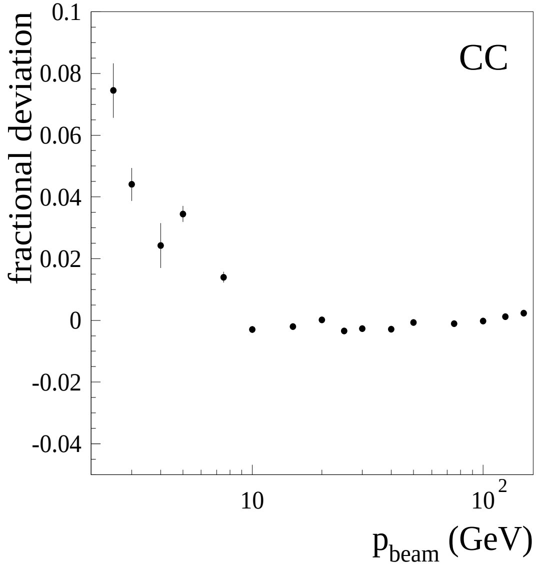
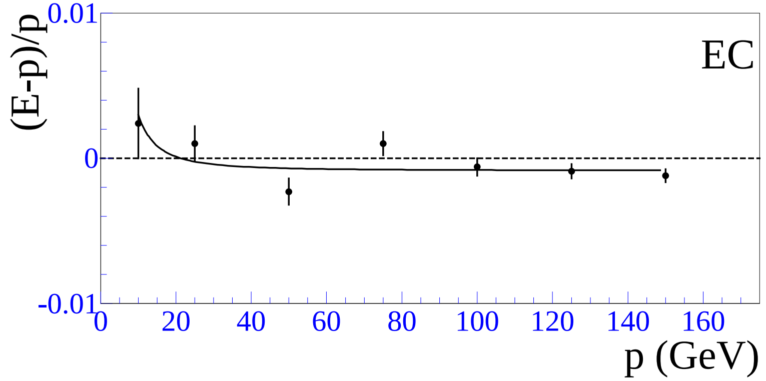
e.m. calibration in Run 1

- sampling weights from Test Beam data
- Run 1 Pulser Calibration
- φ-intercalibration from E_t-flow
- CC absolute scale from Z, J/Ψ, π^0
- EC/CC intercalibration

Thanks to Jon Kotcher!

Calibration from Test Beam Data





linearity < 0.3% for E > 10 GeV (CC)
< 0.1% for E > 20 GeV (EC)

determination of sampling weights from Test Beam Data:

$$E = A\sum_{i=1}^{5} s_i a_i - \delta$$

CC: A=2.94 MeV/ADC δ = -347 MeV s_1=1.31 s_2=0.85 s_3=1 s_4=0.98 s_5=1.84

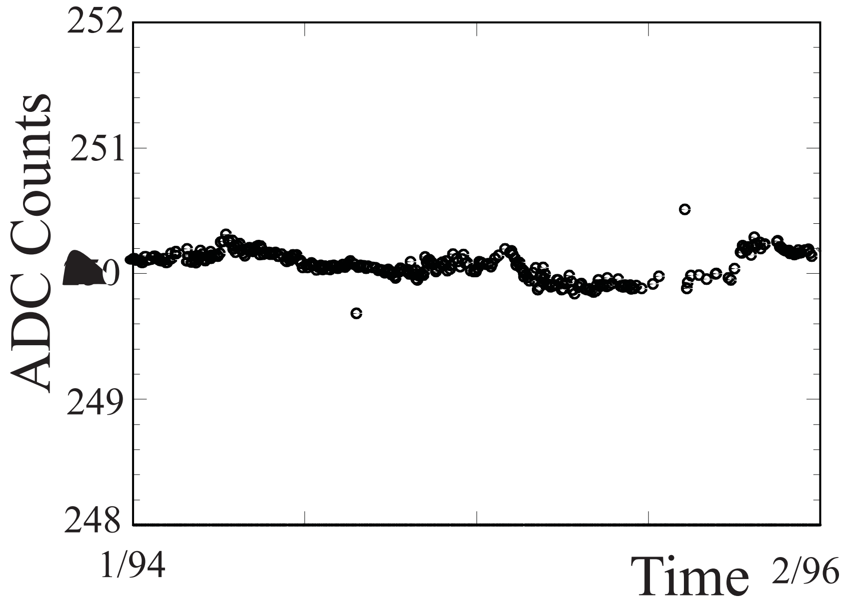
EC: A=3.74 MeV/ADC δ = -300 MeV s_1=1.47 s_2=1.00 s_3=1 s_4=1.10 s_5=1.67

