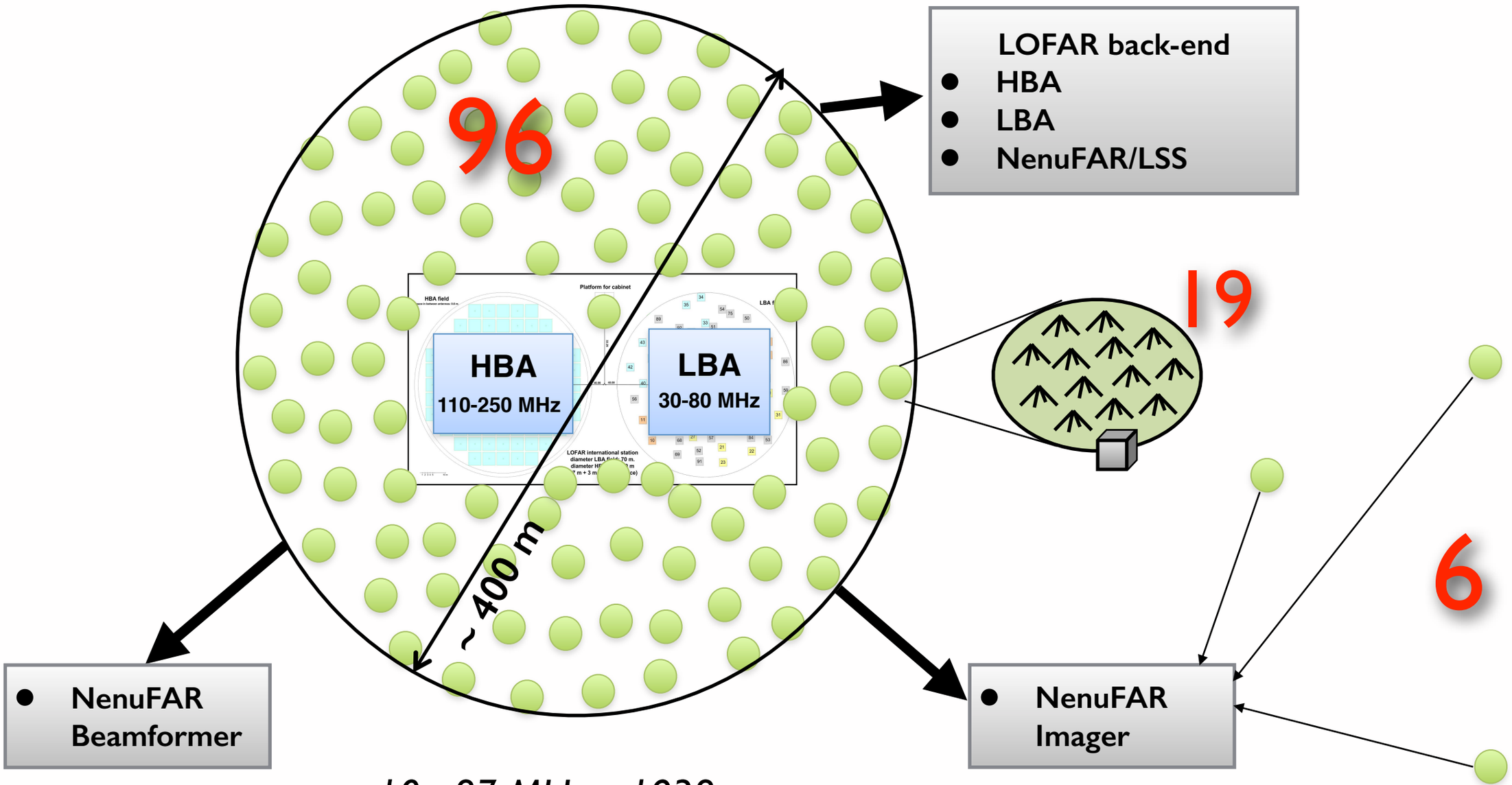
NenuFAR*:
vers une 1ère exploitation scientifique

P. Zarka
& l'équipe NenuFAR-France

*New Extension in Nançay Upgrading LOFAR

NenuFAR : le concept



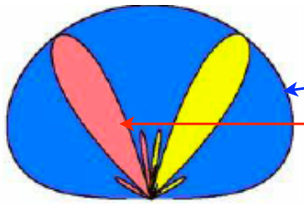
10 - 87 MHz, 1938 antennes

- Beamformer autonome
- Imageur autonome
- Super Station LOFAR

→ SKA pathfinder

IR MESRI (avec LOFAR)

Récepteurs



antenna beam

MA beam (analog-phased) : 8°-64°

Compact core (400 m) : 96 MA x 2 polar.

Distant MA (≤3 km) : 6 MA x 2 polar.

analog signals

analog signals

analog signals

- Digitization
- Channelization

LOFAR FR606 backend

- Digitization
- Channelization
- Beamforming
- Correlation
- Calibration + Imaging

LOFAR Super Station

LaNewBa

- Digitization
- Channelization

- Beamforming

UnDySPuTeD : dynamic spectra

- Channelization
- Integration

UnDySPuTeD : pulsar

- Coherent dedispersion
- Folding / Integration

SETI Machine

NenuFAR Standalone Beamformer

NenuFAR Correlator

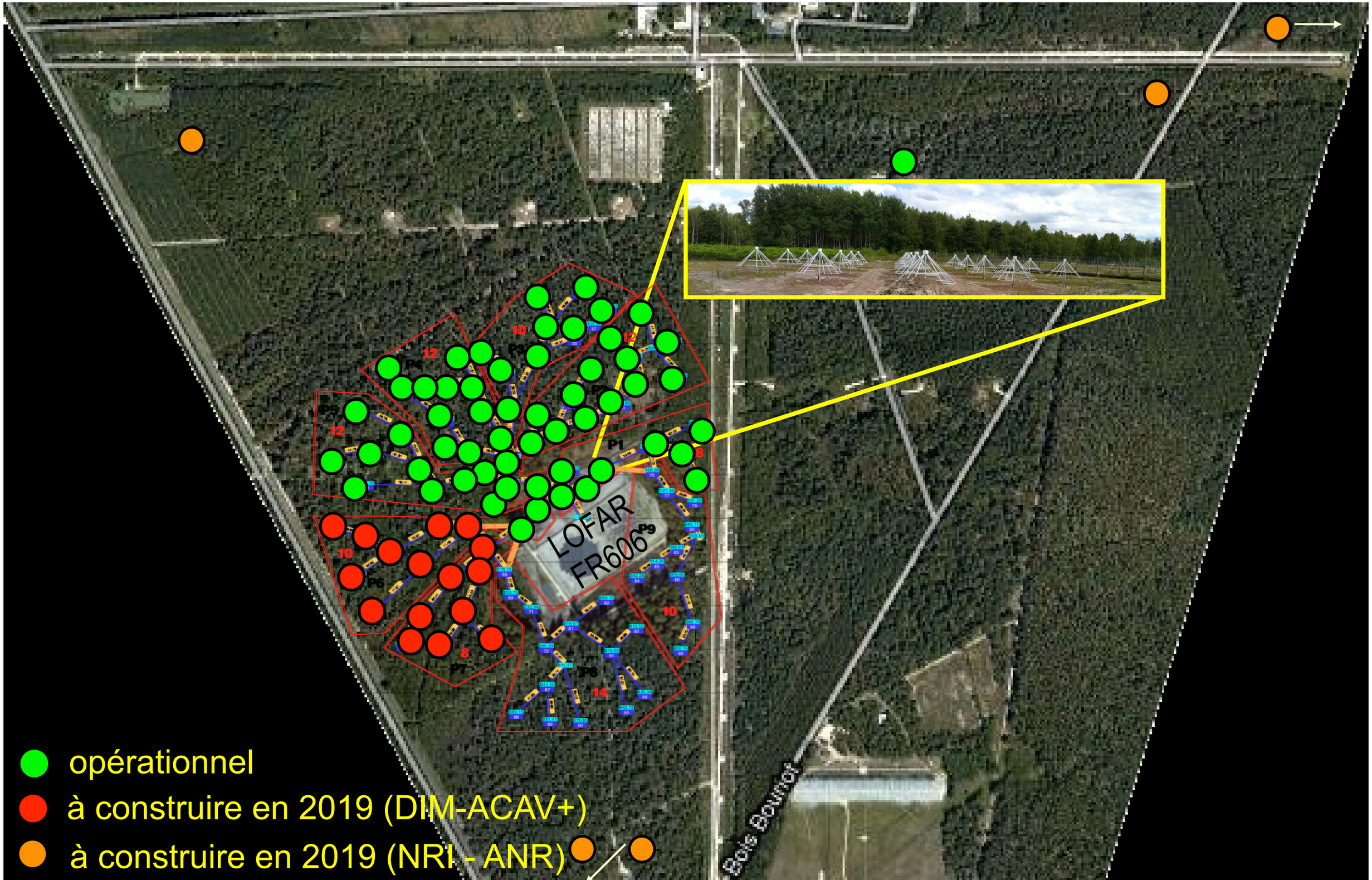
- Channelization
- Correlation
- Calibration + Imaging

