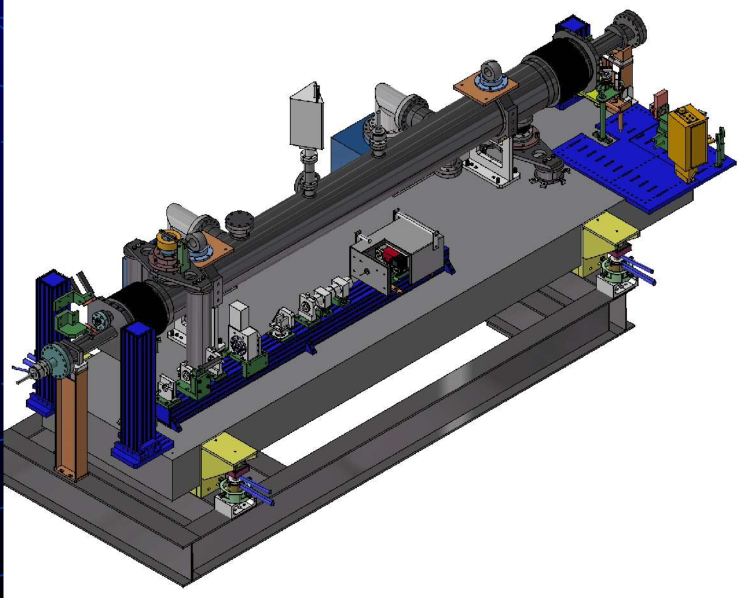
Polarimetry at HERA

- Polarisation
  - Why do we need electron polarisation?
  - How do one obtain polarised electrons?
- Polarisation at Hera
  - How does it work at Hera?
  - Polarisation variations.
  - Which polarimeter?
- New Cavity Lpol
  - Principle
  - Optics
  - Running in 2003-2004



<u>Why do we need to have electrons Polarised ?</u>

Physics interests.

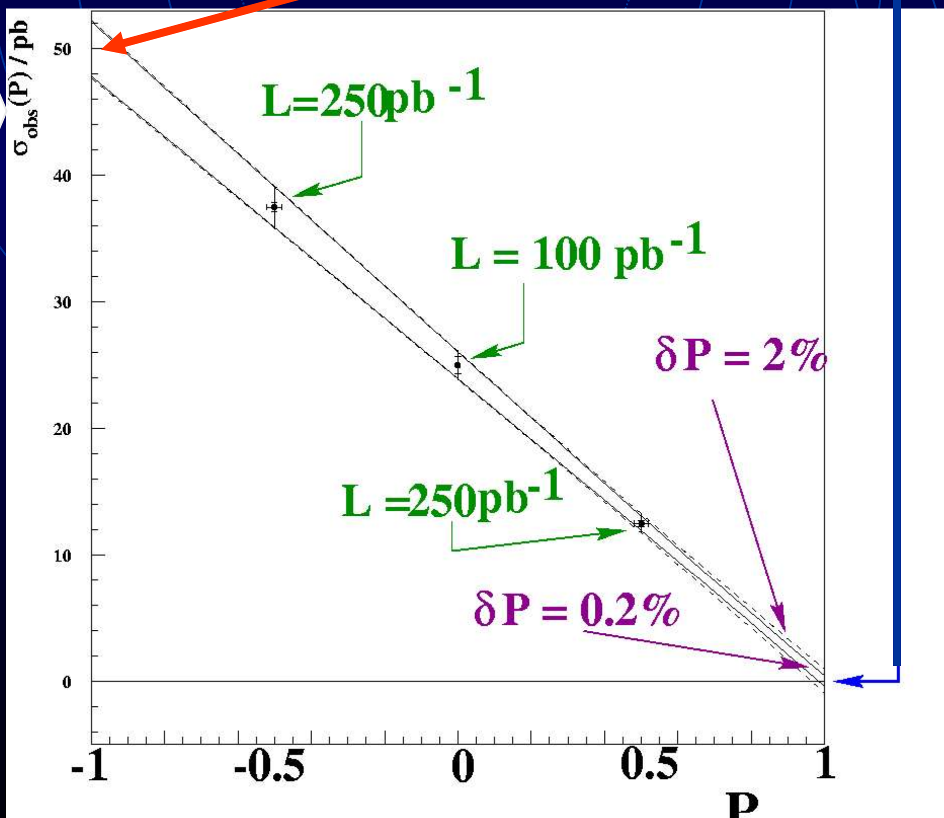
Physics interests (Not exhaustive)

Physic beyond standard model:

Standard Model

Beyond SM

$$\sigma^{e-}_{obs,CC}(P) = \frac{1-P}{2}\,\sigma^{e-}_{CC} + \frac{1+P}{2}\,\sigma^{e-}_{RH}$$



Electroweak physics:

- NC -> qZ couplings : v_q, a_q.
- CC -> W boson (propagator) mass

Precision Measurements (QCD):

- CC & NC very sensitive to P_e (e-polarisation) at high Q².

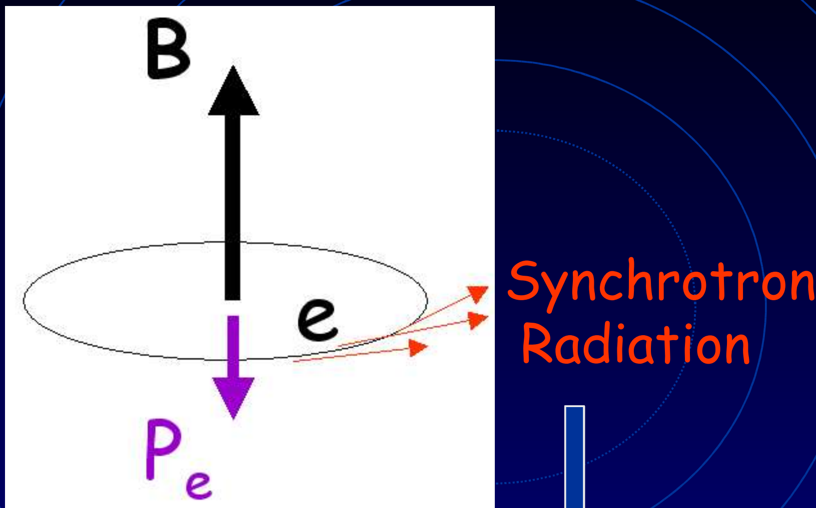
  -> Parton densties at large x

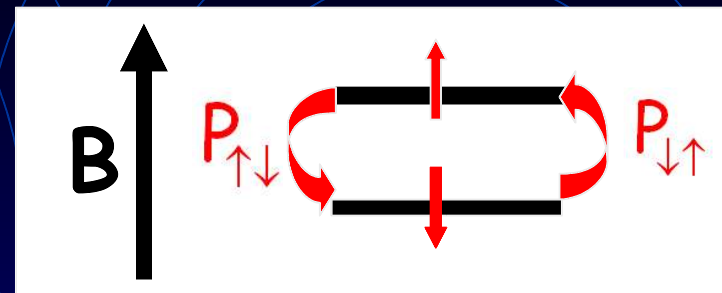
Necessities to measure P_e at the per mil precsion

How do one obtains polarised electrons?

