Analysis of CASTOR calorimeter test beam data 2007

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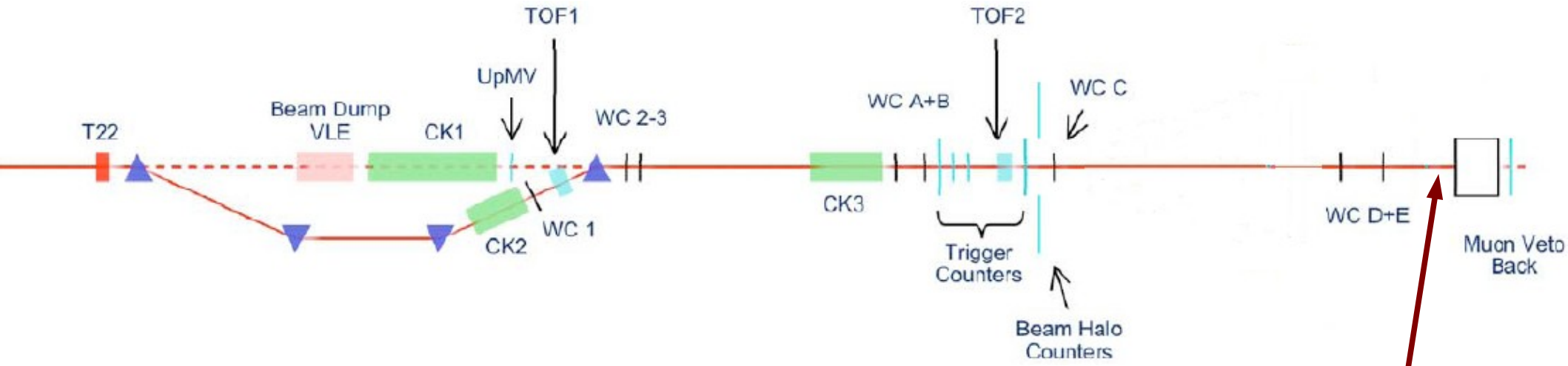
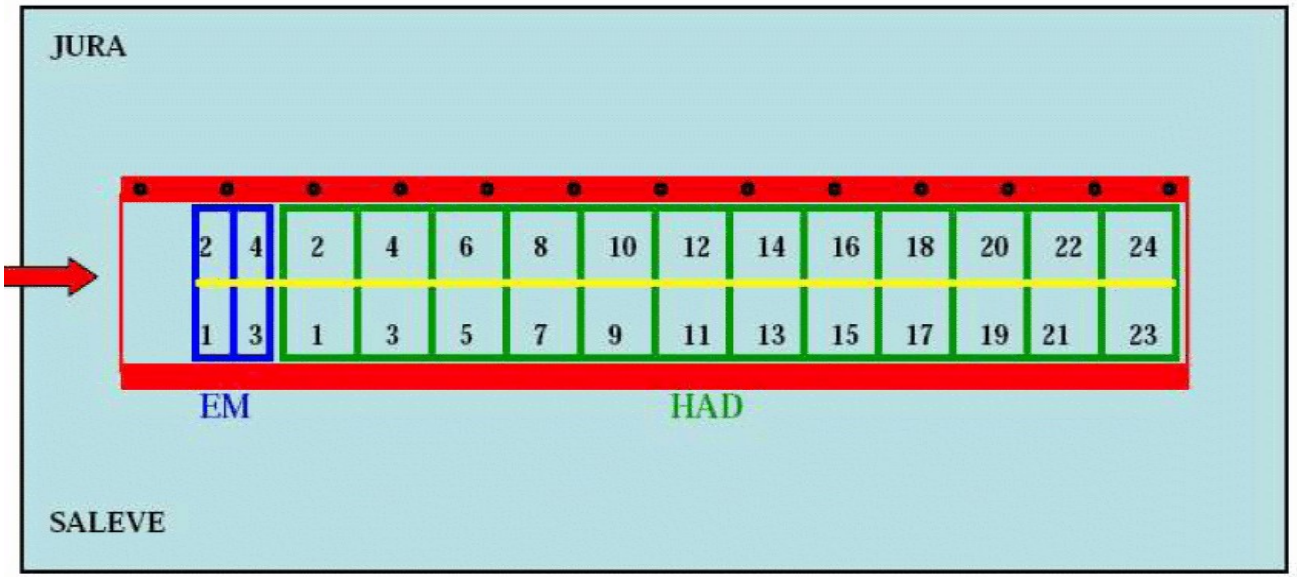
CERN SPS H2 beam line setup



- H2 high energy mode: 400 GeV protons from SPS strike production target to produce 10 – 350 GeV electrons, pions, muons
- Relevant beam line elements: scintillation counters (S1-S4) for triggering, wire chambers (WCA-WCE) for beam position, muon veto counters

CASTOR prototype on movable HF table

CASTOR prototype



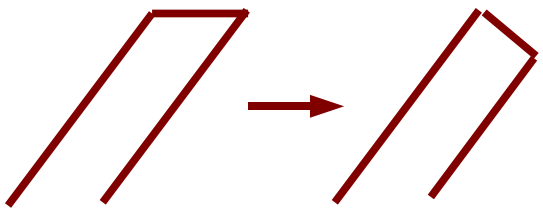
- 2 semi-octants ("Jura" and "Saleve"): 2 EM + 12 HD channels each
- Channel = 5 sampling units

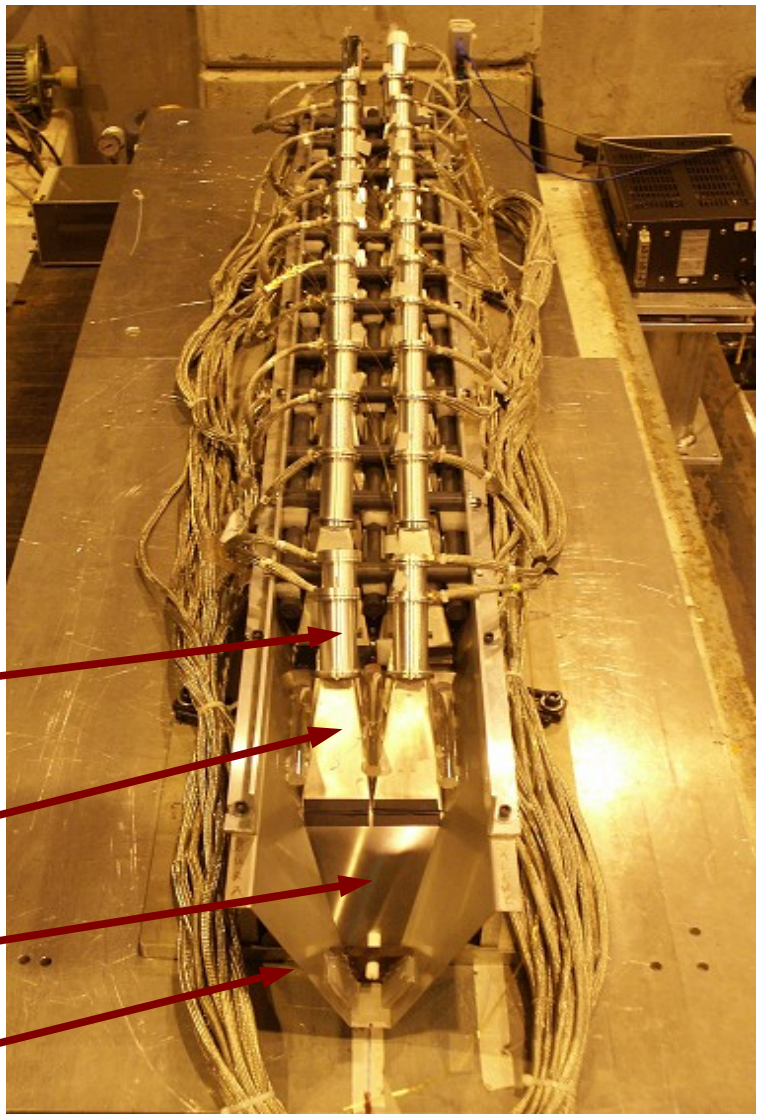
  1 SU = tungsten (W) absorber + quartz (Q) plate
- W/Q thickness: 5 mm (W) + 2 mm (Q) in EM

  10 mm (W) + 4 mm (Q) in HD
- Full-length: all EM ~ 20 rad.l., all EM+HD ~ 10 int.l.

