The beauty of hindsight: a discussion of mis-steps in Virgo

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• Very stimulating talk but...,
  - Complicated, extended and delicate matter
  - A variety of points of view exist

• I will give MY point of view

• I will focus on the Advanced Virgo experience, but cannot avoid to discuss some historical/context aspects
  - Choices which may appear as "errors" are sometimes unavoidable in a given context
AdV – MANAGEMENT ISSUES
A "mild" project structure

PROJECT HEAD OVER A COLLABORATION BODY

EGO MANAGES THE INFRASTRUCTURE WITH A LIMITED ROLE IN CONSTRUCTION

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• Limited control on the work of the labs
  - AdV MoU signed but implementation not monitored on regular basis
  - Labs director (with a crucial role in managing the human resources) did not interact directly with the project

• Lack of central quality control

• Lack of a system engineer

• Resistance to the production of adequate technical documentation

• Resistance to standardization ("Engineers need to develop something challenging to be involved in the project")
BUDGET

• 21.8 MEuros, **budget for investments only** (+ NIKHEF in kind contribution)
  - Very difficult to face urgent/unpredicted manpower needs

• R&D basically halted for the duration of the project
  - Forces people to focus on the detector realization but never a wise decision: risks of jeopardizing the future
AdV – TECHNICAL ISSUES
STABLE REC. CAVITIES

• It was impossible to realize stable recycling cavities (baseline!)
  - Difficult to suspend >1 mirror from a SA
  - No room for more towers
  - No budget for new tubes

• Design modified in a rush after the approval of the project
  - Issue with multipayloads identified late, due to the concurrent effort on Virgo+
  - A time of strong tensions in Virgo

• Problem: not enough focus/resources on the AdV design effort in due time
• ~1 yr needed to understand the cause of monolithic suspension failures

• Dust produced by scroll pumps injected in vacuum at high speed during tower venting

• The lack of a thorough contamination control strategy has been a big mistake
• Single points of failure often threaten the project

• Lessons to be learned:
  - Quality control
  - Documentation
  - Openness: work as a team, address problems openly, ask for help
  - Do not take too many responsibilities
• Simulation is crucial for success, difficult to develop properly, even more difficult to document and maintain

• Too many tools (each one wants his/her own), never enough

• Not a work to be done upon an emergency call: requires preparation, coordination, long-term vision
SIMULATION

• Simulation is crucial for success, difficult to develop properly, even more difficult to document and maintain

• Too many tools (each one wants his/her own), never enough

• Not a work to be done upon an emergency call: requires preparation, coordination, long-term vision
• Virgo main hall is too small/too crowded
  - Makes implementation of upgrades challenging or impossible

• When designing a new detector also add some "room contingency" for upgrades you are not able to imagine now
SOCIOMETRY ISSUES
• Focus on the tasks/expertise of one's own group, losing the global picture

• Difficult to welcome new groups (nobody wants to give away any responsibilities, even when understaffed) and exploit their skills and resources

• Commissioners have a symbiotic relationship with the detector: tendency to become a closed "Delta Force" team
  - Always difficult to welcome newcomers and invest time in training them
  - Eventually, not enough people to cover shifts 24/7. Machine often underused
GW DETECTORS REQUIRE A LOT OF SPECIALIZED SKILLS.
A MAJOR CHALLENGE IS TO MAINTAIN THE GLOBAL VISION
TOP LEVEL ISSUES
historical context
1989: LIGO/Virgo proposal submitted

Funding: LIGO 1992, Virgo 1994

1st signal: LIGO 2015, Virgo 2017


1G design sensitivity: LIGO 2009, Virgo 2011
THE EARLY TIMES

• Skepticism in the funding agencies (far from HEP core business)
  - Virgo funding agencies are the same which funded LEP/LHC

• No data for decades, limited access to R&D funds, positions → weak attractive power

• Too small (born by the effort of just two countries)
  - Virgo has missed the strength and expertise of UK and D
  - Nikhef joining was a big step forward. Now 8 countries in the Collaboration, easier to plan the future
THE CRUCIAL STEPS TOWARDS 2G

• 2003: Virgo inauguration (and first light), aLIGO 1st project review
  - 2005: first efforts towards AdV (White Paper)

• Virgo had too stand a 3-fold effort:
  - Virgo commissioning
  - Virgo+ construction
  - Advanced Virgo design

• This was too much for the Virgo Collaboration as it was in the 2000s
  - Hindsight: doing Virgo+ has delayed AdV
  - On the other hand: Virgo+ was useful as prototype for some AdV technologies
• AdV was funded 2 yrs later than aLIGO. We needed to join the data taking asap (commitment with the funding agencies)

• This triggered some non-optimal technical choices
  - 2-phases project: start without SR to save commissioning time
  - Start with steel wire suspensions upon the multiple failures of monolithic suspension

WAS IT AN "ERROR"?
NOT AT ALL!
THESE CHOICES ALLOWED TO JOIN O2
The BEAUTY of hindsight?
YES, IF THE DETECTOR IS EVENTUALLY DOING SCIENCE!