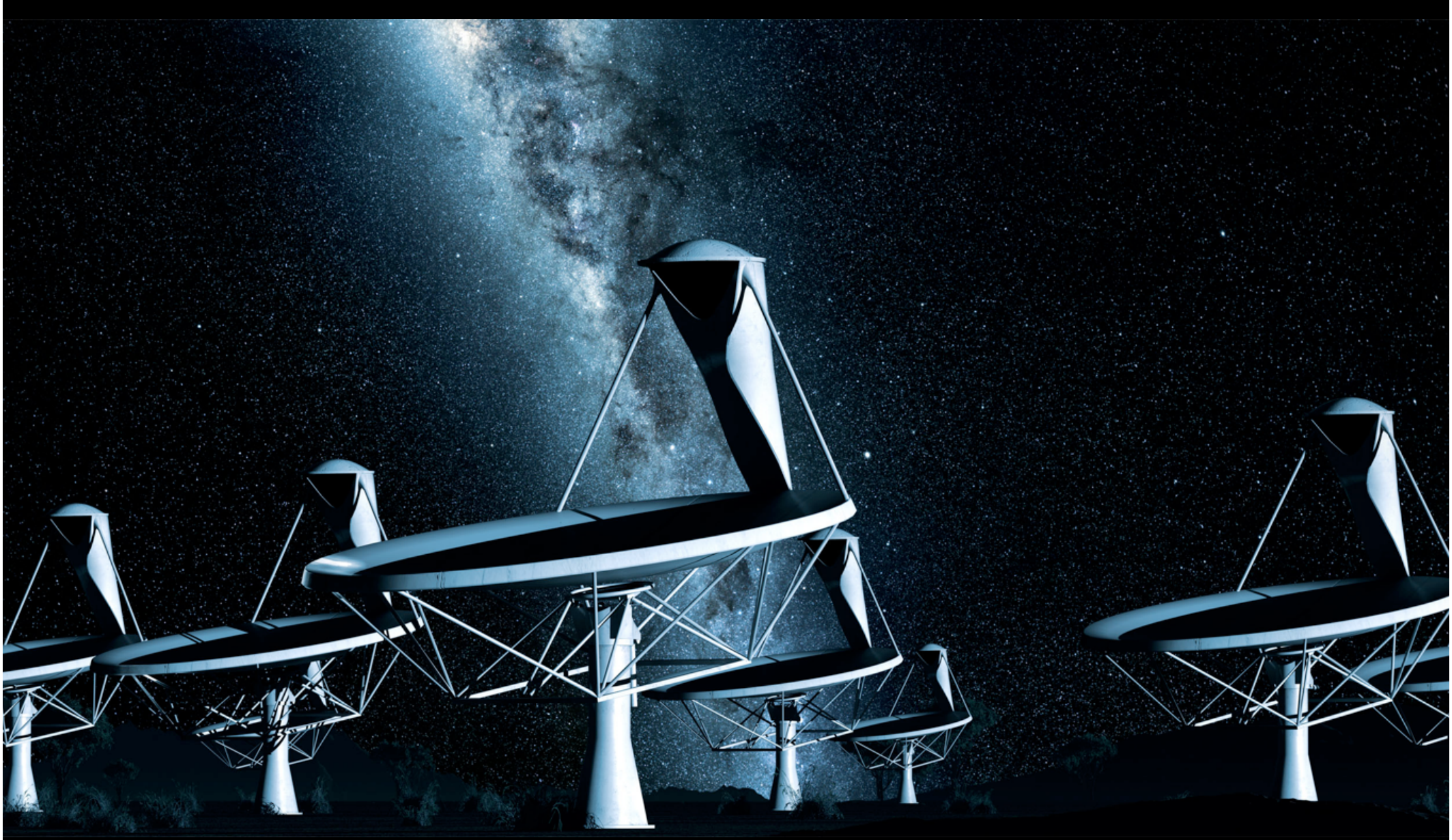
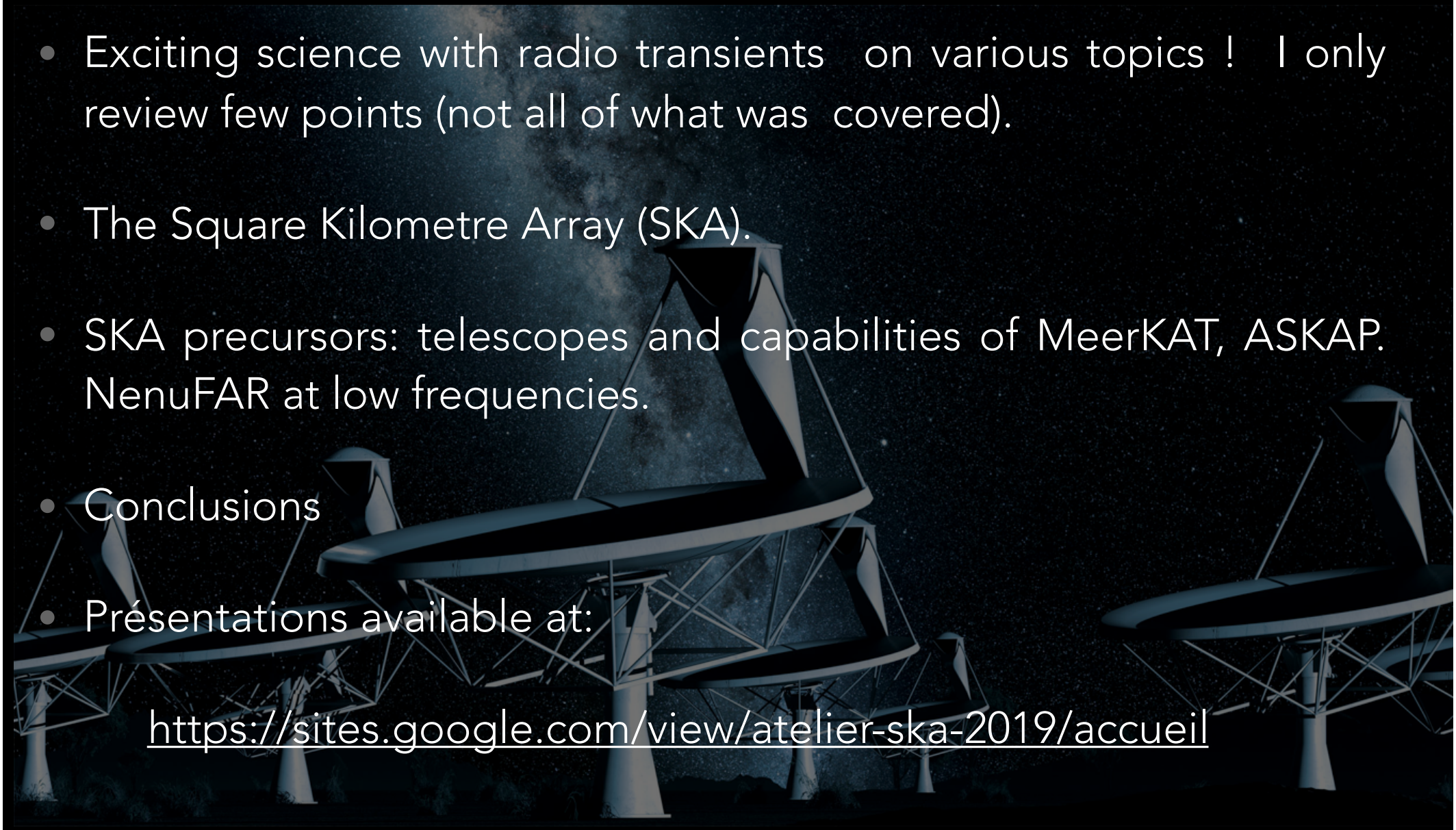


TRANSIENTS WITH SKA AND PRECURSORS : A SUMMARY

S. CORBEL (UNIV. PARIS & CEA SACLAY & OBS. PARIS/USN)

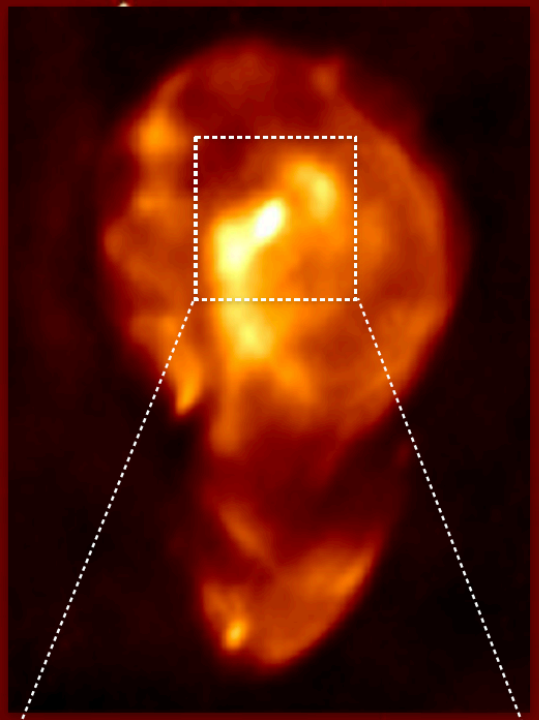
OUTLINE

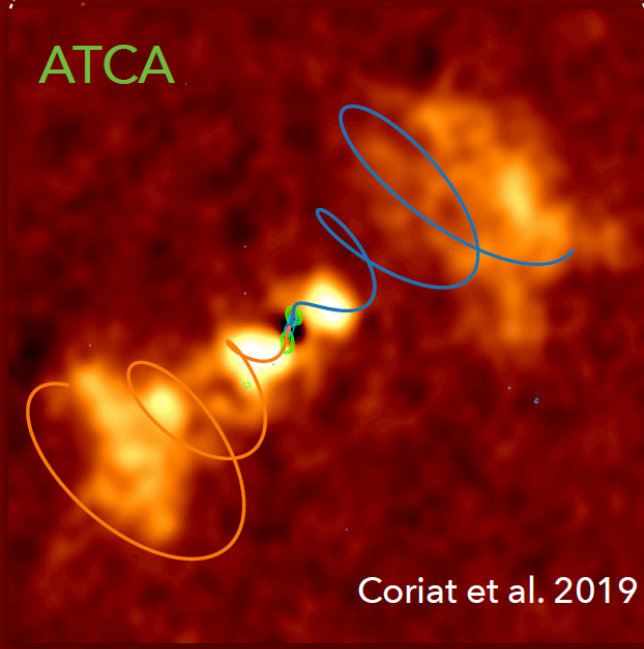


- Exciting science with radio transients on various topics ! I only review few points (not all of what was covered).
- The Square Kilometre Array (SKA).
- SKA precursors: telescopes and capabilities of MeerKAT, ASKAP. NenuFAR at low frequencies.
- Conclusions
- Présentations available at:

https://sites.google.com/view/atelier-ska-2019/accueil

ACCRETING BINARIES (M. CORIAT)



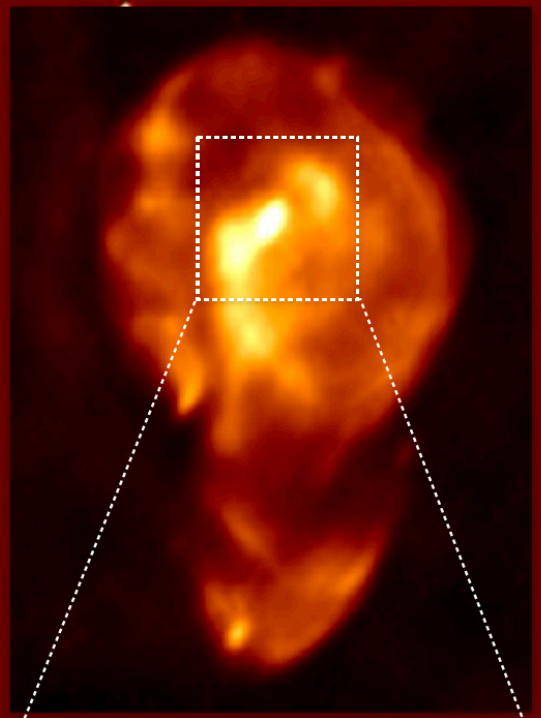


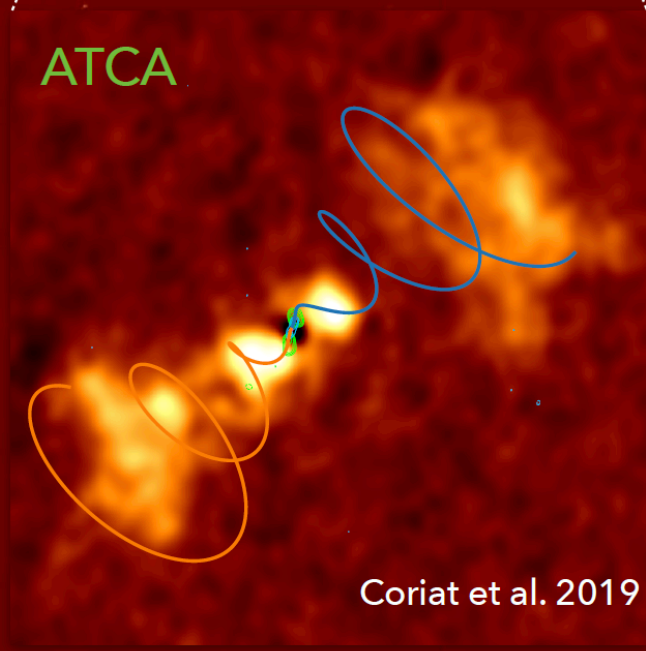
Circinus X-1 (NS, image from MeerKAT)

Coriat et al. in prep

ACCRETING BINARIES (M. CORIAT)

- How are jets launched?
  - What conditions are needed in the accretion flow?
  - Compact vs transient jets
- How do the jet properties vary across compact object classes?
  - BH vs NS vs WD vs…
- How energetic are jets?
  - How much energy do they carry away from the accretion flow?
- What impact do the jets have on their environment?





