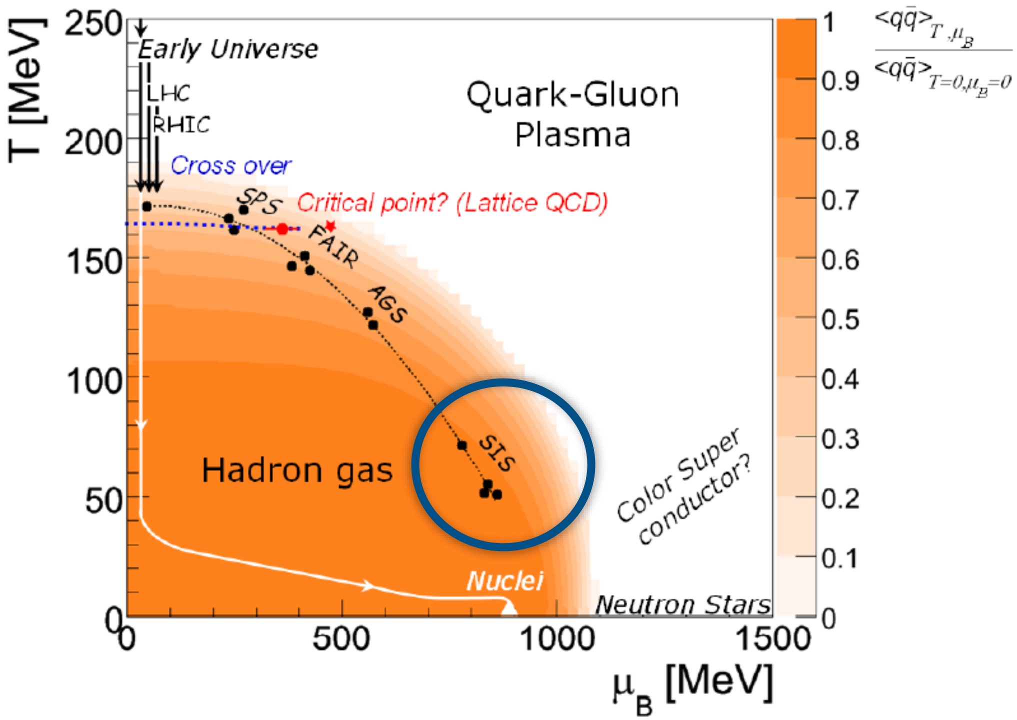
Backtracking algorithm for lepton reconstruction with HADES

PATRICK SELLHEIM

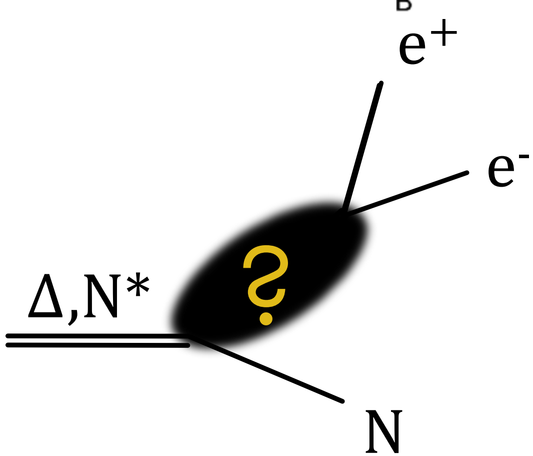
FOR THE HADES COLLABORATION

Motivation
Backtracking
Results

Motivation



- Investigation of long lived ($\tau \approx 10\ \mathrm{fm/c}$) strongly interacting matter at T < 100 MeV and high densities ($\rho/\rho_0 > 2$)
- System is baryon dominated
- In-medium modifications of vector meson spectral functions



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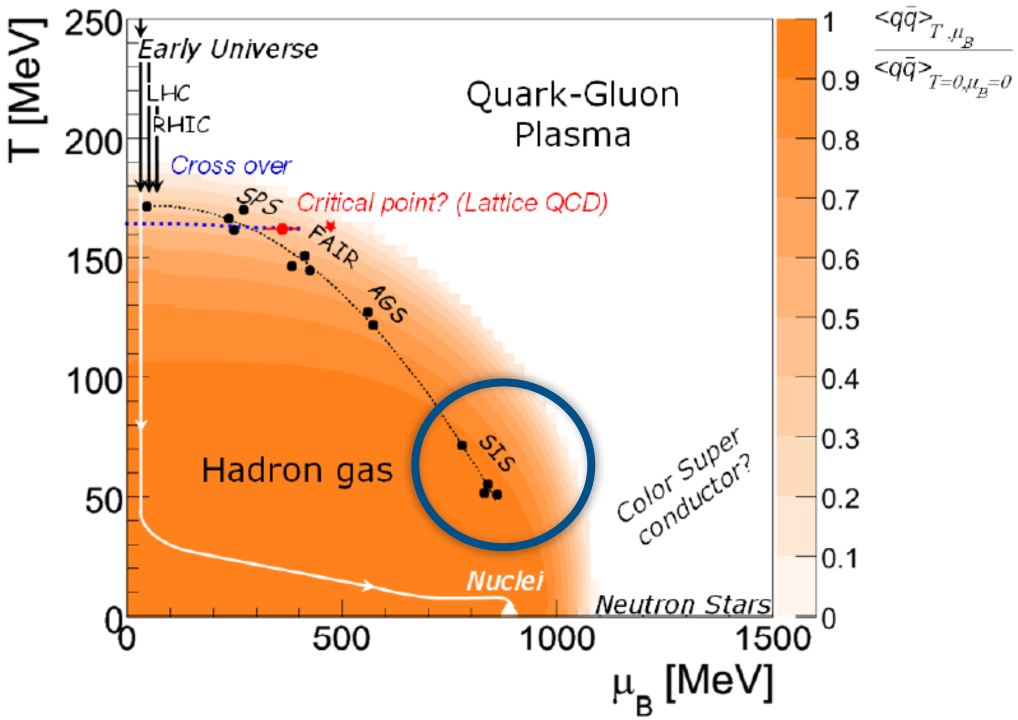

