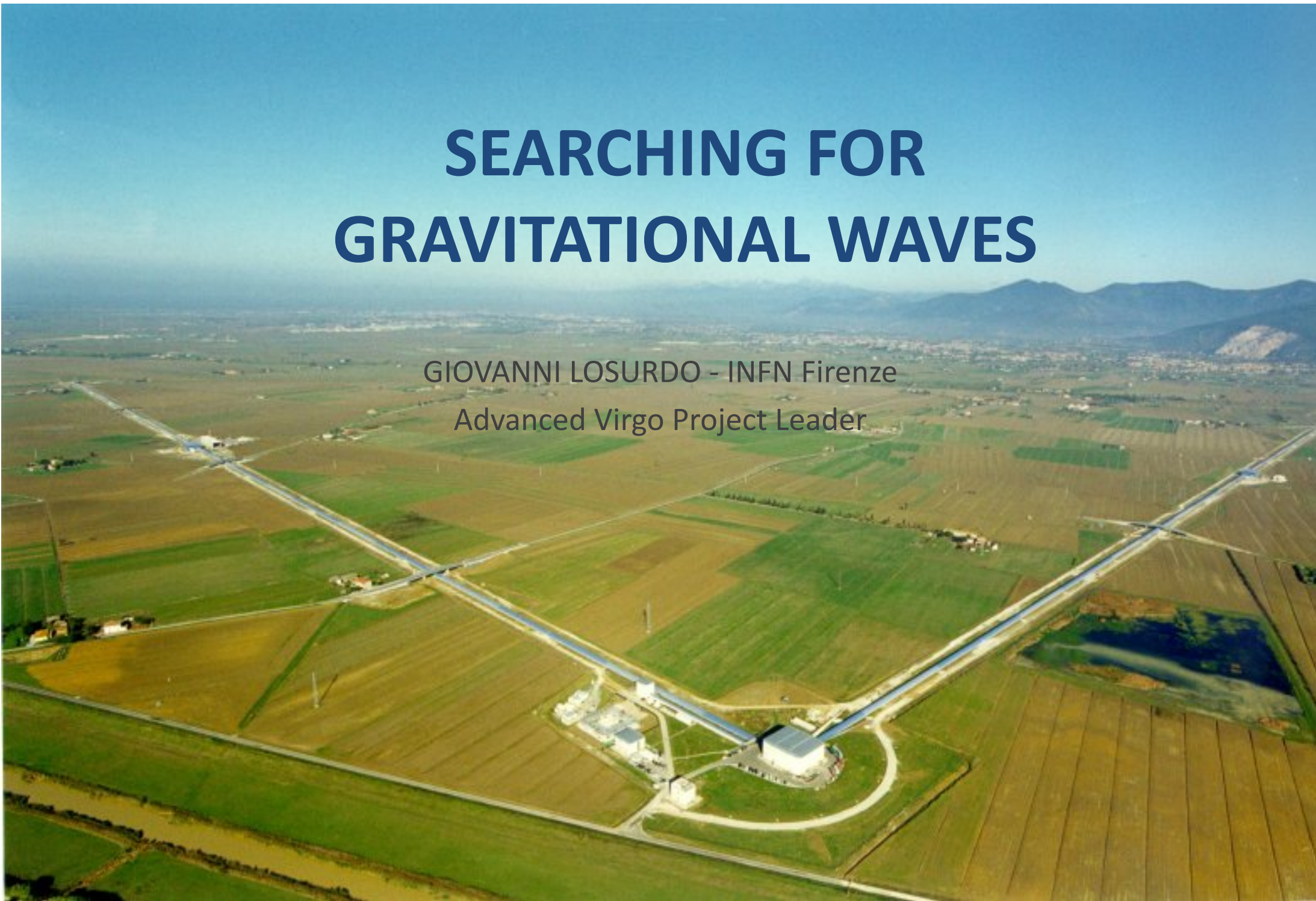


SEARCHING FOR GRAVITATIONAL WAVES

GIOVANNI LOSURDO - INFN Firenze
Advanced Virgo Project Leader



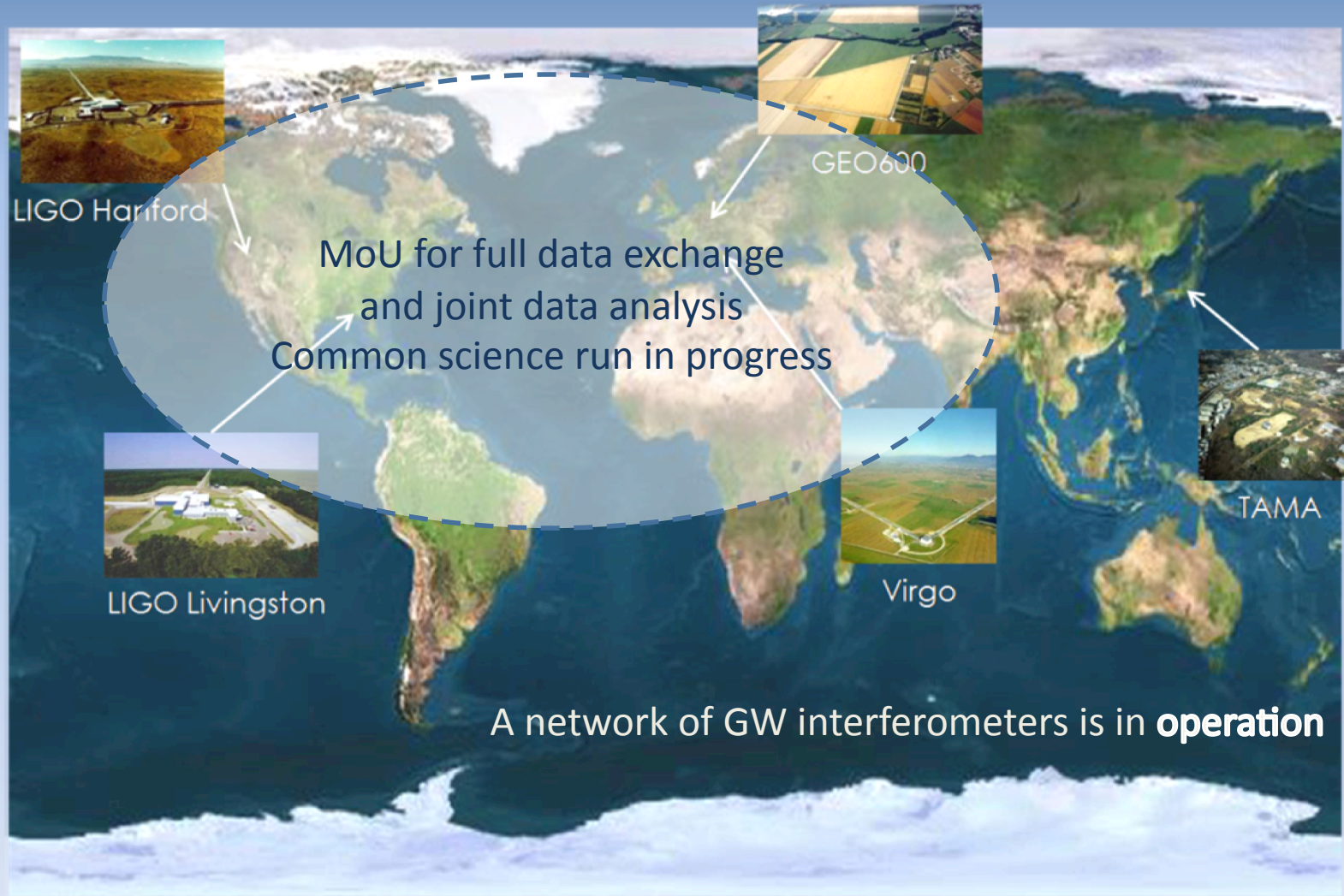
DISCLAIMER

Due to limited time, this talk will concern only the ground based interferometric detectors of gravitational waves (GW), with special focus on Virgo, as co-funded by INFN.

