**AIDA**

Advanced European Infrastructures for Detectors at Accelerators

**Presentation**

# Laser alignment system status and future plans, 24th FCAL Collaboration Workshop

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26 May 2014

The research leading to these results has received funding from the European Commission under the FP7 Research Infrastructures project AIDA, grant agreement no. 262025.

This work is part of AIDA Work Package **9: Advanced infrastructures for detector R&D**.

# LumiCal Laser Alignment System
## Status and Future Plans

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FCAL Workshop, 26-27.05.2014, Bucharest, Romania


PHOTO.1
PARIS

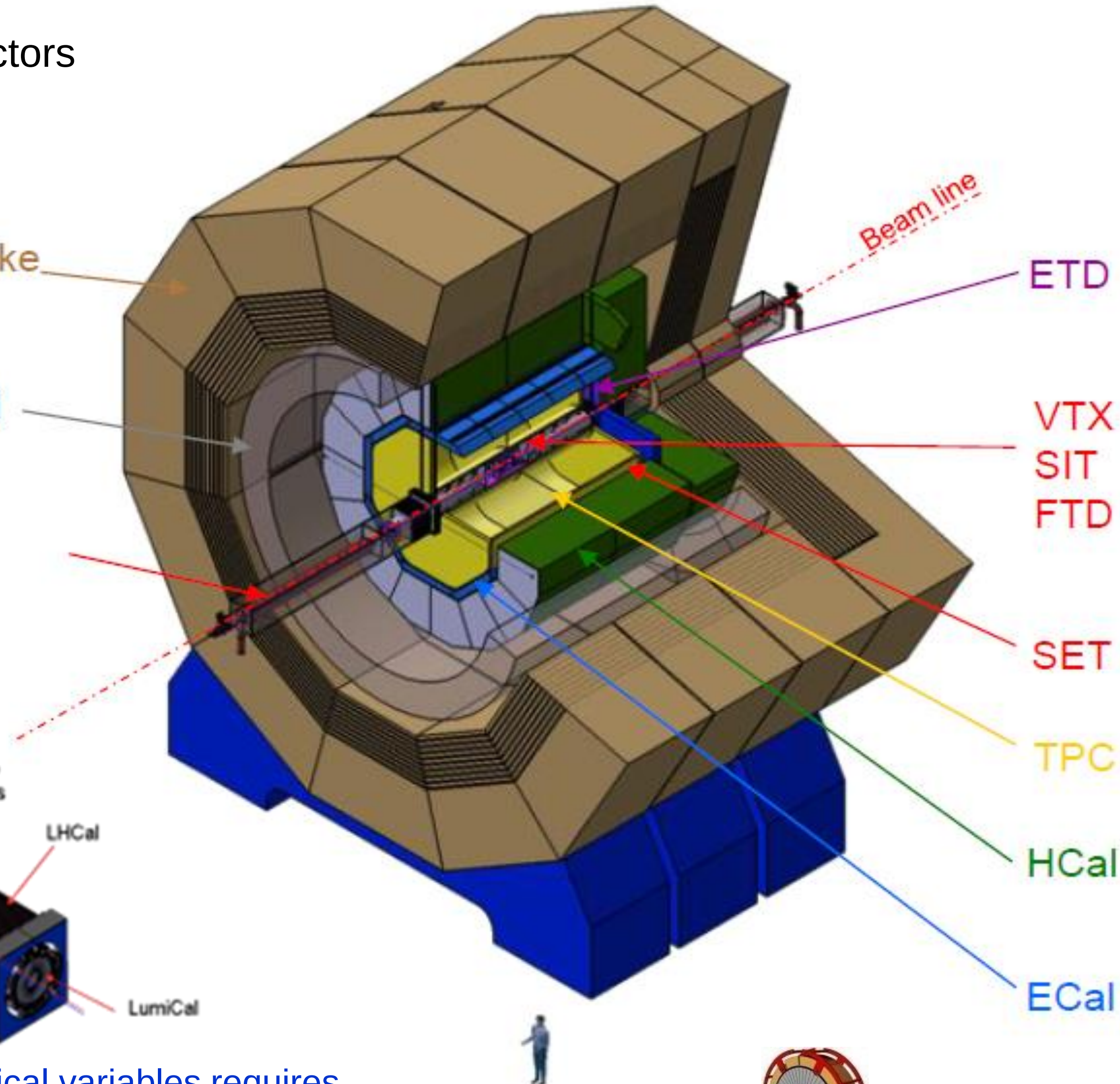
# ILD and LumiCal

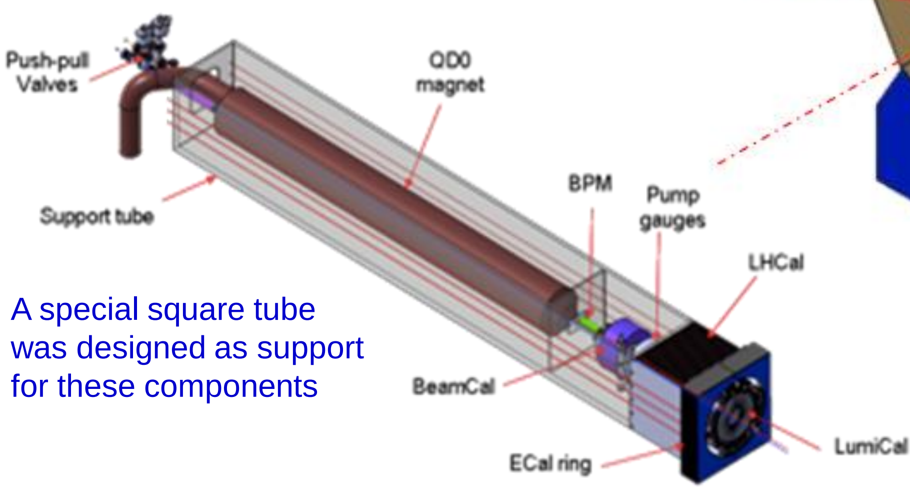
LumiCal - one of the FCAL detectors
placed in forward region of ILD

Return Yoke

Coil

Forward components:
beside calorimeters also
QD0 magnets, pipe and BPM's




A special square tube
was designed as support
for these components

