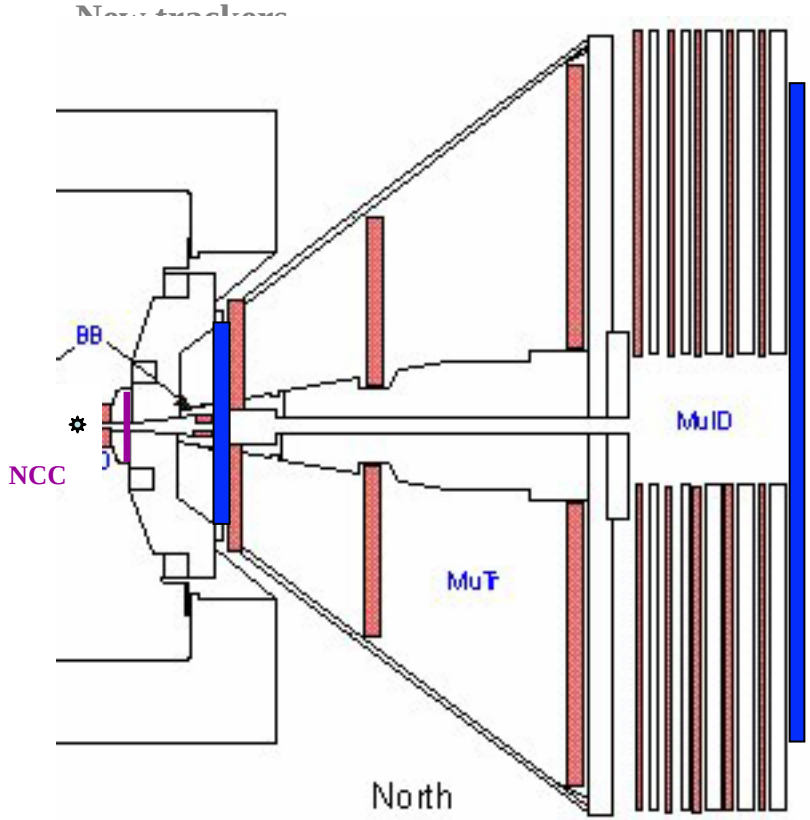
NCC – matching technology to Physics

PHENIX Forward Spectrometer:

Forward Silicon
- **charged particle tracking**

Forward Calorimeter (em and hadronic)
- **energy and position measurements**
- **g/e/jet trigger**

Forward muon system
- **muon tracking**
- **muon trigger**



Same upgrades on South side

Integrating NCC into PHENIX Forward Spectrometer

- reasonable resolution for e/m showers – the only measurement which can be precise given all PHENIX Forward constrains;

- e/γ and charged/neutral hadron separation;

- γ/π^0 identifier;

- jet recognition, good space vector, re nable 4-vector jet measurements;

- combined muon tracking starting cl to production vertex;

- e/γ/jet triggers;

NCC MUST have superior pattern recognition capabilities

fine laterally and longitudinally segmented sampling calorimeter !!!

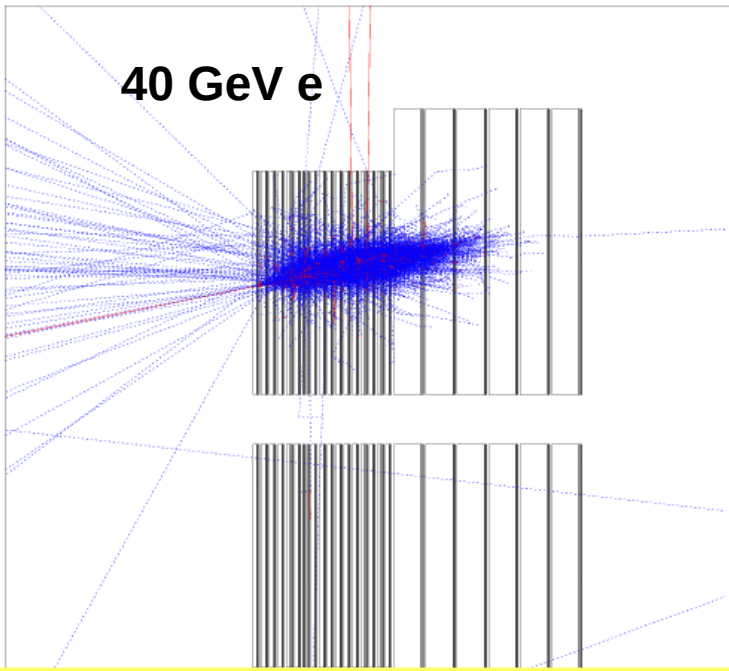
given real estate constrains ->W+Si

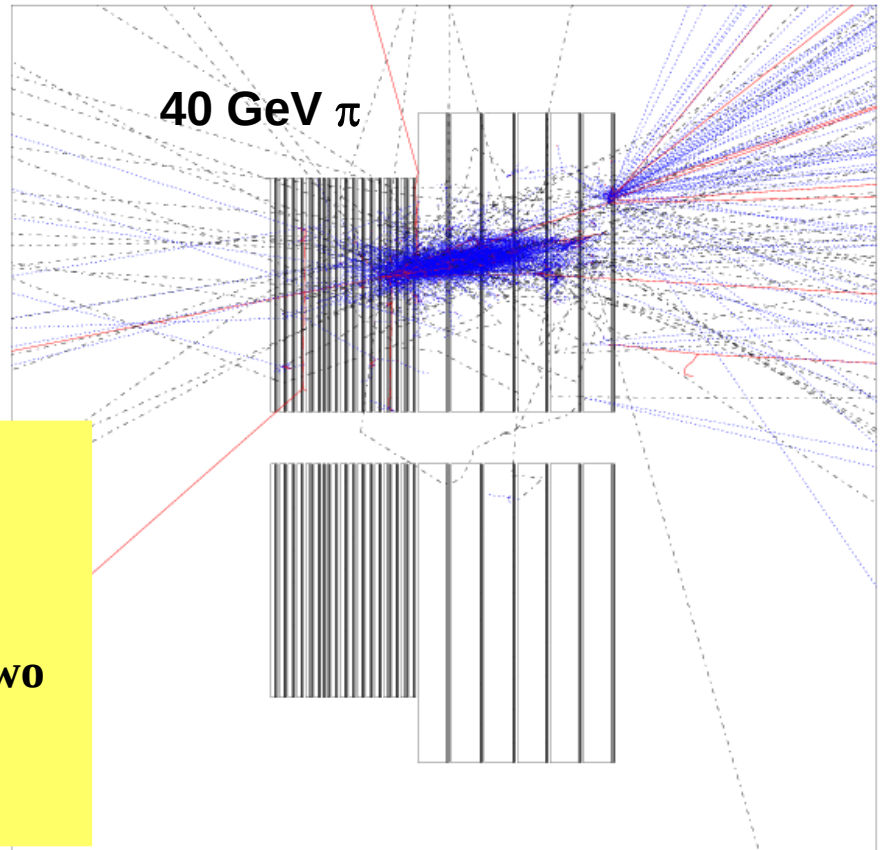
NCC – constrains and design

-only 40 cm apart from collision point …

-only 20 cm of space is available … and then …3.5 Labs of dead material downstream

-impact angles to 45°





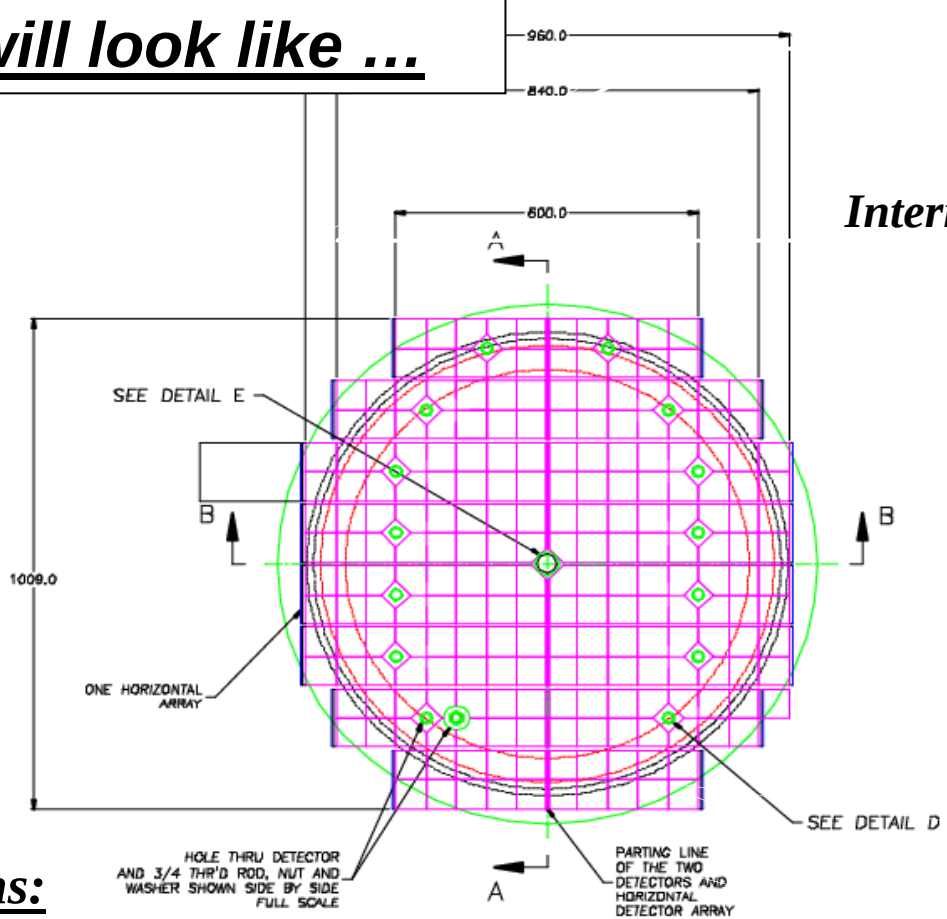
Calorimeter: ~ **40 L_{rad} / 1.6 L_{abs}**

