APD Measurements for the Tile HCAL

APD measurements in e^+-testbeam

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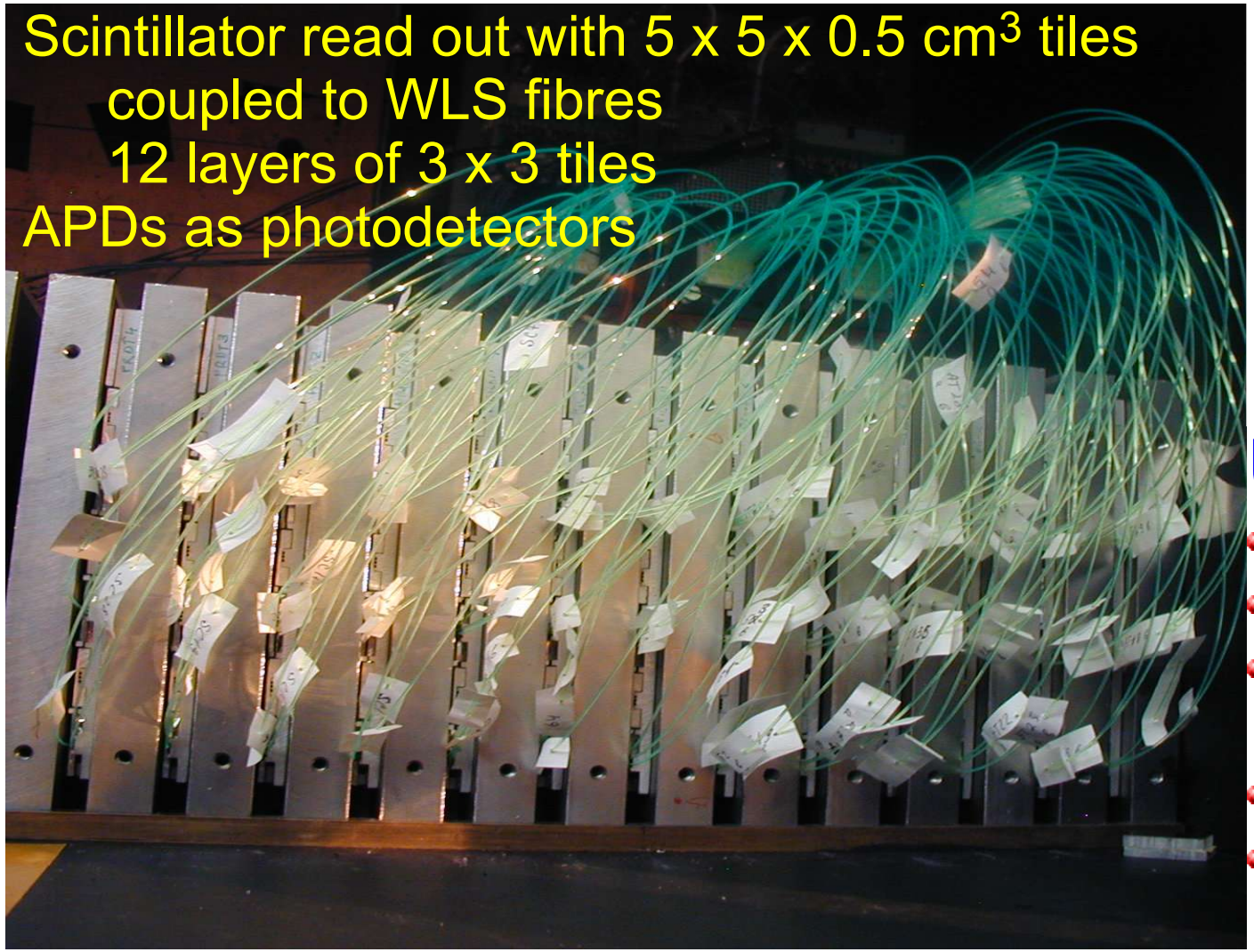
for CALICE – HCAL collaboration

- The MiniCal
- Measurement Setup
- Results
- Conclusions

The MiniCal

2 cm stainless steel absorber plates (1.15 X_0) with 1 cm gaps



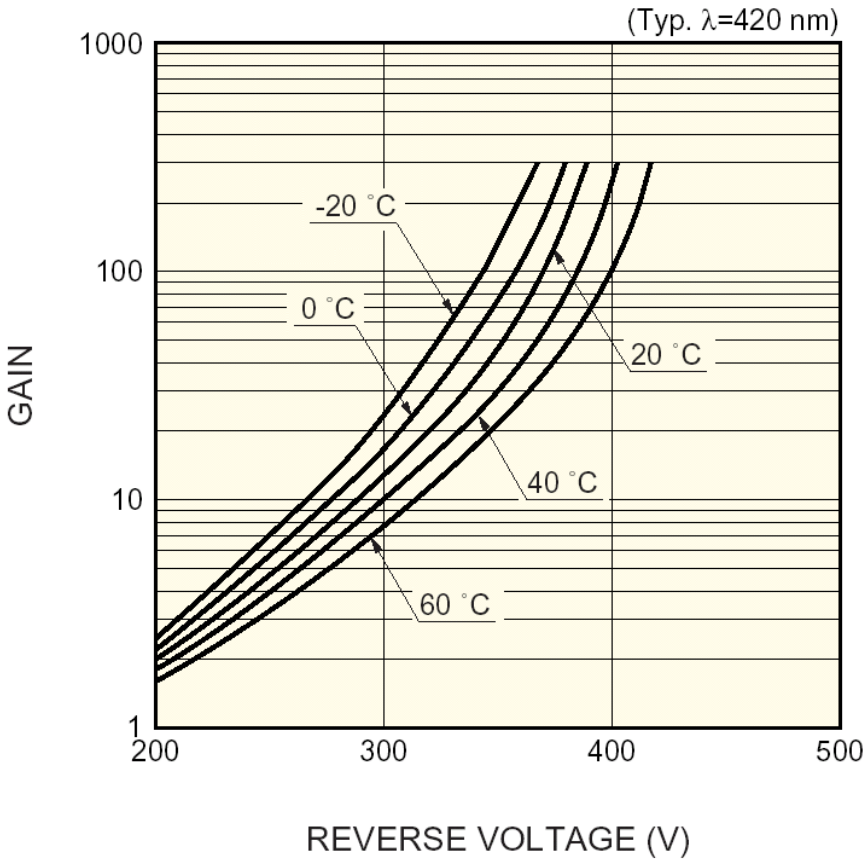
Used for study of:

- Tile Fibre couplings
- New photodetectors
- Read out of multiple channels
- long term stability
- Calibration procedure

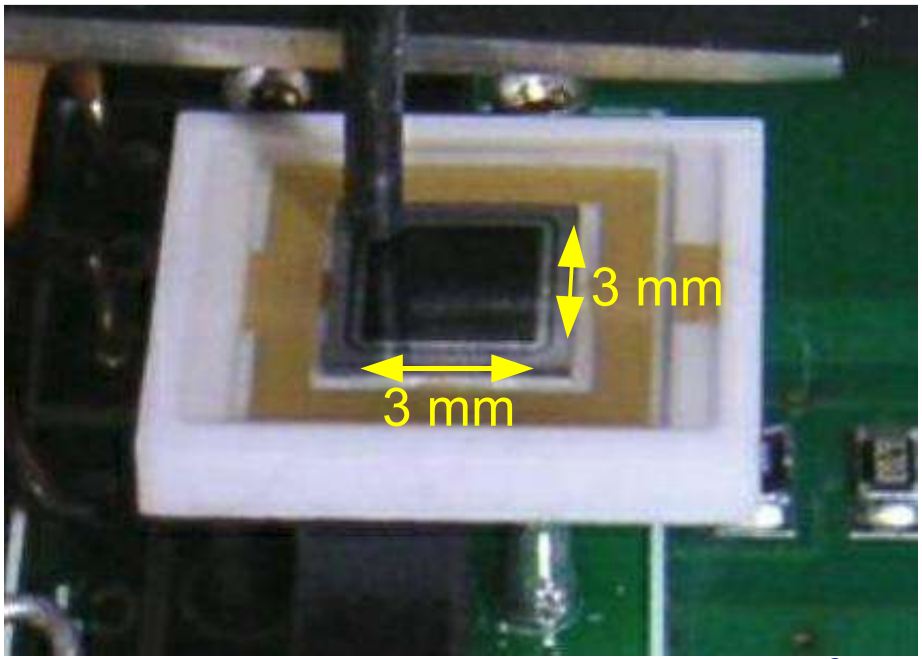
APD properties

Characteristics:Quantum Efficienty 80%
proportional device
sensitive to ~ 10 photons
no dependence on magnetic Field

■ Gain vs. reverse voltage



Hamamatsu APD S8664 – 55 spl



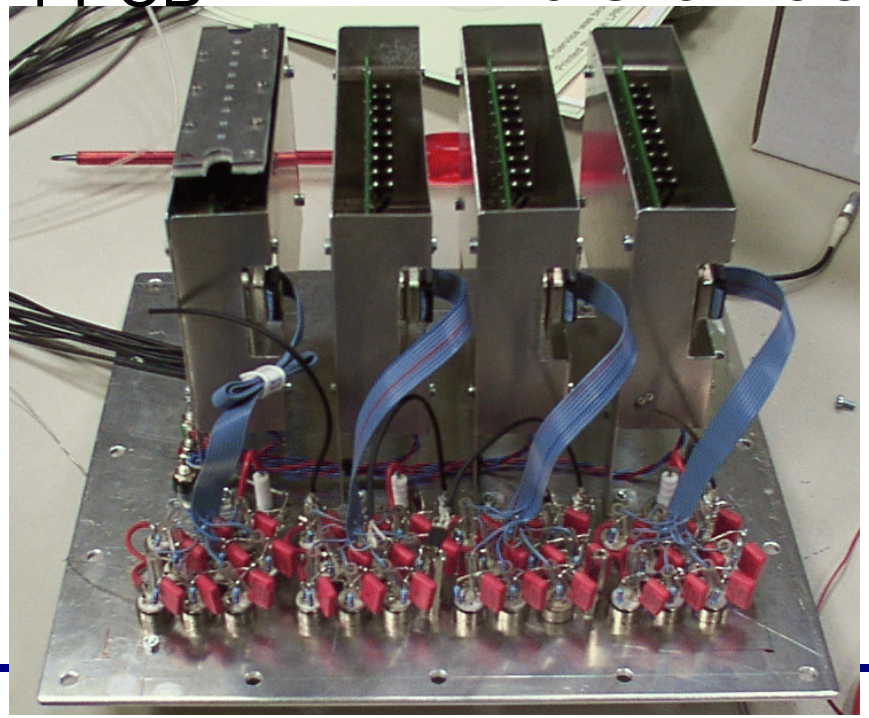
Two Preamplifiers

Prague preamplifier

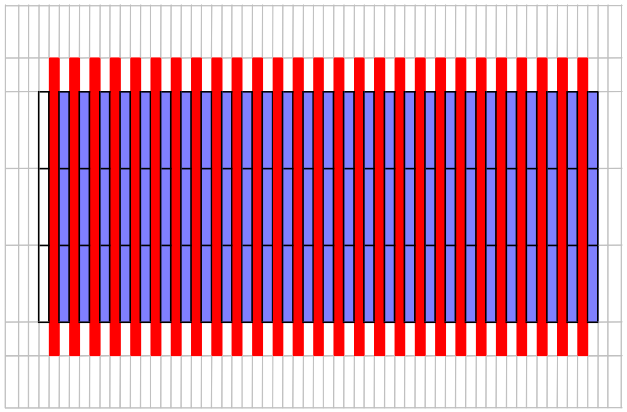
- Voltage sensitve
- peak sensing + shaping
- rise time ~ 40 ns
- fall time ~ 180 ns
- Supply Voltage 10-12V
- 9 Channels on 1 PCB