High precision measurement of the physical variables requires
building an laser alignment system(s) (LAS) for components of ILD also for LumiCal

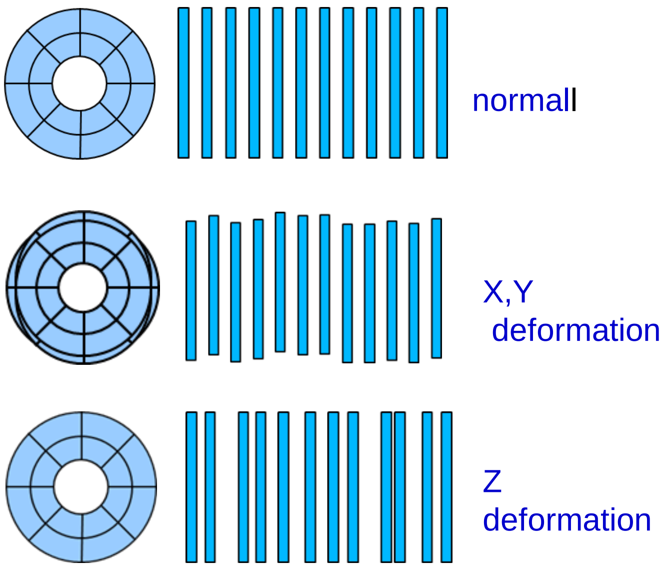
# Alignment LumiCal - requirements

The precise measurements of the LumiCal displacements are necessary for a high accuracy in the measur. of luminosity: ILC/CLIC ($\Delta L/L \approx 2^*\Delta\theta / \theta_{min} \sim 10^{-3} / 10^{-2}$) . The size of $\Delta\theta$ depends on uncertainties of LumiCal Z position and inner radius R (X, Y)

Monte Carlo studies
( ~$10^8$ events – BHLUMI gen.,
ILC500, ILC1000, Giga Z, CLIC3TeV)

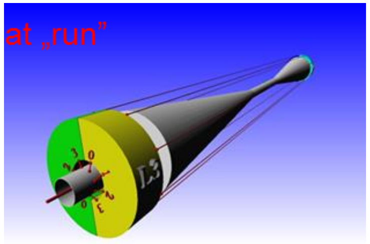
LumiCal det. simul.– example
with a possible deformation
of the inner layers of silicon sensors

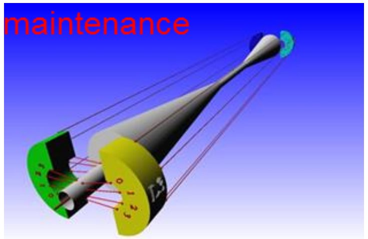
Estimation of the displacement measurements accuracy:
- a few hundred μm in X, Y directions
- about 100 μm in Z direction
- a few tens for internal sensor layers
  but ~ 4 μm for inner radius for Giga Z data

