Fabry-Perot cavity
in
pulsed regime
&
Polarimetry

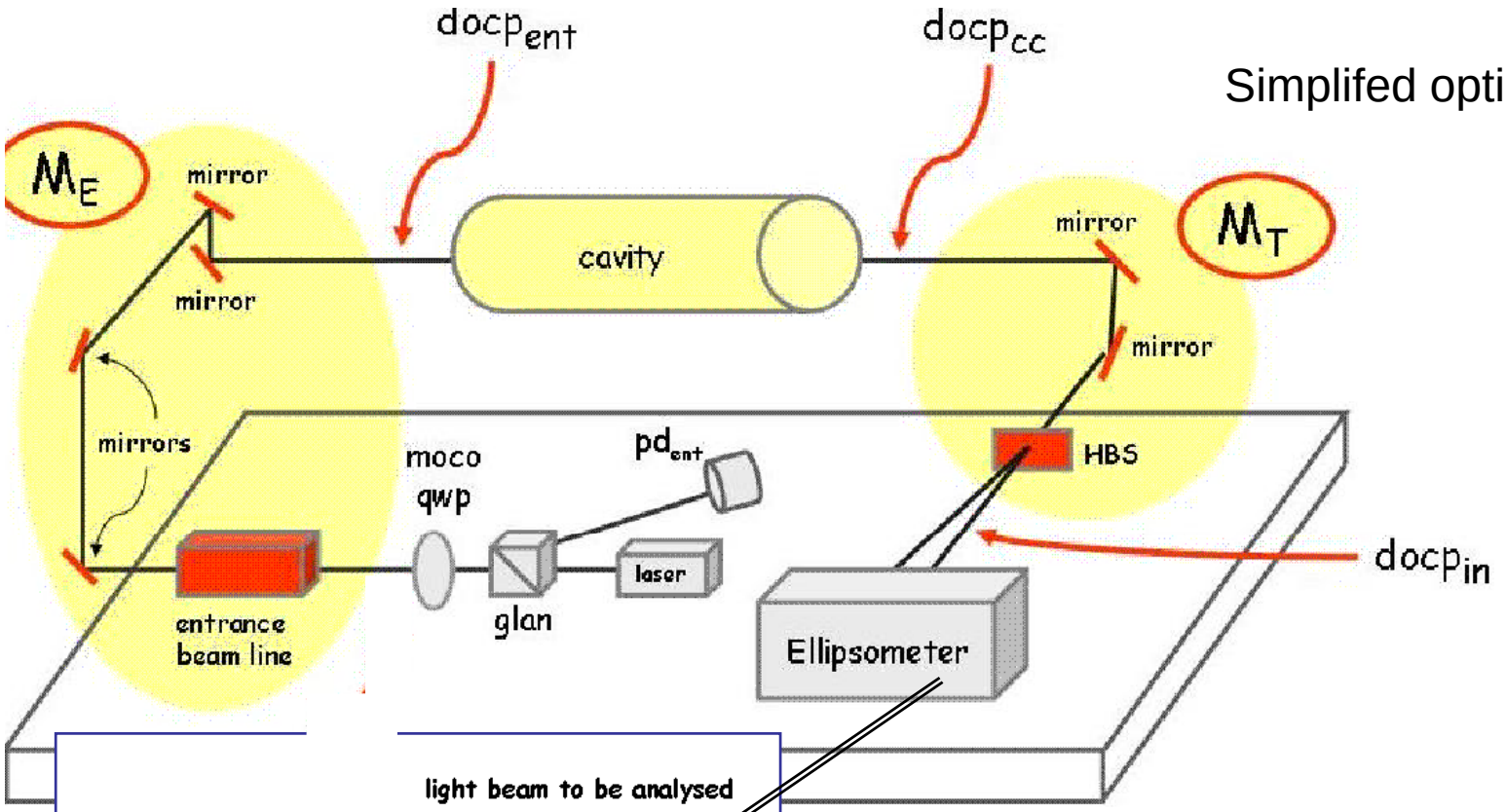
- **Polarimetry related work**
- **Optical cavity related work**

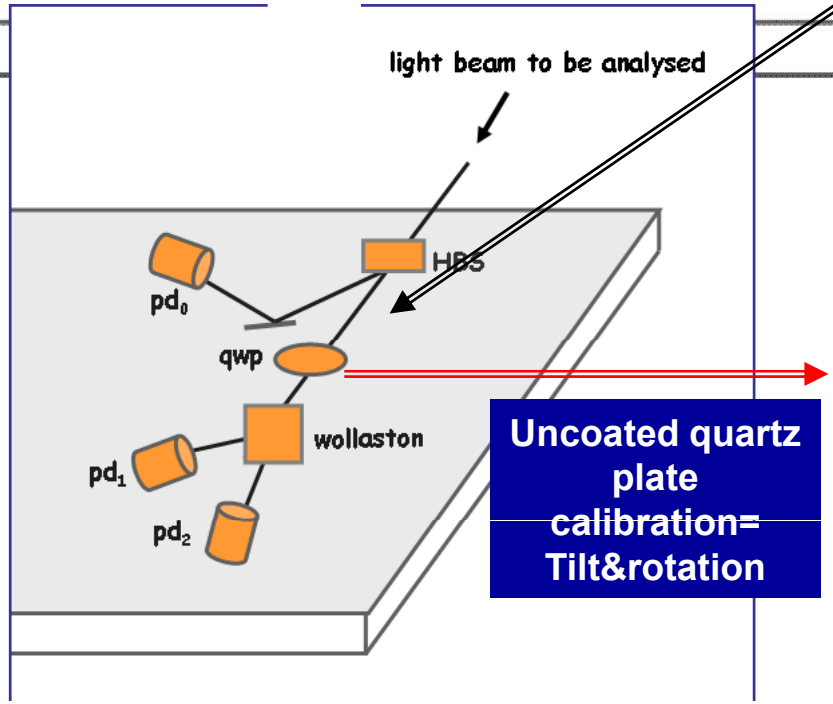
Upsala, Zomer

Polarimeter related work

- Detailed laser beam polarisation measurement and control with HERA cavity polarimeter
  - Document written by M. Jacquet➔Eurotev Note
  - Work inspired by SLAC SLD polarimeter studies and CEBAF polarimeter cavity studies
  - Use of an uncoated quartz plate to measure the laser beam polarisation
    - Reduction of systematics related to anti reflection coating
    - Checks of fitting procedure
  - Detailed systematics
    - On the models, e.g.:
      - effect of the optical activity in quartz plates
      - misalignments and study of parasitic birefringences
      - Use of optical theorems to model the optical beam line transport
    - On the measurements➔photodiode readout noise studies at HERA
- Result: systematics on the «degree of circular polarisation»≈0.5%
  - Dominated by the noise in photodiode readout ➔reducible to the 0.1% level

