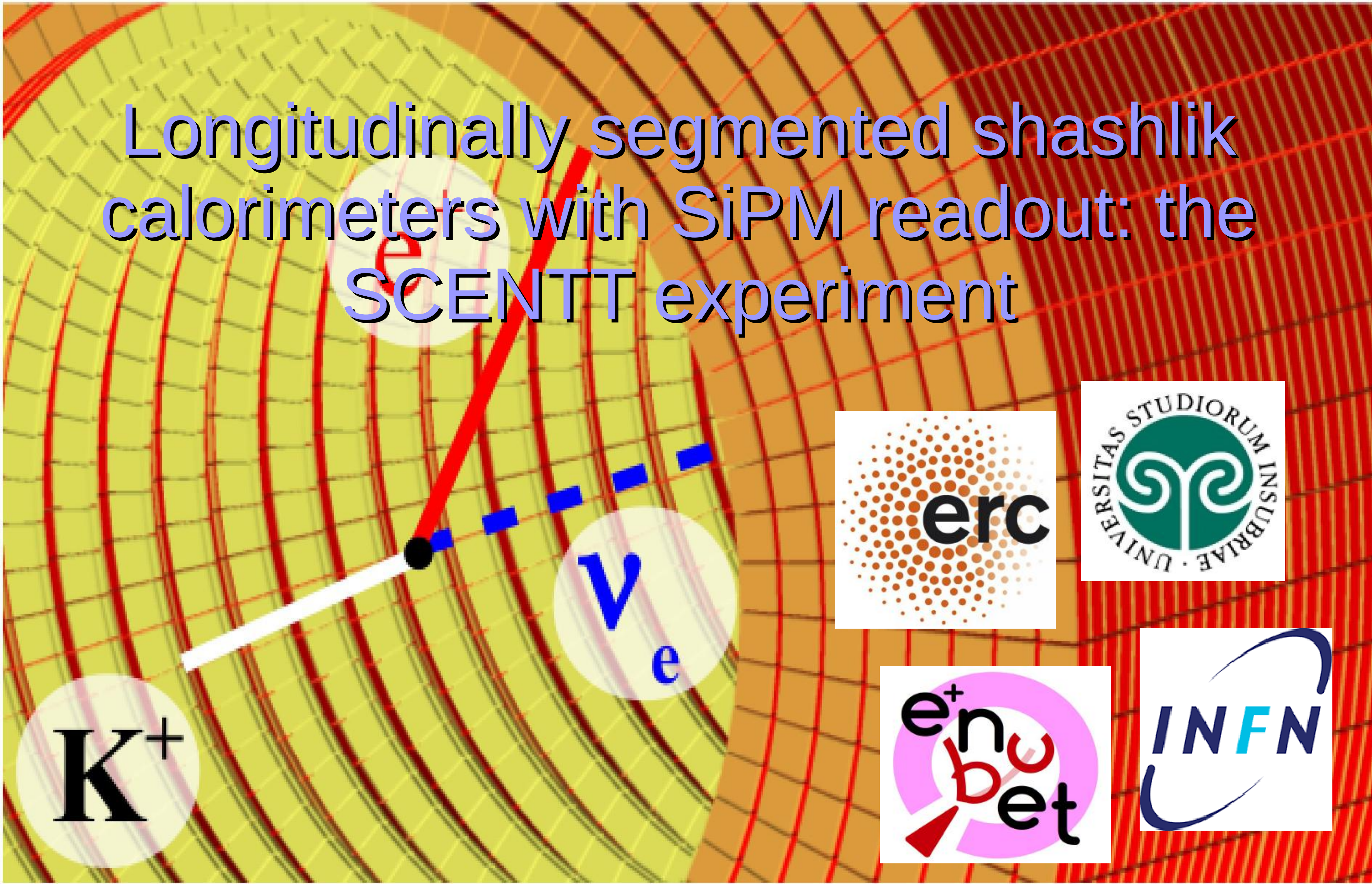
Longitudinally segmented shashlik calorimeters with SiPM readout: the SCENTT experiment



Claudia Brizzolari – 2 November 2016, Strasbourg

Shashlik calorimeters

- low cost
- good energy resolution
- well established technology

The SCENTT-ENUBET project

Shashlik Calorimeters for Electron Neutrino Tagging and Tracing, part of Enhanced NeUtrino BEams from kaon Tagging project - ERC-Consolidator Grant-2015, n° 681647 (PE2)

Goal: improve the sensitivity on σ_ν at ~GeV to 1%

Right now is 10 - 20%

↓

Initial flux of neutrinos unknown, inferred from hadro production data and beam simulation