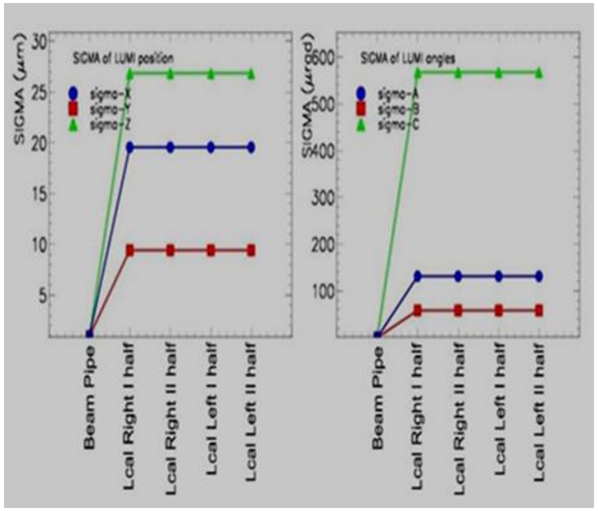



Deformations:
gravitational sag, temperature

The SIMULGEO program - to check if the interferometric method of position measurement can be applied here

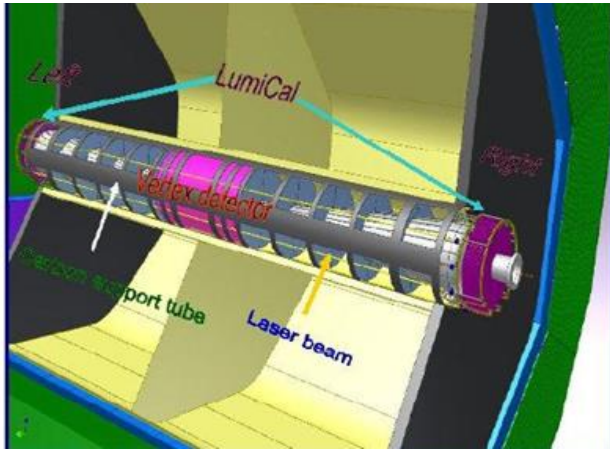


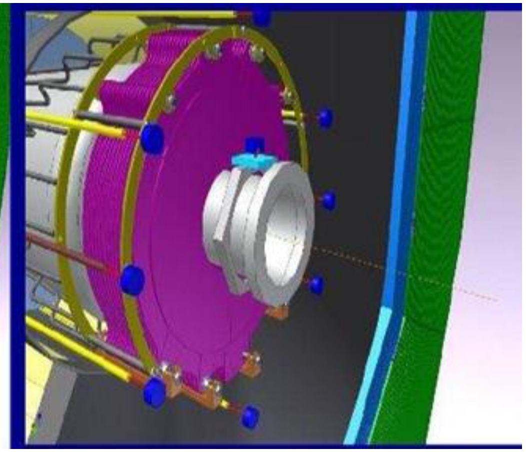




- 6 laser beams between both LumiCal's
- 8 laser beams from each Lumical
  to the beam pipe (X,Y)
- Laser beams for x,y not perpendicular
  to beam pipe axis – possible
  a rotation of LumiCal

# Mechanical aspects of LumiCal alignment



The good reference frame:

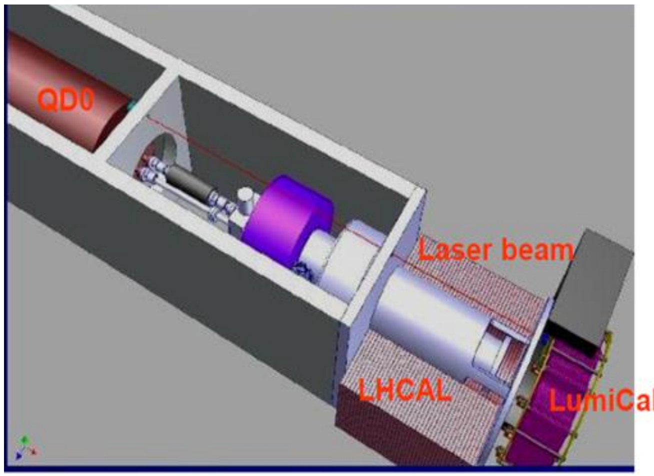
- QD0 magnets
- Beam Position Monitors
- Beam pipe

due to knowledge
of their precise positions

In the frame of the alignment will be performed measurements of absolute distance between the left and right calorimeters and their relative positions with respect to selected reference system

