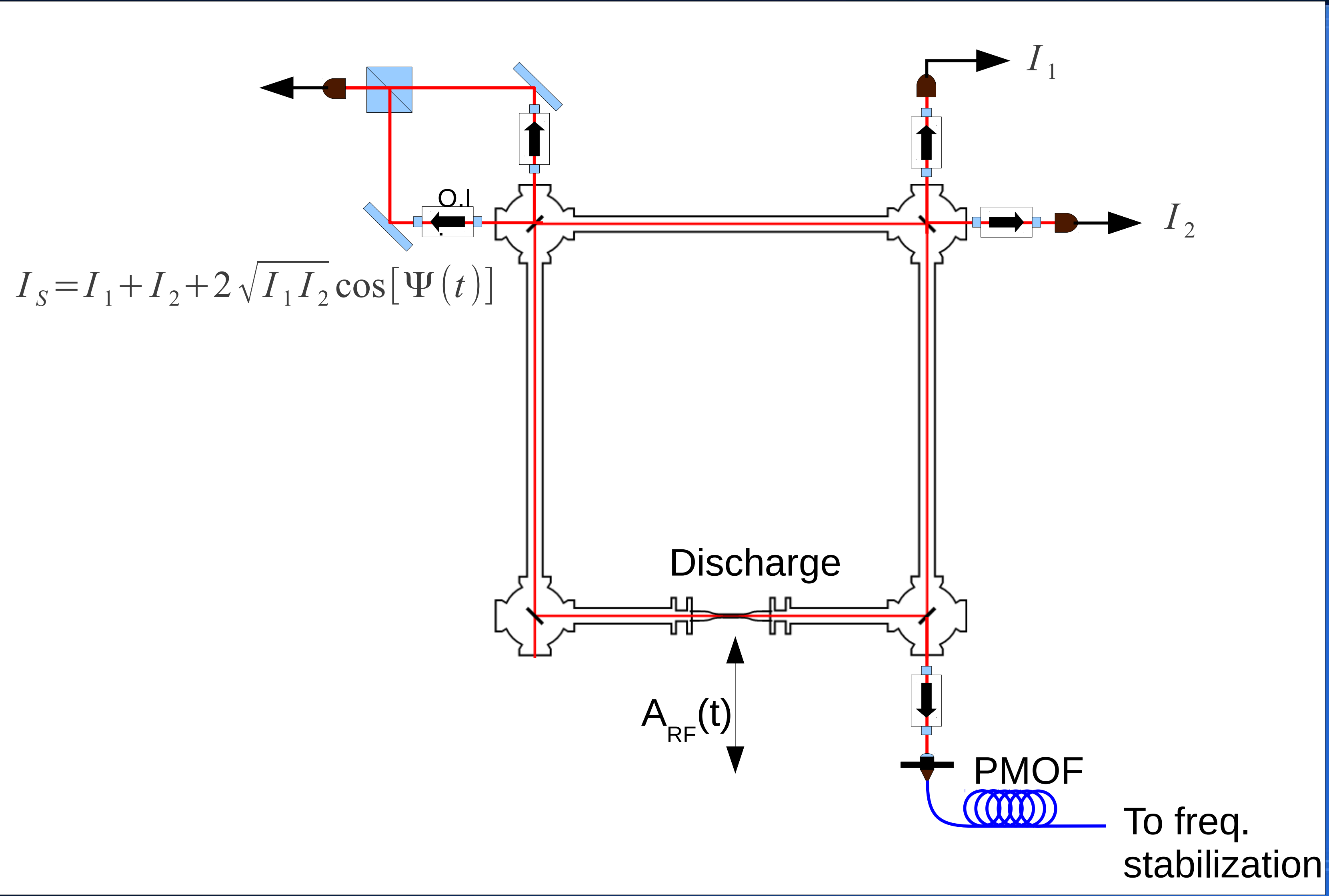