Just leave them!

Natural electron polarisation.





$$P_{\uparrow\downarrow} \neq P_{\downarrow\uparrow}$$

Sokolov Ternov Effect

Natural Electron Polarisation

$$P_e = P_{ST}\left(1 - e^{-t/\tau_{ST}}\right)$$

τ_{ST} 40 mn

P_{ST} 92 %

In a perfect (flat) ring with a stationary B field electrons are polarised by synchrotron radiation

How does it works at HERA?

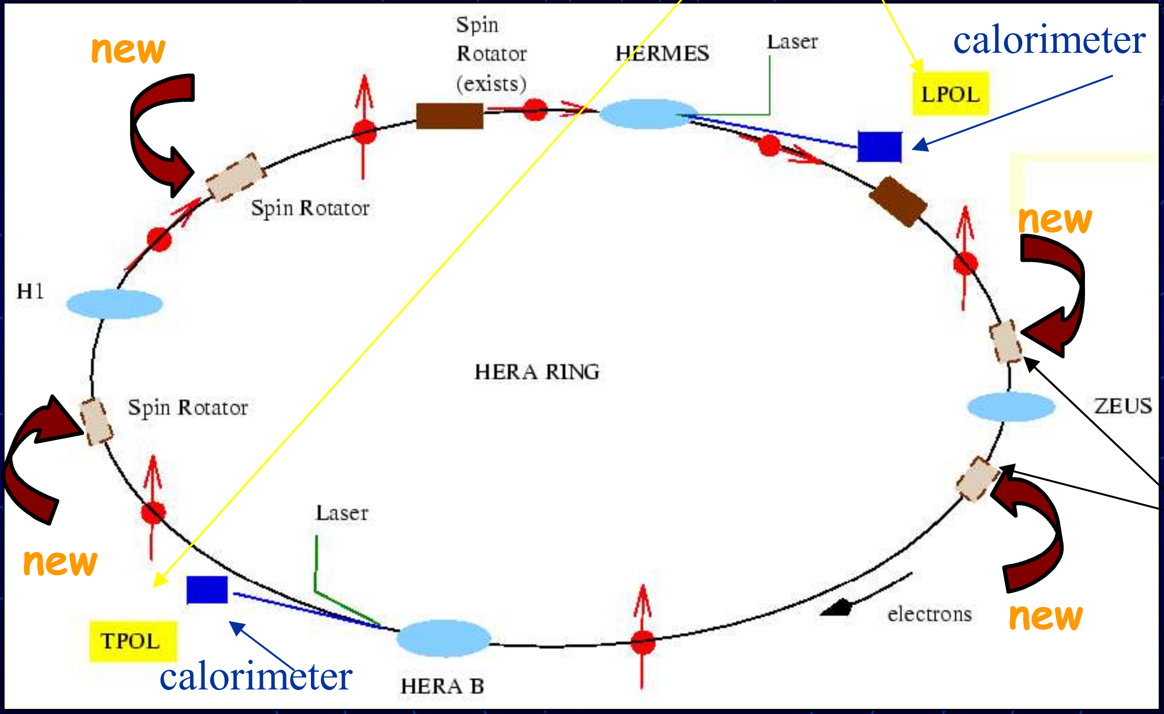
Polarimetry @ HERA.

Measure of the polarisation → Polarimeter

New cavity LPOL after upgrade.

•Longitudinal P_e @ Hermes since 1995

•@ H1& Zeus after upgrade



Spin rotator for longitudinal P_e

There are 3 polarimeters in HERA ring: 1 TPOL, 2 LPOL

Principle of the longitudinal polarisation mesurment

Conpton scattering:

$e+\gamma \rightarrow e+\gamma$

Cross Section:

$d\sigma/dE_\gamma = \sigma_0(E_\gamma) - P_e S_\gamma \sigma_1(E_\gamma)$

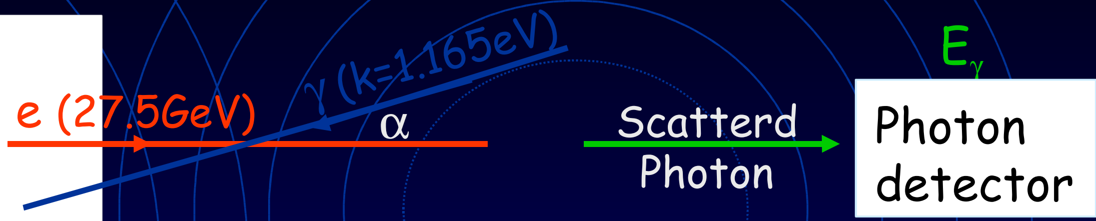
σ_0, σ_1: known (QED)

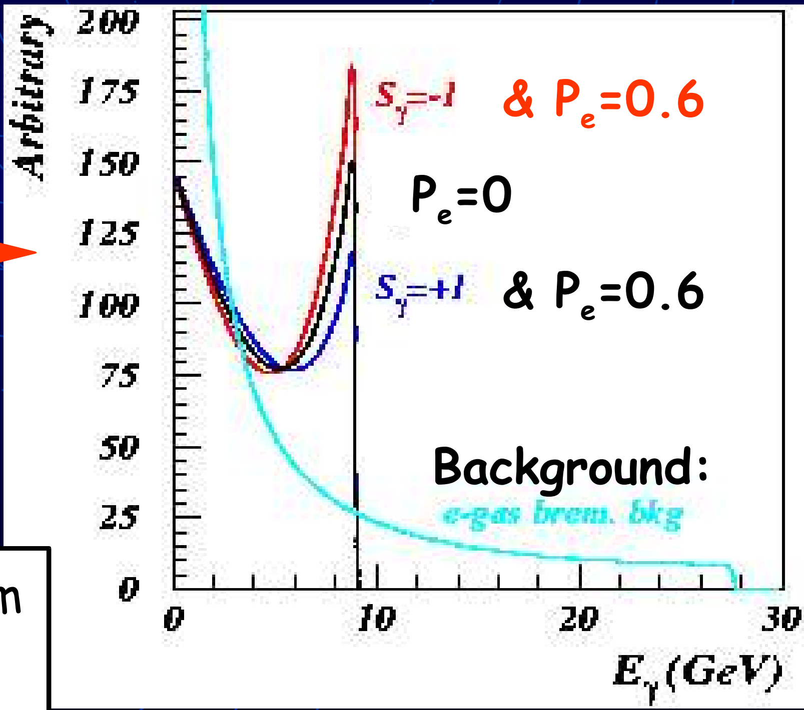
P_e: e- Polarisation determined by fitting

