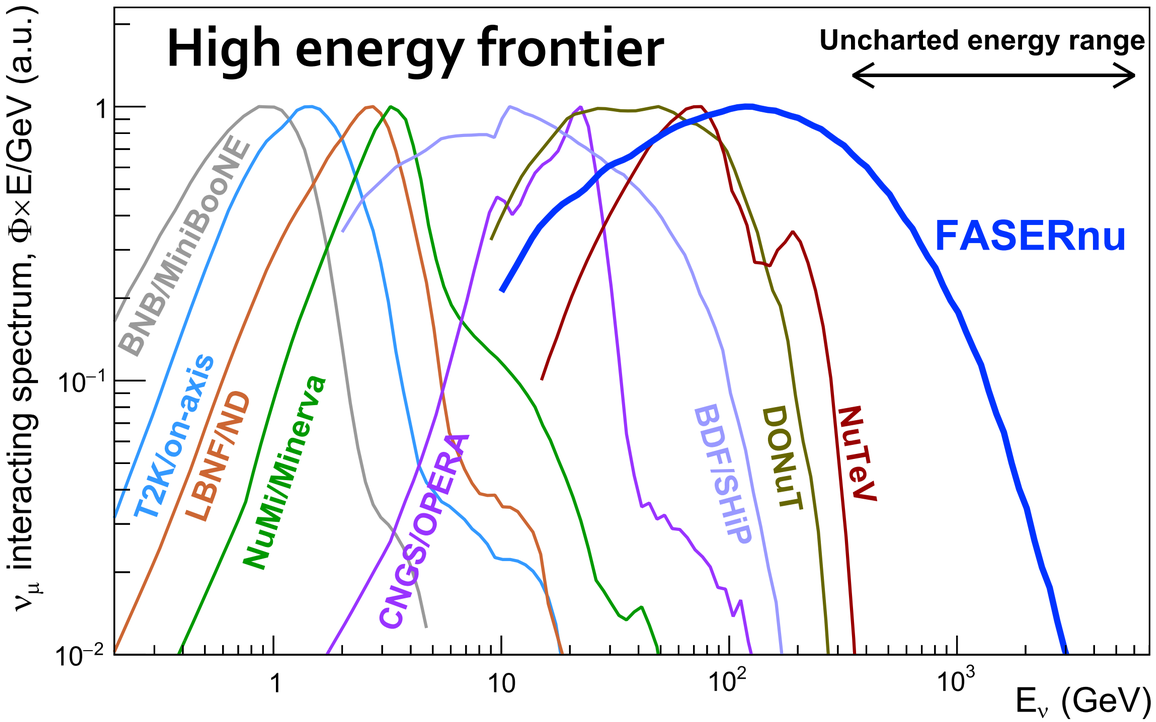
FASERν

Lake Louise Winter Institute
February 24th, 2022

Daiki Hayakawa
on behalf of the FASER collaboration

CHIBA UNIVERSITY

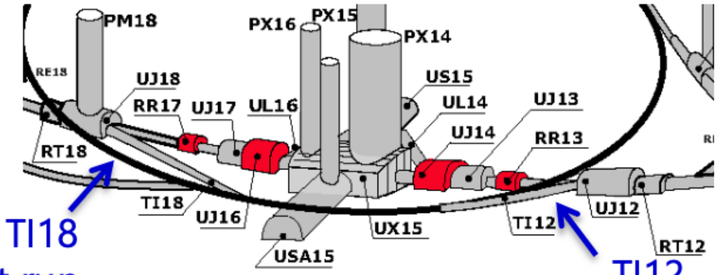
Physics Motivation

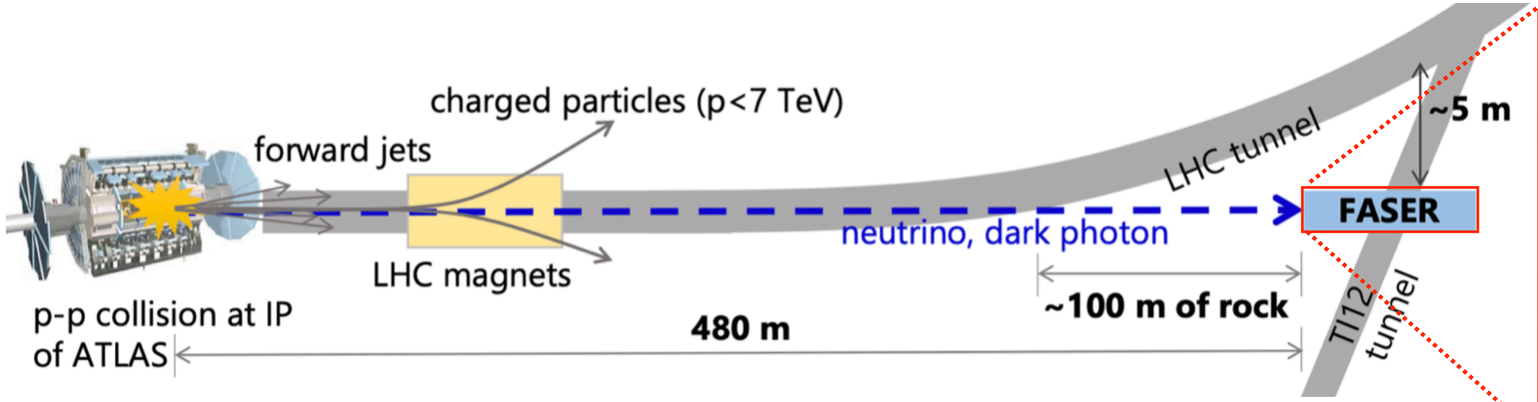


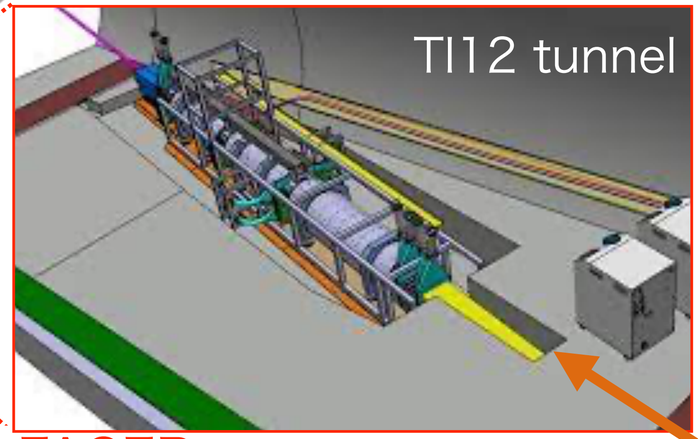
- Studying neutrino in unexplored energy regime
- **Neutrino measurements at the LHC**
  - First detection of collider neutrinos
  - High energy frontier of man-made neutrinos

