AIDA

Advanced European Infrastructures for Detectors at Accelerators

Presentation

LumiCal alignment system, status report

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12 November 2012

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LumiCal Alignment System
Status report

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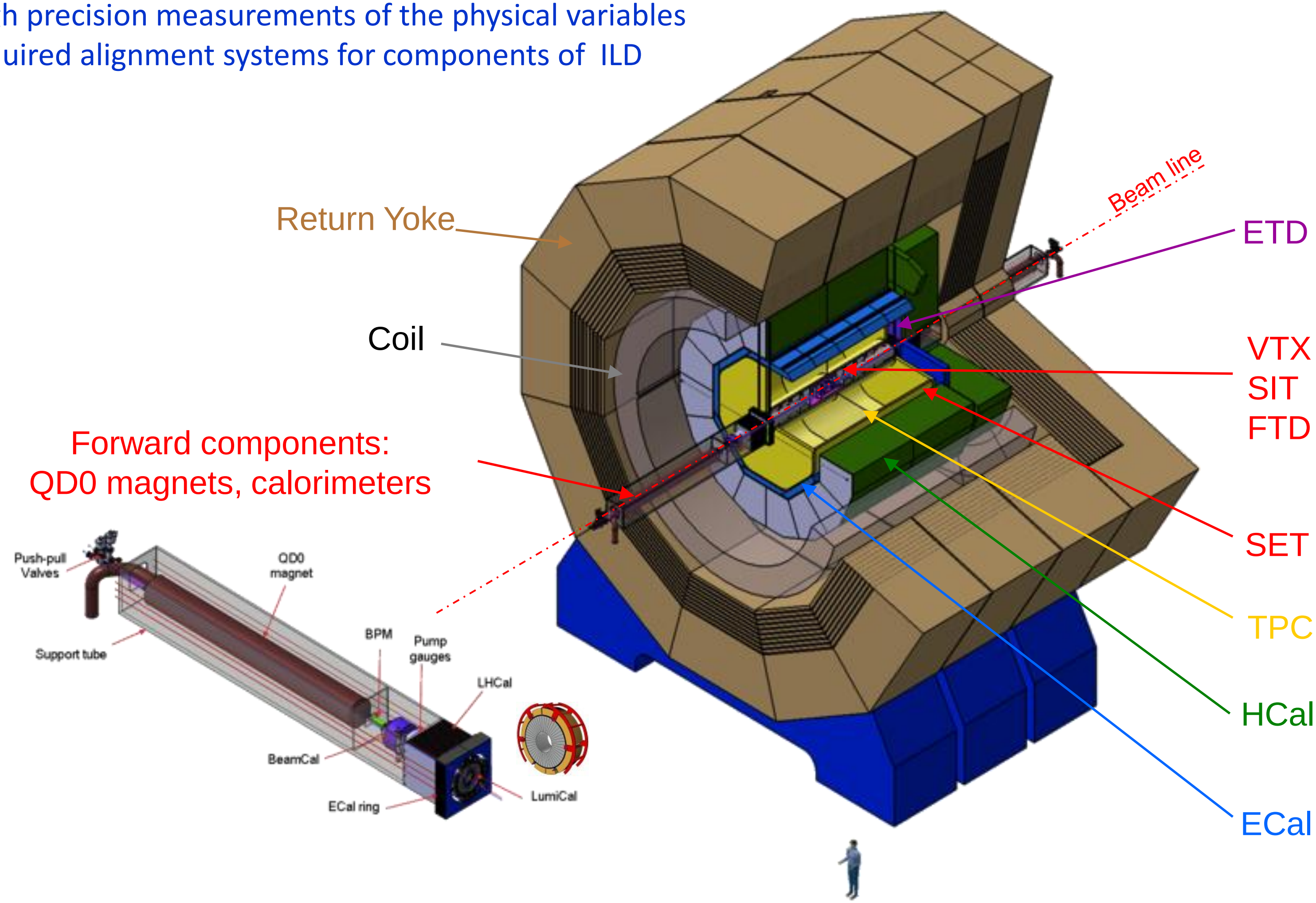
FCAL Meeting, 12-14 November 2012, CERN

ILD : International Large Detector

ILD detector - advanced technology in construction of sub-detectors: highly granular main calorimeters , vertex finding capabilities, superb tracking, forward detector components.
It is optimized (particle flow) for the best resolution what can be achieved in TeV region.

High precision measurements of the physical variables required alignment systems for components of ILD



ILD: Alignment

K. Buesser, LCWS Arlington 2012

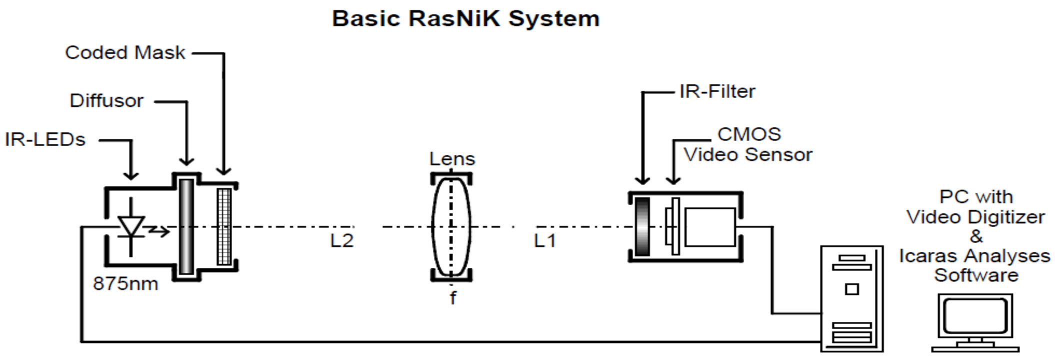
Alignment Requirements

- ILD detector axis:
  - ±1 mm, ±100 µrad
  - laser reference system on platform or hall, positive indexing system on platform
- QD0 magnets:
  - before low current beam is allowed in:
    - ±50 µm, ±20 mrad (roll) ±1 mrad (pitch, yaw)
  - after beam-based alignment:
    - Stability over 200 ms: ±200 nm, 0.1 µrad
    - Vibration stability: less than 50 nm within 1ms bunch train
  - Alignment and positioning system on ILD
  - Cam movers on QD0s
- Reference line: defined by QF1 magnets in the beam line

Stretched wire and
WPS (wire position sensors)

NIKHEF solution - laser optical system

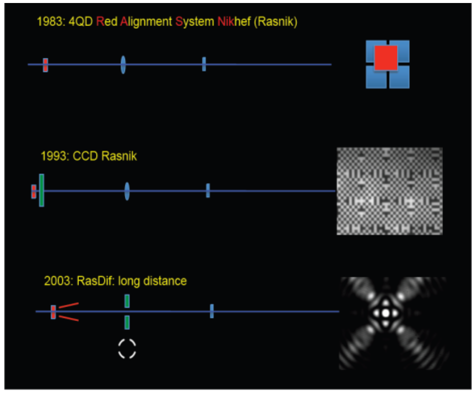
RASNIK (**R**ed **A**lignment **S**ystem **NIK**HEF): consists of an infra-red light source which projects a coded mask via a lens onto an optical image sensor.