Minsk preamplifier

- Charge sensitve
- charge integration + shaping
- rise time ~ 70 ns
- fall time ~ 350 ns
- Supply Voltage 5V
- 9 Channels on 1 PCB



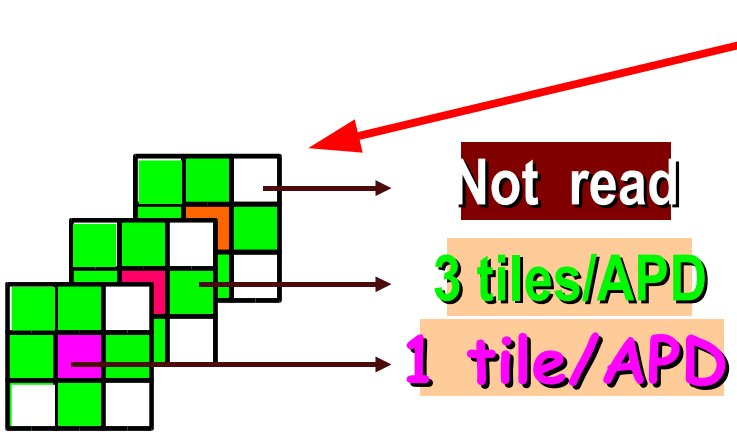
APD Measurement Setup



e^+ beam

- 12 layers equipped
- central stack: 1tile/1APD =12chan.
- 4 sides + 1 corner: 3tiles/1APD

➢ in total 32 channels in readout



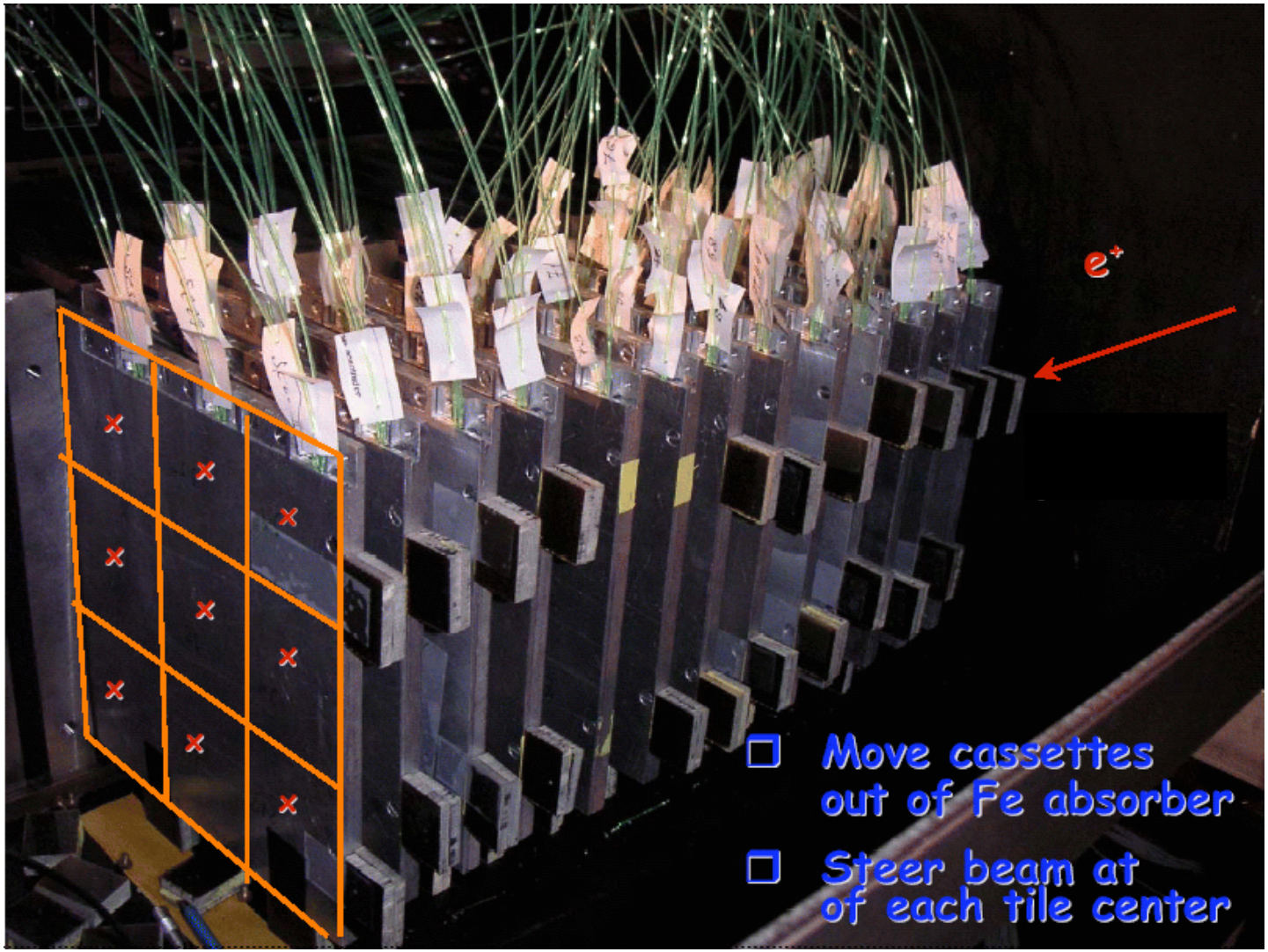
➢ MIP calibration

- using 3 GeV e-beam without absorbers
- shoot at MiniCal along its axis in 6 positions
- extraction of calib factors for each channel

➢ Energy scan

- with beam energy of 1-6 GeV
- Calibrate tile response in # of MIPs
- sum up energy response from all tiles