Apologies to resonant bars and LISA communities.

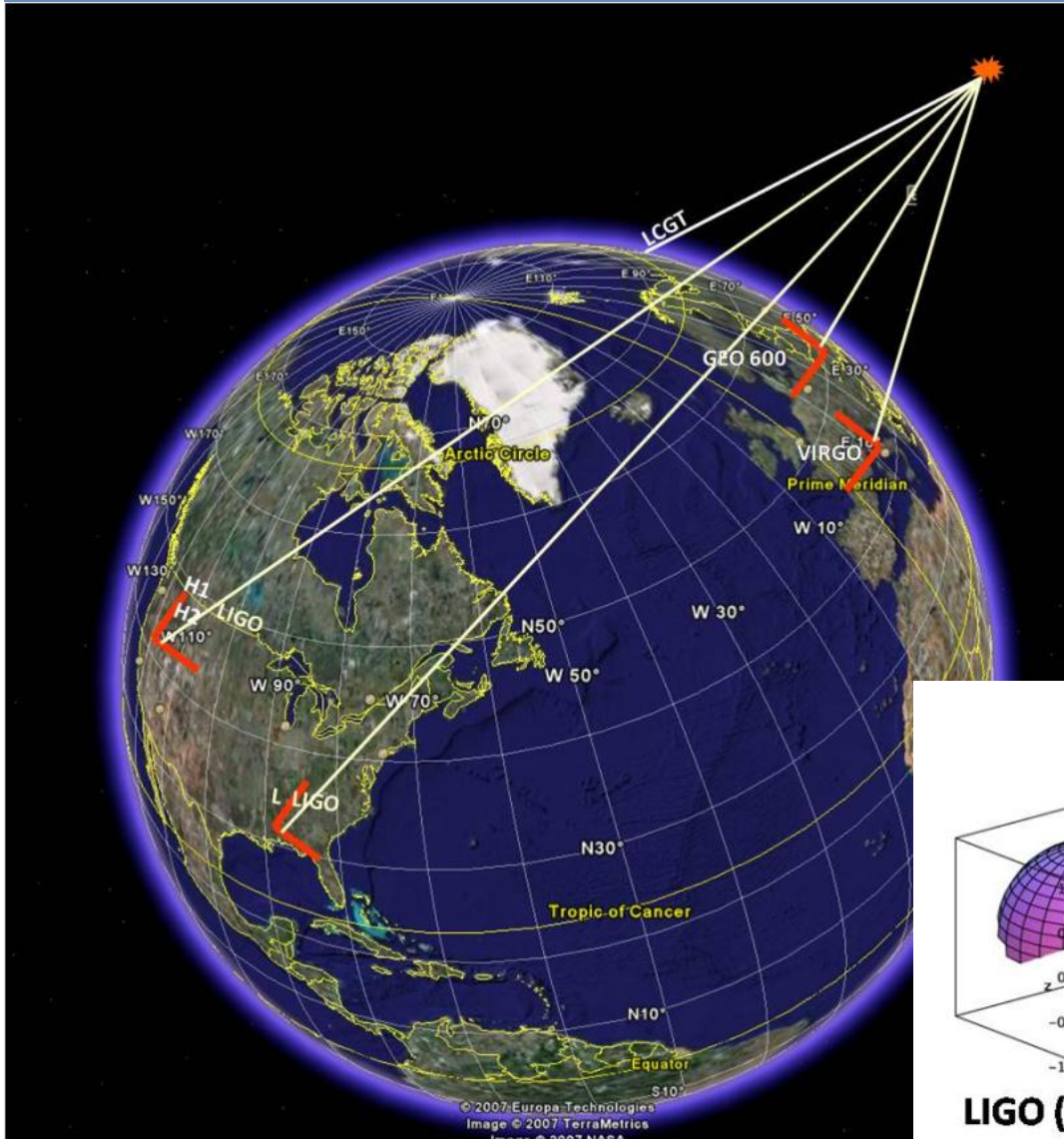
WHERE WE ARE

WW...GW

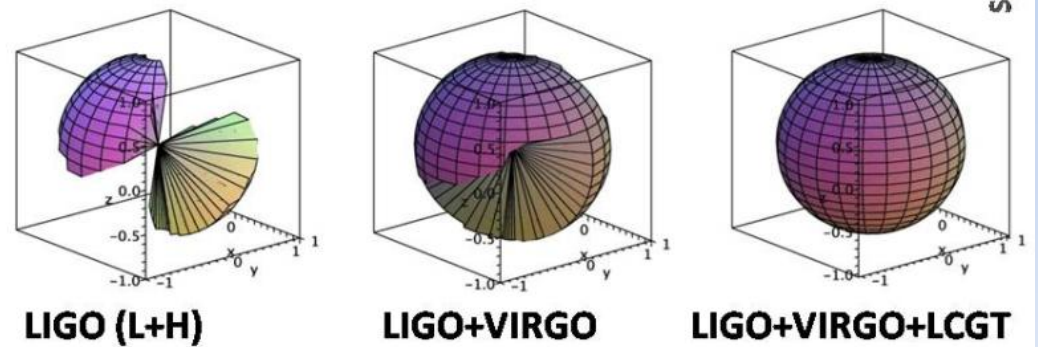


GW NETWORK

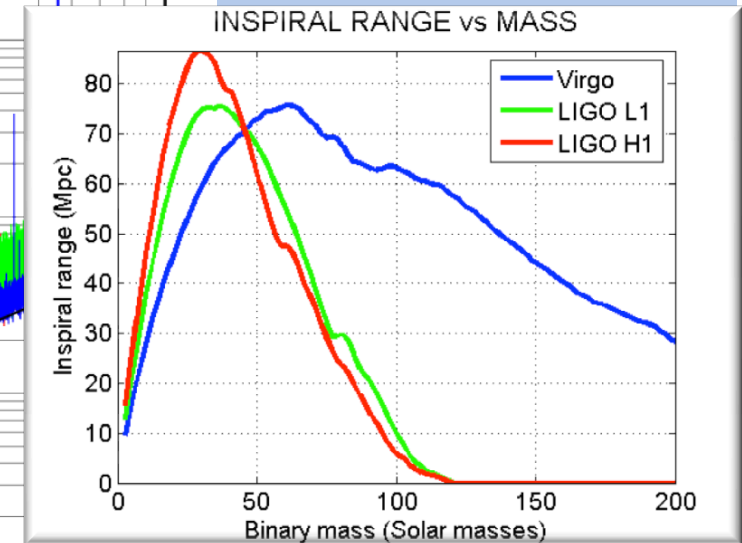
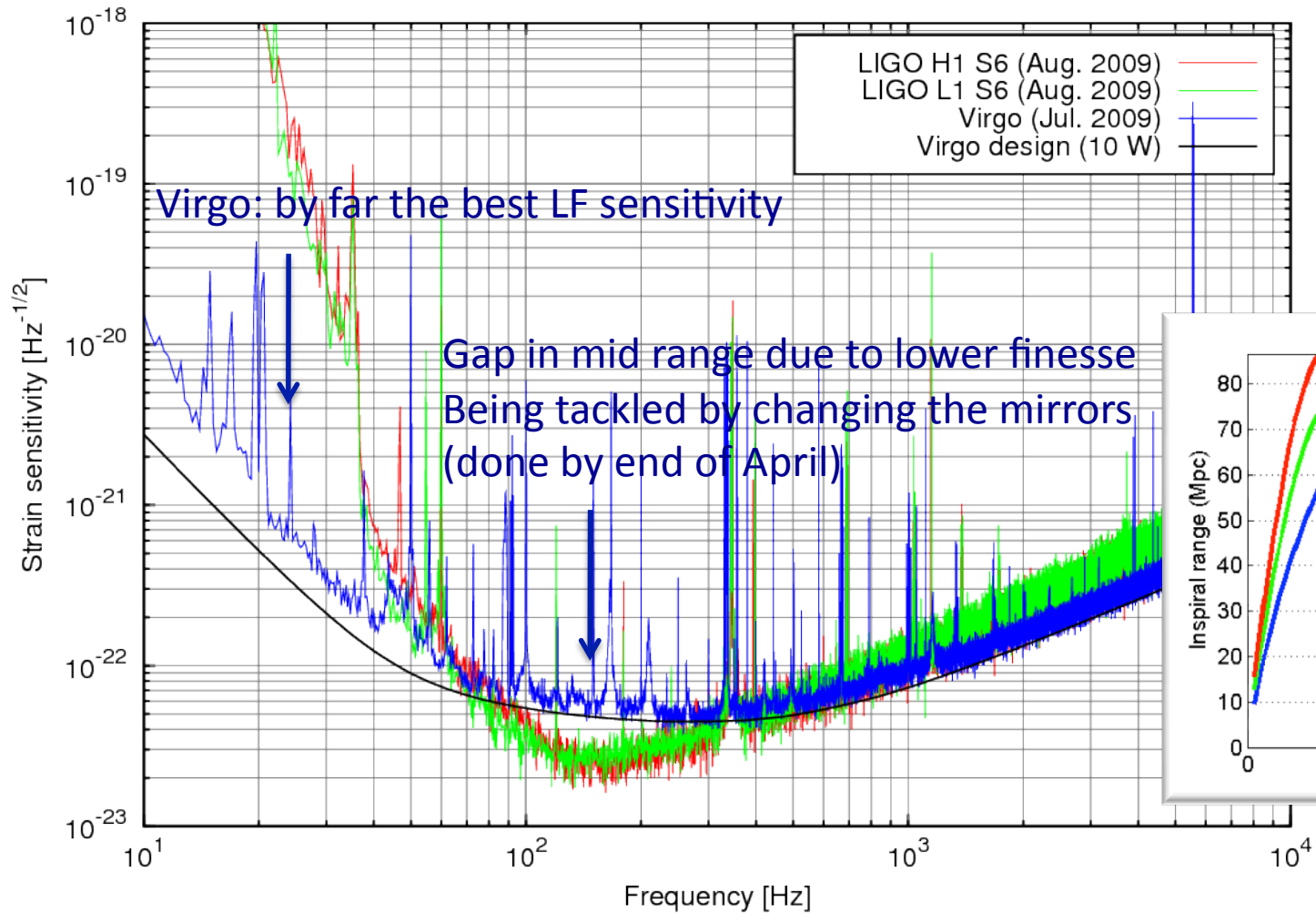
- Event reconstruction
 - Source location in the sky
 - Reconstruction of polarization components
