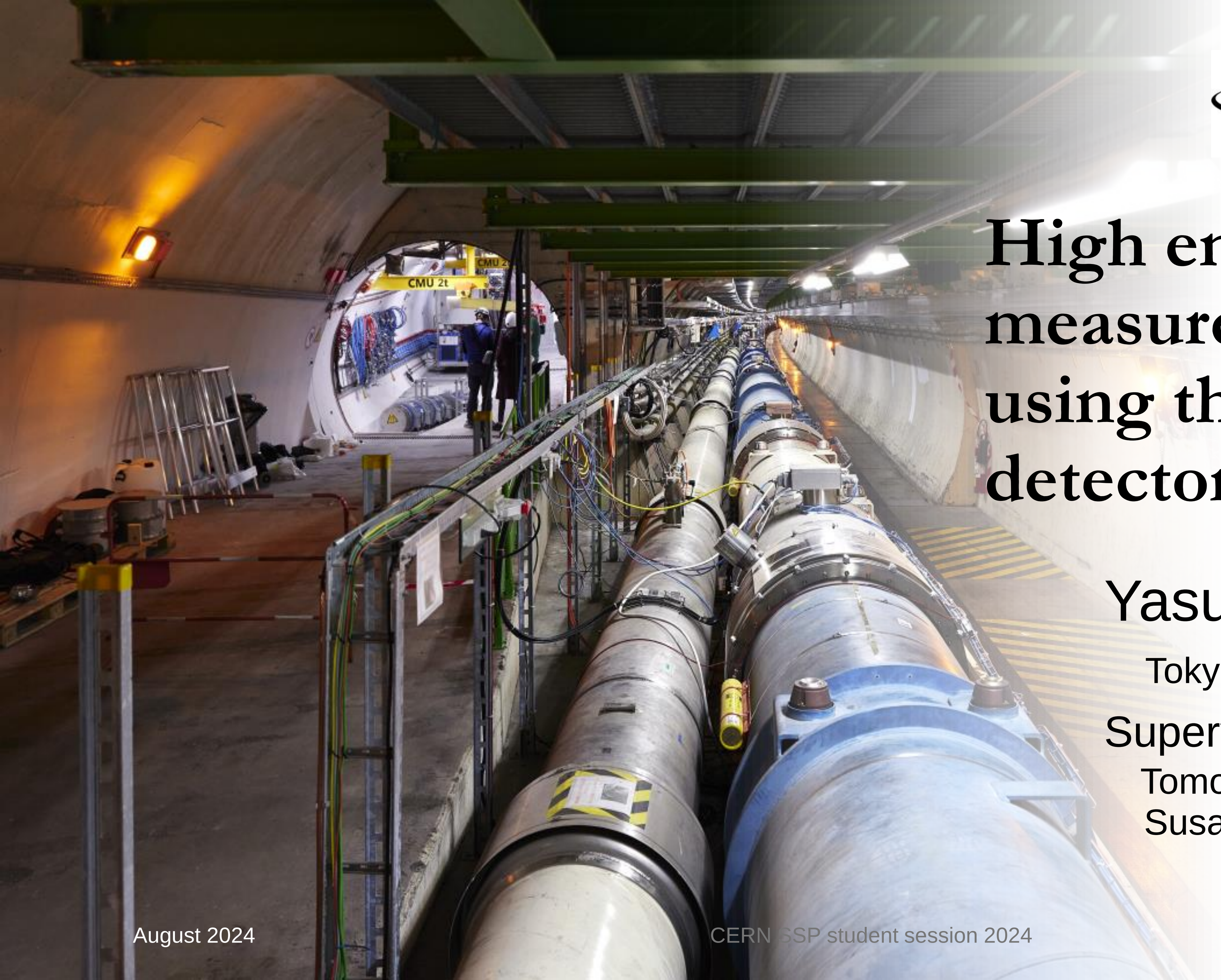

High energy neutrino measurement using the FASER detector

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