Calibration Setup

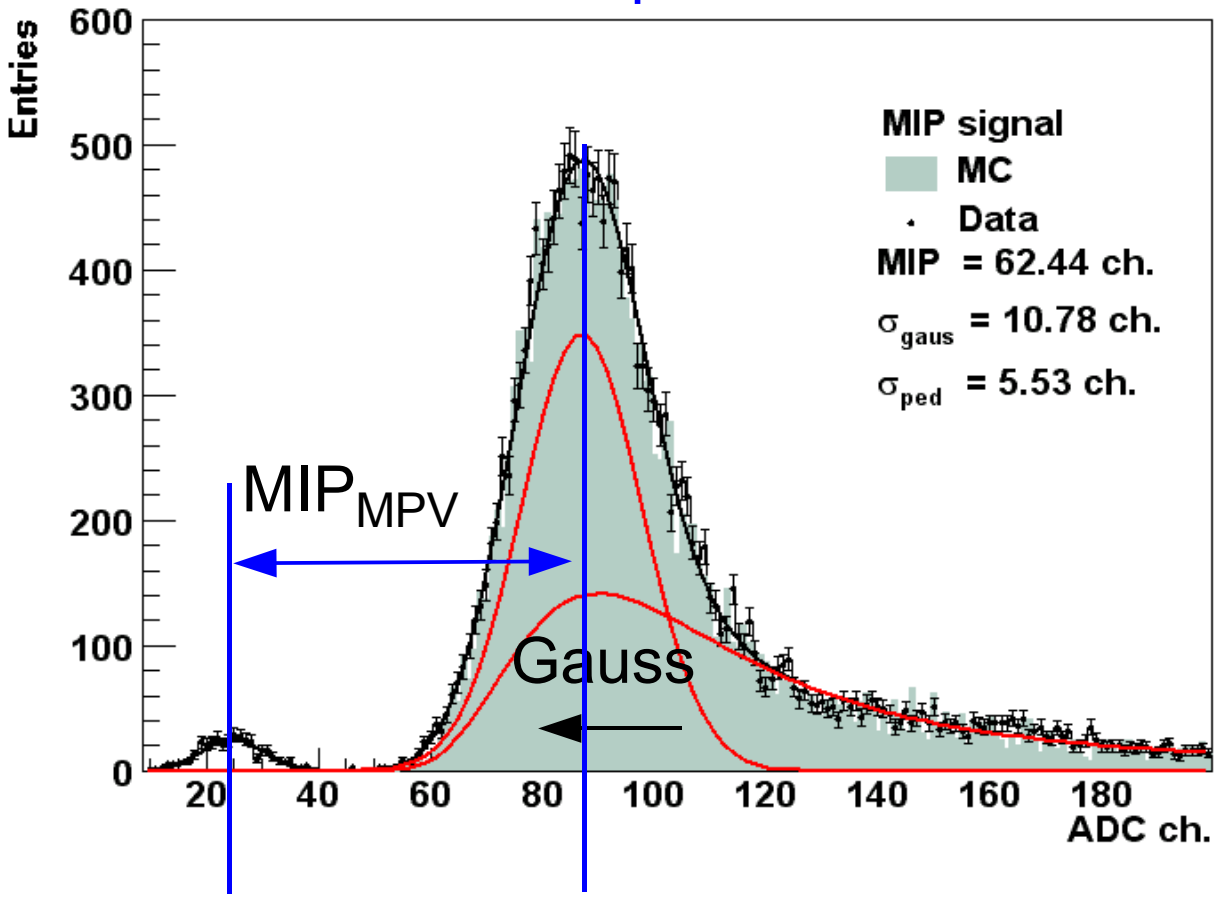


MIP peak: Data compared with MC

MIP_{MPV}=peak-ped

Fit with Gaussian for pedestal

with Gaussian for peak +Landau fct.for tail description



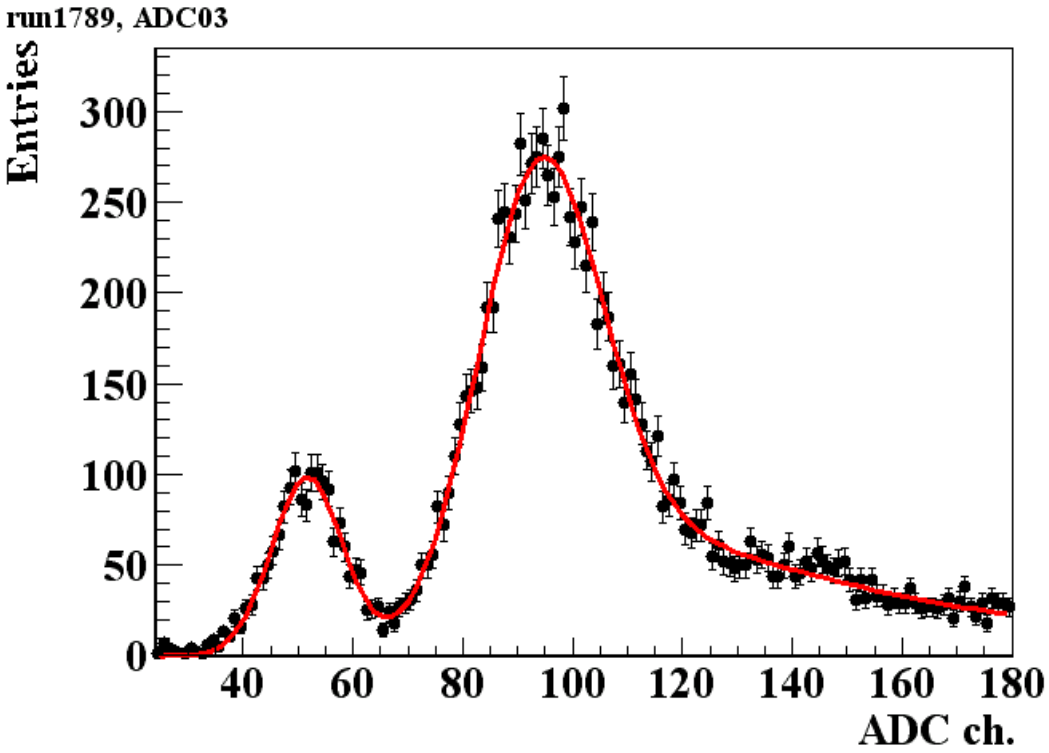
MC parameters optimised to reproduce MIP shape for each Tile.