- **TeV three-flavor neutrino cross section measurements**
- **Measurements of forward particle production at the LHC**

FASER Experiment

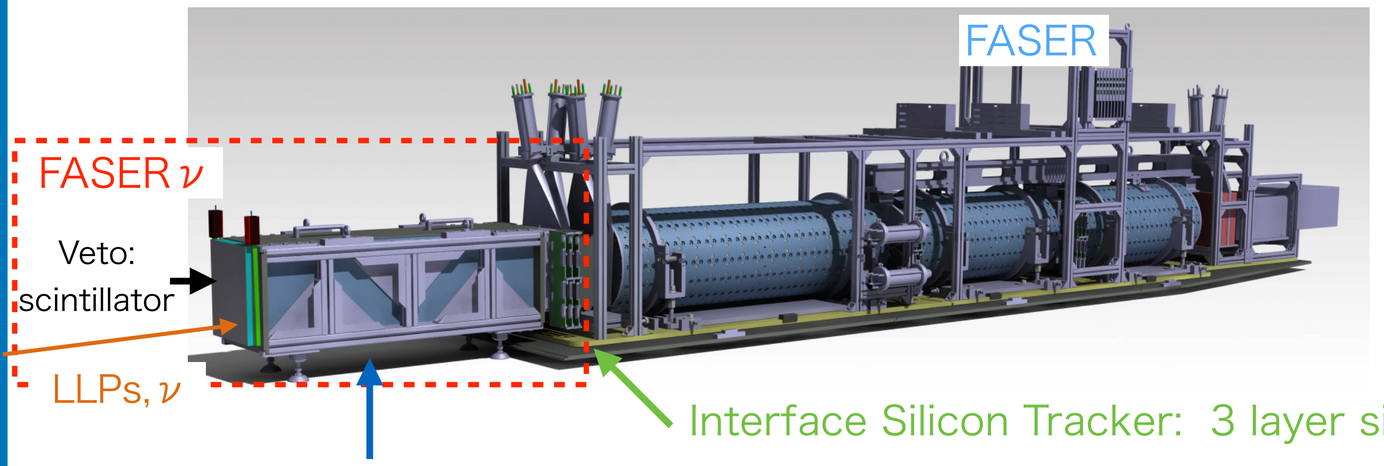


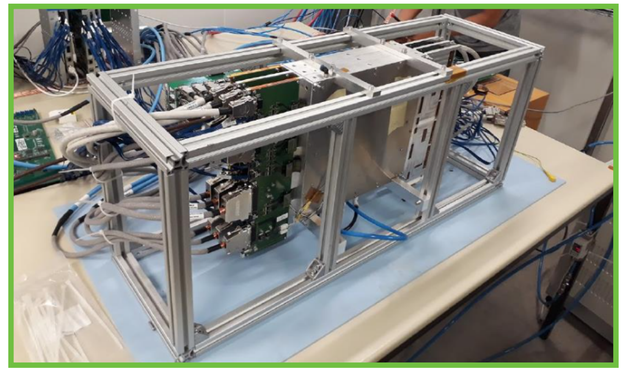




- Particles produced at ATLAS IP
- 480 m away on the beam axis from the experiment location
  - Charged particles are deflected by LHC magnets
  - Neutral particles are absorbed by either neutral beam absorber or 100 m rock
- Ideal location to search for light, long-lived particle (LLP) and measurement of high energy neutrino → Talk by Deion Fellers tomorrow

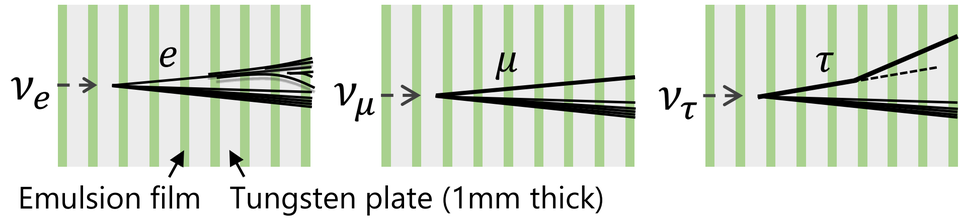
FASER Detector



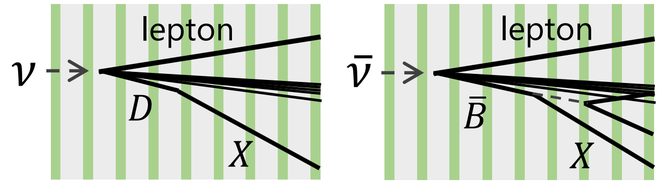


- **FASER ν emulsion detector**
  - 770 × [tungsten (1 mm) + emulsion film]
  - 25×30 cm^2, 1.1 m, 1.2 tons (220 X_0)
  - **Spatial (angular) resolution: 0.4 μm (0.1 mrad)**
- ν flavor tagging with topological/kinematical informations
- Muon charge identification by FASER spectrometer with 0.55T magnets

