

Opportunities and challenges in Big Science:

LISA and KM3NeT

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KM3NeT



Radiation from our Universe:
Neutrinos are the most abundant particle after photons



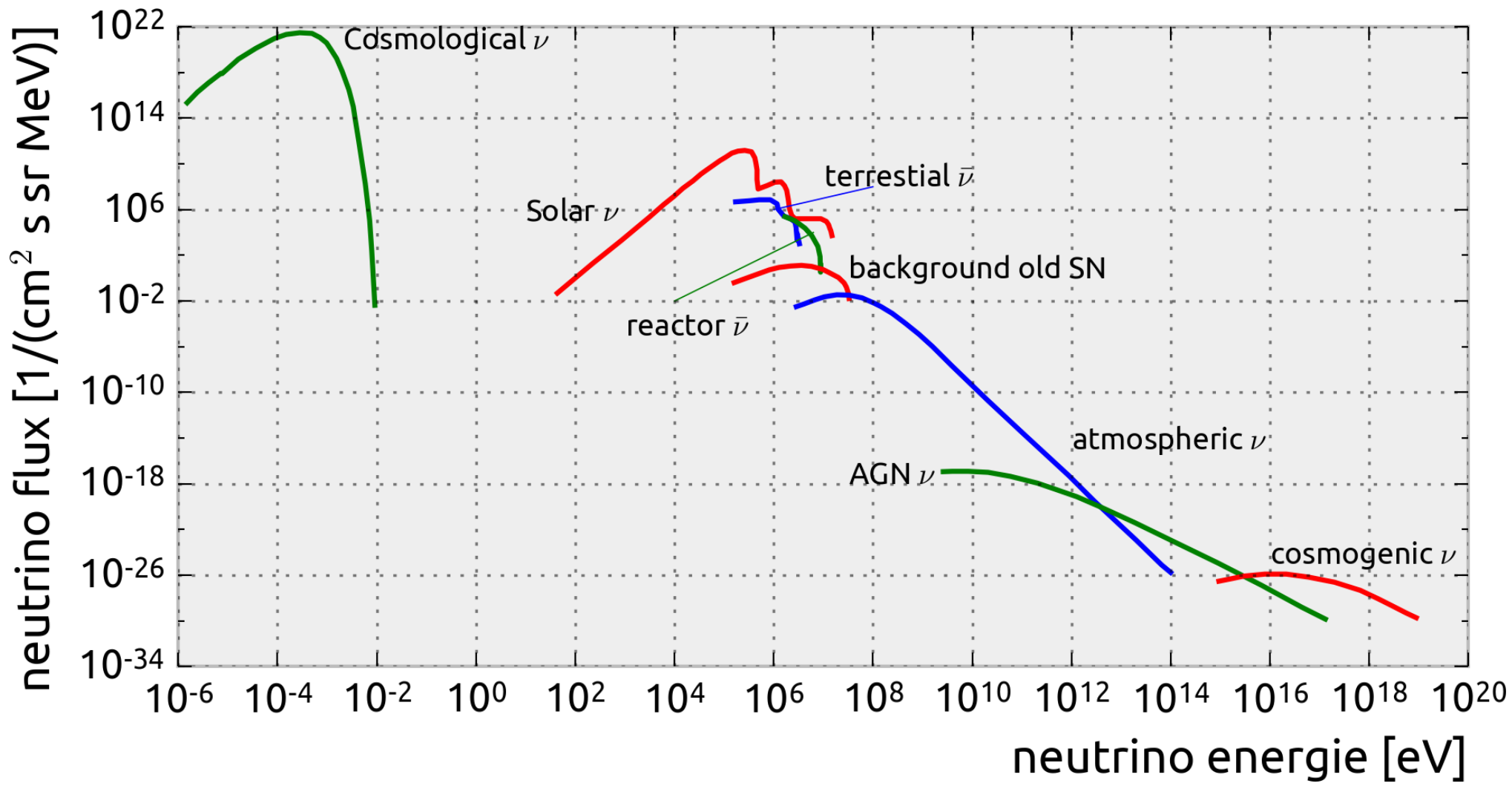
photon

