

2nd NenuFAR User Workshop

# NenuFAR\*

## Presentation & updates on the system

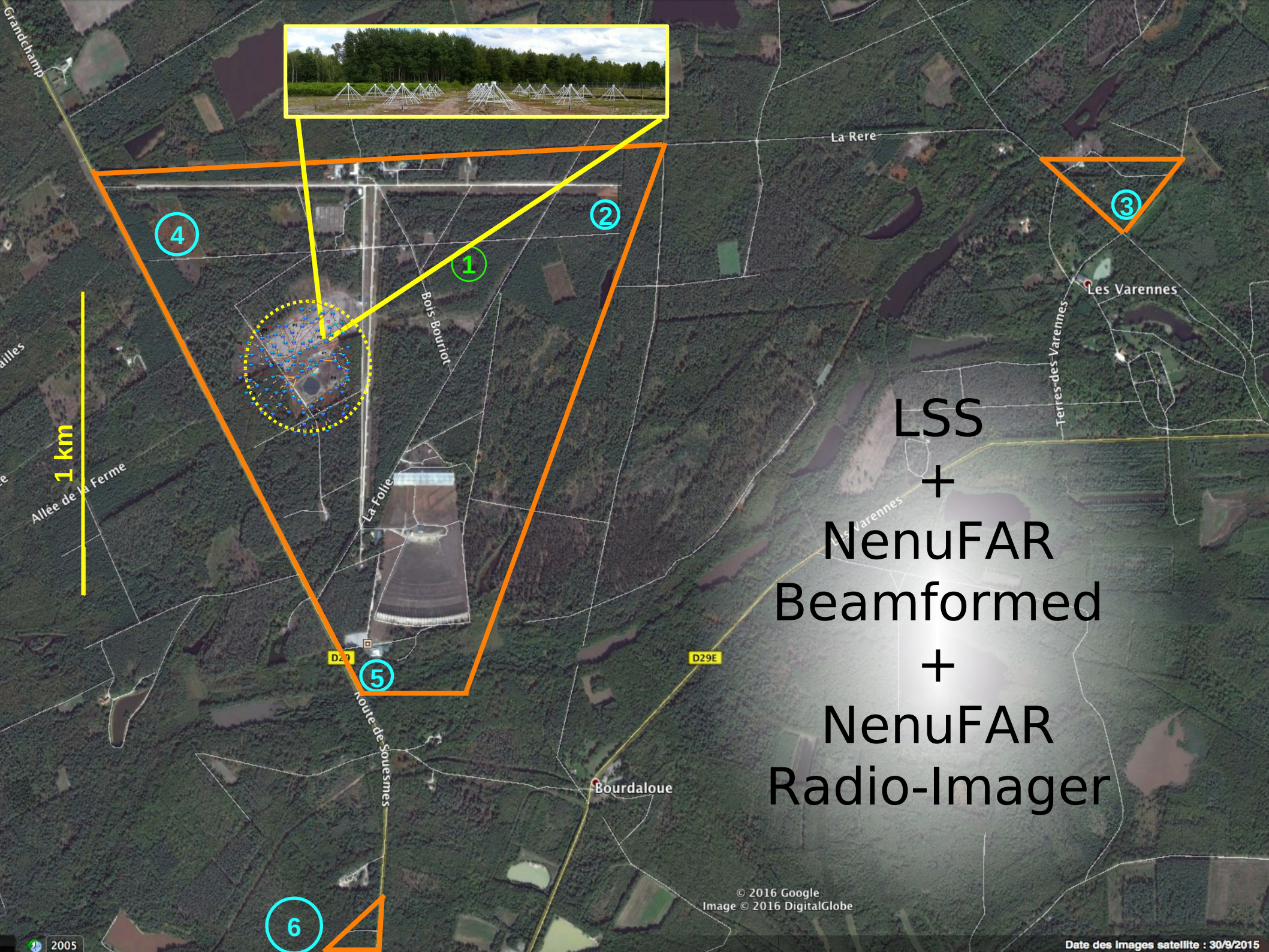
Cedric Viou  
on behalf of the

**NenuFAR-France team\*\***

\*\* : LESIA-OP, LPC2E-Orléans, USN-OP,  
CEA-Saclay, GEPI, LERMA, ONERA,  
ENS/IAP, OCA, ...



\*New Extension in Nançay Upgrading LOFAR



4

2

1

3

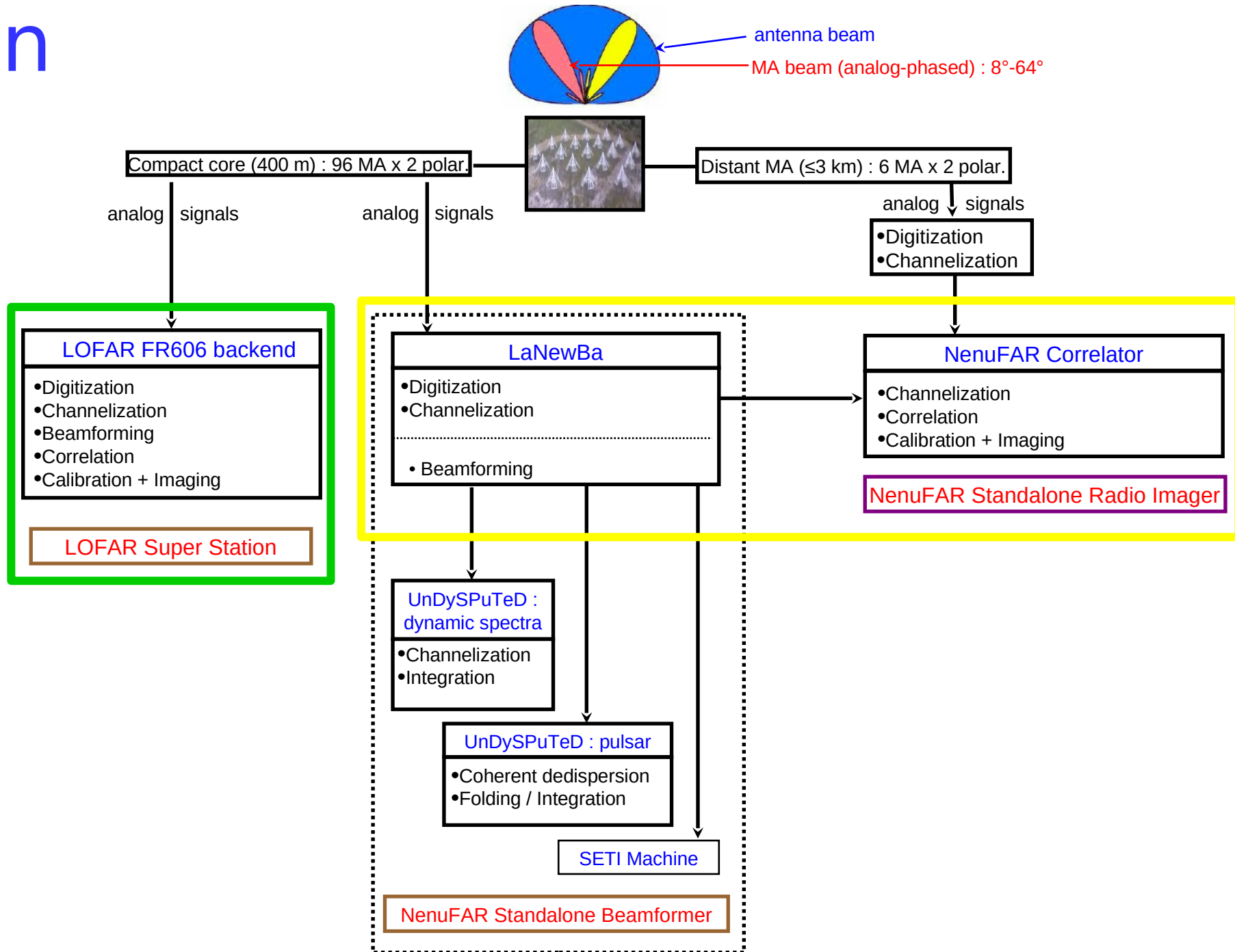
5

6

1 km

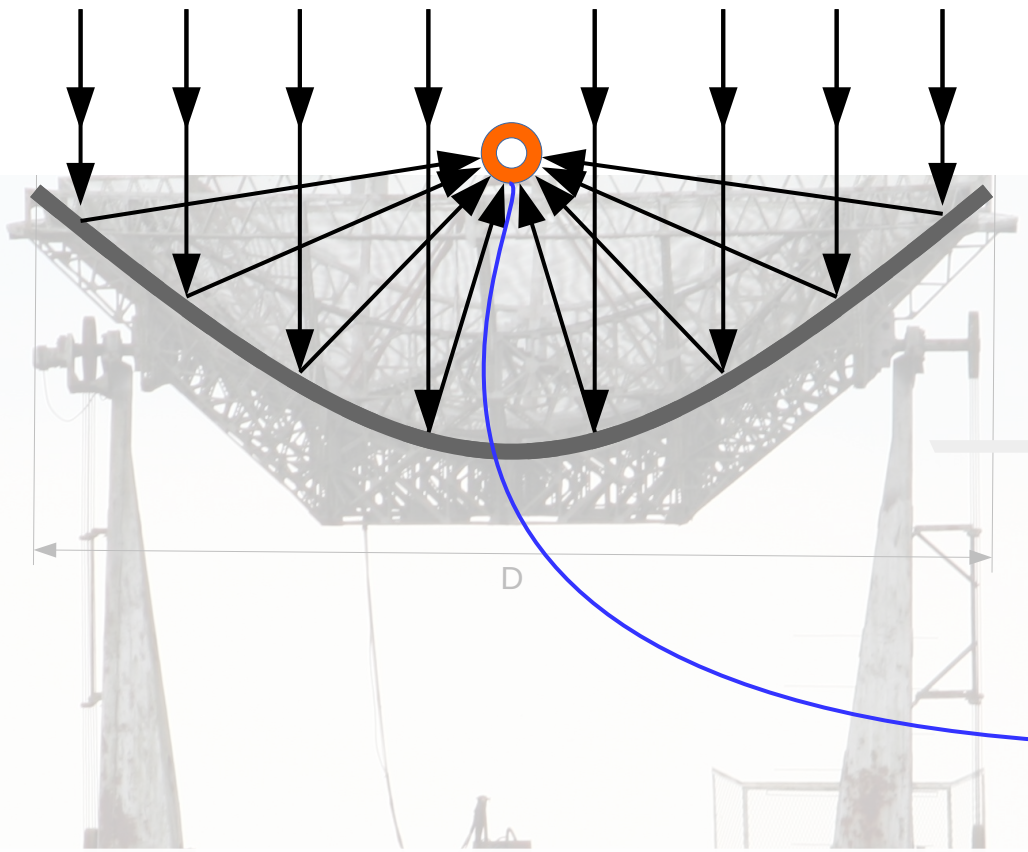
LSS  
+  
NenuFAR  
Beamformed  
+  
NenuFAR  
Radio-Imager

## Plan

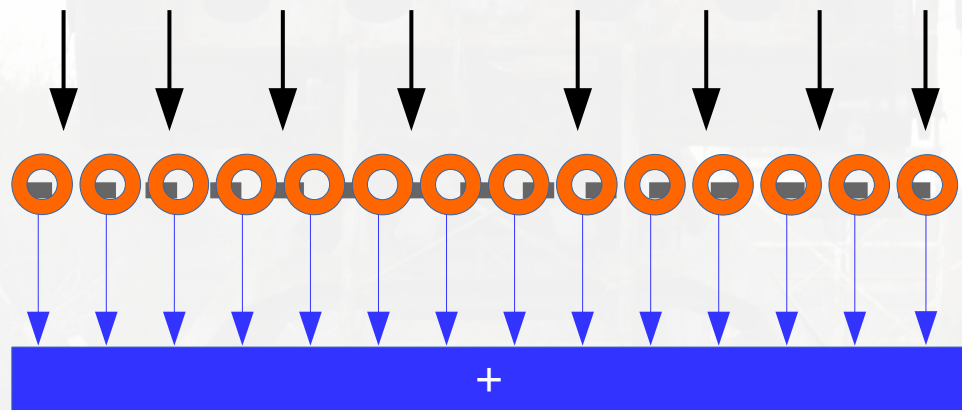


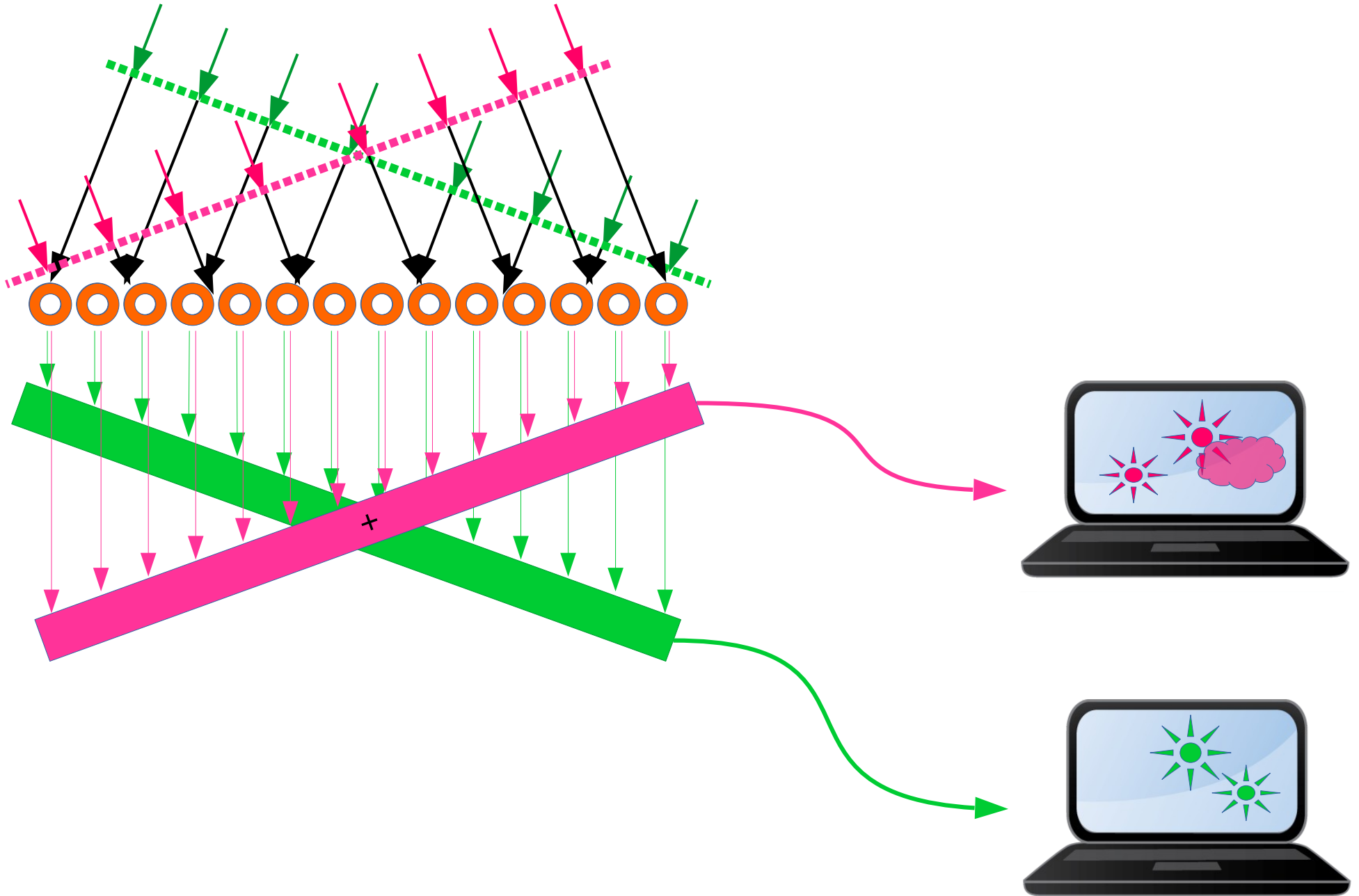
## On-site mini-arrays and computing facilities