Lateral seg. **1.5 x 1.5 cm^2**

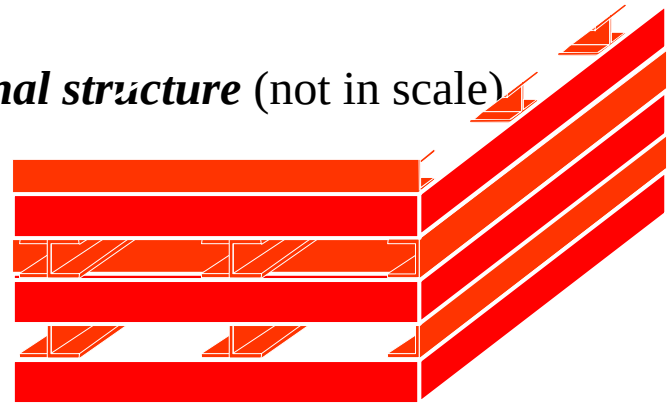
EM section: **10 Lrad**

γ/π^0 identifier: **at a depth ~ 5Lrad (two layers of ~2x60 mm^2 strips)**

How it will look like …



Internal structure (not in scale)



Tungsten plates 2.5 mm

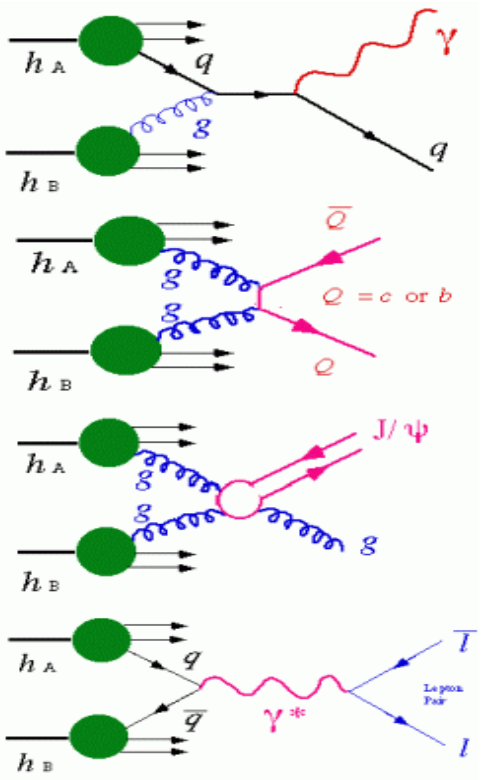
Spacers glued to W

Constrains:

- ***Structure in place prior to SVT installation;***
- ***Easy access for repairs/replacements;***
- ***Minimal power consumption – no forced cooling;***
- ***Competition for the real estate on magnet pole;***

See M.Boesio & G.Zampa talks about similar devices

Why this idea may work …



photon & jet

jet pair

jet & lepton pair

lepton pair

Commonality:

2->2 processes distorted by the initial and final state effects

Tags:

Direct photons
High Pt leptons
Jets
Leading hadrons from jets

Tagged observables

Jets
Leading hadrons from jets

In pp "tags" and "tagged" objects are well isolated, not so in AuAu

But …

PHENIX has no acceptance for jets and soon may be competing against 4π STAR coverage for direct photons

Correlated γ-jet events in PHENIX

Subprocess	σ [mb]
All included subprocesses	1.261E-04
f + fbar -> g + γ	1.643E-05
f + fbar -> γ + γ	9.969E-08
f + g -> f + γ	1.095E-04

10^6 events

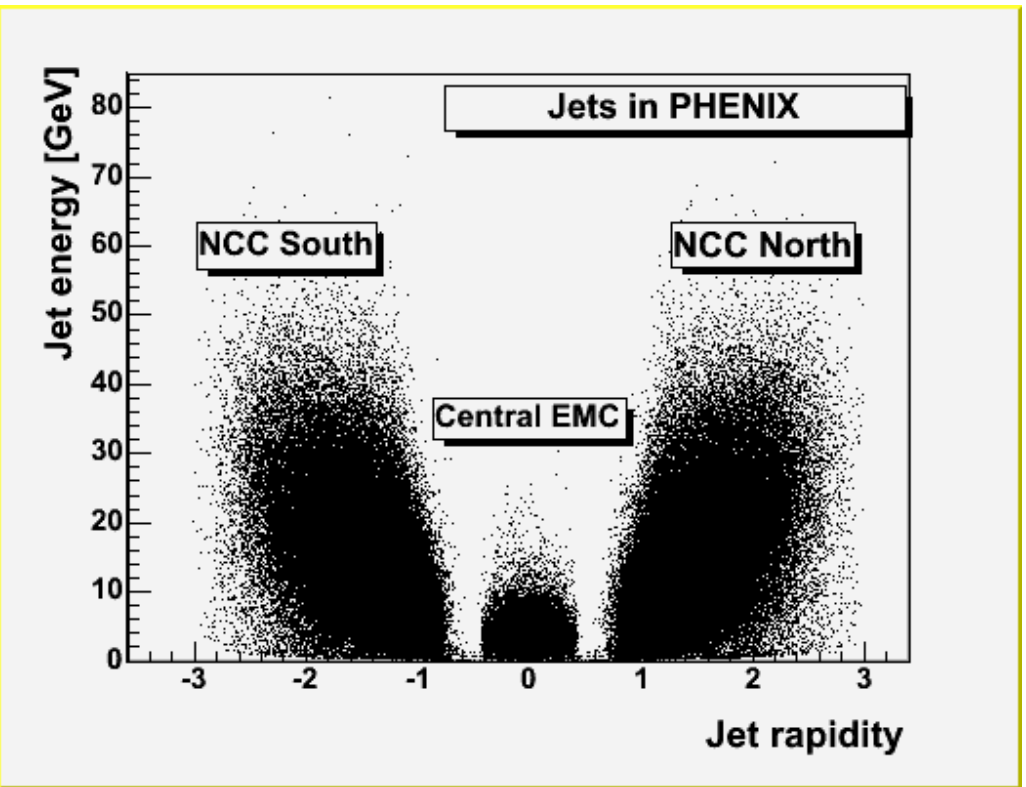
(10 / pb)

