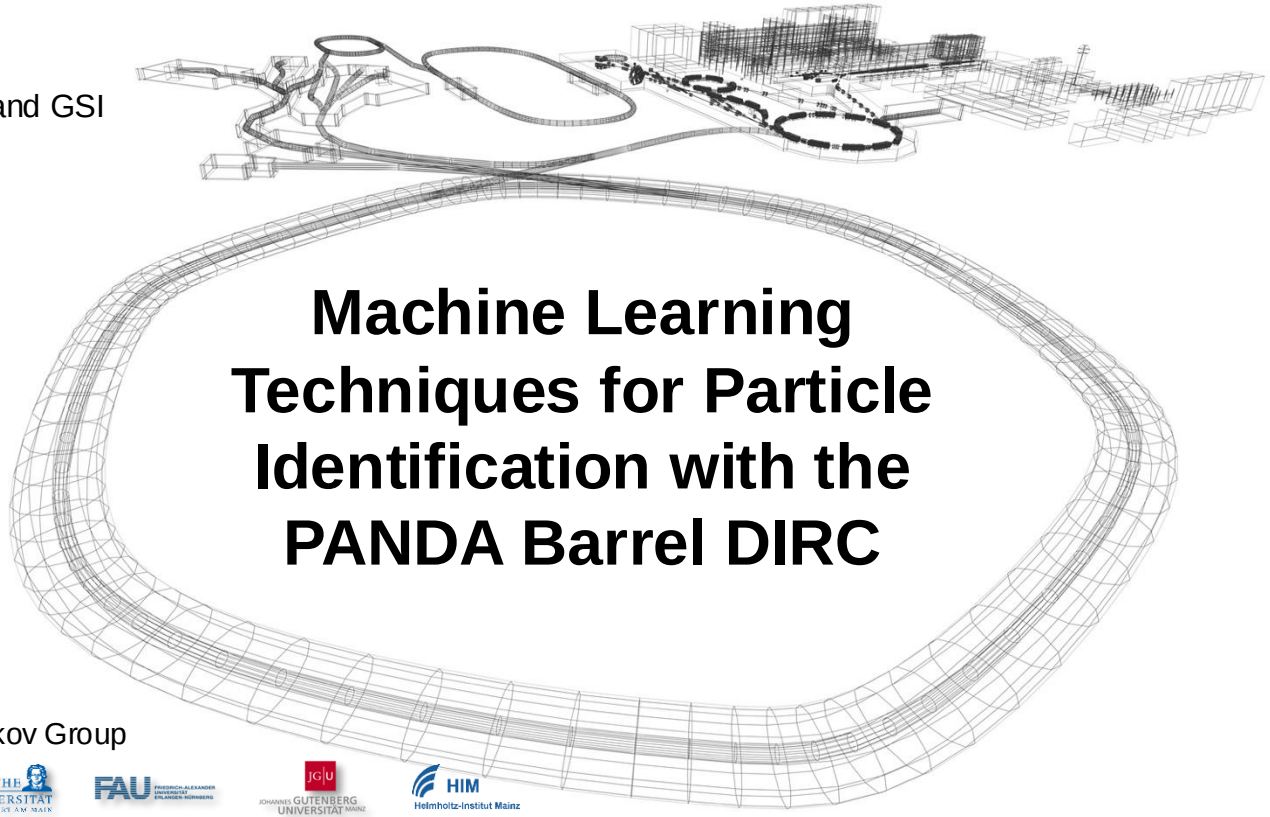
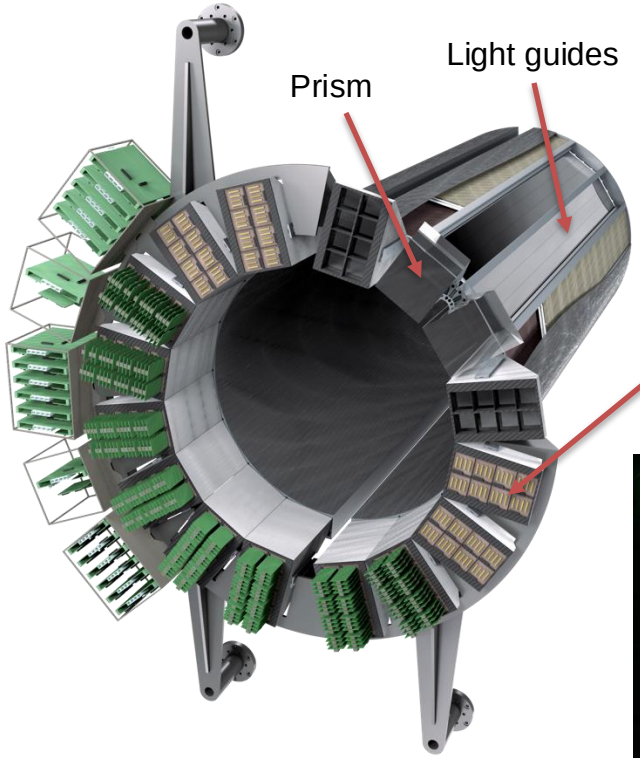
Yannic Wolf
Goethe Universität and GSI