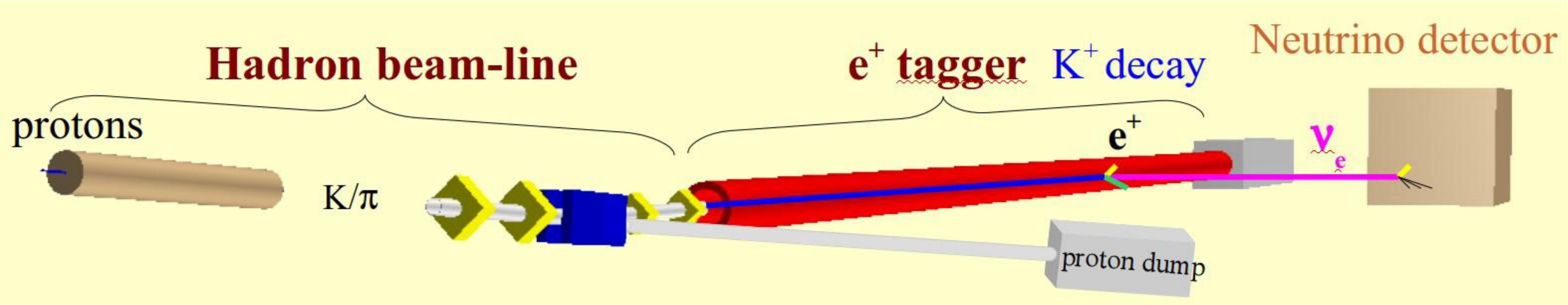
↓

Neutrino flux measured directly in the decay tunnel from

$$K^+ \rightarrow e^+ + \pi^0 + \nu_e \ (K_{e3})$$

Tag e^+ associated with ν_e

The SCENTT-ENUBET project



Hadron beam-line:
collects, focuses,
transports K^+
to the e^+ tagger

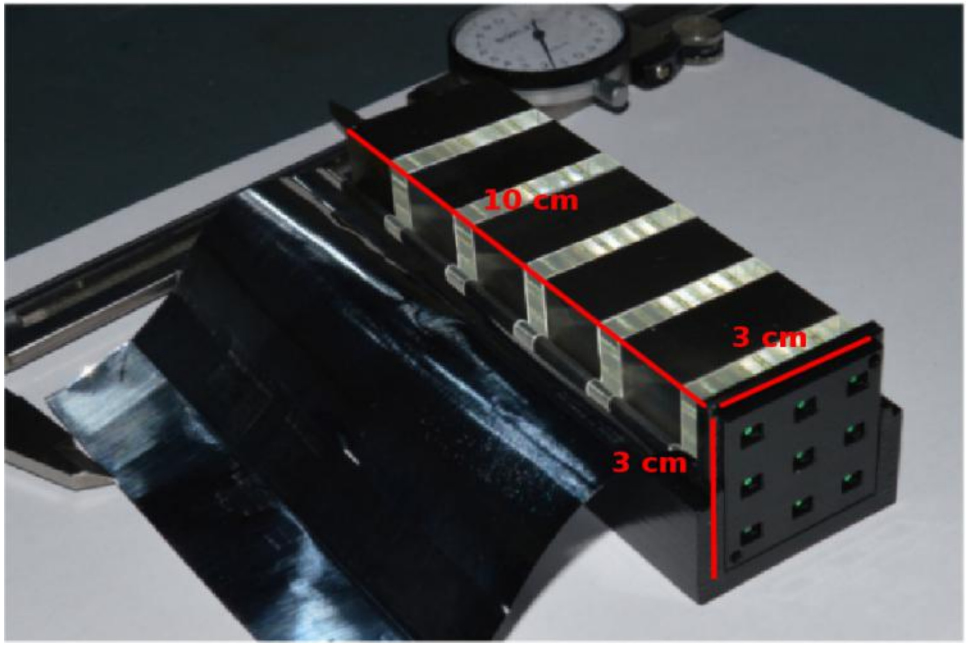
e^+ tagger:
monitors produced e^+.

If ~50 m, at 8 GeV
K_{e3} is the only source
of ν

The Detector

Shashlik calorimeter

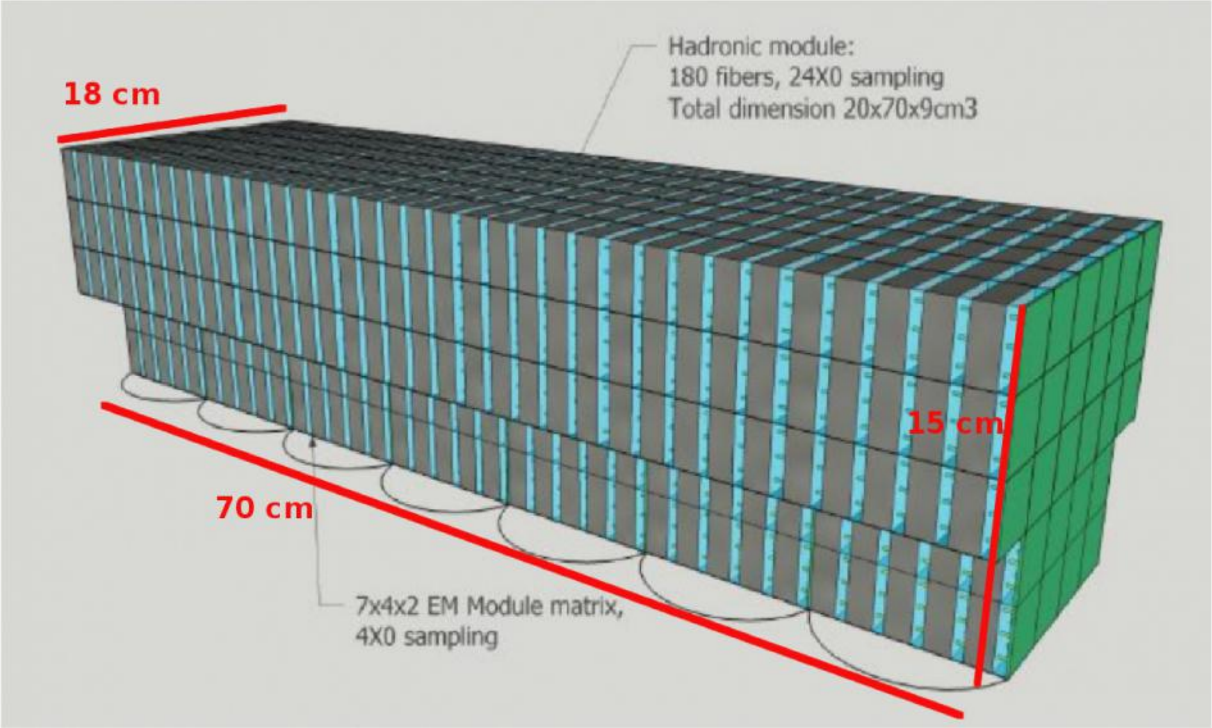
+

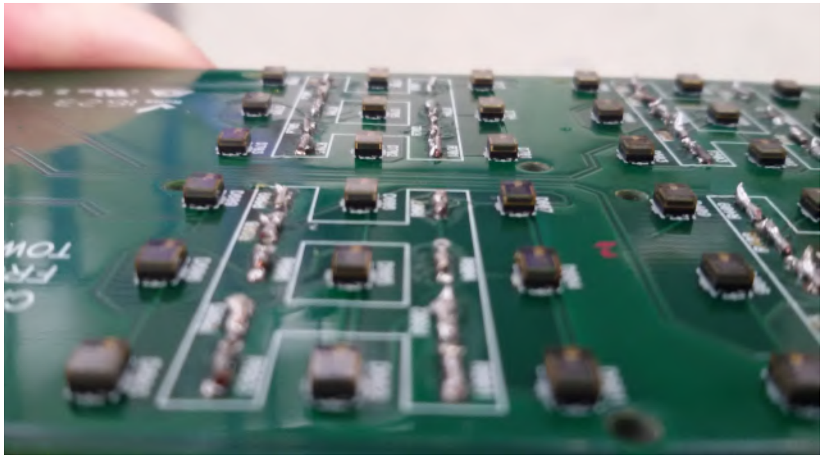


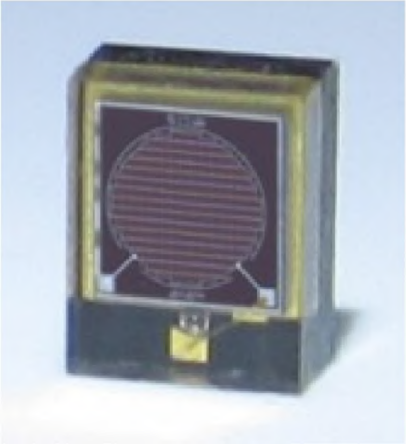
Compact readout based on SiPM

- ✔ Direct fiber-SiPM coupling
- ✔ Readout embedded in the calorimeter bulk → longitudinal segmentation
- ✔ Rate capability > 500 kHz/cm^2

