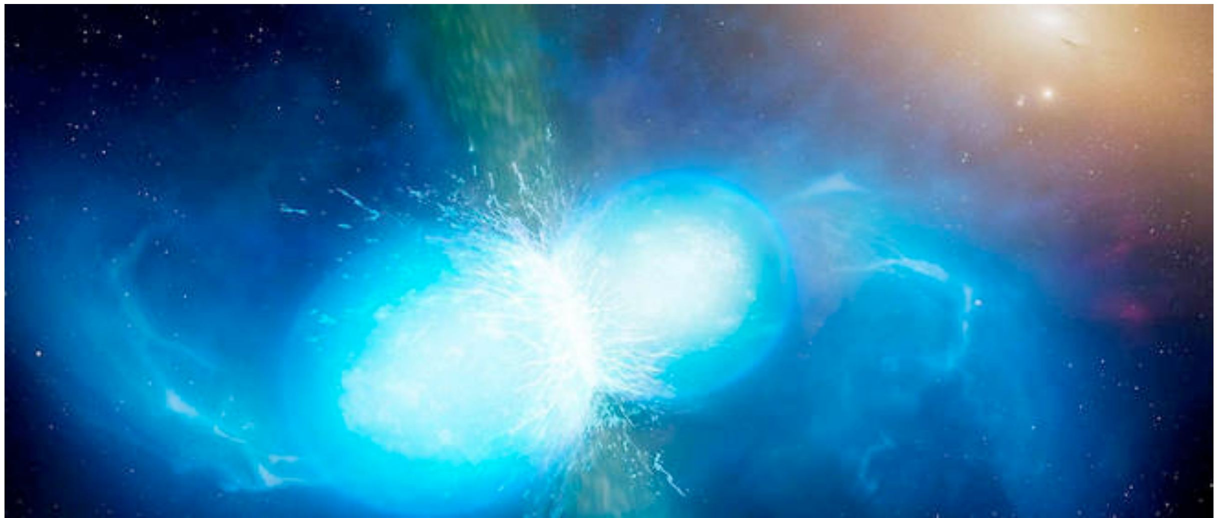
NenuFAR et l'éphémère

The Transient radio sky at low frequencies with NenuFAR

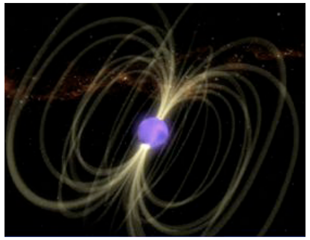
S. Corbel & J. Girard

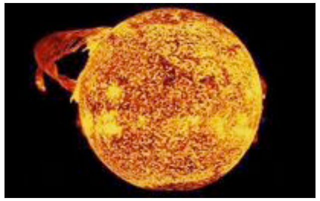
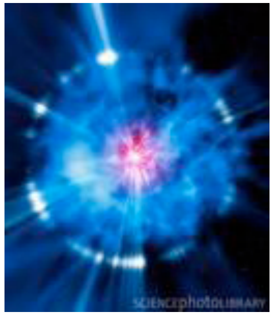
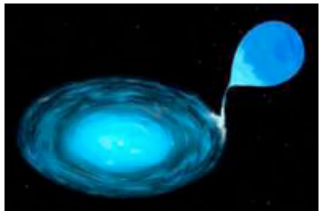


