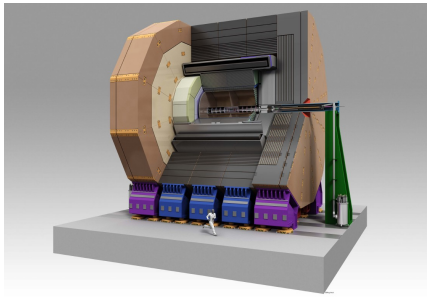
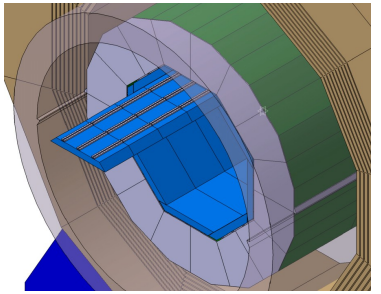
ILC_2: Silicon-Tungsten (SiW) ILD ECAL
LLR - ICEPP, Tokyo Uni - RCAPP, Kyushu Uni collaboration

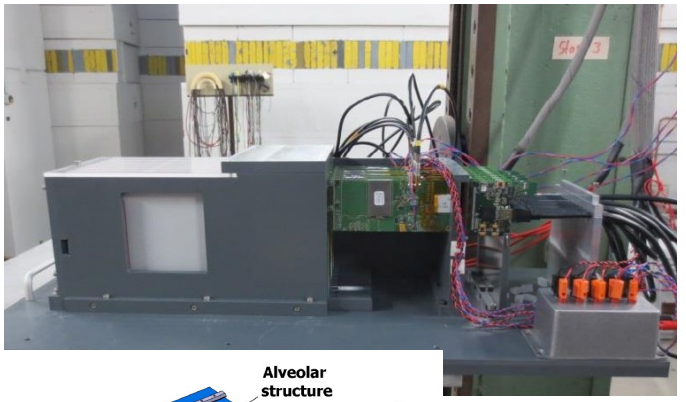
TYL/FJPPL-FKPPL workshop, 26 May 2014
Vladislav BALAGURA (LLR)



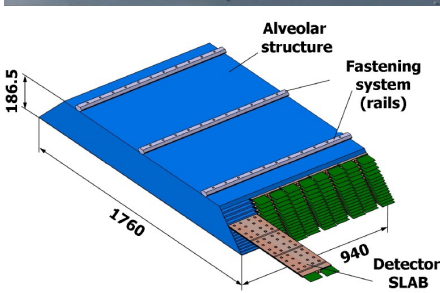
SiW ILD ECAL for PFA (25% jet energy in ECAL, 10% in HCAL):



- Detailed Baseline Design (DBD) in 2013:
  140 t W, 2600 m2 Si, 100 M channels
- Best granularity and compactness
- Simple calibration, low systematics, stable in time, robust
- 10% of bad pixels is affordable (not tracker device), lower price



- Physical prototype (2005-2011) – PFA proof
- Technological prototype (2012-present):
  charge injection + cosmic + laser calibration, 4 tests @DESY 1-5 GeV e-beam
- 2015: test 3/5 x ILD barrel module @CERN



SiW ECAL collaboration

- MoU btw CNRS and Kyushu for sensor R&D in Hamamatsu.
- MoU btw LLR and Kyushu on SiW R&D. LLR (leader of SiW project) has sent to Kyushu in May fully functional prototype, transferred technological knowledge.
- 2 ILD ECAL + 2 CALICE meetings / year,
  remote meetings / 1-2 weeks
- Recent interest to SiW technology for CMS endcap Phase 2 upgrade (HGCAL) and for future circular colliders (TLEP, CEPC)
- ILD ECAL: ANR grant: 330 kEUR / 45 months, IN2P3: 50 kEUR / year

