AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Task 14.3.2
Infrastructure for Very Compact Tungsten-based Calorimetry

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On behalf of

AGH-UST Cracow, DESY Zeuthen, TAU Tel Aviv, IFJPAN (CERN partner)

AIDA-2020 WP14 Face-to-Face Meeting, 13 February 2020 CERN

Outline
AIDA-2020: Task, Milestone, Deliverable

Task: Infrastructure for very compact tungsten-based calorimetry

Milestone:

MS14.5 - Month24: Design and test of ASICs and readout board prototype for the test infrastructure

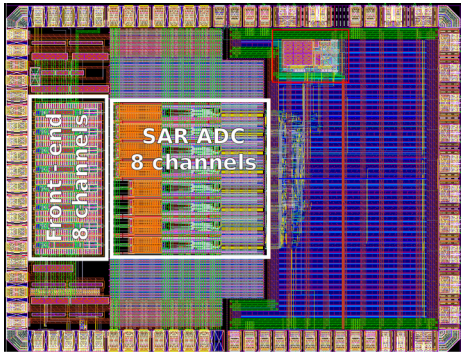
Deliverable:

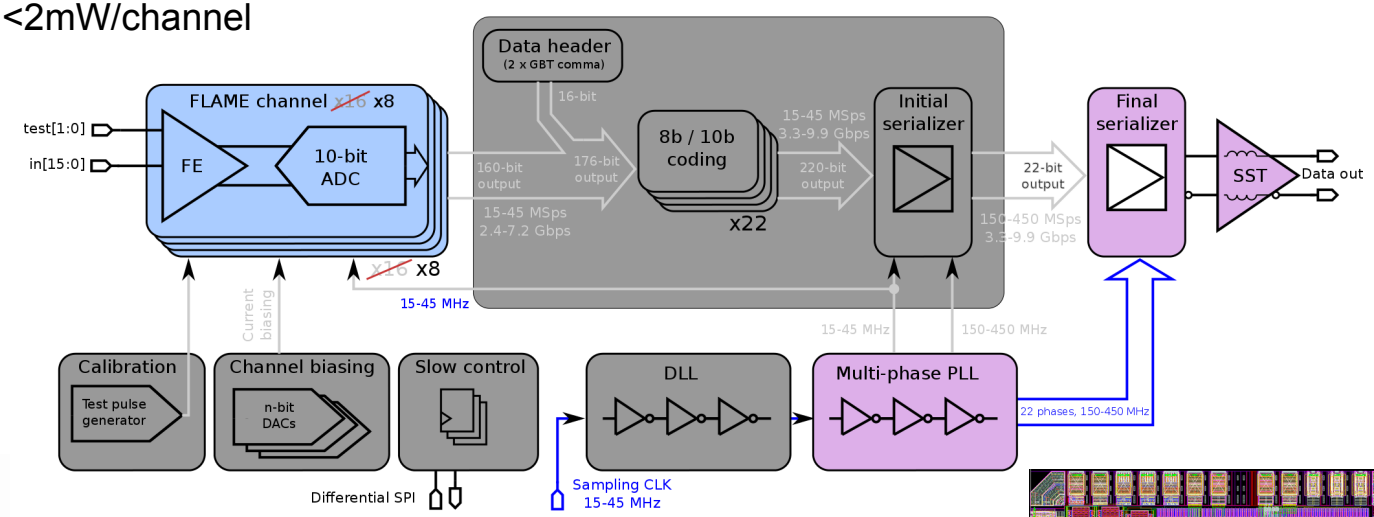
D14.4 - Month48 postponed to M57: Very compact calorimeters

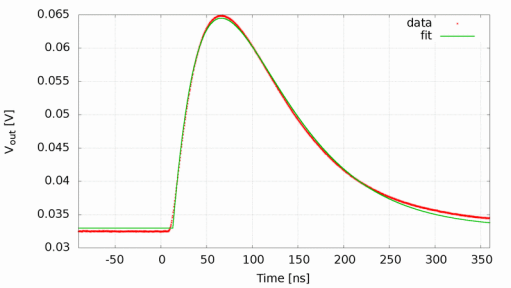
- thin sensor plane
- precise tungsten plates
- FLAME readou ASIC
- beam-test results

MS14.5 – Design of ASICs...

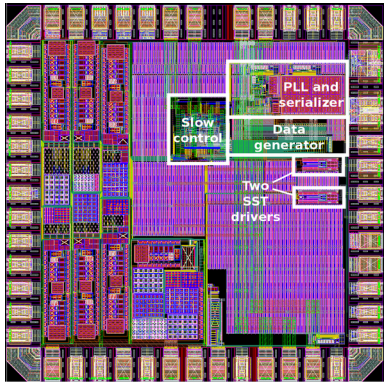
- **Prototype ASIC comprising 8 almost fully functional FLAME channels:**
  - Front-end with variable gain, differential CR-RC shaper, Tpeak = 50ns, ENC~900el@20pF
  - 10-bit multichannel SAR ADC, fs<40MSps
  - Power (FE+ADC) <2mW/channel







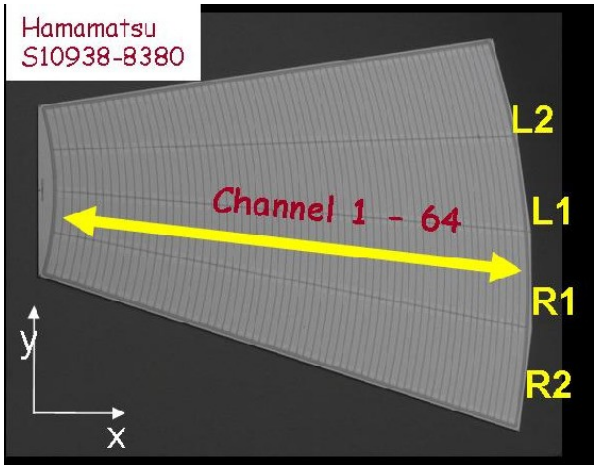
- **Prototype serializer ASIC comprising:**
  - Fast ultra-low power multi-phase PLL
  - Power ~20mW@10Gbps
  - Fast serializer 22b → 1b
  - Fast SST driver



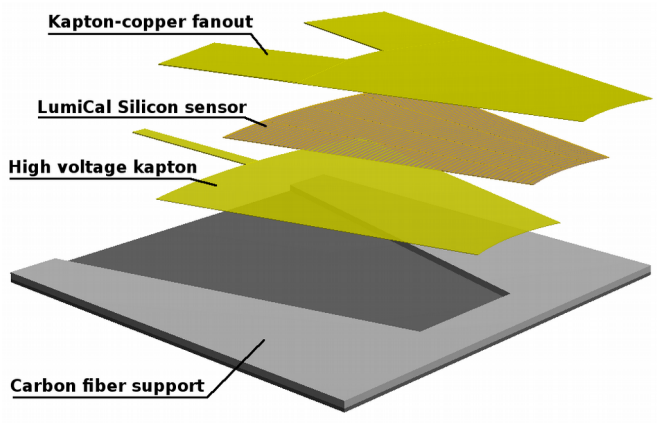
Prototypes of key FLAME blocks fabricated and tested.

D14.4 Very Compact Calorimeter
Thin sensor planes

Silicon sensor



650um thick sensor plane

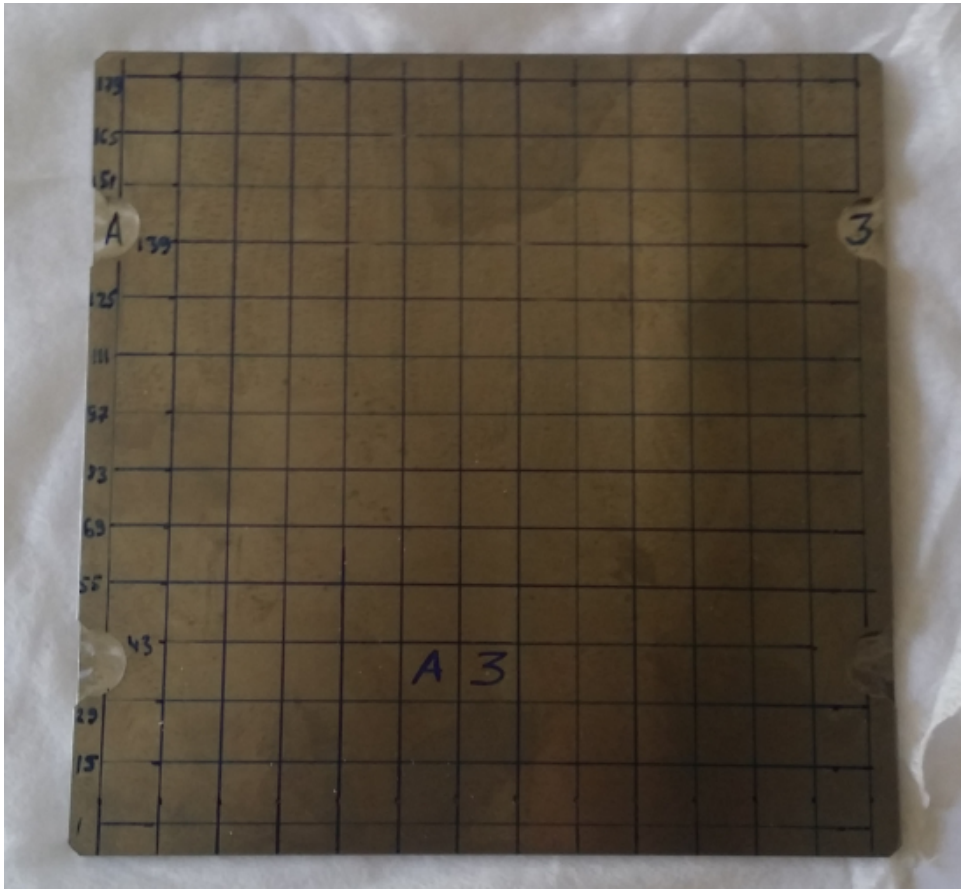


Mounted sensor plane

Thin sensor planes have been developed and fabricated using existing silicon sensors

D14.4 Very Compact Calorimeter
Precise tungsten plates

Tungsten plate

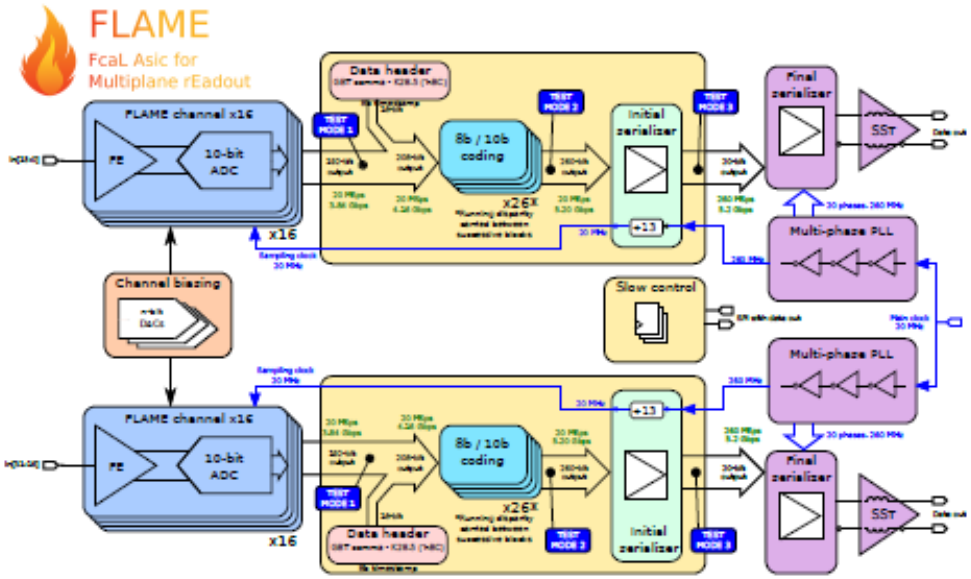


Precise tungsten plates of the size 140mm x 140mm x 3.5mm and flatness of ~50um have been developed and produced.

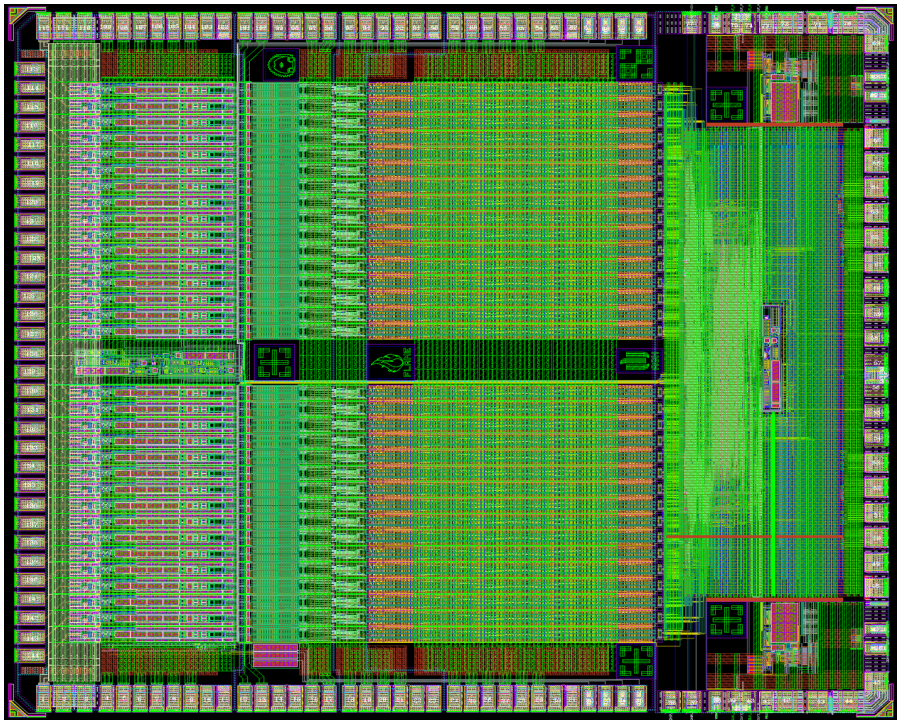
(more than 30 plates available)

D14.4 Very Compact Calorimeter FLAME readout ASIC

Block diagram of 32-channel FLAME



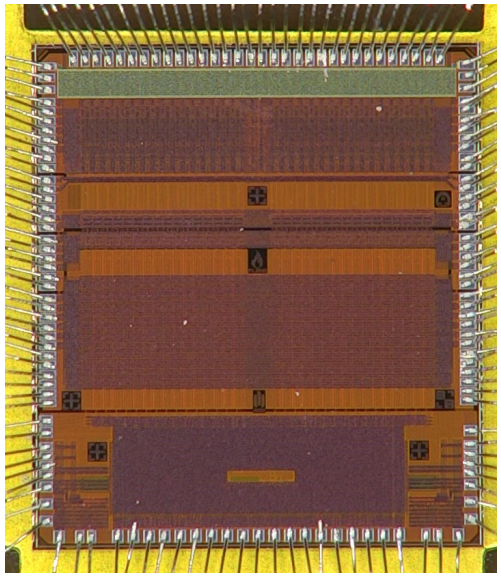
FLAME layout 3.7mm x 4.3mm



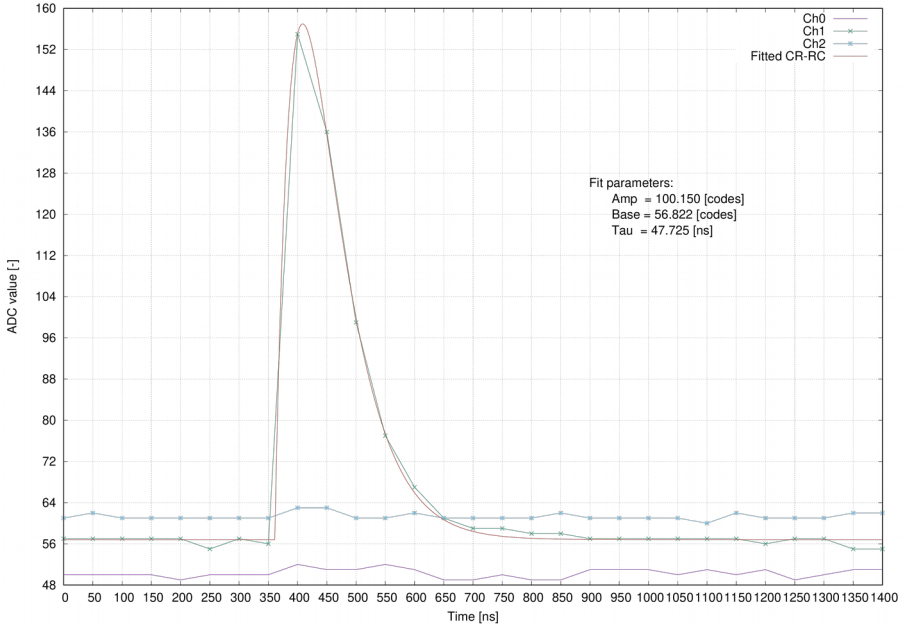
FLAME – a dedicated 32-channel readout ASIC in CMOS 130nm process with FE&ADC in each channel, followed by fast serialization and data transmission, was developed and fabricated. About 80 chips are available.

D14.4 Very Compact Calorimeter FLAME readout

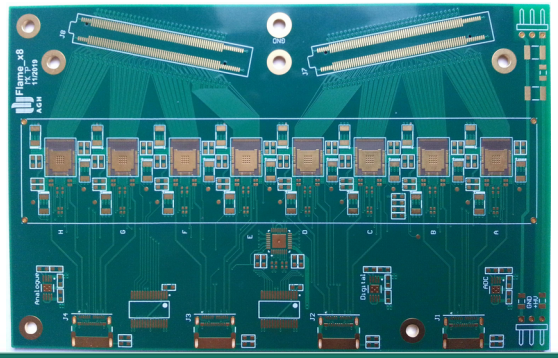
Photograph of bonded FLAME



Example pulse

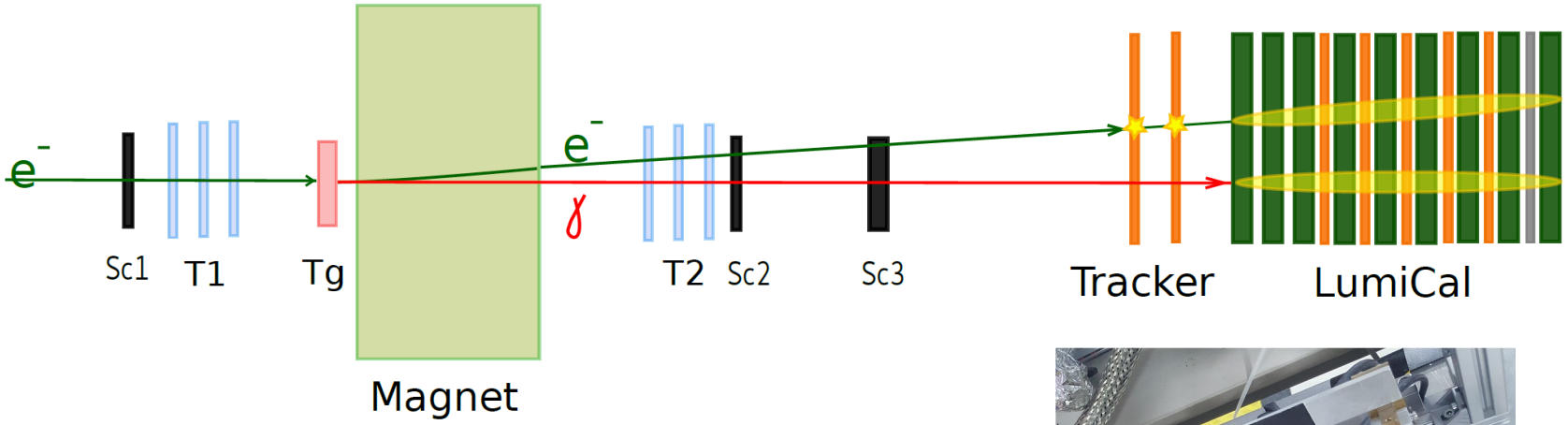


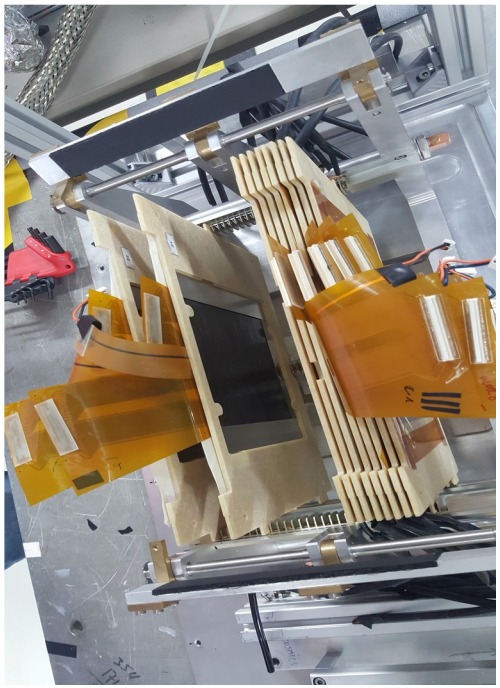
PCB for 8 FLAMEs (256 channels)



FLAME was succesfully tested. PCB readout board to read the whole sensor tile (256 channels) with 8 FLAME chips was designed and produced.

D14.4 Very Compact Calorimeter
Beam-test with compact sensor planes

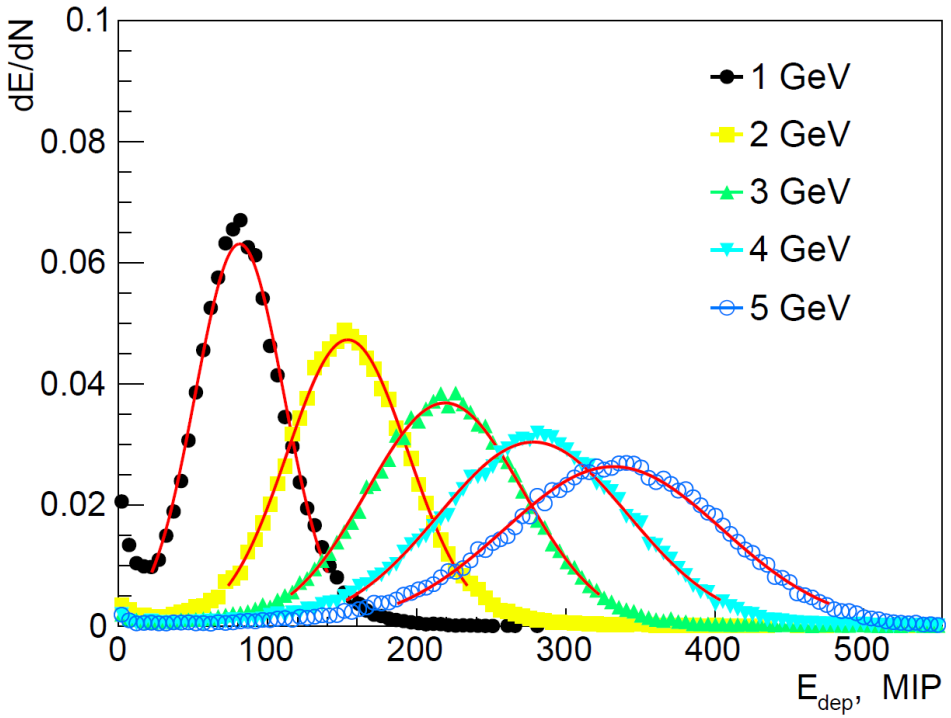




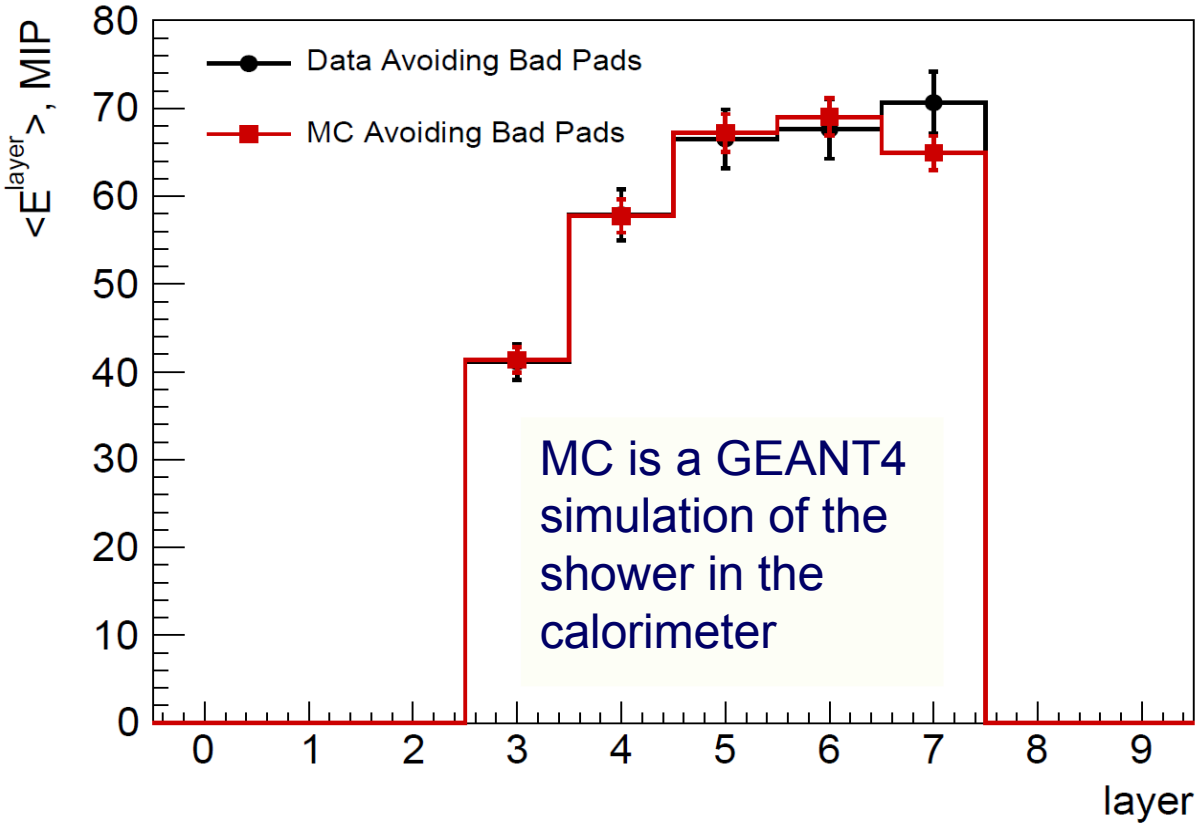
- DESY-II Synchrotron electron beam 1-5 GeV
- Beam size 5x5 mm^2
- T1, T2 Eudet telescopes
- Sc scintillator trigger
- Tg copper target
- Precise mechanical frame
- Eight sensor modules (6 -LumiCal, 2-tracker)
- Eight absorber (W) plates
- External electronics (ASD-based, FLAME was not available yet)

D14.4 Very Compact Calorimeter
Energy deposited in calorimeter

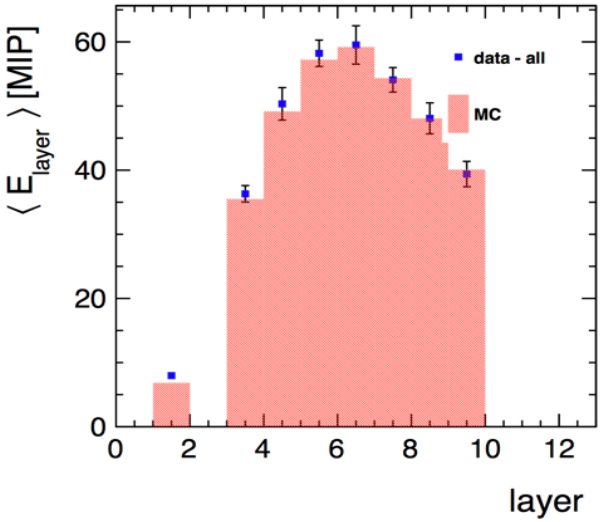
Raw energy distributions



D14.4 Very Compact Calorimeter
Shower development - Longitudinal profile

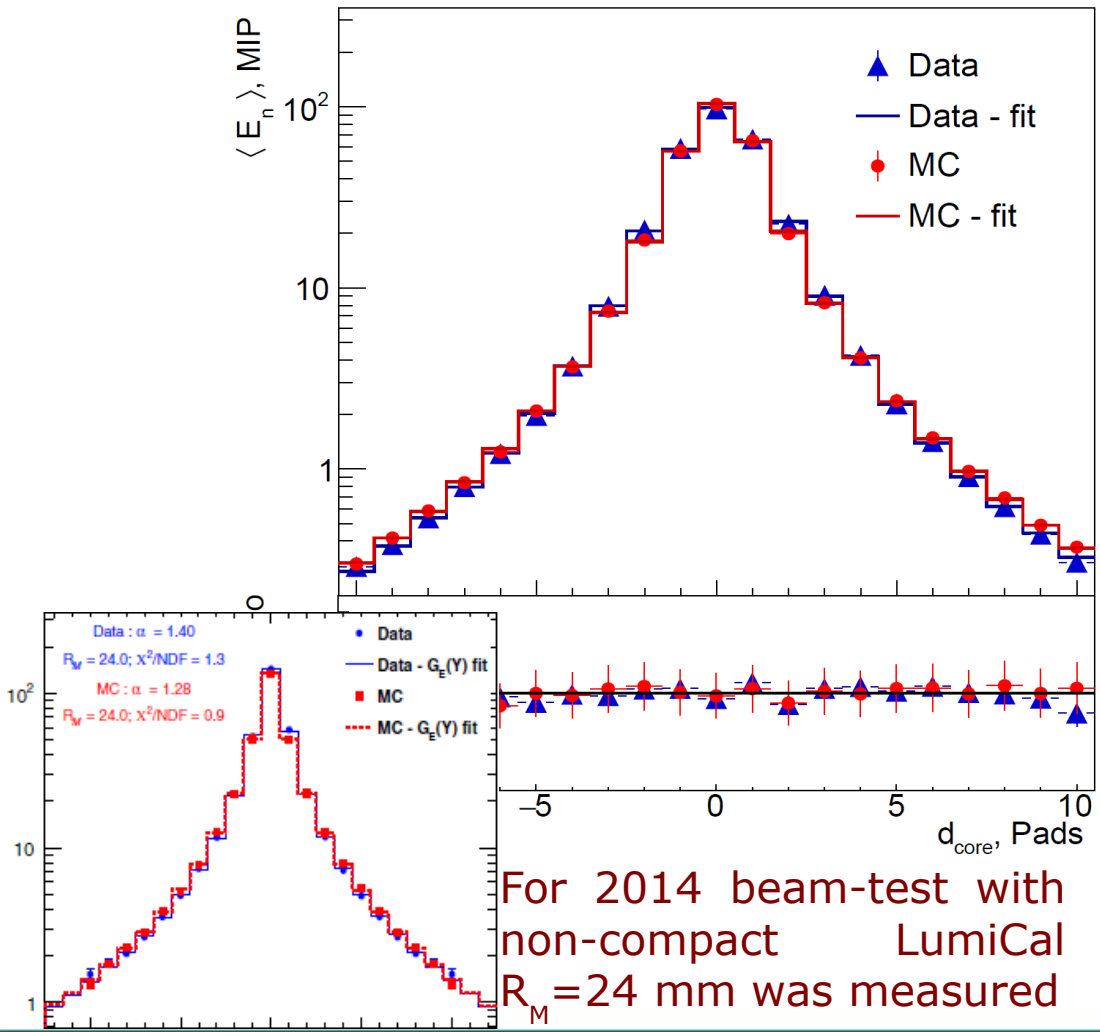


MC is a GEANT4 simulation of the shower in the calorimeter



Above the result from 2014 beam-test for 5GeV electrons

D14.4 Very Compact Calorimeter Shower development - Transversal profile and Moliere radius



For 2014 beam-test with non-compact LumiCal R_M=24 mm was measured

MC is a GEANT4 simulation of the shower in the calorimeter.

For electrons of 5 GeV using the parametrization

$$F_E(r) = A_C e^{-(\frac{r}{R_C})^2} + A_T \frac{2r^\alpha R_T^2}{(r^2 + R_T^2)^2}$$

and

$$0.9 = \frac{\int_0^{2\pi} d\varphi \int_0^{R_\mathcal{M}} F_E(r) r \, \mathrm{d}r}{\int_0^{2\pi} d\varphi \int_0^{\infty} F_E(r) r \, \mathrm{d}r}$$

R_M = 8.1 ± 0.3 mm (data)

R_M = 8.4 ± 0.1 mm (MC)

see Eur. Phys. J. C 79 (2019) 579

Summary

- Infrastructure of a very compact silicon-tungsten sandwich calorimeter was built
- Prototype calorimeter was verified on beam-tests showing excellent results (effective Moliere radus ~ 8.1mm)
- In March beam-test we will add planes with FLAME readout
- As a spin-off, parts of FLAME ASIC are used in HGCAL and MDC readout of CMS experiment

• H. Abramowicz et al, Performance and Molière radius measurements using a compact prototype of LumiCal in an electron test beam, Eur. Phys. J. C 79 (2019) 579, arXiv:1812.11426

• H. Abramowicz et al., Measurement of shower development and its Molière radius witha four-plane LumiCal test set-up, Eur. Phys. J. C 78 (2018) 135, arXiv:1812.11426v2

• Aleksandr Borysov, Beam test results with ultra thin LumiCal detector planes, 2018 JINST 13 C03013

•Veta Ghenescu, Molière radius measurement using a compactprototype of LumiCal in a test set-up, Proc. of Science, The 39th International Conference on High Energy Physics (ICHEP2018)4-11 July, 2018Seoul, Korea

• Itamar Levy, Measurement of shower development and itsMolière radiuswith a four-plane LumiCal test set-up, Proc. of Science, The European Physical Society Conference on High Energy Physics5-12 July 2017 Venice, Italy

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