Simulation Update and Standardized Tools

Jin Huang (BNL)

PHENIX

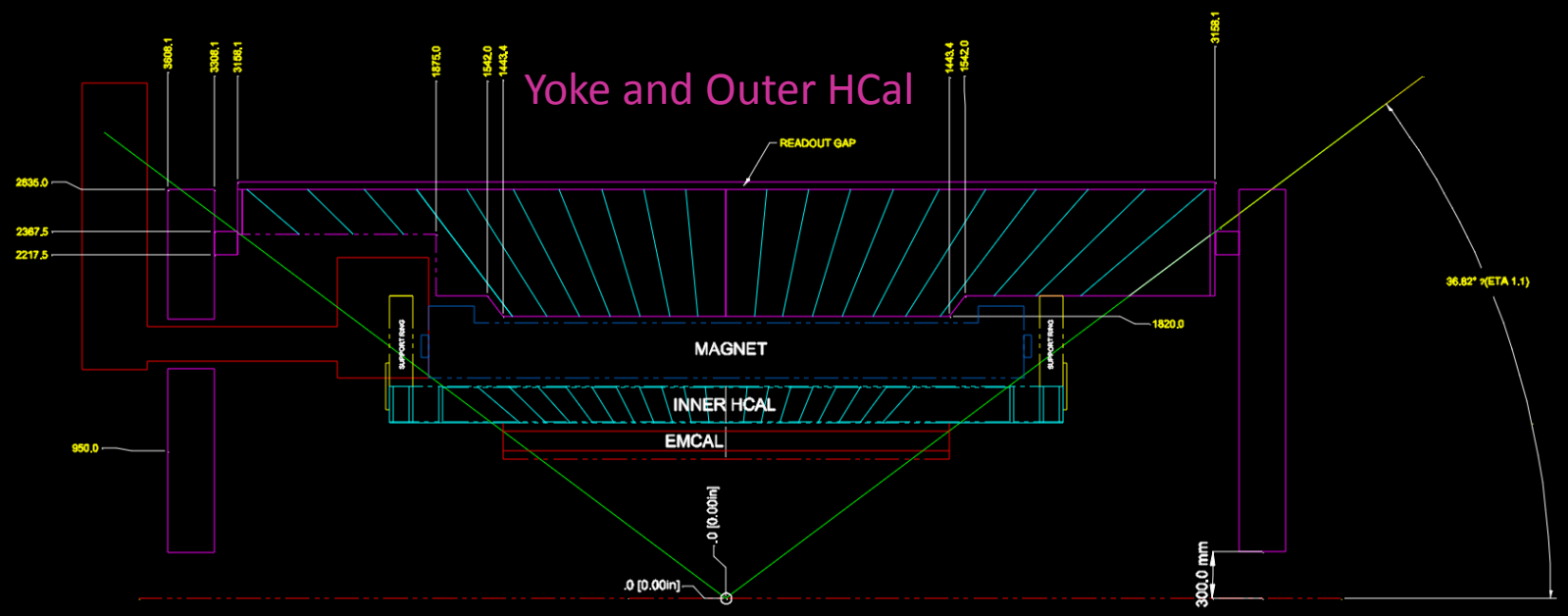
Overview

- Forward Jet tool chain in Geant4 were developed for the Nov-2014 sPHENIX proposal
- Ready for study in full Geant4 simulation for
  - Sivers/Collins projection, resolution effect, background effect
  - Jet, Di-Jet A_{LL}
  - Jet isolation for DY measurement
  - W->Di-Jet with both Jet pt-weighted charge tagging??
- Also forward arm design was updated with the new sPHENIX, Geant4 simulation was updated too
- Both new geometry and analysis chain built in the default macro and submitted to CVS: **Fun4All_G4_fsPHENIX()** in CVS:/simulation/g4simulation/macros/Fun4All_G4_fsPHENIX.C.

Update to new sPHENIX and forward arm design

From R. Ruggiero (BNL/PHENIX)

Presented: Jin, fsPHENIX meeting, Jan 20



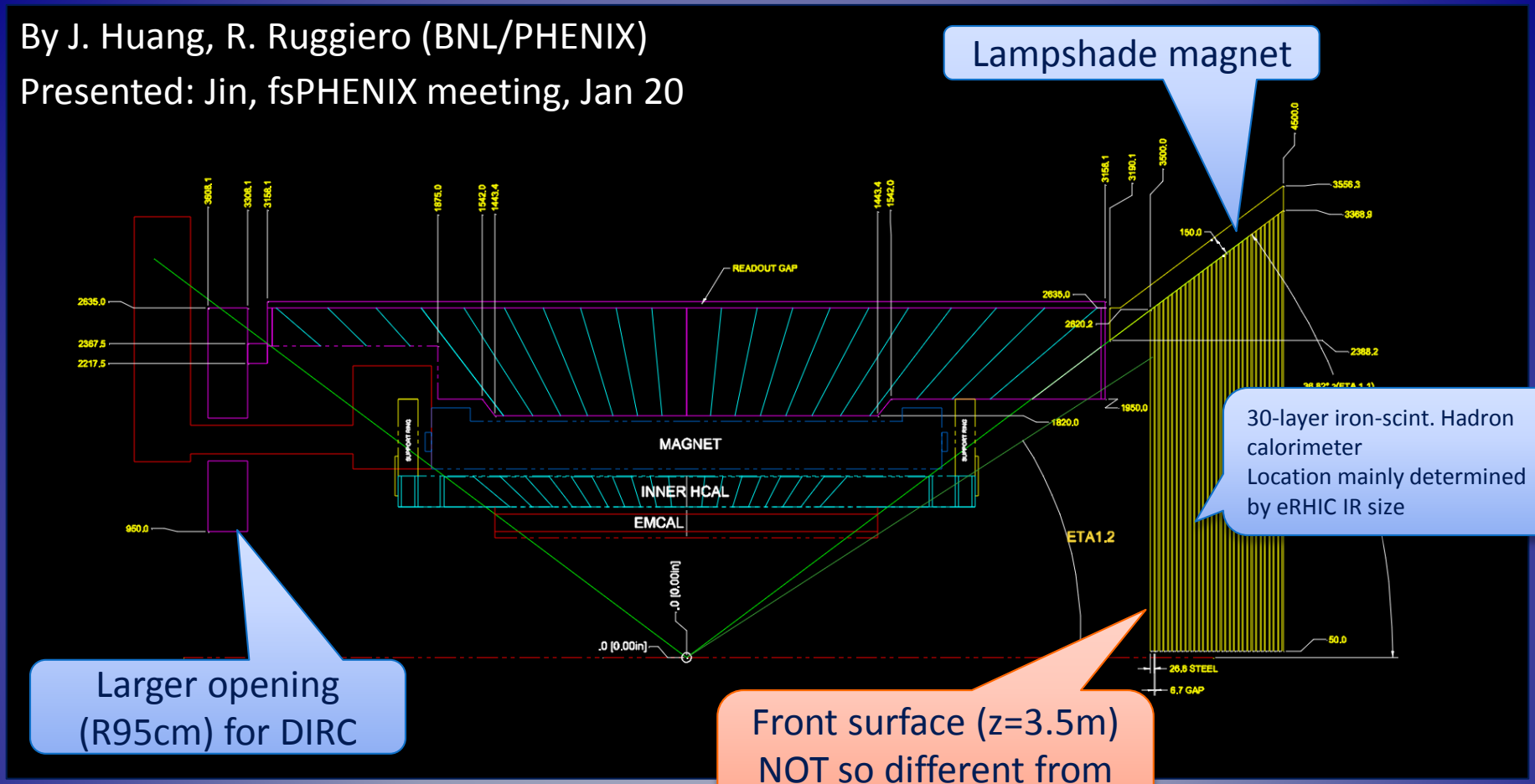
A recently updated sPHENIX mechanical drawing

HCal geometry is significantly revised

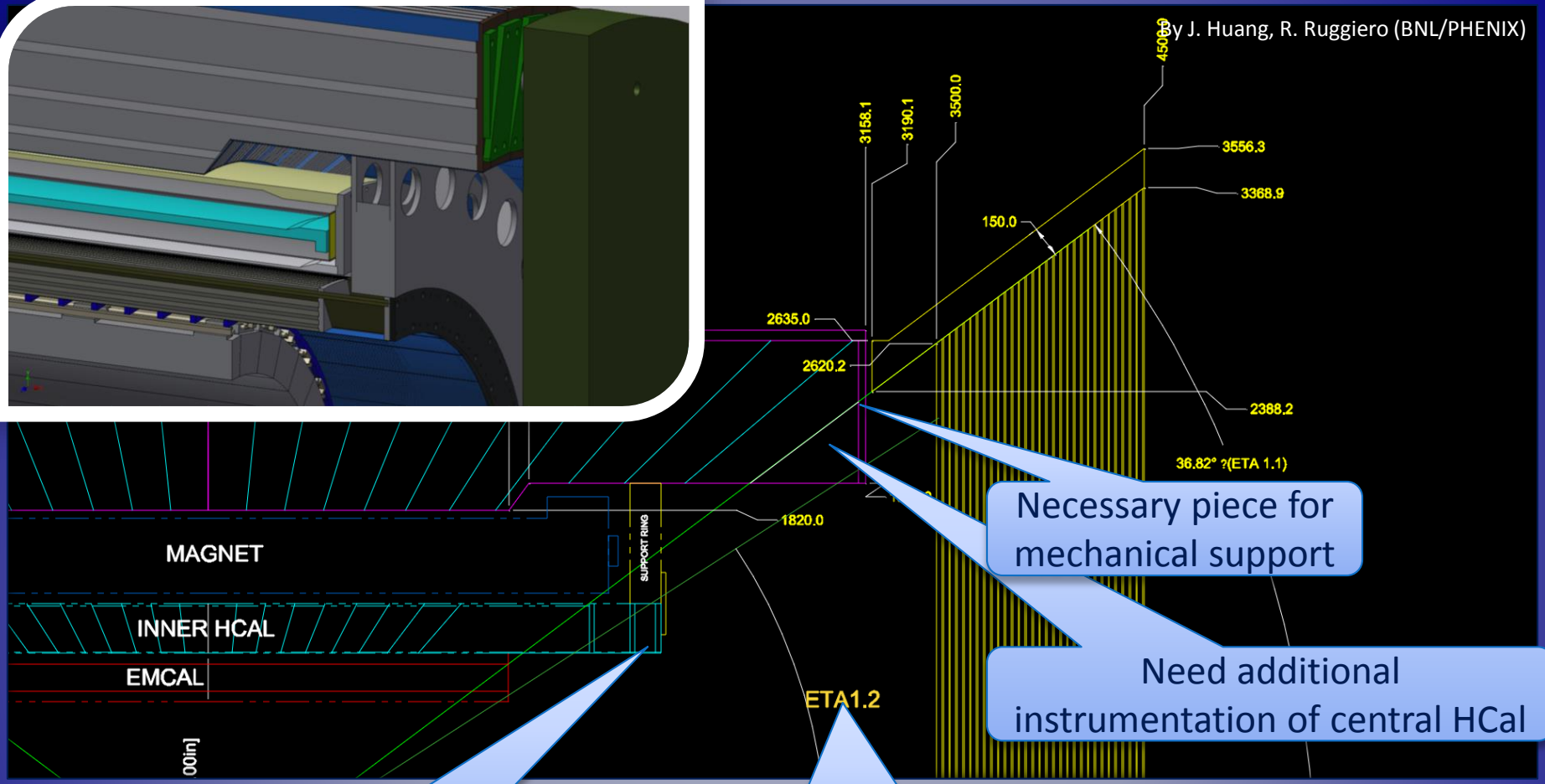
End-door design

By J. Huang, R. Ruggiero (BNL/PHENIX)

