Infrastructure for advanced calorimeters

WP14 Report

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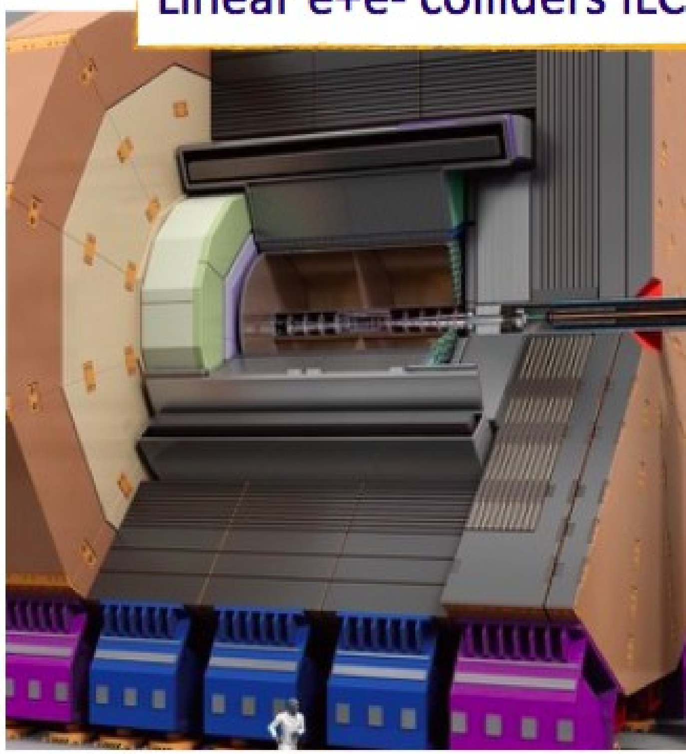
AIDA-2020 Annual Meeting, Paris, April 6, 2017

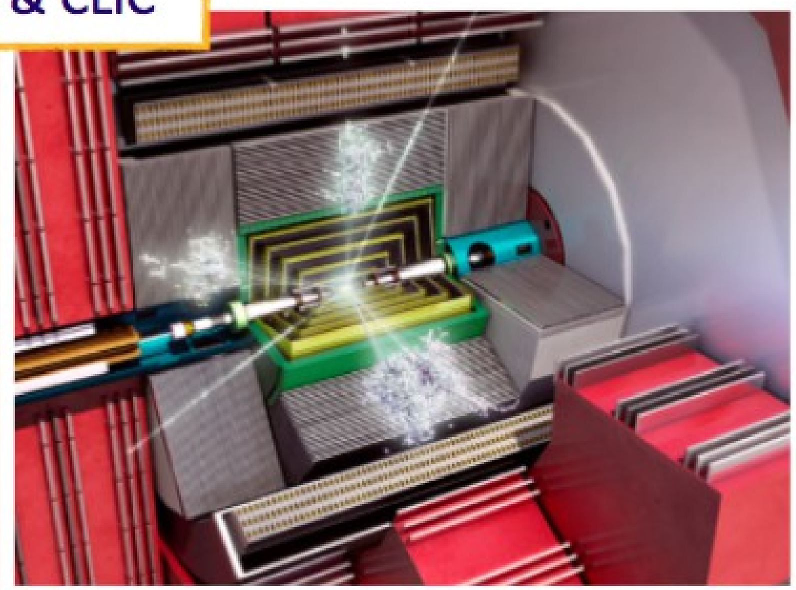
This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement no. 654168.

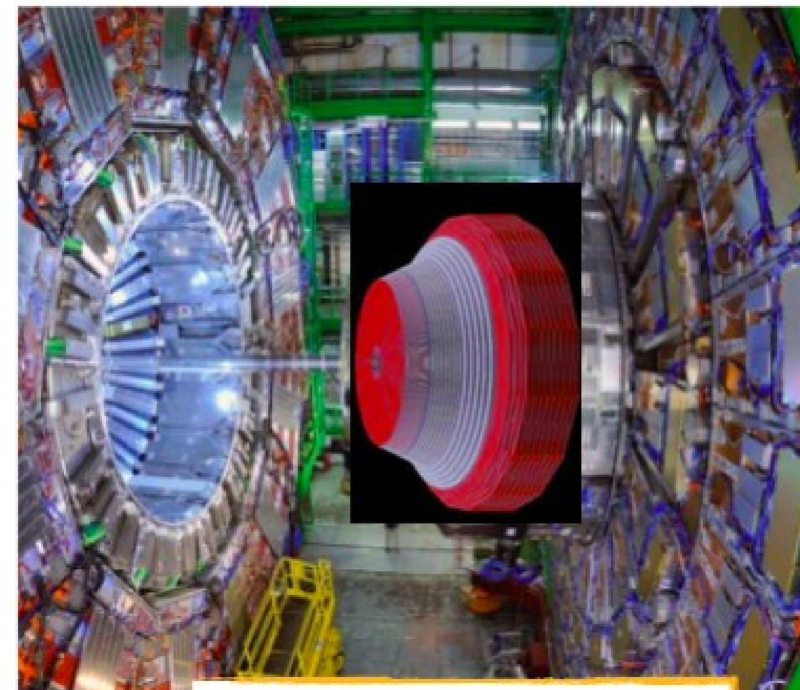
WP14 within AIDA-2020

- Calorimeters are key components of HEP detectors - and an area that is currently seeing quite rapid evolution

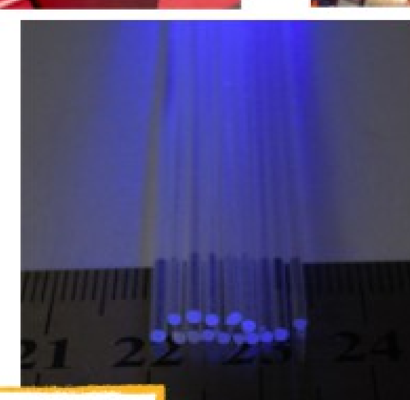
Linear e+e- colliders ILC & CLIC





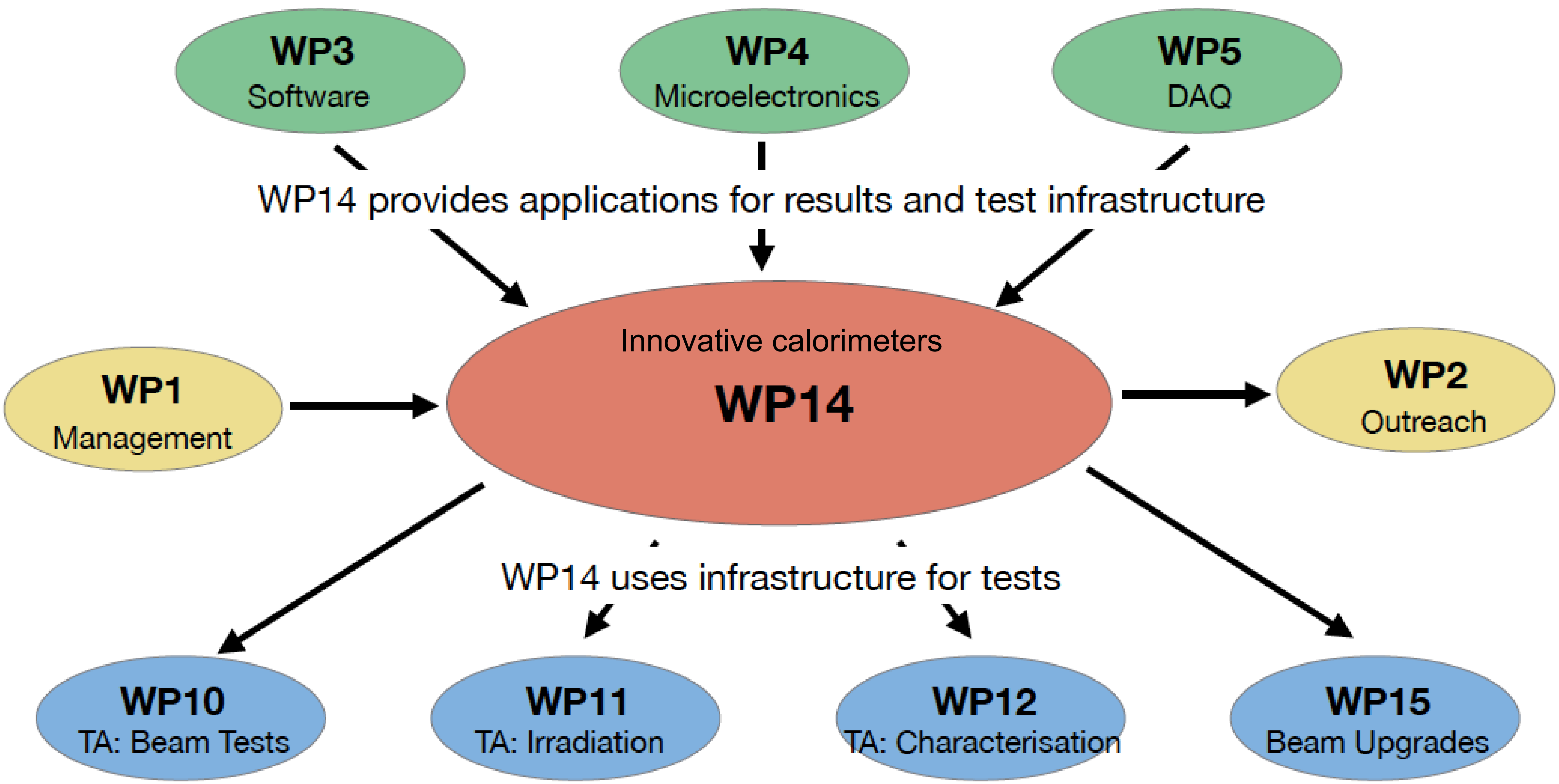


LHC Phase II Upgrades



New Materials

WP14 within AIDA-2020



WP14 Participants

- Beneficiaries
  - AGH-UST
  - CERN
  - CIEMAT
  - CNRS - IPNL, LAL, LLR, LPNHE, LPSC
  - DESY
  - ETHZ
  - INFN - MI, RTV, TO
  - IPASCR
  - JGU
  - MPG-MPP
  - TAU
  - UiB
  - VU

- Associated Partners - receive funding through benef ciaries
- CERN: Brunel, Imperial, Minsk
- DESY: U HD, U W
- INFN: UniMIB
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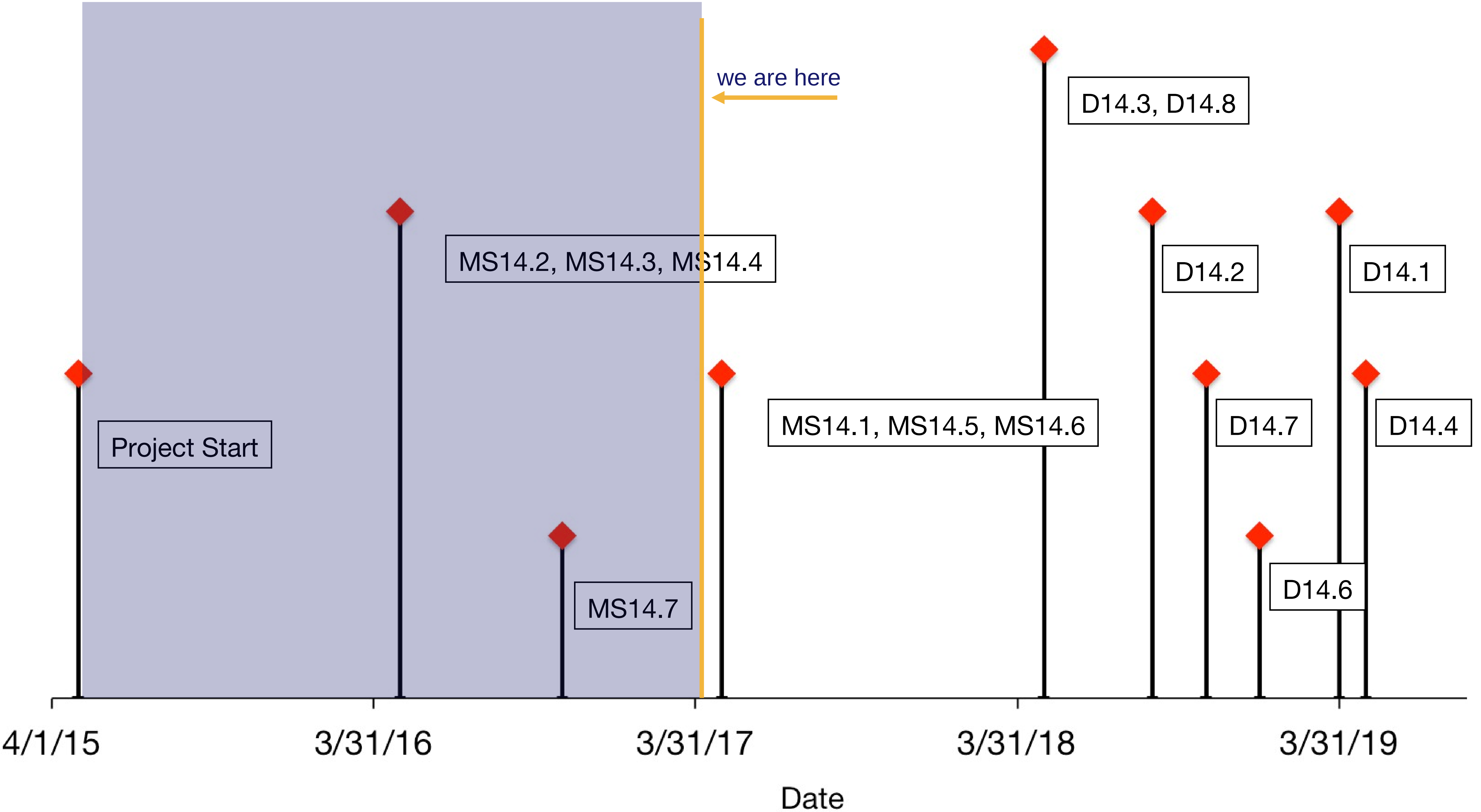
WP14 Time Line



