Future Electromagnetic Calorimetry in the Central Region in STAR

Tom Cormier
Wayne State

Bar Harbor
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The Star EMC in RHIC I and RHIC II

Measurements at the core of STAR's high P_T program

Leading hadron triggers (π^o's, η's)
Jets
Jet fragmentation functions (π^o's, η's)
Electrons (J/ψ, Υ, W, Z)
High P_T Direct Photons (inclusive, γ-hadron, γ-Jet, etc.)

To the extent that RHIC II is focused on high P_T and rare probes, the STAR calorimeter has a central role to play

History of EMC Granularity

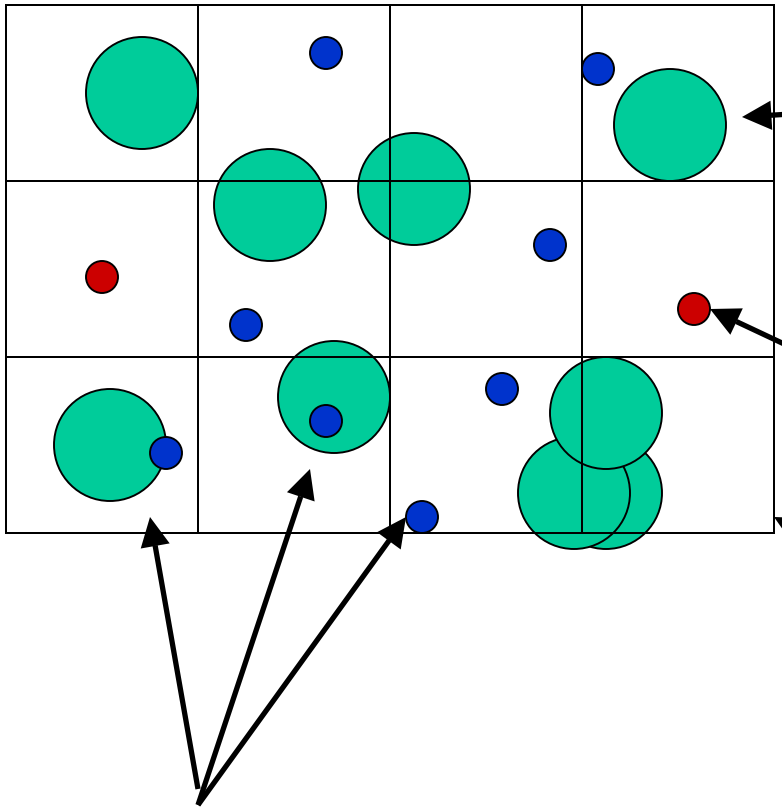
1. **As originally proposed:** 1200 Towers
   18k Shower Max
   $8M

2. **As built:** 4800 Towers
   36k Shower Max
   4800 Pre Shower
   $12.5M

3. **Now Proposed:** 19200 Towers
   36k Shower Max
   19200 Pre Shower
   $8.5M

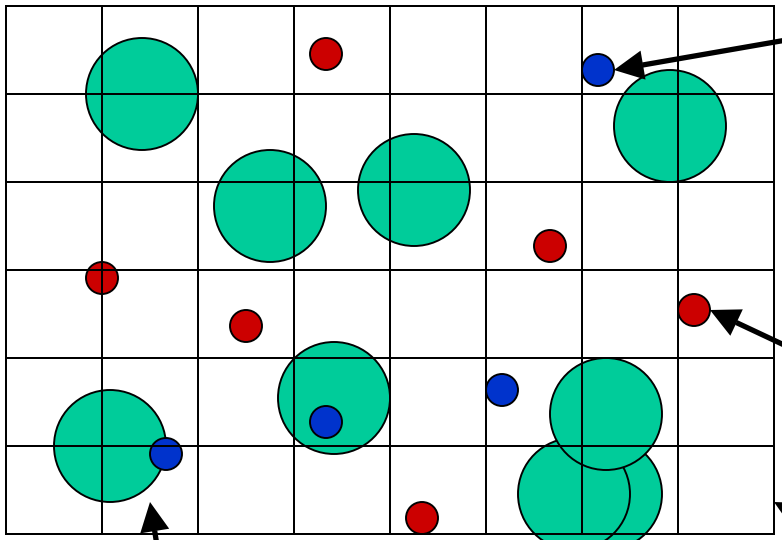
Do we have the best detector for the challenges of RHIC-II?

No, STAR radius is too small by about a factor of two.



Overlapping EM and hadronic showers. **No way to determine EM energy uniquely**

Higher granularity creates more isolated EM Showers



Partially Isolated EM shower

Isolated EM shower

Portion of detector face.

overlapping EM and hadronic showers

Impact of increased granularity corresponding to tower size ~ $2R_M$

1. Improved EM Resolution – Average hadronic background < 50 MeV per tower in central events – This affects everything

2. Improved π^o/γ discrimination over broader P_T range

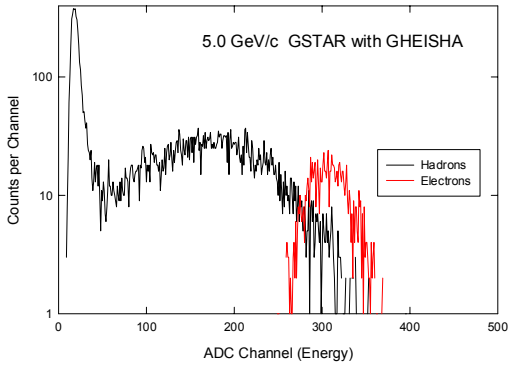
3. π^o/γ discrimination at Level-0

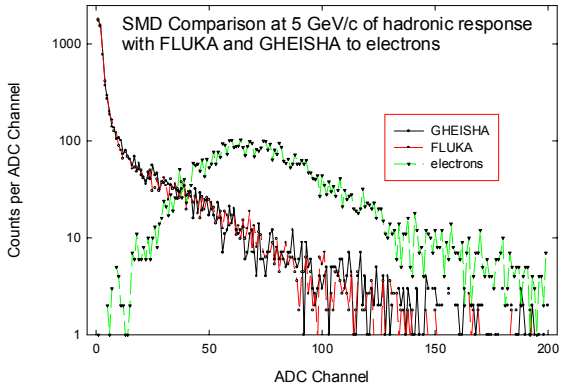
4. Improved e/h discrimination over broader P_T range – Little or no degradation in central events. Effective measurements to ~1 GeV/c ?

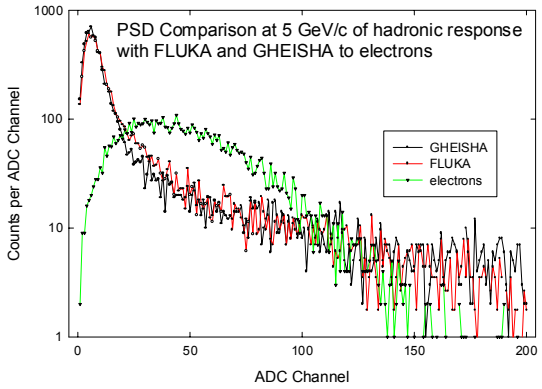
5. e/h discrimination at Level-0 for P >1.5 GeV/c electrons - J/ψ Trigger and greatly improved triggers for ϒ , W, Z.

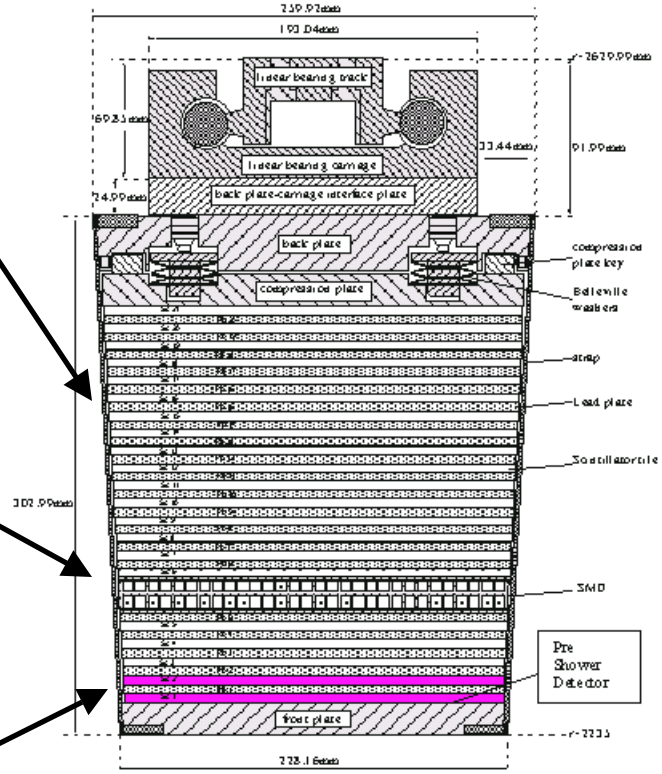
6. Greatly improved hadronic shower identification (e.g. anti-neutrons and anti-protons now occupy 5-8 towers)

