# Advanced Virgo
# BASELINE DESIGN

**Giovanni Losurdo** – INFN Firenze

Advanced Virgo Coordinator

for the **Virgo Collaboration**

LIGO-G070713-00-Z

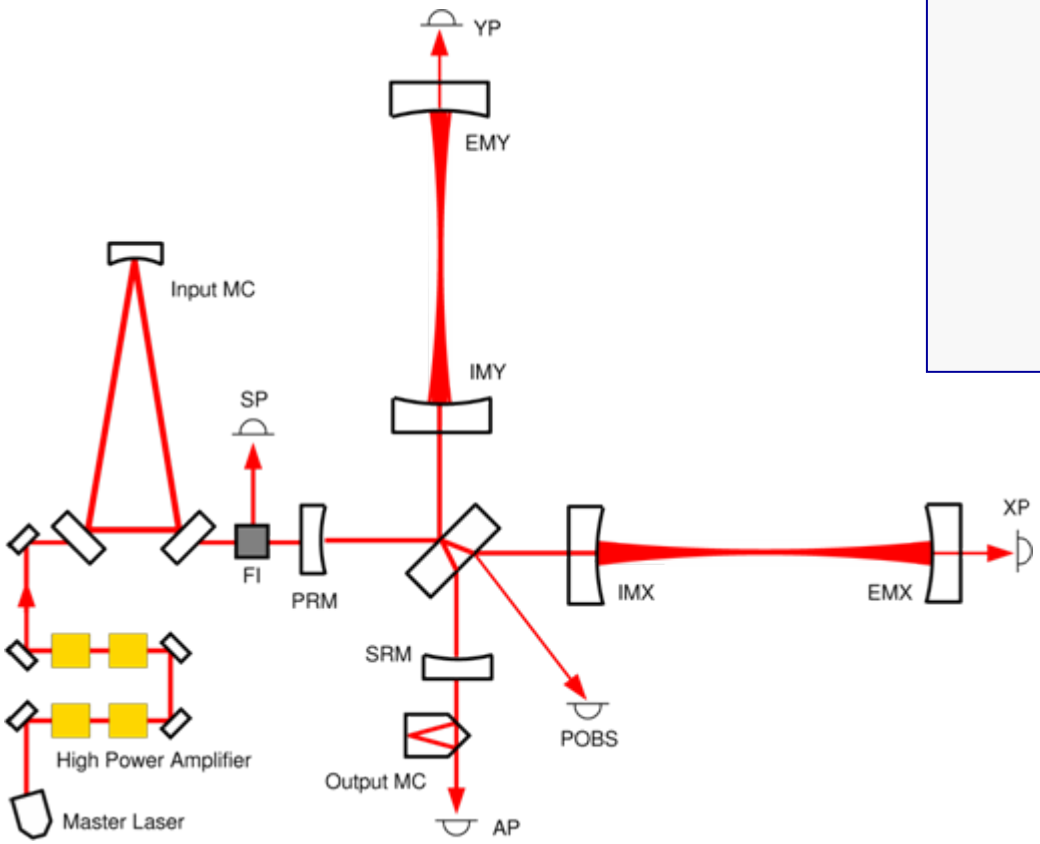
# ADVANCED VIRGO (*AdV*)

**GOALS:**

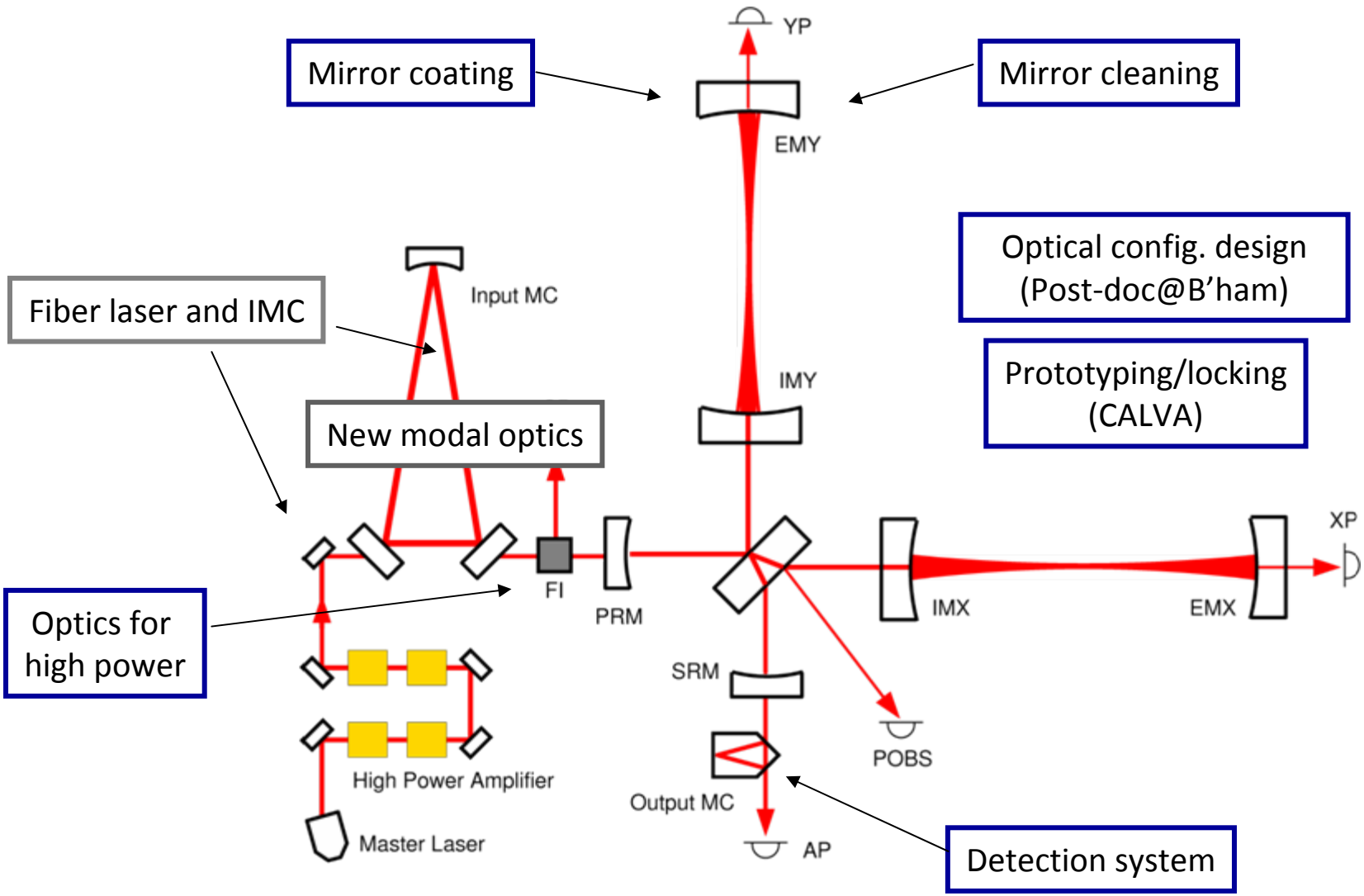
- Sensitivity: about 10x better than Virgo
- Timeline: be back online with AdvLIGO

MAIN CHANGES:

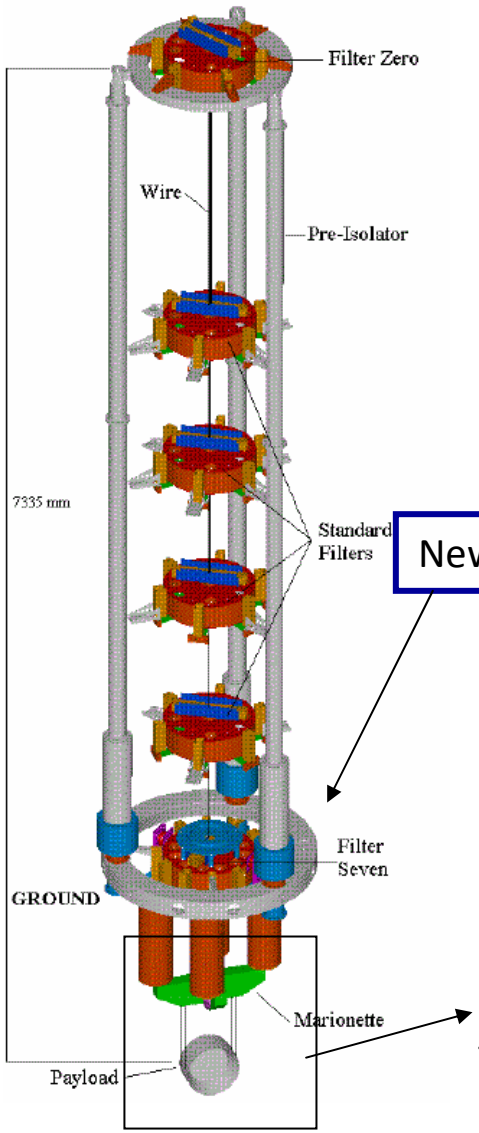
- higher power
- signal recycling
- heavier mirrors
- better coatings
- beam geometry



# ONGOING *AdV* R&D – SUMMARY (I)



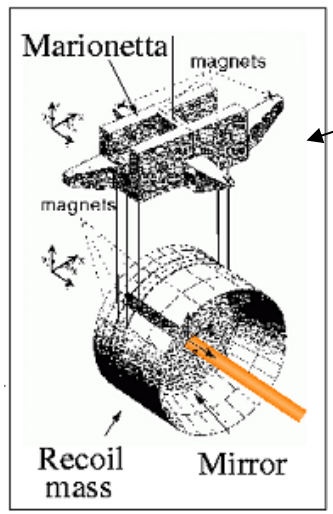
# ONGOING *AdV* R&D – SUMMARY (II)




Tiltmeter

IP upgrade

New payload design




Ribbons for monolithic susp. (Glasgow)

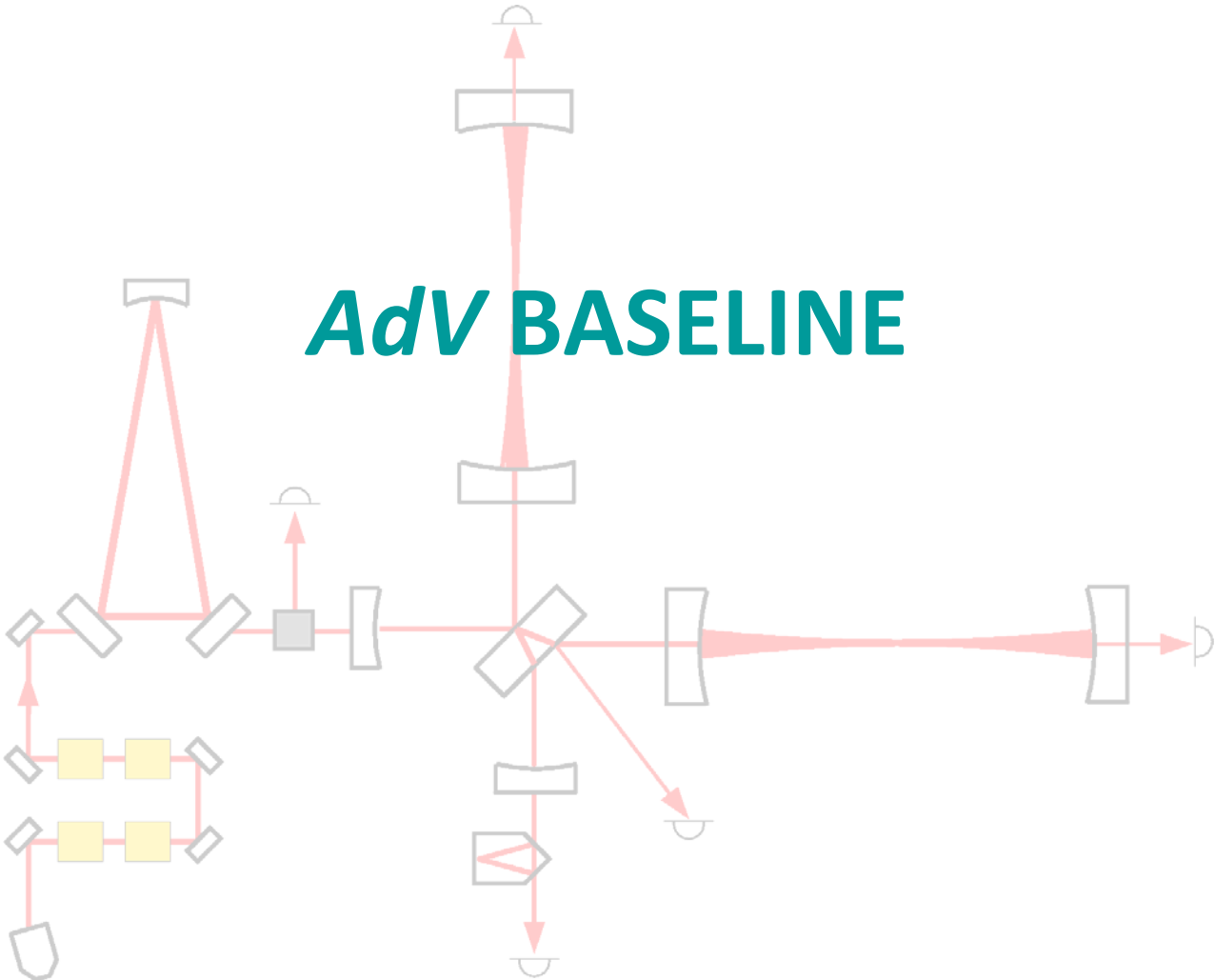
Electrostatic act.

