The proposed questions

Related to the Recycling Cavities (RC) design

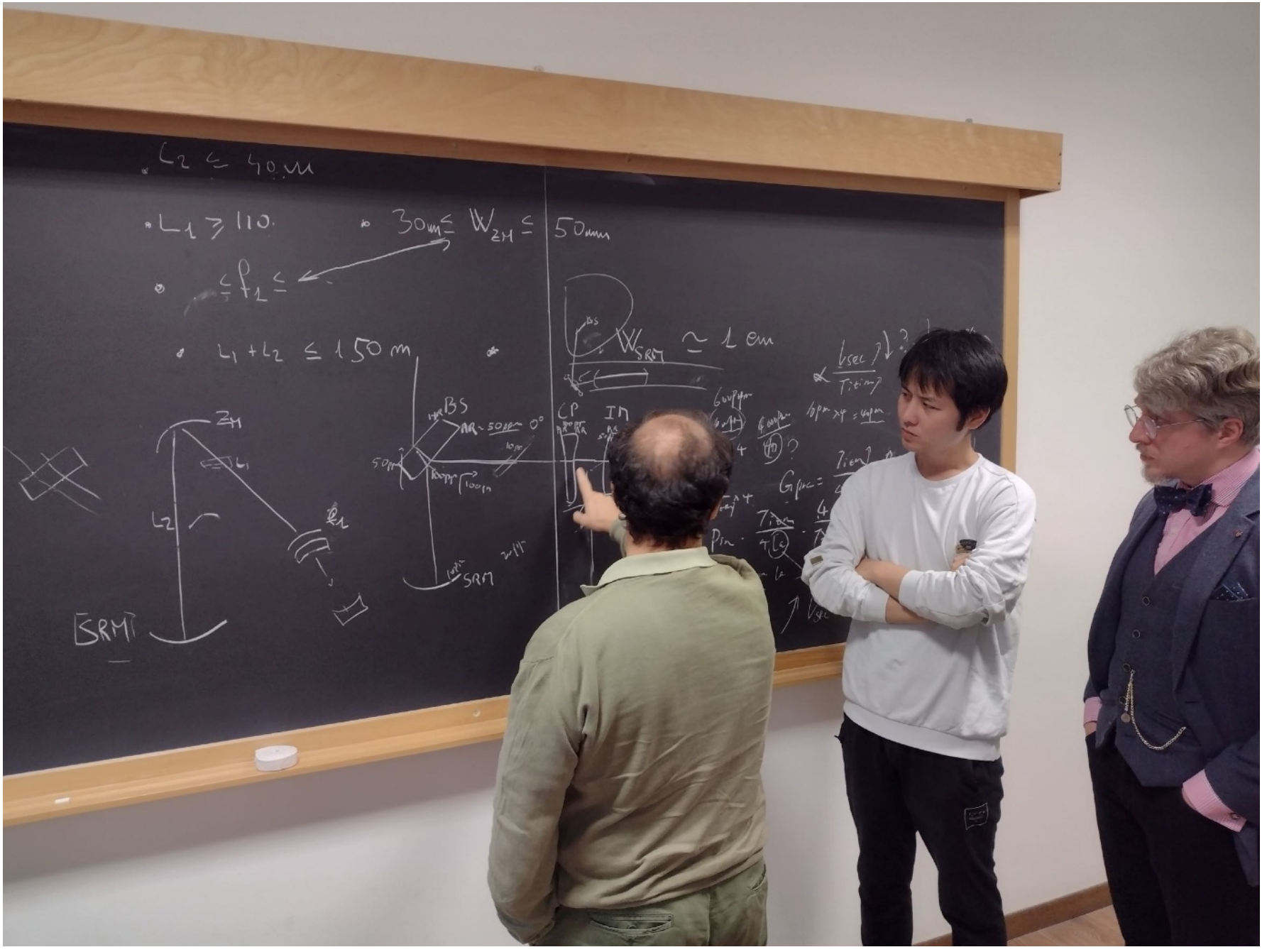
Working space added at the end of:
https://www.overleaf.com/read/yvxmxnsmnbfy

