

Extending the reach of Mu3e from light to heavy new physics

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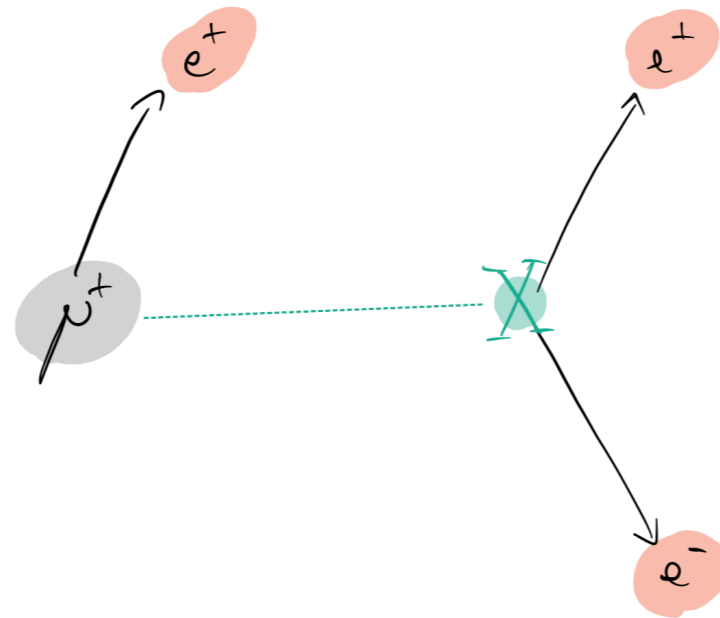


Istituto Nazionale di Fisica Nucleare
SEZIONE DI FIRENZE

Light

Long lifetimes from displaced vertices

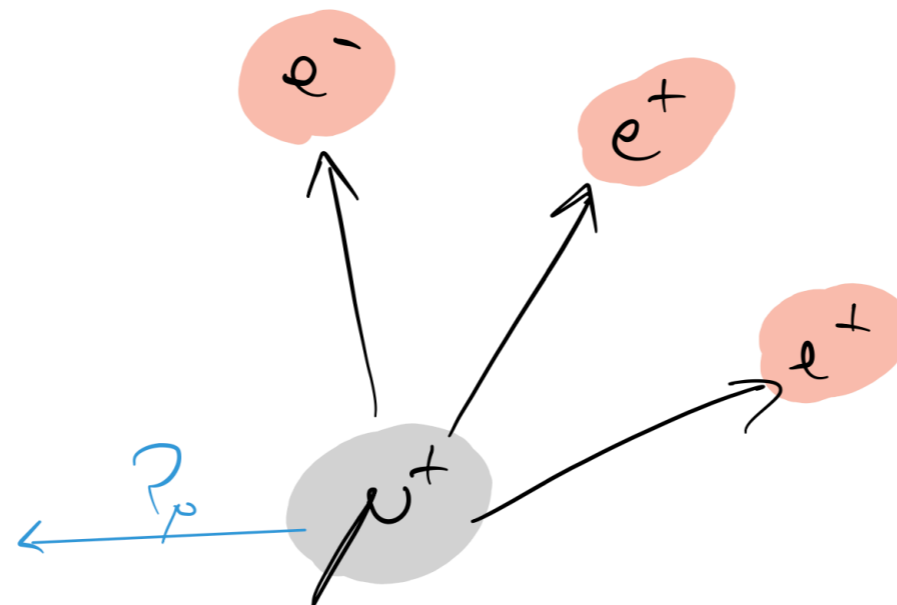
S. Knapen, T. Opferkuch, D. Redigolo, MT: 2410.xxxxx



Heavy

CP Violation in Lepton Flavor Violating decays

D. Redigolo, MT, A. Tesi: 2408.00847

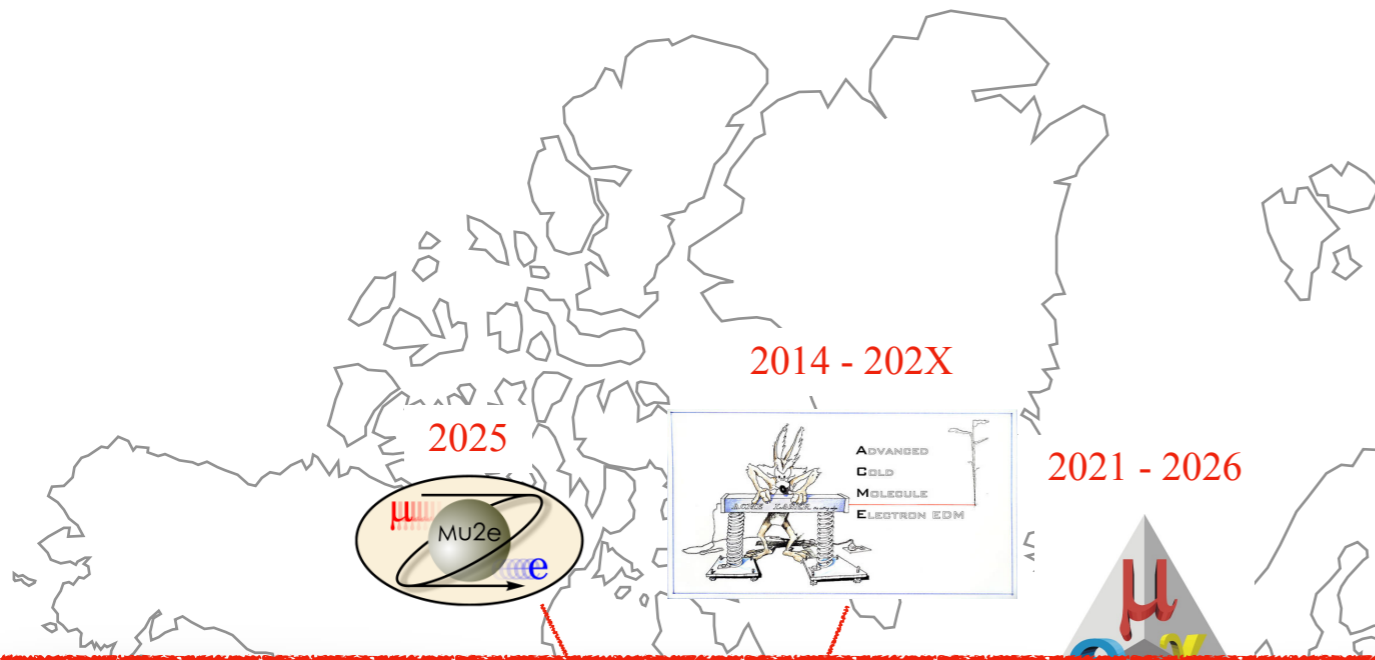


An experiment designed to measure the anomalous magnetic moment of the muon to a very high order of accuracy has completed a preliminary trial run at the CERN proton synchrotron. The run has already confirmed the results of an experiment, known as the ‘g minus 2’ experiment, carried out at CERN five years ago and more detailed measurements are now under way. This article describes the experiment and its relevance to the understanding of the most mysterious of all the sub-nuclear particles — the muon.

‘ Who ever ordered that ? ’

From CERN Courier,
1966





2024



Observables	Current bound	Future sensitivity
$ d_e /e$	1.1×10^{-29} cm	10^{-31} cm
$ d_\mu /e$	1.8×10^{-19} cm	6×10^{-23} cm
$\text{Br}(\mu \rightarrow e\gamma)$	3.1×10^{-13}	6×10^{-14}
$\text{Br}(\mu \rightarrow 3e)$	10^{-12}	5×10^{-16}
$\text{CR}(\mu N \rightarrow eN)$	7×10^{-13}	10^{-16}

μ TRISTAN

???



2022 - ...

