Backtracking algorithm for lepton reconstruction with HADES

PATRICK SELLHEIM

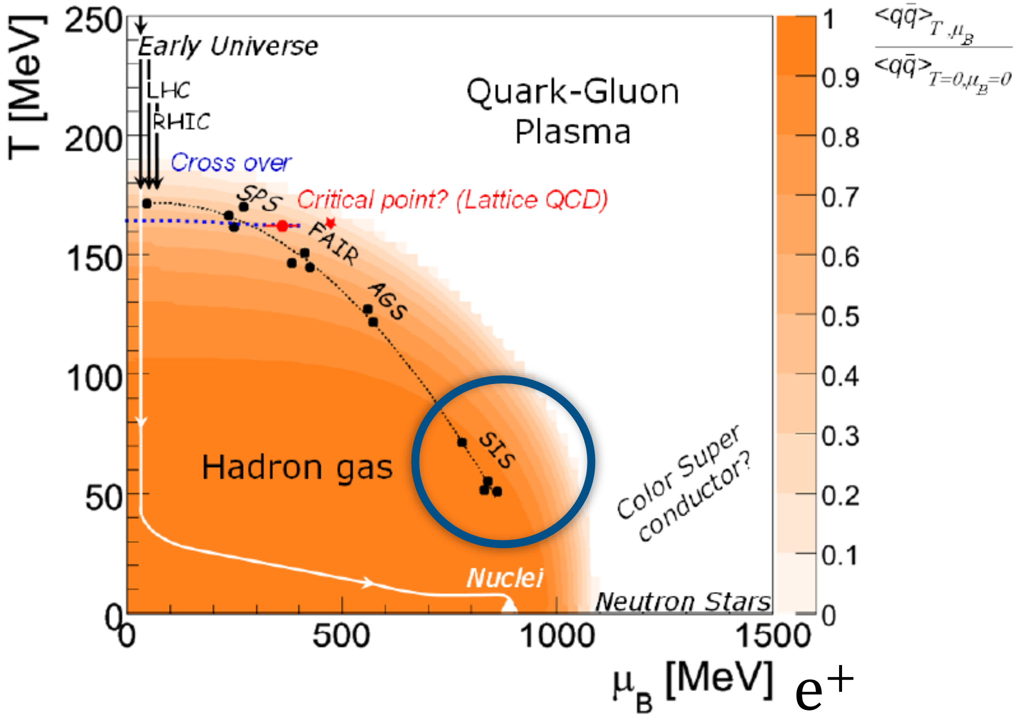
FOR THE HADES COLLABORATION

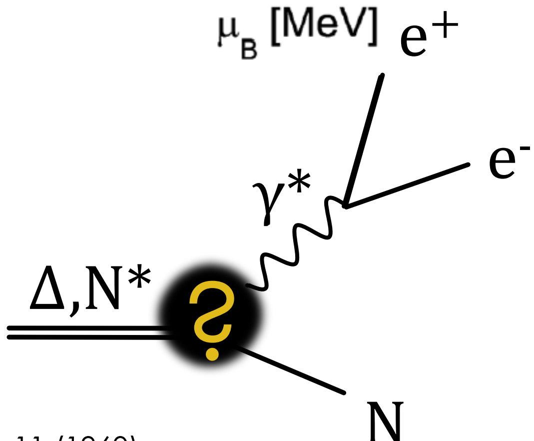
Motivation

Backtracking

Results

Motivation

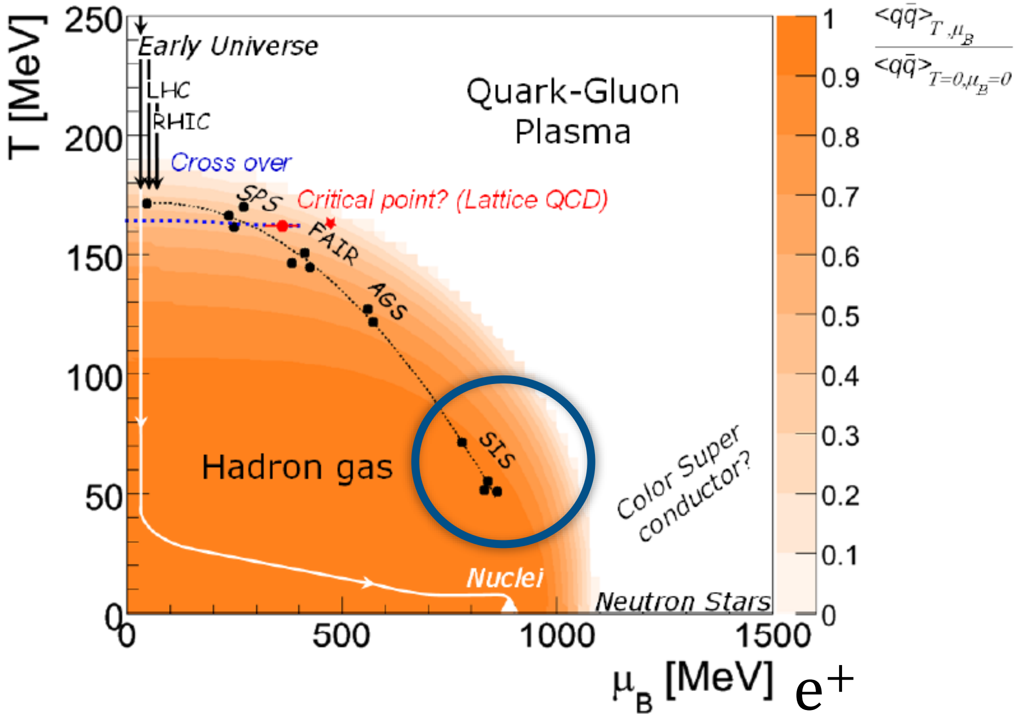




- Investigation of long lived ($\tau \approx 10$ fm/c) strongly interacting matter at T < 100 MeV and high densities ($\rho/\rho_0 > 2$)
- System is baryon dominated
- In-medium modifications of vector meson spectral functions

J. J. Sakurai, Annals Phys. 11 11 (1960)
R. Rapp, J. Wambach, Adv.Nucl.Phys. 25 (2000)
Y. B. Ivanov, V. N. Russkikh, V. D. Toneev, Phys. Rev. C 73 (2006) 044904.

