Links between instrument developments and science with Gravitational Waves :

the LISACode simulator & studies of robust data analysis and calibration methods

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Situation

- Mission accepted: we need now to make it as best as possible.
- Large developments and studies done for LISA and eLISA on:
  - Instrument developments and research on high level technologies.
  - Data analysis and science with gravitational waves.
- BUT there is very little connections between these two aspects ...
- $\rightarrow$ developments of instrument, data analysis and studies of science efficiency of eLISA have to be consider COHERENTLY.
- One example of potential problem:
  - periodicity and not stationarity of the noise that can mimic sources or at least, makes the matched filtering more complex for long standing GW sources.
  - High noise observed: instrument or stochastic background ?

First ideas for “connections” :

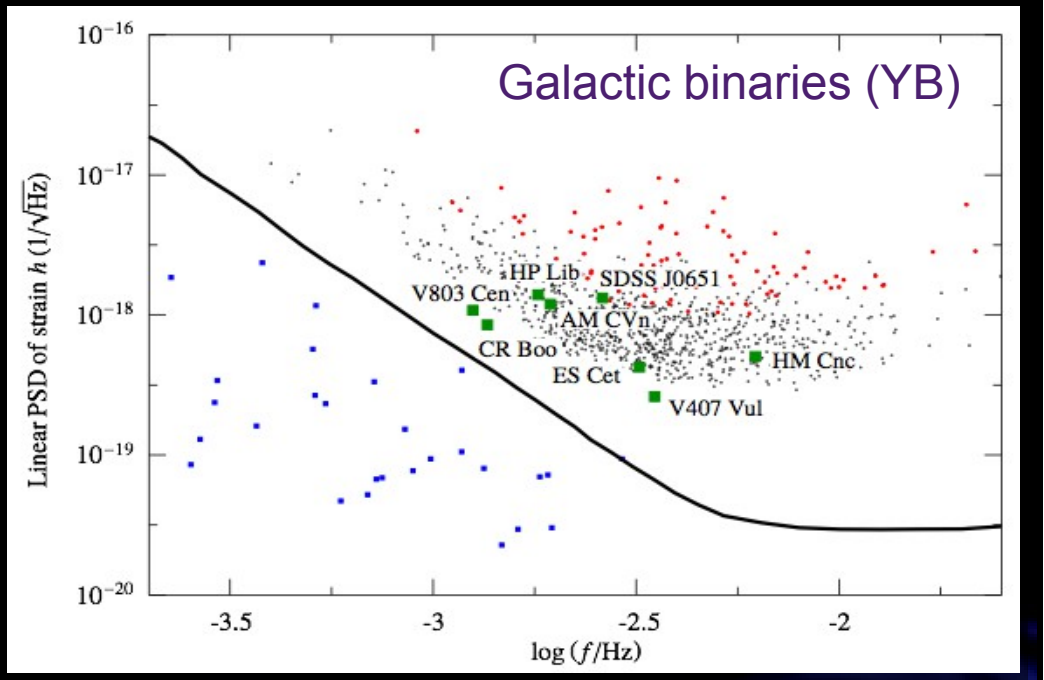
- Several kind of simulators:
  - How they compare ?
  - Are they complementary ?
  - Hardware versus numeric
- Include realistic noises in MeLDC (already plan)
- Connections between IOT (Instrument Operation Team) team and DPC (Data Processing Centre) ?
- Set up calibration procedures ...
- How GW sources could be use to calibrate the instruments ?
- ...

