Electronic Calibration of Hadronic EndCap Calorimeter on the ALTAS experiment

- **HEC calorimeter within ATLAS**
- **Our contribution to**
- **HEC electronic calibration**

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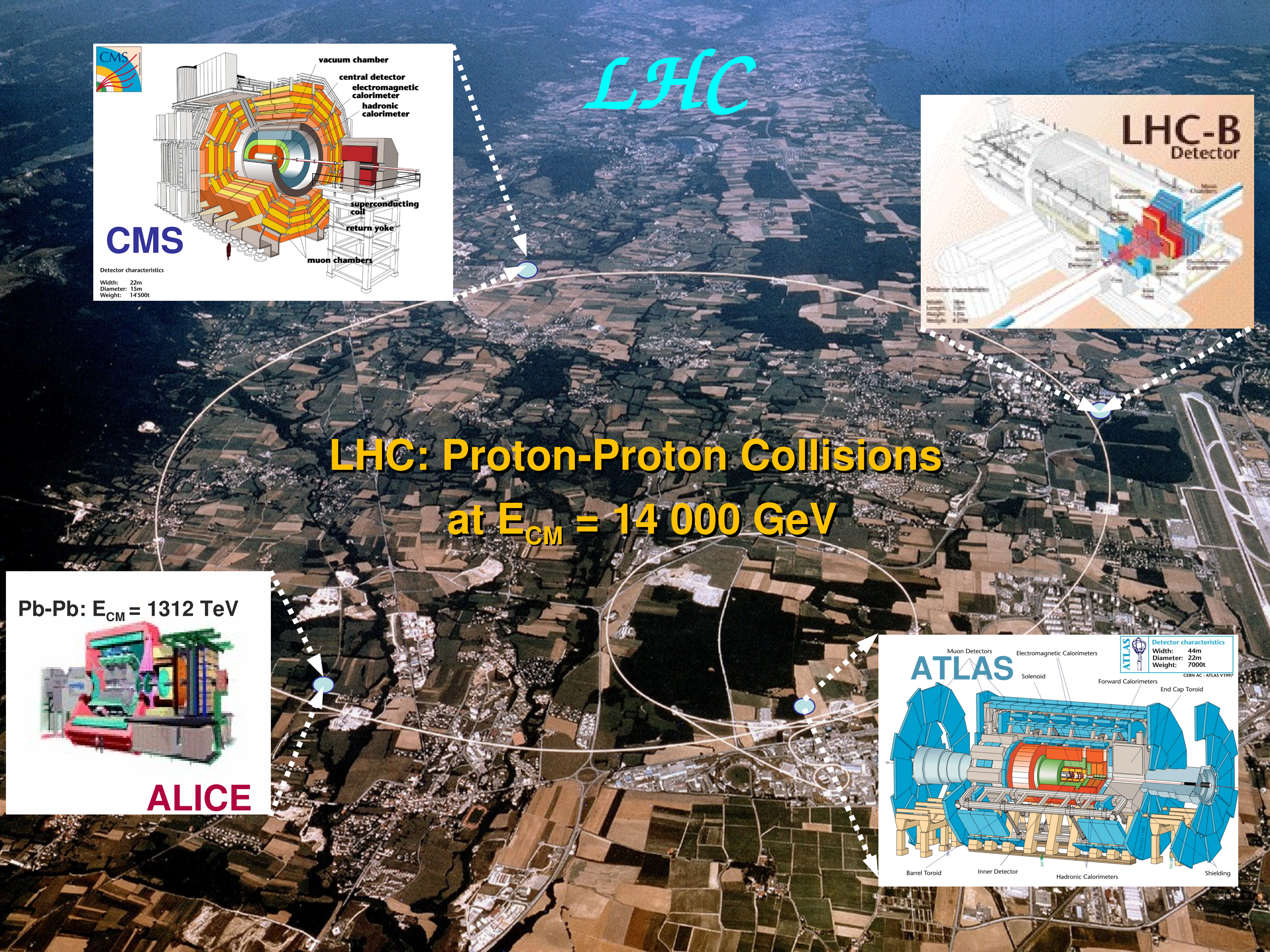
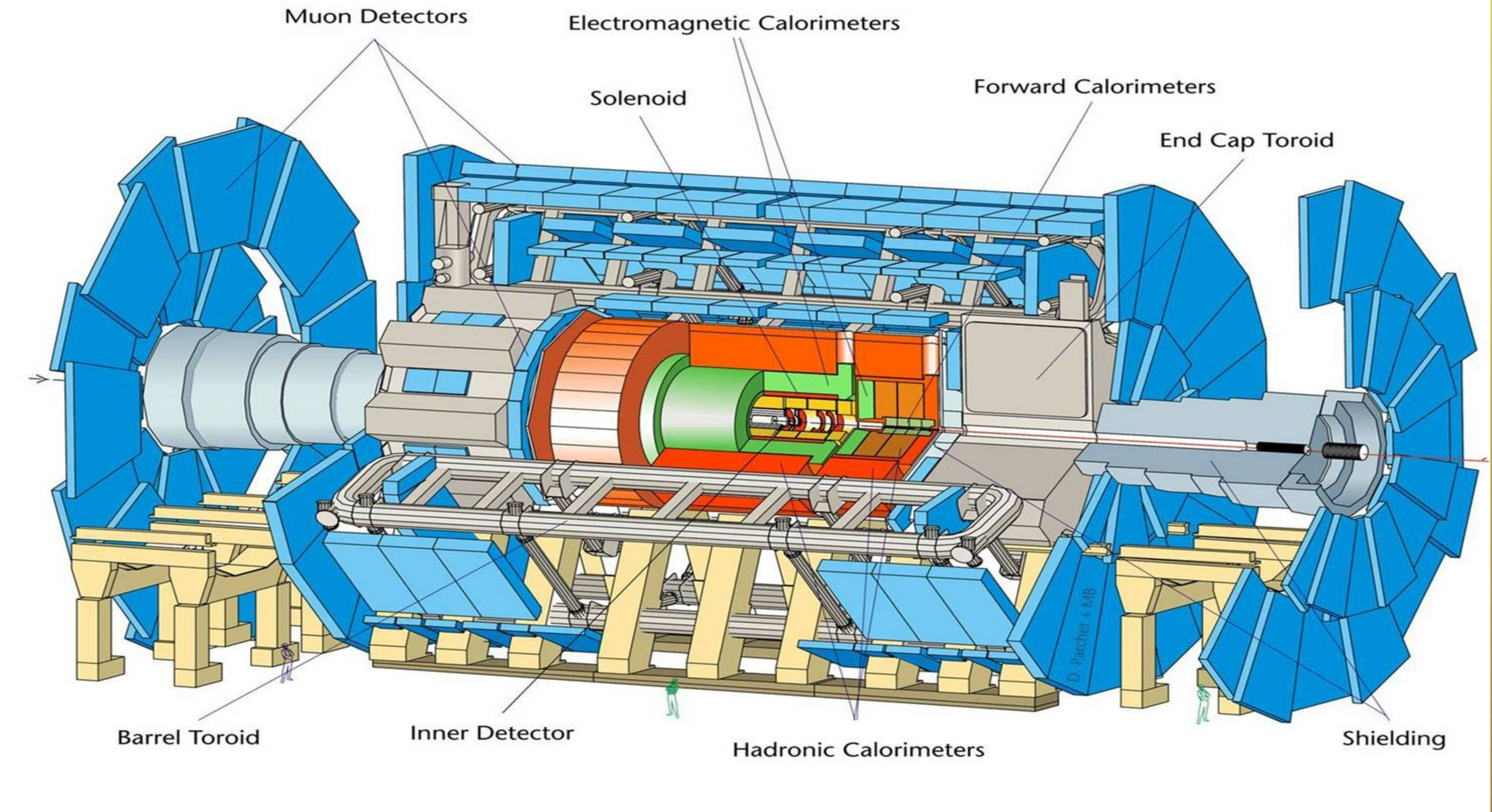
Prague, 31-January-2008