Machine Learning Techniques for Particle Identification with the PANDA Barrel DIRC

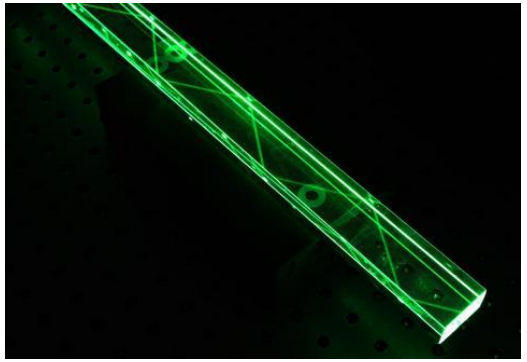
for the PANDA Cherenkov Group

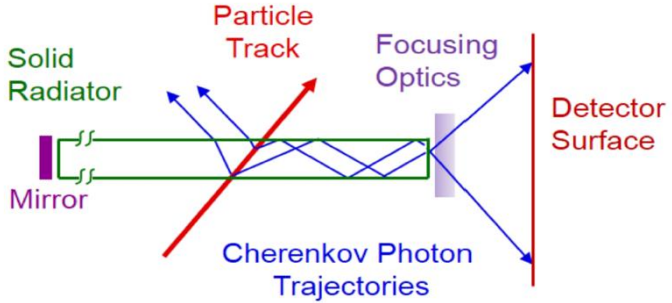
PANDA Barrel DIRC



TDR J. Phys. G: Nucl. Part. Phys. 46 045001,
doi:10.1088/1361-6471/aade3d, arXiv:1710.00684

- **D**etection of **I**nternally **R**eflected **C**herenkov light
  - Compact subtype of RICH detector
- Fused silica bar as Cherenkov radiator and light guide
- Excellent particle identification for polar angle 22°< θ < 140°
- Separation power for pion/kaon 3 s. d. up to 3.5 GeV/c





Observables

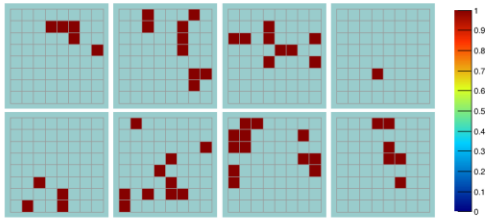
- Location and propagation time of Cherenkov photons with charged track angle/momentum
- Challenge:
  Particle types difficult to distinguish in pixel space

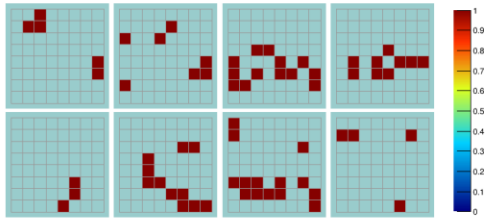
Single photon resolution: 0.1 ns
Space precision: 2mm