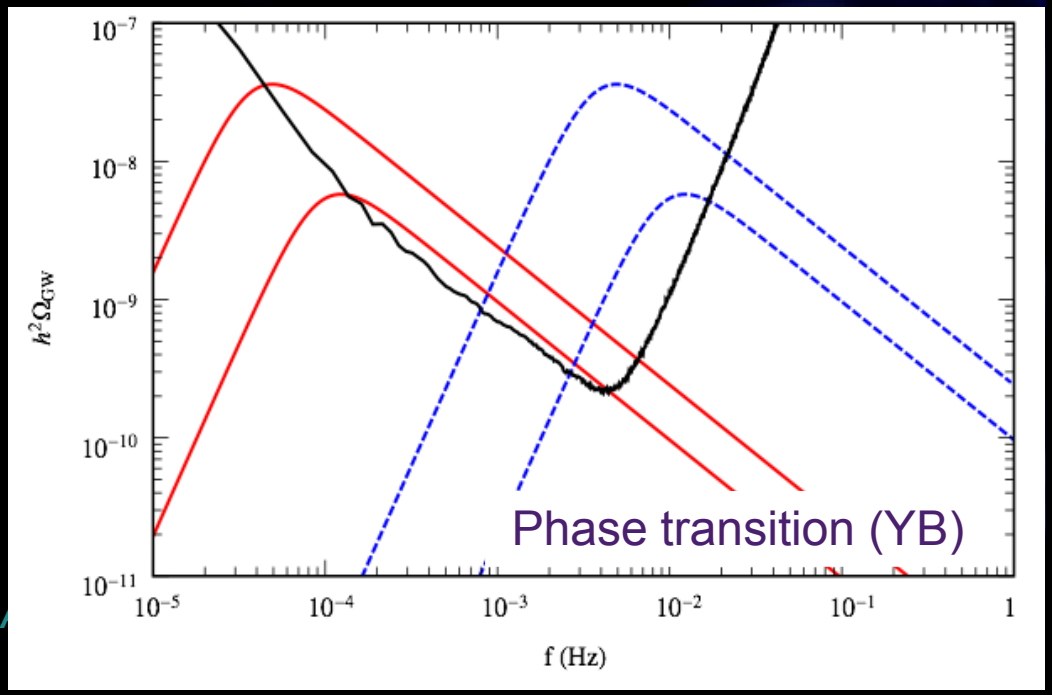
Calibration …

- Use verification binaries to calibrate the noise level …
- Define calibration procedures :
  - Example: Stochastic background from phase transition, cosmic strings: can we really differentiate it from instrumental noise, in particular if it is high and “cover” other GW sources ?

    → Can we do something on instrument to identify the source of this “noise”.

→ Some studies started …





Data analysis

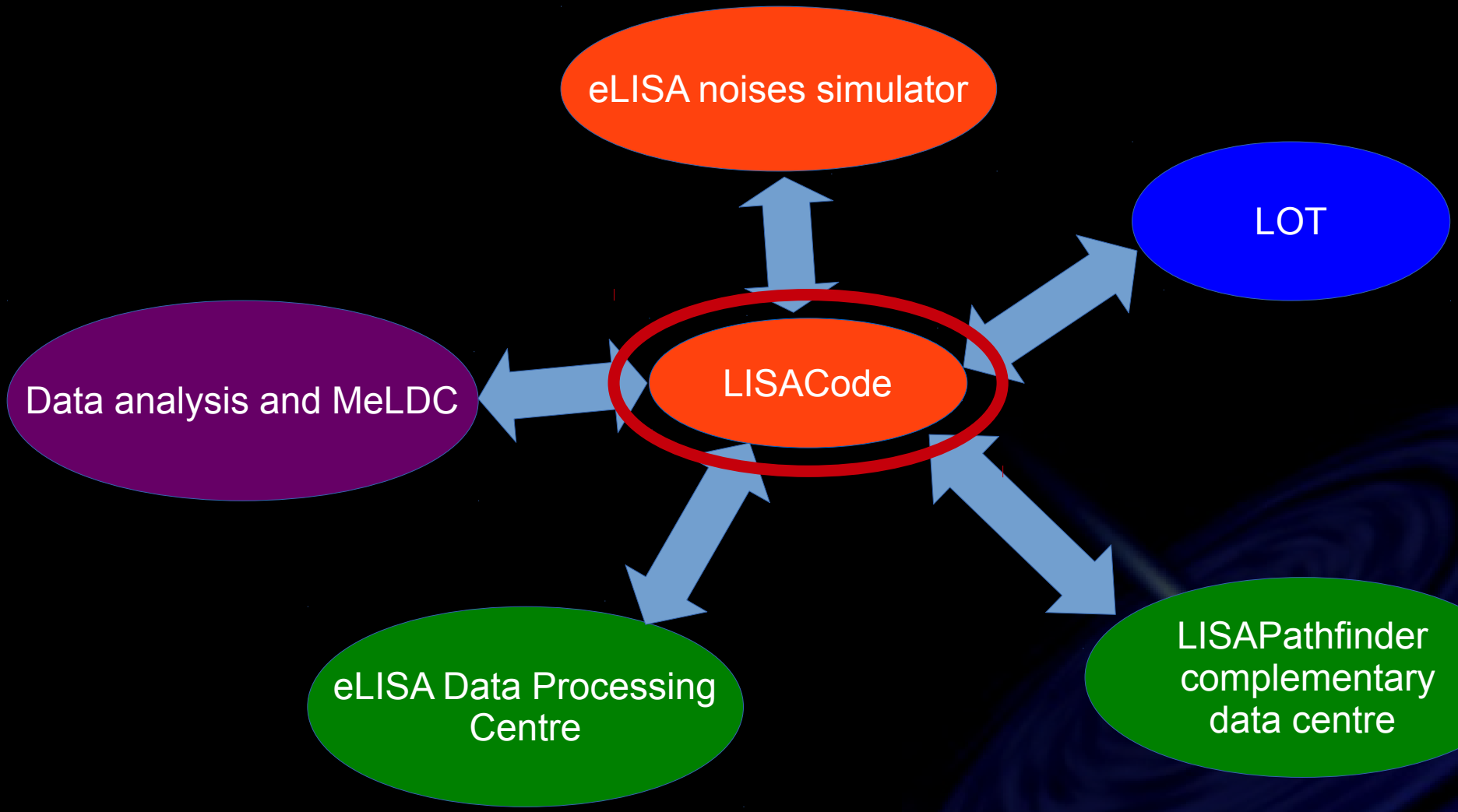
- DA of “known” sources with well known waveforms:
  - Mainly matched filtering.
- DA of “known” sources with leak of understanding on waveforms:
  - DA using generic waveforms,
  - Robust methods (wavelets, ...).
- DA of unknown sources
  - Robust methods
- DA noises (part of the task of Instr. Op. Team):
  - Robust methods ?

→ Robust methods and methods based on “generic” waveforms need to be studied.