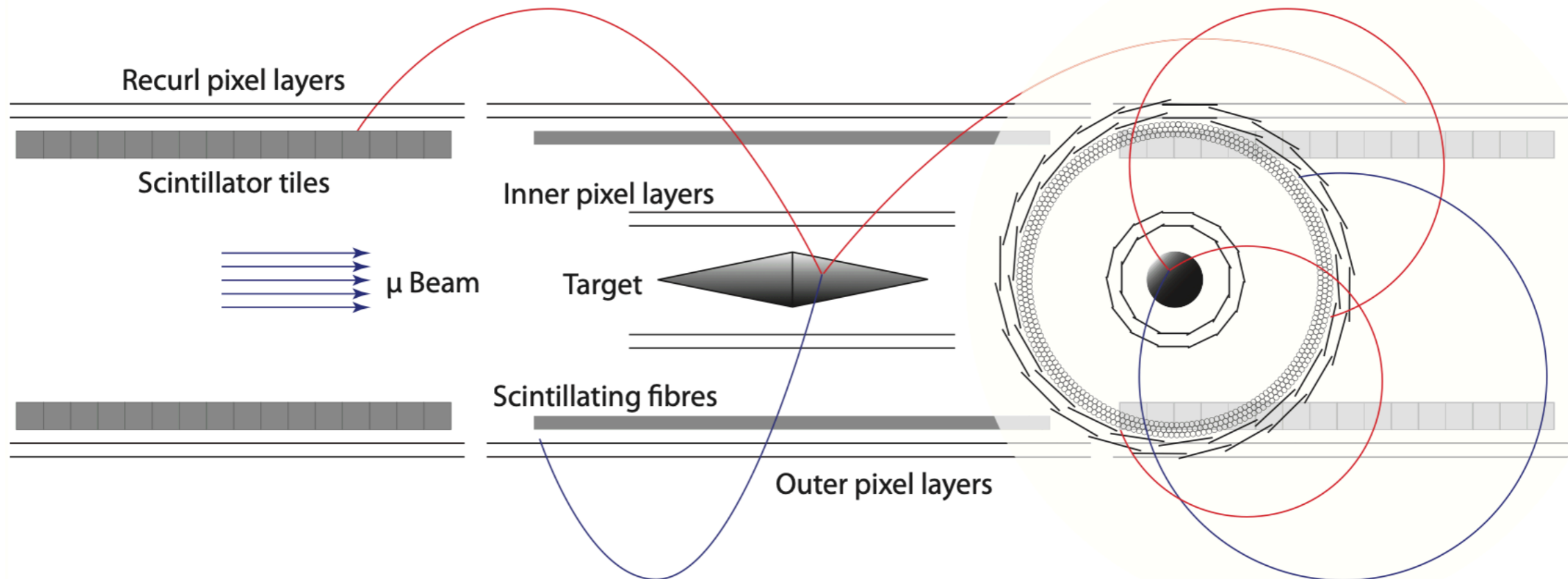
International
UON Collider
Collaboration