 - Reconstruction of amplitude at source and determination of source distance (BNS)
- Detection probability increase
- Detection confidence increase
- Larger uptime
- Better sky coverage



NETWORK SKY COVERAGE



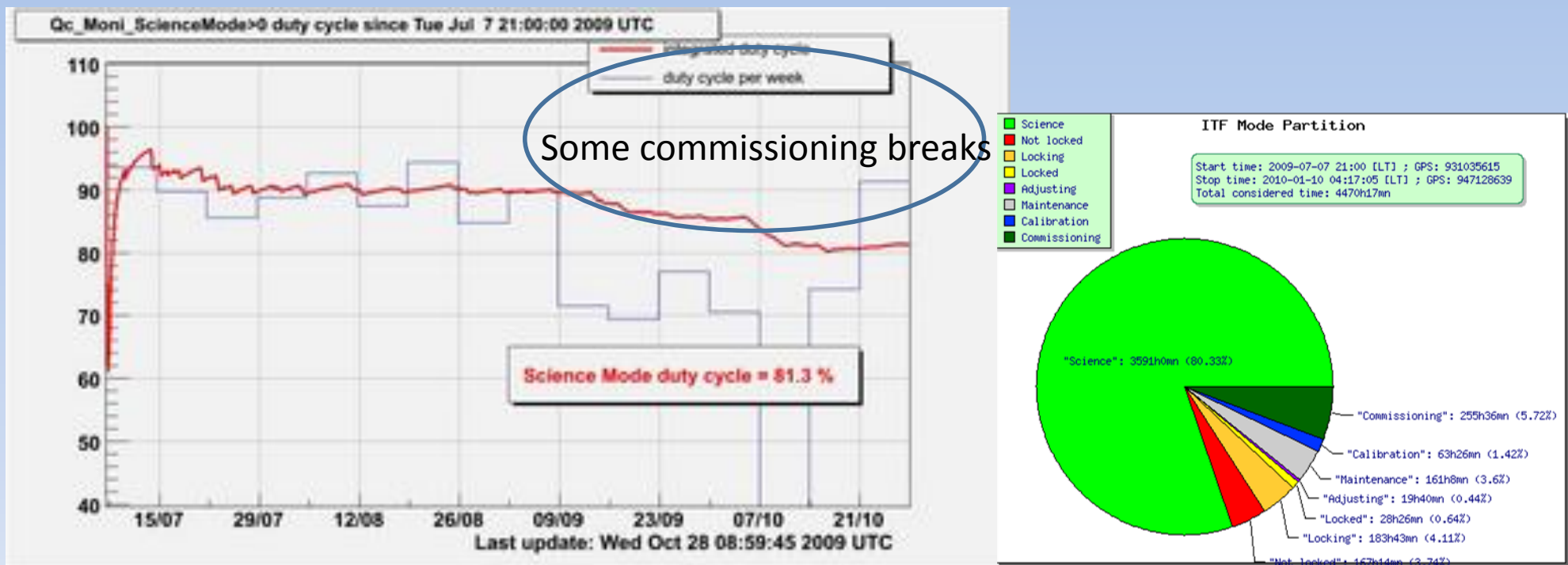
SENSITIVITIES



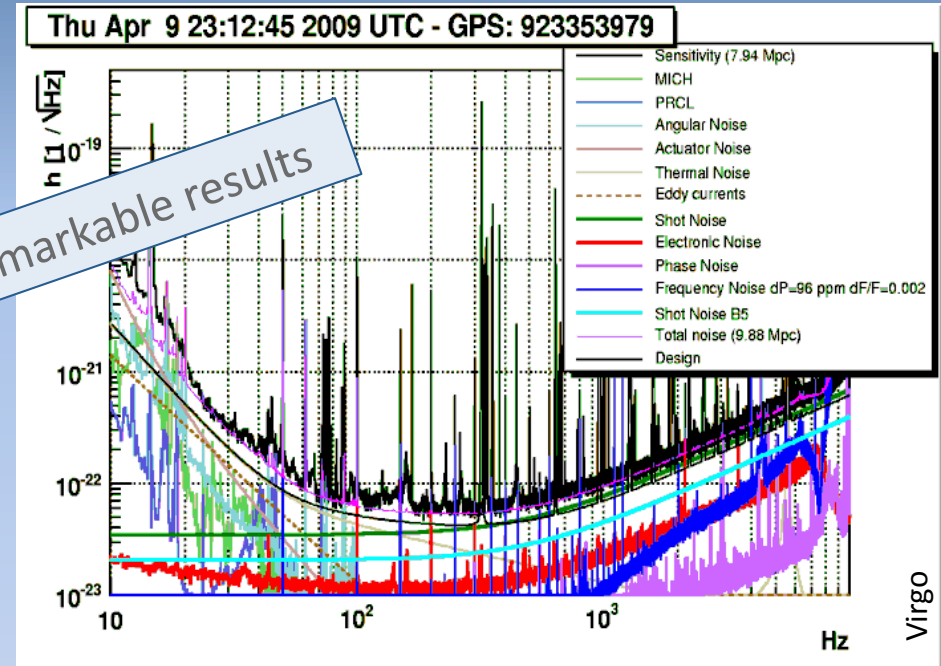
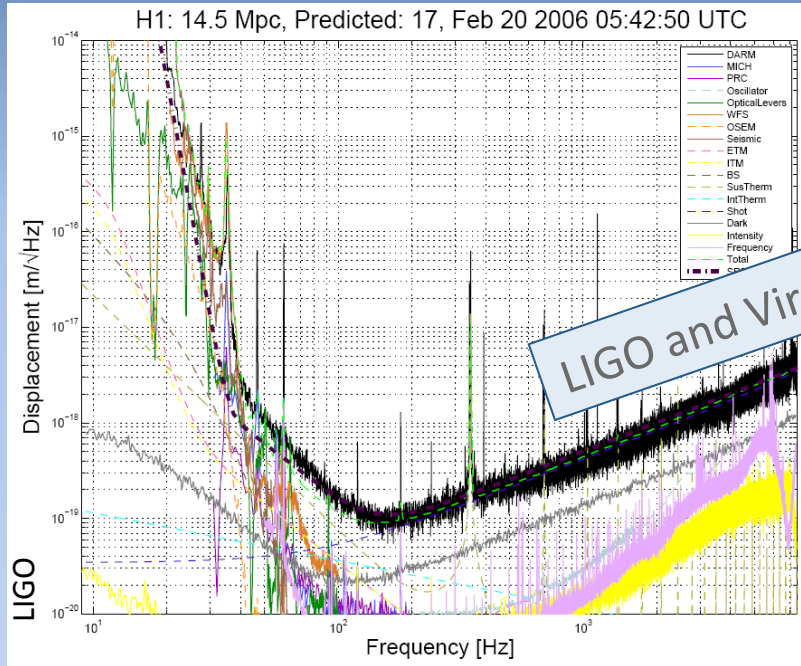
VIRGO-LIGO joint run



