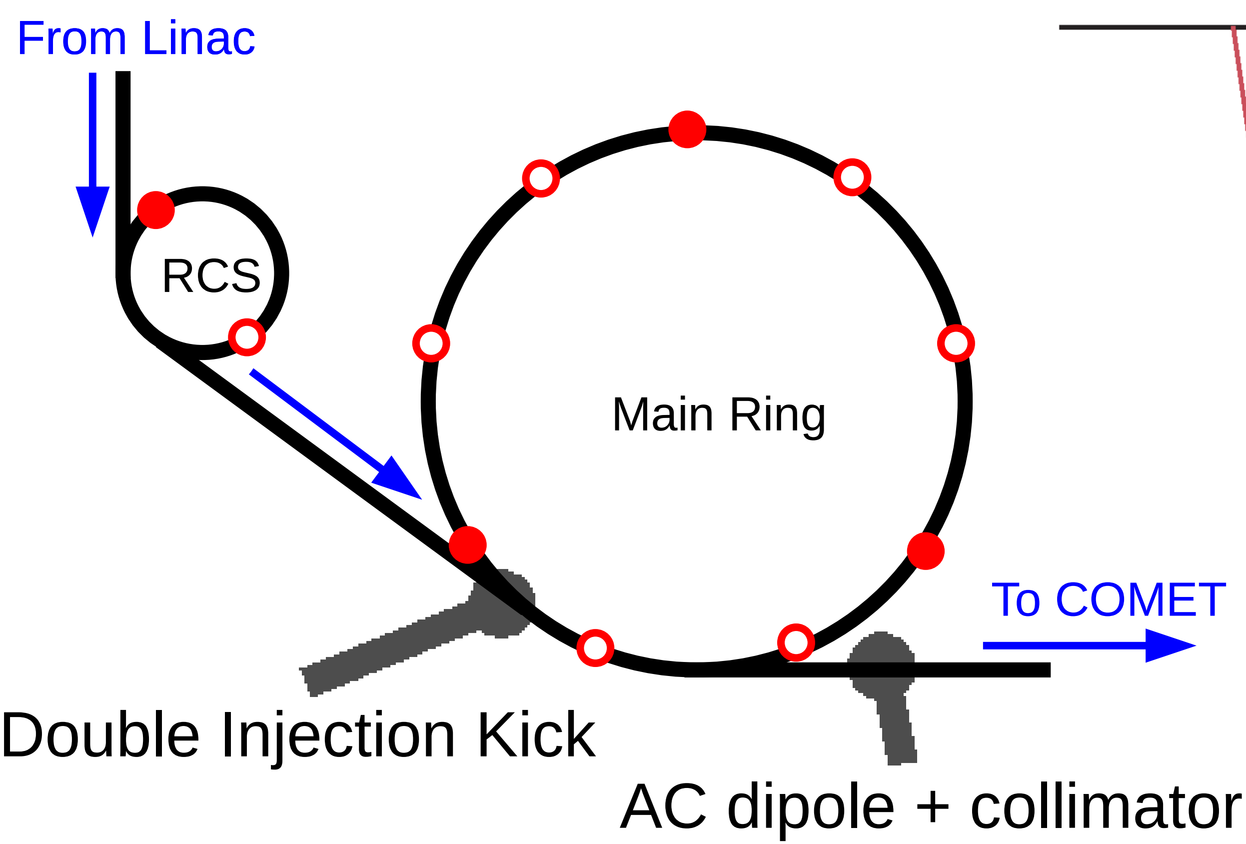

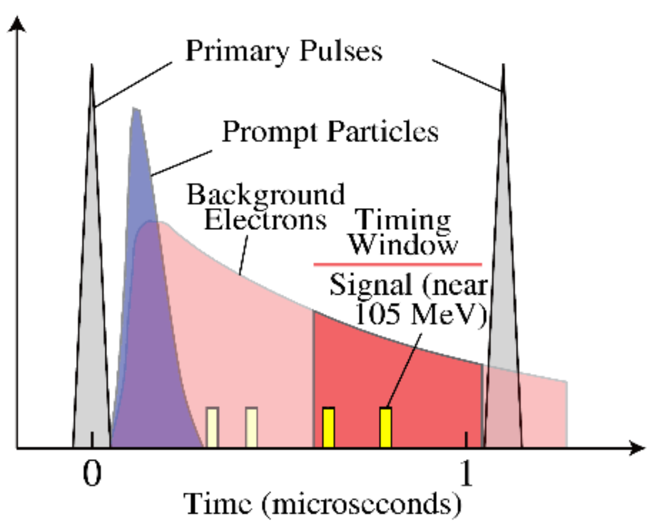