Necessary optical elements need to installed in the LumiCal environment: lasers, beam splitters fibers, retroreflectors, position sensitive sensors, carbon pipe for laser beams

As example : QD0 magnet




An important task in MDI studies:
define available free space for elements
of LAS system in the forward region

# The design of the LAS system

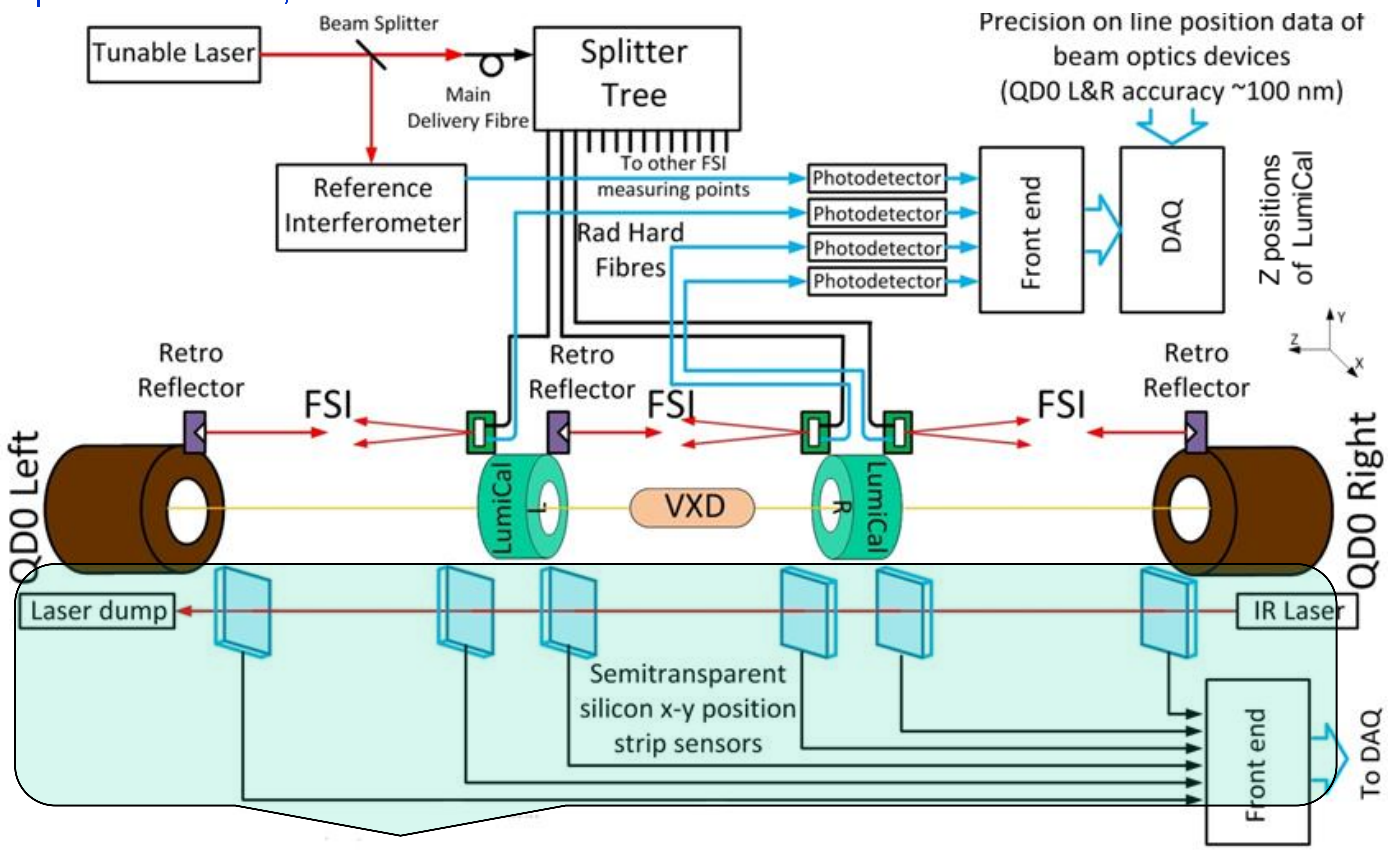
The alignmen system may include two components:

- IR laser + PSD system:

infra-red laser beam and semi-transparent position sensitive detectors

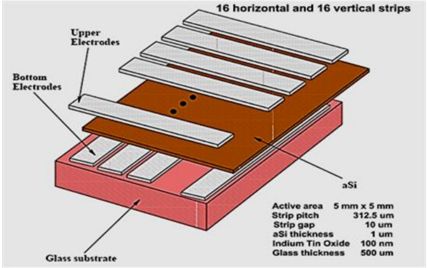
- FSI  system:

tunable laser(s),   beam splitters, isolator, Fabry-Perot interferometer, retroreflectors,  fibers, collimators, photodetectors, lens




FSI - Frequency Scanning Interferometry

The absolute distance measurements between LumiCal's

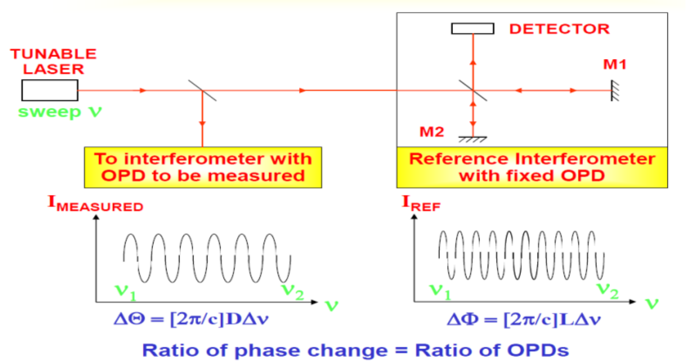



IR Laser + PSD

Relative positions of  LumiCal's and displacments of the internal Si layers

# Frequency Scanning Interferometry

- Frequency Scanning Interferometry (FSI) length measurements are made by monitoring the change of phase of an interferometer as the laser frequency is scanned.
- This technique has been made significantly easier by the recent development of external cavity tunable diode lasers, which offer a wide tuning range, ultra narrow linewidth and a minimum output power of several milliwatts.
- The interferometer with the length being measured is compared with the length of a reference interferometer, by monitoring the phase change in each interferometer.




$\Phi = (\frac{2\pi}{c})\nu\Lambda + \Phi_o$    $\Lambda$ – reference OPD

(OPD = Optical Path Difference)    $\Rightarrow q = \frac{\Delta\Phi}{\Delta\Theta} = \frac{\Lambda}{X}$

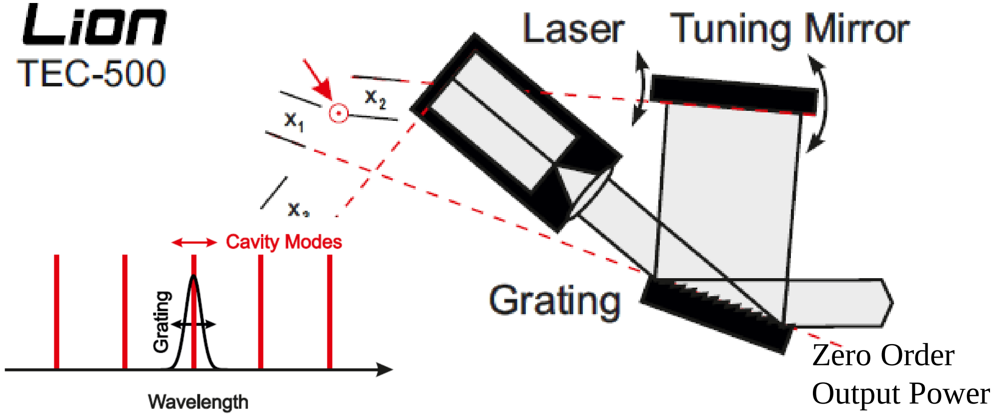
$\Theta = (\frac{2\pi}{c})\nu X + \Phi_o$    $X$ – measured OPD

The measurement of the unknown length depends on measuring the interferometer phase (change) ratio q.