LISACode

- Scientific simulator for LISA type mission (C++)
- GW modeling, noises modeling, transfer functions, orbits, clocks, TDI, sensitivity generator, simple MCMC, ...
- Used in MLDC,
- Used for NGO/eLISA design,
- Flexible,
- ...

Studies started at APC



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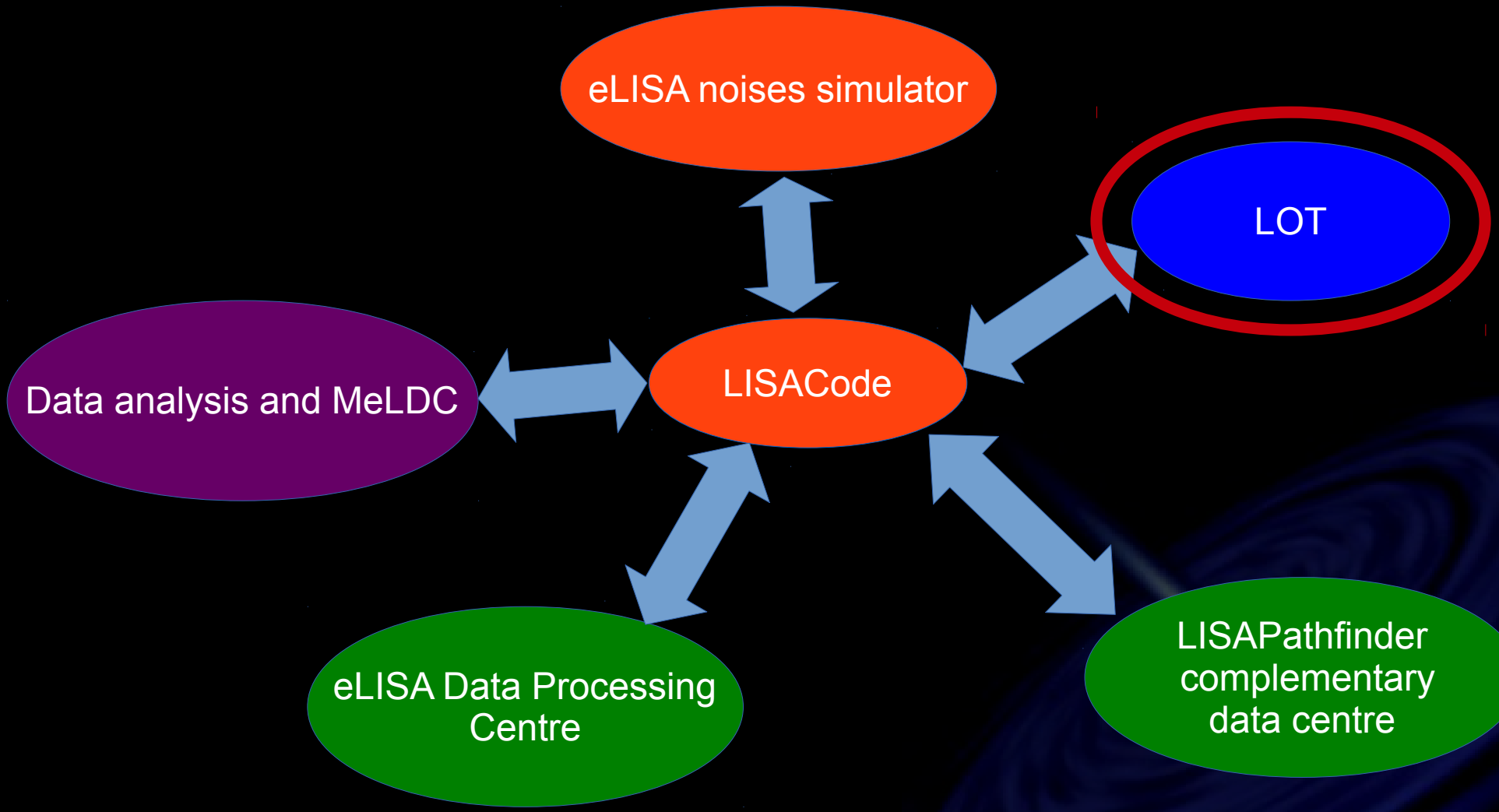


