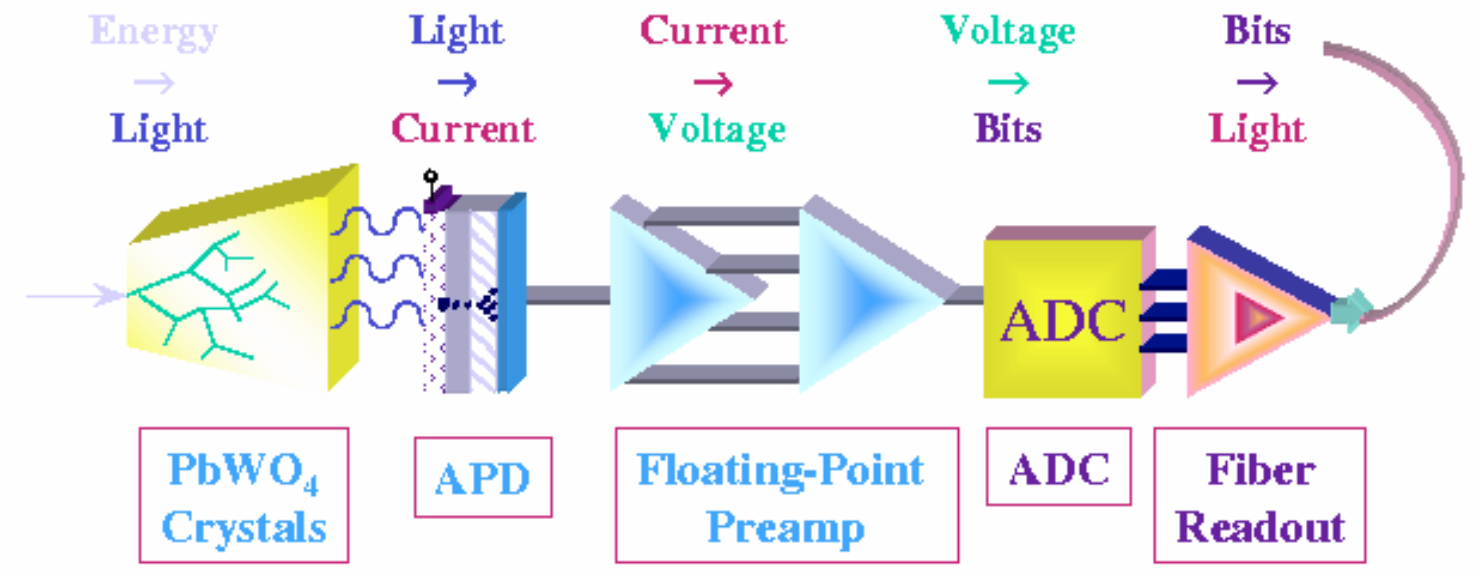
CMS-ECAL Readout Chain



Overview and Problematics

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9 October 2001

CMS-ECAL CERN

Overview of the Presentation

- Aim is
  - to Show the Problematics

  linked to the Readout Chain

  w.r.to Resolution & Calibration of the CMS-ECAL

- In the present talk
  - After **Overview** of ECAL

  → Description Readout Chain
  - **Main streams** of Readout Chain
  - Hallmark the **Sensitive points**
  - Discuss the development of