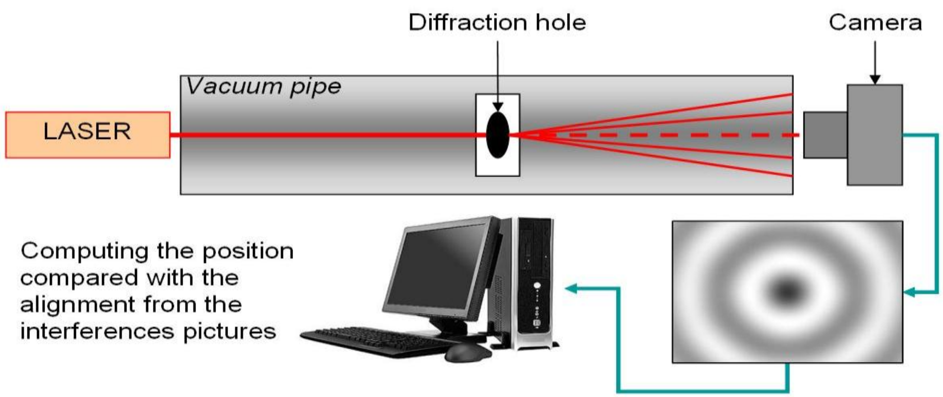


The relative position in X and Y direction is measured along the line mask, optical center of the lens and the CMOS sensor. Also (relative) rotation of the mask or the sensor can be measured. By calculating the actual image spot size and comparing this with the mask spot size, the position of the lens along the Z-axis can be calculated.

RASDIF:

- Objective: to provide transverse positional data on targets distributed over 100 m, with an uncertainty of measurement better than 5 microns.
- Straight line = laser line between source and detector under vacuum
- Concept: target with a hole in order to determine the center of the diffraction patterns





Thermal shielding is necessary:
jitter and refractive bending of light

CLIC: concept of monitoring QD0's positions

H. Schmickler:
IEEE NSS/MIC/RTSD
Anaheim, November 2012

QD0's relative position

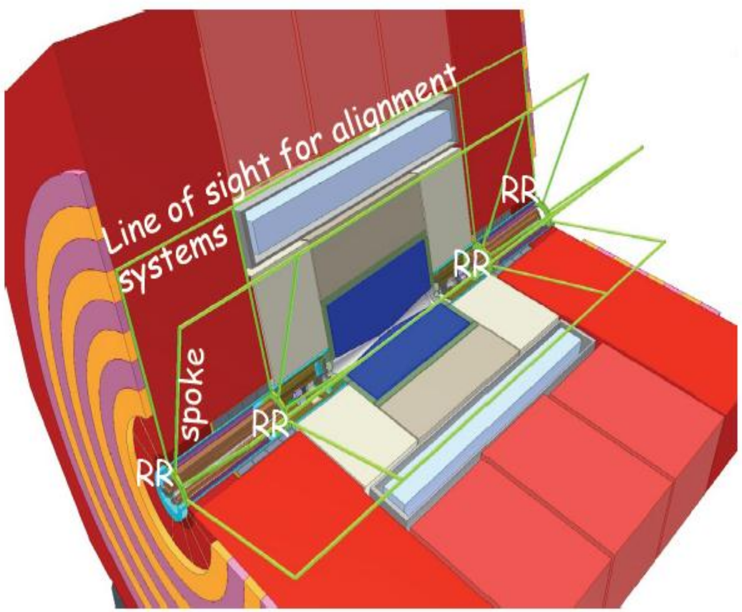
NIKHEF CLIC

Left side w.r.t right side

Monitoring of the position of left QD0 /right QD0: Concept

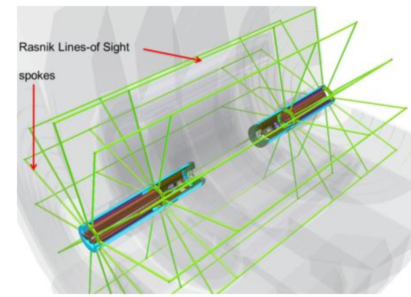
Rasnik/Rasdif

- ✓ 4 Reference Rings (RR) located at each extremity of QD0, supported from outer tube
- ✓ 6 radial spokes per RR



In two steps:

- ✓ A monitoring of the position of QD0 w.r.t RR thanks to proximity sensors. (initial calibration of their position performed on a CMM)
- ✓ A transfer of the position of RR thanks to 6 spokes to alignment systems. By combination of redundant information, the position of the center of 4 RR is computed.



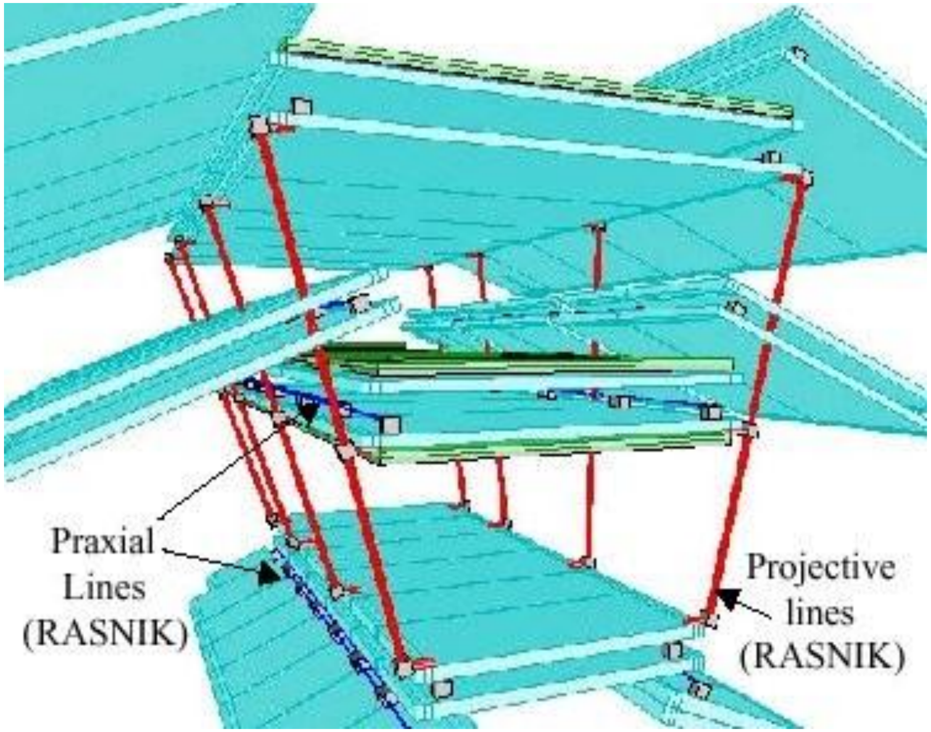
The alignment is not influenced by deformation of RR (sag, spoke load), temperature of individual RR and spoke wheel

Validation of the concept : 2012 /2013?