- **Fe + plastic scintillator**
- **EM + hadronic**



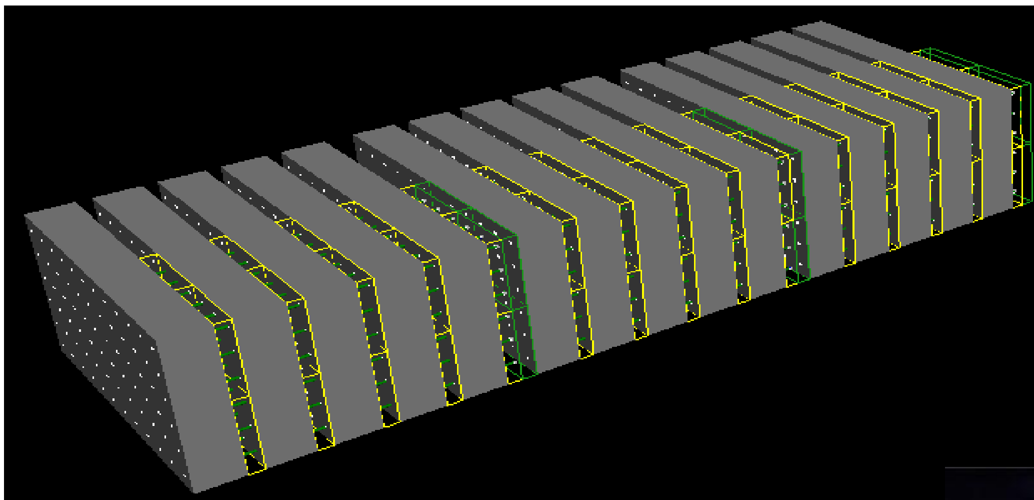




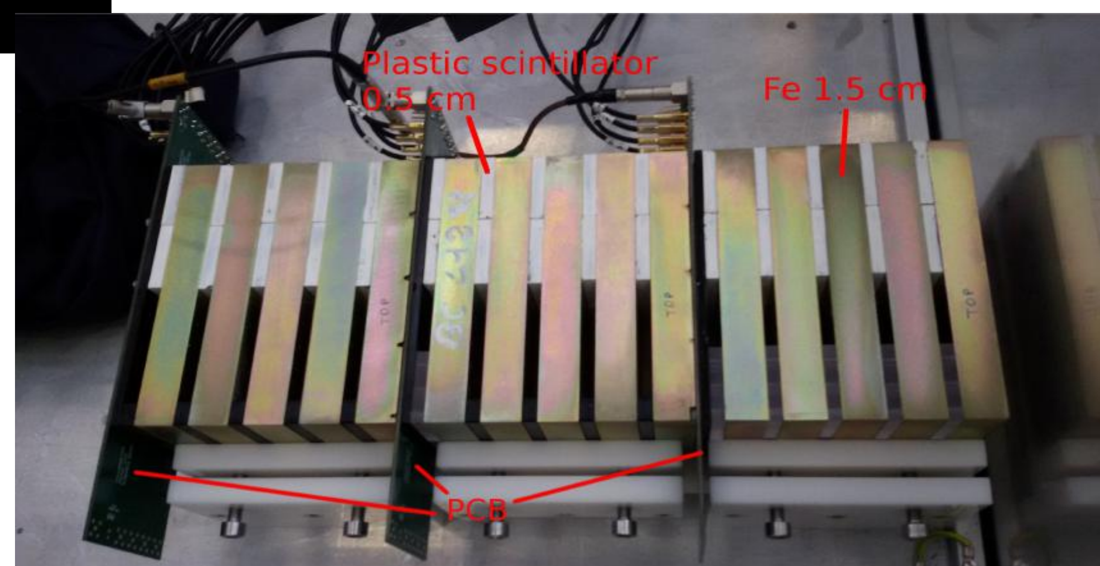
Sensitive area 1x1 mm^2
2500 20x20 μm^2 cells

- **Each SiPM coupled with one WLS fiber**
- **Custom PCBs**

Test Beam July @ CERN PS – T9 beamline: prototype



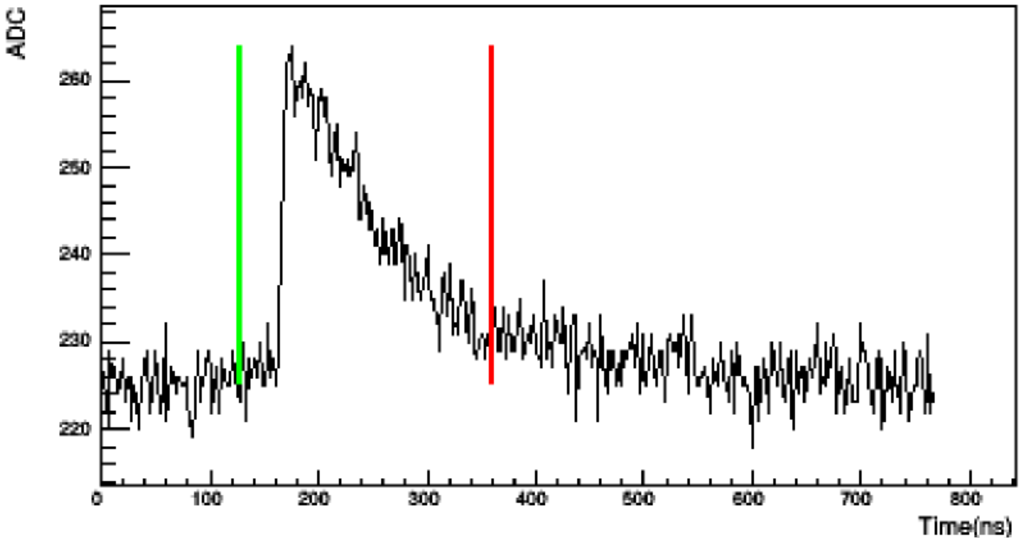
- EM calorimeter
- 30 cm, 3 modules
- 12 basic units
- Fe + SCIONIX EJ-200 or BC412



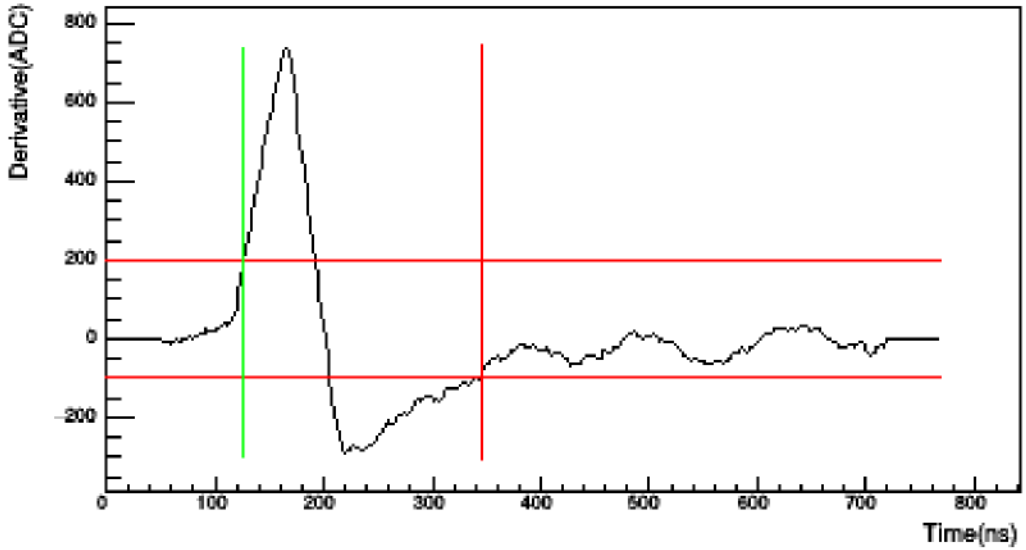
Test Beam July @ CERN PS – T9 beamline: performed tests