$$\mathcal{B}_{\text{SM}}(\mu \rightarrow eee) < 10^{-54}$$

$$N_{\mu} = 2.5 \times 10^{15} - 5 \times 10^{16}$$

$$P_{\mu} \sim -1$$

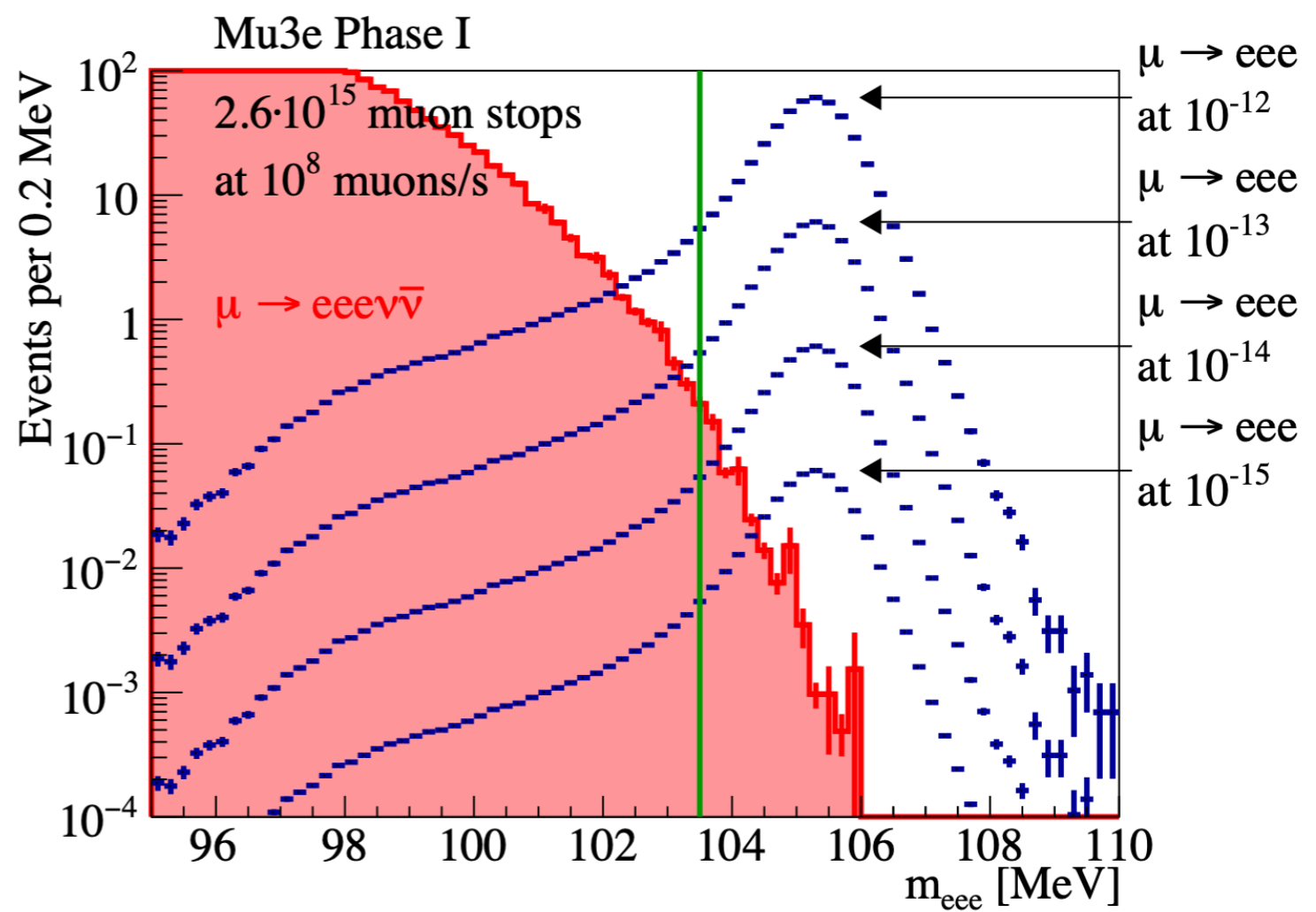


Michel

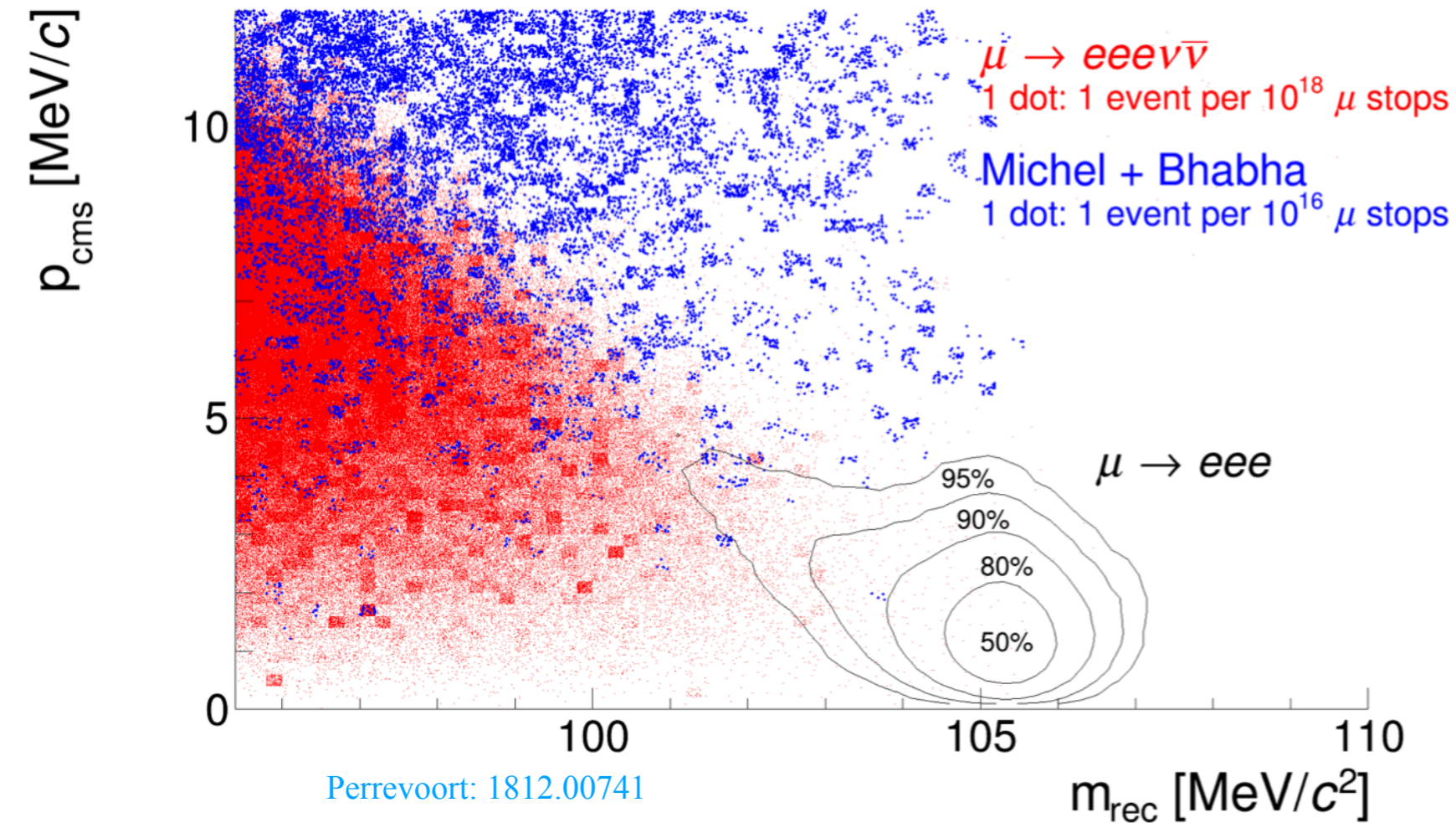
$$\mu^+ \rightarrow e^+ \nu \bar{\nu}$$

Internal conversion

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



Mu3e Phase I Simulation



Bhabha