7.1 Problems to be tackle in smaller groups

- brainstorming on recycling cavity design (where/how to focus)
- simple code to calculate the round trip Gouy phase in the recycling cavities, ABCD matrix/Finesse
- minimal beam size on the arm cavity mirrors (already done, see below)
- maximum astigmatism in the RC, could be defined as coupling loss for the arm cavity
- estimate of the beamsplitter transmissive thermorefractive noise

Using the same piece of code

It generates a lot of exchange



The recommendations

From the TDR organisation talk:

Where we are

- None of the previous requirements are currently satisfied:
  - Feasibility, Robustness, internal coherence, external constrains
- But this is normal:
  - The CDR is still incomplete
  - It needs to evolve toward a complete and consistent feasibility design
  - The TDR(s) will be the target of this process
  - We need to elaborate:
    - Requirements
    - Products
    - Specifications
    - ,,,

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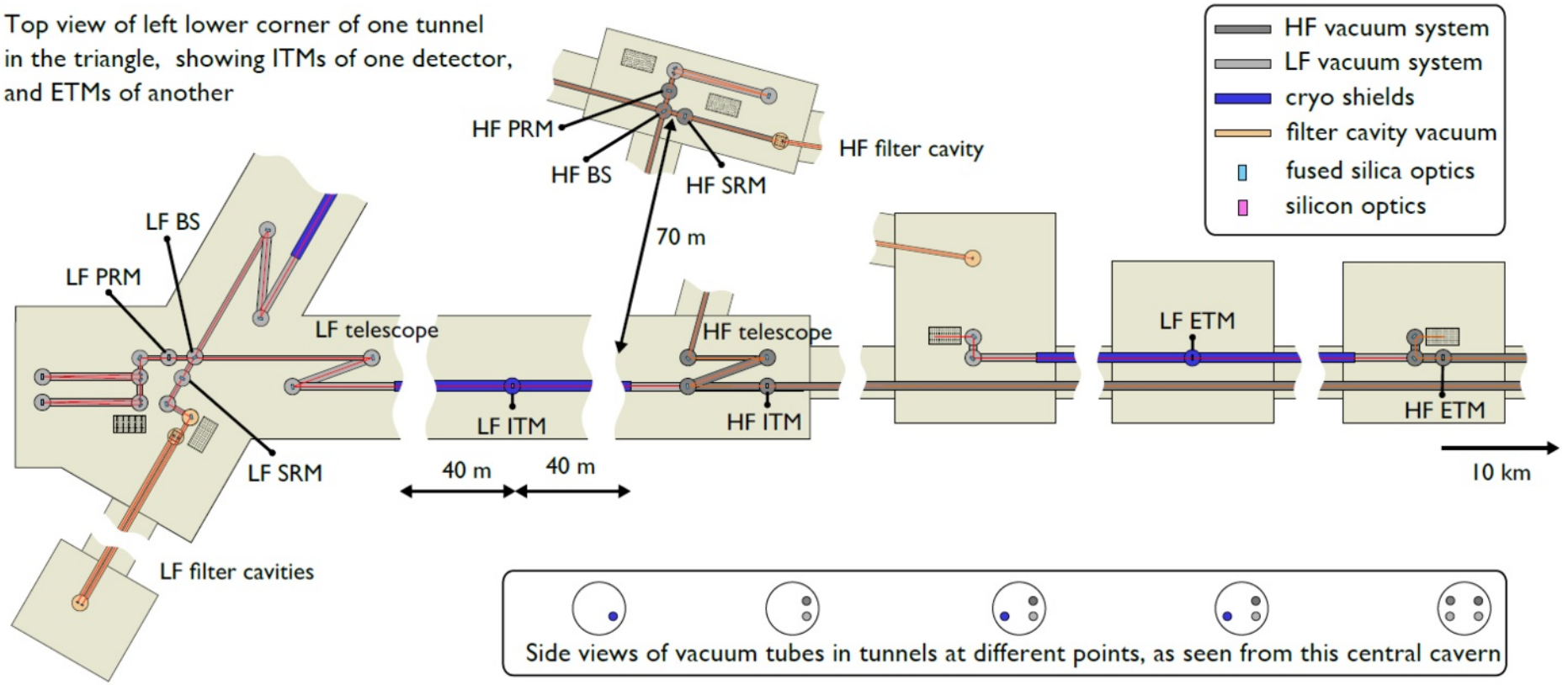
The starting point