- Mixed beam: electrons, muons, pions
- Energy scan 1 - 5 GeV
- Different overvoltages to check for SiPM saturation
- Two readouts: charge integrating ADC (V792, CAEN) and digitizer (V1730, CAEN)

Data Acquisition



- Waveform Digitizer V1730
- Sampled 384 times every 2 ns

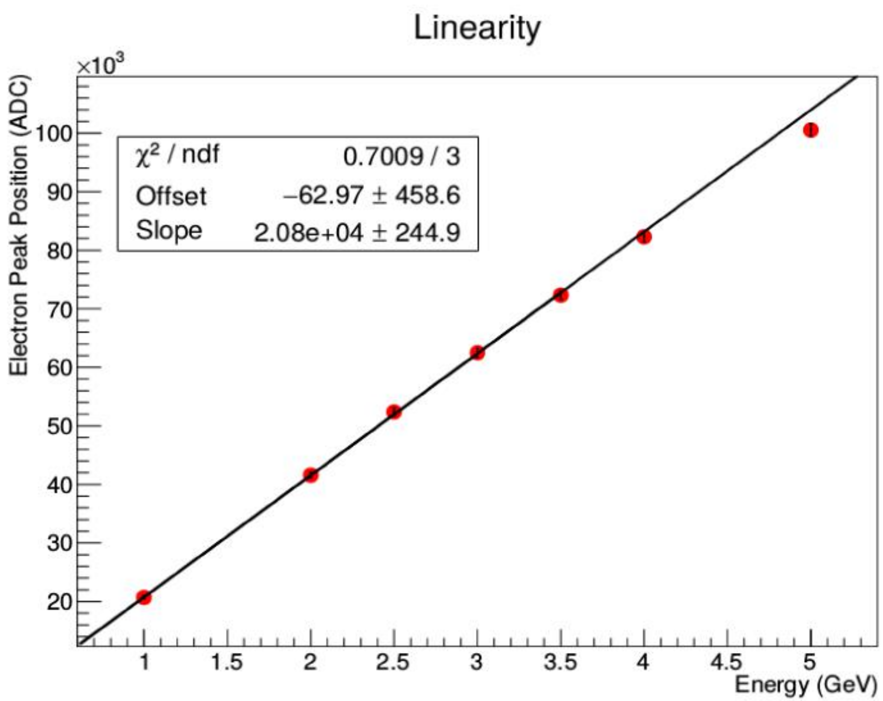


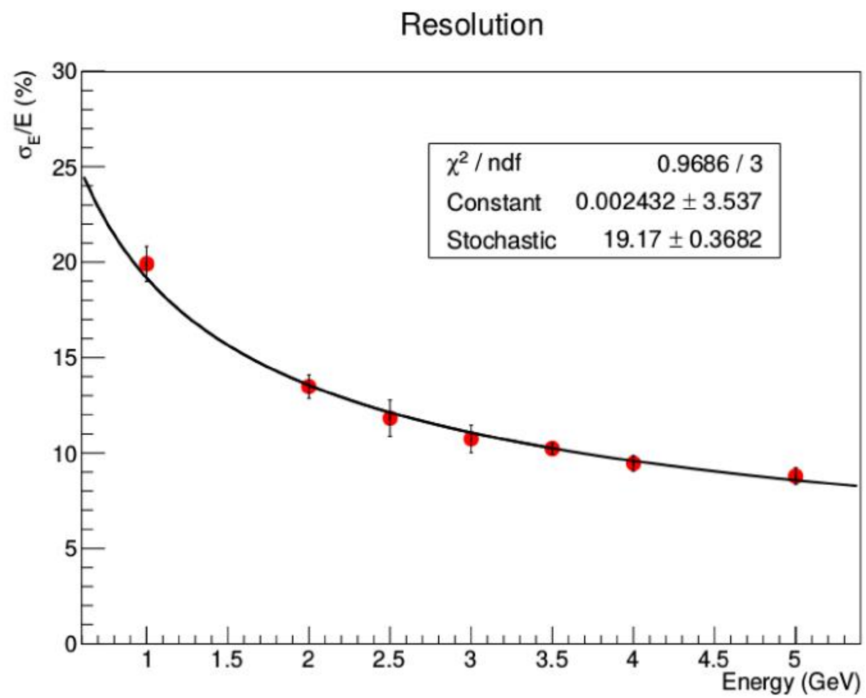
For each waveform, smoothed derivative δ_i of the i-th wave form is computed

