Disegno di Ilaria Nardecchia

ADVANCED DETECTORS

Giovanni Losurdo – INFN Firenze
Advanced Virgo Project Leader

LIGO VIRGO

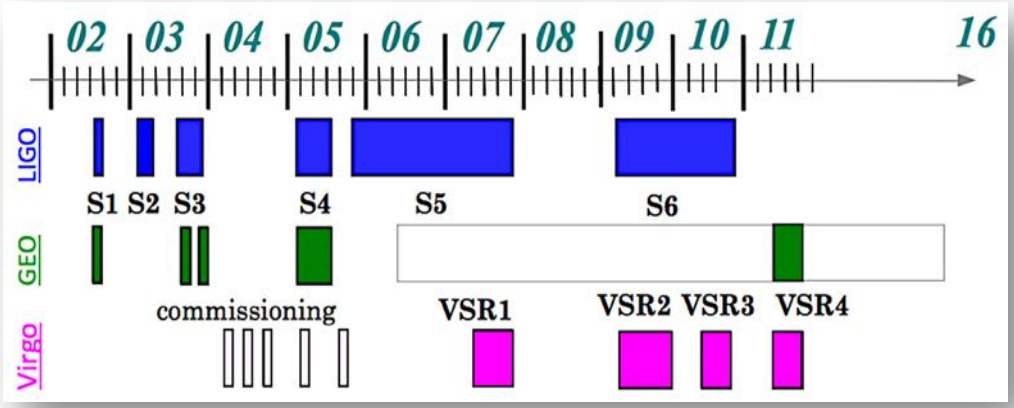
Gravitational Wave Festival

INFN

DIPARTIMENTO DI FISICA
UNIVERSITÀ DI PISA

1st GENERATION DETECTORS

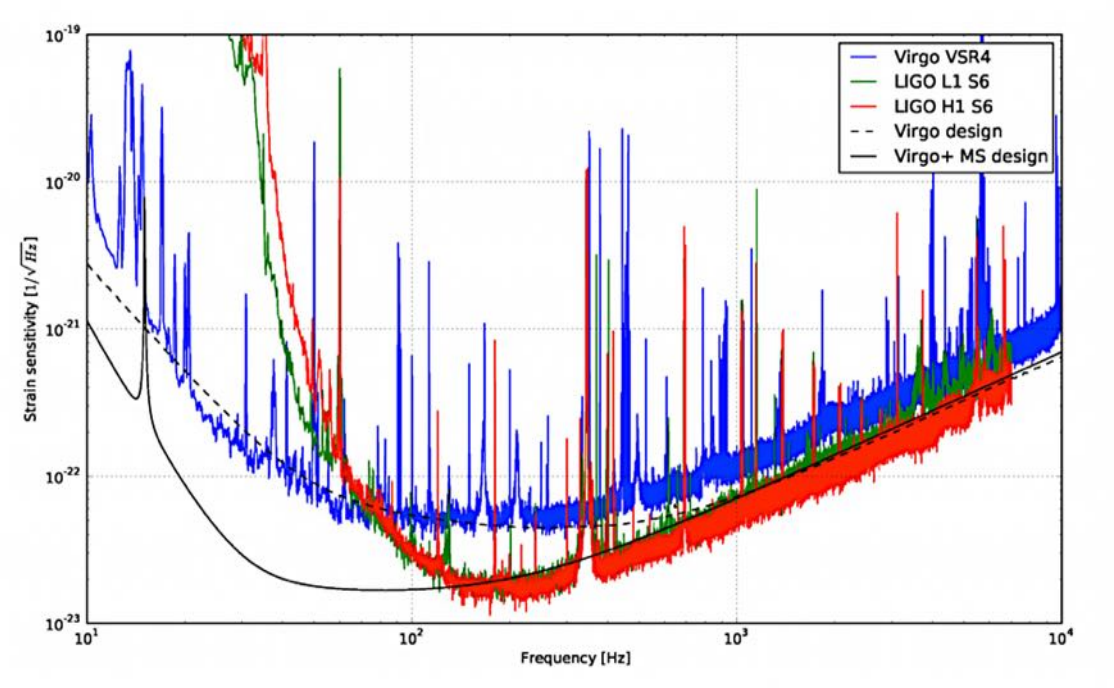
- The interferometers of the 1t generation (LIGO, Virgo, GEO600) have run in the 1st decade of 2000's



- The sensitivity finally achieved was enough to detect a coalescing BNS in ~100 galaxies…
  - …but such events happen ~1/10000 yr per galaxy…
- No detection done but a rich legacy has been left.

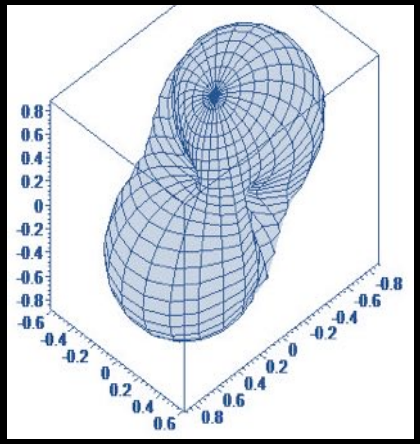
NOISE AND SENSITIVITY

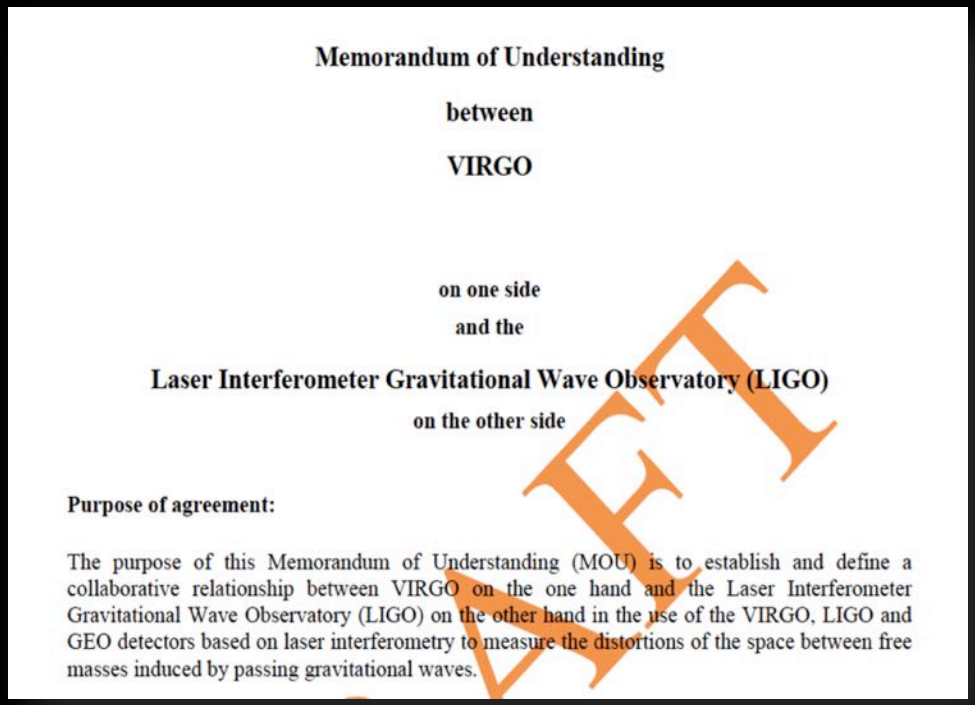
- The noise has been mostly understood
- The 1st generation design sensitivities have been approached closely (and somewhere exceeded upon detector upgrades)
- Excellent duty cycle (~80%): reliable instruments!



NETWORK

A MAJOR STEP TOWARDS GW ASTRONOMY





Memorandum of Understanding

between

VIRGO

on one side

and the

Laser Interferometer Gravitational Wave Observatory (LIGO)

on the other side

Purpose of agreement:

The purpose of this Memorandum of Understanding (MOU) is to establish and define a collaborative relationship between VIRGO on the one hand and the Laser Interferometer Gravitational Wave Observatory (LIGO) on the other hand in the use of the VIRGO, LIGO and GEO detectors based on laser interferometry to measure the distortions of the space between free masses induced by passing gravitational waves.

GW "TELESCOPES"
CANNOT BE POINTED

SOURCE LOCALIZATION
REQUIRES NETWORKING

SINCE 2007: LIGO, VIRGO, GEO
WORKING AS A SINGLE MACHINE

MOU RENEWED IN 2014.