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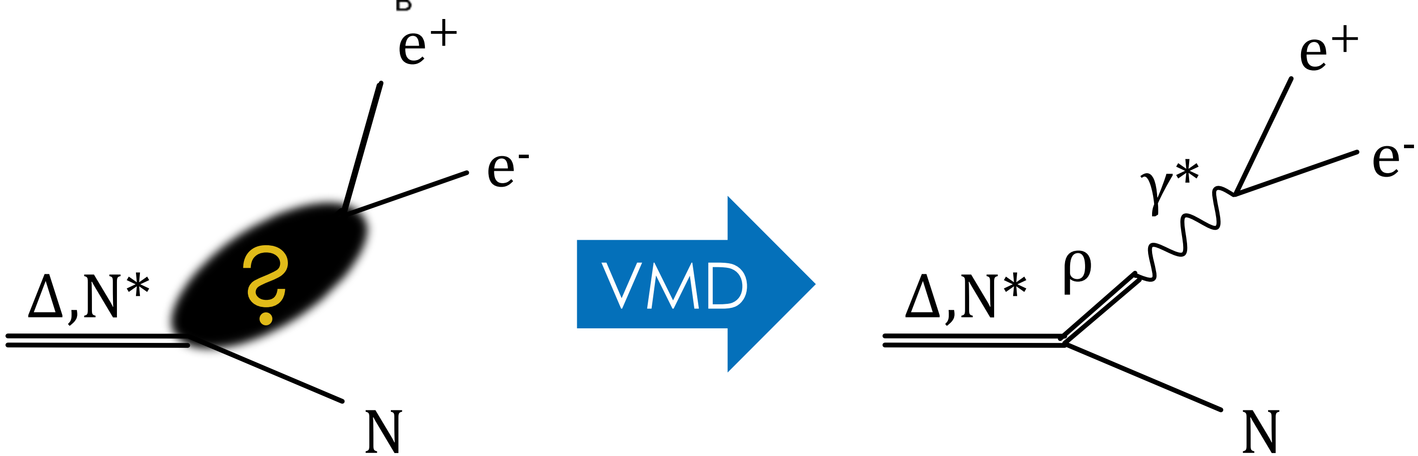
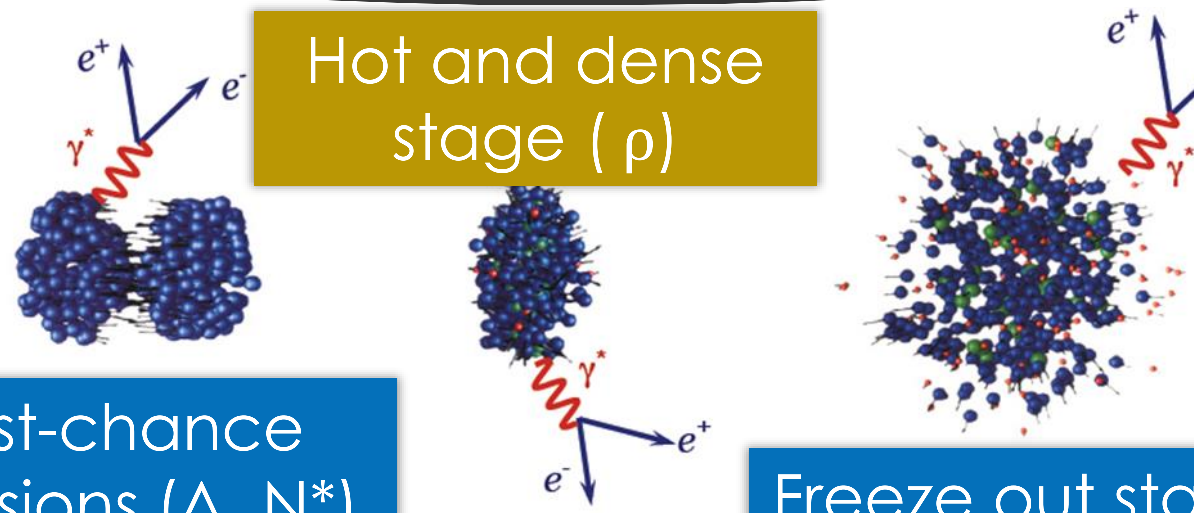


EM probes in heavy ion collisions

Hot and dense stage (ρ)



First-chance collisions (Δ, N*)

Freeze out stage (π^0,η)

γ, γ* do not interact strongly

- Can be used to extract primary information of hot and dense phase

γ, γ* are produced in all collision stages

- Contributions from all stages have to be identified precisely

γ, γ* probe EM structure of strongly interacting matter

- Invariant mass monitors directly spectral function

Challenges and needs

γ, γ^* are very rare probes

- Dilepton production is suppressed by factor α^2: Corresponds to branching ratio $\cong 10^{-5}$
- At SIS18 energy range vector mesons are produced sub-threshold

