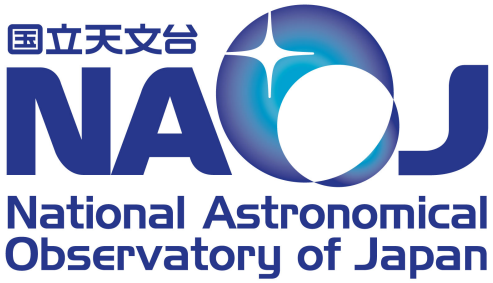


Advanced Virgo telescopes design and realization

Matteo Barsuglia (APC)
On behalf of Virgo Collabration

Outline

- Introduction: advanced Virgo
    - Advanced Virgo optical scheme
    - Telescopes: global view, goals and challenges

- Input (injection system): from the conceptual design to pre-commissioning
    - Optical design
    - Mechanics
    - Mechanical tests
    - Integration

- Dark fringe telescope overview

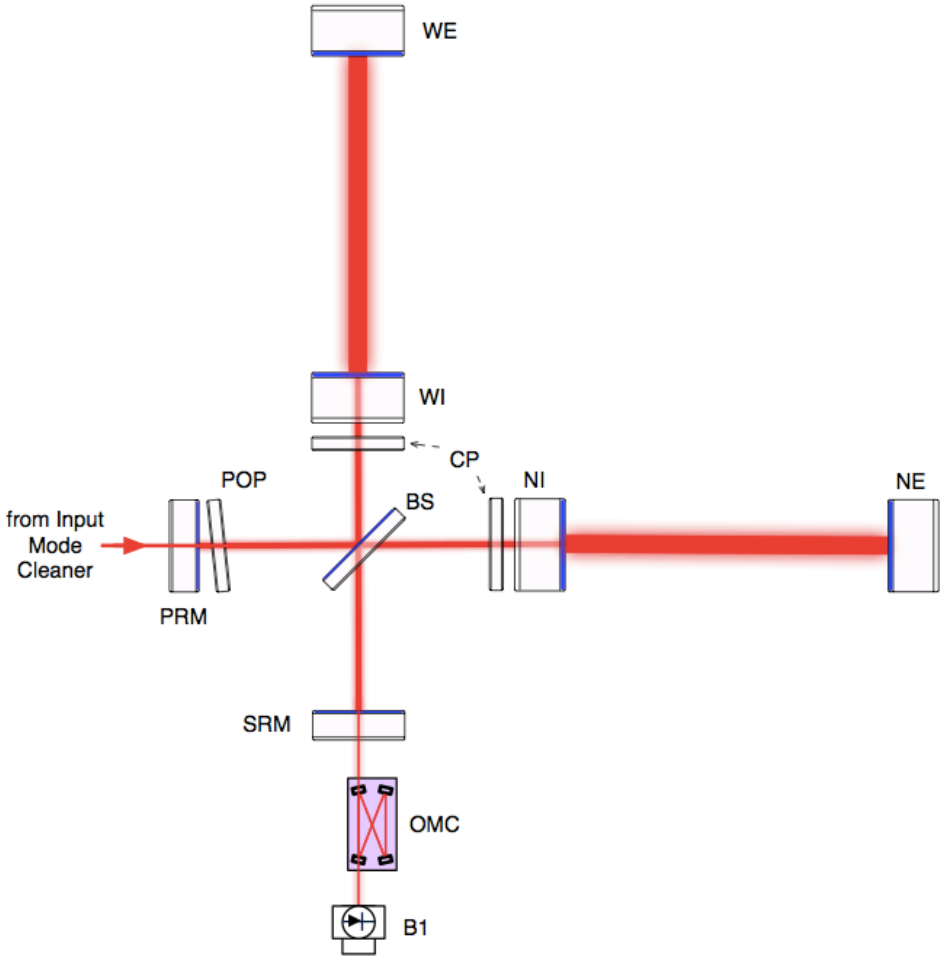
- End transmission (*BRT+Gouy phase*) telescope overview

Introduction

Advanced Virgo optical scheme

- Dual recycled Fabry-Perot Michelson
- Bi-concave arm-cavities
- Marginally stable recycling cavities
- Compensation plates
- Pick-off plate for ITF control

Advanced Virgo main Optical parameters			
Light Power			
arm cavity power	650 kW	power on BS	4.9 kW
Arm cavity geometry			
cavity length L	2999.8 m		
IM R_C	1420 m	EM R_C	1683 m
Beam size on IM w	48.7 mm	Beam size on EM w	58.0 mm
waist size w_0	9.69 mm	waist position z	1363 m
Arm cavity finesse			
finesse	443	round-trip losses	75 ppm
transmission IM T	1.4%	transmission EM T	1 ppm
Power recycling			
transmission PRM T	5%	recycling gain	37.5
PRC length	11.952 m	Beam size on PRM	49.1 (TBC) mm
Signal recycling			
transmission SRM T	20%	finesse	26
SRC length	11.952 m	SRM tuning	0.35 rad
Mirrors			
IM diameter	35 cm	EM diameter	35 cm
IM thickness	20 cm	EM thickness	20 cm



Telescopes: goals and challenges

dark fringe (Output)

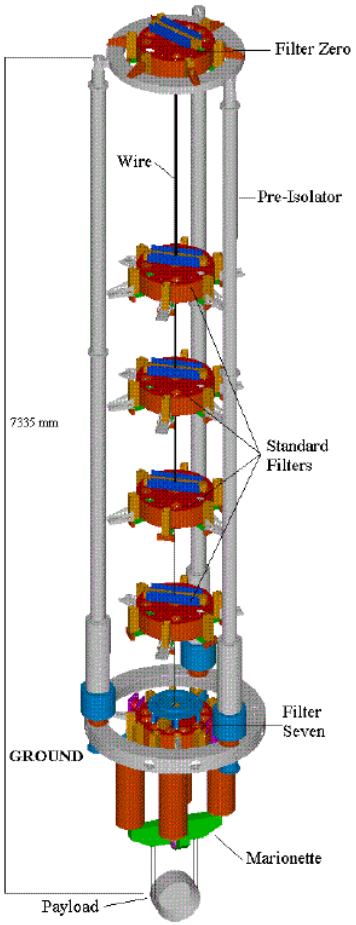
Parameters	Requirements
Mode matching on the OMC cavities	≥99%
Magnification	186
Dimensions	≤800mmx250mm
Noise coming from spurious light	≤AdV sensitivity/10

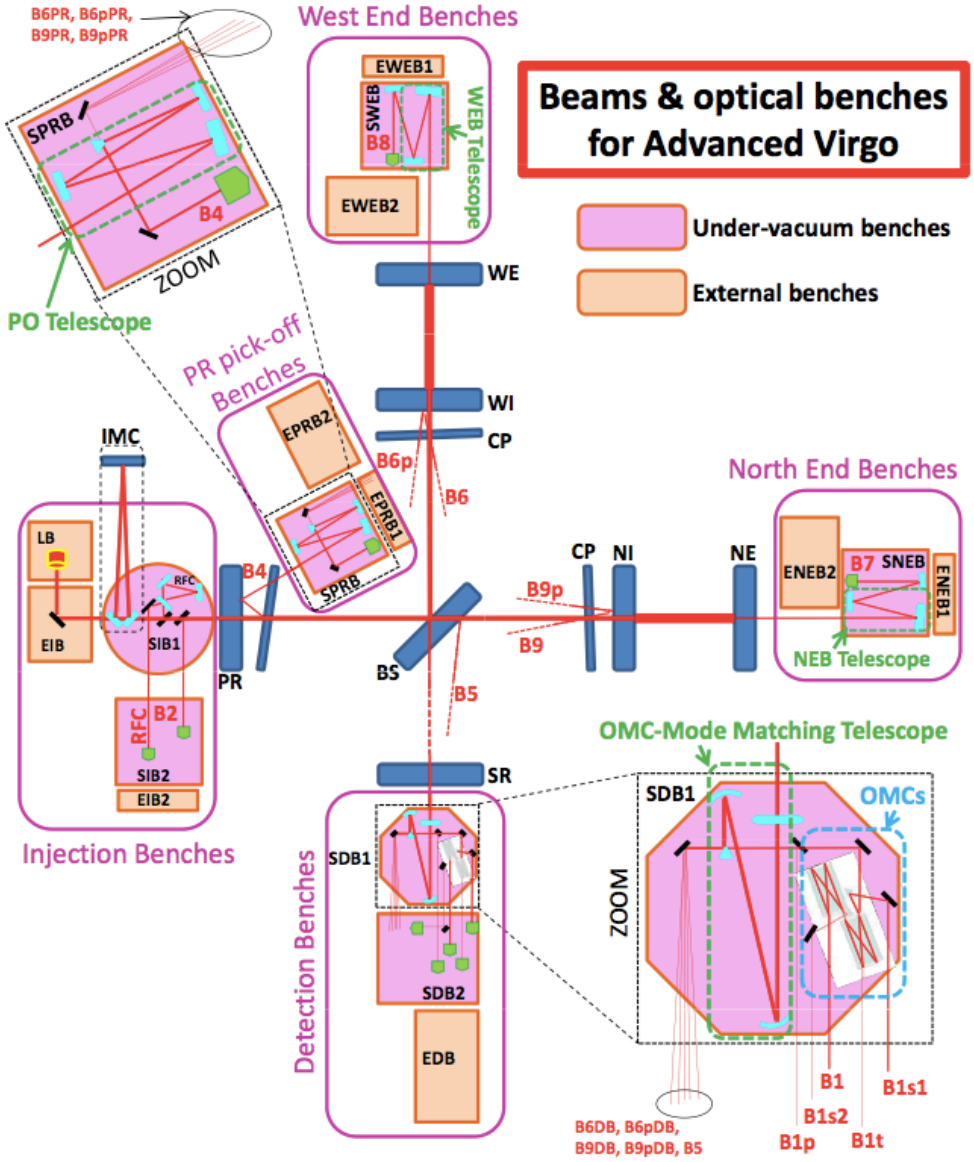
Injection (input)

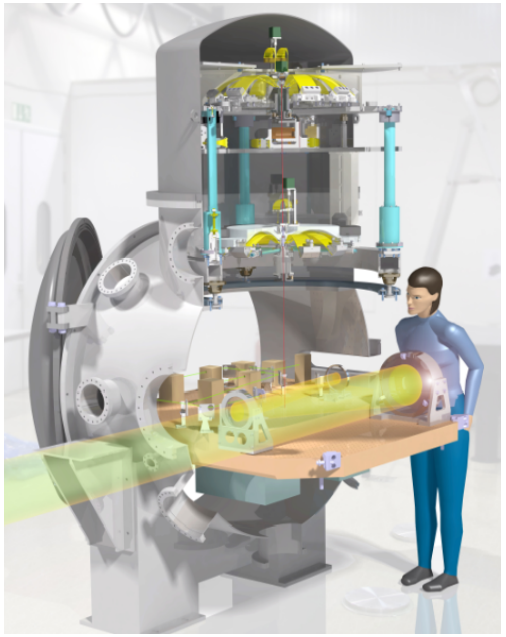
Parameter	Requirement
Mode matching (on the ITF)	≥ 99%
Noise coming from diffused and back-reflected light	≤ AdV sensitivity/10
Magnification	19
Telescope dimensions	< 800 mm x 350 mm

