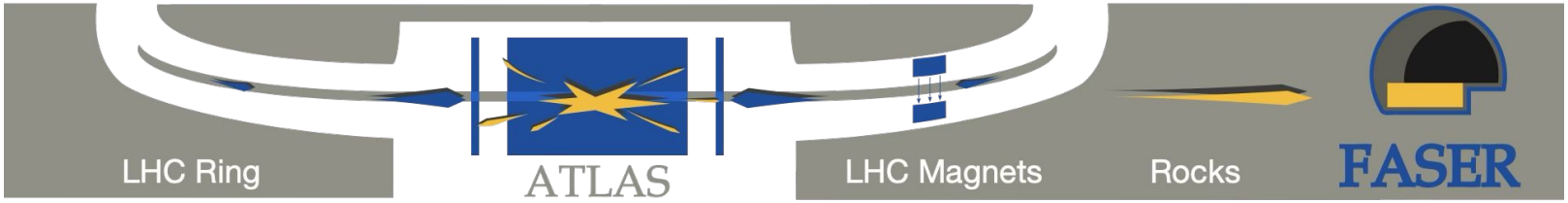
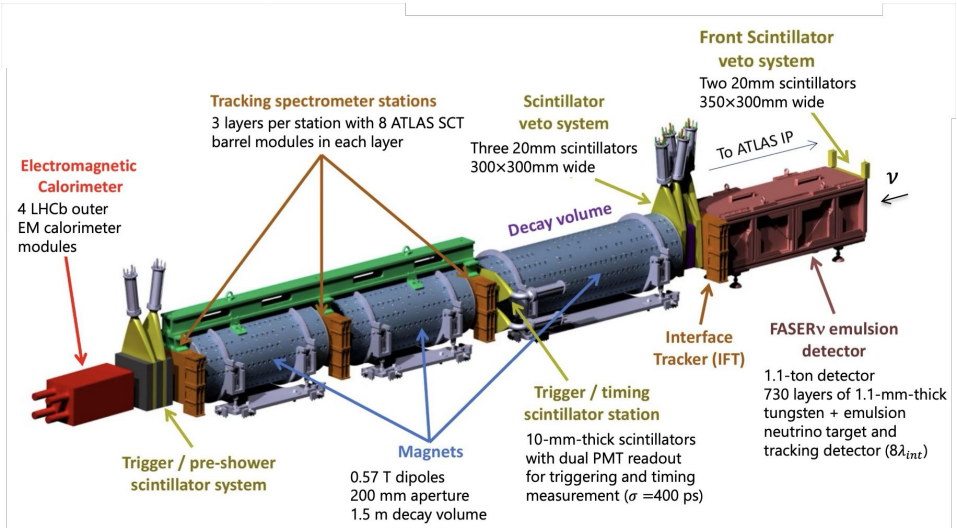
Task 4.4: Future neutrino imaging detectors

Florian Bernlochner

FASER @ CERN





→ **Search long-lived particles (LLPs)**

→ **Study collider Neutrinos**

Physics Highlights

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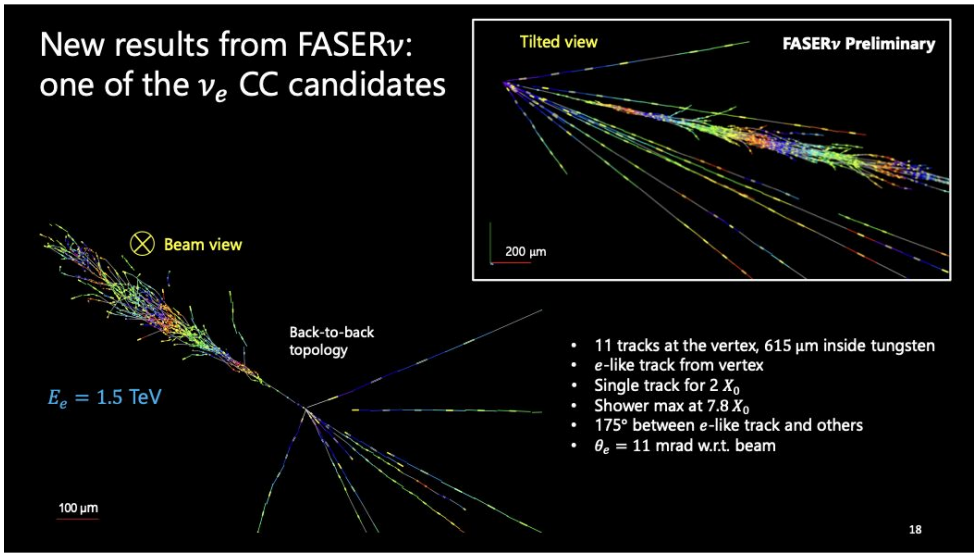
VIEWPOINT

