

CALICE Highlights



AWLC17
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The Motivation: Pushing the Frontiers of Calorimetry

- The original motivation for CALICE: Develop highly granular calorimeters, optimised for particle flow reconstruction
 - ⇒ Granularity goals defined by hadronic shower physics: Segmentation finer than the typical structures in particle showers
 - ⇒ X_0 / ρ_M drive ECAL and HCAL (electromagnetic subshowers)

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Depends on material:

- in W: $X_0 \sim 3$ mm, $\rho_M \sim 9$ mm
- in Fe: $X_0 \sim 20$ mm, $\rho_M \sim 30$ mm

NB: Best separation for narrow showers particularly important in ECAL

⇒ Use W in ECAL!

When adding active elements: ~ 0.5 cm³ segmentation in ECAL, $\sim 3 - 25$ cm³ in HCAL

- ⇒ $O 10^{7-8}$ cells in HCAL, 10^8 cells in ECAL for typical detector systems!
 - ▶ fully integrated electronics needed
 - ▶ requires active elements that support high granularity and large channel counts

CALICE Phases

- **Validation** of the concept of highly granular calorimetry:
Physics prototypes with different ECAL and HCAL technologies in beam

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- **Technical Realisation** of detector systems satisfying collider constraints:
Technological prototypes, with fully embedded electronics, power pulsing,...
tested in particle beams, partially with magnetic field

CALICE Phases

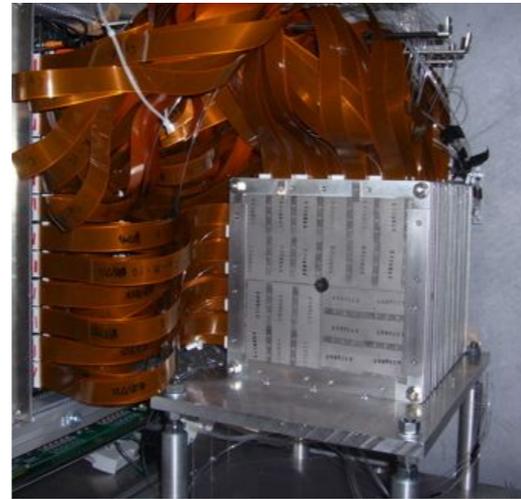
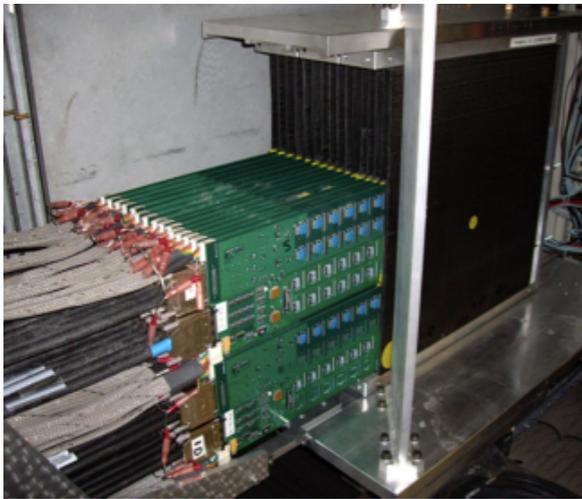
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- **Application** of CALICE technology in running experiments:
 - Use of CALICE detector elements
 - Full detector systems based on CALICE technology

Validation: CALICE Technologies

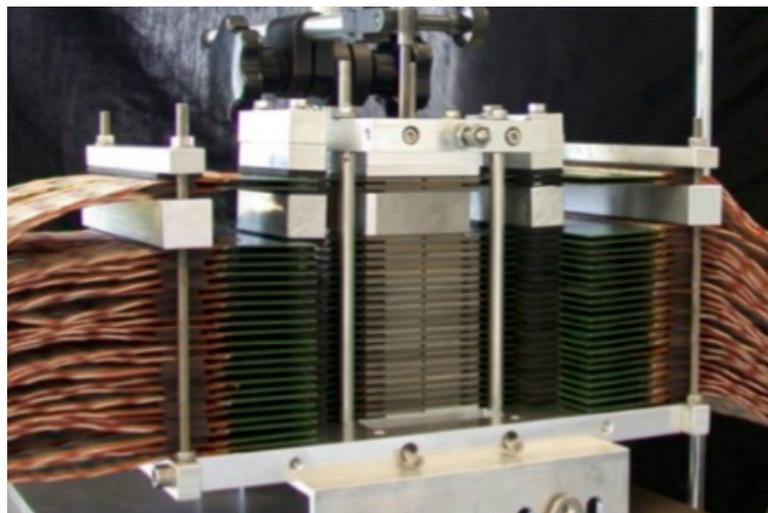
Electromagnetic

Tungsten absorbers

analog: Silicon and Scintillator/SiPM



digital: Silicon (MAPS)



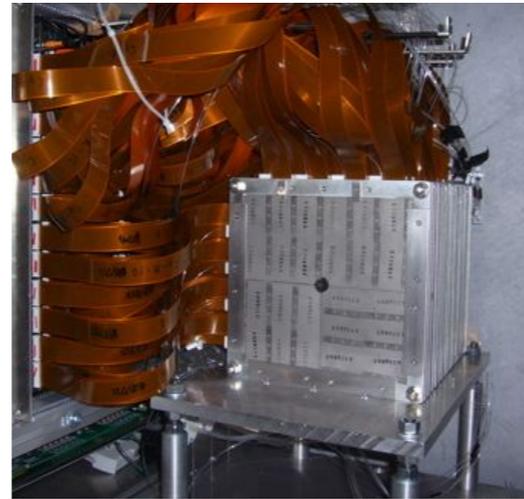
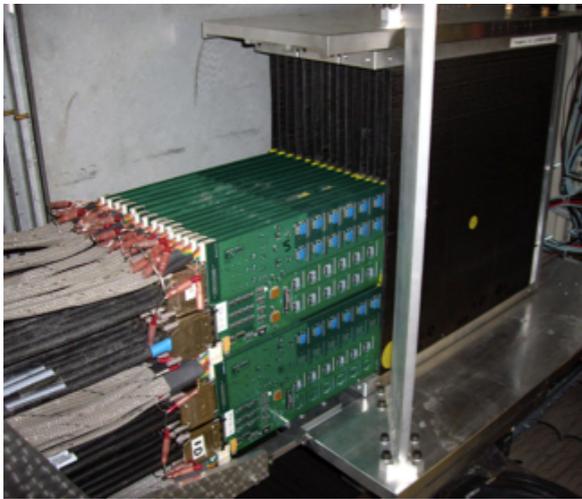
39 Mpixels in
160 cm²

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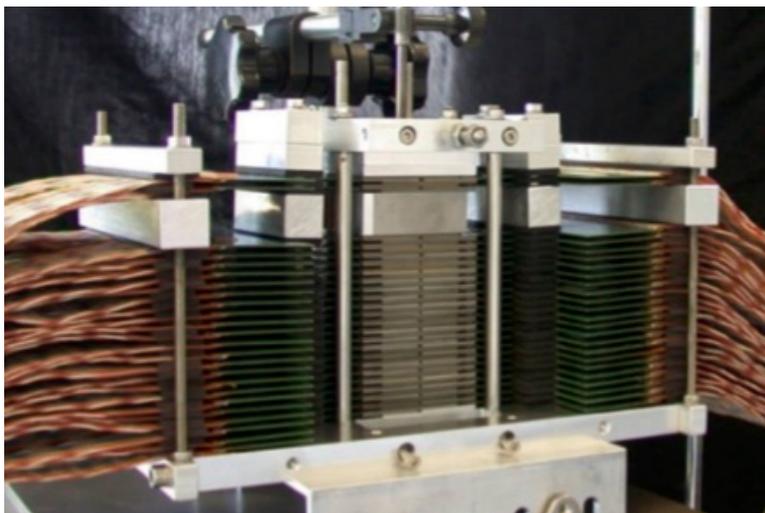
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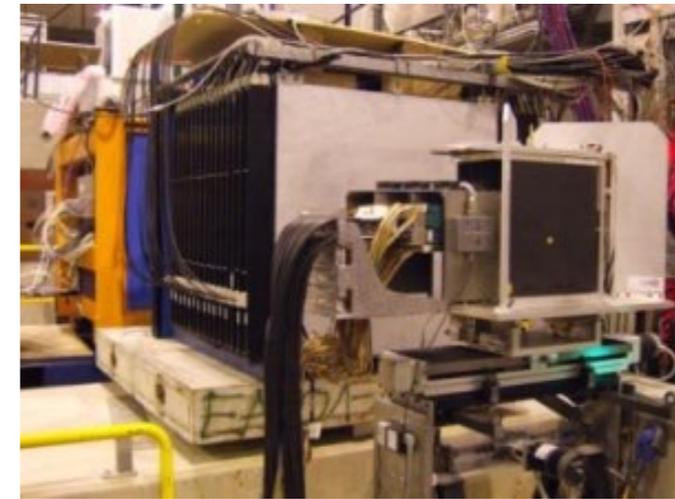


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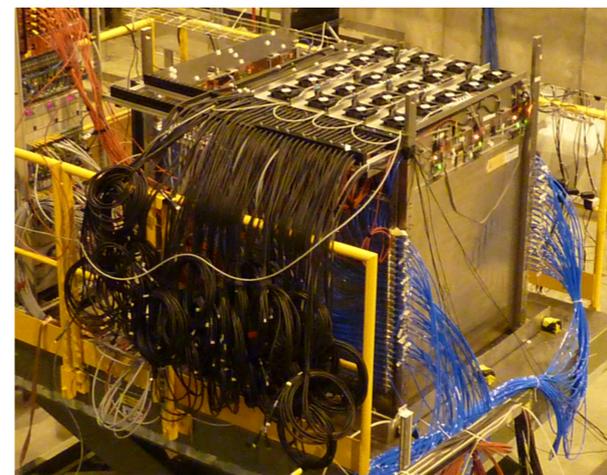
Hadronic

Steel and Tungsten absorbers

analog: Scintillator/SiPM (Fe and W)



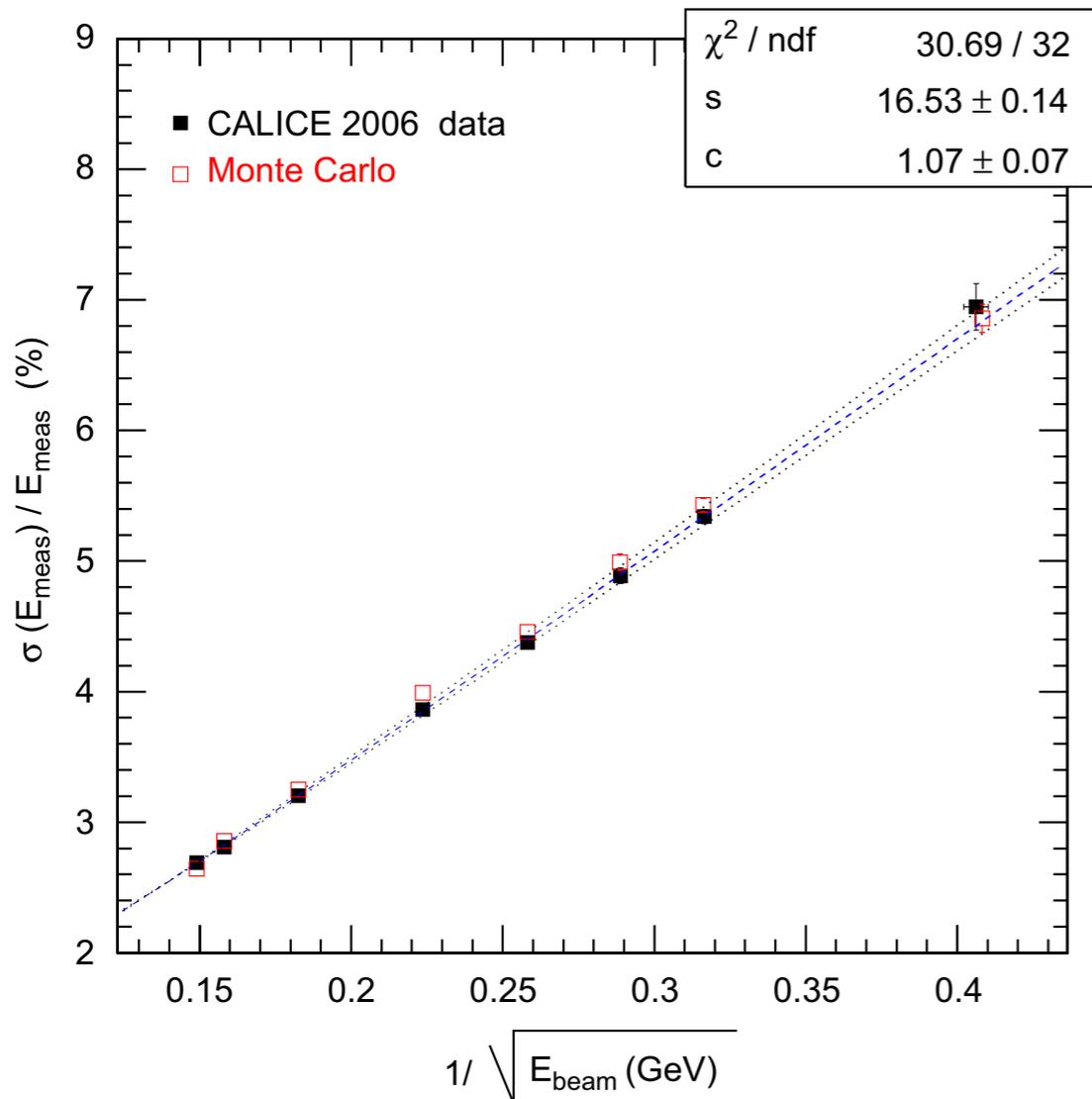
(Semi)digital: RPCs (Fe, W digital only)



+ few-layer SD prototype with Micromegas

Validation: Performance - Resolution

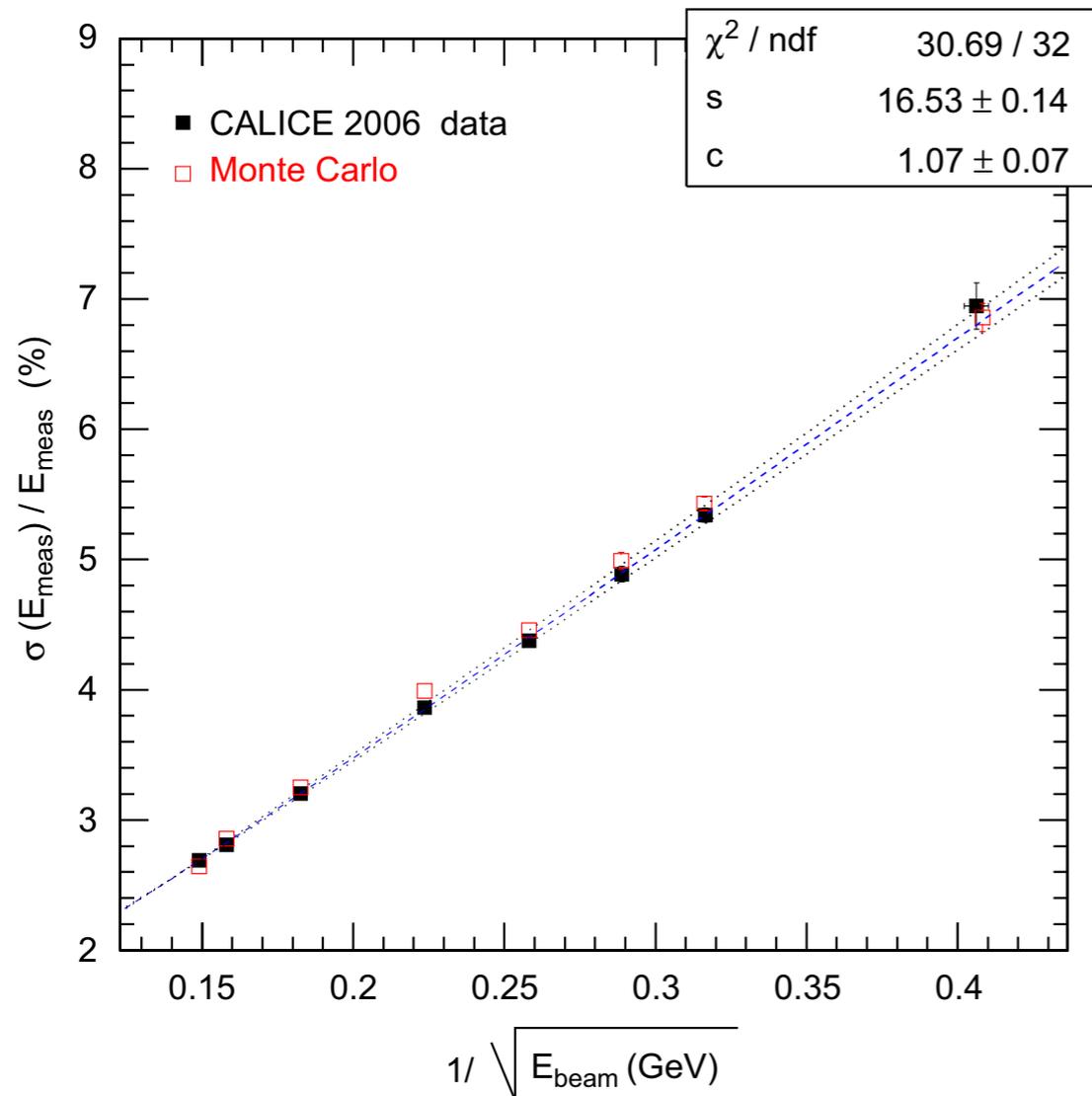
- Demonstrated key performance aspects - three examples:
- Electromagnetic resolution



