Charactérisation des dérives long terme et référencement de l'oscillateur photonique à auto-affinement Brillouin

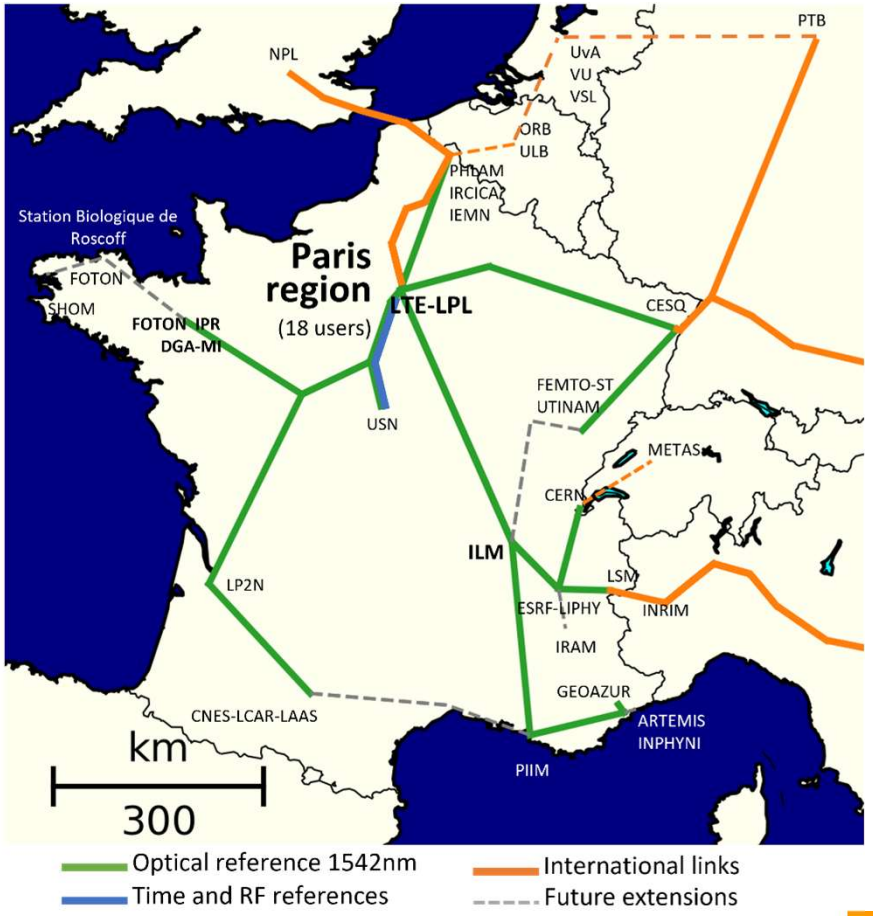
Adèle Hilico[1], Elisa Jarry[2], Etienne Cantin[1], Christian Chardonnet[1], Anne Amy-Klein[1], Pierre Brochard[3], Louis Alliot de Borggraef[3], Marc Vallet[2], Mehdi Alouini[2]

[1]Laboratoire de Physique des Lasers (Villetaneuse)

[2]Institut FOTON (Rennes)

[3]Silentsys

REFIMEVE Network



10,000 km long network dedicated to metrological optical frequency transfert

- Utilisation of French public **RENATER fiber network**
- International connections to England, Germany, Italy

→ **Disseminates** time and frequency references to users (35 labs & 1 company)
  - Central frequency guaranteed at a relative stability of 10^{-15}

→ **Compares Time & Frequency references** across Europe
  - long term frequency transfer at the 10^{-18} level, not limited by the link

⇨**By compensating the noises impacting the fibers**
⇨ **Compensation bandwidth limited (typically 100 Hz for a 100 km link)**
⇨ **Short term spectral purity ("linewidth") is degraded, reaching up to 6.2 kHz at 40 ms in Marseille. Limiting for some applications**

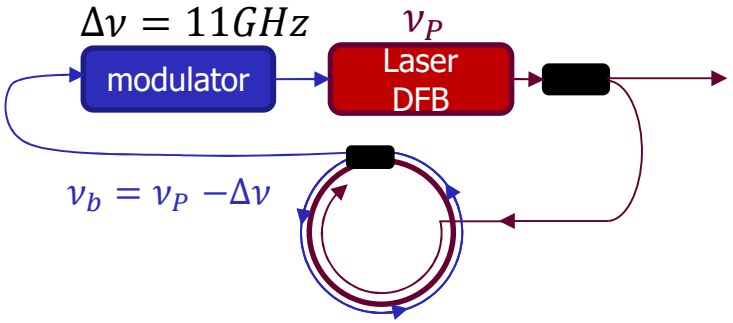
Mathieu Collombon, Etienne Cantin, Gaëtan Hagel, Paul Eric Pottie, Marie Houssin and Caroline Champenois, J. Opt. Soc. Am. B 42, 2429-2435 (2025)

REFIMEVE, spectral purity regeneration

- Laser locked on ultrastable cavities to regenerate the signal.
  - 3 will be installed (Bordeaux, Grenoble, Nice)
    - Ultra low frequency noise 😀
    - Low drift 😀
    - Expensive 😟
    - Bulky 😟
    - Maintained under vacuum 😟

