TB 2022: Geant4 simulations & Data Comparison

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TB 2022 Simulations Step by Step

- **geometry**
  - complete implementation of all type of sensors – Anton1, Yan1, BeamCal, C72, C74, C75
  - re-numbered the pads to correspond to channels from real sensors
  - macro with commands for easily geometry change

- **physics list**
  - check results with another physics list suggested by Geant4 – QGSP_BERT, QGSP_BIC and those with electromagnetic options (_EMV, _EMX, EMZ..)
  - start / stop hadronic processes to investigate their influence on results
  - implement specific physics list - one developed by Alina a few years ago for FCal

- **analysis**
  - evaluate each pad energy deposition
  - fit the energy deposition histograms to get the MPV
  - evaluate MPV for different setup configurations
  - compare simulation results with data from test beam
  - find the longitudinal shower distribution for different configurations (e.g. 1 to 15 W plates in front of sensor)

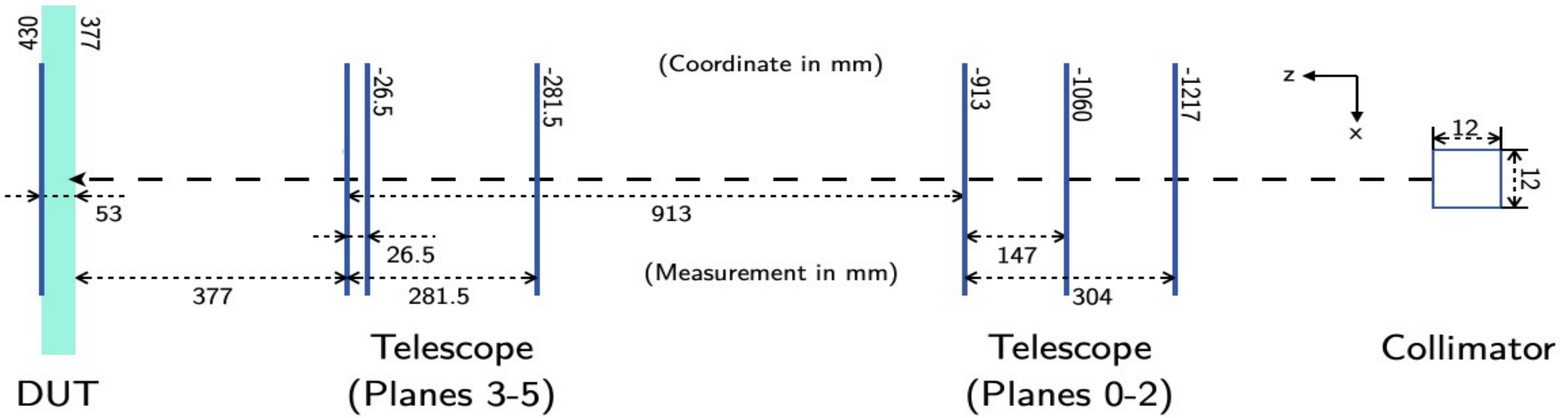
TB 2022: Geometry implementation in Geant4

2 case scenario: Anton1 (GaAs) & C74 (Si) sensors

- Simplest geometry
  - Sensor placed in 1st DUT slot
  - 6 telescope planes
  - all distances implemented as in test beam (thanks, Shan!)

goal: check energy deposition

- get energy deposited in each pad of sensor
- reconstruct hit map



▪ Ga-As sensor – Anton1

- Rectangular shape
- **X dimension:** $\mathcal{L}$ = 4,7mm*15 (pad) + 0,3mm*14(gap) = 70,5mm + 4,2mm = 74,7 mm
- **Y dimension:** ℓ = 4,7mm*10(pad) +0,3mm*9(gap) = 47mm + 2,7mm = 49,7 mm
- **Thickness** 500 µm

▪ Si sensor – C74

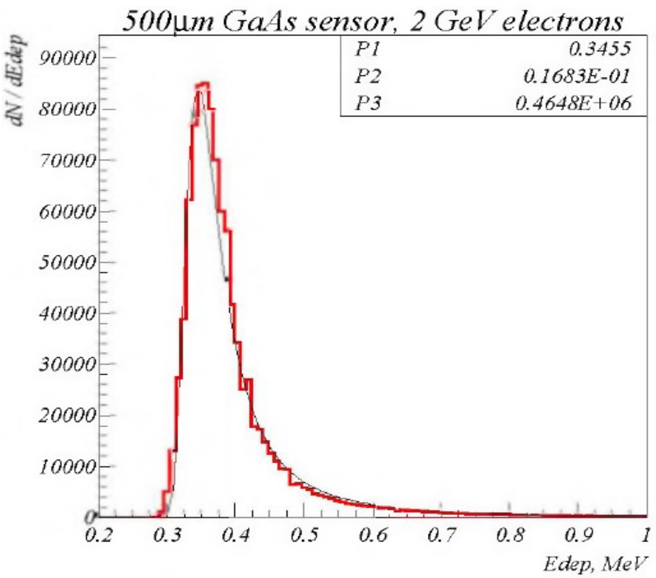
- **Squared shape: 18 cm x 18 cm**
- **Separated in 1024 pads**
- **Thickness**: 320 µm

- **Physics list used: FTFP_BERT & FTFP_BIC**

Simulations: Number of e-h pairs created in GaAs sensor

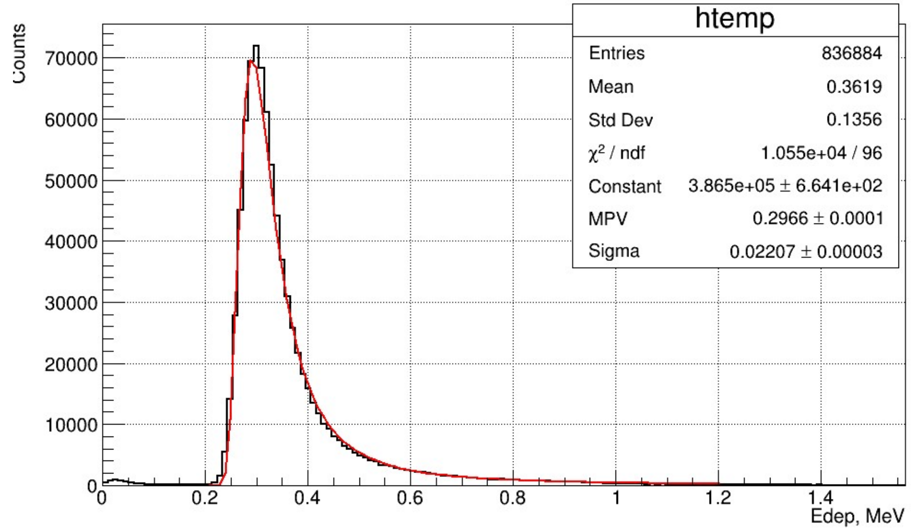
Olga Nogorodova's Thesis:

- **Energy deposition in GaAs sensor**
- **500** µm thickness
- ^{90}Sr, 2, 4 and 4.5 GeV mono-energetic e-
- triggered by 3 scintillators



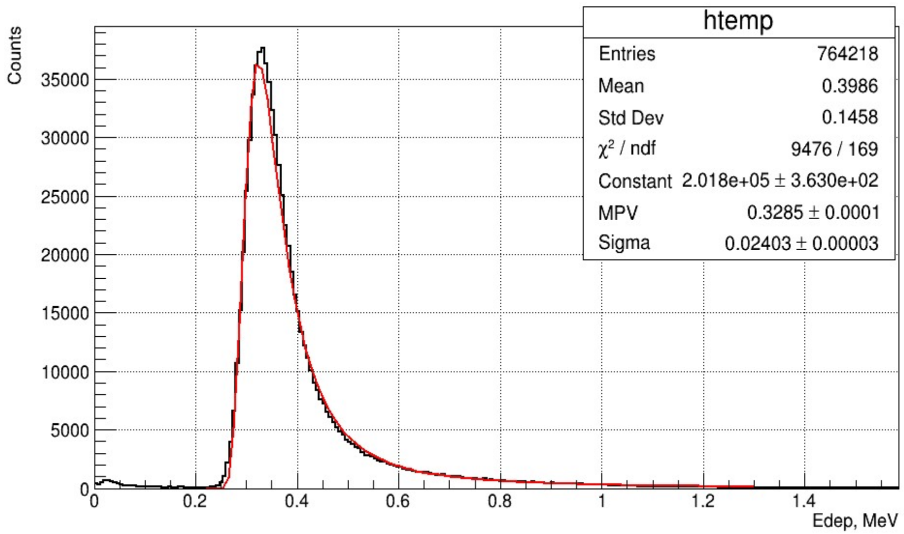
Setup	Dep. En.	e-h pairs per μm
^{90}Sr	0.3512 MeV	163,4
2 GeV	0.3455 MeV	160,7 (2.0 GeV)
4 GeV	0.3513 MeV	163,4 (4.0 GeV)
4.5 GeV	0.3526 MeV	164,0 (4.5 GeV)

goal: check number of e-h pairs created



- **Thickness: 500 µm**
- **E_{e-} = 2 GeV**
- **E_i = 4.3 eV**

137.95 e-h pairs per µm



- **GaAs sensor – Anton1**
  - **Thickness**: 550 µm
  - 5 GeV mono-energetic e-
  - Triggered by 3 scintillators

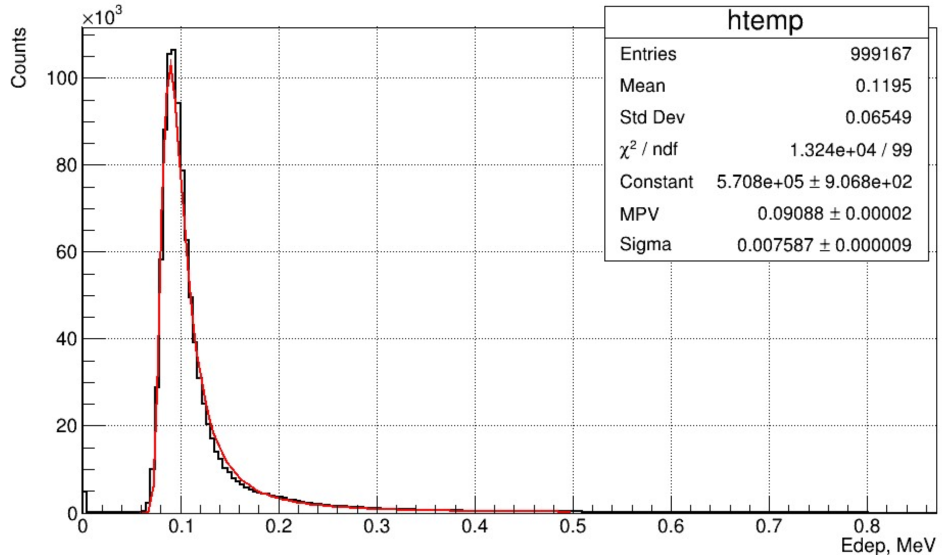
- **Thickness: 550 µm**
- **E e- = 5 GeV**
- **Ei = 4.3 eV**

142.21 e-h pairs per µm

- **Physics list used: QGSP_BERT_EMZ**

Simulations: Number of e-h pairs created in Si sensor

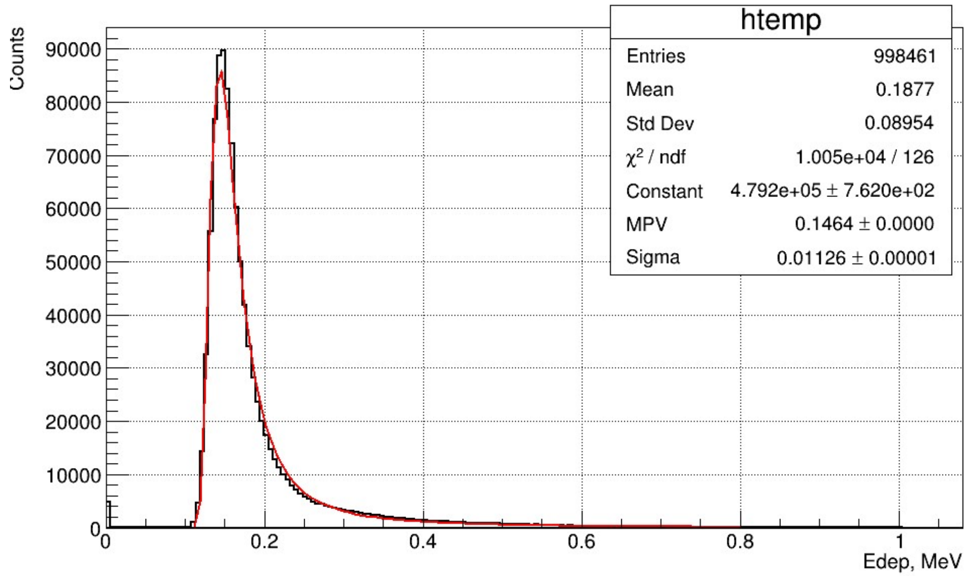
- **Energy deposition in Si sensor**
  - 320 µm thickness
  - 5 GeV mono-energetic e-
  - triggered by 3 scintillators



