

Etude de l'OMC du système de détection Advanced Virgo

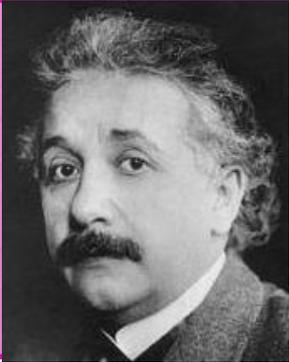


Marine Ducrot

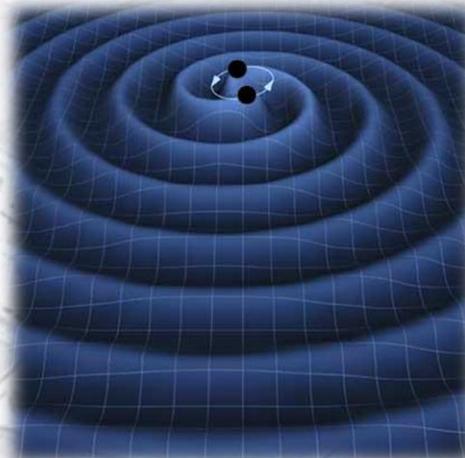
Plan:

- ❖ Enjeux
- ❖ Qu'est ce qu'un mode cleaner (OMC)
- ❖ Caractérisation: Mesure de finesse et filtrage
- ❖ Conclusion

Objectif: détection ondes gravitationnelles

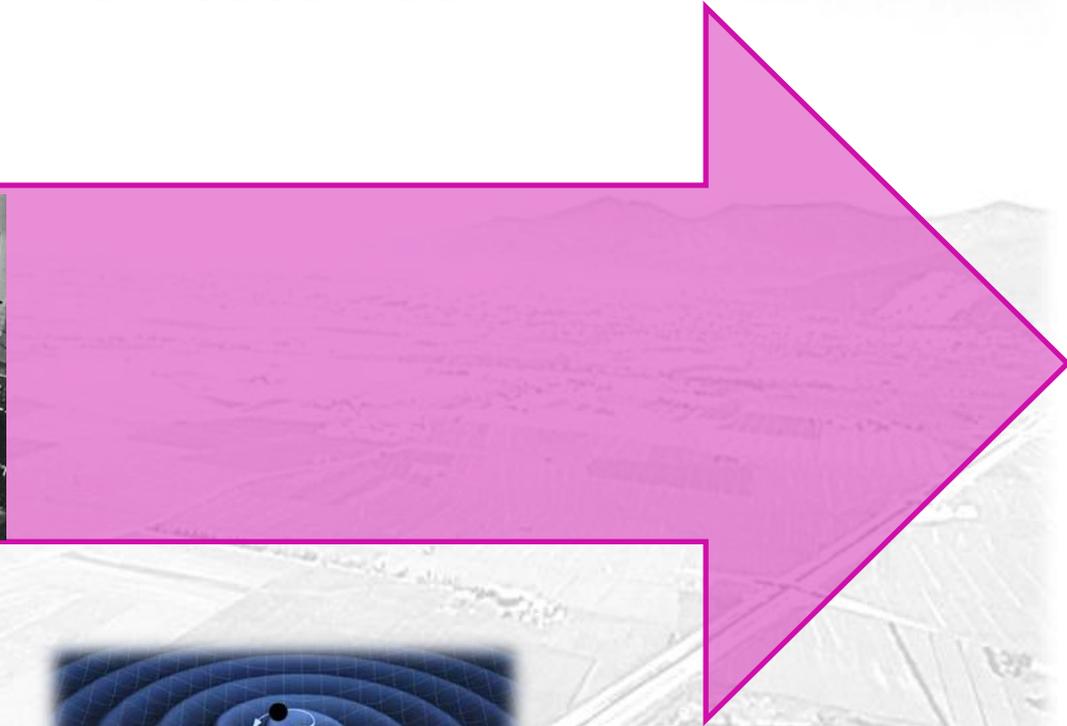
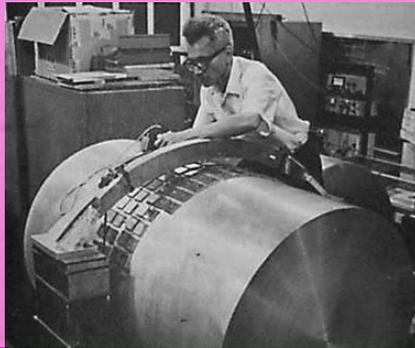
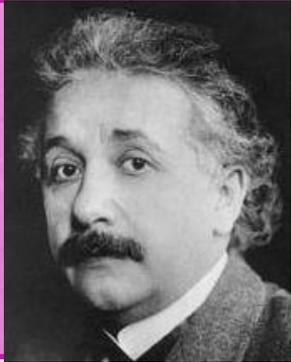


SN 1987A

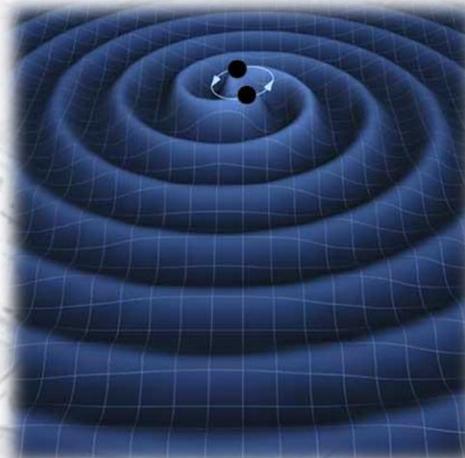


Système binaire

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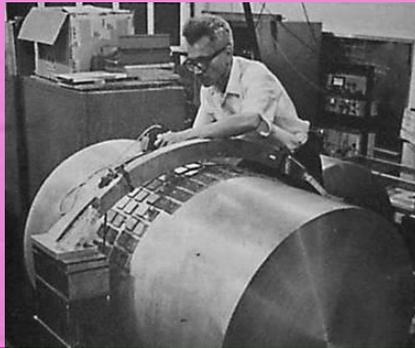
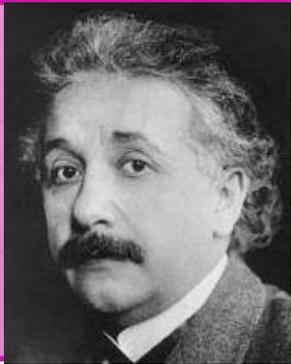


SN 1987A



Système binaire

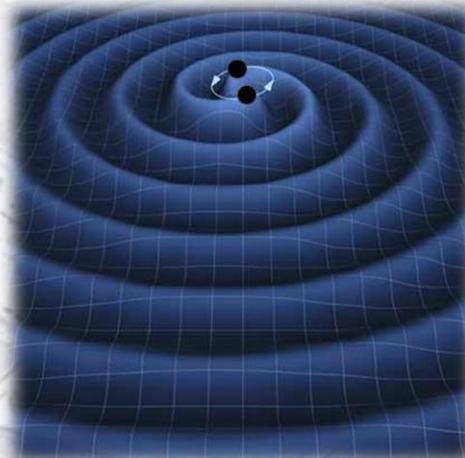
Objectif: détection ondes gravitationnelles



**The Nobel Prize in Physics 1993:
Taylor & Hulse**
for the discovery of a new type of pulsar

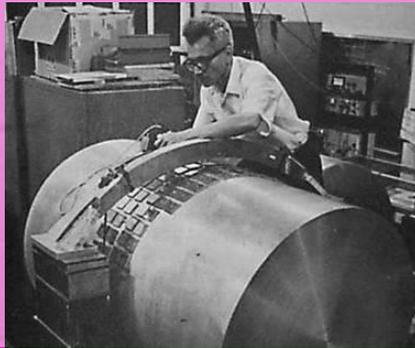
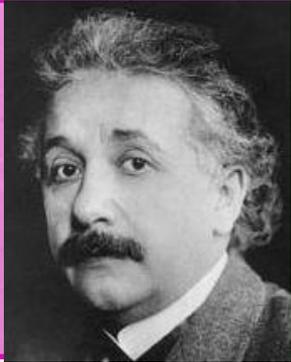


