2 mirrors cavity status report

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KEK-Hiroshima-LAL Meeting
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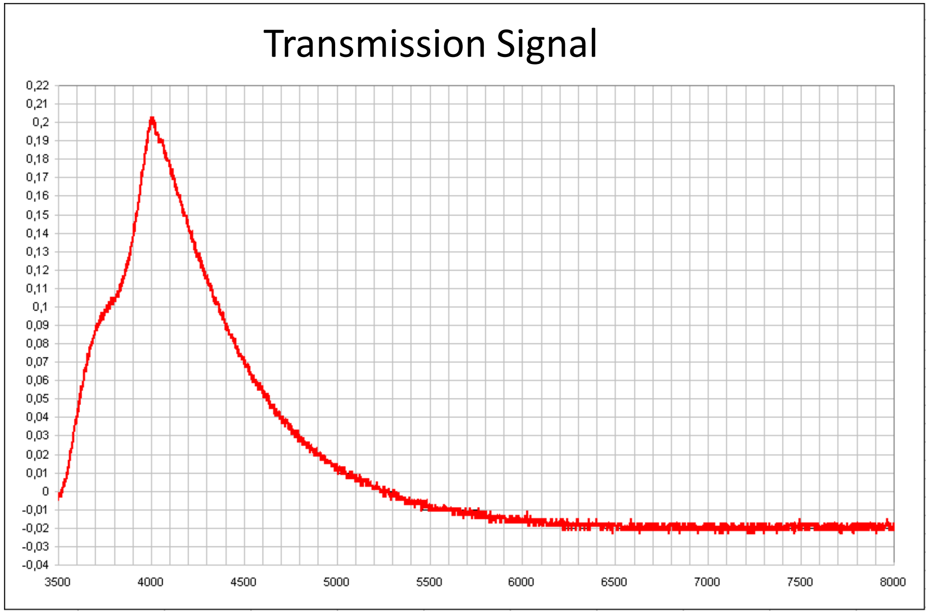
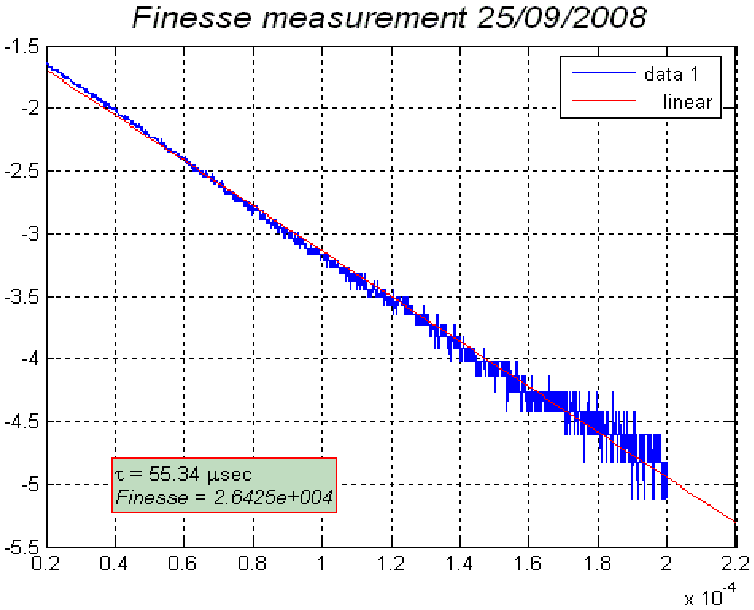
- Fabry-Perot cavity Finesse upgrade & locking
- Locking performances
  - Phase noise and stability for Frep parameter
  - Exploring control of the ΔΦce parameter
- OneFive laser (to be used at KEK) issues
- Prospects