Suspended and under vacuum (remote controlled)

Advanced Virgo benches

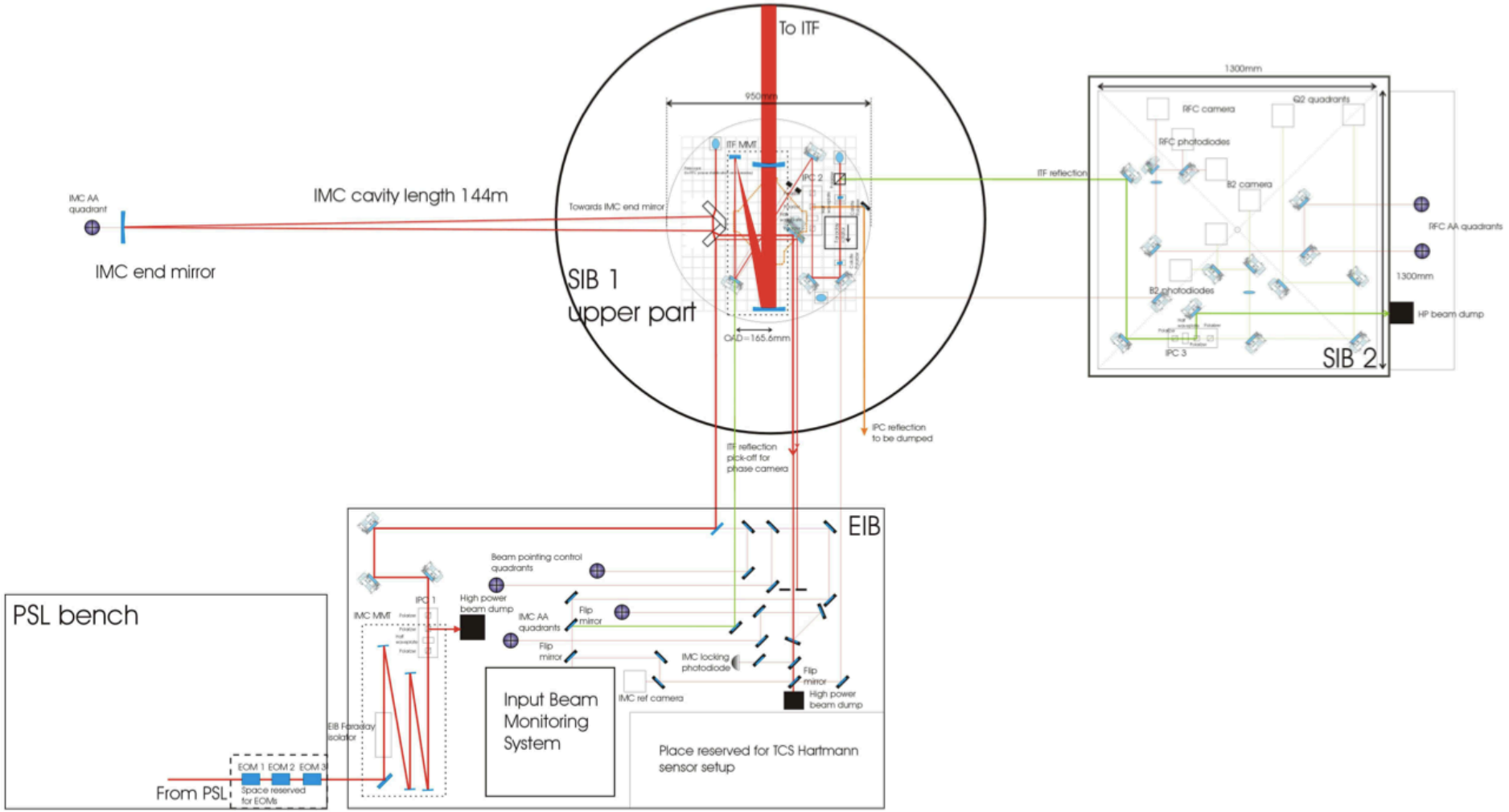




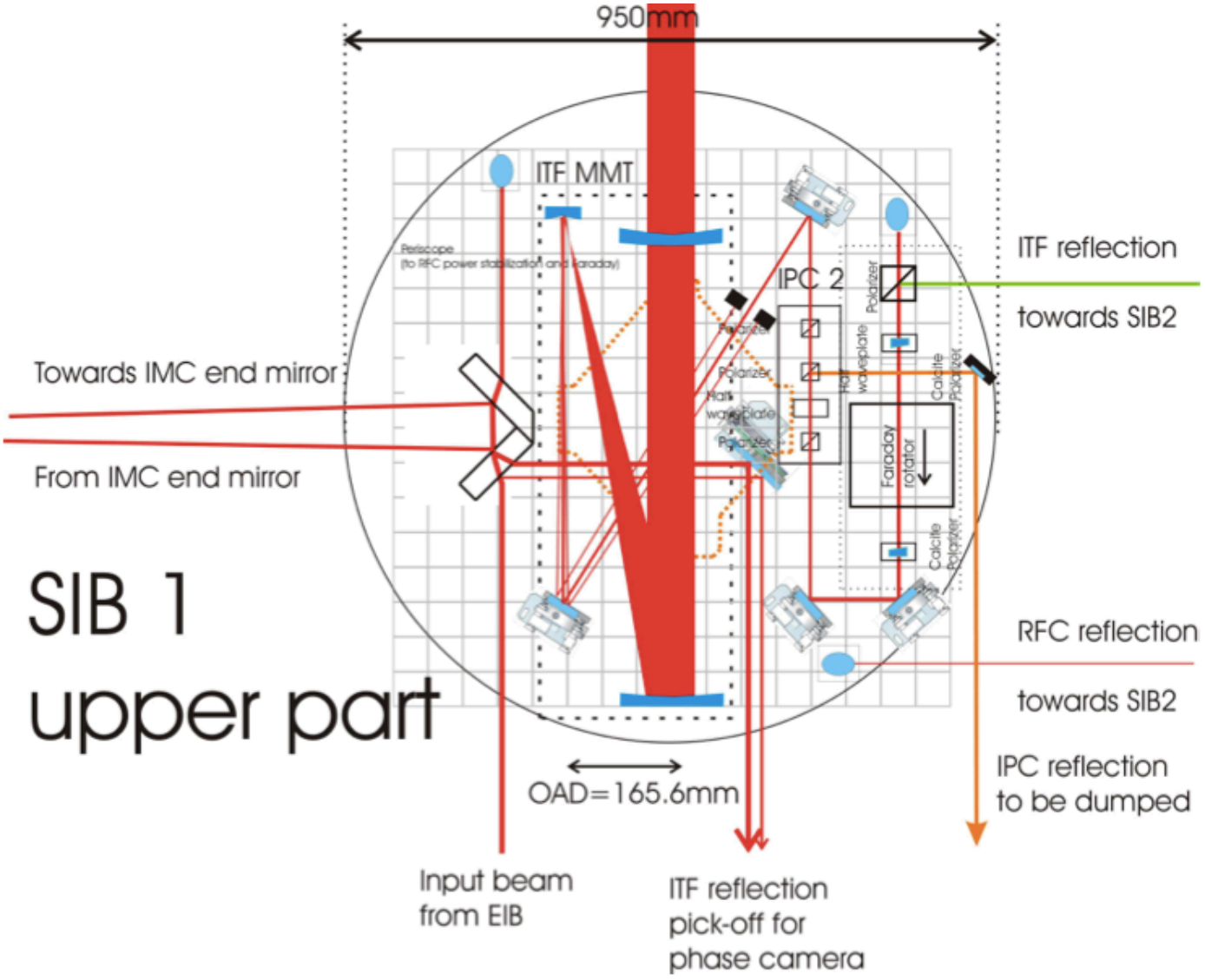


Injecion bench (input) telescope

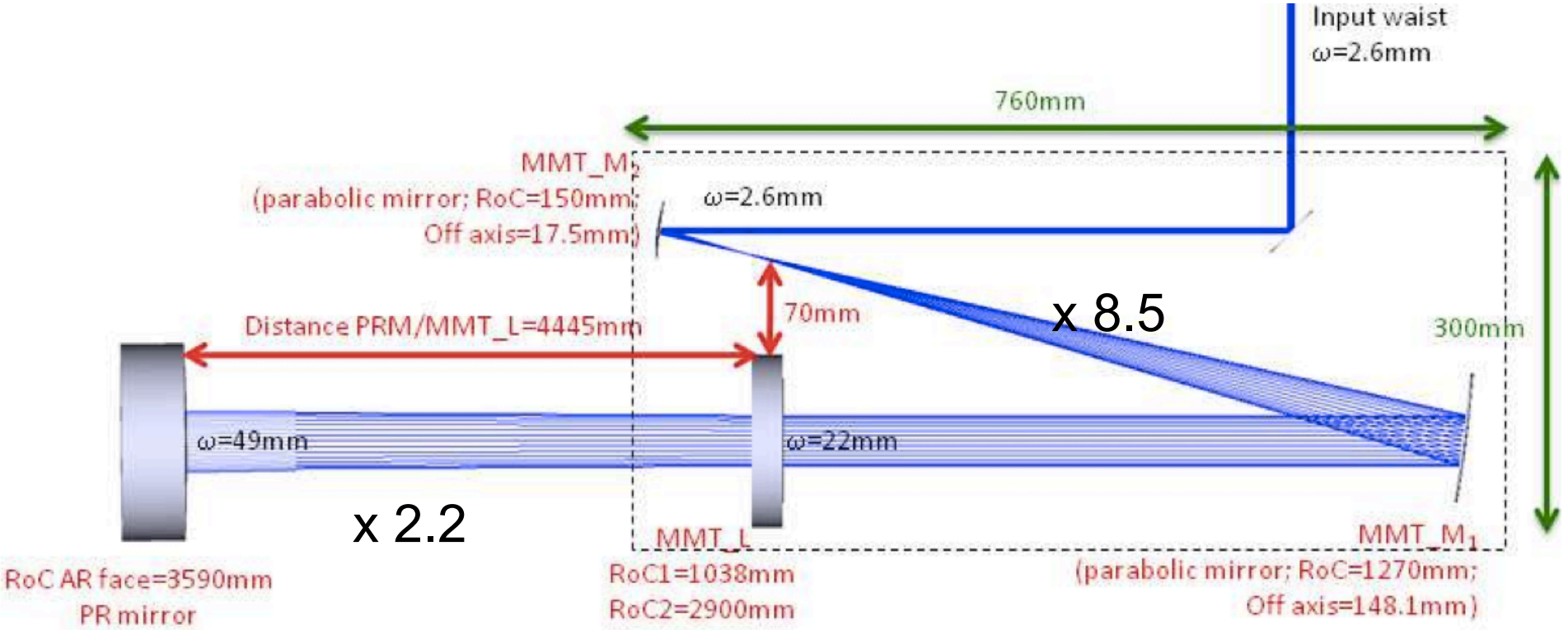
Injection system



Injection bench

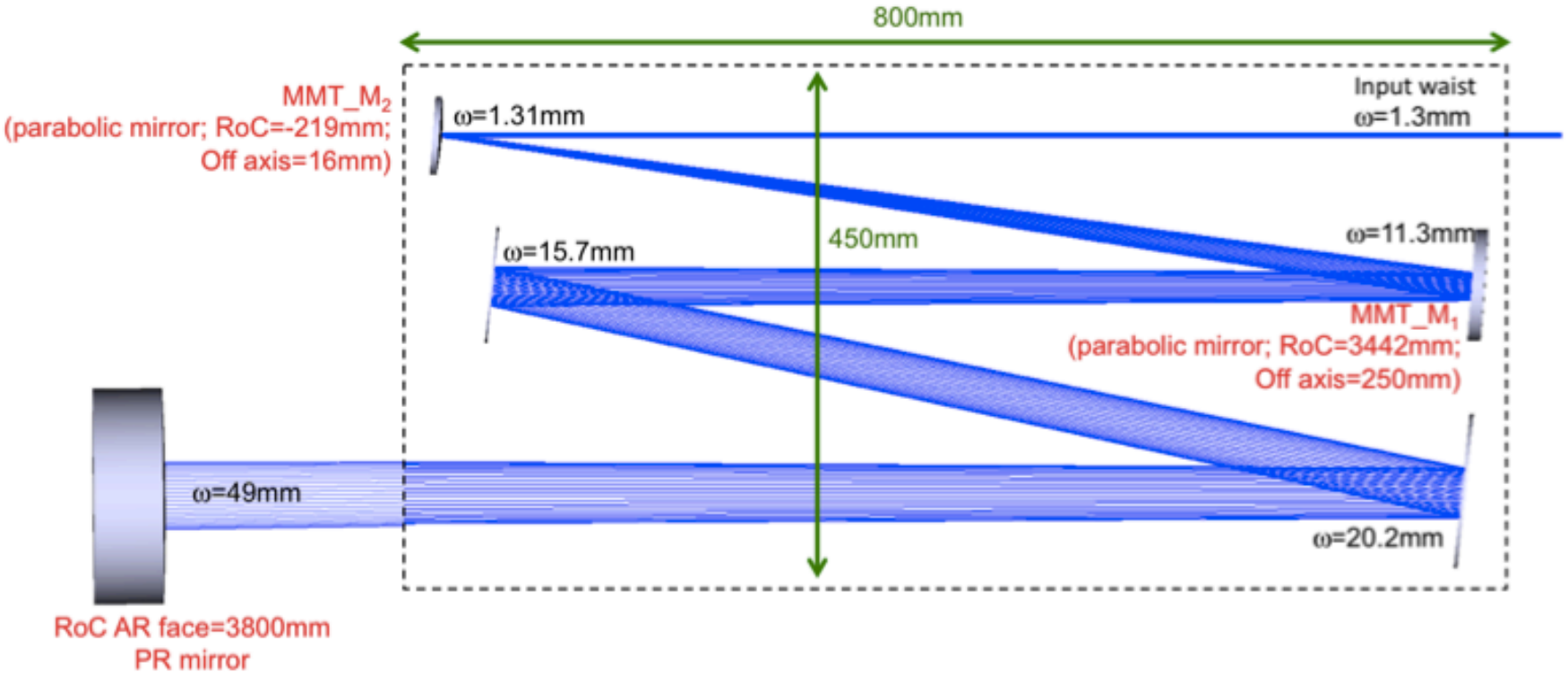


Injection telescope



Parameter	Requirement
Mode matching (on the ITF)	$\geq 99\%$
Noise coming from diffused and back-reflected light	$\leq$ AdV sensitivity/10
Magnification	19
Telescope dimensions	$<$ 800 mm x 350 mm