The previous design, keep the same order for the lengths



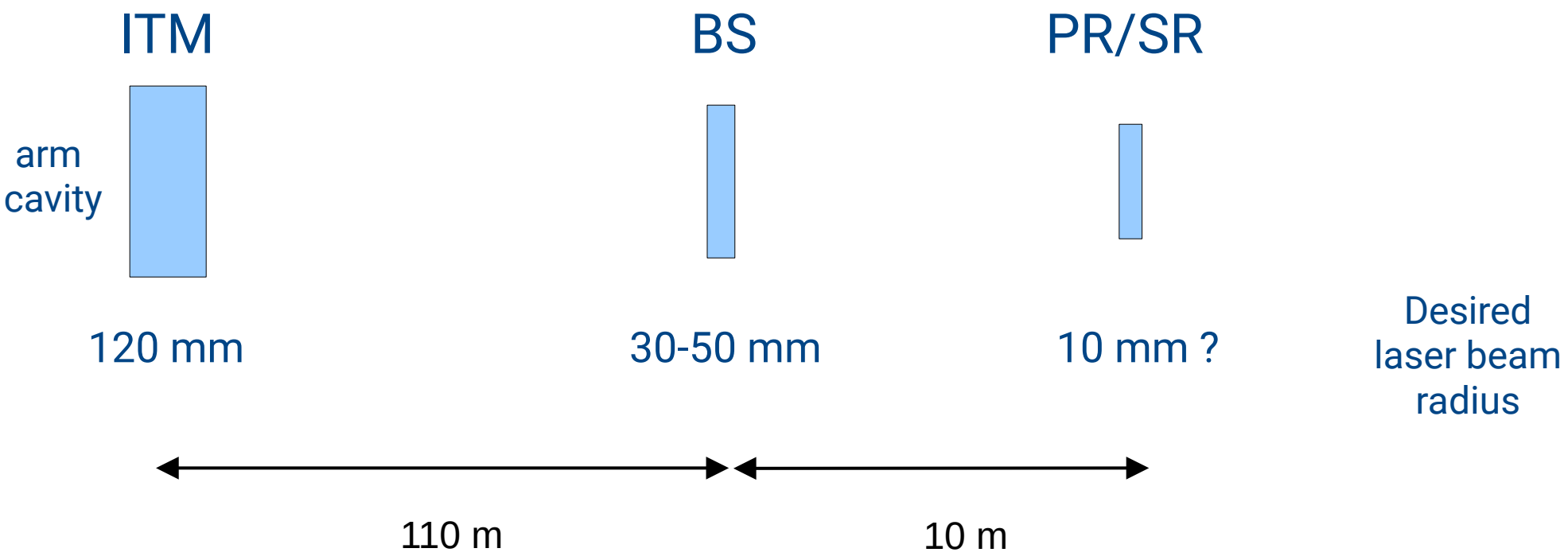
Distance ITM – BS = 110m

BS – PR ~ 10m

Optimised SRC length:
80 – 120 m
(depending on finesse arm cavity)