Cavity Finesse upgrade

- Cavity Finesse upgrade : ~3000 => ~30000
- Finesse measurement



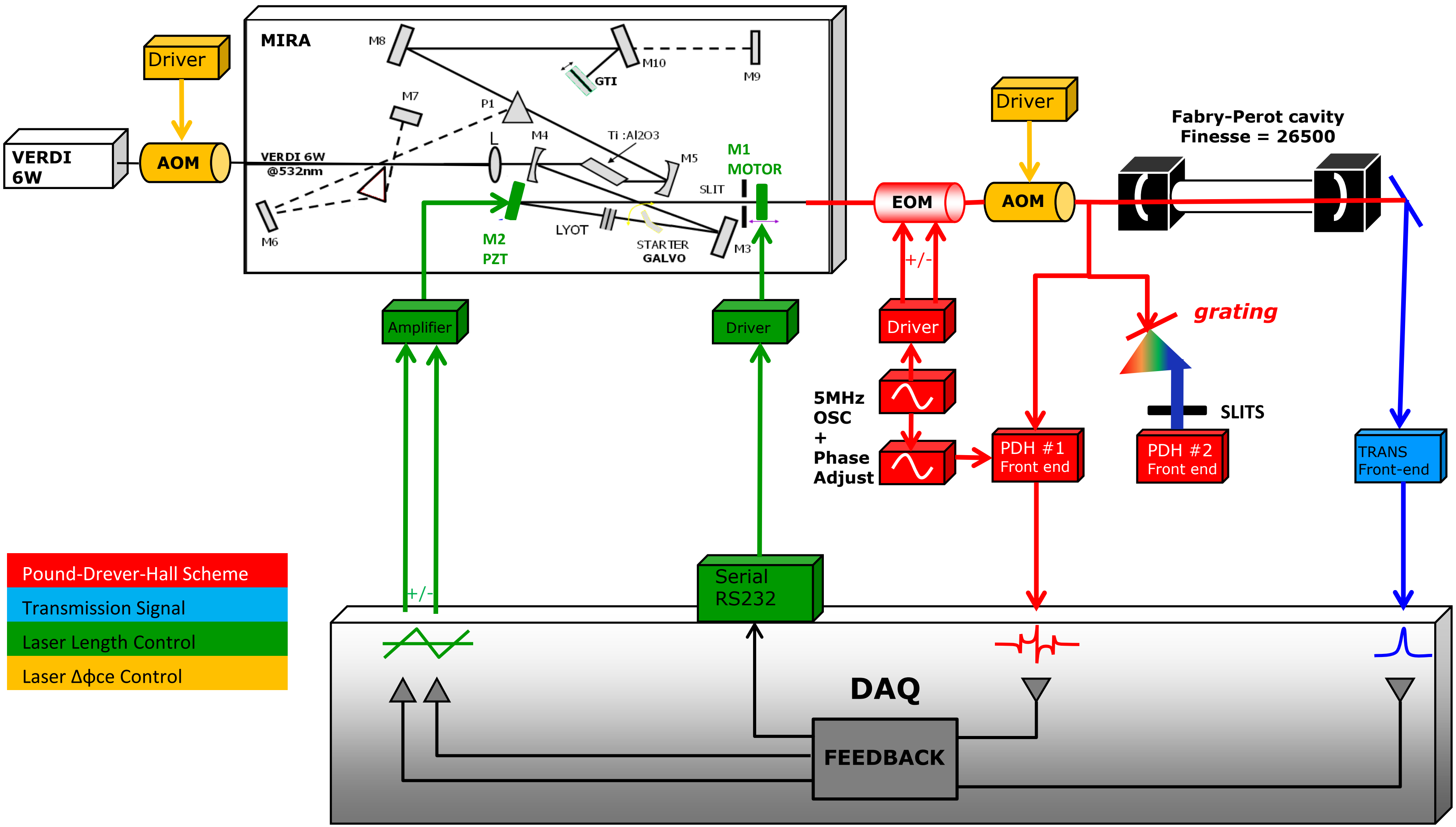
Fabry-Perot decay time fit
in open loop



$$\mathbb{F} = 2\pi\, F_{rep}\, \tau \simeq 26500$$

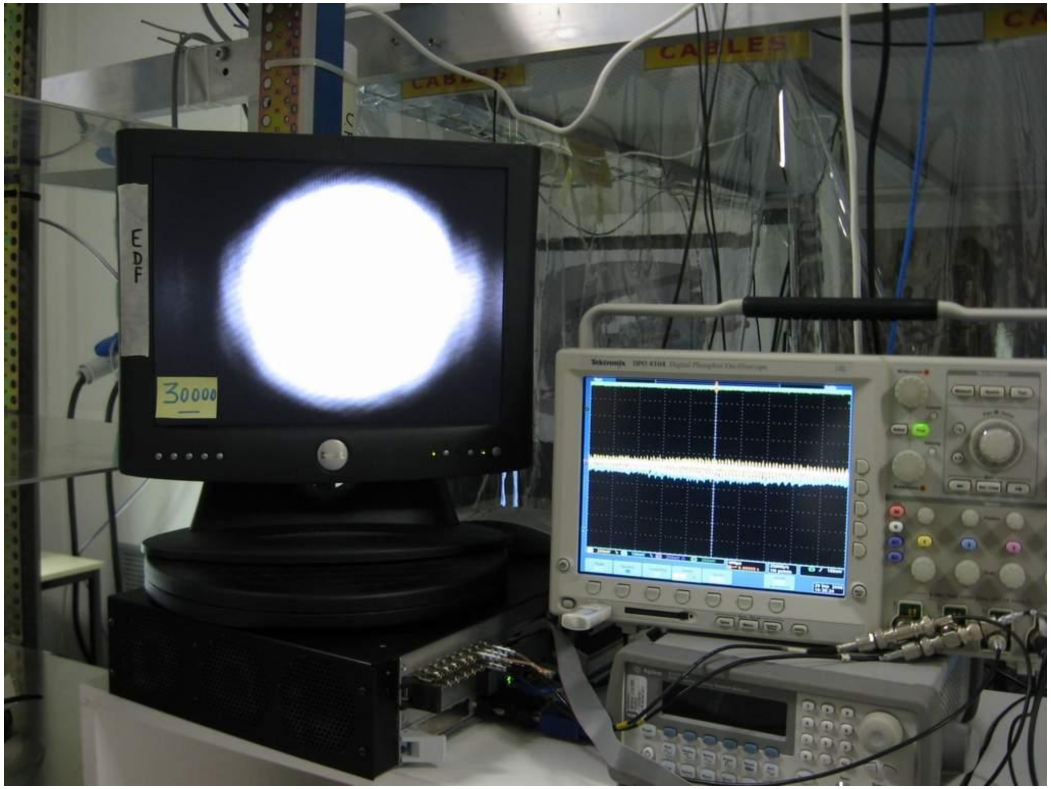
Courtesy to V. Soskov

Cavity locking setup



Cavity locking

PZT gain adaptation : G_{pzt}=3,6 => G_{pzt}=10

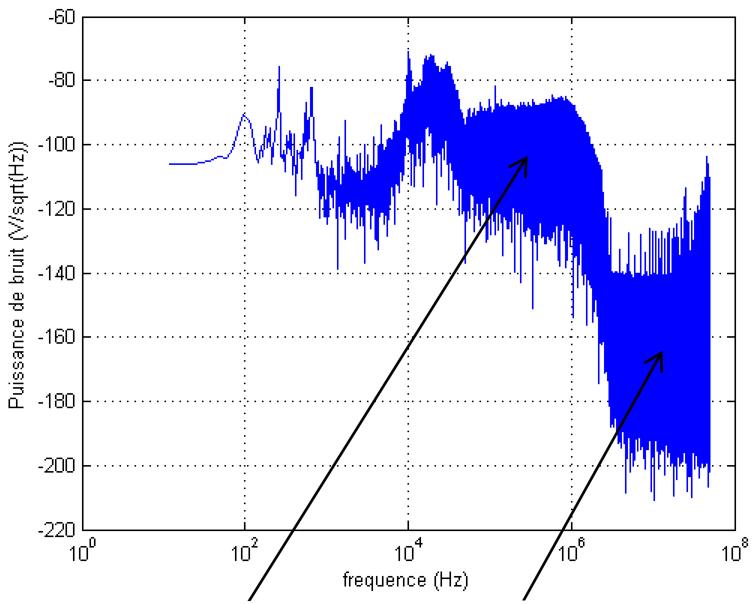


Picture of the Locking : 26 sept. 2008

Very stable during time but poor coupling < 10%

