Laser optics for the ATF Laser-wire

- Laser characteristics
- From the source to the IP
- Focusing the laser light

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BDIR meeting
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Laser characteristics

- The laser used will be provided by KEK
- Green (532nm) Nd:YAG Laser
- Custom made by Positive light for KEK
- Rep. rate: 6.25Hz
- 10mm beam diameter
- Pulses: 200-300ps, 300-600mJ
  => ~1-2 GW peak power
- More than enough power...
- ... but the laser is ~10m away from our interaction point

Laser light transport

- Laser light must be transported over 10-15 m from the laser hut to our interaction point.
- Power must be attenuated to avoid damaging the optics.
- Laser light transport and delivery system has been simulated under Zemax.

Laser Power

Laserwire

Laser Damage Threshold (LDT):

E = 300 - 600 mJoules
Pulse length = 200 - 300 ps
Beam diameter 2.R = 6 mm

$$\text{Power density} = \frac{600\ \text{mJoules}}{\pi \cdot R^2}$$

$$= 2.1\ \text{Joules/cm}^2$$

Best Coating → 20 Joules/cm² @ 532 nm, 8 ns.

$$\text{LDT (8 ns)} = 2.1\ \text{Joules/cm}^2 \cdot \left\{\frac{8\ ns}{0.2\ ns}\right\}^{1/2}$$

$$\approx 13.3\ \text{Joules/cm}^2$$

→ **Safety factor is not enough !**

Attenuate the beam to a couple of 10's MW → several 1000's of photons.

Slide by Chafik Driouichi

Scanning range

Laserwire

Scanning is done with a Piezo driven Scanner:

PI S330: $\theta = \pm 2.5$ mrad, f=1KHz,

good repeatability.

