WG5 (BSM) SUMMARY

Sebastian Trojanowski

AstroCeNT, Nicolaus Coperenicus Astronomical Center of the Polish Academy of Sciences
& National Centre for Nuclear Research, Poland

(sebastian.trojanowski@ncbj.gov.pl)

FPF THEORY DAYS
CERN

September 19, 2023

WG leaders: B. Batell, ST

FPF BSM LANDSCAPE

FPF whitepaper, 2203.05090

ST, 2305.04663
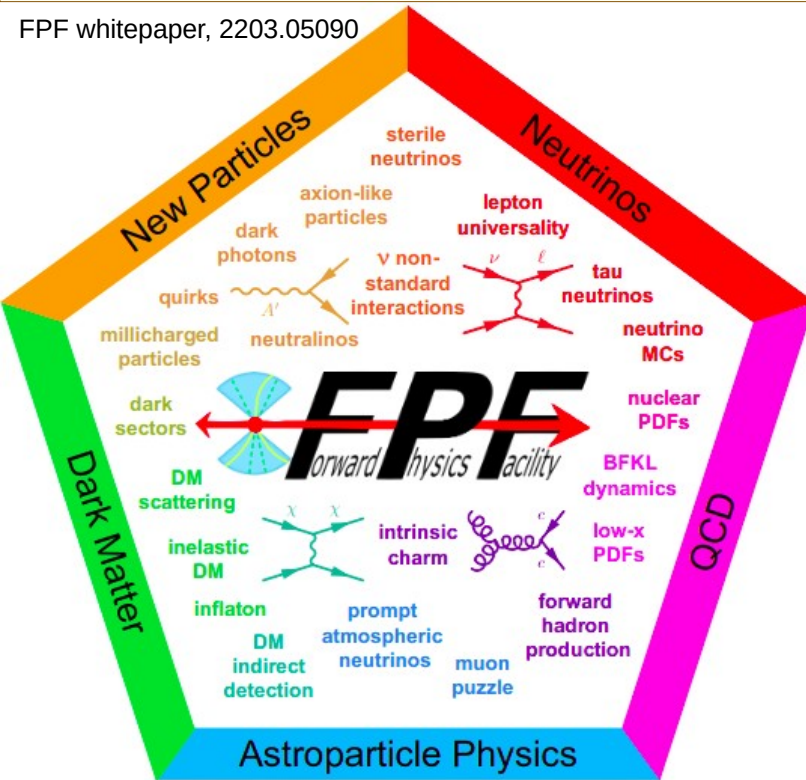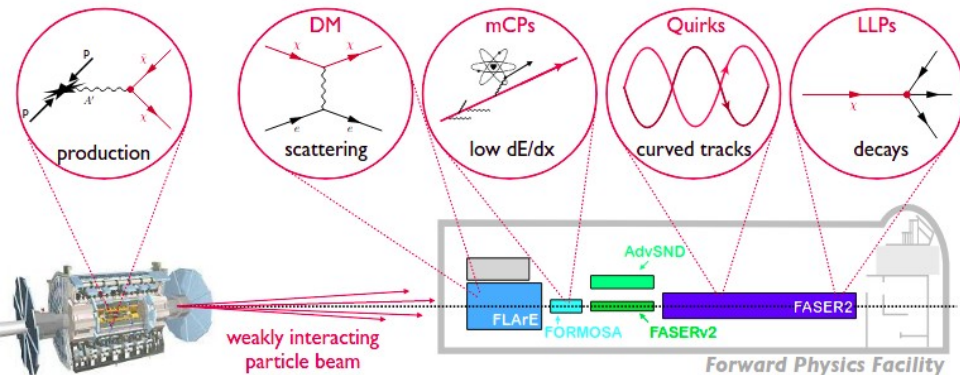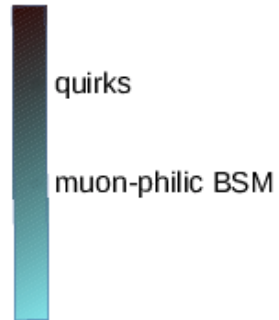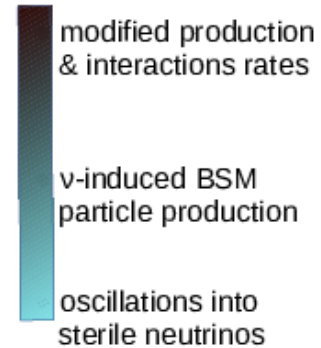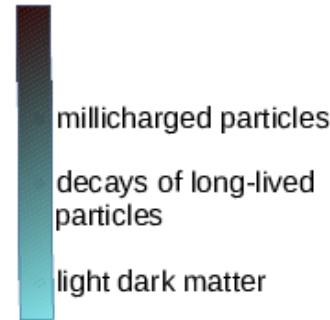
NEUTRINO BSM PHYSICS