Frep phase noise

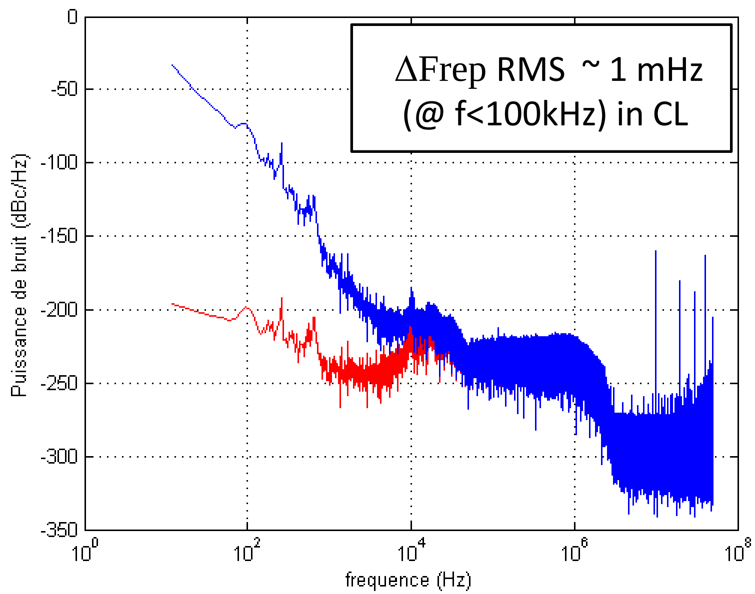
PDH voltage noise power density in closed loop $S_v(f)$ $\Longrightarrow$ Estimation of Phase noise in closed loop and in open loop



PDH noise floor

Detection noise floor

Unity gain frequency ~ 10 kHz



$$\Delta f(n_0) \simeq n_0\, \Delta Frep < \frac{Frep}{6\mathbb{F}}$$

$$\Rightarrow \Delta Frep < \frac{Frep}{6 n_0 \mathbb{F}} \simeq 0.1\, mHz$$

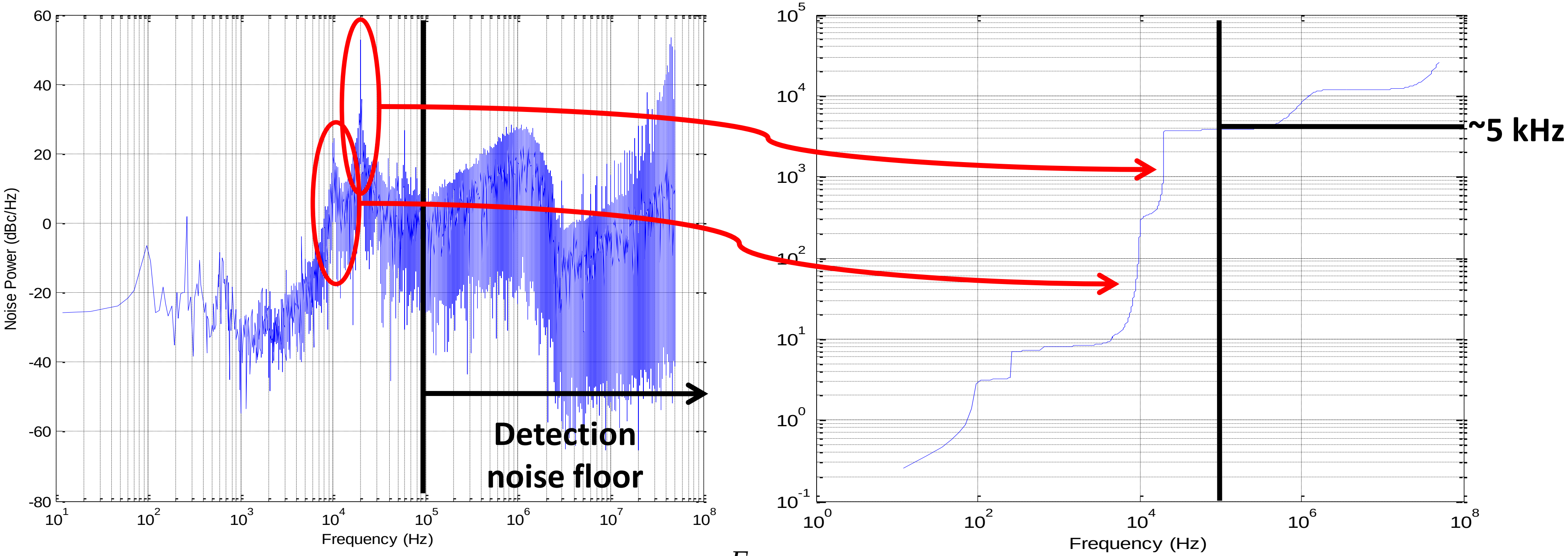
For coupling 90% of the power
One needs ΔFrep RMS ~ 0.1 mHz

