Forward Physics Facility (FPF)
Working Group 4 (WG4) – BSM physics

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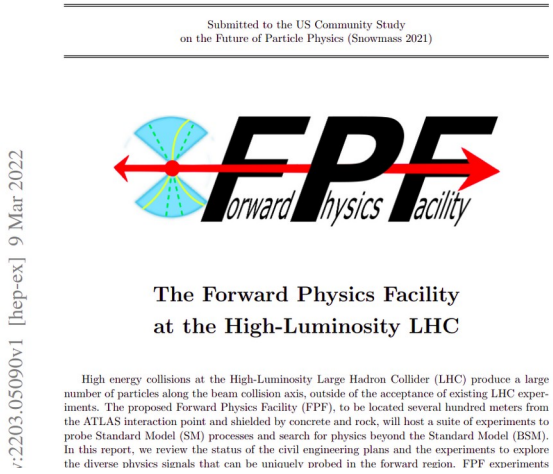
Sebastian Trojanowski

5th FPF meeting, CERN,
November 15, 2022

WHITEPAPER (hep-ex/2203.05090)

- BSM physics case was probably the most thoroughly studied physics case so far
- ~50% of the recent whitepaper is about BSM physics
  (mostly LLPs, but also DM, neutrino BSM, …)



WG4 (BSM) goals:

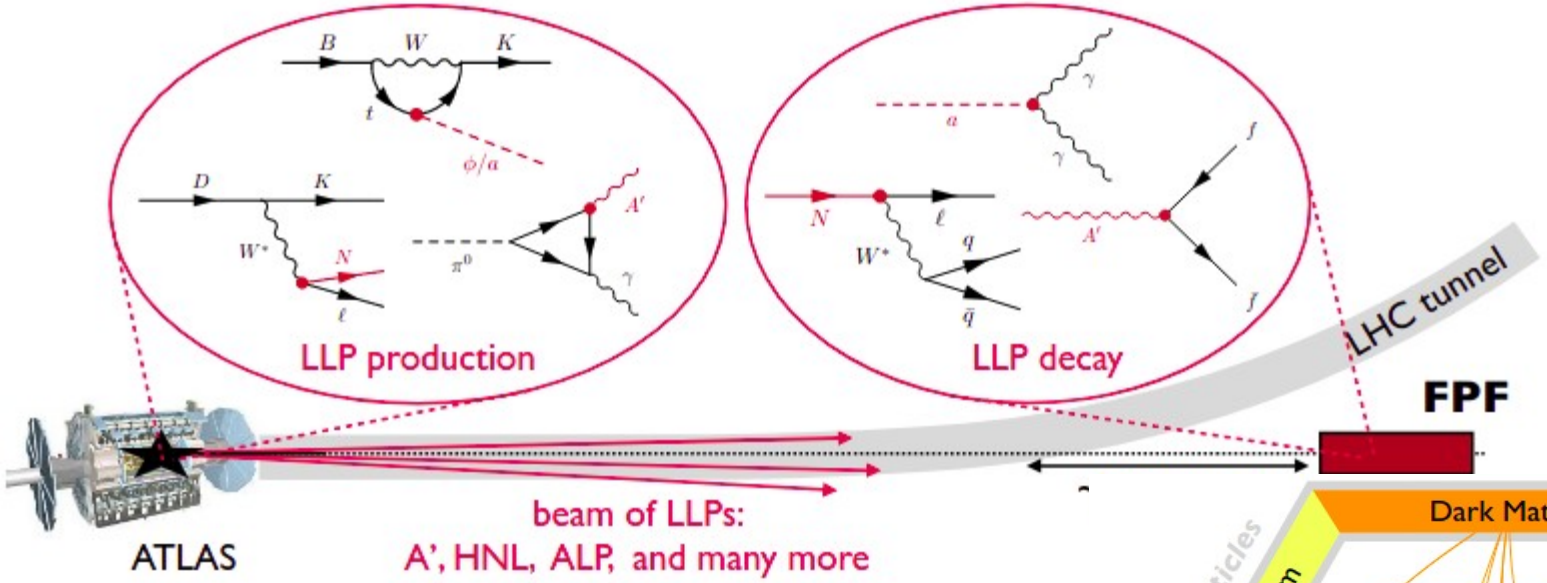
a) **trigger further discussions about possible unique BSM physics opportunities of the FPF**,

