OPO Pump System

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Introductive note for this preliminary draft

The document is only a preliminary draft of the TDR chapter about the OPO pump beam. Of some sections there are only the titles and few indicative rows or are not complete. Some figures are not the definitive or the right one, and in this case are set only to give a sketch.

The part in text that are presented in red color are , like some values -results of measurement or calculation – indicate that at the moment is a reasonable value but that must be verified, like, for example, the closed loop frequency of the pump power stabilization system.

Moreover, since at this time really a lot of decisions had not been done about about the set-up, and in particularly about the pump beam, like

- the pump beam source (commercial doubled laser or home made SHG);
- use of the green mode cleaner

the relative section are presented how possibilities, that once the decision will be taken, could be suppressed or maintained.

The text in green are sentence on which in particulary I would like to have feedback and on which I would focus the attention in the next discussion

(Martina's note)

OPO Pump System

N.B: In grey the section that had not yet been written

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Doubled Laser vs home-made SHG

Homemade SHG with IR Laser

Advantages

- **Total user control**:
  easier to repair in case of damage of some part
  (control of the electronics, of the optics...)
- Least expensive option –
  Backups possible (spare SHG units)

Disadvantages

- Multi Pass -Resonant Thecnology:
  Additional control locking loop
  High photothermal effect even with a low cw pump power
  Long term operation is still an open question

Doubld Nd:Yag Laser (e.g. Prometheus)

Advantages

- Single Pass non resonant system
  (reduce the photothermal aging)
  No control locking loop needed
  Well consolidate technology
- Commercial product
- Less space required

Disadvantages

- Less user control:
- Most expensive option – Backups costly

There are not really scientific reasons to prefear one of them:
a lot of quantum optics exeperiment use the dobled Diabolo laser
For his good spectral features

