SIMULATION ACTIVITIES FOR FCC
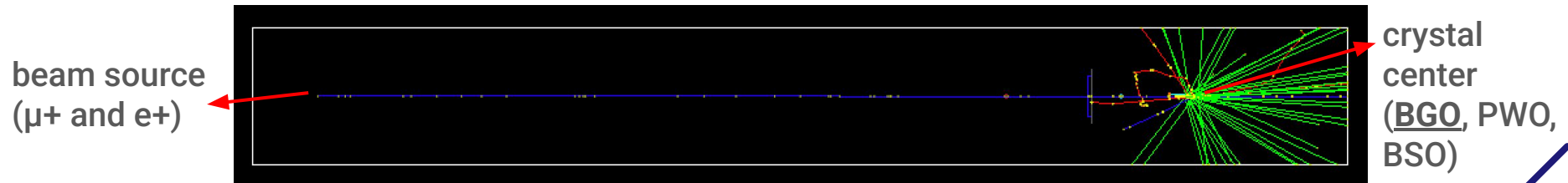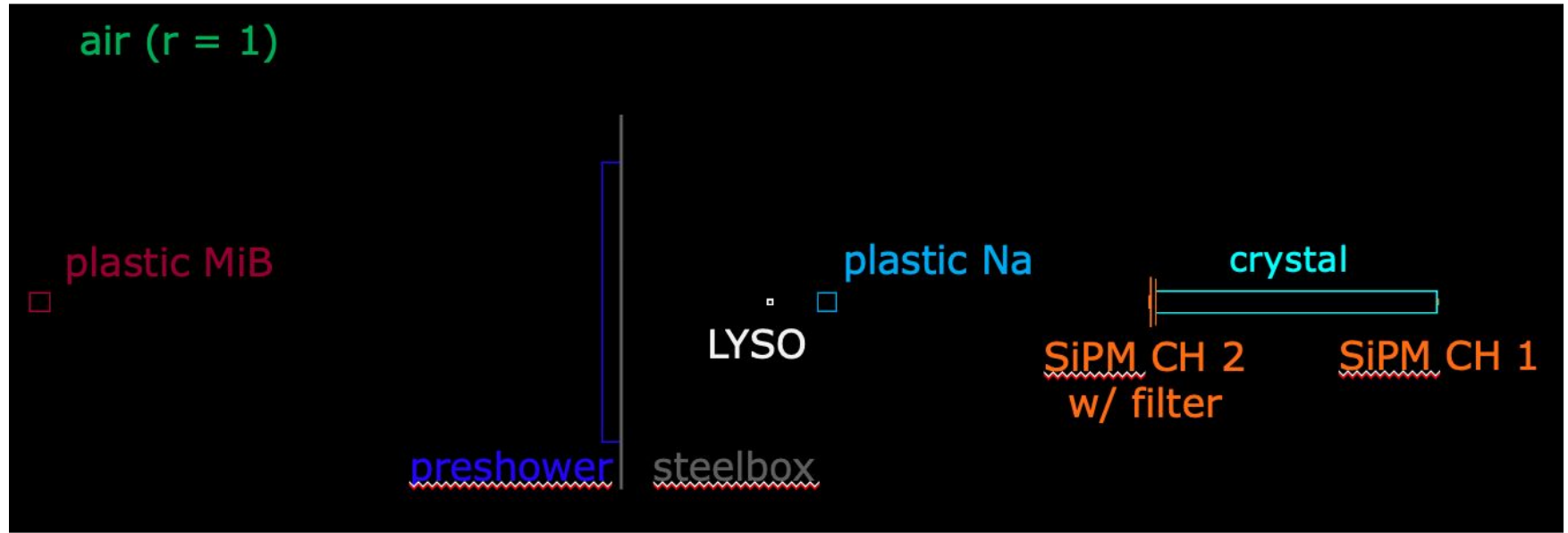
Antonio D'Avanzo on behalf of FCC Na group