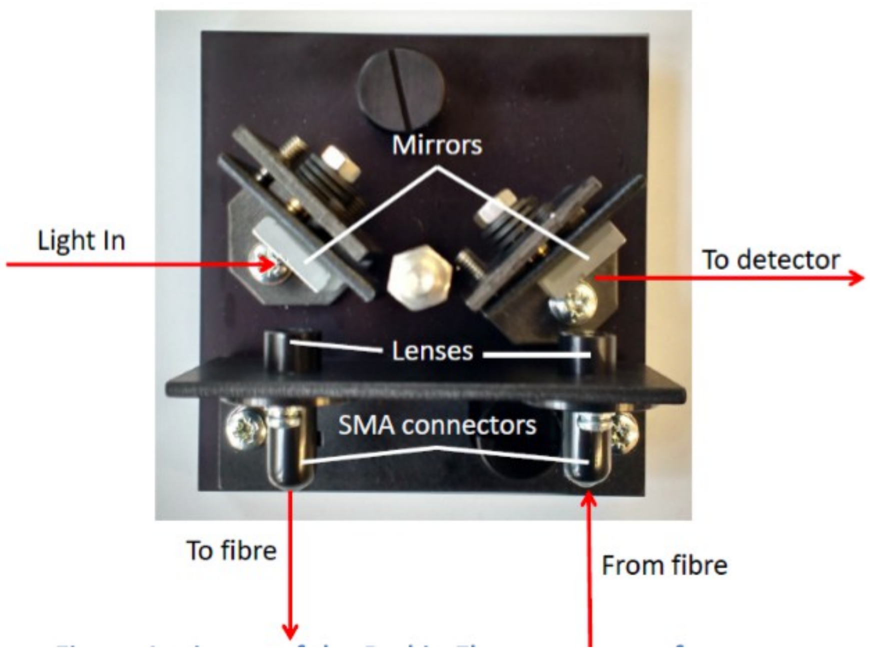
Milestones (and Deliverables)

	Title	Lead Ben.	Task	Month
MS14.1 (56)	Commissioning of fibre test benches	CERN	14.2.1	24
MS14.2 (13)	Specification of systems for highly granular scintillator tests	MPG-MPP	14.2.2	12
MS14.3 (14)	Assembly and QA chain demonstration for highly granular silicon calorimeters	CNRS	14.3.1	12
MS14.4 (15)	Design specifications of test stations for irradiated Si sensors and LHC oriented front-end electronics	CERN	14.3.1	12
MS14.5 (57)	Design and test of ASICS and readout board prototype for test infrastructure	AGH-UST	14.3.2	24
MS14.6 (58)	Definition of optical and electrical coupling of readout, interface functionality and DIF design	CNRS	14.4.2	24
MS14.7 (31)	Design of cooling system for tungsten / carbon-fibre and for HCAL structures	DESY	14.5.2	18

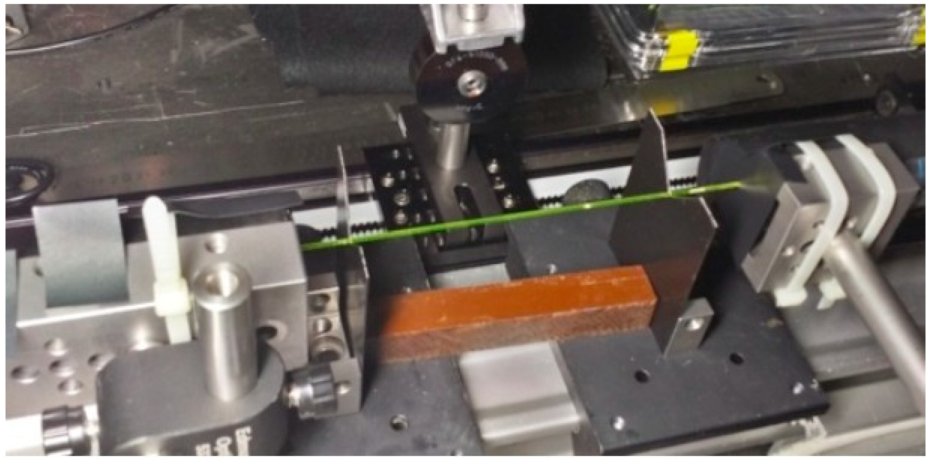
- Five milestones achieved so far!
- Two milestones due by Month 24 (April 2017)
- No deliverable in 2017

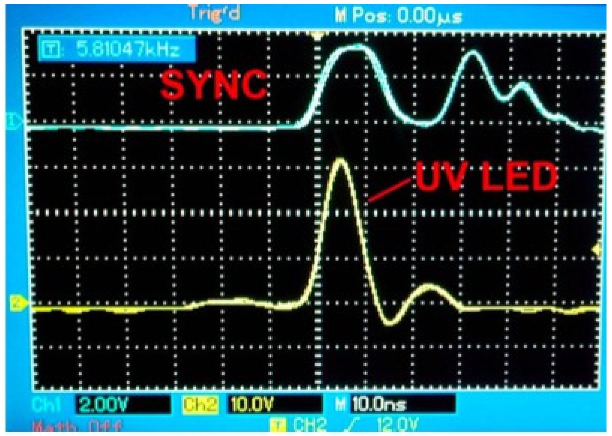
Task 14.2.1: Test benches for characterisation of organic and inorganic scintillator material

Perkin Elmer Spectrometer @UniMIB

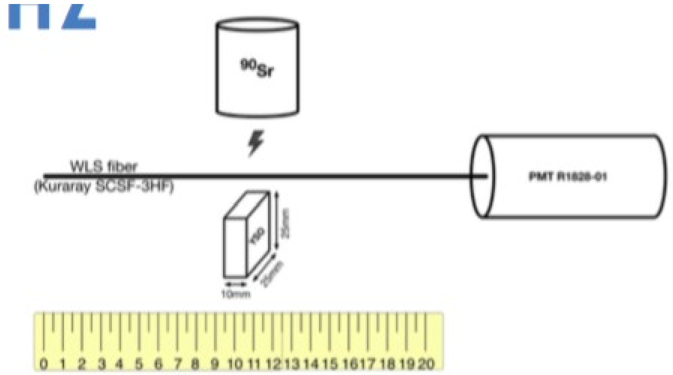


Nanosecond LED Pulsed Sources (CERN, Minsk)





Light Uniformity Setup @ ETH



- Not shown: Test bench for long fibres (900mm) at Brunel
- Tests of many fibre types ongoing
  e.g. SiO2:ce fibres, Garnet fibres

- Network of test benches allow for redundancy
  e.g. between absorption and attenuation results

Qualitative comparison of fibre optical absorption and attenuation measurement

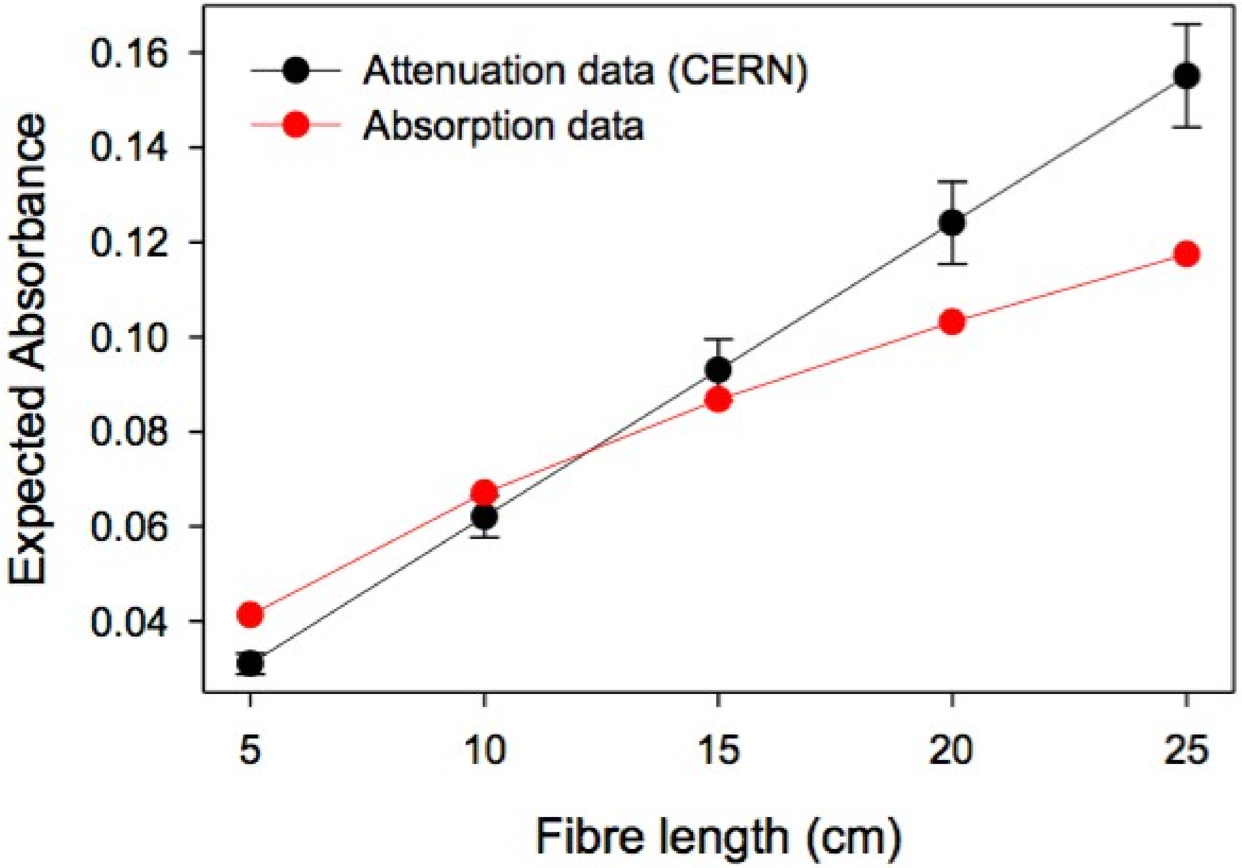
Fibre (lcfce1): attenuation length : 70 cm (from measurements at CERN)

Calculated absorbances match mostly for short fibre lengths.

Causes of discrepancies are under investigations.

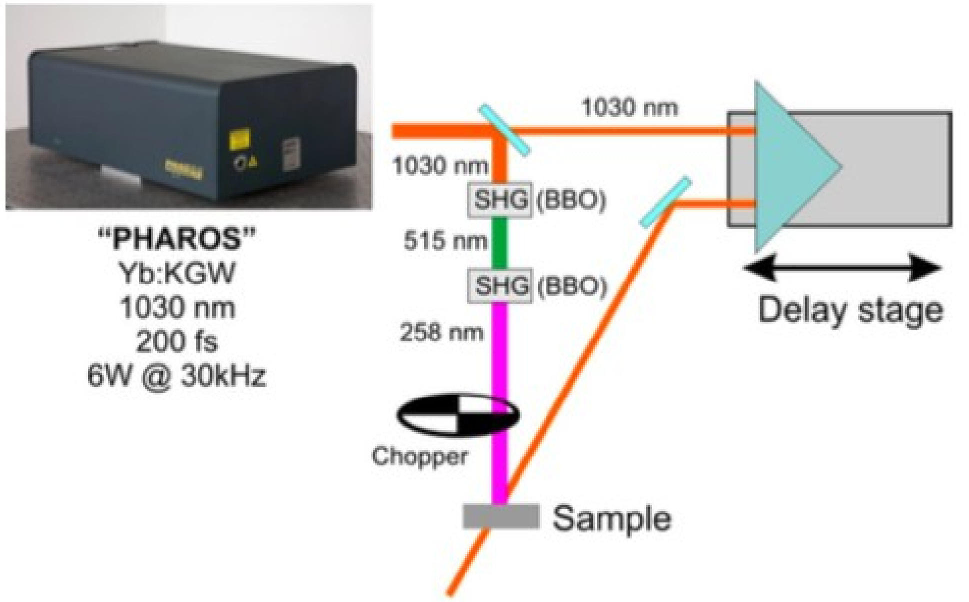
Absorbance of luminescence emission VS fibre length evaluated from:

- Attenuation length data (CERN)
- Absorption spectrum (uniMIB)