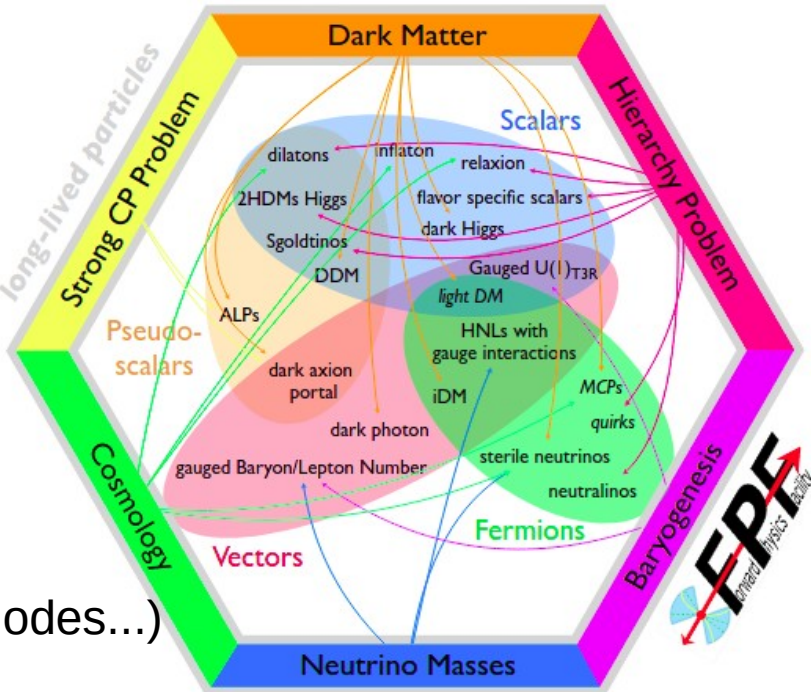
Where do FPF experiments have unique and/or complementary sensitivity in comparison to e.g., beam-dump searches at lower energies and high-pT searches at the LHC?

b) **studies for already proposed benchmarks**
(implementation, modeling uncertainties, new prod. and det. modes)

c) **facilitate exchange of (new) ideas** related to FPF BSM physics (slack channel, community, possible feedback from experimental representatives)

WHITEPAPER – (MANY) LLP STUDIES





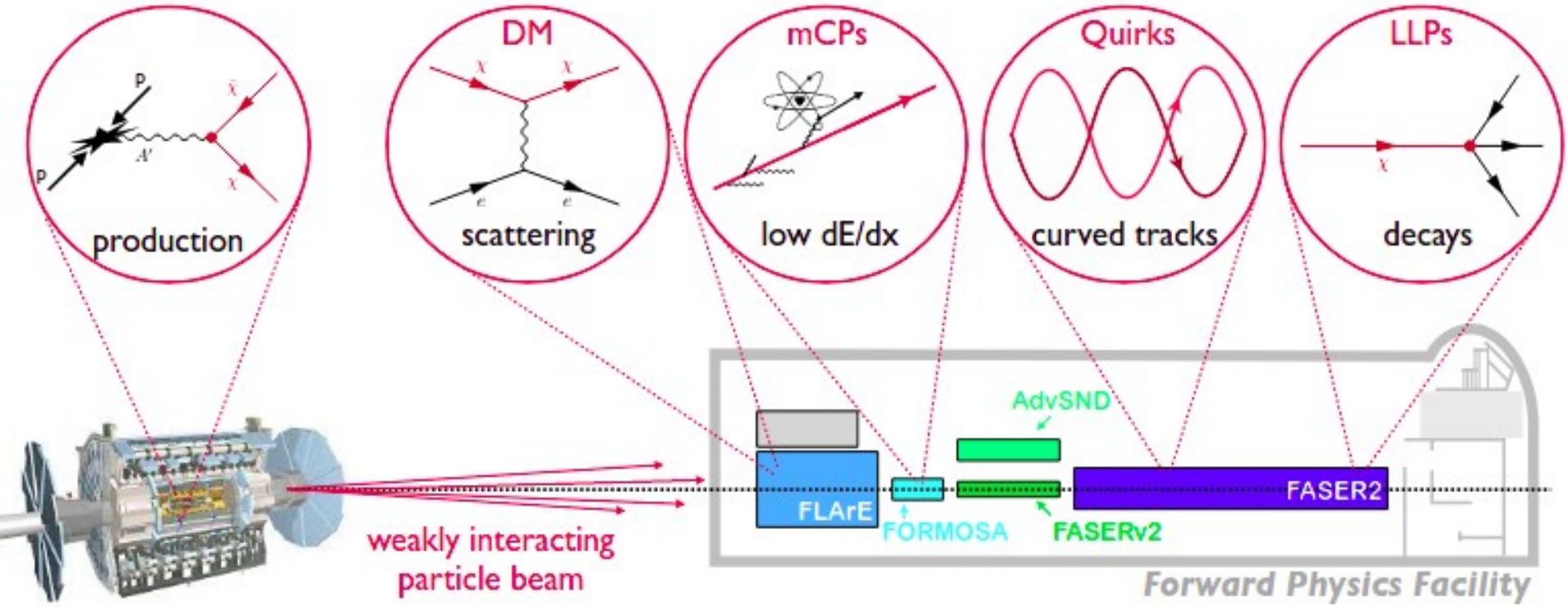
Extensive studies already performed,
including important benchmark scenarios

