Particle Track Reconstruction with ML

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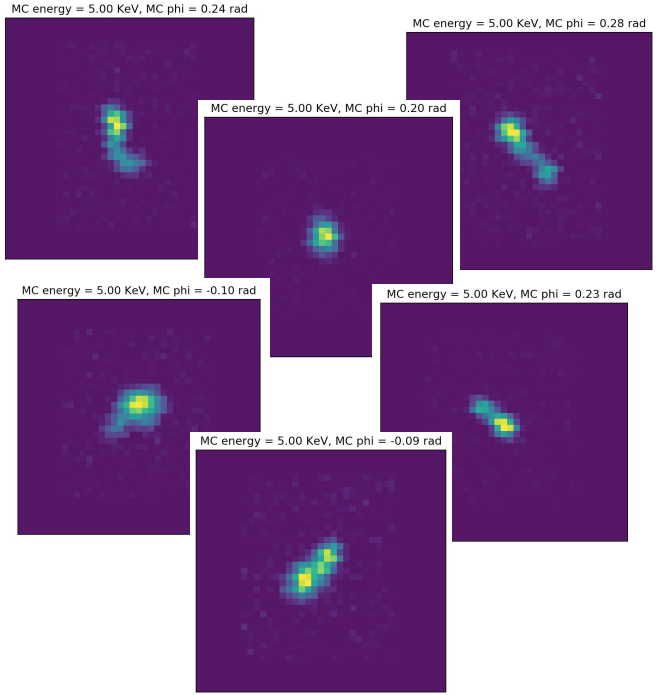
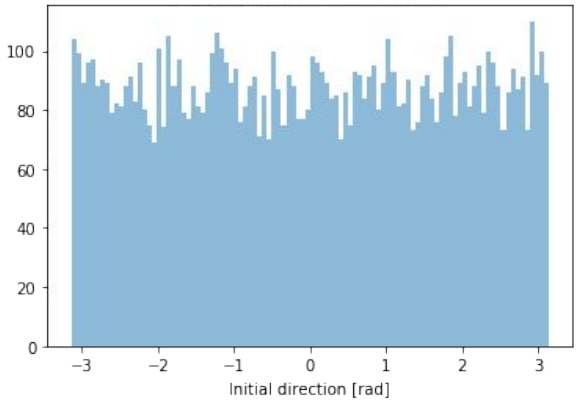
What is the Idea and The Goal of The Challenge?

Original problem we started working on in Leiden: Given a set of simulated track, train a CNN to find the initial direction for each event!





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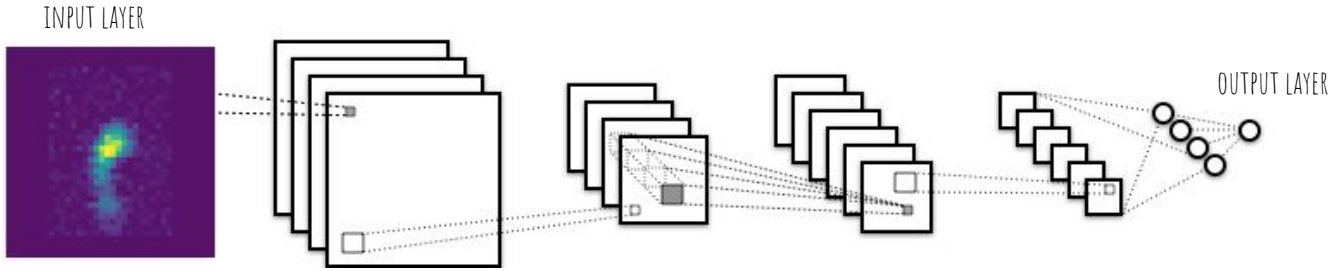
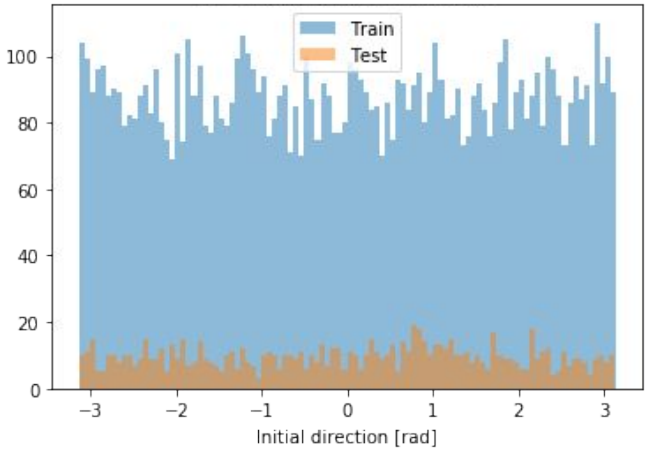
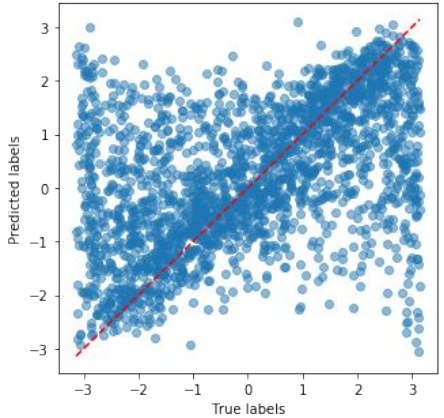
Initial Steps

Direct application of Convolutional Neural Nets (CNNs):







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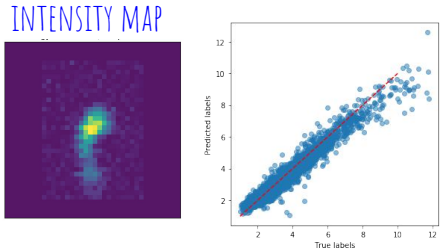
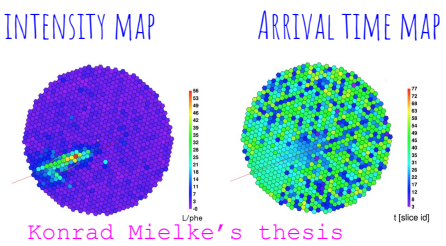
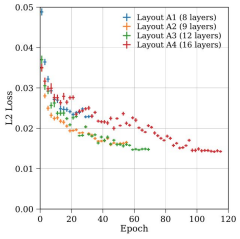
Next Steps & Tasks?

- Intensity or other quantity pixelated maps:
  - **Input**: Single 2D image (or a group of 2D images) for each event
  - **Output**: Track energy, arrival direction, impact point (...)
  - **Performance**: True vs. predicted value and loss functions
  - **ML:** More sophisticated deep learning models taking the additional data into account ...

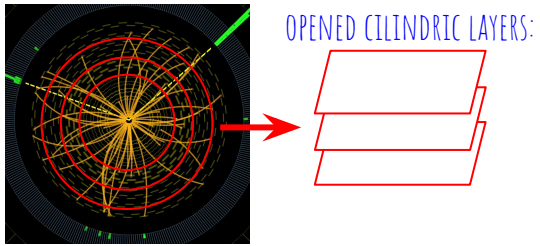


or





- Hits maps:
  - **Input**: 2D images of tracker layers for each event ...
  - **Output**: Number of vertices, energy, ...
  - **Performance**: Efficiency curves (?)
  - **ML:** Similar models as before (stack images). Interesting: Special, time component, maybe sequence models + CNNs.



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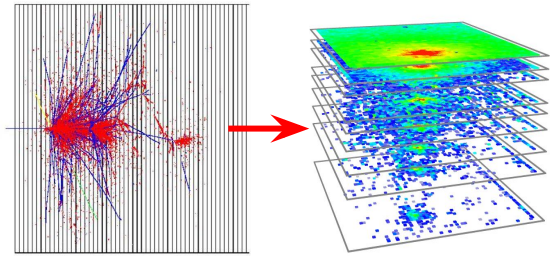
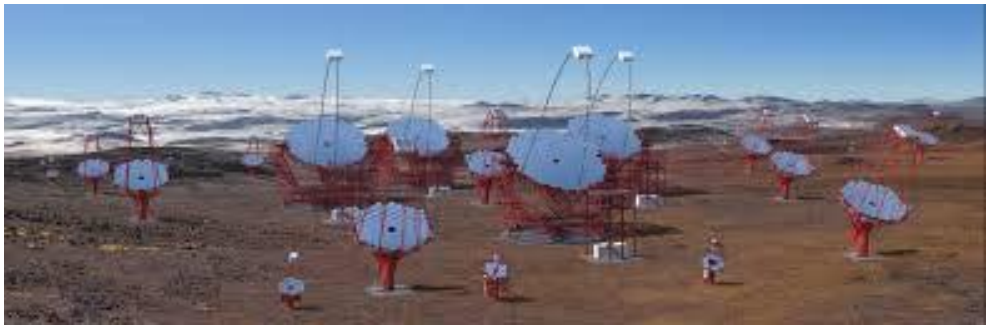
Next Steps & Tasks?

- Showers in calorimeters:
  - **Input**: images (TBD)
  - **Output**: energy incoming particle, discriminate hadrons/leptons
  - **Performance**: TBD
  - **ML:** CNNs, maybe bidirectional RNNs+CNNs



- Telescope arrays:
  - **Input**: images (in time coincidence) from different cameras
  - **Output**: main characteristics of the event (TBD)
  - **Performance**: TBD
  - **ML:** TBD



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What is the idea and the goal of the project?

CNN training set up			
Raw experimental outputs	Input	Output	Performance evaluation
Intensity and/or other-quantity pixelated maps Tracker hits maps Showers in calorimeters Interferometers and telescope arrays ...			

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Is data available? Could be data be generated?

- Generic 2D intensity maps can be easily produced
- Arrival time + intensity maps (TBD, MAGIC events?)
- Hits maps (TBD, Geant4 simulations?)
- Showers (TBD, Geant4 simulations?)

When does the project start?

- Already started (slowly going on), setting up common environments to work together and share files (github / gitlab / overleaf / google drive / …?)

How can I partecipate? Who do I need to contact?

- Michela: Experimental Astroparticle expertise (space- / ground-based observatories)
- Fabian: ML expertise
- Needed: Experts from both worlds :-). For instance, experimental particle expertise (colliders), deep learning experts (LSTMs, CNNS,…), ...

Working via Slack, video meetings, etc... ?

- Skype meetings (we already had two)
- E-mails threads
- Slack channel (planned :-))
- Near future: Joined remote hackathon!