LHC
LHC: Proton-Proton Collisions
at E_{CM} = 14 000 GeV
CMS
vacuum chamber
central detector
electromagnetic calorimeter
hadronic calorimeter
superconducting coil
return yoke
muon chambers
CMS
Detector characteristics
Width: 22m
Diameter: 15m
Weight: 14'500t
LHC-B
Detector
Pb-Pb: E_{CM} = 1312 TeV
ALICE
ATLAS
Muon Detectors
Electromagnetic Calorimeters
Solenoid
Forward Calorimeters
End Cap Toroid
Detector characteristics
Width: 44m
Diameter: 22m
Weight: 7000t
CERN AC - ATLAS V1997
Barrel Toroid
Inner Detector
Hadronic Calorimeters
Shielding

ATLAS detector



Diameter	***25 m***
Barrel toroid length	***26 m***
End-cap end-wall chamber span	***46 m***
Overall weight	***7000 Tons***

Hadronic EndCap Calorimeter (HEC)

- **Sampling calorimeter:**

absorber: Copper plates

active material: **L**iquid**Ar**gon

- consist of two pairs of wheel each with:

depth of 4 m (~10 inter. lengths)

diameter of 7m

- **pseudorapidity range covered:**

1.5 < |eta| < 3.2

- cca 2x3000=**6000 channels**

HEC requirements

Physics motivation:

- The golden channel for Heavy Higgs (m_H>600GeV):

  H->WW, W->jet jet

  H-> b b_bar

- 1% error on the top quark mass

=> jet jet mass reconstruction, capability on jet identification

(jet spectroscopy)

- A0/H0 MSSM particles -> tau tau : good pt_miss resolution

=> **energy resolution**:

$$\frac{\Delta E}{E} = \frac{50\%}{\sqrt{E}} + 3\%$$

=> **fast response of electronics** for minimizing electronic and pile-up noise

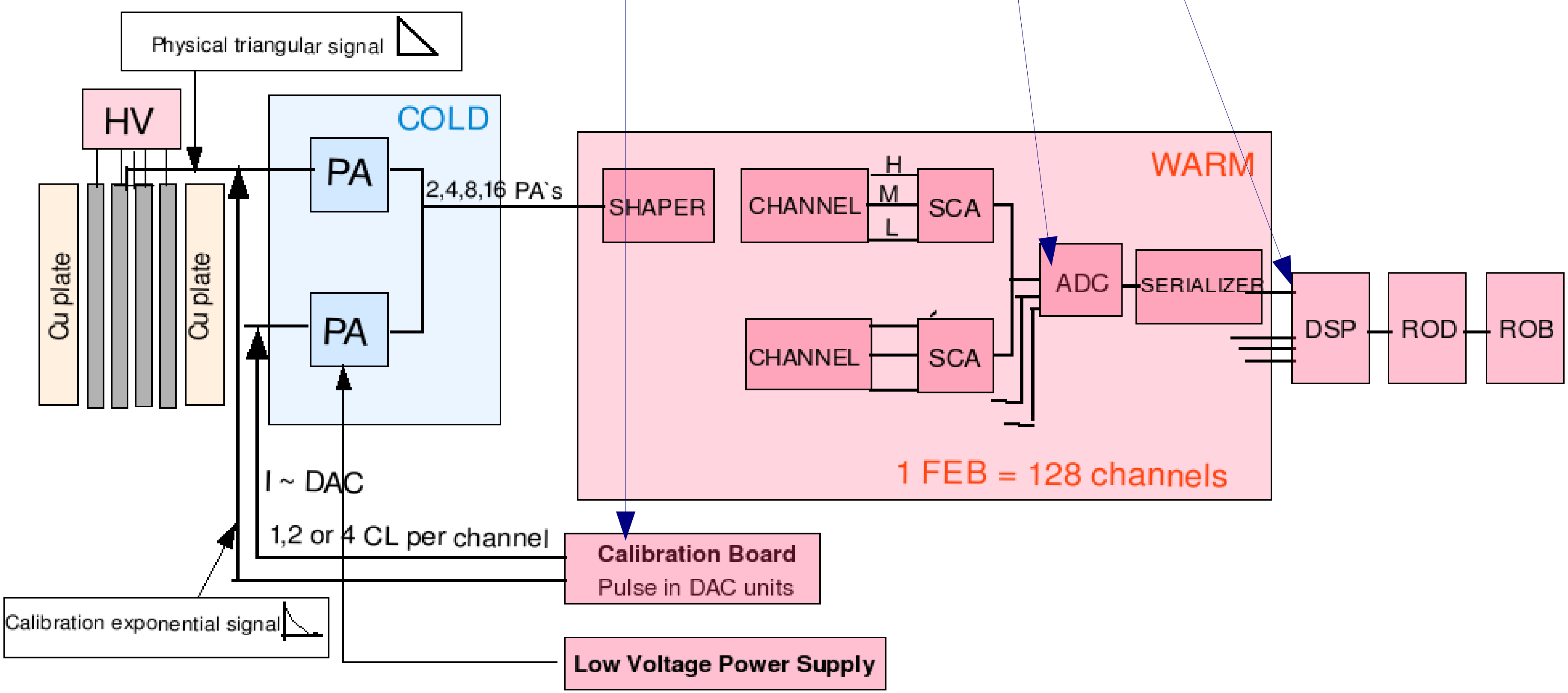
HEC electronics

<u>purpose of the electronics:</u>

- readout of the physical or calibration signal
- monitoring (see talk on topQuark Meeting 14.june 2007, Kosice) &
- calibration of the electronic system

HEC electronic chain

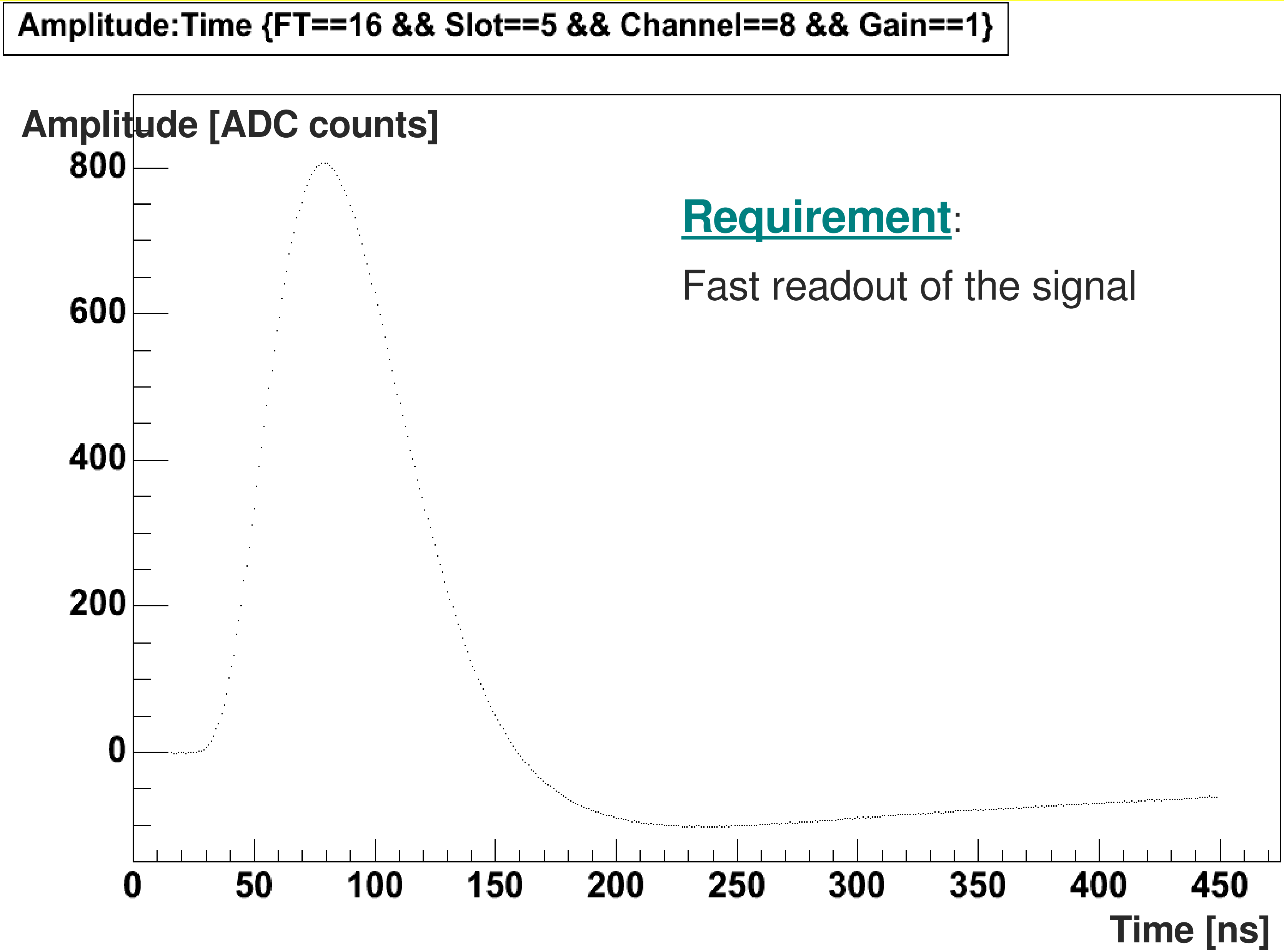
Important devices for calibration : **Calibration Board, ADC & DSP**



PA - preamplifier
SCA - switching capacitor array
Serializer – optimizes dignal for optical trnasition into DSP
H - High gain
M - Medium gain
L - Low gain

1 spec crate: 6 HEC FEBs + 17 EMEC FEBs
2 LV Power Supplies
1 HEC Calib Board + 2 EMEC CB's

