ETIC: phase camera

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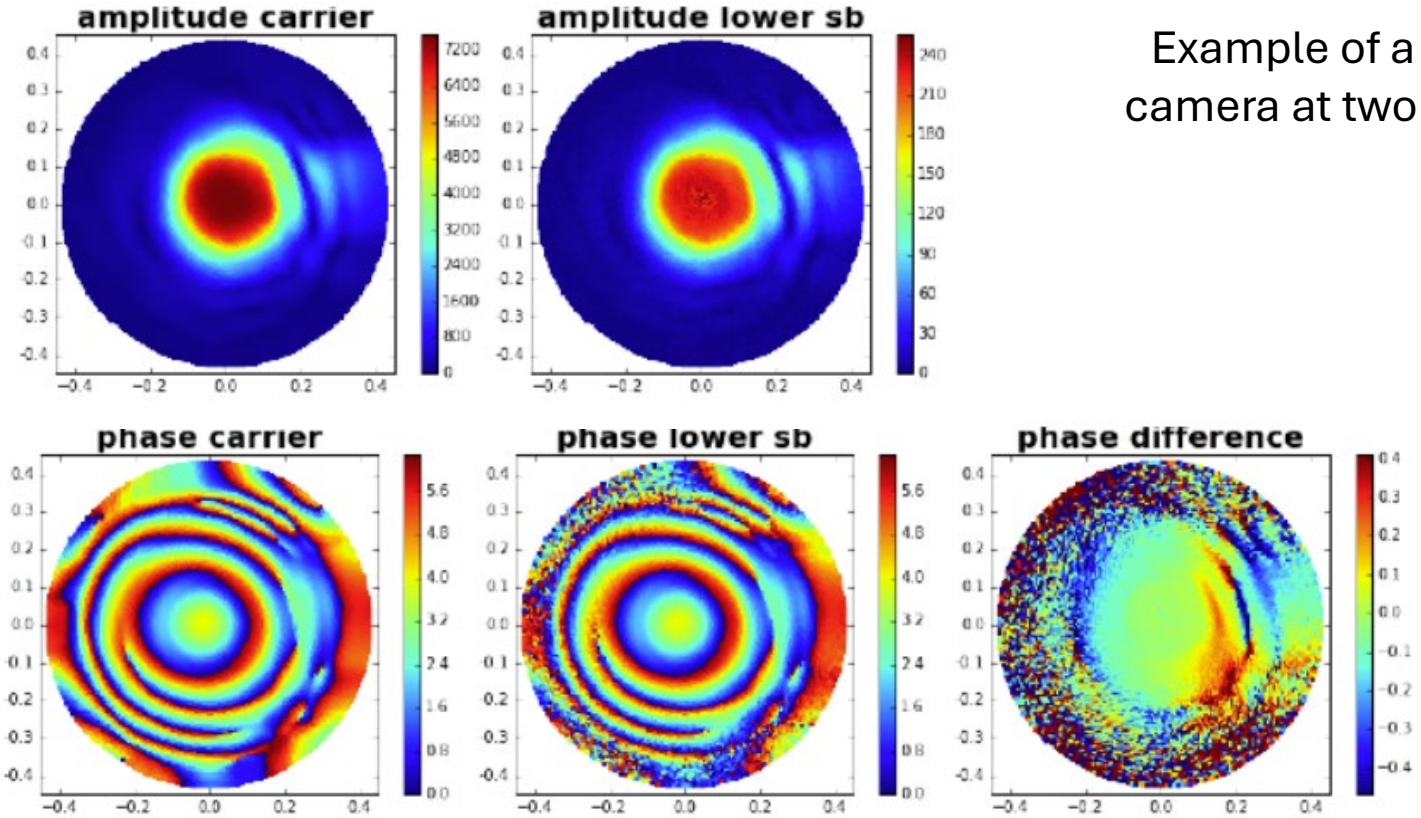
ET Sardegna - Kickoff meeting, 24/06/2024

Phase camera

- A phase camera is a **diagnostic tool for an interferometer:** it measure the phases and amplitudes of the laser-light fields at the frequencies selected to control the interferometer (sidebands)



