CHEF 2017

Technical instrumentation R&D for ILD Si-W ECAL large scale device

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on behalf of SiW ECAL ILD / CALICE collaboration

Outline:

(1) Introduction to ILD Si-W ECAL

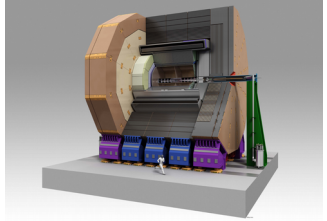
(2) Long slab:

mechanics, electronics, calibration;

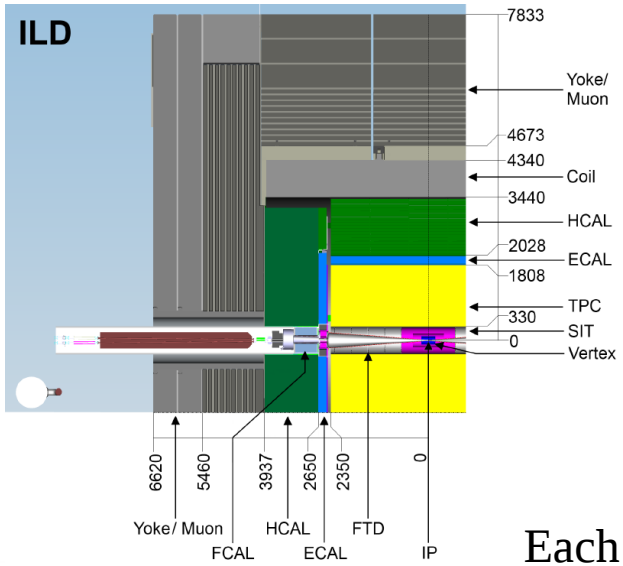
status and plans

(3) Conclusions

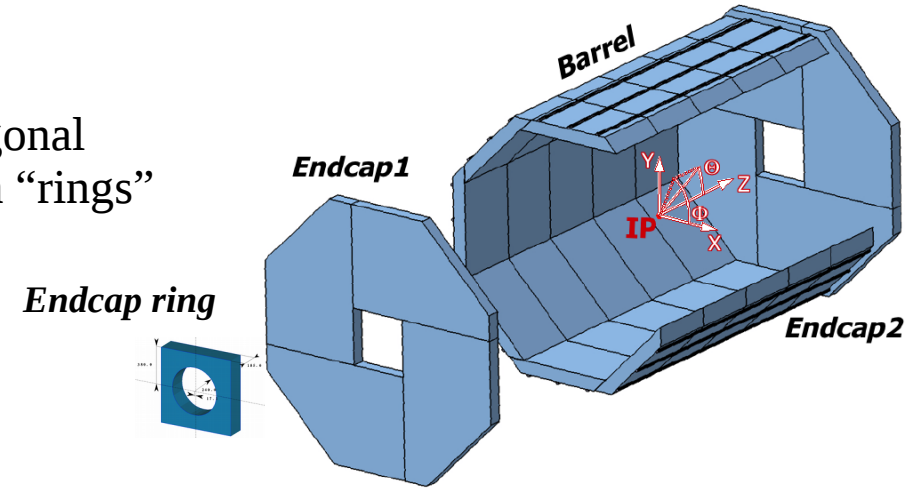
Supported by:

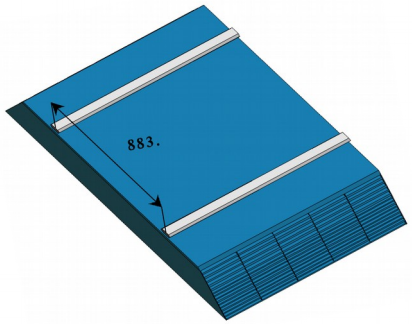


International Large Detector (ILD) Si-W ECAL

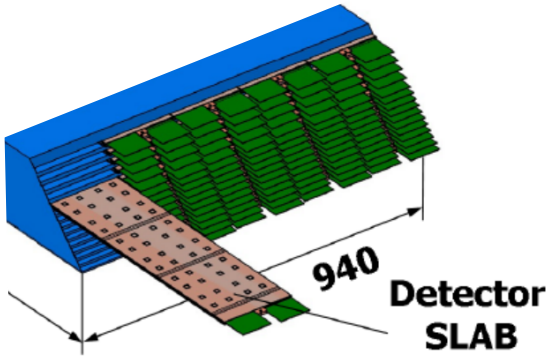


ECAL = modular octagonal barrel + 2 endcaps with "rings"





Each module = carbon-fiber + W structure with alveoli where detector elements (slabs) slide in. Slab = Si matrices of PIN diodes glued to PCB with embedded electronics on both sides of W wrapped into carbon fiber.



