HCAL and PFA Studies

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Plans and goals

- **Short tem: revisit SiD global parameters**
  - Especially those relating to calorimetry
  - Follow up Marcel's "SiDish" study
    - Used in preparing the SiD LOI
    - Many parameters studied
  - Keep in mind physics performance vs. cost as well as jet energy resolution vs. global parameters
- **Longer term: contribute to PFA development**
  - Provide additional effort on existing SiD PFAs
  - And/or investigate PandoraPFA
    - What would be needed to run a Pandora-like PFA in org.lcsim?
    - Identify the important differences between SiD PFAs and PandoraPFA
- **Feedback is welcome**
  - What should be the highest priorities?

Where SiDish studies got us

- Explored a considerable region of detector parameter space
  - B-field (4T, 5T (sid02), 6T)
  - ECAL inner radius (1.0 m, 1.25 m (sid02), 1.5 m)
  - ECAL inner Z (length of SiD) (1.5 m, 1.7 m (sid02), 1.9 m, 2.1 m)
  - HCAL depth (3.5 – 5.5 lambda)
  - HCAL longitudinal segmentation (30 – 60 layers)
  - Documented in Marcel Stanitzki's talk and paper
    - "Detector Optimization for SiD"
    - http://ilcagenda.linearcollider.org/contributionDisplay.py?contribId=147&sessionId=23&confId=2628
    - arXiv:0902.3205
- Used qqbar events
  - at 91 and 200 GeV CMS
  - $|\cos(\theta)| < 0.7$
  - Also studied forward endcap region using *u*-jets
- Provided essential input for the LoI

Resources and running at MIT

- Scripts set up at MIT for easy job submission and book-keeping
- Given stdhep and compact.xml files
  - Run GeomConverter and SLIC
  - Calibrate each detector variant using Ron Cassell's and IowaPFA script
    - Use LCDetectors/detectors/sid02/ calibration files as starting point
    - Sampling fractions
      - Use qqbar at all energies of interest (100 to 1000 GeV)
      - Use QSFCalibrationFromData.java
      - Save AIDA file for inspection
      - Save last set of SF values printed in log files
        - Replace values in ./SamplingFractions/{EM,HAD}{Barrel,Endcap}.properties files
    - Photon and neutral hadron calibration
      - Use ZZnunubaruds events at 500 GeV
      - Use QuickCalibrationFromData.java
      - Save photon and nh values printed in log file
        - Replace values in ./{photon,hadron}Calibration/{photon,nh}Qcal-v2r3p10.properties files
    - PFA calibration
      - Use ZZnunubaruds events at 500 GeV
      - Run Iowa PFA calibration script (likelihood.sh)
      - Produces a binary likelihood.bin file
        - Place this file in the ./structuralPFA/ calibration directory
    - Assume we can use existing sid02 LongitudinalHmatrix.hmx file
      - What sorts of detector variations will require a new version?
        - Major ECAL changes, presumably
  - Run reconstruction/PFA
  - Determine jet energy resolution, other numbers

Resources at SLAC

- **A number of existing detector variants already exist at SLAC**
  - Leverage these where appropriate, noting simulation and recon versions
    - Some variants may benefit from re-running simulation and/or recon/PFA with current org.lcsim code
  - Ron's summary file lists many of these: /nfs/slac/g/lcd/mc/prj/users/cassell/Summary.table