Electron / hadron discrimination in STAR --- RHIC I



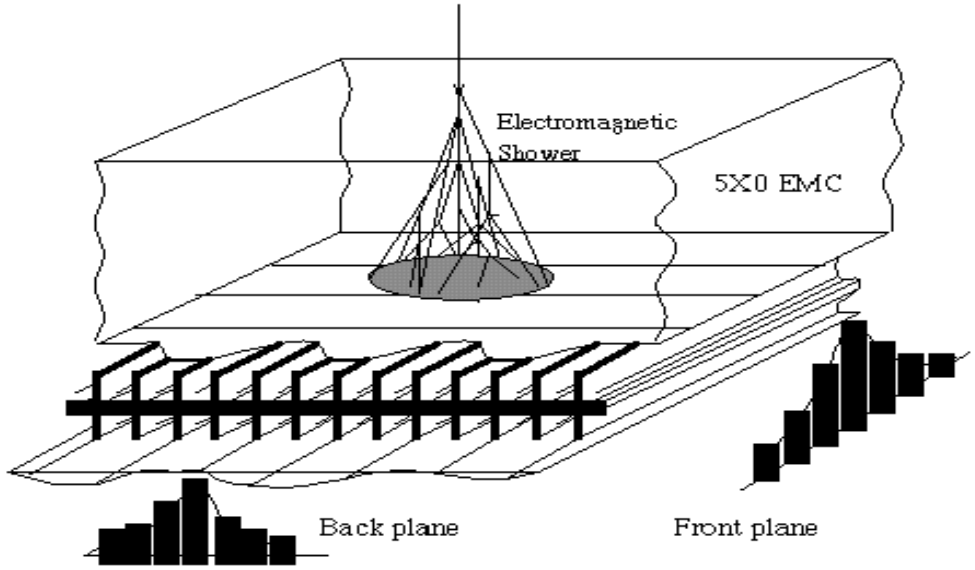






RHIC I Tower size $\Delta\eta$ x $\Delta\phi$=.05x.05

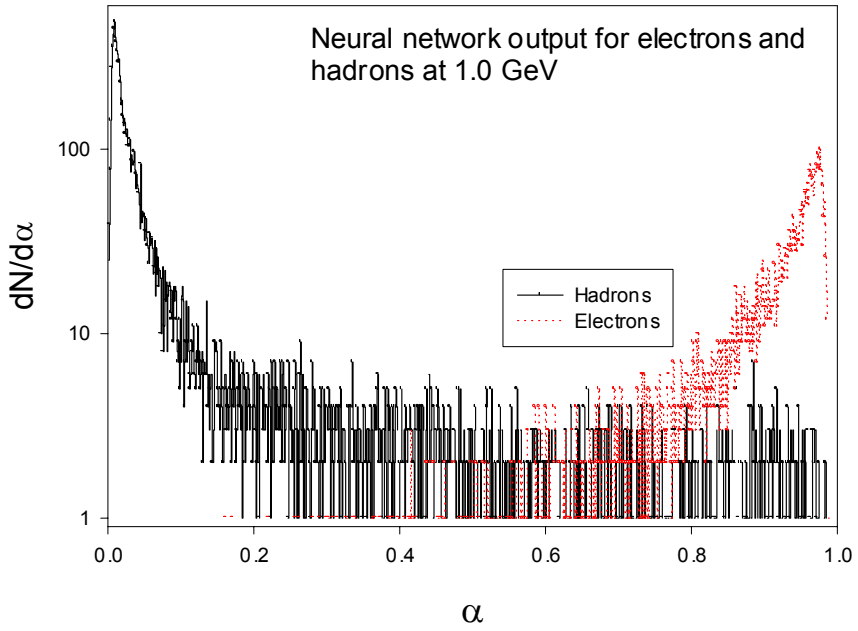
STAR Shower Maximum Concept



Parameters used in e/h discrimination

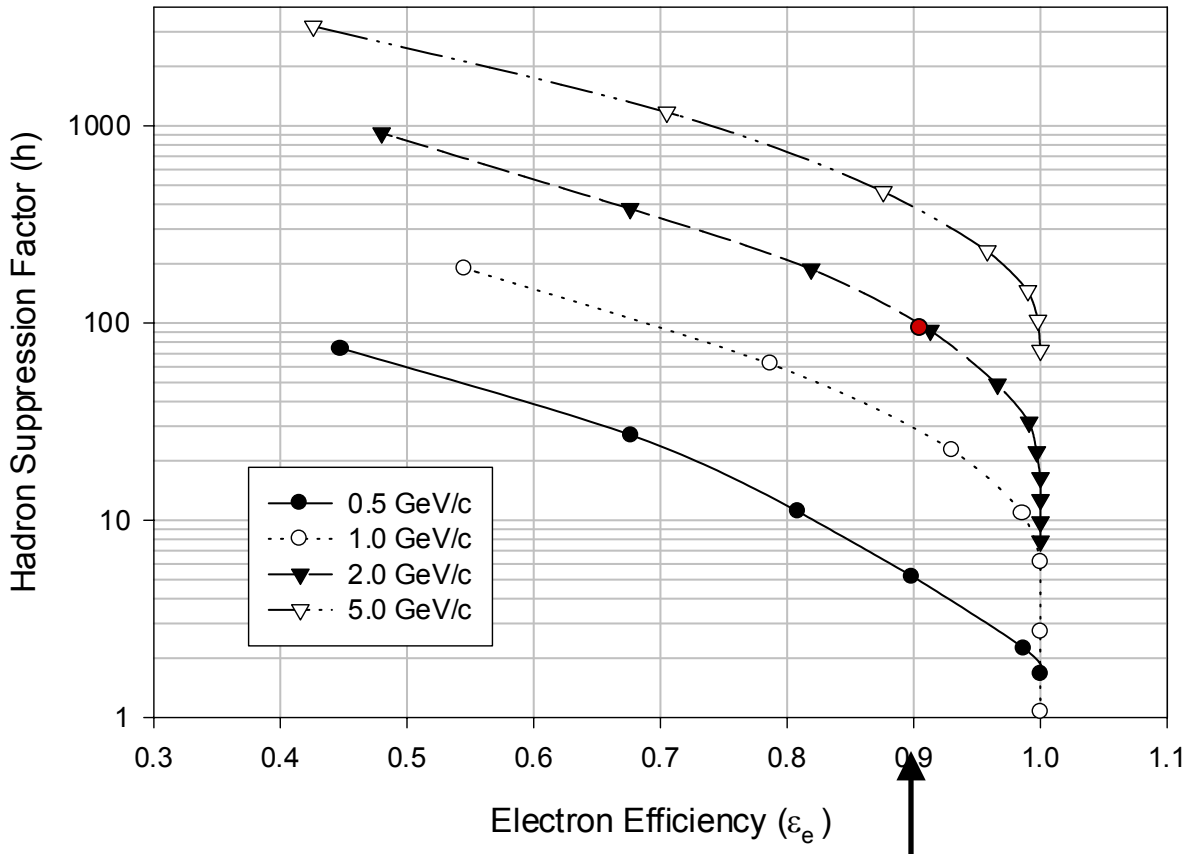
E/p= 1 for electrons, typically <<1 for hadrons
Shower transverse dimensions in η
Shower transverse dimensions in ϕ
Longitudinal shower development at $5X_0$
Longitudinal shower development at ~ $2X_0$
Shower position in η compared to extrapolated track
Shower position in ϕ compared to extrapolated track
TPC dE/dx
SVT dE/dx

Neural network Output at 1 GeV/c



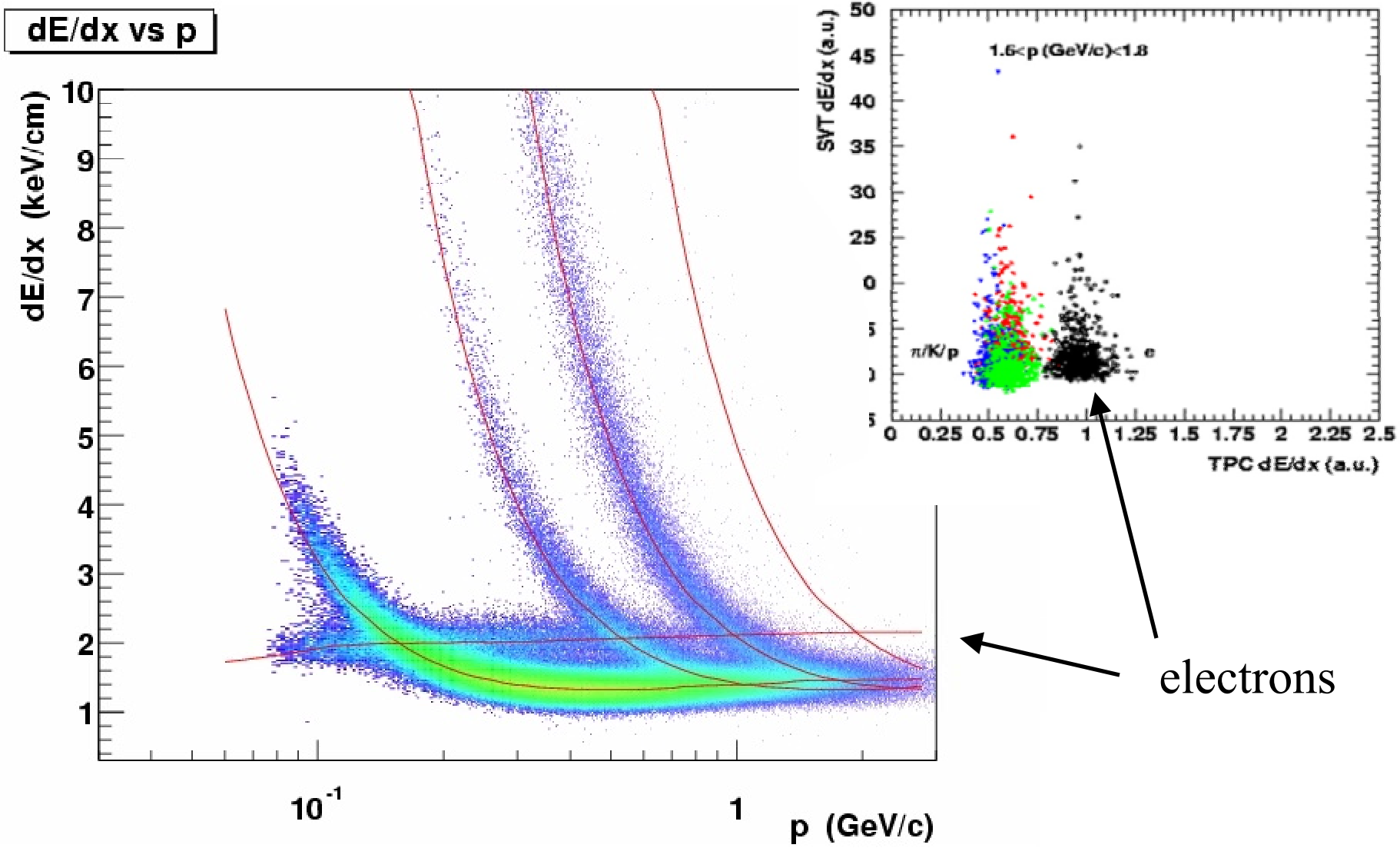
EMC and TPC Tracking Identification of **isolated** Electrons