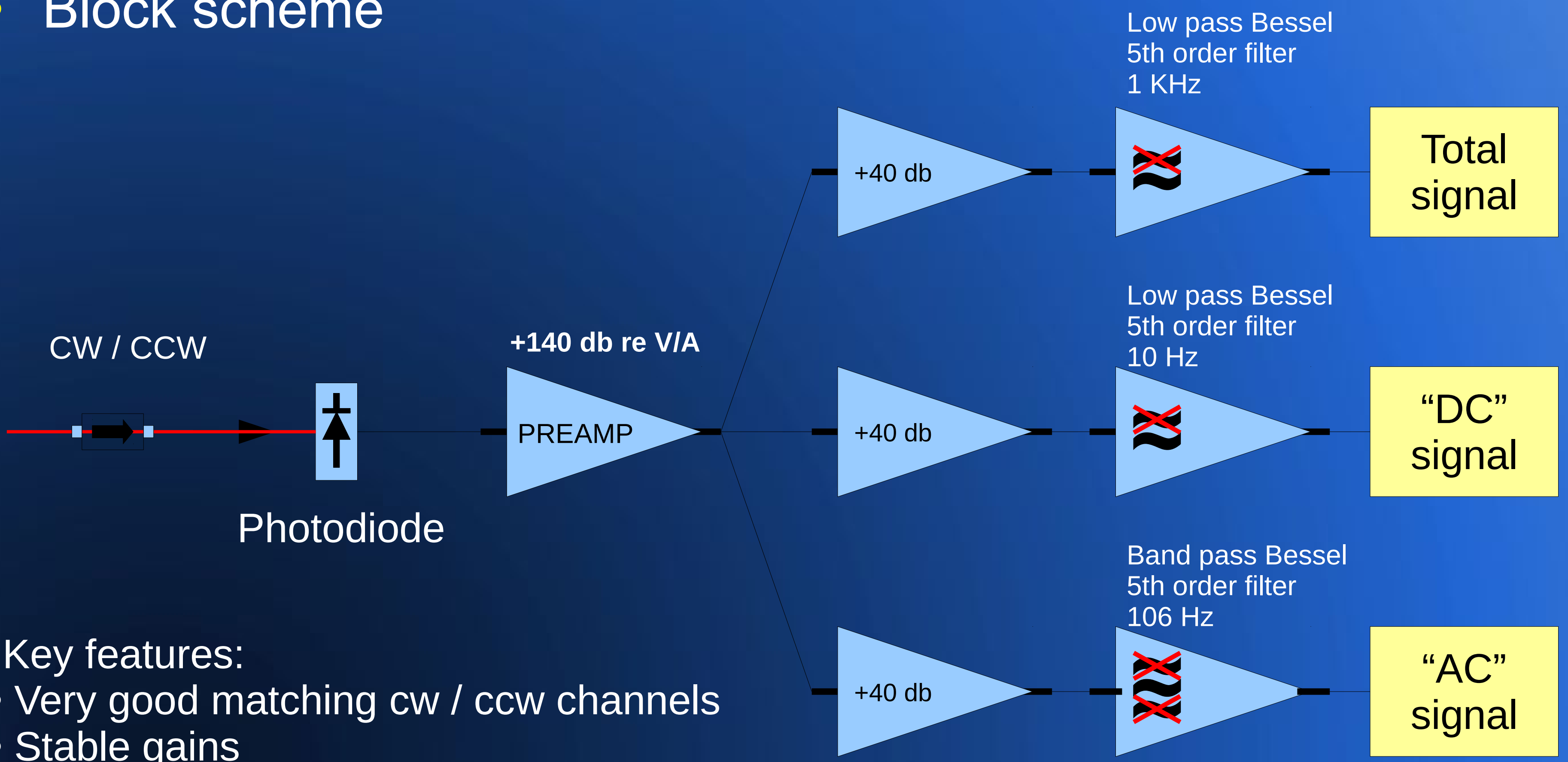
Gyrolaser Optical design: STD op.