Fast detector

- 10-50 kHz trigger rate

Large acceptance

- $18° < \theta < 85°$ (polar angle)
- Full azimuthal angle

Precise particle identification

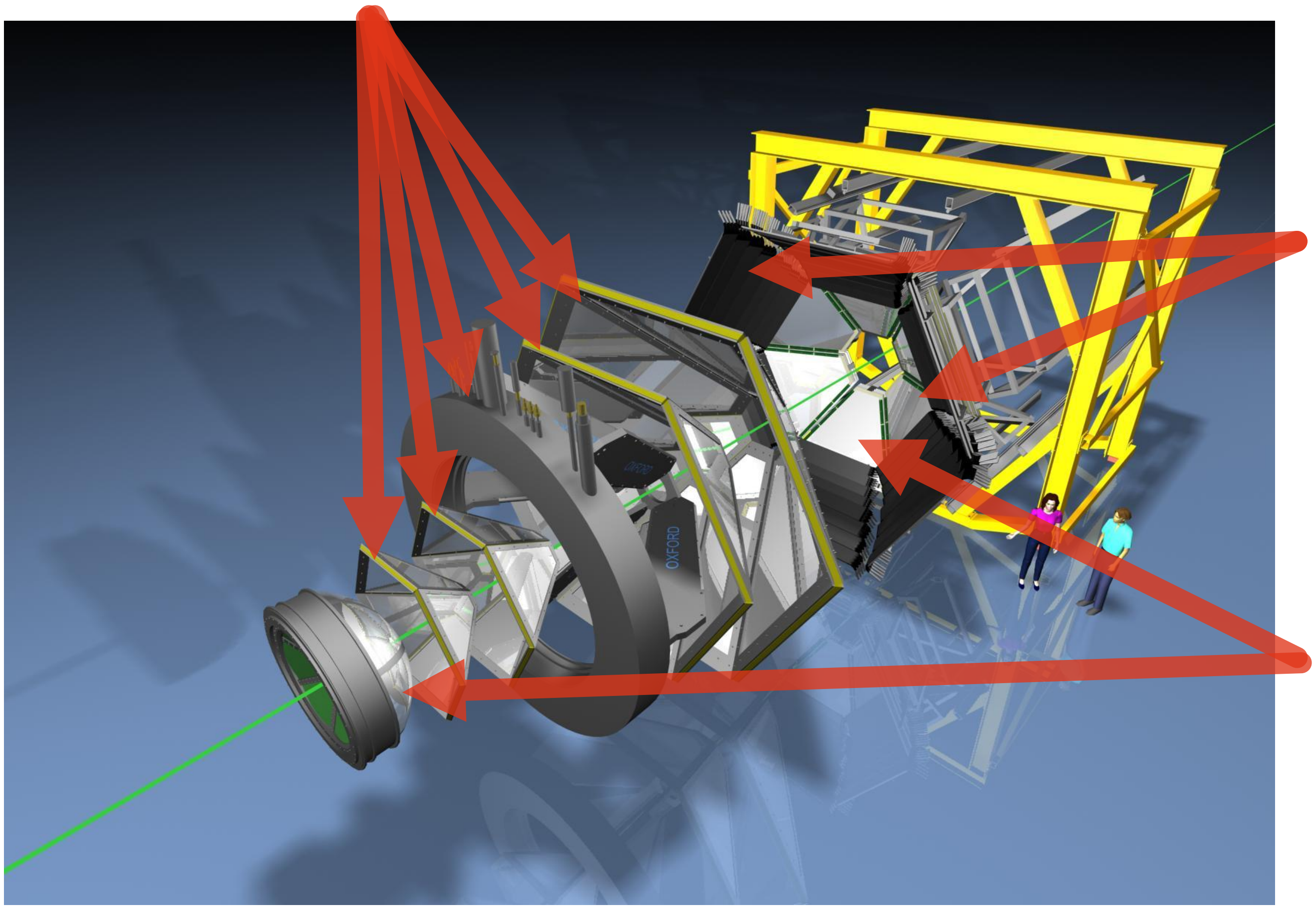
- Hadron identification by means of time-of-flight
- Electron identification using RICH and EM shower