Prototype (cont'd)

- W/Q-plates inclined by 45^0 w.r.t. beam direction to enhance Cherenkov light output
- Q-plates: wrapped with Tyvek paper to diffuse light; copper foil glued on one side to avoid x-talk; in all HD initially top surface cut at 45^0, later changed to 90^0 (but in HD1 only)





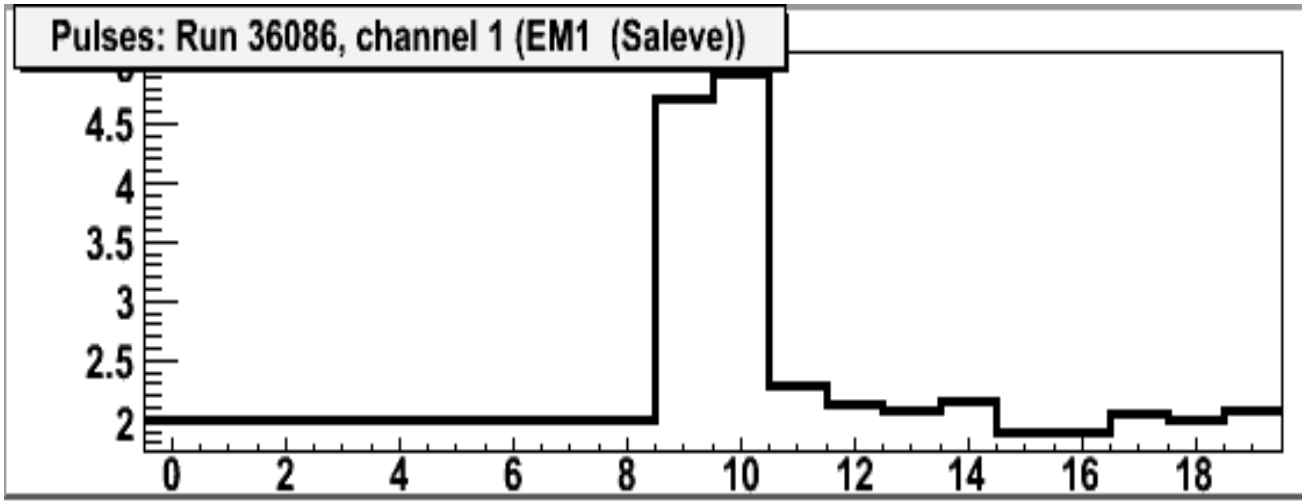
Test beam program

- Energy and position scans with 10 – 200 GeV electrons, 20 – 350 GeV pions
- 50, 150 GeV muons for channel (inter)calibration, response uniformity checks, light collection studies
- PMT studies: Hamamatsu (R5380O) vs RIE (St.Petersburg, FEU-187), pedestals at different HV settings, beam on PMT entrance glass

DAQ + Software

- Readout based on HCAL electronics + CMS xDAQ framework
- TB data: ROOT files kept at CERN on CASTOR2 storage and at DESY on Hamburg CMS workgroup servers
- CMSSW with some tricks/workarounds: (HCAL-)independent CASTOR reco code not fully implemented
- So far several strategies:
  - (old) HTBDAQ_data ROOT class collection to access CASTOR data + CMSSW to access wire chamber info, trigger etc
  - Fully CMSSW-based (HCAL DQM/Monitor modules). Need to mimic HF in electronic maps (DetID=HF)

HCAL electronics: signal timing

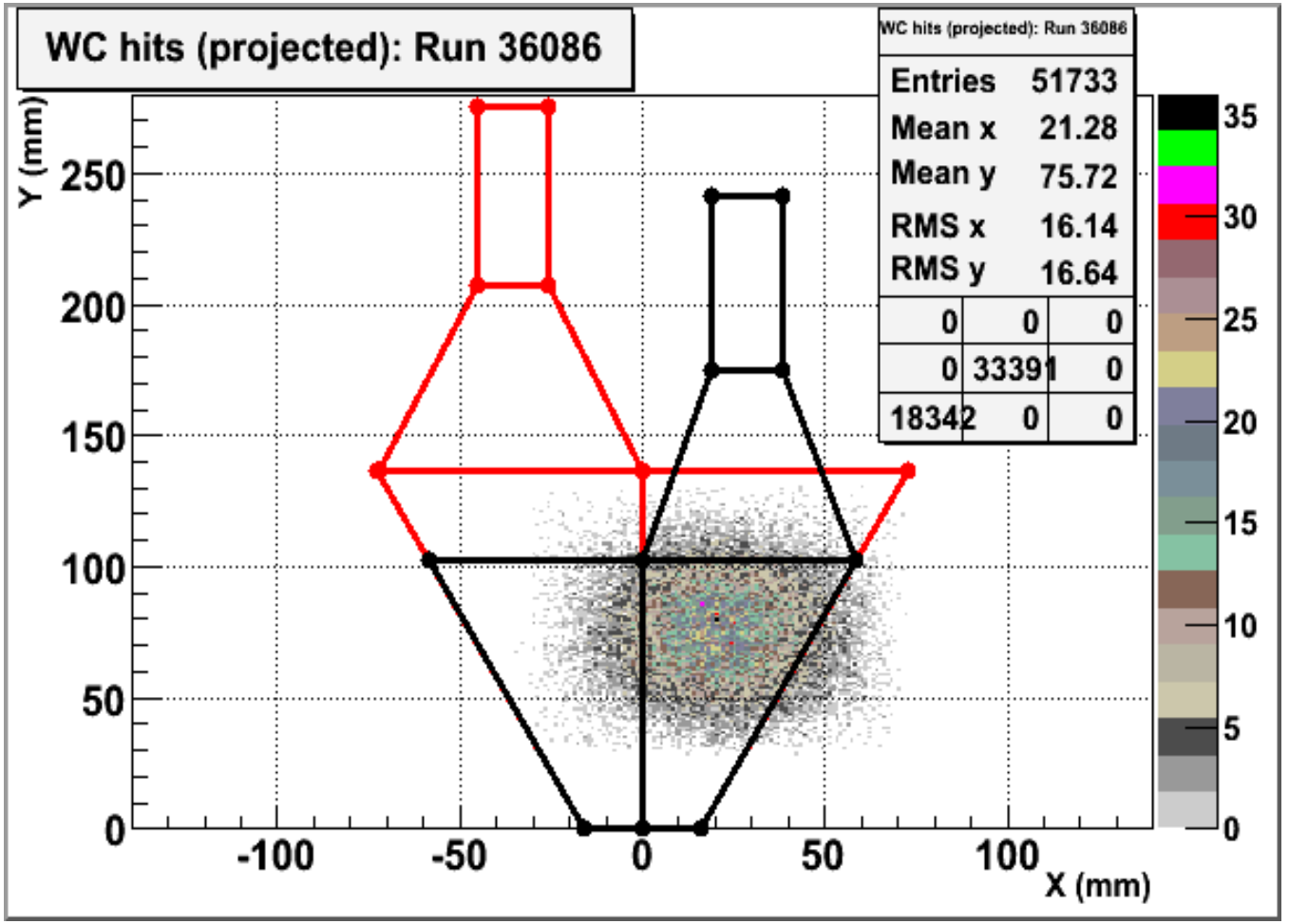


Used two central (#9,10) 25 ns time slices (out of 20 provided by HCAL electronics) to get integrated channel response: proved to provide better resolution

