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Pattern recognition in the PANDA experiment with neural networks

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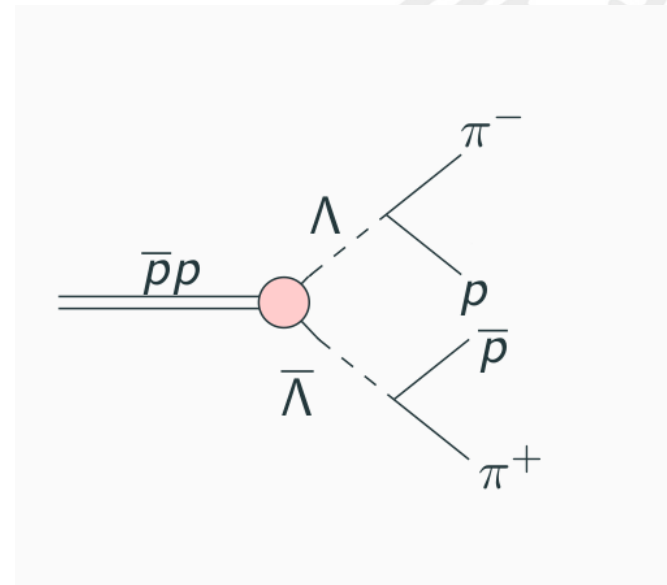
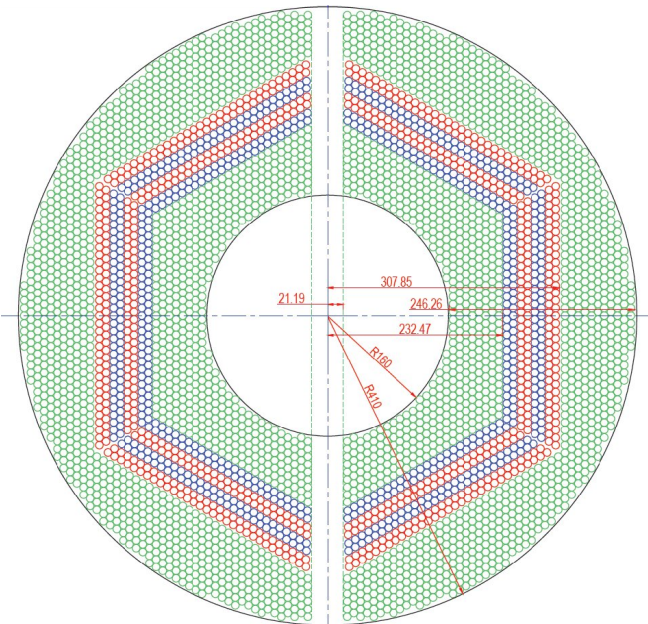
Project background

- Master in engineering physics
- Focus towards computational science
- 10 weeks, 15 credits