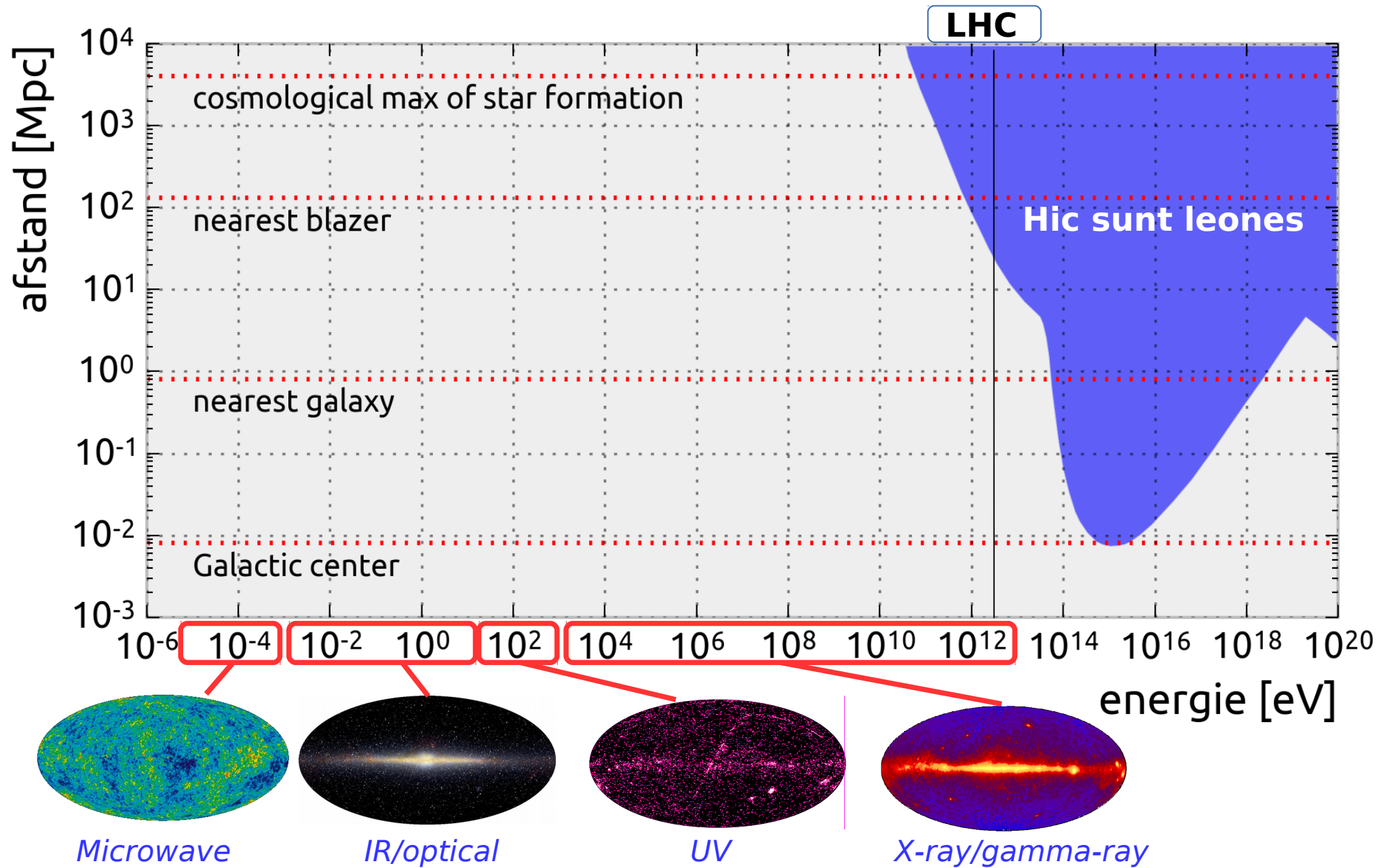


proton

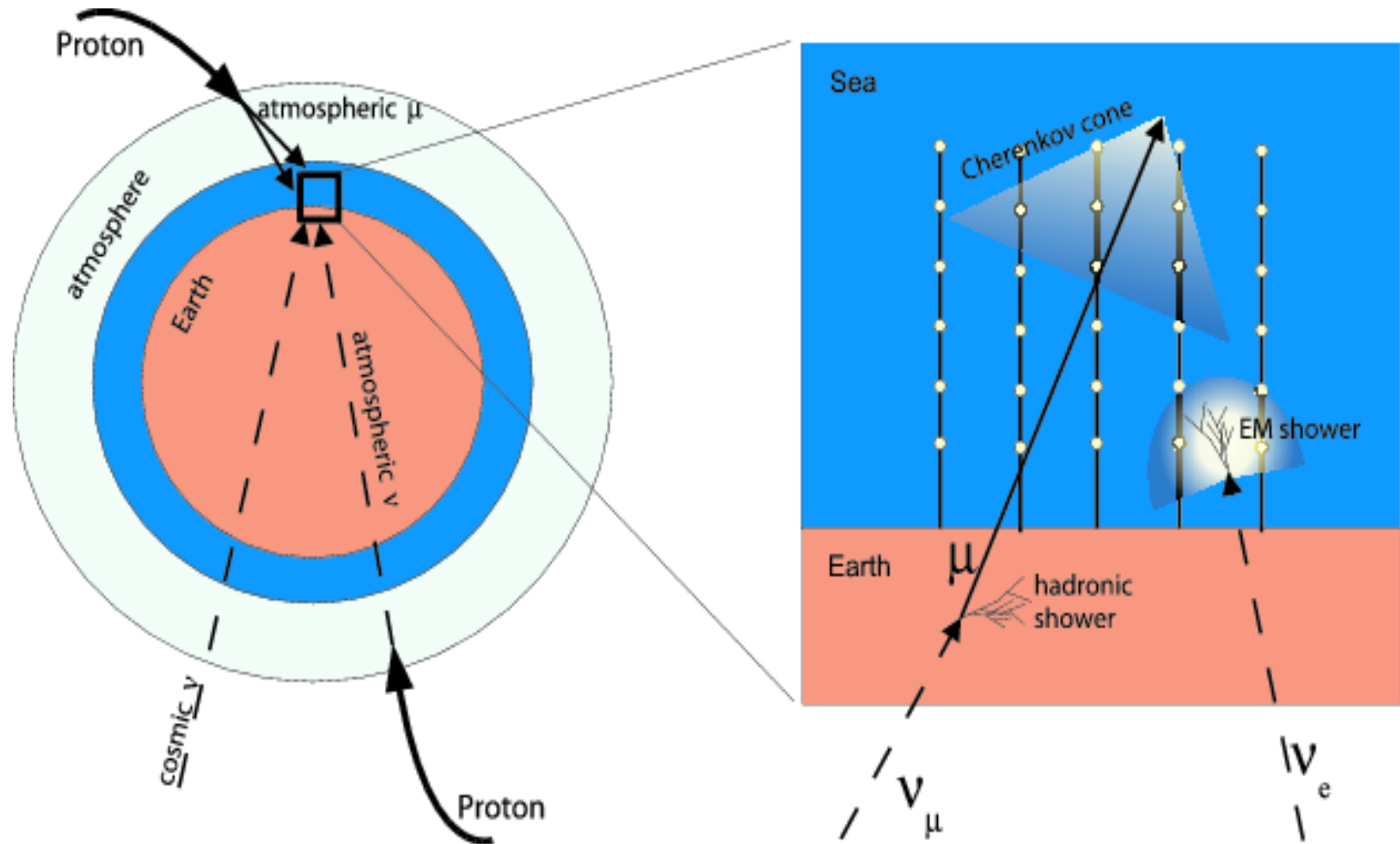


neutrino

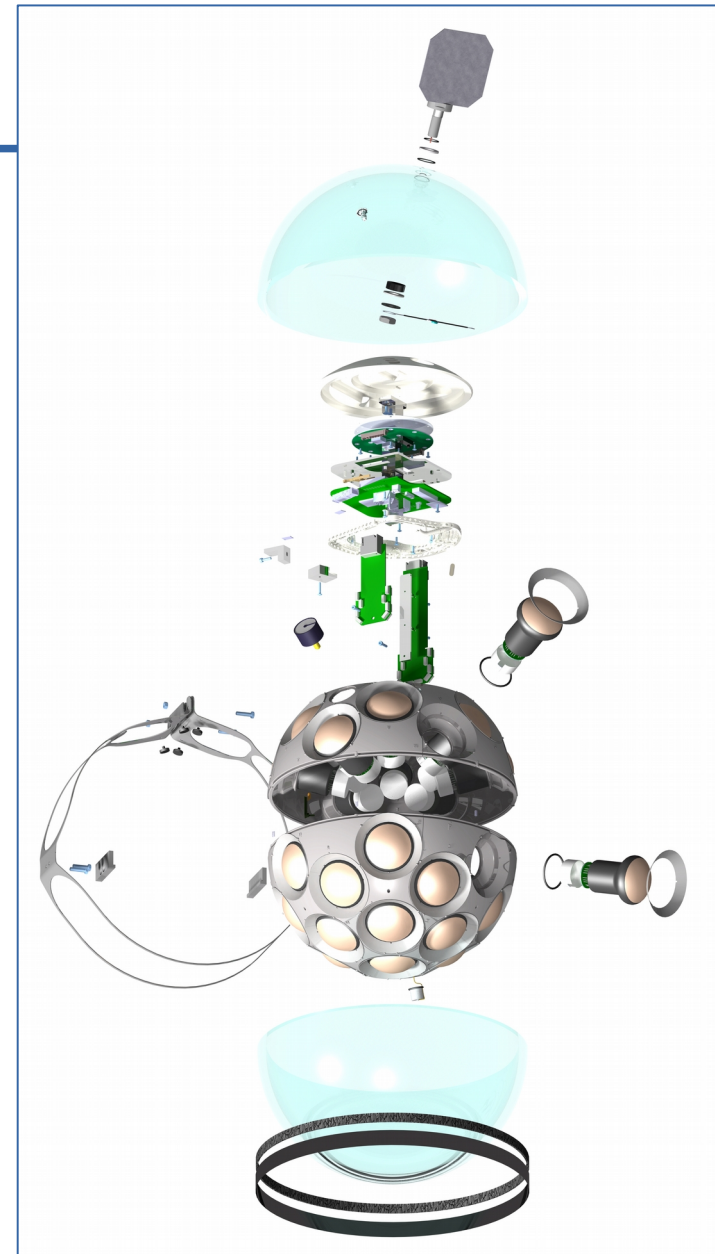


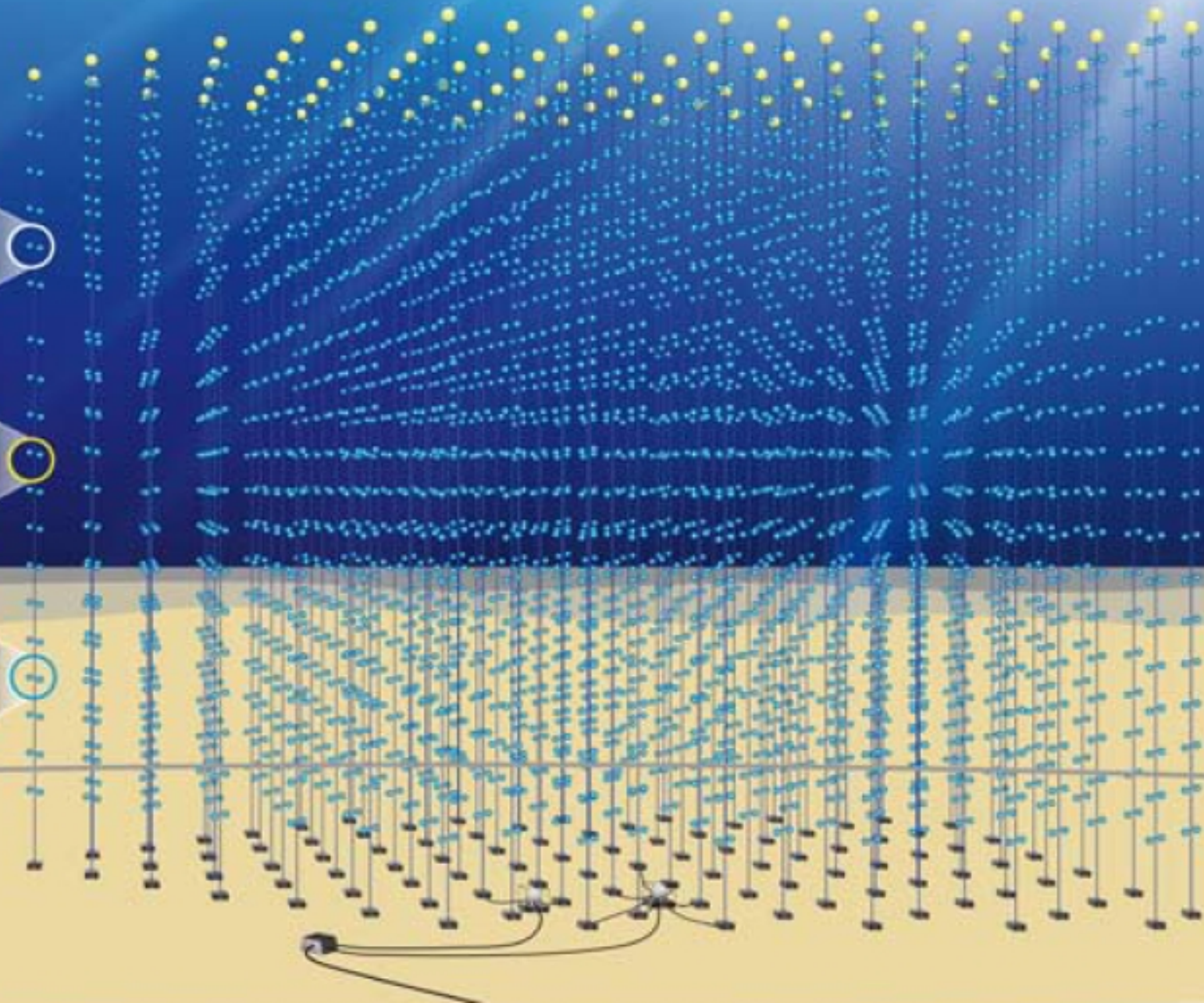


Detecting neutrino's

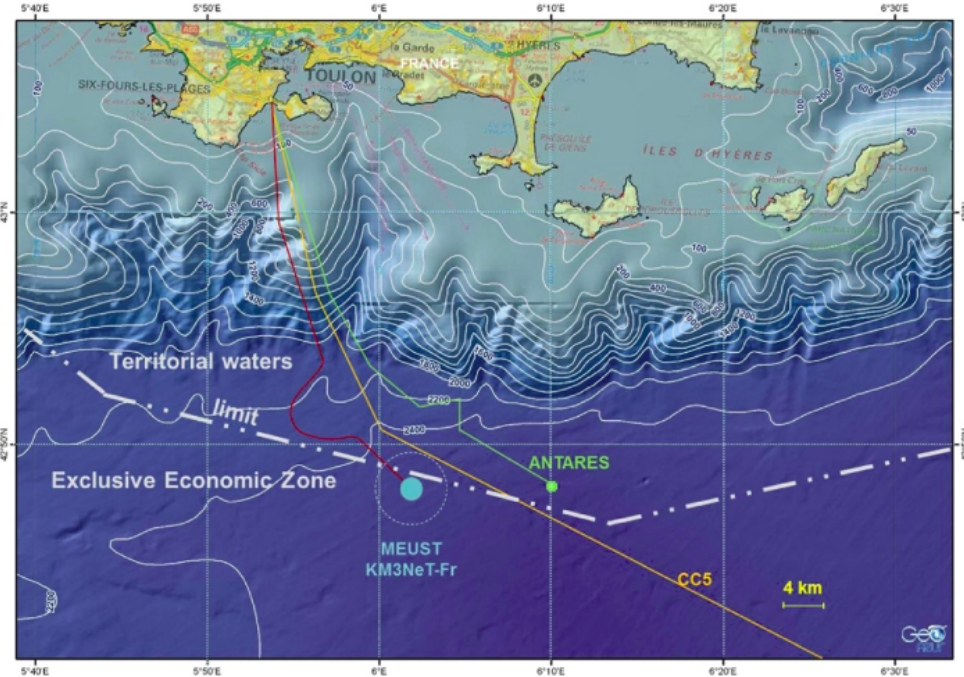


Optical module