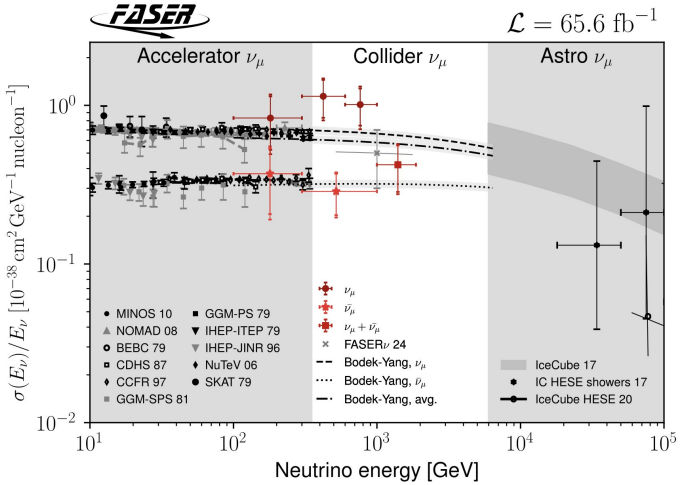
The Dawn of Collider Neutrino Physics

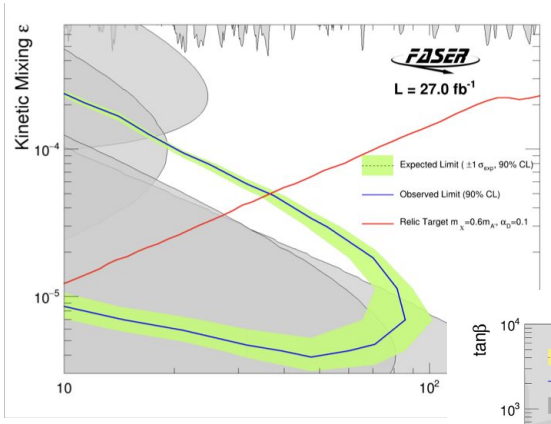
Elizabeth Worcester
Brookhaven National Laboratory, Upton, New York, US

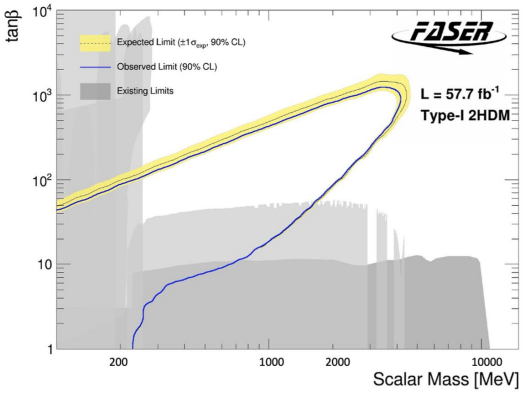
July 19, 2023 • *Physics* 16, 113

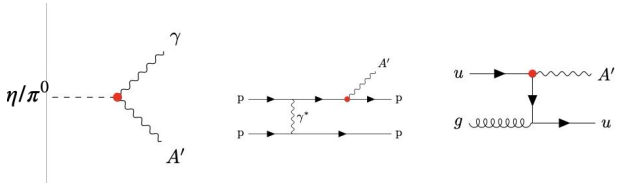
The first observation of neutrinos produced at a particle collider opens a new field of study and offers ways to test the limits of the standard model.