  Tools for **Digitization** and

  Energy Reconstruction

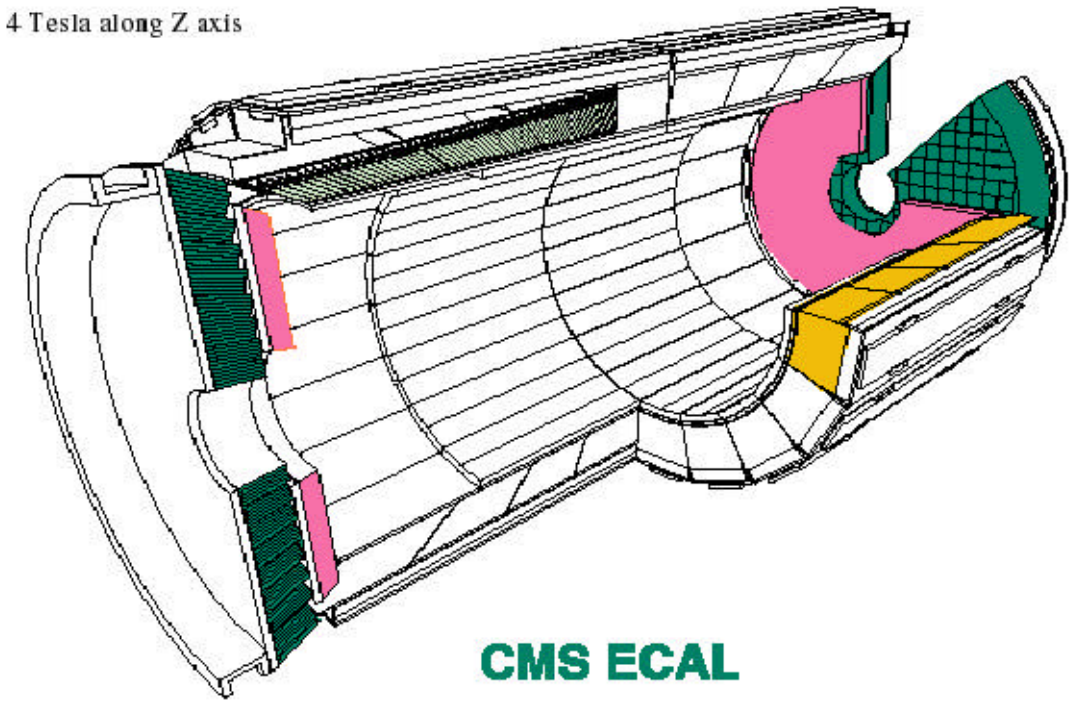
Overview of the ECAL

- 61'200 $PbWO_4$ crystals