Motivation



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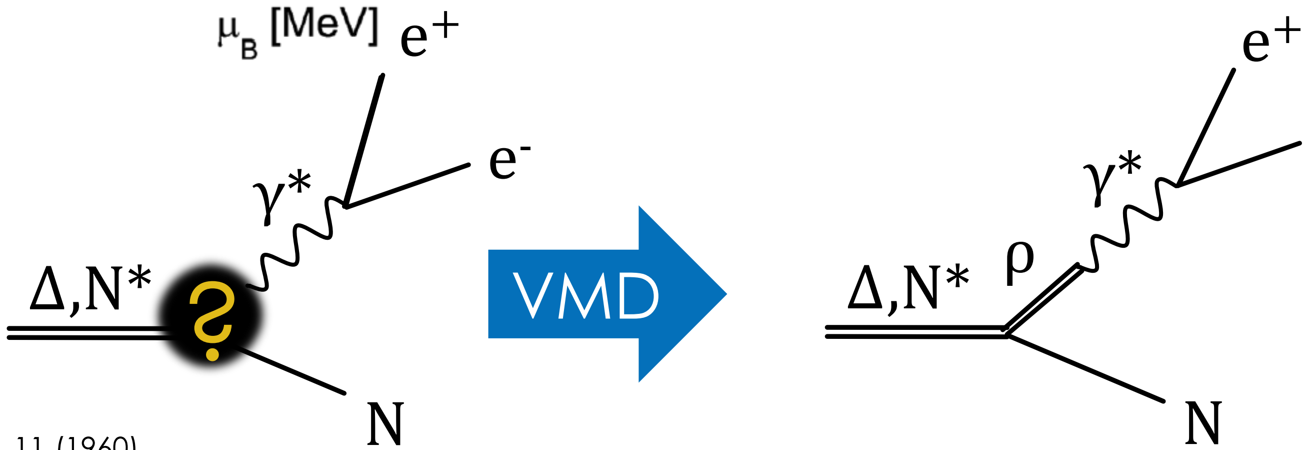

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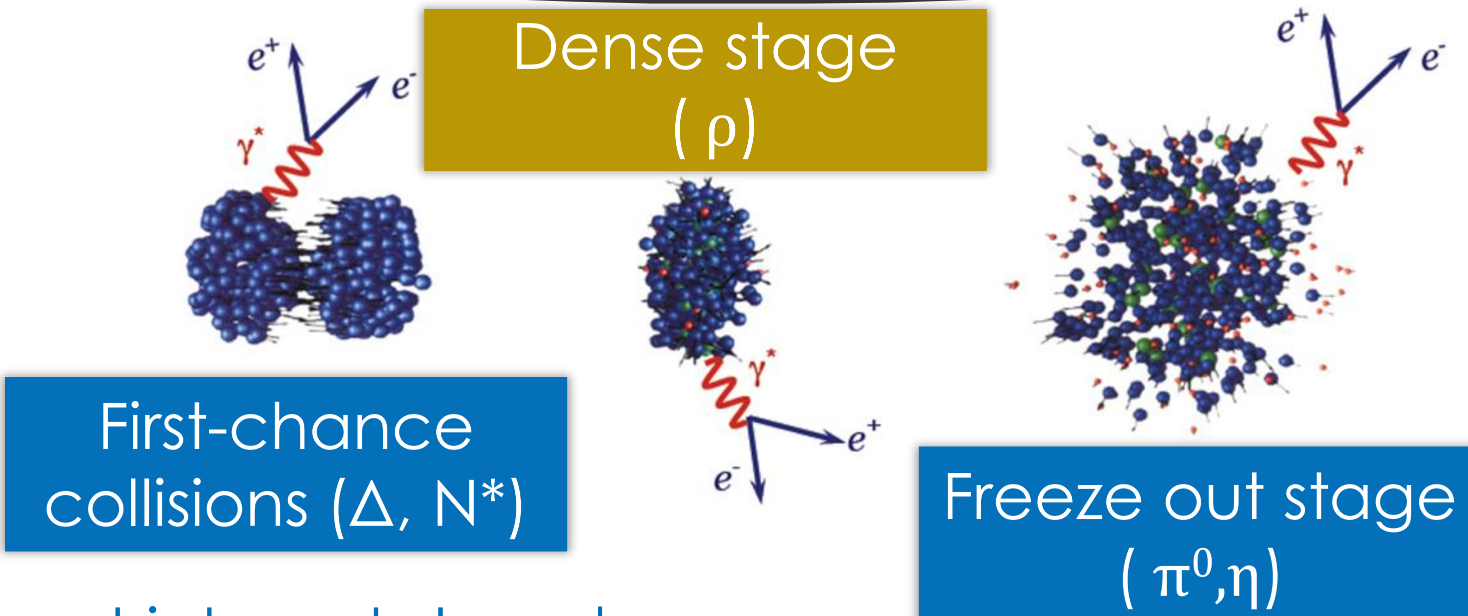
EM probes in heavy ion collisions