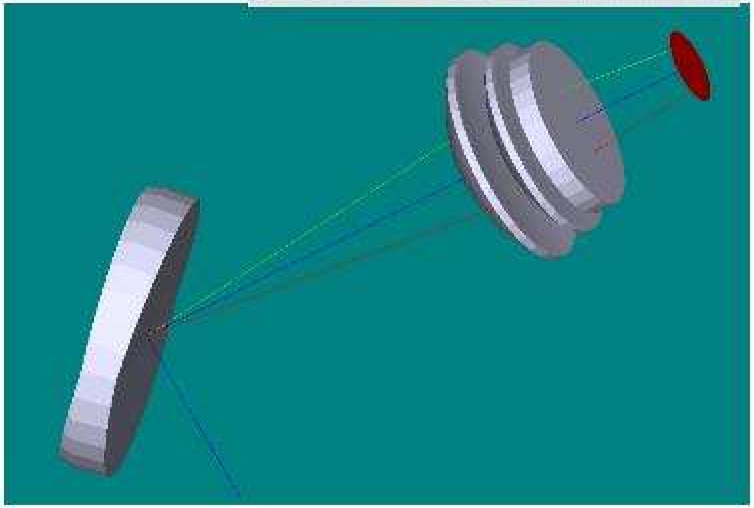
= e-beam size

N= number of sigma scans

Scanning range is: $\theta = N \times \;/f$

Example: f = 60 mm & N = ± 5

σ (μm)	1	6
θ (mrad)	0.08	0.5

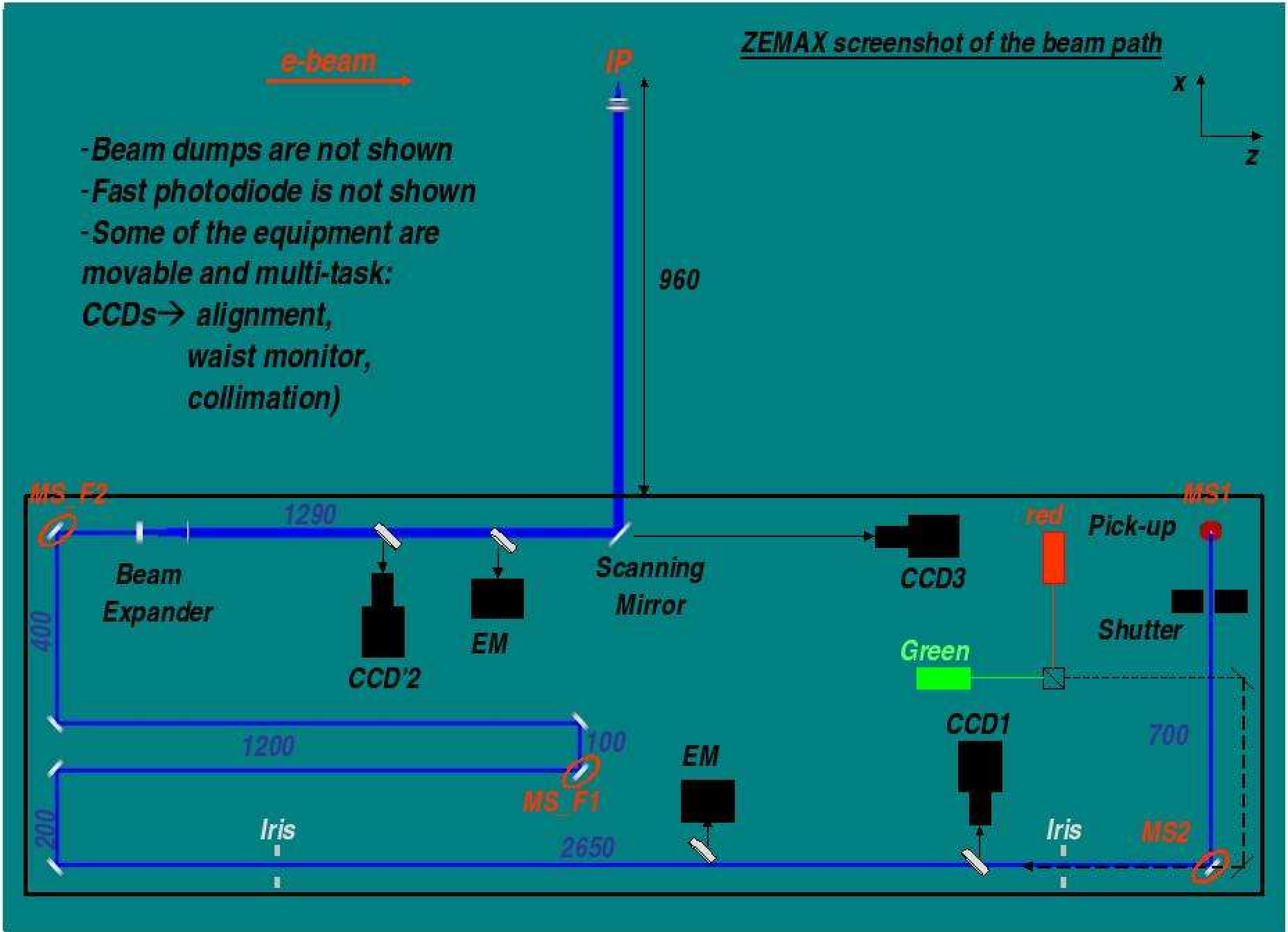


Scan angle over exaggerated

Other options (A.O & E.O) are being investigated.