E.g., sid01

Produce same numbers for variants under study

Detector info	Data	Anal	#evts	Emean90	Erms90	jEres%	alpha%	Mmea90	Mrms90	dM/M %
s_127_S_rpc_dig:	qq200:	PPR	7275:	-0.72:	2.77:	1.96:	19.6:	-0.74:	2.77:	1.39
:	:	DT>2	7275:	-2.16:	3.71:	2.65:	26.5:	-2.17:	3.72:	1.88
:	:	DT>5	7275:	-2.94:	3.84:	2.76:	27.6:	-2.96:	3.87:	1.96
:	:	MatPFA:	7275:	195.14:	6.6:	4.78:	47.8:	-4.98:	6.66:	3.42
:	:	FastMC:	7275:	-1.59:	7.74:	5.52:	55.2:	-1.76:	7.85:	3.96
:	:	PPRGen:	7275:	-0.7:	2.68:	1.91:	19.1:	-0.71:	2.68:	1.35
:	qq500:	PPR	5506:	-1.63:	5.81:	1.65:	26.0:	-1.67:	5.83:	1.17
:	:	DT>2	5506:	-6.52:	20.25:	5.8:	91.8:	-6.52:	20.43:	4.14
:	:	DT>5	5506:	-7.3:	20.36:	5.84:	92.4:	-7.33:	20.57:	4.17
:	:	MatPFA:	6582:	486.76:	21.18:	6.15:	97.3:	-13.36:	21.39:	4.4
:	:	FastMC:	7332:	-8.6:	26.36:	7.59:	119.9:	-9.5:	27.84:	5.68
:	:	PPRGen:	7332:	-1.78:	5.76:	1.64:	25.9:	-1.8:	5.8:	1.16
:	qq1000:	PPR	7246:	-11.86:	18.41:	2.63:	58.9:	-12.06:	18.8:	1.9
:	:	DT>2	7246:	-19.38:	51.57:	7.44:	166.3:	-19.17:	52.44:	5.35
:	:	DT>5	7246:	-20.28:	51.65:	7.46:	166.7:	-20.08:	52.53:	5.36
:	:	FastMC:	7246:	-24.82:	59.46:	8.62:	192.8:	-27.19:	63.86:	6.56
:	:	PPRGen:	7246:	-11.86:	18.38:	2.63:	58.8:	-12.06:	18.77:	1.9
:	ZZ500:	PPR	2639:	-0.29:	3.2:	1.97:	21.2:	0.08:	2.33:	2.55
:	:	DT>2	2639:	-2.19:	6.1:	3.78:	40.6:	-0.86:	2.91:	3.22
:	:	DT>5	2639:	-2.89:	6.18:	3.85:	41.3:	-1.34:	2.97:	3.31
:	:	MatPFA:	2639:	223.12:	28.32:	17.95:	192.5:	-1.89:	4.4:	4.93
:	:	FastMC:	2639:	-2.33:	10.16:	6.31:	67.7:	-1.28:	4.67:	5.19
:	:	PPRGen:	2639:	-0.38:	3.14:	1.93:	20.7:	-0.66:	1.81:	2.0

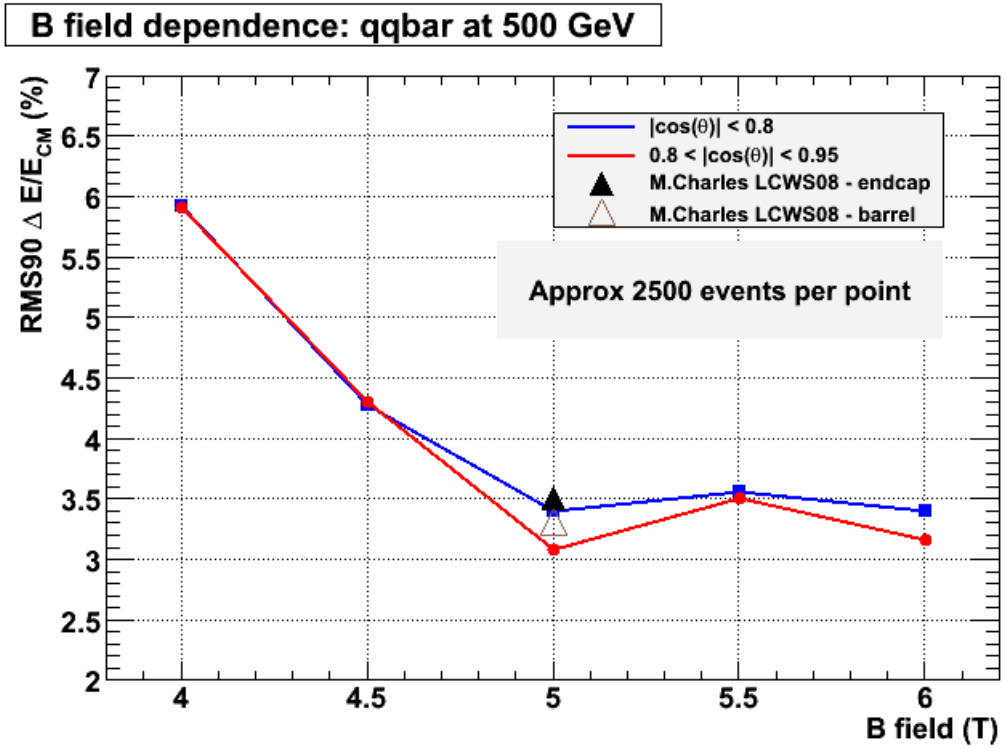
What we're working on

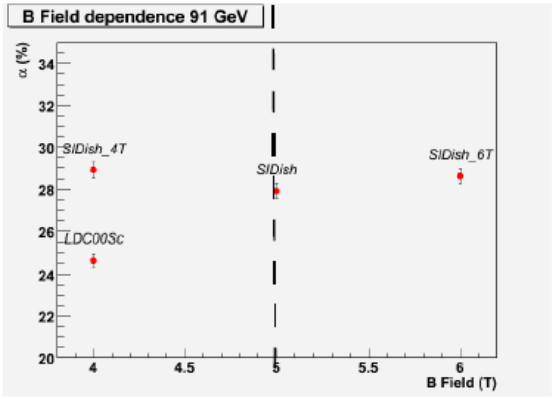
- **Revisit HCAL parameter studies in SiD framework**
  - **Extend to higher energies (500 and 1000 GeV)**
  - **Determine alpha vs. energy for each variant**
  - **Check for any differences with SiDish**
  - **Changes include**
    - `Simulation:` `Mokka → SLIC`
    - `Reconstruction:` `Marlin → org.lcsim`
    - `PFA:` `PandoraPFA → Iowa PFA`
    - `Tracking:` `TPC → All silicon`
    - `Track cheaters → real tracking`
    - `HCAL readout` `Scint/analog → RPC/digital`
    - `HCAL segm.` `3x3 cm → 1x1 cm`
  - **Study single particles too**
    - **Check linearity and resolution for gammas, n's, KL's**
      - **Similar to Norm Graf's studies in sid02_scint**
        - http://ilcagenda.linearcollider.org/materialDisplay.py?contribId=1&materialId=slides&confId=3378

Sid02 variants presently under study

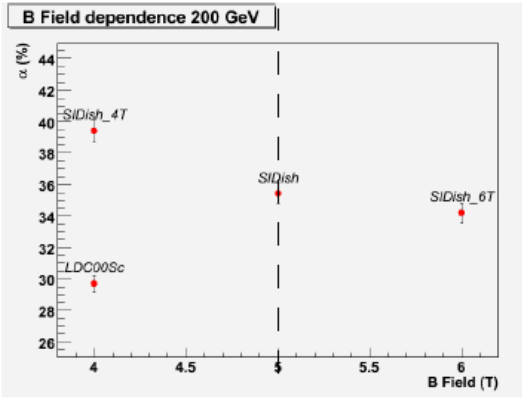
- **Length "stretched" by +10%, +20%**
  - ECAL inner_z
  - Affects ECAL and systems outside it
    - No changes in tracker
- **HCAL depth increased by +10%, +20%**
  - 40 layers → 44, 48 layers
    - Same layer structure
- **B-field**
  - 4, 4.5, 5, 5.5, 6 T
- **HCAL cell size**
  - 5x5 mm^2, 1x1 cm^2, 3x3 cm^2
- **More to come**

B-field variants





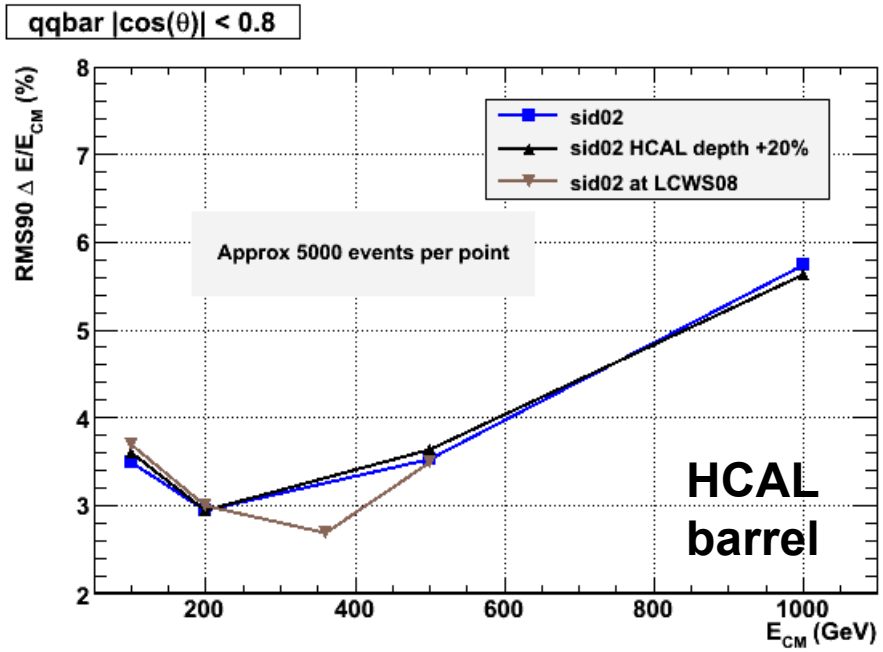
Marcel's "sidish" B-field study at 91 (above) and 200 GeV (below)

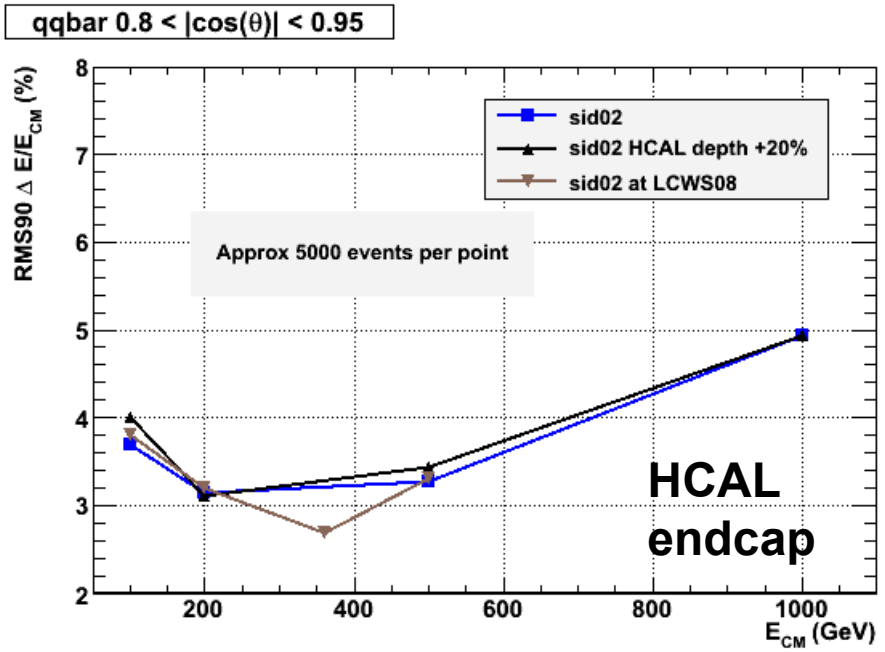


HCAL depth variants

Studied +10% and +20% in HCAL depth

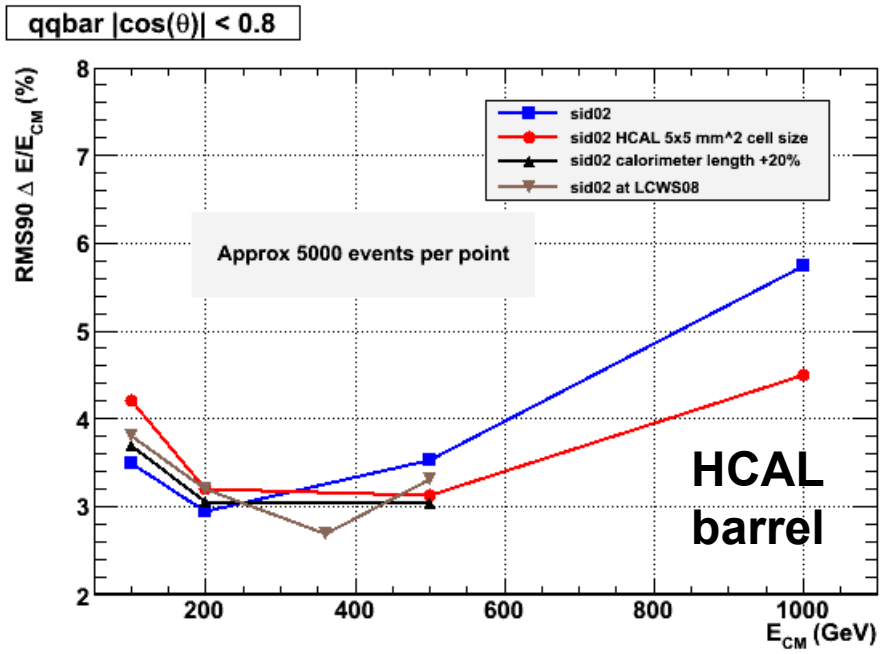
- Retain sid02 cell size and layer structure
- +10% study still in progress