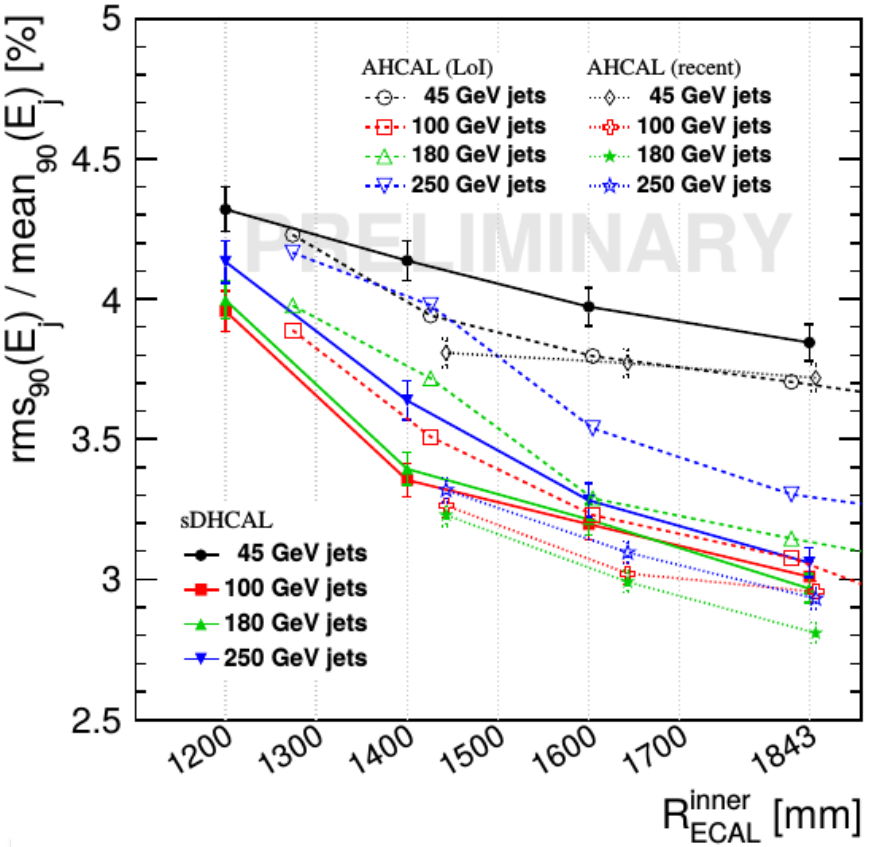
- FJPPL support last year: 2.5 kEUR. Application has been submitted for continuation this year.
- We collaborate with Tokyo and Kyushu Uni and Hamamatsu HPK. Annual visits to Japan of 3-4 people, eg.
  - in 2013 to LCWS workshop joined with ILD ECAL meeting,
  - in 2012 in Tokyo Uni and Hamamatsu.
  2.5 kEUR FJPPL were spent to pay one visit in 2013 (9 days + ticket) and LCWS workshop fee.
- After negotiations with Hamamatsu, in 2013 they reduced Si sensor price (45% of total ECAL price) to 2.5 EUR/cm2 under condition that they produce all Si.
- Currently, no contacts with KEK. Highly interested if Japanese Universities (Tokyo, Kyushu) might participate in FJPPL. Currently, “unilateral” program with only French TYL/FJPPL budget.

Present R&D

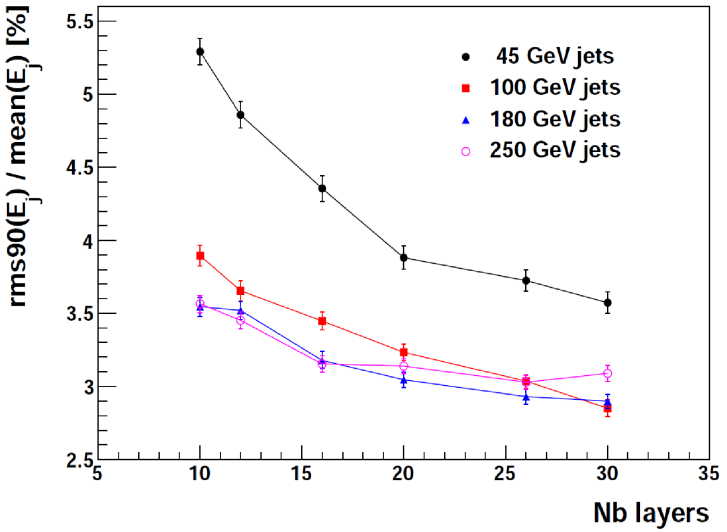
1. Optimization and analysis (Tokyo, LLR)
2. Silicon sensor (Kyushu, LLR)
3. DAQ electronics (Kyushu, LLR)
4. Mechanics (LLR)
5. Software development (Kyushu, Tokyo, LLR)