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

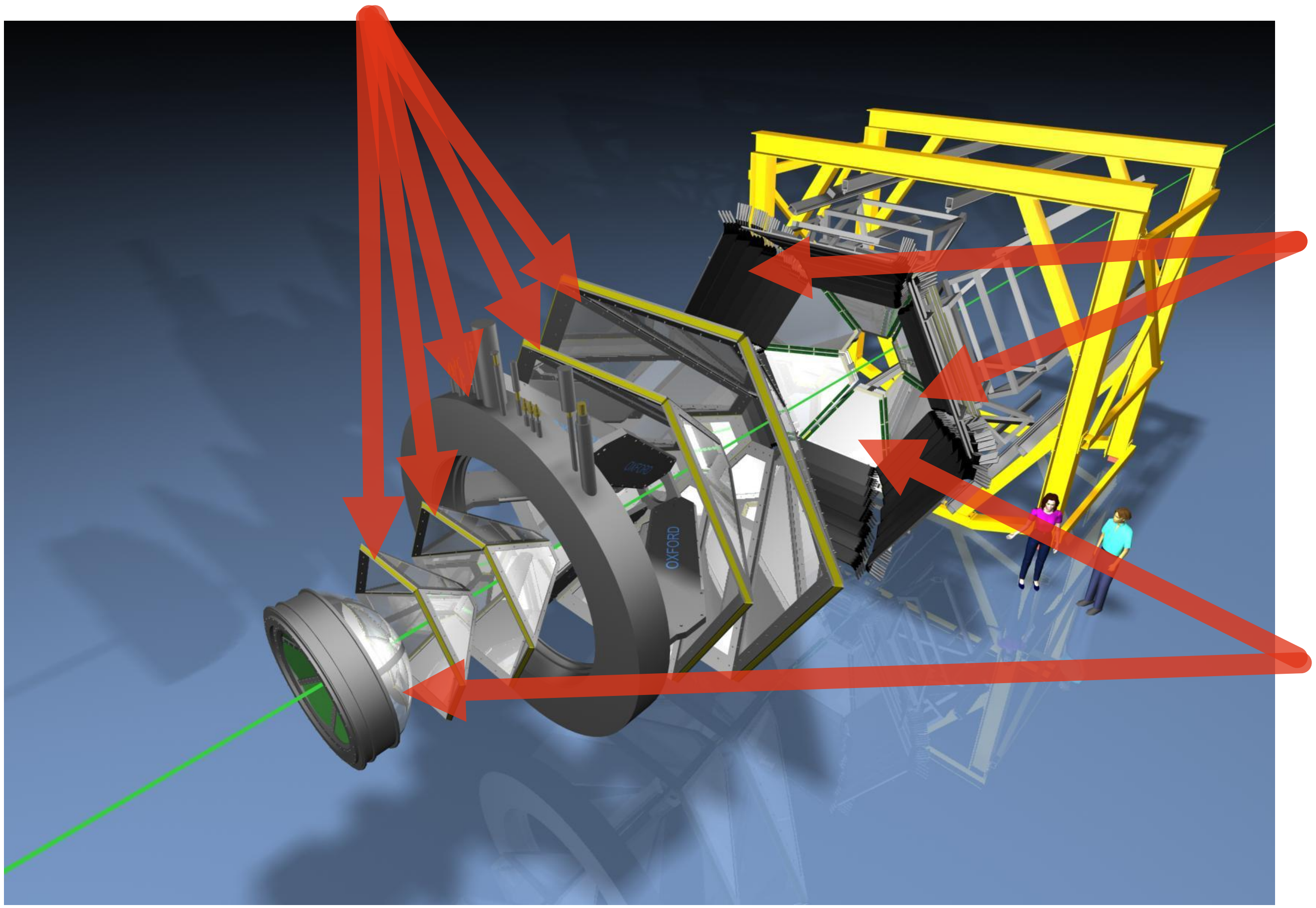
- Hadron identification by means of time-of-flight
- Electron identification using RICH and EM shower

