FLArE search for millicharged particles etc.

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ASTROCENT

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Millicharged particles (mCPs)

Quantised Singularities in the Electromagnetic Field.

By P. A. M. Dirac, F.R.S., St. John's College, Cambridge.

(Received May 29, 1931.)

a) important experimental test of charge quantization

Search for particles with a very small electric charge $\varepsilon \equiv q/e \ll 1.$

b) motivated by GUT and string theories

c) also arise when SM is extended with a massless gauge boson (dark photon)
kinetically mixed with the SM photon

d) rich literature: also dedicated detector at the LHC (milliQan)

e) one of the benchmark scenarios typically considered in light new physics searches (e.g. PBC,...)

Idea for the Forward Physics Facility: FORMOSA

S. Foroughi-Abari, F. Kling, Y.-D. Tsai, FORMOSA, 2010.07941

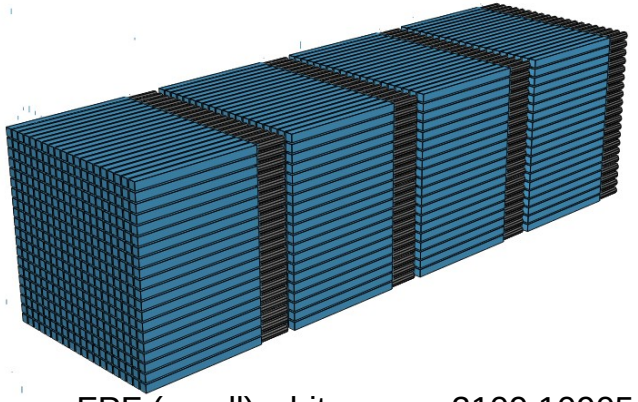
– milliQan-like detector placed in the FPF

sensitive to the small dE/dx of a particle with $Q \lesssim 0.1e$,

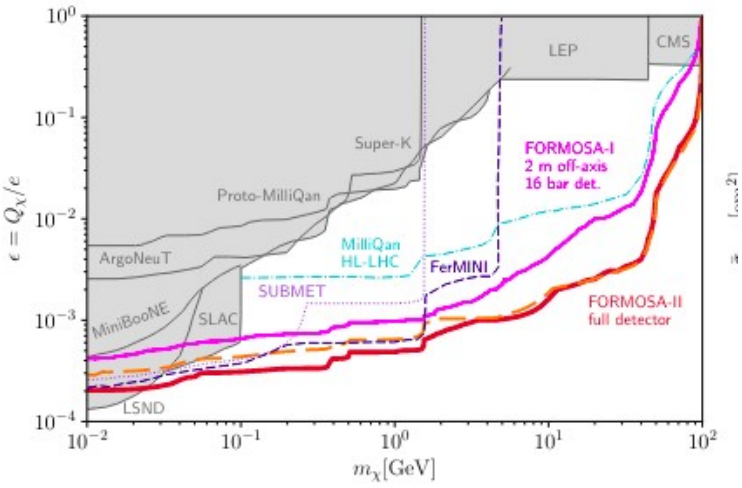
plastic scintillator is chosen as the detection medium

– size: 1m x 1m x 5m
segmented into 4 longitudinal ``layers''
each layer contains 100 scintillator bars
(5cm x 5cm x 1m) organized in a 10 x 10 array

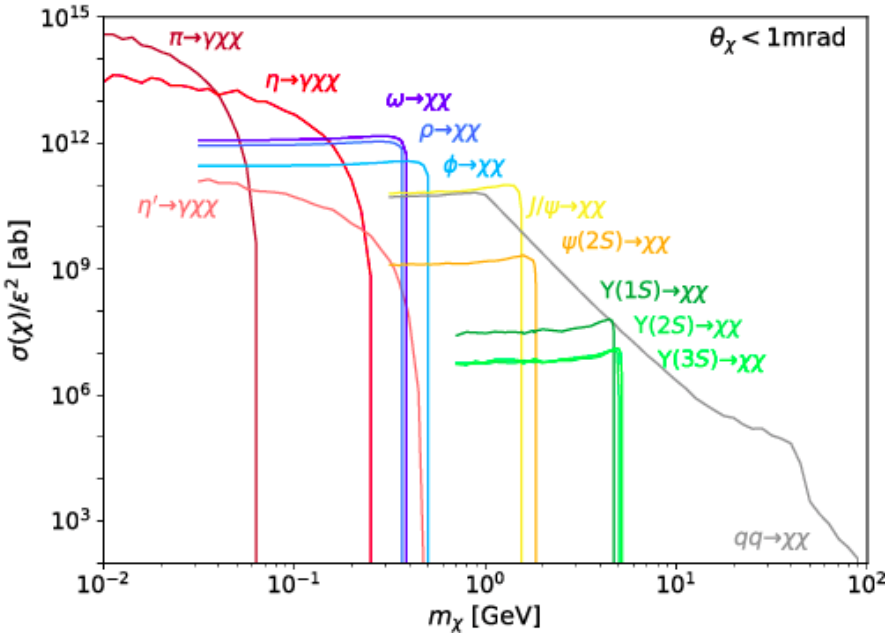
– signature: 4 time-coincident hits (N_{PE}>1)