a) Neutrino charged-current NSI

A. Falkowski, M. González-Alonso, J. Kopp, Y. Soreq, Z. Tabrizi, hep-ph/2105.12136

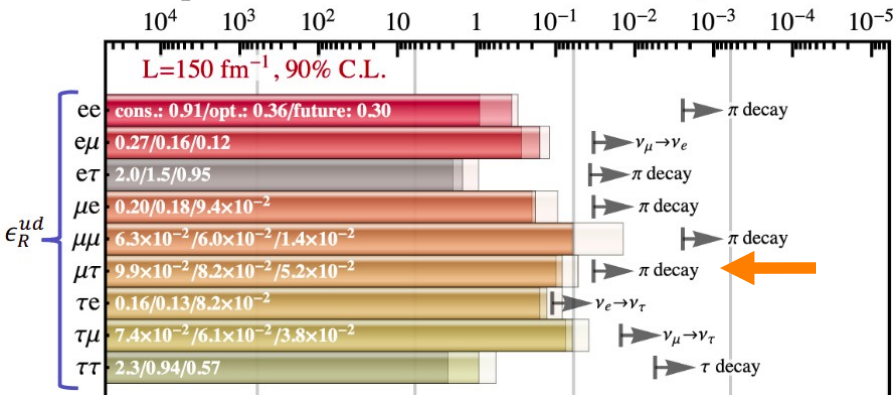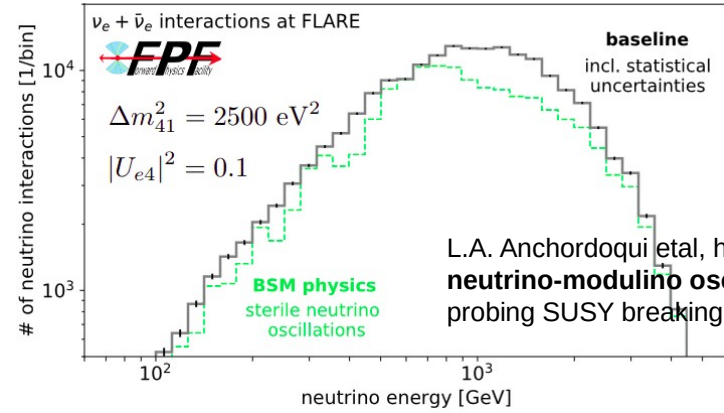$$\mathcal{L}_{\mathrm{WEFT}} \supset -\frac{2V_{jk}}{v^2}\Big\{ [\mathbf{1} + \epsilon_L^{jk}]_{\alpha\beta}(\bar{u}^j\gamma^\mu P_L d^k)(\bar{\ell}_\alpha\gamma_\mu P_L\nu_\beta) + [\epsilon_R^{jk}]_{\alpha\beta}(\bar{u}^j\gamma^\mu P_R d^k)(\bar{\ell}_\alpha\gamma_\mu P_L\nu_\beta)$$

$$+ \frac{1}{2}[\epsilon_S^{jk}]_{\alpha\beta}(\bar{u}^j d^k)(\bar{\ell}_\alpha P_L\nu_\beta) - \frac{1}{2}[\epsilon_P^{jk}]_{\alpha\beta}(\bar{u}^j\gamma_5 d^k)(\bar{\ell}_\alpha P_L\nu_\beta)$$

$$+ \frac{1}{4}[\epsilon_T^{jk}]_{\alpha\beta}(\bar{u}^j\sigma^{\mu\nu}P_L d^k)(\bar{\ell}_\alpha\sigma_{\mu\nu}P_L\nu_\beta) + \mathrm{h.c.}\Big\}.$$