WHAT: SIMULATING CRYSTALS RESPONSE IN GEANT4

- Study of the expected response of crystals for dual-readout electromagnetic calorimeter at FCC-ee
  - Simulation of scintillation/cerenkov light detection with SiPMs

- Fully customizable simulation of test beam setup in July 2024
  - Provided with optical photons tracing, crystal rotation and several materials
  - Able to reproduce data taking configurations to compare with data
 - Built with Geant4 toolkit on INFN IBISCO cluster in Naples

Test beam setup simulation

air (r = 1)

plastic MiB

plastic Na

crystal

LYSO

SiPM CH 2
w/ filter

SiPM CH 1

preshower | steelbox

beam source
(μ+ and e+)

crystal
center
(**BGO**, PWO,
BSO)

Basic simulated physics interactions

- **Monoenergetic beam based on particle type along z direction, 120 GeV for μ+ and 10 GeV for e+**
  - **Gaussian spot of 0.25 cm along x and y direction**
- **Deposited energy from electromagnetic, hadronic and scattering physics in BGO crystal**

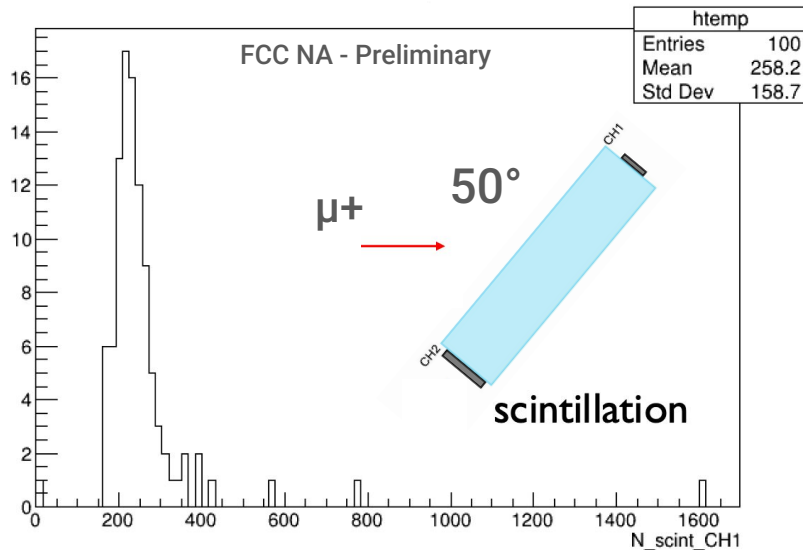**Deposited energy in crystal**
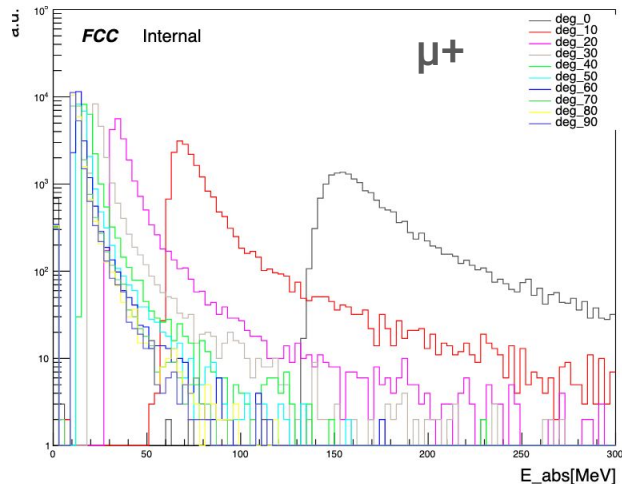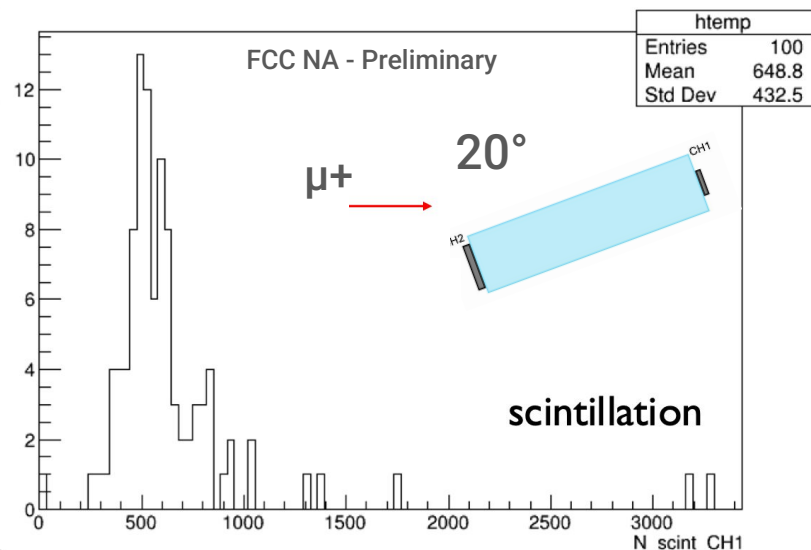
Deposited energy in crystal
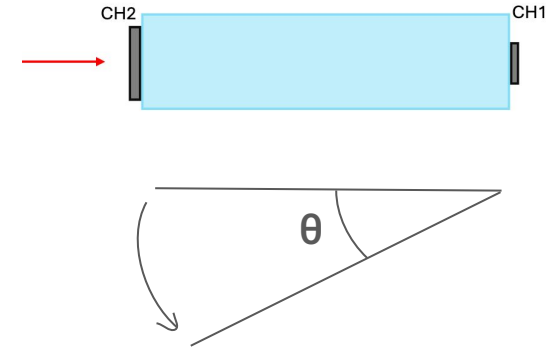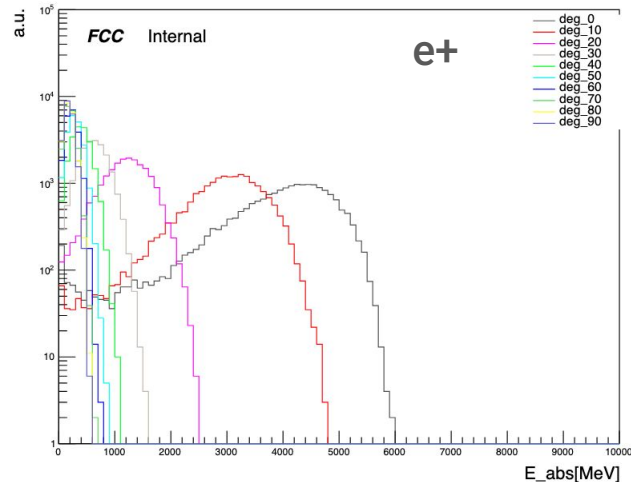
Simulated optical physics