NETWORK

LIGO - WA

GEO600 - D

KAGRA – J
(2018)

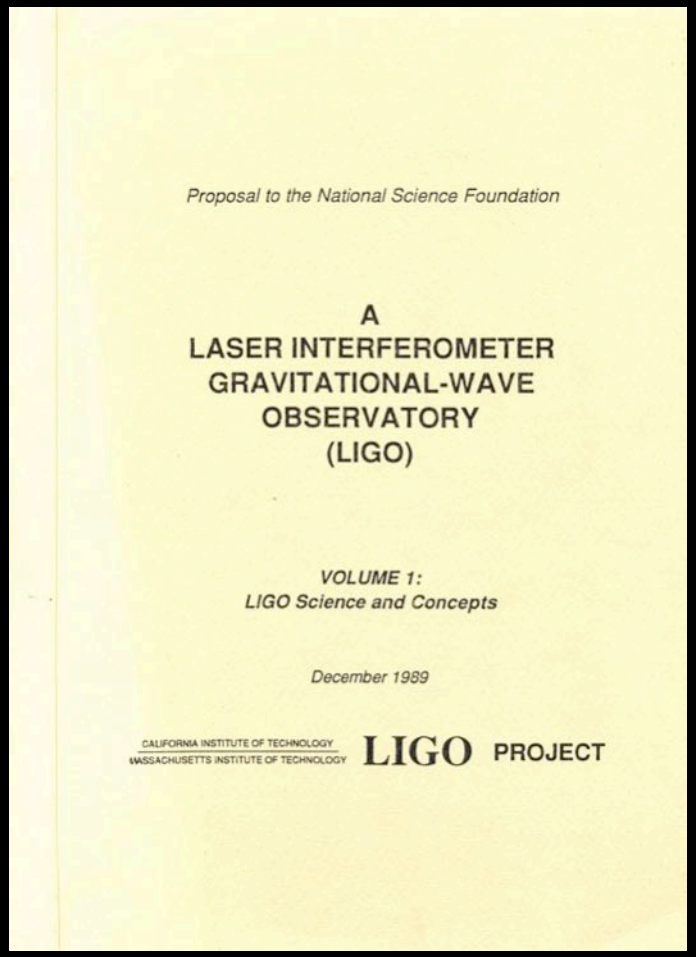
LIGO - LA

Virgo - I

indigo LIGO

LIGO – India
(> 2020)

1989



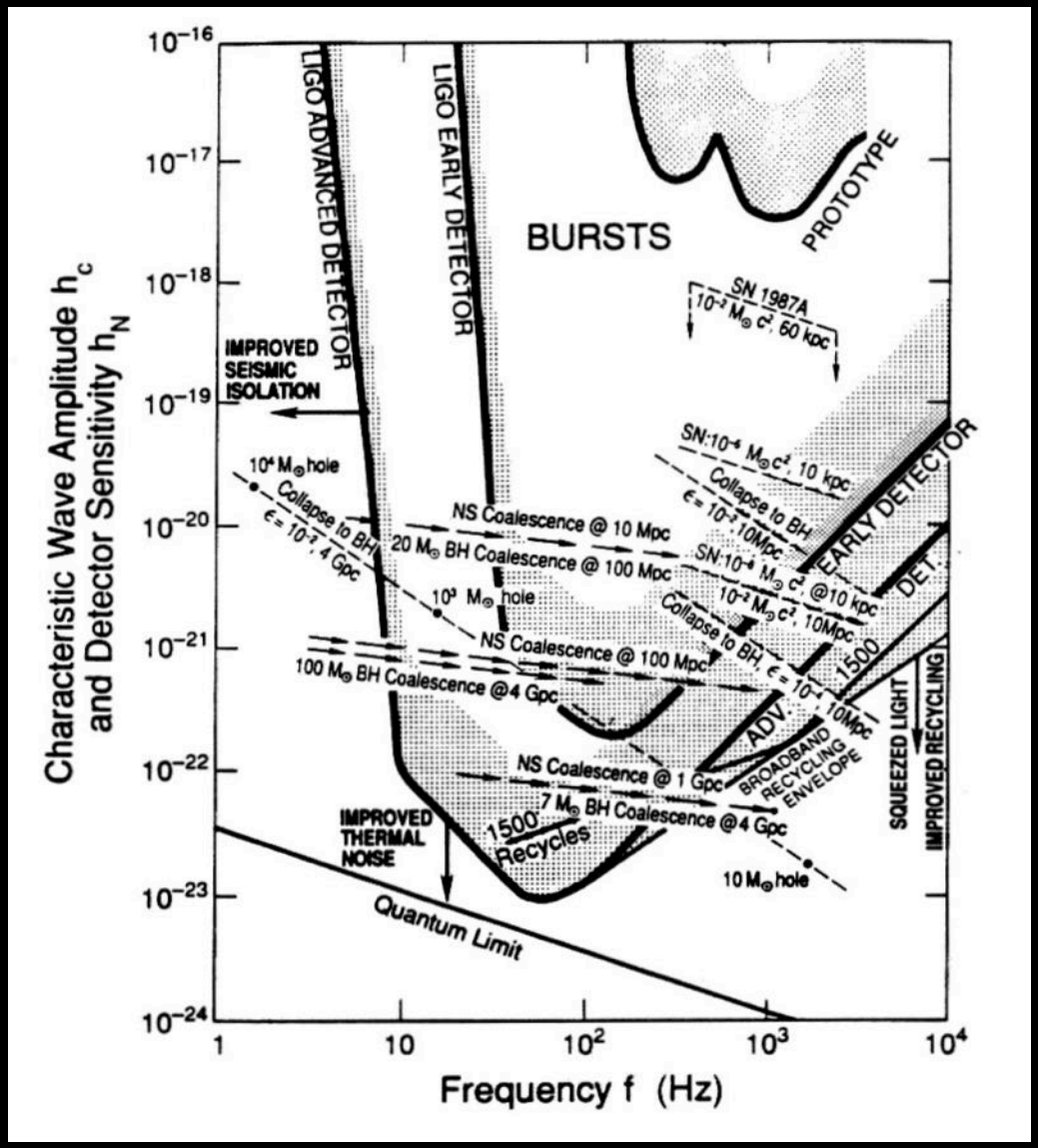
Proposal to the National Science Foundation

A
LASER INTERFEROMETER
GRAVITATIONAL-WAVE
OBSERVATORY
(LIGO)

VOLUME 1:
LIGO Science and Concepts

December 1989

CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LIGO PROJECT



THE CONCEPT OF AN "ADVANCED" DETECTOR IS ALREADY IN THE LIGO PROPOSAL TO NSF

ADVANCED LIGO

- Proposal to NSF: 2003. Project start: April 2008
- Funding: $205 M$ from NSF, in-kind contribution from D/UK/AUS
- Two detectors installed, third interferometer to be shipped to India
- Construction completed: Jul 2014.
- First science run completed.

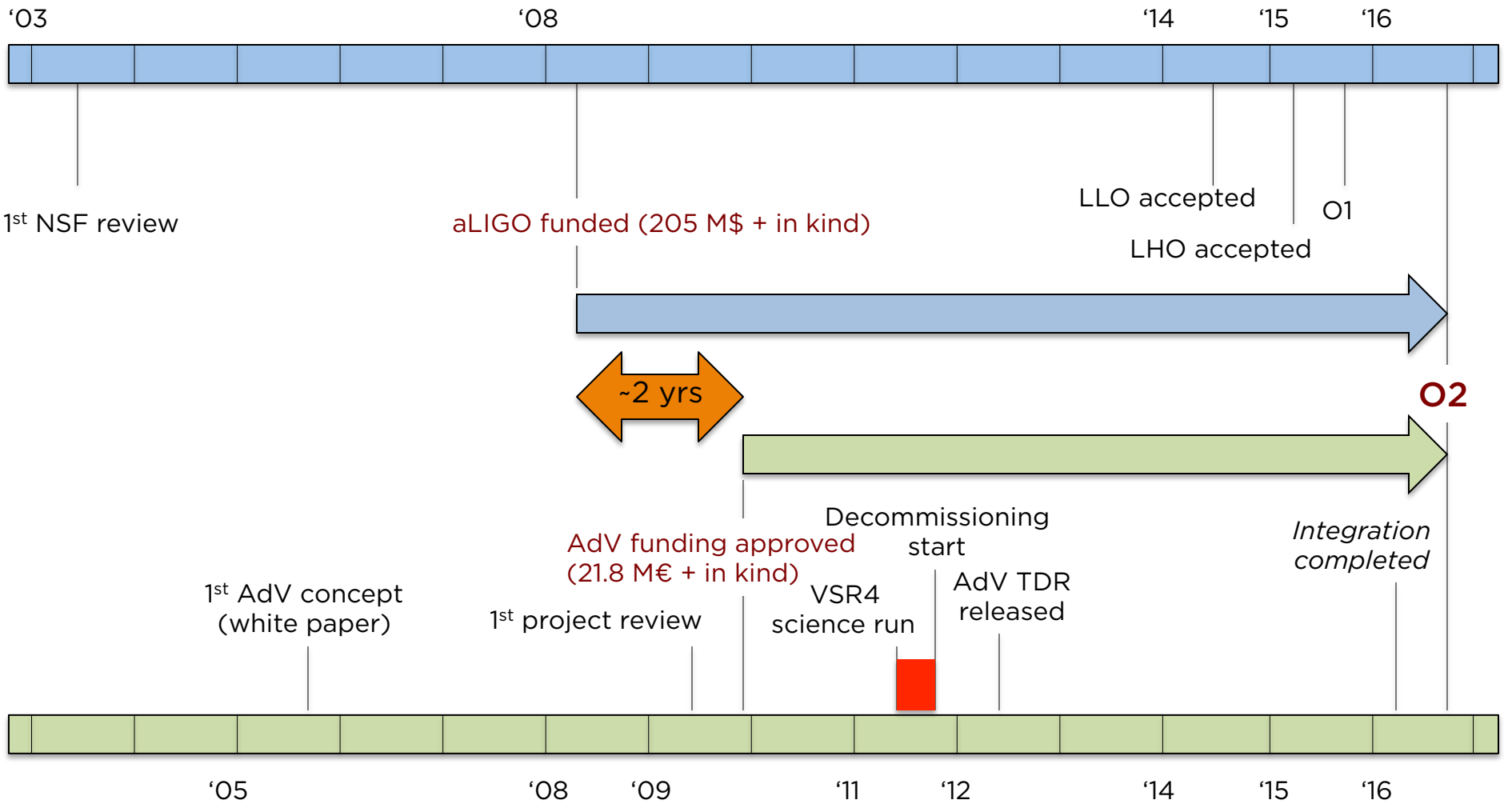
ADVANCED VIRGO

- Funding approved in Dec 2009 (21.8 ME + Nikhef in kind contribution)
- TDR approval: Apr 2012
- Construction in progress. End of installation: spring 2016
- First science data in 2016