Example of a laser wavefront characterized with a phase camera at two different wavelengths (Studies for Advanced Virgo)
DOI 10.1088/1742-6596/718/7/072008

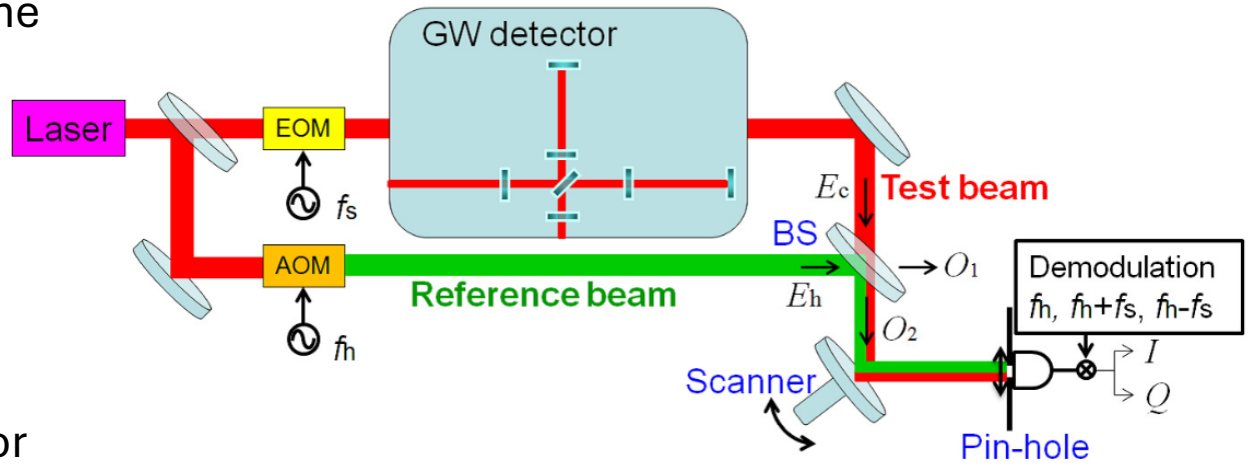
- By measuring phase variation it is possible to determine aberration of the beam in the optical path, due for example to thermal variation
- In advanced VIRGO Phase Camera is used to give feedback to the thermal compensation system to monitor temperature variations of the mirrors of the interferometer.

Phase camera: working principles

- Investigation signal is an interferometer signals: a phase RF modulated beam (carrier+ sidebands).
- **Heterodyne technique**, a reference beam is generated by shifting its frequency through the AOM and combined to the investigation signal in a beam splitter (BS)
- Beating notes of combined beams are different for carrier and sidebands allowing to study phase shifting for the different sidebands
- Combined beam can be scanned by a single photodiode or readout with a matrix of pixels
- Demodulation to extract the phase shifting for every sideband -> measurement of aberrations

EOM: Electro Optic Modulator (for phase modulation)

AOM: Acousto Optic Modulator (for frequency shifts)