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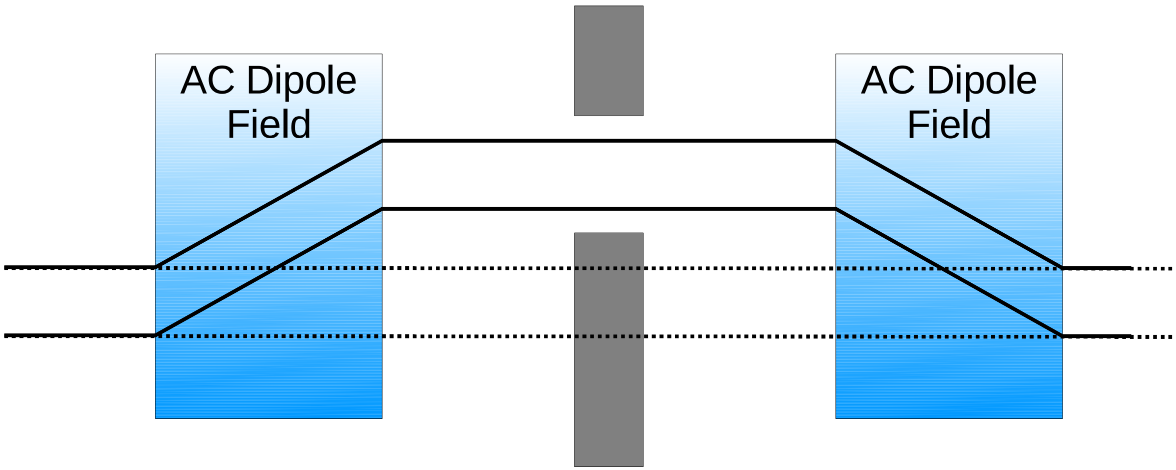