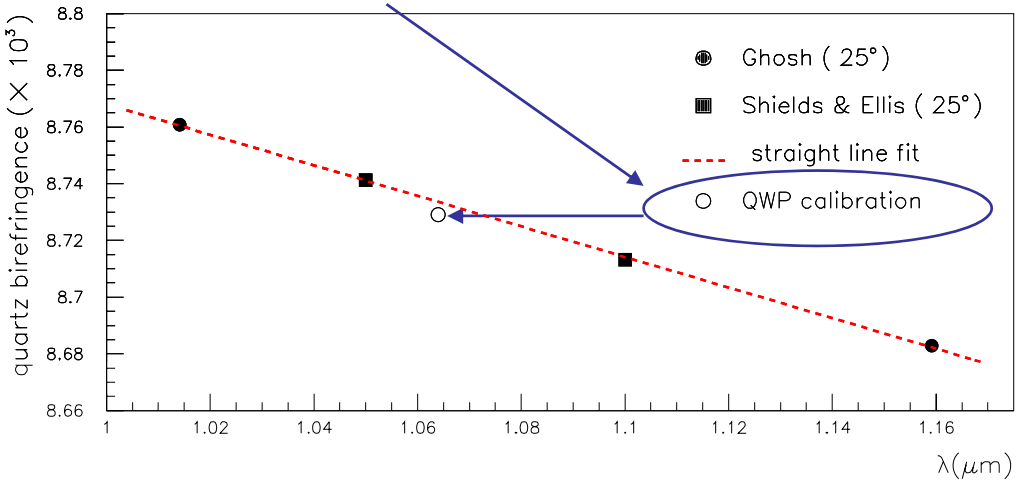
Simplifed optical scheme

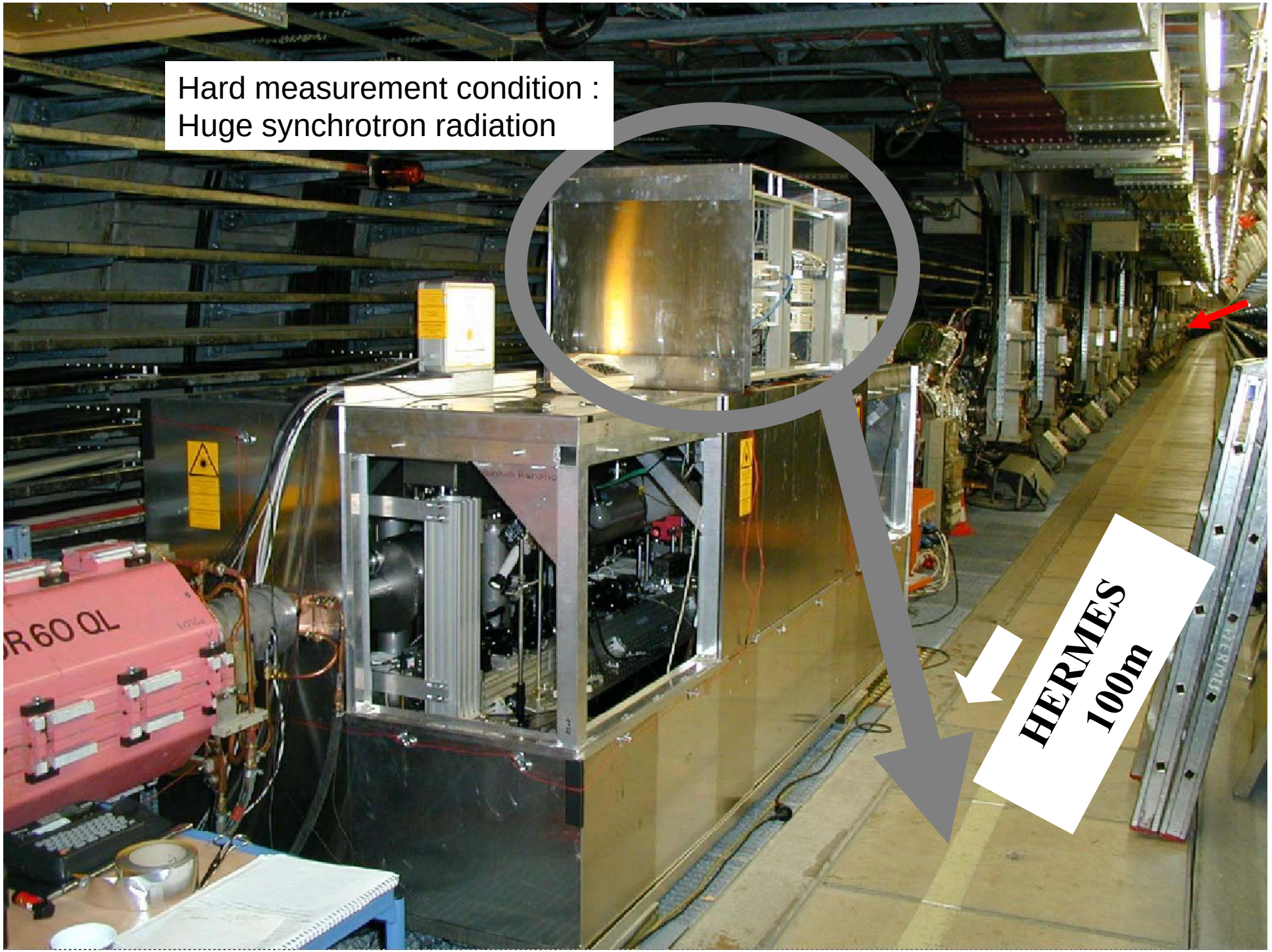


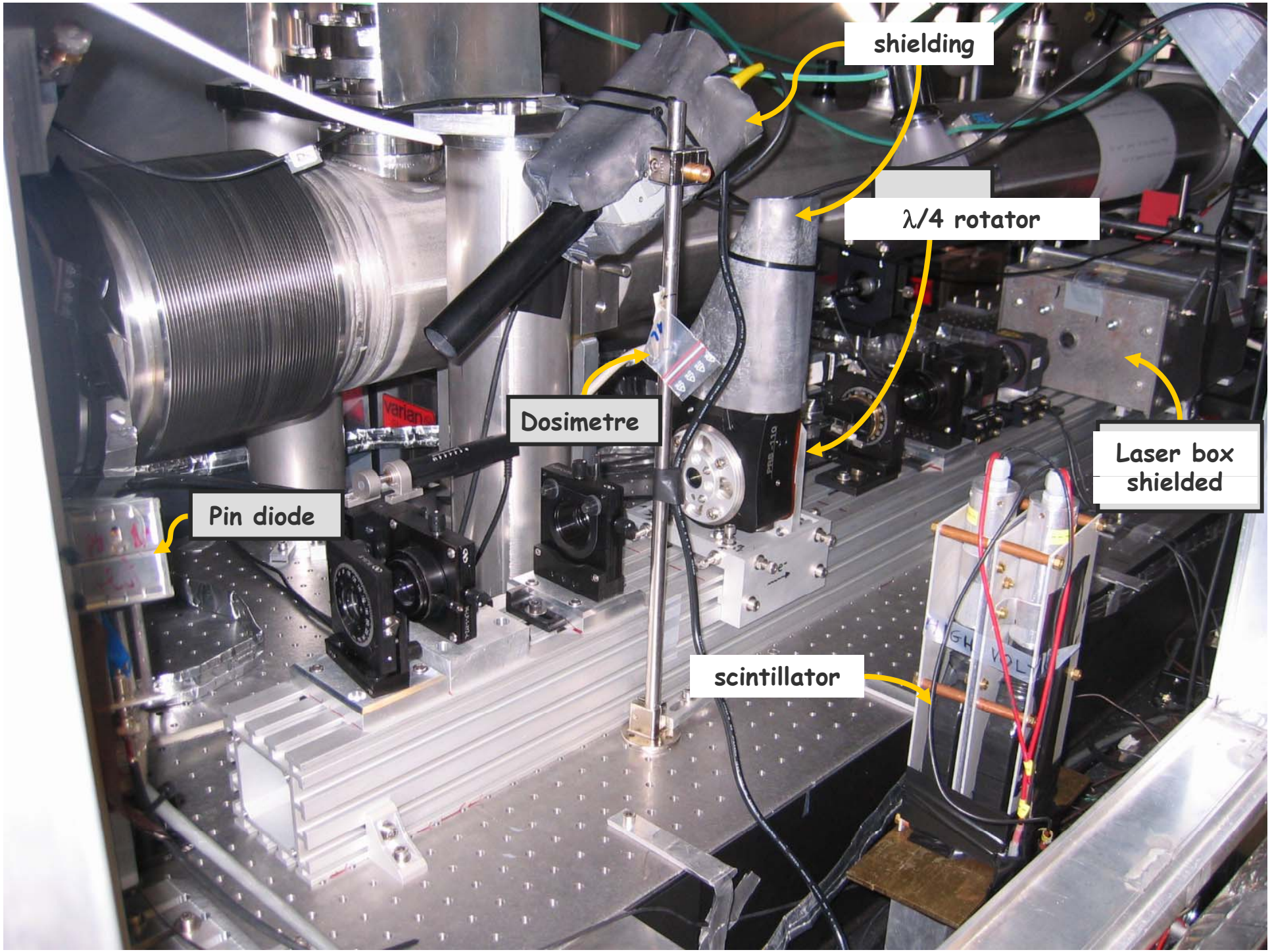


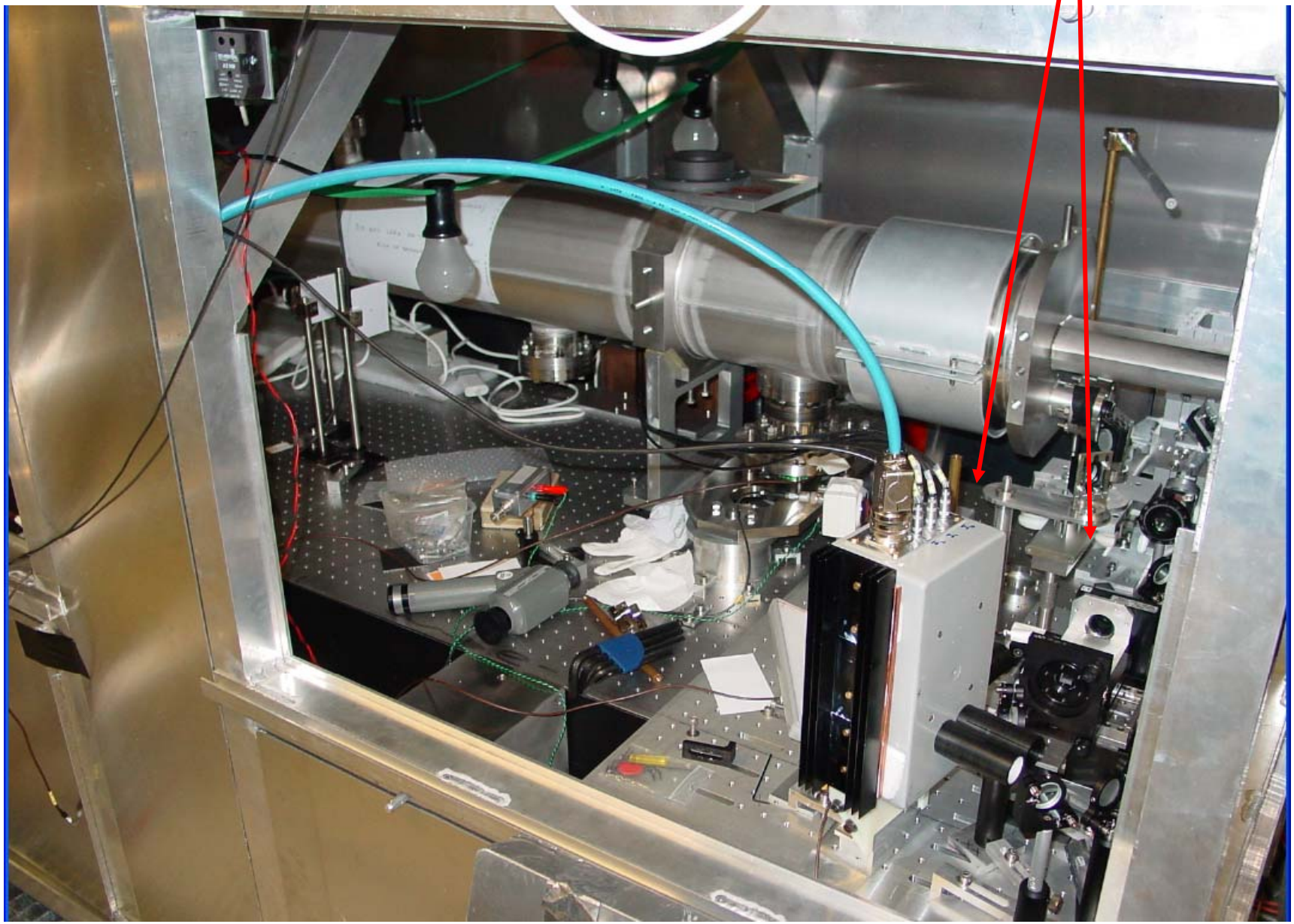
Uncoated quartz plate calibration= Tilt&rotation