WG4:

- implementation of some missing scenarios in FORESEE (hep-ph/2105.07077)

- modeling uncertainties on BSM LLP sensitivity (meson fluxes/spectra, brem, other prod. modes...)

WHITEPAPER – OTHER SIGNATURES



WG4:

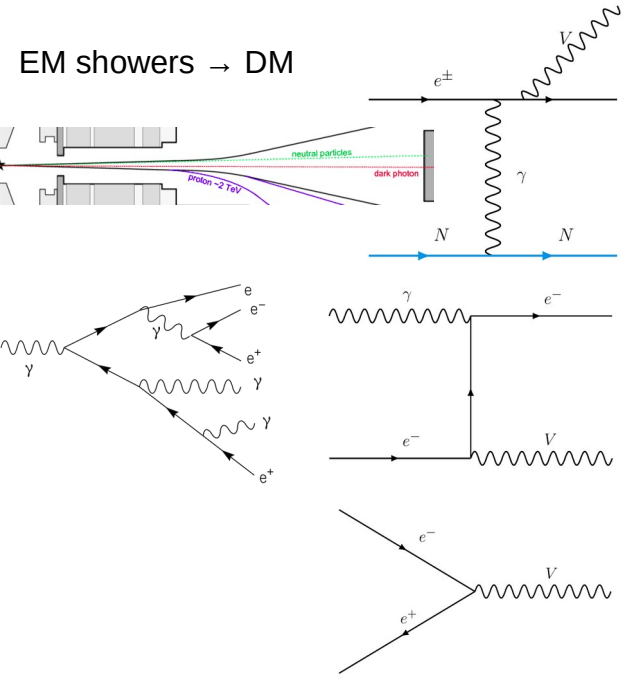
- Various signatures & several dedicated subgroups (see next slides)
- Consider (complimentary) capabilities of different FPF detectors