Excellent mass resolution

- 15 MeV/c^2 in the vector meson region

HADES experiment

Tracking system: 4 drift chamber planes + superconducting magnet

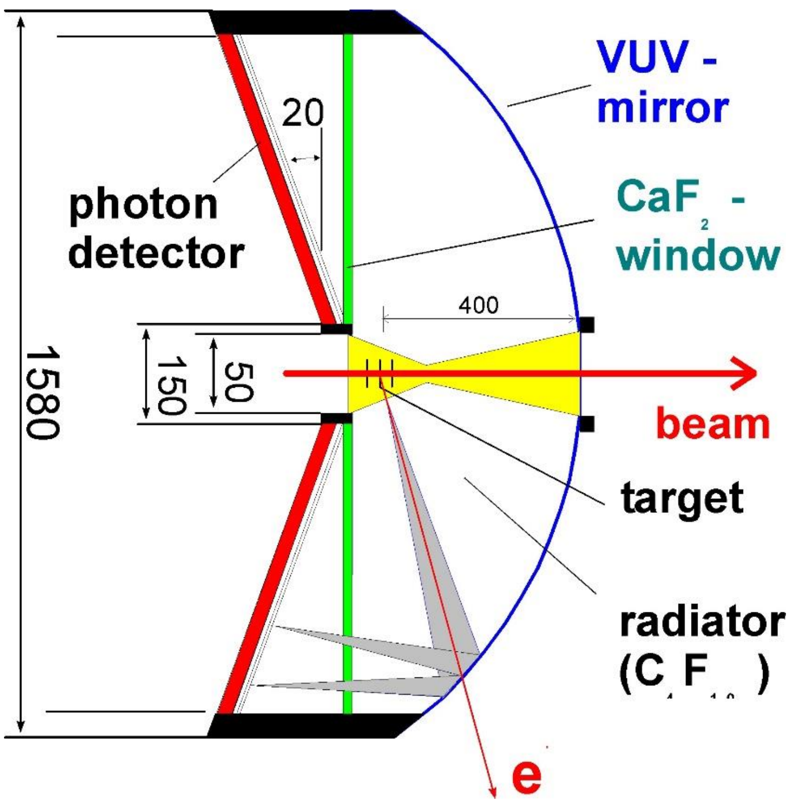


Time-of-flight detectors : RPC + TOF for hadron identification

Ring Imaging Cherenkov detector (RICH) and PreShower: Lepton identification

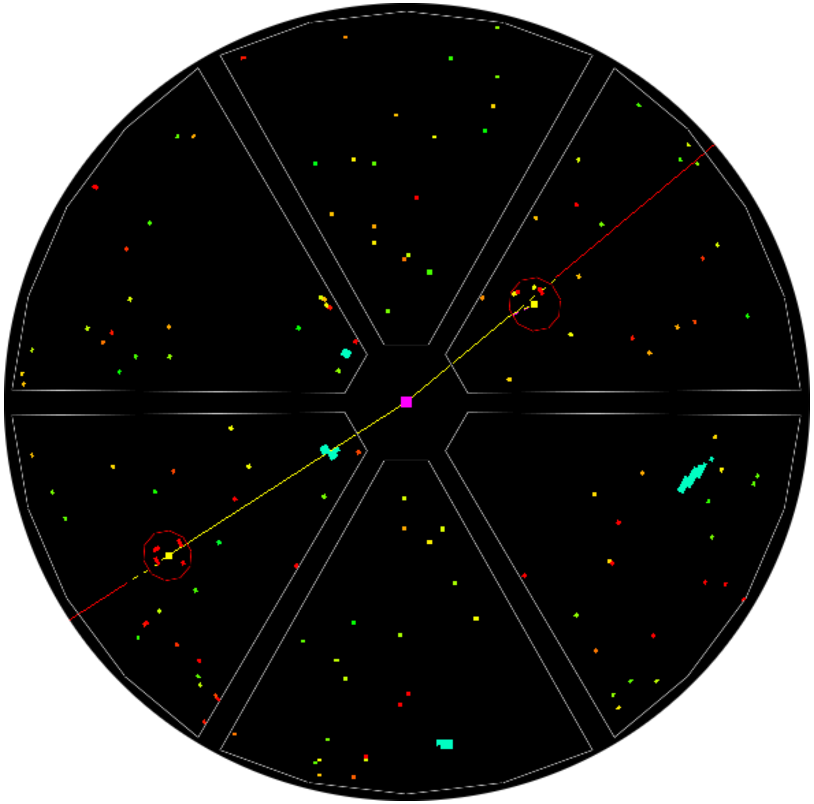
RICH ring finder

Side view



Front view:

Event display of Au+Au beamtime at 1.23 GeV/u



Motivation

Backtracking

Results

Backtracking

Track preselection

- Selection of good lepton candidates based on particle velocity and energy loss

Determination of possible ring centers

- Based on angular information provided by reconstructed particle tracks

Previous knowledge of close pairs

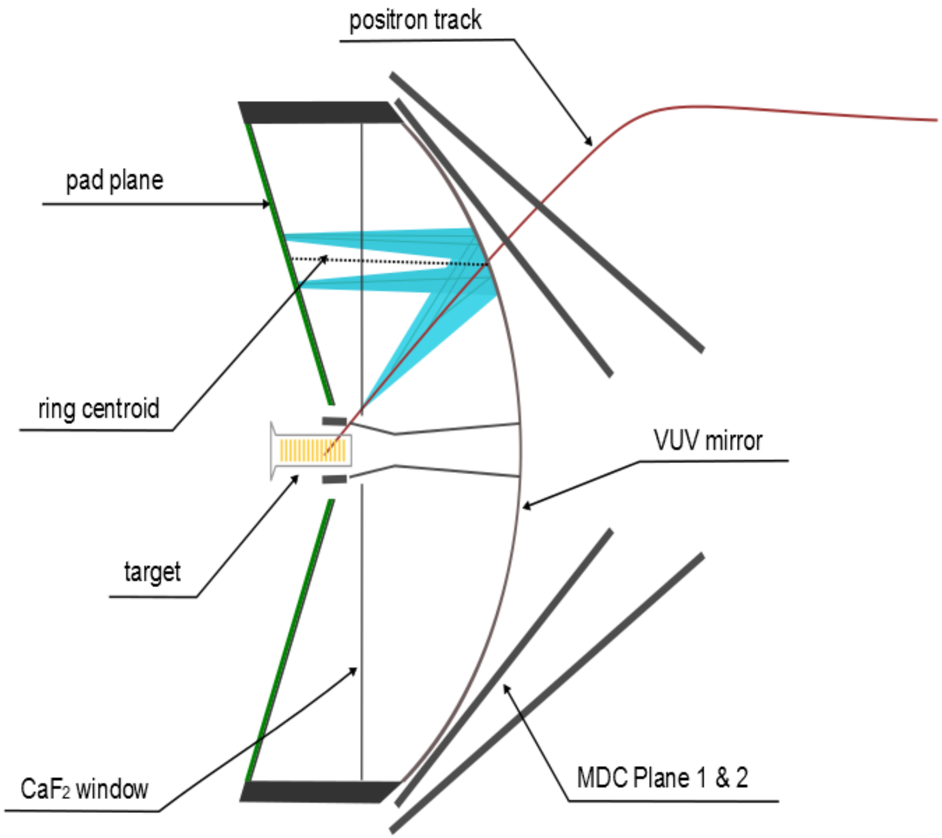
- Track resolution : Opening angle > 2°
- Ring resolution : Opening angle > 4°