# STATUS

- ***AdV* conceptual design** completed
  - Internal review in progress
  - Due to STAC (advisory panel) and EGO Council (funding agencies) this week
- Waiting for the funding agencies approval:
  - New organization being setup. From Working Groups to WBS.
  - Next two years to prepare the *AdV* technical design.

advanced

# *AdV* BASELINE



# LASER

**BASELINE:**

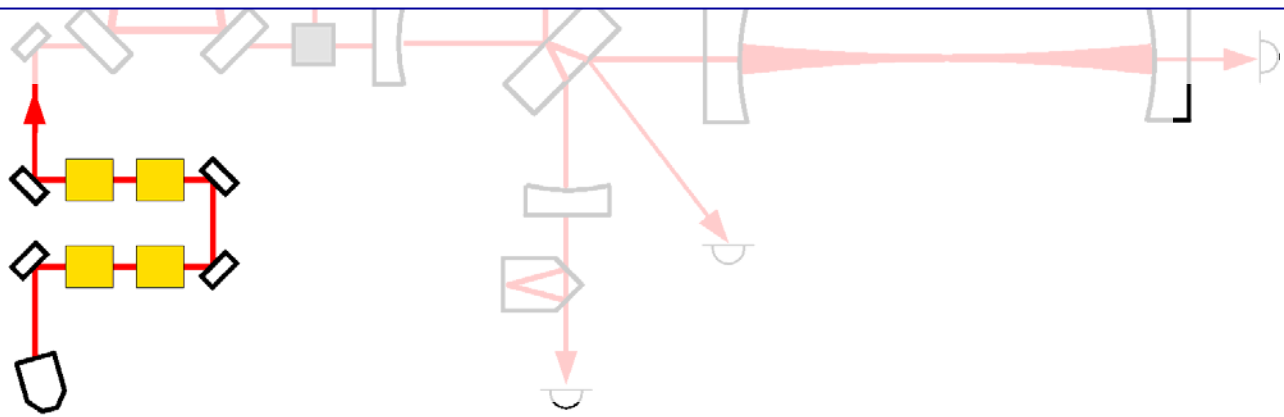
**200 W SOLID STATE LASER AMPLIFIER** (LZH)

Nice Group is already collaborating with LZH for the Virgo+ amplifier.

**ALTERNATIVE OPTION:**

**FIBER LASER AMPLIFIER:** promising research line

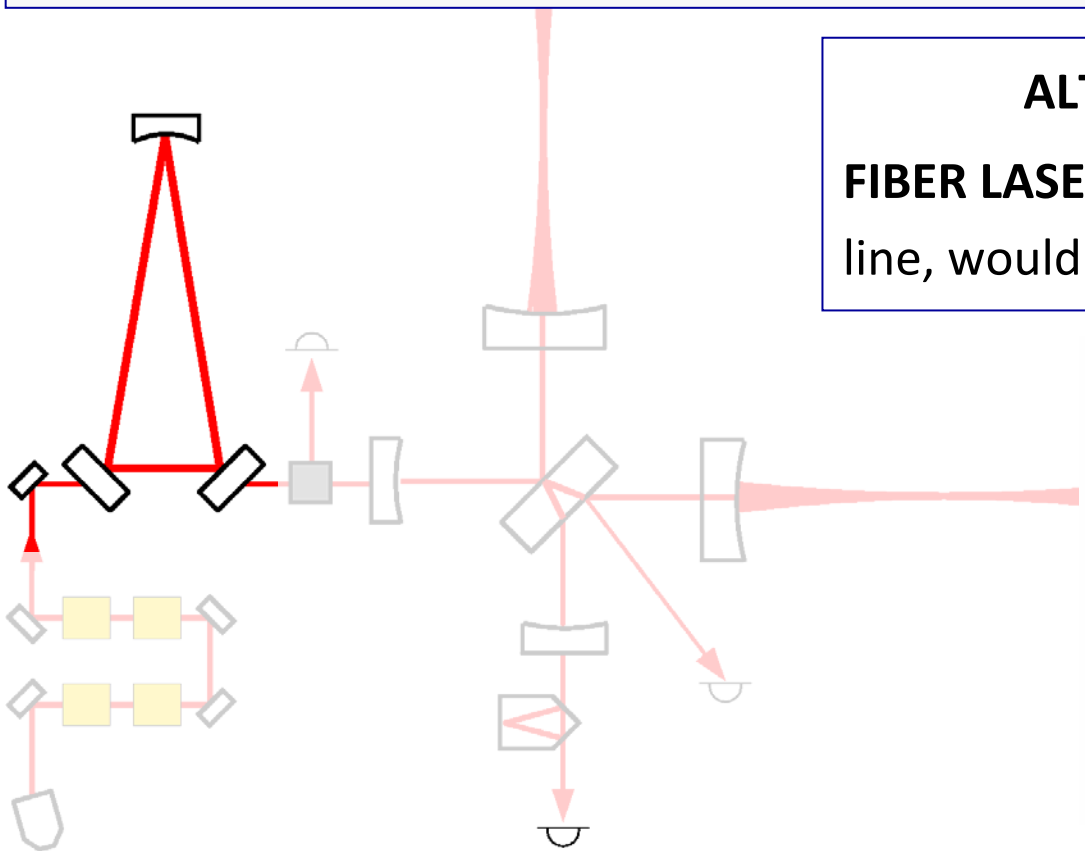
- stabilization to be done
- non linear effects and polarisation maintaining to be investigated with high power