NenuFAR Standalone Radio Imager

Broadcast on VLAN

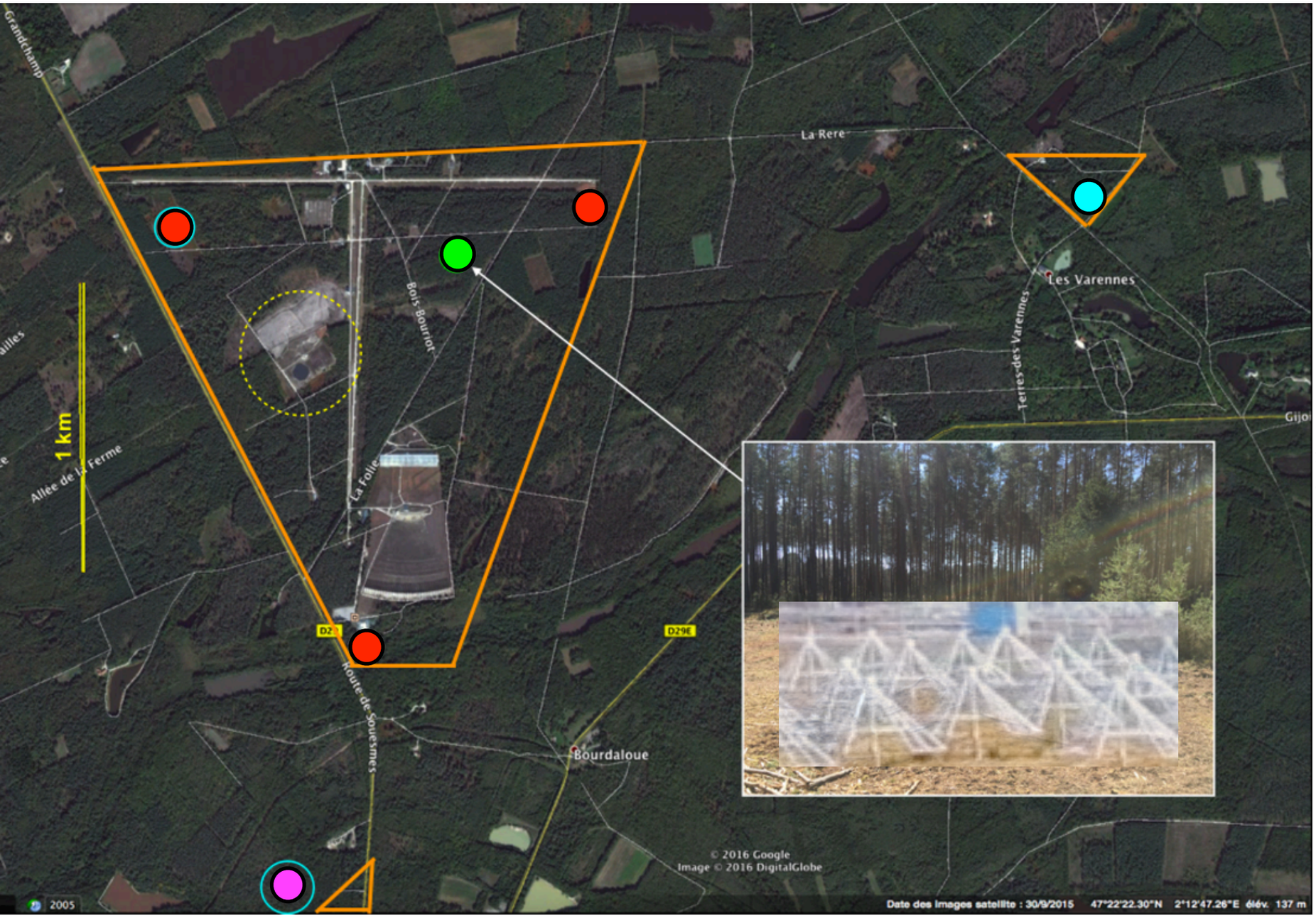
Construction : Coeur

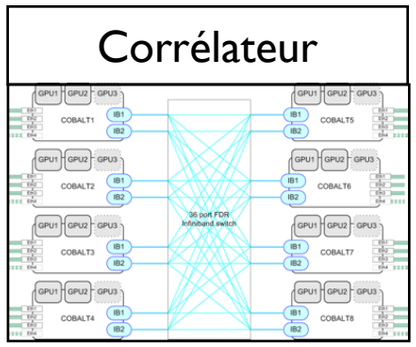
72 MR coeur financés, dont 56 construits & opérationnels (1064 antennes)

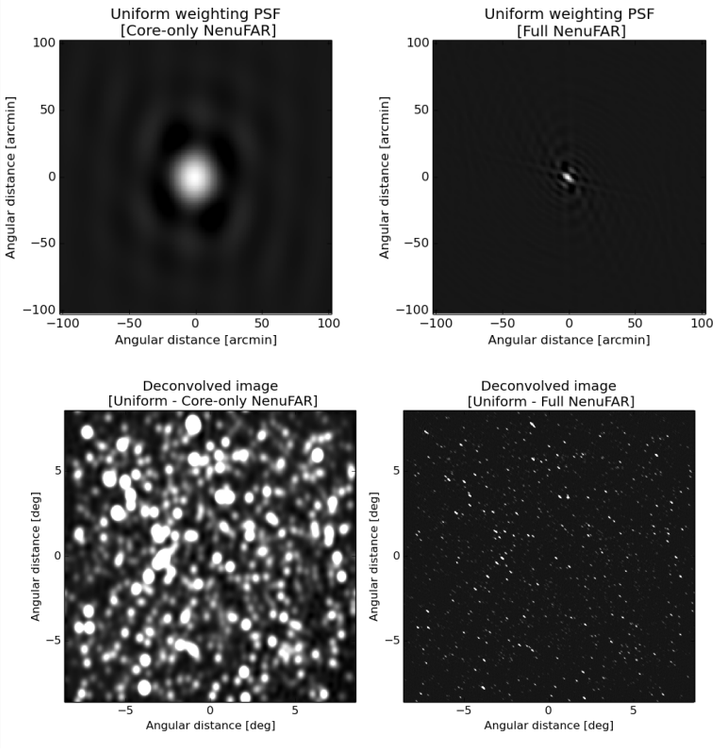


Construction : NenuFAR-Radio-Imageur

6 MR distants + Corrélateur + Synchro ⇒ Financement ANR+INSU







- Coût de génie civil + corrélateur ⇒ Descoping temporaire de 1 (2) MR distant(s)
- Étude corrélateur FPGA (ALSE) // COBALT-2

Etat du développement de NenuFAR

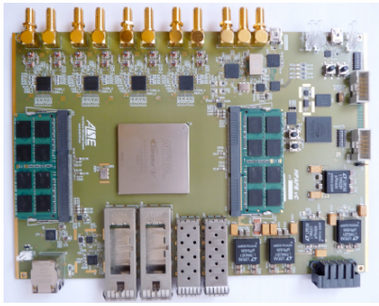
- Pointage opérationnel

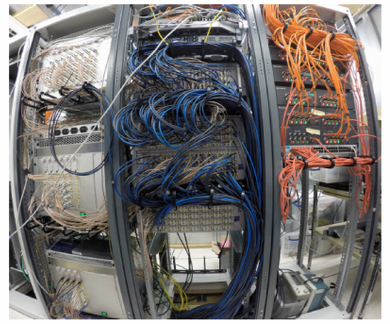
- Récepteur LANewBa finalisé (optimisations finales)
  ⇒ qualification télescope, debugging, parasites

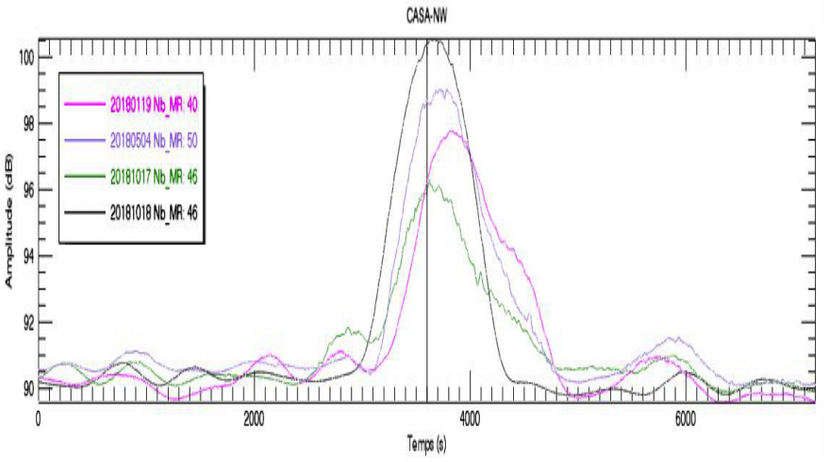
- XST (Cross-correlation statistics)
  ⇒ MS LOFAR
  ⇒ calibration beamformer (labo, ciel) Ok
  ⇒ imagerie, observations de test "Cosmic Dawn"