Implementation

Transformation from track angles to pad plane coordinates

Position depended parameterization of rings

Information extraction out of measured signals



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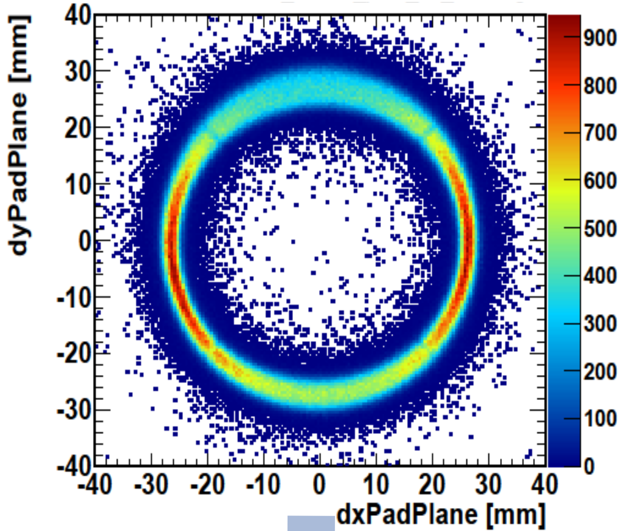

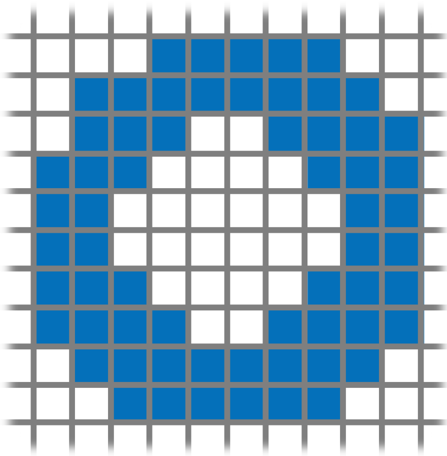

Implementation

Transformation from track angles to pad plane coordinates

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Position depended parameterization of rings

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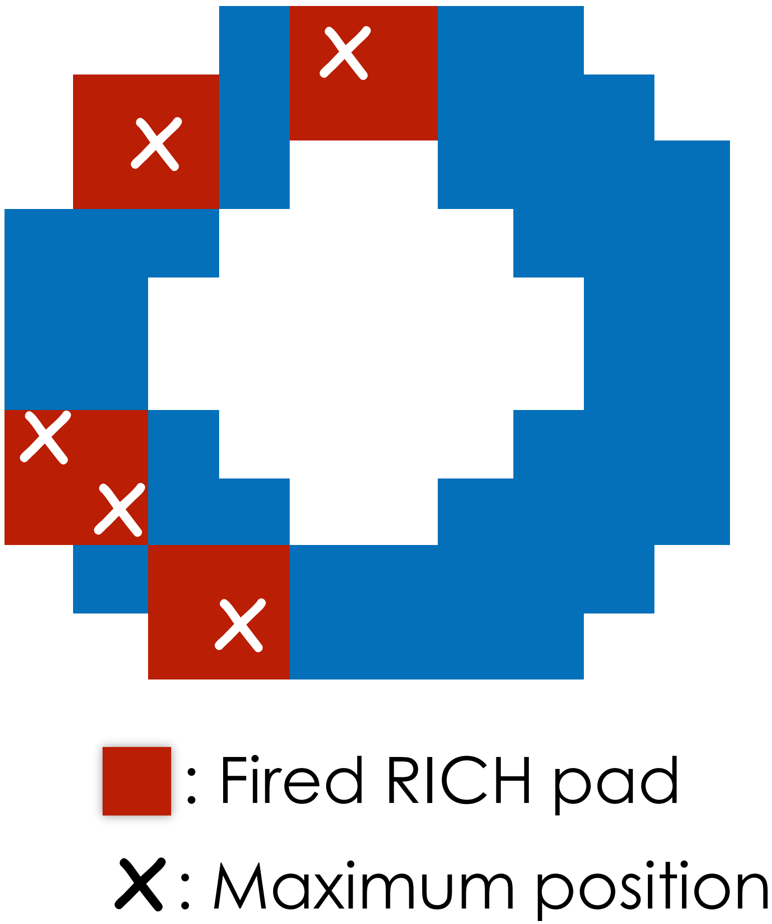
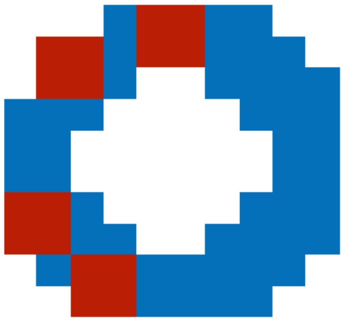
Information extraction out of measured signals