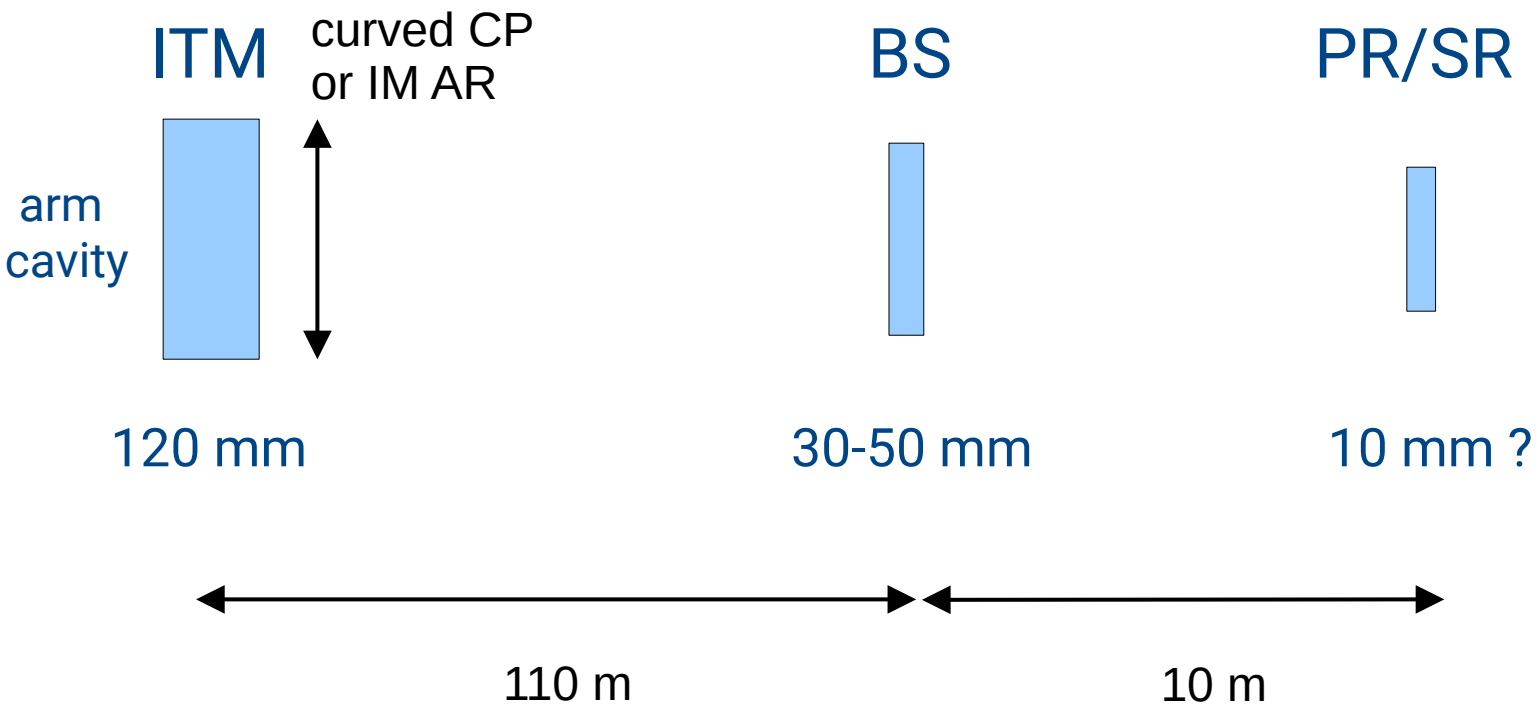
The starting point

Laser beam radius on the recycling cavities (ET-HF)

