



ADVANCED VIRGO

Giovanni Losurdo - INFN Pisa
Advanced Virgo Project Leader

for the Virgo Collaboration and EGO





MAIN MESSAGES

- ❑ AdV construction (phase 1) completed
 - Some integration issues still pending
- ❑ Commissioning: working for the 1st lock
 - MICH and 3km cavities locked independently
- ❑ Goal: be ready for O2b with a sensitivity good enough to contribute to the network
 - minimal requirement: $\frac{1}{4}$ of the LIGO sensitivity for BNS
- ❑ In parallel:
 - working to solve the issue with monolithic suspensions
 - investigating the options for the mid/long-term
- ❑ NEED TO PURSUE R&D

Virgo central hall SPRING 2016





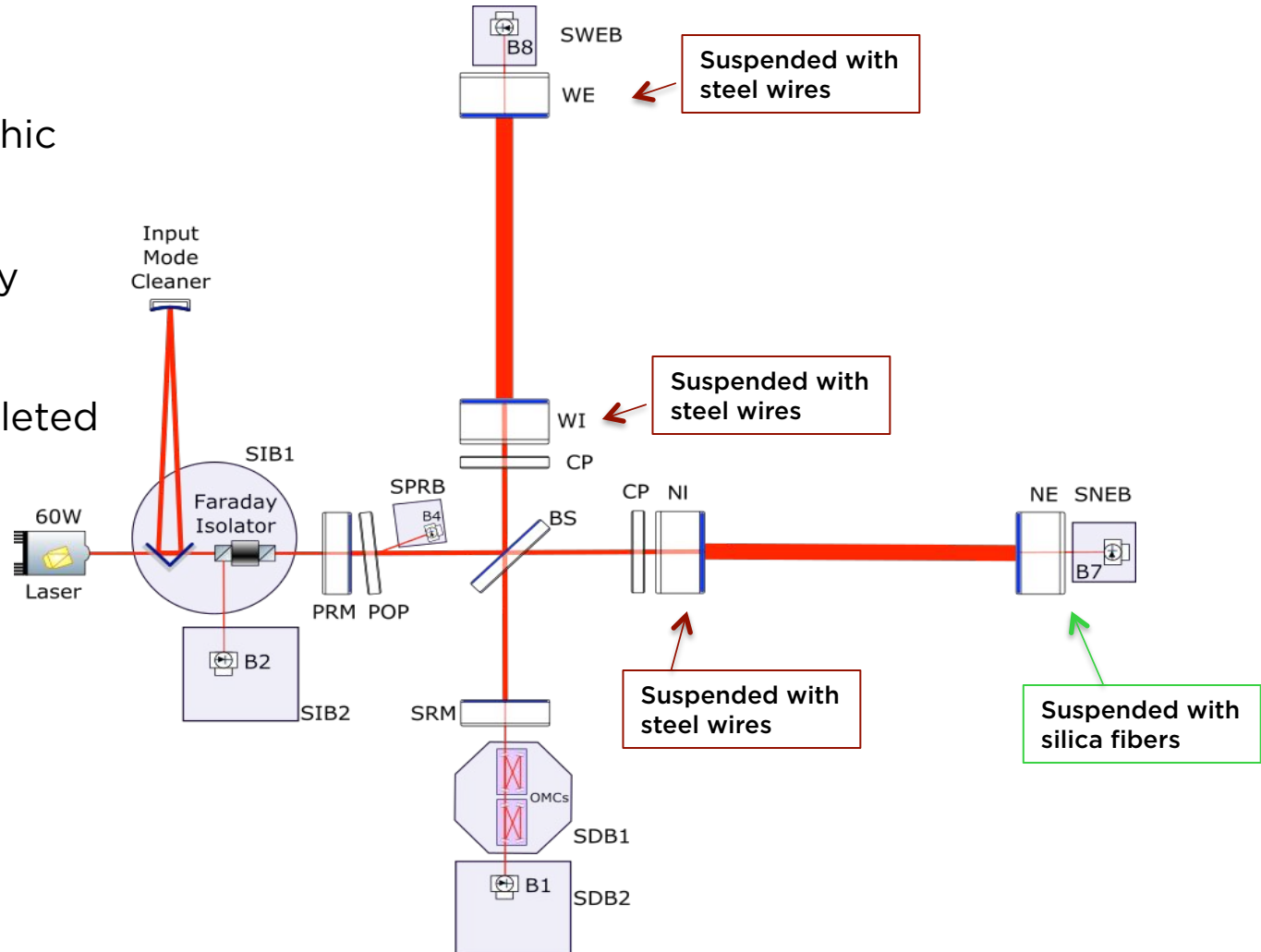
Virgo central hall
SPRING 2013

EXPECTED CONFIGURATION for O2

3 test masses suspended with steel wires, after repeated failures of monolithic suspensions

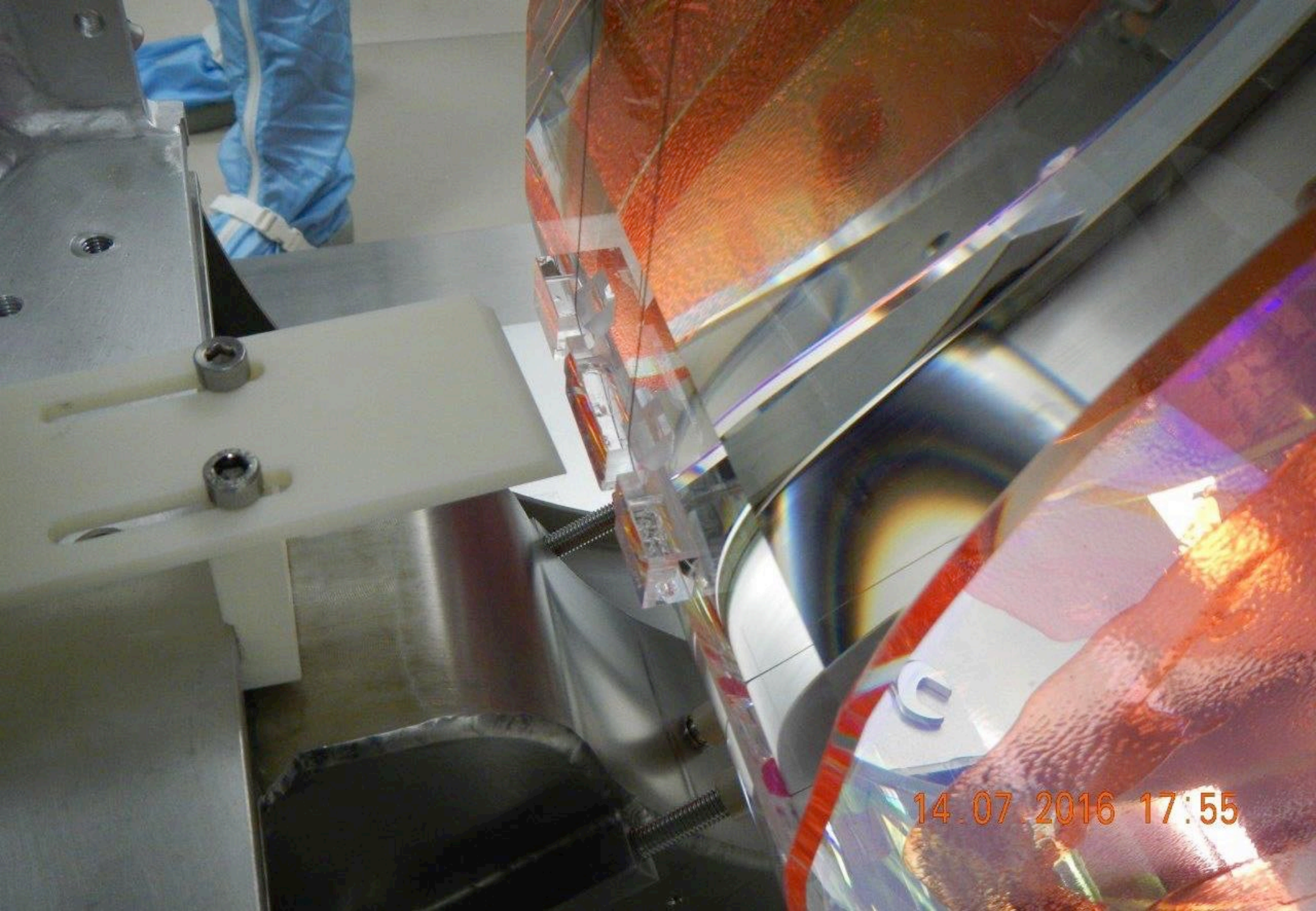
Choice driven by the priority of joining O2