A variety of h.e.transients

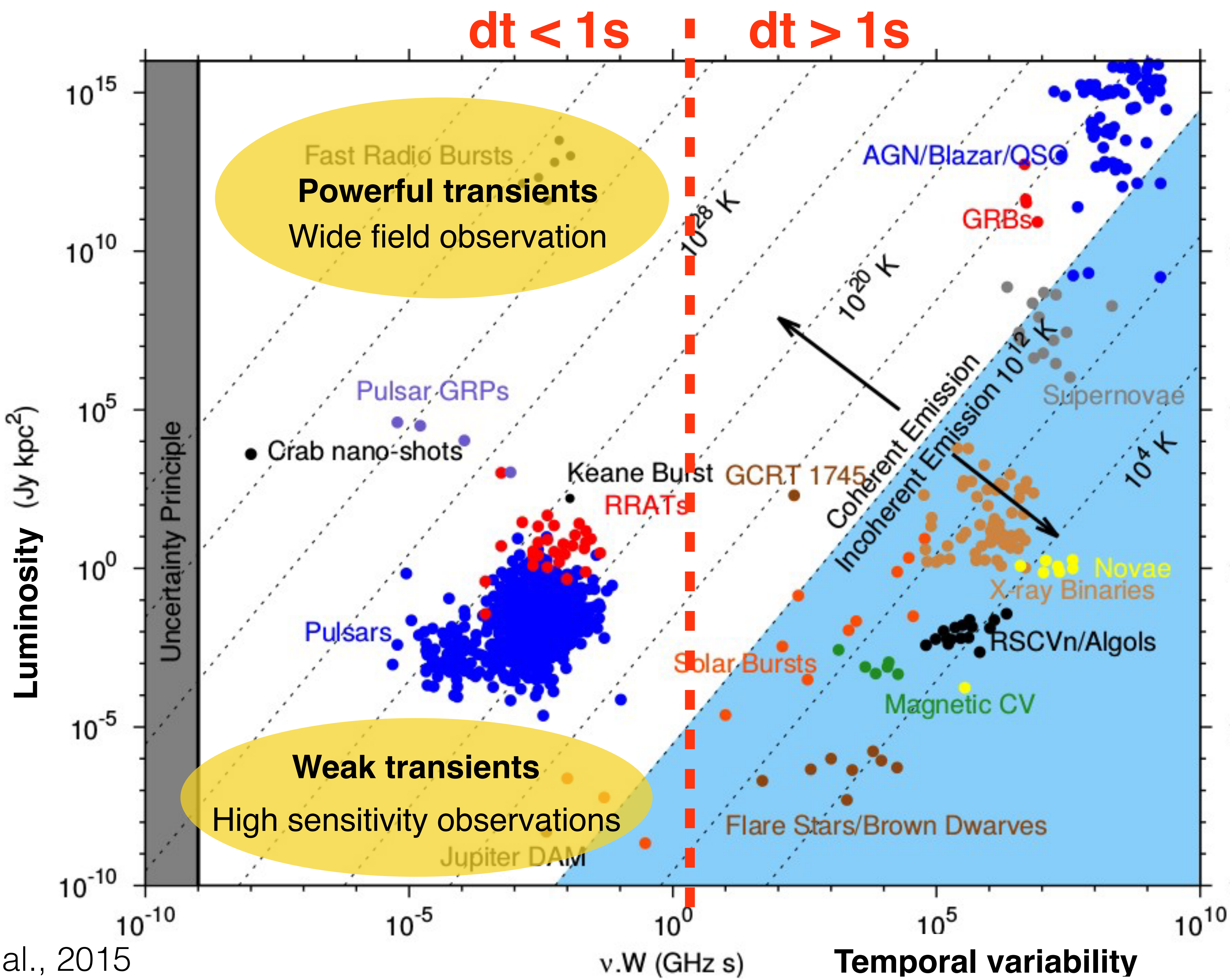
Source	Timescale
TGF	ms
GRB	ms - weeks
SGR	ms - sec
TDE	days - yrs
Solar flare	min
SN/Nova	min - yrs
X-ray bin.	sec - yrs
AGNs	hr - centuries





