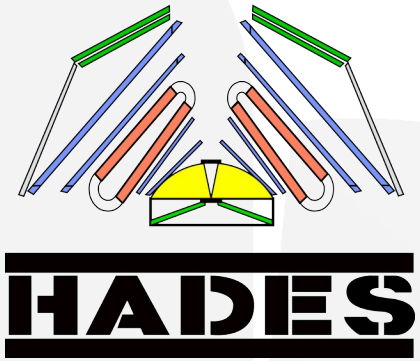
Towards polarization analysis of dielectrons produced in Ag+Ag at 1.58A GeV



Why Angular Distribution and Polarisation ?

In Helicity Frame HX' : virtual photon rest frame

$$\lambda_\theta^{\mathrm{HX}'}(M,|\vec{q}|) \underset{m_l \ll M}{\cong} \frac{\varrho_\mathrm{T}-\varrho_\mathrm{L}}{\varrho_\mathrm{T}+\varrho_\mathrm{L}}$$

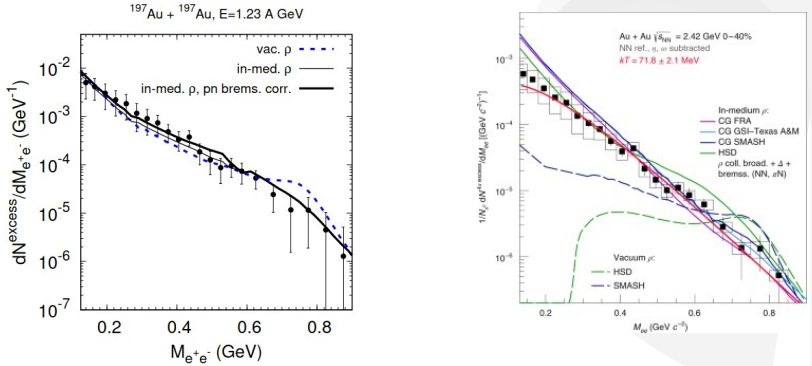
Integrated 1D analysis

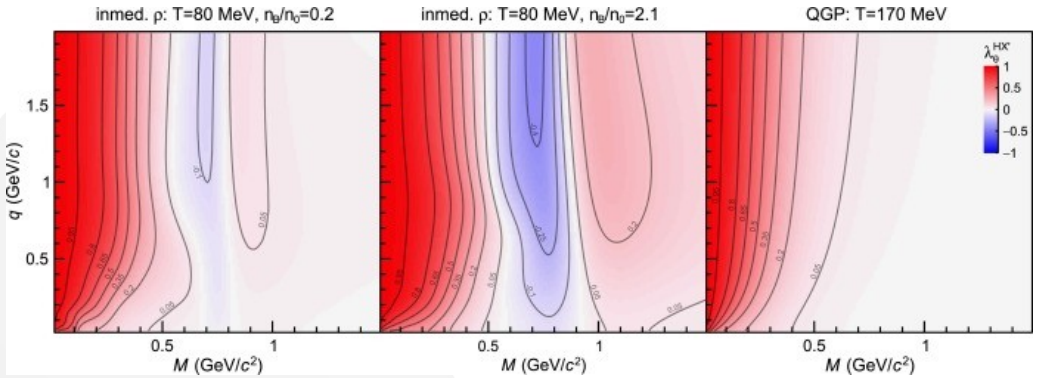
Angular distribution for dilepton decays :

$$\frac{dN_{ll}}{d^4x\ \mathrm{d}^4q\ \mathrm{d}\Omega_l} = \frac{1}{\lambda_\theta+3}(1+\lambda_\theta\cos^2(\theta_l) + \lambda_\phi \sin^2(\theta_l)\cos(\phi_l)+\lambda_{\theta\phi}\sin(2\theta_l)\cos(\phi_l)+\lambda_\phi^\perp \sin^2(\theta_l)\sin(2\phi_l)+\lambda_{\theta\phi}^\perp \sin(2\theta_l)\sin(\phi_l)$$

