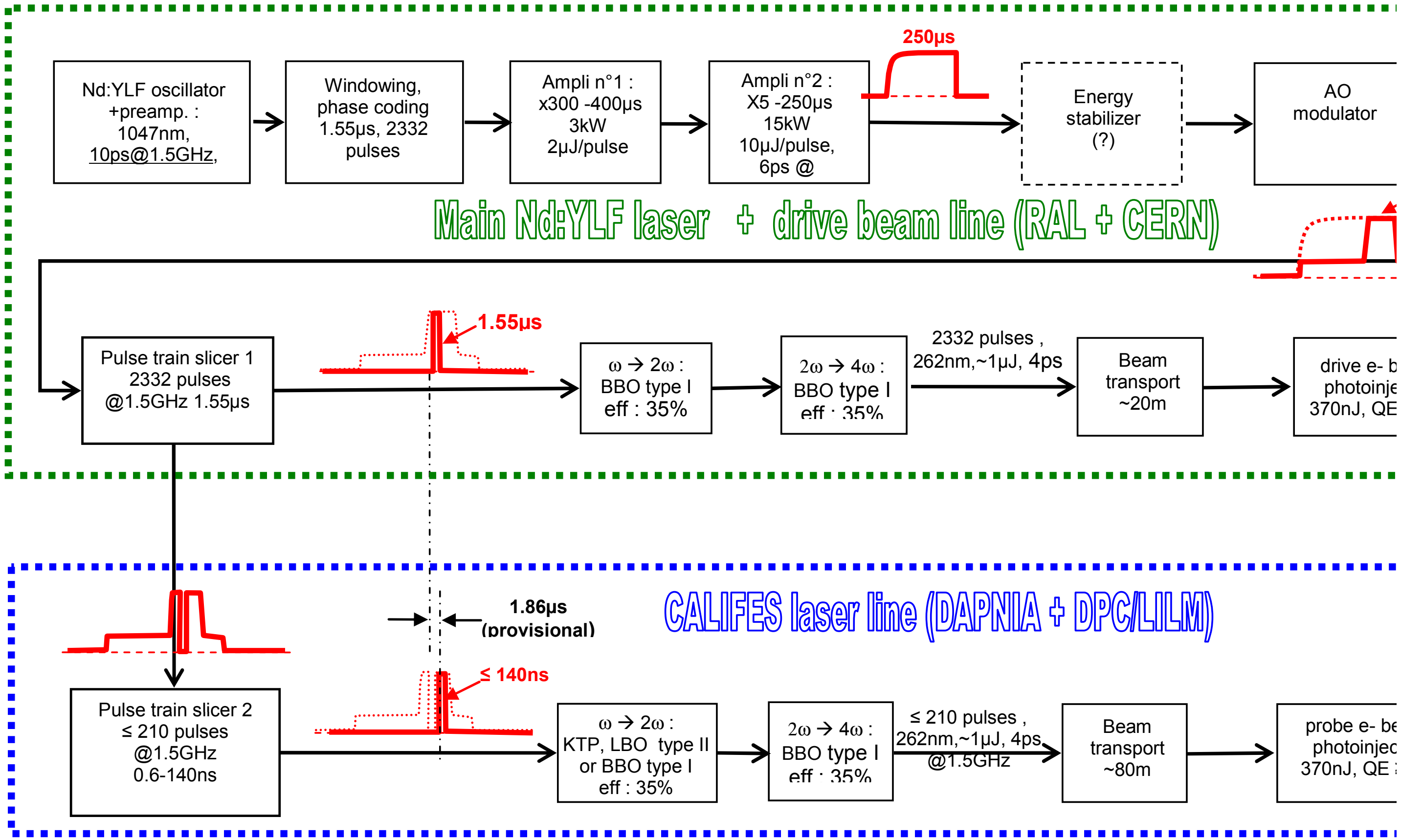
Laser beam for Califes

G. Cheymol - M Gilbert – P.Y Thro
LILM/SCP/DPC/DEN/CEA Saclay

M. Petrarca
CERN

P Girardot and all
SIS/IRFU/DSM/CEA Saclay

Global Scheme



Outlines

1) Pulse picker
2) Frequency conversion
3) Transport
4) Conclusion

Pulse picker: scheme

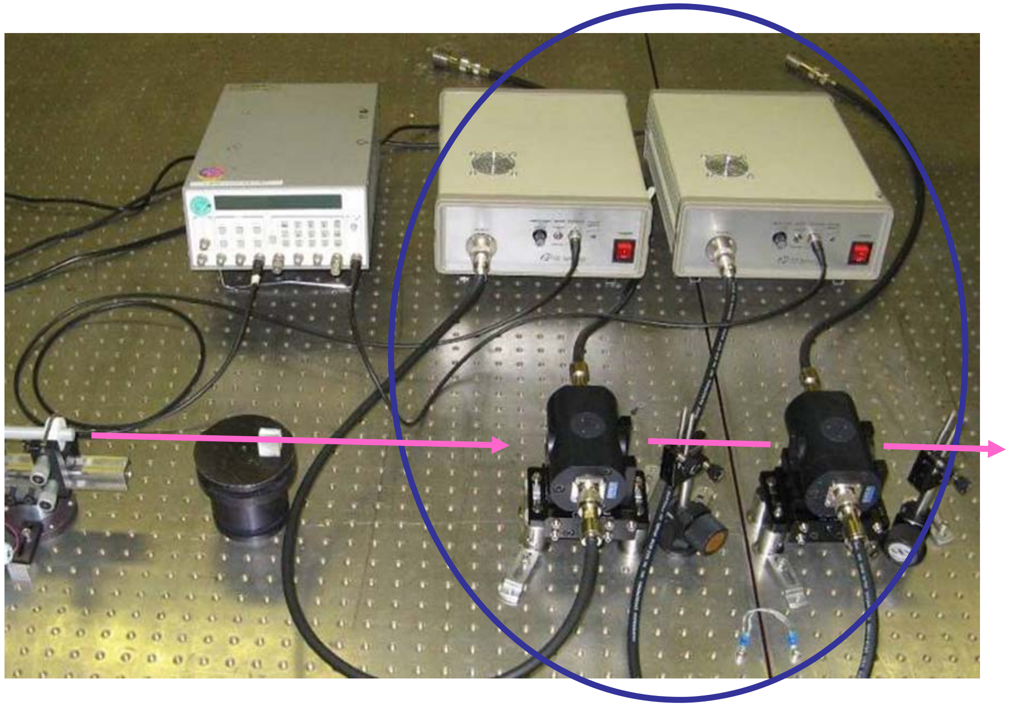
The pulse picker is made with:
- 2 pockels cells (PC)
- 3 polarisers