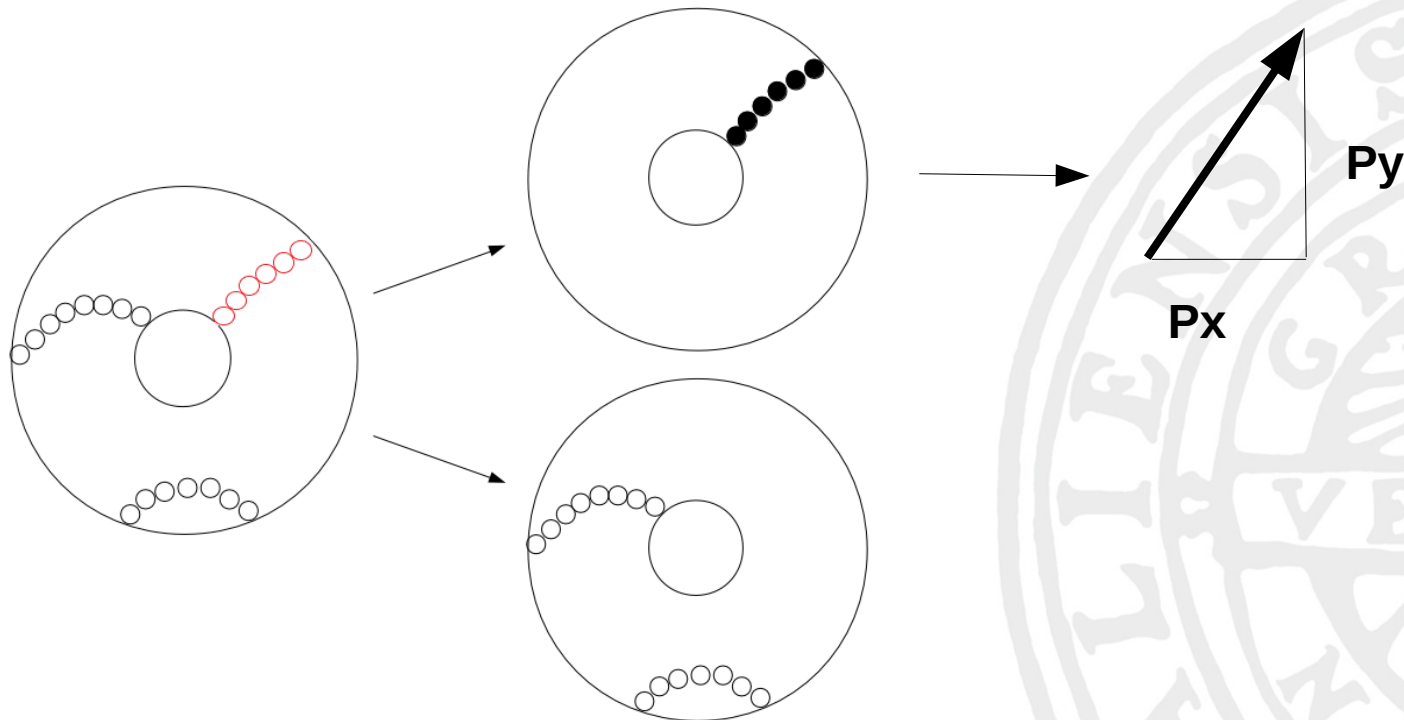
Introduction

- Straw tube tracker
- Λ - $\bar{\Lambda}$ reaction
- 7 GeV

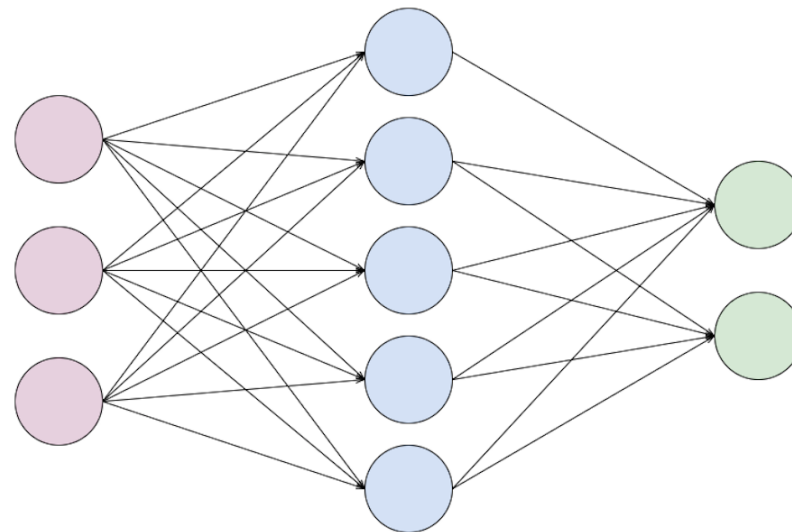


Problem description

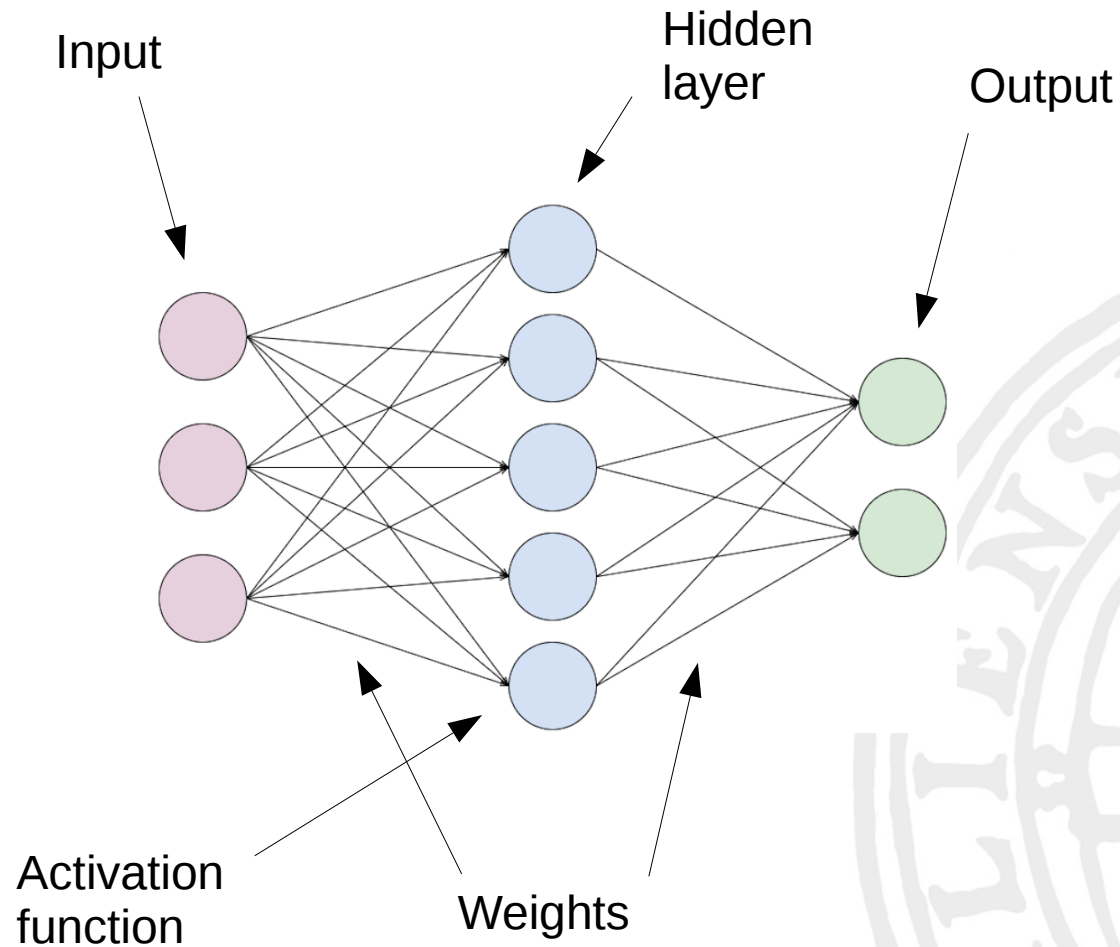
- Identify specific particle tracks
- Extract physical observables
- Are neural networks a viable option?