Slide by Chafik Driouichi

Laser transport layout



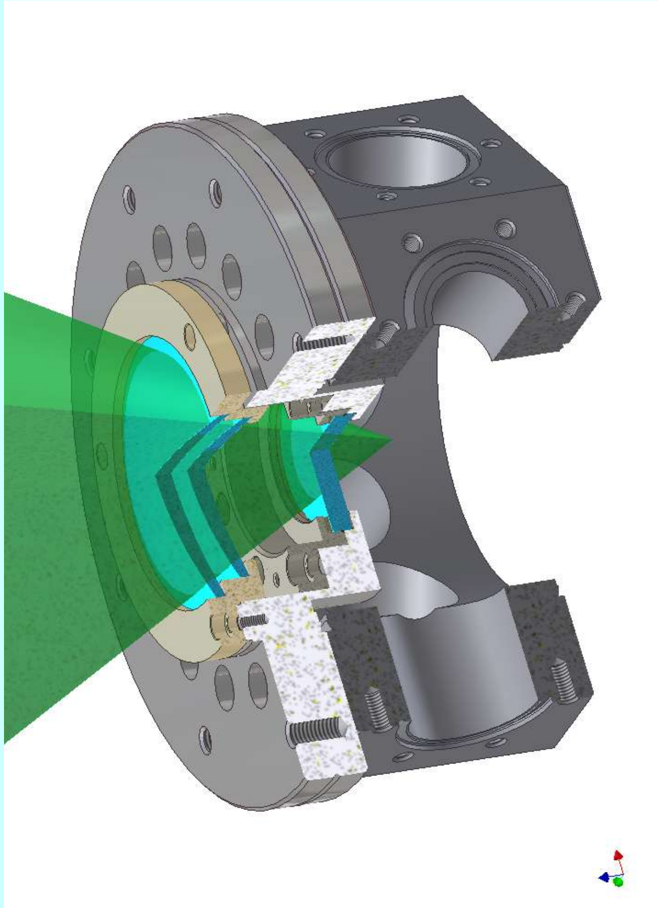
Nicc
http:/

Slide by Chafik Driouichi

Focusing the laser light

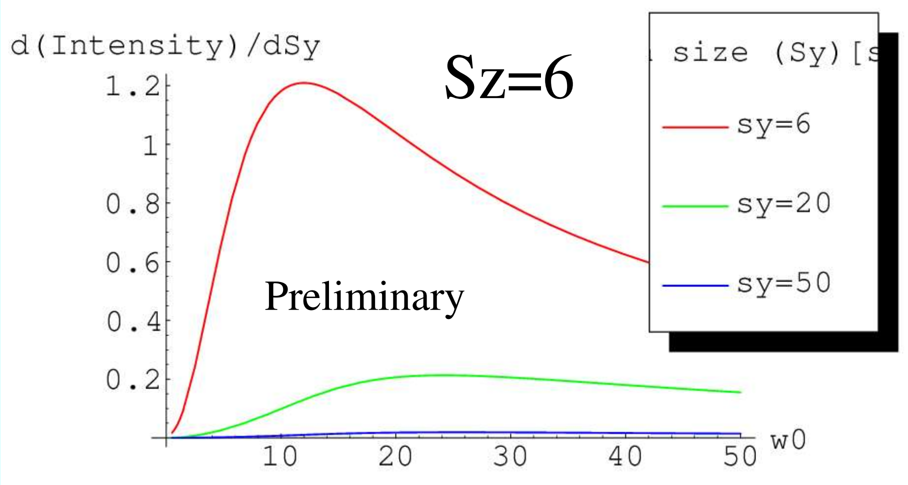
- The laser beam has a diameter of several millimeters.
- We want a wire size of only a [few] micrometers
- The laser light must be focused by wide aperture lens.
- No commercial lens seems to suits our needs

  => Custom design

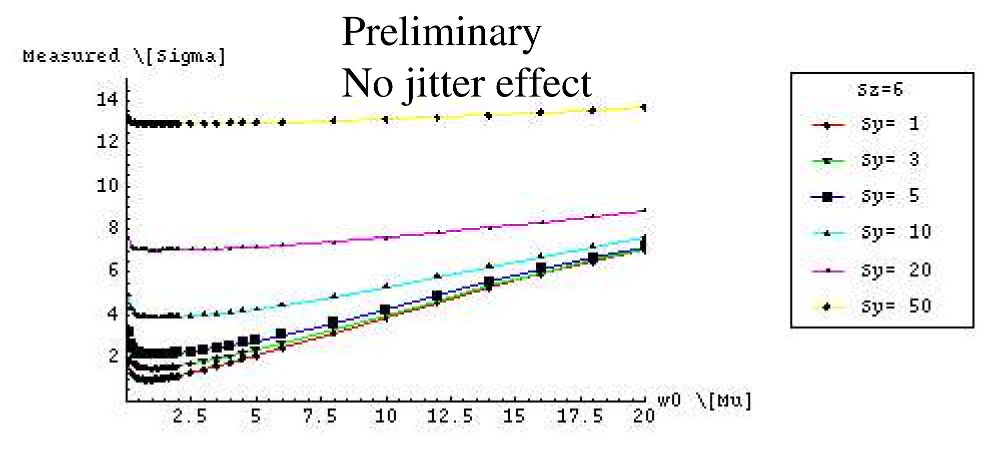


What laser spot size do we need?

- The smallest spot size does not give the best sensitivity.



- But small laser spot size allows us to probe smaller electron beams.