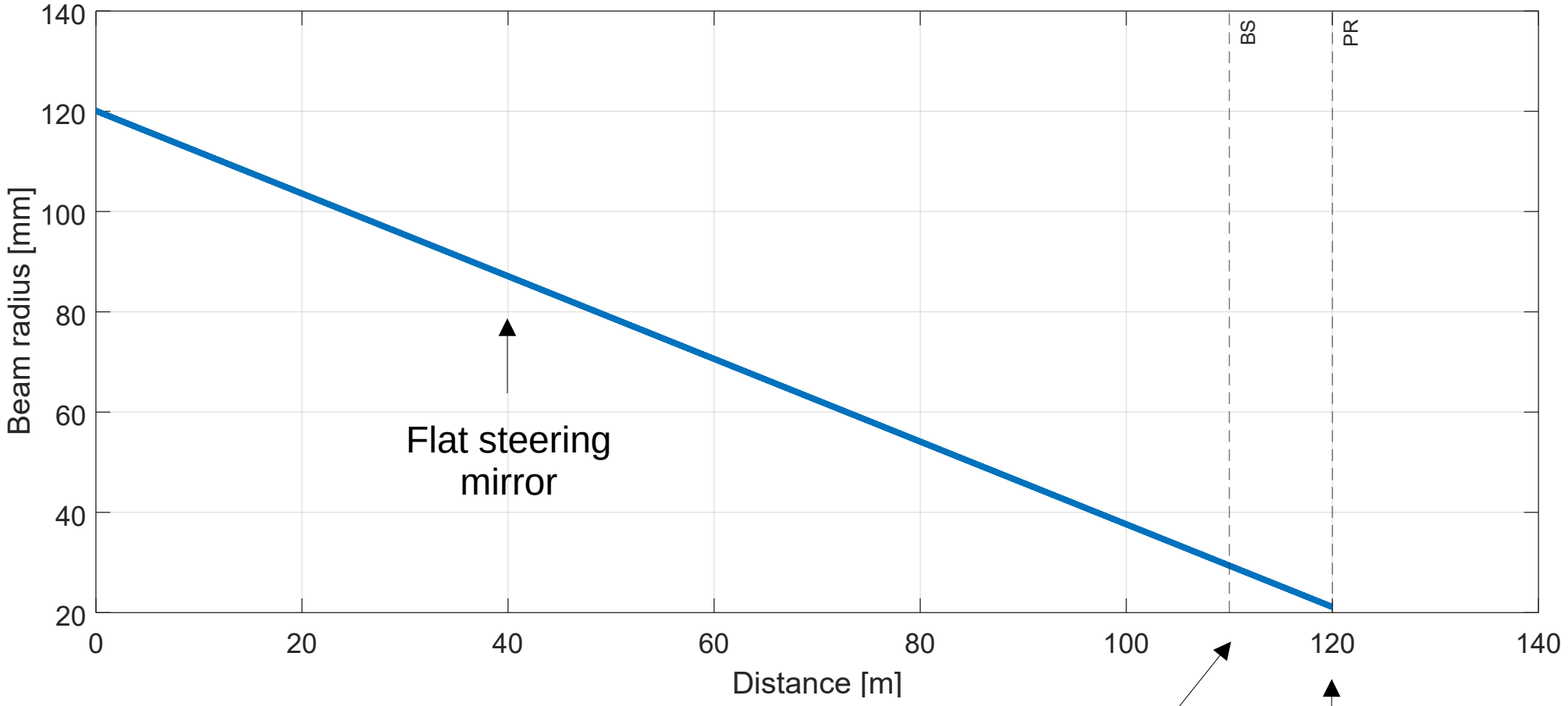


The starting point

Laser beam radius on the recycling cavities (ET-HF)



First iteration



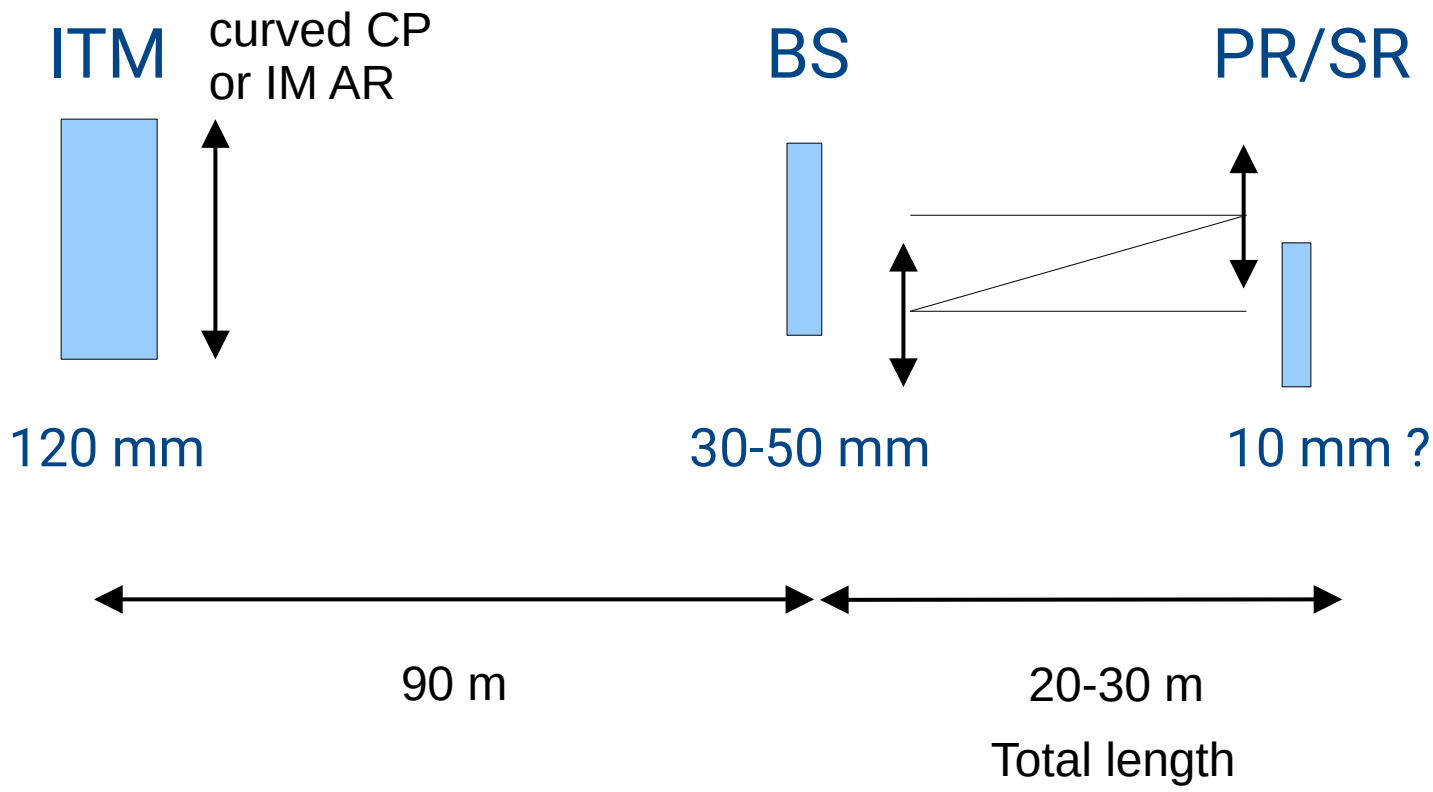
RoC AR ITM = 75 m

Ok
(but not at the waist)

Could be
smaller

More focusing before PR/SR

Laser beam radius on the recycling cavities (ET-HF)



Current work: finding the optimal parameters of the z shape telescope between BS and PR/SR

Dedicated working group

With each participants with a different task:

- model RC, one way propagation, find the best design :
  - with ABCD matrix
  - with Finesse
  - with OSCAR