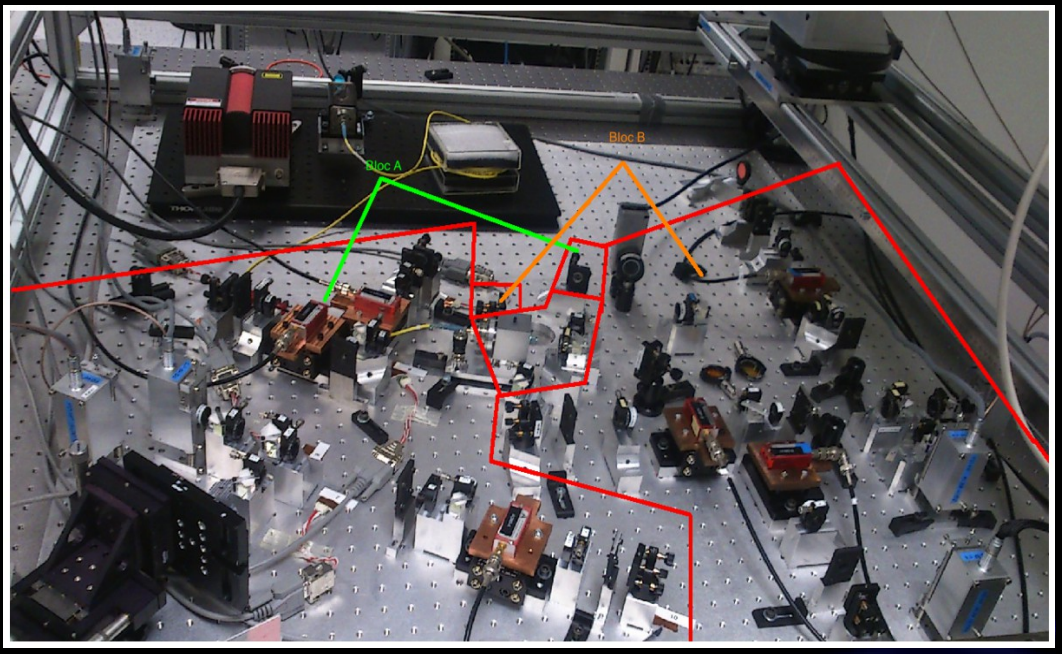
LISA On Table

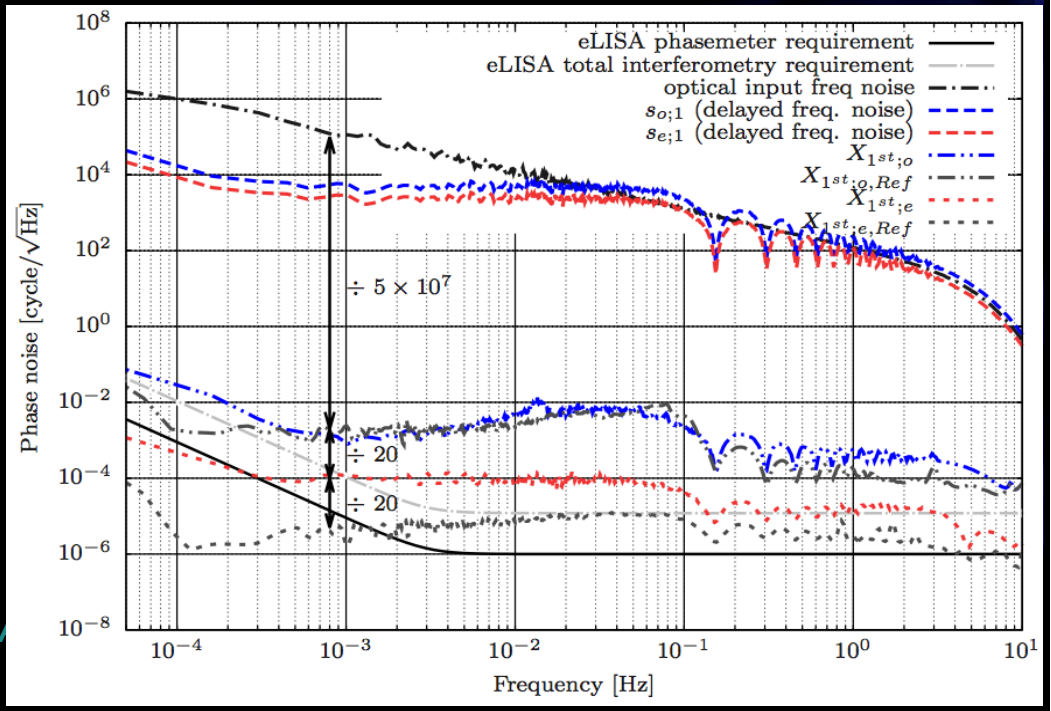
- Electro-optical simulator for eLISA:
  - optic: interferometry.
  - electronic: delay, noise generation.
  - noise injection through AOM.
  - Hardware test of TDI.

→ Connection with LISACode:

- LISACode as noises generator for the LOT.
- LOT provides noise time series to LISACode.