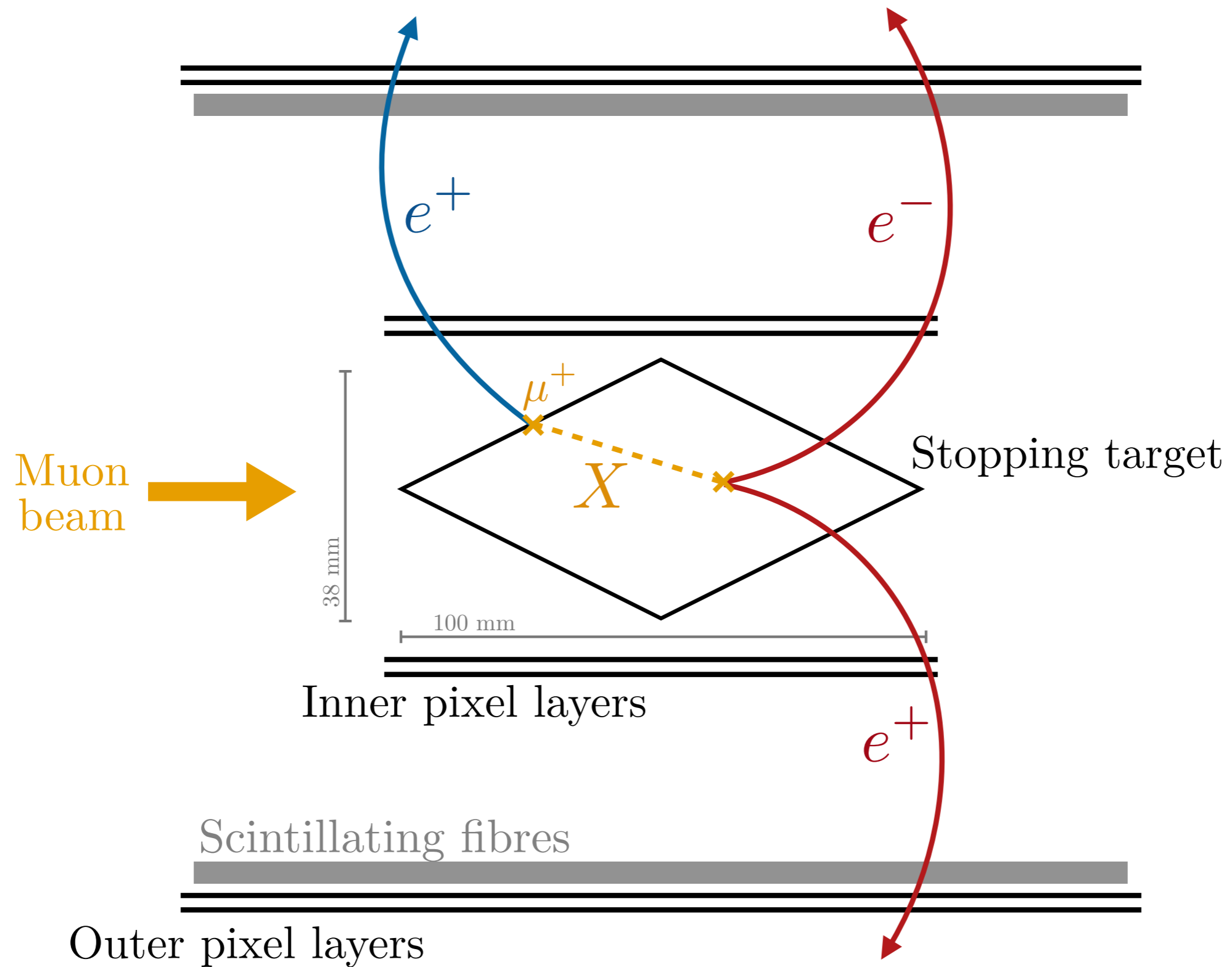
$$\mu^+ \rightarrow e^+ \nu \bar{\nu}$$

+ coincidence

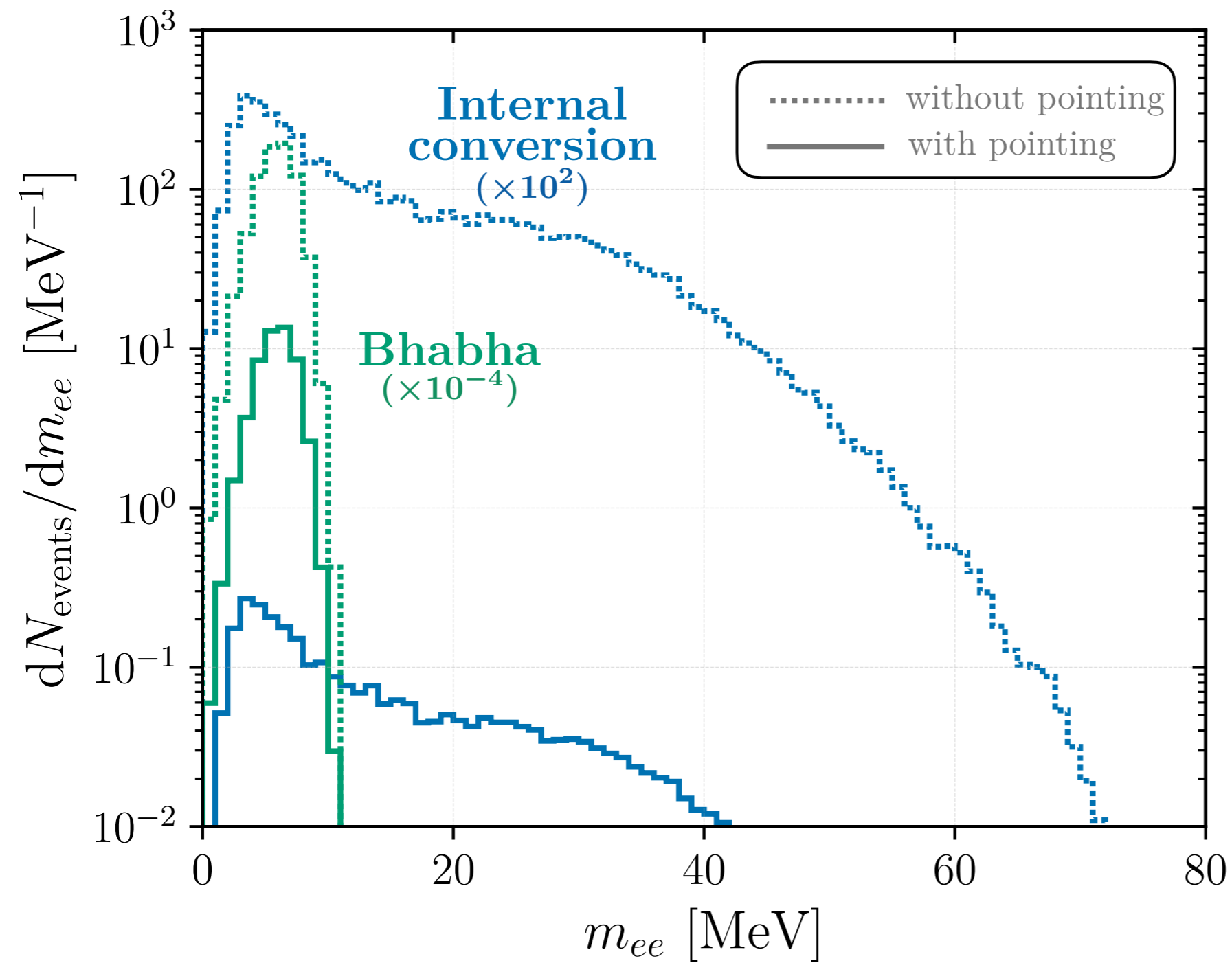
$$\mu^+ \rightarrow e^+ \nu \bar{\nu}$$

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

Displaced vertices



Backgrounds



No “neutrinos”

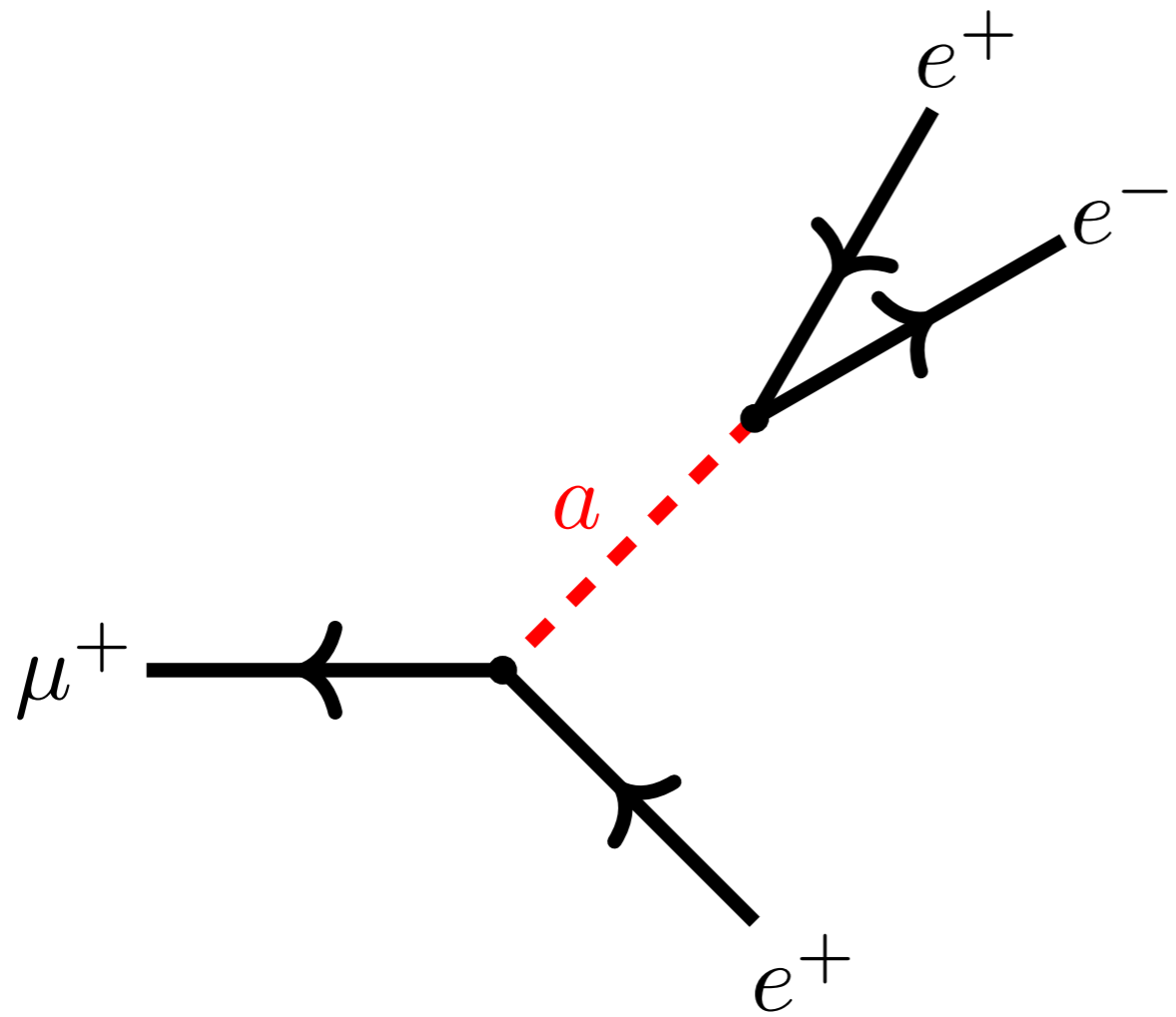
$$p_{\cancel{E}}^{\mu} = 0$$

With “neutrinos”