Used pedestal triggers in every run to calculate pedestals from 1st four time slices (averaged over all run events)

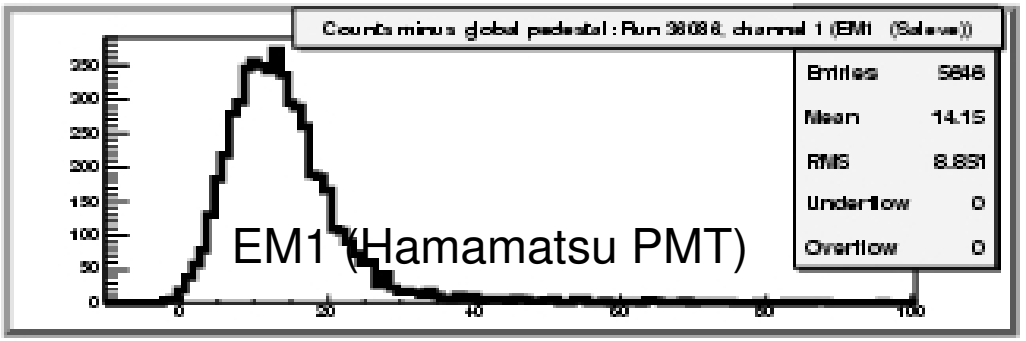
Physics: subtract pedestal, request beam trigger

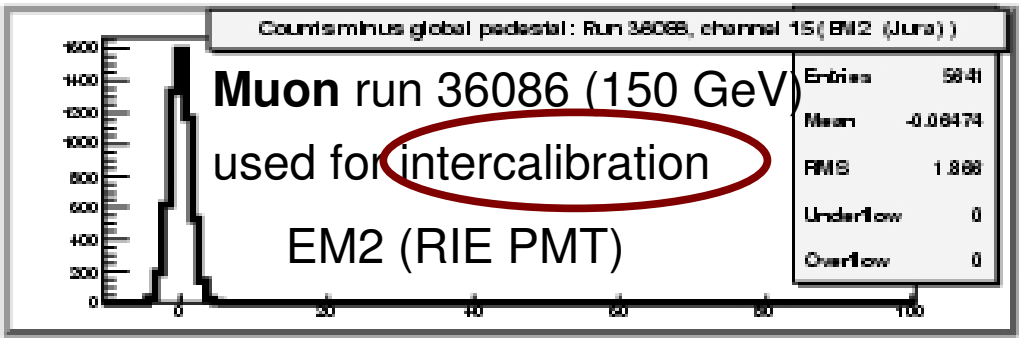
Beam profile

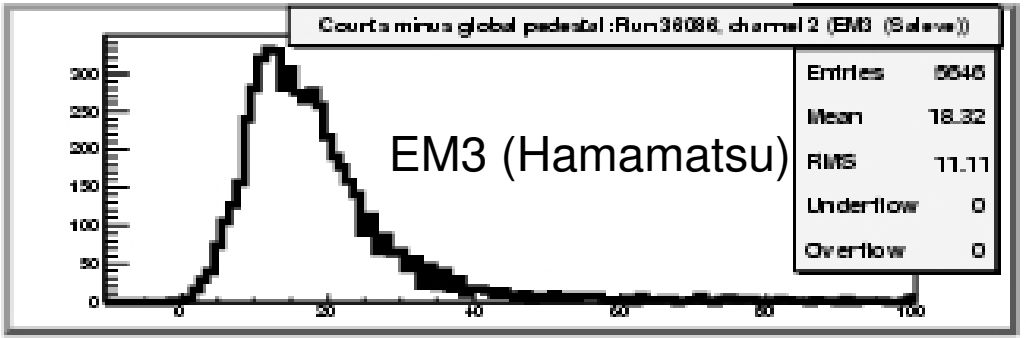


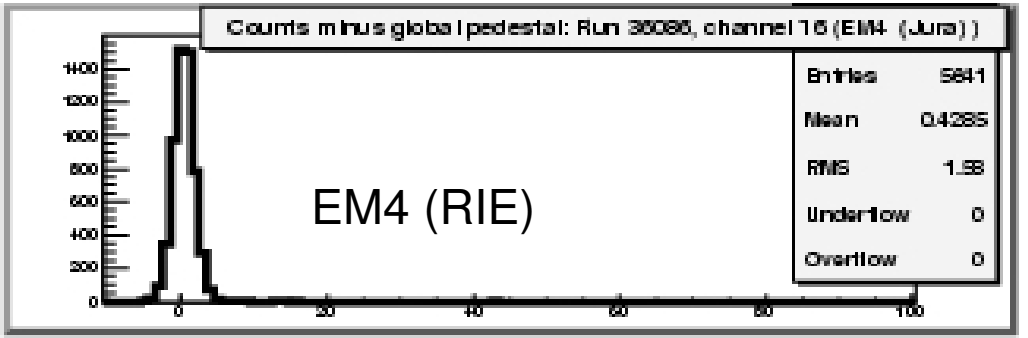
Beam cleaning/selection cuts need to be applied:

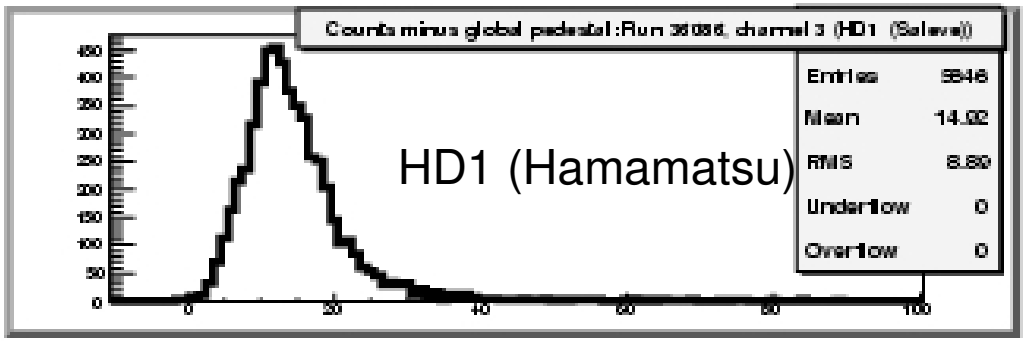
exactly one hit in WCD chamber + radius cut

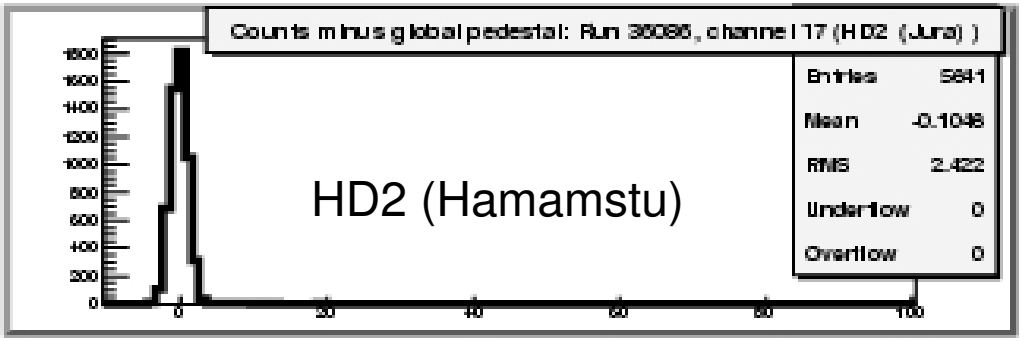

Counts minus global pedestal : Run 36086, channel 1 (EM1 (Saleve))
Entries 5846
Mean 14.15
RMS 8.831
Underflow 0
Overflow 0
EM1 (Hamamatsu PMT)