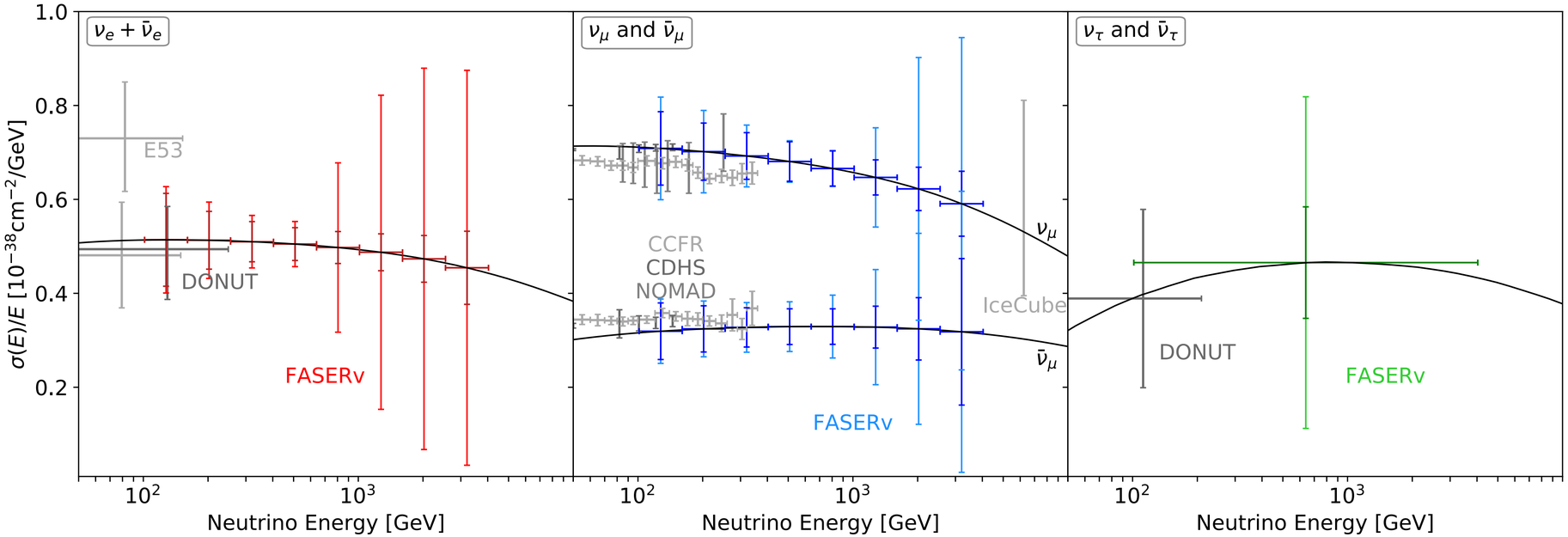
Detection of neutrino interactions in emulsion detector



CC heavy quark production



Physics Reach



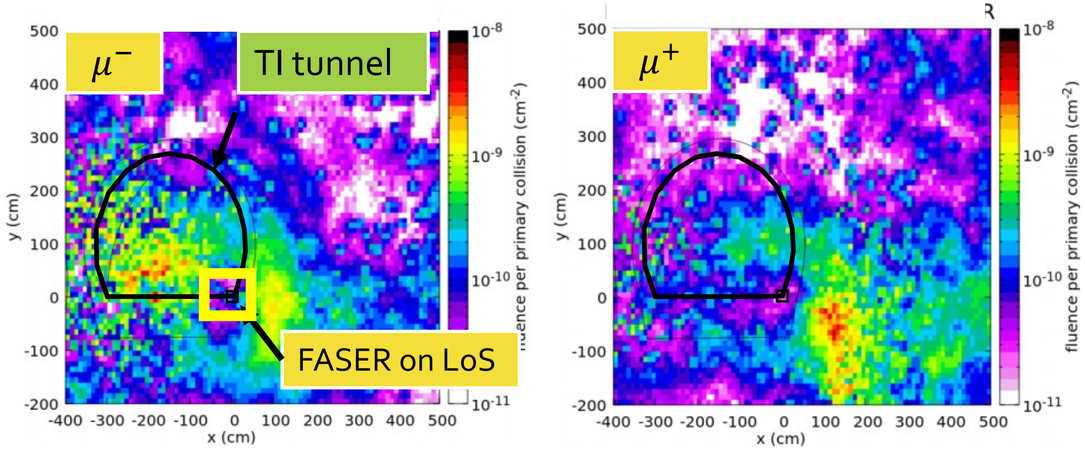
- Three flavors neutrino cross section measurements at high energy
- NC interaction studies
- Neutrino-induced charm/beauty channels
- Approximately 10,000 ν interactions expected in LHC Run 3 (2022 ~ 2025)

Expected CC interaction events

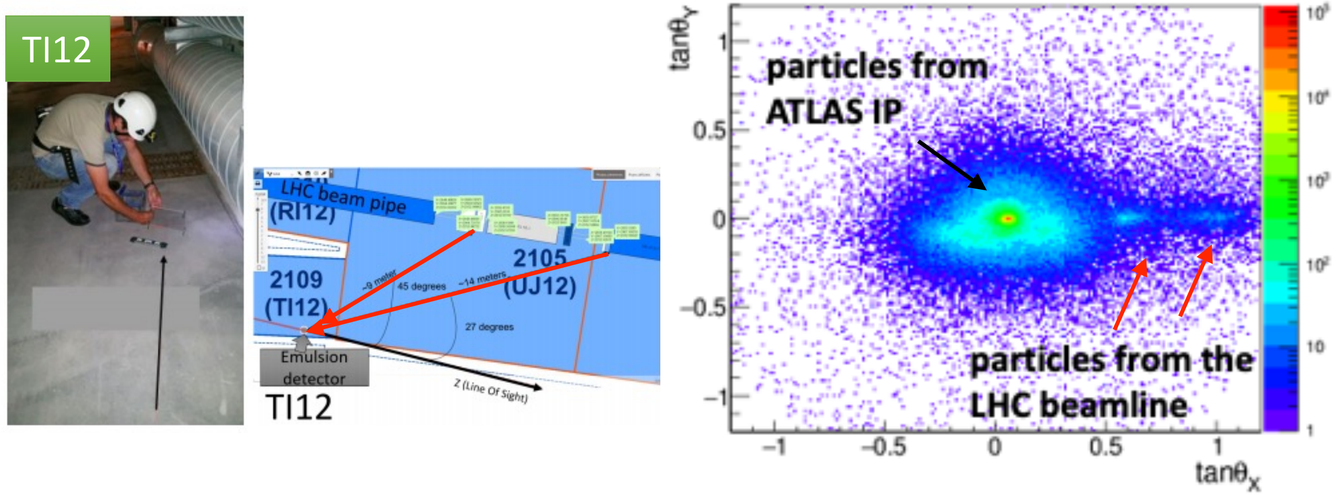
Generators		FASERν		
light hadrons	heavy hadrons	$\nu_e + \bar{\nu}_e$	$\nu_\mu + \bar{\nu}_\mu$	$\nu_\tau + \bar{\nu}_\tau$
SIBYLL	SIBYLL	901	4783	14.7
DPMJET	DPMJET	3457	7088	97
EPOSLHC	Pythia8 (Hard)	1513	5905	34.2
QGSJET	Pythia8 (Soft)	970	5351	16.1
Combination (all)		1710^{+1746}_{-809}	5782^{+1306}_{-998}	$40.5^{+56.6}_{-25.8}$
Combination (w/o DPMJET)		1128^{+385}_{-227}	5346^{+558}_{-563}	$21.6^{+12.5}_{-6.9}$