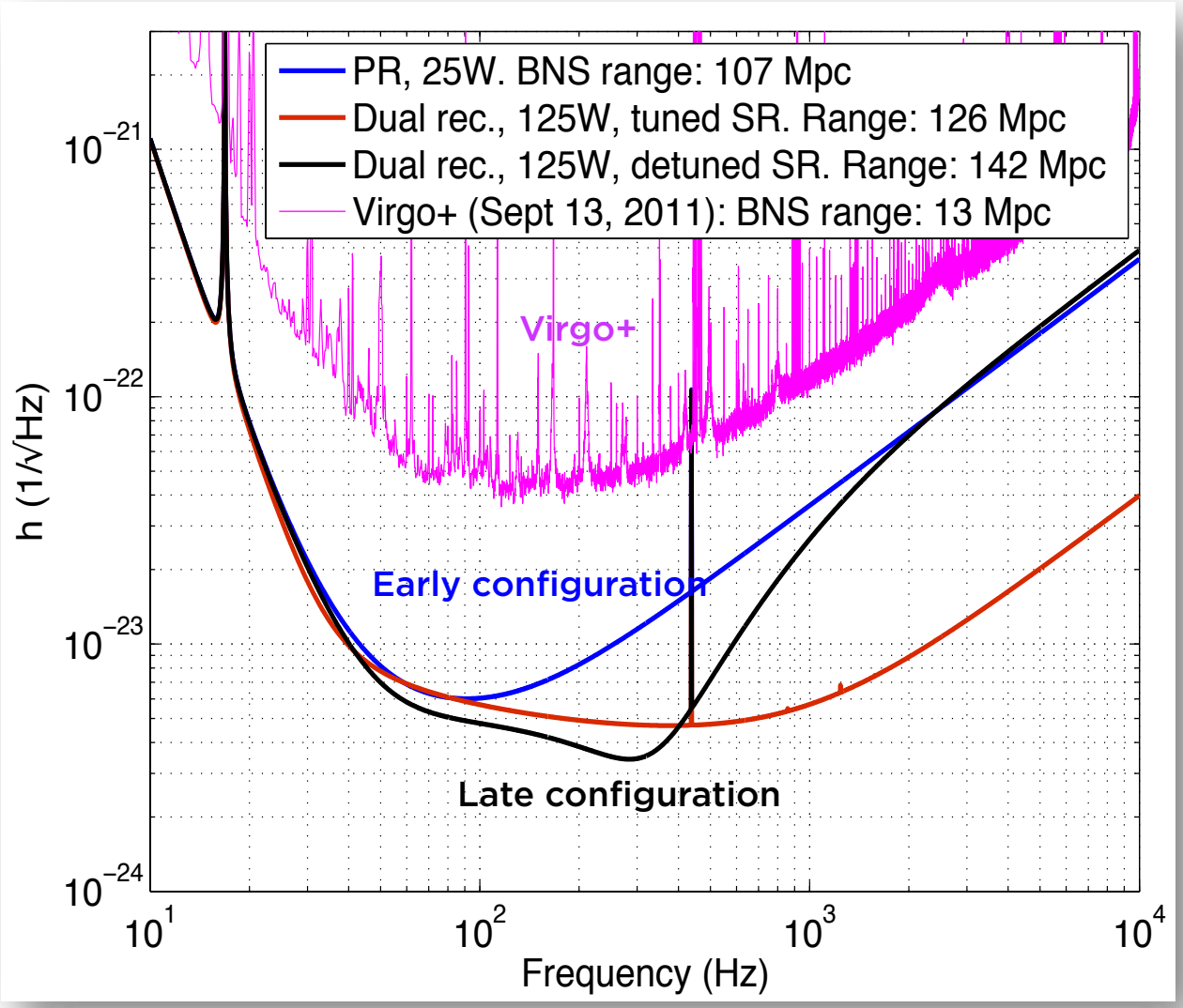
5 European countries
19 labs, ~200 authors

APC Paris
ARTEMIS Nice
EGO Cascina
INFN Firenze-Urbino
INFN Genova
INFN Napoli
INFN Perugia
INFN Pisa
INFN Roma La Sapienza
INFN Roma Tor Vergata
INFN Trento-Padova
LAL Orsay – ESPCI Paris
LAPP Annecy
LKB Paris
LMA Lyon
NIKHEF Amsterdam
POLGRAW(Poland)
RADBOUD Uni. Nijmegen
RMKI Budapest