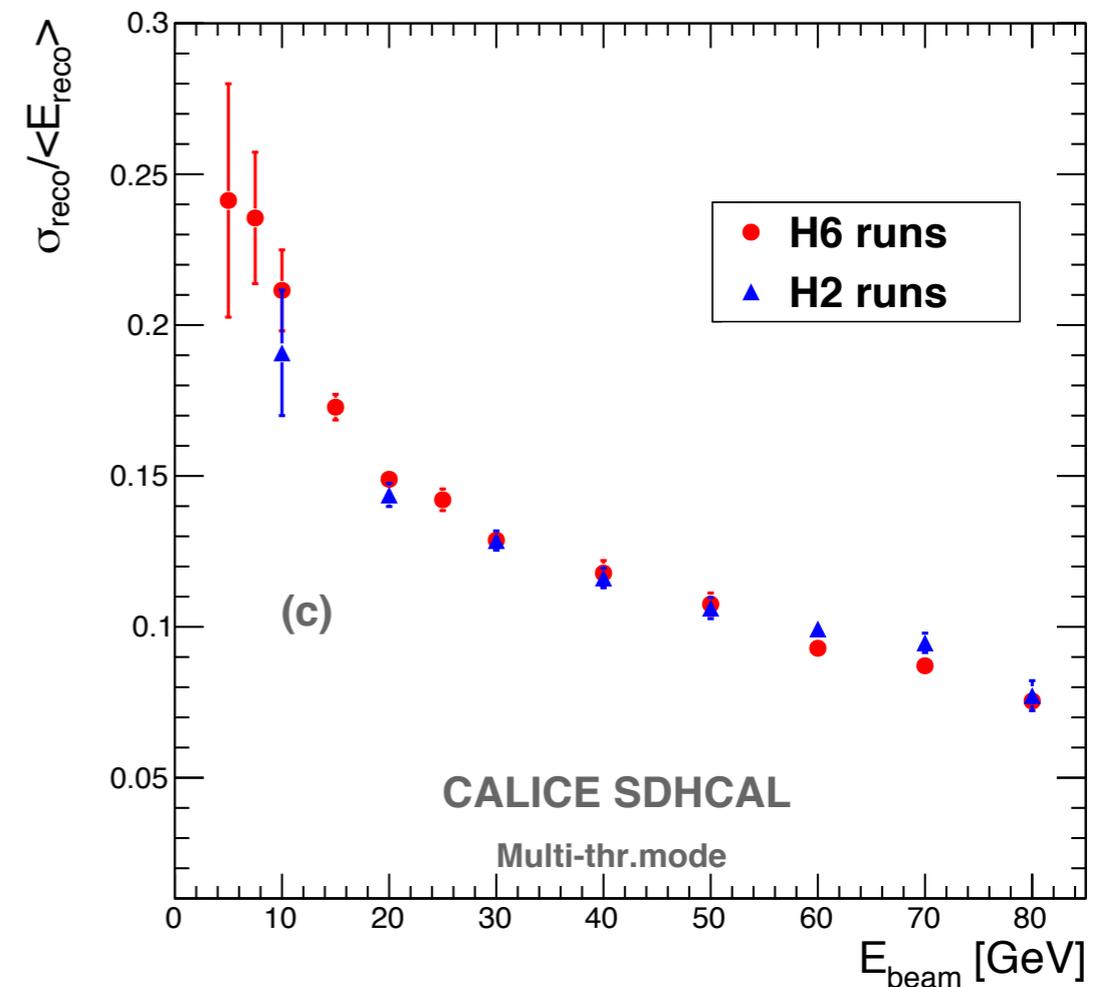
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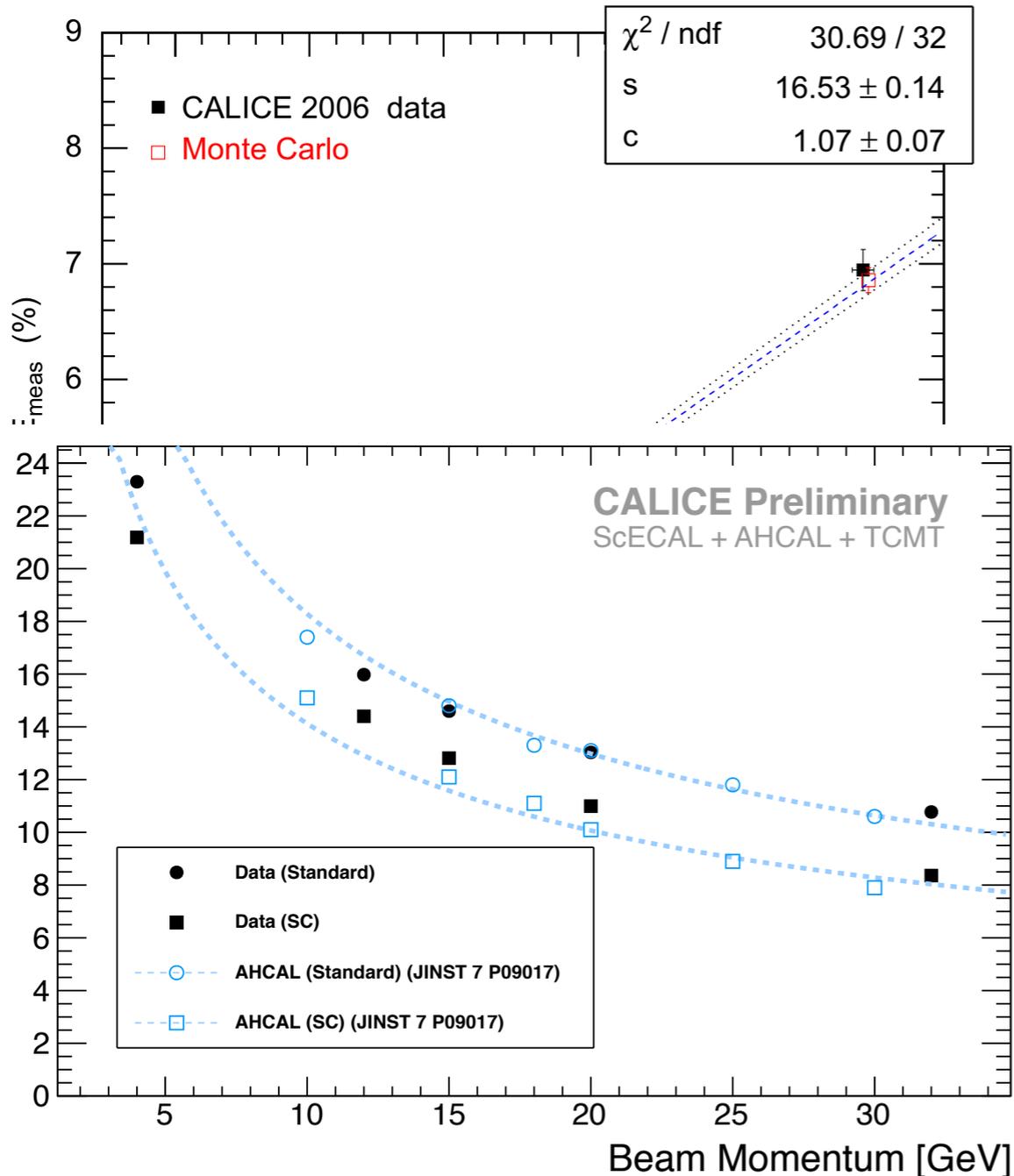


- Hadronic resolution in gaseous calorimeters

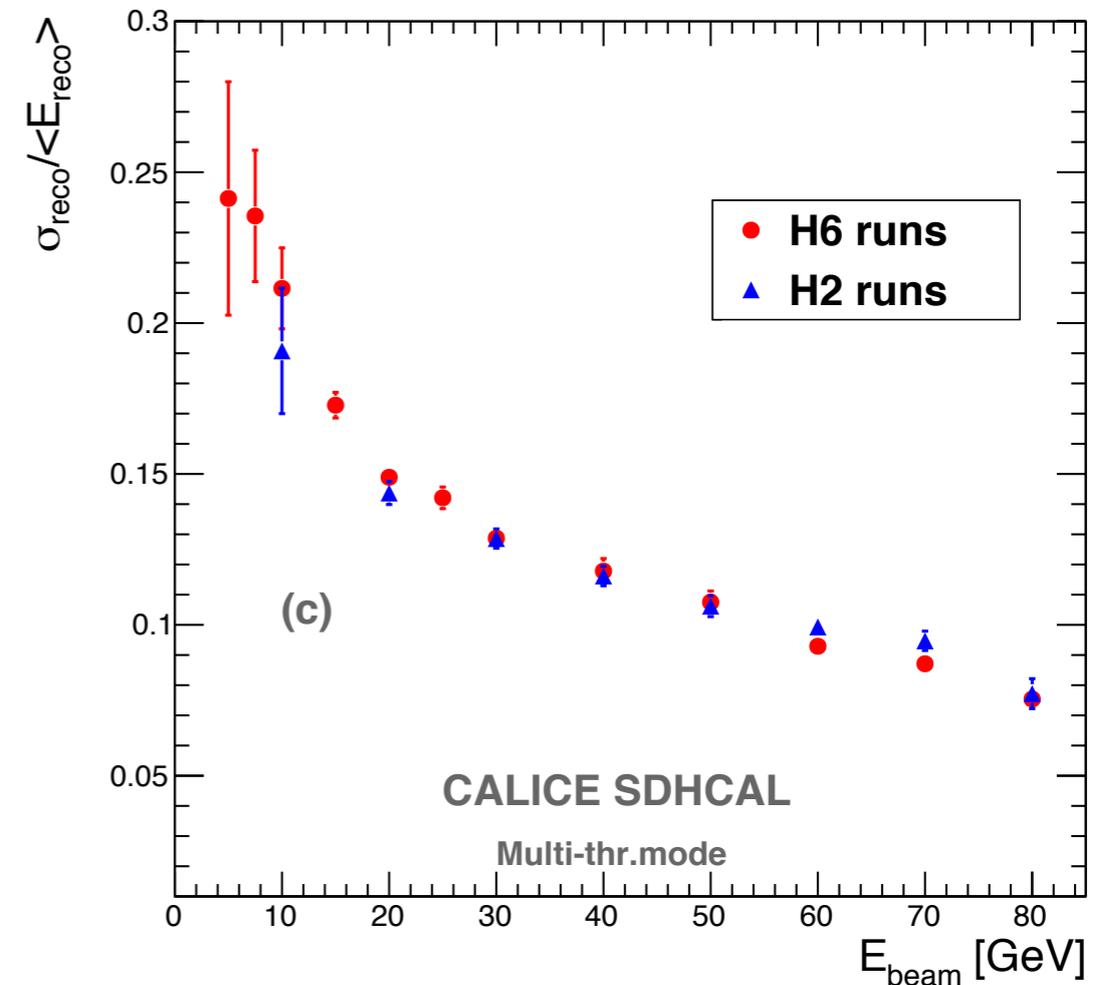


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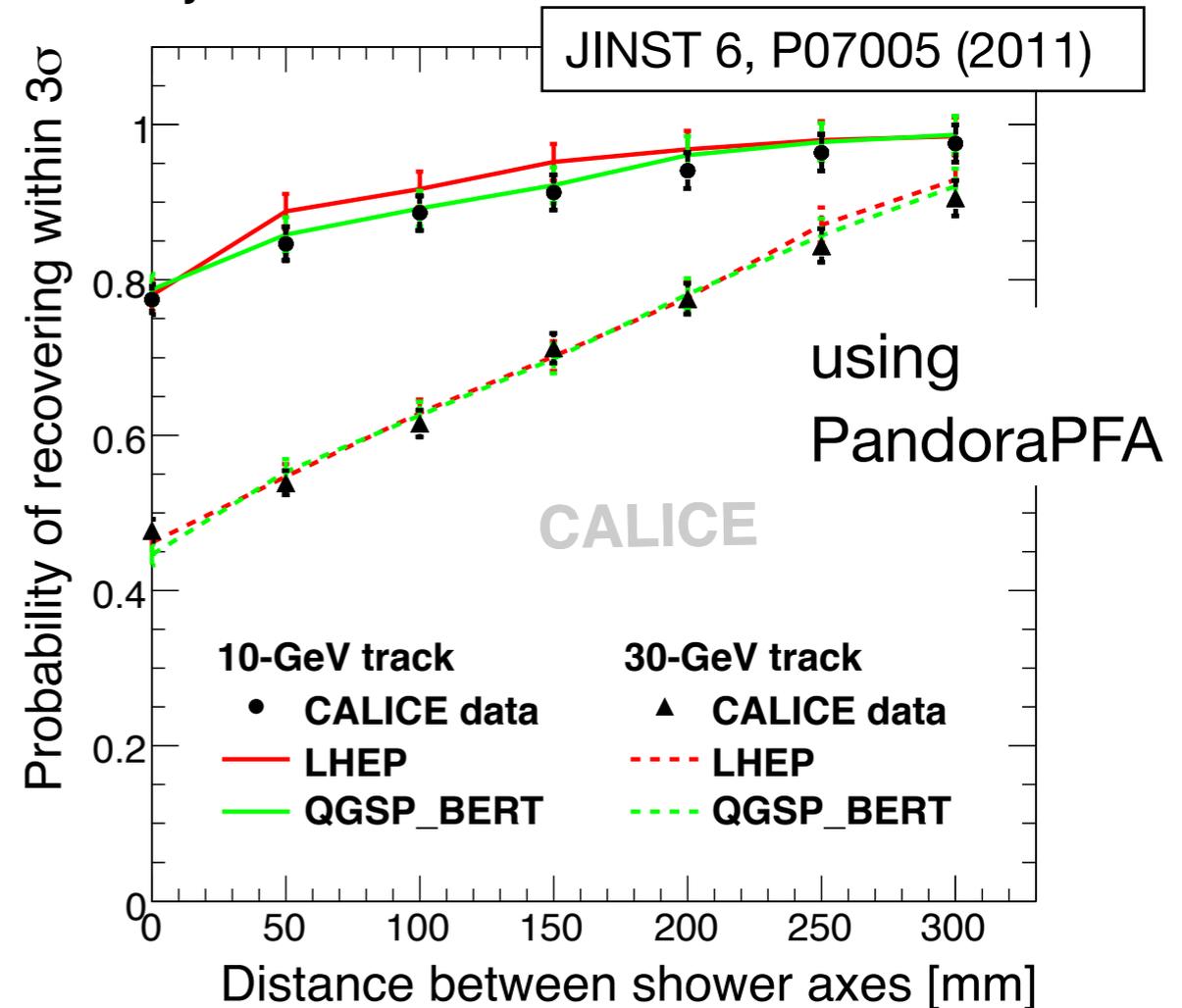
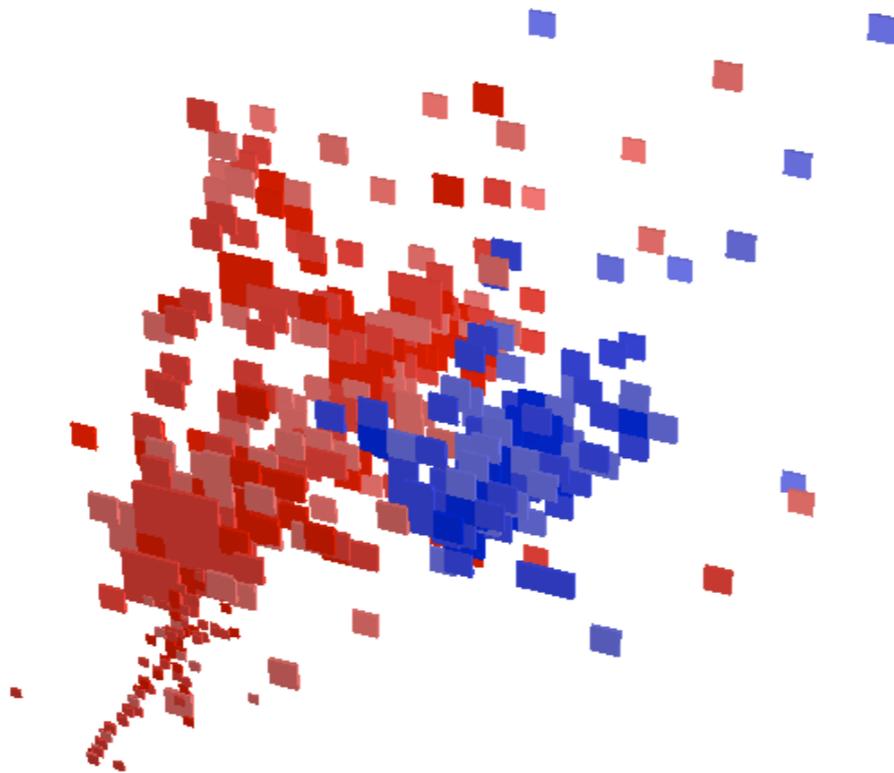


- Hadronic resolution in combined systems with software compensation

Validation: Performance - Separation

- CALICE calorimeters are not (just) about single particle resolution, but PFA performance - which requires particle separation in a jet environment

