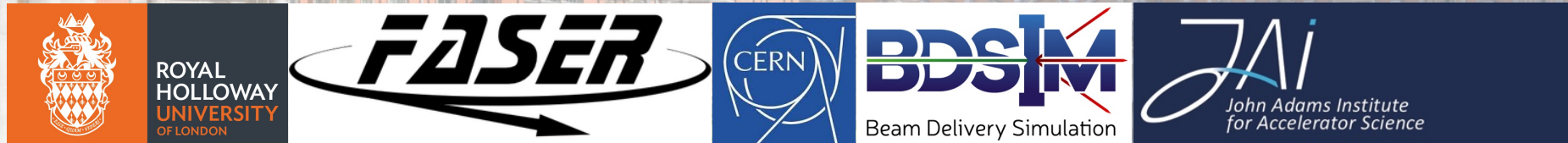# Machine Detector Interface for FASER

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FASER collaboration

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Introduction

FASER

- Planned small-scale and inexpensive experiment at the Large Hadron Collider (LHC) at CERN

- Designed for searches of light and weakly-interacting particles, such as neutrinos and new beyond standard model particles that could be produced during LHC collisions

- Located along the beam collision axis, 480m downstream from the ATLAS experiment interaction point

- Detector volume cylindrical with length 5m and radius 10cm consisting of tracking and calorimeter sections

- Will collect 150 fb^{-1} of data during 2022-24 during LHC Run3
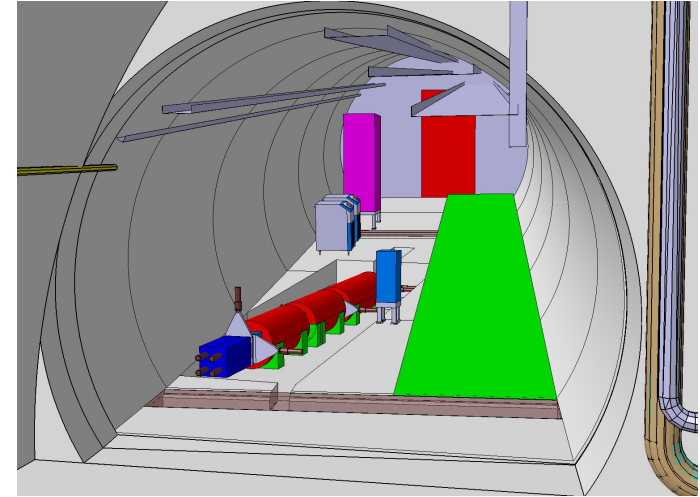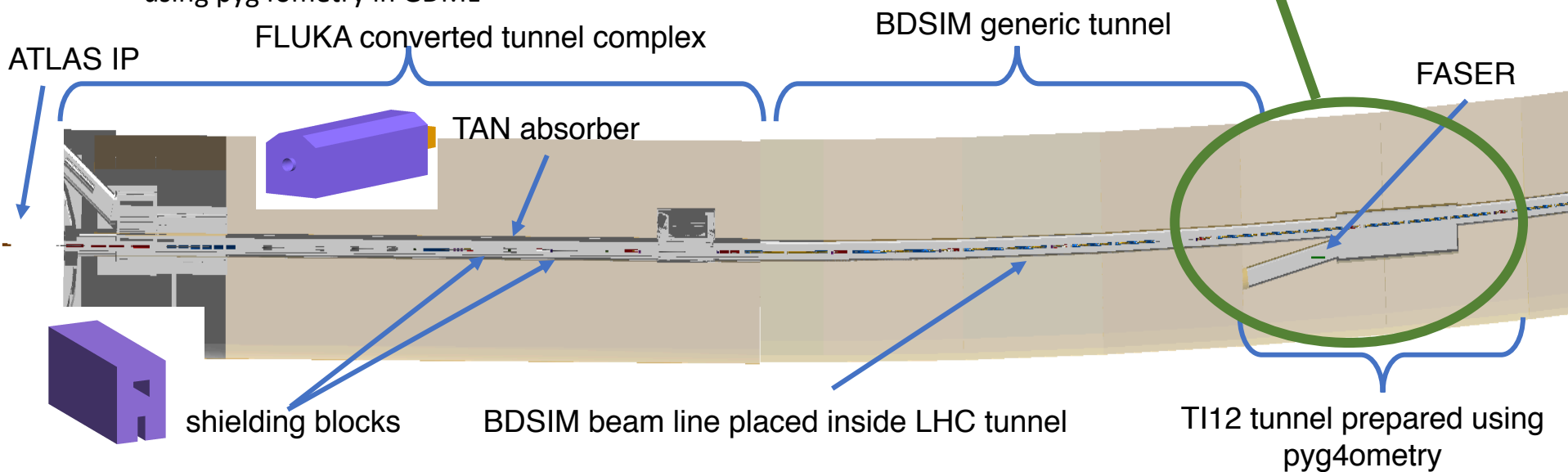

SIMULATION GOALS

- Simulation of particle transportation of events from the ATLAS interaction point to FASER

- Propagation of physics signal and background from proton-proton collisions simulated using the BDSIM framework