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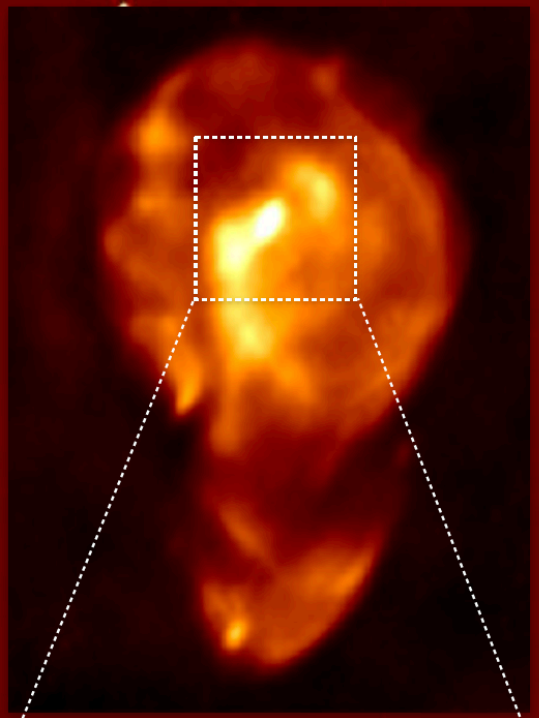
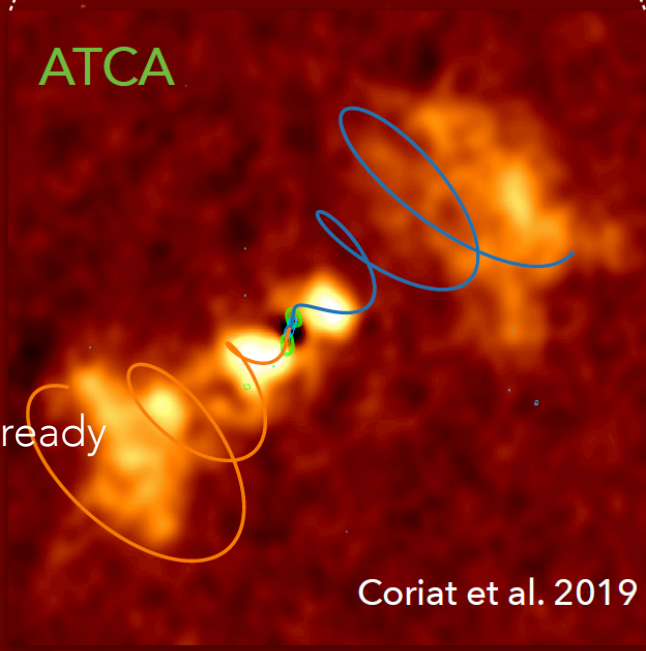
Jets are everywhere : BH, NS (even in high-B system), CV

Radio observations have been playing a key role for several decades already

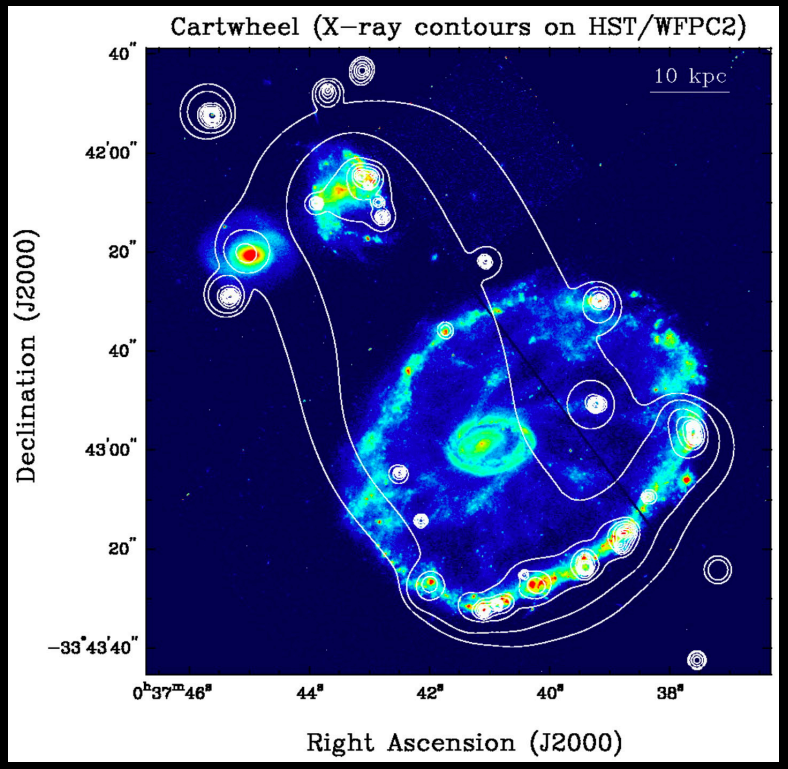


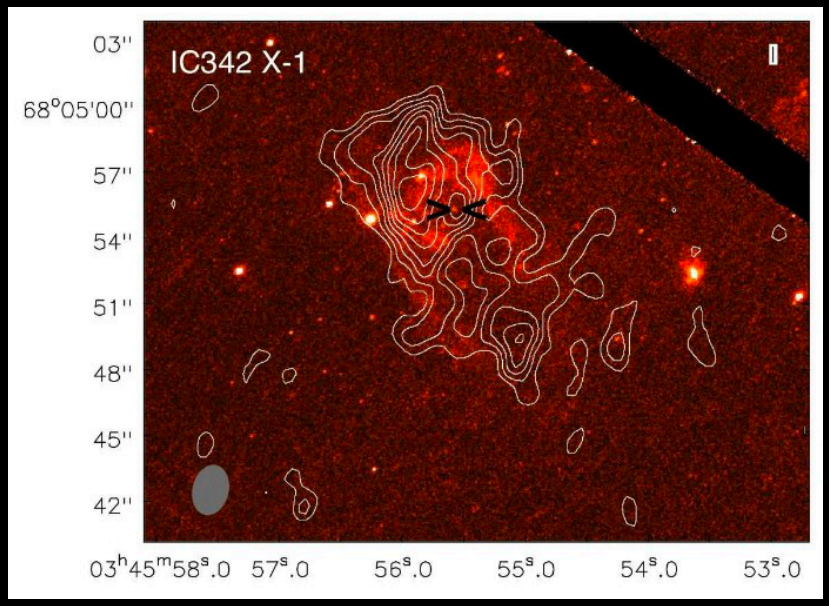


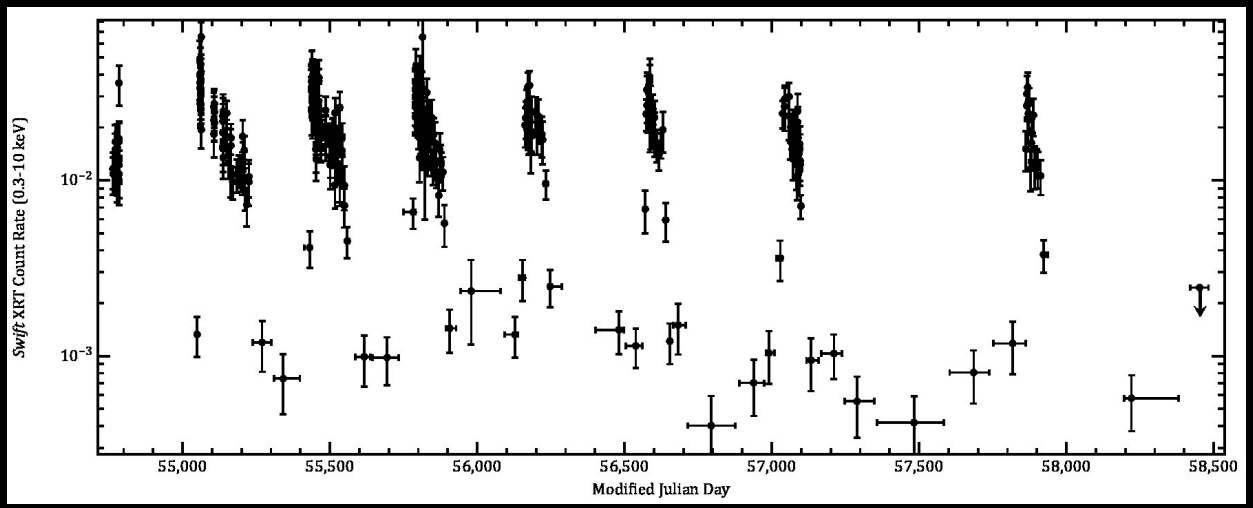
Circinus X-1 (NS, image from MeerKAT)

Coriat et al. in prep

ULX, TDE AND IMBH (N. WEBB)

