

AIDA

Advanced European Infrastructures for Detectors at Accelerators

Presentation

FCAL integration and alignment, LCWS 2013

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The Forward Calorimetry Integration in ILD.

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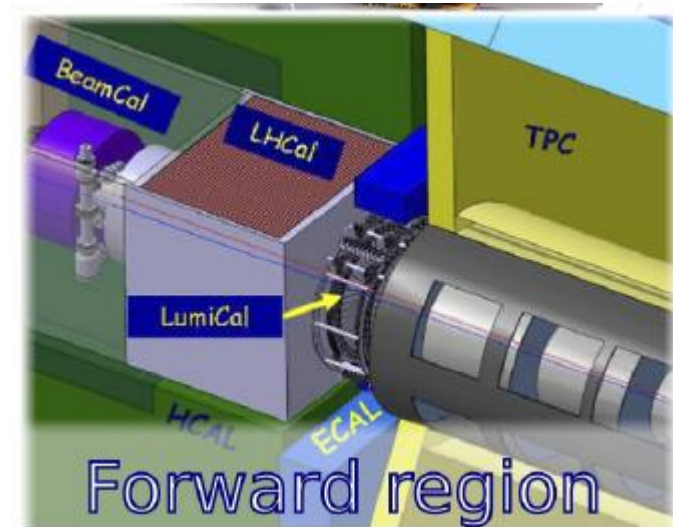
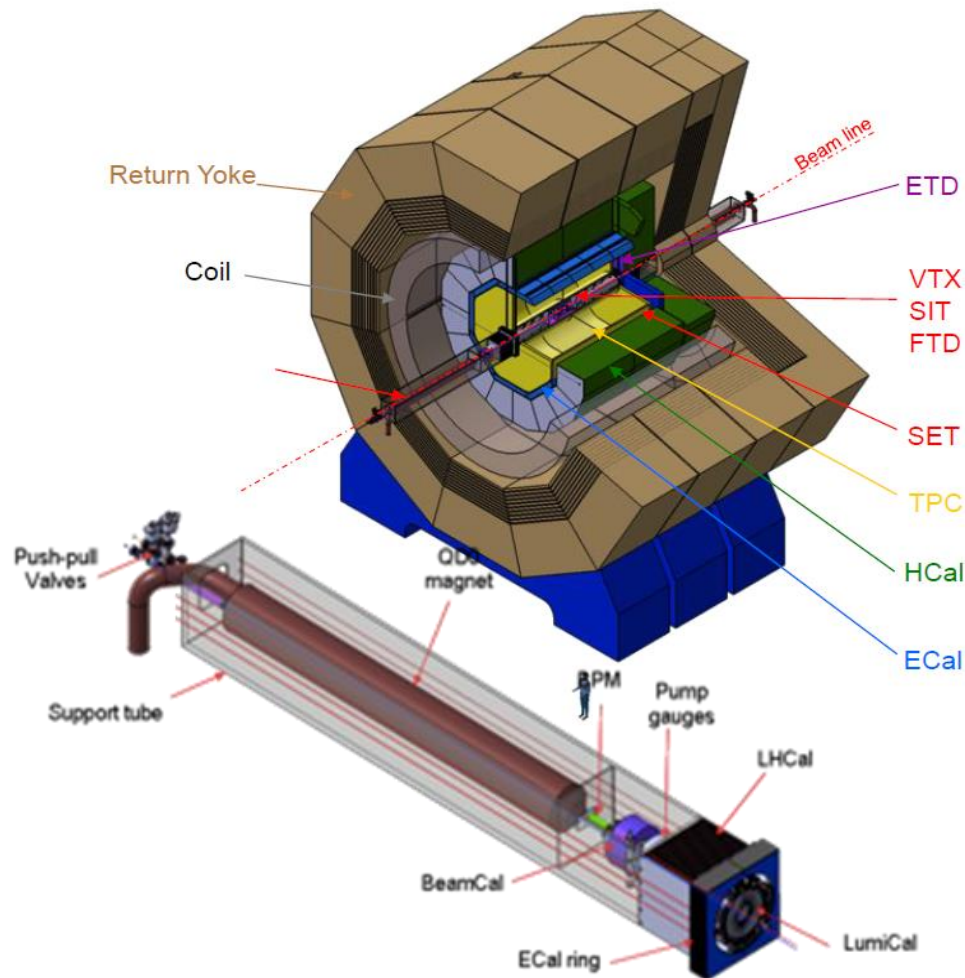
Challenges of Forward Region