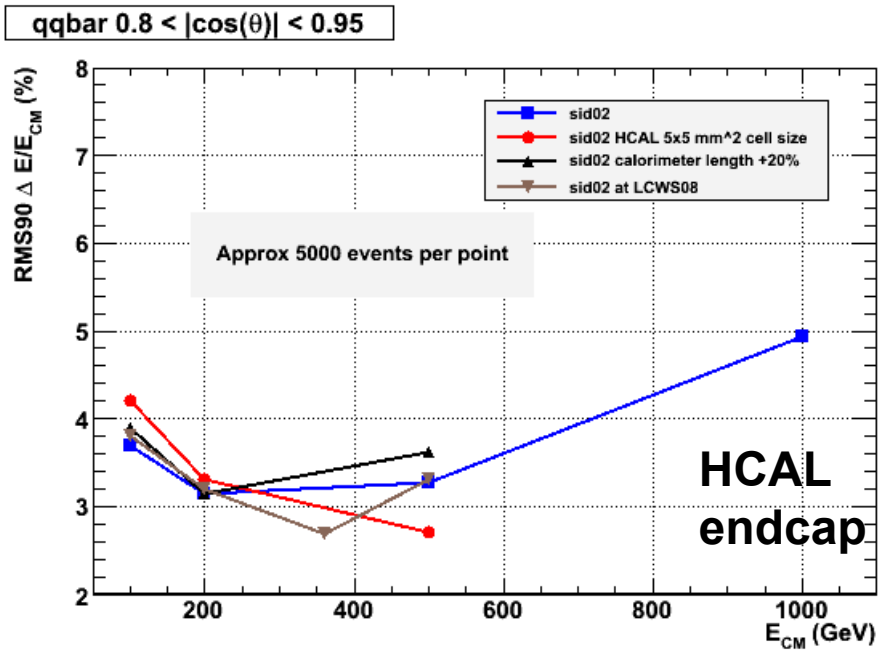




Two more variants

- **Cell size**
  - 5x5 mm^2
- **Length increase**
  - ECAL inner_z +20%





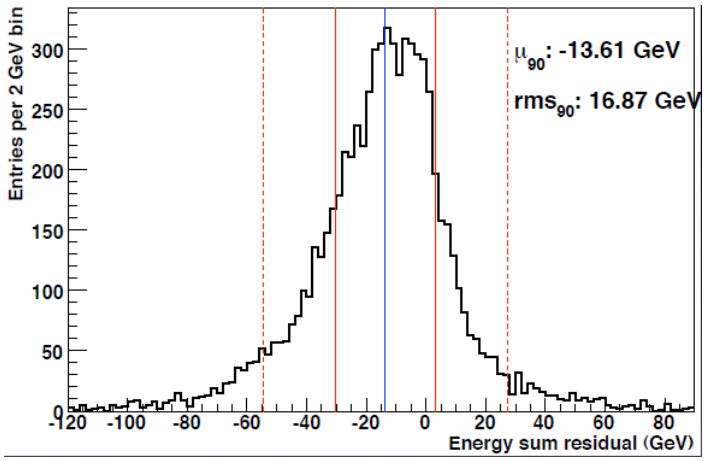
Energy residuals comparison

Double-check our simulation & recon

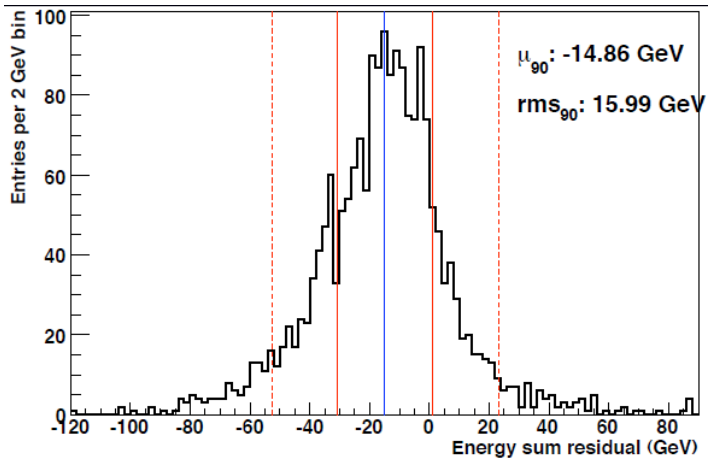
- Compare our sid02 running against "official" sid02 results from LCWS08