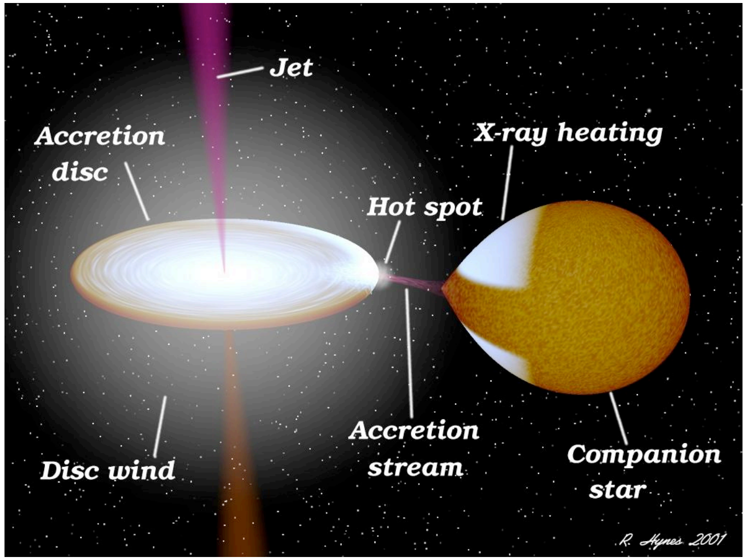

Explore empty domain of the luminosity/variability domain

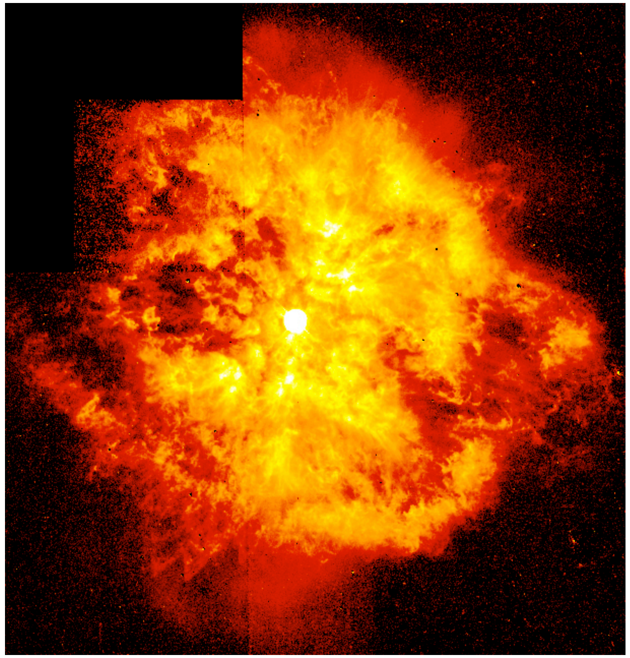


Pietka et al., 2015

Synchrotron transients

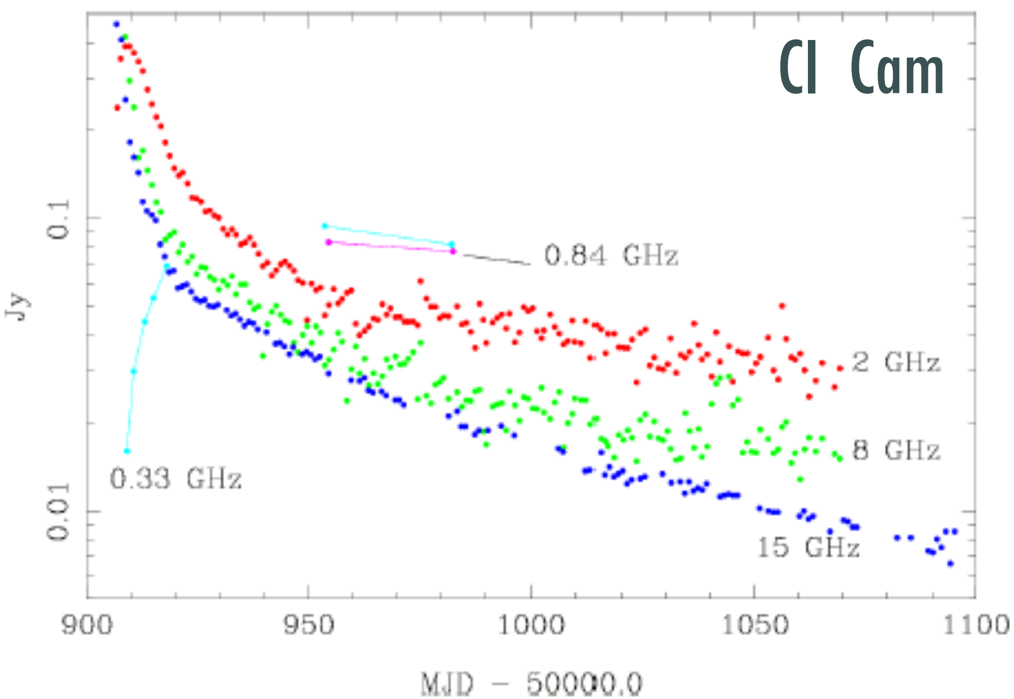
- Primarily explosive events or outflows
- Known source classes:
    - X-ray Binaries (BH, NS, WD)
    - Ultra Luminous X-ray sources (ULX)
    - Isolated black holes and IMBH
    - Magnetar outbursts, gamma-ray binaries
    - Supernovae (SNe)
    - Active Galactic Nuclei (AGN)
    - Tidal disruption events (TDEs)
    - Gamma-ray bursts (GRBs)
    - Some **novae** (usually thermal)

