Virgo+ status and news from the commissioning

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on the behalf of
the Virgo Collaboration

G0900618-v1

Summary

- Virgo+ baseline
- Virgo+ status
- Virgo+ commissioning
  - Injection
  - Thermal compensation system / phase camera
  - Lock acquisition
- Noise hunting
  - Eddy current noise
  - Back-scattered light
  - Magnetic noise
  - DAC noise
- Injection-Brewster baffles break

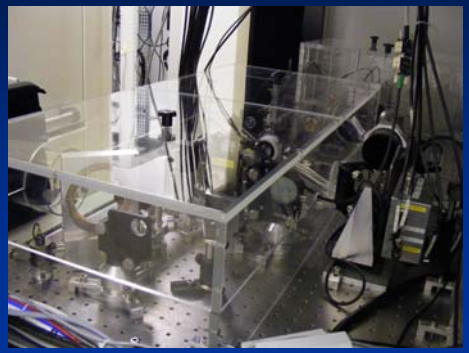
Virgo+ baseline

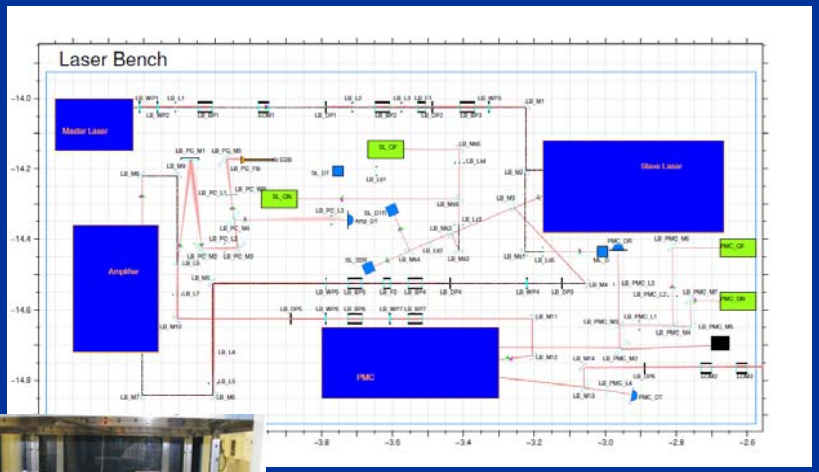
2-steps upgrade towards Advanced Virgo

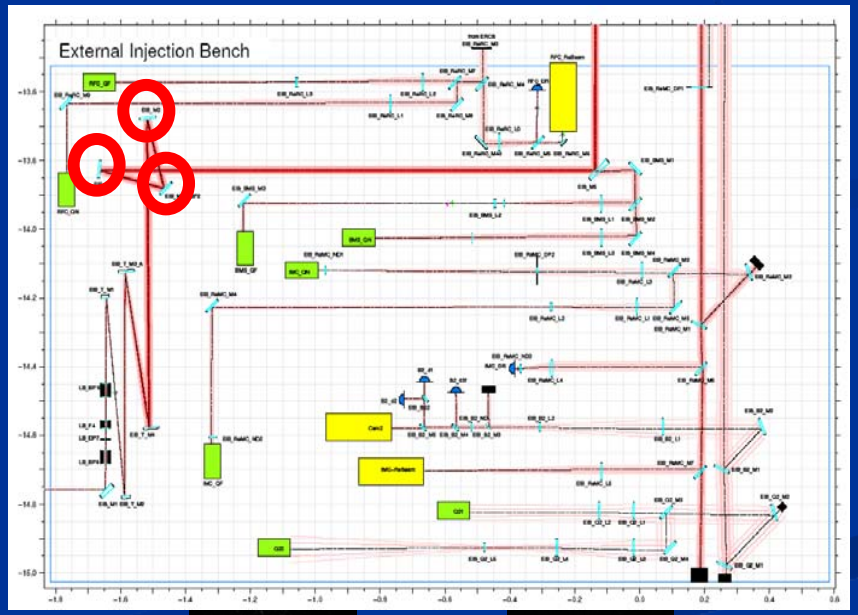
- Summer 2009 VSR2
  - Injection upgrade
    - Laser power up to 50 W
    - Pre Mode Cleaner
    - New Input Mode Cleaner end mirror
    - Suspended injection bench Faraday isolator
  - Thermal Compensation System onto input test masses with CO_2 laser
  - Hardware upgrade
    - Global control on realtime PC
    - New ADC and demodulation boards
    - New DSP
- End of 2009
  - Monolithic suspension (see P. Puppo's next talk)

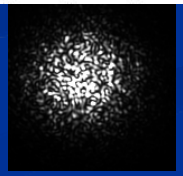
Virgo+ status: injection system

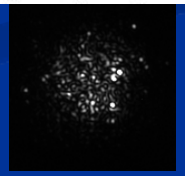
- Laser Amplifier 20W-60W
- PMC losses 3%, transmission 85%
- IMC througput 60% –> 86%
- SIB Faraday isolation 50 dB
- New superpolished mirrors





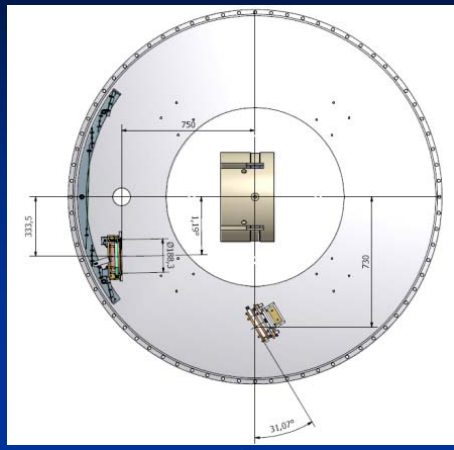


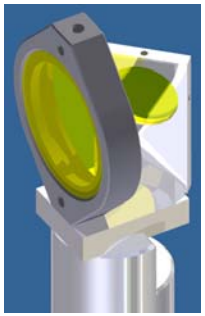


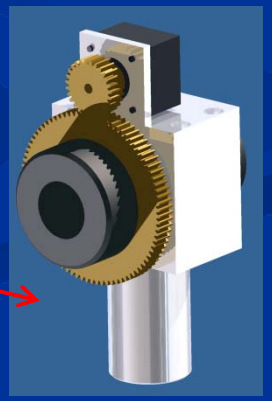


Virgo+ status: TCS

- Installed on benches out of WI and NI
- Allows for 100 mW to 20 W mirror heating
  - Power meter (will be replaced by a photodiode)
  - Motorized Brewster attenuator for power control
  - Rotor in-loop for stabilizing power
- Donut shape created with an Axicon
- Independent Central heating
  - recombined with the ring through a 1” BS 10%R
  - with a spot size tunabe moving LCH1