Excellent mass resolution

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

HADES experiment

Tracking system: 4 drift chamber planes + superconducting magnet

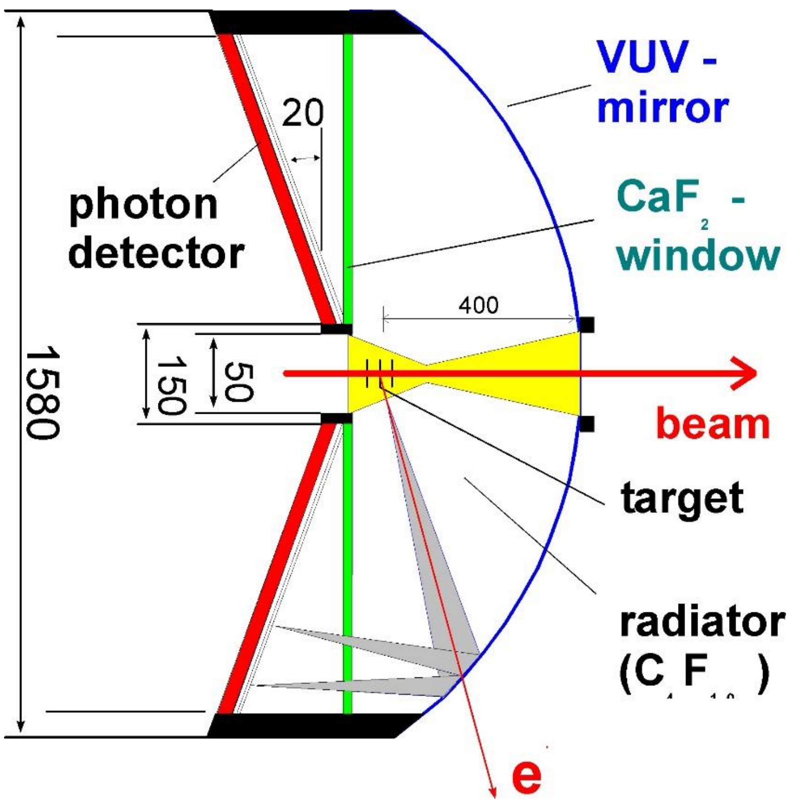


Time-of-flight detectors : RPC + TOF for hadron identification

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

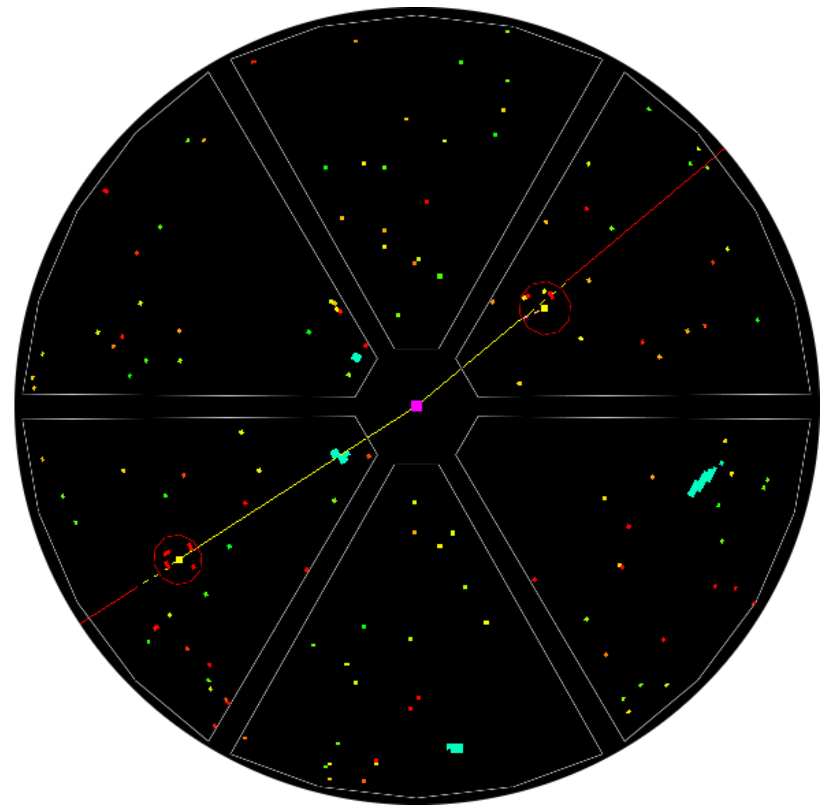
RICH ring finder

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

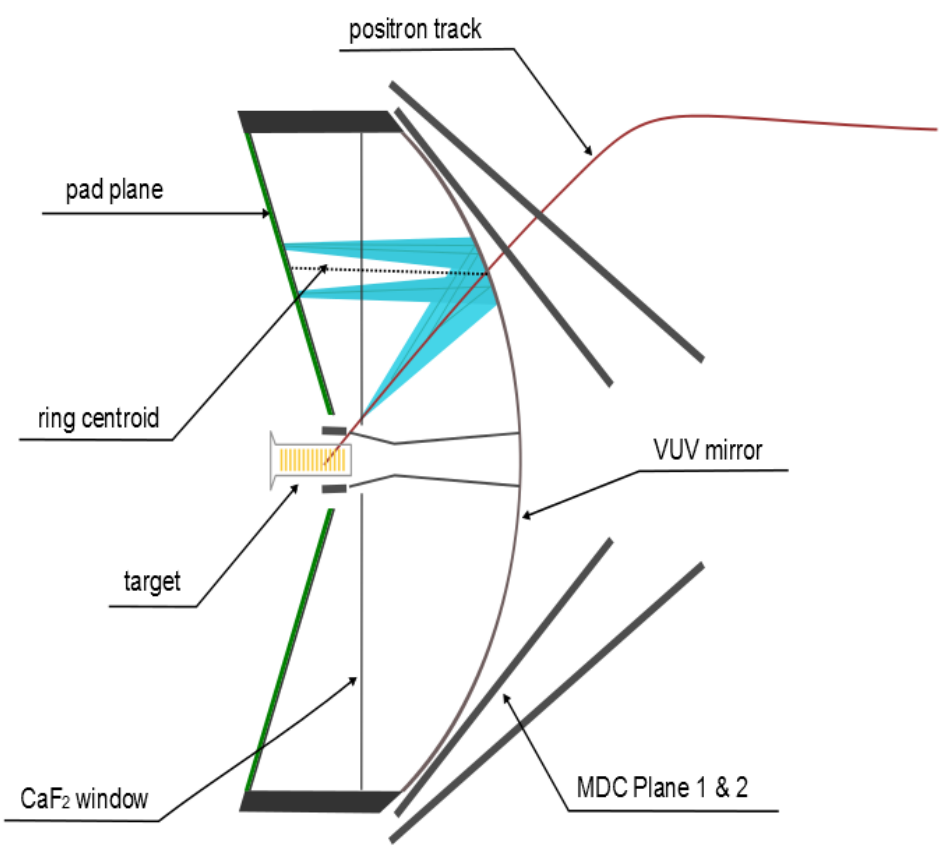
- Track resolution : Better than 2°
- Ring resolution : Opening angle > 4°

Implementation

Transformation from track angles to pad plane coordinates

Position depended parameterization of rings

Information extraction out of measured signals



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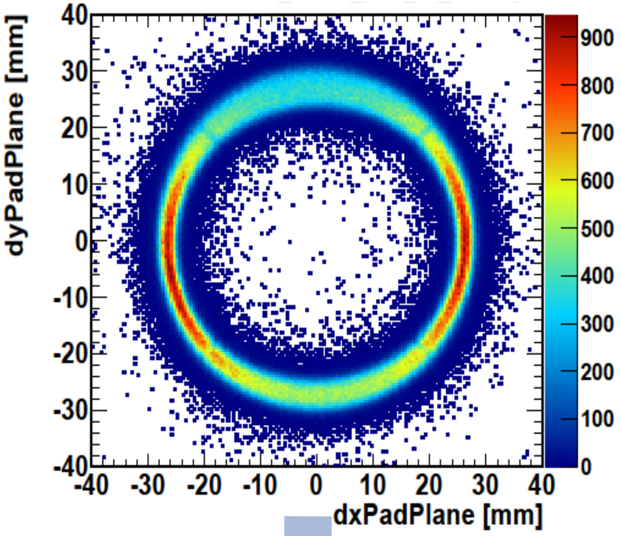

