sPHENIX Calorimeter Calibration Workfest Status/Discussion

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1/16/20

My Plan:

-A little background info

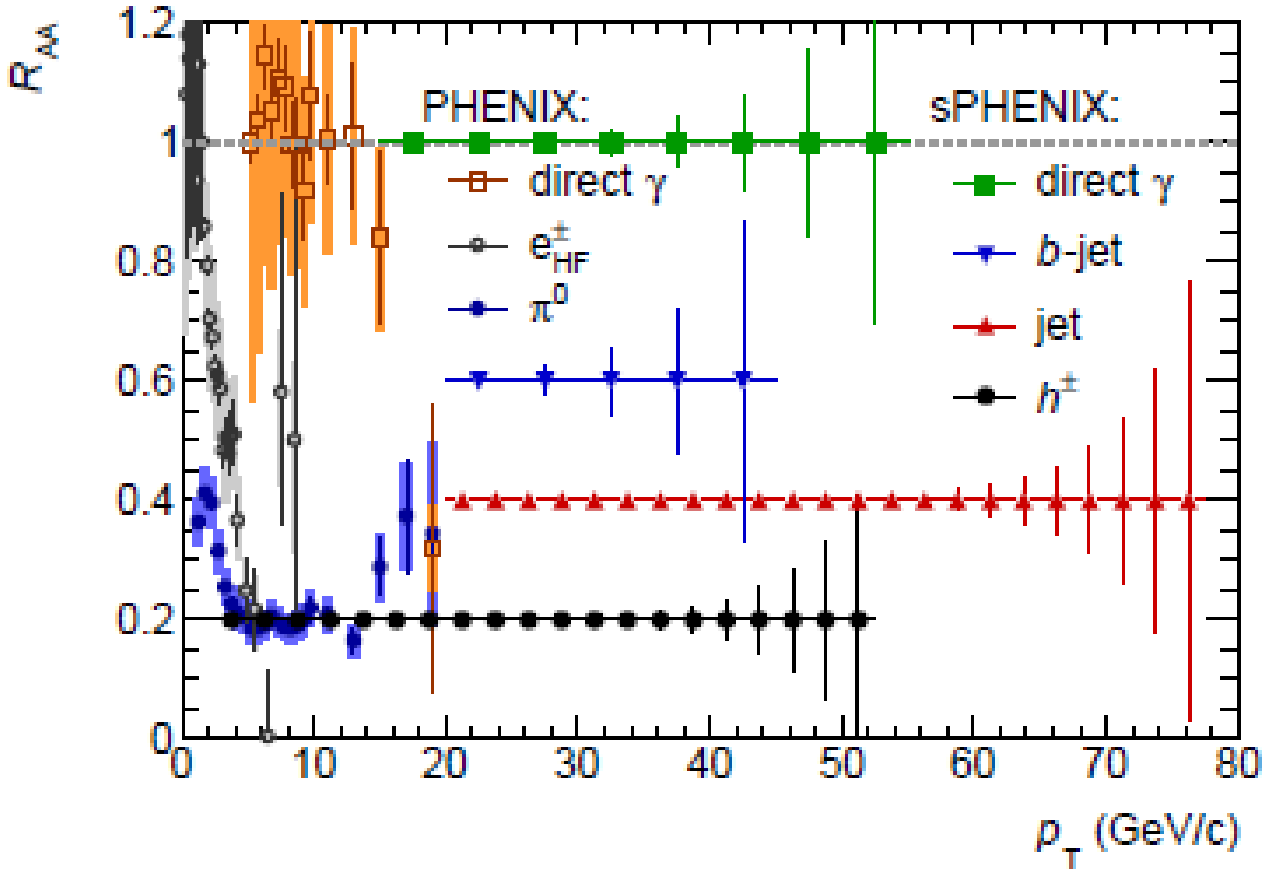
-Discuss Overall Strategy Updates (Proposals No Conclusions Yet)

-Highlight TODO's try to indicate current perceived priorities

These last two are what I'm interested in people commenting on

The Goal: Jets Btw20-70 GeV

- Statistics expected full jets
- TDR States Our Goal is reconstructing jets between “20–70 GeV”
- We need to be able to calibrate the detector to match this range!



From original sPHENIX Proposal

I think statistics estmations have probably actually gone up based on RHIC CAD Projections

Detector Calorimeters

- Hermetic, Uniform 2π ϕ Acceptance:
  - $|\eta| < 0.85$ Base DOE MIE
  - $|\eta| < 1.1$ EMCal recent funding from Chinese consortium!

- Steel plates & scintillating tiles
- 3.8 λ
- Δη x Δφ ~ 0.1 x 0.1
- Also serves as a flux return

