



Results on BSM Long-Lived Particle Searches with the FASER Experiment

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**UNIVERSITÉ
DE GENÈVE**

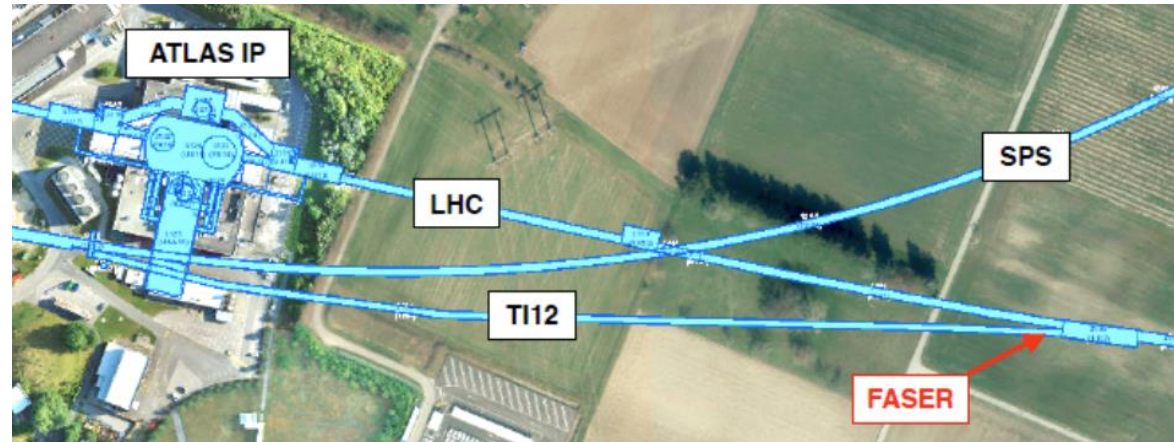
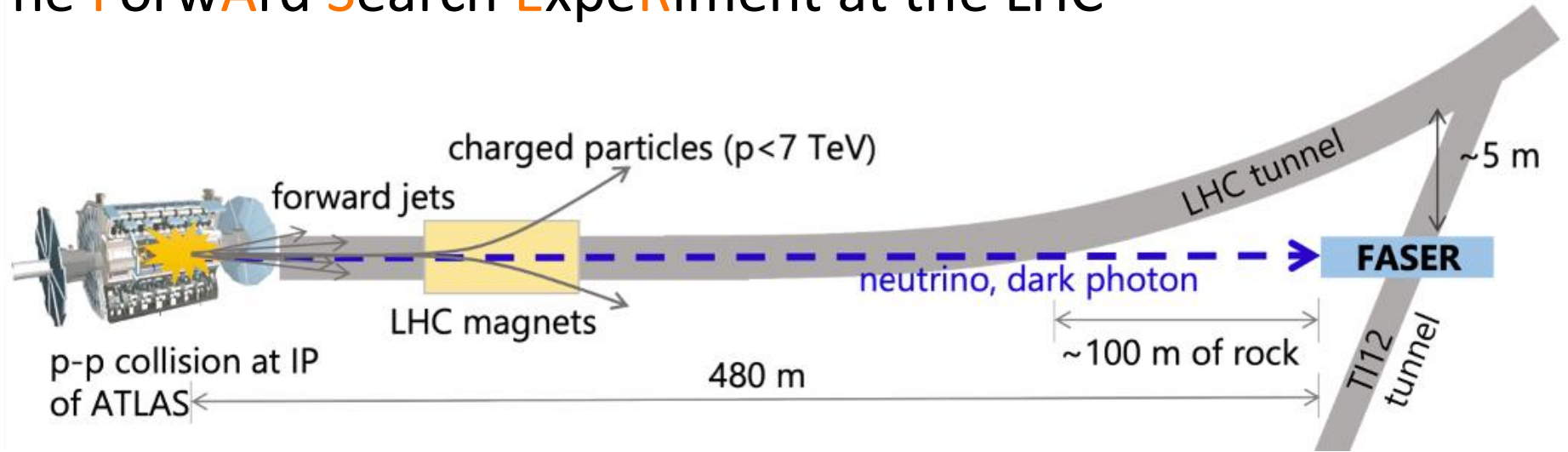
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Introduction

The **FASER** Experiment

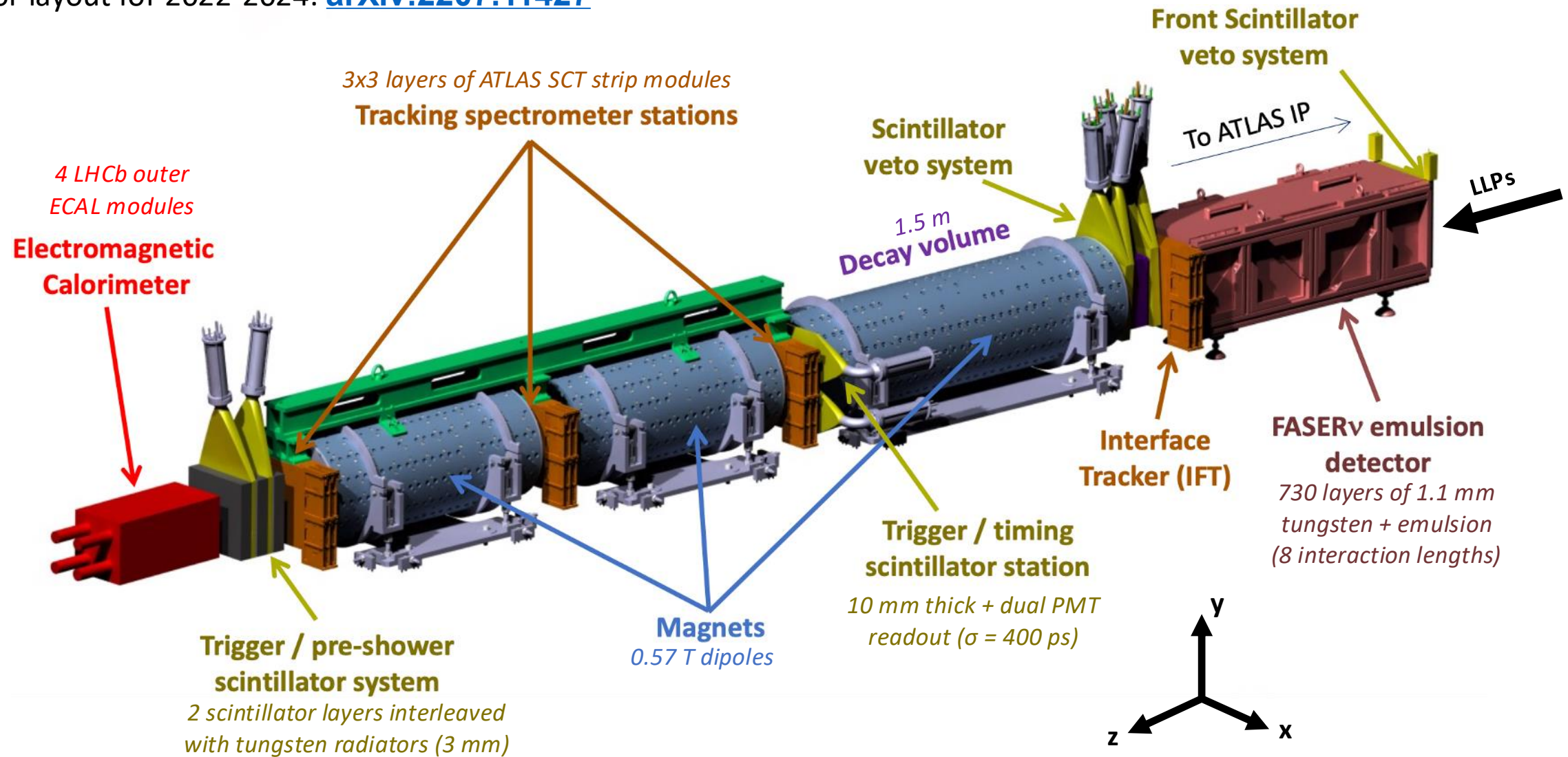
The **ForwArd Search ExpeRiment** at the LHC