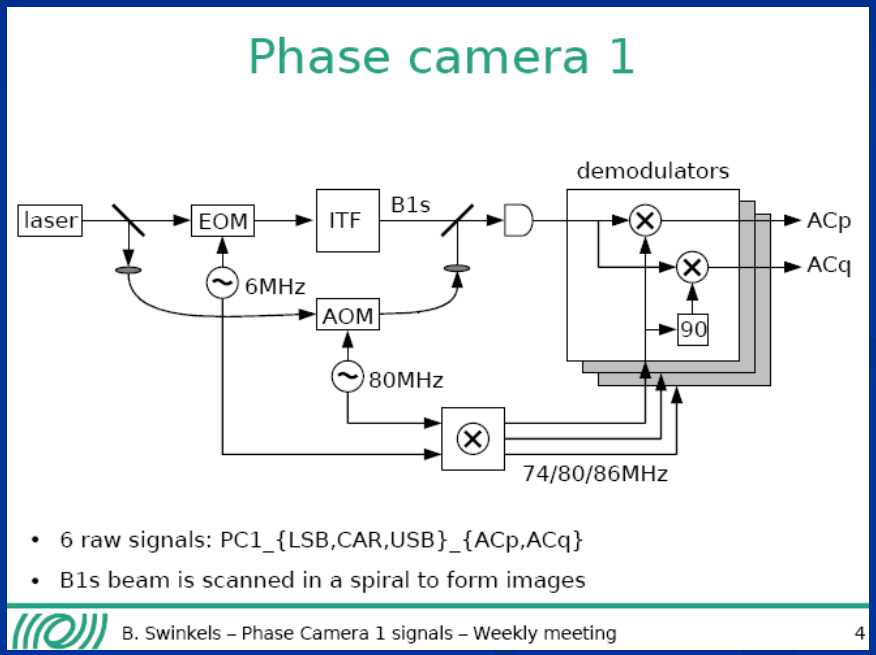






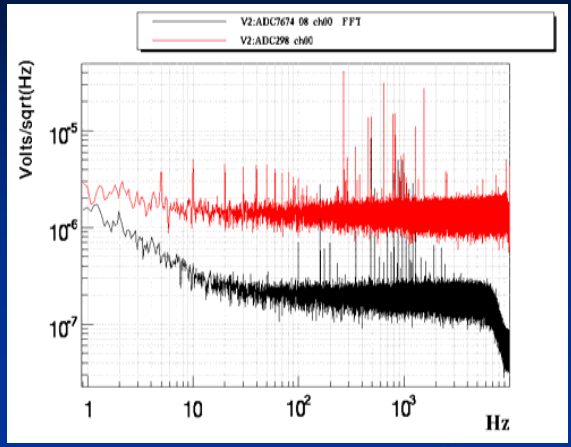
Virgo+ status: phase camera 1

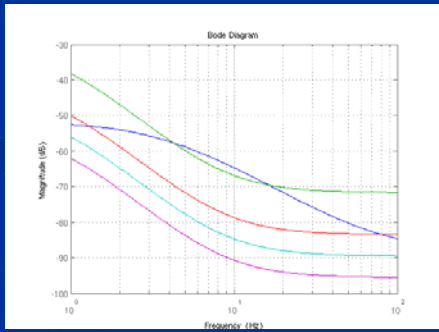
- Pin hole photodiode
- Gives independent information on the phase profile of carrier and sidebands (by spiral scanning)
- Installed on the reflection of the output mode cleaner (OMC)
  - With locked OMC gives info on the aligment of the beam
  - Needs an unlocked OMC to give info on the dark fringe actual shape
- Possibility to integrate with another photodiode used as a reference to subtract common noise

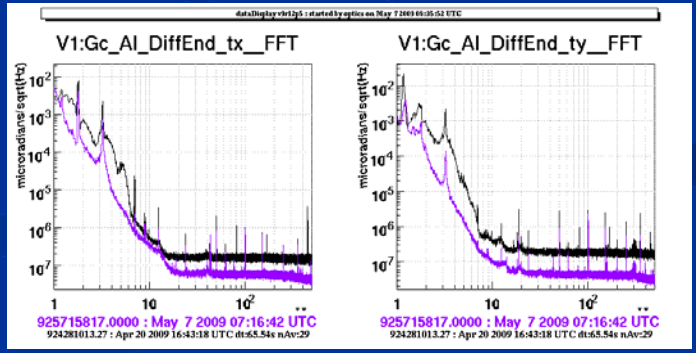


Virgo+ status: new hardware

- New ADC
  - 16 differential input channels
  - 800 kHz
  - Factor 10 lower noise floor
- New coil drivers ($TF_{DAC \rightarrow coil}$)
- New photodiodes central ITF quadrants
- New DSP
  - under testing phase

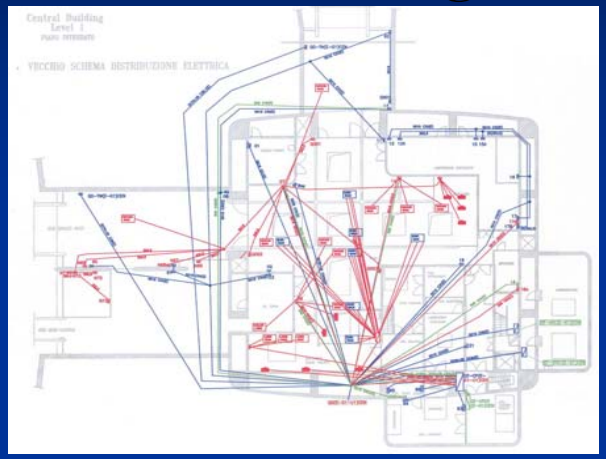






Virgo+ status: infrastructure work

- Electical net reorganization



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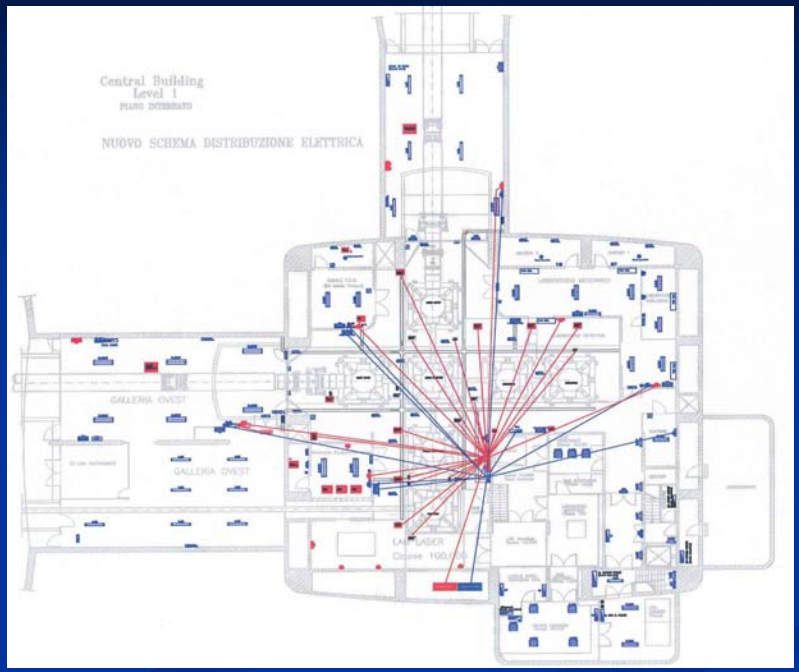