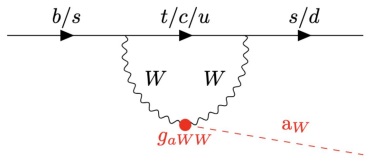












Envisioned Work Packages

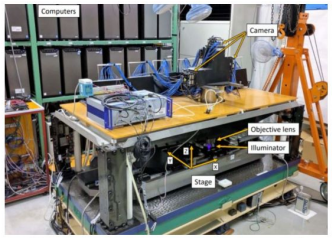
1) **Emulsion alignment**

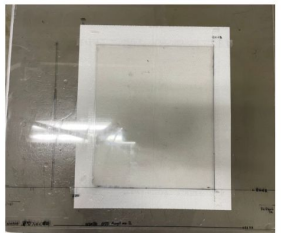
2) **Identification of neutral current (NC) & rare charge current (CC) processes and identification of (anti-)tau neutrinos**

3) **R&D on electronic neutrino detector for Run 4 of the LHC**

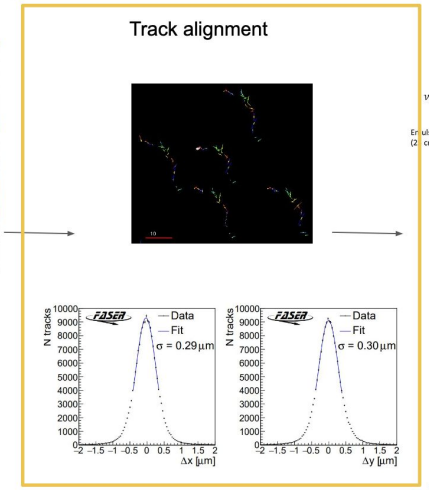
1. Multivariate Emulsion Alignment

scanning and data retrieval

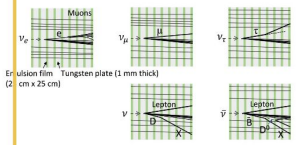


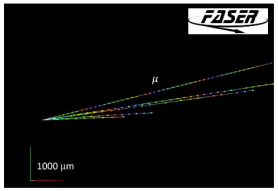


Track alignment



Track reconstruction



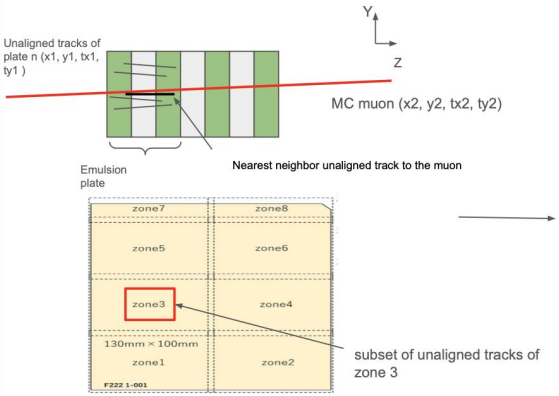


Step 1: Reference Data Preparation

Step 2: Data Pairing Using Nearest Neighbor Algorithm

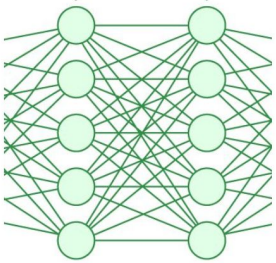
Step 3: Learning Affine Transformations(Training)

Step 4: Applying the Model (Prediction)



