Transients at Low Radio Frequencies

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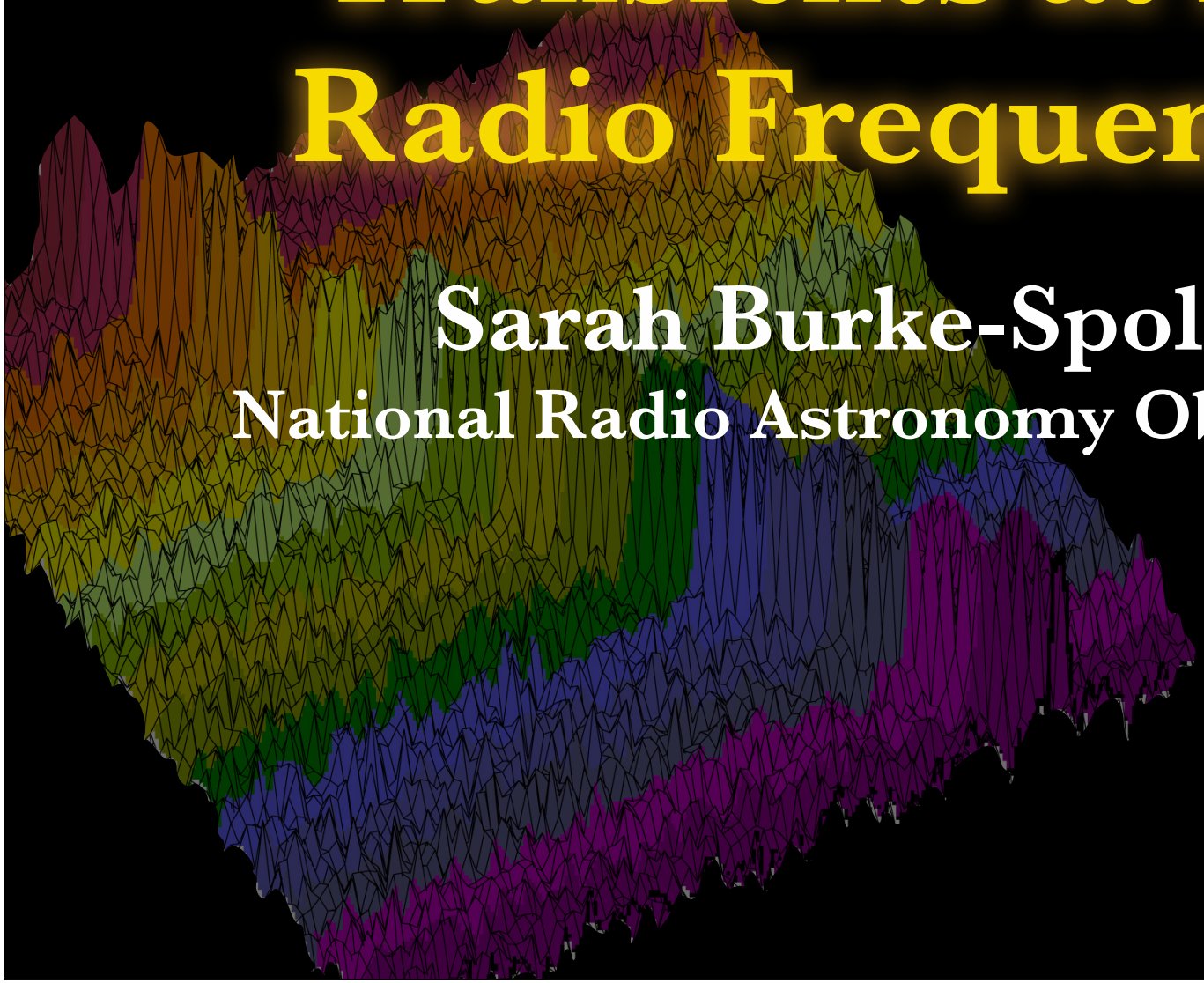
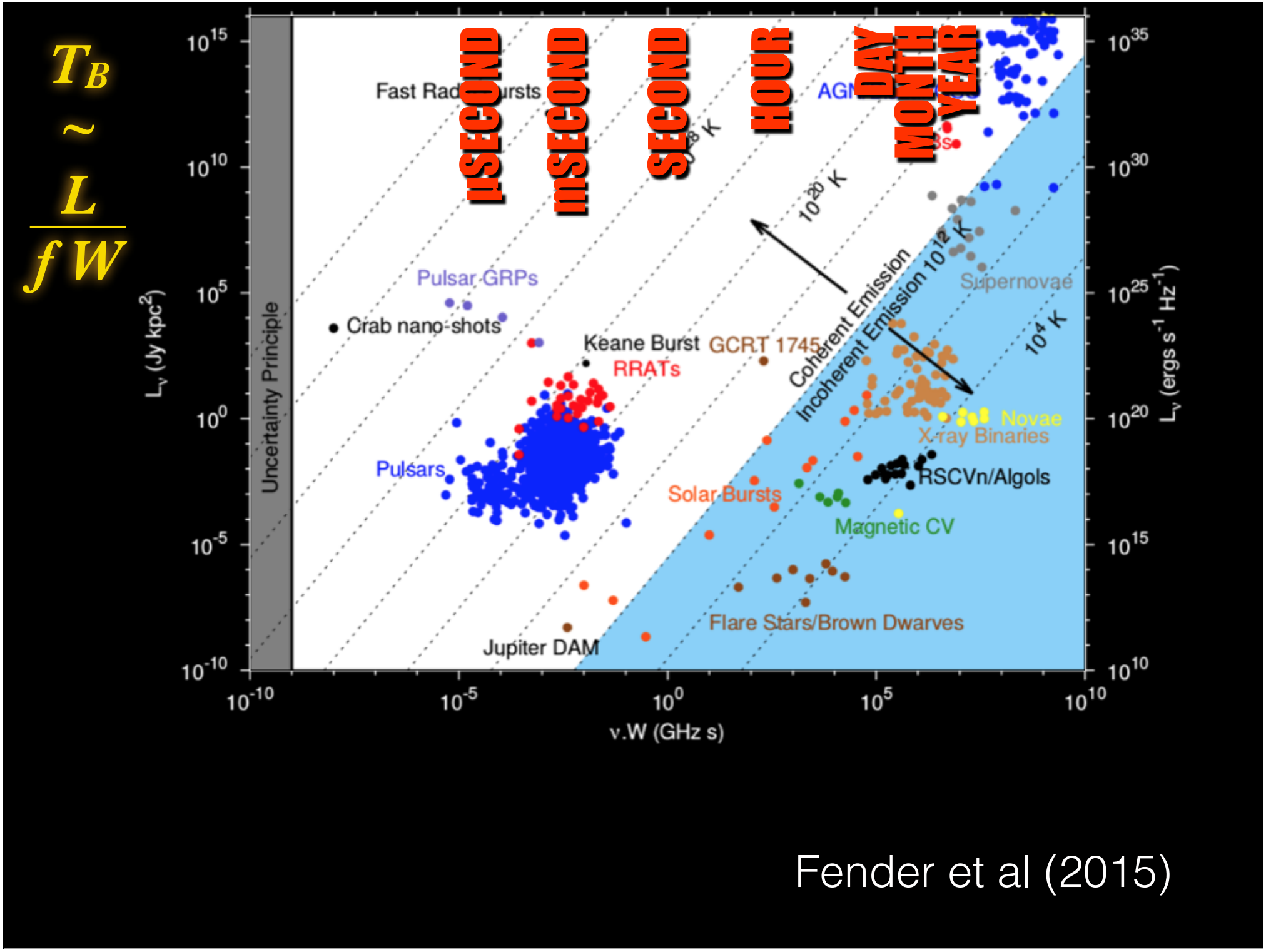