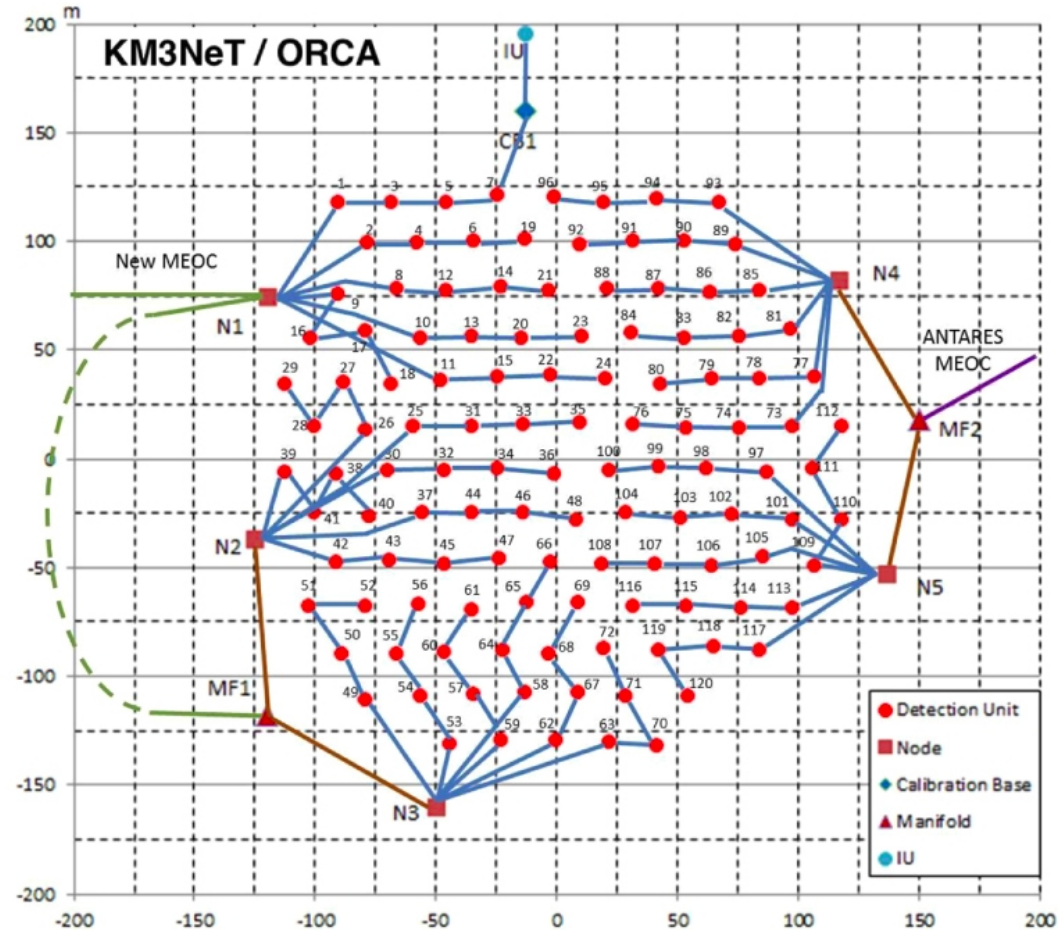




KM3NeT France: ORCA



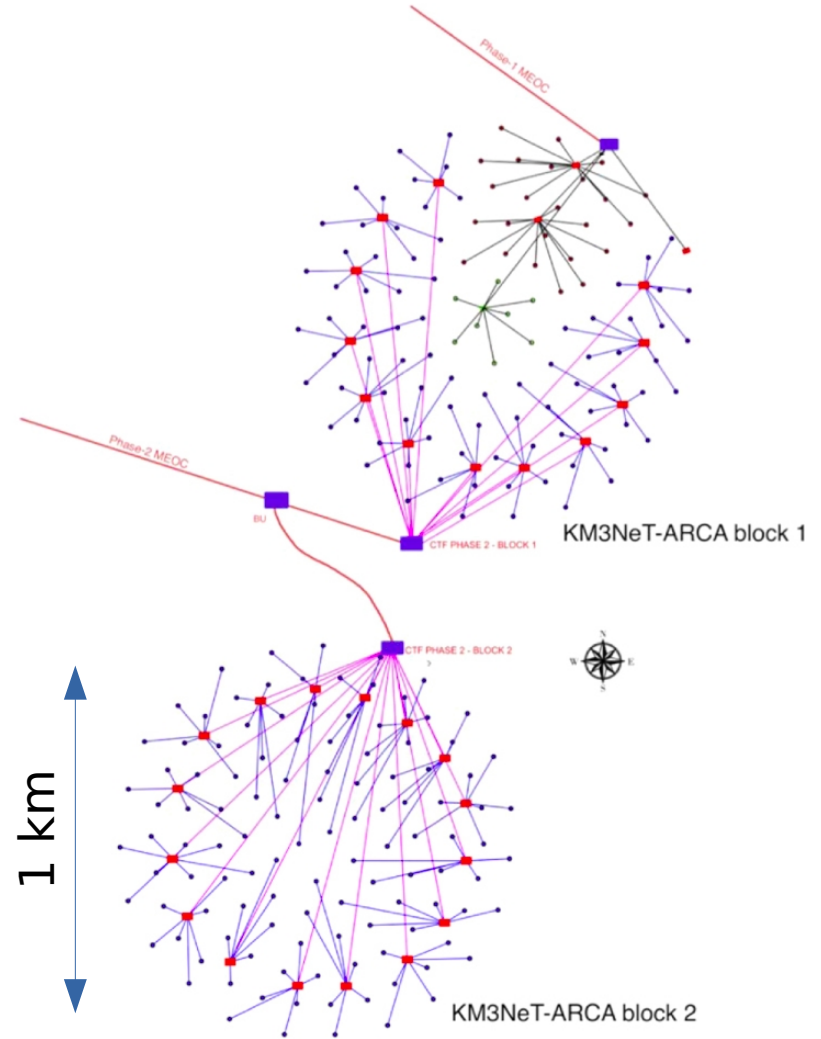
Depth: 2500 m



KM3NeT Italy: ARCA



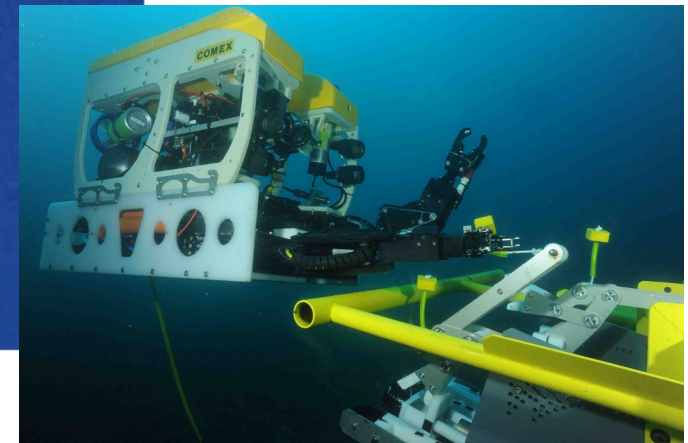
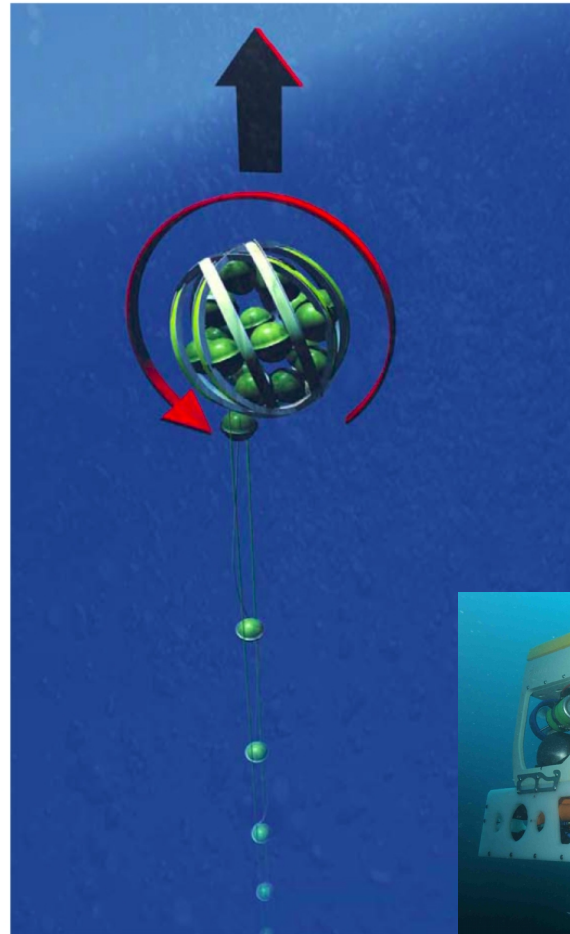
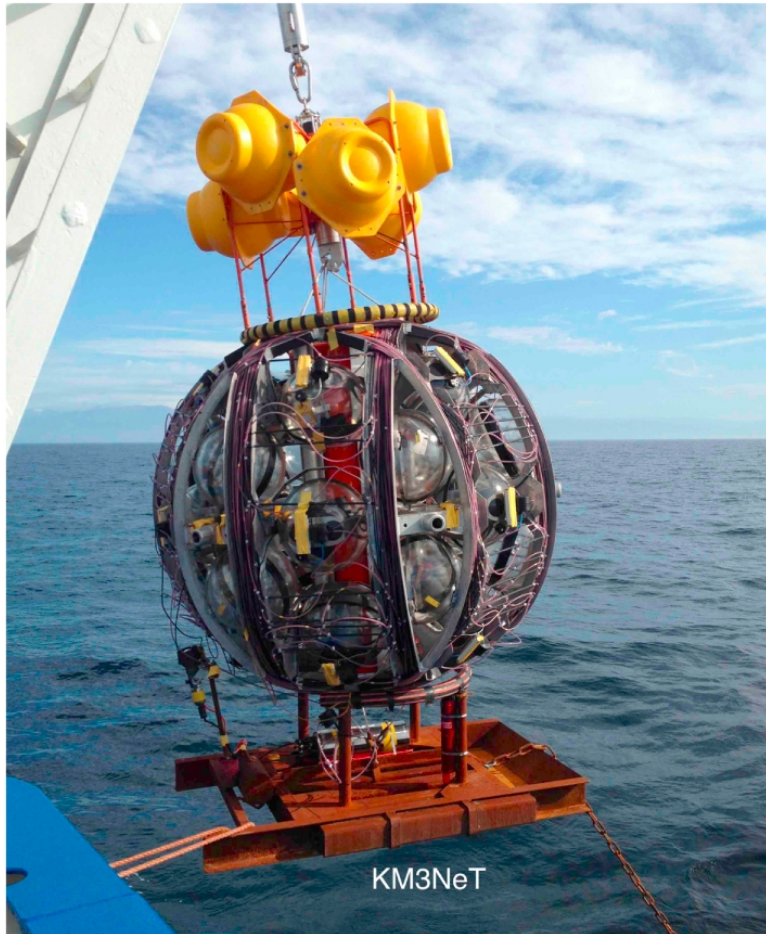
Depth: 3000 m