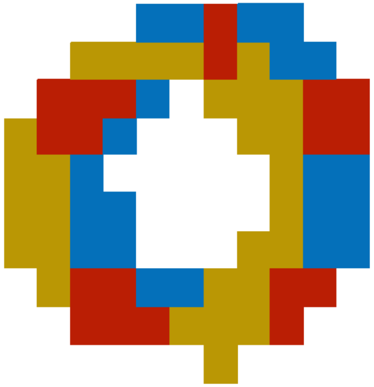


Output variables



Particle observables

- # clusters
- # maxima (= # photons)
- # pads (of ring, clusters)
- Charge (of ring, clusters)
- Quality (maxima positions)
- # Pads outside ring prediction region



Pair observables

- # Maxima shared with various tracks
- # Maxima shared with one track
- Opening angle between particle candidates

Motivation
Backtracking
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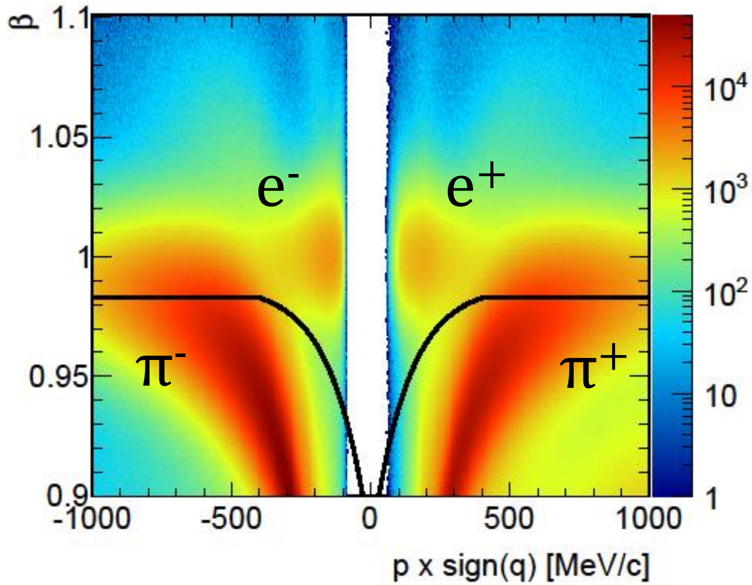
Analysis strategy

Lepton identification

Close pair rejection

Pairing and invariant mass



- Backtracking information
- PreShower information
- Energy loss in drift chambers
- Track matching quality
- Polar angle
- Energy loss in outer ToF detector

Lepton ID using decision trees

List of input variables

Decision trees

Response

#Maxima
#Cluster
PreShower response
Track matching Qa
Energy loss
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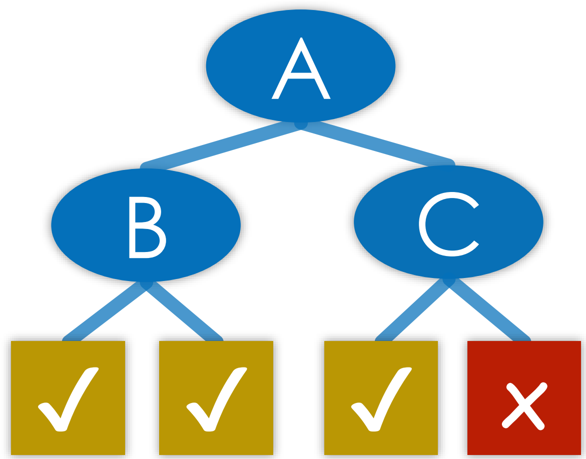
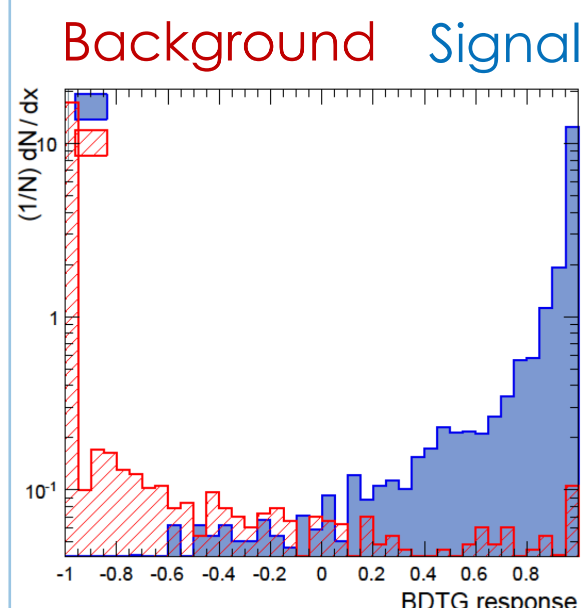
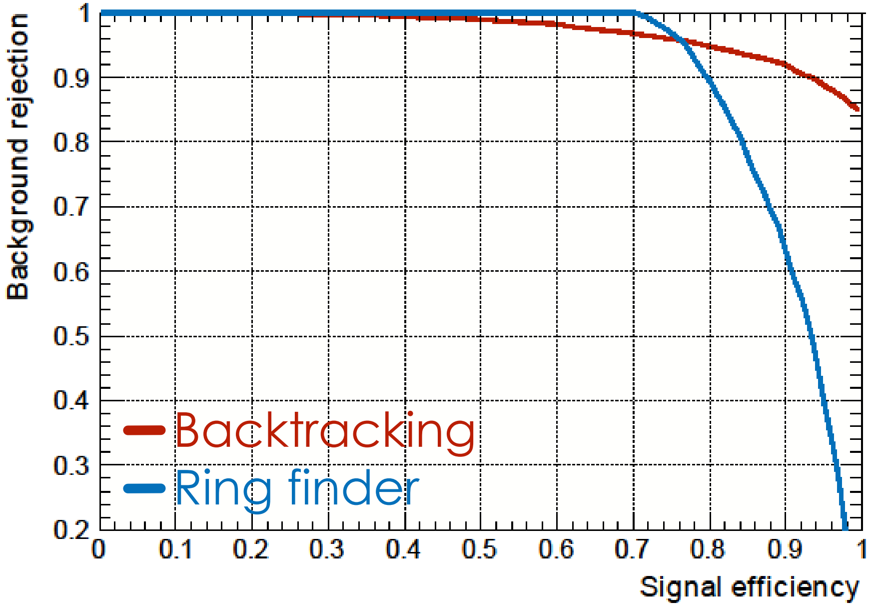