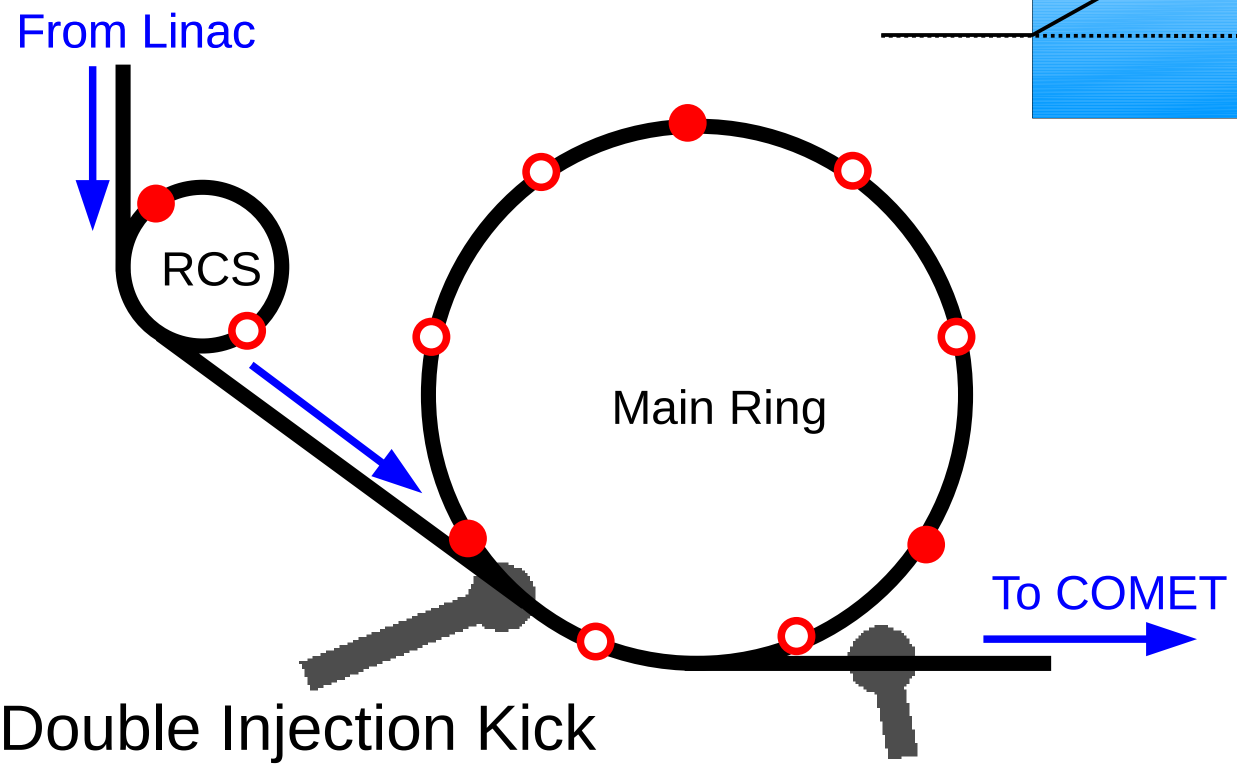
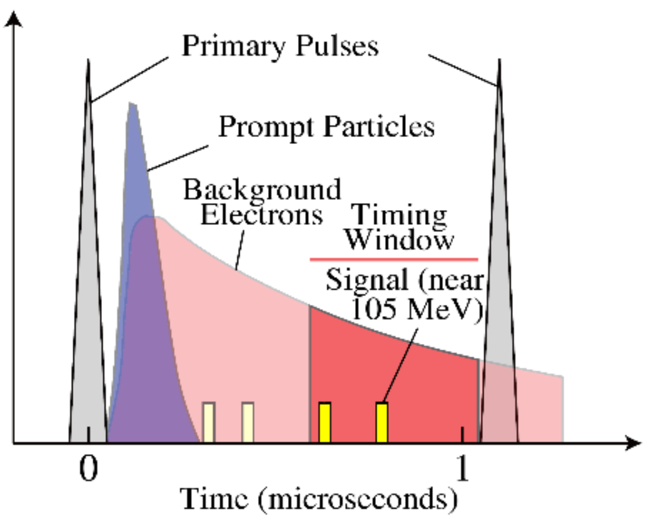