One PC sets the rising edge,
the other sets the falling edge

Each pockels cell is triggered
by a HV pulser

Both HV pulsers are triggered
by a generator

Independant triggering allows to change
the duration of the pulse selected



Pulse picker

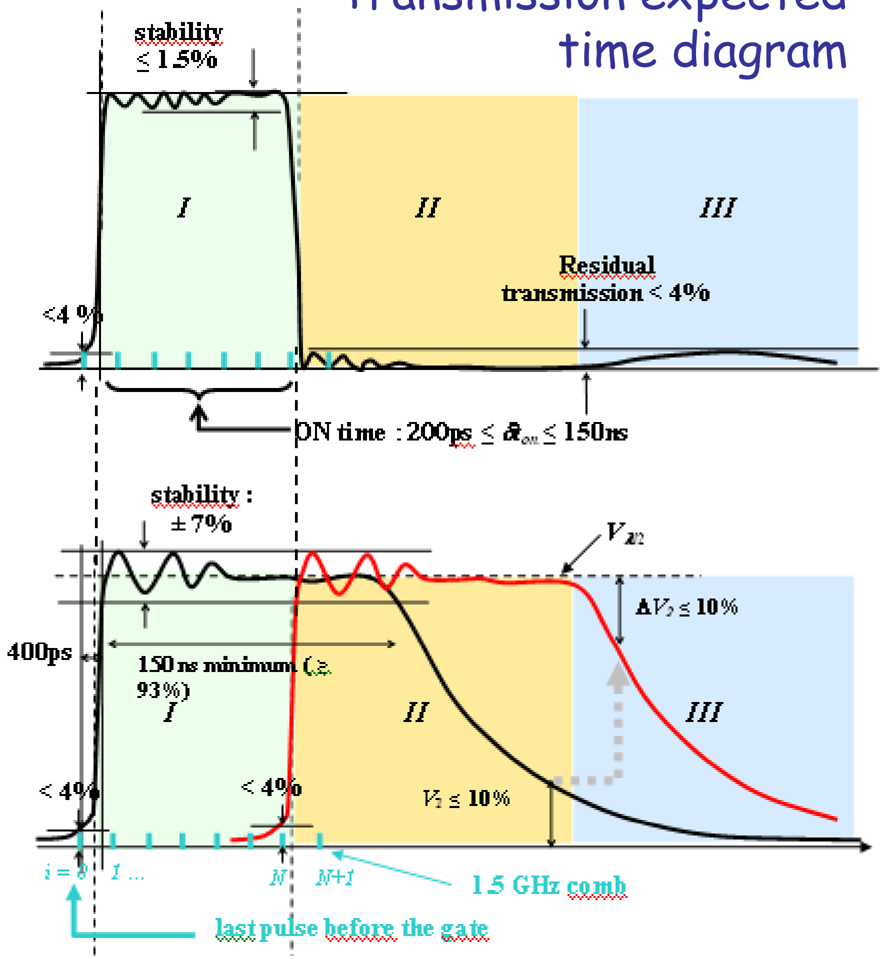
in test in Saclay

Pulse picker ordered to Leysop Ldt : specifications

Mains specifications for the pulse picker:

- sharp rise time and fall time: less than 666ps → ~ 400 ps
- duration ~ 0.5 ns to 140 ns
- with stability better than ± 1.5%
- low transmission (< 4%) out of the pulse selected
- need for high transmission during the pulse

Transmission expected time diagram



Related specifications HV pulse

Pulse picker: choise dry cell /fluid - transmission

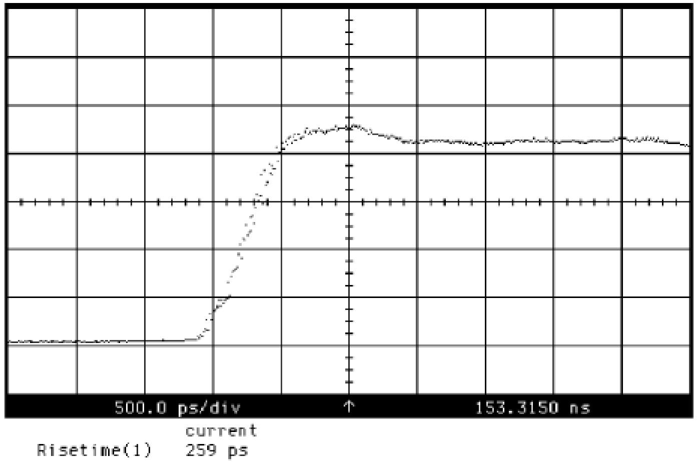
Dry cell was finally preferred:

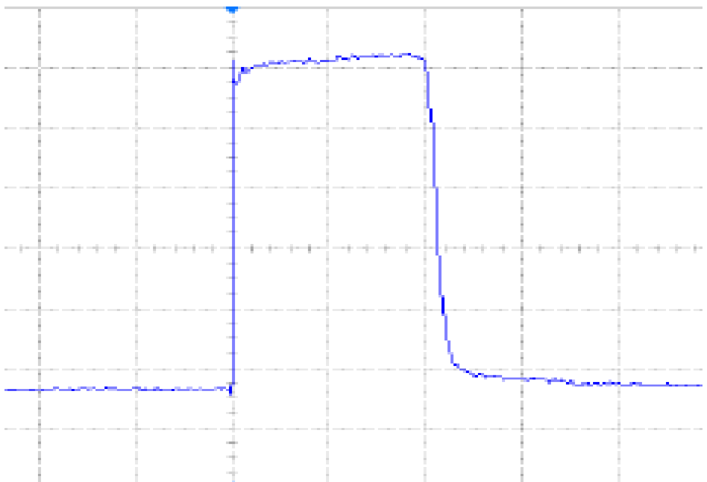
- to avoid degradation of the fluid with peak irradiance, (especially for a long running time).
- in spite of:
    - theoretically less impedance adaptation
    - less transmission (around 1% less per cell)

Finally, the measured transmission was about 92% per cell (a bit less than expected).

For entire pulse picker, at CERN: T~ 80%.