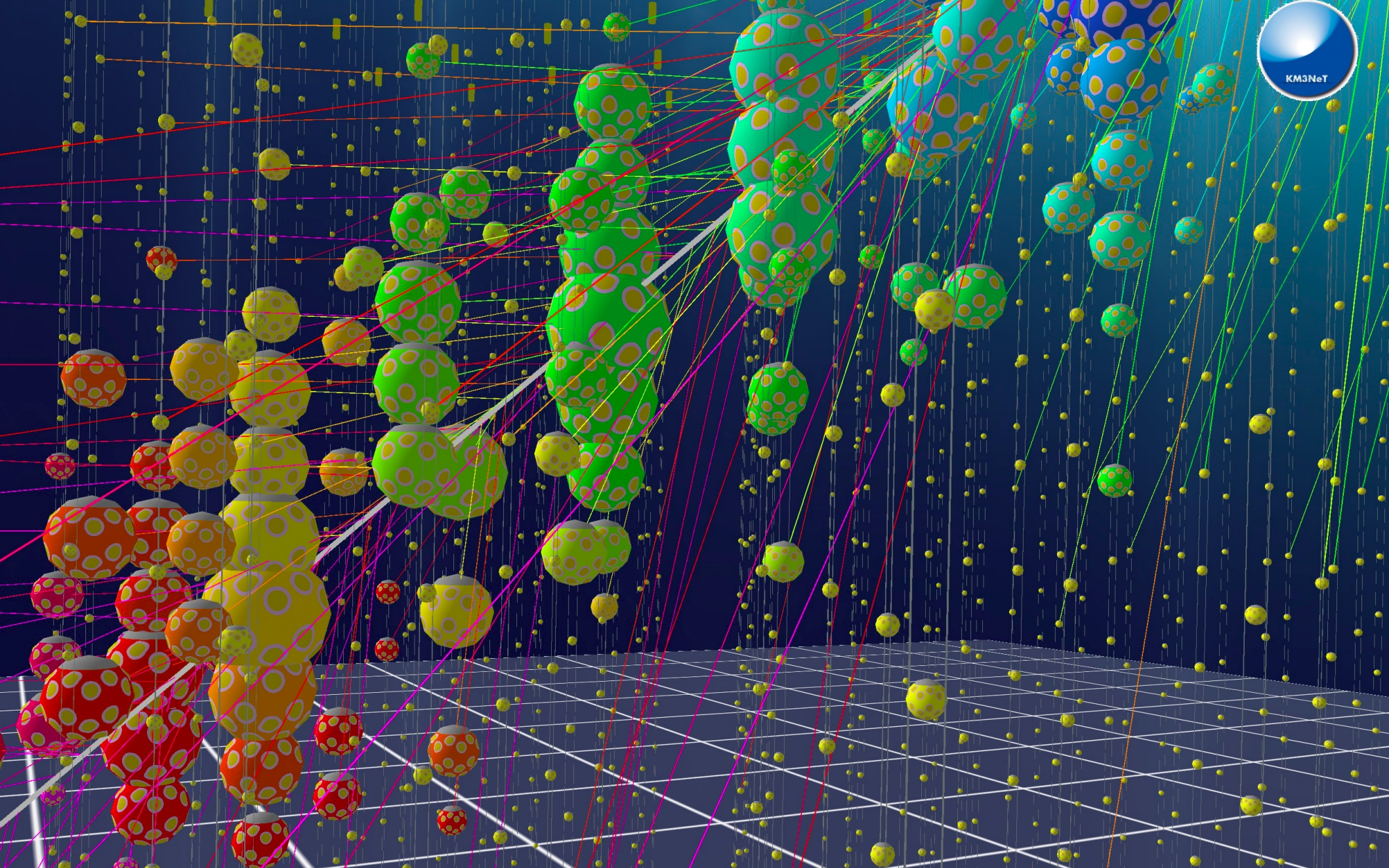




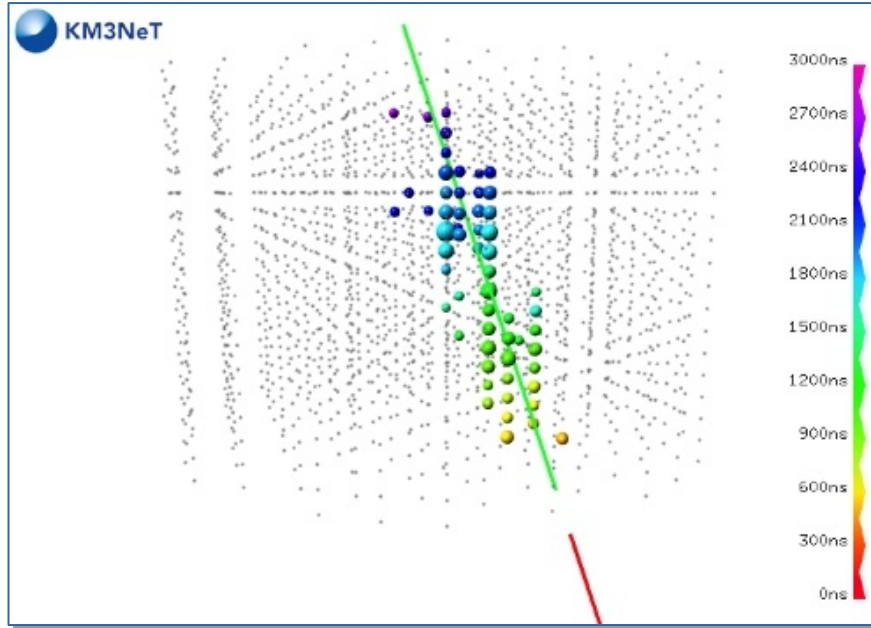
Main cable deployment

Deployment of a neutrino telescope



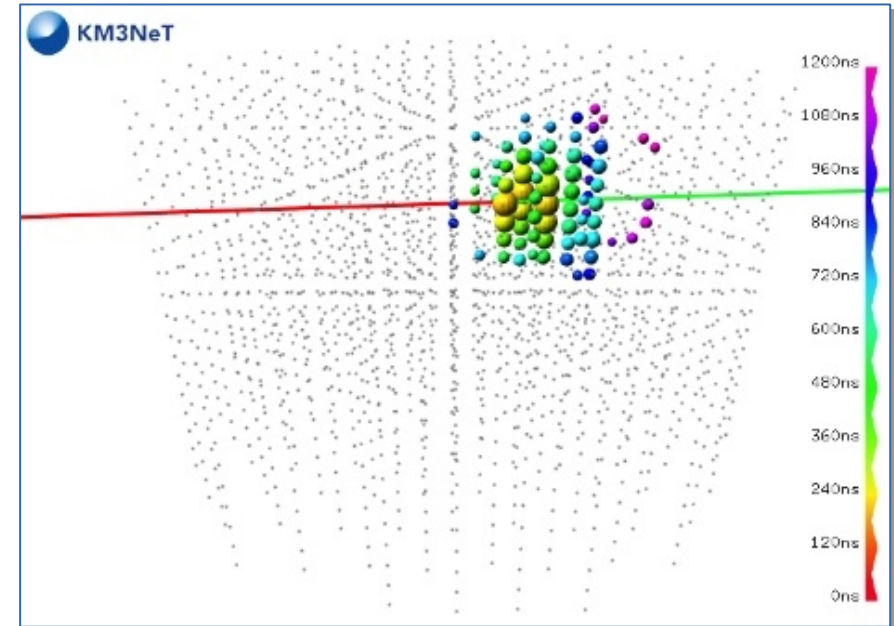


Simulated events

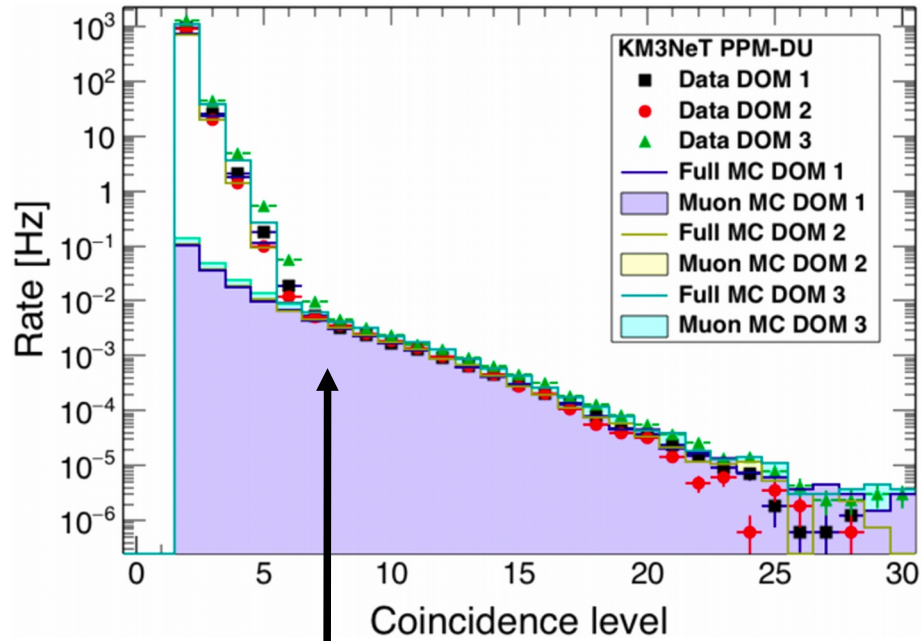


Upgoing muon neutrino

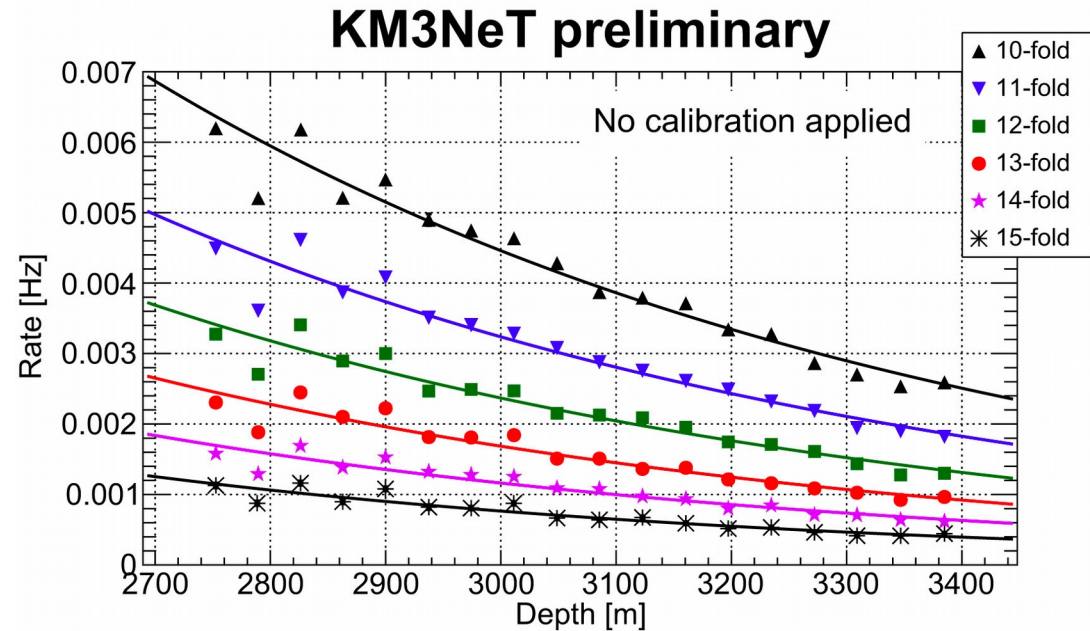
Electron neutrino



First results



Coincidence of 7 PMTs per module rejects the background from radioactive decays.

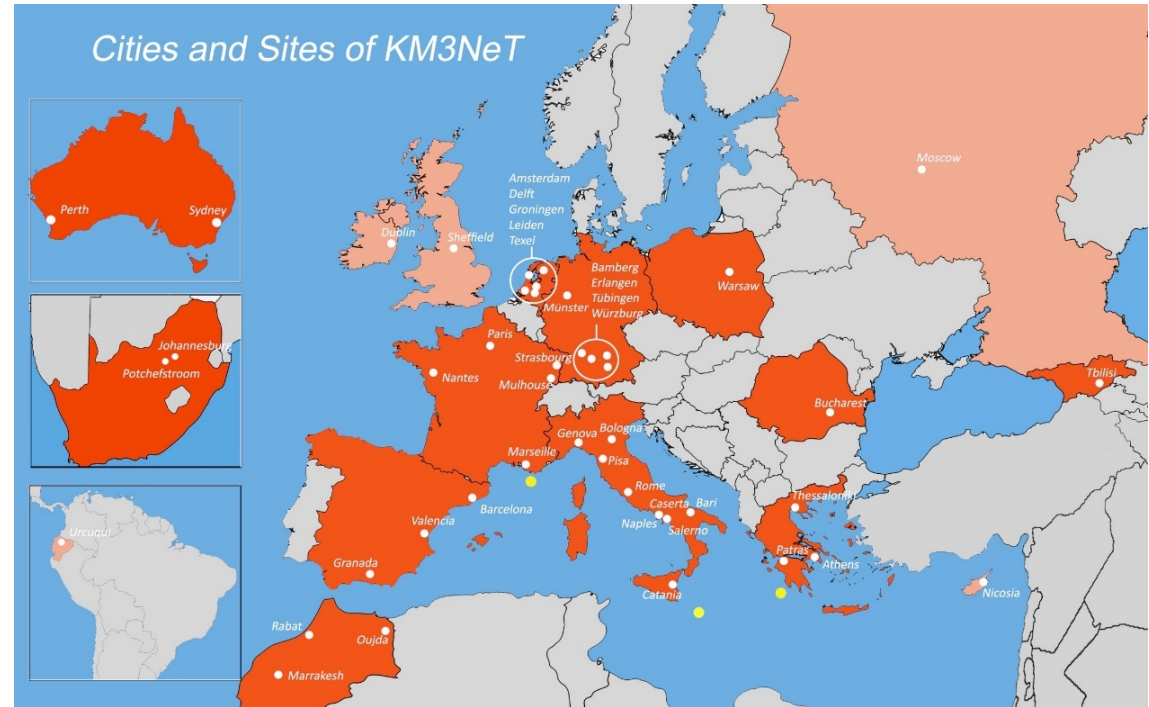


Detection frequency decreases with depth

The KM3NeT collaboration

- 15 countries, 55 institutes, >240 scientists
- Dutch institutes: Nikhef, NIOZ, KVI, U. Leiden, UvA, VU, TNO