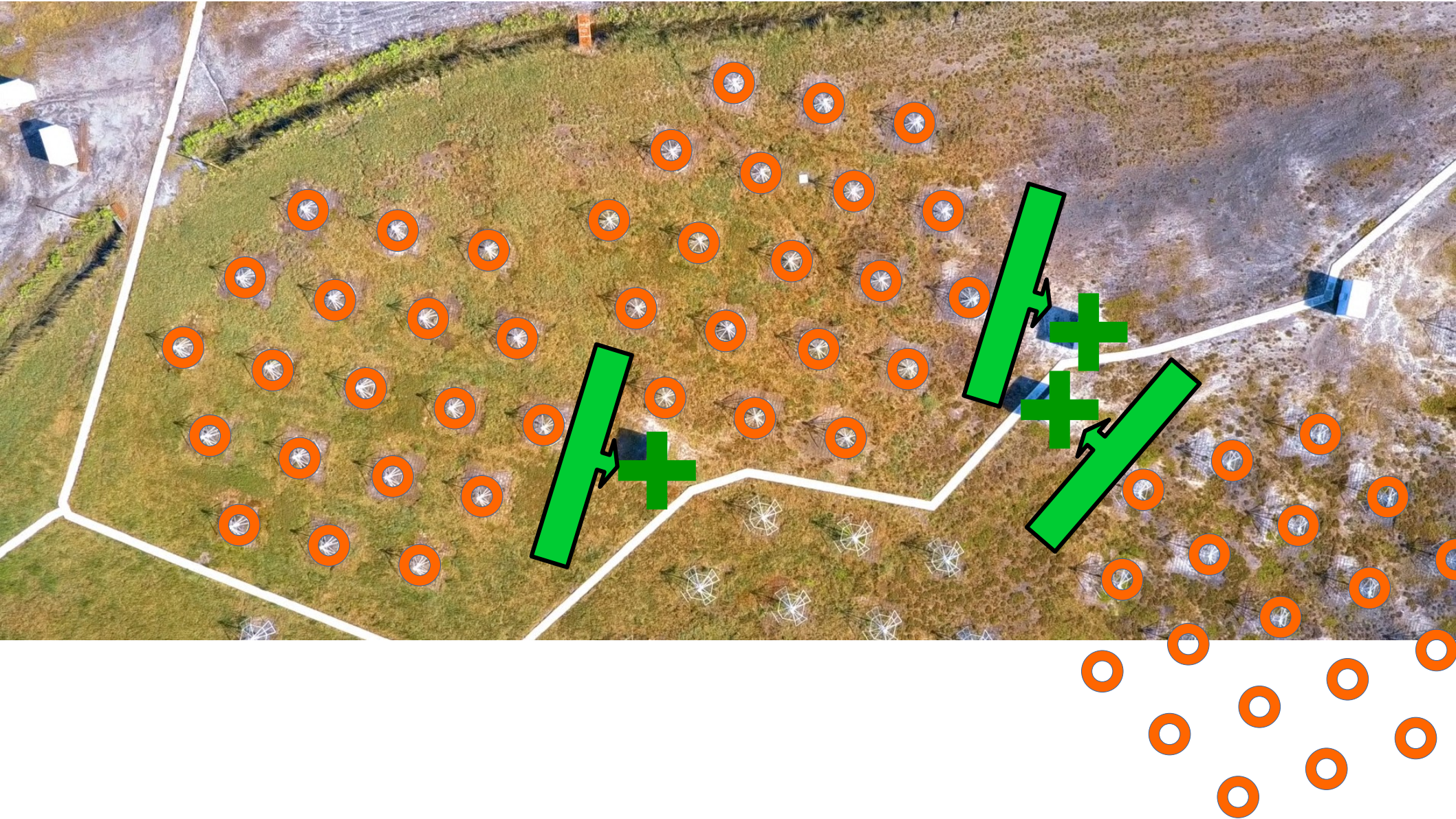




- Grande *surface* collectrice  
→ sensibilité  $\propto D^2$
- Grande extension  
→ résolution spatiale  $\propto \frac{\lambda}{D}$



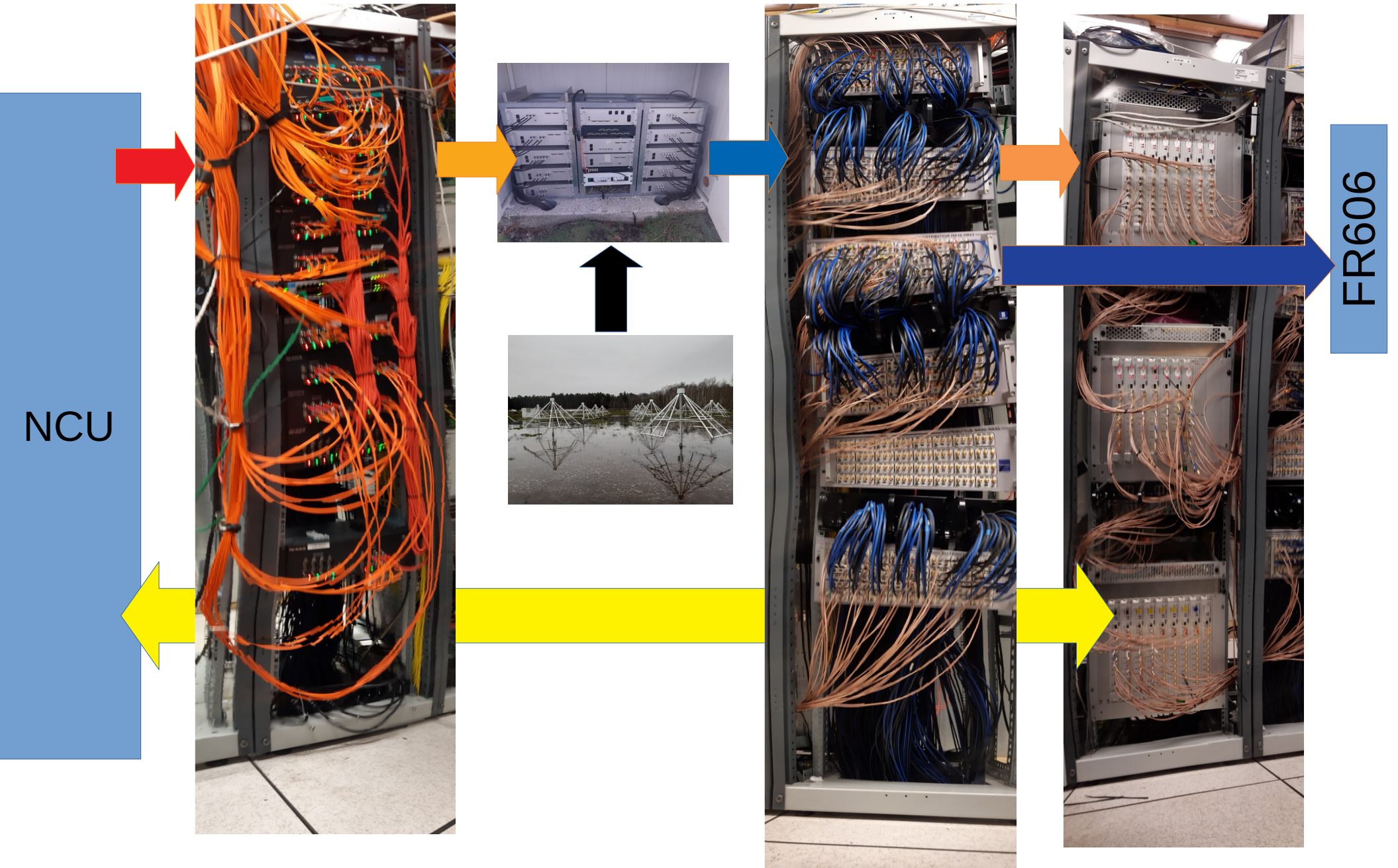




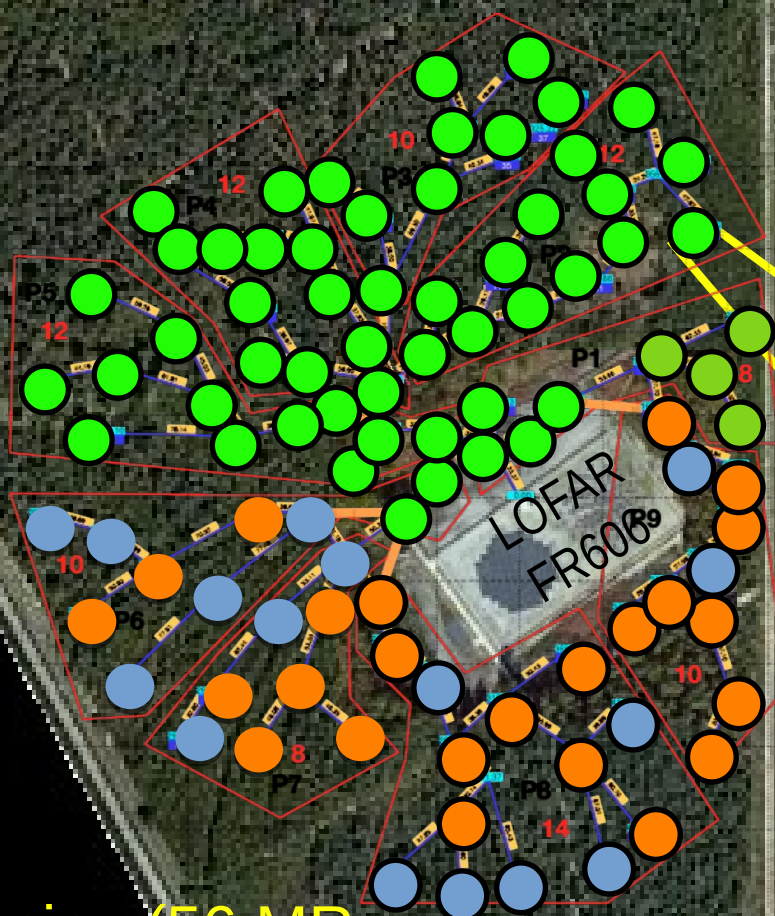
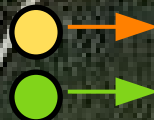