SN 1987A



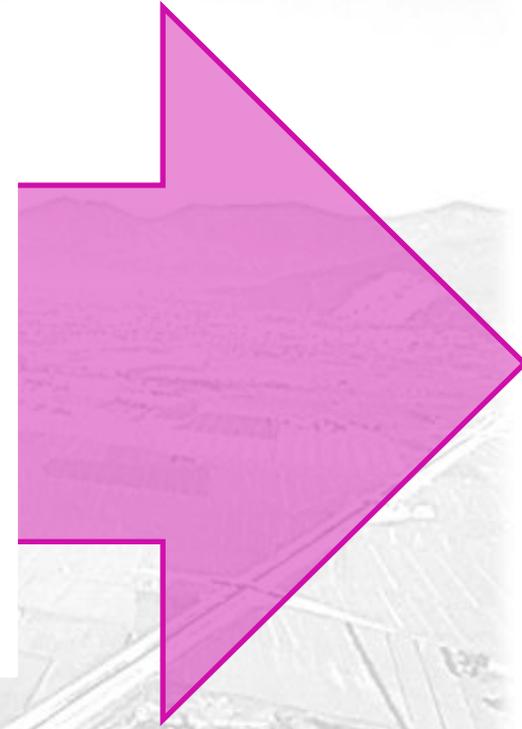
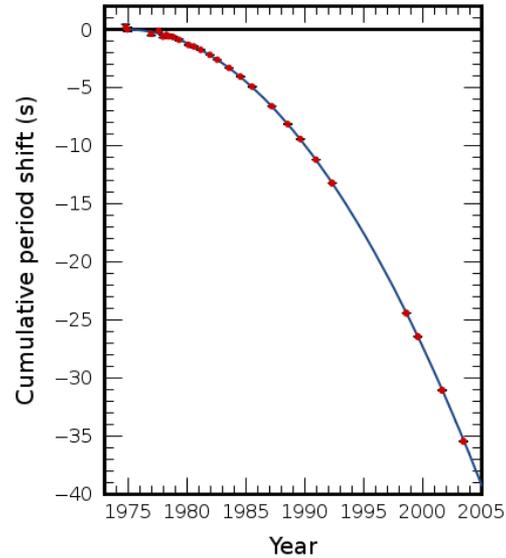
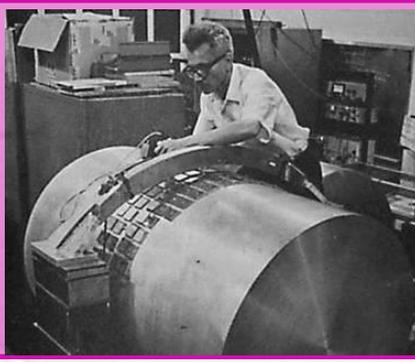
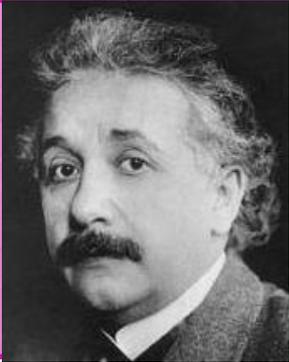
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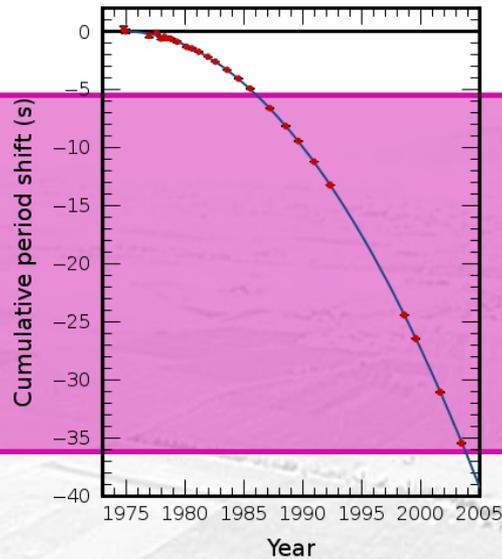
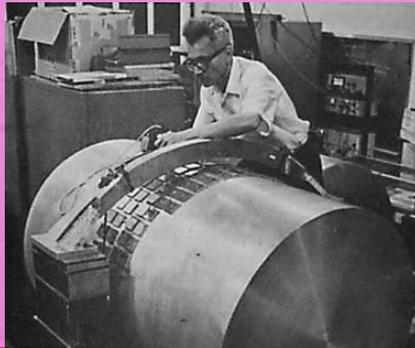
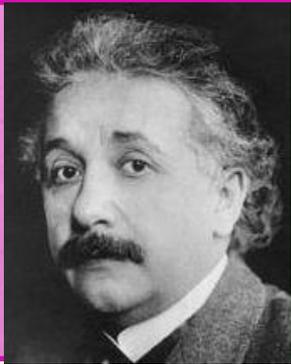


**The Nobel Prize in
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Objectif: détection ondes gravitationnelles



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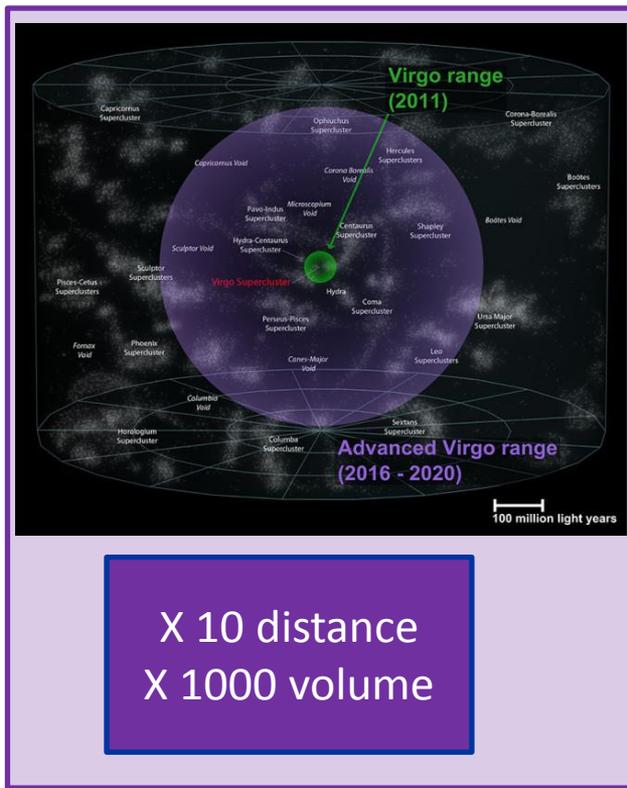