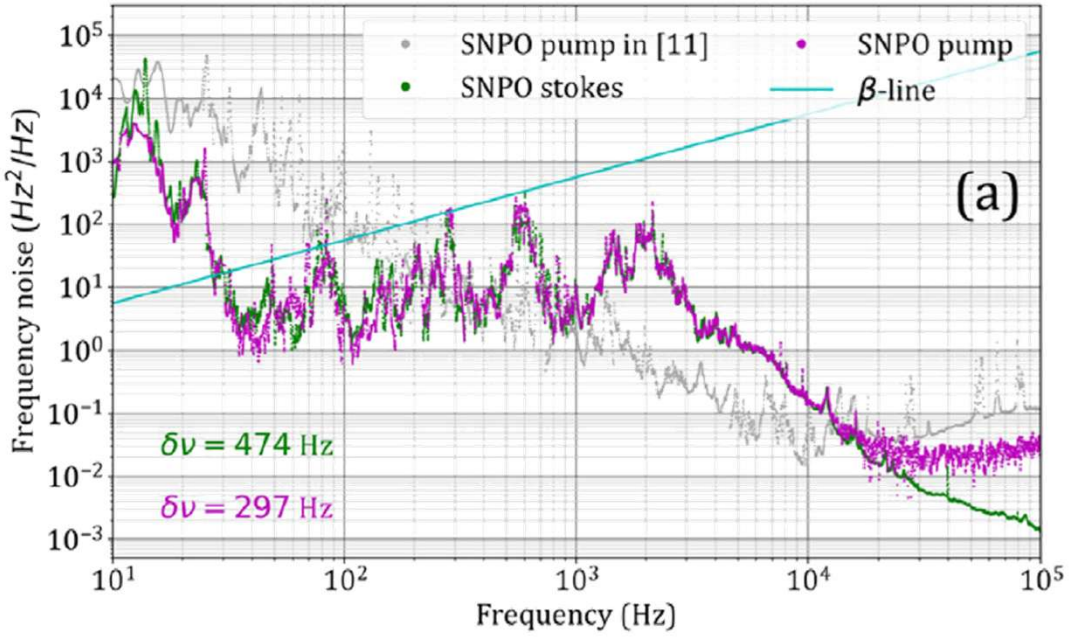
REFIMEVE, spectral purity regeneration

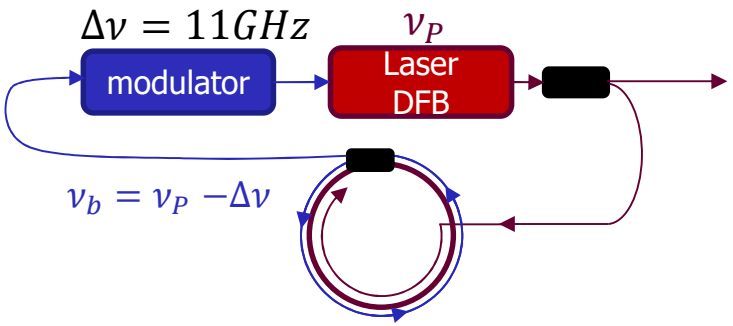
- Laser locked on ultrastable cavities to regenerate the signal.
  - 3 of them will be installed (Bordeaux, Grenoble & Nice)
    - Ultra low frequency noise 😀
    - Low drift 😀
    - Expensive 😟
    - Bulky 😟
    - Maintained under vacuum 😟
- Study an alternative
  - ⇒ Self Narrowing Photonic Oscillator based on Brillouin effect
    - Developed at institut FOTON
    - Showed a low frequency noise
    - No servo locking, optical injection



REFIMEVE, spectral purity regeneration

- Laser locked on ultrastable cavities to regenerate the signal.
  - 3 will be installed (Bordeaux, Grenoble, Nice)
    - Ultra low frequency noise 😀
    - Low drift 😀
    - Expensive 😵
    - Bulky 😵
    - Bulky 😵
    - Maintained under vacuum 😵
- Study an alternative
  ⇒ Self Narrowing Photonic Oscillator based on Brillouin effect





Mehdi Alouini, Gwennaël Danion, and Marc Vallet, Opt. Express **33**, 1021-1033 (2025)

Elisa Jarry, Gwennael Danion, Marc Vallet, and Mehdi Alouini, Applied Opt. 65, 8229 (2026)

Self heterodyne measurement ⇒ Possible drift
⇒ Need for long term characterisation