NIM A 338 (1994) 185
NIM A 324 (1993) 393

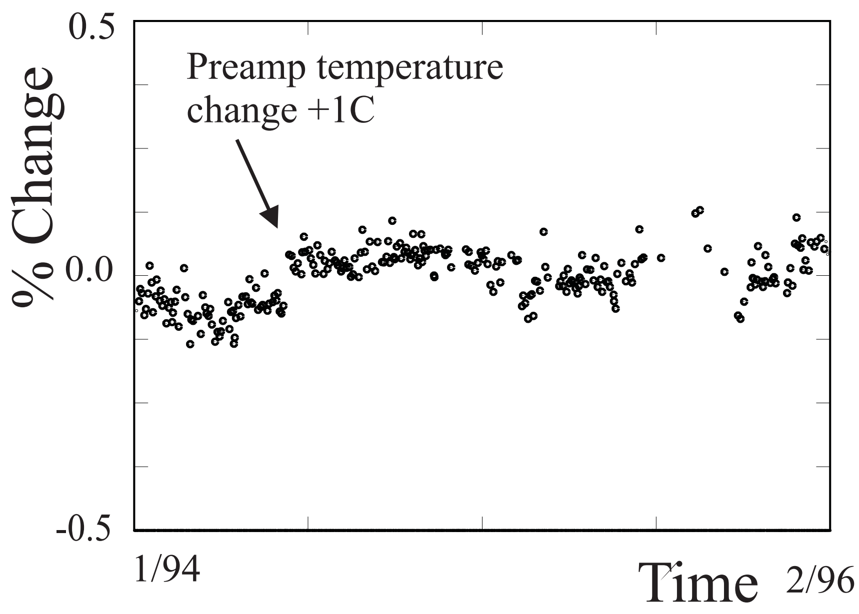
Results from Calibration Pulser

- **channel to channel gain variation measured with pulsers: rms= 3%**
  (corrected for differend detector capacitance)

D0-note 1509 Joan Guida



Pedestal variations << 1 ADC count

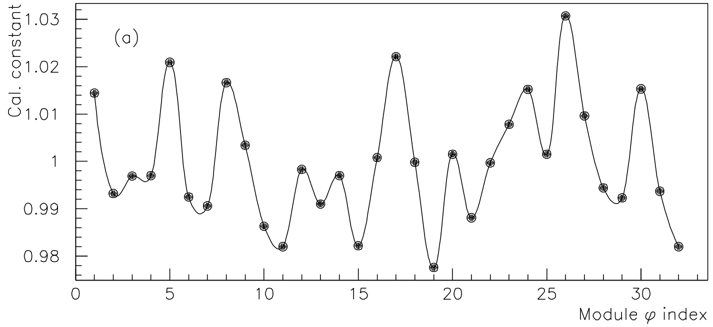


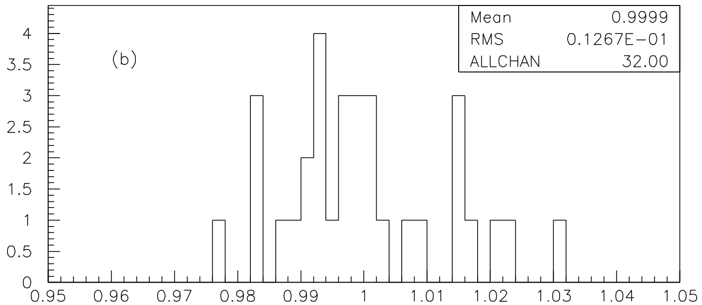
Gain variations < 1%

⇒ high stability of the liq. Argon calorimeter

φ - intercalibration: E_t flow

Ph. D. - Qiang Zhu
D0-note 796 - Paul Grannis





- the number of events above a given threshold p_t^0 should be equal for each φ-module of the calorimeter