More gain @ f > 1kHz needed but stabilty @ 10 kHz must be maintained
=> Find an other actuator ?

Frep frequency noise

Estimation of the
Frequency noise power density
of the carrier in closed loop

Estimation of the
Integrated Frequency noise power
of the carrier in closed loop



$$\Delta f(n_0) < \frac{Frep}{6\mathbb{F}} \simeq 500\,Hz$$

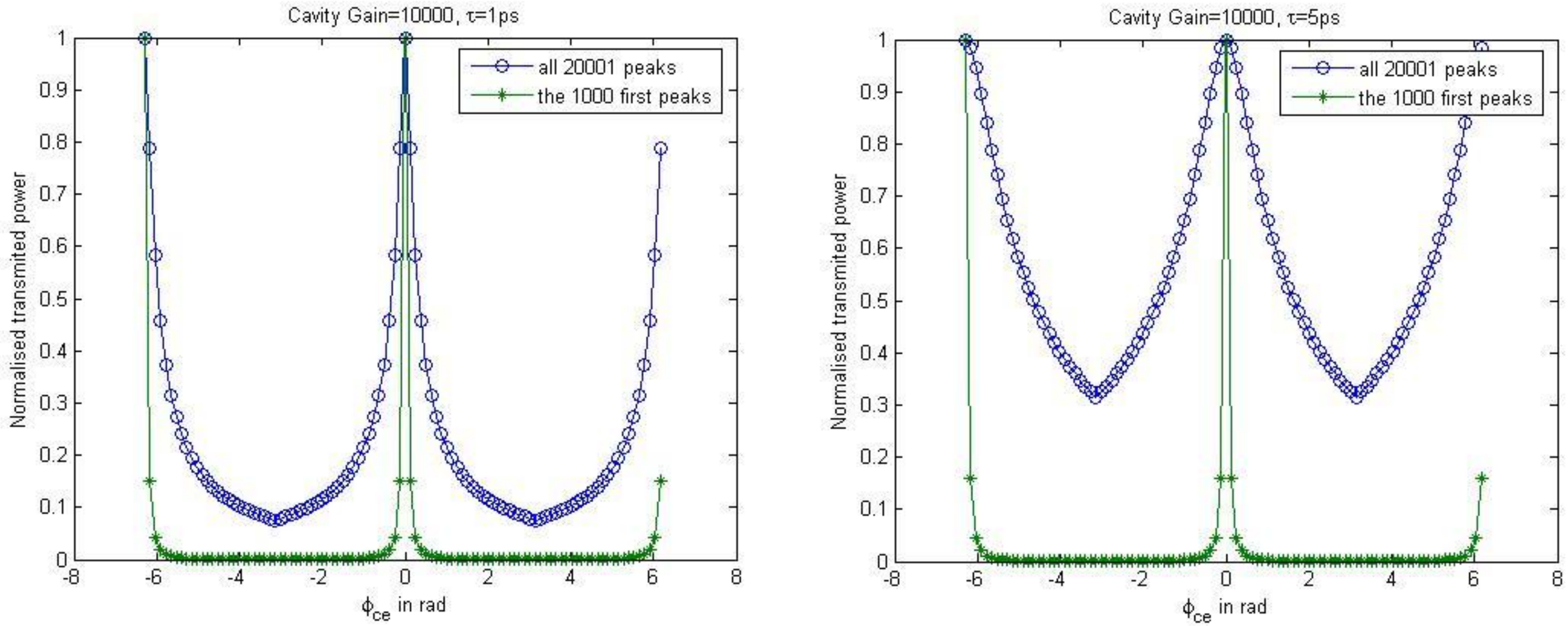
Need to better control the unity gain frequency region of the feedback

ΔΦce effect on coupling

n_0 is the mode number of the center of the laser spectrum

Locking => $\left(n_0 + \frac{\Delta\phi ce}{2\pi}\right) F_{rep} = n_0\, F_{cav} \Rightarrow F_{cav} - F_{rep} = \frac{\Delta\phi ce}{2\pi}\frac{F_{rep}}{n_0} < 2.5\,Hz$