To avoid radial cracks:

(1) trapezoidal barrel shape is "inverted" (Videau structure")
(2) odd # barrel modules
(3) minimal dead areas

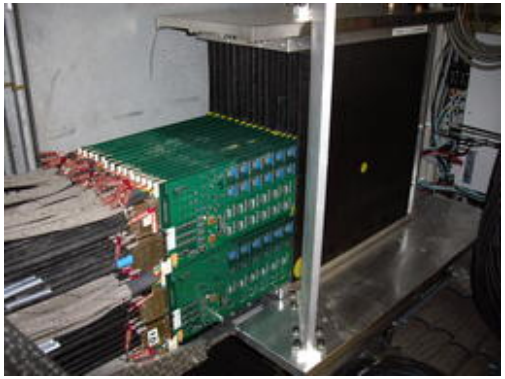
1/8 of barrel

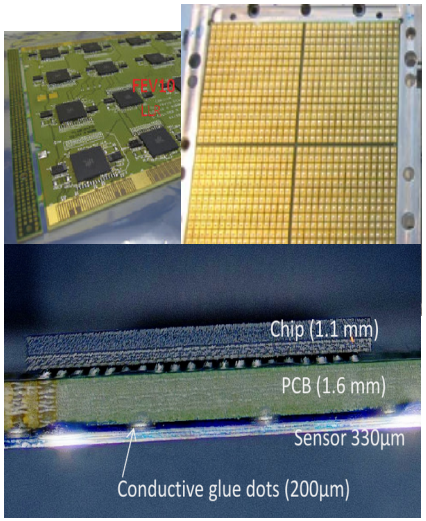
ECAL options: 2012 ILD TDR baseline with 30 layers, 22 layers, 23% smaller radius, thicker and larger Si sensors (725 um, 8" wafers)

CALICE / ILD R&D on SiW ECAL

SiW ECAL "physics" prototype (2005 – 2011).
Proof of PFA principles at test beams.
Technological questions left aside (not embedded electronics, big power consumption).

JINST 3 (2008) P08001
NIM A608 (2009) 372

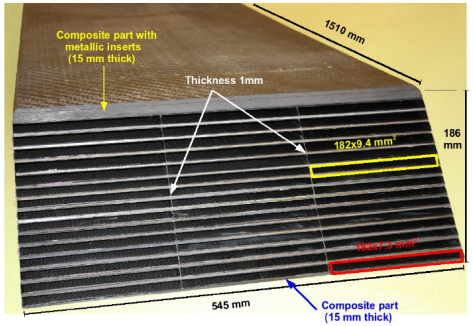




2d generation technological ECAL with embedded electronics (2011 – now).
7 "short slabs" tested, each: 18x18 cm^2 Si, ILD channel density, 1024 pixels, 4 sensors glued to PCB (= Active Sensor Unit, ASU) with 20 um precision.
Power pulsed: readout switched OFF between "ILC trains" (~100 less power)

Current R&D:

- Optimization of Si sensors, laser tests, irradiation tests (50 ILC years Ok)
- **Recent beam test results –** see talk of Adrian Irles later today and also JINST 12 (2017) 7, C07013
- **Tests of 64 ch. front-end ASIC SKIROC –** Taikan Suehara, tomorrow
- **Online software framework** - Frederic Magniette, on Thursday
- Integration and **optimization for ILD –** see talk of J.-C. Brient on Thursday

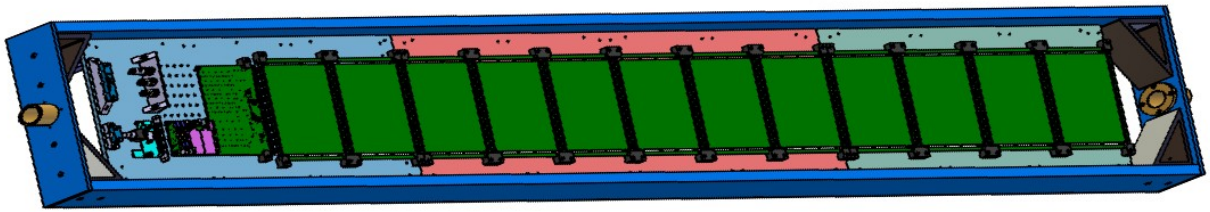


C fiber + W barrel structure manufactured: 3/5 ILD module (5 years of R&D)

- **Endcap mechanics & cooling –** see talk of Julien Giraud on Thursday
- **Analysis of ILD barrel modules under static and dynamic loads –** Thomas Pierre-Emile also on Thursday

