Detecting diphoton events with the FASER upgraded preshower

Jordi Sabater
on behalf of the FASER collaboration

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ForwArd Search ExperRiment

UNIVERSITÉ DE GENÈVE

Forward physics at the LHC

Main detectors at the LHC look at high momentum particles in the transverse plane

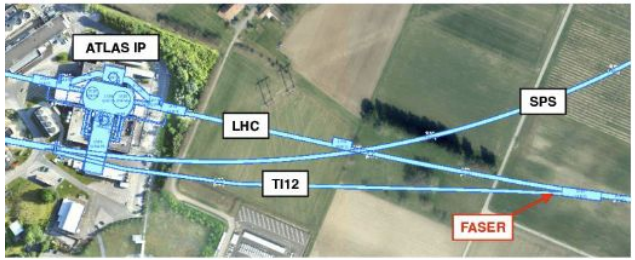
Large forward cross section is not being used

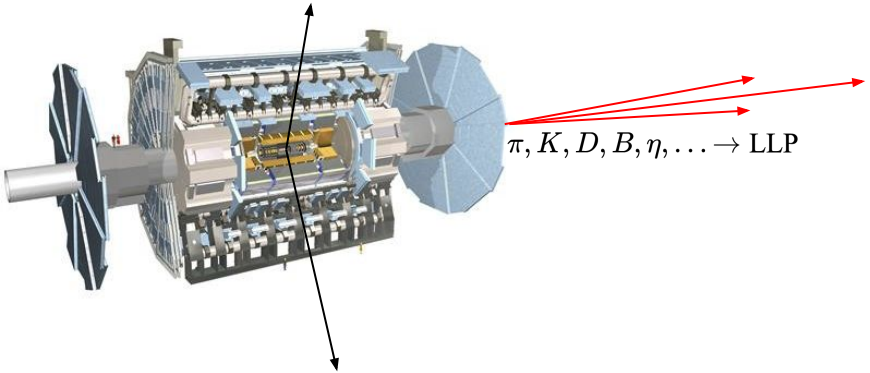
- $N_{\pi^0} \sim 10^{17}$ From inelastic pp collisions ($150\ \text{fb}^{-1}$)

→ FASER located 480m downstream of the ATLAS interaction point
Forward particles are very collimated

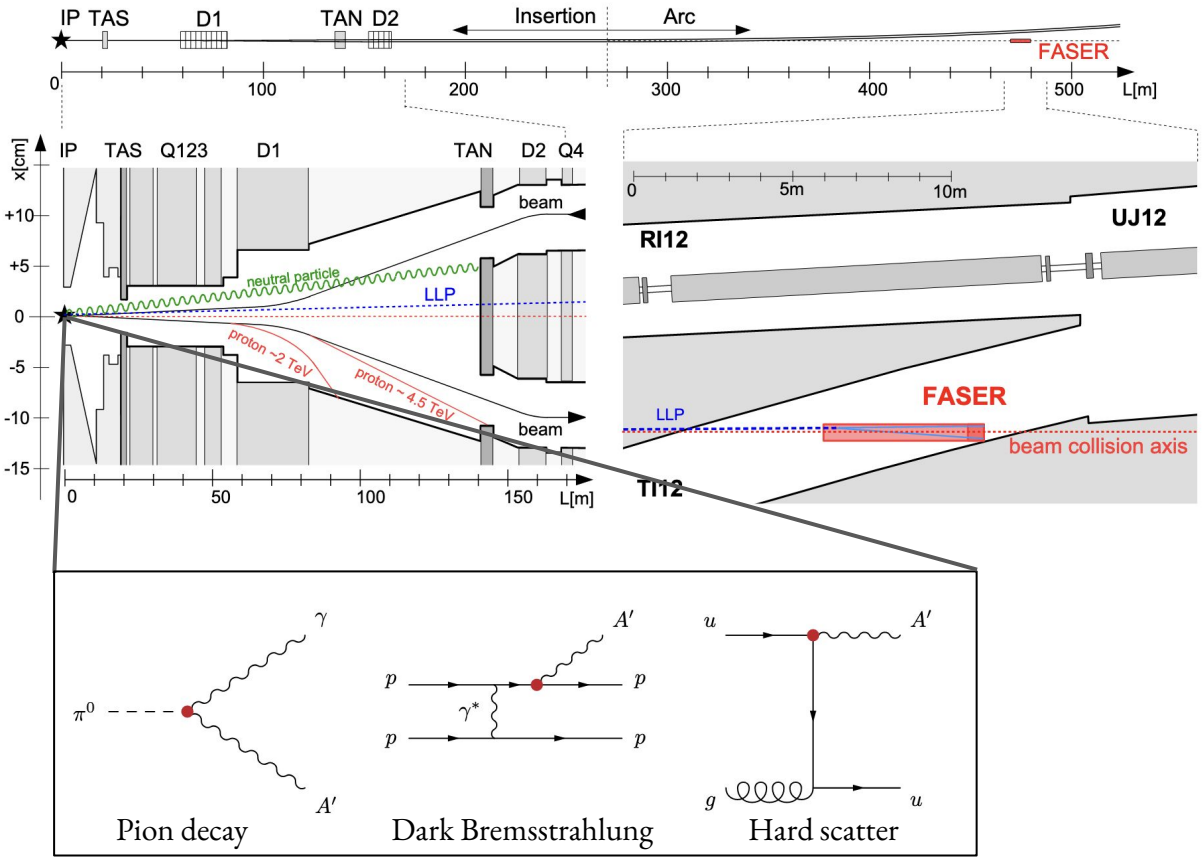
- pp → LLP + X, LLP travels O(100m) forward, $\text{LLP} \to e^+e^-, \gamma\gamma, \ldots$

