Lasers

M. Turconi

From 2nd to 3rd generation of GW detectors

Lasers

	ET- LF	ET-HF	AdV+ Phase 1
Longueur bras	10 km	10 km	3 km
Puissance entrée	3 W	500 W	25-40 W
Longueur d'onde	1550 nm?	1064 nm	1064 nm
Matériau mirroir	Silicium?	silice	Silice
Diamètre mirroirs	45 cm	62 cm	35 cm
Niveau de squeezing	10 dB	10 dB	4.5 dB

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ET Design Report ET-0007A-20

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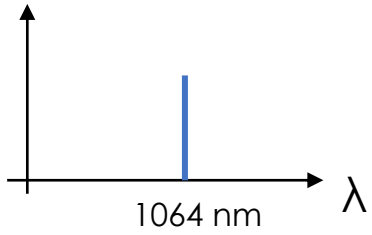
This presentation

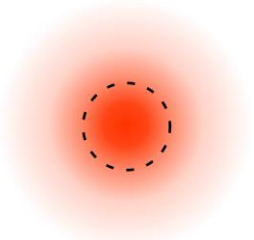
ET Design Report ET-0007A-20

Not just a High-Power Laser

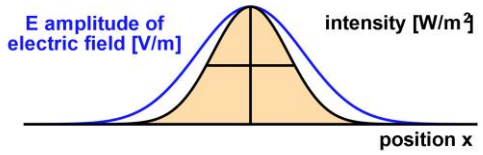
- Continuous wave (CW), low power noise.
- Single-frequency.



- Linearly-polarized Gaussian mode.

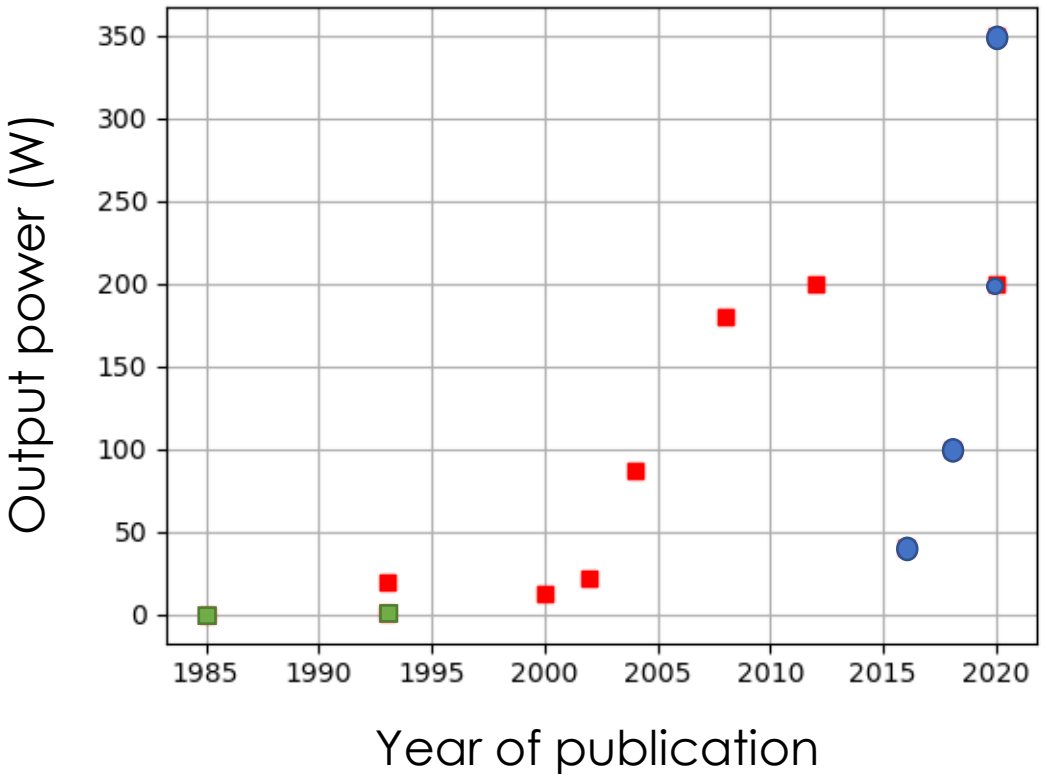


TEM_{00}



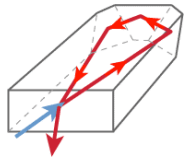
- Long term stability (power and pointing).

Evolution of Laser Power



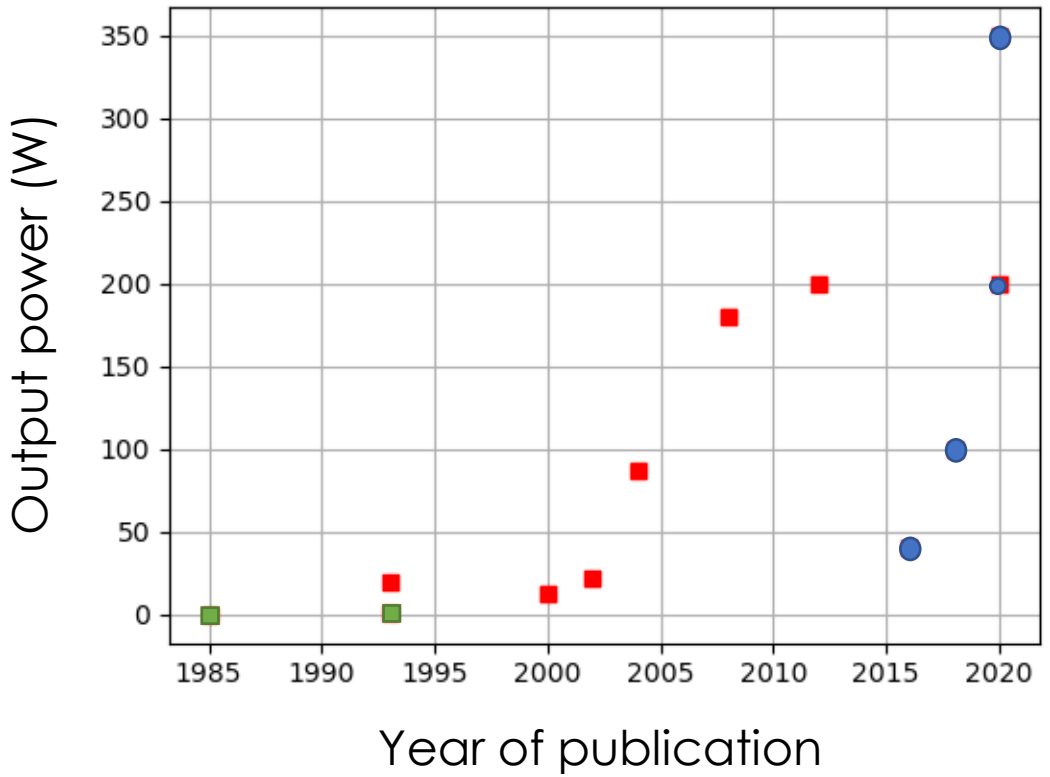
Evolution of Laser Power

- Non Planar Ring Oscillators (NPRO)



Nd:YAG 1064 nm

- Injection-locking schemes with NPRO as master
or
NPRO-seeded solid-state amplifiers



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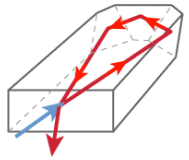