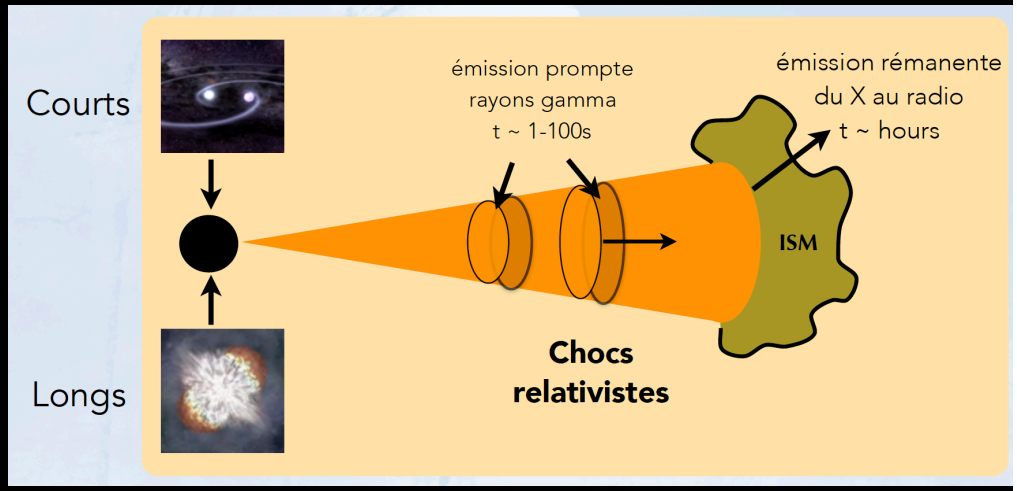


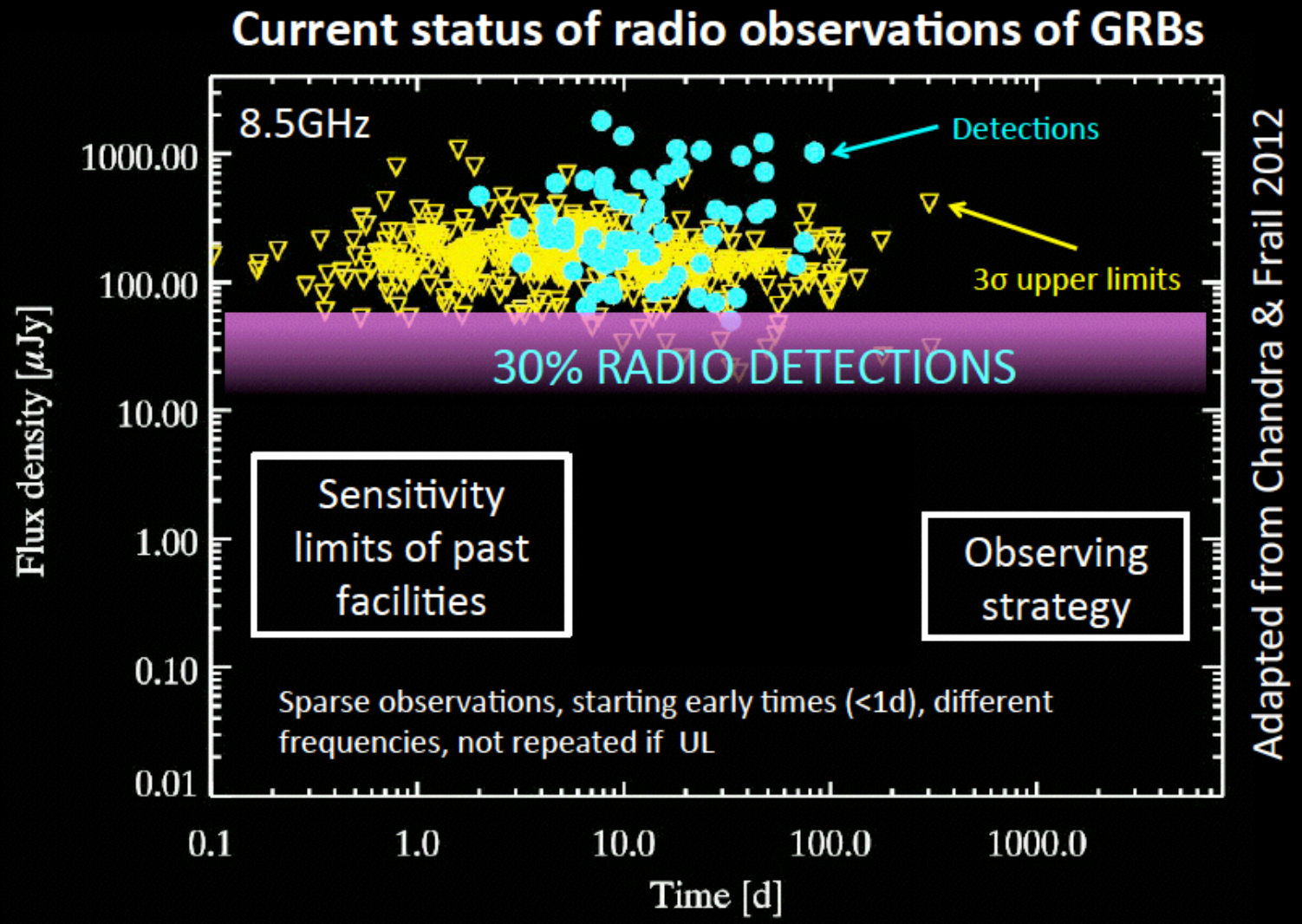




- SKA (μJy sensitivity) observations of ULXs and TDEs should be able to make important contributions to :
  - Accretion and ejection physics
  - When do superEddington disks produce relativistic jets?
  - Understanding the physical nature of the ultraluminous state
  - Identifying the nature of the compact object (pulsations, jets, ...)
  - Understanding the energetics involved in ULXs
  - Finding new TDEs and IMBHs
  - Understanding the nature of the different TDEs
  - Understanding the formation of supermassive black holes

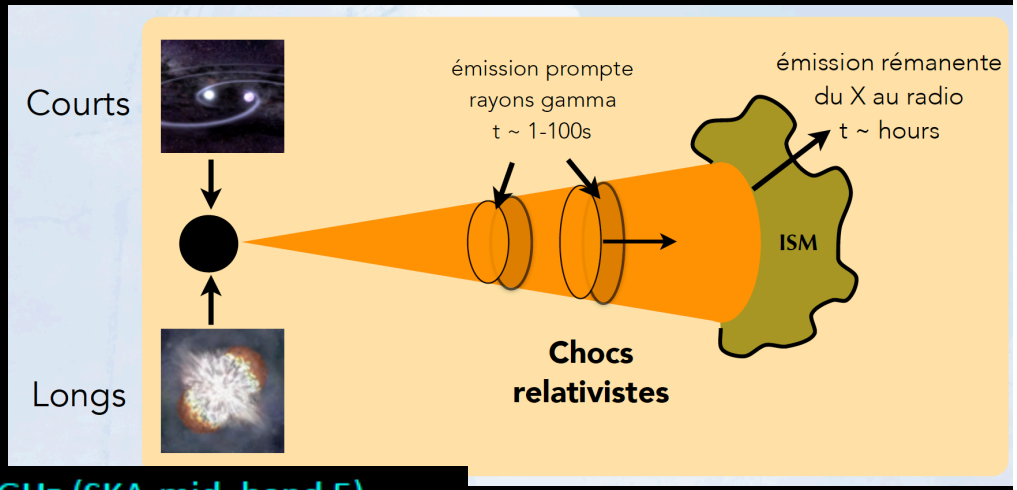
GAMMA-RAY BURSTS (S. VERGANI)

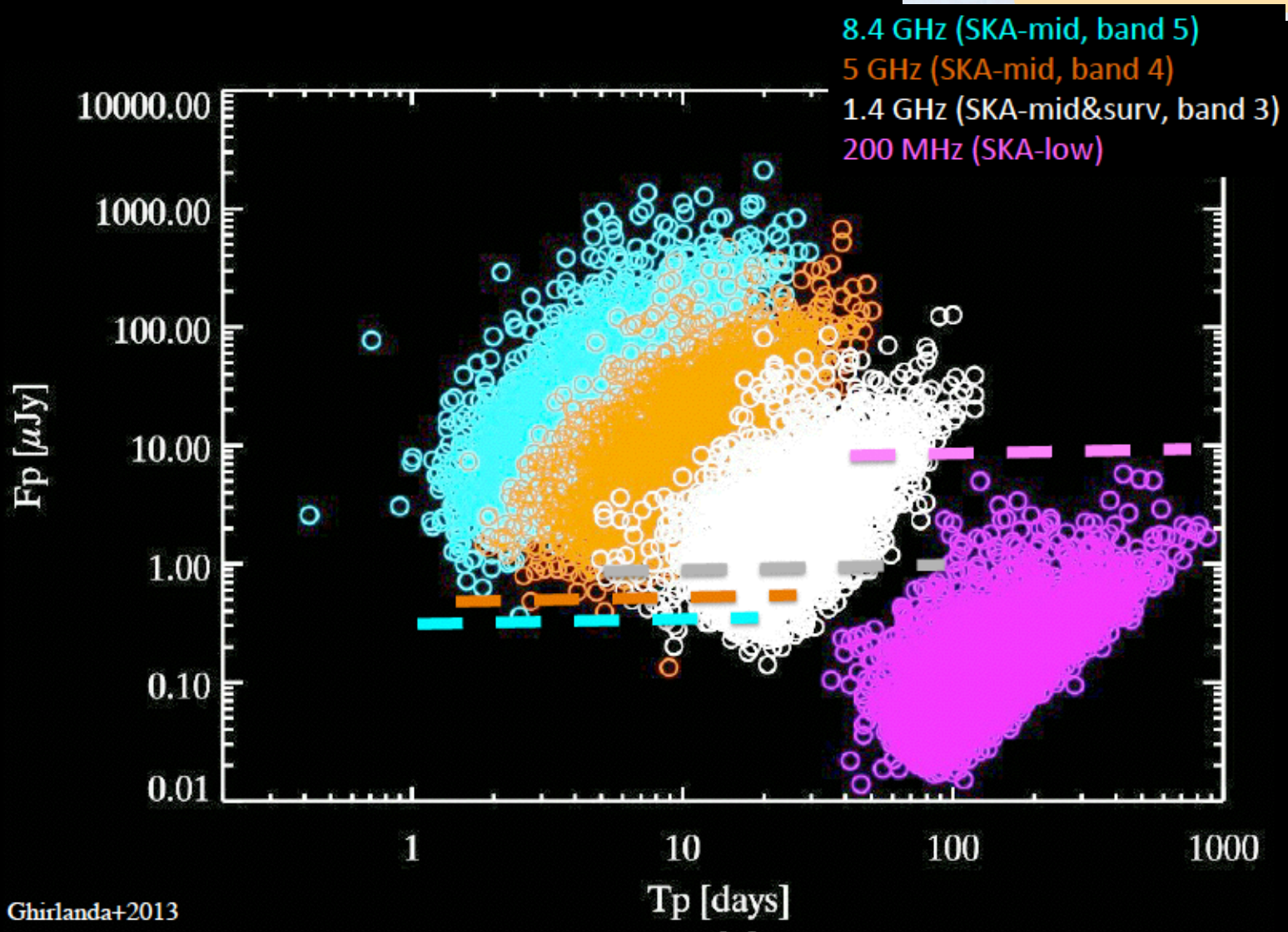




Long GRB

GAMMA-RAY BURSTS (S. VERGANI)



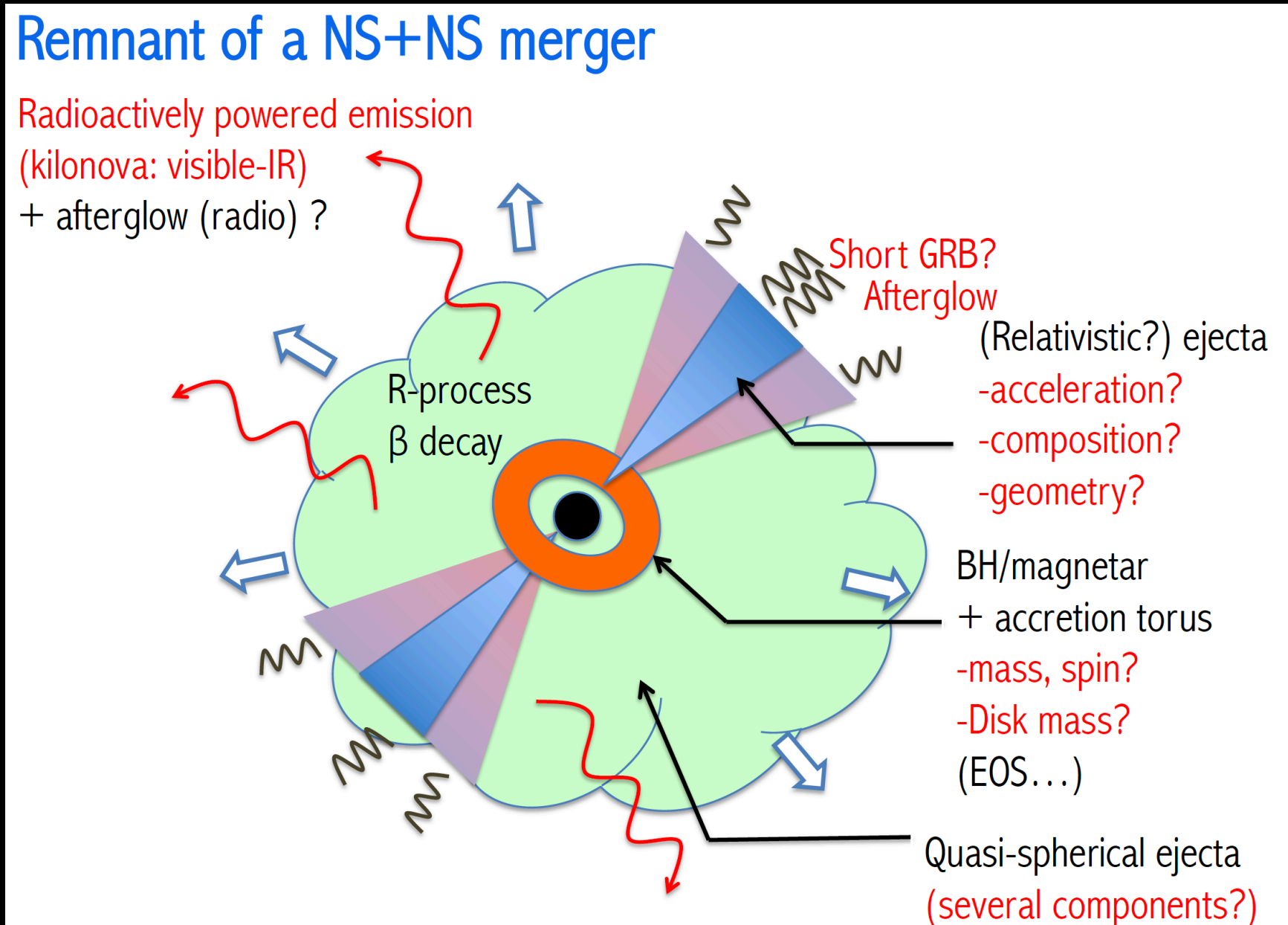


Long GRB

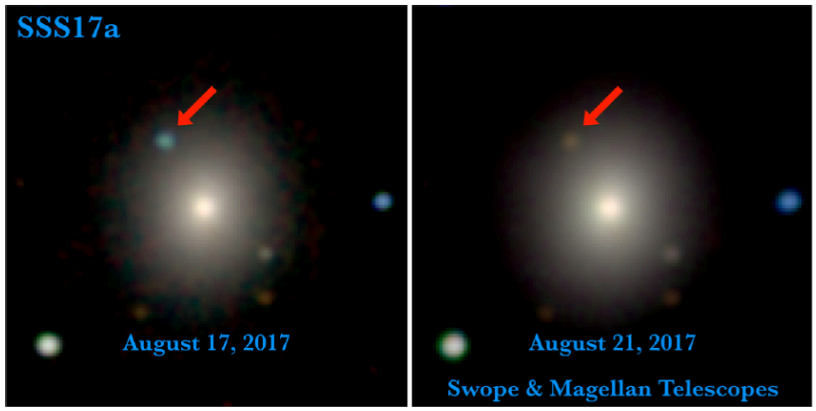
GRAVITATIONAL WAVE EVENTS (F. DAIGNE)