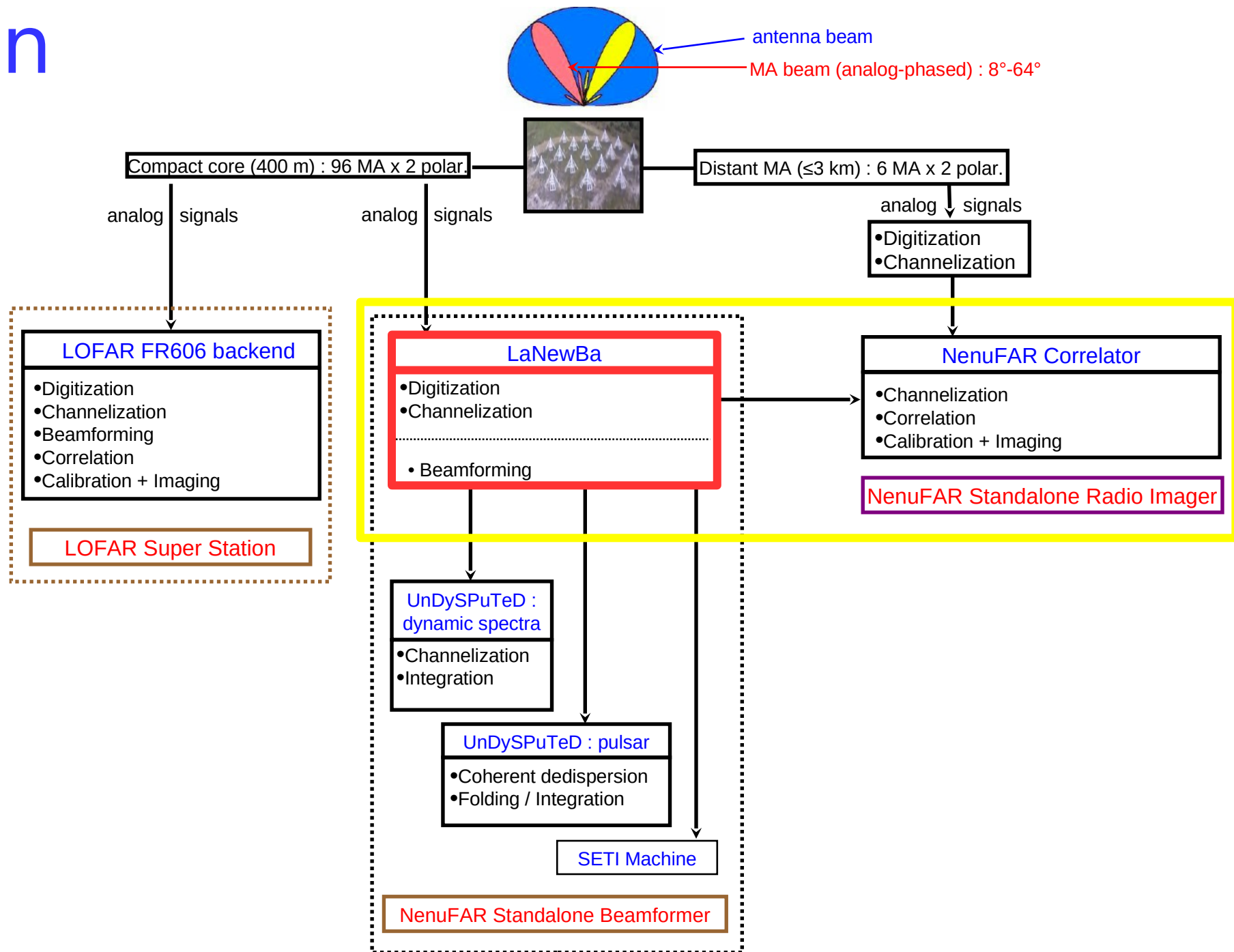
## Deployment progression

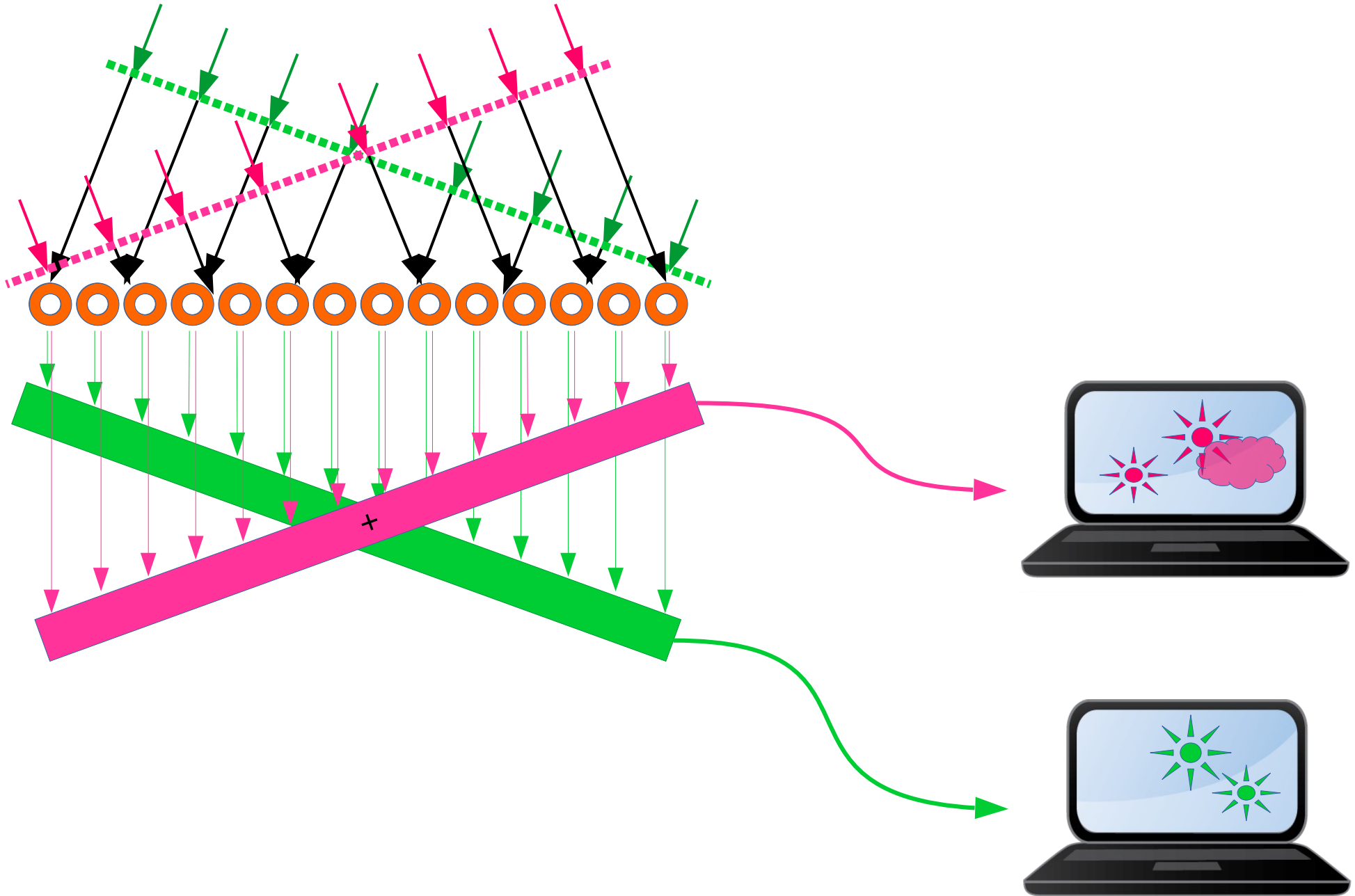


- Up and running (56 MR, 1064 Ant, 3 MRD)
- Deployed, used by NRI, need calibration (+24 MR = 80 MR, 1520 Ant.)
- Funding secured, TBD in 2022 (+16 = 96 MR, 1824 Ant.)

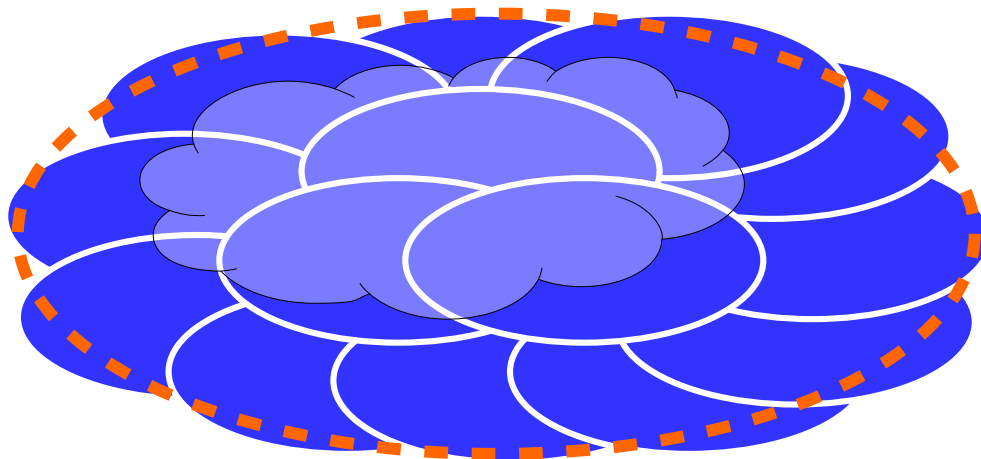
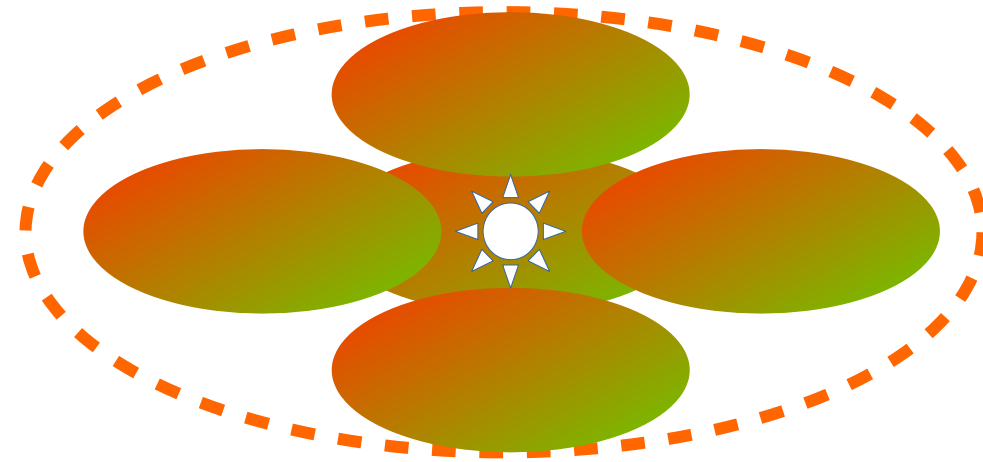
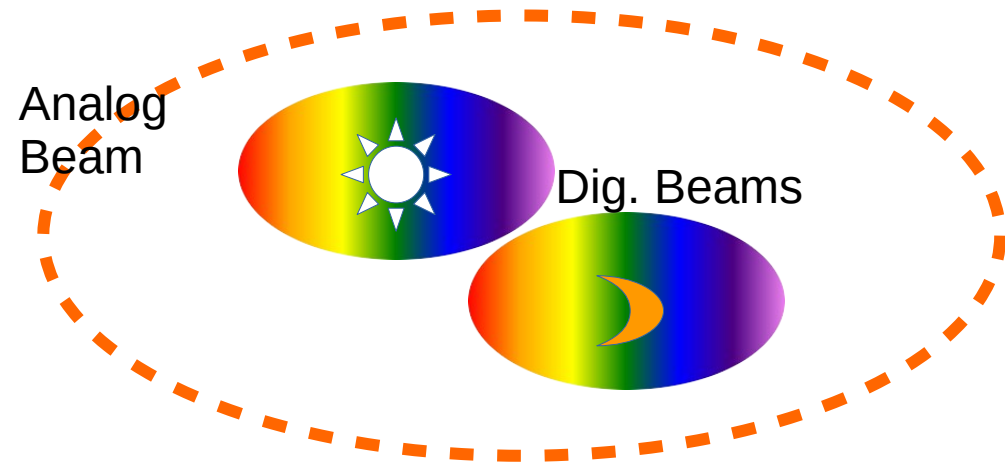


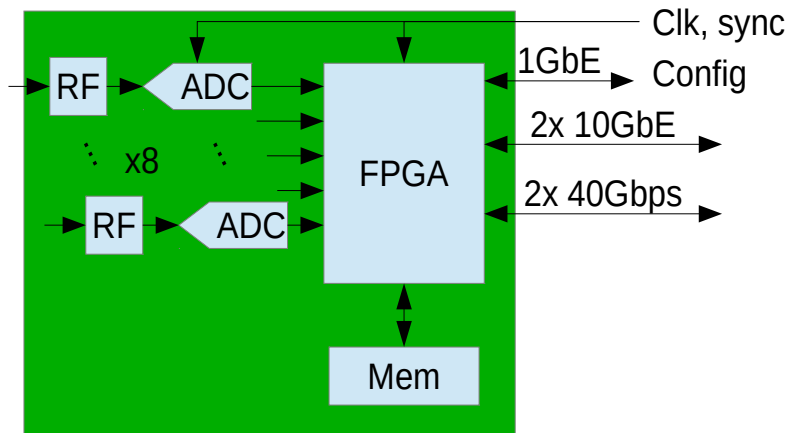
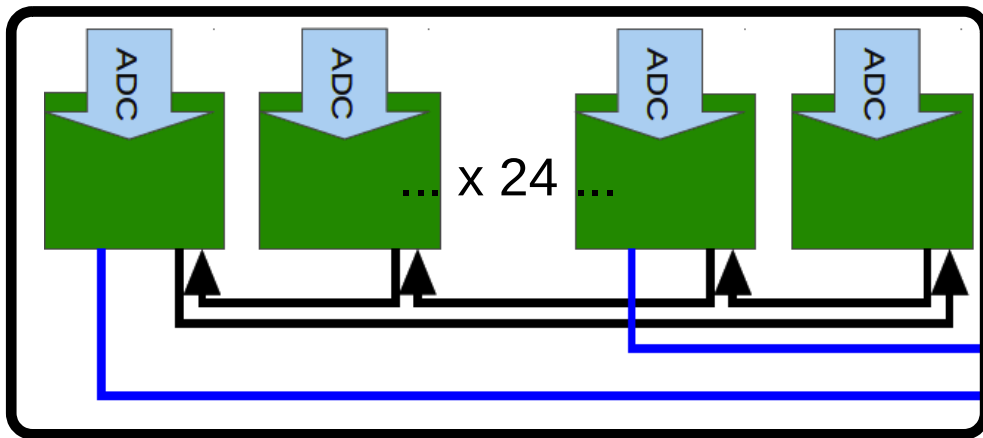
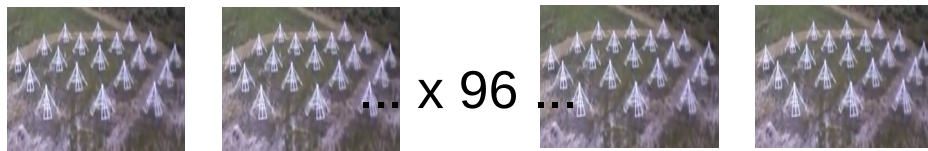
## Plan