Pierre Gruning's talk





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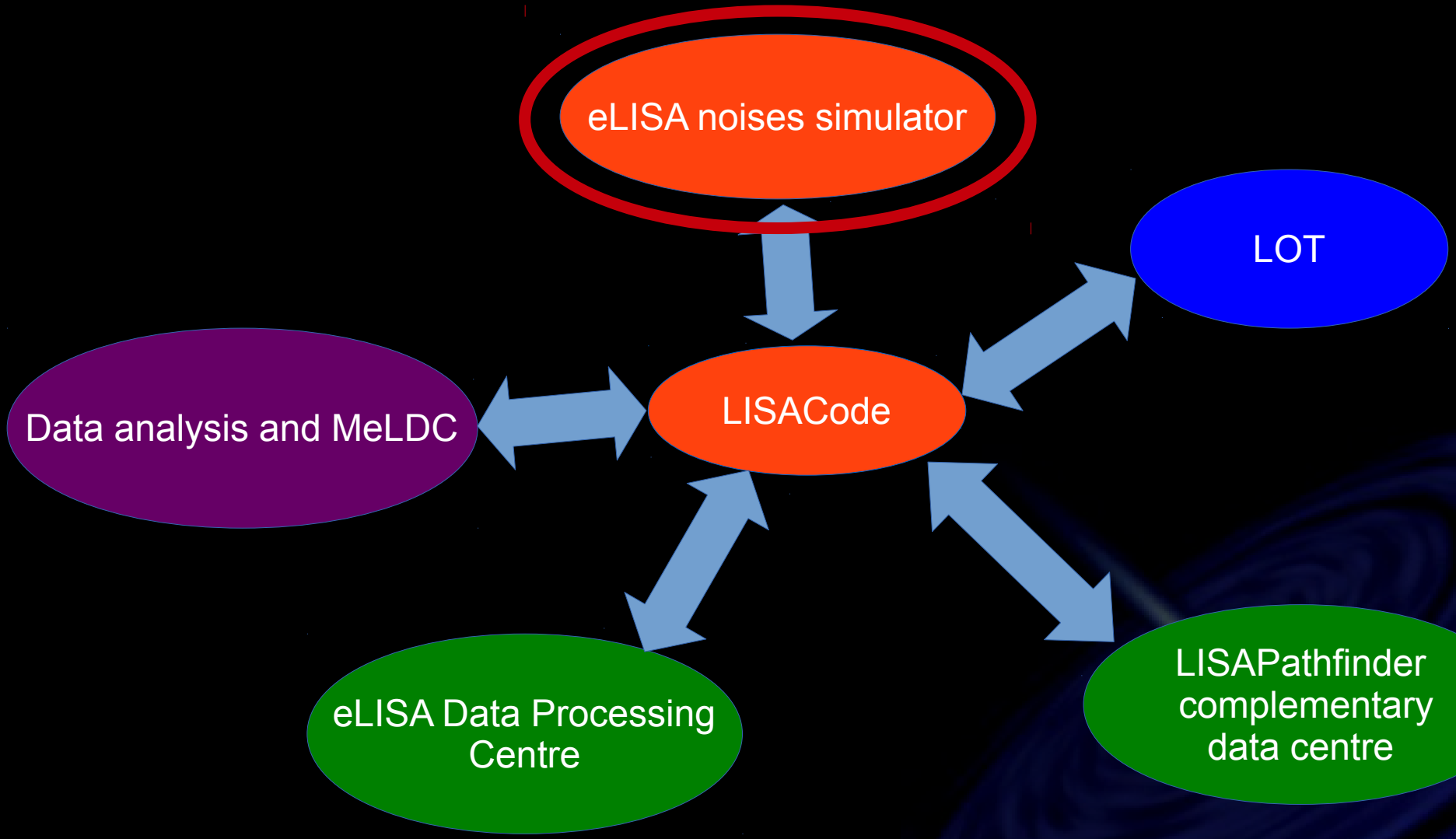
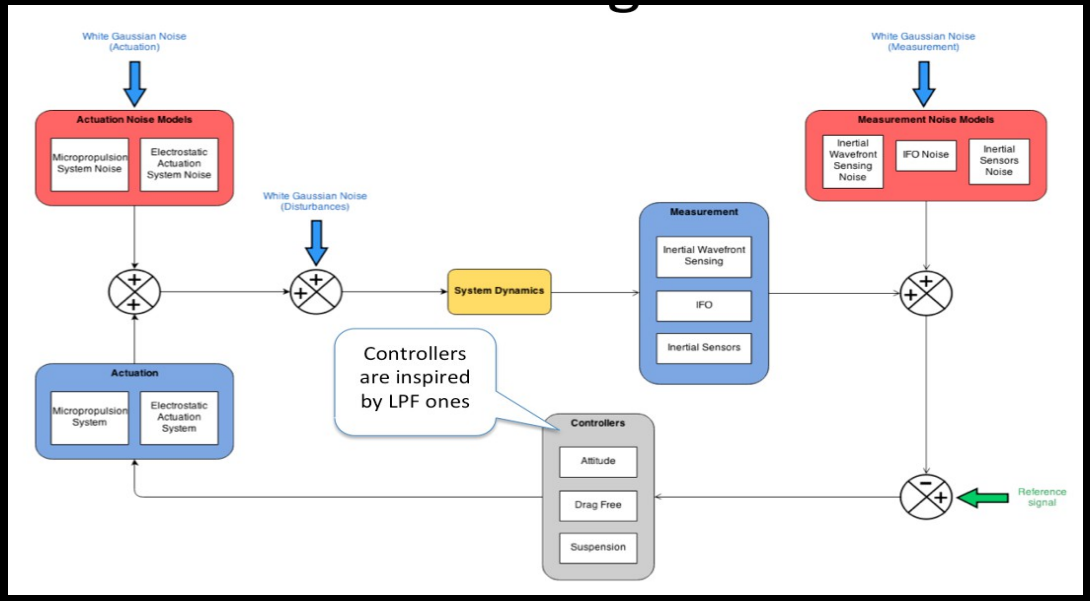