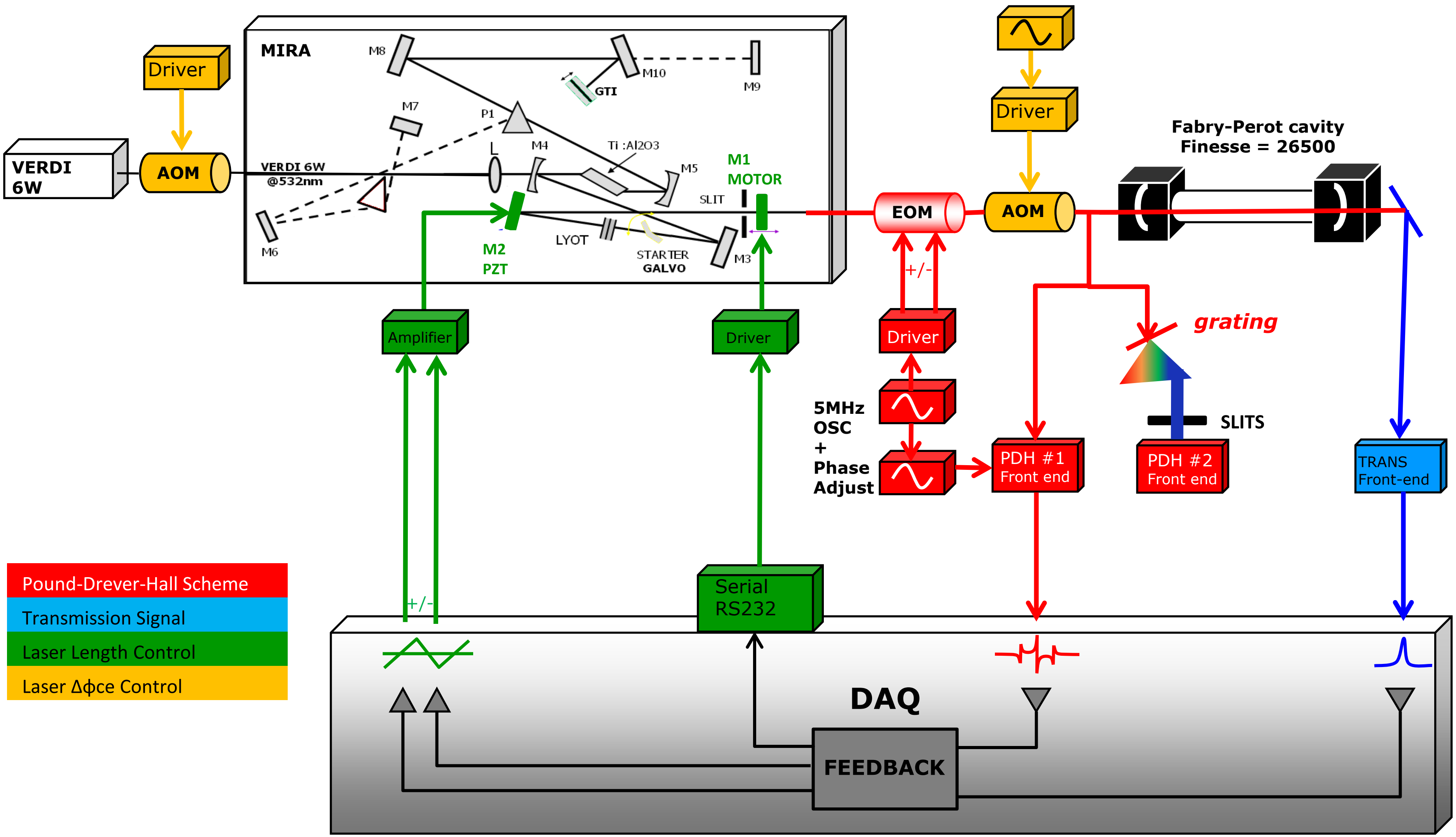
Detuning => $\Delta f(n) = \Delta n\left(F_{rep} - F_{cav}\right) < \frac{F_{rep}}{2\mathbb{F}} \simeq 1.5\,kHz \Rightarrow \Delta n < \frac{1.5\,kHz}{2.5\,Hz} \simeq 500$



