

FASER&FASERv experiments and the contributions from China

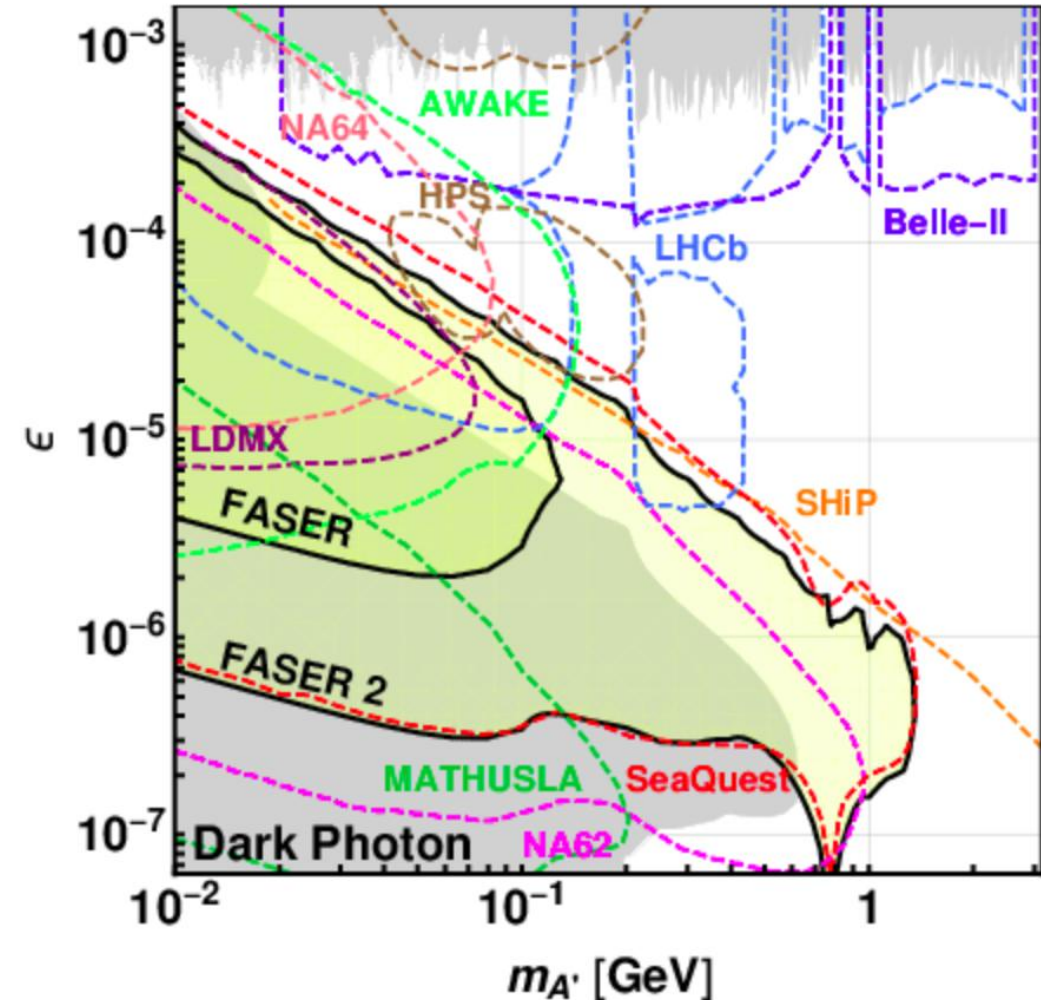
Di Wang (Tsinghua University)

CLHCP 2021



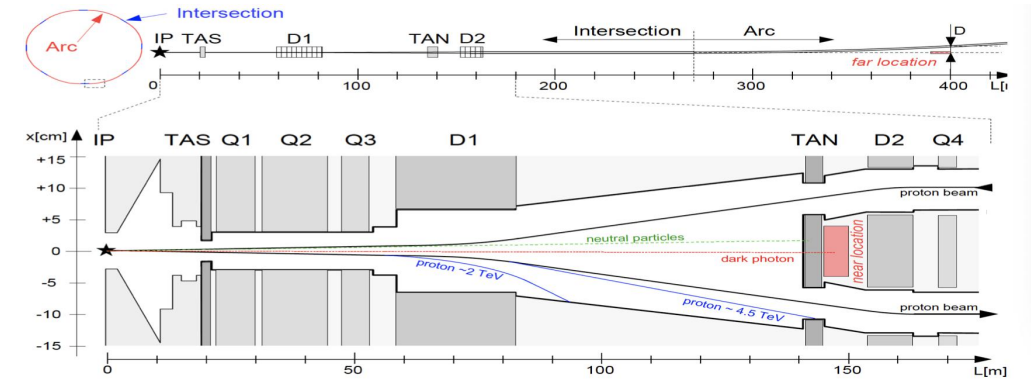
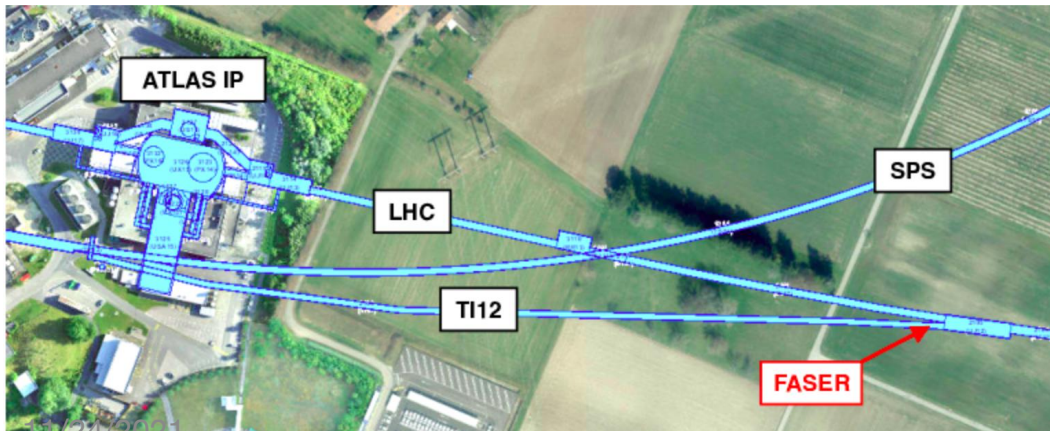
The Physics Prospects

- Most LHC experiments focus on heavy, strongly interacting particles
- The physics goal of FASER(the Forward Search Experiment) is light long-lived particles (LLPs) related to physics beyond the Standard Model
- These new particles are related to many important and basic questions, such as dark matter



The Physics Prospects

- The FASER experiment is a small and inexpensive experiment located at TI12 side tunnel (480 m from ATLAS IP)
- Charged particles produced from the IP are deflected by LHC magnets
- Neutral hadrons are absorbed by LHC infrastructure (TAS/TAN) or 100m of rock between the IP and FASER
- LLPs pass through the LHC infrastructure/rock without interacting