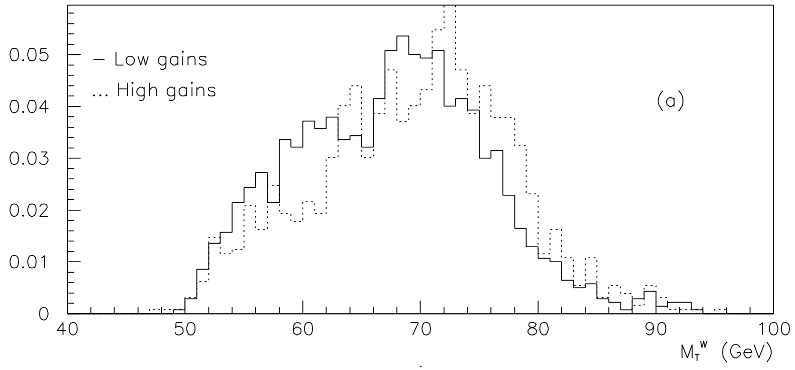
Method I: determine $\alpha_i p_{t,i}^0 = p_{t,ref}^0$ such that $N_i = N_{ref}$
Method II: fit to spectrum $\log N_i = A_0 + A_1\, \alpha_i p_{t,i}^0$
Method III: equalize $p_{t,i}^0 - < p_{t,i} >$ (less precise)

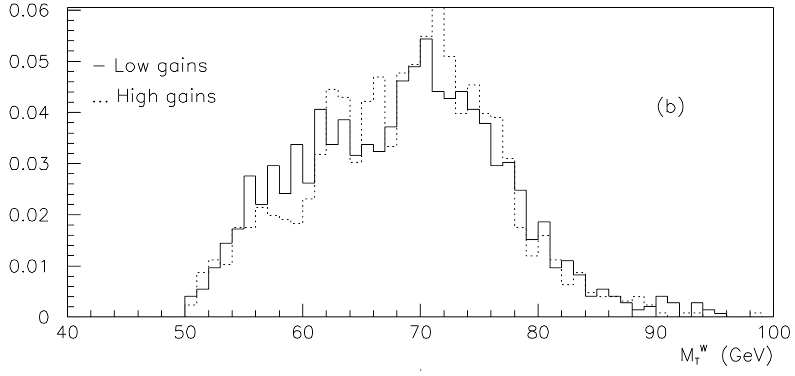
- **Datasets:**

Run 1a: triggers requiring 1 electron with $p_t > 20$ GeV
$\Rightarrow$ 2.3 M events
special run: trigger with L1 $p_t > 5$GeV and L2 $p_t > 7$GeV
$\Rightarrow$ 3.5 M events

- **precision better than 0.5 %**

W-mass spectrum in φ-regions





Verification on W-mass spectrum:

high gain modules: $\alpha_i < 0.99$

medium gain modules: $0.99 < \alpha_i < 1.01$

low gain modules: $\alpha_i < 1.01$

HG: $81.27 \pm 0.36 \rightarrow 79.40 \pm 0.33$

MG: $79.93 \pm 0.20 \rightarrow 79.84 \pm 0.20$

LG: $78.71 \pm 0.31 \rightarrow 80.04 \pm 0.15$

Energy Scale Determination from Resonances

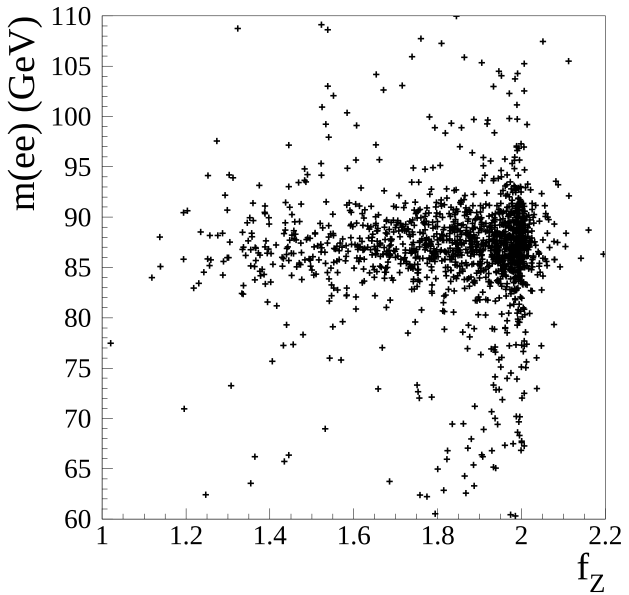
- $\mathbf{E = \alpha\, E_{meas} + \delta}$ $\Rightarrow$ determination of α and δ from Z, J/Ψ and π^0
- $\mathbf{m = \sqrt{2\, E_1 E_2\, (1 - \cos\gamma)}}$ $\Rightarrow$ E1, E2: electron energies, γ: opening angle