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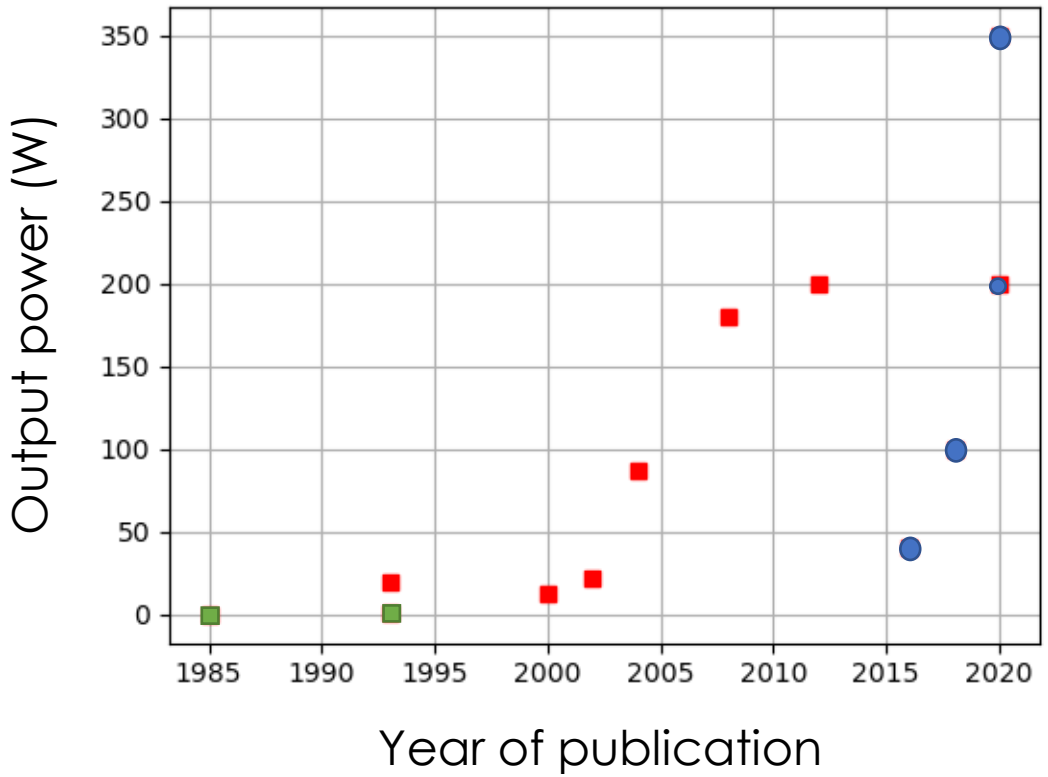
- Fiber amplifiers



C. Dixneuf et al. Optics Express 28,8 (2020)
Bordeaux, France

F. Wellmann et al. Appl. Optics 59,26 (2020)
Hannover, Germany

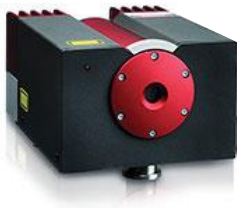
J. Zhao et al. Appl. Phys. (2018)
Bordeaux+ Nice , France

L. Wei et al. Optics Lett. 41, 24 (2016)
Nice, france

High-Power Fiber Amplifier for AdV+

AZURLIGHT SYSTEMS

NPRO



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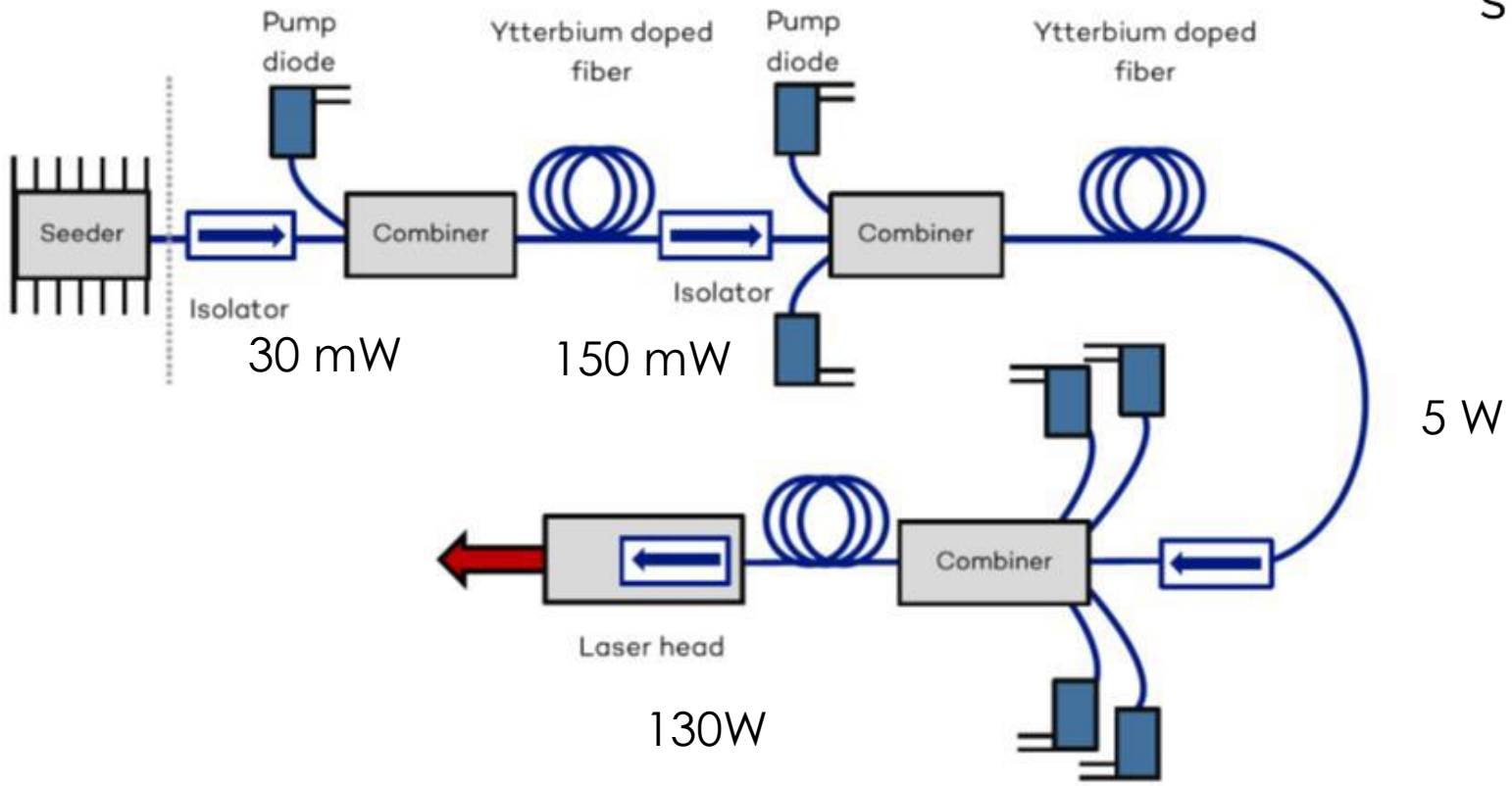
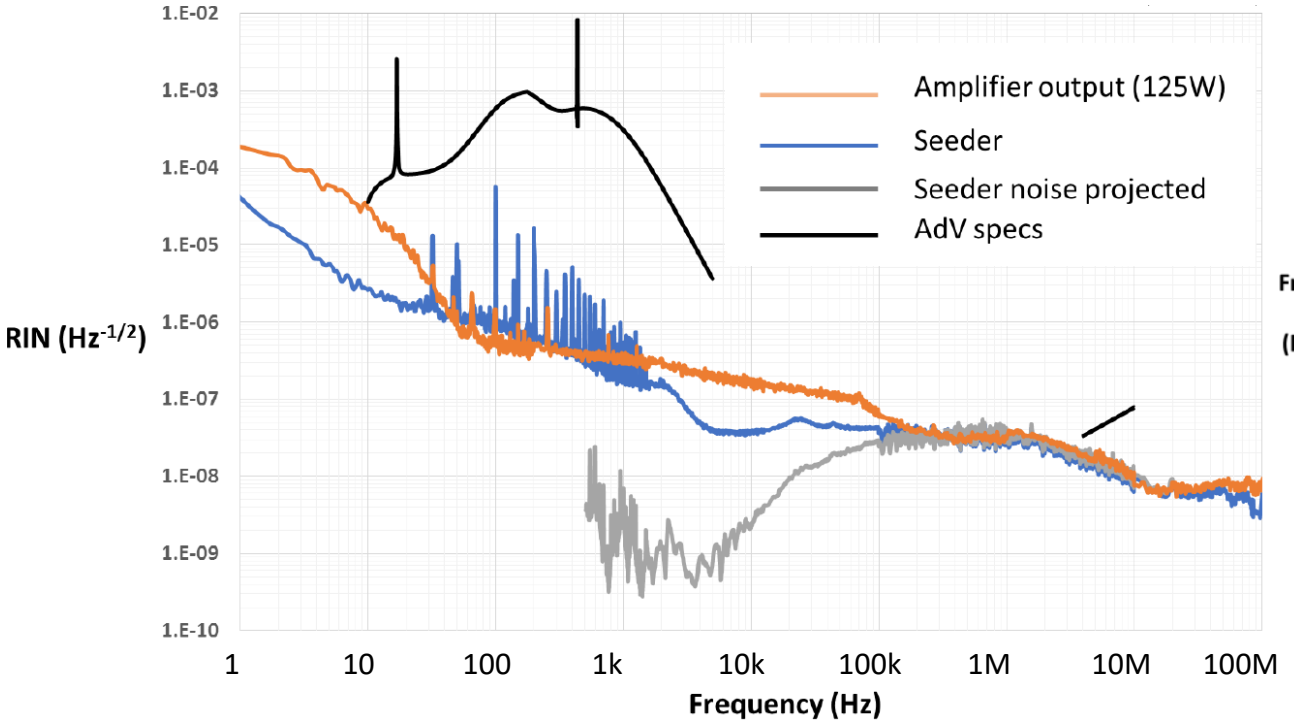