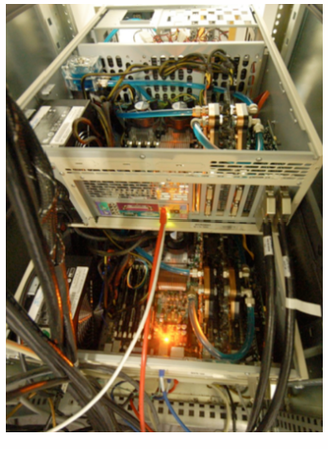
- BHR (Beamformed High Rate)
  ⇒ UnDySPuTeD : 2 Calculateurs ~opérationnels,
  en cours d'interfaçage (GUI) : Pulsars & Temps-Fréquence

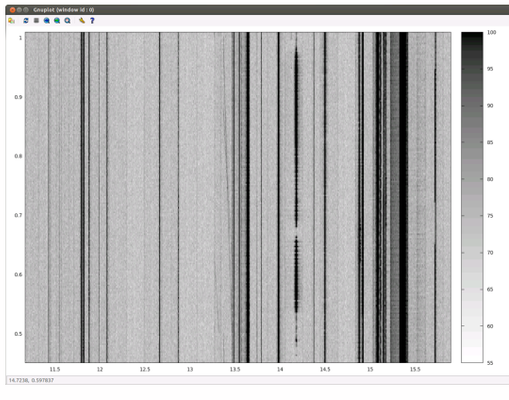
- TBB (waveform) ⇒ en cours de finalisation