- ❑ Science run started in July 2009
- ❑ Virgo: more than 3500 hrs in science mode (>80% duty cycle, 90% locked)
- ❑ Run stopped in January for substantial upgrades. To restart in July



SUCCESS!

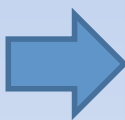


LIGO and Virgo remarkable results

Design sensitivity achieved

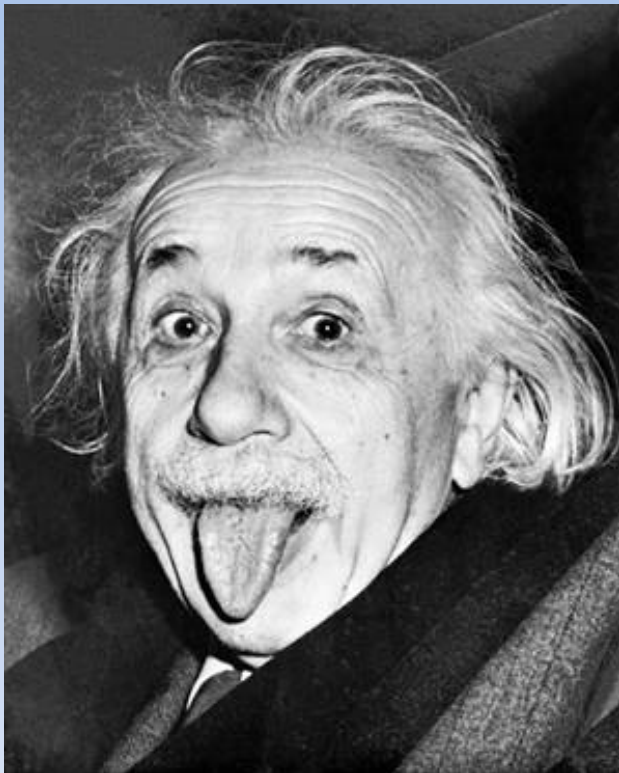
Noise understood

Excellent duty cycle (Virgo close to 90%)



INTERFEROMETER TECHNOLOGY DEMONSTRATED

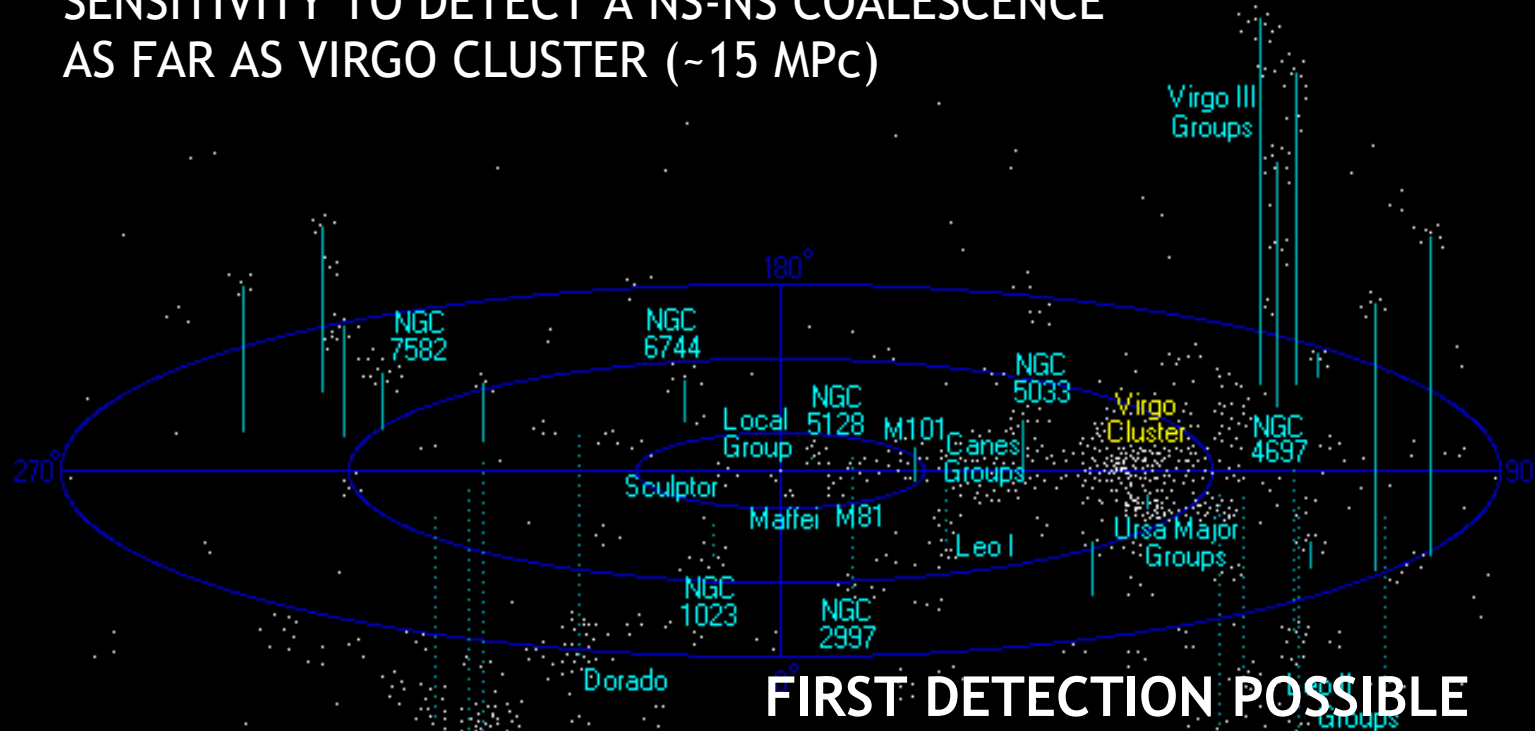
PAPERS BEING PUBLISHED BUT...



NO DETECTION SO FAR
analysis in progress...