S_γ: Polarisation degree of the laser beam (+-1)

Luminosity (electron-laser):

$$Lumi \propto \frac{\lambda P_L I_e}{\alpha \sqrt{\sigma_{e,y}^2 + \sigma_{\gamma,y}^2}}$$





I_e: intensity e- beam

P_L: laser power

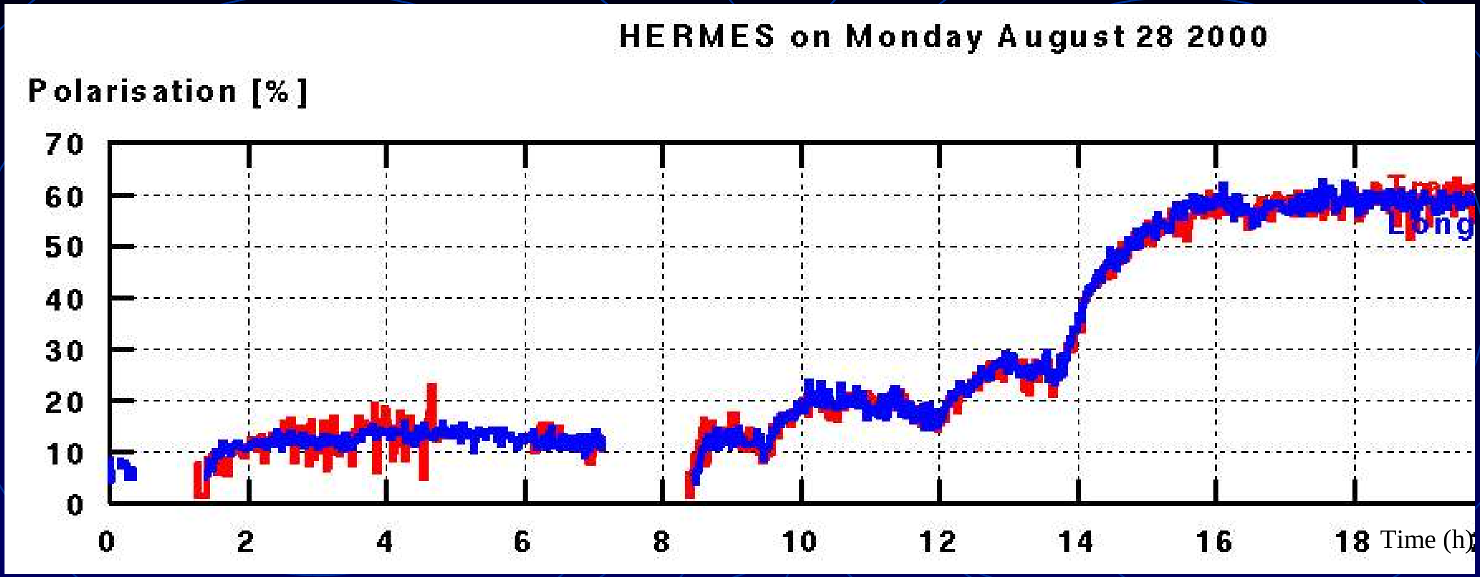
λ : laser wavelength

α : crossing angle

Polarisation variations

Evolutions of the polarisation.

Polarimetry @ HERA.



Polarisation optimised by harmonic bumps:

•Steering by « hand » of 8 dedecated correction coils (magnets).

•Need an automatic procedure to better optimise the polarisation (It 's getting hot in the control room)

Need a Fast and precise polarimeter 1%/bunch/min

Which polarimeter can achieve this precision?

The new cavity Lpol

The existing polarimeters.

TPOL :

- west area
- continuous laser (10W)
- 0.02 evts/bunch

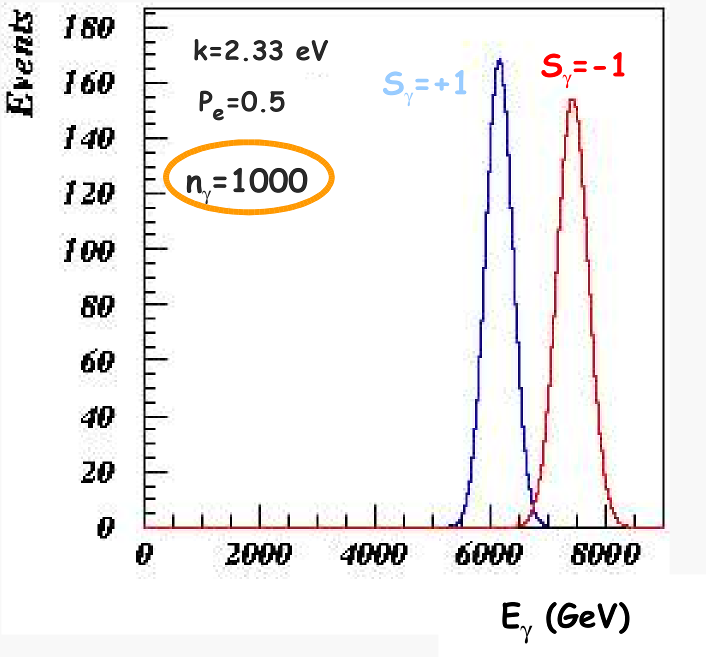
dP/ P ~ 1%

	TPOL	LPOL
Σ bunch	1 min	2 min
1 bunch	15 min	>30 min

LPOL :