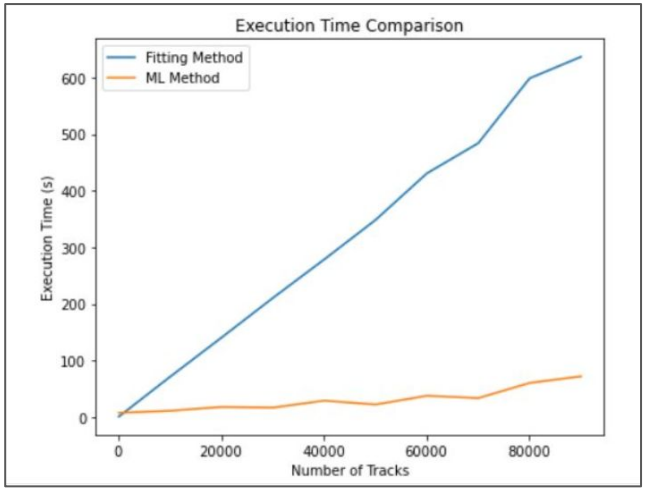
Input: Sin,i = {xin, yin, Txin, Tyin},i = 1..N plate
where: Sin,i are pairs of muons and their nearest neighbor unaligned track for plate i.

Output: Sout,i = {xout, yout, Txout, Tyout}, i= 1…N plate
We use the neural network to get the misalignments of the unaligned tracks.