OPO Pump System

1.3 Homemade SHG

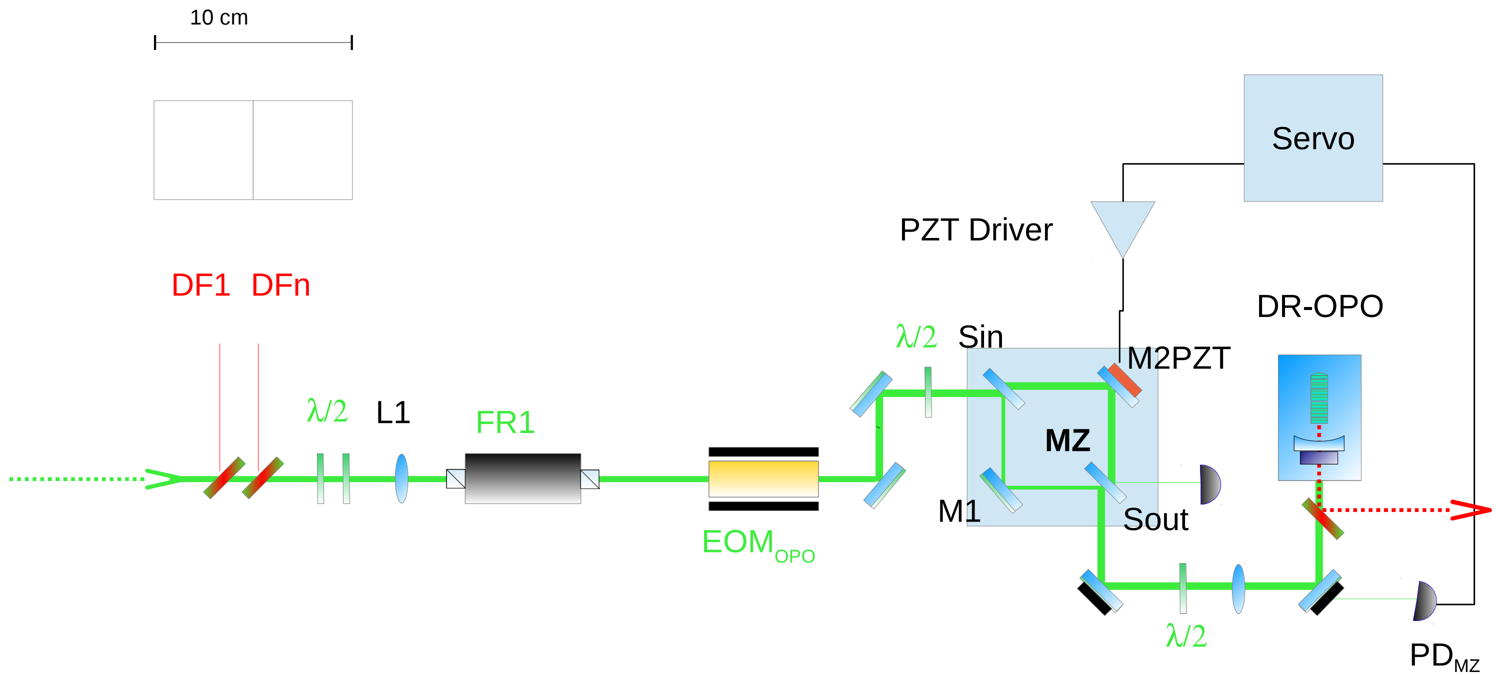
1.3.1 SHG optical design

- NLC
- SHG cavity (optical and geometrical parameters; optical simulation)
- expected threshold and temperature phase matching condition

1.3.2 Temperature control . . . .
1.3.3 Mechanics . . . .
1.3.4 DPH locking system for the SHG . . . .
1.3.5 IR to GREEN convertion . . . .

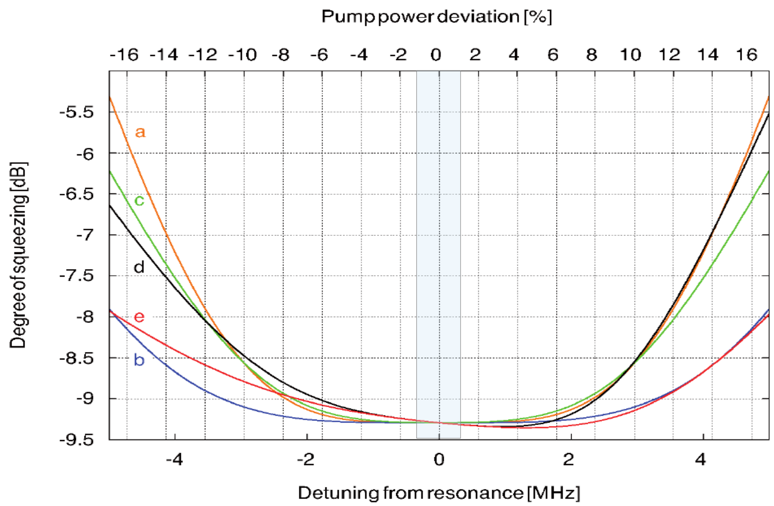
OPO Pump System

Pump Power Stabilization System



Pump Beam Stabilization Requirment

Alexander Khalaidovski PhD Dissertation *(sec. 3.8)*

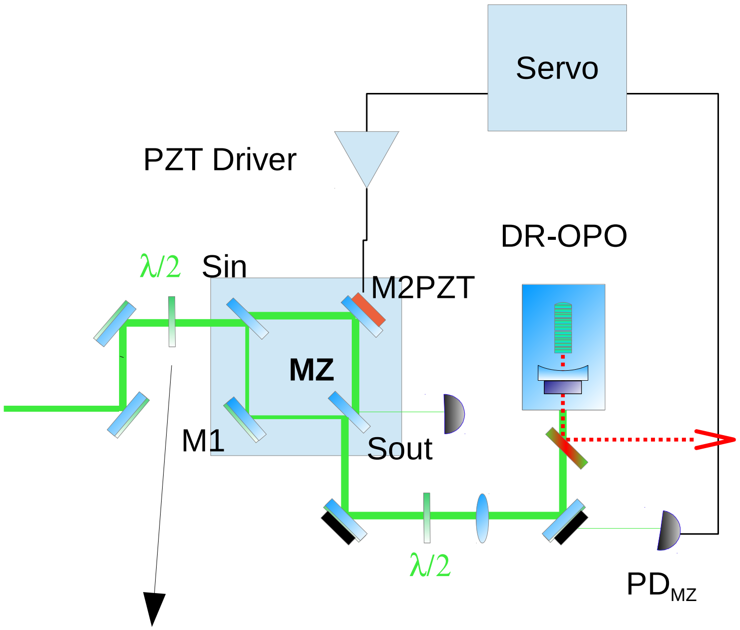


Simulated degree of squeezing detected at a fixed homodyne angle, initially optimized for the nominal pump power of 34.5 mW. The upper x-axis shows the pump power deviation in percent, the lower x-axis gives the resulting cavity detuning for s-polarized light. (a) only considers the rotation of the squeezing ellipse induced by the detuning. (c) additionally takes into account the reduced squeezing output of a detuned cavity. (d) additionally accounts for the optical gain changing with pump power. (e) finally takes into account the detuning-induced rotation of the homodyne readout quadrature. Additionally, (b) shows the effect of the co-rotation of the readout quadrature on trace (a) disregarding the effects of a changing nonlinear gain.