No dE/dx yet



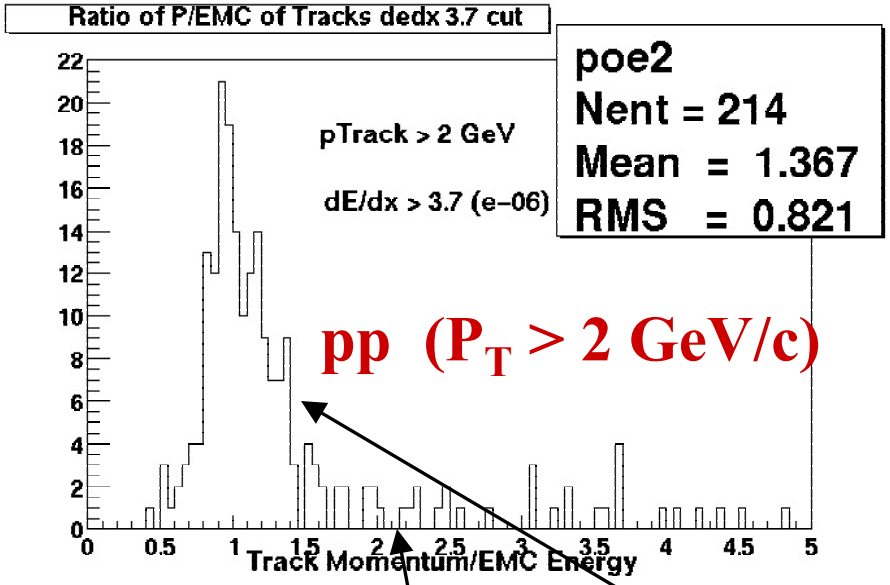
1% Hadron Efficiency

90% e^- Efficiency

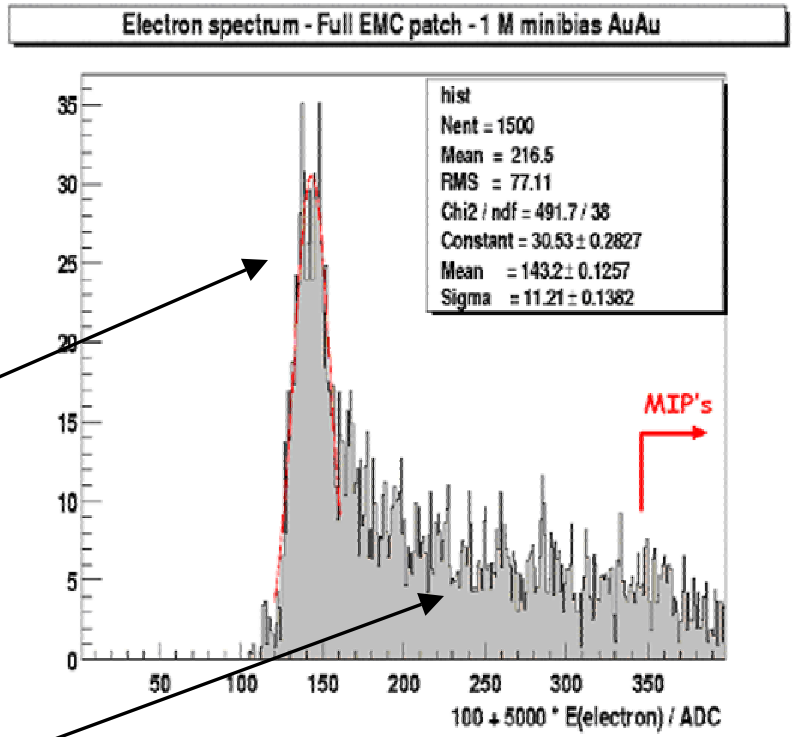

dE/dx vs p
dE/dx (keV/cm)
p (GeV/c)
1.6<p (GeV/c)<1.8
SVT dE/dx (a.u.)
TPC dE/dx (a.u.)
π/K/p
e
electrons

Electron Identification based on dE/dx, EMC Energy and Tracking – No SMD or PSD yet

Min Bias AuAu with Isolation



pp ($P_T > 2$ GeV/c)