- $\theta \sim \frac{m}{E} = 100\ \mu\text{rad} \to 100$ microns after 1m

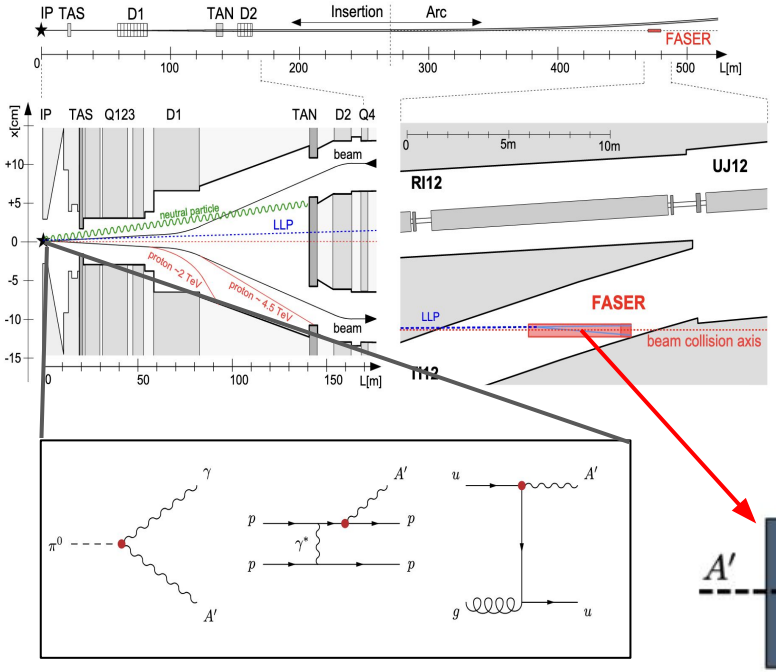


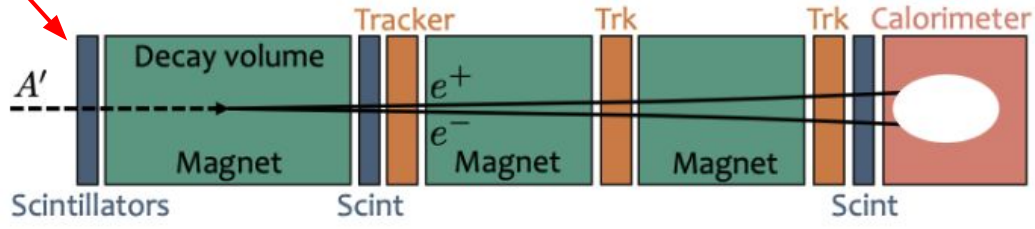


Dark photon production mechanisms