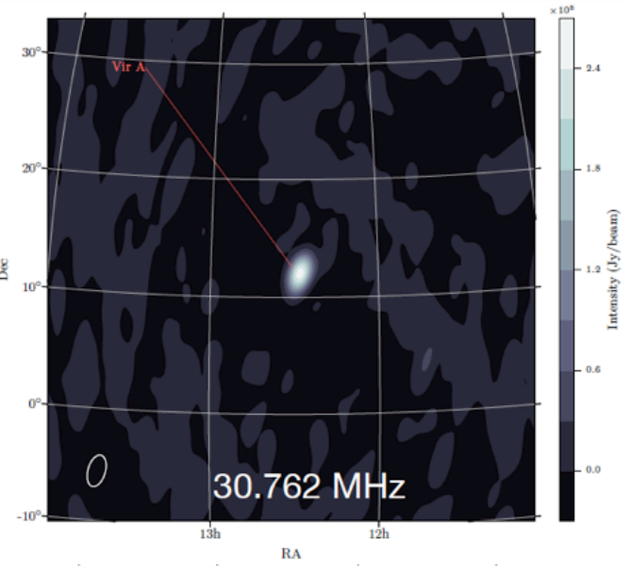


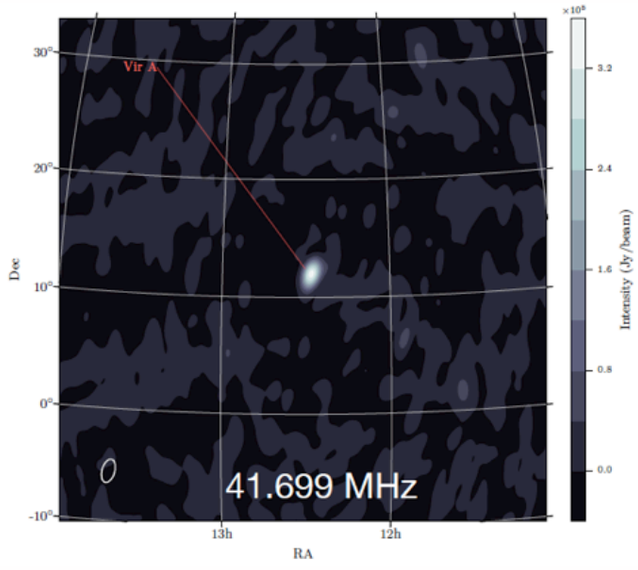


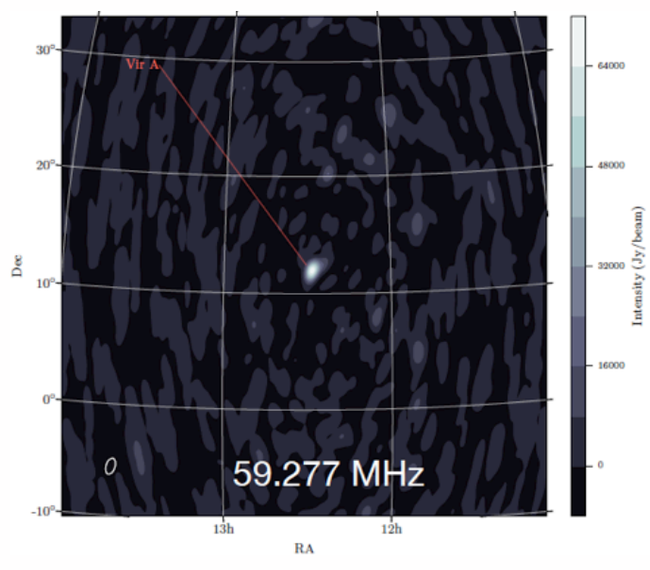


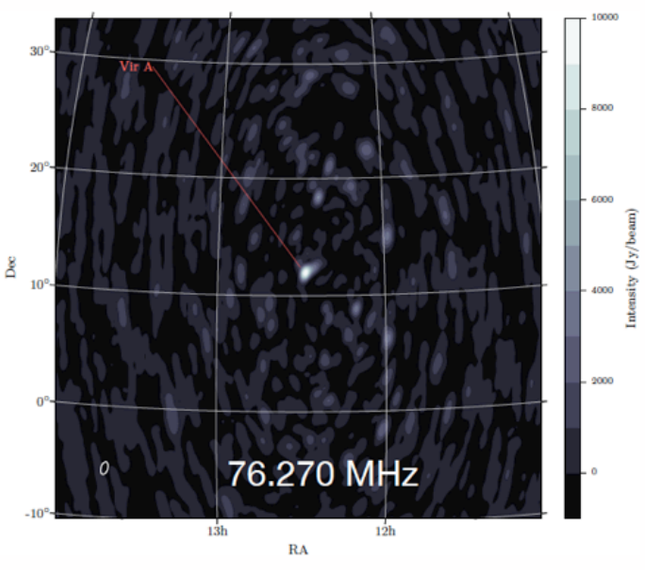


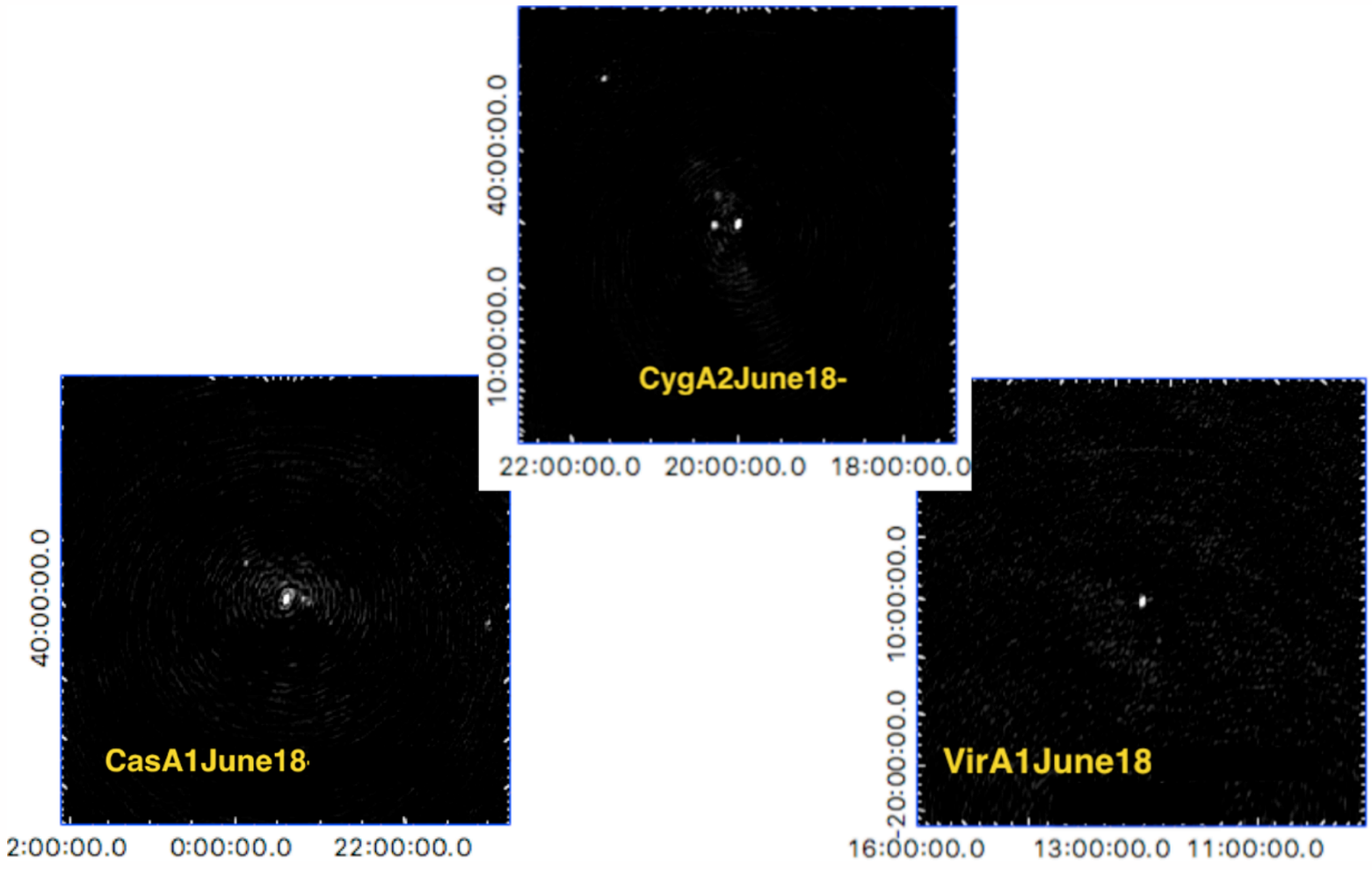
Premières Images



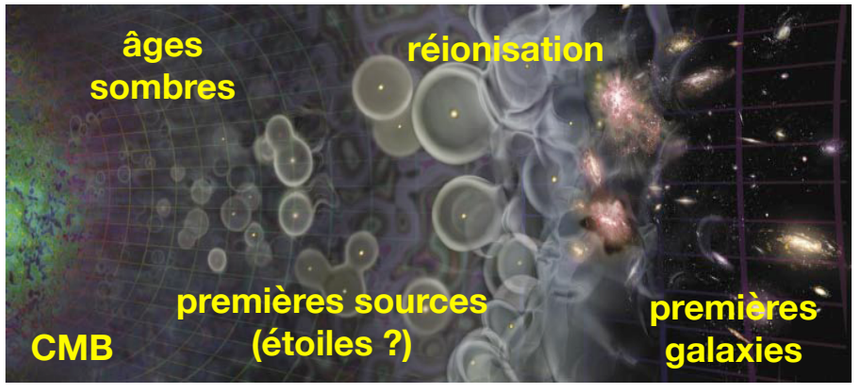


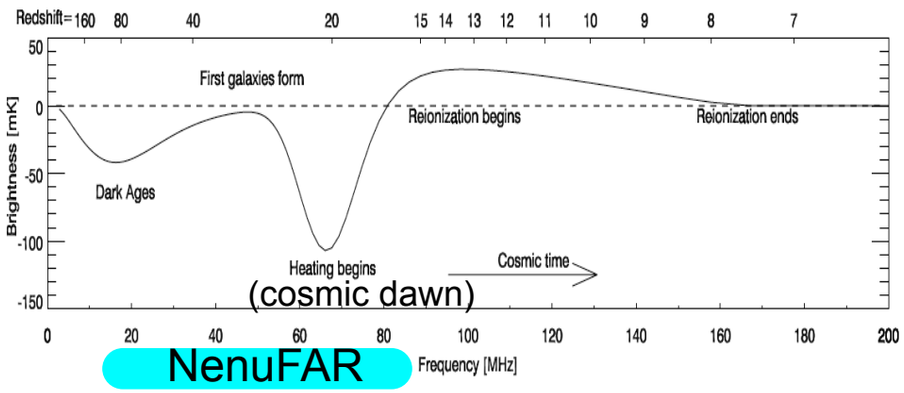


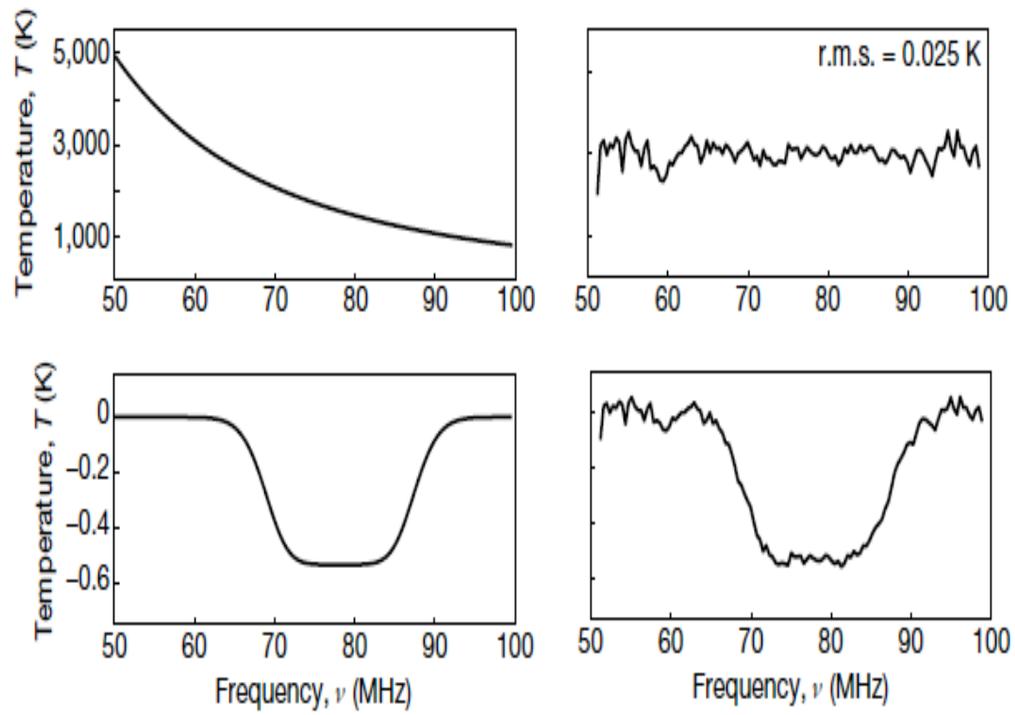




Observation de test "Cosmic Dawn"