LumiCal

precise luminosity measurement
(10^{-3} at 500 GeV @ ILC, 10^{-2} at 3 TeV @ CLIC)

BeamCal (and Pair Monitor)

- low polar angle electron tagging
- beam tuning and beam diagnostics
- fast feedback using special futures of the ASICs

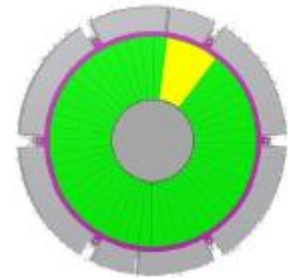
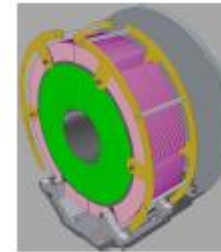


Challenges:

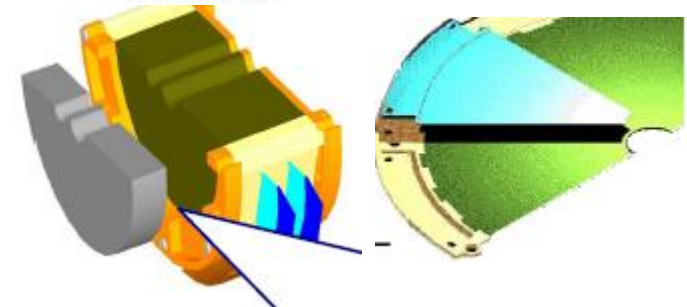
- high precision (LumiCal),
- radiation hardness (BeamCal),
- very fast read-out (both)

Detectors design

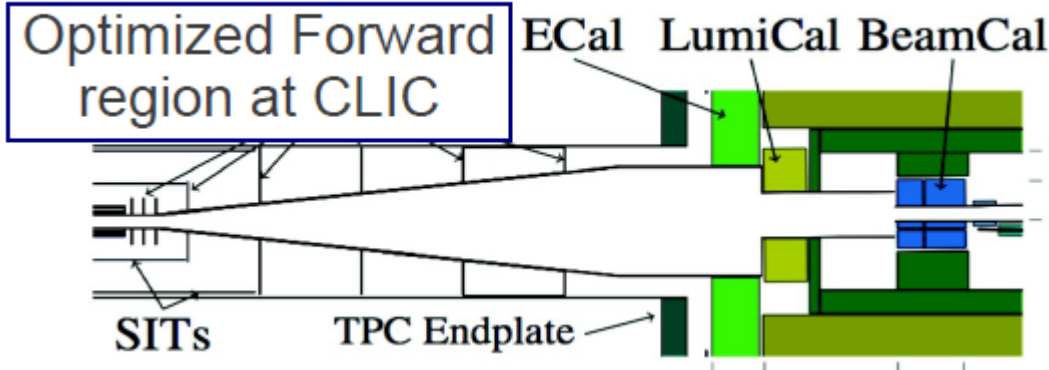
	Unit	ILC	CLIC_ILD
LumiCal			
geometrical acceptance	mrad	31-77	38-110
fiducial acceptance	mrad	41-67	44-80
z(start)		2450	2654
number of layers(W+Si)		30	40
number of channels		~180k	~250k
BeamCal			
geometrical acceptance	mm	5-40	10-40
z(start)		3600	3281
number of layers(W+Sensor)	mm	30	40
graphite layer thickness		100	100
number of channels		~62k	~84k



