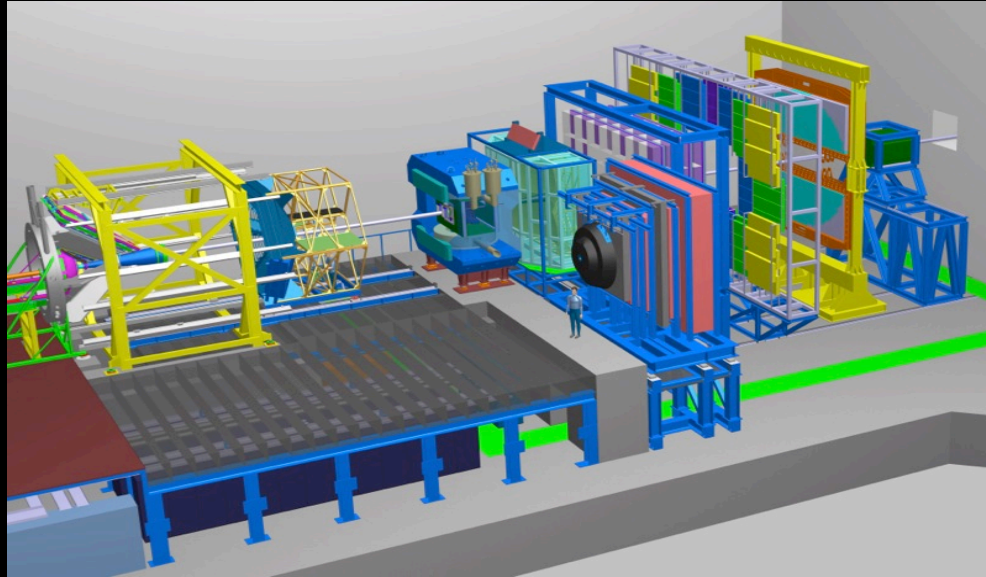


C.B.M.: User Report

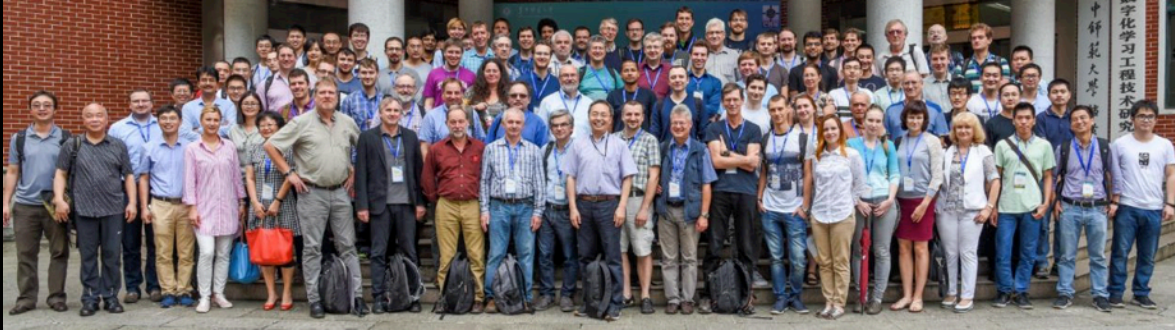
Neural networks in the high level data analysis



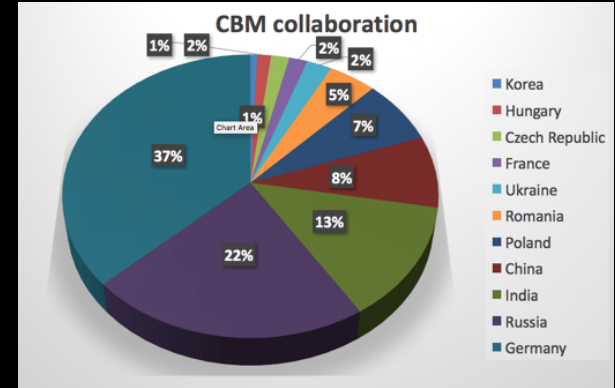
Manuel Lorenz
Goethe-University Frankfurt

C.B.M. Collaborations

CBM Collaboration: 464 scientists, 11 countries



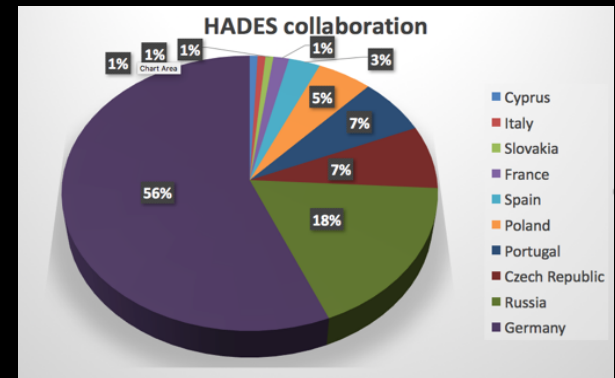
Spokesperson Norbert Herrmann



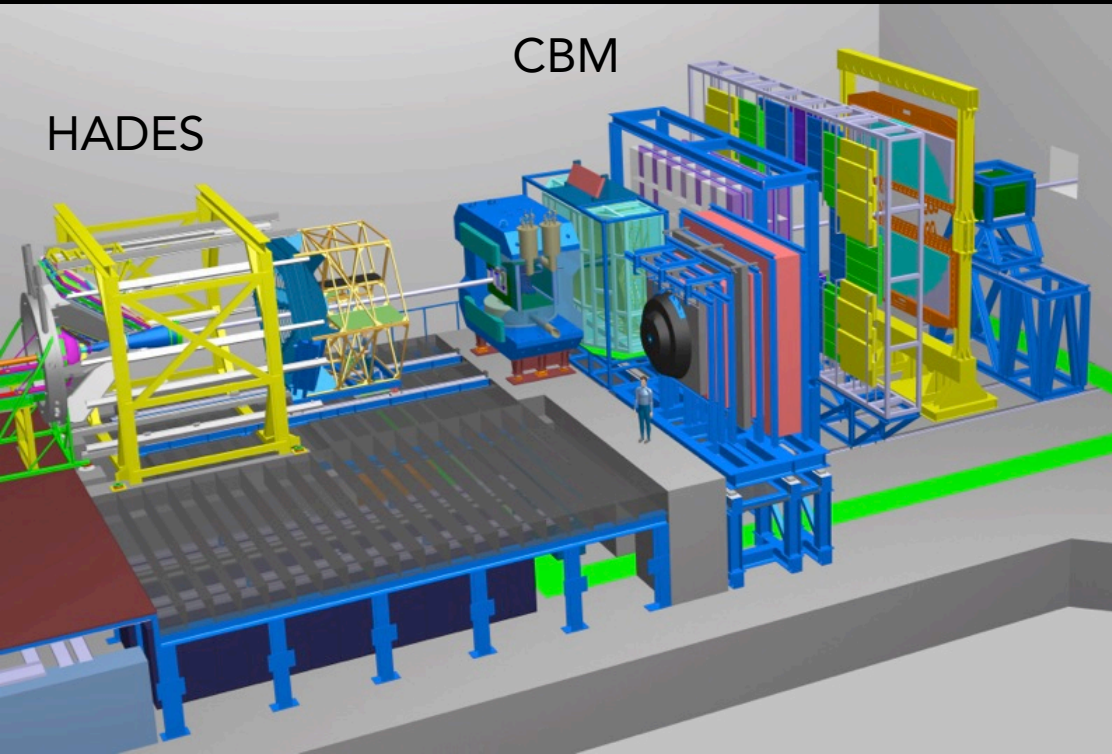
HADES Collaboration: 135 scientists, 9 countries