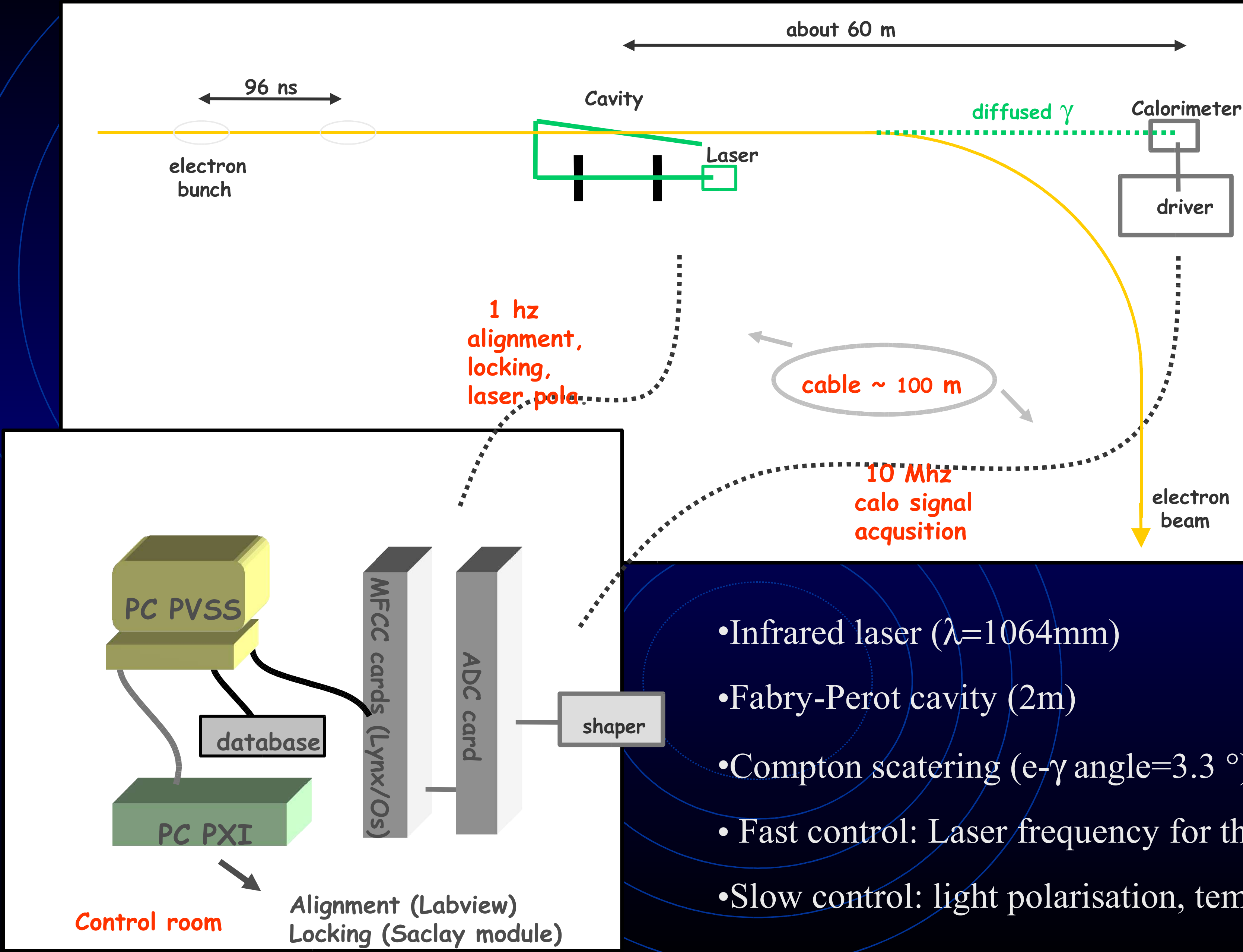
- east area (HERMES)
- pulsed laser (100 Hz)
- multi-photons mode

$$P_e \sim \langle E \rangle_{s=+1} - \langle E \rangle_{s=-1}$$



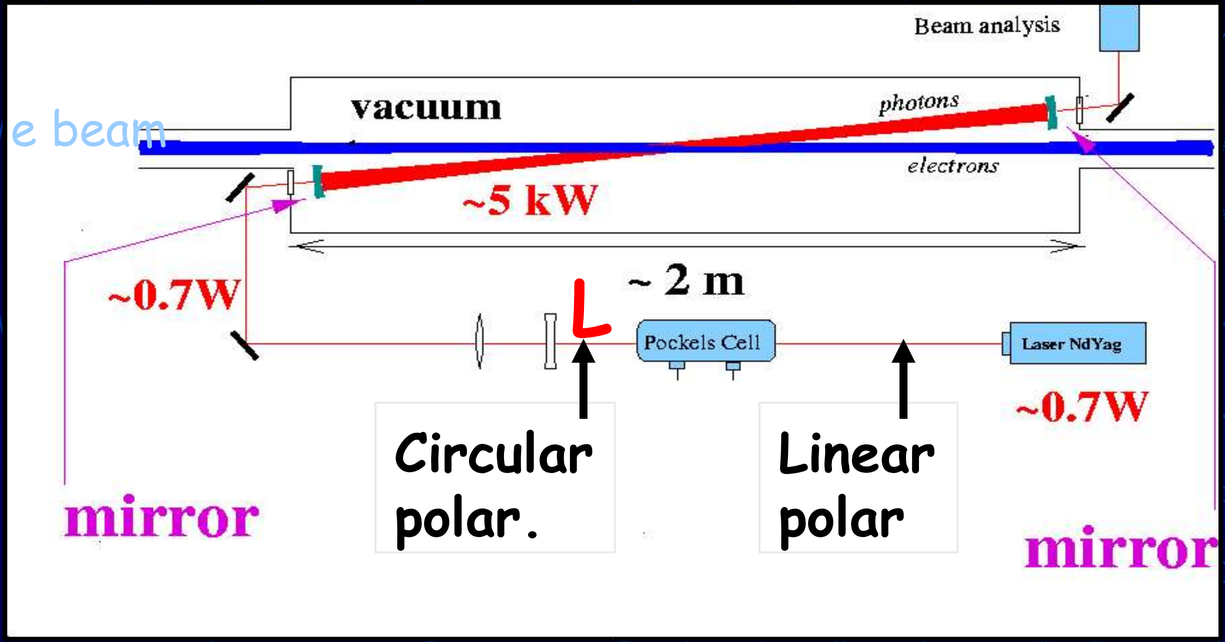
Old polarimeter are not precise enough

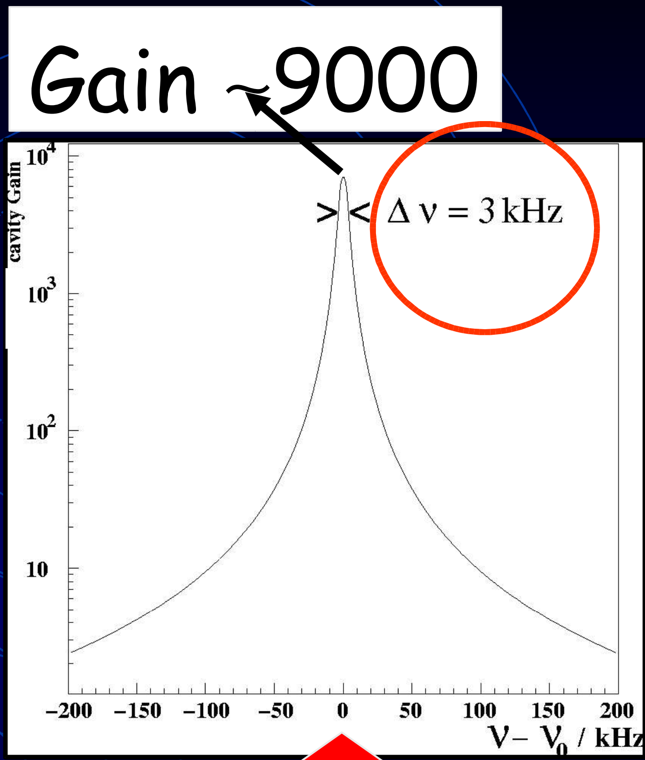
New polarimeter using a fabry perot cavity.