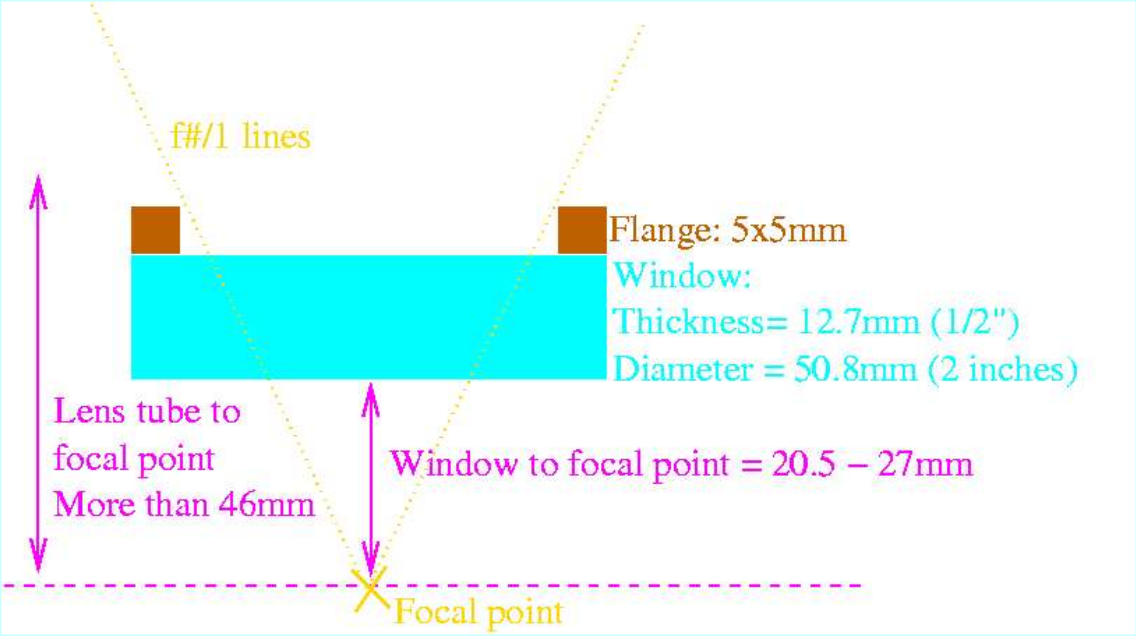


=> First goal 2 micrometers laser spot size

(1 micrometer may be tried later)

Mechanical constraints on the lens

- The lens must fit into the constraints dictated by the design of the vacuum seal and the vacuum vessel.
  [See David Howell's talk]
- For vacuum sealing the lens must include a thick optical flat as last element.



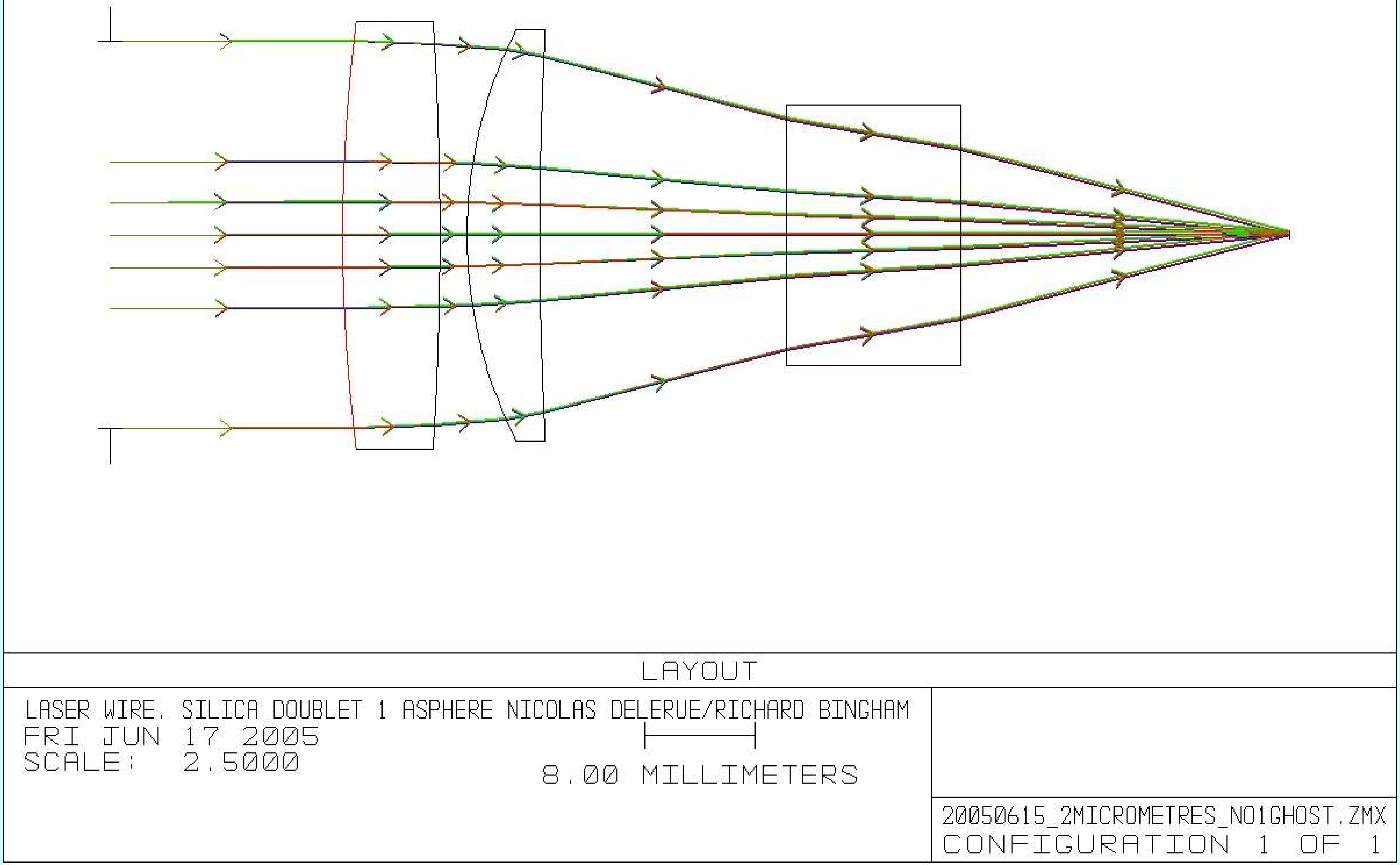
Required performances of the lens

- Goal: concentrate as much energy as possible in the smallest possible radius (gives the best performance).
- As the laser beam will be scanned across the lens, the size of the spot must remain constant over the scanning range.
- As the lens will be used with a high power laser, it must have no first order ghosts and as few second order ghosts as possible.
- To facilitate the alignment of the lens, aberrations must be kept as low as possible.
- Effect of a tilt of one element of the lens with respect to the others must be studied carefully