The Physics Prospects

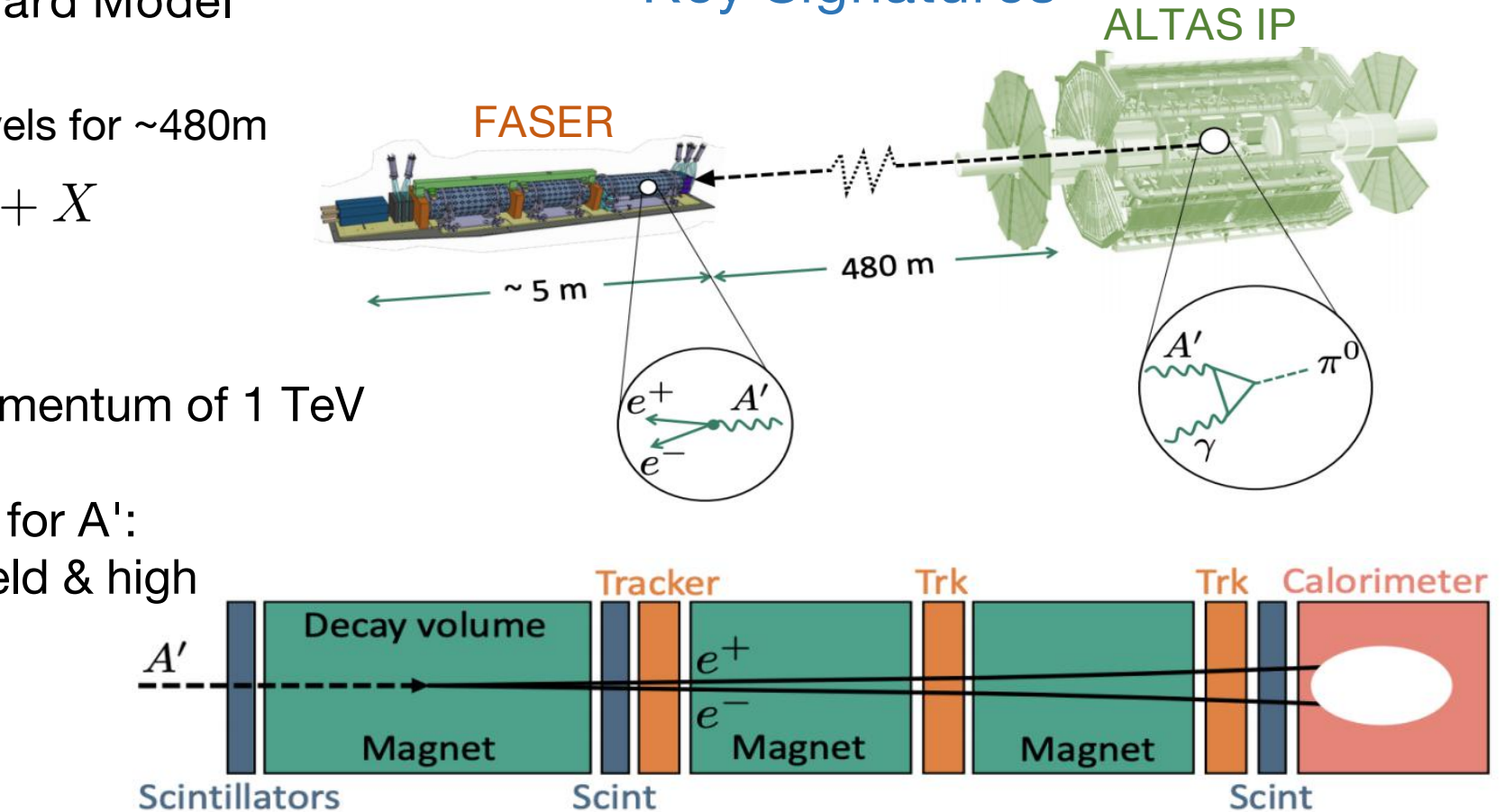
- LLPs will arrive at the FASER main detector and decay into visible Standard Model particles

$PP \rightarrow LLP + X$ LLP travels for $\sim 480\text{m}$

$LLP \rightarrow \text{ChargedTracks} + X$

- Dark Photon (A')
 - Ballpark number for A' : momentum of 1 TeV and mass of 100MeV
 - Decay products collimated for A' : Requirements for magnetic field & high resolution tracker

Key Signatures

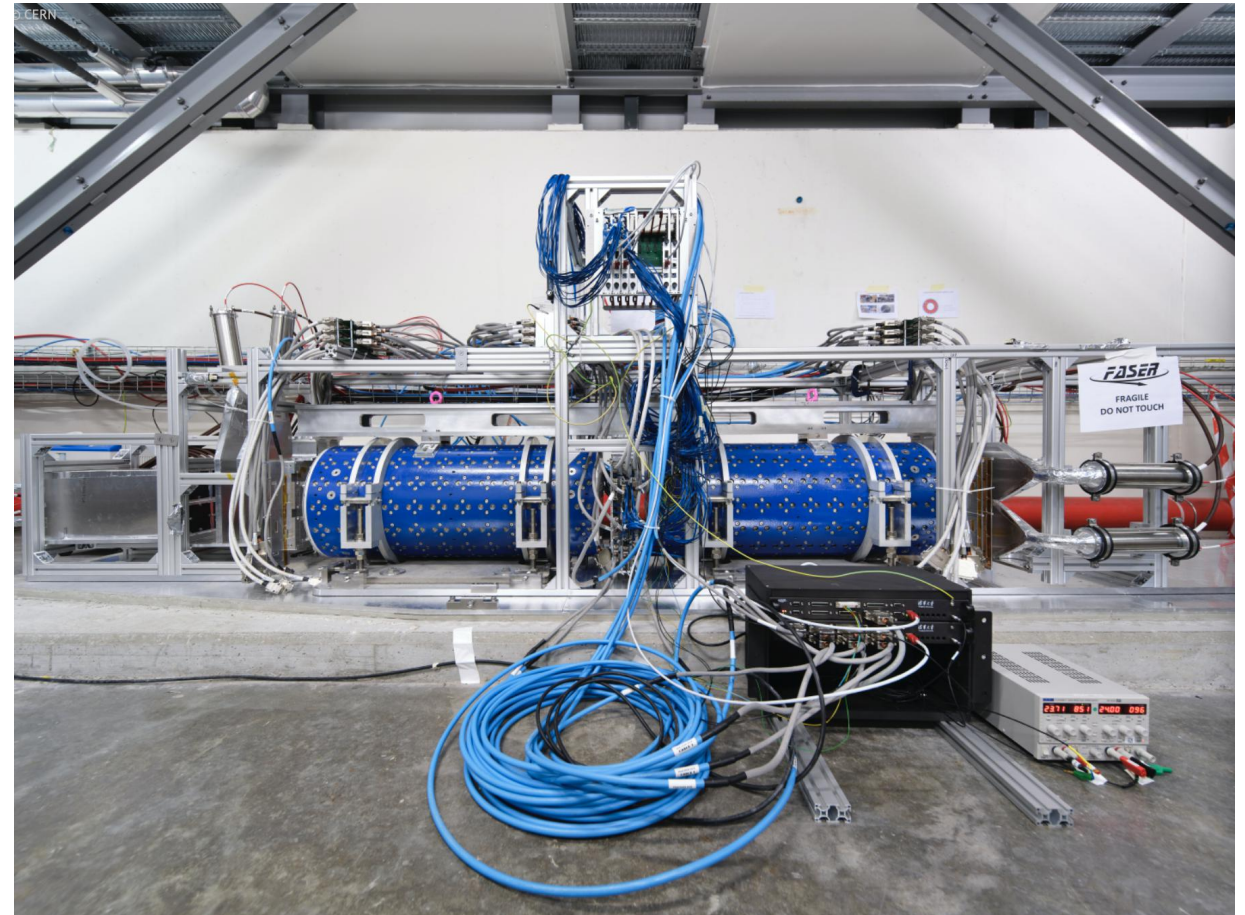
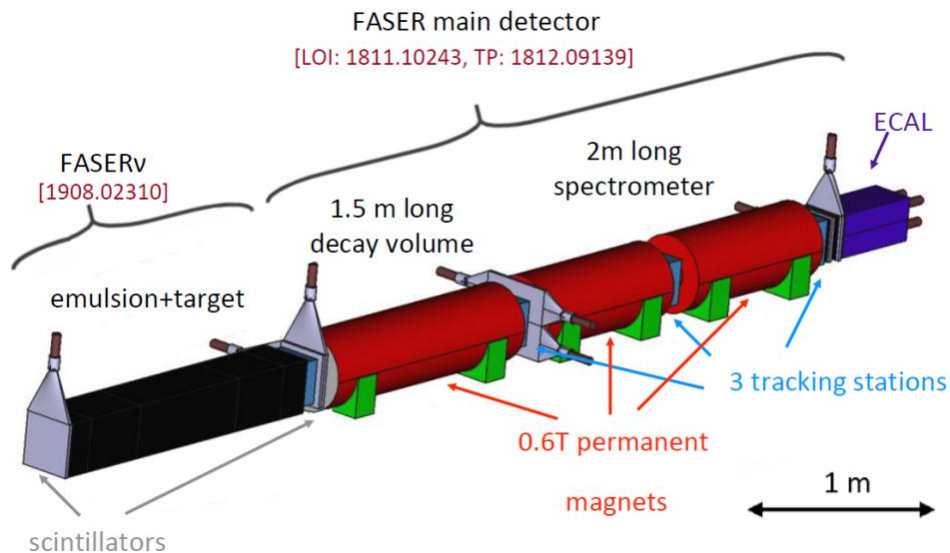