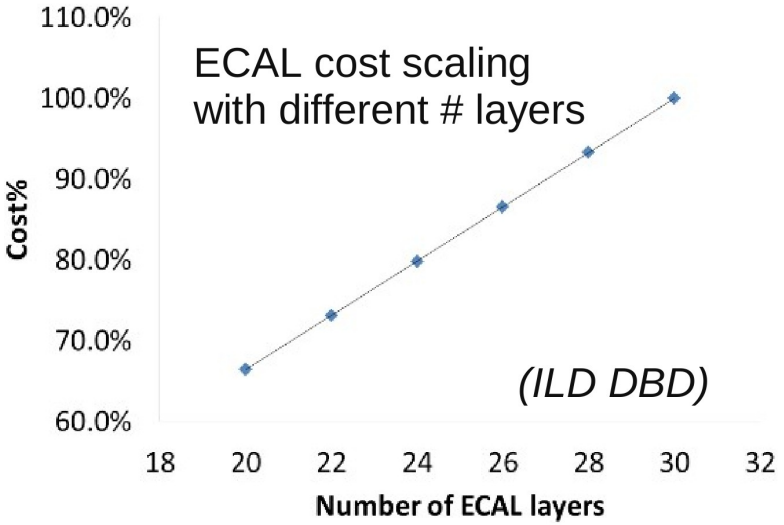
1. Optimization: last year results (LLR)

Jet energy resolution (JER) vs ILD radius (LLR+Cambridge). Cost scales as R^2.
ILD reconsiders ECAL baseline R:
1.843 → 1.5 m (1.5^{-1} lower price)



JER (left), cost (right) vs N ECAL layers (LLR)
→ 19-25 layers are sufficient (in ILD DBD: 29)