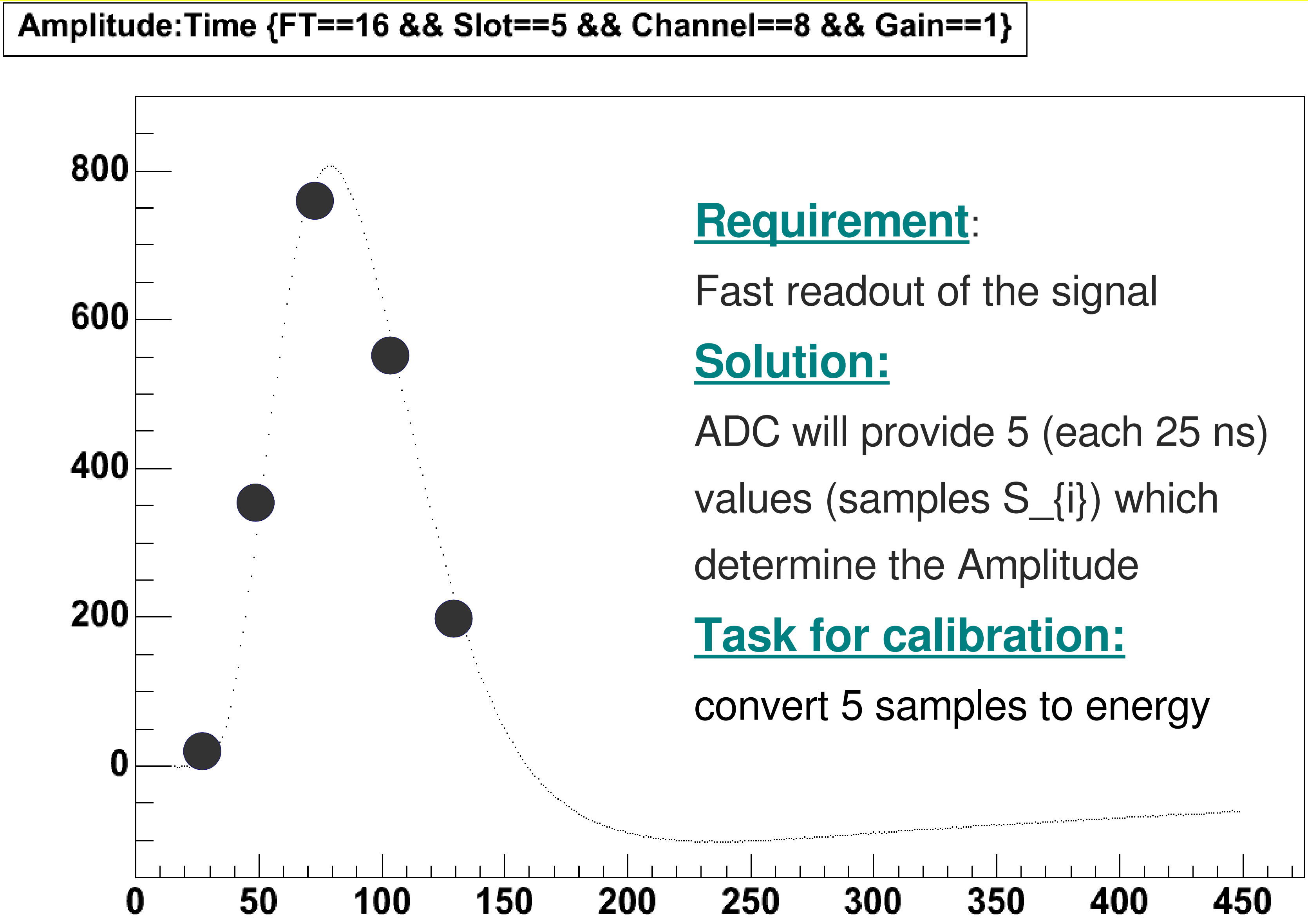
ADC: Sampling of signal



Requirement:

Fast readout of the signal

ADC: Sampling of signal



Requirement:

Fast readout of the signal

Solution:

ADC will provide 5 (each 25 ns) values (samples S_{i}) which determine the Amplitude

Task for calibration:

convert 5 samples to energy

Electronic calibration

- **purpose:** transformation of the charge/current on the energy in MeV
- **procedure:**
  - calibration pulses produced by Calibration Board
  - since no real physical signal => prediction of the signal performed via our software tool
  - all the calib constants need to be written to DB and loaded into DSP

Calibration constants

$$E_{(MeV)} = \underbrace{Ampl_{(ADC)} * M_{phys} / M_{cali} * F_{(ADC \to DAC)} * F_{(DAC \to \mu A)}}_{properties\ of\ electronics} \underbrace{* F_{(\mu A \to MeV)}}_{detector}$$

well determined :

$$F_{(DAC \to \mu A)} = \frac{76.295 \mu V}{R_{inj}}, \ R_{inj} - injector\ resistor$$

$$F_{(\mu A \to MeV)} = \frac{1}{I/E \times f_{sample}}, \qquad I/E - energy\ to\ current\ conversion$$

$$f_{sample} - sampling\ fraction$$

our task: to determine:

$$Ampl_{(ADC)}, M_{phys}/M_{cali}, F_{(ADC \to DAC)}$$

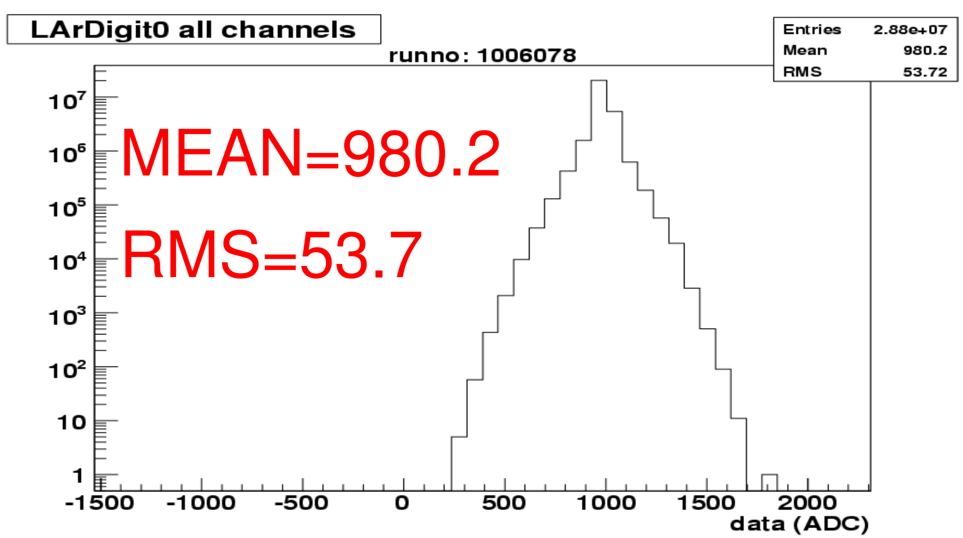
Pedestal determination

Procedure: special runs taken without beams or calib pulses for

- noise monitoring
- pedestal determination (for energy reconstr.)
- autocorrelation matrix calculation (for energy reconstr.)