b) Neutrinophilic dark sector

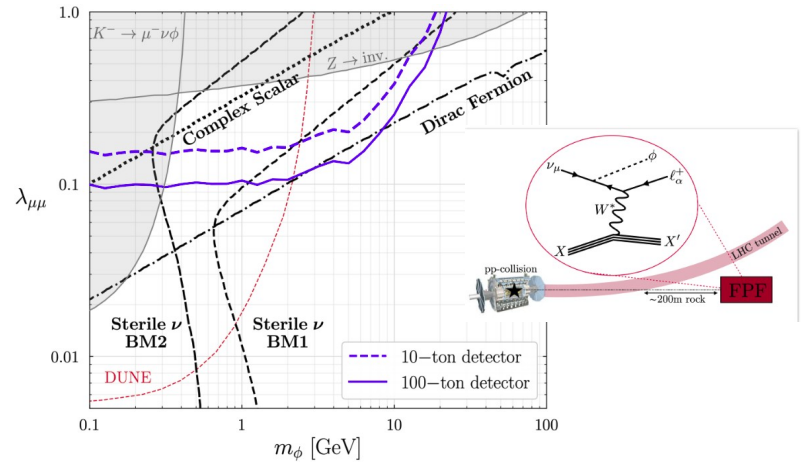K.J. Kelly, F. Kling, D. Tuckler, Y. Zhang, hep-ph/2111.05868

c) Neutrino oscillations

L.A. Anchordoqui etal, hep-ph/2308.11476
neutrino-modulino oscillations
probing SUSY breaking scale

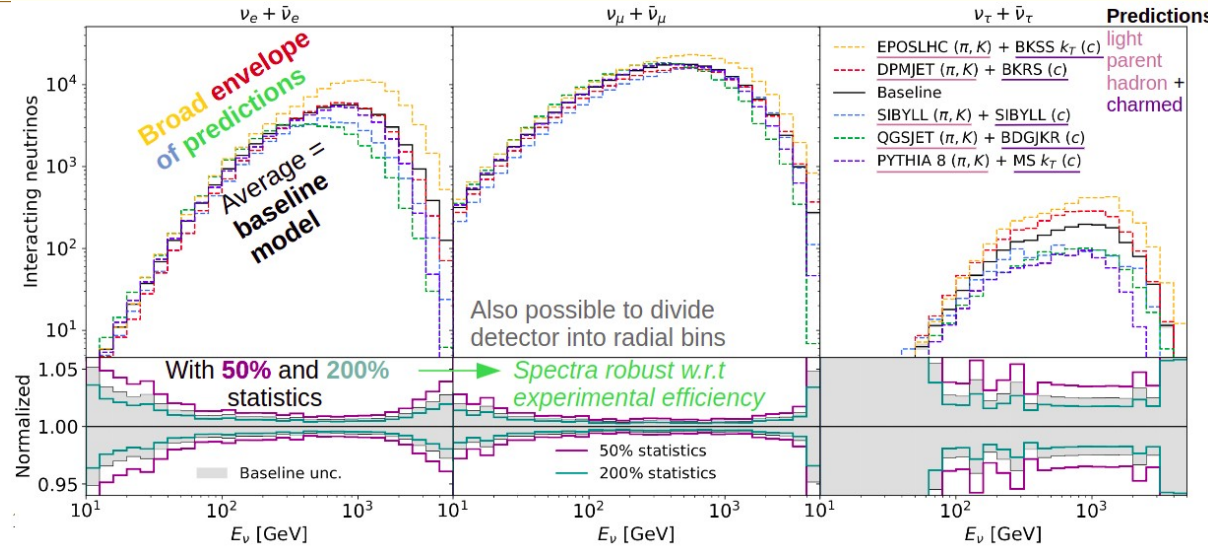## d) Electromagnetic properties of neutrinos
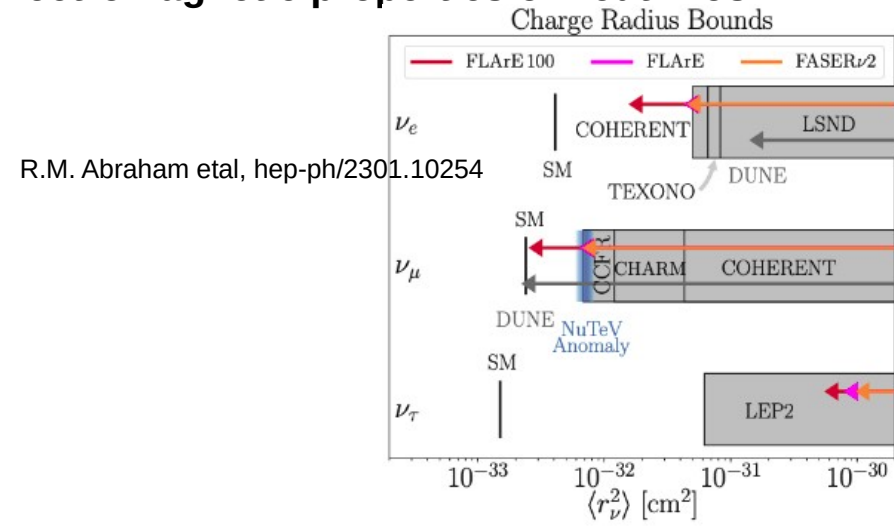
R.M. Abraham etal, hep-ph/2301.10254

# NEUTRINO BSM VS SM UNCERTAINTIES

Talk: Toni Makela

● Neutrino flux predictions still have substantial uncertainties

● How to search for new physics then?

