

Tentative synthesis of the NenuFAR workshop

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- NenuFAR was definitely not born to satisfy the ego of a few (frog) radioastronomers
- The idea emerged "naturally" in the wake of LOFAR installation, due to several existing prerequisites:
 - LOFAR station in Nançay, insertion of our community in LOFAR
 - Experience in VLF (NDA, UTR-2)
 - Nançay radioastronomy station: engineers, room, experience
 - We had mostly an existing expertise in receivers + microelectronics, wish to (re-)develop instrumental experience in antennas, arrays... in order to be able to rebuild (radio)telescopes, not only participate to instruments built elsewhere
 - First we developed the concept of LSS, then the Standalone concept: both together = NenuFAR
- Then other advantages/interests appeared:
 - Need to develop the national LF community for SKA & other new-generation LF instruments
 - Relative ease to insert NenuFAR in LOFAR (LBL input, dialog with LOFAR, support and exchanges with ASTRON: e.g. interest of LOFAR in NenuFAR antennas)
 - Parallel development track with GURT → tight technical collaborations for developing/testing optimized hardware
 - ANR support for the full study
 - LOFAR data + processing center set up in Nançay
- Support from OP (& INSU) progressively builds up, e.g. via the RT21@OP axis, DIM-ACAV ...
- Support from UO and Région Centre (to consolidate the Nançay-Orléans-Paris axis)
- We don't want to oversell NenuFAR
 - Some studies will not be doable with NenuFAR (e.g. cosmic polarization studies with NenuFAR Standalone, because of too low resolution → spatial depolarization ; conversely focussing on the LSS mode will permit to measure small scales with high sensitivity ; in Standalone mode, only measurements on point sources are relevant, and good polarization calibration will be needed in order to correct – at least partly - non orthogonal dipole projection on the sky – use of an artificial star e.g. ExPRI ?)
- NenuFAR is <5 M€ :
 - Compare to 7-8 M€/year for SKA-1 (and NenuFAR budget comes from different funding sources)
 - No competition with LOFAR (different scale : 150 M€, 100's FTE)
- NenuFAR Science :
 - We want to do the best science with NenuFAR, possibly focussing on high-visibility subjects, early enough to stay "in the race"
 - We already attracted attention from foreign colleagues, with strong contributions to the science case (e.g. "Dark Ages")
 - NenuFAR is definitely not optimized for Standalone imaging (low resolution), except slow transient searches

- High resolution imaging will be reached in LSS mode
 - Propagation effects are very large at LF (dispersion, temporal broadening) → need for high spectral resolution and/or waveform measurements
 - LF remain a very prospective domain
 - We will have full polarisation measurement capability
- There are clearly doable science drivers :
 - Fast transient (RRATs, sporadic/intermittent pulsars, Lorimer burst/FRBs, etc.) searches with LaNewBa + "ARTEMIS"
 - Exoplanets: blind searches in the Mini-Array analog beam in Standalone correlation mode ; 7 follow-up observations (e.g. of GMRT candidates or other)
 - Flaring/dwarf/young stars (PNPS – colloquium prospective 24-27/2/2014 Besançon – opportunity ? or collaboration with foreign teams ?)
 - Dark Ages ? (with efforts in foregrounds/confusion removal)
 - Gravitational Waves ?
 - Local emissions : Cosmic Ray showers, TGFs, Meteors... ?
 - + Solar system studies (Sun, planetary magnetospheres, planetary lightning, scintillations, Faraday rotation in Solar wind & ionosphere...)¹
- Structure of NenuFAR community :
 - Large “Science” group with possibly specialized subgroups (Dark Ages, Exoplanets, Fast Radio Bursts dedispersion...) ?
 - Separate discussion groups for “LSS” and “Standalone” science (2 instruments in 1 ; the “Standalone” group should be concerned with the capabilities/performances of the Standalone receiver: δf , multi-FoV, incoherent sum, ...) ?
 - “Development” group, closely related to Nançay (there are still open questions about some functionalities: incoherent sum ? multi-FoV – having NenuFAR mini-arrays pointing in various directions ...) ?
 - “Calibration” group tbd, perhaps divided in mini-array response and confusion/imaging ? (possible issues to address is e.g. the displacement of the more external mini-arrays to larger distances for a gain of x2 to x4 in resolution ; methods for beating the confusion: related effort with LOFAR, SKA, LWA → take advantage and provide feedback – possible coordination by C. Ferrari)
 - “Waveform analysis / CR mode” (TBBs, multi-FoV, ...) ; buffer lengths ? Reflexion to start soon, coordinated by S. Corbel, I. Cognard, R. Dallier)
 - Testing the instrument on the sky at all phases (starting now)
 - Data format, data policy
 - Teaching ? Student projects ?...
 - all groups must interact : annual NenuFAR day ?
- Other remarks:
 - We clearly need strong technical support (construction in Nançay, computing for post-processing of Standalone data ...) : involvement of participating laboratories ? other partners tbd ?
 - stay LOFAR compatible !