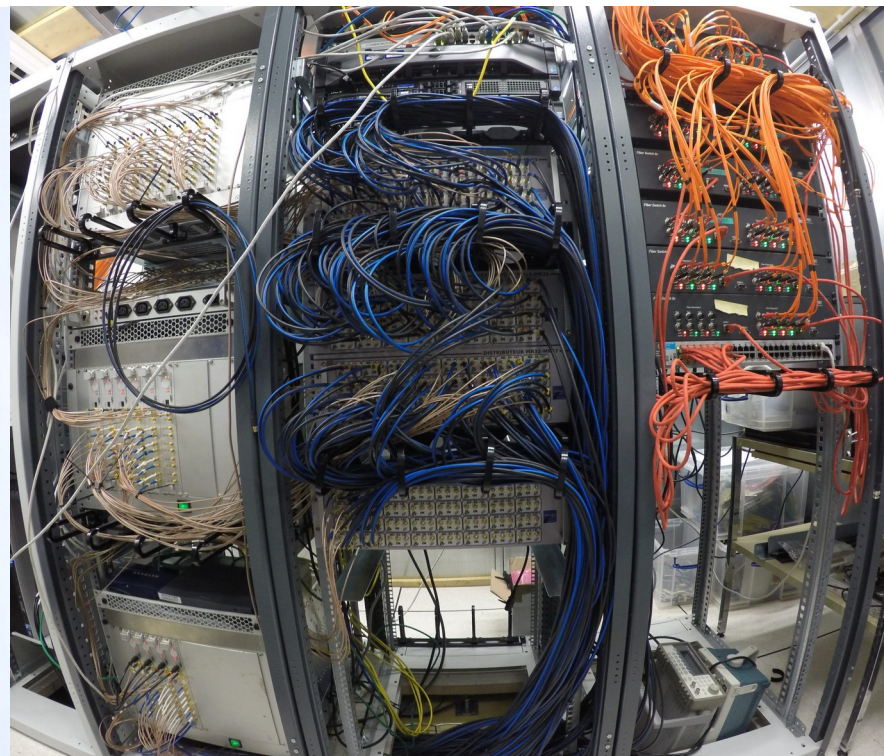
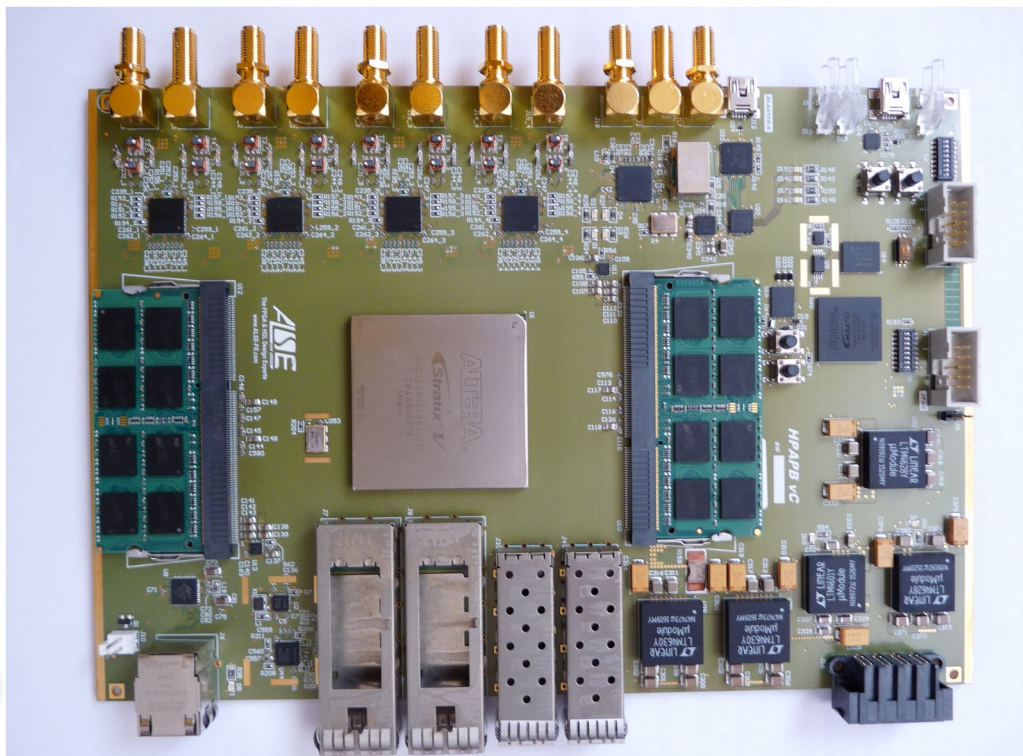
## Possible configuration of beamforming





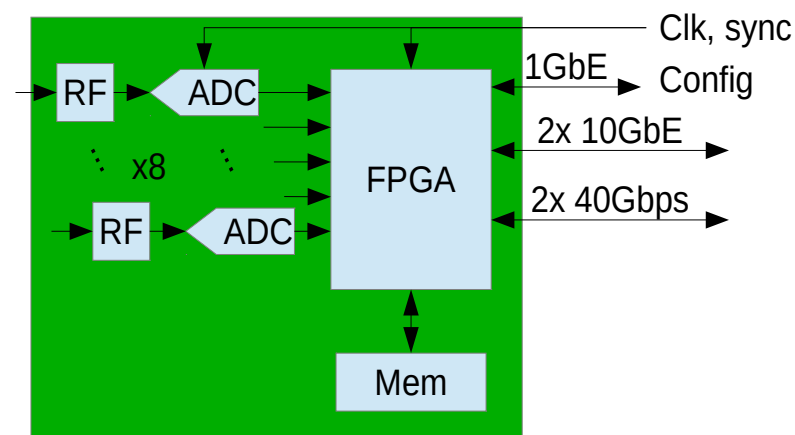
150 MHz beamformed in 10-85 MHz, full-polar.

A.L.S.E  
the FPGA Experts



## LANewBa

- Sampling
  - (96x2) x 200 MS/s - 14-bits ADCs (~400 MB/s/chan)
  - 64 GB/s today, 77 GB/s for full instrument, continuously 24/7
  - Synch < 0.1 ns
- Signal processing implemented on FPGA (Stratix V Altera/Intel)
  - HW interfaces subcontracted to ALSE (ADC, mémoire, 1G, 10G, 40G,...).
  - Signal processing based on VHDL code from RSP LOFAR
  - 1300 GMAC/s distributed over 24 FPGA boards
- Channelization :
  - 512 x 0.195 kHz subbands
  - 16-taps PFB + 1k-FFT (614+192 GMAC/s)

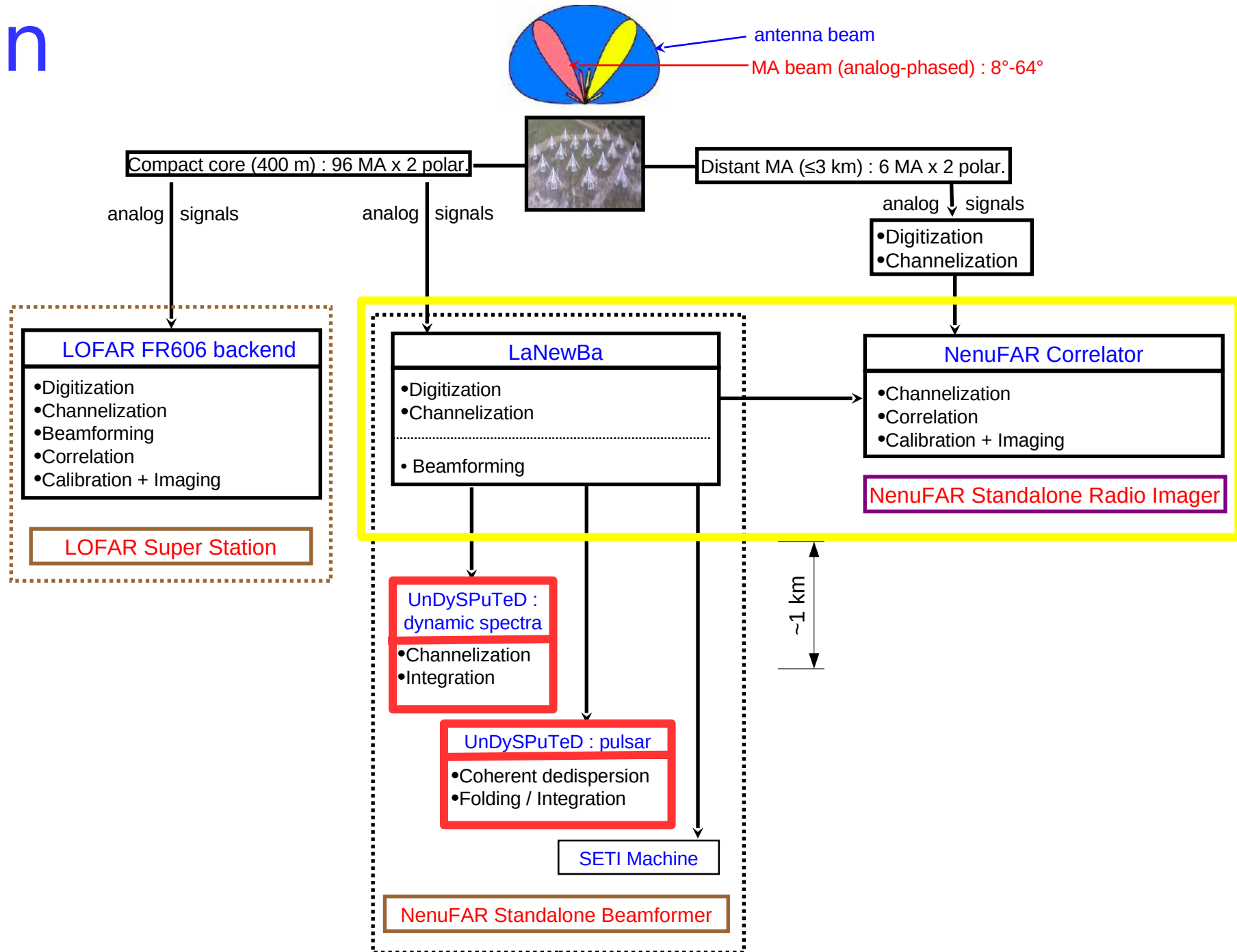




## LANewBa

- Beamforming
  - Subband selection (768 from 512)
  - Delays by  $\exp(i.\phi)$  multiplication
  - Summation in a double ring (14 Gb/s, 58 GAcc/s)
  - 10GbE Export (4x 150-300 MB/s)
- Calibration
  - XST (16 ssb/s -> 512 ssb/30s)
    - Reflet distribution over double ring (18 Gb/s)
    - MAC distributed over the 24 FPGA boards (90 MB/s x 2.2 GB/s)
    - 461 GMAC/s
- Monitoring and diagnostics
  - SST, BST recorded continuously 24/7
  - Continuous recording of physical parameters (T°C, U, I, flags)
  - Fed into a DB
- 1 cabinet, 3 RACKS, 1500 W

## Plan



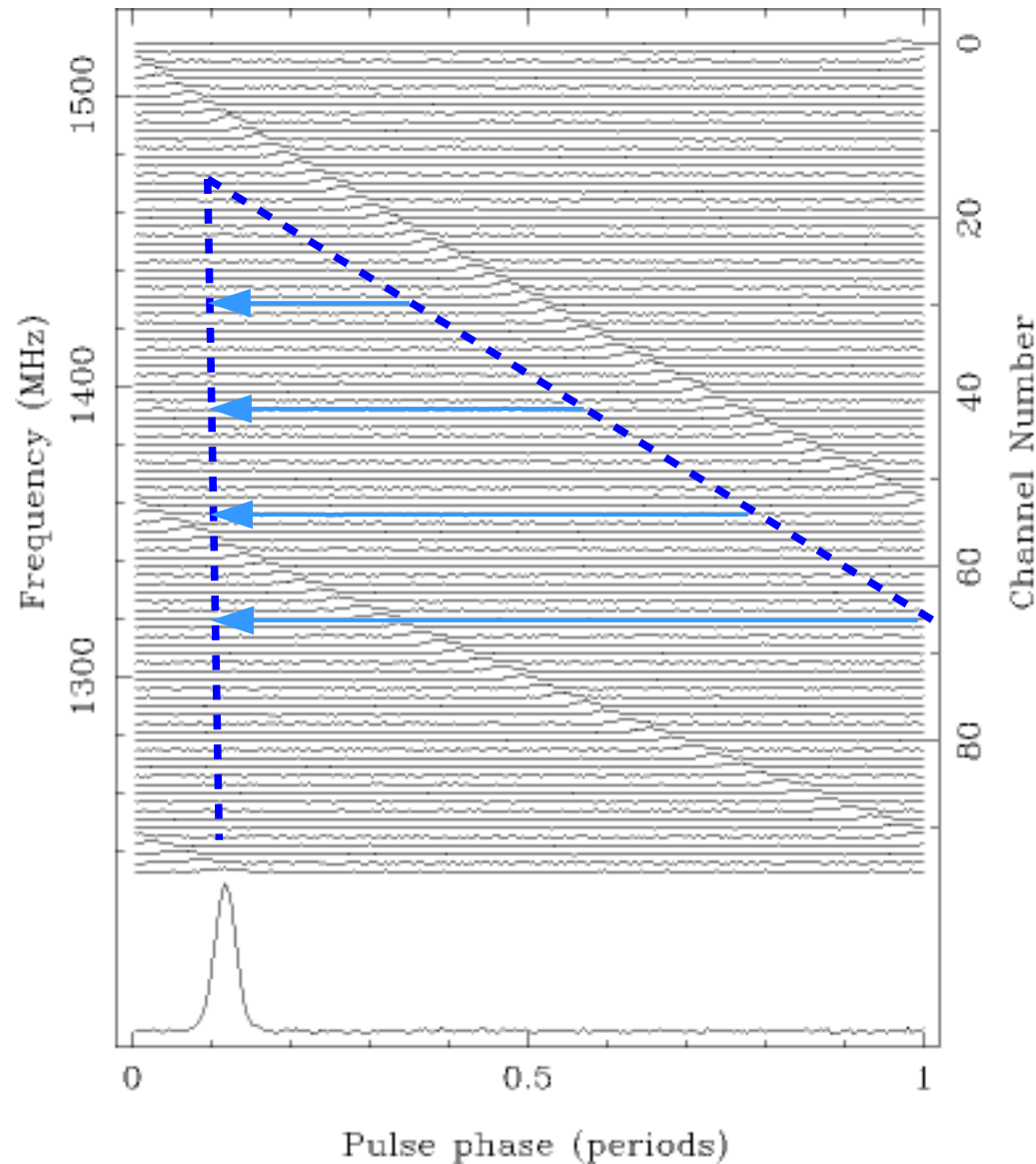
## UnDySPuTeD

- 2x Servers :
  - 2x Intel Xeon E5-2620v4 8cores
  - 256GB DDR4
  - 2x GPU Nvidia GTX 1080

## UnDySPuTeD dynamic spectra

- Dynamic Spectra
  - 1 à 2 streams each at 4.8 Gb/s,  $B=195$  kHz,  $dt = 5.12$   $\mu$ s
  - win-FFT +  $\langle |x_i \cdot x_j|^2 \rangle$  to produce 4 Stokes, continuous, real-time
    - $B_{\min} = 762$  Hz,  $dt_{\min} = 1$  ms
    - $B_{\max} = 195$  kHz,  $dt_{\max} = 1$  s
  - Flux à traiter : 4x 150-300 Mo/s (int8-int16)  $\rightarrow$  1.2 Go/s (float32)
  - Calcul FFT :  $\sim 2$  GFLOPS