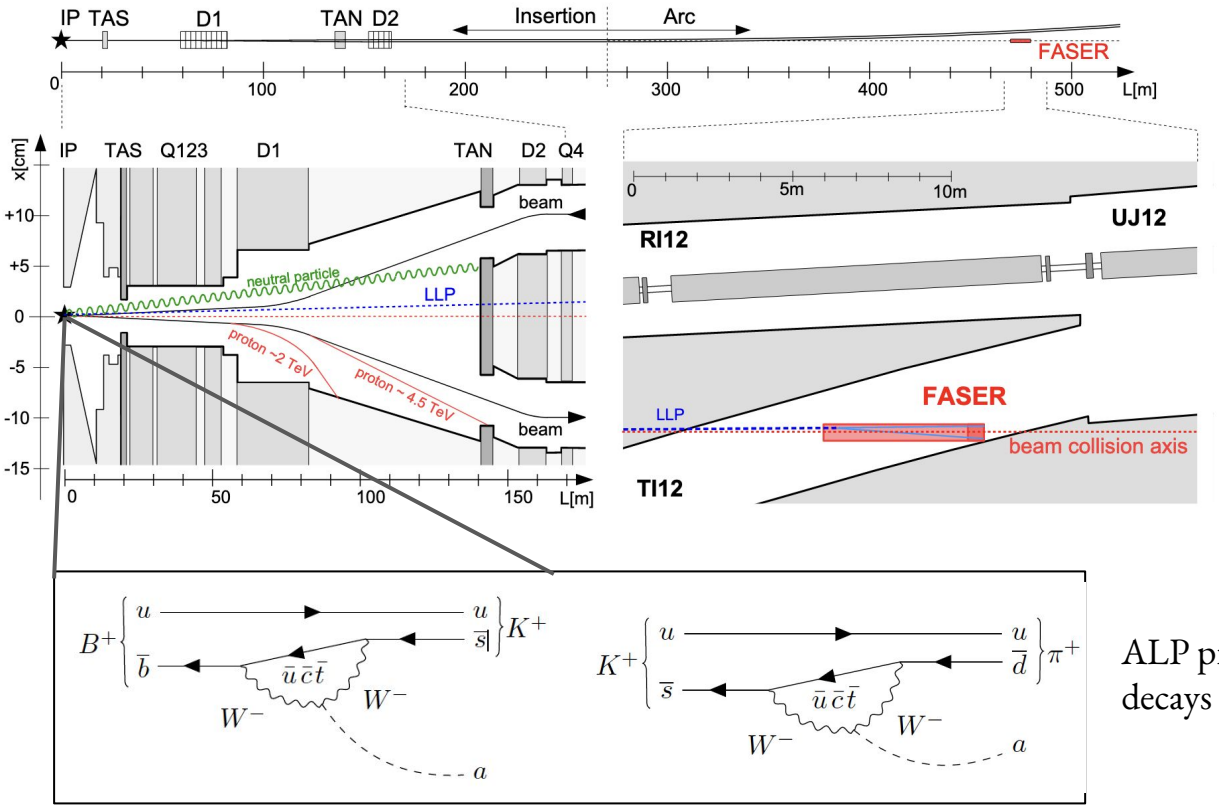
Dark photon detection at FASER





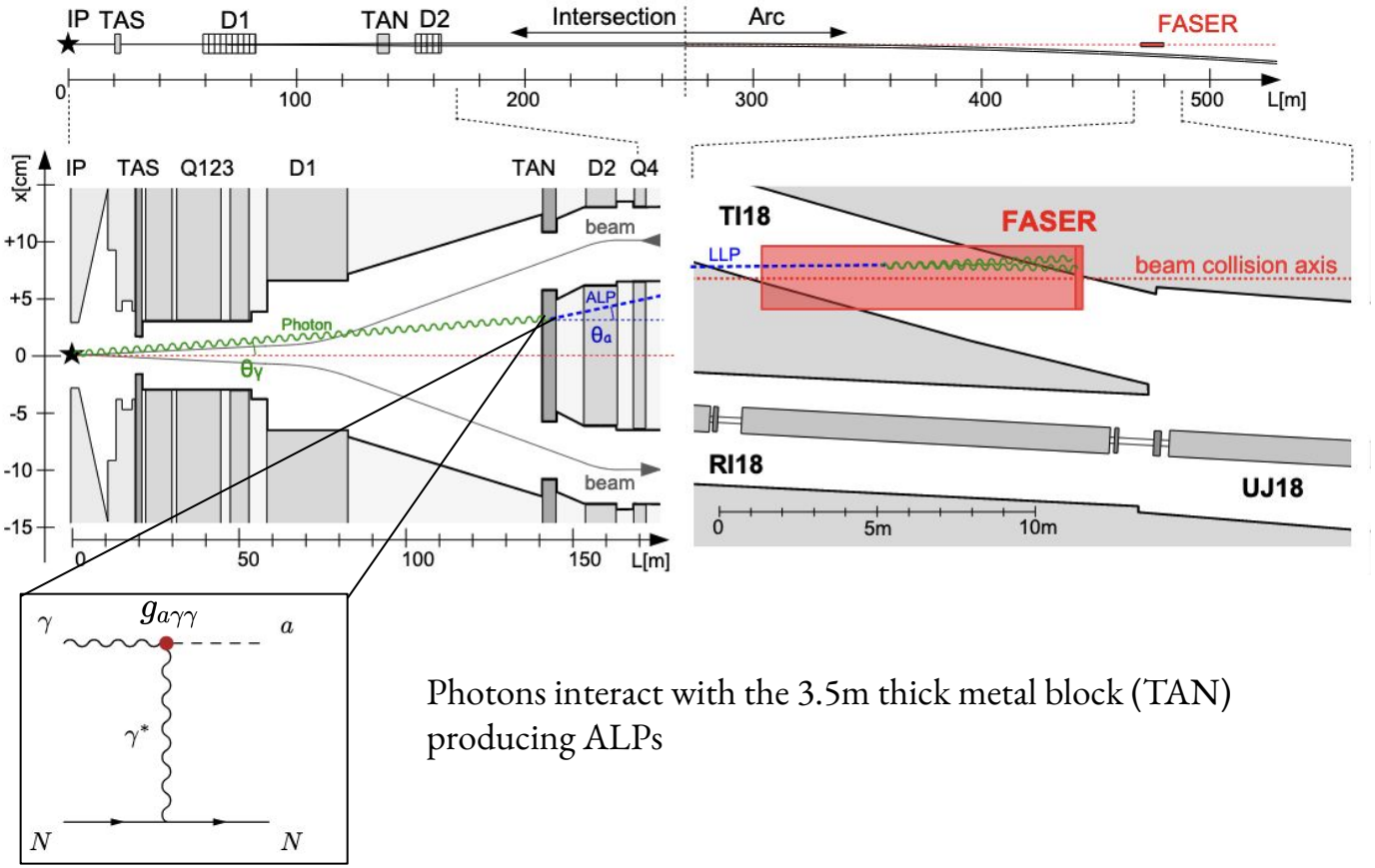
Magnets+tracker stations allow to separate the electron and positron