Double Injection Kick

AC dipole + collimator



Summary

- COMET Phase-I built and taking data by 2015
- $\mu - e$ conversion: big potential for new physics
- High sensitivity from:
  - Pulsed primary beam
  - Careful momentum selection
  - Beam extinction

What is COMET?

Thank you

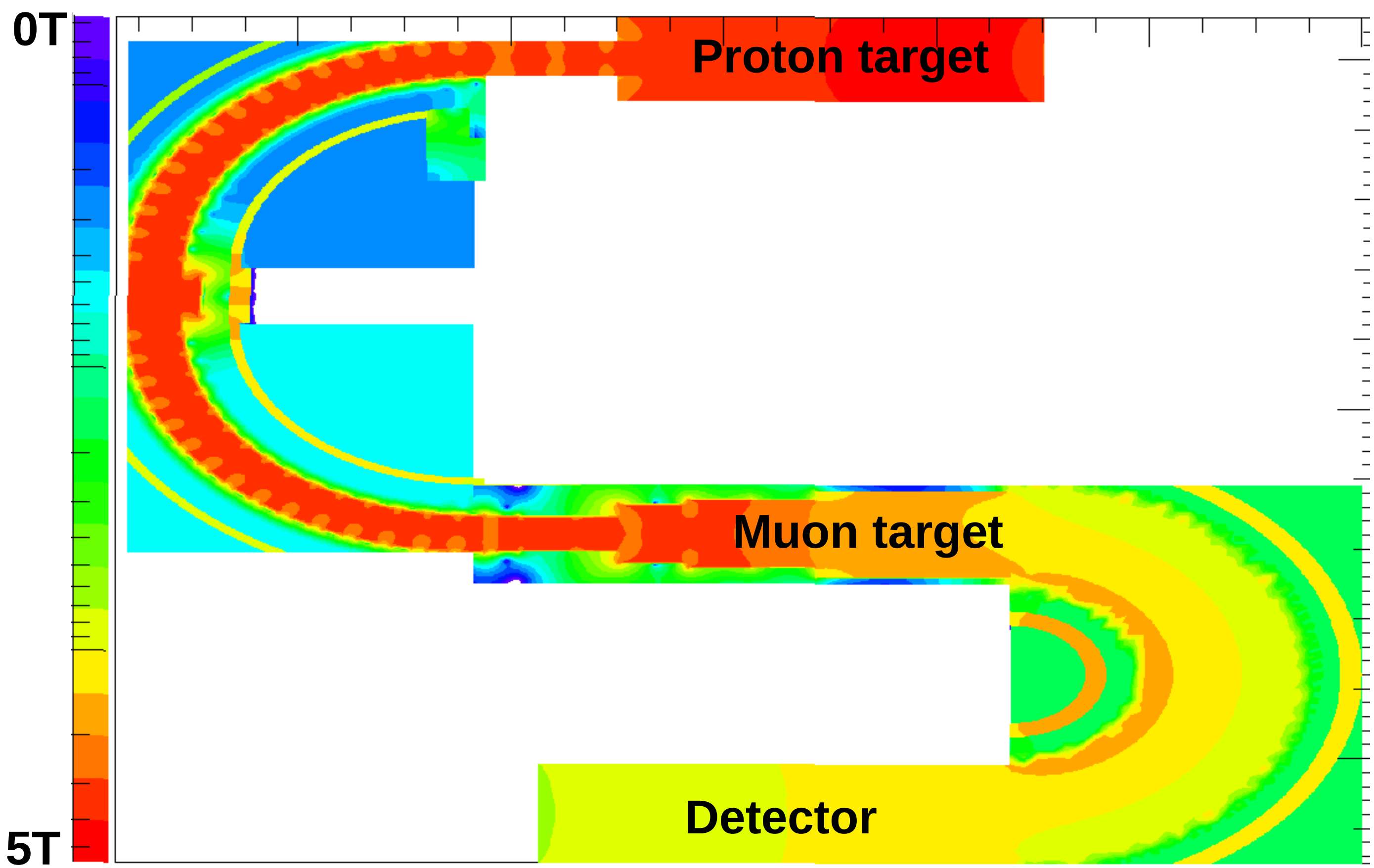
Backgrounds

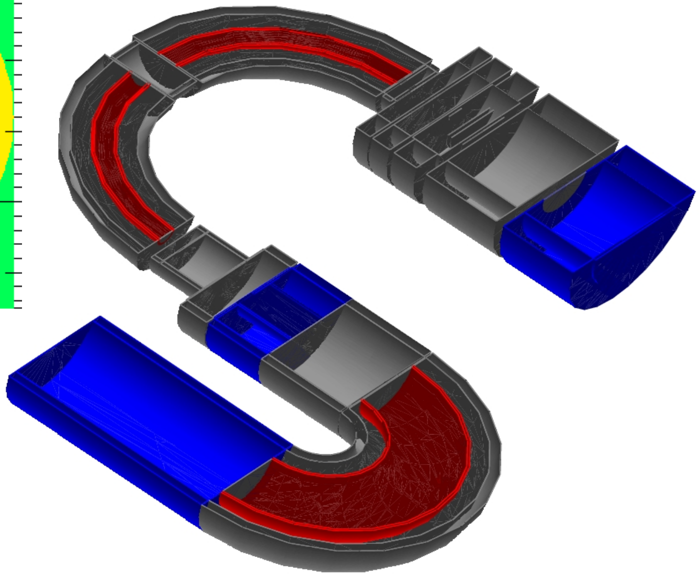
Type	Background	Predicted number of events		
		Phase-I[6]	Phase-II[7]	Phase-I×20
Intrinsic	Muon Decay in Orbit	0.01	0.15	0.2
	Radiative Muon Capture	< 0.001	< 0.001	< 0.02
	μ^- capture w/ n Emission	< 0.001	< 0.001	< 0.02
	μ^- capture w/ Charged part Emission	< 0.001	< 0.001	< 0.02
Prompt	Radiative Pion Capture	0.0096	0.05	0.192
	Beam Electrons	< 0.00048	$< 0.1^*$	< 0.0096
	Muon Decay in Flight	< 0.00048	< 0.0002	< 0.0096
	Pion Decay in Flight	< 0.00048	< 0.0001	< 0.0096
	Neutron Induced	~ 0	0.024	~ 0
Delayed	Delayed Pion Radiative Capture	0.002	0.002	0.04
	Anti-Proton induced	0.07	0.007	0.14
Cosmic	Cosmic Ray Muons		0.002	
	Electrons from Cosmic Ray Muons	< 0.0002	0.002	< 0.004
	Total Background	0.03	0.34	0.6
	Signal (Assuming B.R.$=1 \times 10^{-16}$)	0.032	3.8	0.64
	Exposure time (s):	$\mathbf{10^6}$	$\mathbf{2 \times 10^7}$	$(\mathbf{2 \times 10^7})$