Integration of mirrors completed in July





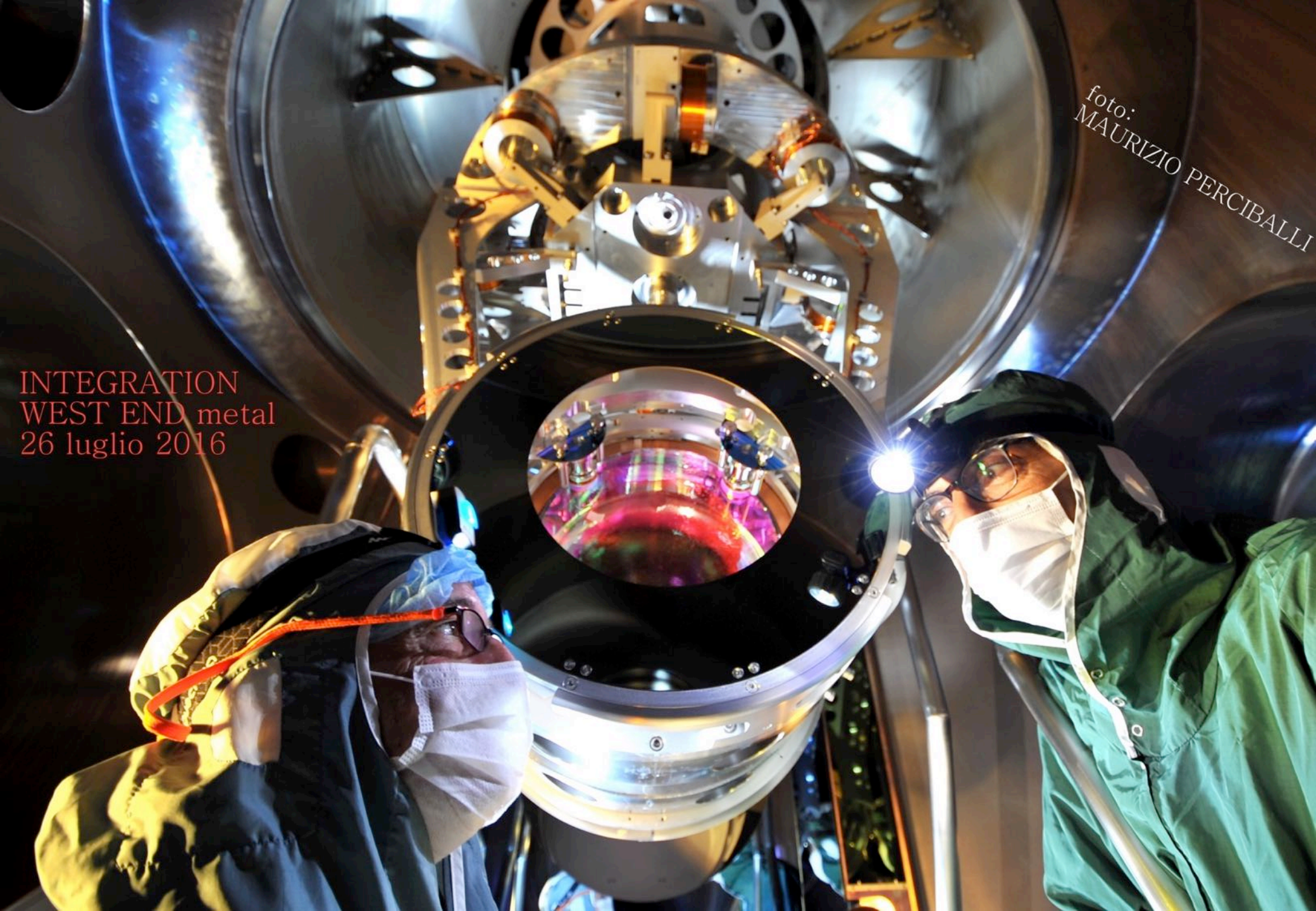
26.11.2015 11:42



14.07.2016 17:55

foto:
MAURIZIO PERCIBALLI

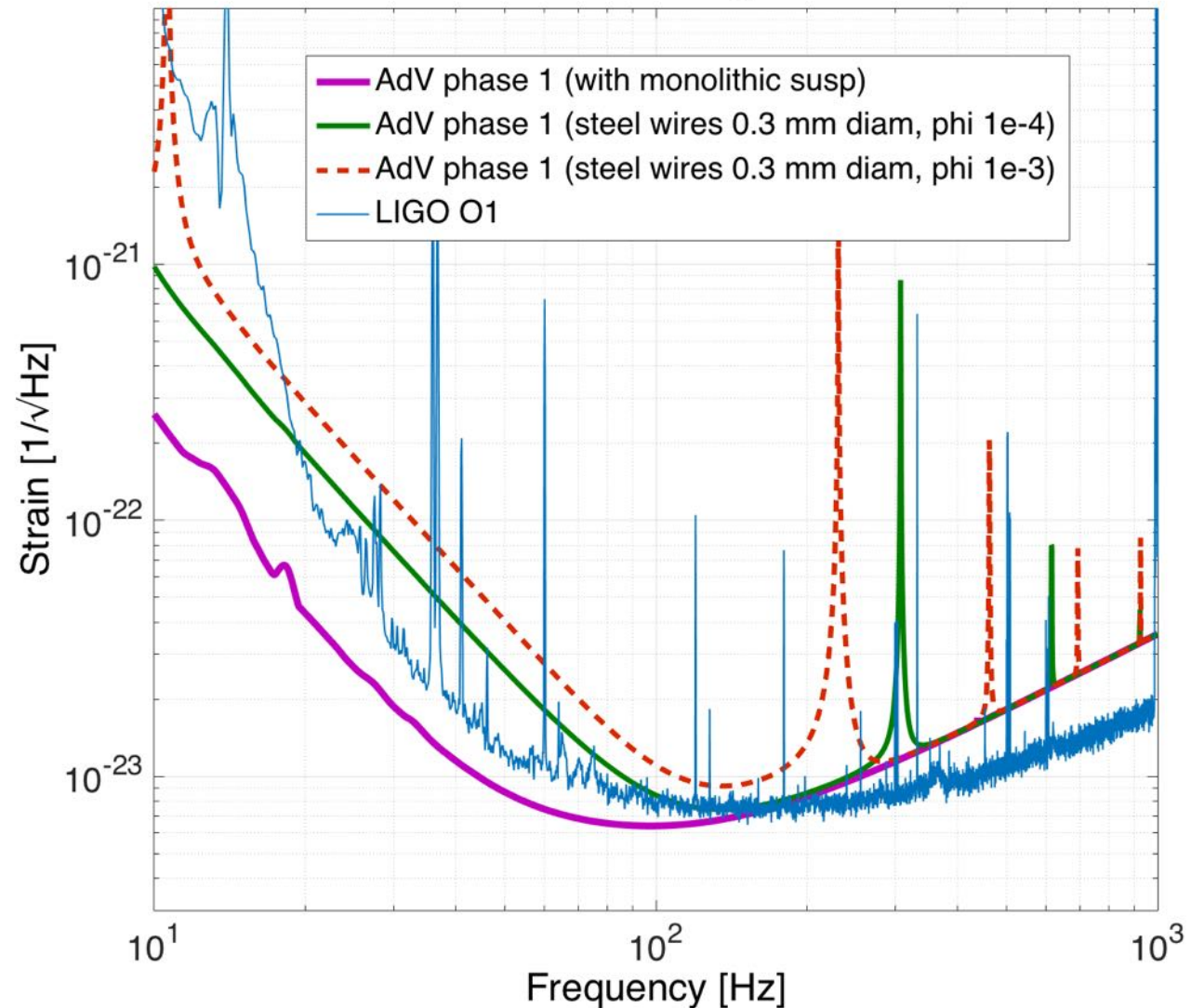
INTEGRATION
WEST END metal
26 luglio 2016



- ❑ The integration of the last mirror (July 2016) marks the “end of the installation”
- ❑ ~7 months of delays with respect to the “end 2015” project milestone