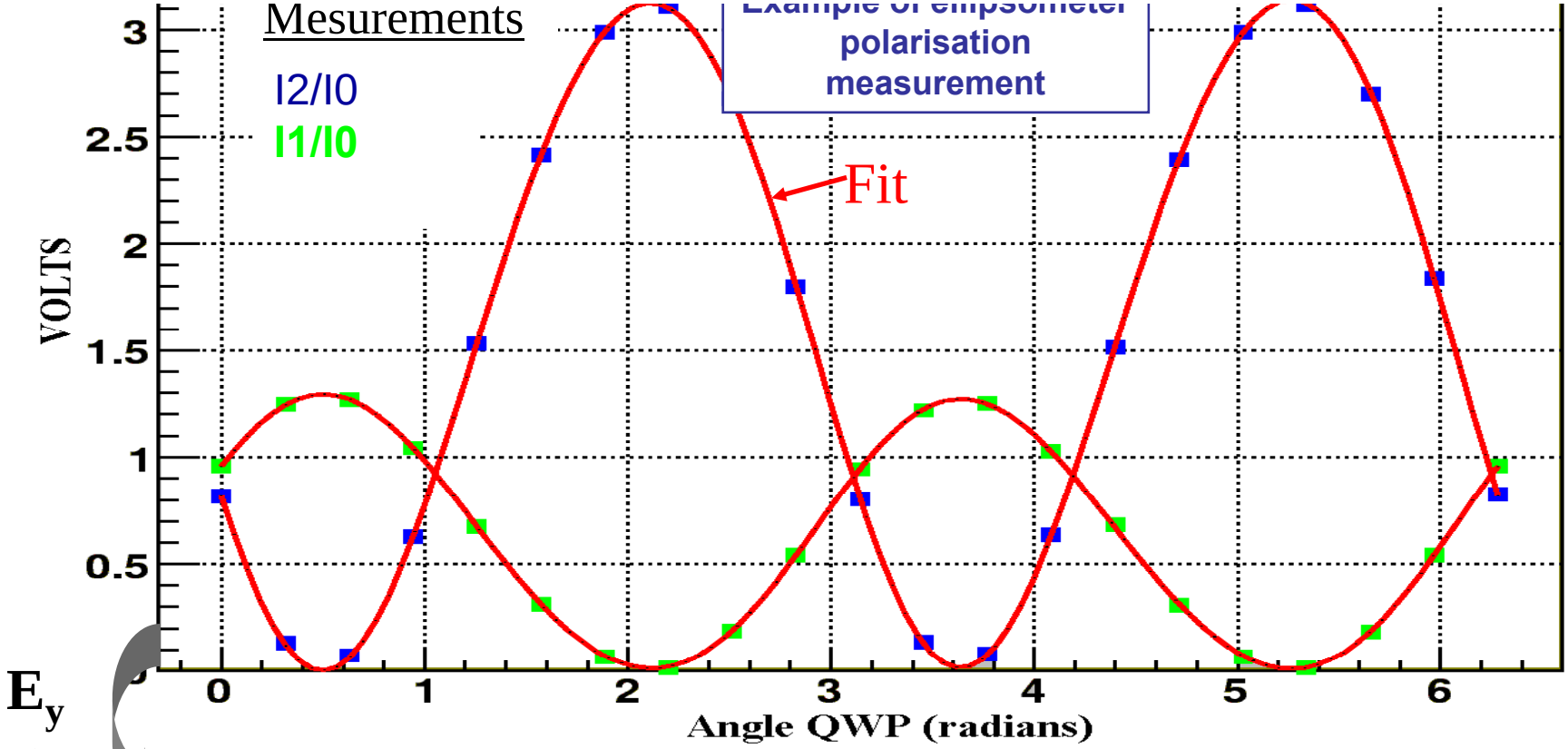
Δn determined at 10^{-6} level



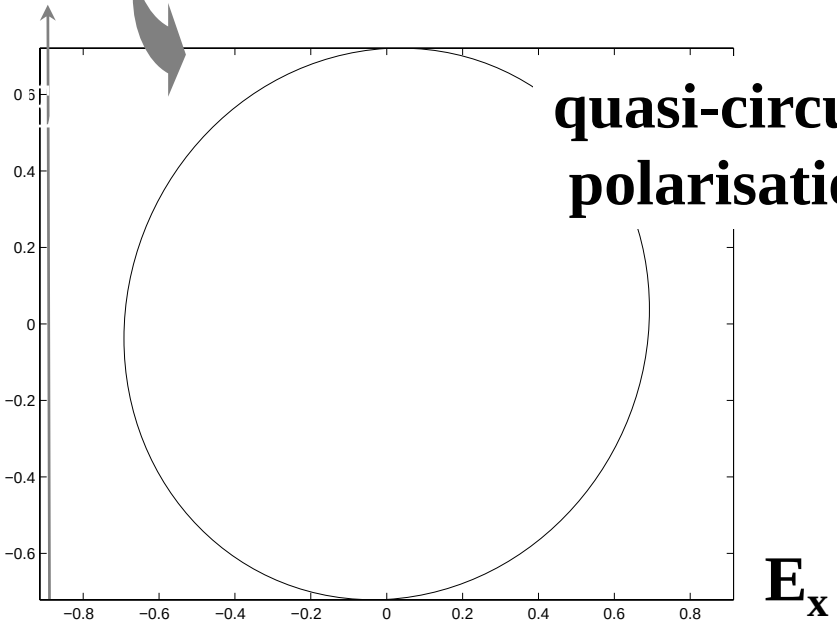

Hard measurement condition :
Huge synchrotron radiation
HERMES
100m


shielding
λ/4 rotator
Dosimetre
Laser box shielded
Pin diode
scintillator


ellipsometer

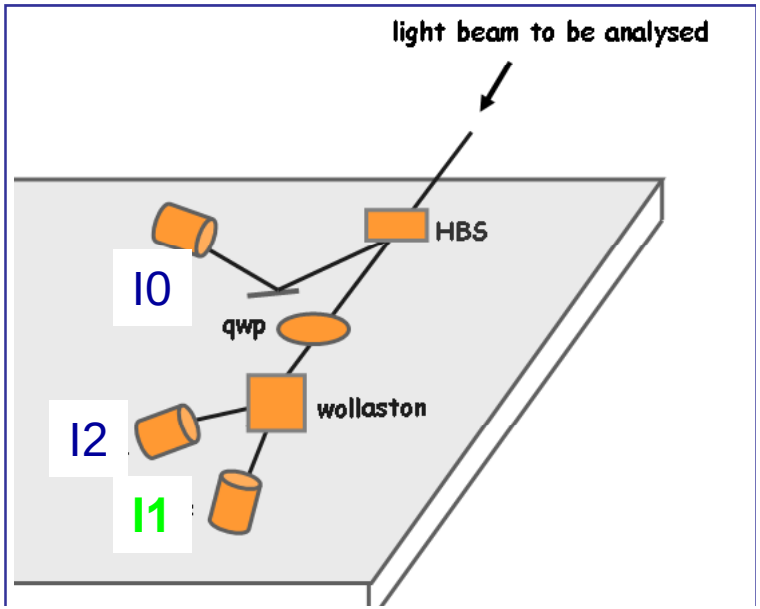


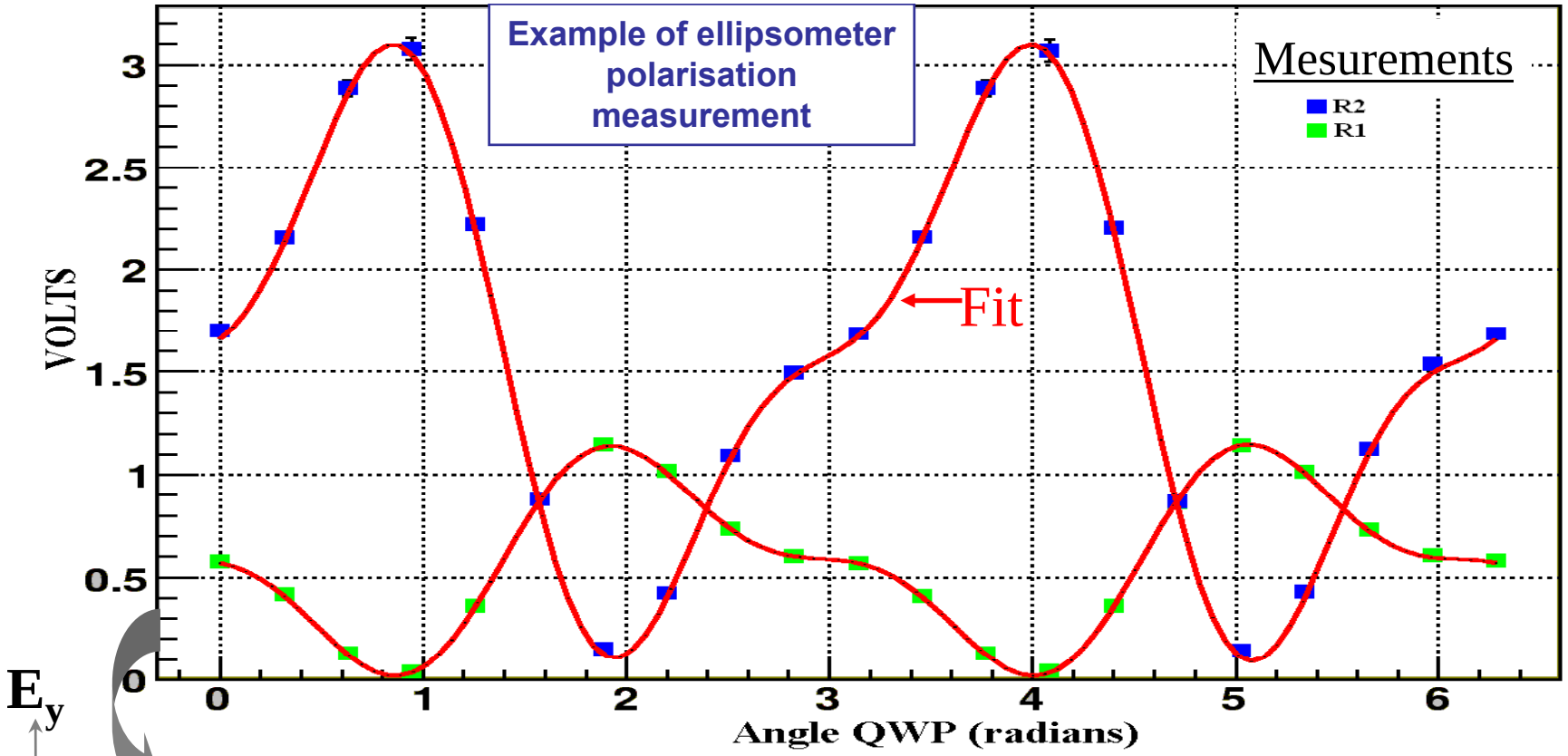
E_y

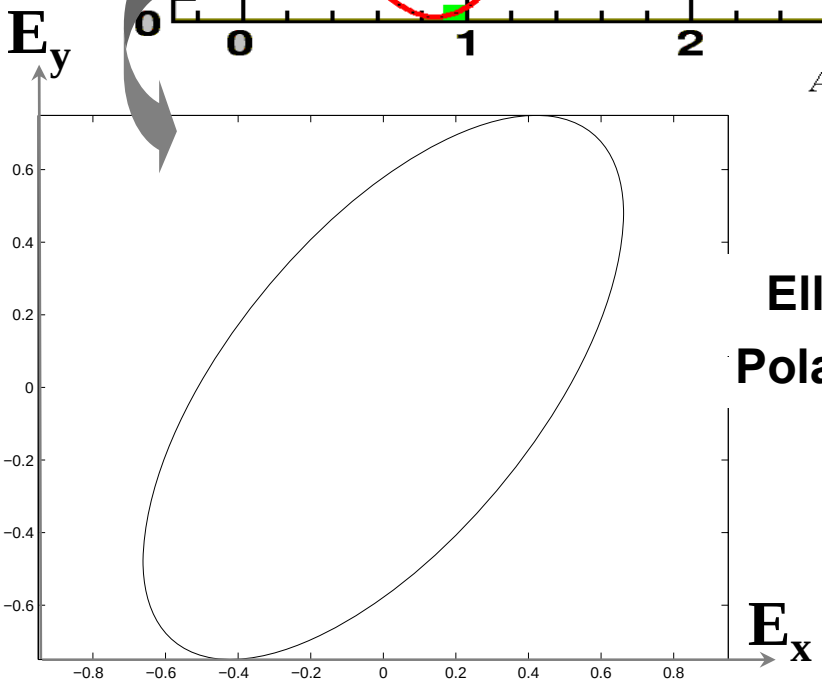


E_x

quasi-circulaire polarisation







Elliptical Polarisation

Laser source related work

- Fabry-Perot in pulsed regime cavity was envisaged for an ILC polarimeter
  - But new amplification techniques have appeared
    - See laser wire project which could fit for the polarimeter laser of *LC-DET-2001-047*

DEVELOPMENT OF A HIGH POWER FIBRE LASER FOR LASER BASED ELECTRON BEAM DIAGNOSTICS*