3-ways analog cw/ccw signal processing

- Block scheme

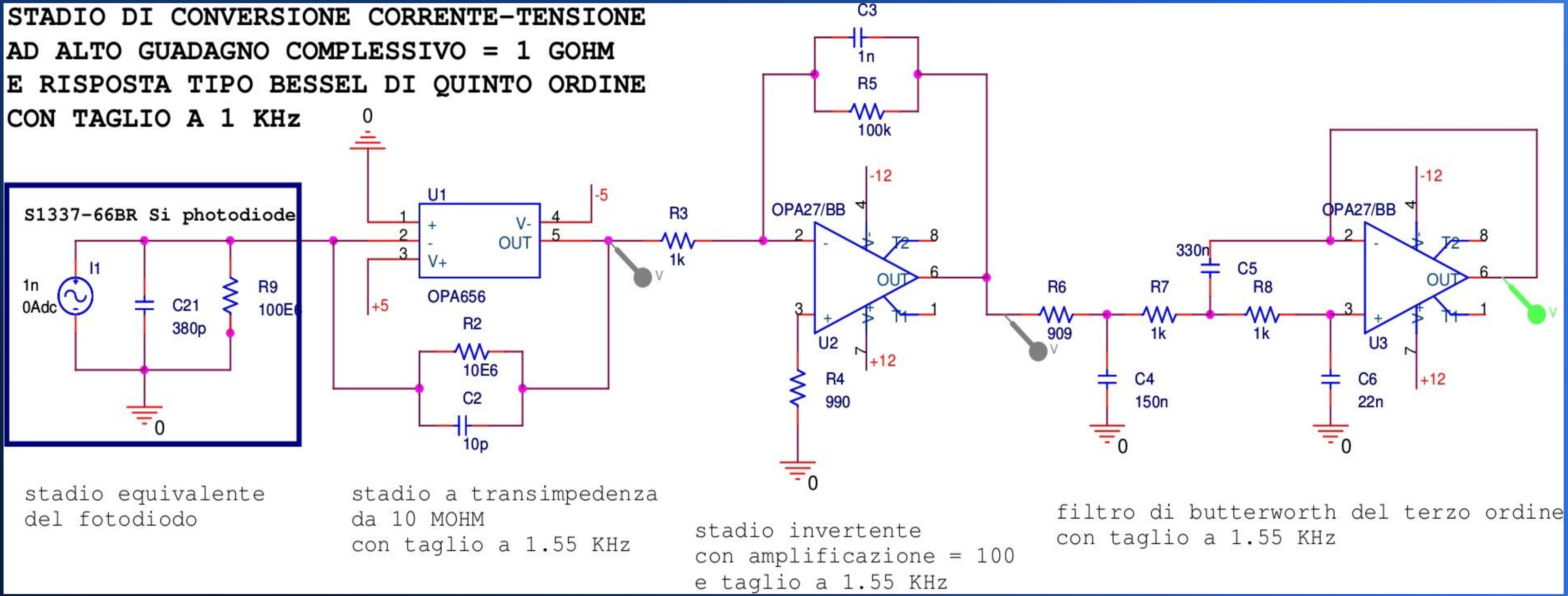


Key features:

- Very good matching cw / ccw channels
- Stable gains
- Noise performances over commercial amplifiers

3-ways analog cw/ccw signal processing

- Electrical scheme of the upper branch



3-ways analog cw/ccw signal processing

- Noise performances vs commercial preamp with equivalent gain

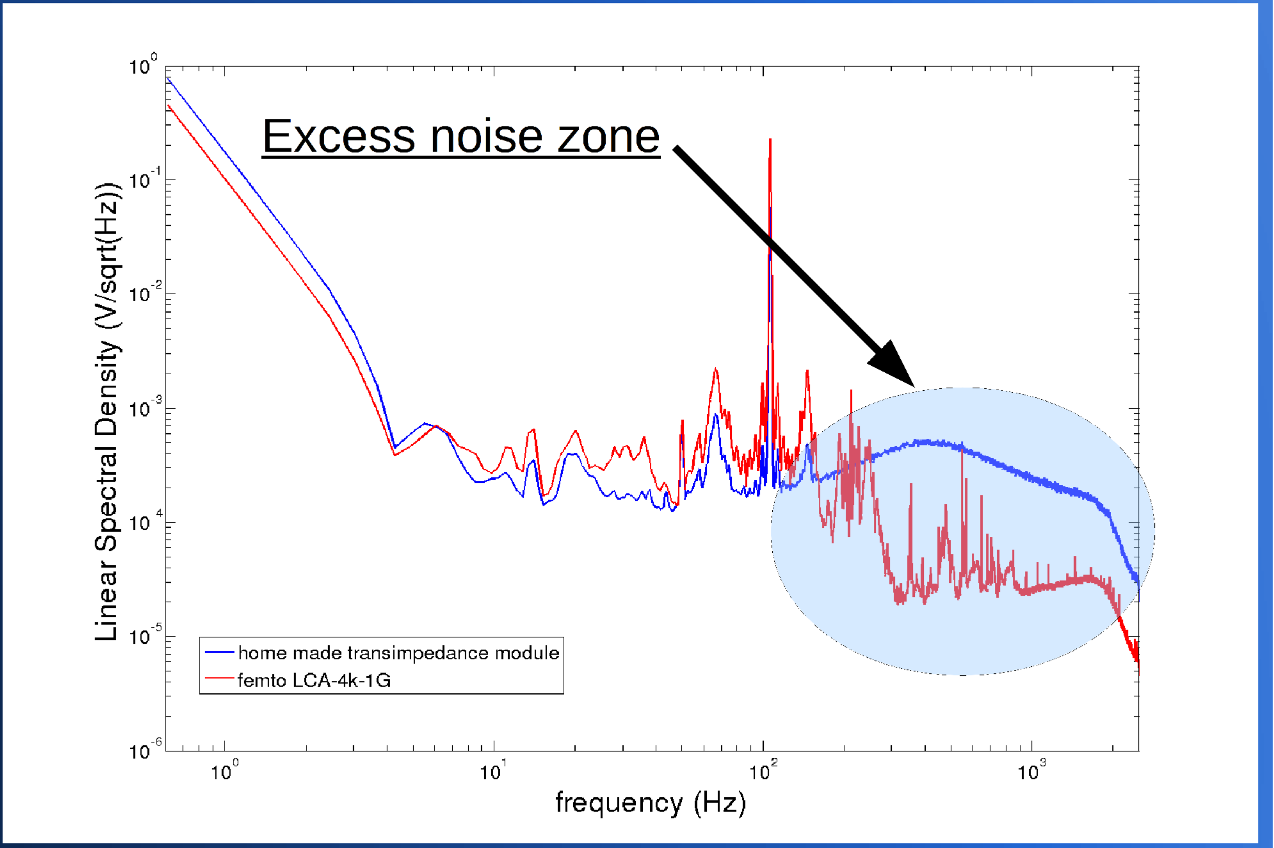
Red line: commercial amp preamp (femto LCA-4k-1G)
Blue line: h.m. module (iccw)