Pulse picker: Test Report-Temporal rise time

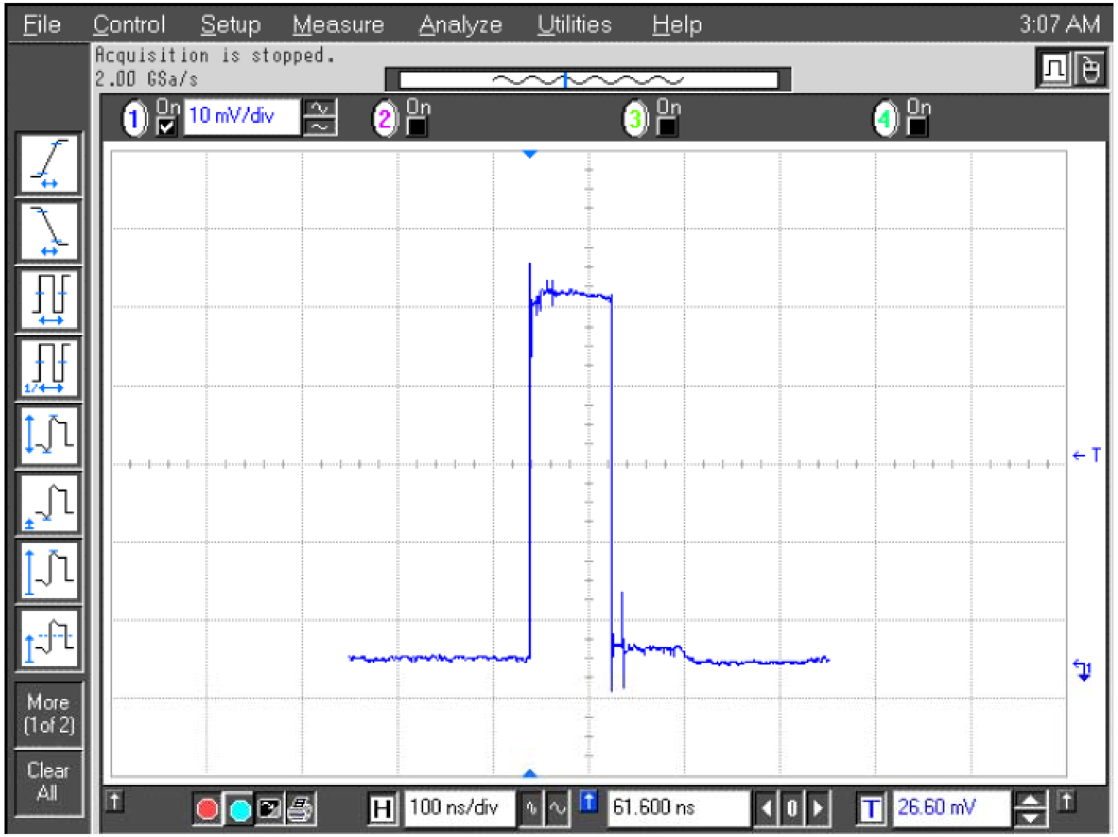




Out of the **pulser (trigerring)** measured rise time ~260ps

Out of one **pockel cell (optical)**: measured rise time: less than ~ 350ps

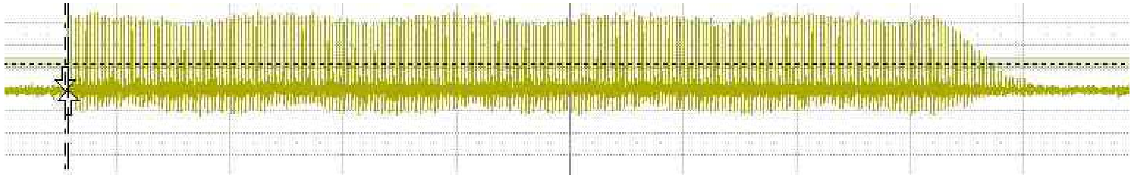
Pulse picker: Test Report- Chopped pulse



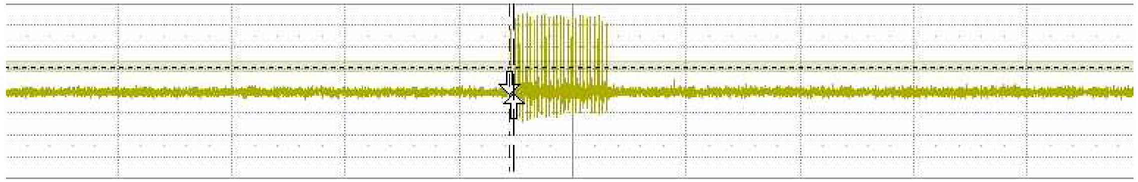
100ns Duration Chopped Pulse

Chopped pulse – at CERN with a 60 GSamples/s oscilloscope

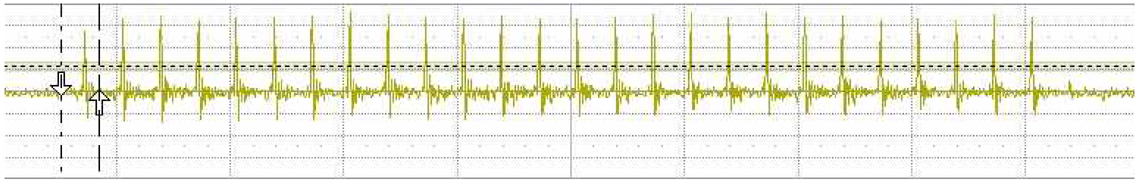
Cell 1 alone
(Cell 2 off)
20ns/div



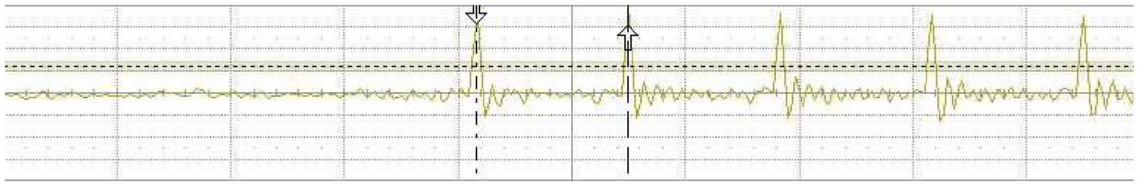
Gate 20 ns
20 ns/div



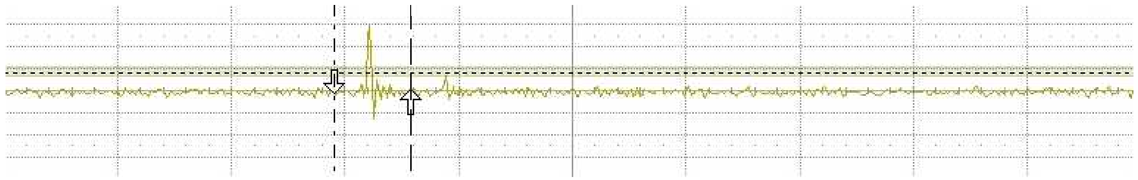
Gate 20 ns
2ns/div



Check of rising edge
500ps/div



1 pulse selected
1ns/div

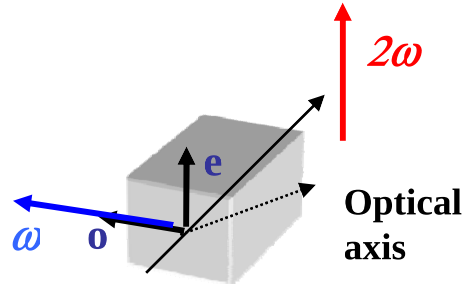


Frequency conversion - crystals considered

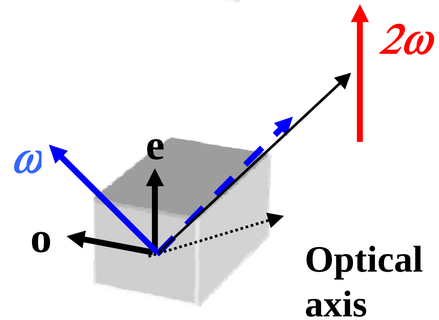
IR → Green   type II: KTP, LBO ; type I: BBO, LBO

Green → UV   type I: BBO, CLBO, KDP

TYPE I :



TYPE II :



Frequency conversion – 1047nm → 523 nm - calculations

Nominal parameters for optimisation:

- entering beam parameters: 10µJ, 6ps, 1047 nm, M^2 (beam quality factor) =1
- CE (conversion efficiency) =35% *(→ 12% for ω -> 4ω)*

	KTP (II)	LBO (I)	BBO (I)
λ_ω incident (nm)	**1047**	1047	1047
d_{eff} :non linearity coeff (pm.V)	**3.0**	0.83	2
L : length of crystal (cm)	**0.6**	1.5	0.8
Φ_{1/e^2}: diameter (mm)	**1.8**	1.5	1.8
Tolerance: *Critical if tolerance parameter approach 1.*			
Angular acceptance: $\xi_\theta = 2\,\theta / \Delta\theta_{acc}$	**0.028**	0.106	0.36
Walk-off : $\xi_\alpha = 2.\alpha_{max}.L / \Phi$	**0.038**	0.17	0.5
GVM : $\xi_{GVM} = GVM.L / Dt_{1/2}$	**0.44**	0.267	0.79