Results:

Pedestals: ~1000 ADC counts



Autocorr matrix:

$$V_{ij} = \langle S_i * S_j \rangle$$

$$i, j - samples$$

Amplitude determination

Procedure: special runs taken with calibration pulses

$$Ampl_{(ADC)} = \sum_{i=1}^{Nsamples} OFC_i * (S_i - Pedestal)$$

computed   measured

Ampl: amplitude of signal (in ADC count)

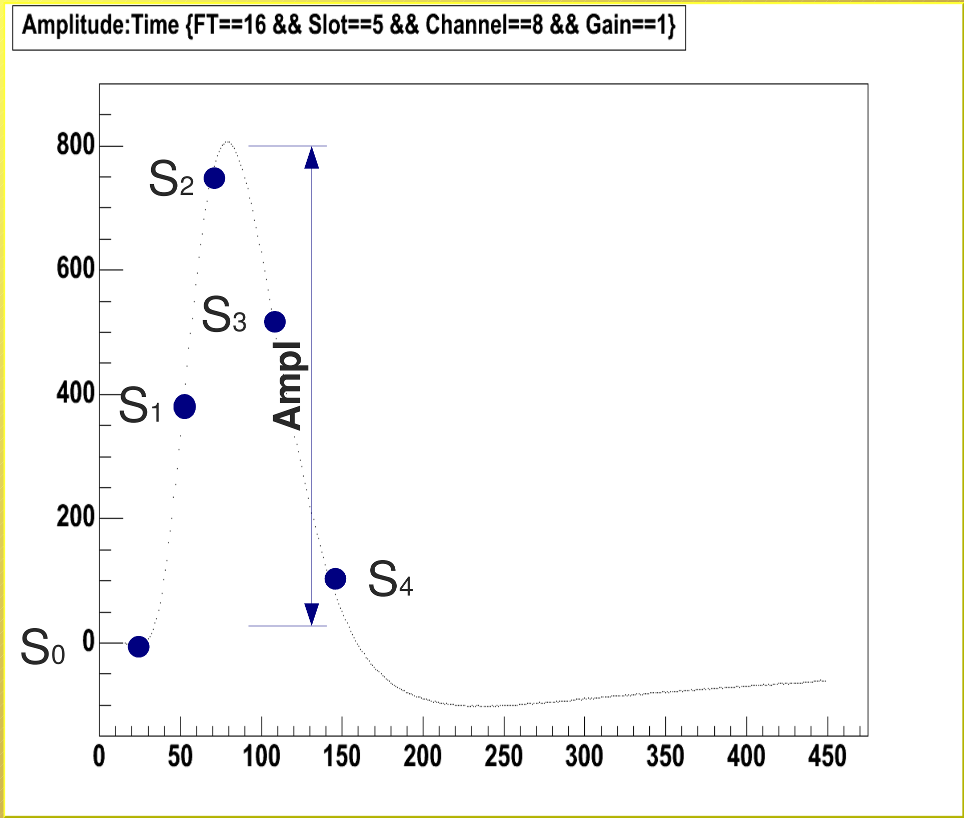
Pedestals: measured (see slide before)

S_{i} : sample - measured

OFC - **O**ptimal **F**iltering **C**onstants

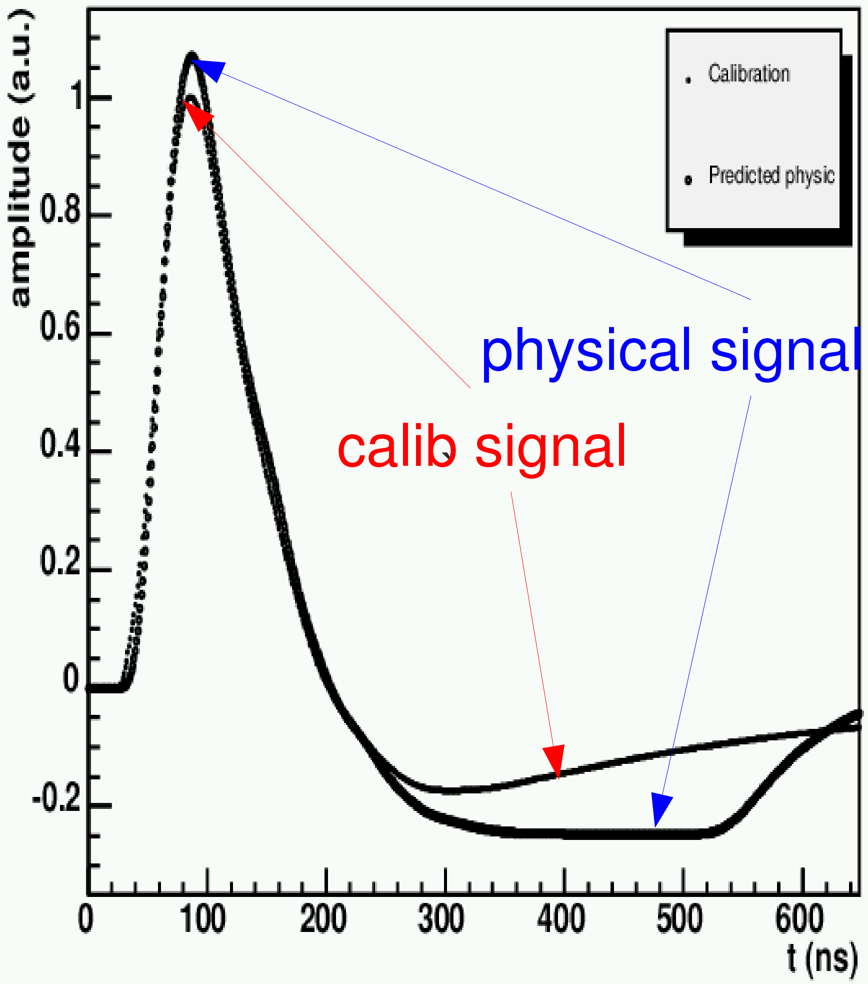
calculated via:

- normalized shape and its derivation
- noise autocorrelation matrix



Mphys/Mcal determination

Purpose: correction on the difference in amplitude between physical and calibration signal = Ampl(phys)/Ampl(calib)



- The physical and calibration shapes exhibit non-negligible difference

- **Consequences:** on the
  1) Amplitude/Energy reconstr and
  2) different OFC for phys and calib signal

- **Idea:** Since there are no real data at the moment the phys signal must be predicted by **new software tool**

Prediction of physical signal

Task: new tool for prediction of physical signal

Question: How to do it ?