- **Thickness: 320 µm**
- **E_{e-} = 5 GeV**
- **E_i = 3.62 eV**

78.45 e-h pairs per µm

- **Energy deposition in Si sensor**
  - **Thickness**: 500 µm
  - 3 GeV mono-energetic e-
  - Triggered by 3 scintillators



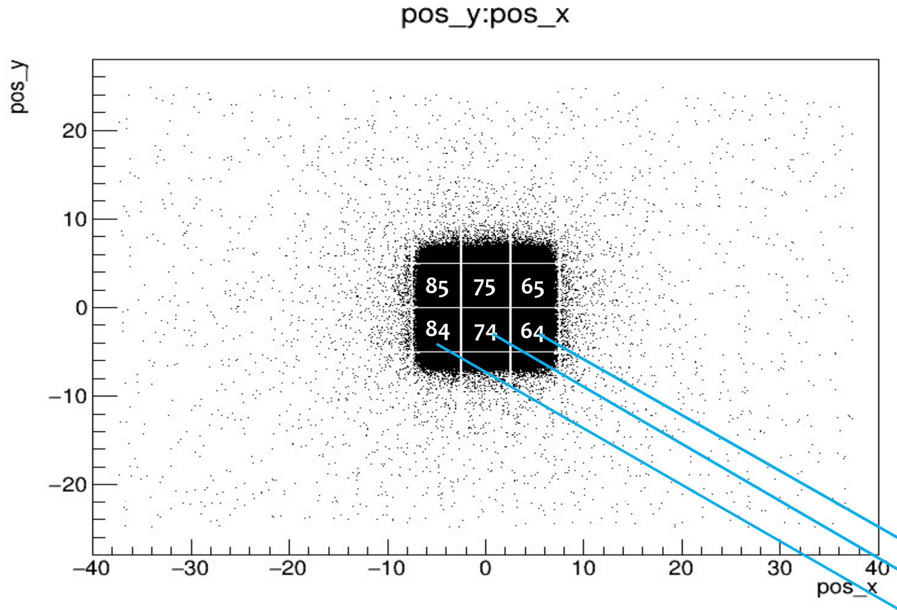
- **Thickness: 500 µm**
- **E_{e-} = 3 GeV**
- **E_i = 3.62 eV**

80.88 e-h pairs per µm

- **Physics list used: QGSP_BERT_EMZ**

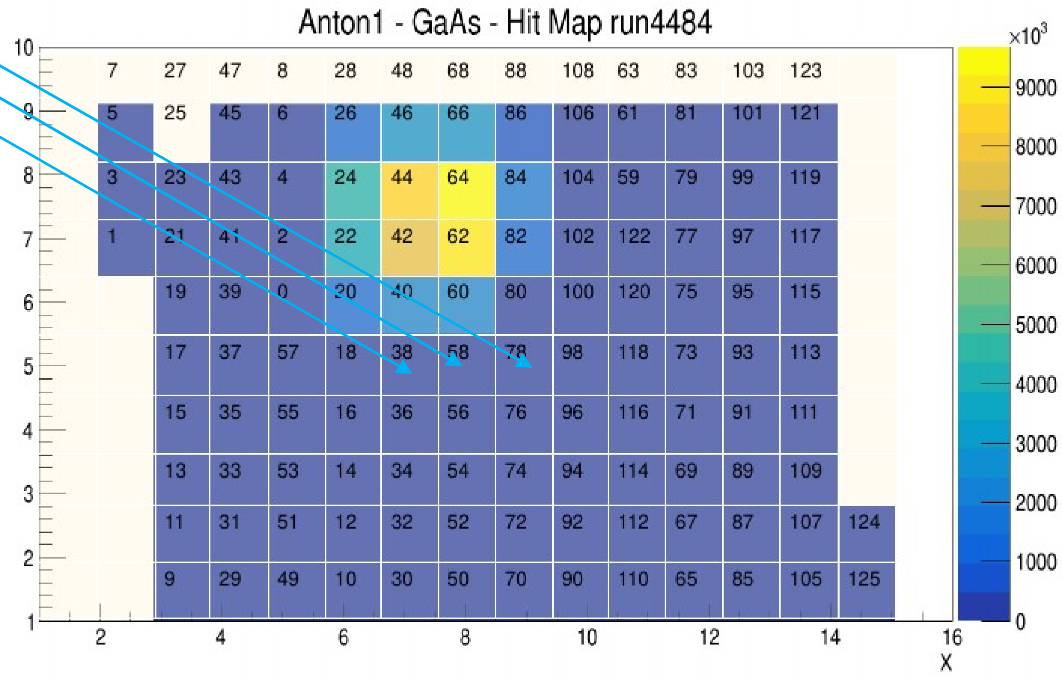
Simulations GaAs: Anton1 sensor

- ## Hit map



Simulation setup

- Primary particle: electron
- Primary particle energy: 5GeV
- Source type:
  - squared,
  - 12 mm x 12 mm
- Number of simulated events: 1 000 000