Lens design

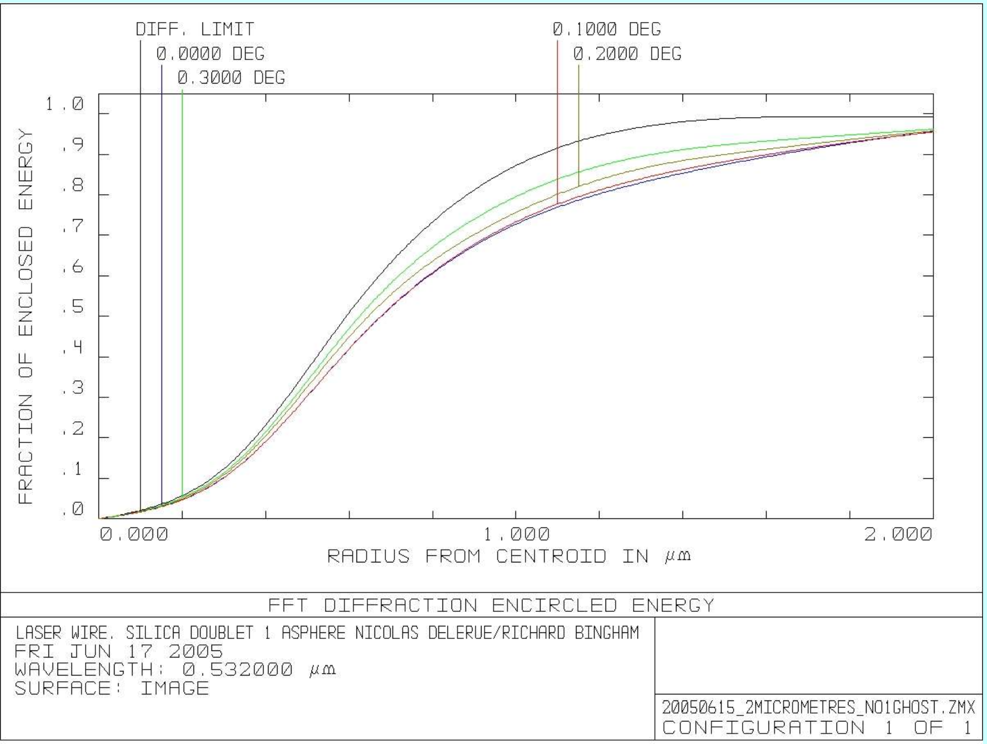
- The lens design was initially done by an external consultant but we had to continue it ourselves.
- The mechanical and performance requirements have been entered into Zemax to optimize the design.
- Design based on a Doublet including an aspheric element for optimal performances.
- All optical elements are made of fused silica to sustain both high laser power and high radiation environment.

Lens layout


LAYOUT
LASER WIRE. SILICA DOUBLET 1 ASPHERE NICOLAS DELERUE/RICHARD BINGHAM
FRI JUN 17 2005
SCALE: 2.5000
8.00 MILLIMETERS
20050615_2MICROMETRES_NO1GHOST.ZMX
CONFIGURATION 1 OF 1