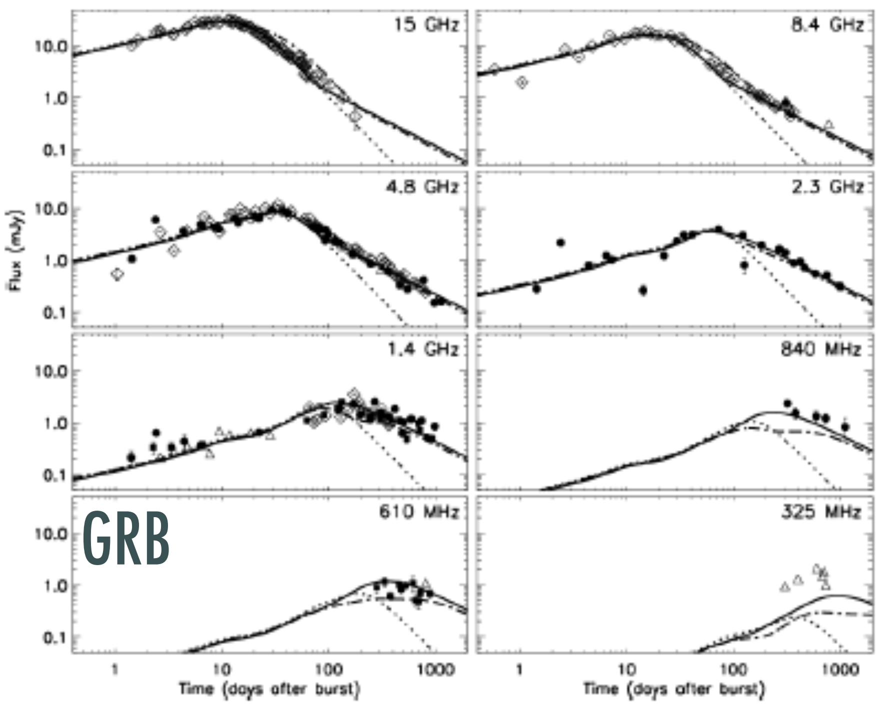




Incoherent synchrotron processes

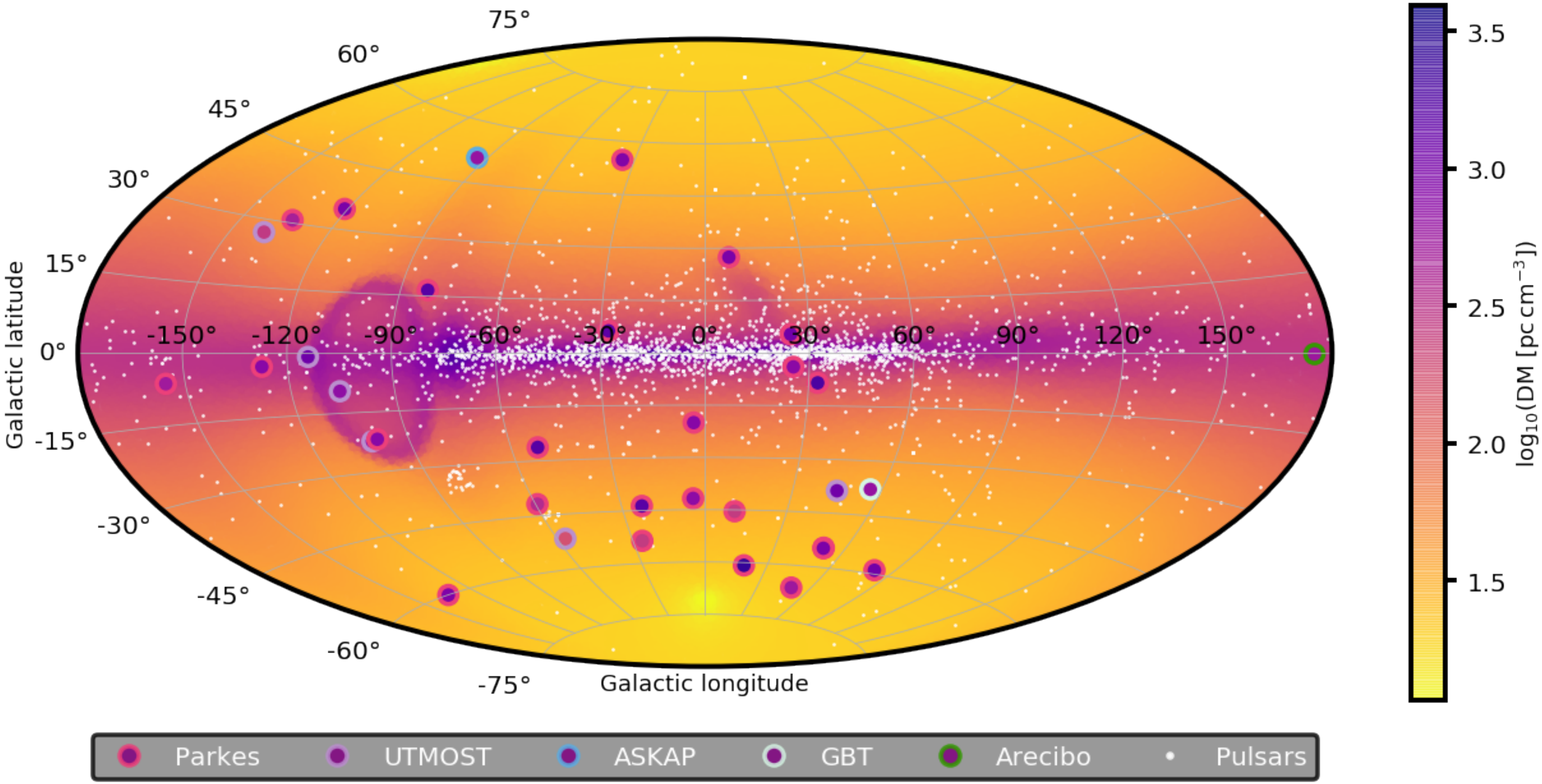
- Shock-accelerated electrons and magnetic fields
- Important frequency evolution. Become optically thin later at lower frequencies (+lower flux also).