Anna Sfyra

2019 Physics potential: [Phys. Rev. D 99, 095011](#)

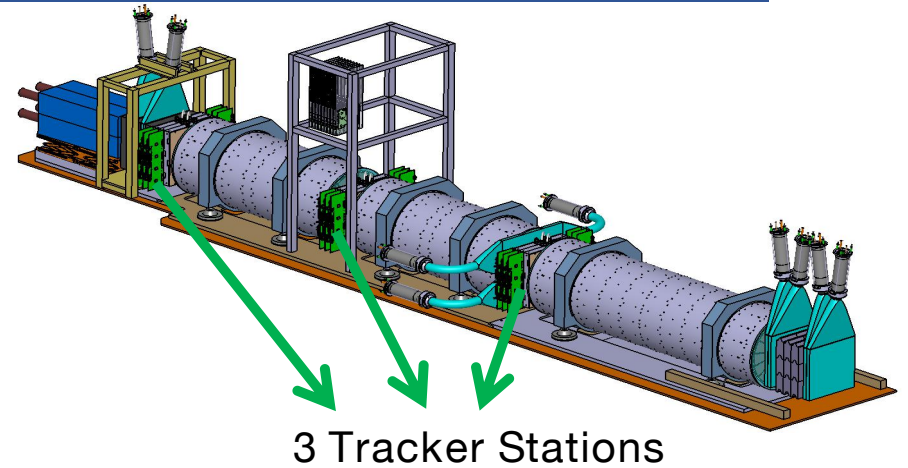
The FASER Detector

- The FASER detector is composed of scintillators, a decay volume, a spectrometer, tracker stations and an electromagnetic calorimeter
- The radius of the FASER main detector is 0.1m and the total length is 5m
- Besides the main detector, there is a subdetector named FASER _{ν} , which will study neutrinos produced at the LHC

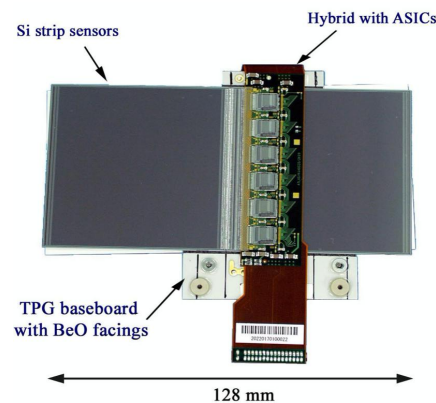


Tracker of the FASER Detector

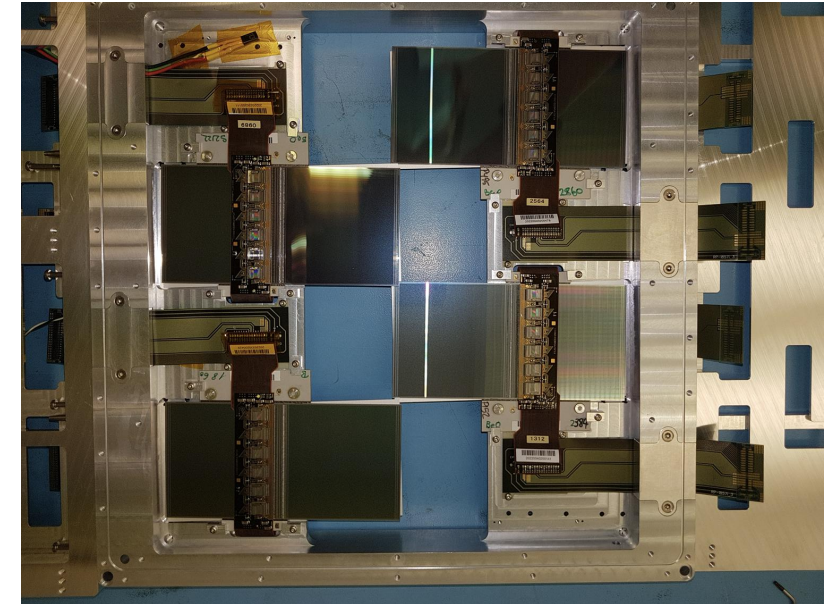
- 3 Tracker stations are installed on the FASER main detector to track the charged particles produced by goal particles decay
- Each tracker station consists of 3 tracker planes
- 8 semiconductor strip tracker (SCT) modules are installed on 1 tracker plane. The SCT modules are spares from the ATLAS experiment
- 3 Tracker Interlock and Monitoring (TIM) boards are installed to monitor the status of the 3 tracker stations of the FASER main detector