× 1000



Lepton ID results

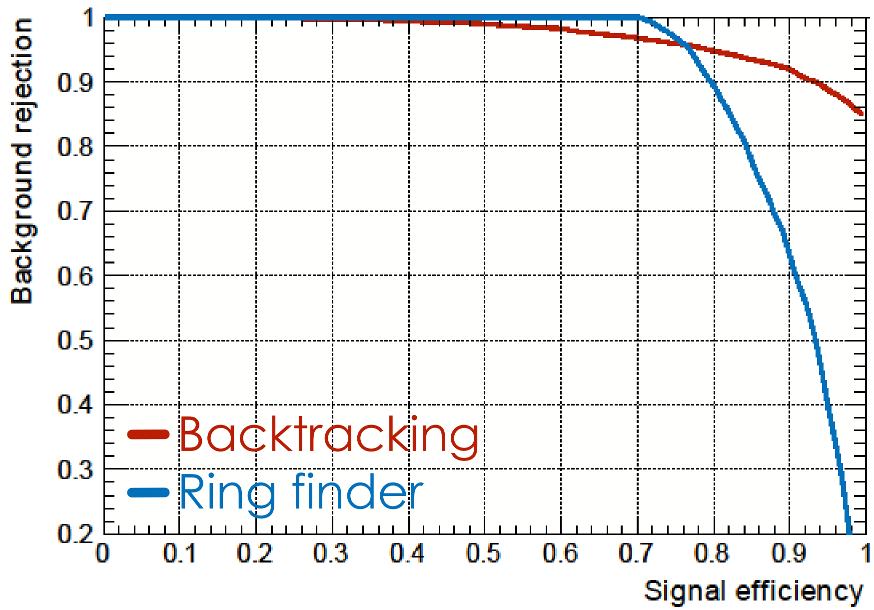
Ring finder vs backtracking

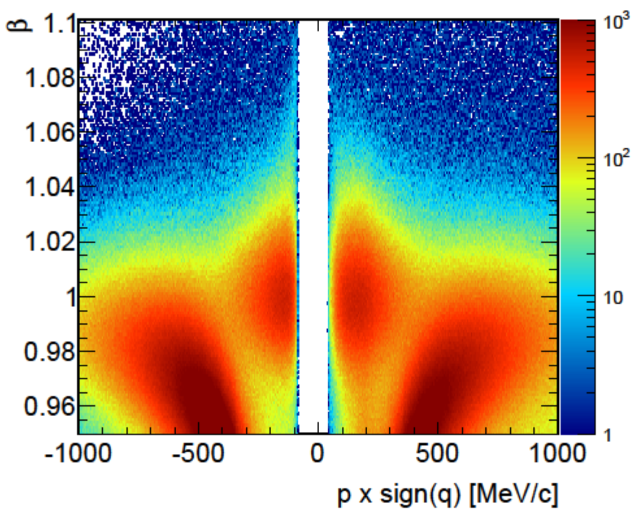


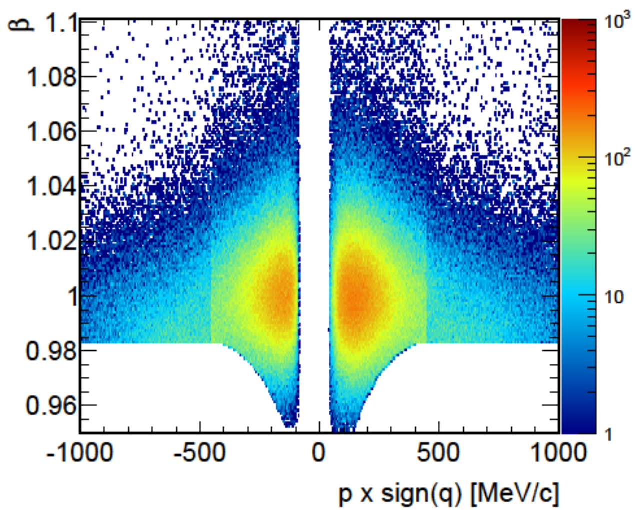
Trade-off between purity and high efficiency