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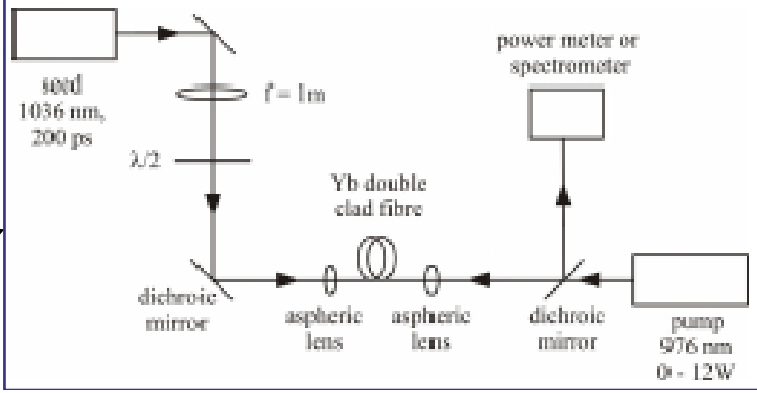
G.A. Blair, S.T. Boogert, John Adams Institute at Royal Holloway, University of London, Egham, Surrey TW20 0EX, UK

Table 1: Required laser parameters

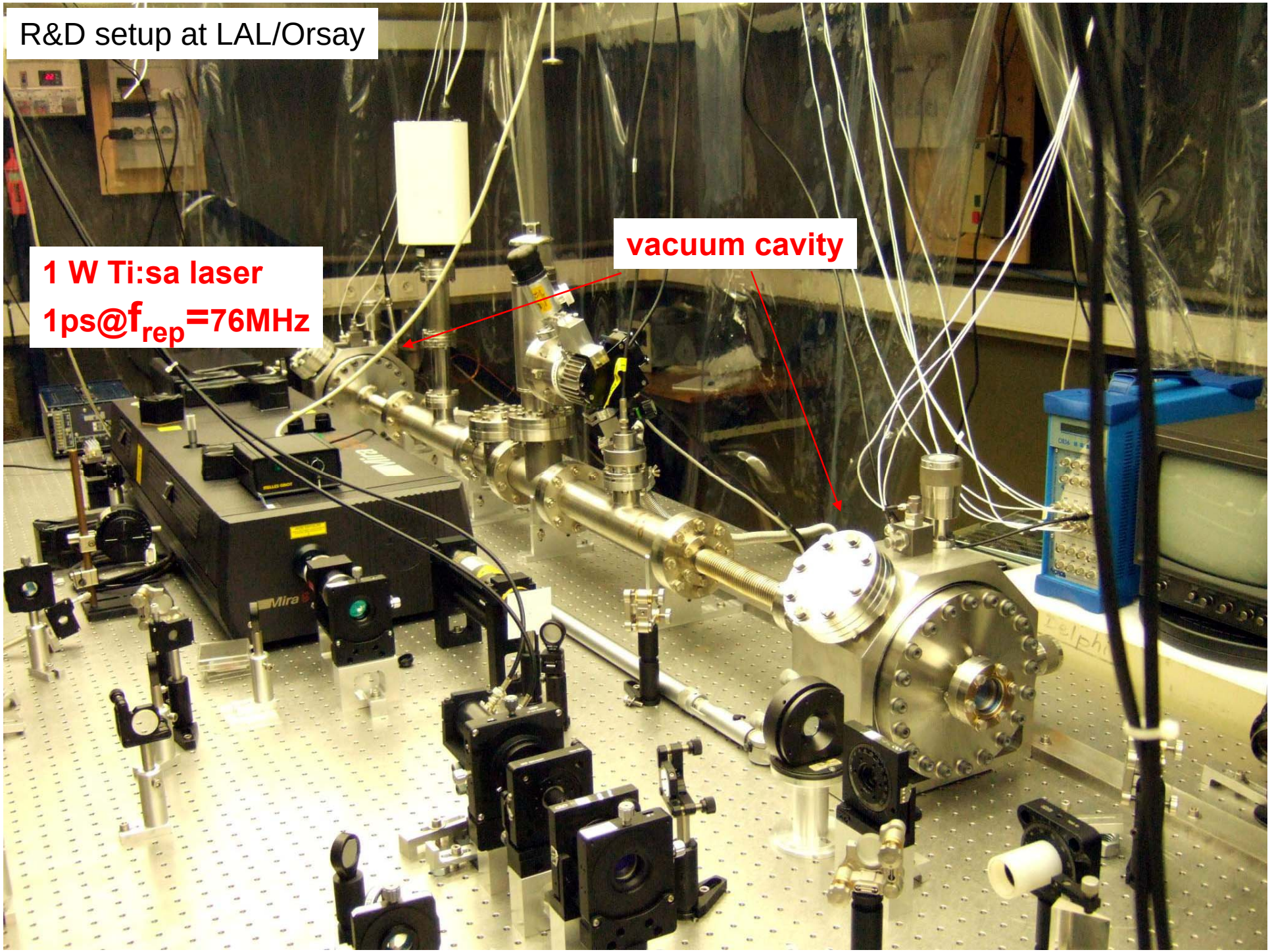
Parameter	Value
Repetition rate	6.49MHz
Pulse energy	50 - 100μJ
Pulse duration	~ 1ps
Beam quality	$M^2 < 1.1$
Wavelength	~ 500nm



- Meanwhile Fabry-Perot cavity in pulsed regime then appears
  - In the Compton e+ polarised sources for CLIC and ILC
  - For the gamma-gamma ILC option
  - In compact Compton monochromatic X-ray sources, with applications in the following fields :
    - Radiotherapy,
    - radiography, coronary angiography
    - nuclear waste management (Japanese project),
    - museum (*Le Louvre* project)