SOME HISTORY



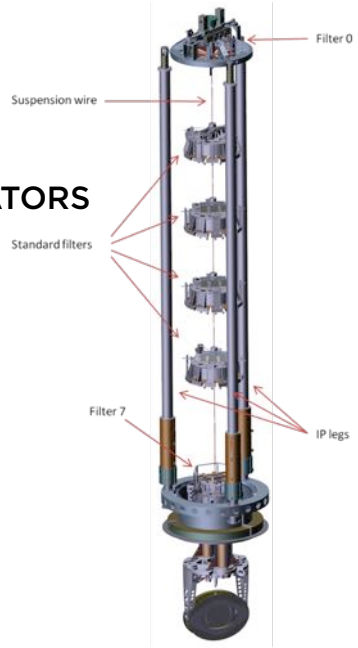
SENSITIVITY TARGETS



HEAVIER
TEST MASSES

SWEB
B8
WE

VIRGO
SUPERATTENUATORS



Input
Mode
Cleaner

LARGER BEAM

WI
CP

THERMAL COMPENSATION
OF ABERRATIONS

HIGH POWER
LASER

SIB1
Faraday
Isolator
200W
Laser

SPRB
B4

CP NI
NE SNEB
BS
B7

PRM POP

B2
SIB2

SRM

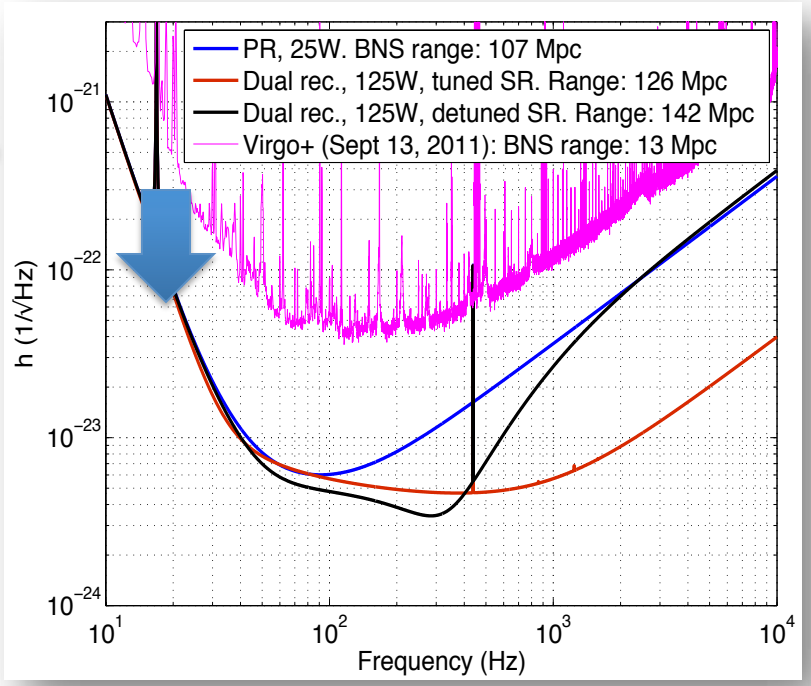
OMCs
SDB1

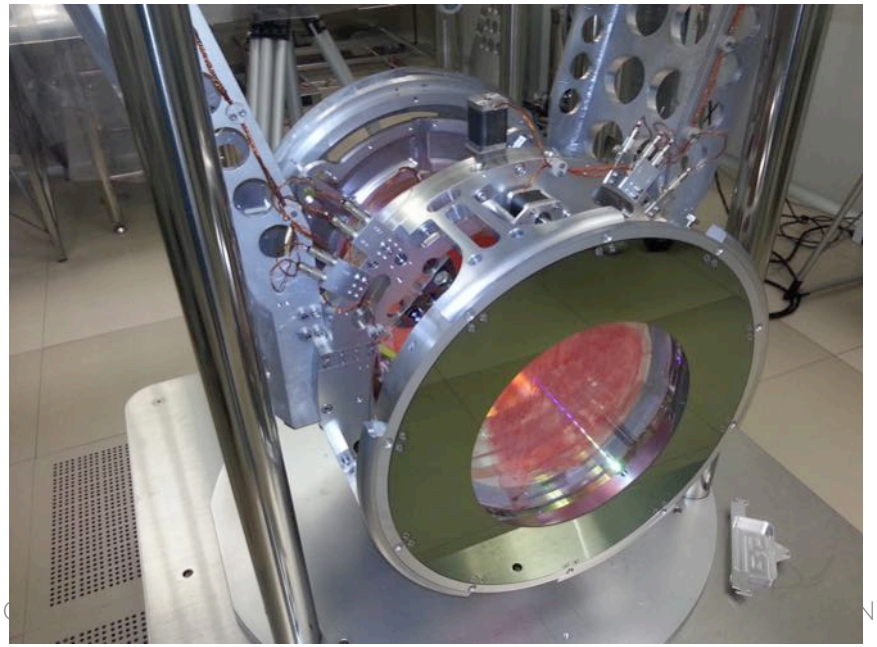
B1
SDB2

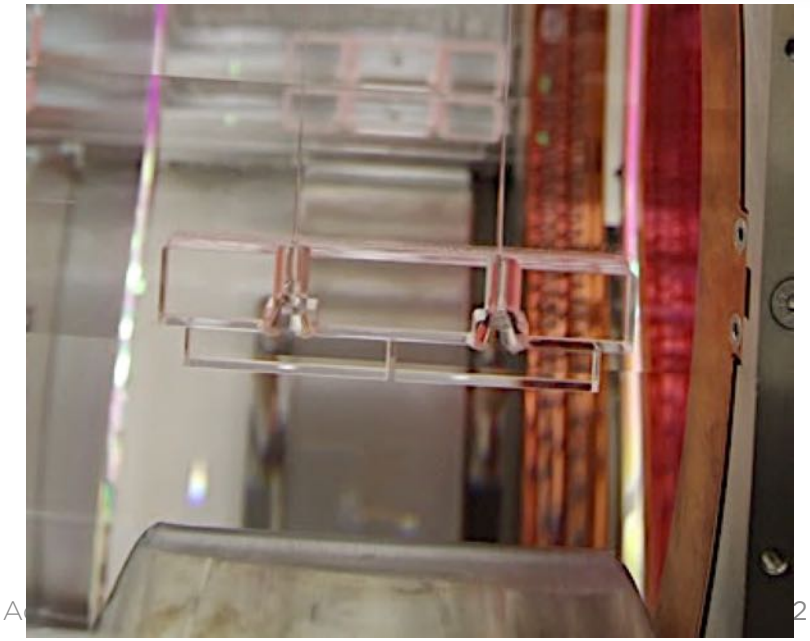
STRAY LIGHT RISK
MITIGATION:
- BAFFLES
- ISOLATED PHOTODIODES

TECHNOLOGIES

- Virgo Superattenuator already compliant with 2nd generation
  - Some upgrades to support heavier payloads
  - New control electronics!
  - Blade issue
- Improve monolithic suspension

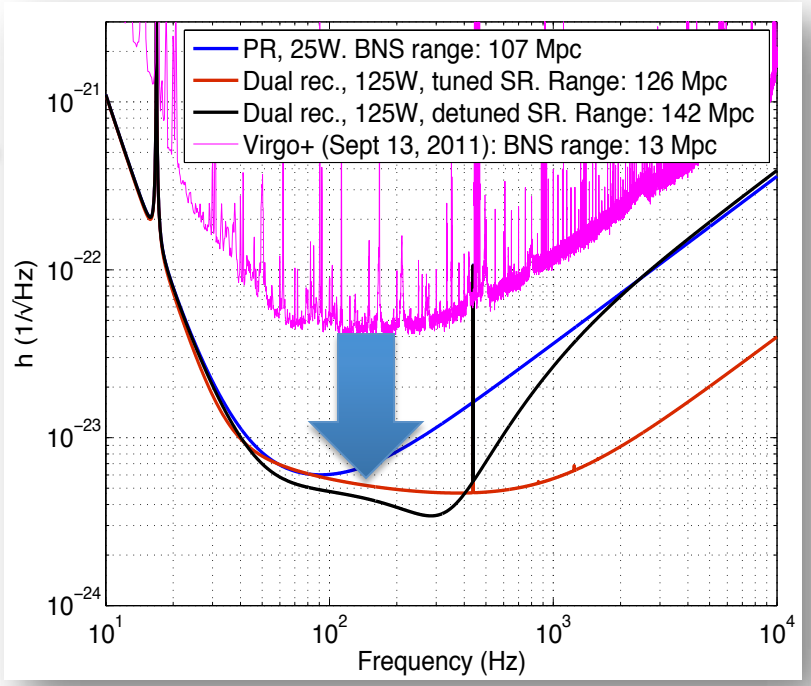


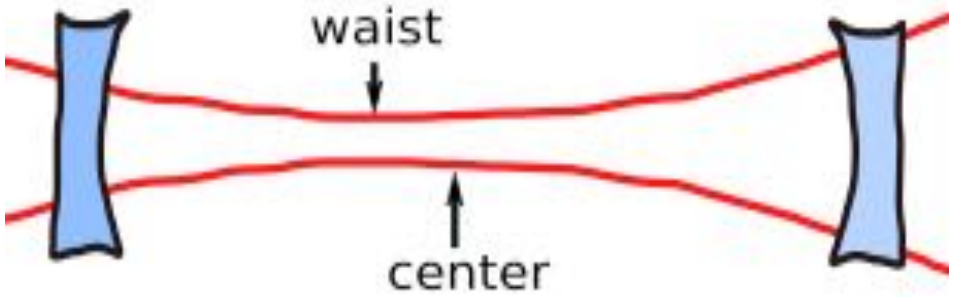




TECHNOLOGIES

- Dominated by thermal noise of mirror coatings
- Reduced by:
  - Improved optical configuration: larger beam spot
  - Mirror coatings engineered for low losses