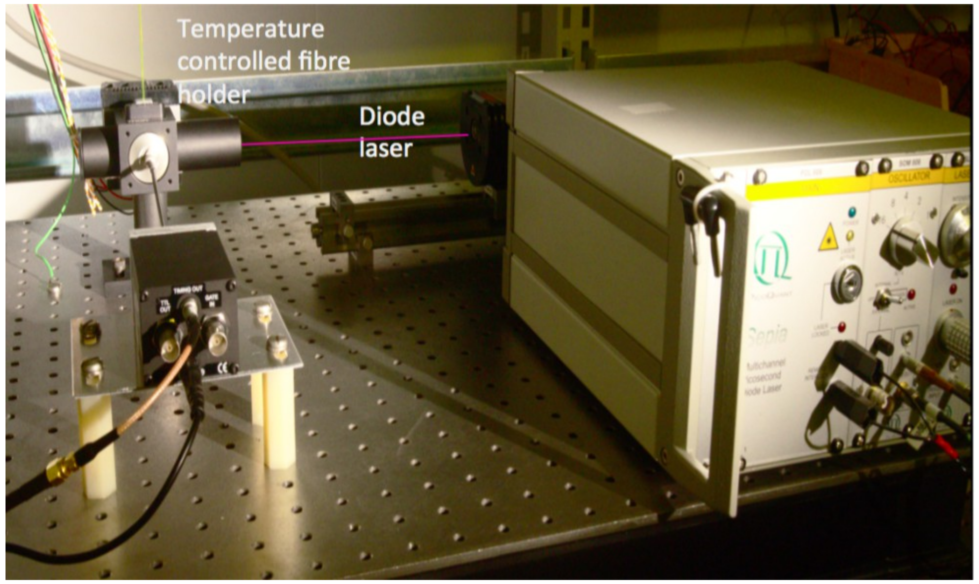


Timing:

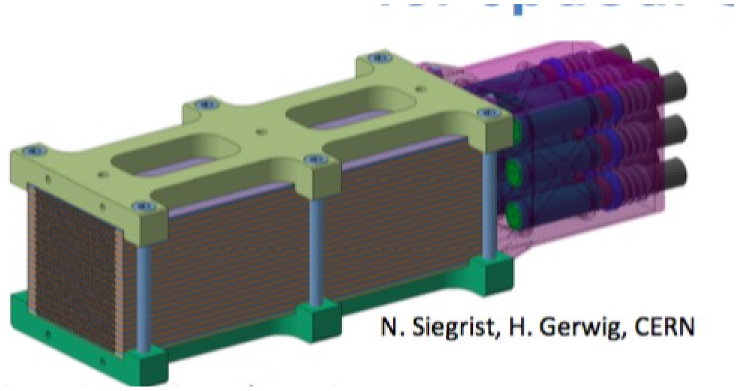
Pump and probe station @Vilnius
To study time structure of excitations in fibres



Fibre fluorescence setup @Brunel
Single photon time correlator



Beam tests: X-tals test in Summer 2016 @ CERN
SpaCal programme for 2017



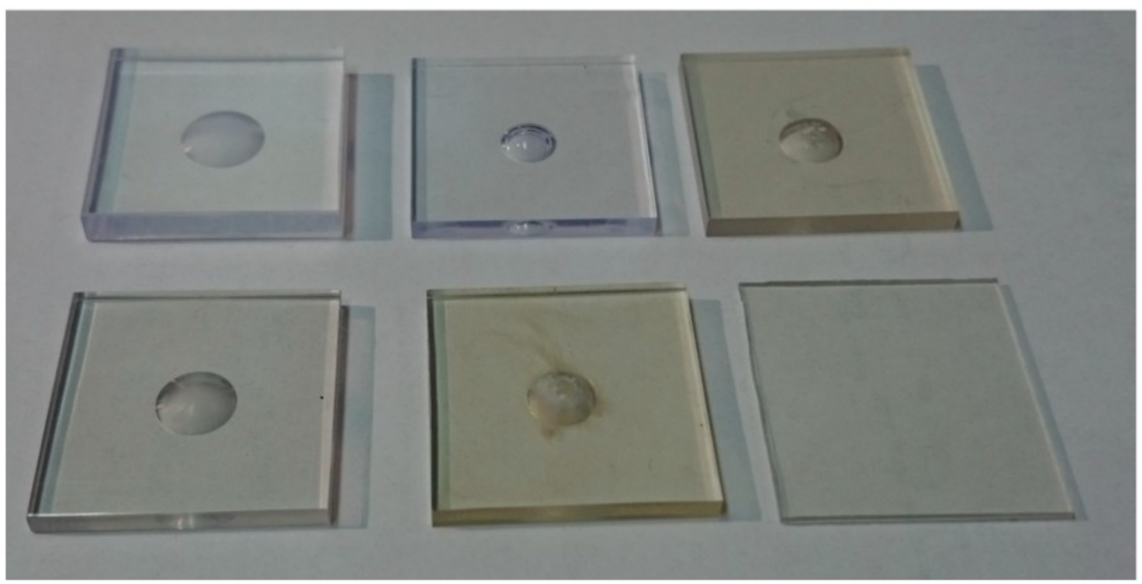
To be equipped with different types of fibres

- Further: Irradiation facilities (Brunel, CERN)
- Many benches are already in use
- **MS56 report available accompanied by longer note, AIDA-2020-PUB-2017-004**

Task 14.2.1 – Task 14.2.2: Characterisation of material for highly granular calorimeters

- Samples of scintillating tiles for tile calorimeters PEN and standard materials
- Characterised at CERN/lab27-crystallab

BC408 Machined | PS Itep Injection moulded | PS Dortmund Injection moulded

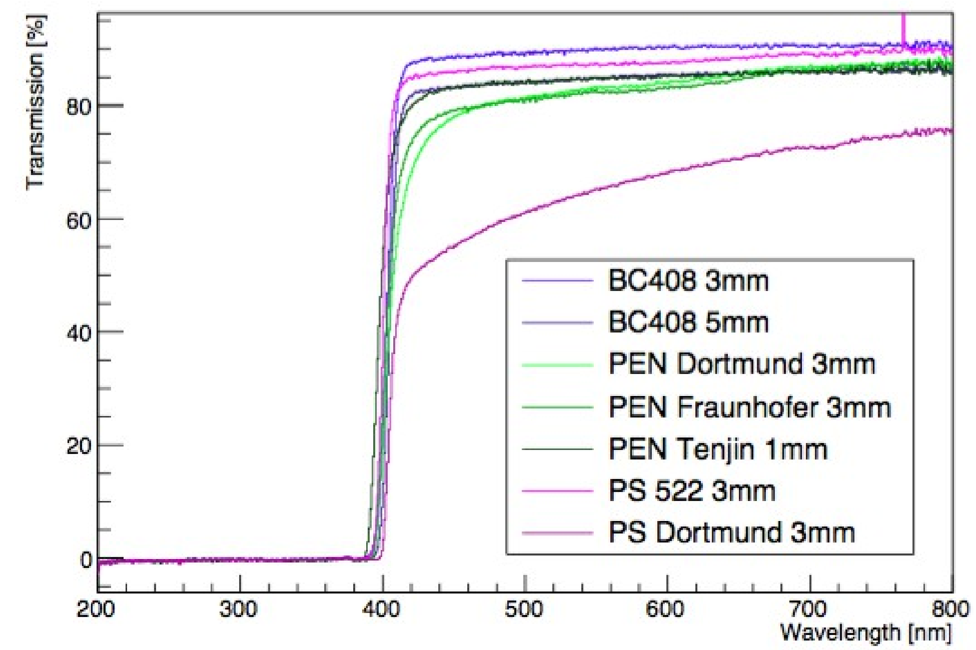


PEN Fraunhofer Machined | PEN Dortmund Injection moulded | PEN Tenjin Original supplier

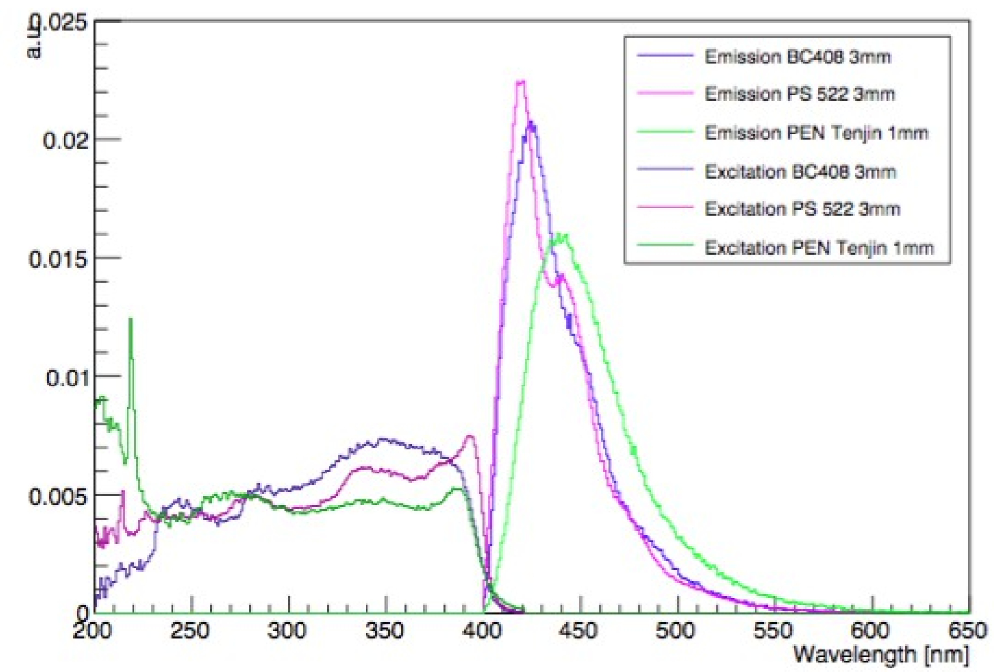
Size about 3x3cm^2

- Opportunity for test series opened/facilitated/fostered through AIDA-2020

Light transmission curves



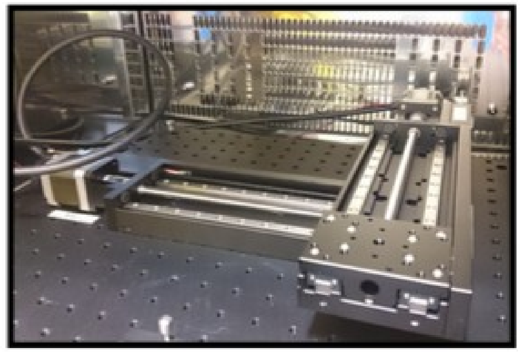
Optical emission after photon excitation



Task 14.2.2: Test benches for the characterisation of highly granular calorimeter elements with scintillator and SiPM readout