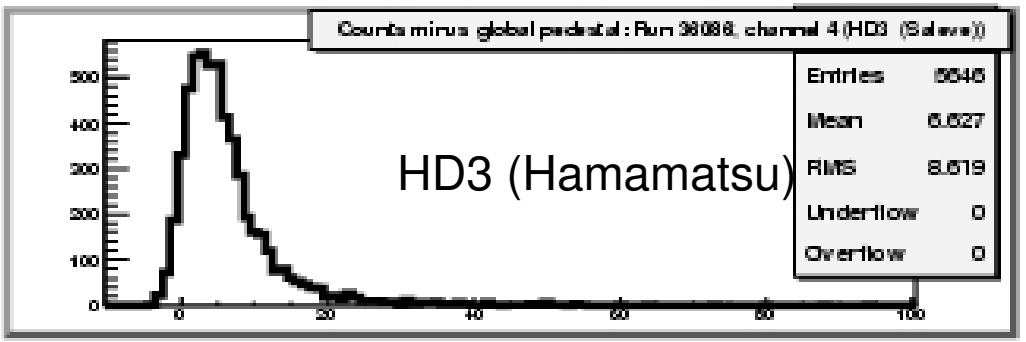

Counts minus global pedestal : Run 36086, channel 15 (EM2 (Jura))
Entries 5841
Mean -0.08474
RMS 1.868
Underflow 0
Overflow 0
Muon run 36086 (150 GeV)
used for intercalibration
EM2 (RIE PMT)

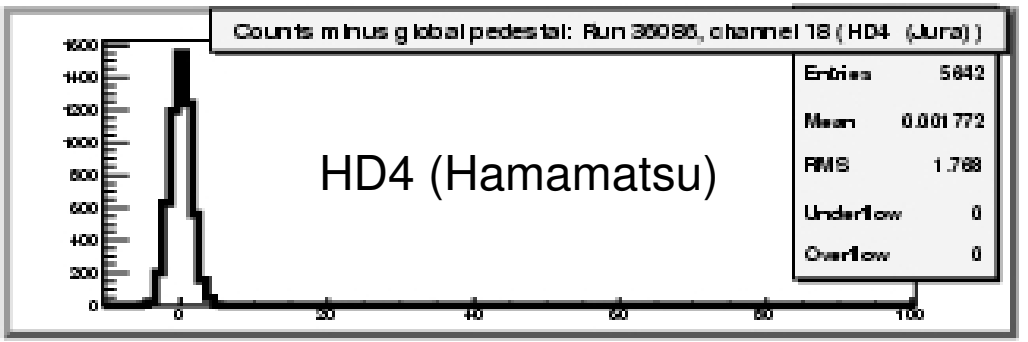

Counts minus global pedestal : Run 36086, channel 2 (EM3 (Saleve))
Entries 5846
Mean 18.32
RMS 11.11
Underflow 0
Overflow 0
EM3 (Hamamatsu)

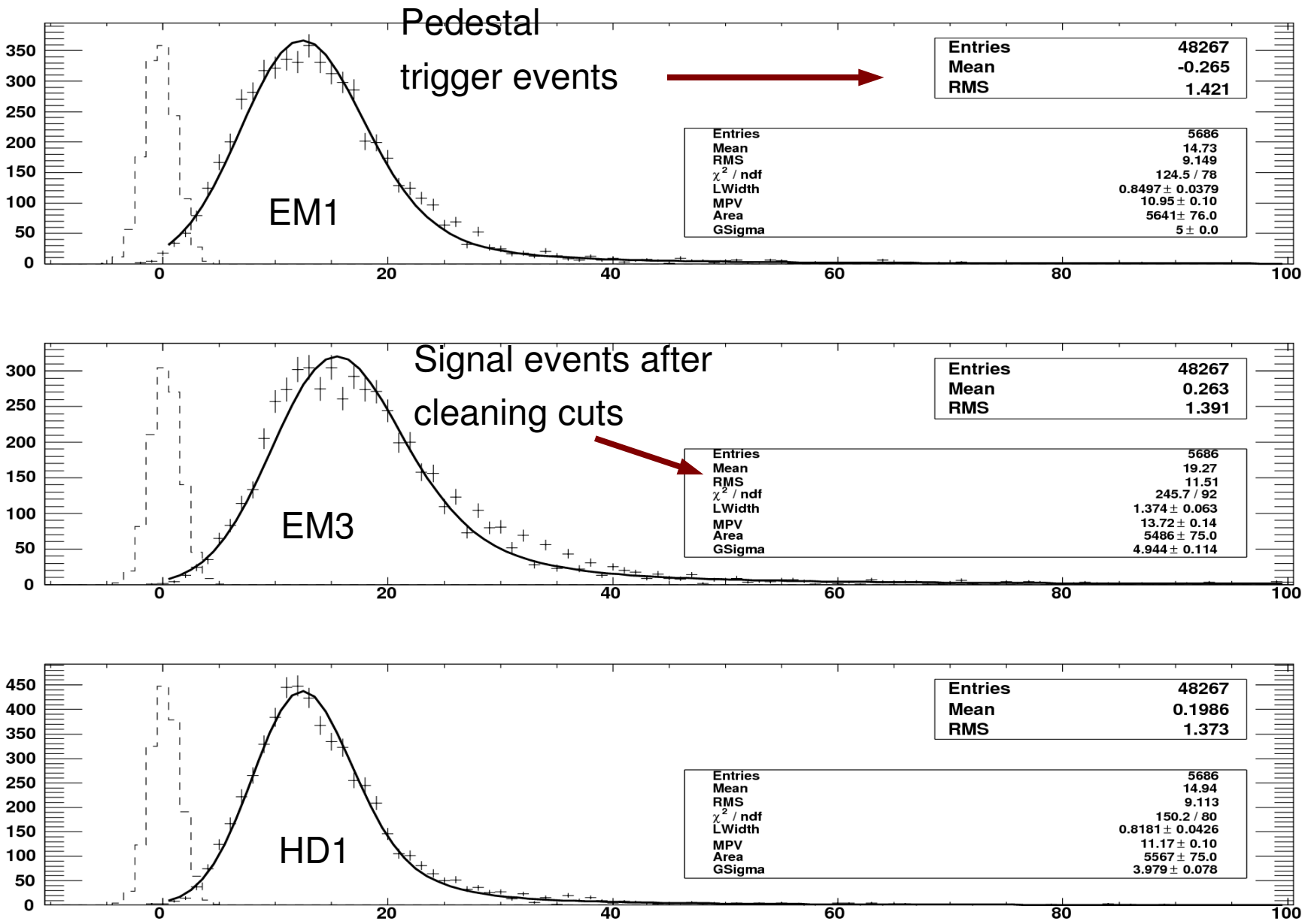

Counts minus global pedestal : Run 36086, channel 16 (EM4 (Jura))
Entries 5841
Mean 0.4285
RMS 1.58
Underflow 0
Overflow 0
EM4 (RIE)


Counts minus global pedestal : Run 36086, channel 3 (HD1 (Saleve))
Entries 5846
Mean 14.02
RMS 8.89
Underflow 0
Overflow 0
HD1 (Hamamatsu)

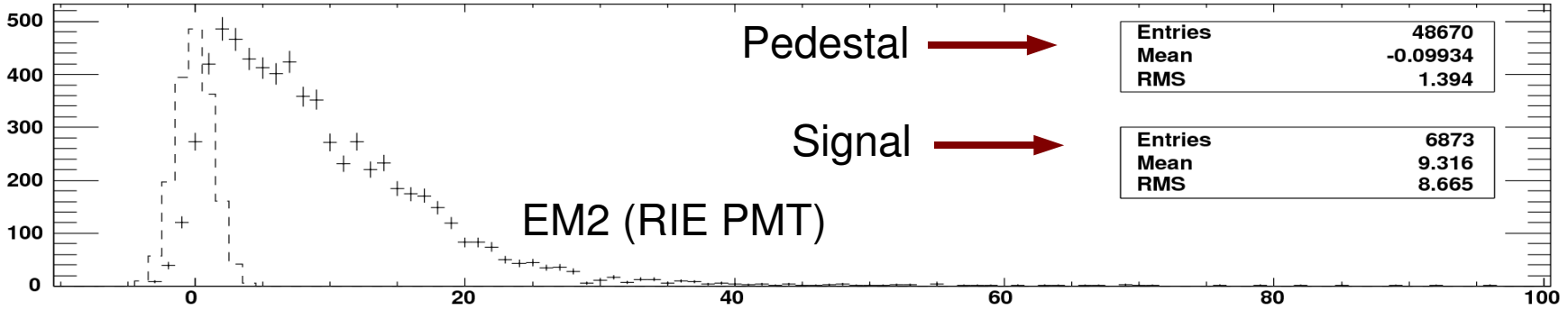

Counts minus global pedestal : Run 36086, channel 17 (HD2 (Jura))
Entries 5841
Mean -0.1048
RMS 2.422
Underflow 0
Overflow 0
HD2 (Hamamstu)