Example: ATLAS Muon Spectrometer - Monitored Drift Tube chambers

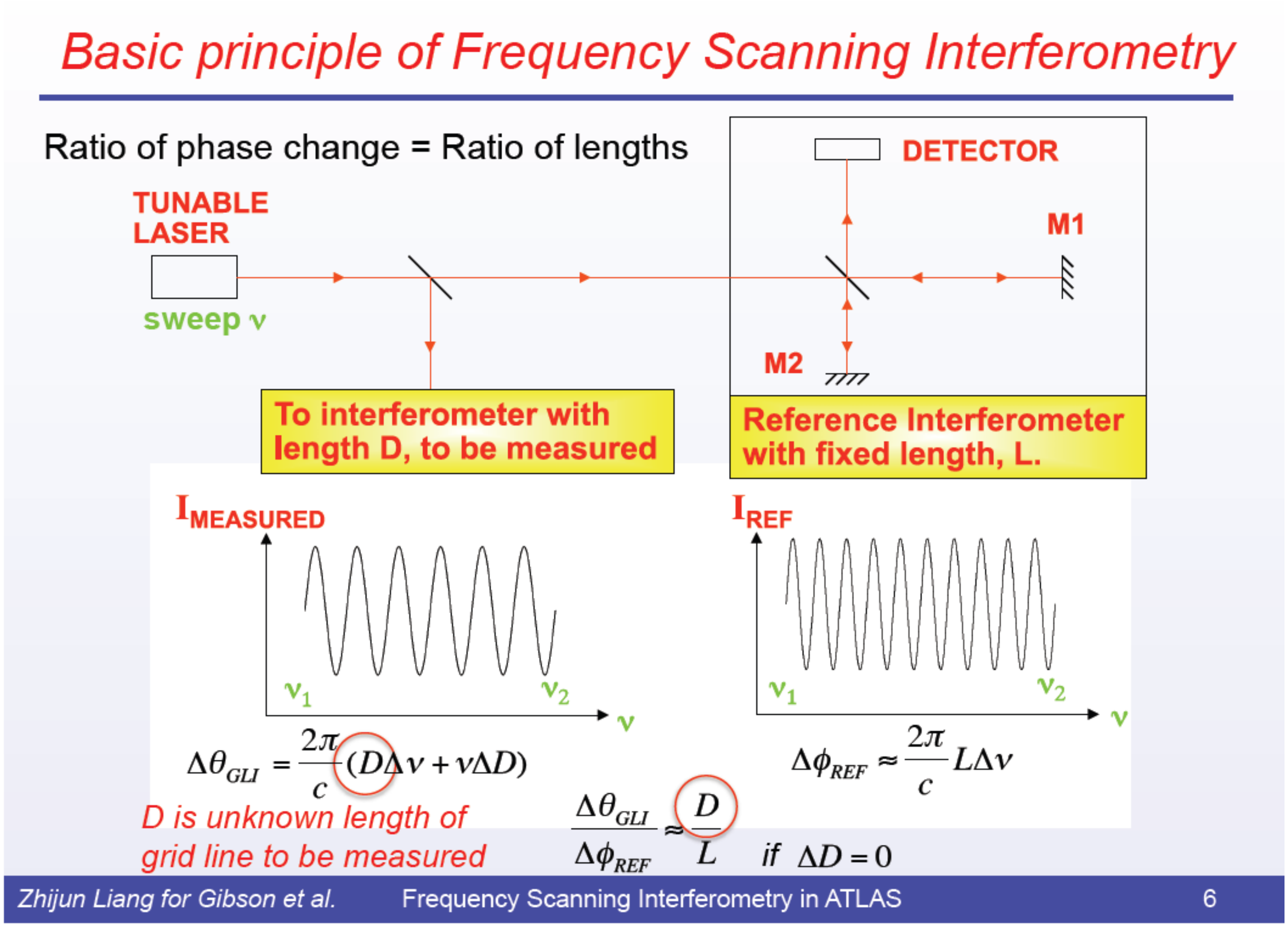
Provide the primary track coordinate measurements

- The most important one → direct impact on the correction to the measured muon track sagitta.
- Monitors the relative displacements of the three MDT chambers



Alignment system based on Frequency Scanning Interferometry

FSI enables remote, multiple, simultaneous
and precide distance measurements



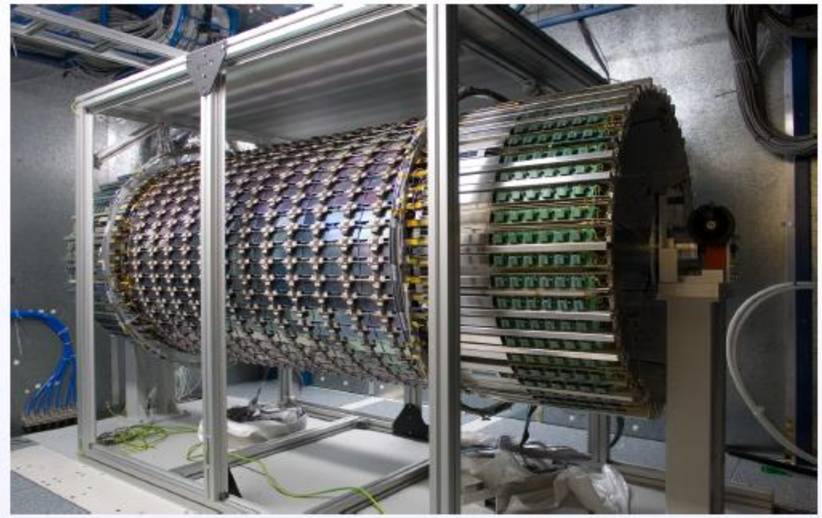
Example: FSI in ATLAS experiment (1)