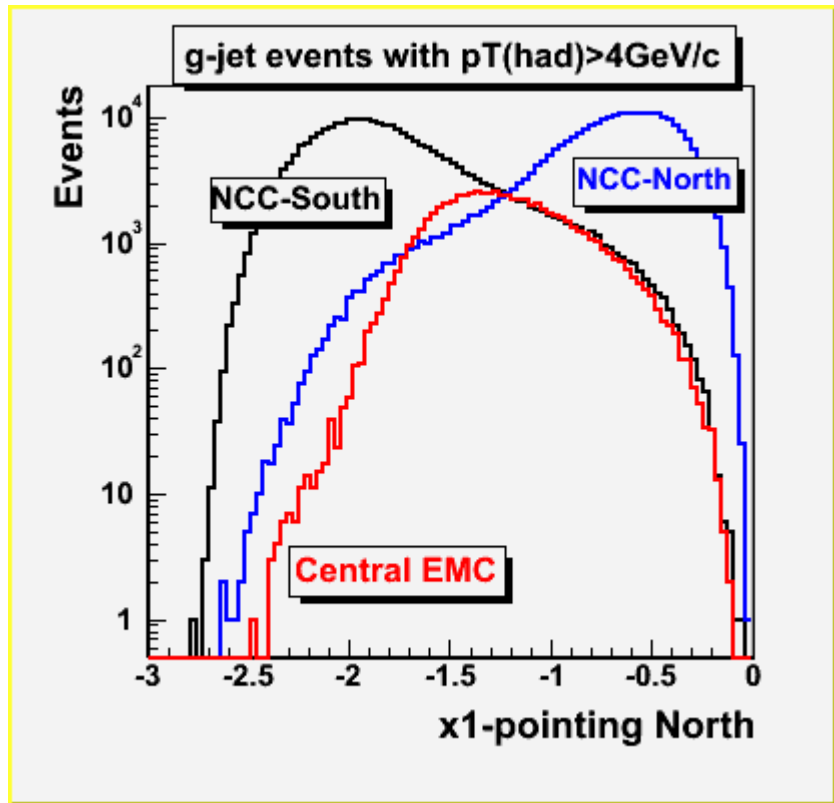
pT(hard)>4 GeV/c

K = 1

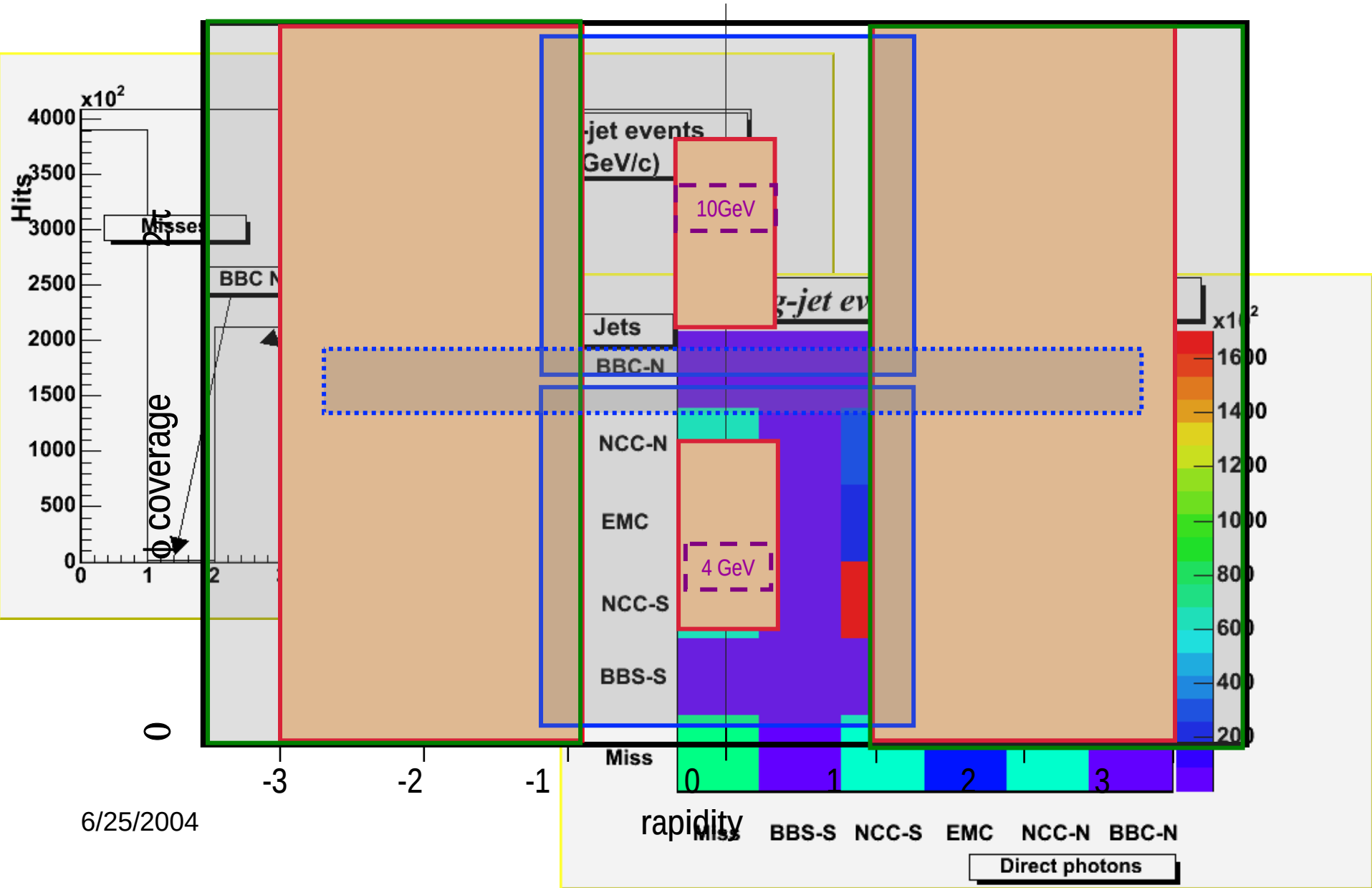
k_T = 1.5

Gluon rad. ON



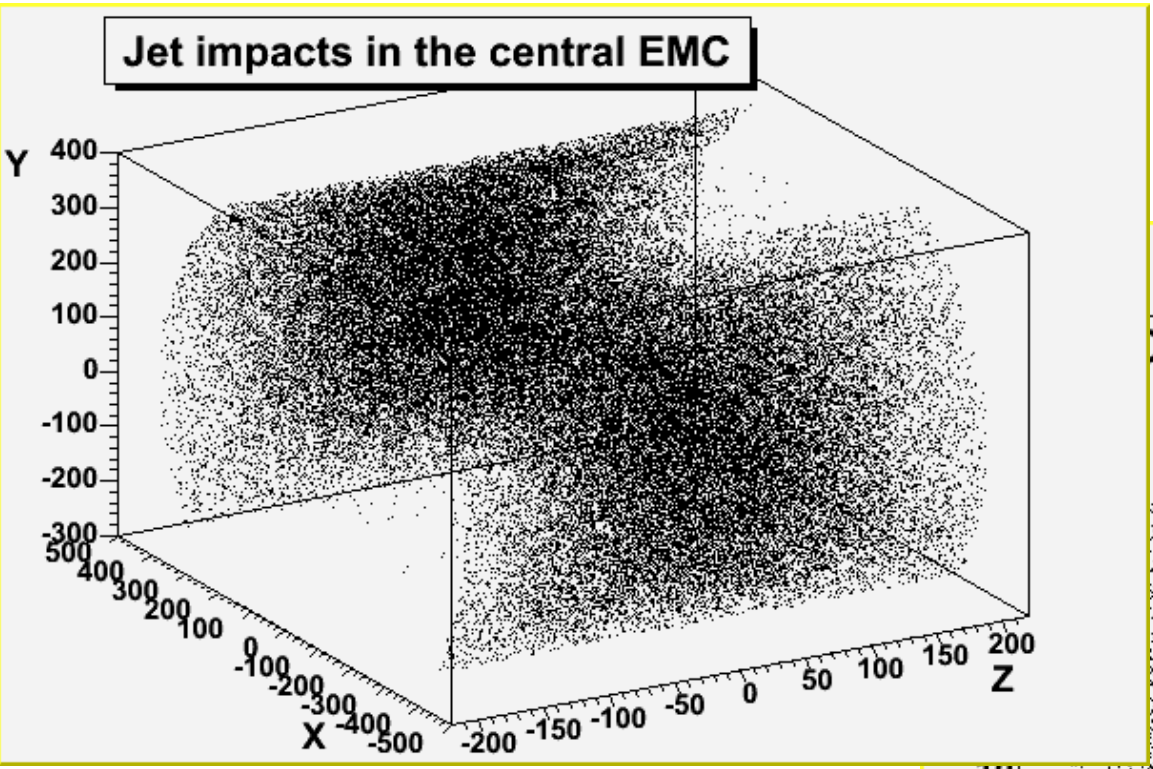


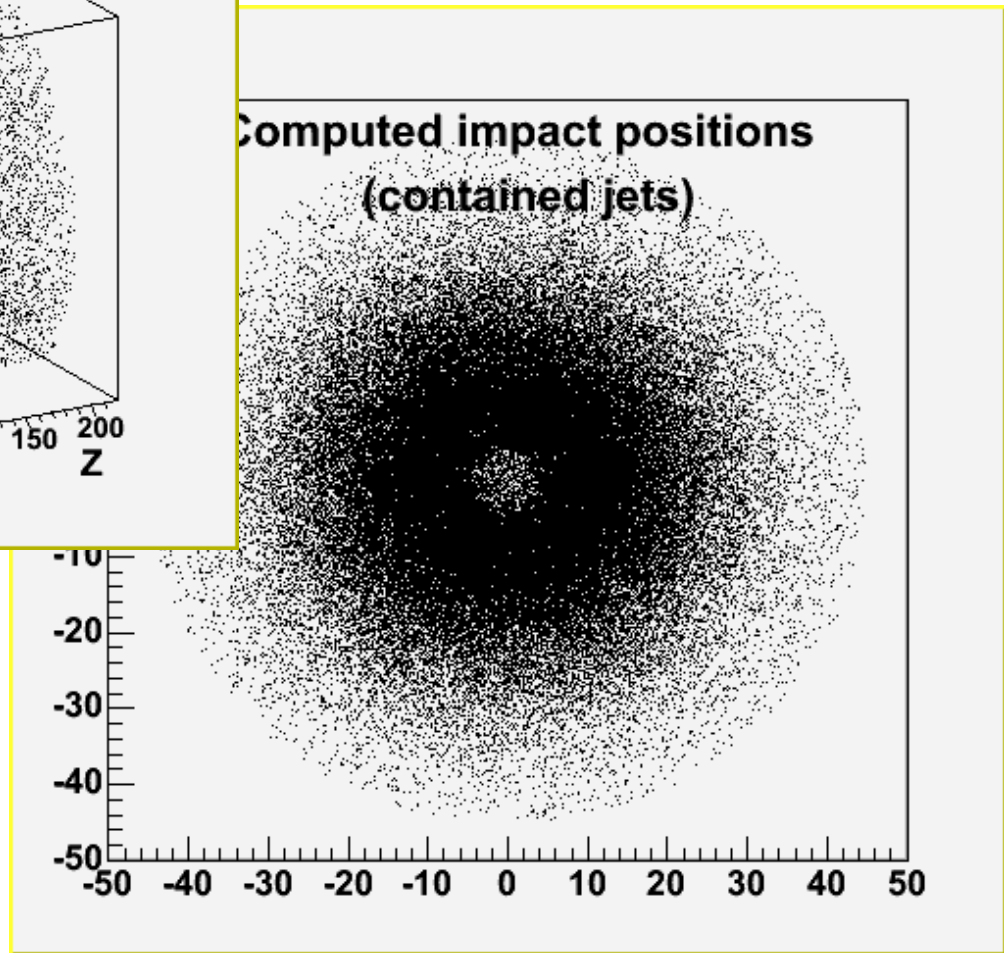
Upgraded PHENIX



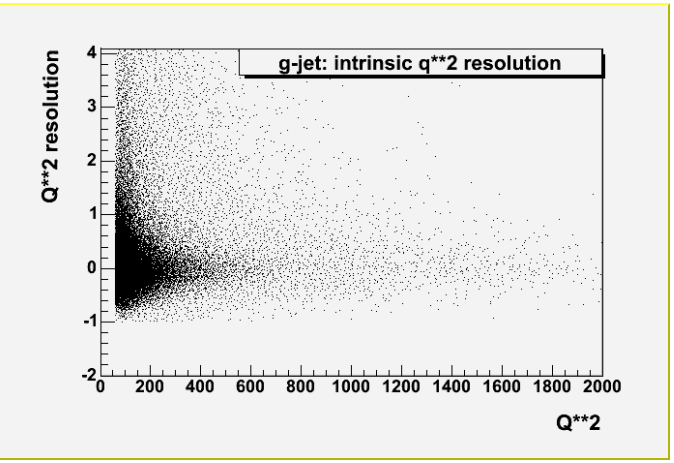
6/25/2004

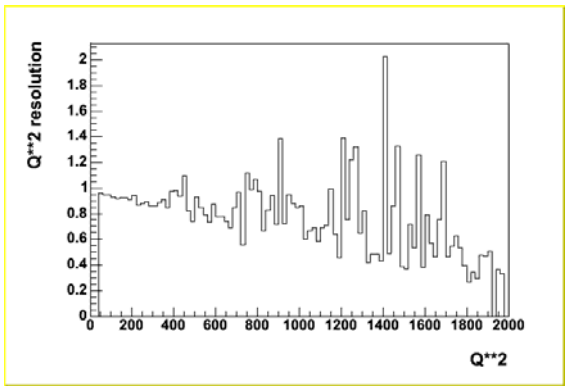
Jet impacts in PHENIX (well contained jets)

