BSM OPPORTUNITIES WITH MUONS IN THE FPF

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FPF THEORY DAYS

CERN

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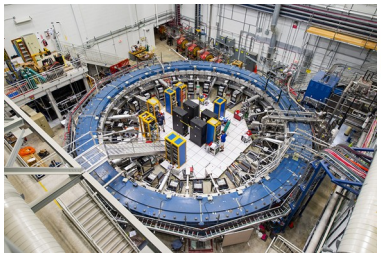
GENERAL MOTIVATIONS

- FPF will deal the most energetic, intensive muon beam in laboratory setup
- Could be prototype for future high-energy muon beam-dump at the muon collider

C. Cesarotti, S. Homiller, R.K. Mishra, M. Reece, PRL 130 (2023) 7, 071803

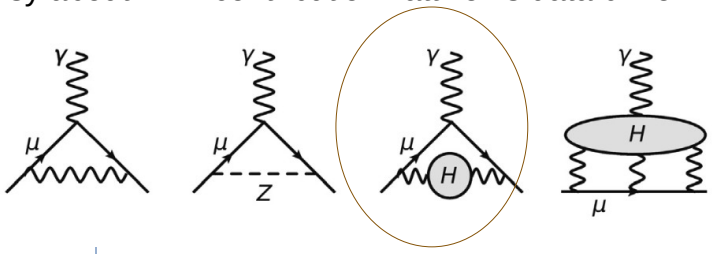
- $(g\text{-}2)_\mu$ – discrepancy between SM predictions and past BNL+new Fermilab measurements

SM : controversy about HVP contribution. lattive vs data-driven



$$\Delta a_\mu^{\mathrm{FNAL+BNL}} = (24.9 \pm 4.8) \times 10^{-10}$$

5.1σ deviation from the SM prediction, but...



- Potential room for new physics

Sample models: **leptophilic scalar** with $g_\ell \propto m_\ell$,

$$\mathcal{L} \supset \frac{1}{2}(\partial_\alpha S)^2 - \frac{1}{2}m_S^2 S^2 - \sum_{\ell=e,\mu,\tau} g_\ell S \bar{\ell}\ell,$$