Courtesy to F. Zomer

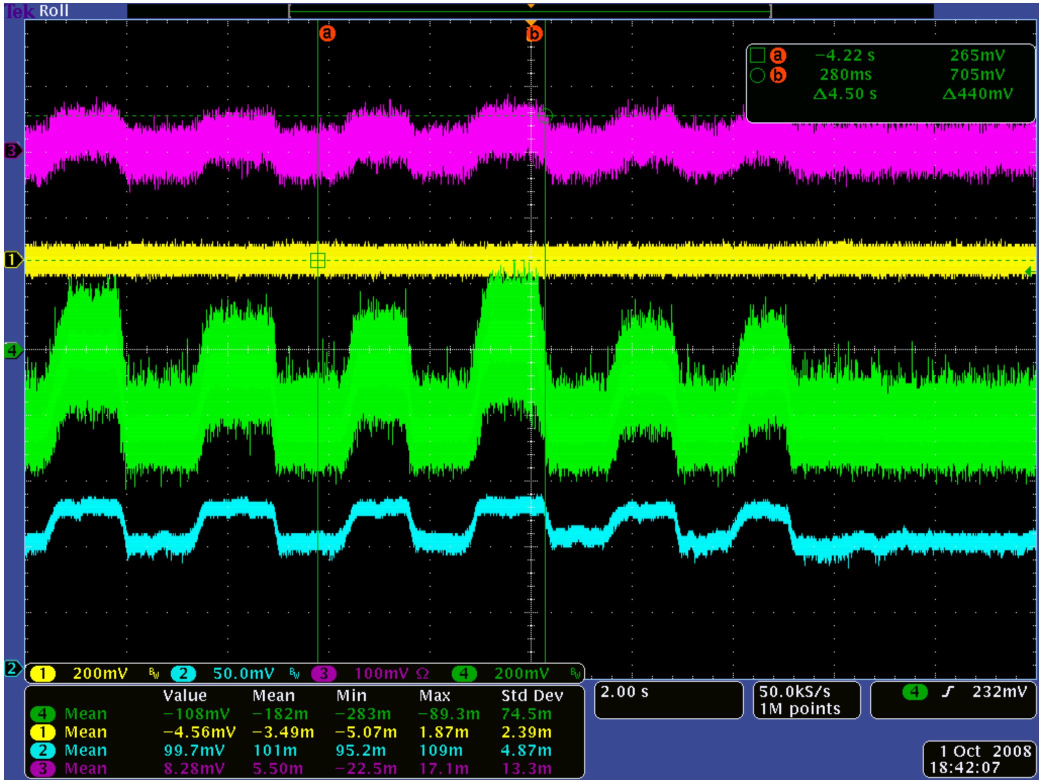
One must be able to adjust Δφce over 2π

ΔΦce with Frequency Shifter setup



ΔΦce with Frequency Shifter

- Very good dynamic range : 5MHz/V (One needs a variation of Frep ~ 75MHz).
- Poor efficiency : < 50%



(purple) : Signal on PZT

=> Frep correction

(yellow) : Signal on PDH1

=> Used for feedback = 0

(green) : Signal on PDH2

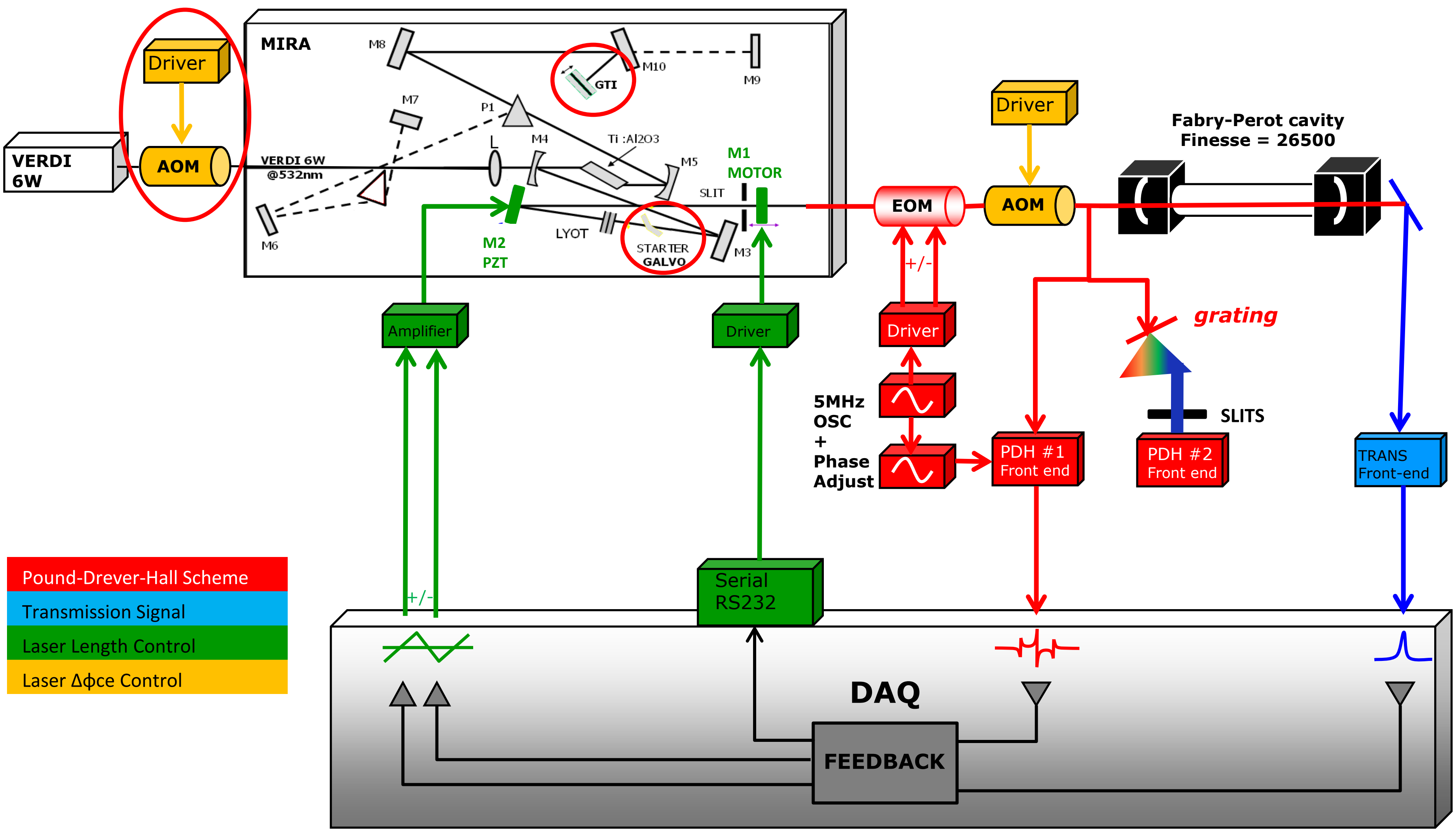
=> Look at the Δϕce effect

(blue) : Signal on Transmission PH

=> Improved by changing Δϕce

But optical misalignment during wide range use
=> cavity unlock (even with a double optical path)