Lepton ID results

Ring finder vs backtracking

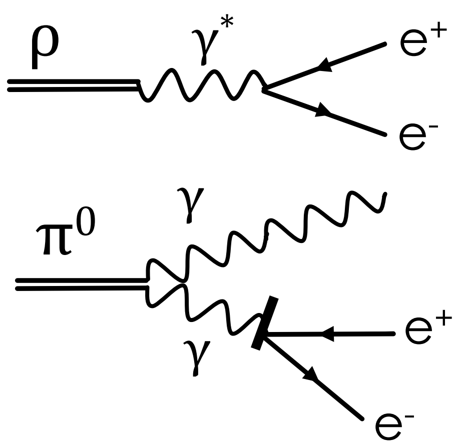






Trade-off between purity and high efficiency

Close pair rejection



- Pairing of all possible combinations
- Subtraction of same-event like-sign background:
  Geometrical mean $= 2\sqrt{N_{++}N_{--}}$

Larger background due to increased combinations

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Larger error after background subtraction

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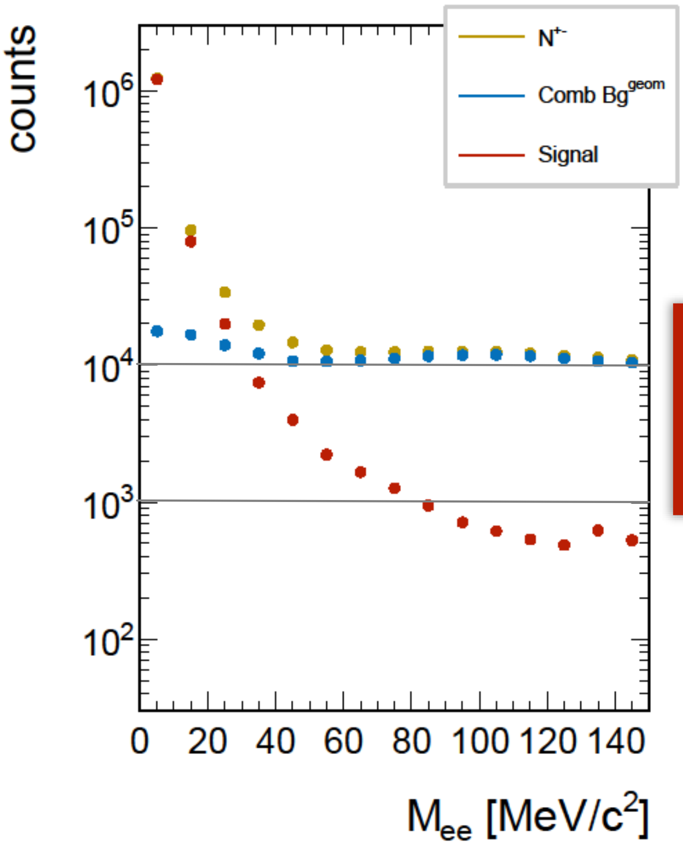
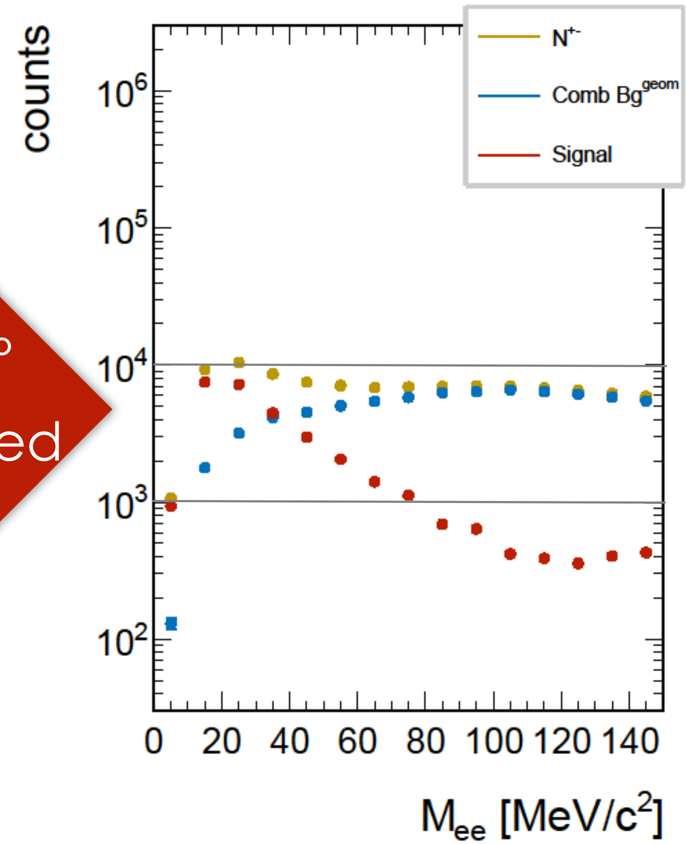
Remove conversion pairs to reduce background

Invariant mass in π^0 region



Opening angle > 5°
<10 % maxima shared



Combinatorial background reduced by factor ≅ 4

Conclusion & outlook

- Combinatorial background reduced by factor of 4
- Higher efficiency improves close pair identification → lower systematical errors
- Multi-differential analysis of invariant mass spectrum (p_T , angular distribution,…)