- Infrared laser (λ=1064mm)
- Fabry-Perot cavity (2m)
- Compton scatering (e-γ angle=3.3 °)
- Fast control: Laser frequency for the cavity
- Slow control: light polarisation, temp

Cavity fabry-perot: principle





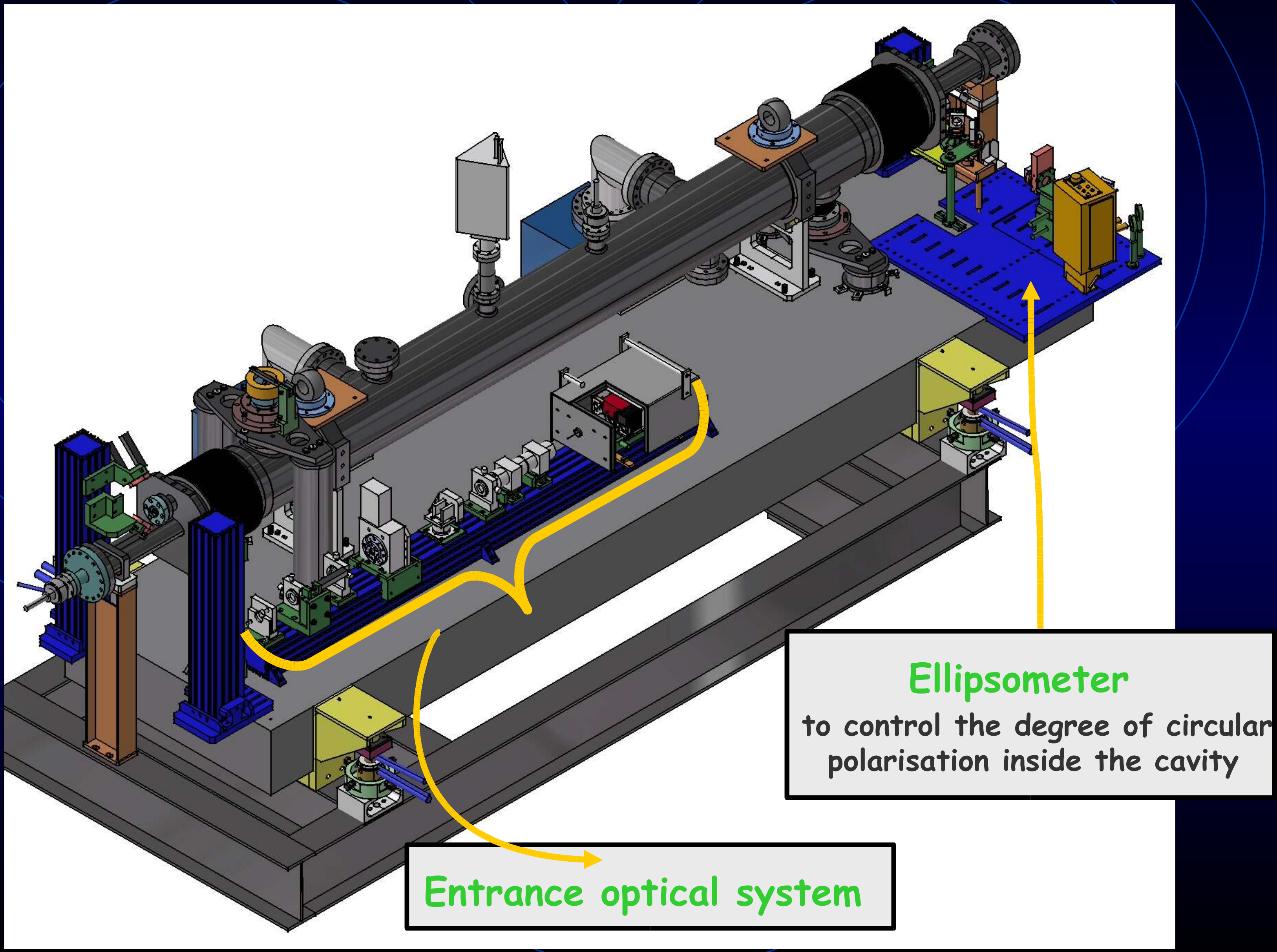
When $\nu_{Laser} \propto c/2L \Rightarrow$ **resonance**

But : $\Delta\nu/\nu_{Laser} = 10^{-11} \Rightarrow$ feedback laser/cavity By `playing' on laser frequency.