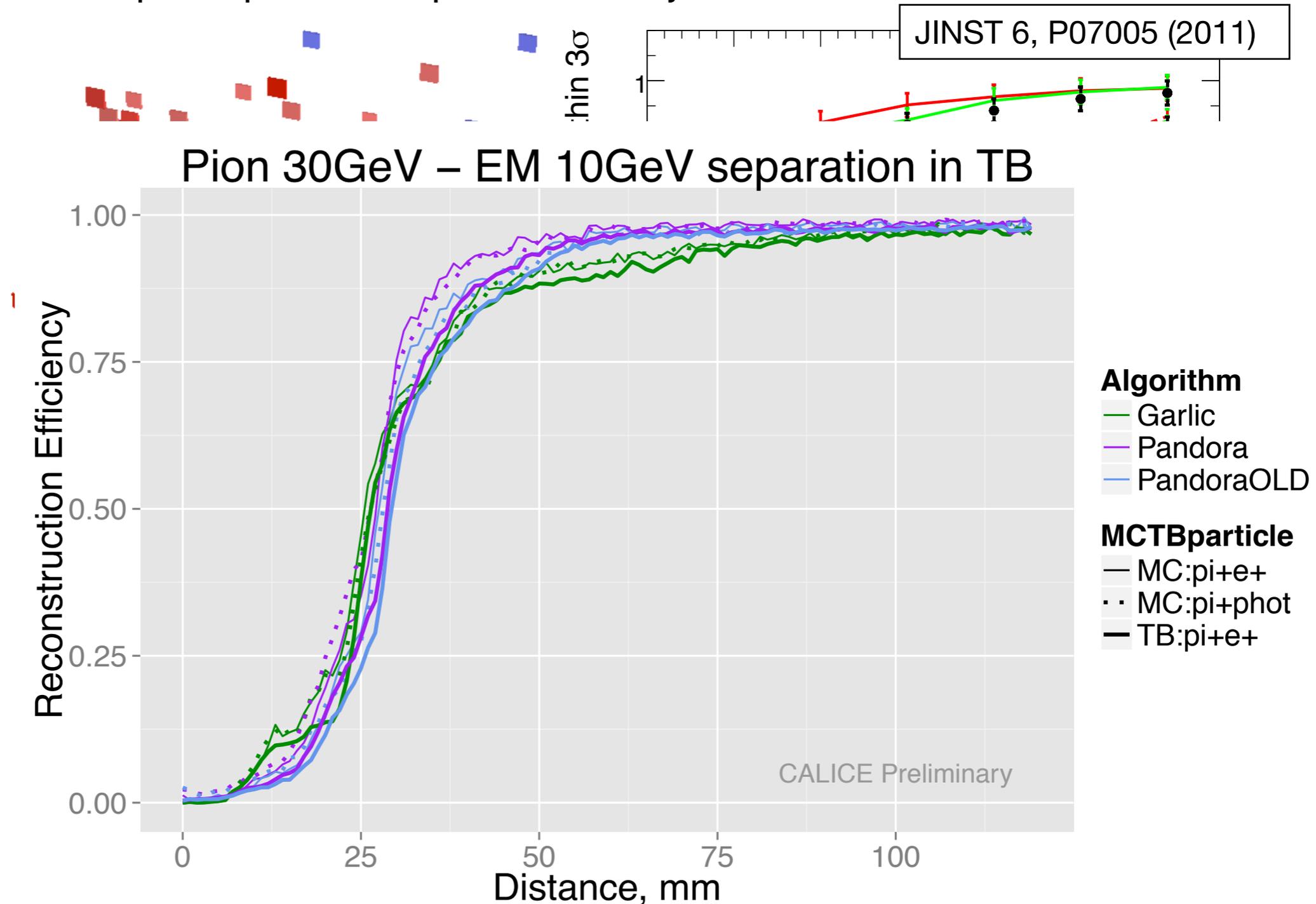
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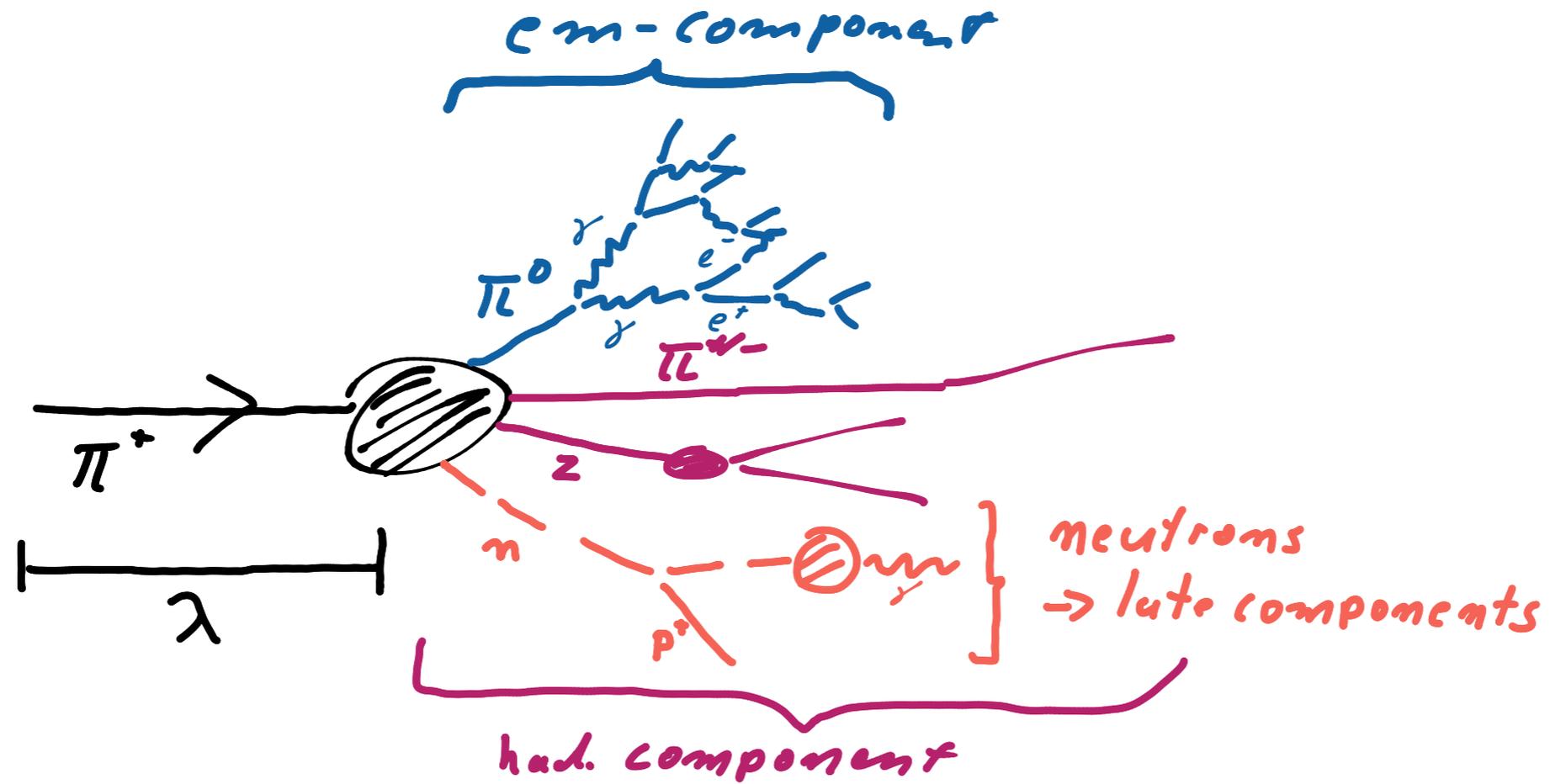
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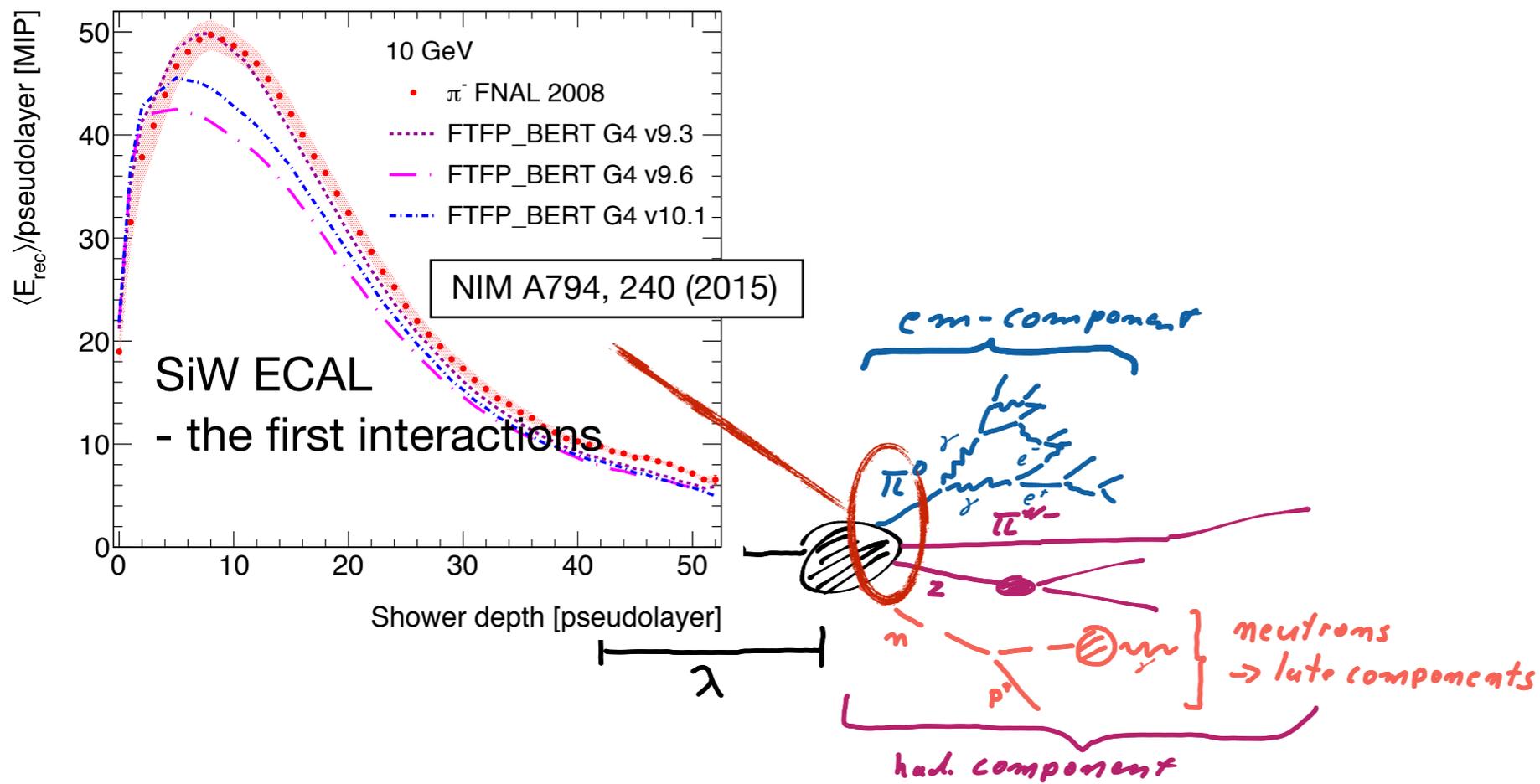
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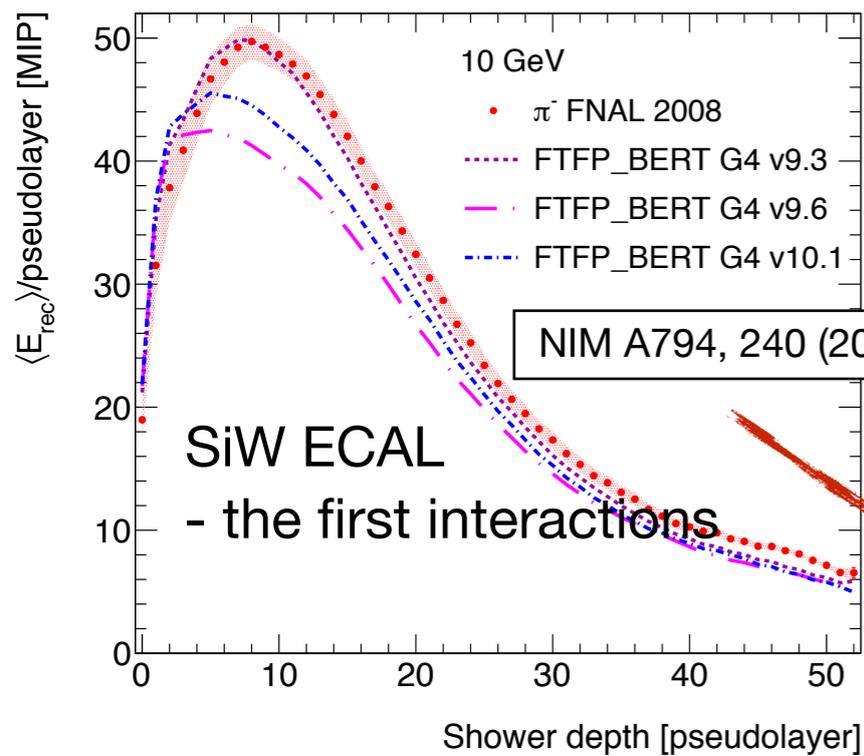
Exploitation: Understanding Hadronic Showers



