Analyzing HBD Data

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PHENIX Focus

2011.03.29

Plan

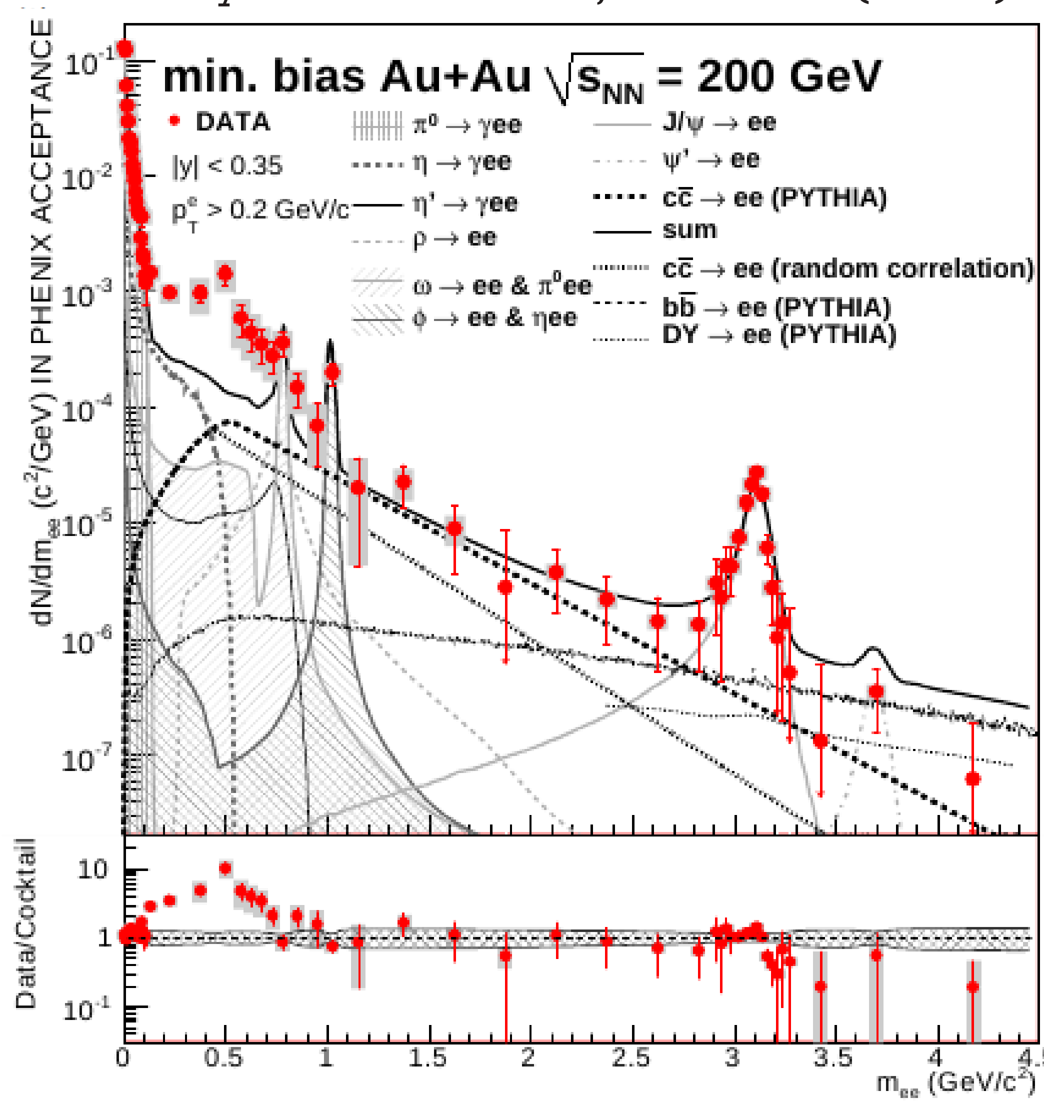
- Physics motivation
- Overview of HBD hardware
- Analyzing HBD Data
  - Monte-Carlo
  - p+p collisions
  - Au+Au

Physics Motivation

Physics motivation: Di-electrons

- QGP (Au+Au/d+Au/p+p)
  - Heavy mesons (J/Ψ) and open charm (Au+Au)
    - Au+Au deconfinement in QGP, Initial state effects
  - Light mesons (ω, φ)
    - Chiral symmetry restoration → in medium modification of mass and width, flow
  - Direct photons
    - Temperature of QGP
- Spin physics (p+p)
  - J/Ψ spin asymmetry

Phys. Rev. C 81, 034911 (2010)



Di-electron spectra in PHENIX

- Pros
  - Very good eid with RICH and EMCal
  - 1% momentum resolution at φ region
  - Excellent triggering (for high rate p+p events)
  - Low material budget (→ Little conversion background)
- Cons
  - Limited acceptance
    - π^0 Dalitz and conversion (dominant source of electrons), only one leg
    - Foreground spectrum is dominated (200:1 at the worst points) by combinatorics

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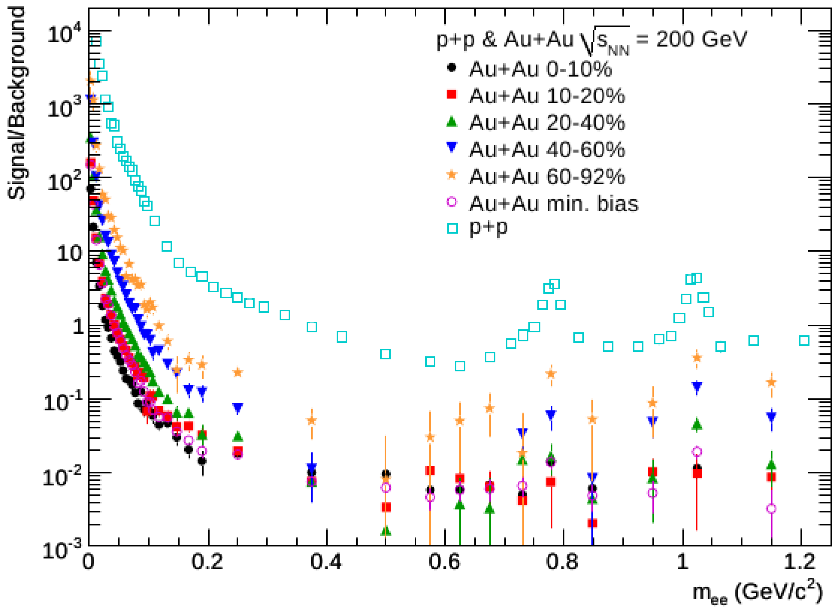
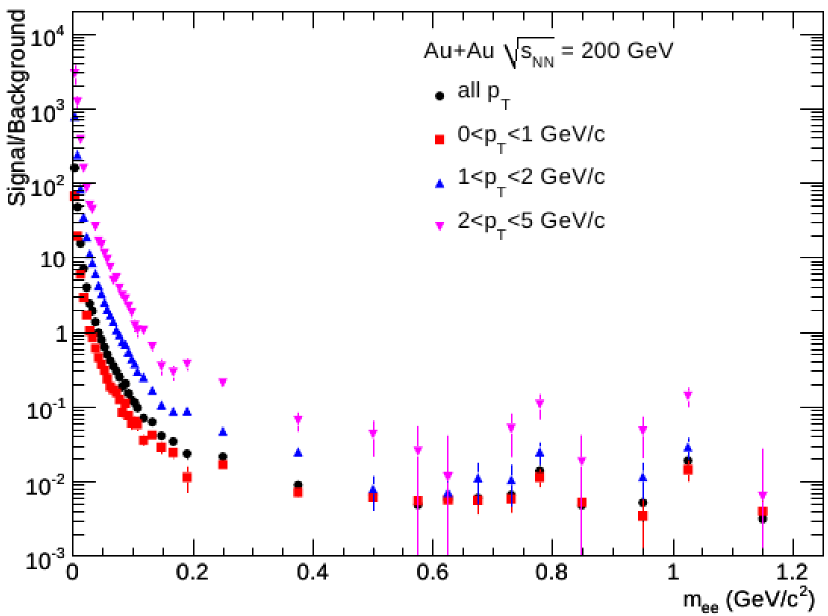
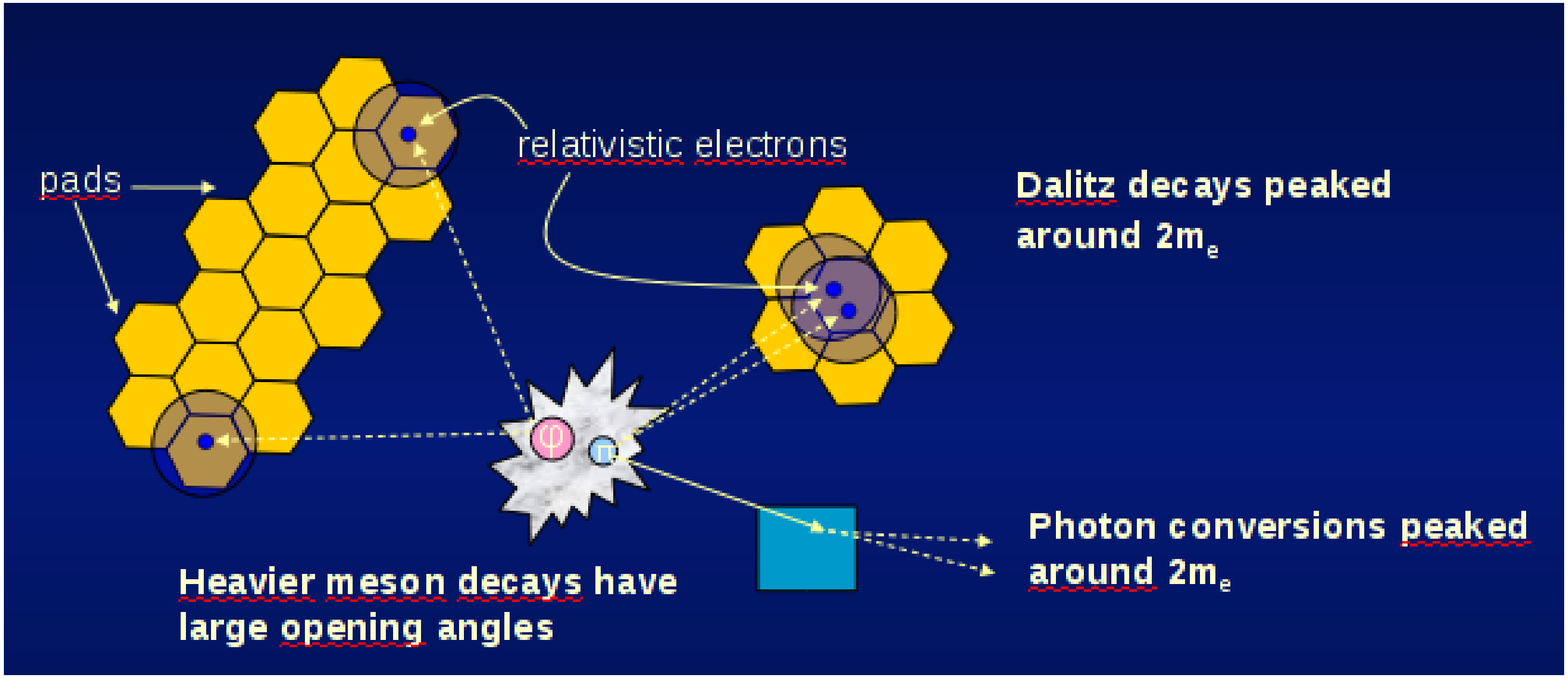




Overview of the HBD

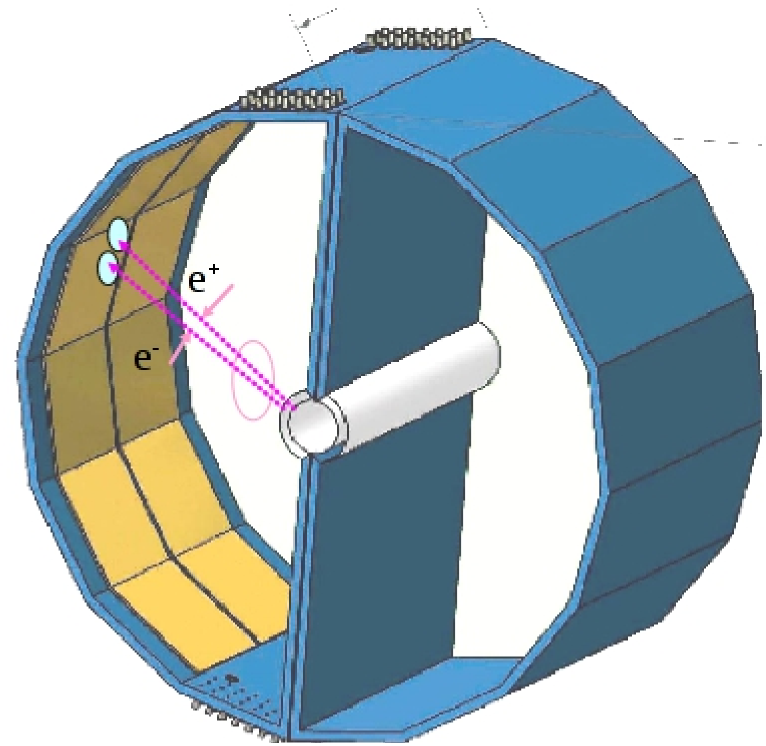
The Hadron Blind detector concept

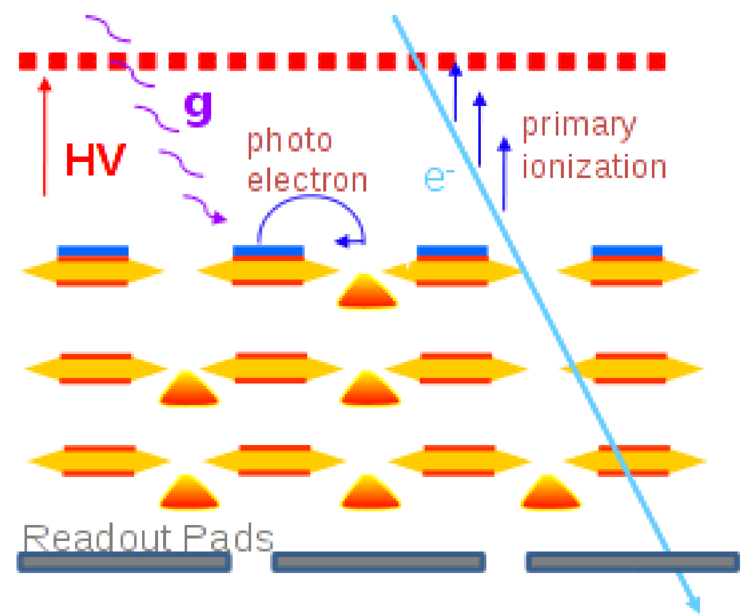
- Reduce combinatorial background
  - Identify Dalitz and conversion electrons even if only one leg reconstructed.
  - Exploit small opening angle: Field free region up to active surface of HBD
  - Signal electrons leave single hit amplitude and background electrons leave double hi



HBD design

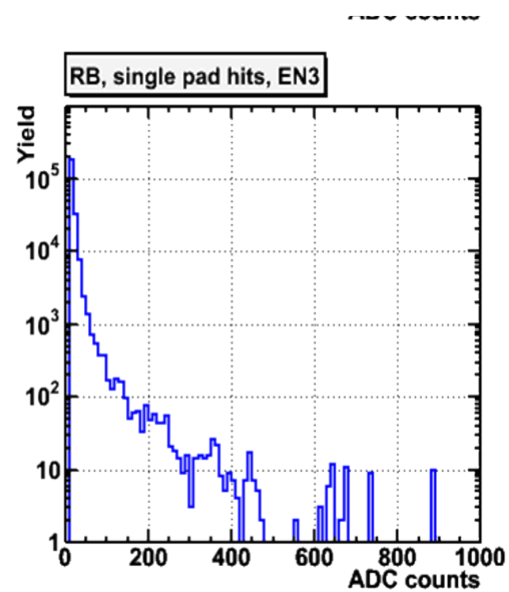
- Windowless proximity focusing Cerenkov detector
- Both radiator and GEMs operated using pure CF_4 (n=1.00062,L_{RAD} =50cm) in the same enclosure (<1ppm H_2O/O_2)
- Cerenkov from electrons forms blobs (r~3.36cm, a~9.9cm^2) on image plane
- 3 stage amplification:
  - Triple GEM stack with CsI coating on the top surface of 1^{st} GEM foil.
  - 1.5mm transfer gaps with total gas gain of 5000 for a moderate bias
- Anode read out: Hexagonal pads of side ~1.55cm (a~6.2cm^2)
- Hadron blindness: Reverse biased mesh, on top of GEM stack collects primary ionization from charged hadrons.
- Operated successfully in 09 (p+p) and 10 (Au+Au)

