technische universität
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Statistical Methods of Data Analysis

Project Exercise

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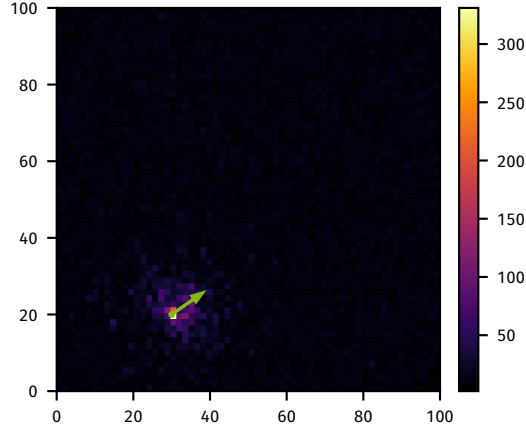
The Project Task

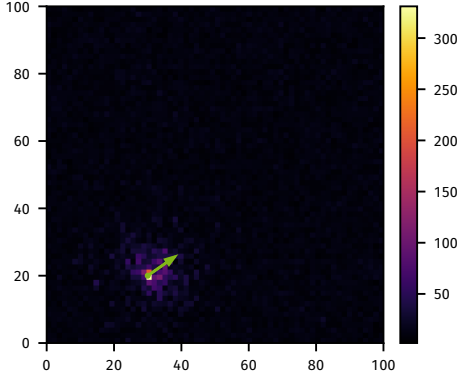
- Complete simulation and analysis chain of high-energy physics experiment
- Simplified 2D world with simple pixel detector
- Nevertheless allows for introduction to (almost) all detector aspects
- No time component

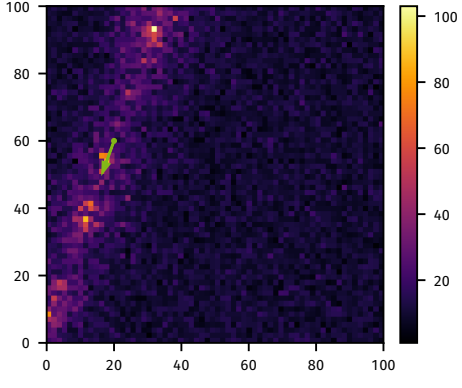


Particles

Every particle has 4 basic properties

- Energy
- Position (x, y)
- direction (one angle $\in [0, 2\pi]$)
- Particle type





Particles

- Particles can propagate
  ⇒ energy losses of intensity I at position (x, y)
- Energy losses distributed stochastically
- Distributions depend on particle type, energy, ...

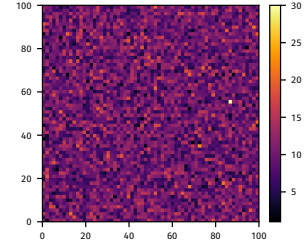
Generators

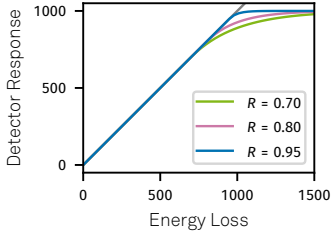
Initialize particles of specific type by sampling their properties from given distributions, e. g. :

- Energy: power law with $E_{\text{min}} = 100$, $E_{\text{max}} = 10^6$, $\gamma = -2$
- Position: x and y are independently uniformly distributed $\in [0, 100]$
- Direction: uniformly distributed $\in [0, 2\pi]$

Detector

- Pixel detector
- Counts energy losses of particles for each event
- Adds noise
- Limited photon detection efficiency
- Limited resolution
- Saturation
- Trigger





Events

- N particles, which reach the detector “simultaneously”, define one event
- $N = 0$: *pedestal*
  - Measurement of detector noise
  - Adjustment of trigger parameters
  - Algorithm optimization for pixel selection (*cleaning*)
- $N = 1$: classical event
- $N > 1$: stacked event

Analysis Chain

1. Simulation of pedestal, signal and background events
2. (Calibration)
3. Data mining / feature generation
4. Reconstruction of energy / direction / particle type
5. High level analysis
   - Unfolding of energy spectrum
   - Point source searches
   - ...