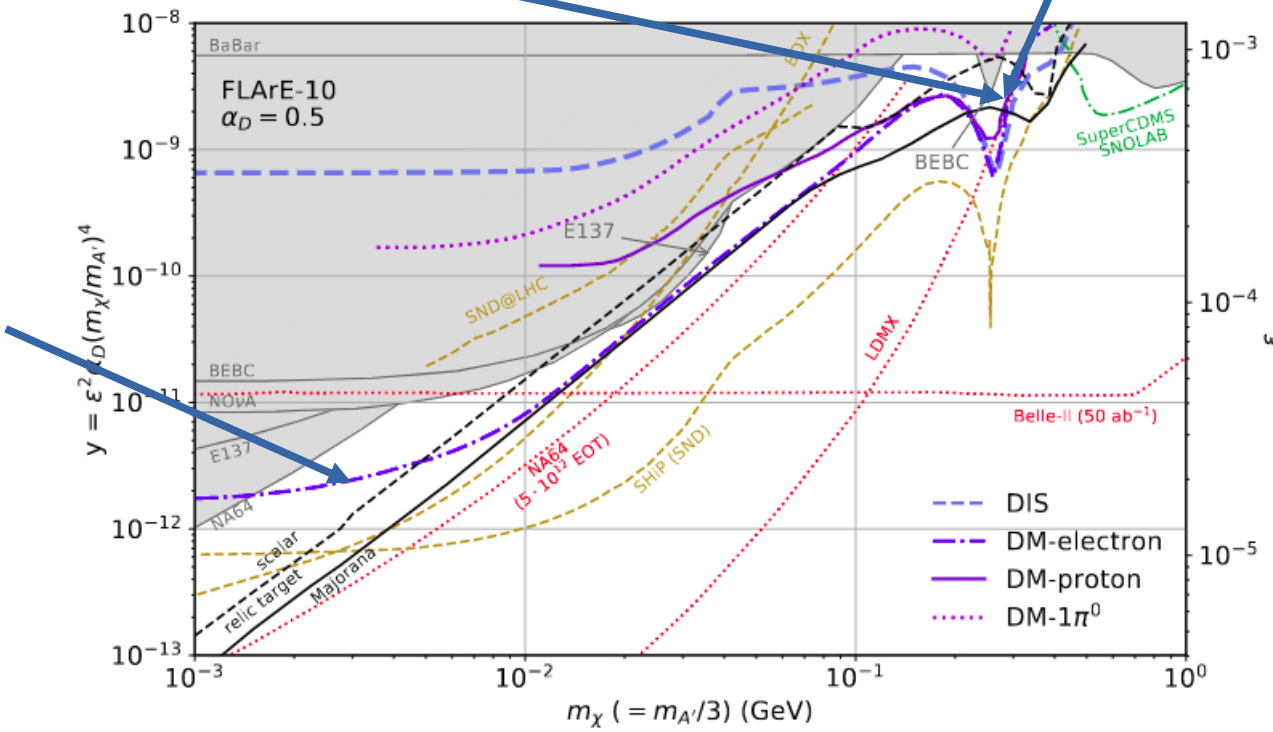
CURRENT BENCHMARKS

WG4 – DARK MATTER

- Cleanest channel: DM-electron scattering but… essential to keep low energy thresholds
- Understand uncertainties on the bremsstrahlung contribution to the DM production rate
- DM secondary production (EM showers in the TA(X)N) *M. Chakraborti, L. Roszkowski, ST, in progress*
- Modeling of DM-nucleus scattering (DIS)

EM showers → DM

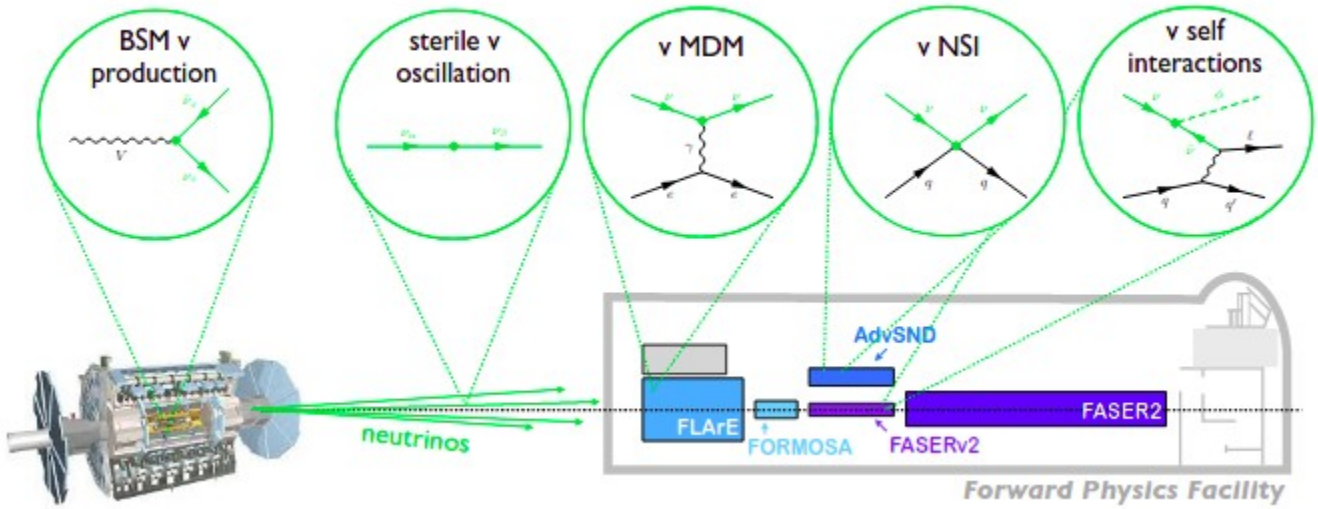




WG4 – NEUTRINO BSM

- Neutrino BSM effects:

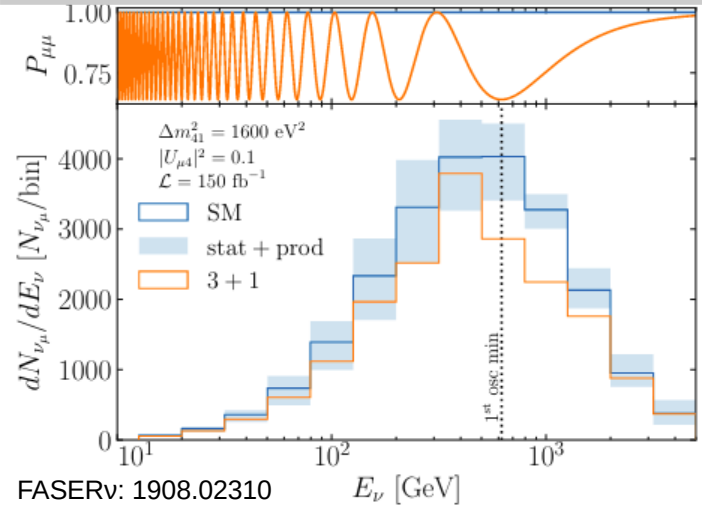
- Production rates
- Propagation (oscillations)
- Interaction rates
  (different channels)
- Event characteristics



Examples:

Oscillations to sterile neutrinos → refine for FPF

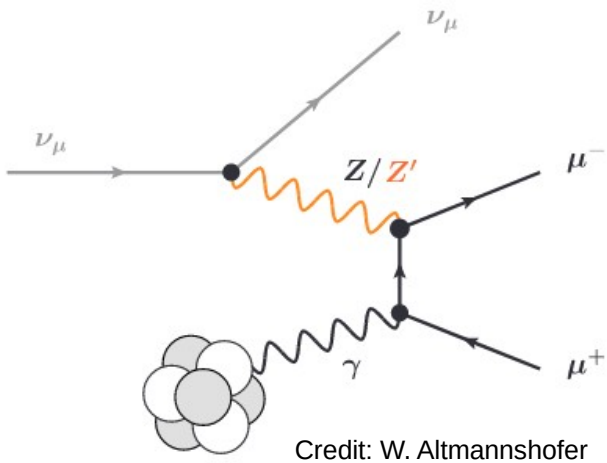
also, BSM-induced matter effects



FASERν: 1908.02310

Tridents

(SM & BSM, various channels)



Credit: W. Altmannshofer

MUONS

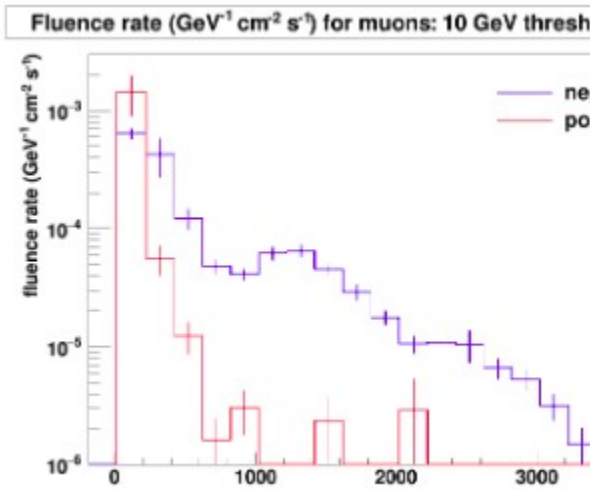
Background for other FPF studies but could it also be a source of interesting signal?