AIDA-2020 Infrastructure

SiPM/Scint. Scanner - MPP

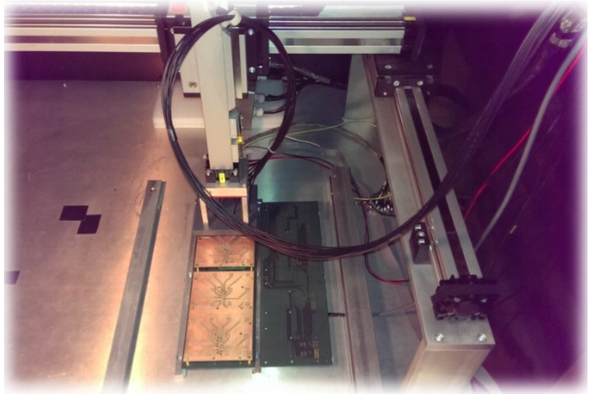


15 cm range translation stages inside the climate chamber

Cosmic Test Bench - JGU

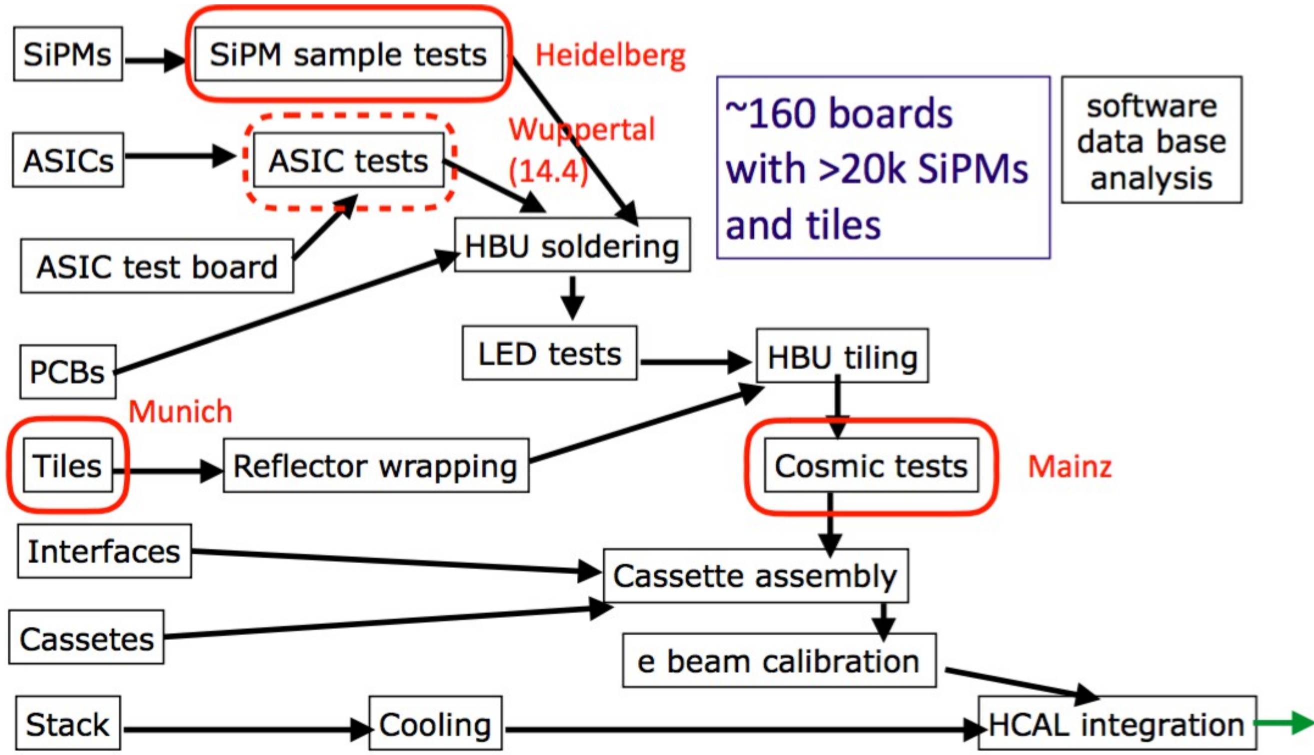
SiPM Gain Stability – UB, Prague

SiPM Characterisation – UHEID

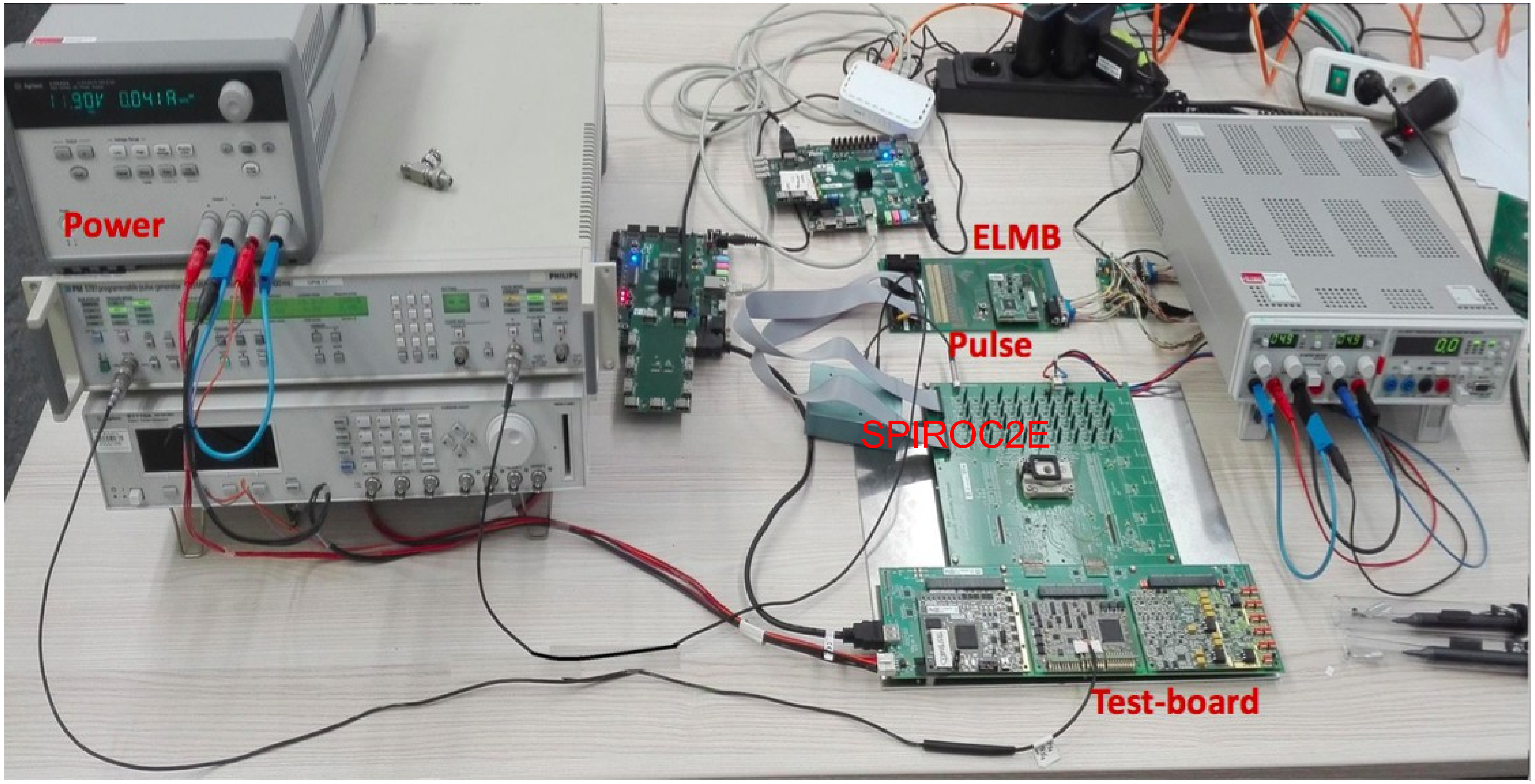


User

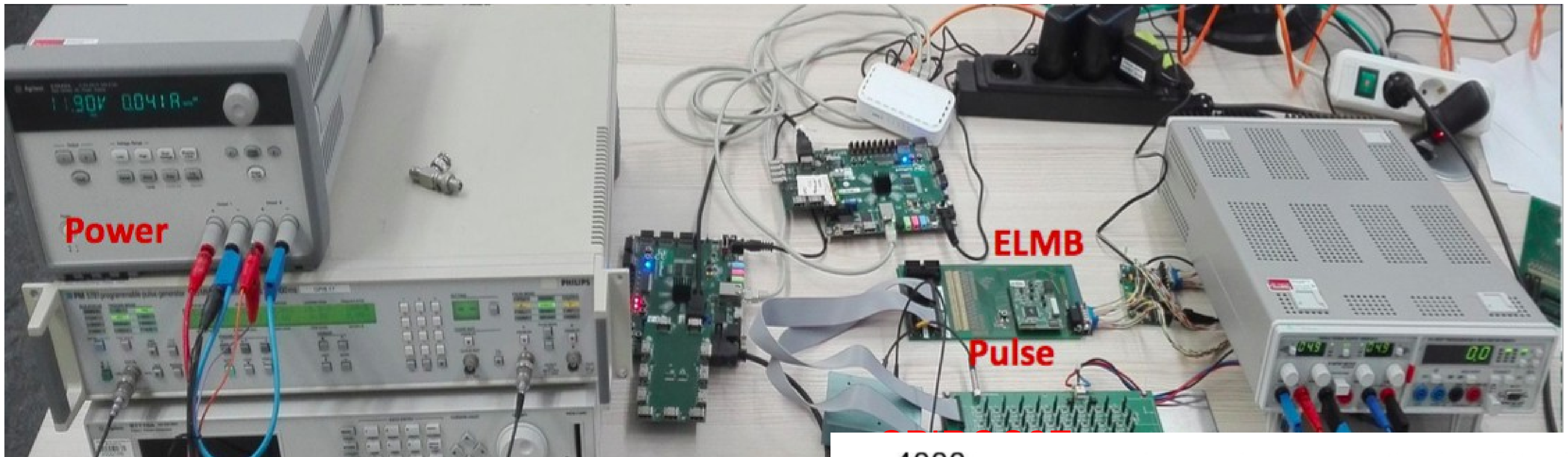
CALICE Scintillator/SiPM hadron calorimeter

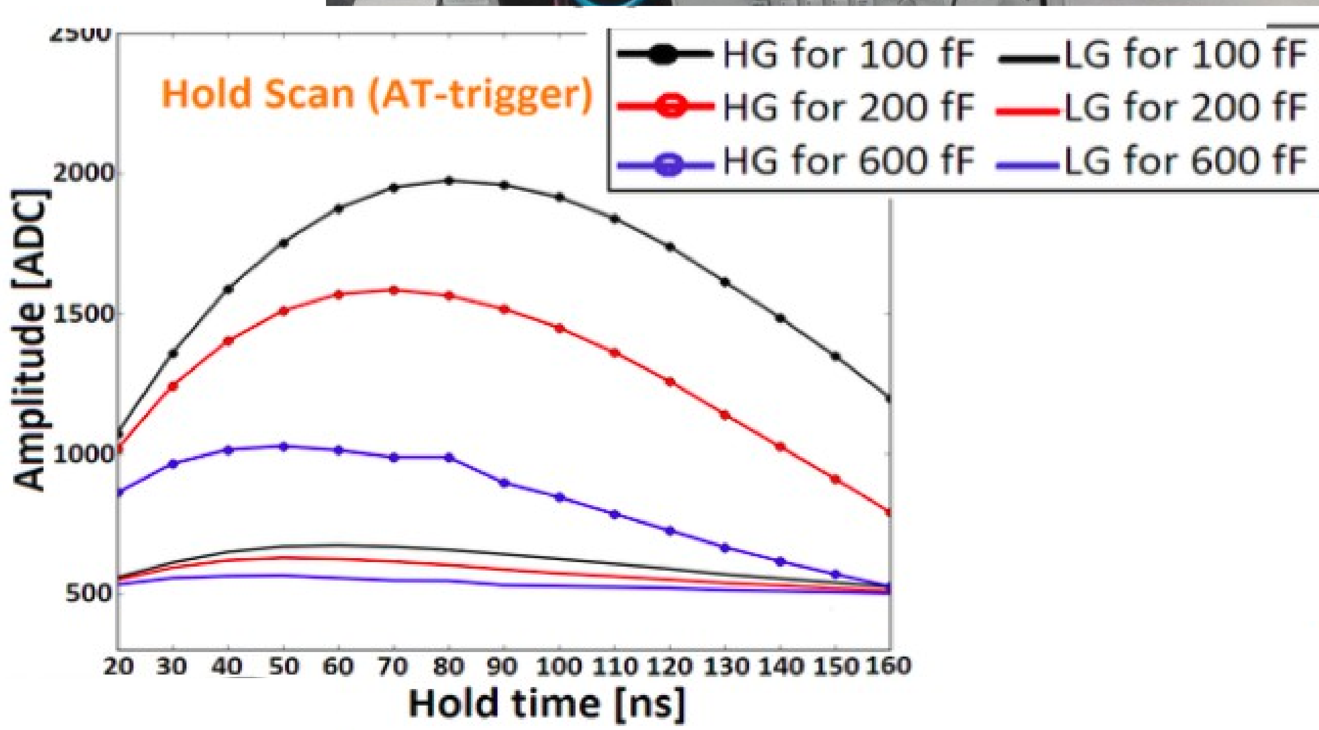


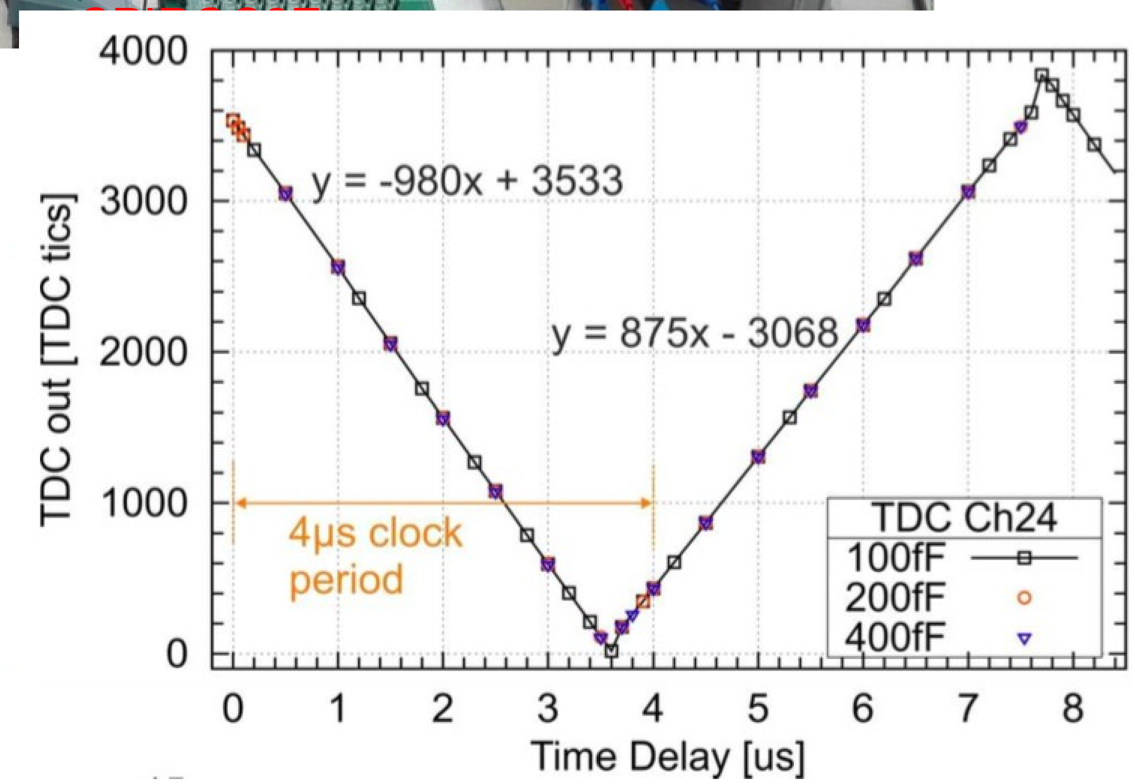
Task 14.2.2: Interplay between WP14 and WP4 - An example SPIROC2E test bench



Task 14.2.2: Interplay between WP14 and WP4 - An example SPIROC2E test bench







- Test bench operational
- Takes 10-15 min./ASIC
- Waiting for about 900 ASICs to be tested

14.3.2: Infrastructure for very compact Tungsten based calorimetry

Precise mechanical frame can hold up to 30 sensor-absorber layers

Detector module (existing)

- readout board with dedicated ASICs&FPGA (top)