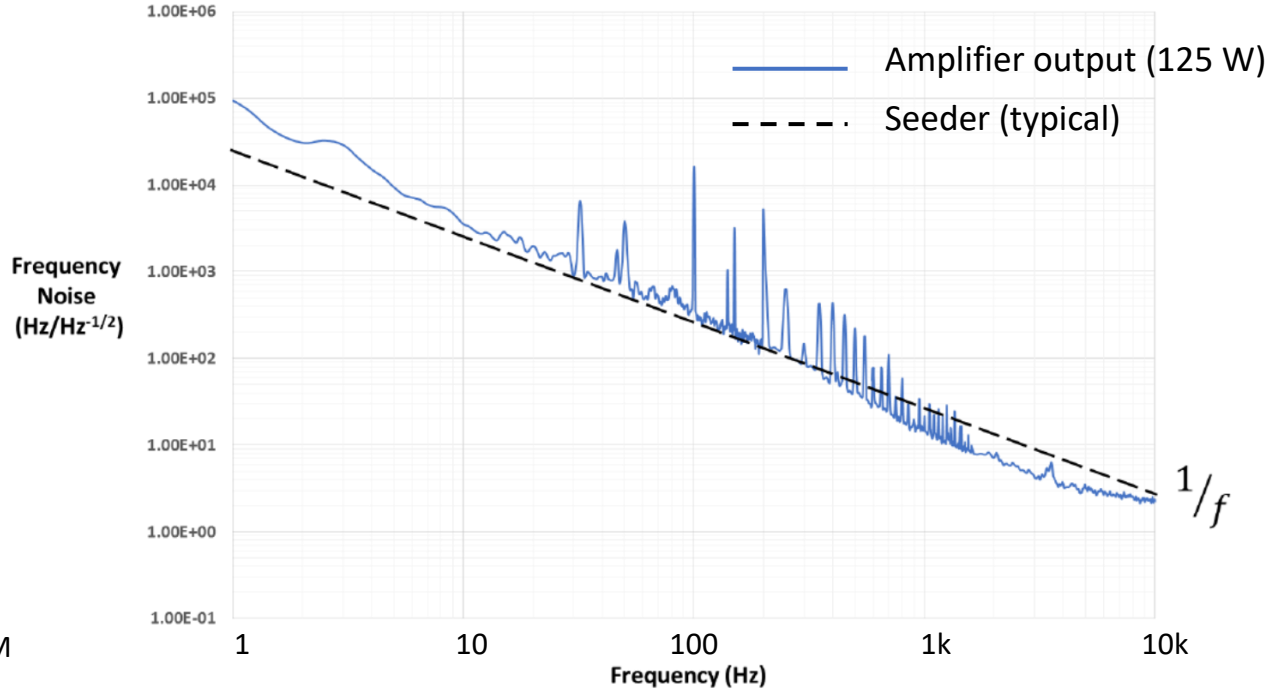
- The same fiber has been tested at 350 W [C. Dixneuf et al. Optics Express 28, 8 (2020)]

Laser characterisation

Relative Intensity noise (RIN)