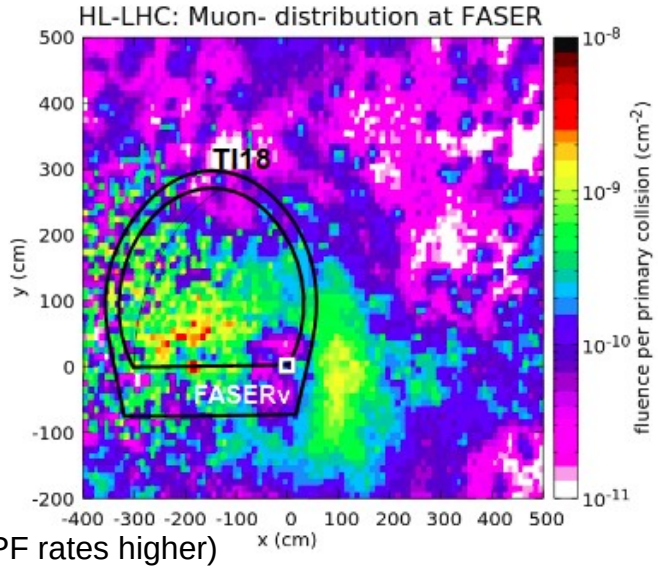
Hard spectrum, up to few TeV energies, not uniform in transverse plane
(can be substantially higher off-axis)

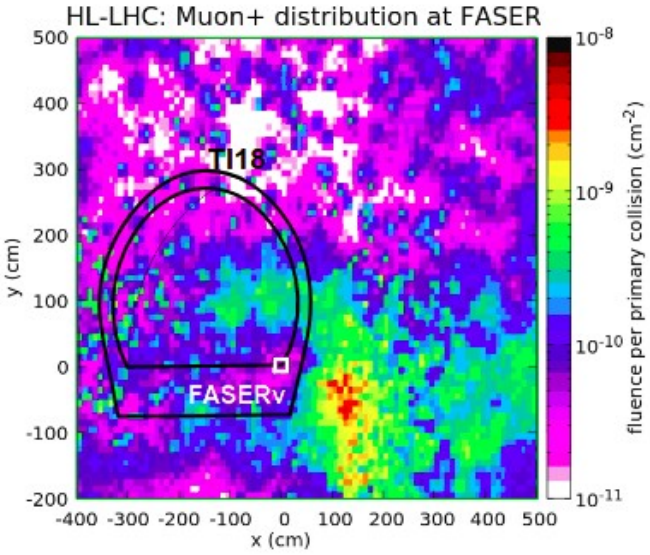
WG4:

● trigger discussions about muon-related BSM physics
(currently ongoing: muon-philic scalars *[B. Batell, F. Kling, P. Foldenauer, ST]*
LFV? …)

● SM physics case?







Run 3, FASERν [hep-ex/1908.02310] (FPF rates higher)

WG4 – VARIOUS DETECTOR CAPABILITIES

Millicharged particles

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

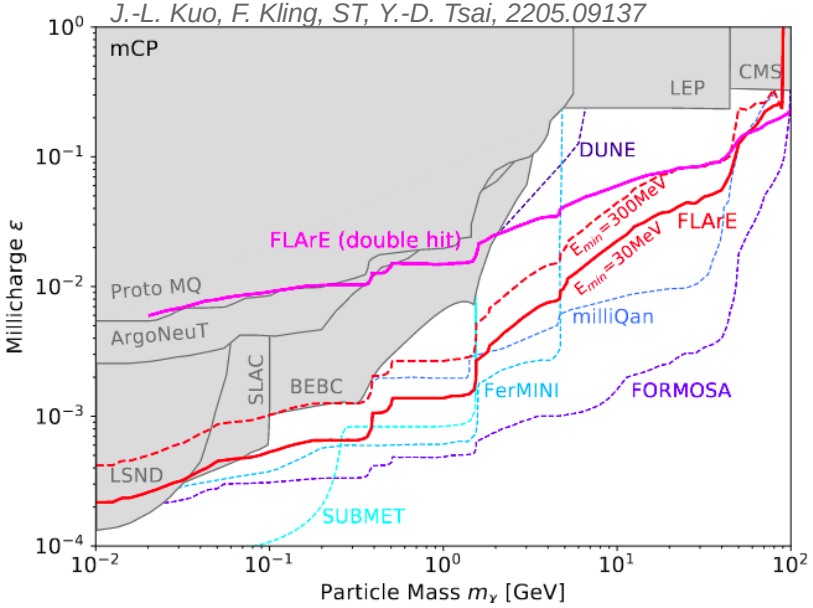
Important BSM target

Projected world-leading bounds
from FORMOSA

FLArE could also contribute, other detectors?

