



**EINSTEIN
TELESCOPE
FRANCE**

Analyse, software, computing

Notes from a local discussion at the ET-France workshop.
Several key members not present, so may not reflect all opinions.

Irina, Nicola, Michele, Tito

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Résumé des grands axes

- Searches, PE, global fit
- Population analysis and cosmology
- Multimessenger
- Computing/AI
- Specific OSB division activities (NOT directly discussed)
 - Nuclear physics
 - Waveform models
 - Theory / testing GR
 - Stochastic
 - Not covered in France: continuous waves , numerical relativity for mergers?

Axe 1 : searches, PE, global fit

- Description courte : methods to identify and characterize different types of GW signals
- Participants ET-France (synergies) : LISA community (eg LISABeta, global fit codes, DDPC), Virgo France community
- Plateforme(s)/infrastructure(s) existante(s) : PyCBC (CBC searches, IJCLab), MBTA (CBC searches and PE, IPHC/LAPP/IP2I), PyGWB (stochastic search/PE, LAPP), CCSN search/inference codes (CEA/IJCLab), Stokes polarization analysis (APC/CEA)
- Collaboration hors France : PyCBC developers (IJCLab + {US, UK, Spain, Italy}), MBTA team (Italy), CCSN collaboration (Australia, Spain)
- Visibilité existante ou attendue dans ET : Lead OSB Div 10, 3, 9, 4, participation to 10, 9, 3, 7, 6 . software mentioned above is used in LIGO-Virgo and can seed developments for ET.

--- Notes :

- **Virgo vs LISA as extremes:** simple (Virgo) vs complex/global-fit (LISA); ET likely sits in between → consider a “soft” global fit approach.
- **Analysis strategy:** CBC searches likely feasible with current pipelines (especially at initial stage not at design sensitivity), but to be demonstrated; handle overlaps selectively → multi-signal analysis only where needed, assume isolated signals elsewhere.
- **Known challenges:** background “estimation” (false alarm rate, not PSD); potentially mitigated with null streams. Large numbers of signals for PE. Fraction of problematic signal overlaps might be a secondary problem.
- **Non-CBC source classes:** unclear if all (continuous, bursts, etc.) must be included from the start → test via MDC injections and assess impact of neglecting them.
- **Hierarchical subtraction vs gating:** gating (removing loud events) already used in searches but may be too approximate; subtraction preferred → need to check event rates to see if gating is viable.
- **Residuals after subtraction:** subtracting max-likelihood signals seems feasible; residual impact not fully quantified but likely small → needs better assessment, coupled with waveform modeling.
- **Stochastic searches:** implications for astrophysical backgrounds (e.g., neutron stars, foregrounds) remain open. Removal of foreground signals potentially challenging.
- **Population inference link:** possible joint population + background analysis with SNR threshold, but complicated by unknown components (e.g., primordial signals).
- **Computational aspects:** search pipelines manageable with current CPU clusters; parameter estimation expected to be more demanding. To be demonstrated and quantified.
- **Next steps / connections:** use MDCs and explore overlap with LISA-style global fit methods as intermediate steps.
- Major problem: use of existing PE codes for large-scale studies (will this impact ET MDC studies?).

Axe 2 : population analysis and cosmology

- Description courte : methods to infer the properties of source populations and the cosmological parameters
- Participants ET-France (synergies) : L2IT, IAP, CPT, APC, ARTEMIS/OCA, Subatech+IJCLab, ENS; synergies: Virgo, LISA, Euclid, galaxy catalogs
- Plateforme(s)/infrastructure(s) existante(s) : icarogw, gwcosmo, chimera, pymcpop-gw, [Alexandre Toubiana's code?]
- Collaboration hors France : Italy, UK, Germany, US,
- Visibilité existante ou attendue dans ET : Div 3, 5 lead, participation to 2,3,5, 6 ,9,10

— Notes

- **Analysis strategy:** likely no extrapolation to ET possible . Consensus that brute-force injection campaigns are not (fully) an option . Alternative strategies . Tradeoff precision/scalability : can it impact the science case ? Model the observed population? Accept semianalytic models? Largely open problem . Use MDC
- **Platforms** : LIGO/Virgo tools for now. Porting on GPU supported. But not yet dedicated codes.

Axe 3 : Multimessenger

- Description courte : methods to combine ET data with other messengers
- Participants ET-France (synergies) : IJCLab, APC/AIM, IAP, LUX, CEA; synergies with FINK, LIGO-Virgo-KAGRA, Rubin, GRANDMA, SVOM, THESEUS, NewAthena, IceCube, KM3Net, CTA
- Plateforme(s)/infrastructure(s) existante(s) : FINK, Galactica
- Collaboration hors France : US, Italy, UK, Geneva
- Visibilité existante ou attendue dans ET: div 10, div 4

Notes

- Discussion ongoing with LIGO-Virgo-KAGRA on future alert systems (multiple ones?)

Axe 4 : Computing/AI

- Description courte : technologies and facilities for performing numerical calculations needed for ET science
- Participants ET-France (synergies) : APC, IP2I, IJCLab
- Plateforme(s)/infrastructure(s) existante(s) : CCIN2P3, Virtual Data
- Collaboration hors France : US (LIGO), Italy (Torino, CNAF), Switzerland, Belgium
- Visibilité existante ou attendue dans ET: div 10 + EIB

Notes

- Strong desire to have a French computing facility for analysis.
- Need for dedicated HPC/HTC infrastructures for waveform modeling ($O(10^6)$ CPU hours) and analysis.

Axe 5 : specific OSB activities

- Description courte : fundamental physics, nuclear physics, stochastic background, modeling
- Participants ET-France (synergies) : IJCLab, LUX, Obs Strasbourg, APC, ENS, Caen, AIM
- Plateforme(s)/infrastructure(s) existante(s) : Compose, PyRing/TIGER?
- Collaboration hors France : Germany, UK, Japan, Korea, Belgium, Ireland
- Visibilité existante ou attendue dans ET: div 1, 3, 6, 7

Notes

- Lack of NR simulation expertise in France for modified gravity theories. Opportunity for starting collaborations, or developing expertise?