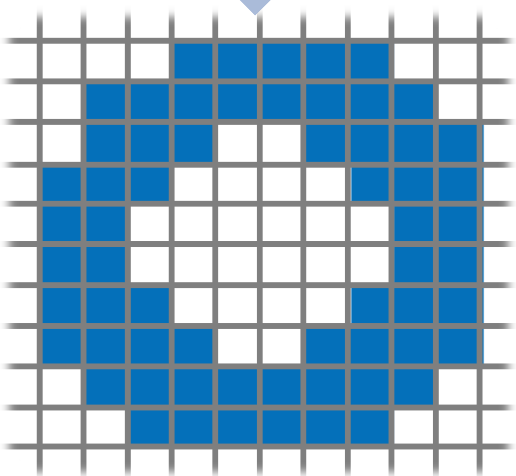

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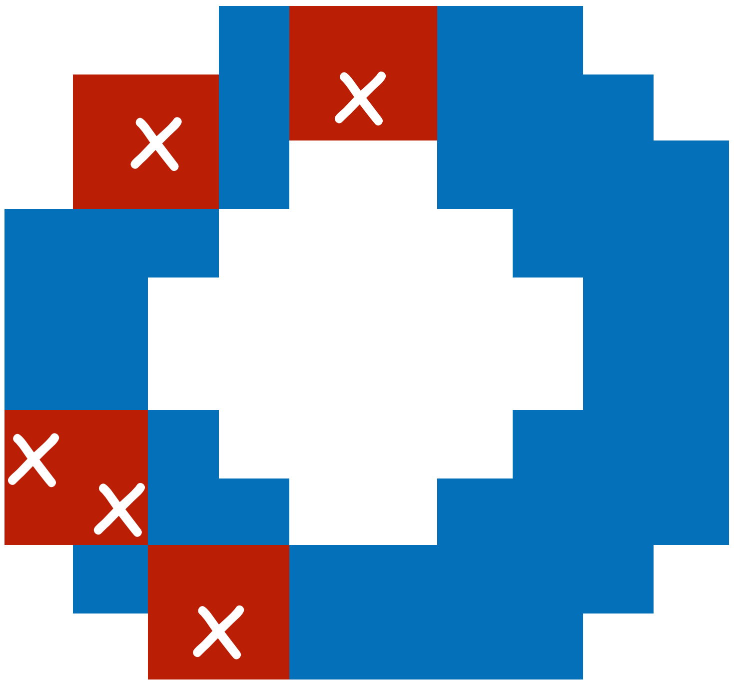