11/24/2021 TIM board



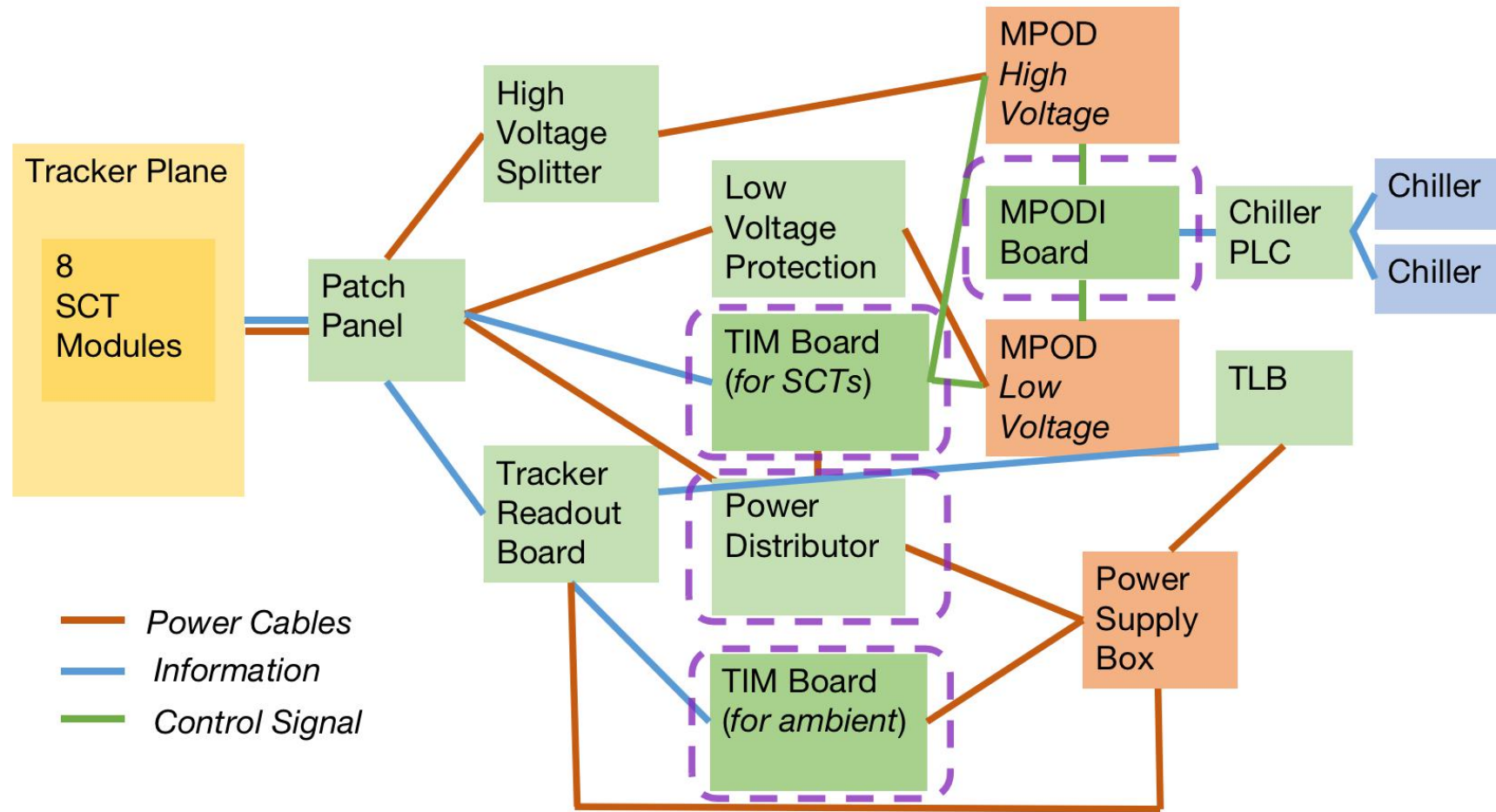
SCT modules



Tracker Plane

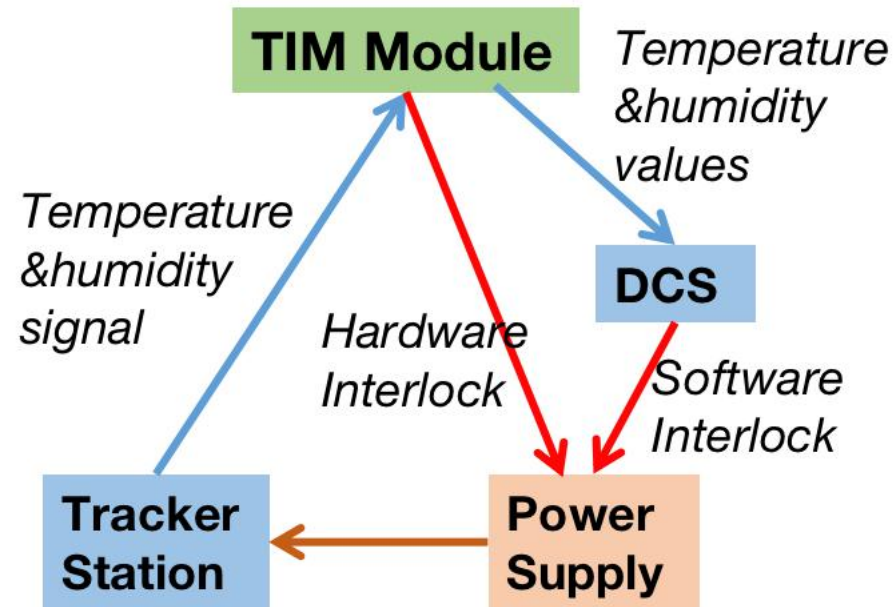
Tracker of the FASER Detector

- Here is the sketch of the FASER tracker station



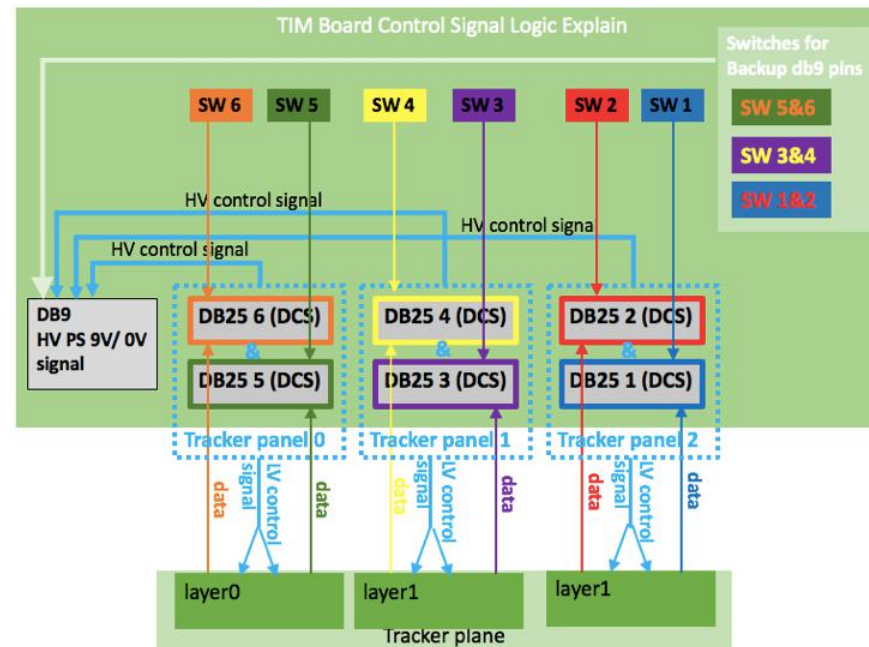
Tracker Interlock & Monitoring Module

- The Tracker Interlock and Monitoring (TIM) module produced by Tsinghua University team is the core of the interlock system of the FASER tracker.
- The main functions of the TIM boards are:
 - Collecting temperature and humidity information from the tracker
 - Sending all information to DCS for further processing
 - Hardware interlock based on temperature



Tracker Interlock & Monitoring Module

- The signal of tracker plane temperature and humidity is sent to the TIM board via 6 DB25 connectors
- When the temperature read by TIM Board is higher than high temperature limit, the HV and LV power supply will be turned off
- The firmware and information such as IP address can be updated on the TIM management system
- Hardware interlock limit can be adjusted on the board
- The dail switches are used to allow TIM to work with a few broken sensors