Anisotropy parameter λ_θ related to transverse and longitudinal polarization
Can be used to discriminate between different production mechanism :

Temperature and density dependent →
Comparison with transport model





HADES Collab : Probing dense baryon-rich matter with virtual photons, Nature Physics

Larionov et al. : Dilepton production in microscopic transport [...] , Phys Rev C

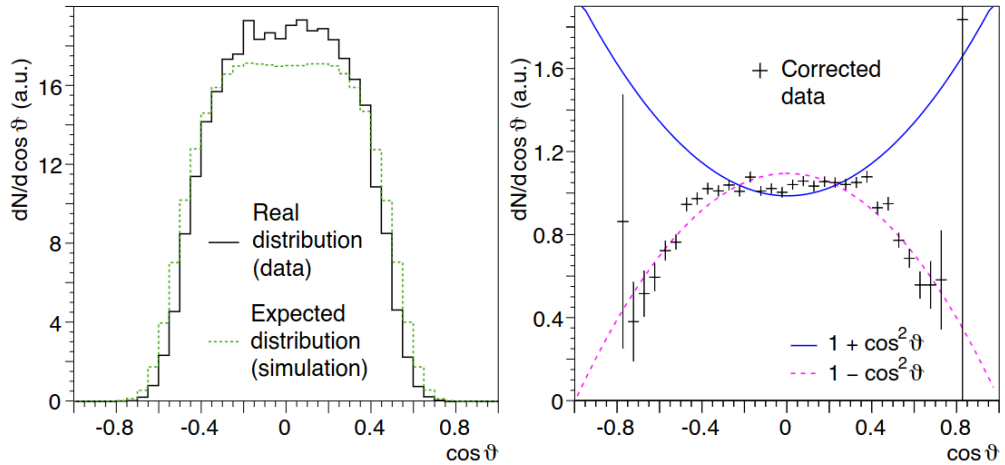
Florian Seck et al. : Polarization of thermal dilepton radiation Phys Letters B

A sensitive Observable

Angular distribution is a very sensitive observable to Acceptance / Efficiency correction

Extracted anisotropy parameter λ_θ is heavily dependent and can vary from +1 to -1 with small differences in correction

A very realistic correction is needed : Comparison of efficiency correction between different simulations White / PLUTO / SMASH



P Faccioli et al : Particle Polarization in High Energy Physics: An Introduction and Case Studies on Vector Particle Production at the LHC : 10.1007/978-3-031-08876-6

Event Selection and Sorter

- kGoodVertexClust
- kGoodVertexCand
- kGoodStart
- kNoStart
- kNoVeta
- kGoodStartVeto
- kGoodStartMeta
- kGoodTrigger
- kNoFlashMDC
- NstartCLuster < 5