# UnDySPuTeD pulsar : LUPPI

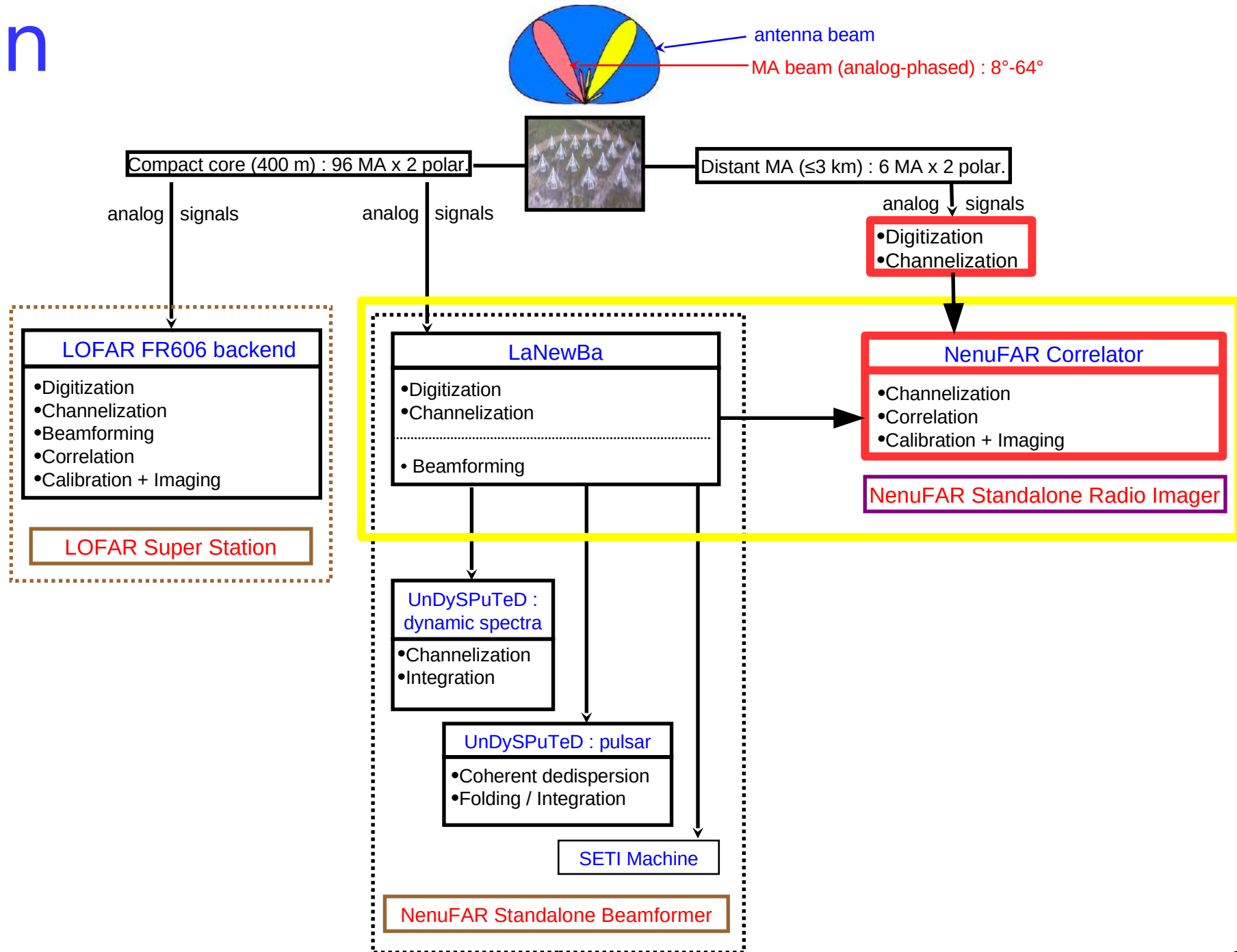


- Dedispersion code from luppi/guppi running on NRT

$$H(\nu + \nu_0) = \exp\left(i 2 \pi D \frac{\nu^2}{\nu_0^2 (\nu + \nu_0)}\right)$$

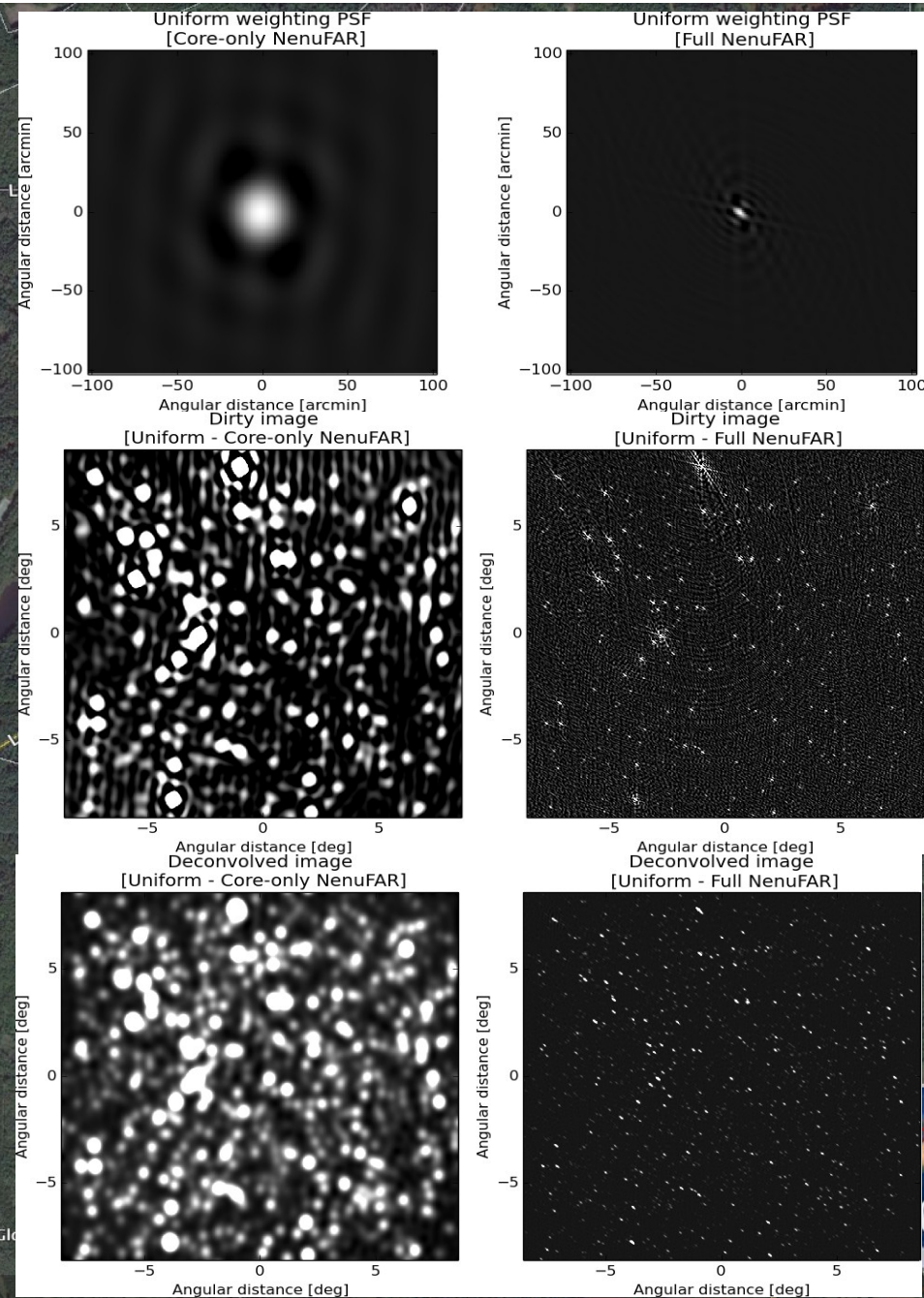
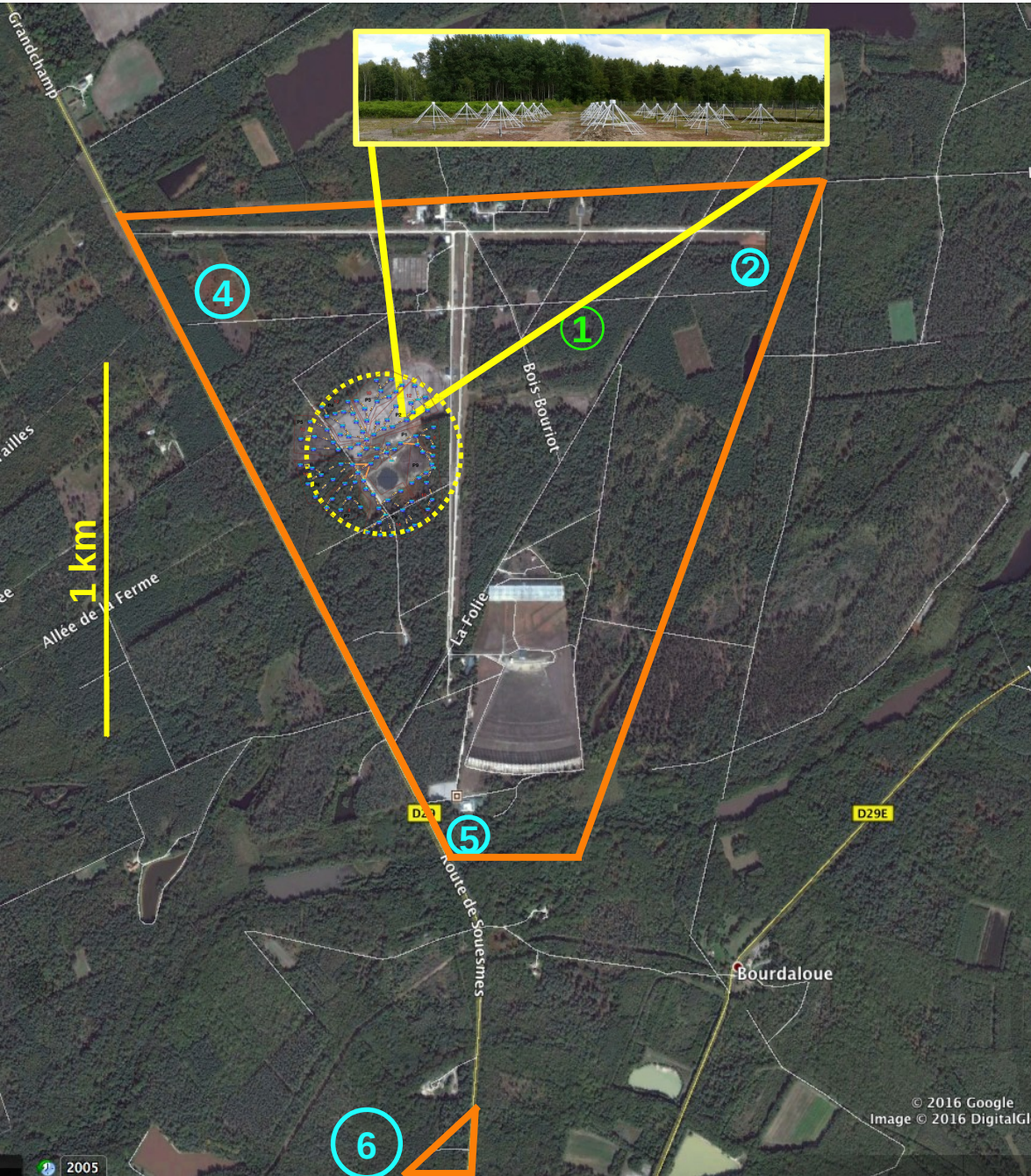
- Modes :
  - Accumulation
  - Single pulse
  - Polarisation dedispersion

## Plan

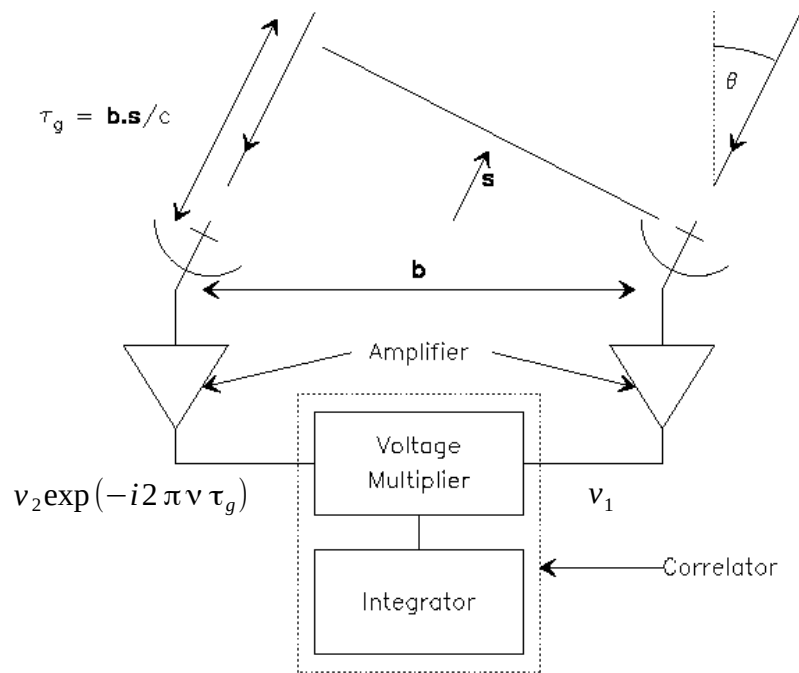
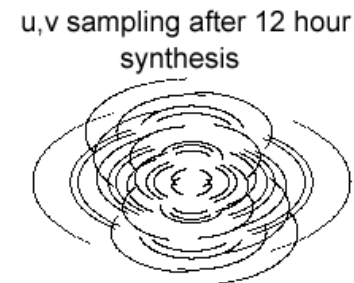
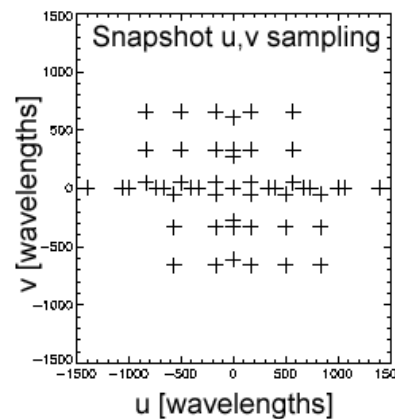
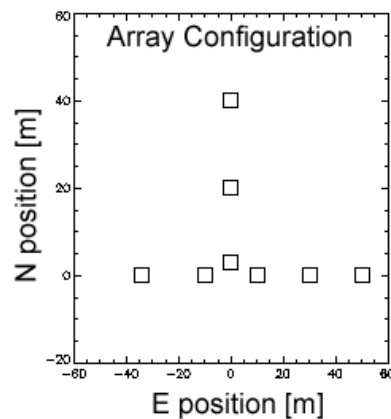
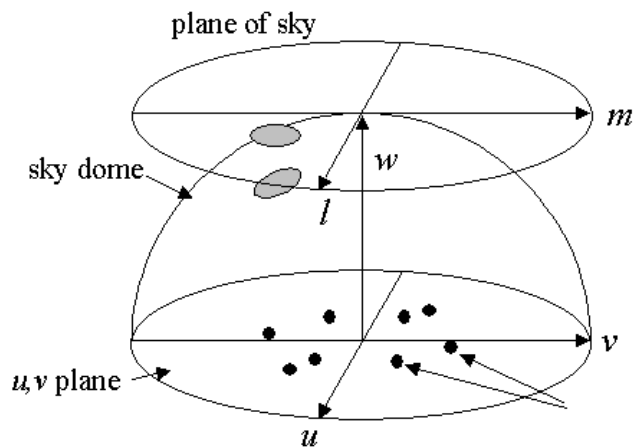