Spokesperson Joachim Stroth



CBM Experiment



- Fixed target experiments
→ obtain highest luminosities
- Free-streaming FEE
→ nearly dead-time free data taking
- On-line event selection
→ high-selective data reduction
- Tracking based entirely on silicon
→ fast and precise track reconstruction
→ 4D Tracking
(see talk by I. Kisel)

Day-1 setup: $R_{\text{int}} = 0.5 \text{ MHz}$ (0.1 MHz with MVD)
Phase-1 setup: → $R_{\text{int}} = 10 \text{ MHz}$

FAIR



SIS 100 accelerator

FAIR



FAIR



CBM+HADES cave

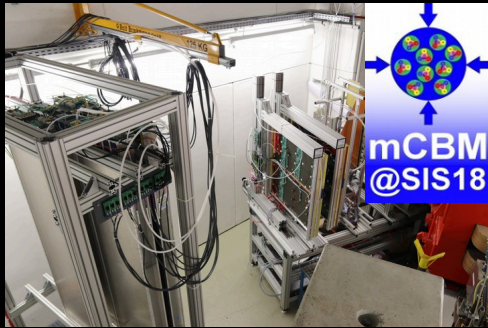


FAIR construction site



SIS 100 accelerator

FAIR



SIS 18 target hall



FAIR construction site

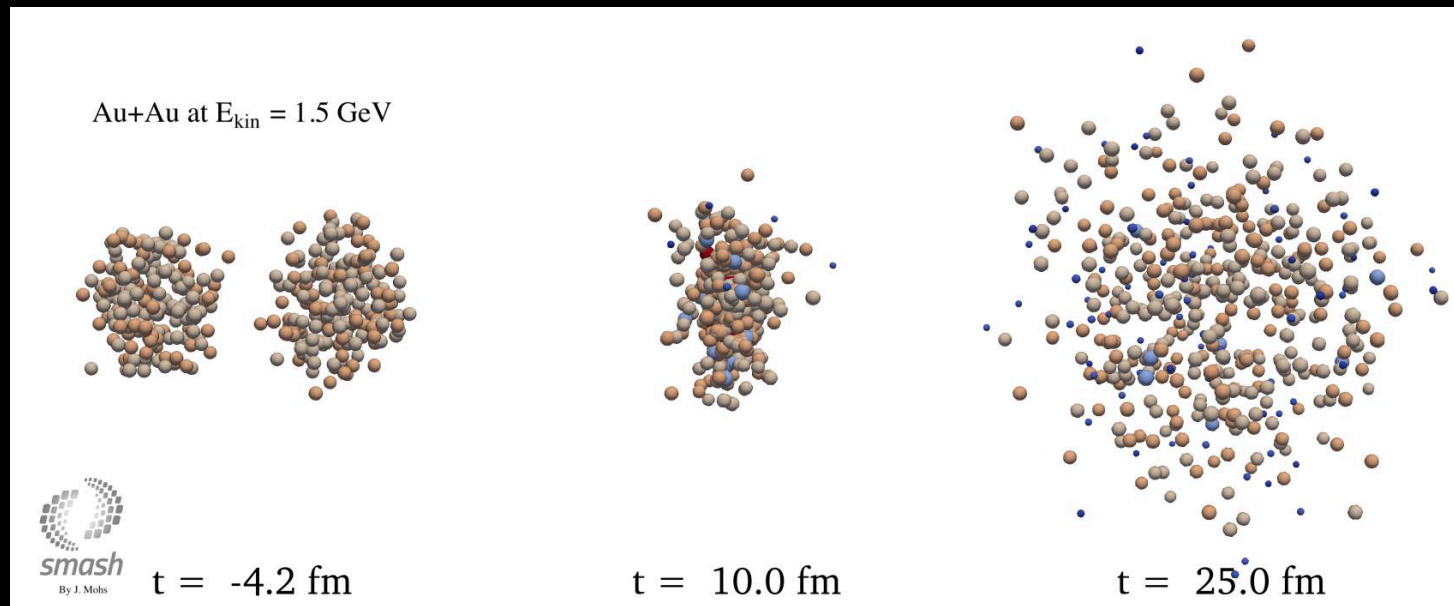


CBM+HADES cave



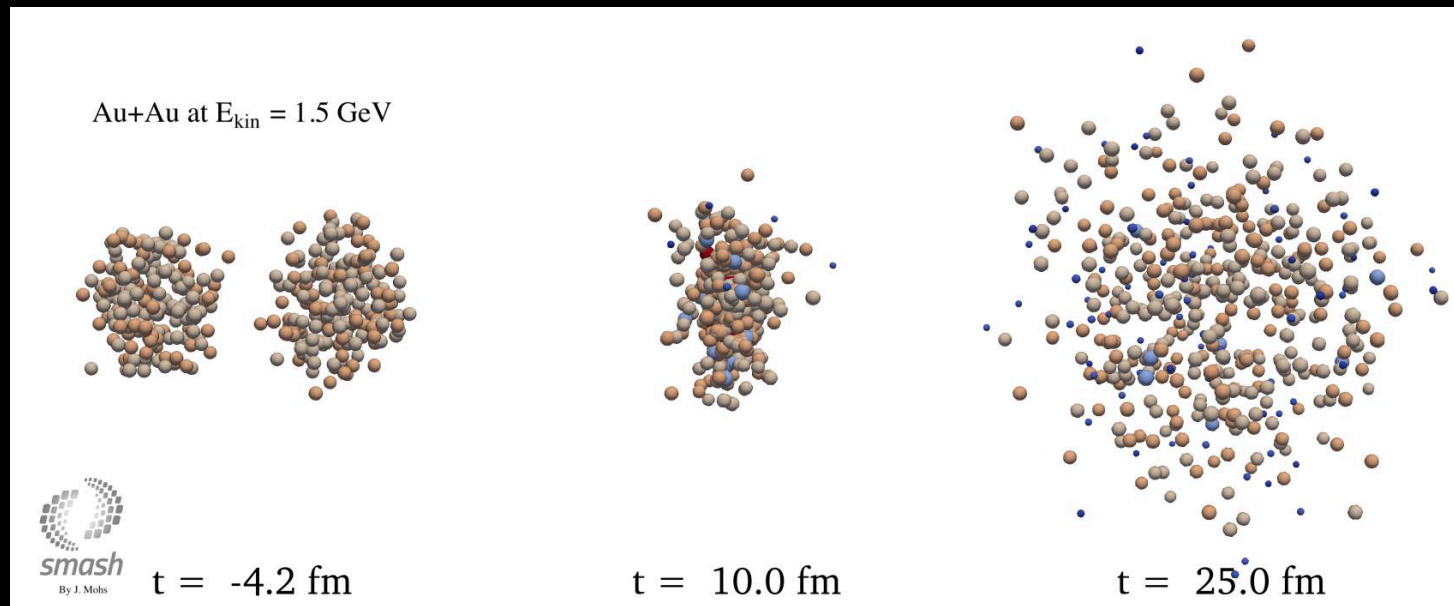