● Combine multiple observables
(energy, pseudorapidity, different flavors)

● SM fluxes correlated by
         the parent meson spectra
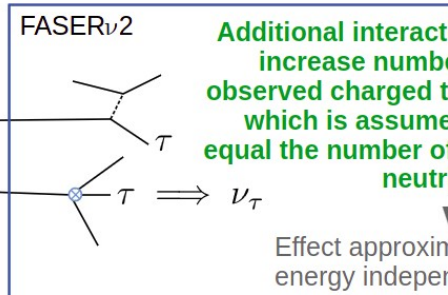
● New effects might clearly differ

$$\mathcal{L} = \mathcal{L}_{\rm SM} - \frac{2V_{ud}}{v^2} \times (\bar{u}\gamma^{\kappa}P_R d) \times \left[\epsilon_R^{\mu\tau}(\bar{\ell}_{\mu}\gamma_{\kappa}P_L\nu_{\tau}) + \epsilon_R^{\tau e}(\bar{\ell}_{\tau}\gamma_{\kappa}P_L\nu_e) \right]$$

Consider changes to tau neutrino spectrum:
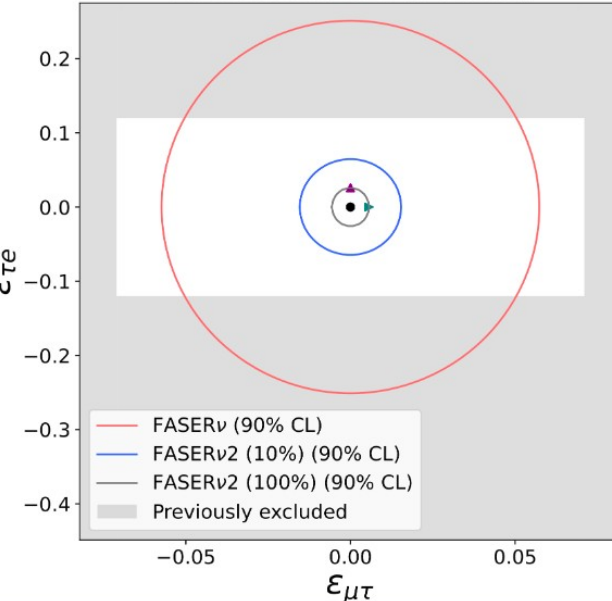
• Effects on **production** side
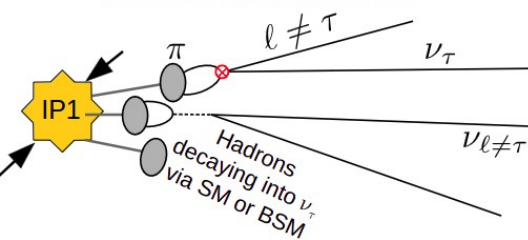
• Effects on **detection** side

FASERν2

**Additional interact
increase numb
observed charged t
which is assume
equal the number o
neutr**

Effect approxim
energy indeper

Profiled over all λ (3 R bins)

Tool available at: https://github.com/makelat/forward-nu-flux-fit

LIGHT LONG-LIVED PARTICLES

K. Jodłowski, 2305.10409

● Light long-lived particles (LLPs) remain essential physics target
for the operating FASER detector and will also be extended to the FPF

$$\mathscr{L}_{\text{dark axion portal}} = \frac{g_{a\gamma\gamma'}}{2} a F_{\mu\nu} \tilde{F}'^{\mu\nu}$$