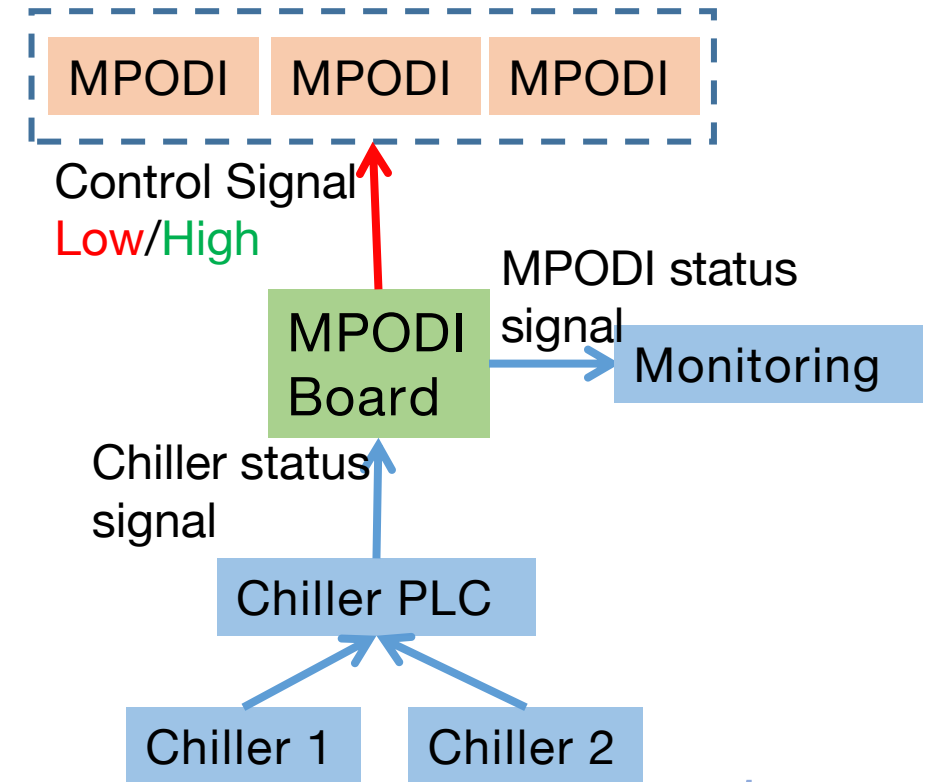
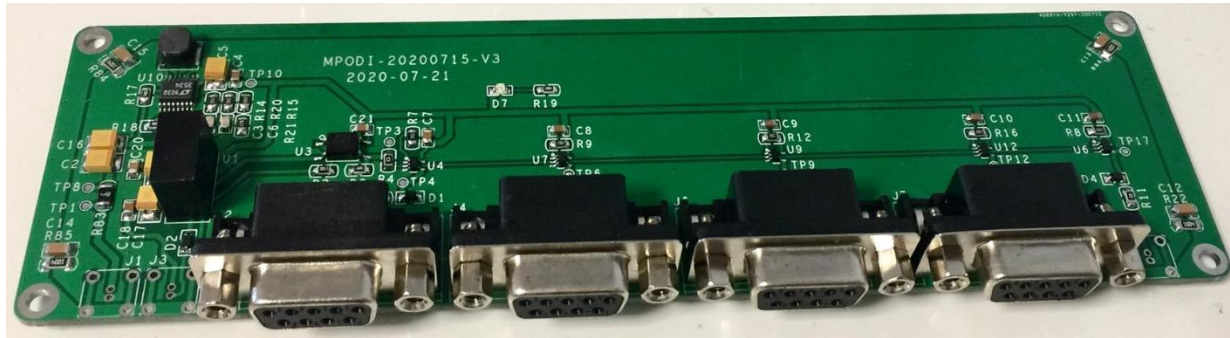
Tracker Interlock & Monitoring Module

- 3 TIM boards are installed to monitor the status of the 3 tracker stations of the FASER main detector
- 1 TIM board is for the FASER ν subdetector
- 4 TIM boards are contained in a TIM box with an extra backup TIM board



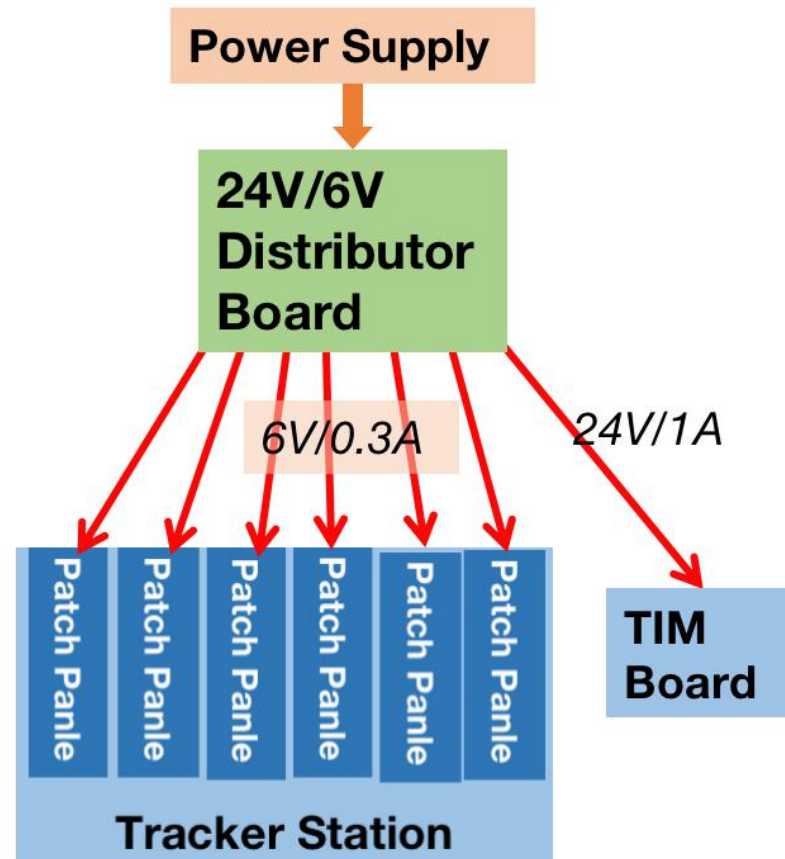
MPOD Interlock Board

- The MPOD provides high voltage and low voltage to the FASER tracker system
- There are two chillers that absorb harmful heat produced by tracker planes
- The function of the MPOD Interlock (MPODI) board is to turn the MPOD off when two chillers stop working to avoid possible damages due to high temperature