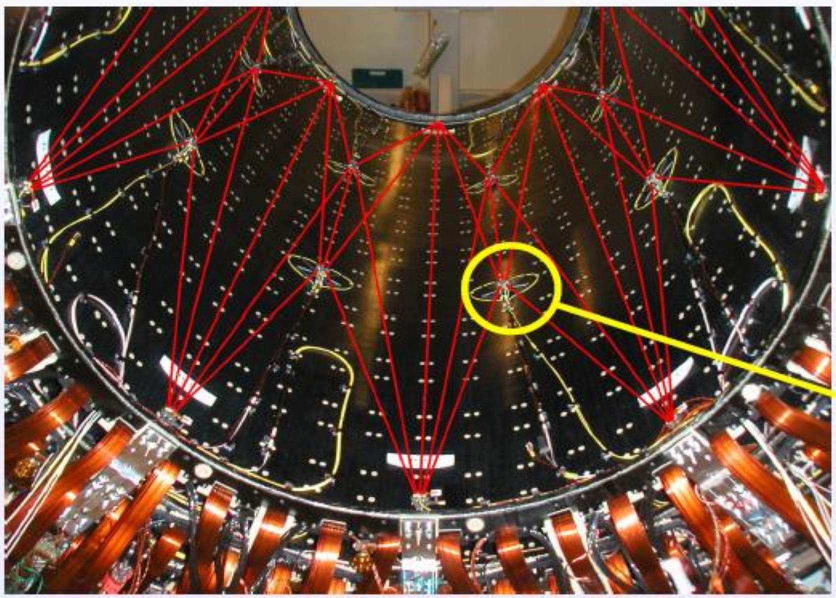
Based on original FSI method developed at Oxford Univers.

Frequency Scanning Interferometry

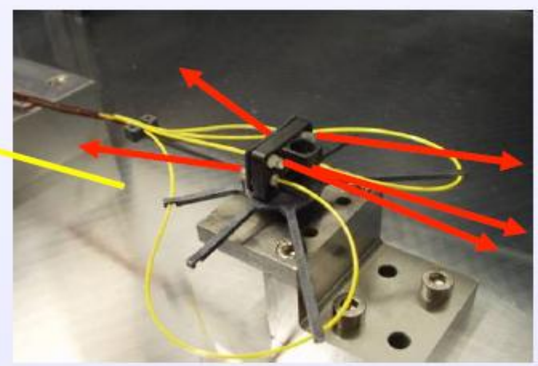
FSI alignment system: 842 simultaneous micron precise distance measurements between grid nodes attached to SCT.

Repeated grid measurements monitor shape *changes* of the SCT.





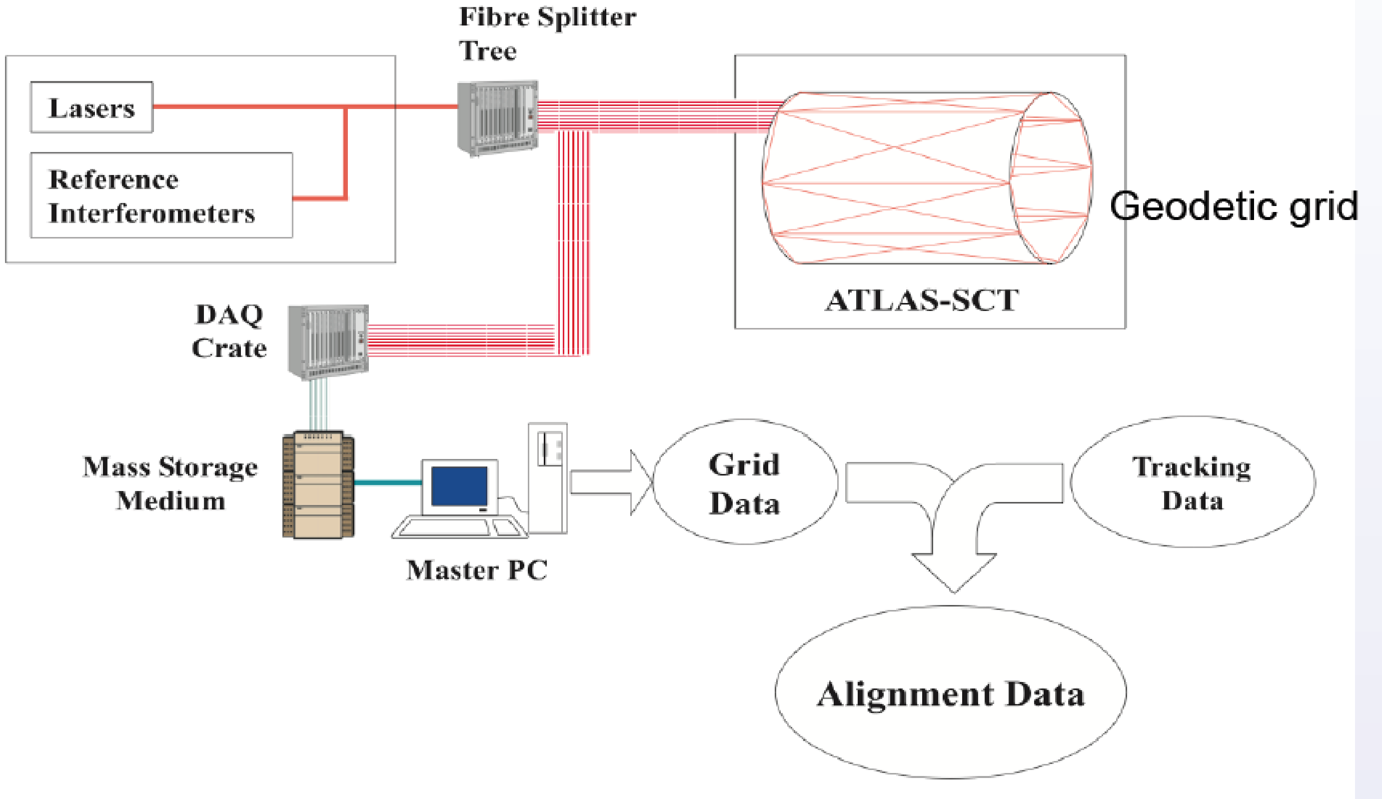
Barrel FSI grid node



ATLAS (2)