● Further models are explored in the community
& connections to more complete models

$$\sigma_{\gamma'N\to aN} \propto \alpha_{em} g_{a\gamma\gamma}^2 Z^2$$

Talks: Krzysztof Jodłowski, Huayang Song

$m_{\gamma'} \ll m_a$

FPF FASER2 ($E_{\gamma\gamma'} > 0.1$ TeV)   FPF FASERν2 (sec., $E_{\gamma\gamma} > 1$ TeV)
FPF FASER2 ($E_{\gamma'e^+e^-} > 0.1$ TeV)   FPF FASERν2 (e^- scat., dec. out.)
FPF FASERν2 ($E_{\gamma\gamma'} > 1$ TeV)   FPF FLArE (e^- scat., decay outside)
FPF FASER2 (sec., $E_{\gamma\gamma'} > 0.1$ TeV)   SHiP ($E_{\gamma\gamma'} > 2$ GeV)

● We keep updating tools,
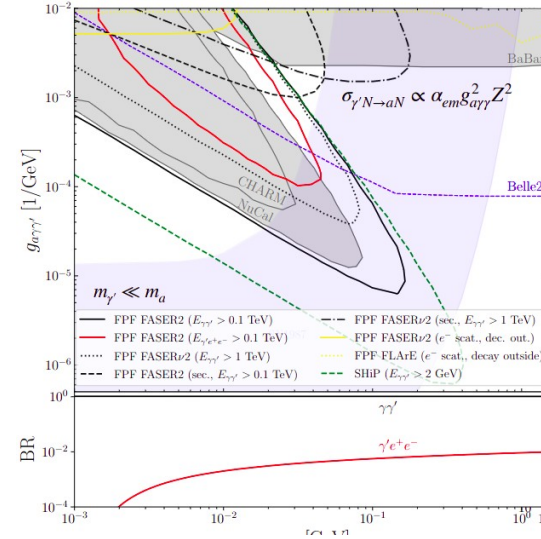
S. Li, H. Song, S. Su, W. Su, hep-ph/2212.06186

- **FORESEE**

F. Kling, ST, hep-ph/2105.07077

Type-I: light H, $\cos(\beta - \alpha) = 1/\tan\beta$, $m_{H^\pm/A} = 600$ GeV

2HDM

- **Talk: Jean-Loup Tastet**, **SensCalc** tool

M. Ovchynnikov, J.-L. Tastet, O. Mikulenko, K. Bondarenko, hep-ph/2305.13383
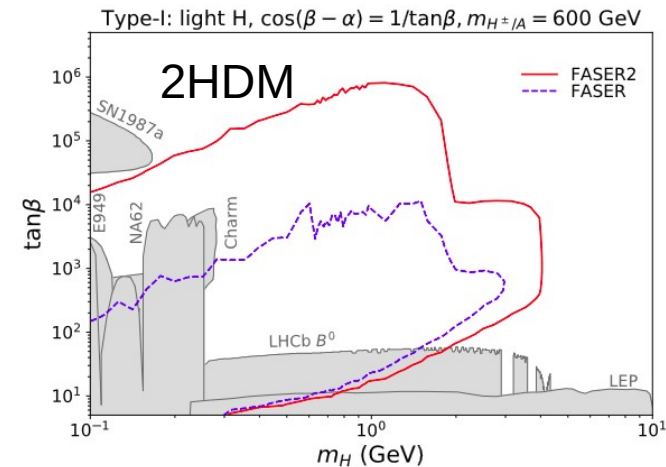
PRODUCTION MODES OF LLPS

Talk: Max Fieg
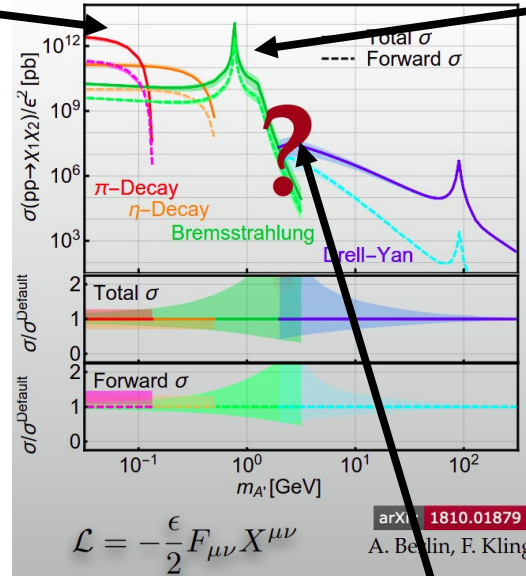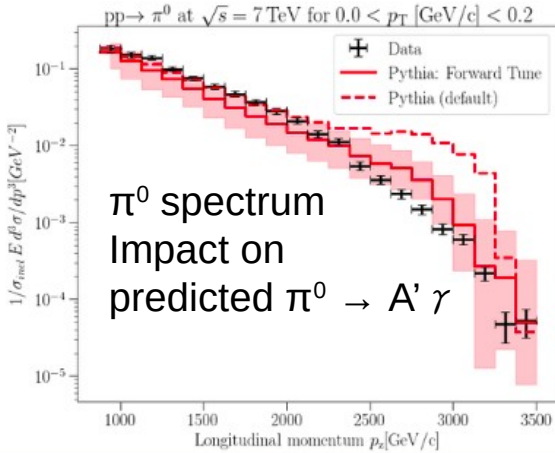
Talk: Saeid Foroughi-Abari