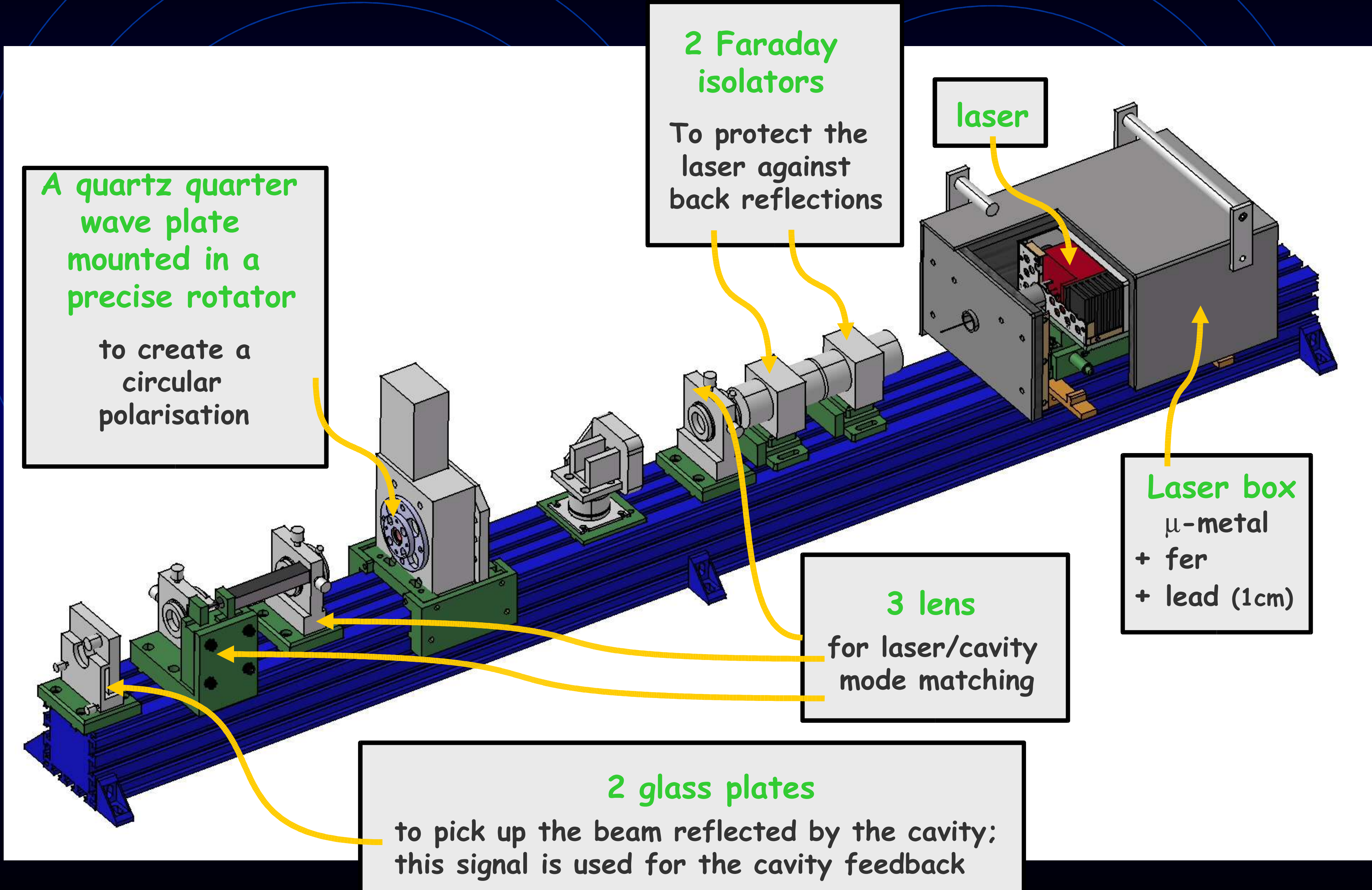
Laser Nd:YAG (infra-red, λ =1064 nm)

With 5 kW we will be at 1%/buch/min level

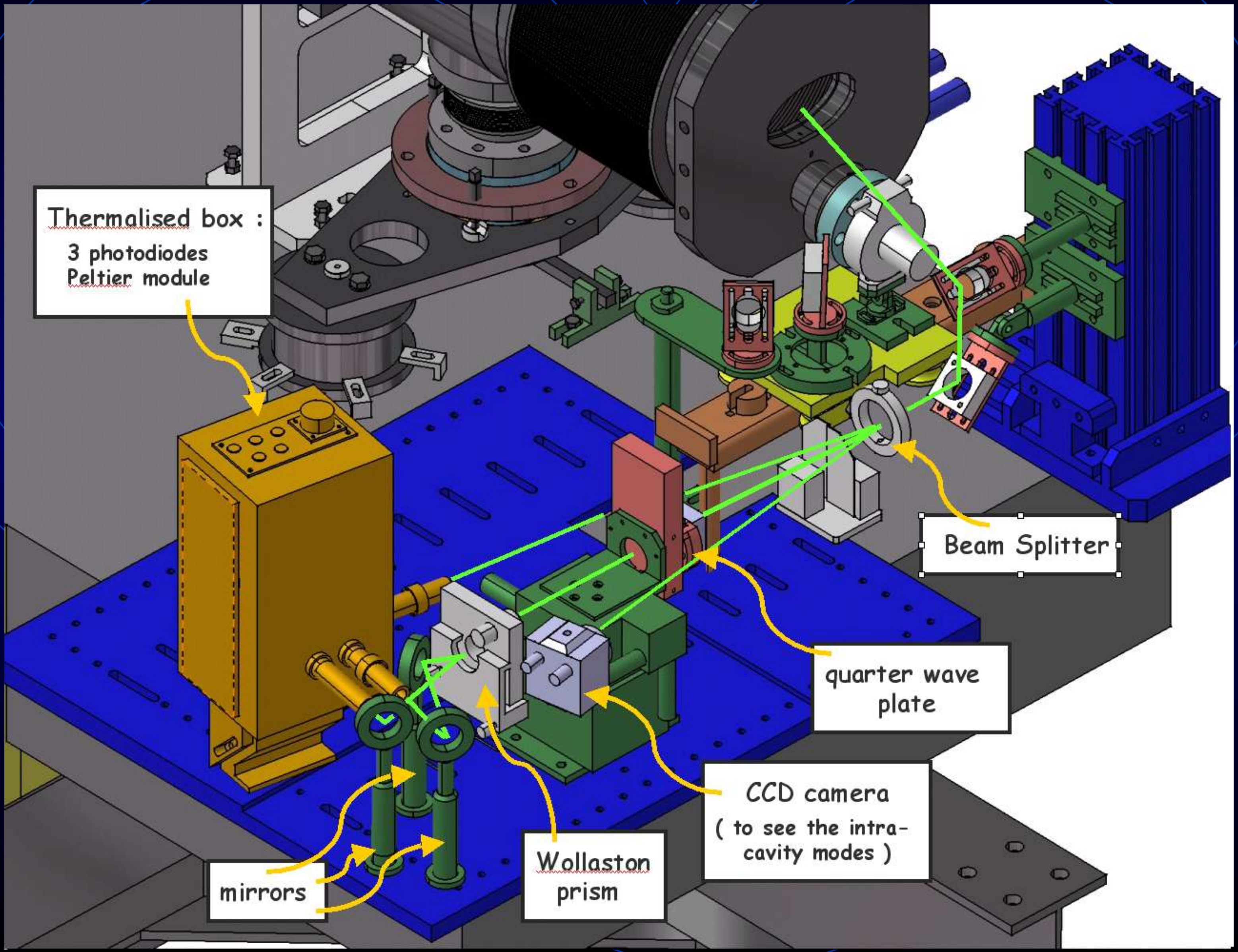
Optics.