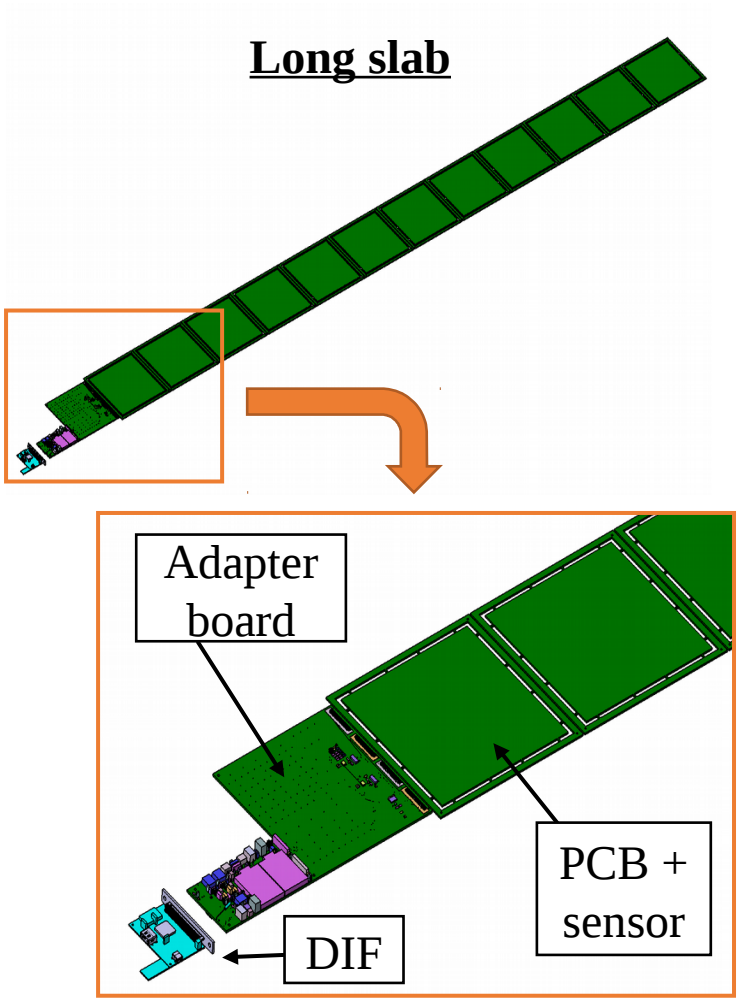
Planning next step: from “short” to “long” slab

- Prototype of “long” slab with 8-12 PCBs, each 18x18 cm^2
  (In ILD of nominal size: 8 ASUs – in barrel, maximally 12 in endcaps. ILD slab: two such detectors on both sides of W+carbon fiber).
- Points to verify w.r.t. to “short slab” with only one PCB:
  - Clock and signal propagation & distortion
  - Low and high voltage distribution
  - Data volume and integrity in DAQ
  - PCB electrical interconnections
- Leave out for simplicity the ILD constraints on dimensions, mechanical tolerances, on 100% reliability of interconnections in mass scale.
- Each of 8-12 PCBs will carry “baby” sensor (4x4 pixels)
- Readout from one end with adaptor board + DIF card, same as in “short” slab
- Add PCBs one by one, check performance after each step, stop if not Ok
- When maximal possible length of <=12 PCBs reached:
  final tests with radioactive source, cosmics, charge injection and then beam-test, to check data consistency over the length.



Long slab design and requirements

- Long slab can be rotated around its middle axis and fixed at any position (for cosmics & beam)
- Can be handled by 2 people (<30 kg)
- Rigid frame, mechanical bending <1 mm within PCB area, absorbed by PCB *flexible* support. Fixation of PCB only at its technical edges.
- Access to electronic boards from both sides
- Light tight
- Electrical isolation of DIF and adapter cards (to avoid noises)