Status of the Fabry-Perot R&D

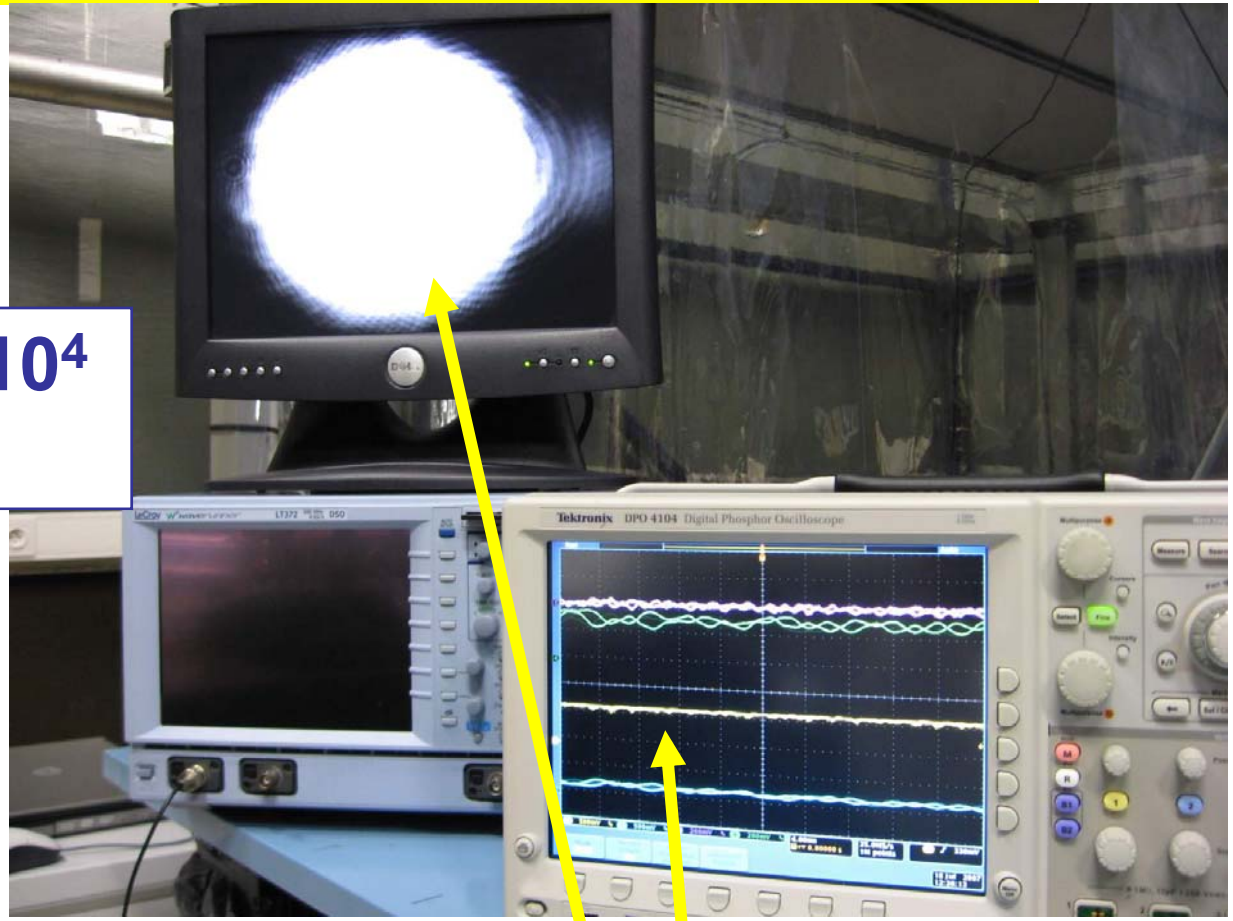
- Locking of laser to cavity
  - Numerical feedback achieved
  - Power Gain 1200 achieved in 2007
  - Power Gain 10000 currently under study
    - 2 publications to come (PRL?, Rev. Sci. Instr)
- Cavity geometry studies
  - 4 mirrors nonplanar design studies to decrease the laser beam waist while keeping power and circular polarisation stabilities: achieved
    - 1 publication in Appl. Opt.
    - 2 publications to come (Opt. Lett., Phys. Rev. E)
    - 1 Phd (octobre 2008)


R&D setup at LAL/Orsay
1 W Ti:sa laser
1ps@f_{rep}=76MHz
vacuum cavity

Status : Cavity locked (*low gain* ~1200)

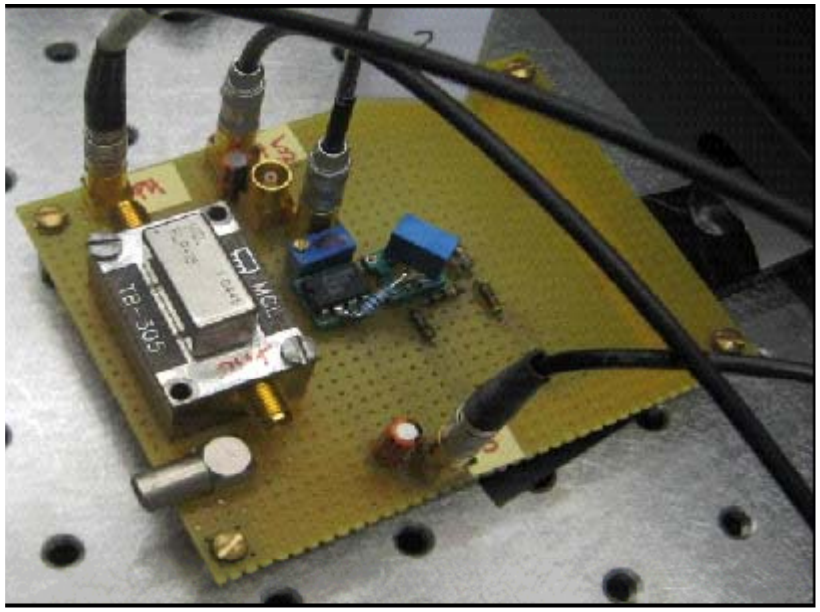
- **Digital feedback (VHDL programming) set up**
- **Already $\Delta f_{rep}/f_{rep} \sim 10^{-10}$ ➔ $\Delta f_{rep} \sim 76$mHz for $f_{rep} \sim 76$MHz**
- **New mirrors in june 2008 ➔ gains 10^4**

Locking with gain 10^4 expected end 2008

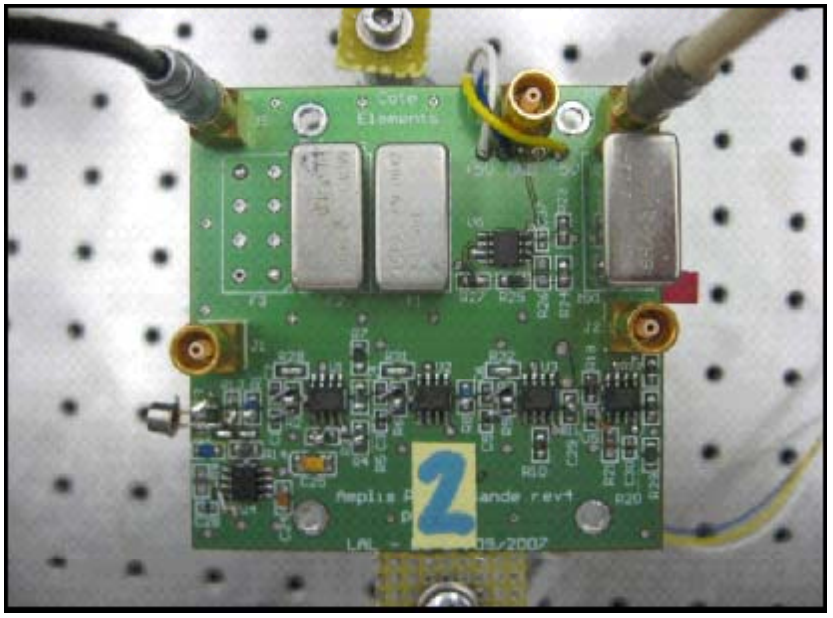


Cavity locked With gain 1200

Transmission Front-end
Pound-Drever-Hall Front-ends

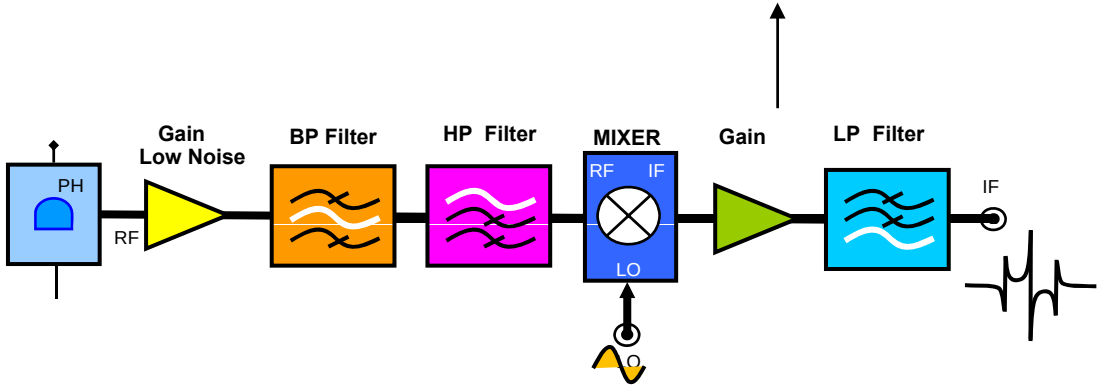


Transmission Front-end (prototype)



Pound-Drever-Hall Front-ends (prototype)

We are implementing digital mixer



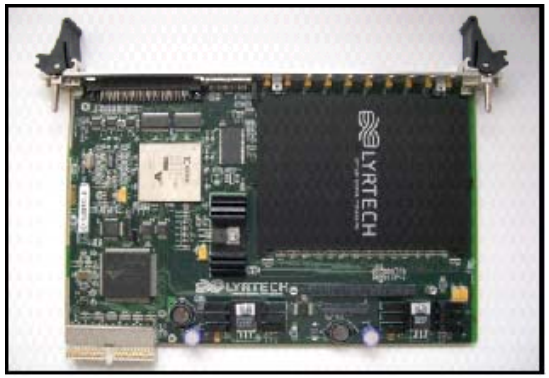
Digital Feedback System

LYRTECH DFS :

- 8 ADC channels
- Sampling @ 105 MS/s
- 14 bits resolution

- Virtex-II FPGA : XC2V8000
- Fixed point arithmetic
- 168 Multipliers 18b x 18b

- 8 DAC channels
- Conversion rate @ 125 MS/s
- 14 bits resolution



LYRTECH DAQ

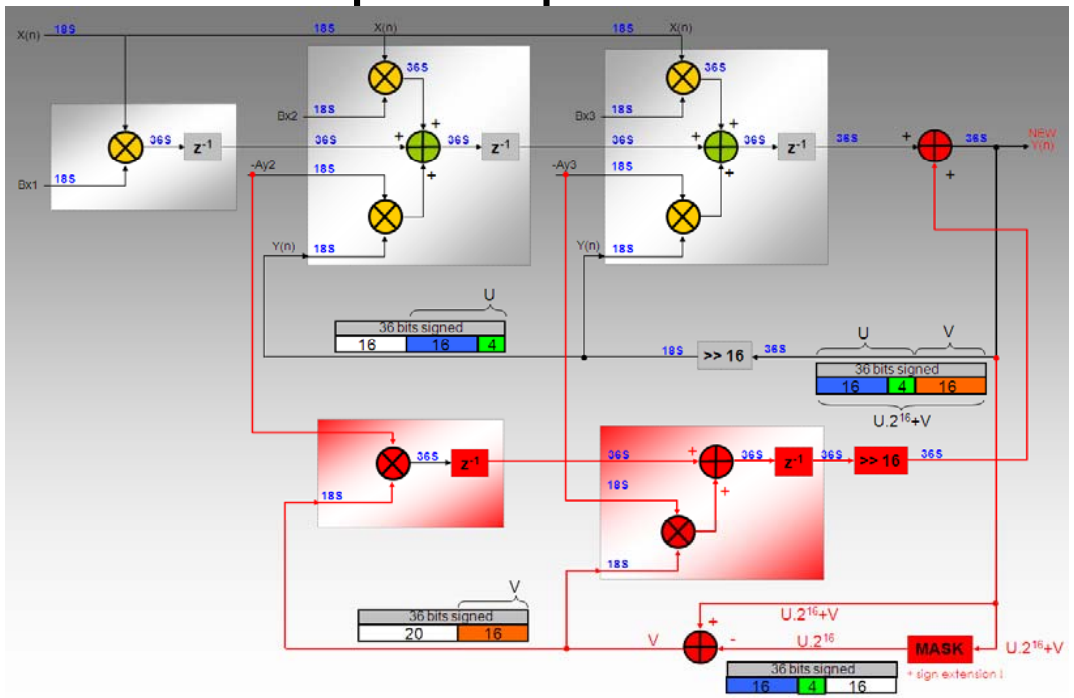
C++ GUI

Feedback System Issues

- Complexity: (10k C++ + 5k VHDL) code lines
- Xilinx firmware : long compilation time > 1h
- Locking Feedback: 3 Integrators + Adaptive Feedback Multiple In/Out Different Dynamic Ranges
- Fixed point computation : complex filter synthesis and implementation to achieve required precision