SIS 100 accelerator

The Challenge: Reconstruction of Rare Probes in Heavy-Ion Collisions at a few GeV



Clear hierarchy in hadron yields:
 $p \approx 100, \pi^- \approx 10, \Lambda \approx 10^{-2}, \omega \approx 10^{-3}$

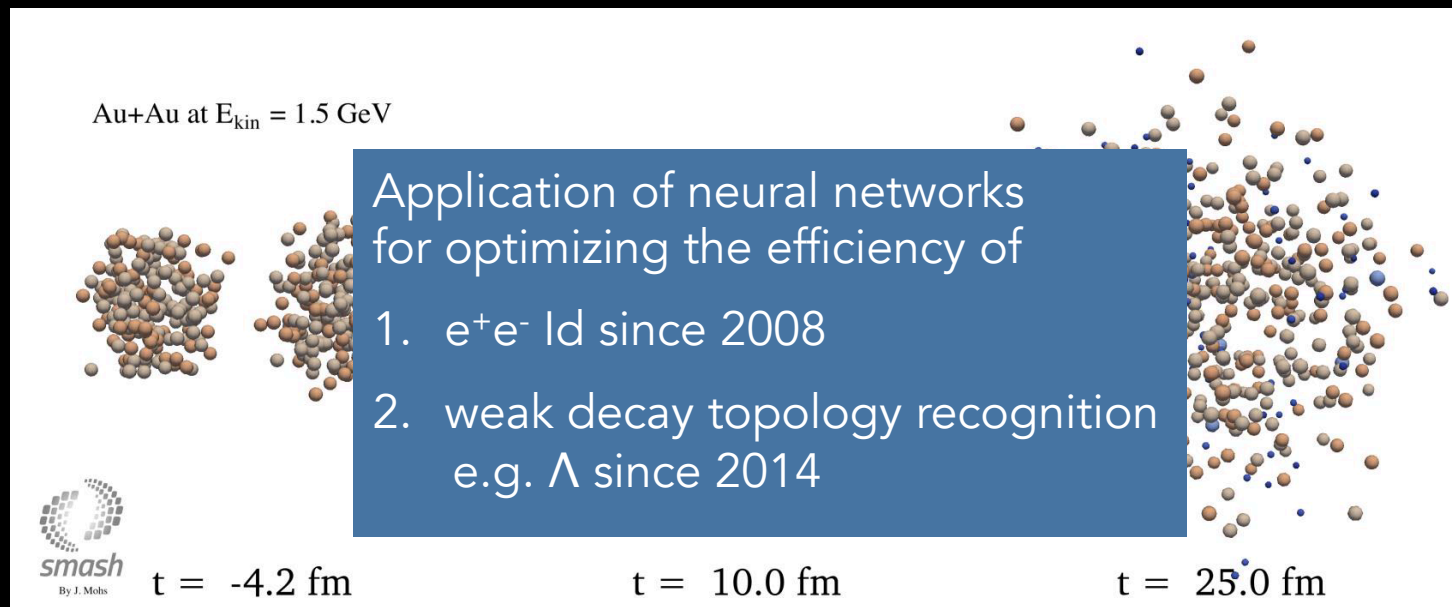
The Challenge: Reconstruction of Rare Probes in Heavy-Ion Collisions at a few GeV



Clear hierarchy in hadron yields:
 $p \approx 100, \pi^- \approx 10, \Lambda \approx 10^{-2}, \omega \approx 10^{-3}$

Large combinatoric background: $\Lambda \rightarrow p + \pi^-$
 ω -meson: electromagnetic decay channel

The Challenge: Reconstruction of Rare Probes in Heavy-Ion Collisions at a few GeV

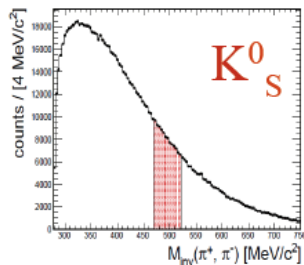
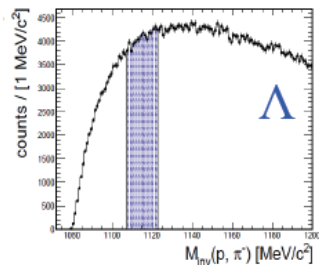
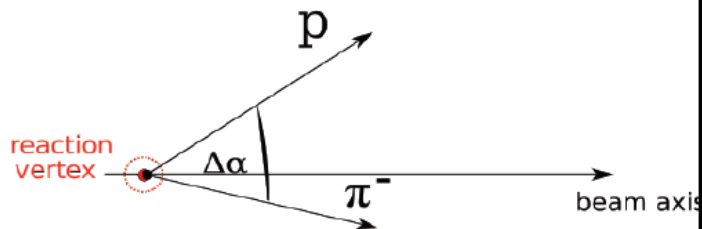