: Fired RICH pad

X : Maximum position

Motivation
Backtracking
Results

Analysis strategy

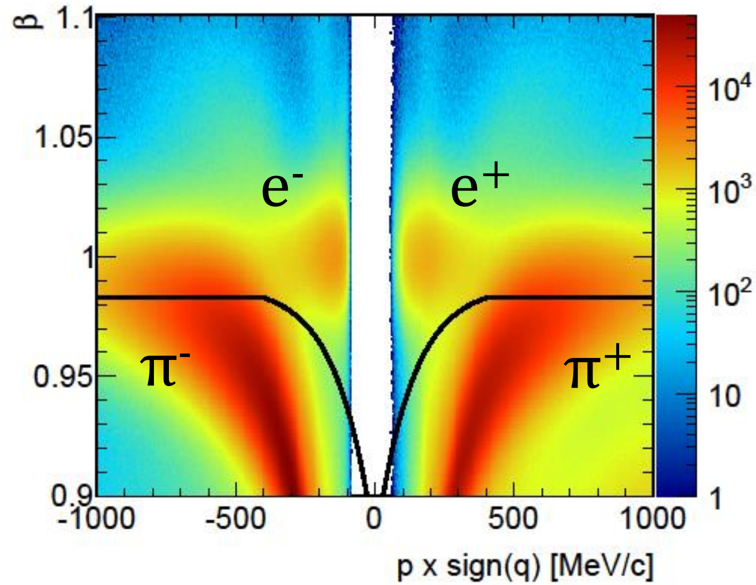
Lepton identification

↓

Close pair rejection

↓

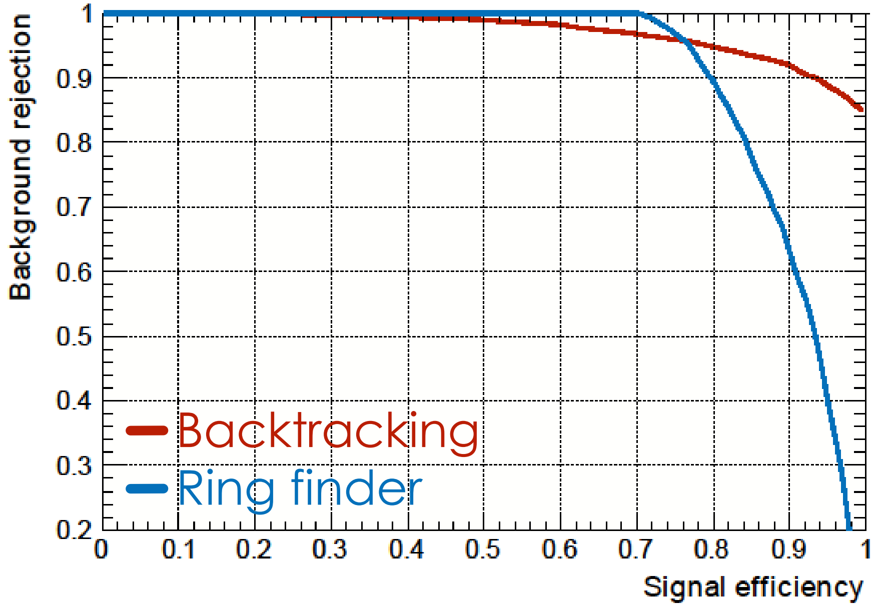
Pairing and invariant mass



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

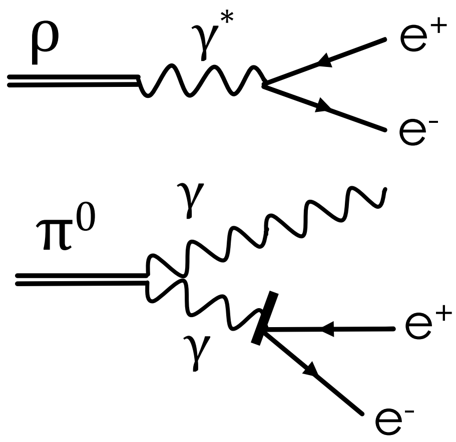
Lepton identification results

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

Larger error after background subtraction

Remove conversion pairs to reduce background

Combinatorial background

Close pair rejection

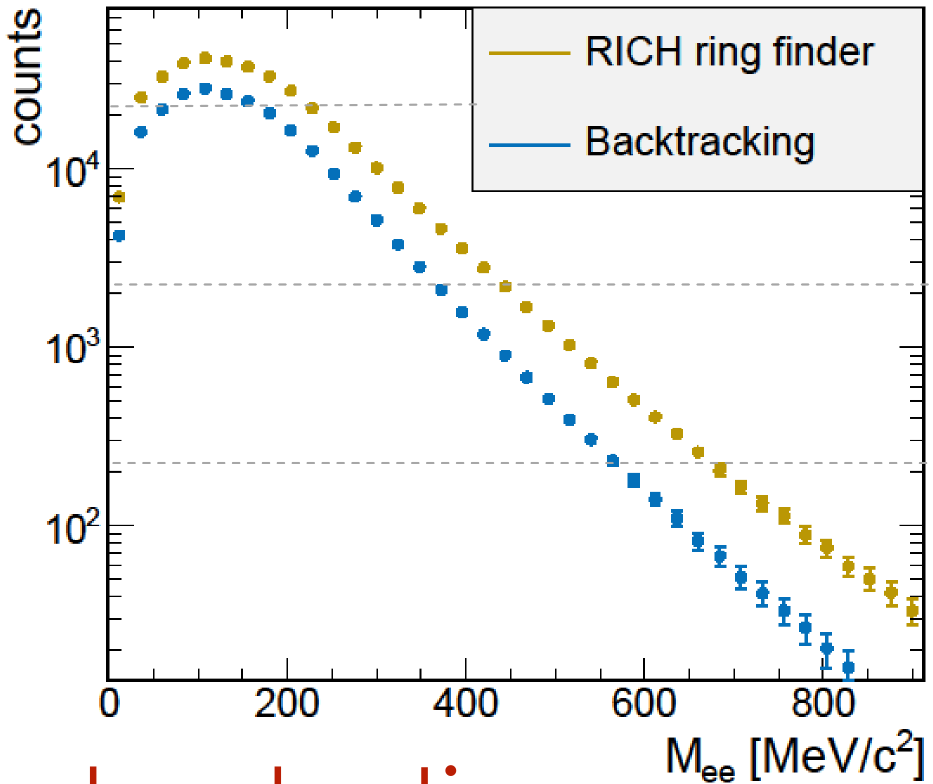
RICH ring finder

- Opening angle > 7°

Backtracking

- Opening angle > 7°
- **Rings without shared maxima**

Combinatorial background



Background reduction by up to a factor of 4!

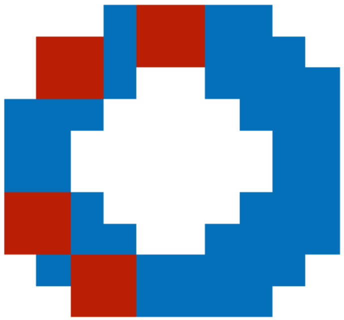
Conclusion & outlook

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

The HADES Collaboration

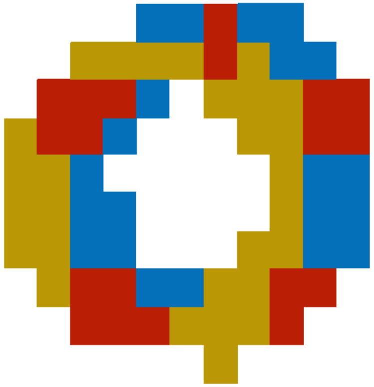
Backup

Output variables



Particle observables

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

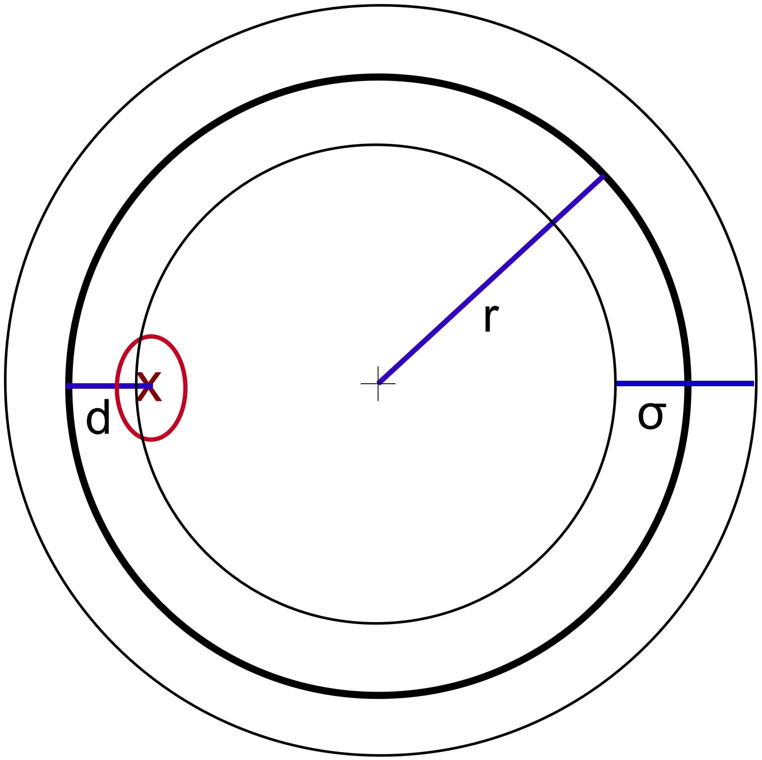


Pair observables

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

Ring quality calculation

- Calculation of distance between maximum position and ring prediction
- Ring χ^2 calculation and application



$$\chi^2_{Bt} = \frac{\sqrt{\sum^n \frac{\sqrt{\Delta x^2 + \Delta y^2}}{\sqrt{\sigma^2_{Geom} + \sigma^2_{Err}}}^2}}{n}$$