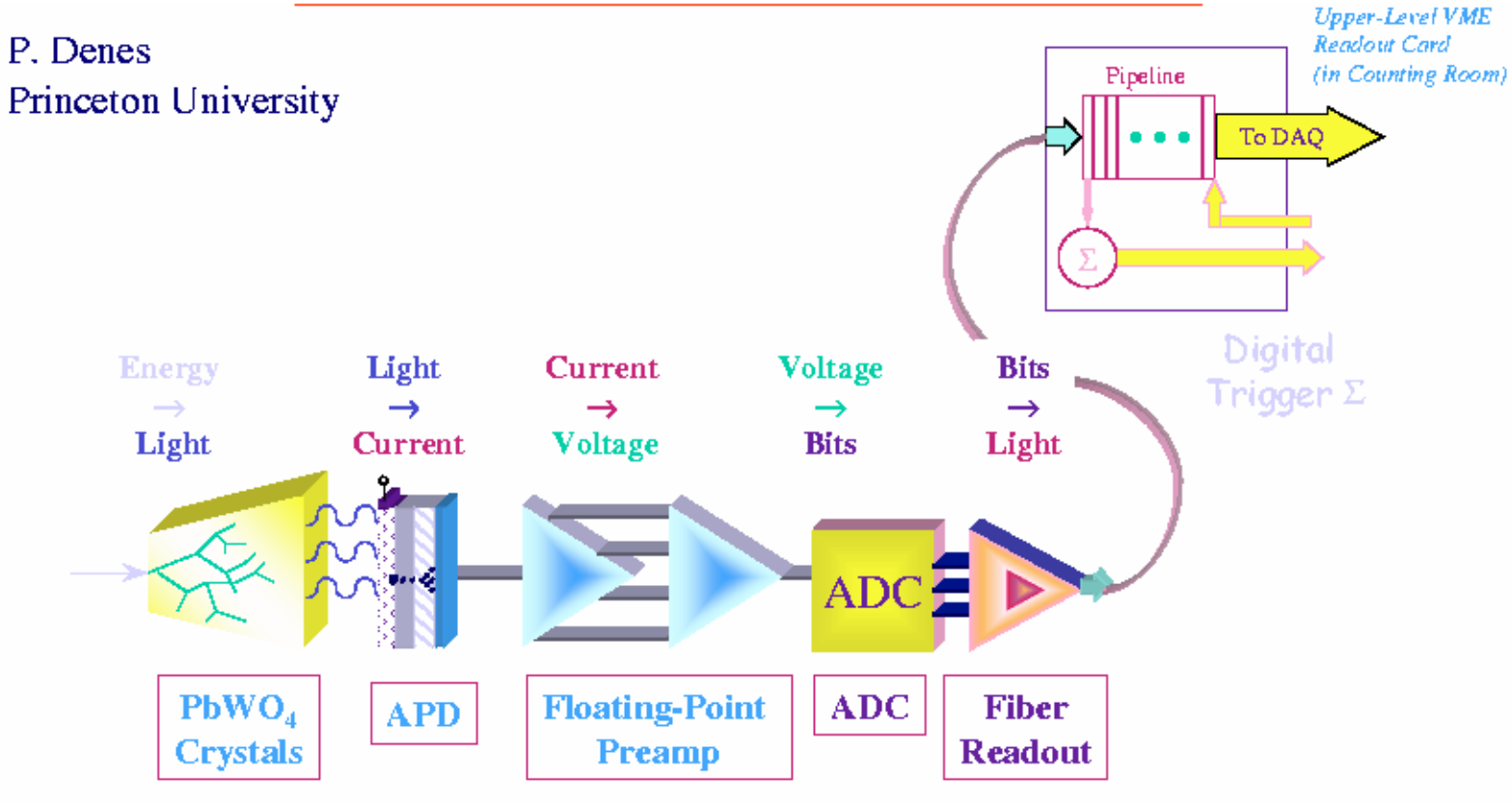
  in the barrel with off-vertex pointing geometry

- mounted with laser monitoring

  to follow evolution of Light Transmission with radiation.