Neural networks

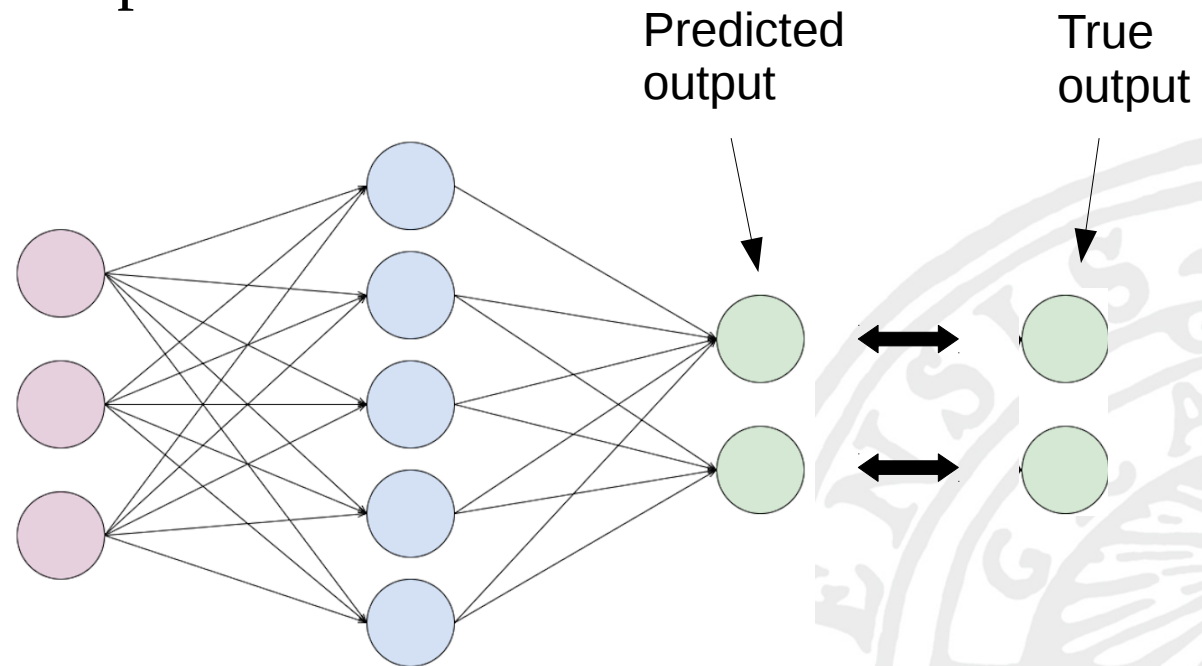


Neural networks



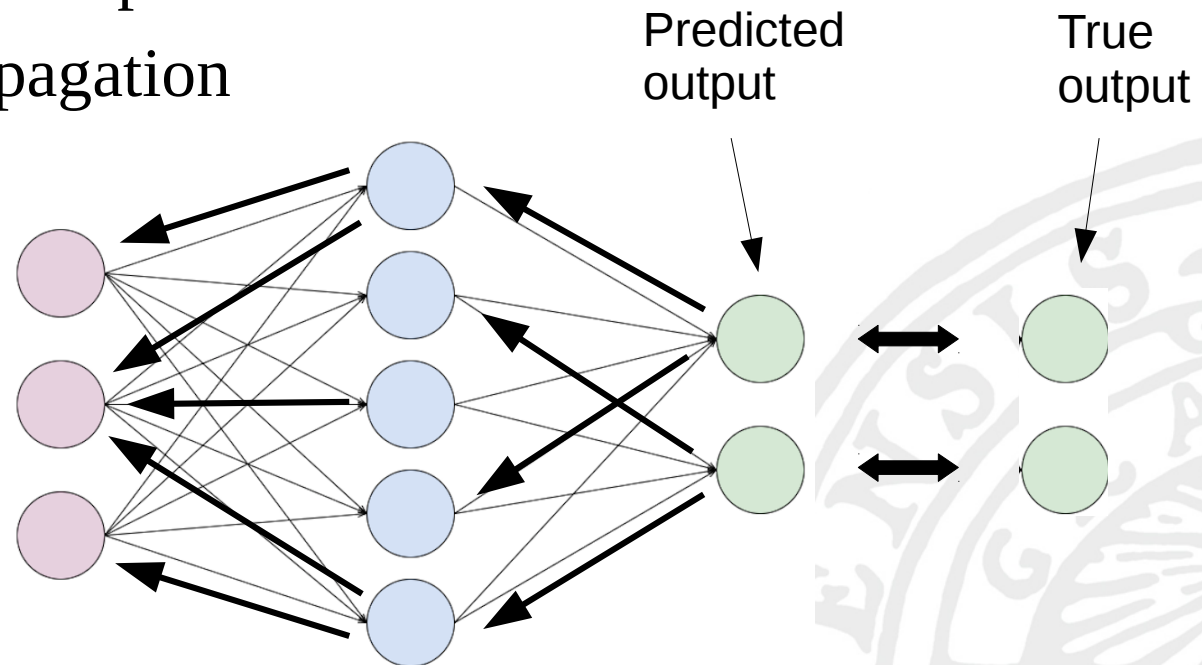
Neural networks

- Compare outputs



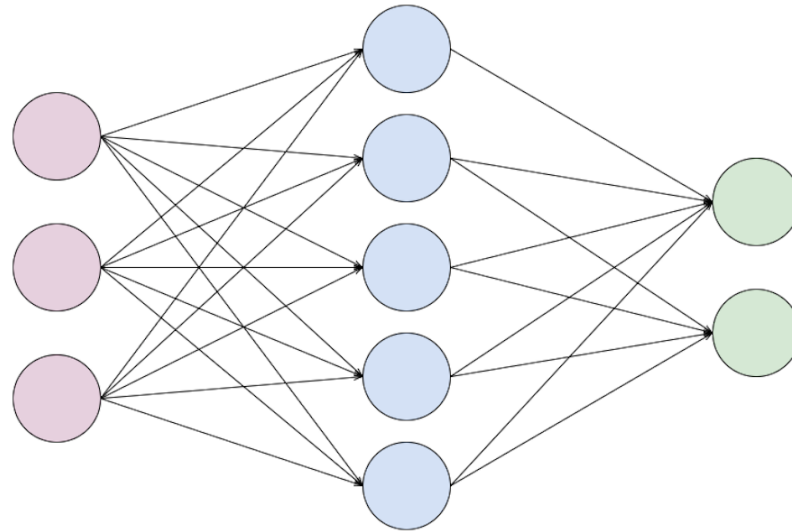
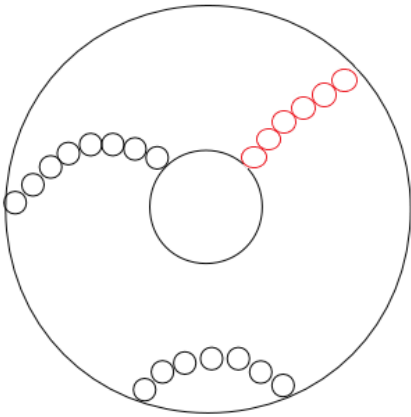
Neural networks