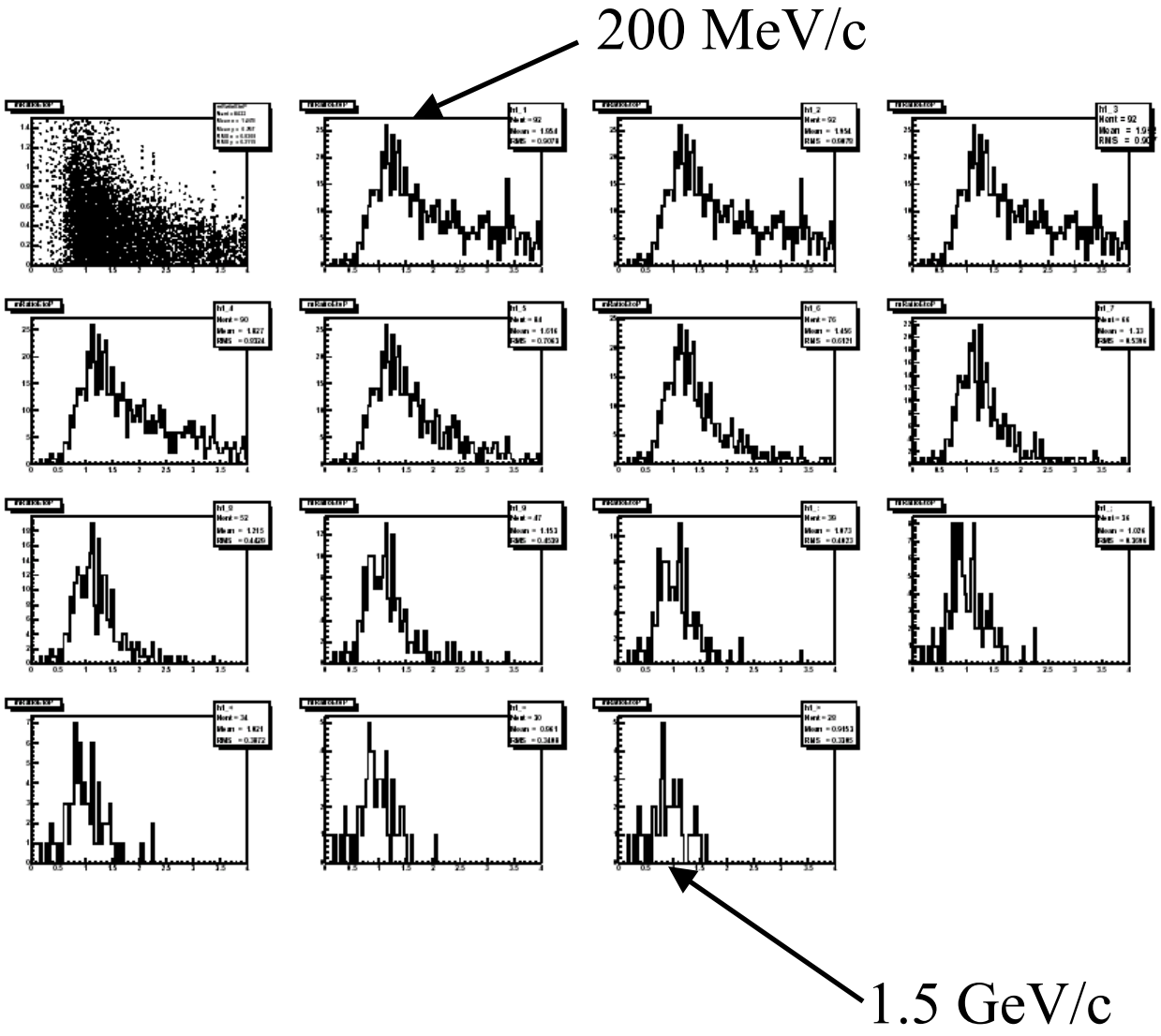


$P_T > 1.5$ GeV/c

electrons

Hadrons

Photon Conversions:
~ zero mass, V0 tracks p/E ratio

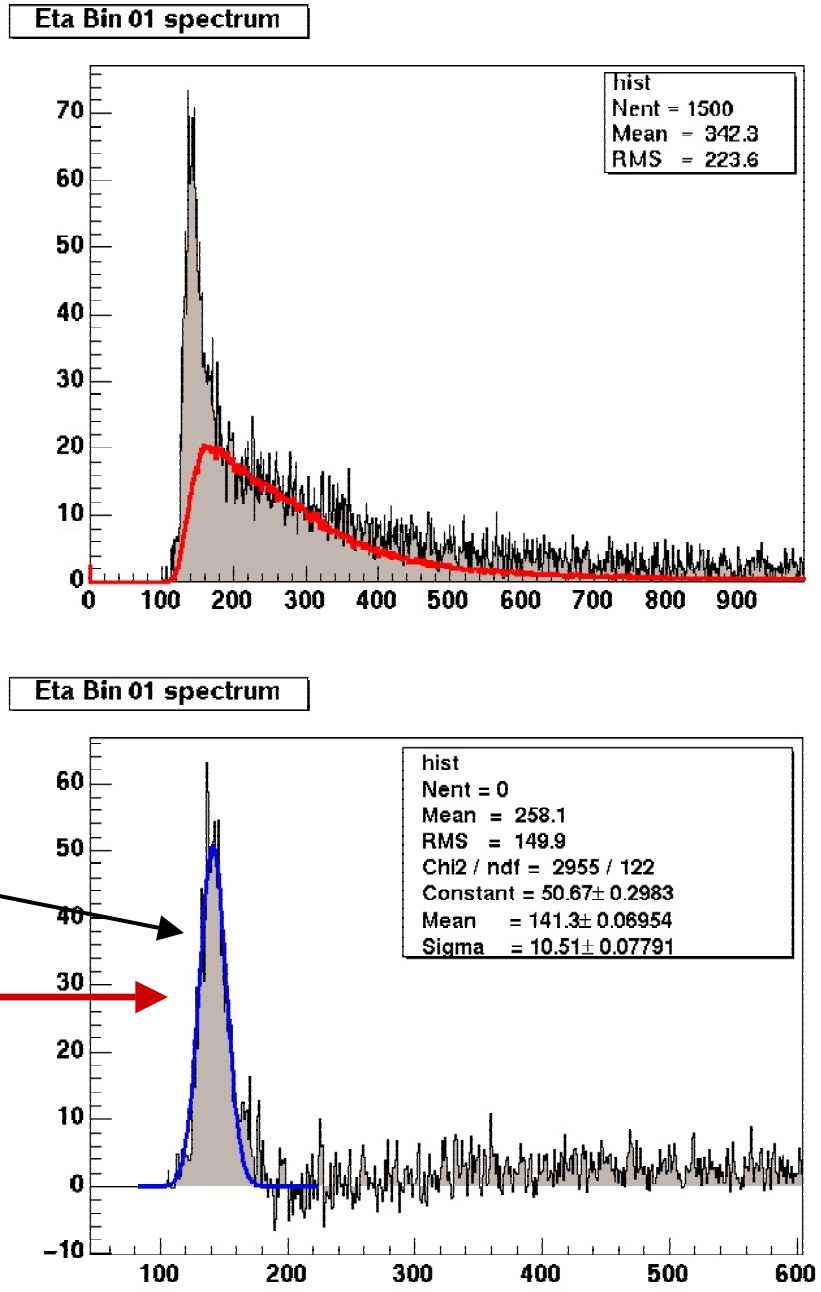


Limitations in e/h due to pileup in AuAu events

Even with a severe isolation cut (0.15x0.15), E/p resolution is still influenced by "unseen" π^0's

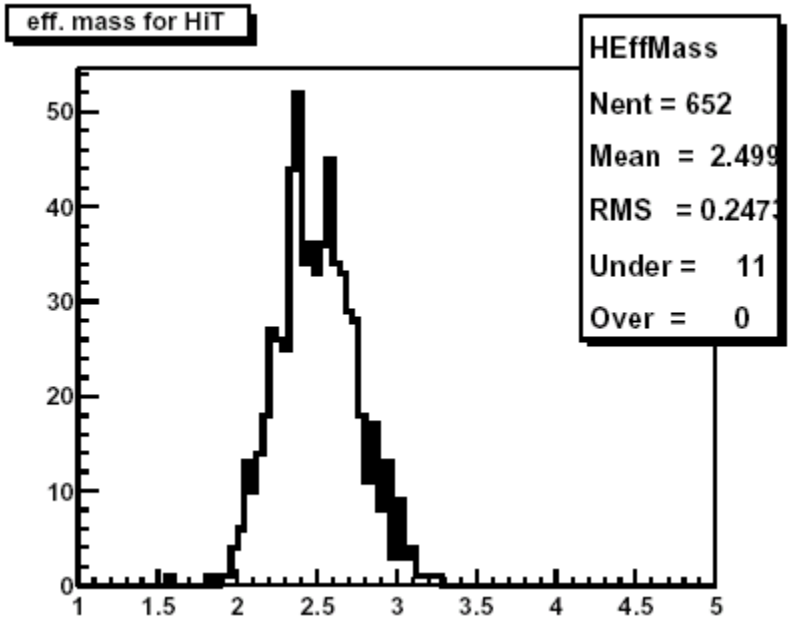
σ/E = 25% Observed

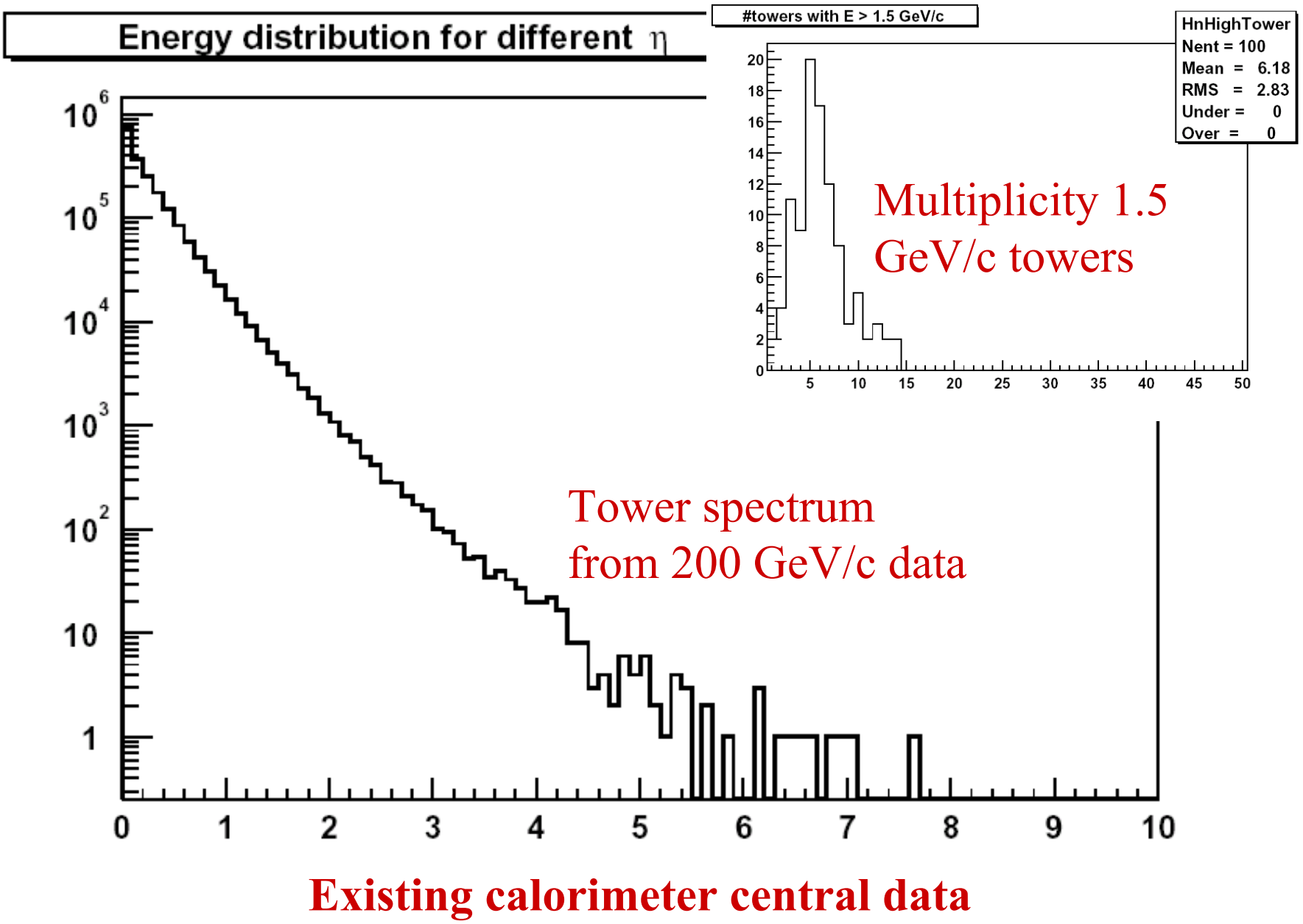
σ/E < 12% Expected for Detector with this e^- sample



An Example: What would it take to trigger on J/Ψ at Level-0?