Frequency conversion – 523 nm → 262 nm - calculations

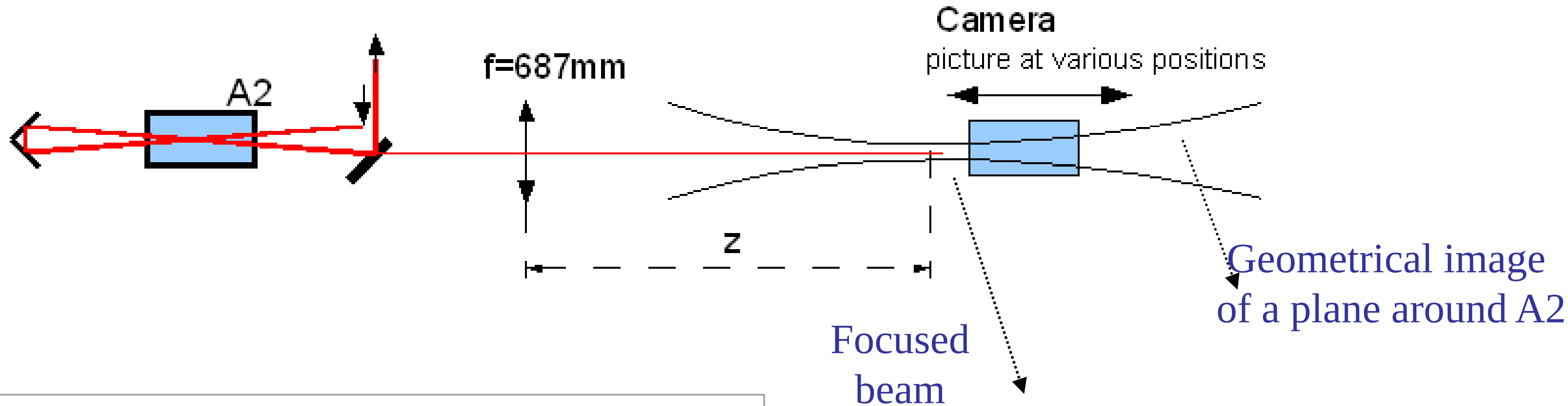
Typical parameters and tolerances

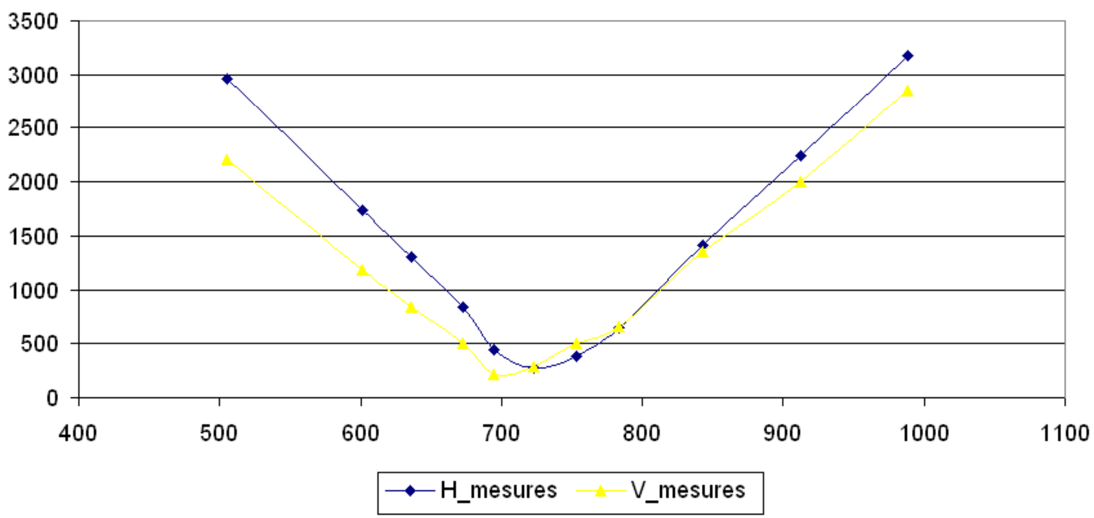
calculations for entering beam parameters: 3.5µJ, 4.9ps, 523 nm, M^2 (beam quality factor) =1

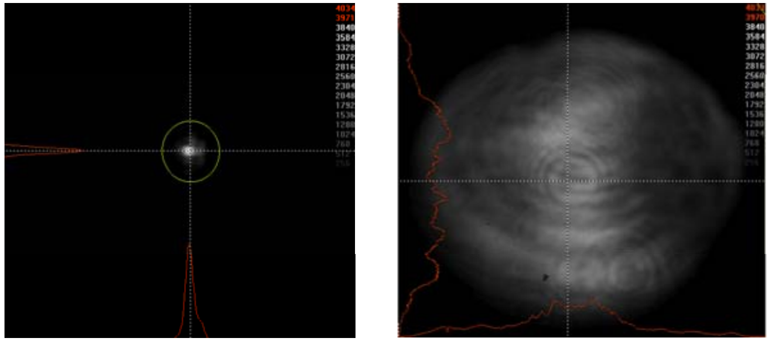
and for CE (conversion efficiency) =35% *(→ 12% for ω -> 4ω)*

	BBO (I)	CLBO (I)	KDP
λ_ω incident (nm)	**523**	523	523
d_{eff} :non linearity coeff (pm.V)	**1.74**	0.8	0.47
L : length of crystal (cm)	**0.8**	1.5	2
Φ_{1/e^2}: diameter (mm)	**2.04**	2.1	0.94
Tolerance: *Critical if tolerance parameter approach 1*			
Angular acceptance: $\xi_\theta = 2\theta / \Delta\theta_{acc}$	**0.48**	0.32	0.2
Walk-off : $\xi_\alpha = 2.\alpha_{max}.L / \Phi$	**0.67**	0.44	0.285
GVM : $\xi_{GVM} = GVM.L / Dt_{1/2}$	**0.97**	1.04	1.24