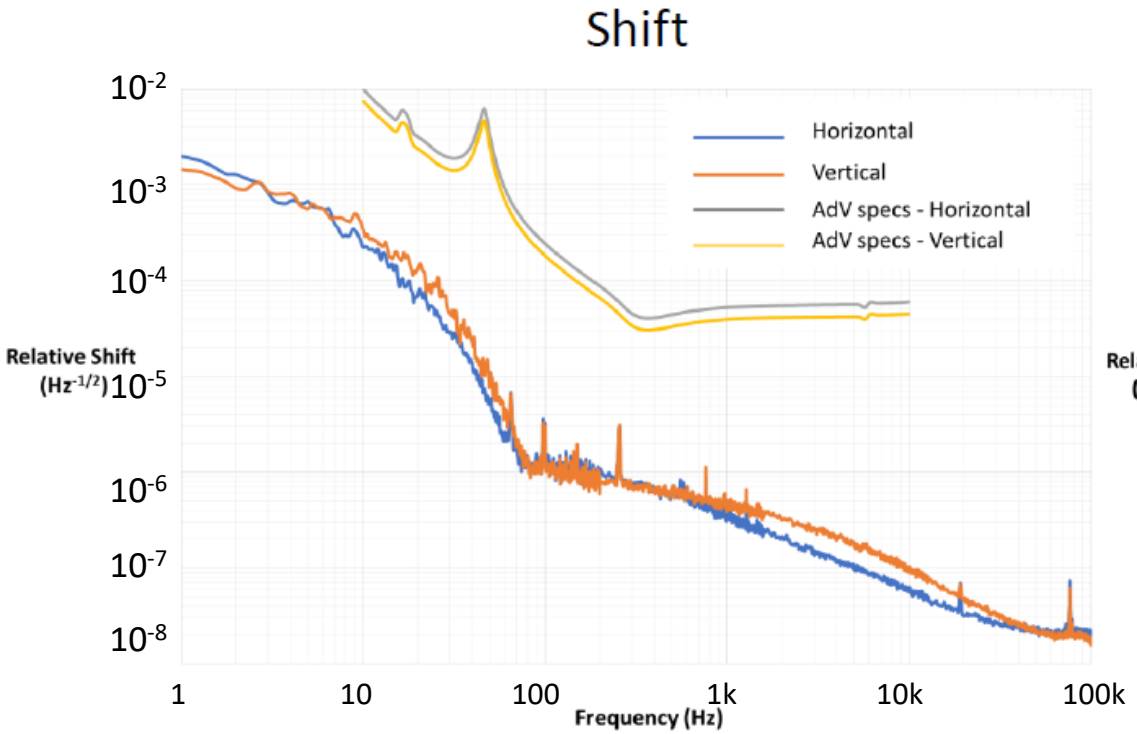


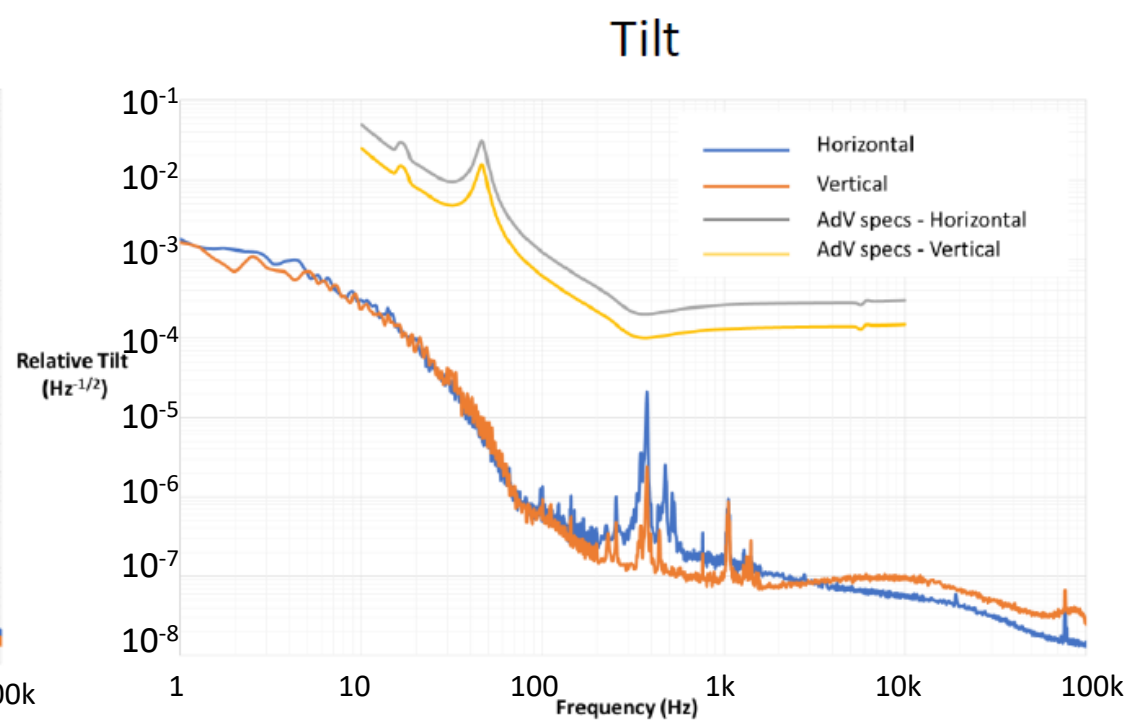
Frequency noise



Laser characterisation

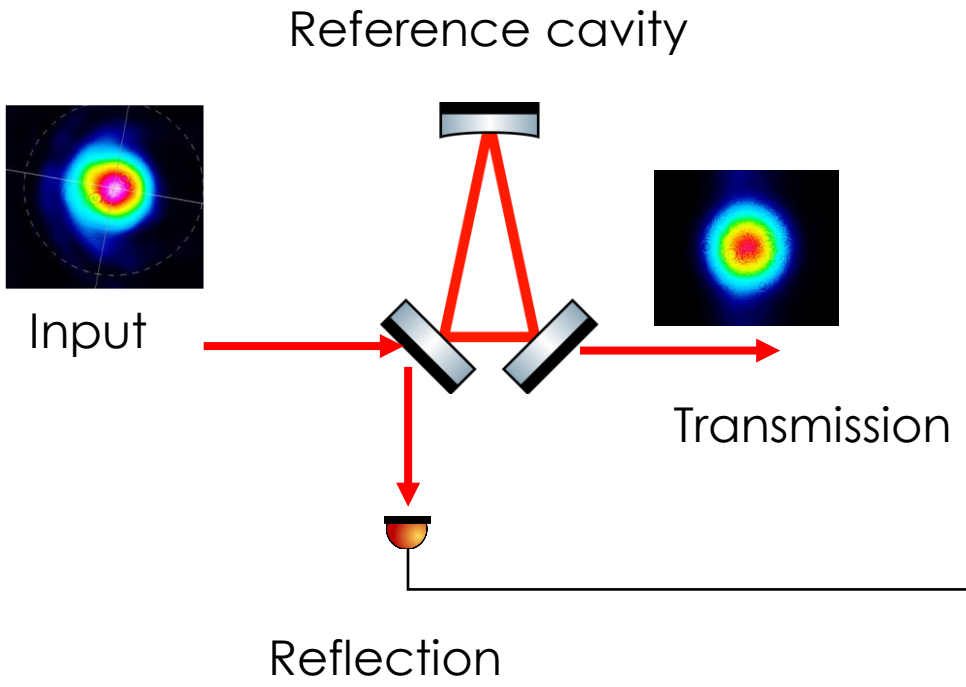
Beam pointing

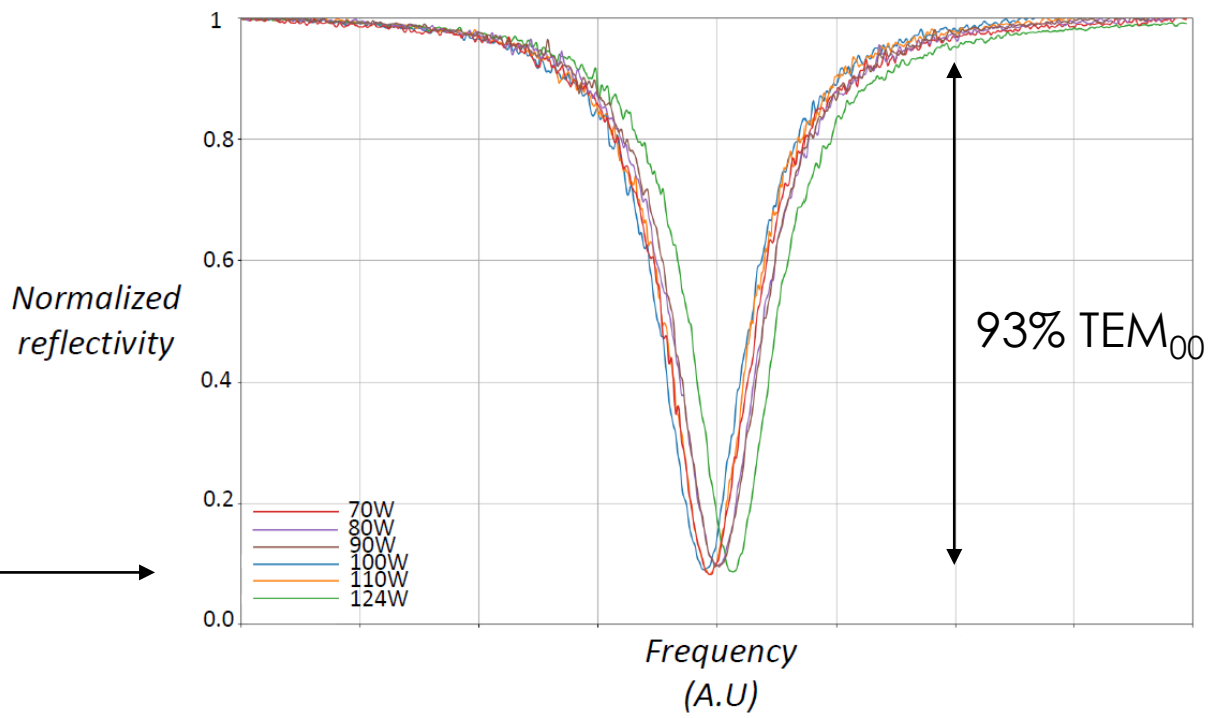




Laser characterisation