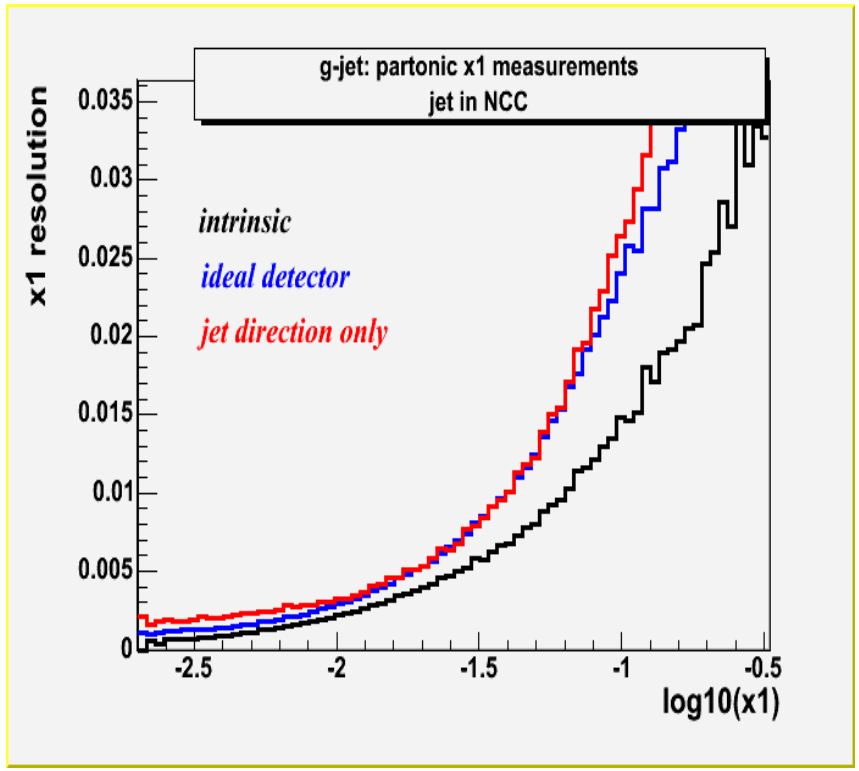




Simple kinematics …







$$x_1\sqrt{s} = P_{T3}e^{Y_3} + P_{T4}e^{Y_4}$$
$$x_2\sqrt{s} = P_{T3}e^{-Y_3} + P_{T4}e^{-Y_4}$$

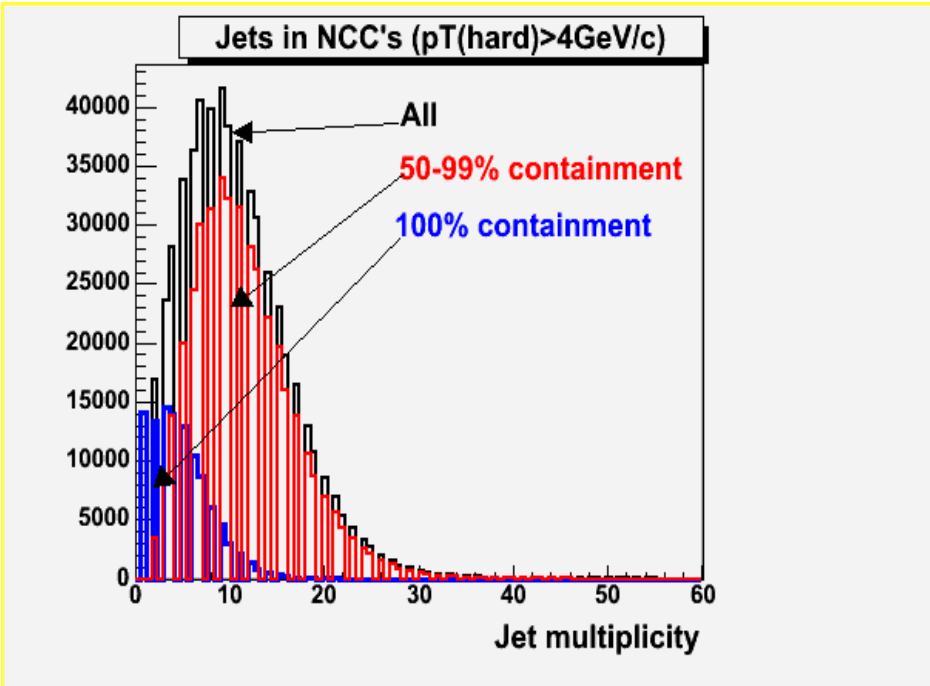
$$Q^2 = 4{p_T}^2\cosh^2\left(\frac{y_3 - y_4}{2}\right) \sim 4{p_T}^2\cosh^2\left(\frac{\eta_3 - \eta_4}{2}\right)$$