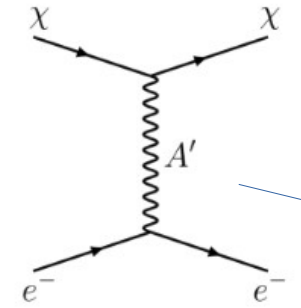
FPF (small) whitepaper, 2109.10905



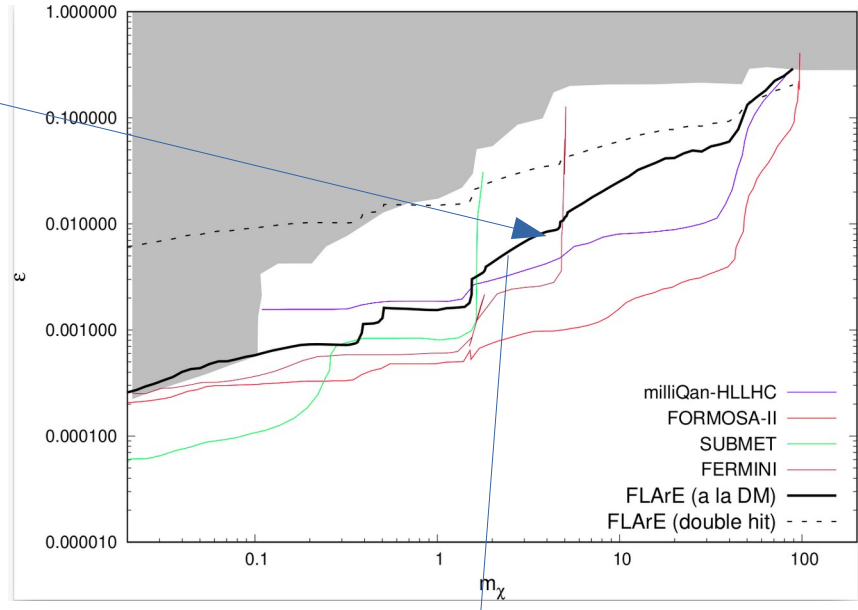
FLArE search strategy: a la DM scattering