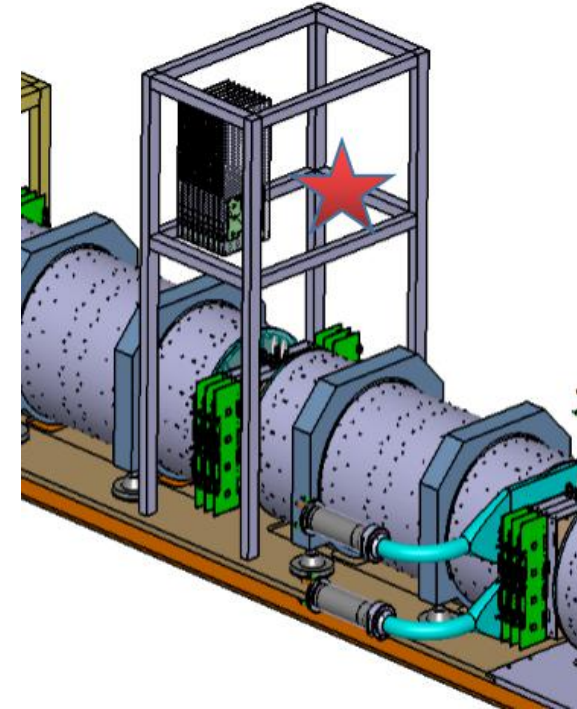
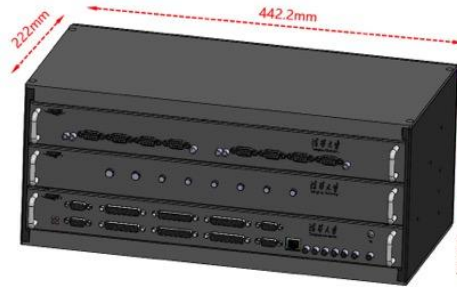
24V/6V Distributor Board

- The function of 24V/6V Distributor Board is to provide 24V and 1A power for the TIM board and 6V and 0.3A power for 6 Patch Panels.
- There are 3 24V/6V Distributor Boards for the 3 tracker stations and another one for the ambient TIM board



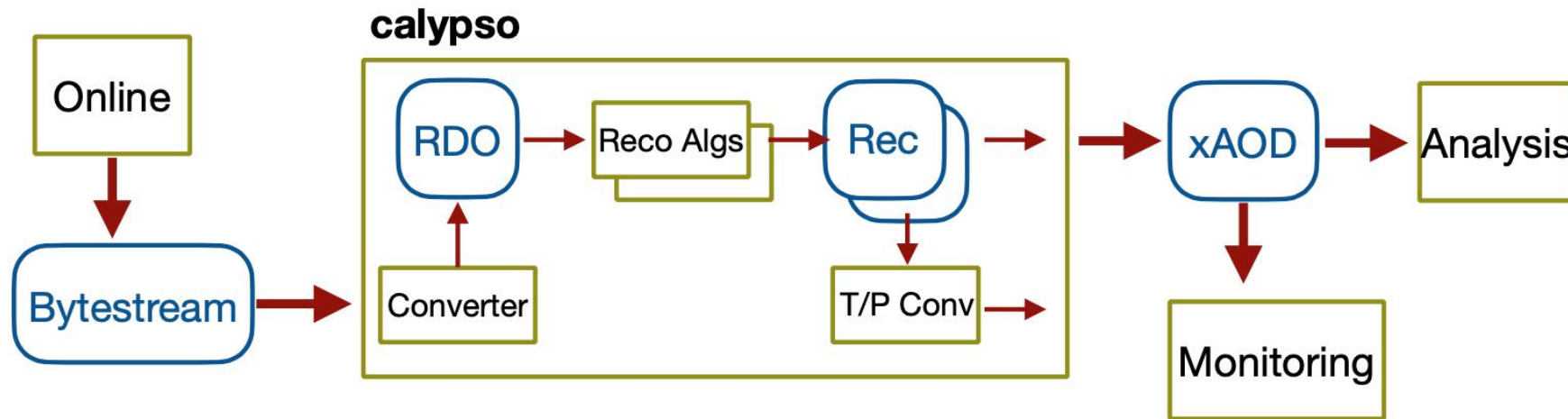
Position of the Modules

- The TIM Box contains 5 TIM boards for tracker planes
- 5 24V/6V Distributor Boards are contained in 1 box.
- 2 MPODI boards, 1 24V/6V Distributor Board and 1 TIM Board for ambient are put in one box
- The boxes will be fixed on the mini-rack near to the tracker station



Offline software

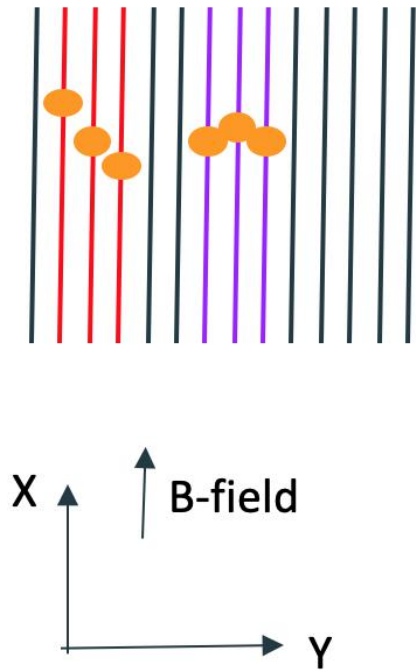
- Calypso is the offline software for FASER experiment
<https://gitlab.cern.ch/faser/calypso>
- Calypso is based on ATLAS Athena framework
- FASER China group develop the track reconstruction function in the Calypso



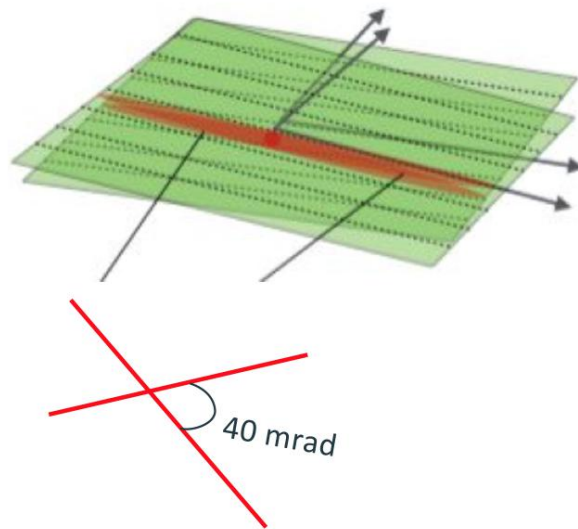
- Bytestream - files written by online, array of bytes
- RDOs - Raw Data Objects, start of reconstruction
- Calypso data is transient, must 'persist' it (i.e write it to a file)
- xAOD - Analysis Object Data - output file (root-readable data format)

Offline track reconstruction

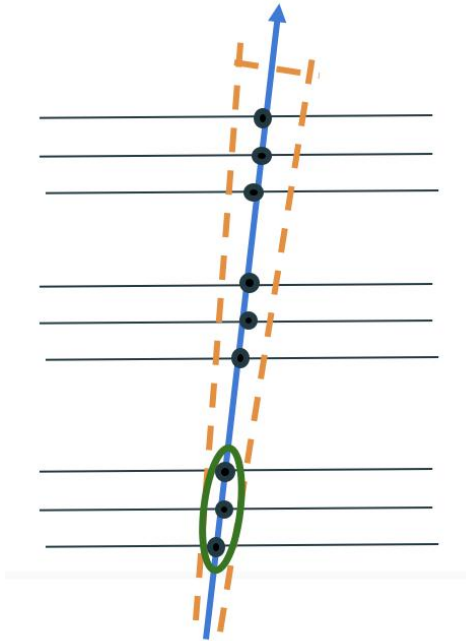
Group adjacent hit strips as clusters



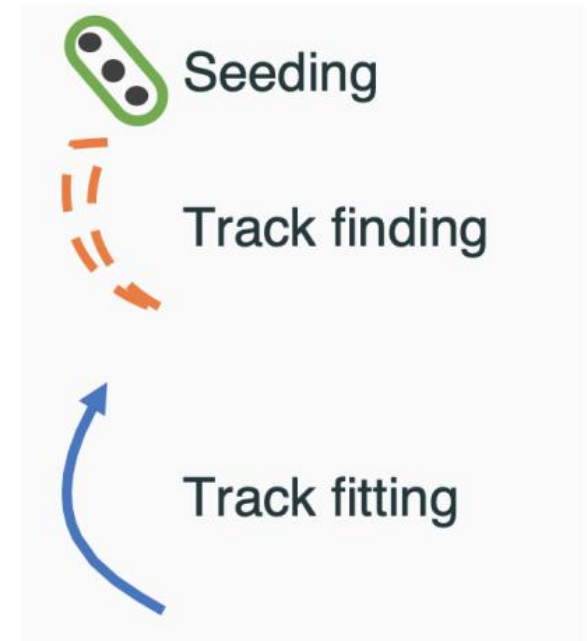
Combine the clusters on front and back sensor of one SCT modules to form space points