- Activated production of optical photons from scintillation and Cerenkov processes, triggered by the particle energy released in the material
  - Optical parameters of materials obtained from lab measurements in Naples or literature
  - Simulated features: number of photons reaching SiPMs, photons energies and timing of arrival on SiPMs
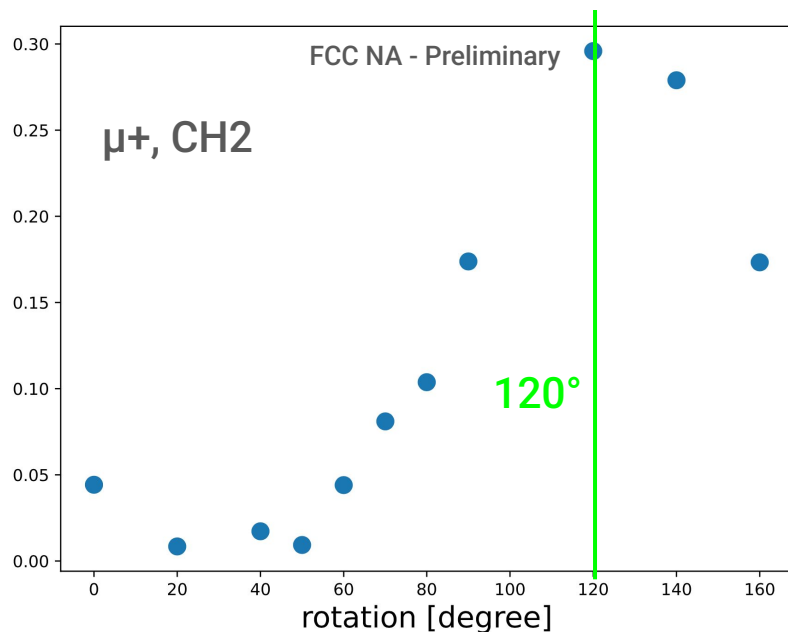
Number of photons in CH1
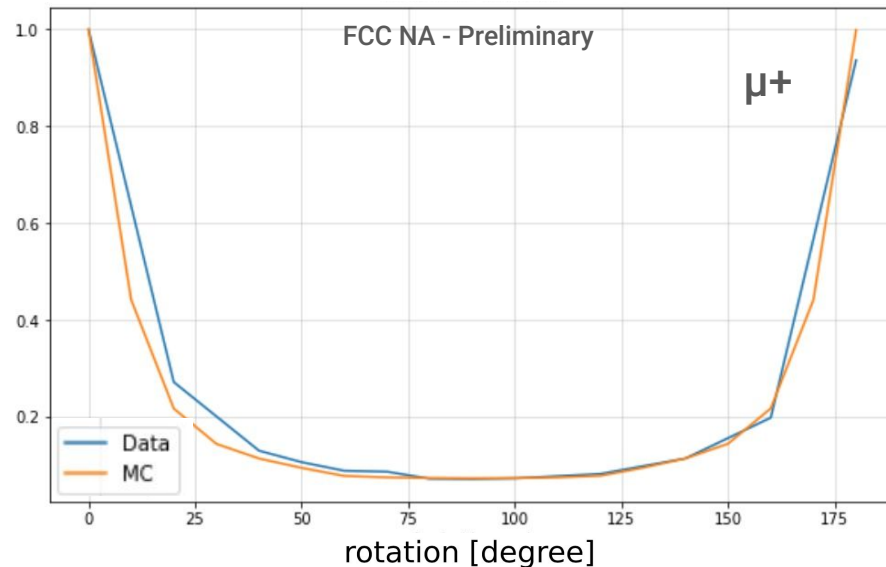
Number of photons in CH1

Data/simulation comparisons

- Cerenkov/scintillation ratio depends on crystal angle: peak at 120° (CH2)

Simulation of results on data from Lucrezia's talk

Comparison of deposited energy in simulation and integrated waveforms from data. Normalized with respect to 0°

Future developments

- Geant4 simulation for dual-readout electromagnetic calorimetry at FCC project
  - Constructed geometry and beam according to test beam setup
  - Implemented optical photons propagation and detection on SiPMs
  - Still **preliminary** but most of the work in Geant4 is done and compatible with expectations

- Future developments:
  - Fine tuning of beam parameters
  - Simulate SiPM response given the number of photons, wavelengths and timing from Geant4
    - At the moment, SiPMs in Geant4 are merely Si blocks
    - Most certainly to be done with post-processing tool
  - Compare obtained waveforms with data

