LIGO-G050510-00-Z

# The status of VIRGO

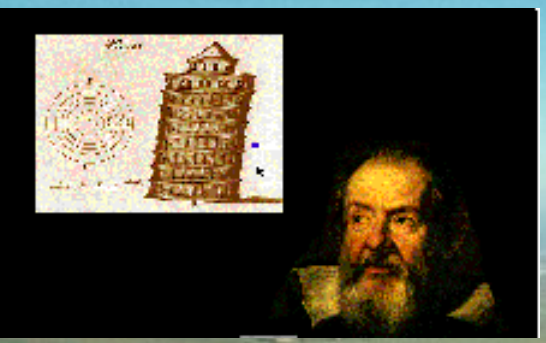
Giovanni Losurdo -INFN Firenze-Urbino

*on behalf of the*

Virgo Collaboration

Workshop on GW detection- Gingin, Oct. 4-7, 2005

VIRGO



***FRANCE - CNRS***

- ESPCI – Paris
- IPN – Lyon
- LAL – Orsay
- LAPP – Annecy
- OCA - Nice

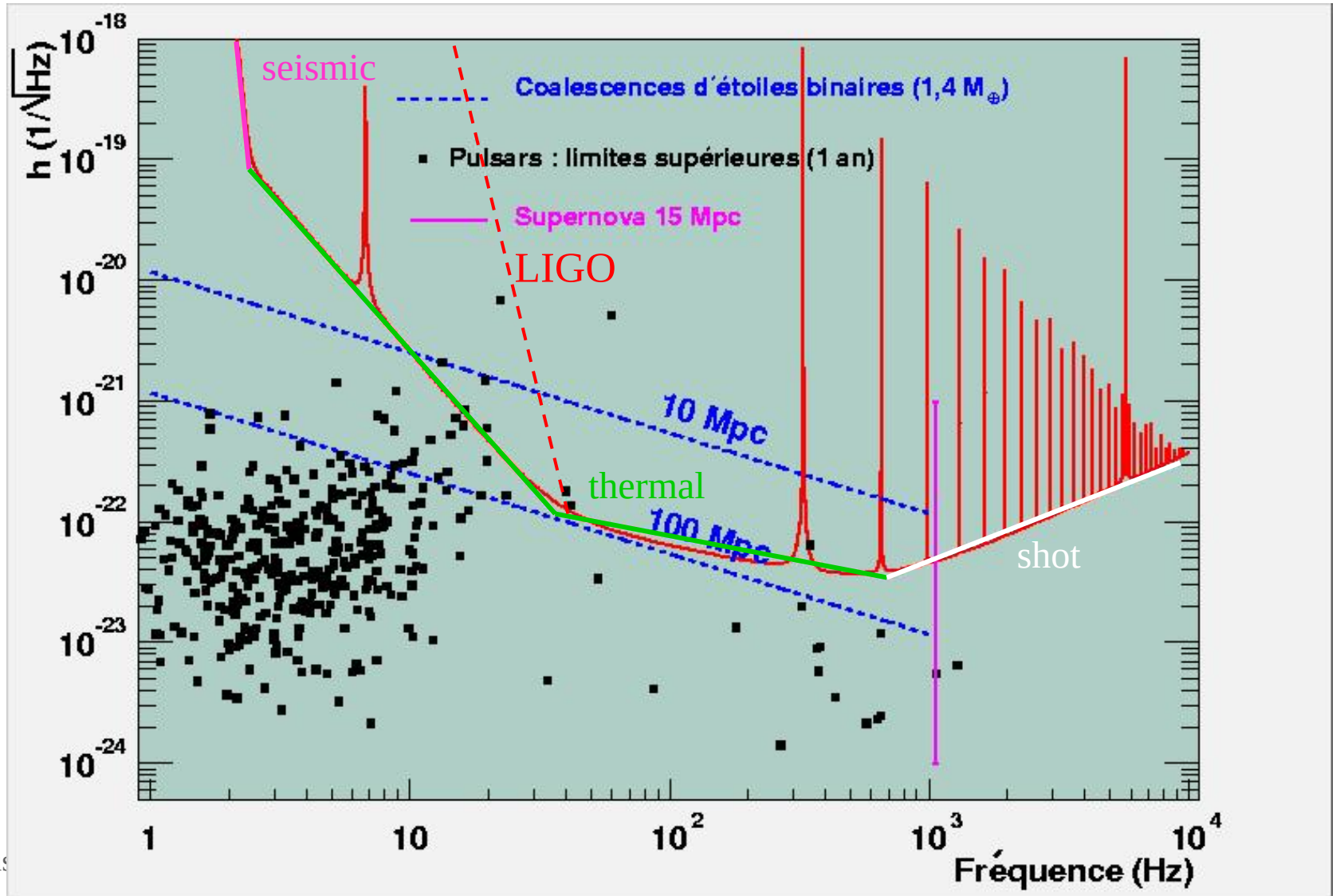
***ITALY - INFN***

- Firenze-Urbino
- Frascati
- Napoli
- Perugia
- Pisa
- Roma

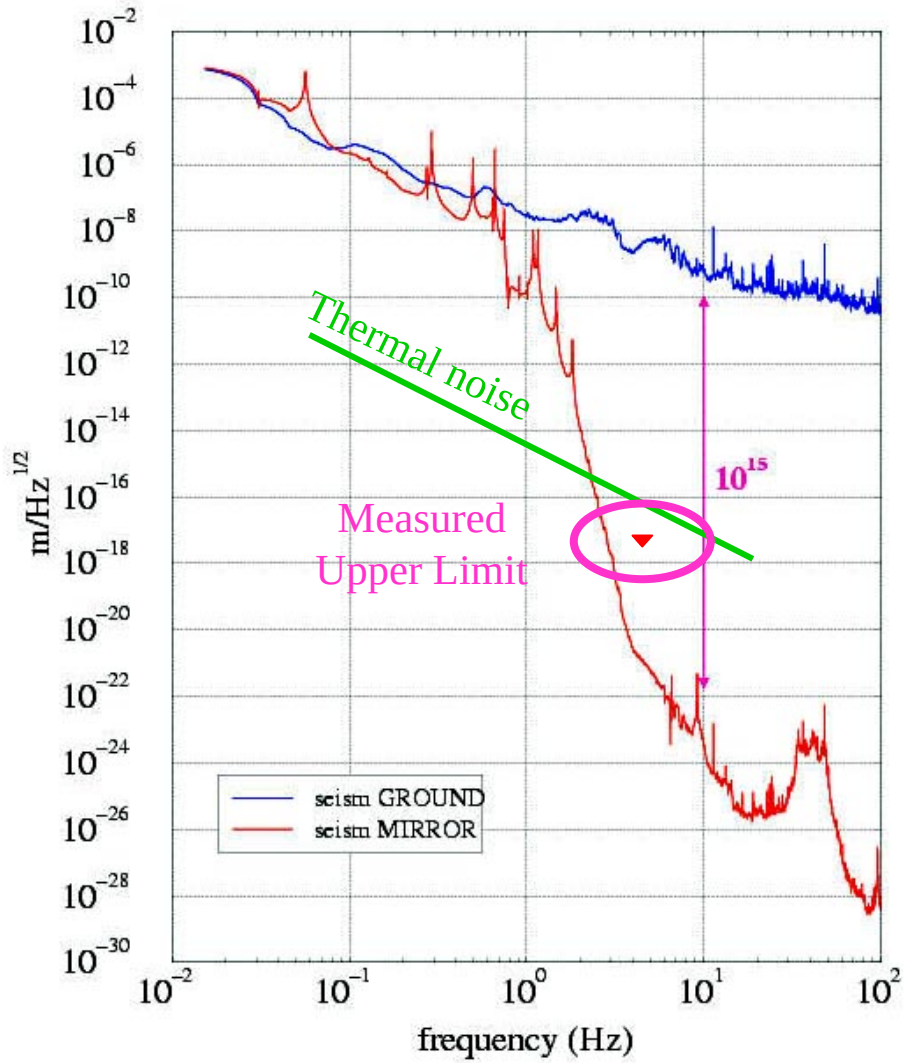
*Inaugurated July 2003*

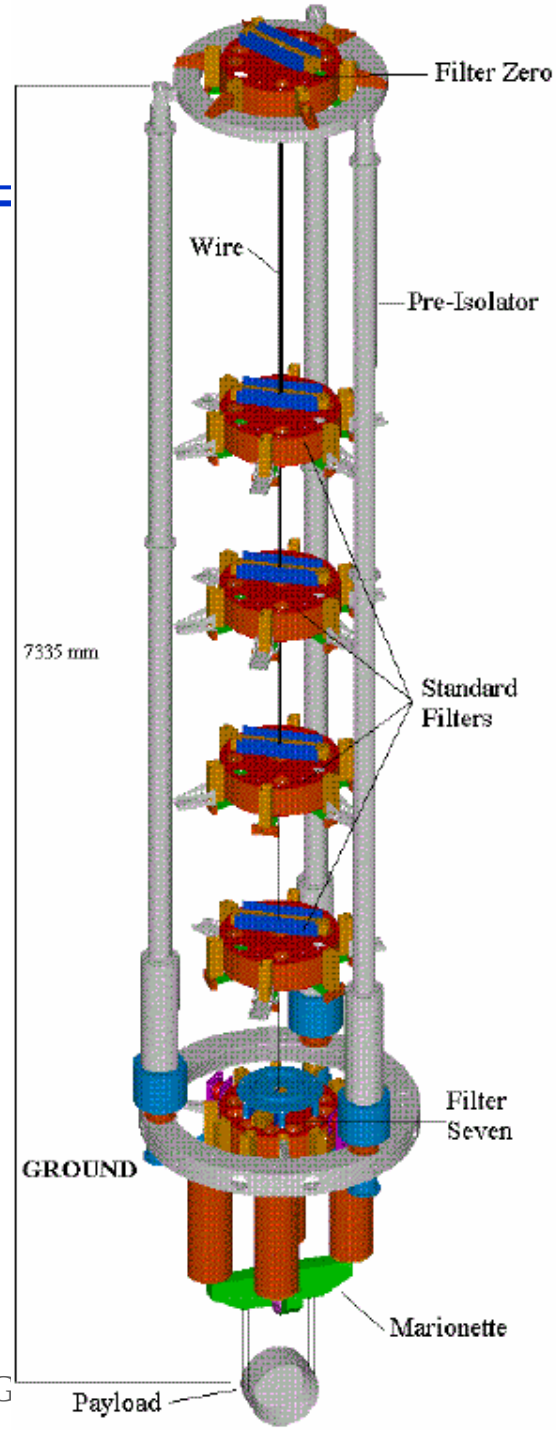
# Sensitivity Goal

*First attempt to extend the detection band down to a few Hz!*



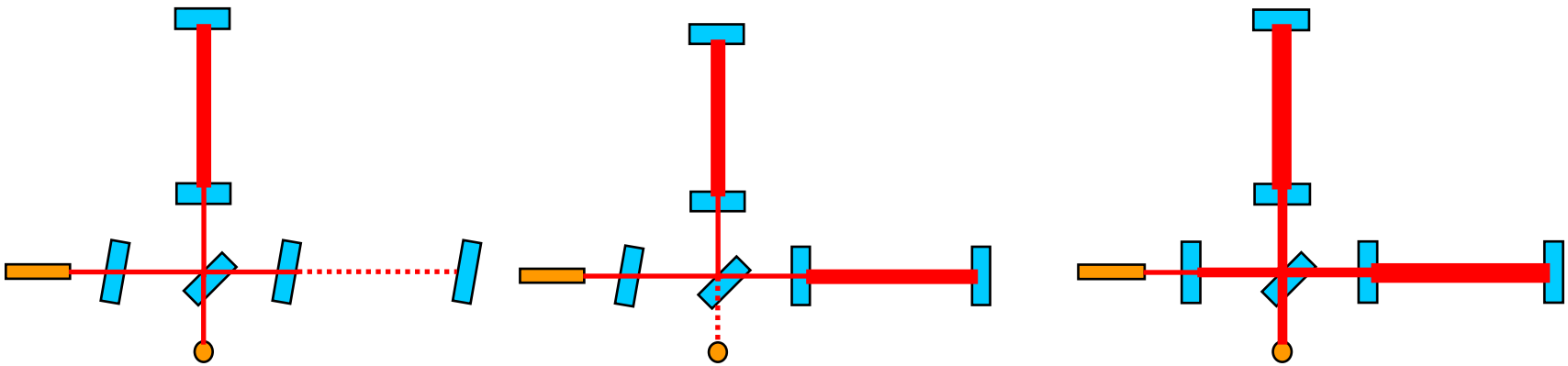
# The superattenuator



# A short summary

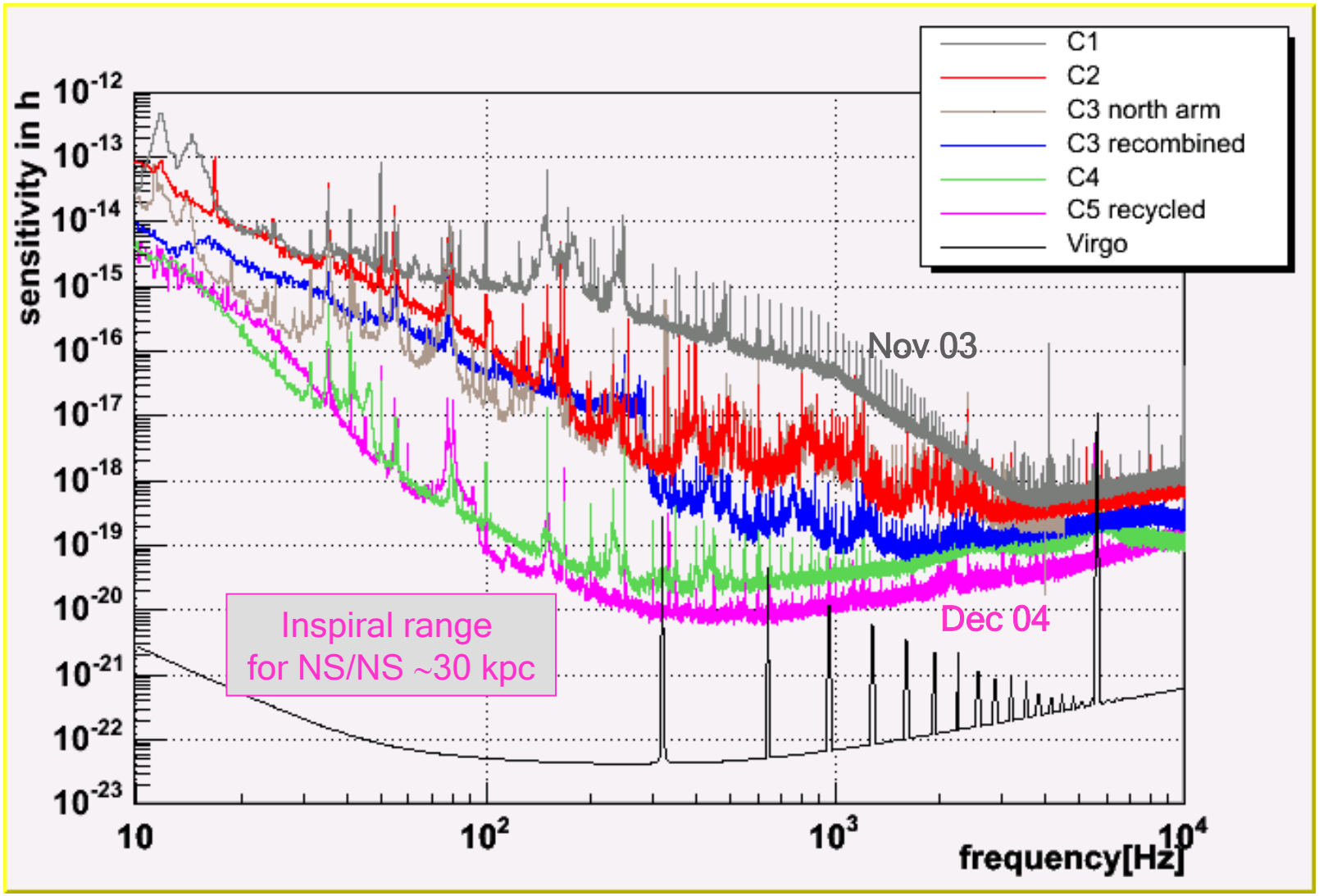
- July 2003: Inauguration. Start of full detector commissioning
- February 2004: first lock in “recombined” mode (Michelson+FP)
- October 2004: first lock in “recycled” mode
- September 2005: inspiral range for NS/NS >1 Mpc