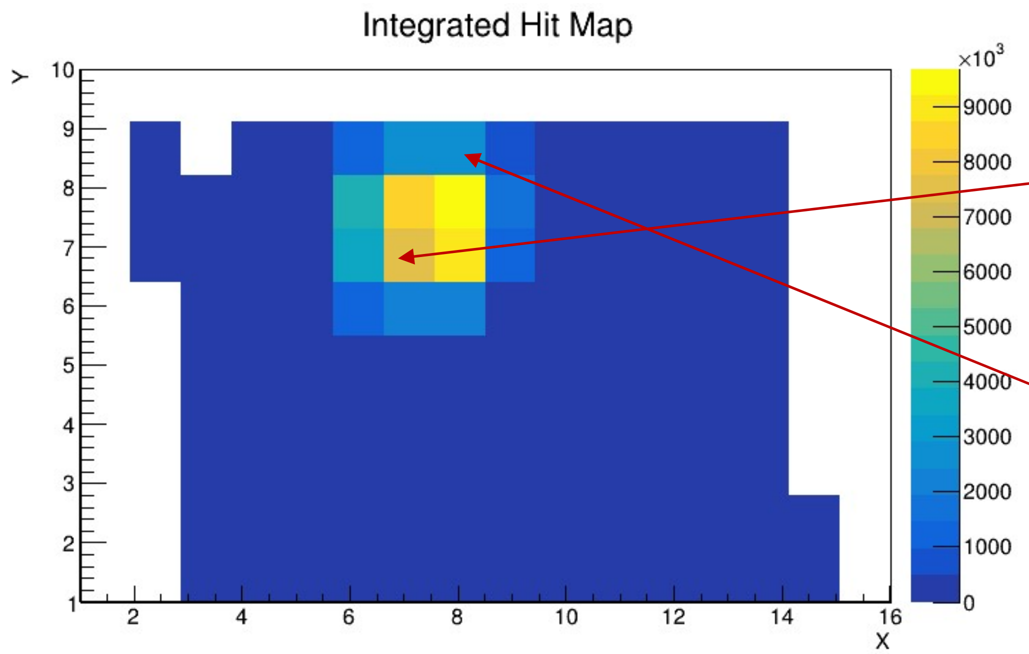


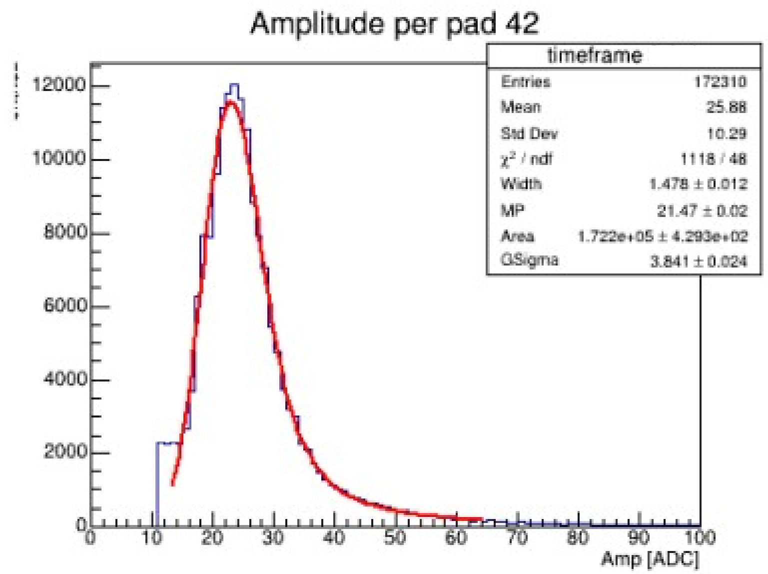
Hits registered position

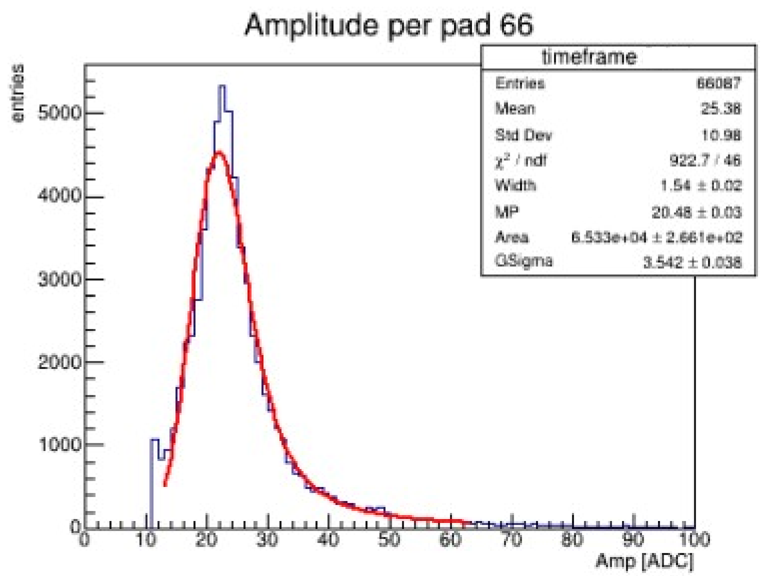
- Centered on pads 64, 65, 74, 75 , 84, 85
- Converted to channel number from sensor

2022 TestBeam: GaAs calibration

- Channel by channel gain calibration can be done by looking on the response of sensor directly exposed on MIPs deposition in Si sensor
- for each pad a (Landau & Gauss) function was fitted to energy spectrum
- The analysis showed very small deviations from channel to channel







Data from run4484 – Anton1 sensor

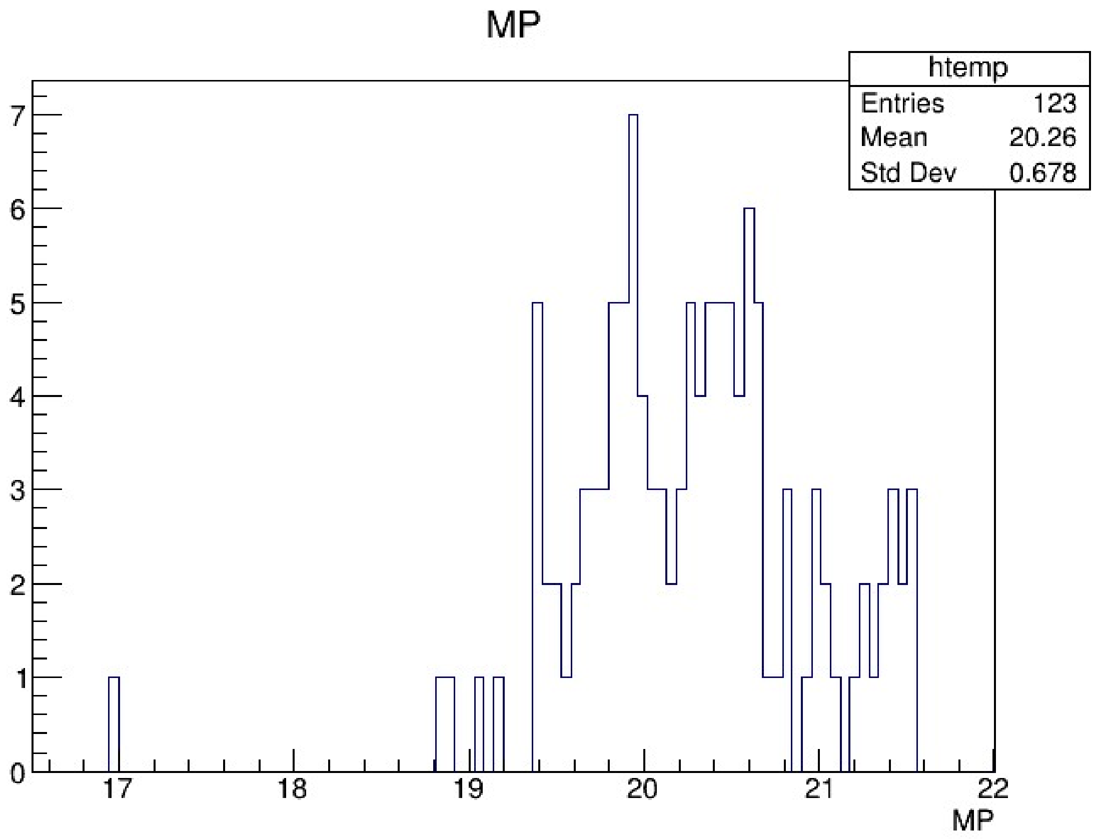
- Beam on pads 42, 44, 62, 64
- Converted to channel number from sensor