Pattern recognition and ambiguity solving



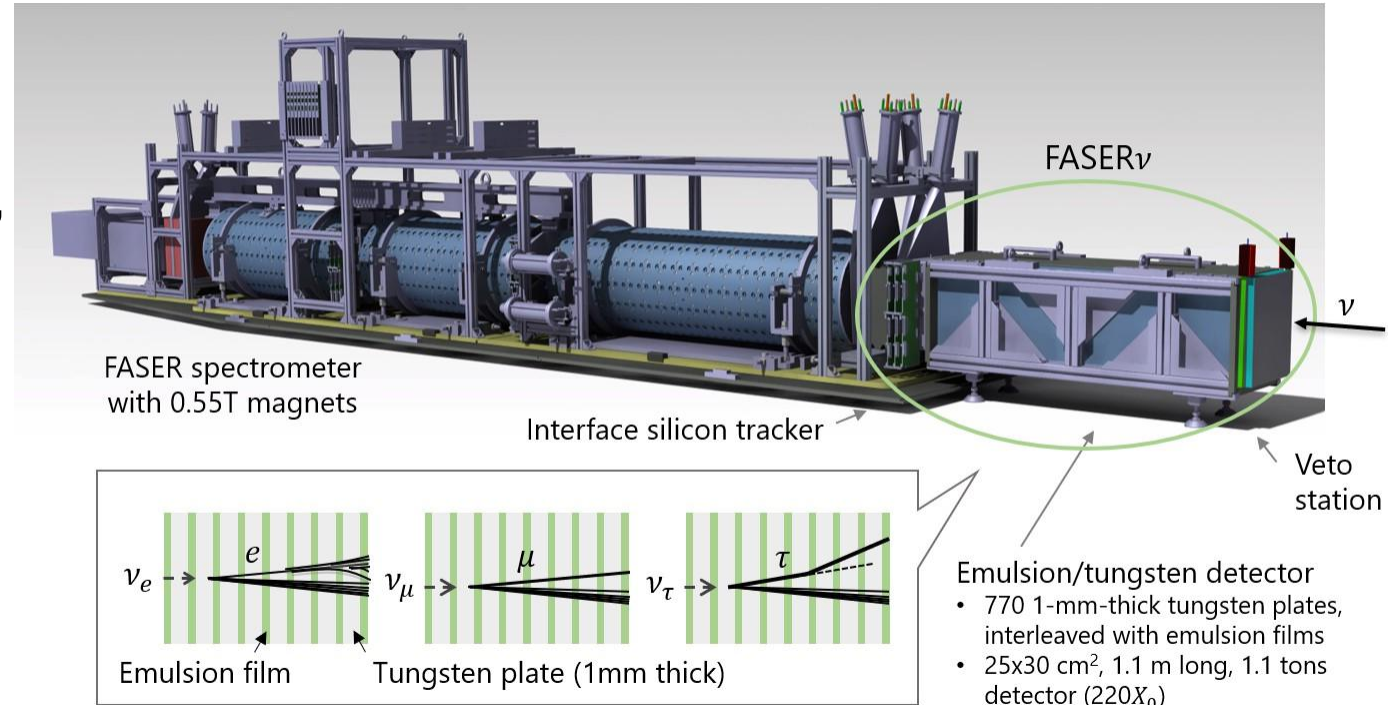
Track fitting with selected space points



FASER ν



- FASER ν is an emulsion/tungsten detector
 - 1.1m long, 25x30cm, 1.1tn detector
 - interface silicon tracker and veto station
 - Made from 770 1mm thick tungsten plates, interleaved with emulsion films
- Detect and measure collider neutrinos
 - A huge number of neutrinos produced in the LHC collisions (hadron decay) traverse the FASER location
 - Measure SM collider neutrinos for the first time and bridge gaps in neutrino cross-section measurements
 - measure also electron neutrinos and tau neutrinos

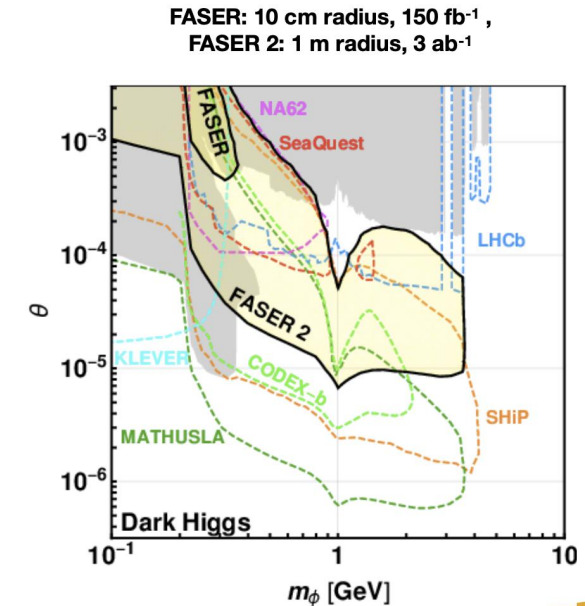
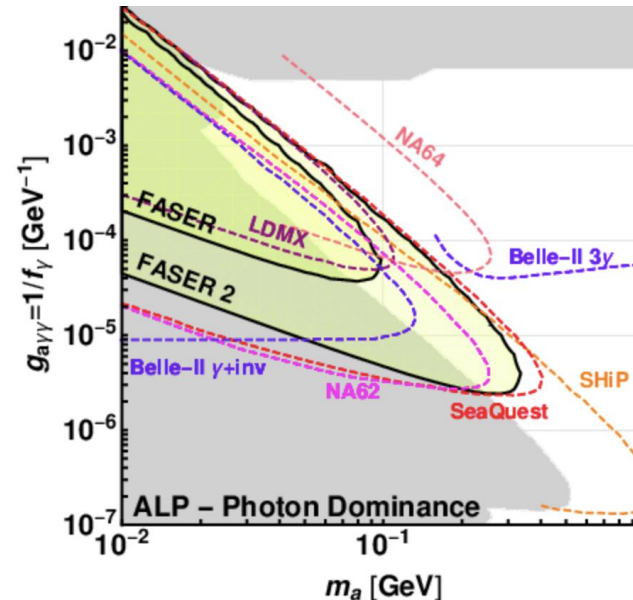
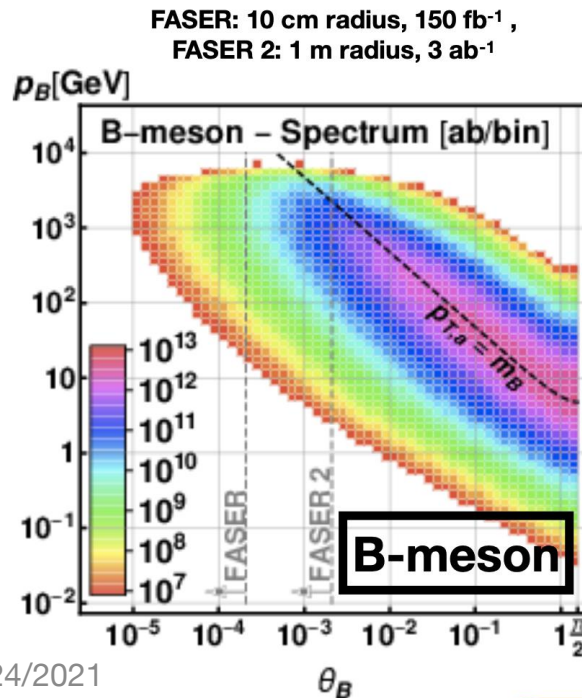
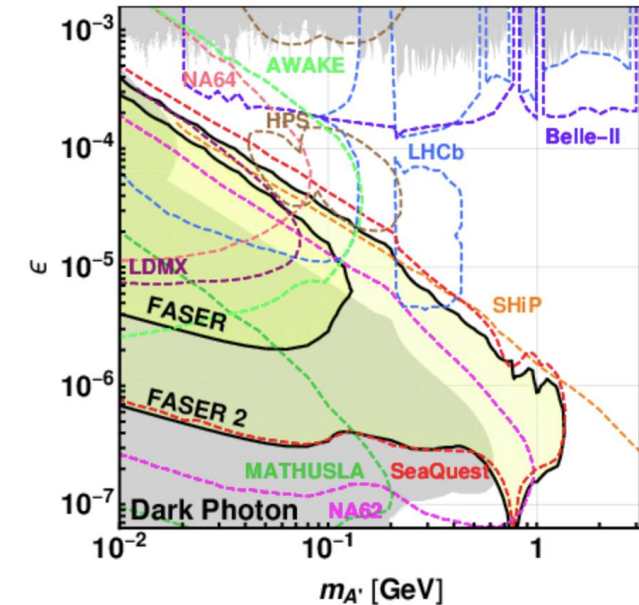