Slimliner

SNPO prototype

- Transportable
- 2.5mW
- Sensitive to environment change

SILENTSYS
ultralow noise systems



Slimliner

- Compact packaging
- Robust
- 10mW
- mK thermal control

Slimliner

SNPO prototype

- Transportable
- 2.5mW
- Sensitive to environment change



Slimliner

- Compact packaging
- Robust
- 10mW
- mK thermal control

metrological characterisation

LPL Laboratoire de physique des lasers

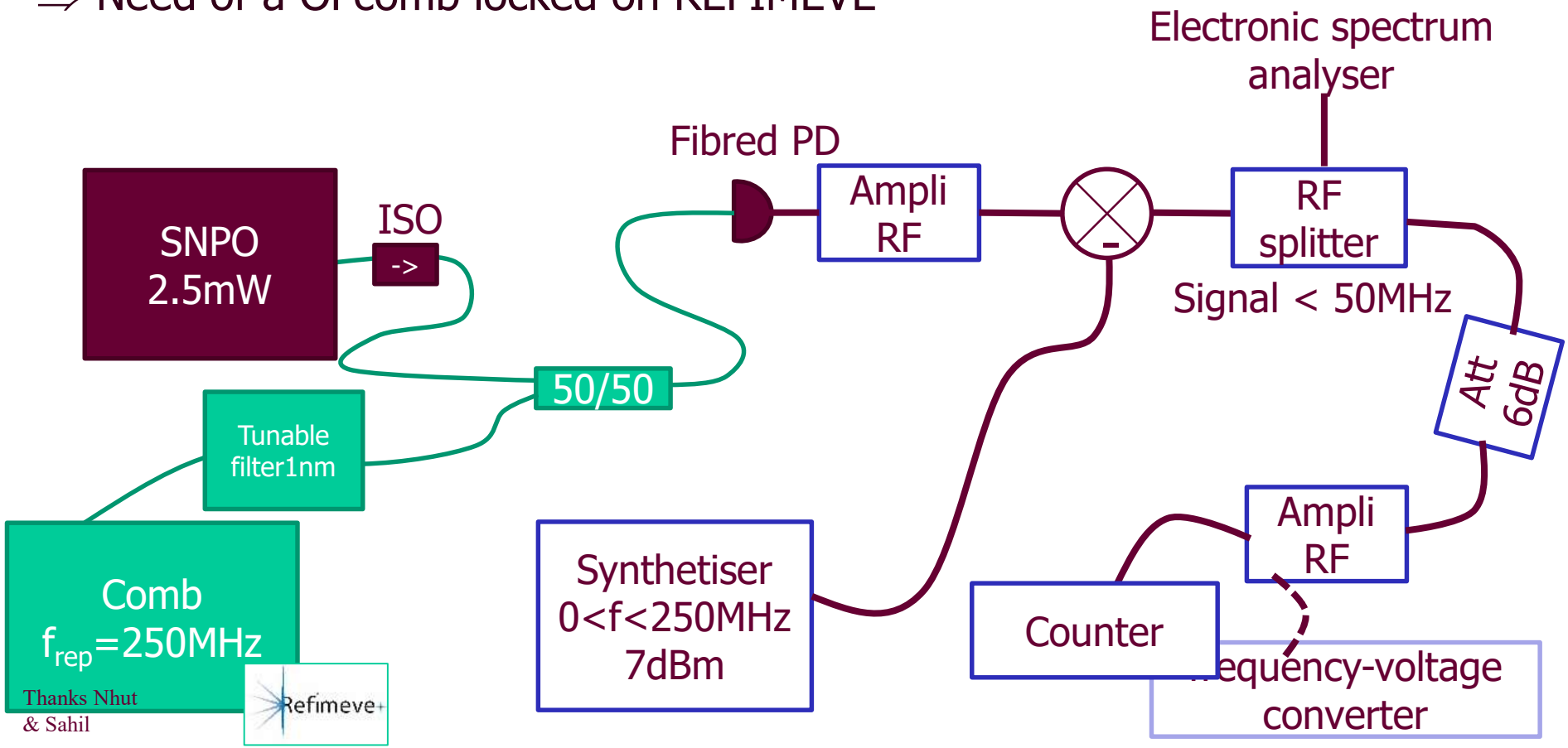
Refimeve+

ultrastable cavities

SNPO at LPL, first test in 2025

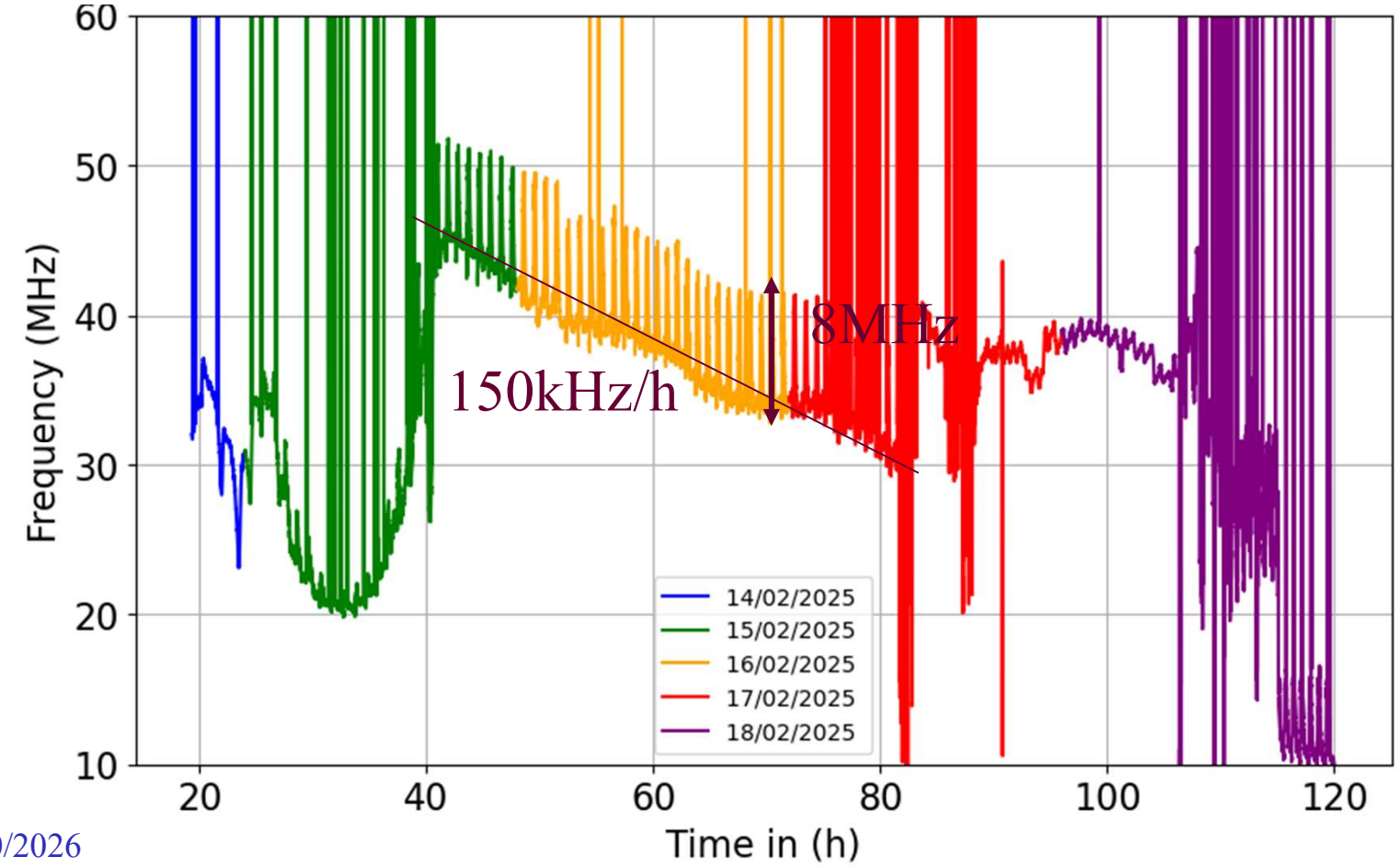
- REFIMEVE not yet implemented at Rennes
- SNPO moved to LPL
- Emission at 1540.438nm whereas REFIMEVE @ 1542.12nm

⇒ Need of a OFcomb locked on REFIMEVE



SNPO at LPL, first test in 2025

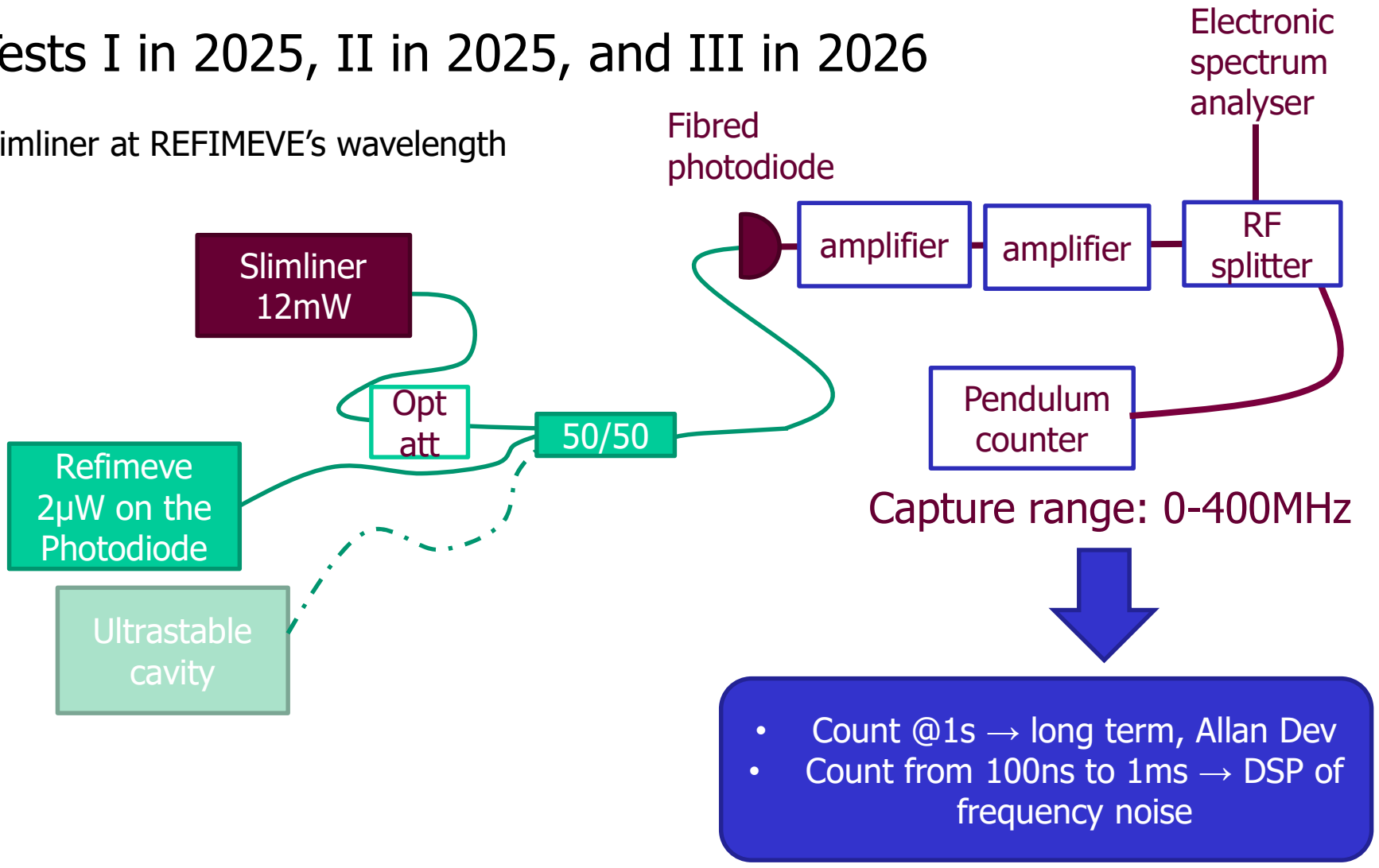
- Several days measurement @ 1s sampling rate
- SNPO sensitive to LPL aircond fluctuations (<10MHz)
- drift 150kHz/h
- Mode hops, laser not stable due to transportation