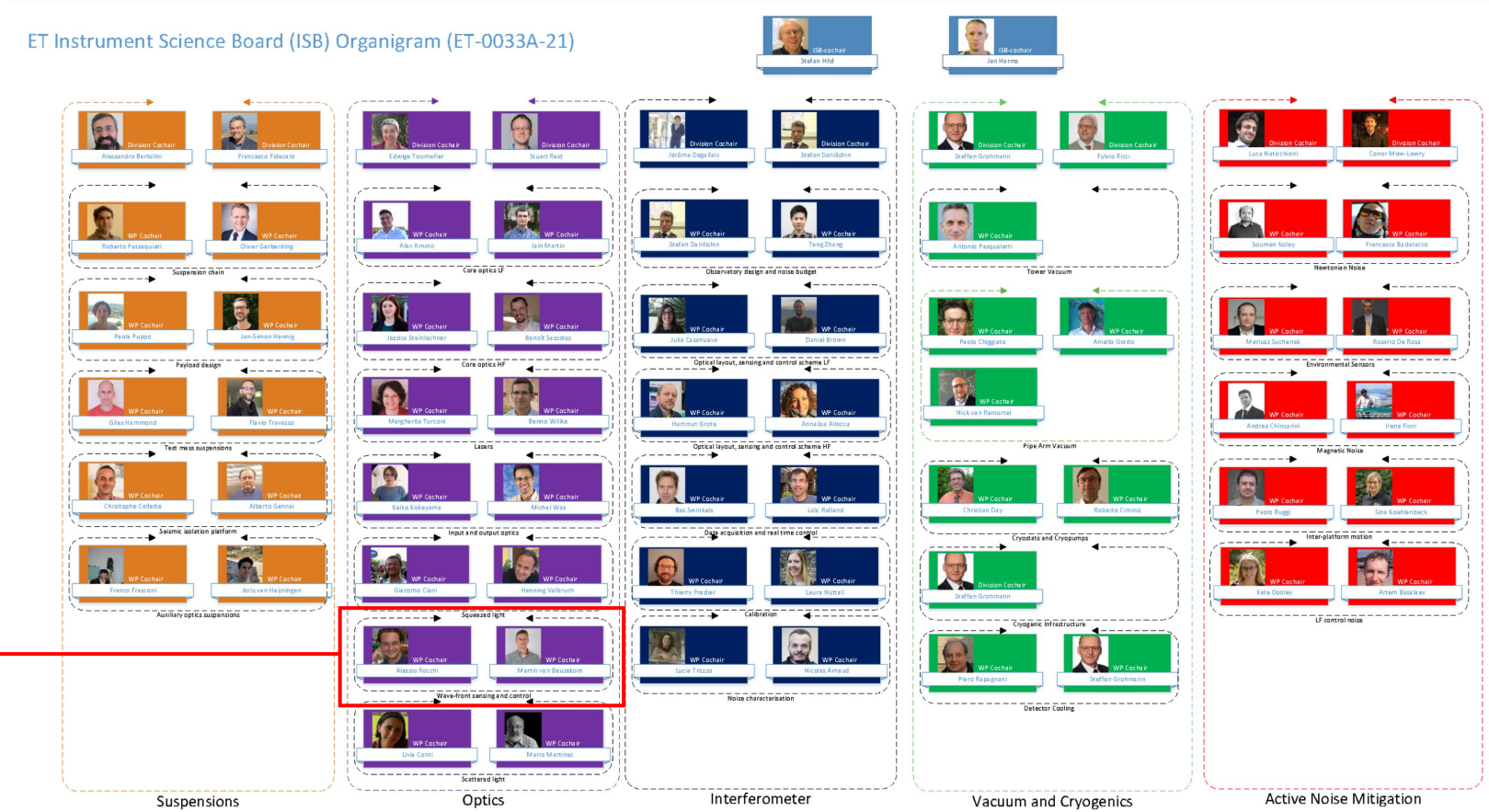
D. Brundu slides for more info

Phase camera activity in ET

- **ISB (Instrument Science Board) Optics Division: <u>Wave-front sensing and control WG</u>**

Current members in this activity
@ INFN Cagliari

D. Brundu, A. Cardini, A. Contu,
A. Lai, A. Lampis, A. Loi, A. Masoni +...



Co-chairs of the WG:

- Alessio Rocchi (INFN Tor Vergata),
  alessio.rocchi at roma2.infn.it

- Martin van Beuzekom (Nikhef)
  martinb@nikhef.nl

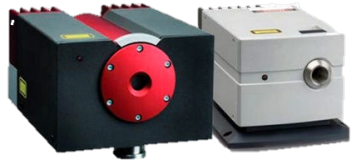
ETIC: Optical diagnostic laboratory

Inside the ETIC project we are developing an Optical diagnostic laboratory, ready in November 2024, for dedicated R&Ds on wavefront sensing

- New optical table will be delivered and installed in **November 2024**

784-677-12R
Research Grade CleanTop Optical Top: 4200 mm x 1500 mm x 300 mm, M6 on 25mm spacing

14-616-45
Gimbal Piston Leg System, 1450mm x 1700mm x 600mm, 2720kg capacity, Plain, Standard Valves