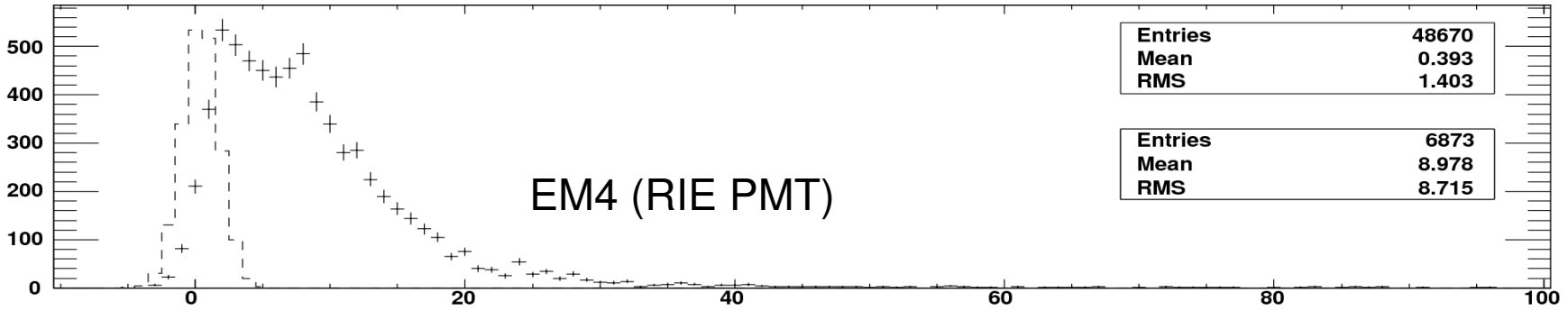

Counts minus global pedestal : Run 36086, channel 4 (HD3 (Saleve))
Entries 5846
Mean 6.627
RMS 8.619
Underflow 0
Overflow 0
HD3 (Hamamatsu)

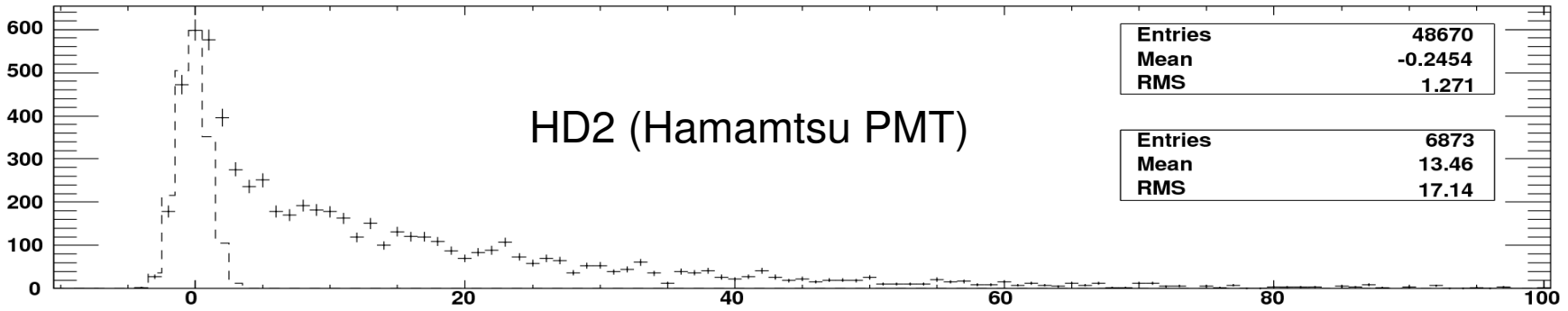

Counts minus global pedestal : Run 36086, channel 18 (HD4 (Jura))
Entries 5842
Mean 0.001772
RMS 1.768
Underflow 0
Overflow 0
HD4 (Hamamatsu)