Answer: conversion of calib signal in 2 steps

1) **extraction of parameters** for calib signal: Tdrift, Tcal – define exponential signal before shaping -standard method implemented in the ATLAS software Athena

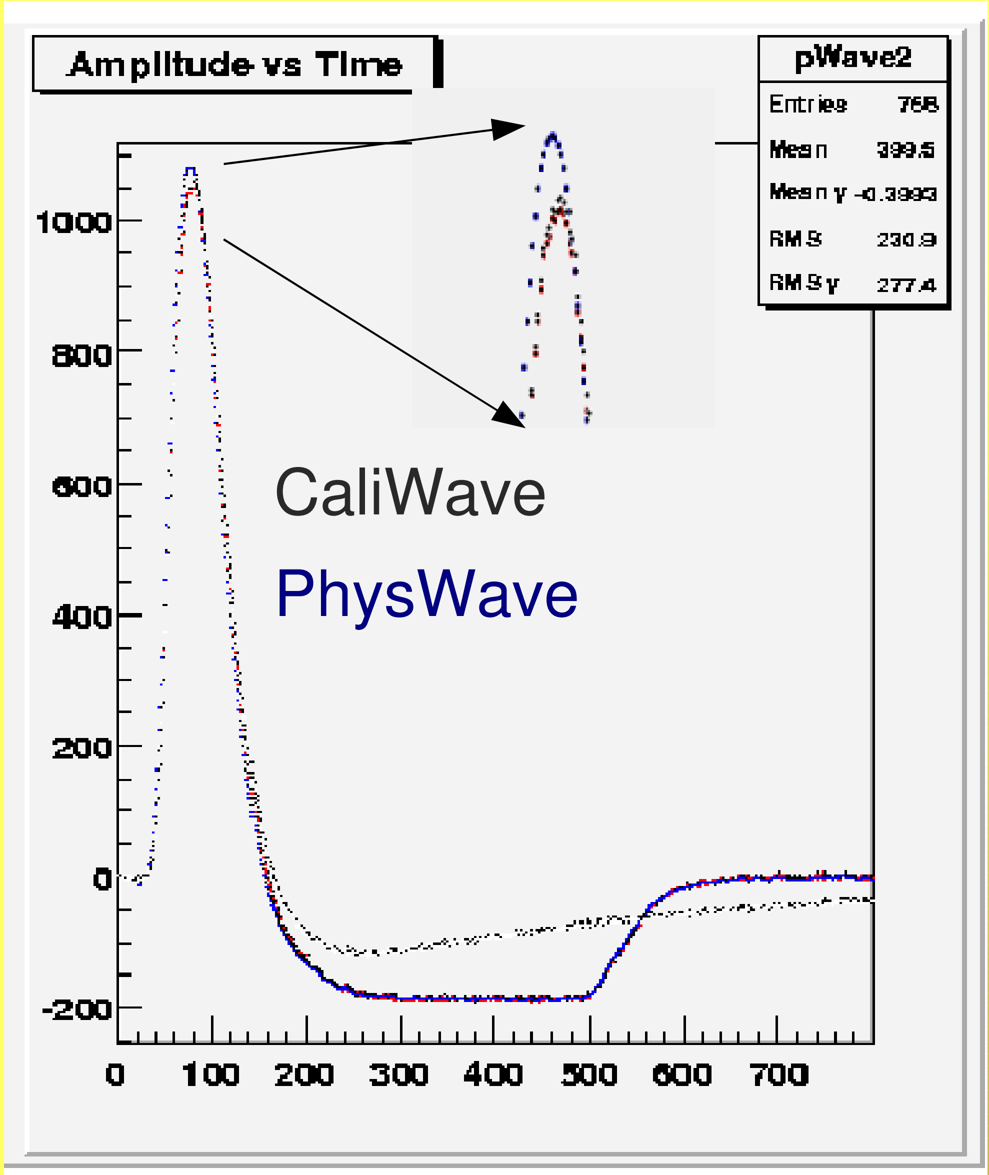
2) **conversion of CaliWave to PhysWave** using parameters from 1) & drift time Tdrift= 449.7 ns – det. property

perfomermed via integrating rather oscilation integrands

$$T_1(t) = \int_{t-d\tau}^{t} T_c(x) R_d(t-x)\,dx \quad and \quad T_1(t) = \int_{0}^{t-\tau\, dt} T_c(x) R_o(t-x)\,dx$$

not trivial solution for integration: standard methods did not work => we had to use GSL library, namely **qawo** function devoted for numerical integration of oscillating functions