- Compare outputs
- Backpropagation

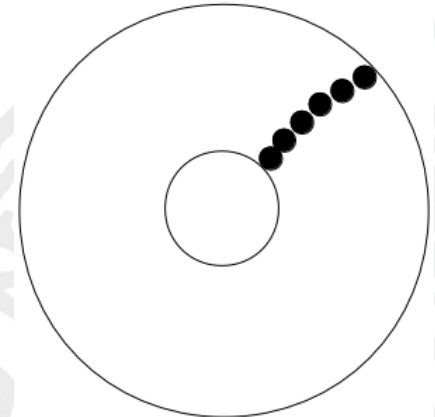


Neural networks

Input:
All tube hits



Output:
Single track

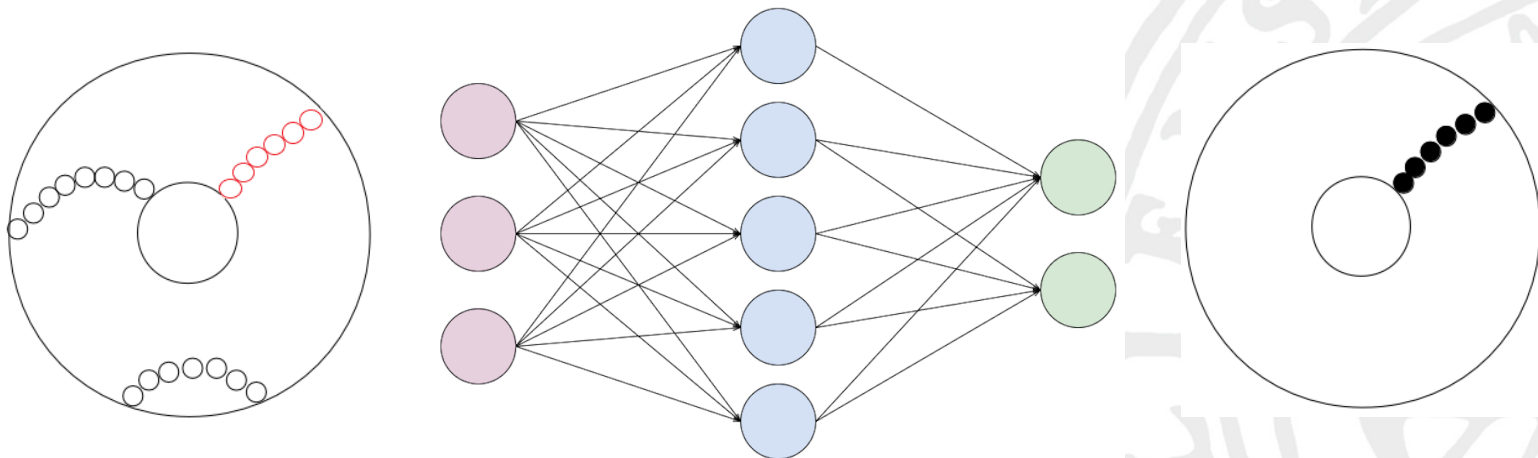


Method

- Two neural networks:
 - Pattern recognition
 - Momentum regression
- Trained on simulated data from pandaroot
 - Input: All registered tube hits
 - True output: SttMvdGemIdealTrackCand
 - Data from 1,000,000 events
- Implemented in Matlab

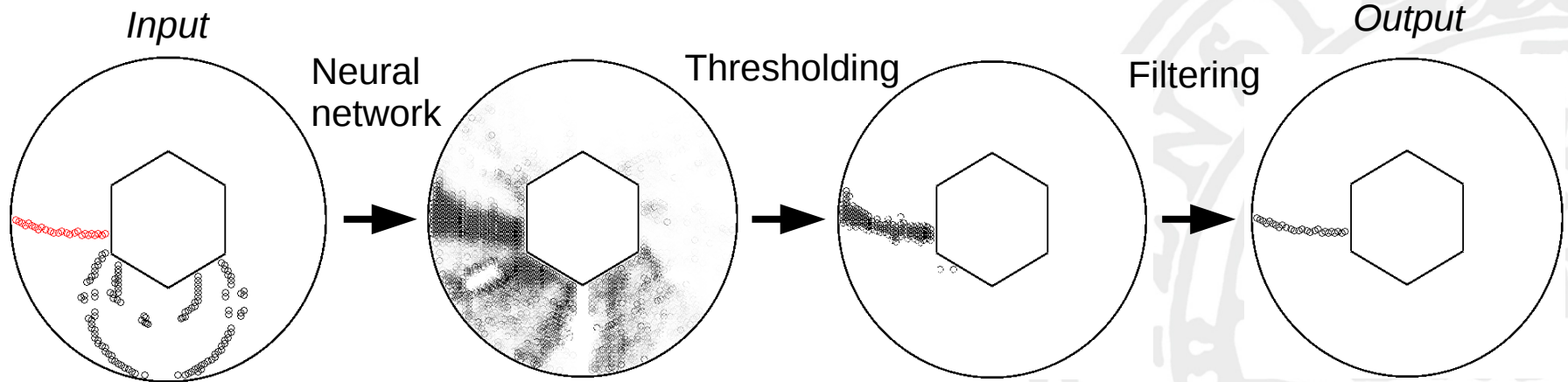
Method – Pattern recognition

- Identify the track of a specified particle (proton)
- Input: Raw STT signals (tube hits)
- Output: Specific particle track
- Four hidden layers