Simulation of Frequency-dependent squeezing affected by Pump Power Fluctuations

Stable squeezing for $\Delta P \leq 1\%$

Pump Power Stabilization System



unbalanced interferometer: equal arms length
unbalanced arms optical power

Sin, Sout: UV fused silica beam samplers **T=0.1** @ 45° p-polarization
T=0.01 @ 45° s-polarization.

Normalized Mean power at the ports:

Port= 0.98 and Ppar= 0.02
with a dynamic range of ±0.02 for the *p-polarization*
Port = 0.82 and **Ppar = 0.18**
with a dynamic range of ±0.2 for the *s-polarization*.

M1 and M2 => R > 0.9999 and a super-polished reflective surface
with rms surface roughness ~ 0.5 A and a scratch/dig of 10/5.

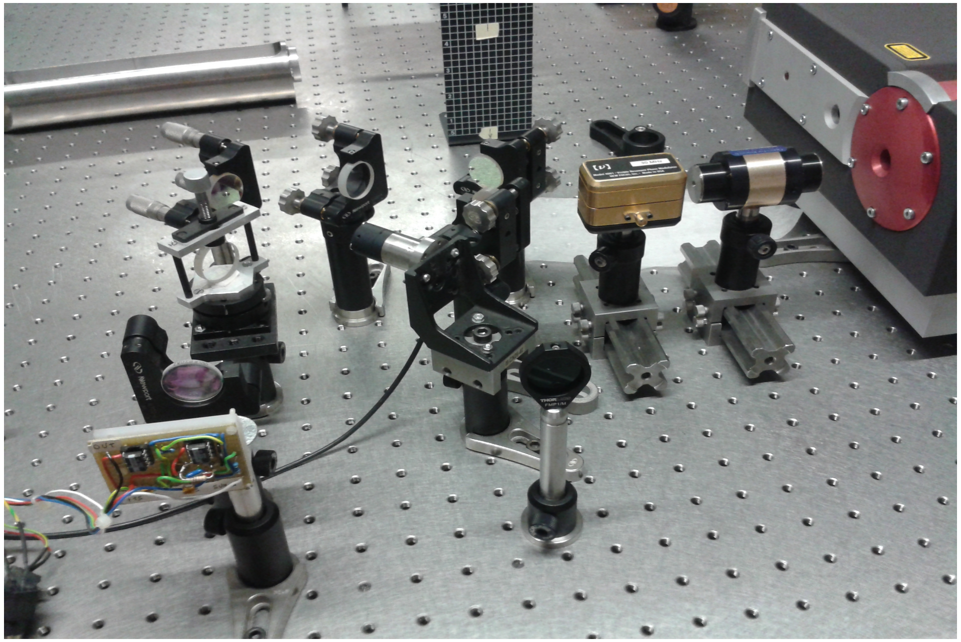
λ/2 waveplate
for the input polarization adjustment → the tuning of the mean transmitted power.

PZT on the mirror M2 PI S-310 compact, high-speed multi-axis tip/tilt and z-positioners,
resonant frequency = 6.1 ± 1.2 kHz with a 1 inch fused silica mirrors.

It allows the fine interferometer alignment, while the rough alignment can be performed by means of the precision adjustment screws on the M1 mirror holder.