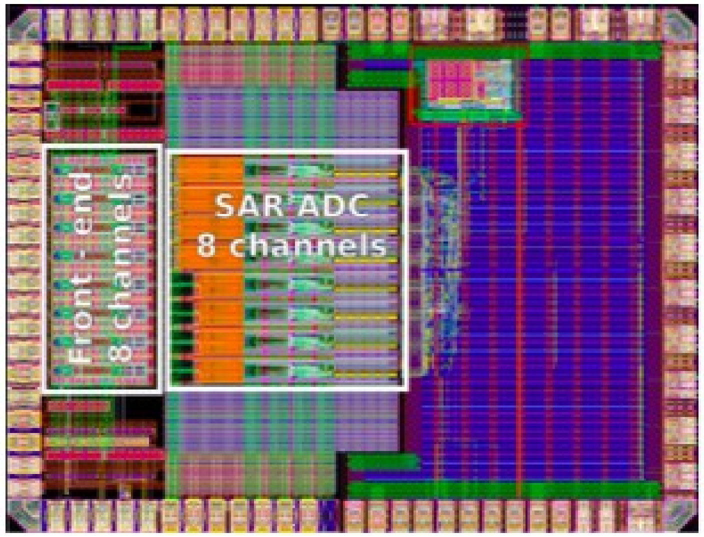
- sensor module (bottom)

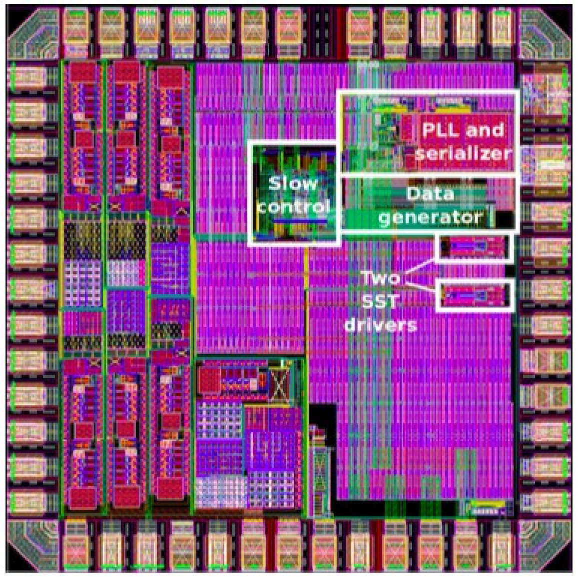
Prototype tungsten plates 3.5 mm thick (1X0), with flatness on front/back side - 10/50um

The GOAL – compact detector module

- Thin (<1mm) sensor module
- Thin (<4.5mm) readout board

MS57: Design and test of ASICS and readout board prototype for test infrastructure





FLAME ASIC:

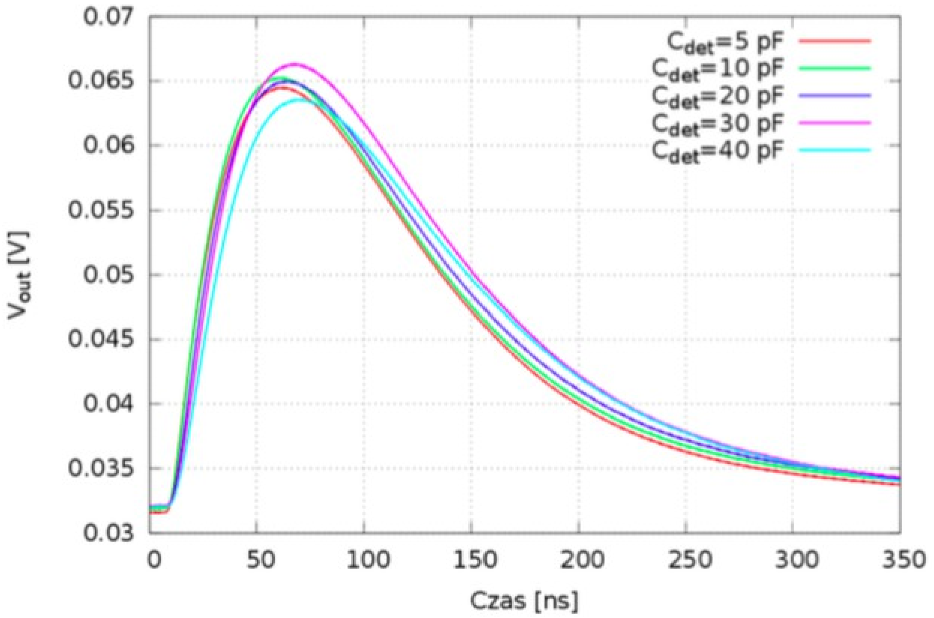
- Ultra-low power readout ASIC in 130 nm
- FE and ADC for each channel
- Fast serialisation and data transmission
- All functionalities in one single ASICS

8 channel version works -> Milestone ok
Work towards 16 channel version

Readout board:

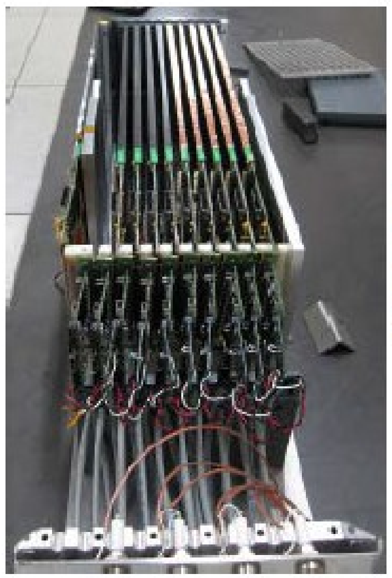
- Artix 7 XILINX Board

-> Milestone ok (though board may evolve)

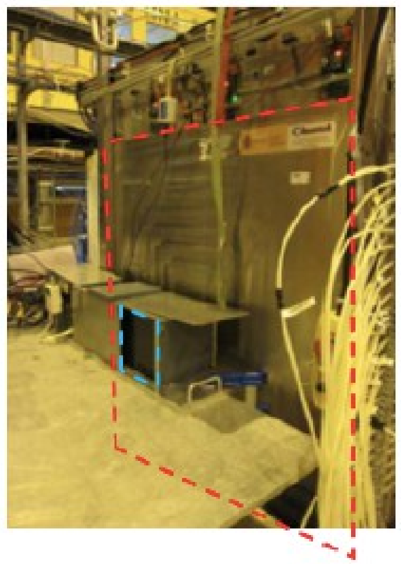


Task 14.3.1: Assembly and QA Chain for silicon-based ECALs

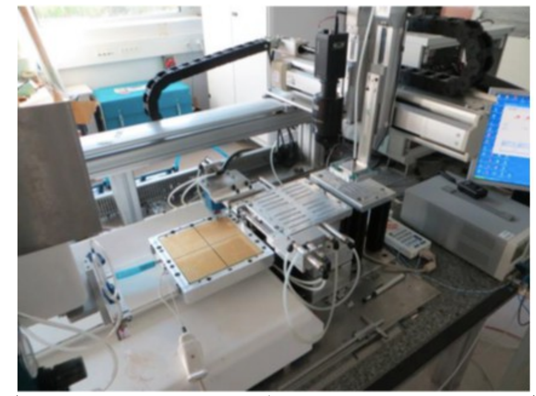
Prototype in test beam 2016



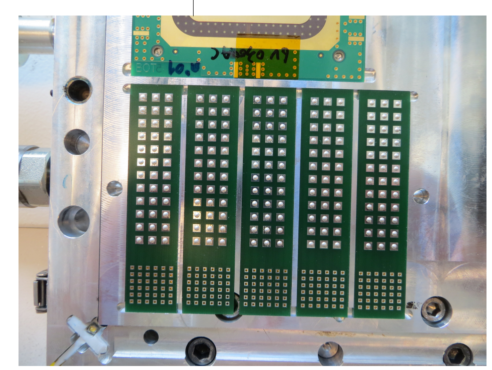
R. Cornat



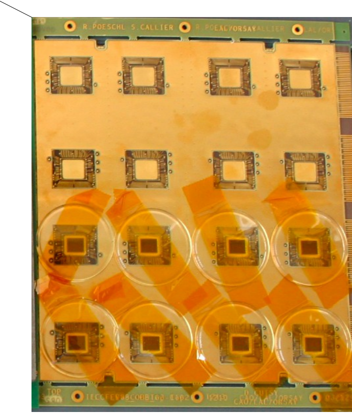
Versatile gluing Prototype



Done, FEV11_BGA (CALICE)



Done, HGTD-LGAD (ATLAS)



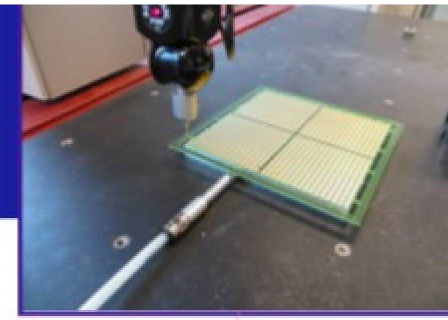
Under discussion, FEV_COB (CALICE)

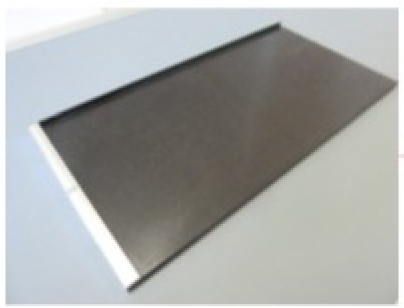
- Important validation of assembly and QA procedures
- (Combined) beam test in June 2016 (Supported by TA)
- ... to be continued in 2017/18
- **Test station of new ASICS (SKIROC2A) operational (France/Japan)**
- **Start planning for long layers**

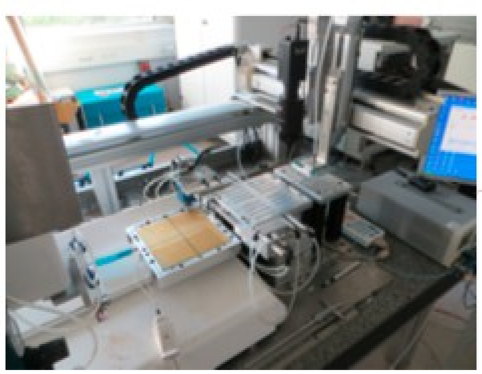
=> Towards deliverable in Month 36

Full assembly chain

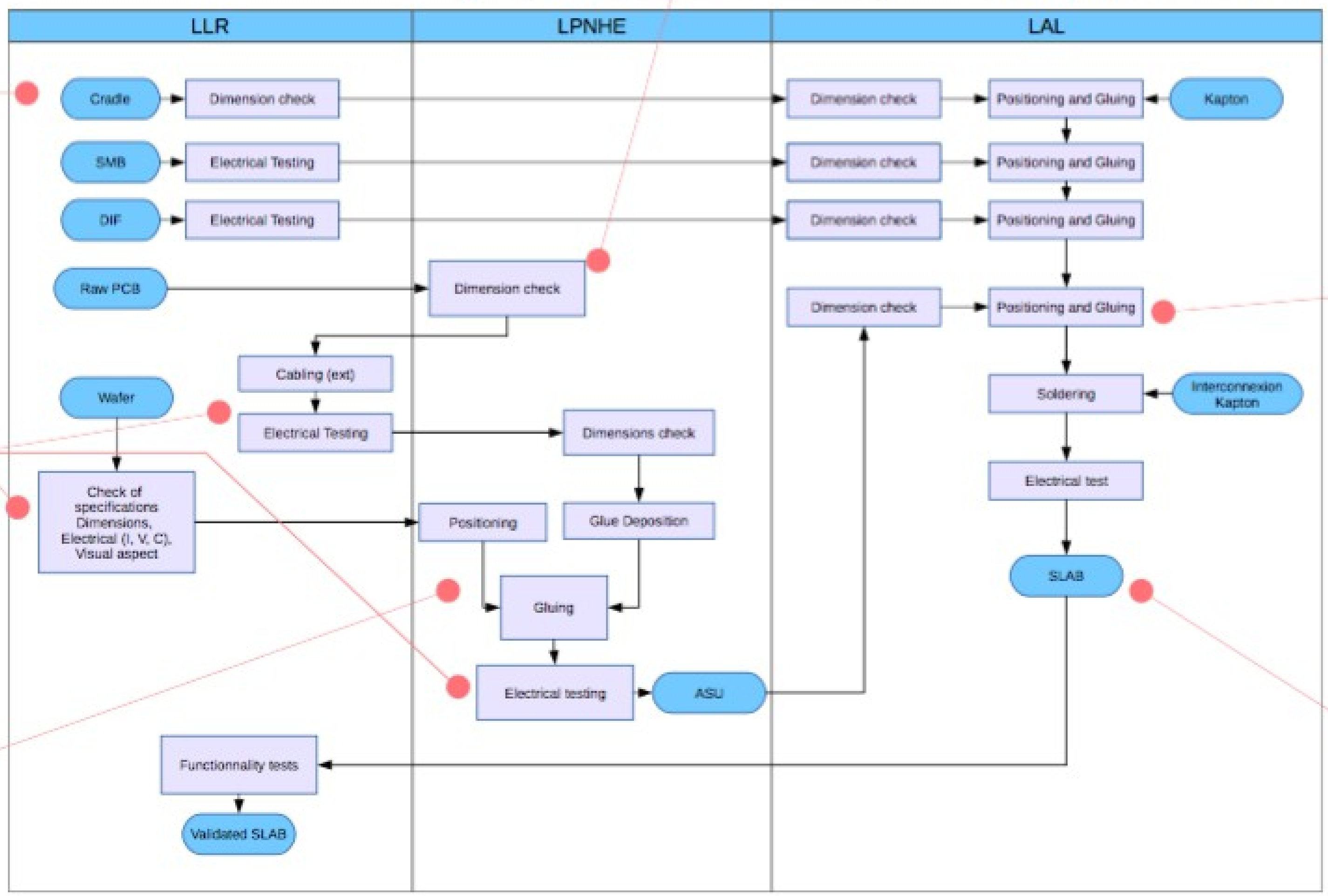
resp: R. Cornat

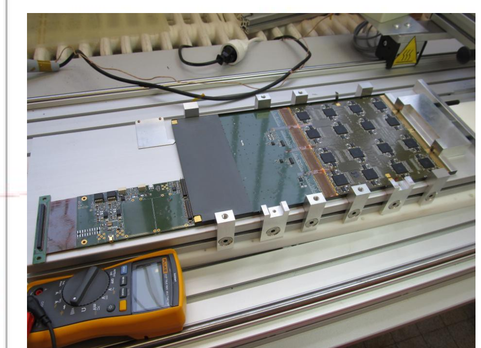


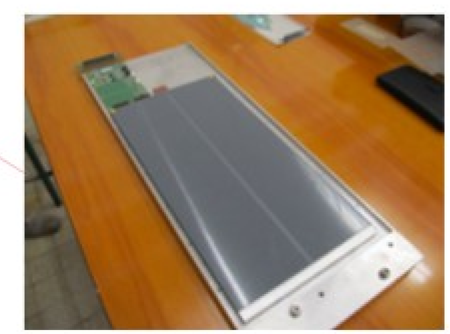




'Simplified view'