Overview of the Readout Chain



Main Streams

- Q $\rightarrow$ V $\propto$ deposited energy in crystals

  $\leftrightarrow$ Preamplificator

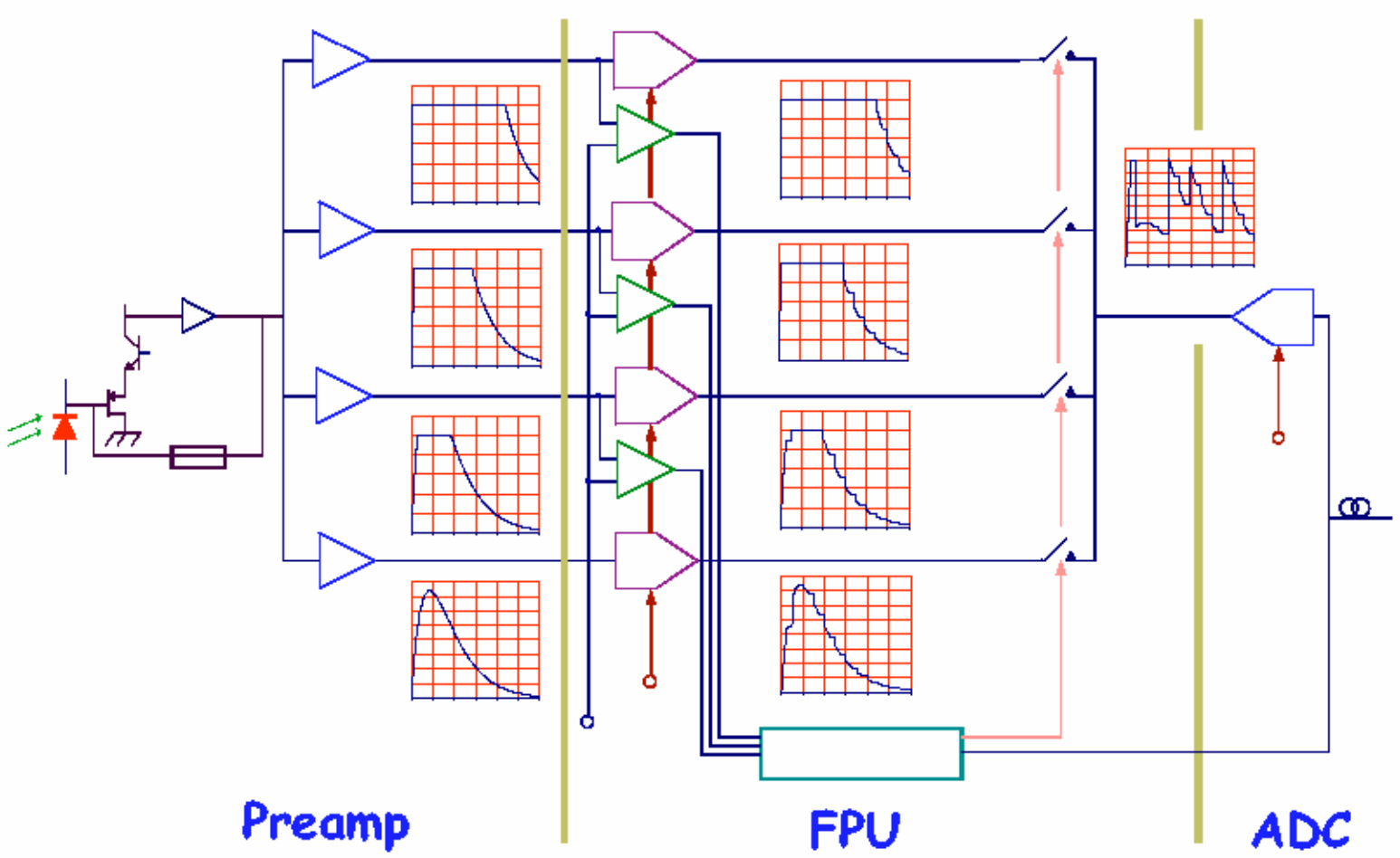
- 90dB dynamic range $\rightarrow$ 1.5TeV

  $\leftrightarrow$ Multi-gain stage

- Signal digitization | no loss in cables until ULR

  $\leftrightarrow$ ADC & optical link

Details of Readout Chain



APD's

- 2 APD's/crystals

  ≡ 5% of crystal rear surface with 80% Quantum Efficiency

  and Gain of 50

  Highly contribute to noise due to 77pF capacitance : 4000e^- → 10k-e^-

- Why ?

  Crystals ⊃ low Light Yield of 4p.e./MeV/Gain ⇒ Gain

  Strong magnetic field of 4T

- Output is

  0 → ~60pC for 0 → 1.5TeV energy deposit.