 - Combined effect of blade/monolithic susp issues
- ❑ Main impact: time for commissioning compressed

O2 TARGET SENSITIVITY

AdV Noise Curve: $P_{\text{in}} = 25.0 \text{ W}$



Inspiral range (Mpc), steel wires
on 4 TM, $\phi = 1e-4$ ($1e-3$)

BNS 60 (45)

BBH 313 (202)

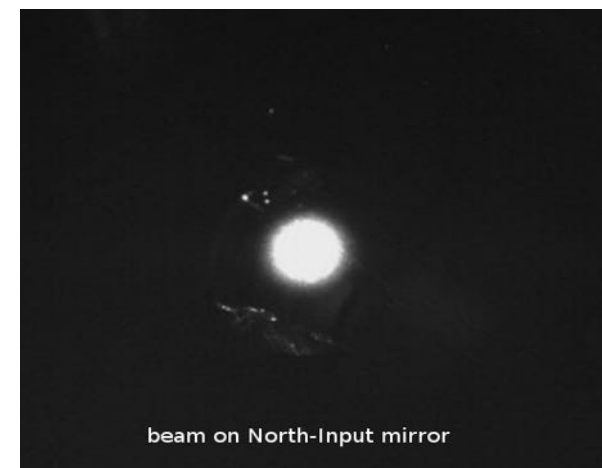
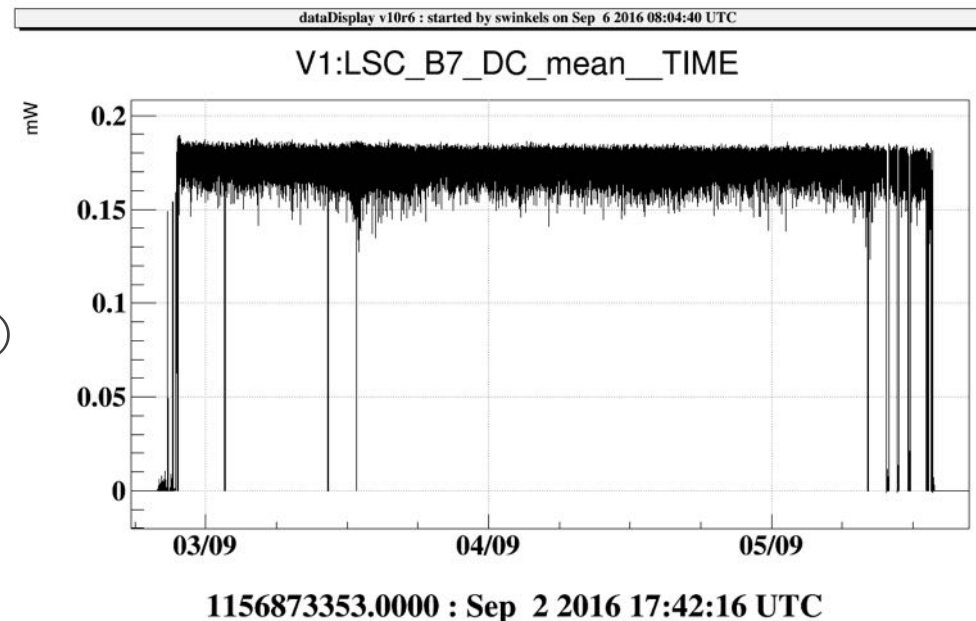
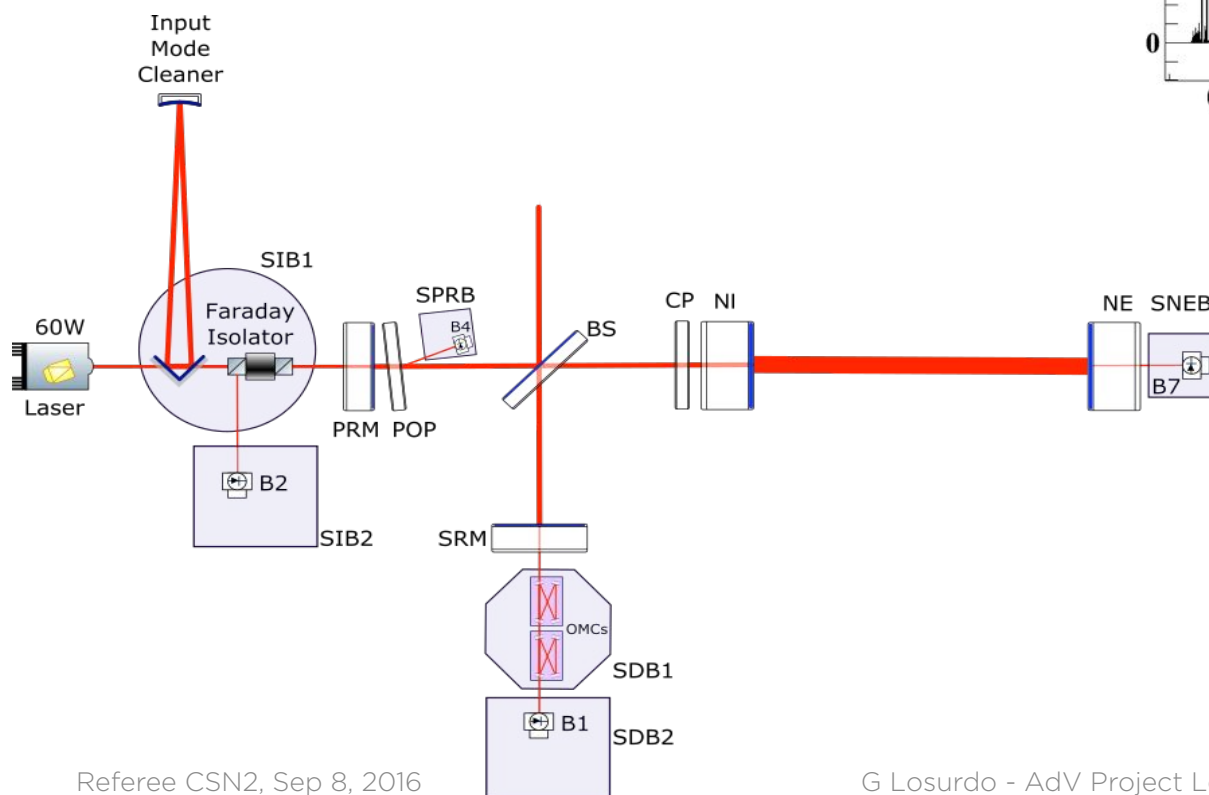