# INPUT OPTICS

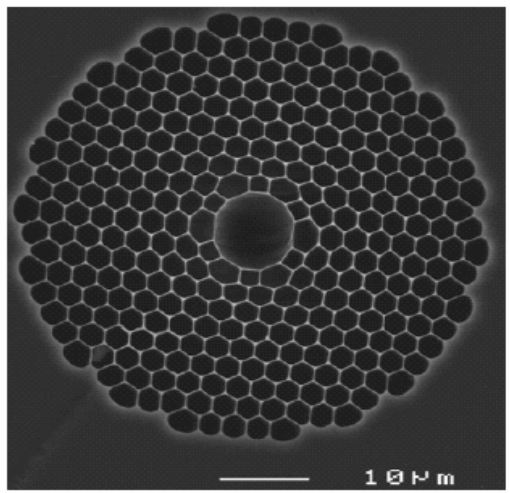
**BASELINE:**

**144 m SUSPENDED RESONANT IMC**: Virgo-like solution. Problem of small angle diffused light to be addressed.

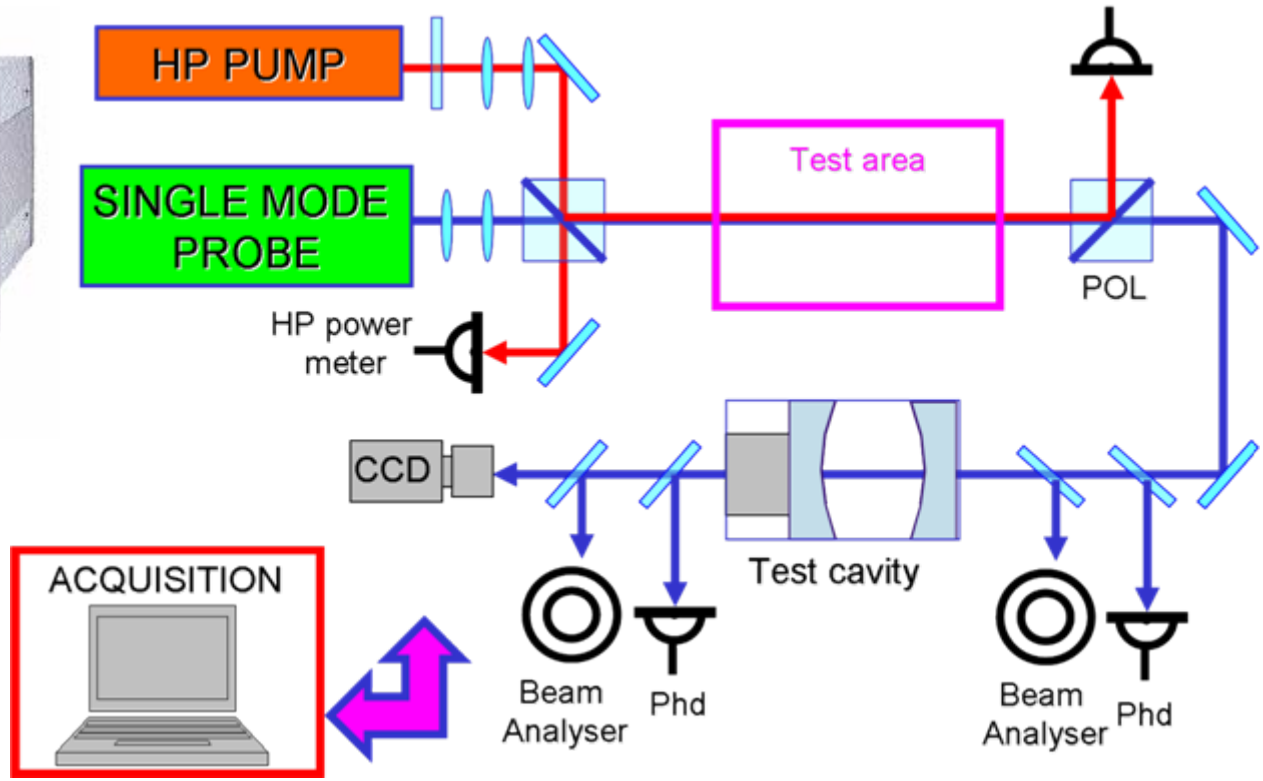


**ALTERNATIVE OPTION:**

**FIBER LASER IMC**: promising research line, would be a **major** simplification.



# INPUT OPTICS

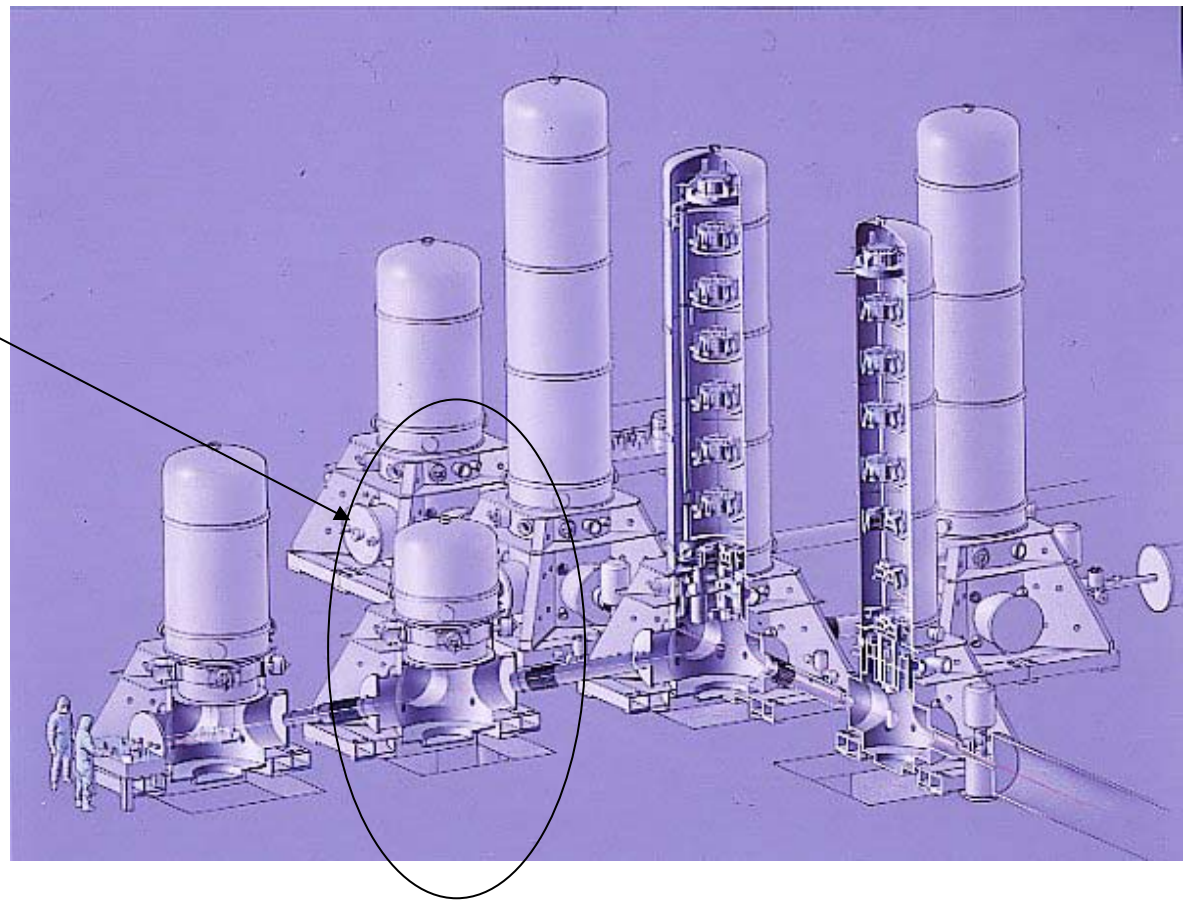

- A dedicated facility being setup at EGO to test the input optics for Virgo+/AdV with high power. 200 W Yb laser available
- Tests on Faraday with passive thermal compensation (DKDP) and EOM (RTP) to start in fall 2008

# OPTICAL CONFIGURATION

**BASELINE:**

**DUAL RECYCLED INTERFEROMETER –** Optical parameters to be defined.

The base for the SR tower is there!



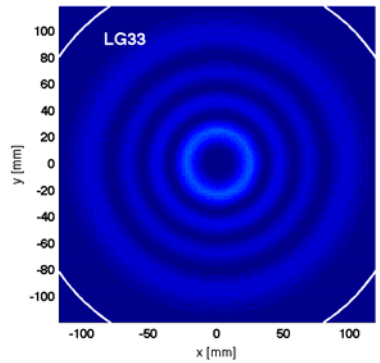
# BEAM - DETECTION

**OPT. LAYOUT BASELINE:**

- **$TEM_{00}$**
- **WAIST IN THE CAVITY CENTER**
- **LARGER BEAM:** requires changing the vacuum links in the central area.