Study case of GW170817

Remnant of a NS+NS merger

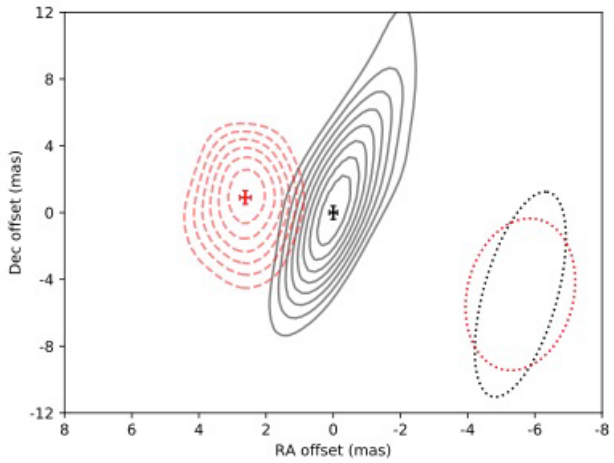


Kilonova= post-merger ejecta: radioactive heating (r-process)/thermal radiation (V, IR)



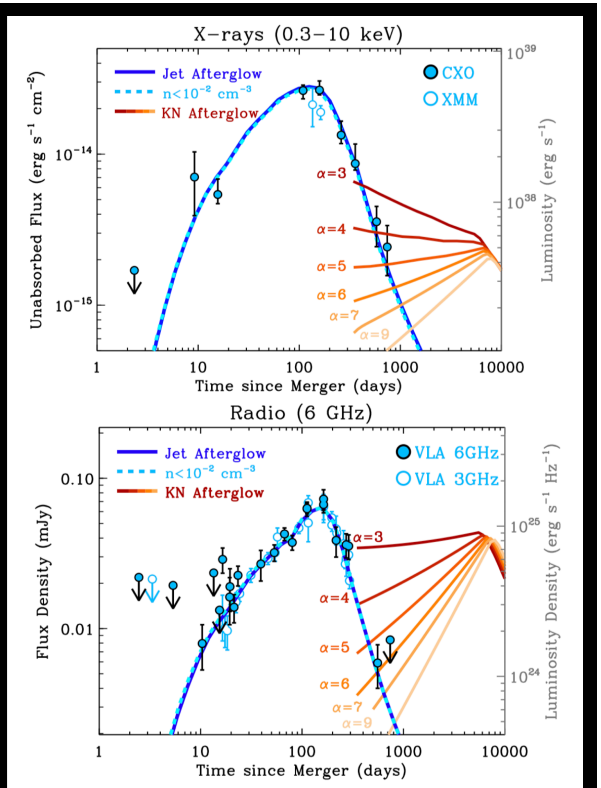
- duration ~ week
- two components: red=dynamical ejecta
  blue=polar ejecta
- a radio afterglow of the kilonova is predicted:
  =deceleration of the KN ejecta
  peak at ~ 10 yr
  peak flux ~ 100 µJy
  can provided an important constraint on the structure of the KN ejecta and on the density of the external medium
- **rate of « orphan » radio KN afterglows? (~BNS rate)**

Afterglow



Proper motion + compact source

- Quasi-spherical afterglow ruled out
- Ejecta with lateral structure pointing towards us



Summary

- Radio observations play a major role for the interpretation of 170817's afterglow
- Radio counterparts of BNS: kilonova afterglow / jet afterglow
  Many constraints: external medium, ejecta/jet structure/geometry, …
- Polarization: constraint on the geometry of the magnetic field
- VLBI: additional constraint on geometry, viewing angle, Lorentz factor

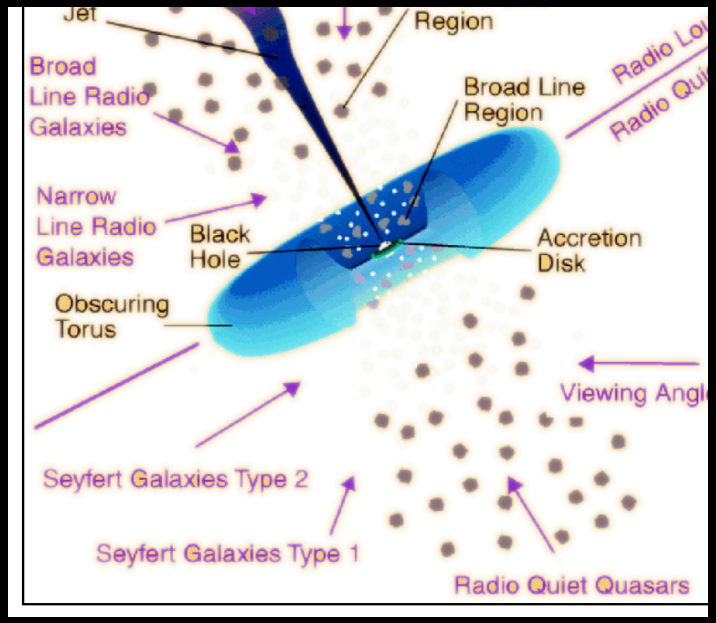
- More observations to come (O3, …): more diversity? (NSBH?)

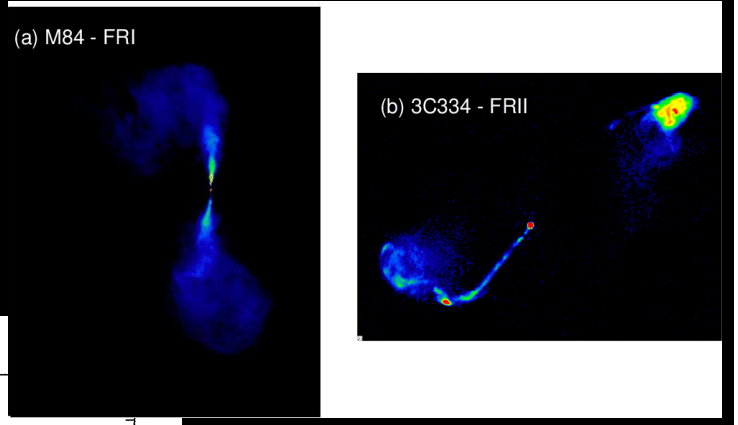
- O3 is here: several BNS events are expected,
  a few with detectable afterglow, all with detectable KN

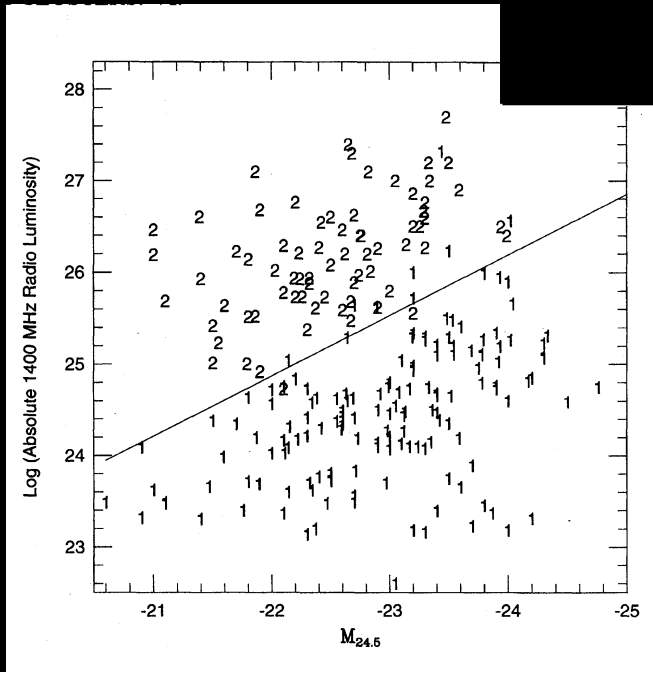
- BUT detectable is not detected! 1. Difficulty to find KN during O3…
  2. Increasing difficulty of VLBI imagery with dist.

- Most events off-axis: probe jet geometry and emission therein
- New constraints on the population of fast-merging binaries.
- Orphan kilonovae/afterglows?

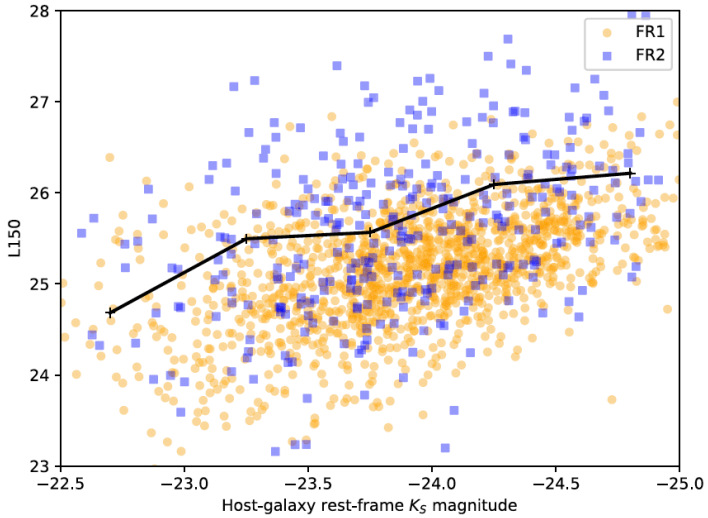
ACTIVE GALACTIC NUCLEI (P.O. PETRUCCI)





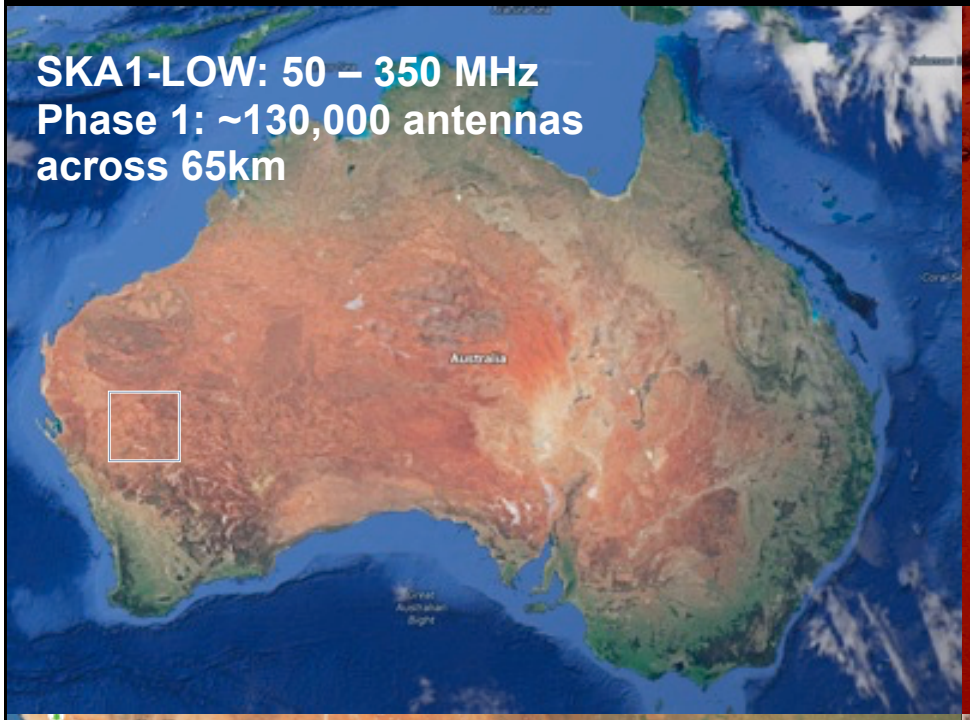


LoTSS (Lofar Two-meter Sky Survey)