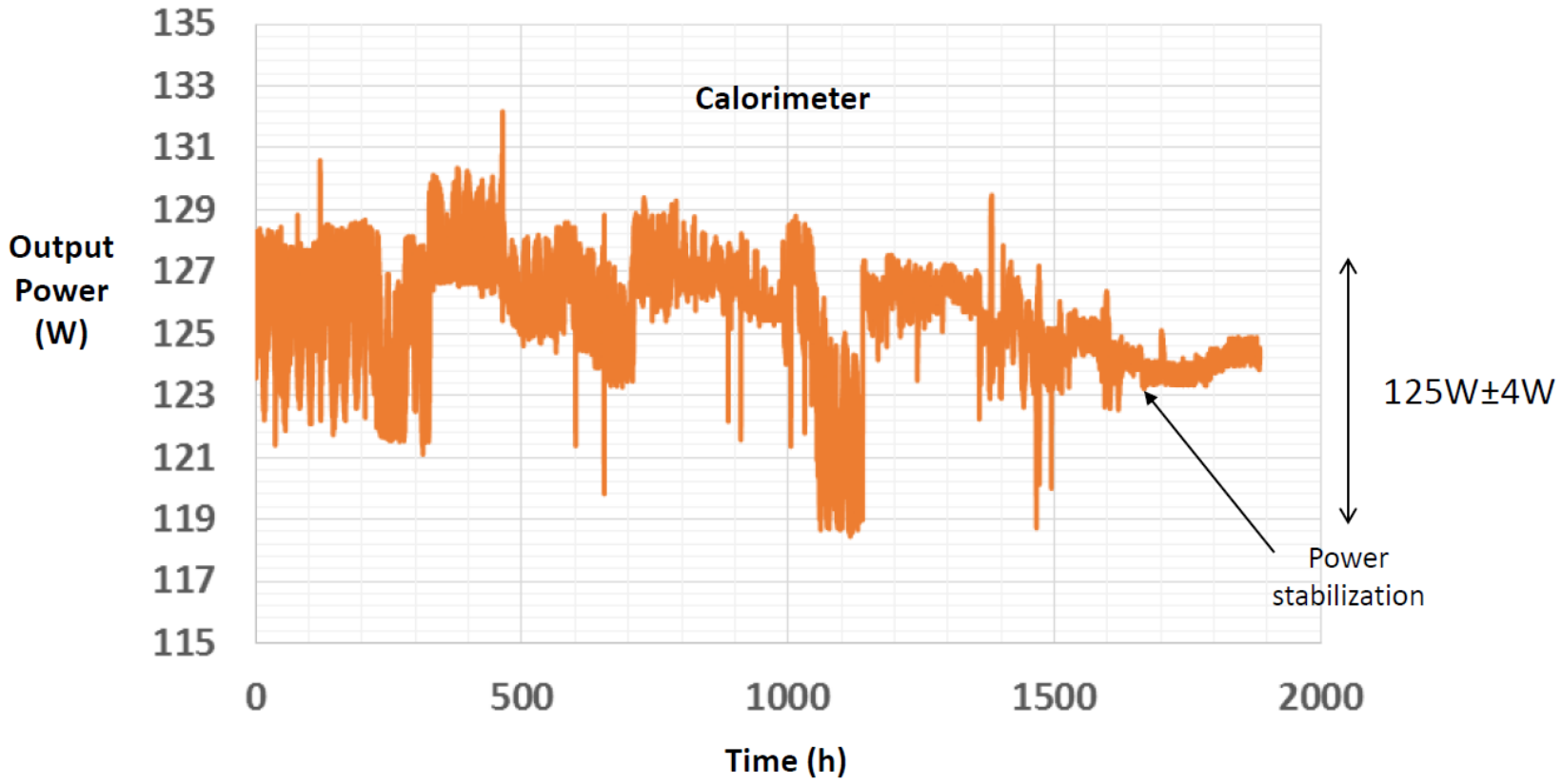
Beam quality



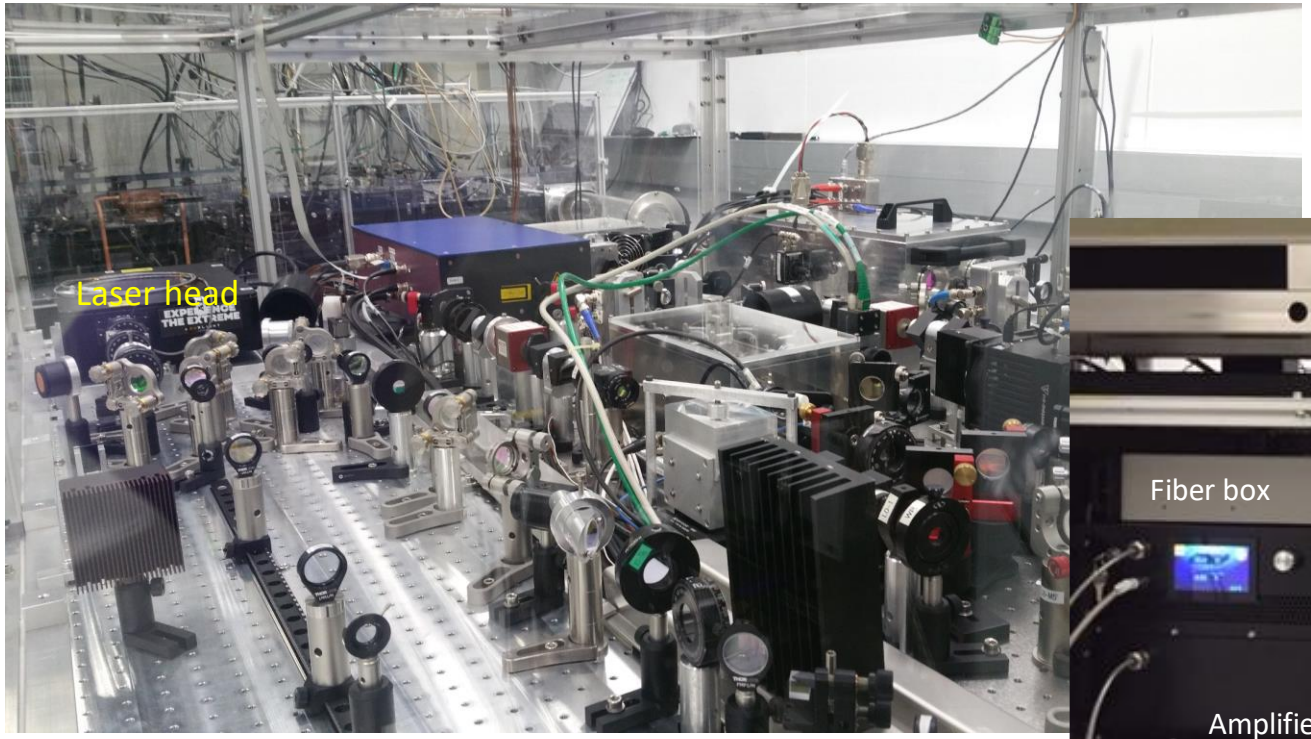


Laser characterisation

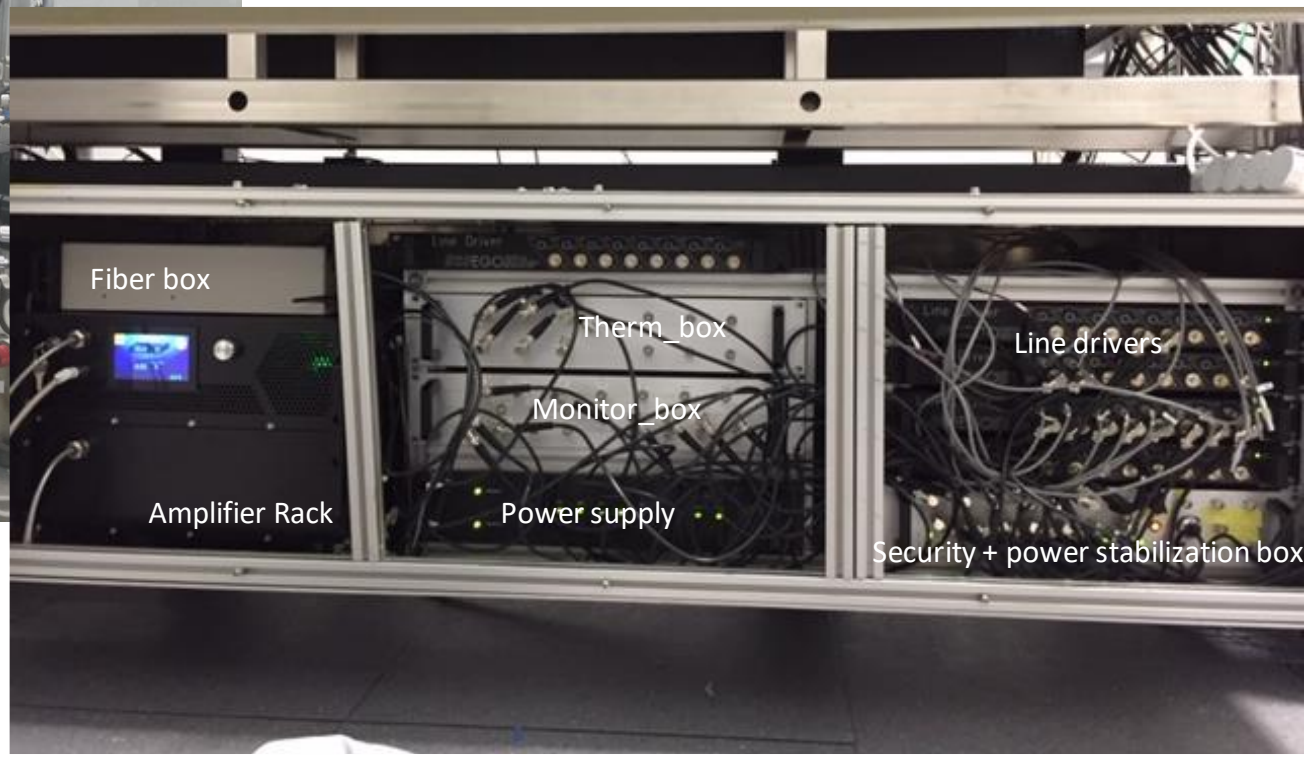
Long term behaviour



First Fiber Amplifier in a GW detector



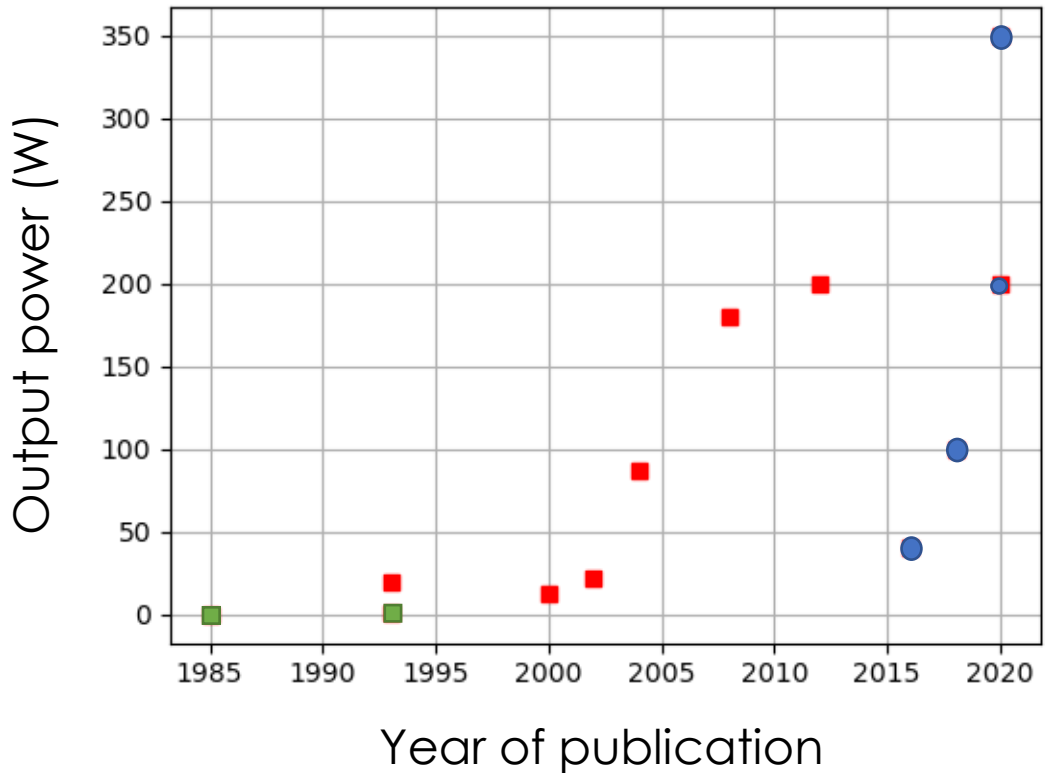
Installation: August-Septembre 2020



