Alignment of LumiCal - current state and possible future solution

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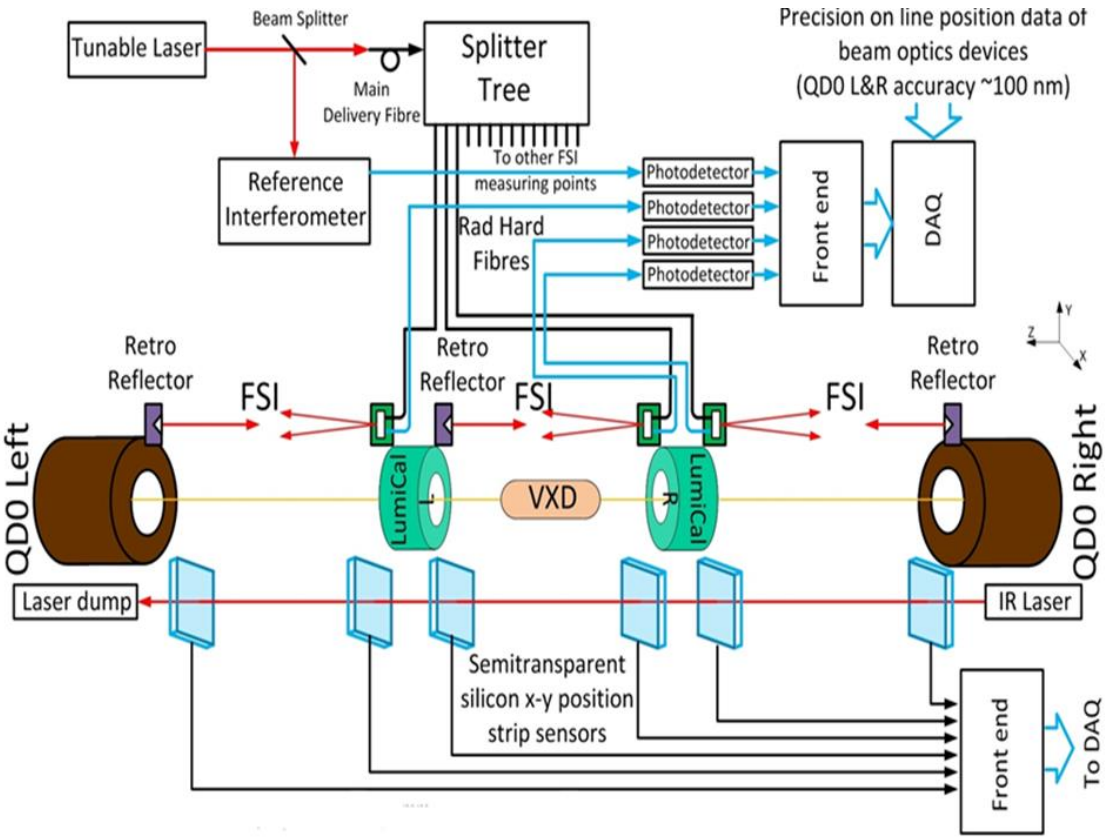
FCAL Hardware WG Meeting, 23.02.2015

The design of the alignment system

The required precision for LumiCal displacement measurements:
less than 400 μm in beam direction over the the distance 5 m,
600 μm for transversal ones and better than 50 um in the case of the Si internal layers monitoring

The laser alignment system (LAS) may include two components:

- **PSD**: Infra-red laser beam and semi-transparent, position sensitive detectorS
- **Frequency Scanning Interferometry**: tunable laser(s), beam splitters, optical isolator,Fabry-Perot interferometer, retroreflectors, fibers, collimators, photodetectors, mirrors, lenses

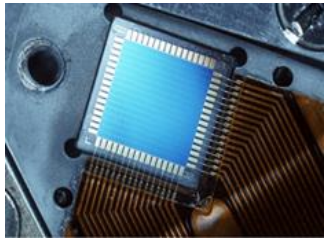


FSI - the absolute distance measurements between two parts of LumiCal detector.
A precision measurement - on the level of few micrometers

PSD - the measurements of the relative distances (relative to QD0 e.g.) and displacements of the internal Si layers of LumiCal. Such system is able to measure the displacement to precision better than 100 μm.

Laboratory demonstration components

PSD

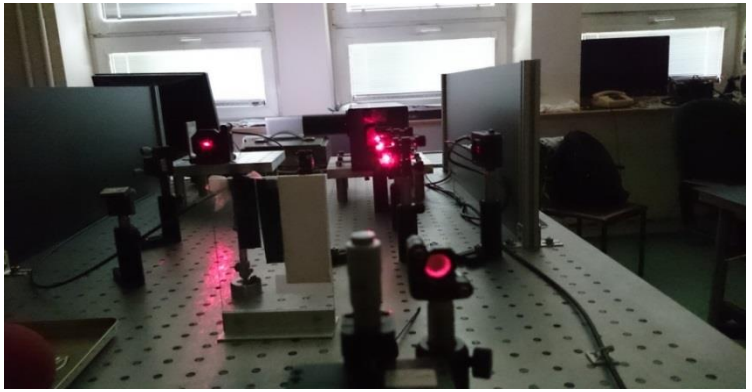


Semi-transparent sensor:
16 strips in the direction
of X and Y axis

The laboratory prototype
with 6 selected sensors

The preliminary results:
the displacement measurement
of the tested elements was measured with precision
at the level of 20 μm

FSI



A typical FSI (red)
and F-B (white) signals.
as seen of the screen
of the DAQ system

Measured signals
in 1 sec window
(5000 samples/sec)

The preliminary results:
The configuration used for the distance measurement
on the distances 30, 50 and 90 cm,
gave accuracy equal to 5, 6 and 15 μm respectively

The obtained results show the possibility to use both methods for monitoring LumiCal displacements

Such a state managed to achieve in the context of limited financial resources
and turbulence in the human resources people related to this subject

What to do next ?

PSD (semi-transarent sensors)

It will depend on the possibility of obtaining a funding. Could it be a part of money within FCAL AIDA2 project, where IFJPAN is an associate partner?

PSD can be used in AIDA calorimeter module to monitor of the displacement of the internal sensor layers.

Questions:

If the existing PSD system with 6 good sensors and other 2-3 acceptable will be still useful and ready for used at test beam measurements?

It should be checked.

Can it be portablable?

Need carefull investigation as the whole system is very old.
Very probable is that the new sensors with readout electronics and DAQ system will be necessary and will required to purchase

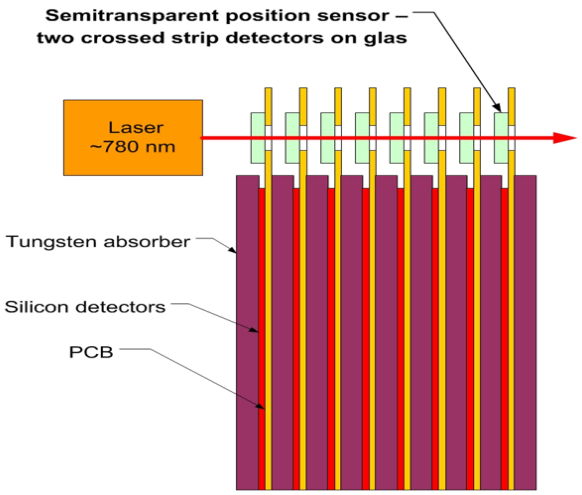
How many transparent sensors should be used in monitoring? 30 in total, for each sensor plane?

Probably yes

How many transparent sensors can be illuminated by one laser beam?

It depends on how the sensors provide light transmission and laser beam property

AIDA like calorimeter module

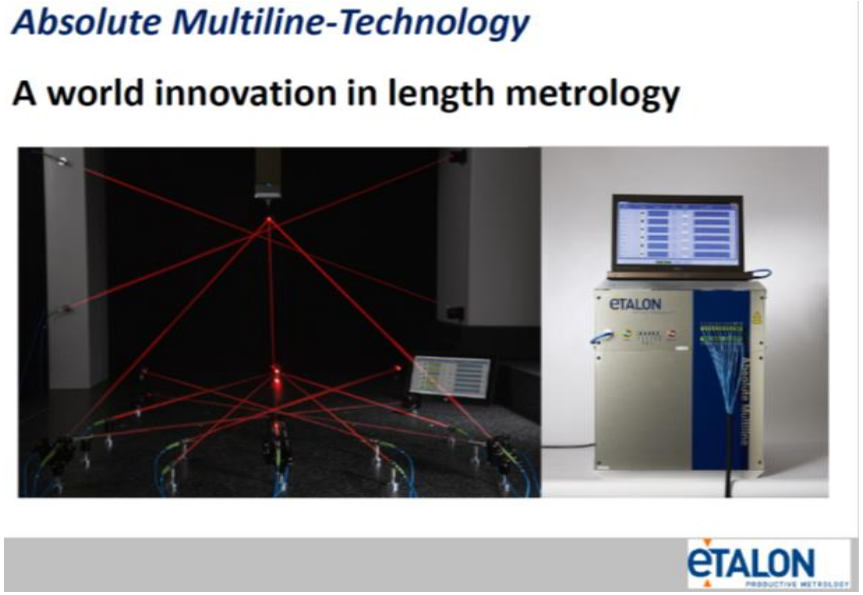


Precision X, Y measurement of silicon sensors position

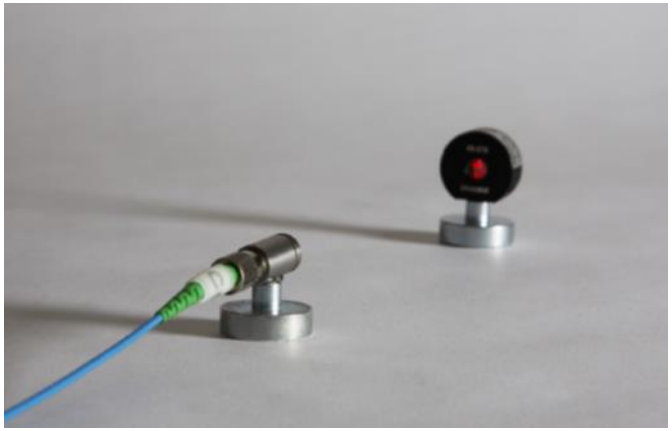
An example for posible solution in the case of the new sensors: as the new X,Y sensors are practically unachievable, one should try to use transmissive, microstrip sensors (1x1 cm^2) (EUDET results) which give output information related to one plane. X, Y data can be obtained from two such sensors put closely to each other.
The readout and DAQ system for these sensors - Spanish company ALIBAVA and a basic version costs ~ 6000 euros for reading of 16 planes sensors and additional money will be needed for sensors production.

FSI (Frequency scanning interferometry)

The situation with FSI is much more complicated. The construction of the realistic, multiline FSI standalone system is presently beyond our reach: lack of financial and human resources.
A commercial product is now available: multi-channel dynamics FSI system manufactured by ETALON AG Germany. It is based on the FSI development given by University of Oxford which has large experience and achievements in FSI topic – as example,FSI system built for ATLAS semiconductor tracker.
ETALON solution is a reliable, portable device which will be further developed.



Single channel: measurement head –optical fiber with beam splitter and retro-reflector



ETALON - the current characteristics : range 0.2 -20 m, multiple simultaneous 3D measurements with uncertainty of 0.5μm/m

Approximate price for 24 measured distances obtained under the ETALON device is about 200k euros

Future solution for LumiCal - ETALON AG FSI system ?

What are the opportunities for us?

CLIC

There is the PACMAN (Particle Accelarator Components: Metrology and Alignment) project hosted by CERN. It is a Marie Curie Initial Training Network implemented as Innovative Doctoral Program (Seventh Framework UE program). One of the Work Packages is Metrology and Alignment. The solutions obtained inside this Package will be used in the future installation of the CLIC modules in the tunnel.
ETALON (FSI) solution is a part of these studies.
If the forward detectors and particularly LumiCal at CLIC still require some alignment solution, than contact with PACKMAN working group will be very useful

ILC

One possibility is to think about a common alignment system for the tracker detector (barrel and forward r egion), LumiCal and QD0 magnets. The ETALON system, which will be further developed (increasing the number of measurement channels and ability to measure several distances from one FSI emitter), can be an attractive solution also for ILD.