Mechanical structure of the LumiCal



Pair Monitor

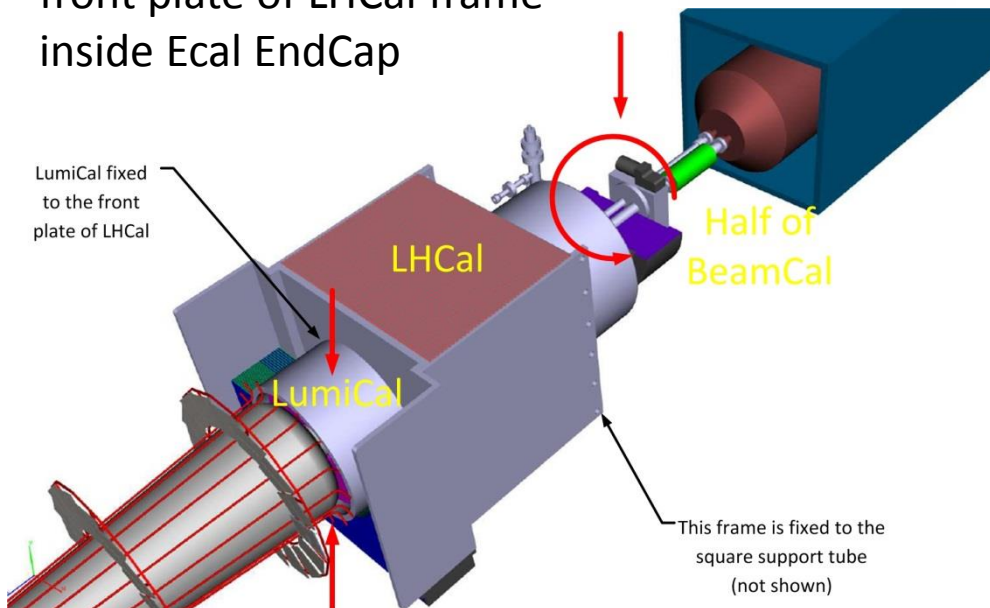
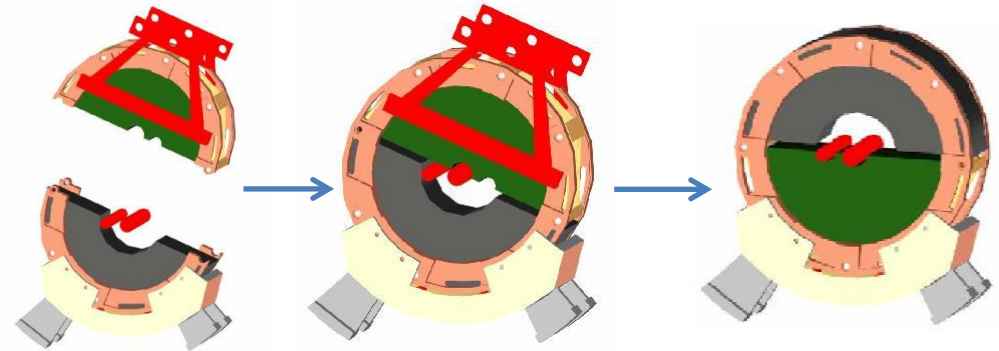


- detector radius 10cm
- pixel size 400x400 μm^2
- total number of pixels ~ 200k

Integration and montage in ILD

LumiCal

Half barrels will be inserted from top and bottom and fixed to the front plate of LHCAL frame inside Ecal EndCap

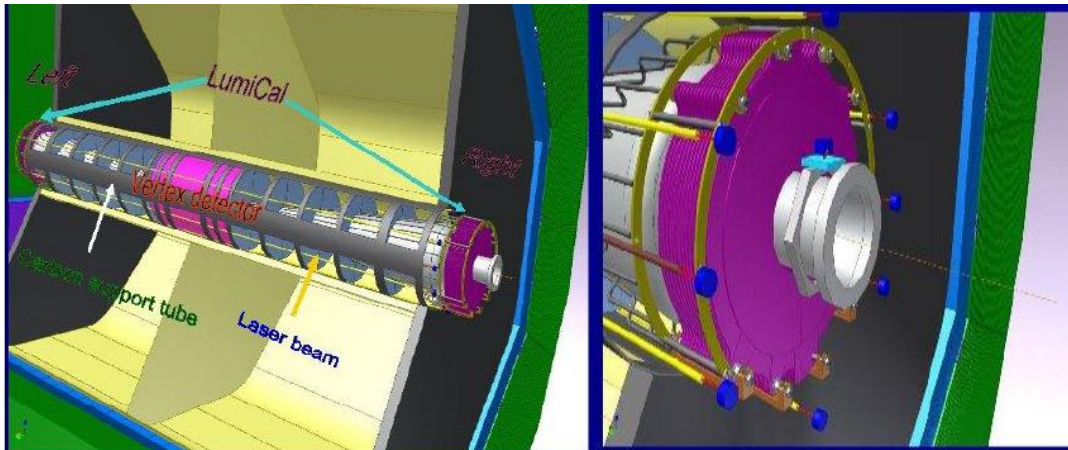


BeamCal

Half barrels will be inserted from top. The bottom part will be rotated 180 degrees under the in- and out-going beam pipes.