- Dutch contributions:
 - Design of optical modules,
 - Design of deployment,
 - Electronics,
 - Optical data communication,
 - Engineering

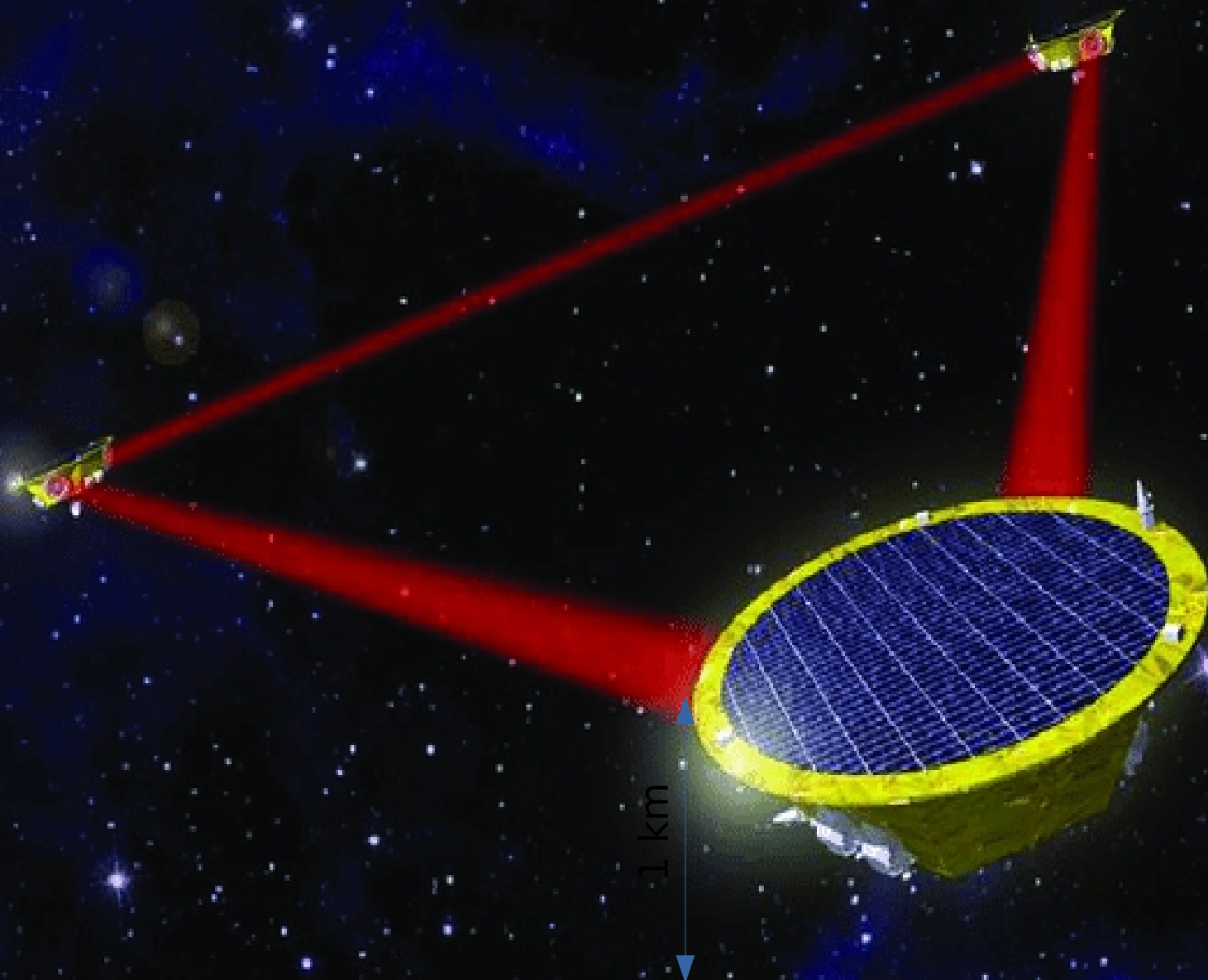


The KM3NeT collaboration: **phased approach**

Phase	Schedule	Deliverable	Funds
1	< 2020	Proof of feasibility and first science results: 24 ARCA strings 6 ORCA strings	Fully funded
2	2020-2025	All flavor neutrino physics and astronomy: 2 x 115 ARCA strings 1 x 115 ORCA strings	Partially funded

Phase 2: In total 345 strings with >6000 optical modules
Transition from first prototypes to full scale production