# NenuFAR-Radio-Imager

ANR «NRI» 2017-2019



## Imagerie par interférométrie radio

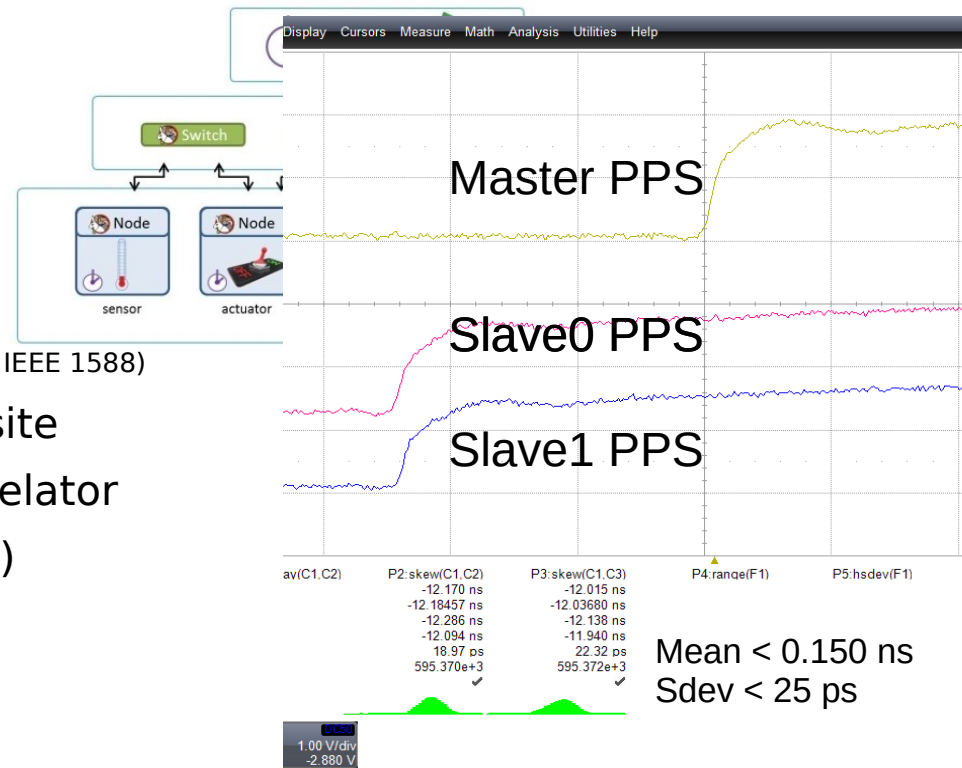


- Instrumental stability required for MRDs (remote mini-arrays)
- N feeds  $\rightarrow$   $N(N+1)/2$  visibilities
  - 96 MRs + 6 MRDs polarisés  $\rightarrow$  20k visibilities
- Antennae/Freq transpose is costly

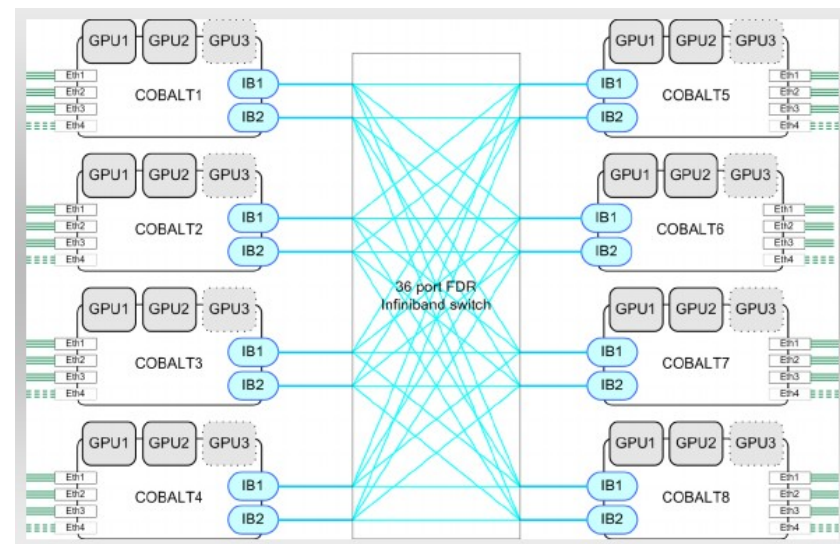
$$V = \langle v_1 v_2 \exp(-i2\pi\nu\tau_g) \rangle = |v_1 v_2| \exp(i2\pi\nu\tau_g)$$

## NenuFAR-Radio-Imageur

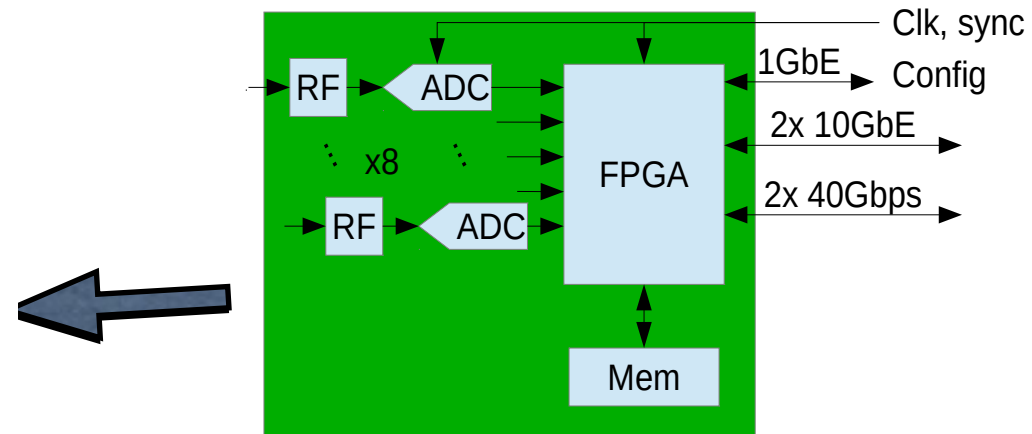
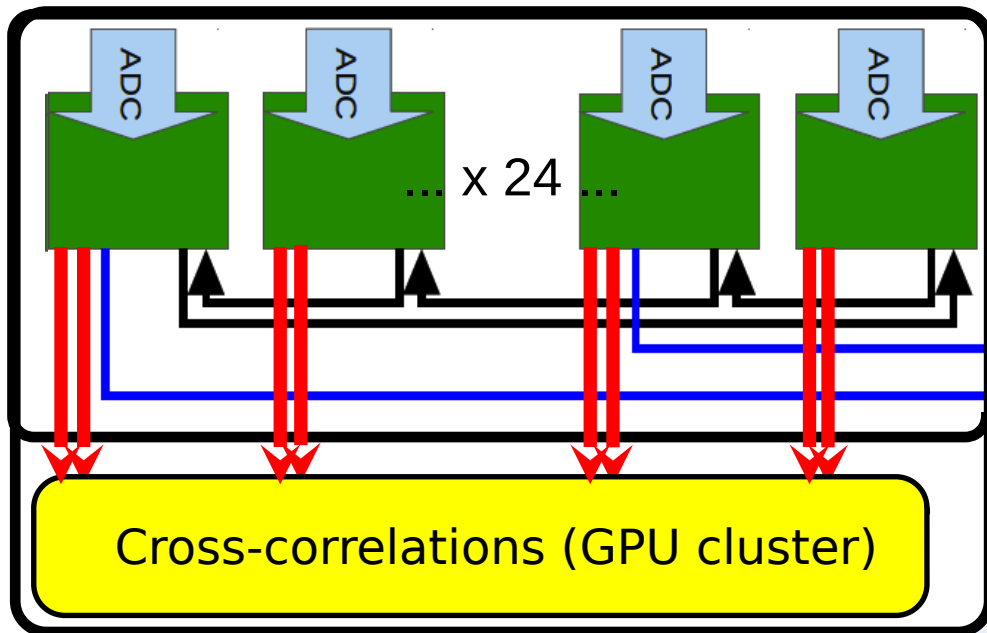
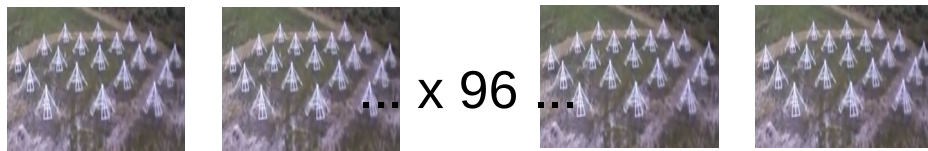
- Remote Digitization
  - WhiteRabbit network
    - Sub-ns fiber-based timing distribution (next IEEE 1588)
    - PPS and 10 MHz refclock regenerated on-site
  - 10GbE streams of beamlets towards the correlator
  - On-field constraints (cooling, RFI shielding,...)
  - 3 in production, 1 in deployment



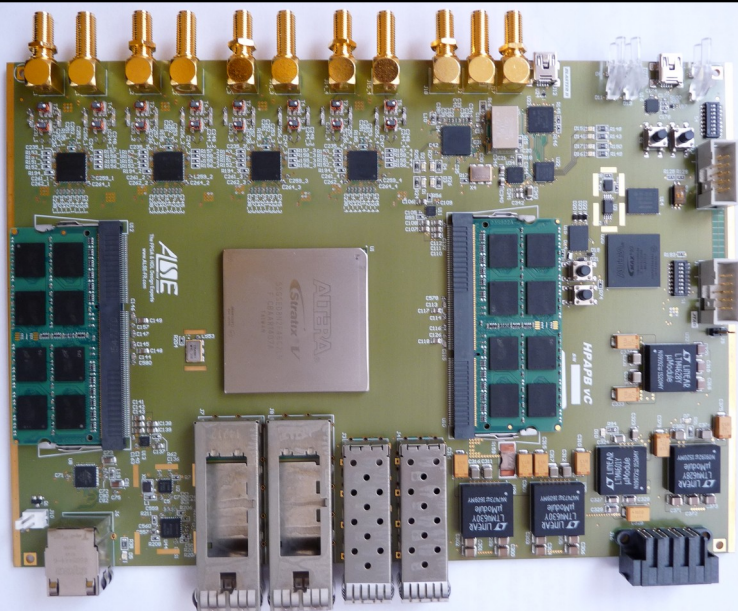
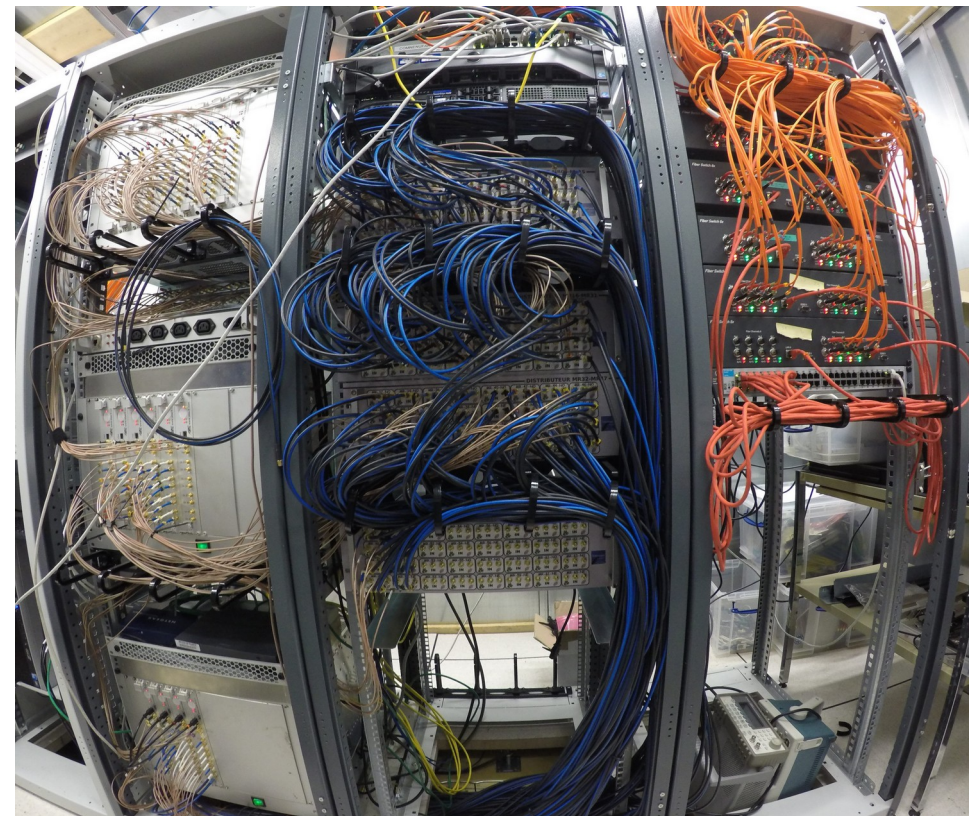
- Correlator → NICKEL
  - LOFAR-COBALT2.0 based
  - 102 antenna fields
  - 384 subbands (75 MHz) (only 244 now)
- Storage → COPPER
  - Real-time recording of MS
  - Automatic pre-processing (under dev)