Autumn 2003: single cavity

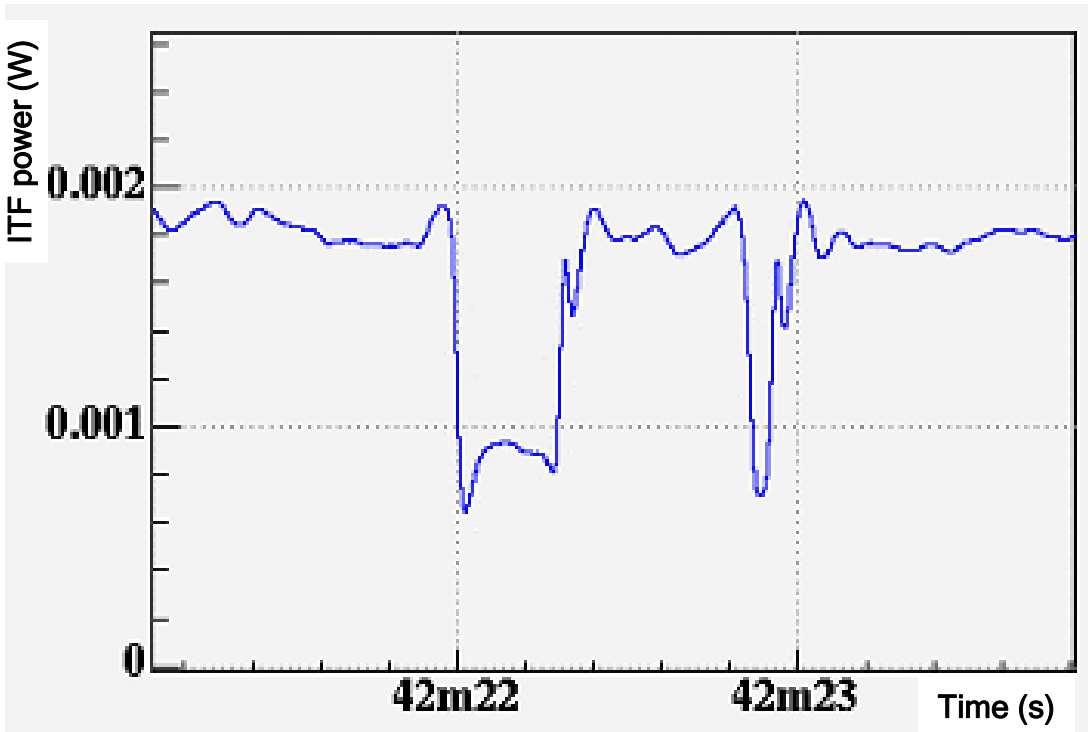
Feb. 2004: recombined

Oct. 2004: recycled


C1
C2
C3 north arm
C3 recombined
C4
C5 recycled
Virgo
sensitivity in h
$10^{-12}$
$10^{-13}$
$10^{-14}$
$10^{-15}$
$10^{-16}$
$10^{-17}$
$10^{-18}$
$10^{-19}$
$10^{-20}$
$10^{-21}$
$10^{-22}$
$10^{-23}$
10
$10^2$
$10^3$
$10^4$
frequency[Hz]
Nov 03
Dec 04
Inspiral range
for NS/NS ~30 kpc

# ITF bistability

- Jan-May 05: commissioning slowed down by ‘jumps’
- Physical origin not fully understood. Solved after work on alignment, locking, detection



C6 and before

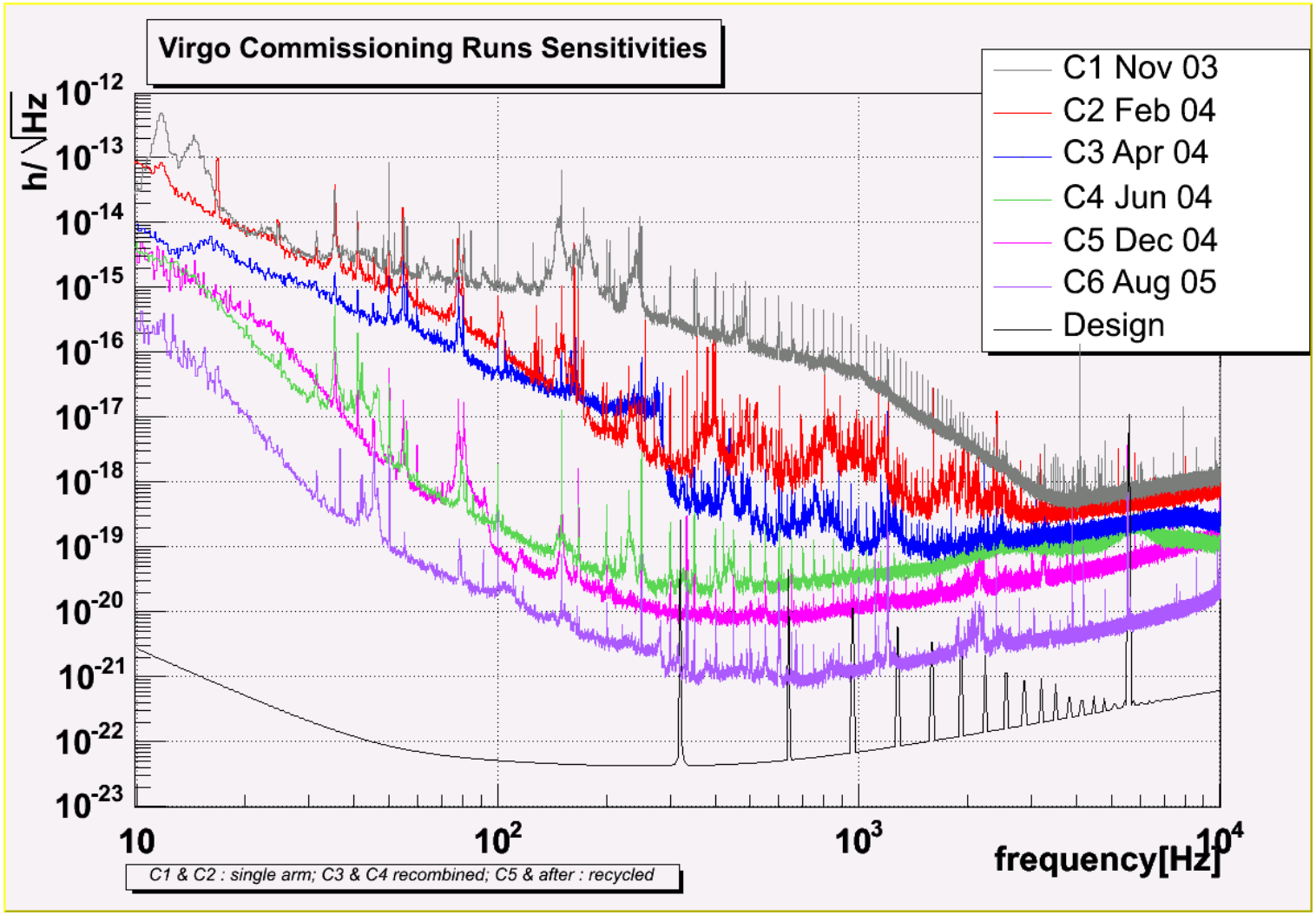
(June-July 05)

- Some ITF adjustments (injection bench alignment, tuning of demodulation phases, photodiode centering) allowed to get rid of the 'jumps'
- ITF stability improved by implementing angular drift control using wavefront sensing
- Low frequency control noise reduced by improving the locking driving matrix
- Locking procedure fully automated

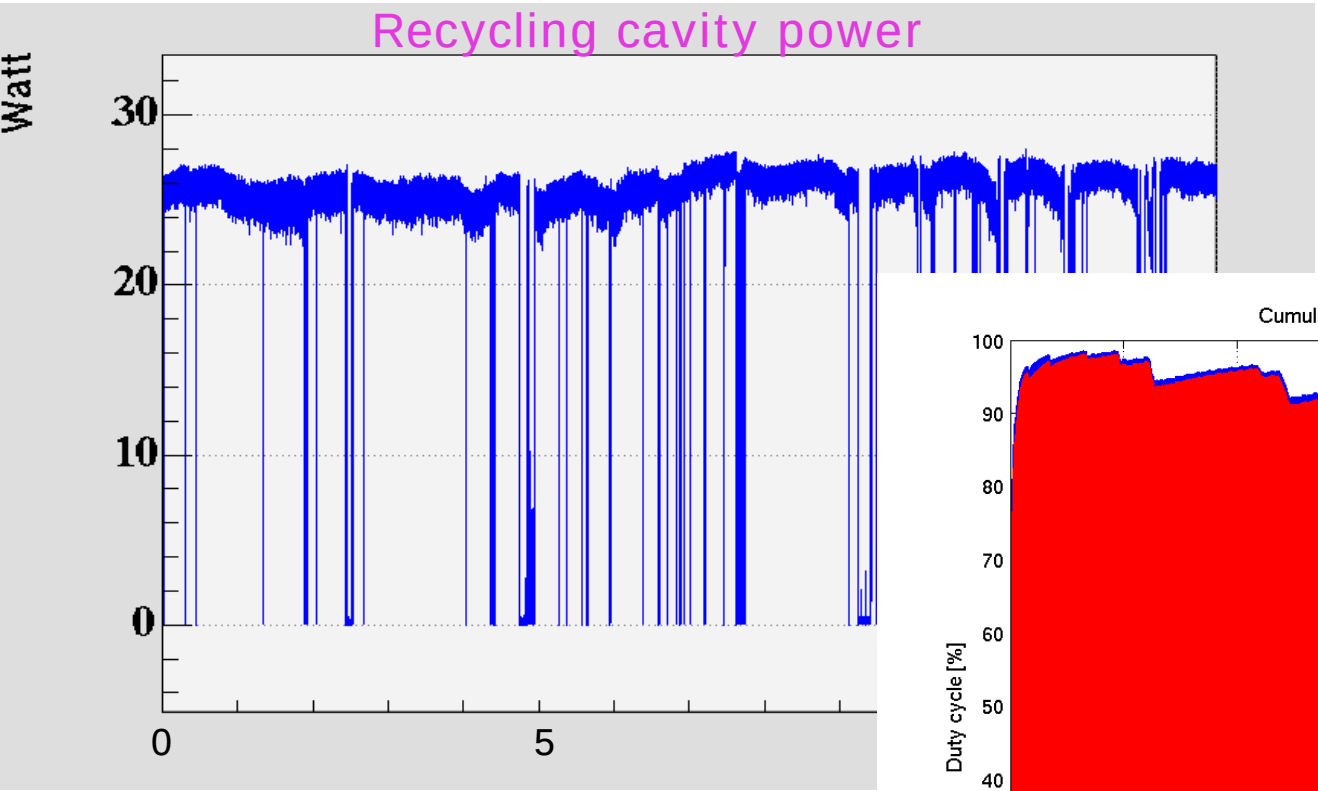
***15 days run** (29 July - 12 August)*

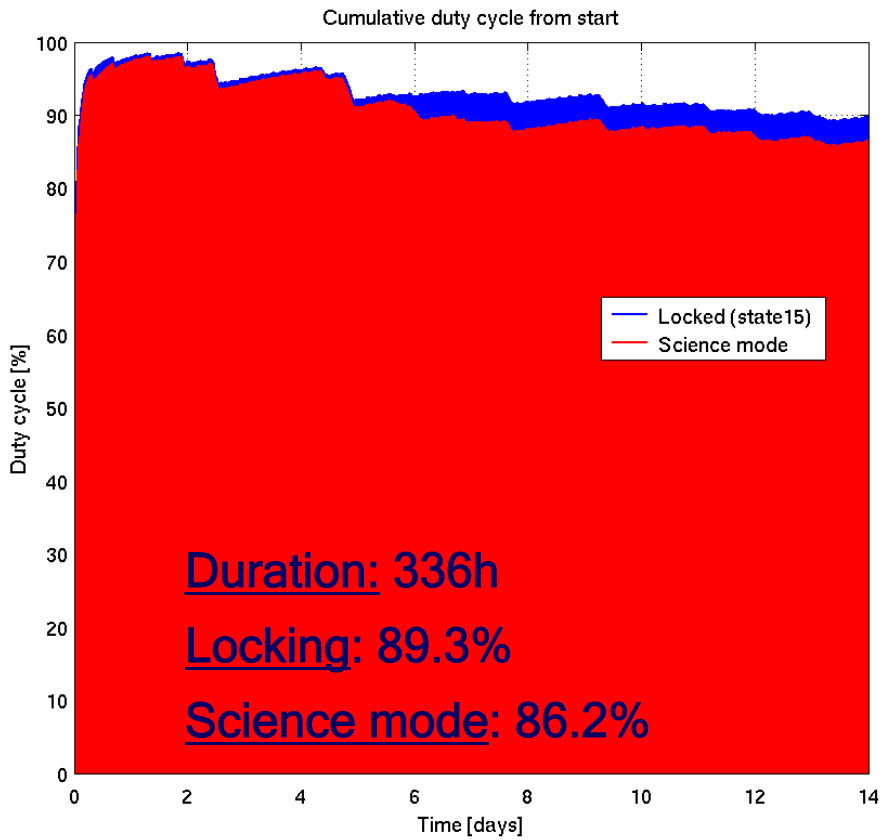
*Remarkable improvement in sensitivity and stability*

# C6 sensitivity



# C6 stability

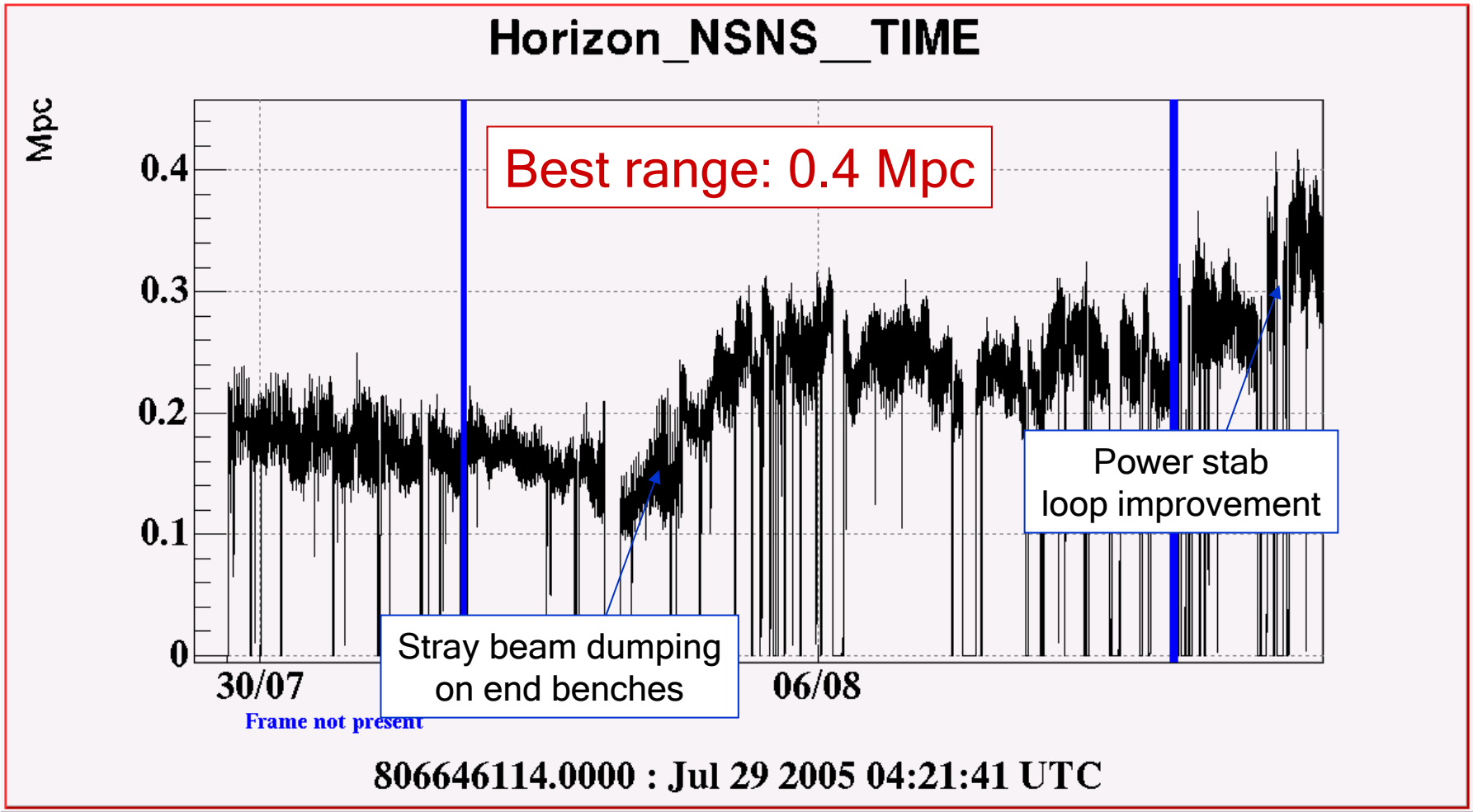



Longest lock stretch: 40 hours!

# C6 inspiral range

Inspiral range for NS/NS: optimal orientation

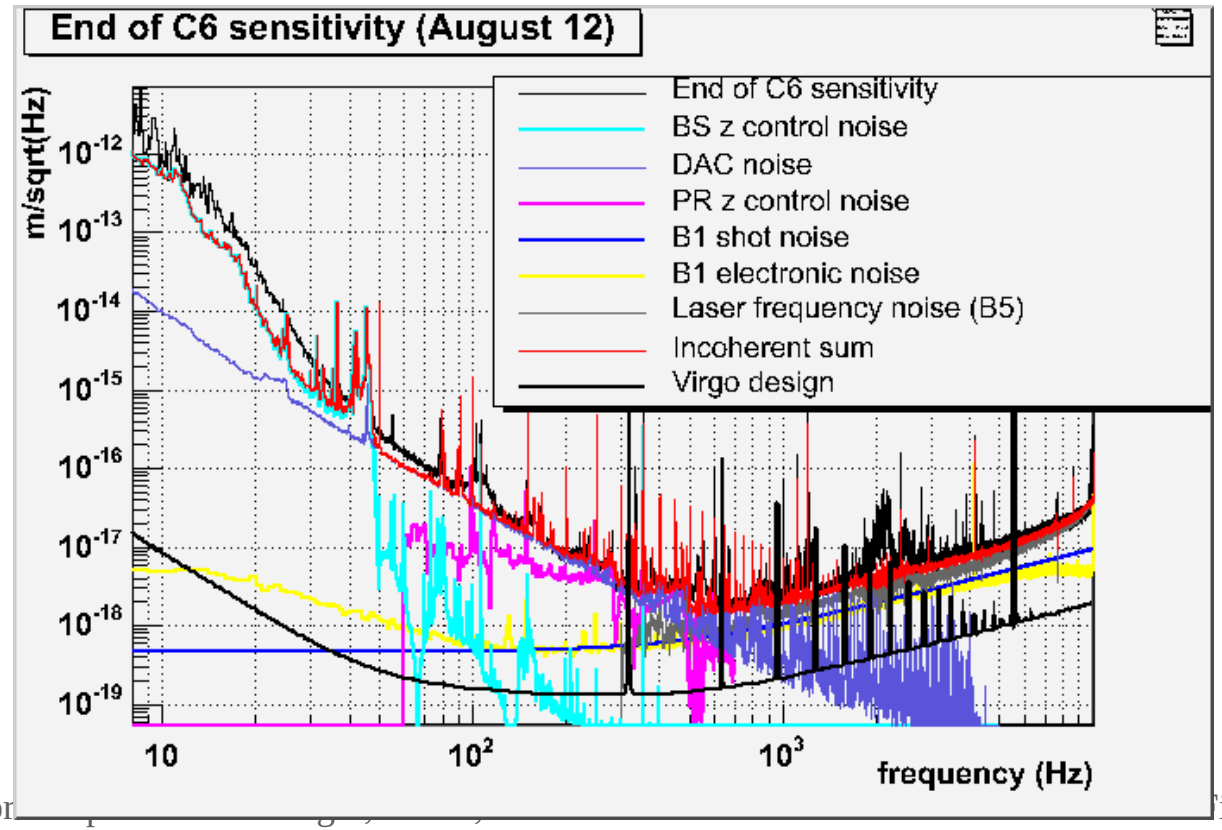



on NE bench

# C6 noise budget

Noise fully understood. Main contributions:

- Length/angular control noise
- Actuation (DAC) noise
- Frequency noise



# After C6

(mid Aug-mid Sep 05)

# Actions after C6

- Control noise reduction:
  - *Autoalignment fully implemented!*
  - Better length control noise rejection
  - Increase of modulation depth
- DAC noise reduction
  - *Full hierarchical control implemented (actuation over 3 stages)*
  - Low gain/noise coil driver
- Frequency noise reduction
  - More power on the photodiode providing the error signal

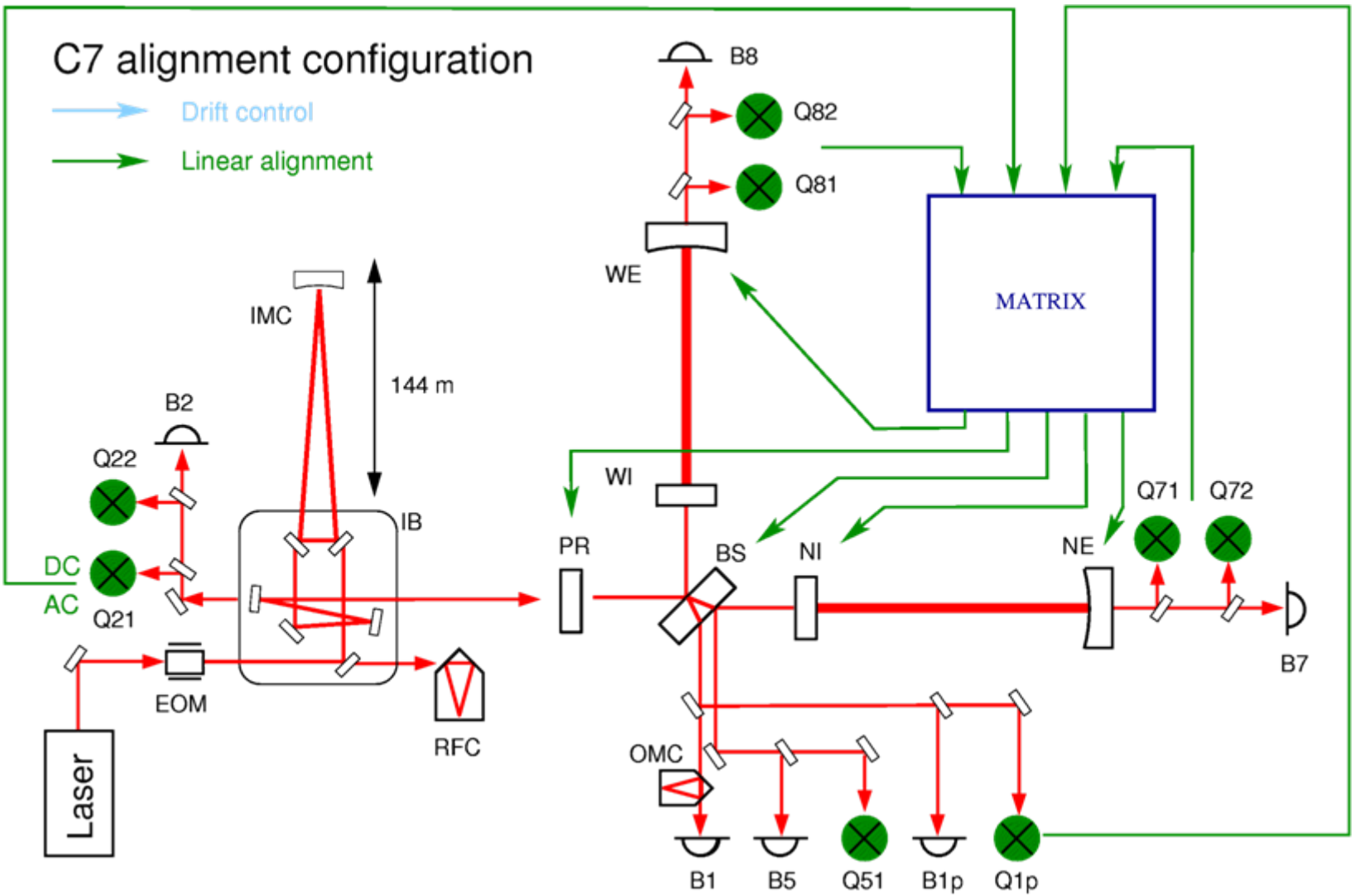
**Important achievements:**

Anderson technique demonstrated

SA control design demonstrated

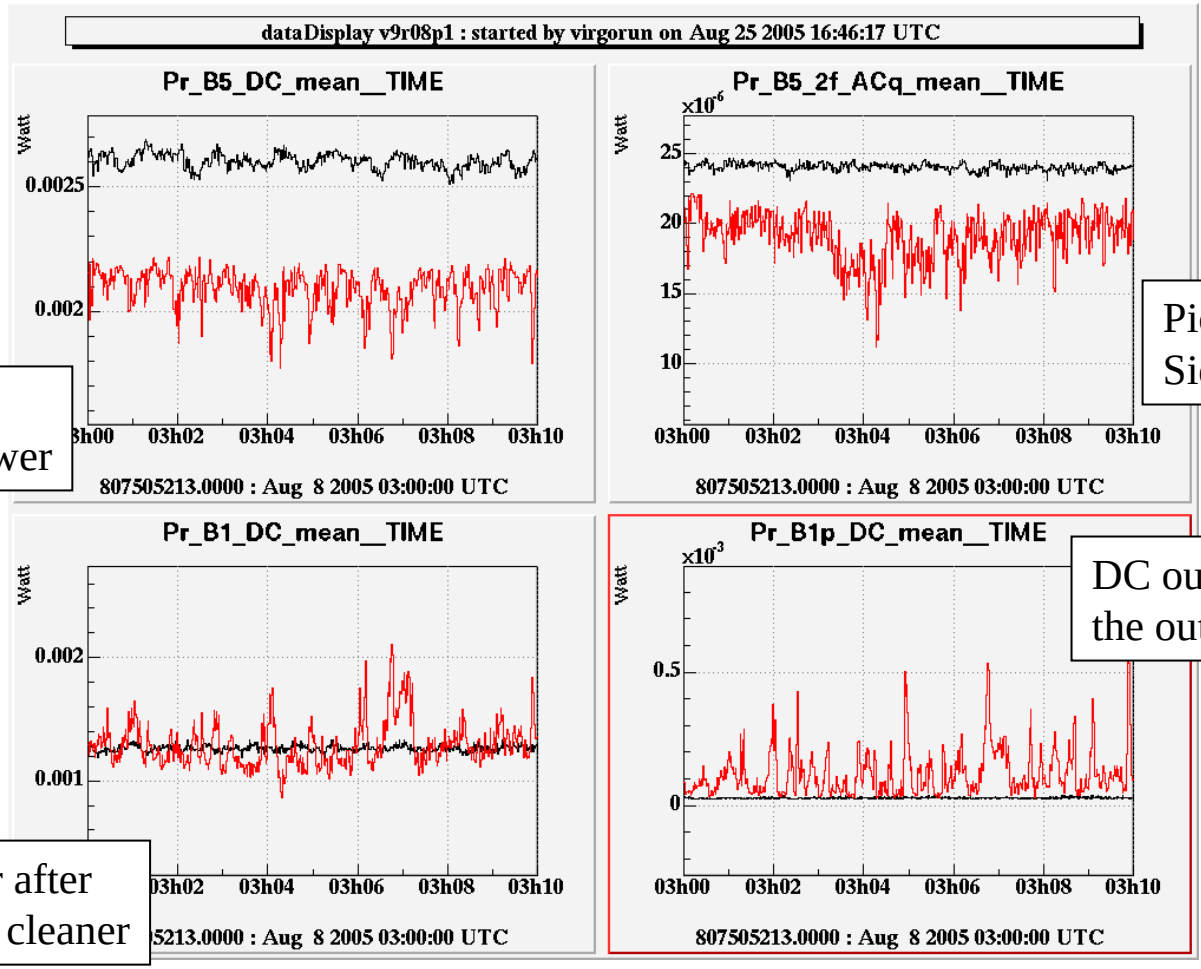
*ITF left locked during night !*

# Autoalignment



# AA effect on ITF signals

Automatic alignment of NE mirror using wavefront sensing of output dark-fringe: NO, YES




Pick-up of power recycling cavity power

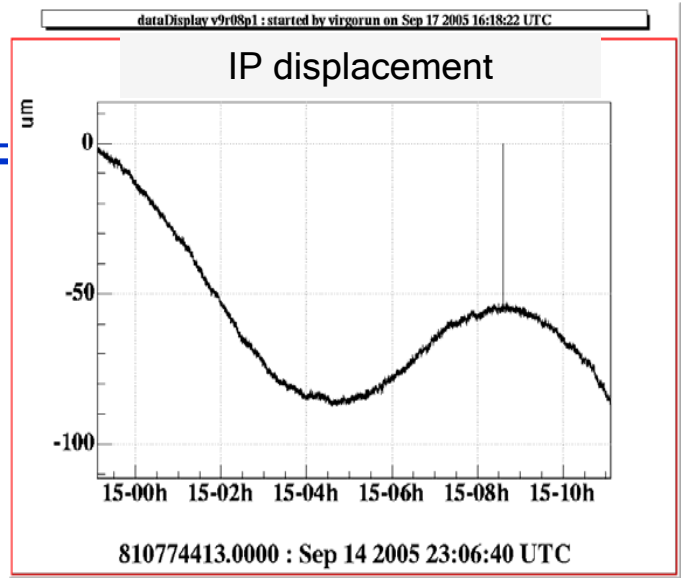
Pick-up of Sideband power

DC output power before the output mode cleaner

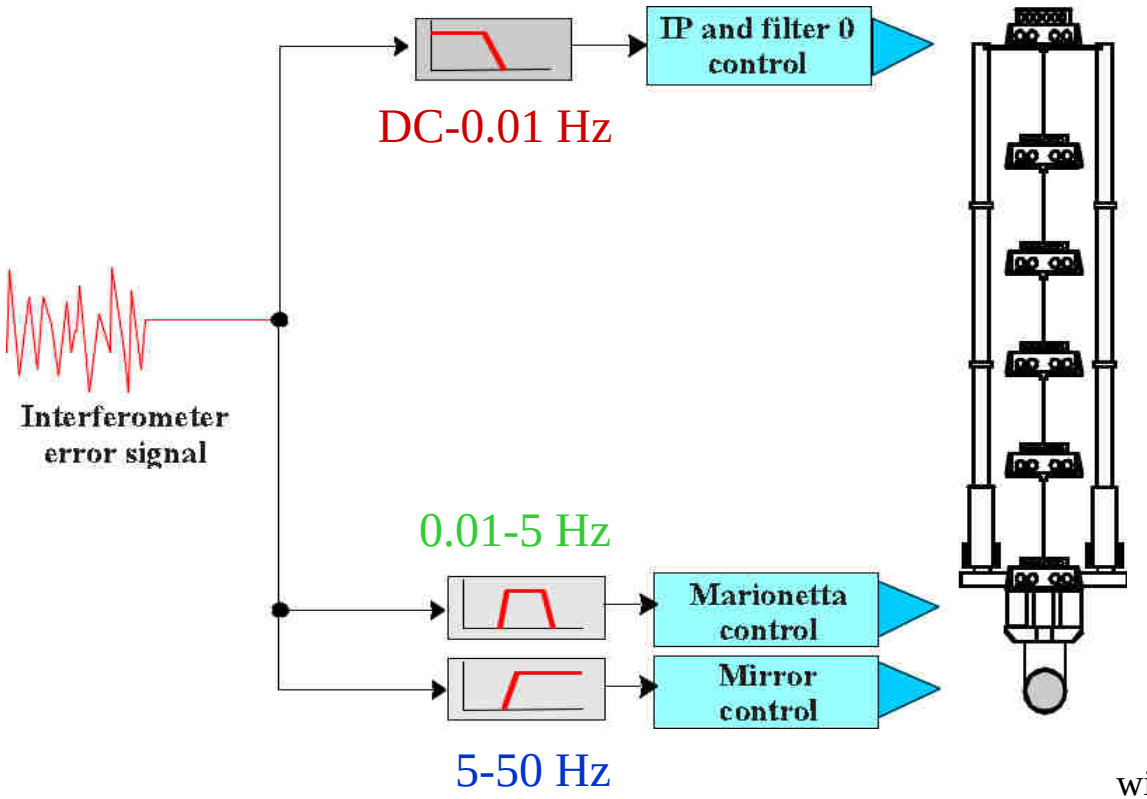
DC output power after the output mode cleaner

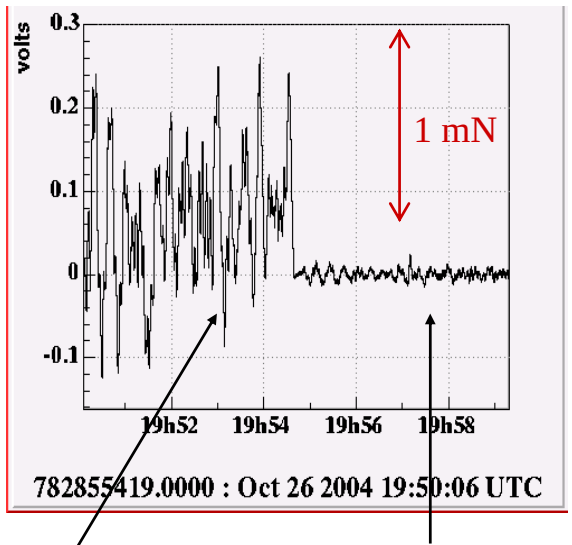
# Hierarchical Control

- Limited dynamic range requires to split forces over more control stages
- Reducing the force on the mirror allows to reduce actuation noise




Force applied to the mirror with hierarchical control (same a.u.)




with tidal control

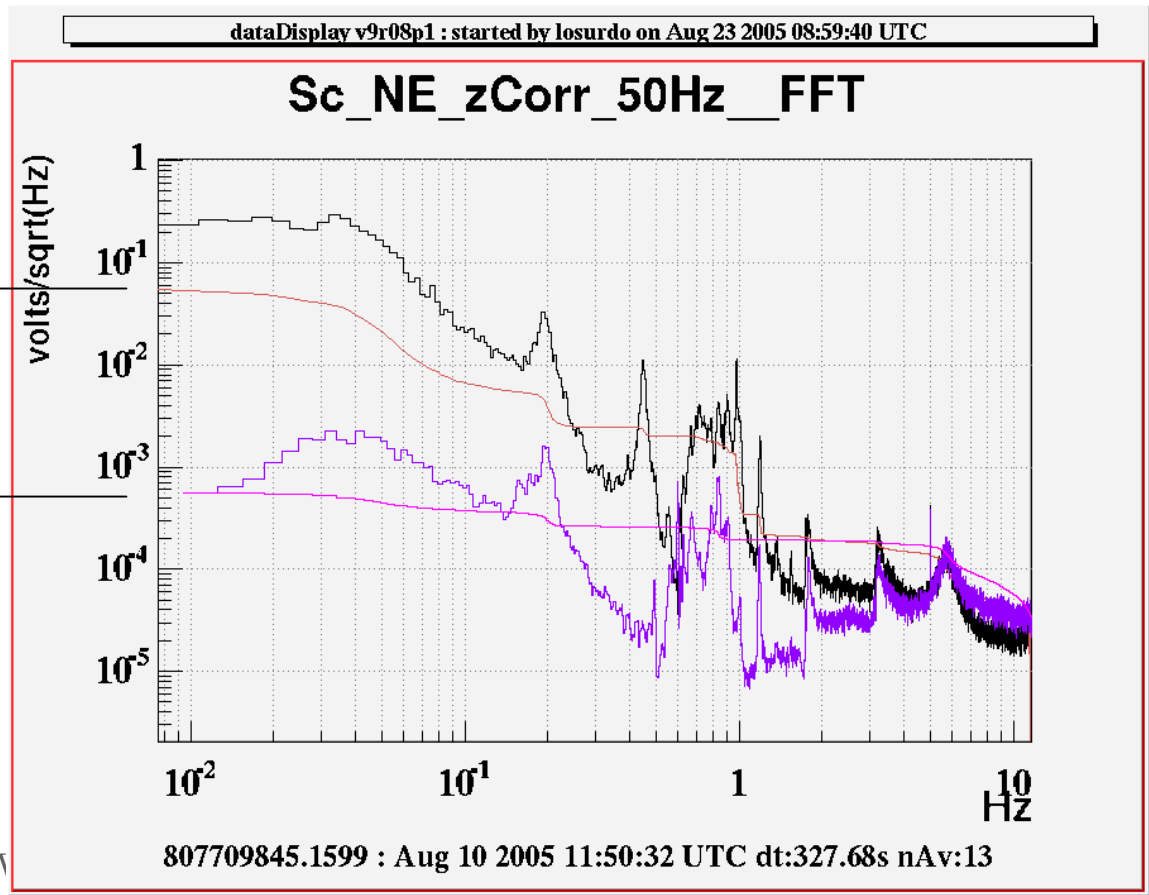
with tidal control & re-allocation to the marionette

# zCorr reduction

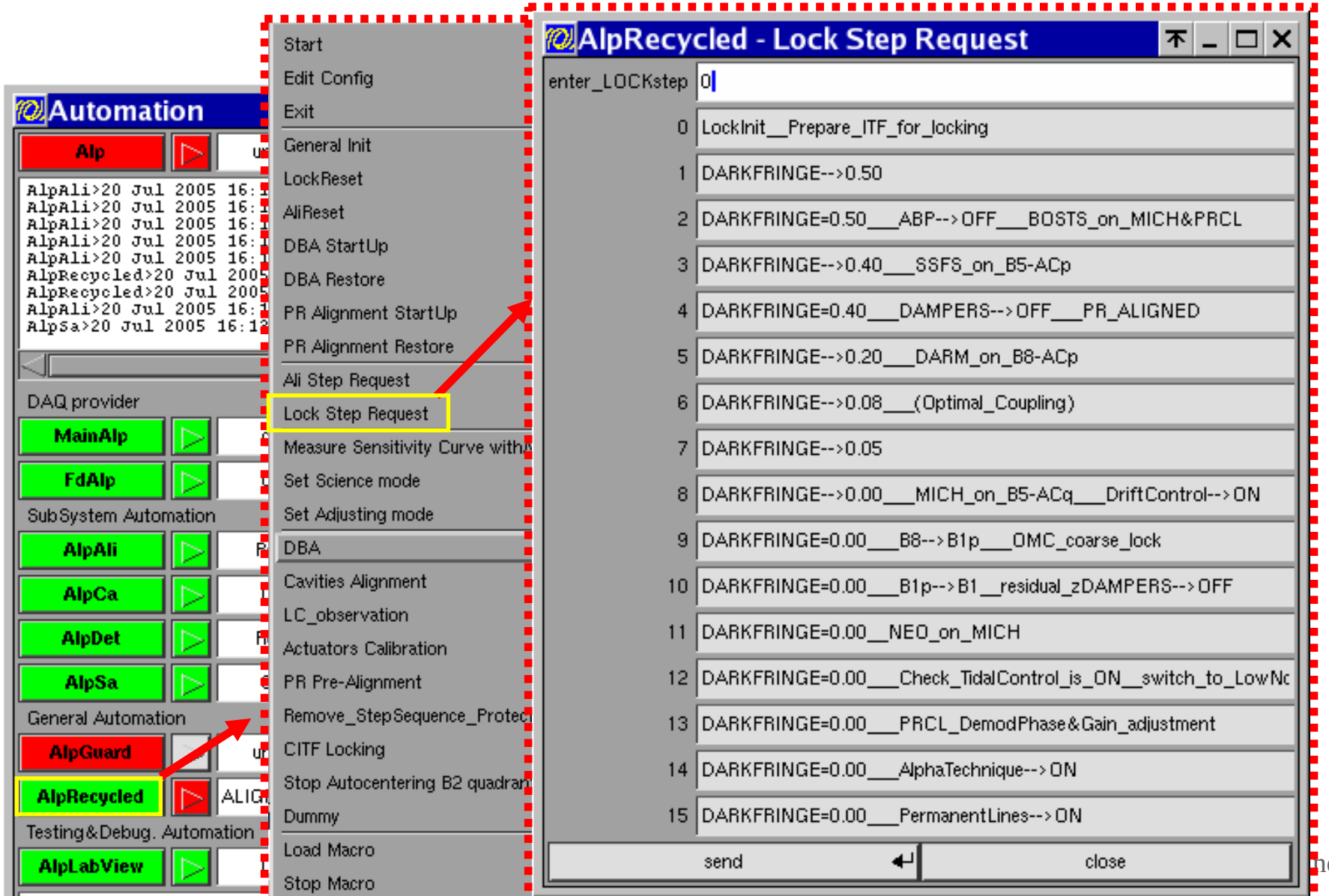
- Marionette/RM crossover @5 Hz
- After reallocation zCorr rms reduced by ~100
- Allows switching to low noise coil driver (talk by A.Gennai)

Without marionette
700 nm rms

With marionette
7 nm rms

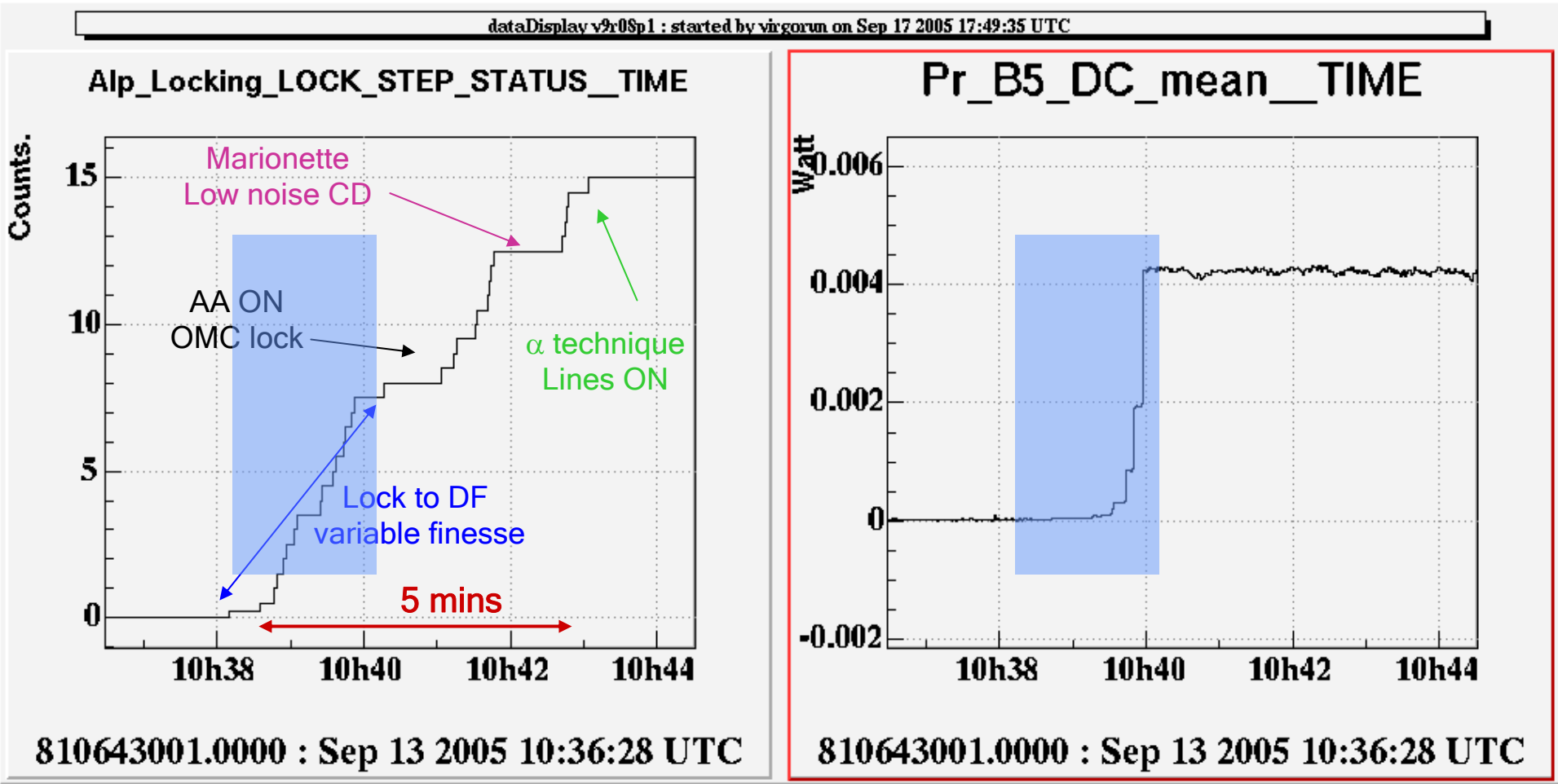


# Automation


Automation
Alp
AlpAli>20 Jul 2005 16:
AlpAli>20 Jul 2005 16:
AlpAli>20 Jul 2005 16:
AlpAli>20 Jul 2005 16:
AlpAli>20 Jul 2005 16:
AlpRecycled>20 Jul 2005
AlpRecycled>20 Jul 2005
AlpAli>20 Jul 2005 16:
AlpSa>20 Jul 2005 16:12
DAQ provider
MainAlp
FdAlp
SubSystem Automation
AlpAli
AlpCa
AlpDet
AlpSa
General Automation
AlpGuard
AlpRecycled
Testing&Debug. Automation
AlpLabView
Start
Edit Config
Exit
General Init
LockReset
AliReset
DBA StartUp
DBA Restore
PR Alignment StartUp
PR Alignment Restore
Ali Step Request
Lock Step Request
Measure Sensitivity Curve with
Set Science mode
Set Adjusting mode
DBA
Cavities Alignment
LC_observation
Actuators Calibration
PR Pre-Alignment
Remove_StepSequence_Protec
CITF Locking
Stop Autocentering B2 quadran
Dummy
Load Macro
Stop Macro
AlpRecycled - Lock Step Request
enter_LOCKstep
0
0 LockInit__Prepare_ITF_for_locking
1 DARKFRINGE-->0.50
2 DARKFRINGE=0.50___ABP-->OFF___BOSTS_on_MICH&PRCL
3 DARKFRINGE-->0.40___SSFS_on_B5-ACp
4 DARKFRINGE=0.40___DAMPERS-->OFF___PR_ALIGNED
5 DARKFRINGE-->0.20___DARM_on_B8-ACp
6 DARKFRINGE-->0.08___(Optimal_Coupling)
7 DARKFRINGE-->0.05
8 DARKFRINGE-->0.00___MICH_on_B5-ACq___DriftControl-->ON
9 DARKFRINGE=0.00___B8-->B1p___OMC_coarse_lock
10 DARKFRINGE=0.00___B1p-->B1__residual_zDAMPERS-->OFF
11 DARKFRINGE=0.00__NEO_on_MICH
12 DARKFRINGE=0.00___Check_TidalControl_is_ON__switch_to_LowNc
13 DARKFRINGE=0.00___PRCL_DemodPhase&Gain_adjustment
14 DARKFRINGE=0.00___AlphaTechnique-->ON
15 DARKFRINGE=0.00___PermanentLines-->ON
send
close

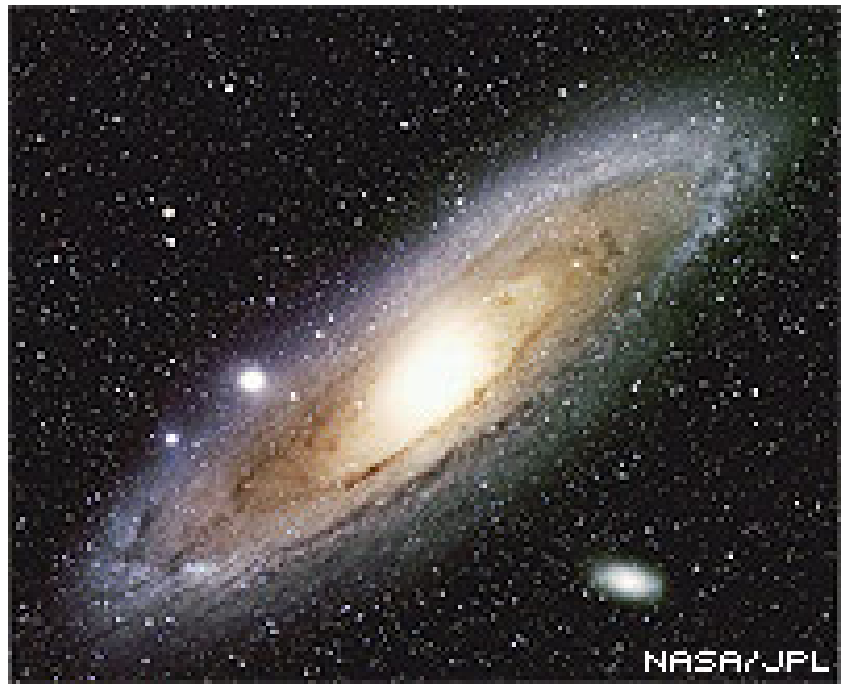
# Automation

- Lock Acq procedure fully automated

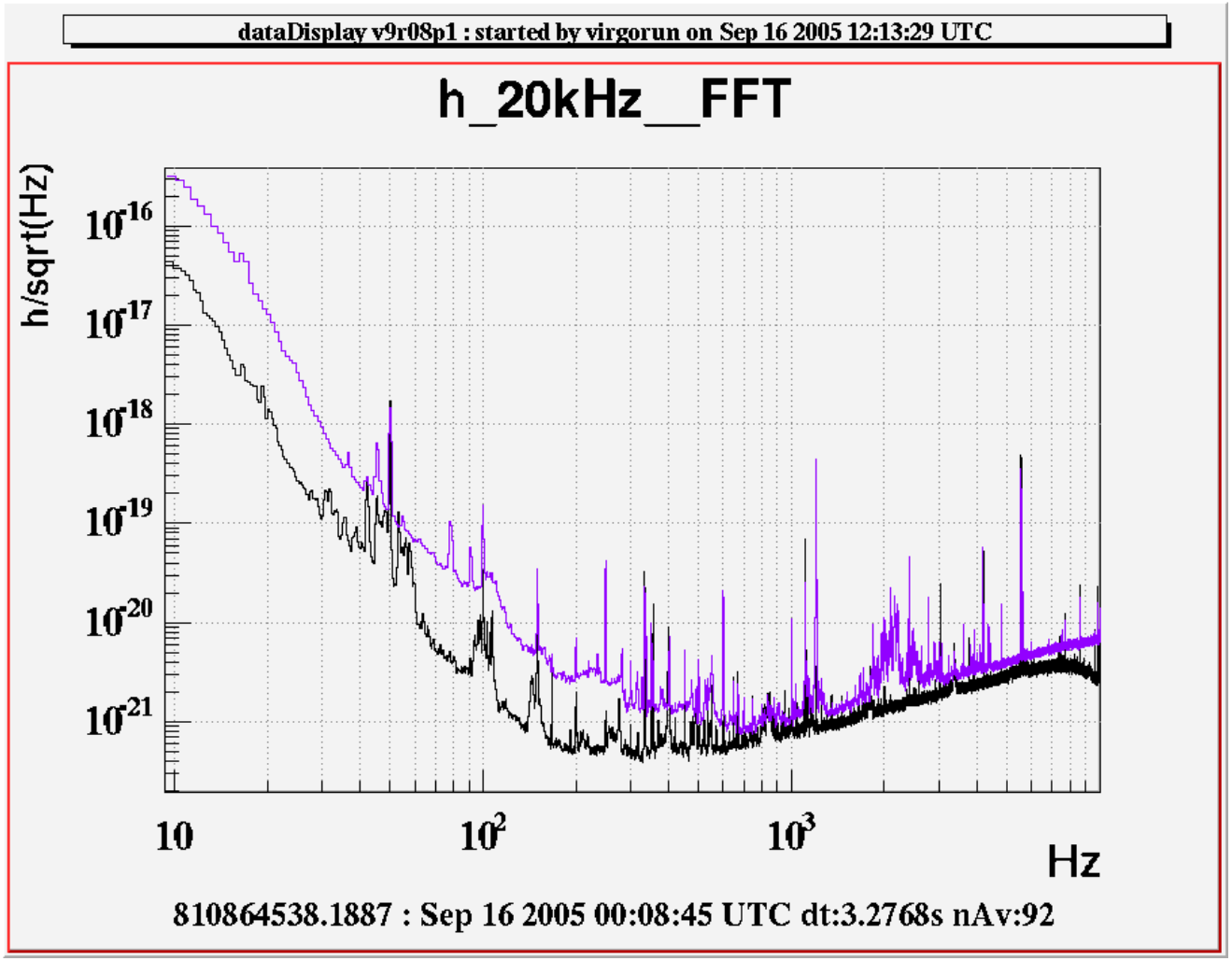


# C7 run

- Many new features implemented, good sensitivity improvement
- NS/NS inspiral range beyond Andromeda
- New run decided before ITF scheduled shutdown
- C7: 14-19 September



# C7 vs C6 sensitivity

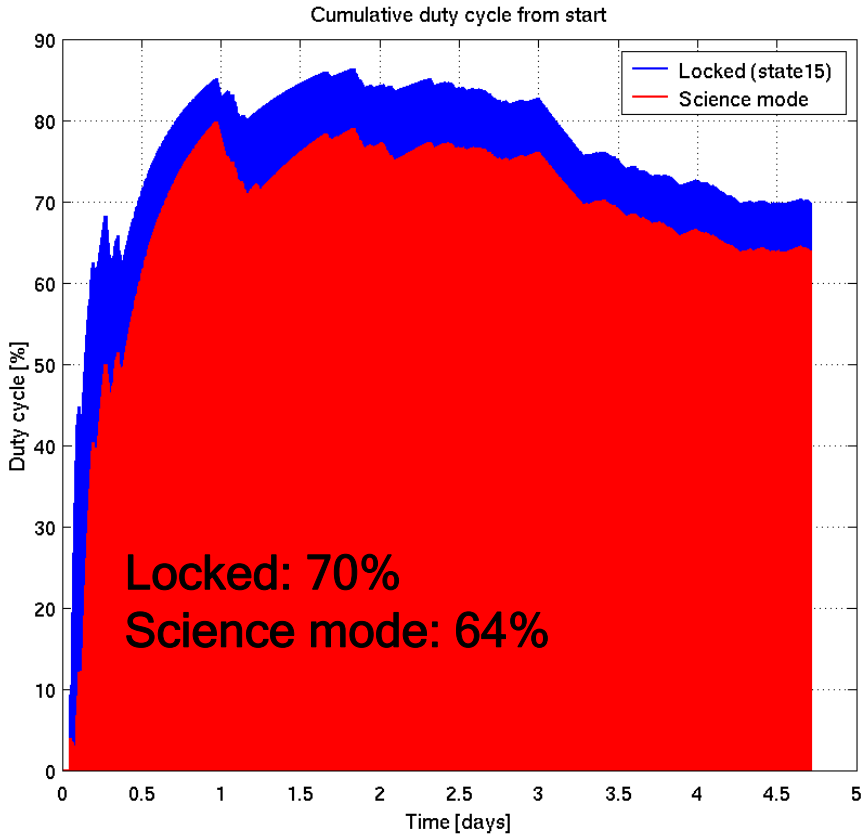


# C7 duty cycle

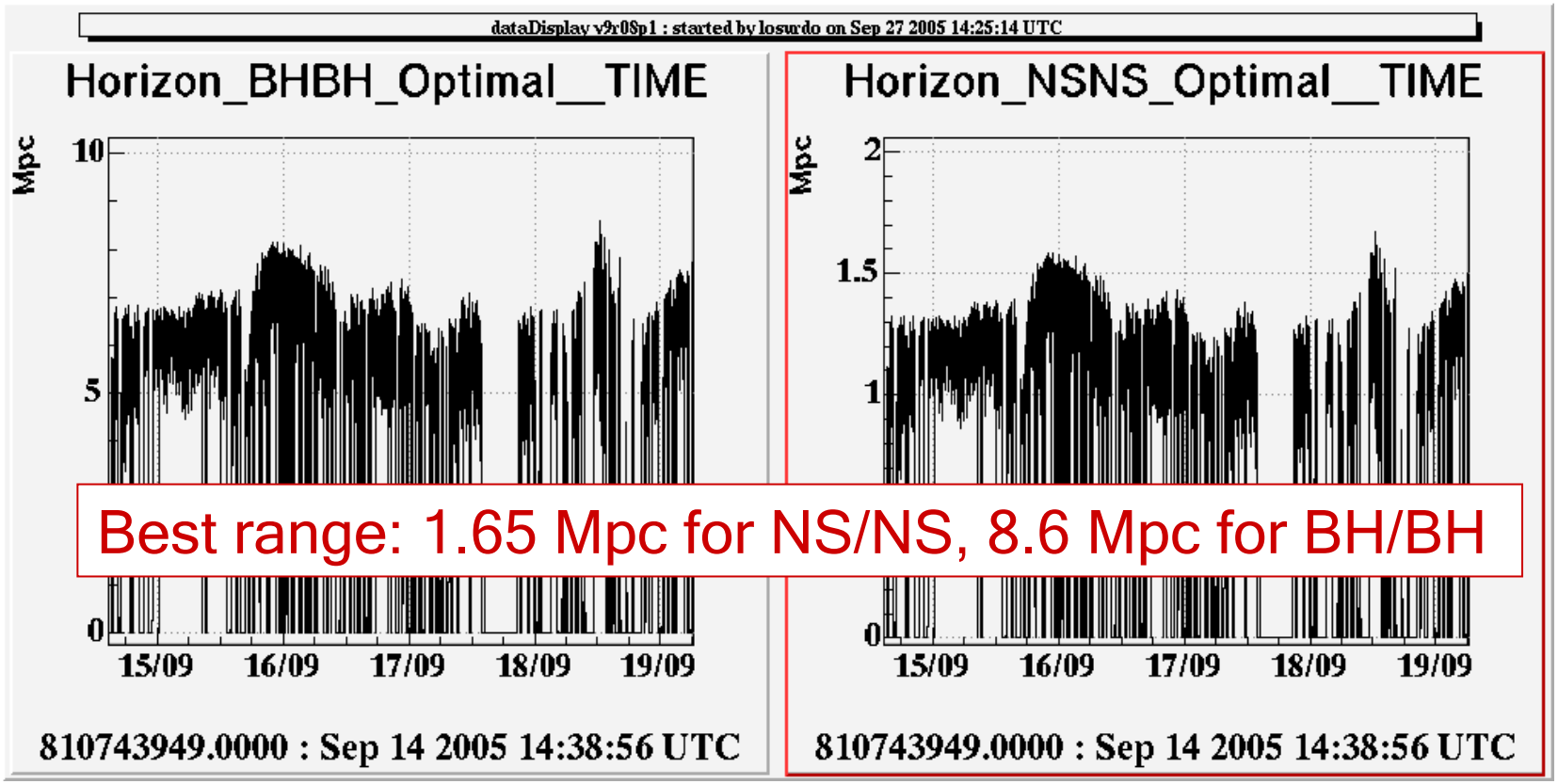
- Too many improvements in a short
- A couple of stormy days

*duty cycle worse than C6*

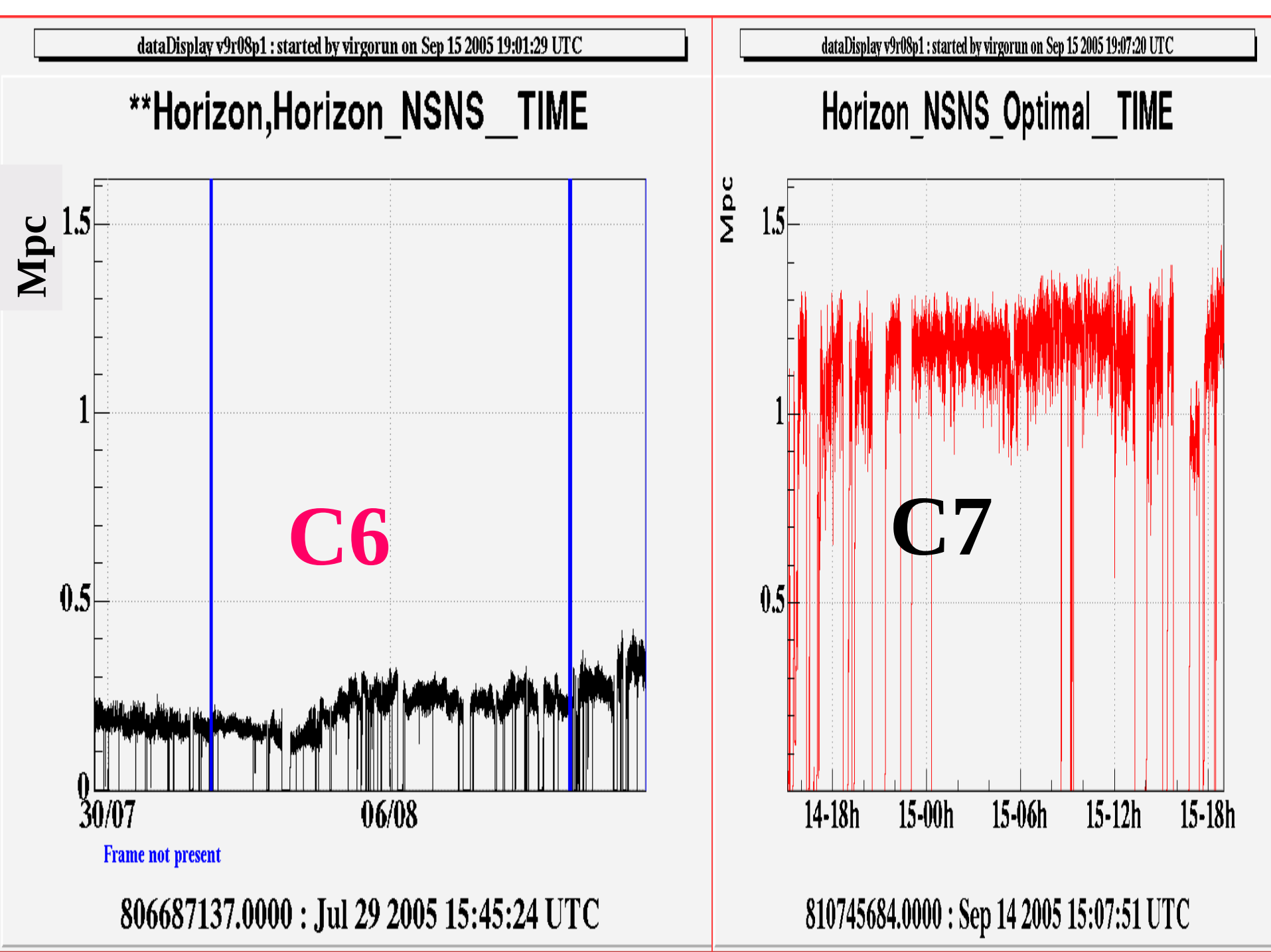
*…though still good*



# C7 inspiral range

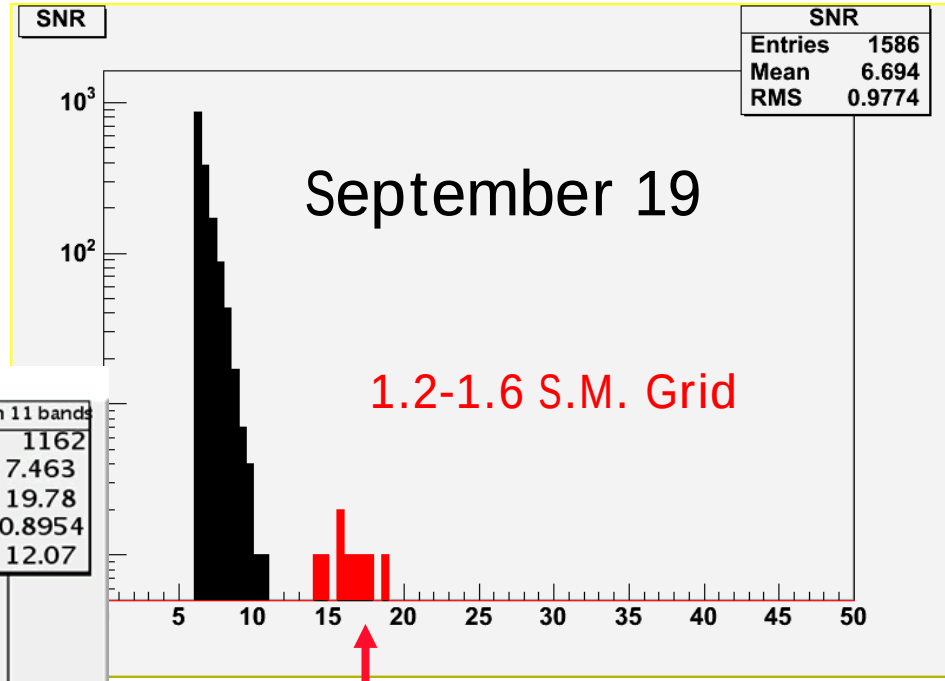


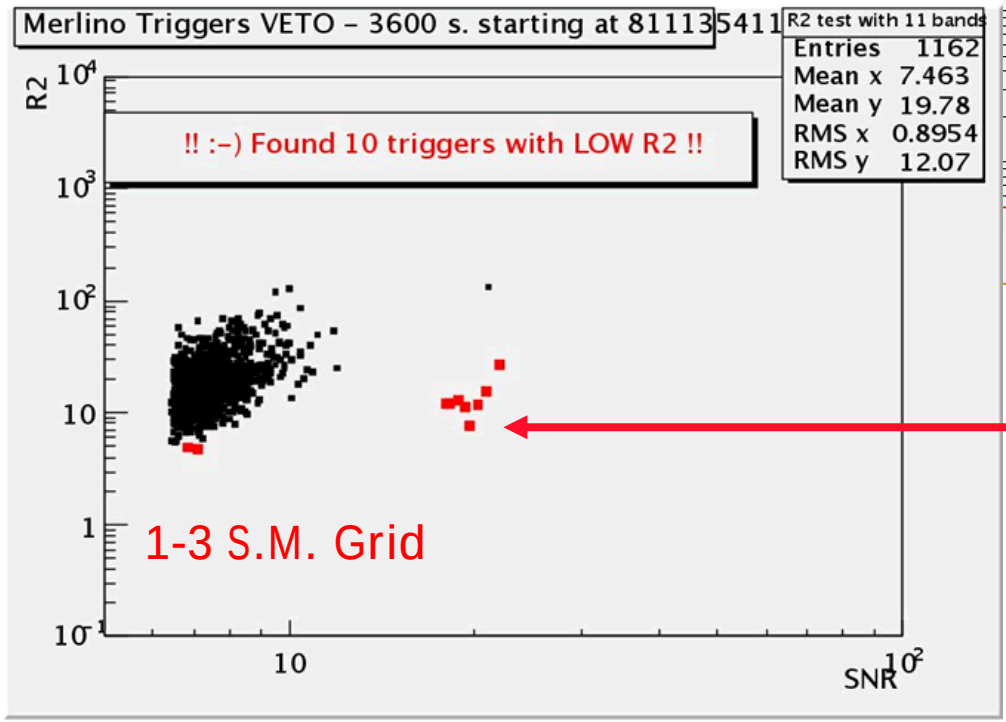

Best range: 1.65 Mpc for NS/NS, 8.6 Mpc for BH/BH

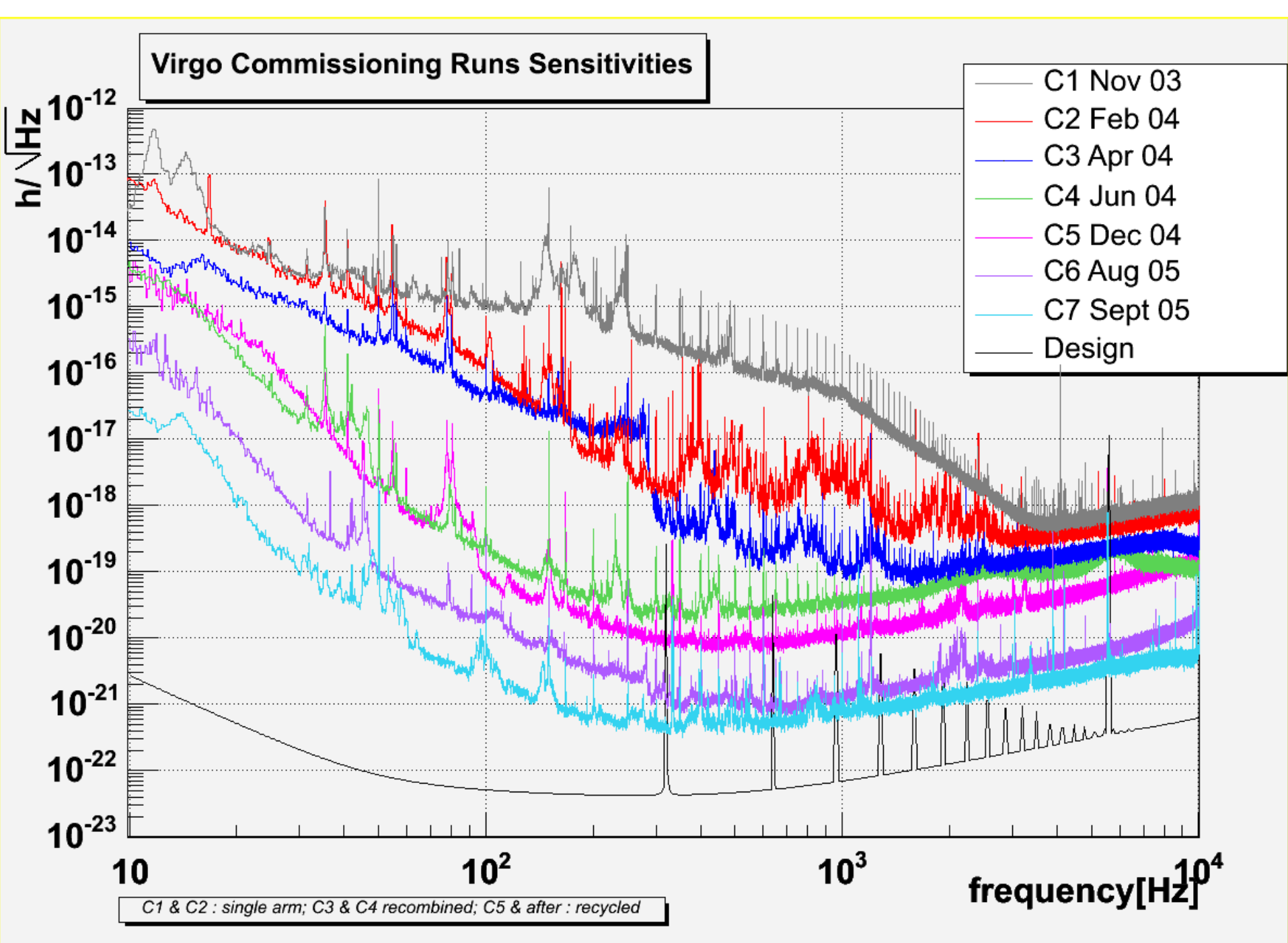

dataDisplay v9r08p1 : started by virgorun on Sep 15 2005 19:01:29 UTC
**Horizon,Horizon_NSNS__TIME
Mpc
1.5
1
0.5
0
C6
30/07
06/08
Frame not present
806687137.0000 : Jul 29 2005 15:45:24 UTC
dataDisplay v9r08p1 : started by virgorun on Sep 15 2005 19:07:20 UTC
Horizon_NSNS_Optimal__TIME
Mpc
1.5
1
0.5
C7
14-18h
15-00h
15-06h
15-12h
15-18h
810745684.0000 : Sep 14 2005 15:07:51 UTC

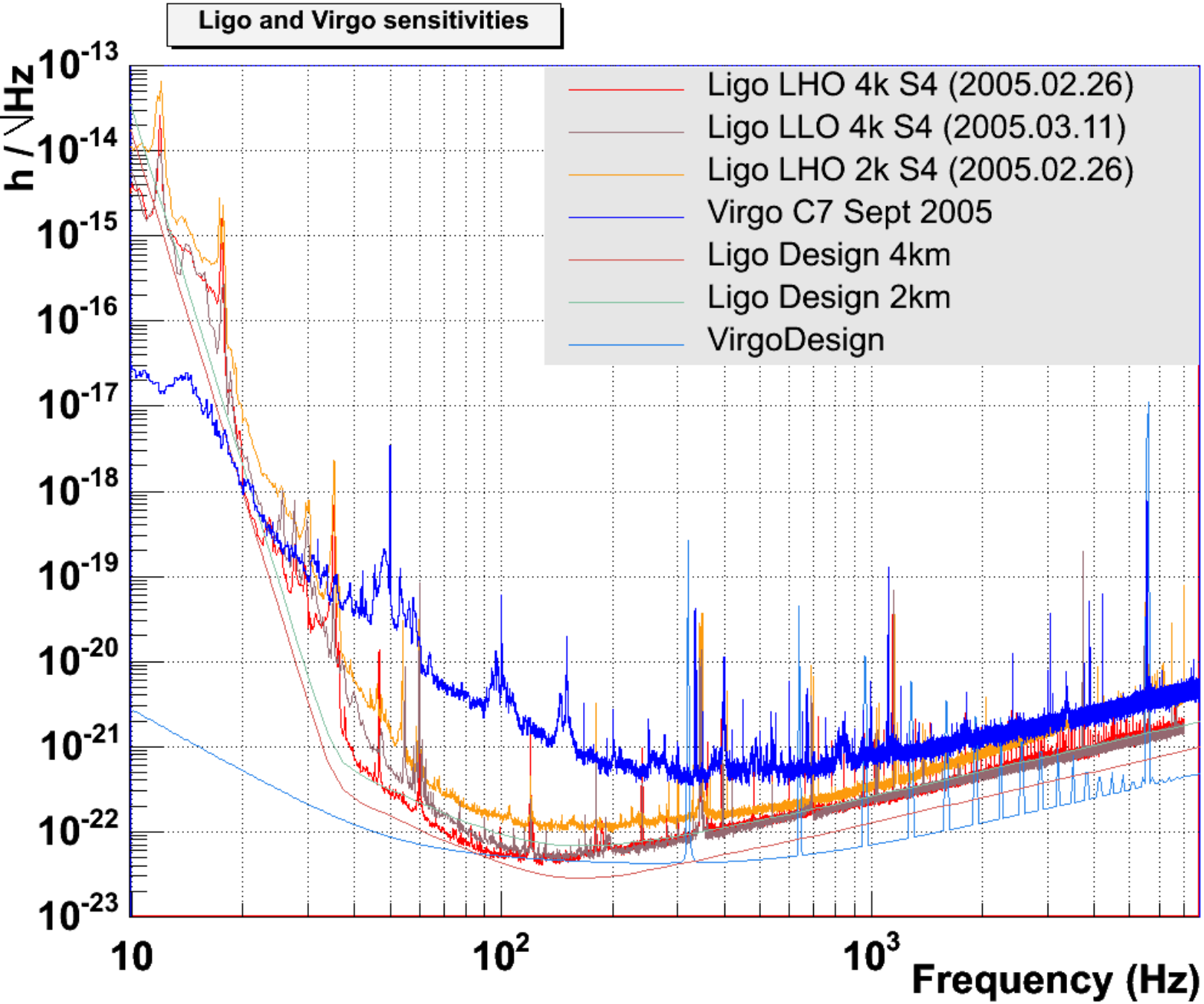
# DA commissioning

- Two online analysis for chirp detection running
- NS/NS events injected




Virgo Commissioning Runs Sensitivities
h/√Hz
10^-12
10^-13
10^-14
10^-15
10^-16
10^-17
10^-18
10^-19
10^-20
10^-21
10^-22
10^-23
10
10^2
10^3
10^4
frequency[Hz]
C1 Nov 03
C2 Feb 04
C3 Apr 04
C4 Jun 04
C5 Dec 04
C6 Aug 05
C7 Sept 05
Design
C1 & C2 : single arm; C3 & C4 recombined; C5 & after : recycled


Ligo and Virgo sensitivities
h / √Hz
10^-13
10^-14
10^-15
10^-16
10^-17
10^-18
10^-19
10^-20
10^-21
10^-22
10^-23
10
10^2
10^3
Frequency (Hz)
Ligo LHO 4k S4 (2005.02.26)
Ligo LLO 4k S4 (2005.03.11)
Ligo LHO 2k S4 (2005.02.26)
Virgo C7 Sept 2005
Ligo Design 4km
Ligo Design 2km
VirgoDesign

# Virgo upgrades

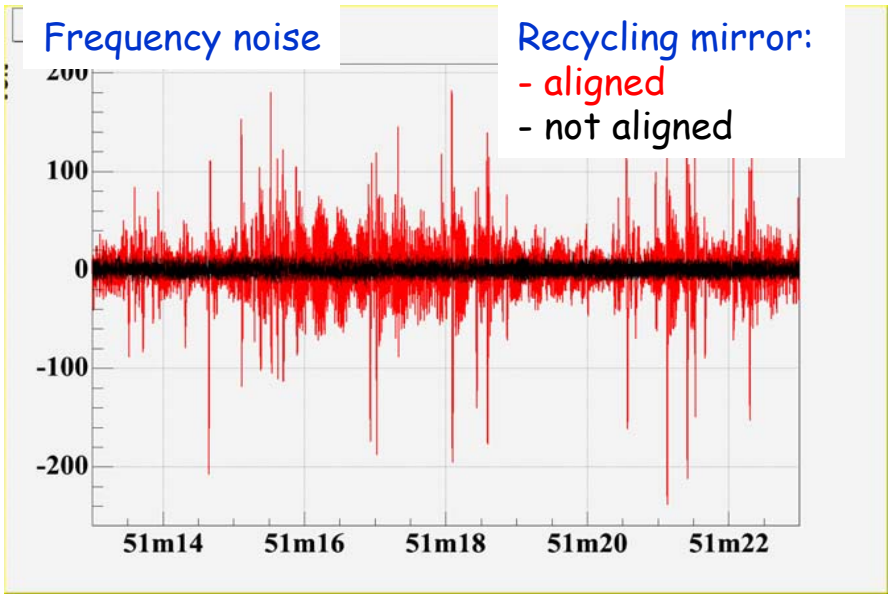
# (Oct-Dec 2005)

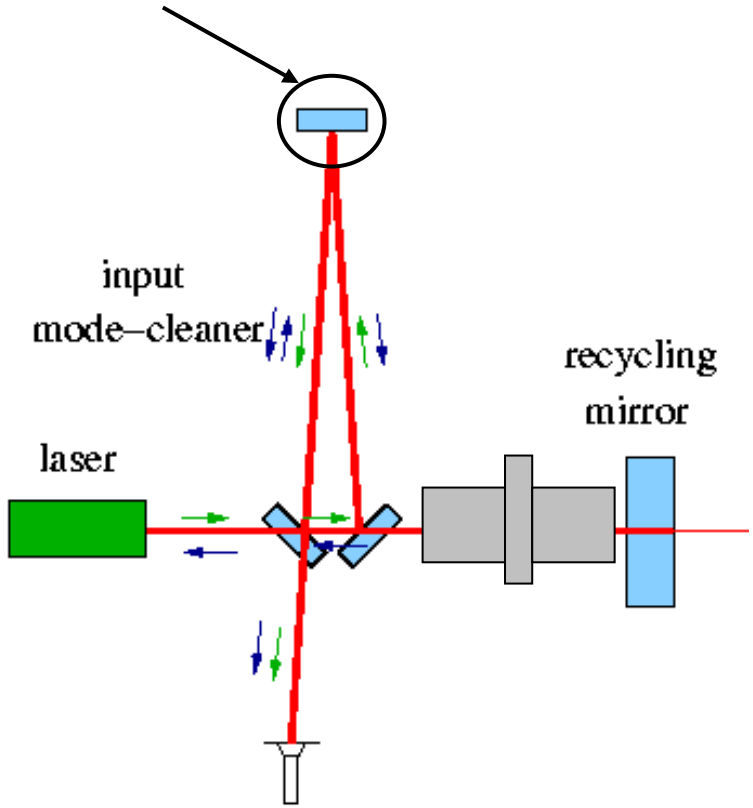
# Problems with injection system

- A small fraction (bigger than expected) of the light reflected by the interferometer is retro-diffused by the input mode cleaner mirror: **spurious interference**
- **Temporary solution:** reduce the power (/10).

  Virgo has been working with $P_{in}$=0.7 W
- **Final solution:** install a Faraday isolator

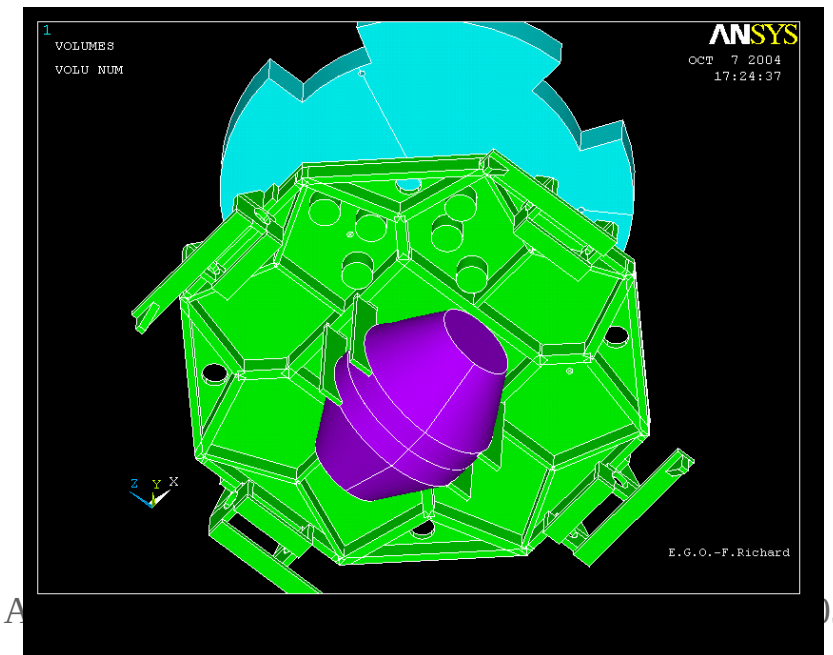
  A new injection bench is needed.



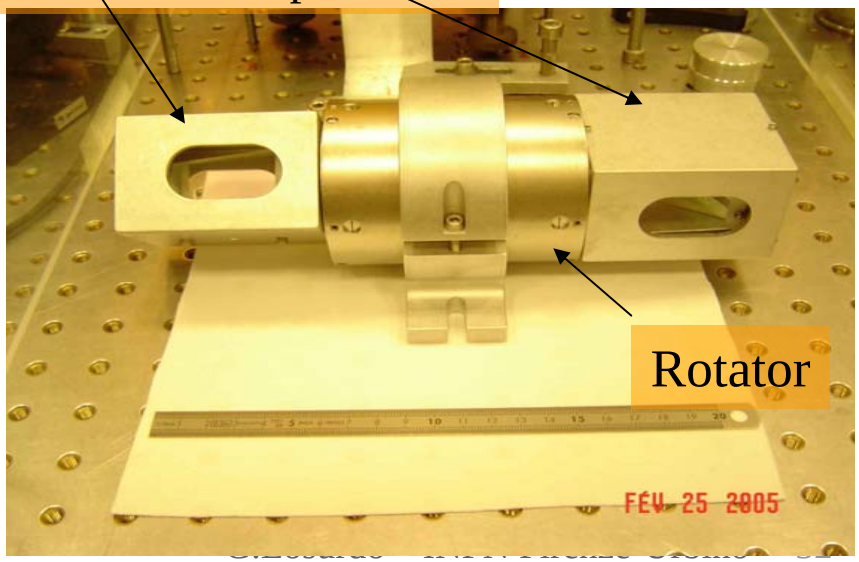



# Injection bench upgrade

- New bench:
  - Larger surface available for optics mounting
  - Higher rigidity
  - New wires
- Faraday isolator TGG (Terbium Gallium Garnet) produced by EOTec:
  - Compliant with 20 W laser
  - 40 dB isolation measured




Brewster dielectric polarizers



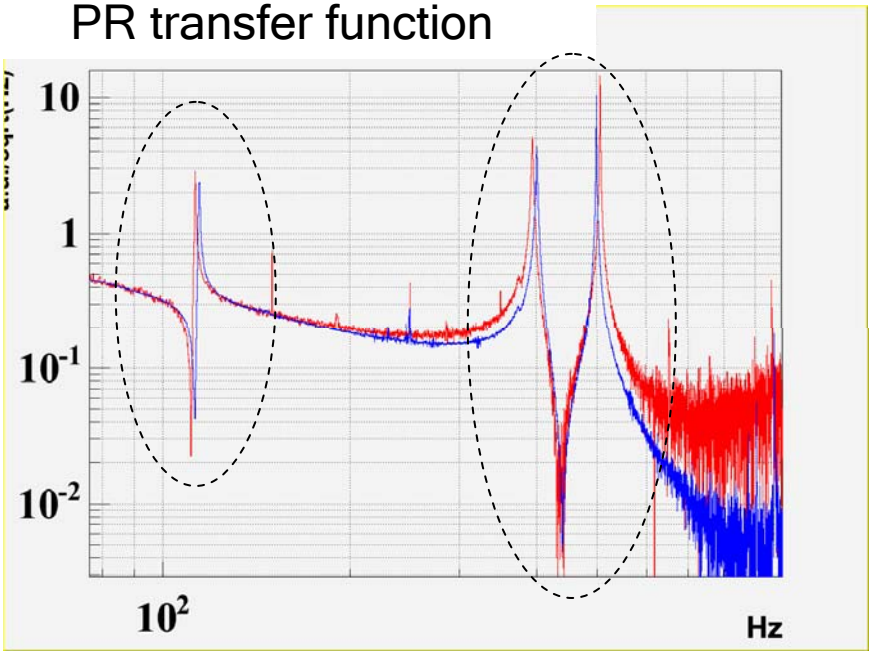
# PR mirror replacement

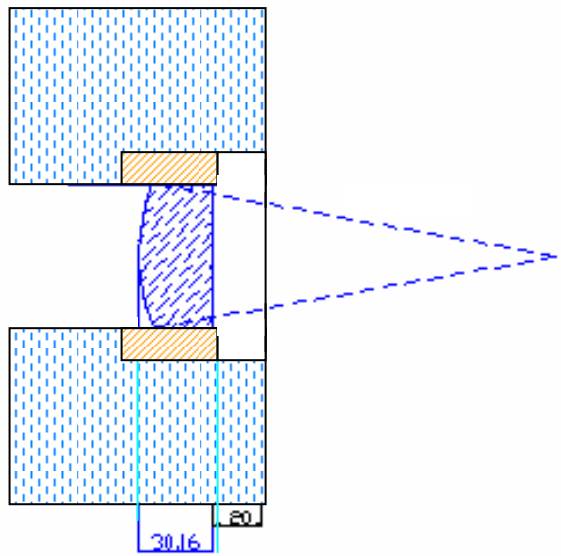
PR mirror: curved and compound

- Nasty internal resonances, very annoying for the locking
- Misalignments and jitter induced by translation

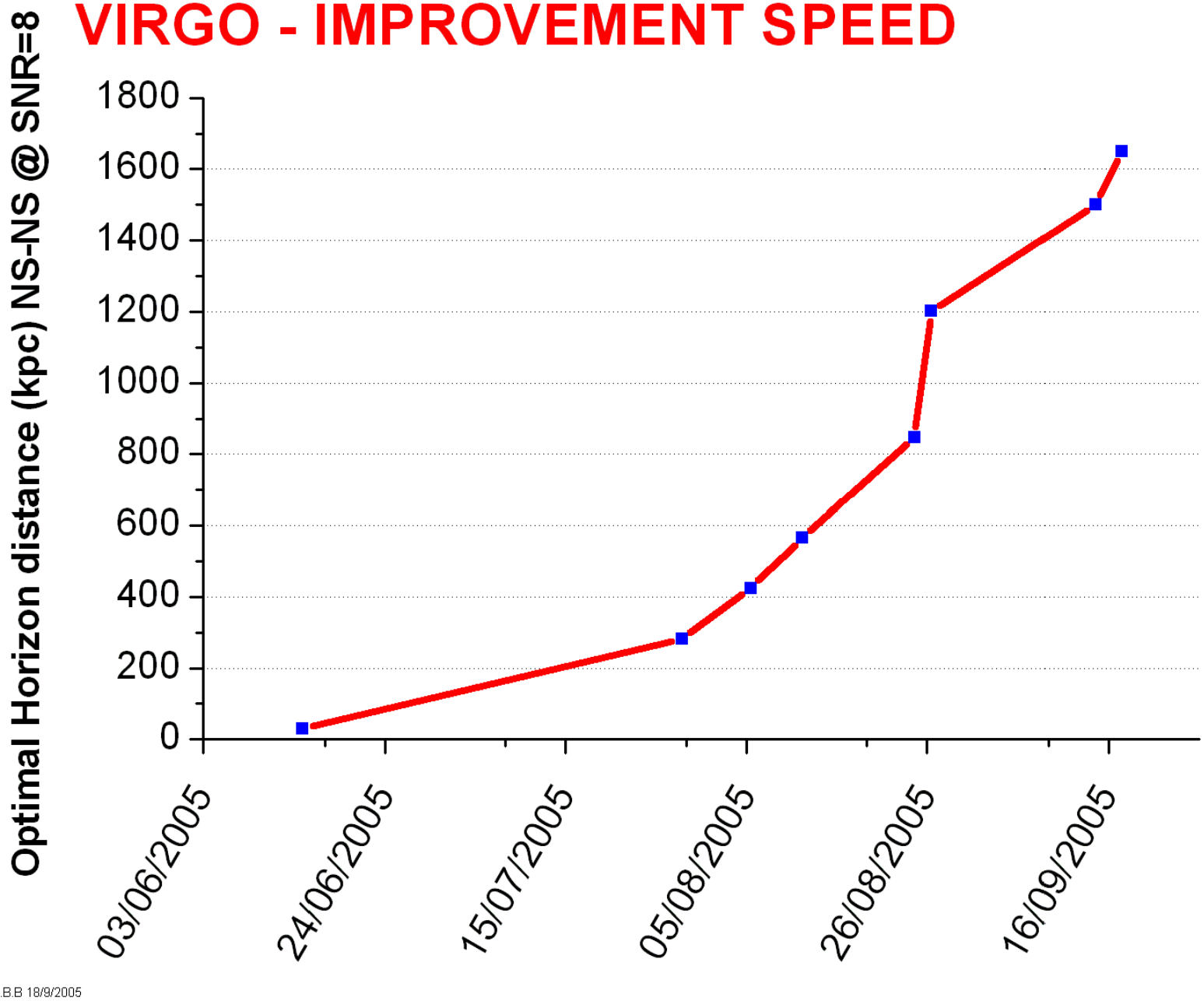
To be replaced with a standard flat Virgo mirror

PR transfer function



# VIRGO - IMPROVEMENT SPEED




L.B.B 18/9/2005

# 2006 plan

Get close to
DESIGN SENSITIVITY

Make a
SCIENCE RUN