Detector Environment

FLUKA simulation



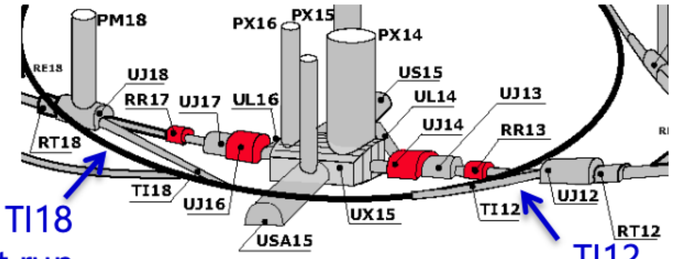
In-situ measurements (2018)



	Flux all [fb/cm^2]	Flux in main peak [fb/cm^2]
TI18 data	2.6±0.7 ×10^4	1.2±0.4 ×10^4
TI12 data	**3.0±0.3 ×10^4**	**1.9±0.2 ×10^4**
FLUKA MC		**2.0 ×10^4**

- Muon flux simulations/measurements
- MC prediction is in good agreement with data
- The expected muon flux is low enough to use the emulsion detector in the tunnel

First neutrino interaction candidates at the LHC

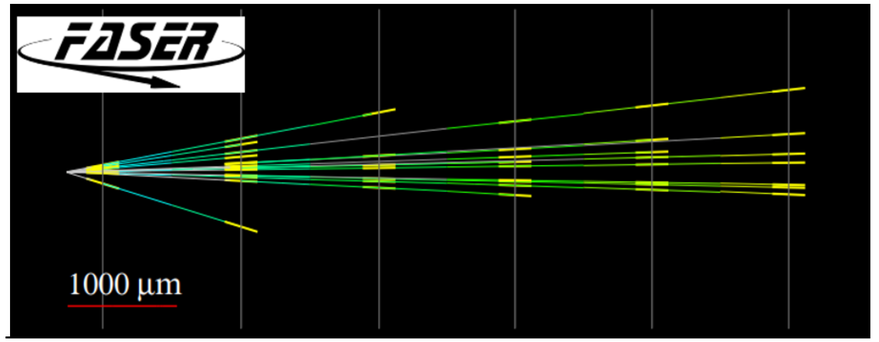