- * Search for light, feebly interacting **long-lived** particles
- * Located 480 m downstream of **ATLAS** along the beam collision axis
- * Shielded by ~100 m of **rock** and **concrete**
- * Low-background environment **ideal** for LLP searches
- * Ideal for **forward physics**, covering an acceptance of $\eta \gtrsim 8.5$



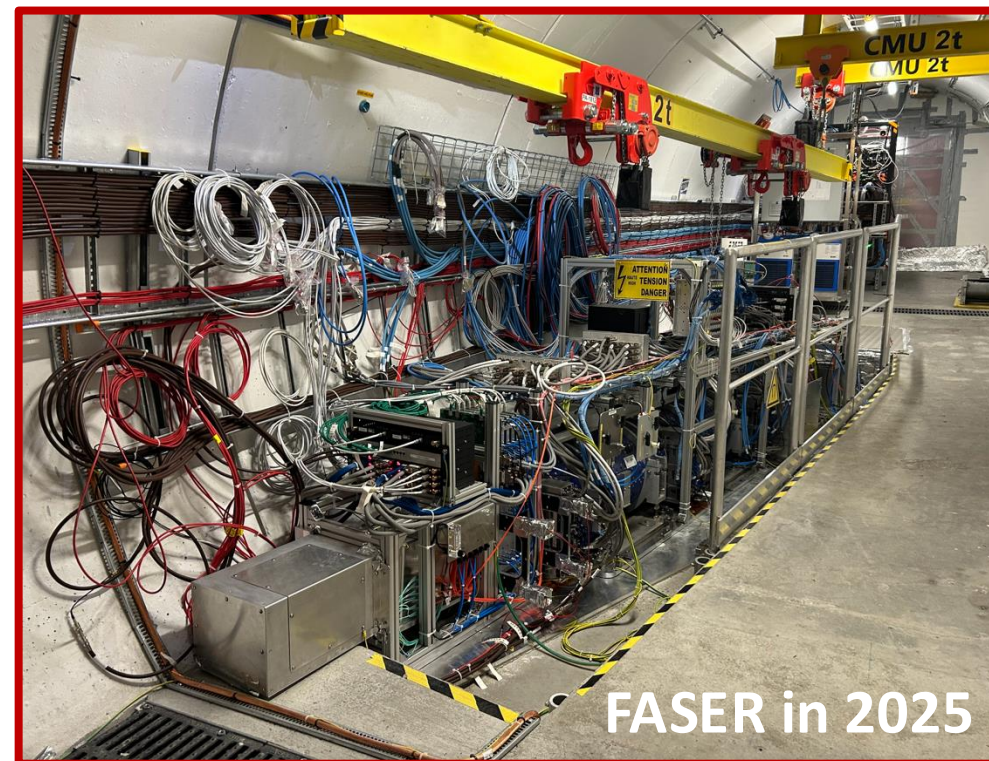
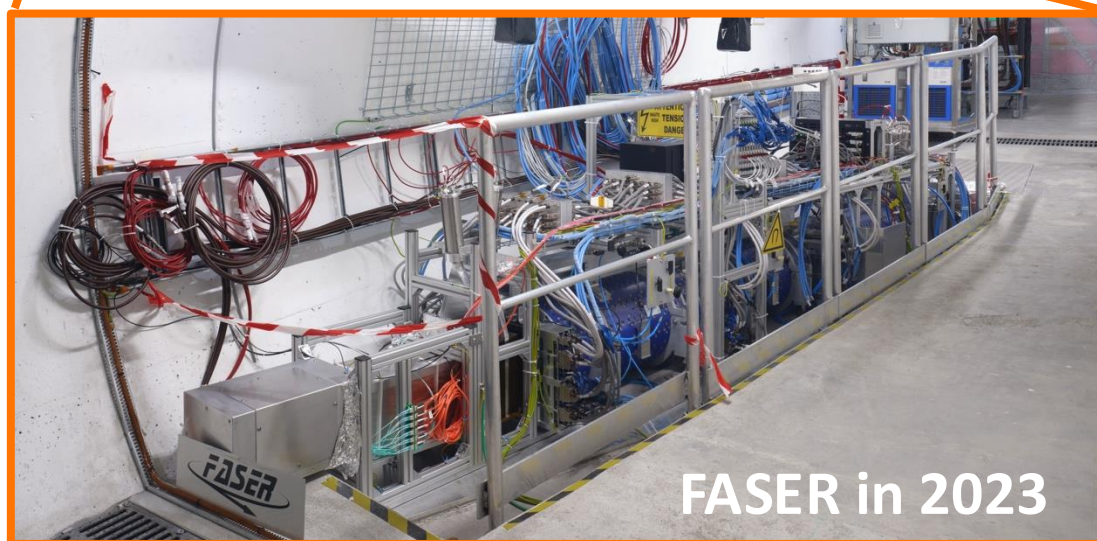
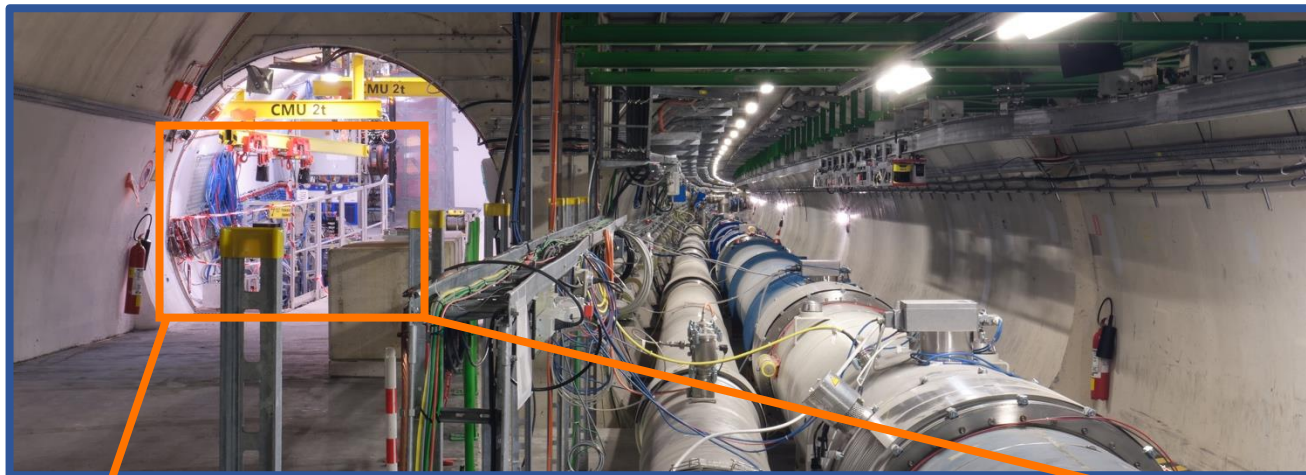
Original Detector Layout

Detector layout for 2022-2024: [arXiv:2207.11427](https://arxiv.org/abs/2207.11427)