**ALTERNATIVE OPTION:**

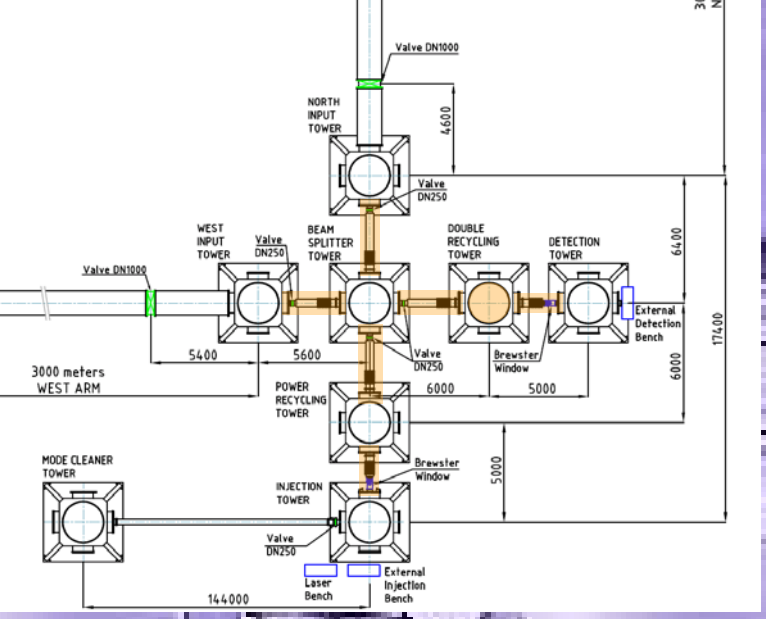
**HIGH ORDER LAGUERRE MODES**






**DET. BASELINE:**

- **PHOTODIODES IN VACUUM**
- **DC DETECTION**




- PIPE Ø = 600 mm
- VALVE Ø = 500 mm

# MIRRORS

**BASELINE:**

- **35 cm Ø, 20 cm thick, 42 Kg FP mirrors**
- **Larger BS (55 cm Ø – TBC)**

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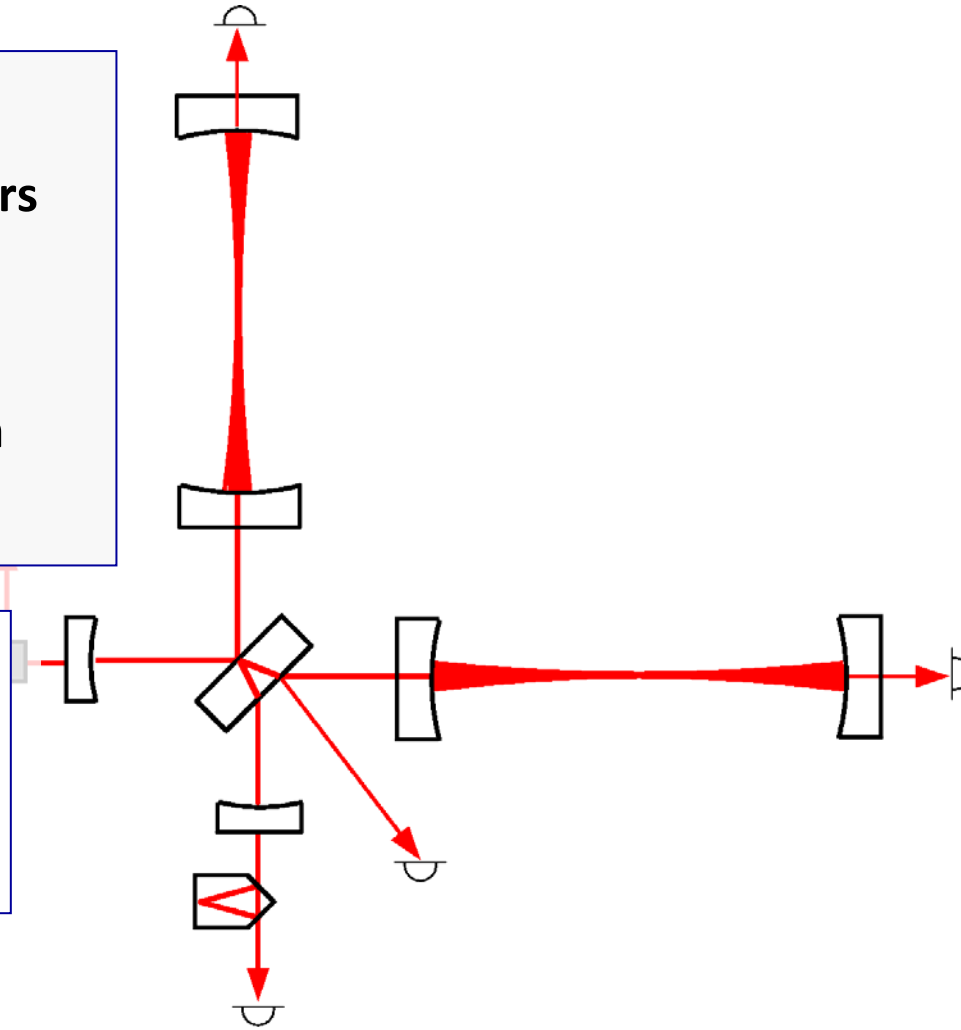
- **STATE OF THE ART COATING (R&D in progress)**

**ALTERNATIVE OPTION:**

**35 cm Ø, 30 cm thick, 63 Kg FP mirrors**

Useful if fiber geometry is optimized



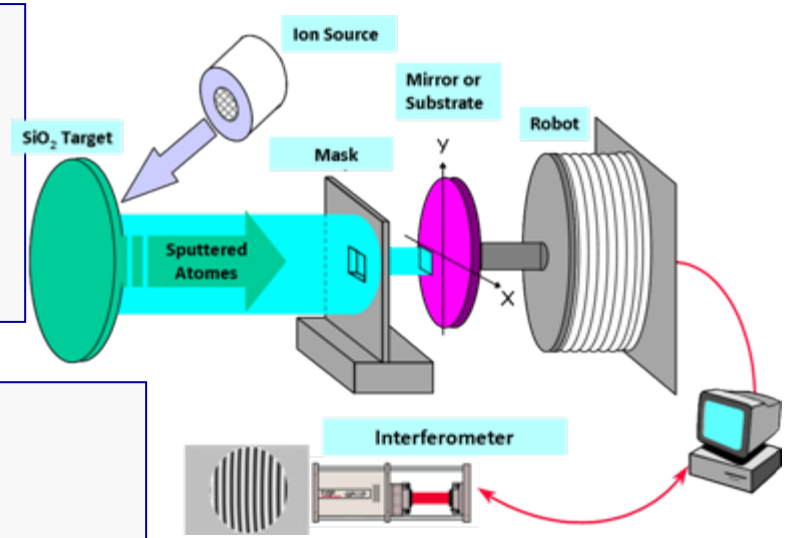
# MIRRORS

## POLISHING

- Flatness, one of the main limitations in Virgo (with cleanliness!)
- Need for better polishing and more precise geometry (r.o.c.)
- Corrective coating

## METROLOGY

- Characterization benches available at LMA
- Modification needed to handle larger mirrors (BS)
- Better metrology → better corrective coating




## CLEANLINESS

- Keep losses in the sub-ppm range
- Proper protection of mirrors surface during installation
- Maintain cleanliness at the site requires the installation of a laminar flux in the towers