COMMISSIONING

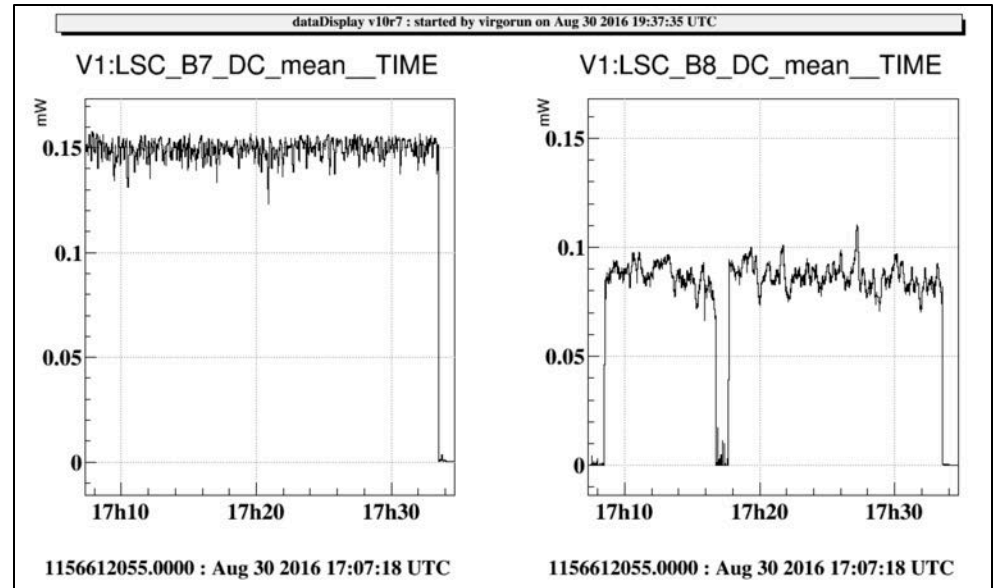
DELAYED BY BLADES AND SUSPENSIONS FAILURES, HAS FINALLY TAKEN MOMENTUM

3 km ARMS

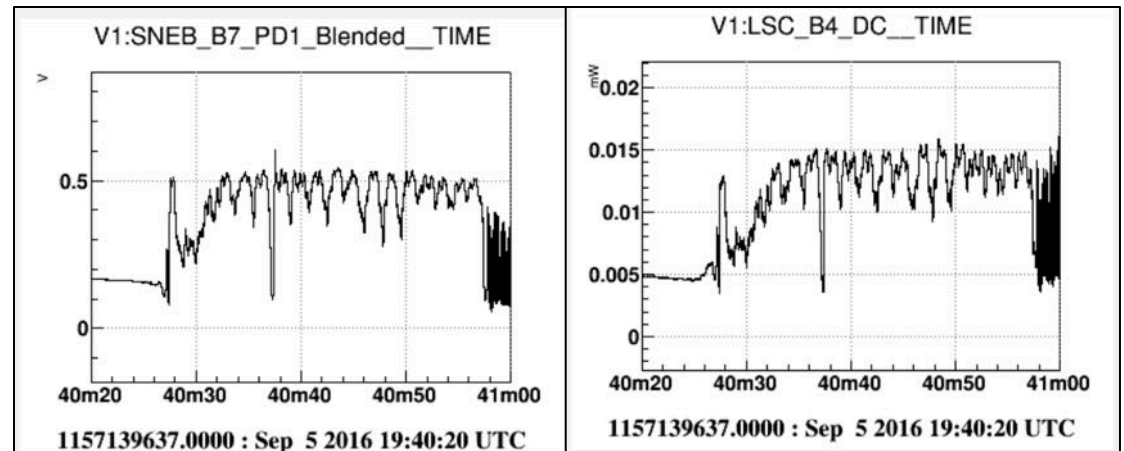
- Both locked (N arm since May)
- Lock very stable (~2 days of continuous lock in the weekend)
- Cavity finesse as expected



- Two arms locked together



- PR-N cavities locked together



- ## Same locking scheme as Virgo+



STEPS TOWARDS O2

Milestone 1: 1st lock

Fix some leftovers:

- replace NI metal susp with optimized ones
- install few more components (some photodiodes, Hartmann sensors, phase cameras)

Address issues with MSRC configuration (thermal aberrations). Requires smart use of TCS

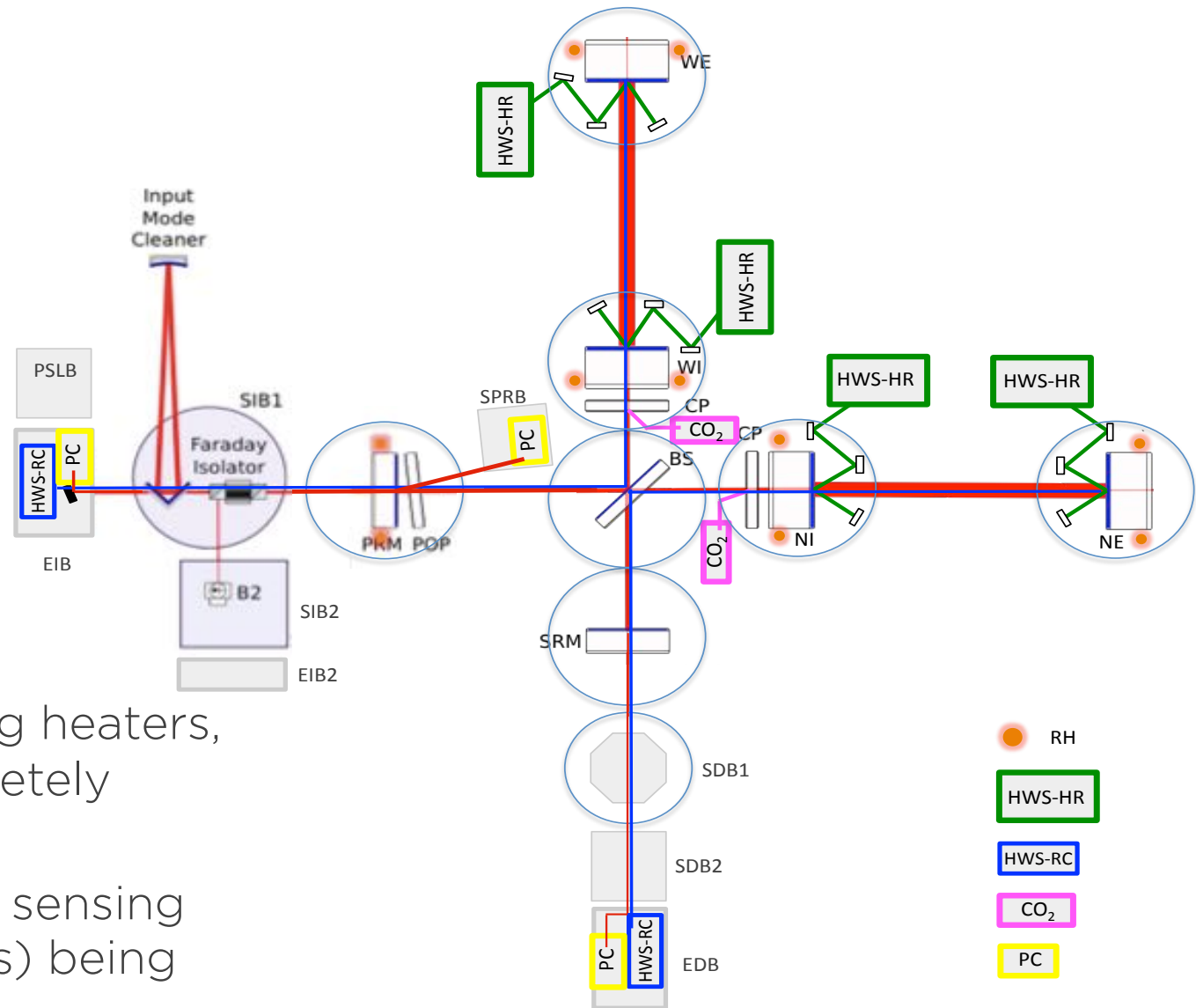
Milestone 2: make lock stable and reproducible