M² measured out of A2 amplifier



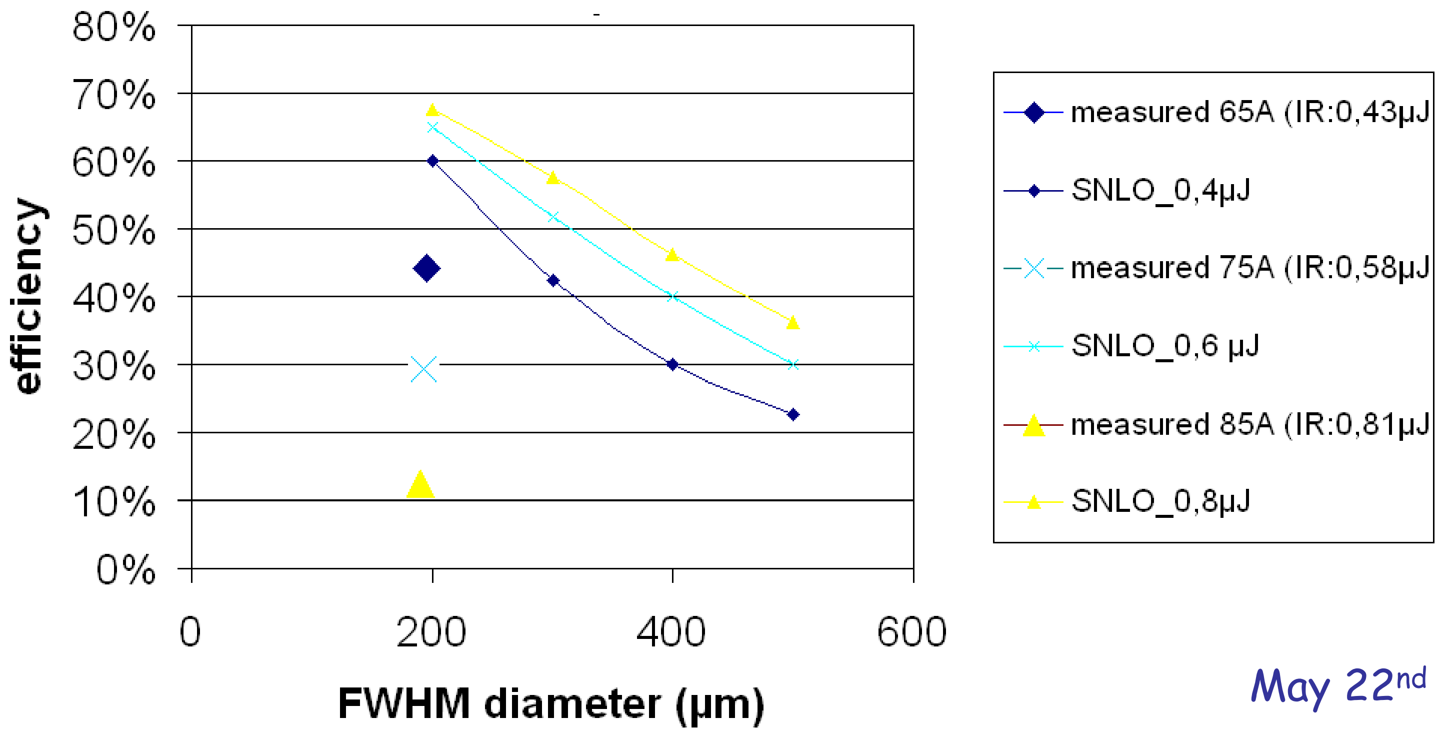




$M^2 \sim 2$ (1.5 to 2.6)
for the beam out of A2

Frequency conversion - 1047→523- simulation/measurements

On KTP, with large margin on angular acceptance, we expect:
conversion efficiency measured ~ conversion efficiency given by simulation.

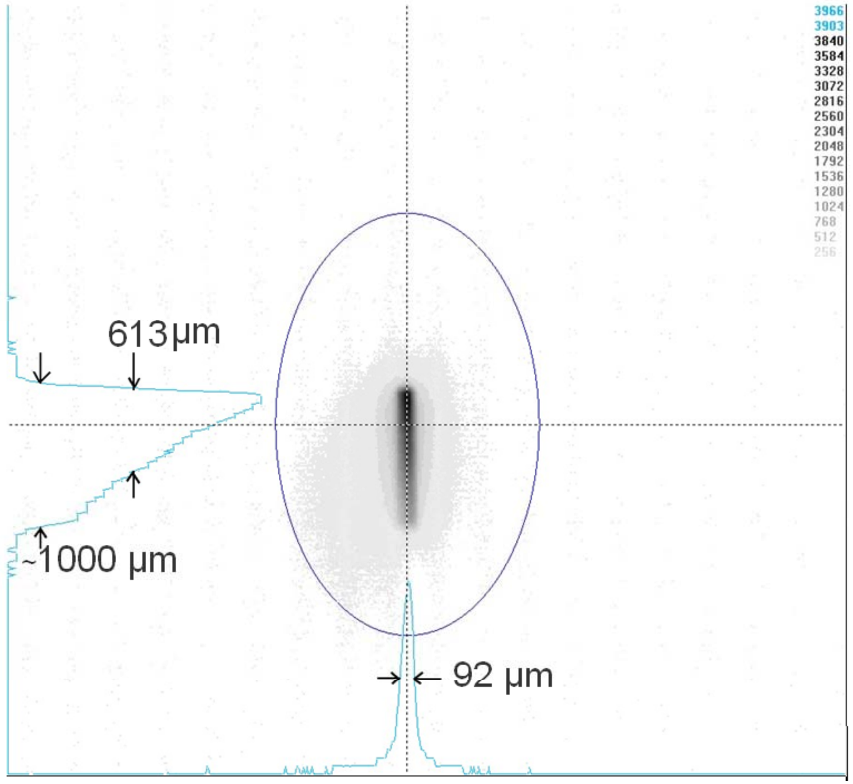


May 22nd 2008

→ ASE of the laser in between the micropulses

Frequency conversion - 523→262 - large walk-off

With low IR energy, the beam has to be focused a lot.
-> walk off and angular acceptance limitations become very critical
-> lack off conversion efficiency
-> high distortion in the UV$_{\text{near field}}$ profile.



Oct 8th 2008
Conversion efficiency (green to UV) ~ 38%
Energy (micropulse): IR:0.82µJ ; Gr:0.32µJ; UV: 0.12µJ
Amp 1 alone
(Dimension of the input green beam: 42µm x 112µm)

Frequency conversion – conclusion

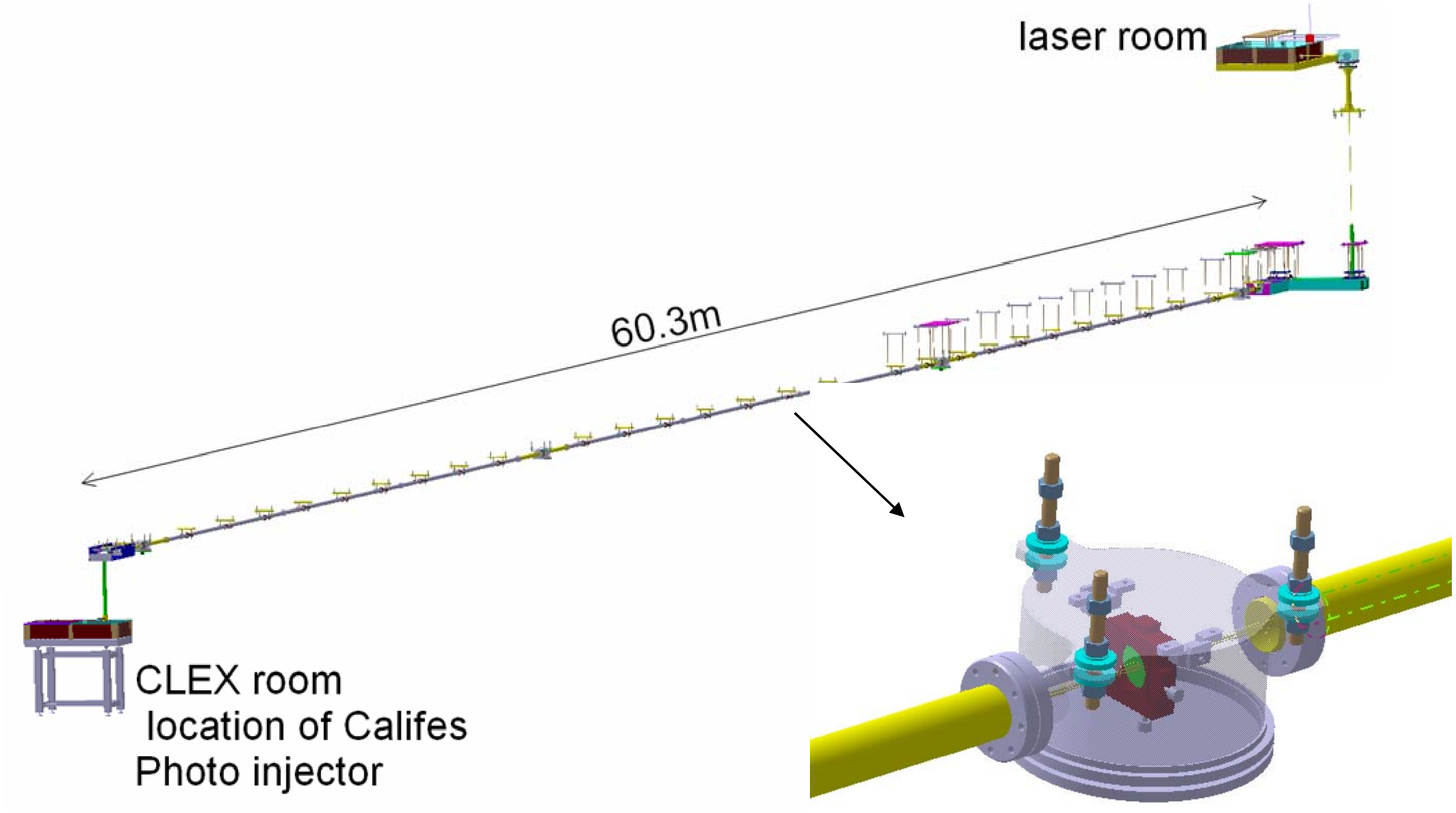
The focusing diameter on the crystal should be increased when the power increase.