Pure J/Ψ sample as seen by the high towers (p>1.5 GeV) of the high granularity barrel calorimeter

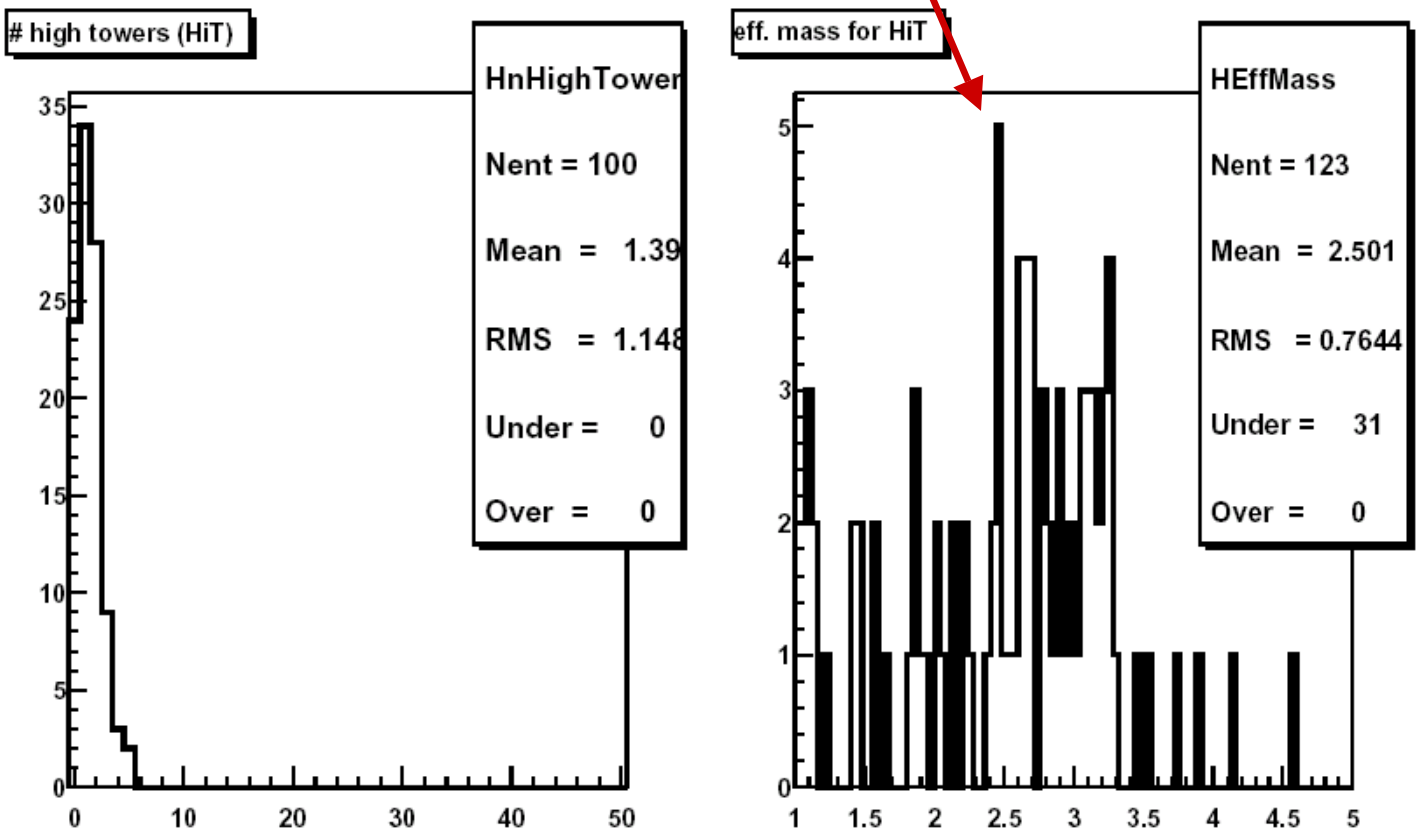



Energy distribution for different η
#towers with E > 1.5 GeV/c
HnHighTower
Nent = 100
Mean = 6.18
RMS = 2.83
Under = 0
Over = 0
Multiplicity 1.5 GeV/c towers
Tower spectrum from 200 GeV/c data
Existing calorimeter central data

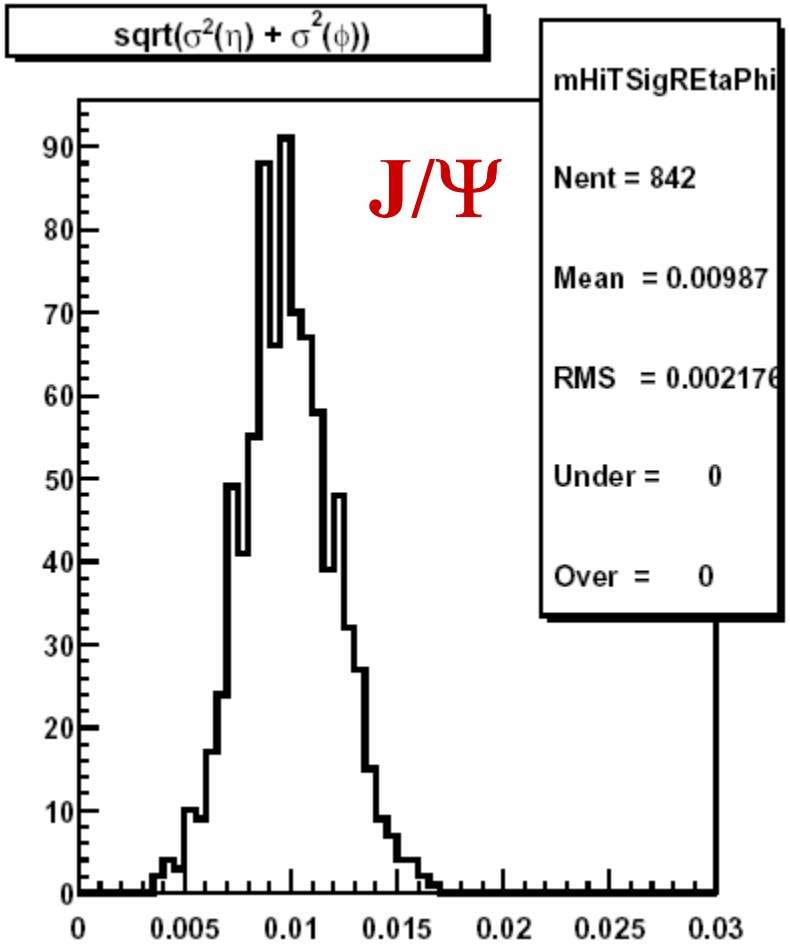
With the higher granularity:

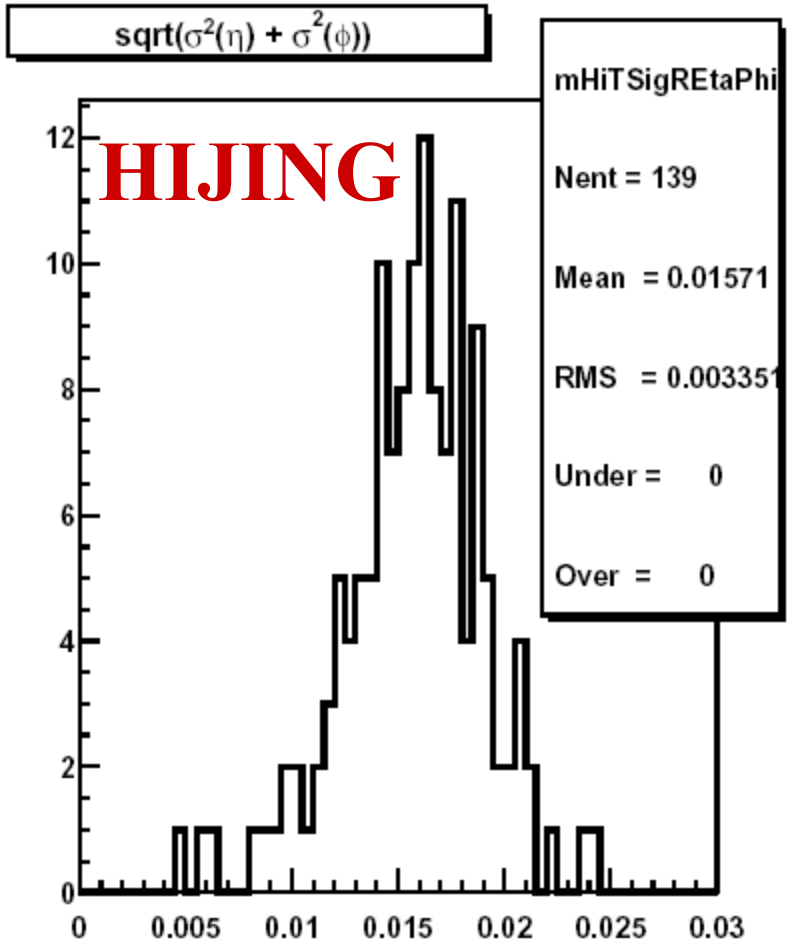
invariant mass of charged track towers with p>1.5GeV/c from central Hijing