Noise, budget, noise hunting, calibration

Milestone 3: good sensitivity, data quality, duty cycle

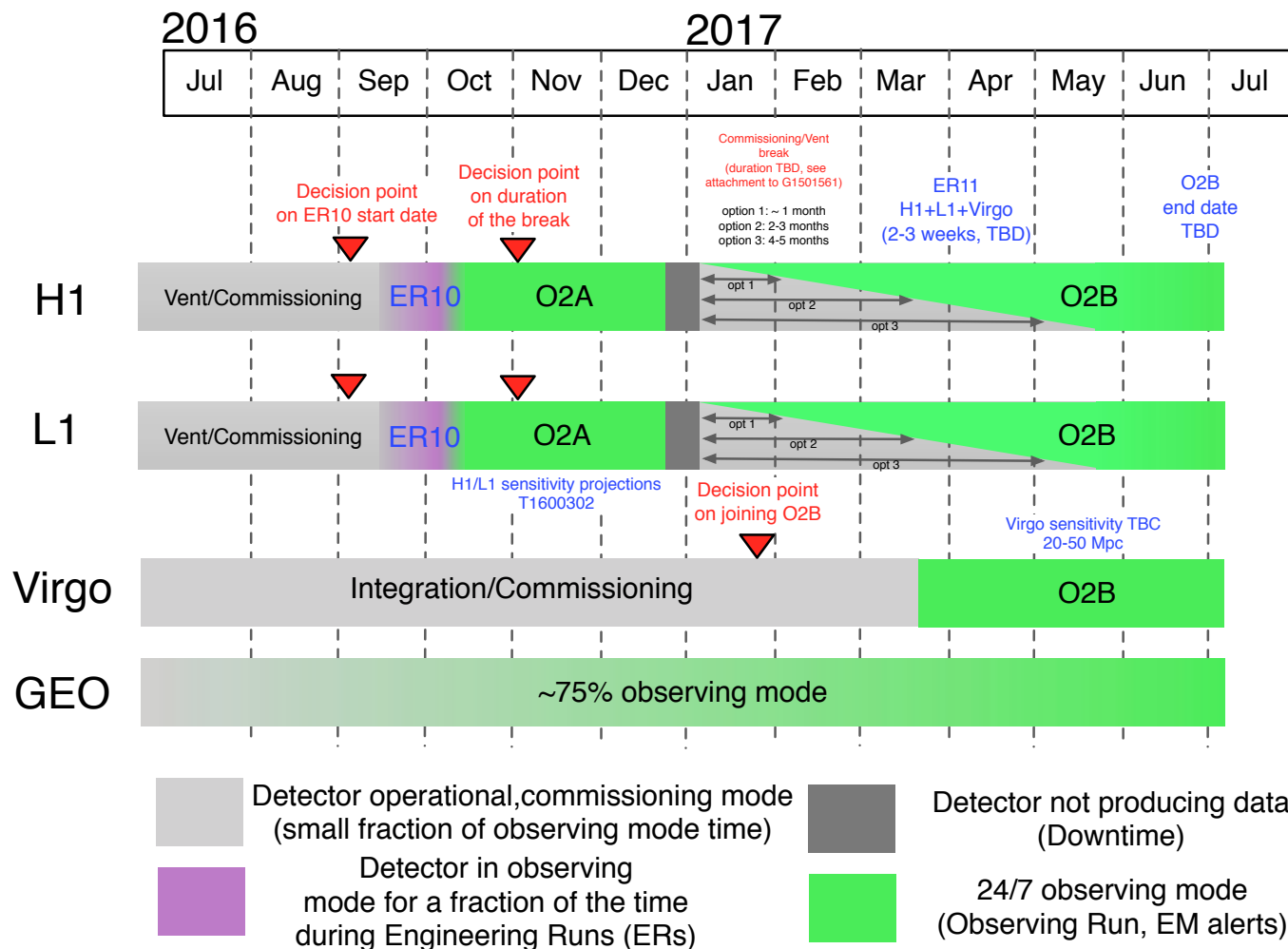
**FINAL GOAL:
Join O2b**



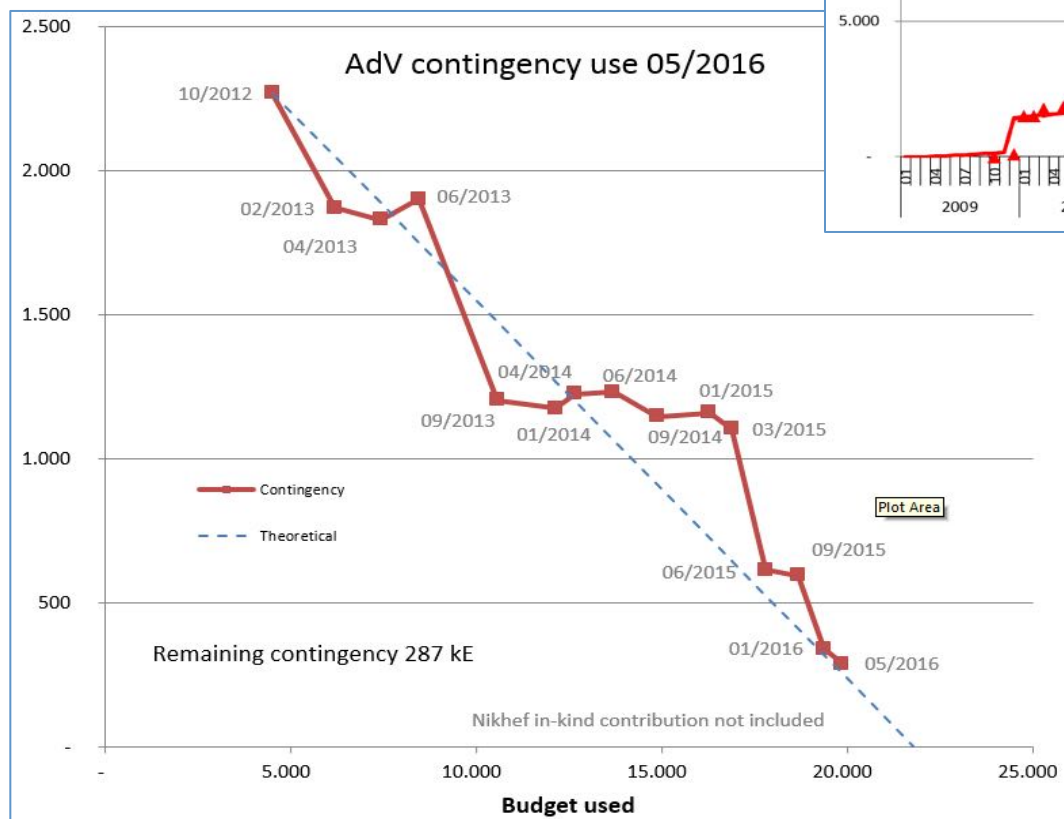
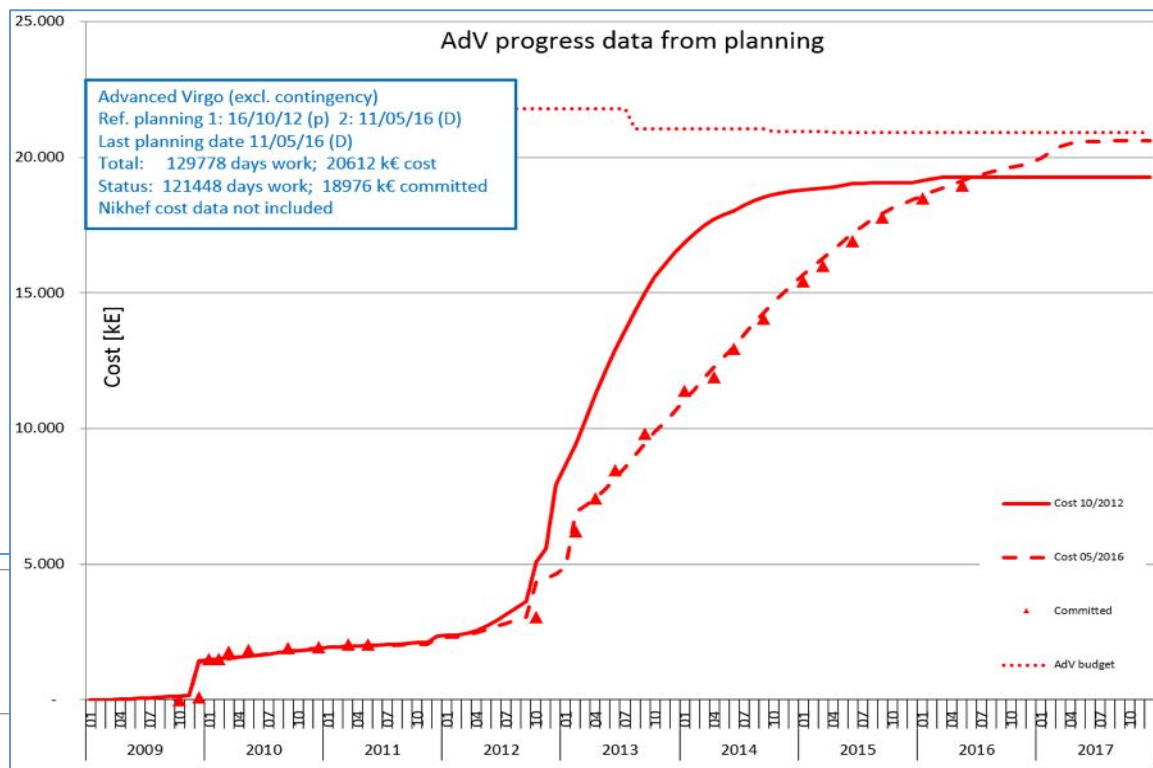


- ❑ TCS actuation (ring heaters, CO₂ lasers) completely installed
- ❑ Integration of TCS sensing (Hartmann sensors) being completed

Joint Run Planning Committee Working schedule for O2 (G1501561- v8)



BUDGET



**92% of project cost committed
 287 k€ of contingency available**

**PROJECT BEING COMPLETED
 ON BUDGET**



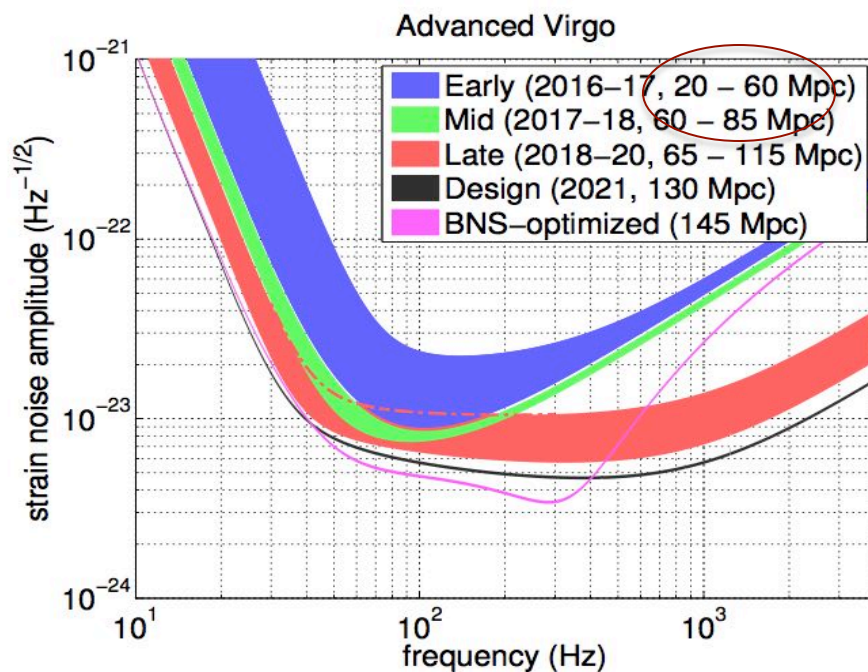
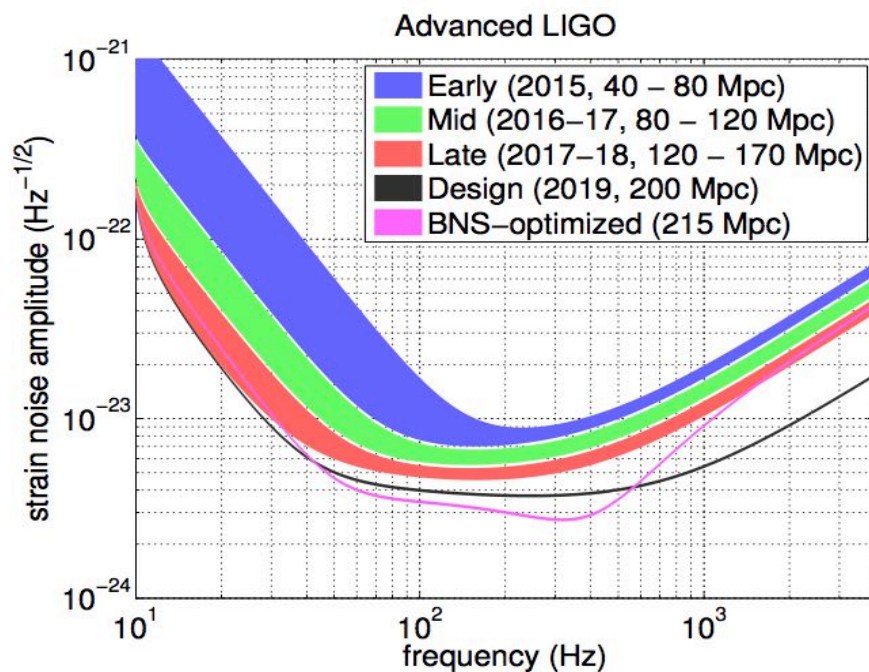
- ❑ The project will formally end when AdV starts the run
- ❑ The mandate of PL and the SSM will end
- ❑ Virgo is preparing the transition
 - Spokesperson proposal to be discussed at the VSC

AFTER O2

Prospects for Localization of Gravitational Wave Transients by the Advanced LIGO and Advanced Virgo Observatories

J. Aasi¹, J. Abadie¹, B. P. Abbott¹, R. Abbott¹, T. D. Abbott², M. Abernathy³, T. Accadia⁴, F. Acernese^{5ac}, C. Adams⁶, T. Adams⁷, P. Addresso⁸, R. X. Adhikari¹, C. Affeldt^{9,10}, M. Agathos^{11a}, O. D. Aguiar¹², P. Ajith¹, B. Allen^{9,13,10}, A. Allocca^{14ac}, E. Amador Ceron¹³, D. Amariutei¹⁵, S. B. Anderson¹, W. G. Anderson¹³, K. Arai¹, M. C. Araya¹, C. Arceneaux¹⁶, S. Ast^{9,10}, S. M. Aston⁶, P. Astone^{17a}, D. Atkinson¹⁸, P. Aufmuth^{10,9}, C. Aulbert^{9,10}, L. Austin¹, B. E. Aylott¹⁹, S. Babak²⁰,

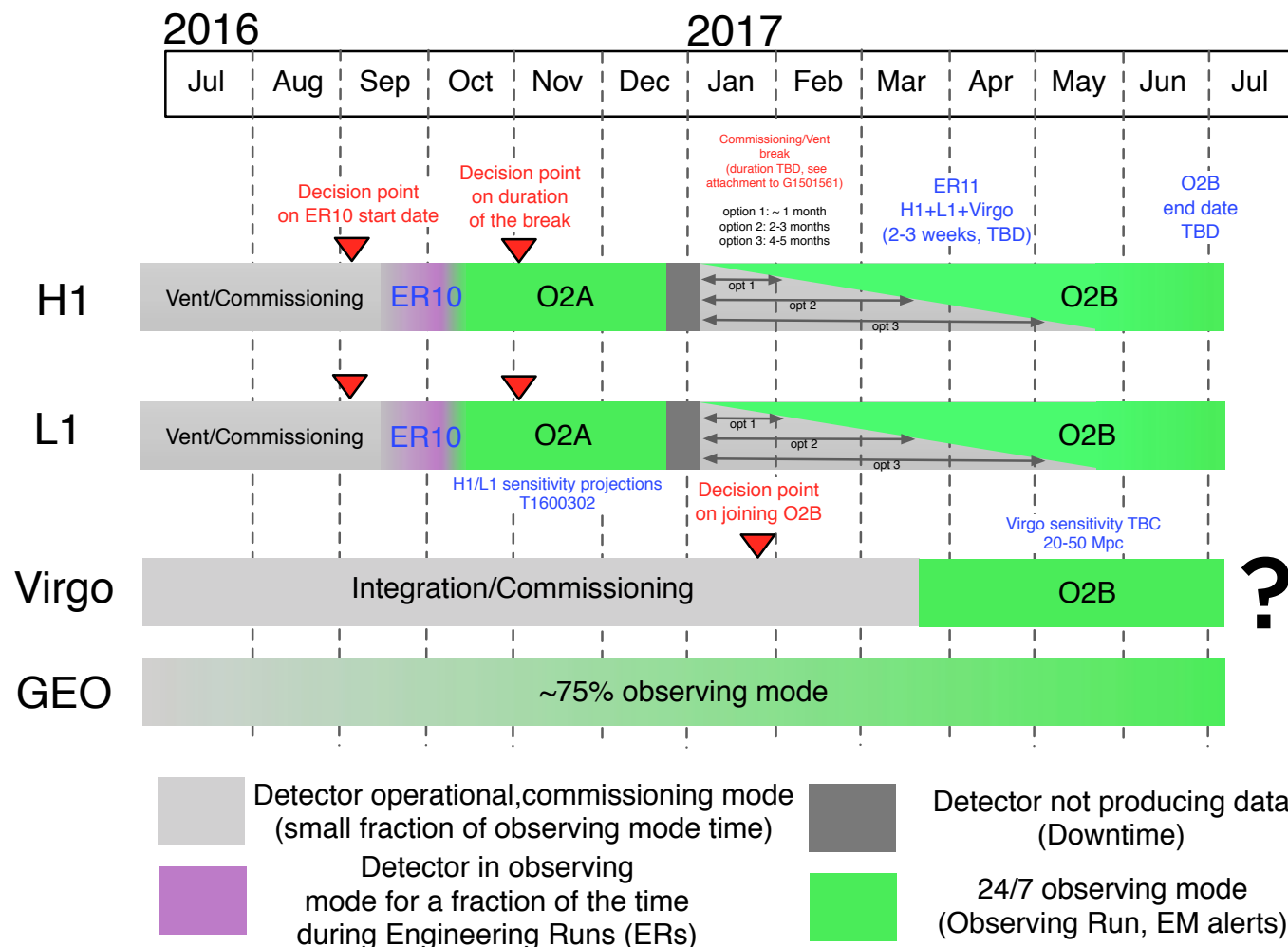
P. F.
L.
J. B.
A.
P. T.
M.
R.
M. C.
S. C.
F.
A. C.
M.
V.
S. D.



J. C. Driggers^{*}, Z. Du²¹, J.-C. Dumas²², S. Dwyer²³, T. Eberle²⁴, M. Edwards^{*}, A. Effler^{*}, P. Ehrens^{*}, S. S. Eikenberry¹⁵, C. Endr  ci⁵⁹, R. Engel¹, R. Essick²⁴, T. Etzel¹, K. Evans³, M. Evans²⁴, T. Evans⁶

AFTER O2

Joint Run Planning Committee Working schedule for O2 (G1501561- v8)



UPGRADES

REQUIRED TO INCREASE SENSITIVITY AS ENVISAGED

- ❑ Install monolithic suspensions (see talk by H Vocca)
- ❑ Install signal recycling mirror
- ❑ Install 100W laser amplifier

GOOD TO HAVE

- ❑ Squeezing (talk by JP Zendri)

HP LASER AMP

- ❑ After a dedicated review we understood that:
 - a reliable 200W amplifier is not available (even the LIGO one has failed)
 - we should rather focus on the coherent sum of two 100W amp
- ❑ A reliable 100W amp is not ready. Two possibilities:
 - a fiber amp developed by Alphanov (prototype under test at Nice)
 - a solid state amp developed by Neolase
- ❑ Path: comparative test in order to choose the final technology
- ❑ Final decision in 2017

GLOBAL FRAMEWORK

Category*	ROM Estimate (FY'17k\$)*
Core optic coating pathfinder	3,546
Core optic production	4,266
FC facility mods	1,023
FC vacuum	1,761
FC seismic isolation	4,728
FC suspensions	990
Balanced homodyne readout	339
Sensing & control	214
Other equipment	601
Labor	5,648
Contingency (25%)	5,779
Total	28,896

PRELIMINARY

A+

- An **incremental upgrade** to aLIGO that leverages **existing technology and infrastructure**, with **minimal new investment** and moderate risk
- Target: **factor of 1.7*** increase in range over aLIGO
→ About a **factor of 5 greater event rate**
- Stepping stone to future 3G detector technologies
- Link to future GW astrophysics and cosmology
- Could be **observing within < 6.5 years** (mid-2022)
– with prompt funding (FY'19 or earlier)
- “Scientific breakeven” **within 1/2 year** of operation
- Incremental cost: **a small fraction of aLIGO**

*BBH 20/20 M_{\odot} : 1.64x

*BNS 1.4/1.4 M_{\odot} : 1.85x

LIGO-G1601435

A+ LIGO DAWN II WORKSHOP ZUCKER

7



GLOBAL FRAMEWORK

- ❑ LIGO is starting a wide and heavy R&D program
 - ~3 M\$ being asked to NSF for research on coating
 - Mid-term target: installation of A+ in ~2019
- ❑ AdV must pursue a continue improvement of sensitivity
 - A “vision document” is being finalized and will be issued soon
- ❑ We need to convince the agencies that the best way to protect the investment done is continue investing

IT'S TIME TO RESTART R&D

A WIDER COMPARISON

SNAPSHOT at the time
of the TDR (2012)

	Advanced LIGO	Advanced Virgo
# DETECTORS	2+1	1
MAX CBC RANGE (BNS)	200 Mpc	140 Mpc
BUDGET	205 ^(A) M\$ + 16 ^(B) (D/UK/AUS)	21.8 ^(C) M€ + 2 ^(B) (NL)
FUNDING APPROVED	Apr 2008	Dec 2009
CONSTRUCTION END ^(D)	Jul 2014	May 2016
1 st PROJECT REVIEW	2003	2008
MEMBERS	~900	~200
COUNTRIES	17	5
LABS	82	19
R&D INVESTMENTS	~60 ^(E) M\$	~2 ^(F) +1.5 ^(G) M€

(A) Includes money for people (“half stuff, half staff”)

(B) In kind contribution

(C) Only for investments

(D) Expected according to the latest planning

(E) Personal communication from D Shoemaker. LIGO lab R&D (+2-3 M\$/yr in other labs)

(F) EGO R&D calls 2003 and 2007

(G) CSN2 funding 2005-2010 (data from Fulvio Ricci)