EM1, EM3, HD1 response to **muons** fitted with convolution of landau and gaus

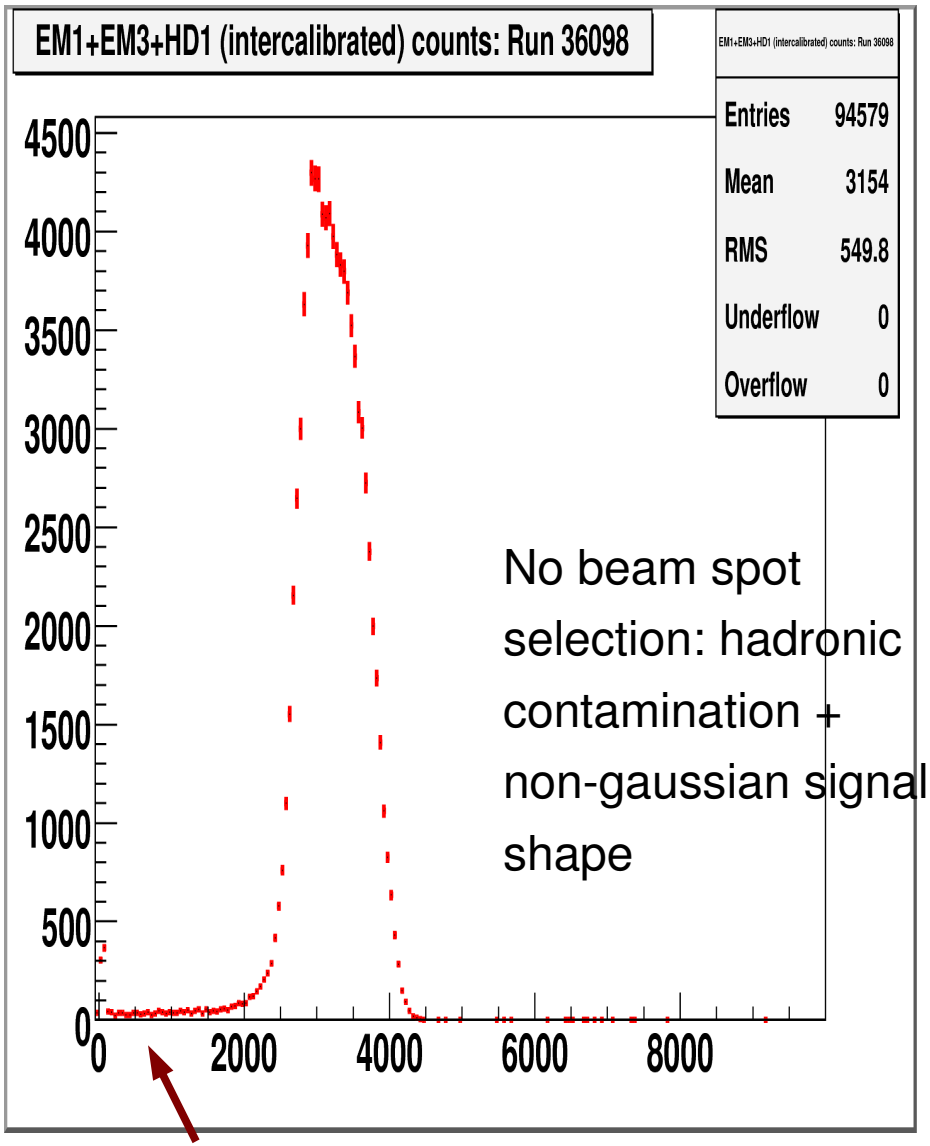


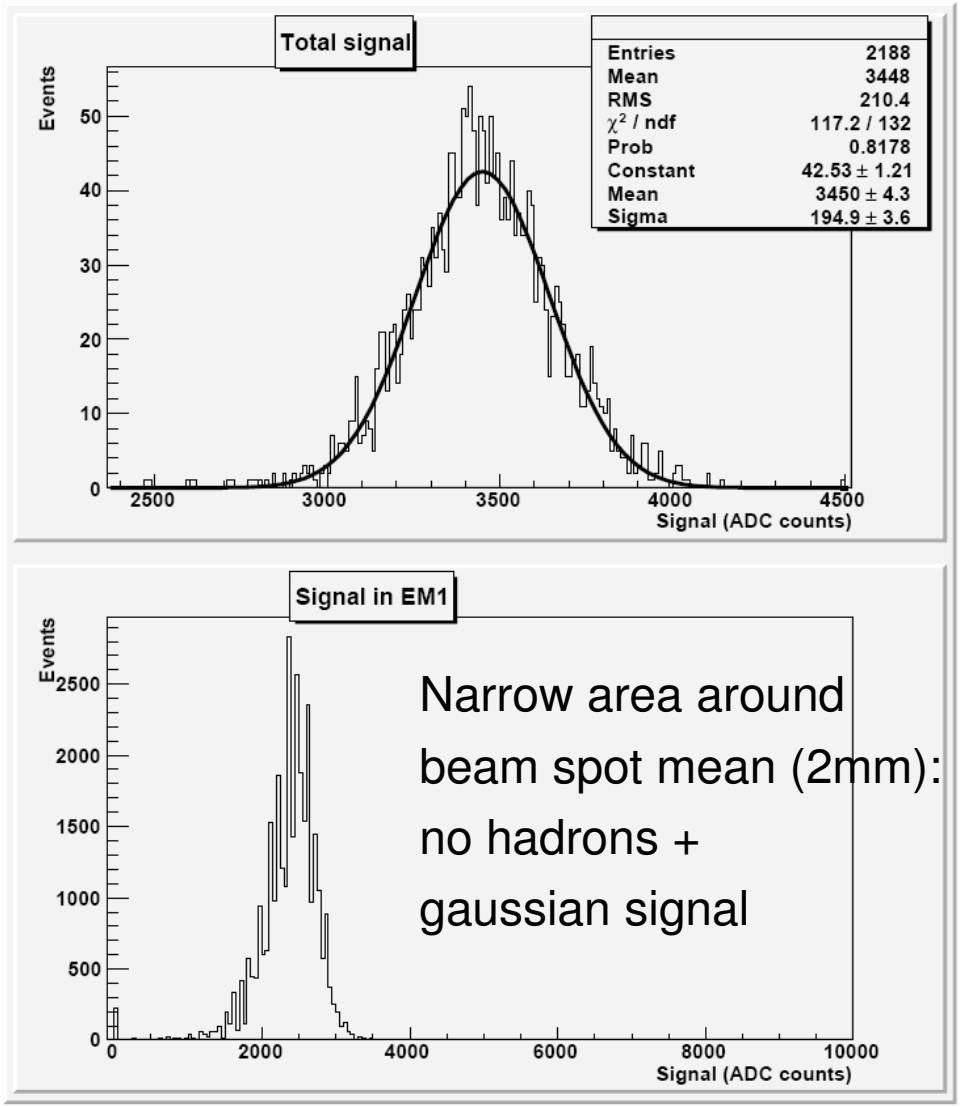


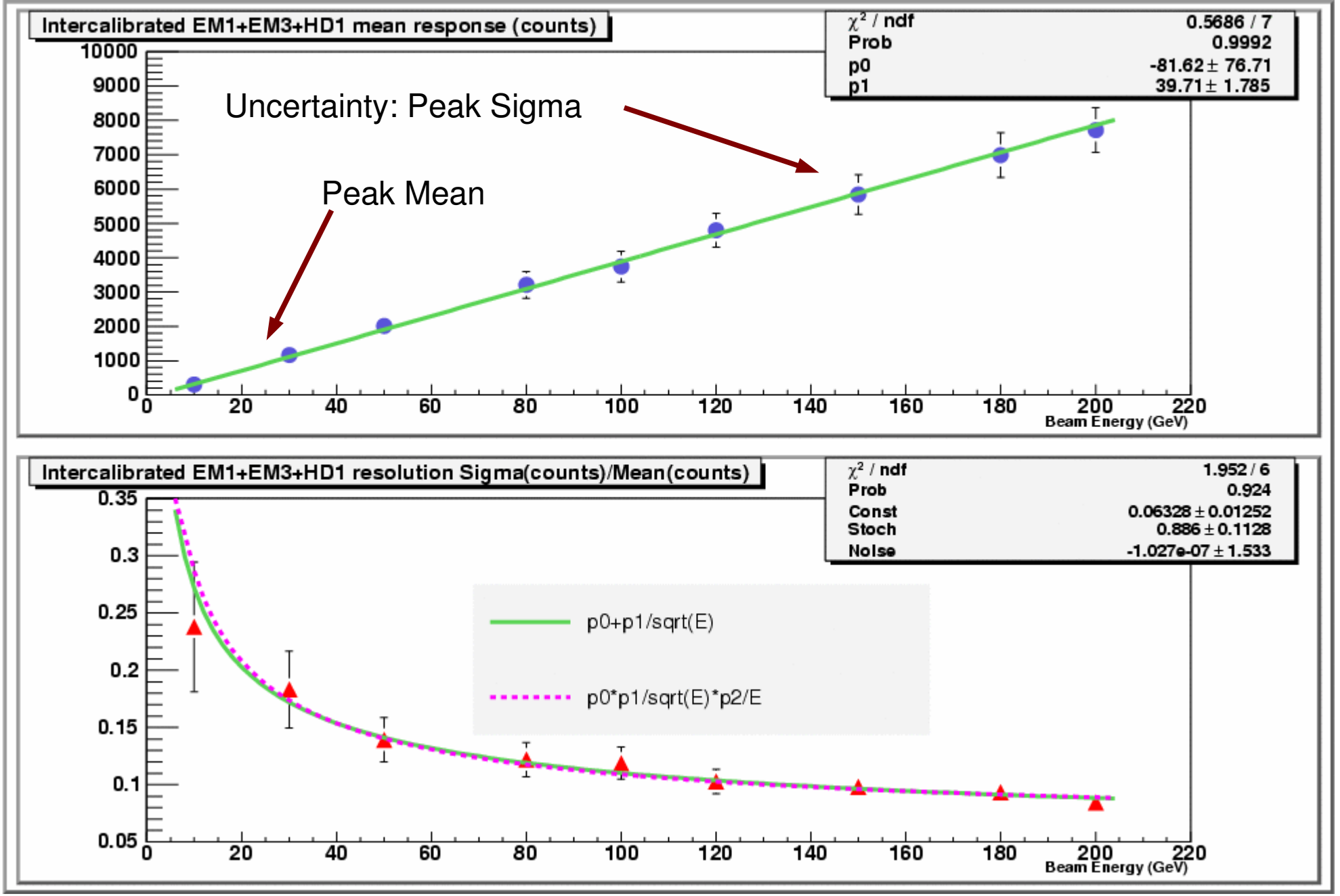