¹ This is the field of application of NDA, whose future must be considered in the context of LOFAR+NenuFAR

- If NenuFAR does good science, it will be an encouragement to have other NenuFARs in Europe (or beyond). NenuFAR design should be open (~ creative commons ...)
- Tools :
 - Web site to communicate and share information : <http://nenufar.obs-nancay.fr/>
 (“private section” : user=lss , pass=anr090509)
 All presentations online (and on <http://nenufar.sciencesconf.org/>)
 - Updated instrument description online all the time (cf. web site)
 - Dictionary of standard terms: NenuFAR, LSS, Standalone, LaNewBa ... (first glossary below)
 - Analysis software
- Actions :
 - Formally label NenuFAR as a SKA pathfinder ? (cf. S. Torchinsky’s talk) → a letter has been addressed by P. Zarka et al. to Phil Diamond (response waited for...)
 Purposes = clarify the relation NenuFAR / SKA-Low in France (path), prepare scientifically the community, exchange technical/analysis expertise , northern hemisphere facility (with LOFAR)
 - Label NenuFAR development as SO2/3 (+6 space weather/environment?) CNAP service : M. Tagger
 - MoU with VIRGO-LIGO (E. Chassande-Mottin, C. Ferrari), follow-up PLATO (P. Zarka), support JUNO/Solar Orbiter/SP+, TARANIS, multi-LOFAR-stations (Chilbolton...) ...
 (on the longer term, organize synergies with different domains – eg ONERA)
 - Pursue collaboration (technical & scientific) with UTR-2/GURT (PICS) : software developments ?
 - Contact GLOW for correlating NenuFAR + stations e.g; in Jülich : M. Tagger
 - Contact A. Karastergion (Oxford) for joining the project : P. Zarka, J.-M. Griessmeier
 - Formal invitation to Ukrainian & Austrian teams : P. Zarka
 - Prepare NenuFAR Science Case for INSU prospective : ~ observation proposals for early phases (commissioning phase expected to start in 2015) + scientific goals for full NenuFAR : we will contact you, please be prepared to contribute.

• Acronyms & definitions:

ANR	Agence Nationale de la Recherche
ARTEMIS	LOFAR post-backend for transients (Oxford: http://www.oerc.ox.ac.uk/projects/artemis)
ASTRON	Netherlands Institute for Radio Astronomy
CNAP	Conseil National des Astronomes et Physiciens du globe
DIM ACAV	Domaine d'Intérêt Majeur: Astrophysique et Conditions d'Apparition de la Vie (Région Ile-de-France)
ExPRI	Expérience de Propagation Radio Ionosphérique (project of small embarked radio emitter)
FoV	Field of View
FRBs	Fast Radio Bursts
FTE	Full Time Equivalent (= homme.an)
GLOW	German LOng Wavelengths consortium
GMRT	Giant Meterwave Radio Telescope (India)
GURT	Giant Ukrainian Radio Telescope
INSU	Institut National des Sciences de l'Univers (CNRS Institute for Astronomy)
LaNewBa	NenuFAR's dedicated backend
LBL	LOFAR's Low Band Low (10-50 MHz)
LF	Low Frequencies (here typically ≤ 1 GHz)
LIGO	Laser Interferometer Gravitational-Wave Observatory (USA)
LOFAR	the LOw Frequency ARray
LSS	LOFAR Super Station
NDA	Nançay Decameter Array
NenuFAR	New extension in Nançay upgrading LOFAR : NenuFAR = LSS + Standalone
OP	Observatoire de Paris
OSUC	Observatoire des Sciences de L'univers en région Centre
PNPS	Programme National de Physique Stellaire
RRATs	Rotating Radio Transients
RT21@OP	Scientific priority axis "RadioTélescopes du 21 ^{ème} siècle" of Observatoire de Paris
SKA	Square Kilometer Array
TBB	LOFAR's Transient Buffer Board
TFGs	Terrestrial Gamma-ray Flashes
UO	Université d'Orléans
UTR-2	Ukrainian T-shape Radiotelescope mark 2 (Kharkov)
VIRGO	European Gravitational waves Interferometer Observatory
VLF	Very Low Frequencies (here typically ≤ 100 MHz)