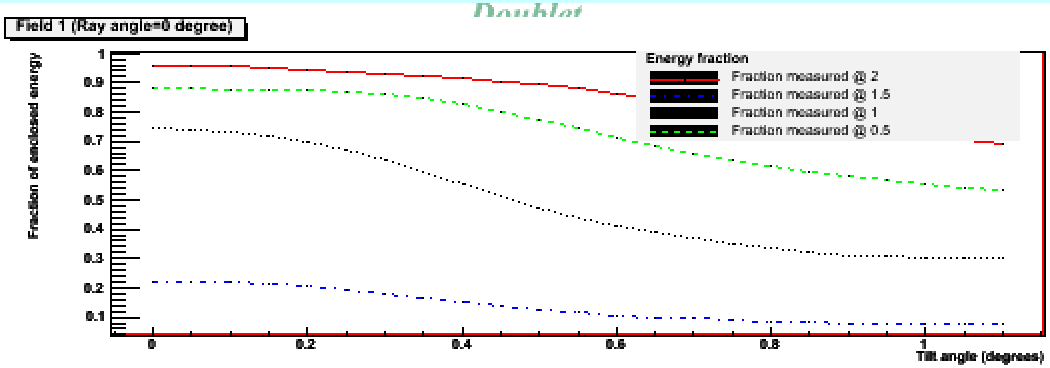
Lens parameters

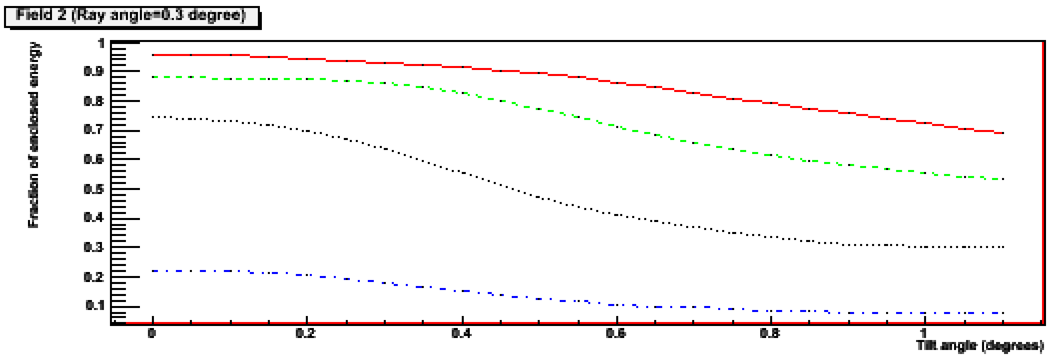
Surf:Type		Comment	Radius	Thickness	Glass	Semi-Diameter	Conic
OBJ	Standard		Infinity	Infinity		Infinity	0.000000
STO	Standard		Infinity	17.000000		14.108400	0.000000
2	Even Asphere		117.126106 V	7.093310 V	SILICA	15.621904	-14.455280 V
3	Standard		-250.070725 V	1.987140 V		15.419735	0.000000
4	Standard		33.118324 V	5.309160 V	SILICA	14.999603	0.000000
5	Standard		274.998672 V	17.985135 V		14.444873	0.000000
6	Standard		Infinity	12.700000	SILICA	9.483961	0.000000
7	Standard		Infinity	24.075710 V		7.084259	0.000000
IMA	Standard		Infinity	-		0.297253	0.000000