S. Foroughi-Abari, F. Kling, Y.-D. Tsai, FORMOSA, 2010.07941



30 MeV < E_e < (3 GeV)

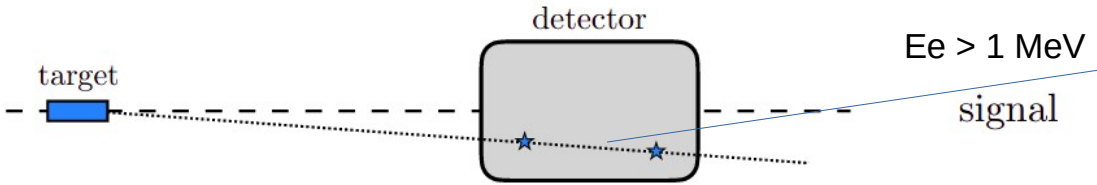


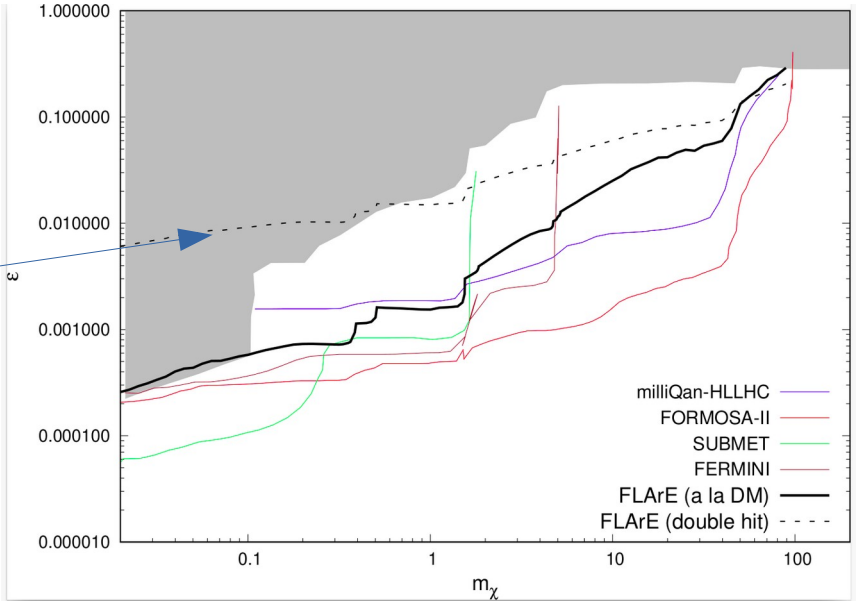
ν-induced BG is suppressed
we assume μ-induced BG is rejected

Other search strategies

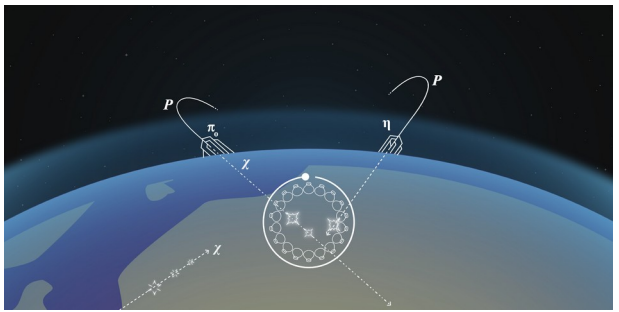
1) Softer double bangs (colinear, time-coincident)

Analysis for LarTPC: R. Harnik, Z. Liu, O. Palamara, 1902.03246





Analysis for IceCube: C.A. Arguelles, K.J. Kelly, V.M. Munoz, 2104.13924



2) Can we search for faint tracks left by mCPs in FLArE?

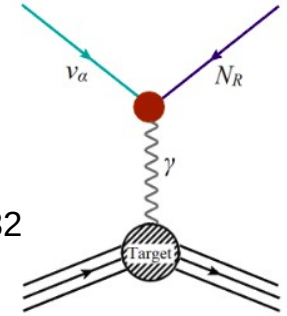
(based on ionization)

DM scattering: 2101.10338 (el. scat.), 2107.00666 (nuclear scat.), 2111.10343 (hadrophilic DM)

Other interesting ideas (possibly different signatures)

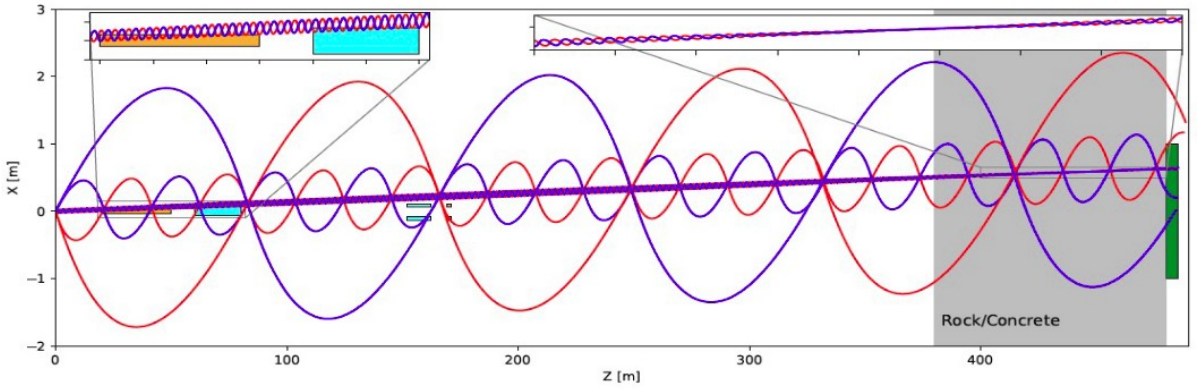
a) Neutrino up-scattering into heavy neutral lepton
Possible subsequent decay (double-bang): $N_R \rightarrow \nu\gamma$