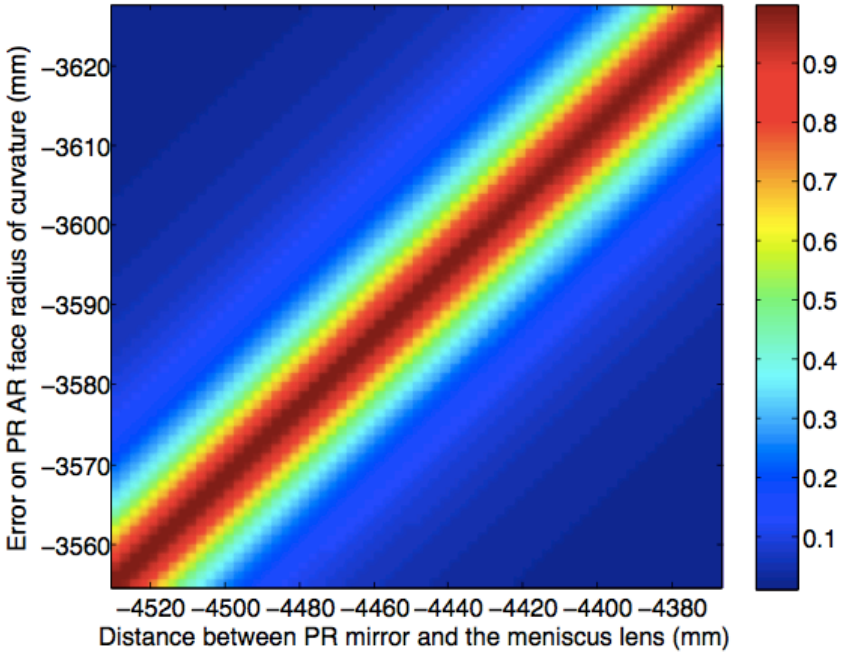
Alternative configuration (reflective) explored

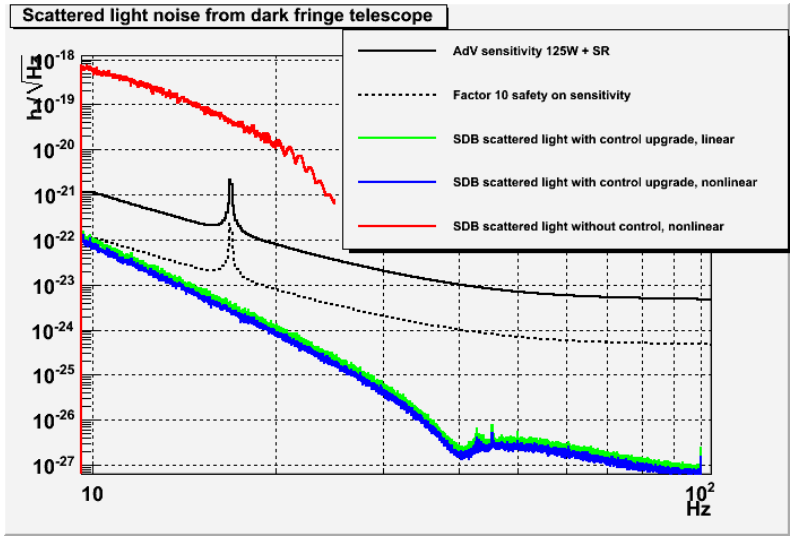


Space problems

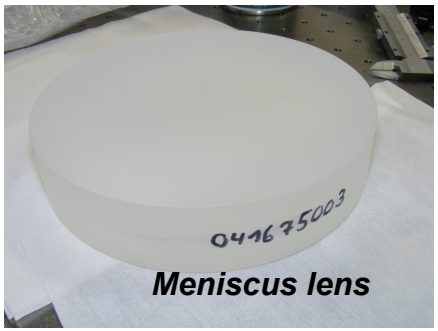
Optical design

- Space constraints
- Aberrations – copupling efficiency
- Tolerancing vs mechanical costraints
- Diffused light

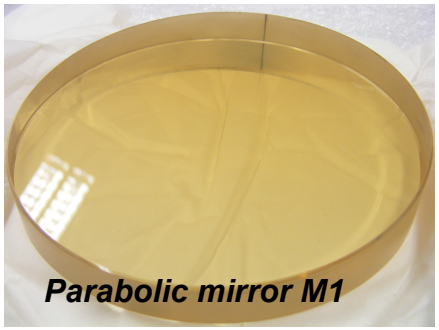




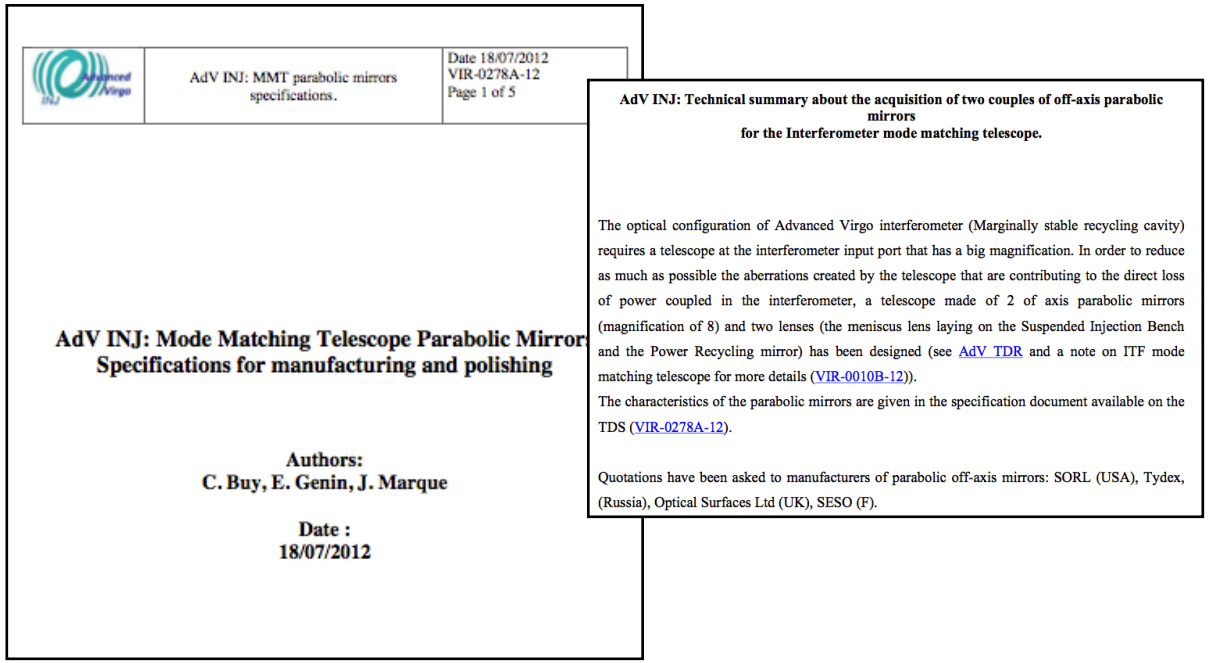
Optics purchase / follow-up



Meniscus lens



Parabolic mirror M1



	AdV INJ: MMT parabolic mirrors specifications.	Date 18/07/2012 VIR-0278A-12 Page 1 of 5