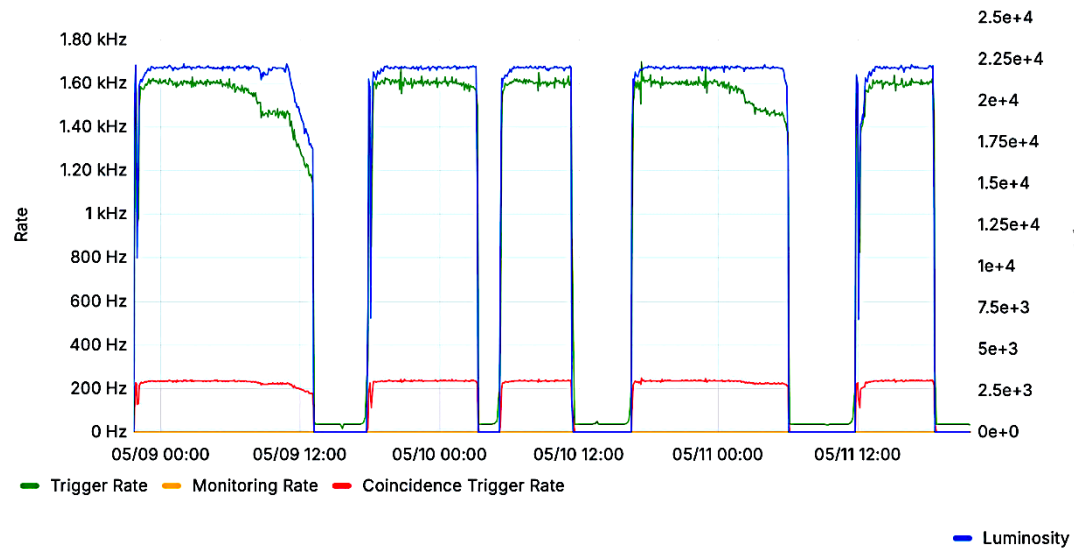
FASER in the T112 Tunnel

FASER was installed and commissioned in time for Run-3 data taking

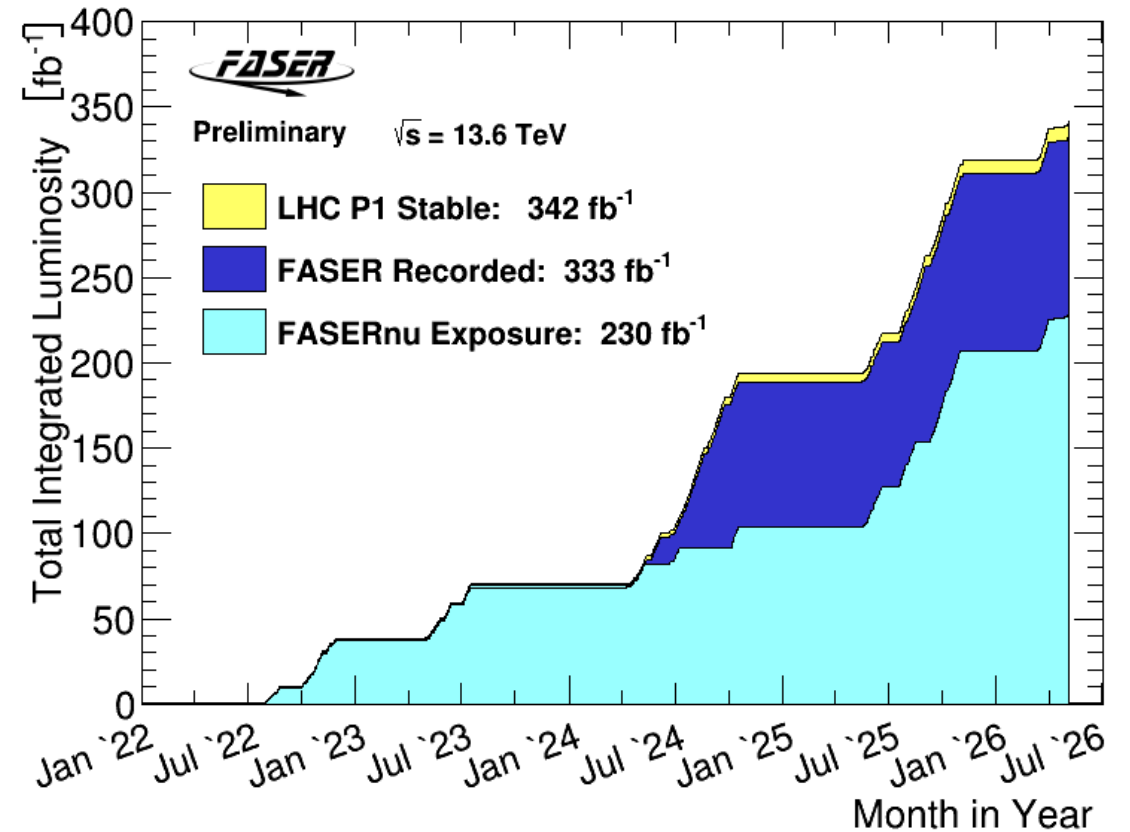


FASER Operations

- * Taking data since 2022
- * 342 fb^{-1} delivered by the LHC
- * **>97%** of data-taking efficiency



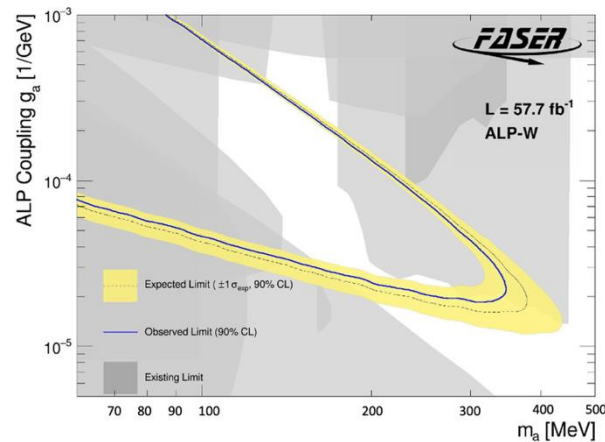
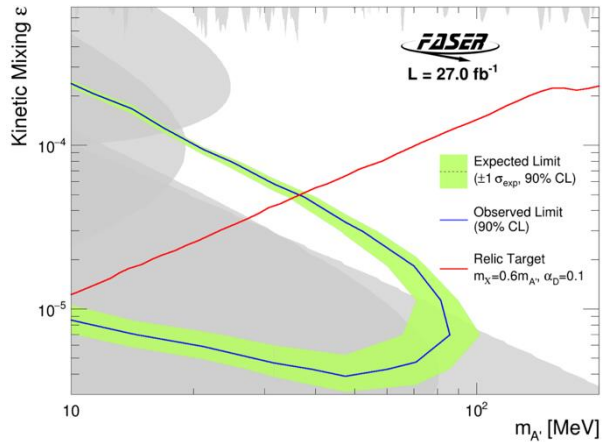
- * Current analyses use up to **178 fb^{-1}**
- * FASERv exposure corresponds to 230 fb^{-1}



FASER Physics Program

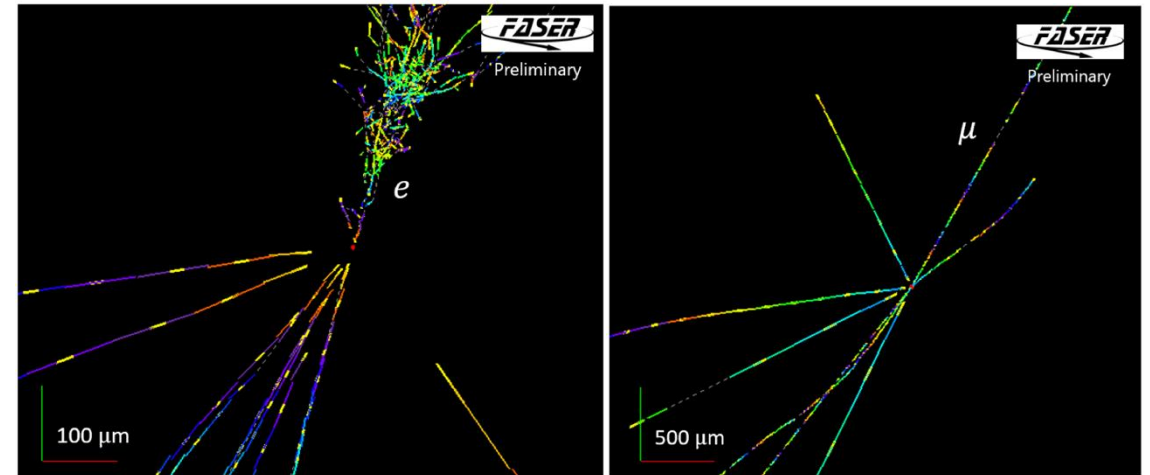
BSM Searches

- * World-leading constraints on:
 - * Dark Photons (A')
 - * Axion-Like Particles (ALPs)
- * Other hidden-sector models



Neutrino Physics

- * First direct detection of collider neutrinos
- * Unique TeV-scale neutrino measurements
- * Energy regime between fixed-target and astrophysical experiments