Walid Chaibi
Rémi Soulard
Jean-Pierre Coulon
Mourad Merzougui
Margherita Turconi

How to reach 700 W for ET-HF?

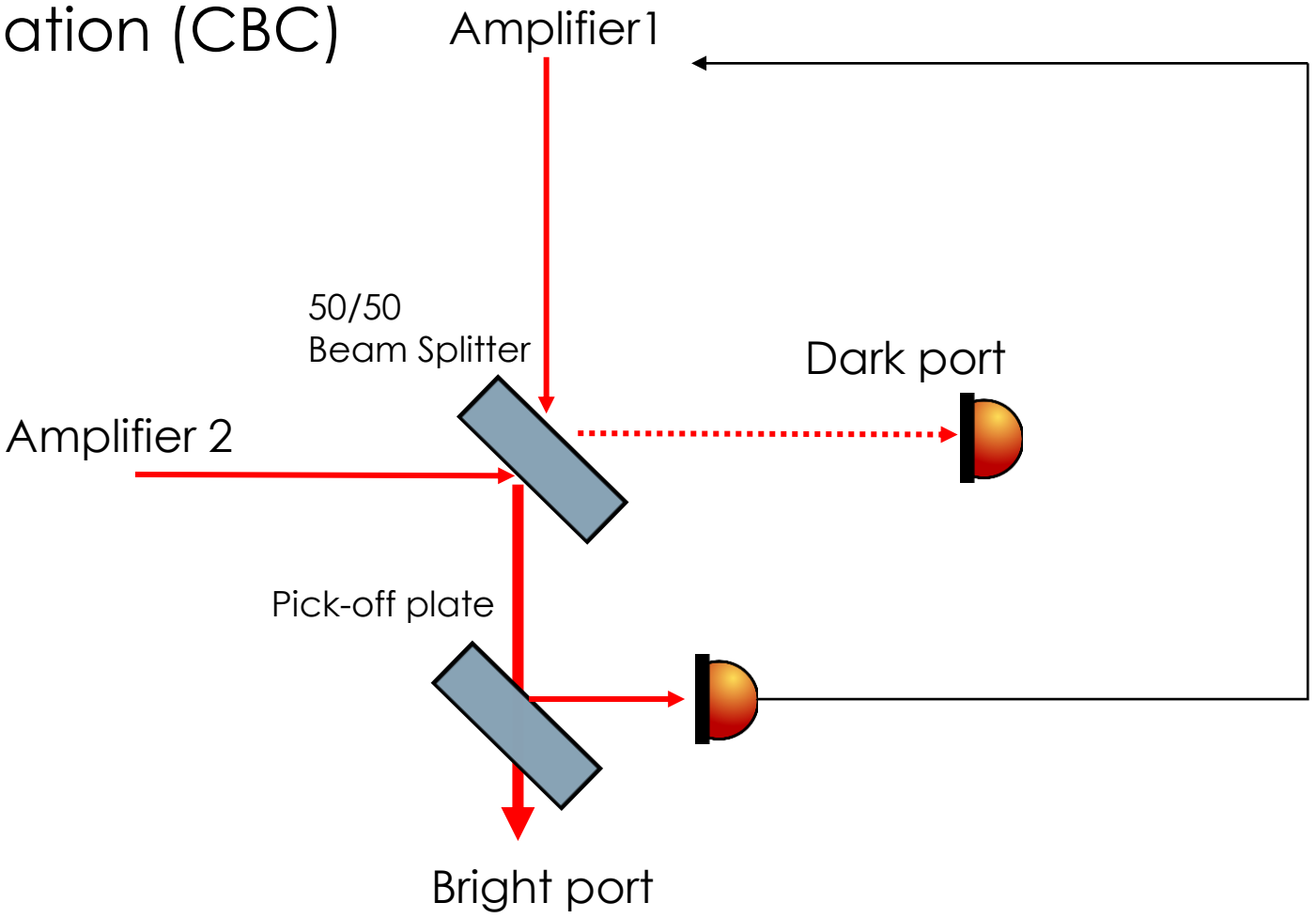
Can fiber-amplifier technology double the output power keeping the stability requirements? When?