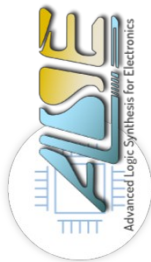


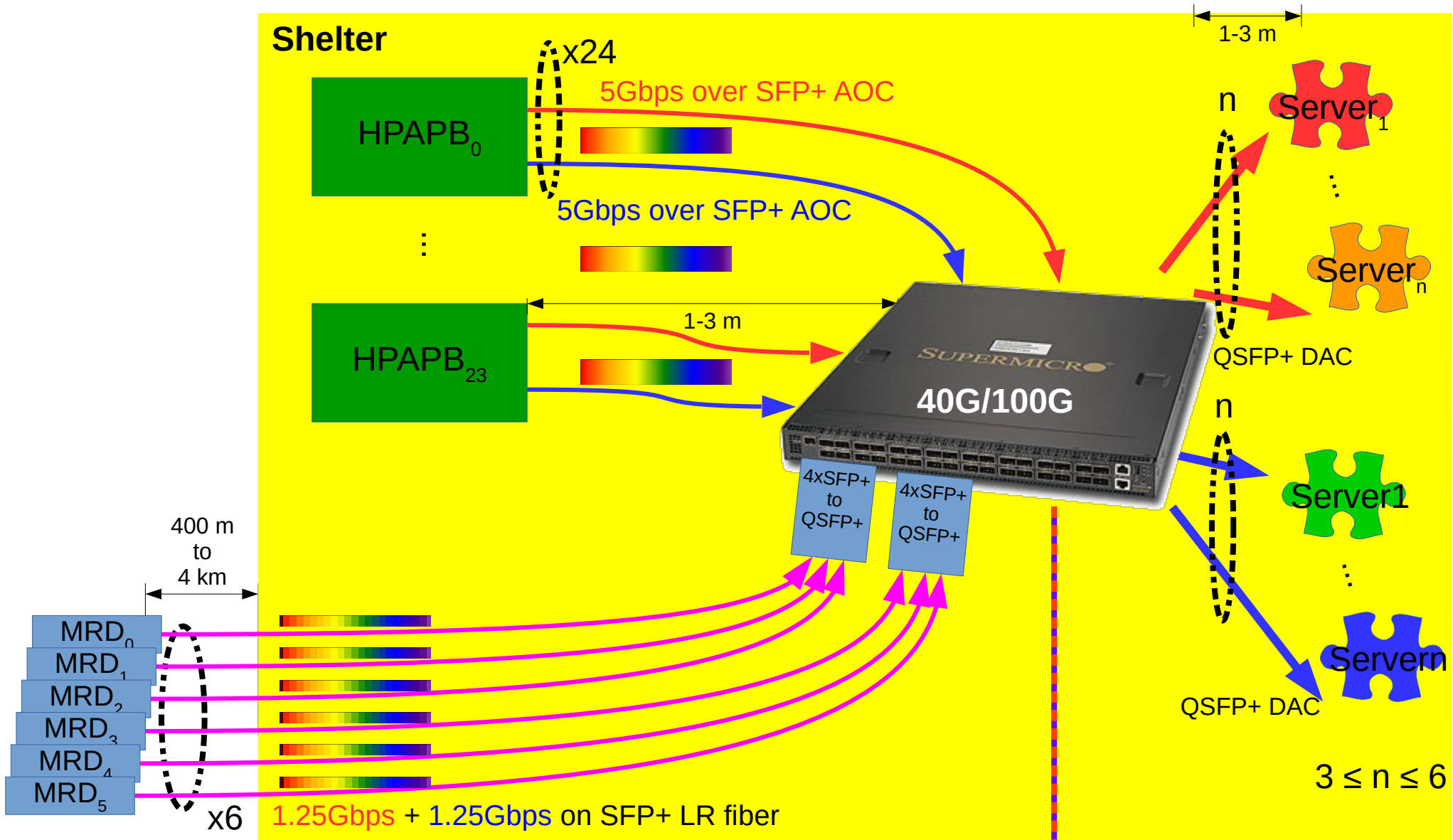


2 beams full-band (~10-85 MHz), full-polar.



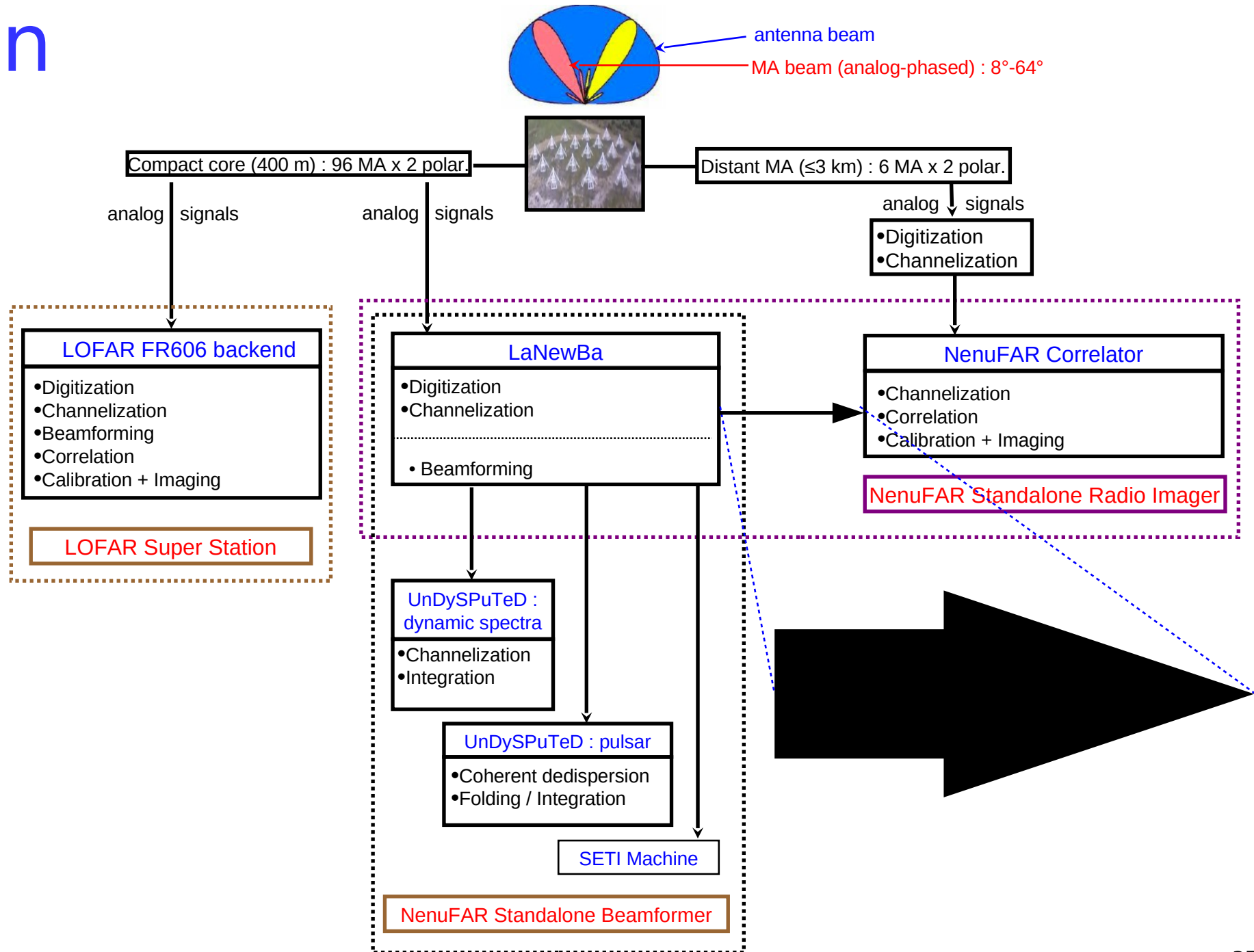
A.L.S.E. the FPGA Experts



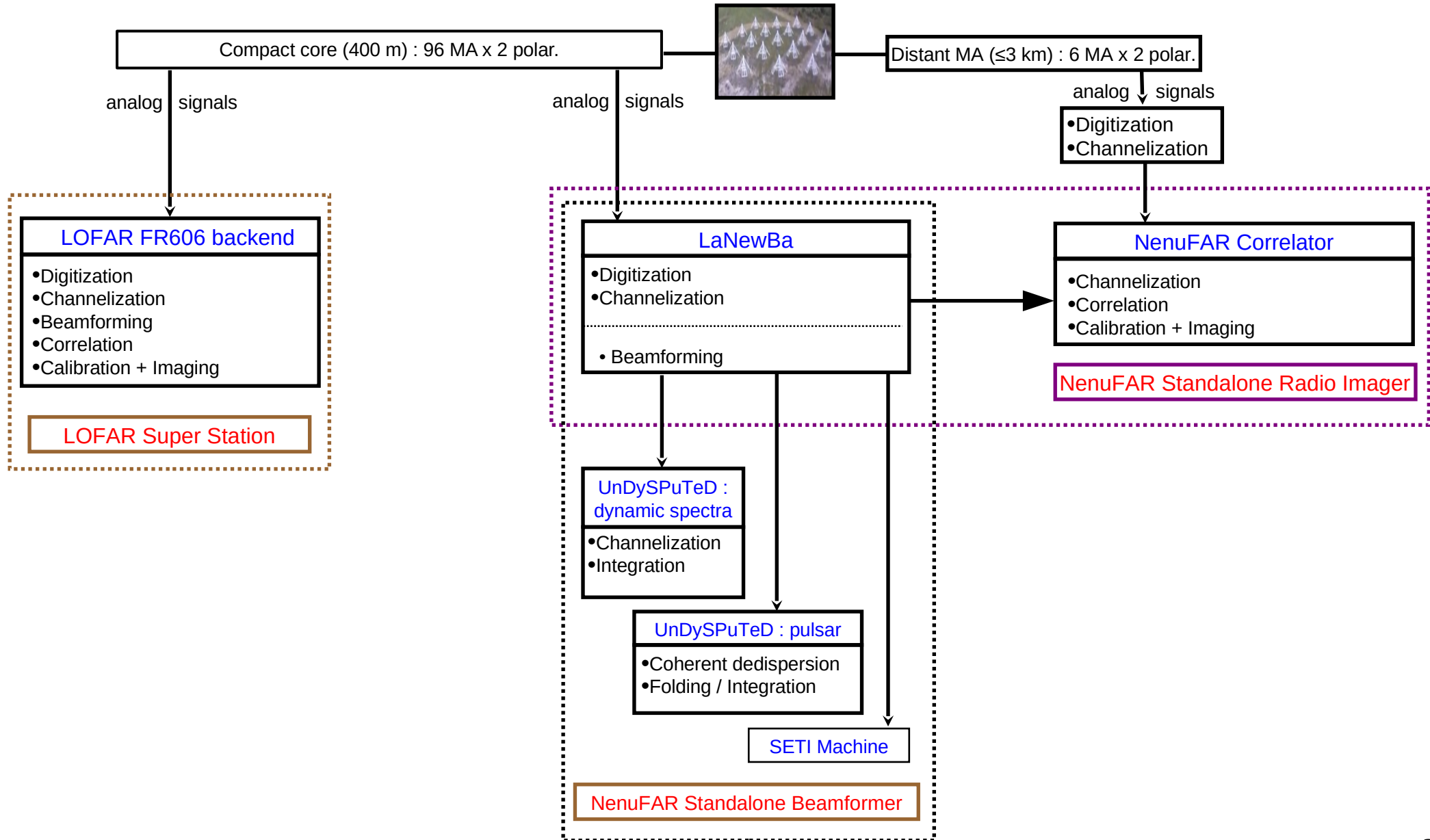
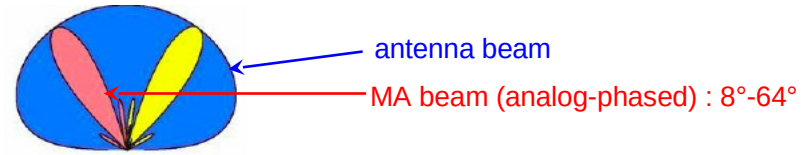


## Data distribution

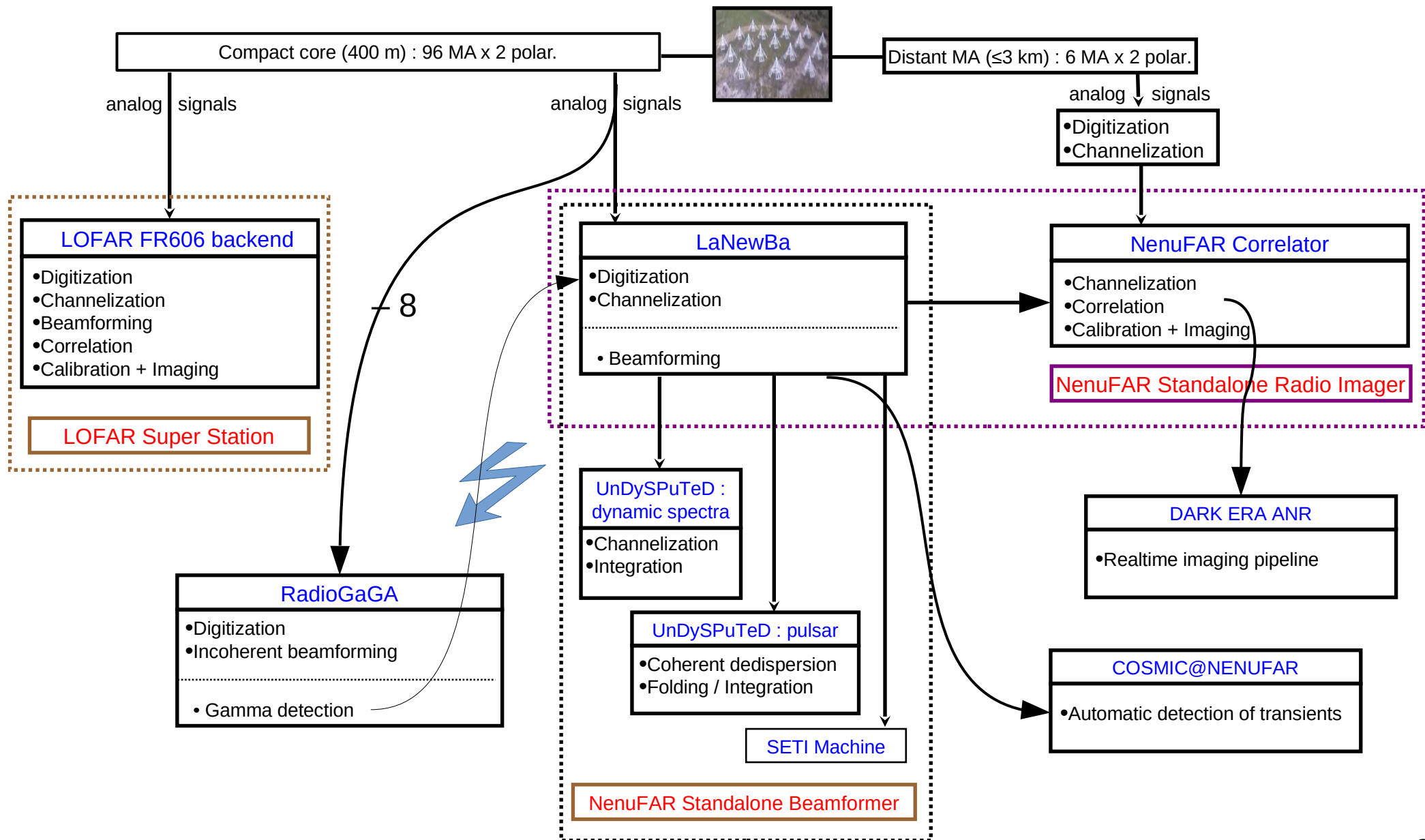
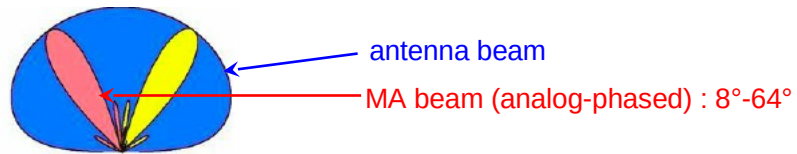
## Plan