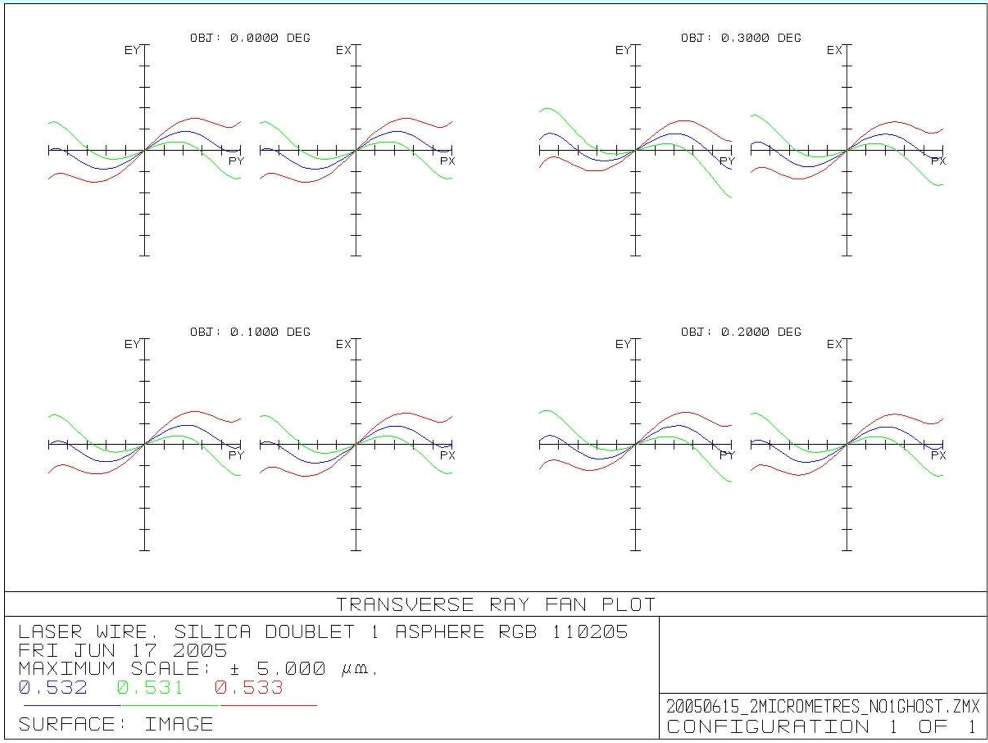


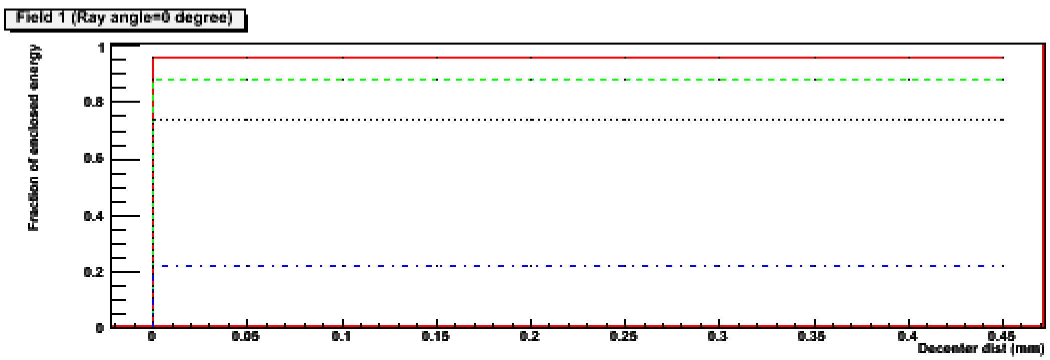
2nd Order Term	4th Order Term	6th Order Term	8th Order Term
0.000000	2.160486E-007 V	-7.467086E-010 V	0.000000

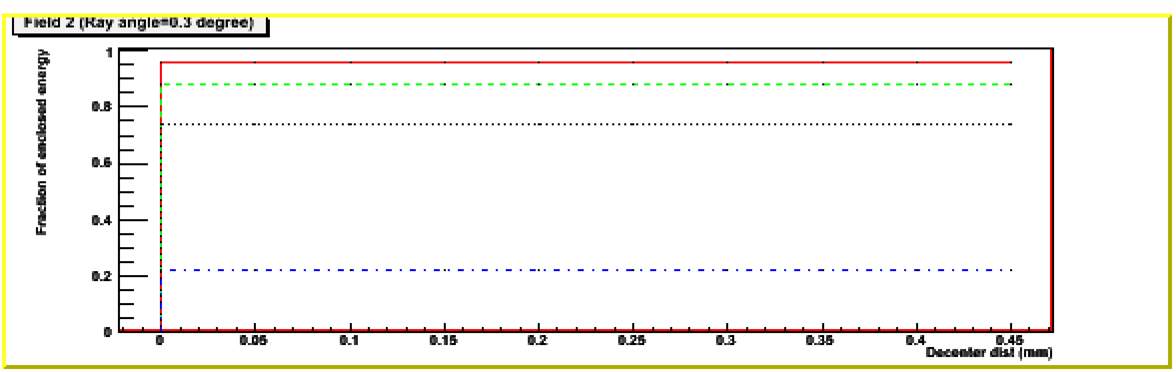
Doublet

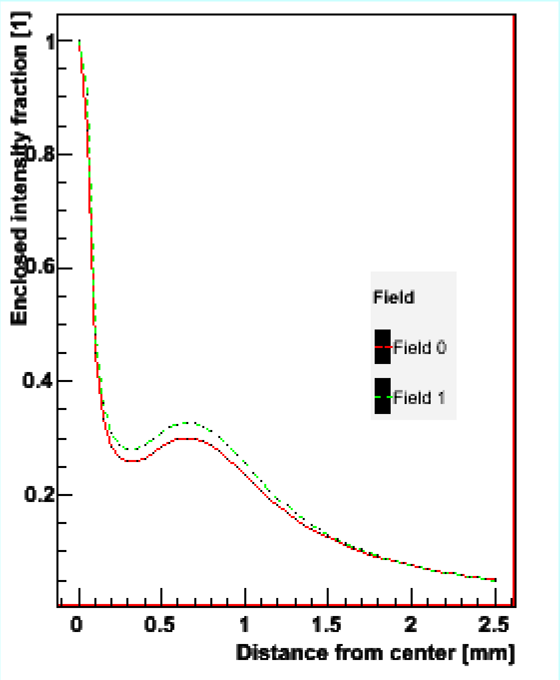

Field 1 (Ray angle=0 degree)
Energy fraction
Fraction measured @ 2
Fraction measured @ 1.5
Fraction measured @ 1
Fraction measured @ 0.5
Fraction of enclosed energy
Tilt angle (degrees)


Field 2 (Ray angle=0.3 degree)
Fraction of enclosed energy
Tilt angle (degrees)