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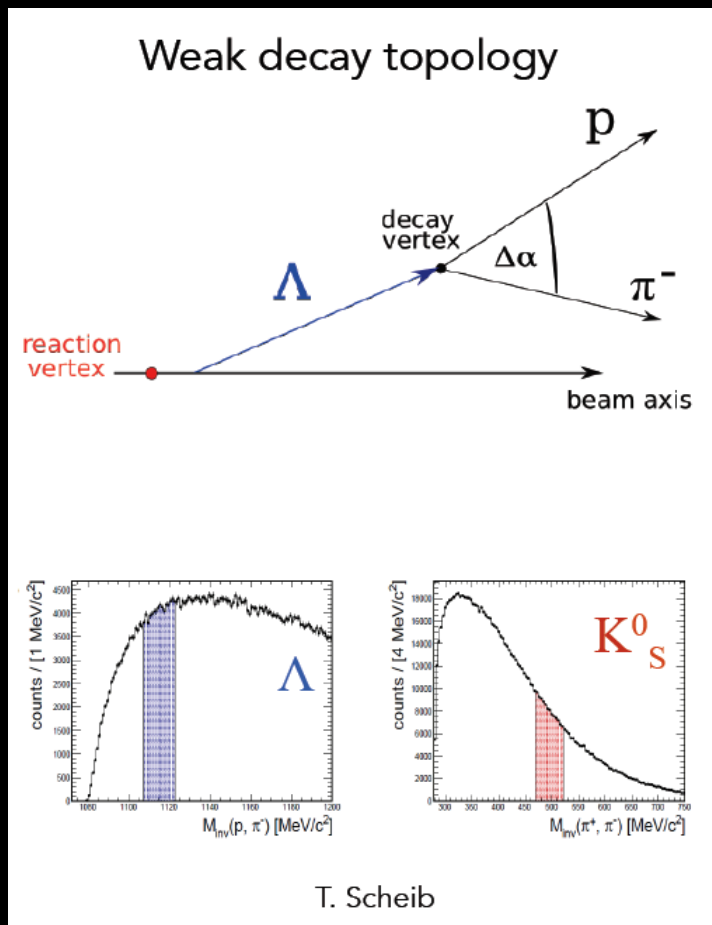
Weak decay topology recognition