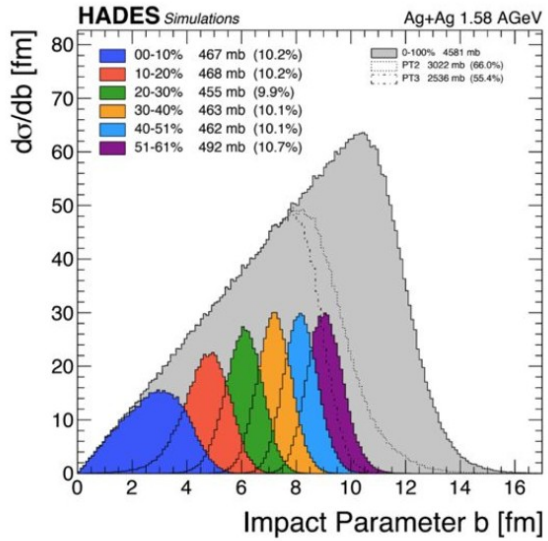
Generation 6

Centrality selection : 0/40%

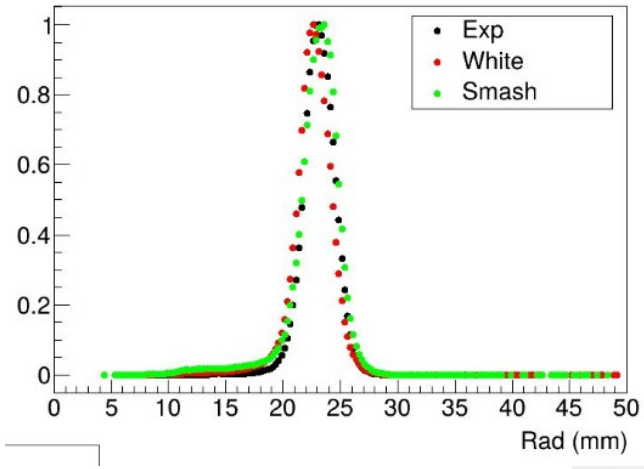
kIsLeptonSorter : default

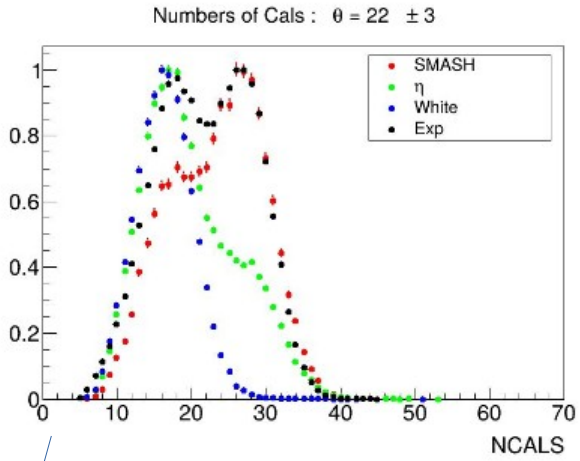
HParticleAngleCor : angular correction

HEnergyLossCorPar : Energy loss correction

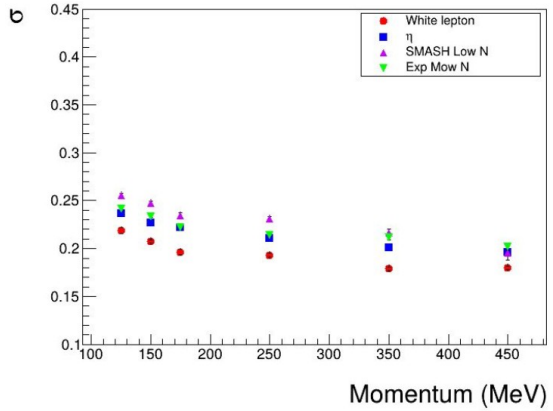


Lepton Selection : Last collaboration meeting reminder





σ of the Δθ ($\theta_{MDC} - \theta_{RICH}$) ring matching track distribution



RICH Ring radius cut :

$-2\sigma < R-\mu < 2\sigma$

$19 < R < 27$ mm

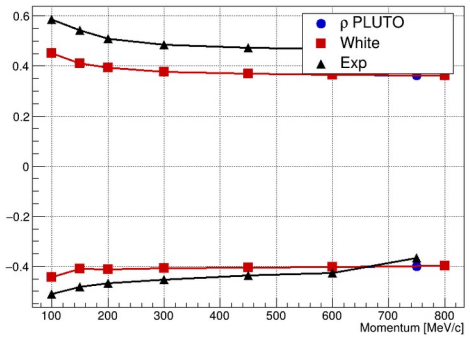
2σ cut of first peak as function of θ

Change to usual method :