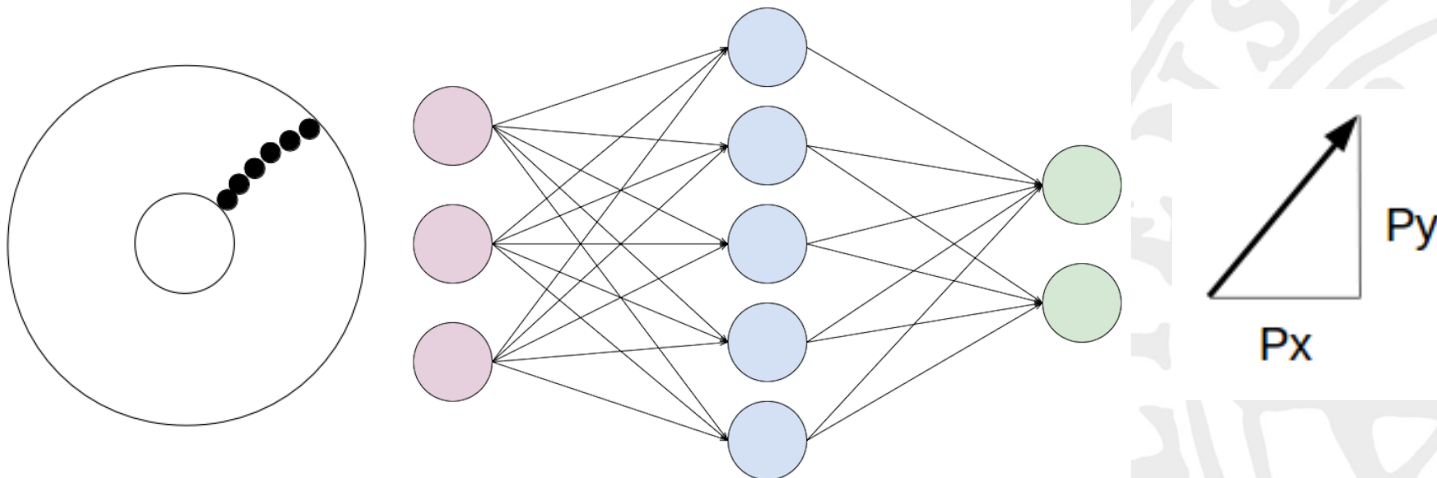
Method – Post processing

- Thresholding
- Filtering

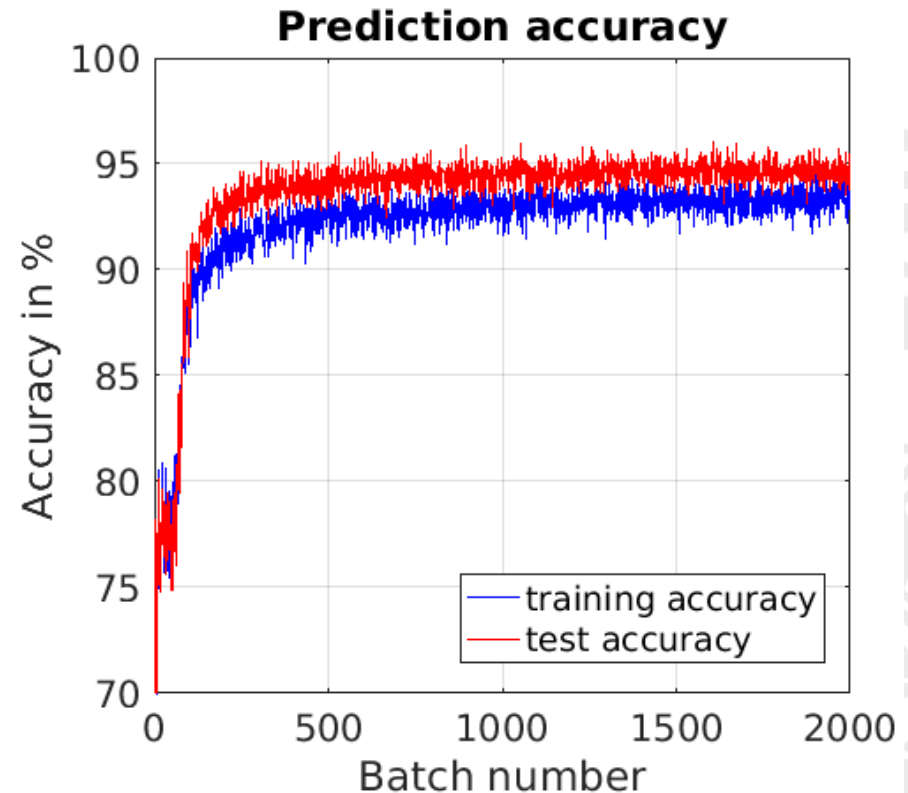
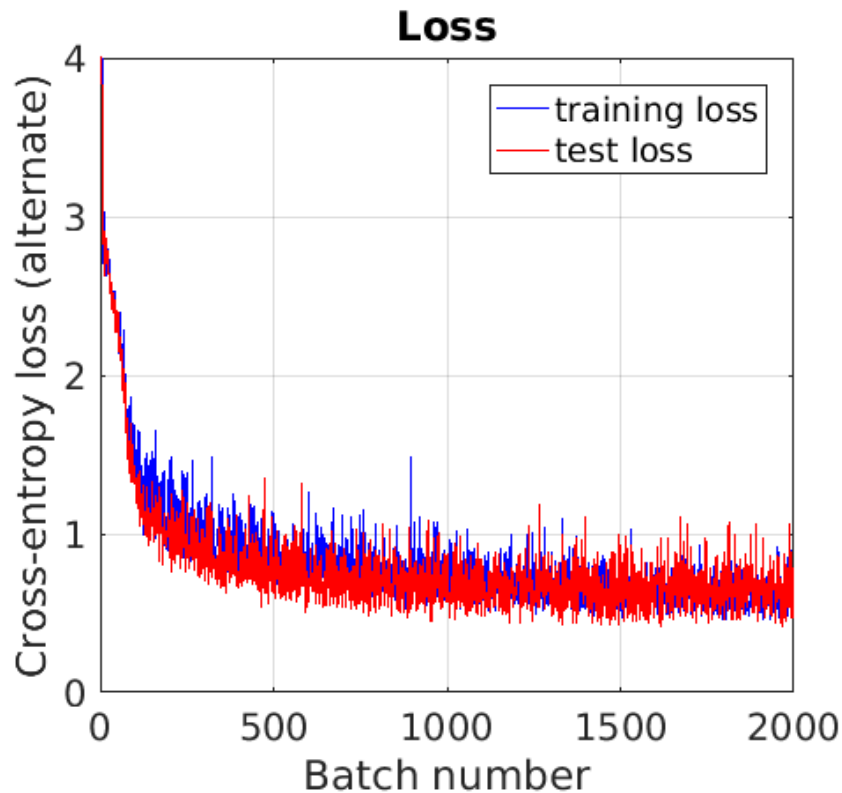