$$p_{\cancel{E}}^2 > 0$$

LFV ALP

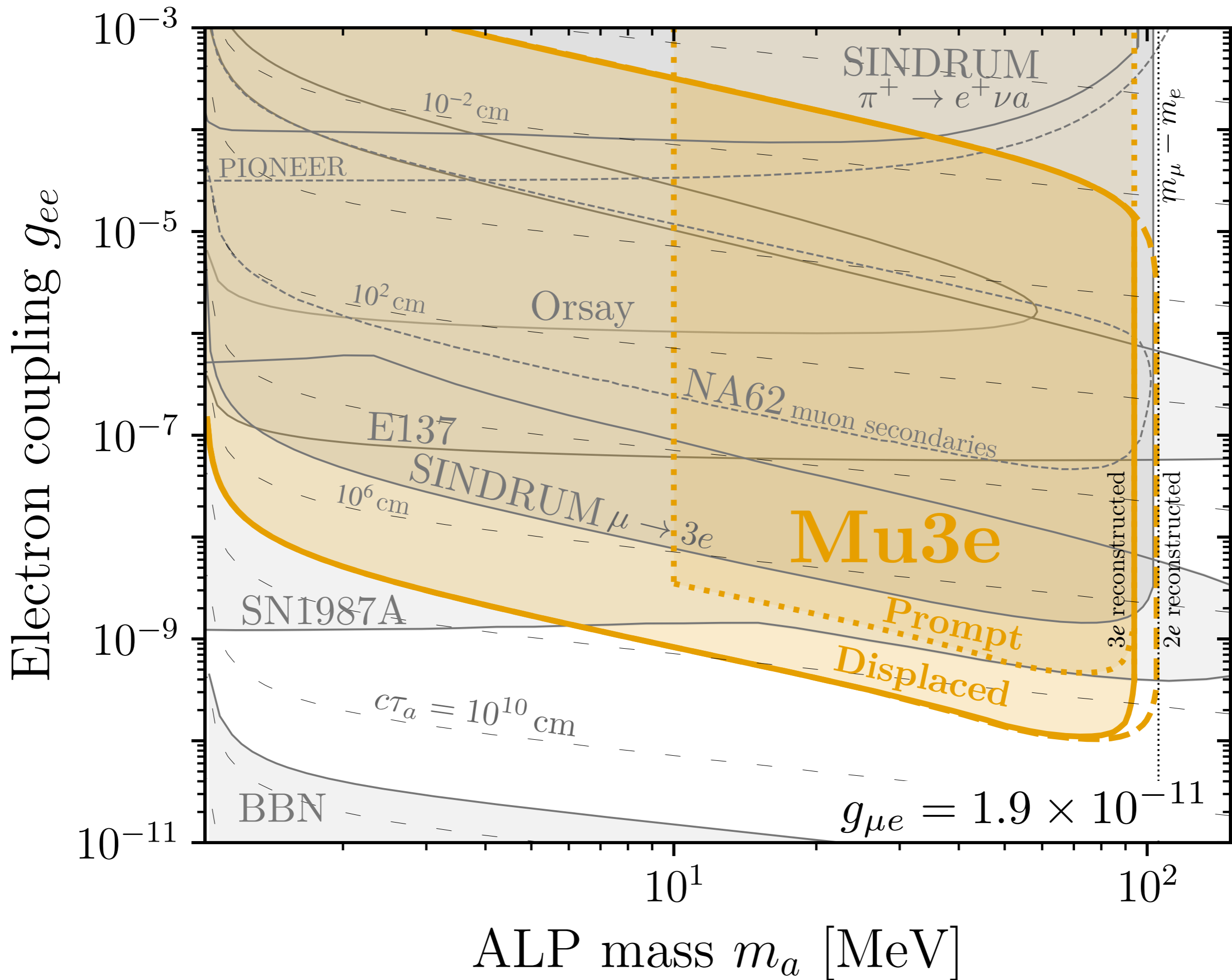
$$\mathcal{L}_a = g_{ee} a \bar{e} \gamma_5 e + g_{\mu e} a \bar{\mu} \gamma_5 e$$