- New ground cabling

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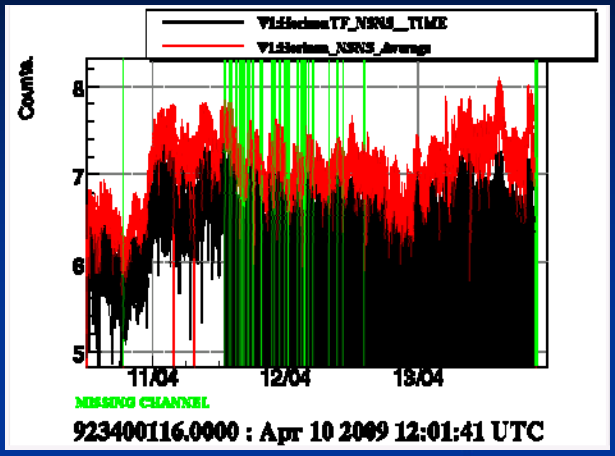
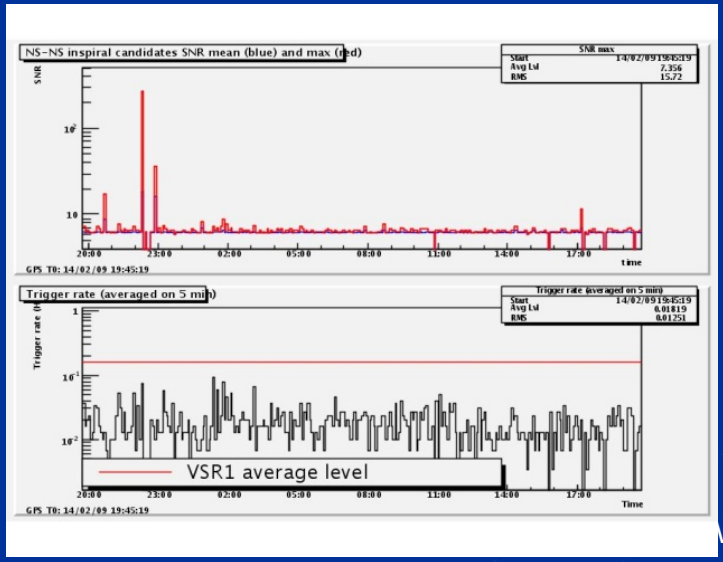
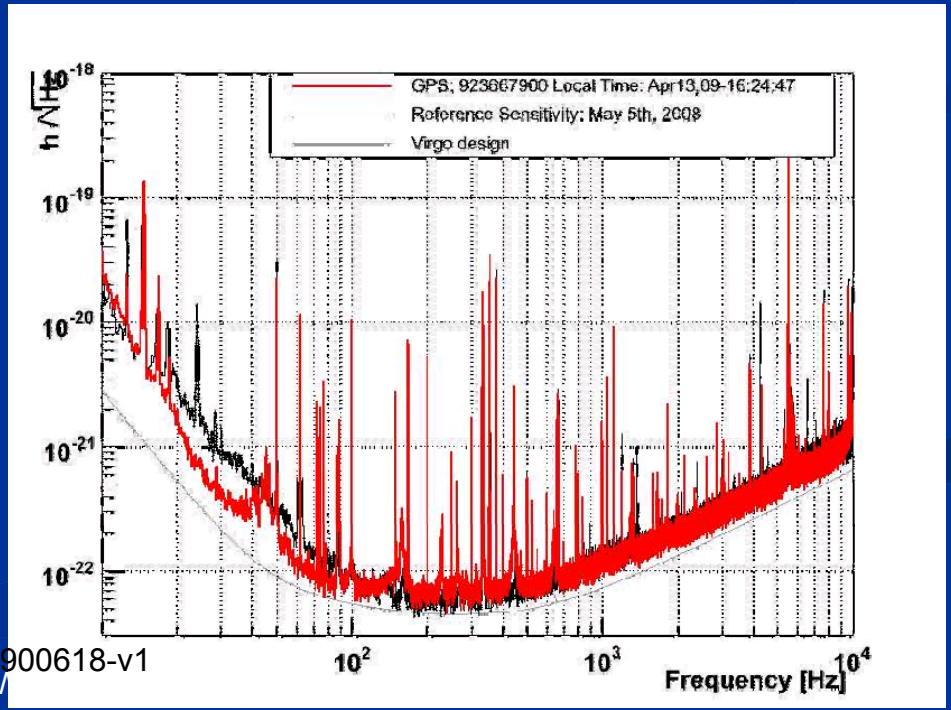
Virgo+ status: ITF performances 1/2

- Nowadays std working condition
  - 12 W input power (after IMC)
  - 3 W on WI TCS, always on to avoid etalon
- Good sensitivity reached (8Mpc)
- Good stability (81 hrs Easter lock)
- Low glitchiness (1/10 w.r.t VSR1)
- Good Gaussianity