AdV INJ: Mode Matching Telescope Parabolic Mirror
Specifications for manufacturing and polishing

Authors:
C. Buy, E. Genin, J. Marque

Date :
18/07/2012

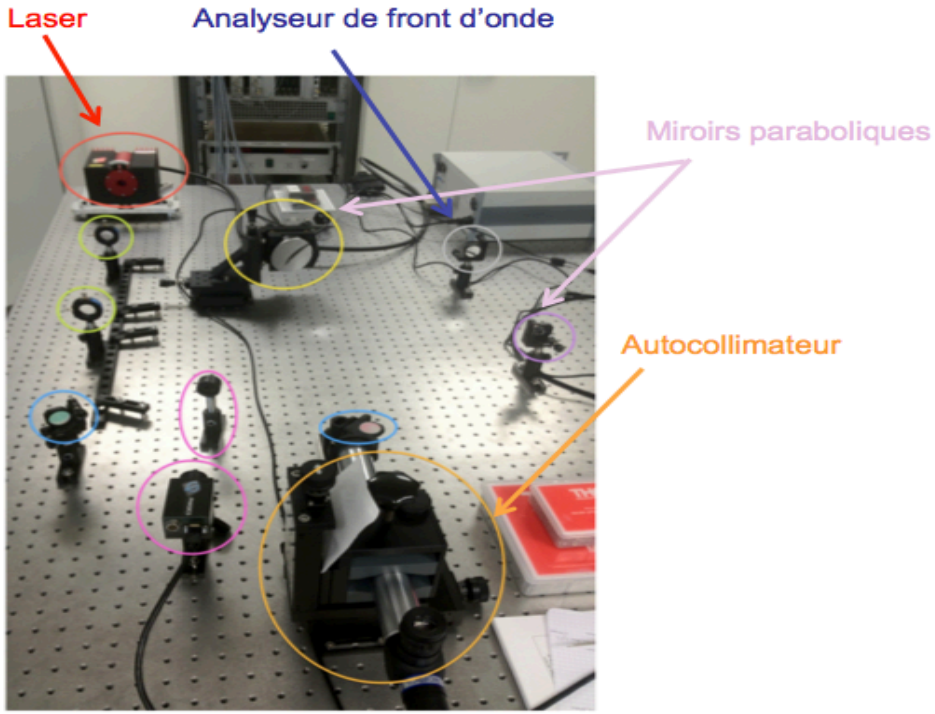
AdV INJ: Technical summary about the acquisition of two couples of off-axis parabolic mirrors
for the Interferometer mode matching telescope.

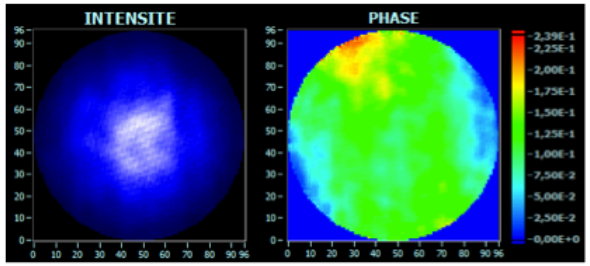
The optical configuration of Advanced Virgo interferometer (Marginally stable recycling cavity) requires a telescope at the interferometer input port that has a big magnification. In order to reduce as much as possible the aberrations created by the telescope that are contributing to the direct loss of power coupled in the interferometer, a telescope made of 2 of axis parabolic mirrors (magnification of 8) and two lenses (the meniscus lens laying on the Suspended Injection Bench and the Power Recycling mirror) has been designed (see AdV TDR and a note on ITF mode matching telescope for more details (VIR-0010B-12)).
The characteristics of the parabolic mirrors are given in the specification document available on the TDS (VIR-0278A-12).

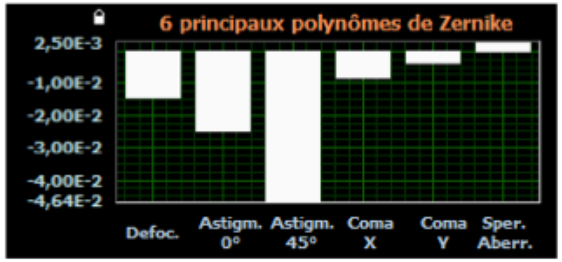
Quotations have been asked to manufacturers of parabolic off-axis mirrors: SORL (USA), Tydex, (Russia), Optical Surfaces Ltd (UK), SESO (F).

- Specification document for each optics (dimensions, surface quality, tolerances…)
- Ask offers to several suppliers(~ 5/6)
- Technical readiness review (technical summary) for the choice of the supplier
- Tracking control, delivery time (respected or not), surface quality (specification respected, impact on the schedule)
- Delivery, coating

Pre-alignment procedure test



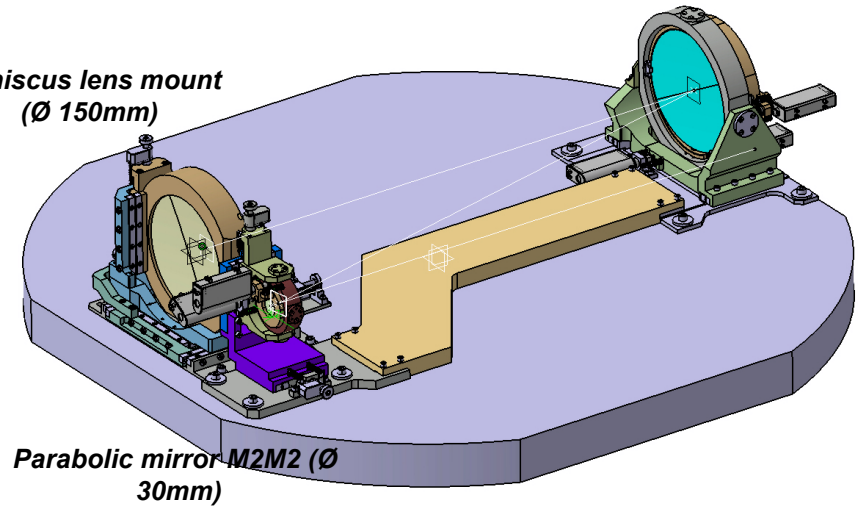




Mechanical design/ integration with the bench

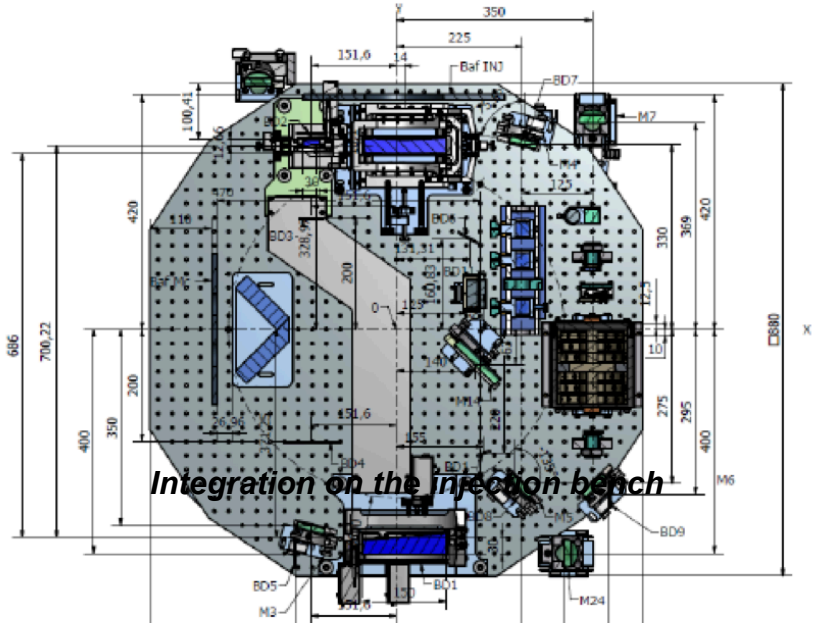
CAO injection

Meniscus lens mount (Ø 150mm)



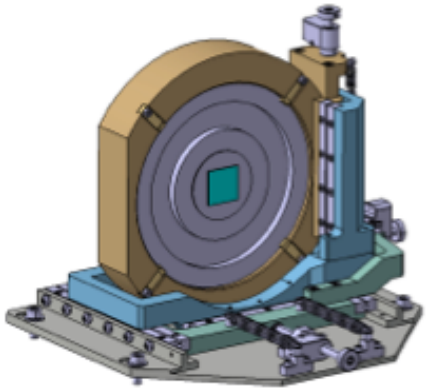
Parabolic mirror M2M2 (Ø 30mm)

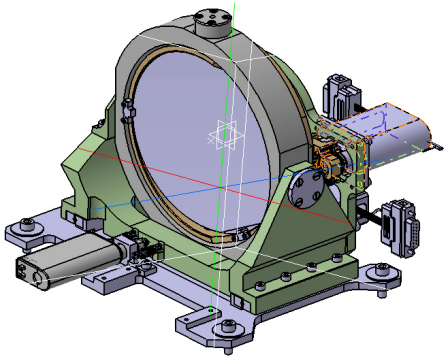
Parabolic mirror M1 (Ø 150mm)