Axion like particle (ALP) production mechanisms



ALP production from light meson decays

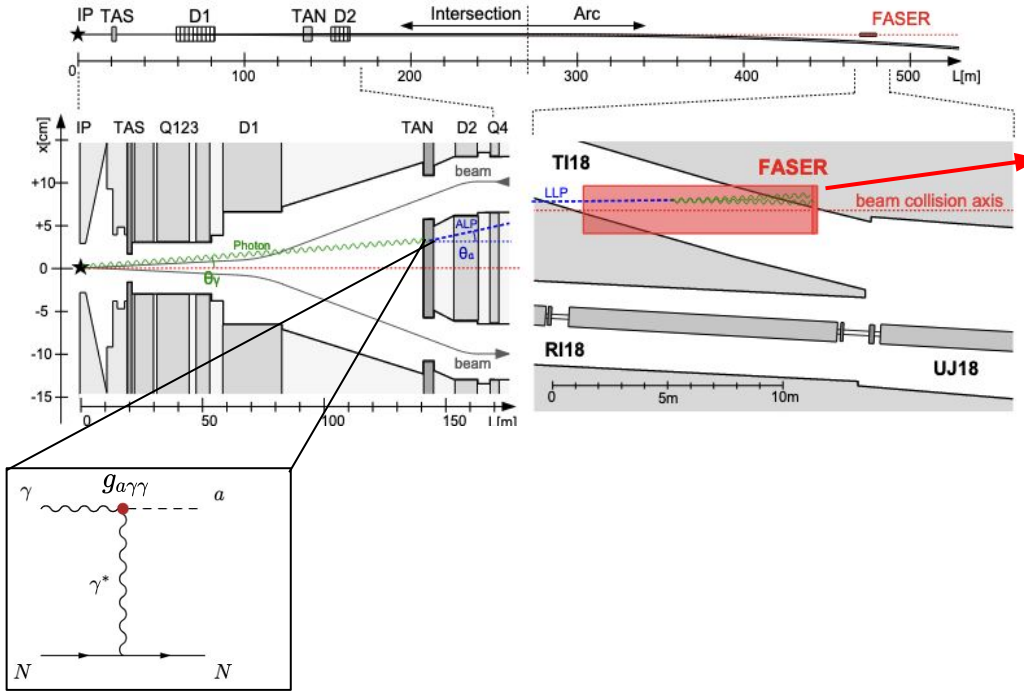
ALP production mechanisms: Primakoff

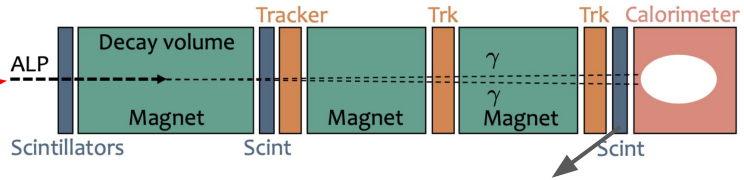


Primakoff

Photons interact with the 3.5m thick metal block (TAN) producing ALPs

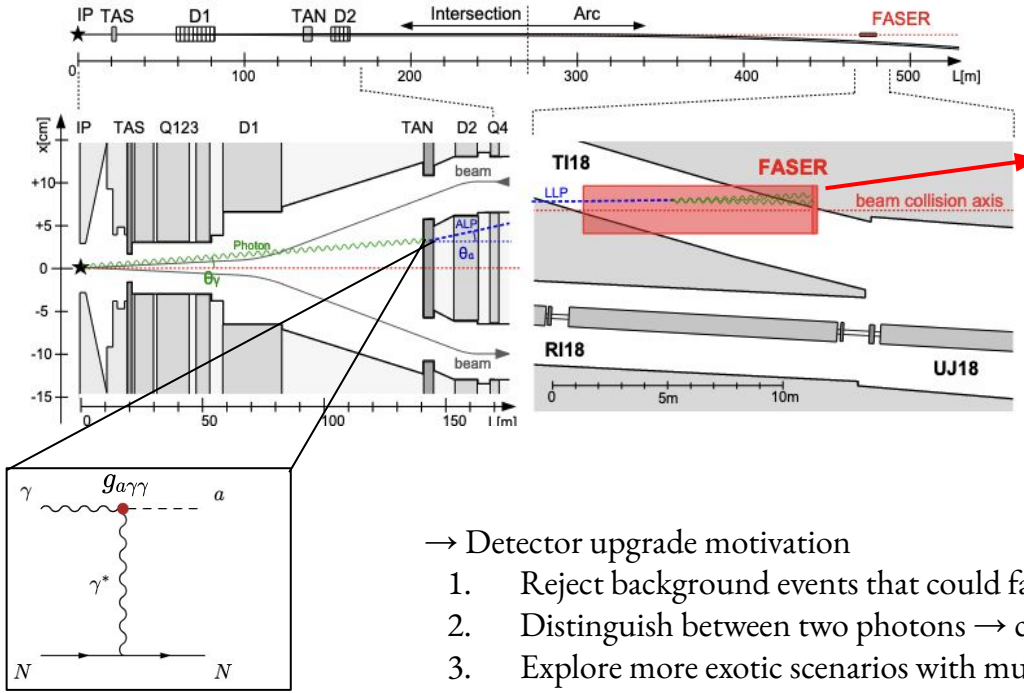
ALP diphoton signature

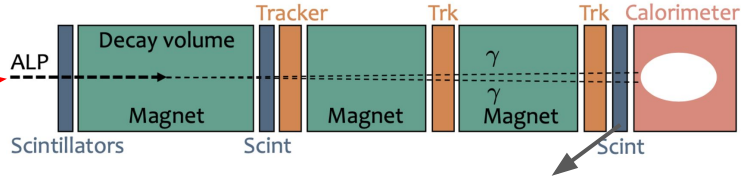




Current preshower: 2 layers of Scintillator + Tungsten
→ Cannot distinguish between 2 high energetic collimated photons
→ Photons cannot be resolved with the current detector