Results from new HEC PhysWave Tool

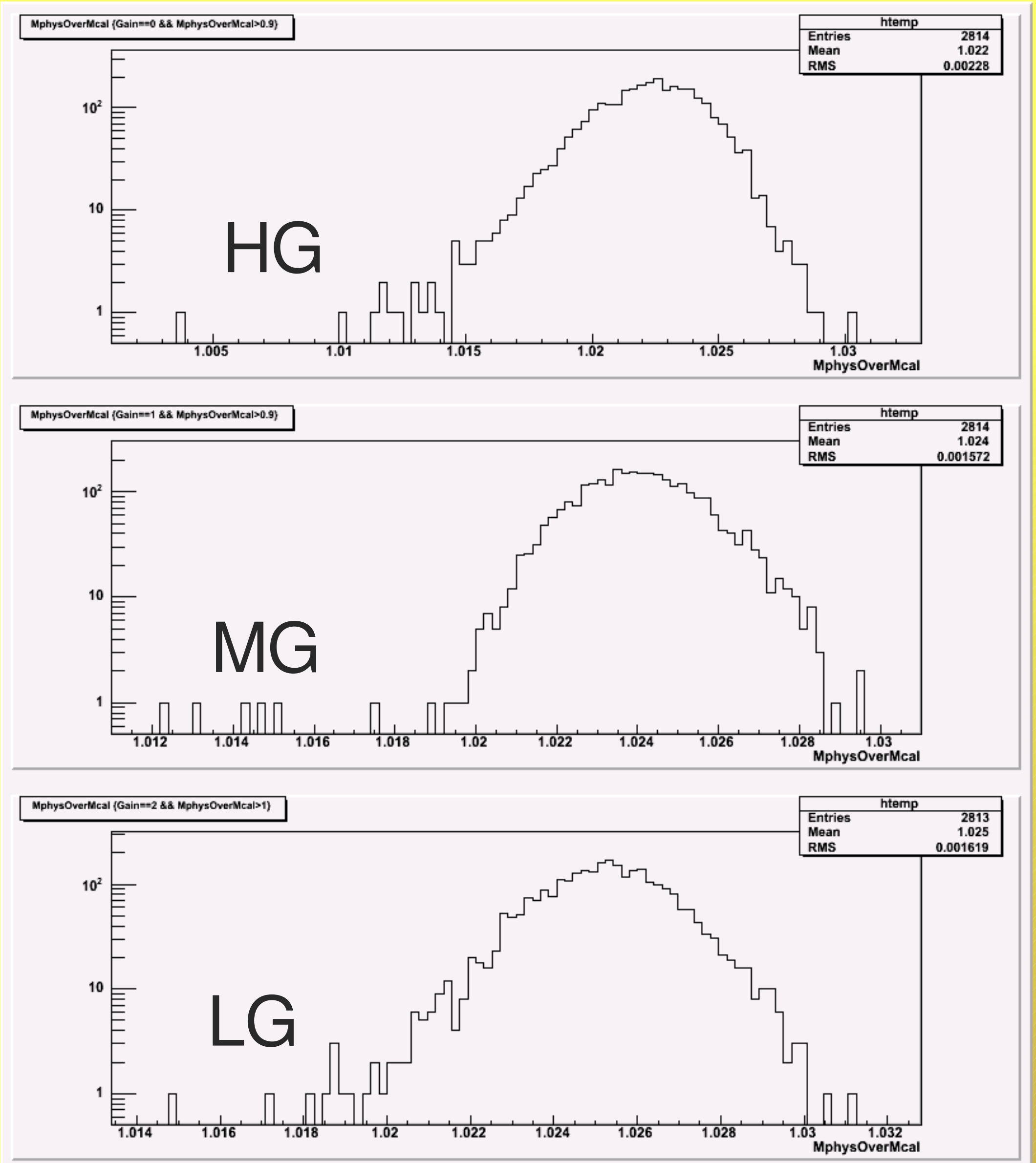


- **New Tool:** Amplitude is ~2.4% bigger than for CaliWave – as expected!

Tail: as expected from phys signal!

- **Conlusion:** our tool works fine

Results for Mphys/Mcal



- Tdrift=449.7ns
- <Mphys/Mcal> gives

  1.022 (High Gain)

  1.024 (Medium Gain)

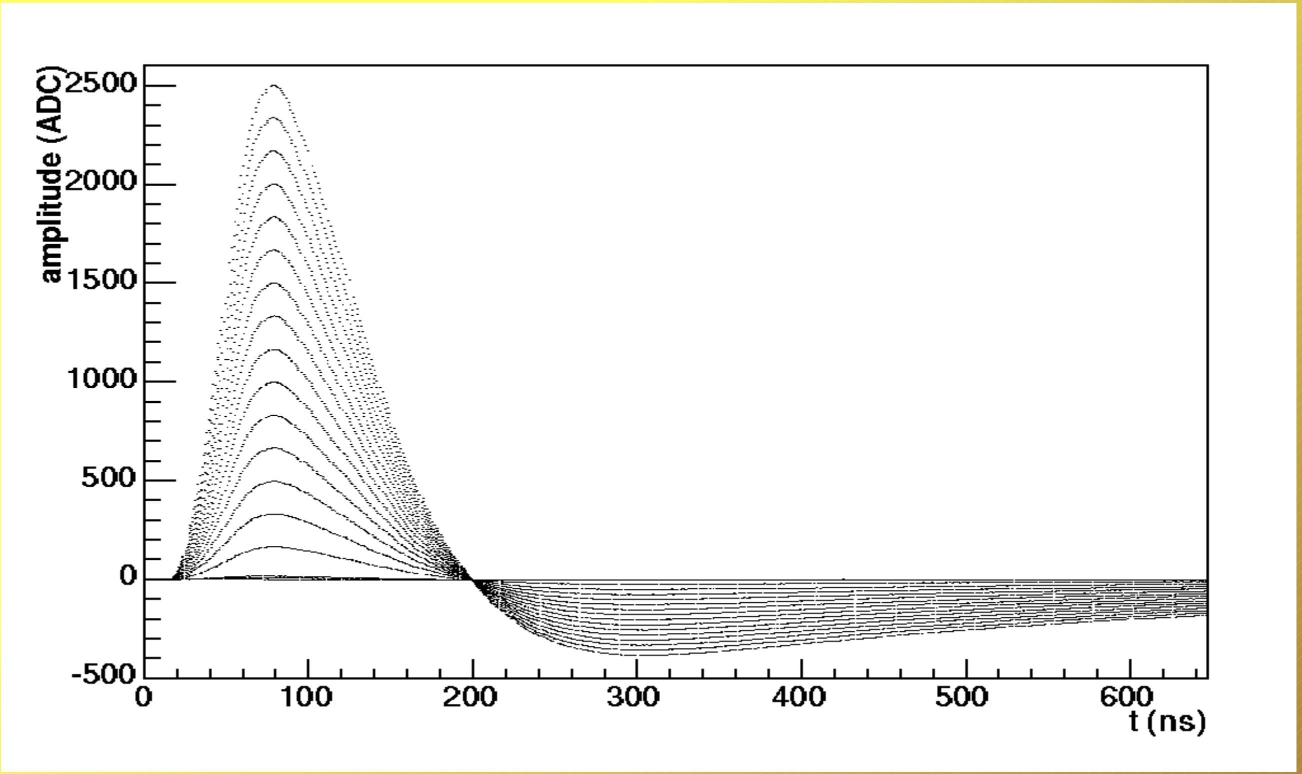
- 1.025 (Low Gain)