EM2, EM4, HD2 response to **muons**

Electrons: 80 GeV

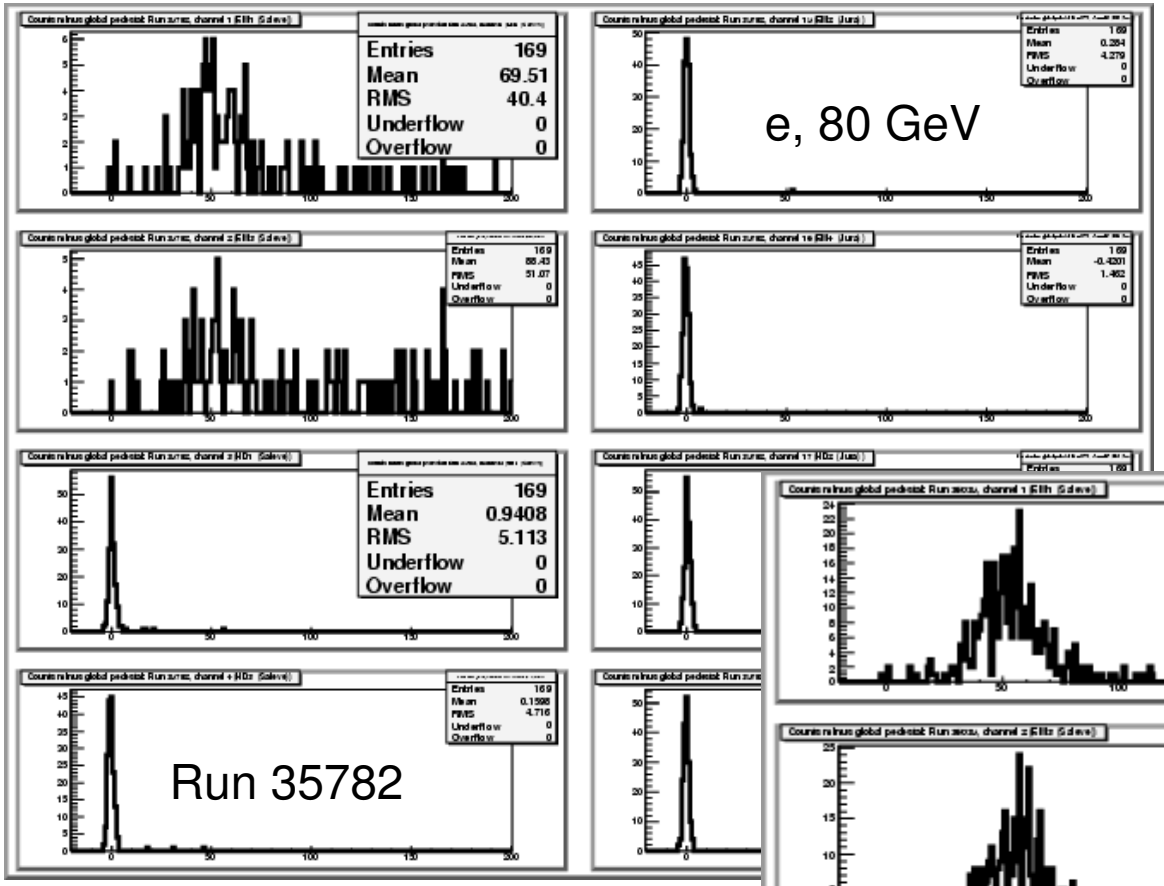




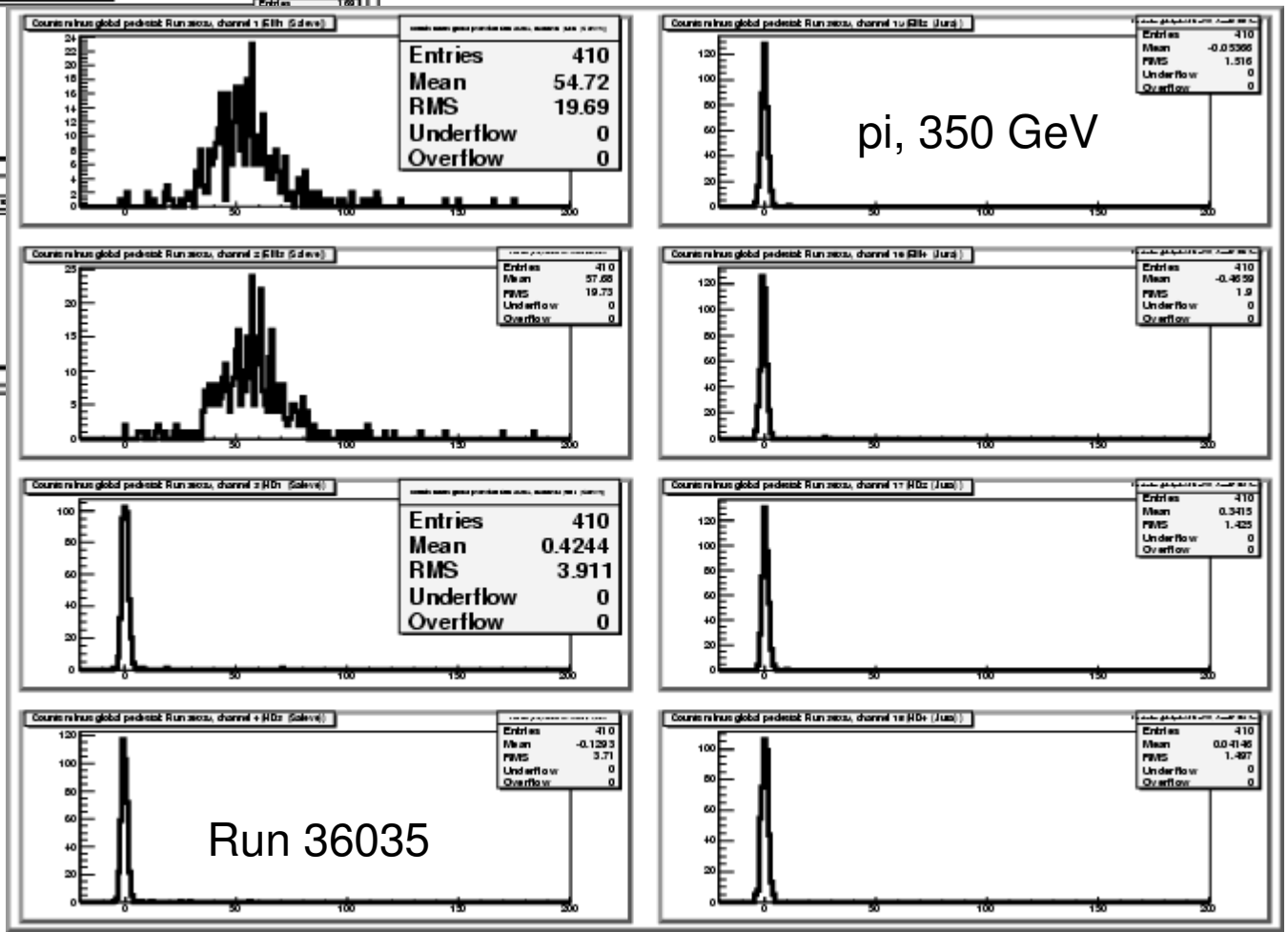


Electron energy scan results to be revisited using wire chamber info + cleaning cuts