Presented: Jin, fsPHENIX meeting, Jan 20



New forward spectrometer design

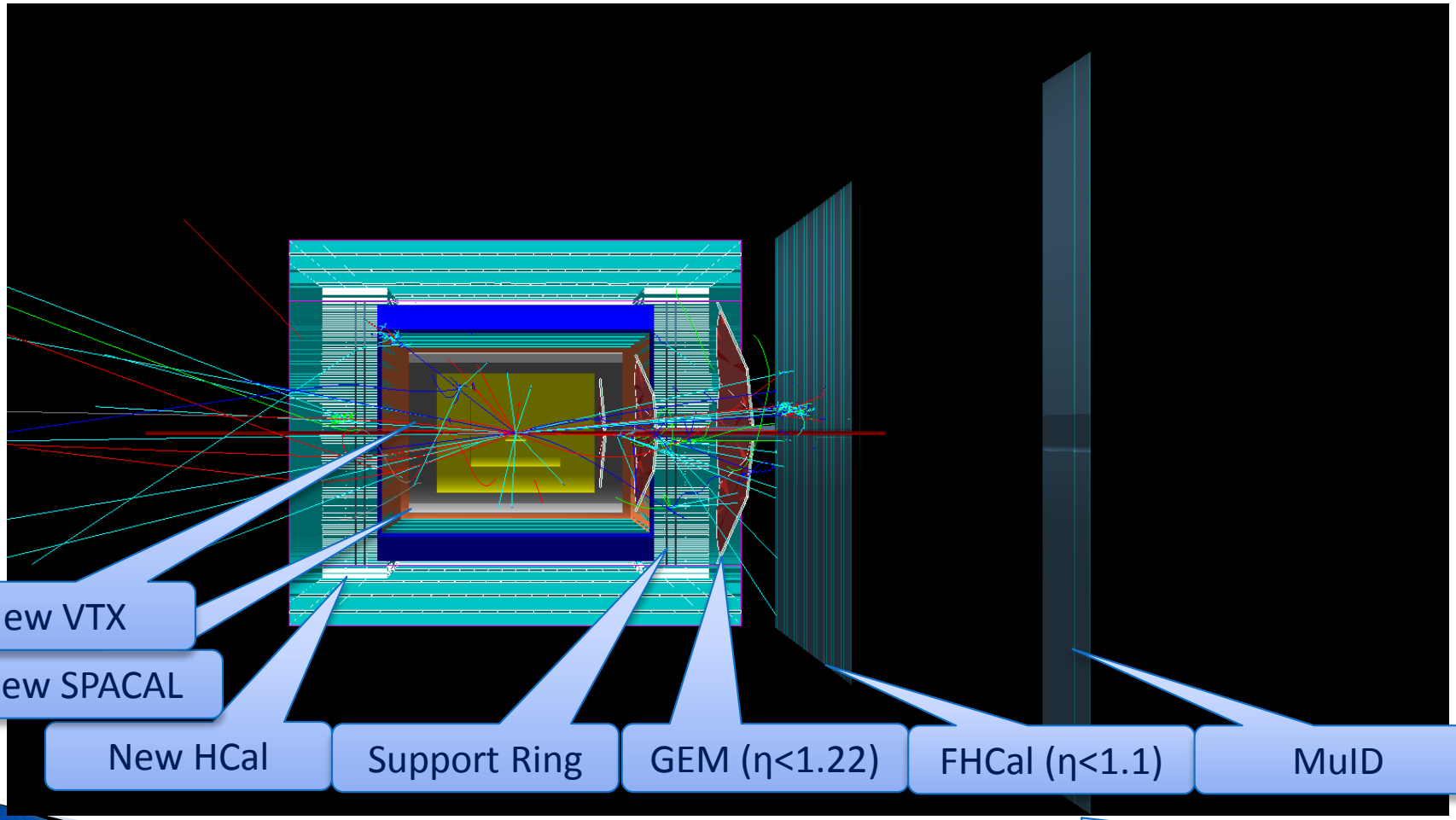


Detailed design »

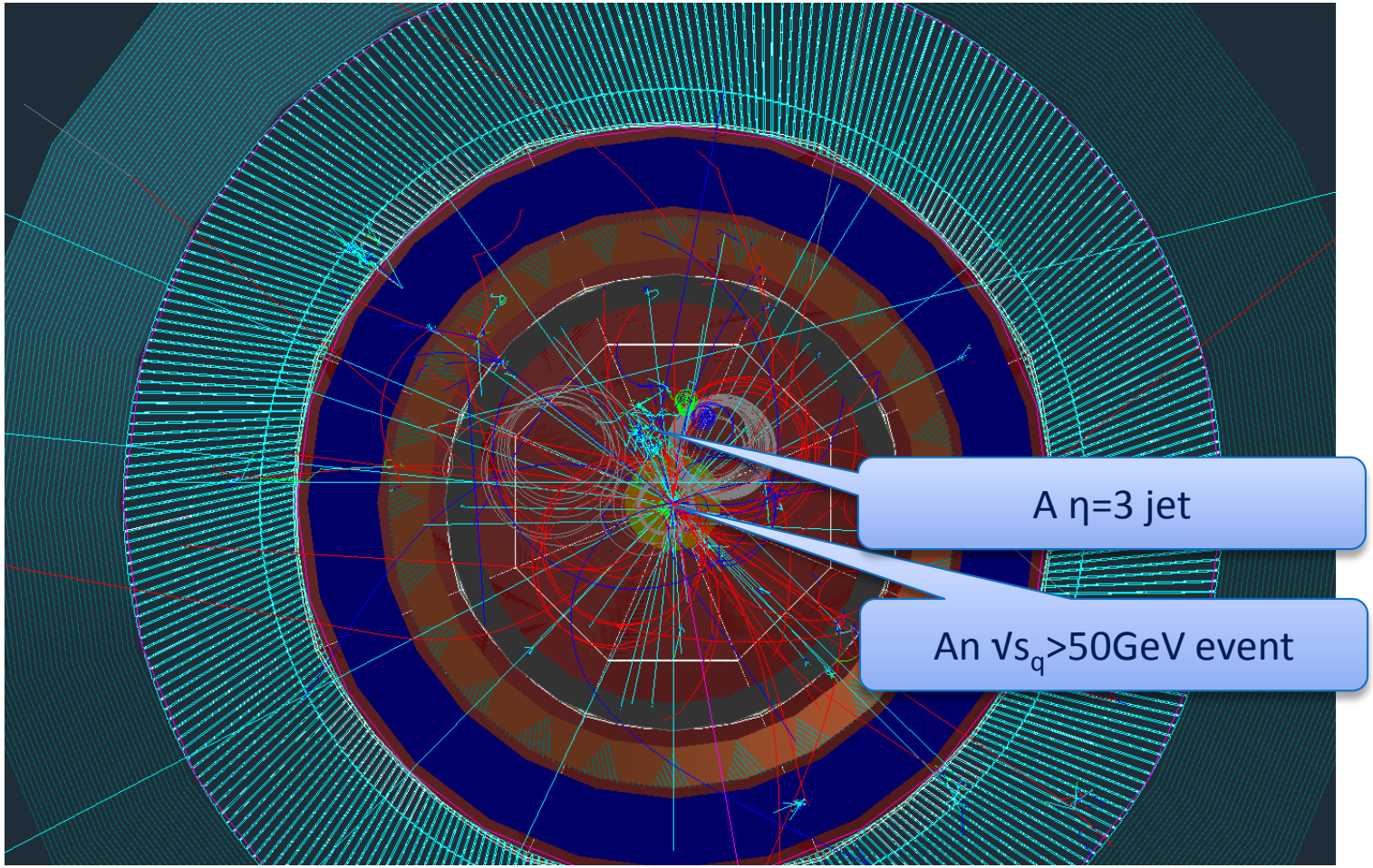
Boundary between sPHENIX and fs/ePHENIX can be well covered by hadron calorimeters for jet measurements. Forward tracking/PID likely start from eta=1.2

Presented: Jin, fsPHENIX meeting, Jan 20

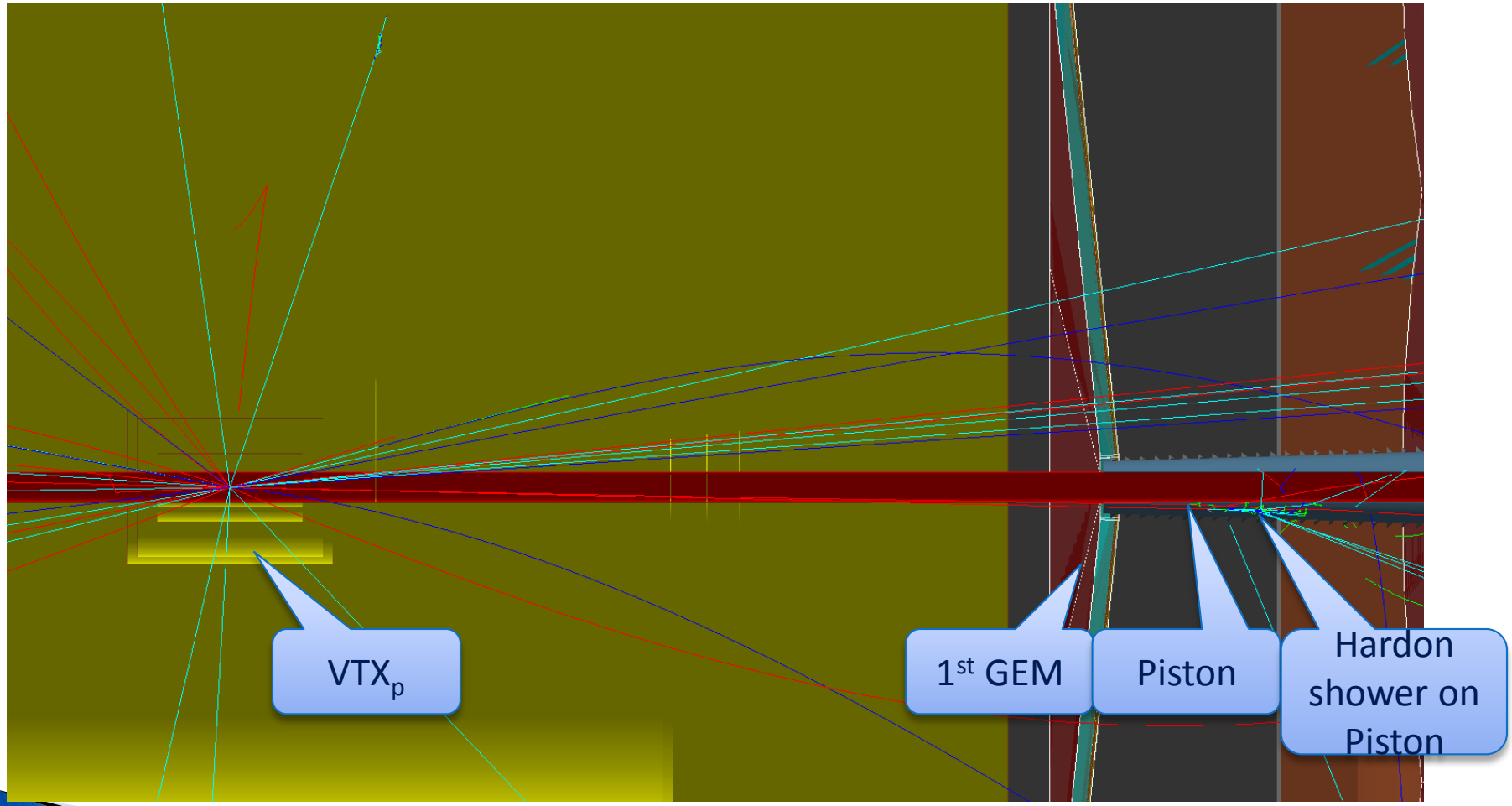
Updated Geant4 Model



New Geant4 Model



New Geant4 Model



Standardized Jet Analysis Tool Chain

Fun4All_G4_fsPHENIX() input param.

CVS:/simulation/g4simulation/macros/Fun4All_G4_fsPHENIX.C

Documentation:
https://www.phenix.bnl.gov/WWW/offline/doxygen/html/d7/d9e/Fun4All__G4__fsPHENIX_8C.html#a76aeb153ec36f57bd23996c1d6a7508a

Function Documentation

```
void Fun4All_G4_fsPHENIX ( int          nEvents = 10,
                           int          nSkip = 0,
                           const char * input_file = "test/ID1200_phpythia_jet_eta0_E4.root.lst",
                           const char * embed_input_file = NULL
                         )
```

fsPHENIX simulation loading script

Parameters

[in]	**nEvents**	Number of events to run. If nEvents=-1, then a event display will be shown
[in]	**nSkip**	Number of event to skip before start processing
[in]	**inputFile**	Input file. Depending on the "Input options" as in the beginning of macro.
[in]	**embed_input_file**	Second input file for embedding. Also depending on the "Input options" as in the beginning of macro.

Definition at line **12** of file **Fun4All_G4_fsPHENIX.C**.

View newest version in PHENIX CVS at line 12 of file Fun4All_G4_fsPHENIX.C

References **PHMCTowerMerge::AddInputMCTower()**, **G4DSTReader::AddJet()**, **Fun4AllInputManager::AddListFile()**, **G4DSTReader::AddNode()**, **G4DSTReader::AddTower()**, **PHG4Reco::ApplyCommand()**, **Cemc_slats_per_cell**, **RawTowerBuilder::Detector()**, **RawClusterBuilder::Detector()**, **PHG4SlatCellReco::Detector()**, **PHG4CylinderCellReco::Detector()**, **RawTowerBuilderCone::Detector()**, **PHG4CalEvaluator::Detector()**, **Fun4AllServer::End()**, **PHG4CylinderCellReco::etaphisize()**

Fun4All_G4_fsPHENIX() input switch

CVS:/simulation/g4simulation/macros/Fun4All_G4_fsPHENIX.C

```
//-----------------------------------------------------------------
  // Input options
  //-----------------------------------------------------------------
  // Either:
  // read previously generated g4-hits or g4-tower DST files, in this case it opens a DST and
skips
  // the simulations step completely. The G4Setup macro is only loaded to get information
  // about the number of layers used for the cell reco code
  const bool readhits = false;
  const bool readtowers = false;
  // Or:
  // read files in HepMC format (typically output from event generators like hijing or pythia)
  const bool readhepmc = false; // read HepMC files
  // Or:
  // read DST files containing PHPythia nodes
  const bool readpythiaDST = true; // read PHPythia files
// Or:
  // Generate pythia event
  const bool runpythia = false; // read HepMC files
  // Or:
  // Run a event display automatically when nEvents<0
  const bool event_display = (nEvents < 0 && !(readhits || readtowers)); // read HepMC files
  // Save G4 raw info?
  const bool save_g4_raw =  readhits ? false: true;
```

Read G4 hits/tower or run the simulation

HEPMC: sPHENIX standard

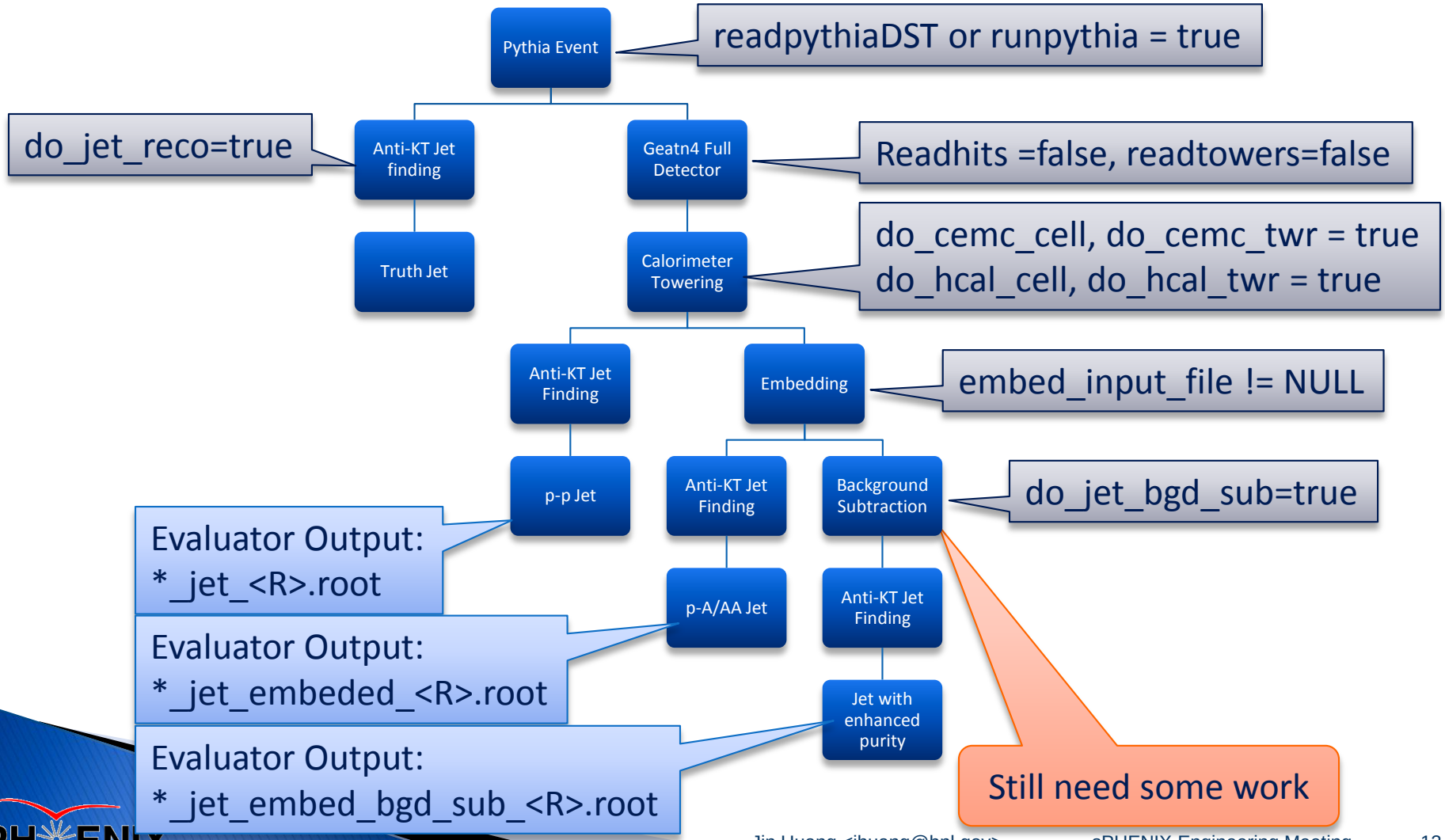
PHENIX PhPythia DST

Or run Pythia directly

nEvent<0 = show event display

Existing Tool Chain and flags

One can break at any stage, and pick up the progress again with same macro

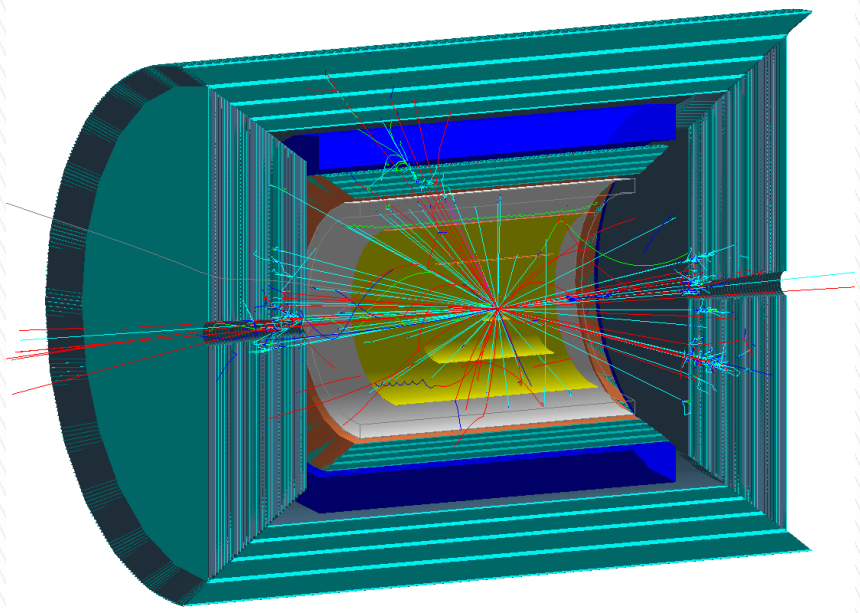


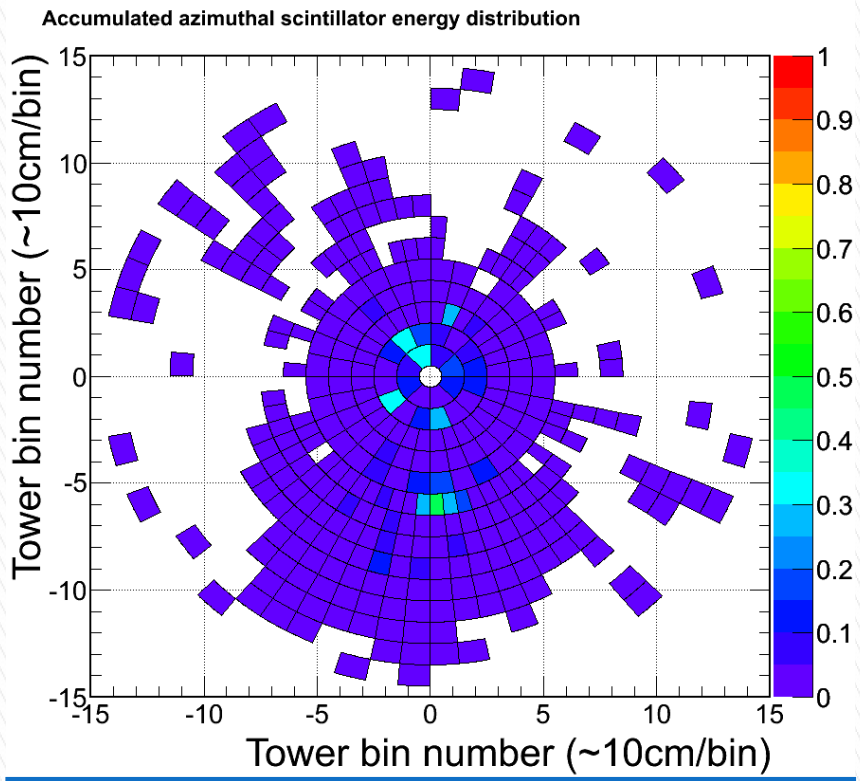
An illustration with 2.5m FHCal results

CVS:/simulation/g4simulation/macros/Fun4All_G4_sPHENIX_plus_fHCAL.C

2.5m FHCal results

- Towering of the FHCal





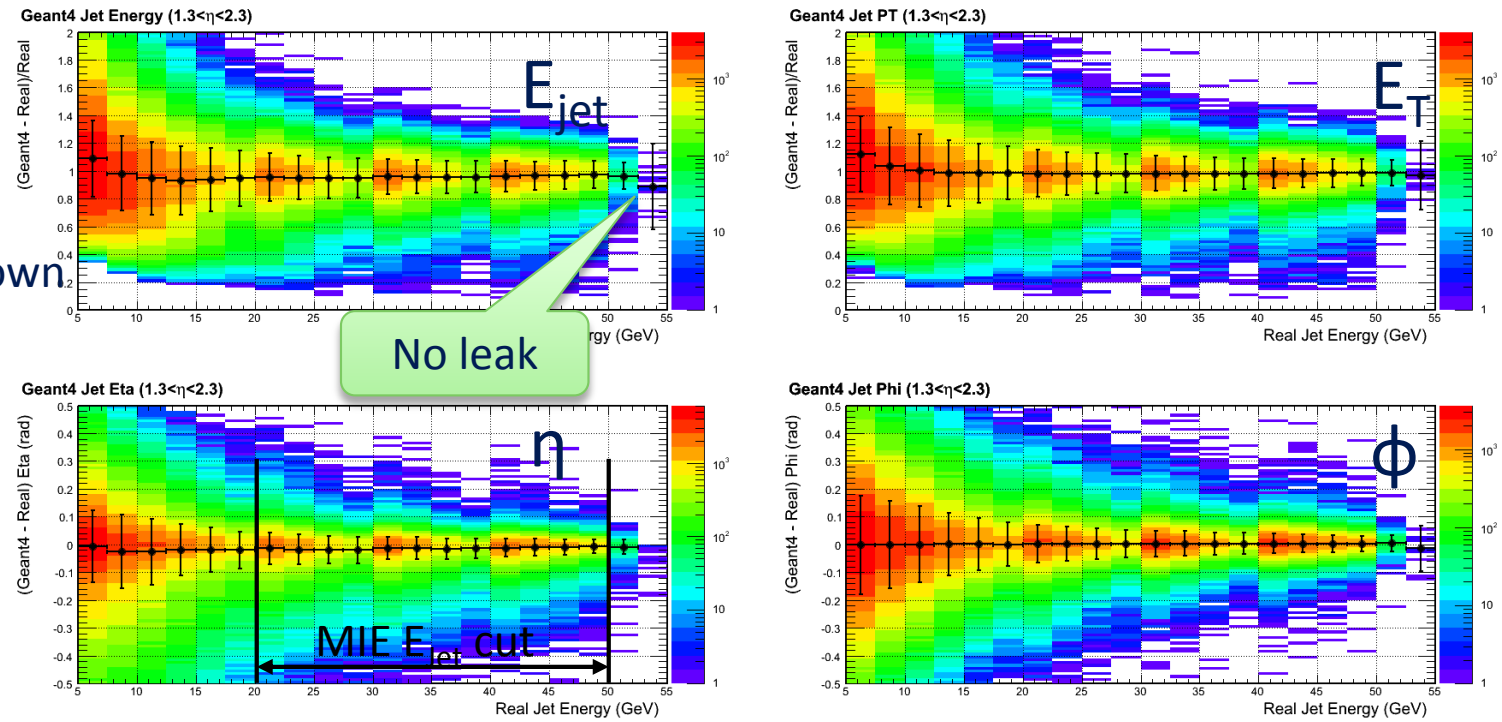
Event display

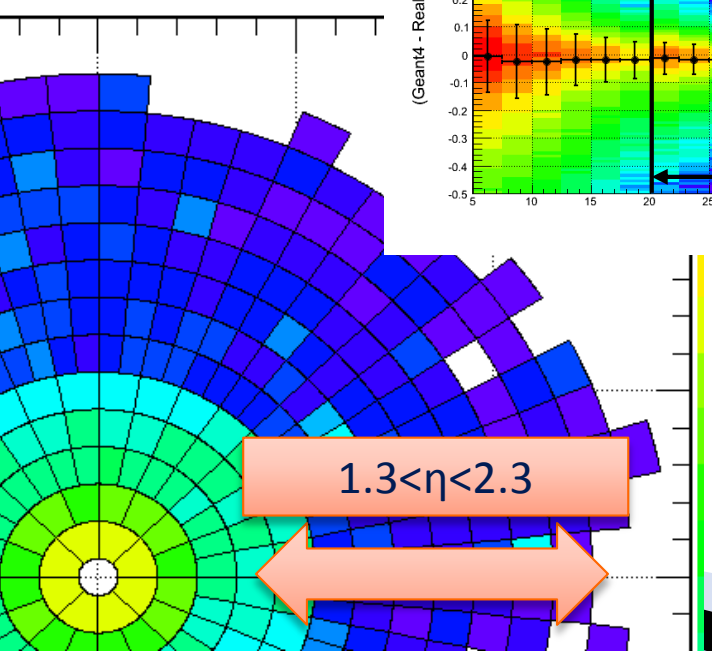
FHCal Segmentation

Jet G4 simulation with 200GeV pp full event – fHCal central

2.5m FHCal results

Anti kT w/ R=0.6
Pythia p+p 200GeV
Gaus fit μ and σ shown





- In a good region where dϕ = 0.1-0.2 per tower
- Major part of the jet within FHCal

Jet G4 simulation with 200GeV pp full event – Connection to sPHENIX

2.5m FHCal results

Anti kT w/ R=0.6
Pythia p+p 200GeV
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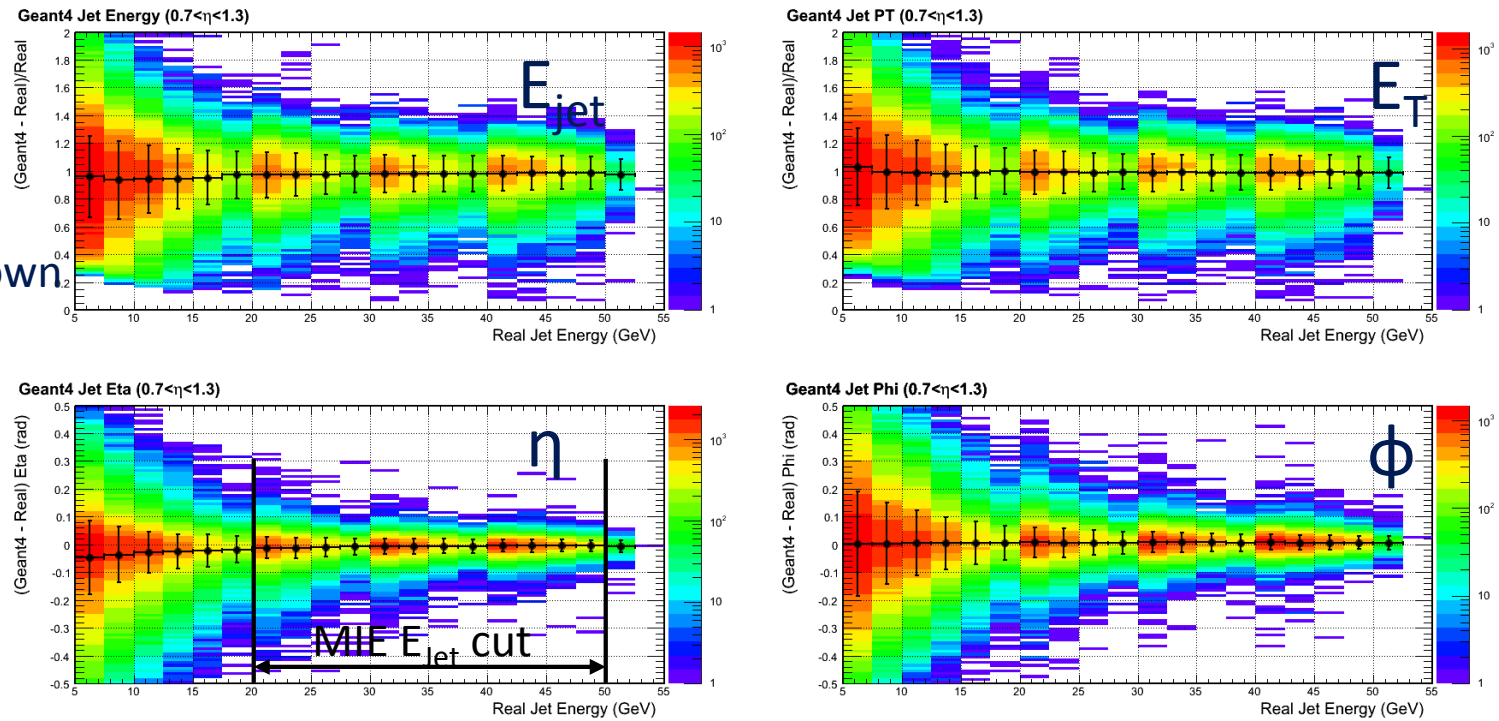

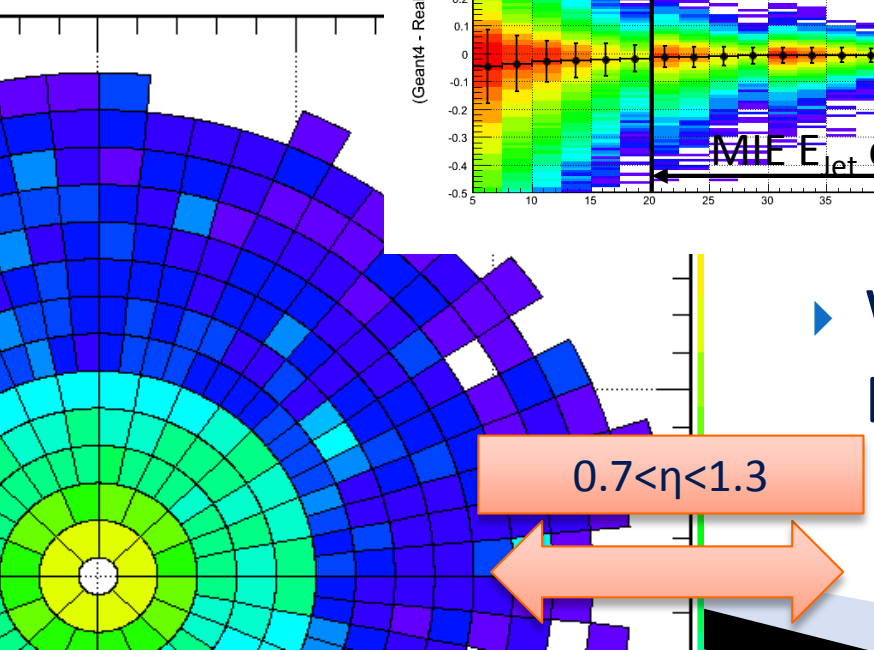

- Works by using EMCal + 2 barrel Hcal + FHCal

Jet G4 simulation with 200GeV pp full event – Towards beam line

2.5m FHCal results

Anti kT w/ R=0.6
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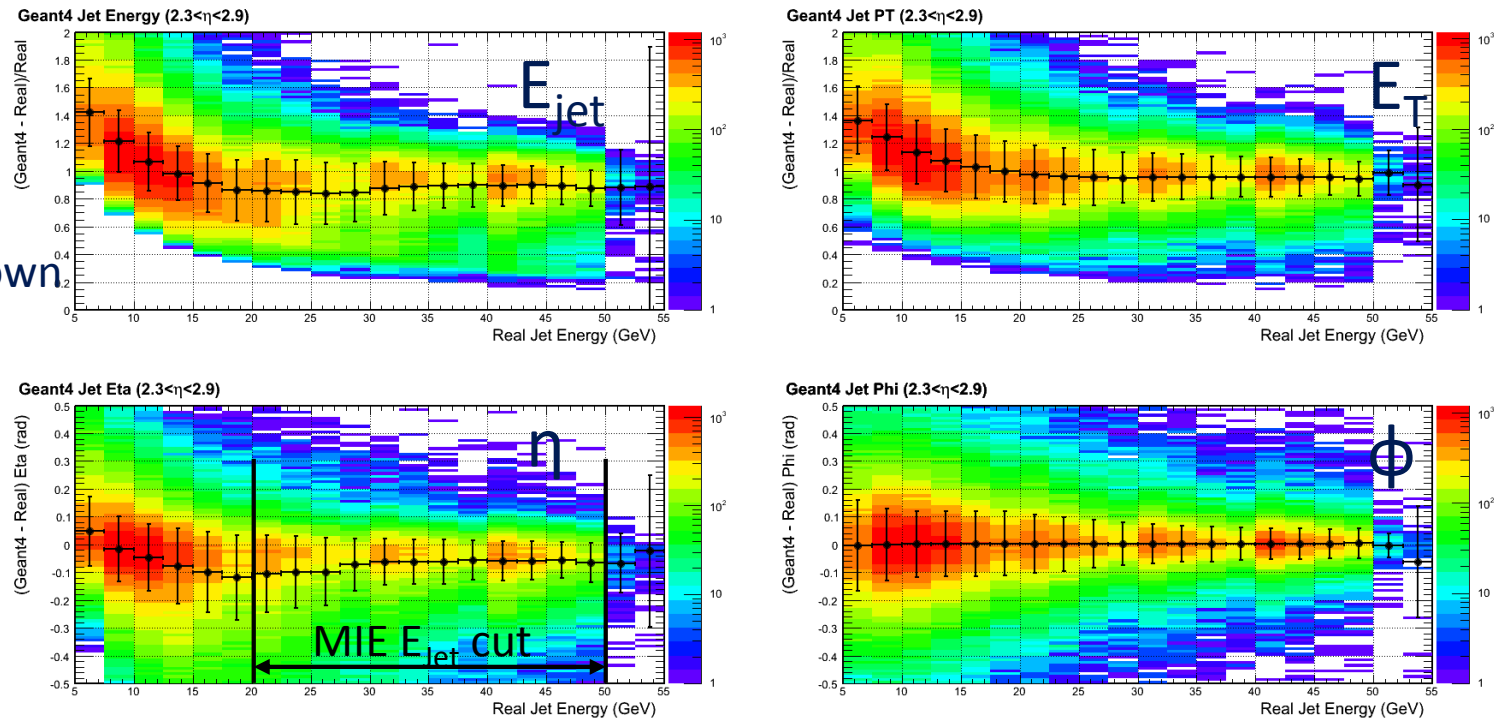
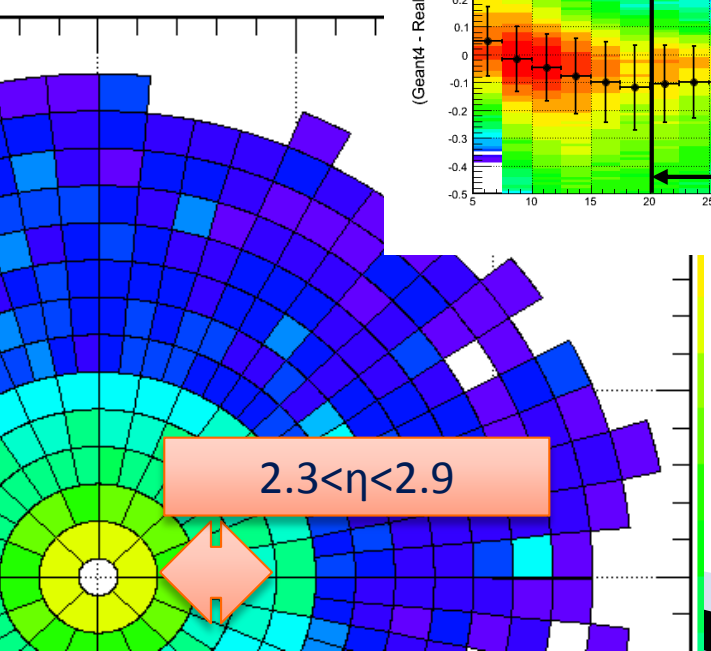
Gaus fit μ and σ shown



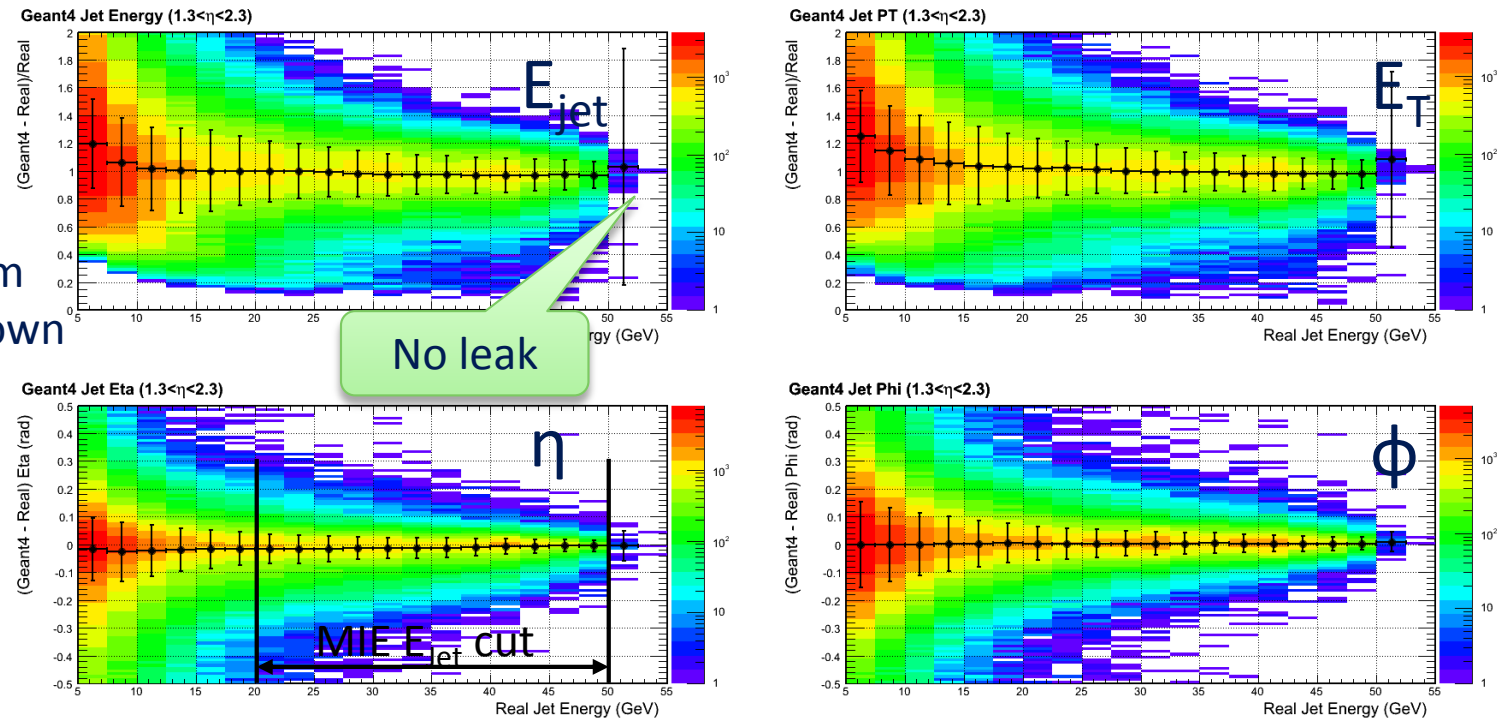


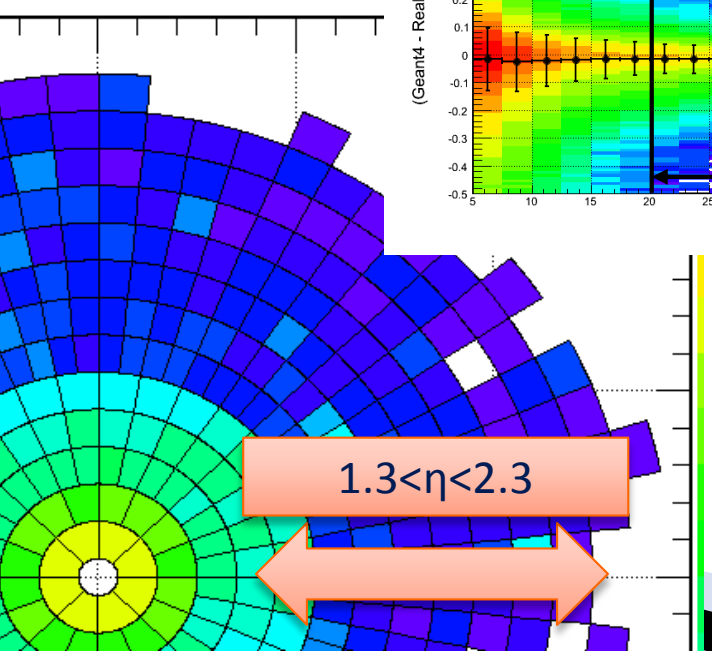
- Stronger bias on eta from binning effect
- Can be corrected buy tricky
- At eta=3, E_{jet} = 20GeV -> E_T = 2GeV!

Jet G4 simulation with pA Embedding – fsHCal central

2.5m FHCal results

Anti kT w/ R=0.4
Pythia p+p 200GeV
+ HIJING pA b=0-4fm
Gaus fit μ and σ shown





- In a good region where dϕ = 0.1-0.2 per tower
- Major part of the jet within FHCal

Jet G4 simulation with pA Embedding – Connecting to sPHENIX

2.5m FHCal results

Anti kT w/ R=0.4
Pythia p+p 200GeV
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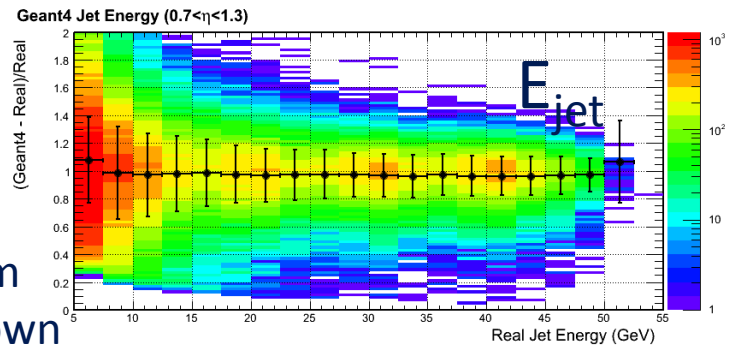
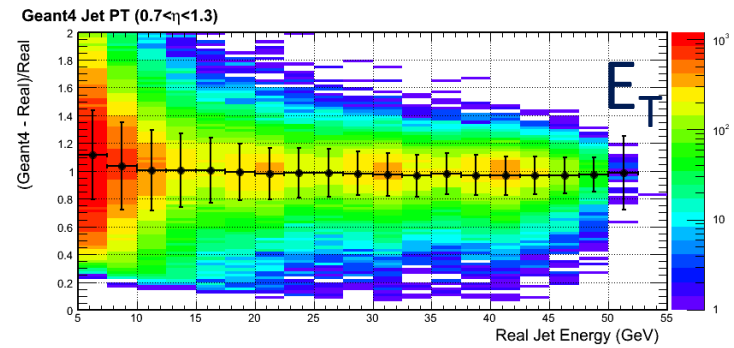
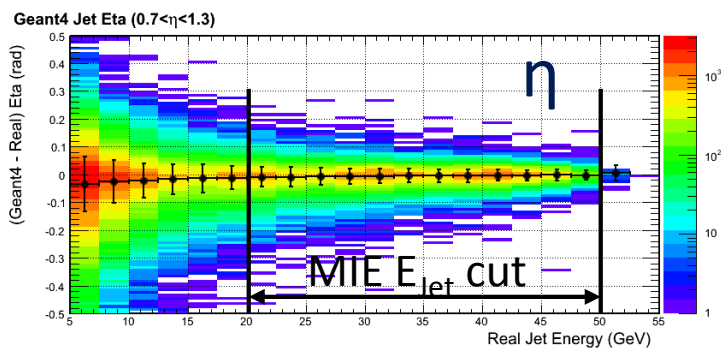
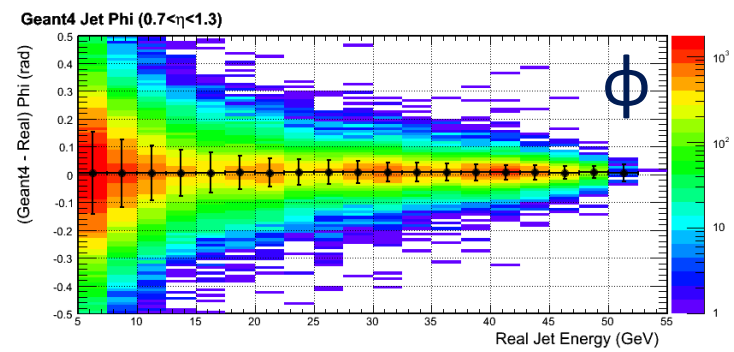
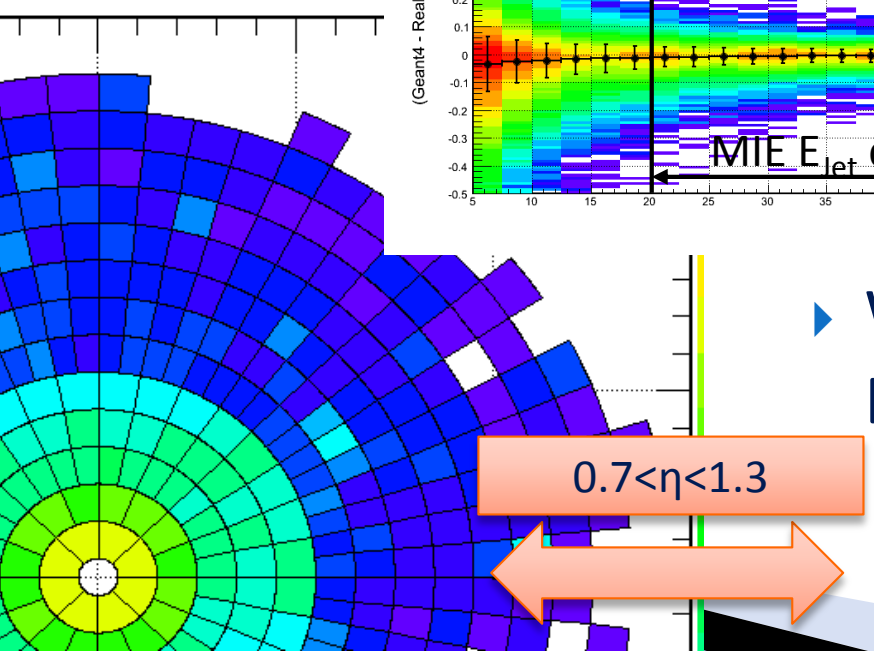
Gaus fit μ and σ shown









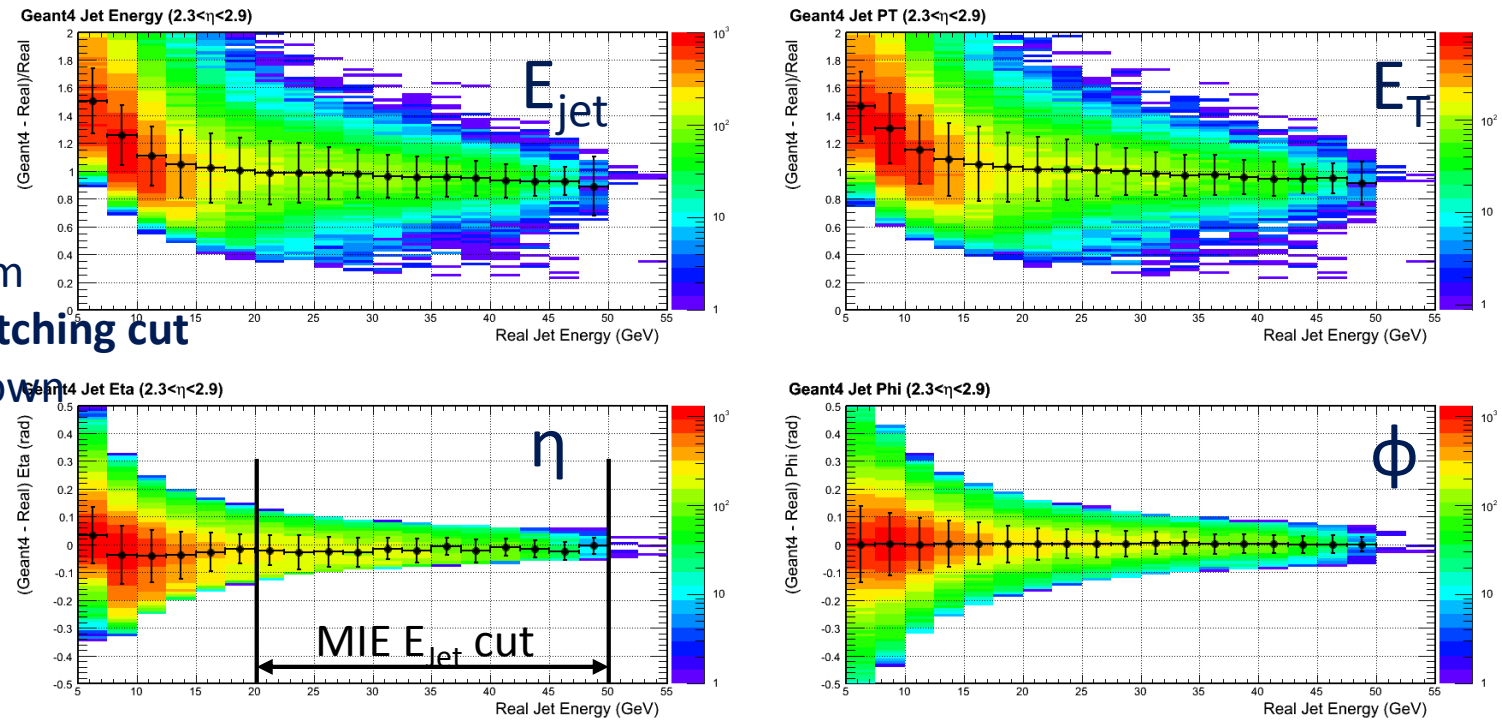


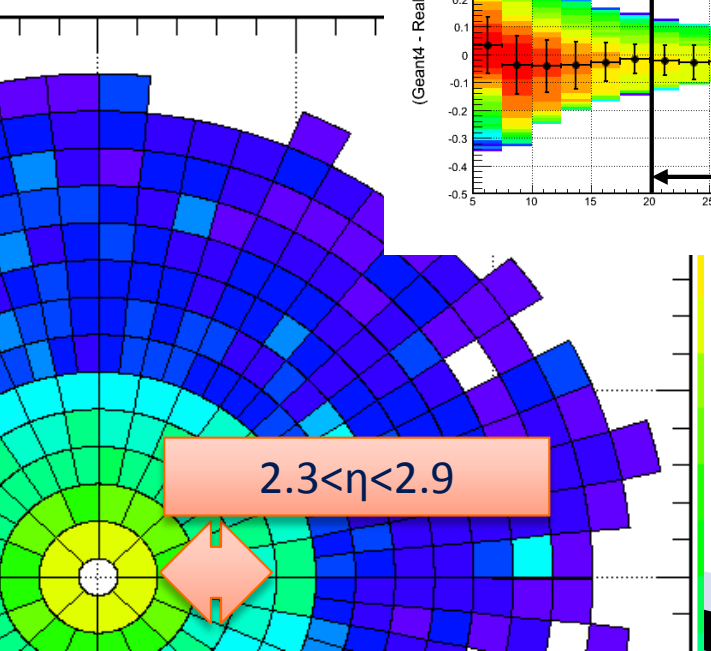
- Works by using
  EMCal + 2 barrel Hcal + FHCal

Jet G4 simulation with pA Embedding – Towards beam line

2.5m FHCal results

Anti kT w/ R=0.4
Pythia p+p 200GeV
+ HIJING pA b=0-4fm
3 sigma eta-phi matching cut
Gaus fit μ and σ shown





- Stronger bias on eta from binning effect
- Can be corrected buy tricky
- At eta=3, E_{jet} = 20GeV -> E_T = 2GeV!

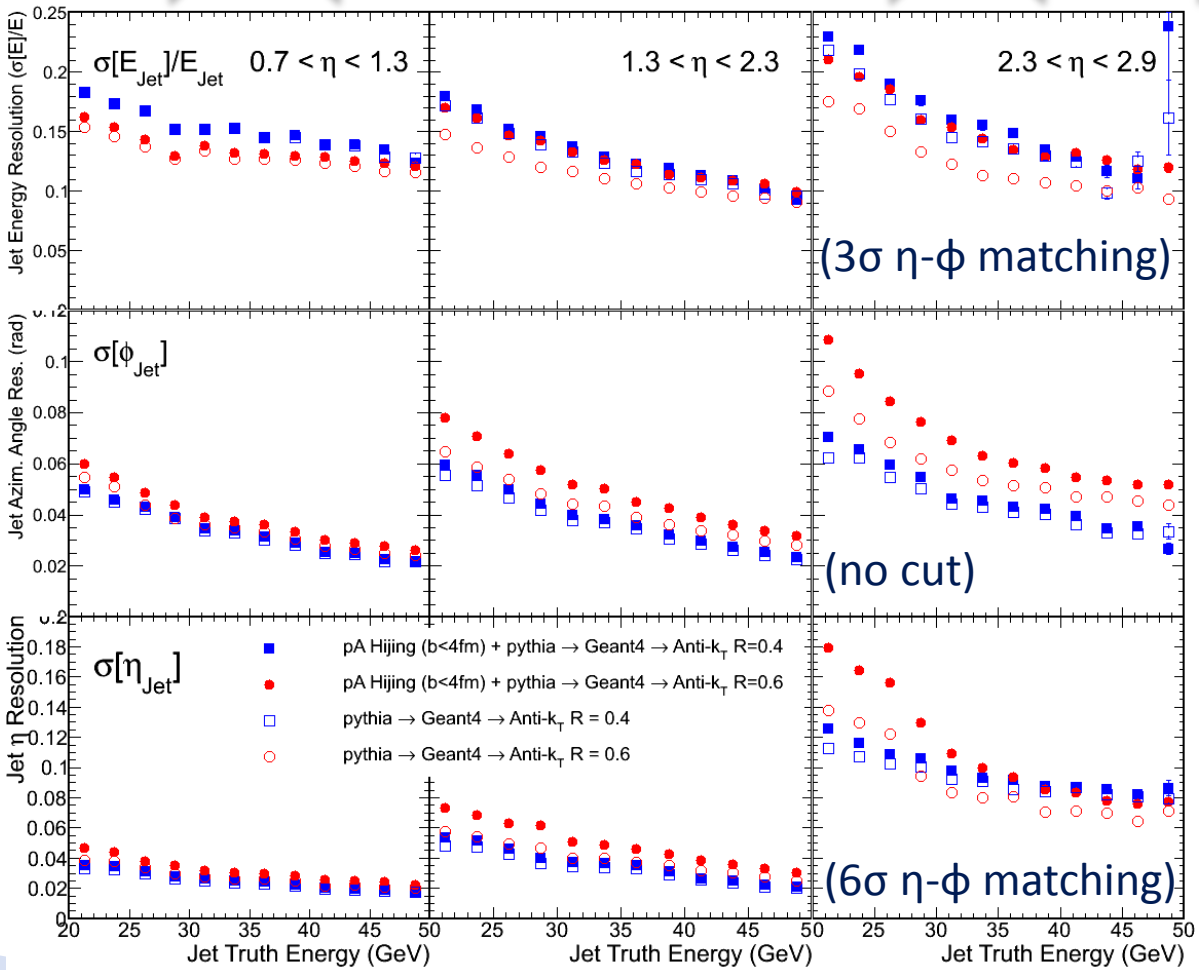
2.5m Hcal summary – 3.5 m Hcal should do better

2.5m FHCal results

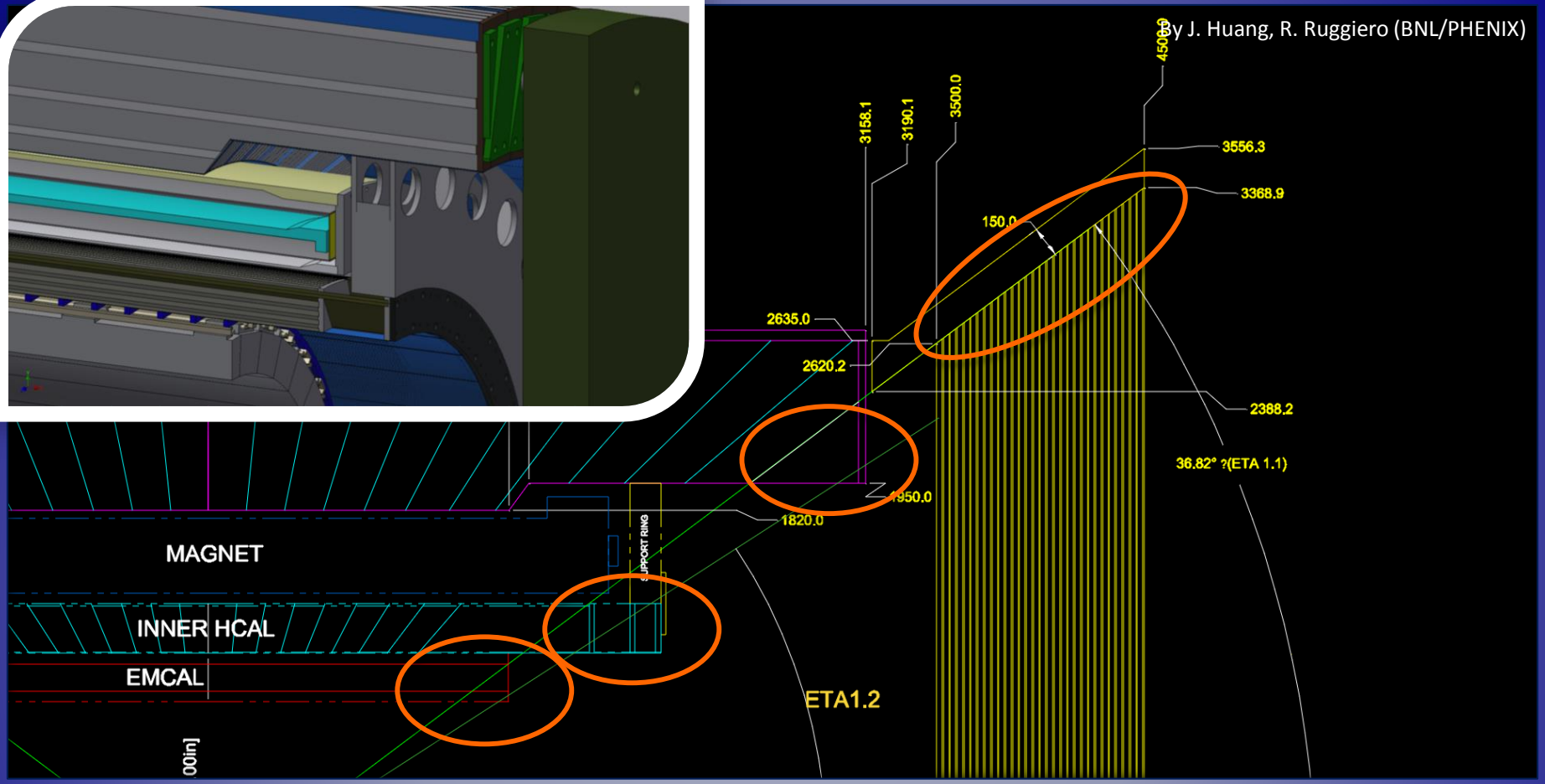
Presented: Jin, sPHENIX simulation meeting, Oct 31 2014

Barrel calorimeter | Forward calorimeter | beam line

- R=0.6 is better for energy resolution
- R=0.4 is better for angular measurement and for pA
- Matching energy resolution in barrel for pp
- Good angular resolution
- Some complexity for
  - Energy matching barrel-forward join region
  - Angular resolution for very forward region



Jet Hermeticity



Would there be a jet coverage gap around η=1?

We were asked when presenting the design

My guess is gap is minimal by summing all four calorimeters

Finished Geant4 Jet production, close to quantify this effect

Jet Isolation

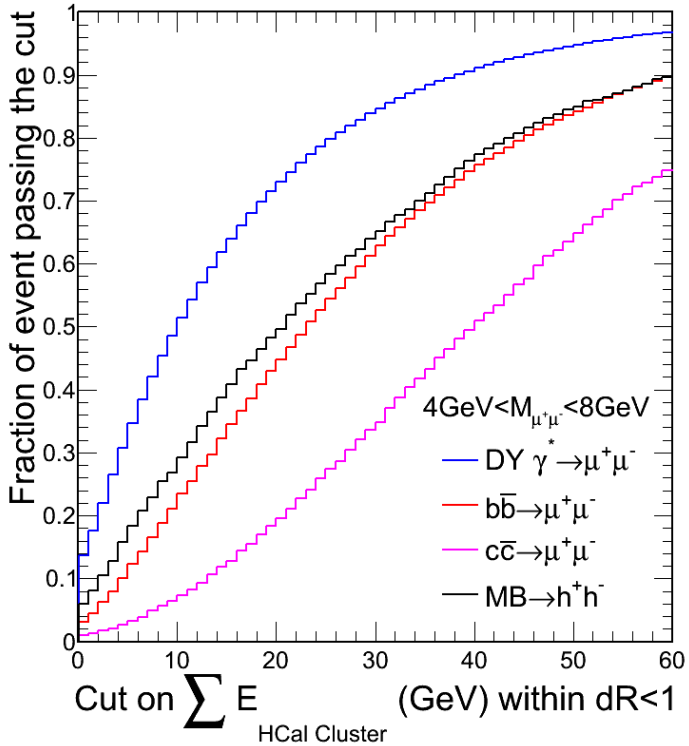
Summary for preliminary studies 2014 Preliminary, Pythia level only