$$\delta_i(N) = \sum_{k=1}^{N} s_{i+k} - \sum_{k=1}^{N} s_{i-k}$$

Positive threshold: 200 ADC
Negative threshold: -100 ADC

Test Beam July @ CERN PS – T9 beamline: results





$$\frac{\sigma_E}{E} = \sqrt{\left(\frac{a}{\sqrt{E}}\right)^2 + b^2}$$

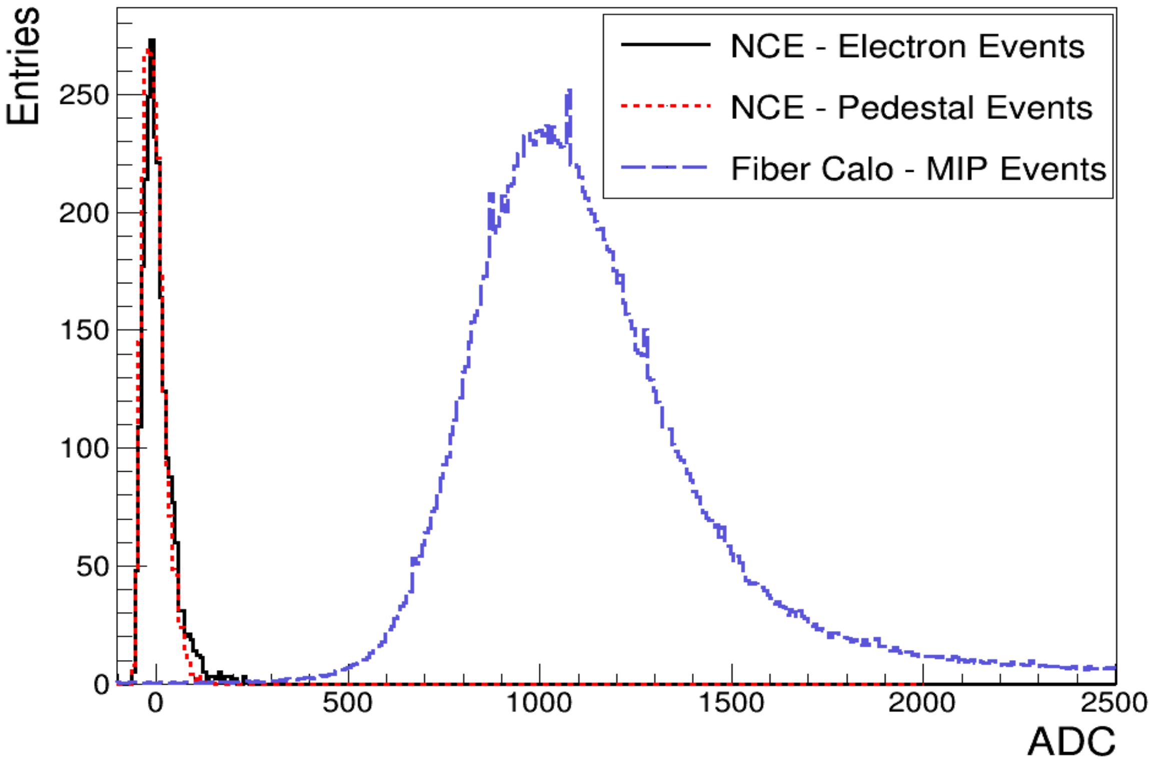
Stochastic term

Constant term

Deviation at 5GeV = -3.4%

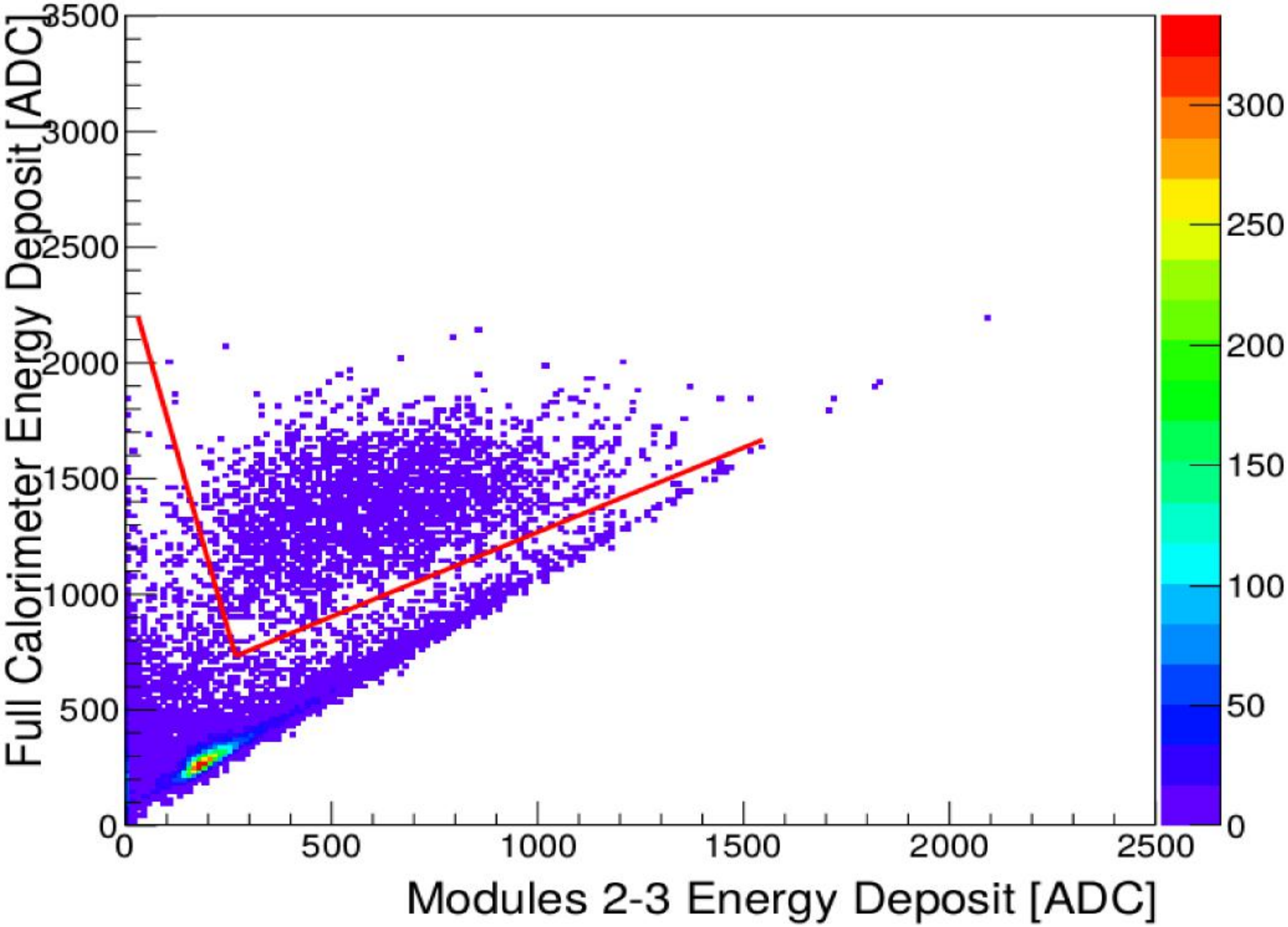
V = 31(3) V

Nuclear counter effect (NCE)



Nuclear counter effect studied in August 2015 on another prototype.
Red and black lines: run at 5 GeV without WLS fibers
Blue line: standard run at 5 GeV
[from: "A compact light readout system for longitudinally segmented shashlik calorimeters", published on Nuclear Instruments and Methods in Physics Research: Section A]