- The simulation models:
    - Interaction of particles with material (magnets, tunnel, shielding etc.)
    - Magnetic fields of all accelerator magnets
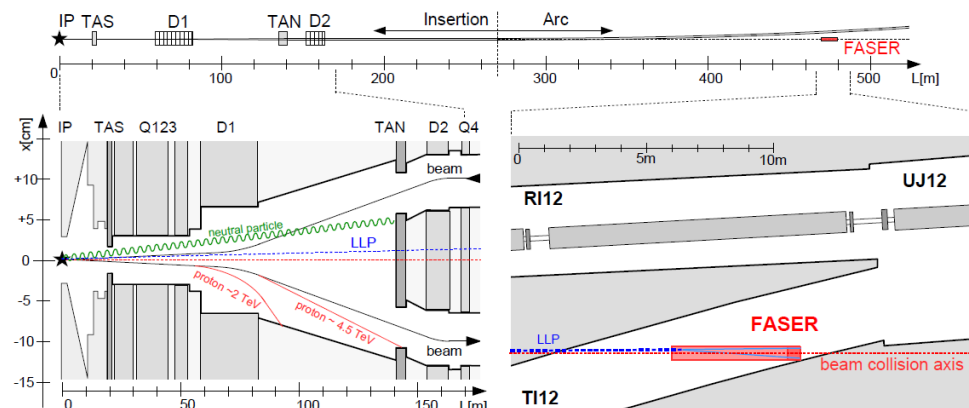
Simulation geometry, physics and event generation

- Model composited from several geometry sources
  - BDSIM beam line including LHC-style dipoles, customised proportions
  - Aperture model from BE / Sixtrack used in beam line conversion from MADX
  - FLUKA IR1 accelerator tunnel complex
  - BDSIM generic LHC tunnel
  - Custom tunnel and several shielding blocks prepared using pyg4ometry in GDML

LHC tunnel   TI12 tunnel   FASER
FASER IP
Sampler plane 1x1m

FLUKA converted tunnel complex   BDSIM generic tunnel

ATLAS IP   TAN absorber   FASER

shielding blocks   BDSIM beam line placed inside LHC tunnel   TI12 tunnel prepared using pyg4ometry

- BDSIM simulation
  - Input from Cosmic Ray MC (CRMC) event generator – proton-proton collisions (LHC Run3 settings)
  - Output at FASER interface plane (FASER IP) – 0.5m in front of FASER detector

Simulation results

Simulation outputs particles at a FASER interface plane, results using 500M inelastic ATLAS p-p collisions

- Particle flux at FASER IP

  - Only muons and neutrinos reaching FASER IP

  - Muon flux (background) minimum at FASER

  - Neutrino flux (signal) maximum at FASER

- Energy spectra at FASER IP

  - Neutrino energies up to 5 TeV

  - Dominant signal – muon neutrinos/anti-neutrinos
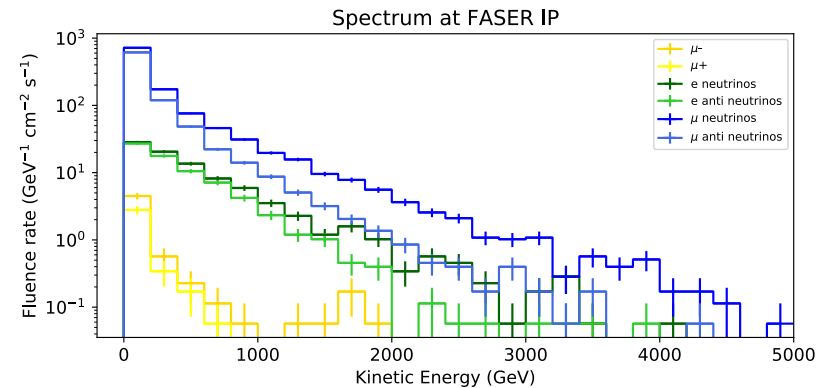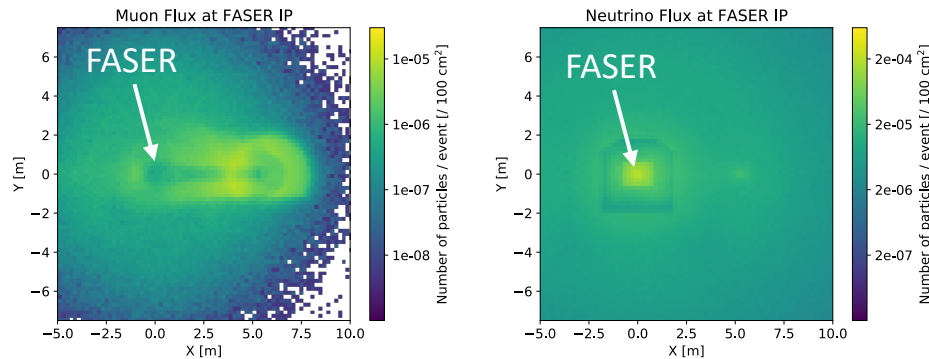
Total particles at FASER IP during LHC Run 3: $3.92721 \times 10^7 \pm 1.8 \times 10^3$ (stat.) cm^{-2} fb

- Systematic error analysis

  - Work in progress

  - Vary parameters in simulation

  - Explore the effects of modelling different event generator, crossing angle of incoming colliding protons, geometry effects etc.

- Conclusion

  - Full model of ATLAS -> FASER particle propagation

  - Simulation datasets produced in this work used for future FASER data analysis