How to reach 700 W for ET-HF?

Coherent Beam Combination (CBC)

- Mach-Zehnder interferometer
- Phase of Amplifier 1 wave is adjusted to have constructive interference on the bright port



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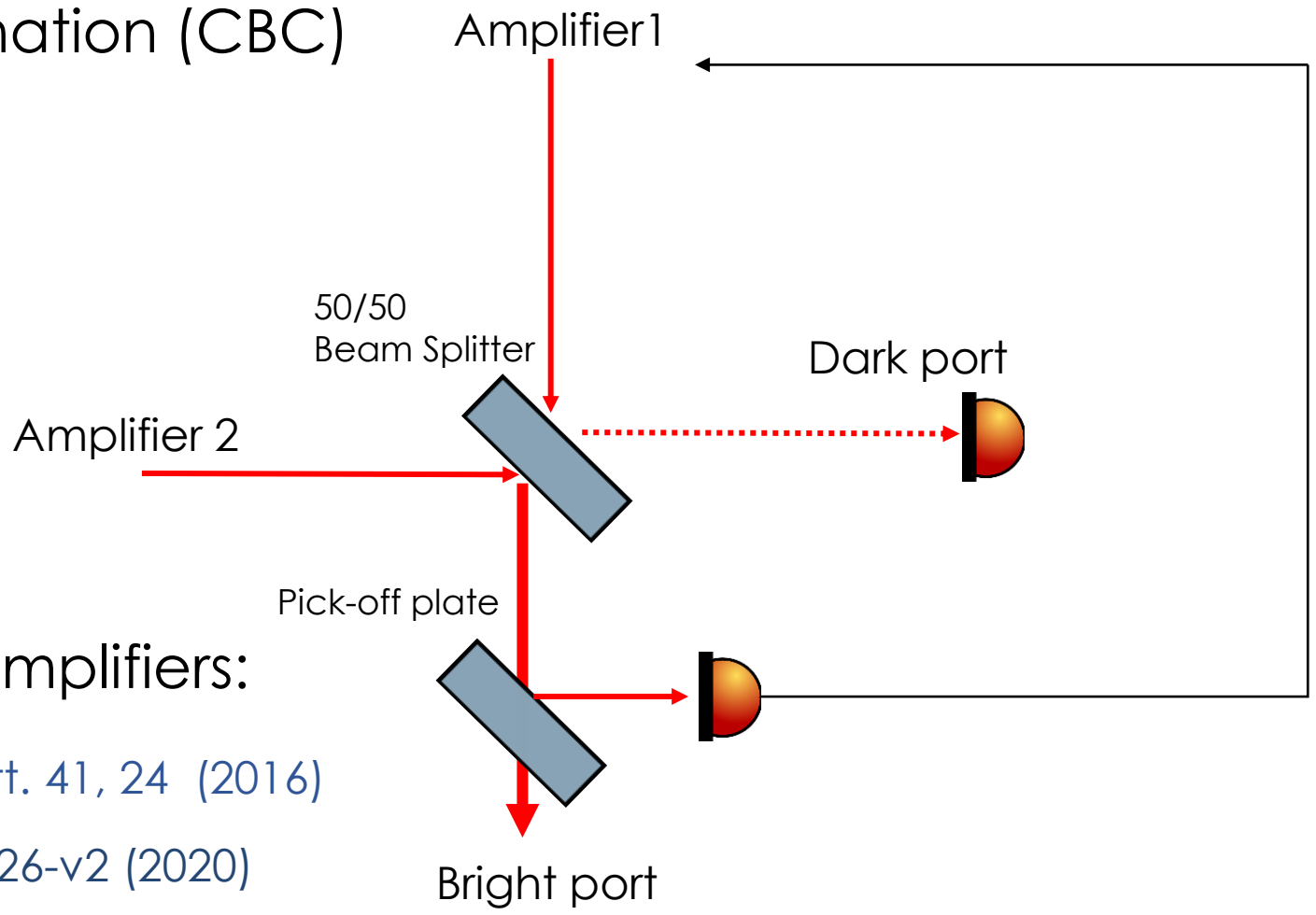
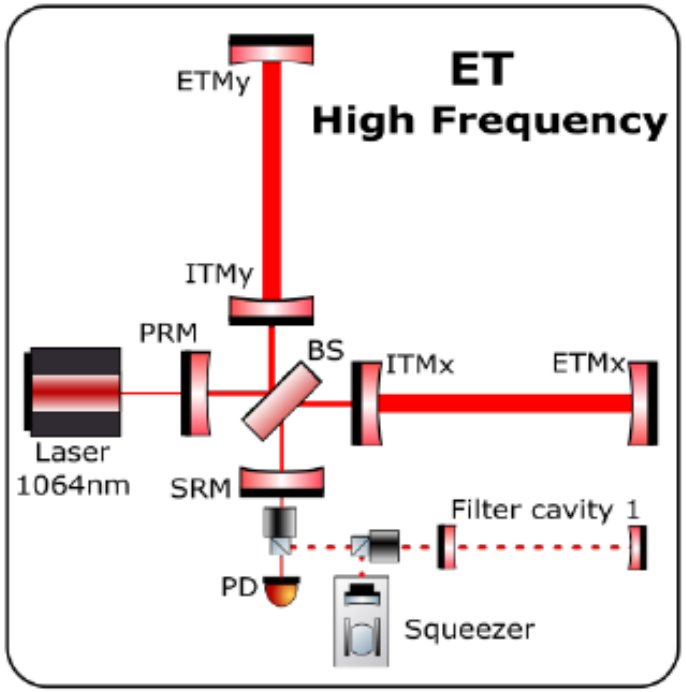


Promising results with fiber amplifiers:

- 40 W+ 40 W : L. Wei et al. Optics Lett. 41, 24 (2016)
- 200 W+ 200 W : LIGO-DCC: G2001526-v2 (2020)