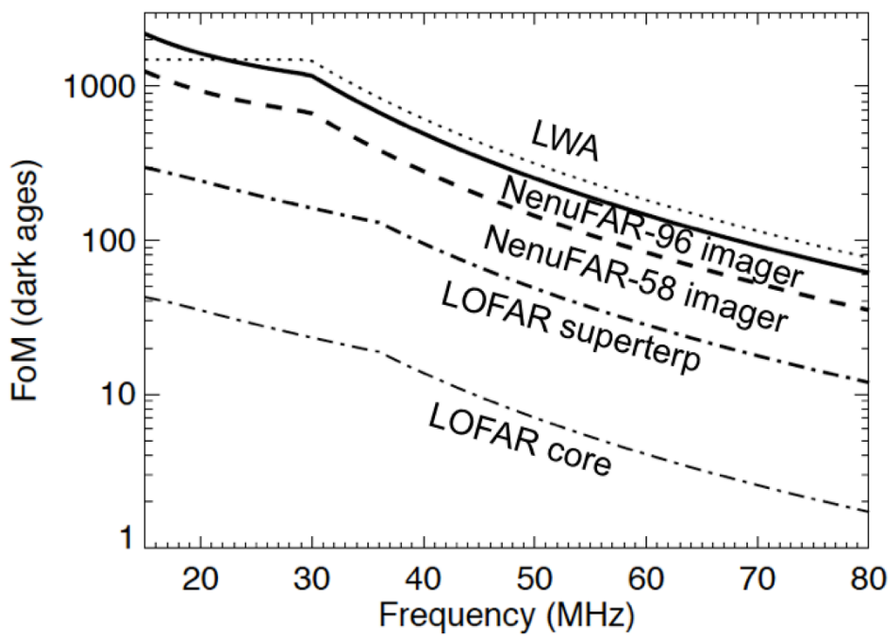


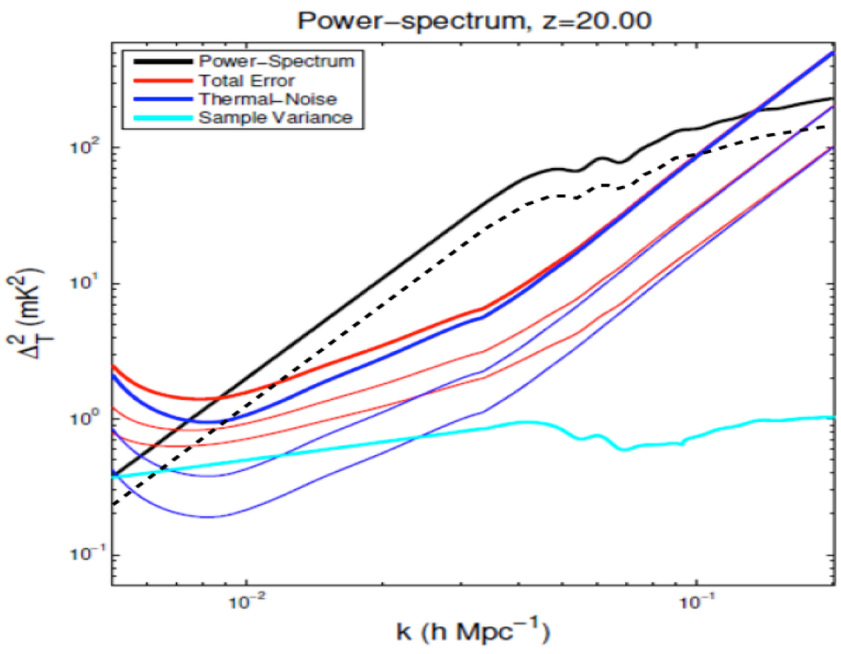




[Bowman et al. , Nature 2018]

NenuFAR



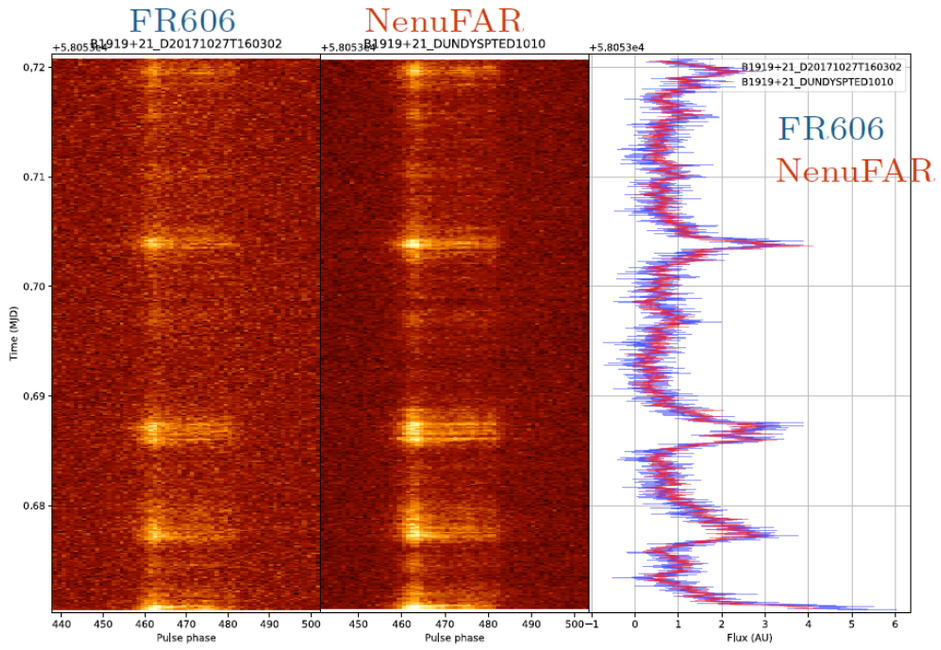


[Koopmans et al. 2015 ; Semelin et al., 2015]

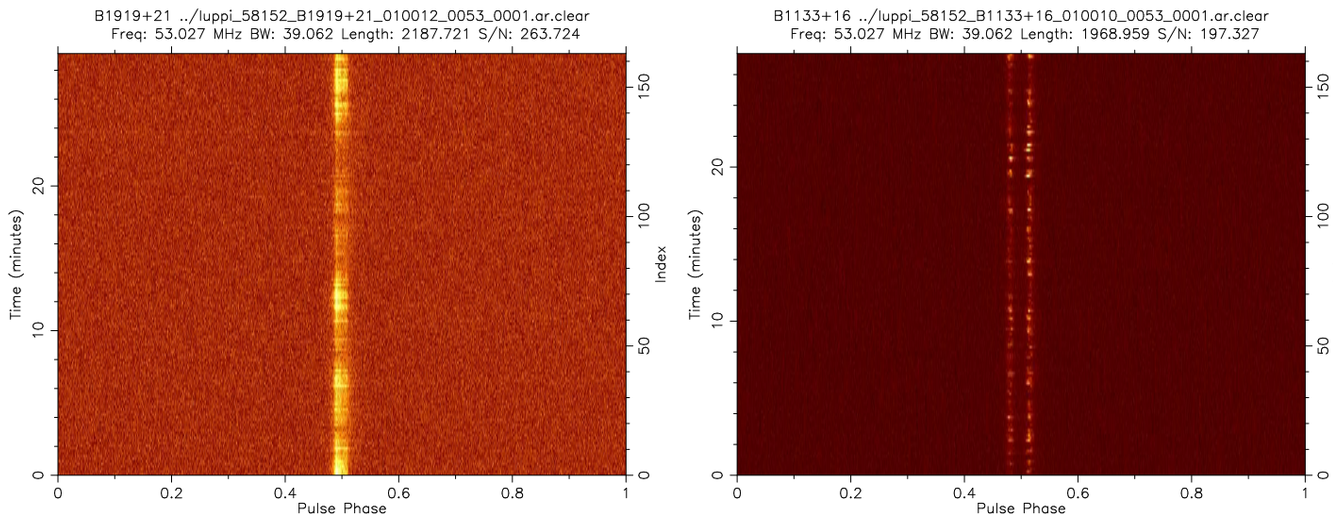
Observation du 2018/10/31, en cours de traitement