FSI System Overview

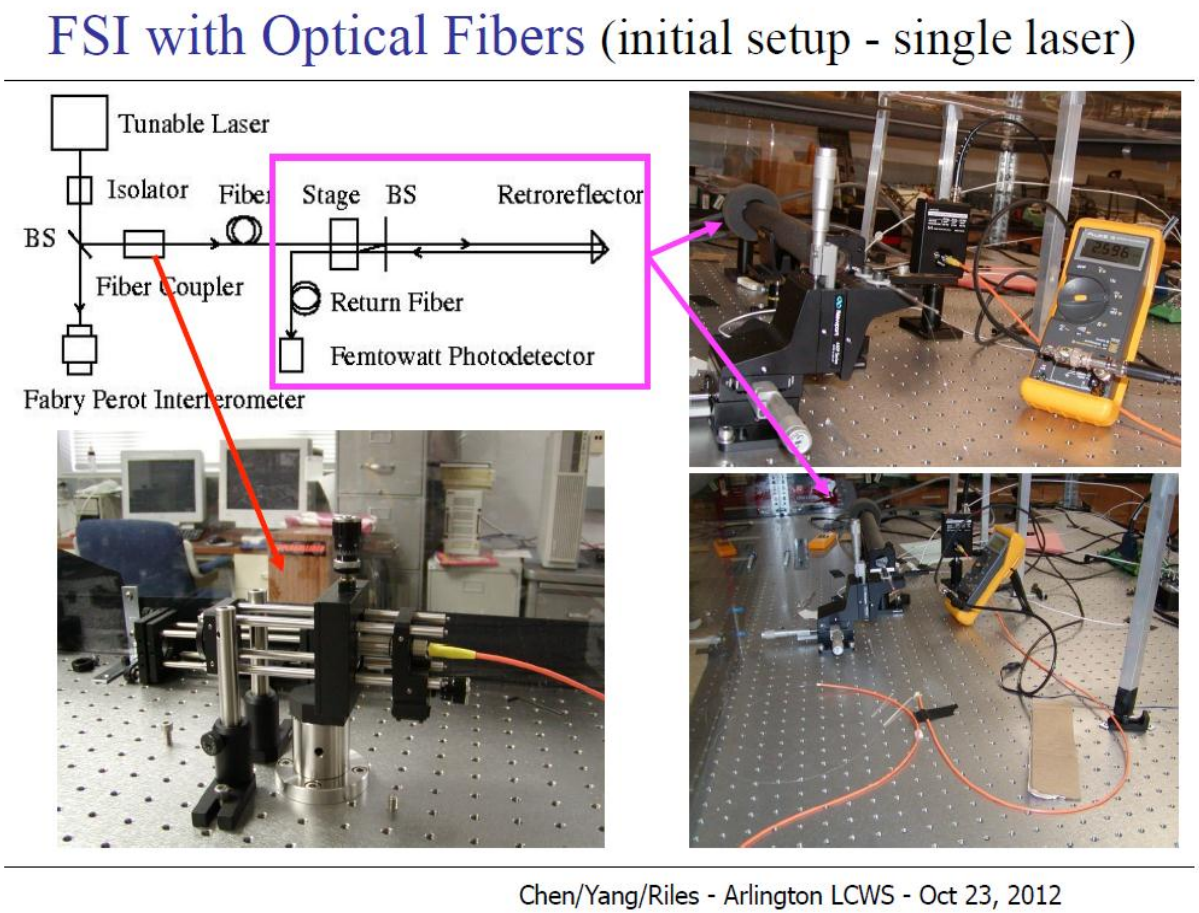
- An automated FSI system operates within the inaccessible, confined spaces and high radiation levels of ATLAS, where a conventional survey is not possible.
- Lasers illuminate reference interferometer and on-detector geodetic grid via optical fibres.

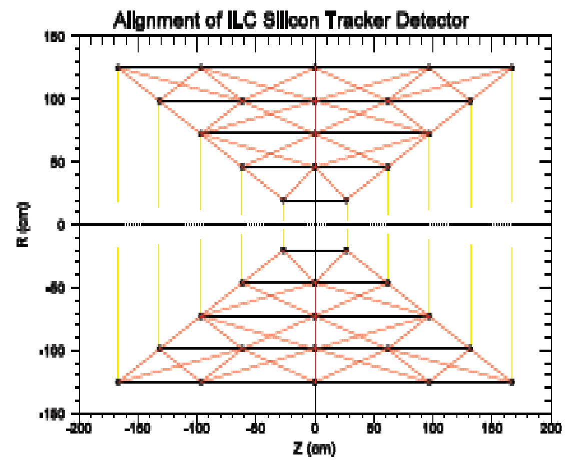


Example (2) : SiD tracker and QD0 alignment studies

FSI system used by Michigan ILC Group is based on ATLAS concept
and was applied to SiD Tracker and and QD0 magnets displacements.
Recent development – multi-channel 3D measurements