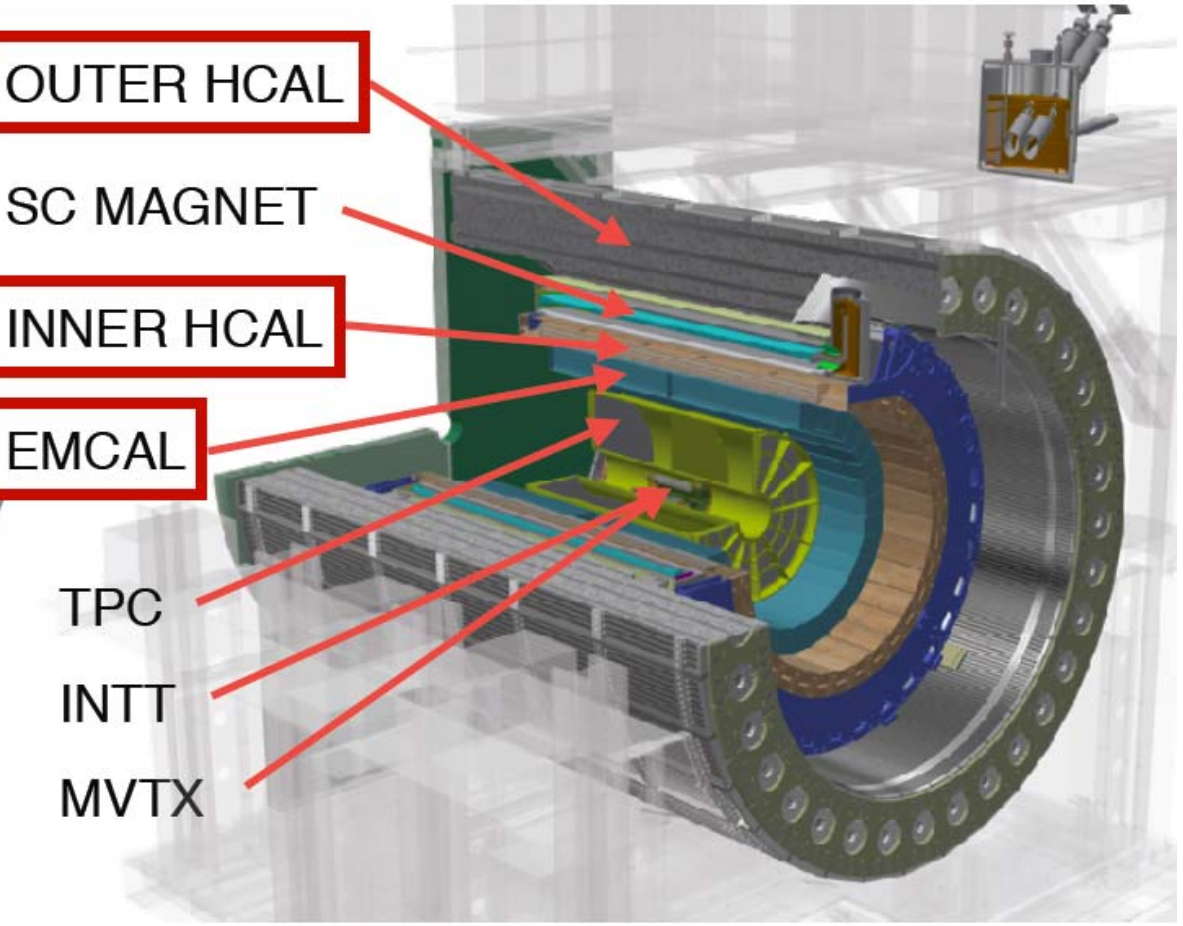
1385 Towers/Channels

- Aluminum Frame
- 0.25 λ
- Potential to be instrumented for increased performance

1385 Towers/Channels

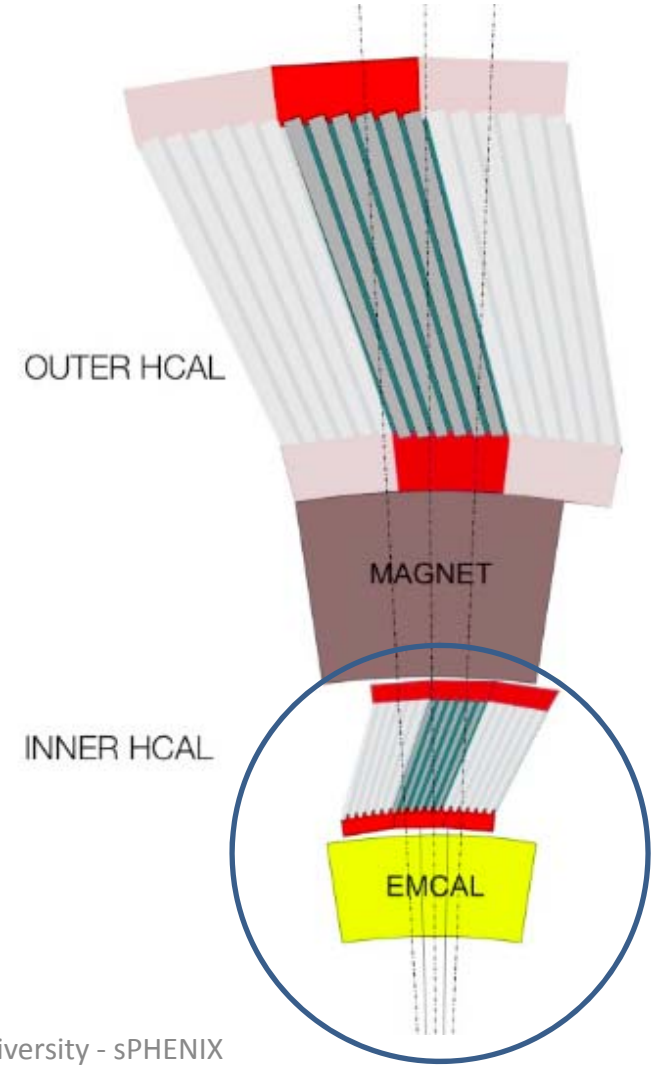
- Tungsten-Scintillating Fiber
- 18 X_0, 1 λ
- Δη x Δφ ~ 0.025 x 0.025

24576 Towers/Channels



Full Calo Stack

- Very unique and complementary calorimeter design
- Unique at RHIC: full Hcal
  - Inner/Outer
- **Photon/EM Measurements Very Important in sPHENIX**
  - EMCal Located Inside Magnetic field region
  - SiPM Light Collection
  - Readout/SiPM temperature control inside field