LIGO - Livingston

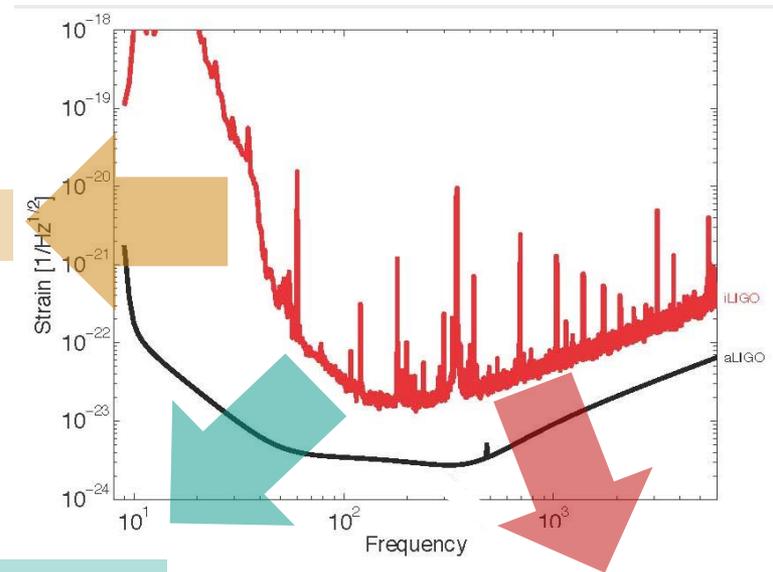


LIGO - Hanford

Virgo → Advanced Virgo



Bruit sismique

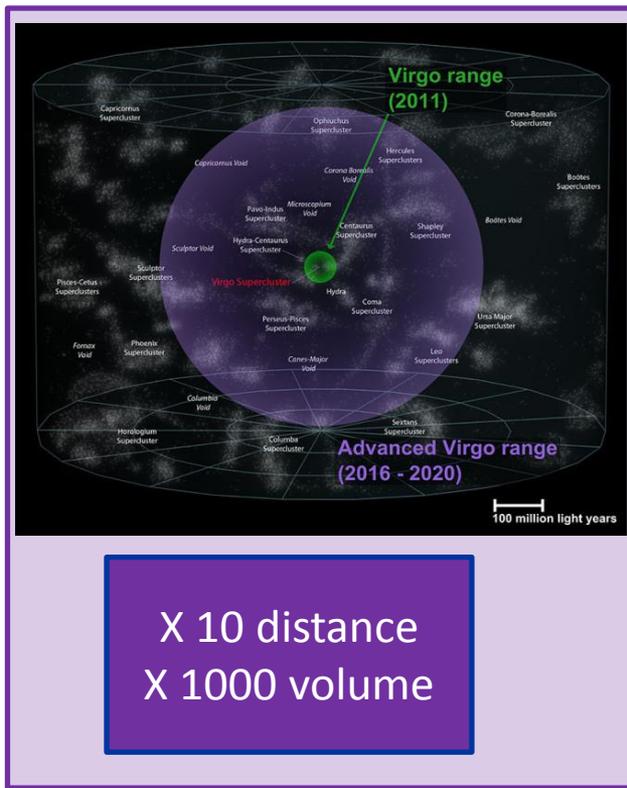


Bruit thermique

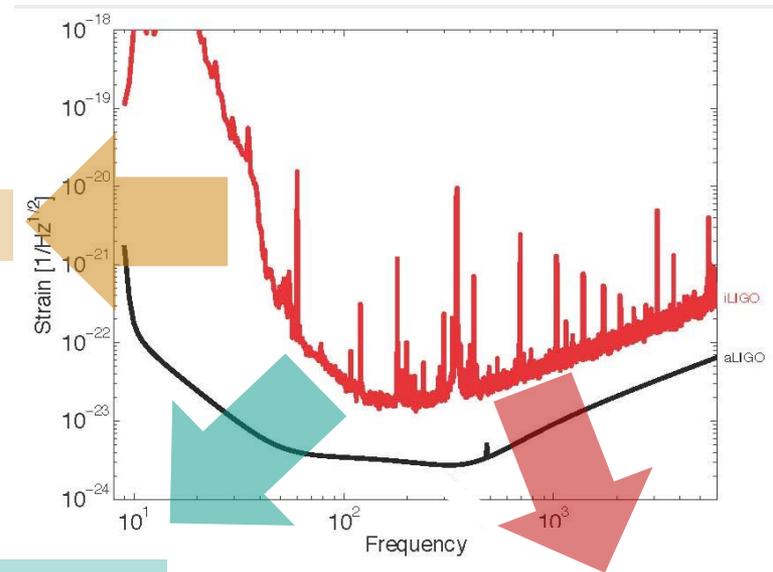
Bruit quantique

$$10^{-19}m$$

Virgo → Advanced Virgo

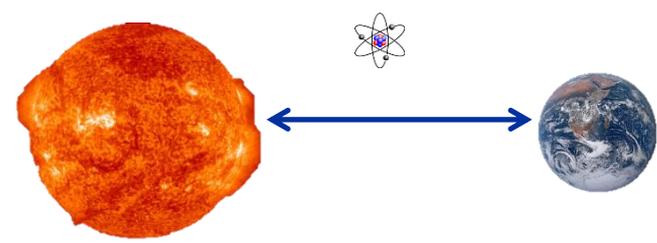


Bruit sismique



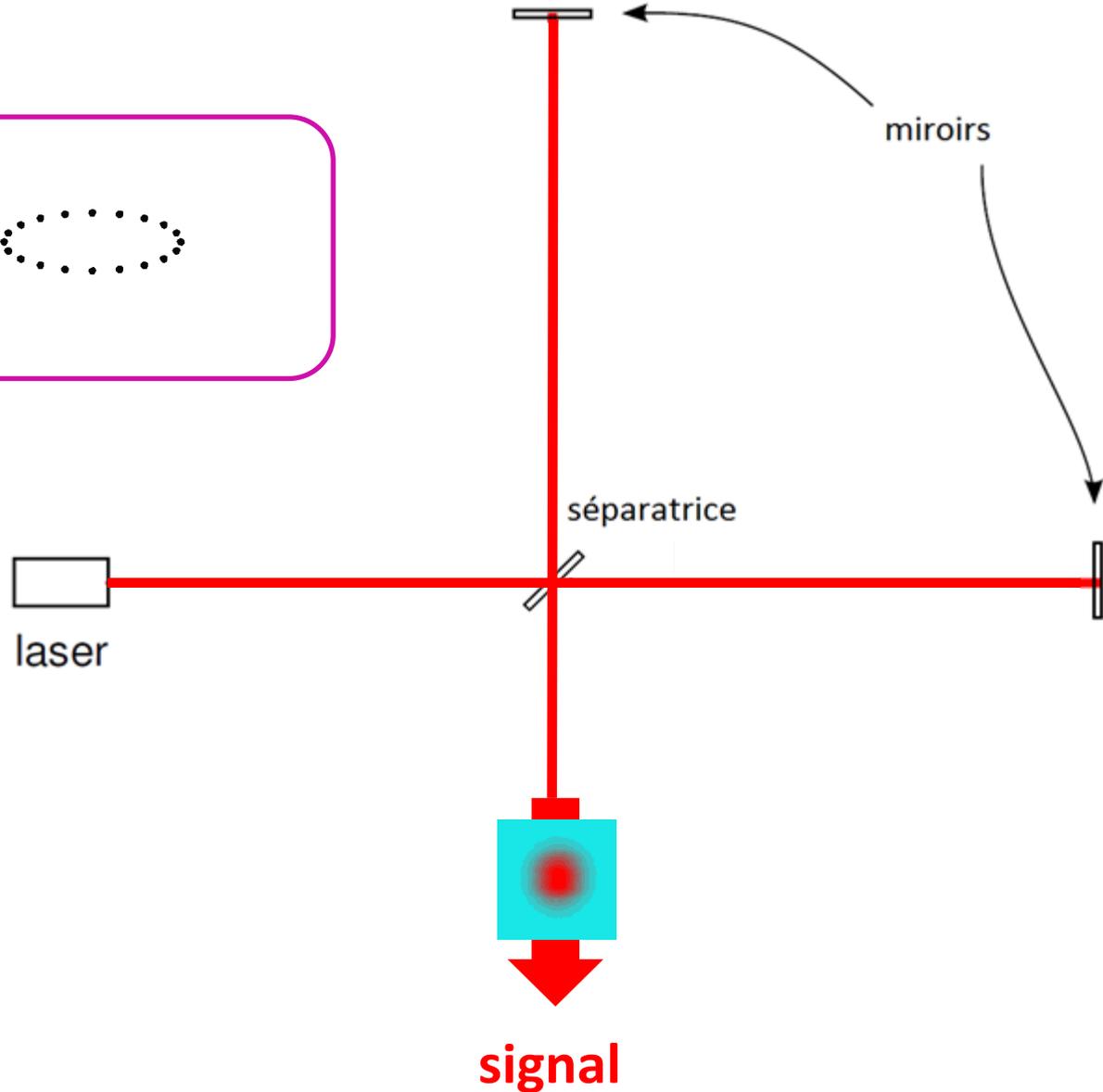
Bruit thermique

Bruit quantique



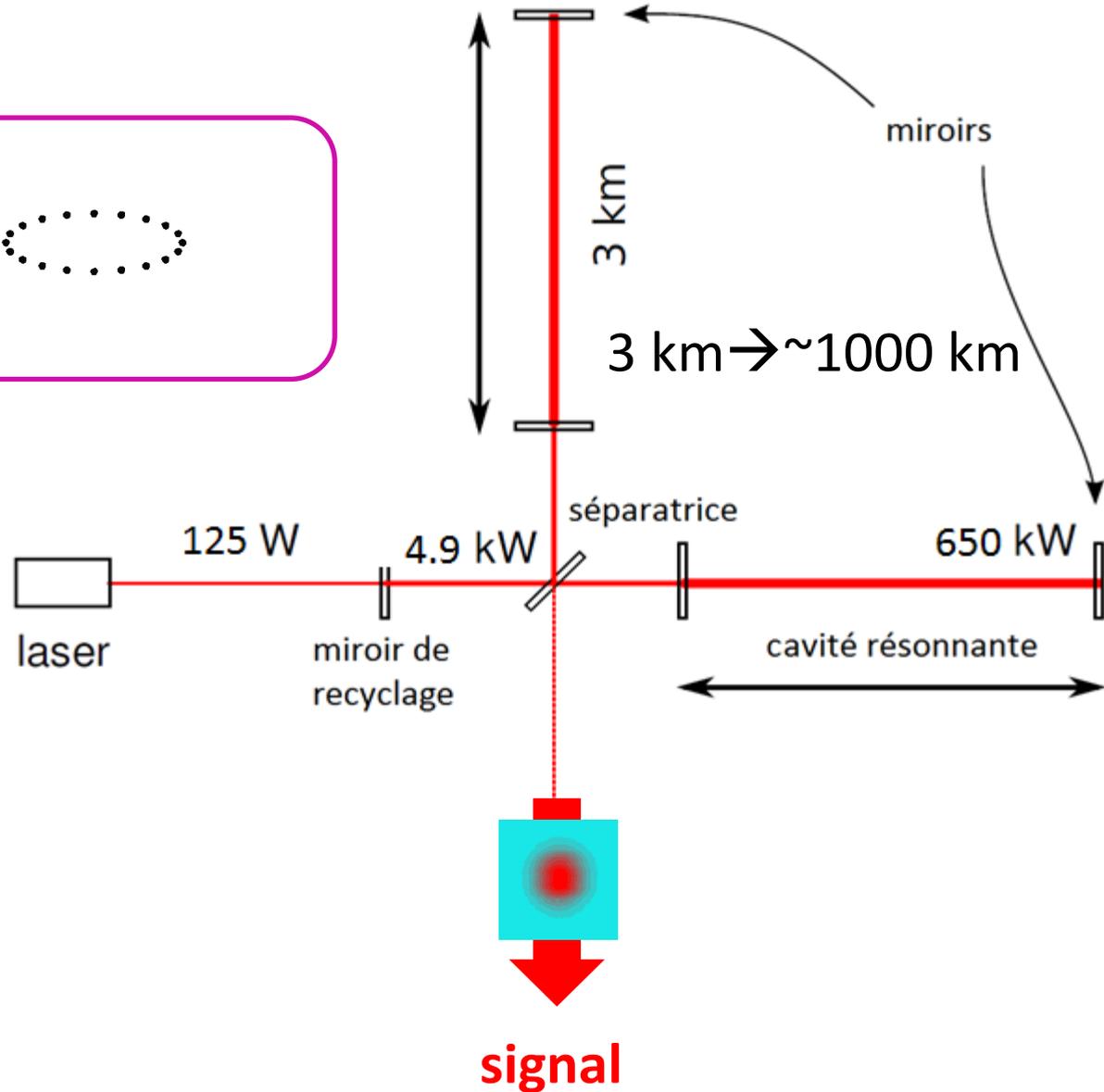
Détecteur

Masses libres: 



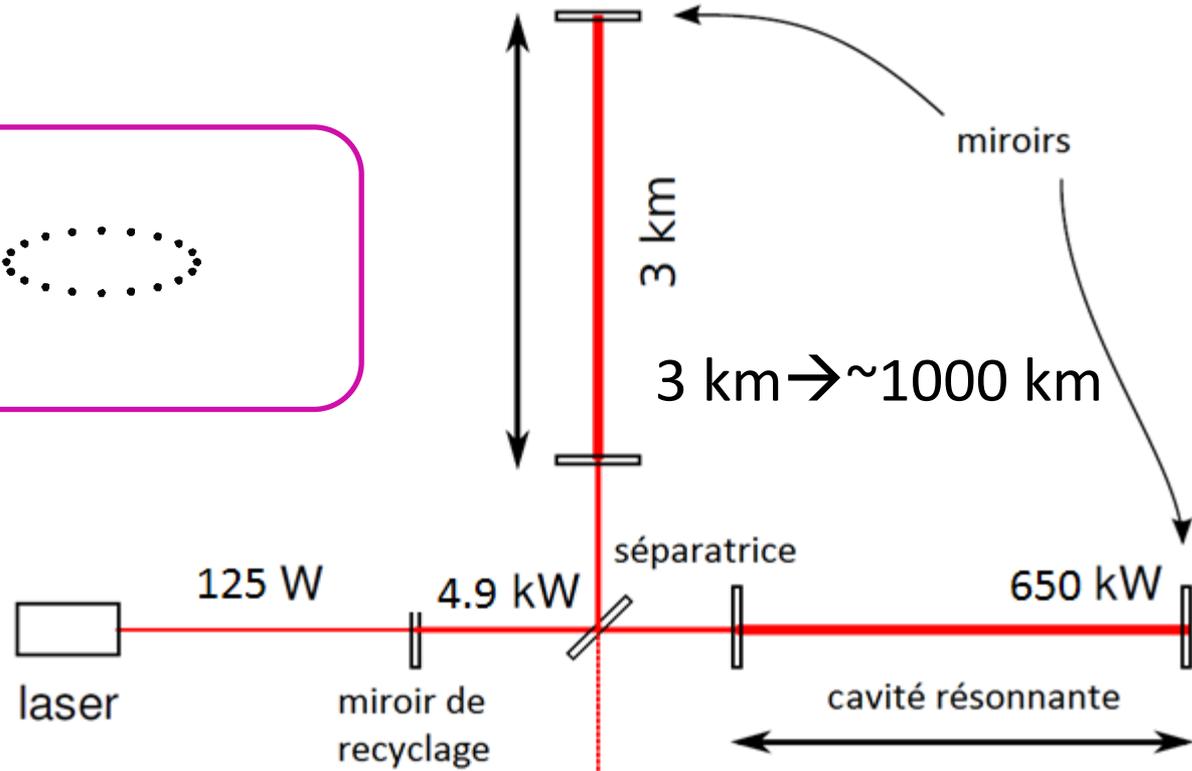
Détecteur

Masses libres:

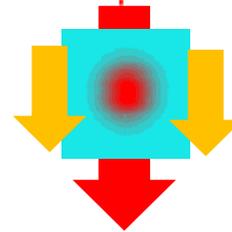


Détecteur

Masses libres:



Faisceaux de contrôle

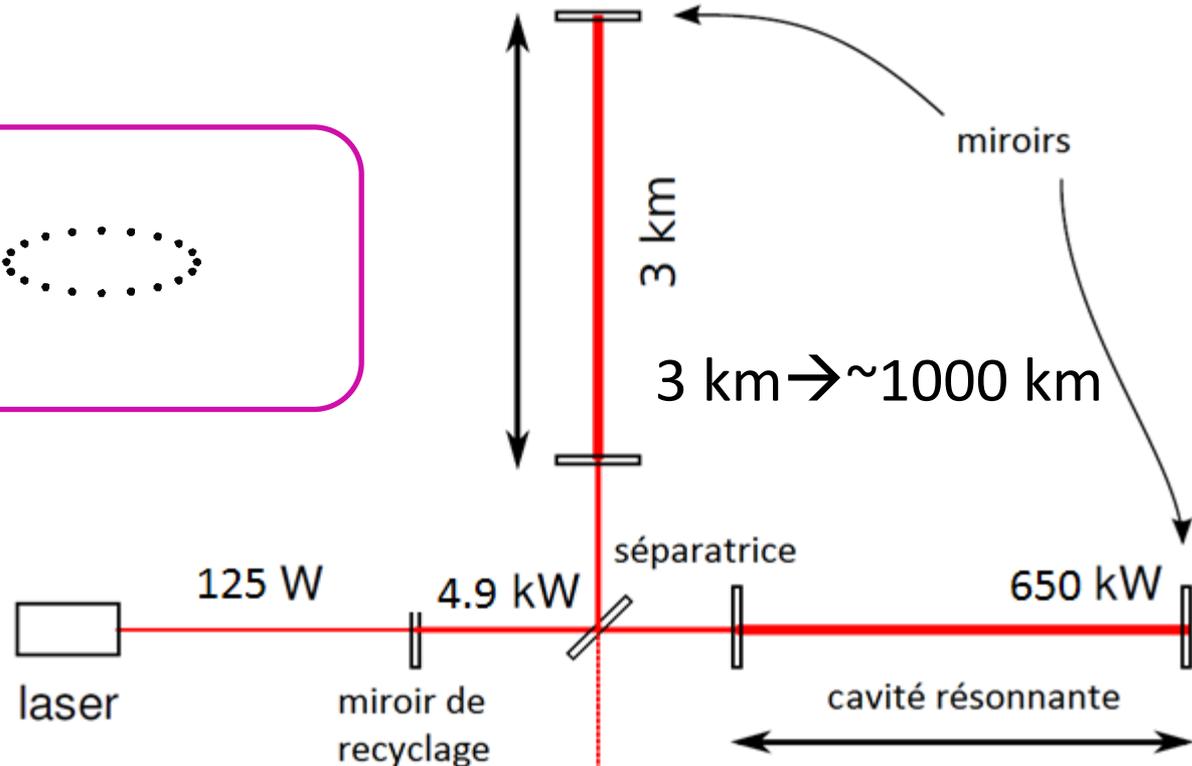


signal



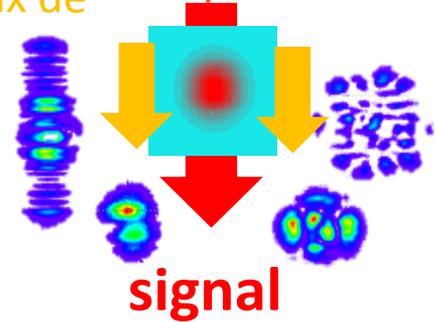
Détecteur

Masses libres: 