arises from $\mathcal{O}_5 = \frac{1}{\Lambda}(\bar{L}E)HS$

UV completions: ~2HDM B. Batell etal, PRD 95 (2017) 7, 075003

vector-like fermions C.-Y. Chen, etal PRD 93 (2016) 3, 035006

PROBLEM: BaBaR & other searches tend to exclude $(g\text{-}2)_\mu$ region

muonphilic scalar

$$g_{\mu,S} S \bar{\mu}\mu \quad (\text{scalar}),$$

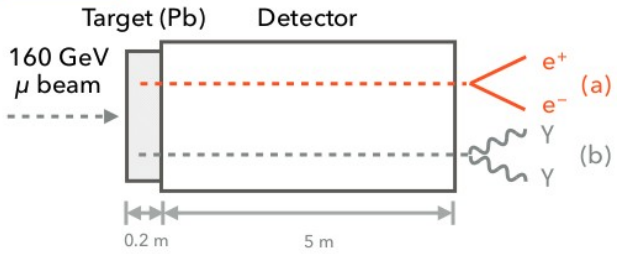
S → μμ, γγ, χχ

BaBaR bounds avoided

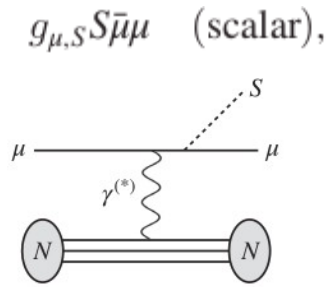
FPF AS A MUON BEAM DUMP EXPERIMENT

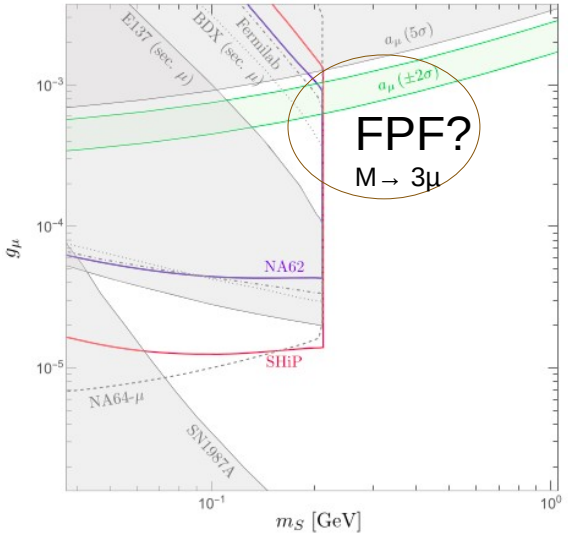
- Some alternative proposals: NA64μ, muons from proton beam-dump exps. (NA62, SHiP)

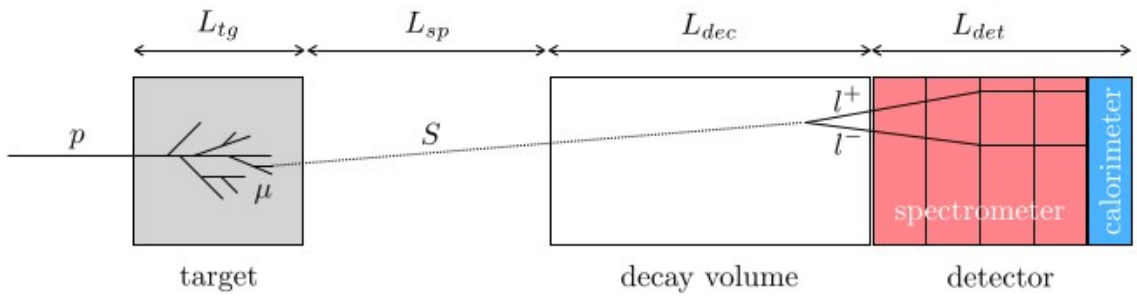
NA64-TYPE C.-Y. Chen, M. Pospelov, Y.-M. Zhong, PRD 95, 115005

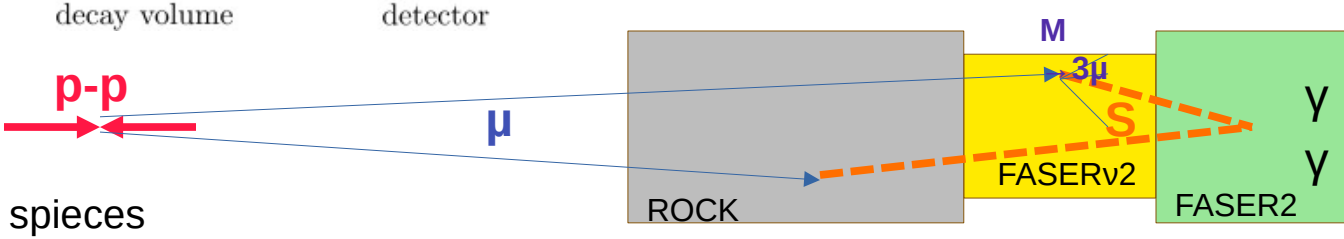


C. Rella, B. Dobrich. T.-T. Yu. PRD 106. 035023 (2022)









- Advantage of the FPF:

larger energy =>
produce directly heavier (B)SM spieces
with larger boost factors (= separation of prod. and decay positions)

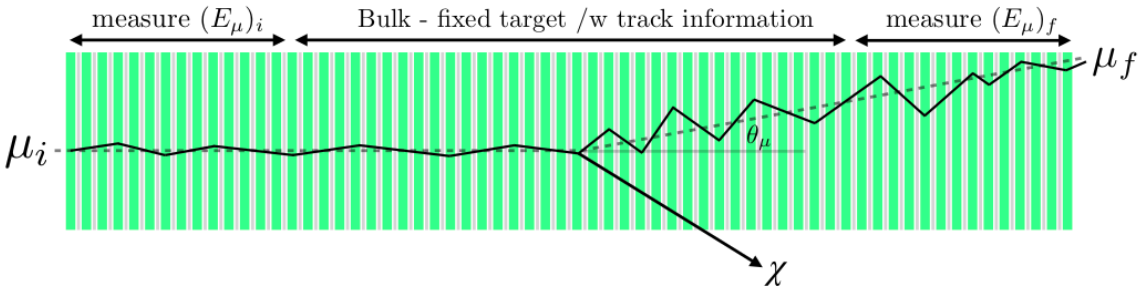
- ...but, emulsion detectors treat muons as BG to neutrino measurements,