K. Jodłowski, ST, 2011.04751
A. Ismail, S. Jana, S.M. Abraham, 2109.05032



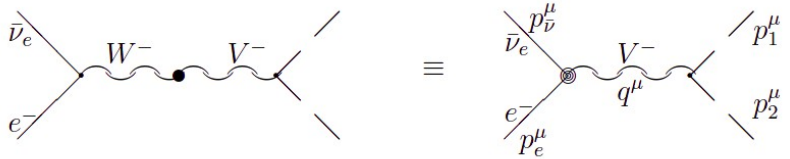
b) Quirks (J. Kang, M.A. Luty, 0805.4642)
Postulated particles charged under a hidden strong force
If they mass exceeds the hidden scale m >> Λ_{hidden}, they do not hadronize
Instead, they are pair produced and remain bounded => they leave very strange tracks

Li, Pei, Ran, Zhang, 2108.06748



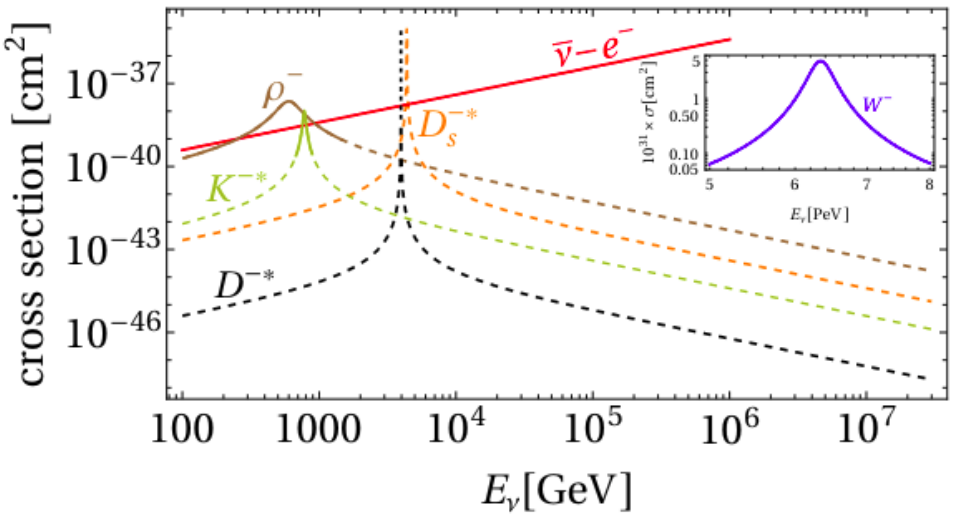
Other interesting ideas (possibly different signatures) (2)

c) Rare neutrino scattering process in the SM



$$\bar{\nu}_e e^- \to \mathfrak{m} \to X$$

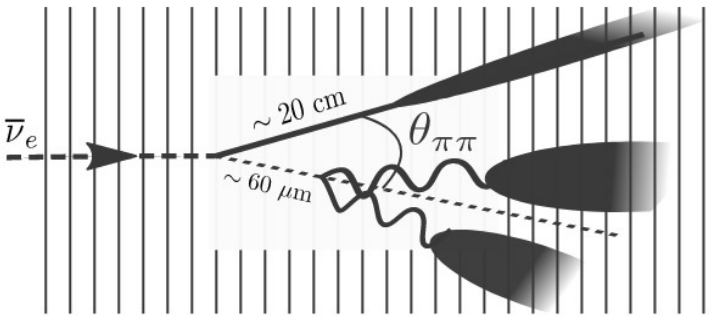
Total absorption of the electron anti-neutrino



Resonances in $\bar{\nu}_e - e^-$ scattering below a TeV

Vedran Brdar, André de Gouvêa, Pedro A. N. Machado, Ryan Plestid

2112.03283



Most promising channel: $\rho \to \pi^- \pi^0$

Overlapping forward charged pion and γγ EM shower

Experiment	ρ^-, $\pm\Gamma/2$	ρ^-, $\pm 2\Gamma$	K^{-*}, $\pm\Gamma/2$	K^{-*}, $\pm 2\Gamma$
FASERν	0.3	0.5	–	–
FASERν2	23	37	0.7	3
FLArE-10	11	19	0.3	2
FLArE-100	63	103	2	8
DeepCore	3 (1)	5 (2)	–	–
IceCube	8 (40)	(17, 83)	–	–