Demonstration of the use FSI system



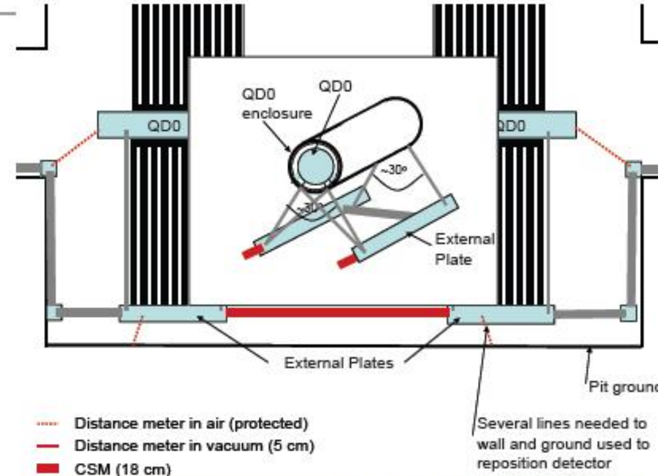


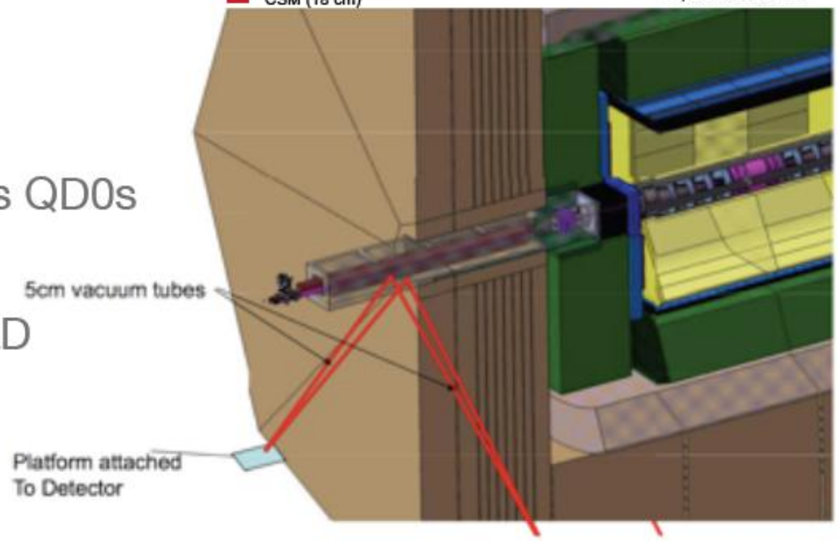
FSI for ILD: QD0's positions monitoring

K. Buesser, ILD Meeting, LAL Orsay, April 2012

QD0 Alignment in ILD LoI

- MONALISA (Oxford)
  - frequency scanning laser interferometer
  - could provide necessary precision for QD0s
  - could align ILD globally
  - could link left and right QF1
- Problems:
  - Lasers need to be in vacuum tubes
    -> No mechanical solution to access QD0s cold mass via yoke end caps
  - Oxford group stopped to work on ILD

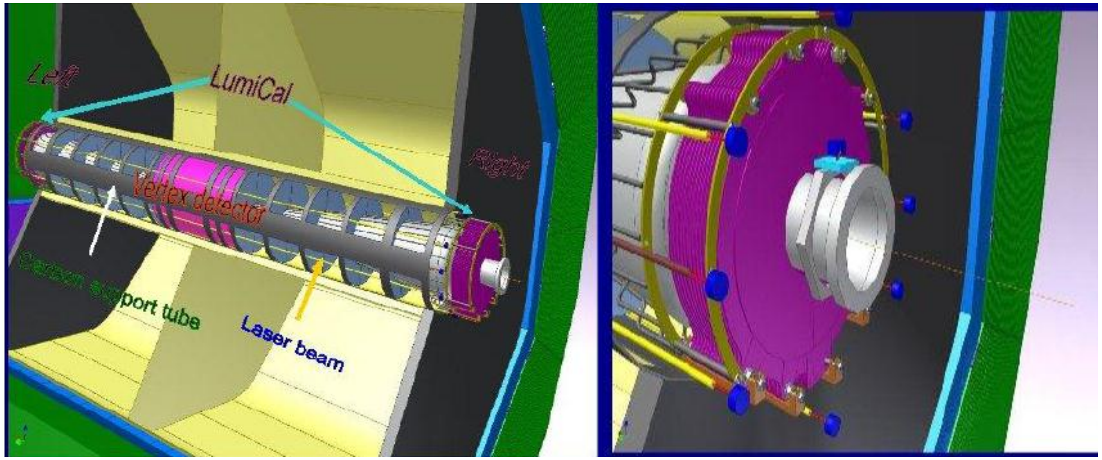


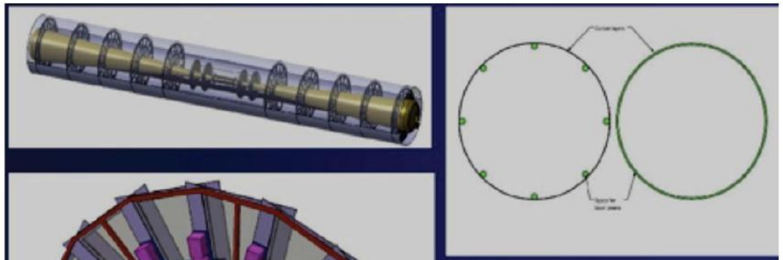


ILD: LumiCal alignment system

Requirements for the positions measurements of the LumiCal detector:
a few hundred µm in X, Y directions, 100 µm in Z direction
and a few microns for internal silicon sensor layers for

Mechanical aspect of alignment LumiCal calorimeters



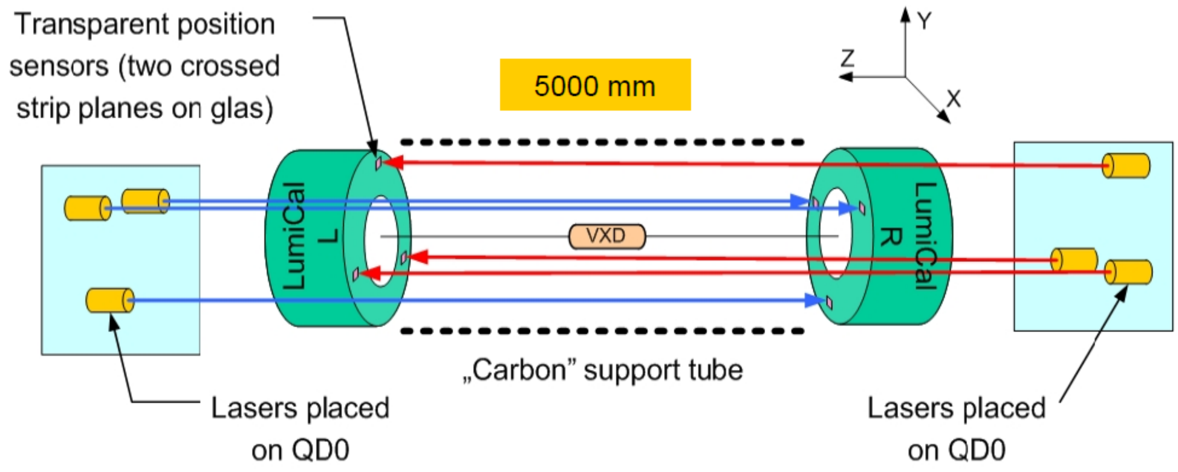


Carbon tube with glued carbon pipes (left) – less material, more stiffness, limited number of laser beams
Double layer carbon tube (right) – less material, more stiffness, lot of space for many laser beams

LAS: reference points

Possible displacement measurements between two (L-R) calormeters:

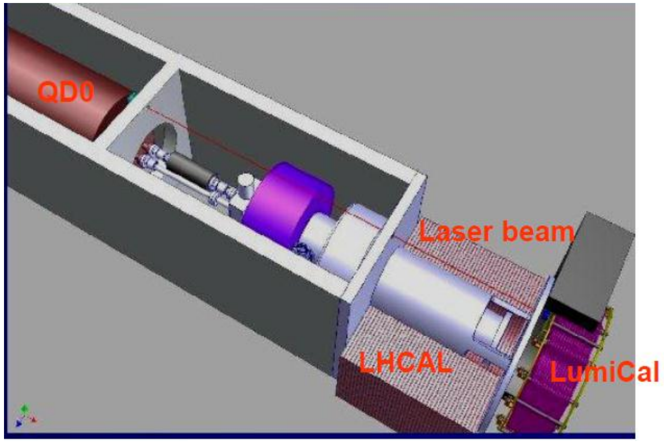
- Laser beams and sensors - at least 6 for space orientation both calorimeters - inside ‘carbon’ support tube – need additional vacuum pipes ?
- System with interferometer, FSI (frequency scanned interferometry)