~ 0.6 false J/Ψ per event - Almost a trigger

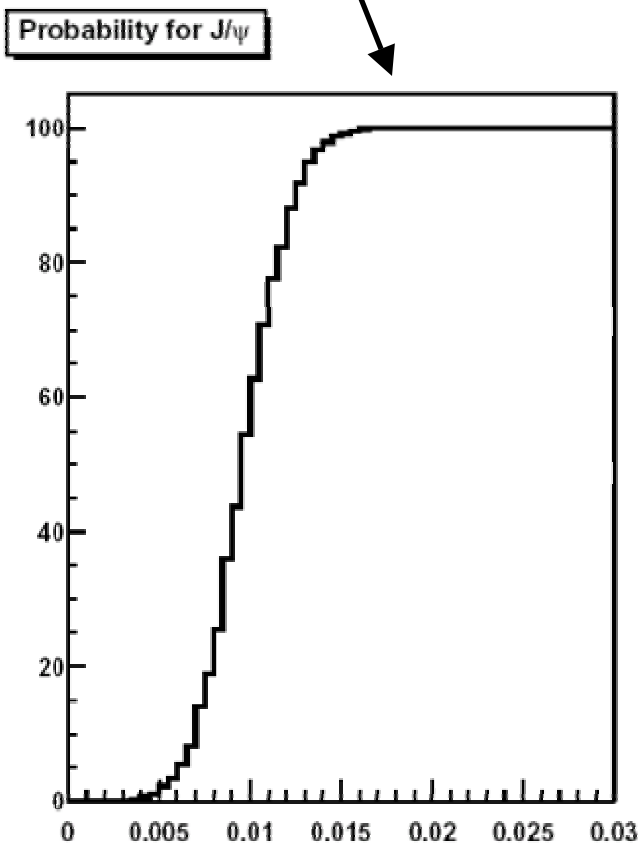


Looking at shower shapes at Level-0

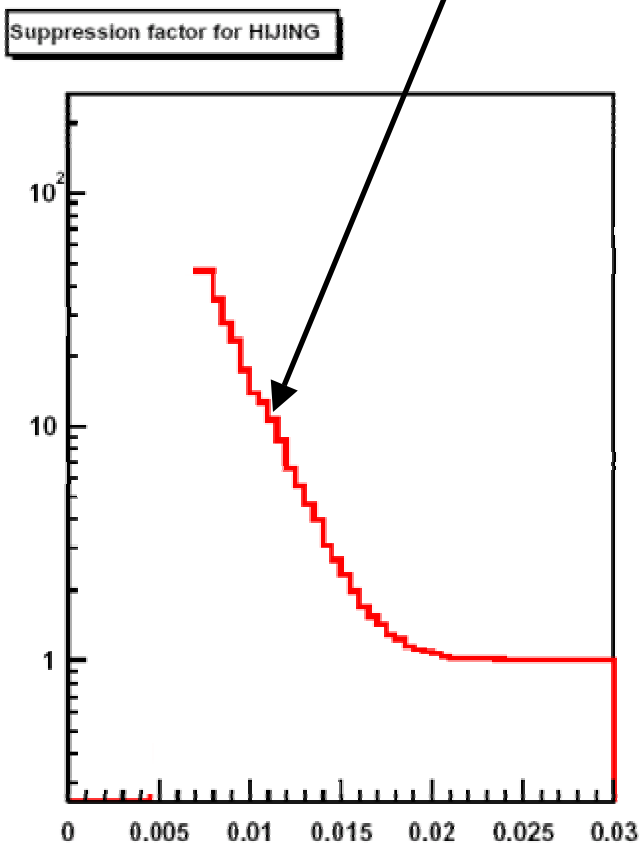




J/Ψ efficiency versus shower size cut

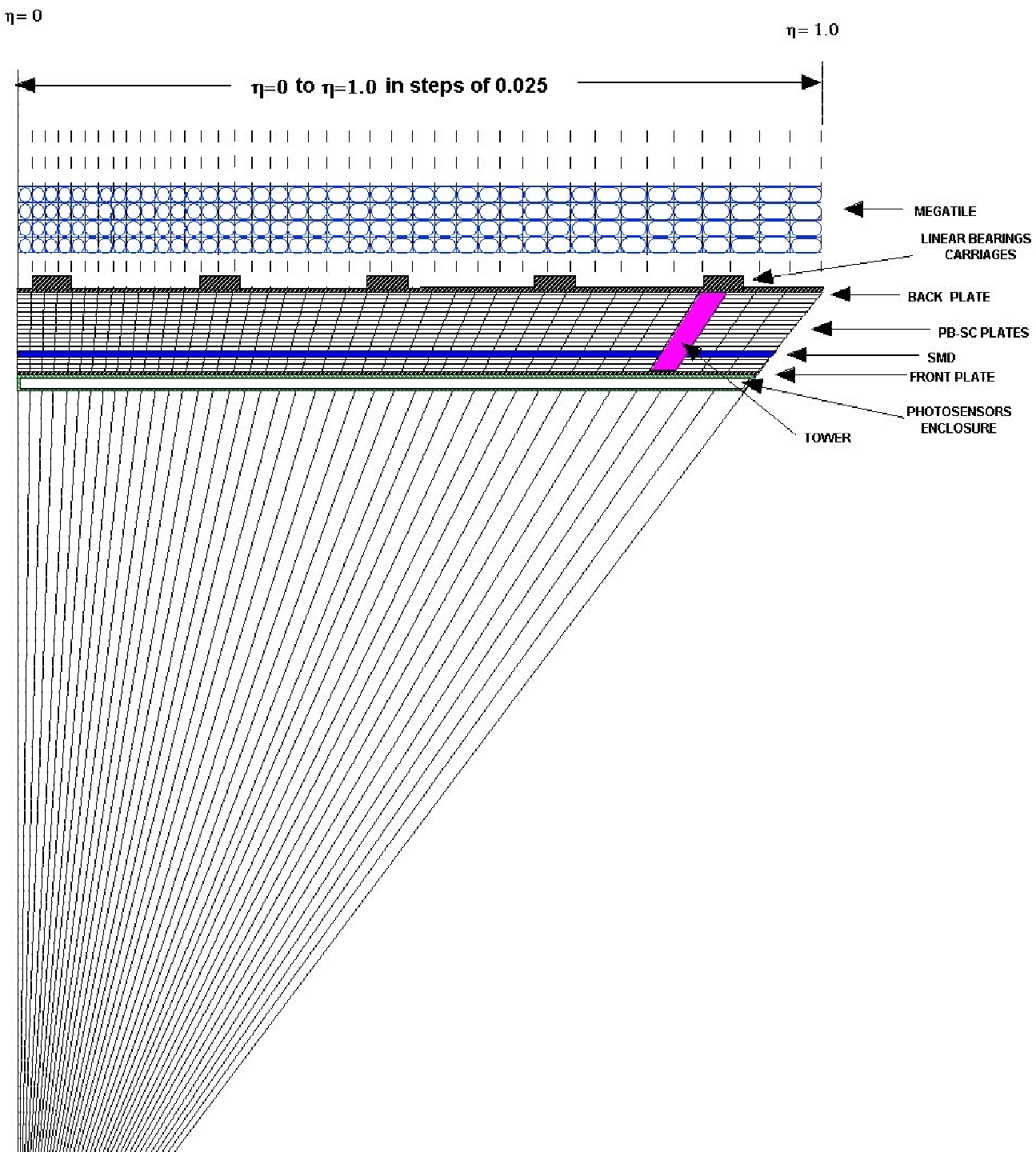


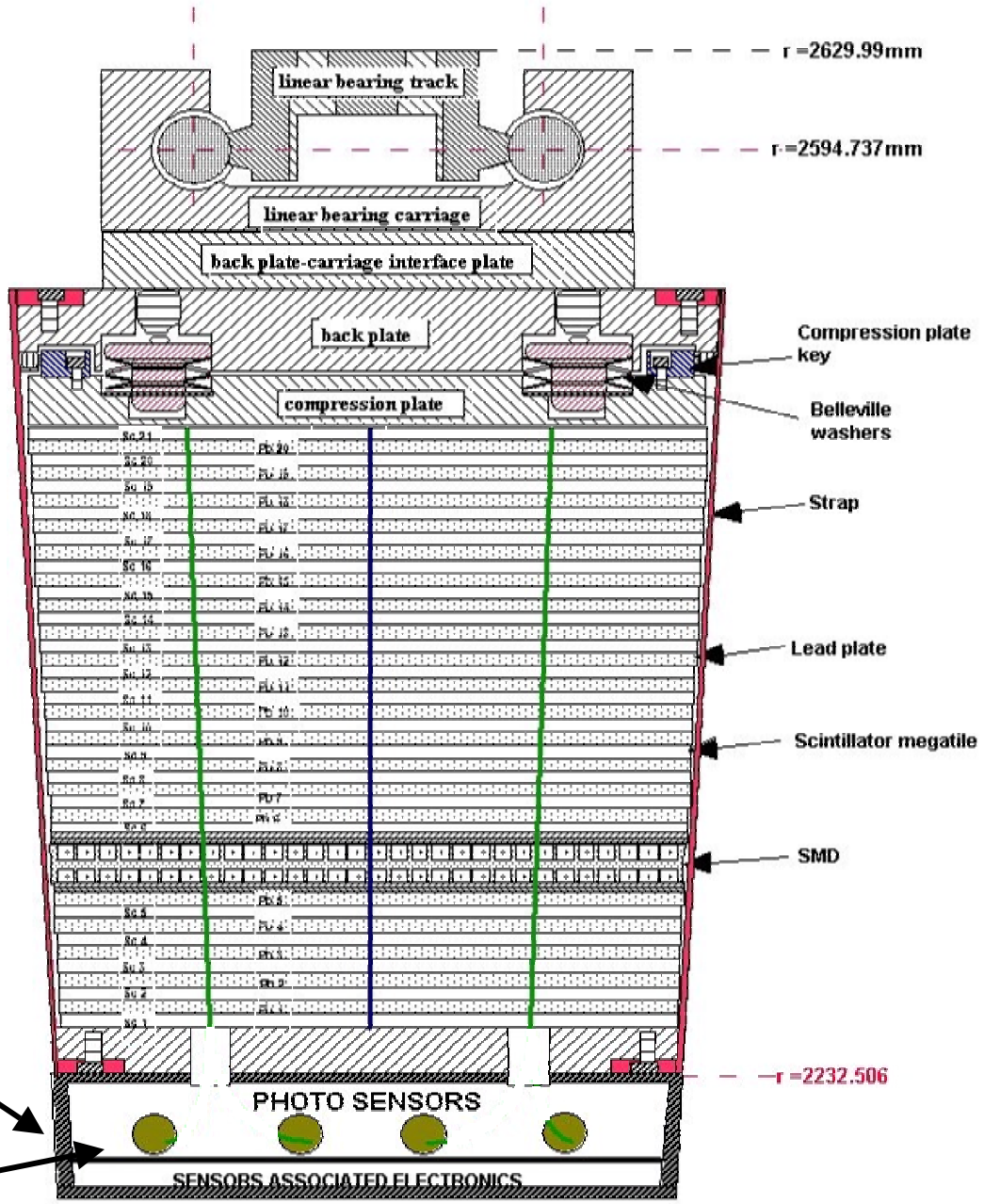
False J/Ψ suppression versus shower size cut