Analysis conditions

- Kept all timeplanes
- Cut on amplitude < 900
- dead channels masked
- langaus fitted in range [12-64] ADC

2022 TestBeam: GaAs calibration

- for each pad a (Landau & Gauss) function was fitted to energy spectrum
- The analysis showed very small deviations from channel to channel



Analysis conditions

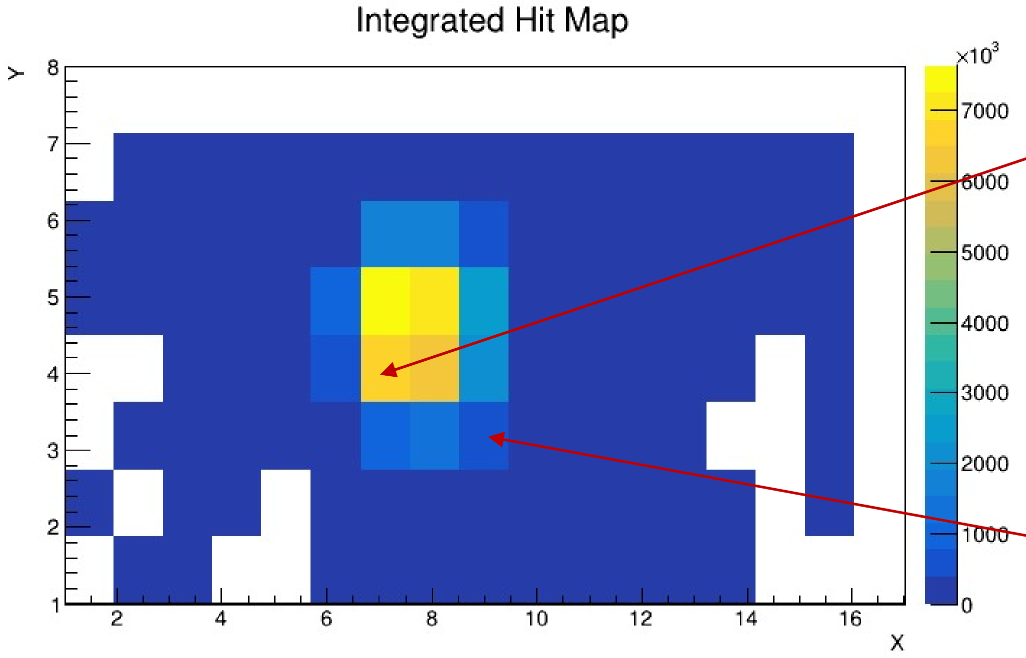
- Kept all timeplanes
- Cut on amplitude < 900
- dead channels masked
- langaus fitted in range [12-64] ADC

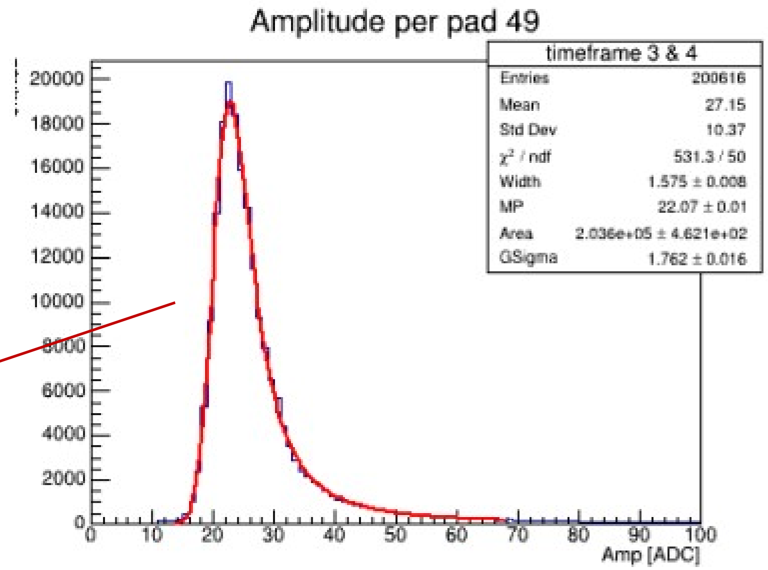
Data from run4484 – Anton1 sensor

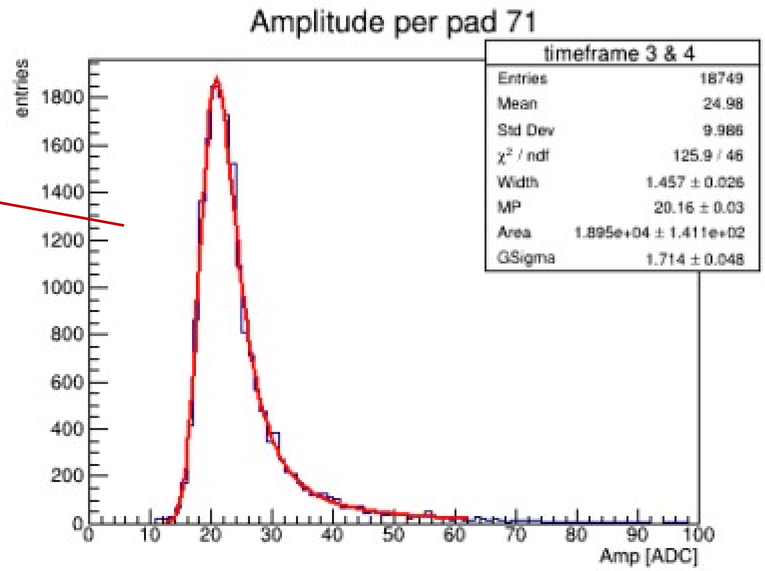
- Beam on pads 42, 44, 62, 64
- **MVP = 20.26 ± 0.68 [ADC]**

2022 TestBeam: Si calibration

- Channel by channel gain calibration can be done by looking on the response f sensor directly exposed on MIPs deposition in Si sensor
- for each pad a (Landau & Gauss) function was fitted to energy spectrum
- The analysis showed very small deviations from channel to channel