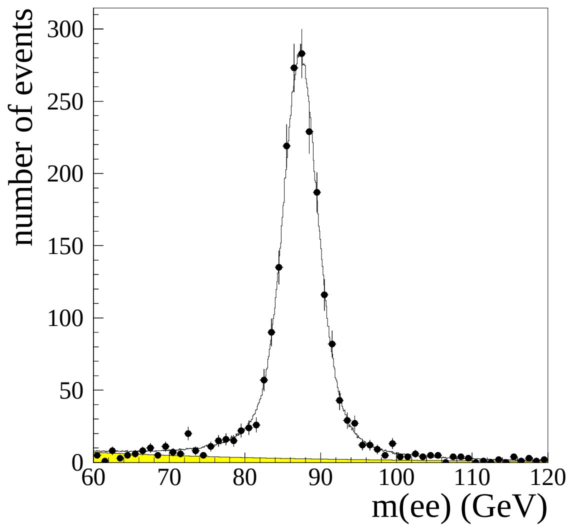
$\Rightarrow$ $\mathbf{M_{true} \approx \alpha\, m + \delta\, f}$ with kinematic factor $\mathbf{f = (E_1+E_2)\,(1-\cos\gamma)/m}$

- $\mathbf{f_{max} = 2}$ for electrons back to back
- $\mathbf{\partial m/\partial\delta = f}$ $\Rightarrow$ sensitivity to an offset δ varies with f

D0-note 1819 - Ulrich Heintz
D0-note 2209 - Ulrich Heintz
D0-note 2298 - I. Adam et al.
PRD 58-12002 - W-mass Run 1a
PRD 58-92003 - W-mass Run 1b

$Z \rightarrow ee$





- non-monochromatic decay electrons:

$\Rightarrow$ extraction of α and δ from m_{meas} vs f_Z

- **Z decays in CC:**
  - L2: $E_t > 20$ GeV
  - $E_t^{1,2} > 10$ GeV
  - $\approx$ 4000 events in Run 1

- fit of Breit-Wigner $\otimes$ Gaussian to m_{meas}
- comparison to MC simulated with different values of α and δ
- errors: stat + background contribution

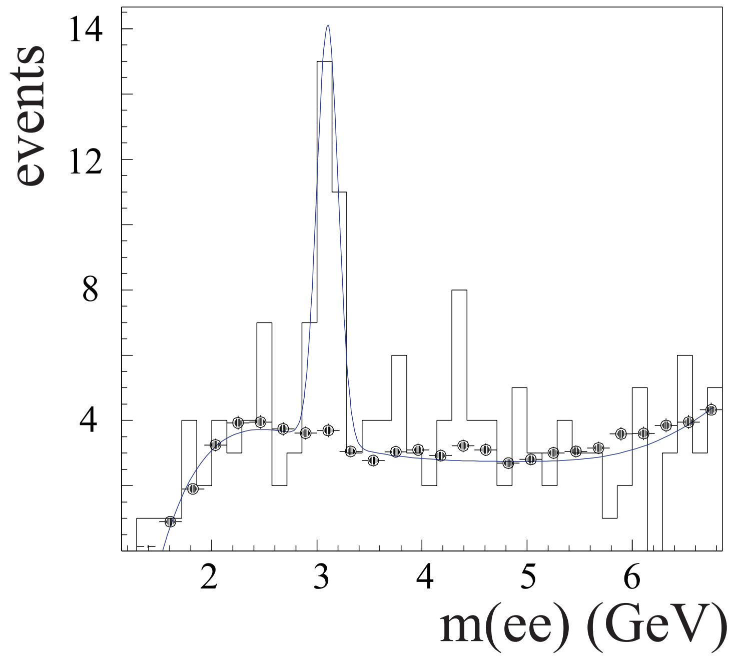
$\boldsymbol{\alpha = 0.9533 \pm 0.0008 \quad \delta = -\ 0.16\ _{-0.21}^{+0.03}}$ **GeV**