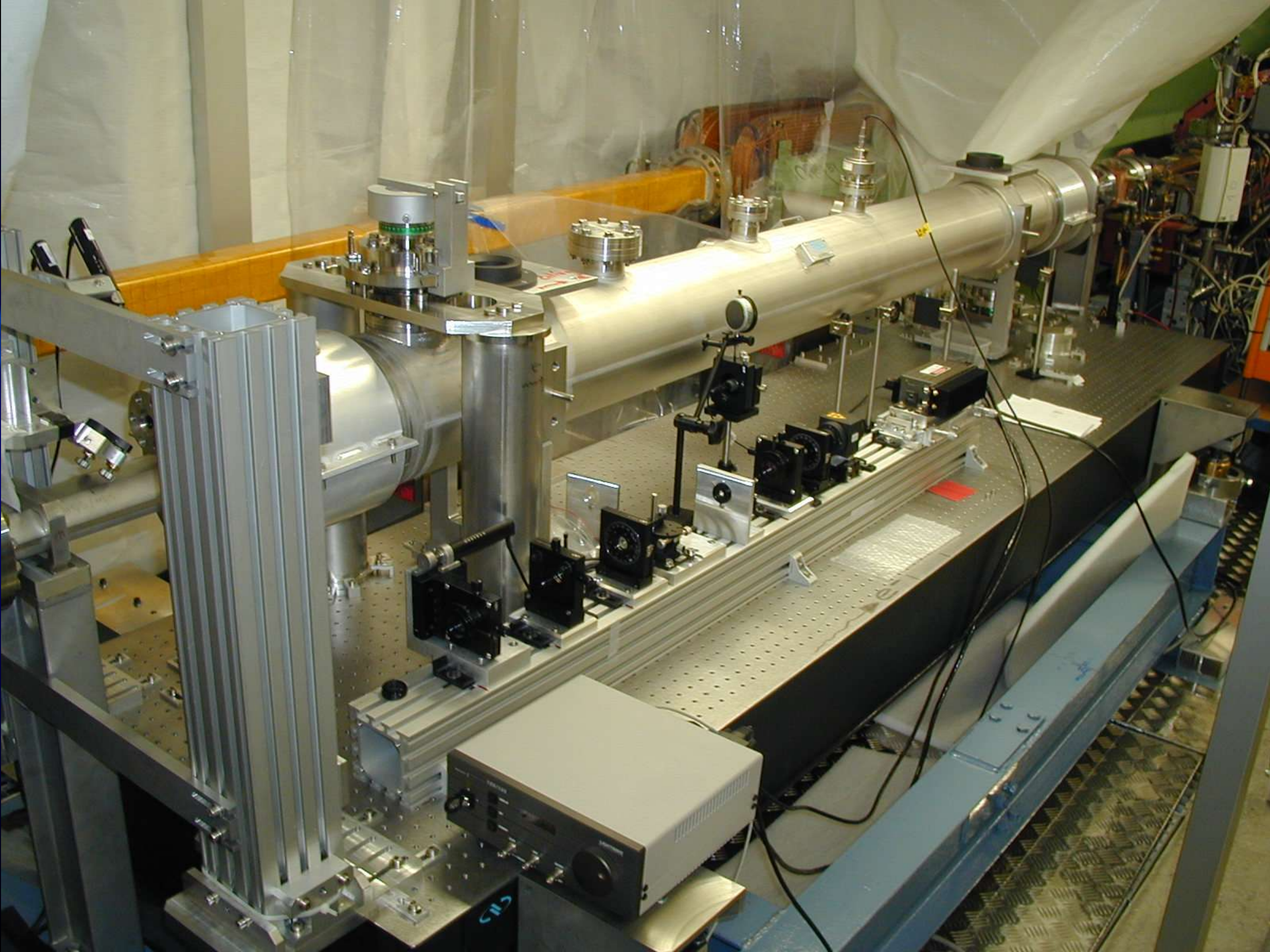

Ellipsometer
to control the degree of circular polarisation inside the cavity
Entrance optical system

Entrance optical system.



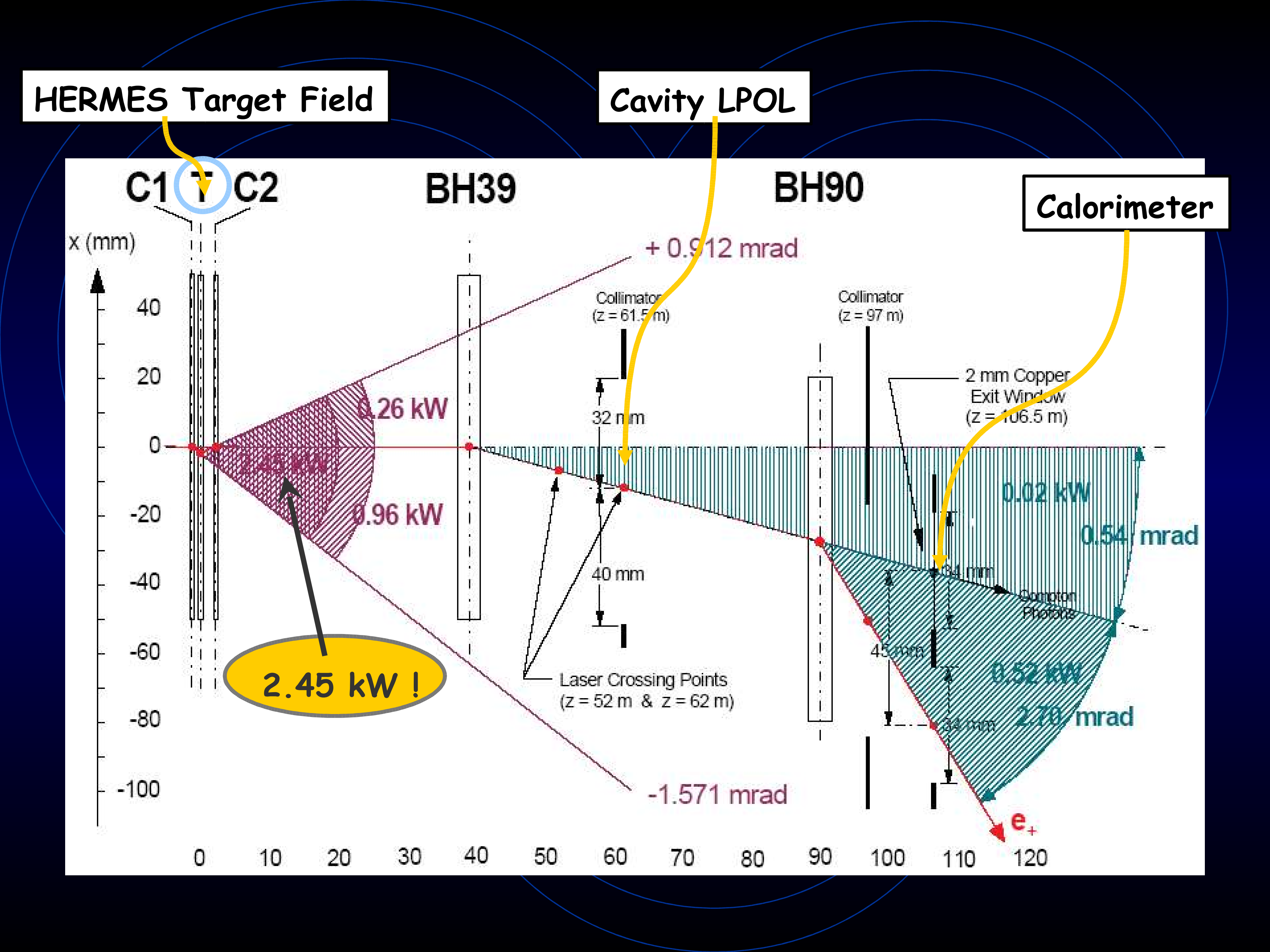
Ellipsometer.