  Typically 50GeV energy deposit in crystal → 1.6pC

  10k-e^- noise ≡ 50MeV

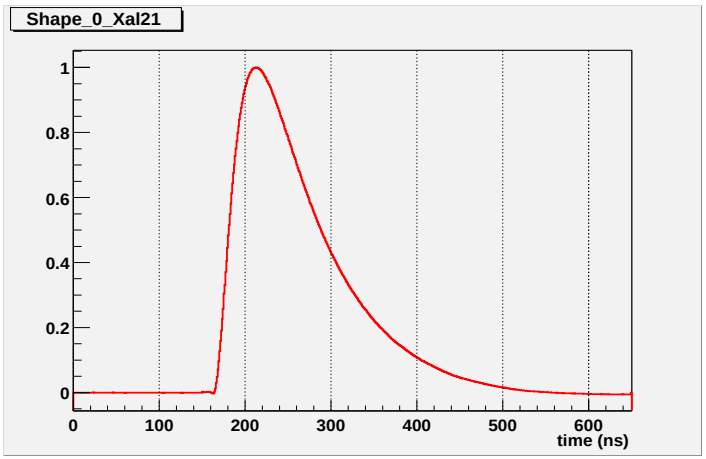
Preamplificator

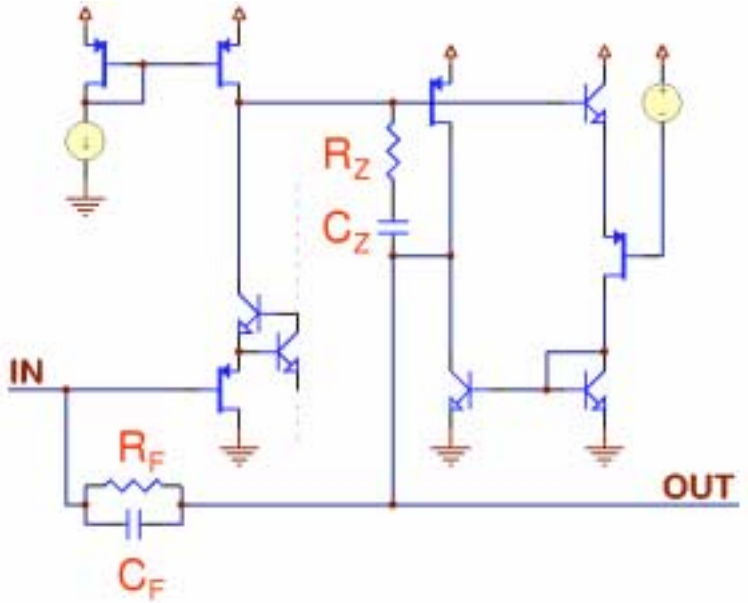
- Converting

  Q → V with 24mV/pC
- with 2 stage-amplification

  with same time constant of 43ns
- and shaping

  of the form $t/\tau \cdot e^{-t/\tau}$





50GeV signal → a pulseshape peaking at 38mV

10k-e^- ↔ 38µV

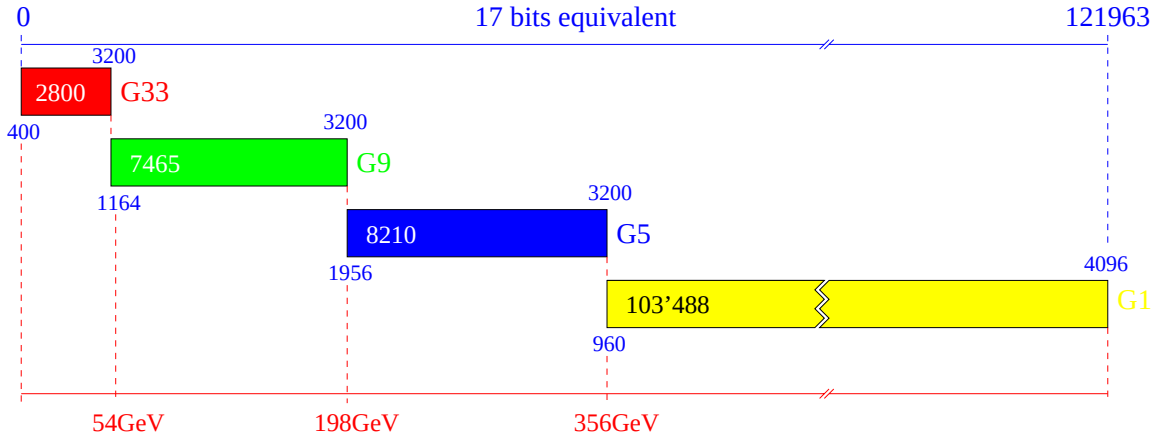
Multi-gain Stage 1/2

- Aim is 90dB dyn. range ≡ 17bits with 10k-e⁻ noise

  but only 12 bit radiation hard 40MHz ADC