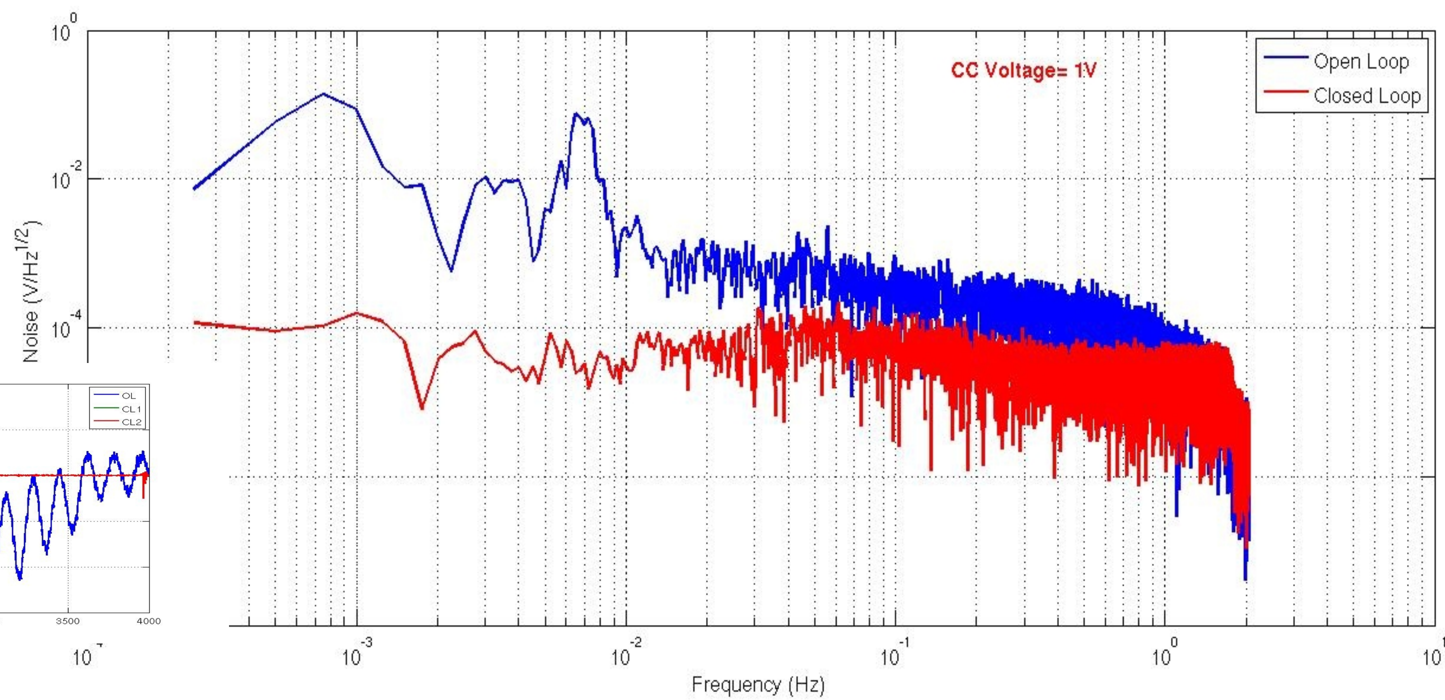
The unity gain frequency of the closed loop system is 1 kHz.

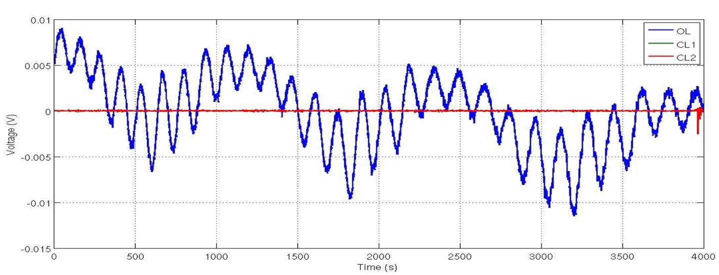
Pump Beam Stabilization Requirment



Our first proptotype of
Mac Zehnder Stabilizator
assures a fluctuations ~ $1x10^{-4}$

The **results** of a preliminary prototype
are already compliant with the specifications,
$\Delta P \leq 1\%$





OPO pre-MC

OPO pre Mode Cleaner: OPEN DISCUSSION

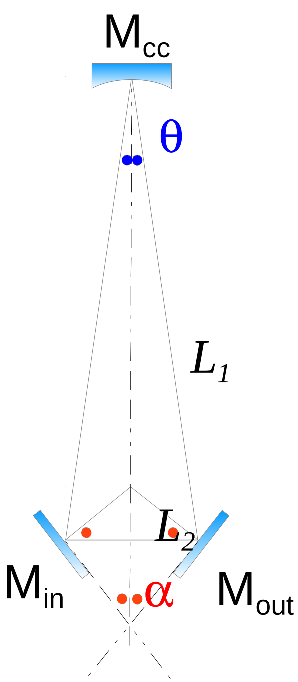
Even though → DR-OPO in principle a NO pump pre-MC required, (pump resonance assure the self mode cleaner)

it could be useful to **introduce a pre-MC cavity** to further filter the OPO pump,

- *the SHG cavity and the OPO have a low finesse….. ....*
- Furthemore a ring pre-MC acts as polarization filter.
- *Moreover it could provide the spatial mode for the homodyne detector, by designing a MC cavity for the homodyne LO equal to the OPO pre-MC and and by suitably matching the latest with the OPO cavity. In fact in this way the identical cavities geometry will determine the spatial mode of the two beams on the homodyne BS and this allows a easy way to maximize the homodyne efficiency, by maximizing its visibility with the best overlap of the two modes on the BS.*

I will dedicate a note about to argue the reasons

MC532 Parameters



Mirrors radius r=25,4 mm;

Concave Mirror RoC R=1m;

α = 43.88° θ = 2.25° L_{MC532} = 582.29 mm.