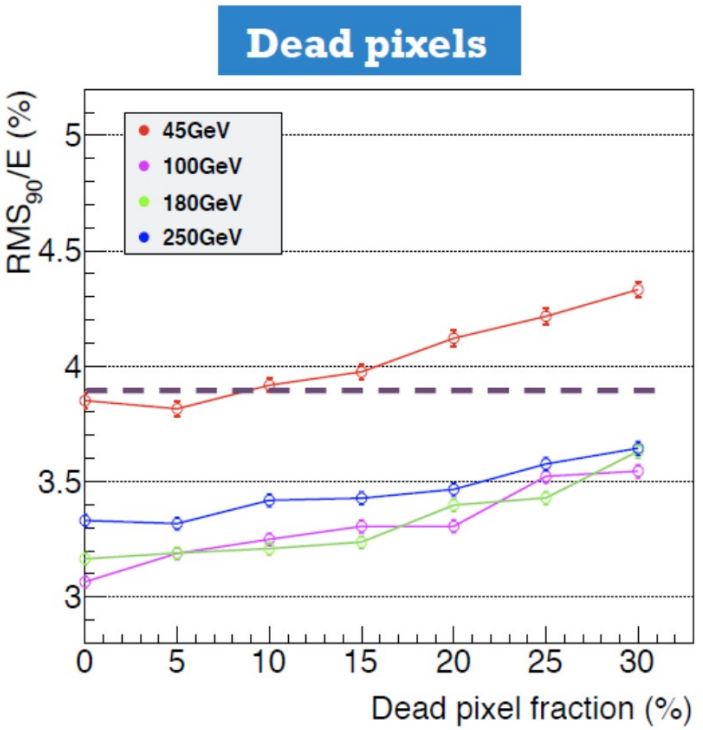


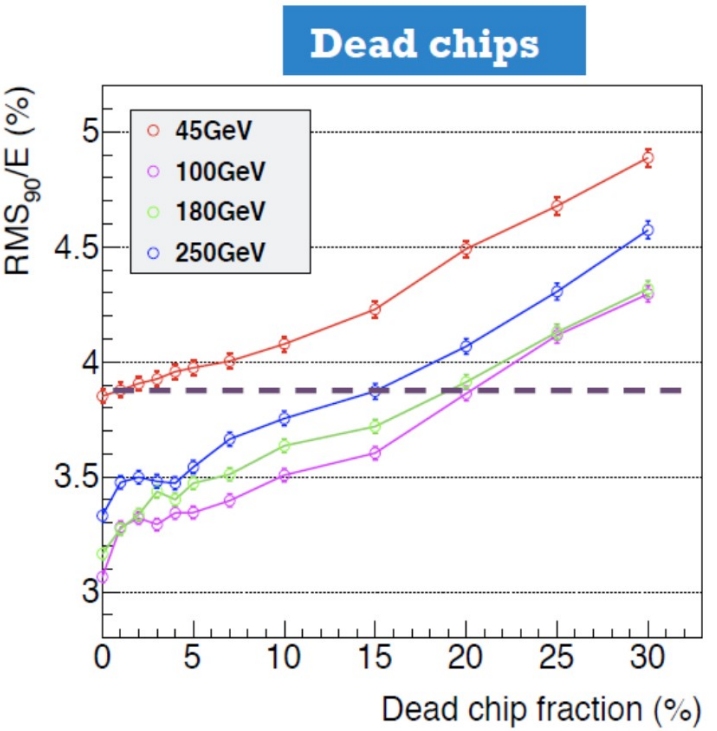


1. Optimization: last year results (Tokyo, LLR)

JER vs fraction of random dead pixels or chips (Tokyo)

10% of dead pixels are affordable. Relaxing Si quality constraints helped to reduce HPK price

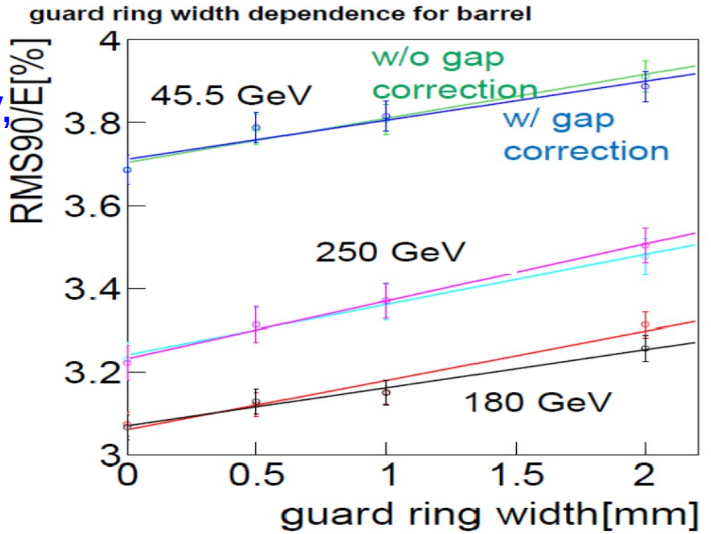


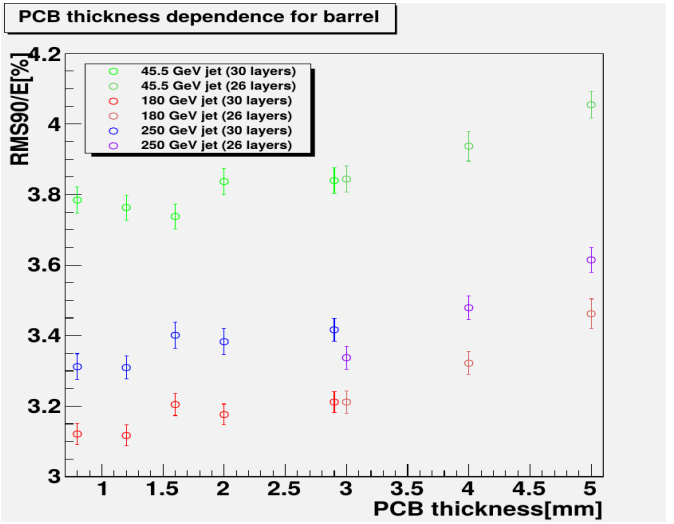


JER vs dead area due to sensor guard ring at periphery, vs PCB thickness.

Also, effects of random noise, miscalibration, xtalk (Tokyo)

Study of ILD front end chip occupancy to constrain chip memory (LLR)

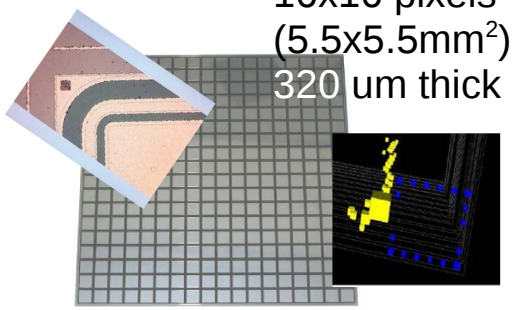




1. Optimization and analysis: plans for this year

- Continue ILD dimension optimization
- Study PFA performance with MC and available physical prototype data
- Improve and make more realistic ECAL description in ILD MC
  (for both Si and scintillator options)
- Current technological prototype: continue data analysis (cosmics, laser, charge injection, cross-talk measurements, beam tests in 2013) and provide fast feedback for technology optimization