Faisceaux de contrôle

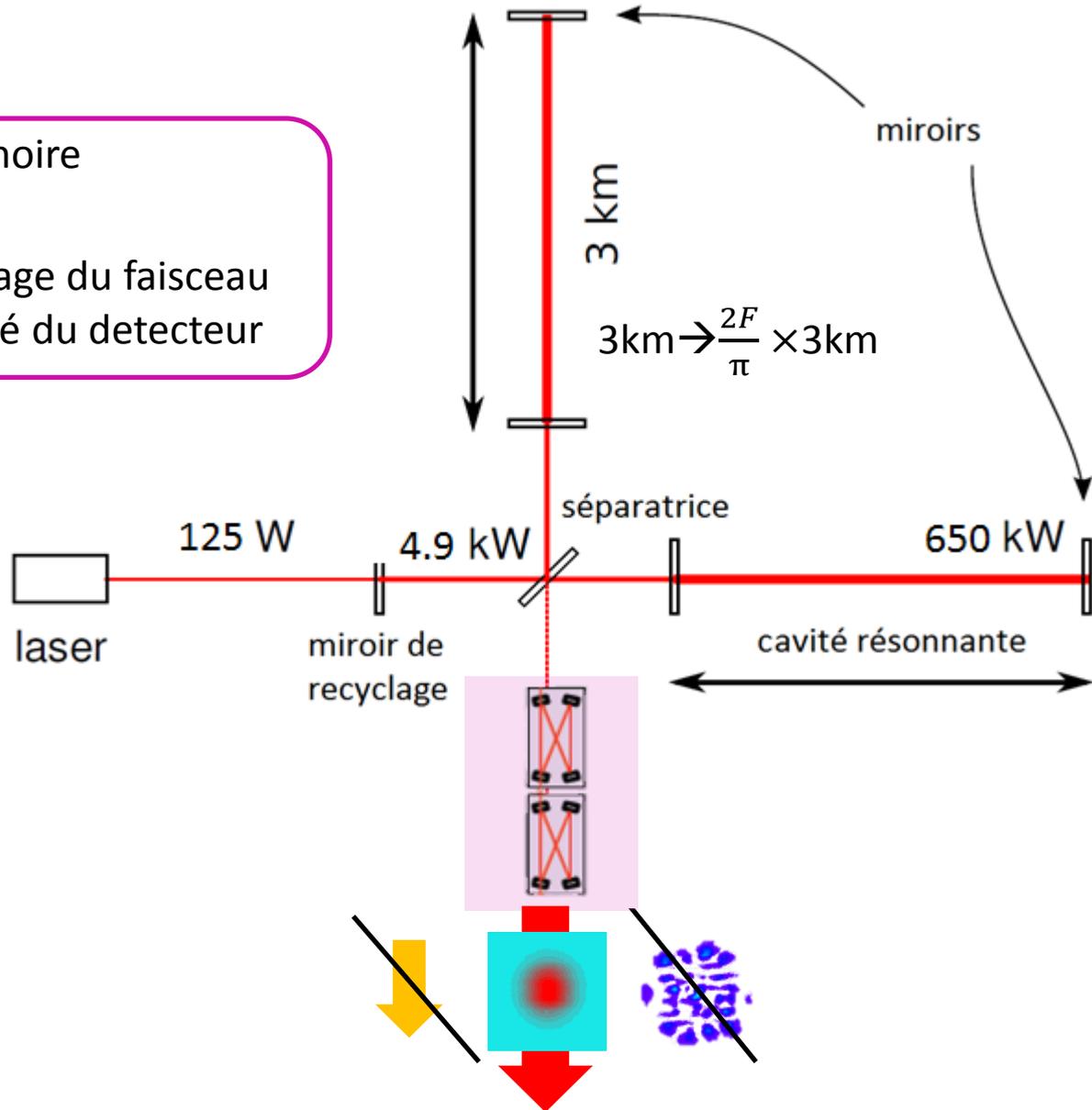
Modes d'ordre supérieurs



OMC

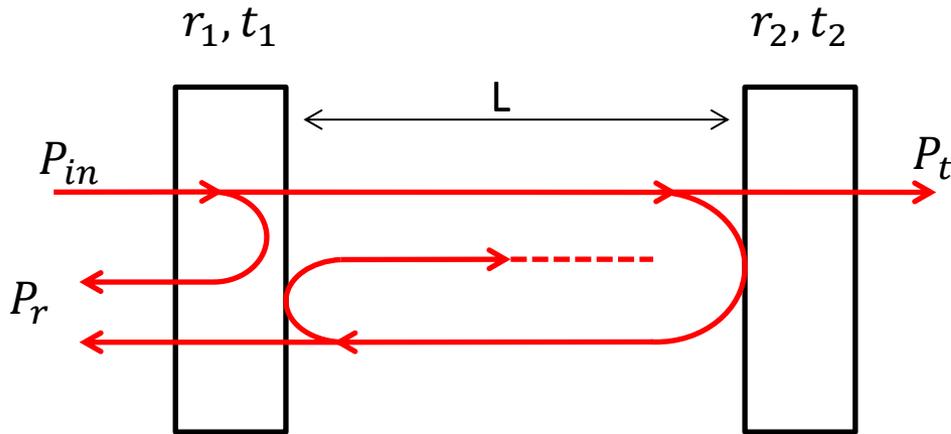
Lock sur la frange noire

Objectif OMC: Filtrage du faisceau
→ gain en sensibilité du détecteur



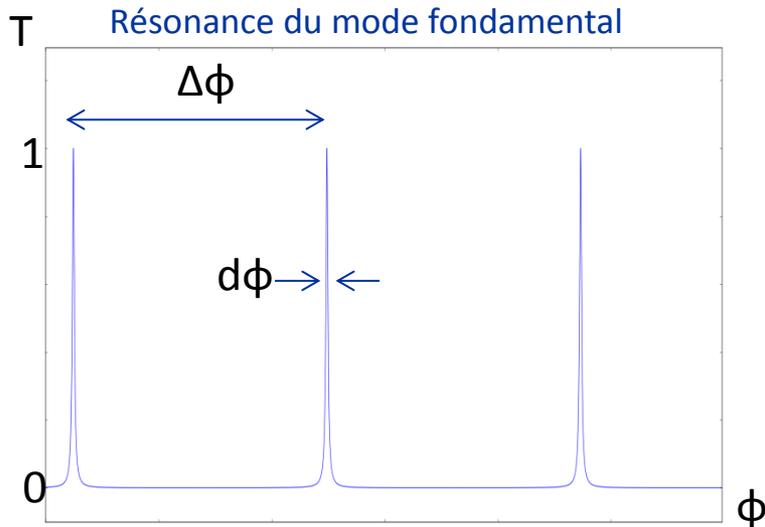
Cavité optique: finesse F

Filtrage fréquentiel



$$\varphi = 4\pi L \frac{\nu}{c} = p2\pi$$

$$F = \frac{\pi\sqrt{r_1 r_2}}{1 - r_1 r_2}$$

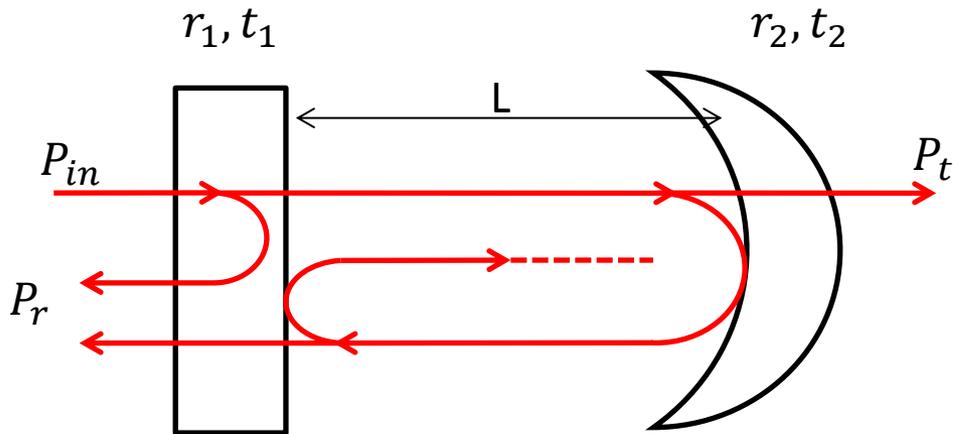
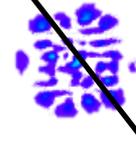


$$F = \frac{\Delta\phi}{d\phi}$$

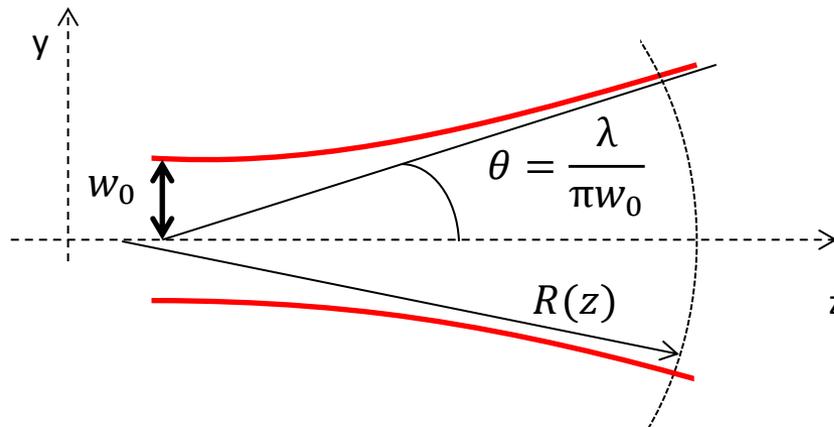
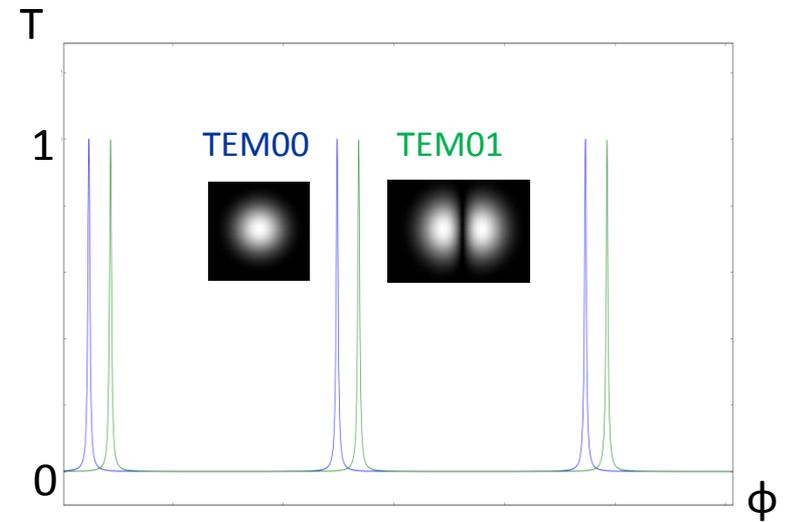
Spécification: $F=143$

Cavité optique: rayon de courbure ρ

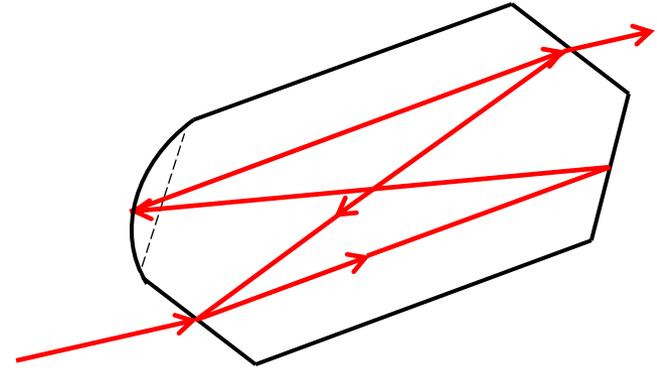
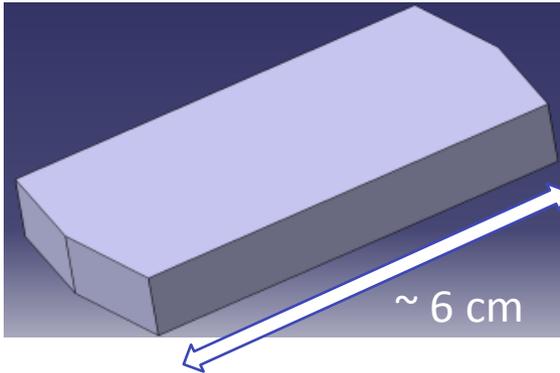
Filtrage géométrique