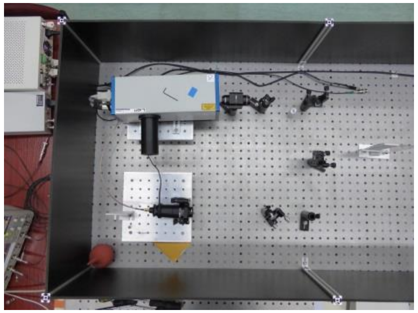
The advantages of frequency scanning are :

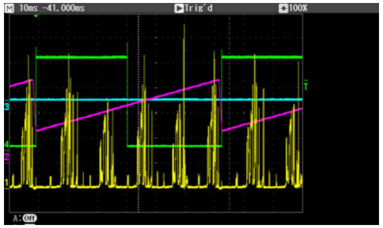
- The measured lengths do not need to be known in advance
- The absolute order number of the interferometer is not needed, only changes in interferometer phase need to be measured.
- The dynamic range is very large and is limited, in principle, only by the coherence length of the light beam in the measured interferometer.

# Tunable Laser



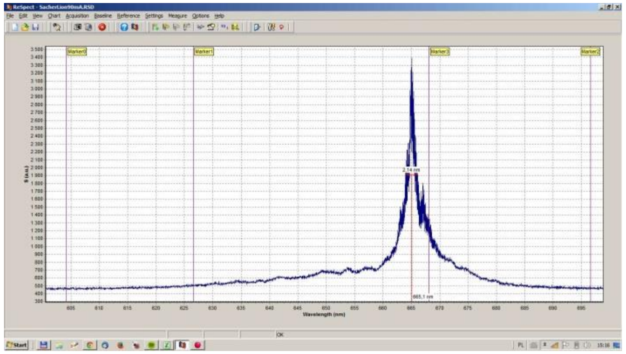

Littman-Metcalf External Cavity Laser 666-678 nm

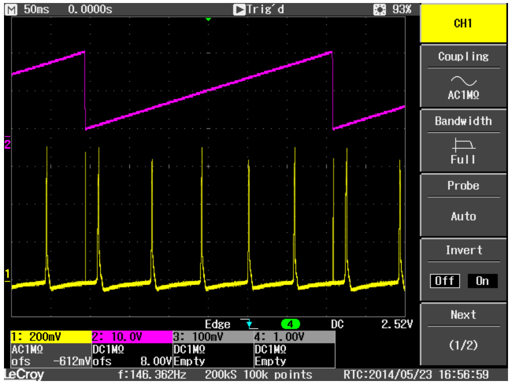




Observed signals from FB using simple laser diode

A problem which was encountered while testing the Fabry-Perot interferometer-spectrometer. All tests indicated the incorrect behavior of the tunable laser and it was sent to the manufacturer for inspection.






After repair (~1.5 month) we have got “working laser” but:

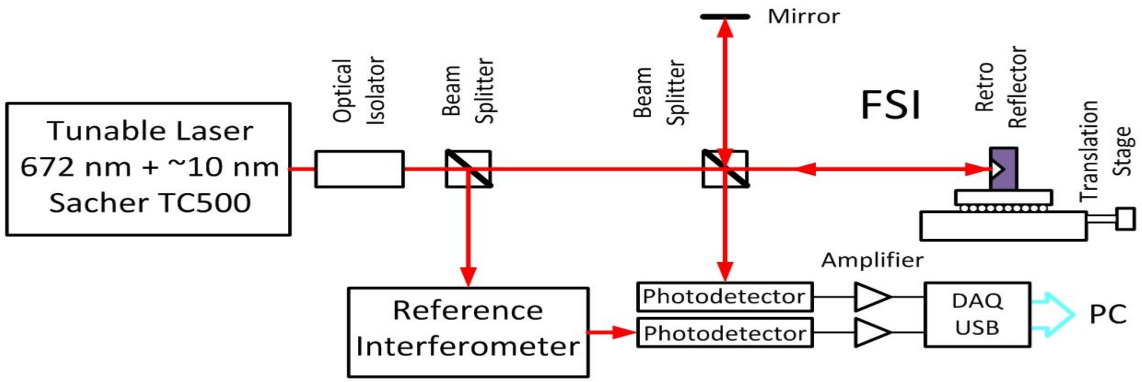
- ❑ The output power is lower (~30%) than specified.
- ❑ The tunable range does not correspond to specified.
- ❑ The center wavelength does not correspond to specified.
- ❑ The Acceptance Protocol does not fit to our laser.
- ❑ The mechanics is different, beam line is 10 mm above previous – all setup needs to be rebuild.
- ❑ The beam is not parallel horizontally to the laser housing and have some elevation tilt (7 mm over 1 m)
- ❑ The beam divergence looks not nice
- ❑ The beam polarization changes from horizontal to vertical and is most probably 45% - needs to check our measurements
- ❑ For some output power sets (LD current) laser is not single-mode, but dual-mode.
- ❑ During tuning the wavelength the laser hope from single to dual mode and back

Last two points kills our FSI.