Second-Order-Section implementation with 18 bits Multipliers

Data path to increase loop computing precision to 36 bits



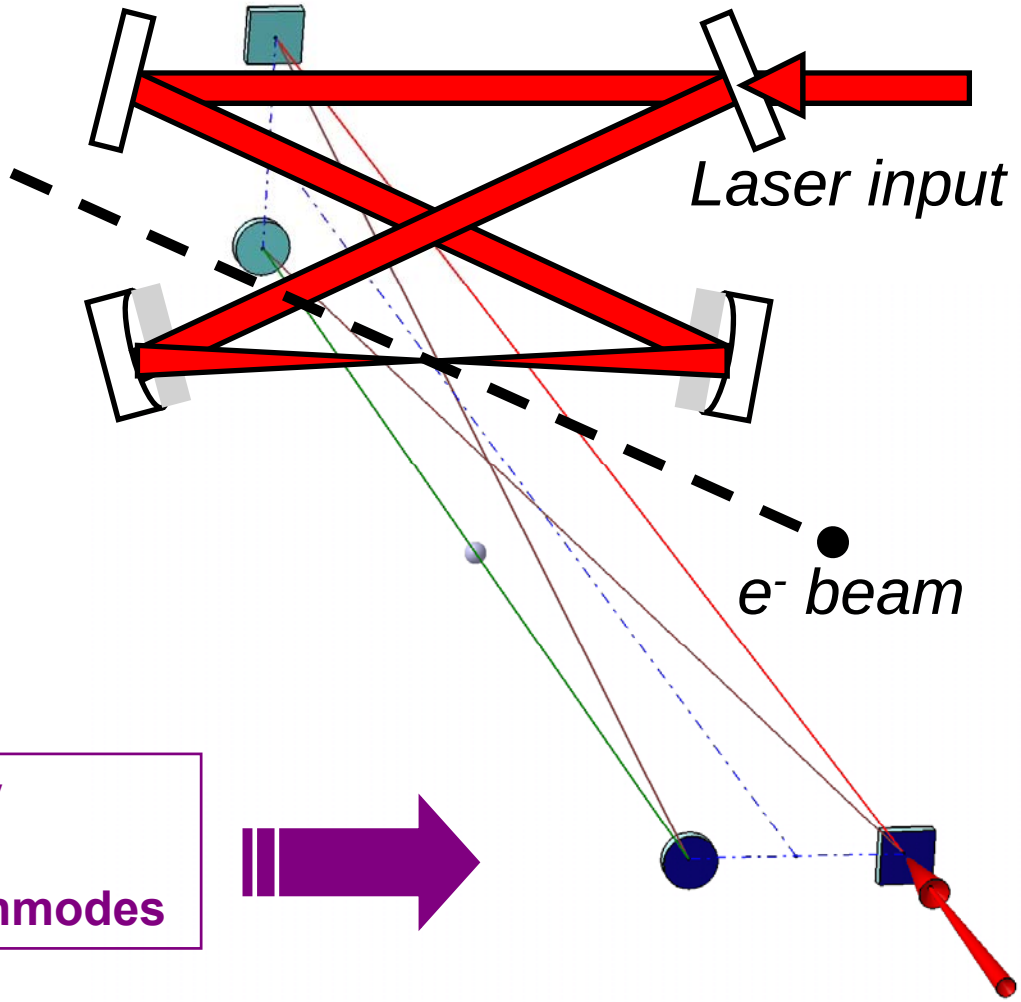
Small laser spot size

Small laser spot size &2 mirrors cavity ➔ unstable resonator (concentric resonator)

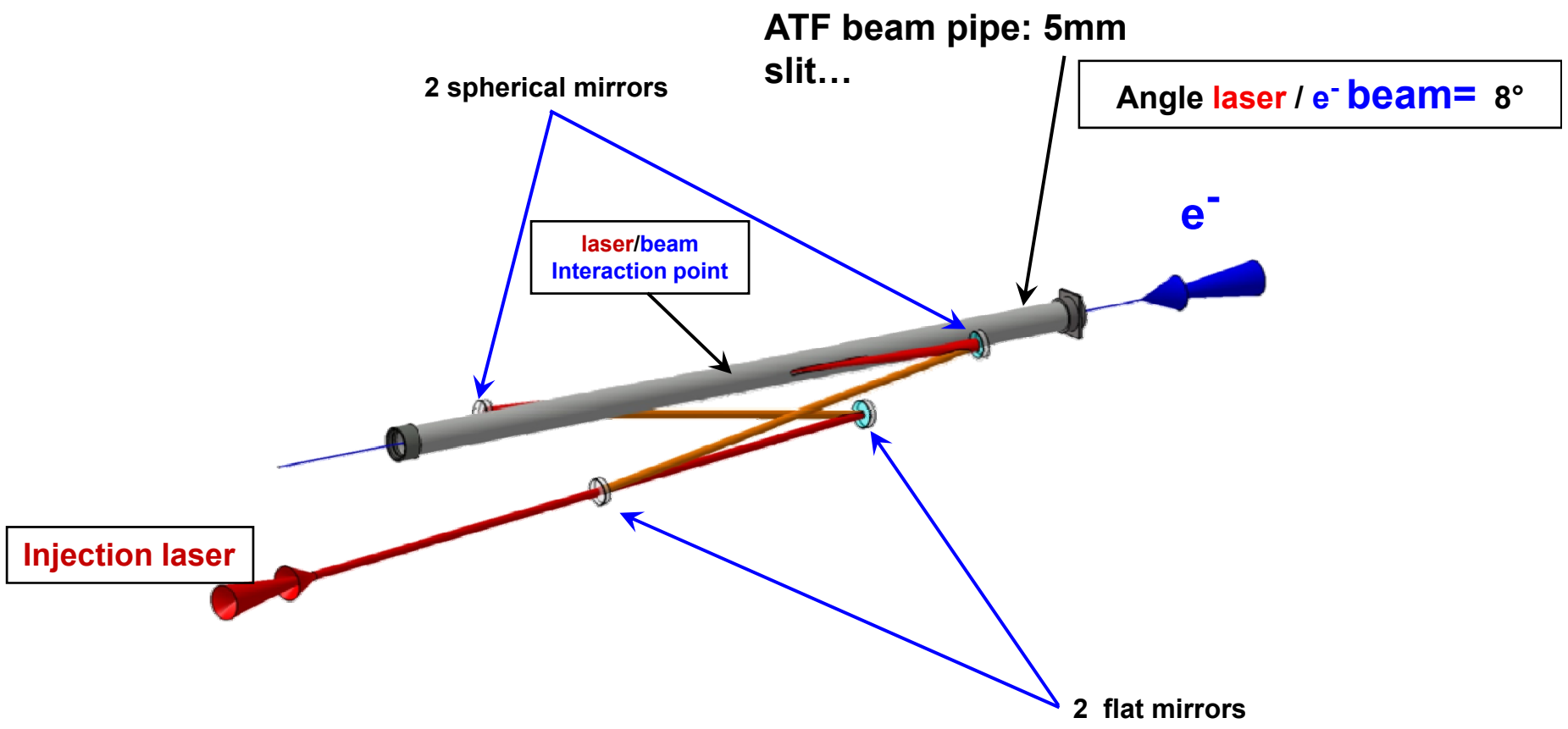
Stable solution: 4 mirror cavity as in Femto lasers

BUT➔ astigmatic & linearly polarised eigen-modes

Non-planar 4 mirrors cavity ➔Astigmatism reduced & circularly polarised eigenmodes