The need for an upgrade





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→ Cannot distinguish between 2 high energetic collimated photons
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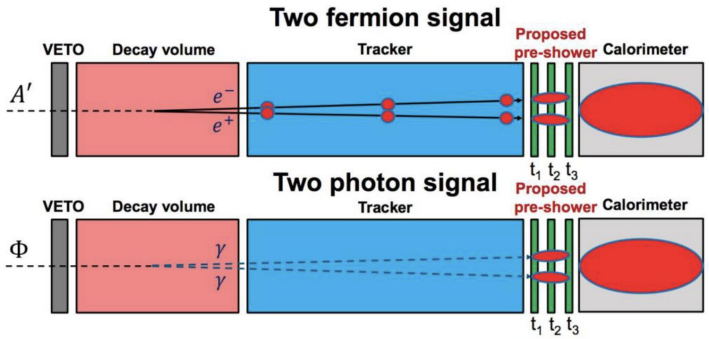
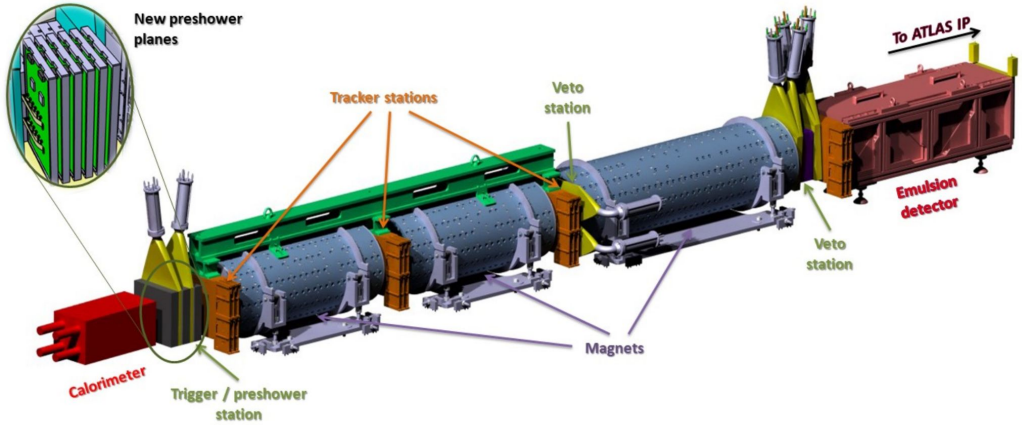
→ Detector upgrade motivation

1. Reject background events that could fake a (diphoton) signal
2. Distinguish between two photons → characterization of new physics signal
3. Explore more exotic scenarios with multiple photons in the final state

FASER preshower upgrade

Install a preshower in front of the calorimeter to distinguish the two (or more) photons