[6] Phase-I proposal

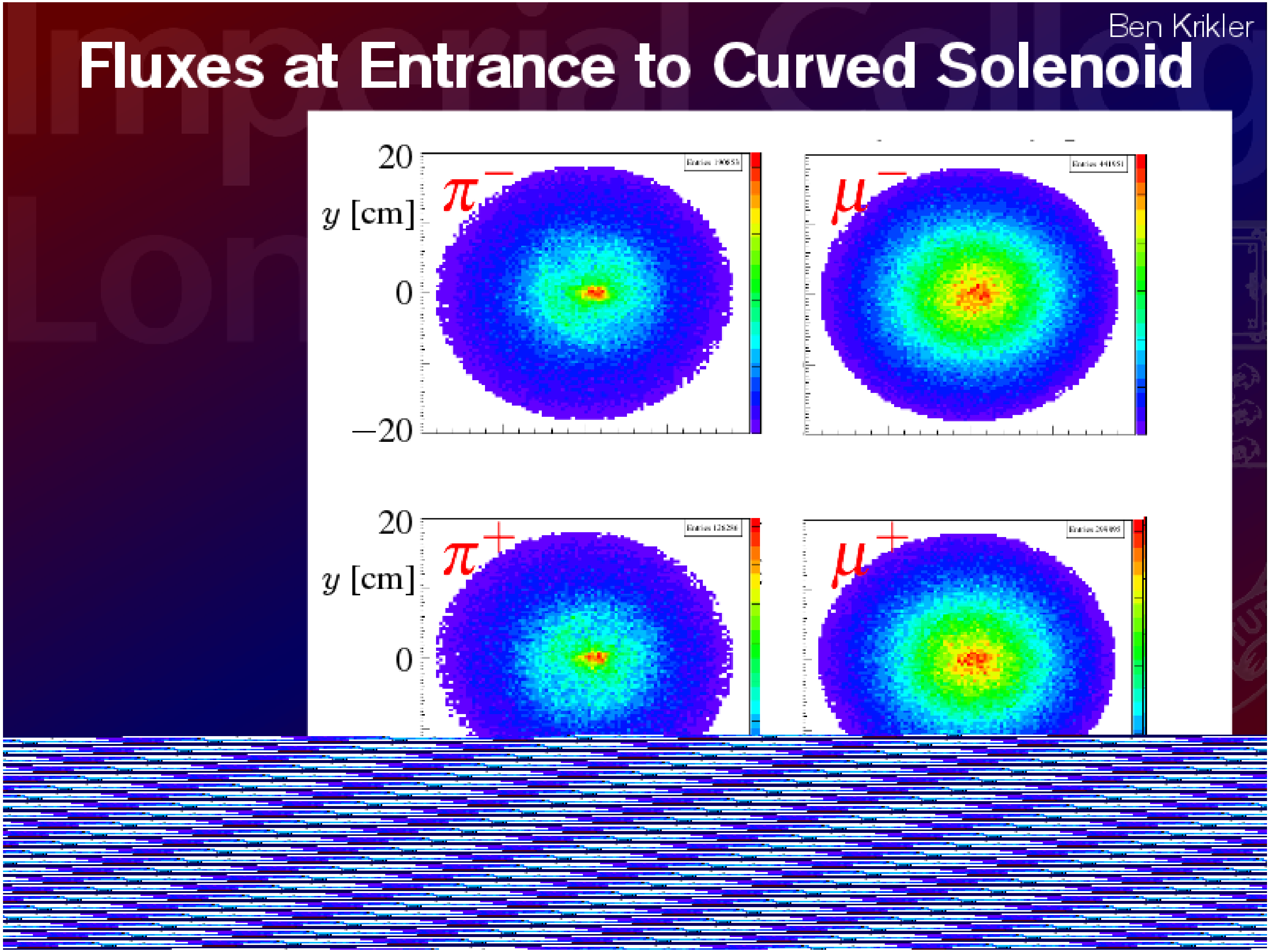
[7] Phase-II CDR

Magnetic Field

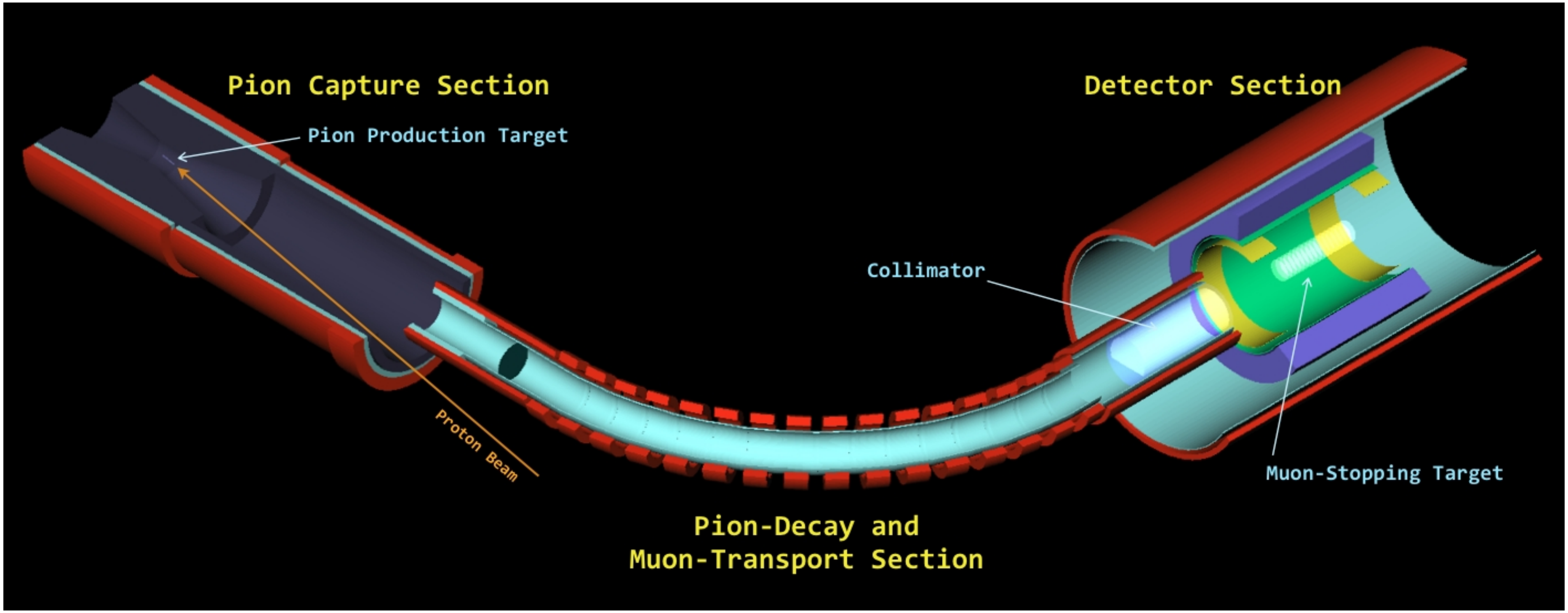




My Previous Work



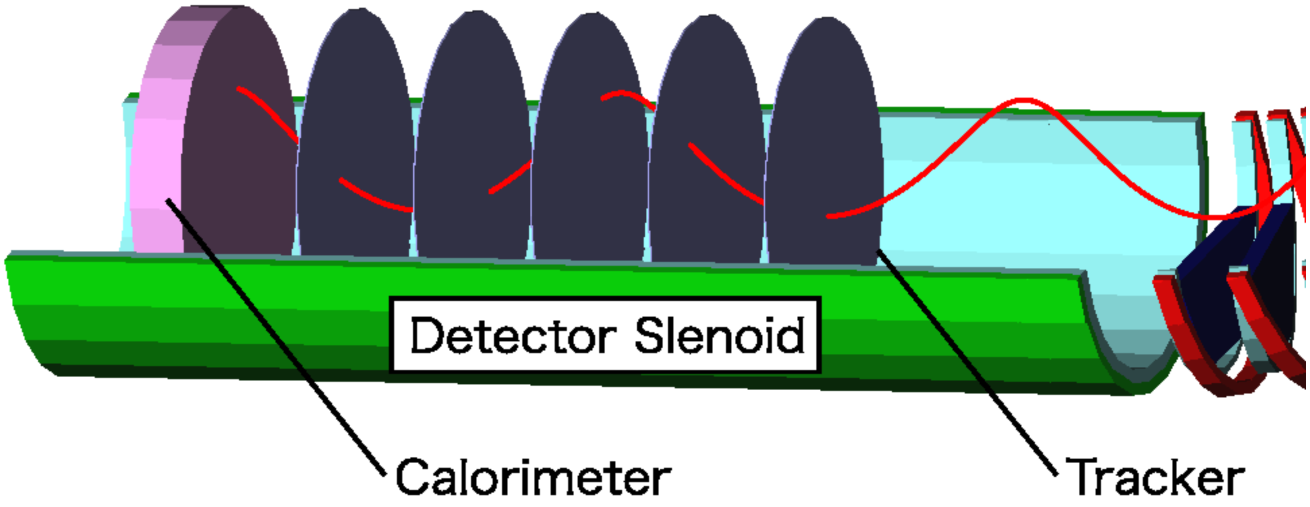
COMET Phase I



1) Proton beam extinction and background studies

2) Search for $\mu - e$ at $\mathbf{3 \times 10^{-15}}$ sensitivity

Phase II Detector



Tracker:

Straw Tubes in 1T field

800 kHz charged particles, 8 MHz gamma

0.4% momentum 700 micron spatial resolution

Crystal Calorimeter:

Energy, position, PID, trigger

5% energy and 1cm spatial at 100 MeV

Backgrounds

	# events in 2×10^7 s run	
Radiative Pion Capture	0.05	Prompt
Beam Electrons	$< 0.1^\ddagger$	Prompt
Muon Decay in Flight	< 0.0002	Prompt
Pion Decay in Flight	< 0.0001	Prompt
Neutron Induced	0.024	Prompt
Delayed-Pion Radiative Capture	0.002	Delayed
Anti-proton Induced	0.007	Delayed
Muon Decay in Orbit	0.15	Intrinsic
Radiative Muon Capture	< 0.001	Intrinsic
μ^- Capt. w/ n Emission	< 0.001	Intrinsic
μ^- Capt. w/ Charged Part. Emission	< 0.001	Intrinsic
Cosmic Ray Muons	0.002	Cosmic
Electrons from Cosmic Ray Muons	0.002	Cosmic
Total	0.34	

‡ Monte Carlo statistics limited.