Long slab design and requirements

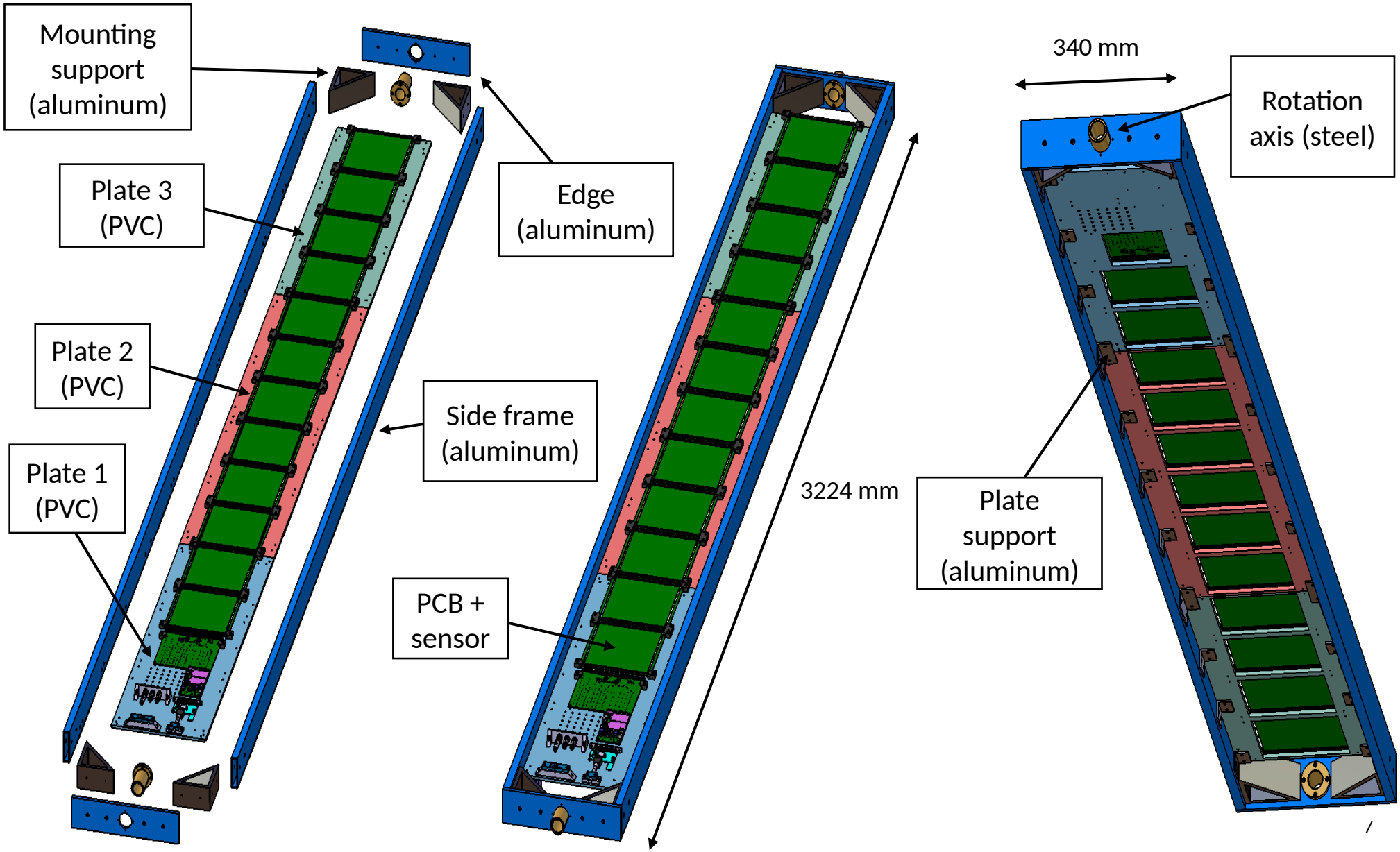
- Even small resistivity in power lines causes LV drops due to large currents. For simplicity, PCBs will be powered not sequentially but by independent cables of equal lengths (two cables for LV and ground).

- “Baby” sensors will be glued to HV line in such a way that every PCB could be disconnected from the chain afterwards (for flexibility).

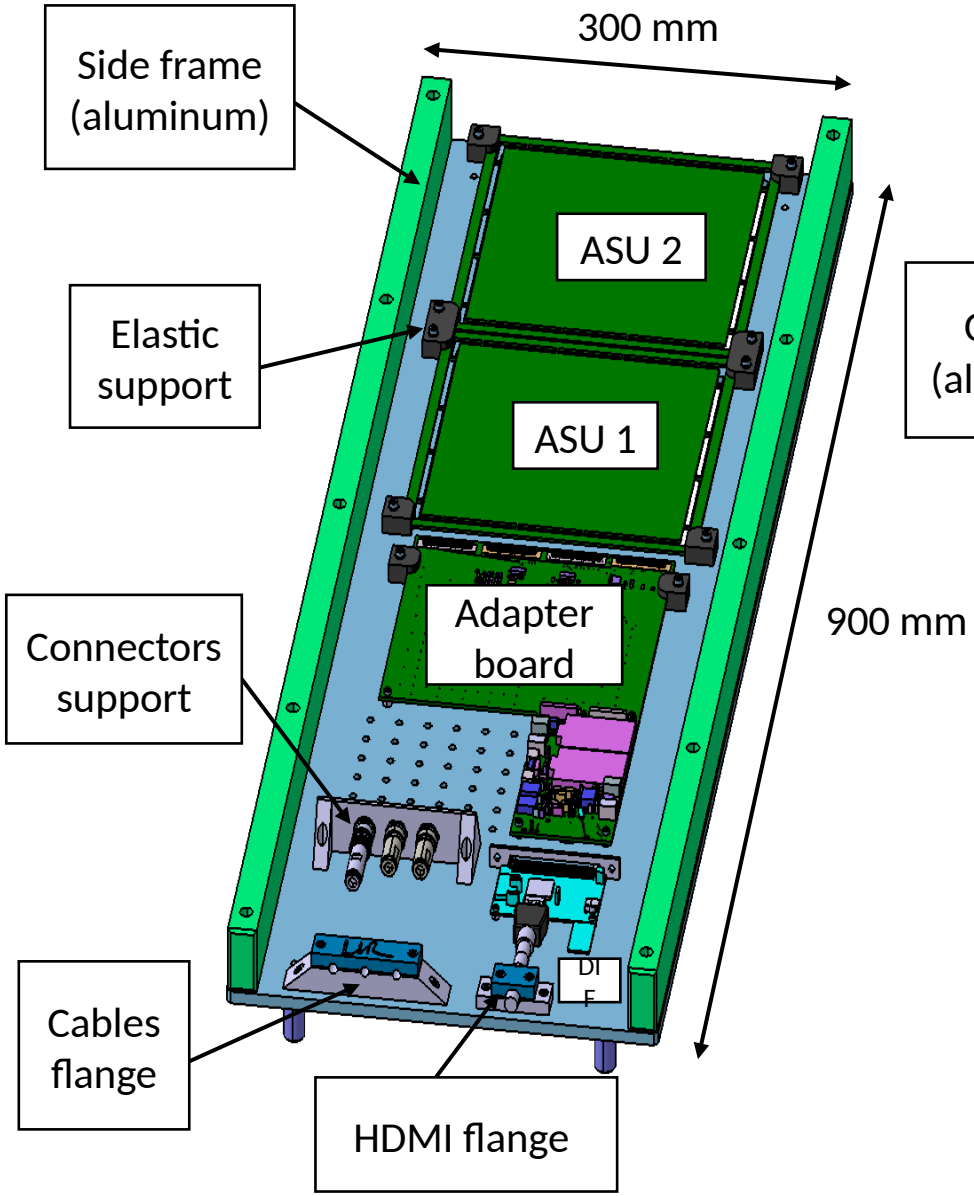
- After adding each PCB: fast tests with radioactive source
  $^{90}_{38}$Sr (e-, 0.546 MeV → $^{90}_{39}$Y, e- 2.28 MeV) and / or
  $^{137}_{55}$Cs (e- 0..512 MeV → $^{137m}_{56}$Ba, gamma, 0.662, 0.032 MeV).