Dark Photon Search

Dark Photon: Motivation

Dark photons are well-motivated mediators between the Standard Model and hidden sectors

- * Vector portal model with kinetic mixing between the dark photon and the Standard Model photon

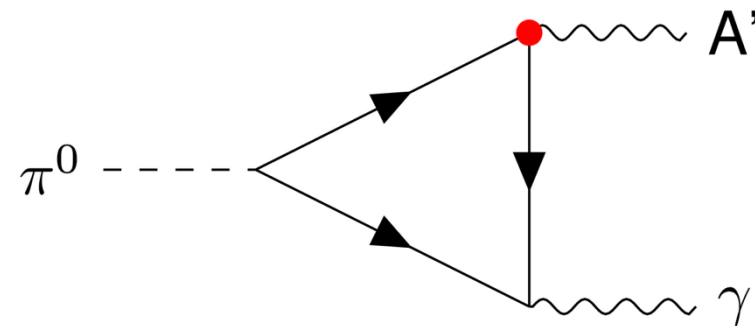
$$\mathcal{L} \supset \frac{1}{2} m_{A'}^2 A'^2 - \epsilon e \sum_f q_f A'^\mu \bar{f} \gamma_\mu f$$

- * Dominant production channels arise from forward light-meson decays
- Additional contributions from dark bremsstrahlung

Sensitivity range for A' :

- * $m_{A'} \sim 10 - 150 \text{ MeV}$
- * $\epsilon \sim 10^{-5} - 10^{-4}$

→ Search targets displaced high-energy e^+e^- signatures inside the detector



Previous Dark Photon Analysis: Event selection

Previous search for dark photons decaying into e^+e^- pairs published in 2023

Analysis based on 27 fb^{-1} of 2022 proton-proton collision data

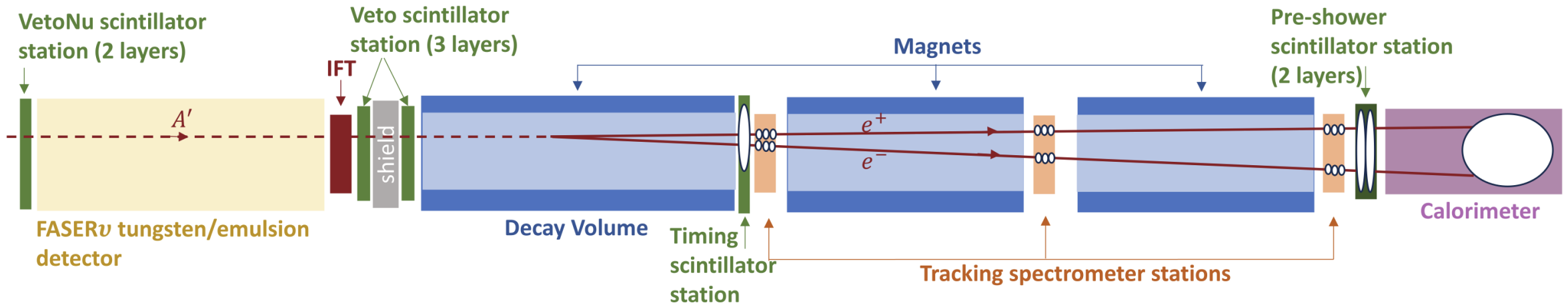
[arXiv:2308.05587](https://arxiv.org/abs/2308.05587)

Baseline signature:

- * No activity in Veto layers (<1 MIP)
- * Displaced e^+e^- decay inside the decay volume, with activity in Timing layer (>2 MIPs)
- * Energy deposit in Preshower and Calorimeter

Two Track Signal Region:

- * Two well-separated reconstructed tracks in the three stations of the spectrometer



New Dark Photon Analysis: Event selection

Extended analysis strategy with two additional signal regions significantly improves sensitivity targeting previously unrecovered decay topologies

One Plus Track Signal Region:

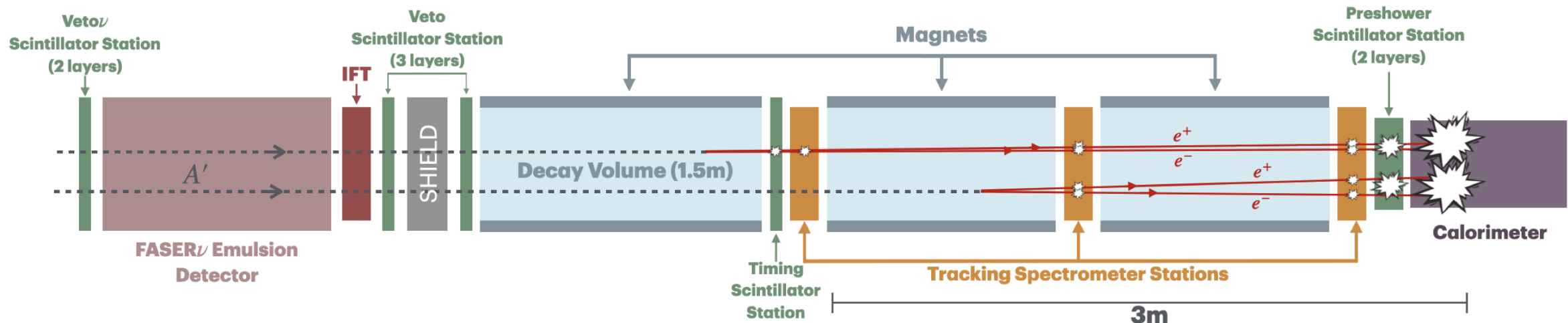
- * Single reconstructed track recovers efficiency for highly collimated decays
- * No charge in Veto layers (<1 MIP)
- * Charge in Timing layer (>2 MIPs)
- * One track in Spectrometer
- * Energy deposit in Calorimeter (>500 GeV)

Segment Signal Region:

- * Targets downstream decays
- * No charge in Veto layers (<1 MIP)
- * No charge in Timing layer (<1 MIP)
- * Track segments in Spectrometer
- * Energy deposit in Calorimeter (>500 GeV)

Analysis based on 178 fb^{-1} of 2022–2024 proton-proton collision data

[CERN-FASER-CONF-2026-001](#)