Pulsars avec UnDySPuTeD

UnDySPuTeD + 41 MR



Single pulse detections

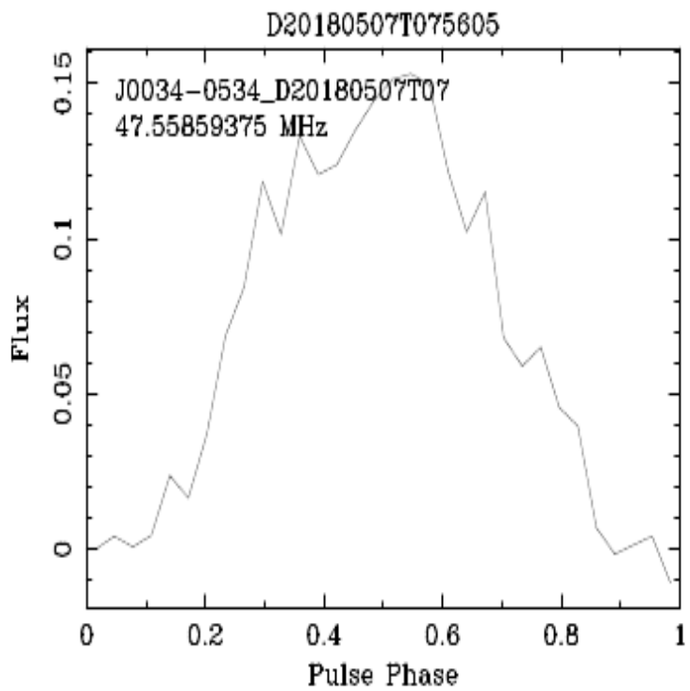


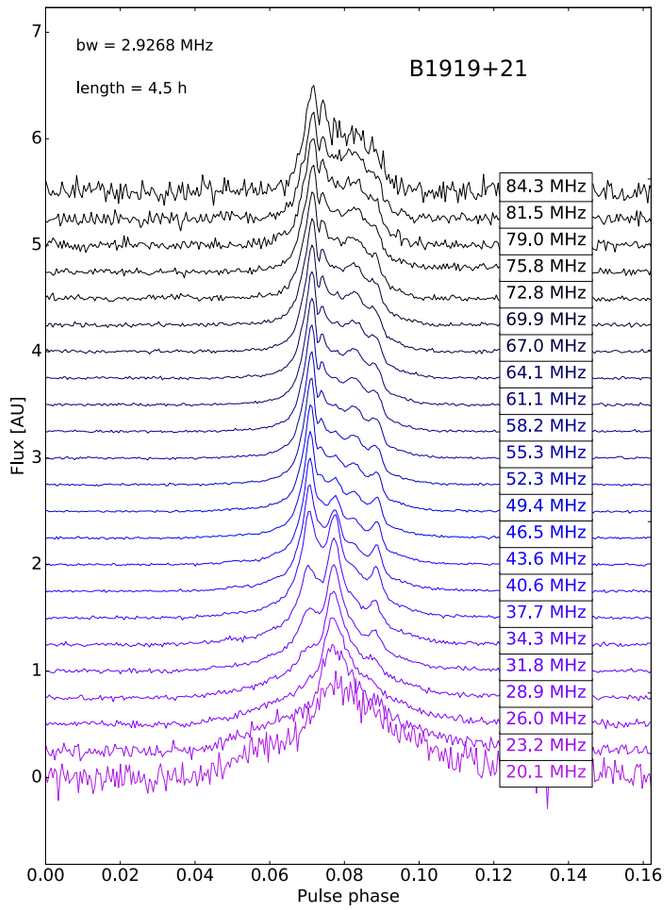
Détection large bande

à 58 MHz: SNR NenuFAR / LOFAR-FR606 (non calibré) ~ 7

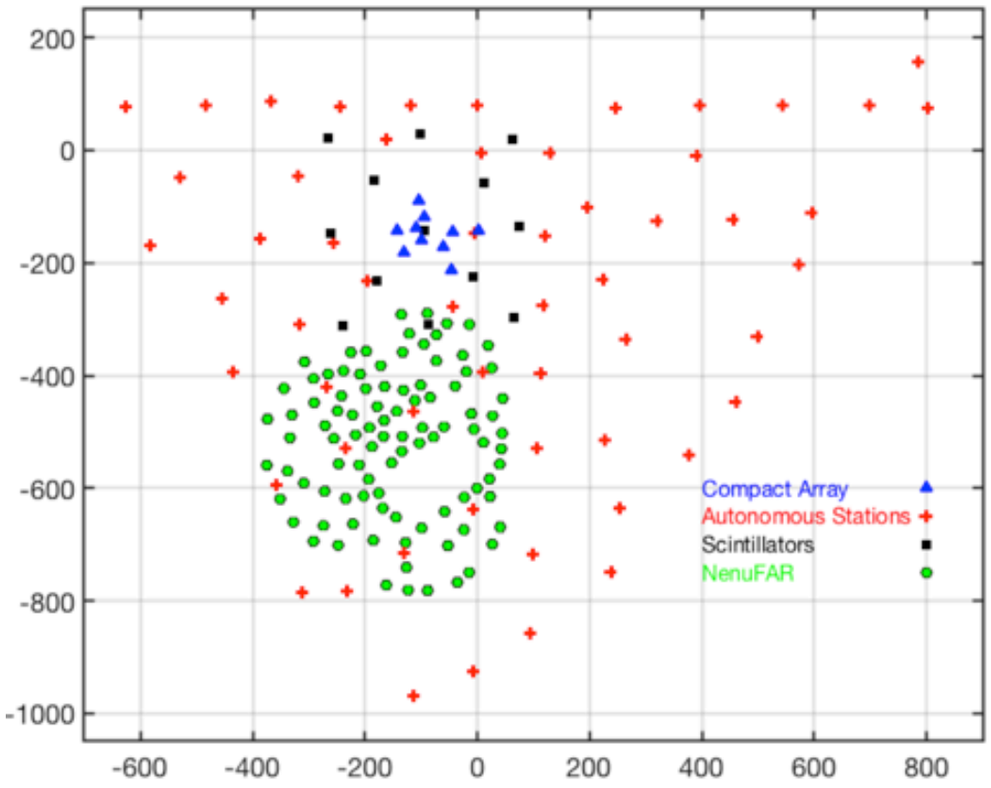
Pulsar milliseconde

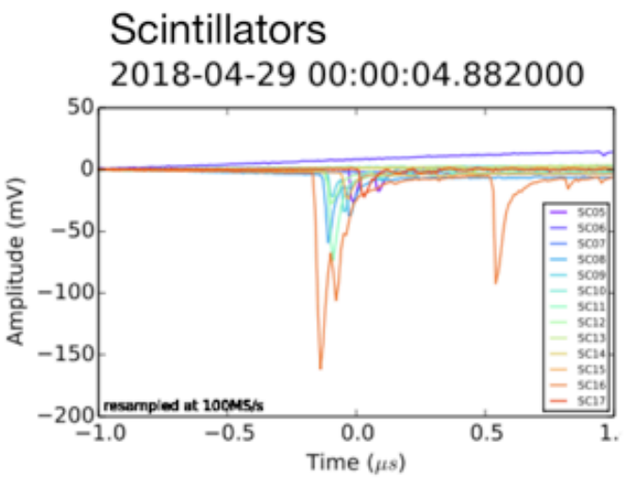
observatory	nenufar
obs.id	J0034-0534_D20180507T075605_010072
PSRNAME	J0034-0534
JNAME	J0034-0534 bhl+94
P0	0.0018770921083743 3
DM	13.7662
length	7247.00540000001
nsubint	150
center freq.	47.55859375
BW	50
S/N	9.71
%RFI	2.42
quicklook created	May 7, 2018
by	quicklook.sh (version 1.11.00, 08.11.2017)

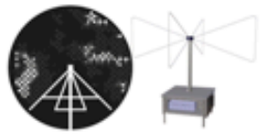




Gerbes cosmiques

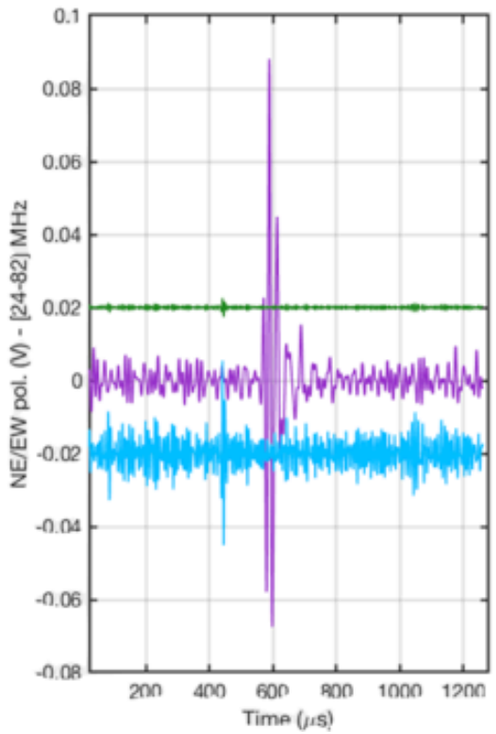


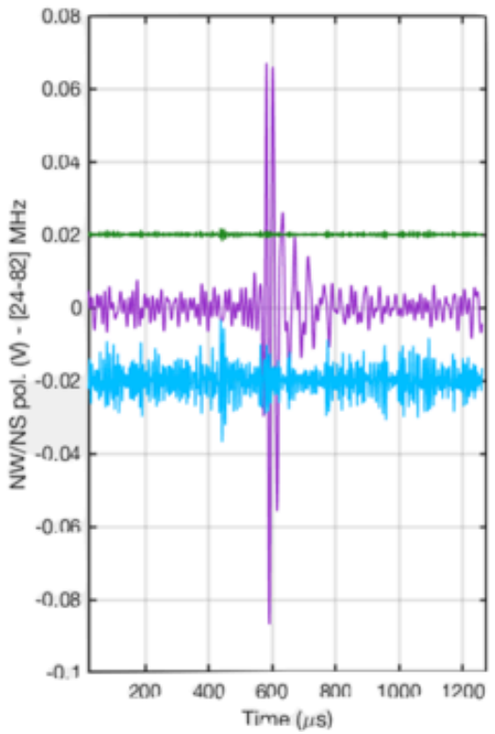




First detection of a cosmic ray event with NenuFAR - MA 12 and CODALEMA

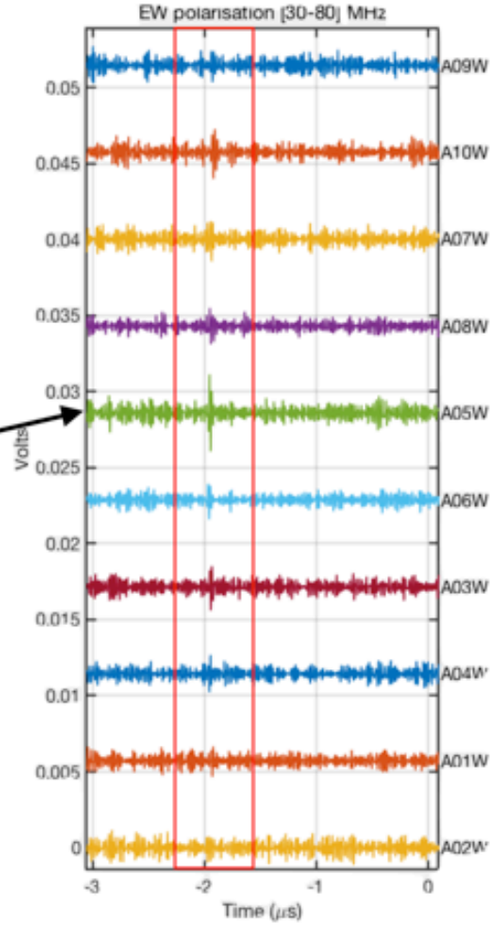
MA12 (purple) - CA#5 (green) - CA#5 x 10 (blue)