Method – Momentum regression

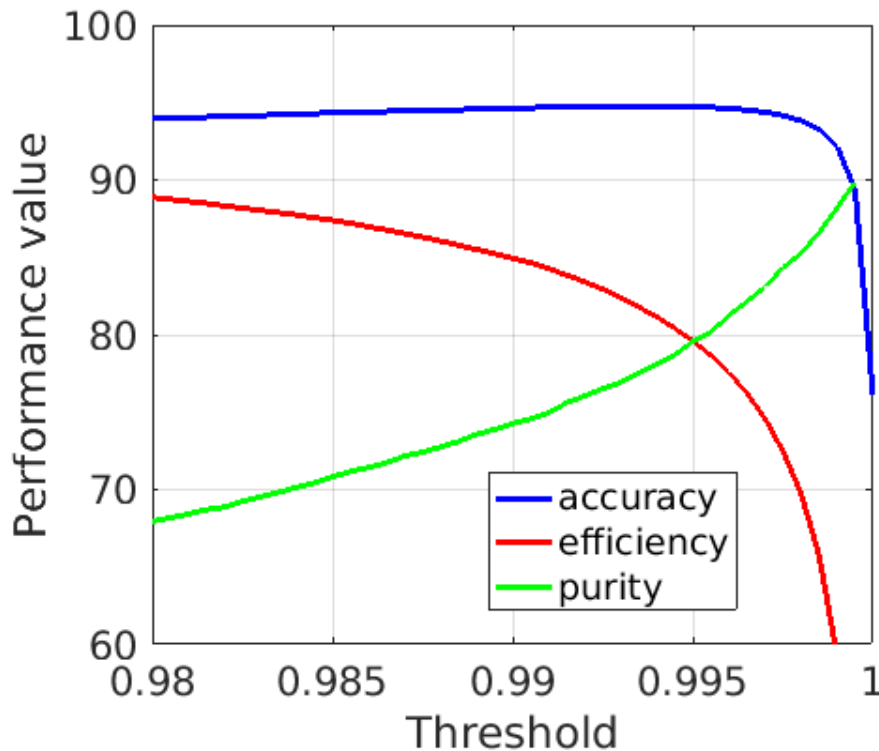
- Extract the momentum of a specified particle
- Input: Specific particle track
- Output: 2D momentum vector
- Six hidden layers