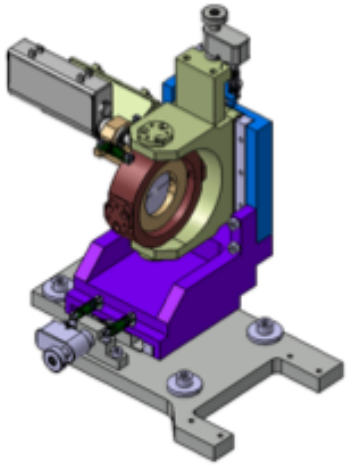


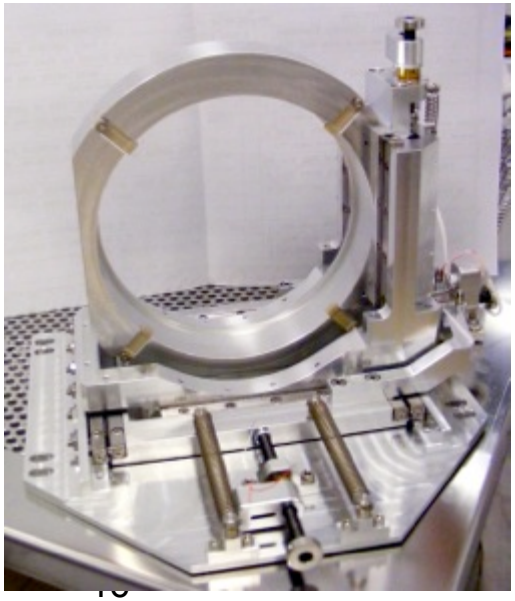
Integration on the injection bench

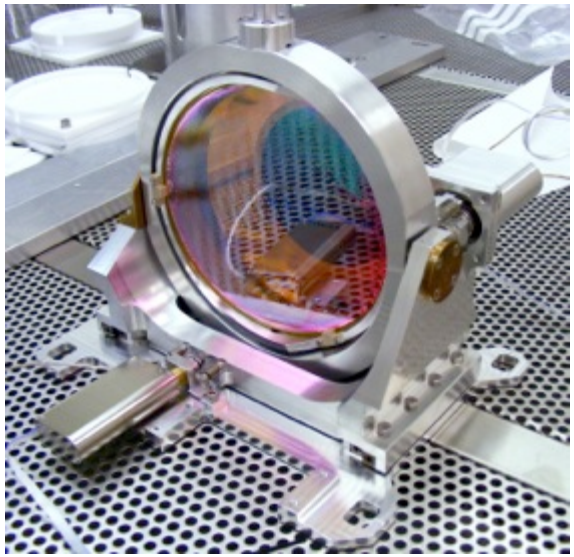
Telescope mechanics

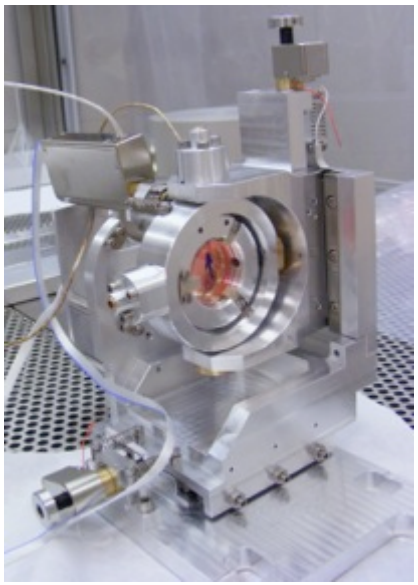




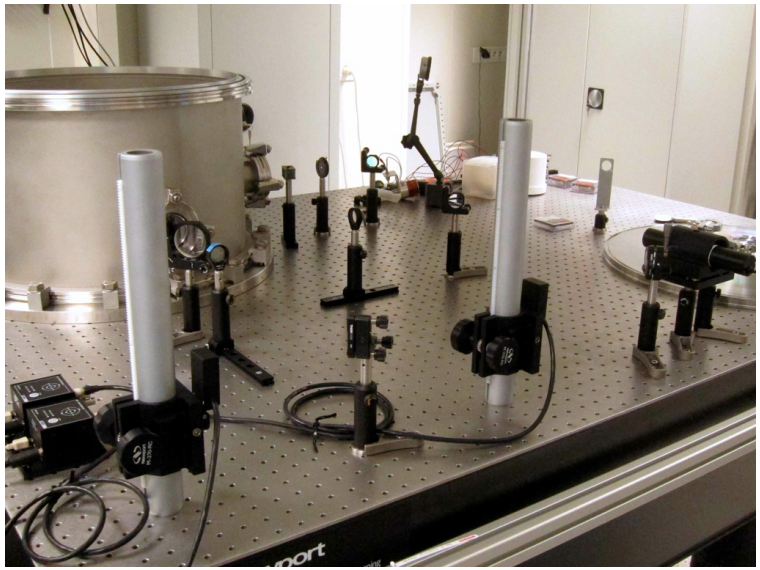


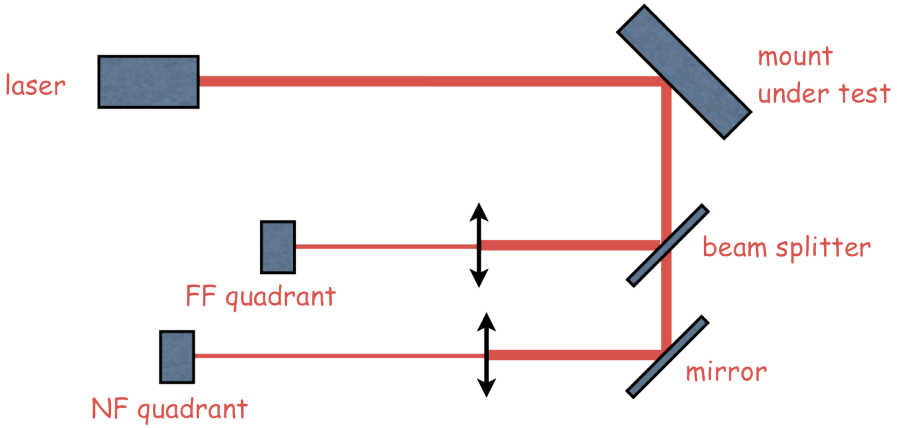


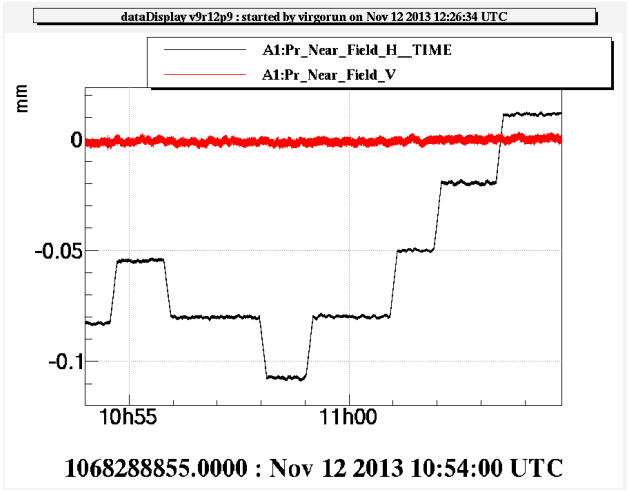


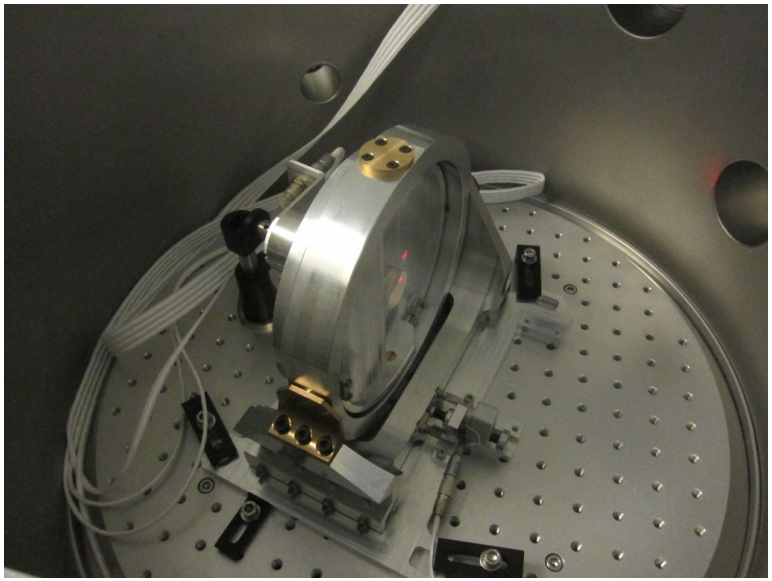


Mechanical mounts tests





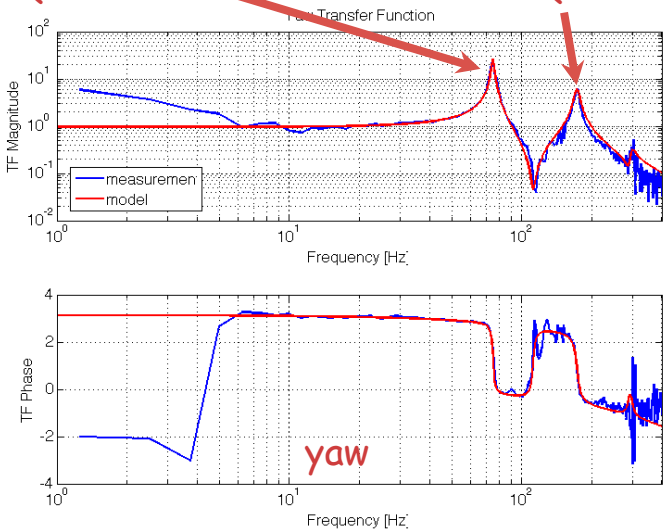