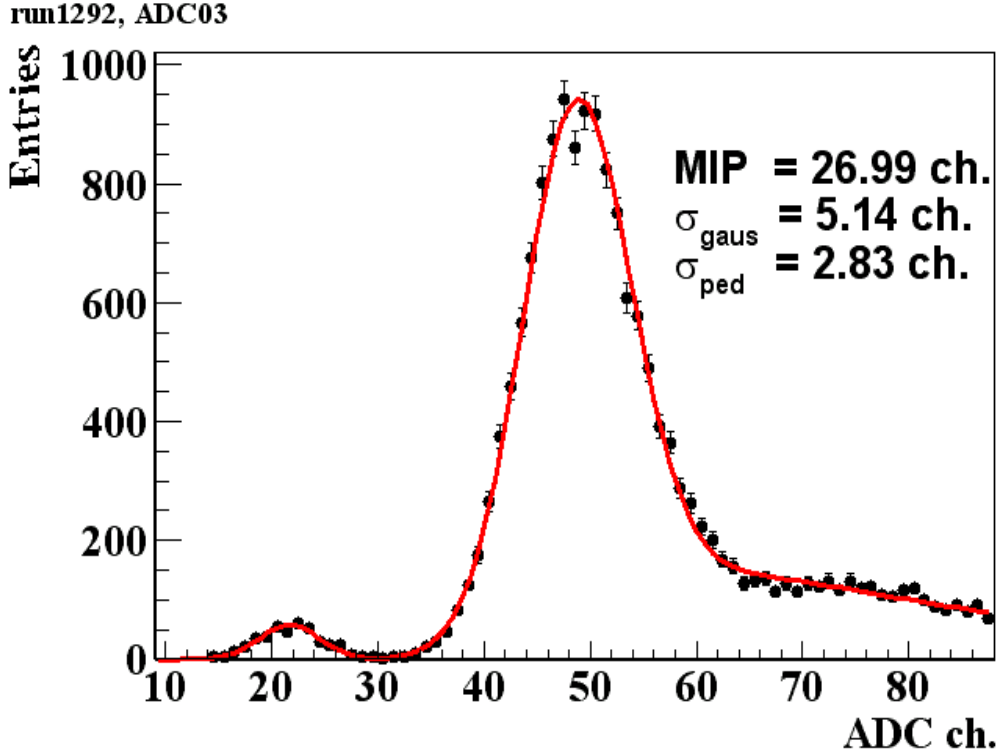
MC includes detector physics. ie. photoelectron statistics...

Mip Calibration comparison

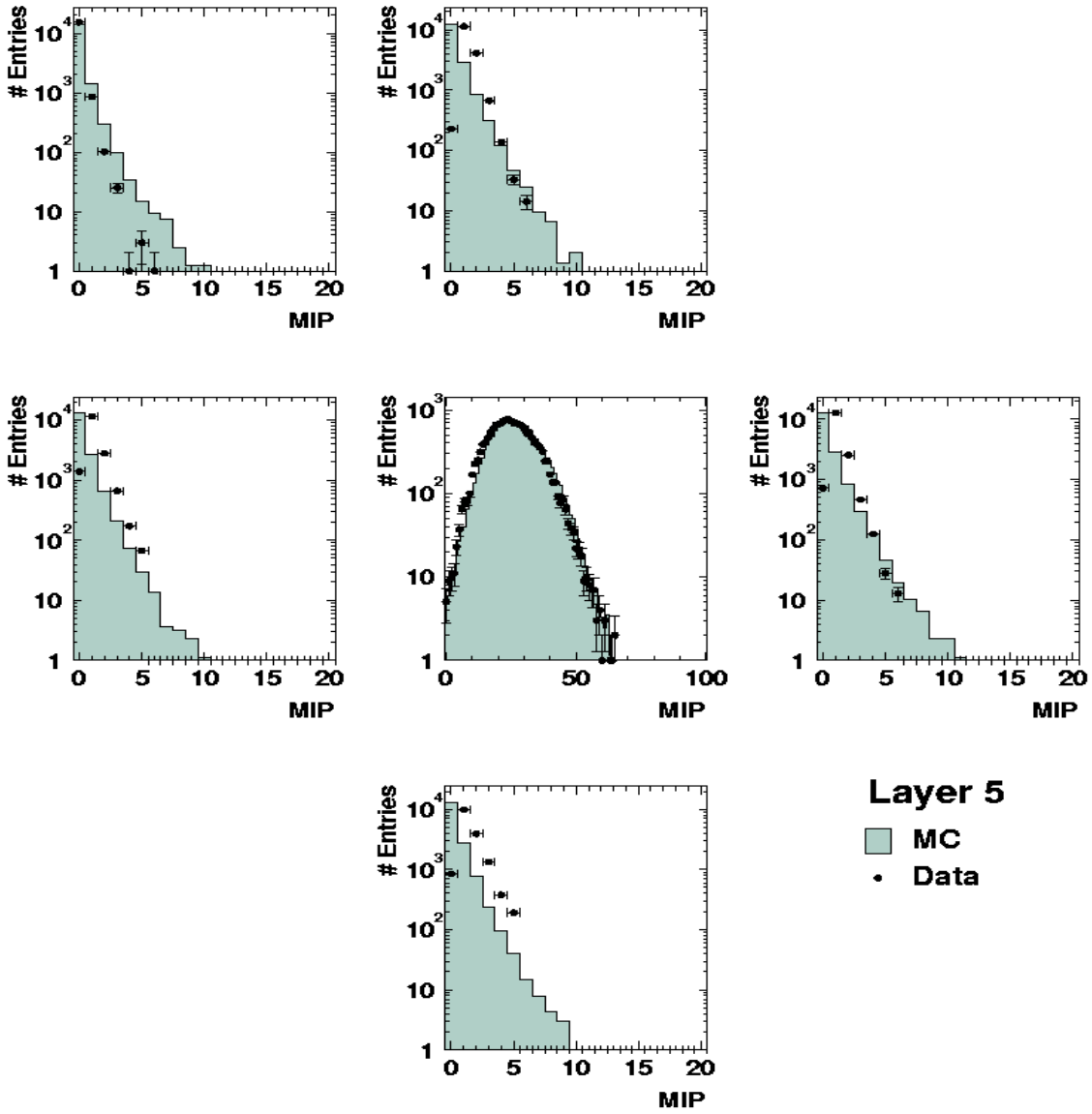
- Prague preamp (V sensitive)
  $S / N = MIP_{MPV} / \sigma_{ped} = 6.6$
  $S / \sigma_{Ped} = 3.7$