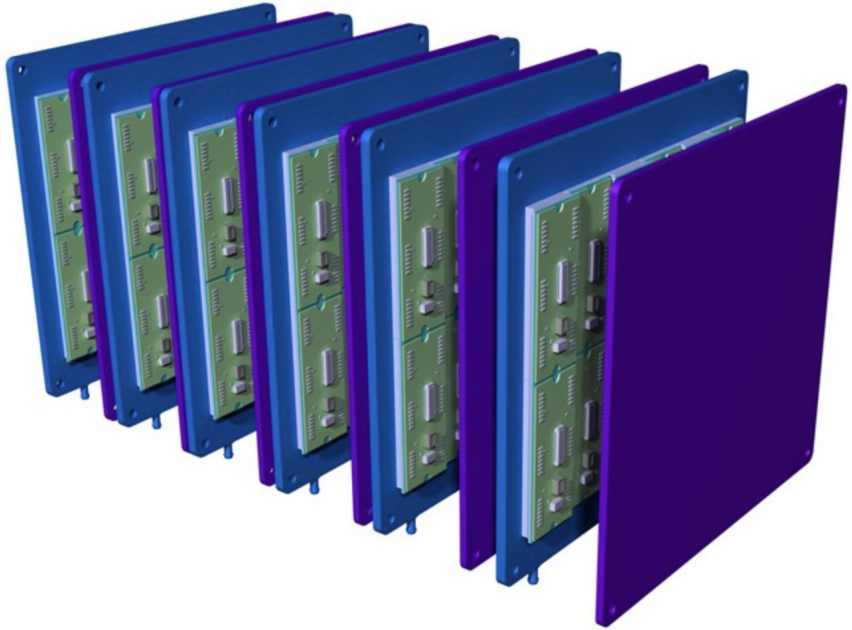


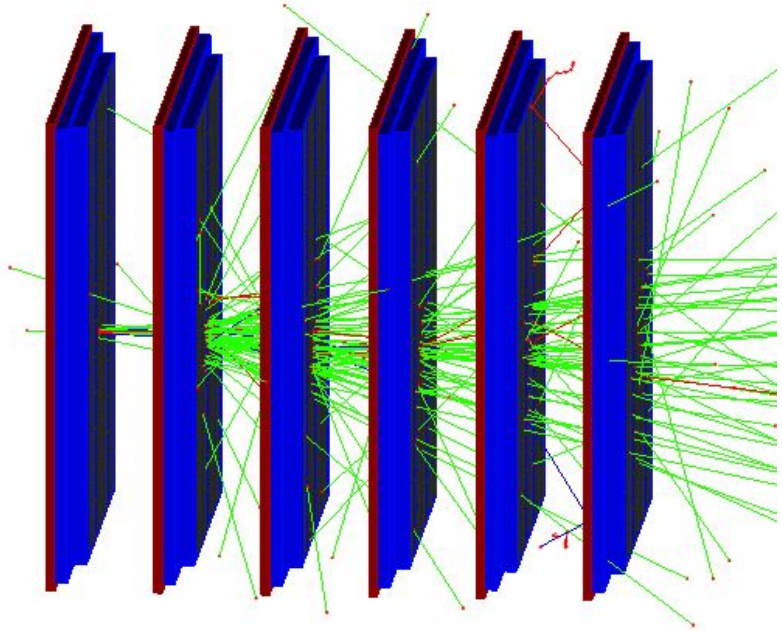


Preshower using Tungsten + Silicon
→ Perfect for high position resolution

Installation scheduled for the HL-LHC phase

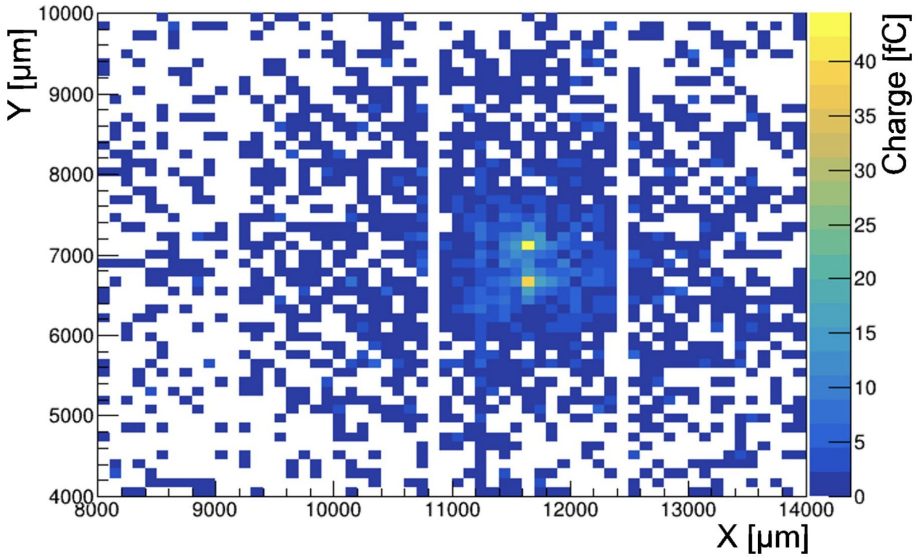
Preshower layout





6 layers of W+Si
Preshower size ~ 200 mm x 200 mm
Hexagonal pixels of 65um sides
Tungsten thickness = 1X0 (3.5mm) → Total thickness 6X0 → 99% probability of conversion