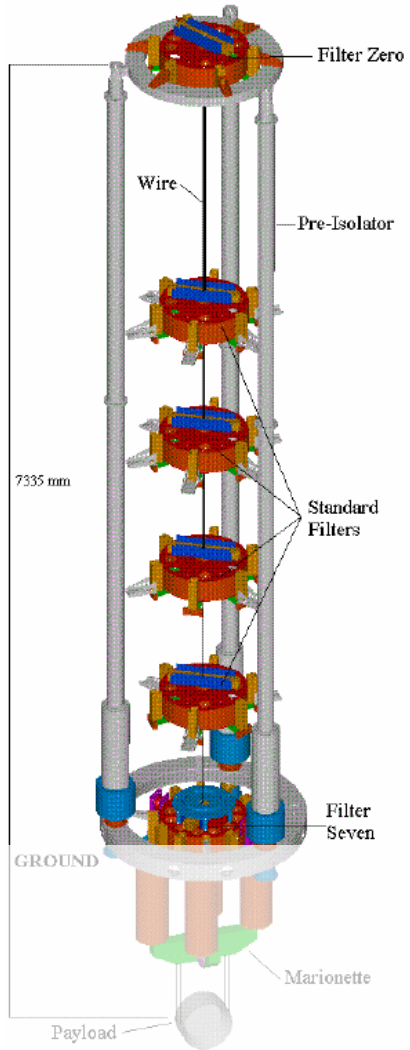
# SUPERATTENUATOR

**BASELINE:**

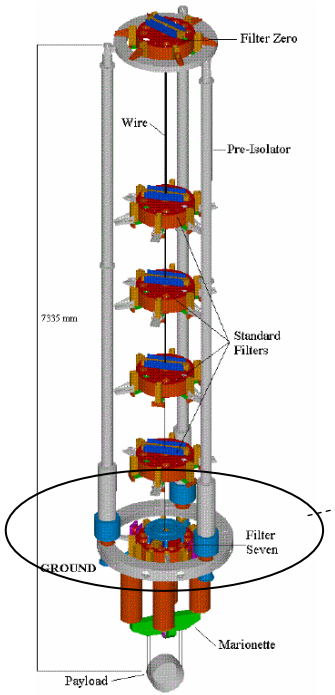
- **VIRGO DESIGN with STIFFER IP LEGS**
- **TILTMETER AND IP 6 DOF CONTROL**
- **MECHANICS: NEW MARIONETTE REFERENCE MASS**
- **MIRROR ACTUATION: COIL-MAGNET PAIRS**

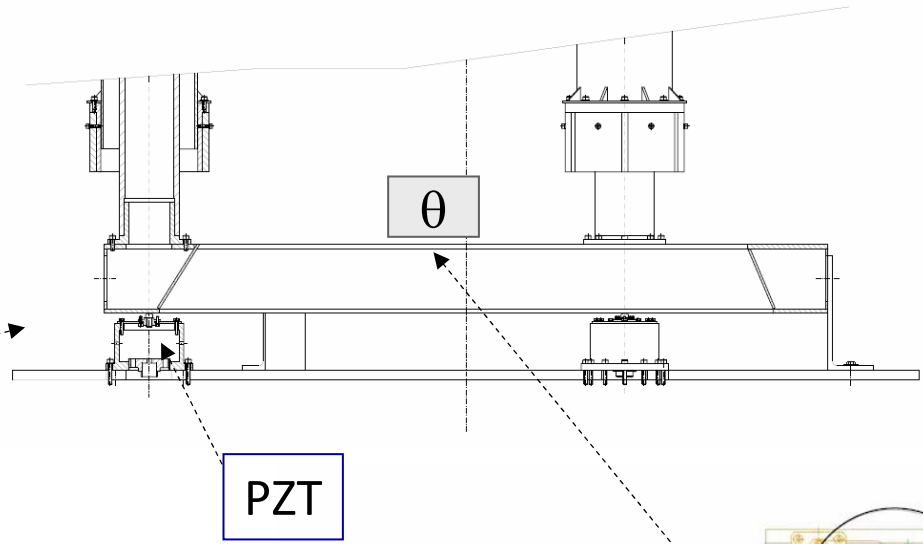
**ALTERNATIVE OPTION:**

**ELECTROSTATIC ACTUATORS**: noise specs to be demonstrated

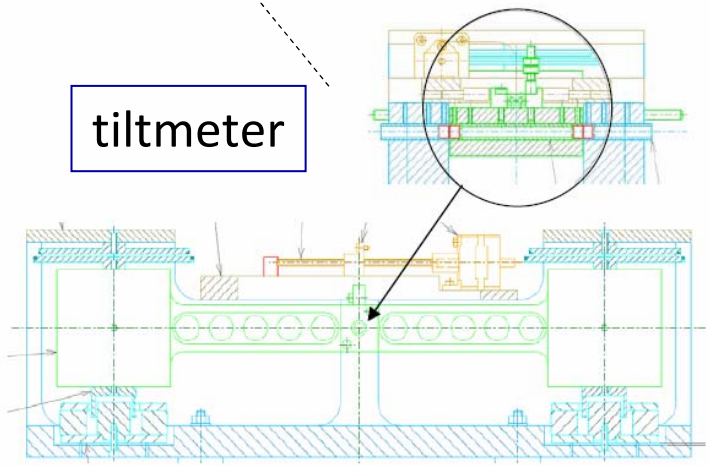


# SUPERATTENUATOR




tiltmeter



- Virgo inertial platform controlled in 4 d.o.f.
- Wind induced ground tilt proved to be a problem
- ***AdV***: implement tilt control