Results – Pattern recognition



Results – Pattern recognition

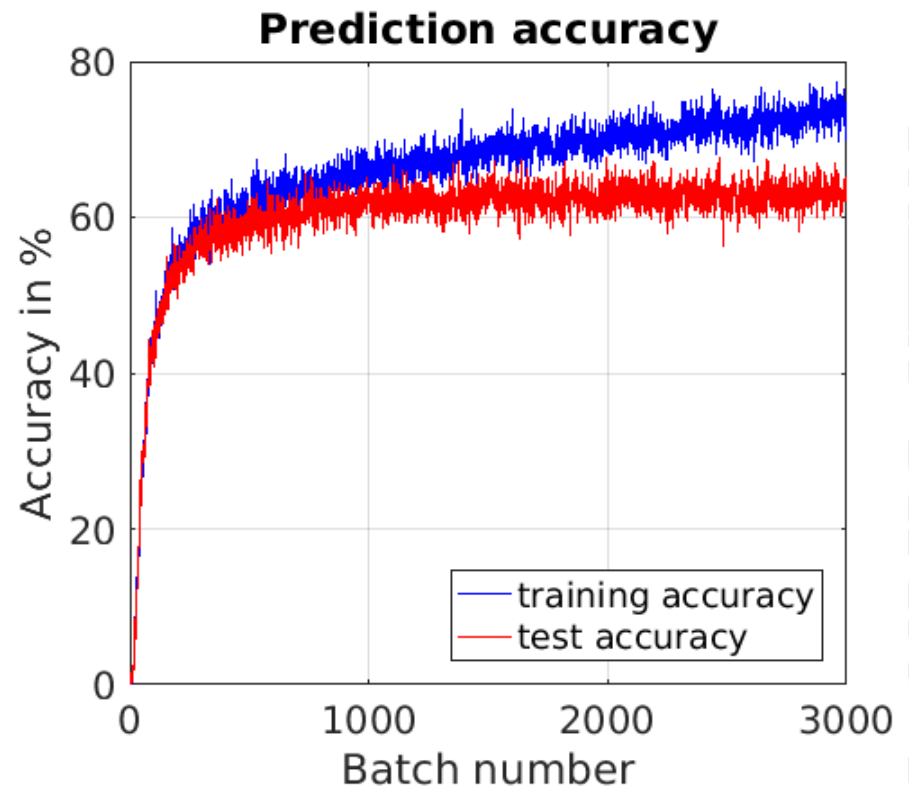
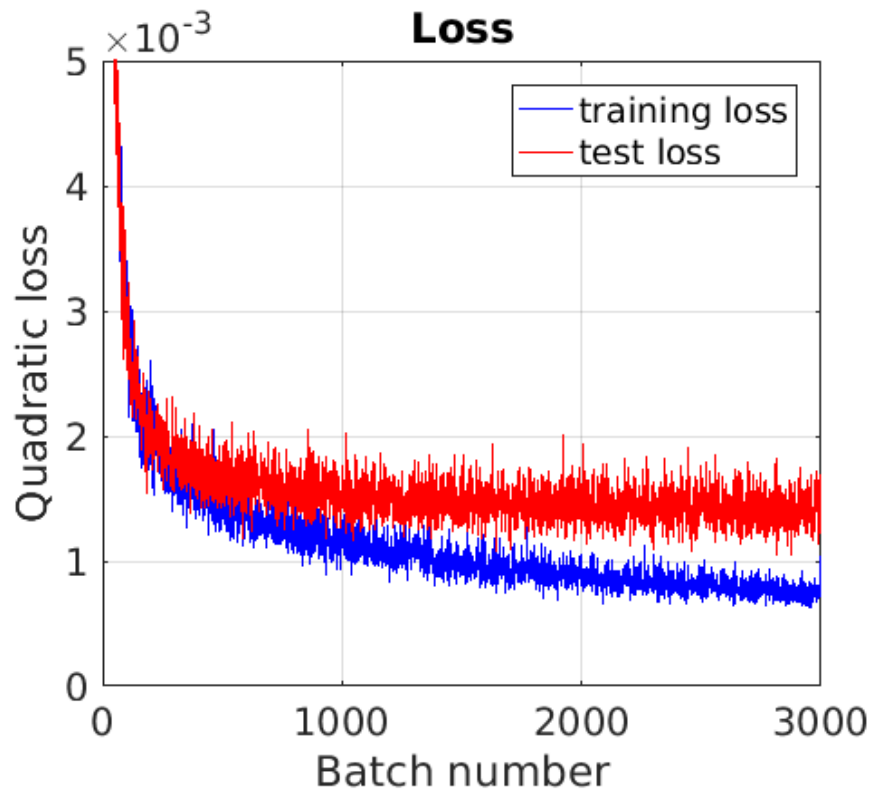


$$accuracy = \frac{TH + TM}{TH + TM + FH + FM}$$

$$efficiency = \frac{TH}{TH + FM}$$

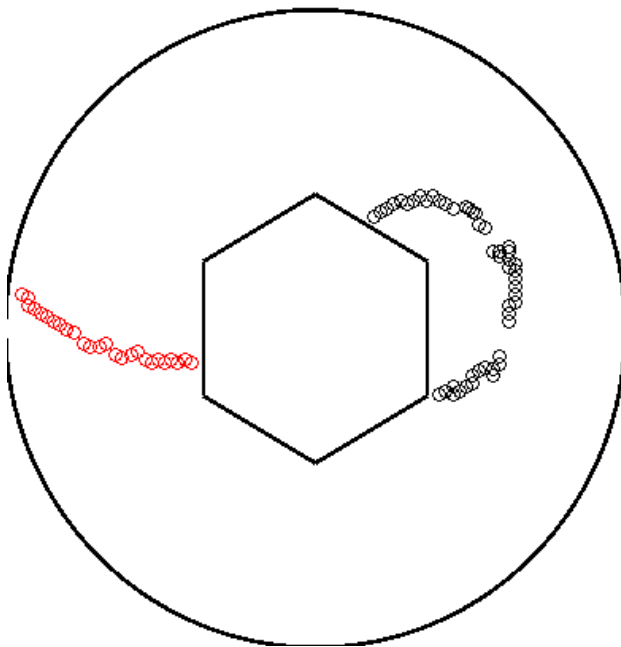
$$purity = \frac{TH}{TH + FH}$$

Results – Momentum regression

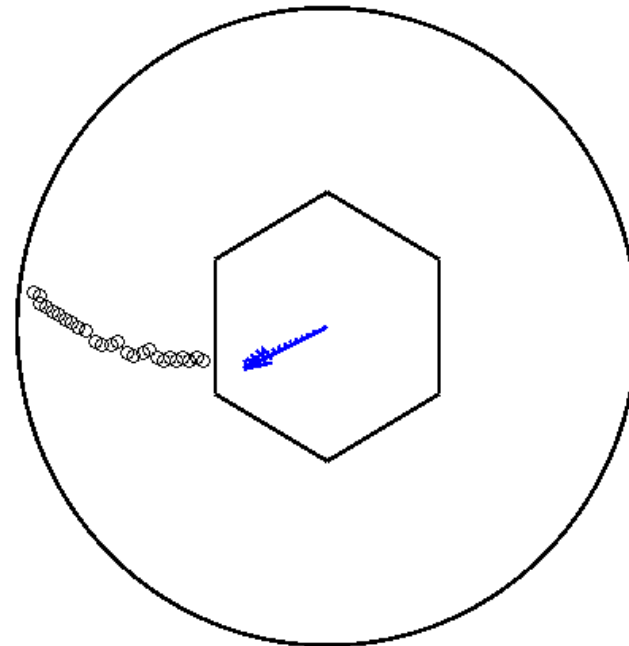


Visualization – Easy case

Input:

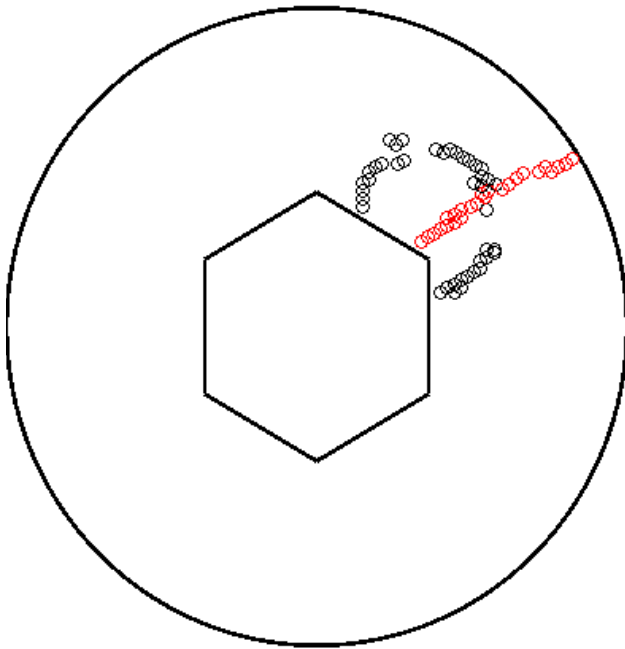


Output:

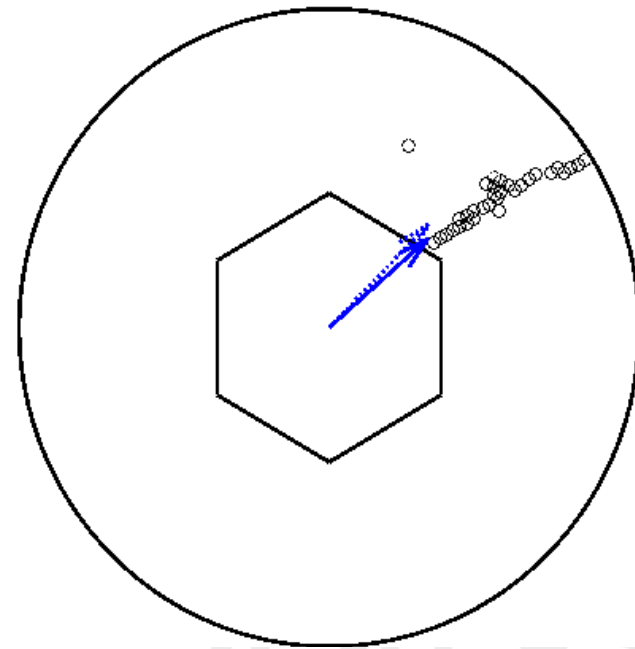


Visualization – Hard case

Input:

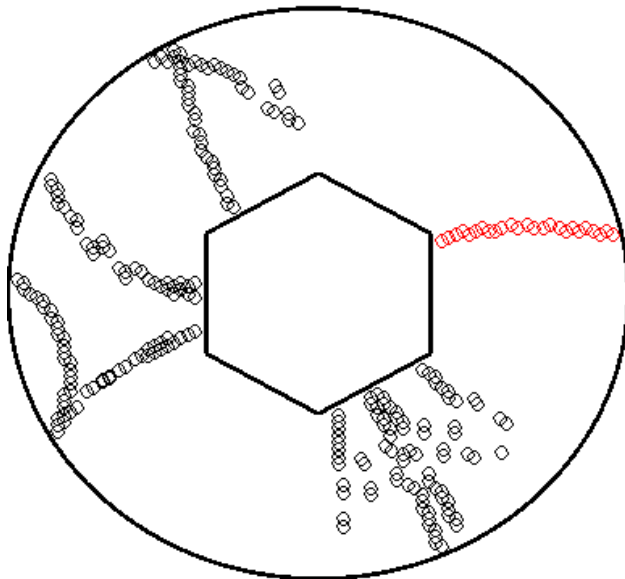


Output:

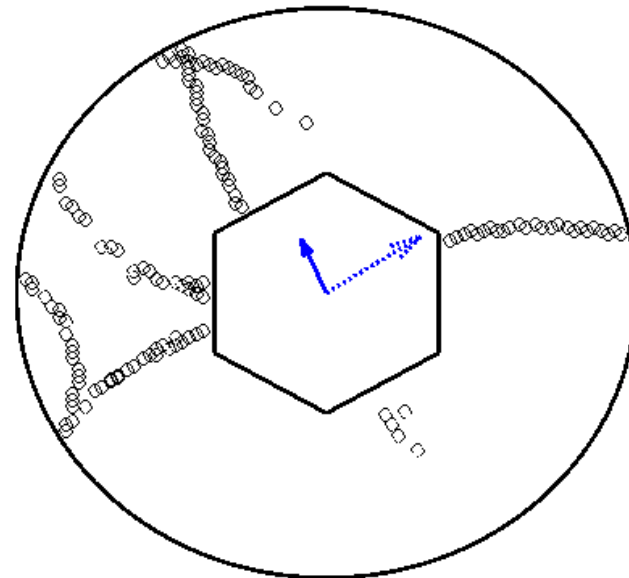


Visualization – Failure case

Input:



Output:



Discussion and conclusions

- Finding good parameters can be difficult
- Large networks require large data sets
- One network for each particle
- Is machine learning a viable option?



Future improvements

- Include other detectors
- Include different decay reactions
- Study different network structures





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Thank you
for listening!