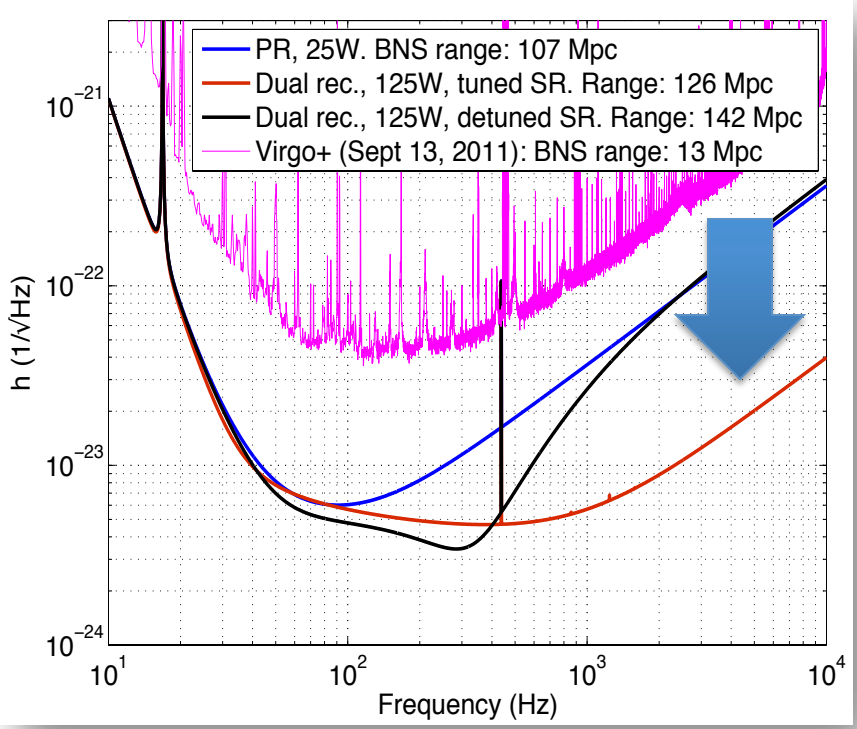




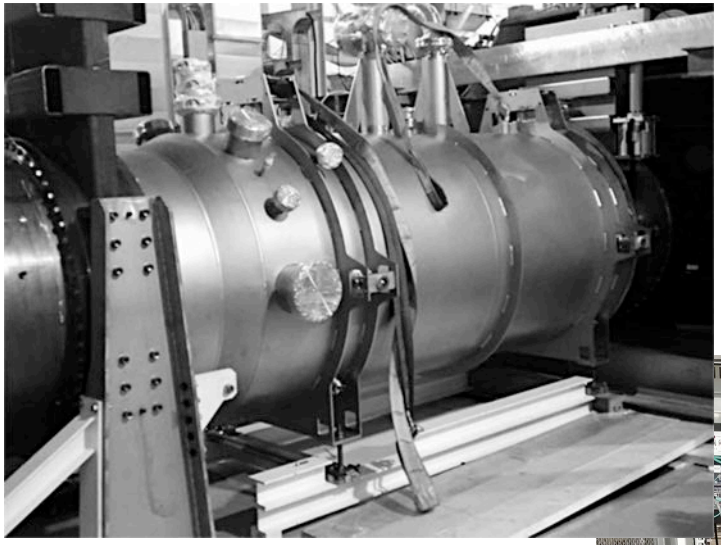
TECHNOLOGIES

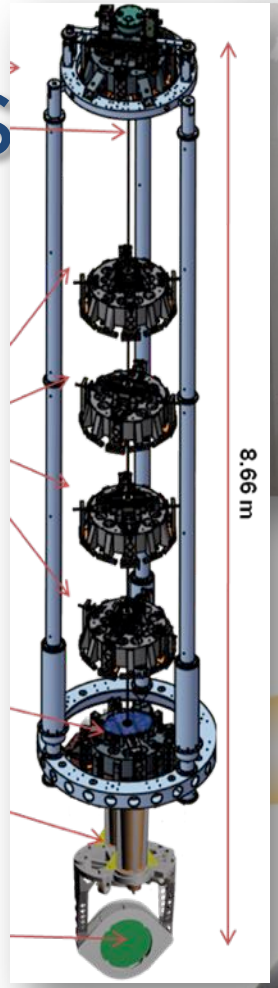
BEATING THE SHOT NOISE LIMIT

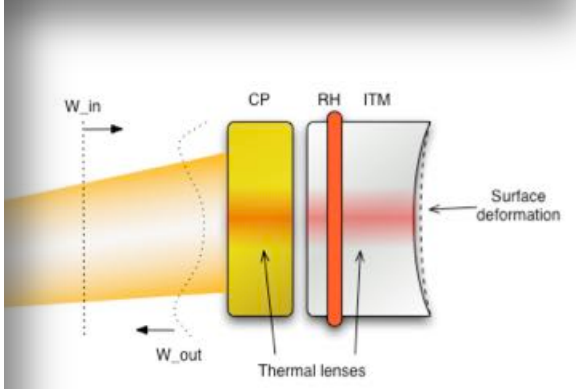
- Increase of laser power 10x
  - Fiber technology being engineered
- Requires:
  - Heavier mirrors
  - Low absorption optics
  - Compensation of thermal aberrations