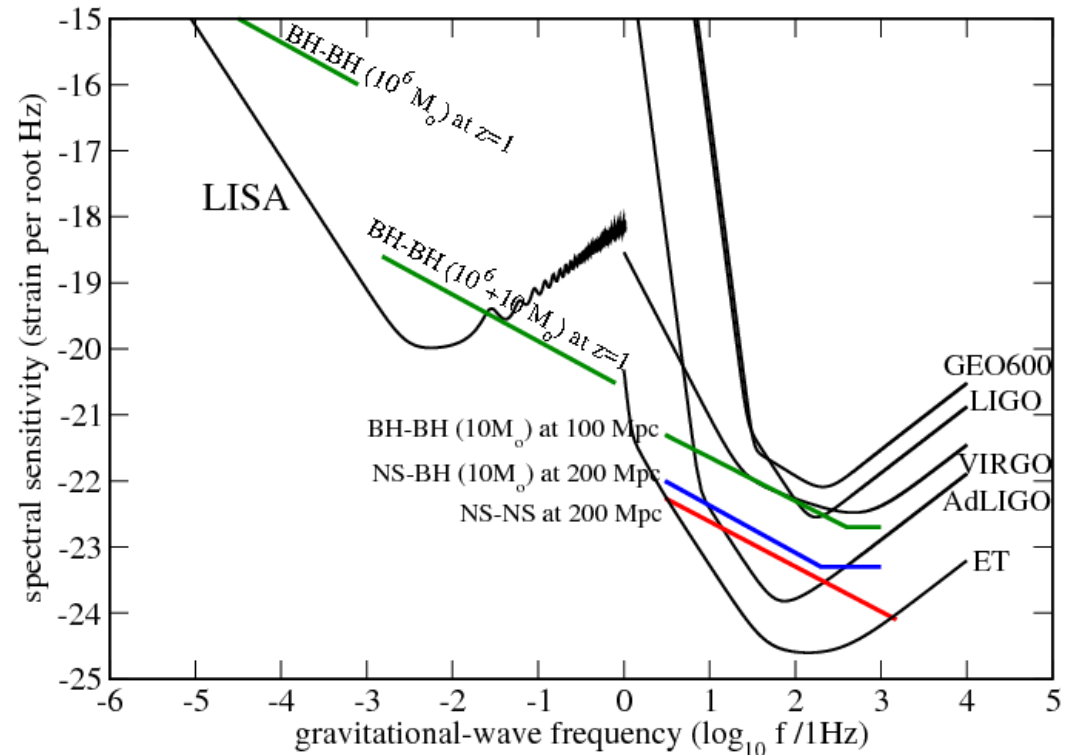
LISA



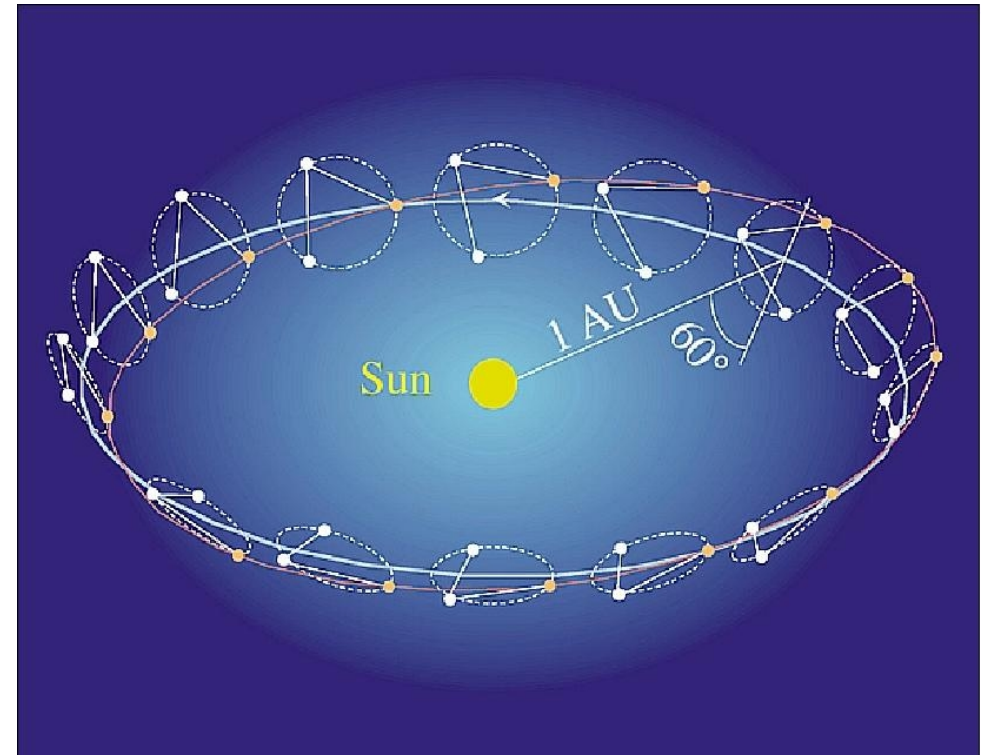
- First gravitational wave detector in space using 3 spacecraft
- Sensitive to low frequency gravitational waves
- ESA-NASA mission
- Planned launch in 2034

- Science objectives:

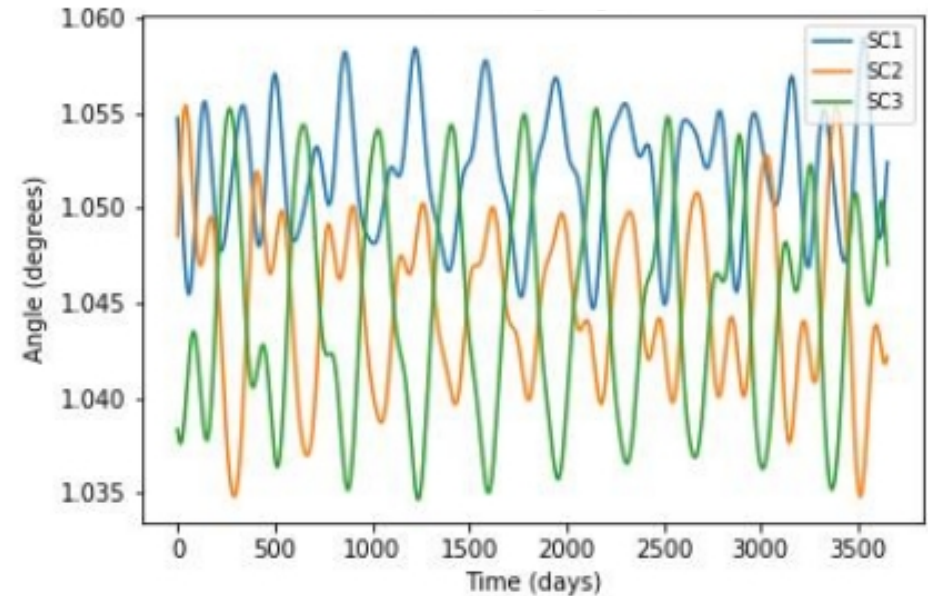
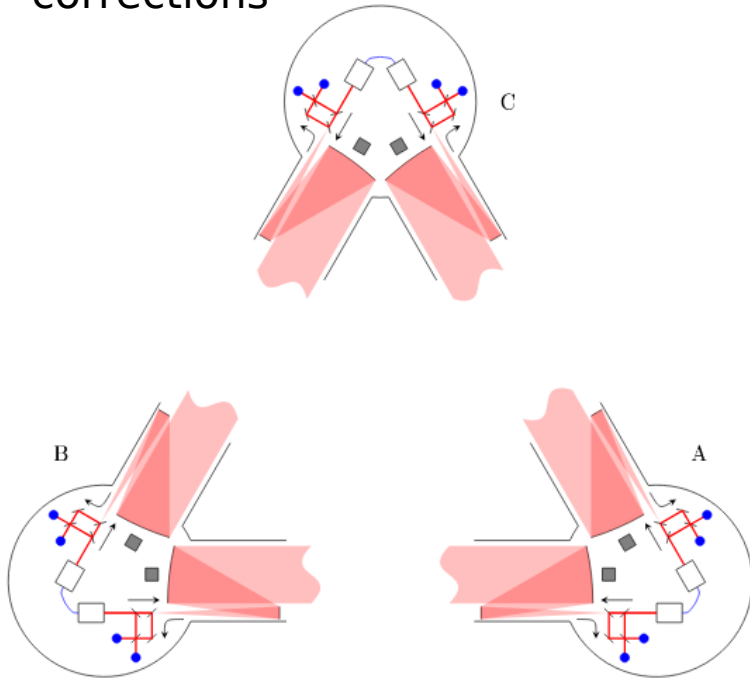
- (Massive) Black hole binaries
- Neutron star binaries
- Test of general relativity
- Etc, etc,



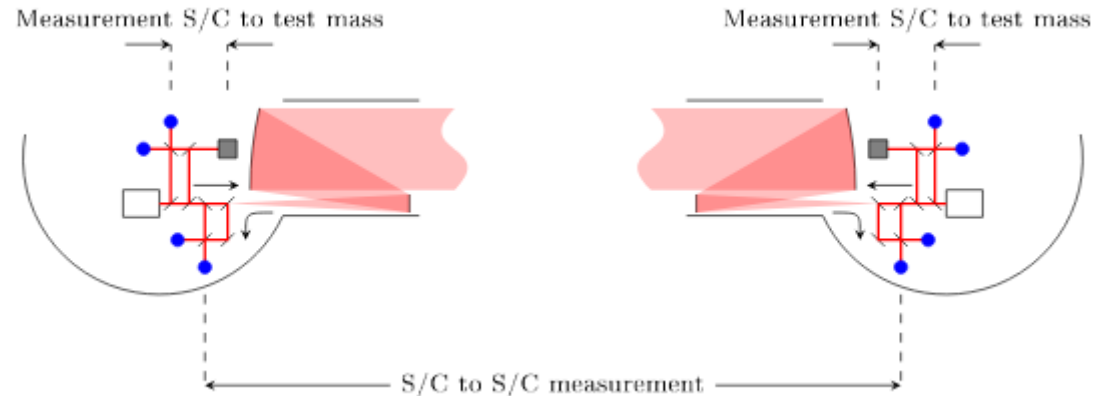
- Three spacecraft in a Kepler orbit around the Sun.
- Triangle formation with arm length 2.5 Mkm
- Triangle in orbit is not static and needs corrections