Slimliner at LPL

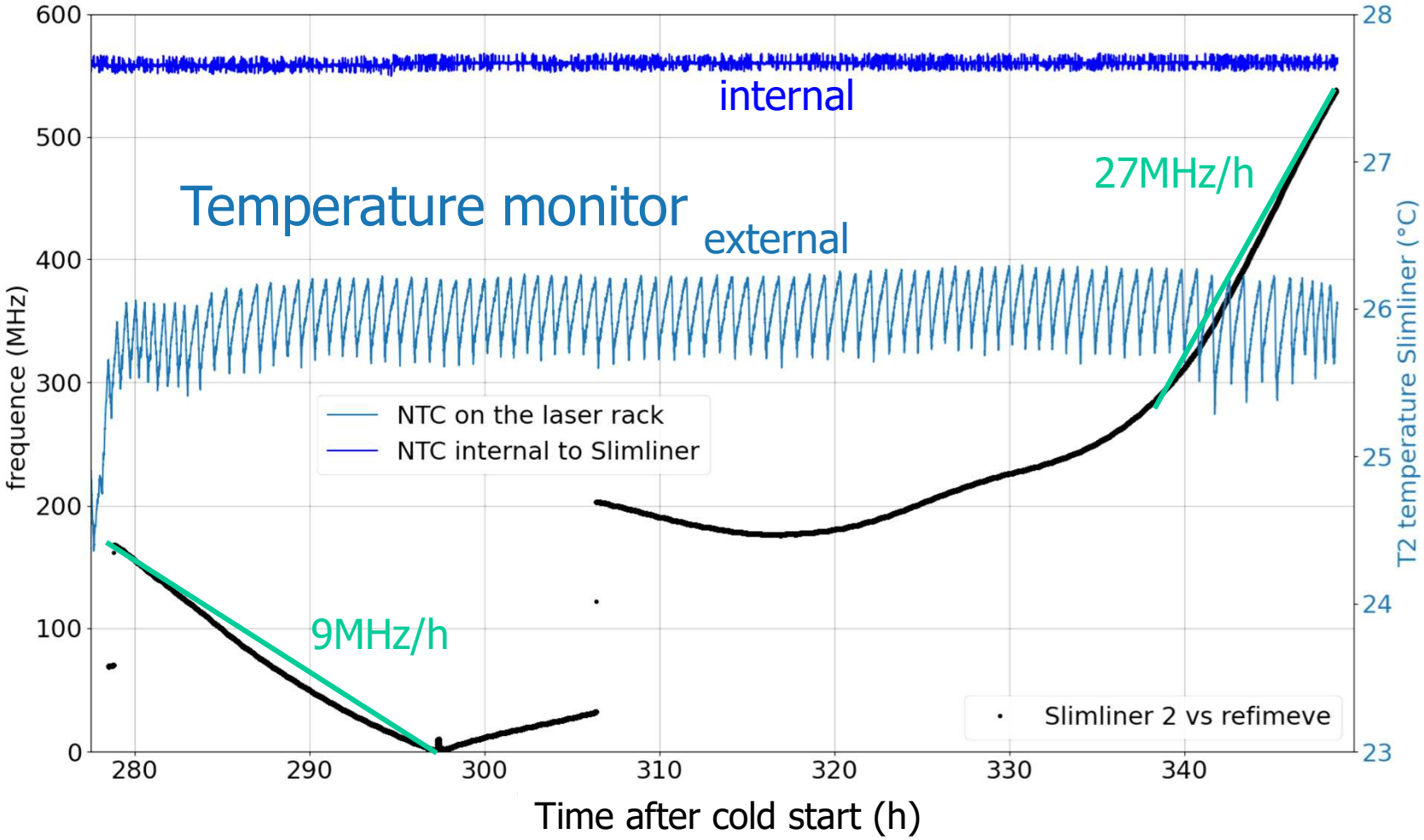
Tests I in 2025, II in 2025, and III in 2026

Slimliner at REFIMEVE's wavelength

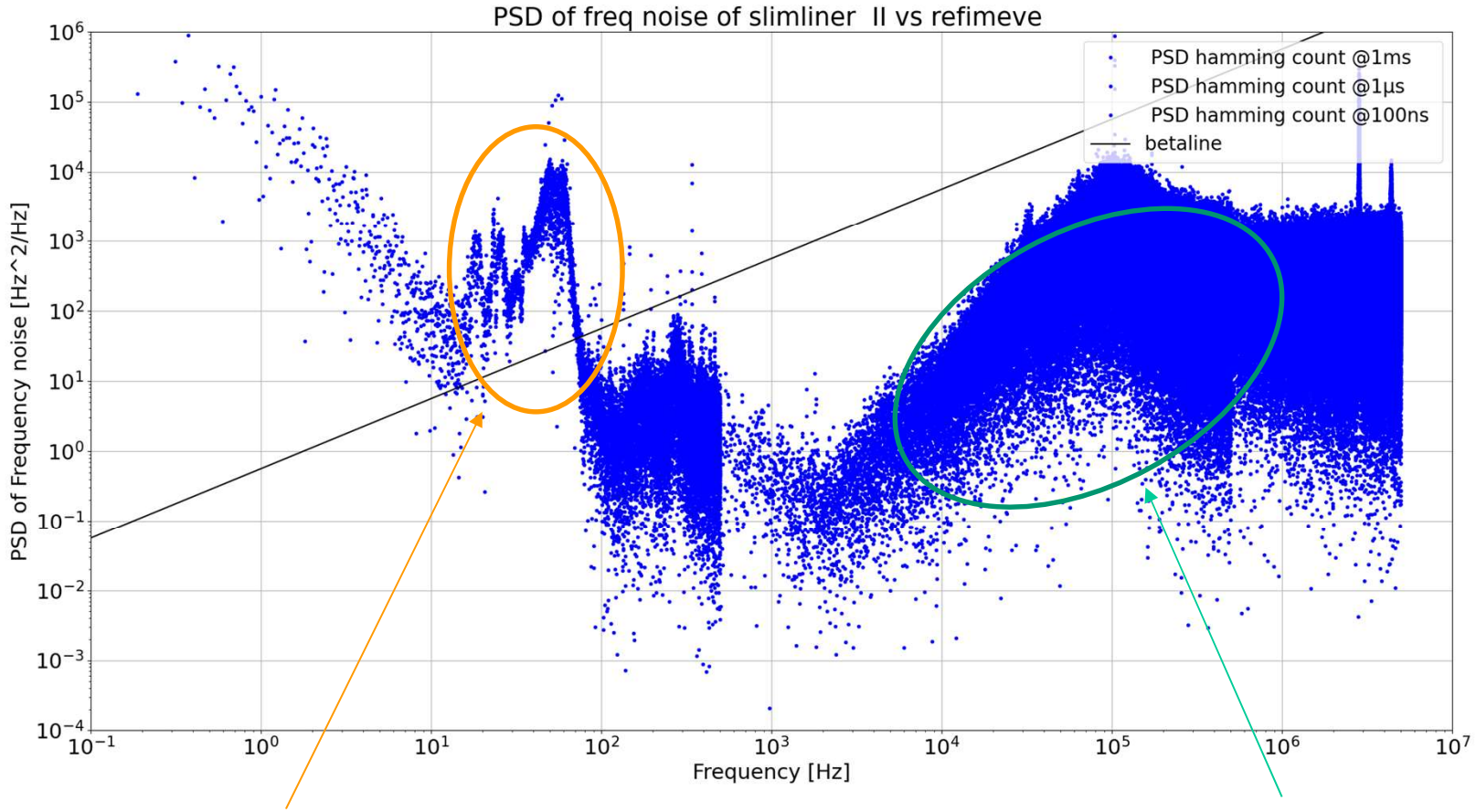


Slimliner II at LPL compared to REFIMEVE

- Problem of unintentional laser cuts
- Modehops



Slimliner II at LPL compared to REFIMEVE

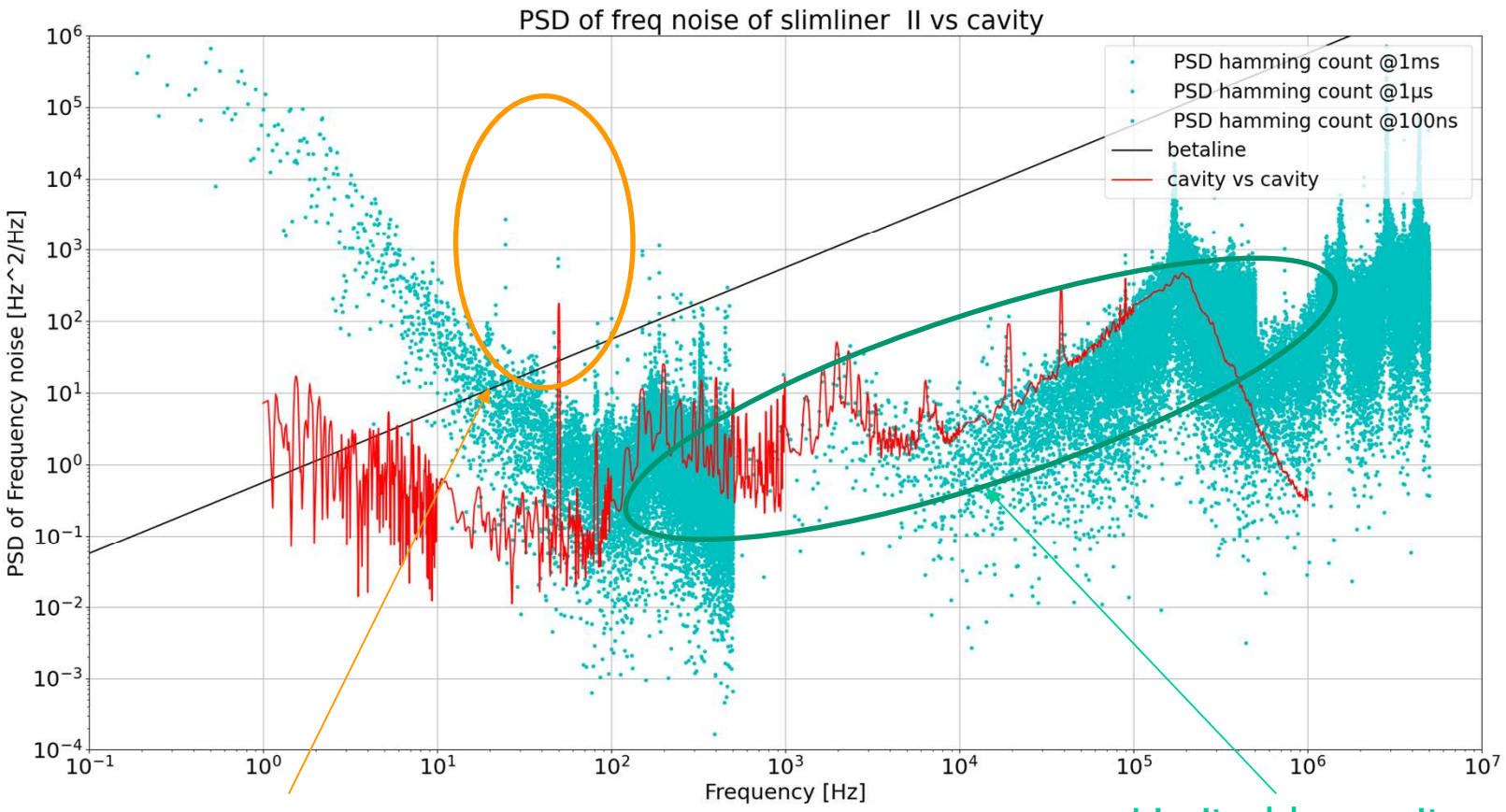


Vibrations in the labroom (2 experiments running on the same optical table)

Due to REFIMEVE lock (laser locked on an ultra stable cavity in Paris Observatory)

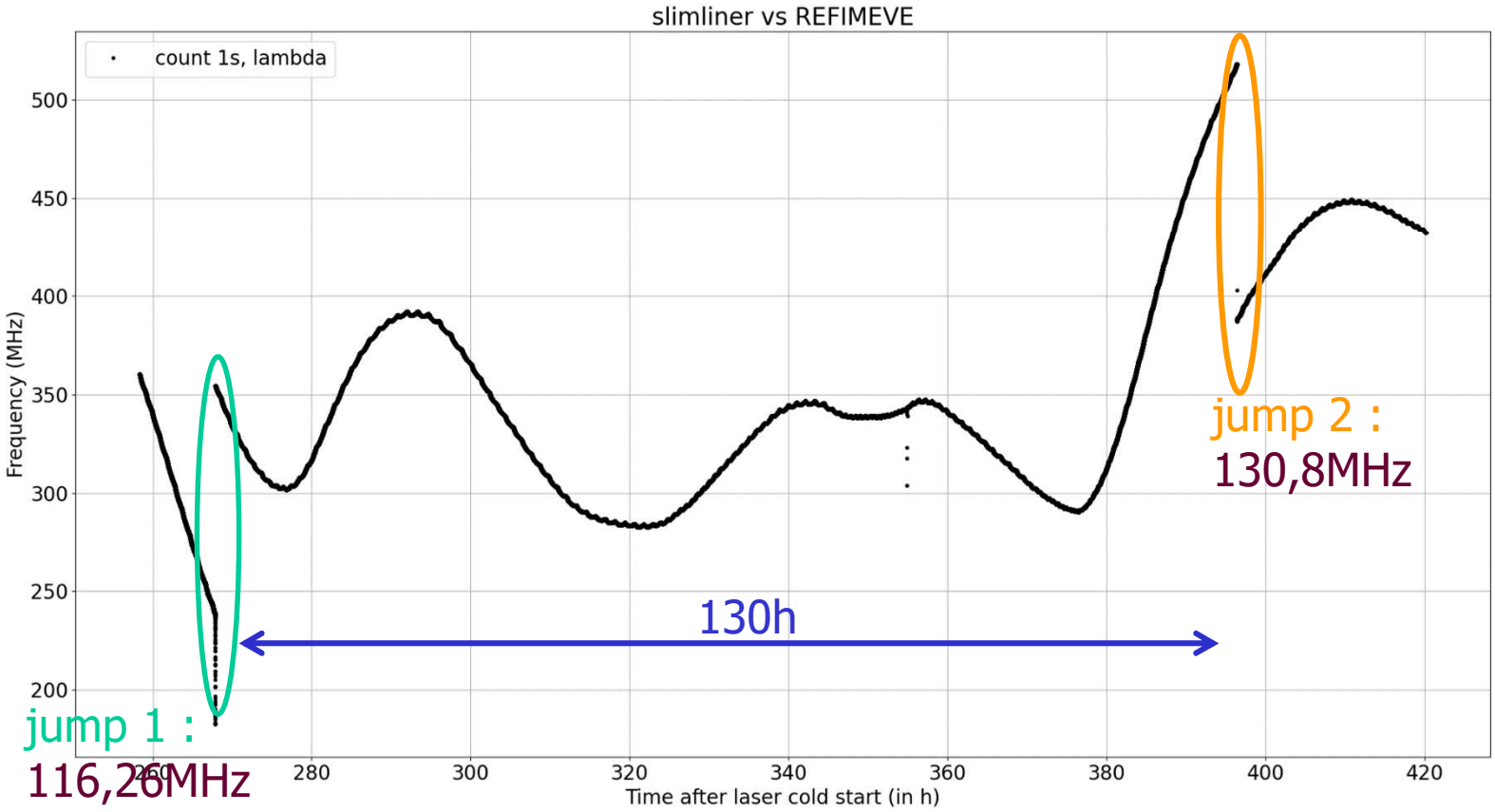
Slimliner II at LPL compared to cavity

laser locked to ULE cavity



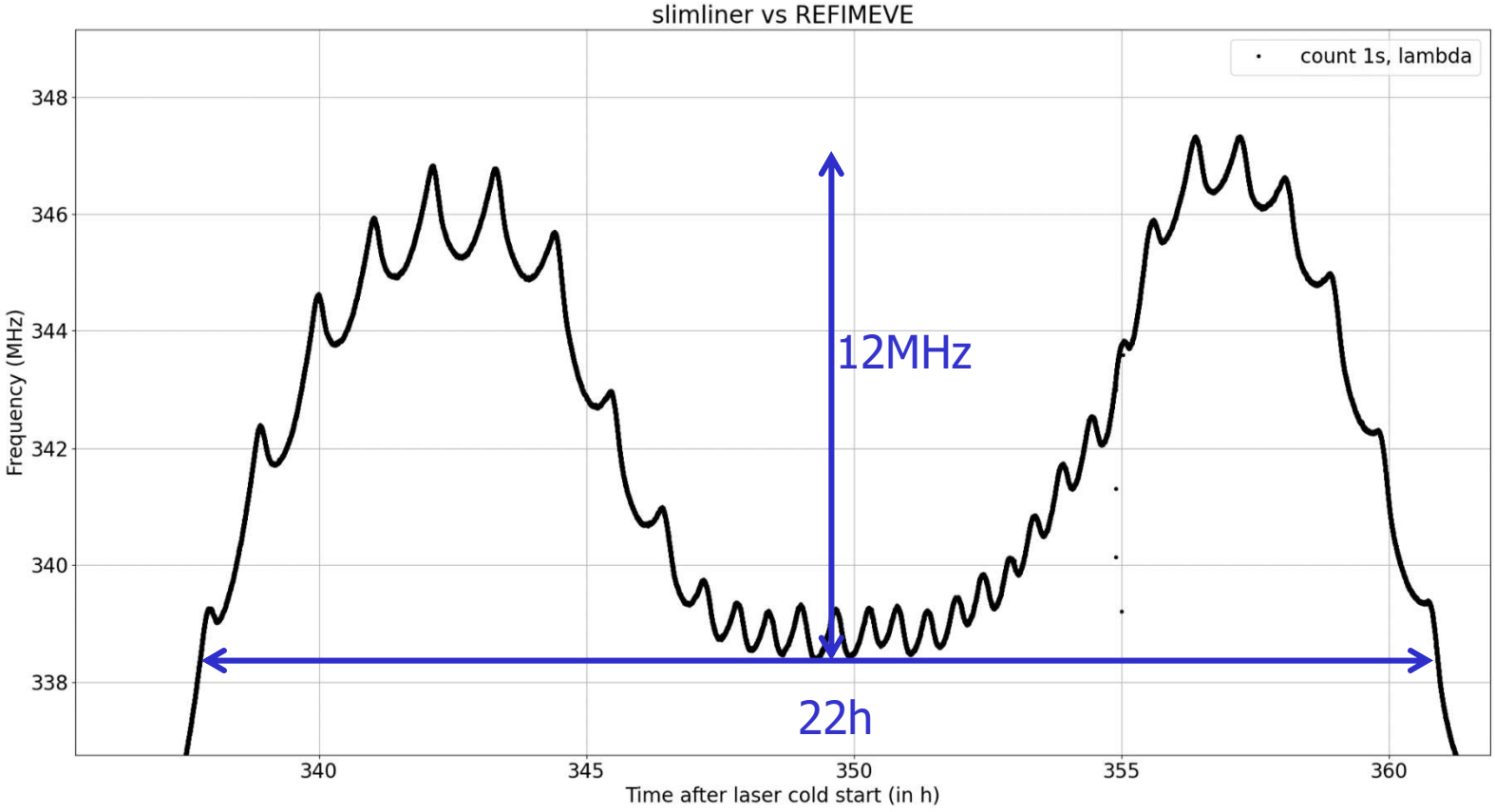
Slimliner III at LPL compared to REFIMEVE

- power cuts issue solved !
- Still modehops



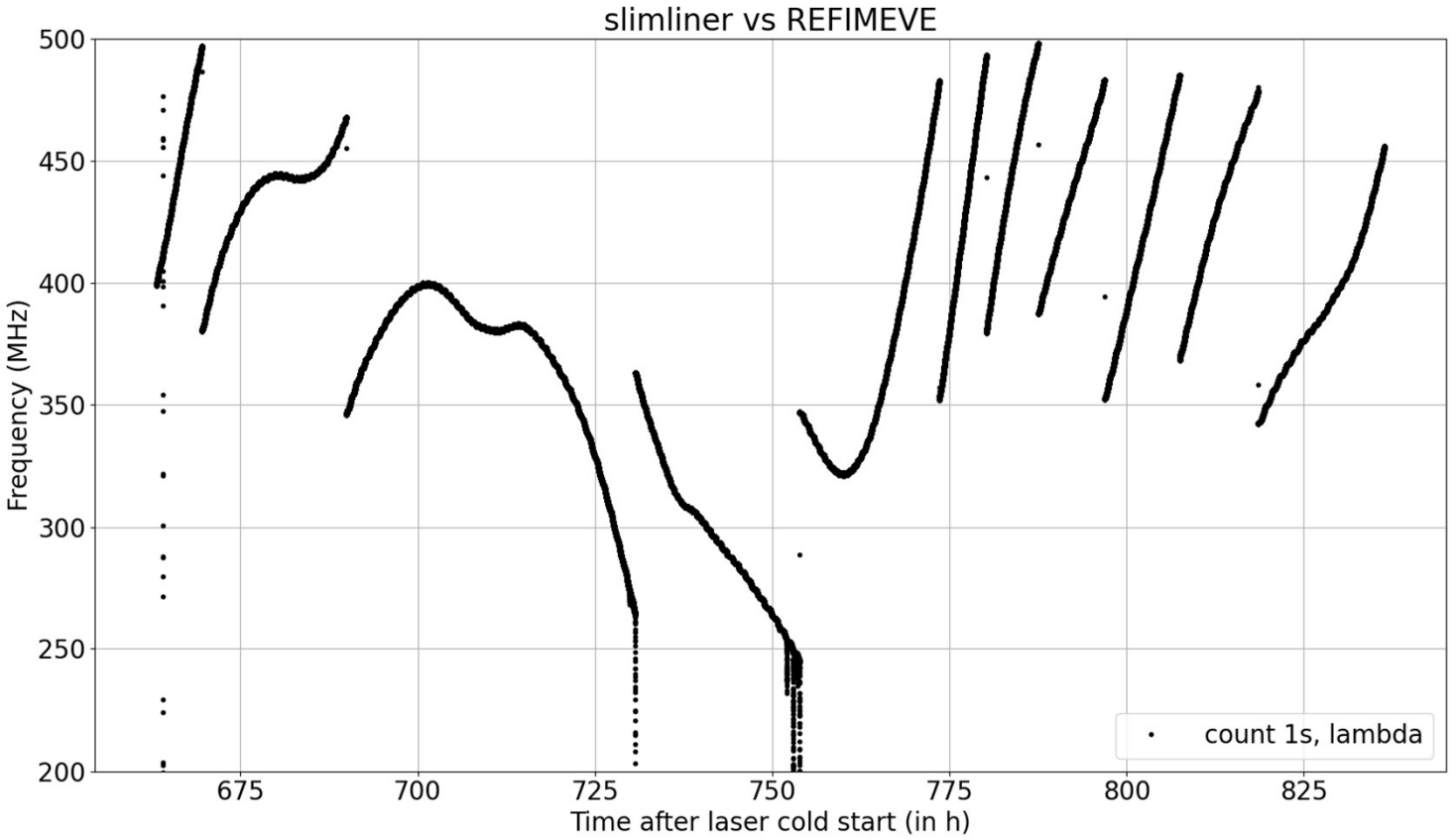
Slimliner III at LPL compared to REFIMEVE

- power cuts issue solved !
- Period of stability, aircond fluctu ~ 1MHz
- Calm period = fluctuation within of 12MHz



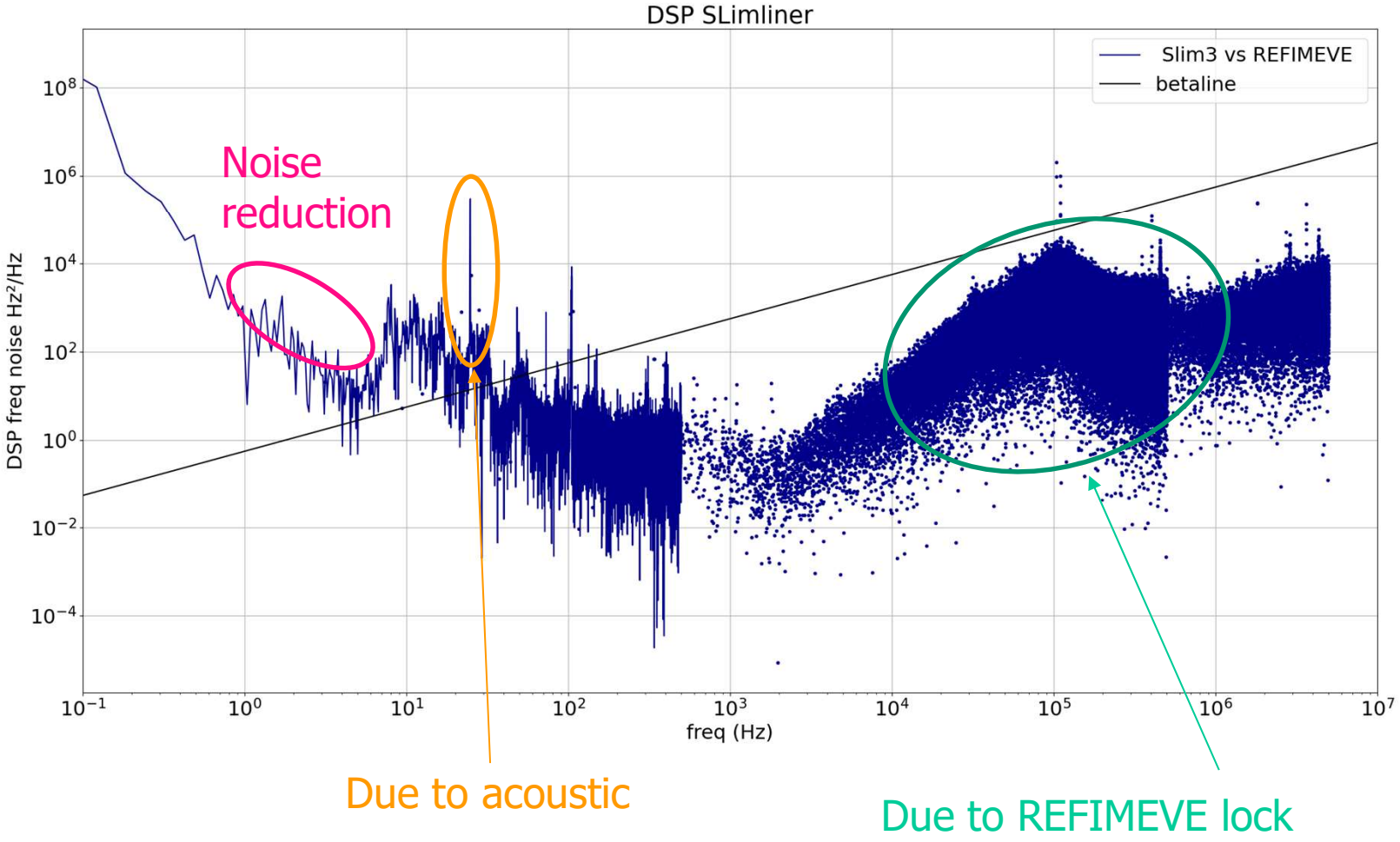
Slimliner III at LPL compared to REFIMEVE