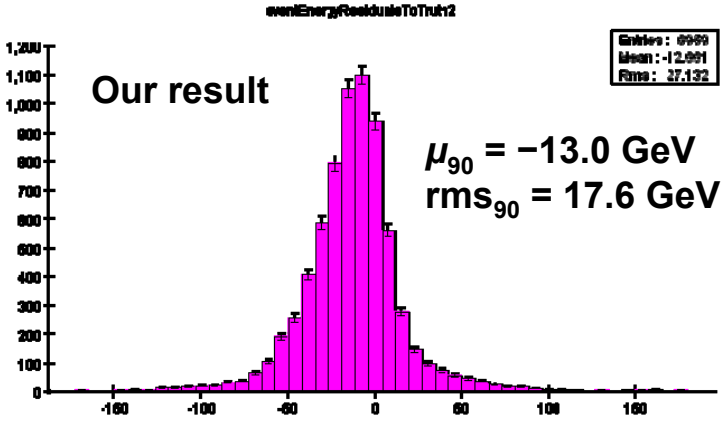
Energy sum residuals at 500 GeV qqbar

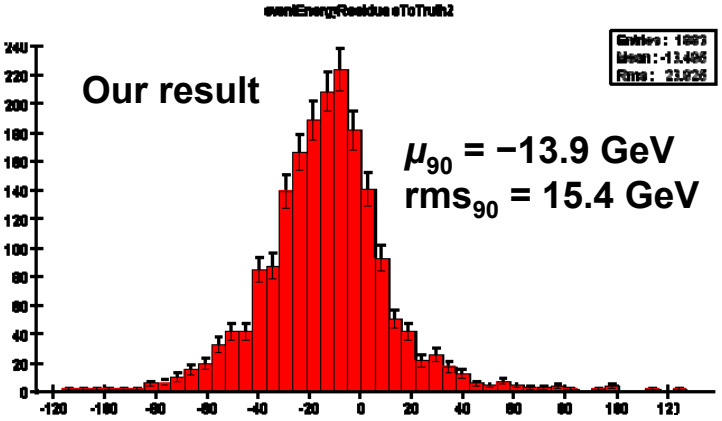
Barrel region



Endcap region







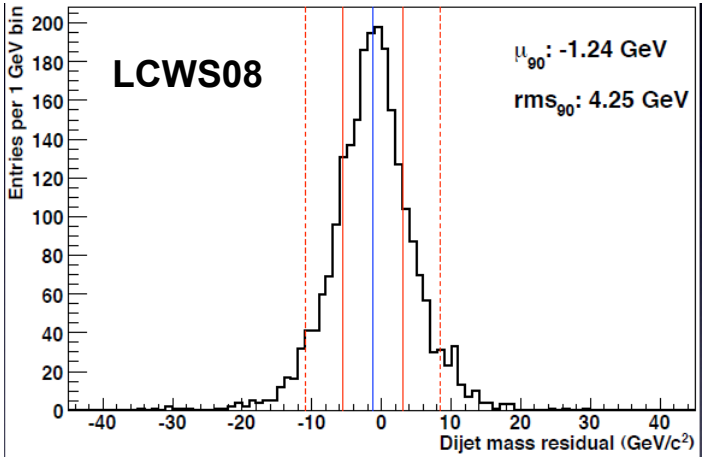
Mass residuals comparison

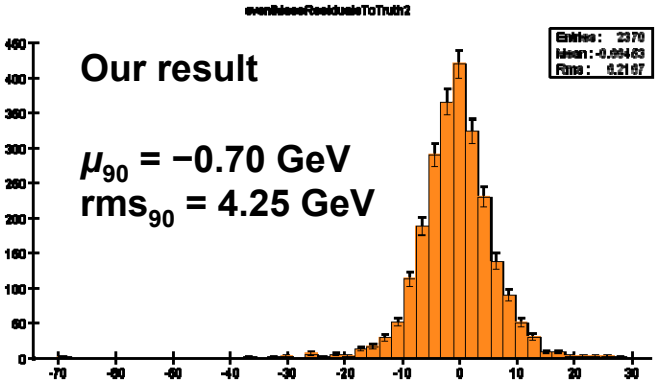
Double-check our simulation & recon

- Compare our sid02 running against "official" sid02 results from LCWS08

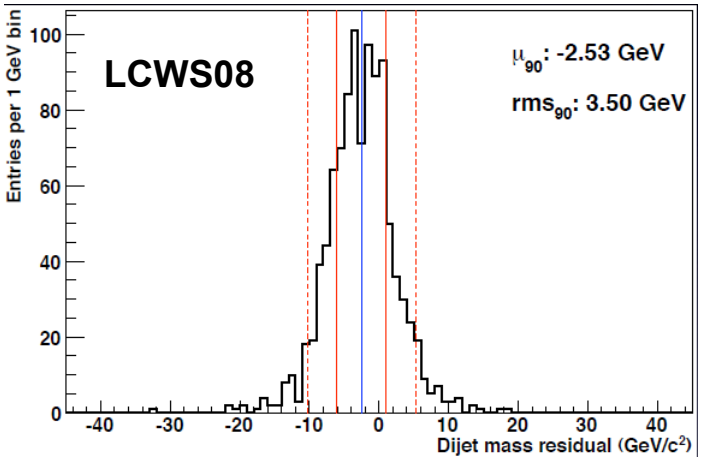
Mass residuals at 500 GeV *ZZ* → *uds* + *vv*bar

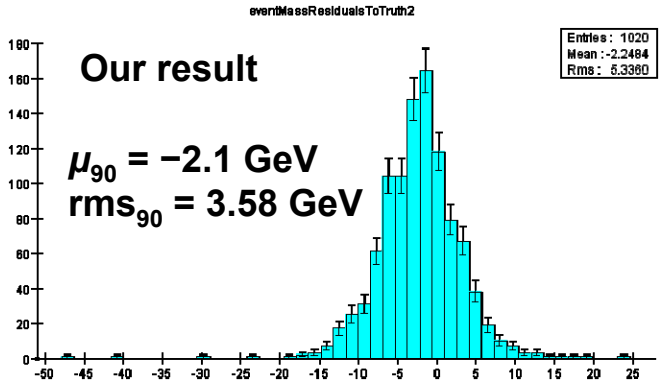
Barrel region





Endcap region





Additional Ideas

- **Remember that the PFA approach is being used outside the context of ILC detectors**
  - **Example: CMS**
    - **Joe Incandela: *"Particle–Flow Event Reconstruction in CMS and Performance for Jets, Taus, and Emiss_T"* http://cms-physics.web.cern.ch/cms-physics/public/PFT-09-001-pas.pdf**
- **It may be useful to keep in touch with folks outside the ILC PFA community as well**
  - **We wonder if it might make sense at some point to hold a PFA workshop addressing both the ILC and non-ILC PFA community**
- **Can other shower characteristics be used to divide showers into categories with different statistical behavior?**
  - **What about the effect of leading particles in showers?**
  - **Can consideration of lateral vs. longitudinal spread provide information?**
  - **Some studies along this line have been done before**
    - **Is it useful to do so again?**
- **Look at effects of HCAL cross-talk/noise using digisim**
- **Choose two or three variants to use as testbed for PFA development**
  - **Get a better idea of how detector and software improvements change energy resolutions**