van der Horst et al. (2008)

FRB

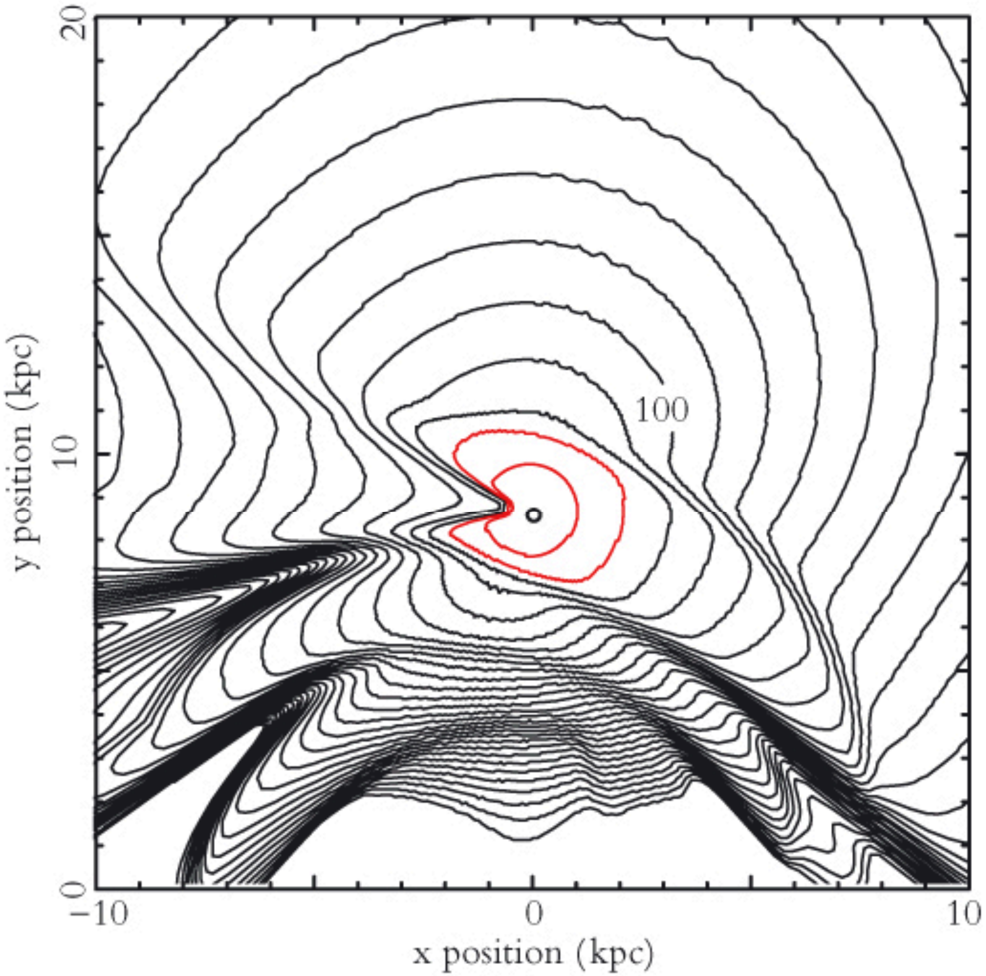


Stolen from

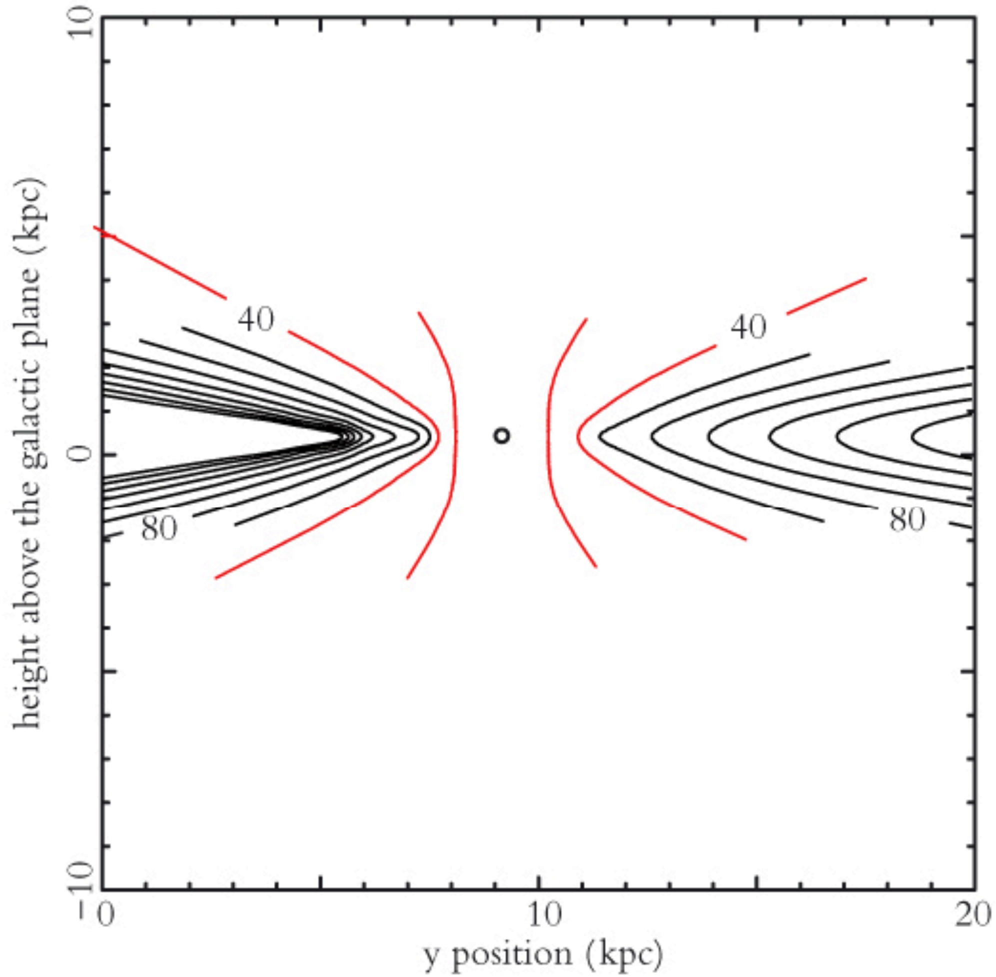
https://www.meertrap.org/science-goals/fast-radio-bursts/

Dispersion Measure

Galaxy top-down



Along galactic plane



Contours of constant dispersion measure
(NE2001 model; Cordes & Lazio)

+ scatter broadening of pulse > Dispersion delays at low frequencies

Transient KP proposed team

Scientific team

S. Corbel, J. Girard, M. Coriat, C. Gouiffes, F. Carotenuto, M. Espinasse, …

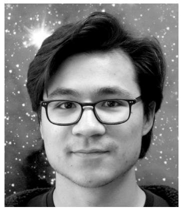
Some team members are also part of ThunderKAT (Transients with MeerKAT), VAST,

Expertise: XRB, Multi-λ, FRB, radio / X correlations, DDE imaging, …

Other possible participants: P. Zarka, I. Cognard, E. Chassande-Mottin, G. Dubus, L. Koopmans, S. Vergani,… Open to contributions

Group Transient pipeline & local implementation

J. Girard, C. Tasse, E. Tremou, A. Loh, B. Cecconi, JL Starck, …

Expertise: in Transient detection pipelines (e.g. TraP), wide-field imaging at low frequencies, sparse image reconstruction, VO and VOevents.