BACKUP

# WHAT: SIMULATING CRYSTALS RESPONSE WITH GEANT4

- **Geant4**: Toolkit for the simulation of the passage of particles through matter.
  - Used in many research fields (nuclear and medical physics), specifically high energy physics
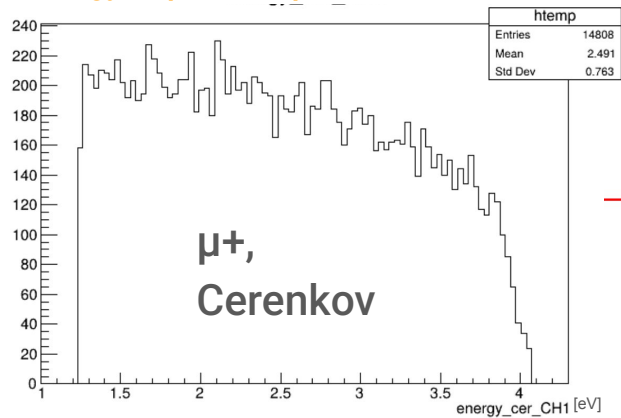- Implemented in C++ macros and compatible with data analysis software ROOT

Simulated optical physics

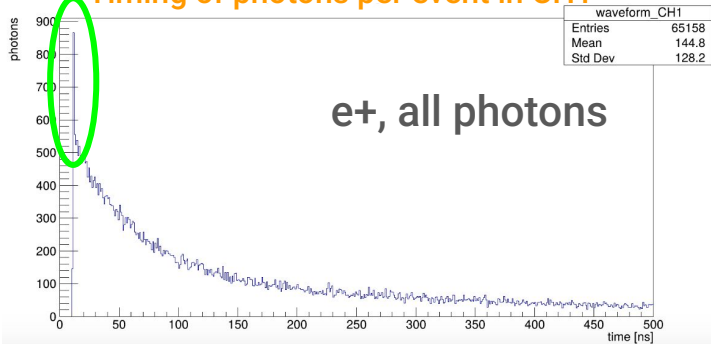- Simulated features: photons energies and timing of arrival on SiPMs
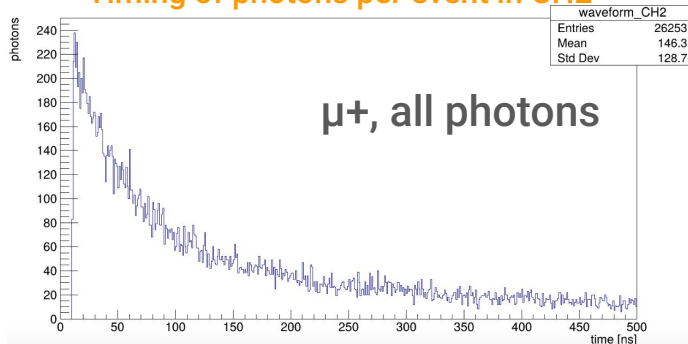
Energy of photons per event in CH1
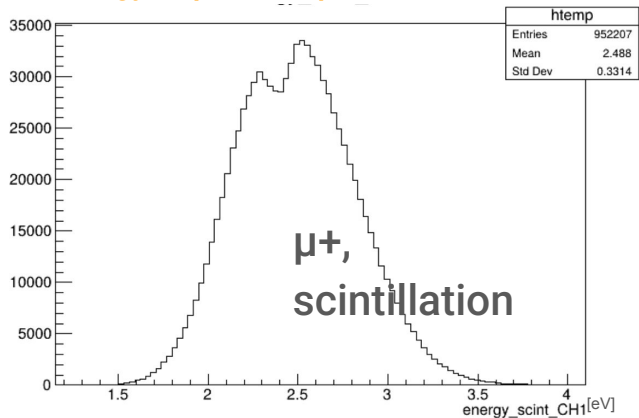
μ+, scintillation

Energy of photons per event in CH1

μ+, Cerenkov

Timing of photons per event in CH1

e+, all photons

Timing of photons per event in CH2

μ+, all photons

prompt cerenkov emission peak