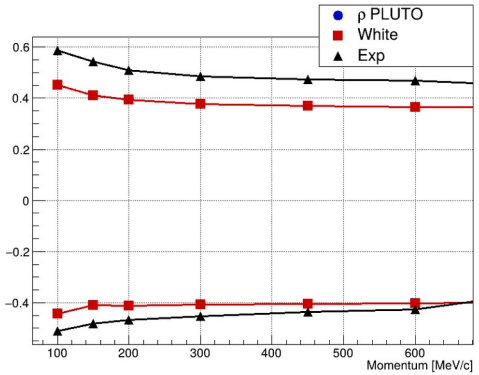
Number of fired Pads in 2*Radius region instead of number of fired Cals per ring

Simulations with close pairs can reproduce quite realistically rich observables from data

PID : updated θΔ,Δφ 90/95 %



90% interval interval cut :
Δθ/e+ /high θ



90% interval interval cut :
Δφ/e- /low θ

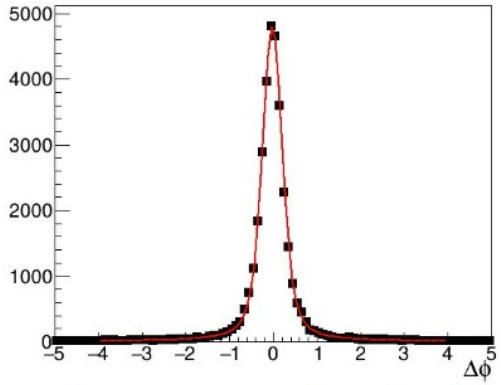
- More accurate PID selection for efficiency correction
- Weak OA effect on distribution

Δθ / Δφ : difference of angle between matching track and ring
Non Gaussian behavior of distribution :

$$f(x) = C + A.e^{(\frac{x-\mu}{2\sigma})^{2-\tanh(\sqrt{2}.\lambda.|\frac{x-\mu}{2\sigma}|)}}$$

λ : tail parameter of distribution

Fit done in charge (e+/e-), momentum and angular bin : 2 * 8 * 2



Δφ :

300 < p < 400 MeV

45 > θ > 16

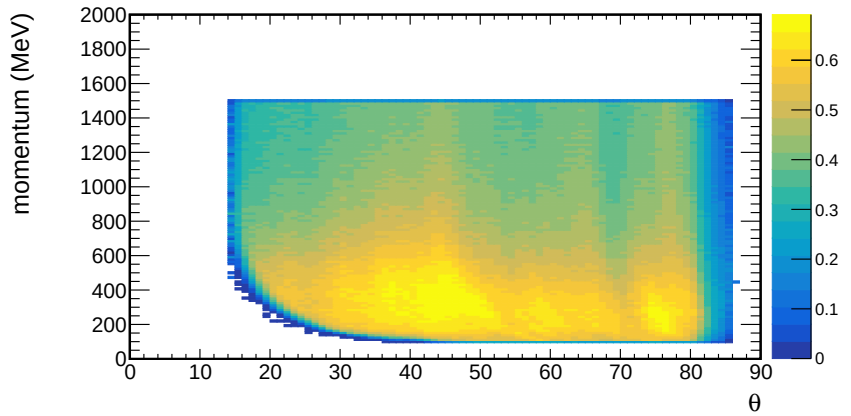
Efficiency correction

White lepton embeded into GEANT 3 simulation of HADES experimental setup :

Uniform phase space filling (p,θ,φ) BUT (with no opening angle correlation)

- $\mathrm{Acc}(\theta,\phi,\mathrm{p}) = \dfrac{N_{Acc}(\theta,\phi,p)}{N_{4\pi}(\theta,\phi,p)}$
- $\mathrm{Eff}(\theta,\phi,\mathrm{p}) = \dfrac{N_{Rec}(\theta,\phi,p)}{N_{Acc}(\theta,\phi,p)}$

- $p_{e+} > \exp(-0.135\,\theta + 8.3) + 100$
- pcand->isAtAnyMdcEdge()