- Minsk preamp (Q sensitive)
  $S / N = MIP_{MPV} / \sigma_{ped} = 9.5$
  $S / \sigma_{Ped} = 5.3$





Lateral Shower Shape



5 GeV e^+ beam
shoot into center tile
5th Layer

MC
simulations

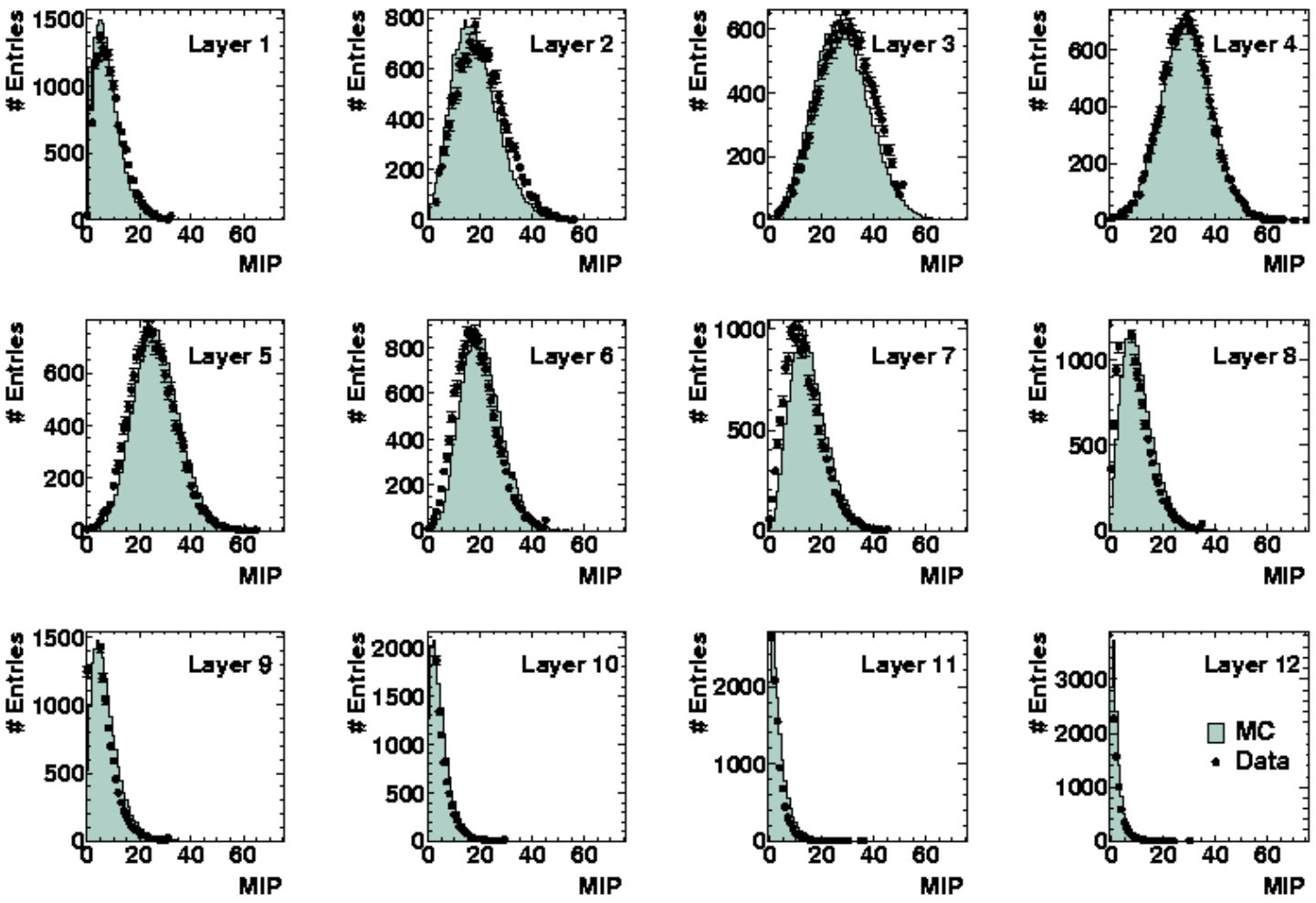
(full histograms)

Measured
data

(open histograms)