Prestabilization



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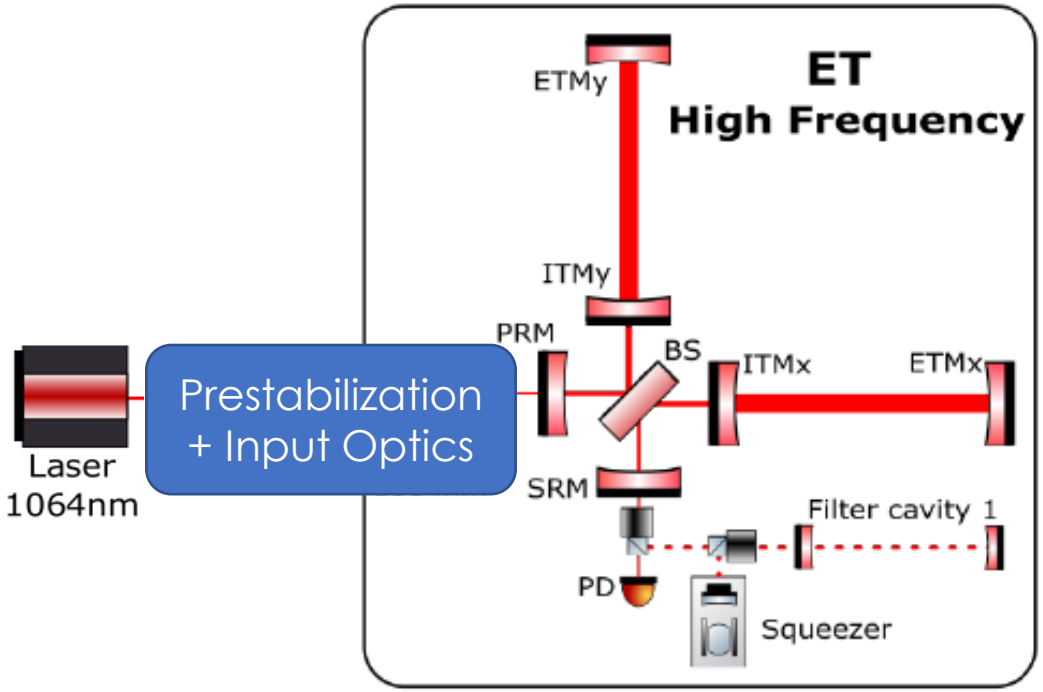

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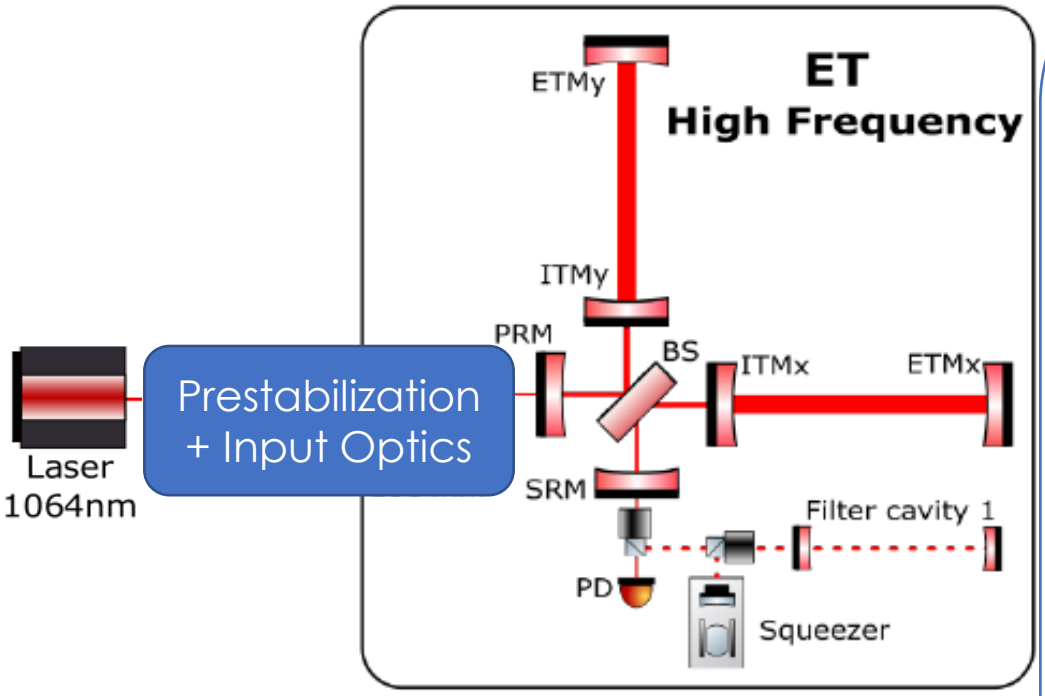
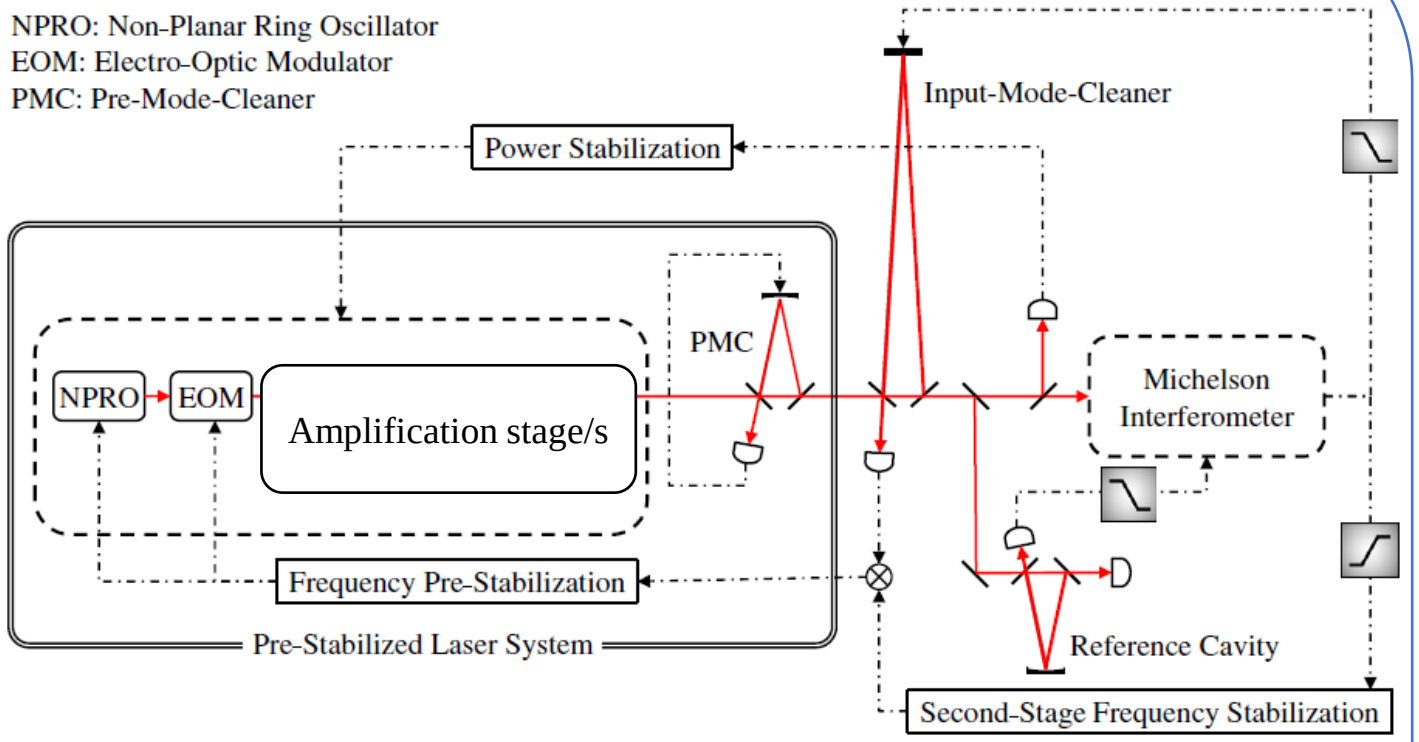


AdV scheme with laser stabilisation



Adapted from L. Wei et al. Optics Lett. 41, 24 (2016)

Summary

- ET-HF is very similar to 2nd generation detectors → same laser prestabilization scheme.
- Fiber based master-oscillator power-amplifiers are privileged choice for ET-HF
- ARTEMIS laboratory has installed the first fiber amplifier at 130 W on VIRGO (AdV+) last summer.

  → promising results on a single amplifiers and on coherent beam combination

- ET-LF wavelength must be fixed, different technologies are available. 1550 nm fiber laser is the most spread.

- WP II.3 Lasers is forming a working group to define the prestabilized laser requirements and technical design.