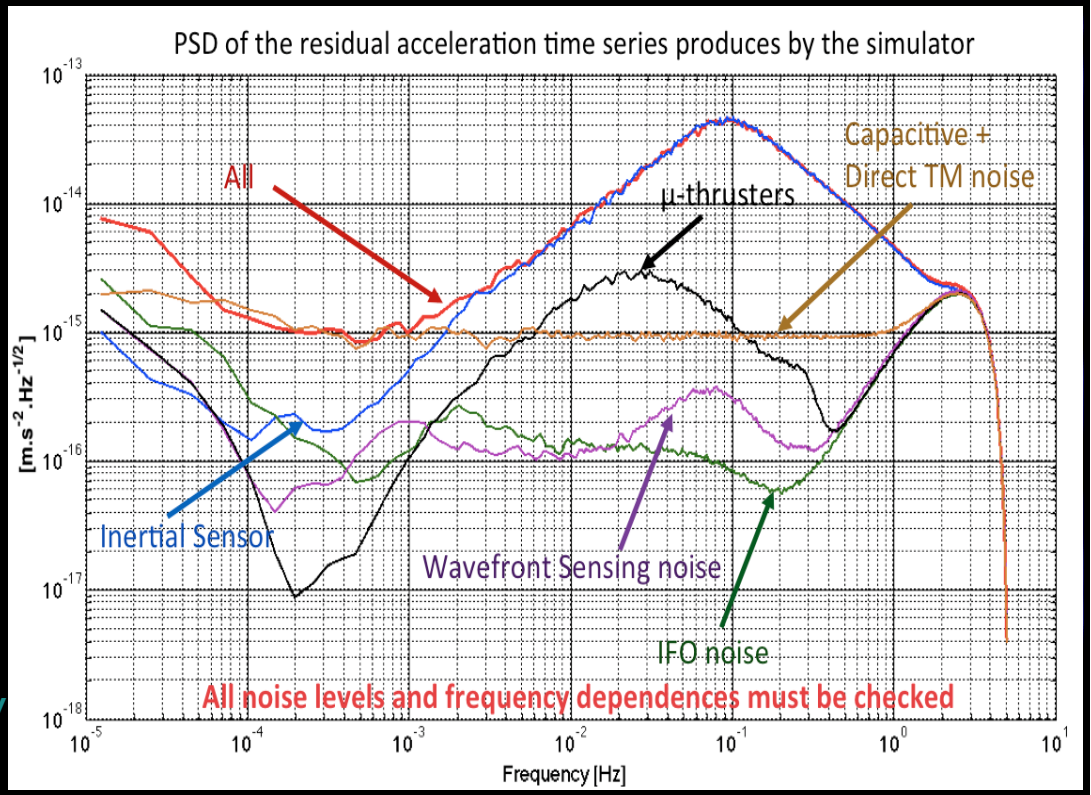
eLISA Noises Simulator

- State Space Model Simulator :
  - eLISA orbits,
  - Attitude controllers,
  - Test mass control,
  - Actuation and sensing noises,
  - ...

  → Detailed simulations providing inputs to LISACode in the form of time series and transfer functions.

Henri Inchauspe's talk





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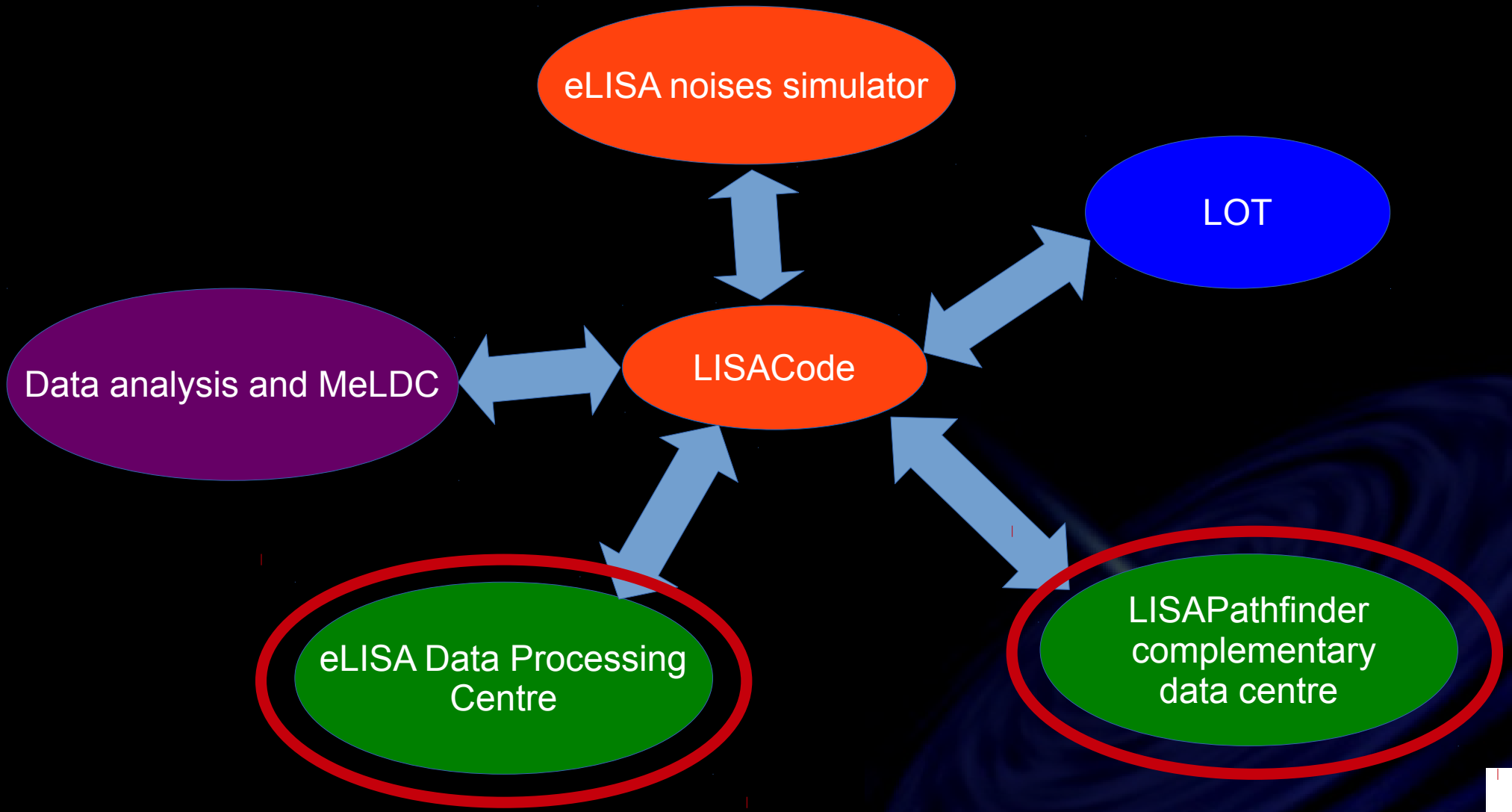