>90% Energy is deposited
in the center
as predicted by MC

Longitudinal Sower Shape



5 GeV e^+ beam

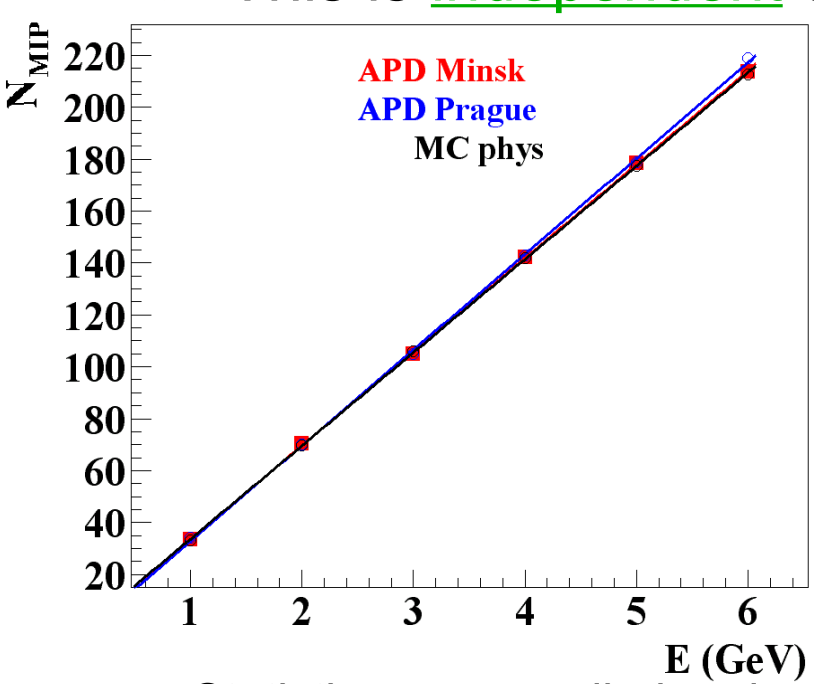
- both preamps have similar spectra

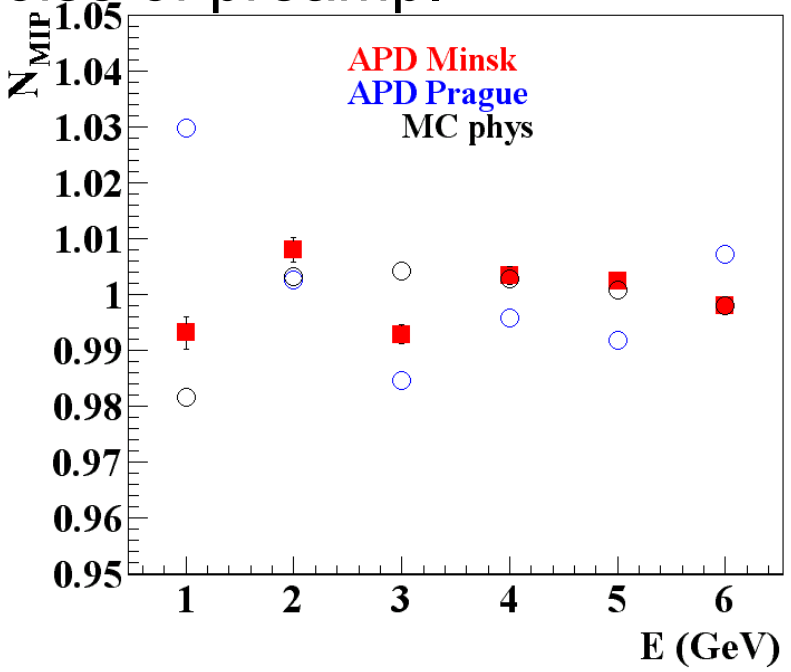
most energetic cells:
Layer 3 - 5

Good agreement between MC and Data for both preamps

Linearity

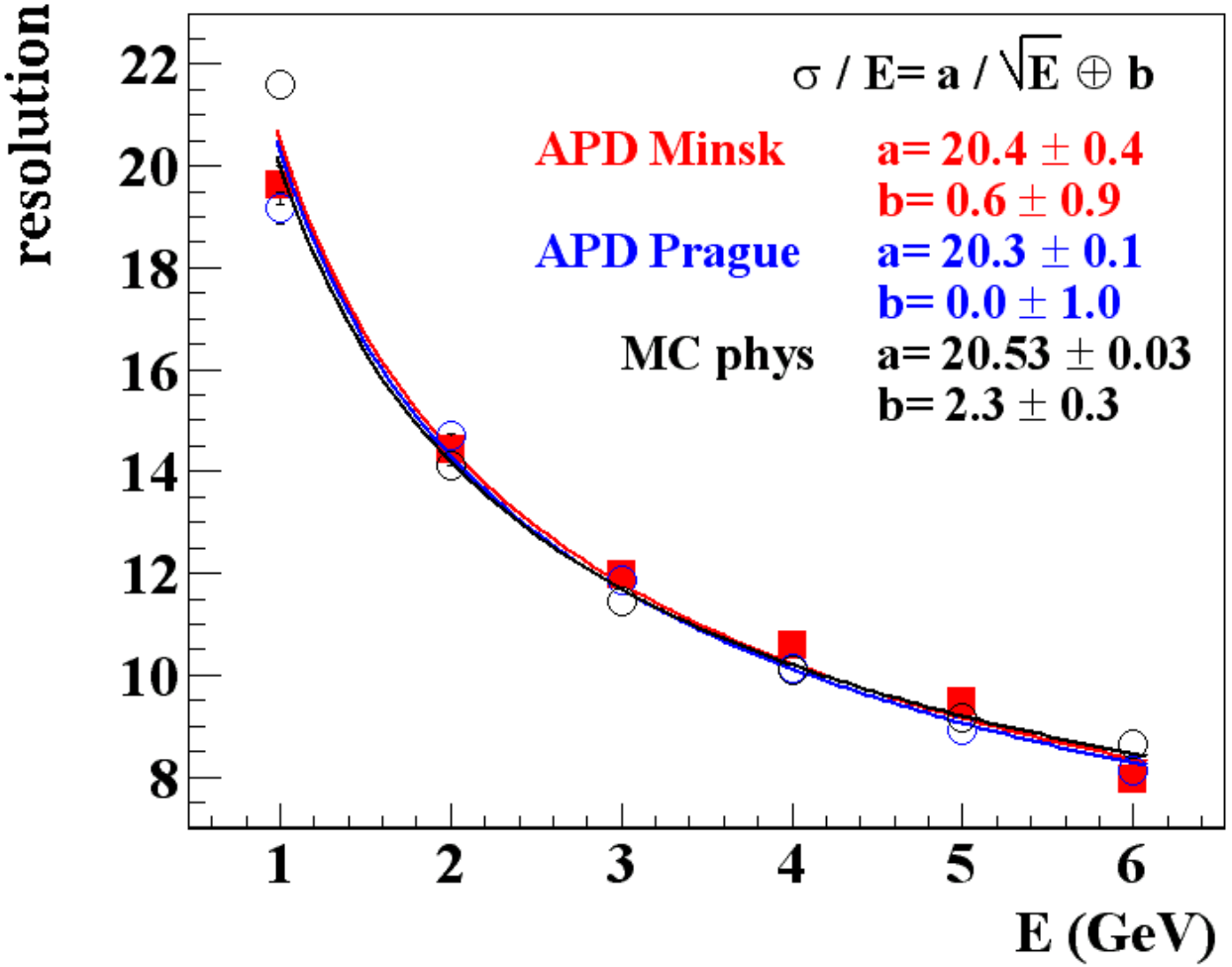
- Energy sum is well described by Gauss
- Data taken with different preamps are consistent.
- This is independent of noise of preamp.