Weak decay topology

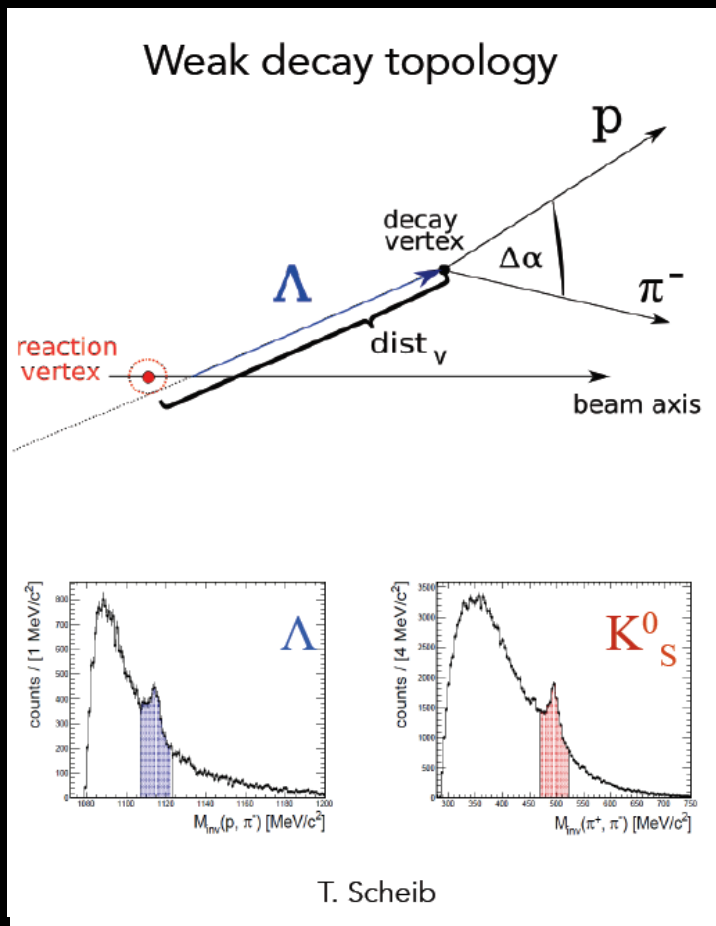


T. Scheib

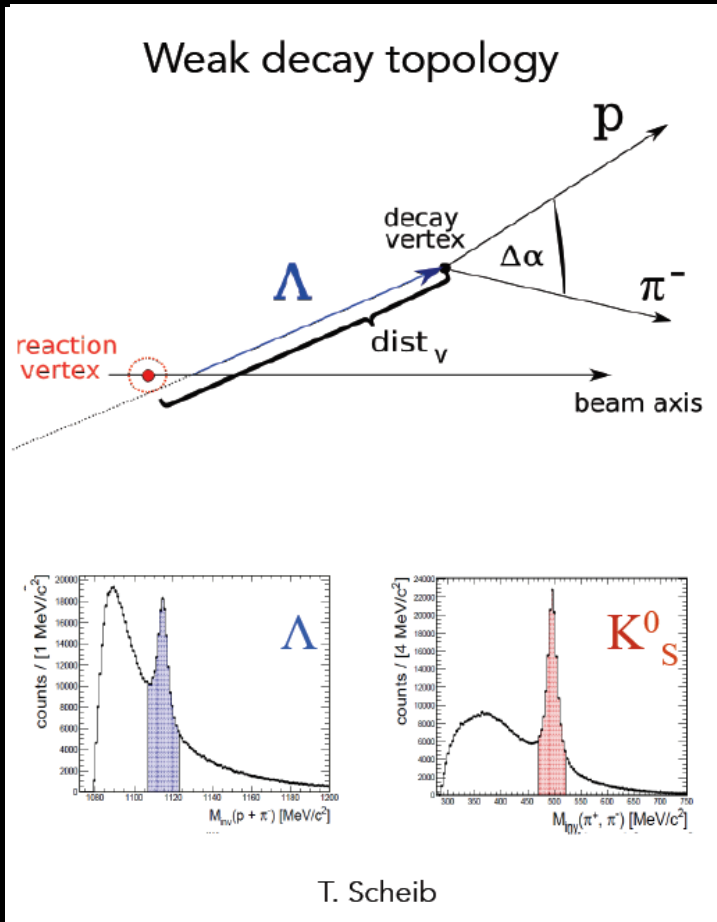
Weak decay topology recognition



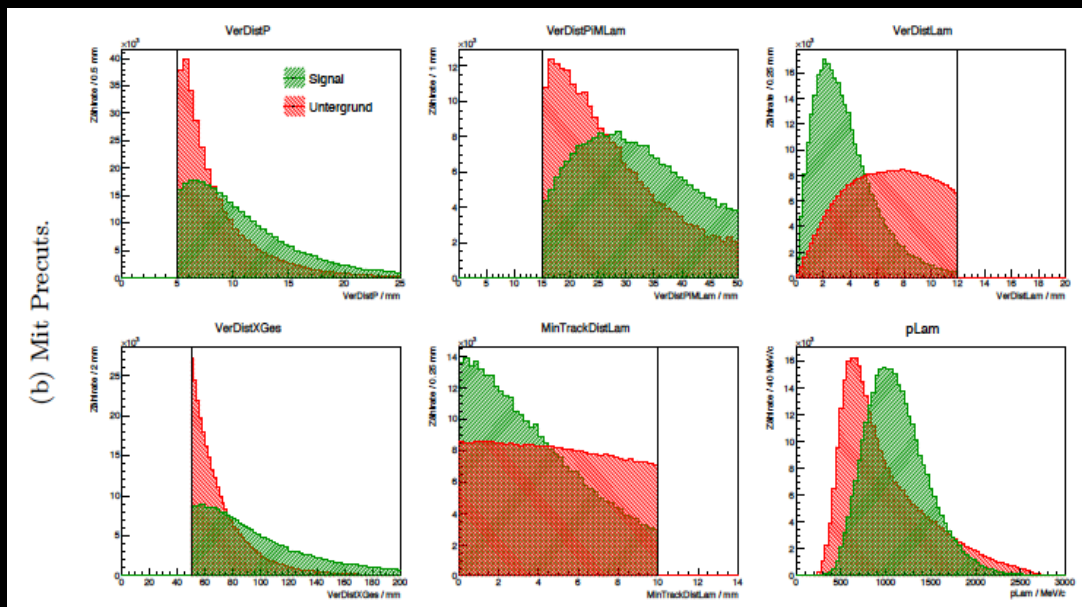
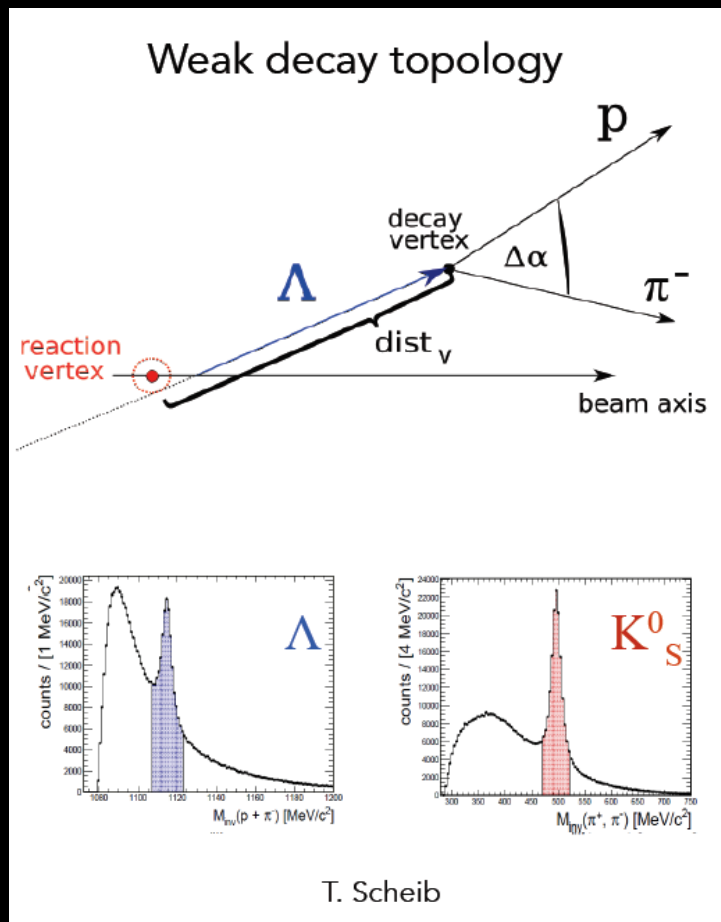
Weak decay topology recognition



Weak decay topology recognition



Weak decay topology recognition

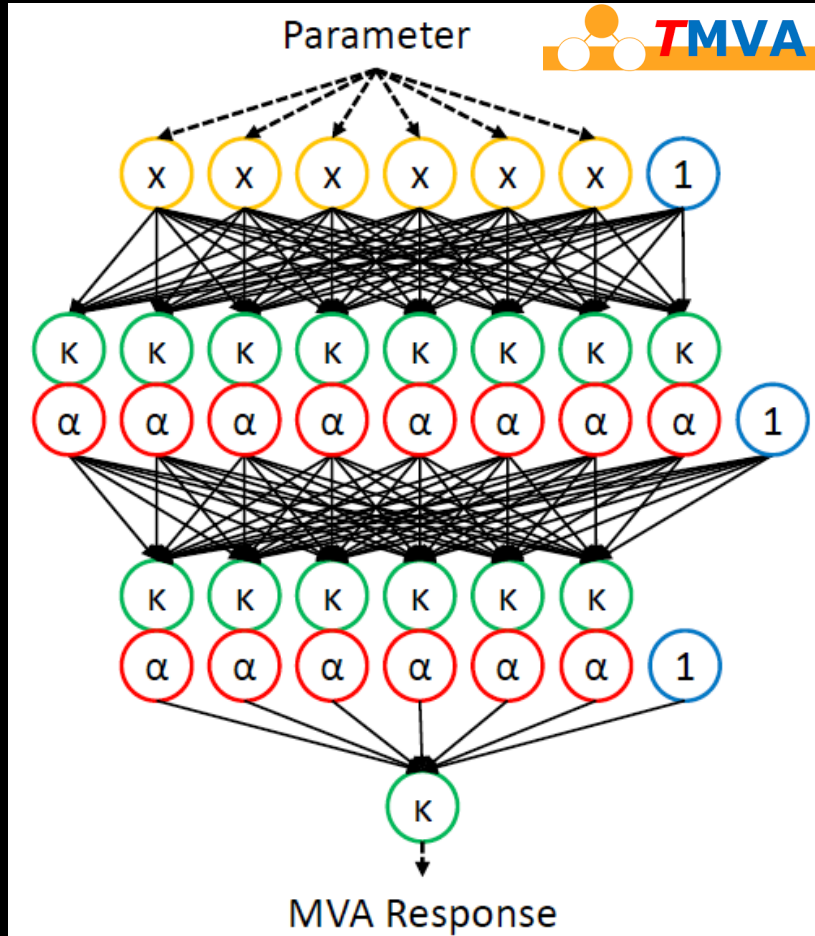


Training samples:

Signal: Simulation embedded into real data

Background: mixed events

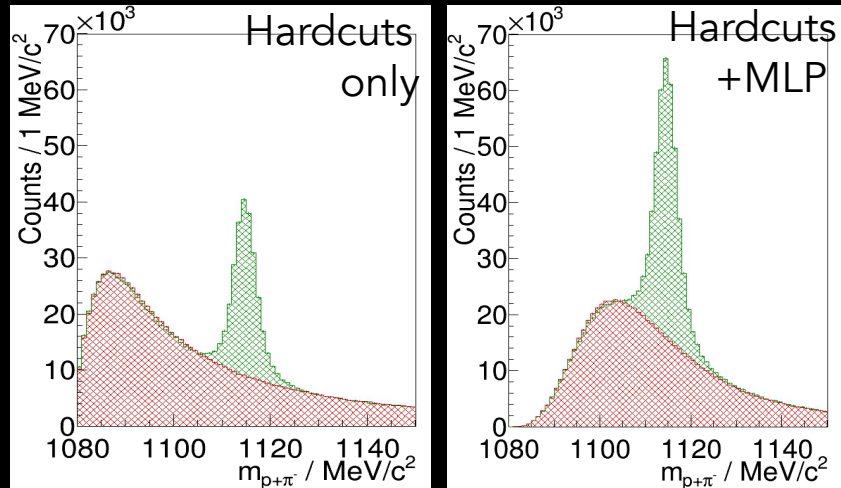
Multi Layer Perceptron (MLP): Setup



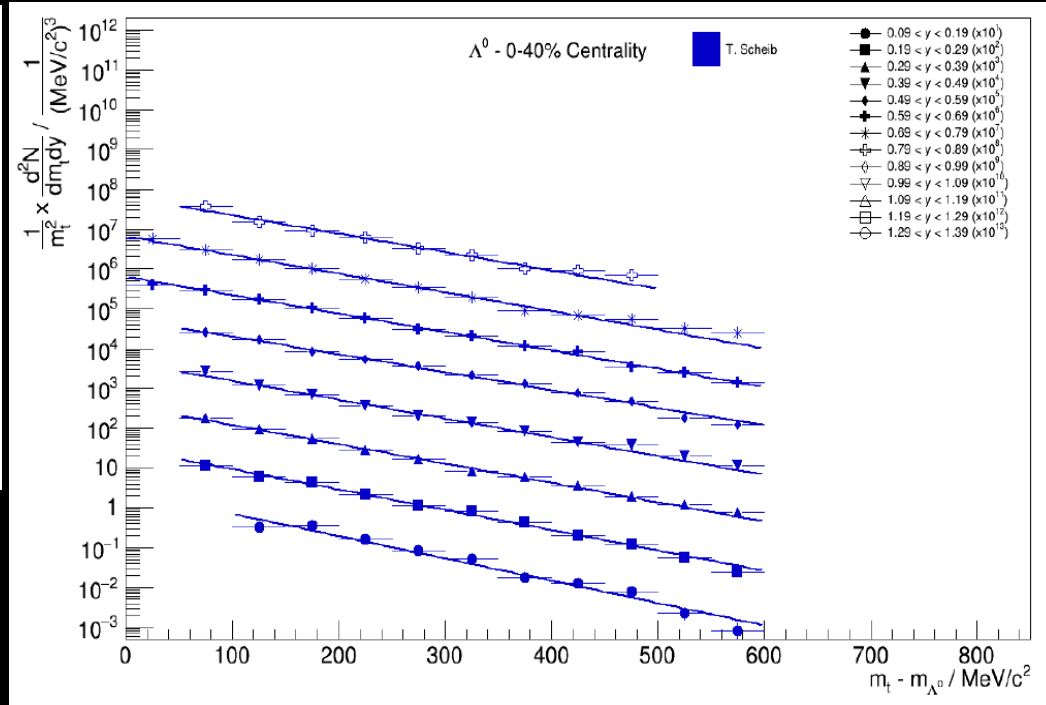
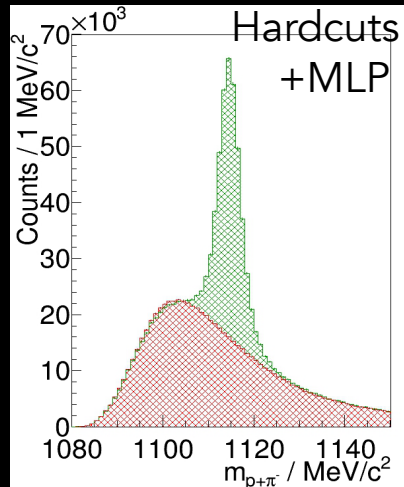
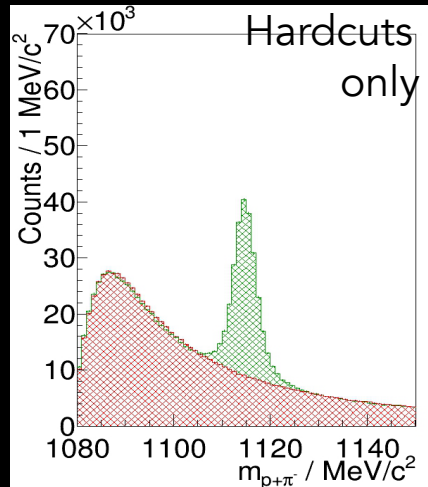
$$\text{synapse function } \kappa: \mathbb{R}^n \rightarrow \mathbb{R} = \begin{cases} \sum_{i=0}^n y_i^l w_{ij}^l & \text{Sum} \\ \sum_{i=0}^n (y_i^l w_{ij}^l)^2 & \text{Sum of Squares} \\ \sum_{i=0}^n |y_i^l w_{ij}^l| & \text{Sum of Absolutes} \end{cases}$$

$$\text{activation function } \alpha: \mathbb{R} \rightarrow \mathbb{R} = \begin{cases} x & \text{Linear} \\ \frac{1}{1 + e^{-x}} & \text{Sigmoid} \\ \frac{e^x - e^{-x}}{e^x + e^{-x}} & \text{Tanh} \\ e^{-x^2/2} & \text{Radial} \end{cases}$$

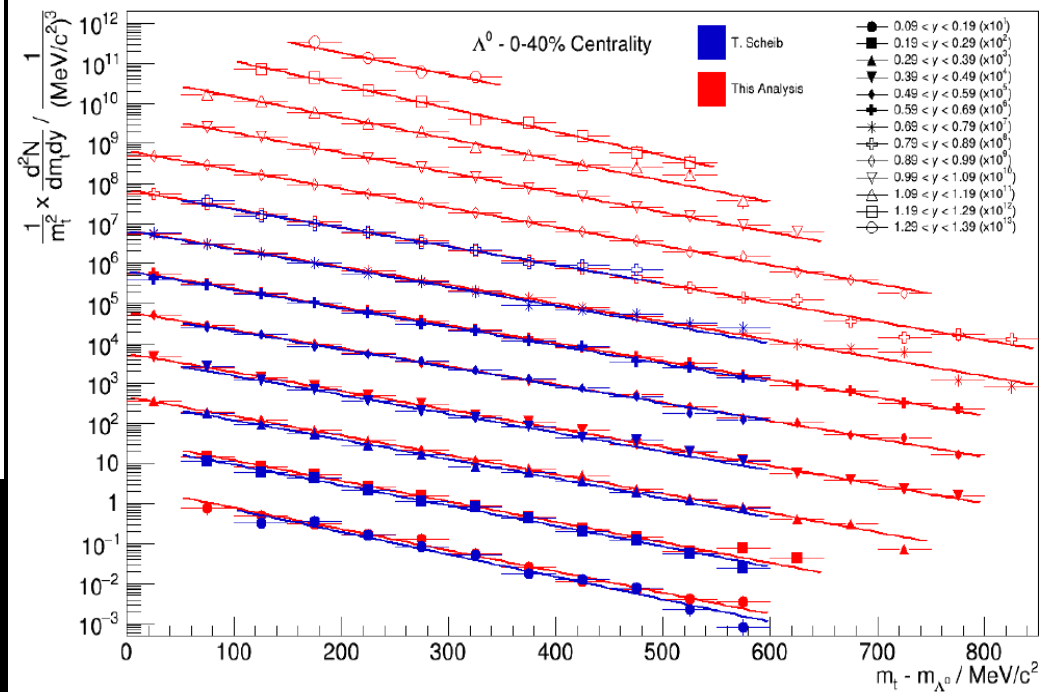
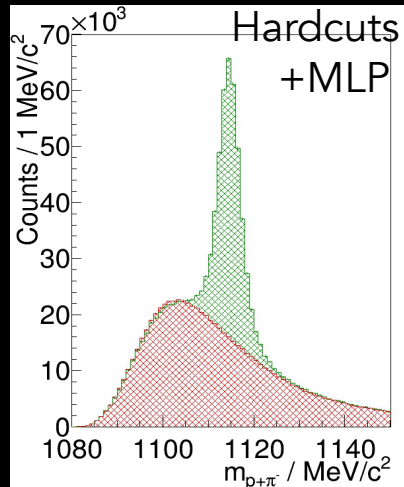
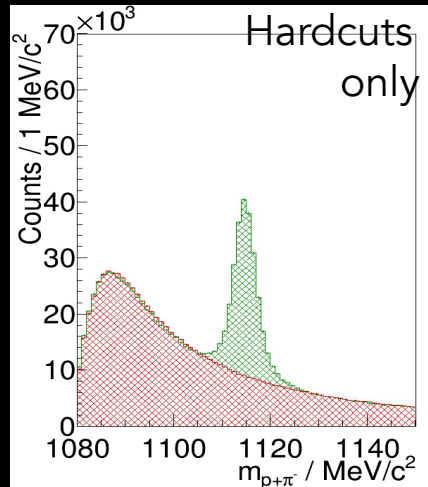
Performance and Uncertainty Estimation