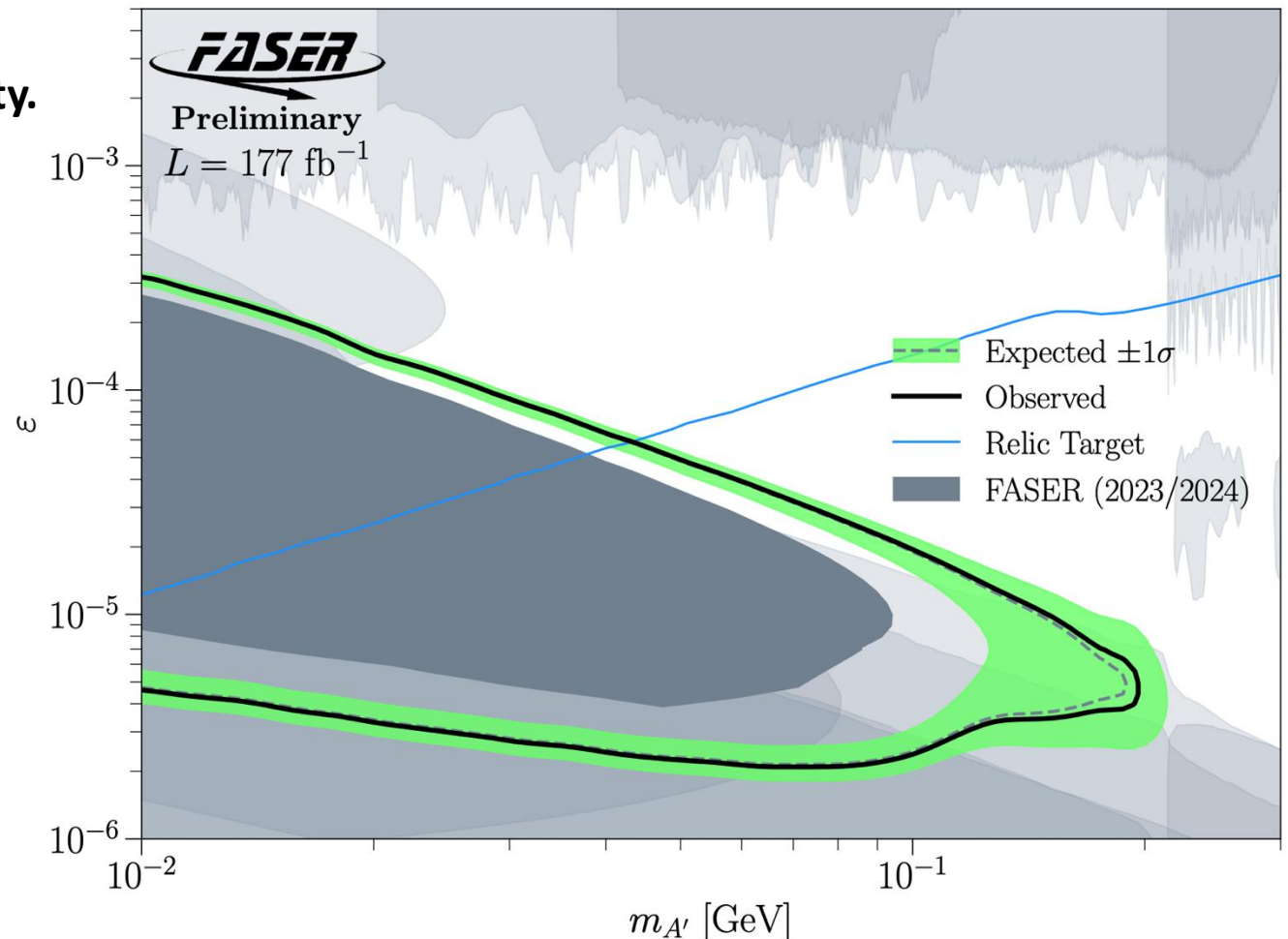


Dark Photon: Results

The expanded Run-3 analysis yields extremely low background levels while greatly improving sensitivity.

- * Near **background-free** search
- * Dominant background from **neutrino** interactions
- * **Small** geometric-muon contribution in the Segment SR

Contribution	Segment SR	One Plus Track SR
Neutrinos	0.025 ± 0.014	$0.050^{+0.024}_{-0.039}$
Geometric Muons	0.002 ± 0.001	0
Neutral Hadrons	0	0
Cosmic	0	0
Beam 1 Background	0	0
Veto Inefficiency	0	0



NO events were observed in any signal region

New world-leading constraints established for dark photons with: $m_{A'} \sim 10 - 200 \text{ MeV}$, $\epsilon \sim 10^{-6} - 10^{-4}$

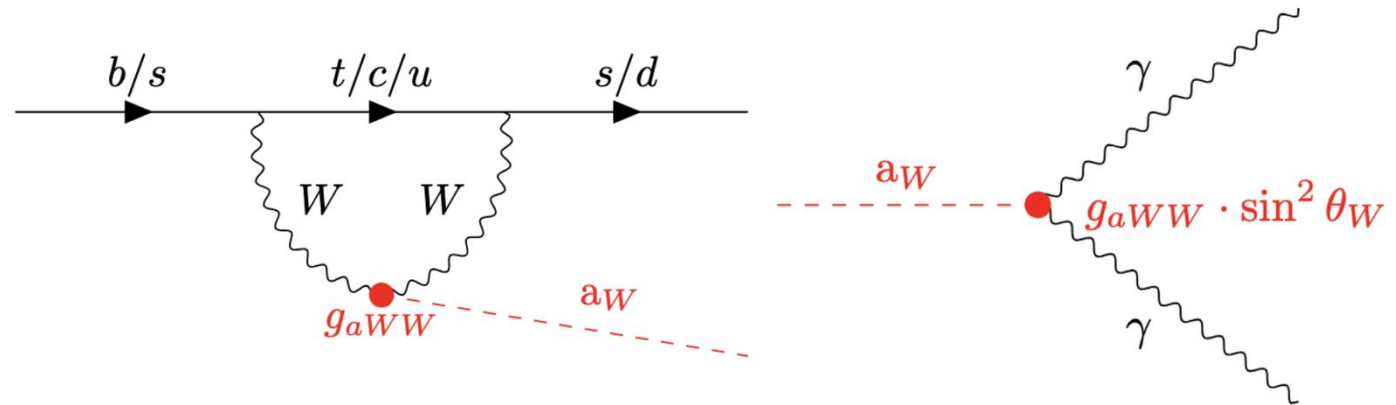
ALPs Search

ALPs: Motivation

ALPs are predicted in many extensions of the SM and can act as mediators to hidden sectors

- * Electroweak-philic ALP model (ALP-W) couples to weak gauge bosons

$$\mathcal{L} \supset -\frac{1}{2}m_a^2 a_W^2 - \frac{1}{4}g_{aWW} a_W W^{a,\mu\nu} \tilde{W}_{\mu\nu}^a$$



- * Dominant production processes come from forward B0 and B± meson decays
- * ALP decays into a highly boosted photon pair
- * This initiates electromagnetic showers in the Preshower and Calorimeter.
- * Search targets highly collimated high-energy photon pairs

Sensitivity range for ALP-W:

- * $m_a \sim 50 - 500 \text{ MeV}$
- * $g_{aWW} \sim 10^{-5} - 10^{-3} \text{ GeV}^{-1}$

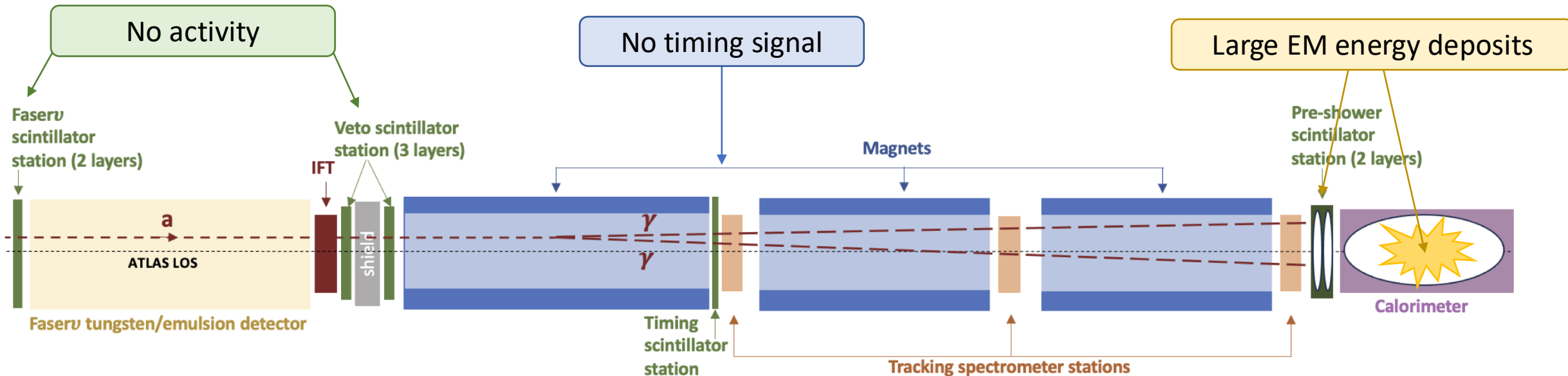
ALPs: Event Selection

Typical ALP signatures consist of:

- * No activity in the Veto-Nu and Veto scintillator layers (<0.5 MIP)
- * ALP decay into a highly boosted diphoton pair inside the Decay Volume
- * No signal in the Timing scintillator station (<0.5 MIP)
- * Electromagnetic showers developing in the tungsten material of the Preshower ($PSR > 4.5$)
- * Large electromagnetic energy deposits in the Calorimeter (>1.5 TeV)

Analysis based on 57.7 fb^{-1} of 2022–2023 proton-proton collision data

[arXiv:2410.10363](https://arxiv.org/abs/2410.10363)