Calib Questions for Workfest (Orig)

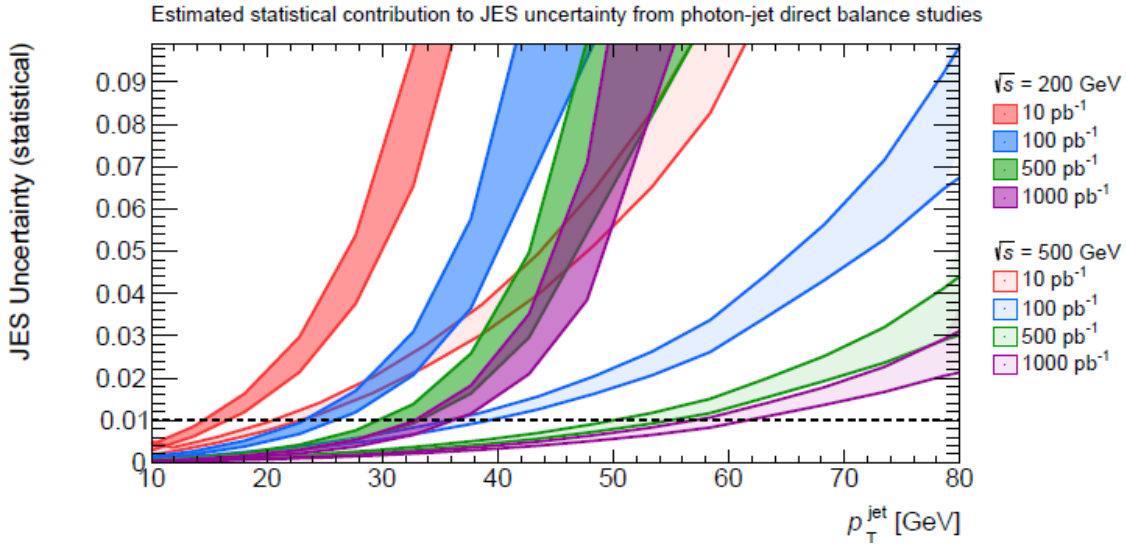
- Key question 1 What is current uncertainty on effect of calibrations (including HCal non-lin's) on key jet results?
- Key question 2 How to initial calibrate, monitor and data-calibrate Hcal?
  - Current method: how good (overlap w/ key question2)
  - Data MIPs : statistics per week, response
  - Isolated charge hadron showers : what properties or response, statistics per week
- Key question 3 Do we need further test beam studies?
  - How much better knowing EMScale of Hcal will help things?
- Key question 4 Make case for 500 GeV p+p calibration running?
  - Jet rate (Aaron already sent some nice plots) look like no brainer (yes 500—calib run ~5-10 x shorter), but how well can calibration @ 500 be translated to 200 GeV
  - J/Psi for EMCal?

Definitions

- Past Experience:
- **Relative Calibration :** Method to Normalize Tower by Tower Differences (Factors/Adjustments)
- Typically using only 1 Energy Point
- Absolute Calibration:

FULL JET CALIB (Top Down)

- Two Codes: Fernando/Aaron, Songkyo
- LOTS OF WORK LEADING UP TO WORKFEST (Esp last week Aaron, Songkyo) THANKS!
- Conclusion: Estimates of Gamma Jet Stats needed, and demonstration of calib method
  - Maybe need 500 GeV Running ?
- Overall Hcal Non-linearity Effects on Absolute Hcal/Jet Calibration FIRST LOOK: SMALL?
- Most important now?: How Monitor/Adjust Relative Hcal Tower by Tower Calib?
- **TODO: STILL NEED TO TRANSLATE TO RAA AND OTHER MONEY PLOTS**



Common Calibration Elements EMCal/Hcal: SiPM's

- Common Light Collecting **SiPMs** for all EMCal and HCal Channels
- siPM Rad Damage and Temperature Variations Are Concerns (10% Gain Change / Degree)
- Monitor/ follow these with a combination of data and LED monitoring
- **(NEW) TODO SOON: We need to characterize LED response and formulate more details on how to drive and record the LED monitoring data in all 3 Cal systems**
  - **(Suggestion: let's at least get this data on**
  - **RCF with Analysis Macros)**
- Common to all 3 Calos: NEED MORE

MONITORING DATA !!! (e.g. Scintillation)

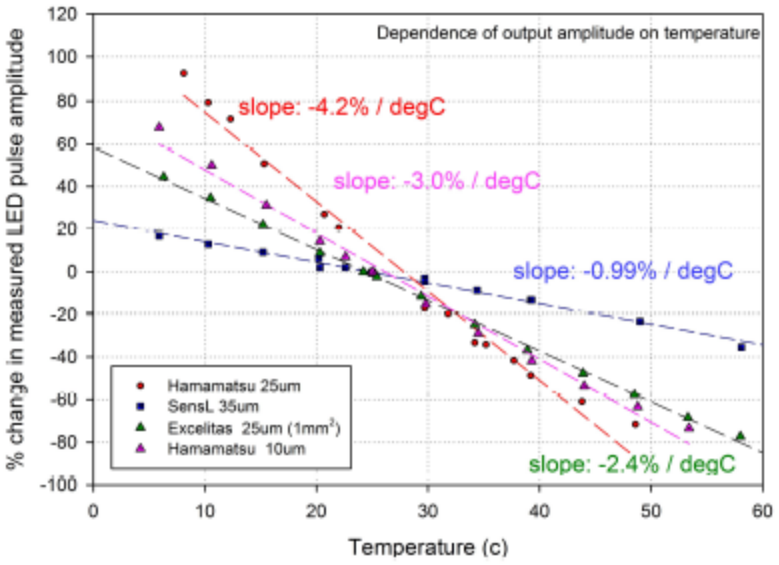
- Solution WILL NEED TO INCLUDE

Data or Cosmic MIPS Understanding

MIP response after Dark Current increase?