Data Processing Centres

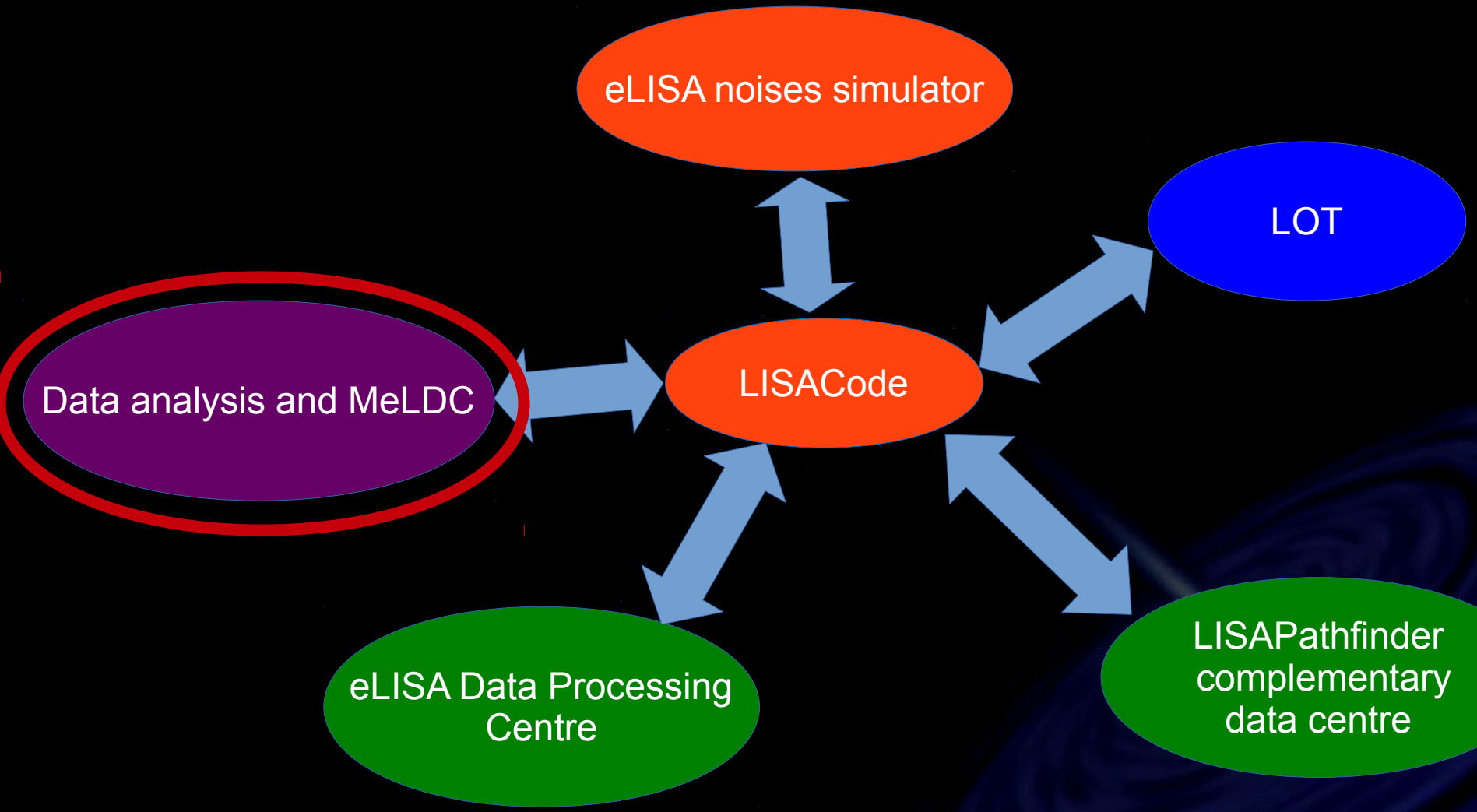
- LISAPathfinder Complementary Data Centre : François Arago Data Centre:
  - Offline analysis for the LPF mission
  - Extensive computation using the FACe cluster, ...