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

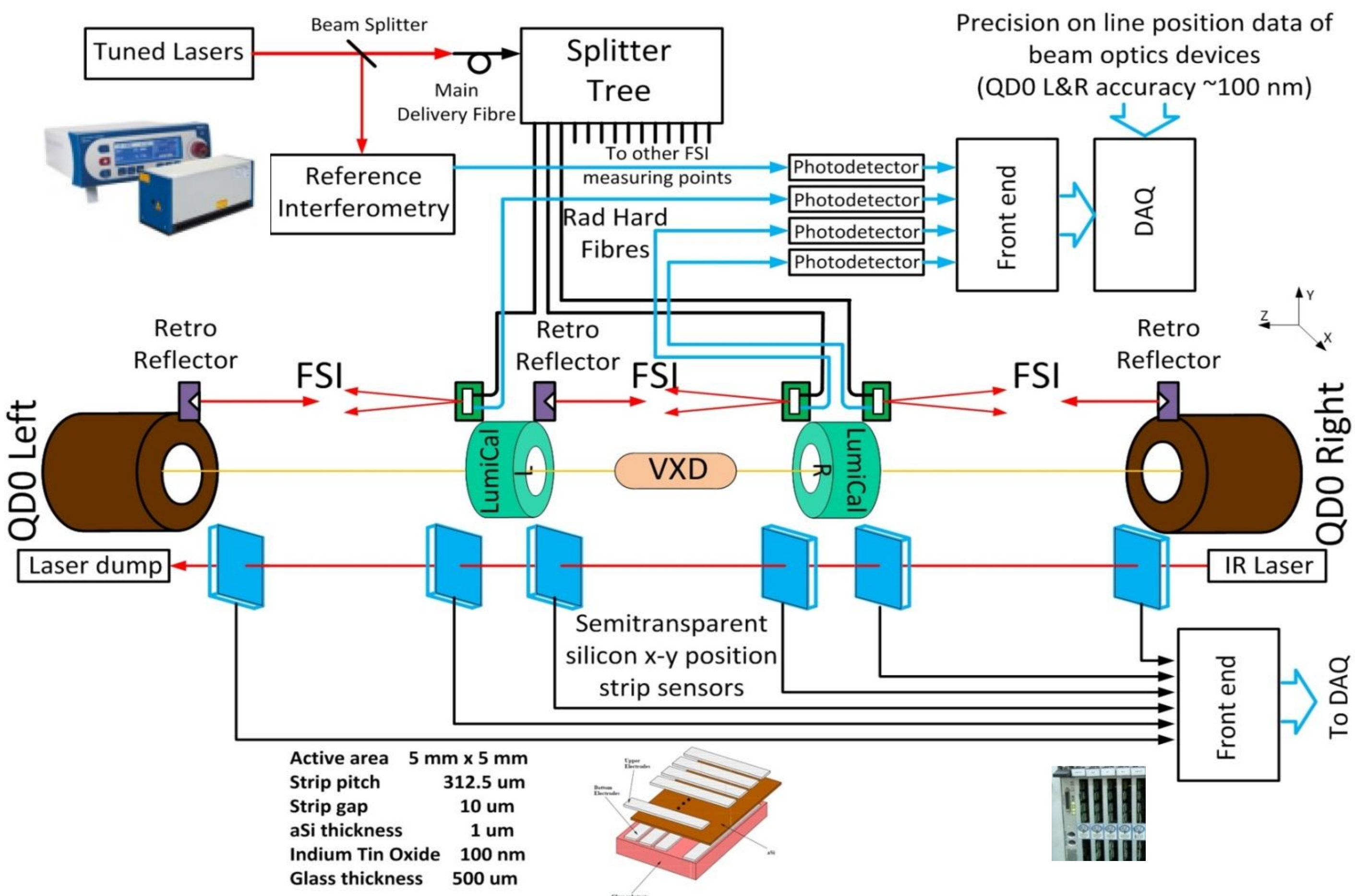
Good reference points
for position measurement of LumiCal can be:

- QD0 magnet
- Beam Position Monitors
- also beam pipe



The design of the LAS system

The laser alignmet system will contain the main components:
- infra-red laser beam and semi-transparent position sensitive detectors (PSDs)
- tunable laser(s) working within Frequency Scanning Interferometry (FSI) system



FSI – will be used for measurements of the absolute distance between LumiCal calorimeters by measurement of interferometer optical path differences using tunable lasers (by counting the frenges

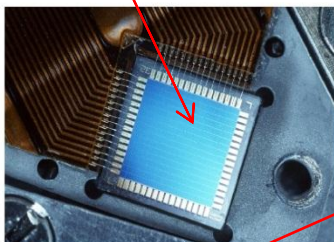
Semi-transparent sensors : LumiCal displacements of the internal Si layers

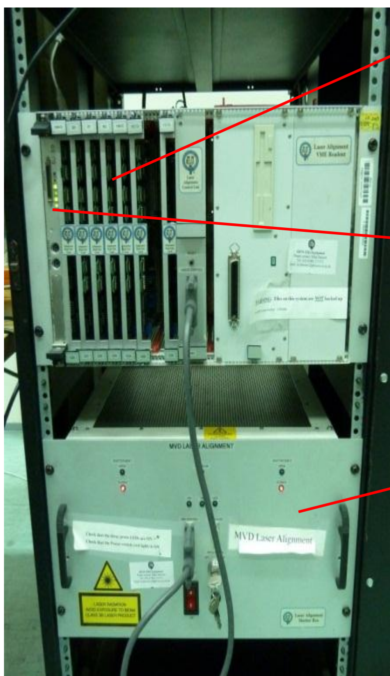
A rougly estimation of the size of output data is of the level of tens kB/s

LAS : available components (1)

Set up with semi-transparent sensors:

Laser diodes : ~ 785 nm
Semi-transparent sensors
with 16 strips along X,Y axes
Accuracy in position measurements ~10 μm

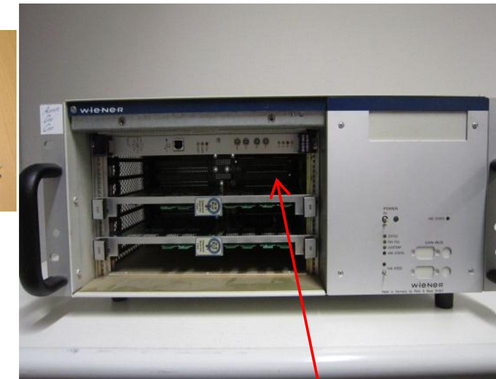




VME crate (ZEUS - Oxford set up)
with new installation
of Lynx0S 3.01 system,
readout cards for sensors
pieces of code for software ,
Box with laser diodes

First test of work for system
will be done soon.