- Dark Current Increase Expected
- Later runs ? noise? MIP Tail/ Double

MIP peak? TODO look into this?



SiPM Temperature Dependence Other Concerns

- Temperature dependences of siPM monitored and in data-stream at some rate
  - what rate?
  - Built-in feedback adjustments in electronics for gain drift – forget using these
- **TODO (down the road, but soon):**
  - **Define LED Data Structures**
  - **Define/ Test DB/Data (John H: preferably also copied in PRDF data)**

sPHENIX EMCal Calib Plan

- **Calib Plan:**
  - A) Initial Calibration from testbeam data + unit variation tracking
  - B) PHENIX-Style, 2-γ pi0 calibration from data fixes tower by tower relative calibration
    - may use primarily peripherial events (expect > 40% centrality acceptable)
  - C) Absolute calib fixed by PHENIX-Style 2- γ η out to ~10-25 GeV & J/Psi->ee to 10-30 GeV (possibly also using 500 GeV p+p for J/Psi stats). [want overlap]
- Expect siPM temperature/time variations are slow enough to allow enough events for B) to be repeated as necessary to follow changes. (e.g. sliding window? ~ 100 M events in 10M ev steps)
- MIP calib possibility if finer time dependence needed btw B?
  - Later runs ? noise? MIP Tail/ Double MIP peak?
- Lateral and/or Longitudinal Cosmic calib is a possibility btw steps A & B.
  - We expect Cosmic Muon Triggers to be defined, but for now are trying to avoid needing to study/design these.

Hcal Calib Goals By End of Workfest (OLD)

- Statistics needed for gamma-jet calibration using full jet reco **(First Results Done Aaron/Songkyo : Extend these?)** What further studies are needed – what further needed to make case for 500 GeV
- Get Fernando's code and/or Songkyo's code running -- better quantify effects of nonlinearities/decalibration on key jet observables - Rerun Songkyo's and/or Fernando-Aaron's code including realistic decalibration
- Determine Data MIP response, performance, and available statistics for data-based (relative and/or absolute) calibration and monitoring Justin/Megan
    - Determining potential MIP to Hcal EMScale mapping
- For Iso Charge Track Shower: Get Dennis's new "TopoCluster" code running, monitor statistics/shower properties for HCAL relative calibration
- Lower priority - Non-uniformities in Hcal as a fn position– Redo non-uniformities plot w/ recent tracking config

Full Test Beam Hcal Calib in Simulation? (Code?)

- YES! Megan's Workfest Wiki:

```
 The code is here:
 // From 2016 Test beam sim
 RawTowerDigitizer *TowerDigitizer = new RawTowerDigitizer("HcalInRawTowerDigitizer");
 TowerDigitizer->Detector("HCALIN");
 //  TowerDigitizer->set_raw_tower_node_prefix("RAW_LG");
 TowerDigitizer->set_digi_algorithm(       RawTowerDigitizer::kSimple_photon_digitalization);
 TowerDigitizer->set_pedstal_central_ADC(0);
 TowerDigitizer->set_pedstal_width_ADC(1); // From Jin's guess. No EMCal High Gain data yet!
TODO: update
 TowerDigitizer->set_photonelec_ADC(32. / 5.);
 TowerDigitizer->set_photonelec_yield_visible_GeV(32. / 5 / (0.4e-3));
 TowerDigitizer->set_zero_suppression_ADC(-0); // no-zero suppression
 se->registerSubsystem(TowerDigitizer);
```

```
 //Default sampling fraction for SS310
 double visible_sample_fraction_HCALIN = 0.0631283 ; //, /gpfs/mnt/gpfs04/sphenix
/user/jinhuang/prod_analysis/hadron_shower_res_nightly/./G4Hits_sPHENIX_pi-_eta0_16GeV-
0000.root_qa.rootQA_Draw_HCALIN_G4Hit.pdf
```

```
 if(inner_hcal_material_Al) visible_sample_fraction_HCALIN = 0.162166; //for "G4_Al", Abhisek
Sen <sen.abhisek@gmail.com>
```

```
 RawTowerCalibration *TowerCalibration = new RawTowerCalibration("HcalInRawTowerCalibration");
 TowerCalibration->Detector("HCALIN");
 //  TowerCalibration->set_raw_tower_node_prefix("RAW_LG");
 //  TowerCalibration->set_calib_tower_node_prefix("CALIB_LG");
 TowerCalibration->set_calib_algorithm(RawTowerCalibration::kSimple_linear_calibration);
 TowerCalibration->set_calib_const_GeV_ADC(0.4e-3 / visible_sample_fraction_HCALIN);
 TowerCalibration->set_pedstal_ADC(0);
 TowerCalibration->set_zero_suppression_GeV(-1); // no-zero suppression
 se->registerSubsystem(TowerCalibration);</sen.abhisek@gmail.com>
```

Full Hcal Calib in Simulation? (Code?)

- Questions about Nonlinearity Lower Priority?
- But TO STUDY: (TODO:) DECALIBRATE WITHIN UNCERTAINTIES ON HCAL Calib
- Also put in known variations on tower by tower e.g. “tile quality”…etc…
- But before this, define relative tower by tower calibration and expected uncertainties on that…

Relative Tower by Tower Calib

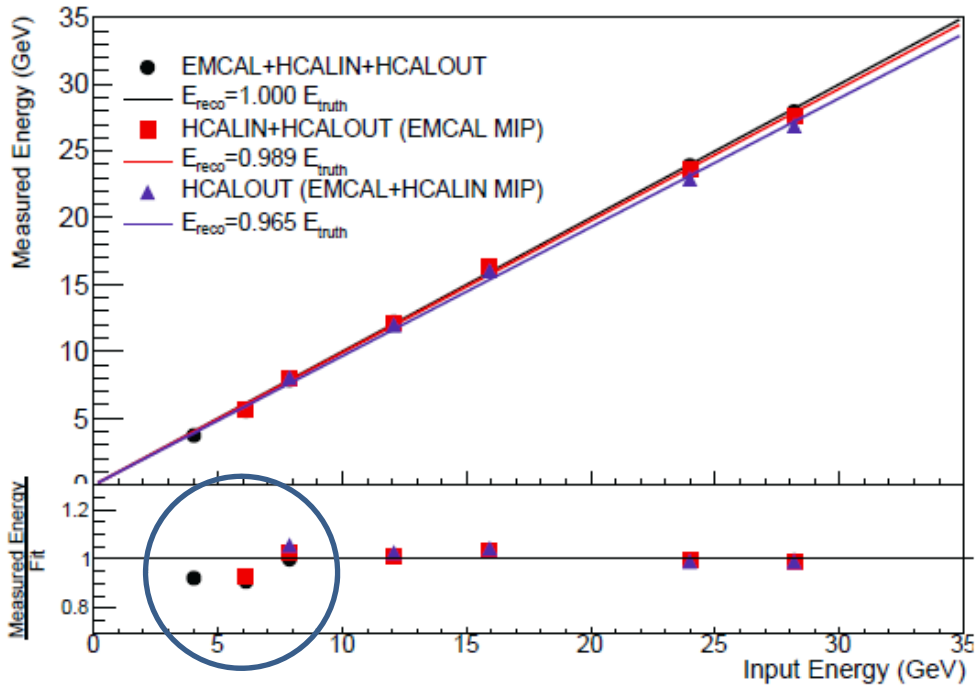
- Discussions so far: should be able to Monitor Relative Calibration For Hcal with:
- 1) DATA MIPS (At least First Year)
  - MIPS Plentiful :
    - 20-50 Charge Pions /event (excluding most central/periph)
    - Data Muons (Tony estimate) 10-20 Million Over Whole Run
      - OHCal: 10K per tower - 3-5 Time Periods?
  - Punchthrough Tracks: TODO Numbers Need Checked!
    - EMCal, Calib Every >=600 K AuAu Events ~500 MIPS PER TOWER
    - IHCal : Int.Length: ~1λ Calib Every 25K-100K Events
    - OHCal : Int Length 5.5 λ Calib Every 2.5M – 6M Events (JIN: Large BKGD?)
  - **TODO: Efforts focused here for Workfest/Near Future**
- 2) DATA Isolated (Charge) Track Had Showers **(ITHS)**
  - Starts with the same 50-100 Charge Pions /event (excluding most central ev)
  - More Work Than MIPS to identify Calibratable Shower Shape Selection
  - Raw stats similar to MIP Estimates Above * Small Shower Selection Efficiency
  - **TODO: Get Dennis's new "TopoCluster" code running, monitor statistics/shower properties for HCAL relative calibration**
  - **TODO: Find Low Hanging Fruit (Partial Punchthrough –e.g. IHCAL)**
  - **GOAL: looking for peaks in E/p – can use multiple (low –ish) points, study Non-Lin effects over larger units of data**

A FURTHER METHOD

- In PHENIX EMCal we also used the tower energy distributions spectral shape, between from MIP to ~1-2 GeV
- This should be possible also for HCal
  - Mix of MIPS/HadShow contributions
- This can even be a third method
  - Needs more statistics than Peak based

In other words…THE CALIB PLAN:

- Base (Rough) Calibration of HCal already defined (previous slide)
  - Nominally hadronic shower scale, based on Cosmic MIPs, but very linear—must be a multiple of EMScale?
  - Improve?



In other words…THE HCAL CALIB PLAN:

- Base (Rough) Calibration of HCal already defined (previous slide)
  - Nominally hadronic shower scale, based on Cosmic MIPs, but very linear—must be a multiple of EMScale?
- Use both 1) MIP & 2) ITHS to define relative tower by tower calibration/monitor/adjuster
  - Needs MODULATED BY Rapidity Dependence From Model !!! **(TODO?—Part of Jet Calib)**
- **Absolute Scale Determined by Jet Calib**

Conclusions

- Lots of FUN!!!!

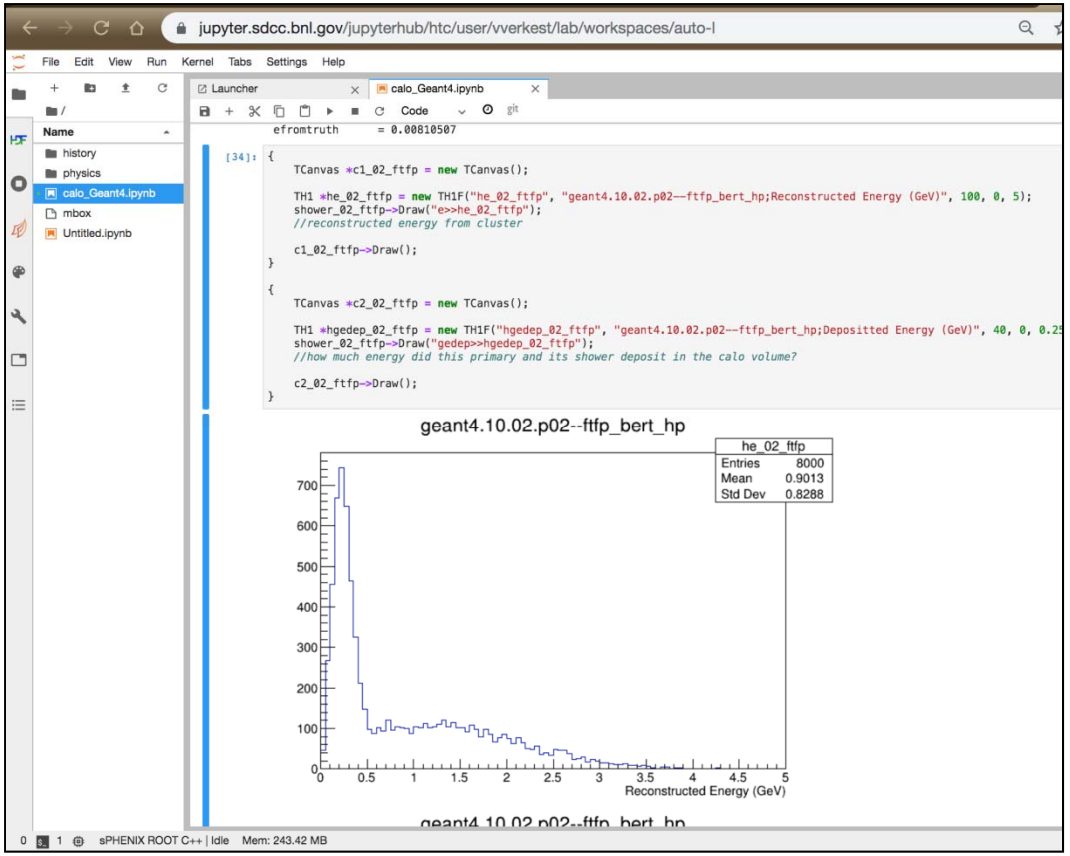
Backup

Various Progresses So Far

- Megan's Workfest Wiki page:
  - https://wiki.bnl.gov/sPHENIX/index.php/MegaWorkfest2020
- Megan Updated Material Calcs
- Bing/Henry J/Psi Eta – EMC
- Nathan Code to Look at Things (MIPS) at ADC level
- Veronica Jupyter Notebook on GEANT Version Changes in Sampling Fraction!:

- Rosi lots of organizational things!

e.g. MIP Peak Fitting code

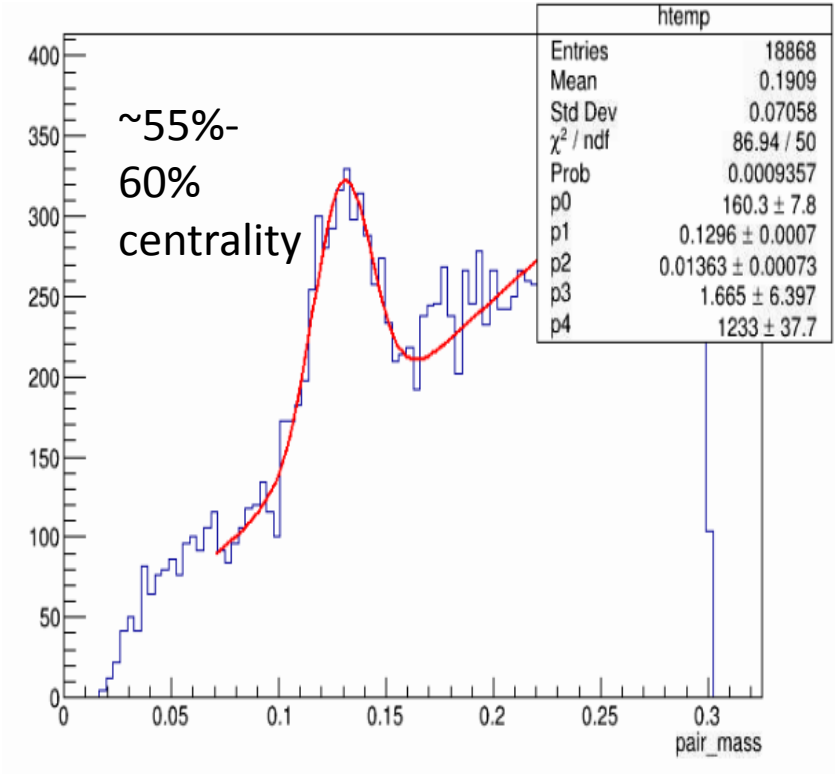


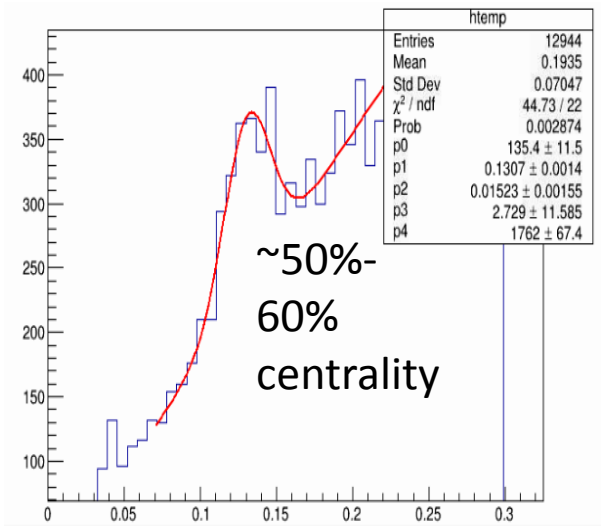
Simulation Details

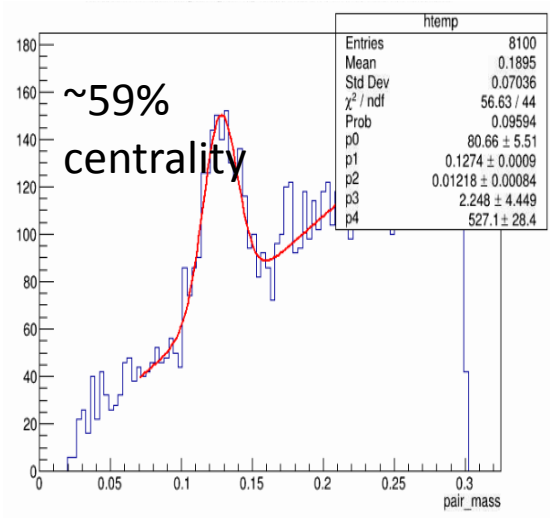
- sHIJING b = [9-11fm] Events (only new production currently available)
  - Just using raw HIJING events for pi0 study
  - Using embedded eta particles for high pt
- b=9,11 corresponds to ~40-60% centrality
- PHENIX method used > 40% centrality

Low pt pi0-by-pi0 Calib check

- Minimal Feasibility:
  - Peaks visible: pi0 pt > 1.2 GeV
  - S/B is OK, not important, even with small statistics / “high bkg” mass value within ~1.5%