# SUSPENSIONS

**BASELINE:**

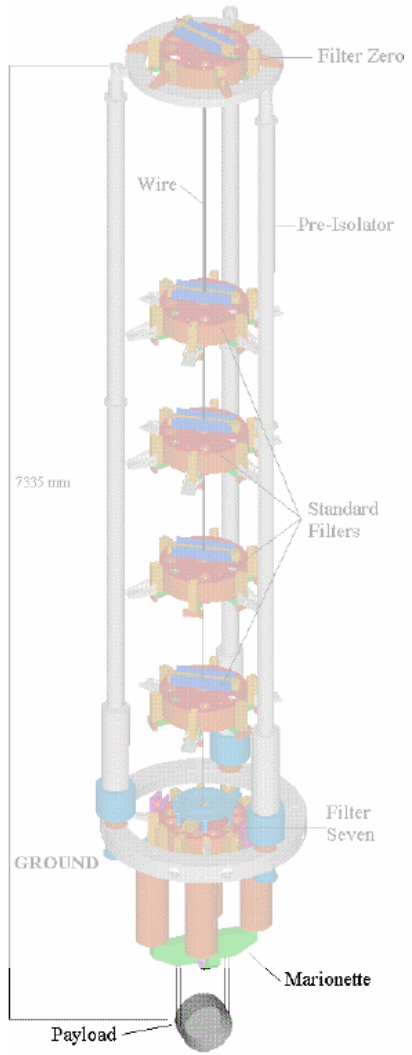
**FUSED SILICA CYLINDRICAL FIBERS**

**ALTERNATIVE GEOMETRIES:**

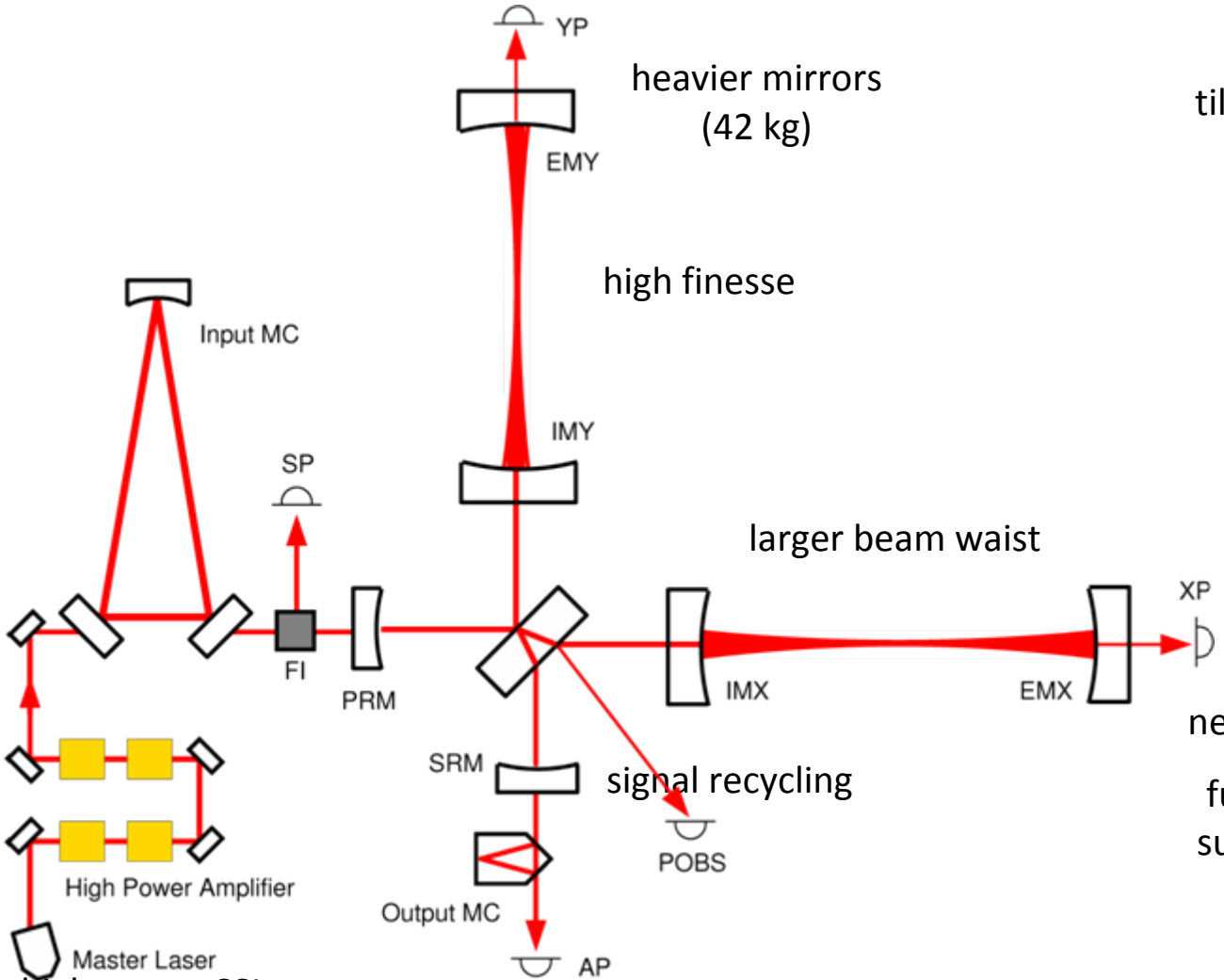
**FUSED SILICA RIBBONS**

**DUMBBELL FIBERS**

Virgo+ activity: dummy mirror suspended with silica fibers



# *AdV* BASELINE - SUMMARY




heavier mirrors
(42 kg)

high finesse

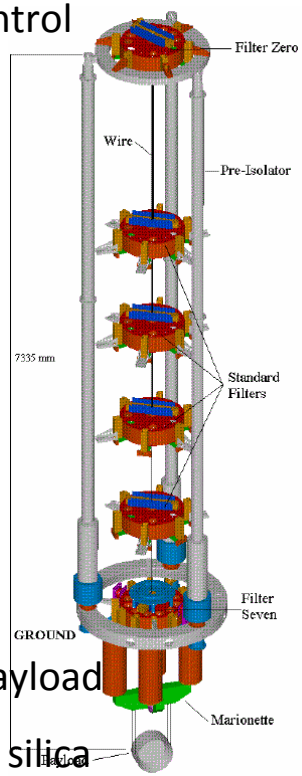
larger beam waist

signal recycling

high power SSL
(200 W)

DC detection

new IP
tilt control




new payload

fused silica
suspensions

# SENSITIVITY CURVE - preliminary

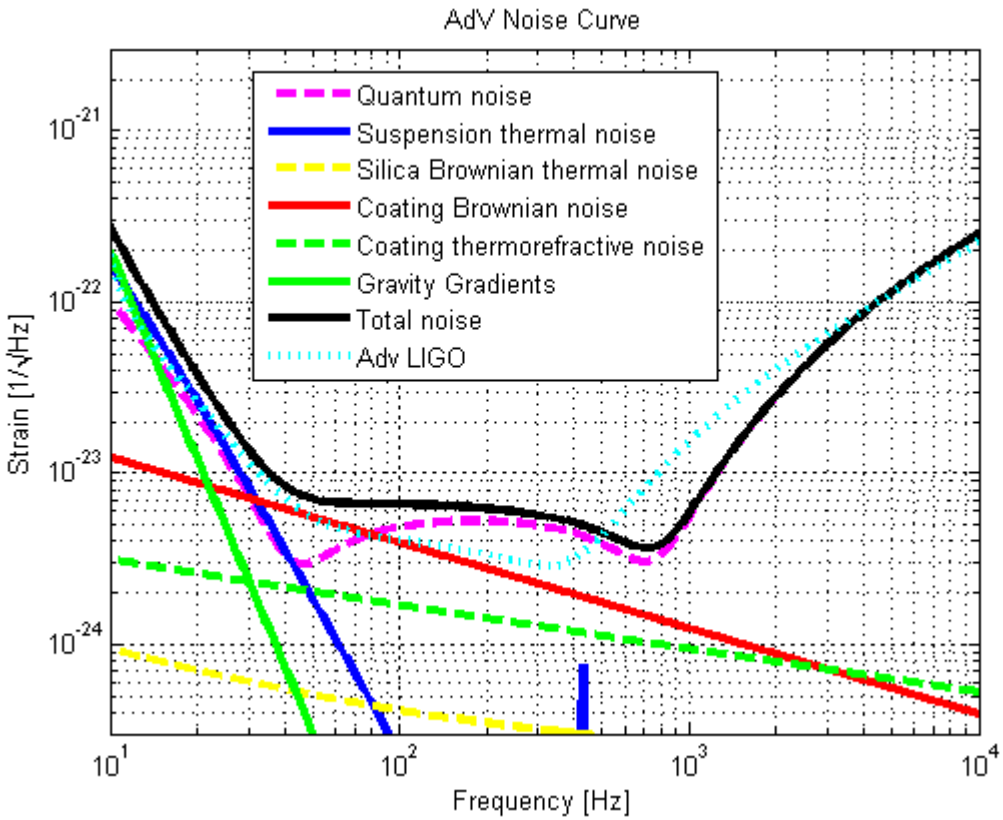
**DESIGN PARAMETERS:**

- SR mirror transmittance: 0.04
- Input mirror transm: 0.007
- Finesse: 885
- PR factor: 23.5
- Power on BS: 2.9 kW