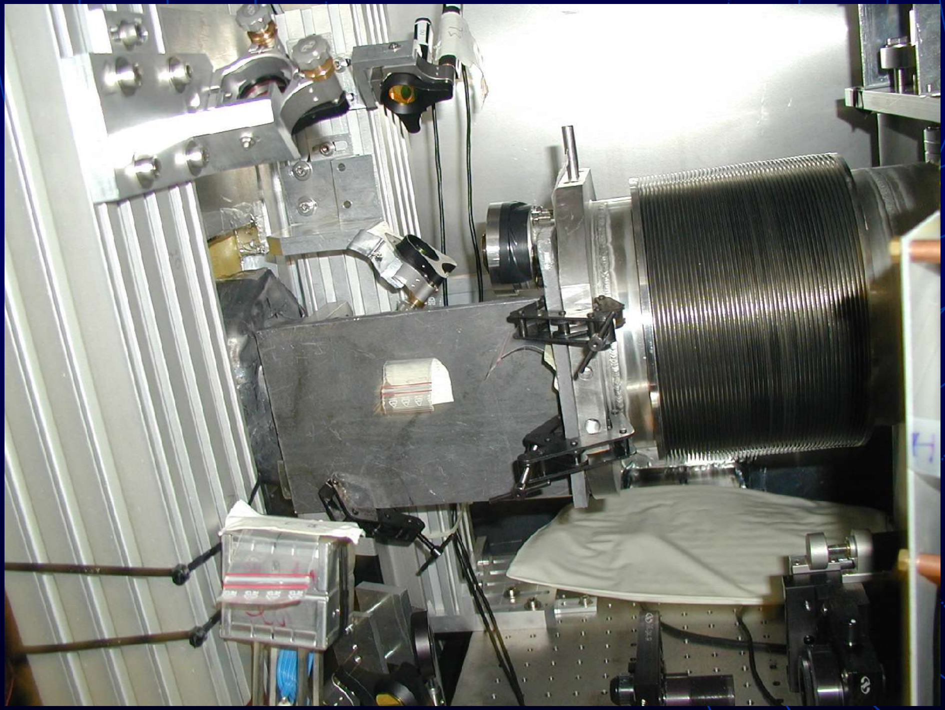

Synchrotron isolation : 3 mm of lead
Thermic isolation with aluminium
ZEUS
HERMES

Hole in the lead

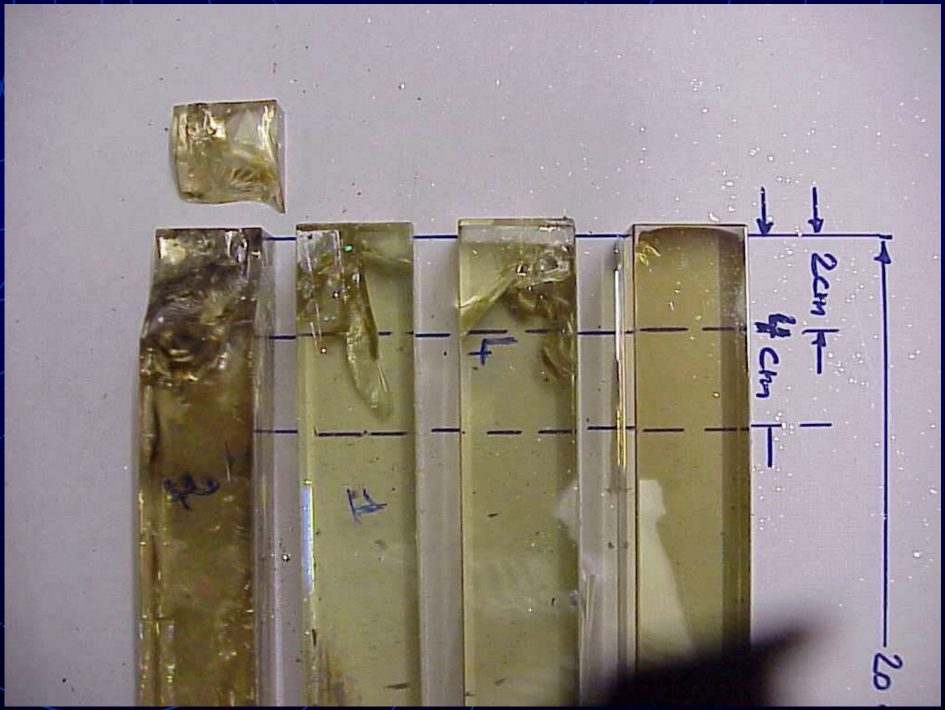

HERMES Target Field
Cavity LPOL
Calorimeter
C1 T C2
BH39
BH90
x (mm)
40
20
0
-20
-40
-60
-80
-100
+ 0.912 mrad
-1.571 mrad
0.26 kW
2.45 kW
0.96 kW
2.45 kW !
Collimator
(z = 61.5 m)
Collimator
(z = 97 m)
32 mm
40 mm
Laser Crossing Points
(z = 52 m & z = 62 m)
2 mm Copper
Exit Window
(z = 106.5 m)
0.02 kW
0.54 mrad
Compton
Photons
0.52 kW
2.70 mrad
e_+
0
10
20
30
40
50
60
70
80
90
100
110
120

Consequences of radiations:

Isolation and instrument for monitoring radiation



Replacement of damaged system



Conclusion

- Polarisation is important for physics analysis.
- In a perfect machine electrons are polarised naturally by a transverse magnetic field.
- 3 polarimeters at HERA including a brand new Lpol.
- A fabry-perot cavity is used for the new LPOL ->1%/min/buch.
- Due to radiation damage during 2003-2004 the polarimeter is not working yet, but sould be, before the next lumi run.
- It will be fast and precise to be used for an automatic polarisation optimisation procedure and for physics analysis.
- What need to be done: Make lepton interaction with laser, automatic procedure for optimising polarisation, maintain the cavity, and of course do the analysis.