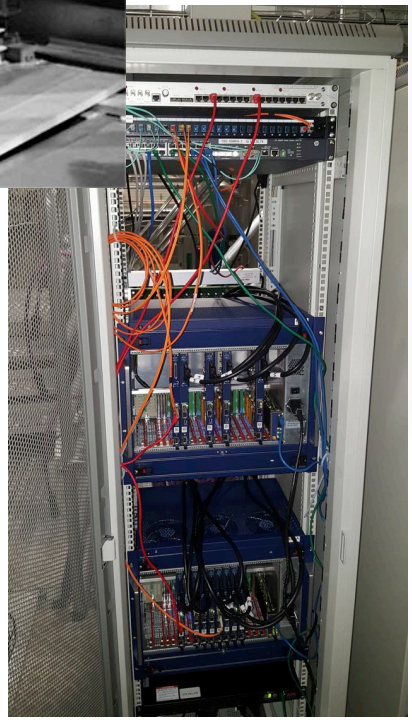


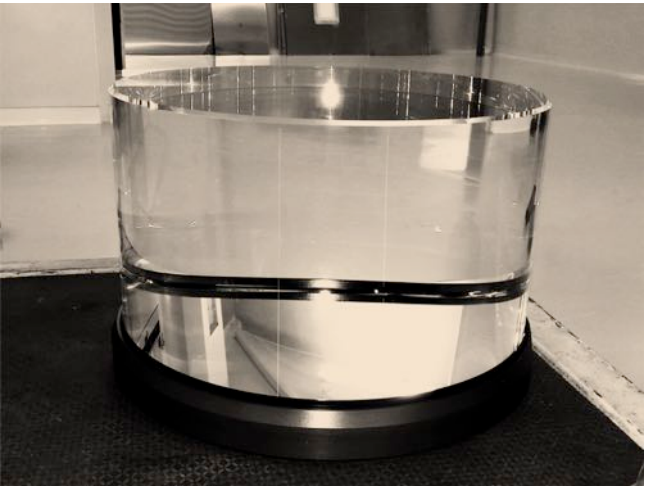
TECHNOLOGIES

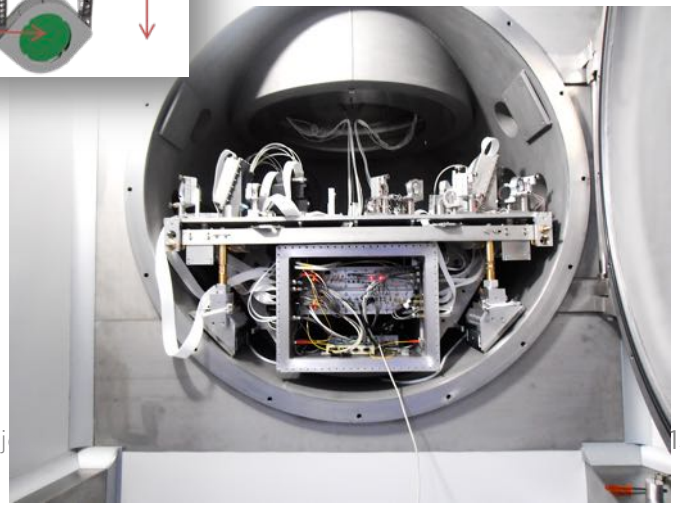








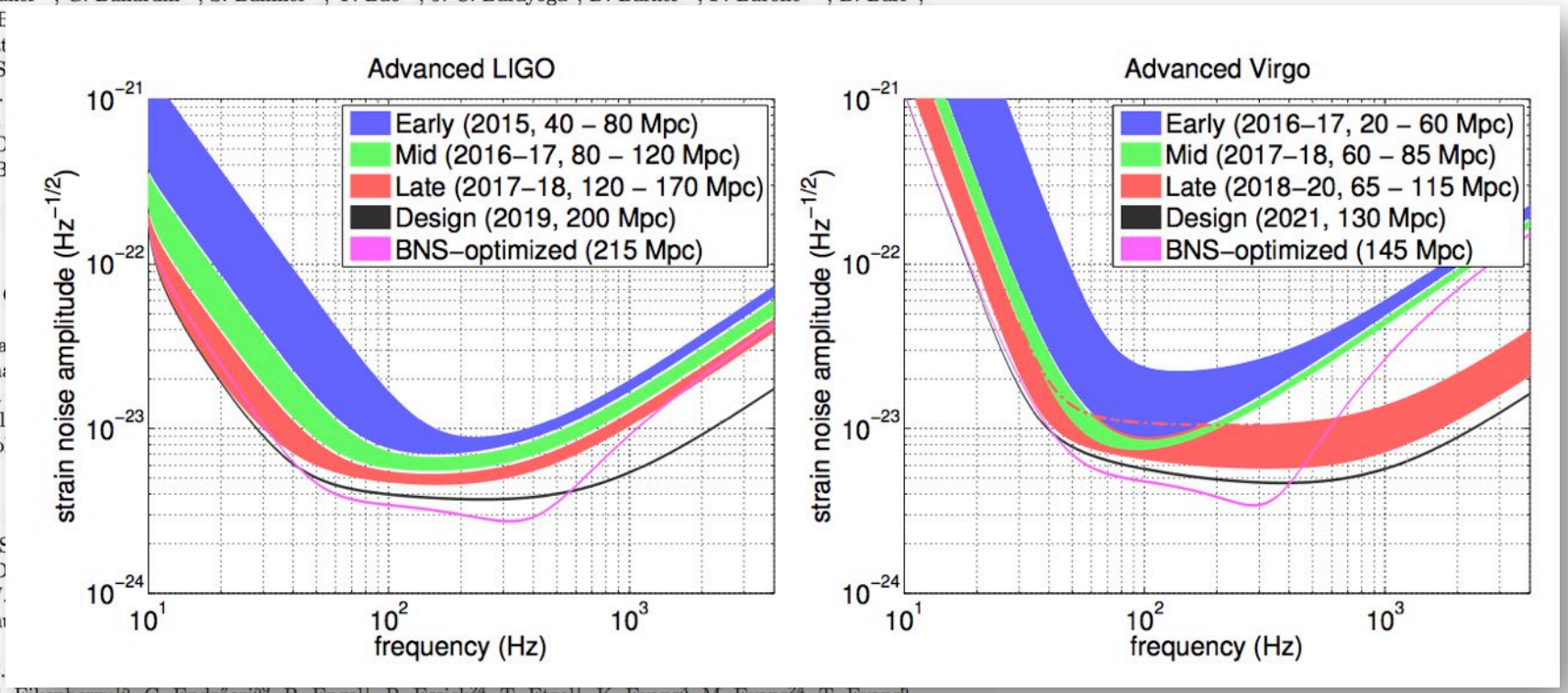




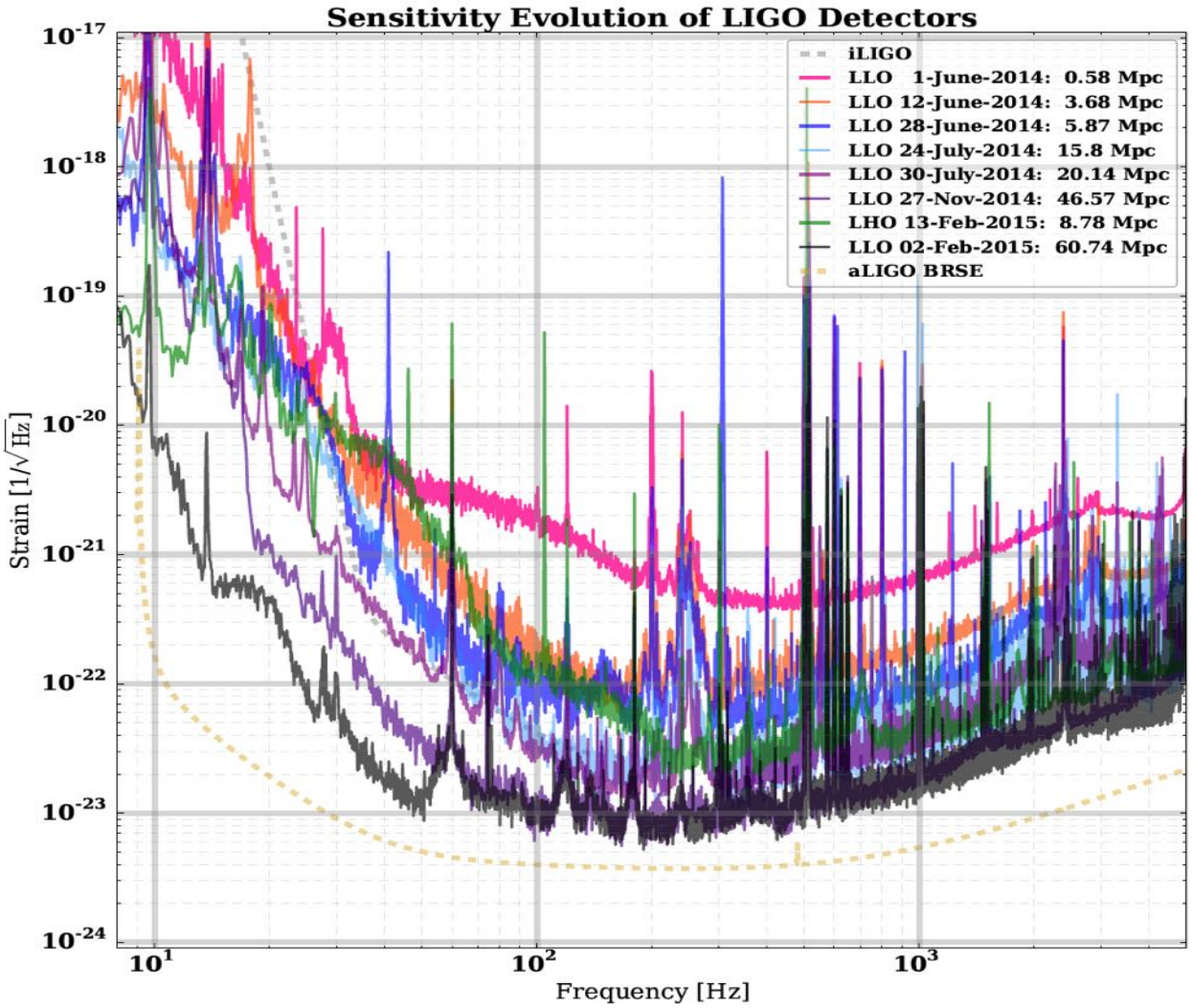
SENSITIVITY EVOLUTION

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

J. Aasi[1], J. Abadie[1], B. P. Abbott[1], R. Abbott[1], T. D. Abbott[2], M. Abernathy[3], T. Accadia[4], F. Acernese[5ac], C. Adams[6], T. Adams[7], P. Addesso[8], R. X. Adhikari[1], C. Affeldt[9,10], M. Agathos[11a], O. D. Aguiar[12], P. Ajith[1], B. Allen[9,13,10], A. Allocca[14ac], E. Amador Ceron[13], D. Amariutei[15], S. B. Anderson[1], W. G. Anderson[13], K. Arai[1], M. C. Araya[1], C. Arceneaux[16], S. Ast[9,10], S. M. Aston[6], P. Astone[17a], D. Atkinson[18], P. Aufmuth[10,9], C. Aulbert[9,10], L. Austin[1], B. E. Aylott[19], S. Babak[20], P. Baker[21], G. Ballardin[22], S. Ballmer[23], Y. Bao[15], J. C. Barayoga[1], D. Barker[18], F. Barone[5ac], B. Barr[3],