Bottom Line: ~factor of 10 false J/Ψ suppression for 90% real J/Ψ efficiency

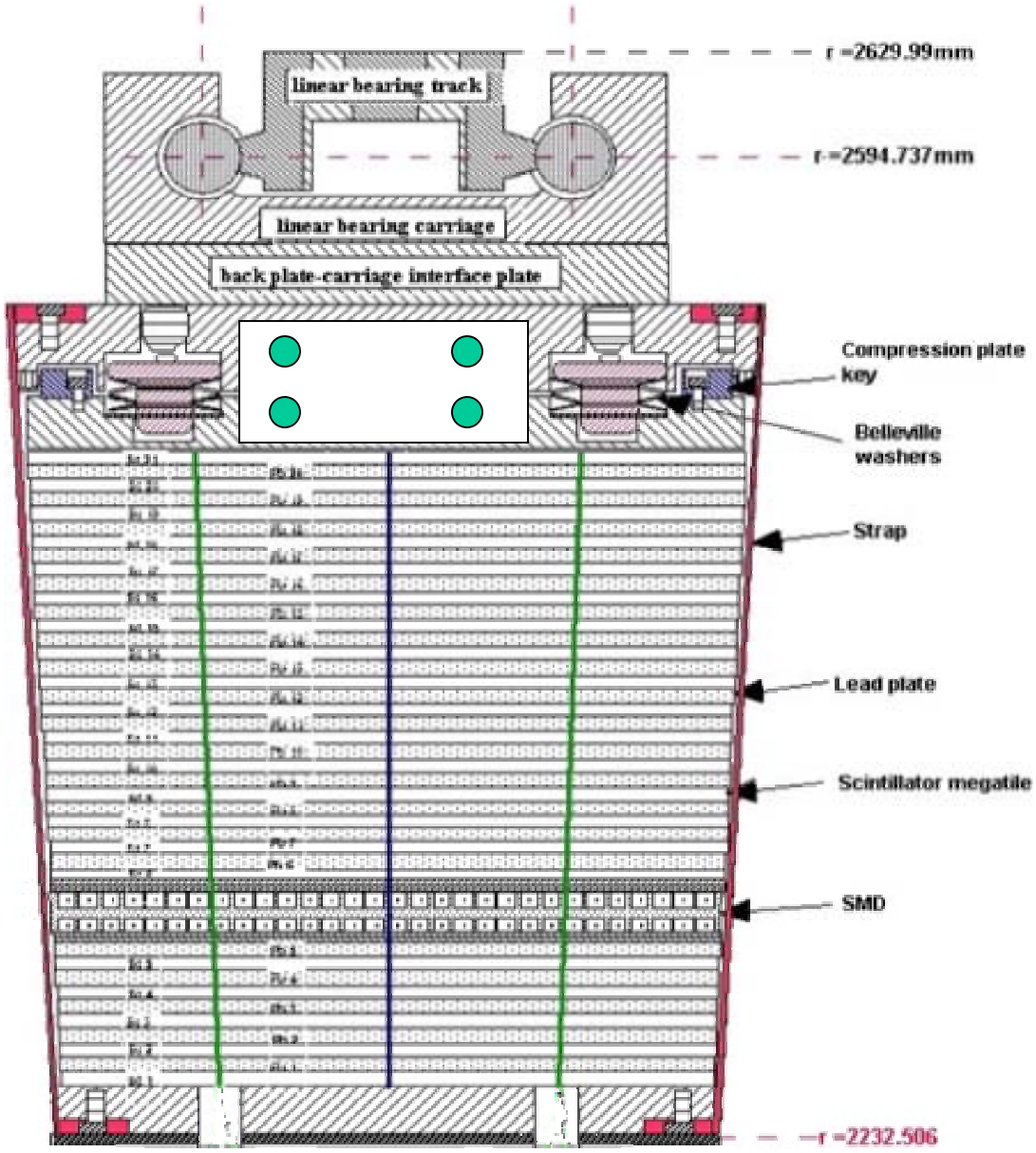
Detector issues

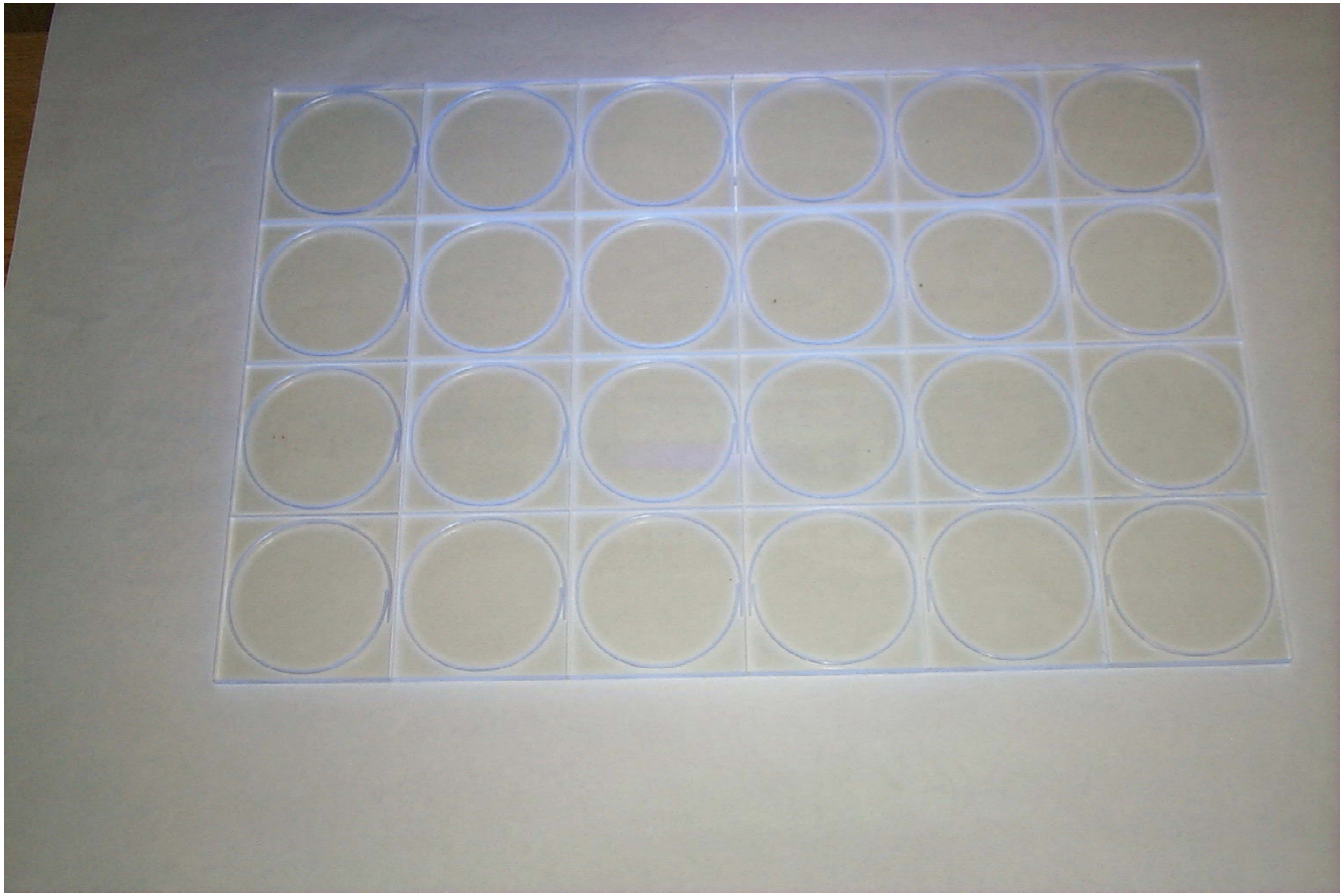

η= 0
η= 1.0
η=0 to η=1.0 in steps of 0.025
MEGATILE
LINEAR BEARINGS
CARRIAGES
BACK PLATE
PB-SC PLATES
SMD
FRONT PLATE
PHOTOSENSORS
ENCLOSURE
TOWER