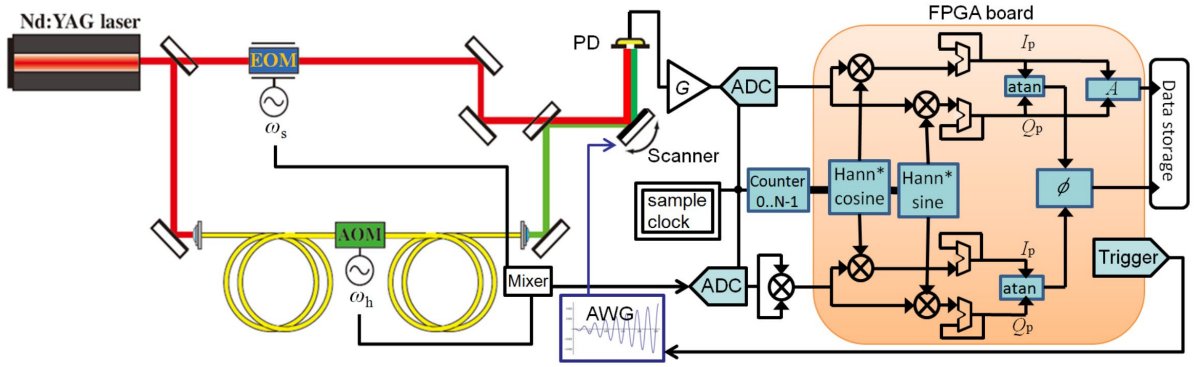


- Coherent Mephisto 2000
  - Diode-pumped LASER
  - Single-frequency CW output (1064nm) @ 2W of power
  - Technical specs:
    - Coherence length: >1km
    - Optical noise (measured from 10Hz – 2MHz): <0.03 % rms
    - Relative intensity noise (RIN, f >10kHz): < -140 dB/Hz
- Additional info
  - Used within most ET/VIRGO related optical laboratories (NIKHEF, UNIFE etc.)
  - **Purchase order is currently being processed**

Setups to start

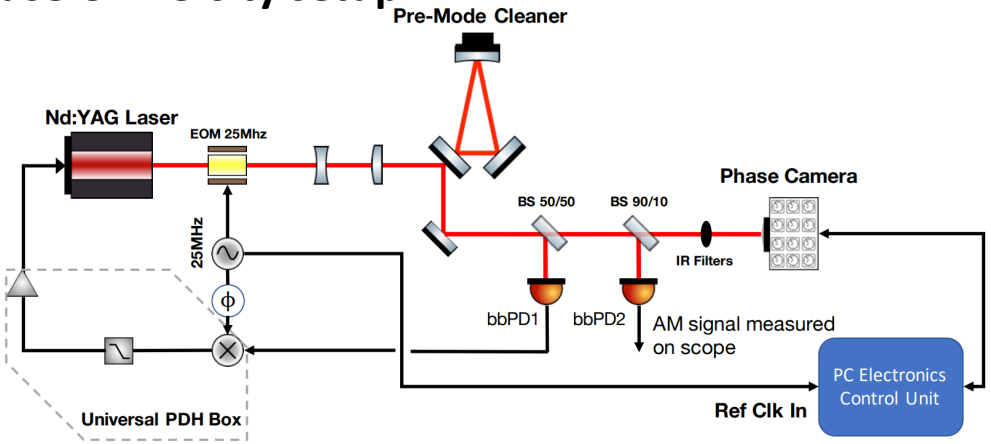
- Started by studying two existing setups for VIRGO and LIGO:

Nikhef setup: LINK



Single photodiode readout + FPGA for demodulation

Syracuse University setup: LINK



Pixel matrix readout (Time Of Flight camera)

- Have a first dedicated setup to test this type of systems
- Understand the requirements for phase cameras and in general Wavefront sensing for ET
- R&Ds on new readout systems + FPGA to meet ET requirements

Conclusion

- New research field for our group, all the people involved have a background in particle detectors for high energy physics.
- Currently studying working principles of phase cameras and performance requirements for ET.
- Purchasing optical and mechanical elements to develop phase cameras test setups to start R&Ds.
- Space for simulation activity to study the setups and new wavefront sensing techniques (available tools e.g. FINESSE3).
- Goal is to improve current phase camera by using the knowledge on sensors and electronics from particle detectors developments (e.g. matrix of pixels and ROC).

Space for both simulation and hardware activities feel free to join if you are interested