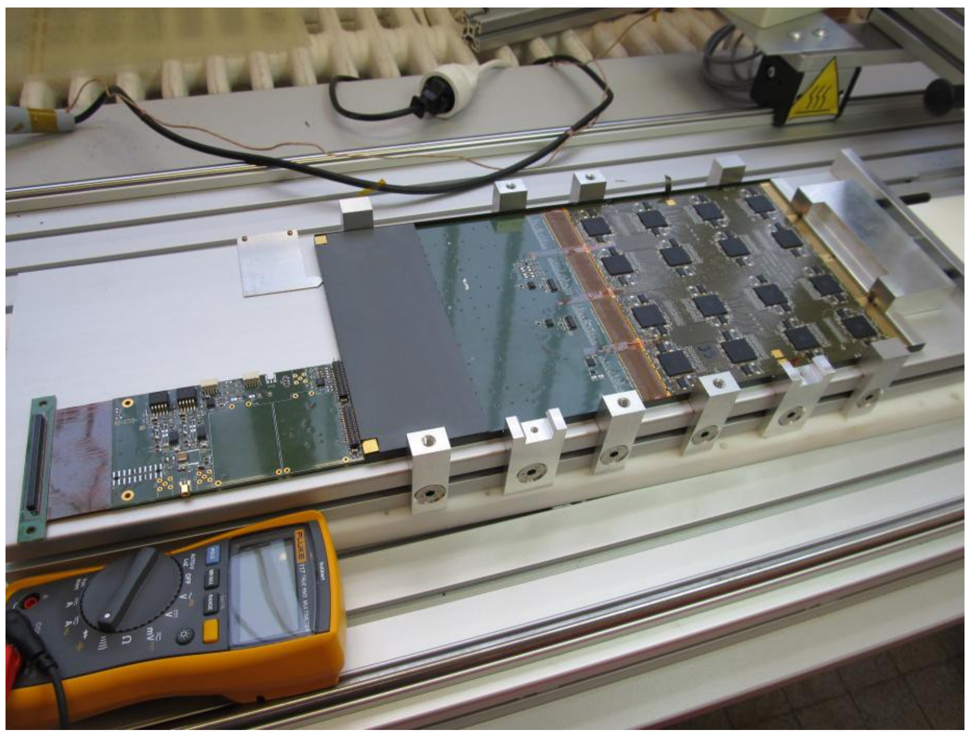


- Documentation on different production steps on paper
- Electronic based system desirable and needed

Task 14.3.1: Assembly and QA Chain for silicon-based ECALs

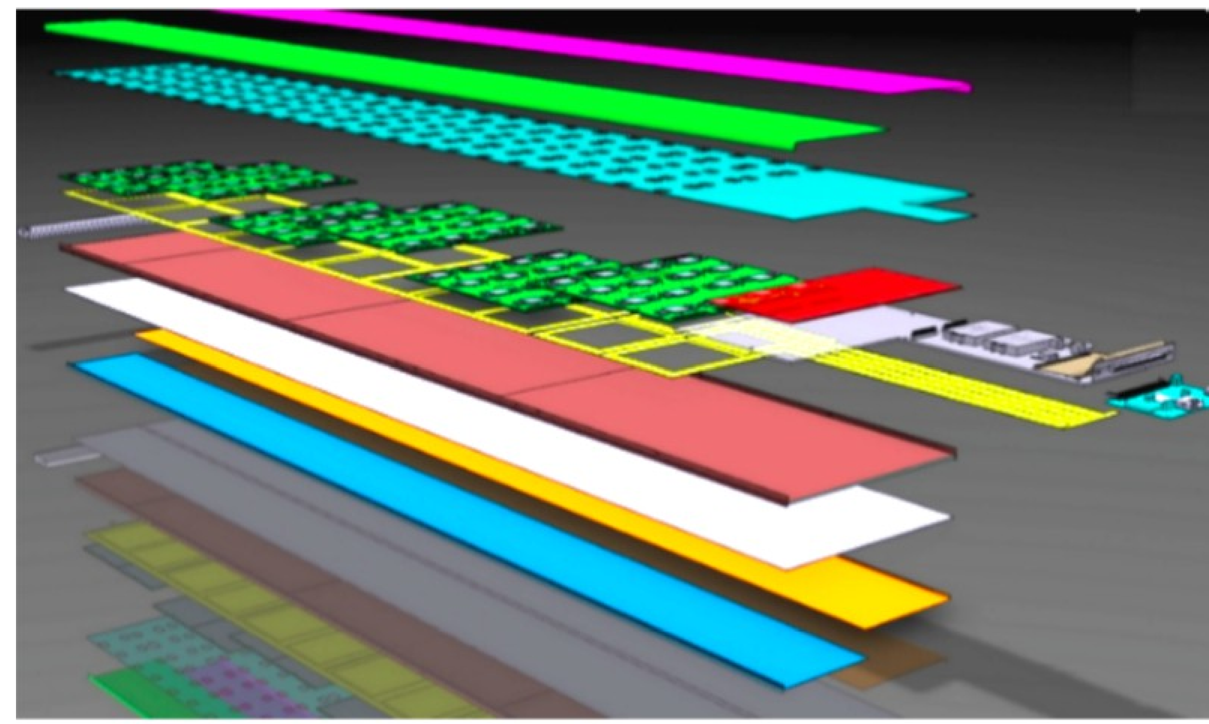
Next step:

Getting from here ...



Layer with one active element as achieved for 2016 MS14

to here ...



Layer with several active elements as needed for full size prototypes

- First considerations/models emerging (see WP14 session)
  - Will be scrutinised further in coming weeks
  - Mounting of bench will start in late spring/early summer
  - Advanced assembly and QA infrastructure is deliverable for AIDA-2020, first user Ile-de-France South Excellence project HIGHTEC

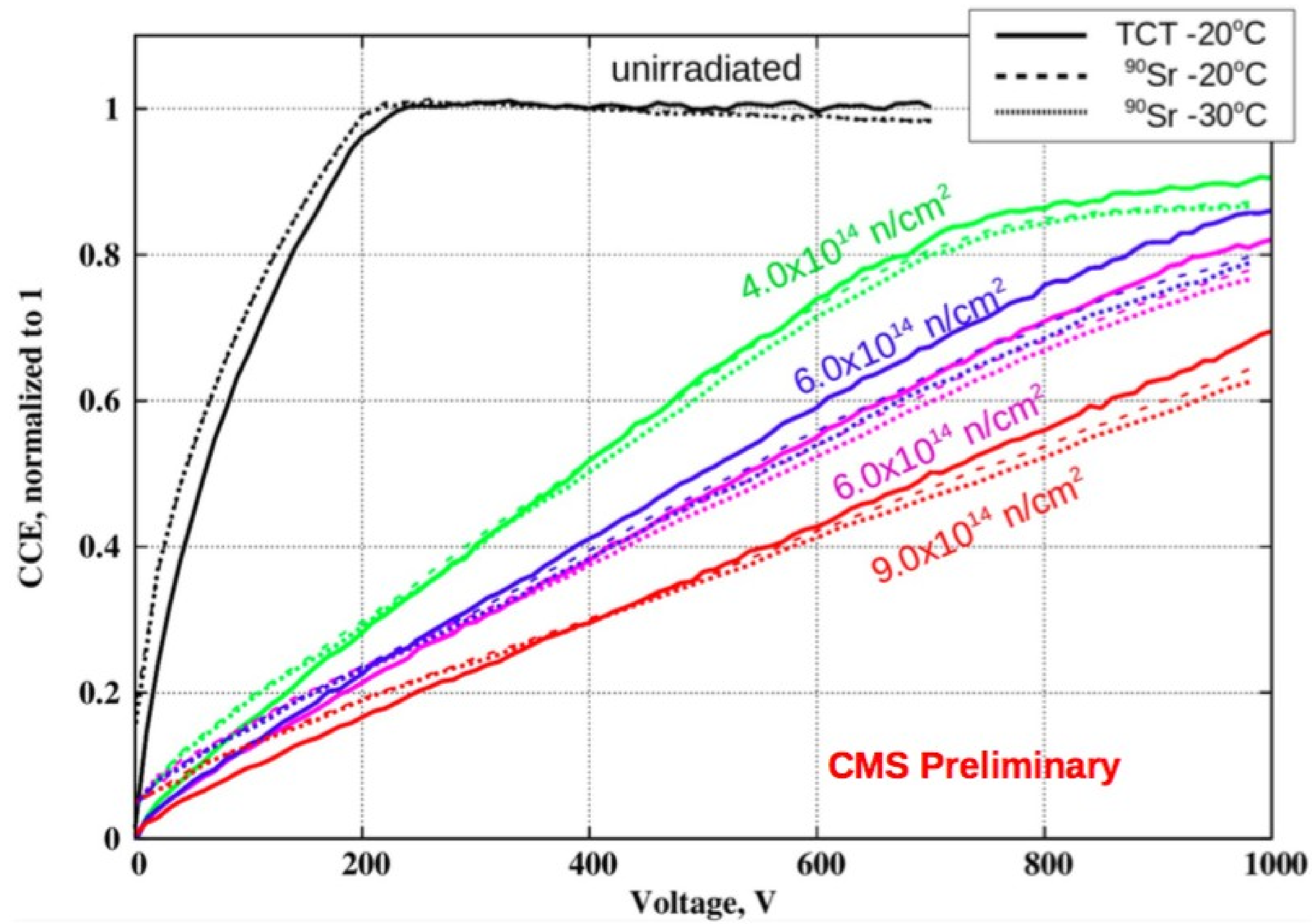
Test stations for irradiated silicon sensors and LHC oriented front-end electronics

Climate chamber with Sr90 source to characterise (irradiated) Si wafers

AIDA-2020 MS15

Application of climate chamber

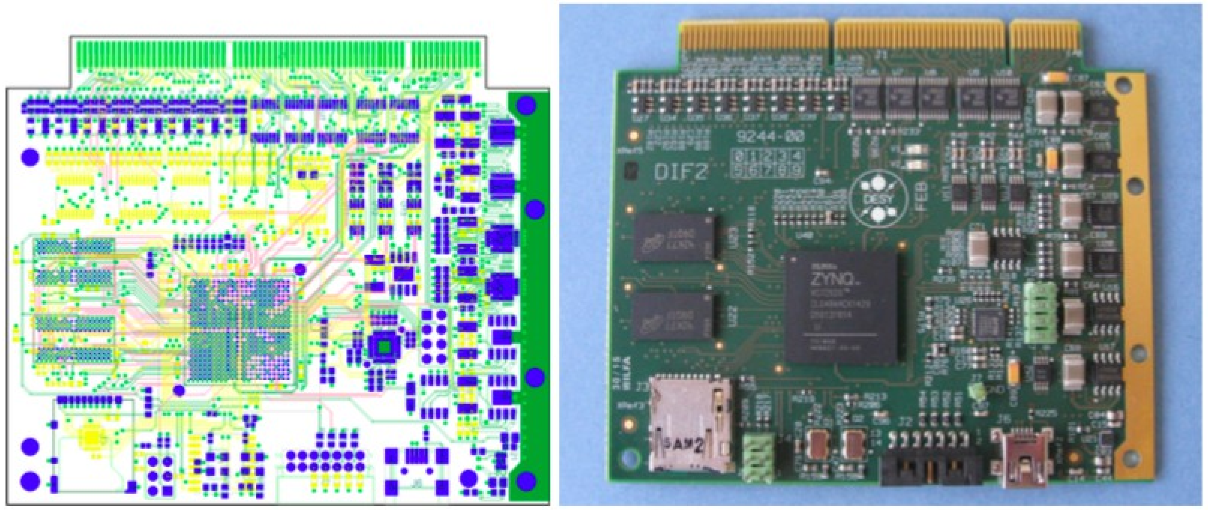
- Charge collection study of dd-FZ 320 mum n-on-p Si diodes
- Comparison ^{90}Sr source (1 MIP) and Laser (TCT, 40 MIP)