Further improvements on noise performances of our modules are still (hopefully) possibles

Simulated noise

An unexpected parasitic capacitance is responsible for the noise peaking

Measured noise



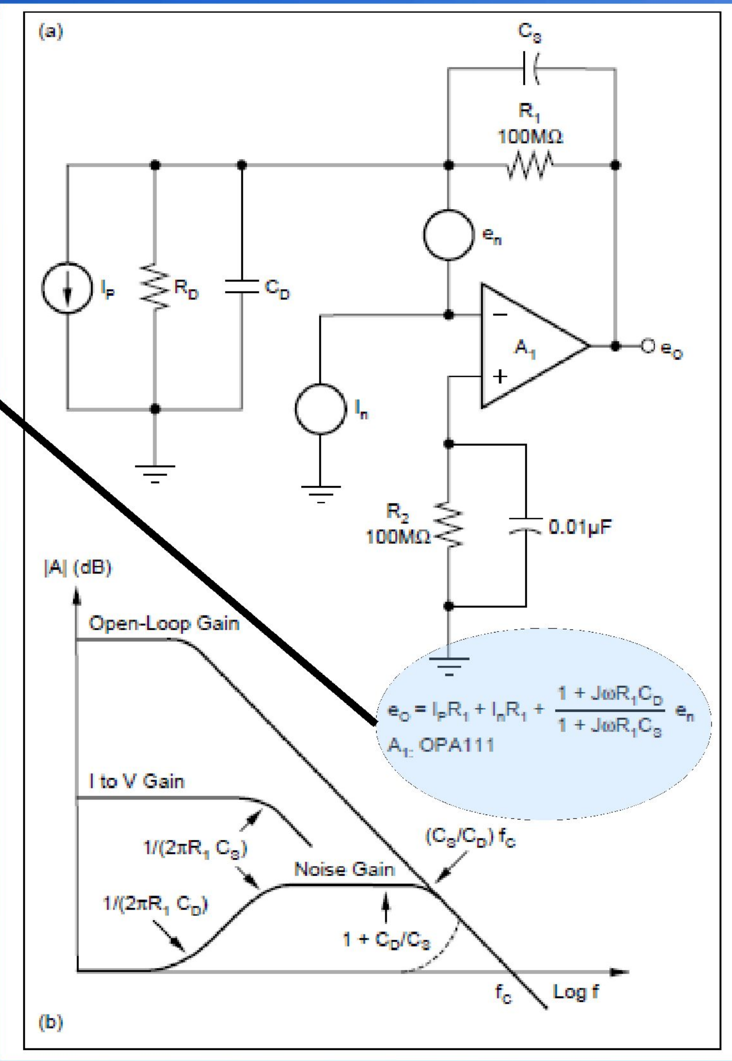
3-ways analog cw/ccw signal processing

- An explanation from circuit theory

Cs = 10 pF
~~Cd = 380 pF~~

Cd = 10 nF !!