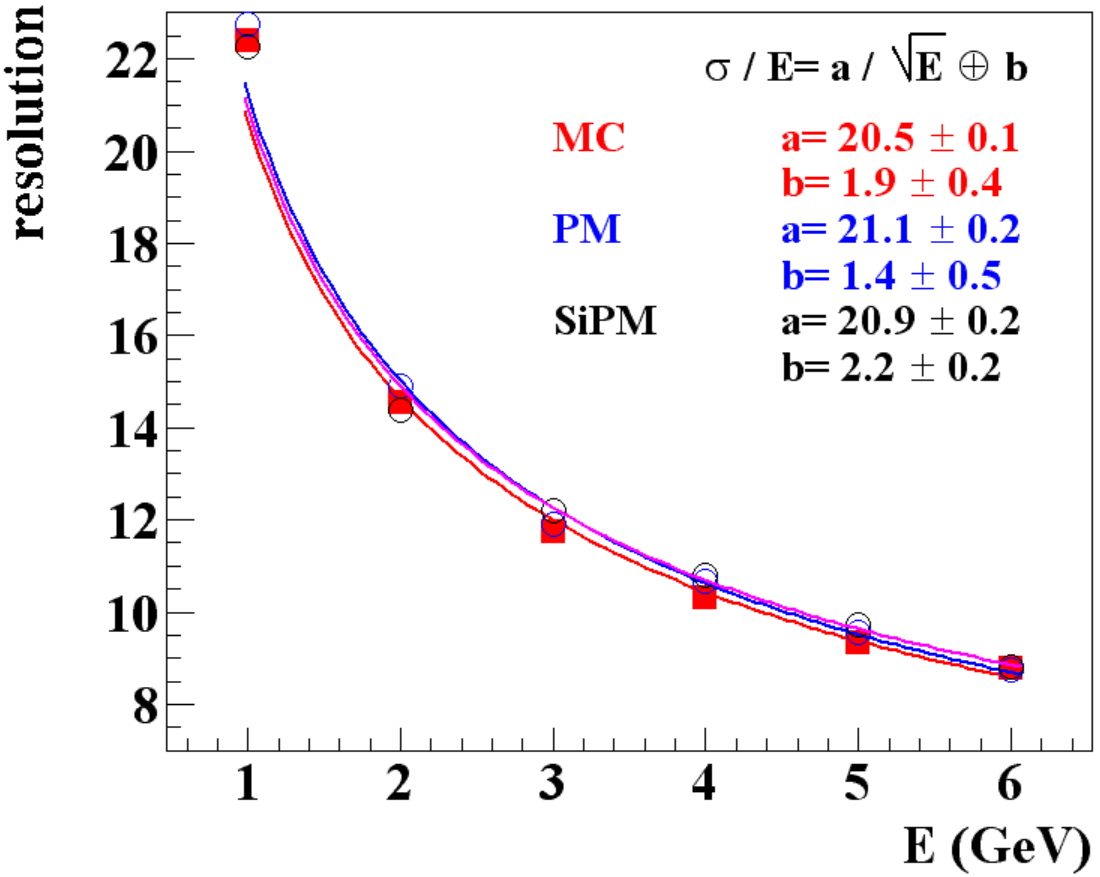
- Statistic errors applied and systematic uncertainties assumed to 5%
  (from calibration, temperature correction, ADC effects, beam spread,…)

Energy Resolution



- Data taken with different preamps are consistent.
- stochastic term for both preamps is about 20% (for EM showers)

PM and SiPM Resolution



Analysis of SiPM and PM already presented.

MC fits data within 5% level

Different Photodetectors

Energy resolution: $\frac{\sigma_E}{E} = \frac{a}{\sqrt{E[GeV]}} \oplus b$

	a	b
APD_{Prague}	20.3 ± 0.1	0.0 ± 0.9
APD_{Minsk}	20.4 ± 0.4	0.6 ±1.0
PM	21.1 ± 0.2	1.4 ± 0.5
SiPM	20.9 ± 0.2	2.2 ± 0.2
$Mc_{phys,APD}$	20.52 ± 0.03	0.0 ± 0.1
MC_{ideal}	18.5 ± 0.1	2.3 ± 0.3

← Constant term due to leakage

All photodetectors have similar energy resolution.
The APD measurements are not sensitive to the constant term.

Conclusions

- Significant progress in measurement & analysis of APDs as photo detectors in MiniCal
- Data taken with different preamps are consistent.

- Good agreement among data of APD, PM, SiPM and MC

- For APDs we need final study on systematic uncertainties

APDs proven to be alternative photo detectors for the tile-HCAL !