Spécifications: $\rho=1.7\text{m}$

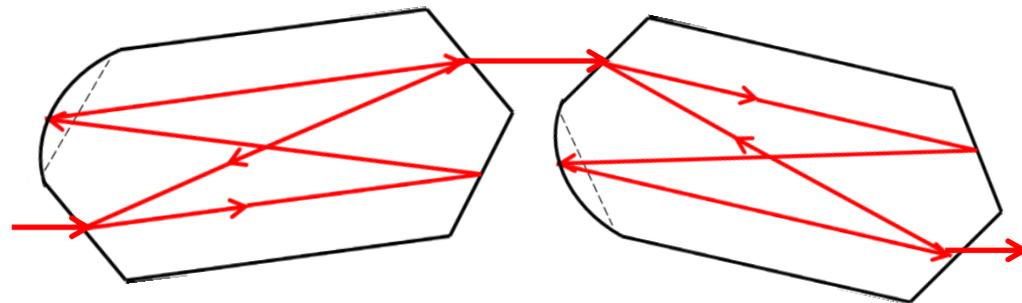


AdV OMC

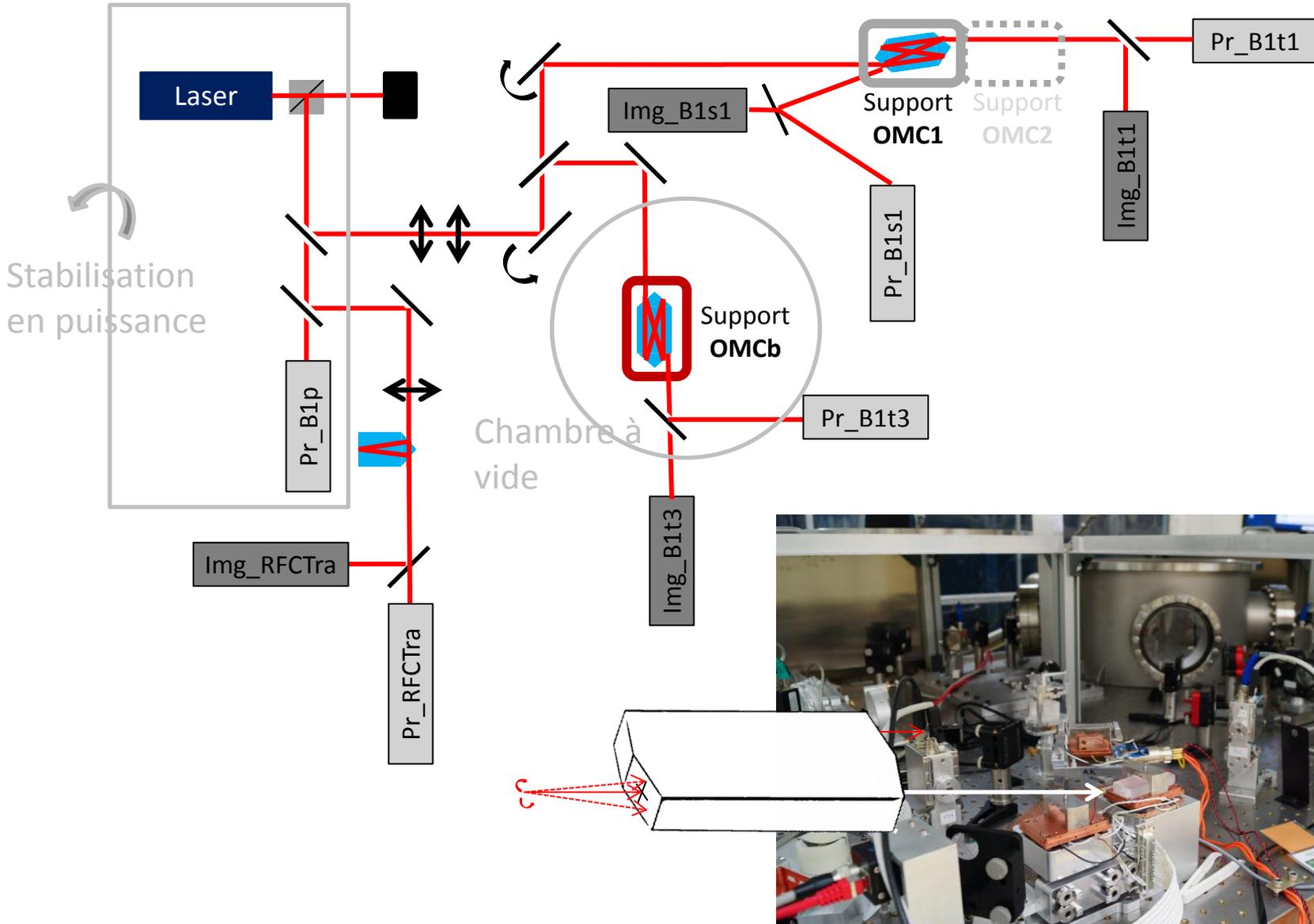


- **Production de 4 substrats**
 - **Polissage**
 - **Traitement de surface**
- **Tests**

- **1 face sphérique**
- **3 faces planes**



Banc de tests des cavités



Mesures de la finesse

- A partir des paramètres de surface
 - avec les valeurs de transmissions du LMA
 - avec les valeurs de transmissions du LAPP
- A partir des scans
 - variation en fréquence du laser
 - variation en longueur de la cavité

Mesures des réflectivités → F



4 témoins

Paramètres
de surfaces

$$F = \frac{\pi\sqrt{r_1 r_2 r_3 r_4}}{1 - r_1 r_2 r_3 r_4}$$

Mesures
LMA

Sur des
témoins

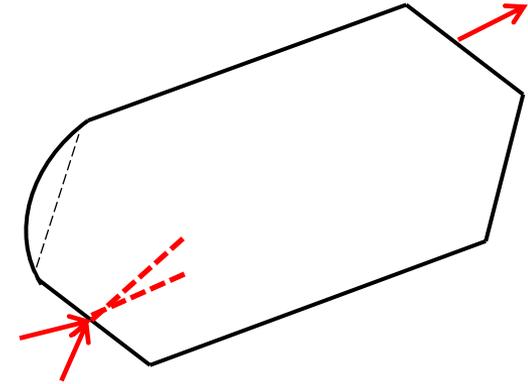
	OMC#6	OMC#7 and OMC#5
$F_{\text{transmission LMA}}$ on test sample	T - S	T - S
	150.5	146.3

Mesures des réflectivités → F



4 témoins

Paramètres de surfaces



$$F = \frac{\pi \sqrt{r_1 r_2 r_3 r_4}}{1 - r_1 r_2 r_3 r_4}$$

Mesures LMA

Mesures LAPP

$$T = \sqrt{\frac{P_{out}}{P_{in}}}$$

Sur des témoins

Sur les vraies cavités

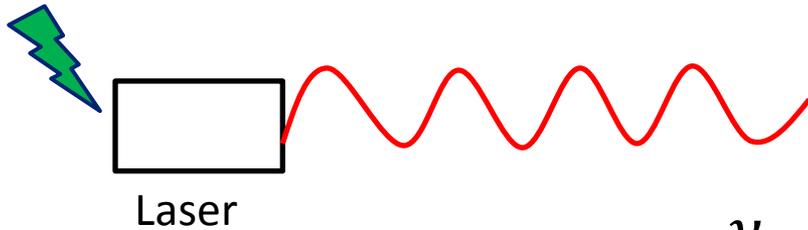
	OMC#6	OMC#7 and OMC#5
$F_{transmission\ LMA}$ on test sample	T - S	T - S
	150.5	146.3

		OMC#7	OMC#5
$F_{transmission\ LAPP}$ on OMC	1	125 ± 5	118 ± 5
	2	125 ± 5	126 ± 5

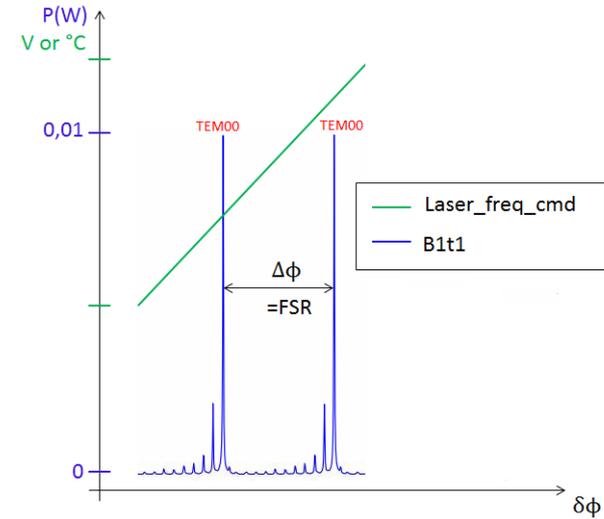
Deux méthodes différentes, deux résultats sensiblement différents

Mesures de F (scans)

- Variation en fréquence :

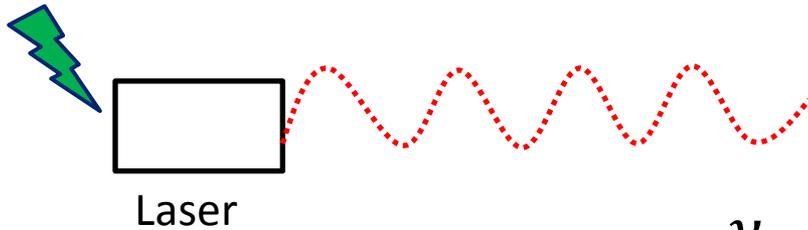


$$\varphi = 4\pi L \frac{\nu}{c} = p2\pi$$

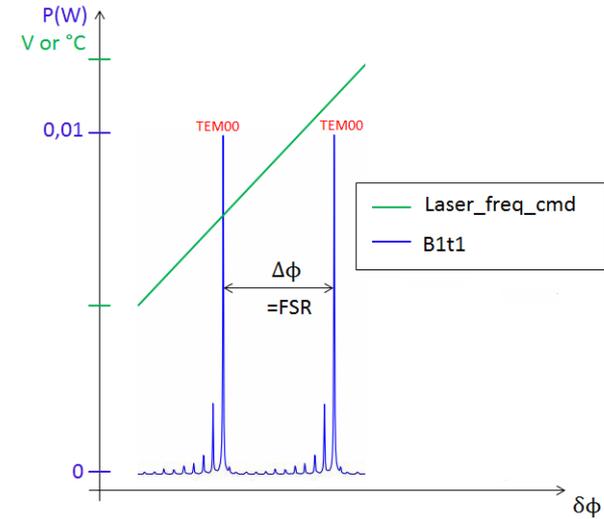


Mesures de F (scans)

- Variation en fréquence :



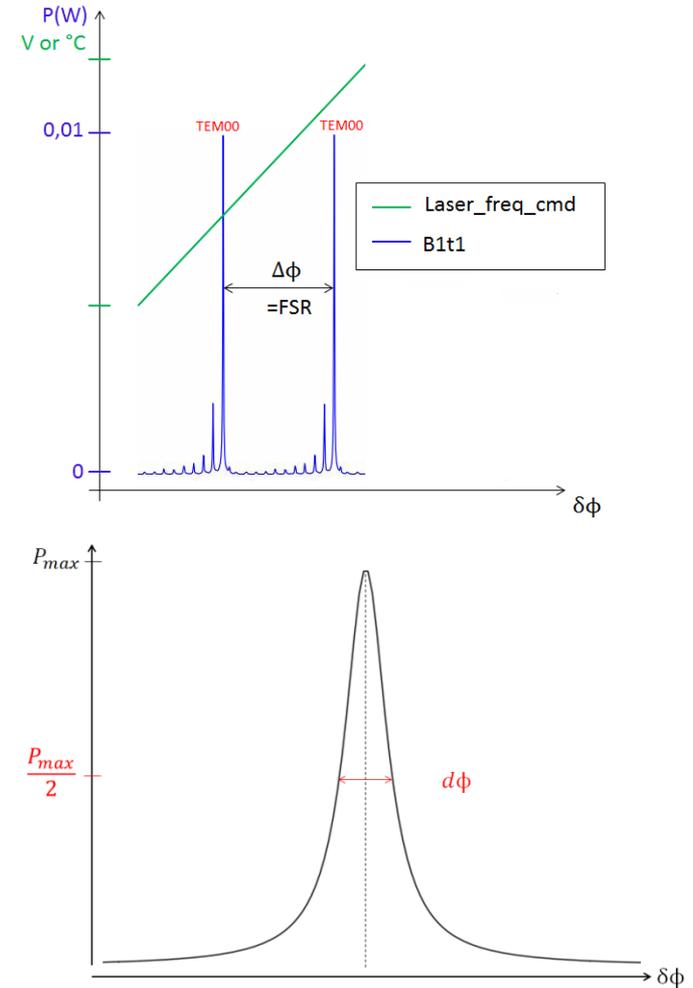
$$\varphi = 4\pi L \frac{\nu}{c} = p2\pi$$



Mesures de F (scans)

- Variation en fréquence :

$$F = \frac{\Delta\phi}{d\phi}$$



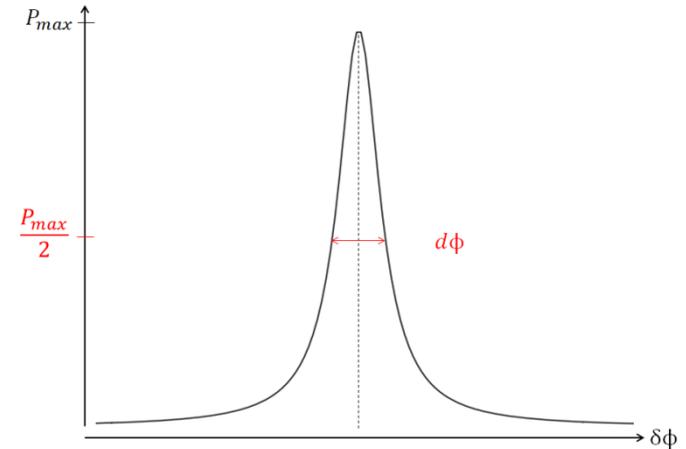
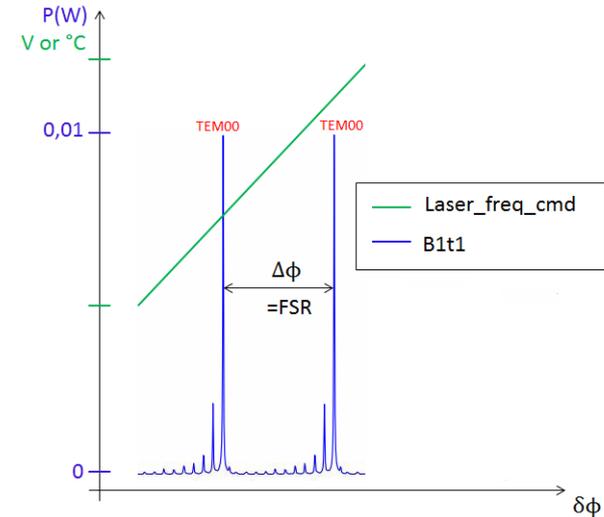
Mesures de F (scans)

- Variation en fréquence :

$$F = \frac{\Delta\phi}{d\phi}$$

- Variation en longueur :

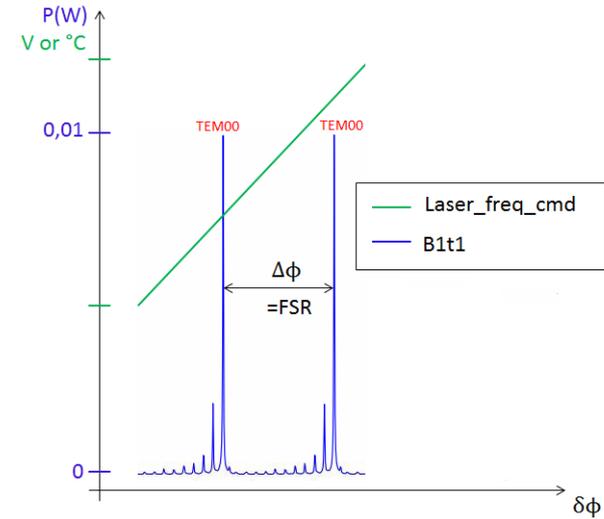
$$\varphi = 4\pi L \frac{\nu}{c} = p2\pi$$



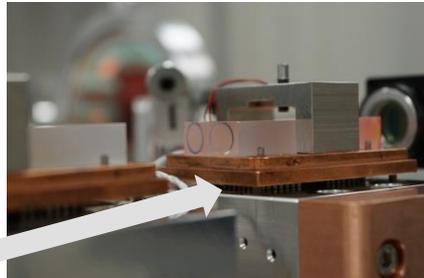
Mesures de F (scans)

- Variation en fréquence :

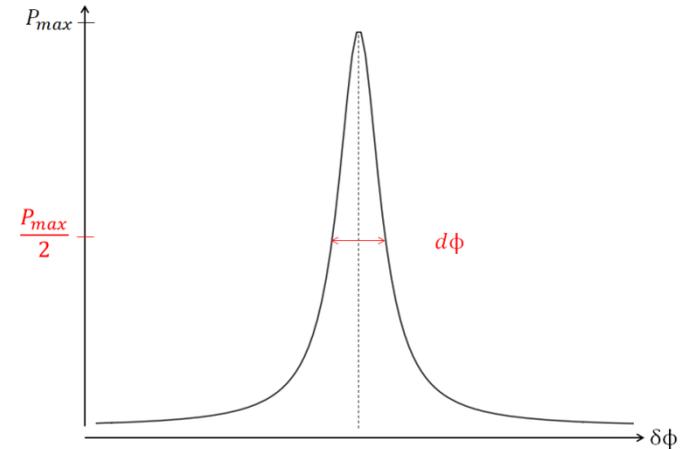
$$F = \frac{\Delta\phi}{d\phi}$$



- Variation en longueur :



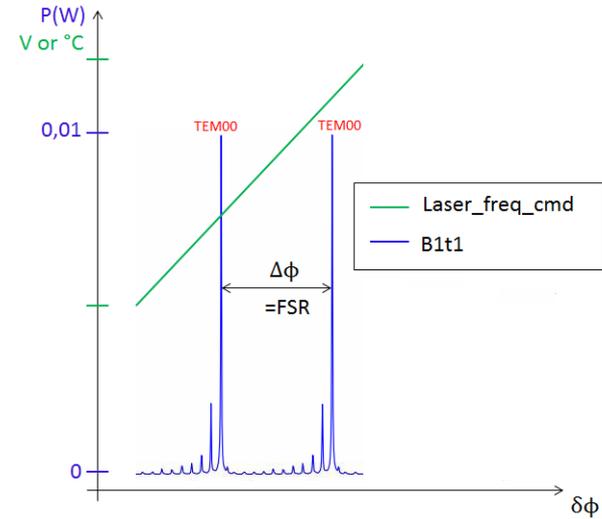
Cellules de Peltier



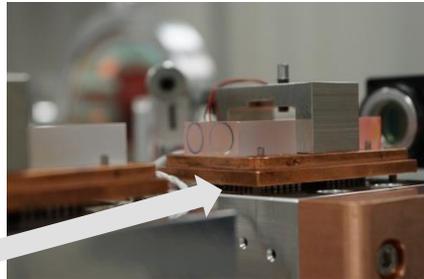
Mesures de F (scans)

- Variation en fréquence :

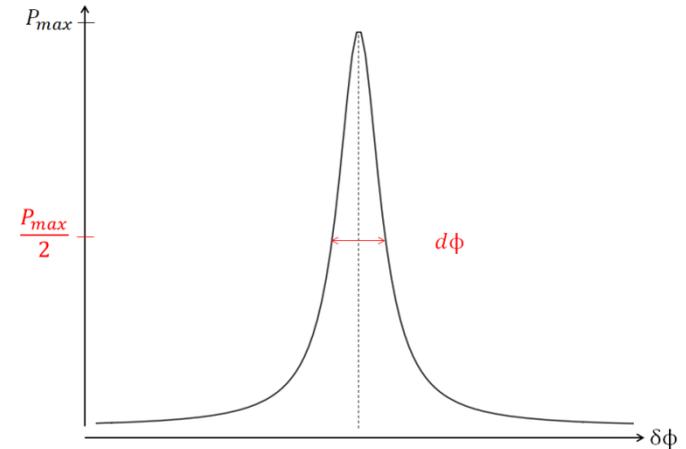
$$F = \frac{\Delta\phi}{d\phi}$$



- Variation en longueur :