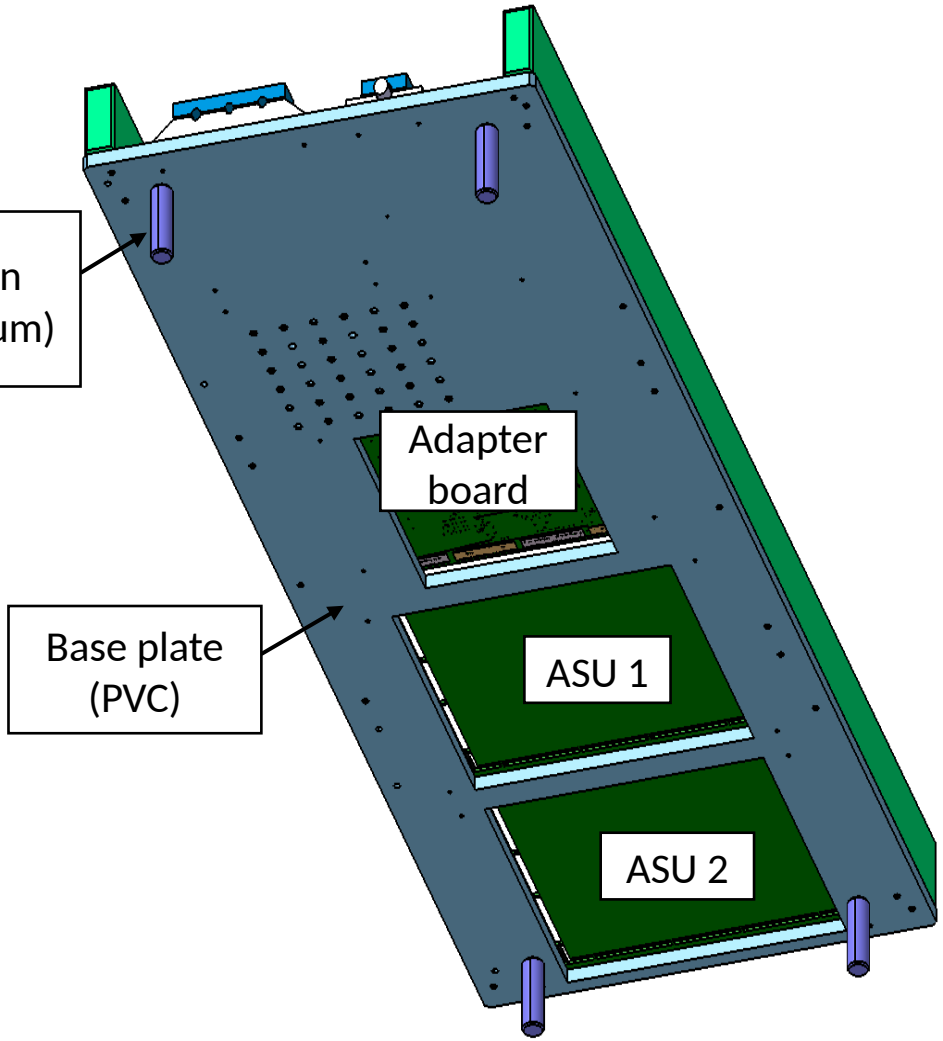
Production of long slab elements is finishing in LLR