$$d = \sqrt{\Delta x^2 + \Delta y^2} \qquad n = Number\ of maxima$$

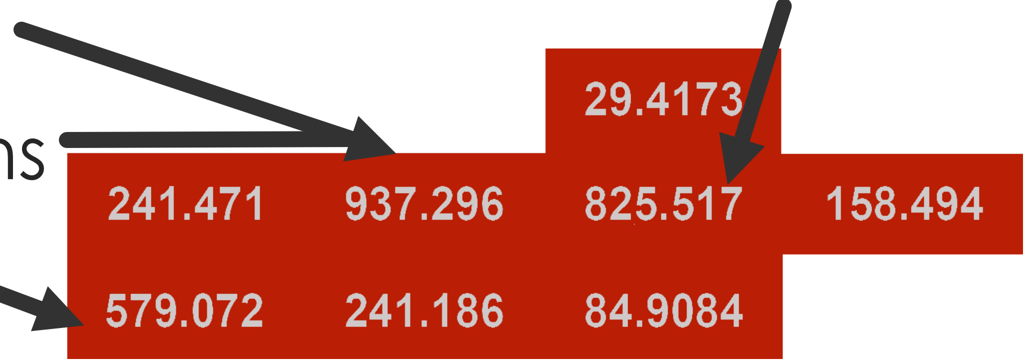
$$\sigma_{Err} = \frac{1}{2} Pad \qquad \sigma_{Geom} = Photon\ distribution\ width$$

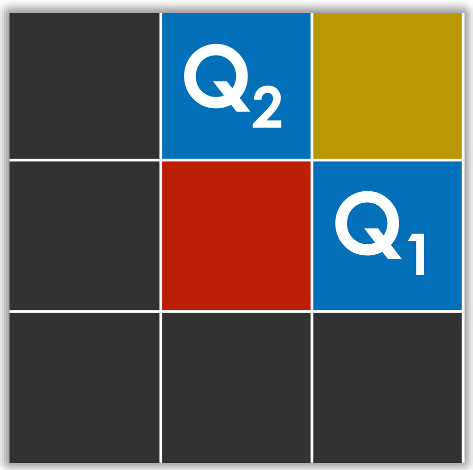
Maximum search

3. photon?

Maximum8: 1 Photon

Maximum4 : 2 Photons





Maximum 7

If $Q > Q_2$

→ Q_1 = **2. Maximum**

Analysis strategy

Neural network

Background sample

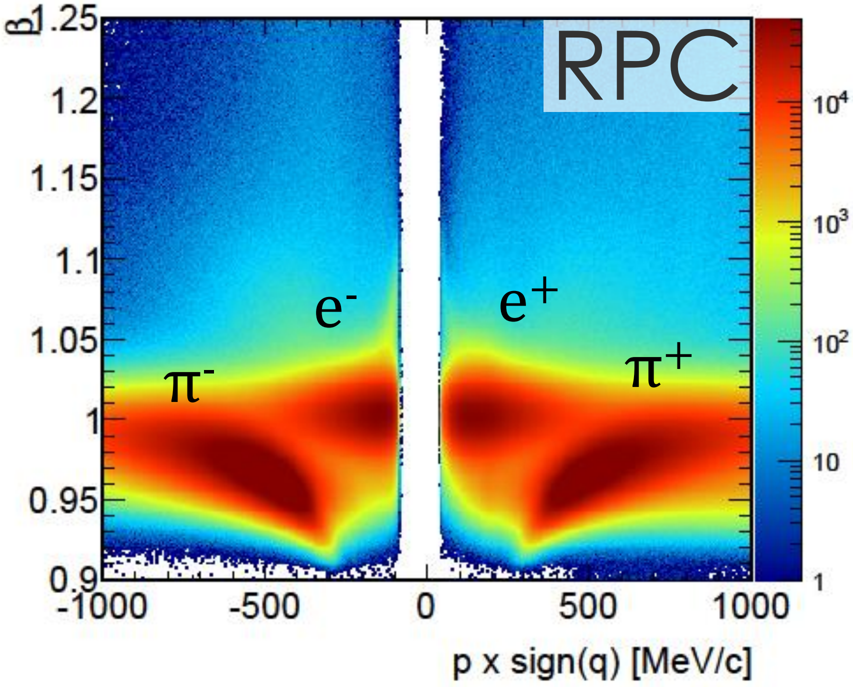
- rotated RICH data
- mass > 100 MeV/c^2

Signal sample

- Simulation with Geant PID =2,3
- Weak classifier: maxima > 0
- Strong classifier: maxima > 1

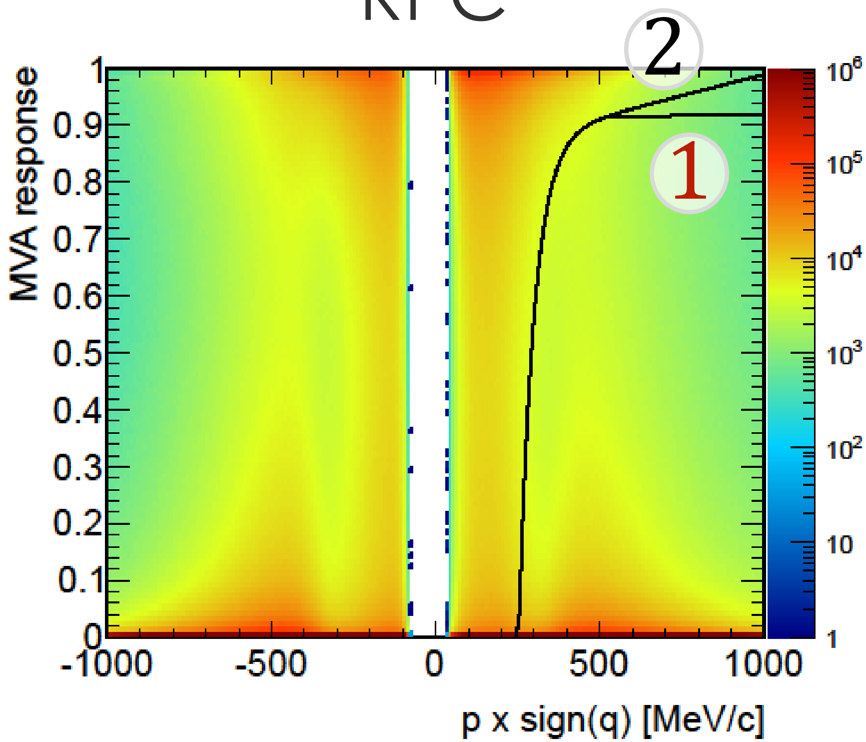
Event selection

- PT3
- GoodVertex()
- GoodStartTimeWidth()