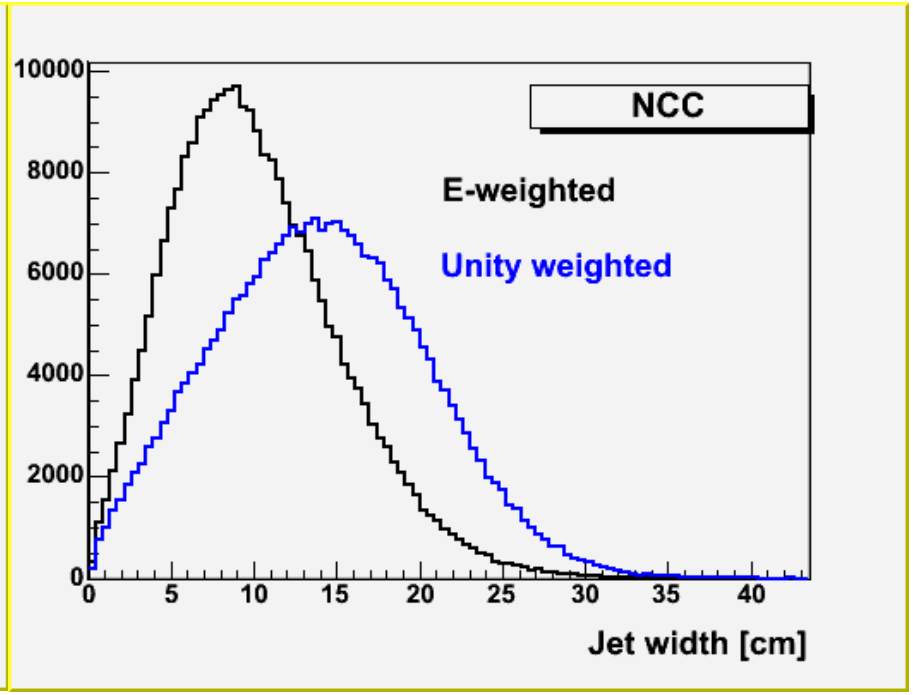
6/25/2004

Need to answer if x 2 in x_1 resolution will help

Otherwise – all we need is the space vector

Snapshot of jets seen in PHENIX NCC

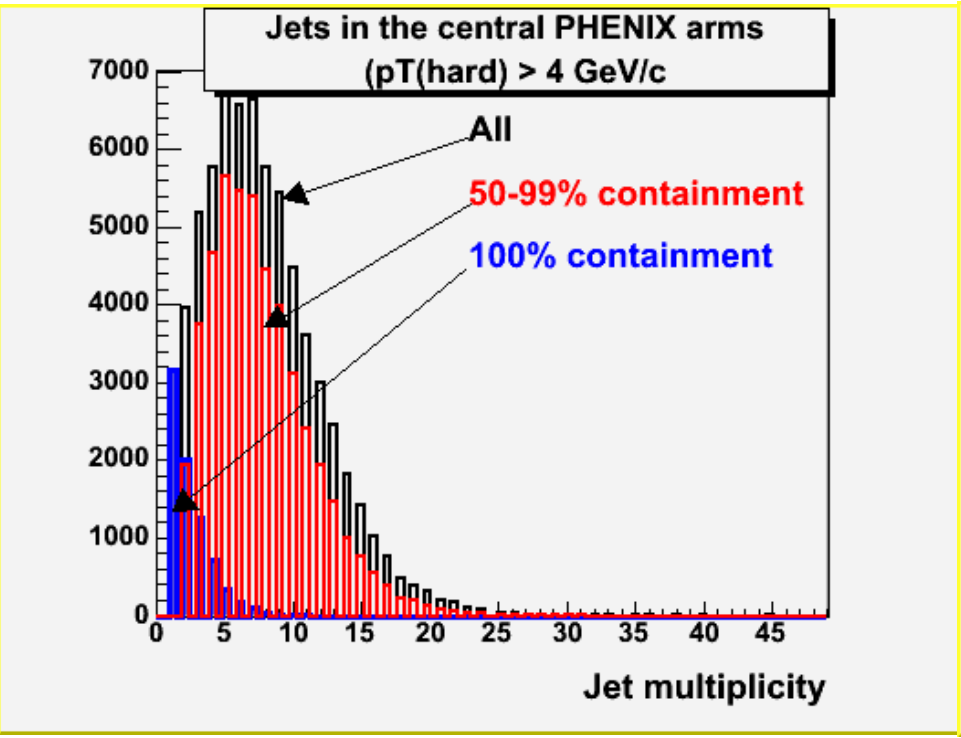


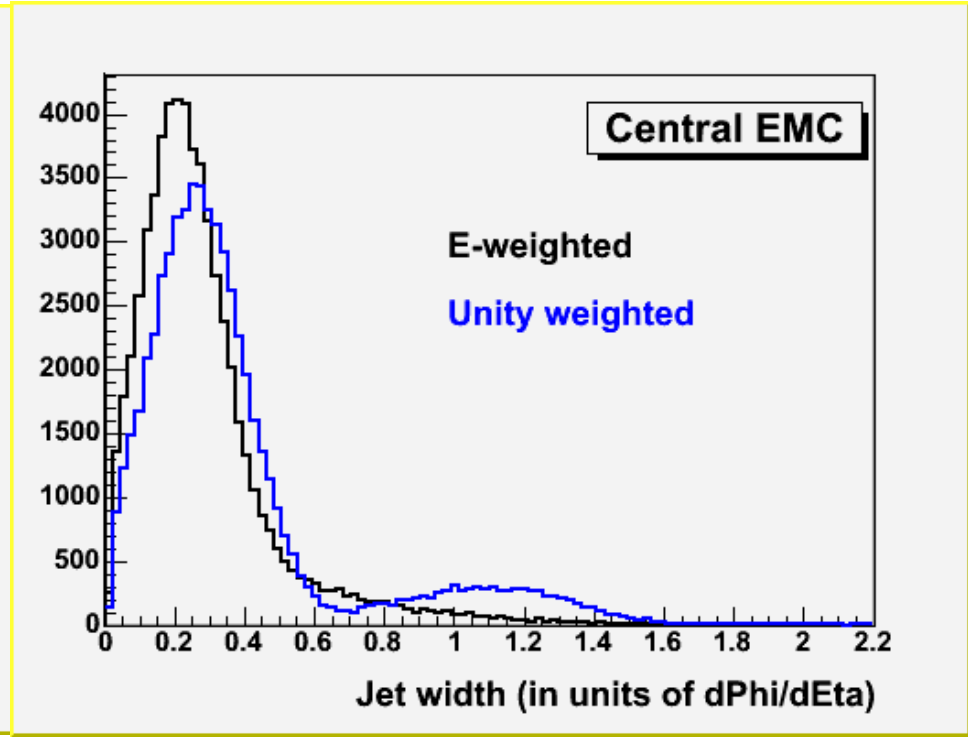


- ***Jet finding needs energies;***
- ***Space vector measurements need energies;***

Jet trigger needs energies. In may be rather simple to do – natural seed area is 12x12 cm2 (64 towers).

"in PHENIX" competitor - central EMC



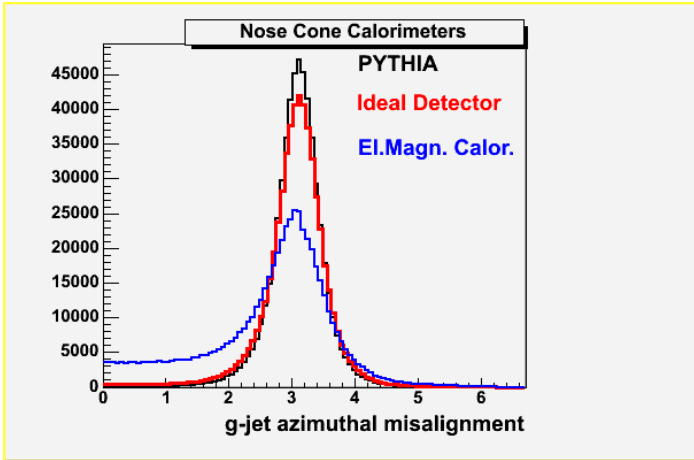


- ***Artificially narrow jets – we measure "size" of calorimeter instead of a jet size;***
- ***Weighting is ~irrelevant;***
- ***Large fraction of jets has energy reasonably well contained (makes leading particle analysis easy) but triggering is out of question.***

Role of hadronic section in NCC

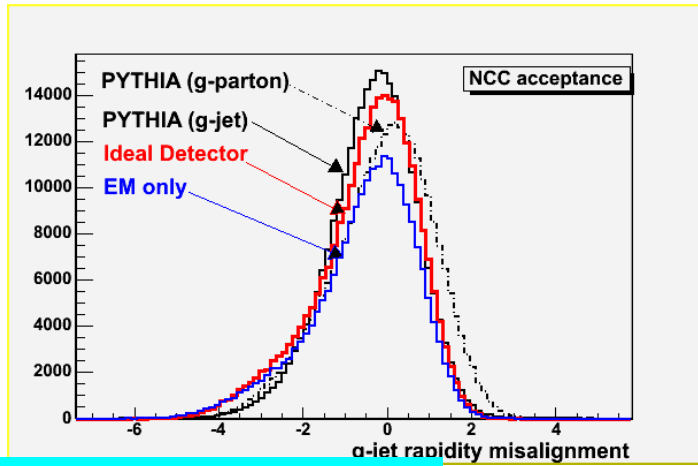
On one hand

- ***misalignment measurements are totally dominated by intrinsic resolution (gluon radiation);***
- ***angular resolution of EM only is clearly sufficient to measure space vector***



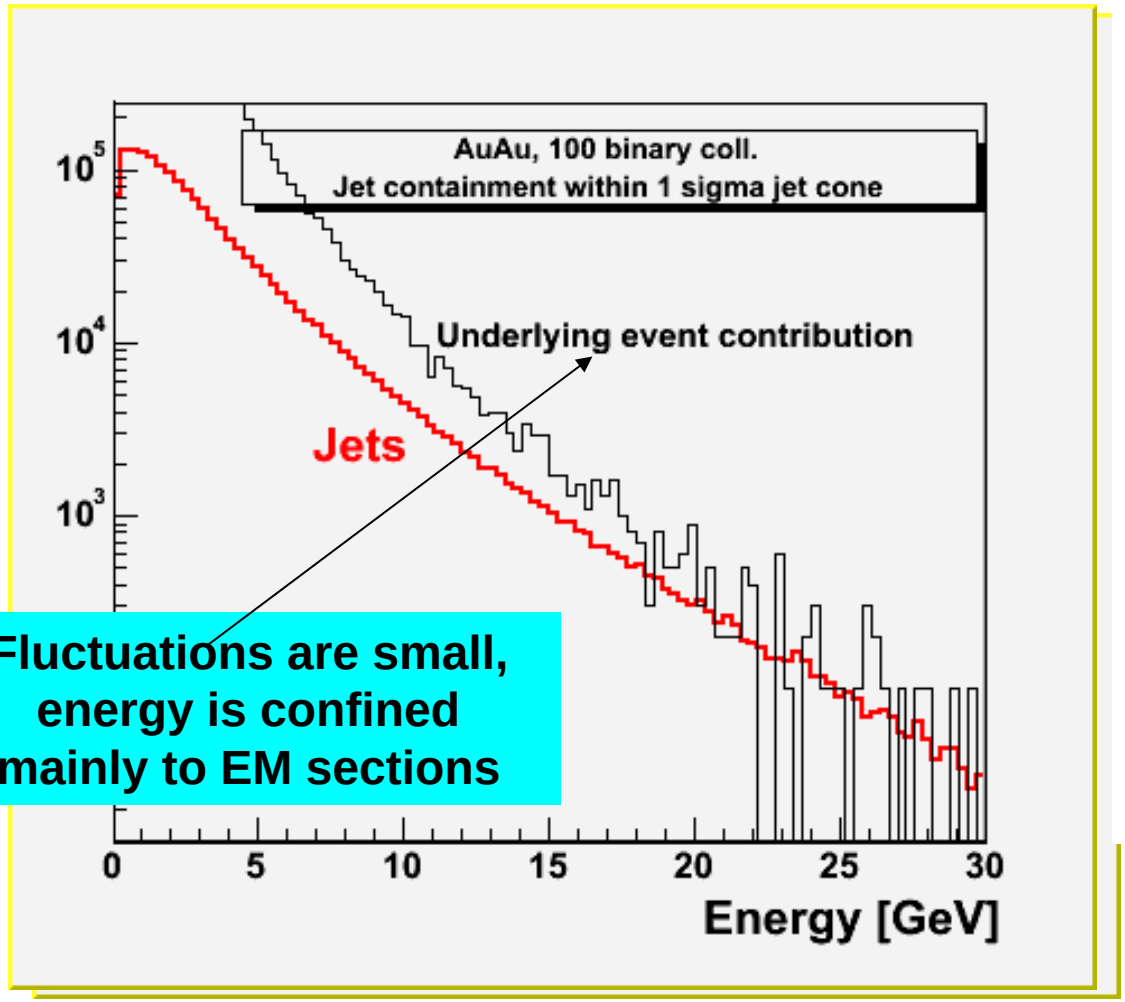
On the othe hand

- ***no jet trigger;***
- ***jet finding in the EM only does not work;***
- ***no hadron rejection;***