TIME DOMAIN vs TRANSIENT

BOOM!

whhhhhooooooossss
sshhhh

$$T_B \sim \frac{L}{f W}$$



Fender et al (2015)

Unique regimes: Slow and Fast Transients

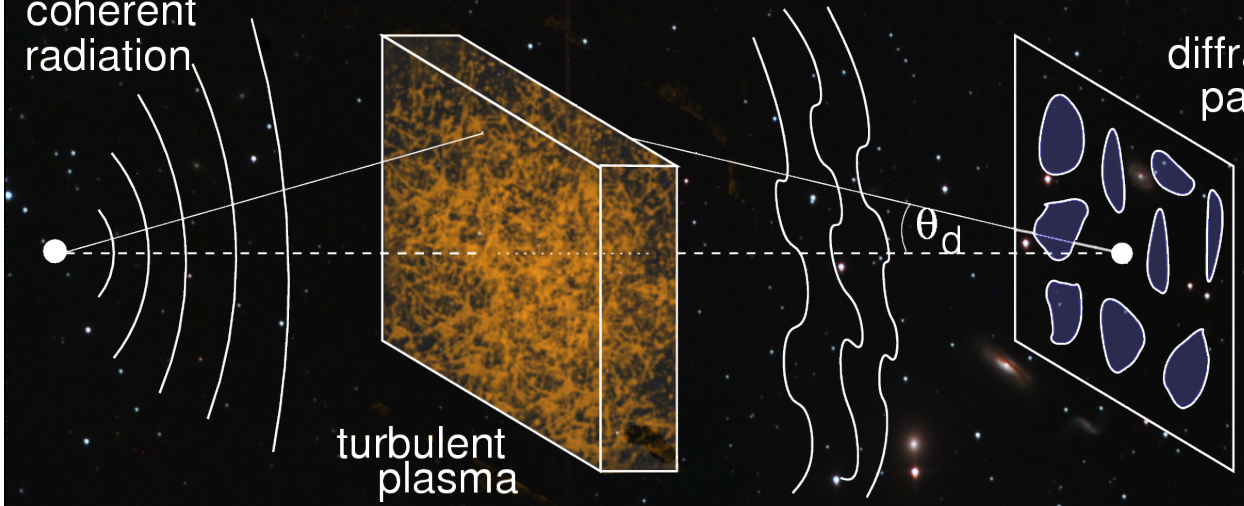
	Physics:	Instruments/strategy:
FAST	★ Intervening media ★ Huge brightness temperatures	★ Phased/beamformed ★ Computation heavy ★ Enormous data sets ★ Real-time identification
BOTH	★ CATACLYSMS!	★ Commensal ★ Automated classification/ machine learning
SLOW	★ Ejecta afterglows ★ Relativistic jets ★ Kinetic feedback measurements	★ Image plane