THE CASE FOR ADVANCED DETECTORS

1ST GENERATION IS CLOSE TO REACHING THE SENSITIVITY TO DETECT A NS-NS COALESCENCE AS FAR AS VIRGO CLUSTER (~15 Mpc)



EXPECTED EVENT RATE:
0.01-0.1 ev/yr (BNS)

**FIRST DETECTION POSSIBLE
BUT NOT PROBABLE
EVENT RATE TOO LOW FOR GW
ASTRONOMY**

WHERE WE WANT TO GO

Initial configuration (2001-2008)

- Infrastructure established
- Design Sensitivity Reached
- Data Analysis paradigms developed
- Many new upper limits, important non-detections

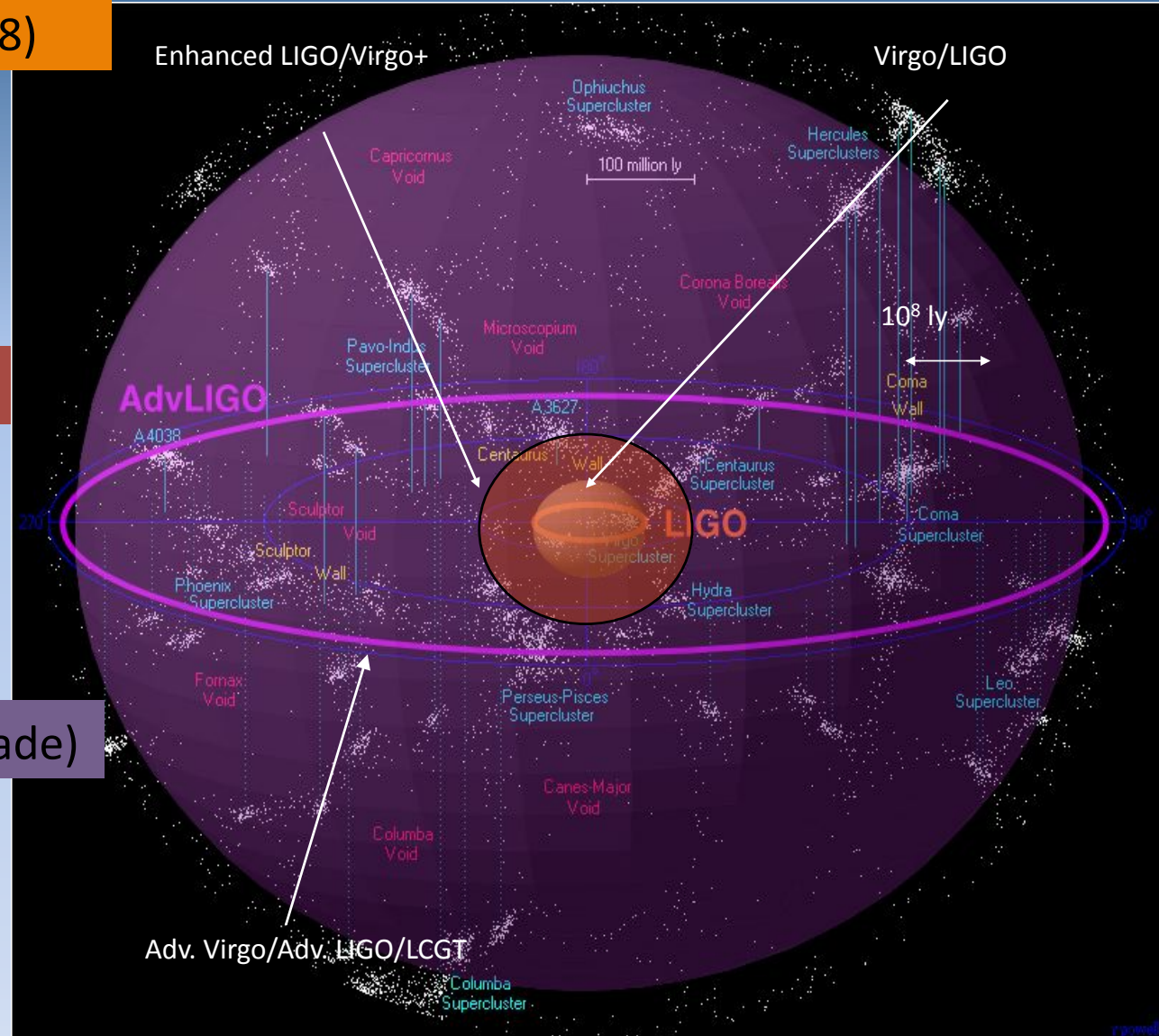
Enhanced Detectors: Now

- Sensitivity improvement by a factor 2-3 using some of the Advanced Detectors technologies
- Detection still unlikely, but surprises possible.

Advanced Detectors (next decade)

A factor of ~ 10 improvement in linear strain sensitivity over the initial instruments: $\sim 10^3$ more candidates into reach

=> 10's–100's signals/year

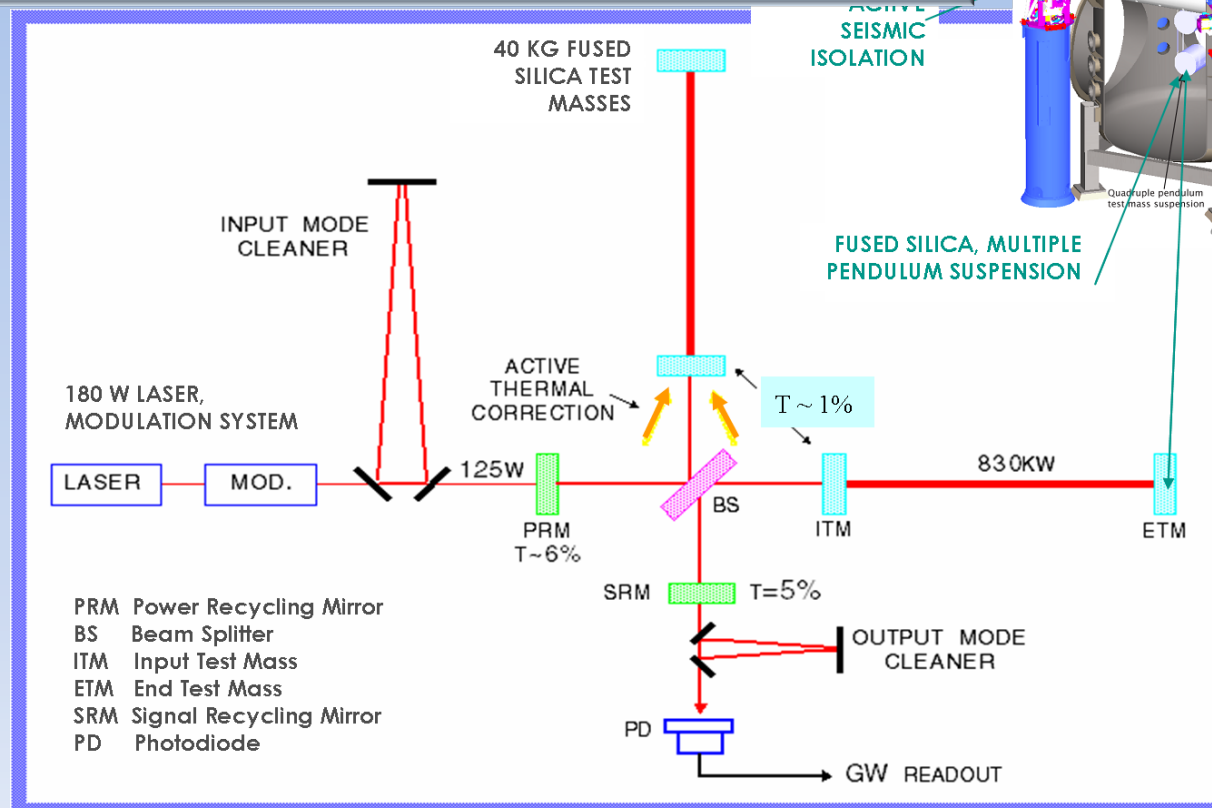


Credit: R.Powell, B.Berger

ADVANCED LIGO (aLIGO)



- ❑ Project started in April 08
- ❑ Upgrade of the 3 LIGO interferometers to 2nd generation
- ❑ Installation to start in 2011, end in 2014



ADVANCED VIRGO

- Main design novelties:
 - high power laser
 - heavier mirror
 - new optical configuration
 - larger beam
- Investment cost: 21.8 ME
- TDR in preparation



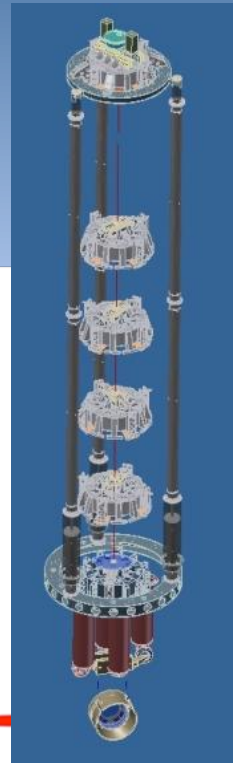
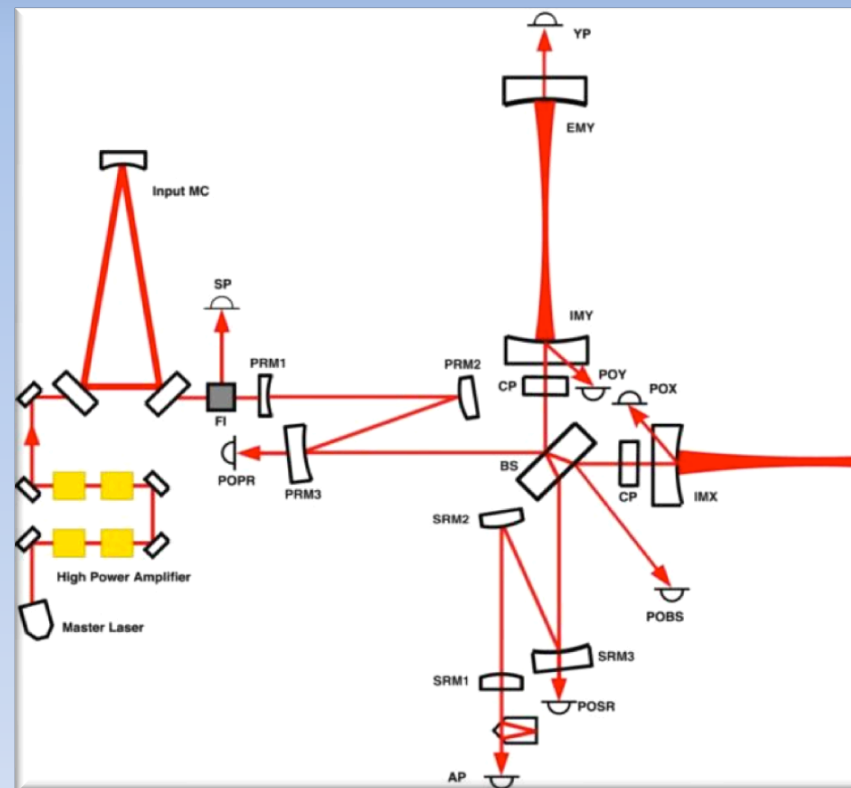
Advanced Virgo Baseline Design

VIR-027A-09

Issue 1

The Virgo Collaboration

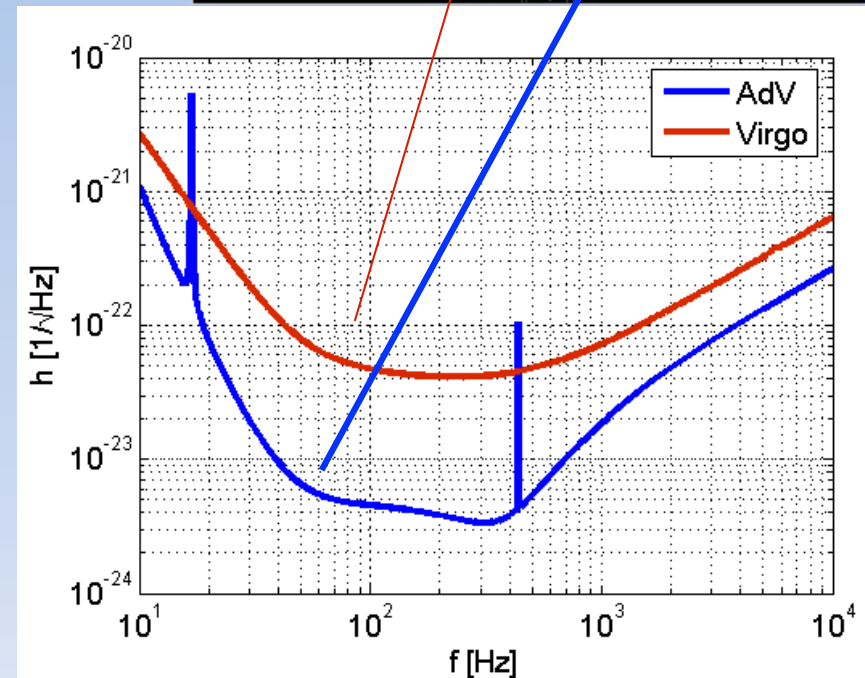
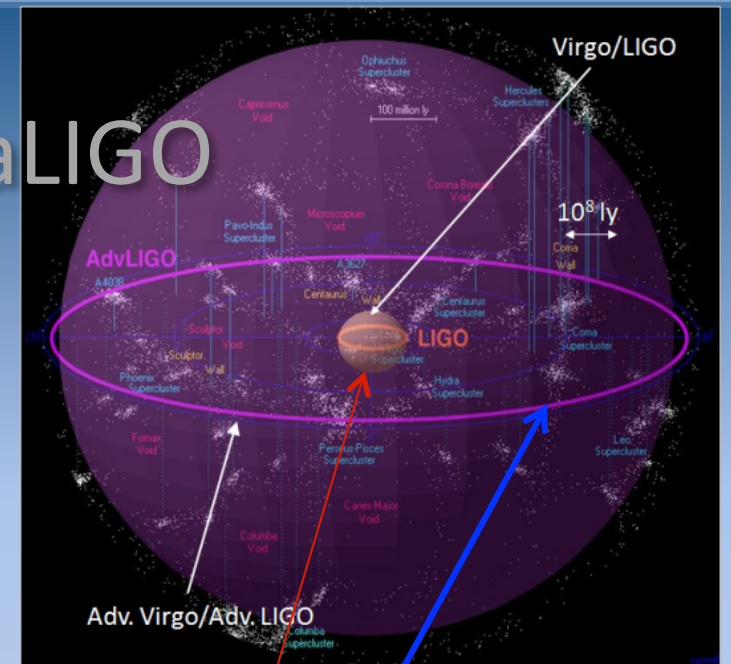
May 16, 2009





SCIENCE WITH ADV/aLIGO

- Sensitivity improvement: $\approx 10\times$
 - Detection rate: $\sim 1000\times$ better than Virgo/LIGO
 - 1 day of Adv data \gg 1 yrs of Virgo data
- Range for coalescing binaries:
 - Neutron stars: ≈ 150 Mpc
 - Black holes: ~ 1 Gpc
- Expected detection rates:
 - **Neutron stars: ~ 40 ev/yr**
 - Black holes: strongly model dependent (0.1-100 ev/yr). Adv will measure it!
- Adv in the network with aLIGO:
 - much better event reconstruction
 - Detection probability increase: 40% more events than Advanced LIGO only
 - Detection confidence increase



INTERMEDIATE STEP: VIRGO+



GOAL: use technology already available to improve sensitivity and reduce risk for Advanced Virgo

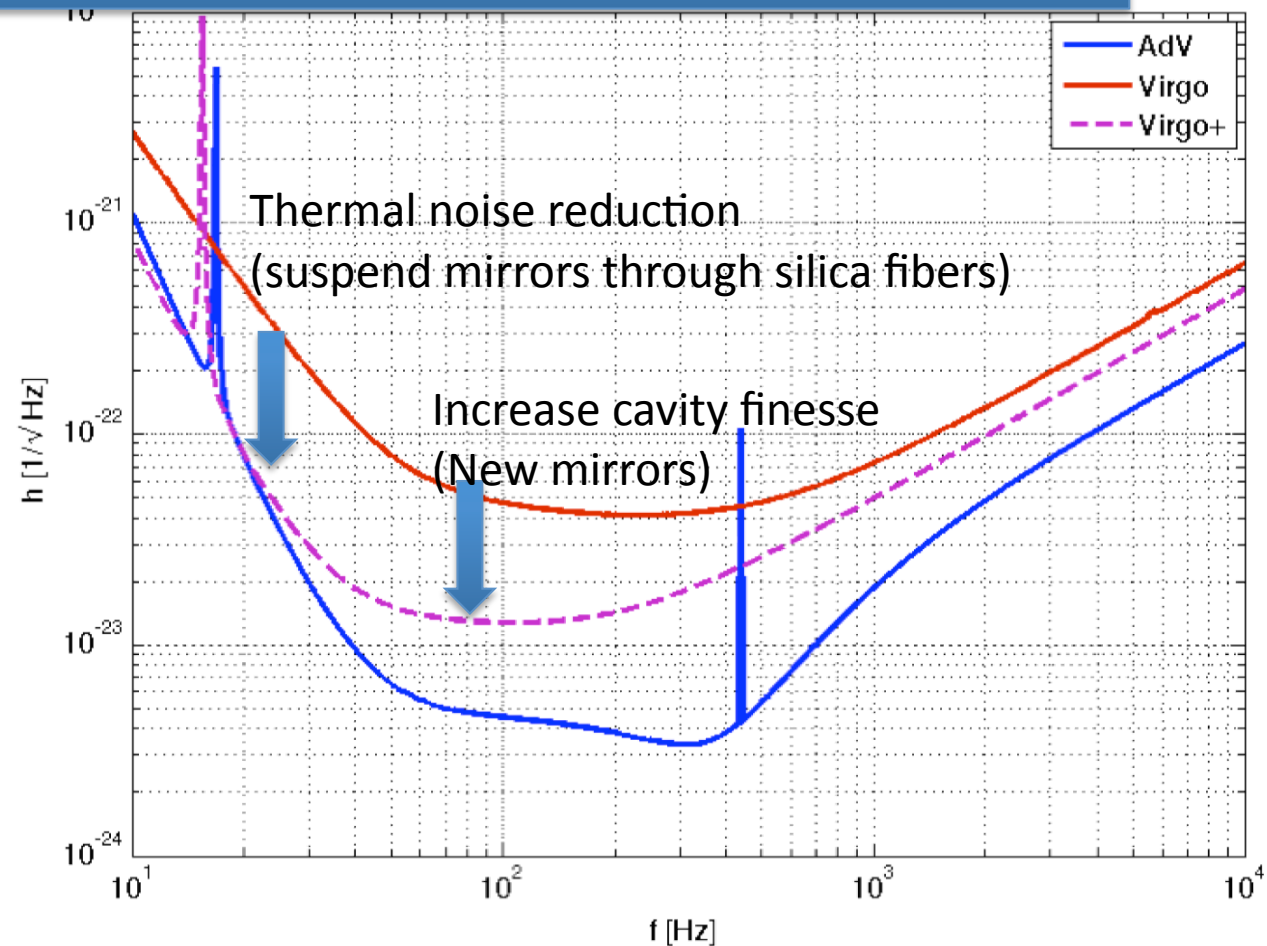
Inspiral range for binary neutron star

~10 Mpc

~50 Mpc

~150 Mpc
(~20 ev/yr*)

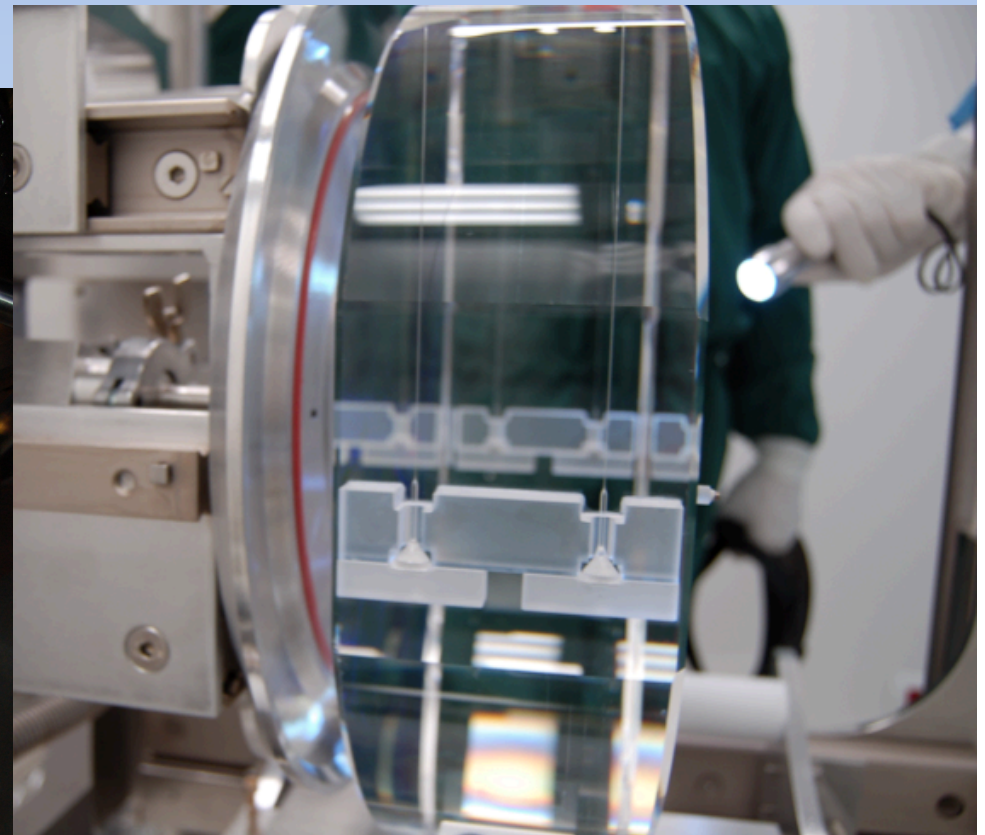
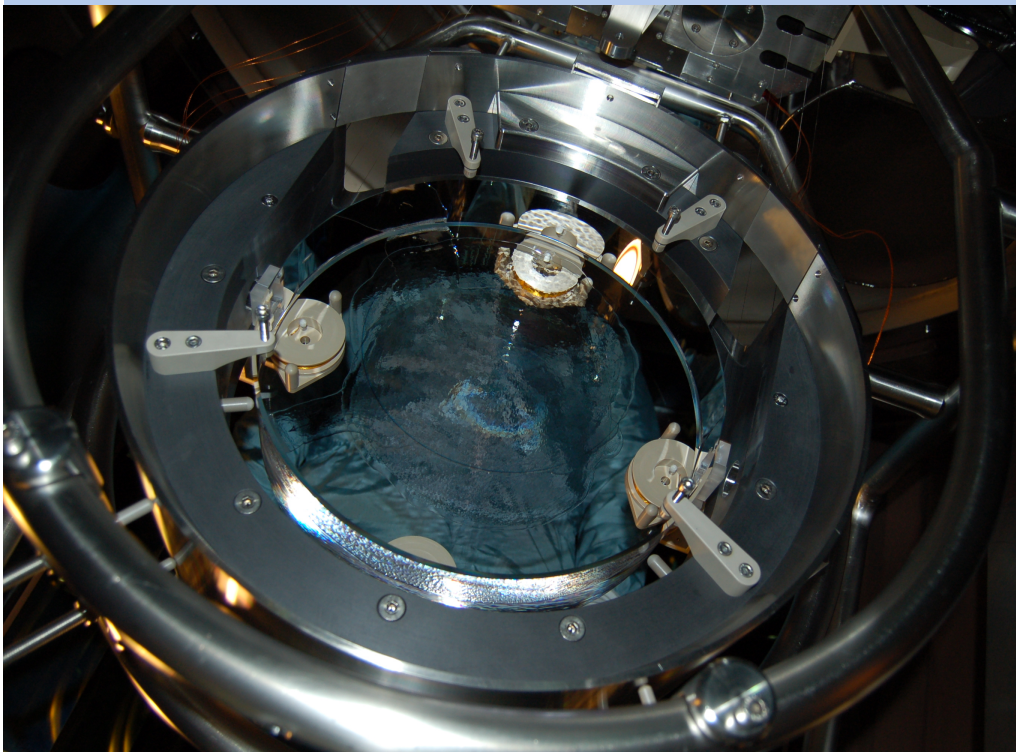
*based on the "realistic" rate as defined in arXiv:1003.2480



VIRGO+



- ❑ GOAL: improve dramatically LF sensitivity (reduction of suspension thermal noise)
- ❑ Two/4 monolithic payloads suspended. Two more in April.
- ❑ Amazing technological achievement!