- Slow drift to a non stable position => modehops

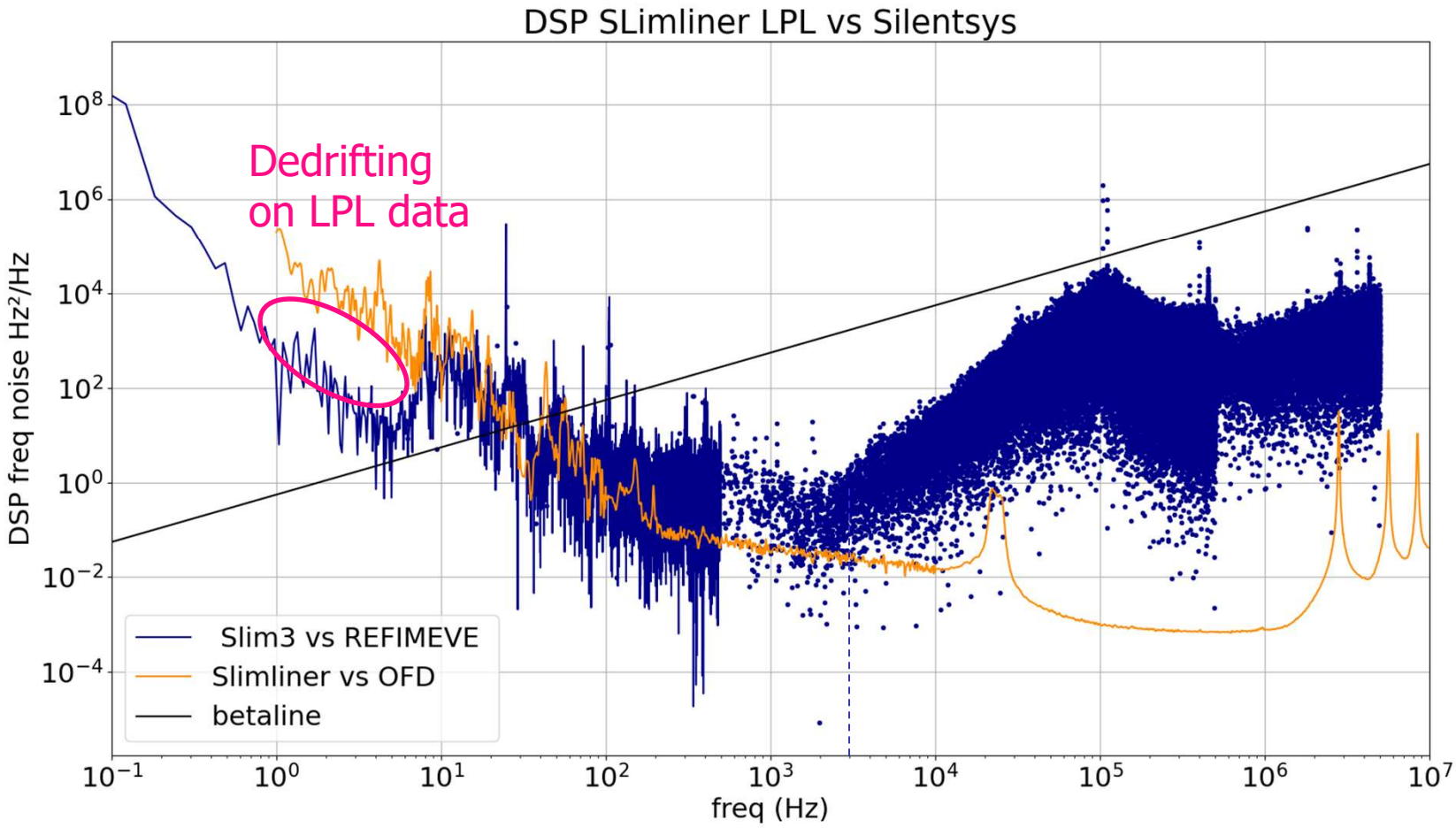


Slimliner III at LPL compared to REFIMEVE

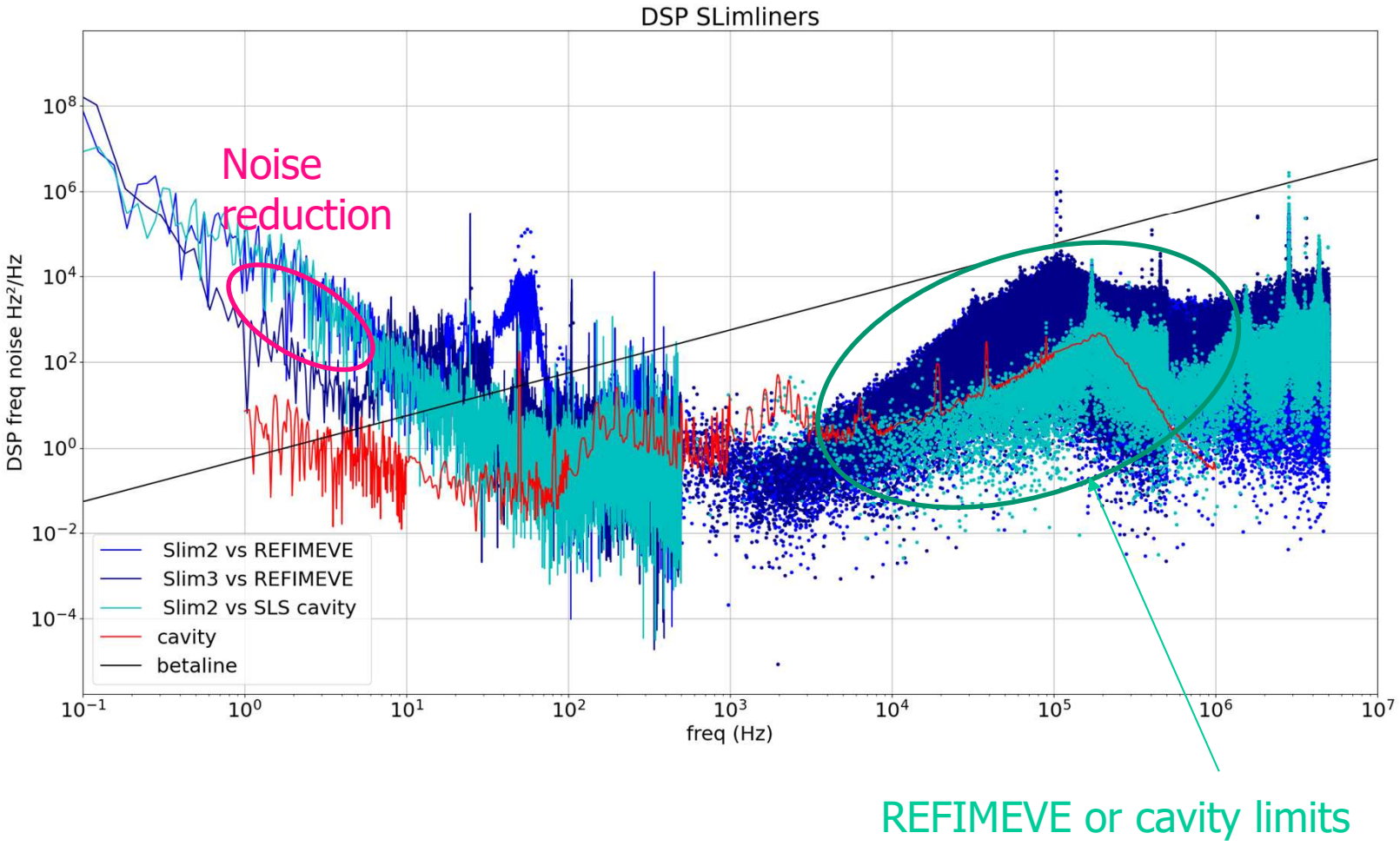
- Better acoustic damping
- Lower noise at low frequency



Slimliner, LPL vs Silentsys characterisation



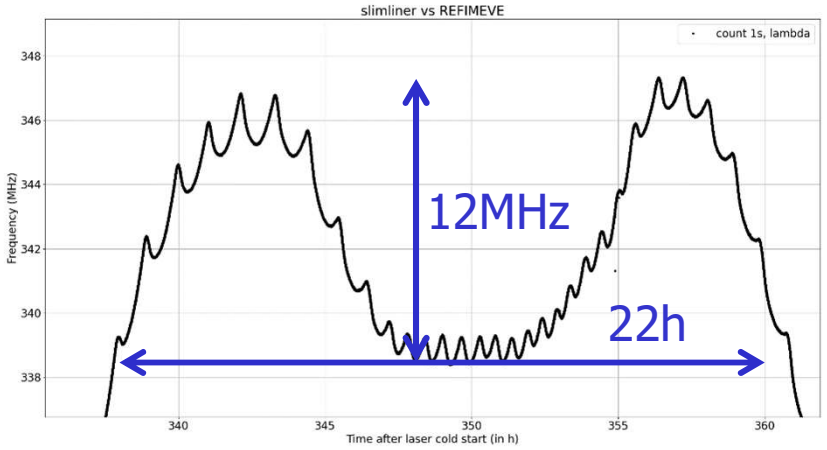
Slimliners at LPL, summary

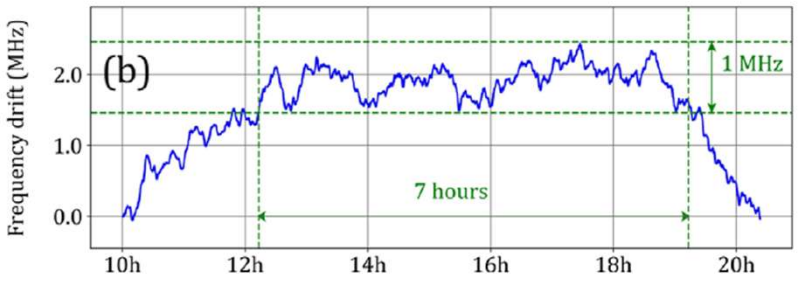


Conclusion & perspectives

- **A fruitful collaboration that led to prototype improvements**

- Perspectives
  - **Slimliner IV planned for end of 2026**
  - including a piezo with 500MHz tuning range to compensate for drift
  - Locking test on REFIMEVE
  - Test of Slimliner for OFDR measurement
  - **SNPO from FOTON to be compared to REFIMEVE signal at Rennes**





Comparison SNPO drift vs an ultrastable cavity. Elisa Jarry, Gwennael Danion, Marc Vallet, and Mehdi Alouini, Applied Opt. 65, 8229 (2026)


LPL
Laboratoire de
physique des lasers


SILENTSYS
ultralow noise systems


INSTITUT
foton

Merci à Vous


UNIVERSITÉ
SORBONNE
PARIS NORD


cnrs


Université
de Rennes


INSA
INSTITUT NATIONAL
DES SCIENCES
APPLIQUÉES
RENNES


Refimeve+


FIRST
TF