Most important – upgrade should work for AuAu

From pp to AuAu



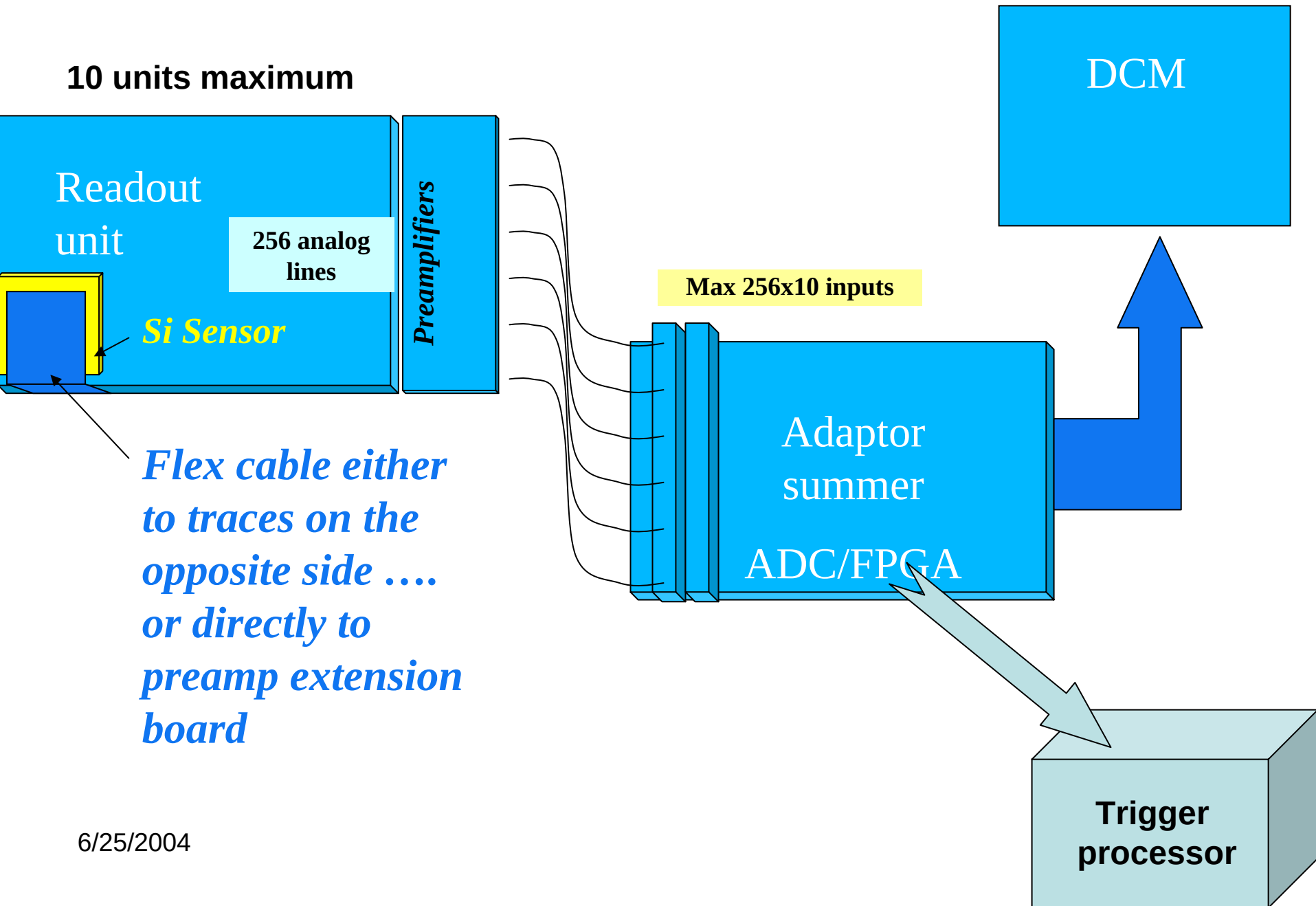
Fluctuations are small, energy is confined mainly to EM sections

Trigger on jets in AuAu will require:

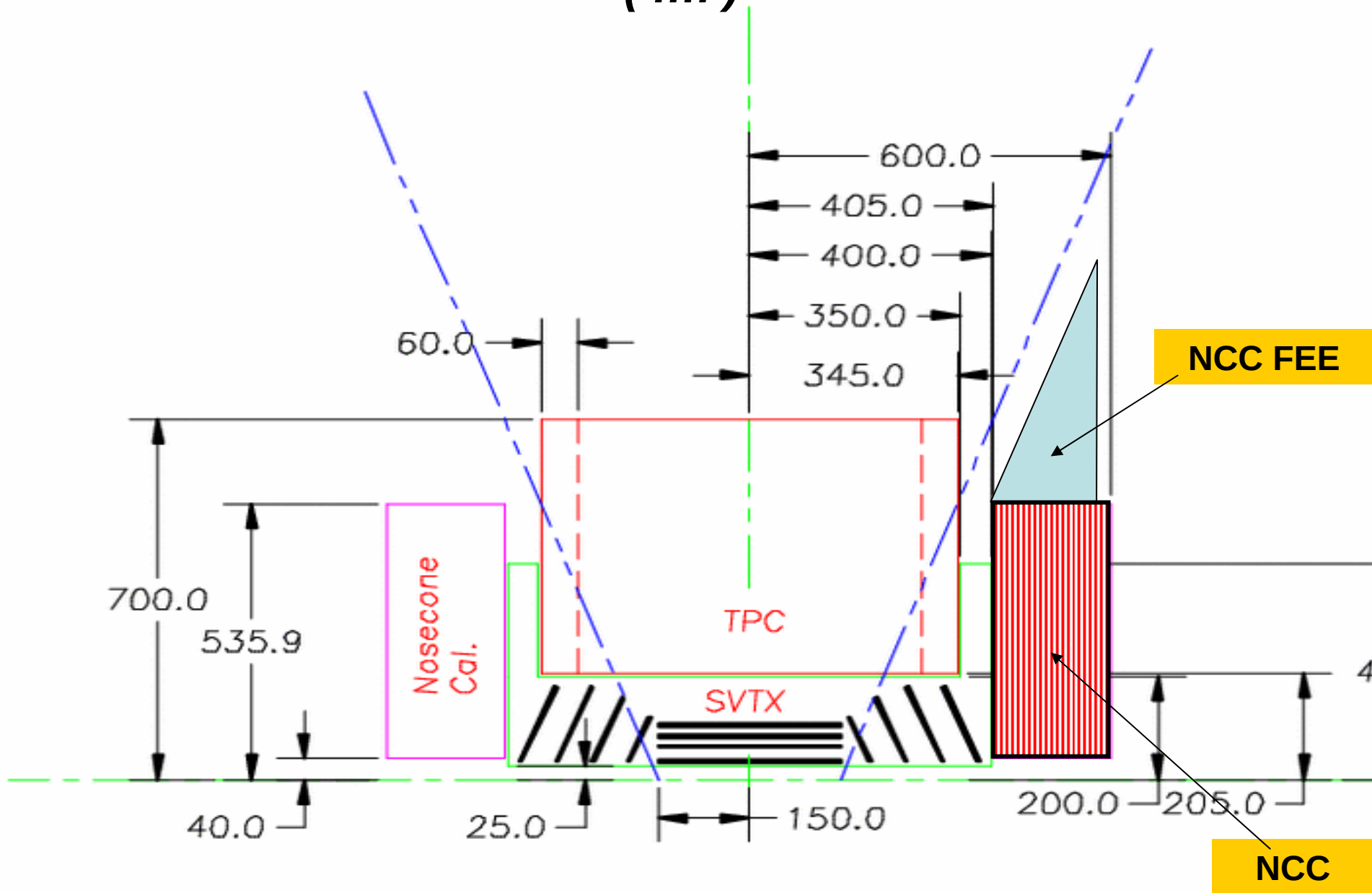
- hadronic section;
- knowledge of event centrality;
- soft <dE/dPhidEta> estimate (including fluctuations);
- underlying event subtraction, jet search among the remnants

100% digital trigger

AA becomes the driver for readout concept



Do we have a space for this detector (….)



In place of summary ..

Forward Spectrometer (tracking, NCC, Muons) if built will result in x10 gain in sensitivity and x10 gain in partonic reach in physics of hard scattering. It will add new reaches to existing PHENIX capabilities for

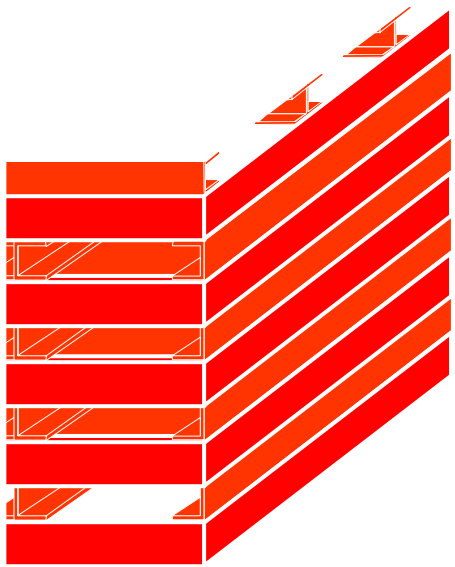
- **Photons & p0's;**
- **Electrons;**
- **Jets;**
- **Triggering;**
- **Event shape measurements;**
- **etc …..**

Proposed implementation for NCC (detector & readout) is driven largely by need for the whole system to work in AuAu collisions. Conclusive answer requires that in AuAu

- **photon & jet triggering is feasible;**
- **energy from underlying event can be held under control, jets could be found in analysis;**
- **Limitations to photon measurements are fully understood;**

We also need to look for new ways of treating the data – an example – using energy flow instead of leading particles momenta for correlation analysis.

2005 (???) Prototype



- 22 sampling cells
- Realistic mechanical structure
- Realistic mother board able to carry up to 4 sensors (256 traces to allow for realistic crosstalk measurements)
- Prototype flex cables
- Two sensors per board installed
- Readout – depends on the time scale for the whole project

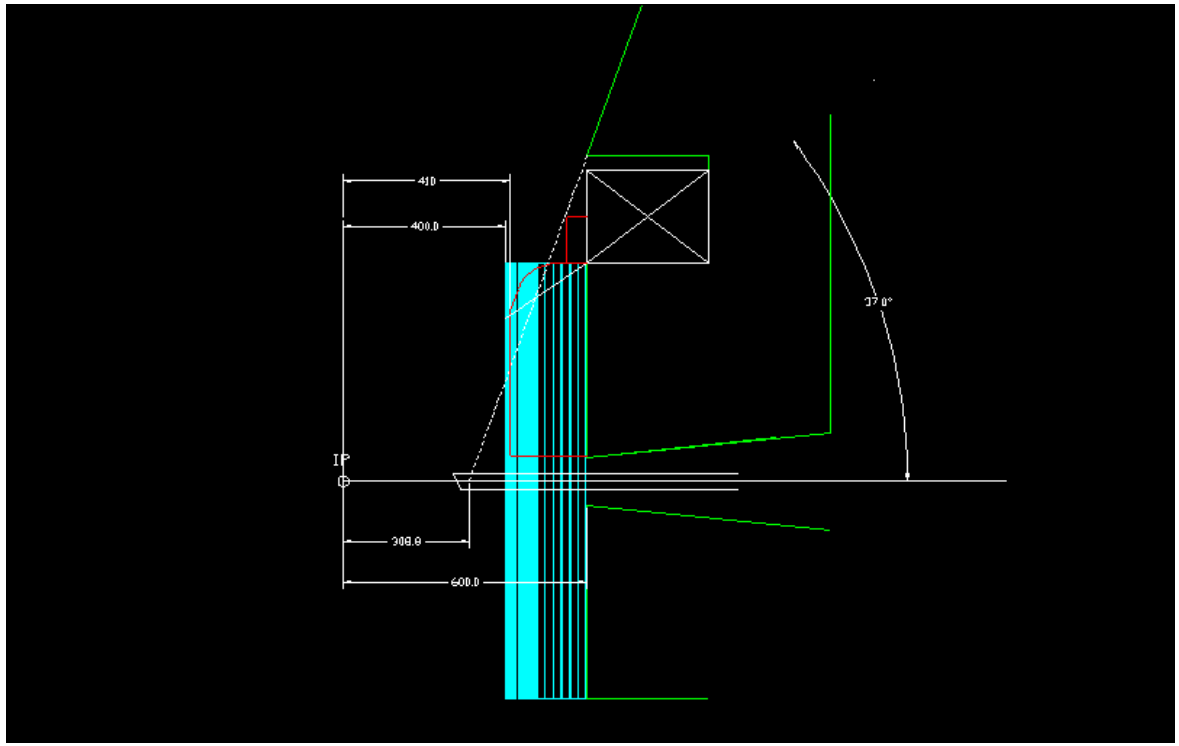
Realities and dreams of today …

R&D Project Collaborators

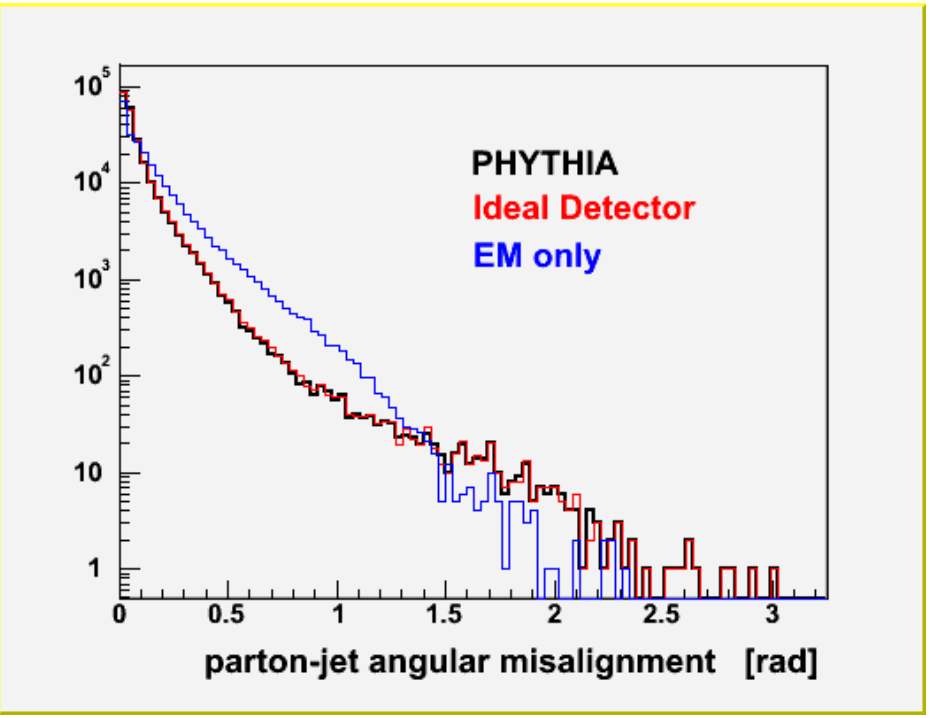
BNL, UI, UCR, Iowa, NM, Trieste, MSU, Prague(?)

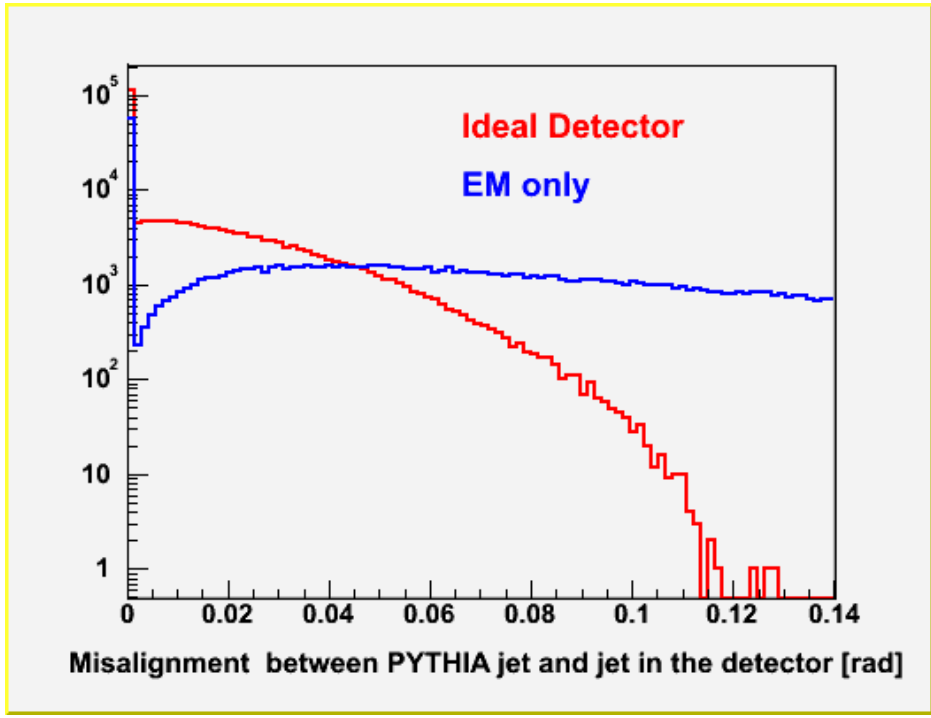
Areas of interest

– ***Concept***	
– ***Funding***	***UCR, BNL, Trieste***
– ***Mechanical structure***	***NM, BNL, UCR***
– ***Sensors***	***MSU***
– ***Cables***	***MSU***
– ***Readout units***	***BNL, UCR, MSU***
– ***Preamp/ADC***	***Trieste***
– ***Digital pipeline***	***Nevis, Trieste***
– ***Trigger***	***Iowa***
– ***Simulation***	***BNL, Trieste, NM, UCR***


410
400.0
17.0°
IP
300.0
600.0

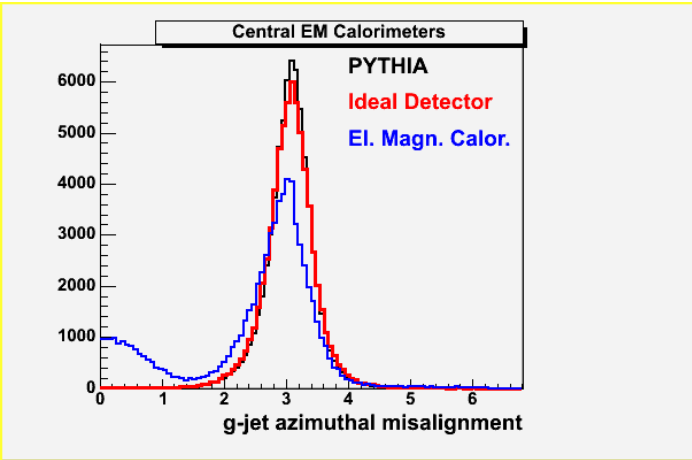
NCC
Fragmenting parton – jet misalignment