Key motives for a transient KP

1) Explore the variability of transient at LF with NenuFAR

Slow transients (T > 1-10min)
Image plane

Fast transients (T < 1min)
Dynamic spectroscopy

Offline dynamic spectroscopy from visibilities
(Loh et al., SF2A, 2017)

Observation of FRB (repeaters: FRB121102, FRB170827)

Radio frequency counterparts of GW, GRB events

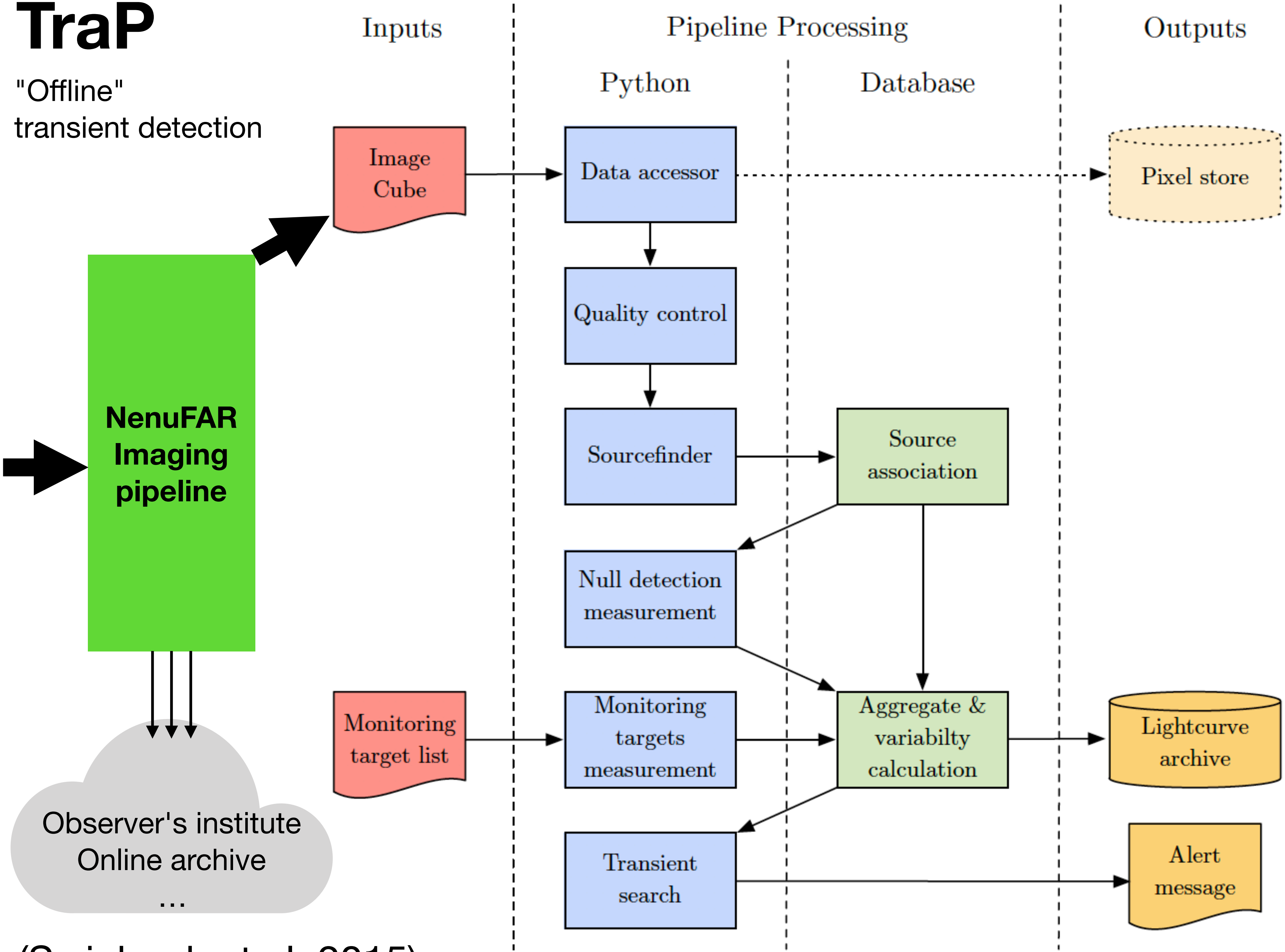
Serendipitous transients

2) Expertise for the development of transient pipeline

Deployment of Transient Pipeline (TraP, Swinbank et al. 2015)

TraP

"Offline"
transient detection



(Swinbank et al. 2015)

Key motives for a transient KP

1) Explore the variability of transient at LF with NenuFAR

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Observation of FRB (repeaters: FRB121102, FRB170827)

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Serendipitous transients… Response to VO Event

2) Expertise for the development of transient pipeline

Deployment of Transient Pipeline (TraP, Swinbank et al. 2015)

3) Opportunity to carry dedicated exploration/monitoring of sources

piggy-back exploration of transients

follow-up obs. from external triggers

Requested Observing Modes

"Early science" phase (end 2019 - end 2021)

