CALORIMETRY AT DØ
with the French

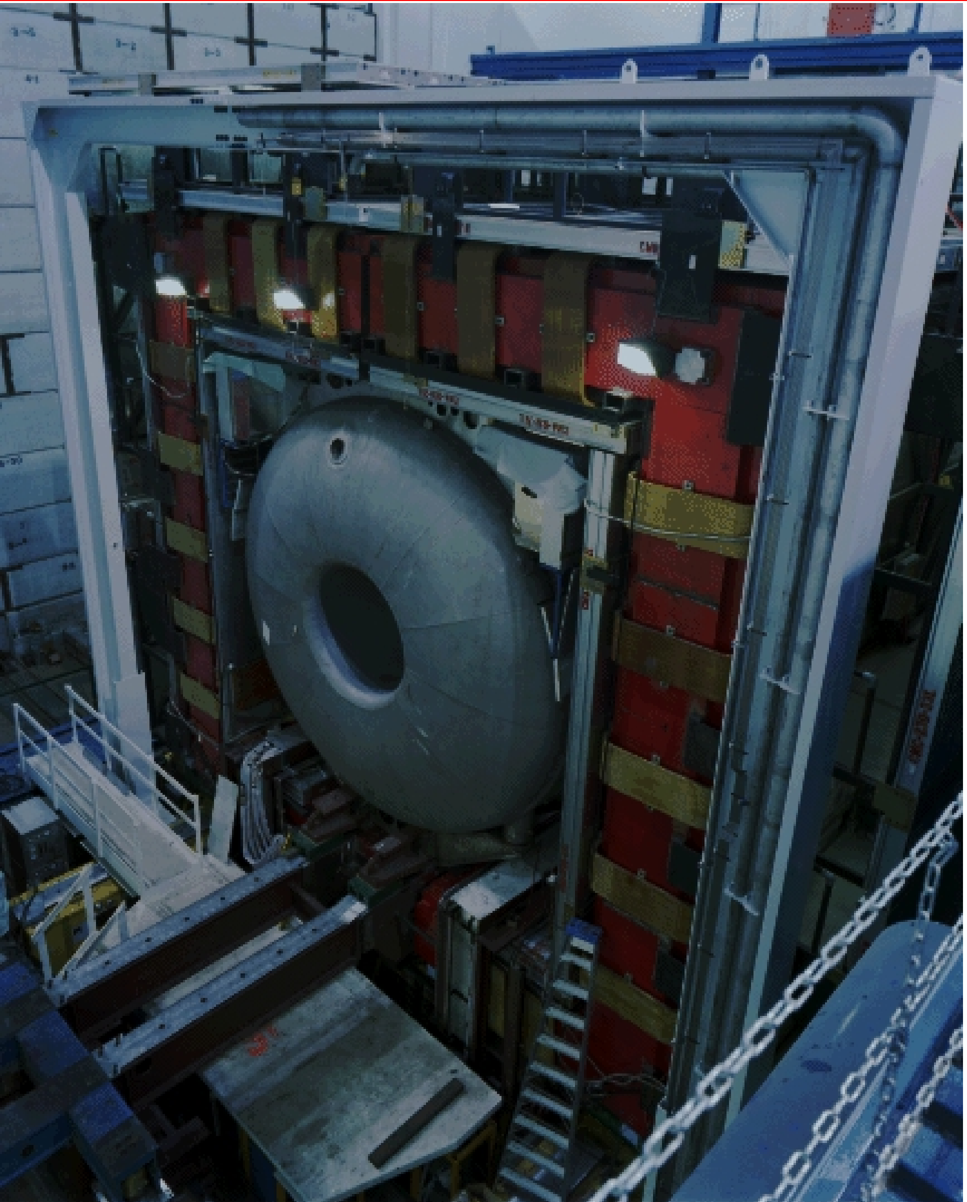
Calorimeter hardware and software contributions for Run II

What it needs to get the thing running…
Highlights and break-troughs

Certainly a biased selection – sorry!

Thanks for help and contributions!

First you need:



a nice calorimeter!

55000 channels Uranium/liquid Argon

Fine segmentation:

5000 readout towers ($\Delta\eta\times\Delta\varphi$ = .1 x .1)
1200 trigger towers ($\Delta\eta\times\Delta\varphi$ = .2 x .2)
4 em layers (2, 2, 7, 10 X0),
“shower-max” (EM3): .05 x .05
4/5 hadronic layers (FH + CH)

Hermetic with full coverage

$|\eta| < 4.2$ ($\theta \approx 2$o), λint > 7.2 (total)

To get it read out:

55k dual FET PreAmps
23k Switch Capacitor Arrays (SCA) with 8M storage cells on
1200 Base Line Subtraction (BLS)-boards
crate controllers with timing jumpers, ADC cards, timing and control cards…

Then you need:

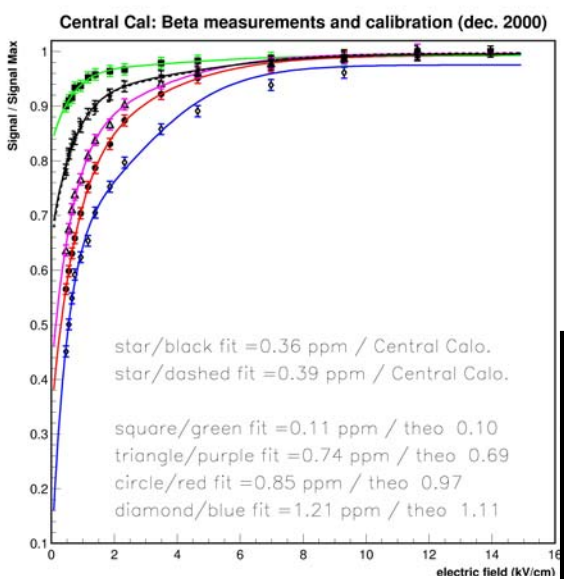
Liquid Argon purity

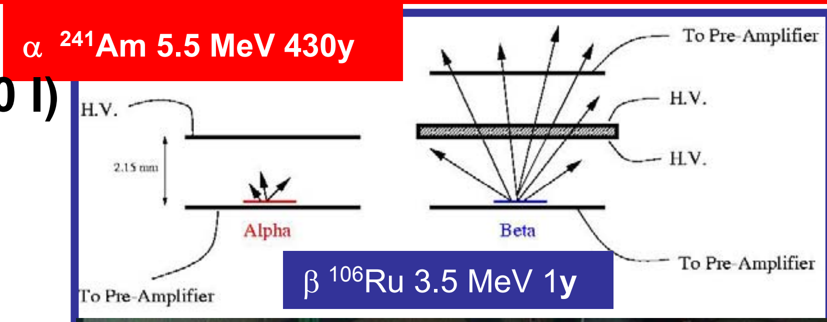
LAr stocked in a dewar for 5 years (~ 75000 l)

Upgrade for Run II

- New Beta source
- New electronics and acquisition
- calibration and complete check of the cryostat

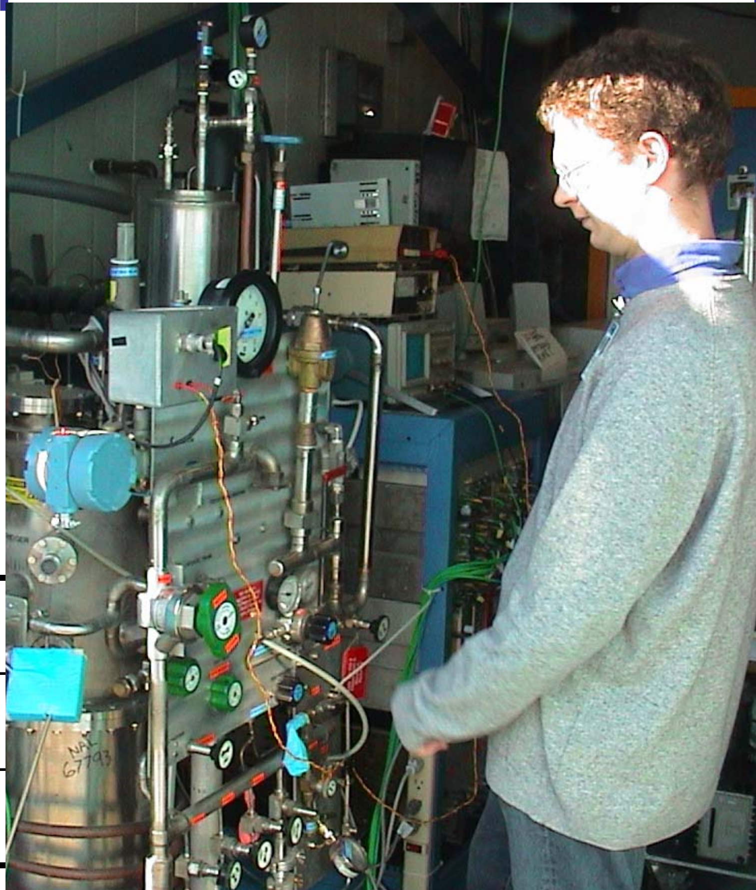
Dewar and Calorimeter measurement





Requirements:
- **purity better 0.5!**
- **error < 0.15 ppm**
- **stable in time**

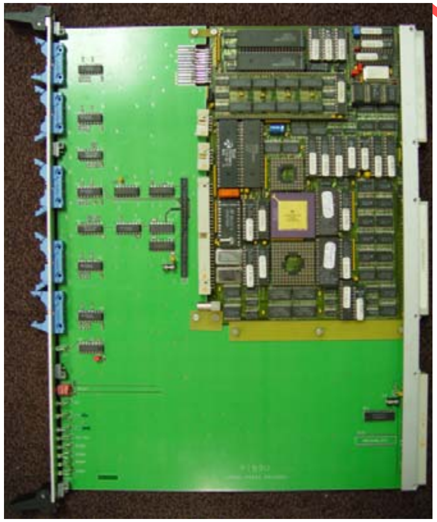
CC	0.07±0.12	0.10±0.09
ECN	0.11±0.12	0.09±0.09
ECS	0.17±0.12	0.14±0.10

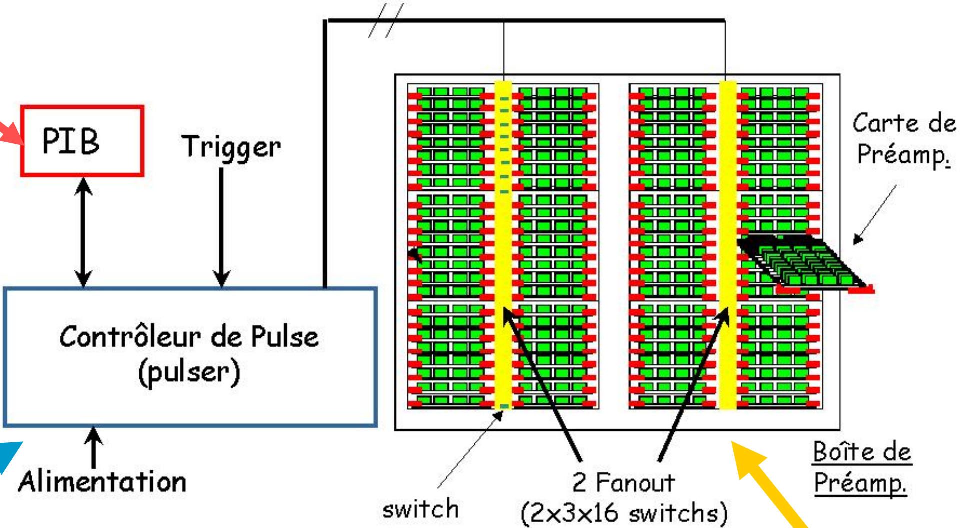


Online calibration

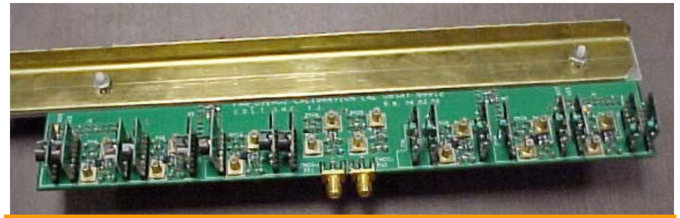
- precision on linearity of the currents < 0.1%
- principal uncertainty: parasitic capacities

Pulser Interface Board: automatic configuration



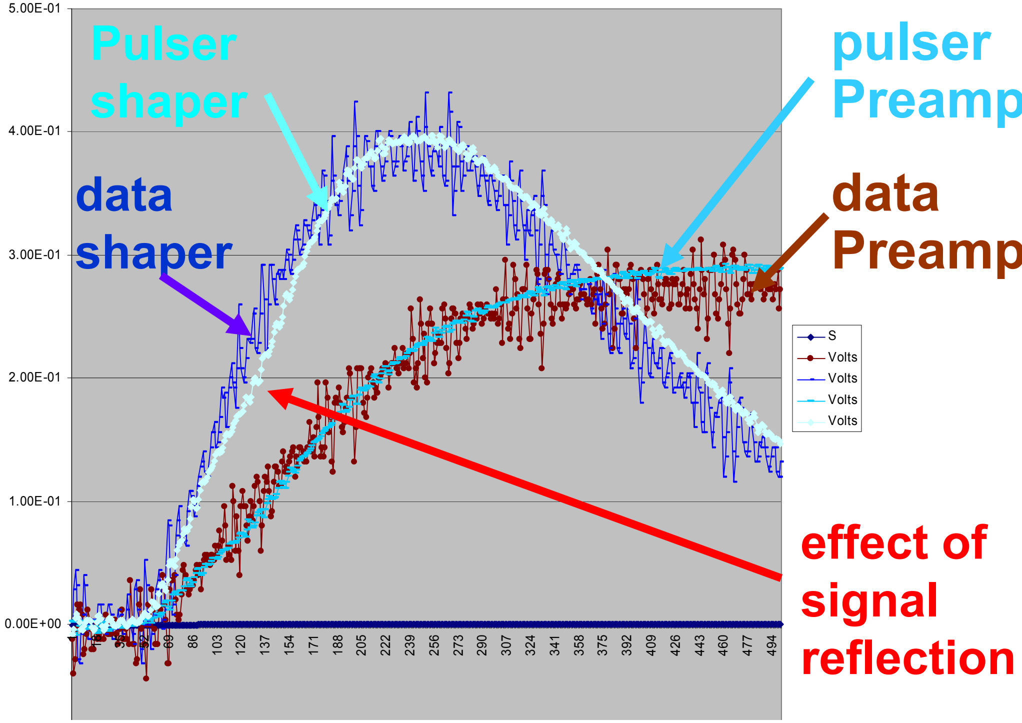


12 “Pulsers” deliver continuous current $\propto$ pulse height
Command signal determines pulse start

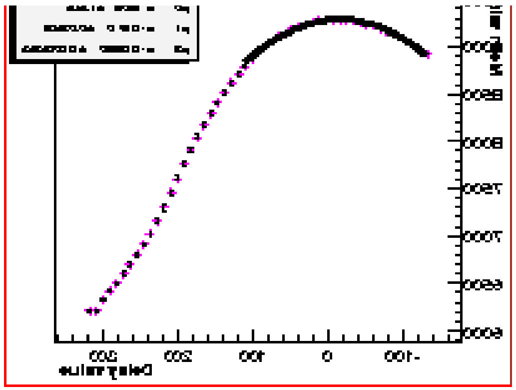


On 6 active fan-outs per pulser , 16 switches open on pulse start to form the pulse

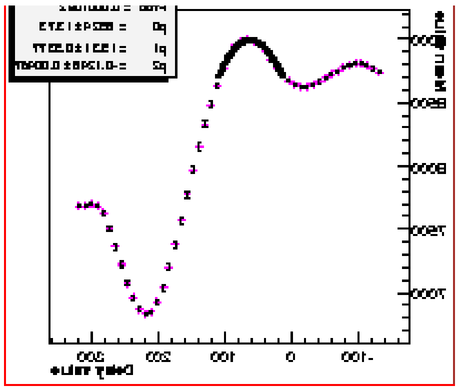
Understanding pulses



em channels:



hadronic channels :



Systematic effects can render the establishment of the calibration somewhat more difficult :

Pulse reflection on calorimeter cell has a big effect on hadronic pulse shape

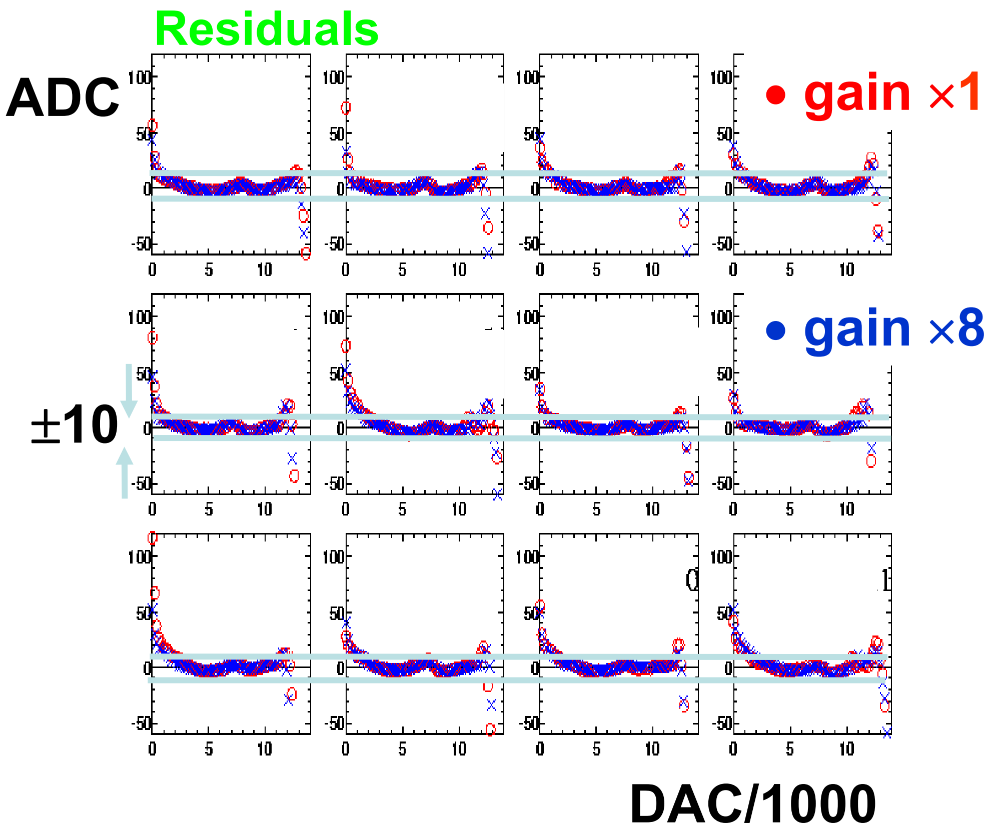
➔ trying to understand the pulses with

- Reflection measurements
- Waveform measurements
- Comparison of measured pulse shape from data and pulser

➔Simulation

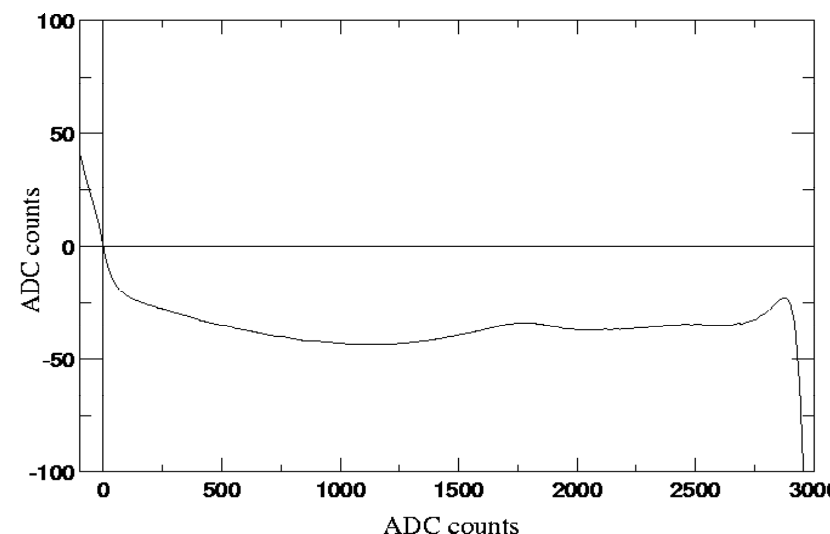
Comparison of measured pulse shape and corresponding ADC counts allowed to pin down the “resistor inversion” and its scaling factor on first W-peak!

Non-linearity



Saturation effects in SCA cells produced a non linearity in the energy reconstruction

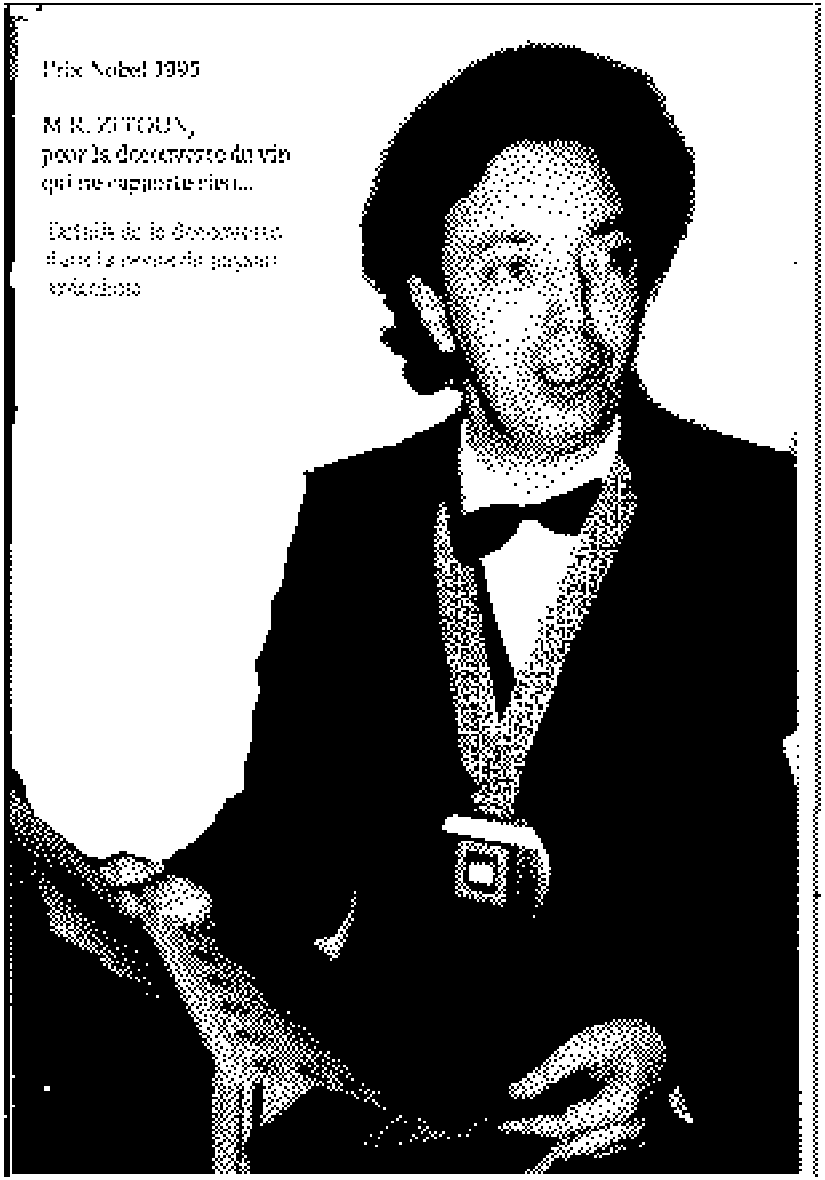
- Comparison of residuals of a linear fit after appropriate scaling for gain ×1 and ×8
- below ±10 ADC counts (<0.3%) above ~2 GeV
- non linearity similar for all channels



- ADC to energy conversion with an universal function for SCA non linearity

⇒ residuals better than +/-5 ADC counts on the whole range for both gains

also indispensable!



φ-intercalibration

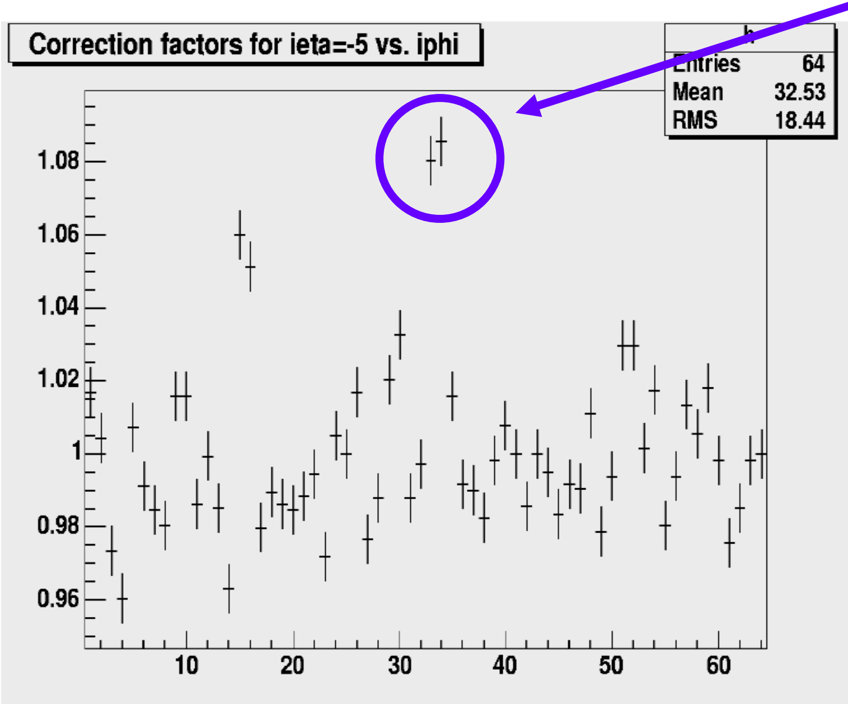
Electronics calibration is not sensitive in variations on the calorimeter cells

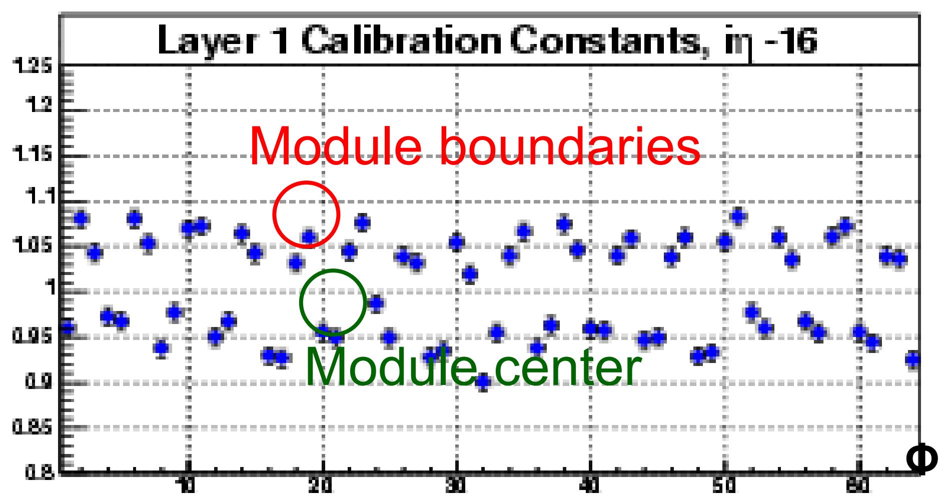
Beams are not polarized, therefore the energy flow has no azimuthal dependence
➔ equalize the energy response in one η-ring (depending on cell depth)

Difficulty: trigger should not bias the sample ➔ low L1 trigger threshold; yet take enough data ➔ “parasitic mode”

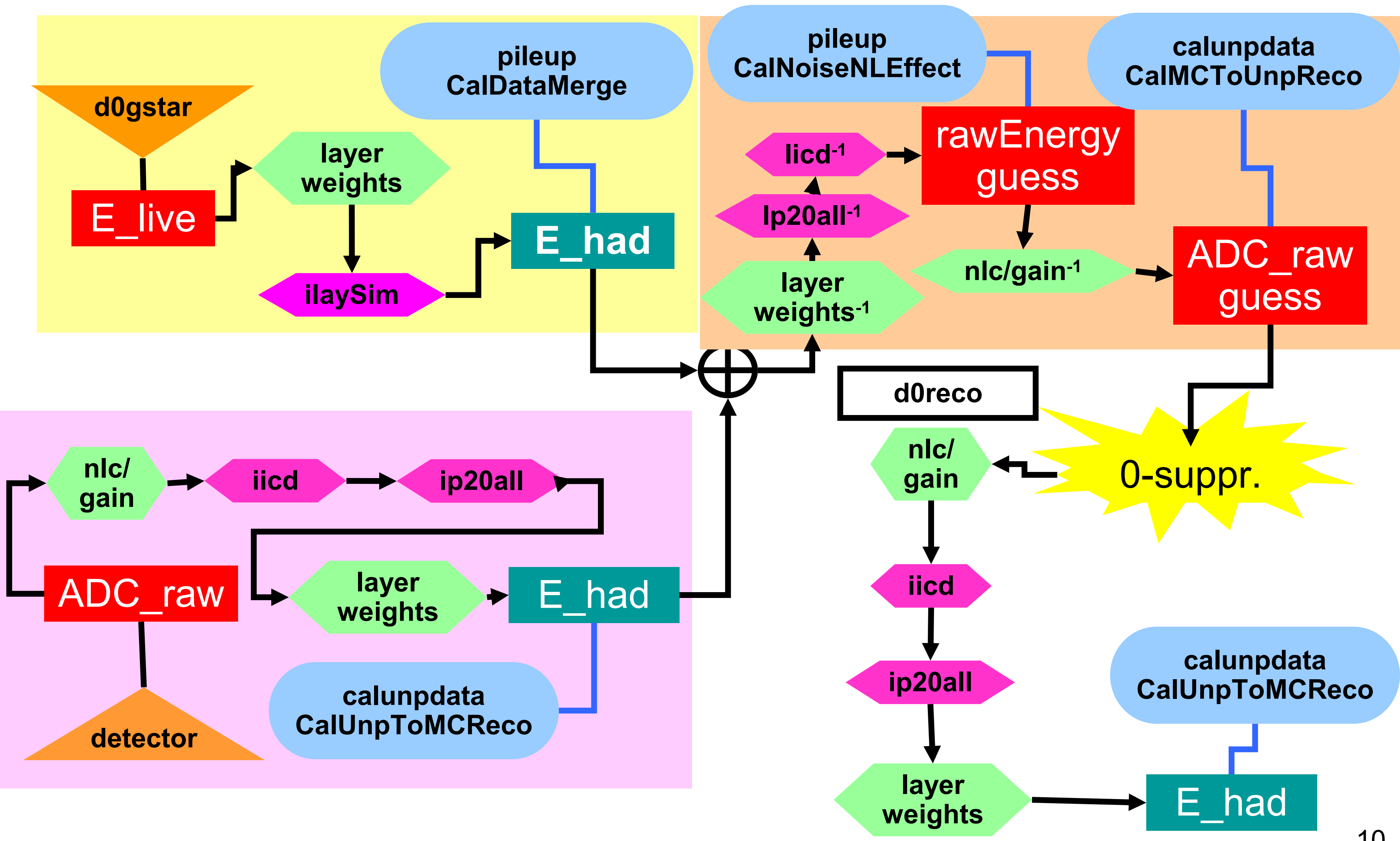
Also in hadronic calorimeter and ICD!

Module 17 dropped during the calorimeter construction in mid 1980’s ➔ stable response over decades!





Then: reconstruction and simulation!

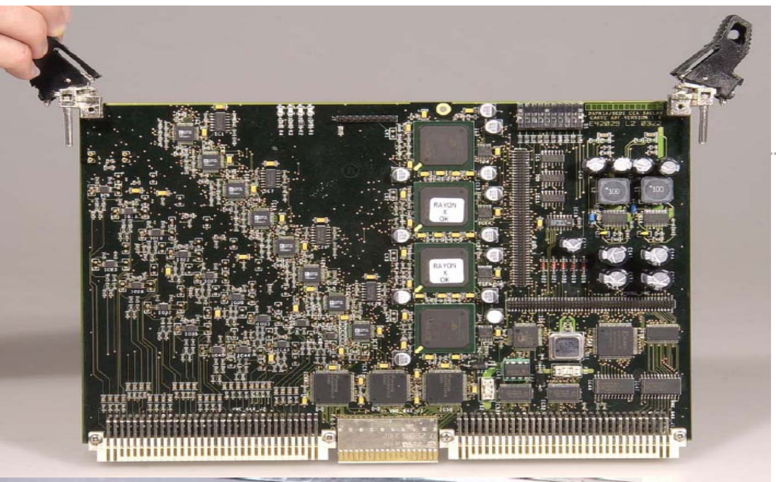


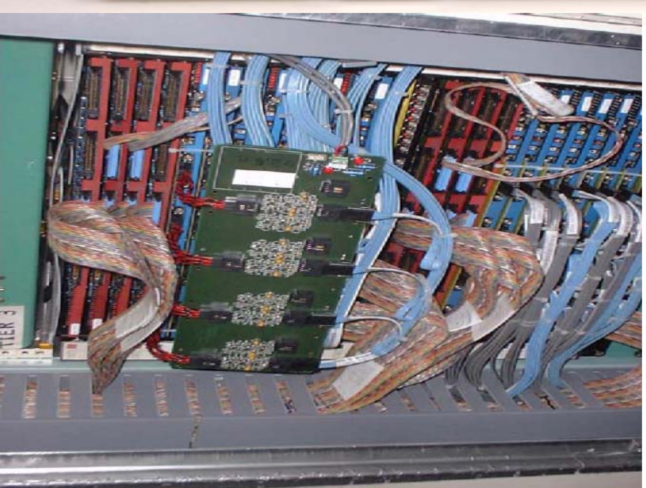
getting the events!

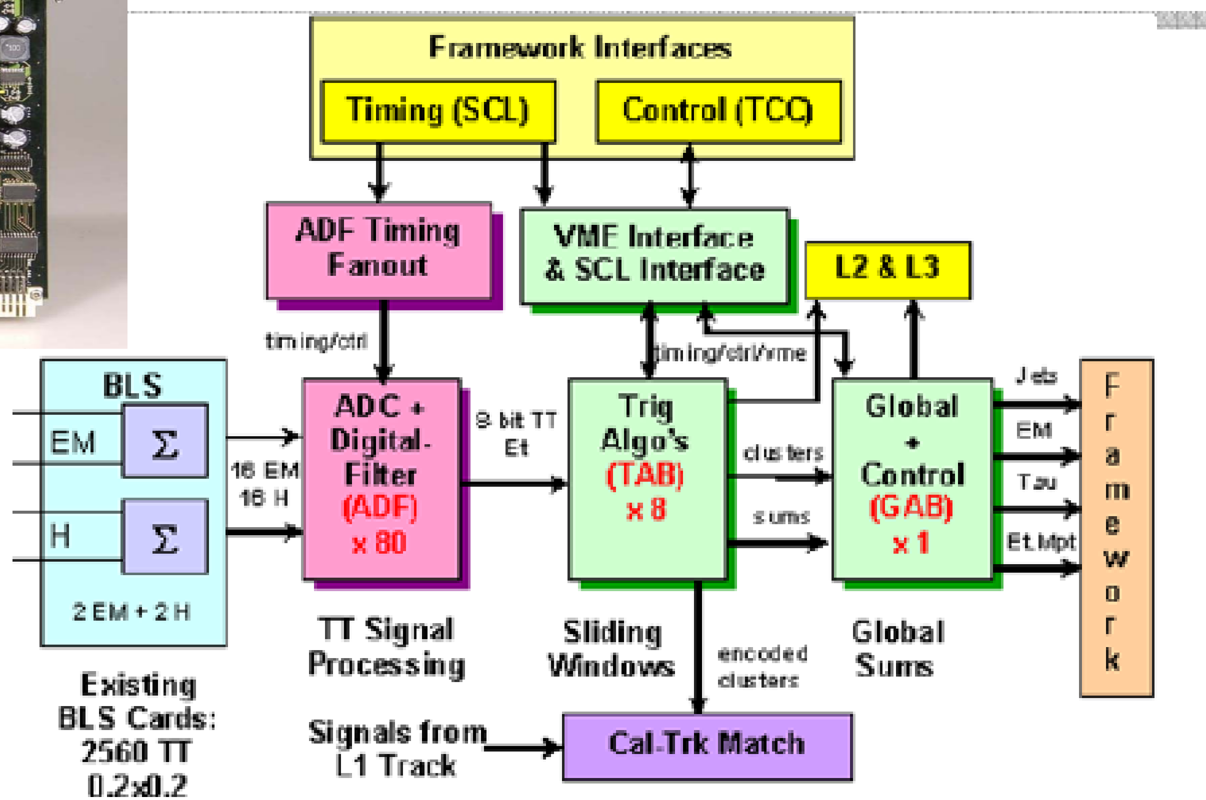
L1 CAL trigger upgrade

- allow for 132ns bunch x-ing: digital filtering

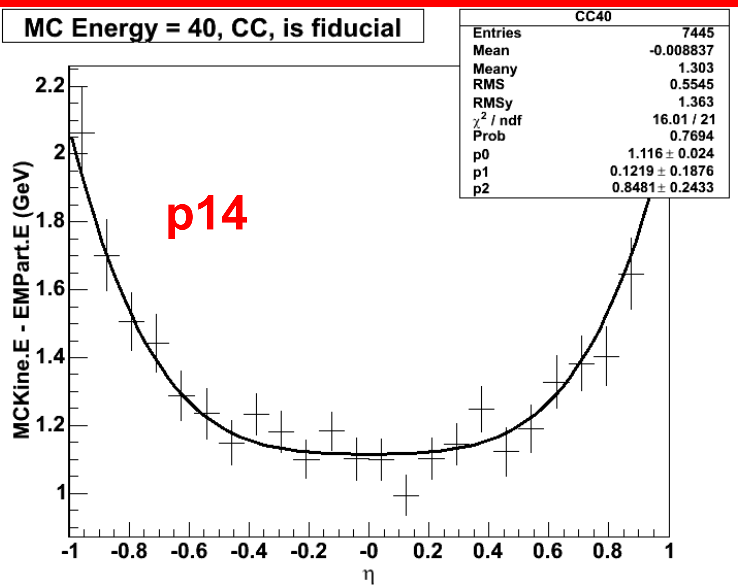
- Improve resolution and turn on curves: sliding window

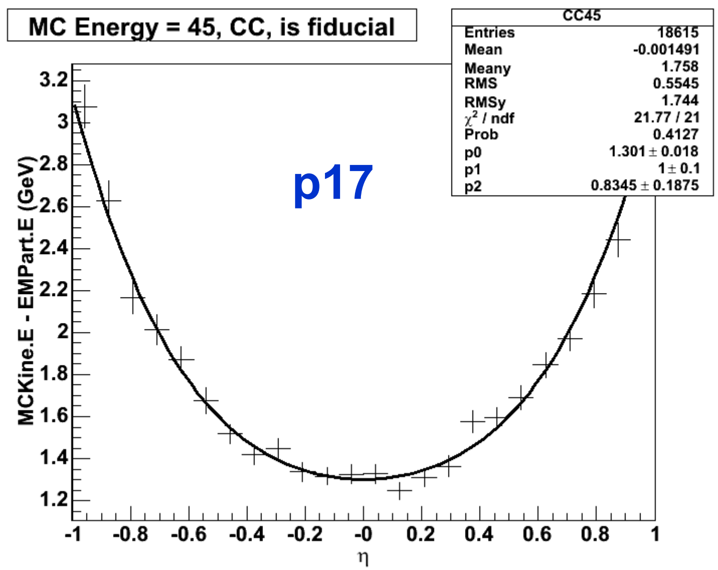






«geometric » corrections

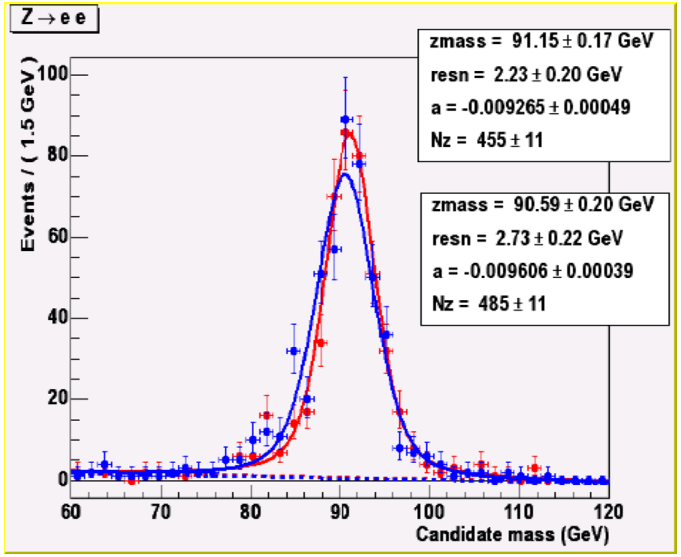




Correction derived from Monte Carlo

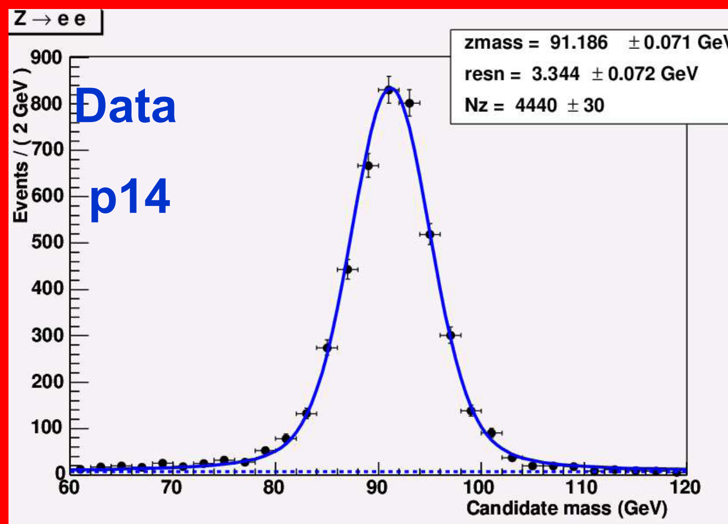
- put reconstructed energy to “particle energy”
- determined as function of η and energy

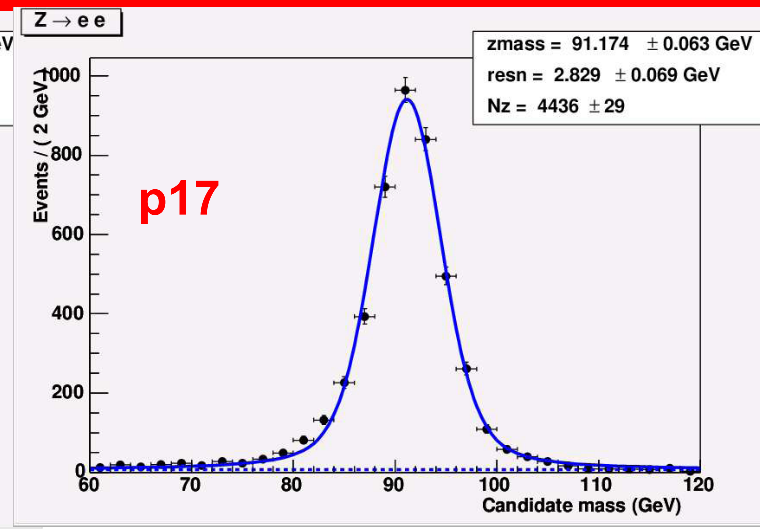
➔ increase with improved dead material description in p17 Monte Carlo – decrease of Z-resolution!

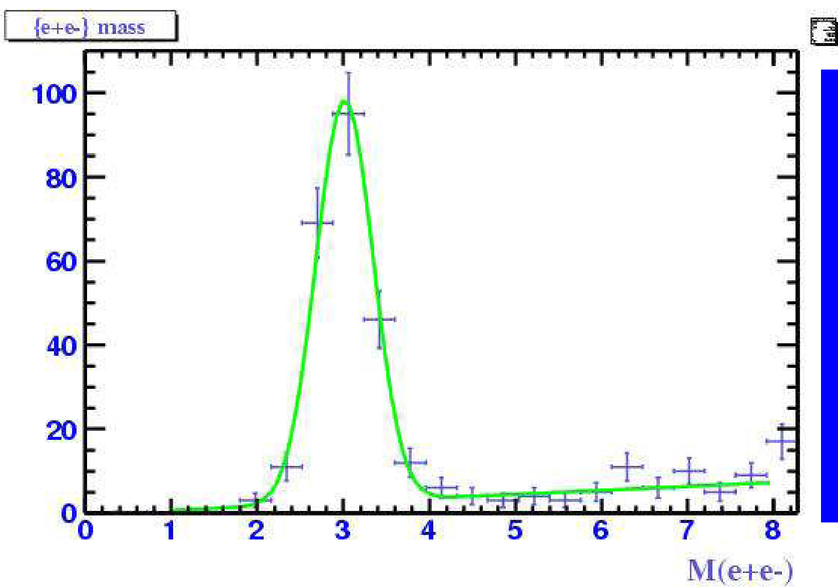


…a long way not only to the Z

Taking into account all calibrations for the p17 reconstruction improves resolution by 15%



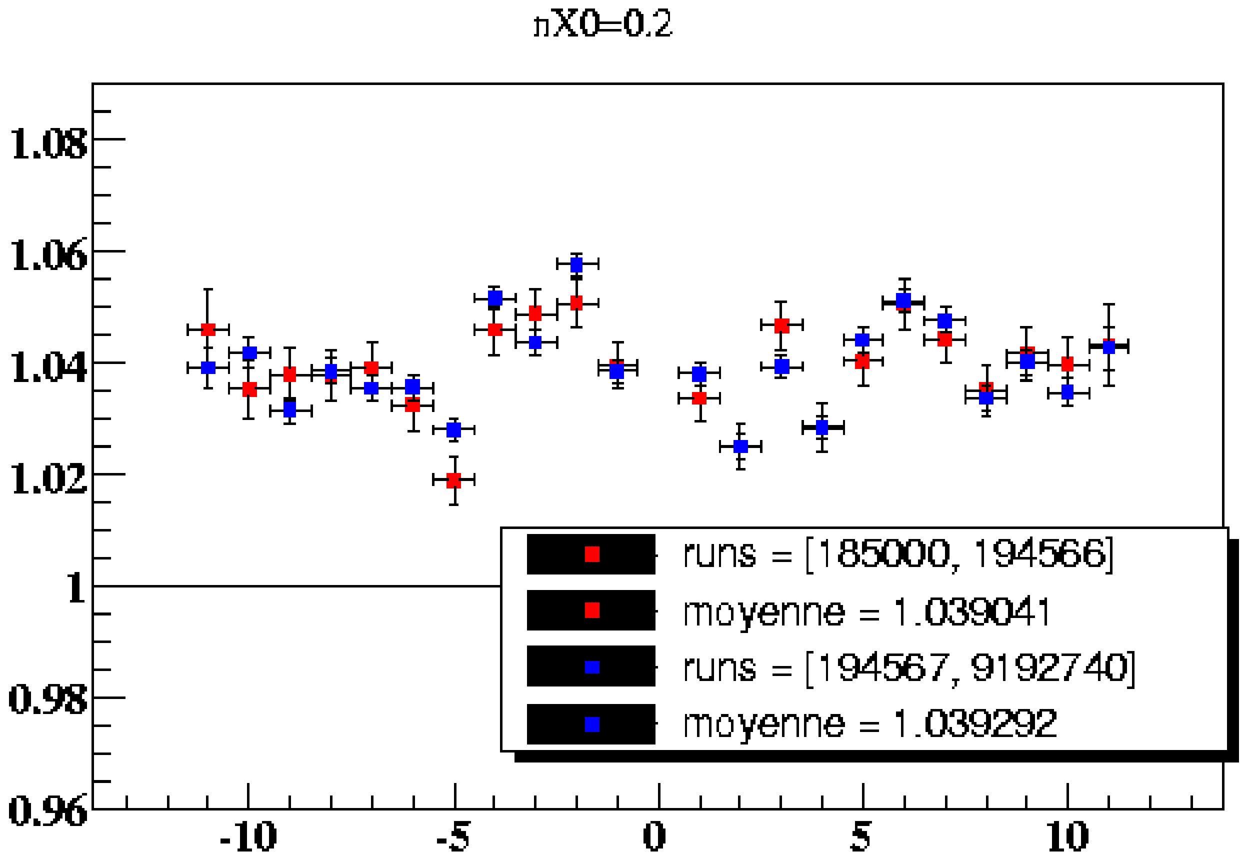




Reconstruction of the J/Ψ using the « road method » and track based trigger :

- **extrapolating tracks in the calorimeter**
- **cells crossed and neighbors belong to the electron**
- **developed also for soft-electron b/c tagging**

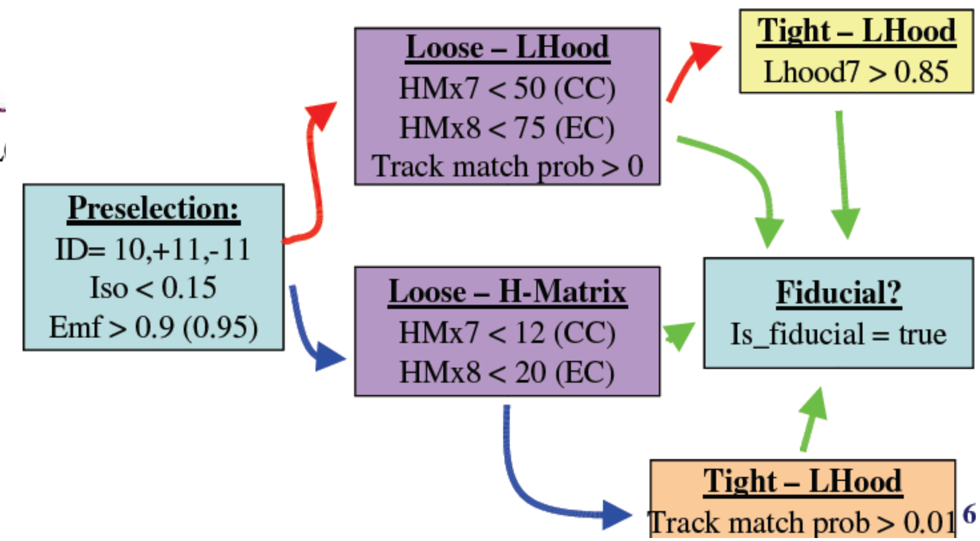
once you have it, it stays!



Z calibration for two run periods over one year

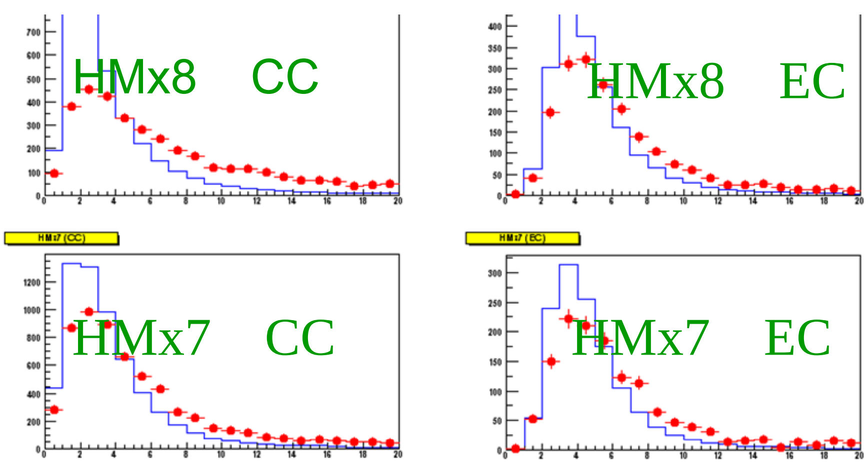
In RunII a remains stable!

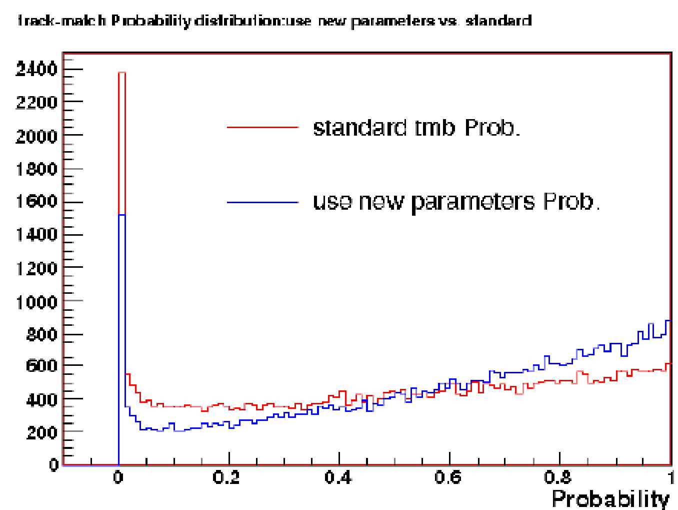
Em-id: H-matrix etc.



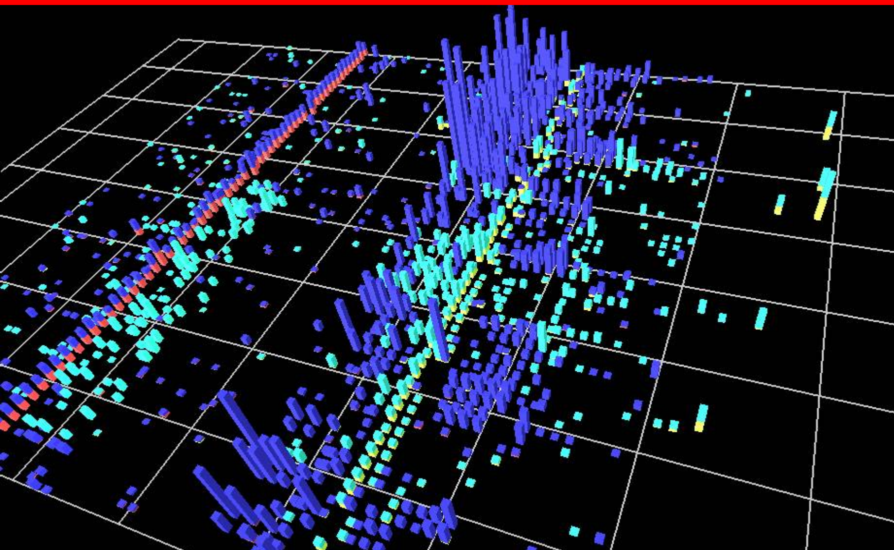
Identification of isolated em-clusters based on shower shapes:

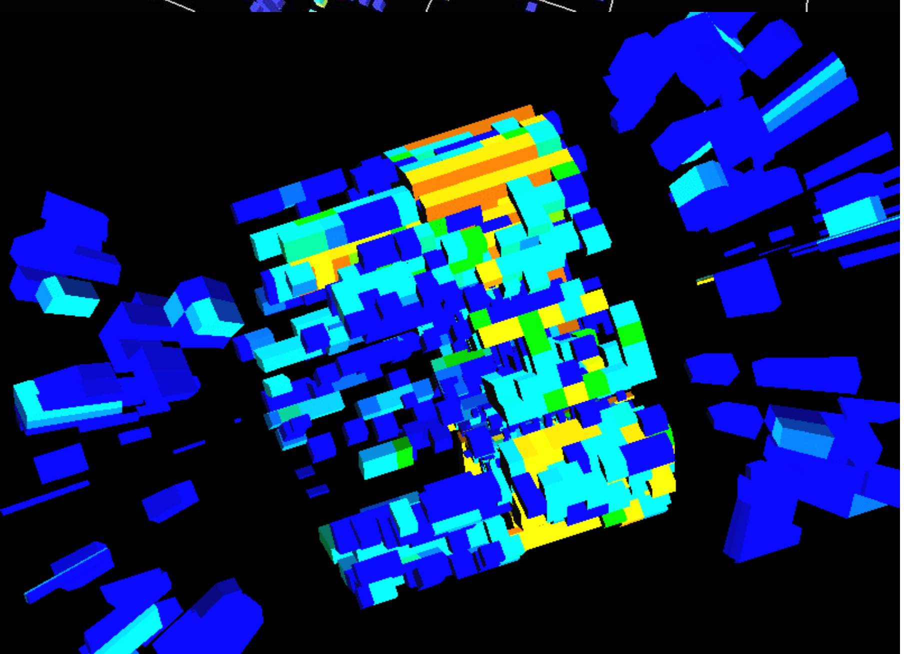
- H-matrix based on 7/8 variables built from energy deposits in em-layers
- For electrons, track cluster match is required in addition
- CPS calibrated





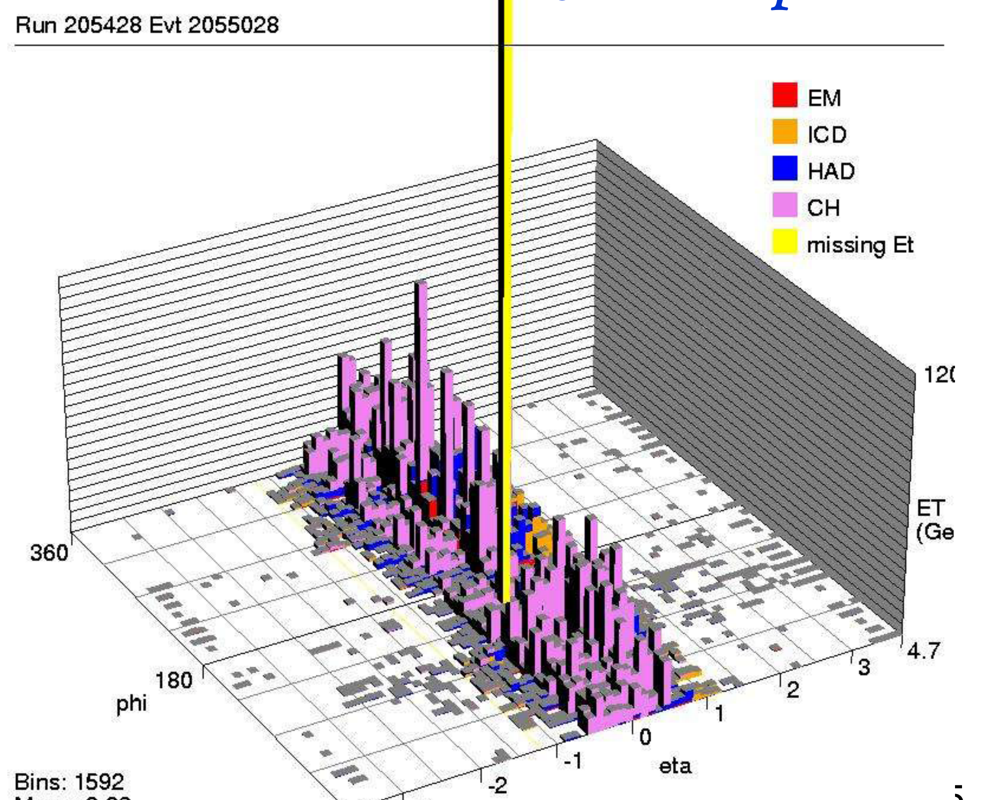
Noise!



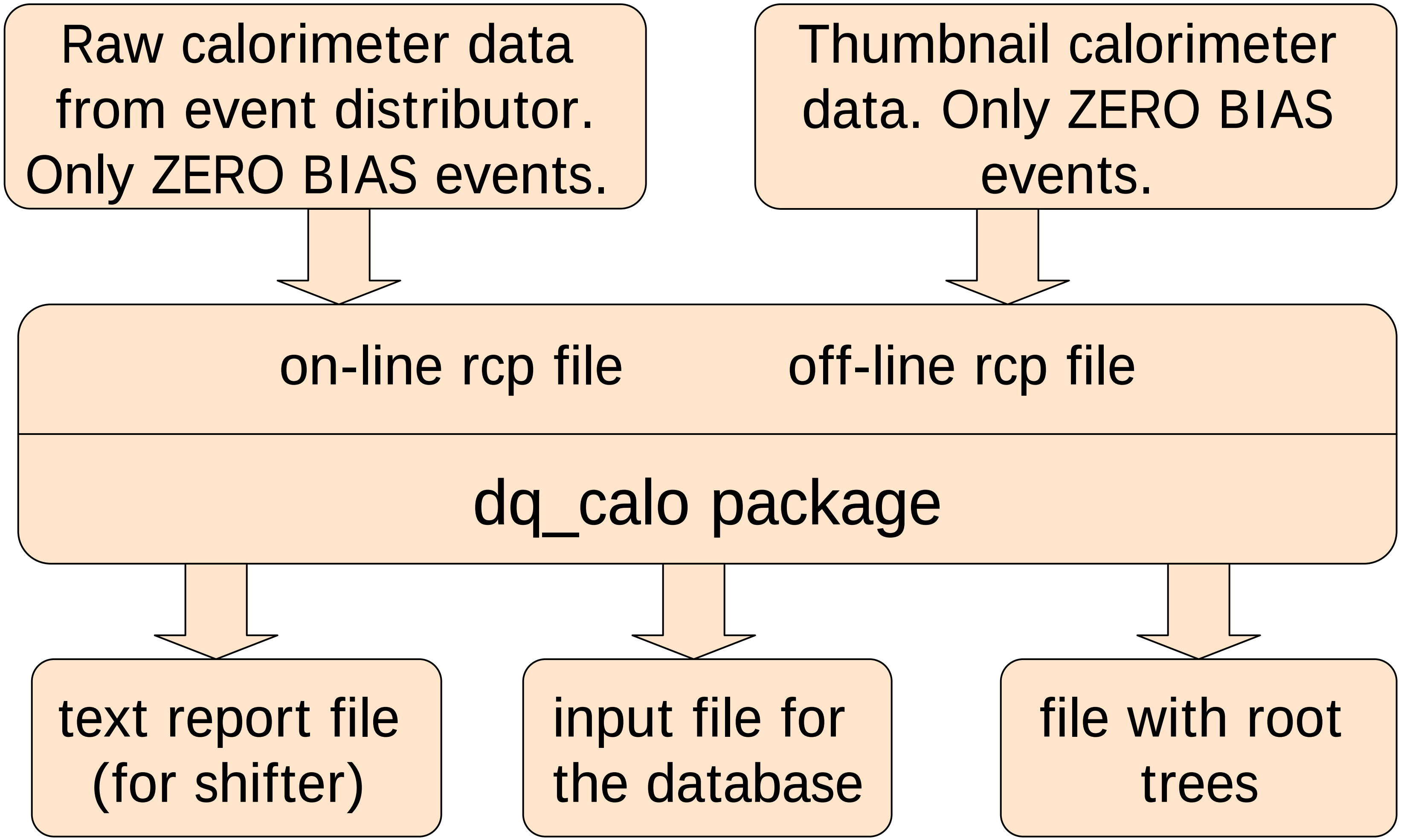


Ring of Fire
Noon Noise
Purple Haze

But also:
Energy sharing
Tower 2
Cable swap



Data quality control

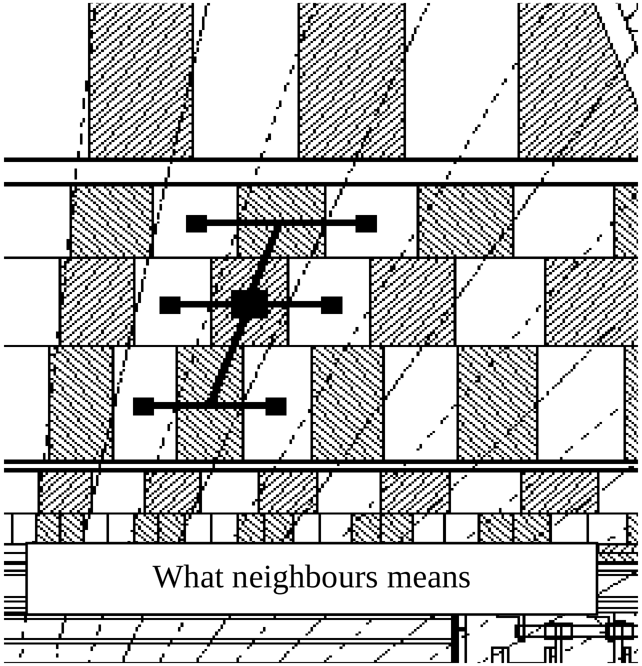


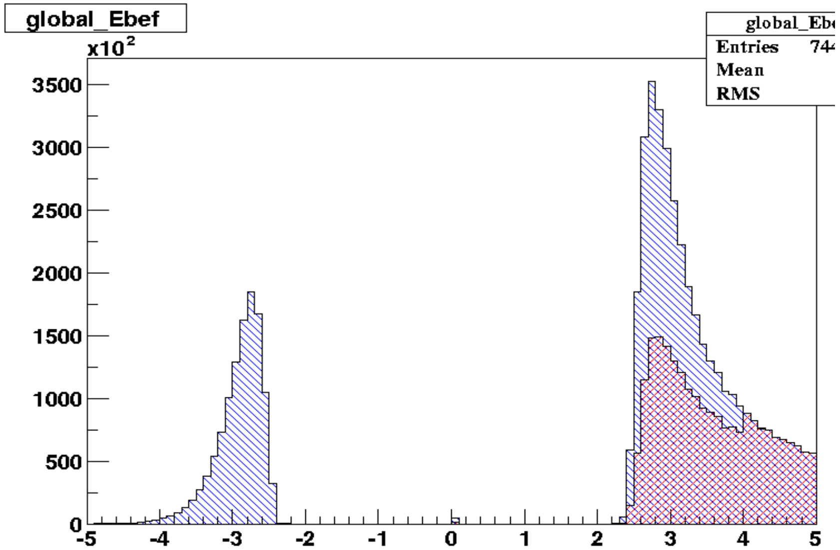
Nada and Tea for Two

Standard noise suppression based on pedestal measurement :
1.5σ online suppression and 2.5σ offline suppression

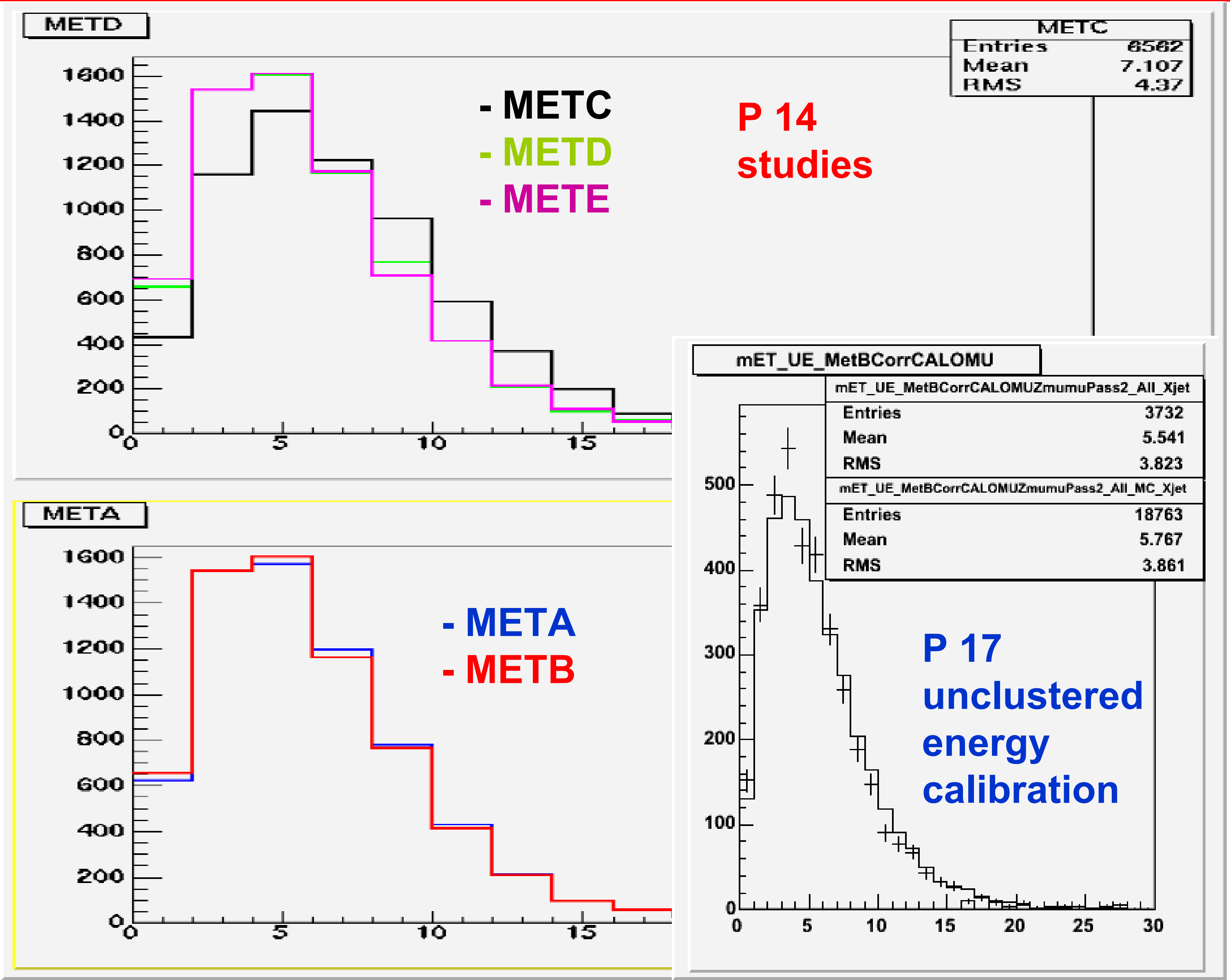
NADA:
searching for isolated cells above threshold
⇒ Good efficiency (>90%), with low mis-id (<1%)

T42:
- **Topology dependent noise suppression keeping only cells > 4 σ and their direct neighbors**





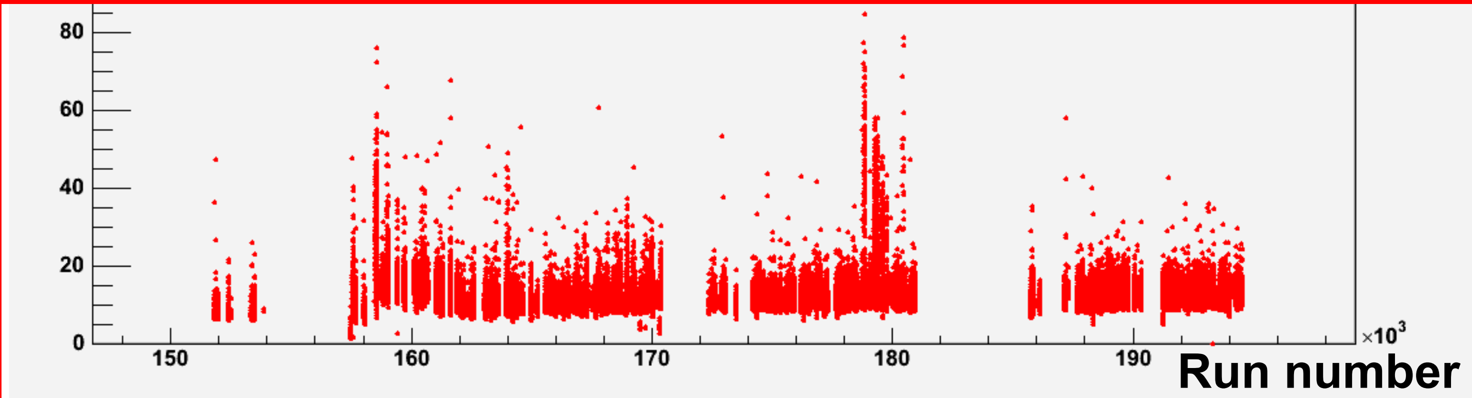
What MET would you like?

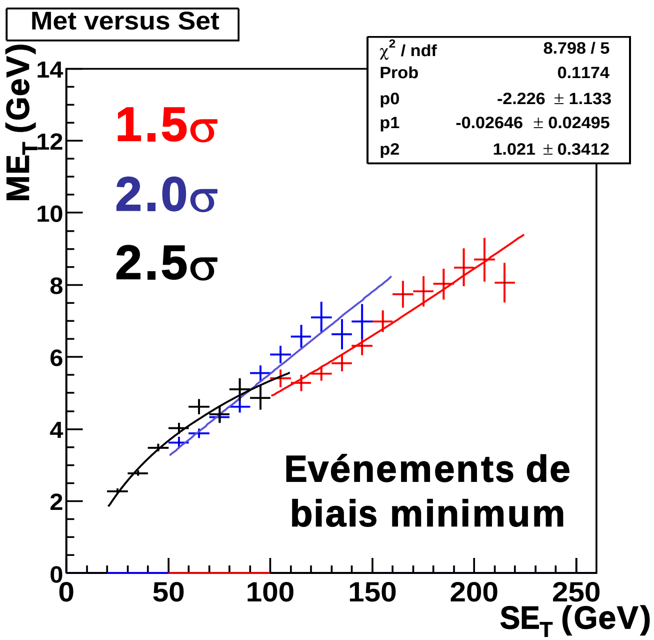


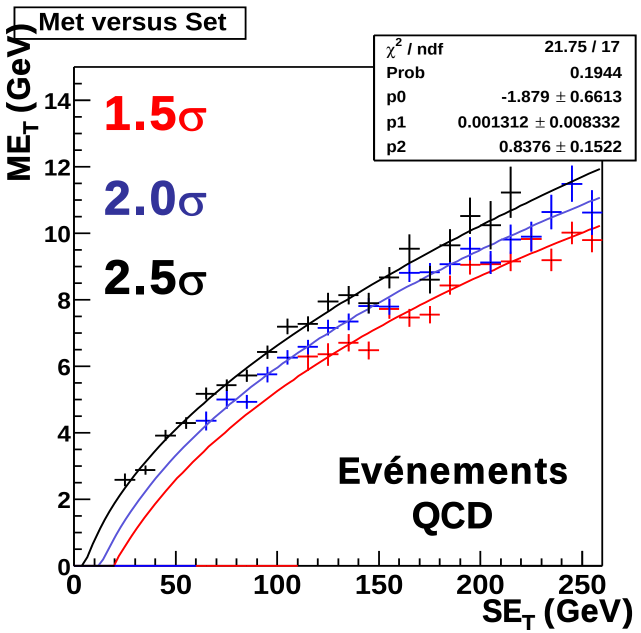
Missing E_T is in principle simple, but how to choose the calorimeter objects and and calibrate them, treate noisy parts of the calorimeter, and calibrate unclustered energy

Using MET

MET has been a very useful tool for the Run selection and Data monitoring!





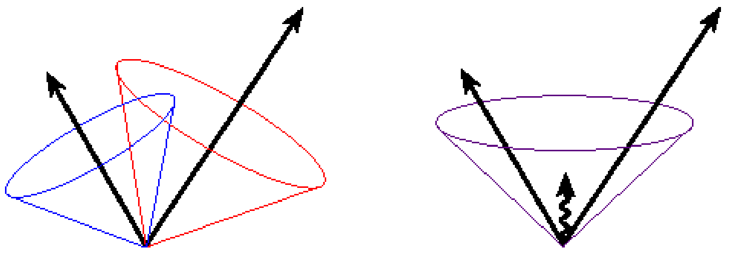


And MET has been used to study the 0-suppression threshold

Jet id

Define a jet algorithm -

- **Infrared safe**
- **Split and merge strategy**
- **Determine thresholds**
- **Define what a good jet means!**



The new jet ID cuts for p17 data are:
A jet passes the new maximal CHF cuts if:

- it has $CHF < 0.4$, or,
- it has $CHF < 0.6$ and $8.5 < |\eta_{det}| < 12.5$ (in the ECMH) and $n90 < 20$, or,
- it has $CHF < 0.44$ and $|\eta| < 0.8$ (central), or,
- it has $CHF < 0.46$ and $1.5 < |\eta| < 2.5$ (end cap excluding forward regions).

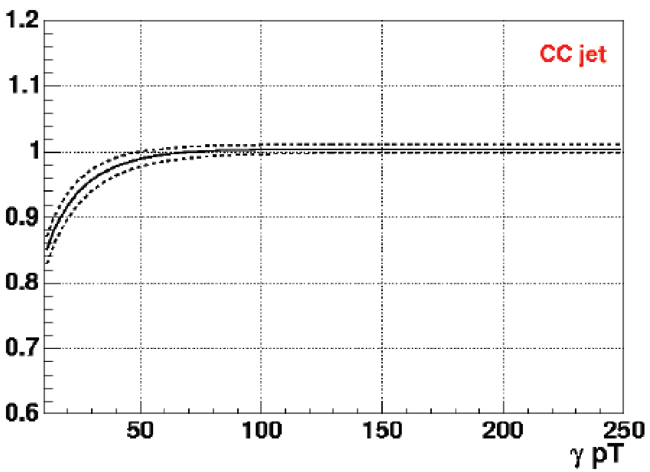
A jet passes the new minimal EMF cuts if:

- it has $EMF > 0.05$, or,
- it has $1.3 > ||\eta_{det}| - 12.5| + \max(0, 40 \times (\sigma_\eta - 0.1))$ (in the No EM Gap).
- it has $EMF > 0.03$ and $11.0 < |\eta_{det}| < 14.0$ (in the No EM Gap), or,
- it has $EMF > 0.04$ and $2.5 < |\eta|$ (forward).

A jet passes the new minimal $L1_{ratio}$ cuts if:

- it has $L1_{ratio} > 0.5$, or,
- it has $L1_{ratio} > 0.35$ and $p_T < 15$ and $1.4 < |\eta|$ (end cap), or,
- it has $L1_{ratio} > 0.1$ and $p_T < 15$ and $3.0 < |\eta|$ (forward), or,
- it has $L1_{ratio} > 0.2$ and $p_T >= 15$ and $3.0 < |\eta|$ (forward).

where $L1_{ratio}$ is calculated excluding the massless gap energies from the precision (and L1) sum.

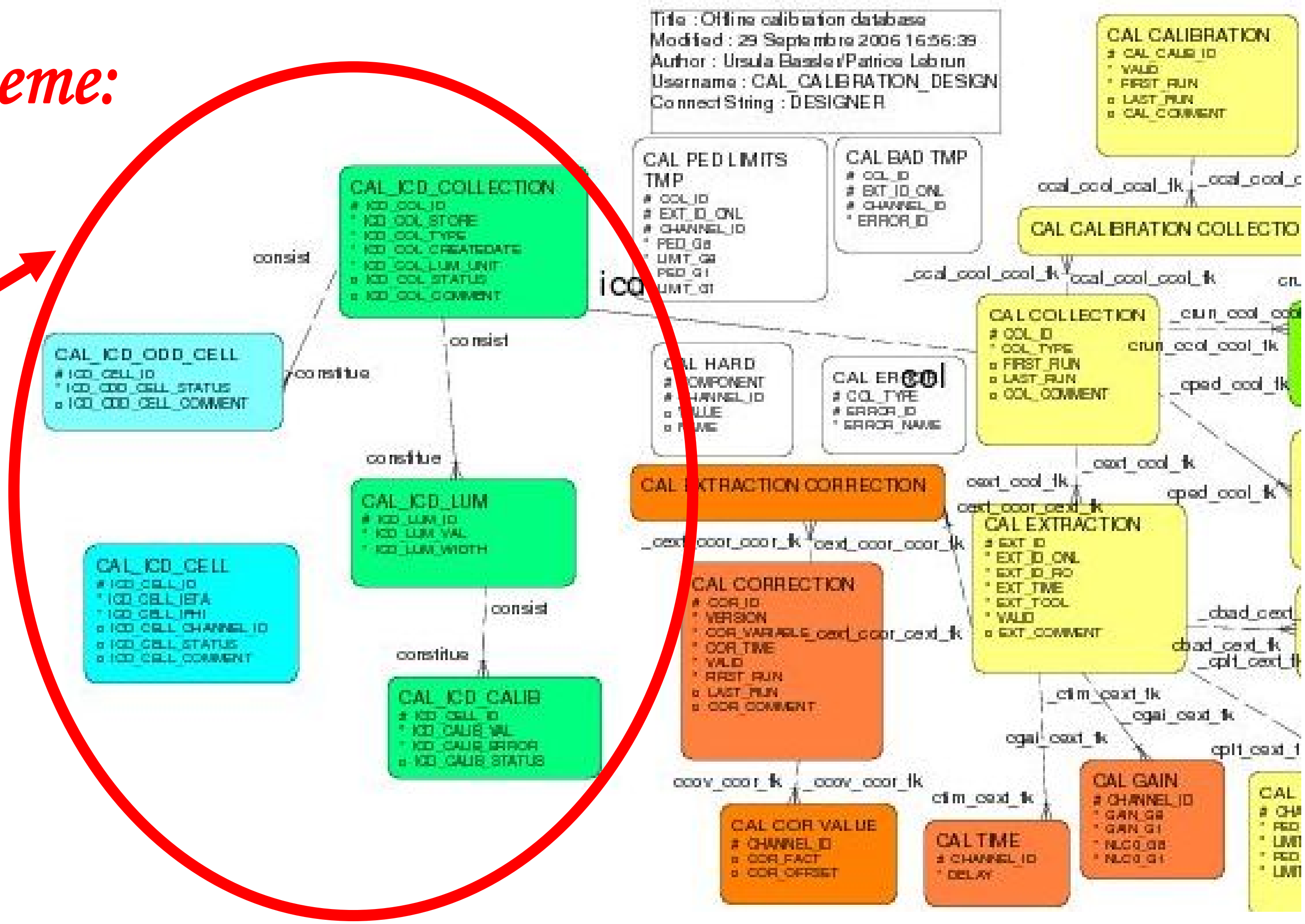


- and measure its efficiency

Before handling everything over to the JES group!

In case you missed…

A database scheme:



Luminosity dependent ICD calibration tables!

30 Juillet 1997

Proposition de Participation à la Phase II de l'Expérience DØ à Fermilab

Institut des Sciences N
Marie Laure A
Centre de Physique des Pa
Alain Bonissent, Marie Claude Co
Anne Ealet[1], François Etienne, D
Elemer Nagy, François T
Laboratoire de l'Accélérateur Li
Philip Bambade[1], Laurent Duflot, Jean
Michel Jaffré, Pierre Pétr
Laboratoire de Physique Nucléaire et des Haute
Ursula Bassler, Gregorio Bernardi, Did
Philippe Schwemling[1].

Résumé

Nous proposons de participer à la phase II de l'expérience D
Cette participation permettrait à des groupes français[2] de collabo
gramme unique de physique vers l'an 2000. Elle porterait essentiell
préparation à l'analyse et sur l'analyse elle-même, sur les thèmes de
du top, la recherche de nouvelles particules au delà du modèle Stan
physique de la beauté. Elle serait aussi une bonne préparation à la
au LHC. Elle bénéficierait de la collaboration avec un groupe du DAPN
Saclay[3].

[1]Contribution envisagée à partir de l'an 2000
[2]La participation des signataires ci-dessus ne prendra effet qu'après l'accord de leu
respectifs
[3]B. Bloch-Devaux, P. Bonamy, P. Le Du, C. Guyot, J.F. Laporte, L. Chevalier, A. Ph
Virchaux, A. Zylberstejn.

1

Sommaire

1 Introduction
2 Principaux éléments de l'amélioration
2.1 Amélioration du détecteur DØ
2.2 Performances attendues
2.3 Principaux sujets de physique
2.3.1 Physique du top
2.3.2 Physique électrofaible
2.3.3 Au delà du Modèle Standard
2.3.4 Physique des quarks b
2.3.5 QCD
3 Comparaison CDF/DØ
3.1 Le détecteur de traces interne
3.2 Calorimétrie
3.3 Le détecteur de muons
3.4 Déclenchement sur un vertex secondaire
4 Participation
4.1 Calorimètre
4.1.1 Calibration Electronique
4.1.2 Calibration avec les données
4.1.3 Reconstruction
4.2 Le détecteur de traces
4.2.1 algorithmes de reconstruction de traces
4.2.2 Etude d'un déclenchement sur vertex secondaire
4.3 Simulation et Analyse
4.3.1 Simulations Monte-Carlo
4.3.2 Développement de Logiciels de Reconstruction
4.3.3 Préparation à l'Analyse
4.4 Sujets d'Analyse
4.4.1 Analyse des données du Run I
4.4.2 Analyse des données du Run II
5 Demandes
6 Conclusion
A Bilan des Runs précédents
B Amélioration du TeVatron

and since..

many French thesis have extended Calorimetry Chapters

and you got :

Contributions & Conveners in Construction, Commissioning, Calibration, CALOP and CALGO