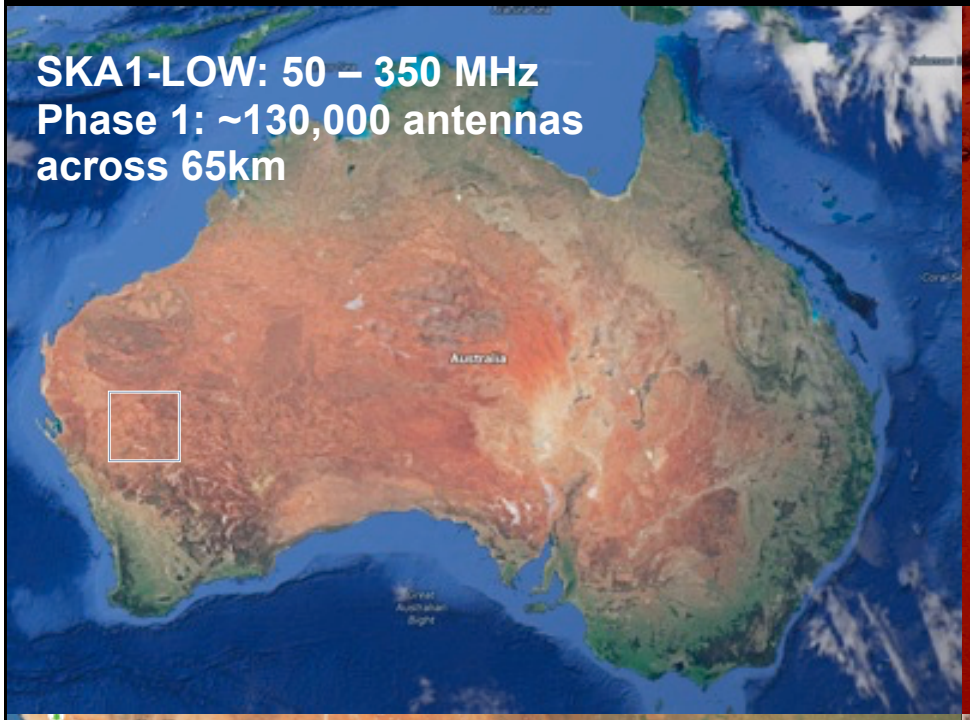
- A great degree of overlap exists between the FRI and FRII populations
- Importance of selection effect

STATUS OF SKA (C. FERRARI)



Construction: 2021 – 2028; Cost cap: €675M

STATUS OF SKA (C. FERRARI)



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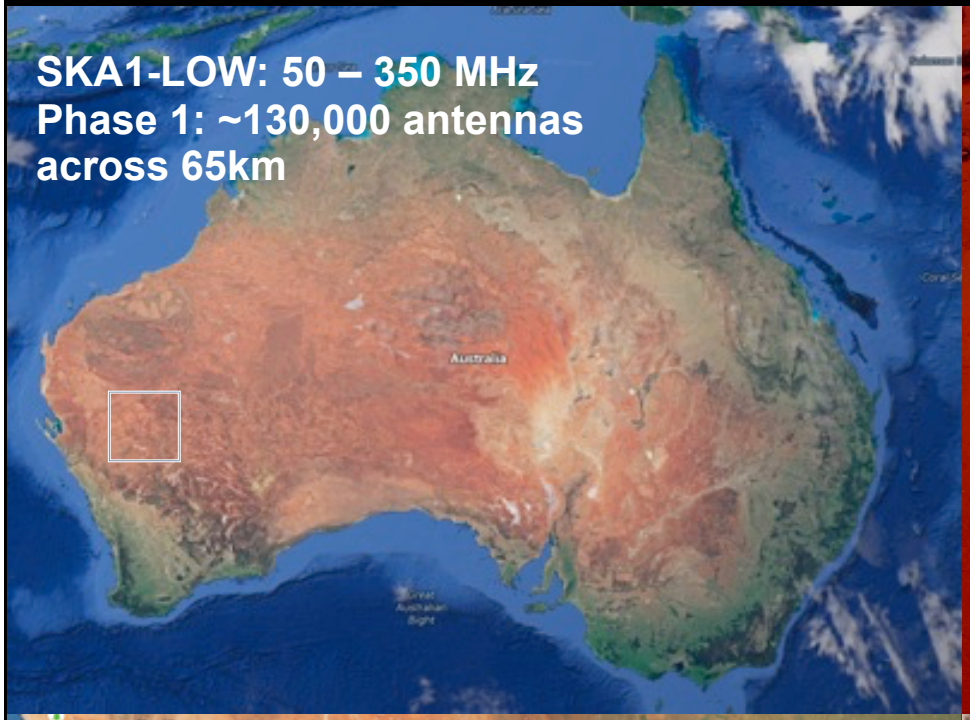

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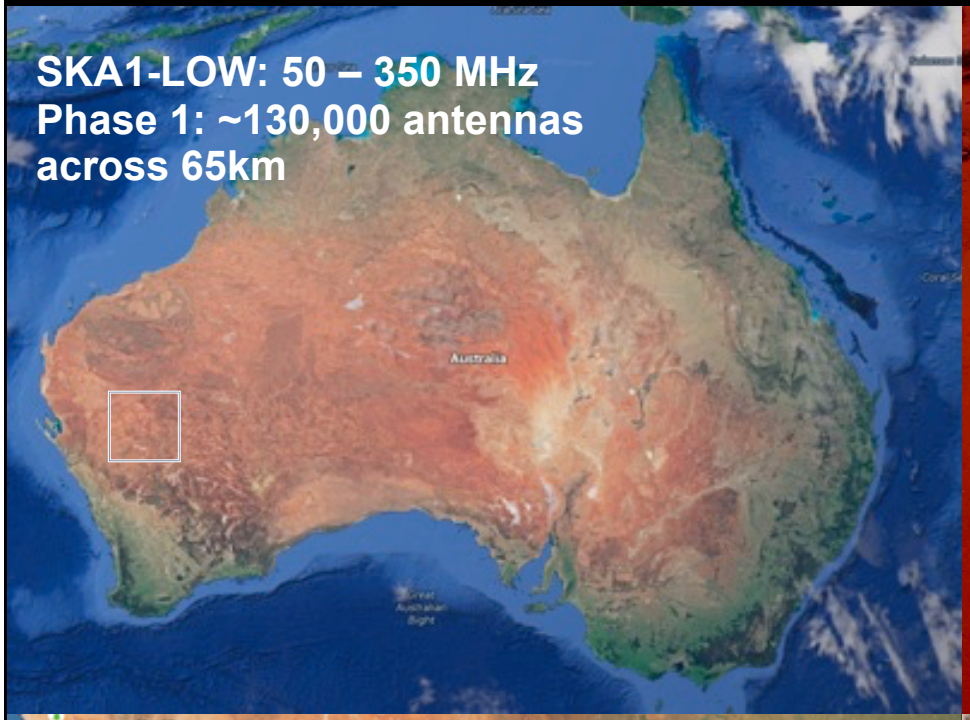

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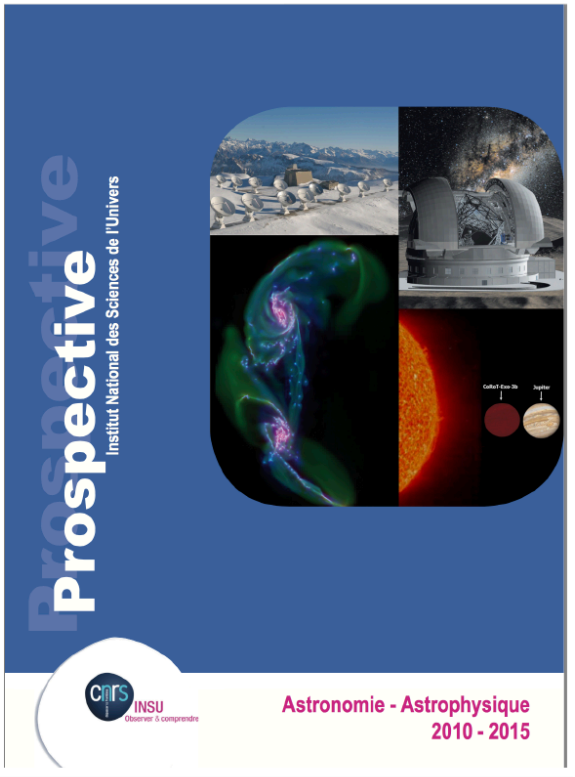
La science de SKA

Adéquation avec les "Grandes Questions" des Programme Nationaux (prospective INSU 2014/2015)

Planétologie/ Berceau de la vie	Comment se forment les étoiles et les planètes? Molécules organiques complexes dans les régions de formation stellaire. Exoplanètes. Soleil et magnétosphère planétaire
Physique fondamentale avec objets compacts	Quel ciel nous révélera l'astronomie des ondes gravitationnelles? L'hypothèse d'équivalence d'Einstein est-elle un principe exact de la physique? La relativité générale est-elle la bonne théorie métrique de la gravitation?
Les sources transitoires	Comment explosent les astres? Quelle est l'influence des objets compacts sur leur environnement?
Evolution des galaxies: gaz & continuum radio	Quelle est l'histoire cosmique des baryons? Quels processus physiques régissent l'évolution des galaxies et leur cycle de matière?
Cosmologie	Dans quel univers vivons-nous? Quelle est la nature de la matière noire?
Origine et évolution du magnétisme cosmique	Génération des champs magnétiques et impact sur l'évolution des structures
Epoque de réionisation & Aube du cosmos	Quelle est l'histoire cosmique des baryons?

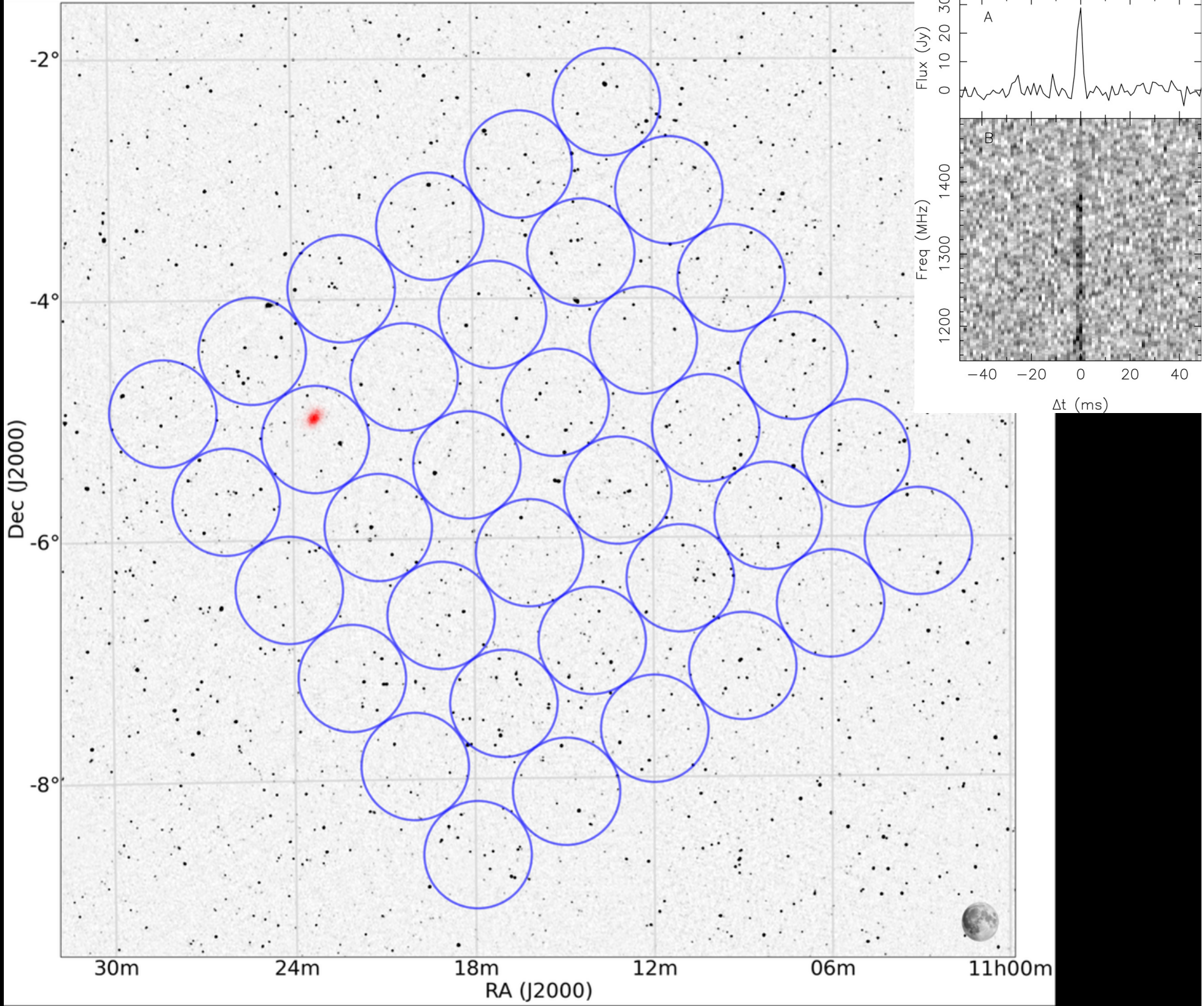


- **Le projet SKA en France:**
  - SKA inscrit en tant que projet sur la Feuille de Route nationale des Infrastructures de Recherche par le MESRI en 2018
  - Le CNRS, chef de file de la MSF, membre de l'Organisation SKA depuis juillet 2018
  - Prochaine révision de la feuille de route en 2020, avec publication attendue des résultat en 2021: nous travaillons pour que SKA y apparaisse comme TGIR