Configuration Available MA + Remote(?) MA

Focus on Development of a transient detection pipeline

Requested time 50 h/yr ? Dedicated source follow-up, testing, blind search

"Open" community approach They bring the data, we bring the expertise

Most of the effort, put on "offline" detection in all data

For the few targeted observations

A) "Low-rate" imaging (XST) Preferable observing window **>60-88 MHz**

1 digital beam **3.125 MHz per beam** (16 SB per 1s) (beam squint set at ~60-70 MHz)

Sweeping subbands = broadband & "offline" dedispersion

B) High-rate imaging (Vis) Dt = 1s

Two beams Calibrator **37,5 MHz per beam** **192 SB / 2..64 ch**
Target **Calibrating and imaging (up to 1 Hz ?)**

(e.g. ~AARTFAAC calibration & imaging σ=10 Jy on bw=90kHz)

C) Dynamic spectra observations (DynSpec) in coord. with other KP expertise

UnDySPuTeD **64 ch / 1-10 ms** t-f flag / dedispersion / rebin

Requested Observing Modes

KP program + PI programs (2022 - 2024)

Configuration Core + Remote MA Resolution θ=5' at 85 MHz

Sensitivity ~9 mJy at 85 MHz with Δf=10 MHz x Δt=1 h

Focus on Exploitation of all data from all programs

Process external triggers (VOEvent)

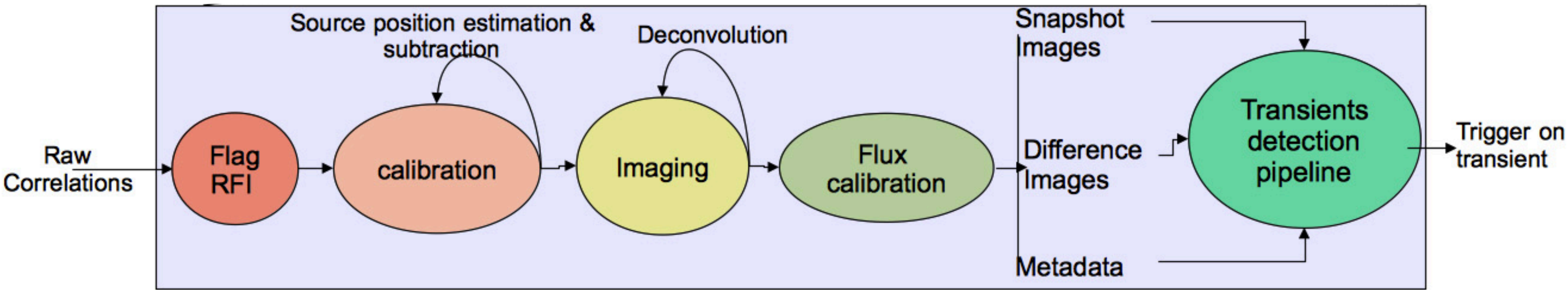
Ingestion of all KP data in the transient pipeline (Dark ages, extragalactic, ...)

Real-time or "near" Real-time fast transient detection pipeline ?

Requested time tbd h/yr ? Only for dedicated source follow-up upon trigger

A) "Low-rate" imaging (XST) → Data for continuous transient monitoring?

Near Real-time transient pipeline for NenuFAR ? AARTFAAC-like



(Adapted from Prasad et al., 2014)

Localising fast radio bursts and other transients using interferometric arrays

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Received December, 2014; accepted February 2015

Requested Observing Modes

KP program + PI programs (2022 - 2024)

Configuration Core + Remote MA Resolution θ=5' at 85 MHz
Sensitivity ~9 mJy at 85 MHz with Δf=10 MHz x Δt=1 h

Focus on Exploitation of all data from all programs
Process external triggers (VOEvent)
Ingestion of all KP data in the transient pipeline (Dark ages, extragalactic, …)
Real-time or "near" Real-time fast transient detection pipeline ?

Requested time xx h/yr ? Only for dedicated source follow-up upon trigger

A) "Low-rate" imaging (XST) ⟶ Data for continuous transient monitoring?

B) High-rate imaging (Vis) with the NenuFAR dedicated correlator

Two beams Calibrator **37,5 MHz per beam** **192 SB / 2..64 ch**
Target **Calibrating and imaging (up to 1 Hz?)**
(e.g. ~AARTFAAC calibration & imaging σ=10 Jy on bw=90kHz)

C) Dynamic spectra (DynSpec)

UnDySPuTeD **64 ch / 1-10 ms** t-f flag / dedispersion / rebin

Simultaneous monitoring DynSpec / Vis observations if/when available