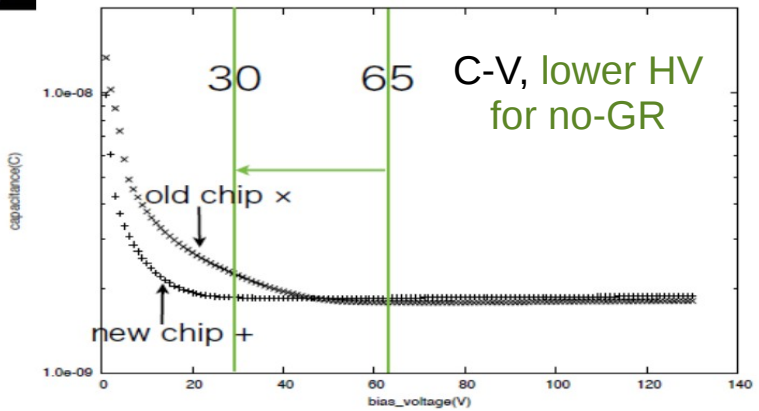
2. Si sensor (Kyushu, LLR)



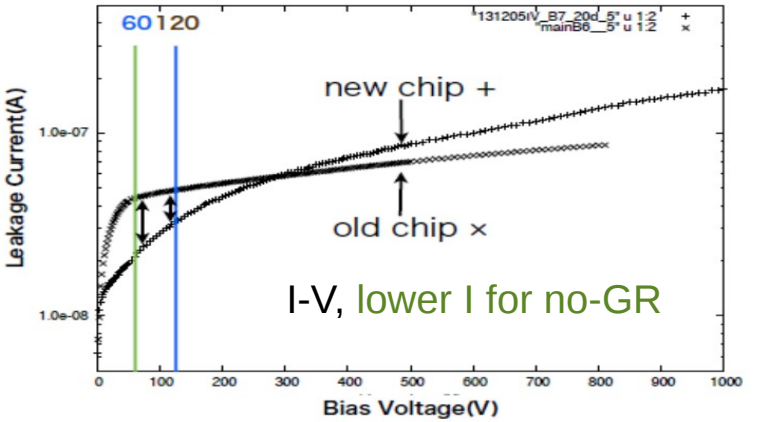
16x16 pixels
(5.5x5.5mm^2),
320 um thick

Si sensor

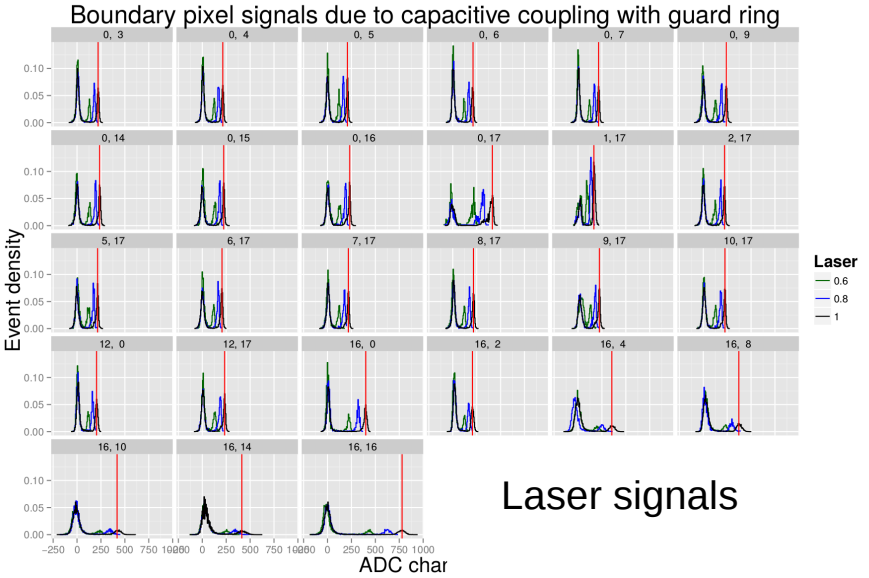
1. Tests of different Hamamatsu Si designs (0,1,2,4 guard rings): C-V, I-V curves (Kyushu-LLR). Recently: promising no-GR design
Plan: test more sensors



The leakage current at 120 V is 31nA (old : 48nA), at 60 V is 21nA.