C'est le moment de mobiliser des acteurs au niveau académique et industriel, pour intégrer les équipes internationales, et préparer les futures contributions nationales au projet

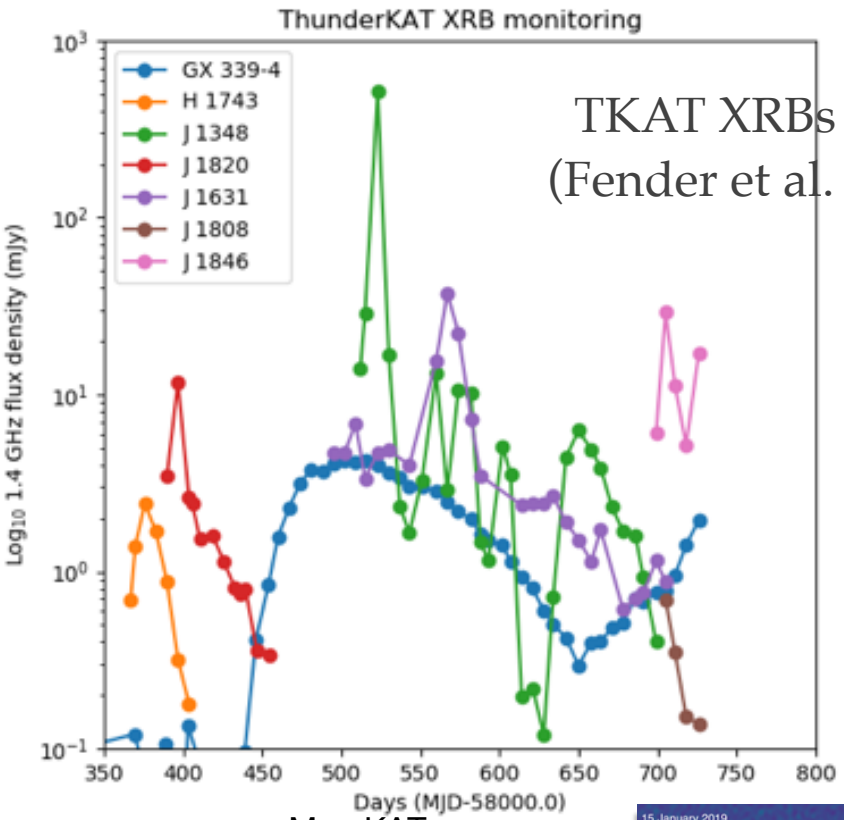
SKA PRECURSORS: ASKAP

- Location: Australia
- Max Baseline : 6 km
- Frequency coverage: 0.7-1.8 GHz
- 36 antennas (12 m) with PAF (30 deg^2 FOV)
- Fully operational, all antennas equipped with PAF


-2°
-4°
-6°
-8°
Dec (J2000)
30m
24m
18m
12m
06m
11h00m
RA (J2000)
A
Flux (Jy)
0
10
20
30
B
Freq (MHz)
1200
1300
1400
−40
−20
0
20
40
Δt (ms)

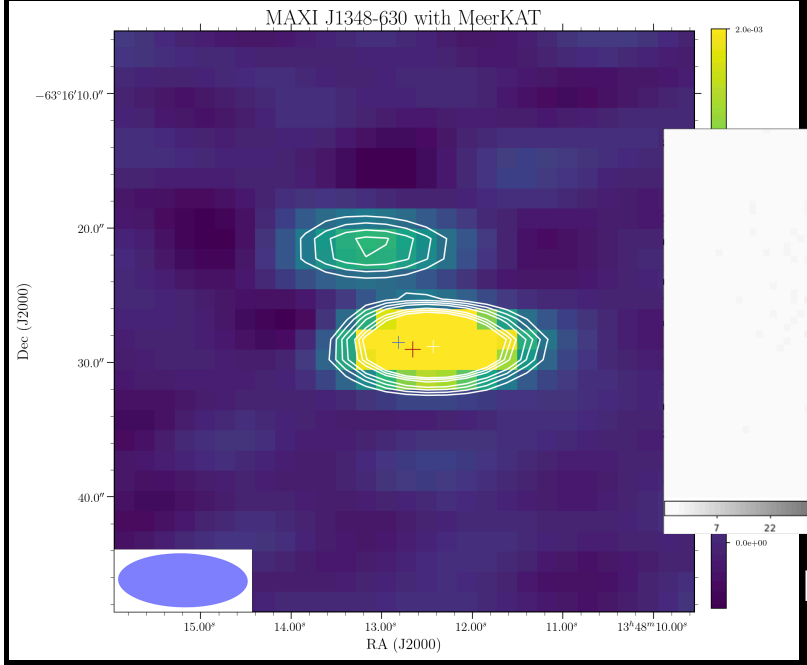
SKA PRECURSORS: MEERKAT

- Location: South Africa
- 64 antennas (13.5 m) over an 8-km baseline
- Frequency coverage: 0.5-10 GHz (now L-band (0.9–1.67 GHz), UHF (0.58–1.0 GHz) : 56 active antennas, S-band (1.75–3.5 GHz – by MPIfR) to come.
- Expanded MeerKAT+20 15-m dishes, baseline up to 18 km
- FOV: 1.69 deg^2 @ 1 GHz
- Inauguration in July 2018. Observations continue for MeerTime, ThunderKAT, MIGHTEE, and Open Time projects



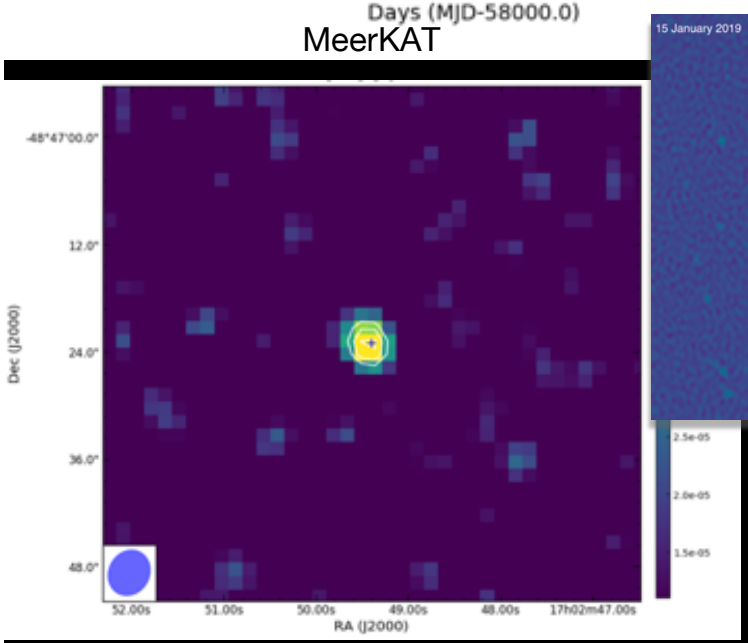
TKAT XRBs (Fender et al.)