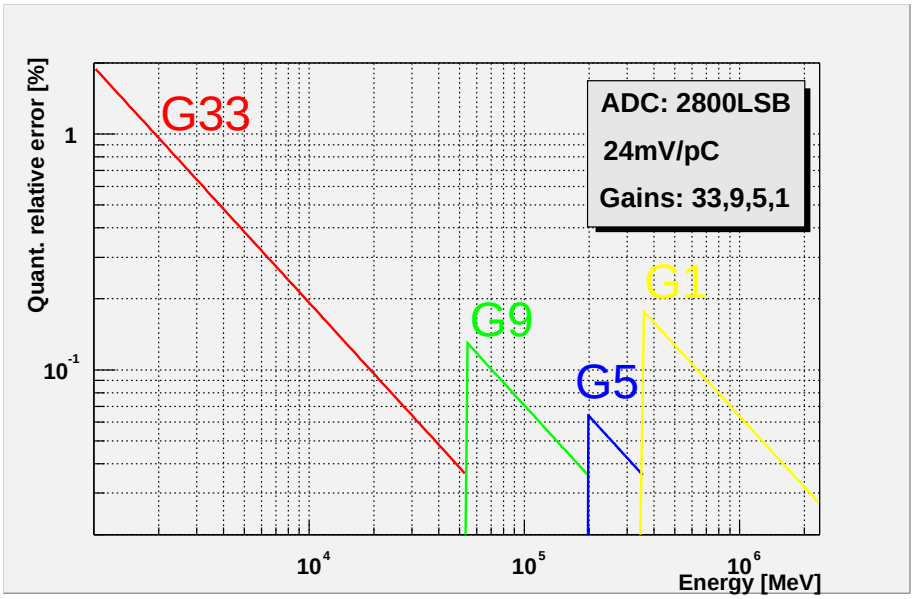
  so needs amplification

  with gains G33 → G9 → G5 → G1



- such as to keep low quantification error

  over all dynamic range → 1.5TeV



50GeV signal → 1.27V 10k-e⁻ noise ↔ 1.27mV

Multi-gain Stage 2/2

- Amplify output of FPPA

  in parallel by gains 33, 9, 5, 1

- compare signal

  in each gain with threshold @ 80% of voltage range

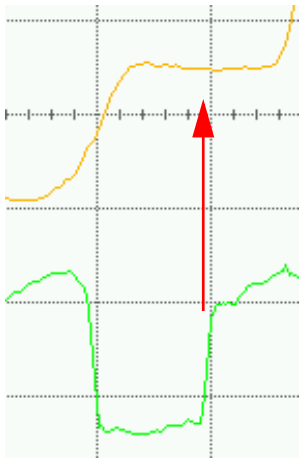
- The logic chooses

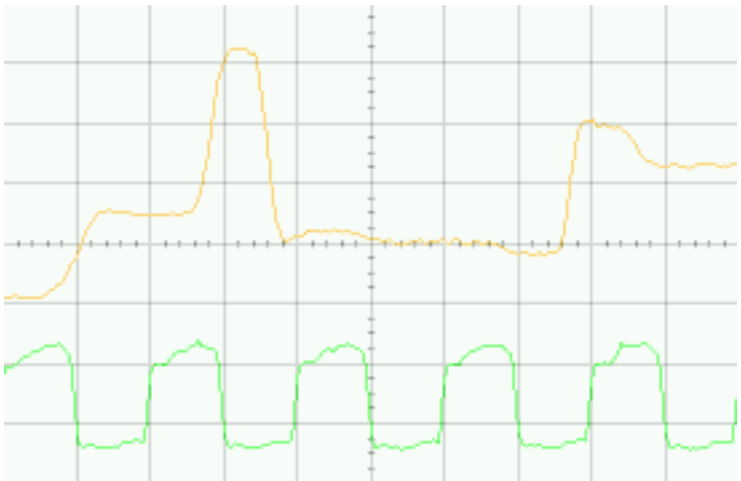
  the highest gain below threshold and set the MUX to that gain @ each clock counting 40MHz