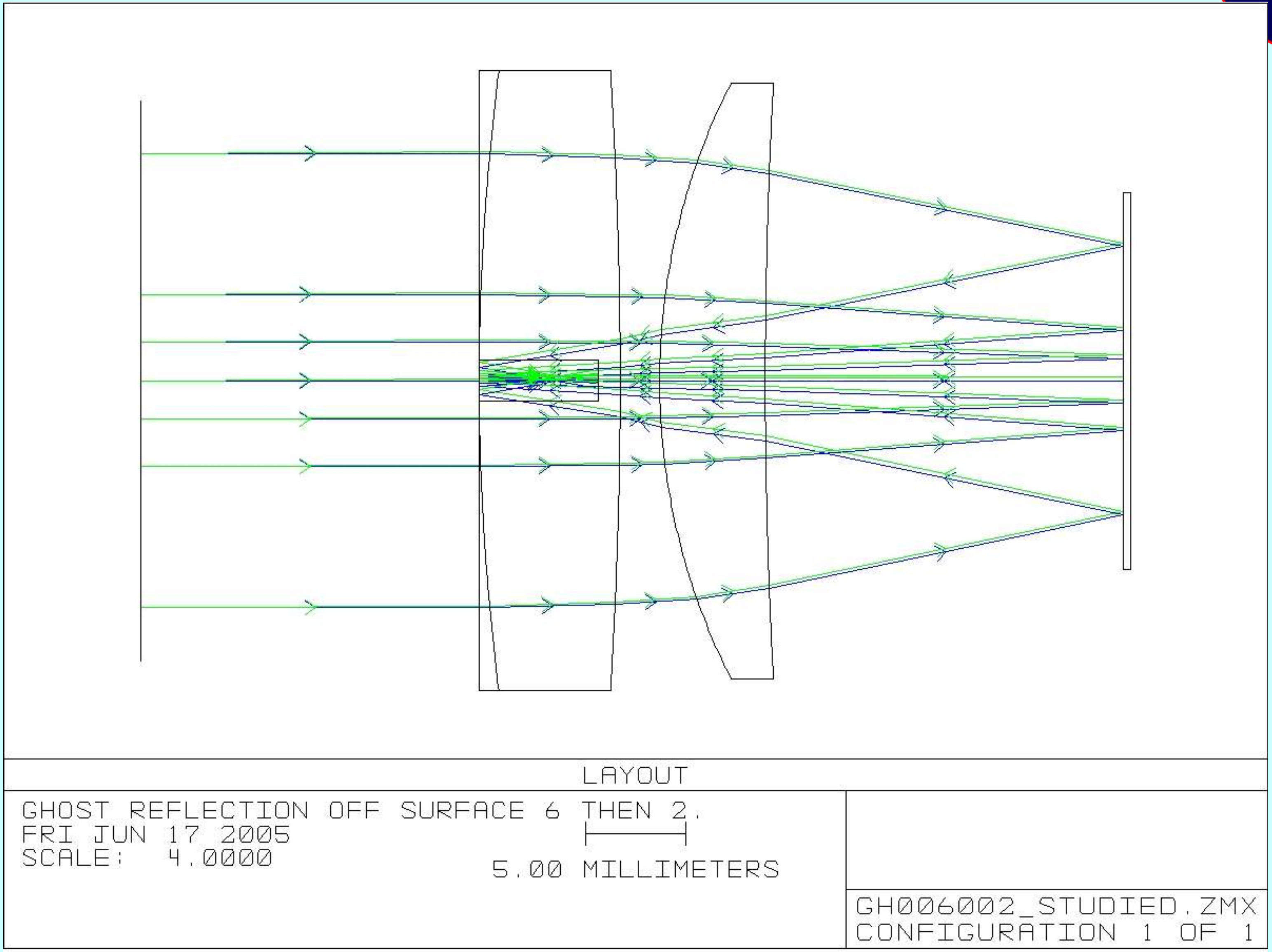

OBJ: 0.0000 DEG
OBJ: 0.3000 DEG
OBJ: 0.1000 DEG
OBJ: 0.2000 DEG
TRANSVERSE RAY FAN PLOT
LASER WIRE, SILICA DOUBLET 1 ASPHERE RGB 110205
FRI JUN 17 2005
MAXIMUM SCALE: ± 5.000 µm.
0.532 0.531 0.533
SURFACE: IMAGE
20050615_2MICROMETRES_NO1GHOST.ZMX
CONFIGURATION 1 OF 1


Field 1 (Ray angle=0 degree)
Fraction of enclosed energy
Decenter dist (mm)


Field 2 (Ray angle=0.3 degree)
Fraction of enclosed energy
Decenter dist (mm)


Enclosed intensity fraction [1]
Field
Field 0
Field 1
Distance from center [mm]

Ghost



This design has only 1 second order ghost (weakly focused)

Conclusion

- A proper handling of the laser beam is critical to achieve good laser-wire performances.
- The laser transport system has been designed and will be tested soon.
- The focusing lens is still under study but should be ordered soon.
- We hope to install everything at the ATF in September