Resonances

f1 = 75 Hz
Q1 = 40

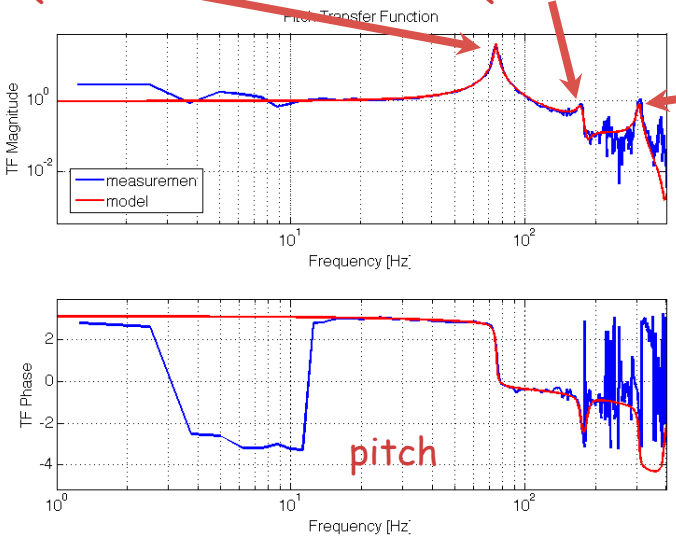
f2 = 172 Hz
Q2 = 20

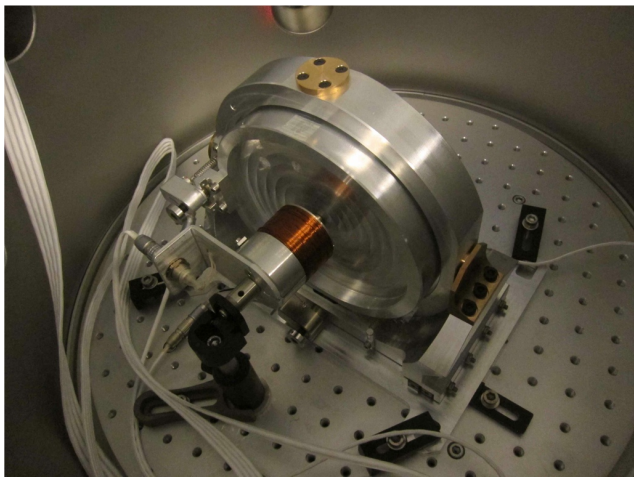


f1 = 75 Hz
Q1 = 40

f2 = 172 Hz
Q2 = 20

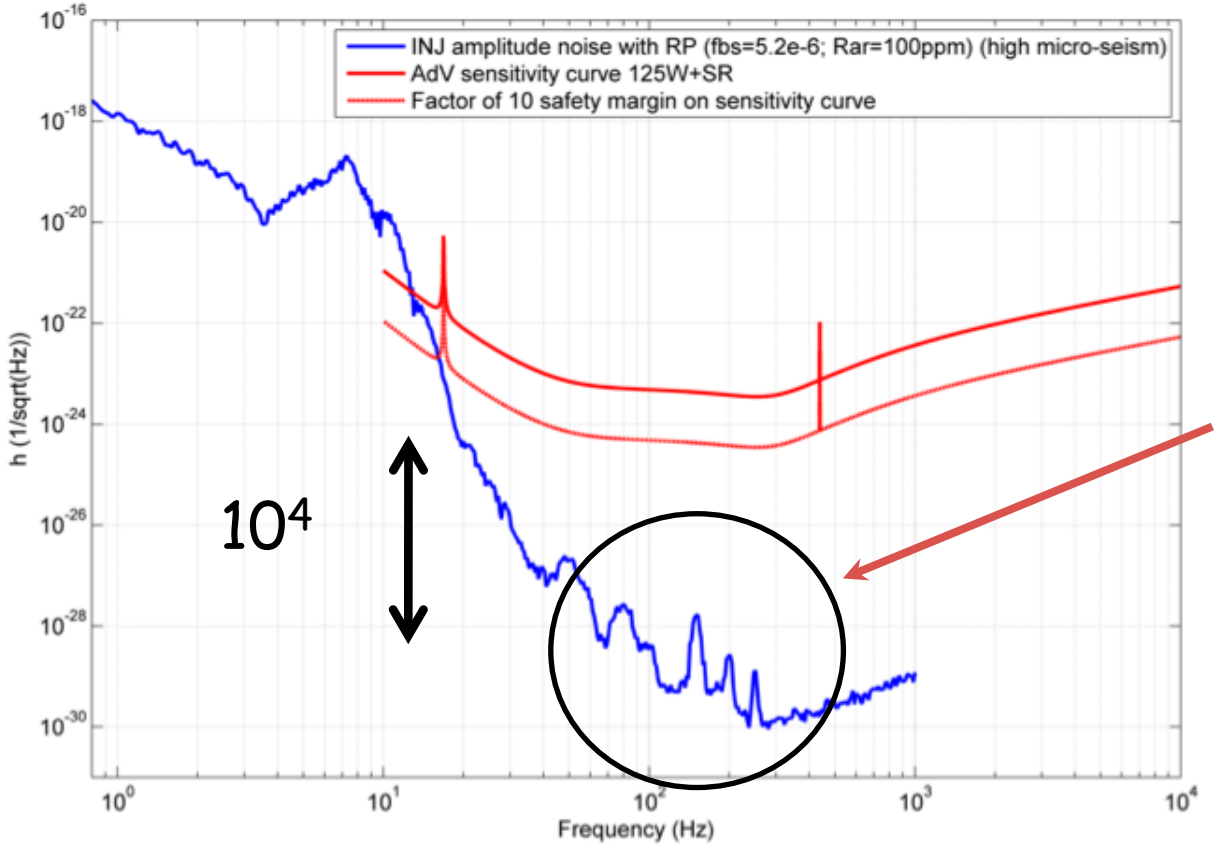
f3 = 305 Hz
Q3 = 40





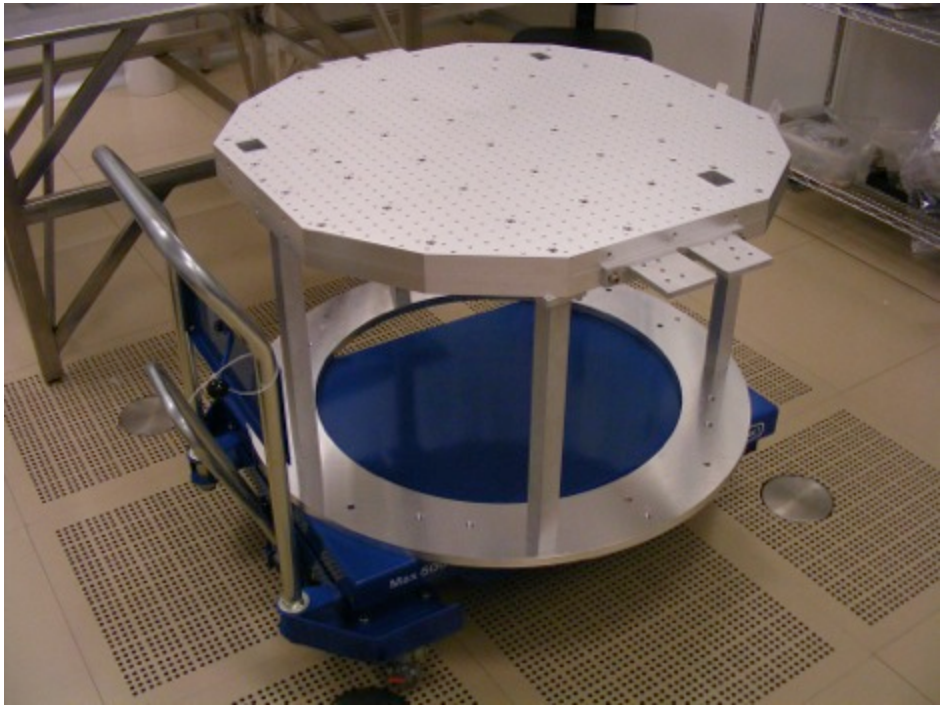
	Meniscus Lens	Parabolic Mirror M1	Parabolic Mirror M2
Frequency f1 Q1	75 Hz 40	116 Hz 40	145 Hz 20
Frequency f2 Q2	172 Hz 20	252 Hz 40	232 Hz 30
Frequency f3 Q3	305 Hz 40	355 Hz 20	331 Hz 30