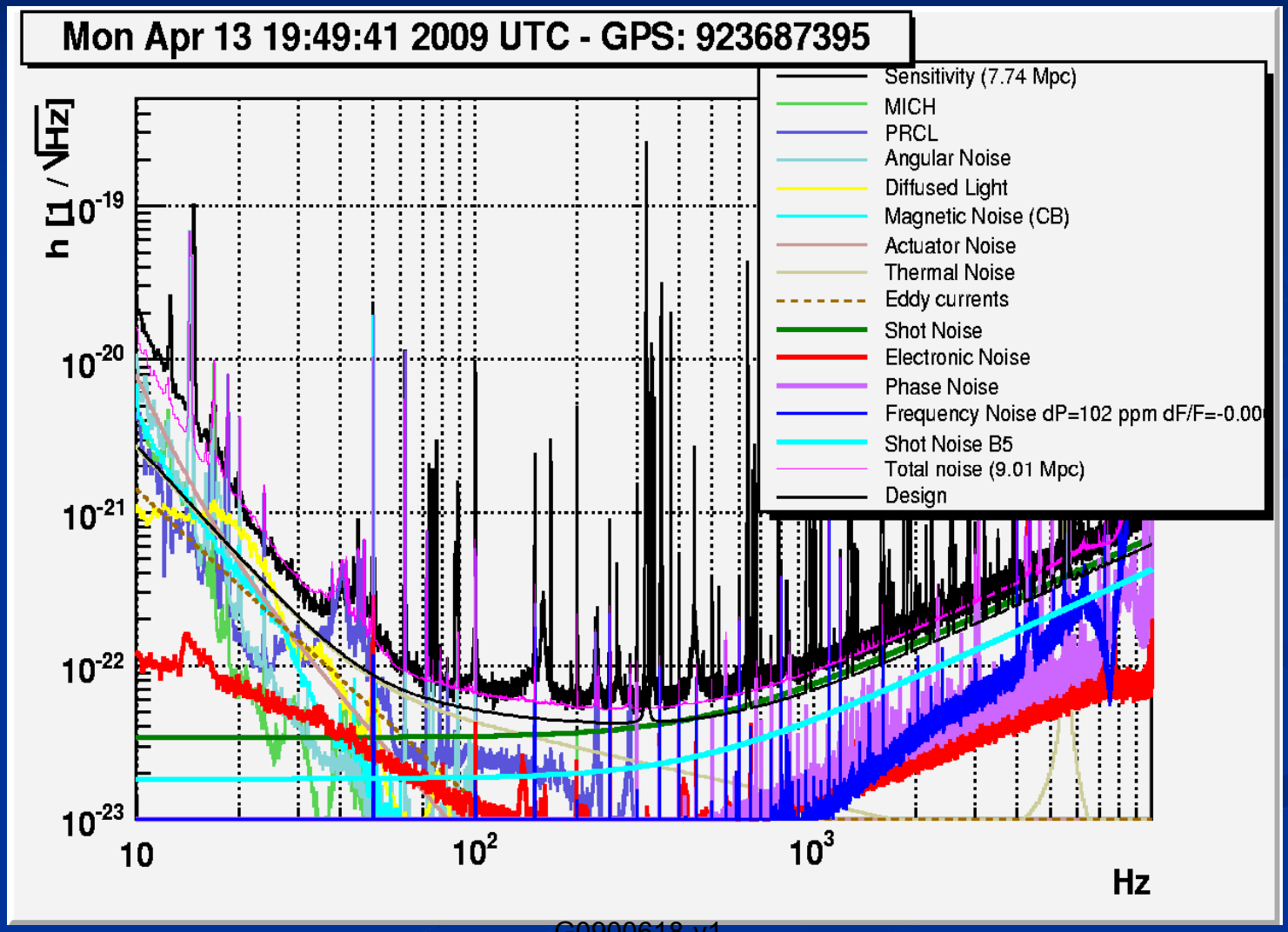






Virgo+ status: ITF performances 2/2

- Good noise understanding

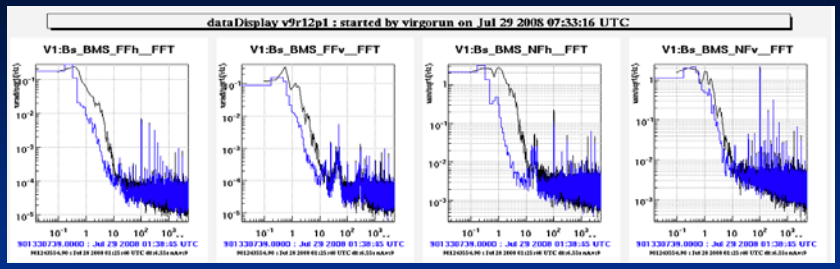


Commissioning: injection

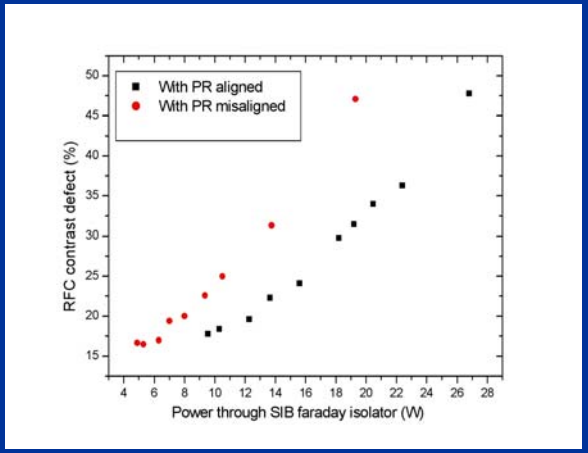
- Effect of the plexiglass cover in the external injection bench

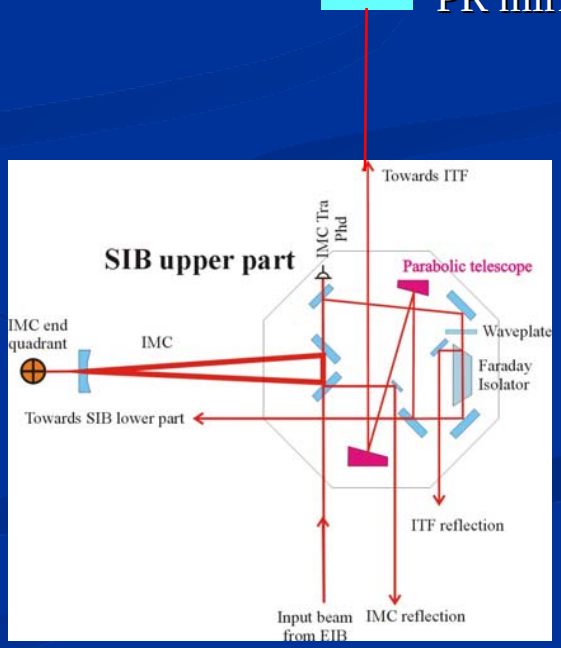
  Black: without cover

  Blu: with cover



- Laser bench temperature following PMC trans power (10 W on a beam dump) -> Water cooled beam dump
- Evidence of thermal effect in IMC cavity
  - We measured RFC contrast defect at different powers

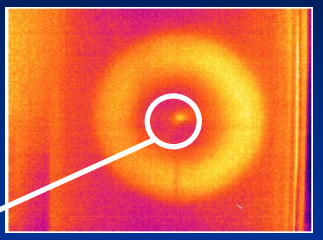


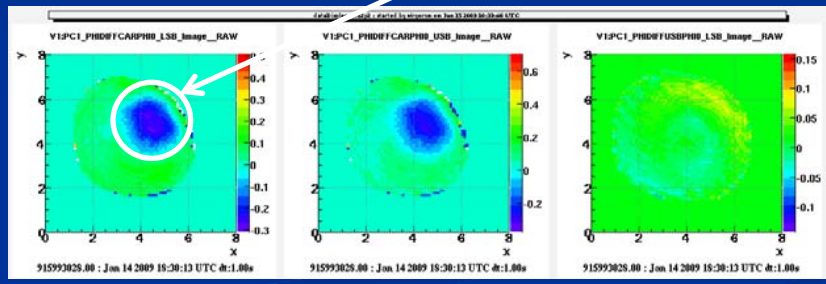


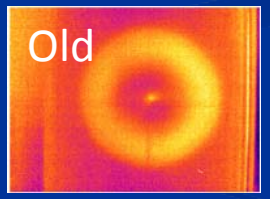
⇒ Thermal lensing in the Faraday is present but we have also some thermal lensing in the IMC cavity since with the same amount of power travelling through the Faraday, RFC contrast defect is worse when there is more power inside the IMC cavity.

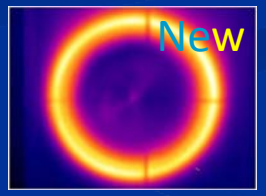
Commissioning: TCS / ph. camera

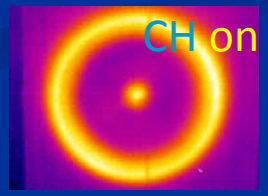
- Phase camera images useful in a qualitative way
  (See bottom images with OMC locked)
- Problem of positive curvature induced by a bright spot at the annulus center
  - Caused by the spherical aberration of a lens that is converted by the Axicon
  - Changing annulus shape
    - Weaker bright spot
- Annulus centering
  - Clear negative lens
- Central heating centering
  - Clear positive lens
  - Nedeed deeper understanding



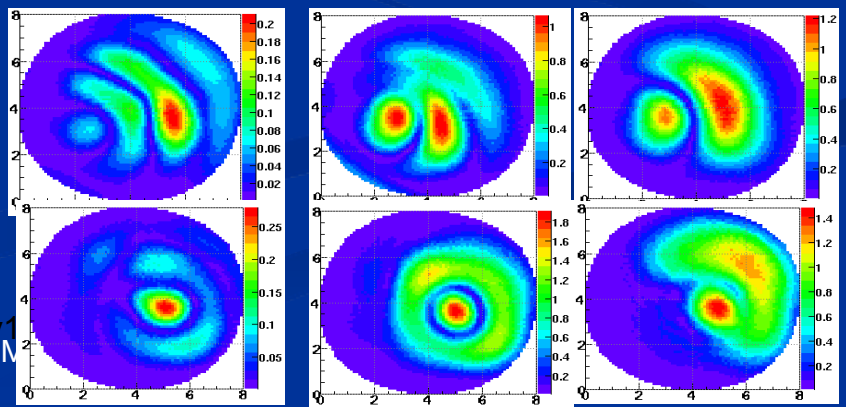








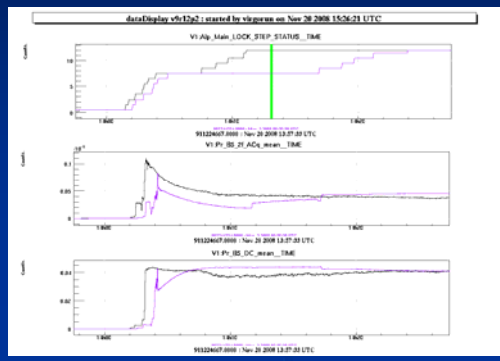
Carrier USB LSB



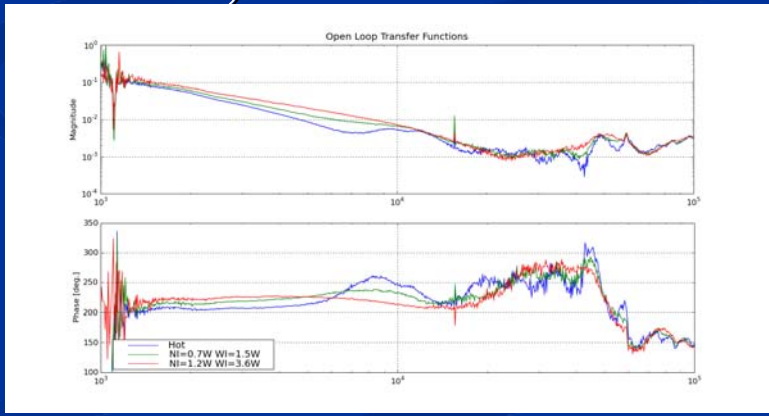
Very tiny misalignment is corrected
(<50nrad on differential end dof)

Commissioning: lock acquisition

- After summer 2008 shutdown thermal transient changed
  - More stable, smoother sidebands power transients
  - Allowed us to pass from 25 to 15 min lock acquisition
  - Related to the new operating point
    - Cause not understood (new nord end mirror?)
    - SSFS filter needed to be tuned because its OLTF changed
      - Simulation predicts the behavior (bef/aft)



- Tuned for 12 W with the use of TCS on WI only
  - Use of B2_8MHz (not sensitive to thermal transients) for PRCL
    - Except during PR mirror alignment
  - SSFS OLTF dependent on thermal effect
    - Confirmed by simulation
    - Problem because the SSFS has an analog filtering that is time demanding in updating
  - Problem of TCS laser power stability
    - Particularly big on NI TCS (waiting new chiller and new photodiode)
    - TCS WI power kept to a set point acting on a rotaror

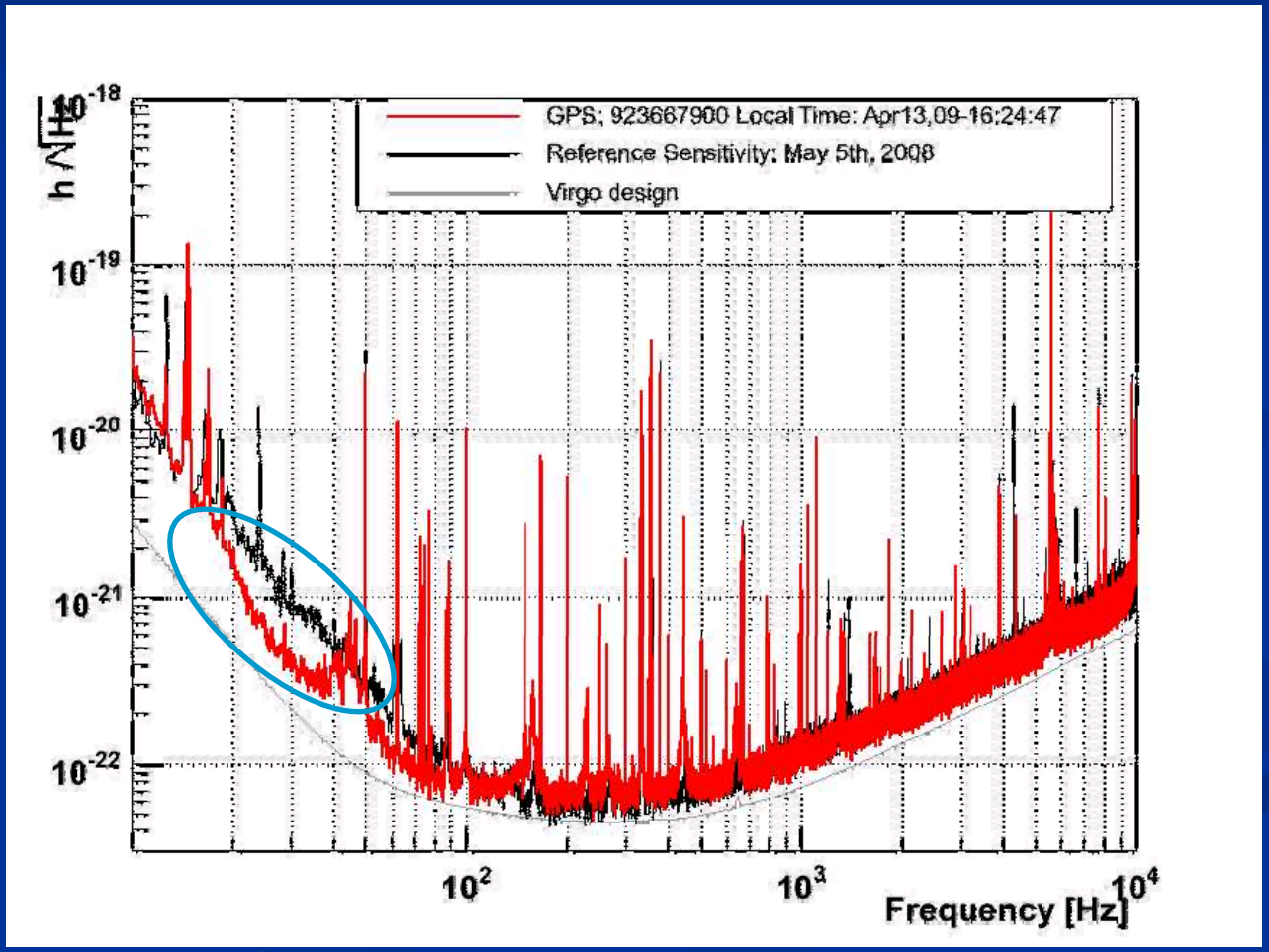


Commissioning: slow servos

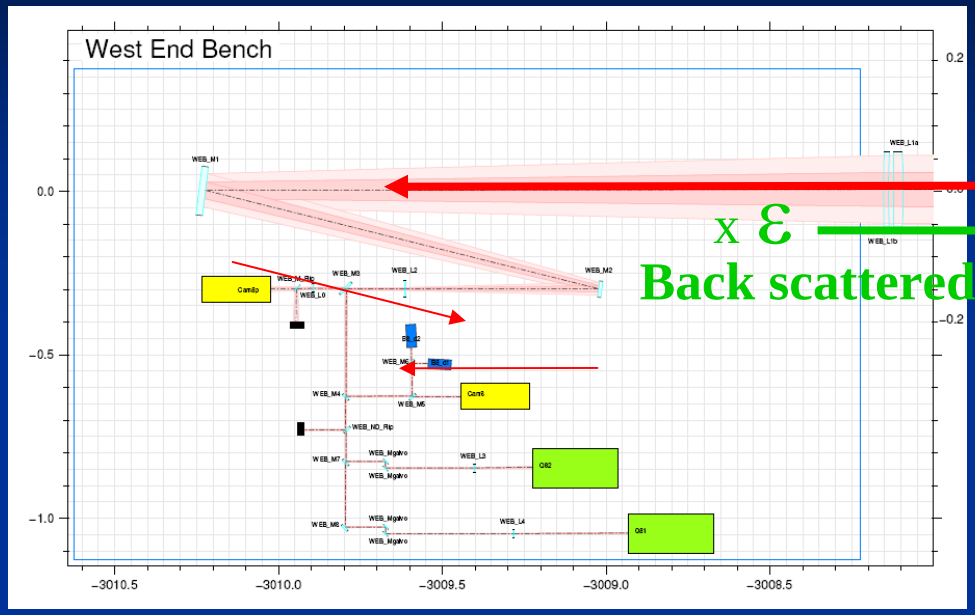
- Slow servos implemented for controlling long term drifts
  - Fluctuation of laser power transmitted by the IMC
    - Controlled through a servo acting on a rotator
  - Phase noise entering the dark fringe through B1_ACq
    - Minimized keeping B1_ACq to 0 through offset on MICH
  - Phase noise on SSFS signal
    - Minimized keeping MICH offset to 0 moving the set point of the TCS power loop
  - Etalon, clearly visible on the fraction of PRLC coupling to the dark fringe (WI heating –> change in thickness –> change in etalon –> finesse asymmetry –> pure common modes couple to differential –> PRCL enters differently the dark fringe –> gain beta changes)
    - Kept constant moving the input power of the interferometer (change of input power –> change of the lensing –> change of MICH offs –> change of annulus power –> change of mean mirror temperature)
    - Works but still has to be validate on days time scale

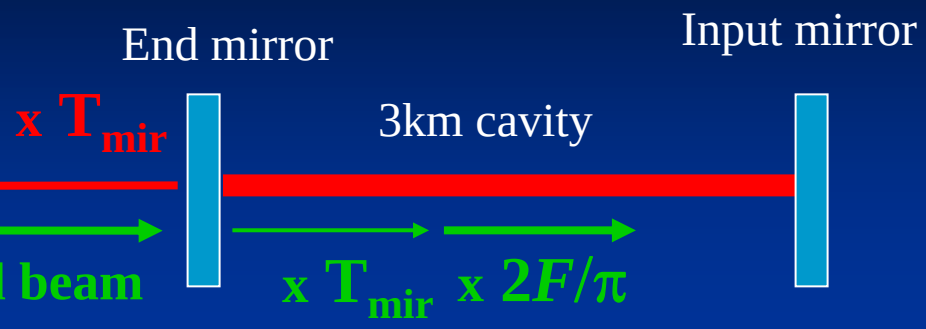
Noise hunting: Eddy currents noise

- Replacing the magnets (1/5 magnetic field) has been effective



Noise hunting: back scattered light 1/2





It is unavoidable that some light is diffused by optical components on the bench and gets back into the ITF (back scattered beam) adding as noise to the main beam.

The amplitude multiplied by: $T_{mir}\sqrt{\varepsilon}\sqrt{2F/\pi}$ = G

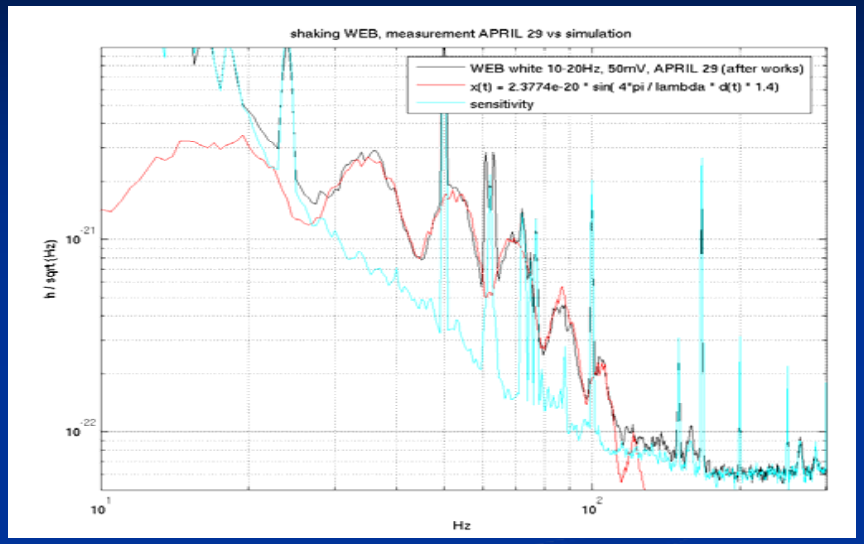
The phase modulated by the displacement of the scattering surface x(t): $\phi(t) = 2\frac{2\pi}{\lambda}x(t)$

- The noise seen at ITF output is: $h_{noise} = G \cdot \sin(\frac{4\pi}{\lambda} \cdot x(t))$
  - The model works fine
    - From noise injection measurements you can extract G coupling factors
    - From noise in std condition you can evaluate noise projection

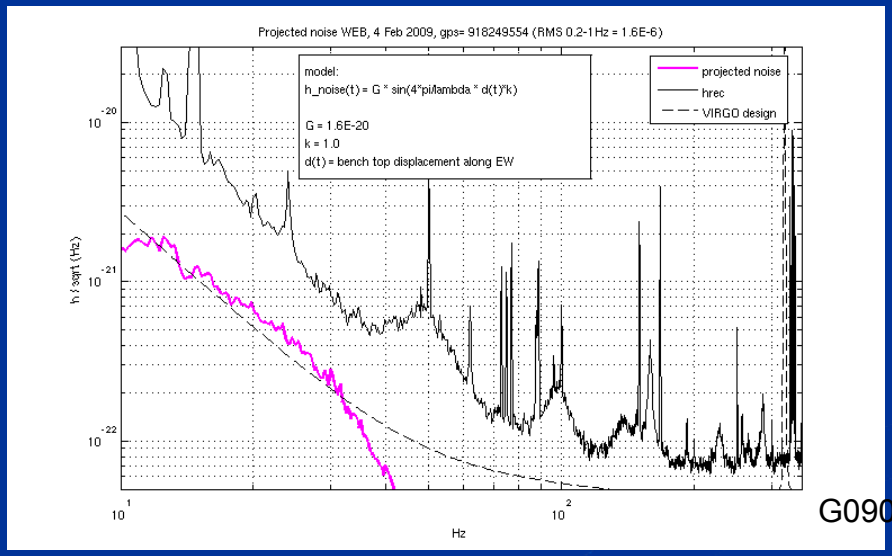
Noise hunting: back scattered light 2/2

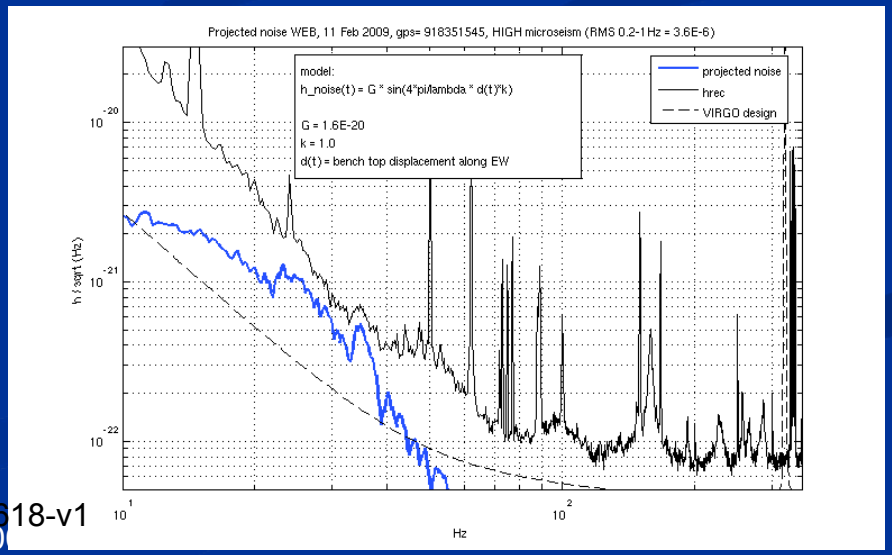
- WE bench example
  - Fit for extracting G

	NEB	WEB	EDB	EIB
G (x10^{-20})	1	2	0.7	1.2



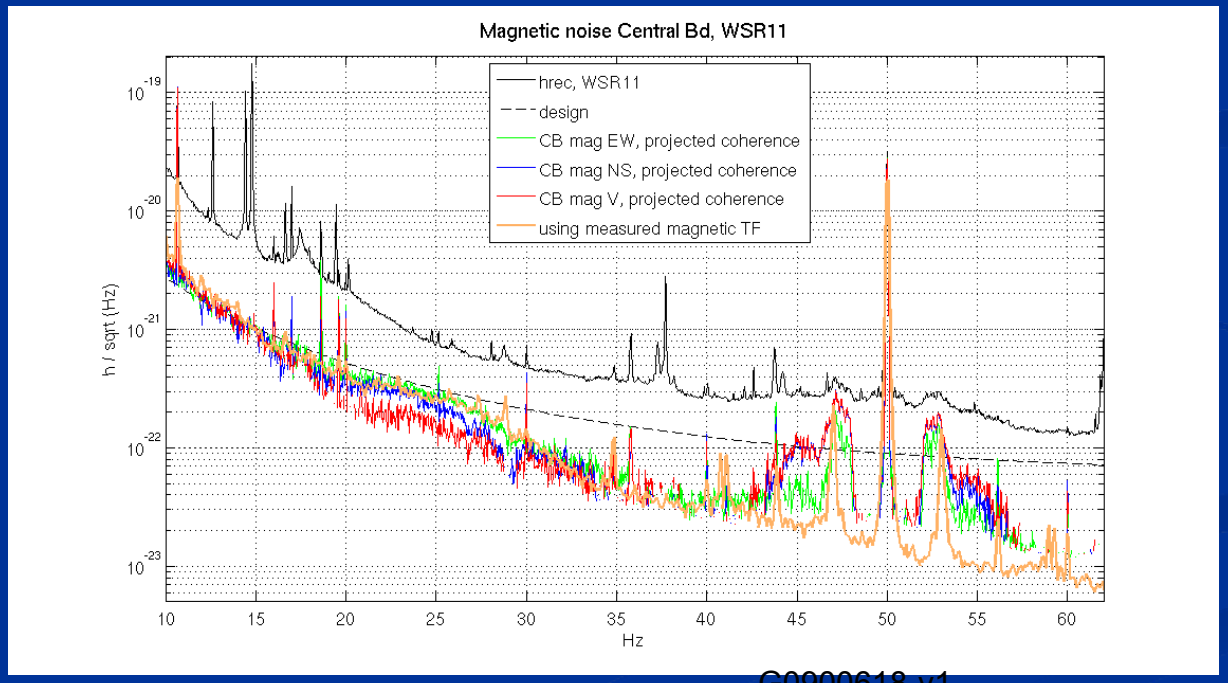
- Projections
  - Standard sea condition / strong sea condition 5 % of the time





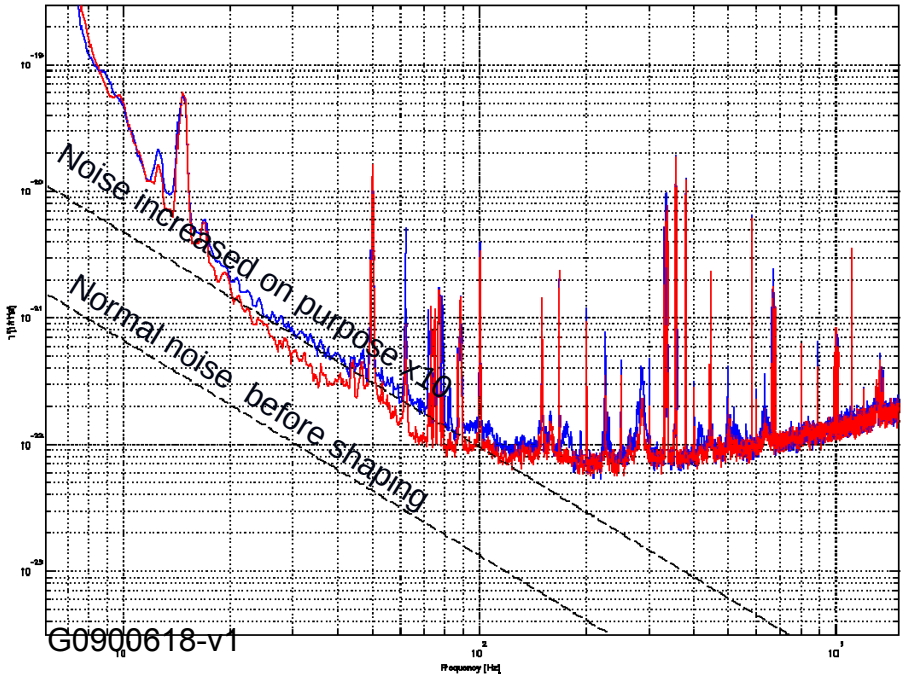
Noise hunting: magnetic noise

- Measurements performed injecting noise
  - Big coil
    - Optimized for having strong 100 Hz magnetic field
    - 1 m diameter, 50 windings, few kg
  - Noise injection campaign on central building mirrors
  - Projection for the central building mirrors



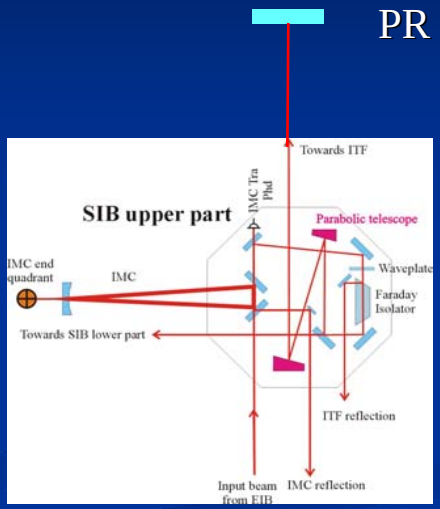
Noise hunting: DAC noise

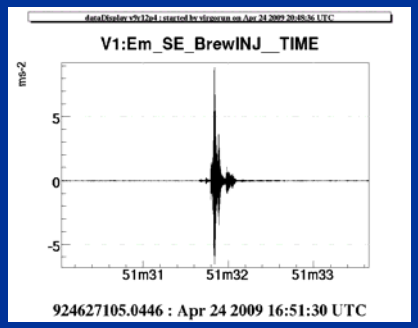
- Test on PR DAC shunting an actuation resistor
  - Gives a x10 noise increasing
  - Noise levels, shown on plot, enters the sensitivity
- Reduced PR DAC noise implementing a shaping filter
  - It was not limiting anyway
  - 100 times less noisy



Injection Brewster baffles break

- After some aligning procedure before a lock acquisition the beam became really distorted in coincidence with a "seismic" event detecded by Brewster accelerometers
- Opened both suspended injection and power recycling towers
  - Very carefully not to enhance with a differential pressure an eventual damage in the Brewster window among the 2 towers
  - Found 2 broken baffles inside the PR tower
- We used to misalign of more than 5 mrad PR mirror and the direct reflection clearly burnt one of them in 2 spots
- 1W/mm^2 absorption limit was high but measured in-air
- Removed both of them
  - Seems not to be a problem without them



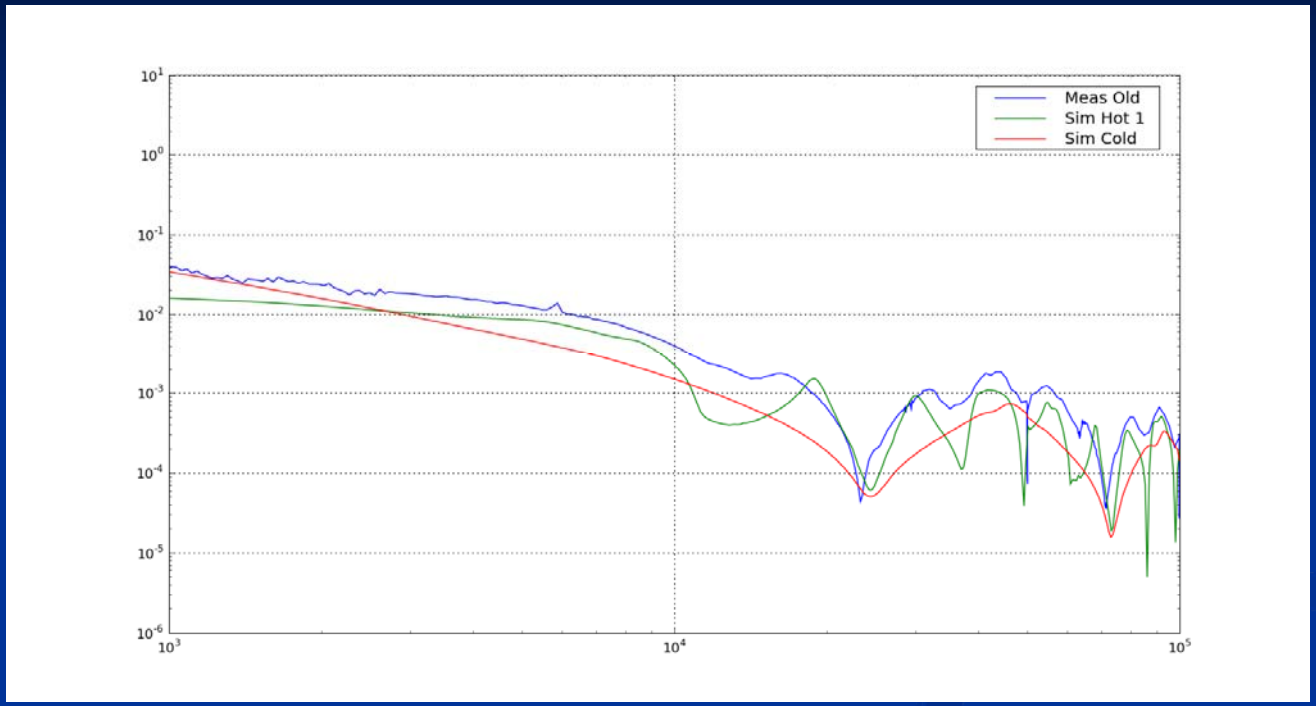


Next steps towards VSR2

- Test 18 W lock acquisition with TCS on both input mirrors (ongoing this week)
- Move up to 25 W
- Freeze the ITF configuration preparing for the run
  - Perform final calibration measurements
  - Continue noise hunting profiting of the continuity of the ITF operation
- VSR2 in coincidence with LIGO from July the 6th

… monolithic suspension installation

THE END


Meas Old
Sim Hot 1
Sim Cold
10^{1}
10^{0}
10^{-1}
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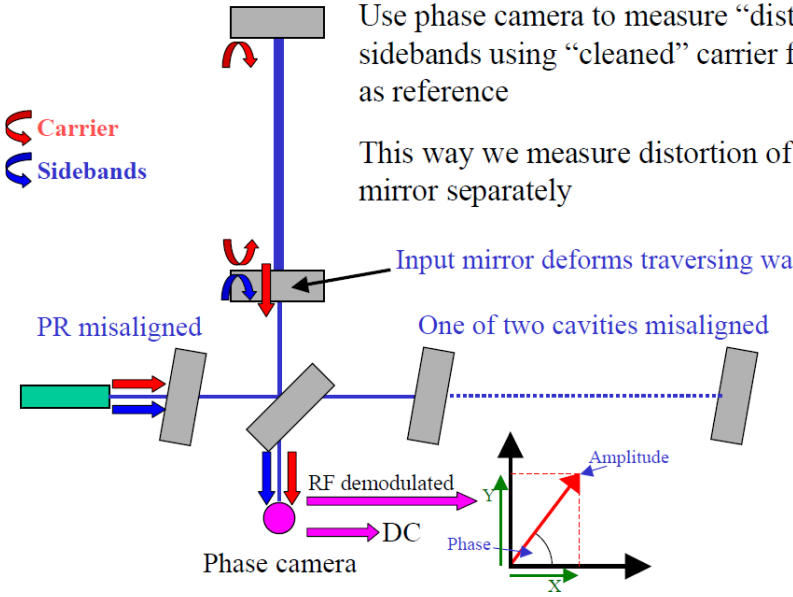
Spare slide: TCS calibration with phase camera

Proposed solution

Use single Fabry-Perot cavity



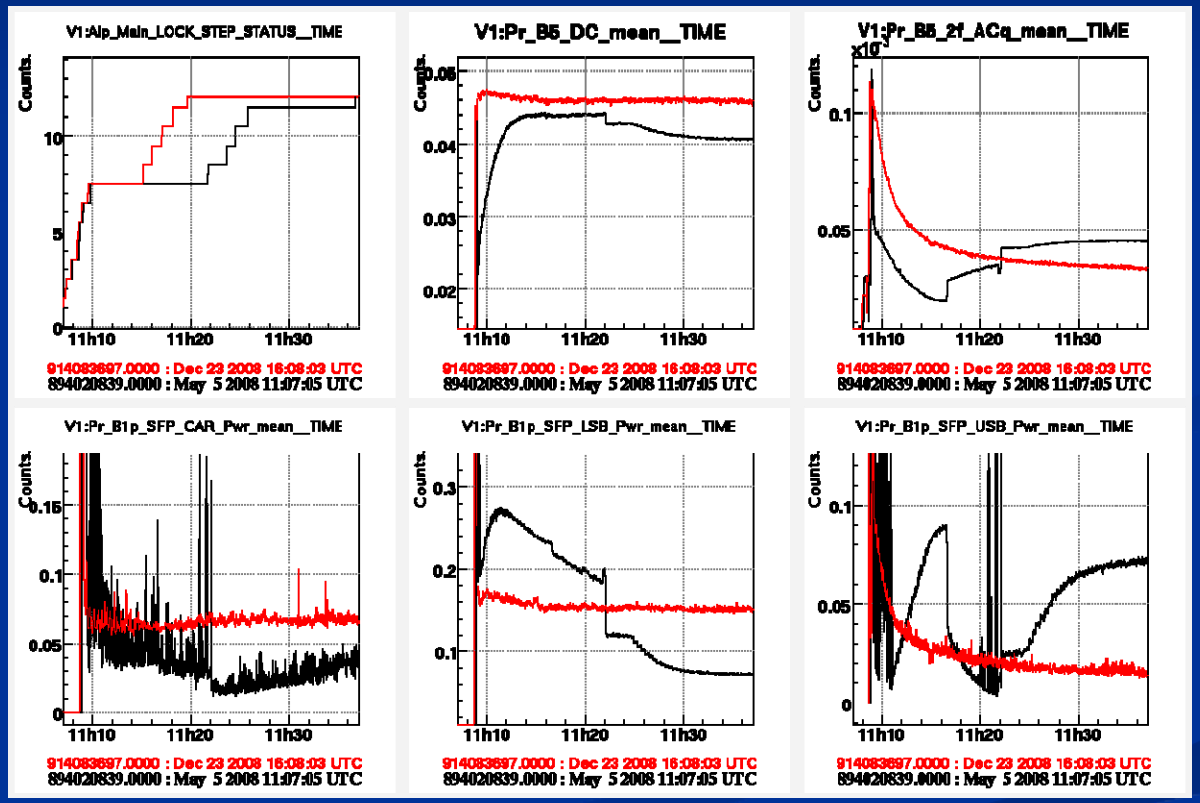
Calibration procedure

Calibration would go something like this:

1. Measure distorsion on cold mirror.
2. Carry out full lock at 8 W.
3. Measure distorsion straight after lock.
4. Switch on central spot and obtain same distorsion as fully locked ITF at 8W (3).
5. Swich on heating ring and obtain same distorsion as cold mirror (1).
6. Carry out full lock at 8 W switching off central spot when lock obtained.
7. Measure distorsion straight after lock to check that distorsion is equivalent to cold ITF.
8. Carry out full lock at 16 W with thermal compensation for 8 W laser.
9. Measure distorsion straight after lock.
10. Increase power of central spot (with heating ring for 8 W laser still on) to obtain same distorsion as fully locked ITF at 16 W (9).
11. Increase power of heating ring to obtain same distorsion as cold mirror (1).
12. Carry out full lock at 16 W switching off central spot when lock obtained.
13. Measure distorsion straight after lock to check that distorsion is equivalent to cold ITF.
14. [illegible] this way until we reach full laser power.

Spare slide: Different locking working point

- Since first lock acquisitions after restart, different thermal transient
  - ITF shows no more bi-stability
  - But it seems much more robust during transient
  - Lock acquisition could be simplified
  - Shorter lock acquisition by 10 minutes



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