$$e_o = I_P R_1 + I_n R_1 + \frac{1 + j\omega R_1 C_D}{1 + j\omega R_1 C_S} e_n$$



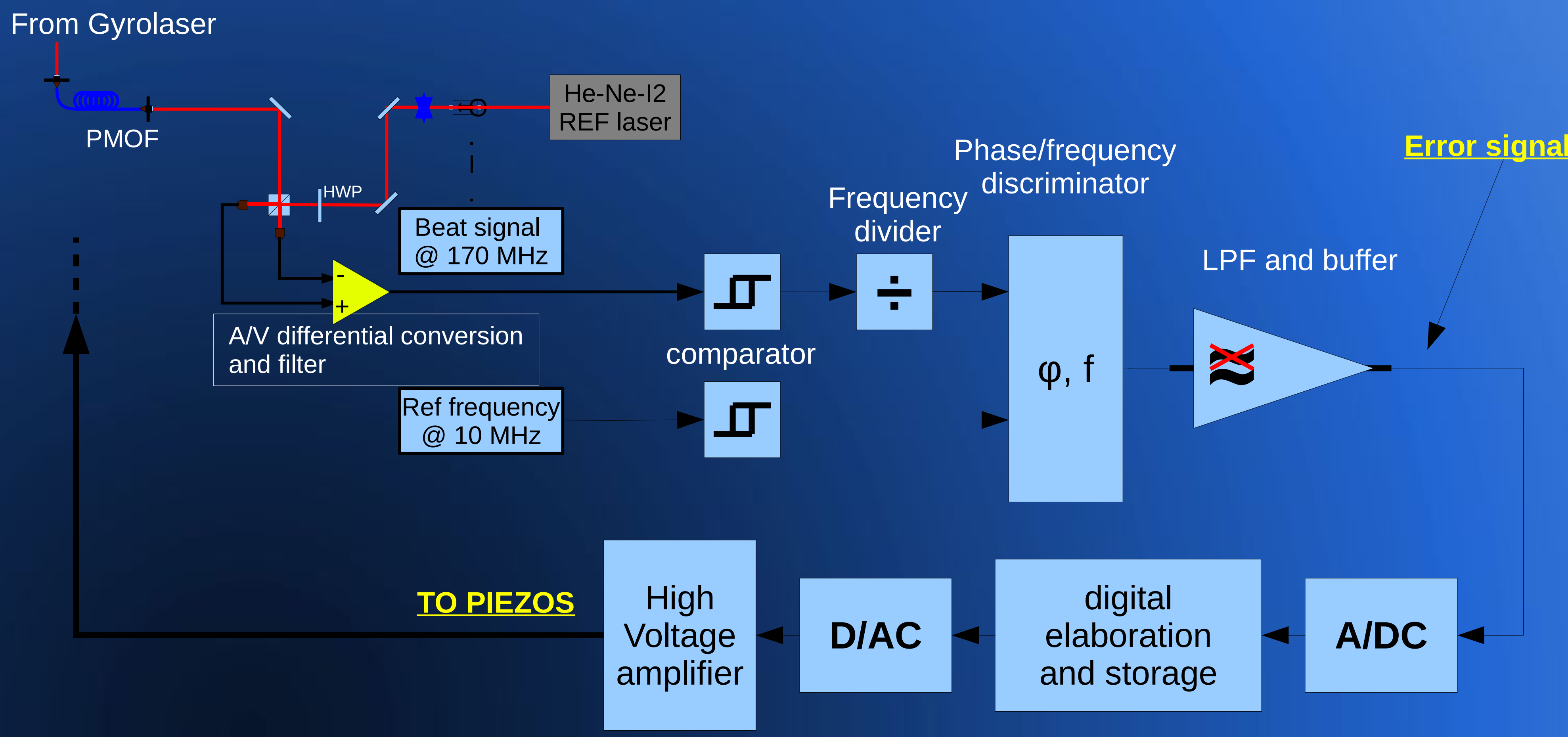
Possible cause: parasitic from breadboard
We can try with a PCB board

Simulated noise

An unexpected parasitic capacitance is responsible for the noise peaking

Measured noise

Perimeter lock: PLL phase and frequency lock



Perimeter lock: some considerations on SNR / 1

- “Best case”: FEMTO- pre amplifier:

  let 100 uW = power of stabilized laser = Ps

  1 nW = power of gyrolaser = Pg (P>1 nw → multi mode)

  power of beat = 2*sqrt(Ps*Pg) (peak value) = 600 nW peak
- After the P.D. and the pre-amplification we get 1,1 mVrms of signal
- Preamp data sheet:
  - equivalent input noise current @100 MHz = 21 pA/sqrt(Hz)
  - Standard deviation of output noise = 300 uV rms

SNR= 10 dB

SNR very close to 0 dB even in “ideal” conditions

Perimeter lock: some considerations on SNR / 2

- A significantly lower SNR can be expected:
  - *Many others sources of noise than the input equivalent noise current:*
    - Voltage input noise
    - Transimpedance thermal noise
    - Op-amp voltage and current noise noise
    - Shot noise
  - *The signal is lower*
    - Light losses
    - Non-ideal light coupling with the photodiode
    - Non-ideal polarization of incident beams

Perimeter lock: some considerations on SNR / 3

Measurements of SNR on “real” working conditions:

RBW of the real time spectrum analyzer = 100 Khz

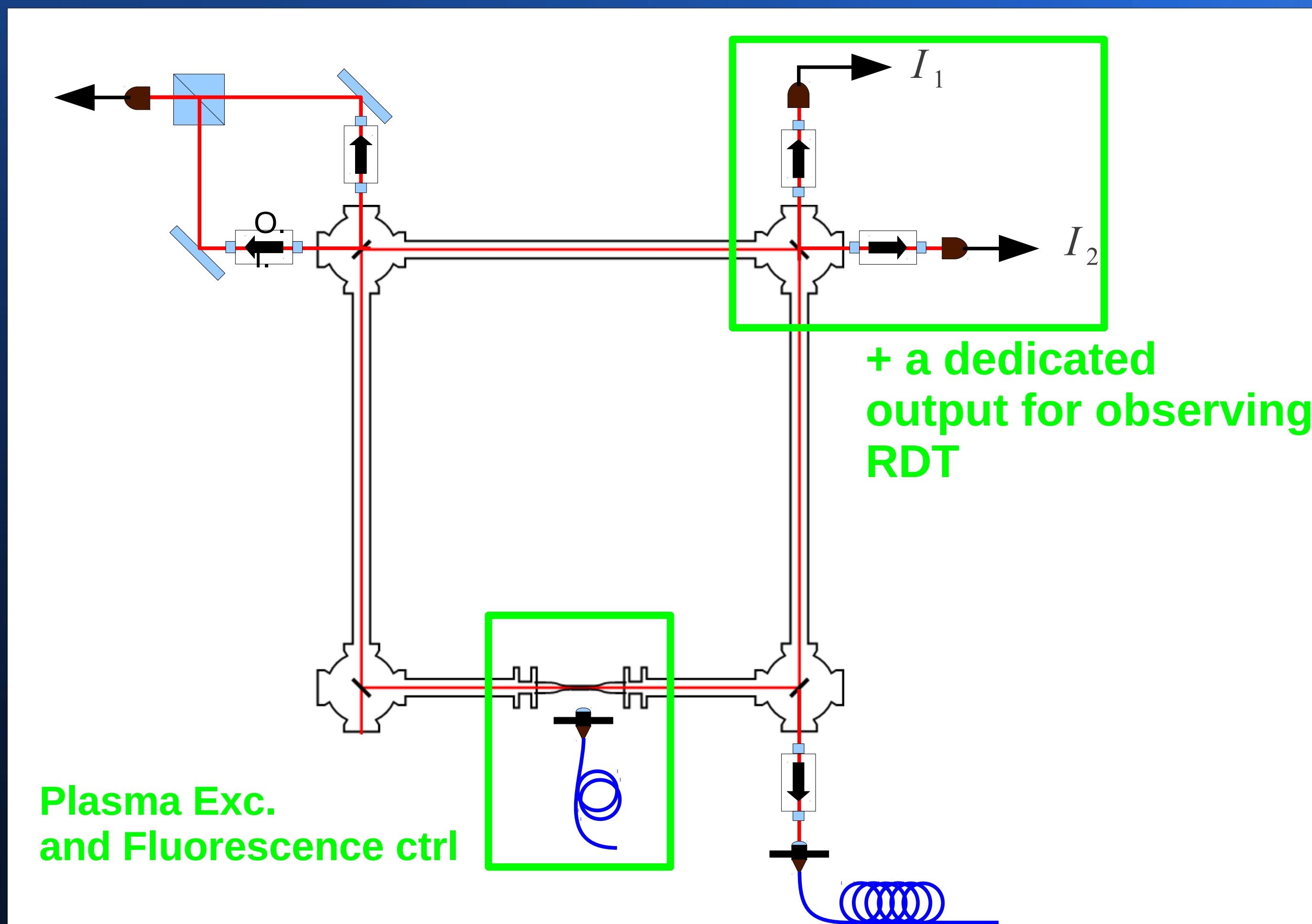
- Noise floor -86 dbV (corresponding to 158 nV/sqrt(Hz), near to the data-sheet value of 100 nV/sqrt(Hz))
- Beat from 31 uW + 10 uW He-Ne beams: **-36 dBV @126 MHz**
- Beat from 31 uW + 10 nW He-Ne beams: **-67 dBV @126 MHz**
- Beat powers are scaling according to the relation $2 * \sqrt{P_1 \cdot P_2}$

but 10 dB (a factors of 10 in power) is missing

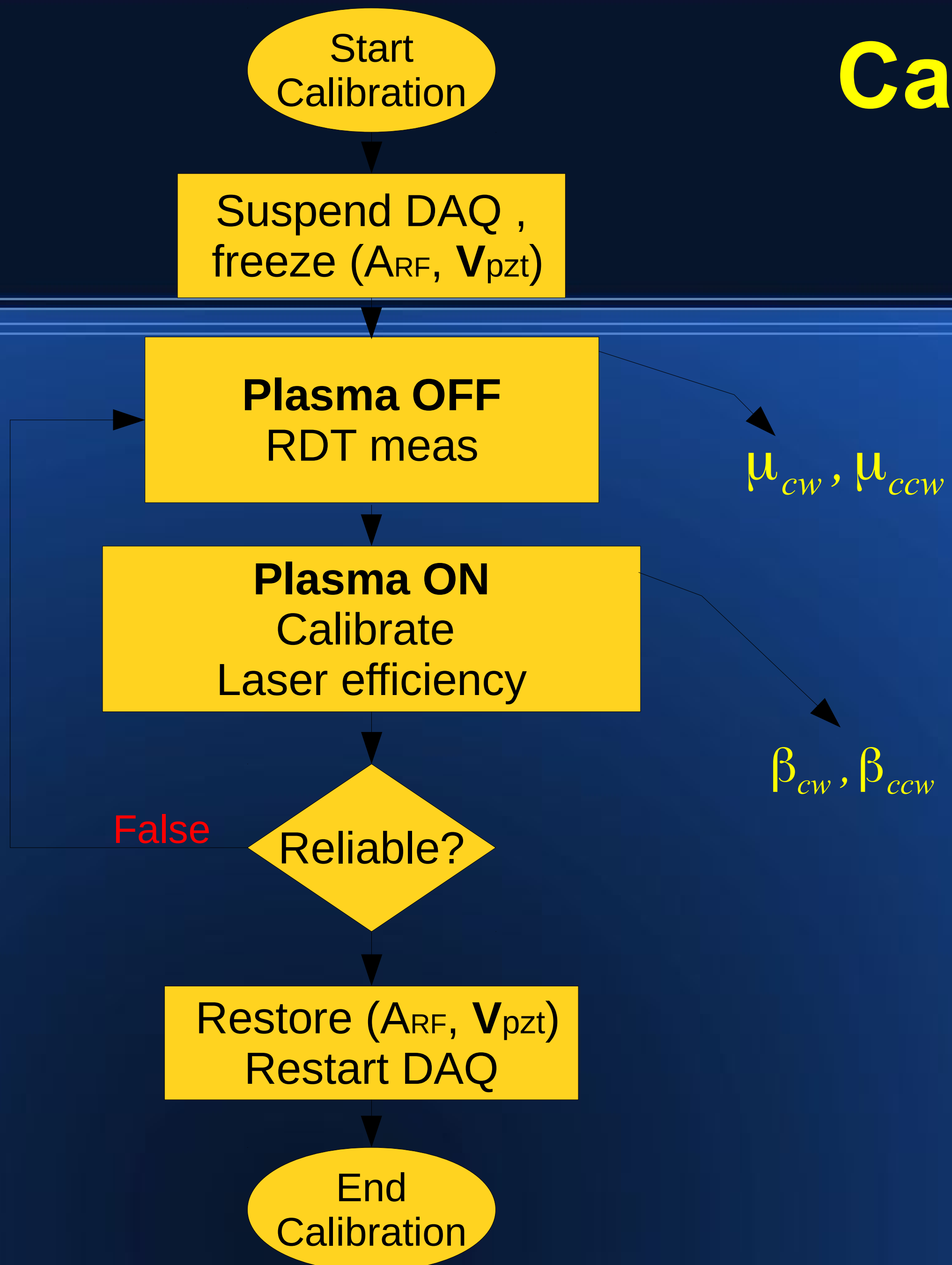
- We can take into account those 10 dB considering the non ideal working conditions (for signal and noise) as considered above
  - we measured a loss due to optical coupling of 5dB
  - Beam polarization: work in progress . . .