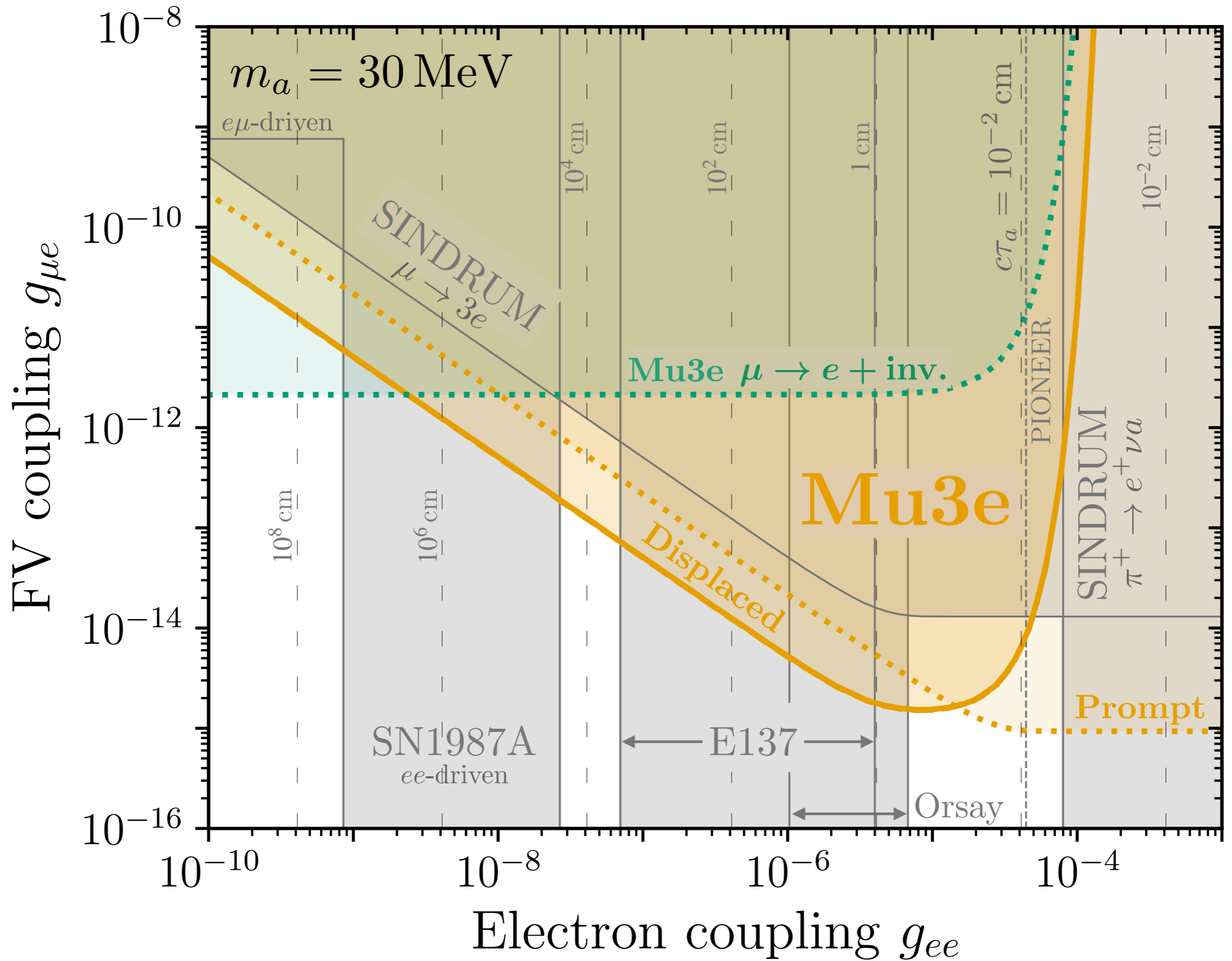


Pointing



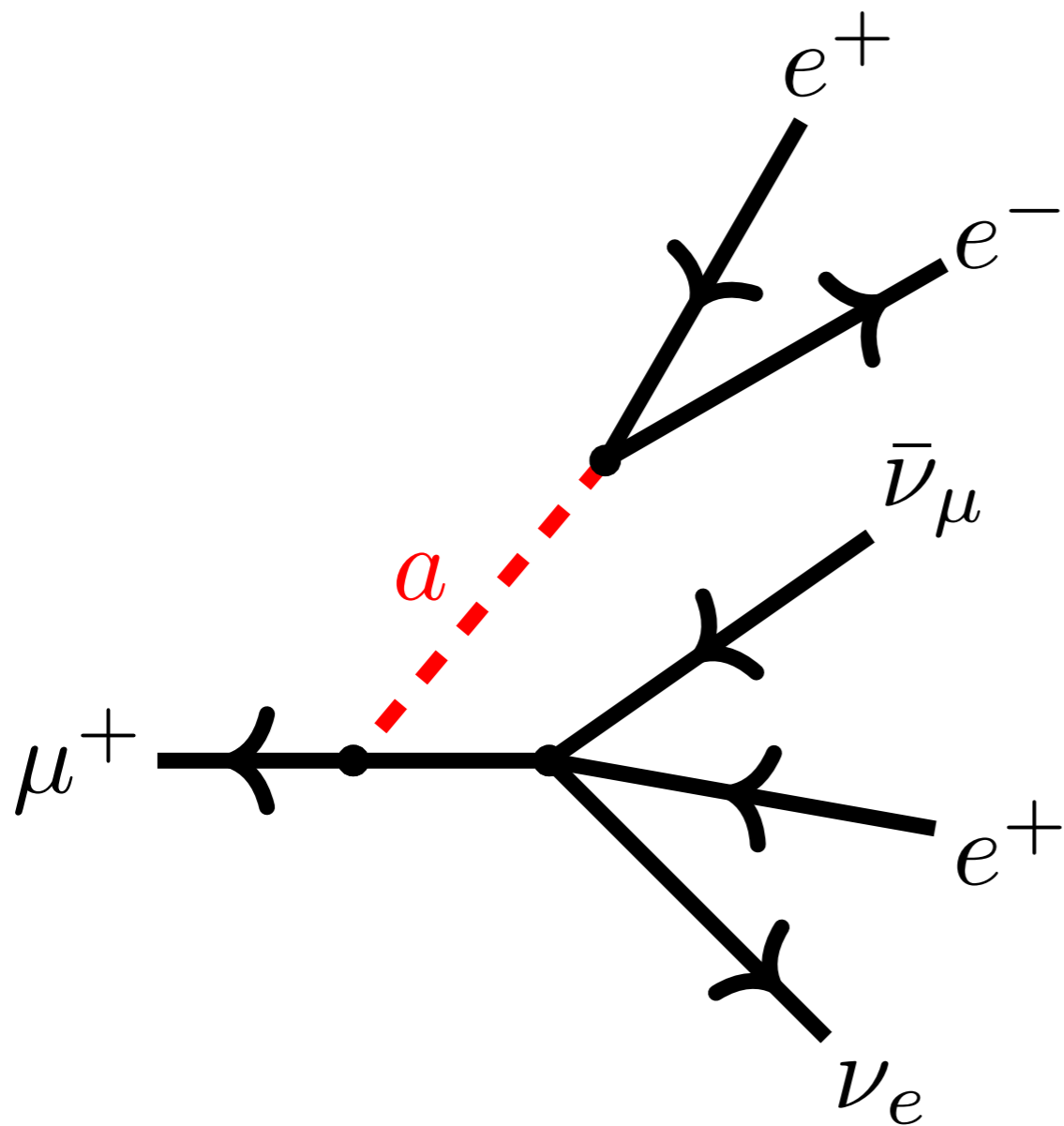
Mass reconstruction





LFC ALP

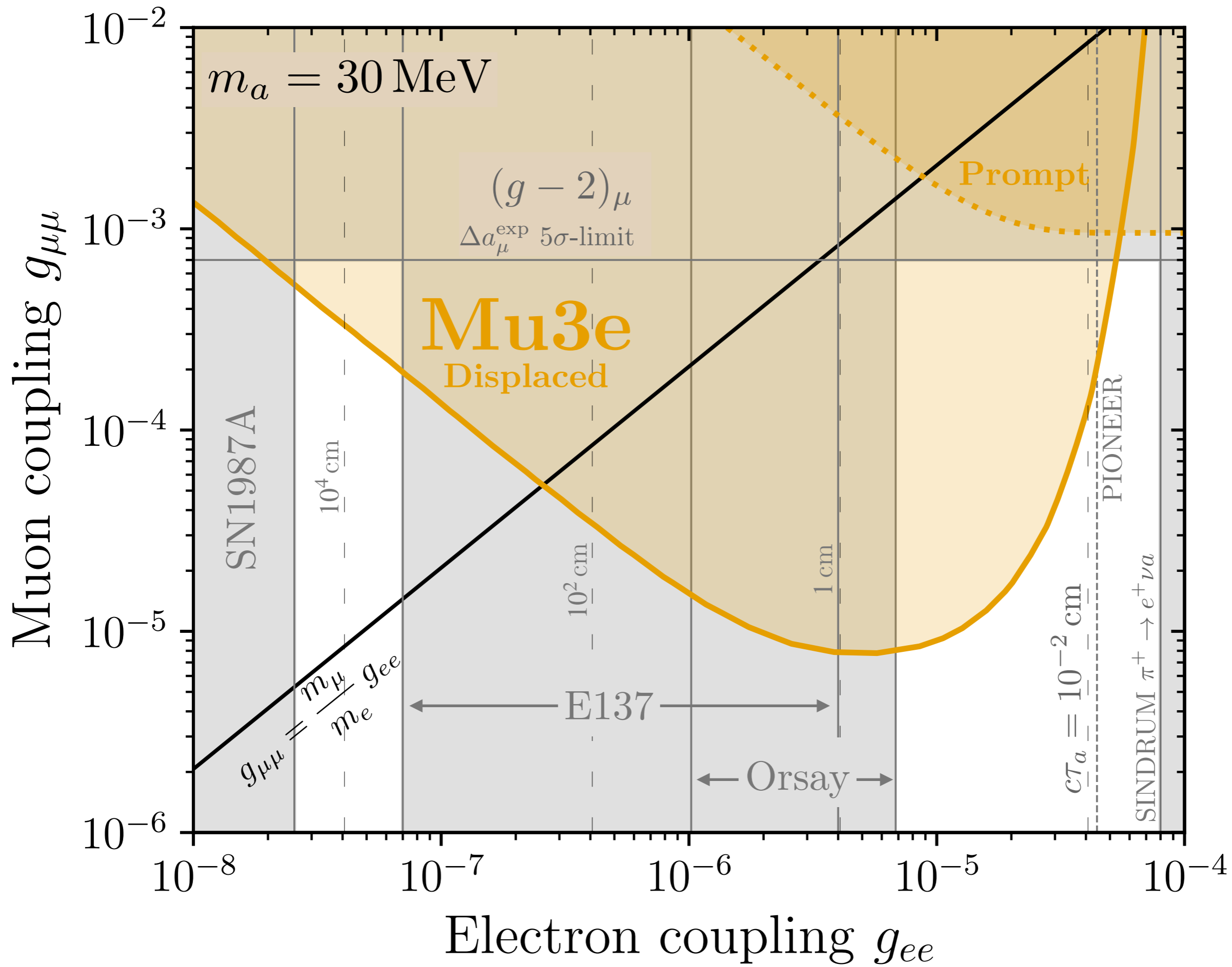
$$\mathcal{L}_a = g_{\mu\mu} a \bar{\mu} \gamma_5 \mu + g_{ee} a \bar{e} \gamma_5 e$$