π^0 spectrum
Impact on
predicted $\pi^0 \to A' \gamma$
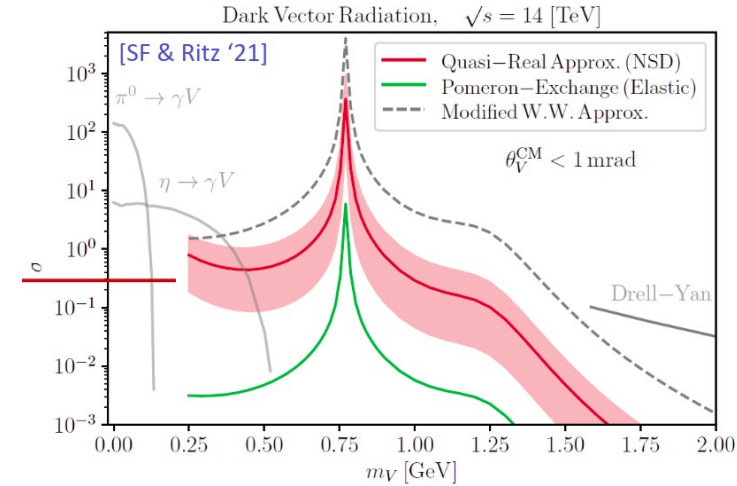
Talk: Peter Reimit, ISR & FSR

ISR

could be relevant for dark
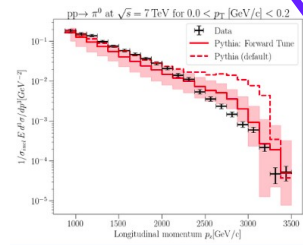photon search at FASER(2)
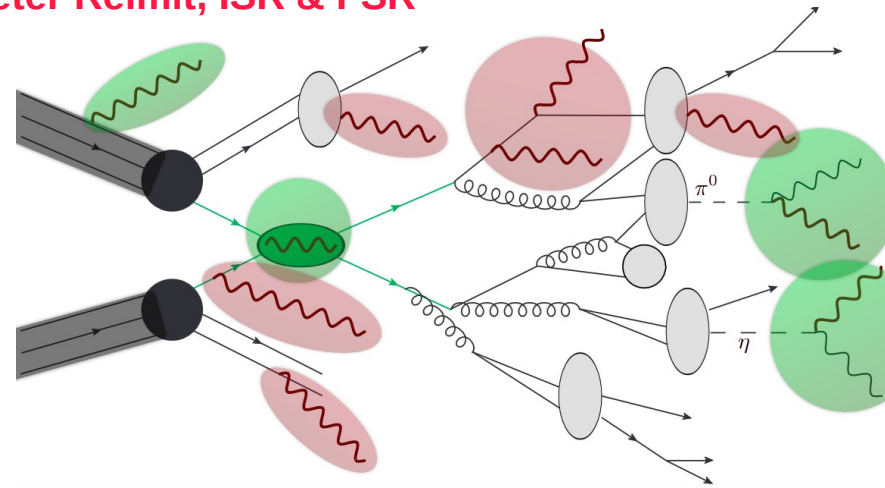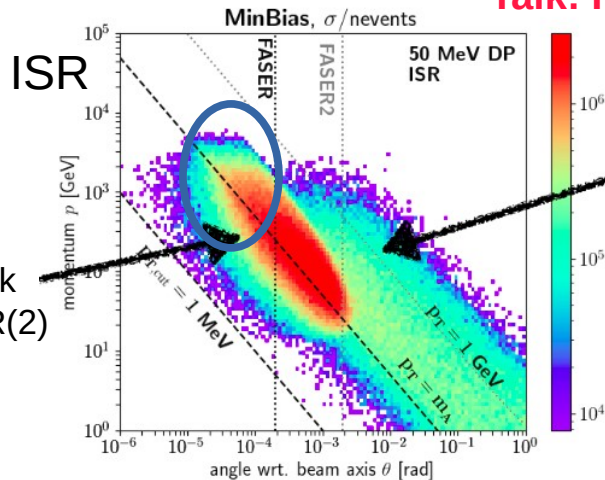
- Impact of additional prod. modes
  even more important
  for stable dark species
  (even softer dark species matter)