A stabilized IR beam should allow to optimise a "final" configuration.

Optimized cylindrical focusing could be tested.

Other crystal (KDP) could be tested

Transport- tables and mechanical supports



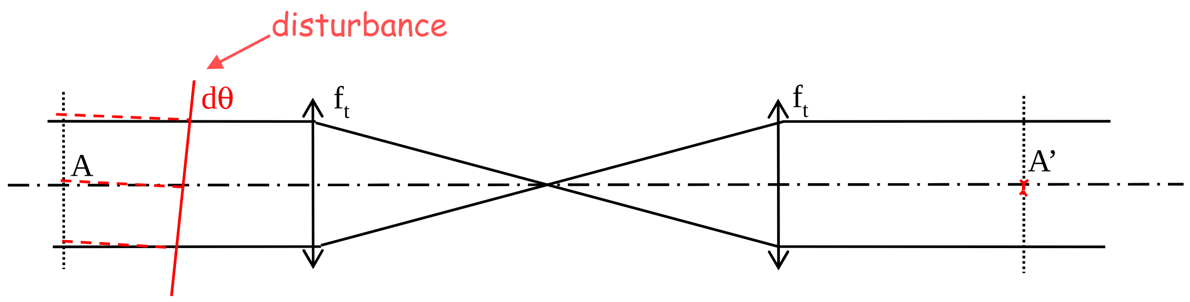
under air / under vacuum beam delivery

- Consequence of Temperature and Pressure variations:
  - n-1 (~ 3.10-4) proportional to P et T. n: air optical index
  - l = 80m and ΔT or ΔP = 1% → Δ (n .l) ~ 0.3mm → Δt ~ 1 ps.
- Attenuation (@ 262 nm):
  - Rayleigh Diffusion → Transmission = 98%.
  - Ozone absorption:
    - α= ~10^{-17} cm^{-2} (max at 255 nm). α: absorption cross section
    - 40 ppb ozone, l= 80m → T=92%.

→ Transport under vacuum to be preferred

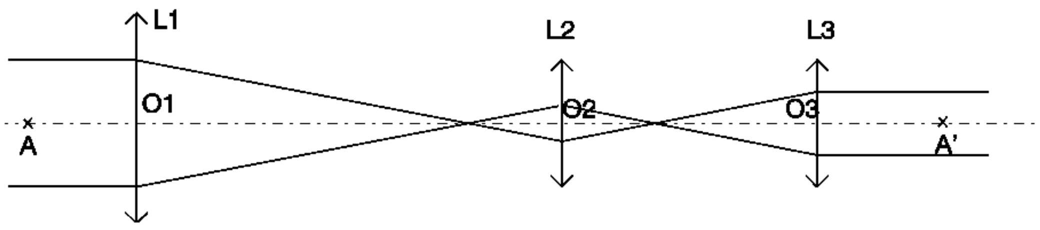
Only the straight line under the roof in CTF2 + CLEX is put under vacuum.

Optical relay /telescope



Optical relay reduce consequences of mirror vibration, air turbulence in plane A'

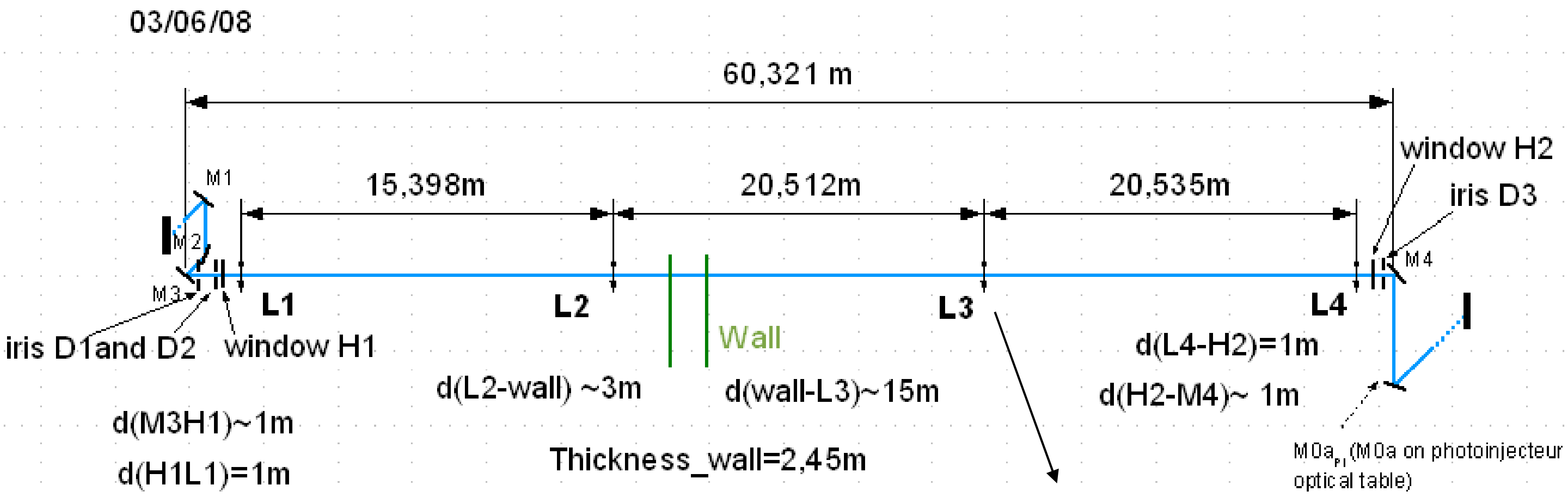
(A' geometrical image of A)



3 lenses telescope allows to:

- decrease the footprint of the optical system for a given relay distance.
- change zoom factor and relay distance (to some extent)

« under the roof », 2 telescopes (2lenses) transport the beam from the laser room to the photocathode