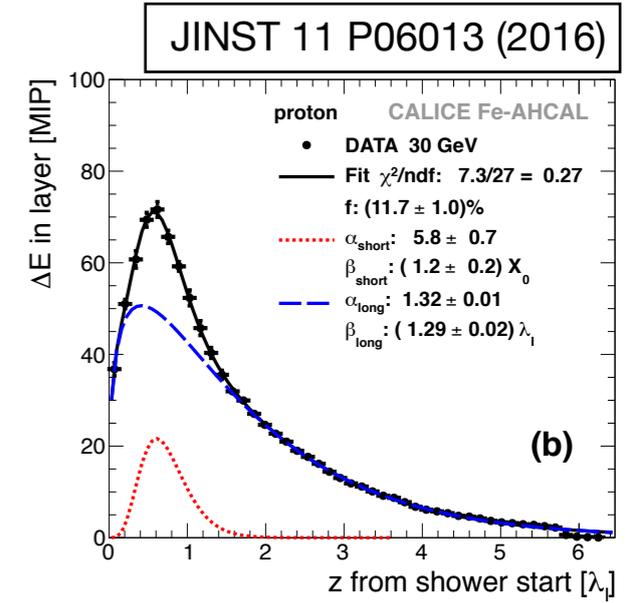
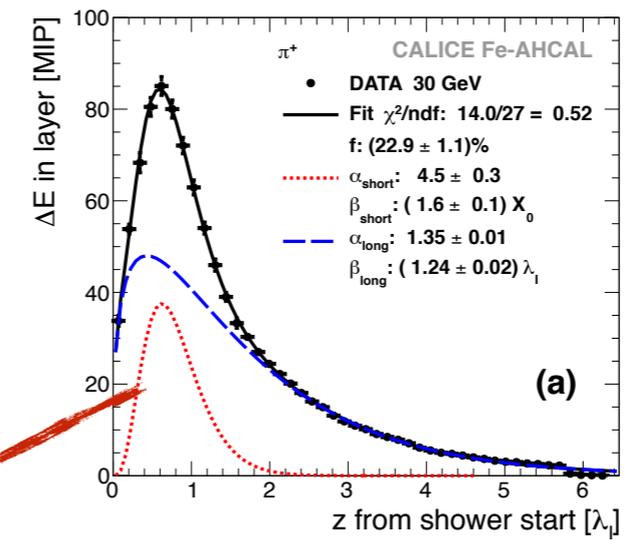
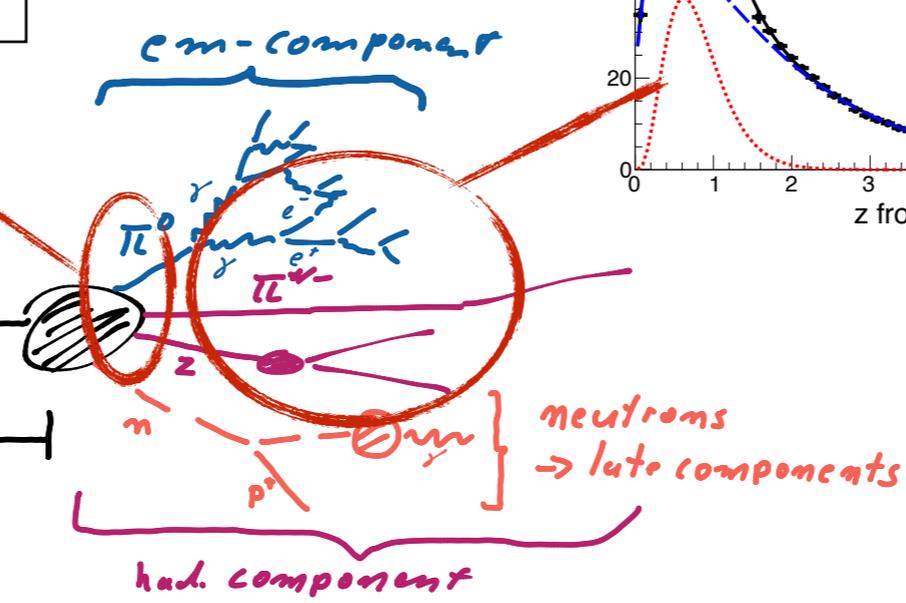
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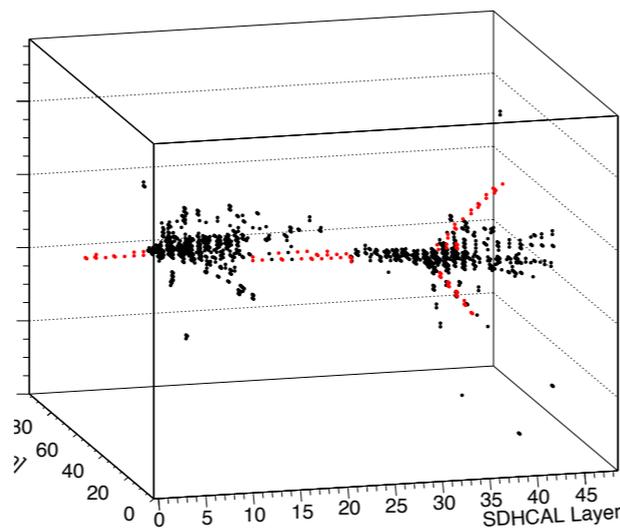
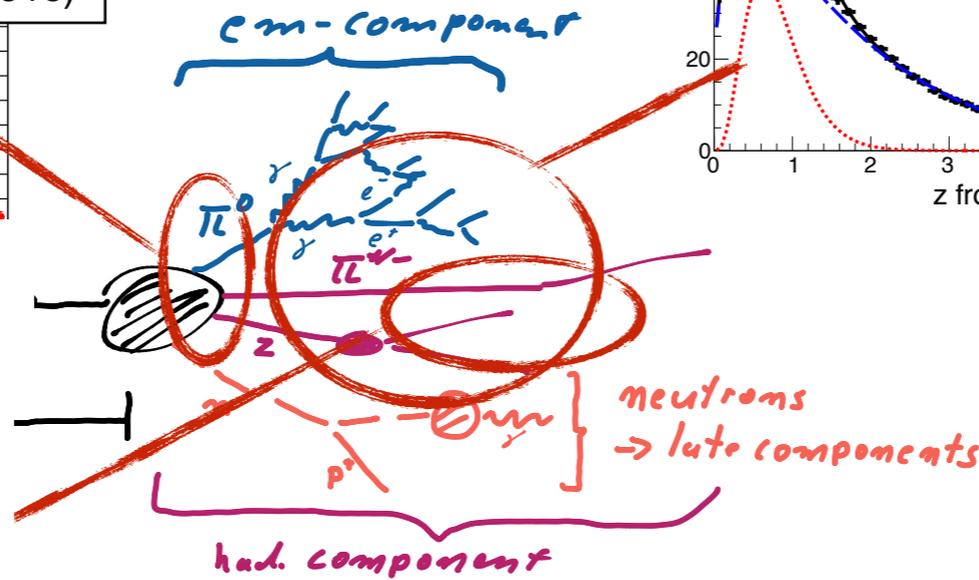
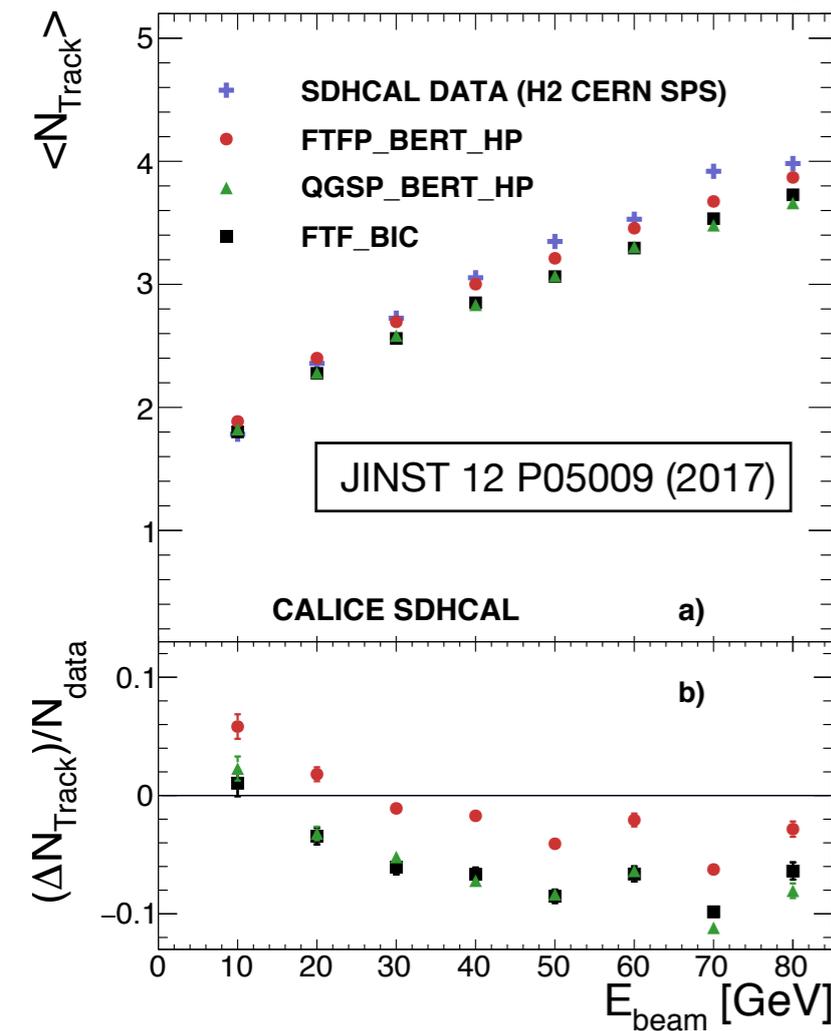
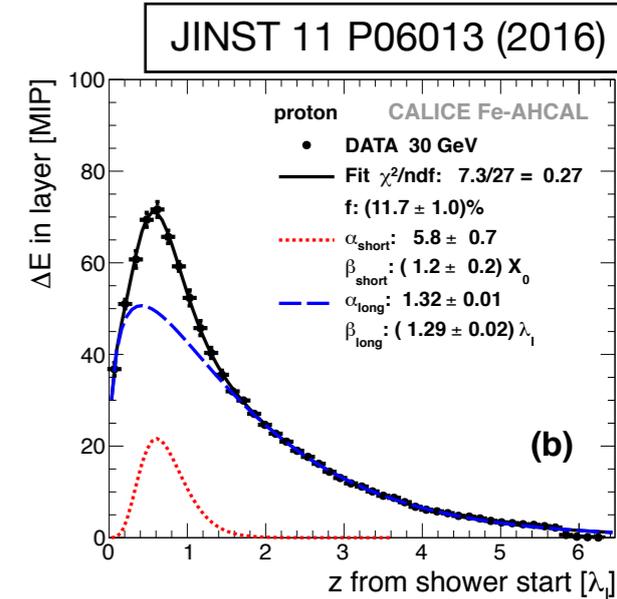
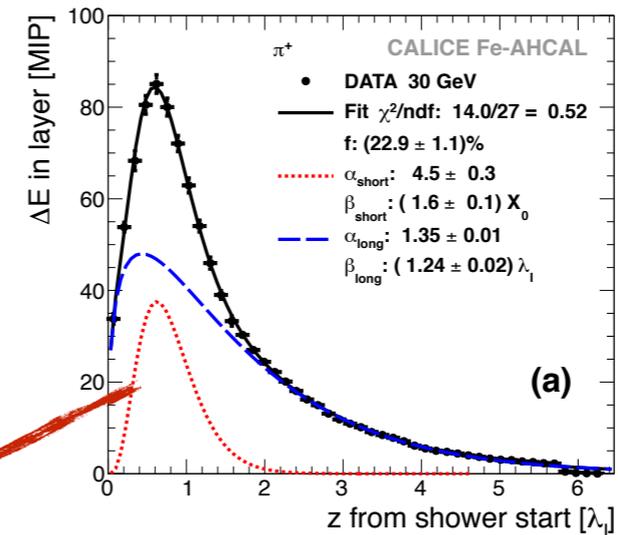
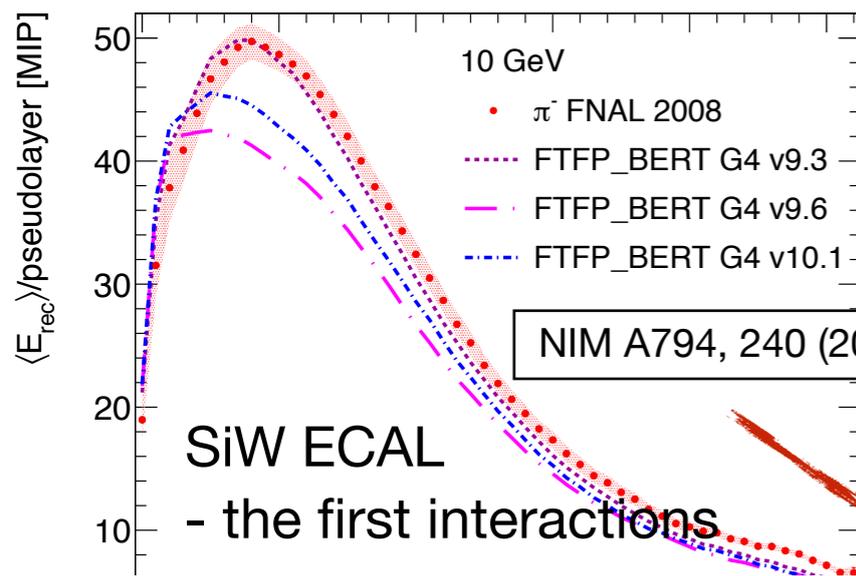
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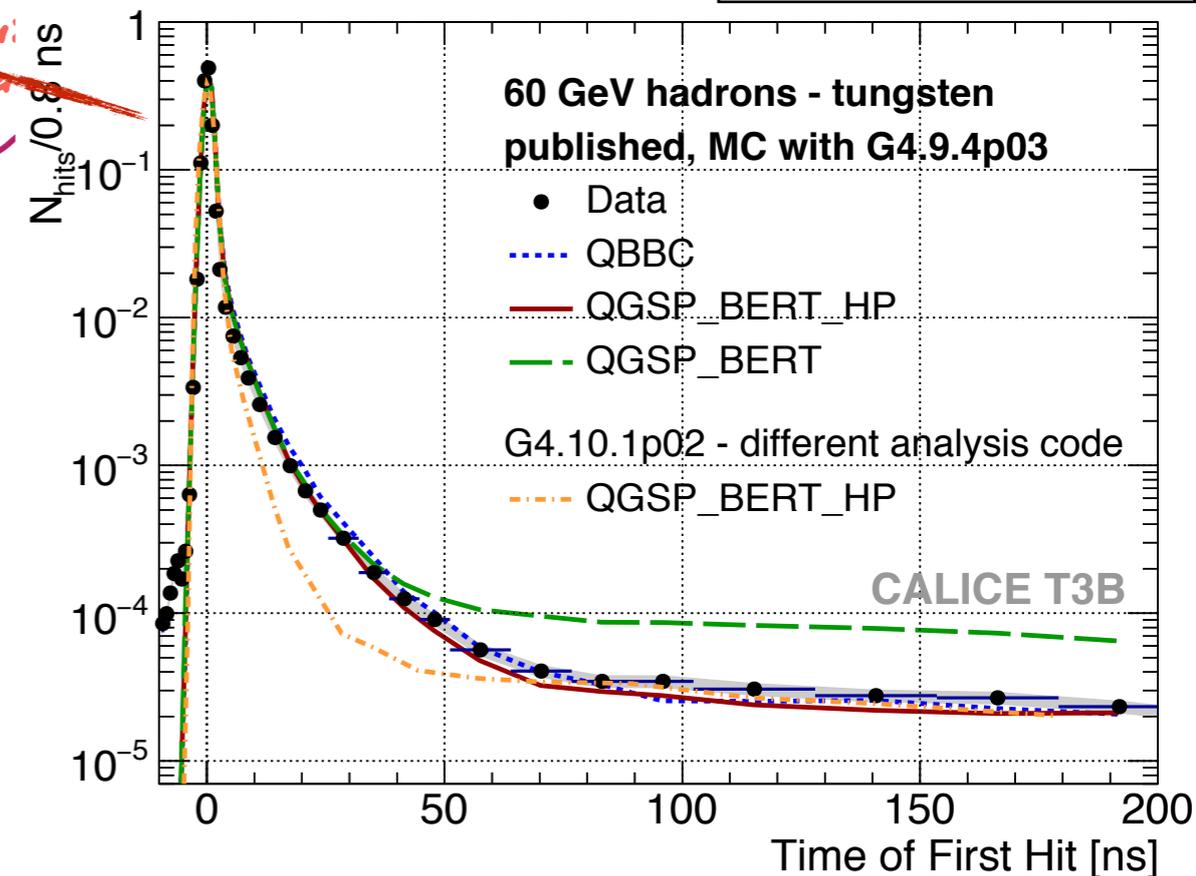
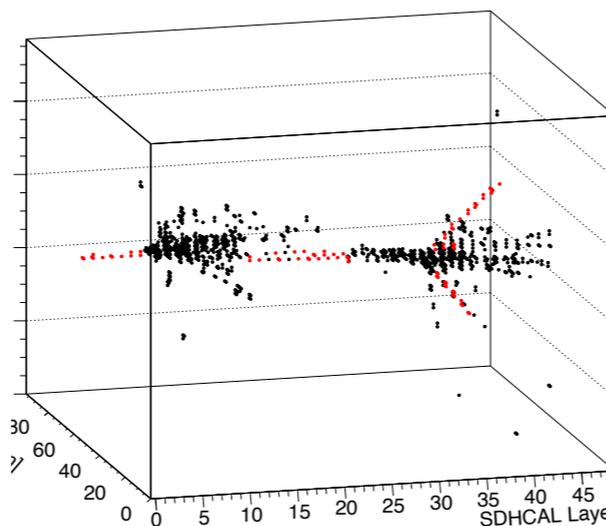
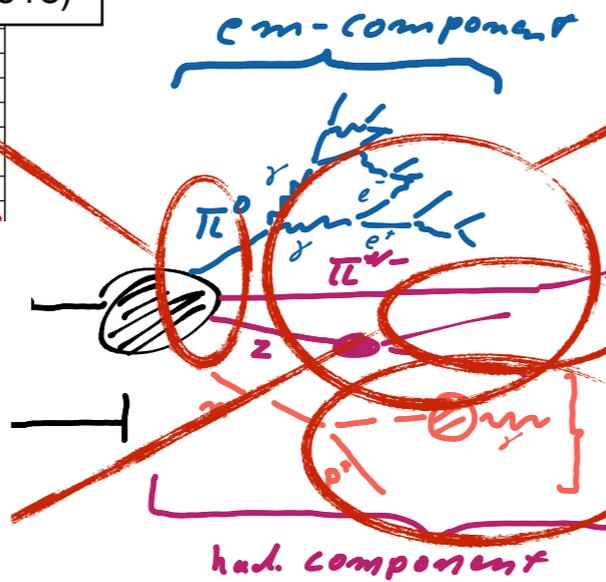
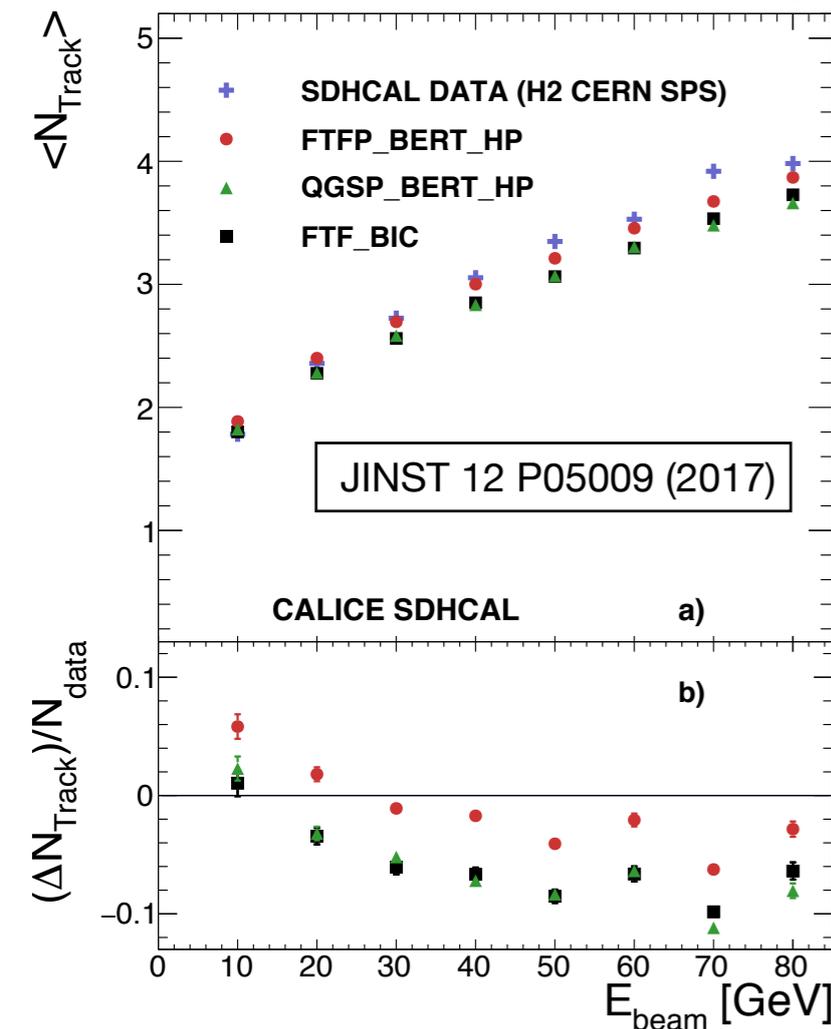
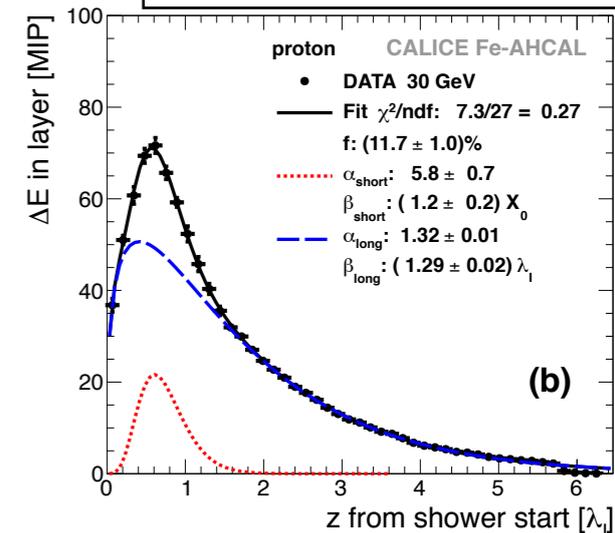
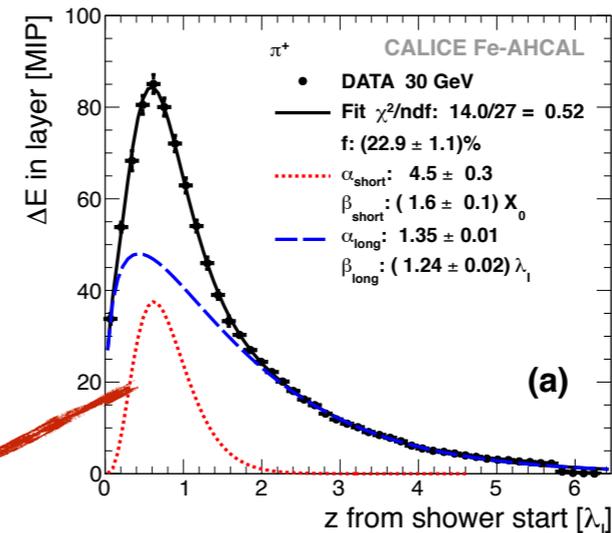
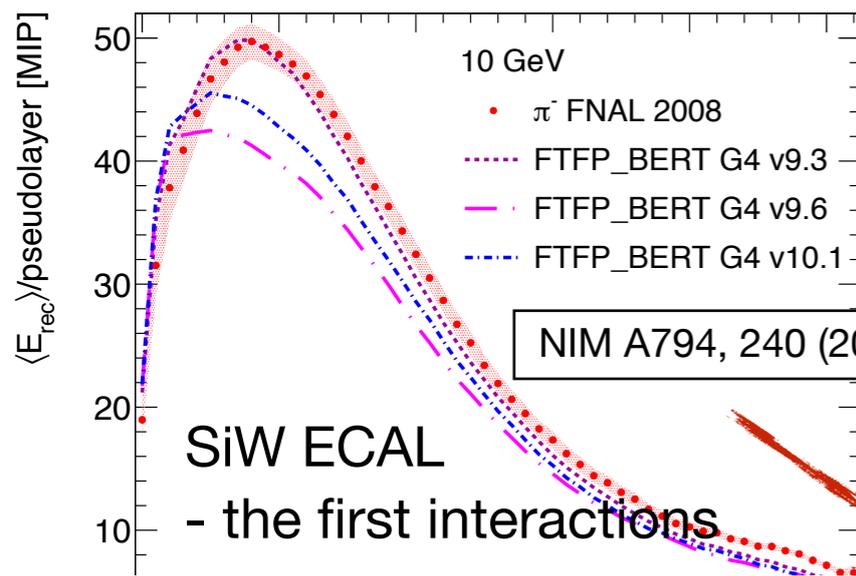
SiW ECAL
 - the first interactions



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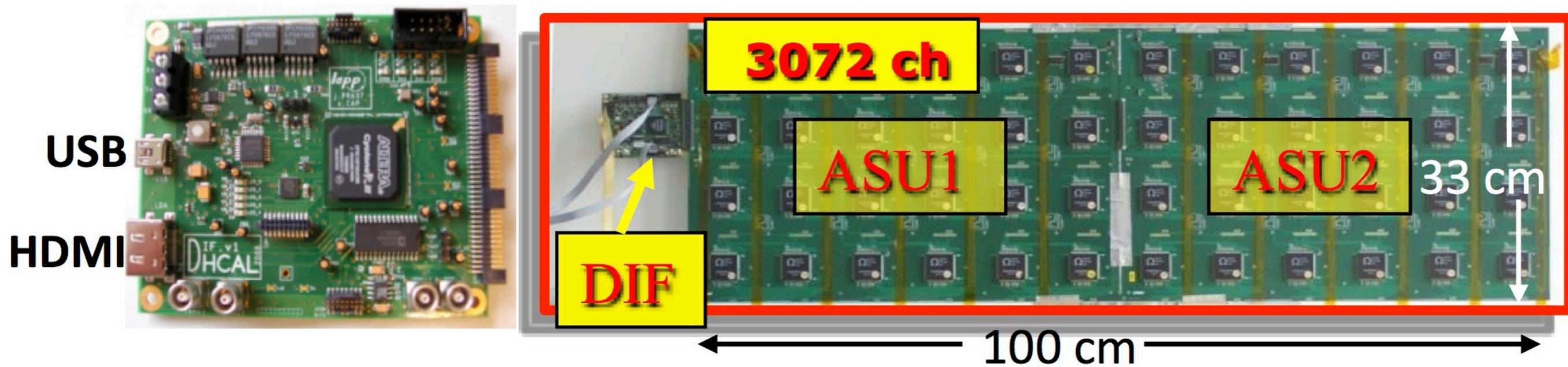


Exploitation: Understanding Hadronic Showers



Technical Realisation: The SDHCAL

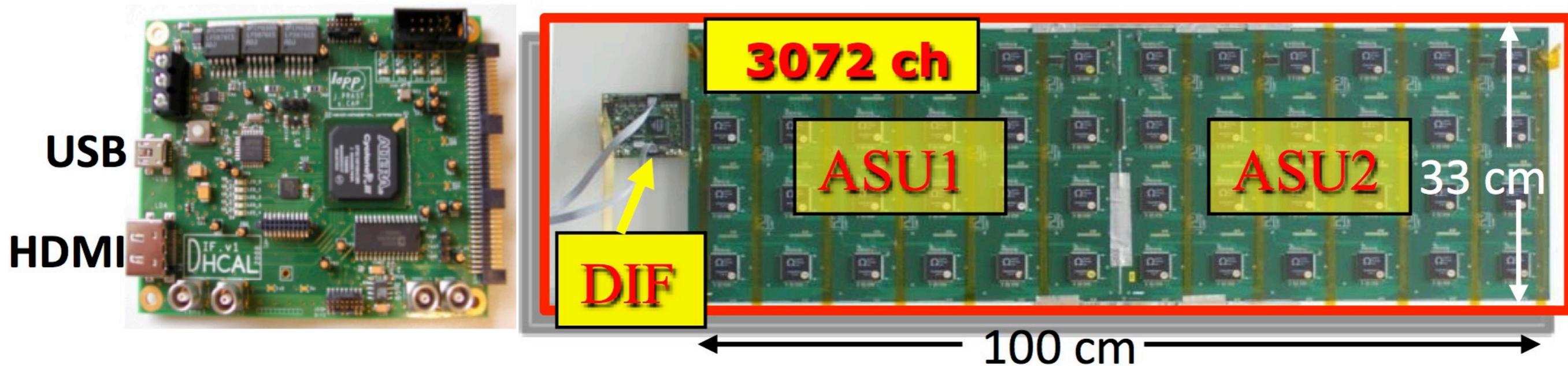
- The SDHCAL was already a technical prototype: many of the features required for a full system already included: Embedded electronics, power-pulsing, ...



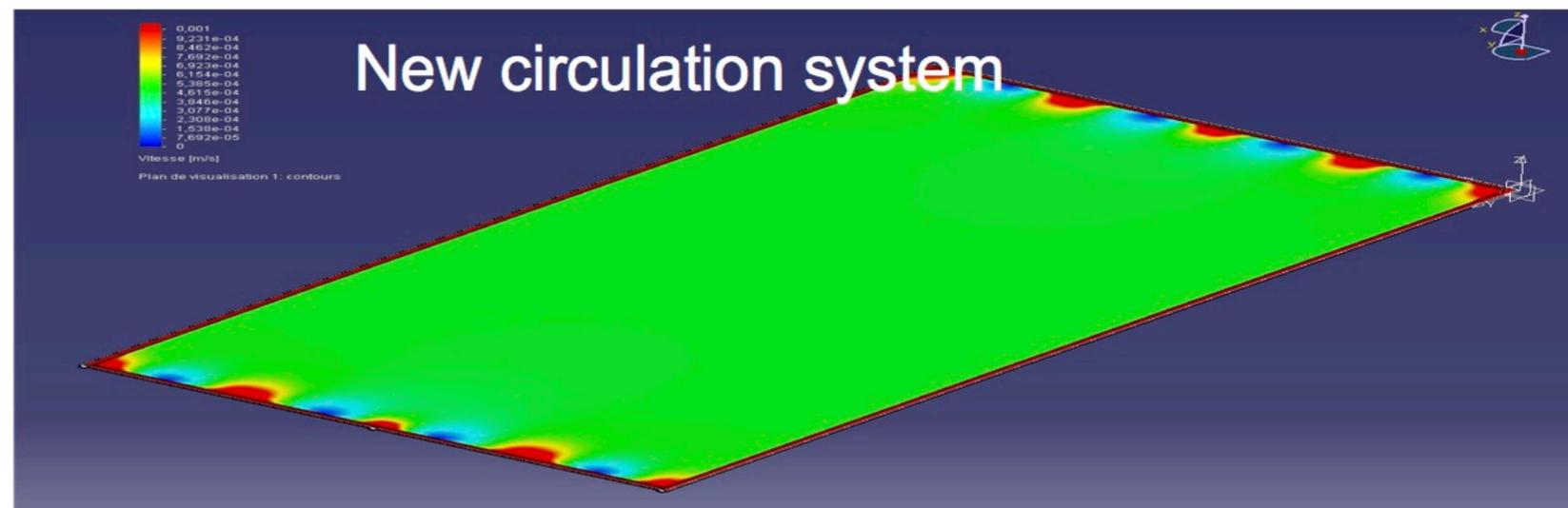
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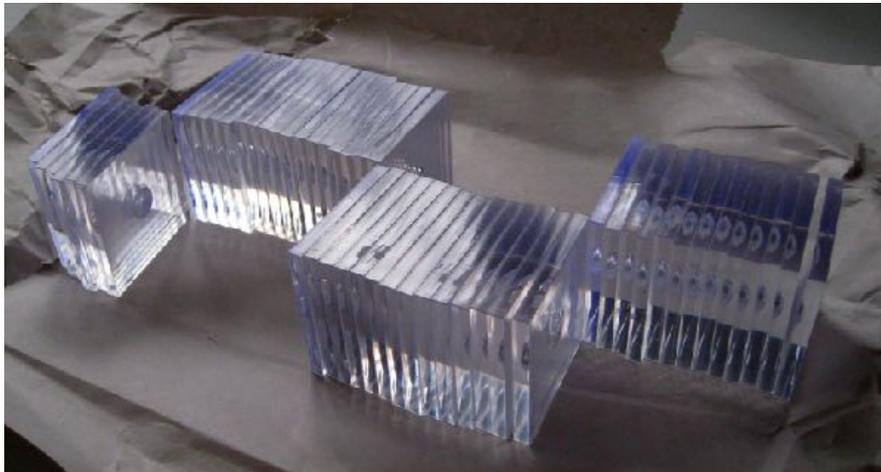


- Now: Updated ASICs, also new interface electronics to account for realistic constraints
- Towards full systems: Larger area RPCs required - optimisation of gas flow to obtain uniform response for 2 m² detectors ongoing



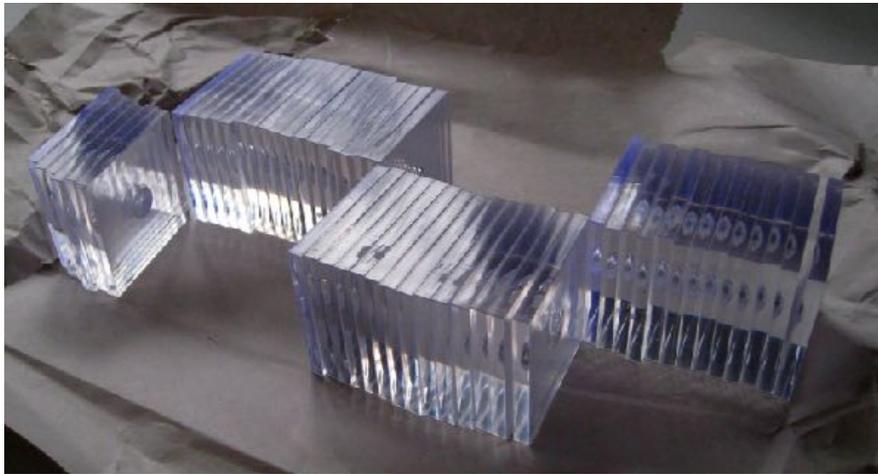
Technical Realisation: The AHCAL

- Construction of a full hadronic prototype ongoing - 24k channels - ready in 2018
 - Demonstrates technological solutions for a collider detector, addresses issues of mass production and scalability

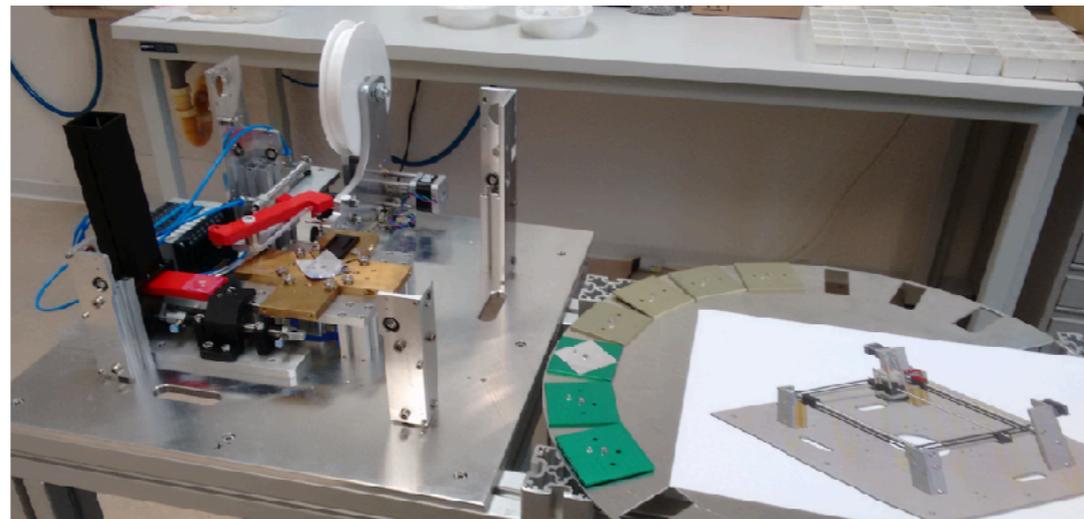


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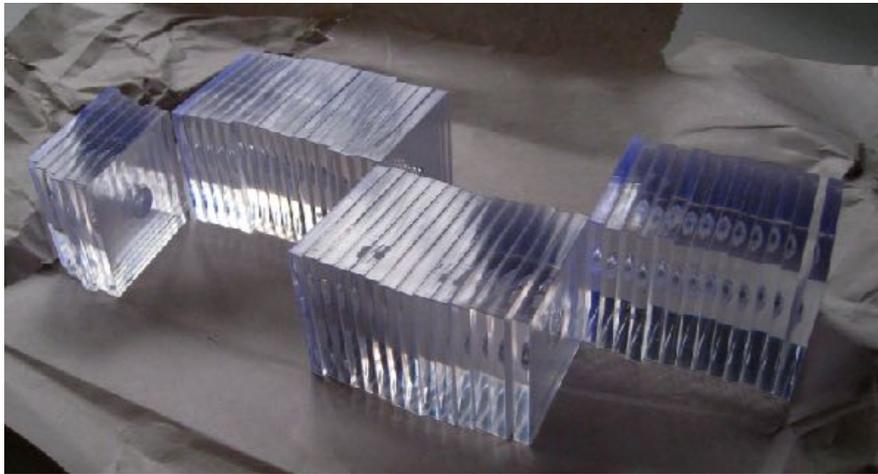


automatic wrapping of injection-molded scintillator tiles

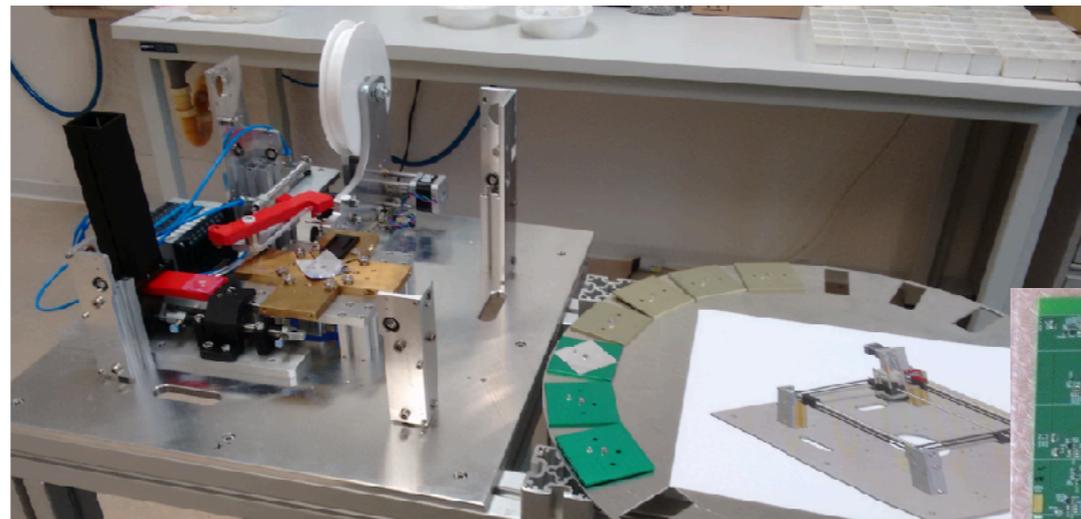


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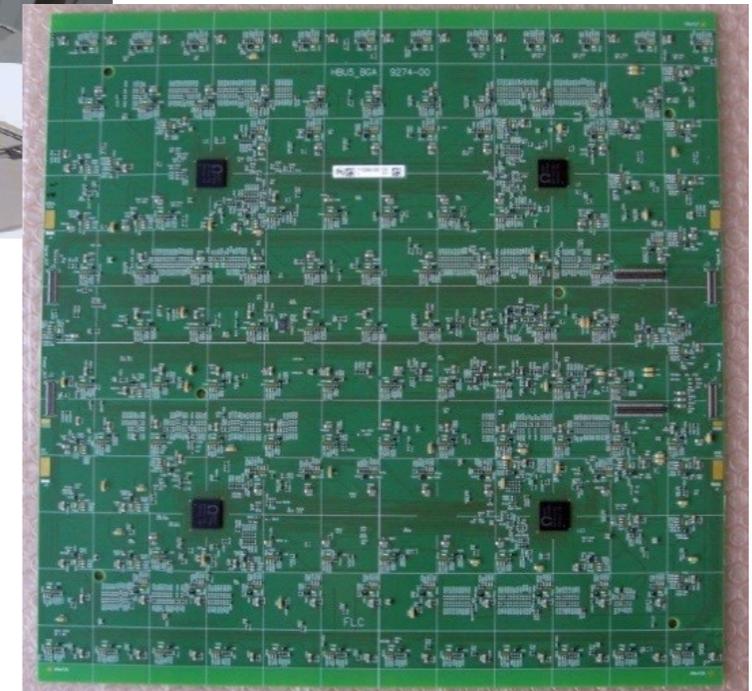
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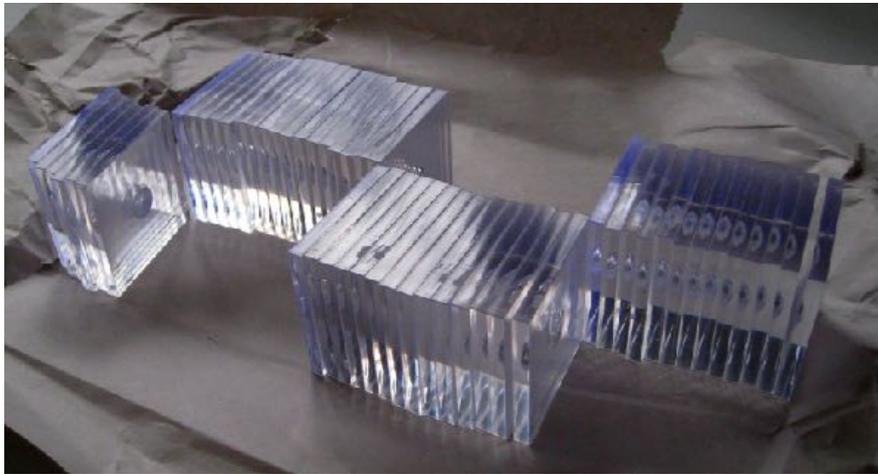


new generation of ASICs

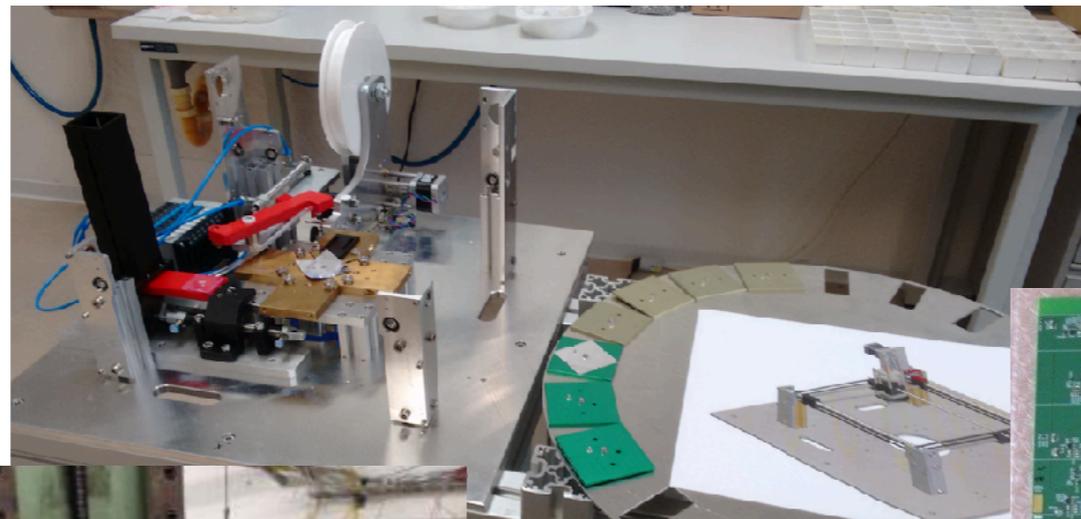


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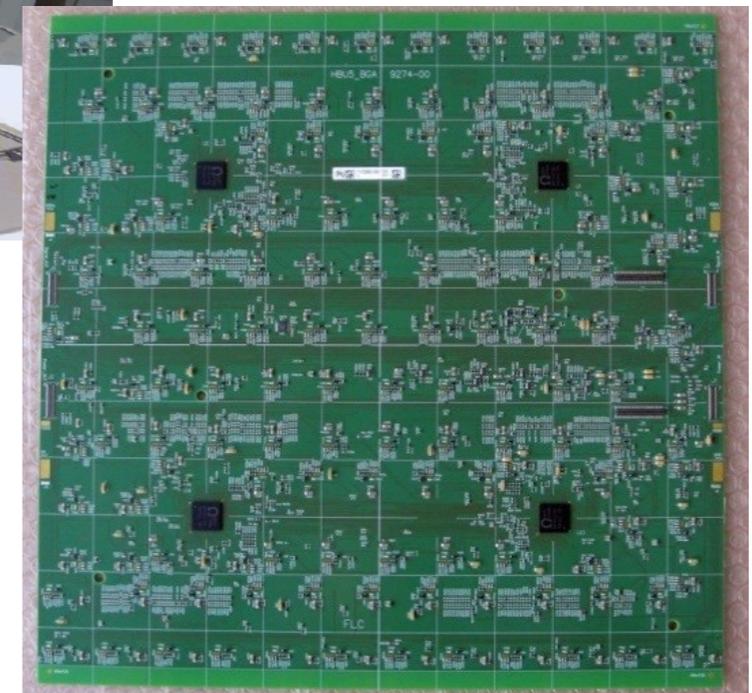
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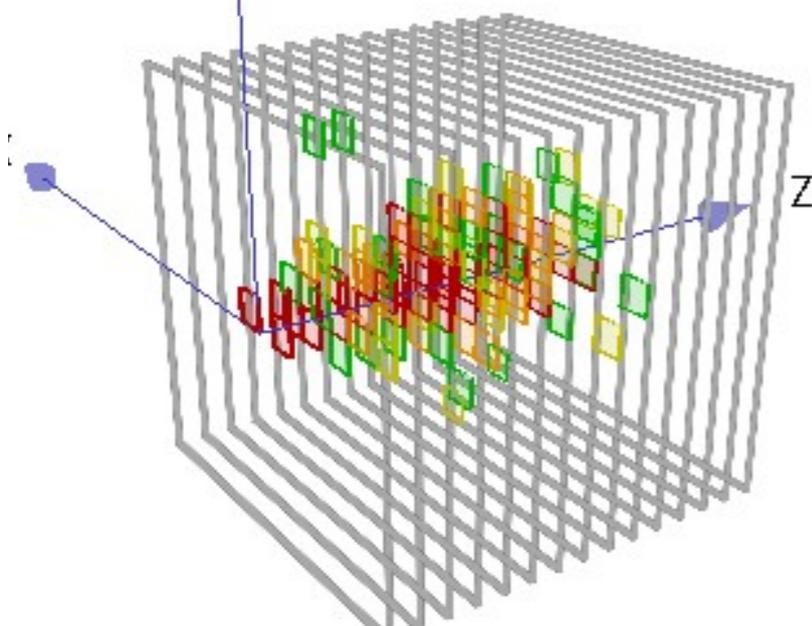
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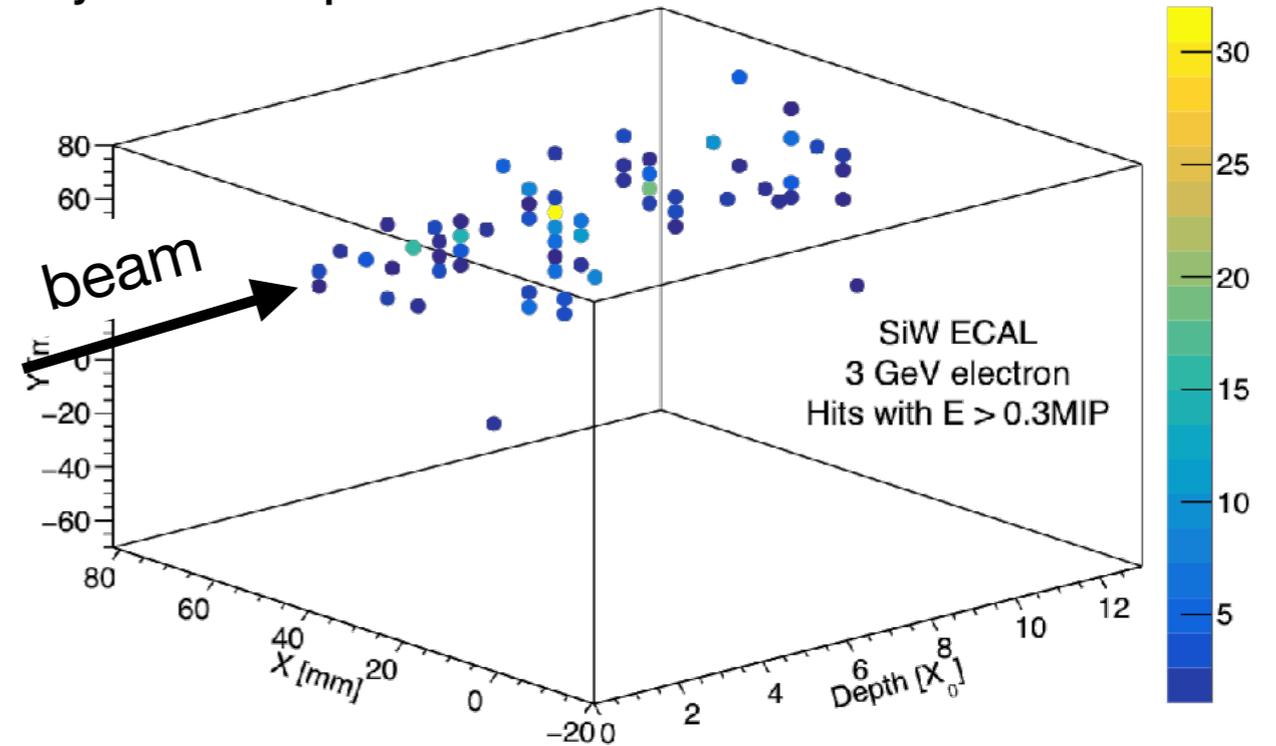
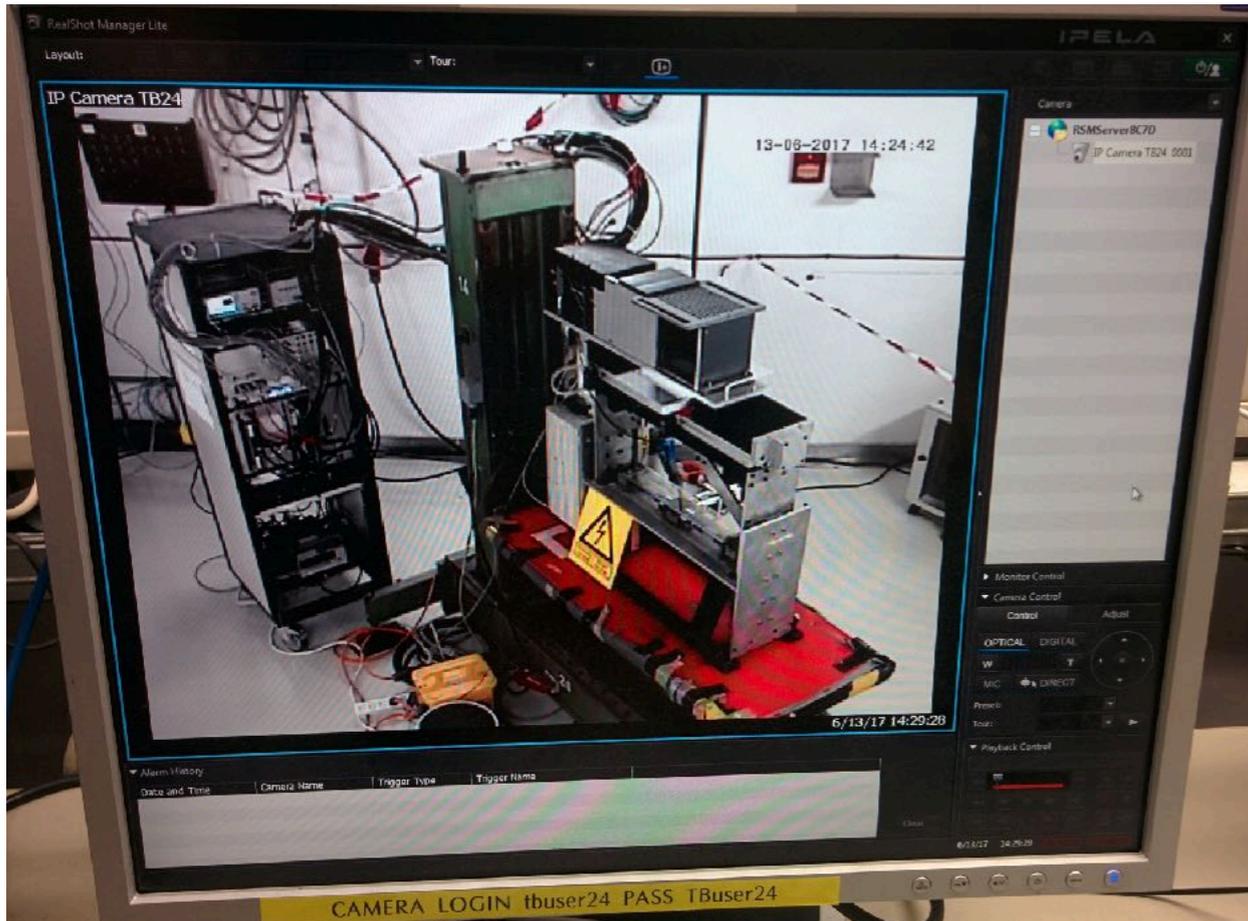
60 GeV e^- , in 1.5 T field



first test with smaller prototype successful

Technical Realisation: The SiW ECAL

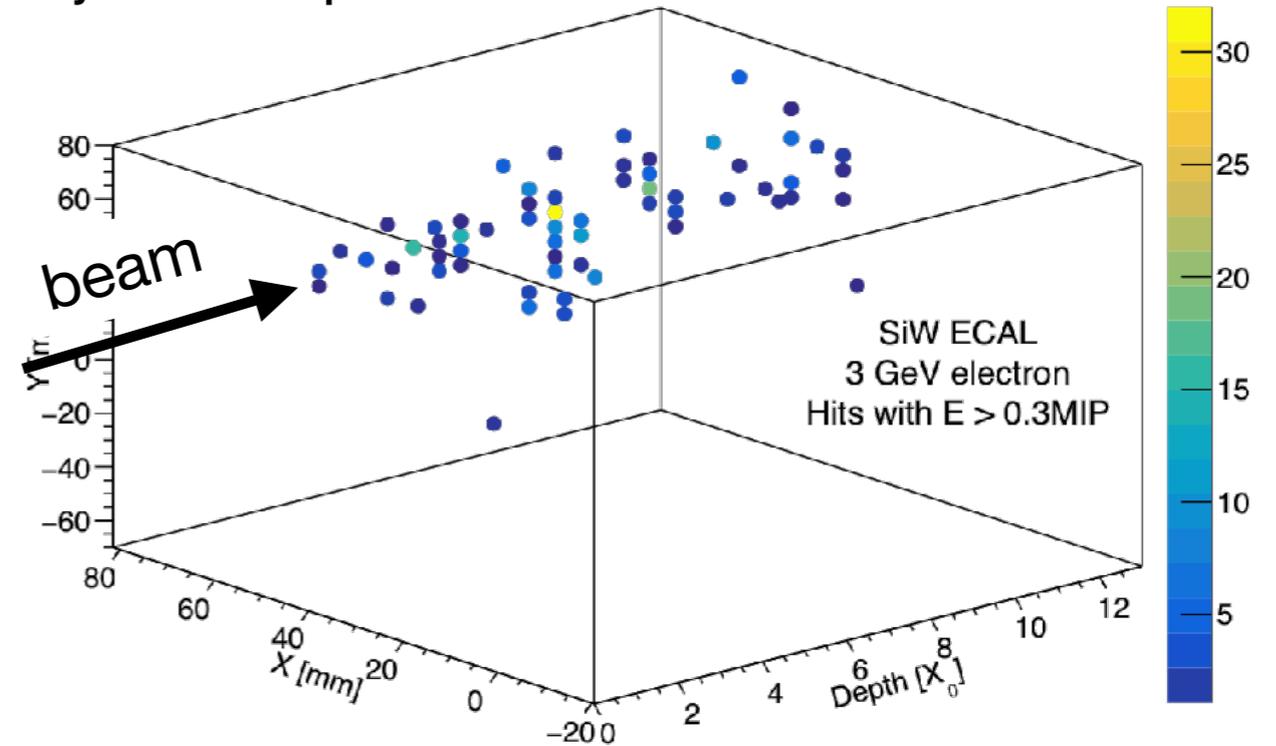
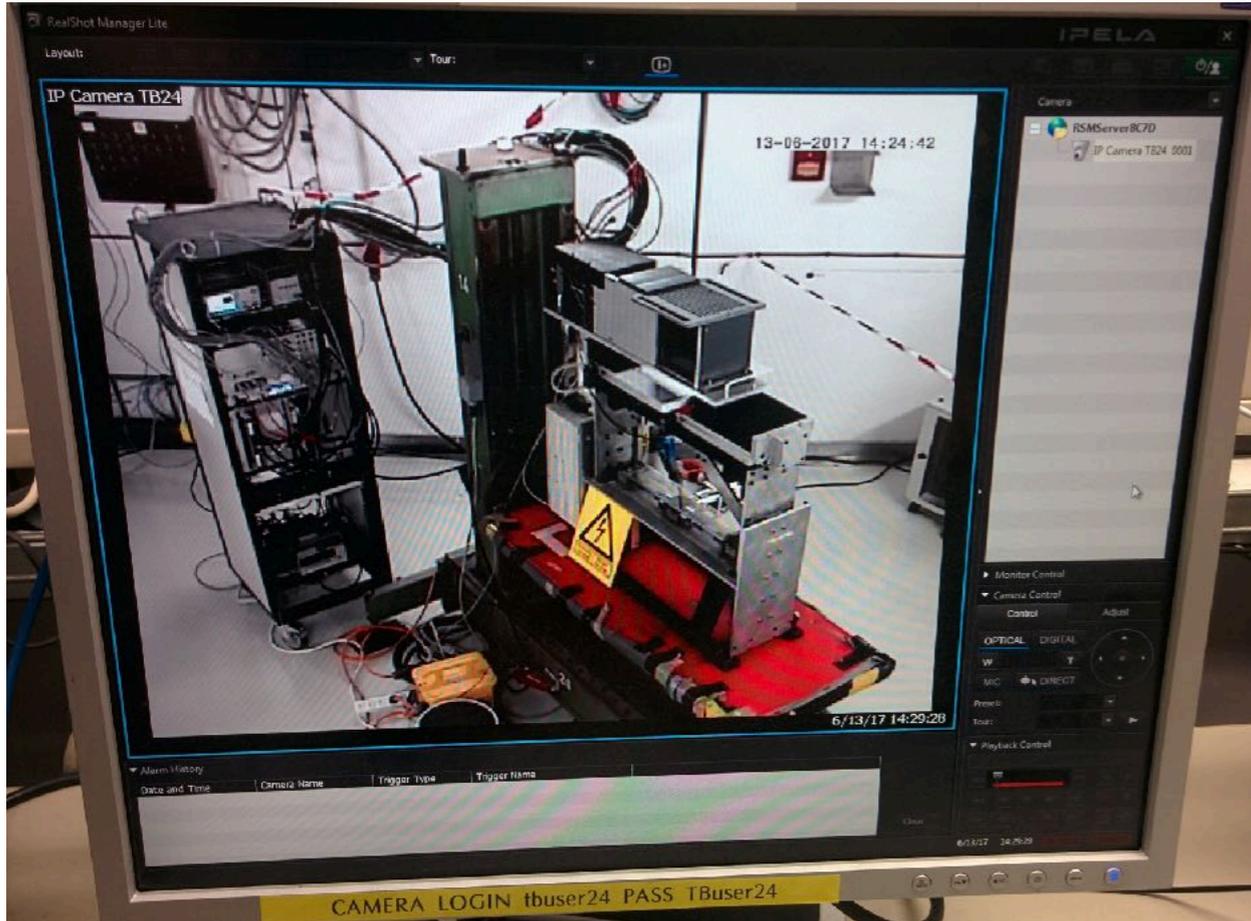
- Test beam at DESY with 7 single-ASU layers just completed



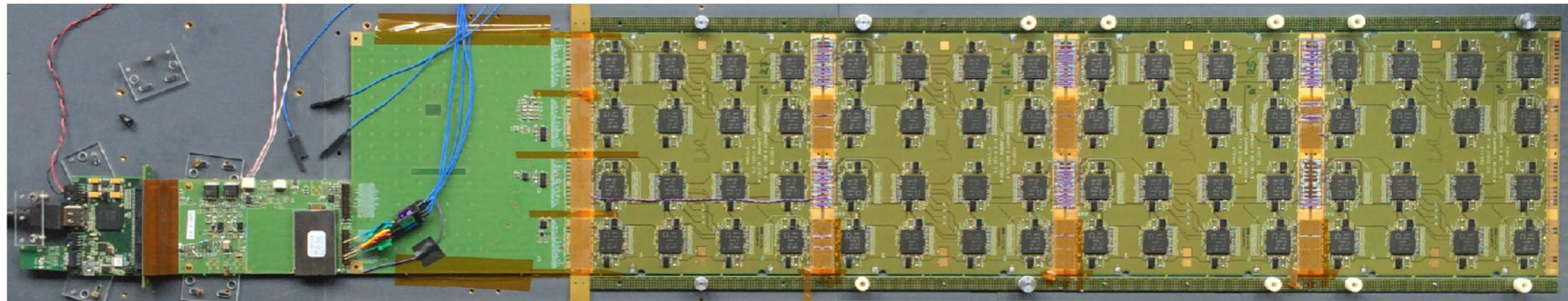
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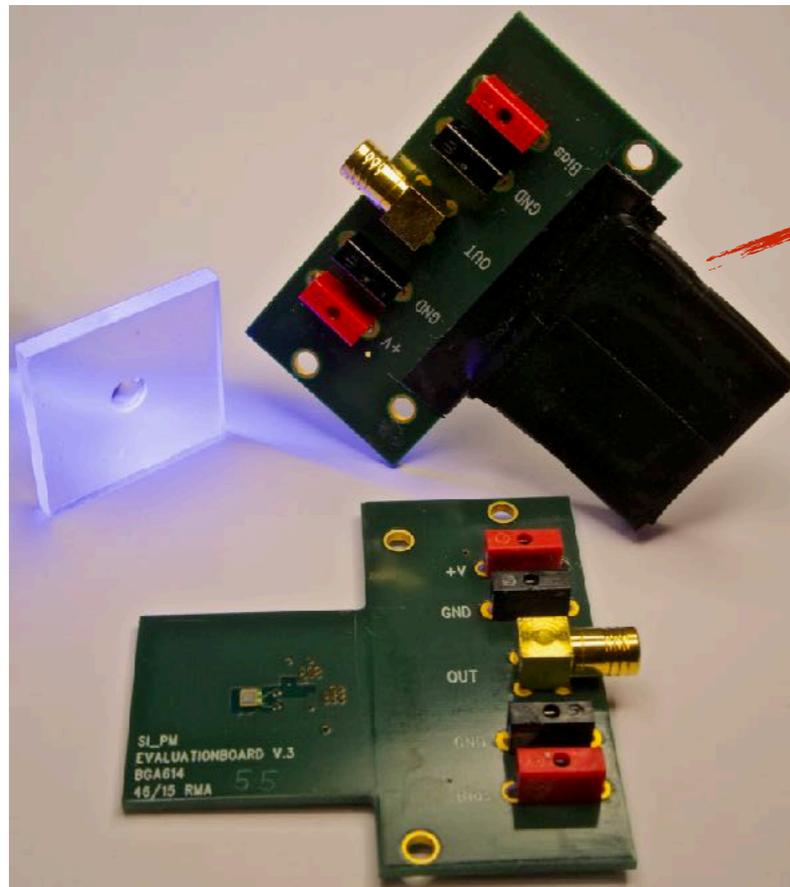


- Test with ILC-like beam structure, power pulsing, also tests in magnetic field
- Towards full detector requirements: long modules - here 4 ASUs, ultimately up to 10



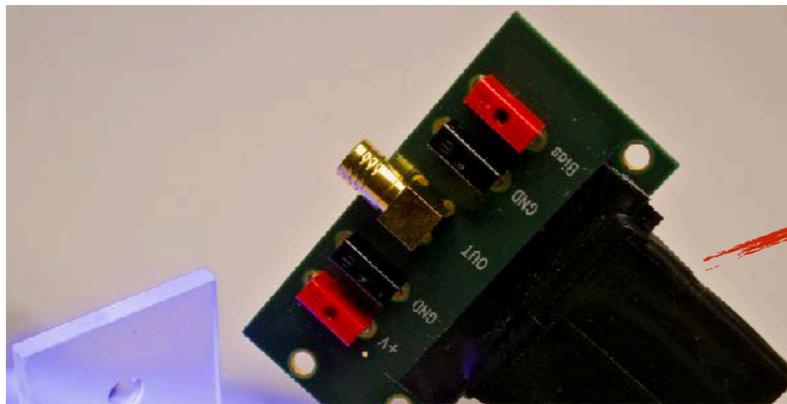
Application: CALICE Detector Elements

- Detector technologies developed in CALICE have many applications outside of collider calorimeters - two examples:
- Beam background time structure during SuperKEKB commissioning: Using scintillator tiles with SiPM readout and sub-ns sampling with ms buffers
 - Based on CALICE-T3B

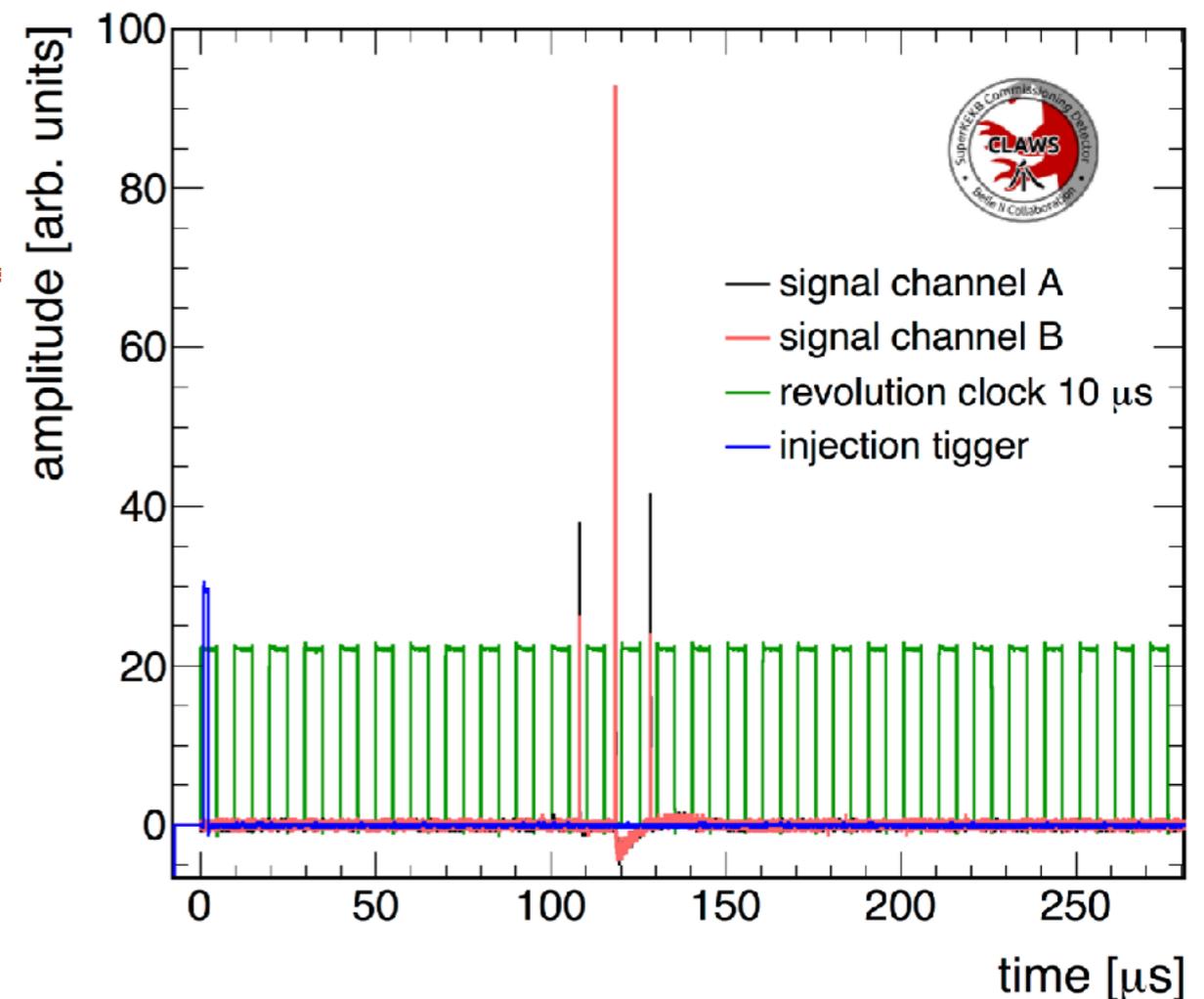


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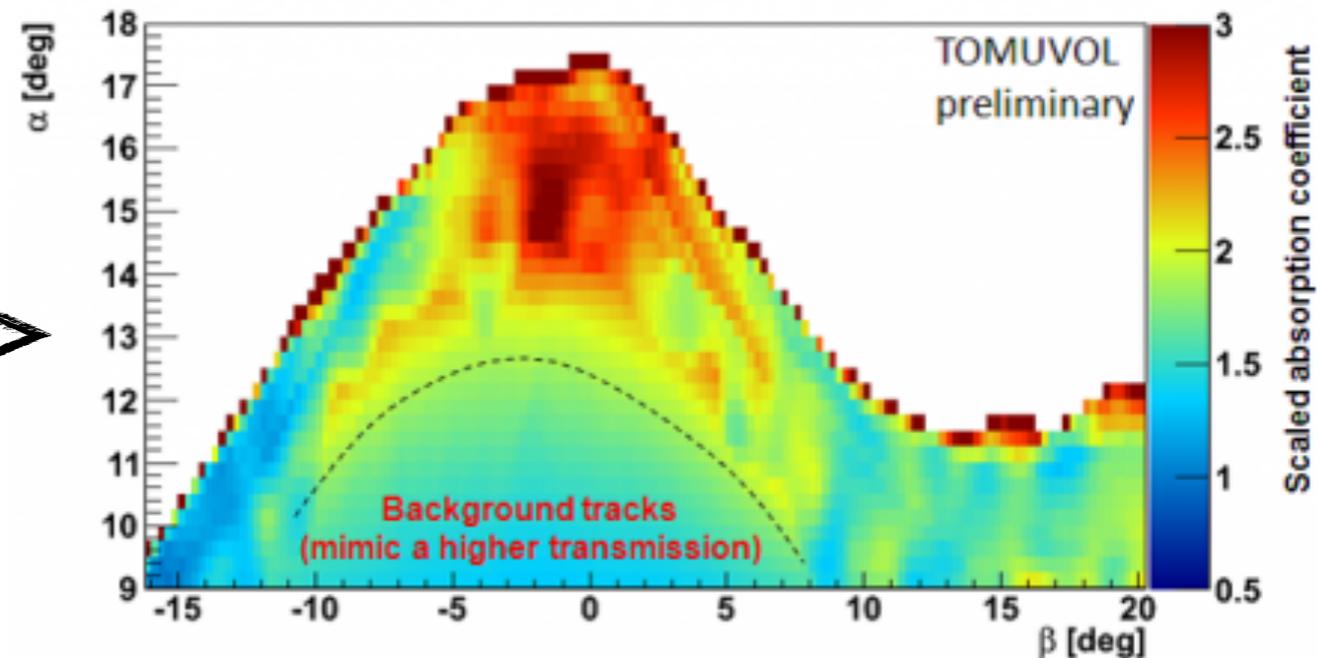
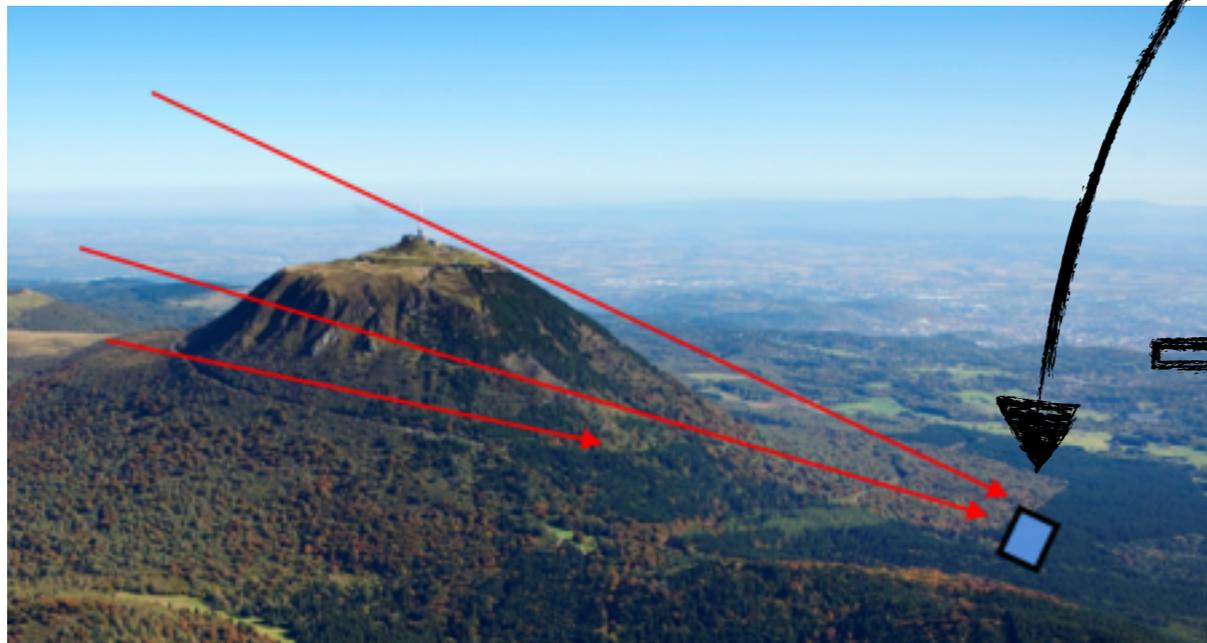
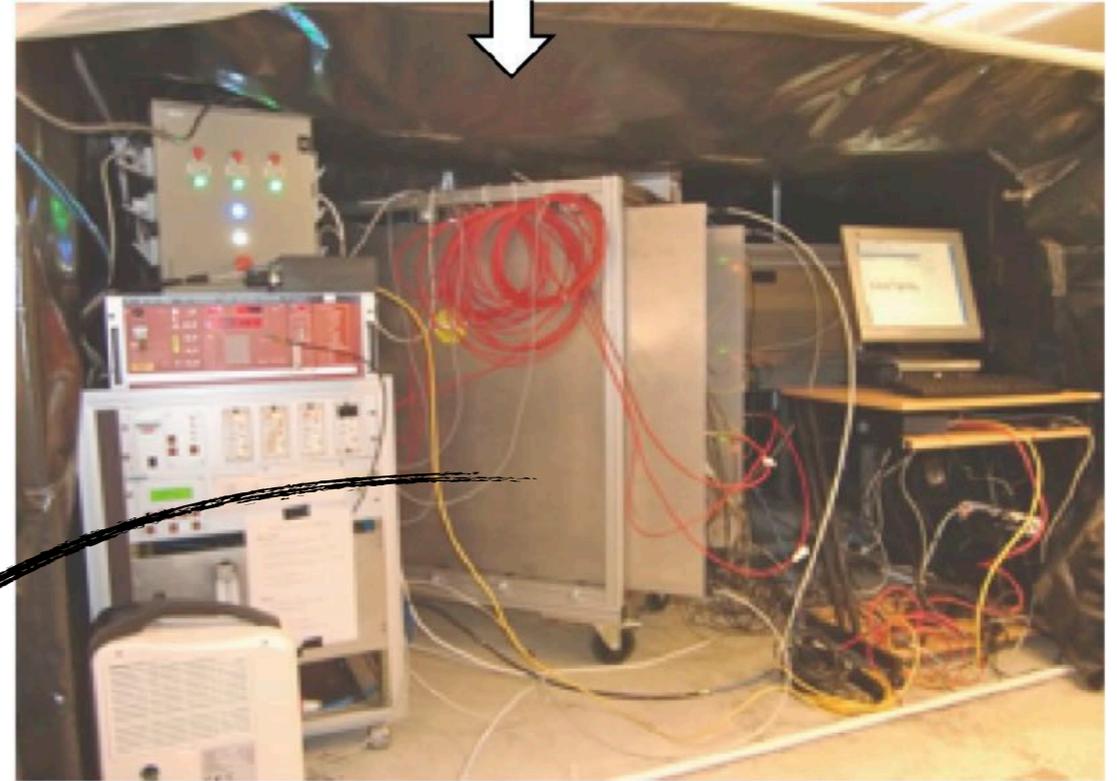


- The first detector to see particles from the accelerator during “first turns” on February 8, 2016



Application: CALICE Detector Elements

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- Muon tomography of volcanoes with large-area RPCs
 - Based on GRPCs developed for the CALICE SDHCAL

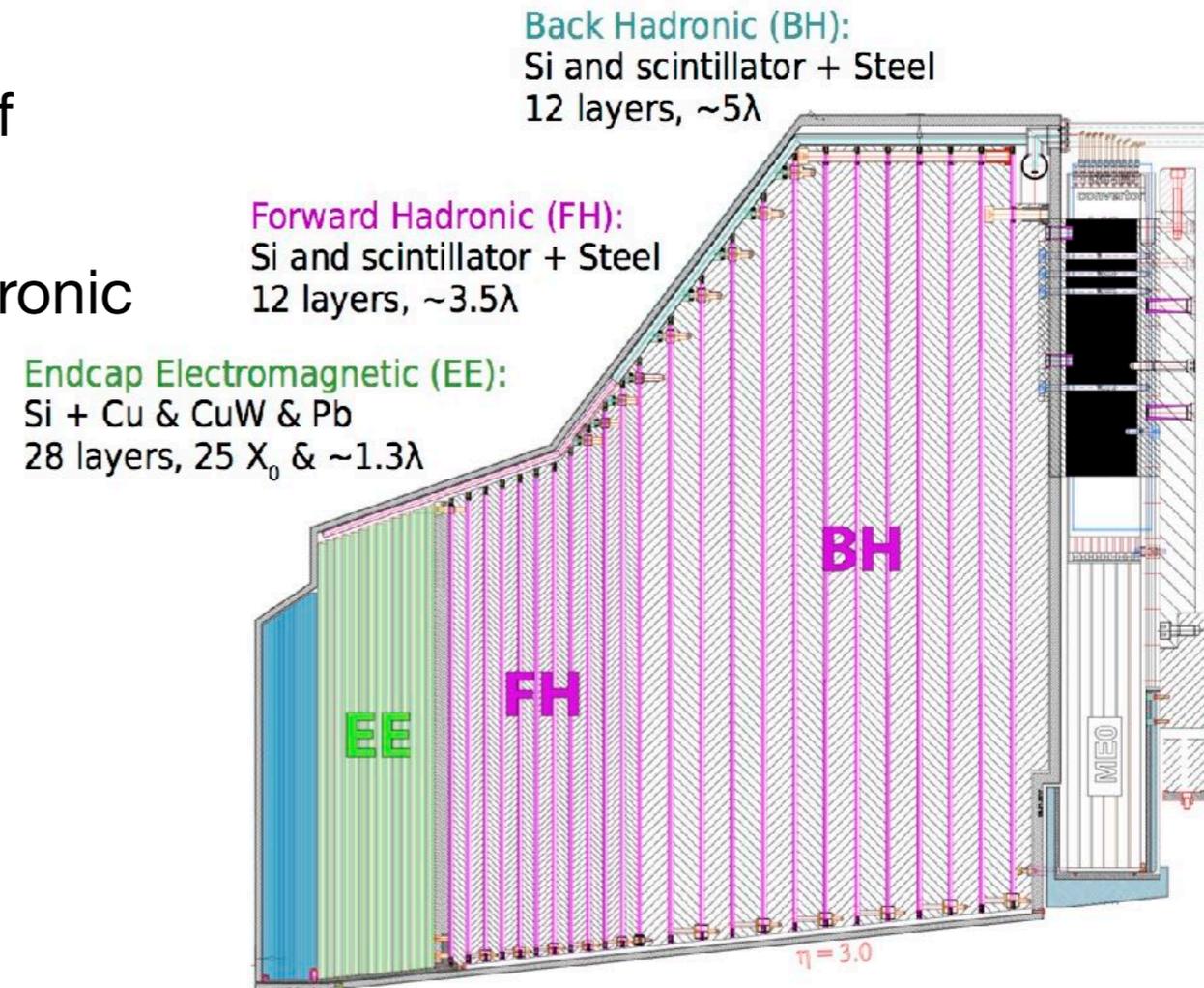


Applications: Running and Future Experiments

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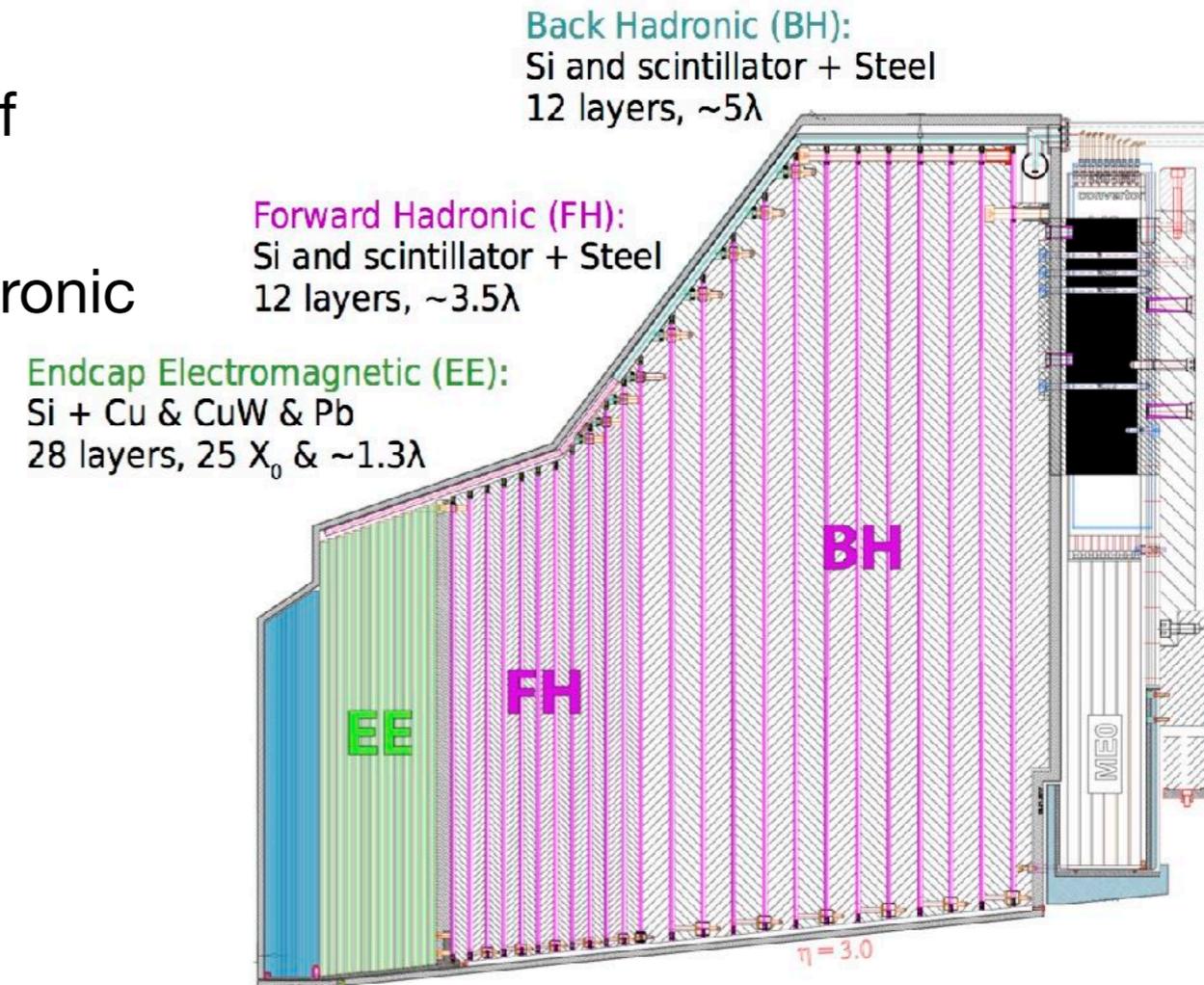
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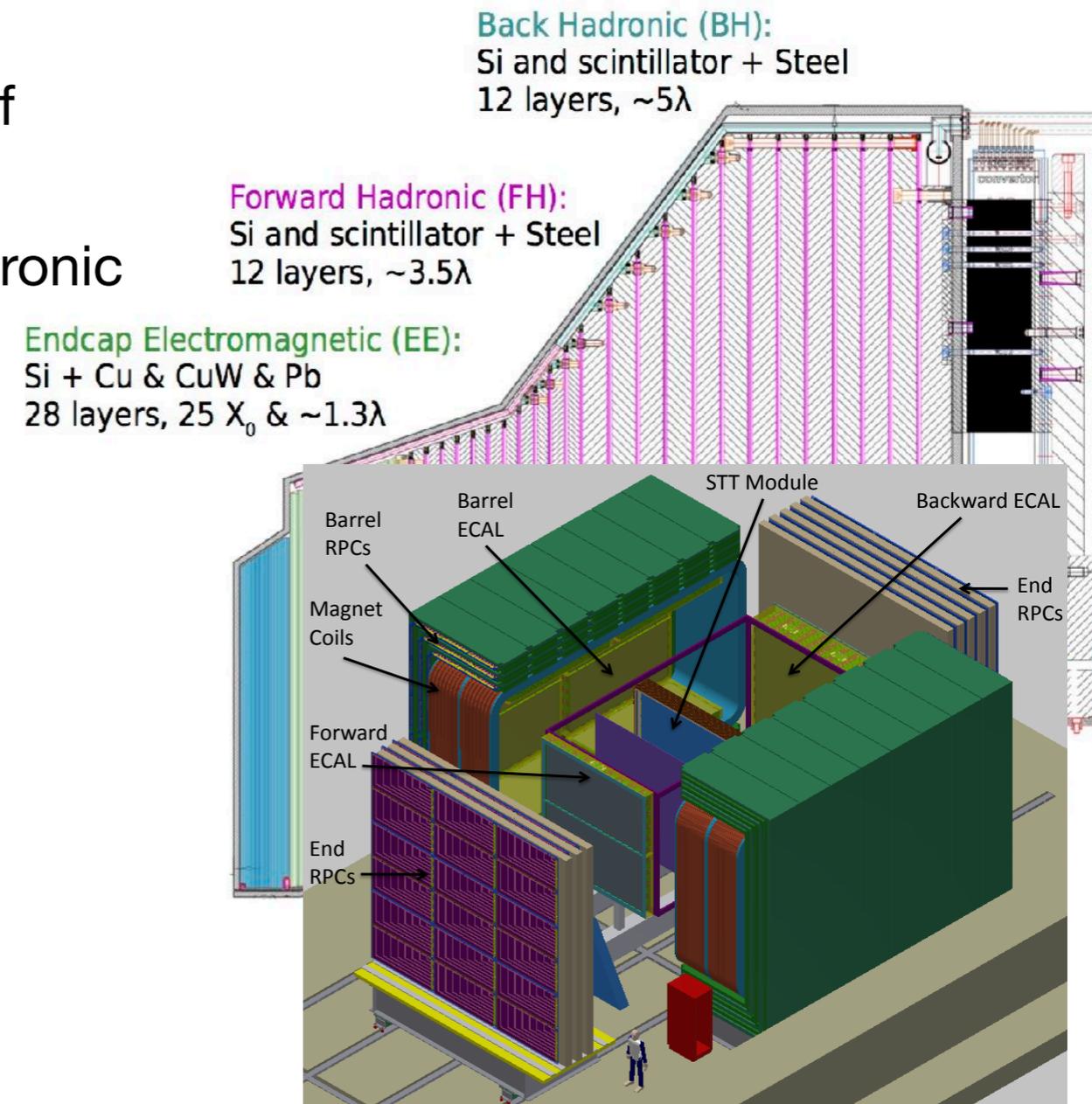
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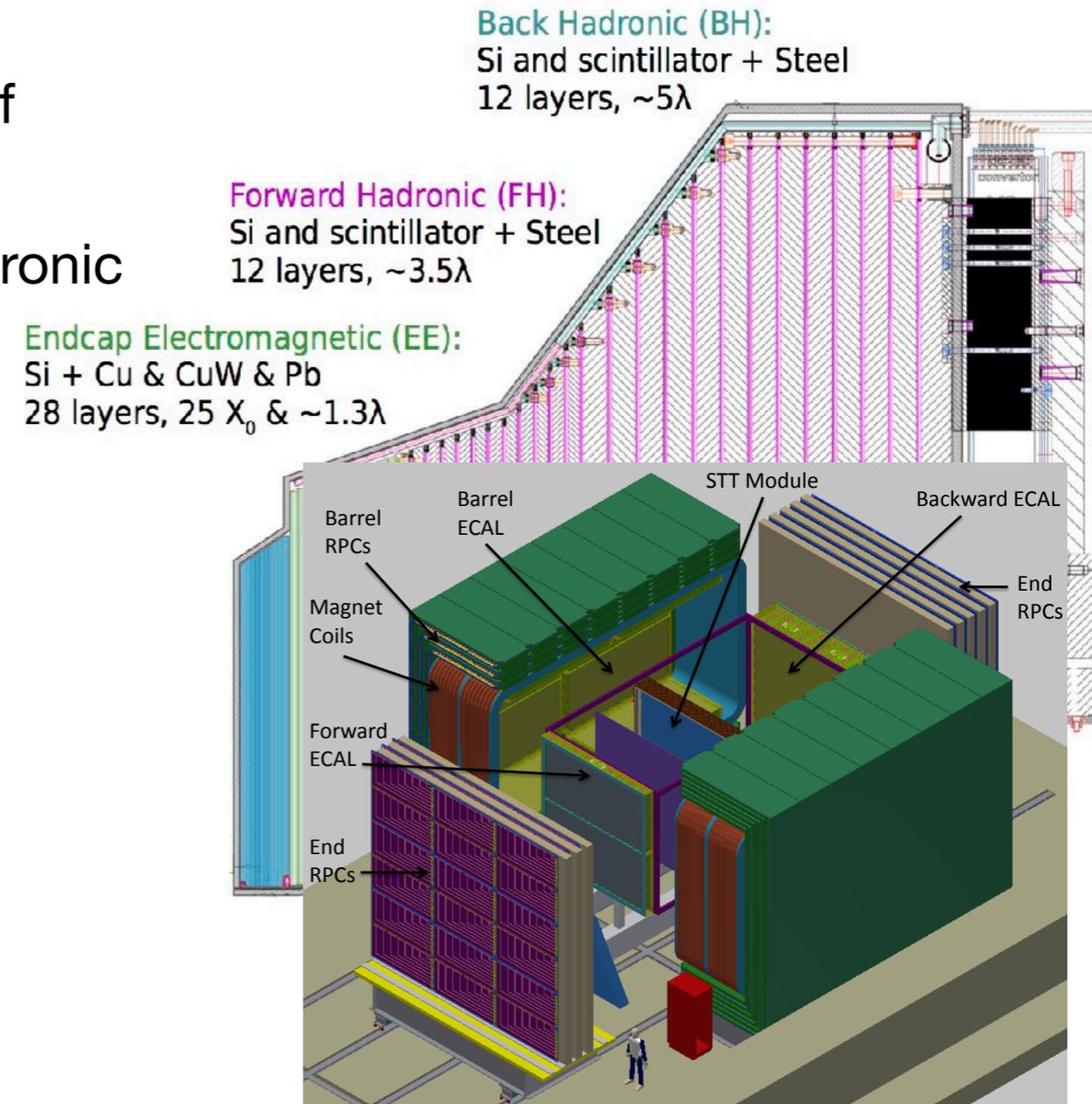
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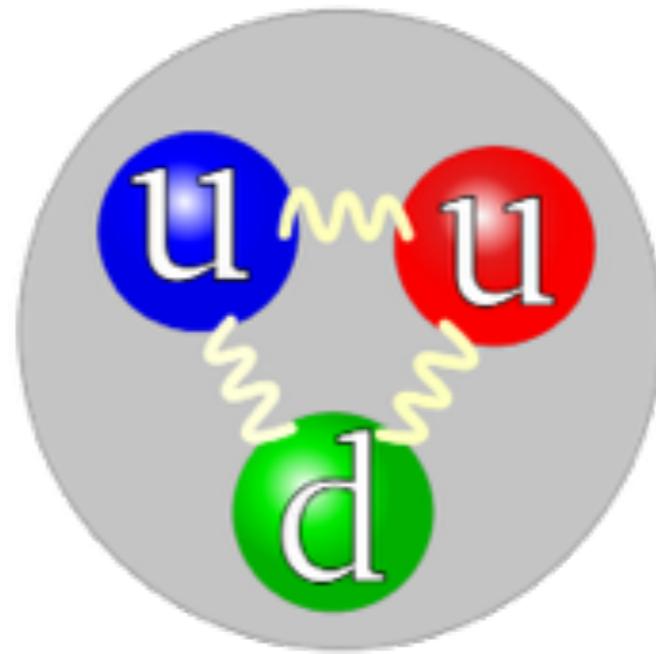
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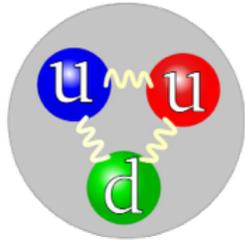
... all of those projects with direct contributions of CALICE groups.

CALICE and Linear Colliders

- CALICE is one of the “gluons” of Linear Collider detector concepts

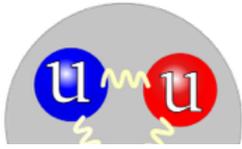


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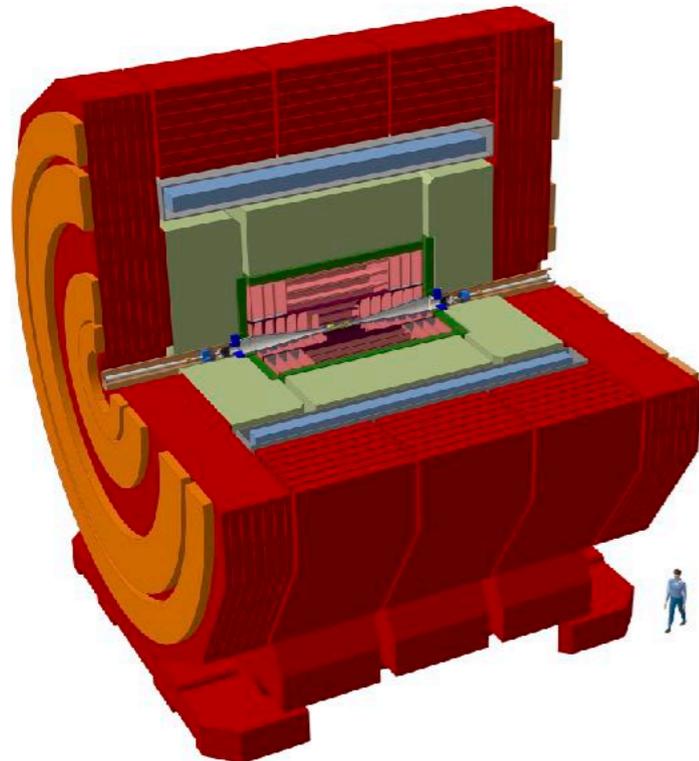
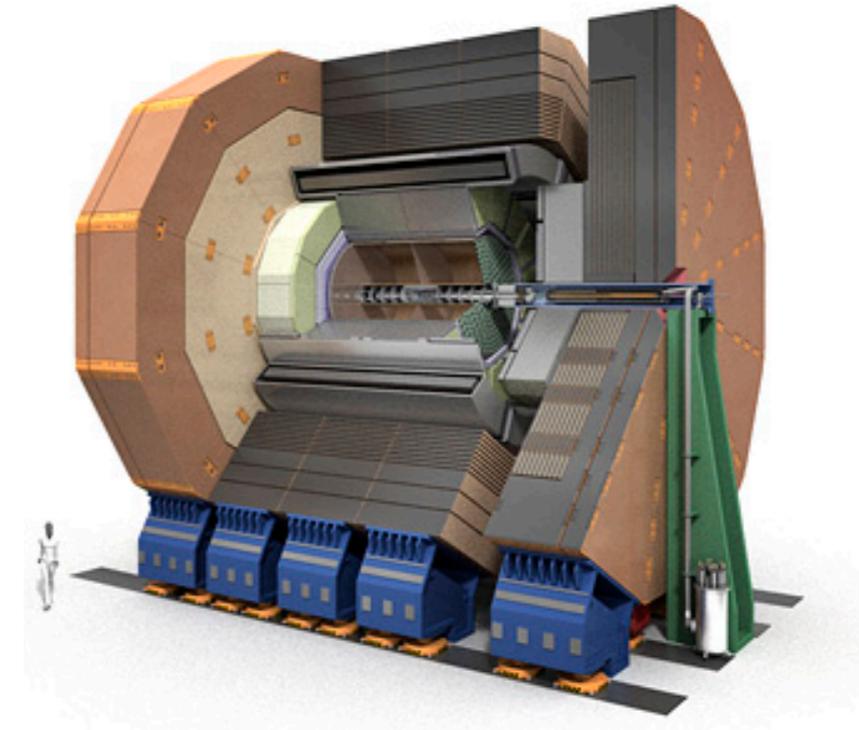
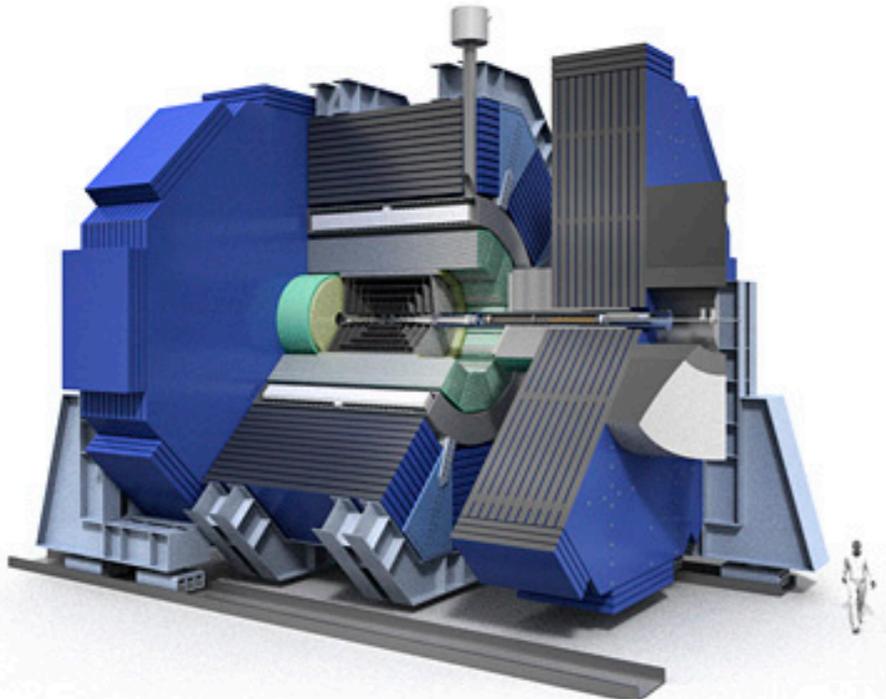


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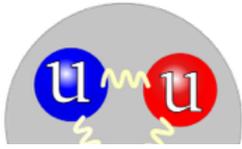
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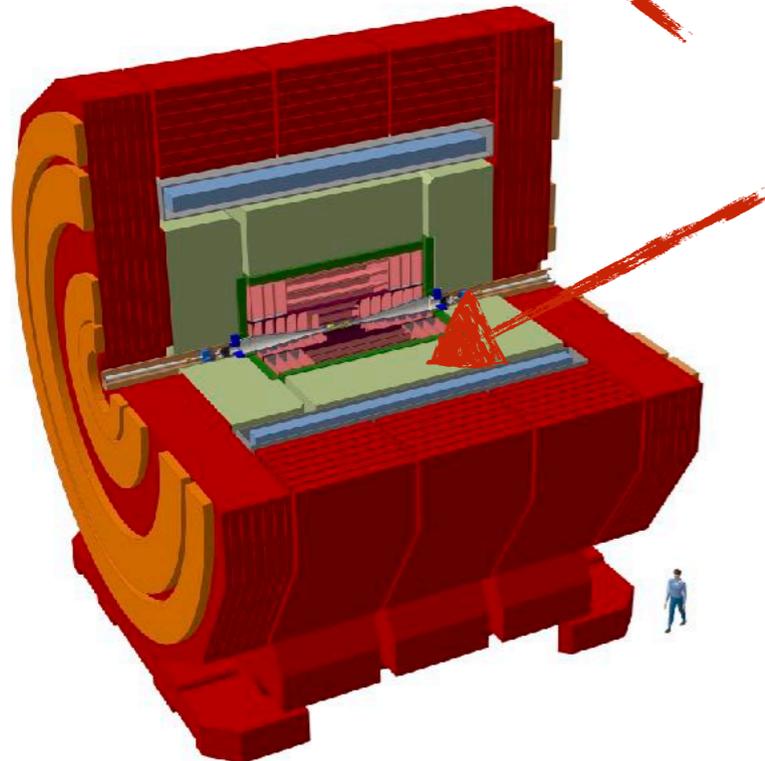
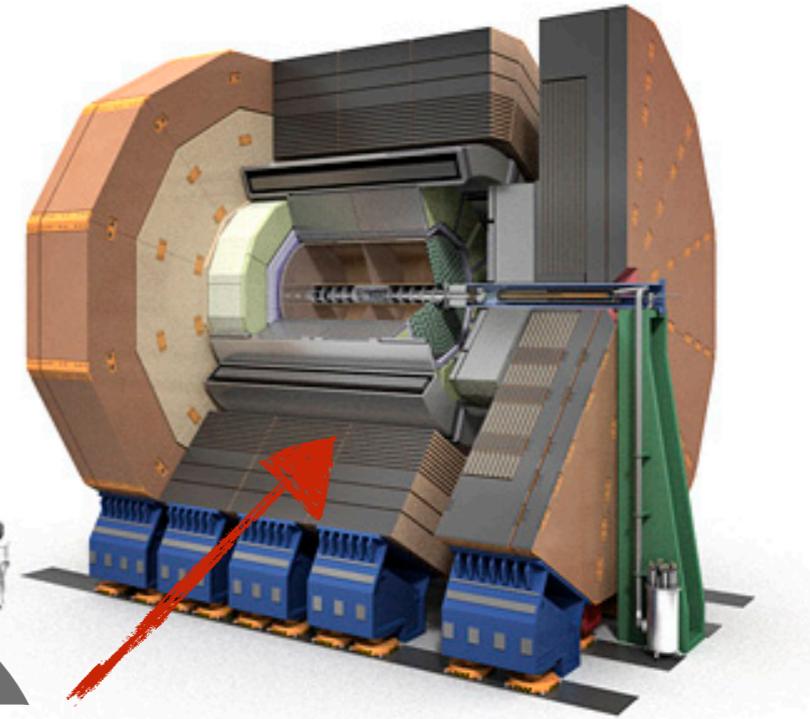
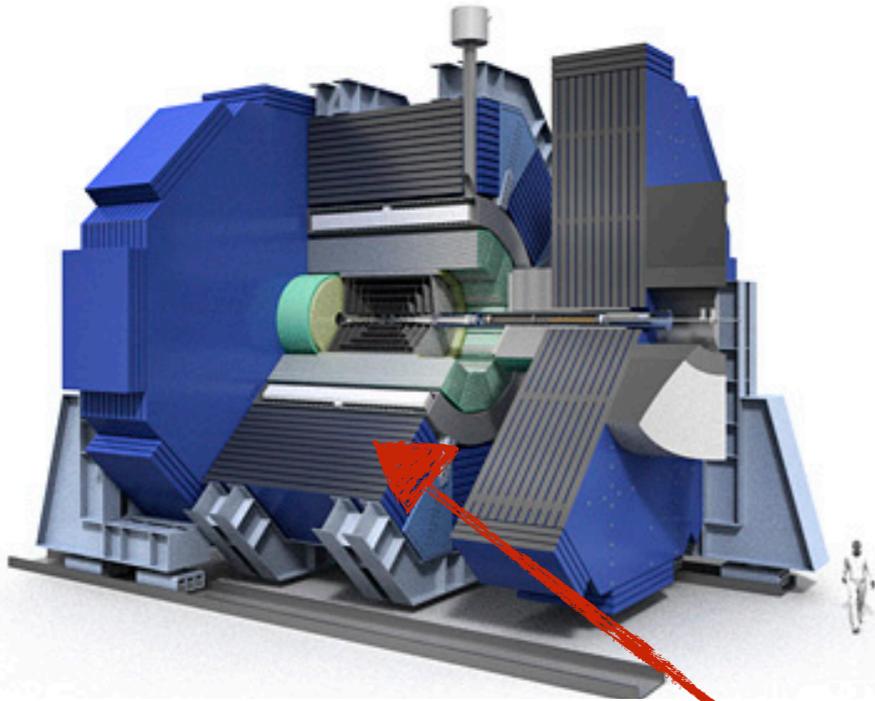
All LC detector concepts build on CALICE calorimeters:

- ILD: ECAL (Si or Sc) + HCAL (Sc or SD)
- SiD: HCAL (Sc or D)
- CLIC: ECAL (Si or Sc) + HCAL (Sc)

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Conclusions

- Highly granular calorimetry is now widely accepted in HEP - as the solution of choice for optimal event reconstruction with particle flow, and to control backgrounds and pile-up
- CALICE has successfully demonstrated different technologies - the results from the beam tests provide important input for the validation and further development of GEANT4 shower simulations
- Significant progress towards technological prototypes:
 - 1m³ RPC SDHCAL with embedded electronics in beam, R&D towards larger areas
 - Full hadronic prototype of AHCAL in construction, ~24k channels, to be tested in beam in 2018 - smaller EM stack (2k channels) successfully tested in up to 3T
 - Multiple layers of SiW ECAL TP in beam at DESY last week

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... and much more results of tests and exploitation of new prototypes to come!

CHEF 2017

Calorimetry for the High Energy Frontier

CALORIMETERS : Today and for future projects

2 - 6 october 2017, Lyon

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Timing
New Concepts in calorimeters
Calorimeters technology
Simulation
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