Data from run4436 – C75 sensor

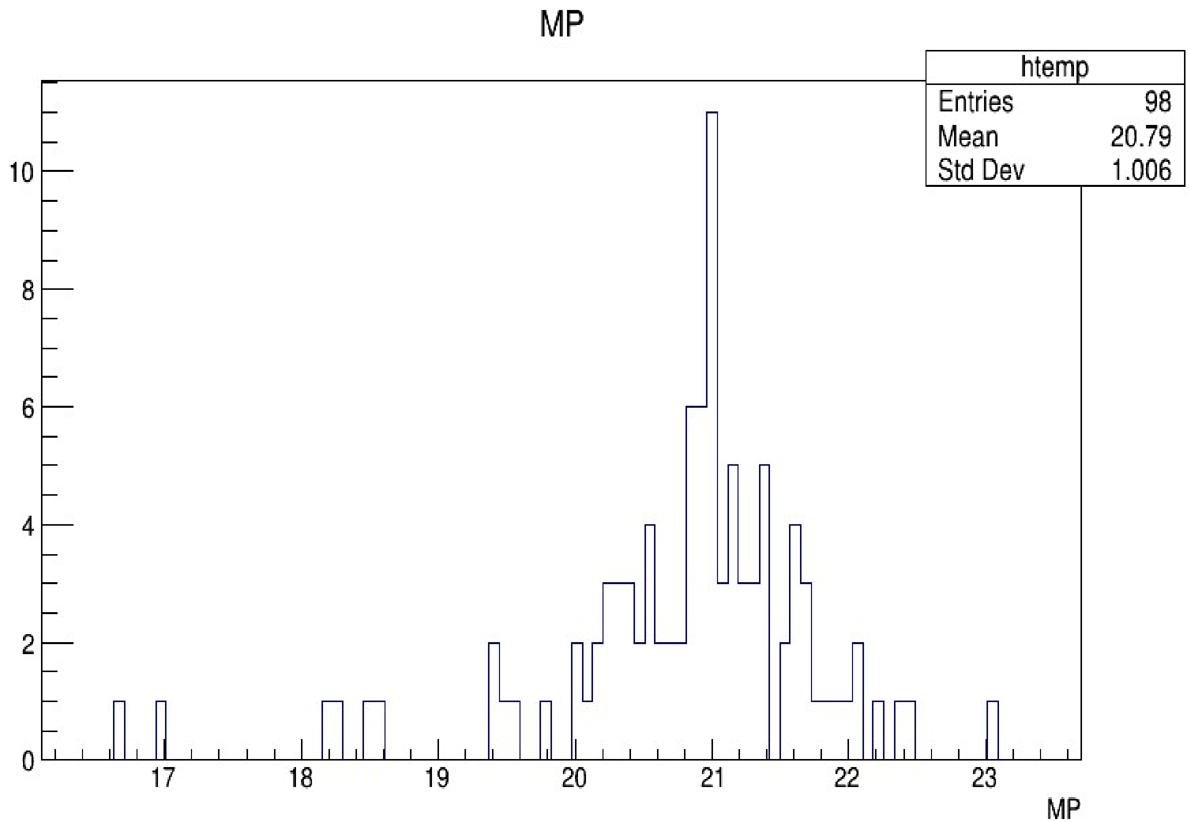
- Beam on pads 49, 51, 59, 61

Analysis conditions

- Kept all timeplanes
- Cut on amplitude < 900
- dead channels masked
- langaus fitted in range [12-64] ADC

2022 TestBeam: Si calibration

- for each pad a (Landau & Gauss) function was fitted to energy spectrum
- The analysis showed very small deviations from channel to channel



Analysis conditions

- Kept all timeplanes
- Cut on amplitude < 900
- dead channels masked
- langaus fitted in range [12-64] ADC