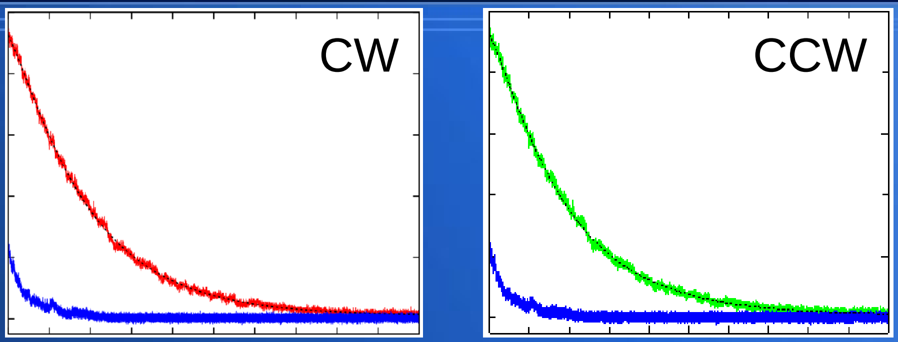
Automated calibration for:

$$\beta_{cw}, \beta_{ccw}, \mu_{cw}, \mu_{ccw}$$

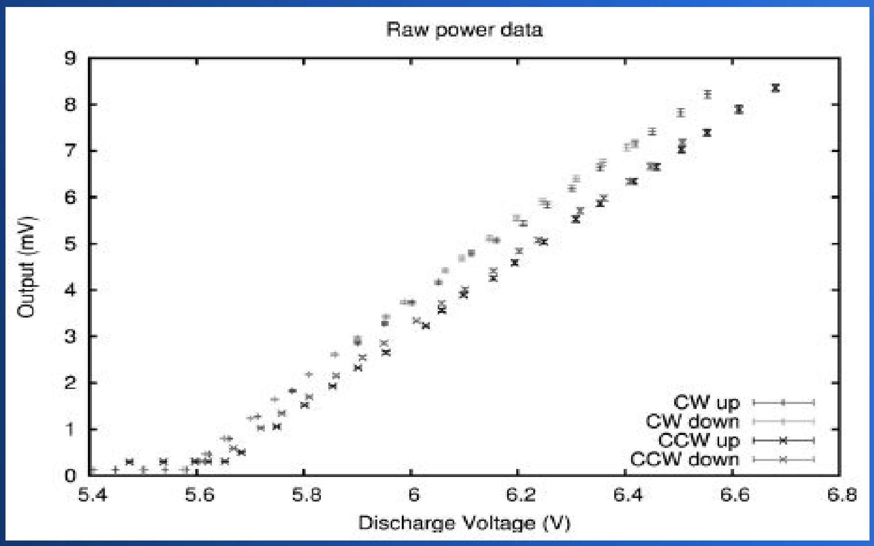


Calibration Logic (PC driven)





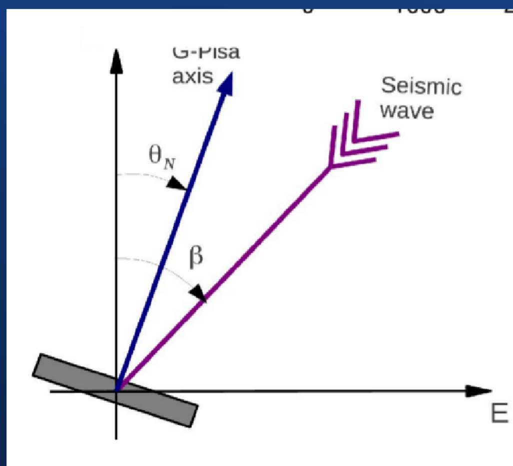
Losses estimation (non reciprocal.)



Laser efficiency

Effects of wind speed and direction on Sagnac frequency

Orientation of G-Pisa:



~ 270 degrees

Further Investigations required

~ 80 degrees

Same average speed