BNS range: **121** Mpc

BBH range: **856** Mpc

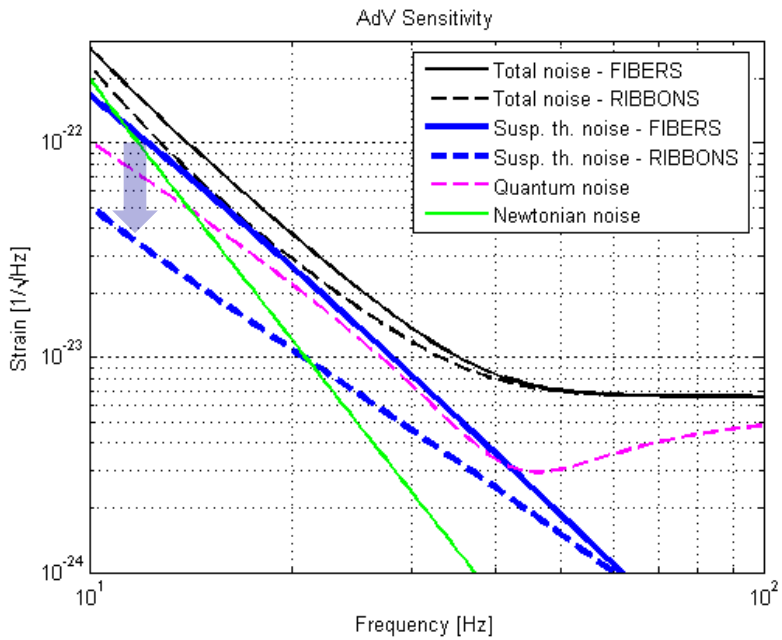
1 kHz sens.: 6 $10^{-24}$/√Hz



# *AdV* sensitivity vs Fiber geometry

- The ribbon choice reduces considerably the contribution of suspensions thermal noise
- Dumbbell fibers can also improve the performance
- The benefits on the sensitivity are limited by radiation pressure, newtonian and CONTROL NOISE (unmodelled so far)

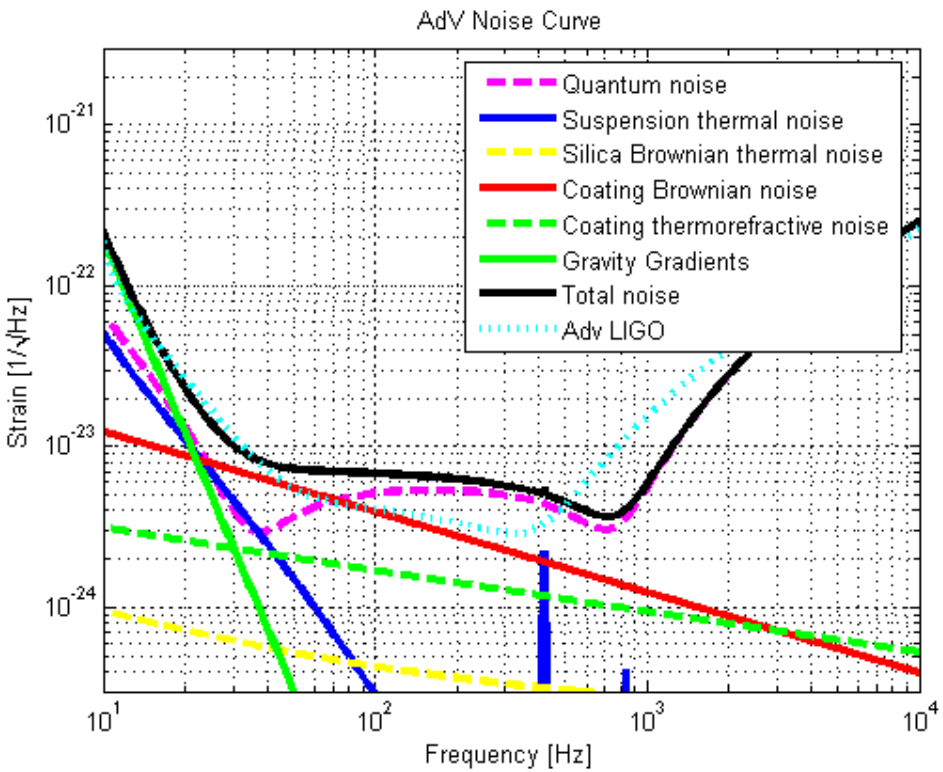
| ***fiber geometry*** | ***cylindrical*** | ***ribbon*** |
|---|---|---|
| ***Finesse*** | *885* | |
| ***G*** | *23.5* | |
| $P_{BS}$ | *2.9 kW* | |
| ***BNS*** | *121* | *126* |
| ***BBH*** | *859* | *959* |



# HEAVIER MIRRORS?

- If ribbons are used, low frequency sensitivity can be further improved by using thicker mirrors (30 cm diam., 63 kg mass)
- The low frequency sensitivity is then limited by newtonian noise (model uncertain) and coating brownian noise

| *fiber geometry* | *BASELINE* | *ribbon 63 Kg mirr* |
|---|---|---|
| ***Finesse*** | *885* | |
| ***G*** | *23.5* | |
| ***$P_{BS}$*** | *2.9 kW* | |
| ***BNS*** | *121* | *130* |
| ***BBH*** | *859* | *1053* |



# TWO-STEP STRATEGY?

We are considering the idea of a two-step strategy:

- Start *AdV* WITHOUT SR mirror and learn to operate the power recycled interferometer with high power
- Add the SR mirror afterwards

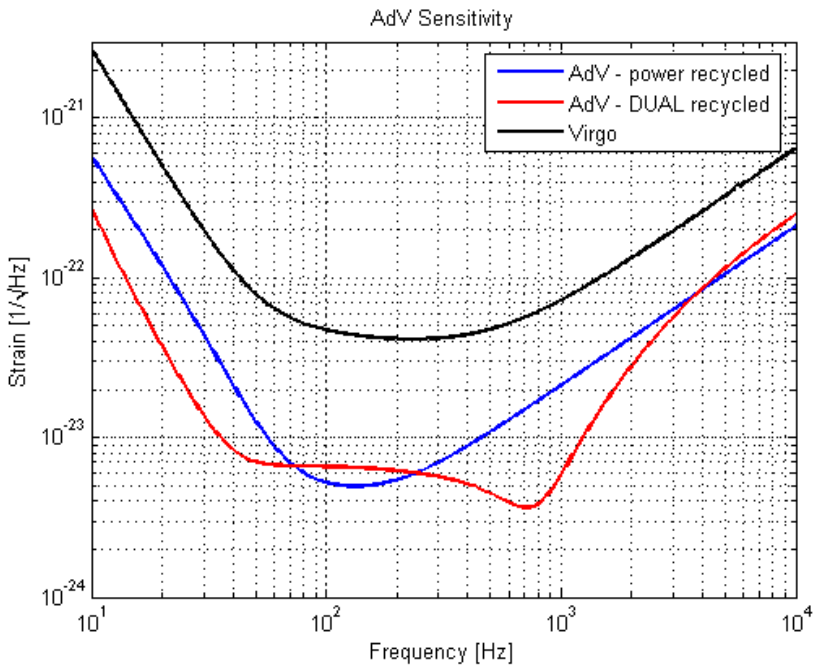
- A good "intermediate" sensitivity can be achieved, even better with heavier mirrors

**Power rec *AdV***

BNS range: 97 Mpc
BBH range: 265 Mpc
1 kHz sens.: 2 $10^{-23}$

**Dual rec *AdV***

BNS range: 121 Mpc
BBH range: 859 Mpc
1 kHz sens.: 6 $10^{-24}$



# SUMMARY

- A baseline design for ***AdV*** has been proposed
- Possible changes to the baseline will be considered (on the strength of the R&D progress) and discussed next year within a new ***AdV*** organization
- Important design parameters to be decided next year

**We look forward to an intense exchange with LSC to make the best possible design of *AdV***