Data from run4436 – Anton1 sensor

- Beam on pads 49, 51, 59, 61
- **MVP = 20.79 ± 1.07 [ADC]**

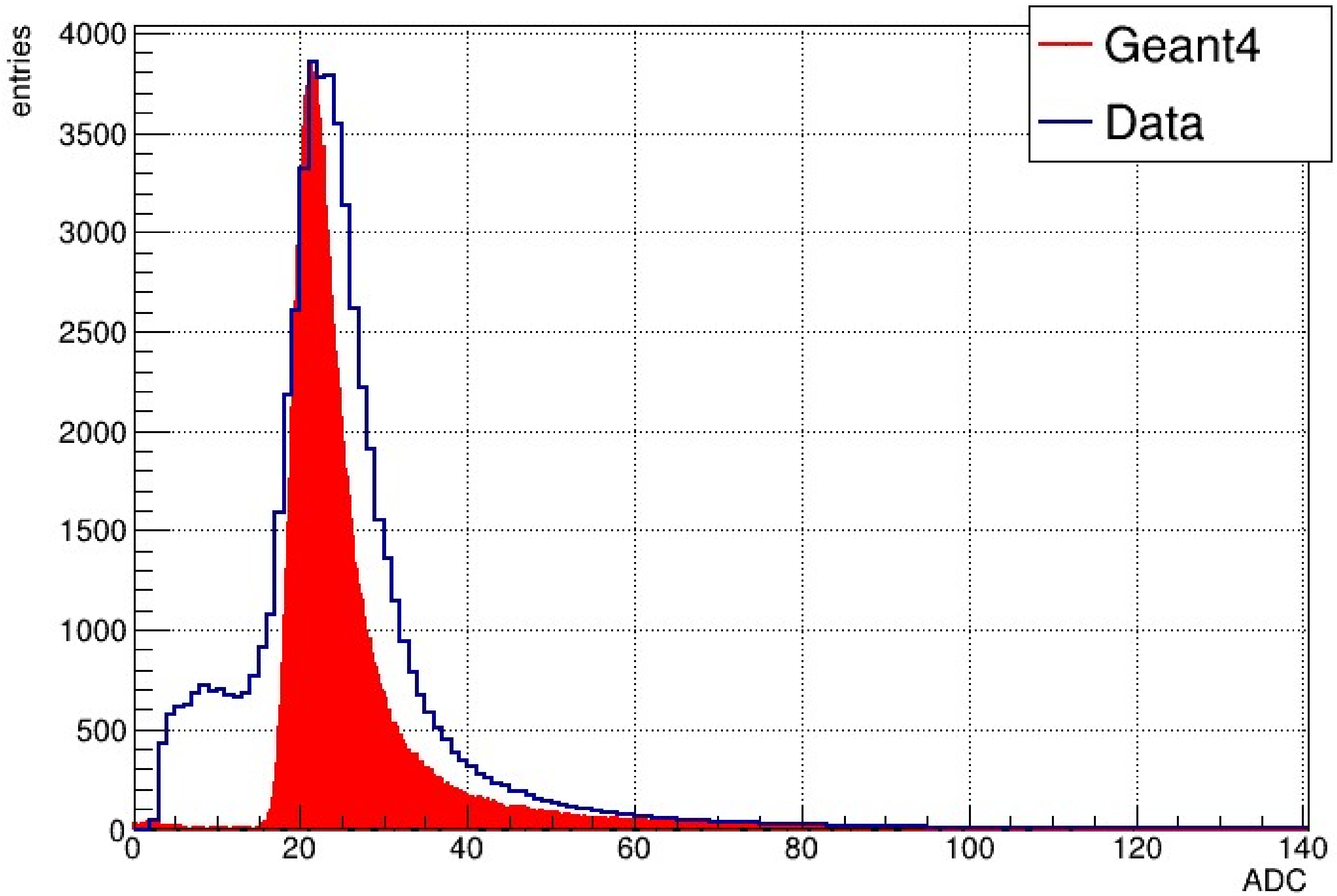
TB 2022: Simulations vs Data

2 case scenario: GaAs sensor

- **1 MeV = 61.67 ADC**

goal: compare simulations with data

run4484 – Anton1 sensor



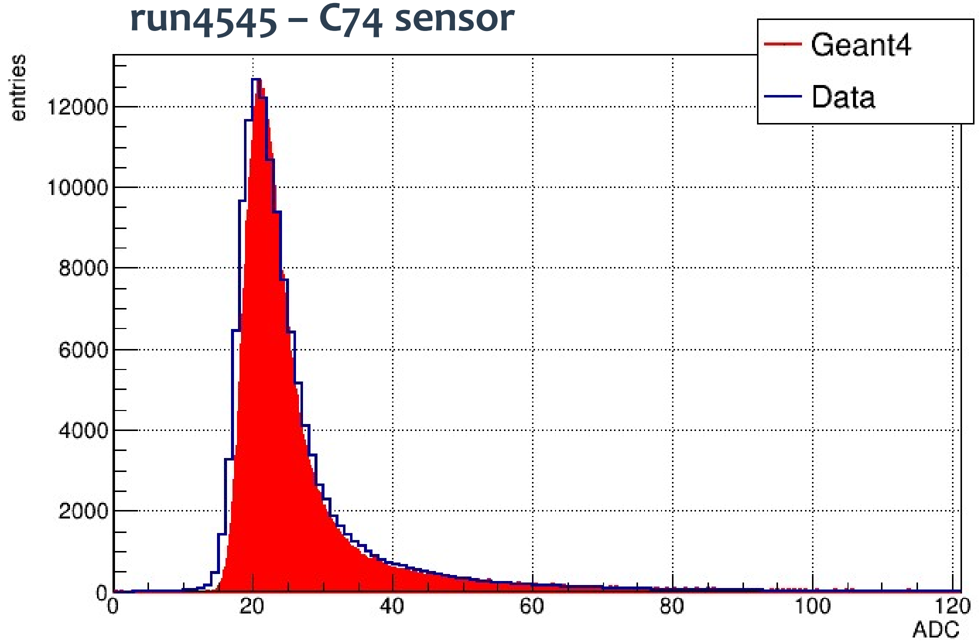
TB 2022: Simulations vs Data

2 case scenario: Si sensor

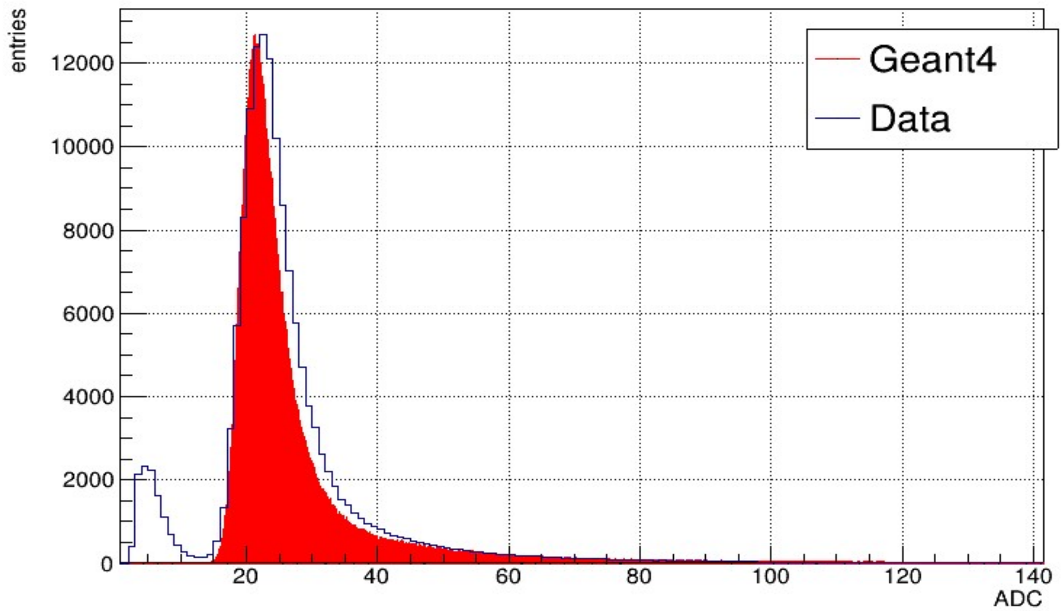
- **1 MeV = 228.79 ADC**

goal: compare simulations with data

run4545 – C74 sensor



run4436 – C75 sensor



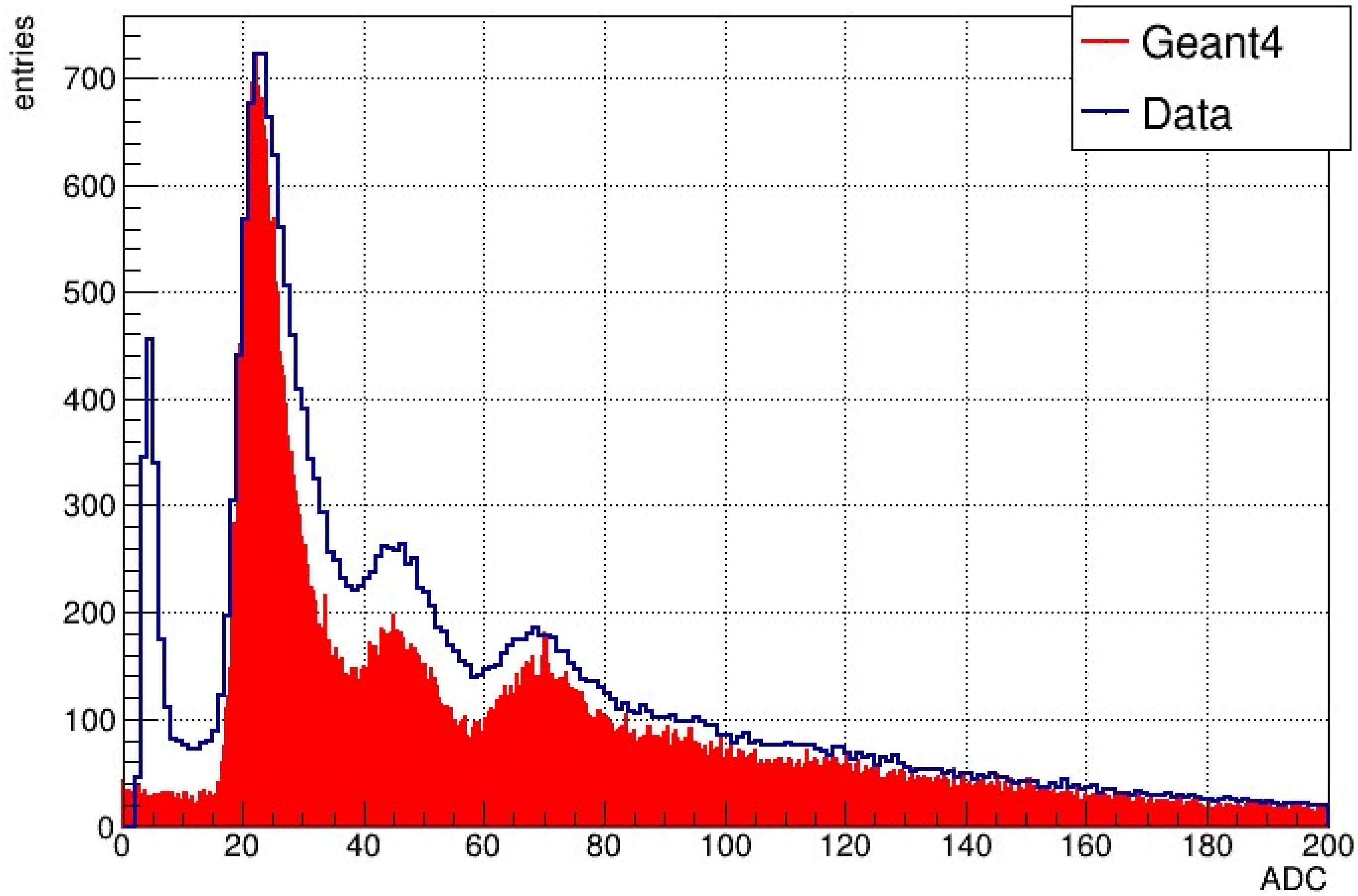
TB 2022: Simulations vs Data

2 case scenario: Si sensor

- **1 MeV = 228.79 ADC**

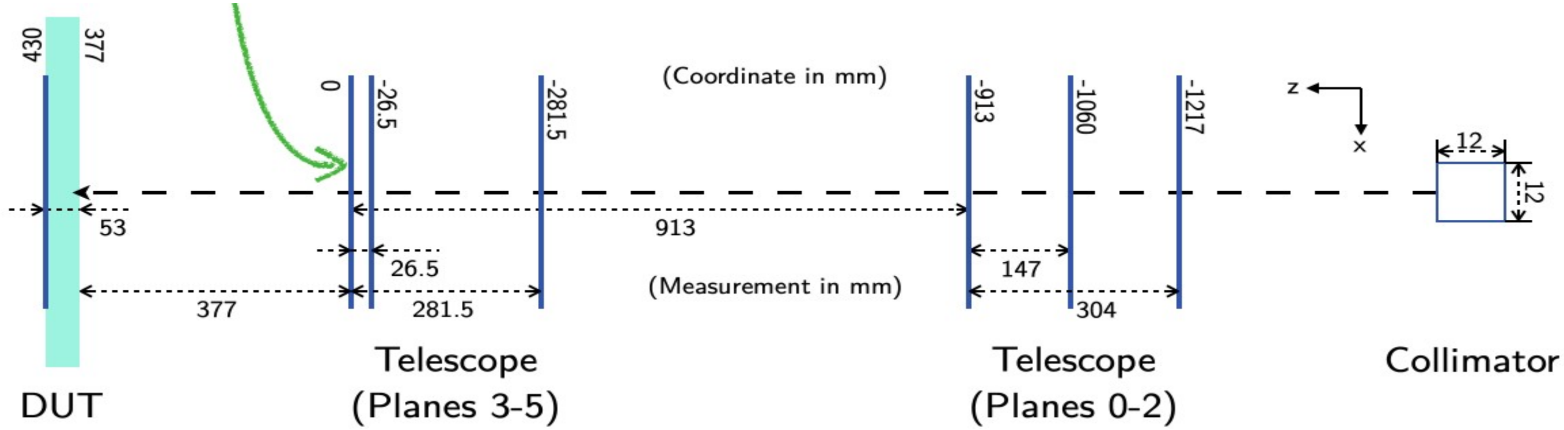
goal: compare simulations with data

run4749 – C74 sensor with 1 tungsten plate in front



TB 2022: Configurations

- Geometry implementation in Geant4 - 10 experimental setups - 38 different configurations



- Ga-As sensor – Anton1
  - 1 exp. setups without any W plates
    - Energies: 5 GeV c
- Ga-As sensor – Yan1
  - 1 exp. setup without W plates
    - Energies: 5 GeV
  - 1 exp. setup with 5 W plates
    - Energies: 1 GeV, 3 GeV, 5 GeV
  - 1 exp. setups with decreased no of plates 15 -> 1 W
    - Energies: 5 GeV
- Ga-As sensor – BeamCal
  - 1 exp. setups without any W plates
    - Energies: 5 GeV
- Si sensor – C72
  - 1 exp. setups without any W plates
    - Energies: 5 GeV
- Si sensor – C74
  - 1 exp. setups without any W plates
    - Energies: 5 GeV
  - 1 exp. setup with 5 W plates
    - Energies: 1 GeV, 3 GeV, 5 GeV
  - 1 exp. setups with decreased no of plates 15 -> 1 W
    - Energies: 5 GeV
- Si sensor – C72
  - 1 exp. setups without any W plates
    - Energies: 5 GeV