- Similar results for source and laser
- Similar results at -20°C and -30°C

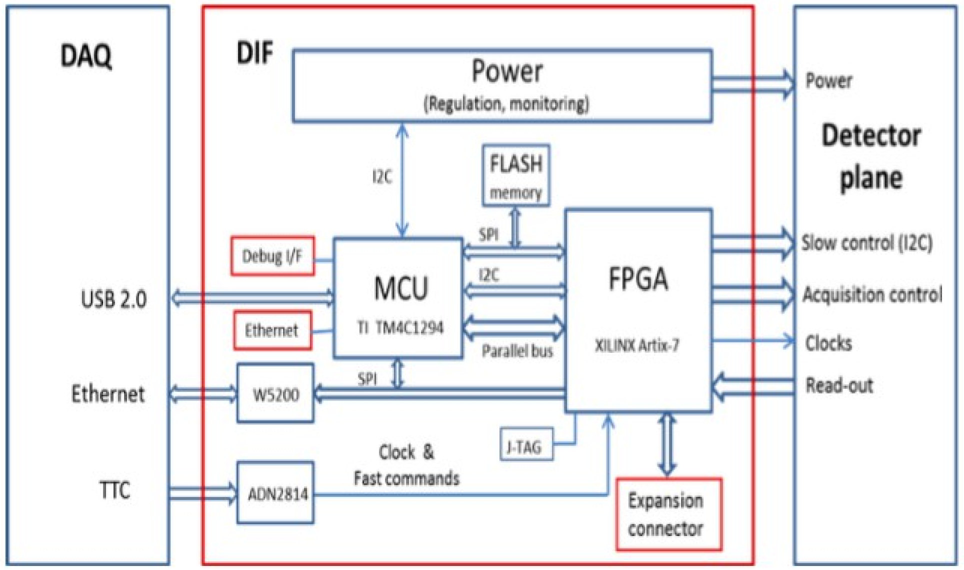
Towards Milestone 58 (Month 24): Definition of optical and electrical coupling of readout, interface functionality and DIF design

DIF Card for optical tile calorimeters



20 DIF produced
Already used in beam test

Layout of DIF card for gaseous calorimeters



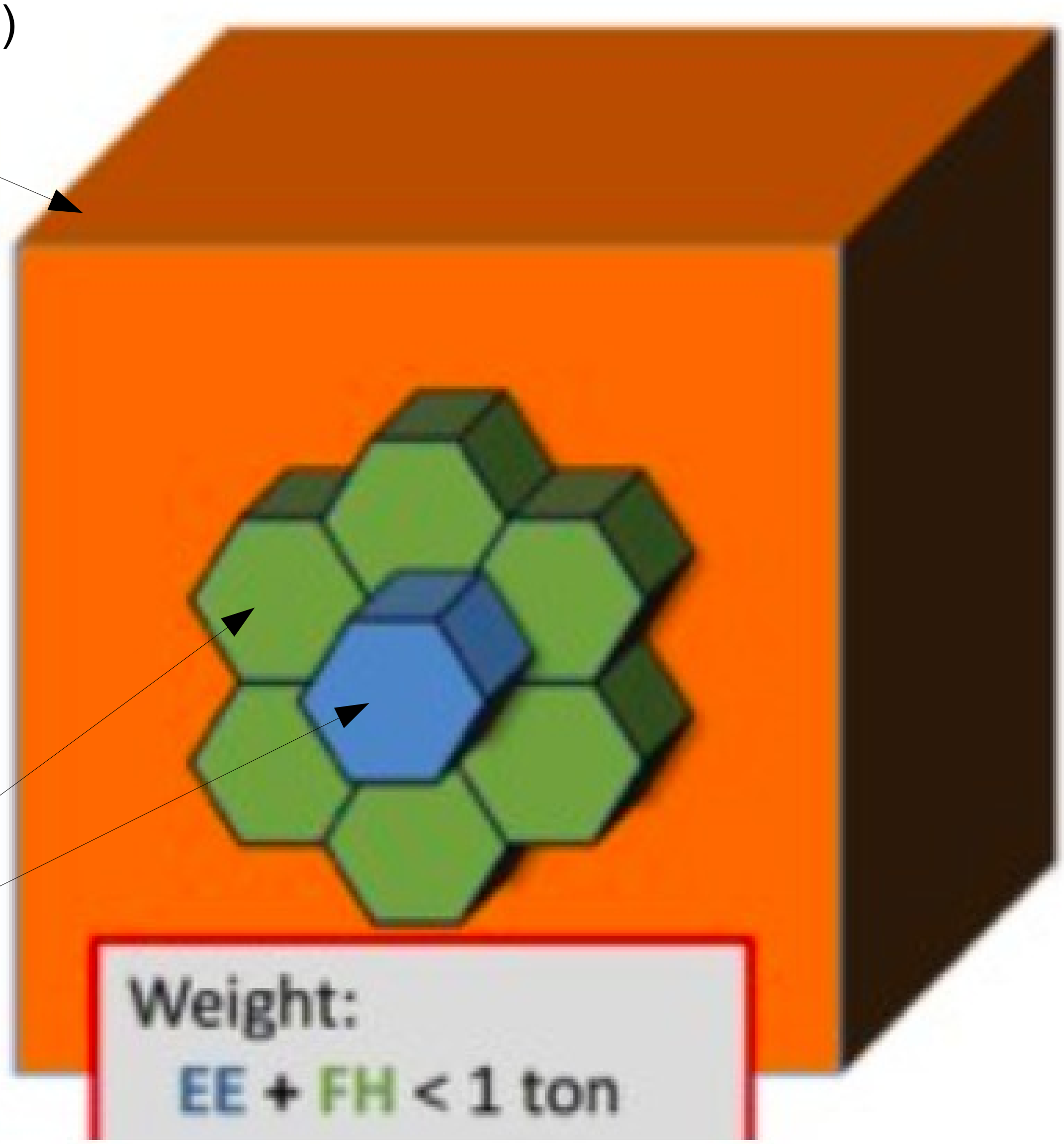
Uses GBT-based communication system à la CMS

- MS Document finished

-> Milestone ok

14.4: Common running of calorimeter prototypes

CALICE
Highly granular analogue
hadron calorimeter
(with coarser absorber structure)



CMS
EM Section and
Front hadronic section

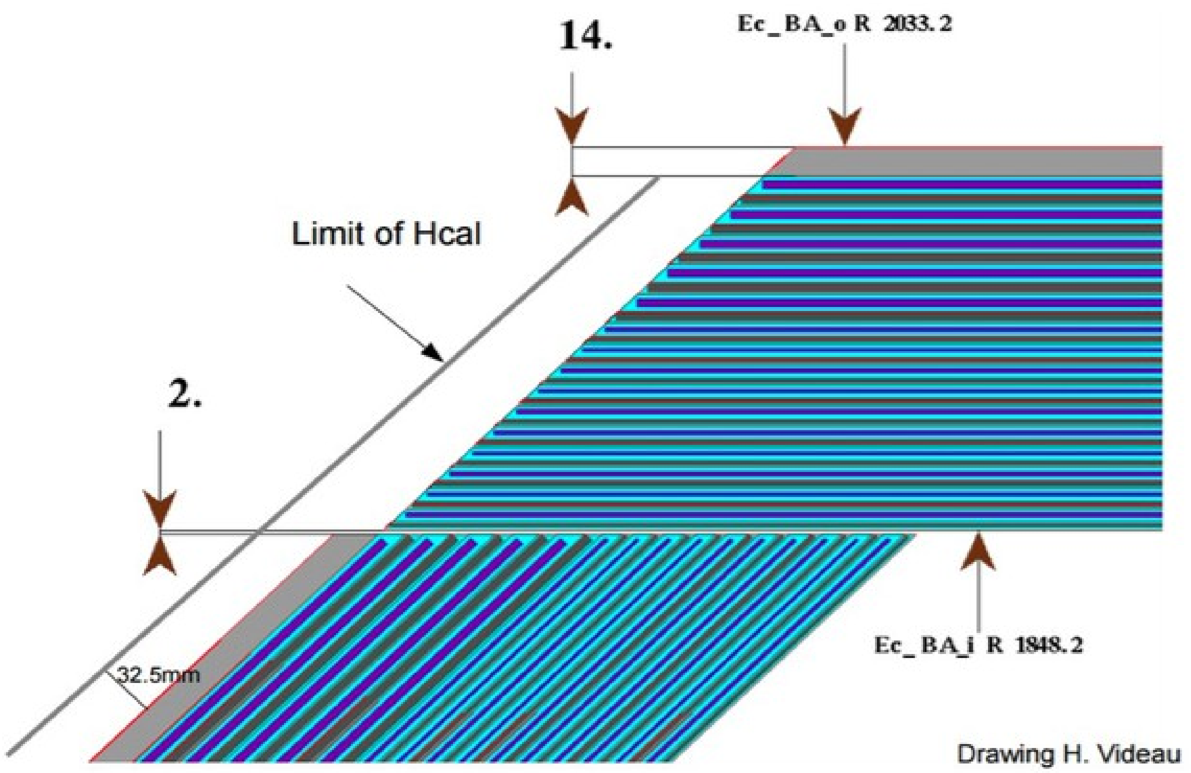
Combined readout system:

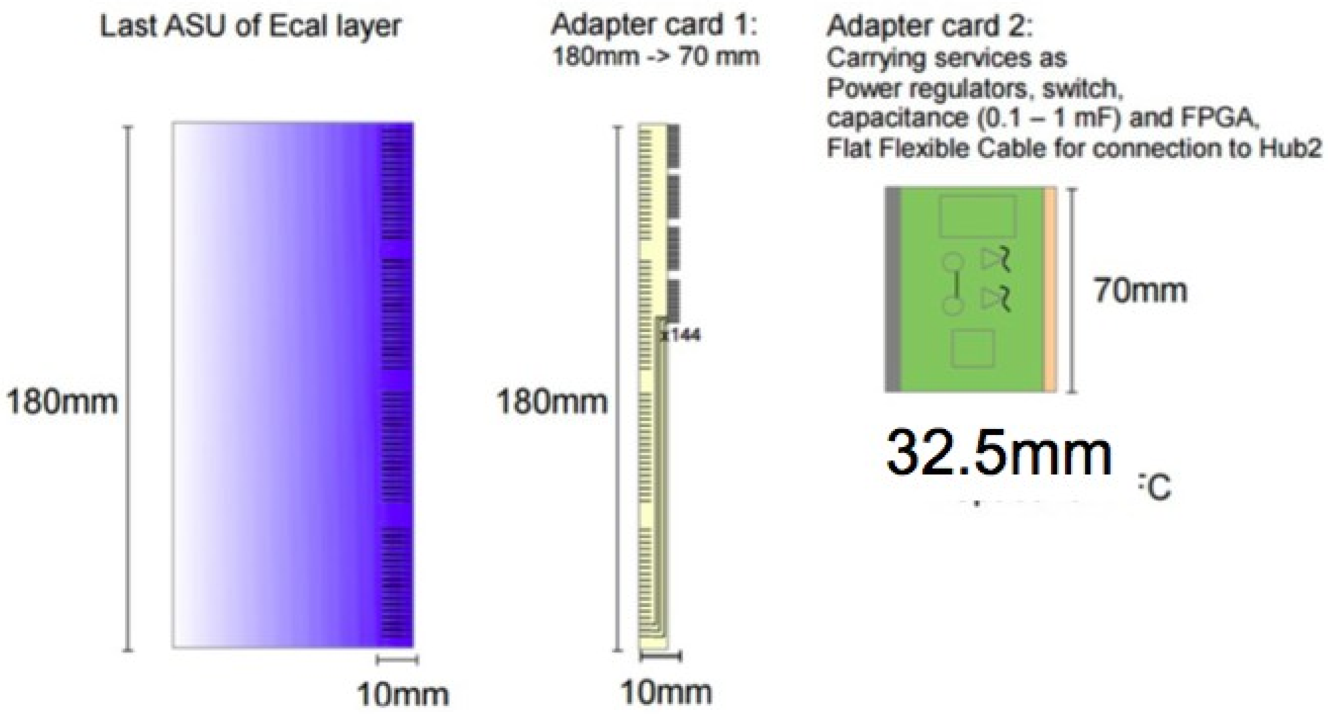
- Needs to synchronise externally triggered devices with internally triggered device
- Synchronisation will make **use of EUDAQ**
- Benefit from experience from AHCal/Beam Telescope tests
- Testbeam planned for Summer 2017

14.4: Adaptation for readout systems in “hermetic” LC Calorimeter structures

Definition of space and functionality ongoing

- r/o electronics in gap between LC Ecal and HCAL
- Paris Metro Ticket to readout 10000 cells
- Design question: Separation of detector and readout?