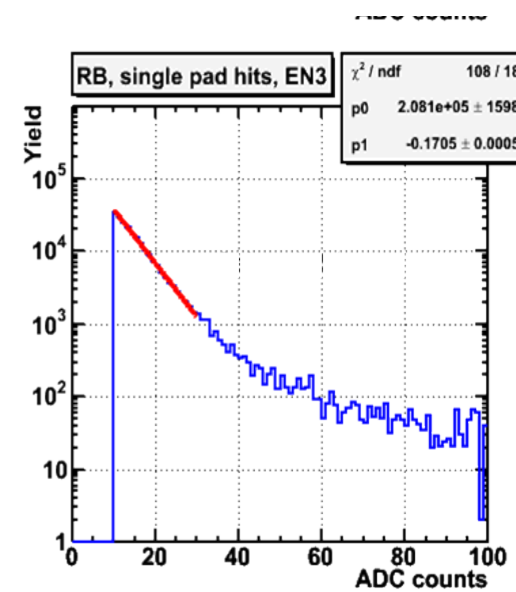


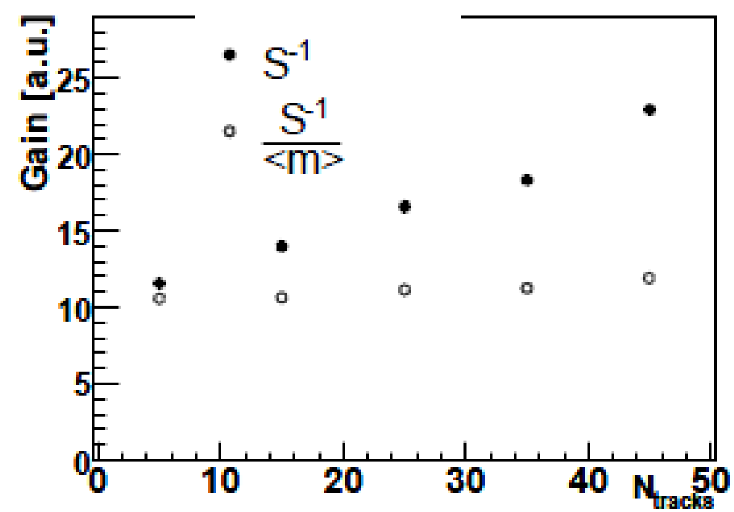


Scintillation & HBD Gain calibration

- Gain calibration: fitting the scintillation yield
- ADC count distribution from identified single pad hits fitted to an exponential:
  - 1/slope= G x <m>
  - <m> average npe/pad
  - p+p: <m> = 1
  - Au+Au: <m> = $\frac{\mu}{1-e^{-\mu}} \approx 1+\mu/2 = 1-\ln[\mathbf{P}(0)]/2$
-



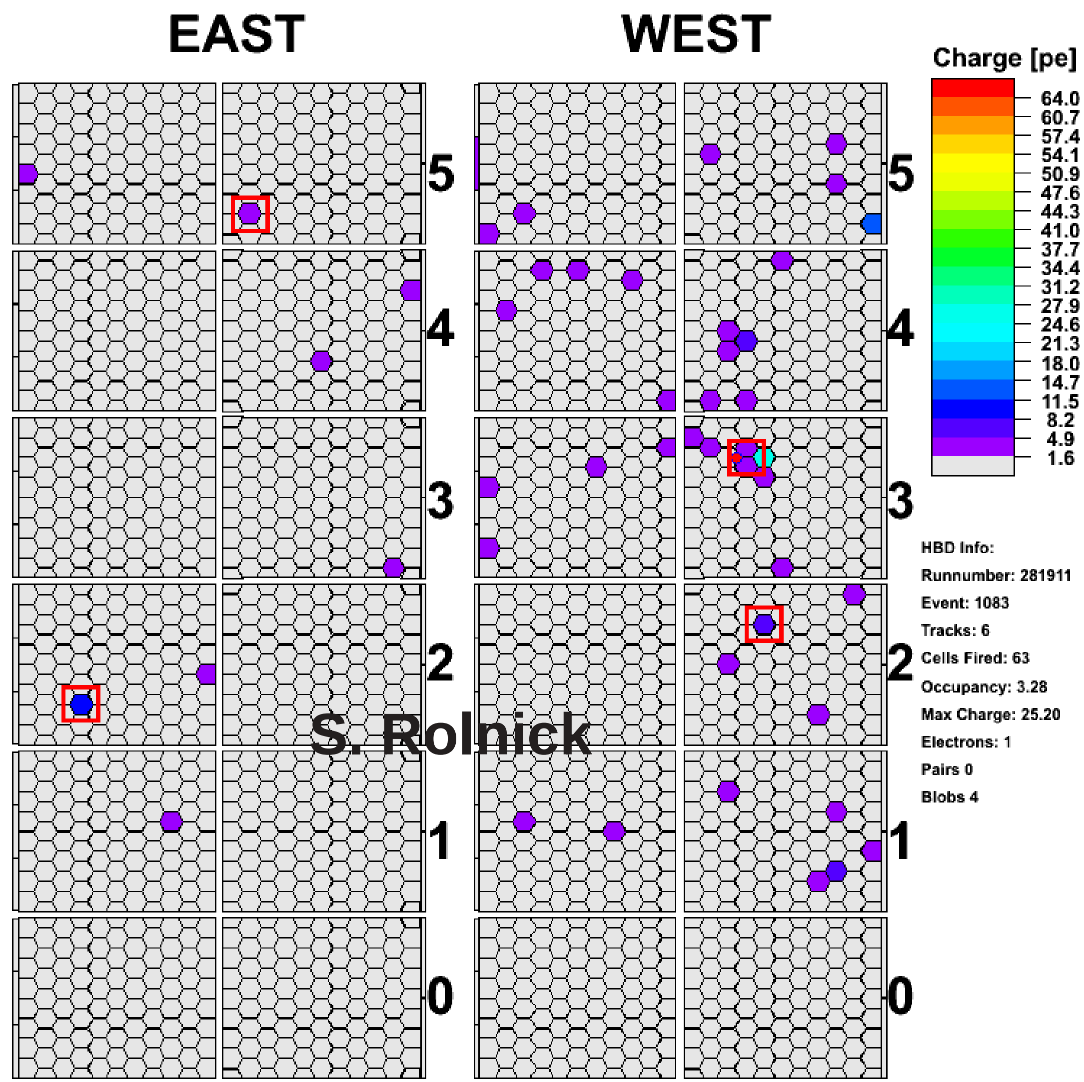




HBD in p+p collisions

HBD operation in p+p collisions

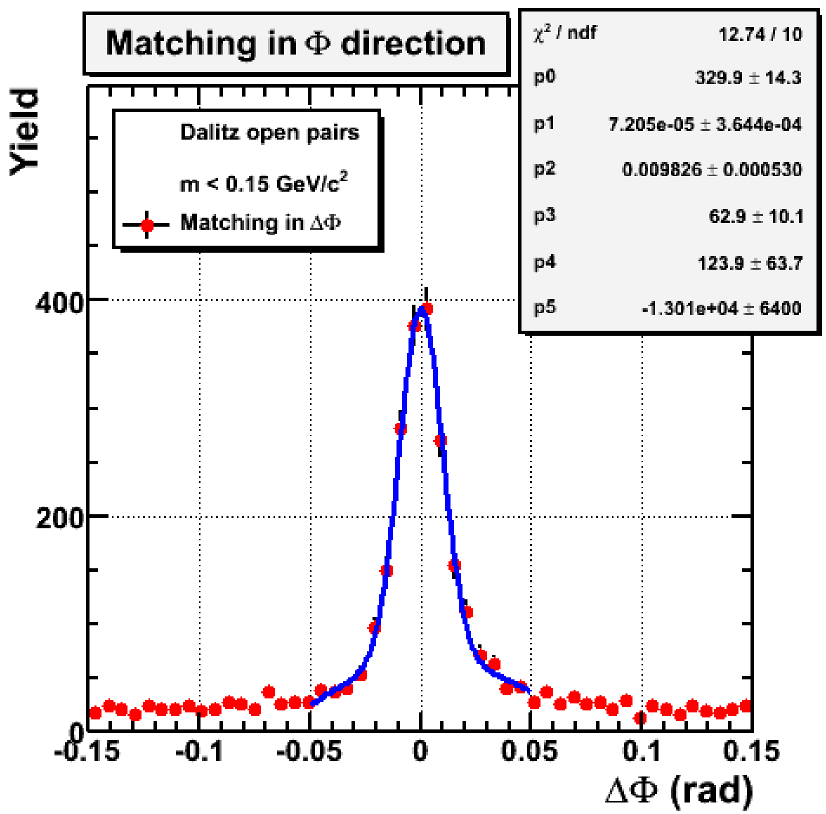
- The 200GeV part of run9
- Magnetic field +- used for 200GeV part
- Reverse Bias operation mode → hadron blind
- Clean events
- Relatively simple clustering algorithms work



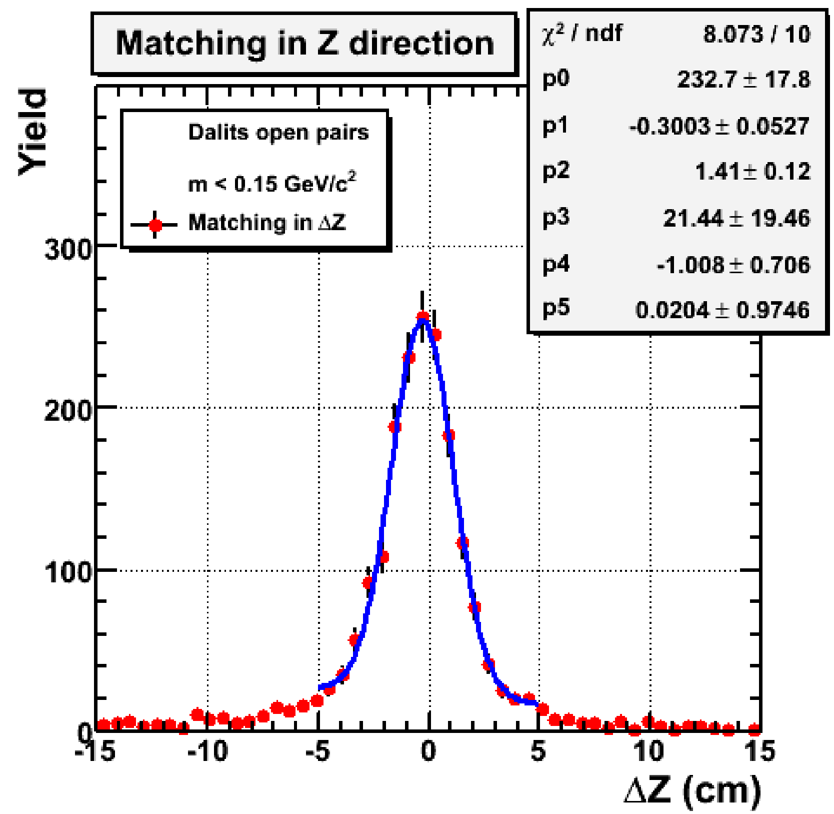
Track matching to clusters

- Residual distributions between track projection position in the HBD and reconstructed cluster

Source: Open Dalitz electron pairs (m<150MeV, large opening angle)



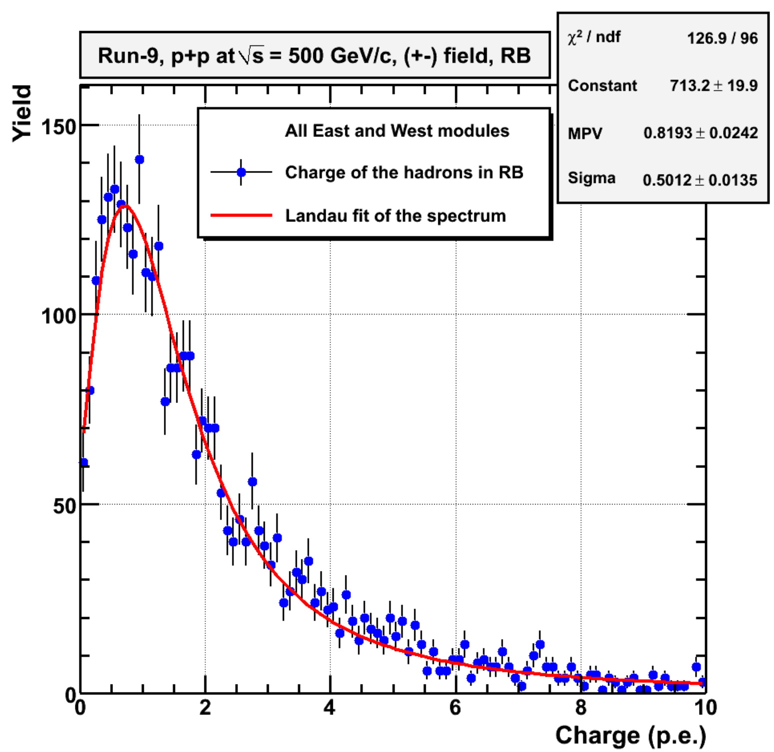
σ(Δϕ) ~ 0.01 rad

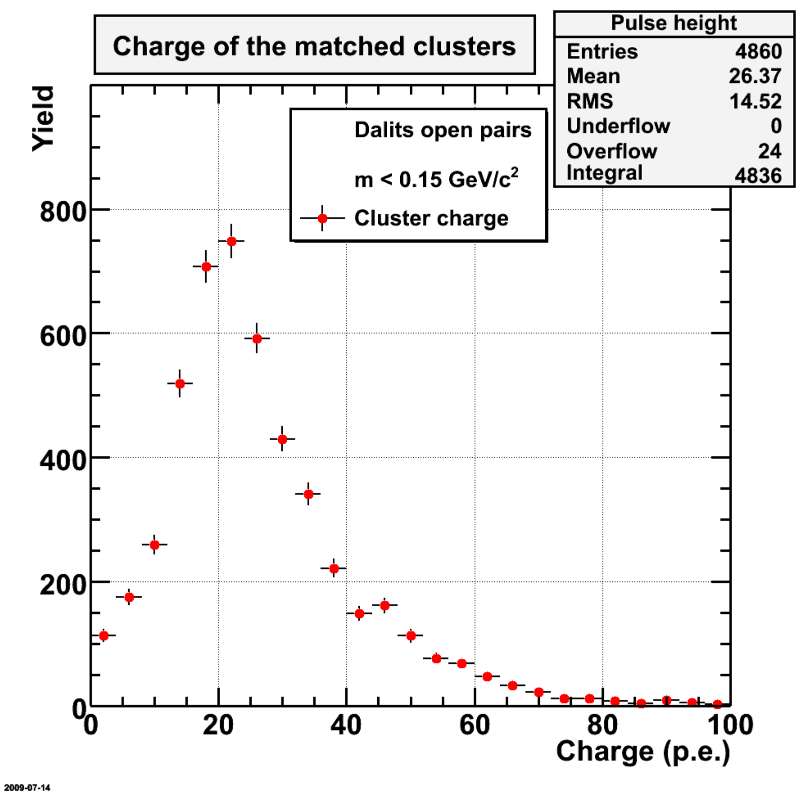


σ(Δz) ~ 1.41 cm

Response in p+p (single vs. none)

- Response to hadrons and electrons in RB mode
- Central arm tracks projected to HBD
- Single electron: From open Dalitz pairs (m<150MeV,large OA)