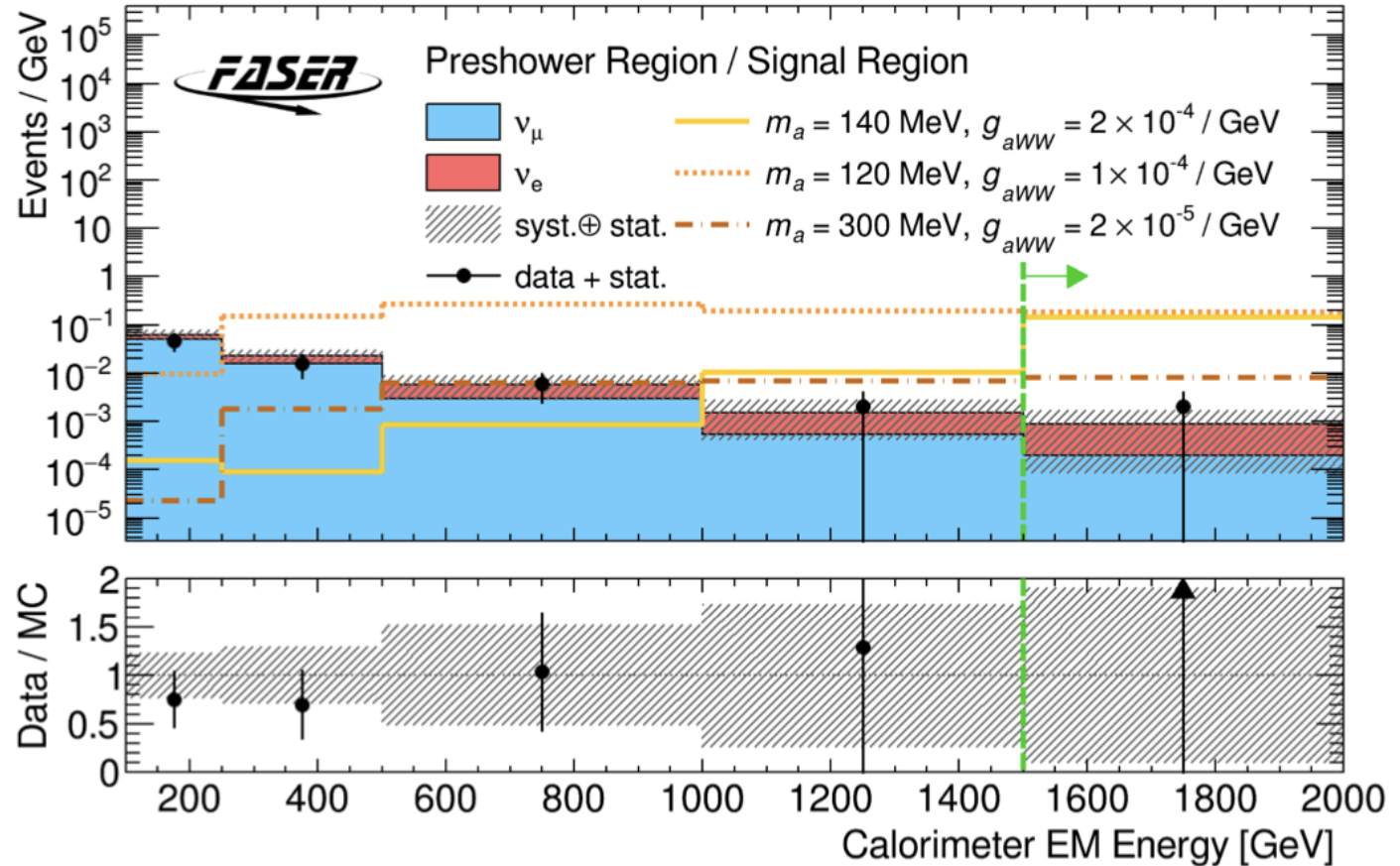
ALPs: Background Estimation

Dominant background

- * Charged-current neutrino interactions

Other backgrounds (negligible)

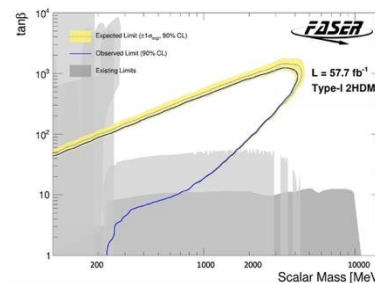
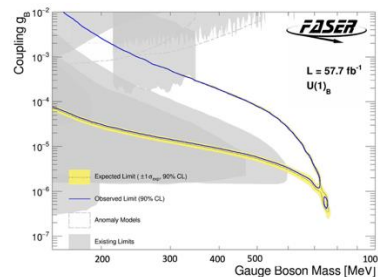
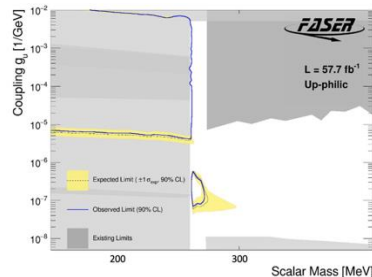
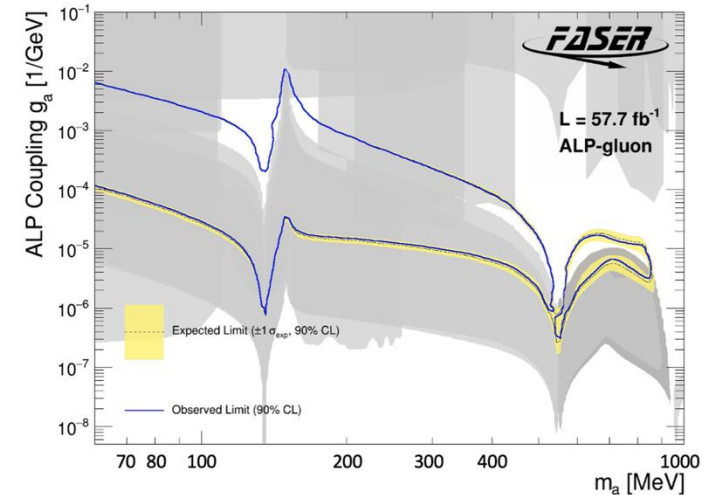
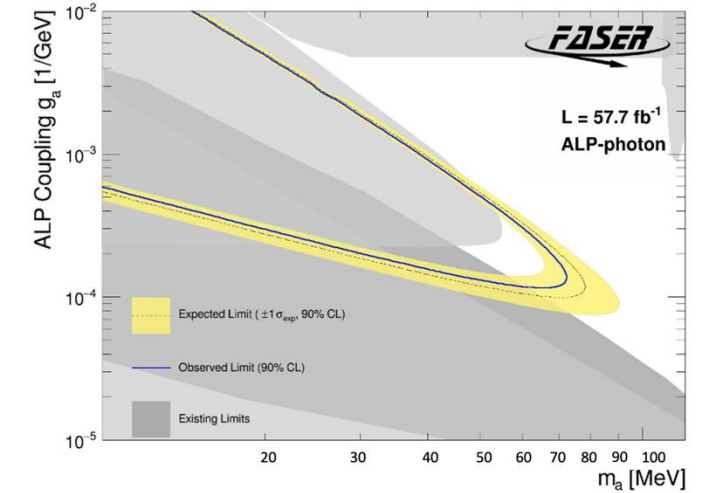
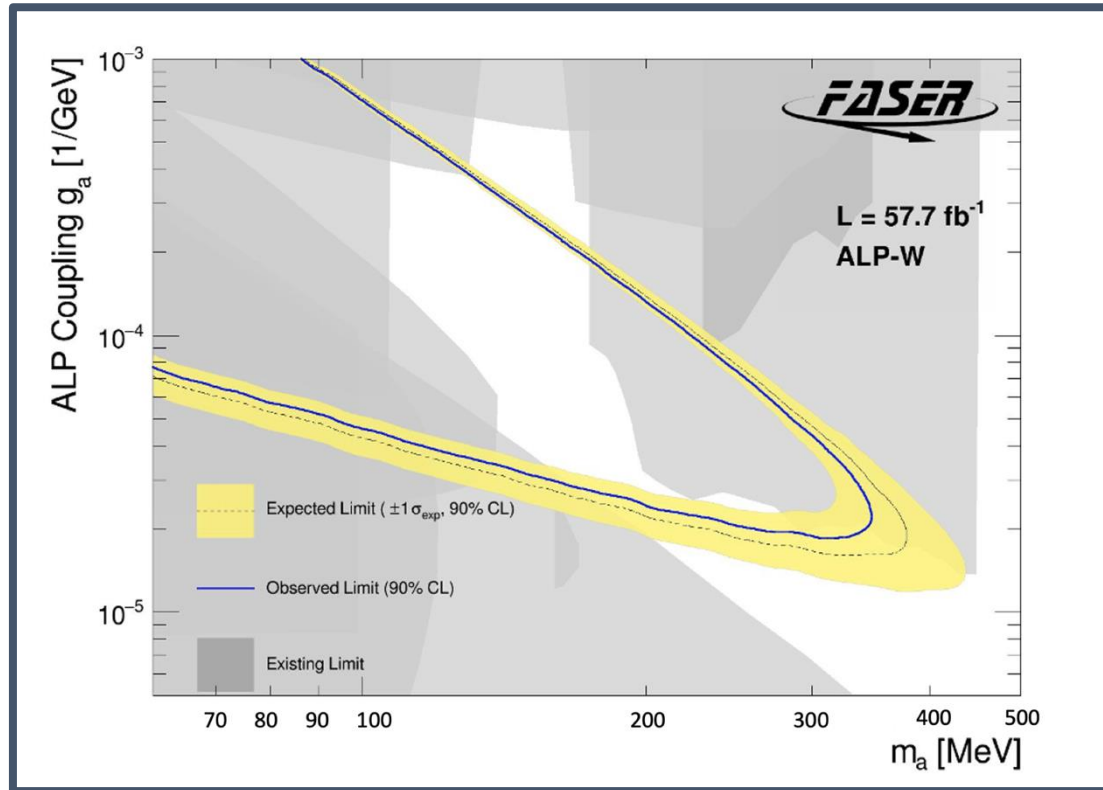
- * Geometric muons
- * Neutral hadrons
- * Beam-induced backgrounds
- * Cosmic rays