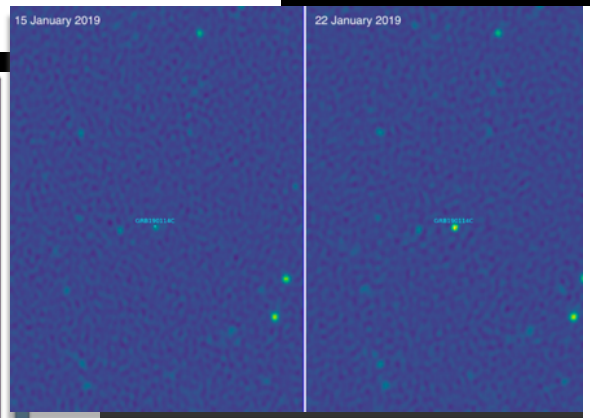
MeerKAT



Espinasse et al. 2019

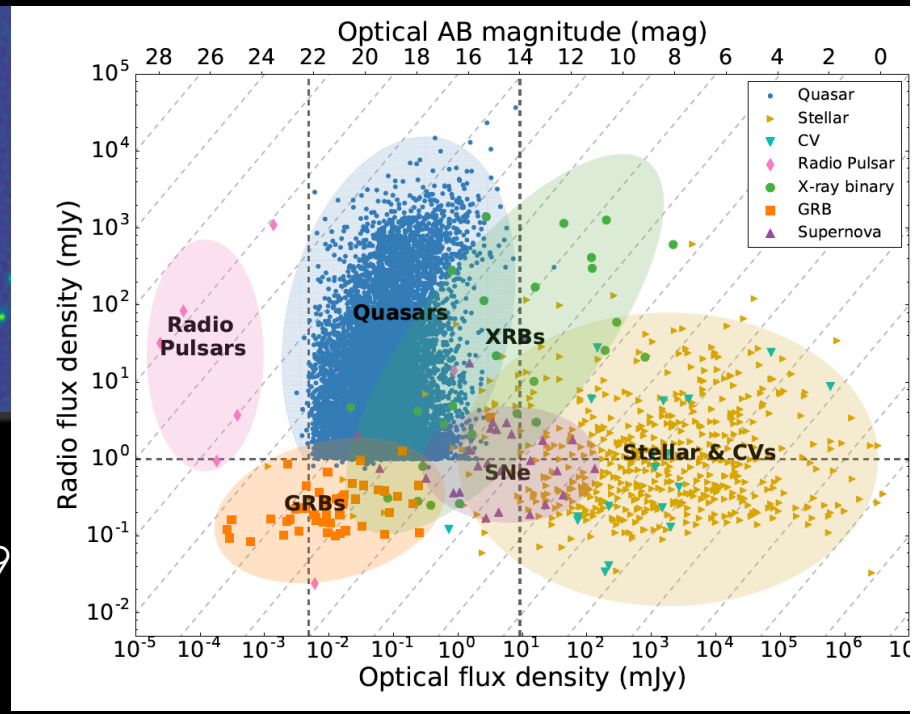
Carotenuto et al. 2019



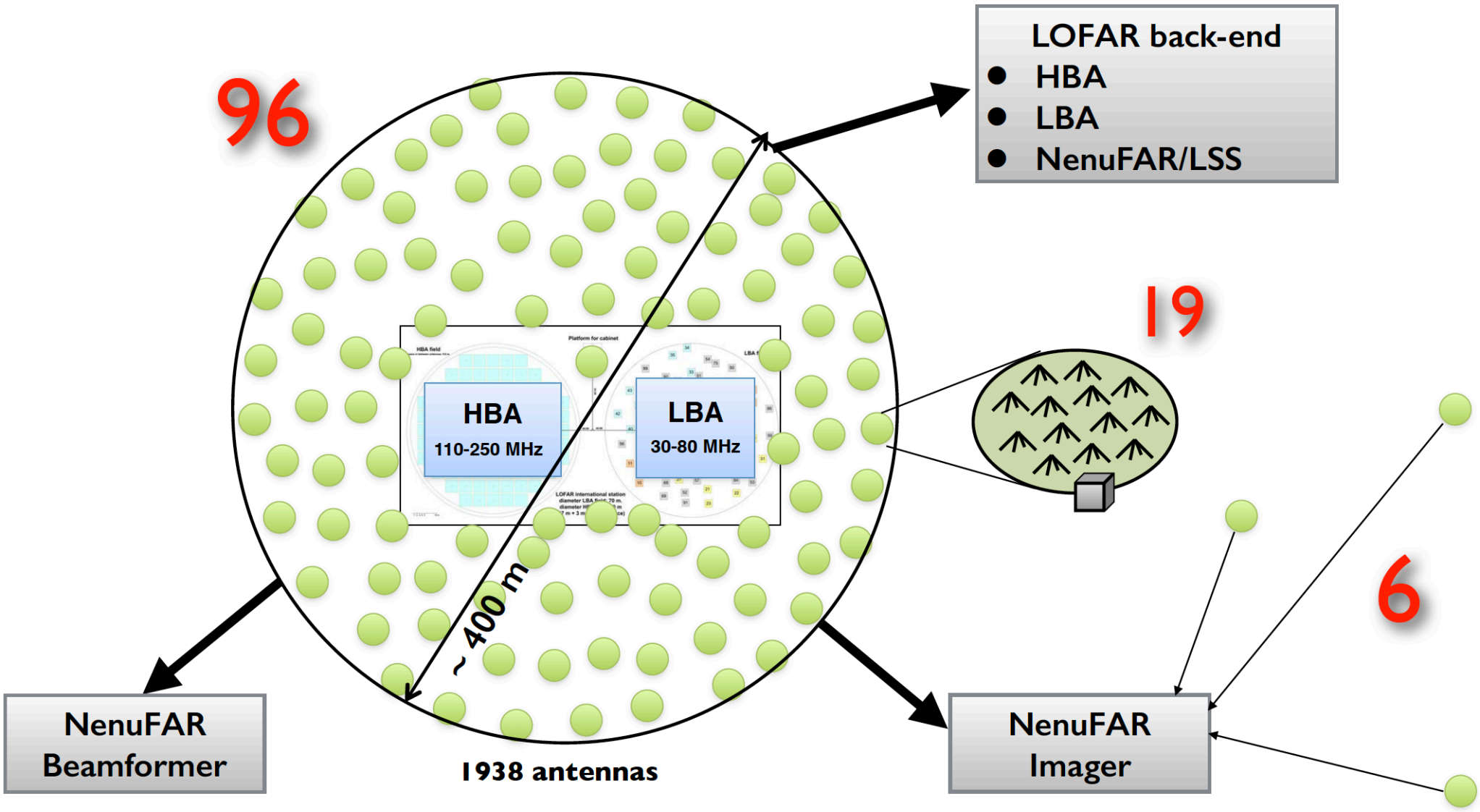


GRB 190114C: Magic collaboration et al. 2019

GX 339-4: Tremou et al. 2019a



SKA PATHFINDER : NENUFAR (J. GIRARD)



- Standalone Beamformer
- Standalone Transient Buffer
- Standalone Imager
- LOFAR "Super Station" mode

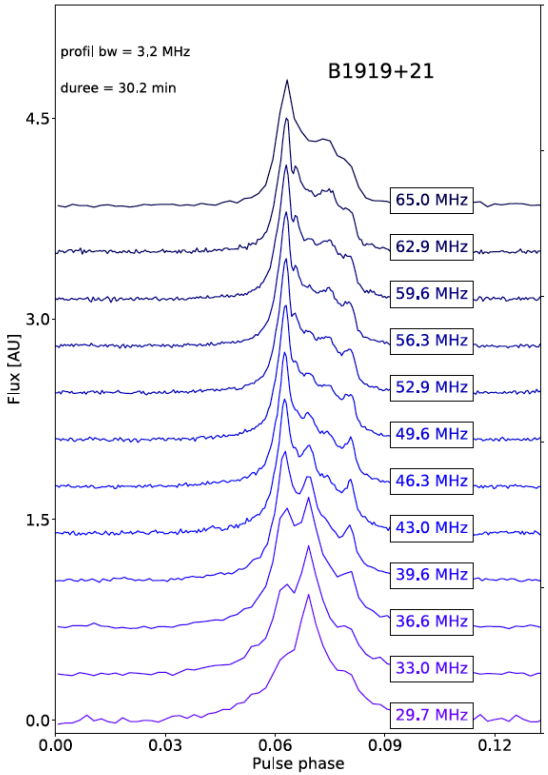
Sensitivity 2-8 x LOFAR

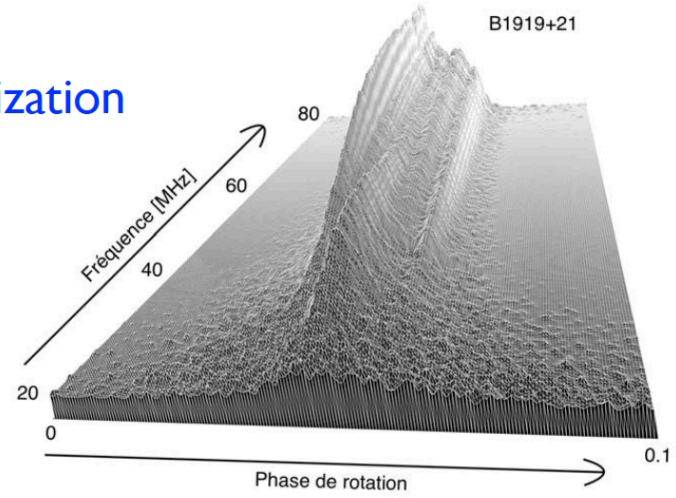
⇒ The world's most sensitive radiotelescope in the range 10-85 MHz

Commissioning / Early Science

- **Pulsars**

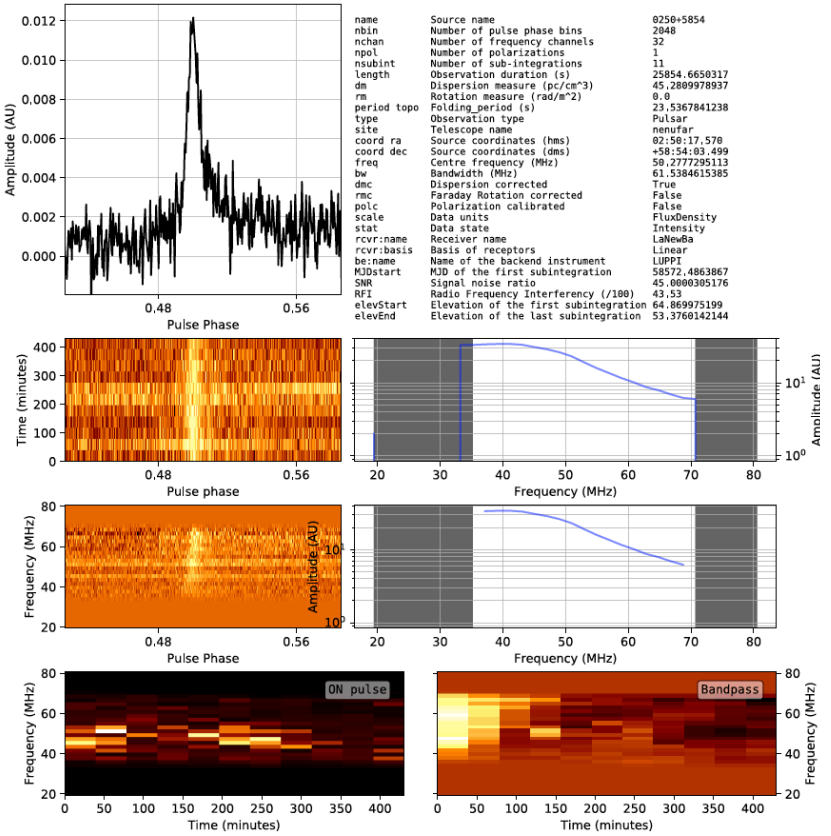
Broadband detection / Polarization



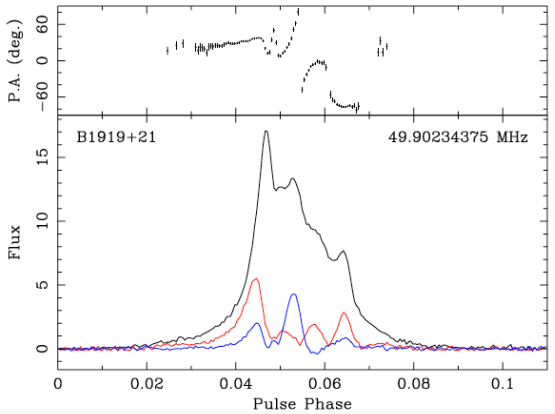


Bondonneau L.
PhD Thesis

Slow pulsar

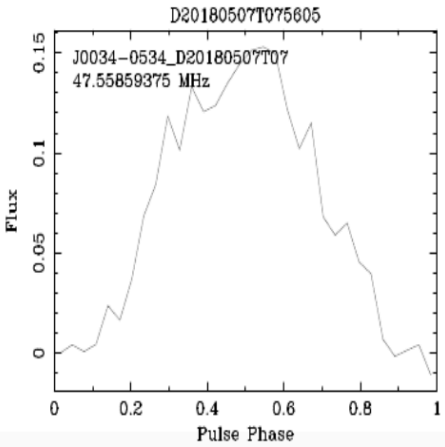


name	Source name	0250+5854
nbin	Number of pulse phase bins	2048
nchan	Number of frequency channels	32
npol	Number of polarizations	1
nsubint	Number of sub-integrations	11
length	Observation duration (s)	25854.6650317
dm	Dispersion measure (pc/cm^3)	45.2809978937
rm	Rotation measure (rad/m^2)	0.0
period topo	Folding_period (s)	23.5367841238
type	Observation type	Pulsar
site	Telescope name	nenufar
coord ra	Source coordinates (hms)	02:50:17.570
coord dec	Source coordinates (dms)	+58:54:03.499
freq	Centre frequency (MHz)	50.2777295113
bw	Bandwidth (MHz)	61.5384615385
dmc	Dispersion corrected	True
rmc	Faraday Rotation corrected	False
polc	Polarization calibrated	False
scale	Data units	FluxDensity
stat	Data state	Intensity
rcvr:name	Receiver name	LaNewBa
rcvr:basis	Basis of receptors	Linear
be:name	Name of the backend instrument	LUPPI
MJDstart	MJD of the first subintegration	59572.4863867
SNR	Signal noise ratio	45.0000305176
RFI	Radio Frequency Interferency (/100)	43.53
elevStart	Elevation of the first subintegration	64.869975199
elevEnd	Elevation of the last subintegration	53.3760142144



Millisecond pulsar

observatory	nenufar
obs.id	J0034-0534_D20180507T075605_010072
PSRNAME	J0034-0534
JNAME	J0034-0534 bhl+94
P0	0.00187709210837433
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)