Precision LumiCal alignment

High accuracy in luminosity measurements at ILC/CLIC ($\Delta L/L \sim 10^{-3}/10^{-2}$) require precisely measurement of the luminosity detector displacements: less than 500 μm in X,Y directions , 1 mm in Z direction and a few microns for internal silicon sensor layers

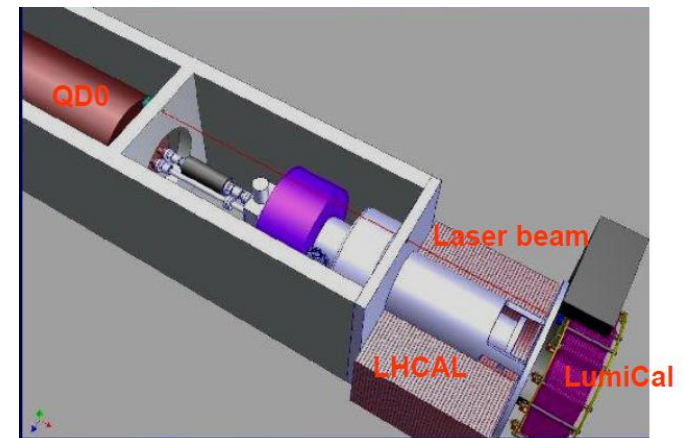


The measurements of absolute distance between Left and Right LumiCal calorimeters

The measurements of the relative distances to QD0 in X,Y and Z directions

Good reference points for position measurement of LumiCal can be:

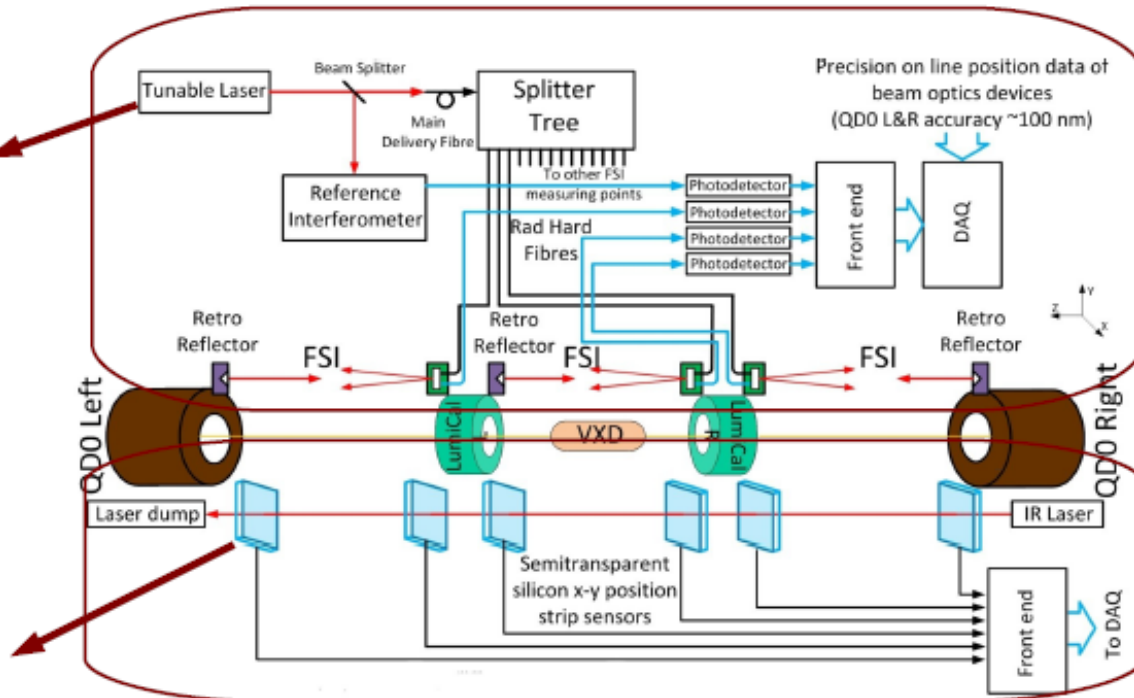
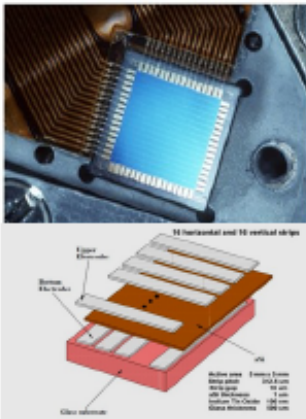
- QD0 magnet
- Beam Position Monitors
- also beam pipe