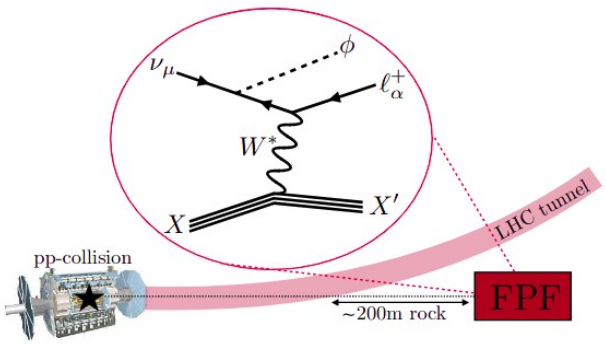
Other interesting ideas (possibly different signatures) (3)

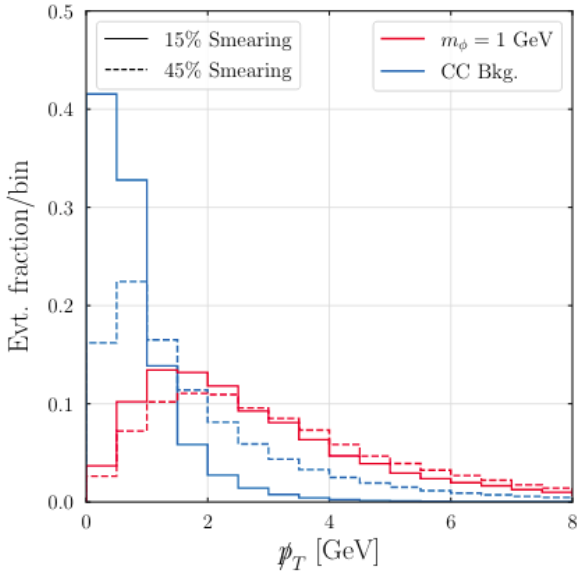
d) Neutrino-philic DM – neutrino CC scatterings with large MET

2111.05868

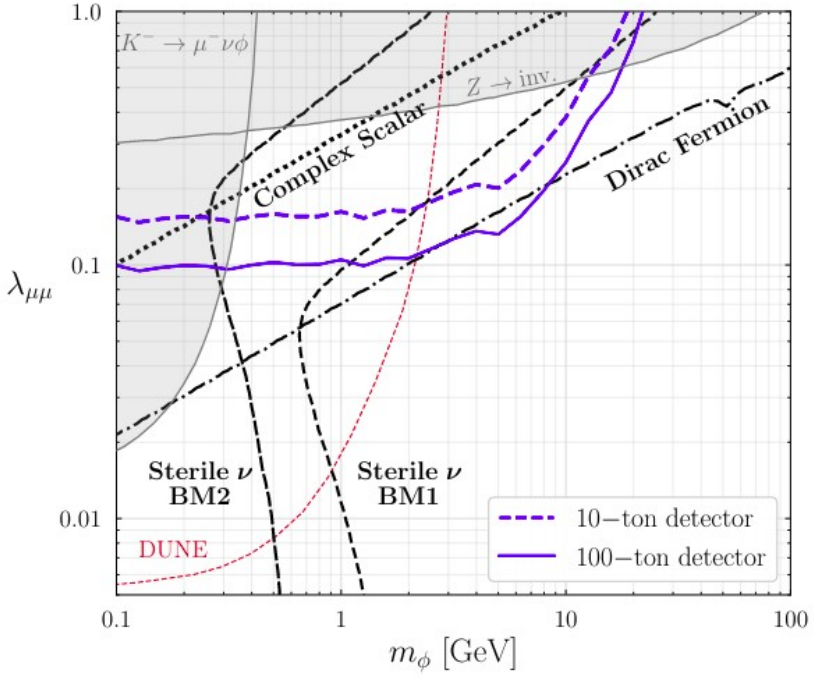
Probing Neutrino-Portal Dark Matter at the Forward Physics Facility

Kevin J. Kelly,[1,2,*] Felix Kling,[3,4,†] Douglas Tuckler,[5,‡] and Yue Zhang[5,§]





$$\mathcal{L} \supset \frac{1}{2}\lambda_{\alpha\beta}\nu_\alpha\nu_\beta\phi + \text{h.c.}\ ,$$



Summary

– millicharged particles:
interesting and widely-discussed target for light new physics searches
Forward Physics Facility – large flux of far-forward mCPs produced

– Currently proposed FORMOSA,
FLArE can contribute with the mCP-electron scattering signature

– **Could FLArE see faint tracks generated by mCP ionization?**

– There could be many more interesting types of searches to be performed in FLArE
depending on detector capabilities