Performance and Uncertainty Estimation



Performance and Uncertainty Estimation



Neural network improves significantly y -coverage
 → reduction of uncertainty for 4π yield extraction.

Summary and Outlook

Application of neural networks in the high level analysis for

1. e^+e^- Id since 2008 (HADES)
 2. weak decay topology recognition since 2014 (HADES, CBM)
 - Improved reconstruction efficiency
 - Uncertainty estimation via “standard analysis”
- Improvement of network architecture and application in low level analysis.
 - Uncertainty estimation (systematic uncertainties will be dominant in future high rate experiments)

RPC / Shower

TOF

RICH

Target

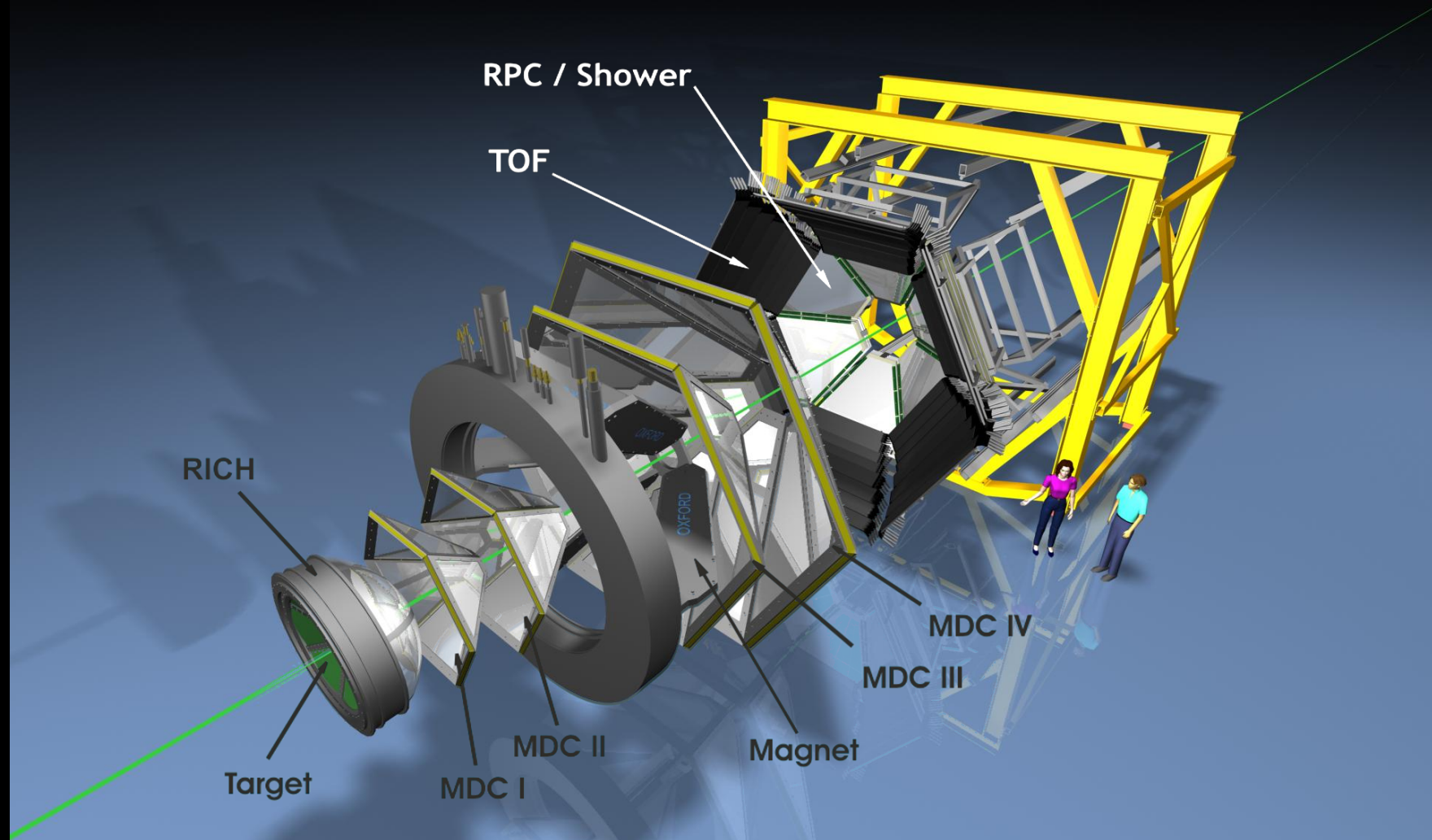