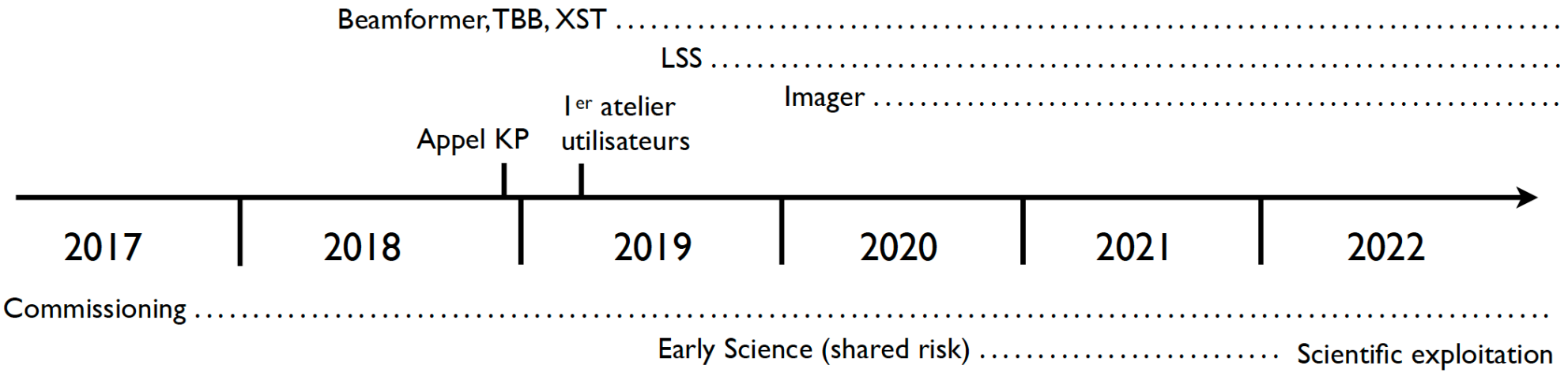


Timeline

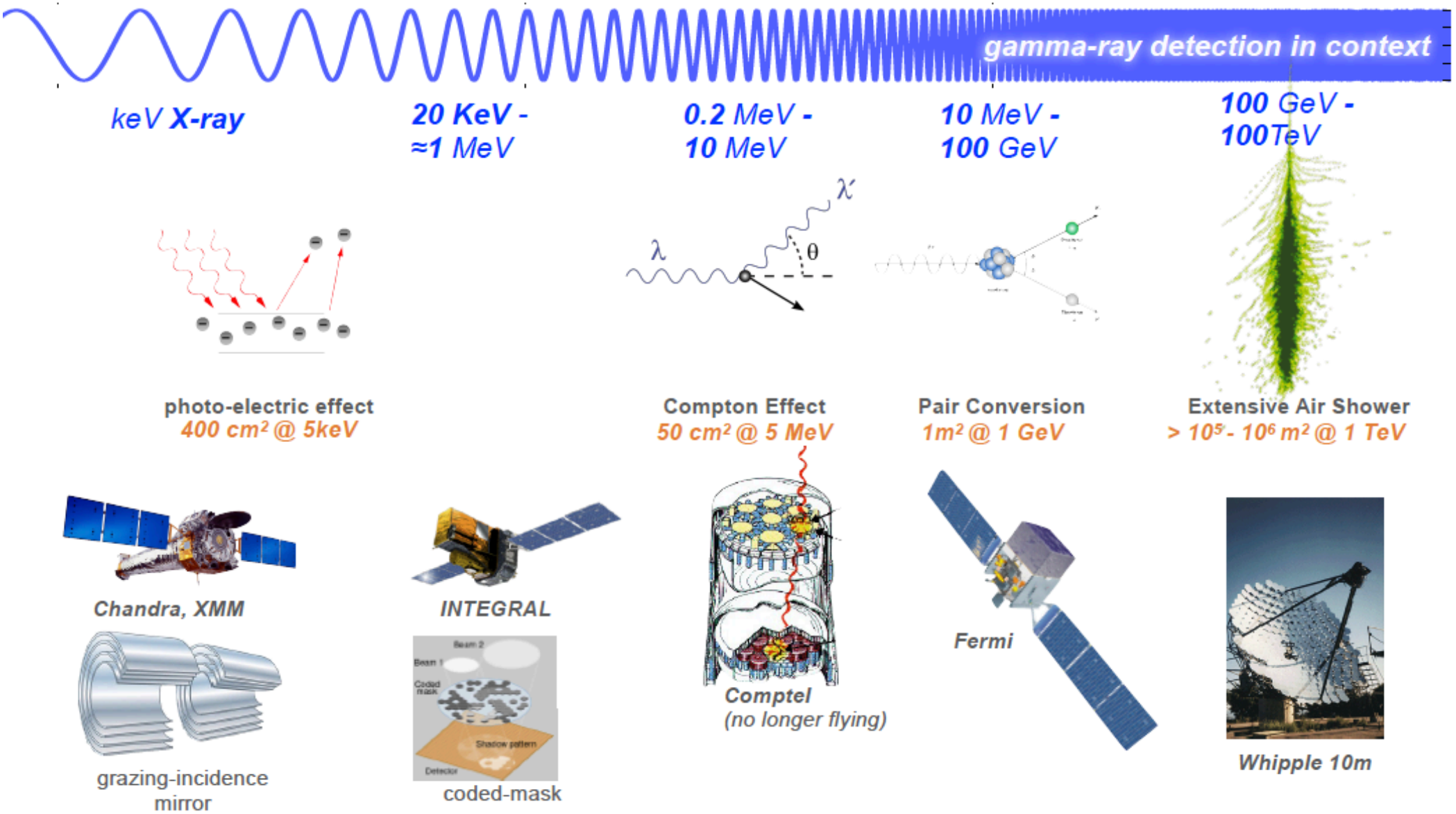
- 2008 : Initial idea & workshop :
- 2009-2013 : Design study
- 2014-2019 : Construction (75%)
- 2016-2019 : Tests, Qualification, Commissioning
- 2019/03 : 1st Users Workshop
- 2019/7/1 : Early science begins
- 2019/10/03 : Inauguration of NenuFAR
- 2022/1/1 : Early science (and construction?) ends ; start of nominal exploitation

  => gradual increase of open time from ~10-30% to ~100% in 5-10 years

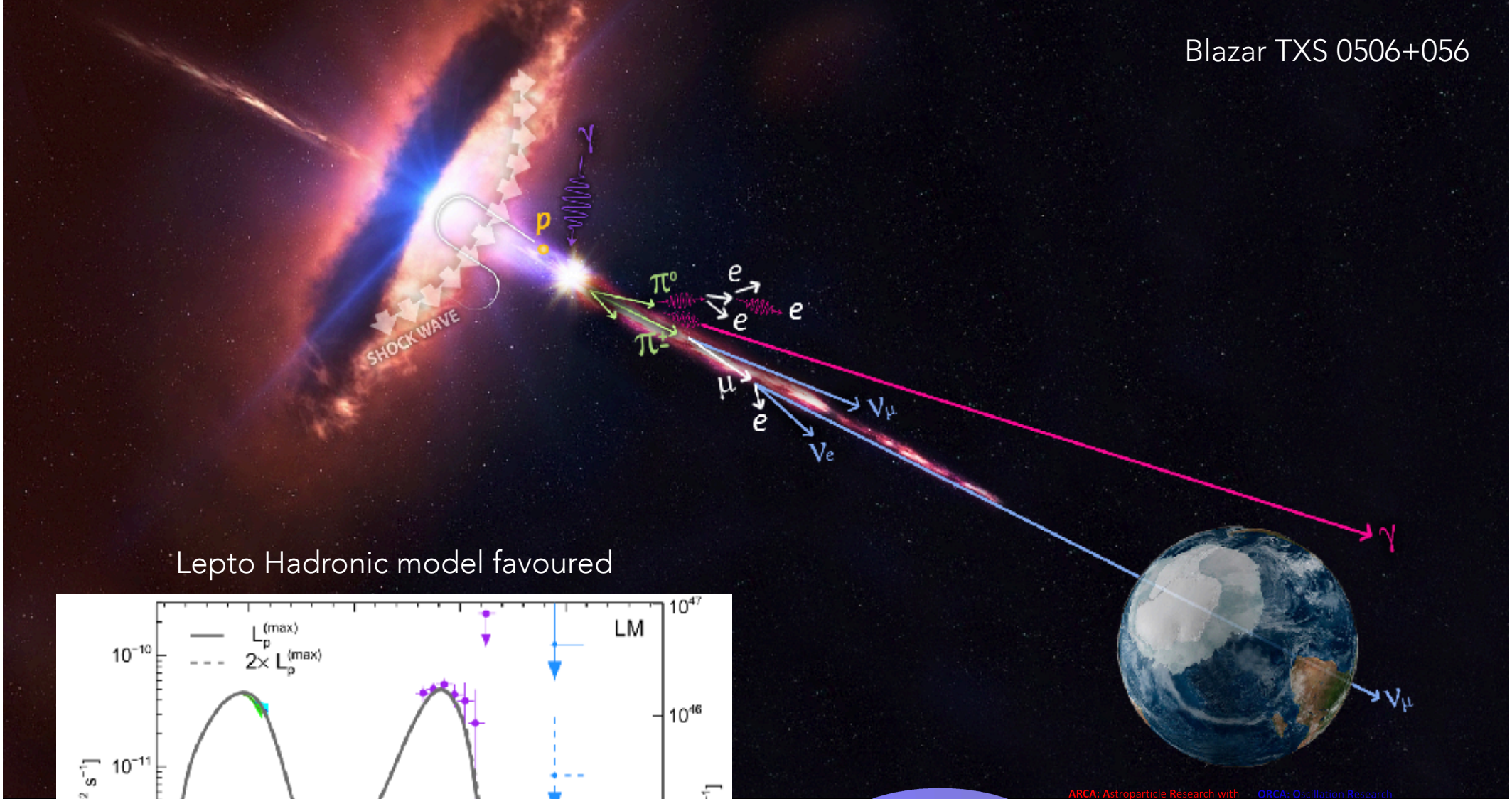
KP on Transients (Corbel, Girard), Pulsars (Griessmeier), FRB (Decoene)



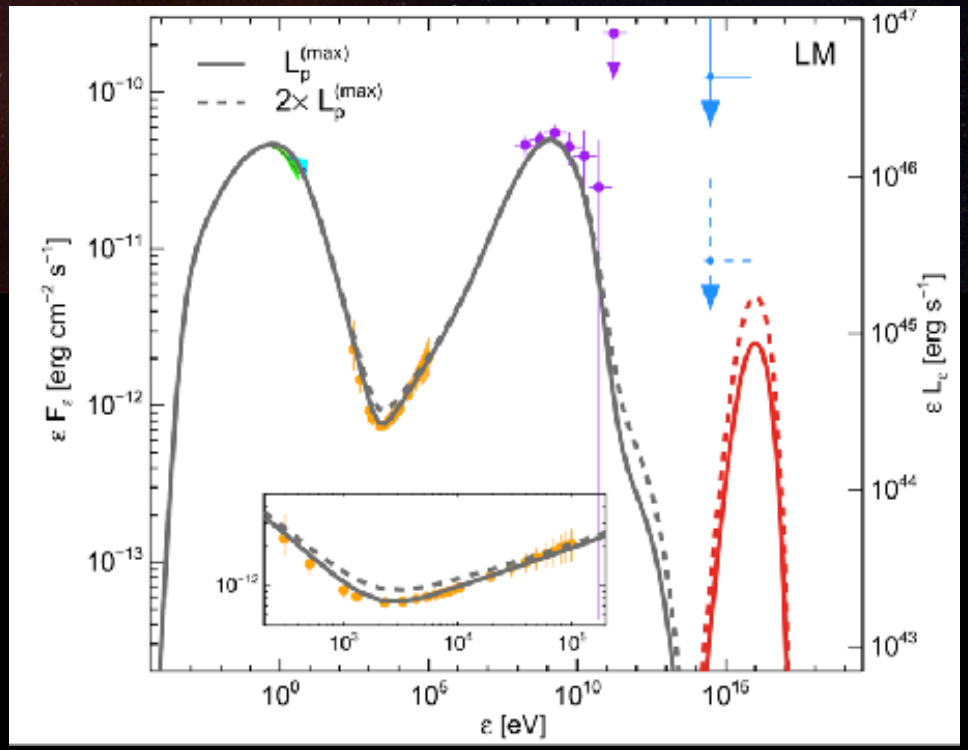
SYNERGIES, MULTI-WAVELENGTH, MULTI-MESSENGERS (D. GOTZ, A. COLEIRO)

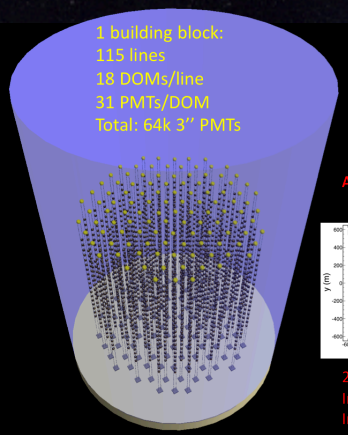


Blazar TXS 0506+056



Lepto Hadronic model favoured

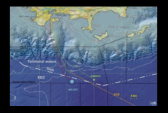




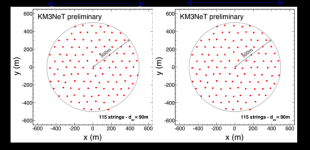
ARCA: **A**stroparticle **R**esearch with **C**osmics In the **A**byss

All-flavour neutrino astronomy

ORCA: **O**scillation **R**esearch with **C**osmics In the **A**byss



Neutrino physics: Mass hierarchy, oscillations



2 building blocks (1 Gton)
Inter-DOM spacing: ~36m
Inter-DU spacing: ~100m

1 building block (6 Mton)
Inter-DOM spacing: ~9m
Inter-DU spacing: ~23m

KM3NeT 2.0 Letter of Intent:
J. Phys. G 43 (8), 084001, 2016

CONCLUSIONS

- Une riche diversité de chercheurs dans différents domaines avec des contributions significatives (en radio mais pas que) :
    - XRB (découvertes des microquasars, corrélation radio/X/OIR, modélisation)
    - ULX (première contrepartie radio des ULX = bubble + HLX-1) + TDE
    - Pulsars (PTAs!), FRB (campagne multi-longueurs d'onde du 1er répéteur)
    - AGNs (de fortes similarités avec binaires, radio discriminant ?)
    - GRB, GW: Une physique très riche avec les suivis des rémanences
- SKA: Grand observatoire pour les 50 années à venir. Grande capacité de survey.
- Précurseurs/éclaireurs: ASKAP/MeerKAT et NenuFAR à basse fréquence. Même si SKA n'est pas encore disponible, il y a largement de quoi s'impliquer dès maintenant avec les précurseurs et éclaireurs
- Synergies multi-longueurs d'onde (hautes énergies, LSST, …), multi-messengers, ..
- Prospective INSU: Rapports des différents groupes de travail disponibles, forum de discussion : https://extra.core-cloud.net/collaborations/ProspectiveAA2019/SitePages/Accueil.aspx