Long slab support is made of 3 pieces and can hold 2, 8 or 12 PCBs

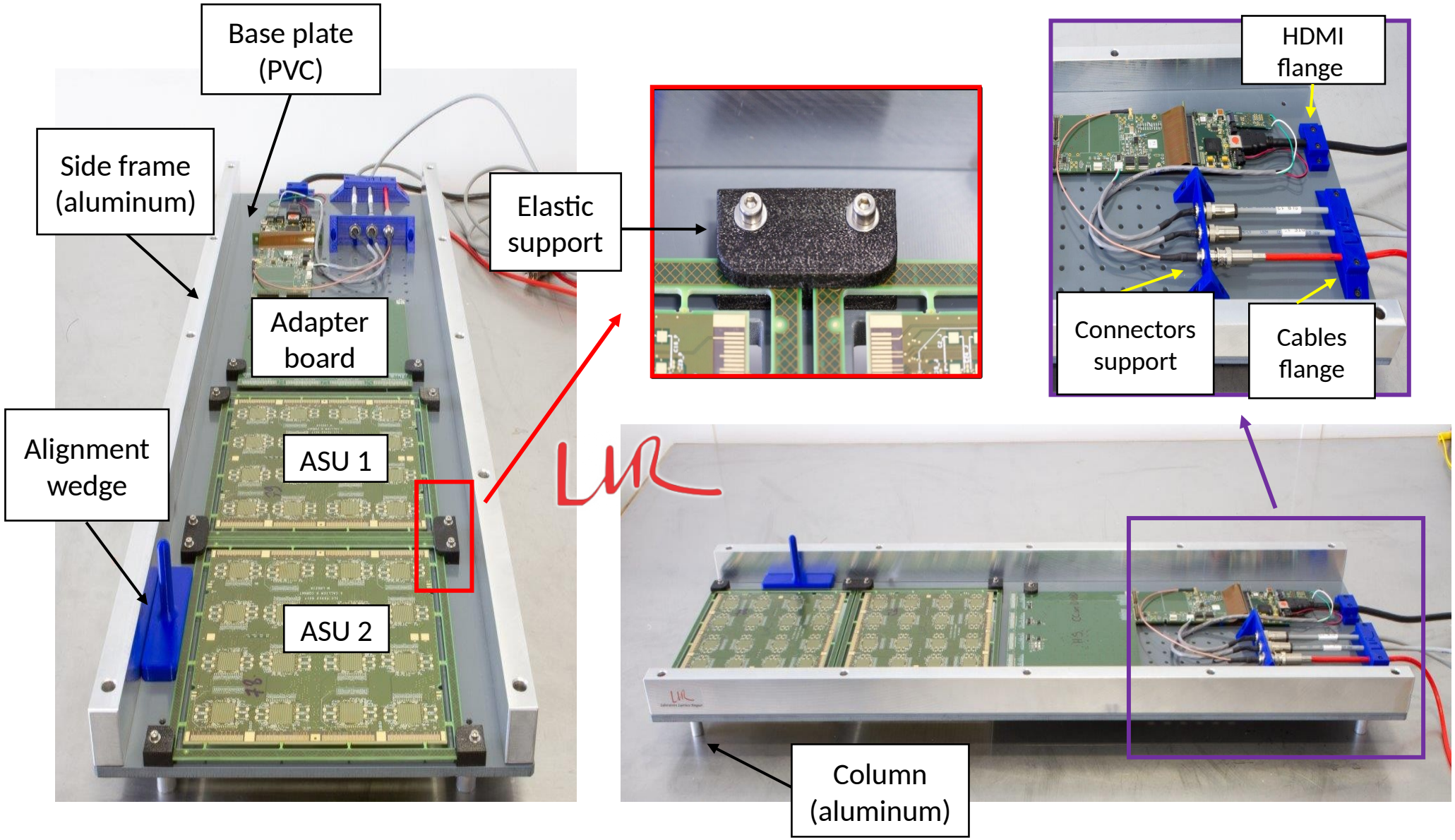


The end part serving 2 first PCBs is ready





The first part with 2 first PCBs assembled

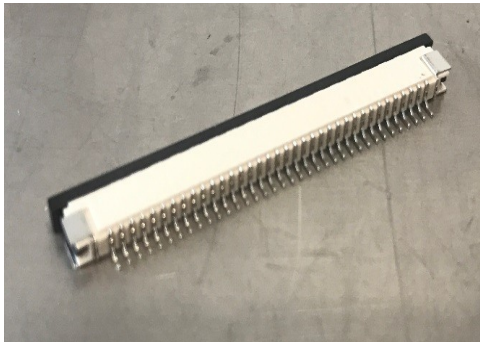


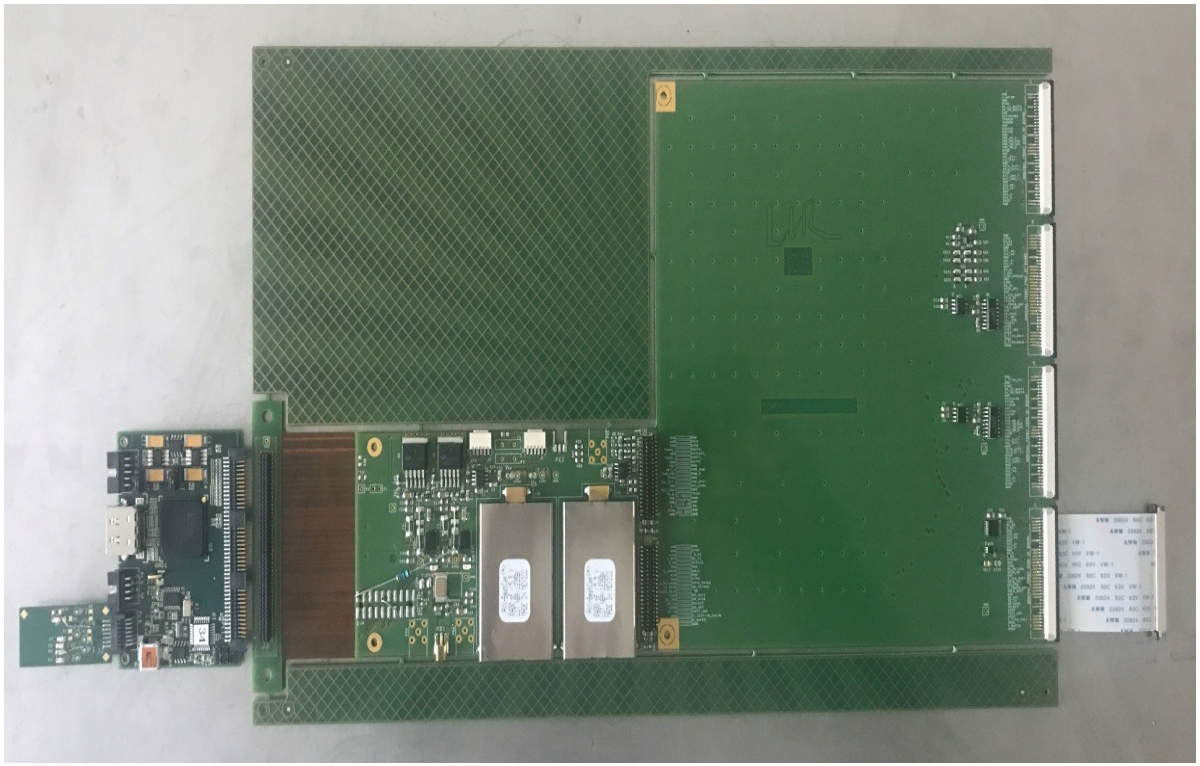
Elastic PCB support (which absorbs bending of base plate) is printed on 3D printer.