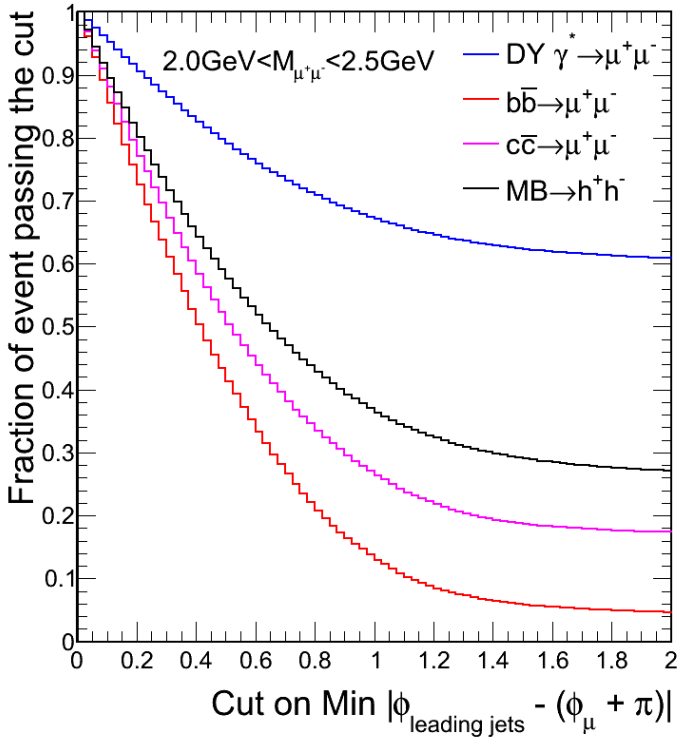
Presented by Jin & Cesar, June 10, 2014

Cuts	Relative Rejection @ 90% DY Eff	Relative Rejection @ 50% DY Eff
Track multiplicity near the muon candidate	2-3	2-4
Hcal energy deposition near the muon candidate	Moderate-factor of 2	2-10
LHCb-type jet-cone isolation	Moderate-factor of 2	2-10
Distance between nearest jet near and the muon candidate	Moderate-factor of 2	2-6
Angle correlation between backward going jet and the muon candidate	moderate	2-3 for high mass 2-10 for low mass

Summary for preliminary studies 2014 Preliminary, Pythia level only

Presented by Jin & Cesar, June 10, 2014





High mass region in 510pp:
HCal jet-cone isolation cut

Low mass region in 510pp:
Back-to-back jet-veto cut

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  - Sivers/Collins projection, resolution effect, background effect
  - Jet, Di-Jet A_{LL}
  - Jet isolation for DY measurement
  - W->Di-Jet with both Jet pt-weighted charge tagging??
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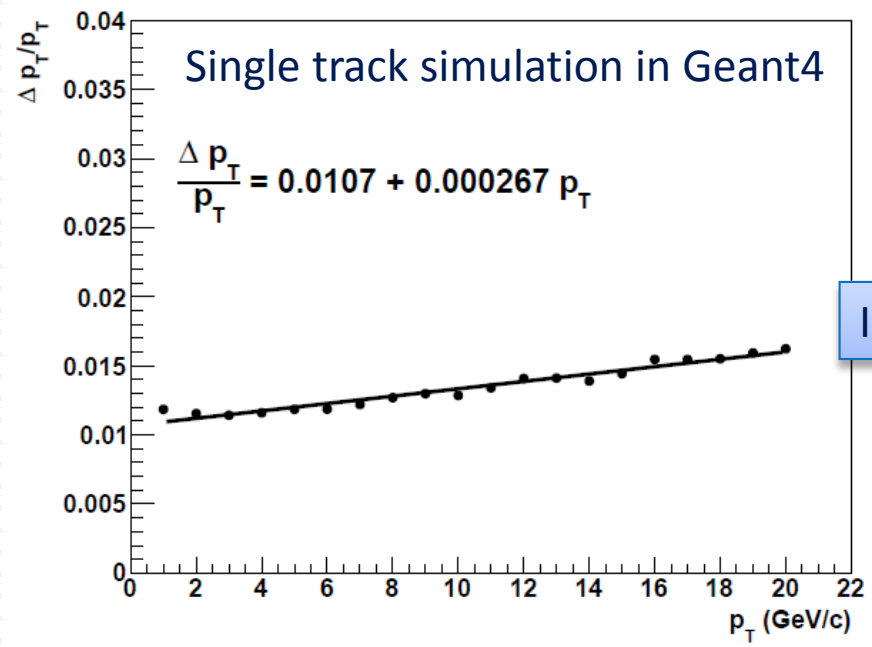
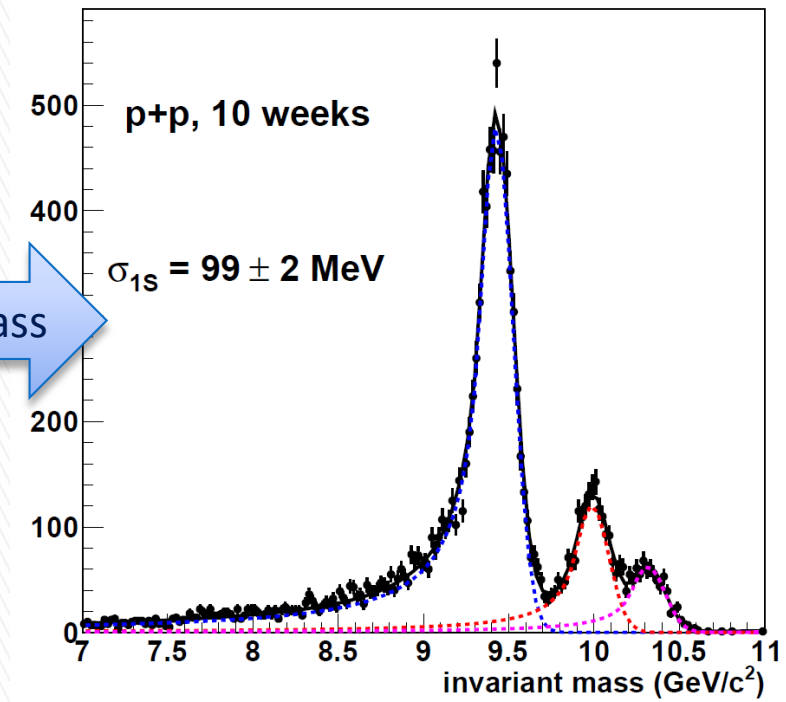
Extra Stuff

Tracking : Performance in Geant4



Inv. Mass

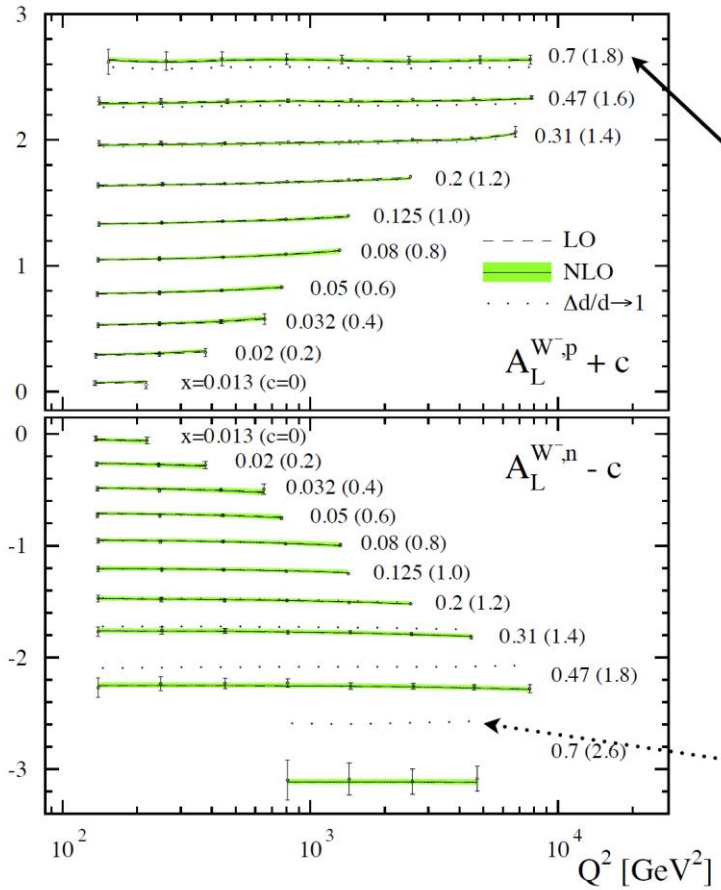


Also full detector HIJING simulation in Geant4
Eff. = 92% at 1 GeV/c and 97% at high p_T.

Single track performance

Invariant mass for e^+e^- pairs

EIC W simulation



A_L^W results

- Large A_L^W at large x ~80%
- NLO effects small
- $\sigma(A_L^W)/A_L^W$ small
  - <~5% for **p**
  - <~8% for **n**
  - ~25% at x limits
- Sensitive to "helicity retention"

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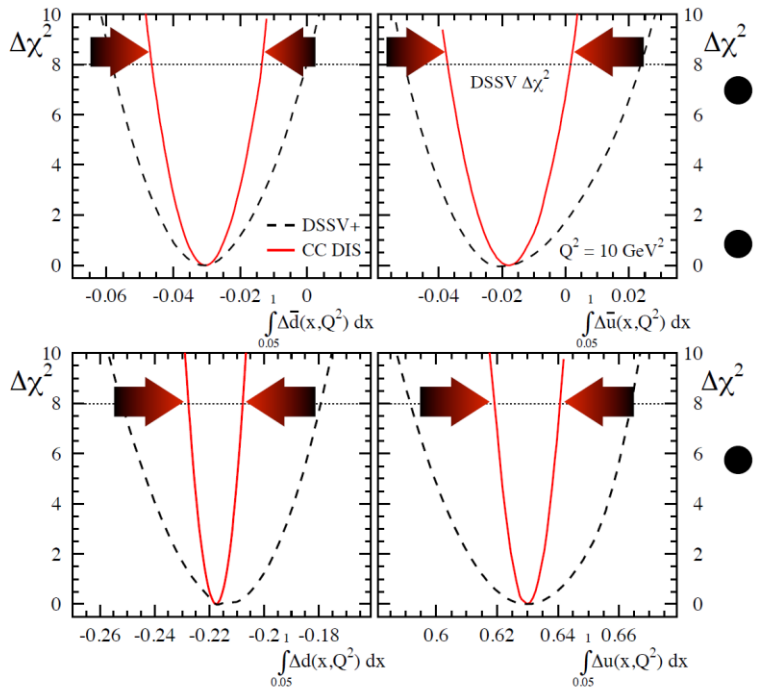
EIC W simulation

Impact on global analyses



- Constrain **u**, **d** & **anti-q** helicities
- Flavour constraint independent of **fragmentation**
- Important cross check on **SIDIS**
  - low Q^2, higher twist effects

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