ΔΦce with other actuators setup



ΔΦce with other actuators

We tried several other ΔΦce modulation schemes :

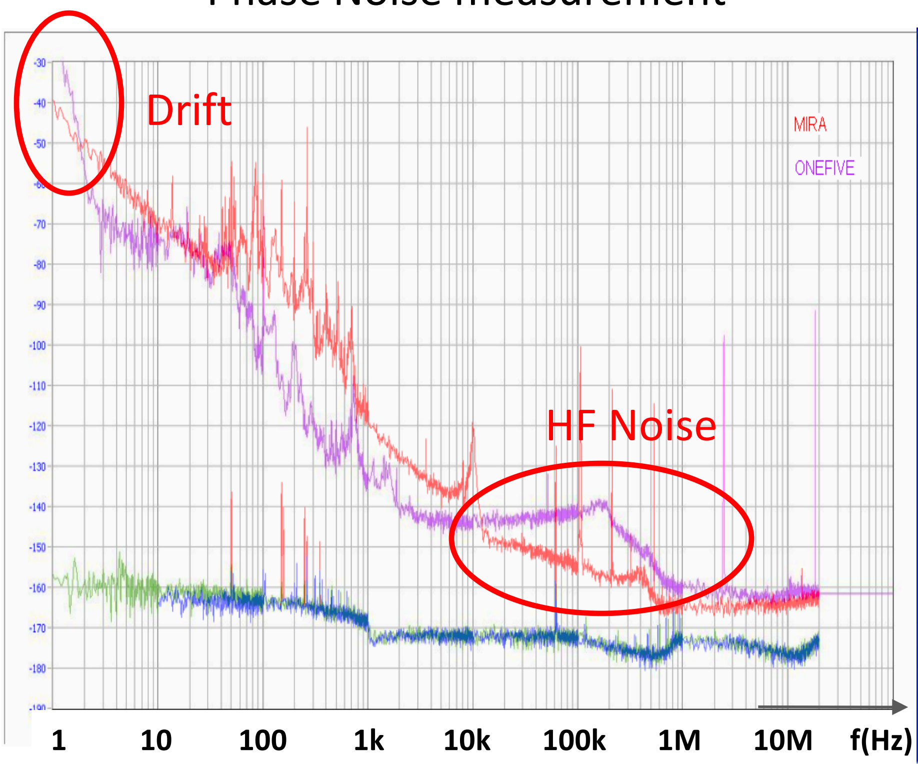
- AOM modulating the pumping power
  => dynamic range not enough but can be used for
  feedback at « high speed »
- GTI inside laser
  => No effect
- Starter-Galvonometer inside laser
  => No effect
- Starter-« Butterfly » Galvonometer inside laser
  => No effect (not enough ?)