e^-/π separation



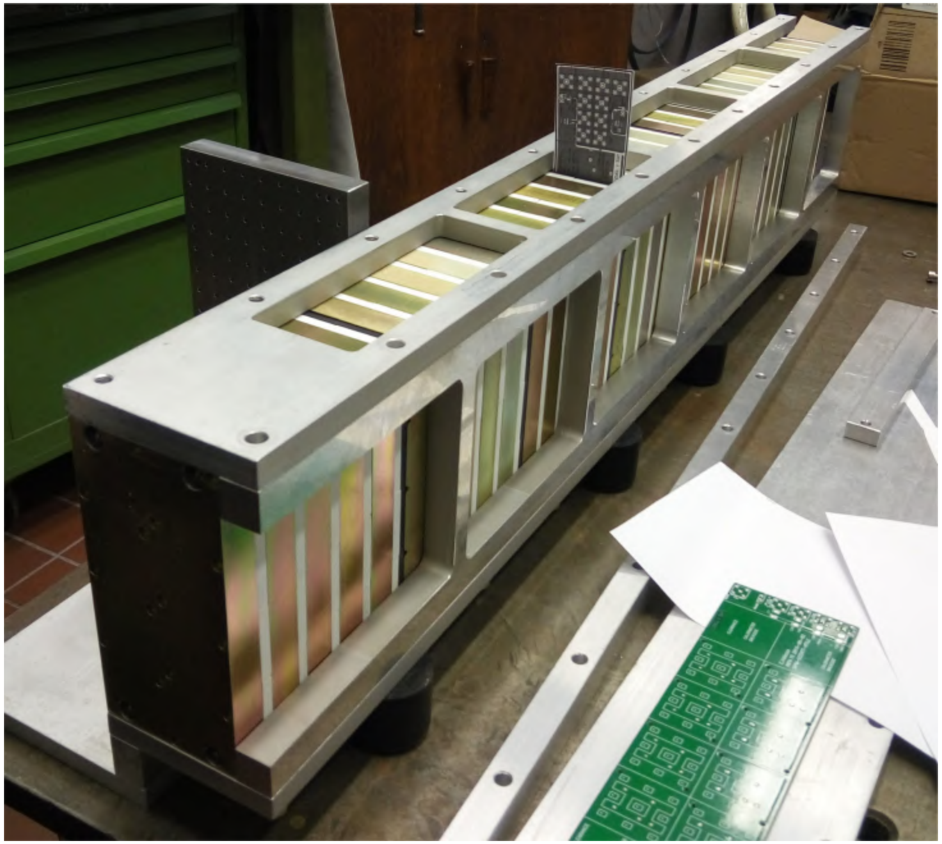
Run @ 2GeV

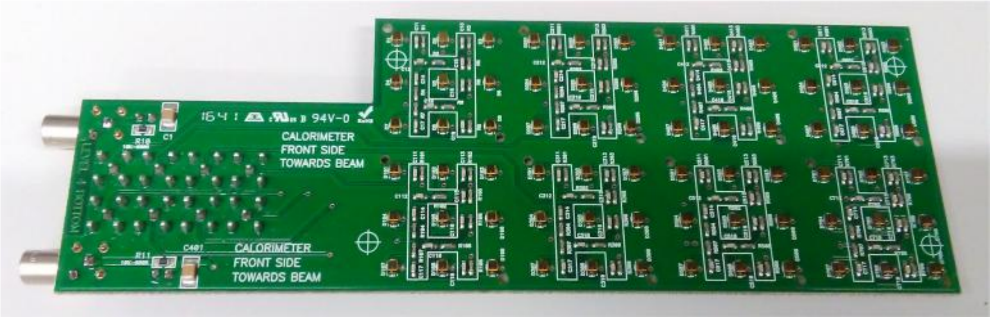
Conclusions and next plans

- no Nuclear Counter Effect, E resolution = 19% / $E^{1/2}$ → **OK!**
- investigate electron efficiency and purity in EM calorimeter

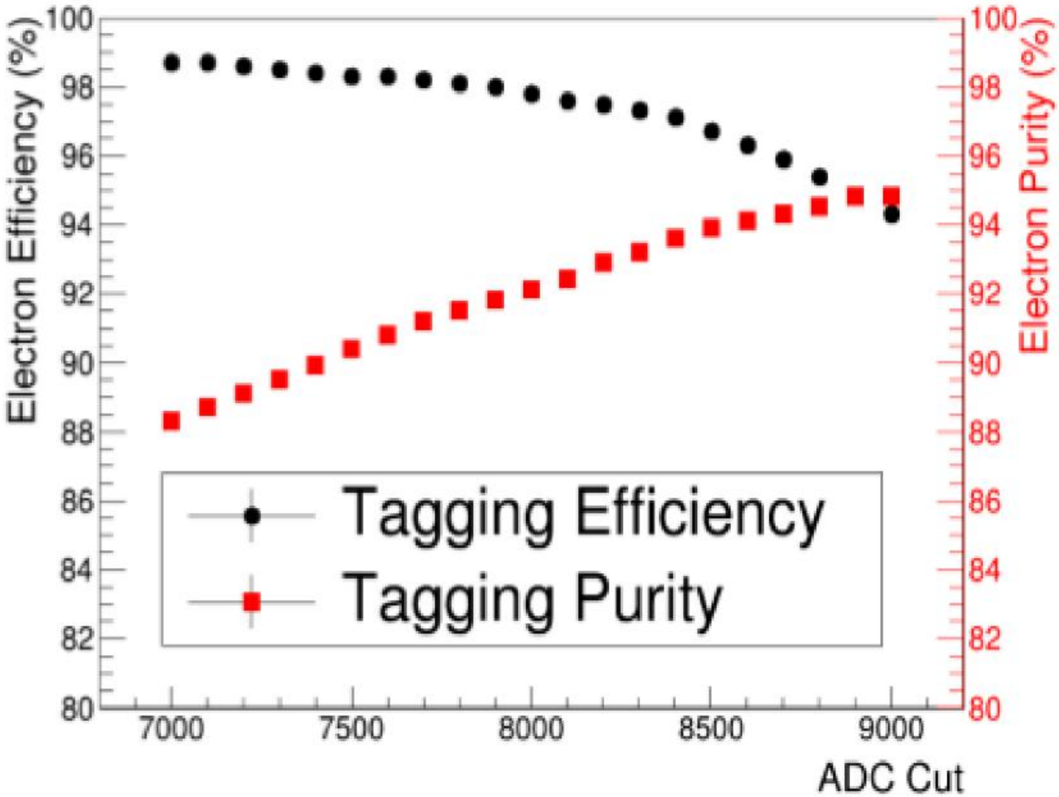
Conclusions and next plans

- testbeam scheduled for November 2016 @ CERN on EM + hadronic calorimeter → verify e^+/π