My private opinion – newer buy Sacher lasers.

# The steps towards the final FSI prototype

1. The single laser beam in air from tunable laser
   - no optical fibers retroreflector on translation stage

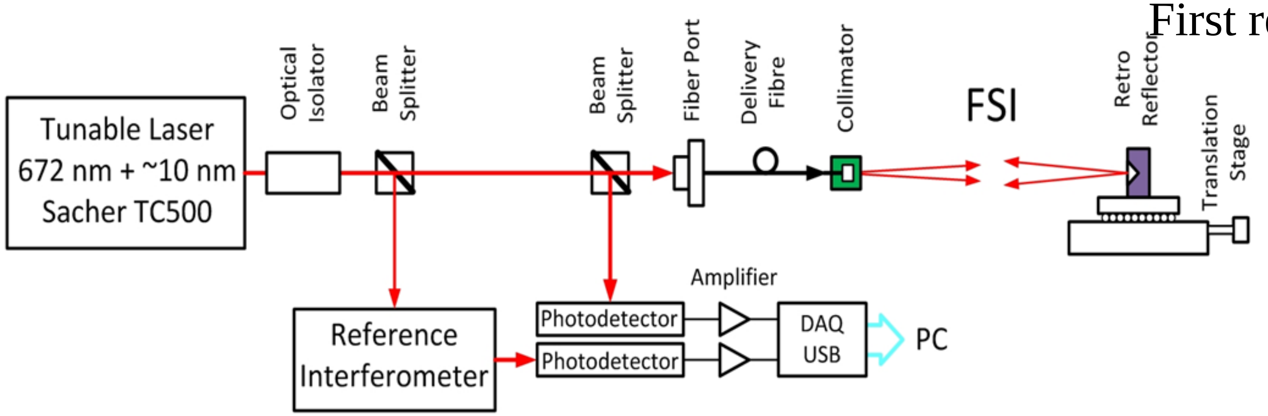



Setup is ready (Michelson type)
DAQ card still missing.
Not yet tested because of problems with laser (returned 20.05.2014).
First results – end of 2014 (est.)

2. Laser beam coupled into a single-mode optical fiber with fiber coupler-colimator

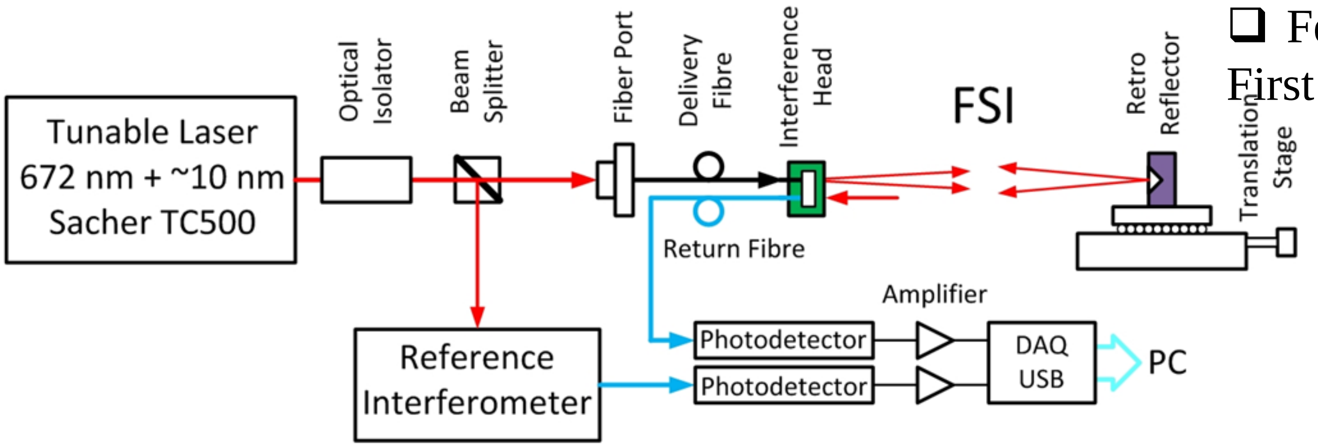
Main problems:
- ❑ Feed the beam to fiber
- ❑ Collimator

First results – end of 2015 (est.)