Expected background:	Observed:
0.44 ± 0.39 events	1 event

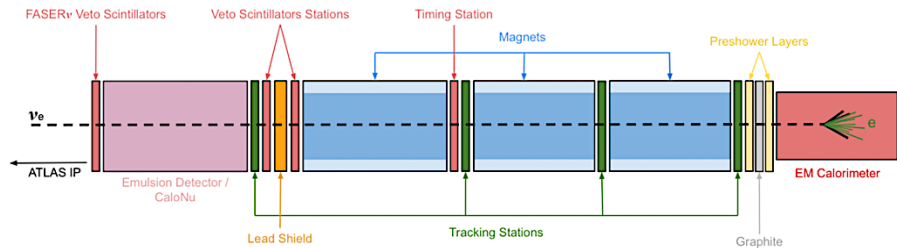
ALPs: Result and Reinterpretations

- * **1 event** observed, consistent with the expected background
- * World-leading constraints established for **ALP-W**
- * Previously unexplored regions of parameter space **excluded**
- * Results can be reinterpreted in a **variety** of models

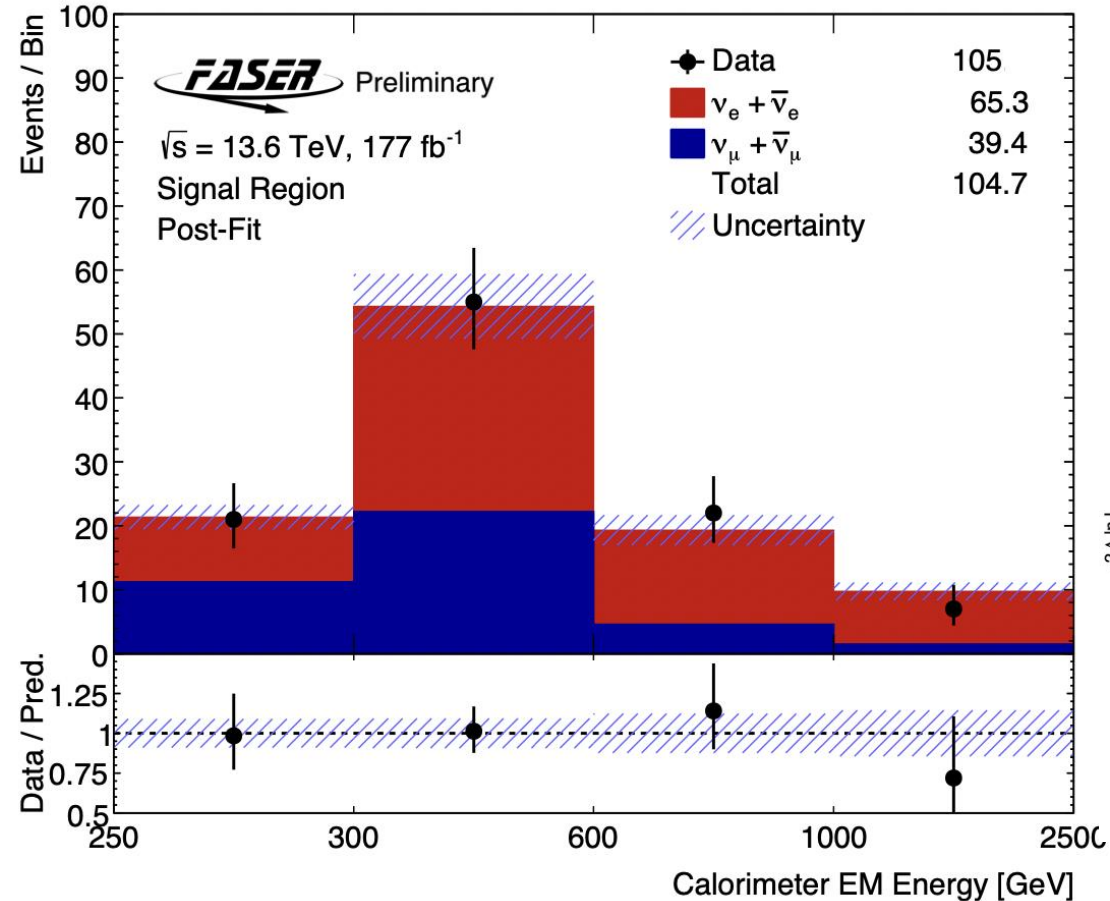


ν_e Measurement in the EM Calorimeter

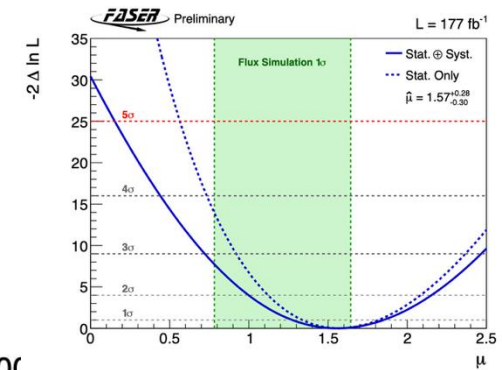
CERN-FASER-CONF-2026-004



- * **First** measurement of ν_e interactions in the electronic detector
- * Signal region from ALPs control region
- * Main background constrained with the muon neutrino analysis
- * Observation of CC+NC ν_e in the EM calorimeter (5.5σ)



- * **Constraint of forward hadron production**
- * **Key milestone towards cross section of ν_e**