Beam Parameters

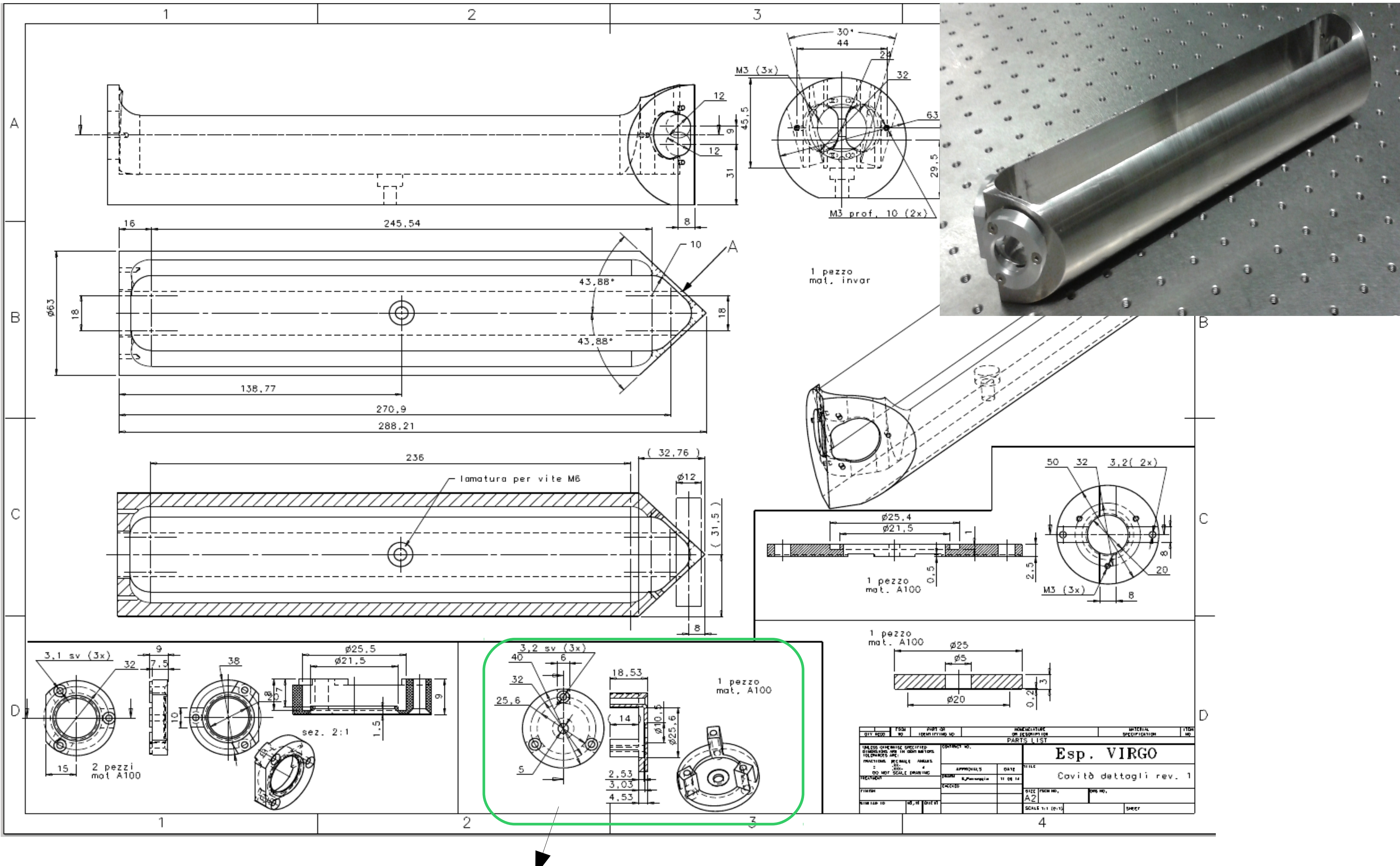
–	w_0	w_{in}	w_{out}	w_{cc}	z_R	Gouy phase	g
–	(μm)	(μm)	(μm)	(μm)	(mm)	(π)	
x	392.036	392.151	392.151	465.785	453.797	0.3625	0.6991
y	392.463	392.577	392.577	465.996	454.784	0.3631	0.7006

$$\mathcal{F} = 614.$$

$$FSR = 514.85 \text{ MHz}$$

$$FWHM = 514.85 \text{ MHz}$$

MC532 technical design



This must be redesigned

Pump Power Stabilization and MC