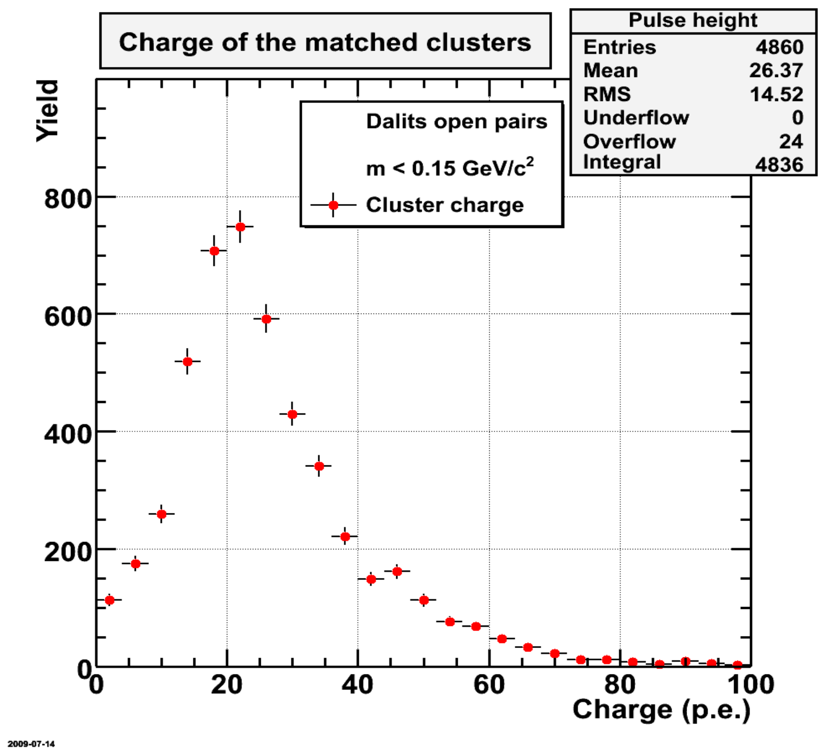


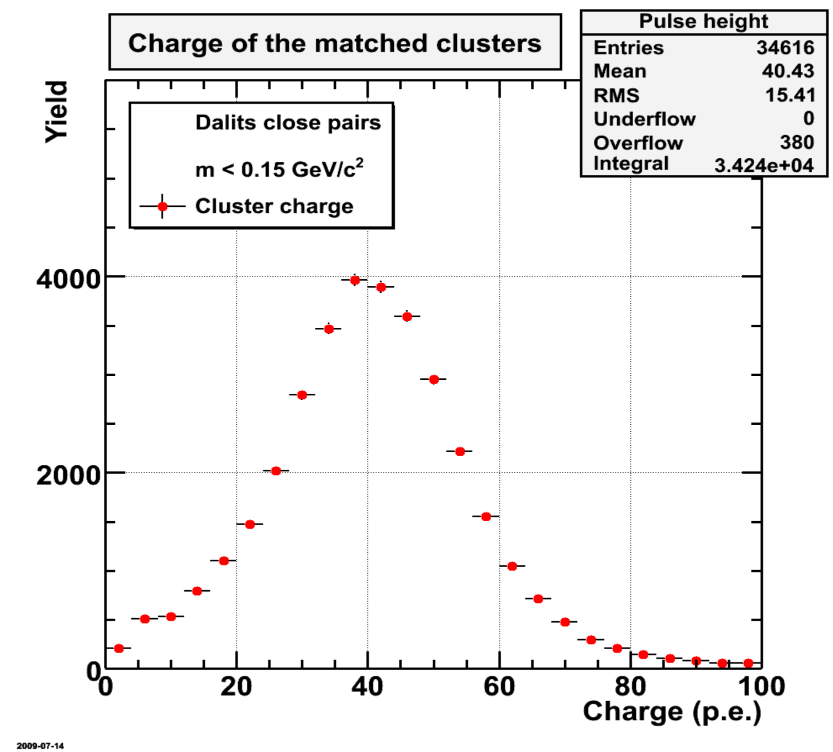
Hadron dE/dx signal in the small (~100μm) region above the top GEM and in the first transfer gap very small wrt electron Cherenkov signal

Ilia Ravinovich

Response in p+p (single vs. double)

- Response to hadrons and electrons in RB mode
- Central arm tracks projected to HBD
- Double electron: From closed Dalitz (m<150MeV,oa<?)



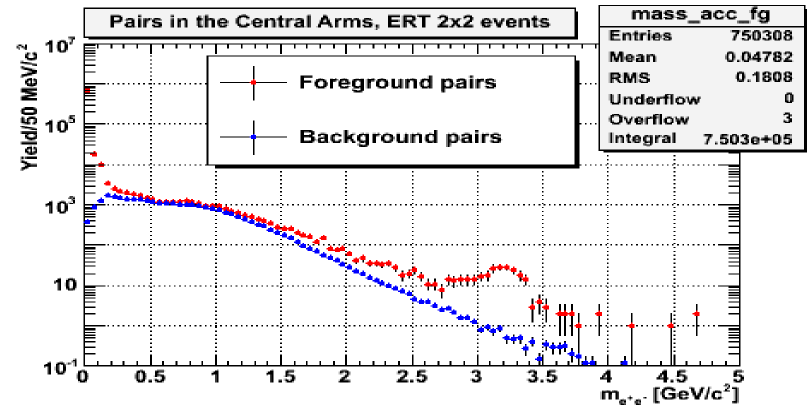


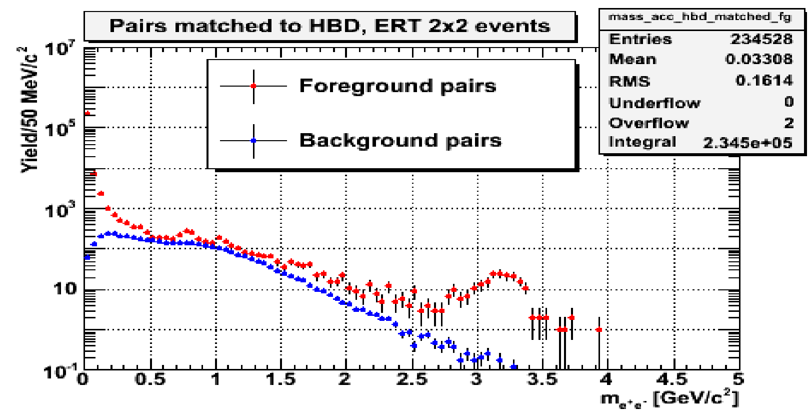
Good closed Dalitz and photon conversion rejection
while maintaining good pair efficiency

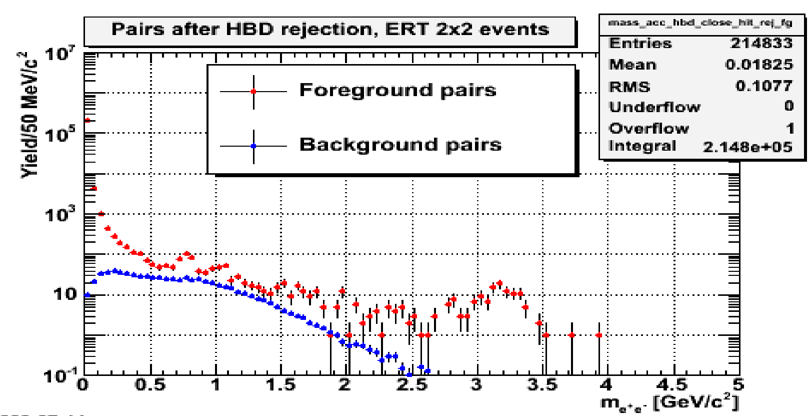
Ilia Ravinovich

Effect on pair spectrum (p+p)

- Rejection in p+p
  - Track-cluster matching
    - Backplane conversion
    - Mis identified pion
    - S/B larger by factor ~2
  - Cut on cluster charge
    - Require maximum
    - No close-by clusters
    - Rejects conversions and closed Dalitz
    - S/B larger by factor ~6.5
  - Cut on cluster size
    - Require minimum size of 2pads
    - S/B larger by ~2.0



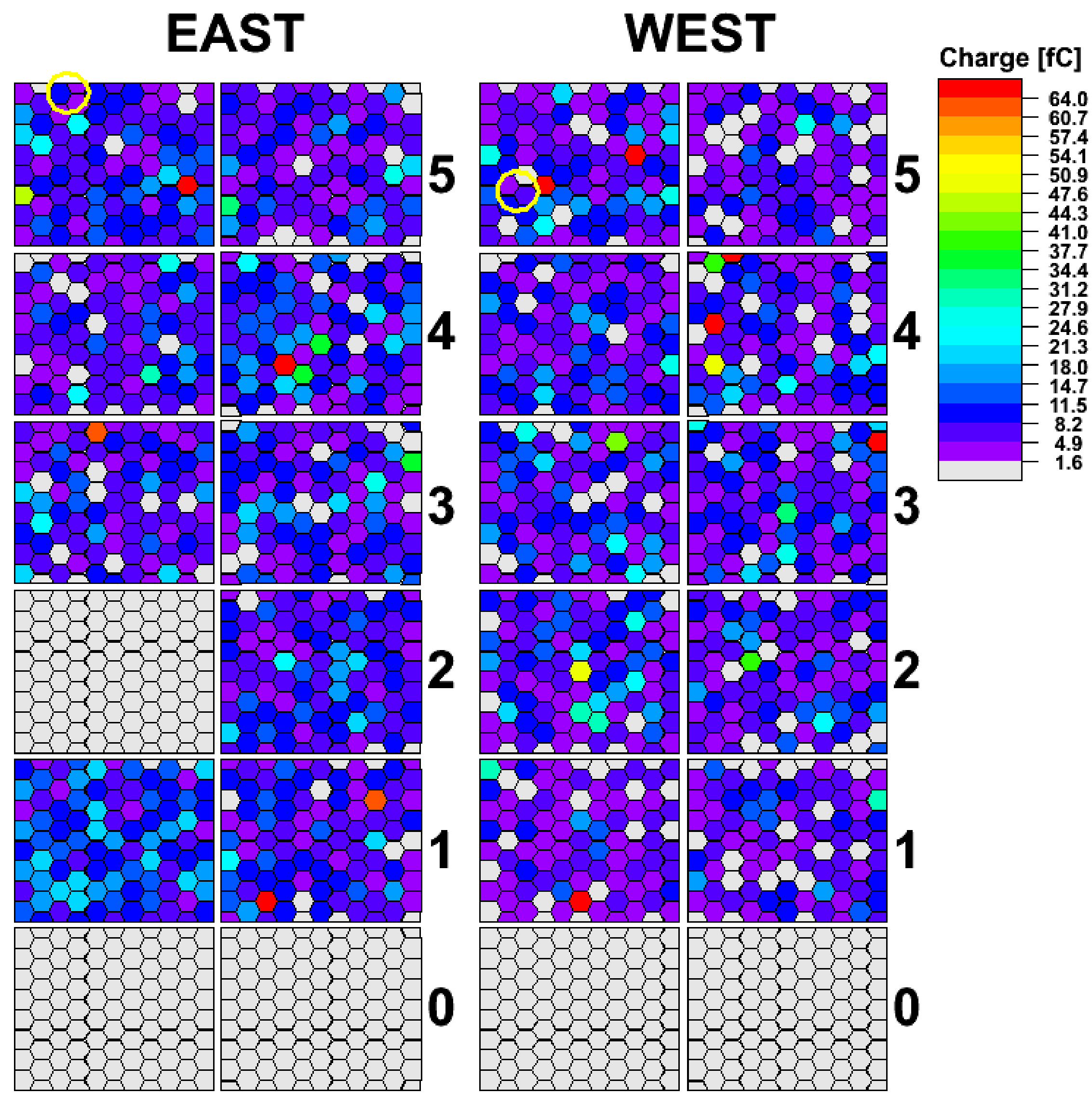




HBD in Au+Au Collisions

HBD operation in Au+Au collisions

- In central Au+Au events (of highest physics interest) getting information from HBD is difficult
- Huge amount of scintillation light
- Almost 100% occupancy
- <npe>/pad ~ 11
- Total signal ~ 20pe
- Simple clusterization algorithms fail



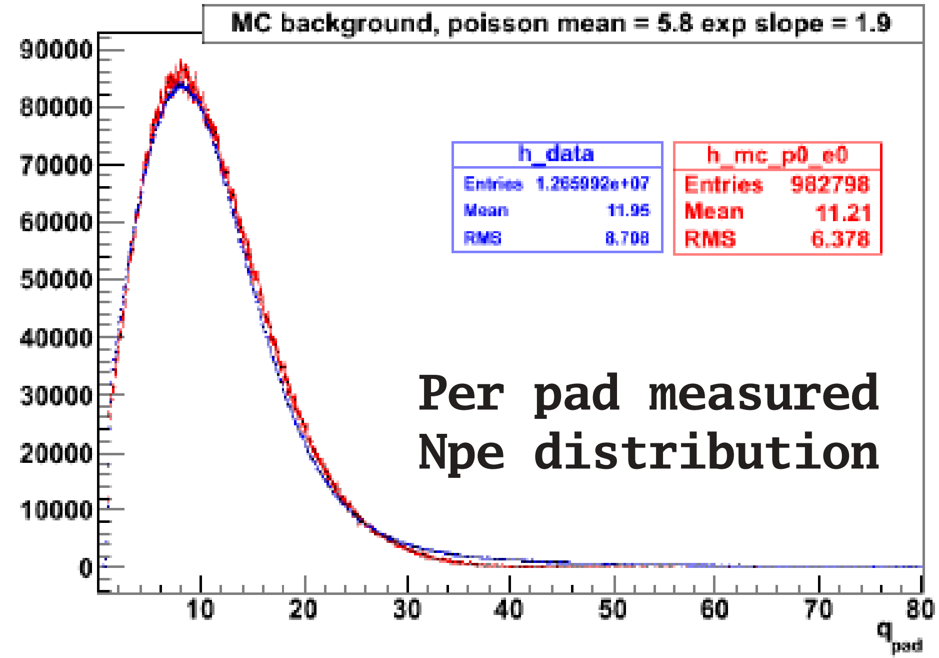
Central Au+Au event display

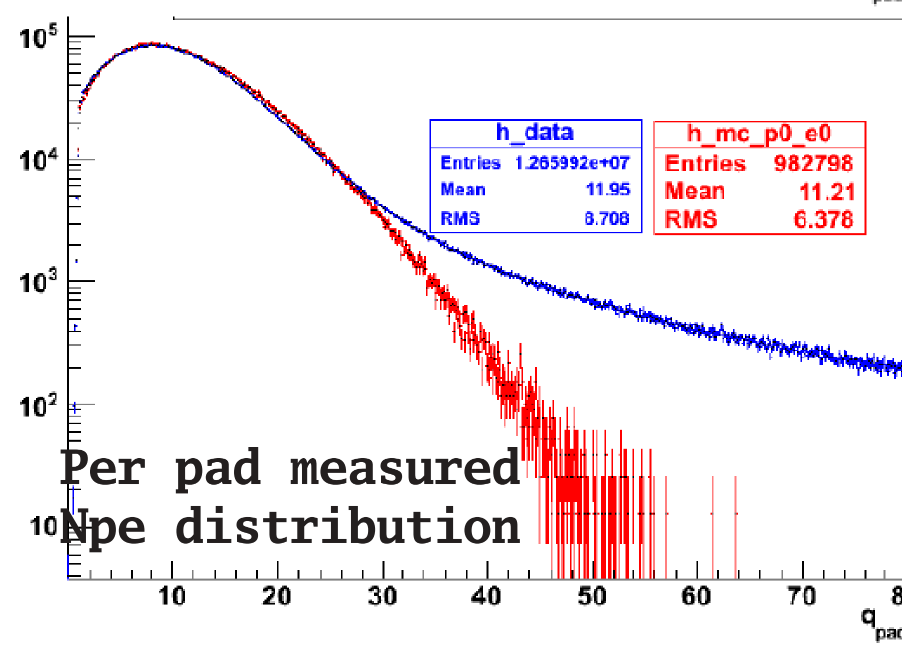
Sources of difficulty

- High scintillation background
  - The peak can be simulated in a fast MC

$$q = \sum_{0}^{P(M)} \exp(\tau)$$

  - Event by event background subtraction: multiple approaches!
- The high end tail:
  - HIP, gitter
  - Throw out high firing pads → limit bias on background estimators
  - Very small loss of acceptance (~0.4% for <60)

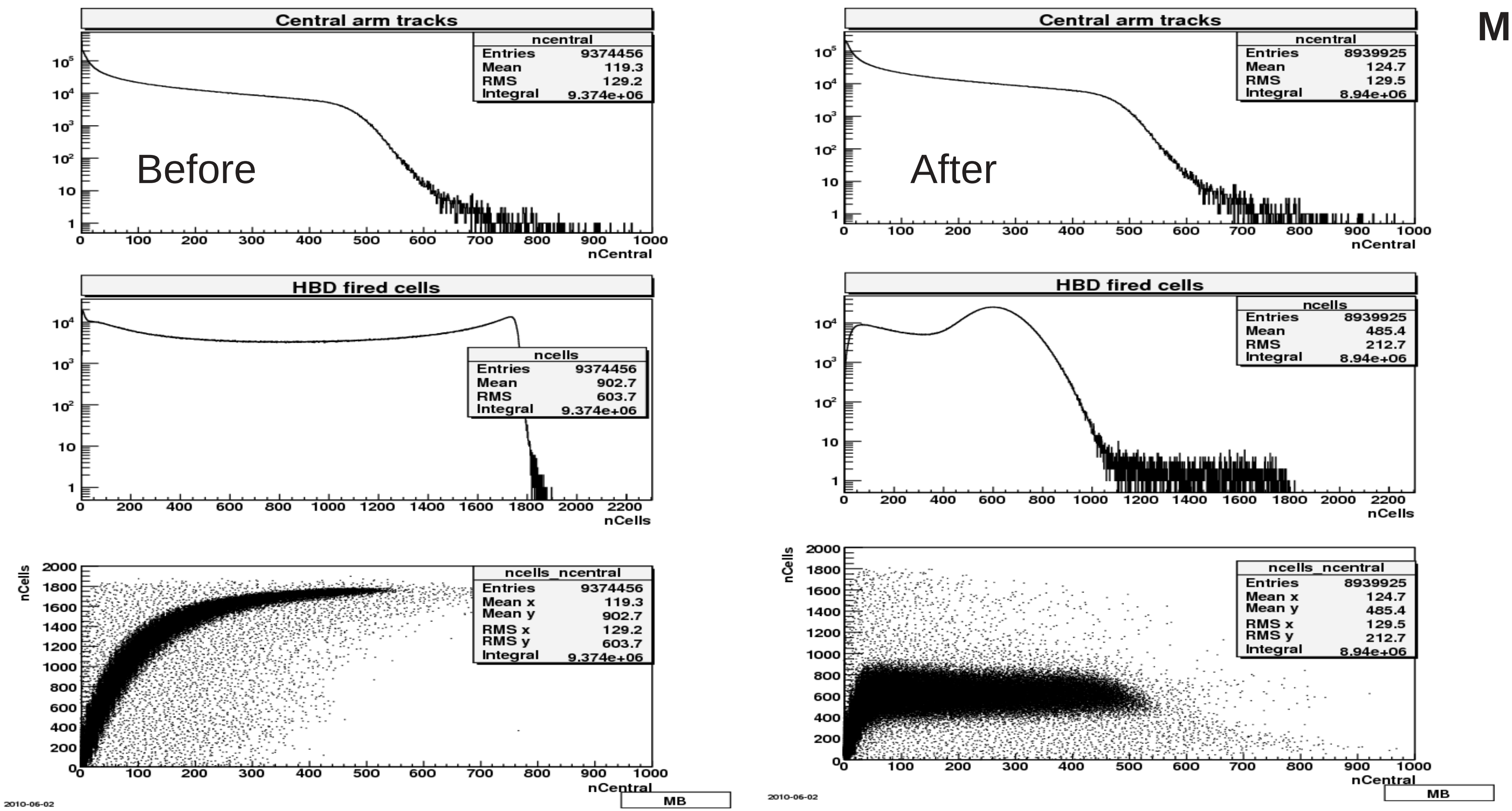




Subtraction of scintillation

- One approach: Subtract event by event, pad-wise average photon yield from every pad
- This reduces occupancy significantly
- p+p algorithms can then be run on subtracted yields

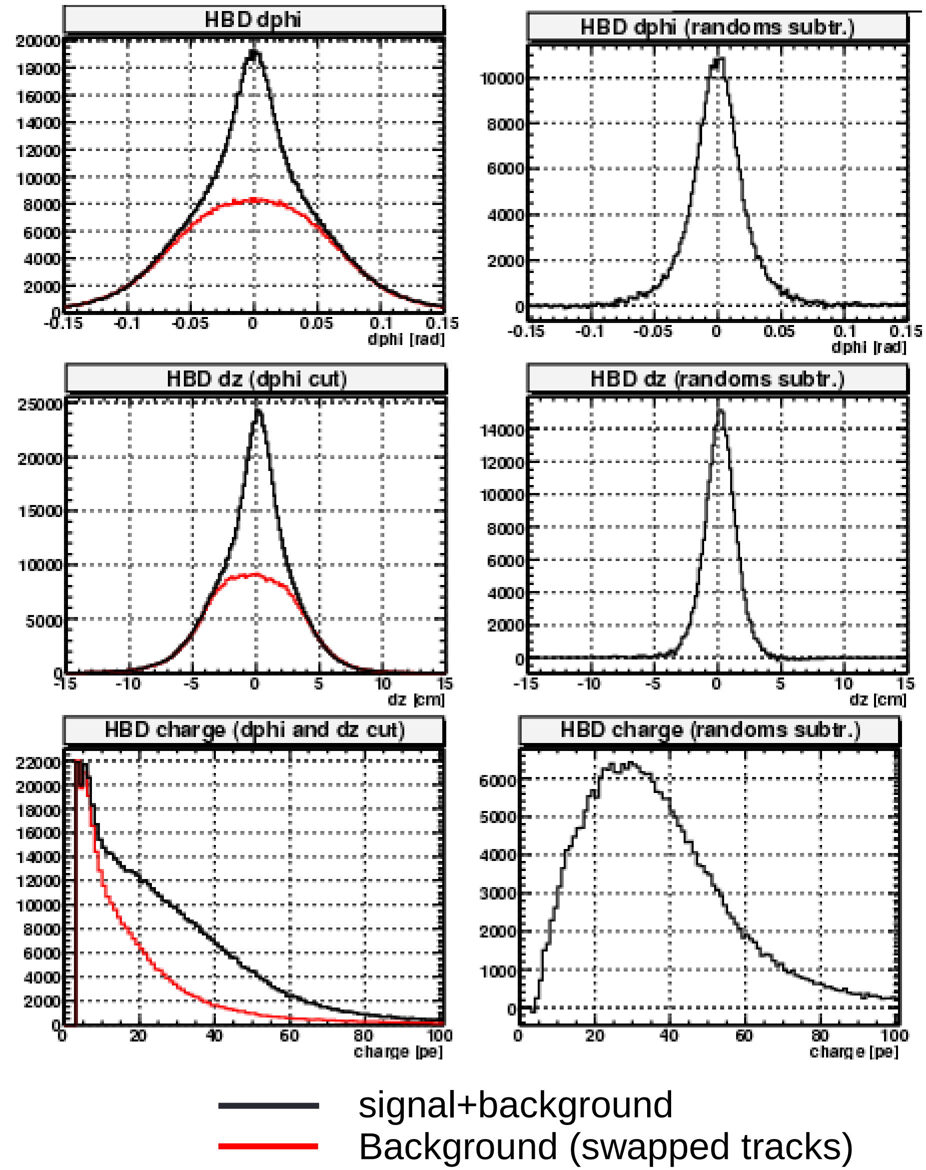
M. Makek



Results of this method

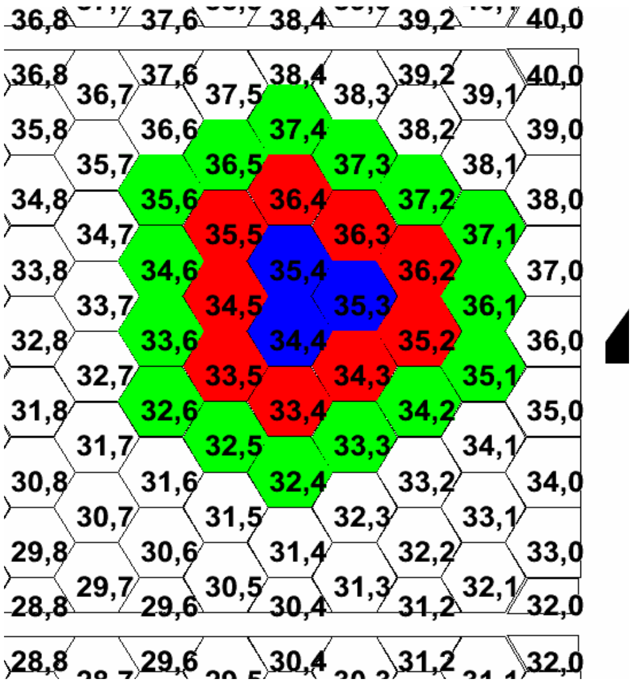
- LHS Black: all id-ed electrons
  - Signal (single hit)
  - Background (double hit)
  - Late conversions (no hit)
- LHS Red: swapped
- RHS: Black-Red
- The subtracted matching distributions match well the ones seen in p+p
- S/B = (Black-Red)/Red 43% & efficiency ~67%
- Requiring that track should point to the max firing pad, and putting a threshold on max firing pad improves S/B to 28% at a cost of about 10% loss in efficiency

M. Makek



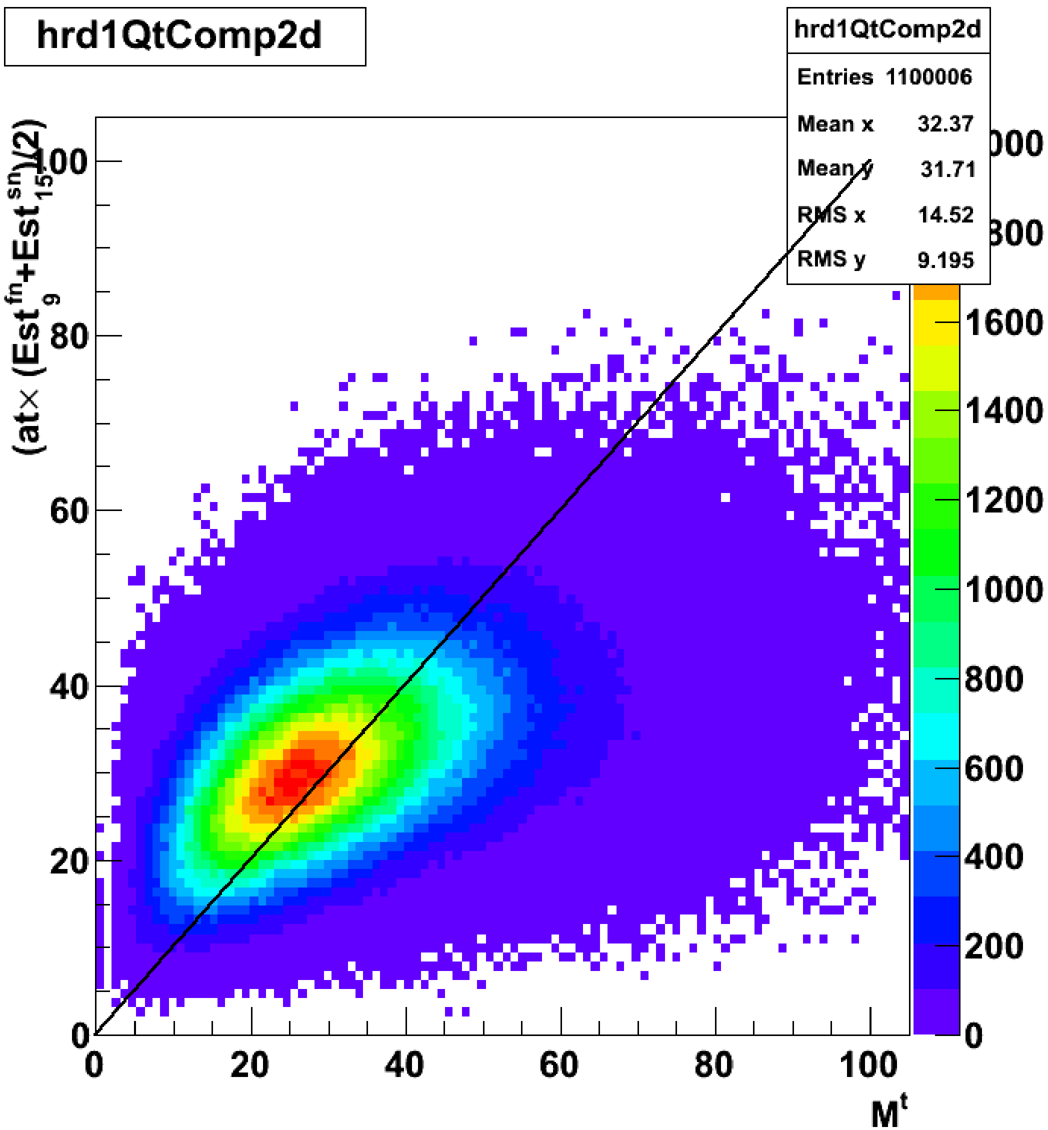
More local background estimation

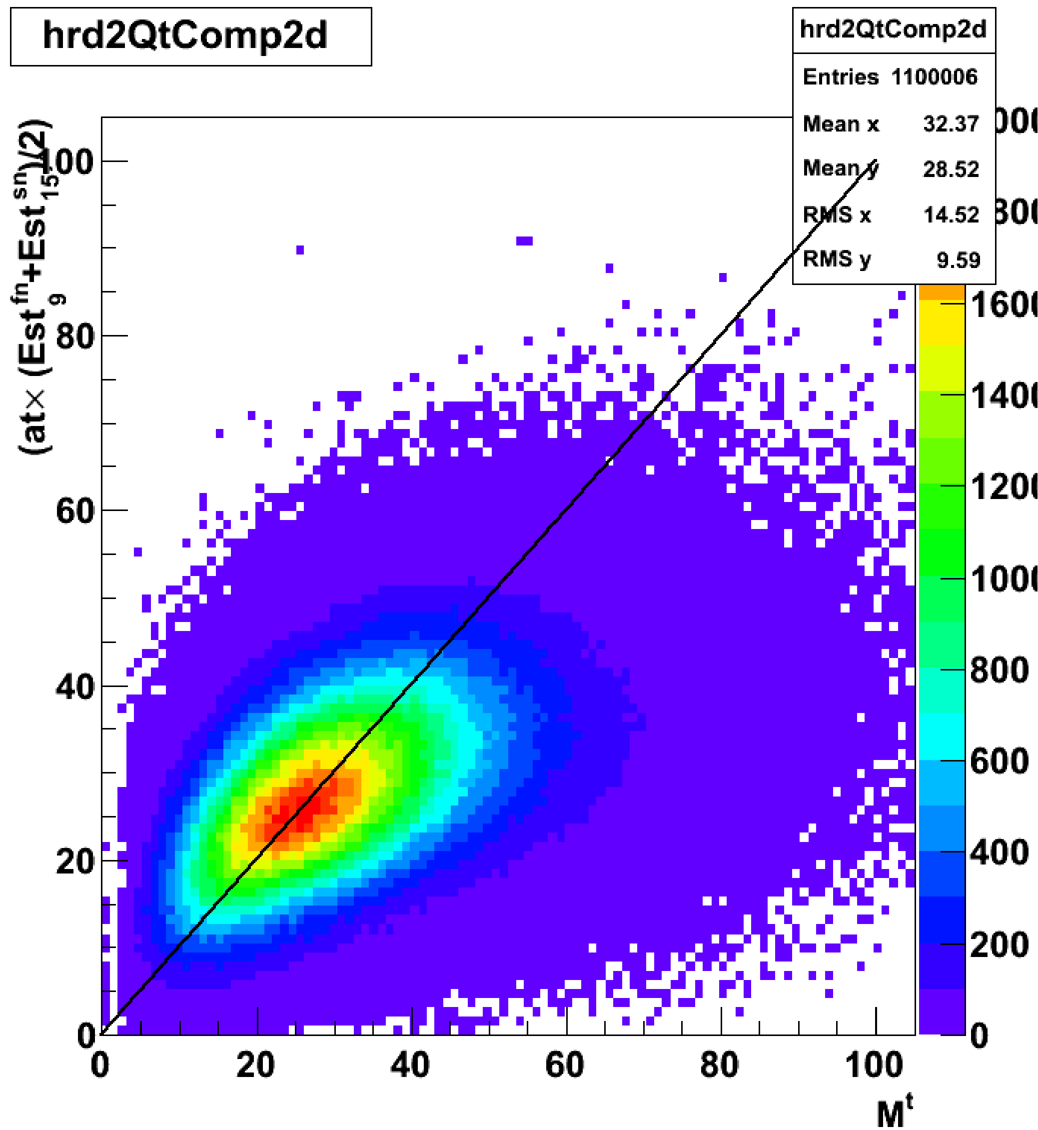
- Basic idea: The best place to look for an estimator of the background for any given cluster is its immediate neighborhood
- There is some correlation between charge measured in a triplet and charge in the surrounding background.
- Exploit this correlation to calcluate on cluster-by-cluster basis what the scintillation contribution to the measured charge in the cluster amounts to



- Background:
  - 0.5 * at * (Bkg1 + Bkg2), where
  - Mean based:
    - Bkg1 = (Σqfn) /(Σafn) and
    - Bkg2 = (Σqsn) /(Σasn)
  - Median based:
    - Bkg1 = Med(qfn/afn) and
    - Bkg2 = Med(qsn/asn)
- Figure of merit in comparison :
  - width of Bkg2-Bkg1 distribution.
- Notation:
  - M_t → Measured total charge in triplet area
  - Est_9 → Estimated background from first neighbors area (9 pads)
  - Est_{15} → Estimated background from second neighbors area (15 pads)

$M_t : Est_{9+15}$

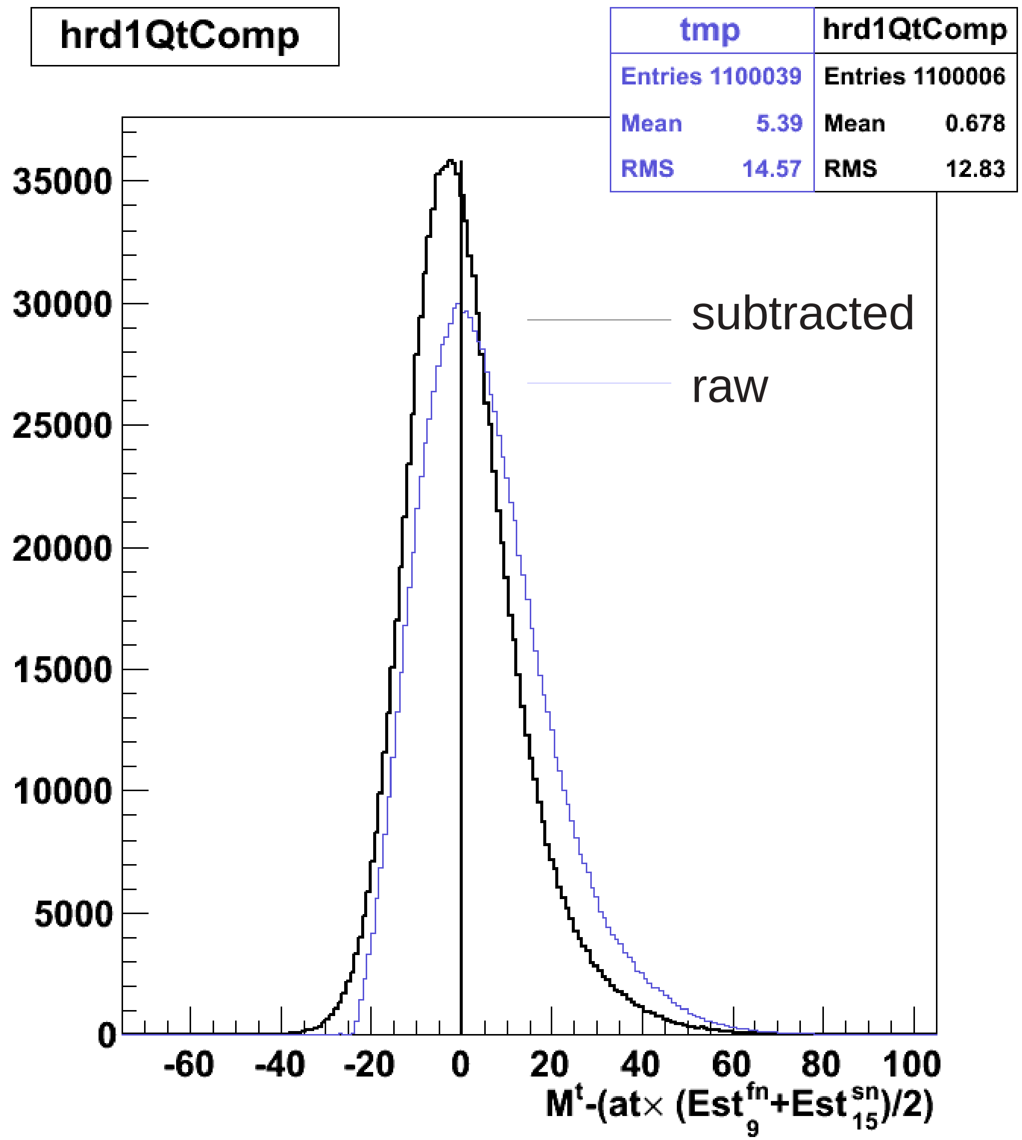


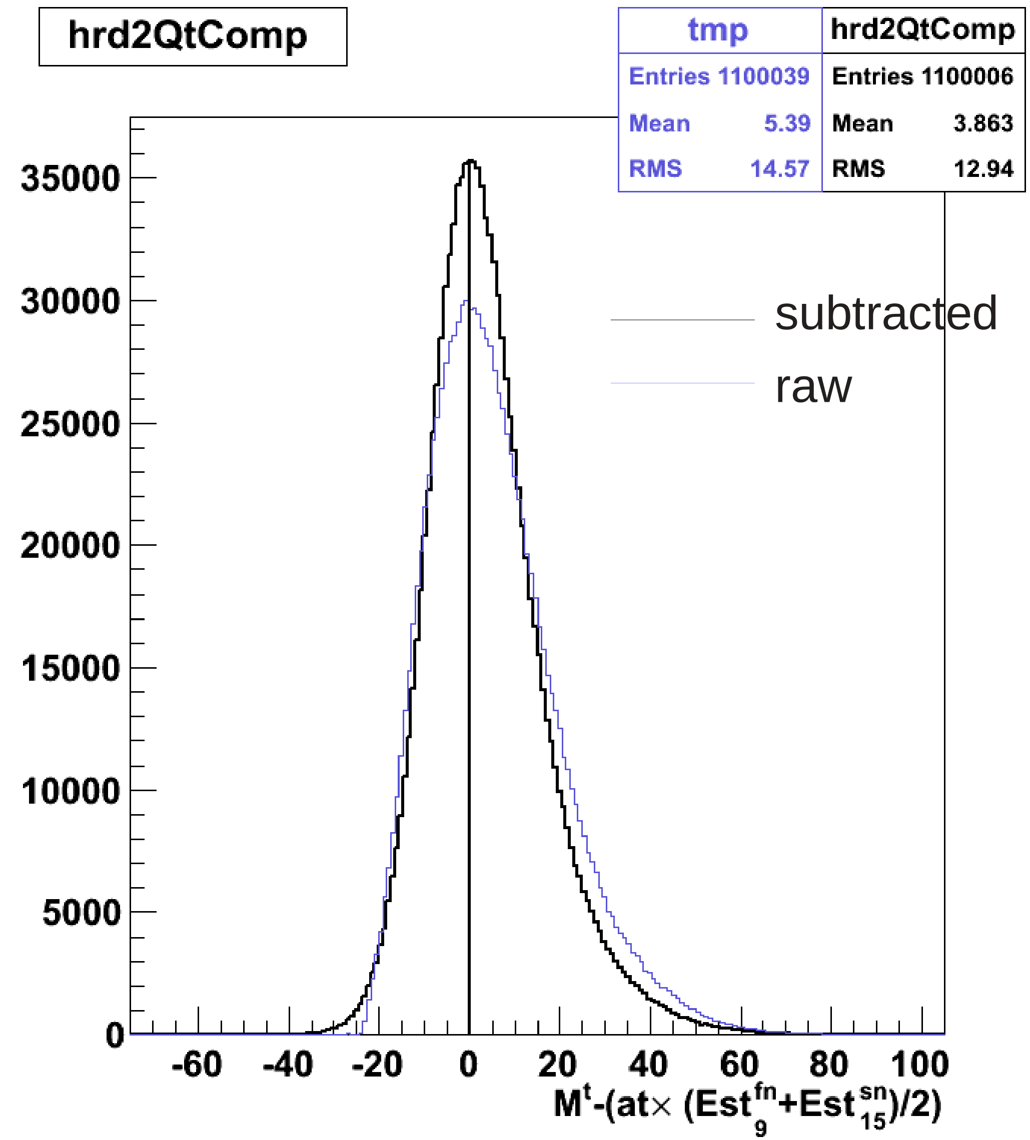


Mean based estimators

Median based estimators

$M_t - Est_{9+15}$



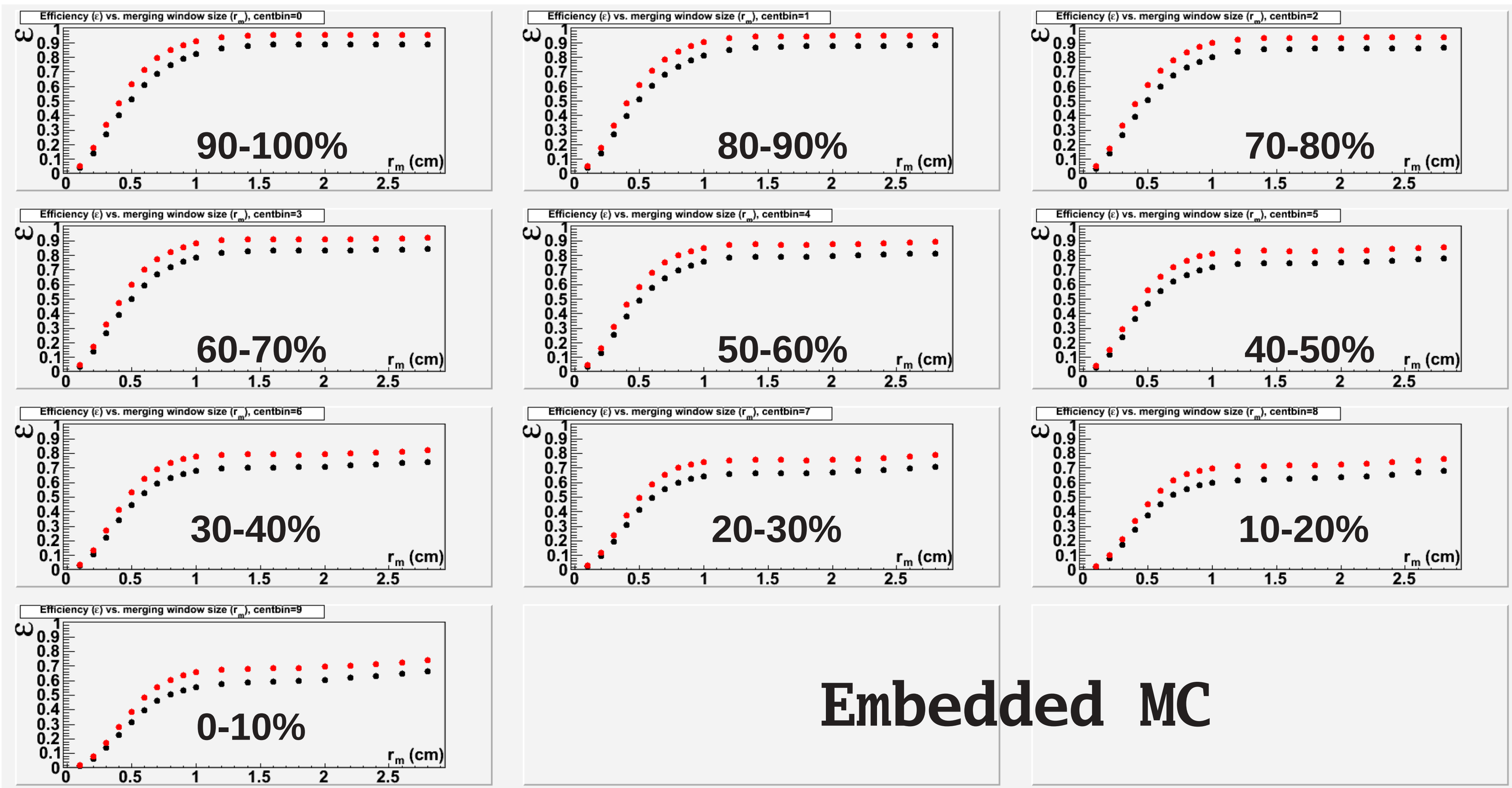


Mean based estimators

Median based estimators

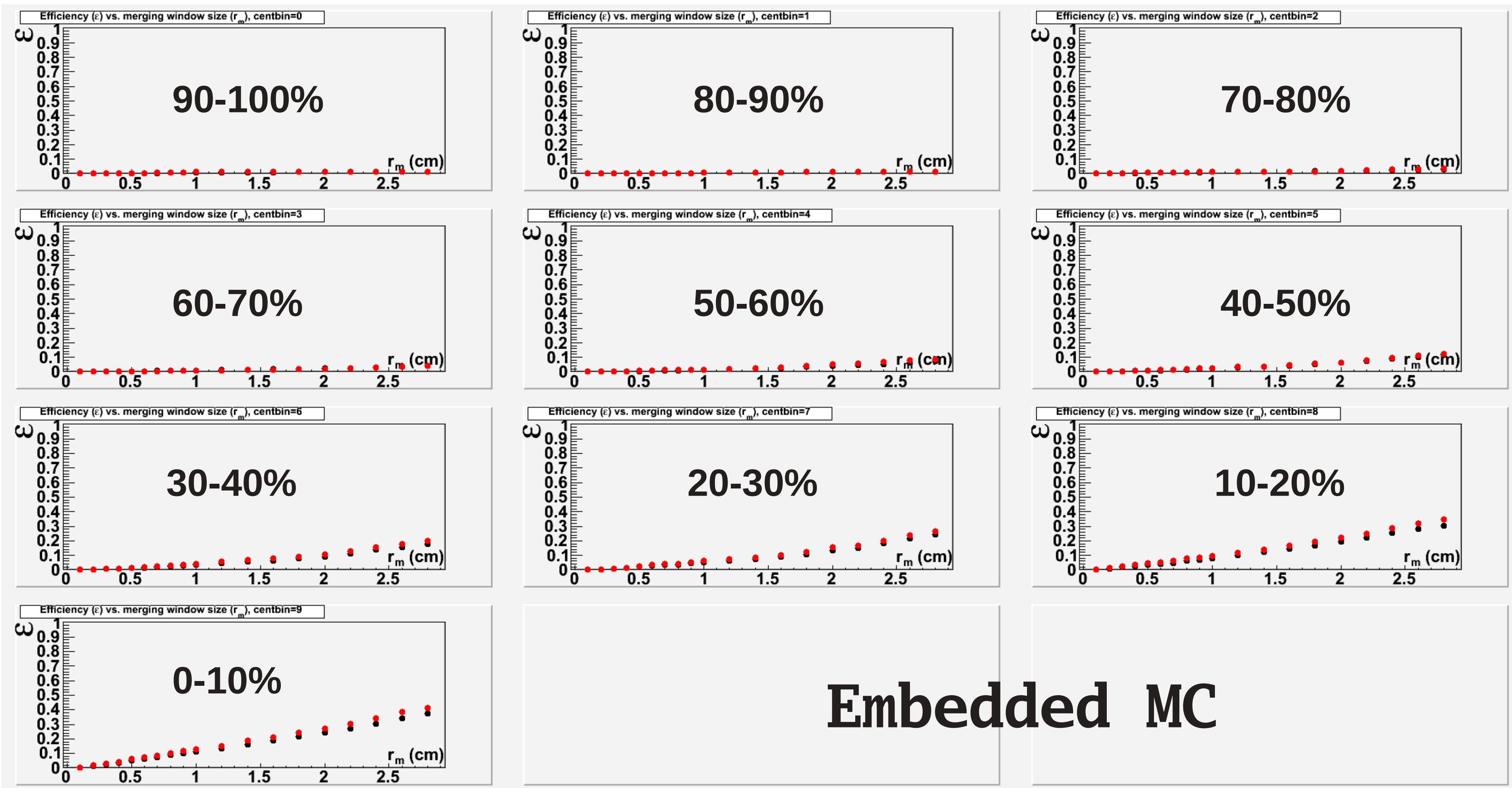
Efficiencies of local background estimation

- The pre-cluster triplets merged around track projections. The efficiencies below plotted are as a function of merging window radius (track projection to CG of the pre-clusters)



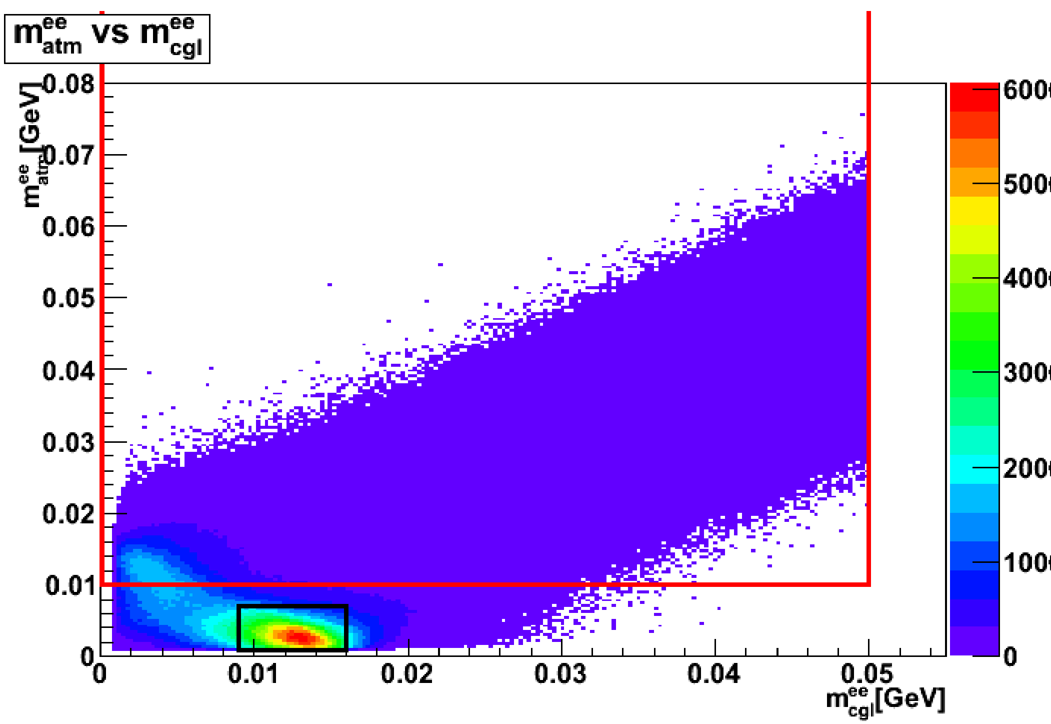
Rejection of local background estimation

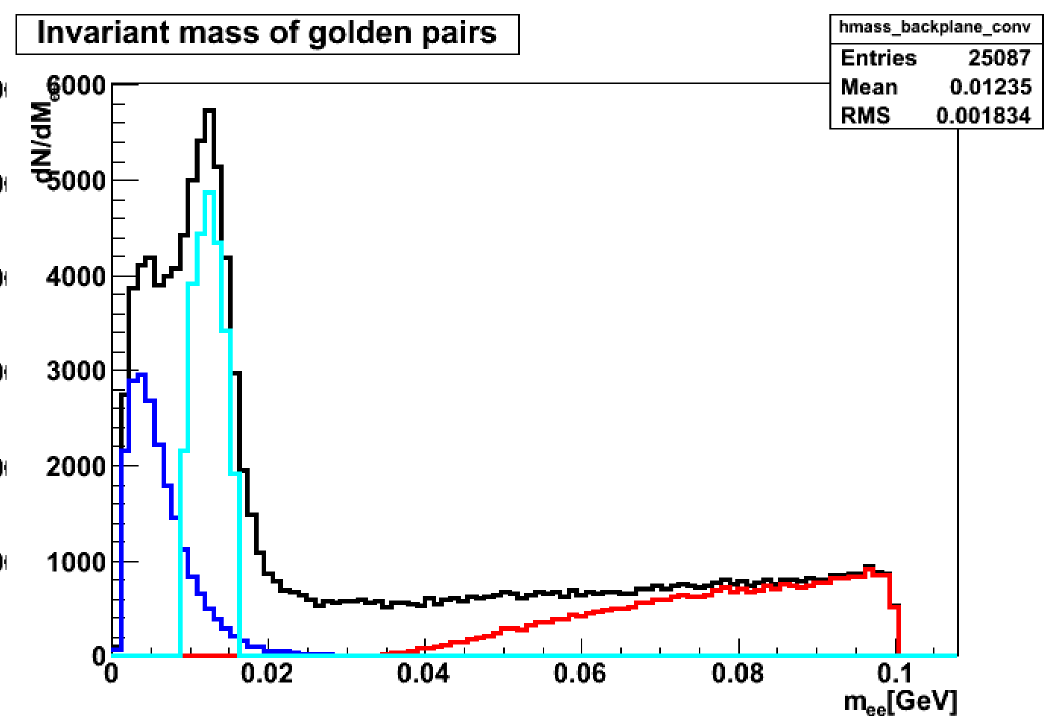
- The pre-cluster triplets merged around track projections. The efficiencies below plotted are as a function of merging window radius (track projection to CG of the pre-clusters)



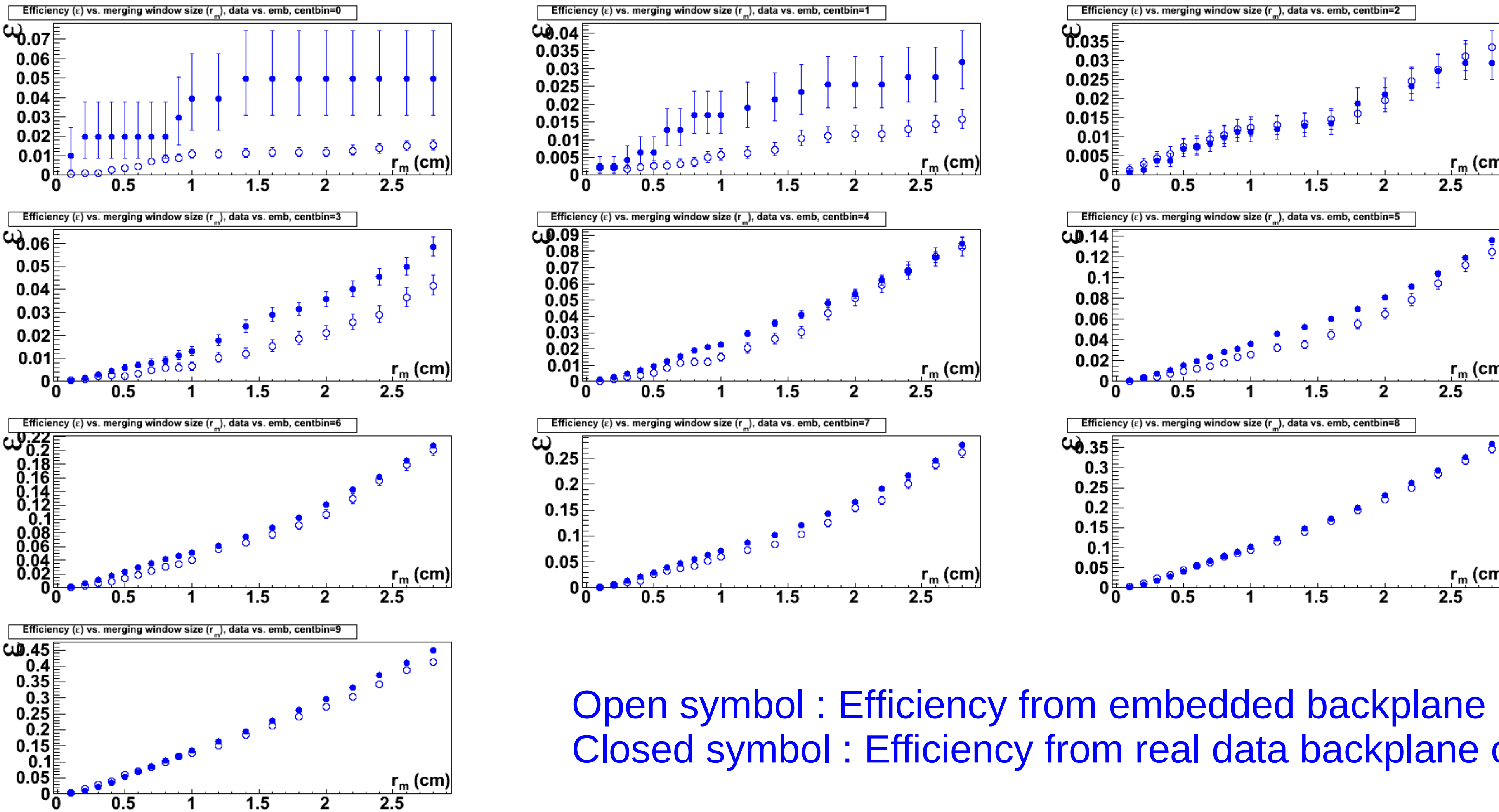
Real data golden tracks

- MB events |zvtx| < 10 cm, and containing clearly identified electron pairs
  - Backplane conv. : eid && M<7MeV && 9Mev<M_{cgl}<16Mev && oa_{atm}<30mr
  - Open Dalitz pairs : eid && M_{atm}>10MeV + M_{cgl}<50MeV && oa_{cgl}>150mr
  - Closed Dalitz pairs : eid && M_{atm}>10MeV && M_{cgl}<50MeV && oa_{cgl}<30mr





Confirming Bplane rejection

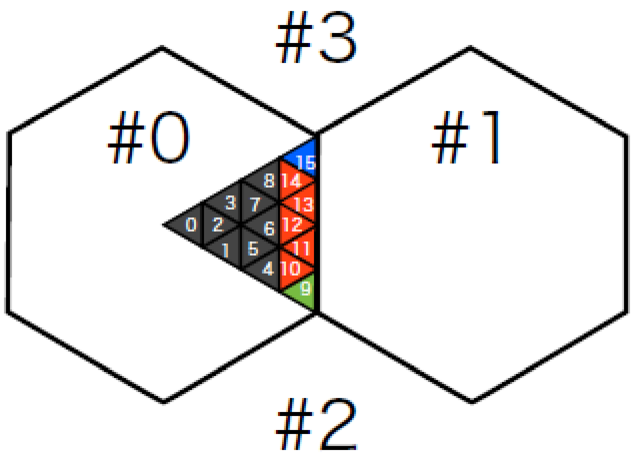


Open symbol : Efficiency from embedded backplane conv.
Closed symbol : Efficiency from real data backplane conv.

- This shows not only we select a very good sample of backplane conversions (if both legs are reconstrcted) but also embedded MC has a good control over background rejection estimations

Last possible level of detail

- Use central arm projection to determine which pads are relevant for the track in question



Expected cluster

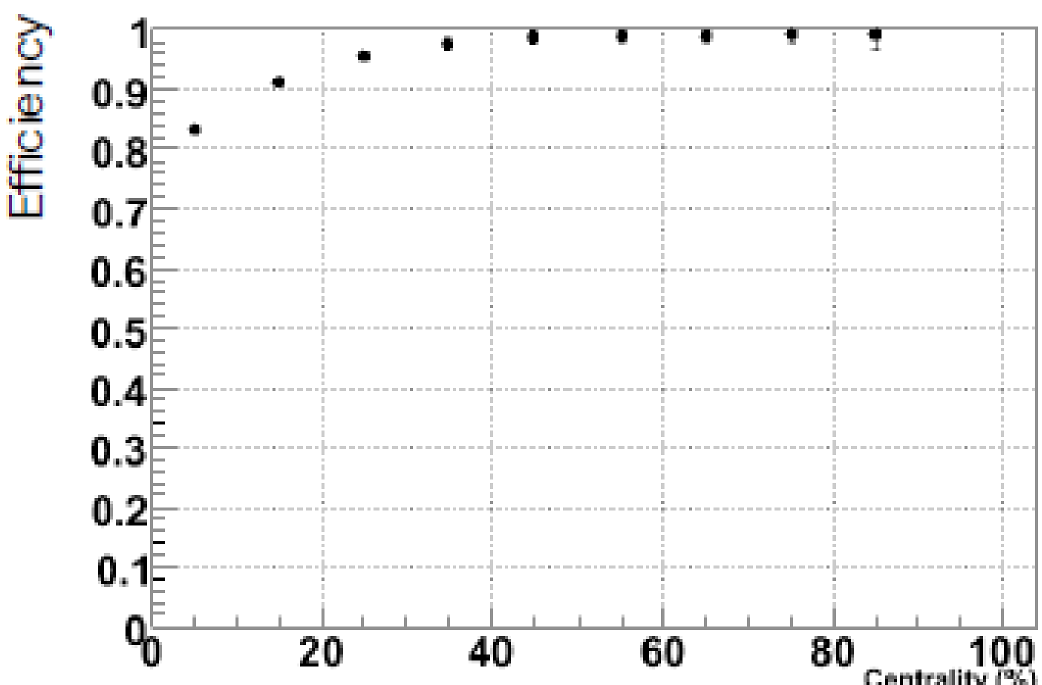
Black:	#0
Red:	#0, #1
Green:	#0, #1, #2
Blue:	#0, #1, #3

Y. Watanabe

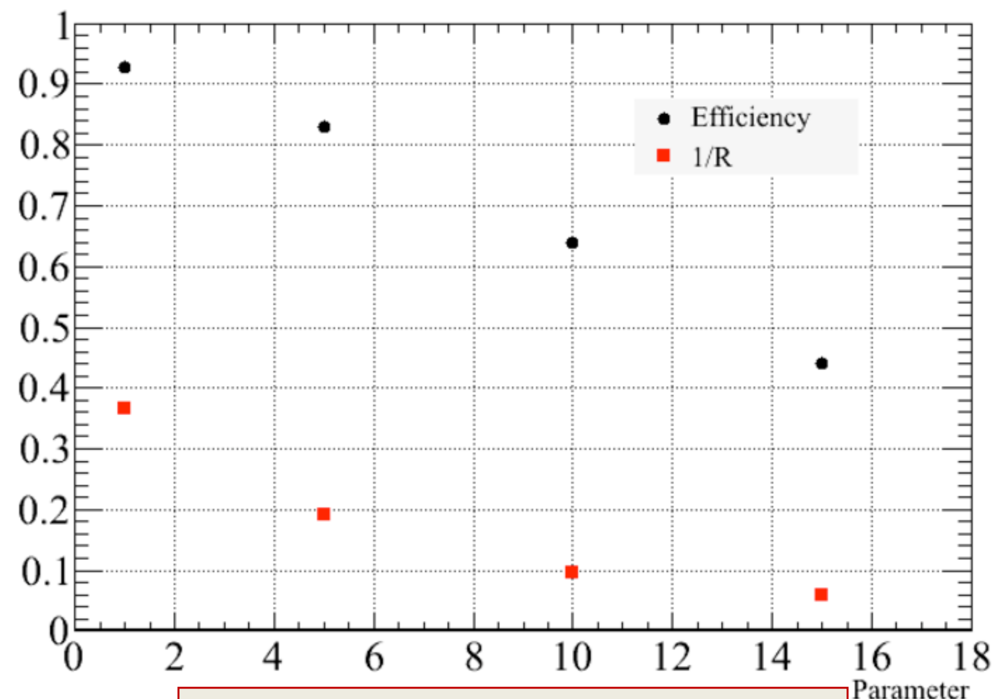
- Do event by event pad by pad subtraction of estimated scintillation background
- Sum the charges in the deemed relevant pads
- Determine a threshold for any level of back plane conversion electron rejection, and see if the efficiency for signal is enough

Results from pointing method

- This method seems to give a good combination of rejection and efficiency. Wizmann collaborators have started doing actual analysis using this.

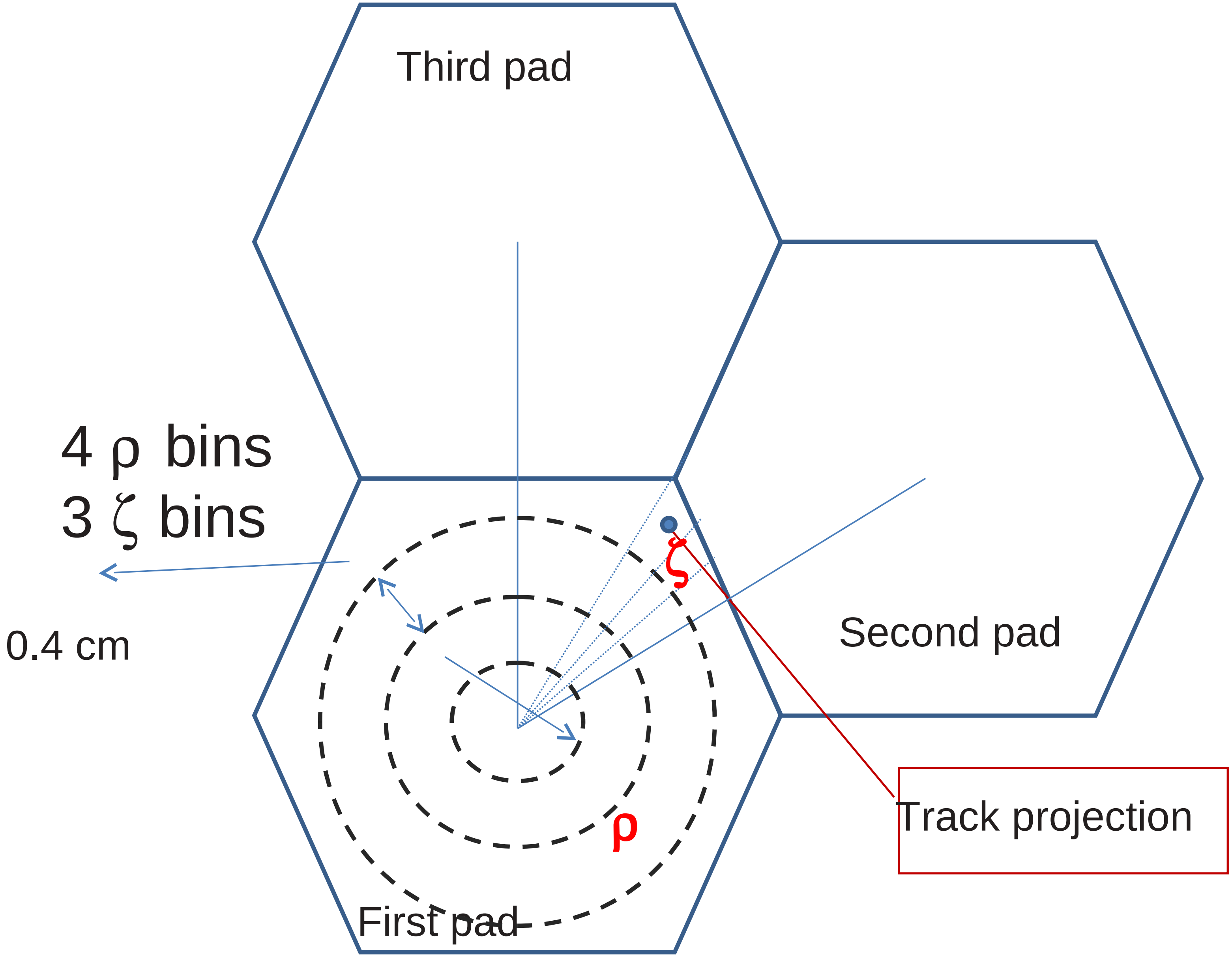


62 GeV tuned for x10 rej.



200 GeV, 0-10% centrality

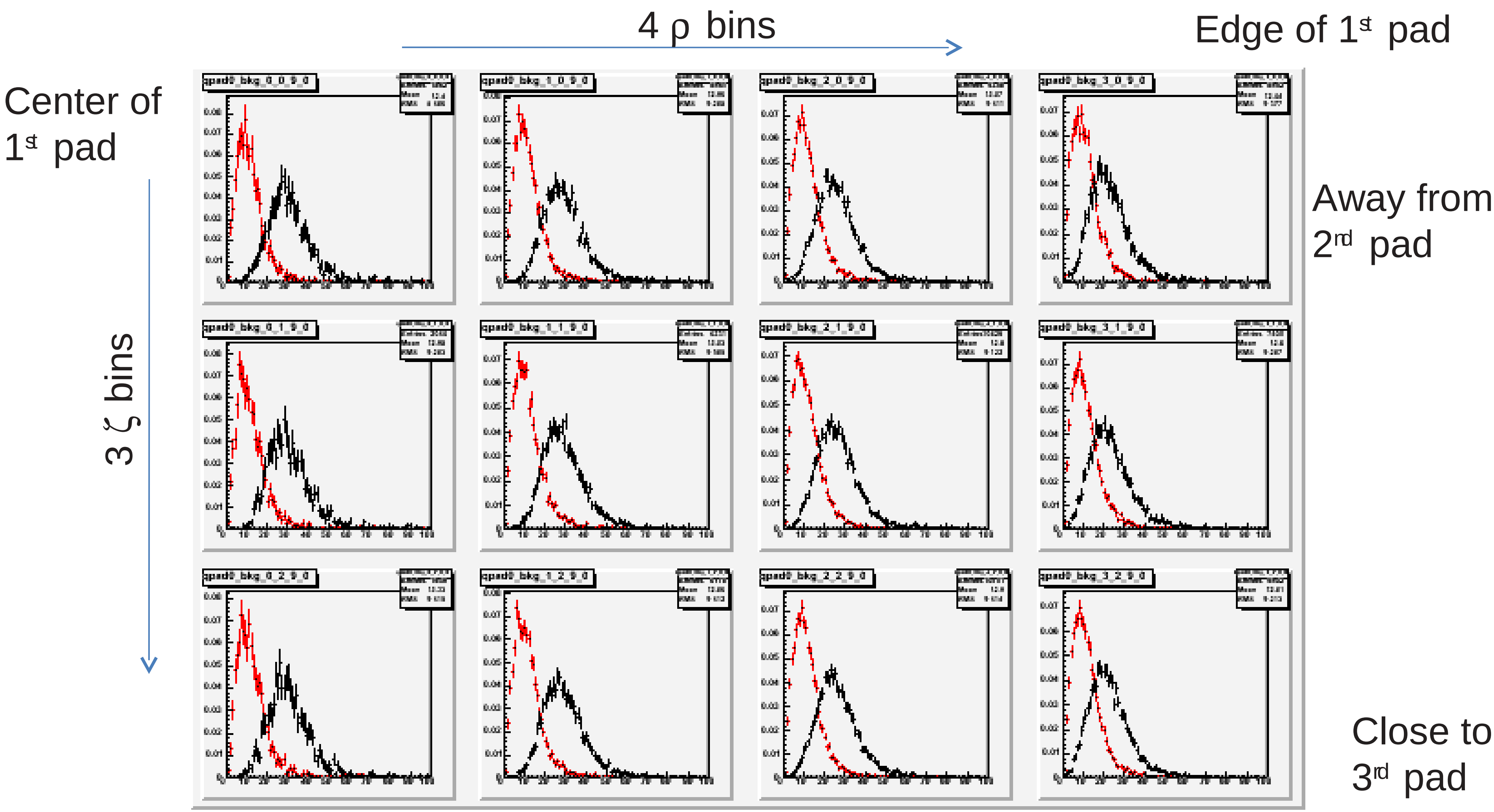
Taking this idea a little further



Neighboring pads: background

1^{st} pad distribution(central events)

- At 1^{st} neighbor background >9
- Embedded vs. Swapped tracks (Embed Omega→ee)



2nd pad distribution (central events)

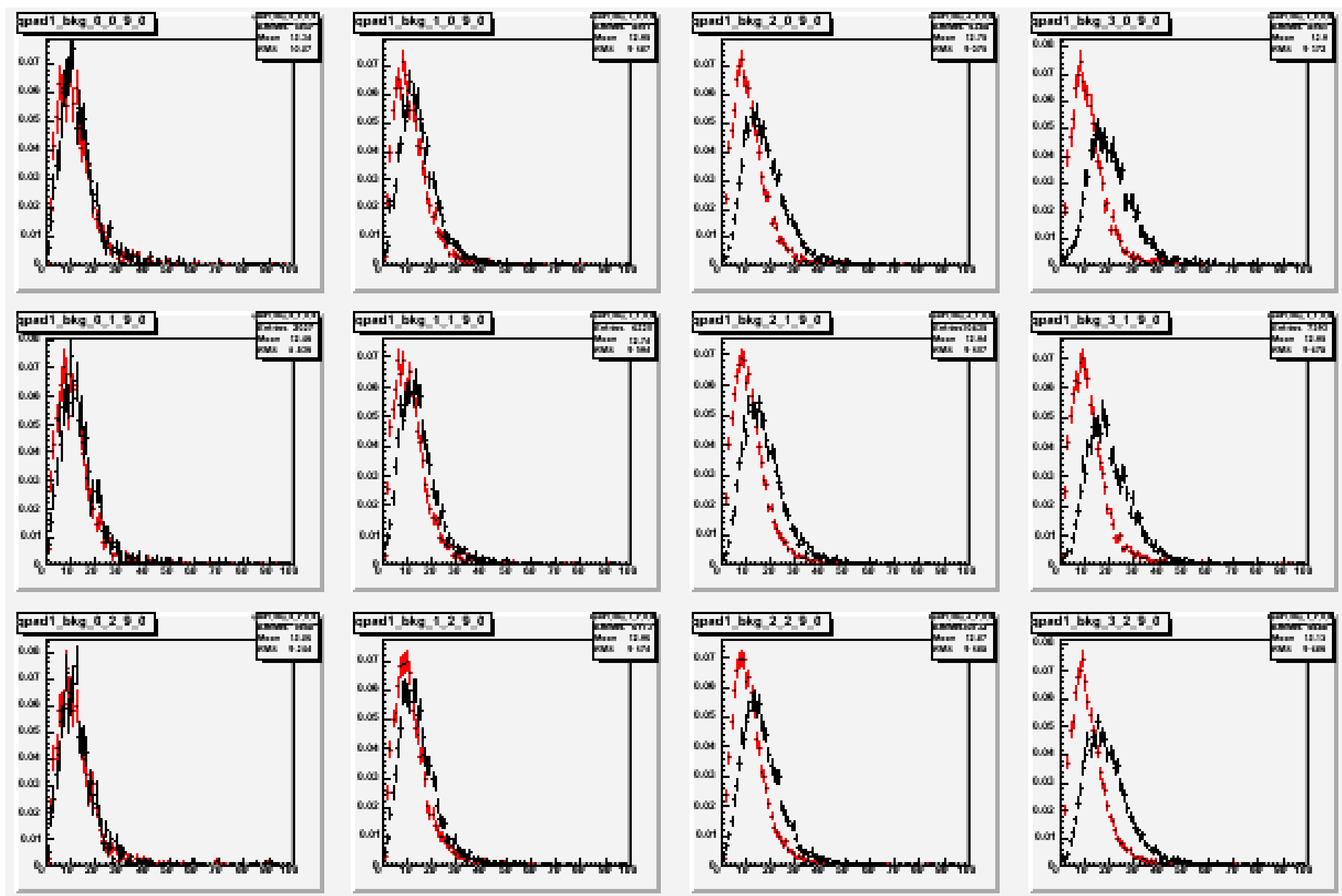
- At 1st neighbor background >9
- Embedded vs. Swapped tracks (Embed Omega→ee)

4 ρ bins

Edge of 1st pad

Center of 1st pad

3 ζ bins



Away from 2nd pad

Close to 3rd pad

3rd pad distribution (central events)

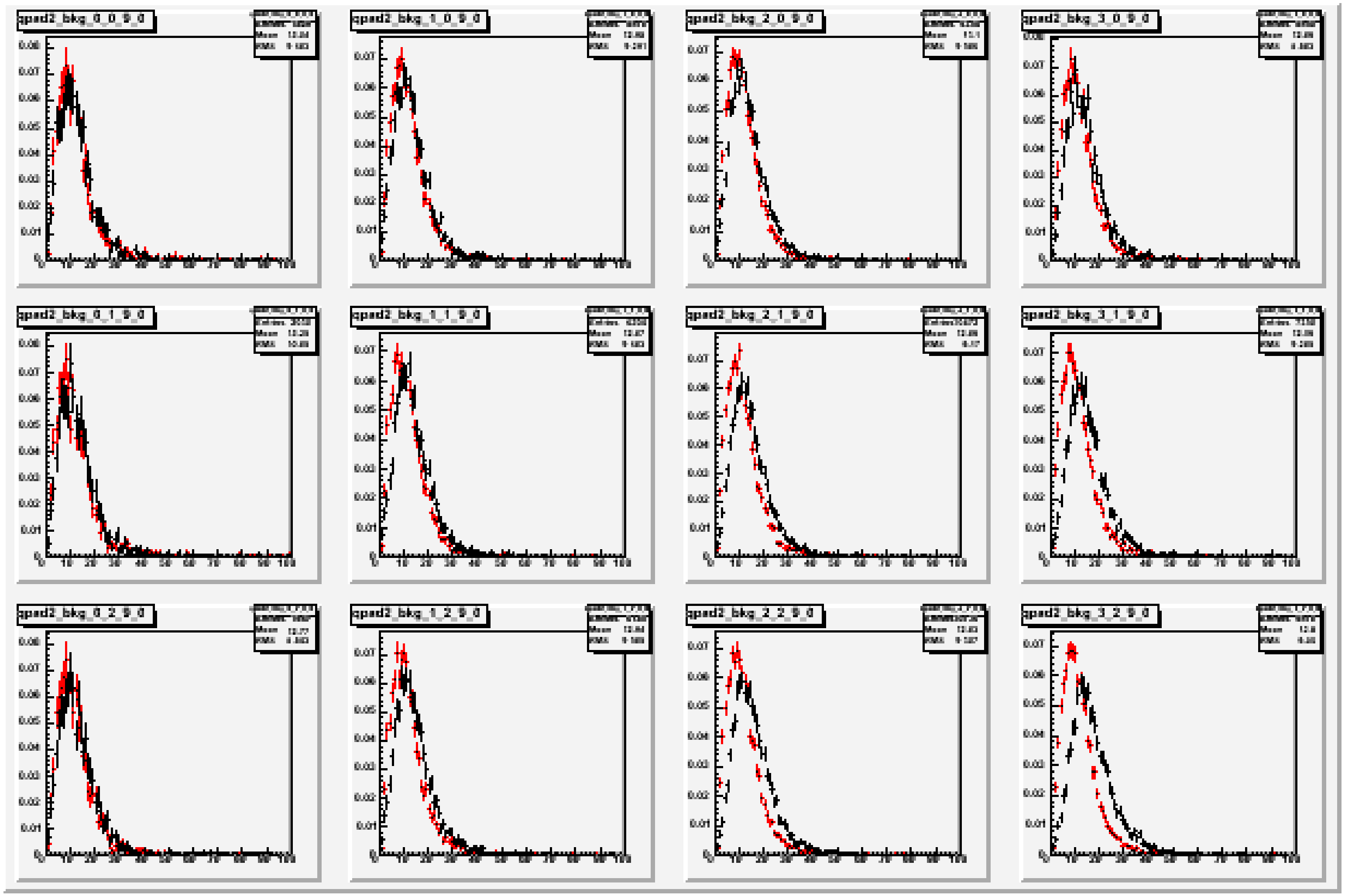
- At 1st neighbor background >9
- Embedded vs. Swapped tracks (Embed Omega→ee)

4 ρ bins

Edge of 1st pad

Center of 1st pad

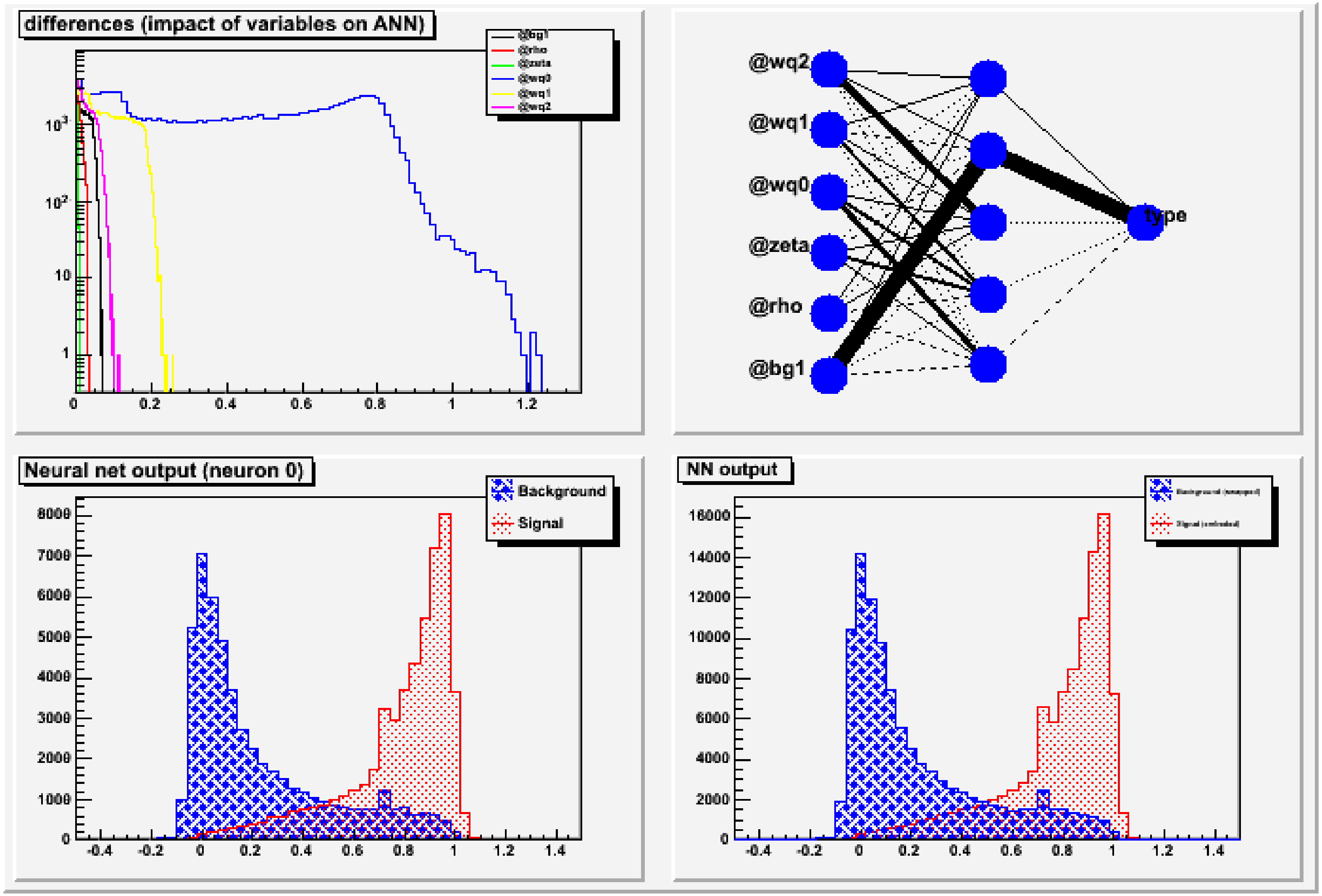
3 ζ bins



Away from 2nd pad

Close to 3rd pad

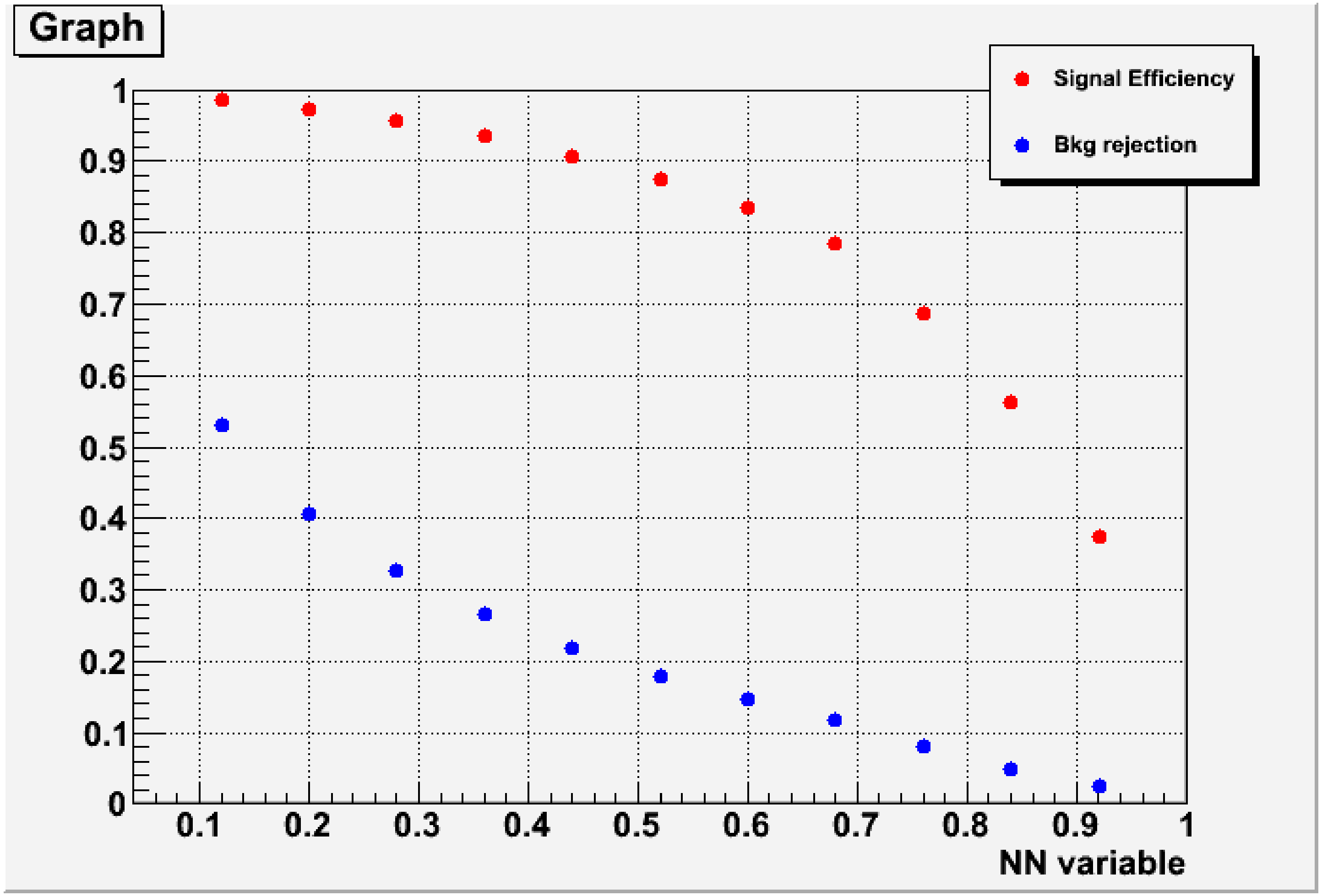
NN result: 0–20% most central AuAu@200 GeV



Testing samples

All samples

Efficiency vs. cut on NN variable



AuAu 200 GeV 0–20% most central events

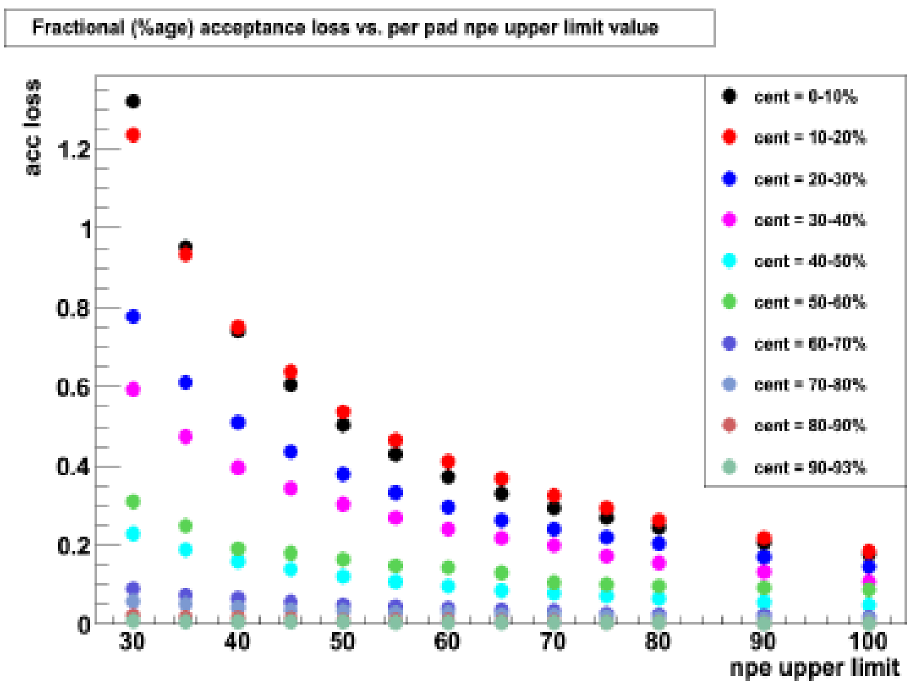
Summary

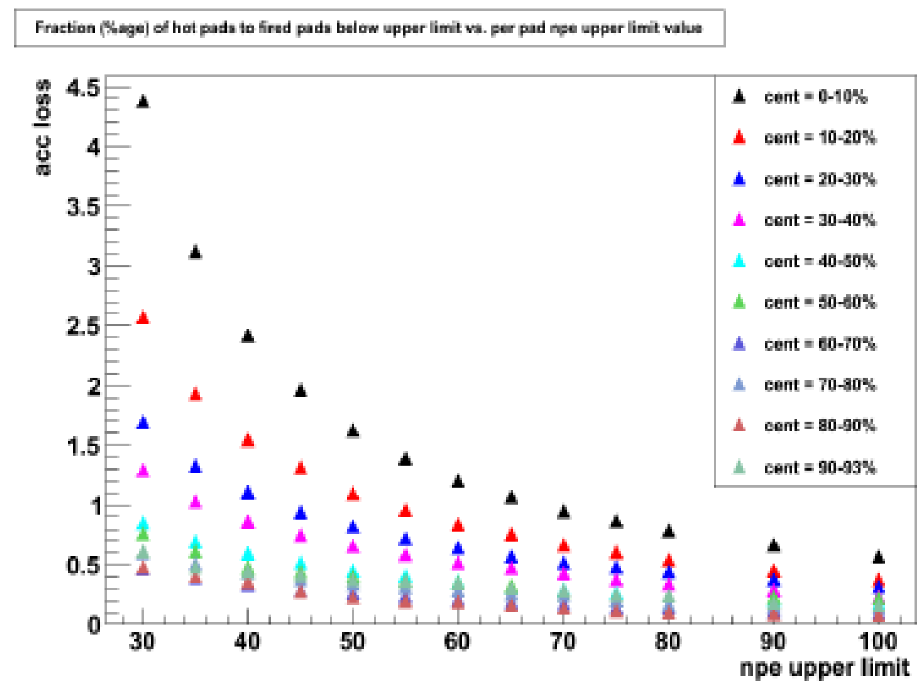
- The HBD was operated in run 9 (p+p) and run 10 (Au+Au) collisions
- The p+p data analysis seems to show that the design objectives are met
- In Au+Au events, the objective is difficult to meet as a result of high scintillation background
- Multiple approaches to handle the problem are being investigated, the current status of these approaches was discussed.

Backup

Effect of upper limit on pad npe

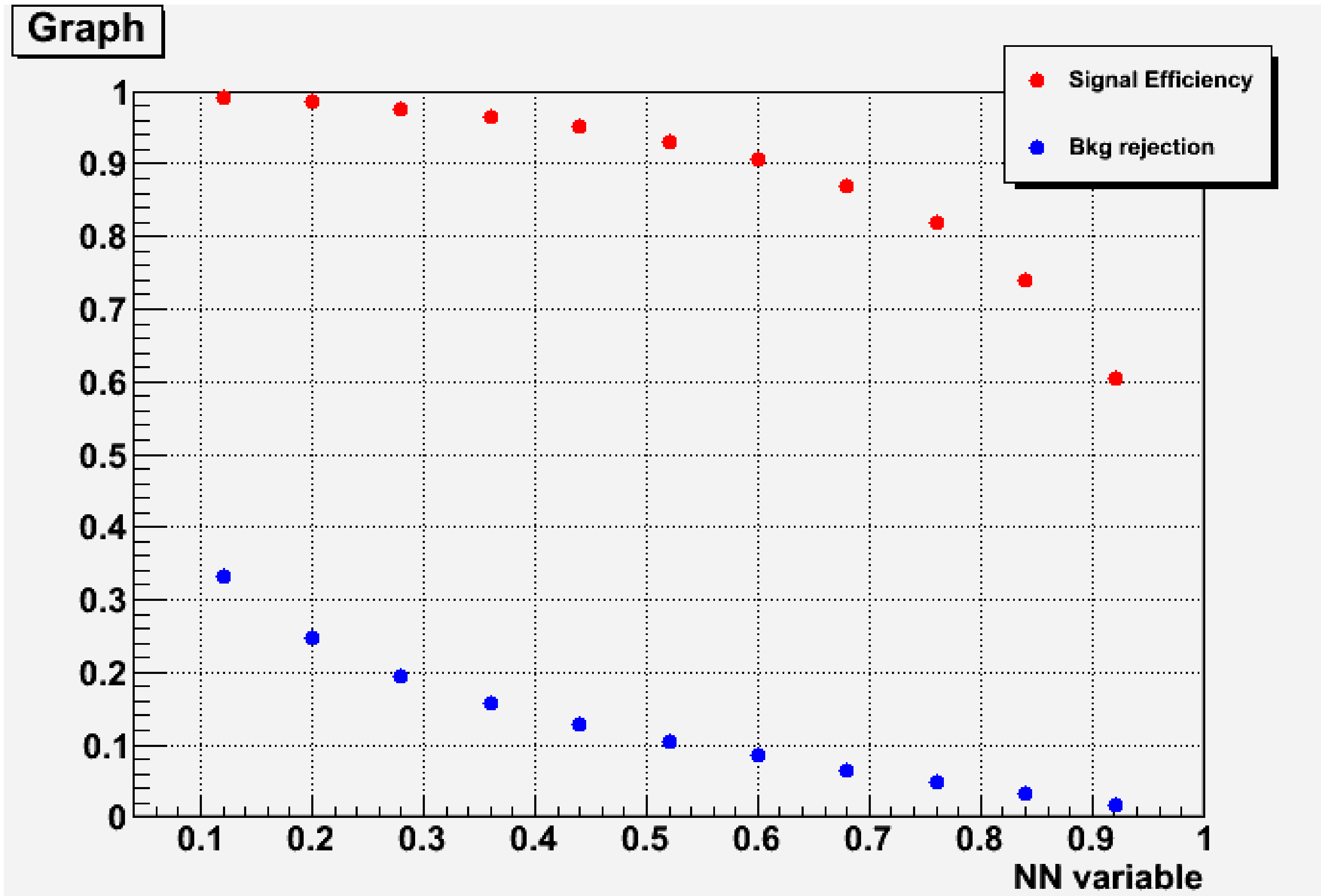
- Before clusterization one can set npe=0 for those pads that fire above a certain upper limit
  - Plot on left: Event averaged fraction of acceptance loss incurred by throwing out pads firing above un UL, vs. the value of the ul for different centralities
  - Plot on right: Fraction of pads firing above upper limit to those firing below upper limit but still above threshold



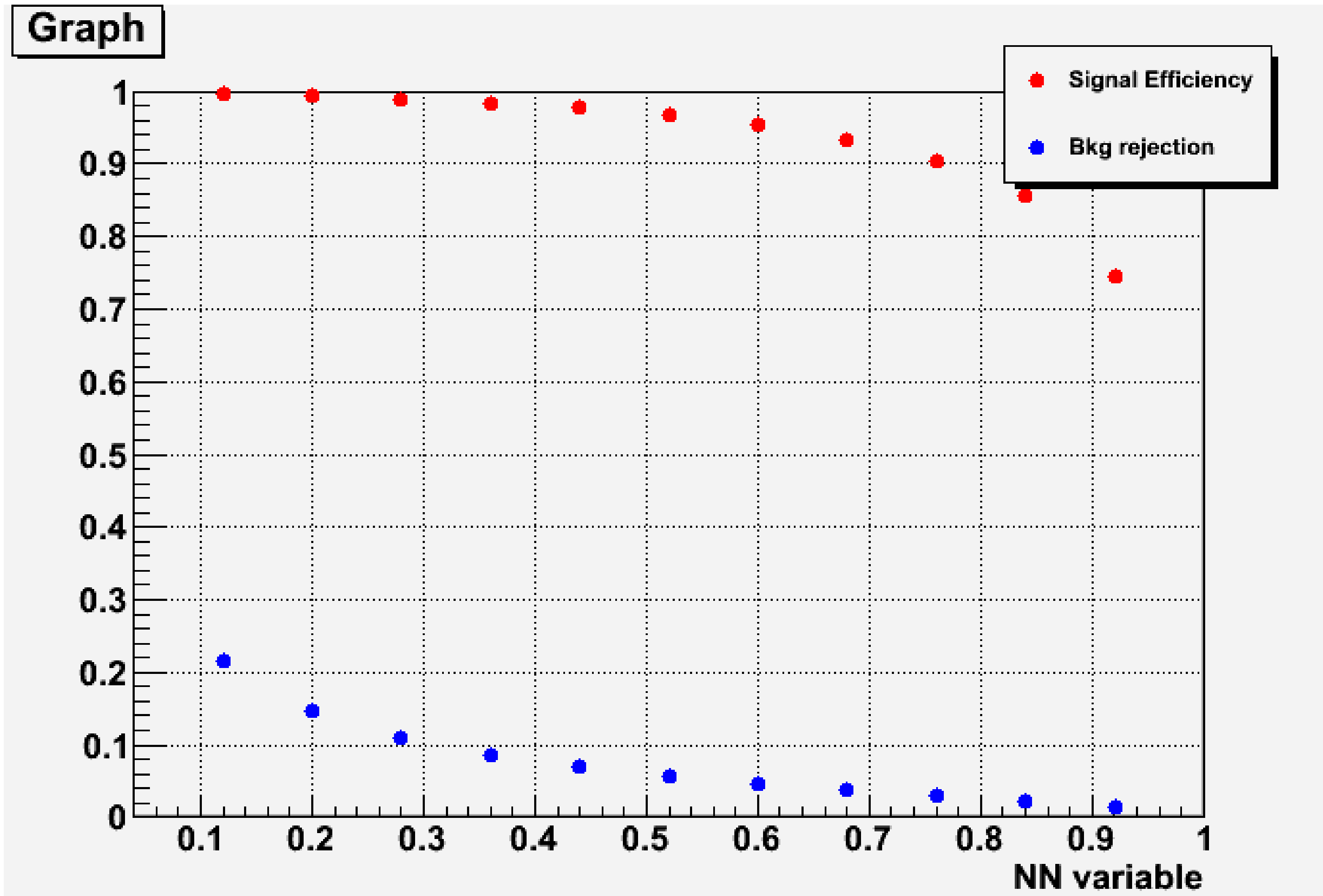


Cutting at 50 seems safe. <2% of fired pads are lost even in most central event

Efficiency and Rejection
centrality: 20-40%
AuAu@200GeV



Efficiency and Rejection
centrality: 40-60%
AuAu@200GeV



Efficiency and Rejection
centrality: 60-92%
AuAu@200GeV