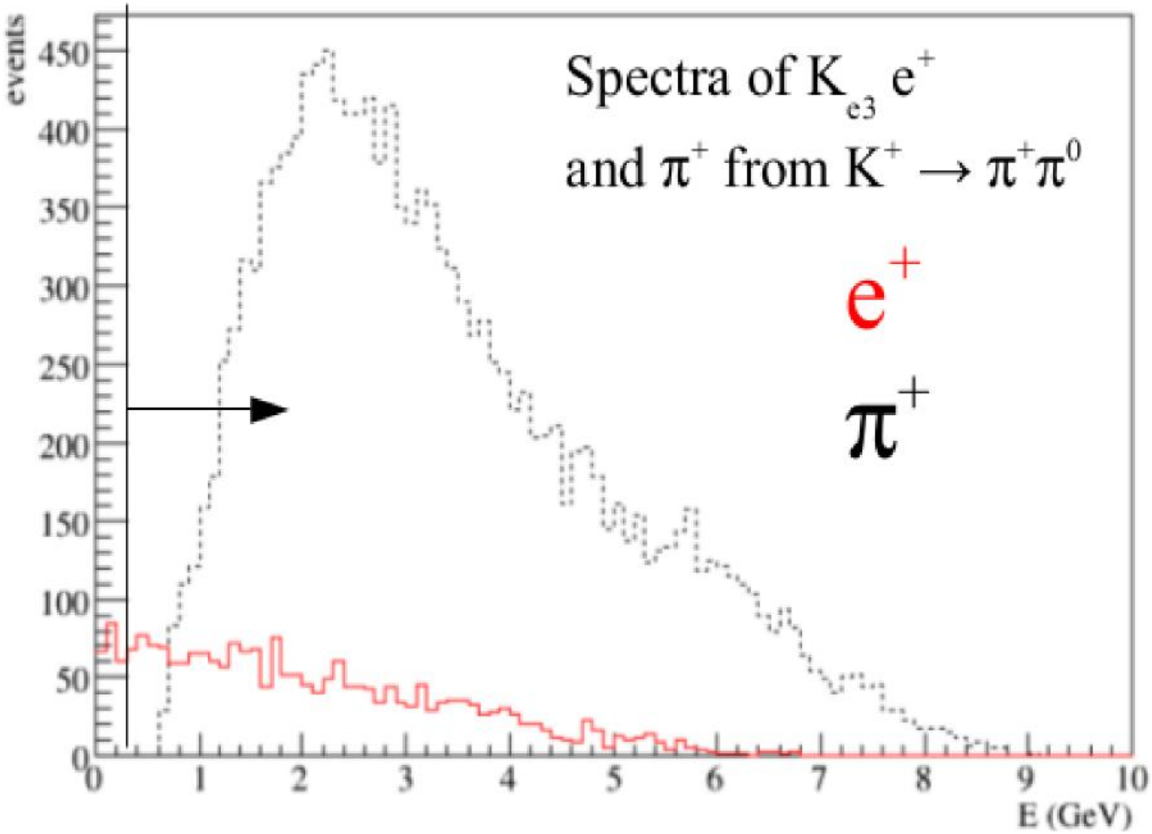


Appendix



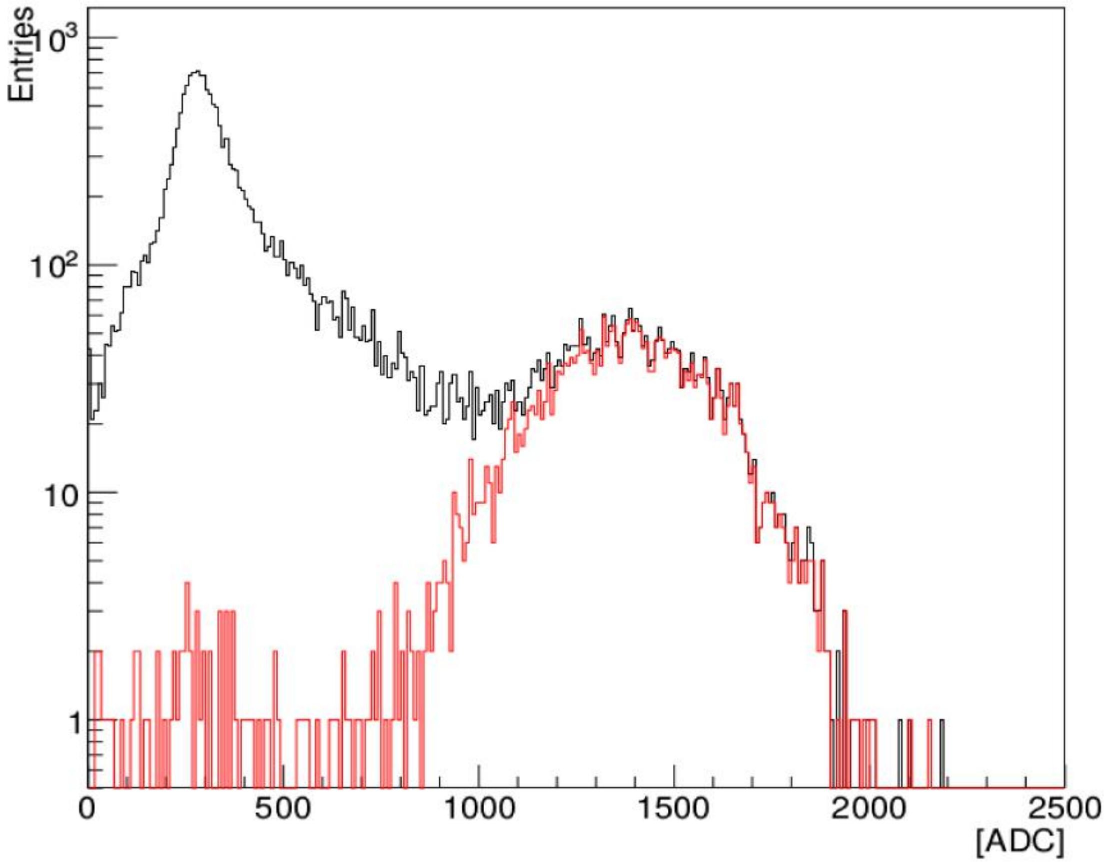
Comparison between the efficiency (in black) and the purity (in red) obtained varying the energy cut *[Alessandro Berra]*

Appendix



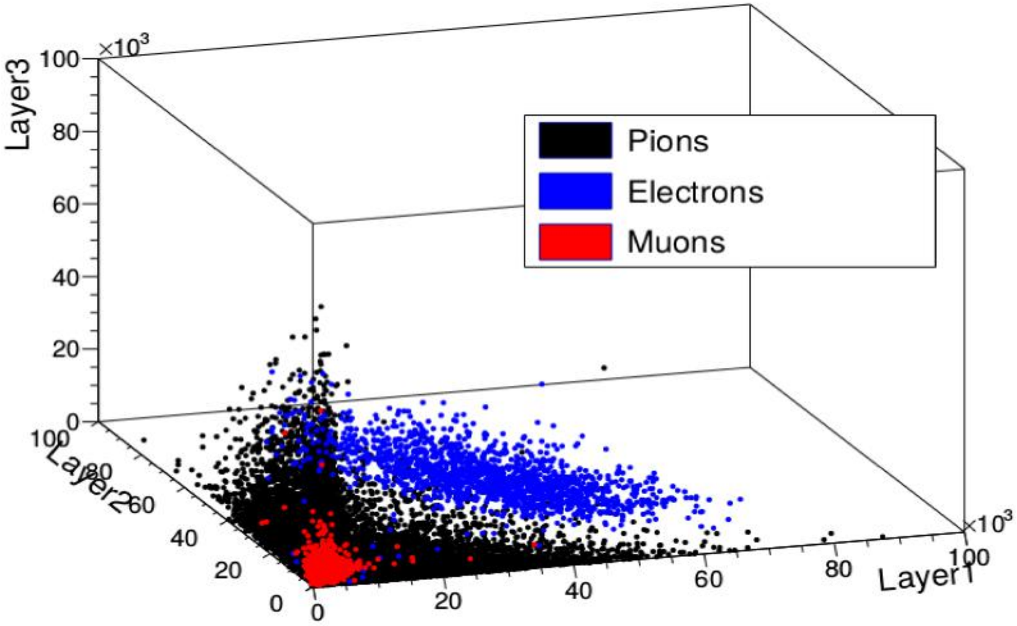
[Andrea Longhin]