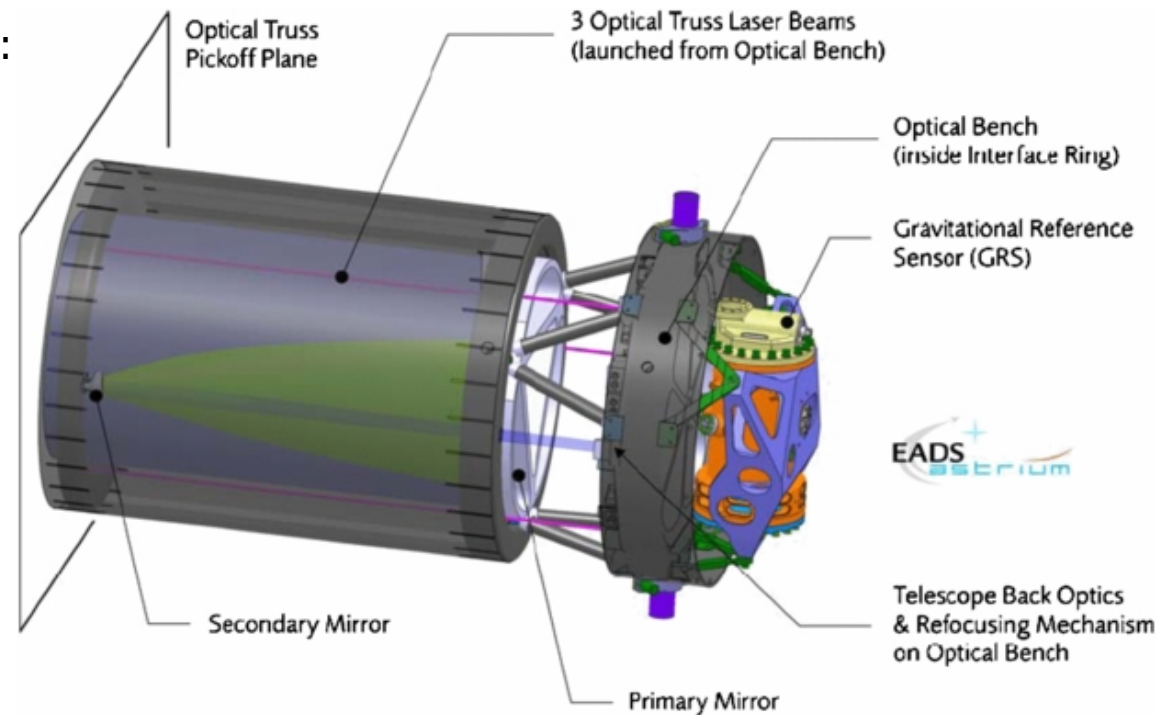
- Three spacecraft in a Kepler orbit around the Sun.
- Triangle formation with arm length 2.5 Mkm, i.e. 8.3 s
- Triangle in orbit is not static and needs corrections



- Measurement principle: distances between free falling test masses in spacecraft.
- Telescope for sending and receiving laser light: Received light 150pW/W: no stray light allowed!
- MOSA: Moving optical sub-assembly:
 - 1) Telescope
 - 2) Optical bench
 - 3) Test mass

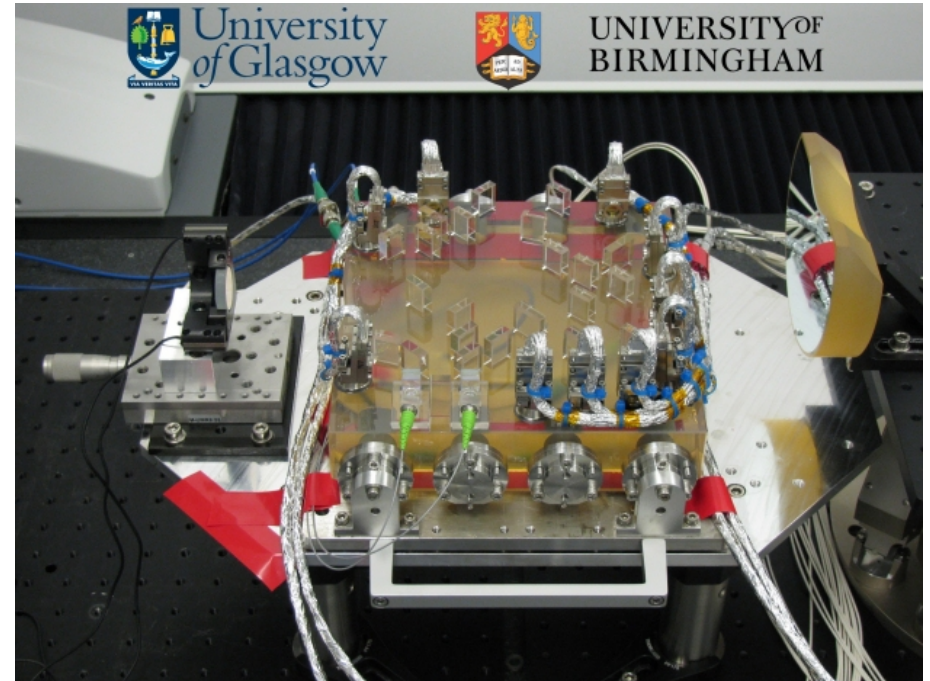
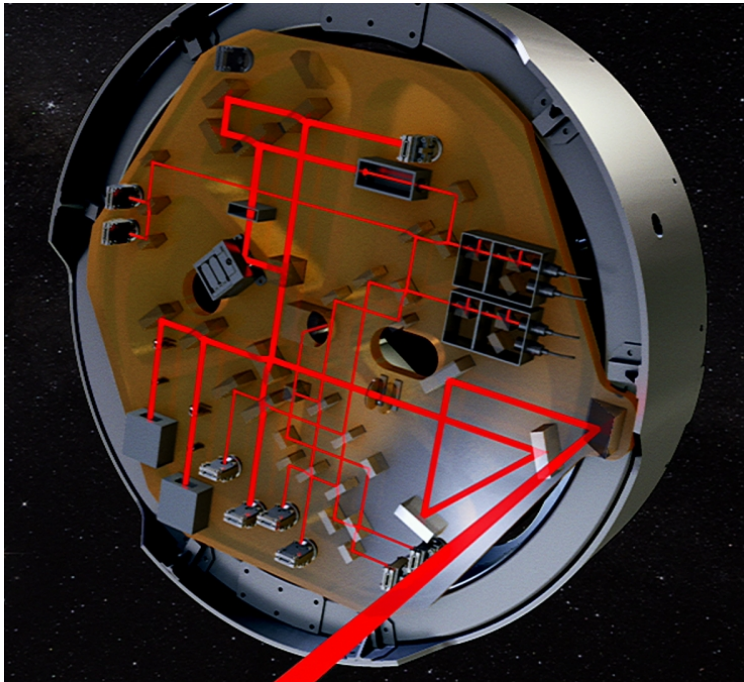


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LISA science payload

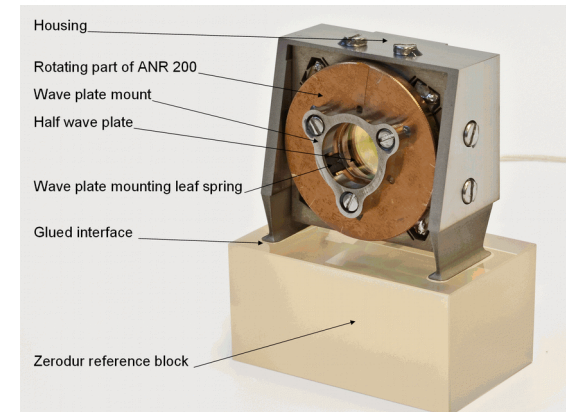
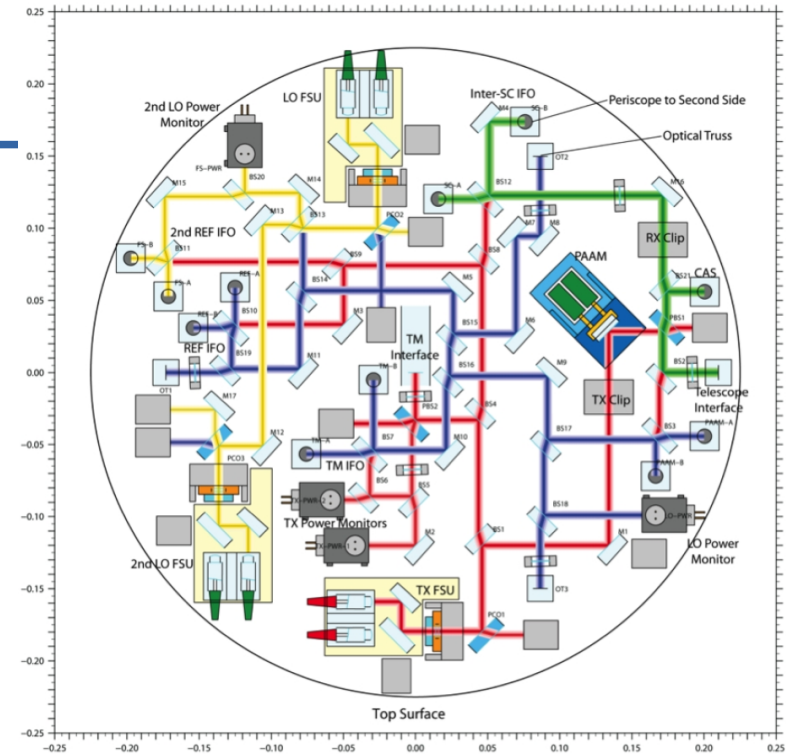
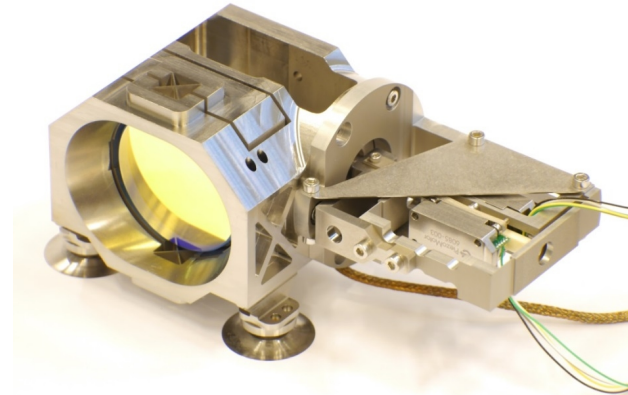
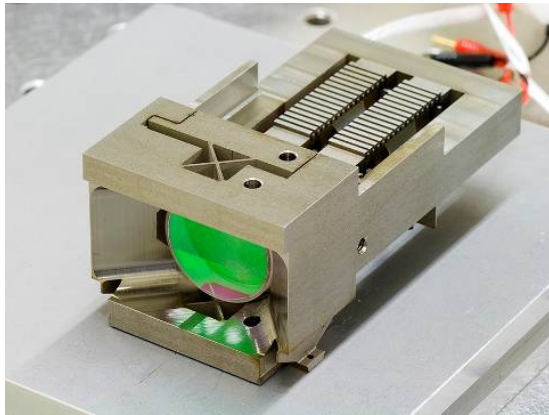
- Optical bench: connecting the dots.
- Zerodure, optical element bonded on both sides