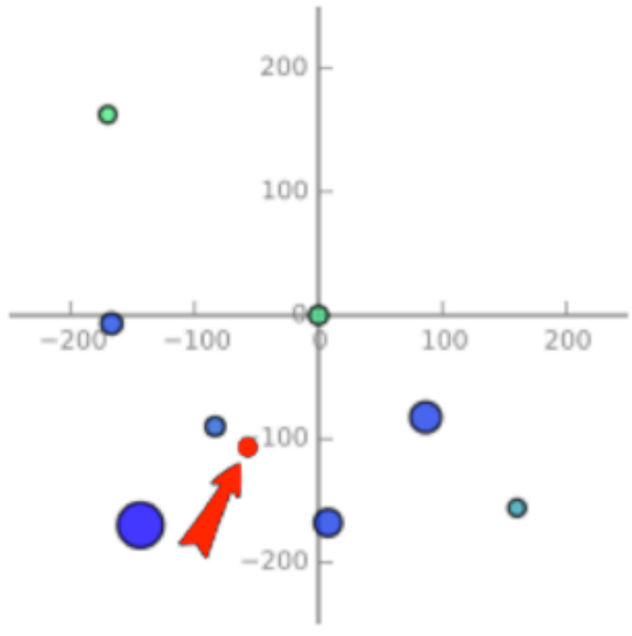




x1

x10

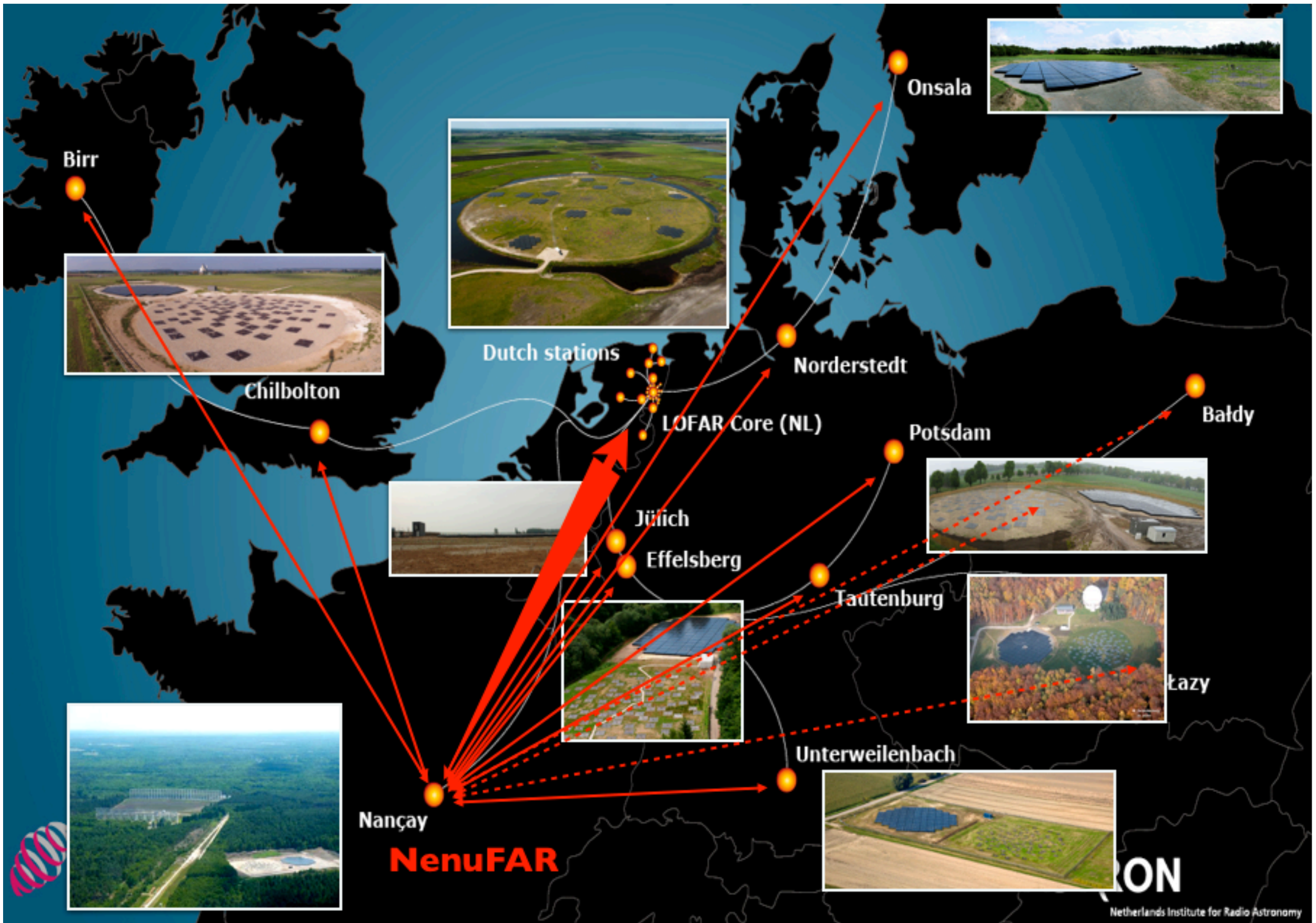




Mode LOFAR Super Station

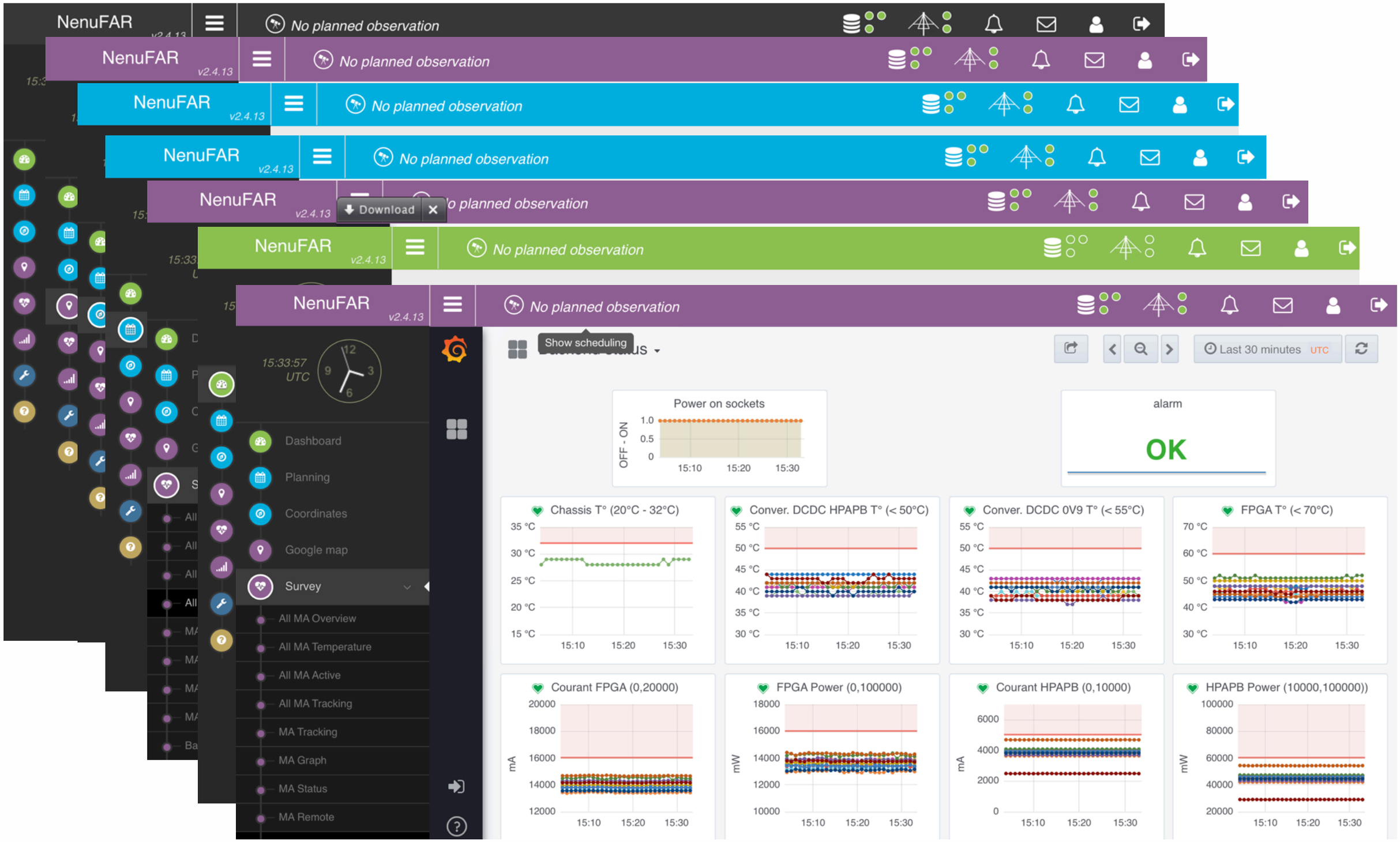
Protocole avec ASTRON, tests techniques fonctionnels Ok 2018/10/18