Actuator to work on ΔΦce over 2π has not been found yet

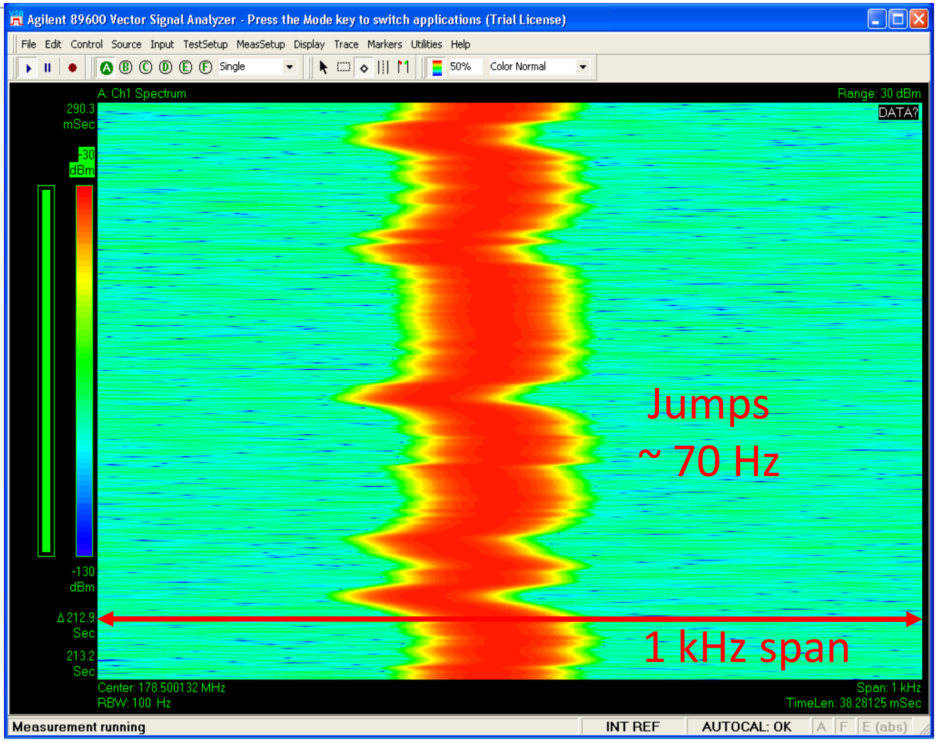
OneFive laser stability issues

- <P> = 1.7 W
- λ = 1030 nm
- Repetition rate = 178.5 MHz
- Δt = 0.9 ps

Phase Noise measurement



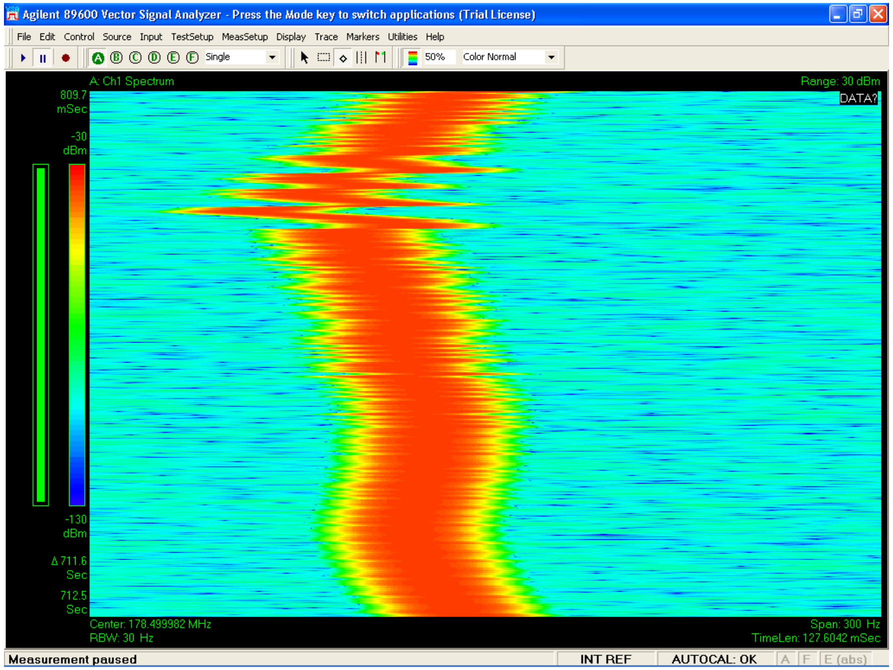
Frequency drift during 3.5 min



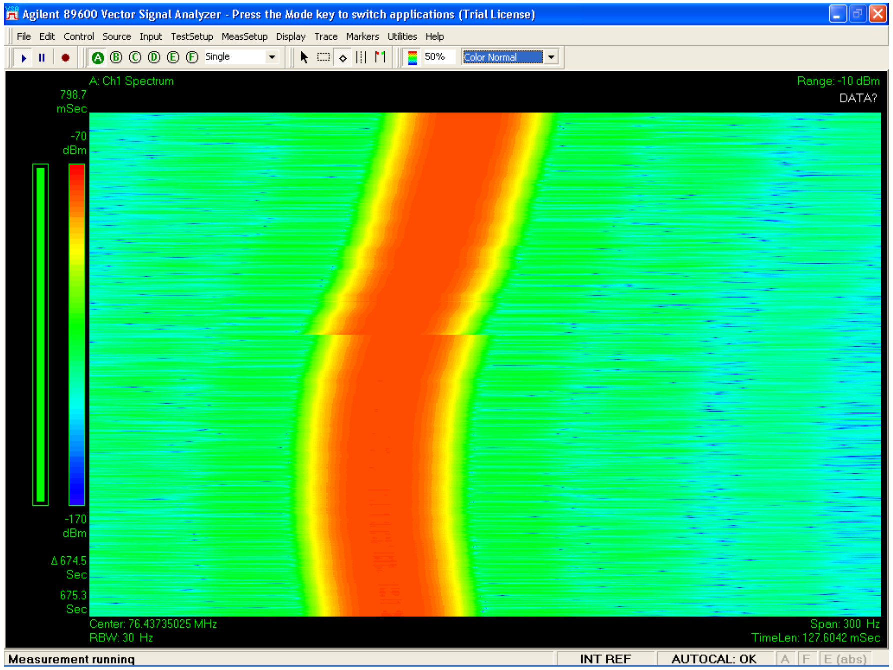
OneFive laser stability

- Drift and jumps could be improved with a simple cover

  => to be studied (new software bought for our Agilent RF spectrum analyzer)
- HF phase noise has to be checked as measurements near the instrument noise floor are not very easy (saturation) => Fabry-Perot absorption measurement ?



OneFive frequency stability with cover
Span : 300 Hz



Comparison with Mira frequency stability
Span : 300 Hz

Prospects

- ΔΦce :
  - 1st priority : find a candidate to work on the full ΔΦce dynamic range
    if we dont find a candidate => insert a double prism inside the Mira : standard solution
  - Copy the feedback channel (inside the DAQ) from Frep to ΔΦce
- Noise improvement :
  - Estimate the system parameters to improve the locking filters to increase stability : already tried in closed loop but without success => open loop
  - Increase the gain on the high frequency part of the Frep loop to improve the RMS noise
  - Improve the PDH floor noise to have a better sensitivity in high frequency for the measurement
- OneFive laser :
  - Improve the phase noise measurement front-end to validate the high frequency behavior of the OneFive laser
  - Fix the low frequency stability issue of the OneFive laser : design of a special cover ?
- DAQ change :
  - Change the present PDH scheme to a Digital PDH scheme to fulfill the new DAQ board constraints (board which will be installed at KEK) : local oscillators and mixers will be made inside DAQ, only preamp and band-pass filter will stay in analog way.
  - Re-writting the C++ code to bypass some software issues : very slow access to the GUI in programming mode