FASERnu LOI, Eur. Phys. J. C 80 (2020) 61, arXiv:1908.02310

First neutrino interaction candidates at the LHC, arXiv:2105.06197

FASER 2

- FASER2: A possible future upgrade after Run 3
- radius $R=1\text{m}$, length of decay volume $D = 5\text{m}$
- luminosity: 3ab^{-1}
- good sensitivity to particles produced in heavy meson decays (B,D)



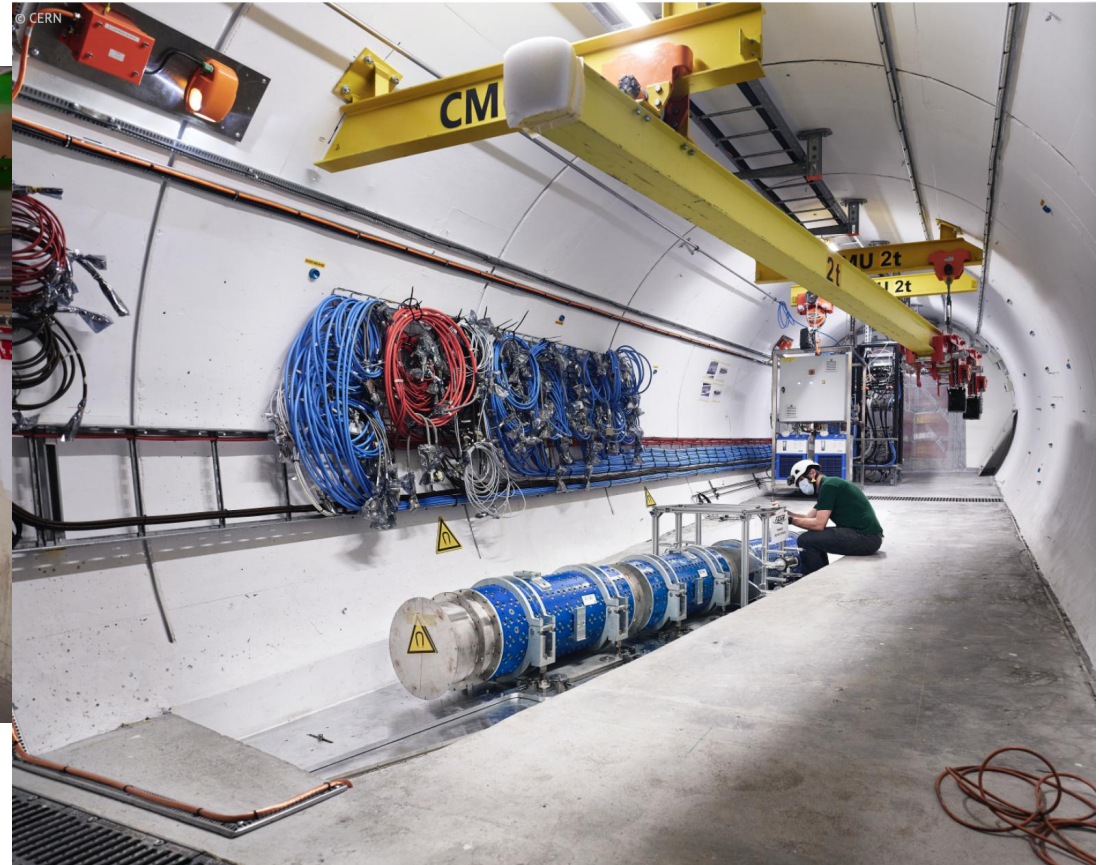
FASER 2

- FASER (Run 3): sensitive to unexplored phase spaces for a range of hidden sector physics
- FASER 2 (HL-LHC): opportunity to probe **more** benchmarks (e.g. new particles produced in heavy meson decay (D, B))

Benchmark Model	Label	Section	PBC	Refs	FASER	FASER 2
Dark Photons	V1	IV A	BC1	[7]	✓	✓
$B - L$ Gauge Bosons	V2	IV B	—	[30]	✓	✓
$L_i - L_j$ Gauge Bosons	V3	IV C	—	[30]	—	—
Dark Higgs Bosons	S1	V A	BC4	[26, 27]	—	✓
Dark Higgs Bosons with hSS	S2	V B	BC5	[26]	—	✓
HNLs with e	F1	VI	BC6	[28, 29]	—	✓
HNLs with μ	F2	VI	BC7	[28, 29]	—	✓
HNLs with τ	F3	VI	BC8	[28, 29]	✓	✓
ALPs with Photon	A1	VII A	BC9	[32]	✓	✓
ALPs with Fermion	A2	VII B	BC10	—	—	✓
ALPs with Gluon	A3	VII C	BC11	—	✓	✓
Dark Pseudoscalars	P1	VIII	—	[36]	—	✓

Timeline

- Refurbishment of TI12 to be an experiment site was completed in winter 2020
- All detectors have been installed in TI12
- Data taking will start at LHC RUN-3 2022



Thanks For Listening