Other way to sensors readout



VM-USB VME controller
with USB2 interface:
To read directly data
from cards and for
integration with DAQ system
It is placed together
with sensors cards in Wiener crate

LAS: available components (2)

FSI :

Sacher Lasertechnik - TEC-500-0670-010 tunable laser
((External Cavity Diode Laser in Littman/Metcalf
Confoguration).
Automatic tunning,
Power: 10 mW
Wavelength range: 663 – 678 nm
Fine tuning range (mode-hop free) : up to 60 GHz

It will come in December

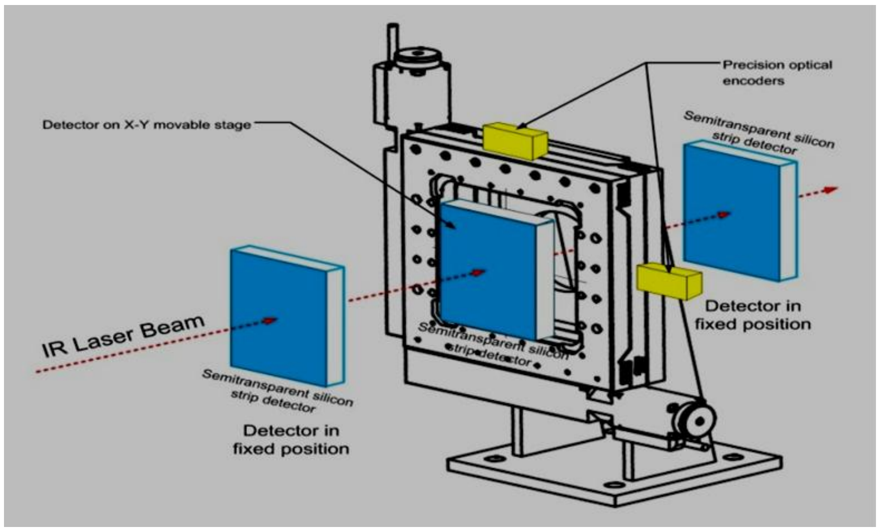
Towards the complete FSI prototype for laboratoty studies (2013 ?):

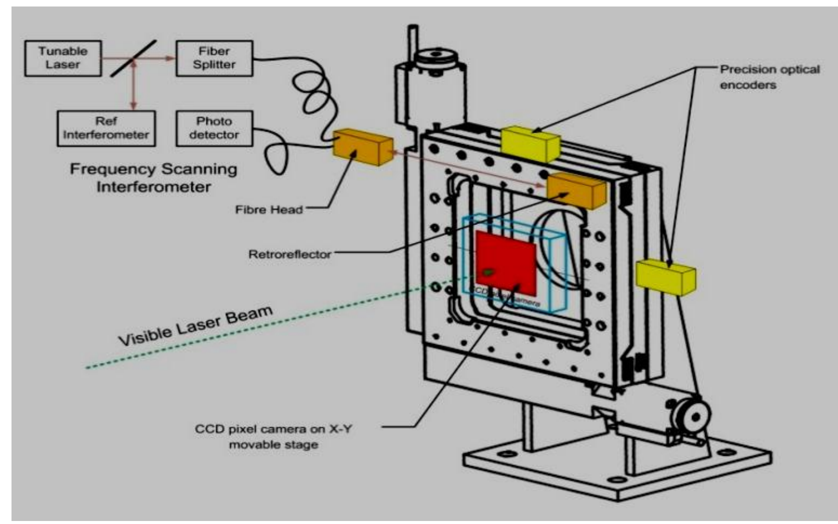
- Still is a chance to order in this year a honeycomb optical table.
- Some other components like:
  interferometers, retroreflectors, optical fibres, optical isolator, beam splitter,
  femtowatt photodetector with electronics, … will be order in the next year if
  our budget will allow for this.

Nest step: measurements with AIDA calorimeter :

Semi-transparent sensors placed
on several silicon layers will be iluminated by laser.
Measurements   of X, Y displacements can be done
after some ”deformation”   structure of the AIDA layers.
Needs a laser reference beams

AIDA cal. will be on the movable table (X, Y).
and equipped with several retroreflectors (interferometers)
connected to fibers. The tunable laser beam for FSI
distance measurement will be splitted to a few points
and distributed via fibers optics.
The ends of fibers will be fixed to base table.





The output data from laser positioning system should be integrated
with main DAQ system of LumiCal detector

For MDI activities in forward region of ILD there can be problem to find a free place for optical fibers (expected many cables). The tunable laser(s), reference interferometer(s), photodetectors must placed outside the LumiCal region

Conclusions

- A prototype of the laser alignment system for LumiCal detector is under construction.
  At begin the system will contained two components :
  position sensitive detectors and FSI system.
  Some help in building of the LAS system can be obtained
  from LHC experiments: ATLAS – FSI, CMS – semi-transparent sensors.

- Unfortunately, for FSI, the most of component are very expensive - a problem to build a laboratory system in reasonable time period (2013 ?)

- The predictions from Monte Carlo alignment system will be very helpful

Conclusions cd.

- We need to write something about the QD0 alignment in the DBD
- The LoI system was MONALISA: open technical questions; no-one is working on it anymore for ILD
- CLIC has much more stringent requirements and the CLIC group is working on an alignment system for ILD@CLIC
- Should we copy it?
- If yes, what do we still need to do:
  - continue discussions with CLIC experts
  - assign space in the detector for spokes and lines of sight for RASNIKs
  - understand differences
    - definition of magnetic axis at s/c quadrupoles different than at permanent quadrupoles (CLIC)
- Look for synergies (e.g. combine systems for QD0 alignment and LumiCal)

K. Buesser, ILD Meeting, April 2012

- At the end of this year a commercial FSI system - ETALON based Telecom solution (lasers with wavelength ~ 1500 nm – common work with Oxford University) become available.
  High accuracy in position measurements, complete automatic system.
  The expected cost for 24 beam lines (channels) is 200 000 Euros.
  The number of channels can increase with additional price for channel
  Can it be used for alignment in the case of the forward components of ILD?
  Only as common effort of several ILD components