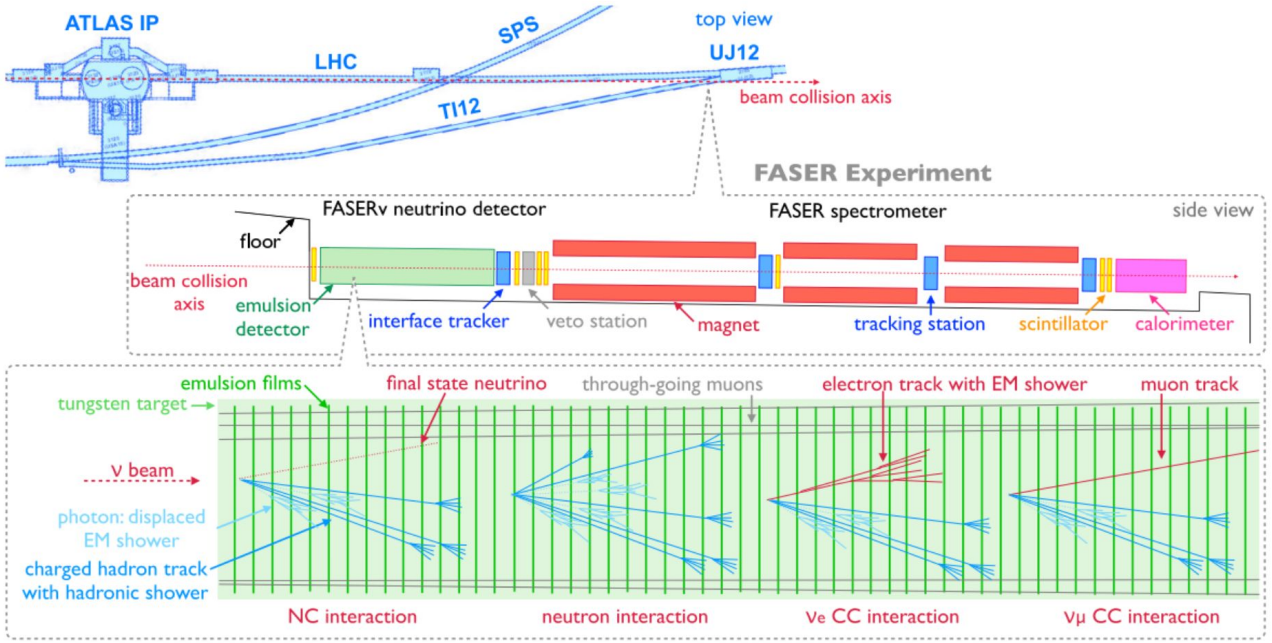


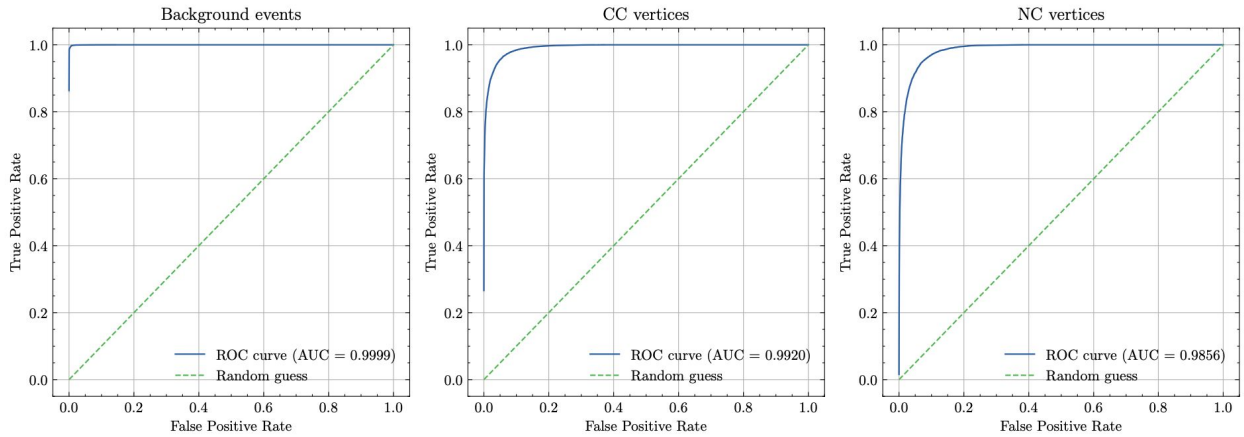
used data:

80% of training
20% testing



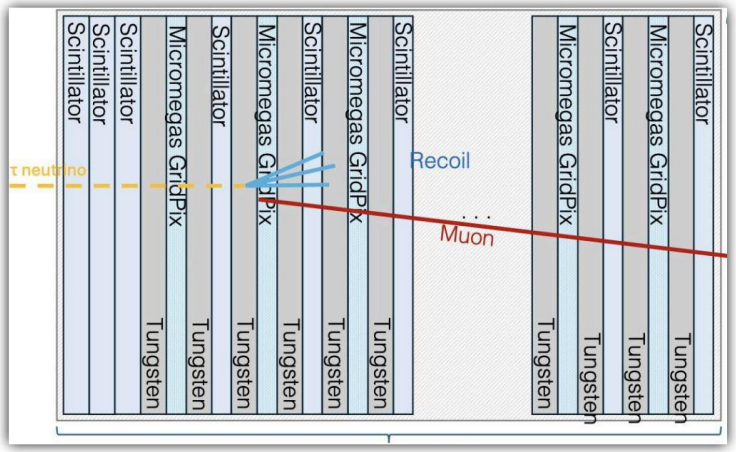
2. Efficient Identification of NC & CC signatures