Pointing



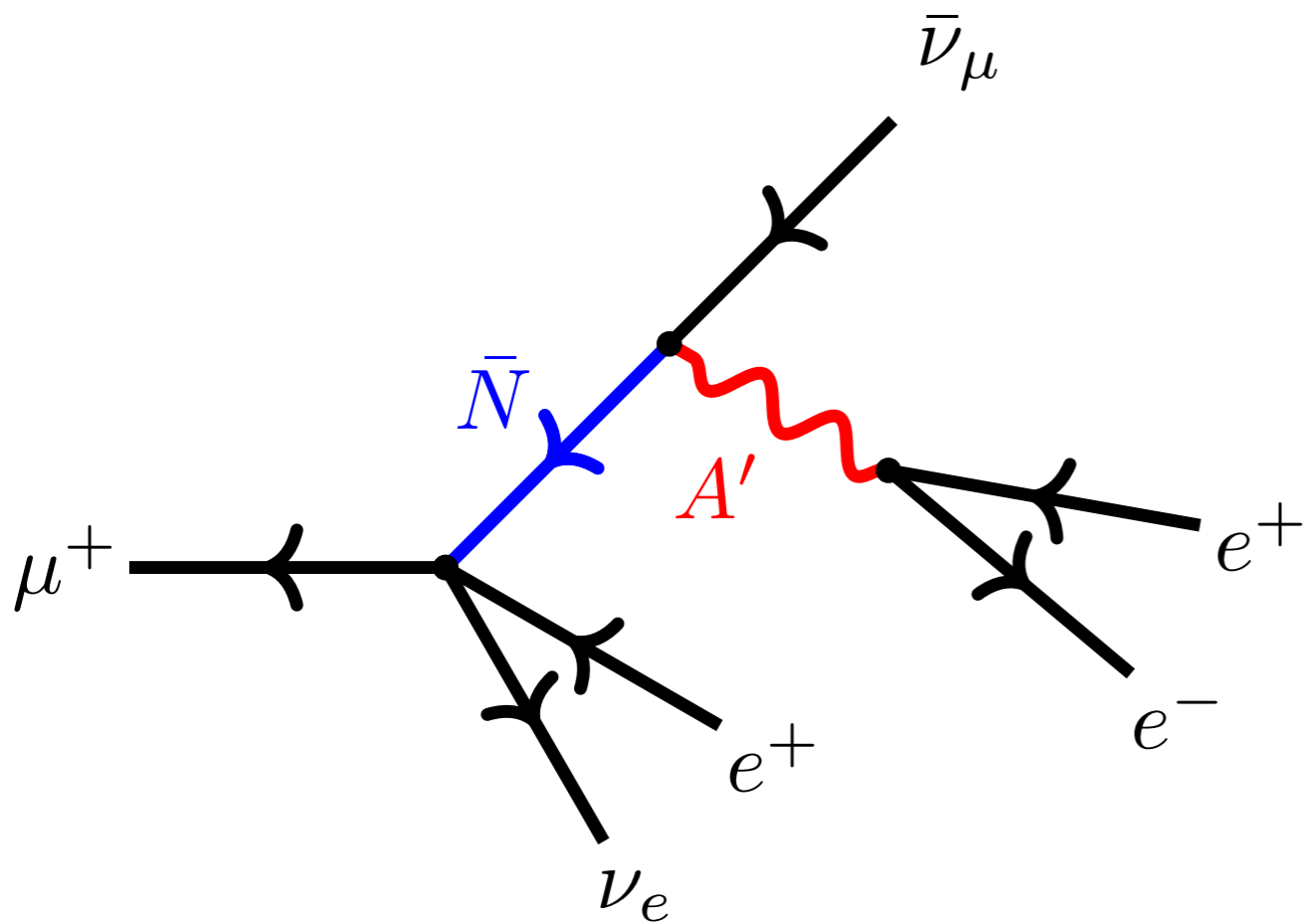
Mass reconstruction



HNL + Dark Photon

Ballett, Hostert, Pascoli: 1903.07589

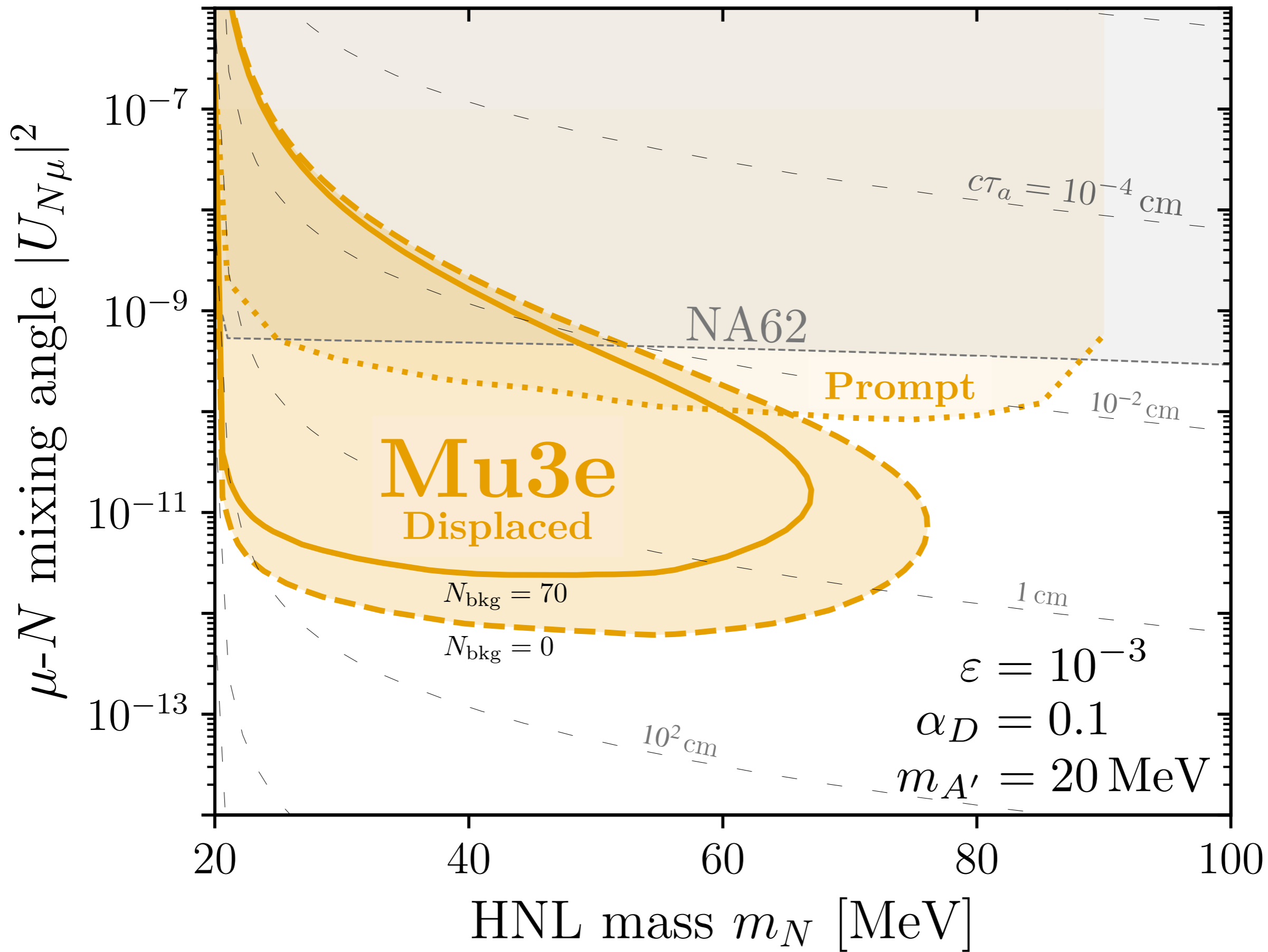
$$2m_e < m_{A'} < m_N < m_\mu$$



Pointing



Mass reconstruction

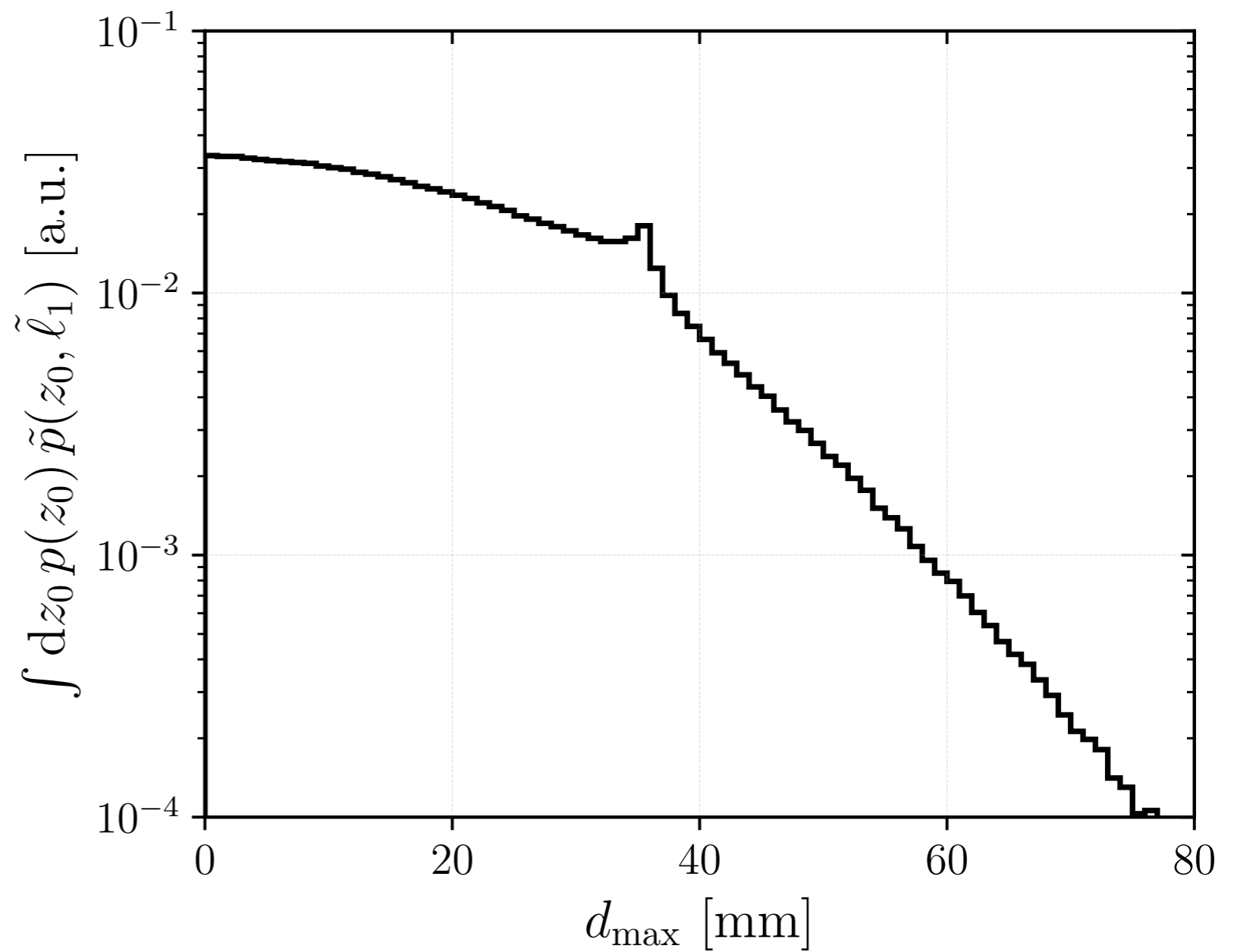
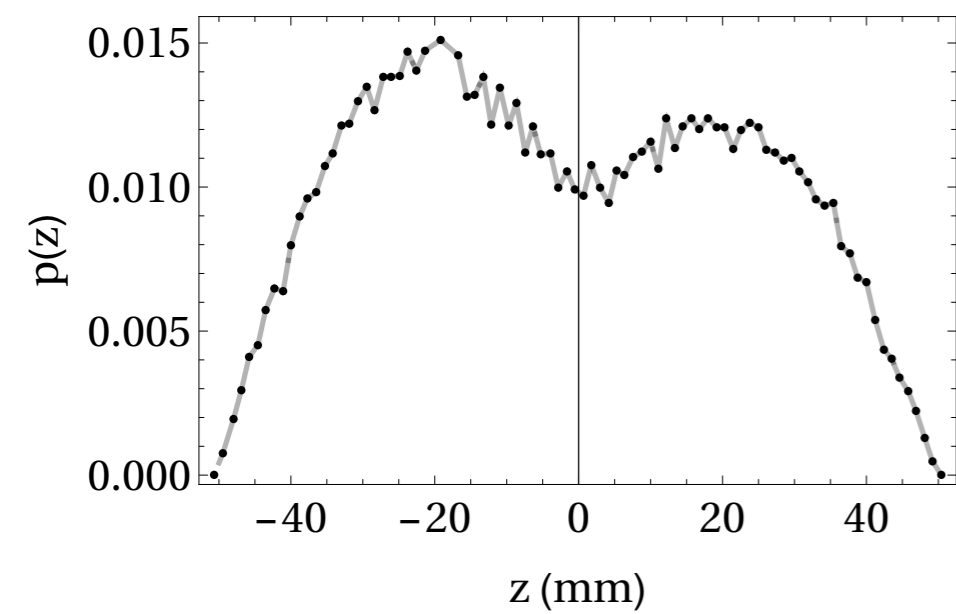


Summary

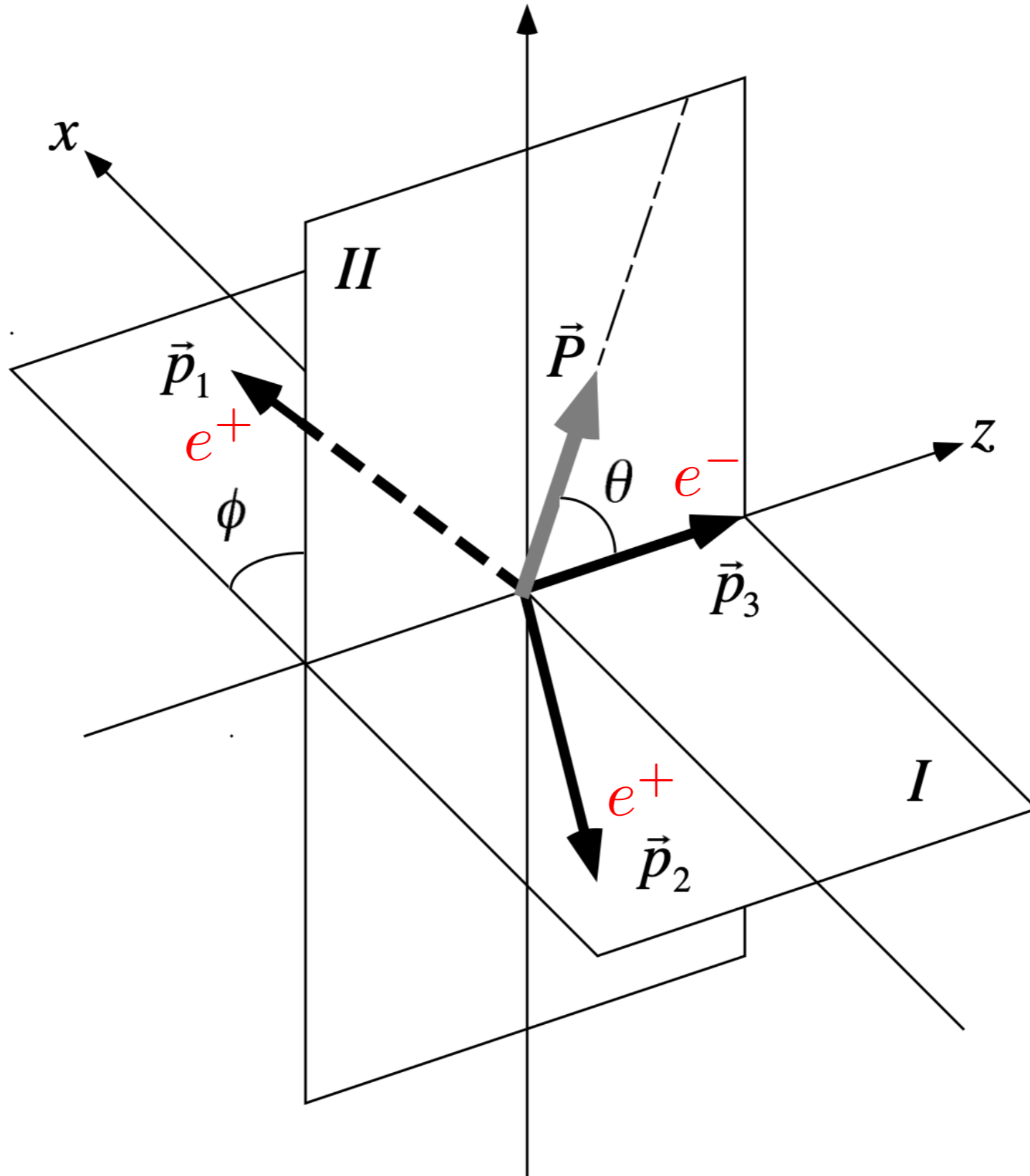
- Muon experiments: COOL
- Displaced vertices: COOL
- CP violation: COOL (but you don't know how much)

Backup slides

$$P(\ell) = \int dz_0 d\phi d\cos\theta p(z_0) \times A(z_0, \phi, \cos\theta) \times [e^{-\ell_0/\ell} - e^{-\ell_1(z_0, \phi, \cos\theta)/\ell}]$$



$$A_T^{\mu 3e} \equiv \frac{\Gamma(\mu \rightarrow 3e; c_\phi > 0) - \Gamma(\mu \rightarrow 3e; c_\phi < 0)}{\Gamma(\mu \rightarrow 3e)}$$



$\Lambda = 10^7 \text{ GeV}$