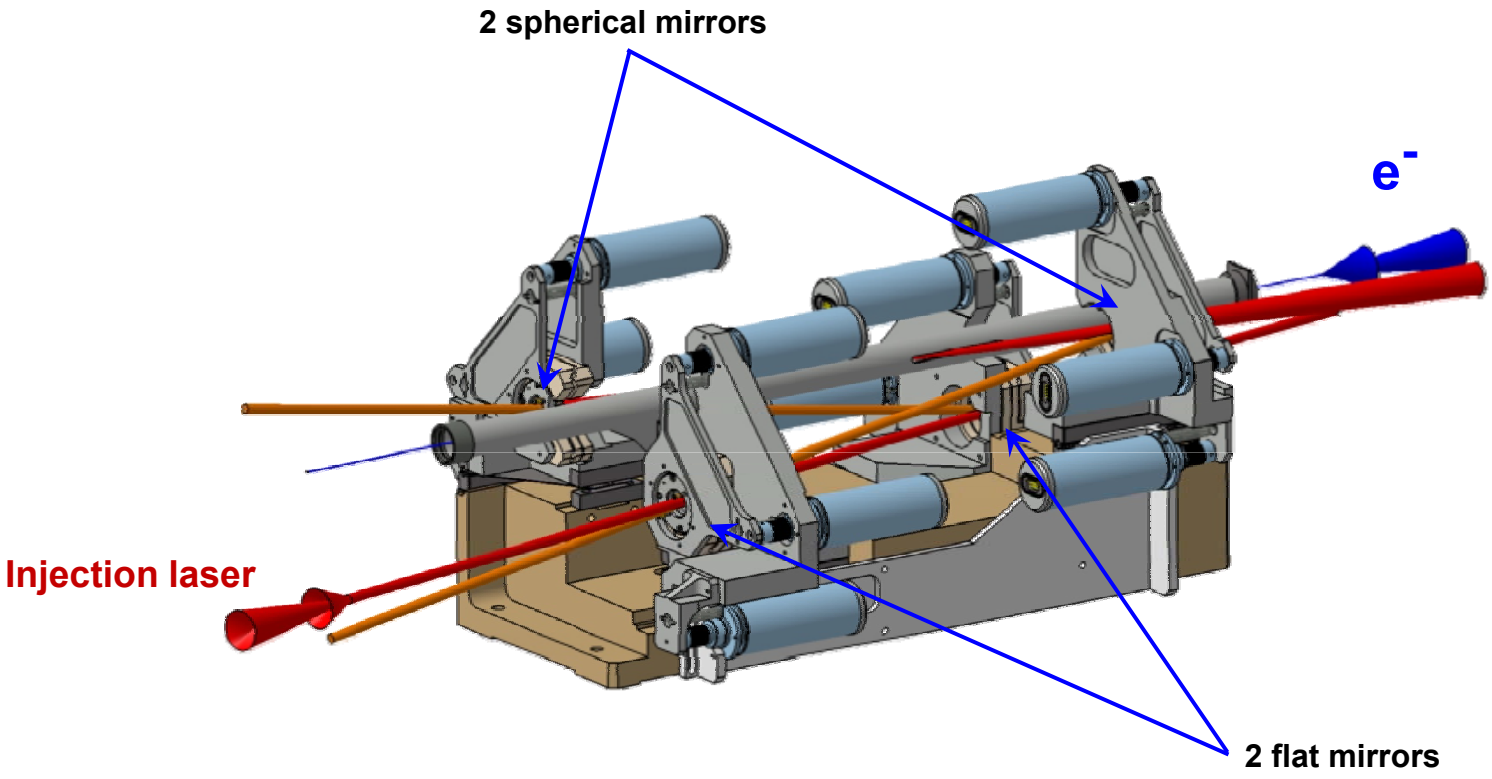


4 mirror cavity for KEK

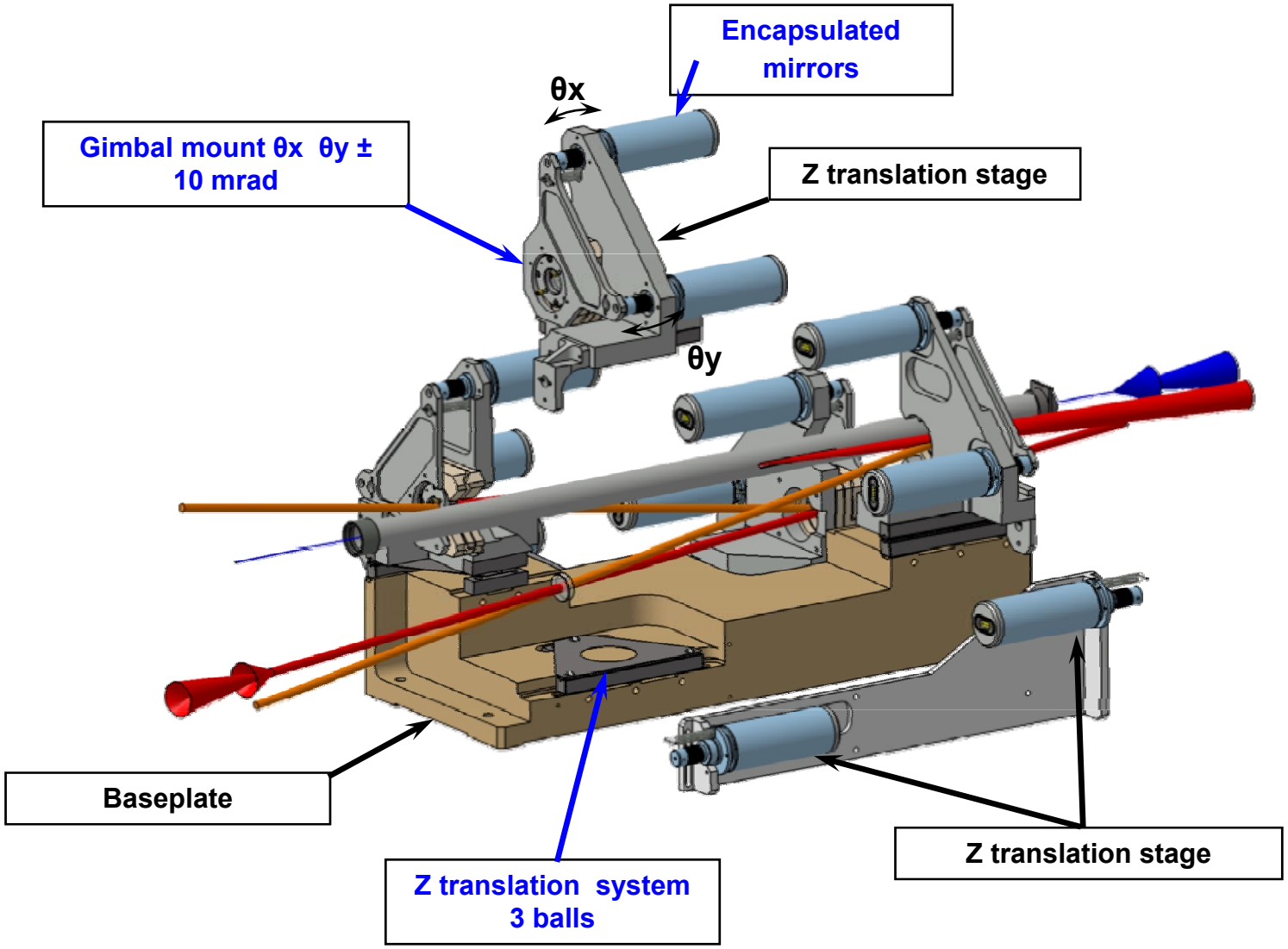


4 mirror cavity for KEK

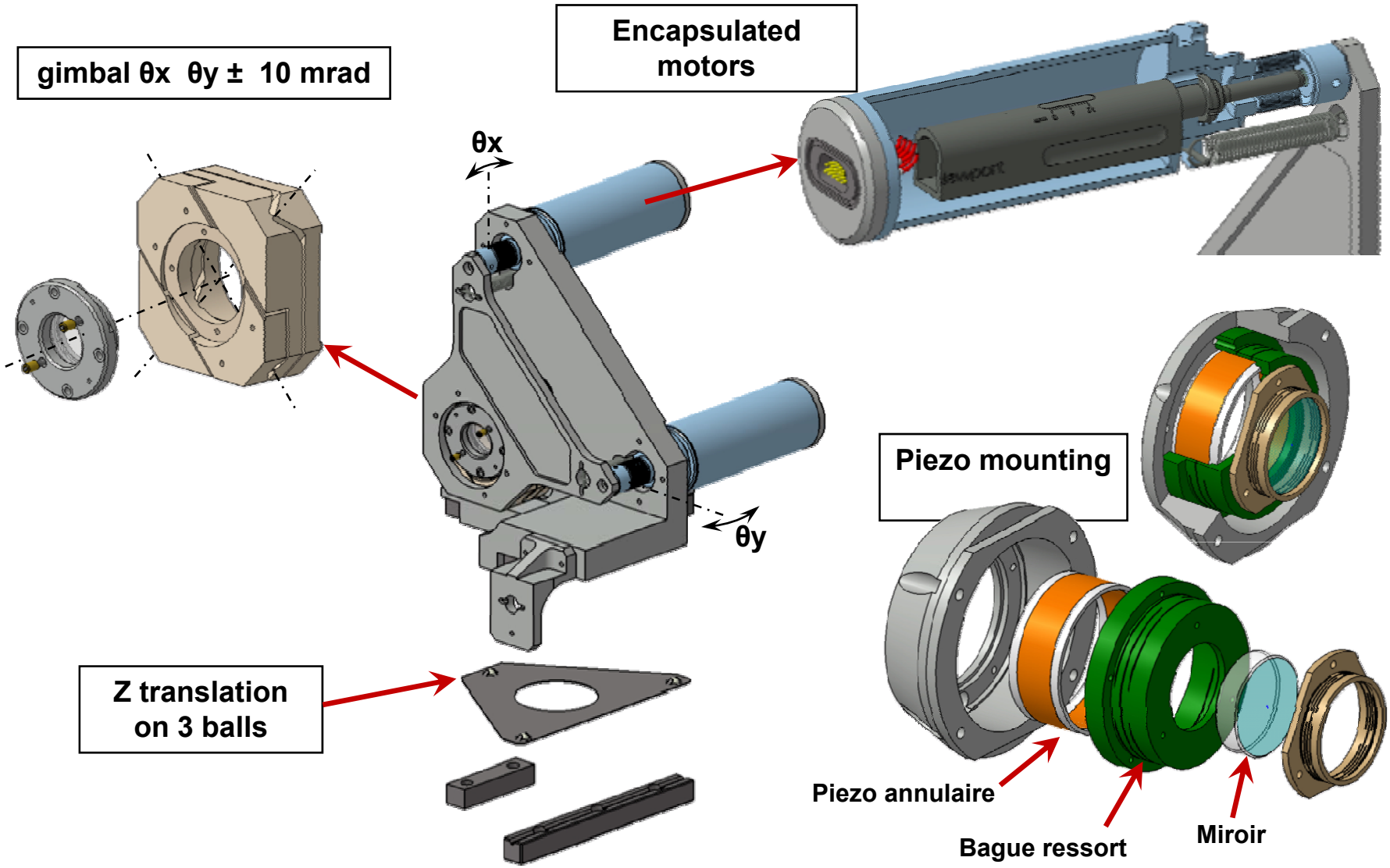
Mirror positioning system



Specific design studies

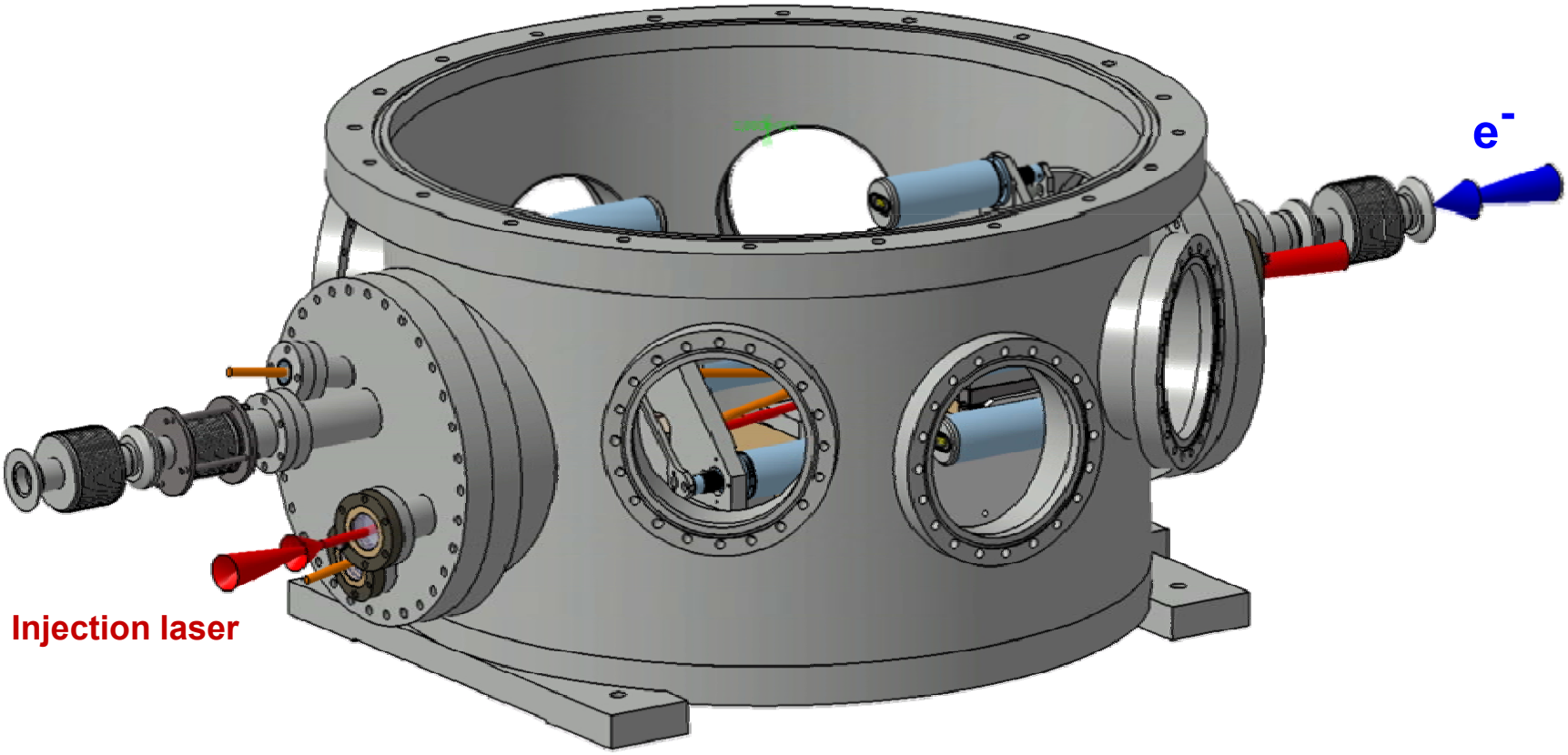


Specific design studies

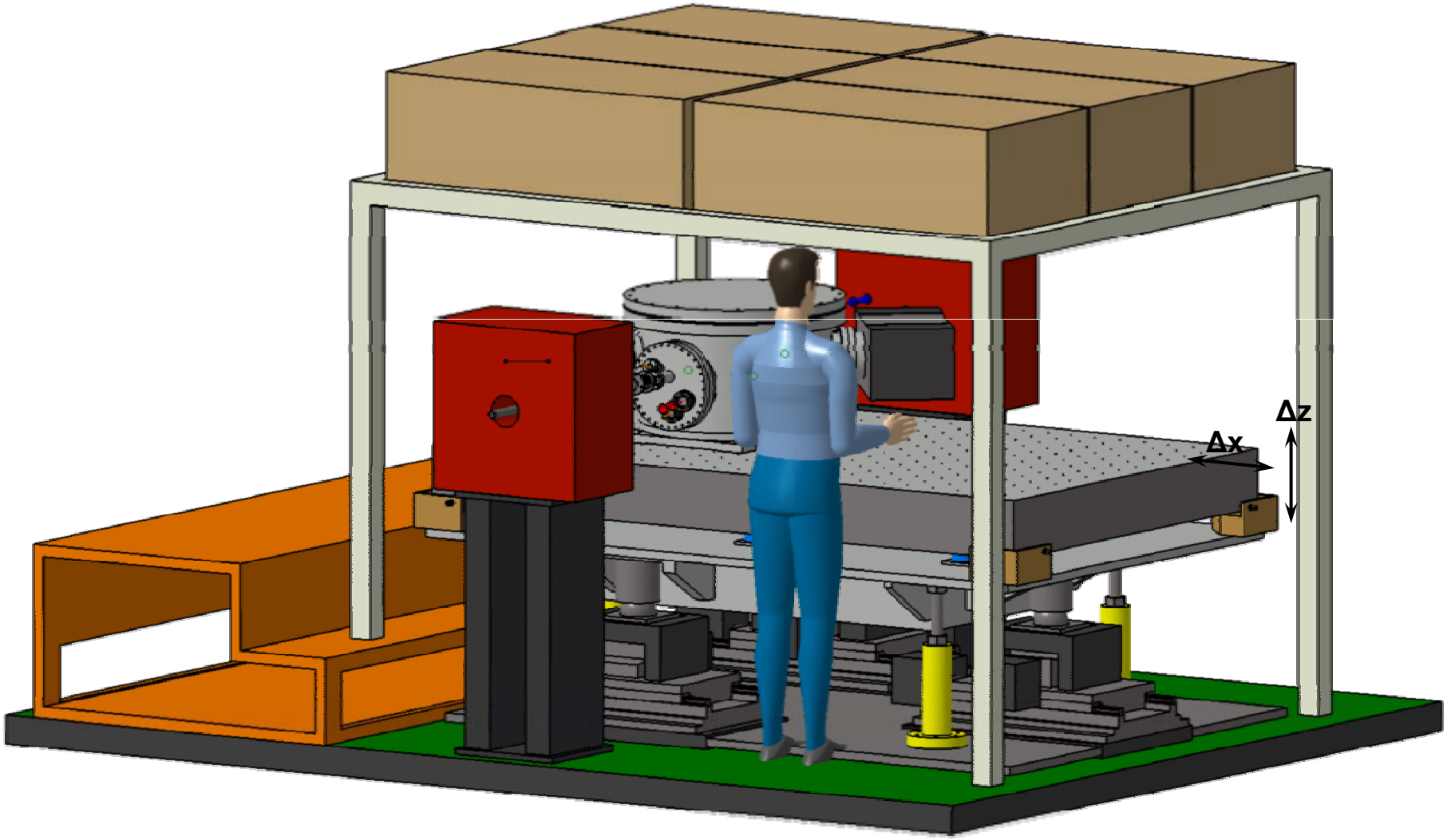


Protoype and vacuum tests of all elements undergoing

Vacuum vessel for KEK



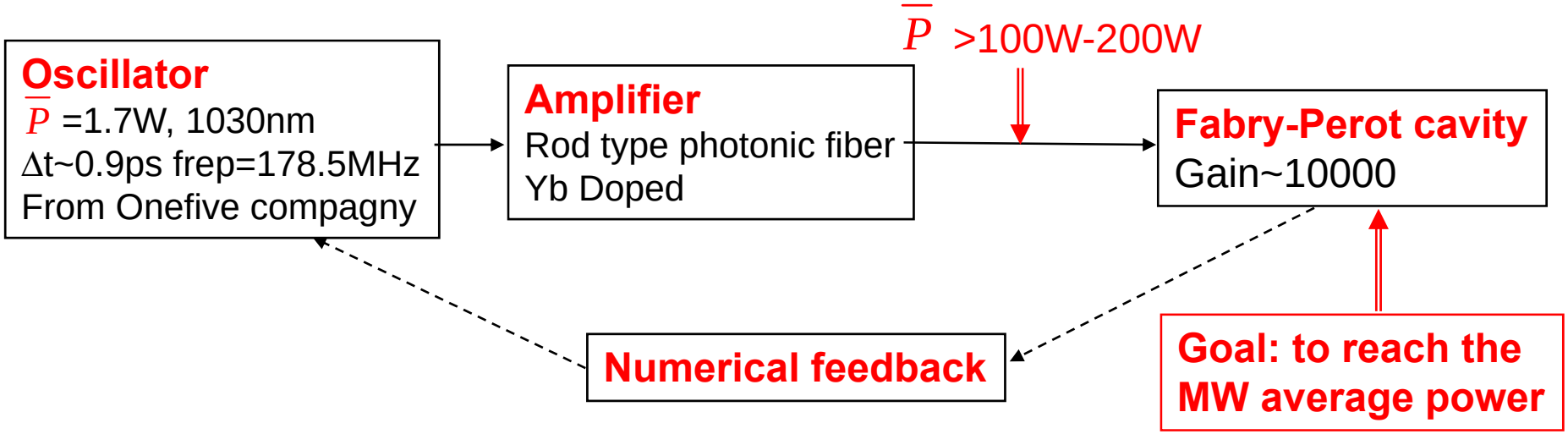
Implantation at ATF



Continuation of the R&D will start 2009

thanks to French ANR fresh funding

1. Setup the following system at Bordeaux/Orsay



2. Installation of the system at ATF/KEK, Collaboration with ATF group

Summary

- Work on the HERA polarimeter to study systematics related to the determination of the degree of circular polarisation of the laser beam
  - Report written by M. Jacquet
- Cavity locked in pulsed regime with gain 1200
  - Locking with cavity gain 10000 expected end 2008
    - Technically difficult & we have been delayed by asbestos pb (➔building new clean optical room during winter 2007-2008…)
- Cavity geometry design studies to reduce the laser beam waist achieved
  - Prototype and tests under construction/realization
- This R&D will go on at KEK/ATF