Examples:

- ASU + Adapter1 + Adapter2
- ASU+Adapter12
- Special ASU integrating first level of digital r/o

14.5.1: Precision mechanics for calorimeter structures

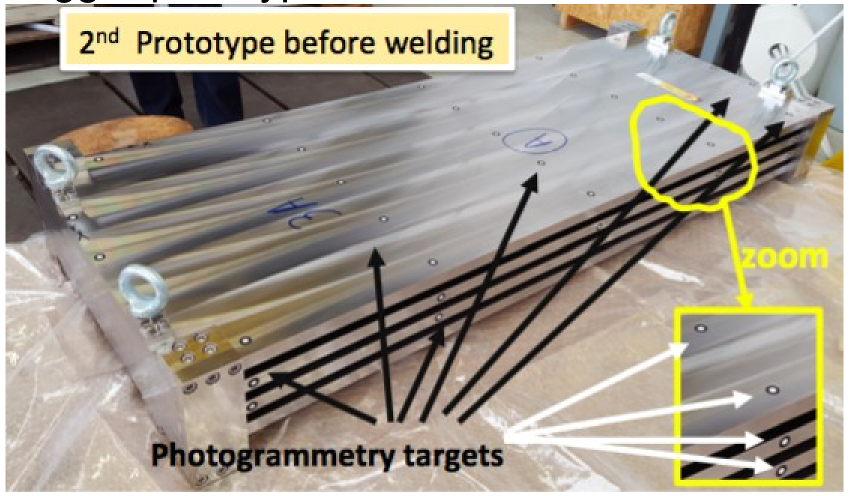
Goal **To investigate the suitability of the electron beam welding (EBW) technology for very precise absorber mechanical structures for highly compact imaging calorimeters**

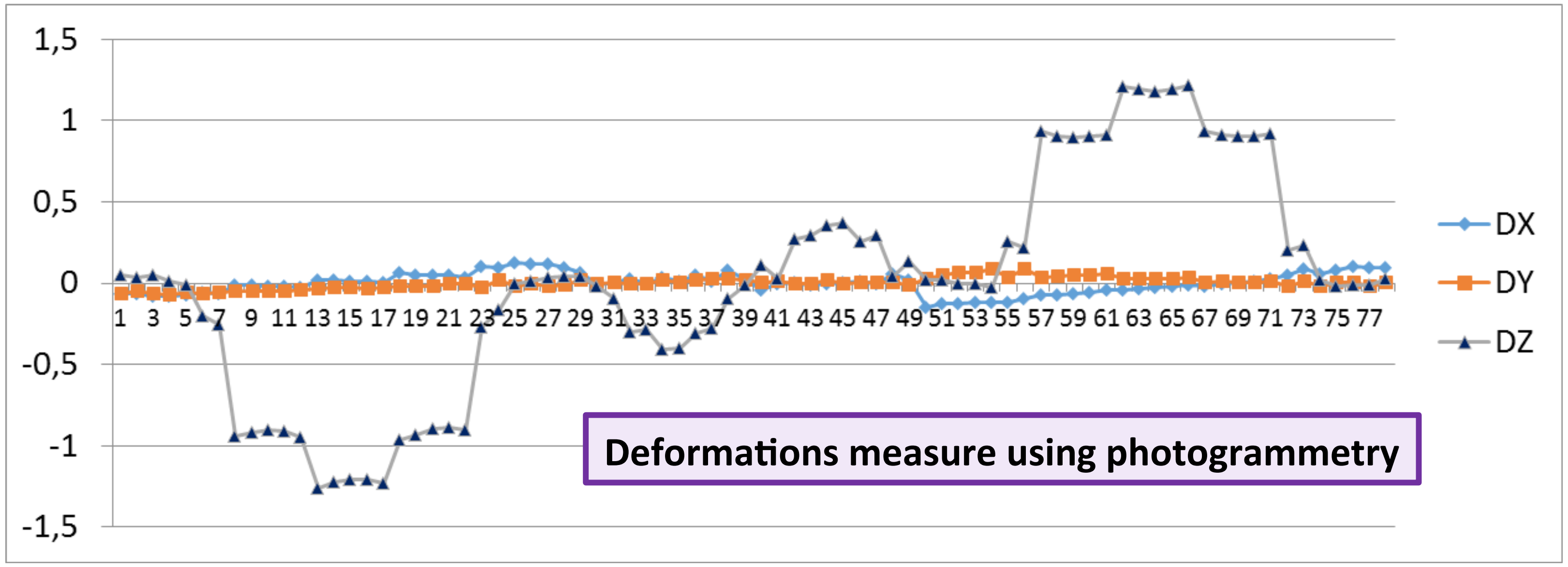
Reminder: Roller leveling at ARKU fine, beam electron welding of bigger prototype of 100x100 cm^2 at CERN satisfactory

Second small prototype: 4 plates 1x0.5 m2

Welding performed **changing a bit the welding sequence** with respect to the first prototype

Deformations found: **worse than in the first prototype**





Results subject of discussion between CERN and CIEMAT
Next step is welding of thin and bars 1x100 cm^2 and then again 50x100 cm^2
~beginning of 2017

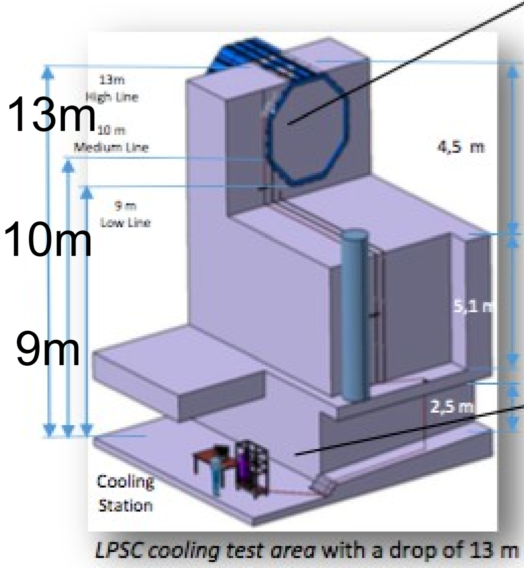
14.5.2: Mechanical and thermal tools for innovative calorimeters

MS31 (October 2016): Design of cooling system for tungsten / carbon-f bre and for HCAL structures - **Achieved**

... now towards big things ....

Demonstration and performance
of a large leakless cooling loop
on three levels
13m – 10m – 9m

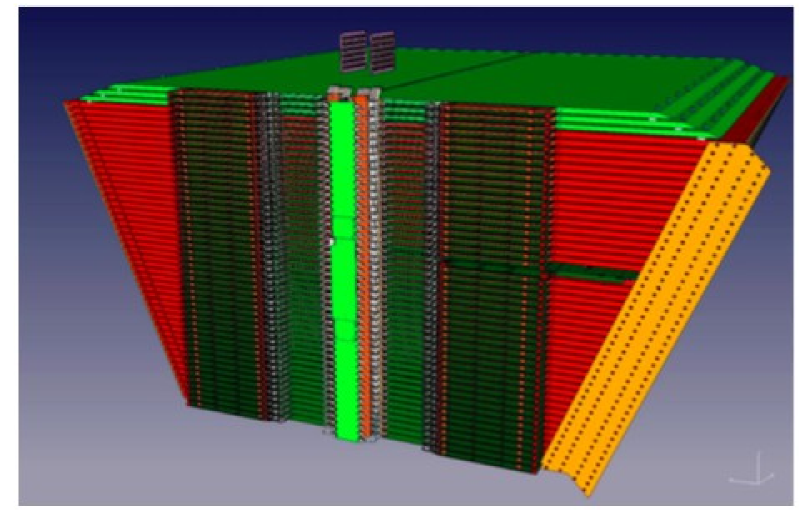
Suited to serve needs of e.g.
ILD SiW Electromagnetic Calorimeter

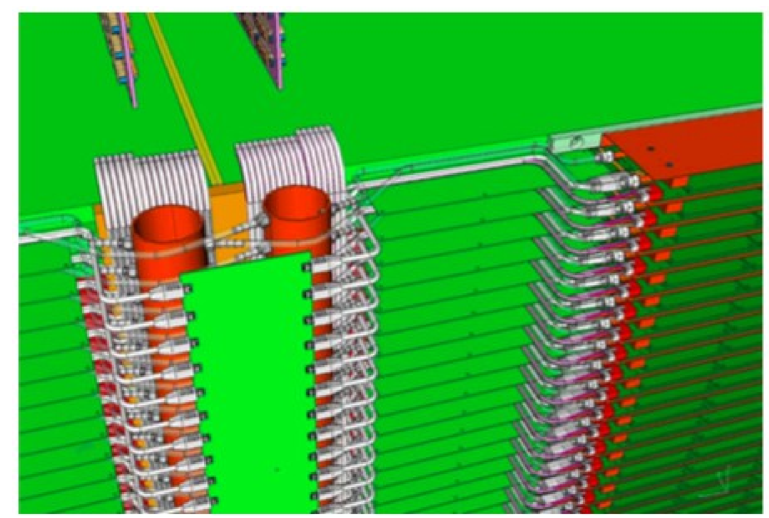


LPSC cooling test area with a drop of 13 m

(Maybe) the “largest”
project in AIDA-2020 ;-)

Cooling system for large
CALICE Scintillator/SiPM hadron calorimeter





- Minor adaptations necessary w.r.t. milestone
- Case study for ILD hadronic calorimeter

Conclusions

- Broad variety of activities on infrastructures for calorimeter R&D covered by WP14
- The various projects are taking shape at different places in Europe
  => All activities are on track
- All seven milestones will have been achieved in April 2017
- All milestones achieved. This concludes first phase of WP!4 work
- Common activities and spin-offs are several places
  - Gluing for ATLAS
  - Scintillator tests for Belle II (see report at last Annual Meeting)
  - Test beam plans CMS/CALICE
  - Contacts with industrlal partners
- Phase towards deliverables will allow for consolidating cooperation between various partners

Summary of Silicon Workshop 2016

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ENERGY AND TIME MEASUREMENTS WITH HIGH-GRANULAR SILICON DEVICES

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ABSTRACT. This note is a short summary of the workshop on *Energy and time measurements with high-granular silicon devices* that took place on the 13/6/16 and the 14/6/16 at DESY/Hamburg in the frame of the first AIDA-2020 Annual Meeting [1]. This note tries to put forward trends that could be spotted and to emphasise in particular open issues that were addressed by the speakers.

1. INTRODUCTION

Silicon is particularly well suited for the design of compact and highly segmented calorimeters. Calorimeters with silicon as active elements have a tradition that goes back to the LEP era. Small silicon-tungsten calorimeters (with a diameter of around 30 cm) were used e.g. by the OPAL collaboration for luminosity measurements in the forward regions of the detector [2]. This "tradition" will be followed up by the luminosity calorimeter that is designed for future linear electron-positron colliders. A highly segmented calorimeter is also beneficial in more central regions of the detector. A first attempt was made by the ALEPH collaboration. The ALEPH detector featured an electromagnetic calorimeter

- Workshop on Energy Timing Measurements With silicon devices 13/6/16 – 14/6/16 at DESY

- Short summary written by M. Mannelli, A. Seiden and R.P.

- Available as AIDA-Note **AIDA-NOTE-2017-005** and arxiv **1704.01304**

- May serve as brief introduction and appetiser to join the field

Backup

- Contribution to MT report on time
  - Update on publications
  - Regular reminders to participants to respect AIDA-2020 publication policy
- WP14 Face-to-Face Meeting 19/1/17 at CERN
  - https://indico.cern.ch/event/577704/
  - 20 participants
  - Reports from all groups with focus on upcoming milestones
  - “Guest” contribution by WP4 on Microelectronics
  - Will continue this good practice in all coming face-to-face meetings
- Etiennette from WP14 member of Academia meets industry event at this workshop
- Proof of concept call
  - Proposal for neutron detector (Vilnius/Minsk with CIVIDEC [Vienna]) not succesful

The Tasks of WP14

- **14.1** Scientific coordination (MPP-MPG, CNRS-LAL), 16kEUR
- **14.2** Test infrastructure for innovative calorimeters with optical readout, 340kEUR
  14.2.1 Test benches for characterisation of organic and inorganic scintillator material (CERN [CERN, RINP, Brunel], INFN [Torino, Roma, MiB, UNIMiB], VU, ETHZ)
  14.2.2 Test benches for the characterisation of highly granular calorimeter elements with scintillator and SiPM readout (JGU, DESY [Uni Heidelberg], MPG-MPP, UiB, IPASCR
- **14.3** Test infrastructure for innovative calorimeters with semiconductor readout, 345kEUR
  14.3.1 Assembly and QA Chain for silicon-based ECALs (CNRS [LLR, LAL, LPNHE], CERN [CERN, Imperial])
  14.3.2 Infrastructure for very compact Tungsten based calorimetry (DESY [Zeuthen], AGH-UST, TAU [Tel Aviv, IFJPAN], Vinca)
- ***14.4*** Readout systems for innovative calorimeters, 150kEUR
  14.4.1 LC Calorimetry specific DAQ interfaces (IPASCR, CNRS [IPNL, LLR], DESY [Hamburg])
  14.4.2 Low Power Readout & Monitoring systems (CNRS [LAL, IPNL], DESY [Hamburg, Uni Wuppertal])
- **14.5** Mechanical and thermal tools for innovative calorimeters, 115kEUR
  14.5.1 Precision mechanics for calorimeter structures (CIEMAT [Madrid])
  14.5.2 Infrastructure to evaluate thermal properties of calorimeter structures (CNRS [LPSC], DESY [Hamburg])

The Team of WP14

- Two task leaders for each task - to provide expertise in all topics within a task and to represent the full breadth of the WP14 community

- Work package leaders (and Task 14.1):
  Roman Pöschl (CNRS-LAL), Frank Simon (MPG-MPP)
- Task 14.2: Etiennette Auffray (CERN), Lucia Masetti (JGU)
- Task 14.3: Vincent Boudry (CNRS-LLR), Marek Idzik (AGH-UST)
- Task 14.4: Katja Krüger (DESY), Dirk Zerwas (CNRS-LAL)
- Task 14.5: MaryCruz Fouz (CIEMAT), Denis Grondin (CNRS-LPSC)

- Technology Transfer Officer (TTO): Etiennette Auffray (CERN)

Deliverables

	Title	Lead Ben.	Task	Month
D14.1	Fibre test benches	CERN	14.2.1	47
D14.2	Performance of test infrastructure for highly granular optical readout	MPG-MPP	14.2.2	40
D14.3	Advanced assembly chain for Si calorimeters	CNRS	14.3.1	36
D14.4	Very compact calorimeters	AGH-UST	14.3.2	48
D14.5	Common running of calorimeter prototypes	DESY	14.4.1	36
D14.6	Updated readout system	CNRS	14.4.2	44
D14.7	Electron beam welding demonstrator	CIEMAT	14.5.1	42

- No deliverables in 2016