} cross-checking and build blocks for larger models, check Gouy phase

- Resurrect the ET full finesse model

Work in progress

Possibility to minimise the astigmatism

TECHNICAL NOTE

Design of a low-loss off-axis beam expander

Patrice Hello and Catherine Nary Man 1996

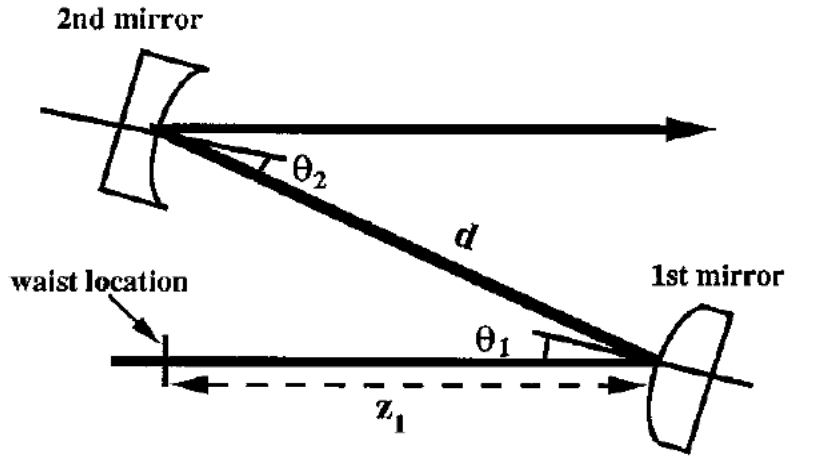
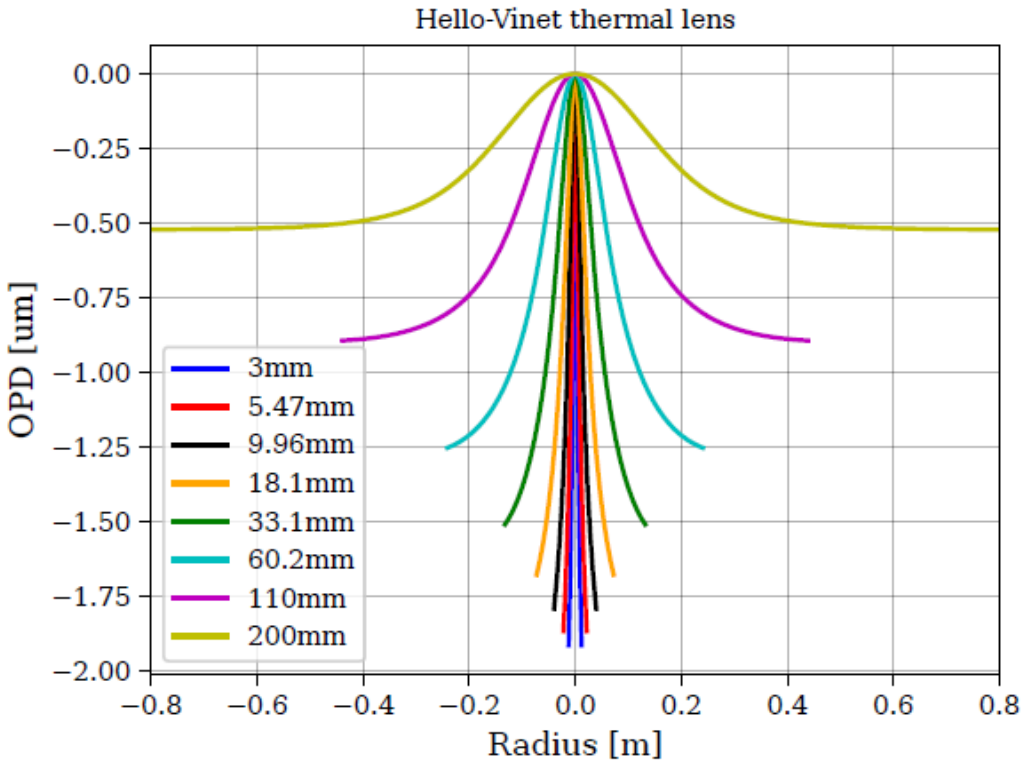


Fig. 1. Two-mirror off-axis beam expander.