Appendix



at 2 GeV

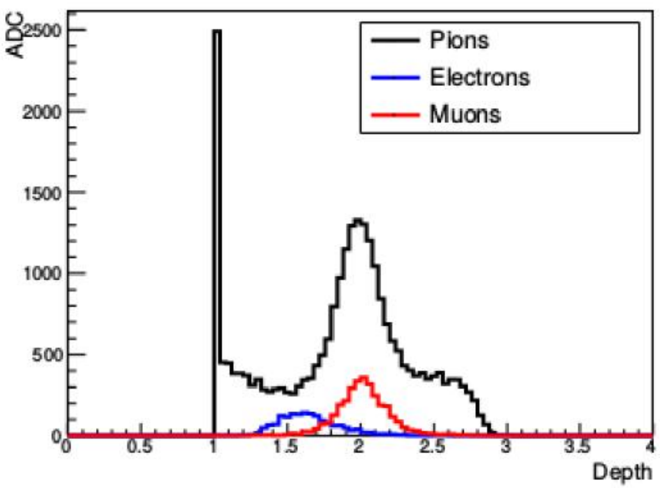
Appendix: e⁻/π separation



Energy deposit at 4 GeV
in each layer

Energy deposit at 4 GeV for each particle in the layers. Each layer is given a different weight.

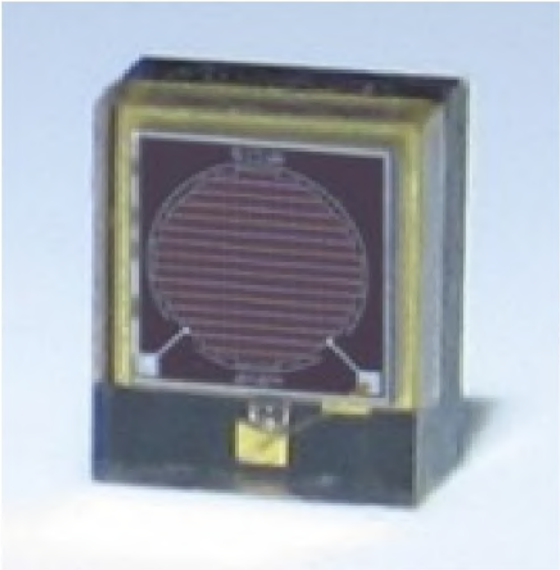
$$Depth = \frac{layer\,1*1 + layer\,2*2 + layer\,3*3}{layer\,1 + layer\,2 + layer\,3}$$



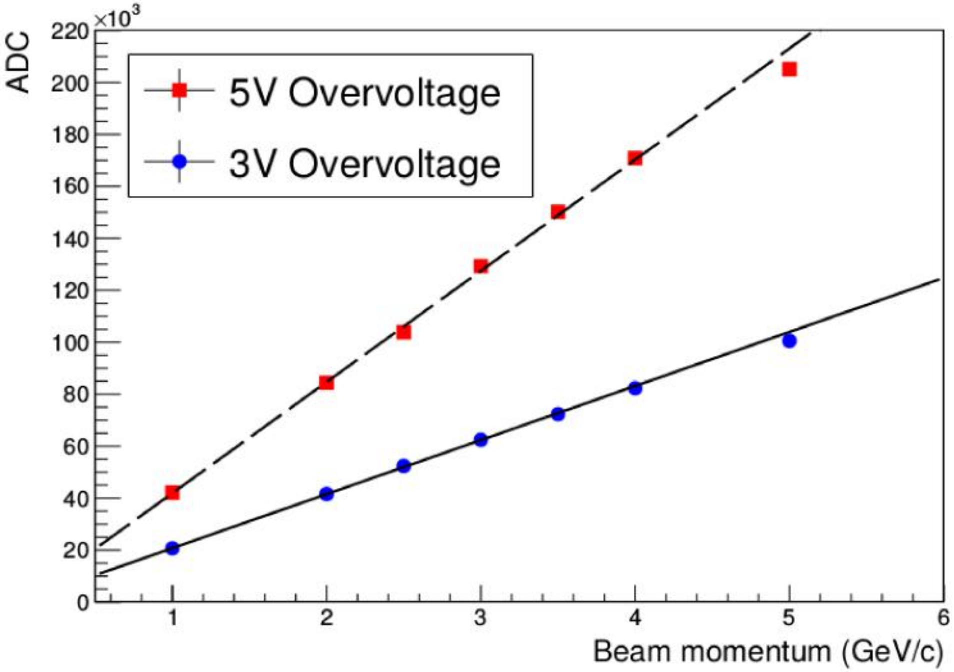
Appendix: SiPMs

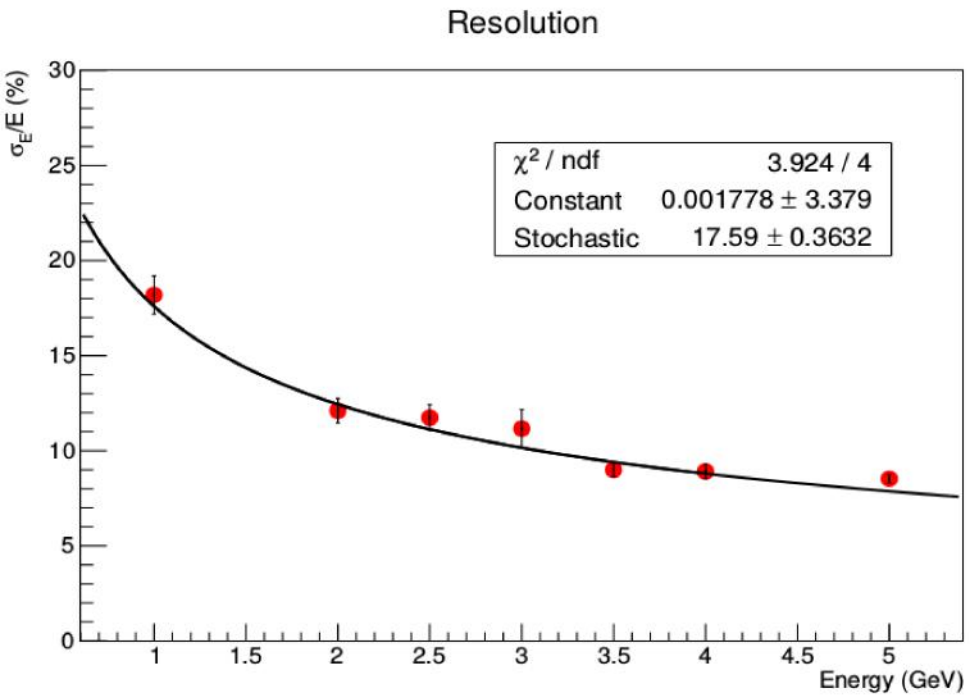
- FBK (Fondazione Bruno Kessler)
- SiPM RGB-HD (High Density)
- Sensitive area 1x1 mm^2
- 2500 cells 20x20 μm^2
- Breakdown: 28 V

FONDAZIONE
BRUNO KESSLER



Appendix: 33V OV





33V OV deviation at 5 GeV: -3.9%

31V OV deviation at 5GeV = -3.4%