Beam on PMT



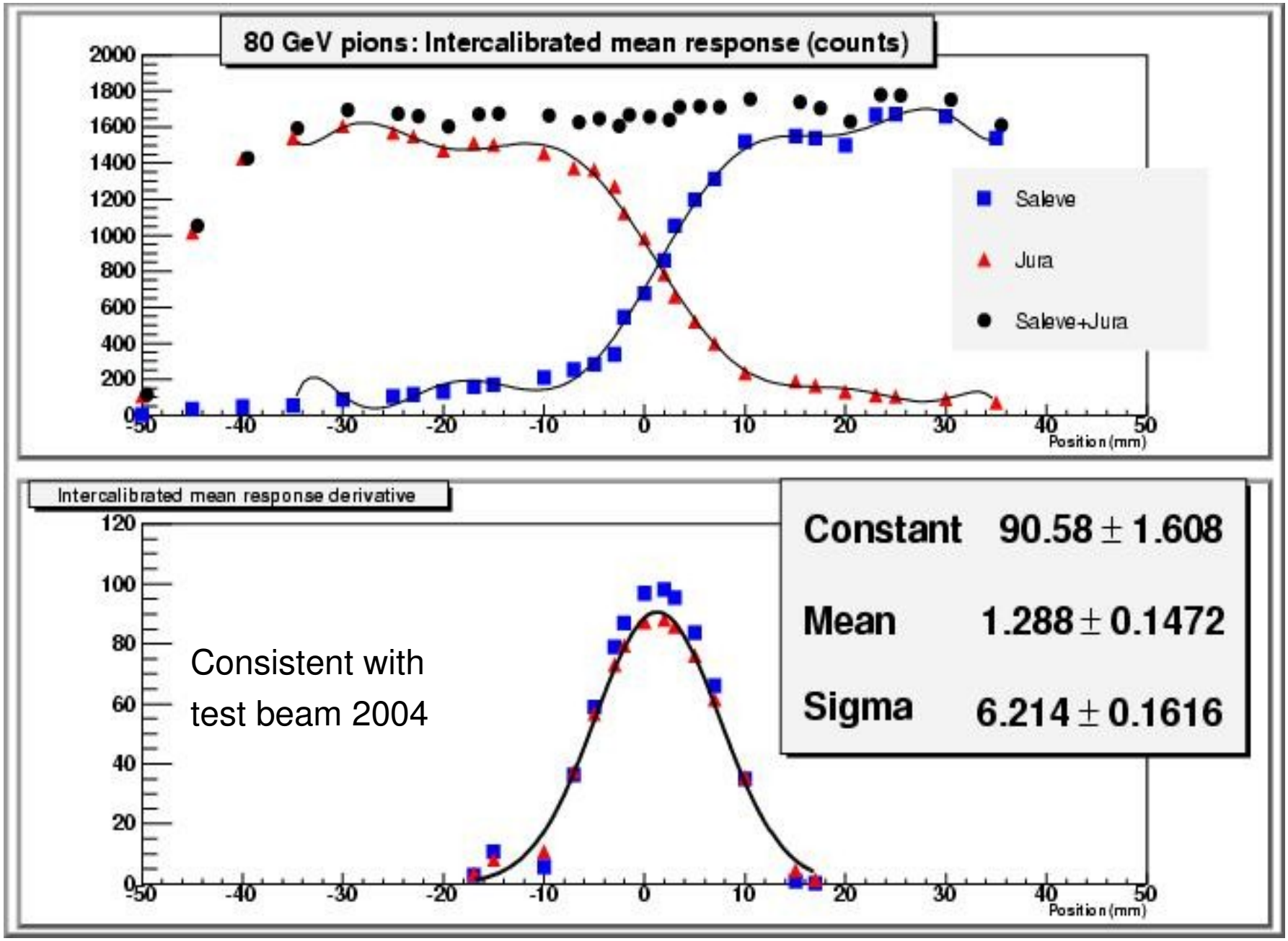
Observed signals of at least several mips; to be carefully checked with simulation



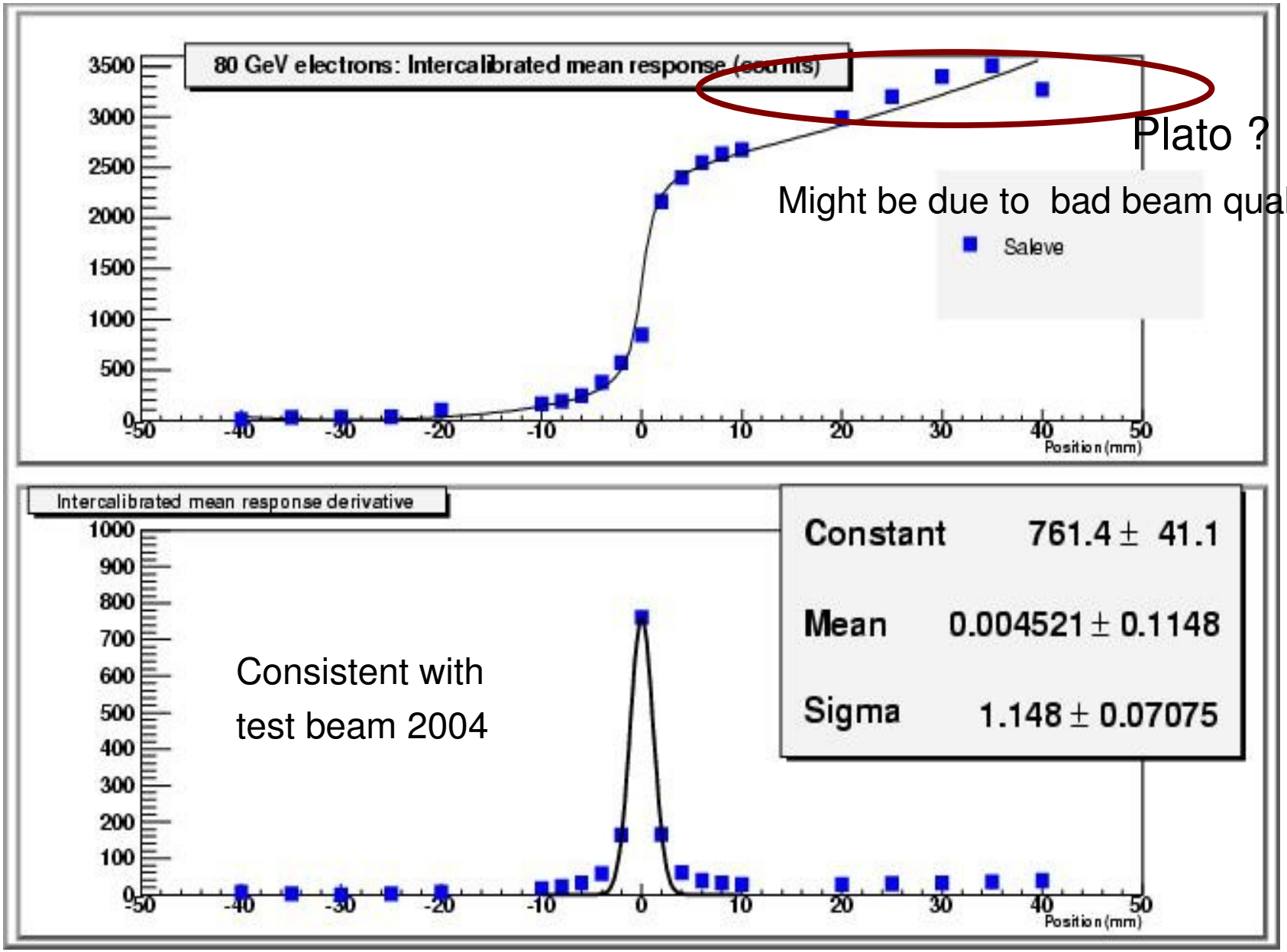
Position scan analysis

- Scan with 80 GeV pions:
  - Runs 35954, 35973, 35960, 35962, 35929, 35966, 35968, 35970, 35932 (before quartz replacement in HD1)
  - HD12 had bad PMT base => last 7 channels (both Jura and Saleve) excluded
  - Used two runs hitting semioctant centres to equalise response of corresponding Saleve-Jura channels
  - Beam profile cut: r < 5 mm
- Scan with 80 GeV electrons:
  - Just 1st try: Saleve side only
  - Runs 36151, 36147, 36144, 36128, 36136, 36140
  - Beam profile cut: r < 6 mm

Position scan with pions



Position scan with electrons



Summary and outlook

- Full-length calorimeter prototype thoroughly tested with beams of 10-350 GeV electrons, pions, muons
- Test beam analysis progressing well: preliminary results on response linearity/uniformity, energy resolution, shower width meet expectations
- Outlook: finalise results, perform comparison to simulation