Next steps: check baby sensors, glue them, interconnect PCBs

Interconnections between PCBs

To connect / disconnecting individual PCBs, interconnections between them (144 pins on each side) will be realized with Flat Flexible Cable (FFC) connectors (36 pins, 1 mm pitch).

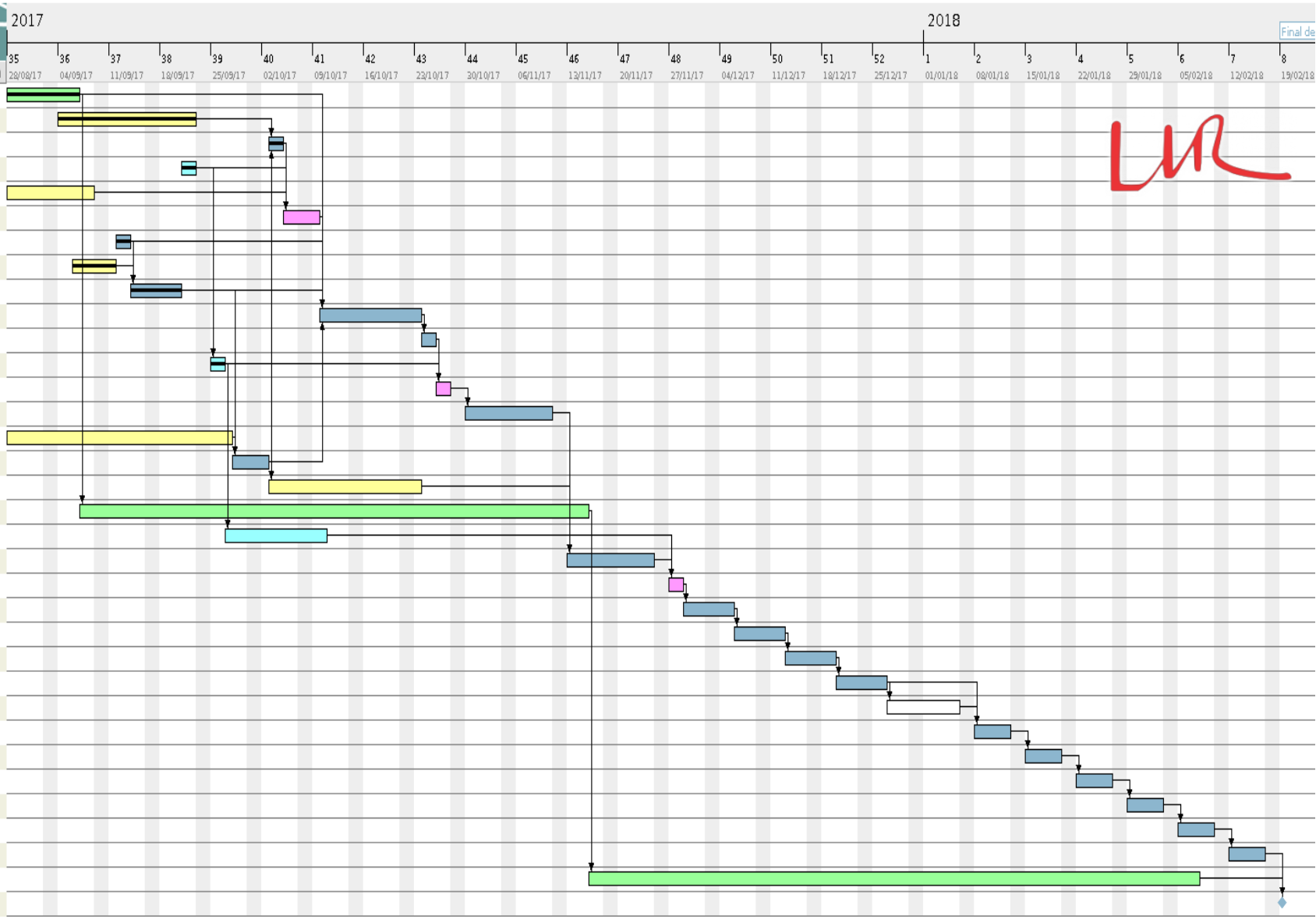
In ILD: soldering (Kapton cable) for reliability.