- S/H insures

  that signal is stabilized @ ADC digitization

- We end up with





Digitization

- Output buffer

  adapts FPPA voltage range to ADC with multiplication coeff. of 1⁄2

- ADC

  → 12 bits

  pedestal @ 400 ADC counts

- via optical link

→ Upper Level Readout
@ $20 \times 40\,\mathrm{MHz} = 800\,\mathrm{MHz}$

50GeV signal → 400 + 2600 = 3000 ADC counts

10k-e^- noise ↔ 2.6LSB

Sensitive Points

- Hallmark the points

  suspected to affect the resolution and master them

- APD

  is taken as input signal for different particles

  e^-, γ w.r.to laser,

  or background pile-up,...

- Preamp'

  linearity of amplitude v.s. energy

  stability of pedestal

  independance from trigger phase w.r.to clock

  $\leftrightarrow$ dispersion of peaking time

- Gain

  should not affect the preamp' response

  reach stability @ gain switches

- as an example

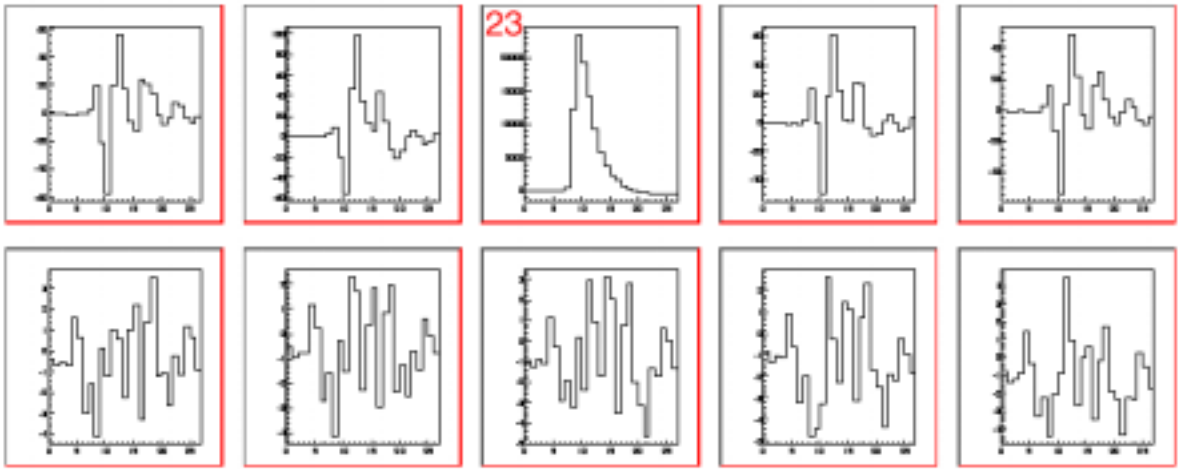
  cite the Crosstalk issue...