LISA Pathfinder optical bench

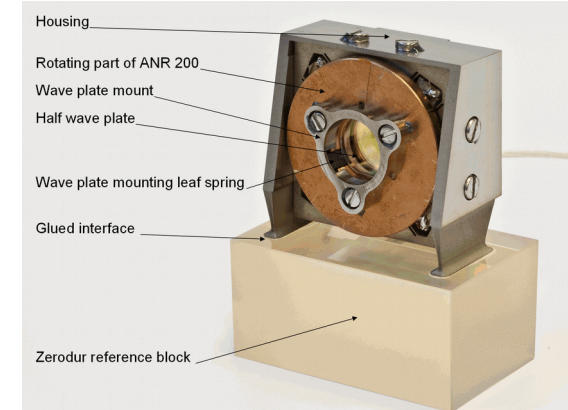
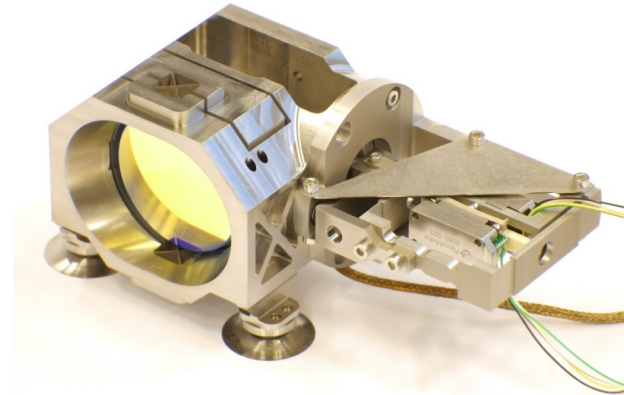
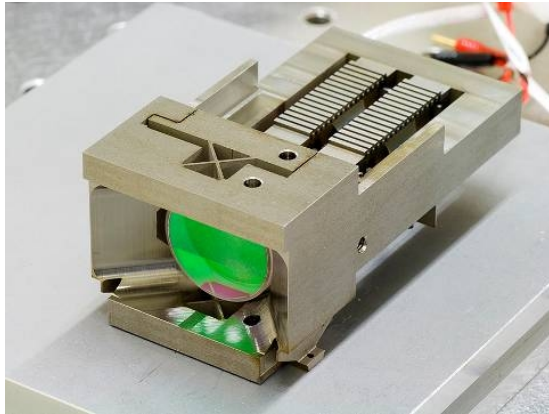
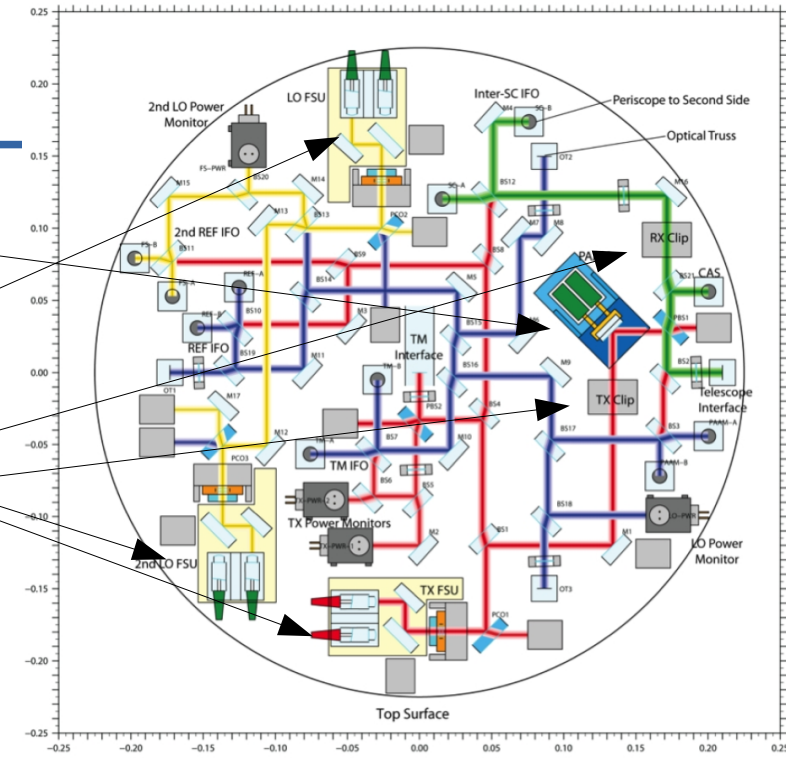
LISA optical mechanisms

- 1) Point ahead angle mechanism: PAAM
- 2) In-field pointing mechanism: IFPM
- 3) Fiber switching unit actuator: FSUA
- 4) Active aperture mechanism: AAM
- 5) Refocusing mechanism: RM
- 6) Optical assembly telescope mechanism: OATM

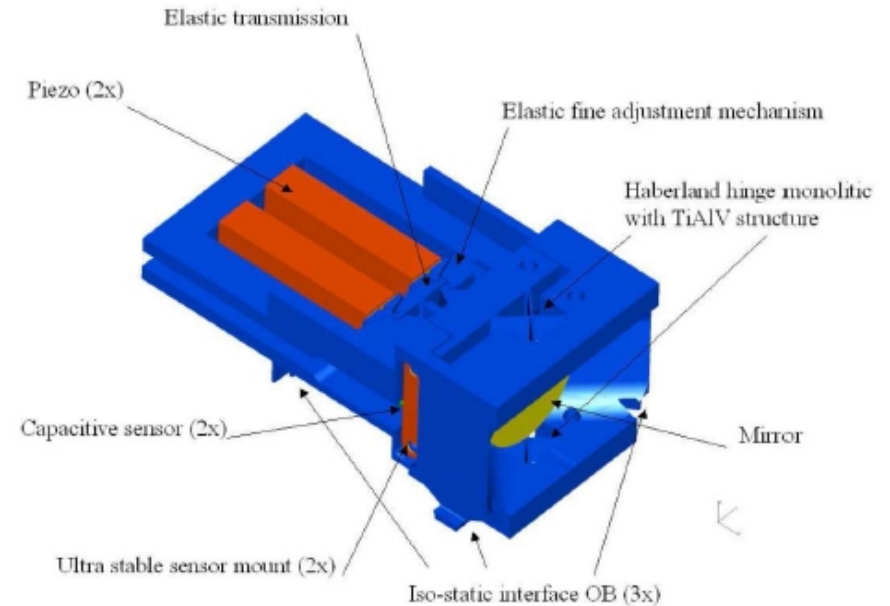
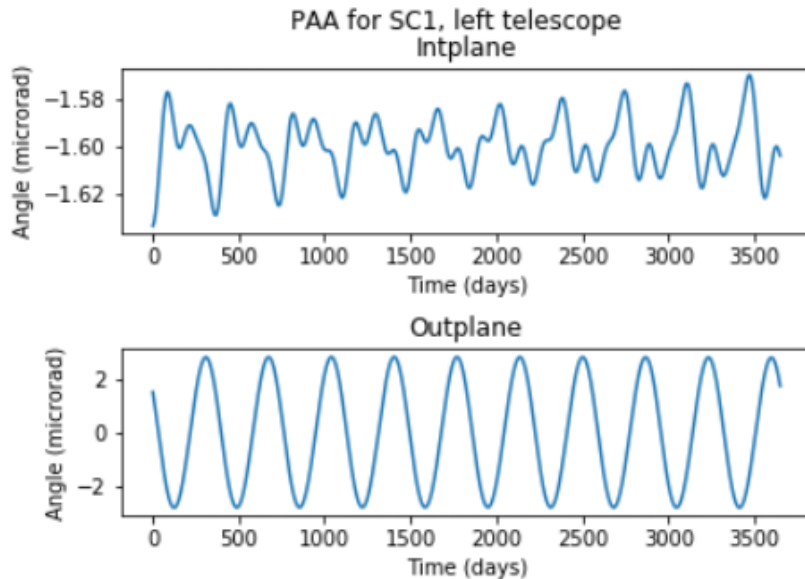


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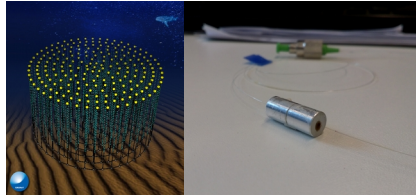


- Point ahead angle need to be corrected:
 - In-plane point ahead angle by initial alignment
 - Out-of-plane angle needs constant correction: piezo steering actuator
 - PAAM directly in measurement arm: *Allocated error budget ~picometer*



Big science instrumentation for the coming years

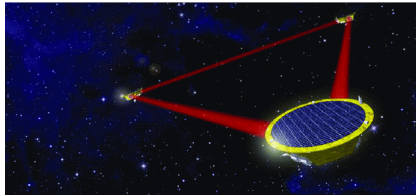
KM3NeT



2020: KM3NeT phase 2 kick-off
Neutrino (astro)physics and acoustic particle detection
Fiber optics hydrophone, systems engineering

2025: KM3NeT-phase 3??

LISA

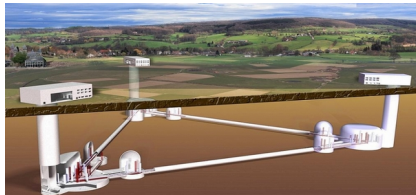


2019: Phase A
Dutch hardware contribution to ESA L-class mission
Design of opto(mechanical) components, performance assessment

Phase B/C

2034
LISA launch

EINSTEIN



2019: ET pathfinder kick off
Preparing Advanced Virgo+

2022: ET site selection

2032
ET kick off

2019-2020

2025 →

Multimessenger: gravitational waves + neutrinos