$J/\Psi \rightarrow ee$

• J/Ψ production from χ_c and B decays and fragmentation

• $m_{J/\Psi} = 3.097$ GeV

• datasets:
special run between 1a/1b $L_{int} = 100\ nb^{-1}$
– **L1:** 2 em-towers $E_t > 2.5$ GeV and $E_t^{had} < 1$GeV
– **L2:** 2 em-objects with $E_t > 3$GeV
$\Rightarrow$ 600 k events
– major background from π^0 and η



$m_{J/\Psi} = 3.032 \pm 0.035 \pm 0.190$

• main systematic error sources:
– energy contribution from underlying event **$\delta_m = 0.08 \pm 0.08$ GeV**
– non-linearity: 0.170 GeV
• calibration coefficients determined for boosted system
$\rightarrow \langle f_{J/\Psi} \rangle = 0.61 \pm 0.1$

$\pi^0 \rightarrow \gamma\gamma \rightarrow$ eeee

- **π^0 signature:**

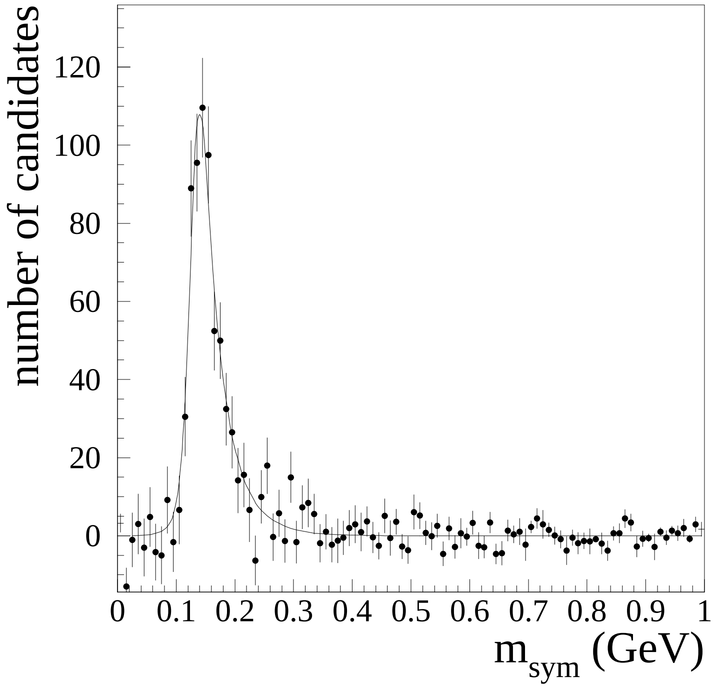
– $E_{\pi 0}$> 1 GeV non-resolved $\gamma\gamma$
– γ conversion into non-resolved ee
$\rightarrow$ 1 cluster + 2 tracks with dE/dx ≈ 2 dE/dx (e)
$\Rightarrow$ **reconstruction of "symmetric mass":**

$$m_{sym} = \sqrt{E^2(1-\cos\alpha)/2}$$

α: opening angle between the 2 tracks

- **dataset** (Run 1a + J/Ψ run): ≈ 15k events (CC)