Positron efficiency matrice 2D (mom,θ) projection

Self Consistency test

- In order to know if efficiency correction is correct one needs to use a self consistency test with other simulations : PLUTO Cocktail / SMASH
- Particles are filtered on the GEANT kine level
- In Acceptance from kine : Smeared Momentum
- Reconstructed : Efficiency corrected with white leptons matrices after PID selection

Ratio of (M_{ee},OA) distribution

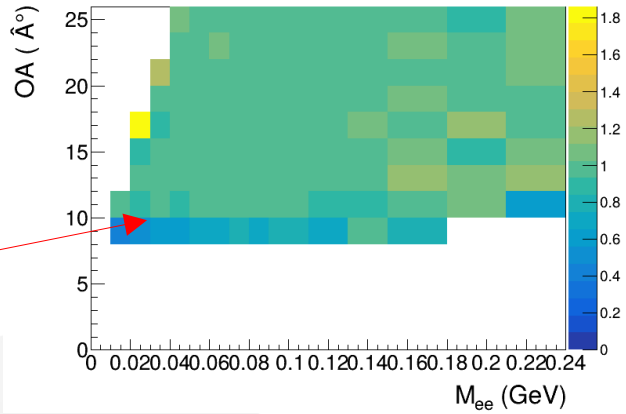
If PID selection and efficiency correction it should be near 1

Self Consistency test : PLUTO cocktail

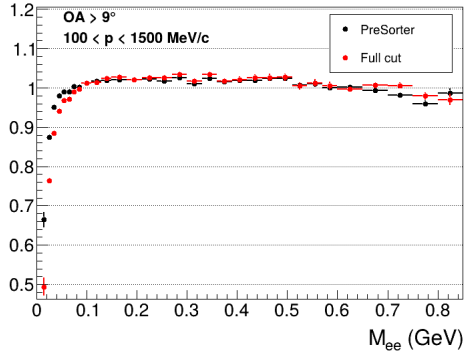
OA kine > 9°

OA / M_{ee} self consistency test for full cuts

Drop at 9°



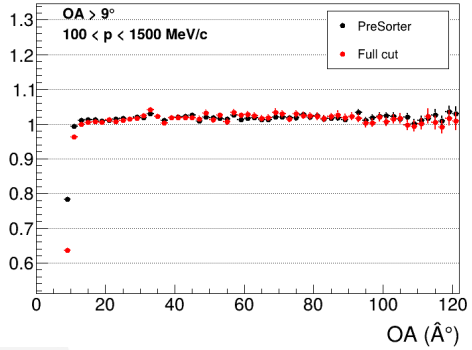
1D M_{e+e-} projection



Efficiency reconstruction is badly reproduced at low OA and Invariant Mass which are two correlated observables

- Close Pairs near the cut value of 9° are wrongly corrected
- Loss of efficiency reconstruction
- Expected as white leptons do not simulate them
- PreSorter is also impacted which show it doesn't depend on PID