2. Laser tests (LLR, Kyushu): xtalk via 2-GR: 0.4-0.5% per outer pixel side.
New: baby chips w/meshed electrodes for injection inside pixels (Kyushu)
Plan: test them and other sensors w/various GR, use new improved DAQ electronics

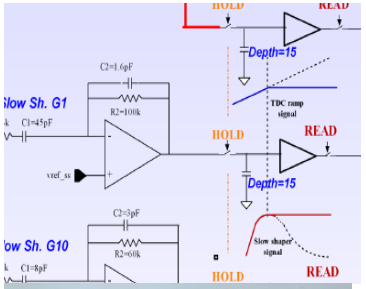


Laser signals

3. Plan: Irradiation tests (γ,n) (Kyushu, Tokyo)

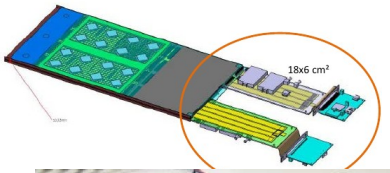
3. DAQ electronics (Kyushu, LLR)

1. FE chip SKIROC2 developed by Omega (Ecole polytechnique)
   Power pulsing successfully tested in 2013
   New production with bug fixes in fall 2014
   New BGA packaging, first batch produced (LLR)



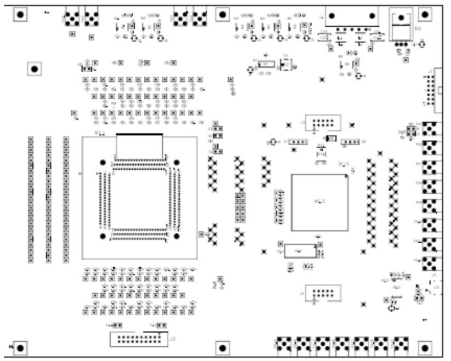
2. New PCB design + industrial production, detector size and channel density as in ILD (LLR):

a) PCB with sensors and FE chips (FEV9-10):
QFP->BGA chip packaging, x4 channels, many improvements (summer 2014)



b) clock + voltage distribution (SMB4), serves 1 -> 8 FEVs
First production started

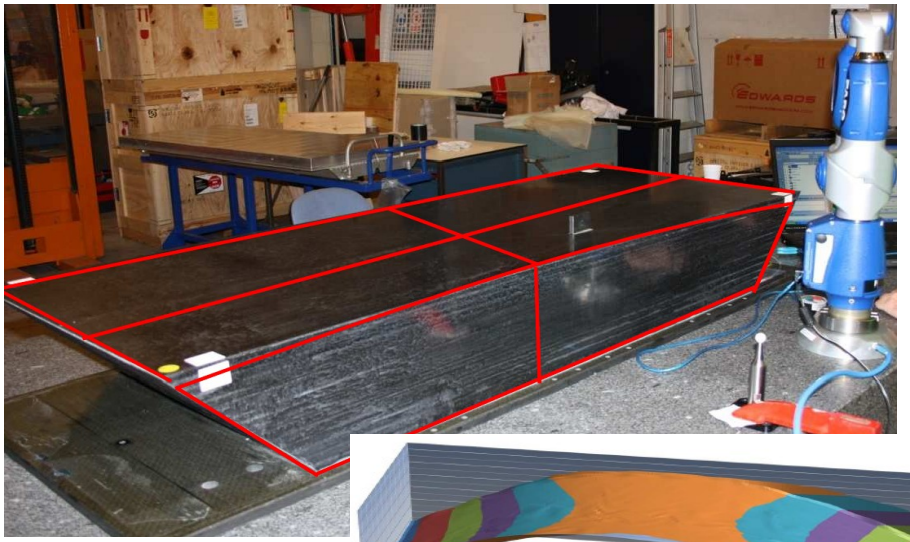
c) Gigabit Data Concentrator Card (GDCC) sending data to PC
Working version in spring'13, continuously improved.