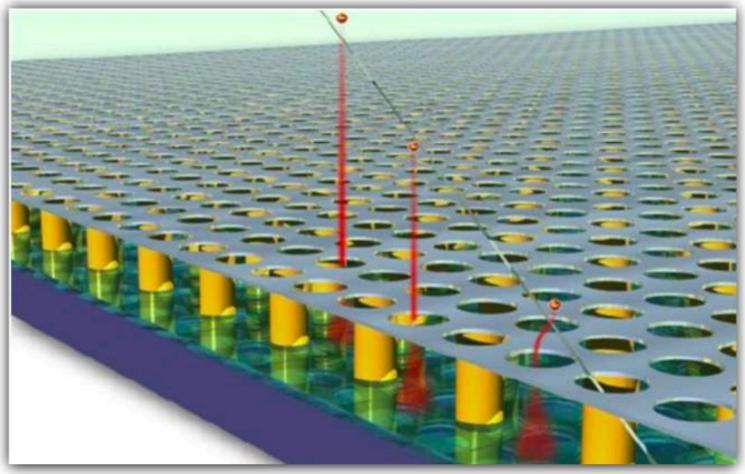


3. Development of a new electronic neutrino detector concept using GridPix chips and scintillators

module name	installed period	load	integrated luminosity per module (fb^{-1})
2022 1st module (F221)	Mar 15 - Jul 26	30%	0.4705
2022 2nd module (F222)	Jul 26 - Sep 13	100%	9.523
2022 3rd module (F223)	Sep 13 - Nov 29	100%	28.9082



- GridPix with TimePix-3 readout
  - Mircomegas principle with pixel-readout including time-information
  - Baseline technology for babyIAXO
  - Bonn has significant expertise
- Specifications
  - Per layer position resolution 20-30µm, Angle resolution of tracklet: <0.2°
  - Allows vertexing
  - Rates of 100Hz/cm² no problem
- Costs (including readout)
  - 26 layers with 20x30cm: approx 600-800kEuros

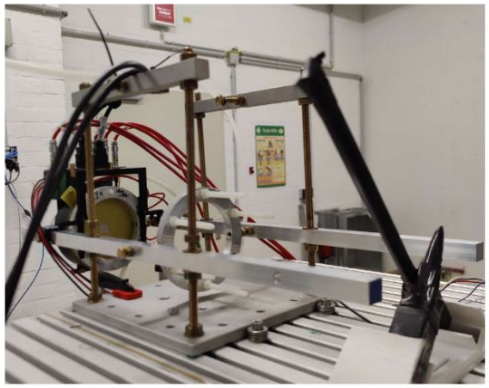


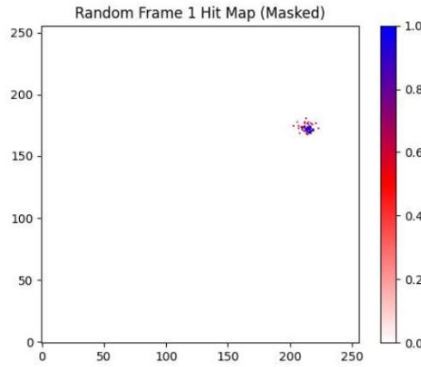
Test beam results

GRIDPIX AT ELSA TESTBEAM

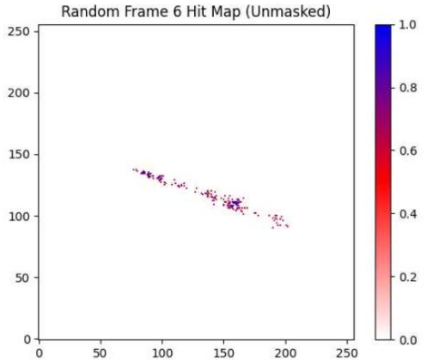
Dhruv Chouhan, Konstantinos Soyrou, Matthias Schott

- GridPix detector with TimePix ASIC, previously used with experiments like CAST
- TimePix ASIC with 256 x 256 pixels, detection efficiency much better than 90%, Noise-free detection due to low threshold requirements, rarely any detector interruptions
- A version of GridPix with total dimension of 2.1 mm put into testbeam at ELSA
- ELSA facilitates an electron beam, 2.6GeV during our measurements
- Measurement taken by rotating (0 and 30 deg) and tilting (2 to 20 deg) the GridPix in order to better characterise and perform trajectory reconstruction with the chip
- In testbeam measurements, detector was operated all the way upto 200 KHz beam rate and suffered no issues
- ASIC operated in Time of Arrival and Chess Matrix modes
- Both masked and unmasked event displays show no noise





Event with GridPix at 0 degree tilt and 0 degree rotation in plane



Event with GridPix at 20 degree tilt and 30 degree rotation in plane