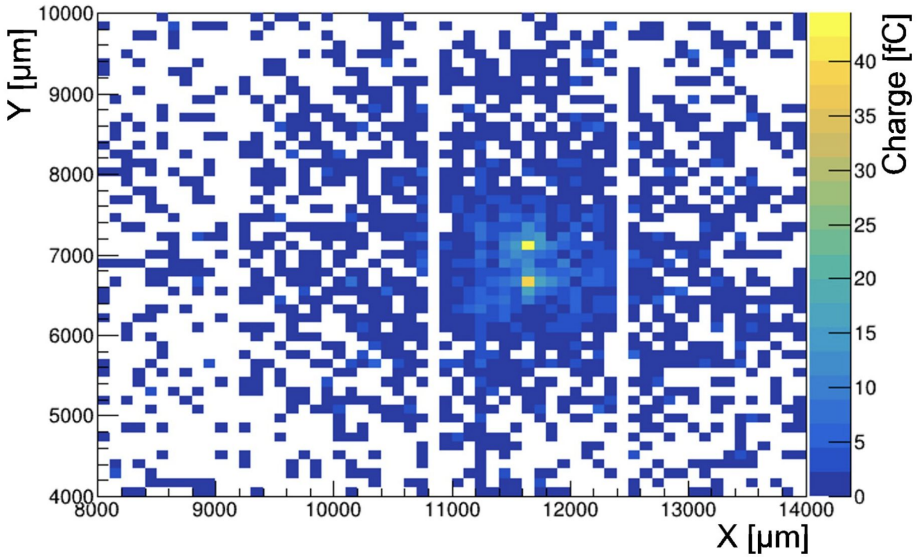
Shower profiles and reconstruction

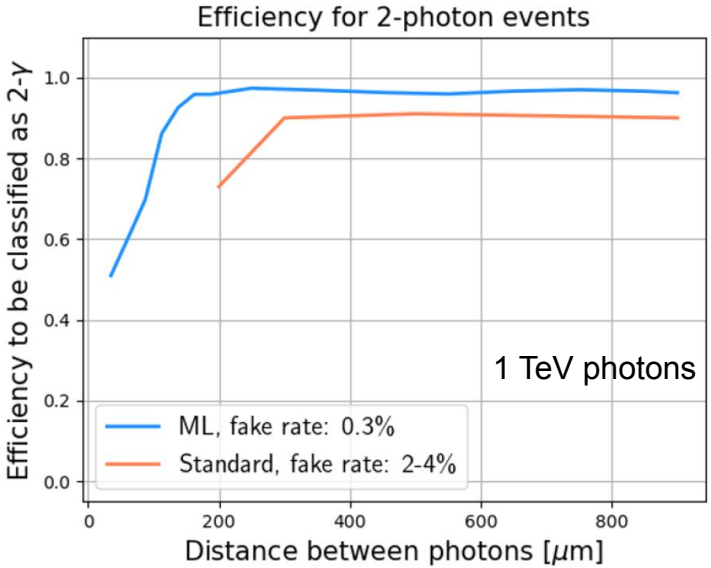


2 photons with E = 2 TeV shot at the preshower with a separation of 500um

Signals are clearly distinguisable

Shower profiles and reconstruction





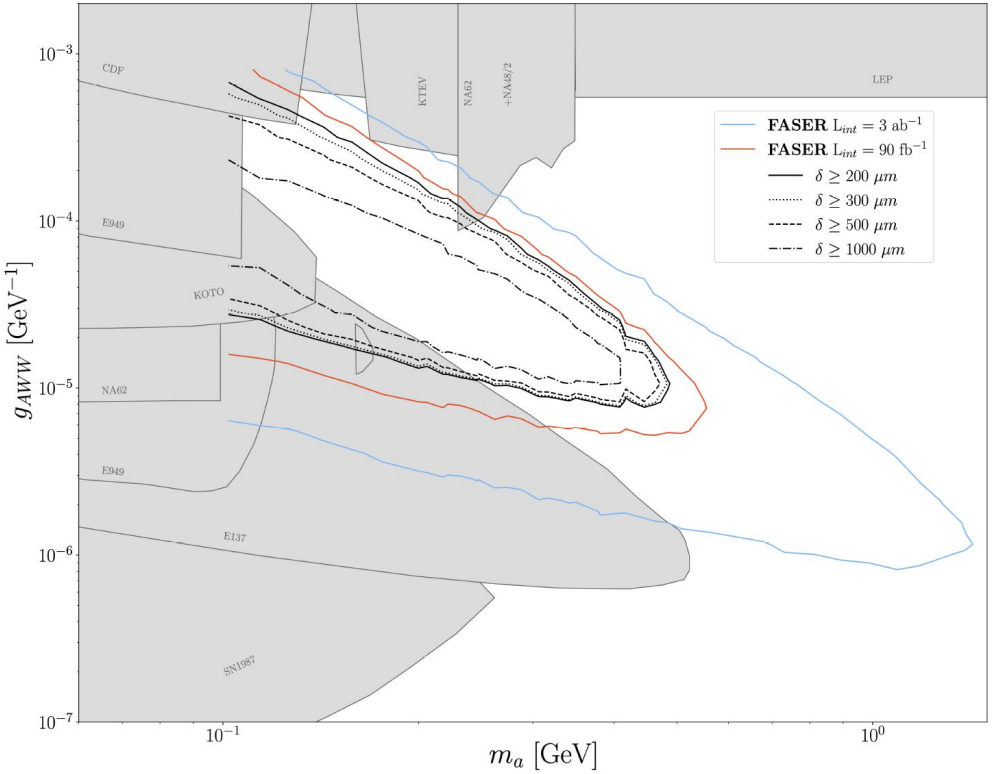
2 photons with E = 2 TeV shot at the preshower with a separation of 500um

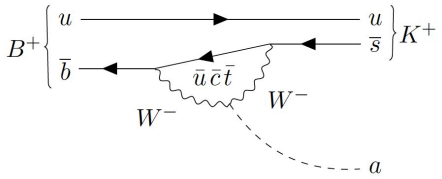
Signals are clearly distinguisable

Efficiencies above 80% obtained for separations above ~250um

Neutrino interacting with the preshower may fake a photon signal!

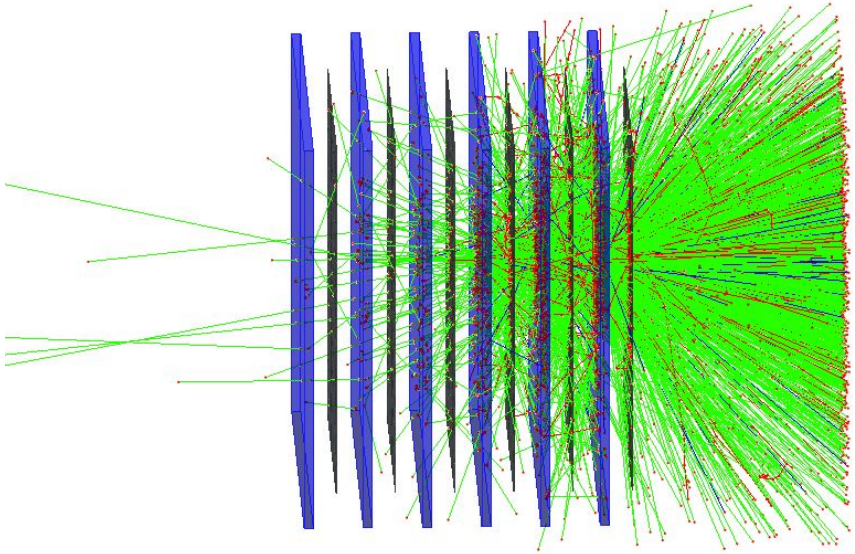
Expected sensitivity at FASER





- Sensitivity reach for different photon separations
- FASER has access to an unprobed regions of the phase space!
- Lots of room for improvement since a simple reconcstruction algorithm was used

Backup



Acknowledgements

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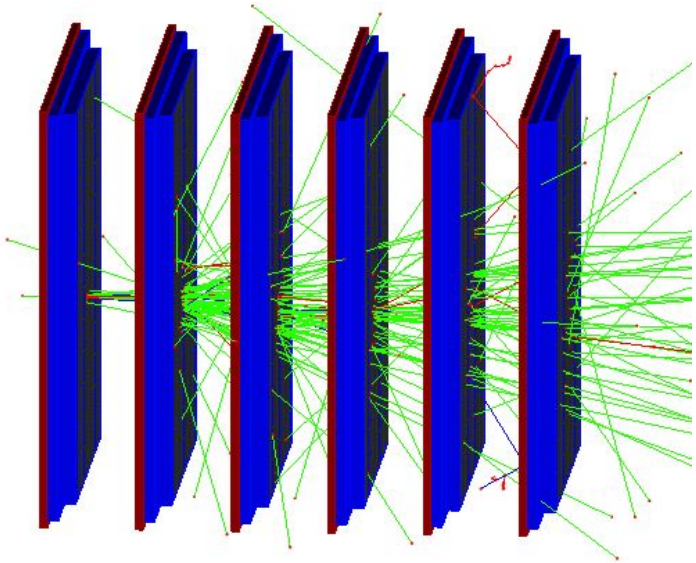
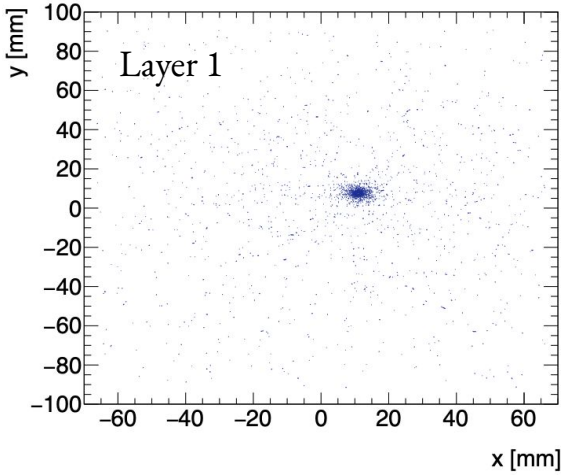
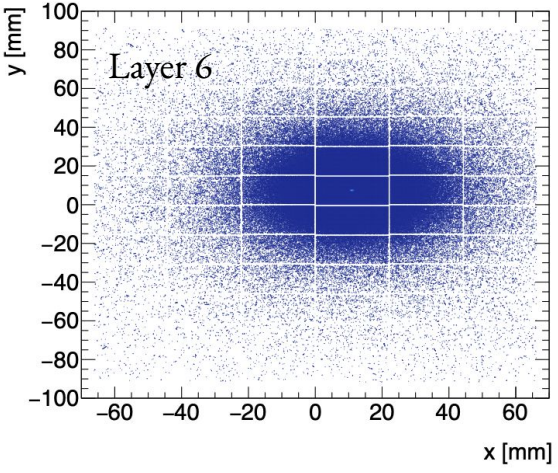
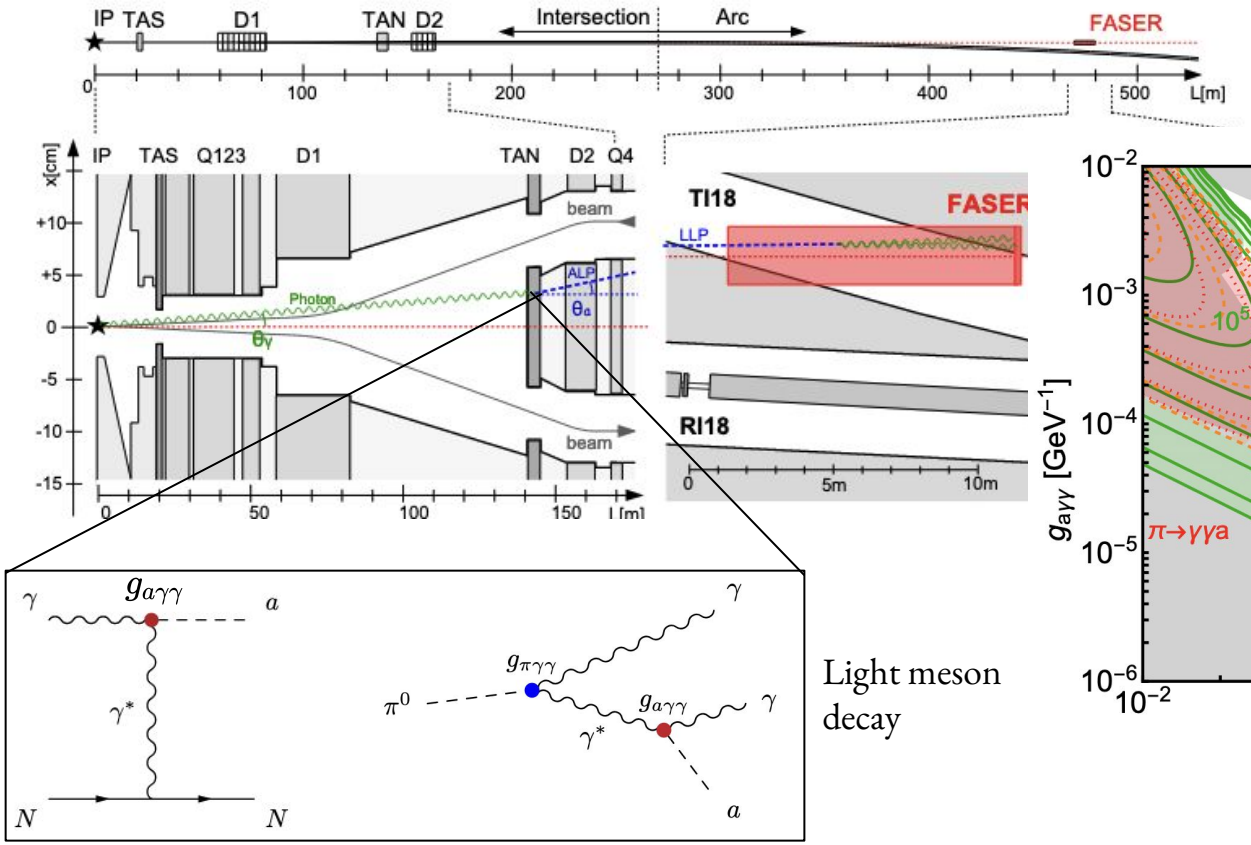
Shower profiles







ALP production mechanism



Primakoff

Light meson decay