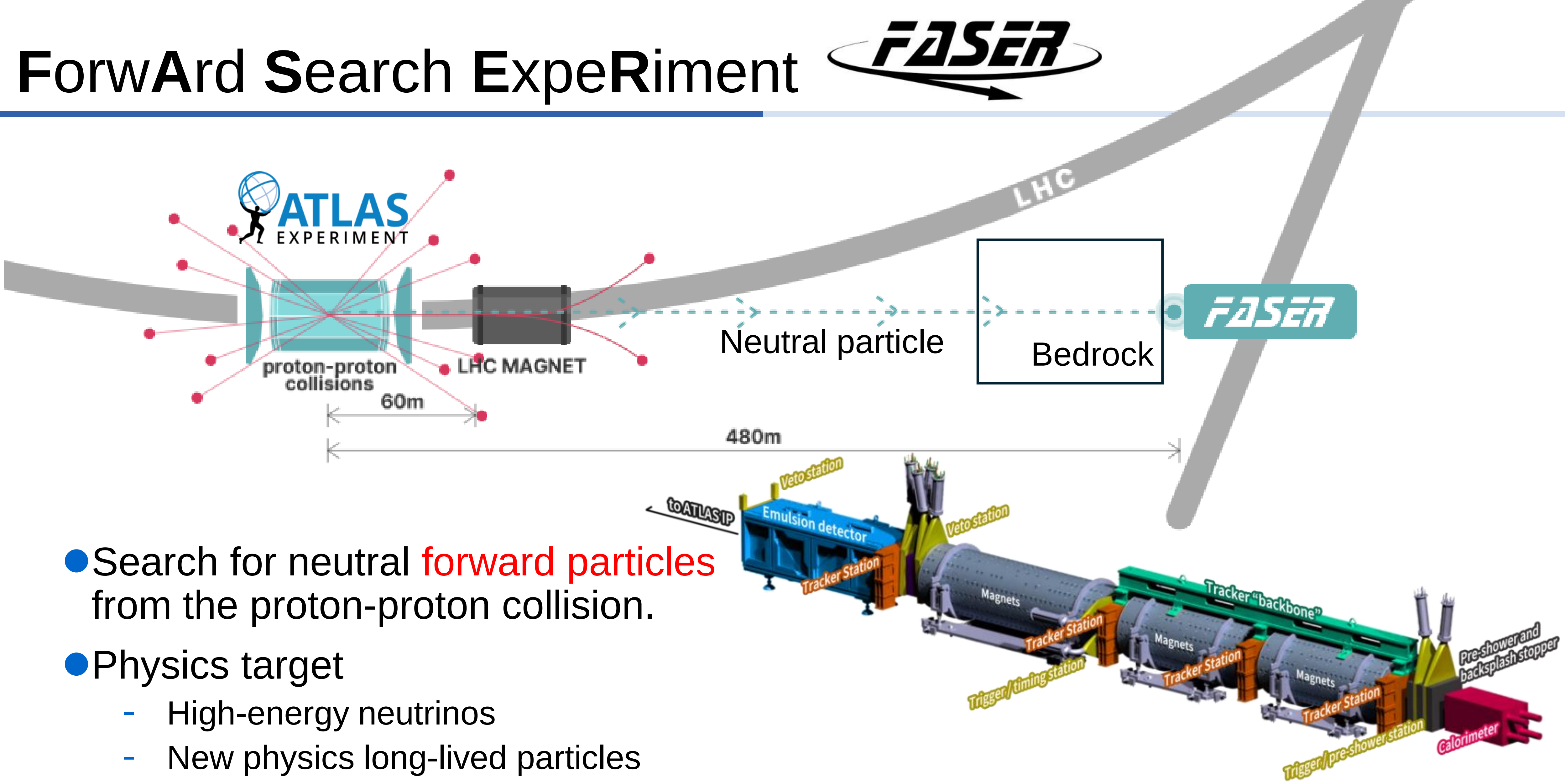
Tokyo Institute of Technology

Supervisor :
Tomohiro Inada,
Susanne Kühn.

ForwArd Search ExpeRiment

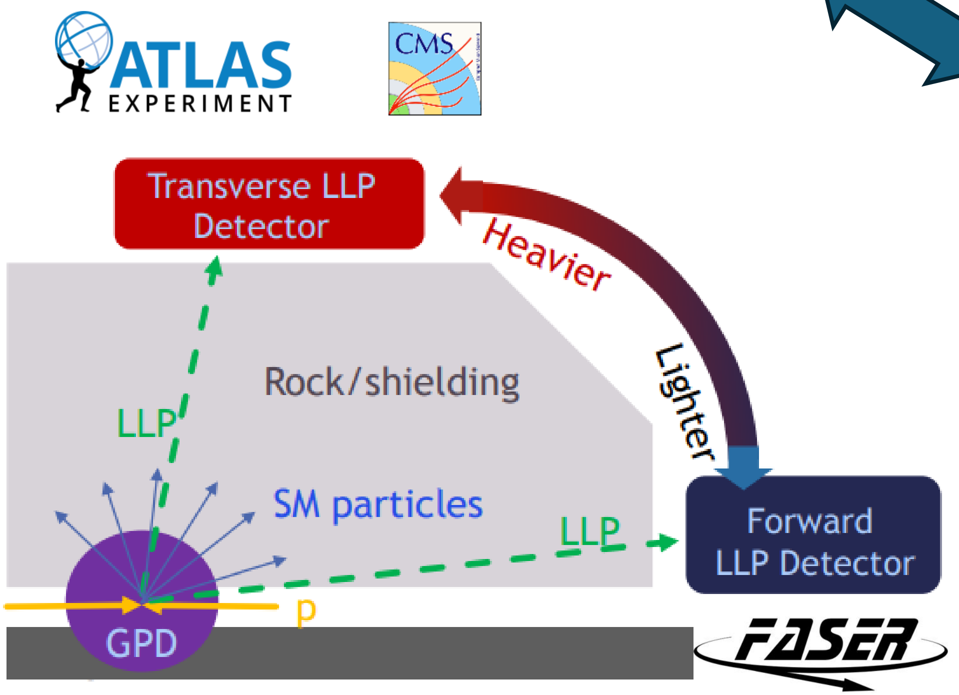


- Search for neutral forward particles from the proton-proton collision.
- Physics target
  - High-energy neutrinos
  - New physics long-lived particles

LLPs –why FASER

- **ATLAS** and **CMS** devote considerable efforts to searches for LLPs in LHC.

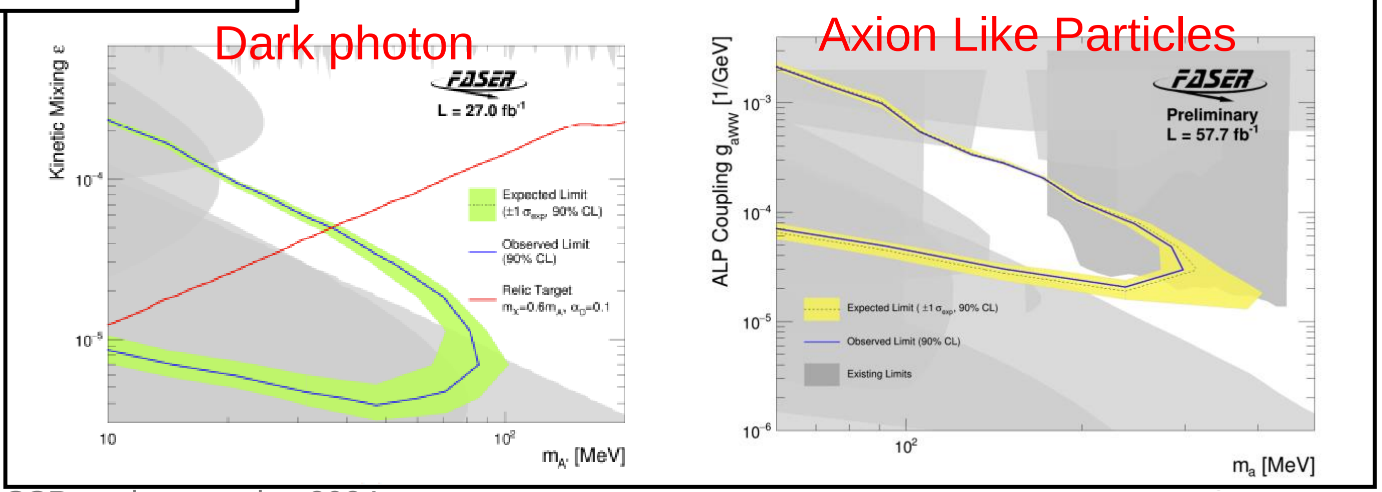
→ designed to search for heavy new particles (SUSY, WIMPs)



Monica DOnofrio, IPA2022

- **FASER experiment**
  Searching for light new particles (Dark photon, ALPs)
  - Background mitigated by rock/shielding
  - No triggering is needed

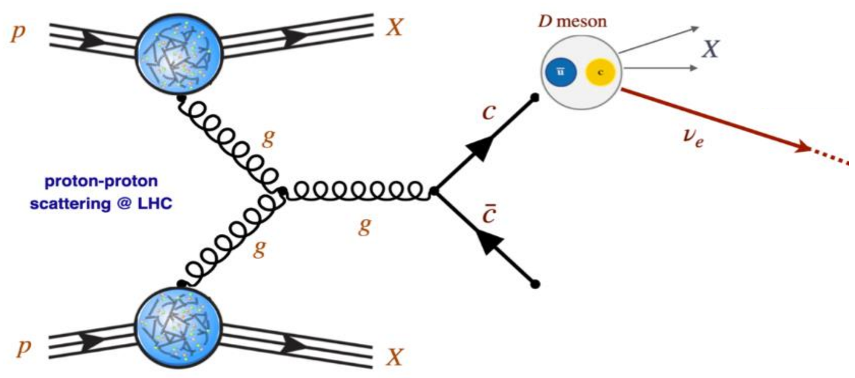
First results



arXiv: 2308.05587 CERN-FASER-CONF-2024-001

Neutrino - motivation

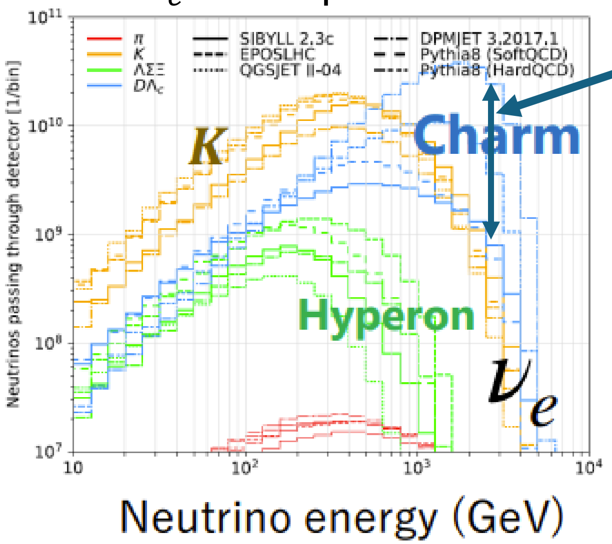
- Measuring the flux of Neutrino **as a probe to forward hadron production**



High-energy neutrinos are produced by hadron decay.
These hadrons are produced by QCD interaction in p-p collision.

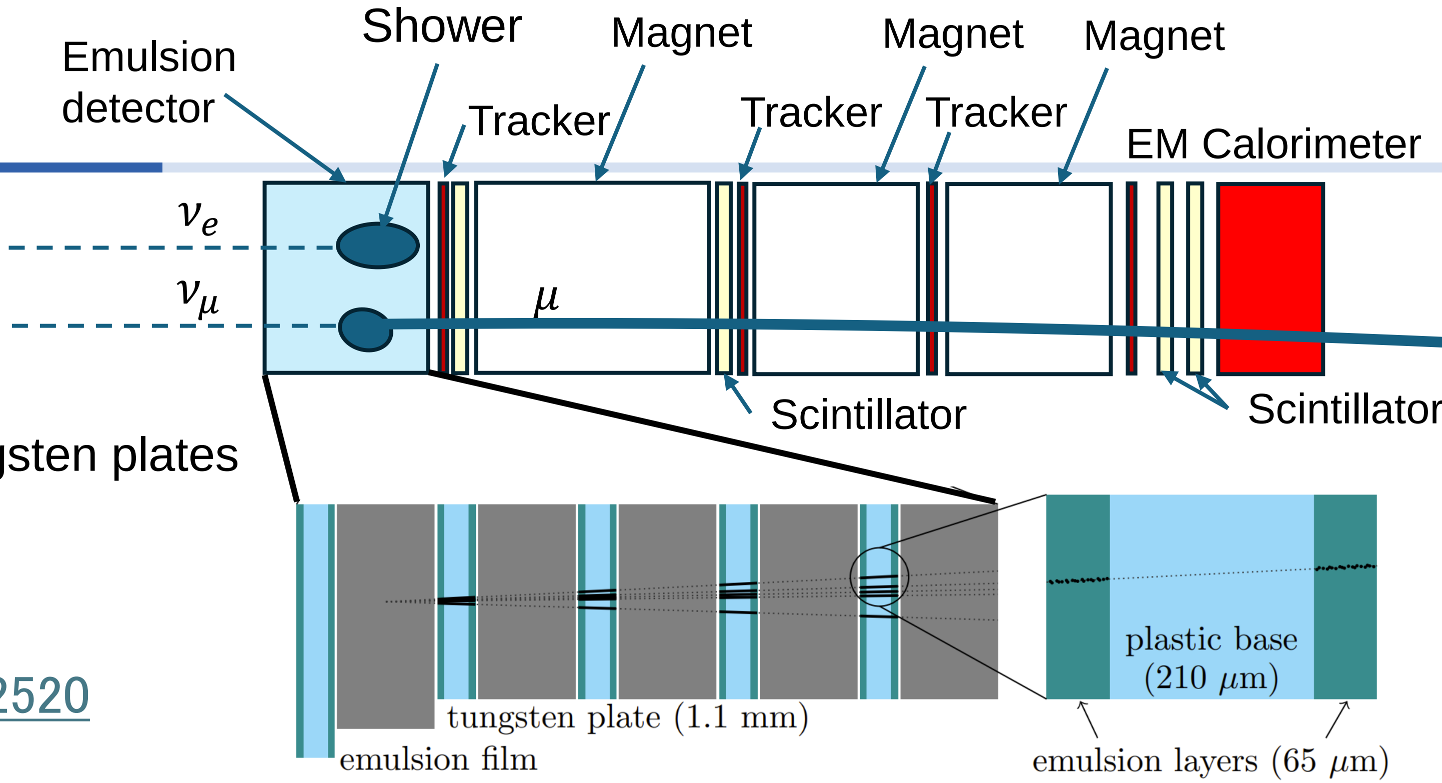
There are a lot of undefined things in QCD interaction.
→ We can't expect the flux accurately.
→ The flux expectation is different between models.

ν_e flux expectation



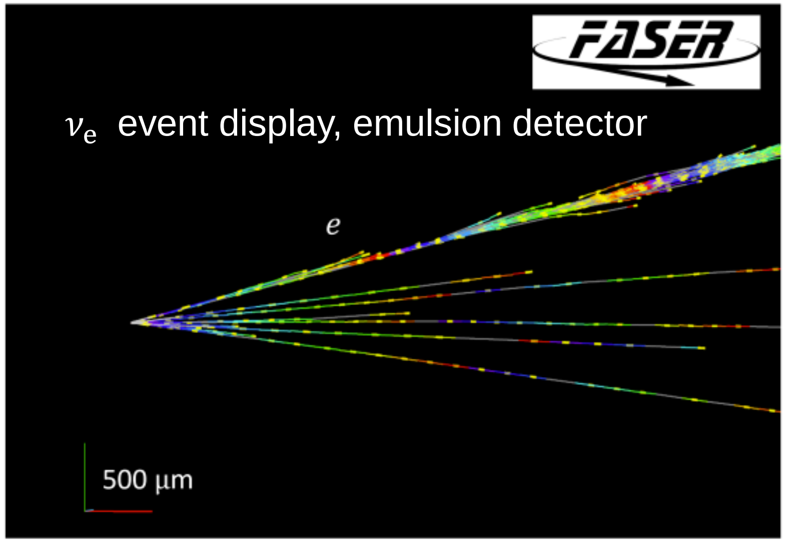
FASER measures the flux of neutrino.
→ We can define which model is better.
→ Further understanding of QCD.

How to detect neutrino



Two ways to detect neutrino

- **Emulsion detector**
  - Sandwich of emulsion films and tungsten plates (730 layers)
  - Tracking particles produced in ν_e, ν_μ interaction.
    $\rightarrow$ can detect ν_e, ν_μ. arxiv: 2403.12520
- **Tracker**
  - Tracking the muon produced by ν_μ interaction in the tungsten plates
    $\rightarrow$ can detect only ν_μ. arXiv: 2303.14185
    $\rightarrow$ can't detect ν_e.



➡ Now, we don't have a way to detect ν_e only using electric detector.