Design of LAS system

The proposed laser alignment system for LumiCal combines two components:

- infra-red laser beam and semi-transparent position sensitive detectors (PSDs) - **already available**
- tunable laser(s) working within Frequency Scanning Interferometry (FSI) system - **in preparation**

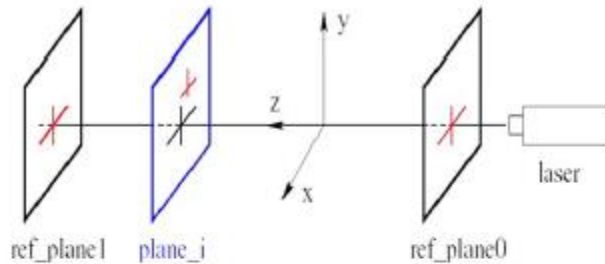


FSI – using tunable lasers will measure the absolute distance between LumiCal calorimeters by measurement of interferometer optical path differences (counting the fringes)

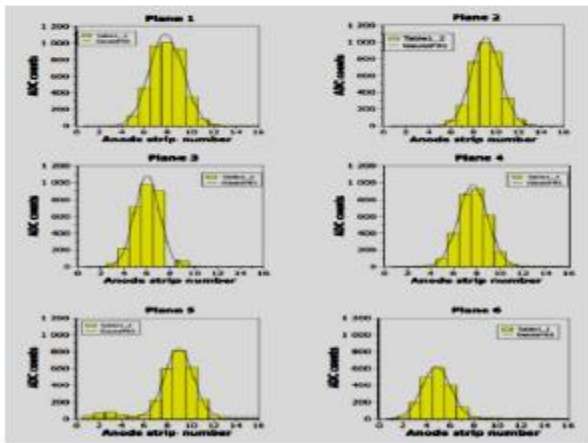
Semi-transparent sensors : LumiCal displacements of the internal Si layers and detectors relative positions

Semi-transparent sensors PSD

Laboratory setup : 6 PSD sensors

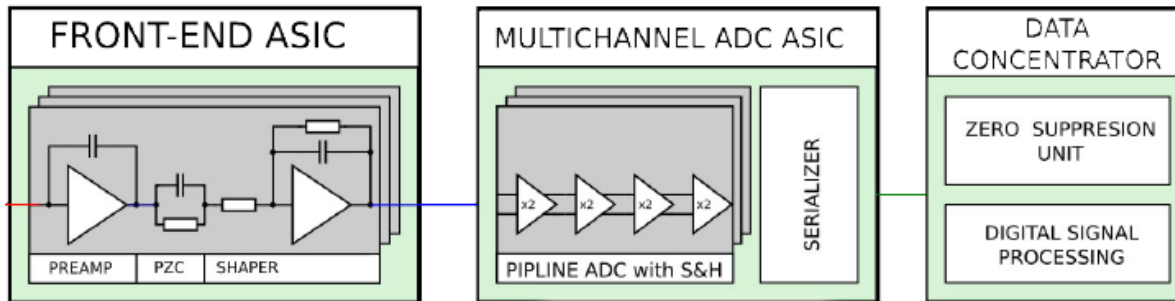


Laser beam-profile signals from anode of sensors measured along beam line



LAB prototype system with optical movable 2D table. It allows studies of sensor behaviour, laser beam and calculation of displacements. Expected accuracy: few microns

Power dissipation of LumiCal & BeamCal readout



8 channel Front-End ASIC

- Preamp. + PZC + CR-RC
- $T_{\text{peak}} \approx 60 \text{ ns}$
- C_{det} up to 100pF
- Switched gain: $\sim 2fC < Q_{\text{in}} < 10 \text{ pC}$
- Event rate up to 3 MHz

8 channel 10-bit ADC ASIC

- 1.5 bit pipeline architecture
- Digital serializer
- $F_{\text{max}} 25 \text{ Ms/s}$ (9.7 ENOB)
- Power: $\sim 1.2 \text{ mW/chan/MHz}$
- Power pulsing embedded

Power dissipation

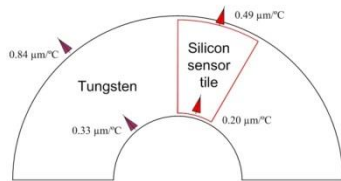
- Front end electronics will be the major source of heat in the LumiCal.
- Thanks to the power cycling during brakes (199 ms) between trains (5 Hz, 1 ms) the dissipated power in one LumiCal will be around 30 W.
- We overestimate 60 W per detector which gives $\sim 2 \text{ W}$ per sensor plane.