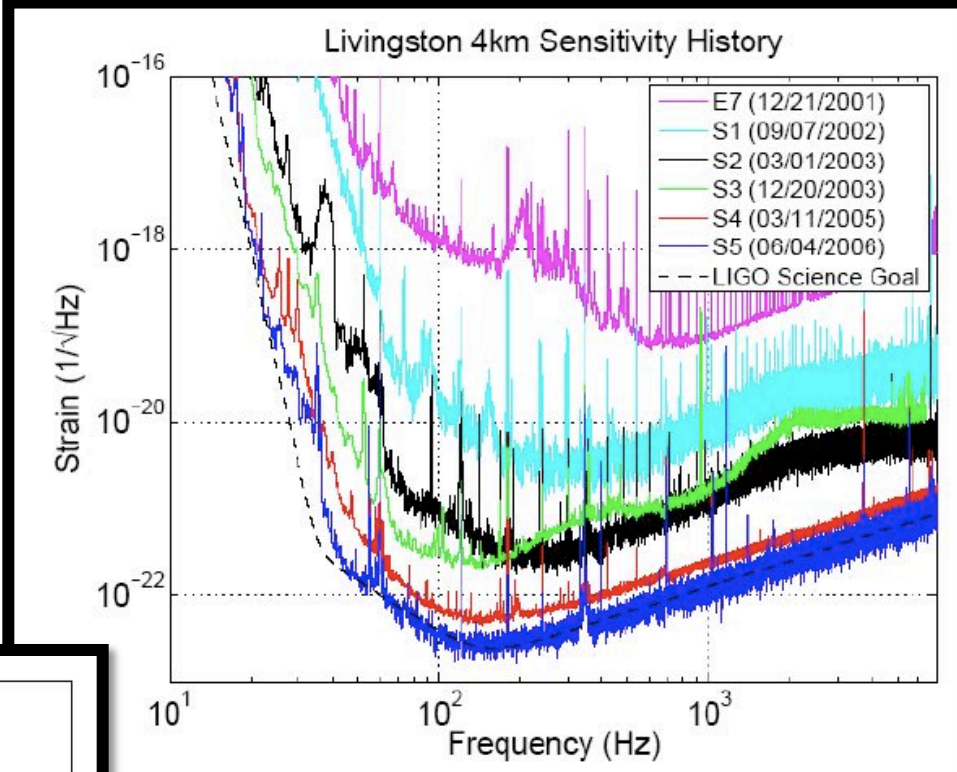


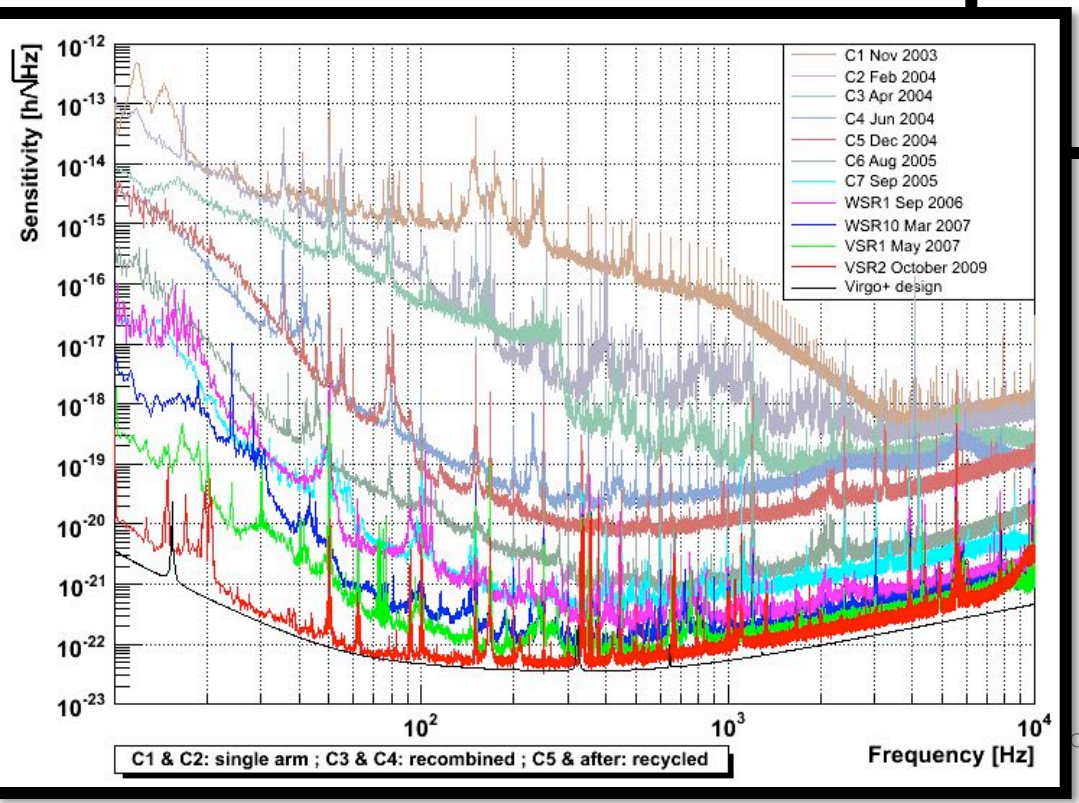
aLIGO COMMISSIONING



FROM 0 TO 60 Mpc
IN 80 MONTHS

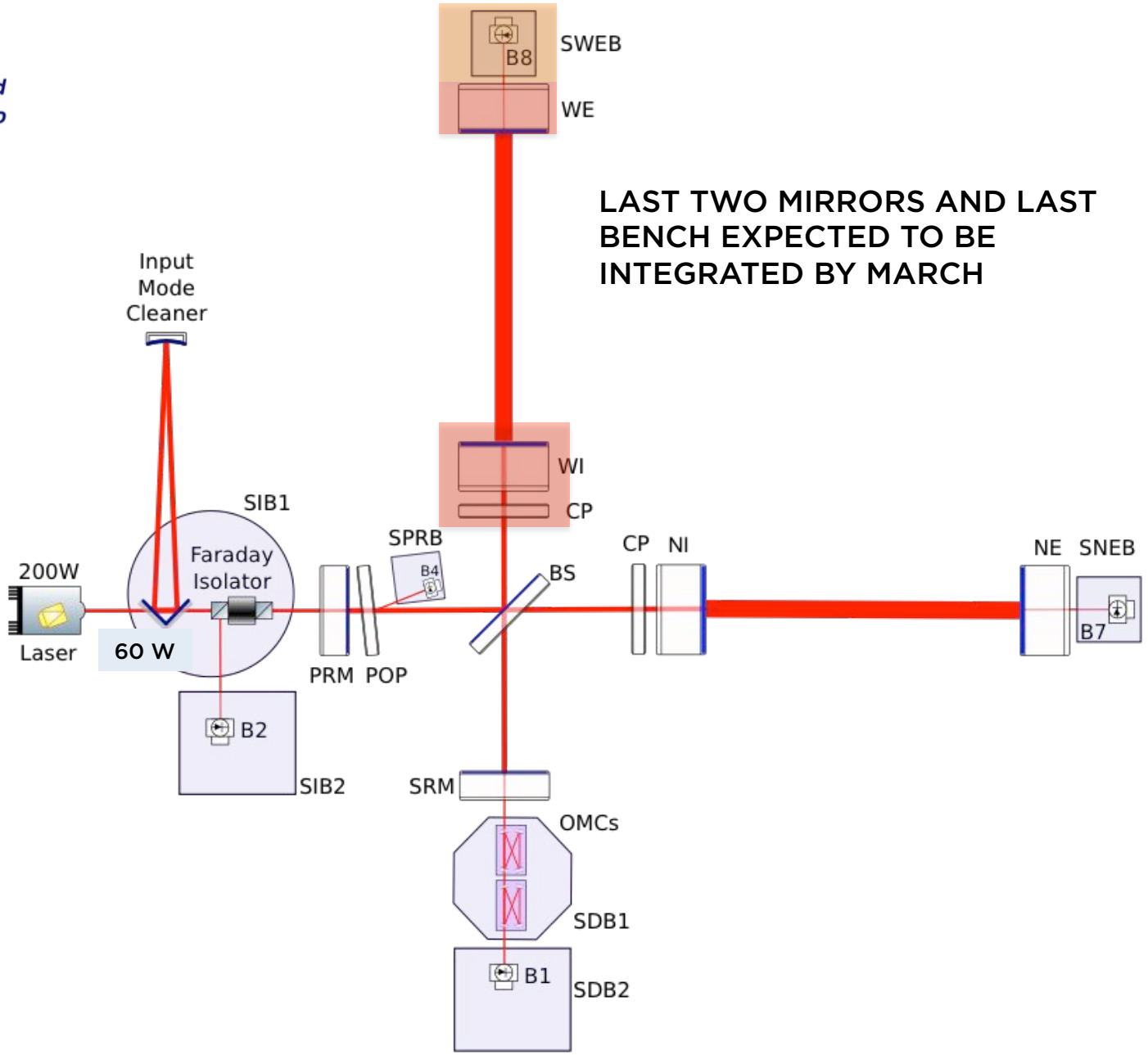
LIGO/VIRGO



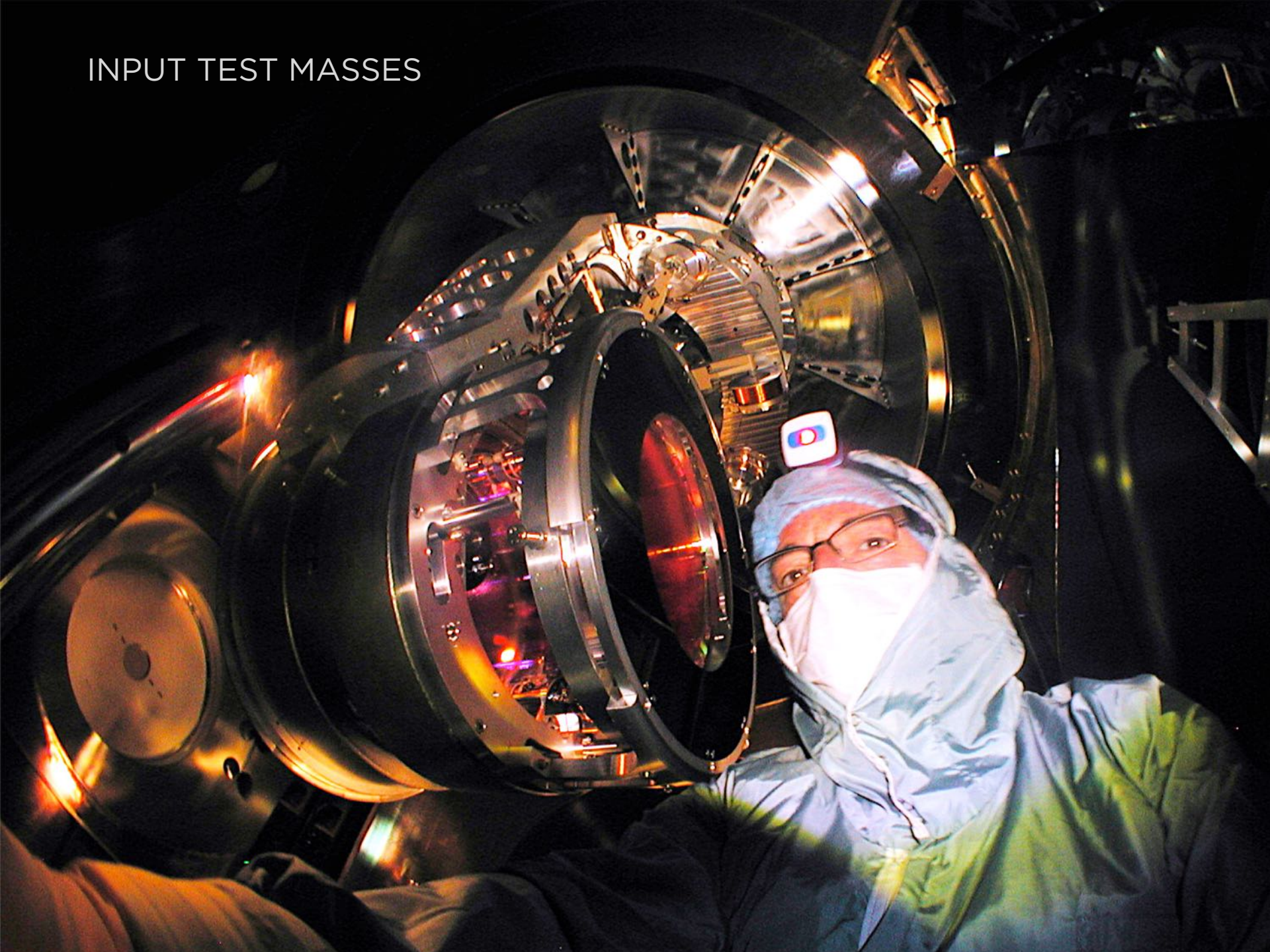


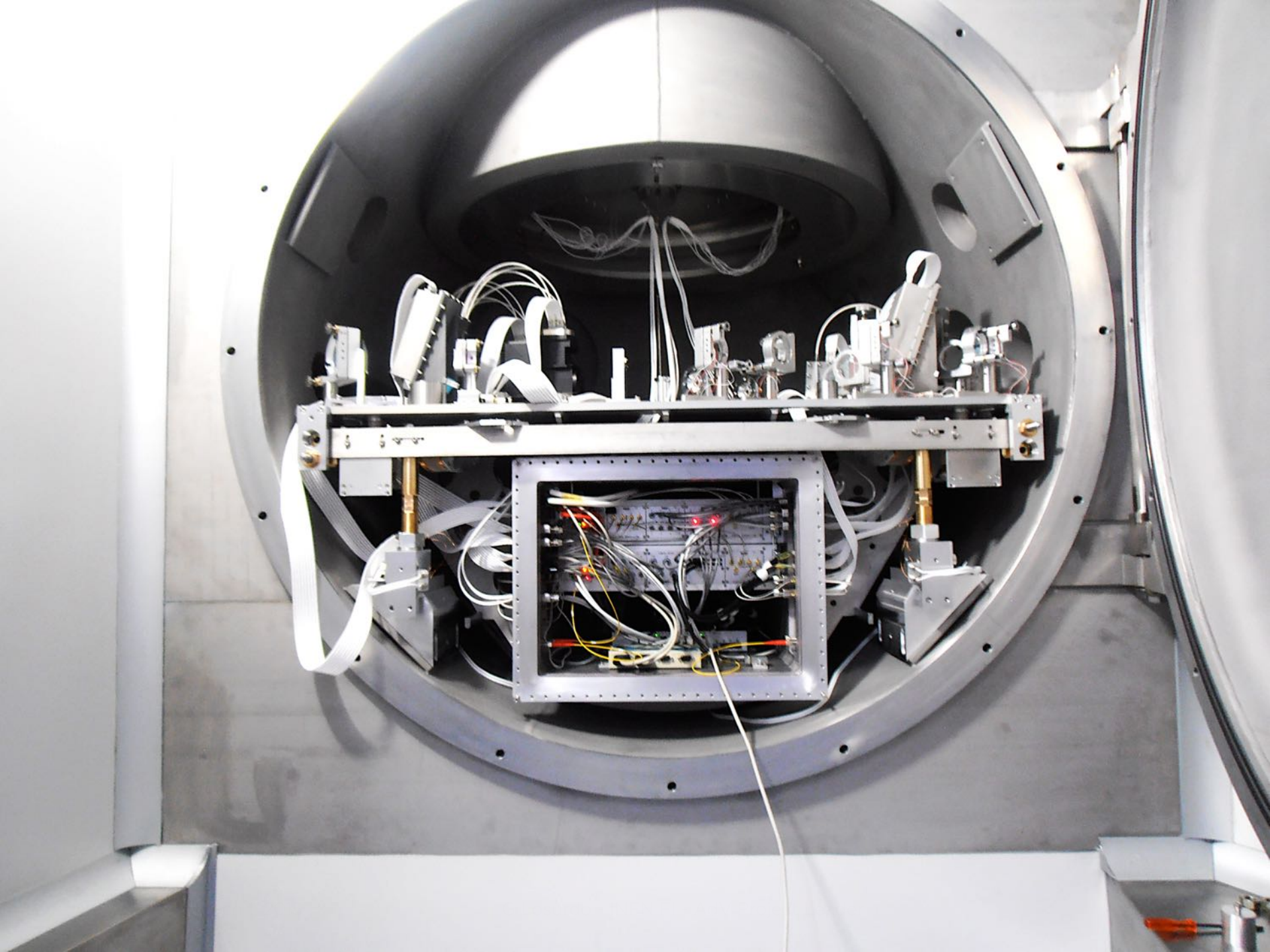
5-6 YRS (INCLUDING DATA TAKING) TO REACH THE TARGET SENSITIVITIES


ADVANCED VIRGO

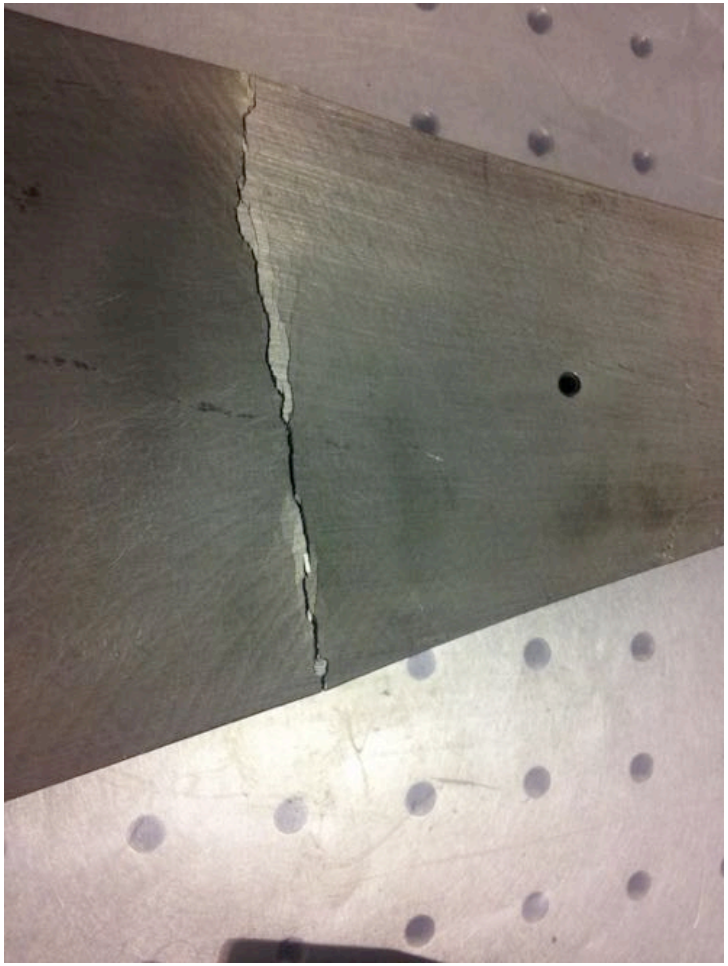

SWEB
B8
WE
LAST TWO MIRRORS AND LAST BENCH EXPECTED TO BE INTEGRATED BY MARCH
Input Mode Cleaner
WI
CP
SIB1
SPRB
B4
CP
NI
NE
SNEB