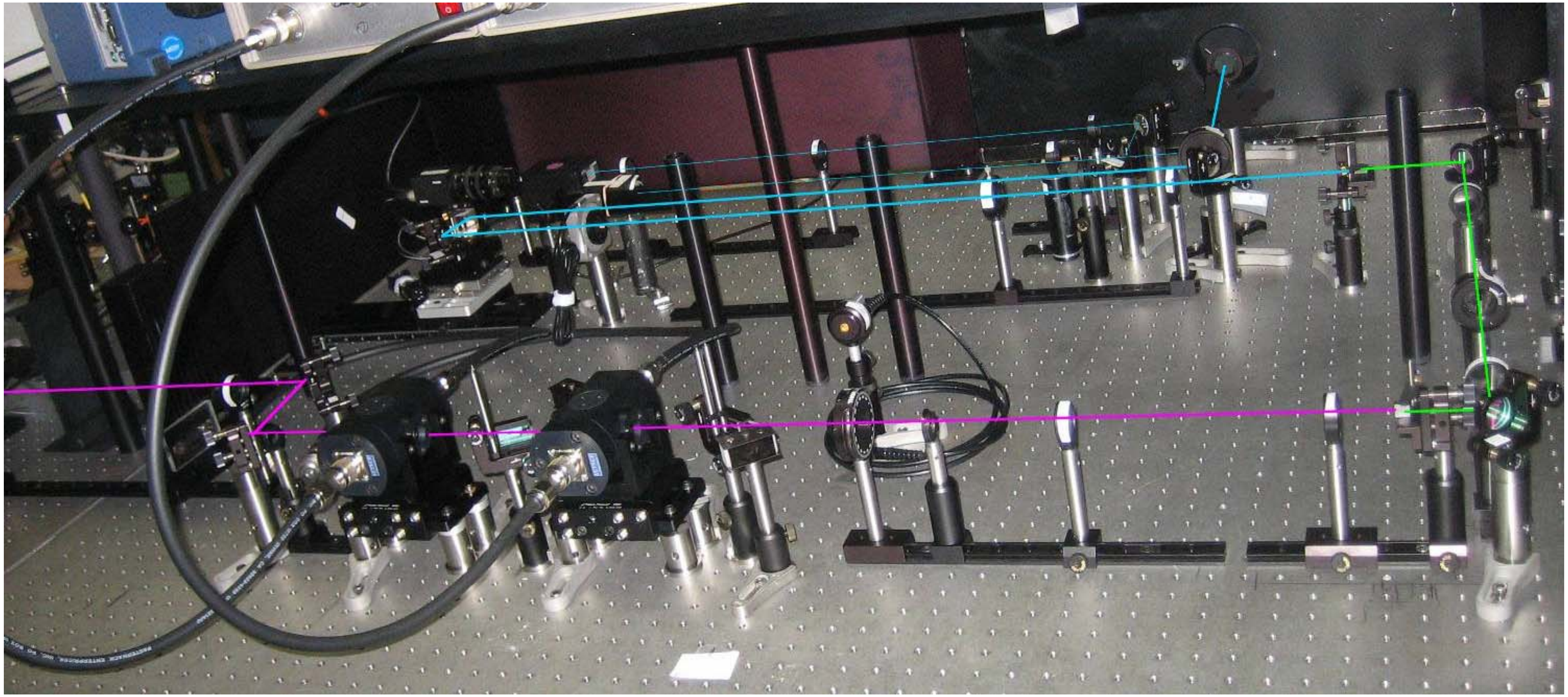


2 telescopes (2lenses) :

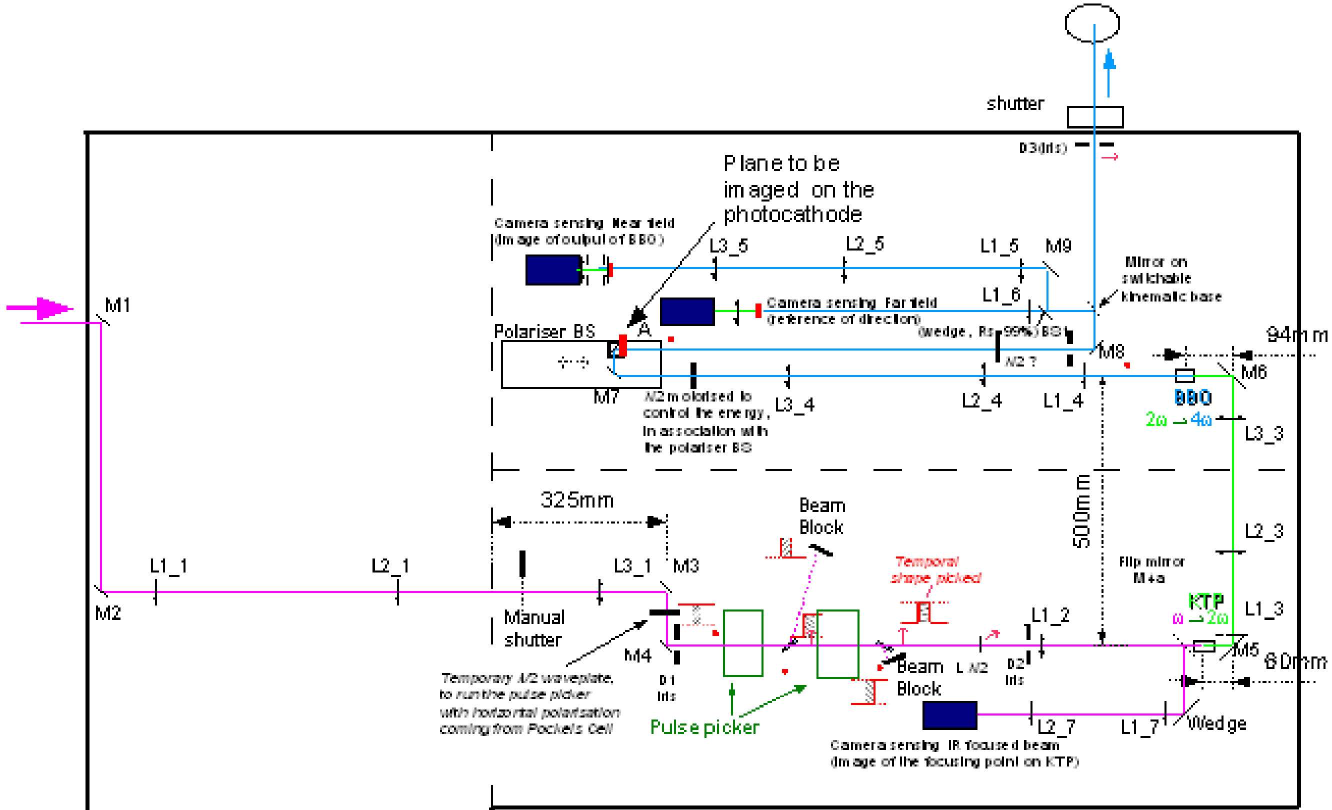
L1-L2 with f~ 10 m

L3-L4 with f~ 7.5m

Optical path on the Califes laser table



Optical path on the Califes laser table



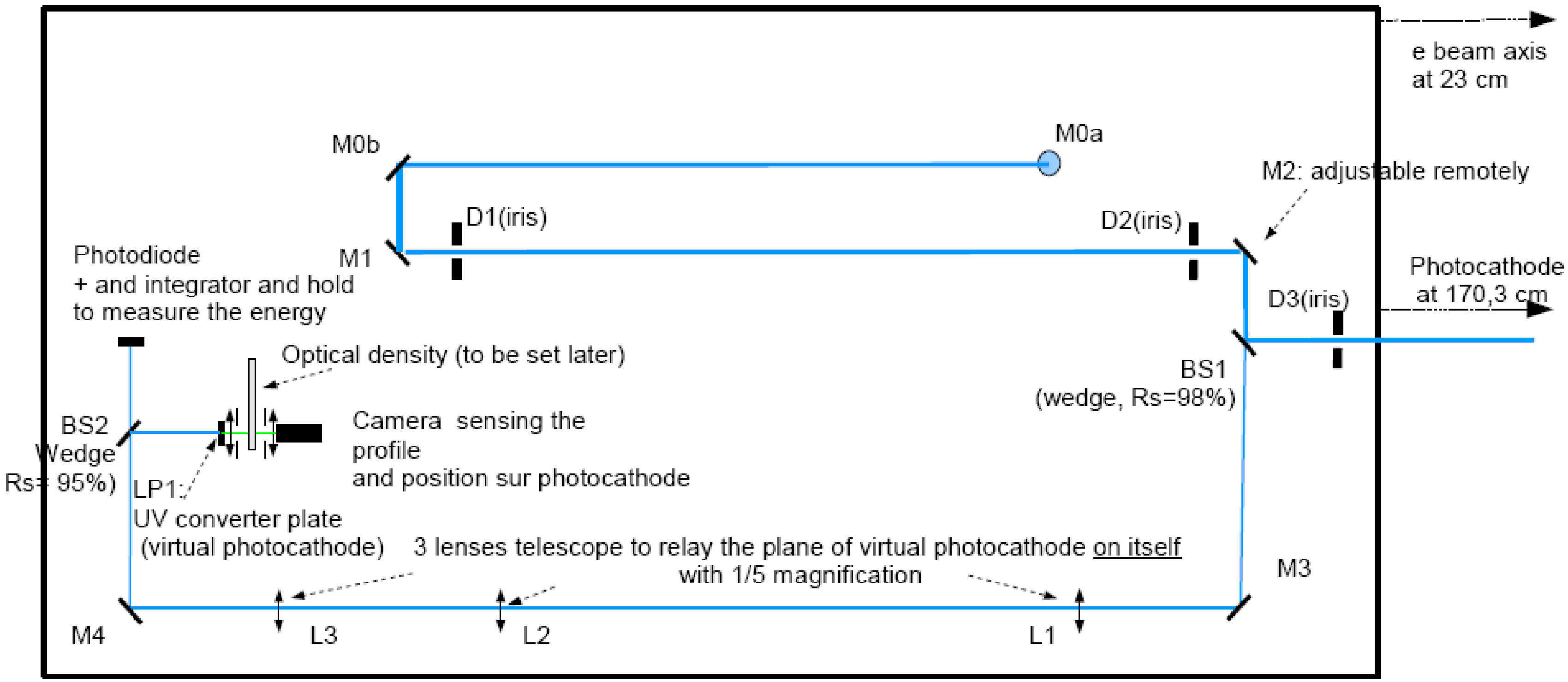
Setup of Laser table

14/10/08:

- telescope 1 to image PC on PP (Magnification = 0.8)
- combination 2 for focusing on KTP (replaced by only one focusing lens: f= 200mm)
- telescope 3 to image KTP on BBO: Mag. adjustable (0,7 on that date)
- telescope 4 to image BBO on objet plane for transport and to adapt the size (Mag= 3,4)
- telescope 5 to image the objet plane for transport on the camera sensing output the output plane of BBO (Mag=0.2).
- L1_6 for sensing direction of the beam before transport/reference of direction
- telescope 7 for imaging the focusing point (on KTP) of IR beam on the camera (Mag= 1)

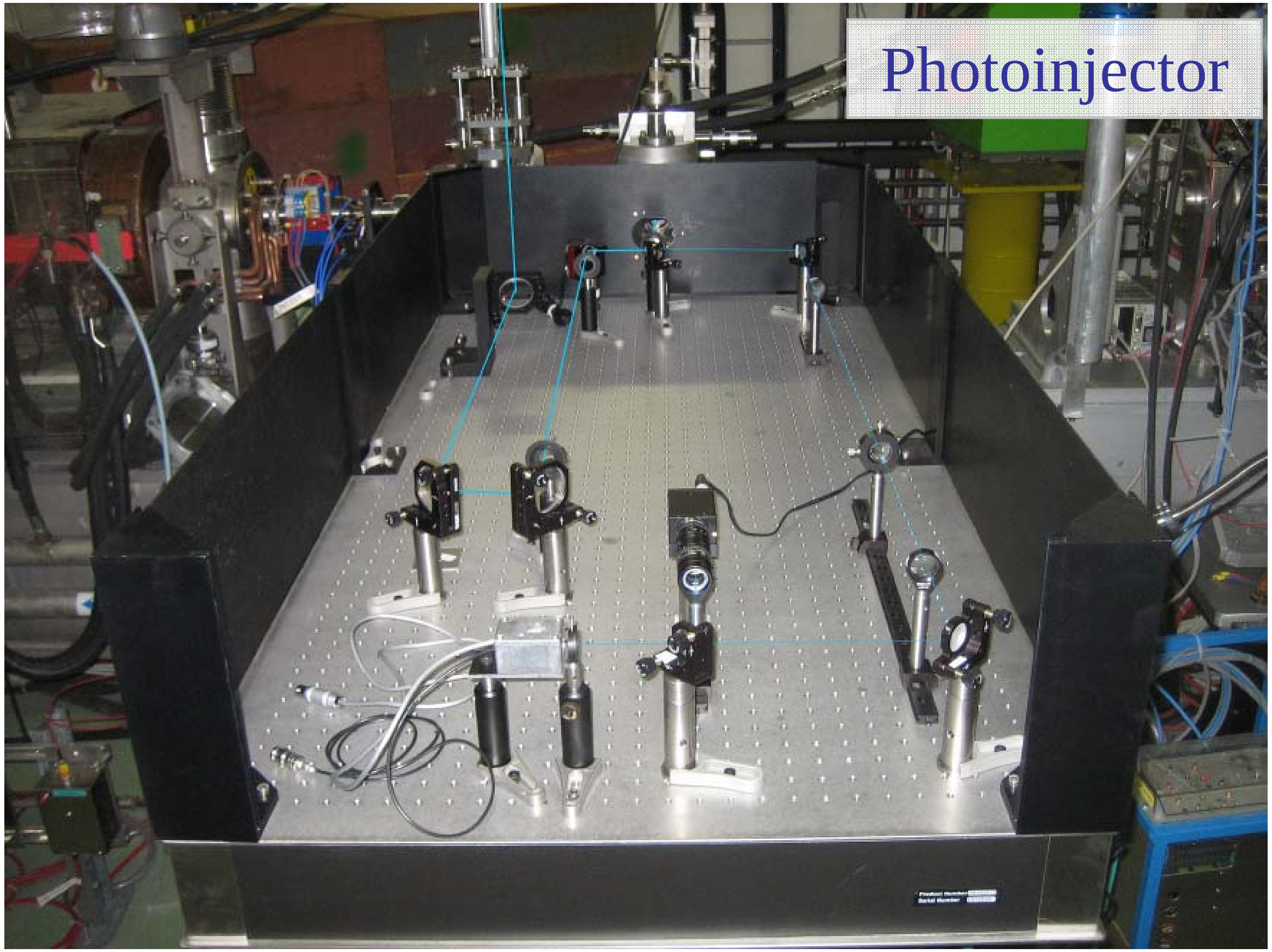
·↑ red arrows (or red points) indicate the polarisation of the beam

« photoinjector » optical table



Photoinjector

« photoinjector » optical table



Transport and sensing/ conclusion

- Some lack of quality on UV components ordered. Many components tested and returned.
- about 25 lenses, mirrors or windows between BBO and photocathode. Transmission should be 75 to 80% (85% measured between laser room and photoinjector table).
- image transport perform well, but with great walk off on BBO, the image on the photocathode is distorted.
- procedures for adjusting all systems have been provided.

General conclusion

- Pulse picker, transport and various sensing perform quite well

- Frequency conversion has still to be optimised with the IR laser beam working better.

Thank you for your attention

Pulse picker: how it works?

In red: the different temporal shapes of the pulse