Power consumption

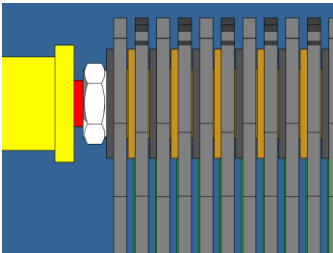
- At 40MS/s $\sim 1 \text{ mW}$
- Power scaling $\sim 25 \text{ uW/channel/MHz}$
- In AMS0.35um it was 1 mW/channel/MHz
- With power pulsing (1% duty cycle)
 $\sim 0.25 \text{ uW/channel/MHz}$

Thermal expansion

The most important parameter for luminosity measurement is the inner radius of LumiCal silicon sensors. This parameter should be known and stable with the accuracy better than $4 \mu\text{m}$.



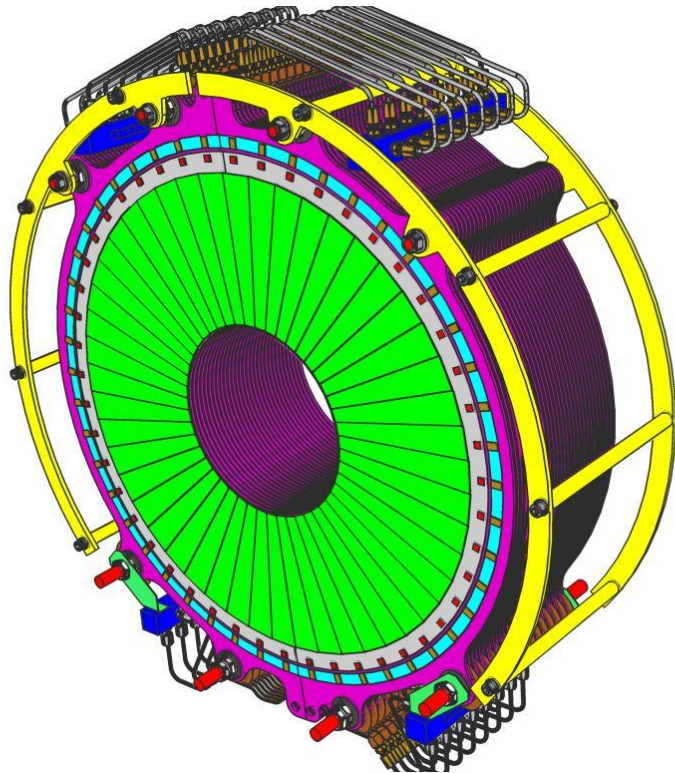
- The silicon sensors are glued on the tungsten absorber with Kapton E foil insulation. Tungsten has a small coefficient of thermal expansion α (CTE = $4.3 \times 10^{-6} \text{ K}$).
- The inner radius of LumiCal absorber (76 mm) will expand thermally by $0.33 \mu\text{m}/^\circ\text{C}$.
- The outer active radius (195.2 mm) will change by $+ 0.84 \mu\text{m}/^\circ\text{C}$.
- Silicon has coefficient of thermal expansion α ($2.5 \times 10^{-6} \text{ K}$) ~ 2 times smaller than tungsten. We can roughly estimate that **the inner radius of LumiCal will expand less than $0.5 \mu\text{m}/^\circ\text{C}$.**



MC simulations have proved that inaccuracy in distances among tungsten plates and silicon sensors along the LumiCal axis less than $50 \mu\text{m}$ has negligible influence to the luminosity measurement.

- The length of LumiCal is $\sim 135 \text{ mm}$ and will expand $+ 2.41 \mu\text{m}/^\circ\text{C}$.
- **This distances between two silicon sensors will change in z less than $0.1 \mu\text{m}/^\circ\text{C}$.**

LumiCal temperature stabilization



- It is foreseen to use the water as a temperature stabilization medium for the LumiCal.
- Thermal insulation of the LumiCal to prevent temperature changes is necessary.
- Assume the temperature change of ± 2 °C which seems to be a save estimation.
- The thermal expansion of LumiCal silicon sensors **inner radius will be smaller than $\sim 2 \mu\text{m}$ ($< 4 \mu\text{m}$)**.
- The water flow of ~ 0.5 l/min. per plane will take heat off with 0.1 °C temperature increase. The total water flow in one LumiCal will be less than ~ 5 l/min.

Cabling and services

LumiCal:

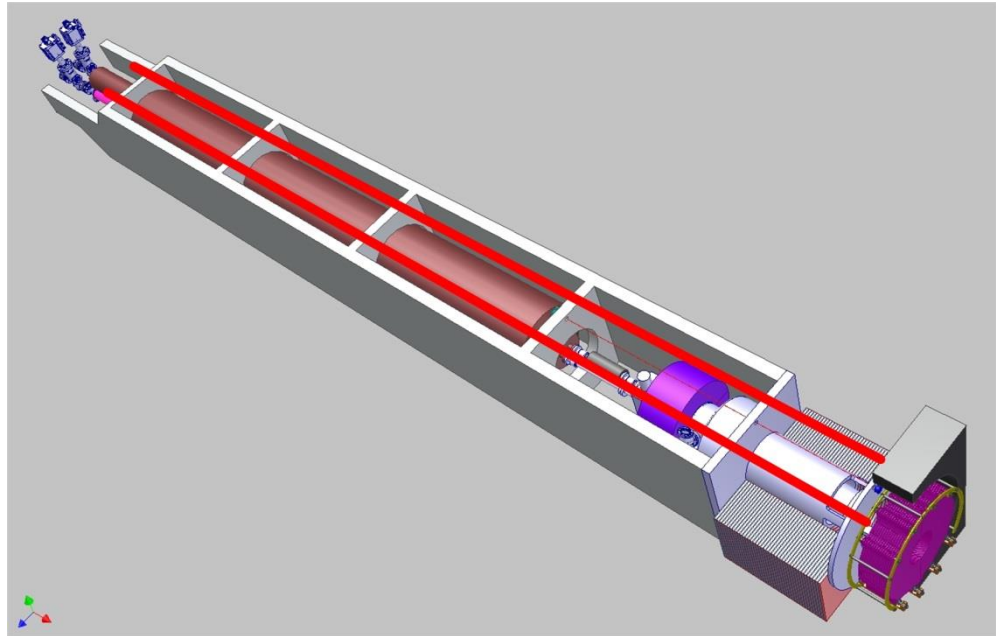
- Signal cables TP or FO $\sim 10 \text{ cm}^2$
- Power cables, ground $\sim 5 \text{ cm}^2$
- Water pipes $\sim 5 \text{ cm}^2$

Total $\sim 20 \text{ cm}^2$

BeamCal

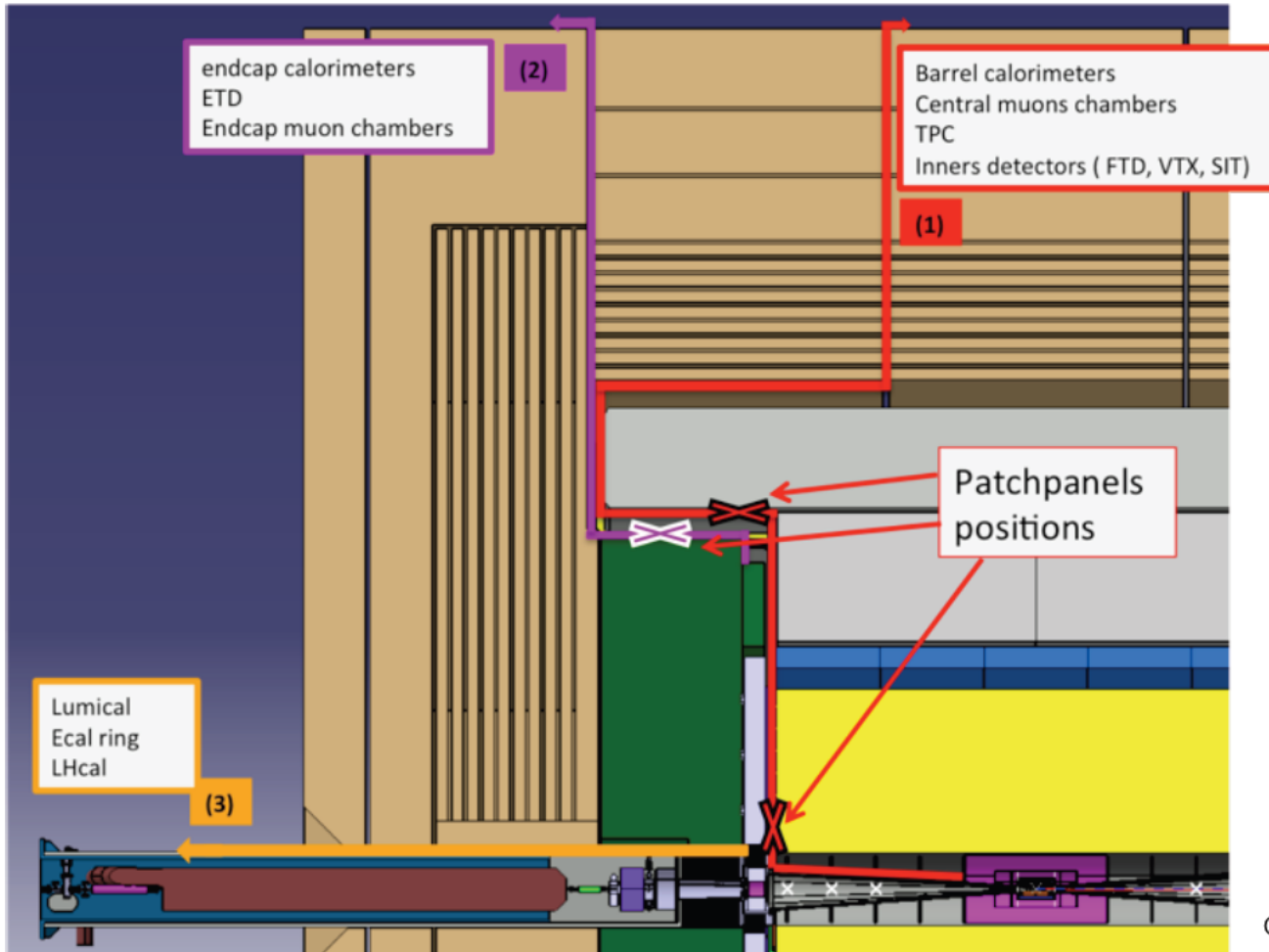
- Signal cables TP or FO $\sim 10 \text{ cm}^2$
- Power cables, ground $\sim 5 \text{ cm}^2$
- Water pipes $\sim 5 \text{ cm}^2$

Total $\sim 20 \text{ cm}^2$



All signal and power cables and water pipes from LumiCal and BeamCal should go inside the square support tube. The space for cables and services can be shared with other components (Vertex, FDET etc.).

Cabling and services



The cables from inner detectors and TPC should have connectors to allow to pull out of TPC. The LumiCal and BeamCal cables should have connectors and patch panels to allow dismantled half barrels.

C. Clerc

Next steps

- More effort on FCAL 3D model improvement (detailed mechanical design, implementation in ILD model).
- Build of FSI alignment system in laboratory similar to that used for SiD (ATLAS concept).
- Detailed cables, services path and connectors space desing.
- Design of LumiCal thermal insulation.
- Design od temperature stabilization concept.

FCAL Collaboration



Institutes involved:

AGH-UST, Cracow, Poland
 DESY, Zeuthen, Germany
 ISS, Bucharest, Romania
 NCPHEP, Minsk, Belarus
 Tel Aviv University, Tel Aviv, Israel
 University of Colorado, Boulder, USA

ANL, Argonne, USA
 IFIN-HH, Bucharest, Romania
 JINR, Dubna, Russia
 SLAC, Menlo Park, USA
 Tohoku University, Sendai, Japan
 Vinca, Belgrade, Serbia

CERN, Geneva, Switzerland
 INP PAN, Cracow, Poland
 LAL, Orsay, France
 Stanford University, Stanford, USA
 UC California, Santa Cruz, USA
 Pontificia Universidad Católica, Chile