Interferometer Division presentation

The division chairs and work package leaders

The Interferometer division is composed of 6 Work Packages (WP) that are detailed below. For additional information do not hesitate to contact the WP leaders: https://wiki.et-gw.eu/ISB/Interferometer/WebHome

III.1 Observatory design and noise budget

Scope:

- Development and continuous updating of noise budgets for ET, including both, the LF and HF detector with theoretical noise curves.
- Acting as interface to the science case
- Ensuring optimisation of LF and HF design for the frequency range where they cross over
- Providing some basic science figures of merit indicators that can be used for design decisions and trade offs.
- Organise with input from the various relevant WP trade-off decisions of global parameters such as ET-LF mirror temperature of ET-LF laser wavelength.

Deliverables:

- Up-to-date noise budgets (fundamental noise) for ET-LF, ET-HF.
- For LF: mirror optimal temperature with input from Optics division
- Development and maintenance of basic science figure of merit indicators.
- Maximum sensitivity achievable with the current infrastructure

III.2 Optical layout sensing and control scheme LF

Scope:

- Development of optical layout of ET-LF core interferometer
- Acting as collection point for all of the detailed optical layouts from the various subsystems (input optics, output optics etc) and maintain a repository with the overall optical layout of ET-LF
- Development of LSC and ASC concepts for ET-LF
- Review of simulations codes, highlighting missing features

Deliverables:

- 3D optical layout
- Main mirrors specifications for substrate, polishing and coating
- Longitudinal and angular strategy scheme with SB frequencies and photodiode ports

Questions:

- Detuned SRC operation for ET-LF ?
- Optical layout - telescopes before or after BS ?

Interfaces:

- V.5 LF control noise + V.4 Inter-platform noise: Understand the noises that will have to be suppressed by the control loops (all DOFs in all directions!!), try to understand the upper limits so that control noise won't limit the sensitivity and identify if any noise cancellation strategy will be needed.
- II.4 Input and output optics:
    - performance of the OMC needed, will depend on choice of sidebands and optical configuration of the ITF.
    - Beam size at the input of the ITF depending on the optical layout, who makes the auxiliary optics?
- II.3 Lasers: decide modulation depths, modulation frequencies and requirements in terms of RAM/modulation phase noise
- II.6 Wave-front sensing and control: there will be very low power reaching the PDs, which frequencies will be needed? Broadband PDs or resonant ones?
- I.2 Payload design OR I.3 Test mass suspension: decide dynamics of actuators and requirements on magnetic noise, evaluate the shape of the Transfer Function
- II.1 Core optics LF: defects on the test masses, tolerances on the reflectivities (finesse), tolerances on the RoCs

III.3 Optical layout, sensing and control scheme HF

Scope:

- Development of optical layout of ET-HF core interferometer
- Acting as collection point for all of the detailed optical layouts from the various subsystems (input optics, output optics etc) and maintain a repository with the overall optical layout of ET-HF
- Development of LSC and ASC concepts for ET-HF
- Review of simulations codes, highlighting missing features

Deliverables:

- 3D optical layout
- Main mirrors specifications for substrate, polishing and coating
- Longitudinal and angular strategy scheme with SB frequencies and photodiode ports

Interfaces:

- II.4 Input and output optics:
  - performance of the OMC needed, will depend on choice of sidebands and optical configuration of the ITF. The possible choice of Balanced Homodyne readout affects, for instance, LO beam design.
  - Beam size at the input of the ITF depending on the optical layout and telescope design and positioning.
- II.3 Lasers: decide modulation depths, modulation frequencies and requirements in terms of RAM/modulation phase noise.
- II.6 Wave-front sensing and control: which frequencies will be needed? Broadband PDs or resonant ones? Digital demodulation?
- I.2 Payload design OR I.3 Test mass suspension: decide dynamics of actuators and requirements on magnetic noise, evaluate the shape of the Transfer Function.
- Core optics HF: defects on the test masses, tolerances on the reflectivities (finesse), tolerances on the RoCs

Urgent Questions:

- Beam size on BS? Will affect the contrast defect because of thermal effect in case of small beam size.
- Will the telescope be installed before or after the BS?
- Alignment control bandwidth to control optical springs?
- Parametric instabilities:
  - simulations needed for the optical design definition.
  - active/passive control?
- Thermal effects and their control: are additional cavity diagnostic tools needed?

III.4 Data acquisition and real-time control

Scope:

- Development of the requirements for the ET control and data acquisition systems
- Timing system
- Specifications for the different DAQs (sampling frequencies, resolution)
- Review of budget for control hardware

Deliverables:

- Clear definition of boundaries between other SS
- With input from various subsystems, maintain a channel count estimate
- Choose DAQ architecture (Virgo style / LIGO style / commercial …)
- Cost estimate

Interfaces

- Most subsystems that have sensors or actuators
- Computing for final archiving of data

- Calibration or Data analysis for low latency signals

III.5 Calibration

Scope:

- Development of detailed calibration requirements (phase/amplitude, relative/absolute, individual detector/LF+HF combination, nullstream etc) to achieve ET science goals.
- Design for required calibration hardware
- Calibration methods: PCAL and NCAL - any more?
  - Free Michelson, Phase Noise Injection (Scattered Light, to be tested)

Deliverables:

- Strategy for the calibration and infrastructure required
- Cost estimate for the different calibration instruments

Questions:

- Are there any groups that are working on the cal system for ET or have expressed an interest?

Interfaces:

- Other divisions (OSB) such as those in cosmology and astrophysics to understand the accuracy needed for their analyses. Also to understand whether we can use any verification binaries/what systems we have (benchmarks).
- Payloads/actuators/photodiodes
- Data acquisition and real-time controls
- Infrastructure - for integration of PCal/NCal instruments
- Optical benches/photodiodes for Free Michelson/Scattered Light

III.6 Noise Characterisation

Scope:

- Review of all detector subsystems from a viewpoint of future detector characterisation work: Do all subsystems have included enough sensors, actuators, interfaces etc to allow the identification of noise coupling paths and measurements of coupling transfer functions? Dummy example: Is a baffle built in a way that we can measure its motion, can sense the intensity hitting it and maybe even shake it?

Deliverables:

- List of noises we want in a technical noise budget
- Proposed strategy to project correctly those noises during the operation of the detector

Interfaces:

- Interfaces with others divisions and work packages: like suspensions, payload, etc.
- Within interferometer division: obvious interface with III.1 Observatory Design and Noise budget
  - We measure noise couplings and characterize the noises
  - These measurements are inputs to the noise budget
- Low-frequency noises will be critical
  - Suspensions, Newtonian, scattered light, controls, radiation pressure due to high stored power
  - Technical noises: cryogenics plant, other services, environmental noises
- High-frequency noises
  - Frequency noise
  - Shot noise