F(ADC->DAC) determination

Purpose: converts Amplitude to DAC units and monitor gain instabilities

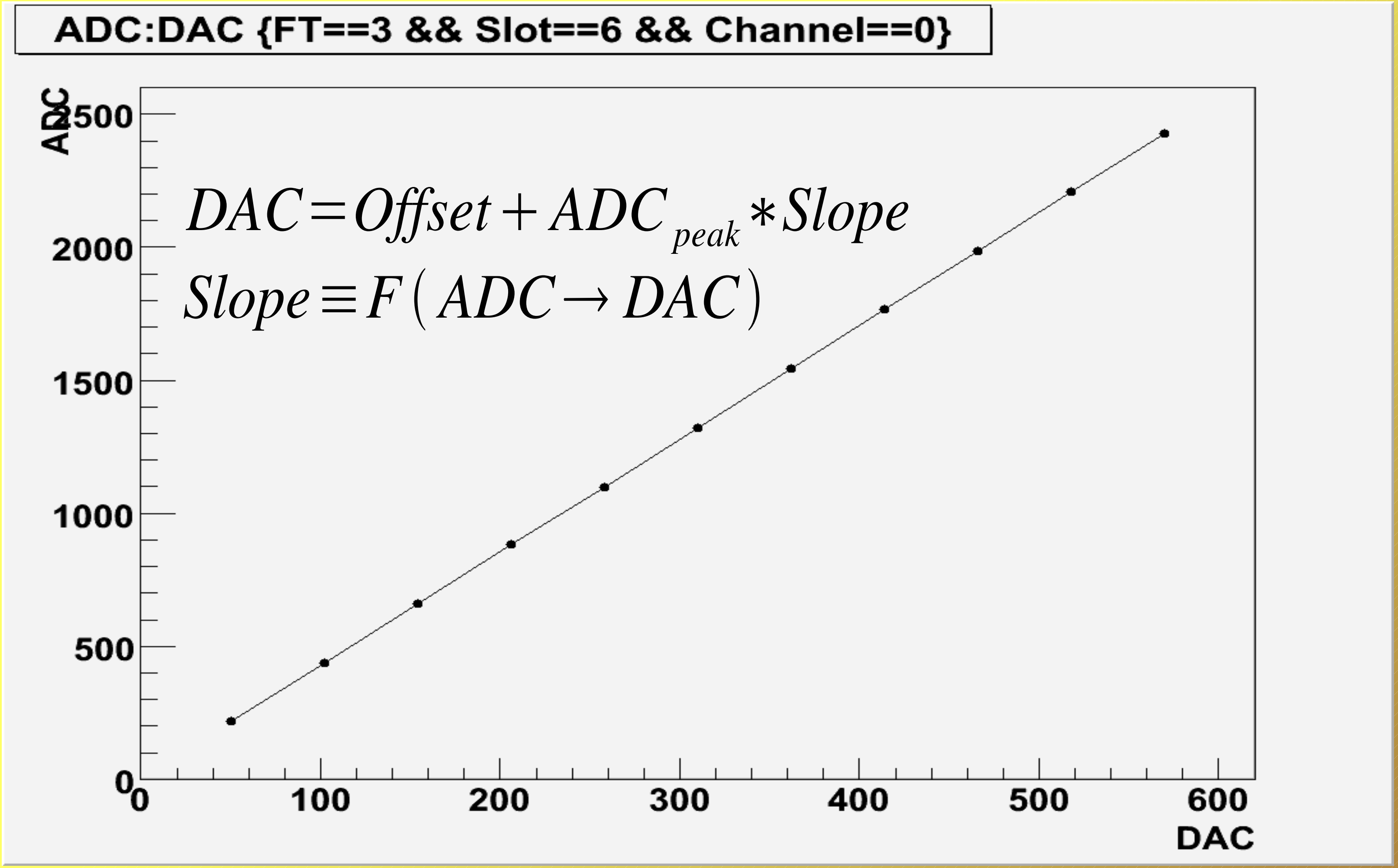
Procedure: special calib runs (ramp) runs with differrent values for DAC values – pulse strengt

Taks: find relation between Amplitude in ADC and DAC



F(ADC->DAC) determination

- Amplitude is calculated by OFC method
- F(ADC->DAC) is obtained from the fit:



$$DAC = Offset + ADC_{peak} * Slope$$

$$Slope \equiv F(ADC \rightarrow DAC)$$

Summary on the constants

- two set of constants were obtained:

1) **calibration constants:** (accessory constanst used for computation of physical constants)

CaliWave, OFC cali, PhysWave, PhysShape

2) **physical constants:**

Pedestal & Autocorr, Ramps, MphysOverMcal,OFCPhys

- both set of constants were written into DB and are used for reconstruction of first cosmics data

Summary and Outlook

Our contribution to HEC calibration:

- **tool for prediction of physical signal** was developed
  - is not yet in public/official (in group area)
- **all calibration/physical constants were calculated and written to DB** and are used in the reconstruction in the first cosmics data

Outlook:

- to make our tool for PhysWave prediction public
- to make monitoring tool tools public (I mentioned them in the last topMeeting)

Tool for Prediction of PhysWave for HEC: Changes in the code

- new TOOL: **LarPhysWaveHECTool.cxx**

- **Method developed** for Phys Wave Prediction**:**

makeLArPhysWaveHEC(..input...) - performes integration of

rather oscillating function -> standard methods do not work=>

Integration is performed by using GSL library, namely function :

gsl_integration_qawo (&gsl_func,a, epsabs, epsrel, limit, w, wf, &result, &abserr)