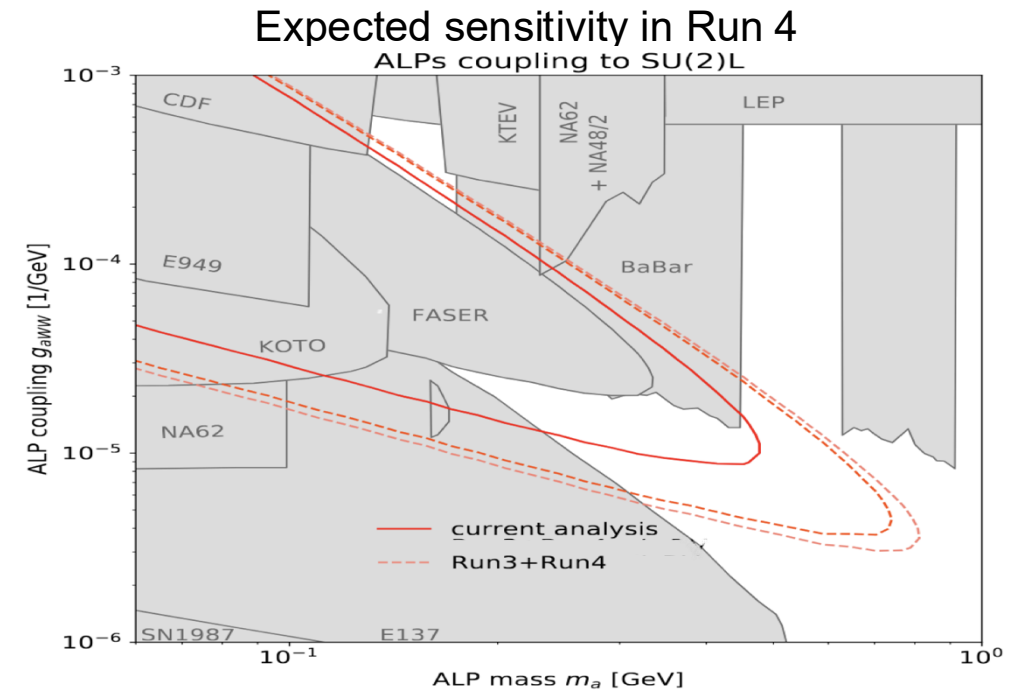
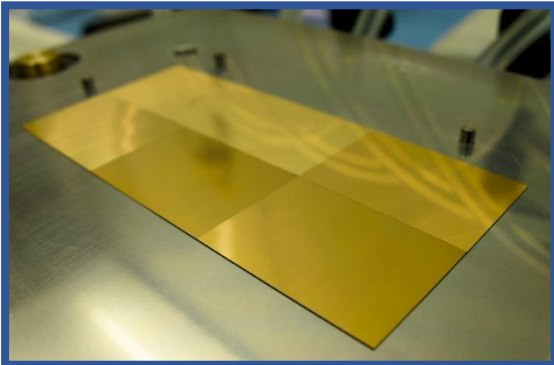
Expected events:	Observed:
81 ± 29 events	105 events

**Highest energy event
E=2.1 TeV**

Prospects for the future

FASER Upgrades and Physics Reach

- * FASER continues to expand its LLP and neutrino physics program with new detector upgrades and ongoing Run-3 data taking
- * New highly granular Preshower detector installed in 2025
 - Allowing for multi-photon shower reconstruction
 - Improved separation of highly collimated photon pairs from boosted ALP decays
 - Extends FASER sensitivity to forward LLP signatures

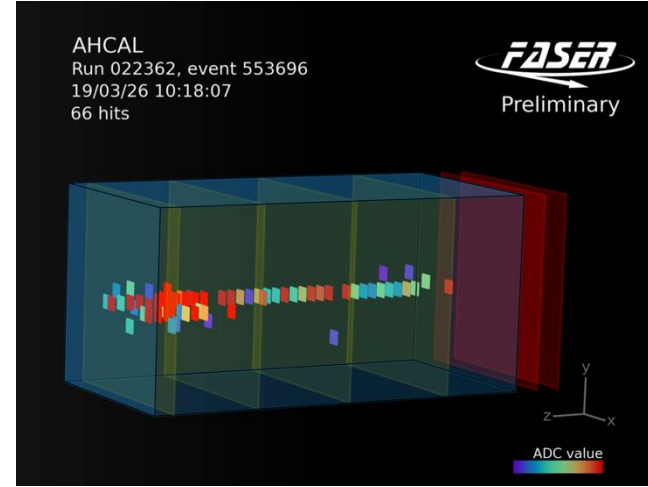
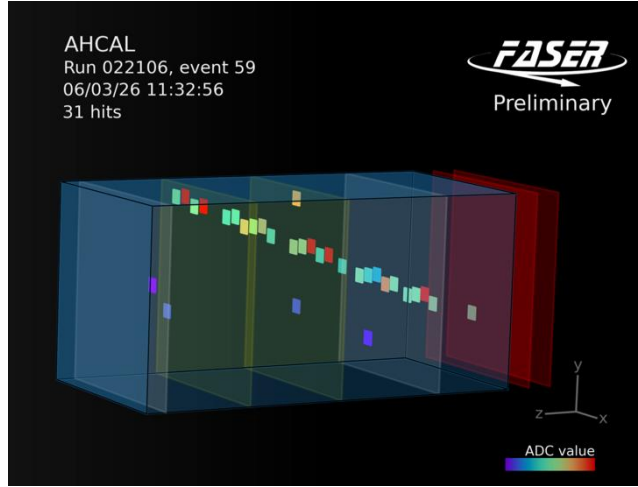


Looking Forward to Run-4

The FASERCAL and AHCAL prototypes have been installed in the TI12 tunnel and are currently taking data

Cosmic muon event vs. track with high energy deposit event from LHC

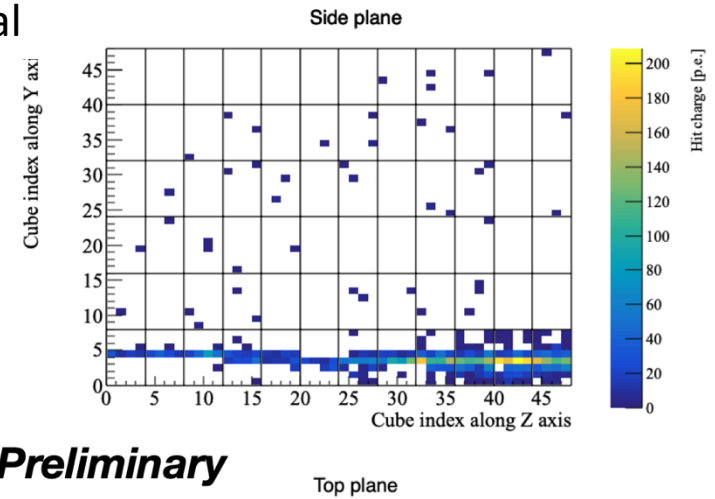
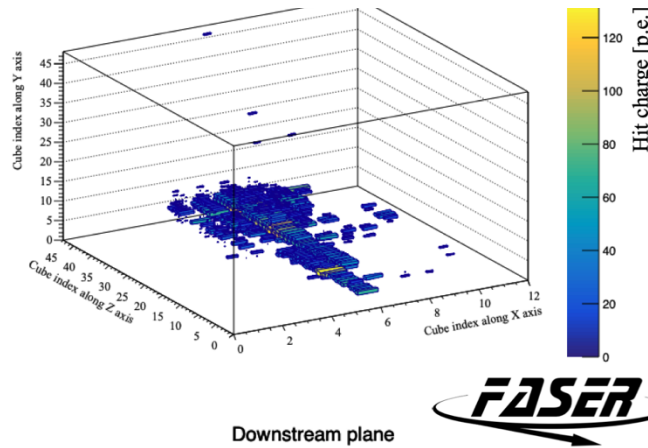
The AHCAL Prototype



The FASERCAL Prototype



Muon event showering within FASERCAL



Summary and Outlook

- * FASER has operated successfully throughout LHC Run 3 and is approved for Run 4, with ongoing detector upgrade studies
- * FASER continues to deliver world-leading sensitivity to light long-lived particles, including dark photons and ALPs
- * New Run-3 analyses significantly improve sensitivity to highly collimated and downstream LLP decays
- * FASER also provides a unique forward neutrino physics program at the LHC

Many thanks for the support of:





FASER

**Thank you very much for your
attention!!**