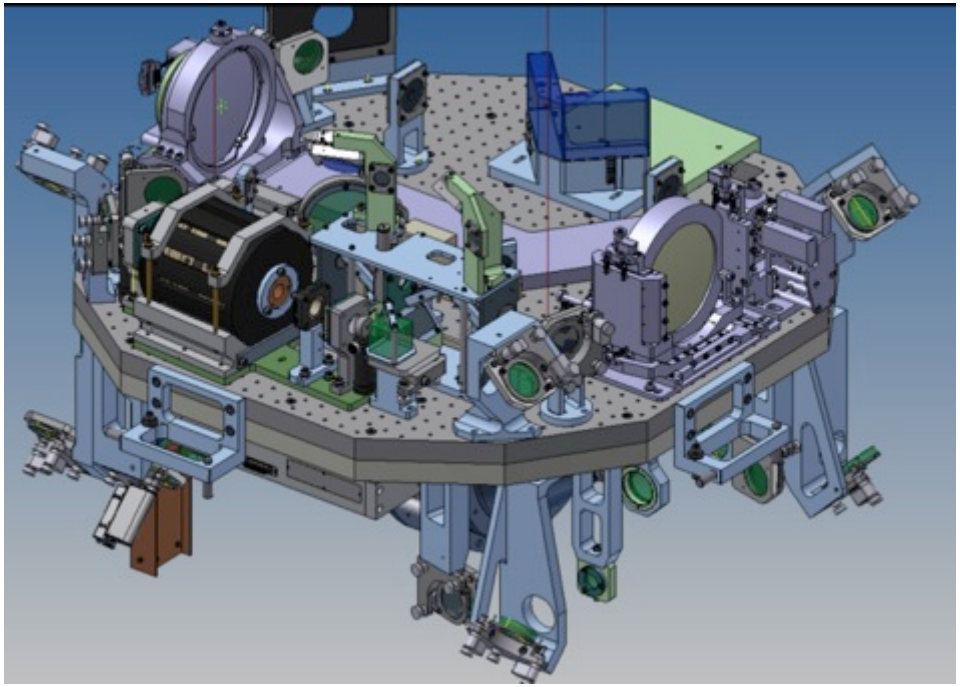
Diffused light projections

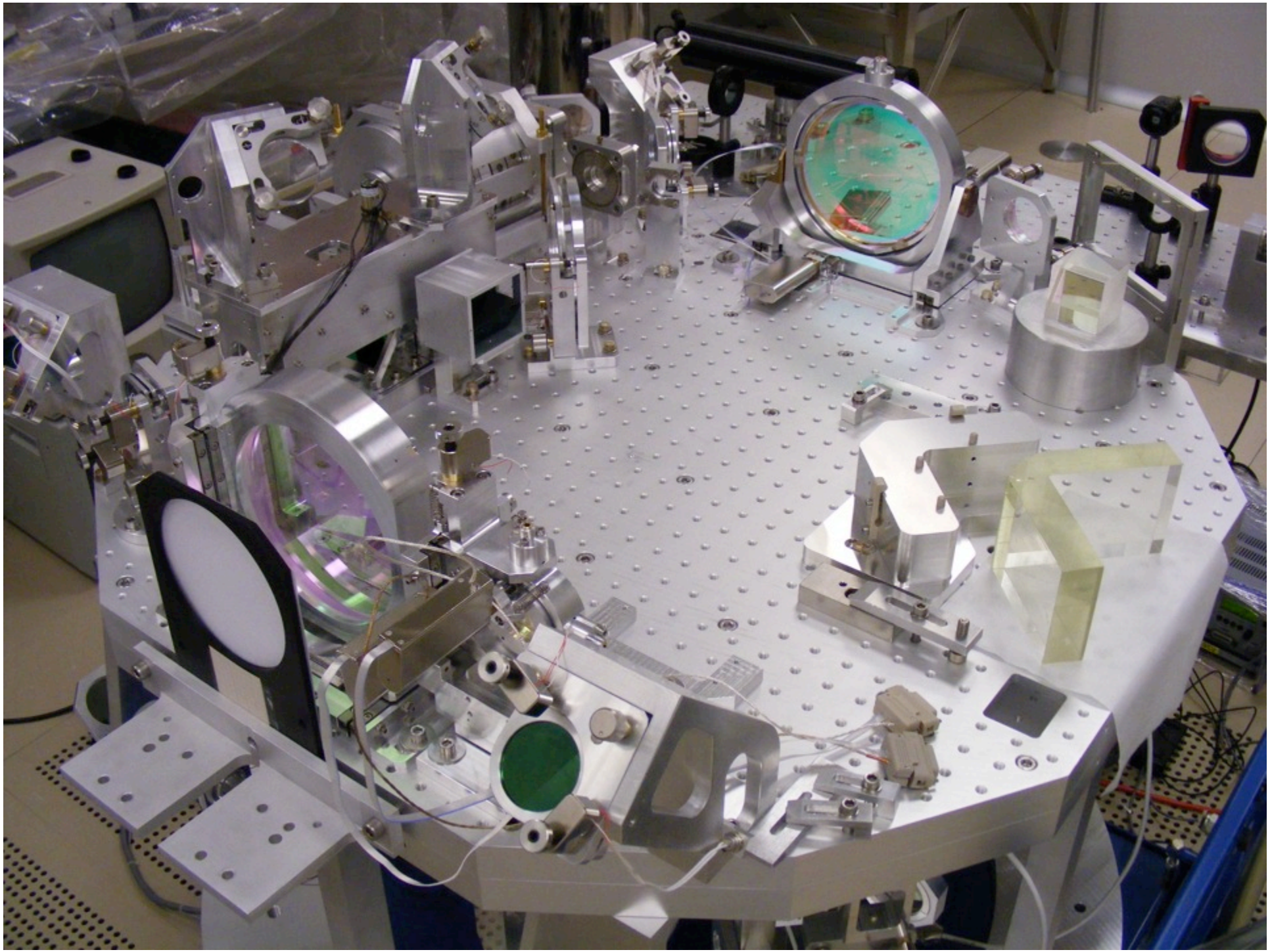


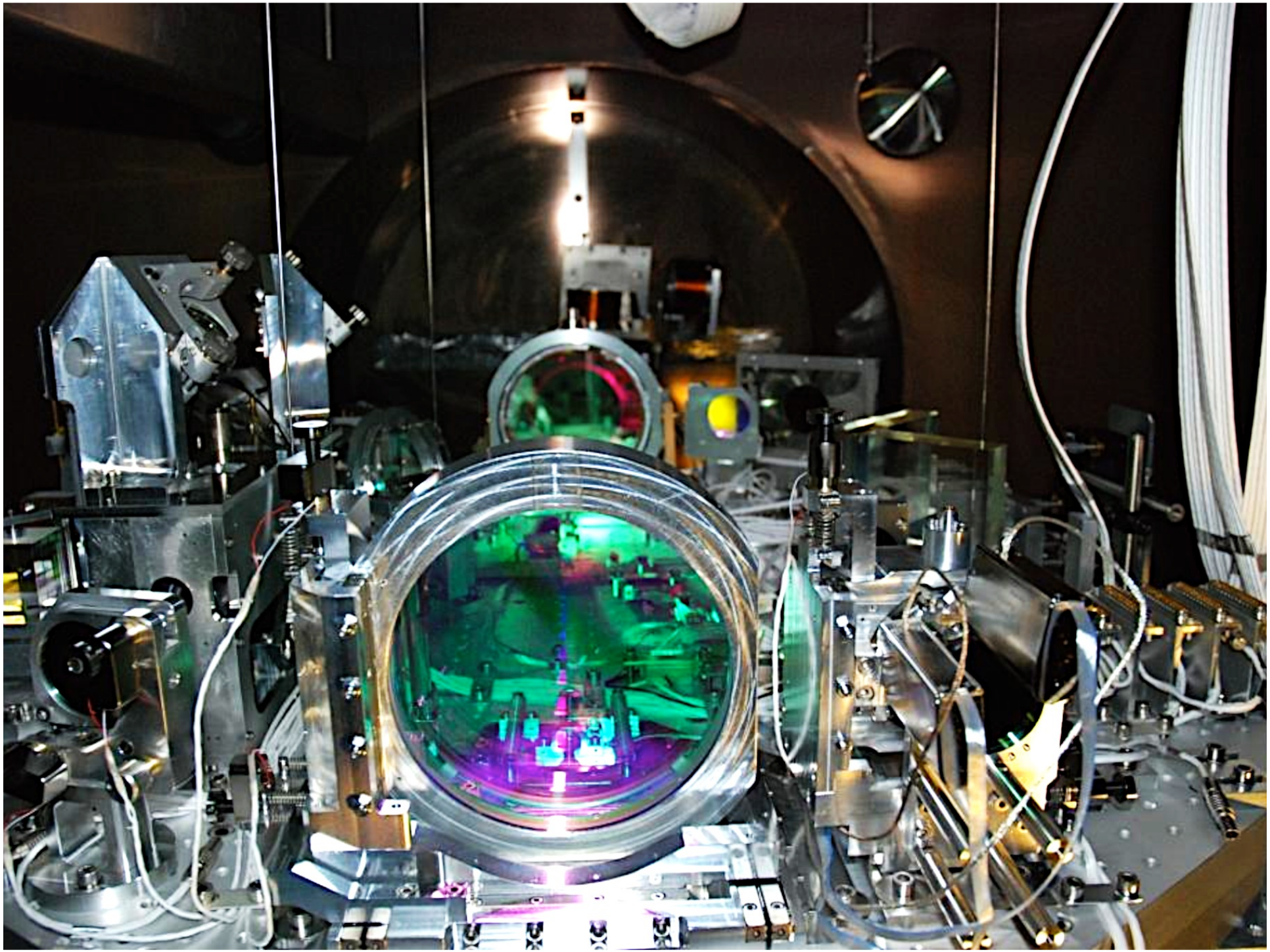
Resonance frequencies range (max Q = 40)