- Potentially significant impact on
  - dark matter (DM)
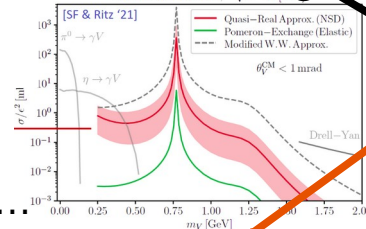 - millicharged particles (mCPs)

- Heavier mesons relevant for
HNLs (charm), dark Higgs (B mesons), …

- Important **cosmological bounds** on
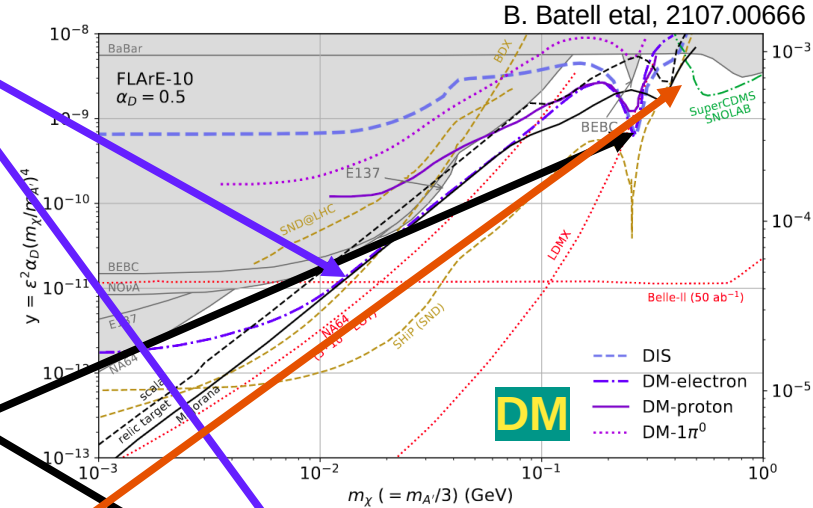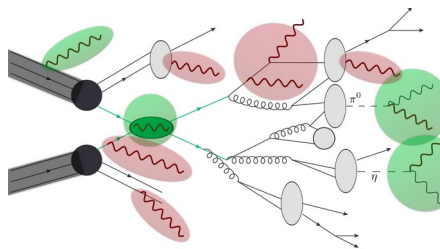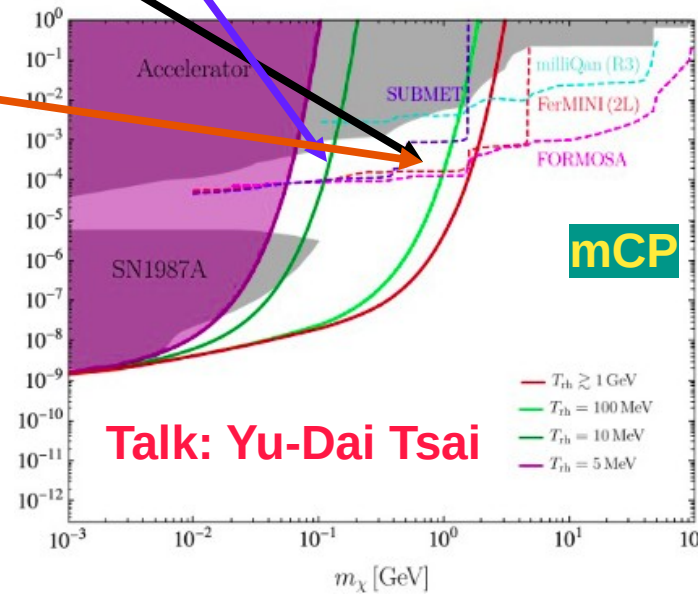 sub-GeV millicharged particles
                    with massless A'

Emphasize the need to extend the search to larger masses with

FORMOSA

Light mesons

Bremsstrahlung

ISR & FSR

B. Batell etal, 2107.00666

DM

X. Gan, Y.-D. Tsai, hep-ph/2308.07951

$\Delta N_{\rm eff}$ Constraints for mCP with Dark Photon

mCP

Talk: Yu-Dai Tsai

EXPLOITING HIGH-ENERGY IN BSM SEARCHES

● High-energy pp collisions at the LHC open up possibility to directly produce TeV-scale particles