200W
Faraday Isolator
BS
Laser
60 W
PRM
POP
B7
B2
SIB2
SRM
OMCs
SDB1
B1
SDB2

INPUT TEST MASSES





2015 ISSUES



BROKEN SUPERATTENUATOR BLADES

BROKEN MONOLITHIC SUSPENSIONS

NEXT STEPS

Last to mirrors to be installed by the end of March: end of integration

Focus on the commissioning. Goal: joining aLIGO in O2

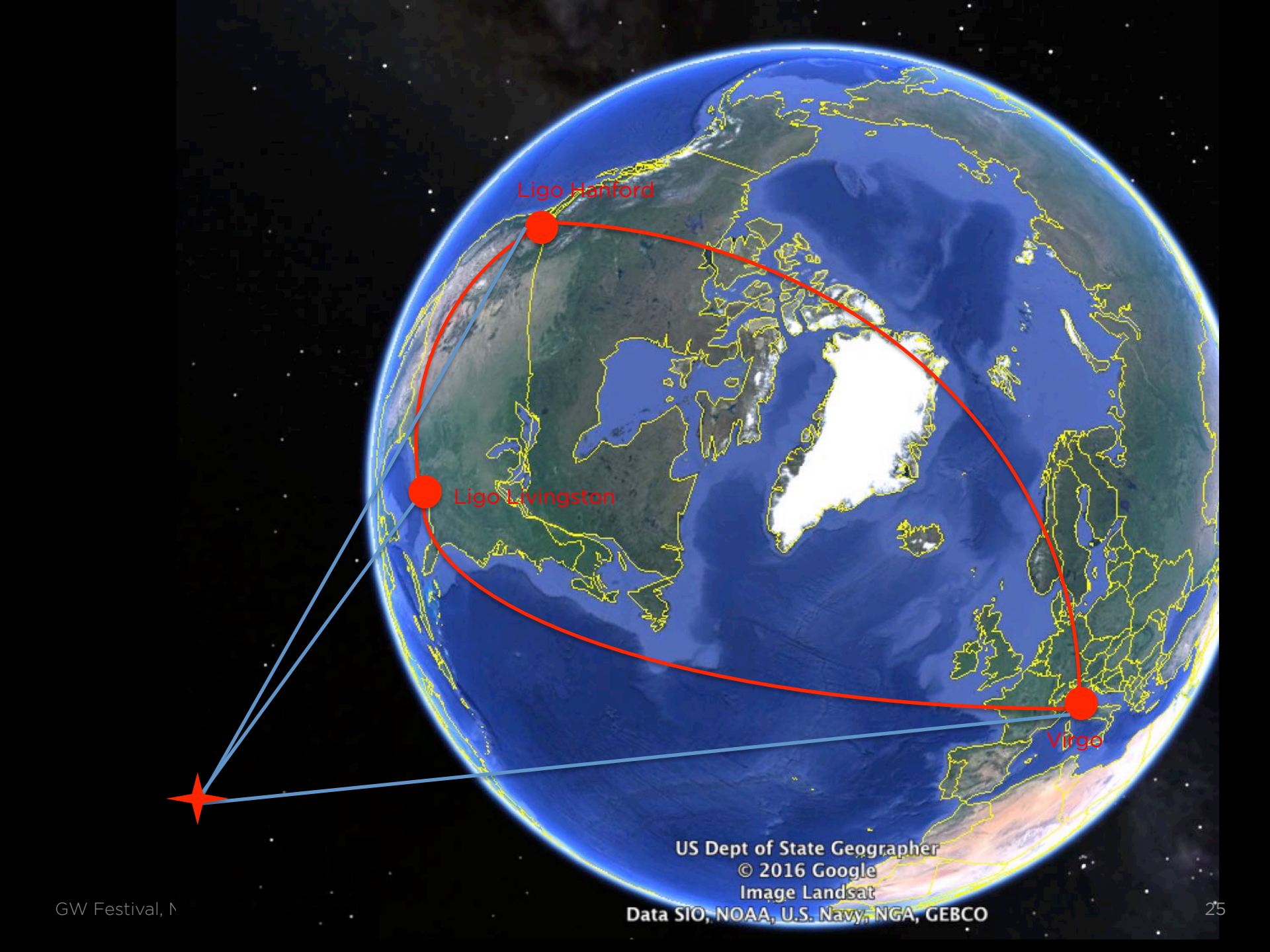

Ligo Hanford
Ligo Livingston
Virgo
US Dept of State Geographer
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Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO