# Commissioning of Advanced Virgo




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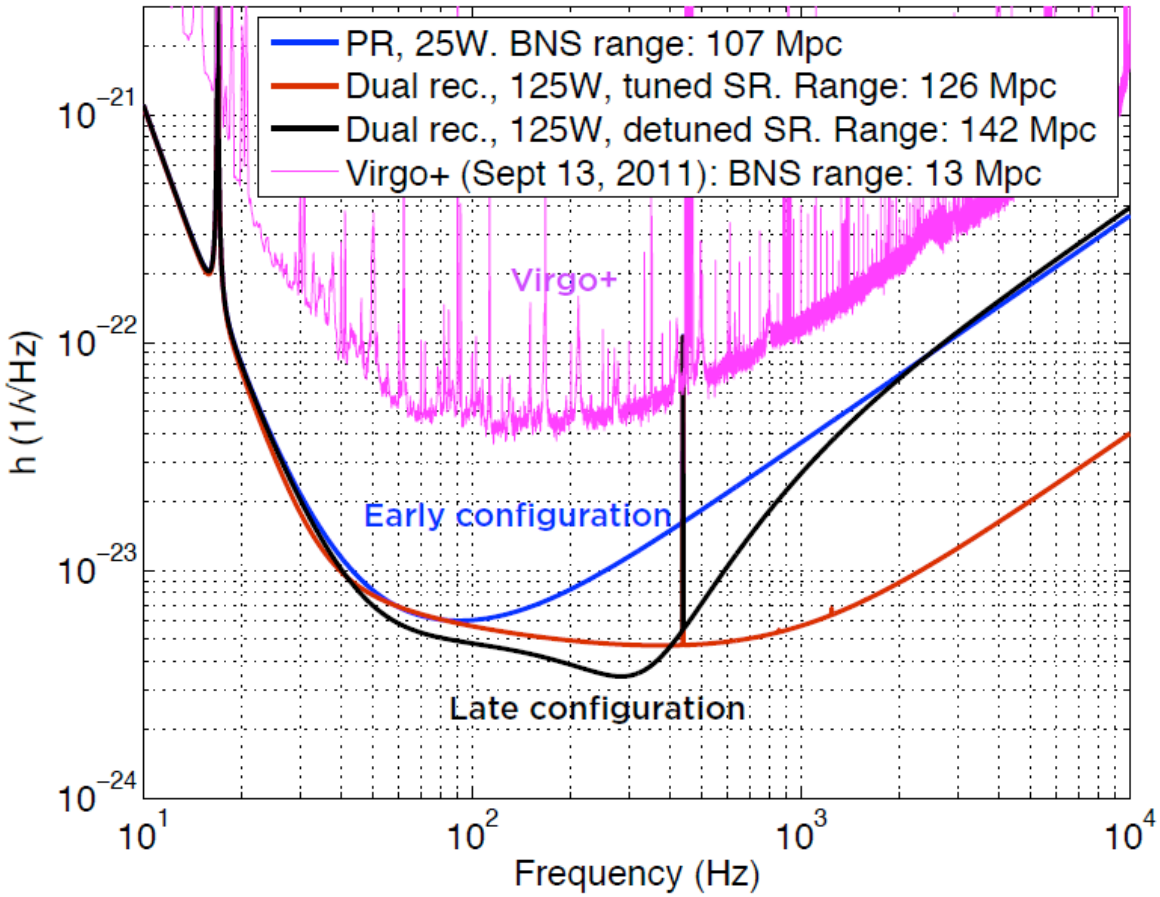
# Advanced Virgo overview

- Major upgrade of the Virgo interferometer
- Constructed by the Virgo collaboration (France, Italy, Netherlands, Poland, Hungary)
- Virgo+ shut down in 2011, installation should be complete fall 2015
- Hope to be taking science data again in 2016
- This talk: not an Advanced Virgo status talk, will focus on commissioning plans and challenges

# Advanced Virgo strategy

- Stay close to Virgo+ design, to save commissioning time
  - seismic isolation was already good enough
  - keep marginally stable recycling cavities
    (forced choice due to various constraints)
- Staged installation, to get back online as soon as possible
- First step:
  - start without signal-recycling mirror (lens with AR coating)
  - start with old Virgo+ laser, we don't need a lot of power initially
- Second step:
  - change coating of SR mirror to nominal reflectivity
  - upgrade to new, high-power laser
  - install green auxiliary laser system similar to LIGO design

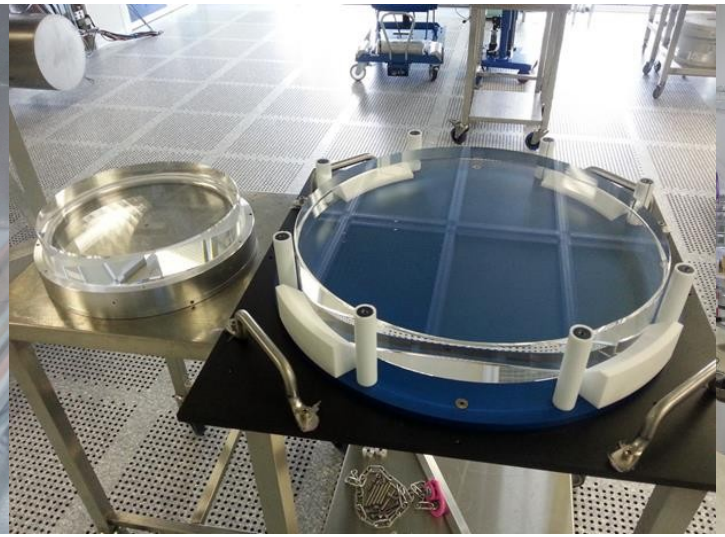
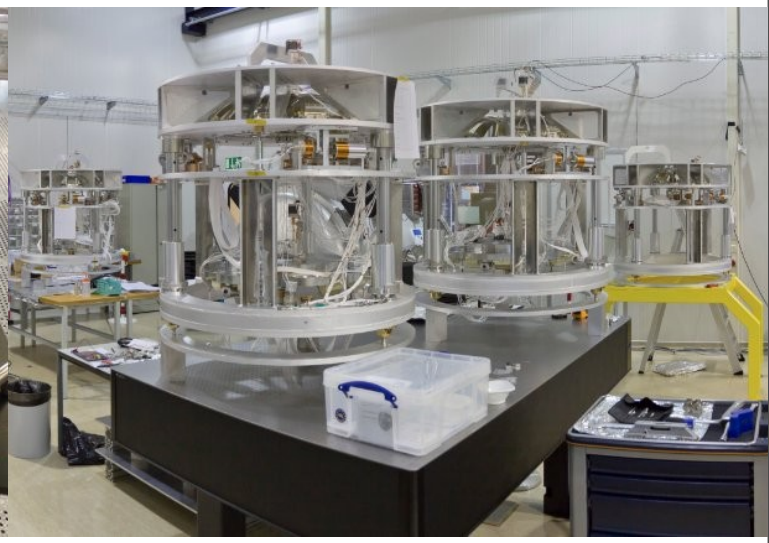
# Advanced Virgo sensitivity



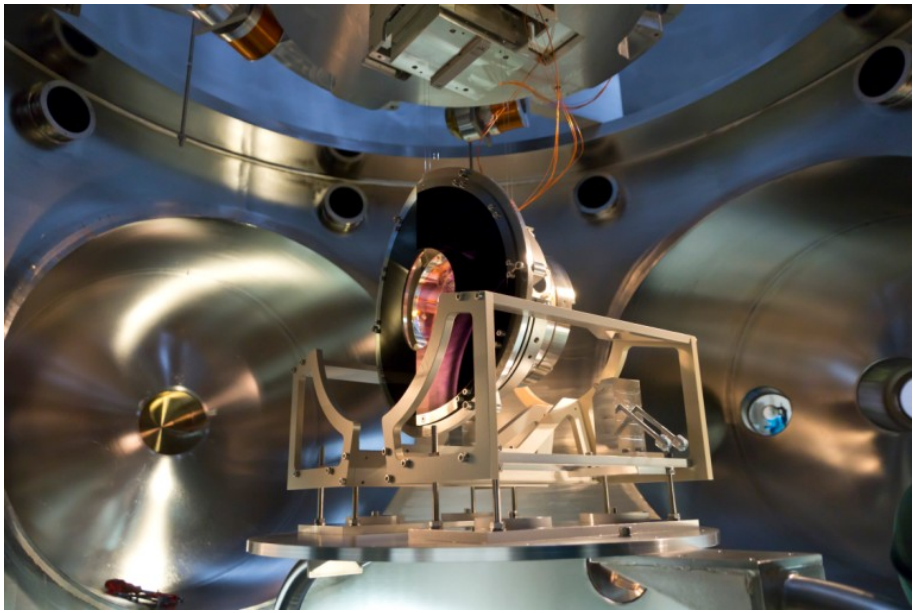

- Start at low power, no signal recycling mirror
- Add signal recycling mirror in tuned configuration
- Slowly increase input power
- Detuned signal recycling

# Advanced Virgo status

- Heavy infrastructure works mostly finished: building modifications, new cleanrooms, upgraded air-conditioning, ...
- First large optics polished, good results so far (RMS < 1 nm)
- Most sub-systems near the end of construction
- First items already installed on site (MC, injection benches, cryotrap)
- Peak of installation starting in the next months, will last about 1 year

# Input Mode Cleaner installation/pre-commissioning



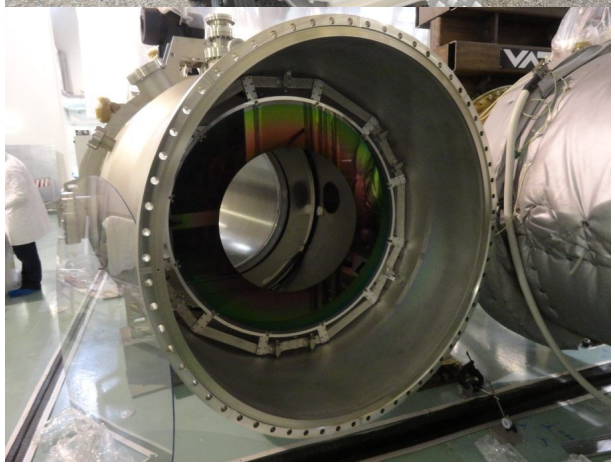
- Old Virgo+ laser restarted, 42 W available before IMC
- First 2 payloads suspended: input mode cleaner end-mirror and suspended injection bench
- Some typical issues with payload balancing, but almost on schedule
- Will try to lock this week

# Input Mode Cleaner commissioning

- July: slow ramp up of commissioning
- First real activity involving multiple sub-systems (PSL, INJ, PAY, VAC, ...)
- Full characterization of IMC, fine-tuning of loops, tests at high power ...
- Noise injections (mainly acoustic), make noise budget
- Restart all the monitoring web-pages, automatic alarms, automation
- Try to collect some 'science mode data', in weekends, holidays or dedicated engineering runs (join ER6?), analyze using existing DetChar tools
- Start pre-alignment of beam into interferometer
- About half a year in this configuration, might do many tests, train students ...

# Peak of installation / pre-comissioning activity

- Starting around July, many sub-systems will be installed on site
- Largest part of detection system: in-vacuum suspended benches to house photodiodes, double OMC, in vacuum electronics
- Finish upgrading super-attenuators
- Install all payloads in central area
- Upgrade computing facilities, Control Room
- New cryo-traps at both ends of arms
- Baffles everywhere
- Requires tight coordination between remaining installation and early commissioning activities
  (noisy morning shift, quiet night shift)



# Preliminary configurations

- First 4 mirrors in central area (BS, NI, WI, PR) available by Feb 2015
- Lock PRMI with photodiodes in reflection only (B2), then with photodiodes on dark-fringe (B1p)
- Earliest opportunity to test many new systems: payloads, digital demodulation, TCS, phase-cameras, real-time software, ...
- First end-test-mass installed by May 2015
- Pre-alignment of beam into arms
- Lock single arm cavities with photodiodes in reflection and transmission
- First optical characterization: PR cavity length, arm finesse, losses, ...
- Might conduct several engineering runs, test new DetChar tools
- Prepare automation of full interferometer

# Full interferometer commissioning

- By fall 2015, installation should be largely complete
- Start lock-acquisition of power-recycled interferometer using variable-finesse technique, at low power (1 hour lock milestone)
- First tuning of thermal compensation system
- Finish optical characterization: asymmetries, losses
- Noise and glitch hunting, with help of DetChar
- Automate as much as possible
- Calibration, prepare for first science run

# Late commissioning

- Remaining upgrades:
  - install signal-recycling mirror with real HR coating
  - install new high-power laser
  - install auxiliary laser system for locking arm cavities
- Commission double-recycled interferometer, scheme for lock acquisition still TBD
- Slowly increase input power, while keeping aberrations under control
- Even later: squeezing? Space reserved in detection lab, R&D started
- Hard to make accurate planning yet

# Technical and schedule risks

- Very tight schedule, many sub-systems on or close to critical path
- Several new, complex sub-systems, not yet completely tested
  - very complex payload of Input Test Masses (42 kg mirror, compensation plate, ring-heater, baffles)
  - complex detection system (double OMC, digital demodulation, in-vacuum electronics)
  - complex TCS system
- Commissioning risks
  - compensation of thermal effects to achieve good recycling gain
  - finding and curing all environmental noises (magnetic, ...)
  - scattered light issues
  - lock acquisition of double-recycled interferometer
- Availability of experienced manpower on site

# Thermal aberrations

- Unique issue for Virgo: high sensitivity to aberrations due to marginally stable recycling cavities
- Both polishing errors and thermal aberrations will reduce the sideband recycling gain
- Much more critical in Advanced Virgo than in Virgo+
- Add many sensors: phase cameras, Hartmann sensors in transmission and reflection of test-masses
- Add many actuators: ring-heaters, $CO_2$ laser with fixed ring, scanning $CO_2$ laser
- Combine everything into one big adaptive optics system
- Risk reduction: add extra modulation sideband at 132 MHz, which is less sensitive to aberrations, only used during initial commissioning
- Try everything in simulation, see talk R. Day @ GWADW Elba, 2013

# Commissioning workshops

- Exchange commissioning experiences in small, focused meetings





- Next one TBD: suspensions?
- Apart from workshops: visits of individual people at the right moment

# Conclusion

- Advanced Virgo installation well underway
- Input-mode-cleaner completely installed, will try to lock this week
- Lock of partial configurations (PRMI, 1-arm) possible starting from early next year
- Commissioning of full power-recycled interferometer by fall next year
- In a second step, add signal-recycling mirror, auxiliary laser system, high-power laser
- Many challenging issues, prepare using simulations, exchange of ideas
- Advanced Virgo is slowly coming to life, a very interesting period will start soon


End