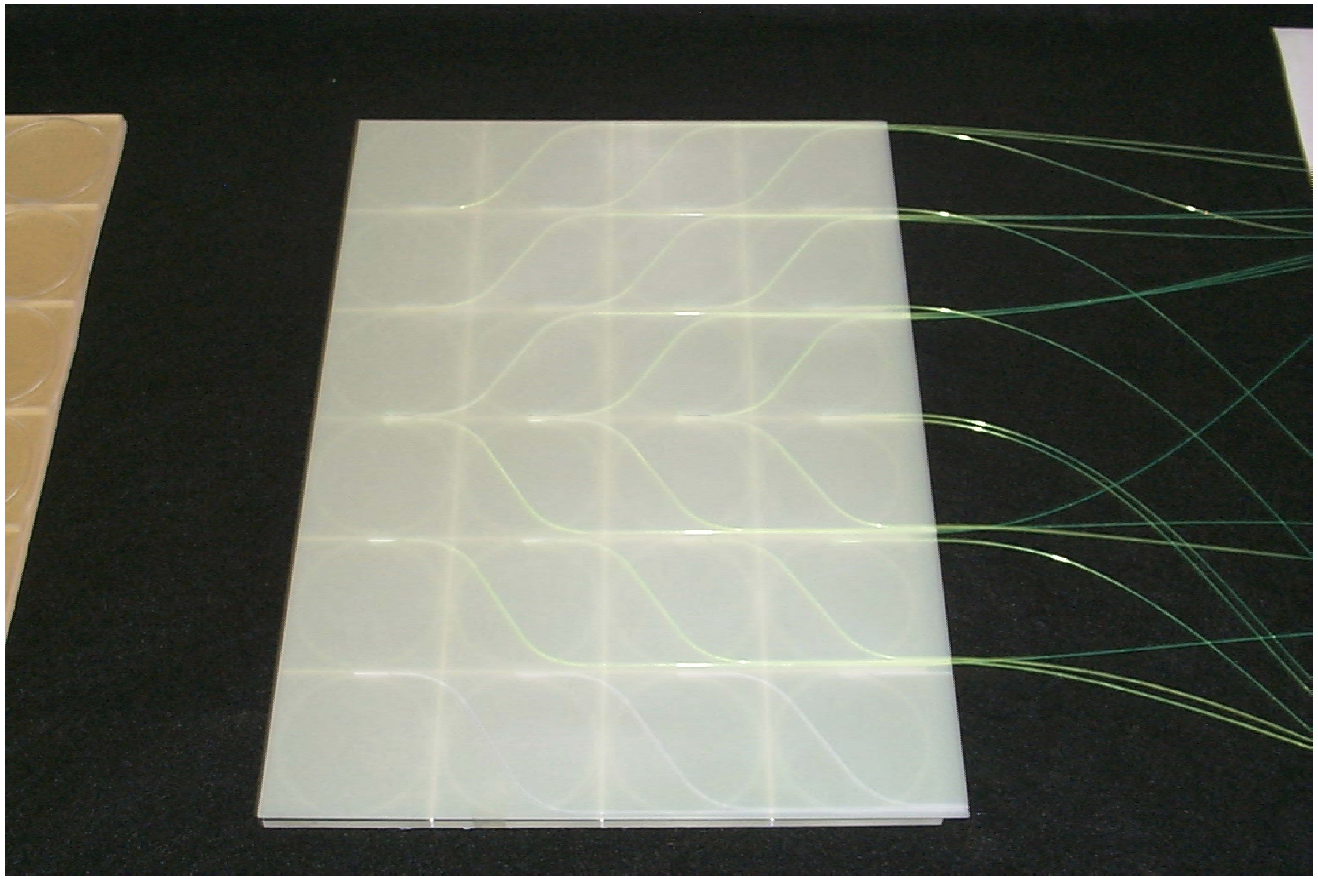
CTB Integration Volume

APD's

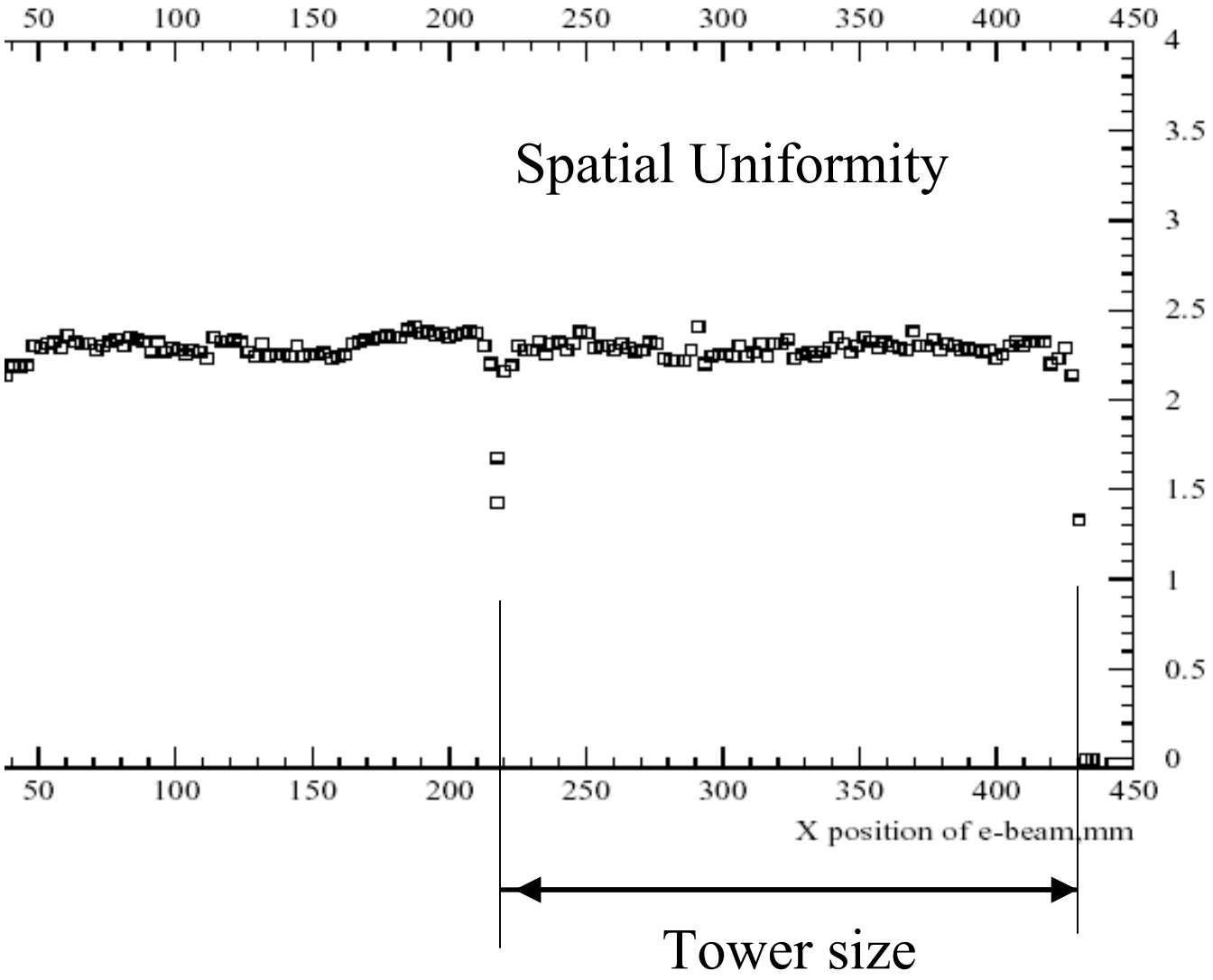

r =2629.99mm
linear bearing track
r =2594.737mm
linear bearing carriage
back plate-carriage interface plate
Compression plate key
Belleville washers
Strap
Lead plate
Scintillator megatile
SMD
r =2232.506



Prototype megatile -- 4 towers (ϕ) by 6 towers (η) near η=0



Prototype megatile and fiber routing layer
-- 4 towers (ϕ) by 6 towers (η) near η=0


Spatial Uniformity
50
100
150
200
250
300
350
400
450
0
0.5
1
1.5
2
2.5
3
3.5
4
X position of e-beam,mm
Tower size

Summary

Proposed scope: 19200 Towers with resolution 15%/sqrt(E) available at level-0, charged track occupancy ~7%

36000 SMD channels imaging showers in η and ϕ available by early level-2

19200 PSD channels, one per tower available by early level-2

Cost: $8-9M *(editorial comment: Most physics per $$)*

Schedule: One long shutdown or 3 or 4 short shut downs