## Plan



## Plan



Activités | Navigateur Web Firefox | mer. 10 nov. 09:41:07

https://gui-nenufar.obs-nancay.fr/Current-status

**NenuFAR** v3.18.6 | SIMULT\_NRT\_J1400-1431 | 1 hour

Hello, Cedric Administrator | 08:41:06 UTC

Stairway To Heaven | Planning | Coordinates | **Dashboard** | Real time | Google map | Survey | Reports | Maintenance | Tools | Documentation

**LST**

**12:08:49**

**SST**

769.43 MB (08:00:00)

**(11/10) 08:40:59**

**BST**

25.07 MB (07:30:00)

**(11/10) 08:40:55**

**MA**

MA2, MA21 : Disabled 81 MA enabled

**BK**

Monitor, SST, XST, BST on all MA for each enabled BK 24 BK card enabled

**Services**

All services running

**Disks space**

DATANCU 9 TB used on 22 TB

Recent activity

2021-11-08 to 2021-11-1

Last error : 2021-11-08 20:50:03 ( from BackendControl )

- 2021-11-10 07:29:55 - Pointage\_Auto - stop by stopTime
- 2021-11-10 07:29:02 - BackendControl - Observation finished  
20211110\_063000\_20211110\_073000\_SIMULT\_NRT\_J1022+1001.parset
- 2021-11-10 06:30:04 - Pointage\_Auto - End of initialization
- 2021-11-10 06:30:04 - BackendControl - End of initialization
- 2021-11-10 06:30:03 - BackendControl - Thread configuration ready for observation
- 2021-11-10 06:30:03 - BackendControl - BST fits file ready for observation
- 2021-11-10 06:30:02 - BackendControl - Observation started  
20211110\_063000\_20211110\_073000\_SIMULT\_NRT\_J1022+1001.parset - beam=2 and analog beam=1
- 2021-11-10 06:30:02 - Fire - send 'start' to codalema (192.168.17.159:8094)
- 2021-11-10 06:30:02 - Pointage\_Auto - 572 tracking orders
- 2021-11-10 06:30:02 - Fire - send 'start' to seti (192.168.17.226:8094)
- 2021-11-10 06:30:02 - Pointage\_Auto - Disabled MA: 2 21 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79
- 2021-11-10 06:30:02 - Fire - send 'start' to undysputed2 (192.168.17.225:8094)
- 2021-11-10 06:30:02 - Fire - send 'start' to undysputed (192.168.17.224:8094)

1 2 3 4 5 6 7 »

https://gui-nenufar.obs-nancay.fr/Current-status

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https://gui-nenufar.obs-nancay.fr/Planning/2021-11-01

**NenuFAR** v3.18.6 | SIMULT\_NRT\_J1400-1431 | 1 hour

Nov 1 - 7, 2021 | timetable | week | Filters

	Mon 11/1	Tue 11/2	Wed 11/3	Thu 11/4	Fri 11/5	Sat 11/6	Sun 11/7
00:00	21:00 - FRB180916_TF_PULSAR	21:00 - FRB180916_TF_PULSAR	21:00 - FRB180916_TF_PULSAR	20:59 - 04:00 NCP_COSMIC_DAWN		23:30 - 01:30 EPS_ERI_TRACKING	00:12 - BEAM25_0332+5434
02:00					02:00 - SETI 03:00 - SETI	01:30 - 06:00 COROT-7_TRACKING	01:22 - BEAM26_0528+2200 02:29 - 04:18 BEAM27_0719+6518
04:00				04:00 - 10:00 FRB20200120	04:00 - 10:00 FRB20200120		04:21 - BEAM28_0814+7429 05:30 - BEAM30_0922+0638
06:00						06:00 - 10:00 WISEPA_J101905	06:23 - BEAM31_0949+0853 07:16 - BEAM0_1136+1551
08:00	08:00 - 09:58 POLARISATION_CALIBRATION						08:09 - 09:35 BEAM1_1239+2322
10:00	10:00 - 11:58 POLARISATION_CALIBRATION					10:00 - 12:00 MARS_TRACKING	09:38 - 11:19 BEAM2_1306+1106
12:00	12:00 - 13:58 POLARISATION_CALIBRATION		12:10 - 13:55 SOLAR_WIND-2021-11-03		12:00 - 19:00 J1825-134_TRACKING		11:22 - BEAM3_1509+5531
14:00	14:00 - 15:58 POLARISATION_CALIBRATION	14:00 - 16:30 JUPITER_TRACKING		13:53 - JUPITER_TRACKING		14:40 - BEAM0_1720+1311 14:40 - BEAM0_1813+4013 14:40 - BEAM11_1820+5640	
16:00	16:00 - 17:58 POLARISATION_CALIBRATION		15:48 - 17:52 JUPITER_TRACKING	17:00 - 20:00 JUPITER_TRACKING		16:24 - BEAM14_2020+2847 17:21 - BEAM15_2113+2754	16:00 - 19:00 SATURN_TRACKING
18:00						18:21 - BEAM16_2145-0750 18:57 - BEAM17_2219+4754	
20:00	20:00 - PSRB0329+54 21:00 - 01:00 FRB180916_TF_PULSAR	20:00 - PSRB0329+54 21:00 - 01:00 FRB180916_TF_PULSAR	20:00 - CYGA TRACKING COSMIC 20:59 - 04:00 NCP_COSMIC_DAWN		19:00 - 21:00 EV_LAC_TRACKING 21:00 - 23:30 UV_CETI_TRACKING	19:45 - BEAM18_2330-2005 20:33 - BEAM19_0030+0451 21:04 - BEAM20_0038+0638 21:04 - BEAM22_0141+6000 21:54 - BEAM23_0152+1622	20:00 - 05:00 CRAB_TRACKING
22:00					23:30 - EPS_ERI_TRACKING	22:58 - BEAM24_0323+3944	

Activités | Navigateur Web Firefox | mer. 10 nov. 09:43:34

https://gui-nenufar.obs-nancay.fr/Quick-Look-SST

NenuFAR v3.18.6 | SIMULT\_NRT\_J1400-1431 | 1 hour

Hello, Cedric Administrator | 08:43:33 UTC

- Stairway To Heaven
- Planning
- Coordinates
- Dashboard
- Real time
  - Subbands
  - Beamlets
  - Crosslets
  - Quick look SST
  - Quick look BST
- Google map
- Survey
- Reports
- Maintenance
- Tools
- Documentation

MA 00 ( Rot : 0°) | MA 01 ( Rot : 30°) | MA 02 ( Rot : 300°) | MA 03 ( Rot : 200°)

MA 04 ( Rot : 20°) | MA 05 ( Rot : 180°) | MA 06 ( Rot : 180°) | MA 07 ( Rot : 230°)

MA 08 ( Rot : 150°) | MA 09 ( Rot : 240°) | MA 10 ( Rot : 290°) | MA 11 ( Rot : 310°)

MA 12 ( Rot : 250°) | MA 13 ( Rot : 40°) | MA 14 ( Rot : 330°) | MA 15 ( Rot : 280°)

https://gui-nenufar.obs-nancay.fr/Google-map



Activités | Navigateur Web Firefox | mer. 10 nov. 09:44:40

https://gui-nenufar.obs-nancay.fr/Google-map

### NenuFAR v3.18.6

SIMULT\_NRT\_J1400-1431 1 hour

#### Status of mini-arrays Today at 08:44:38 UTC

**Nançay coordinates**  
Latitude : 47.375944°  
Longitude : 2.193361°  
Altitude : 136.195m

Select a mini-array to see its position on the map :

MA0

Antennas issues  
 Amplifiers issues

- Last amplifiers test** : 18 hours ago.  
2021-11-09 15:13:00
- Last antennas test** : 17 hours ago.  
2021-11-09 15:36:00
- Last relay test cell** : 18 hours ago.  
2021-11-09 15:11:00
- Last relay test full** : 4 months ago.  
2021-07-01 14:58:00

Facebook | Twitter | RSS

Activités | Navigateur Web Firefox | mer. 10 nov. 09:45:16

https://gui-nenufar.obs-nancay.fr/Backend-Hardware

NenuFAR v3.18.6 | SIMULT\_NRT\_J1400-1431 | 1 hour

### Backend status

- Power on sockets: OFF-ON (0 to 1) | 04:00 to 08:00
- Temp Threshold: 35°C to 15°C | 03:00 to 08:00
- alarm: OK
- Chassis T° (18°C - 33°C): 10°C to 40°C | 04:00 to 08:00
- HPAPB DCDC converter T°: 20°C to 50°C | 04:00 to 08:00
- 0V9 DCDC Converter T°: 20°C to 50°C | 04:00 to 08:00
- FPGA T°: 20°C to 70°C | 04:00 to 08:00
- FPGA Current (0,20000): 12000 to 18000 mA | 04:00 to 08:00
- FPGA Power (0,100000): 12000 to 18000 mW | 04:00 to 08:00
- HPAPB Current (0,10000): 3750 to 4500 mA | 04:00 to 08:00
- HPAPB Power (10000,100000): 45000 to 52500 mW | 04:00 to 08:00
- Horloge PPS Counter [0-2\*32-1]: 0 to 1 | 04:00 to 08:00
- Horloge Eth 1GbE PLL [0-1]: 0 to 1 | 04:00 to 08:00
- Horloge JESD CLK [0-1]: 0 to 1 | 04:00 to 08:00
- Horloge Eth 10GbE PLL 0/1 [0-1]: 0 to 1 | 04:00 to 08:00
- ADC Overflow counters 0A 0B: 0 to 1 | 04:00 to 08:00
- ADC Overflow counters 1A 1B: 0 to 1 | 04:00 to 08:00
- ADC Overflow counters 2A 2B: 0 to 1 | 04:00 to 08:00
- ADC Overflow counters 3A 3B: 0 to 1 | 04:00 to 08:00

08:45:15 UTC

- Stairway To Heaven
- Planning
- Coordinates
- Dashboard
- Real time
- Google map
- Survey
  - Alerting
  - SST 10s display
  - Mini-Arrays
  - Backend
  - Hardware
  - Software
  - RadioGaGa
  - Servicing
  - Hosts
  - Weather
  - Key projects
- Reports

Facebook | Twitter | RSS

Activités | Navigateur Web Firefox | mer. 10 nov. 09:46:18

https://gui-nenufar.obs-nancay.fr/Logs

NenuFAR v3.18.6 | SIMULT\_NRT\_J1400-1431 | 1 hour

Hello, Cedric Administrator

08:46:17 UTC

- Stairway To Heaven
- Planning
- Coordinates
- Dashboard
- Real time
- Google map
- Survey
- Reports
  - Daily
  - Daily data
  - Logs
  - GUI statistics
- Maintenance
- Tools
- Documentation

### All software logs

Soft logs	Size	Last modified	Status
SQL error (DATANCU inconr)	33kB	2021-10-26 20:00:14	unchanged
From LCU (DATANCU inconr)	1kB	2019-01-17 16:10:56	unchanged
NenuFAR Todo (FNCU)	13kB	2021-05-20 03:30:17	unchanged
Maintenance Auto (FNCU)	190kB	2021-11-07 10:10:08	unchanged
Mr Status Error (NCU)	5MB	2021-11-09 15:27:32	modified
Signal Test (NCU)	395kB	2021-11-09 12:58:15	modified
Test Ampli (NCU)	810kB	2021-11-09 15:13:03	modified
Test Relay cell (NCU)	4MB	2021-11-09 15:11:24	modified

Backend logs	Size	Last modified	Status
FPGA version (NCU)	241kB	2021-11-09 12:43:37	modified
Configuration Error (NCU)	131kB	2021-11-08 20:55:00	unchanged
Controller Error (NCU)	3MB	2021-10-30 06:15:04	unchanged
Pointing Error (NCU)	6kB	2021-01-11 07:59:00	unchanged
Read Stats Error (NCU)	1MB	2021-11-08 20:50:18	unchanged
TBB service Log (nenufarB0)	1MB	2021-11-10 00:01:02	modified

GUI logs	Size	Last modified	Status
WebServer	5MB	2021-11-09 12:45:43	modified
WebServer Beta	64kB	2021-11-08 13:03:24	unchanged
Deploy	135kB	2021-10-19 11:30:38	unchanged
Zip Creation	843kB	2021-11-05 14:52:40	unchanged
Import Trace	93kB	2021-10-22 21:23:26	unchanged
SubmitLoop	69kB	2021-06-28 07:52:30	unchanged
Gui Mails	3MB	2021-11-10 00:01:01	modified

Releases Notes	Size	Last modified	Status
AntennaTest	432 B	2018-04-03 14:52:17	unchanged
CreParsetFile	3kB	2020-04-30 13:55:27	unchanged
MRStatus	846 B	2019-05-02 08:28:39	unchanged
PointageFire	792 B	2021-07-07 08:17:38	unchanged
BackendControl	9kB	2021-10-13 07:59:22	unchanged
HPAPBFirmware	1kB	2021-02-25 11:07:58	unchanged
PointageAuto	832 B	2021-10-28 15:28:05	unchanged
PointageListen	578 B	2021-10-28 15:27:44	unchanged
SignalTest	402 B	2021-07-12 13:40:51	unchanged
GUI	72kB	2021-10-19 11:24:43	unchanged

# Questions ?