Other FORMOSA BSM prospects (ionization)?

J.-L. Kuo, F. Kling, ST, Y.-D. Tsai, 2205.09137



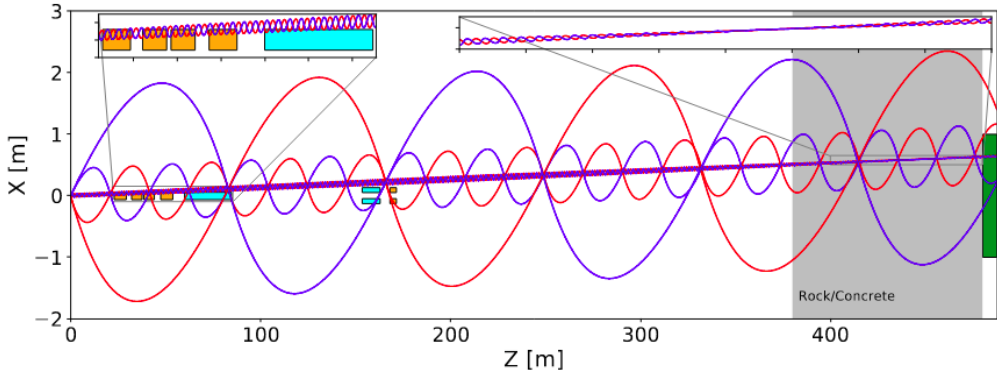
Quirks

J. Li, J. Pei, L. Ran, W. Zhang, 2108.06748

Example of heavy BSM physics,
not possible at lower energies

Fancy tracks: FASER 2, FLArE (?), ...

Further handles (timing?)



ORGANIZATION OF WG4 EFFORTS

- **mostly work in subgroups & individual projects / papers of WG4 members**

- slack channel for communication with the entire WG4
(emails -> we will copy all the essential updates to the slack channel)

- number of general WG4 meetings will be kept low
(next update meeting ~Feb/Mar 2023)