- lowering the muon rate is best for the main physics case (& avoid saturating emulsion with muon tracks)
- muon rate can increase by 1-2 orders of magnitude off the beam collision axis (spectrum there?)

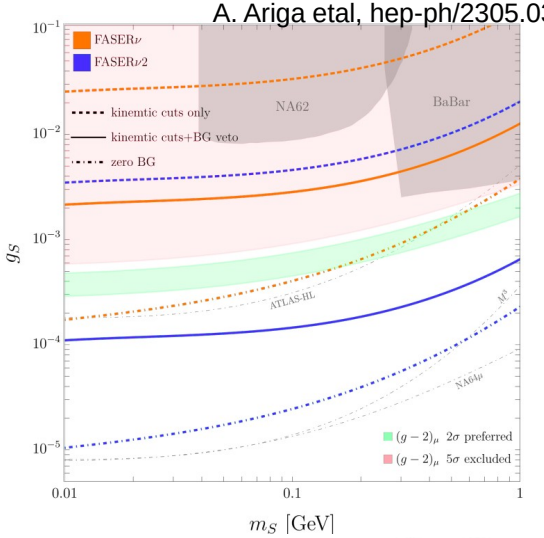
→ **DEDICATED FPF MUON EXPERIMENT?**

FPF AS A MUON BEAM DUMP EXPERIMENT

- Missing-momentum signatures in emulsion



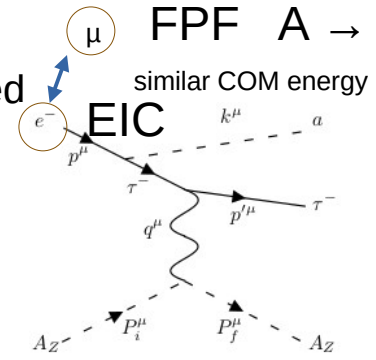
A. Ariga etal, hep-ph/2305.03102

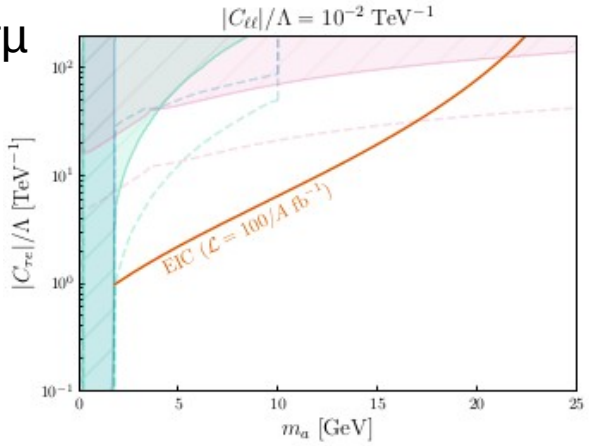


- Probe charged Lepton Flavor Violation (cLFV)

If diagonal coupling are suppressed,
stringent bounds from LFV decays can be avoided

$$\mathcal{L}_\ell = \frac{C_{\ell\ell'}}{\Lambda}\partial_\mu a \sum_{\ell\ell'} \bar{\ell}\gamma^\mu \left(\sin\theta_{\ell\ell'} - \cos\theta_{\ell\ell'}\gamma_5\right)\ell' + h.c.$$





H. Davoudiasl, R. Marcarelli, E.T. Neil, JHEP 02 (2023) 071

- Opportunities with high-energy μ-e scatterings?
- Other ideas?