The Crosstalk Problem

- 5 channels readout card

  showed oscillations @ 1.5GeV level

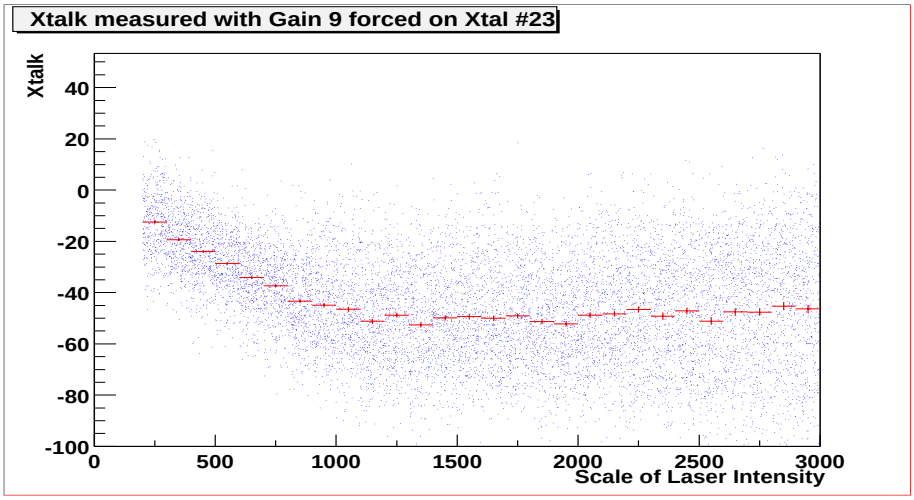
  and crosstalk via capacitive coupling 2GeV p-p



- Lab test performed

  by analysing both analog (scope) and digital (DAQ) signals

  Origin of crosstalk isolated and matched with setting of preamp' DC functionning value



Sensitive Points & Resolution

- Example of crosstalk shows

  that physicists focus

  on understanding the details of VFE electronics

- and

  on hallmarking the key points in the readout chain

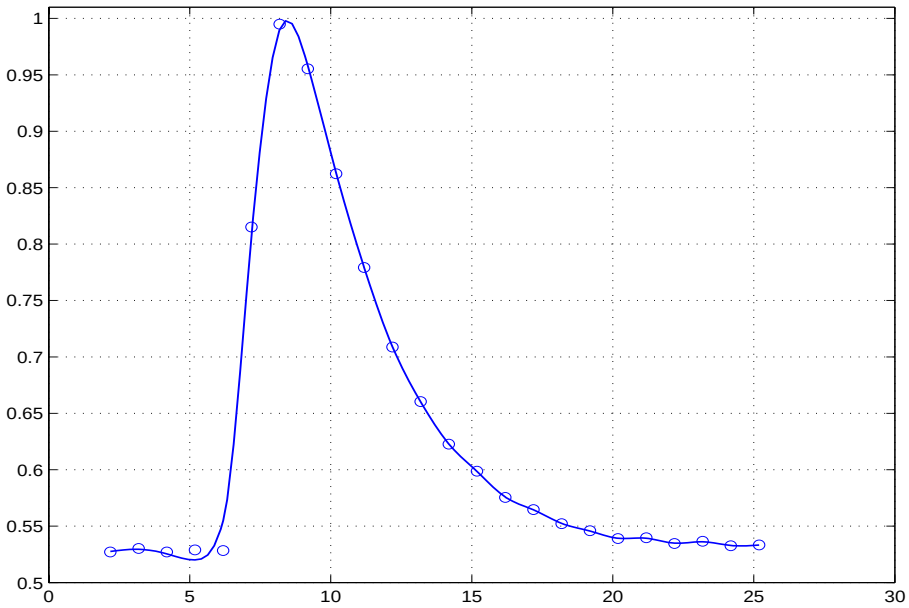
  together with their role in the resolution

- Now, the resolution reveals itself

  in processing the sample data and reconstructing the energy

- This needs

  to be tested and optimized w.r.to sensitive points



Energy Reconstruction & Digitization

- Development of an Energy Reconstruction tool

  taking into account particular aspects of noisy, digitized data

  ↔ «Smoothing Splines» reached better than 4‰ resolution @ low energy with inperfect FPPA

- and of a Digitization/Simulation

  in order to parametrize the key parts of the Readout Chain

  and test the energy reconstruction tool.

Suite l'année prochaine