Observation de démonstration imminente



Opération & Contrôle

GUI de commande, monitoring, gestion du télescope et des données en temps réel



En cours (→ 2019)

- Coeur ⇒ 72 MR, NRI ⇒ 4 (5) MR distants
- Sélection & construction du corrélateur
- Finalisation des logiciels utilisateurs (Python, IDL)
- Centre de données / archive long terme
- Mesures de lobes de MR par hélicoptère
- Préparation de NenuFAR-TV
- Contexte LOFAR 2.0
- Formation des KP, Early Science
- ...

Préparation de l'exploitation scientifique

- Formation du Comité Scientifique NenuFAR (CSN)

  ⇒ Science Management Plan de NenuFAR :

  Principes d'exploitations, Phases, Key Programmes,

  Politique des données, Politique de publication

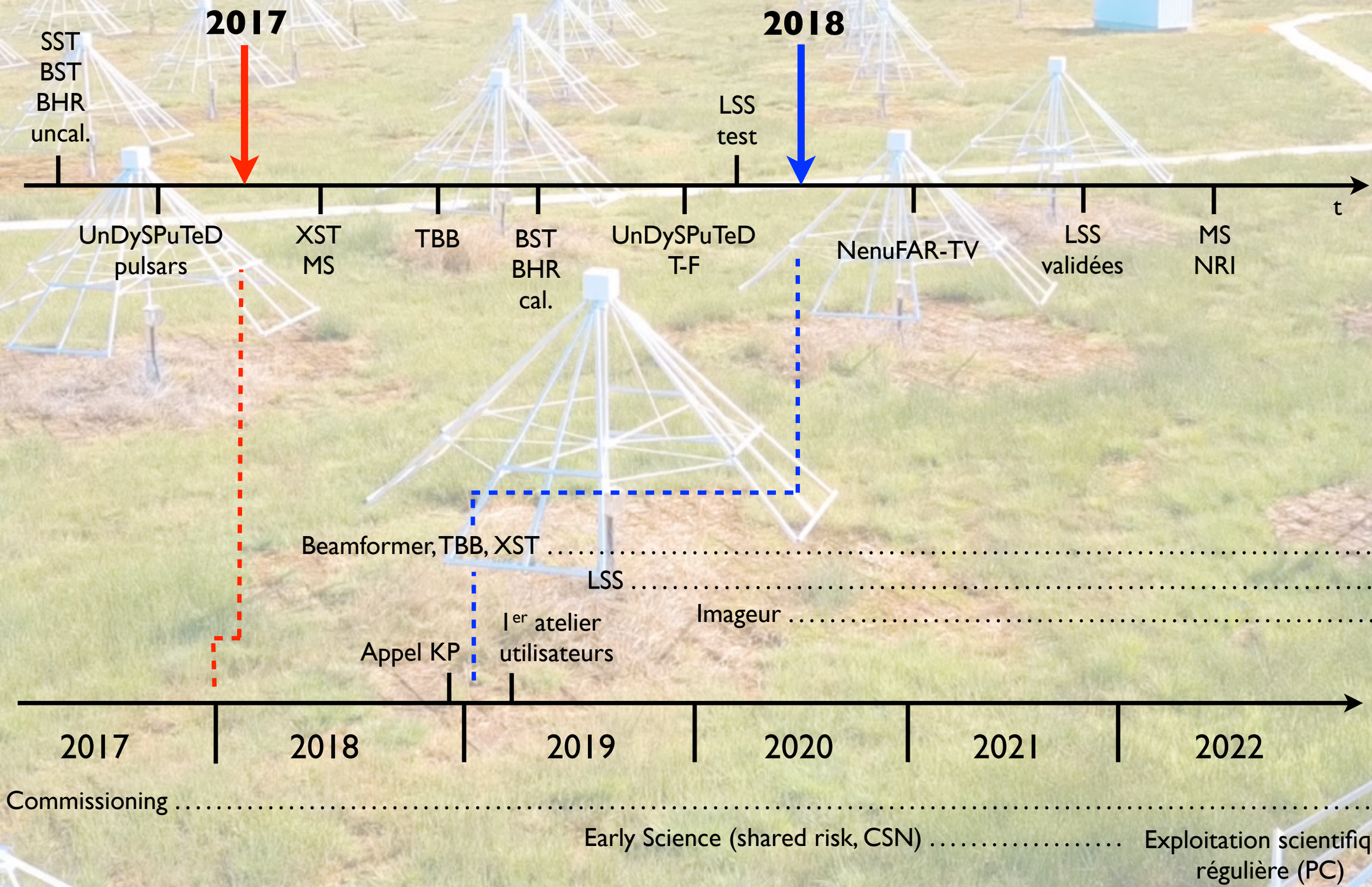
- Appel (national + invitations internationales) à Key Programmes (20/12/2018) :

  Cosmic Dawn, Pulsars/FRB, Exoplanètes/*, Planètes (éclairs),

  Transitoires / Ondes grav., Gerbes & γ cosmiques, AGN, SETI

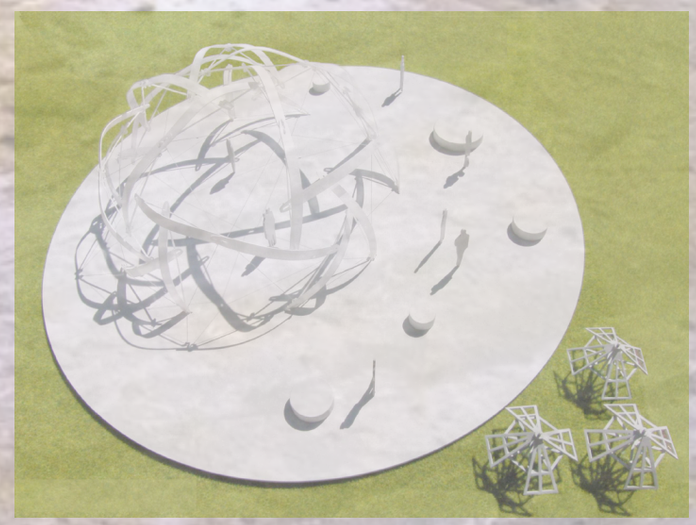
- 1er atelier utilisateurs NenuFAR : Data & Early Science (≤3/2019)

Calendrier


2017
2018
SST
BST
BHR
uncal.
LSS
test
t
UnDySPuTeD
pulsars
XST
MS
TBB
BST
BHR
cal.
UnDySPuTeD
T-F
NenuFAR-TV
LSS
validées
MS
NRI
Beamformer, TBB, XST
LSS
Imageur
Appel KP
1er atelier
utilisateurs
2017
2018
2019
2020
2021
2022
Commissioning
Early Science (shared risk, CSN)
Exploitation scientifique
régulière (PC)

Budget, Équipe, Outils, Événements

- Coût total ~ 5.9 M€ (x2 consolidé)
- Financements acquis : 4,7 M€
  - ➡ 11 grants : Région Centre & IdF, CPER, ANR + soutien INSU & OP
- ERC Advanced Grant en cours d'évaluation
- Petite équipe de commissioning : ~ 3 ETP
- Site web (public & "astronomers")
- Inauguration : fin septembre 2019



Merci.