  → direct injections LISAPathfinder measurements (extrapolated for eLISA)
- eLISA Data Processing Centre in France :
  - CNES Phase 0 conducted in 2013 : feasibility, cost, studies of different computing strategies, ...
  - Core of DPC will start to be build soon & can support some of the eLISA activities.

  → run simulation for noises and GW astrophysics

  → test data analysis

Studies started at APC



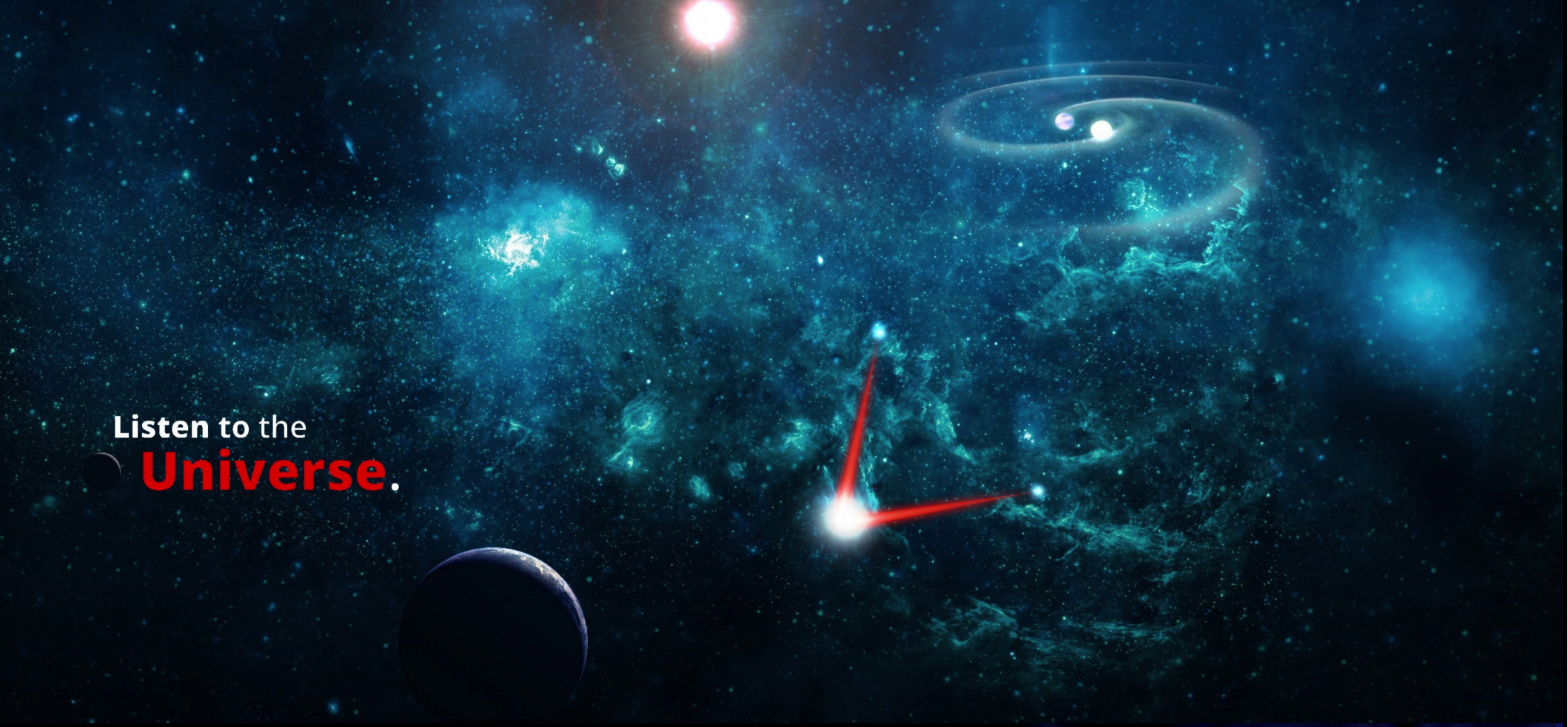
Mock eLISA Data Challenge & Data Analysis

- A large number of development already done within the context of the MLDC (2005-2012):
  - Most part of the methods based on matched filtering
  - Limitations : limited number of sources, very simple noise
- Future: Mock eLISA Data Challenge (MeLDC)

  → Developments needed :
  - Matched filtering methods considering realistic noises and large number of GW sources,
  - Methods based on generic waveform,
  - Development robust methods.

Conclusion

- We need coherent developments on instrument, on data analysis and on science with GW.
- Calibration methods have to be defined.
- Data analysis for instruments and GW signal.
- Studies start at APC with LISACode simulator as a central connector between :
  - LISA On Table,
  - eLISA noises simulator,
  - LISAPathfinder Complementary Data Centre,
  - eLISA Data Processing Centre,
  - Data Analysis developments and MeLDC.



Thank you !