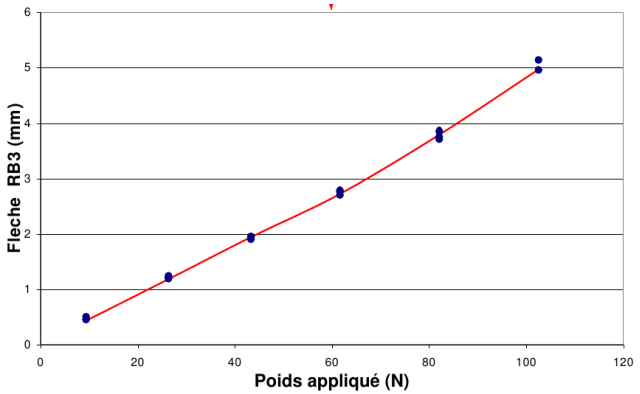
3. Omega SKIROC test board (Kyushu) with analog+digi outputs, QFP->BGA packaging, possibility to connect DIF or old FPGA (summer 2014)

4. Mechanics (LLR)

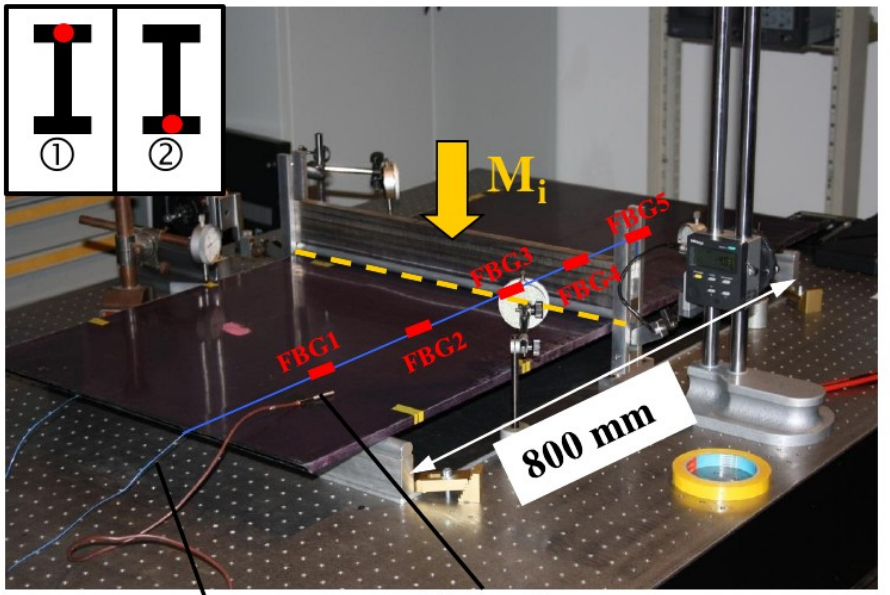
Big prototype with 15 alveoli has been built:
3/5 of one ILD barrel module, ~600 kg.
Separately built layers “cooked” together.
Simulated mechanically & thermally.



Another prototype with molded Bragg grating fibers, 2013. Detailed verification of simulated elongations under loads (by monitoring frequency shift of light reflected by fiber).



Vérification des paramètres du modèle en comparant la flèche FBG3 mesurée et simulée



Plan: design and produce slabs with sensors and new electronics,
to be placed inside alveoli.

5. Software development (Kyushu, LLR)

- DAQ software “CALICOES” (LLR)

  Routinely used from Jan'2013. Continuous improvement (also by Kyushu).

- Tools for online/offline data analysis, automasking, chip configuration (LLR)

  Developed in 2013, continuously improved

  For next year:

- Debugging tools (Kyushu, LLR)

- Adaptation to larger DAQ (Kyushu, Tokyo, LLR)

Conclusions

Plans:

1. Finalize optimization (geometry, Si sensor, GR, electronics)
2. Prepare beam test in CERN in 2015
   a) with new electronics (FEV10 / SMB4 / GDCC) and software
   b) larger production scale
3. Prepare for mass production
4. Widen the collaboration

Recent interest to Si ECAL technology from future circular colliders TLEP/CEPC and CMS endcap calorimetry Phase 2 upgrade project, HGCAL. Decision on HGCAL or shashlyk by end 2014.

Requested budget:
5 kEUR (2 travels to Japan for 10 days each), French side
0 from Japanese side, as no KEK participants.
(last year: 2.5 kEUR + 0)

We are very interested, if Japanese Universities (Tokyo, Kyushu) might participate in TYL/FJPPL program

We plan to prepare and sign PICS with Tokyo, Kyushu Uni in the future

KEK participants are very welcome