1D OA_{-} projection

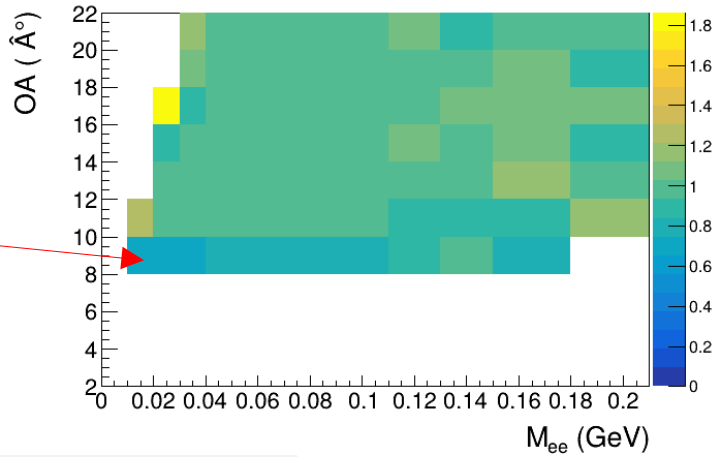


Self Consistency test : PLUTO cocktail

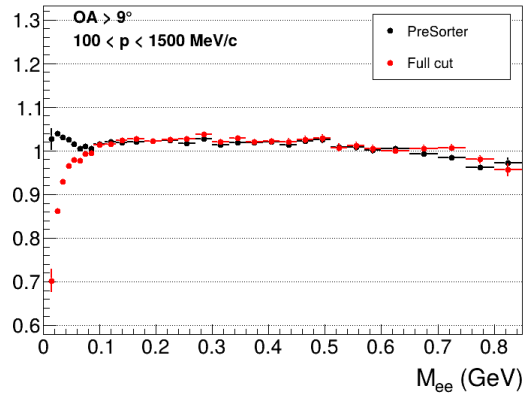
OA kine > 0°

OA / Mee self consistency test for full cuts

Drop at 9°



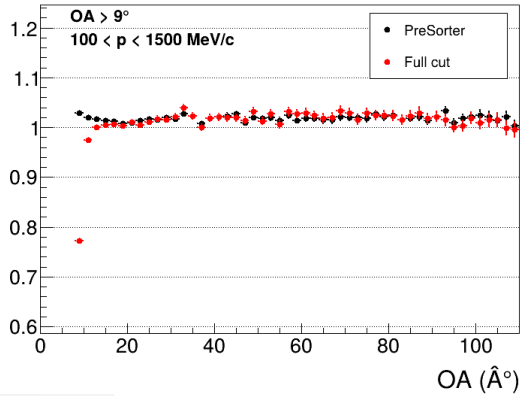
1D M_{e+e-} projection



- Without OA restriction from kine level, PreSorter gets a better consistency
- Angular reconstruction resolution plays a role : Real Opening Angle are smeared, pairs with OA < 9° are reconstructed with an OA >9°
- Multiple effects add up : Angular resolution, loss of efficiency reconstruction

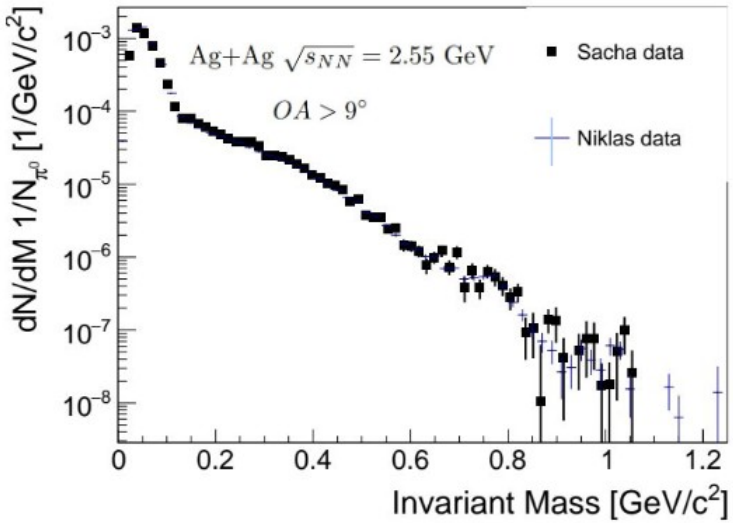
  ----> Apply the self consistency test as an <u>additional correction factor</u>

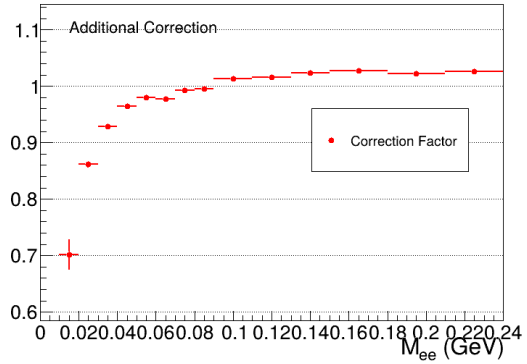
1D OA_{-} projection



Correction factor

Use self consistency factor as an additional efficiency factor (OA or Mee dependent)