Kaon

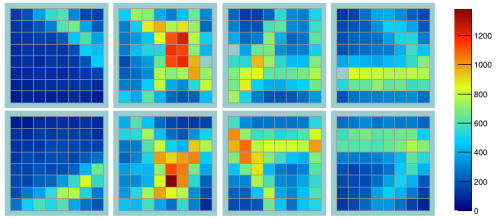
Pion

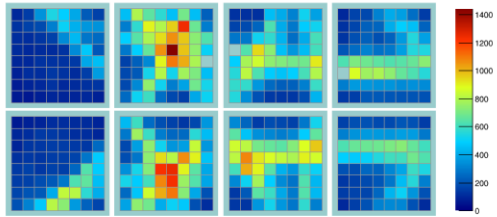
Hit pattern for 1 track

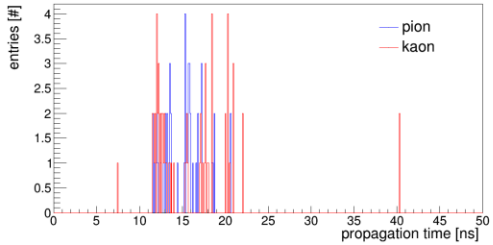


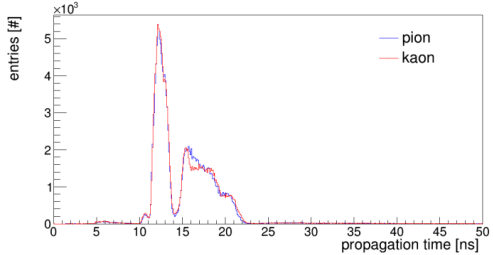


Accumulated hit pattern for 5k tracks





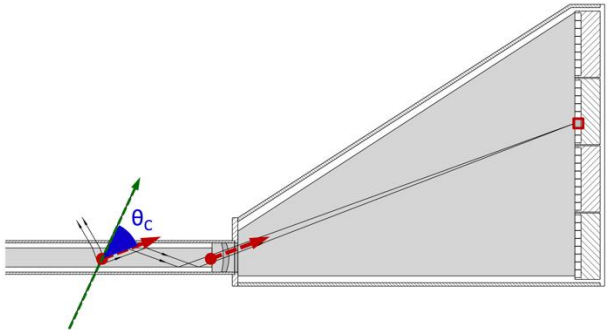




Conventional Reconstruction Methods

Geometrical Reconstruction

- Uses hit positions
- Location of pixel defines 3D photon vector
- Calculate Cherenkov angle



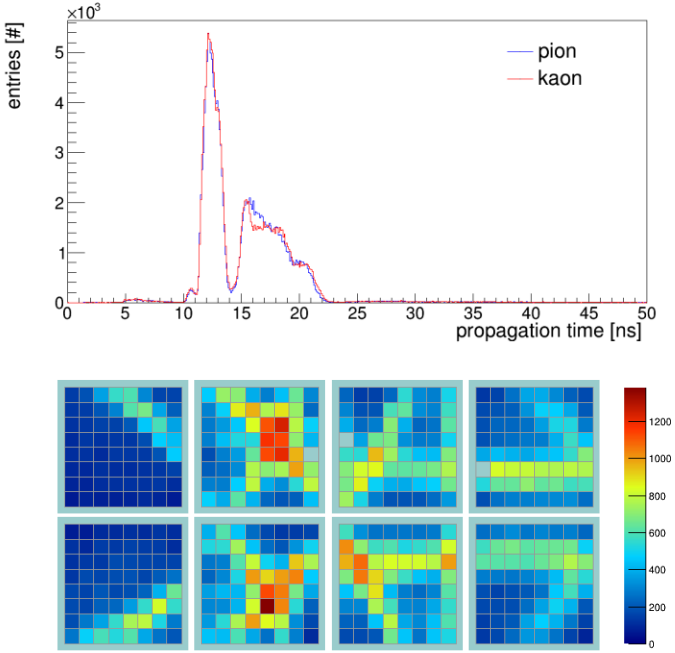
Time Imaging

- Optimal use of time information
- Compare photon arrival time in each pixel to expectation, based on Probability Density Functions
- Better separation power