- essential to make progress in selected topics within the next year

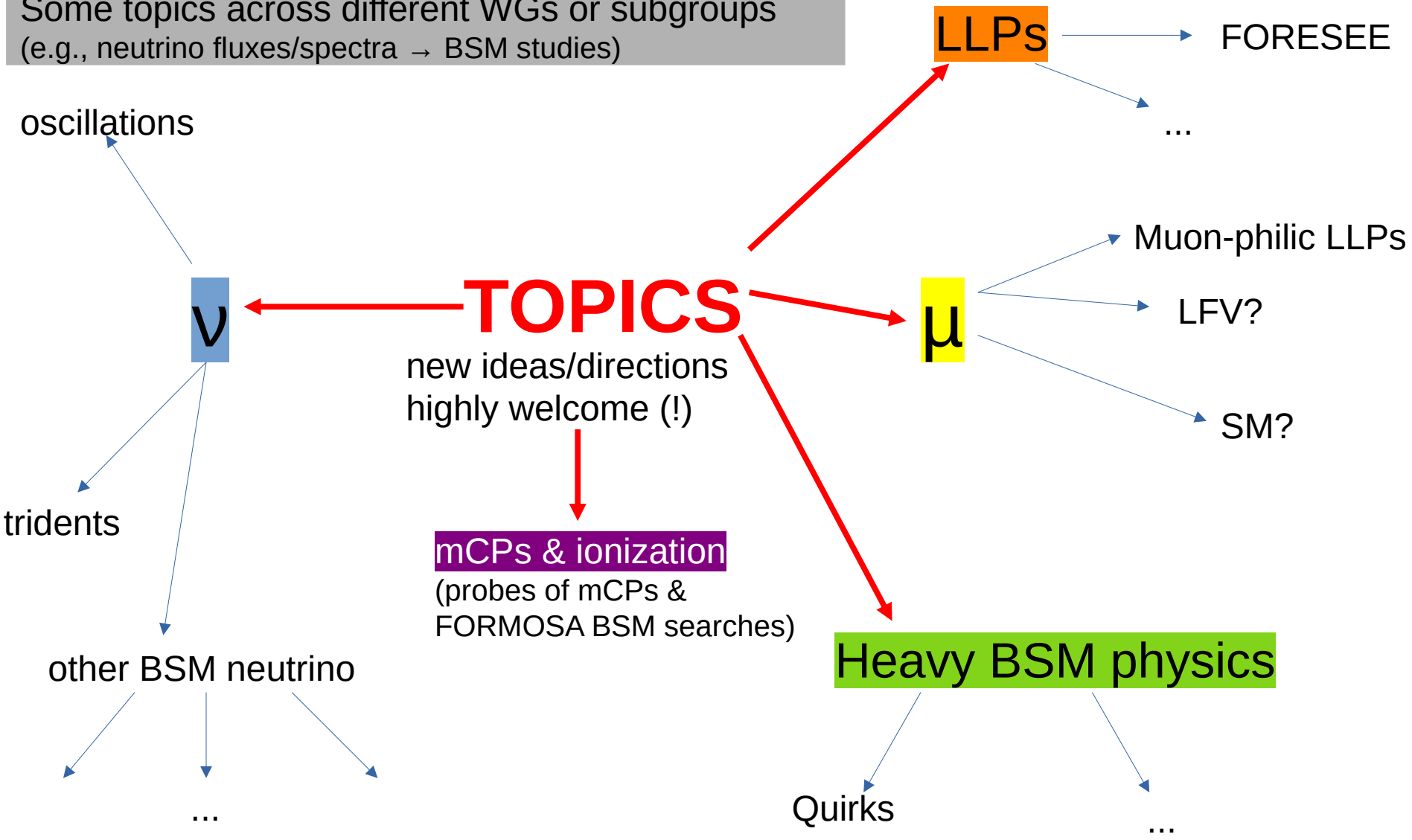
- all new ideas are certainly very highly welcome:
  – provide feedback,
    slack channel/google doc for keeping track of different projects
  – will ask experimental representatives if new signature etc. is proposed

Working Group Experimental Contacts:

	WG5 FASER2	WG6 FASERnu2	WG7 FLArE	WG8 AdvSND	WG9 FORMOSA
WG4	Josh McFayden	Aki Ariga, Tomoko Ariga	Steve Linden, Wenjie Wu	Cristovao Vilela	Matthew Citron

SUBGROUPS (OPEN LIST)

Some topics across different WGs or subgroups
(e.g., neutrino fluxes/spectra → BSM studies)



DOCUMENTS & PLANS

DOCUMENTS

- New results produced within subgroups could certainly lead to publication(s)
- Other individual research papers prepared by WG4 members

PLANS

- Setting up working subgroups
- Let us know if you have ideas for various subgroups and want to join...
- ...or if you want to propose a new topic
- if you work / will work on individual research projects related to BSM & FPF, we are happy to provide feedback

Currently WG4: ~35 members + ~30 more followers on Slack
Kick-off meeting: Nov, 9th

FPF was thought to significantly extend physics goals of the LHC
This includes BSM studies but also a broad SM physics programme
WG4: What other unique/interesting BSM physics scenarios can be studied there?

DISCUSSION

Where do FPF experiments have unique and/or complementary sensitivity in comparison to e.g., beam-dump searches at lower energies and high-pT searches at the LHC?

In the BSM context: models employing high-energy/boost, neutrino & muon flux, other?

- How can we leverage simultaneously different FPF detector capabilities in probing new physics?

- Is timing information and/or complimentarity to ATLAS useful and possible to realize?

- Can all interesting/essential new (&SM) physics opportunities be realized with the detectors already proposed for the FPF?

CURRENT BENCHMARKS:
- Are there important benchmark scenarios not discussed yet for the FPF?
- Do we employ all the dominant modes of production and detection?
- What are uncertainties on BSM flux and signal modeling?

EXPERIMENTAL FEEDBACK:
- Muons: flux and spectrum for the FPF? How much it grows away from the beam-collision axis? How well we can measure muons (also incoming?)
- Neutrino interactions: how well we can measure exclusive channels (e.g. tridents)?
- DM / mCPs etc.: How low can relevant energy threshold be?
- How large will energy threshold be for FASER 2?

Any other topics for discussion are welcome