ADVANCED VIRGO PATH

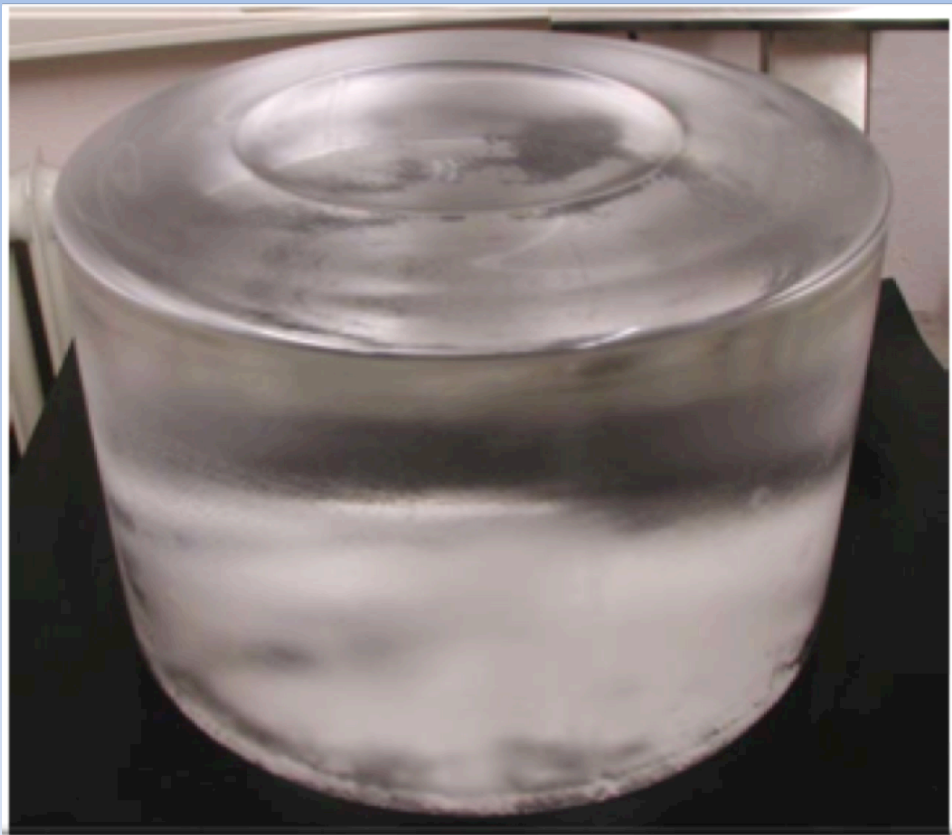
- ❑ Project reviewed by an External Review Committee chaired by B.Barish
- ❑ Review started in Nov 08 and concluded in May 09
- ❑ Final report submitted to the EGO Council (funding agencies): the ERC supports Advanced Virgo as a worthwhile investment for funding

- ❑ INFN reviews (in parallel)
 - Project approved by CSN2
 - CCS (chaired by N.Cabibbo): Advanced Virgo top ranked (with NA62)

AdV formally approved by the EGO Council on Dec 4 2009

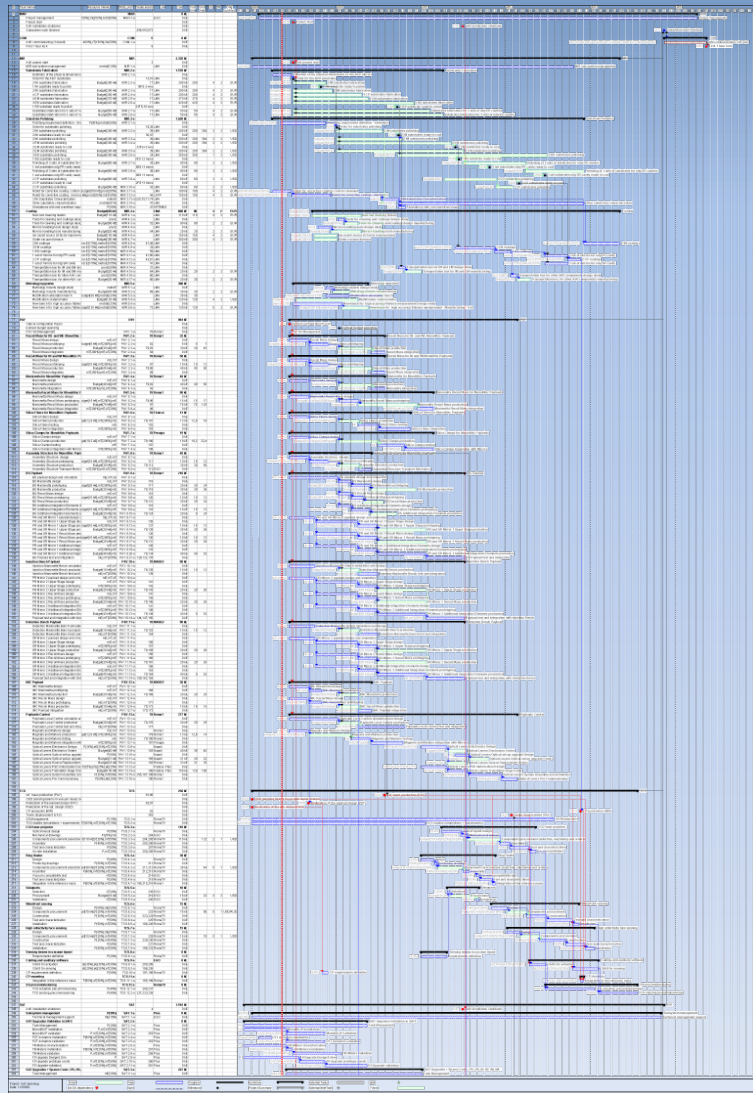
AdV CONSTRUCTION

- ❑ First big order (large mirrors) placed a few days after formal approval
- ❑ Mirrors now being produced at Heraeus



Material: Suprasil 3002
Quality factor: $\sim 10^9$
Absorption: 0.2 ppm/cm
Dimensions: 20 cm thick, 35 cm diam.
Weight: 42 kg

PROJECT MILESTONES



- ❑ **December 2009** – Project start
- ❑ **July 2011** – Virgo+ shutdown, start of AdV installation
- ❑ **March 2014** – End of assembly & integration phase
- ❑ **End 2014** – Interferometer robustly locked

BEYOND 2nd GENERATION



- ❑ Underground detector
- ❑ Mirrors at cryogenic temperature
- ❑ Longer arms, new geometry
- ❑ Aim for further 10x improvement in sensitivity

E.T. - Einstein gravitational-wave Telescope

- ❑ Design Study Proposal funded by EU within FP7
- ❑ Large part of the European GW community involved (EGO, INFN, MPI, CNRS, NIKHEF, Univ. Birmingham, Cardiff, Glasgow)



**COMING SOON...
ADV INAUGURATION CEREMONY**