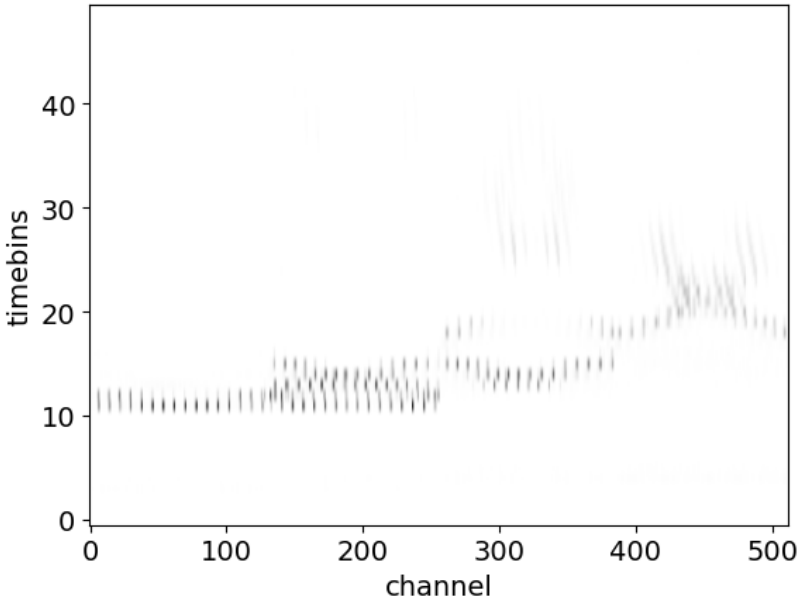
PDFs need large amount of input data over whole phase space

→ Reduce amount of data by using Machine Learning

Change of Data Representation



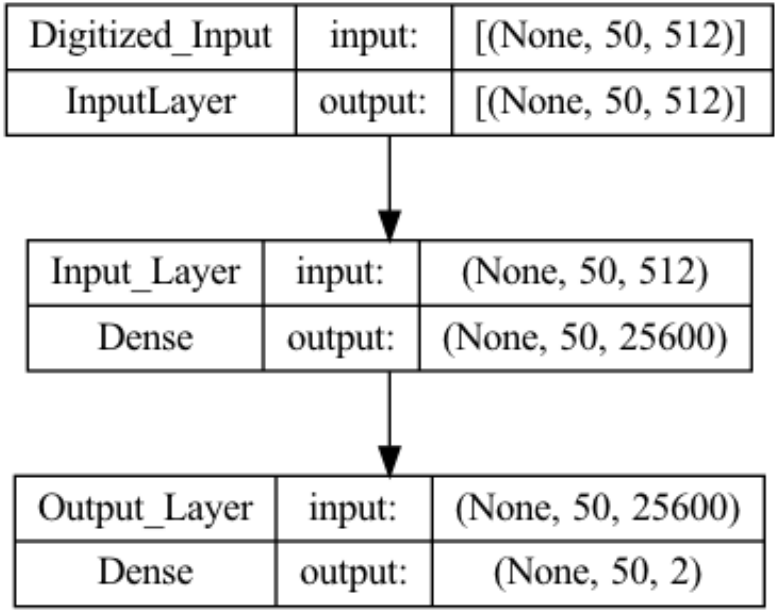
Pixel representation on detector



Representation in binned time over channel

Angle-wise training

- Training with fixed track parameters
- Performance of angle-wise trained neural network comparable to conventional methods
- Efficiency up to 99.2 % (≈4.9 s. d.)
- Different ideas to increase performance
  - Change number of time bins
  - Decrease size of space in time dimension



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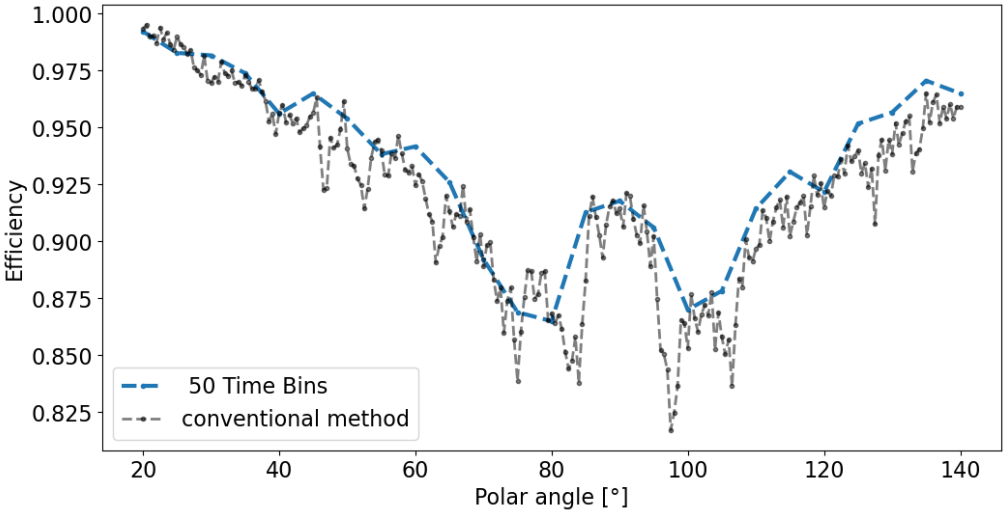

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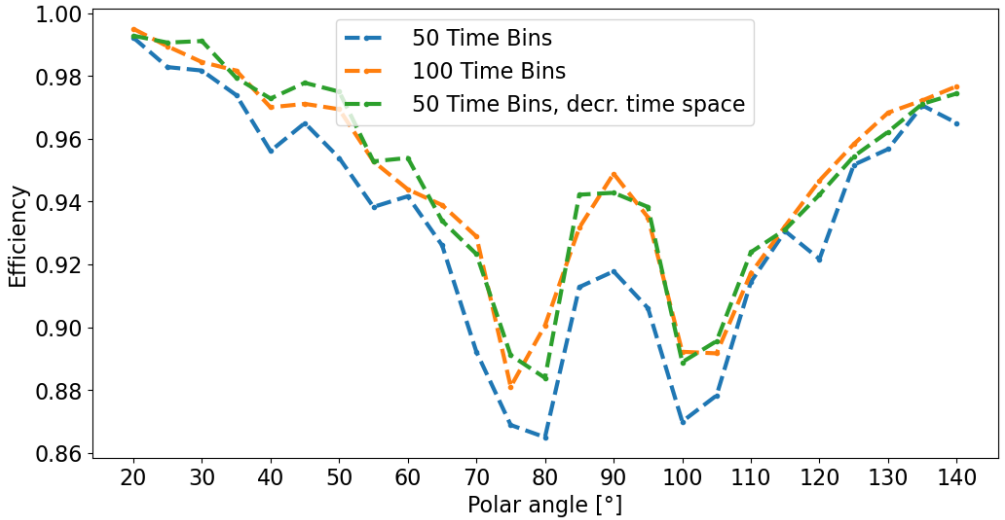
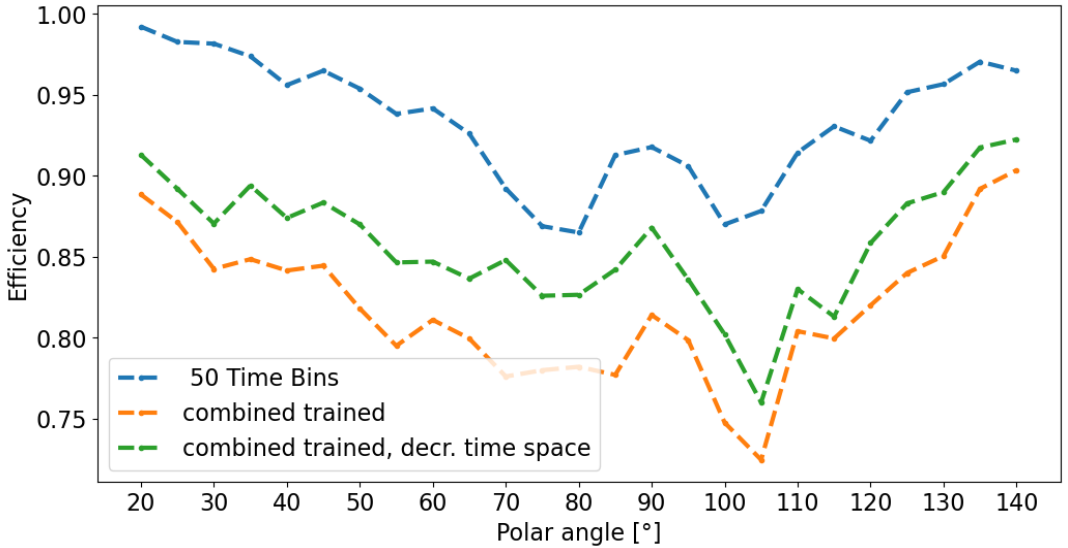


Training over multiple angles

- Training on dataset with multiple angles
  - Efficiency decreases
- Efficiency can be increased by shown methods
- Efficiency drops for untrained intermediate angles
  - Network can not anticipate intermediate angles

- More complicated network needed



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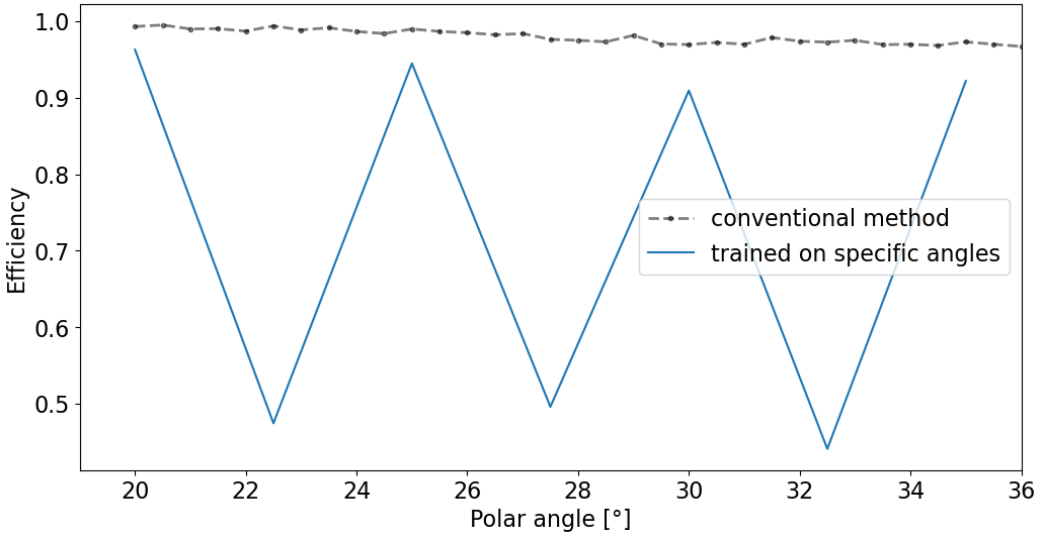
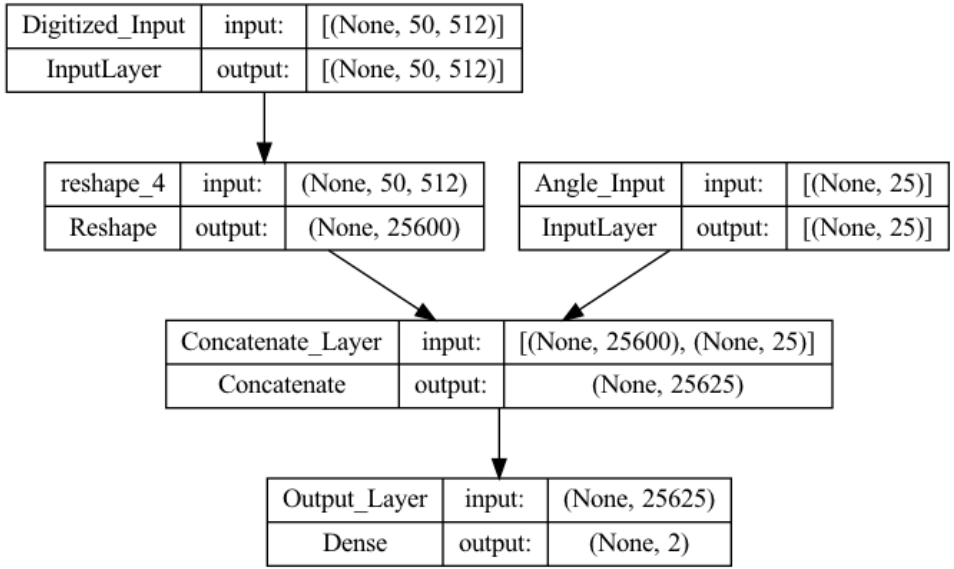


Additional parameters

- Increase network complexity by adding additional parameters (angles, momentum,…)
  - Start with angle
  - How to add the additional information?
- Try as float or binned data
- Adding angle information shows no performance increase



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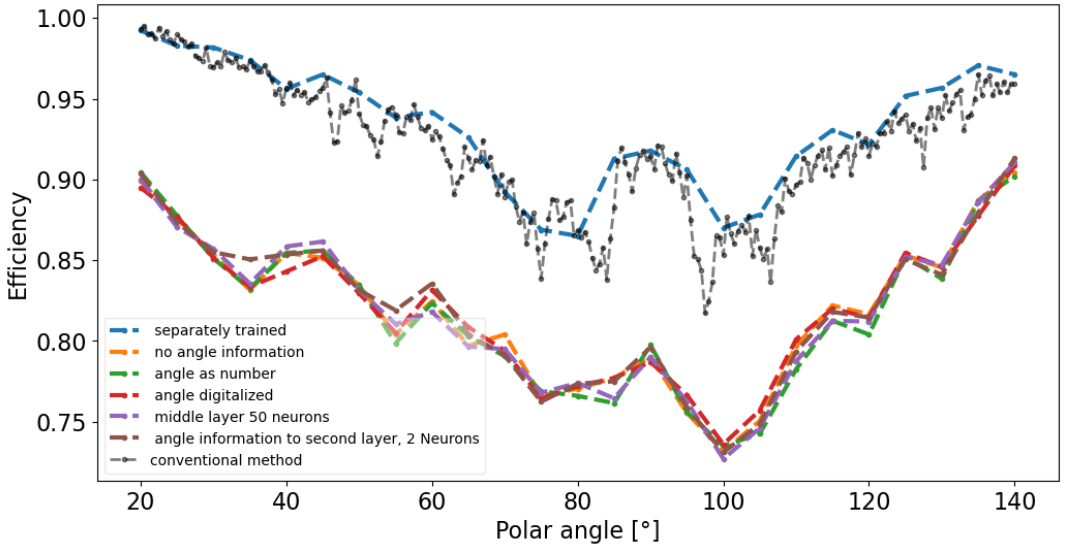
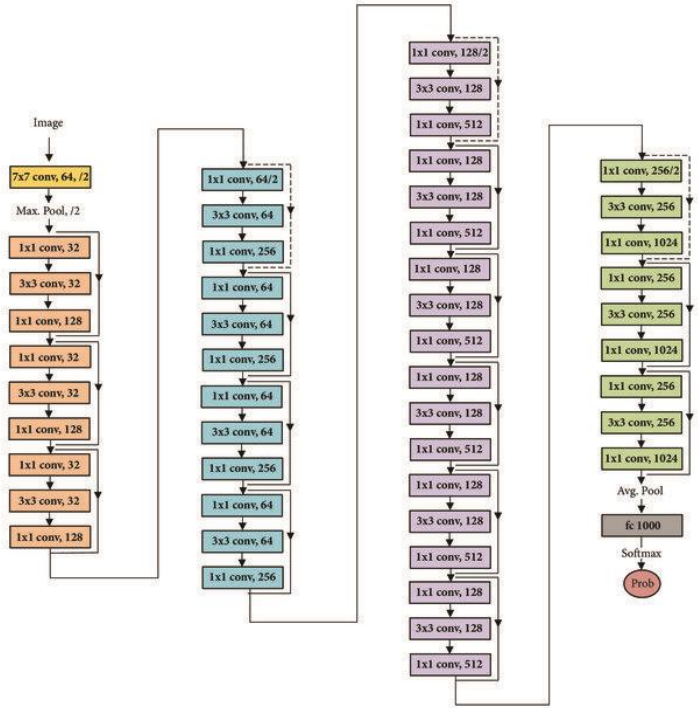


First tests on complex networks

- RESNET50
  - CNN
  - more complex network
- Performance similar to other neuronal networks
- Additional input information not used by network

- Change the network type?



https://www.researchgate.net/publication/326198791_Explicit_Content_Detection_System_An_Approach_towards_a_Safe_and_Ethical_Environment

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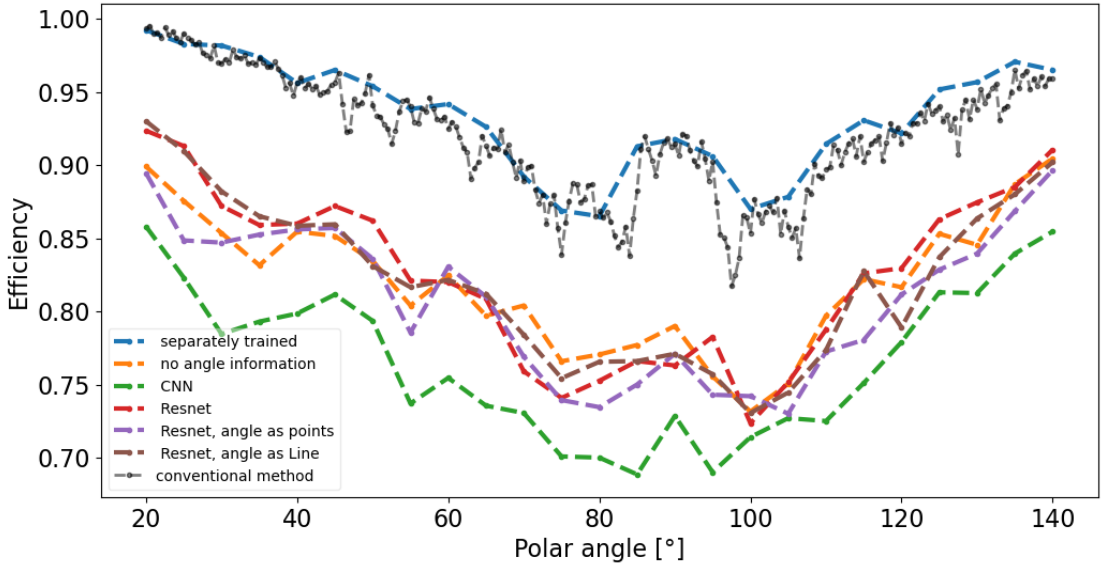
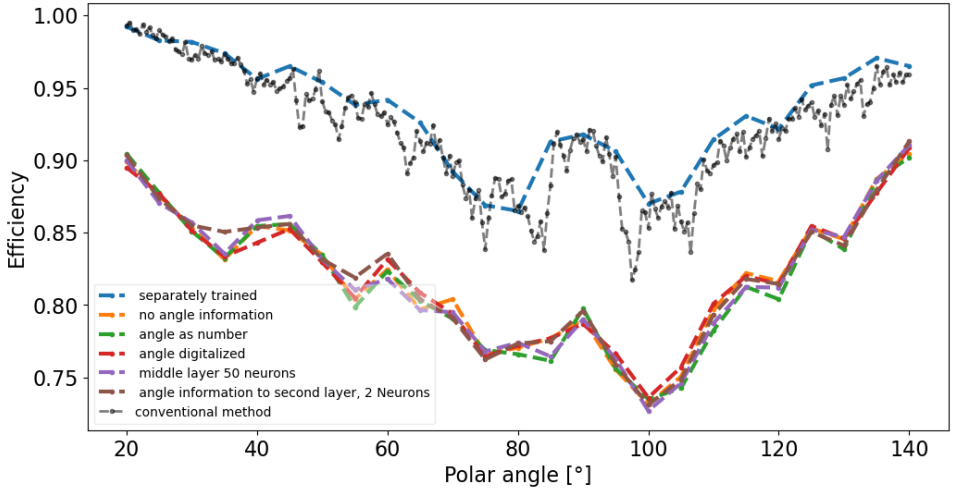


Summary & Outlook

- Neural network trained on single angles efficiency comparable to conventional methods
- For multiple training angles the efficiency is becoming lower
- Until now: Additional input information not used by network



- Better performance with other network type?
  - Generative AI studied for GLUEX DIRC
  - Test probability distributions/ normalizing flows

Thank you for your attention