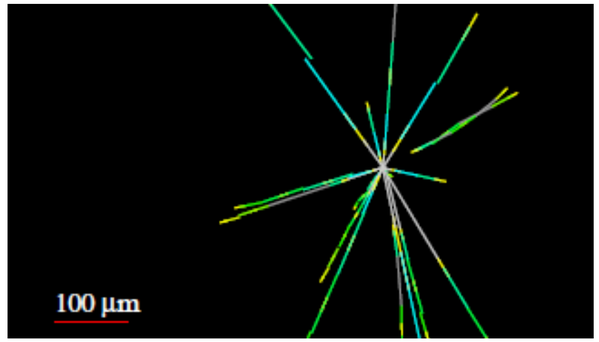
TI18
FASERν pilot run

ATLAS

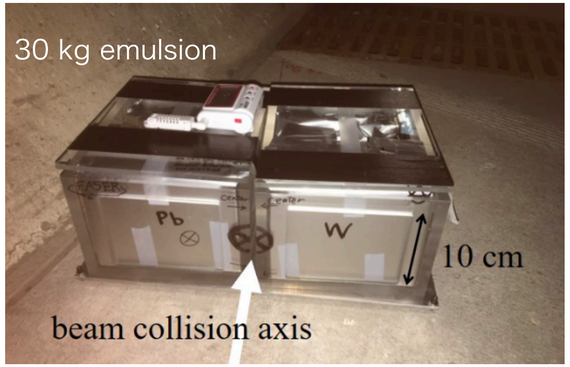
TI12
FASER/FASERν

Neutrino candidate

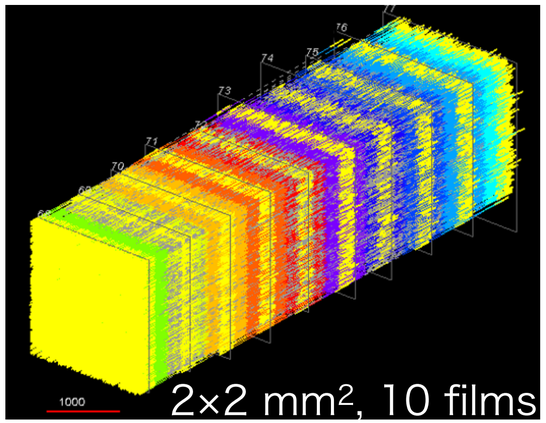




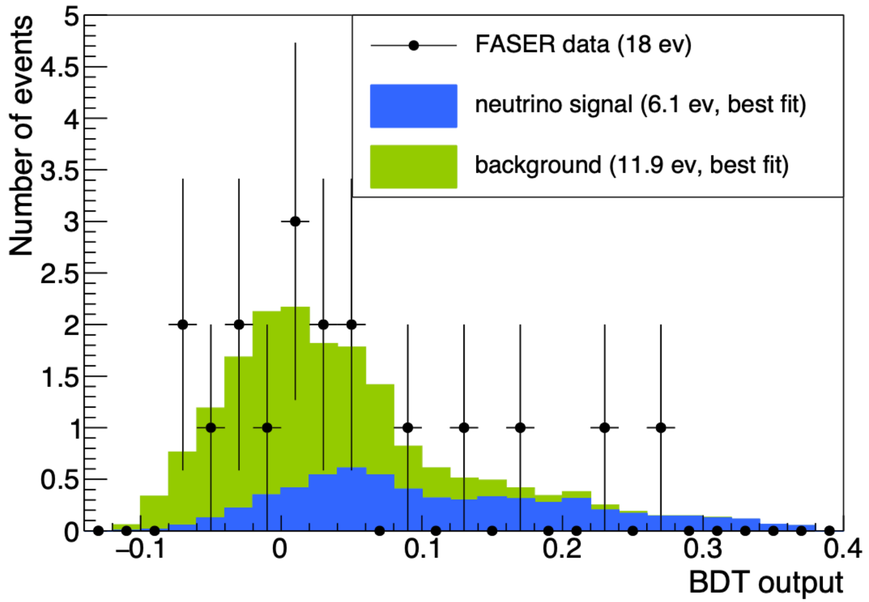
Detector at TI18 in 2018



Reconstructed tracks

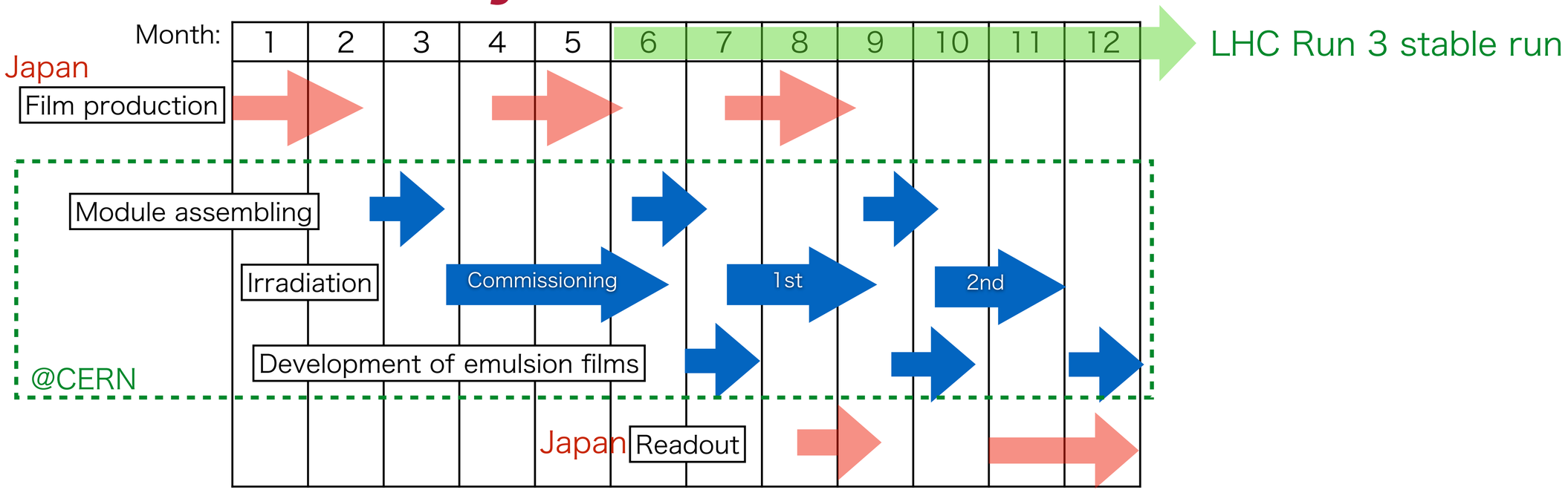


BDT analysis result



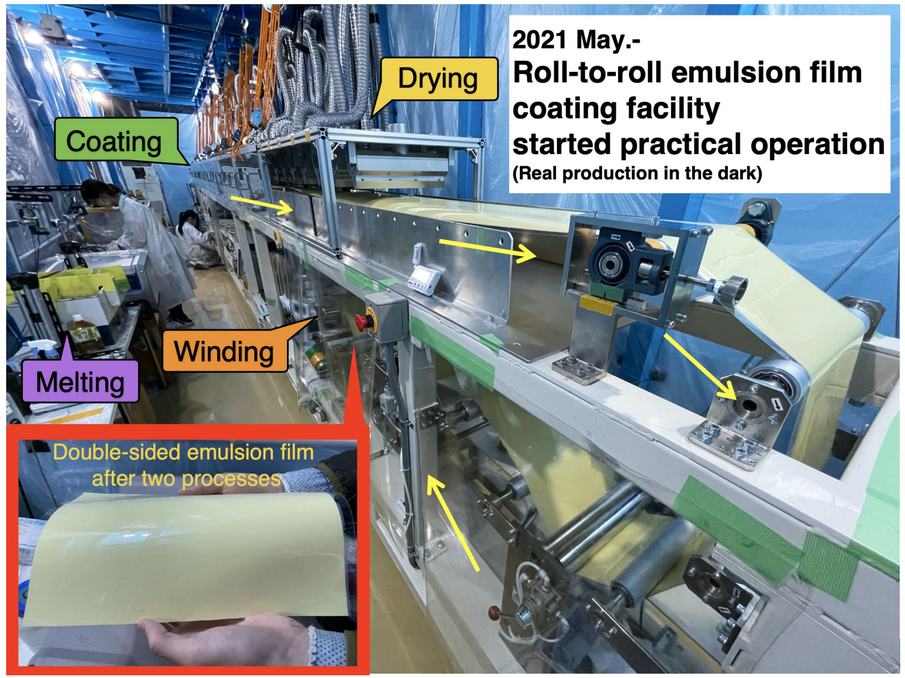
- Pilot run in 2018, 1 month exposure (12.2 fb-1)
- Statistical significance: 2.7 σ from null hypothesis
- Paper: Phys. Rev. D 104, L091101

Timeline for Physics Run

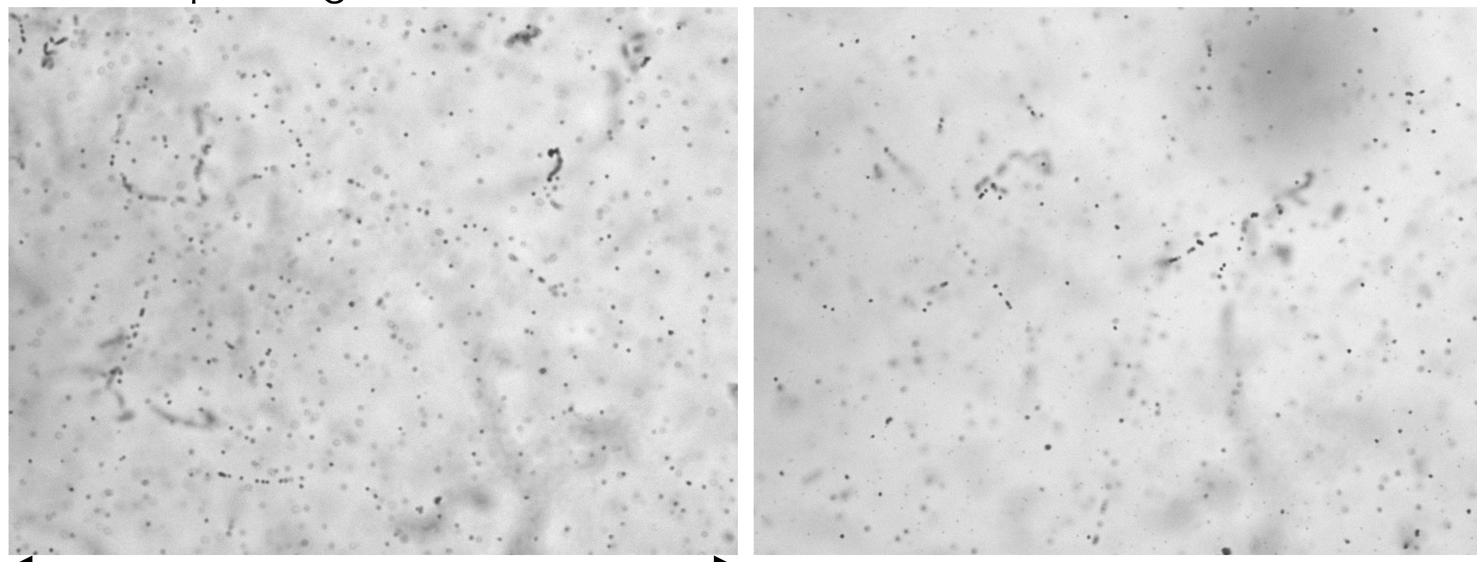


- **Data taking for 11 times (~ 60 m² each) in Run 3 (2022-2025)**
- Commissioning module (1/3 of the FASERν full size) will be installed in this March
- Readout of emulsion films (HTS-1)
  - Field of view: 25 mm², readout speed 0.45 m²/h/layer
  - Fast enough to readout in parallel with irradiation

Emulsion Film Production

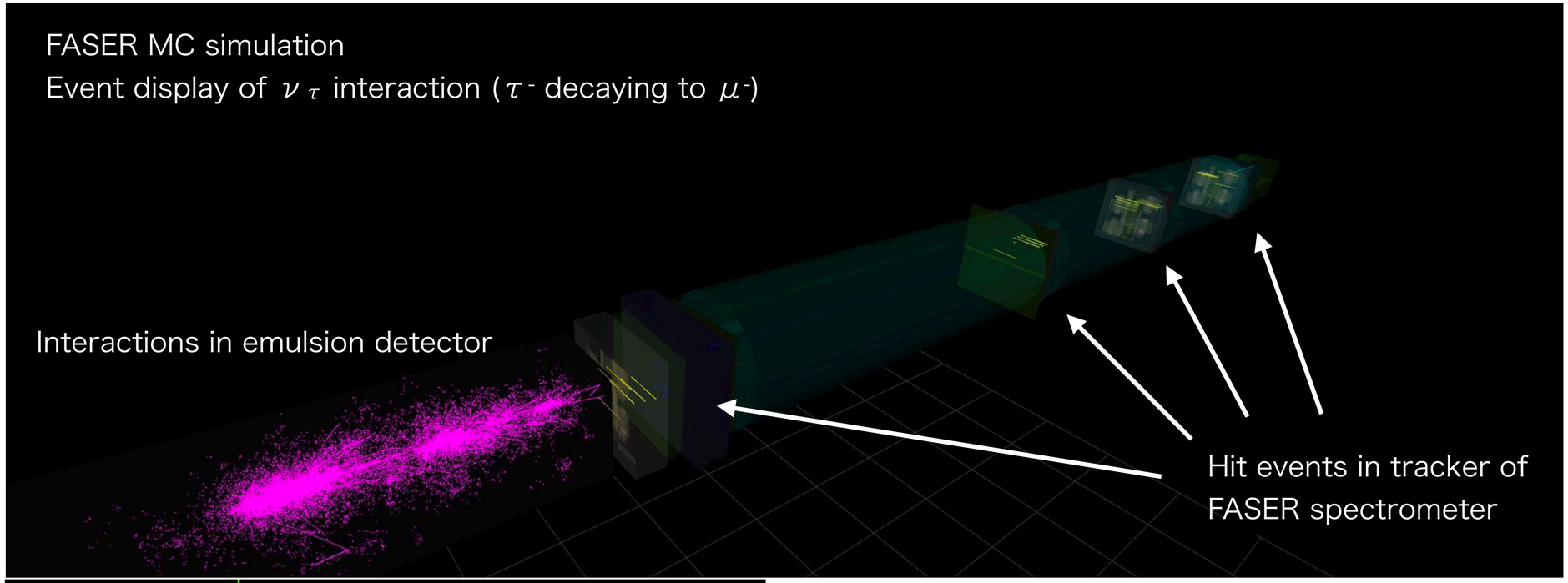


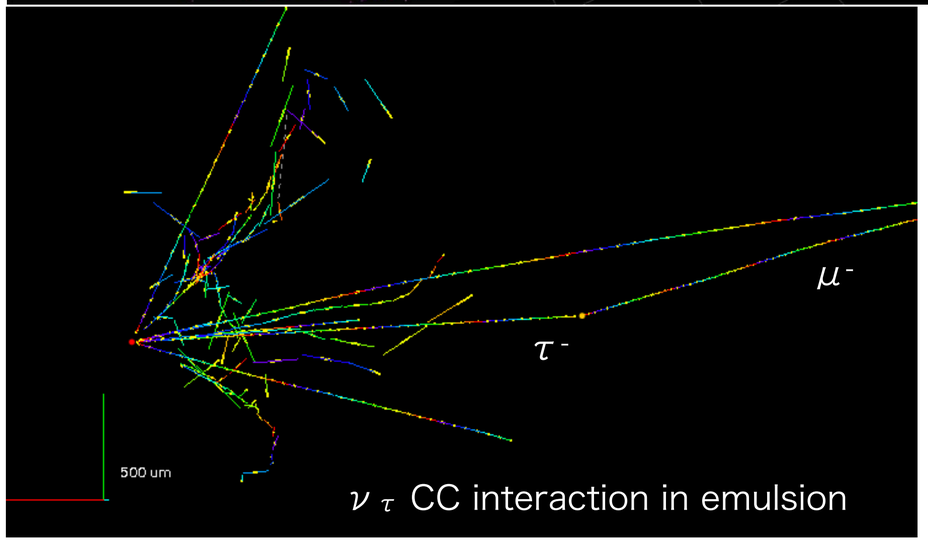
Microscope images



- 268 films (~ 20 m^2) were produced for the commissioning module
- Most of the films show good quality
- The module will be assembled with tungsten plates from next week

Offline Software





- Simulation and offline software reconstruction frameworks are developed
- Muon charge identification for ν_μ / $\bar{\nu}_\mu$ classification will be performed with global analysis of FASER spectrometer and FASER ν

Collaboration

74 members from
21 institutions and 9 countries

Conclusions

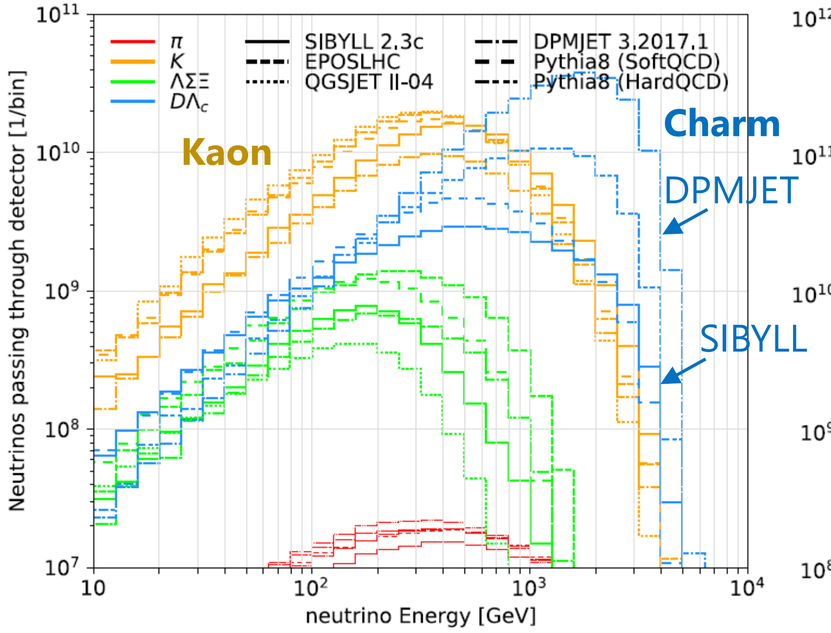
- FASERν studies three flavor neutrinos at the high energy frontier
- Environmental study and pilot run results proved
  the feasibility and potential of the experiment
- Emulsion films for commissioning module were produced and
  the module will be assembled and installed in this March

Supported by

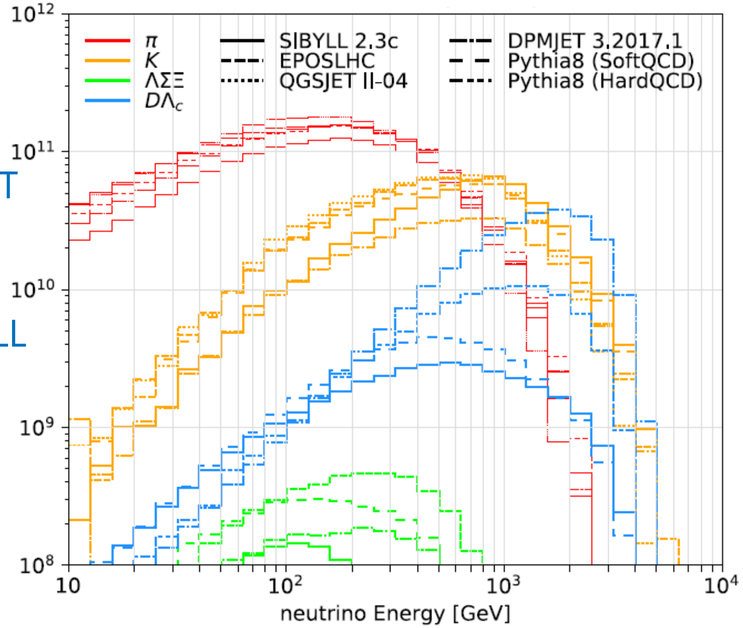
Backups

Neutrino production

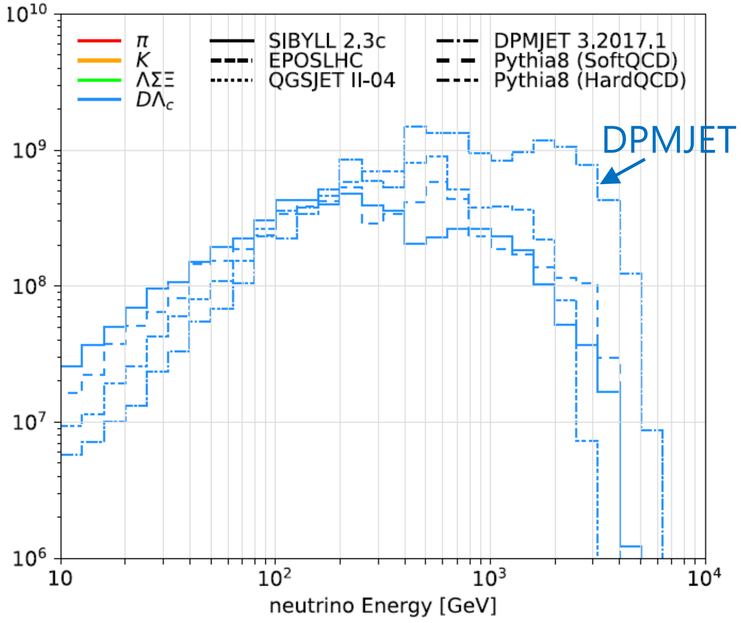
ν_e mainly from kaon and charm decays



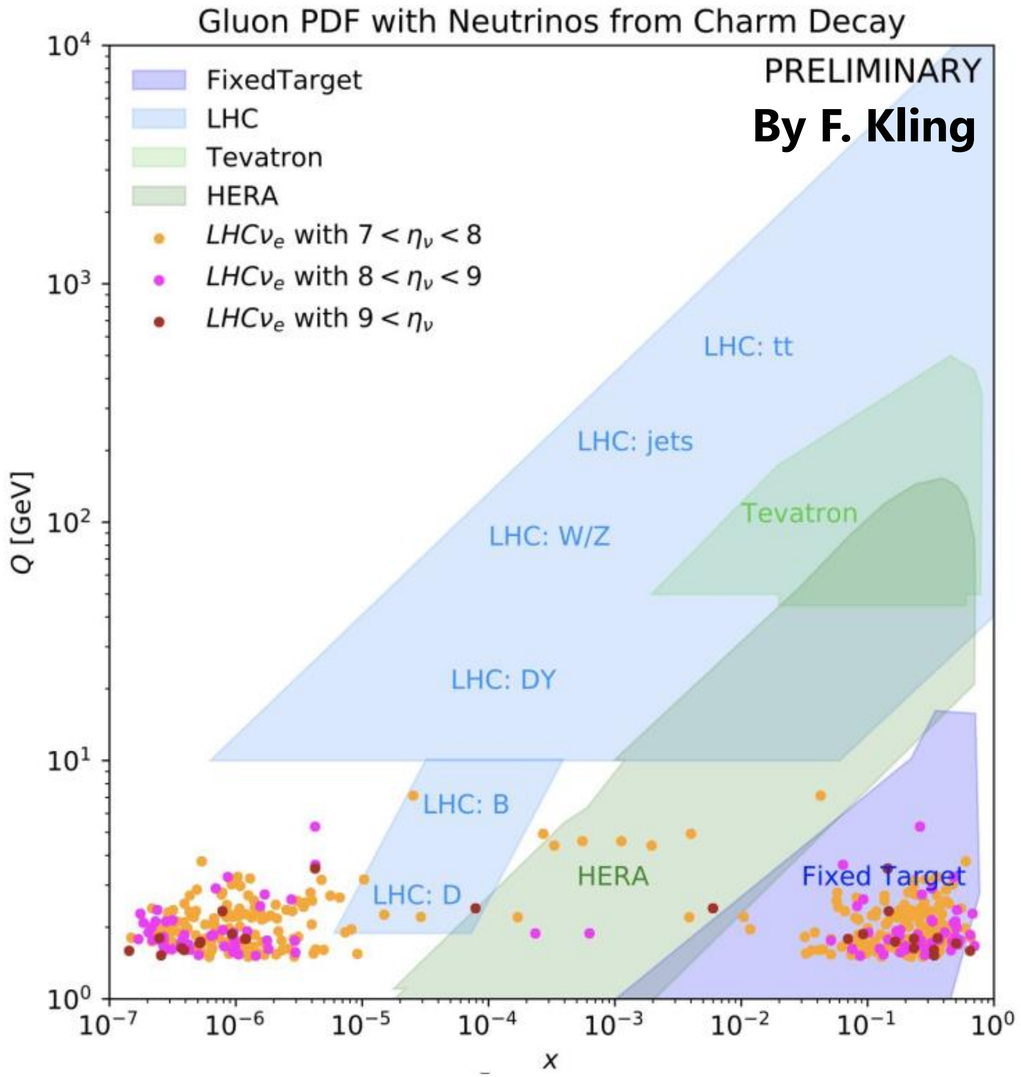
ν_μ mainly from pion and kaon decays

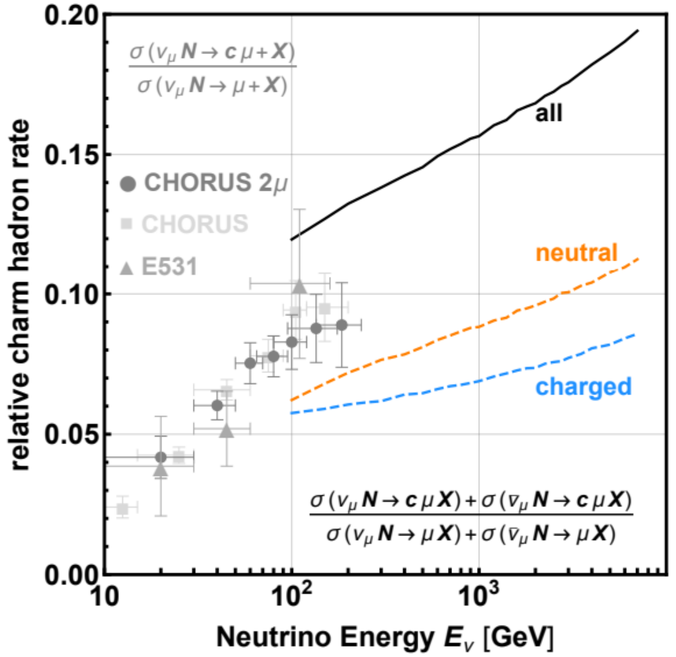


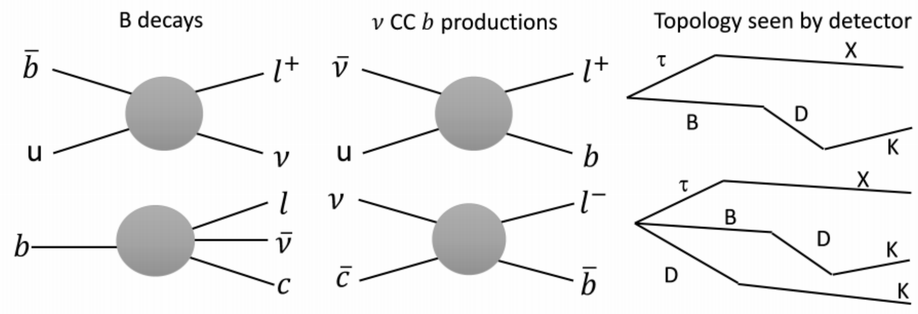
ν_τ mainly from D_s and subsequent τ decays



Physics







$\bar{\nu}N \to \ell \bar{B} X$

$\nu N \to \ell B D X$