# The steps towards the final FSI prototype (cd)

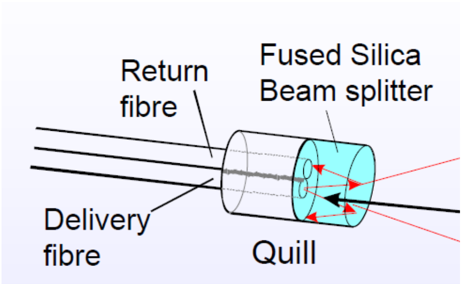
3. Interference head and forward and return fibers



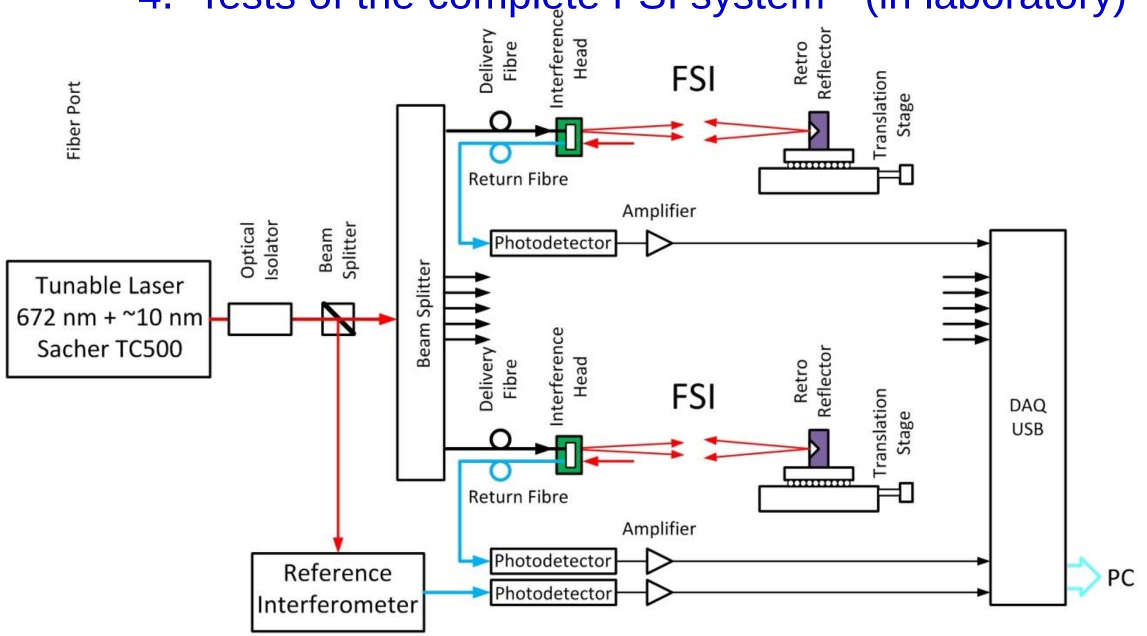

Main problems:

- ❑ Interference head
- ❑ Femtodetector

First results – end of ??? (2016)




4. Tests of the complete FSI system - (in laboratory)

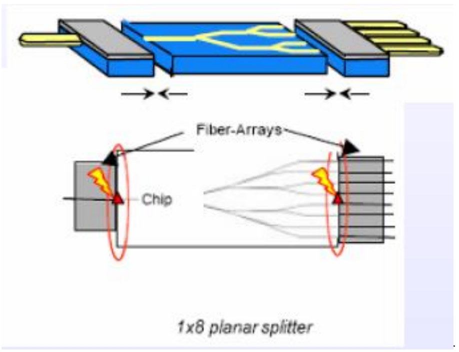



Far future.

Main problems:

- ❑ Beam splitter
- ❑ More DAQ channels

First results - ???



# Major problems

- Lack of laboratory optics equipment due to very small financial support
- Lack of manpower – now ~2 persons involved, later ?
- Lack of knowledge and experience – in FSI devil is in details
- Long delayed orders due to the administrative rules
- Exchange/repair of tunable laser or buy a new one (money ~10 k€)
- Coupling a laser beam to the fiber is a challenge
- Split the laser beam to many (hundred) delivery fibers (many measurement points) is a challenge

Thank you, not only, for attention, but…


CEC 150 Bank
CEC 150 Bank

# Thank you for ~12 years of collaboration.

I have to release IFJ PAN
(Head Director is no longer interested in collaboration with XFEL via DESY)
to finish my duties as technical coordinator in XFEL, so I have no chance to continue work in FCAL.

# Farwell Friends

# Adio Prieteni