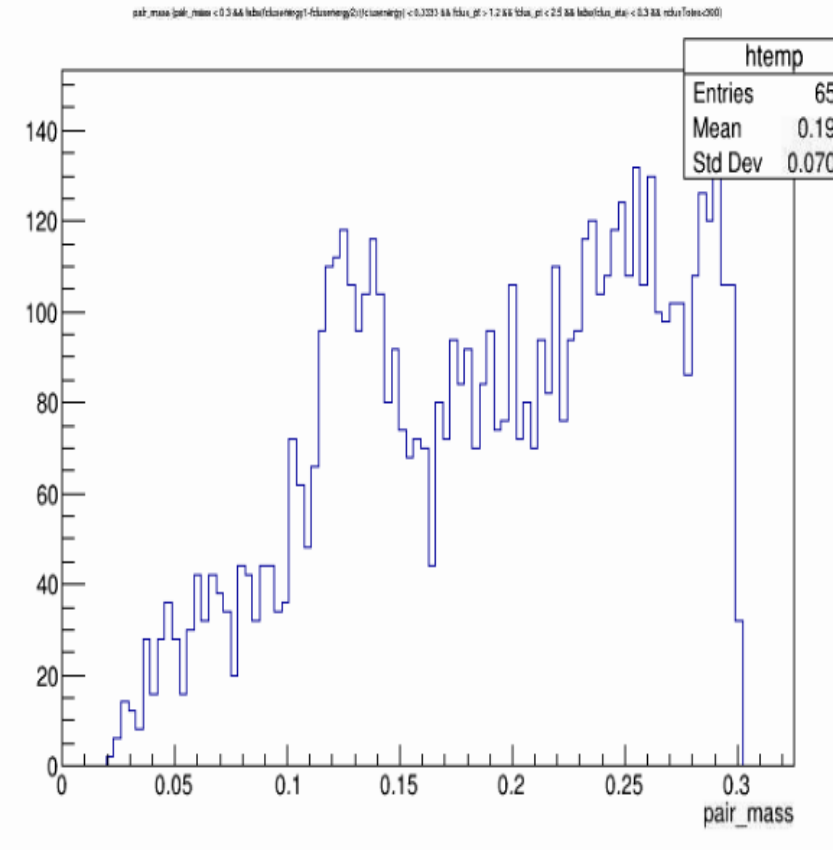


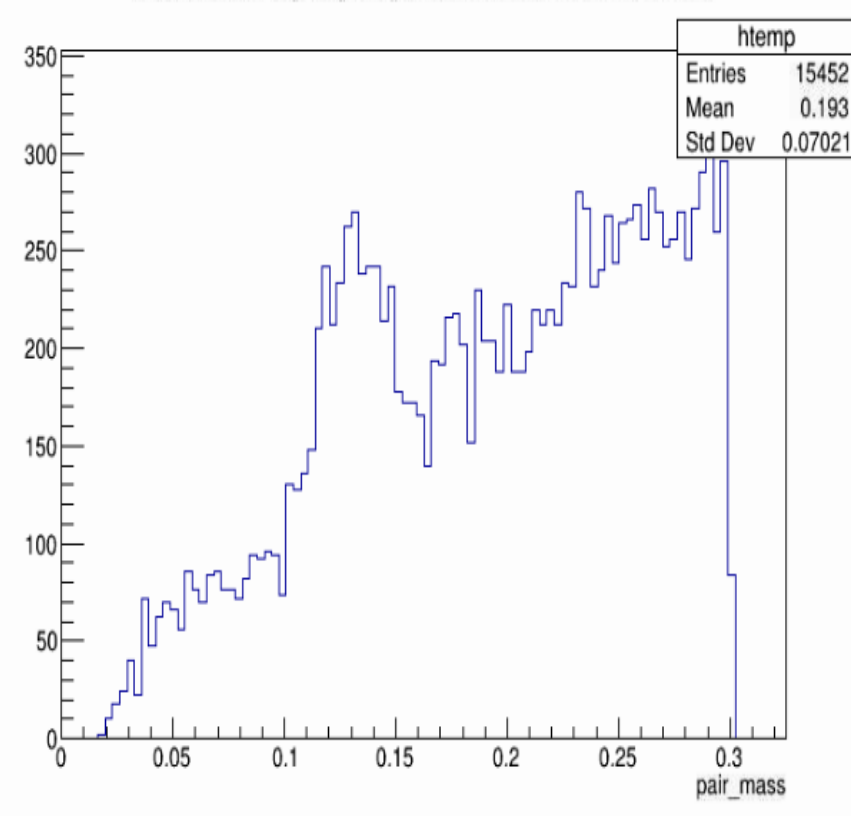




Pseudorapidity Dependence

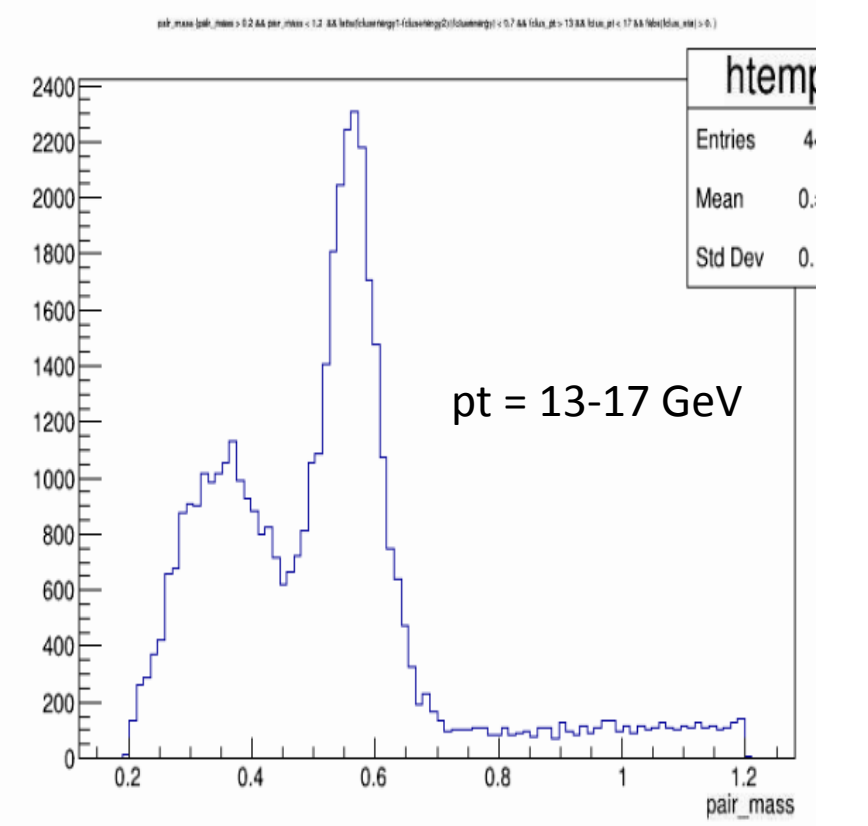
- No strong η dependence (same pi0 pt > 1.2, cuts)

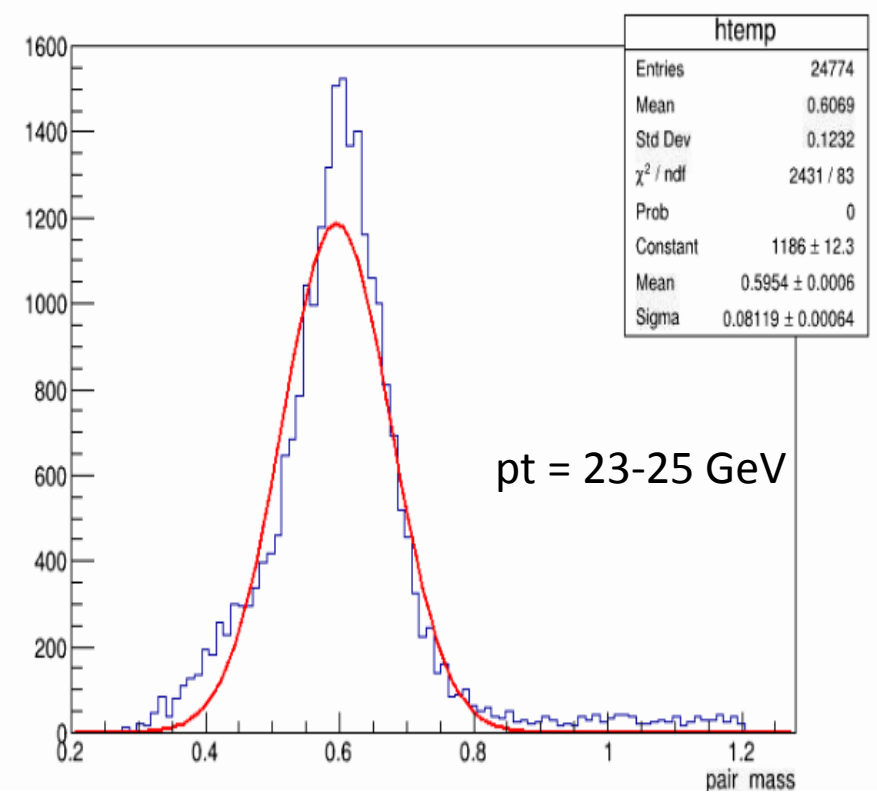




Eta Particle for Abs. Calib

- Good 2-γ Eta Reconstruction Out to > 25 GeV
  - (need to check peak location at highest pt)





CPU/Computing Needs Estimate

- Based on per event processing time (real time/ whichever is reported by Fun4All timers)
- Pi0 event by event time dominates, 100 ms/event
- MIP calib if needed for finer granularity on following temperature dependent gains

Backup

Calibrations

- Collect Test Beam paper