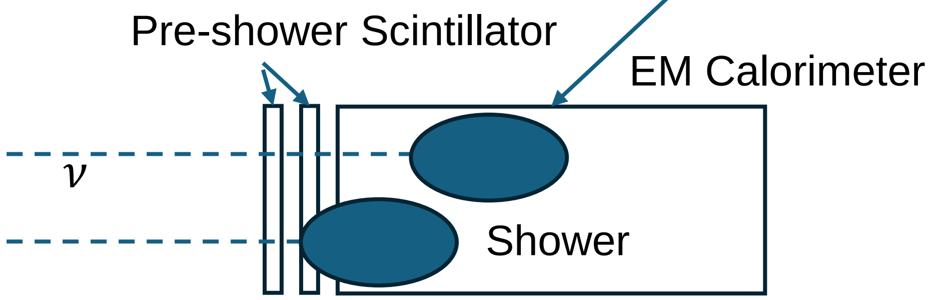
Issue and my study

Issue and My Study Motivation

- In HL-LHC, too many muons come to the FASER detector.

→ Due to too many tracks, need to change the emulsion detector more often.

→ Developing a new way to measure the high-energy ν_e using only electric detectors.



New method

Target: Electron neutrinos interacting in the calorimeter and pre-shower system.

- It makes a shower and high energy deposits to the calorimeter.

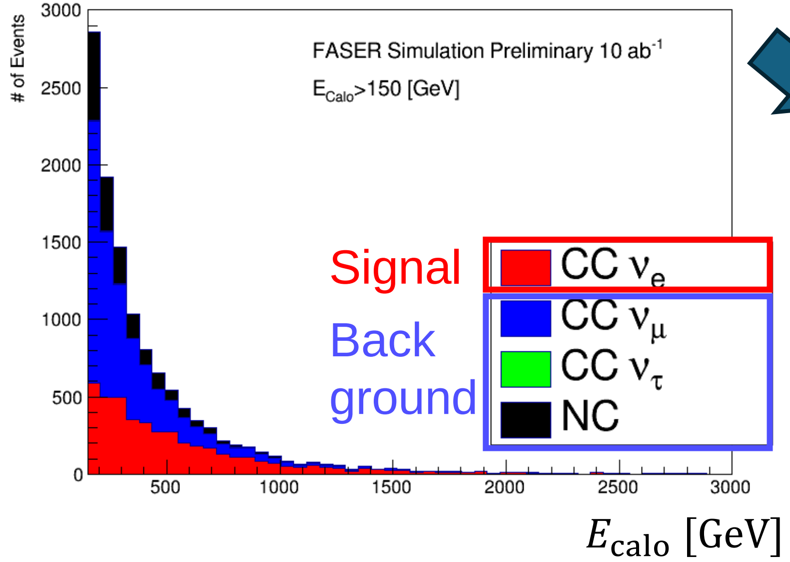
My study:
Evaluating the possibility of detecting electron neutrinos using MC simulation. (Not using real data)

the possibility of detection in 1 slide

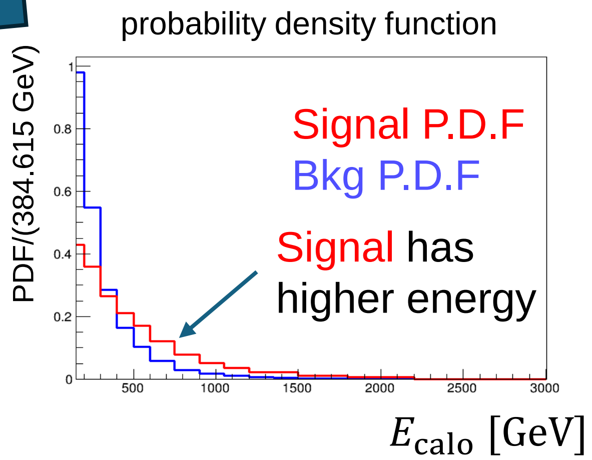
$$\text{p-value of no signal} = \int_Z^\infty \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} dx$$

MC simulation at the current condition of FASER detector

- Other neutrino interactions become backgrounds



normalize

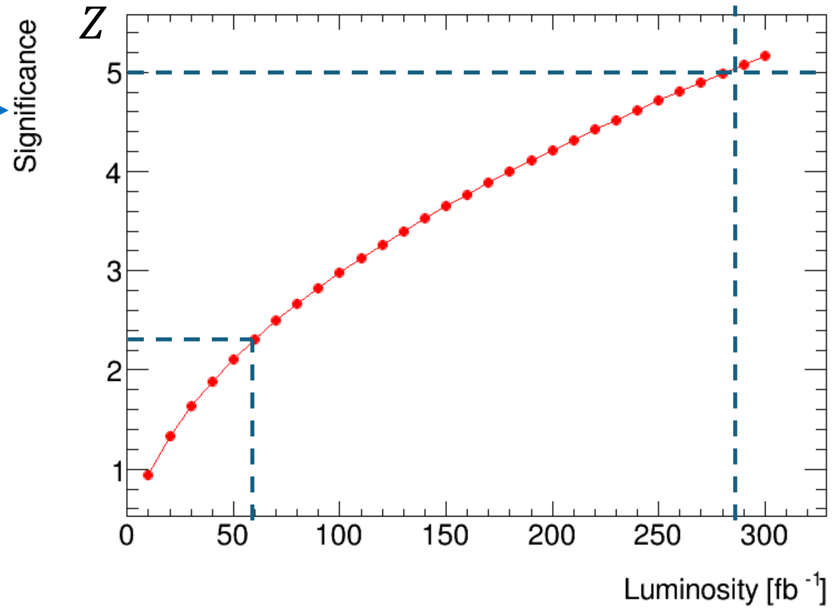


Likelihood func using f: P.D.F. w/o systematic uncertainty.

$$L(n_{sig}, n_{bkg}) = \prod_i \text{Pois}(n_{data} | n_{sig} f_{sig}(i) + n_{bkg} f_{bkg}(i))$$

i is the bin number of E_{calo}

Calculating **significance** (Z) of n_{sig} against n_{bkg} by fitting likelihood to scaled MC data. (Asimov fit)



- 2.3σ @ 60 fb^{-1} (already opened)
- 5.0σ (discovery) @ 281.4 fb^{-1}

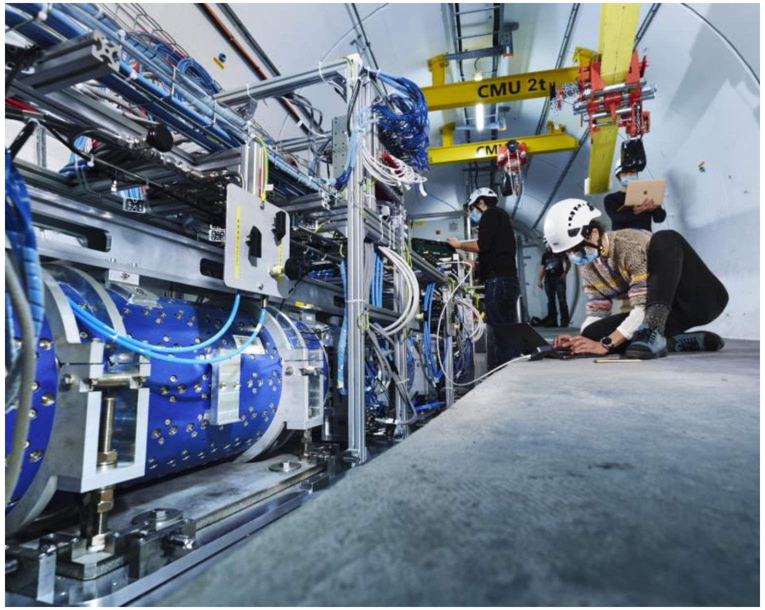
We can't detect ν_e currently, However, it is possible to detect ν_e in Run4 (first run of HL-LHC)

Summary

- FASER experiment search
  - New physics long-lived particle
  - High energy neutrino
- There is an issue with detecting the electron neutrino in HL-LHC,
  We must develop a way to detect electron neutrino.
- My Study
  - Evaluating the possibility of detecting ν_e that interacts in the calorimeter and pre-shower system.
    We can't detect ν_e currently,
    However, it is possible to detect ν_e in Run4.
  - Not mentioned in this presentation.
    - Evaluating the possibility of measuring the flux.
    - With systematic uncertainty likelihood.

To do: Considering the effect of luminosity increase at the Run4.

Optimize the binning.



Thank you!