Strategy exists to minimise the astigmatism

Thermal lens model

First model for the BS thermal lensing



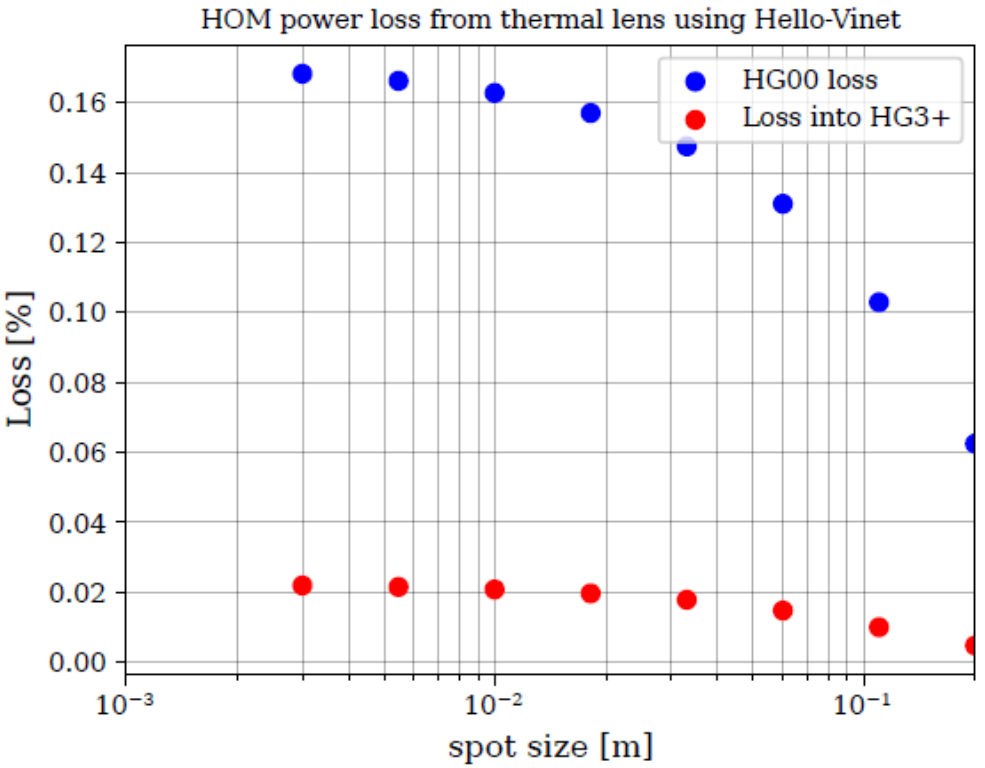


Figure 1: Power loss into higher order modes for different sized thermal lenses, on-axis. Shown is how much is lost out of the HG00, compared to how much is loss out of the HG00+HG20+HG02. Assumes 0.1W of coating heating into a fused silica 10cm substrate from Hello-Vinet.

The minimal beam size

7.2 Minimal beam size

The minimal beam size in a symmetric linear cavity is given by [7]:

$$w^2 = \frac{L\lambda}{\pi}\sqrt{\frac{1}{1-g^2}} = \frac{\lambda}{\pi}\sqrt{\frac{RL}{2-L/R}}$$

For a symmetric cavity the minimal values ($g = 0$) are:

L [km]	λ [nm]	Beam radius [cm]	Mirror diameter [mm]
10	1064	5.8	350
15	1064	7.1	430
20	1064	8.2	500
10	1550	7.0	420
15	1550	8.6	520
20	1550	9.9	600
10	2000	8.0	480
15	2000	9.8	600
20	2000	11.3	680

The mirror diameter is assumed to be around 6 times the beam radius.

Beamsplitter thermorefractive noise

$$S_h(\omega) = \frac{\pi^2}{L^2\mathcal{F}^2}\frac{4k_b\kappa T^2\beta^2\alpha'}{\pi(C\rho r_0^2\omega)^2}\frac{\eta+\eta^{-1}}{2\eta^2}\left[1+\frac{2k^2r_0^2\eta}{(\eta+\eta^{-1})\,(1+(2kl_{th})^4)}\right]$$