$m_{\pi 0}$ = 0.1354 ±0.010

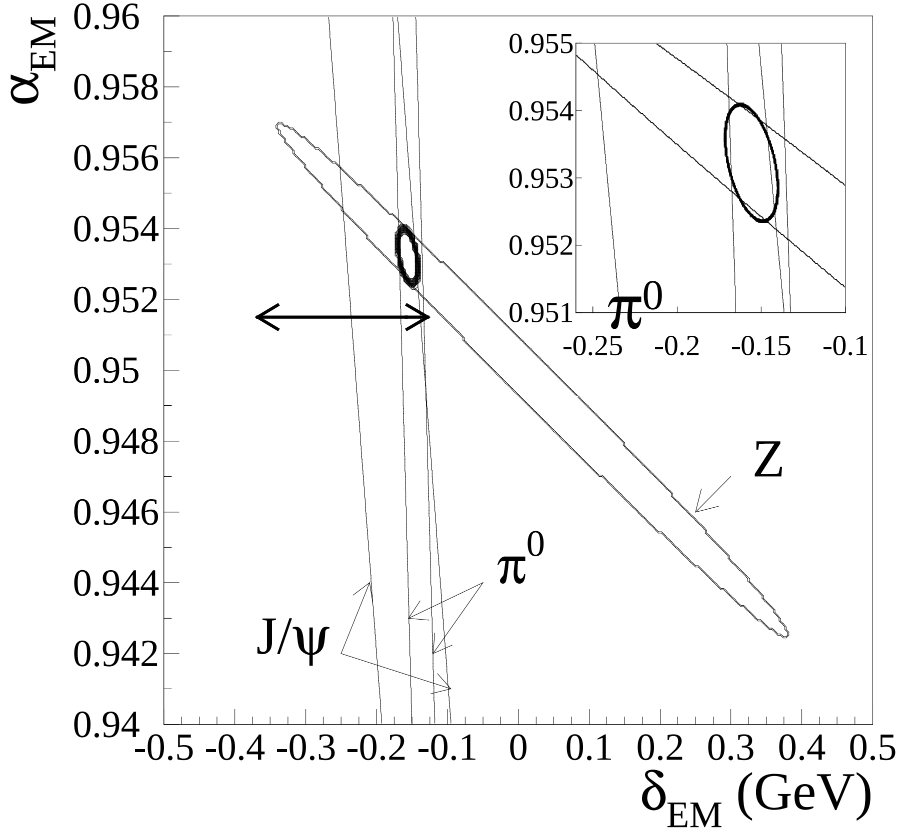


- **main systematic error sources:**

– energy contribution from underlying event+instrumental effects **δ_m=0.30±0.10 GeV**

- **calibration coefficients mainly sensitive to δ, as $\delta_{\pi 0}$=4δ**

α_{em}, δ_{em} determination



Combined constraints:

- $\alpha_{em} =$ **0.9533 ±0.0008**
- $\delta_{em} =$ **- 0.16$^{+0.03}_{-0.21}$GeV**

⇒ Z constrain on α_{em} and δ_{em}
⇒ J/Ψ and π^0 constrain δ_{em}

not used in Run 1:

- $\Upsilon \rightarrow ee$
- $\eta \rightarrow \gamma\gamma$

EC-CC intercalibration

$Z \to ee$: CC/EC 1265 events
EC/EC 422 events

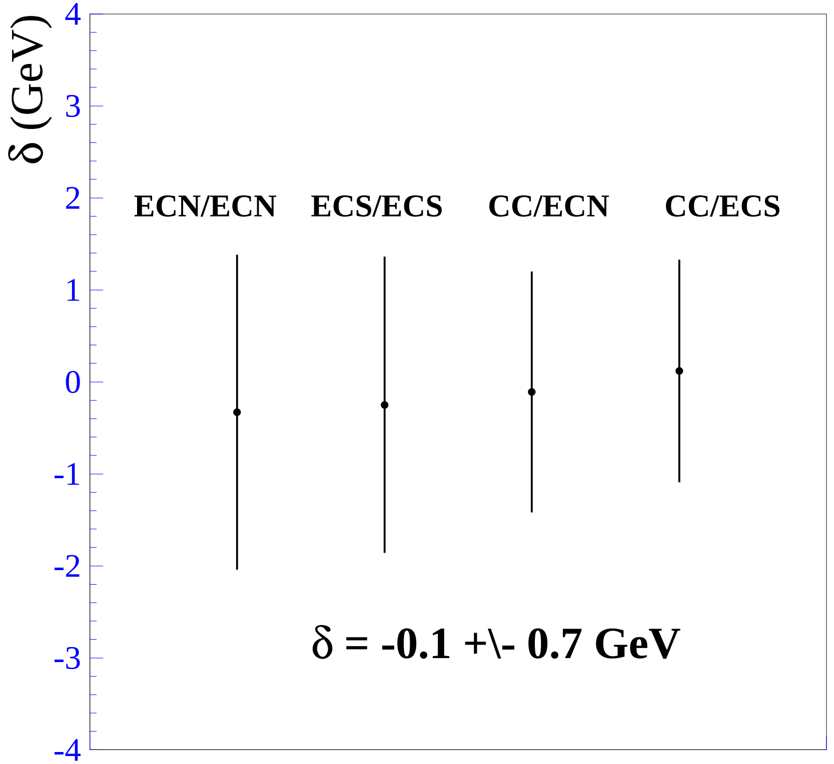
both e in EC: $\mathbf{m = \alpha_{EC} M_Z + f_Z \delta_{EC}}$