MDC I

MDC II

Magnet

MDC III

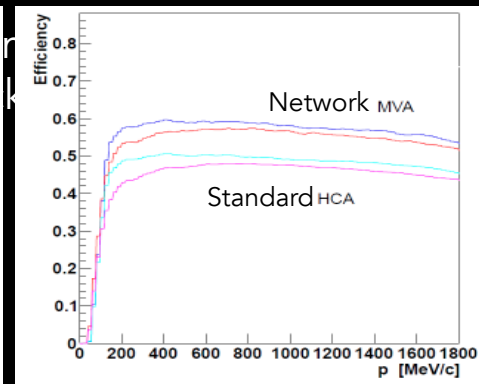
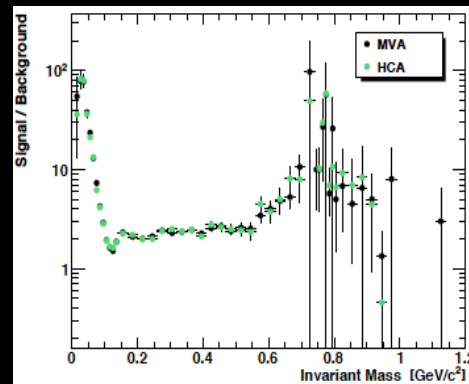
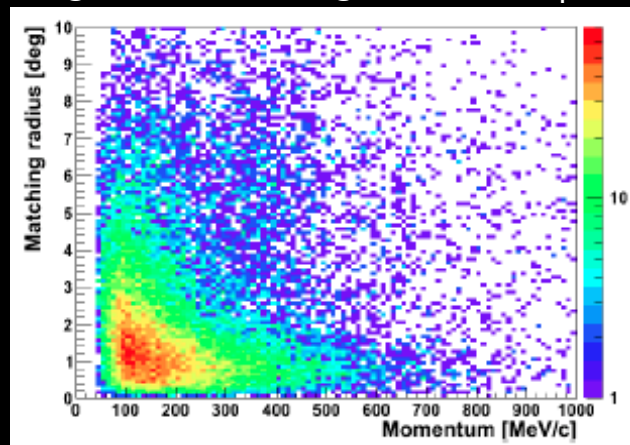
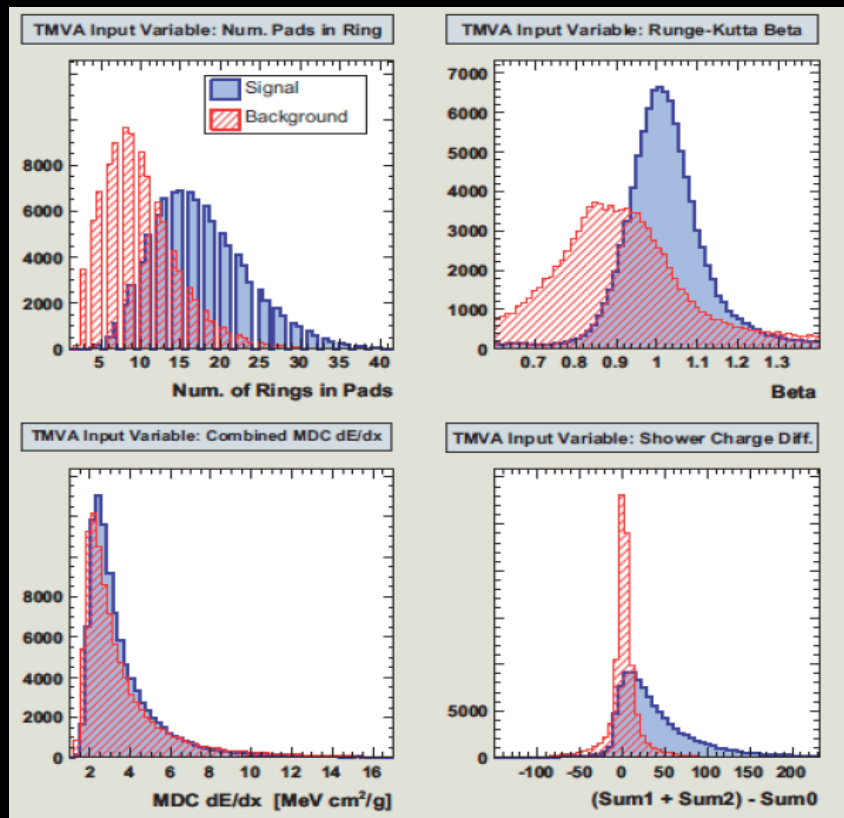
MDC IV



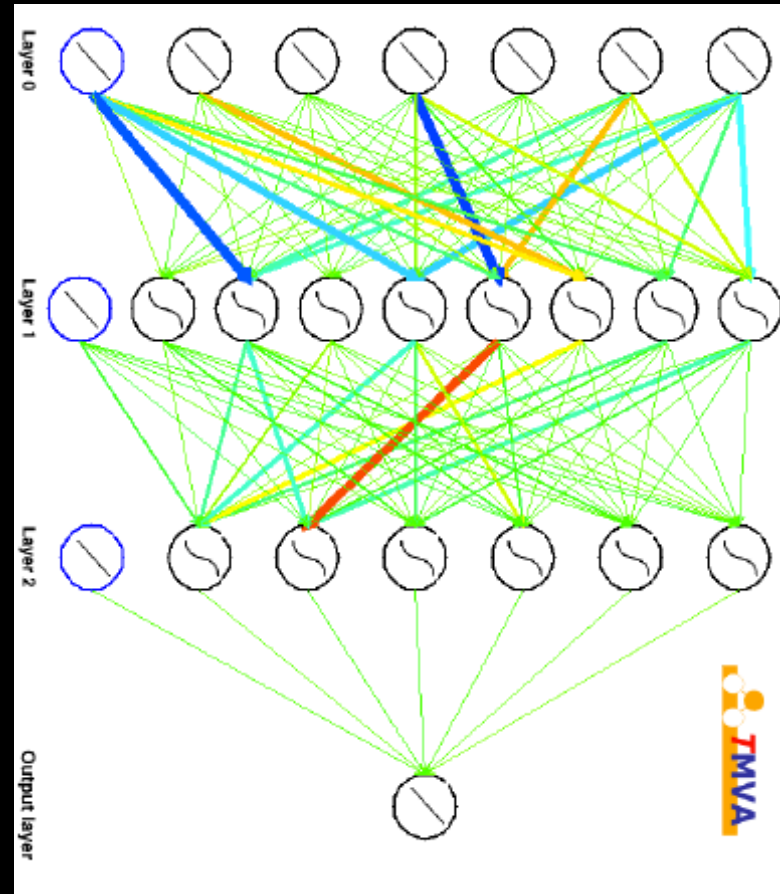
$$e^+e^- \text{Id}$$

TMVA: Toolkit for Multivariate Data Analysis

Signal and Background sample:



Multi Layer Perceptron (MLP): Setup



synapse function

$$\kappa: \mathbb{R}^n \rightarrow \mathbb{R} = \begin{cases} \sum_{i=0}^n y_i^l w_{ij}^l & \text{Sum} \\ \sum_{i=0}^n (y_i^l w_{ij}^l)^2 & \text{Sum of Squares} \\ \sum_{i=0}^n |y_i^l w_{ij}^l| & \text{Sum of Absolutes} \end{cases}$$

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Performance study