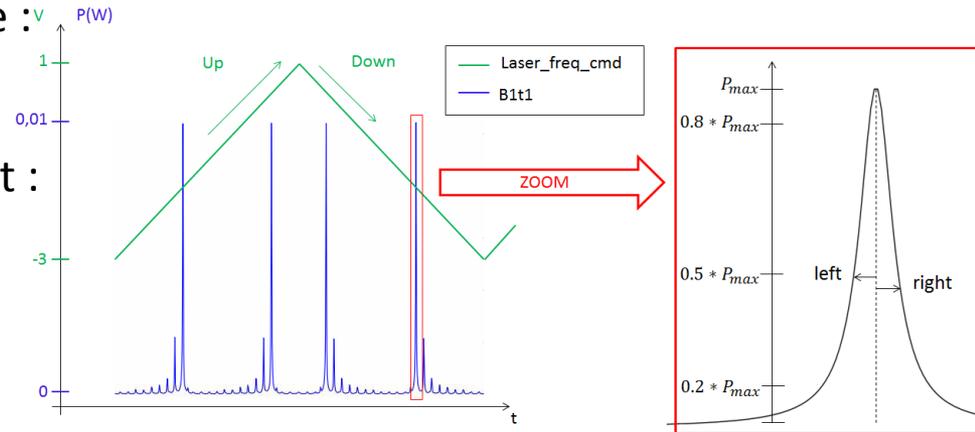
Cellules de Peltier



CCL	OMC#6	OMC#7	OMC#5	OMC#8
F	121.3 ± 0.1	124.6 ± 0.1	124.2 ± 0.1	126.4 ± 0.1

Erreurs systématiques

- Effet de la puissance du laser :
- Influence de la vitesse du scan :
- Influence de la stabilisation en température :
- Effet de la fréquence d'échantillonnage :
- Effet de la profondeur de modulation du pzt :
- Montée/descente :
- Effet de p dans $F = \sqrt{\frac{1}{p} - 1} \frac{\Delta\phi}{2 \sin(\frac{d\phi}{2})}$:
- Droite/gauche: pour P_{16mW} → Corrigé



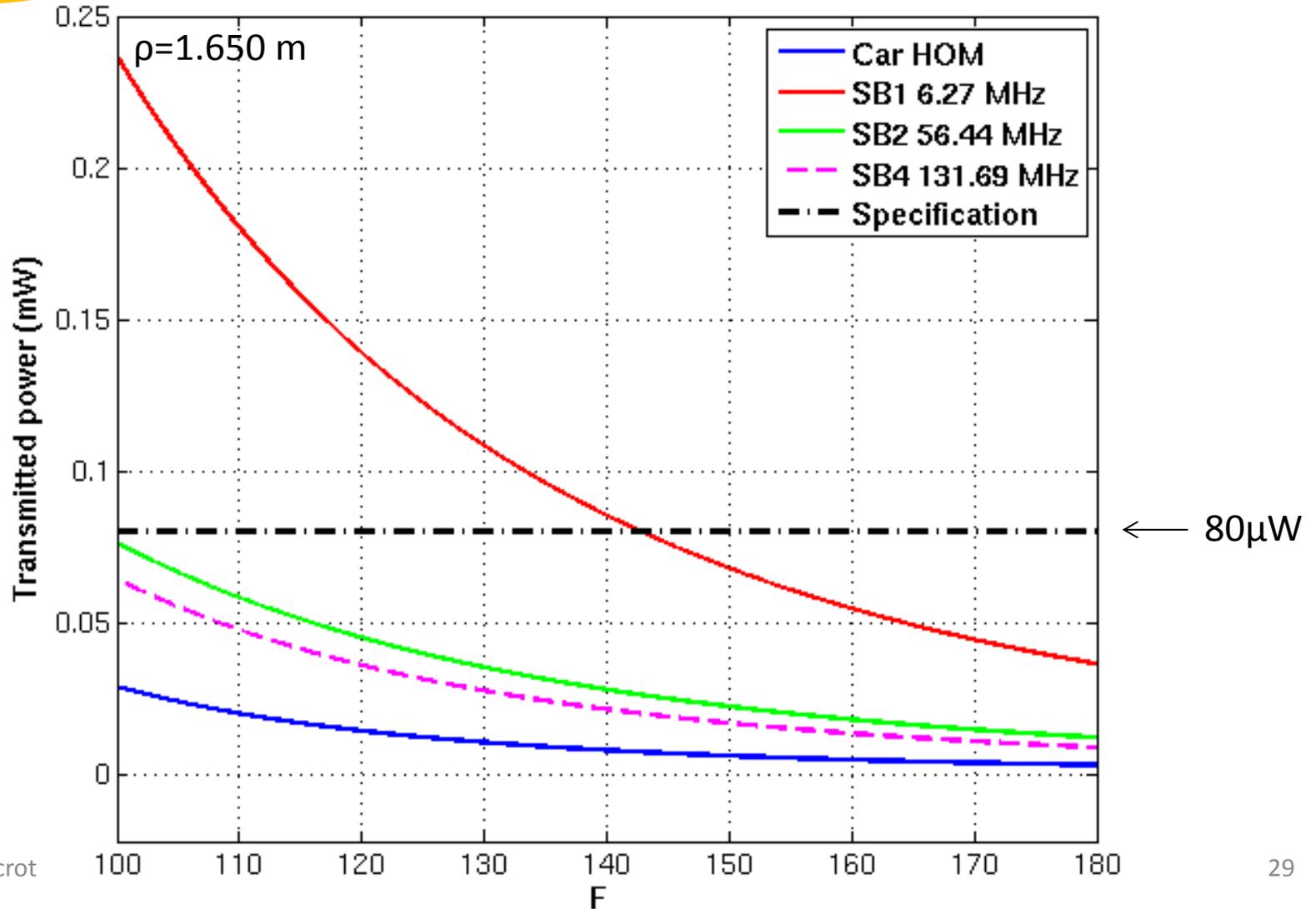
CCL	OMC#6	OMC#7	OMC#5	OMC#8
F	121.3 ± 2.9	124.6 ± 2.9	124.2 ± 2.9	126.4 ± 2.9

→ Systématiques ~ 2.5% domine largement l'erreur totale

Qualité globale du filtrage

1.6W à l'entrée de l'OMC

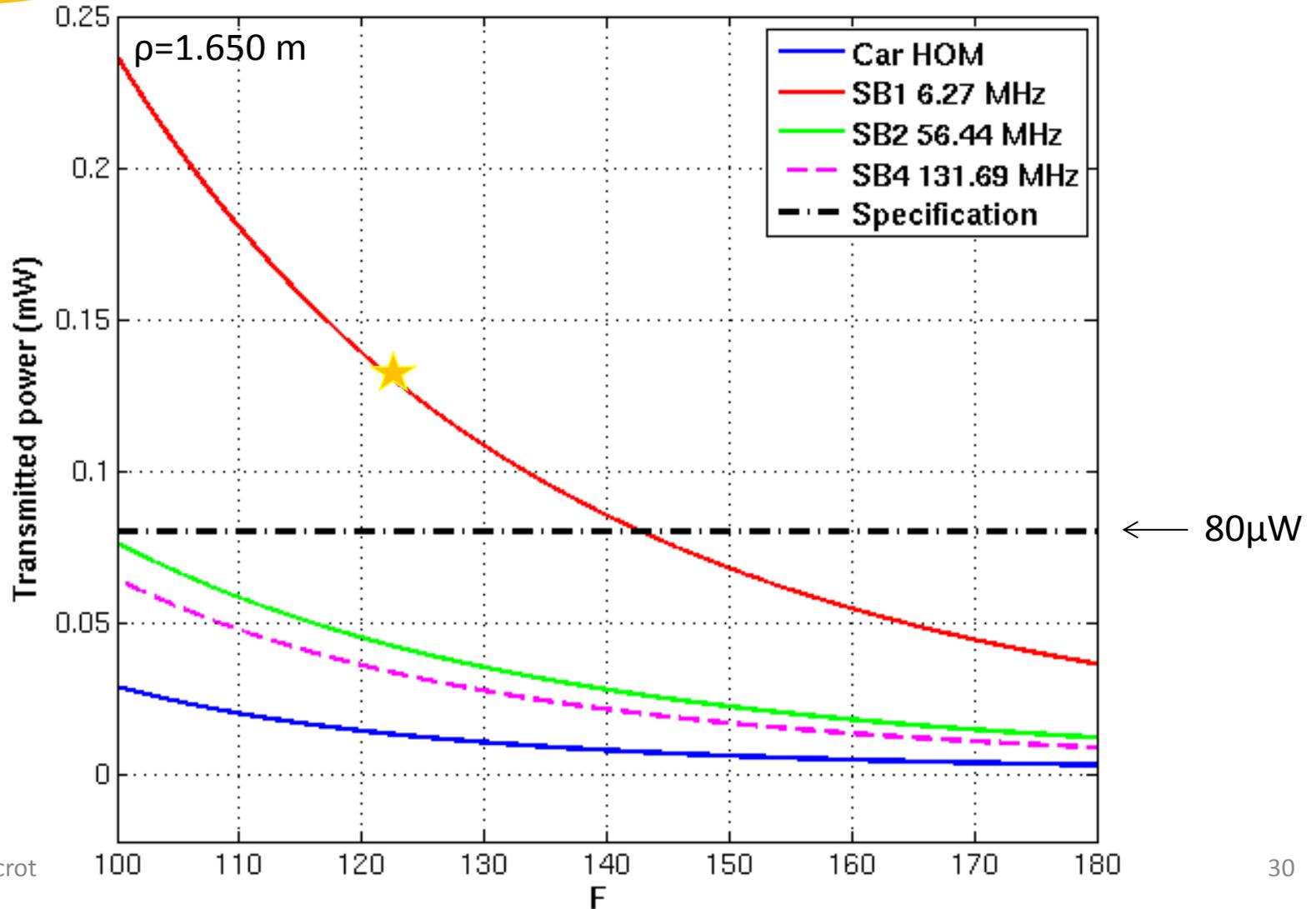
Puissance attendue en transmission de l'OMC



Qualité globale du filtrage

1.6W à l'entrée de l'OMC

Puissance attendue en transmission de l'OMC



Perspectives

- Perspectives:
 - Mesures complémentaires
 - Alignements optiques et installations des derniers bancs
 - Etude du filtrage avec le faisceau Virgo
 - Participation aux tests et installations du système DET
- 1er Run Ad. Virgo prévu en 2016

Merci