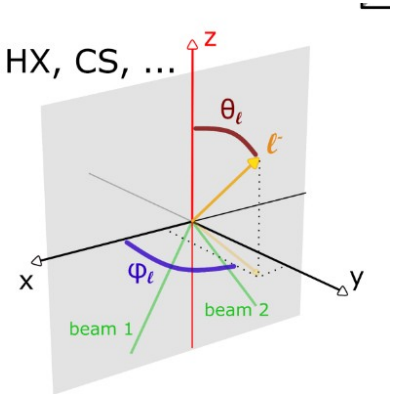
If (M_{ee} > 100 Mev/$c^{2)}$: factor =1

For invariant mass, the additional factor effect lies within the systematic uncertainties but might have an effect on Polarization

π^0 Invariant Mass region as a baseline for validation of polarization extraction

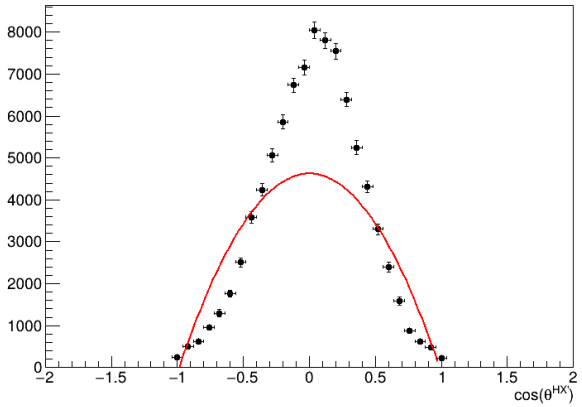
Angular distribution 1st attempt

Angular distribution in Helicity Frame process :



Boost Dileptons pairs → Center of Mass frame → Define virtual photon z axis → Boost to virtual photon reference frame

θ defined along z Axis of virtual photon and perpendicular plane (x,y) axis



Efficiency corrected $dN/d\cos(\theta^{HX'})$ distribution :

- No Background Substraction
- No Acceptance correction
- Nonphysical ƛ value

Summary

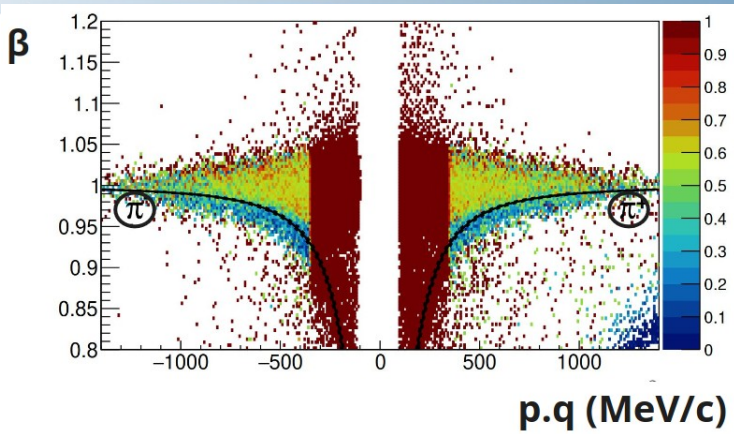
Summary :

- Improved Lepton selection
- Additional efficiency correction factor
- Systematic effects on Invariant Mass and (S+B) angular distribution in helicity frame

Outlook :

- Background substraction ? (θ,φ,M_ee) from lab or from helicity frame ?
- Hypothesis validity of boosting to rest frame ?
- Try unbiased efficiency/acceptance anisotropy parameter extraction

PID : updated β / Momentum*Charge



Ratio of RPC β/mom*charge distributions filtered through ECAL

Gaussian fit in momentum bins for β width

Better controlled efficiency correction