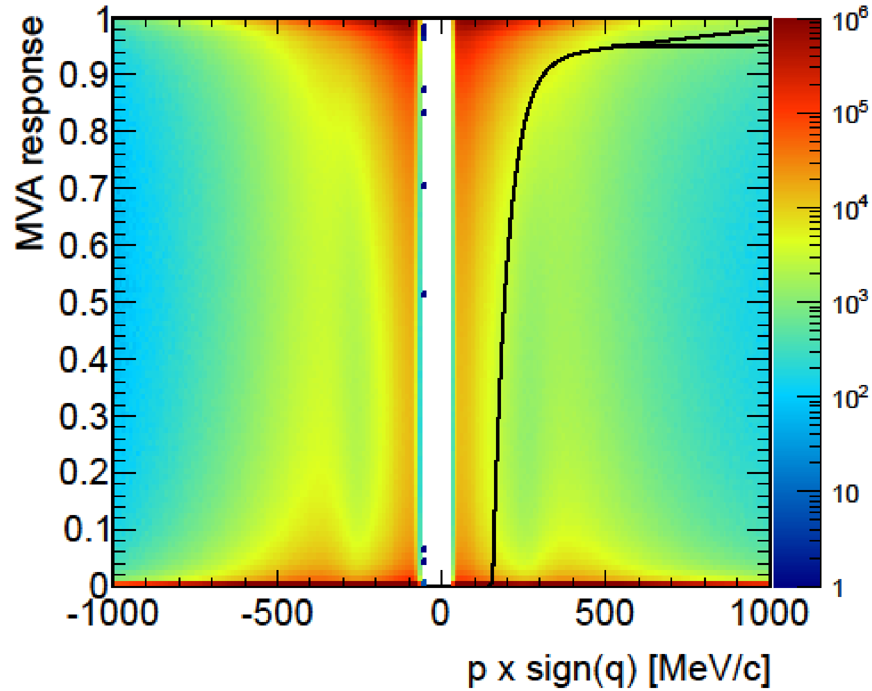


MVA response of strong classifier

RPC

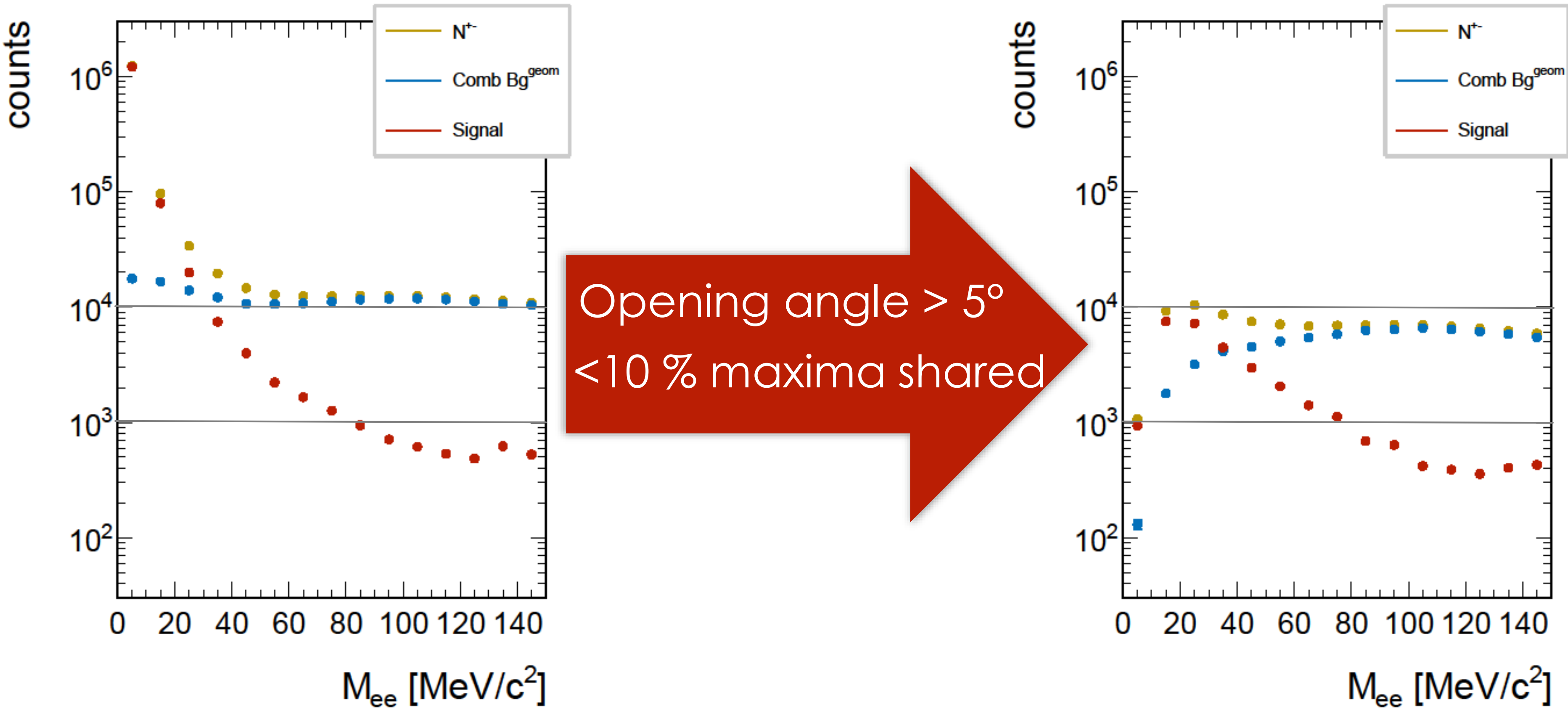


TOF



- Backtracking information
- β
- MDC and TOF dE/dx
- PreShower information
- Meta matching quality
- Φ per sector
- Runge kutta χ^2
- Charge

Invariant mass in π^0 region



Combinatorial background reduced by factor ≅ 4