Long slab production timeline

Nom	Date d...	Date de fin
Meca part1 construction	28/08/17	06/09/17
Cabling 2 FEV	04/09/17	22/09/17
Testing FEV1 on singlebench	03/10/17	04/10/17
Testing BW1	21/09/17	22/09/17
Buying Glue	28/08/17	08/09/17
Gluing BW1	05/10/17	09/10/17
Preparing SMB	12/09/17	13/09/17
Buying connectors	06/09/17	11/09/17
Training on connectors	14/09/17	20/09/17
Mounting and testing ASU1	10/10/17	23/10/17
Testing FEV2 on singlebench	24/10/17	25/10/17
Testing BW2	25/09/17	26/09/17
Gluing BW2	26/10/17	27/10/17
Mounting and testing ASU2	30/10/17	10/11/17
Packaging new skirocs	28/08/17	27/09/17
Testing new skirocs	28/09/17	02/10/17
Cabling 10 FEV	03/10/17	23/10/17
Meca part2 construction	07/09/17	15/11/17
Testing 10 BW	27/09/17	10/10/17
Testing 10 FEV	13/11/17	24/11/17
Gluing 10 BW	27/11/17	28/11/17
Mounting and testing ASU3	29/11/17	05/12/17
Mounting and testing ASU4	06/12/17	12/12/17
Mounting and testing ASU5	13/12/17	19/12/17
Mounting and testing ASU6	20/12/17	26/12/17
Christmas holidays	27/12/17	05/01/18
Mounting and testing ASU7	08/01/18	12/01/18
Mounting and testing ASU8	15/01/18	19/01/18
Mounting and testing ASU9	22/01/18	26/01/18
Mounting and testing ASU10	29/01/18	02/02/18
Mounting and testing ASU11	05/02/18	09/02/18
Mounting and testing ASU12	12/02/18	16/02/18
Meca support and covers	16/11/17	07/02/18
Final delivering	19/02/18	19/02/18



New long slab prototype is due in mid-February'18

Conclusions

(1) 7 18x18 cm^2 SiW ECAL detector elements ("short slabs") have been built and successfully tested with beams and cosmics. They have ILD channel density (1024 channels).

(2) In ILD of nominal size up to 8 (12) in barrel (in endcaps) such detector elements will be connected together in a "long slab", readout from one end.

In parallel to "short slab" R&D, we have started construction of "long slab" prototype. It should verify the readout performance of up to 8-12 detector elements connected sequentially.

- The prototype has been designed.
- The emphasis is on electronics, while ILD mechanical constraints on slab dimensions, dead zones etc. are for a moment left out.
- For the prototype we foresee the possibility to connect / disconnect individual PCBs, so there will be connectors between them (in ILD for reliability interconnections are soldered).
- Production of mechanical parts of the prototype is finishing.
- One "baby sensor" with 4x4 pixels will be glued on each PCB. Such detector elements ("baby sensor" + PCB) will be added one by one to "long slab" until the end (max 12) or until there will be a problem with the readout.
- "Long slab" is due in mid-February next year.