J. Li, J. Pei, L. Ran, W. Zhang, hep-ph/2108.06748

● Example: quirks **Talk: Jonathan Feng**

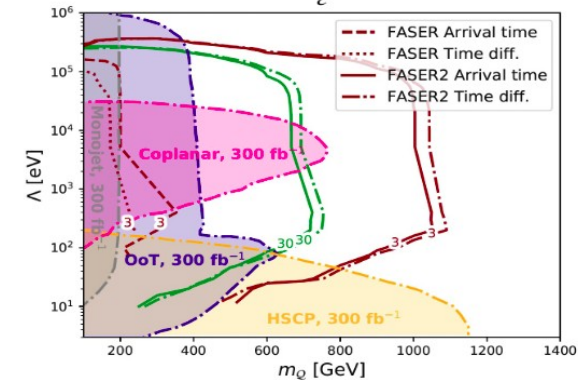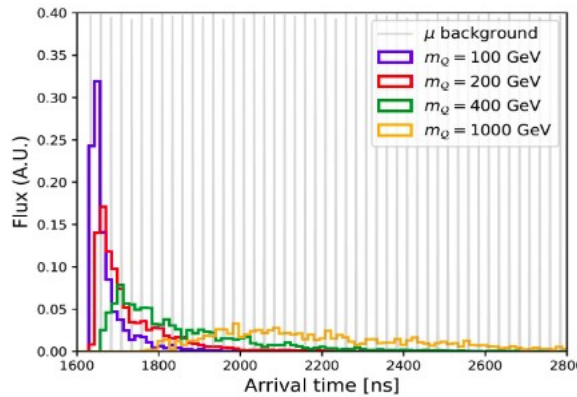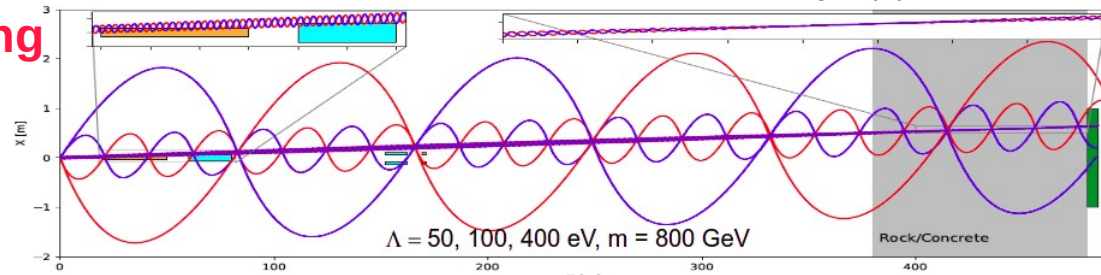- hidden strong force with $m_{quirk} \gg \Lambda_{hidden}$

- quirks are stable and do not hadronize

- they are bound by the color string & oscillate around their COM

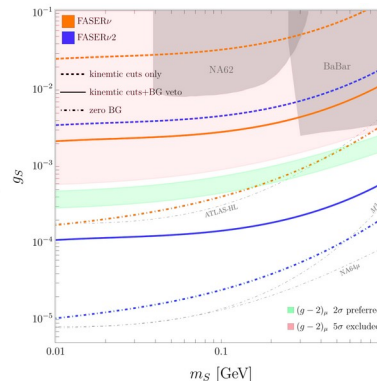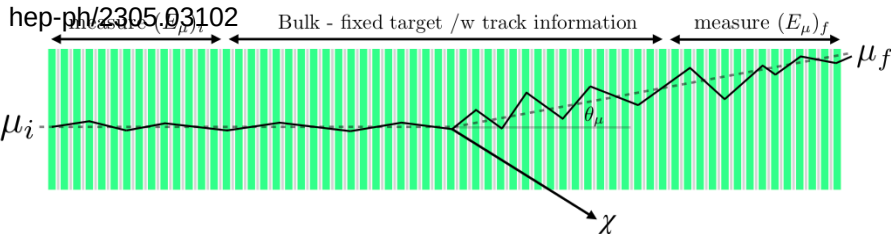- heavy quirks are slow interactions not consistent with bunch crossing

- timing & fancy signatures
→ BG free search

● Discussions about muon-induced new physics

A. Ariga etal,
hep-ph/2305.03102

**Talk:
Monday session about muons**

THANK YOU !