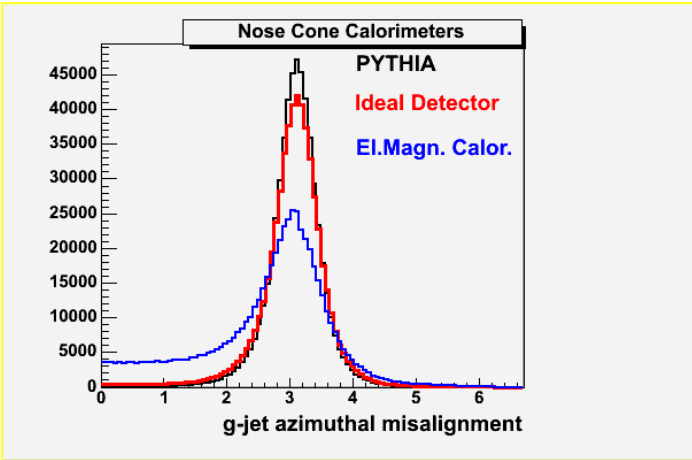


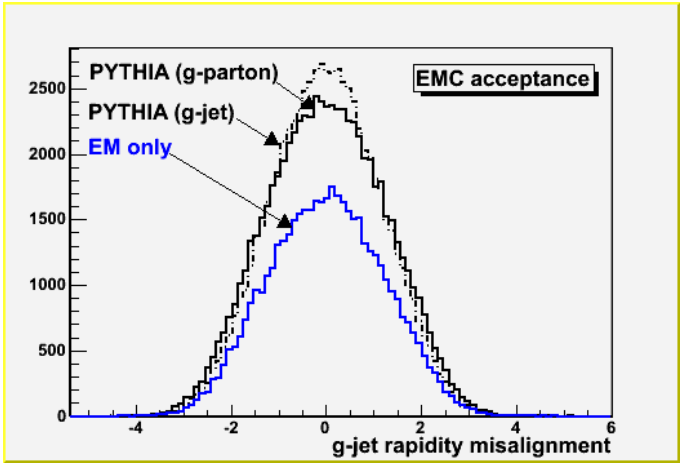


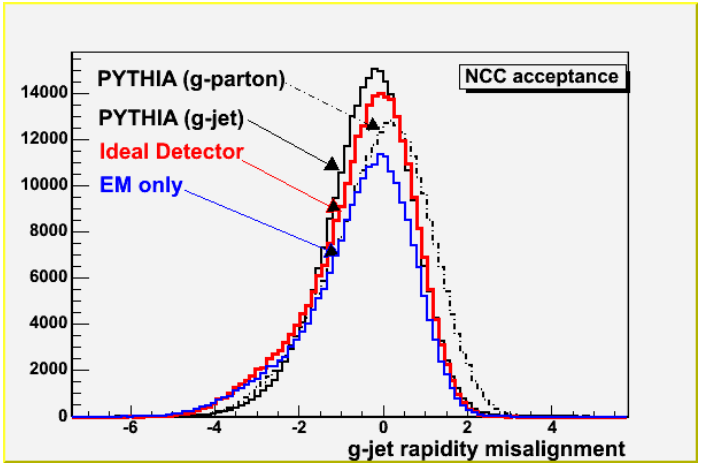
- ***Reducing calorimetry to EM only considerably degrades jet direction measurements***
- ***What's matter for jet measurements is not the acceptance but ability to select particles which belong to the jet and measure their total aggregate energy.***

g-jet misalignment

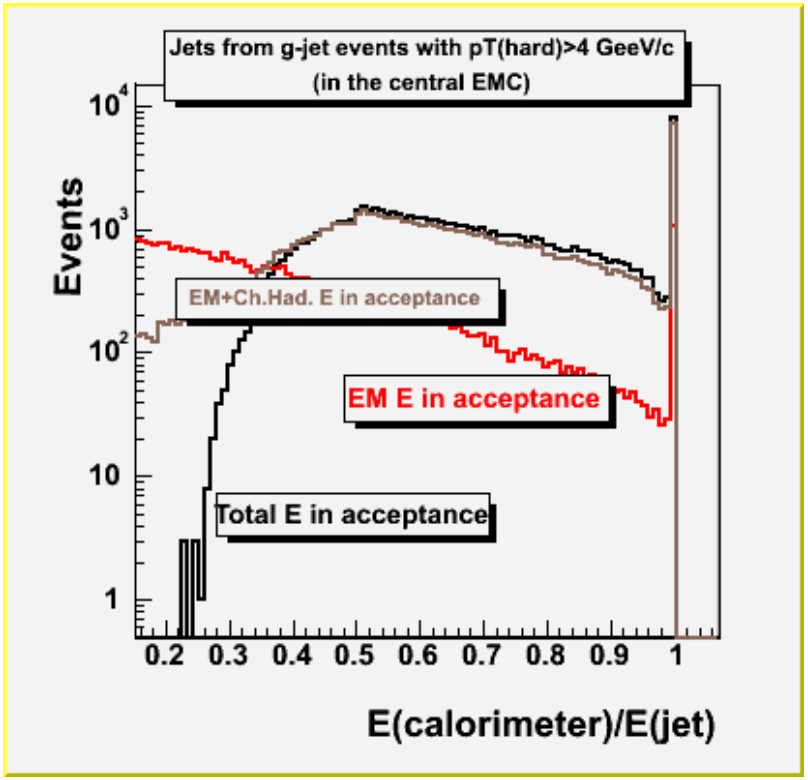


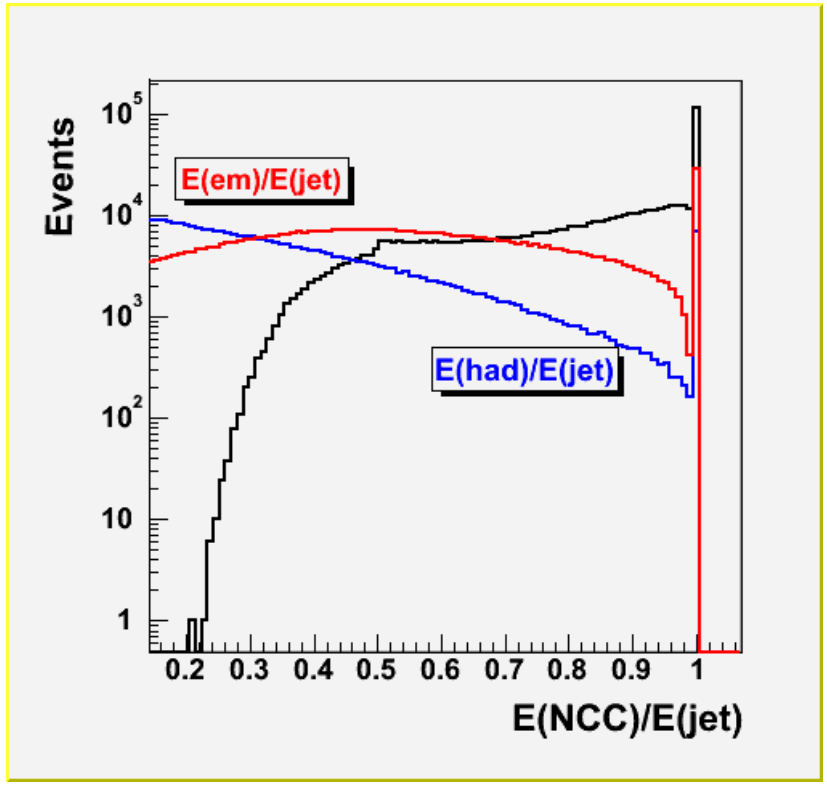


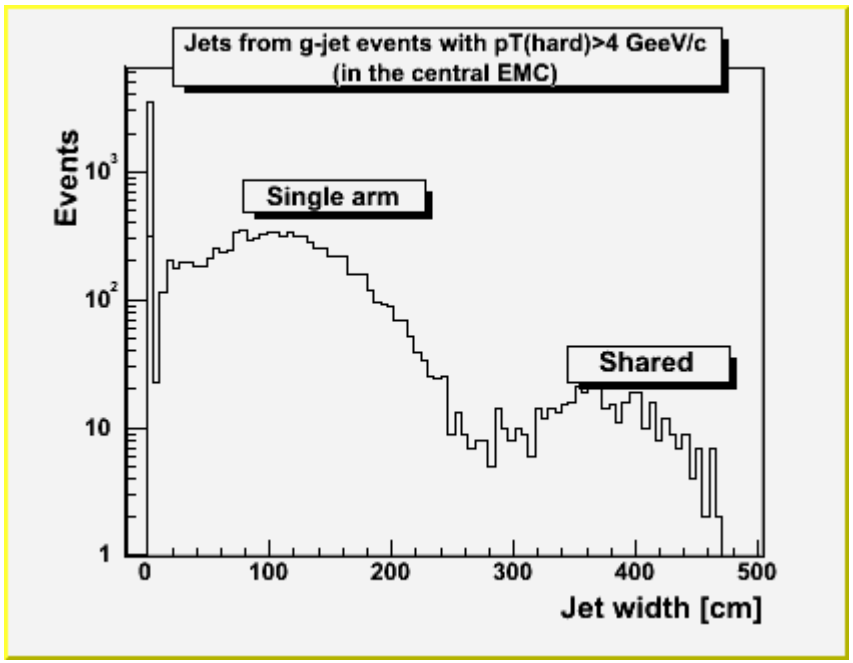




Jet energy containment






Jets from g-jet events with pT(hard)>4 GeeV/c
(in the central EMC)
Events
10^3
10^2
10
1
Single arm
Shared
0
100
200
300
400
500
Jet width [cm]