e in CC/EC: $\mathbf{m = \sqrt{\alpha_{EC}} \sqrt{\alpha_{EC}} M_Z + f_Z \delta_{EC}}$

- energy scale for CC taken from previous analysis

$\Rightarrow \delta_{EC} = -\ 0.1 \pm 0.7$

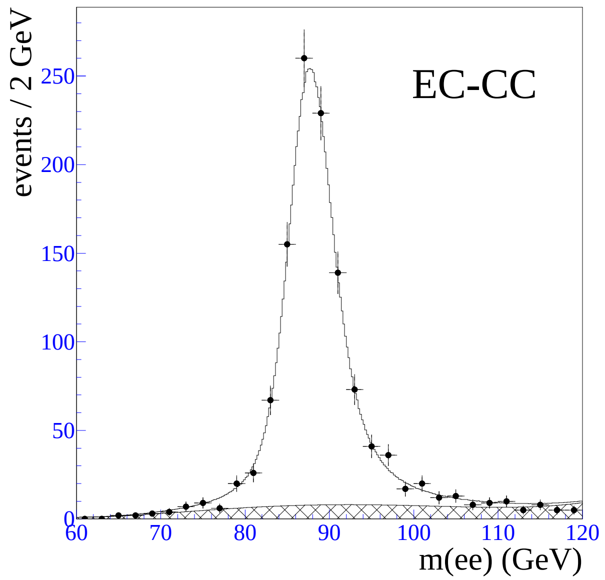
error dominated by statistics

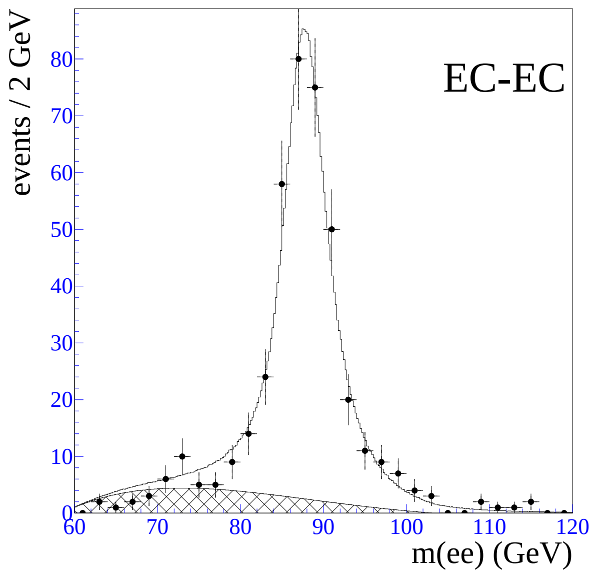


Cryostat Combination

PRD submitted

EC-CC intercalibration





$\alpha_{EC/CC}=0.95143\pm0.00259$

$\alpha_{CC/CC}=0.95230\pm0.00231$

- error dominated by statistics
- no measurable effect from background

and for Run II?

- higher statistics $\rightarrow$ finer local calibration
  - calibration φ in using $W \rightarrow e\upsilon$?
  - segmentation in η using resonances?

- how to check sampling weights and dead material corrections?

- π^0, η: magnetic field $\rightarrow$ opening angle of e^+e^- reconstruction with single converted γ?

- use of E/p, especially at low energies