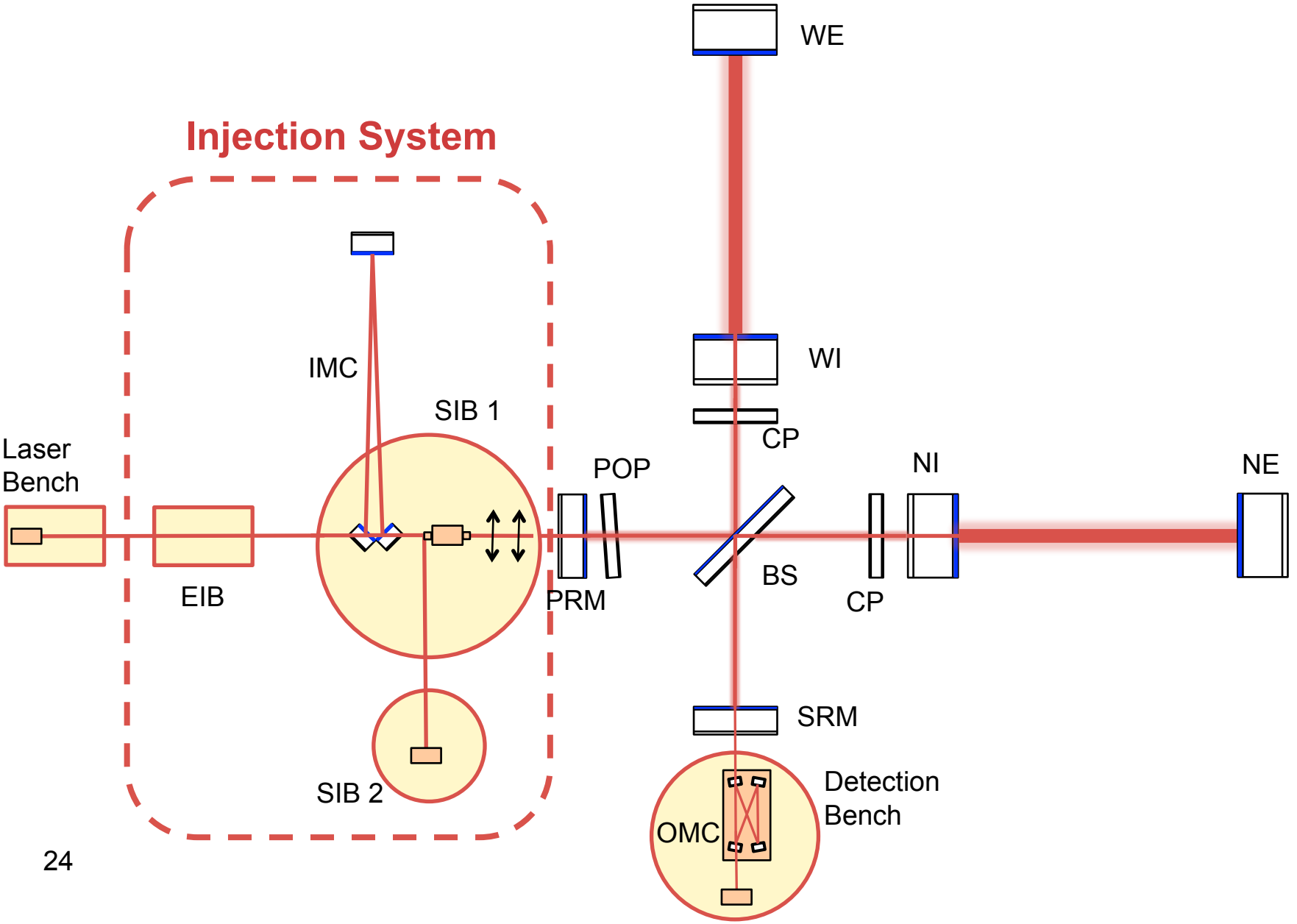
Suspended injection bench integration





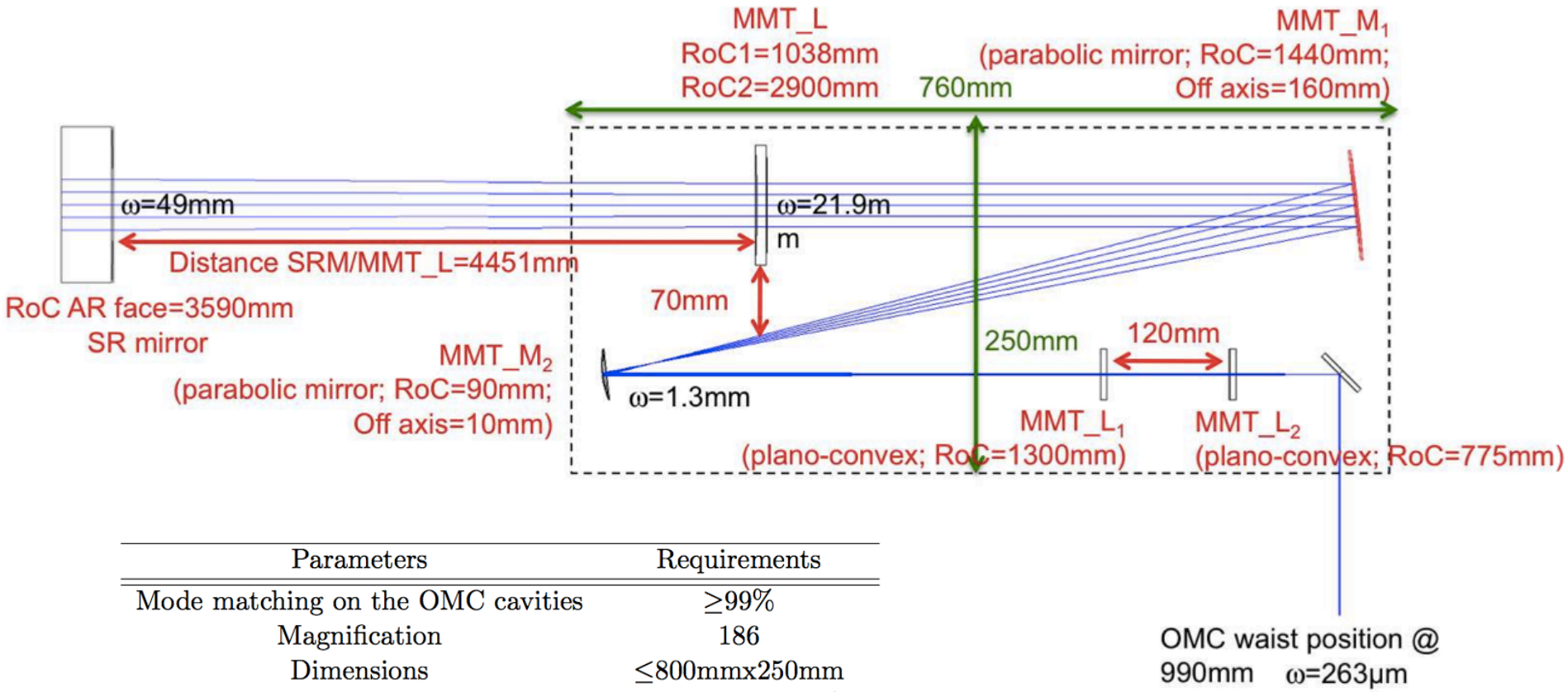





Injection System
WE
WI
CP
NI
NE
IMC
SIB 1
Laser
Bench
POP
EIB
PRM
BS
CP
SRM
SIB 2
Detection
Bench
OMC

Dark fringe telescope

Dark fringe telescope

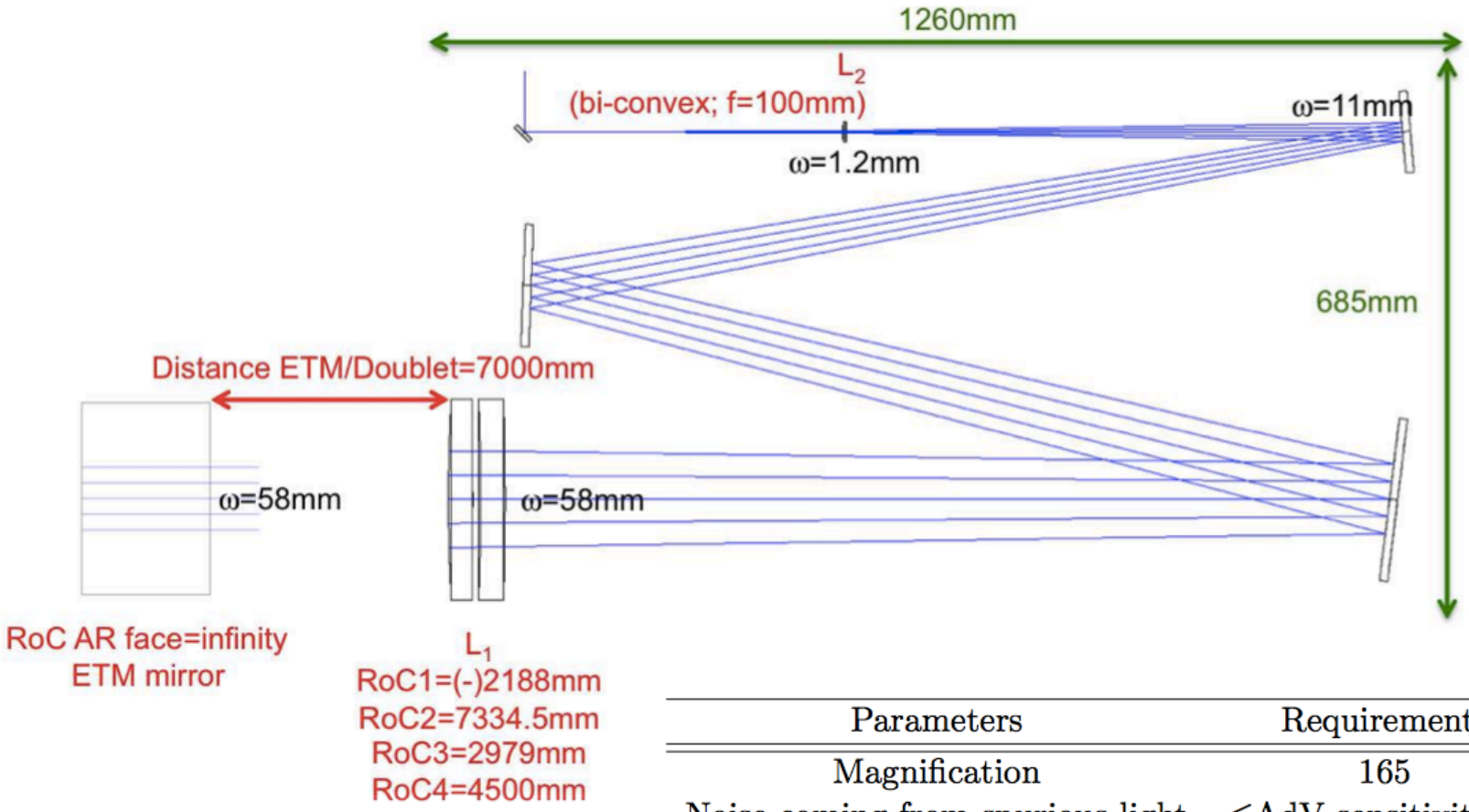


Parameters	Requirements
Mode matching on the OMC cavities	≥99%
Magnification	186
Dimensions	≤800mmx250mm
Noise coming from spurious light	≤AdV sensitivity/10

2 alternative configurations explored
(reflective / strong lens on SR)

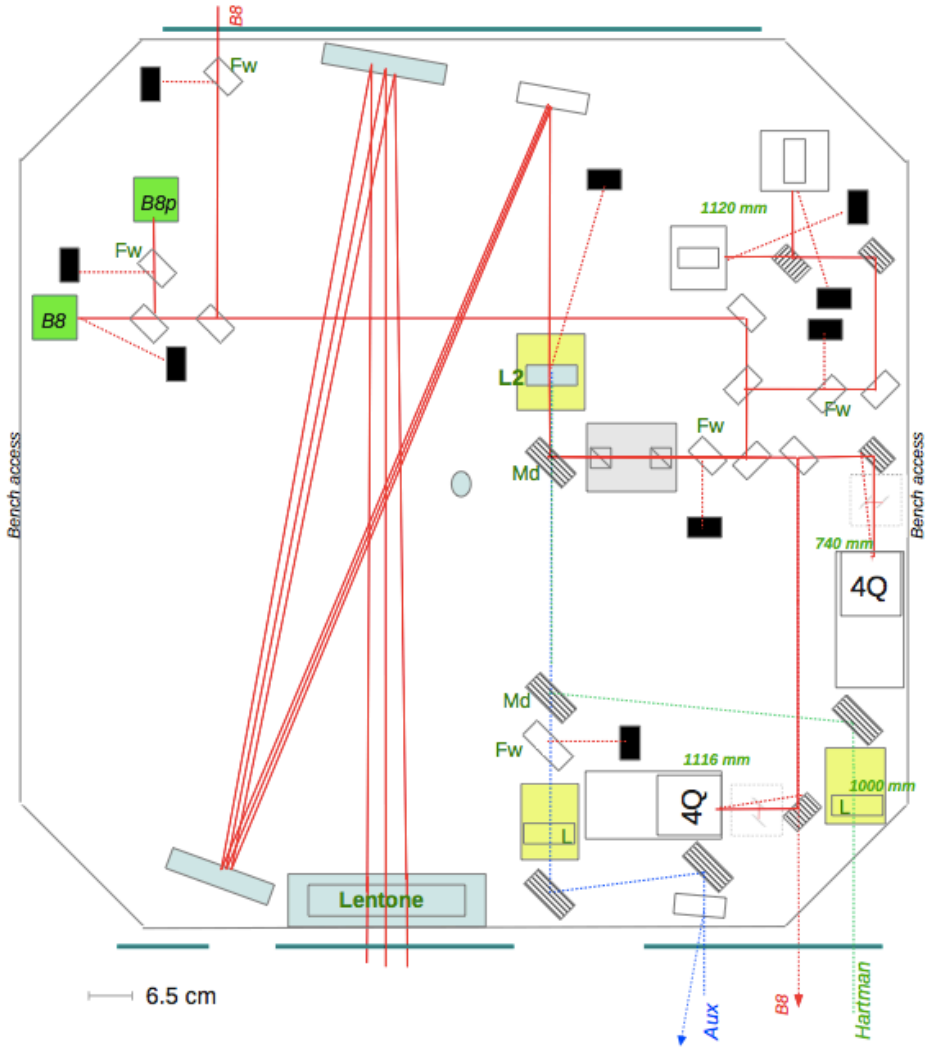
End bench telescope

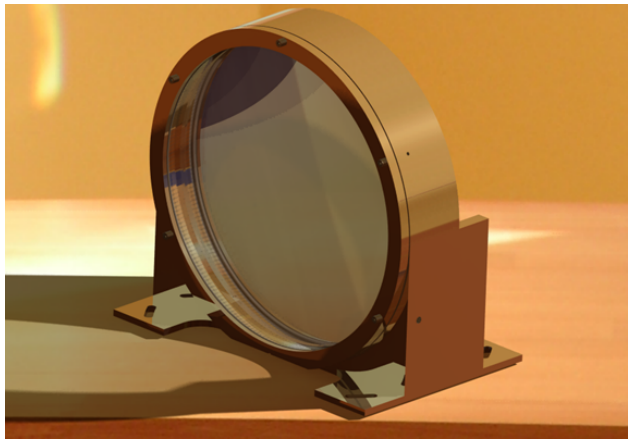
End benches telescope



Parameters	Requirements
Magnification	165
Noise coming from spurious light	≤AdV sensitivity/10
Gouy phase difference	90 deg ± 20 deg

End bench


B8
Fw
B8p
Fw
B8
L2
1120 mm
Fw
Fw
Md
Bench access
Bench access
740 mm
4Q
Md
Fw
1116 mm
4Q
1000 mm
L
L
Lentone
6.5 cm
Aux
B8
Hartman



Implementation inside the minitower