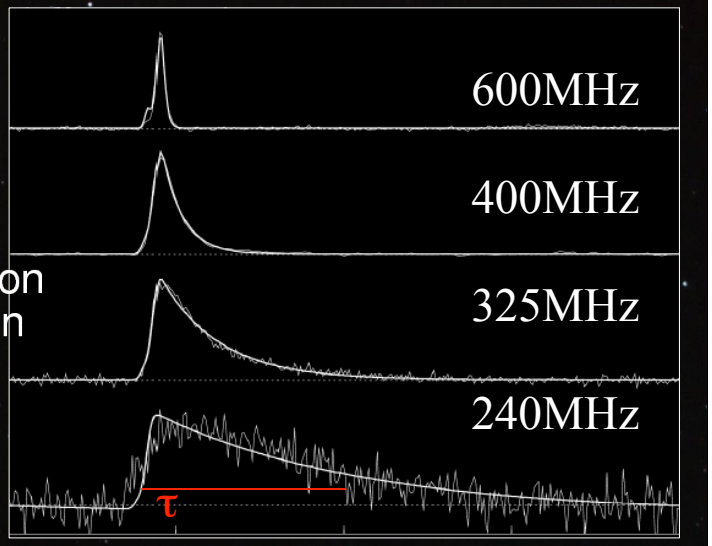
Dispersion

$\sim f^{-2}$

Scattering

$\sim f^{-4}$





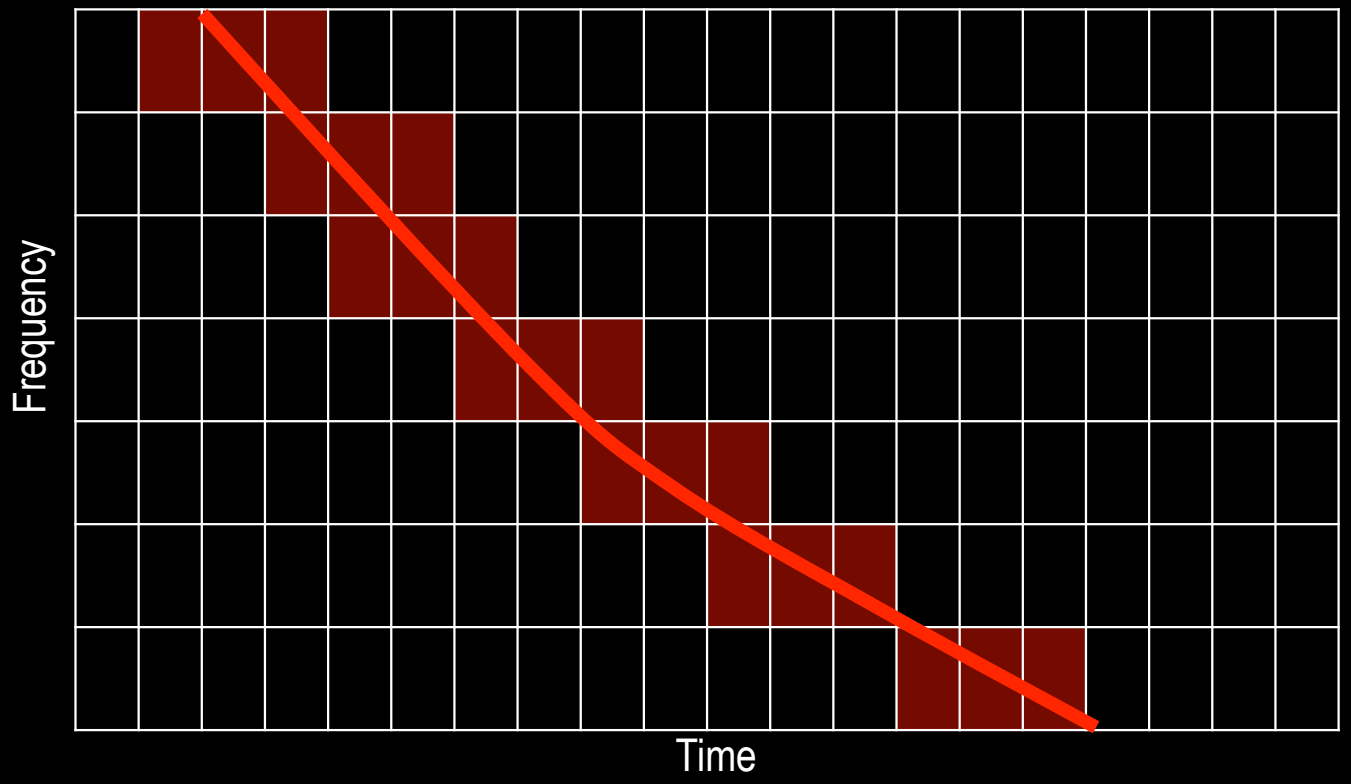
Lorimer+Kramer05

Lorimer+Kramer05

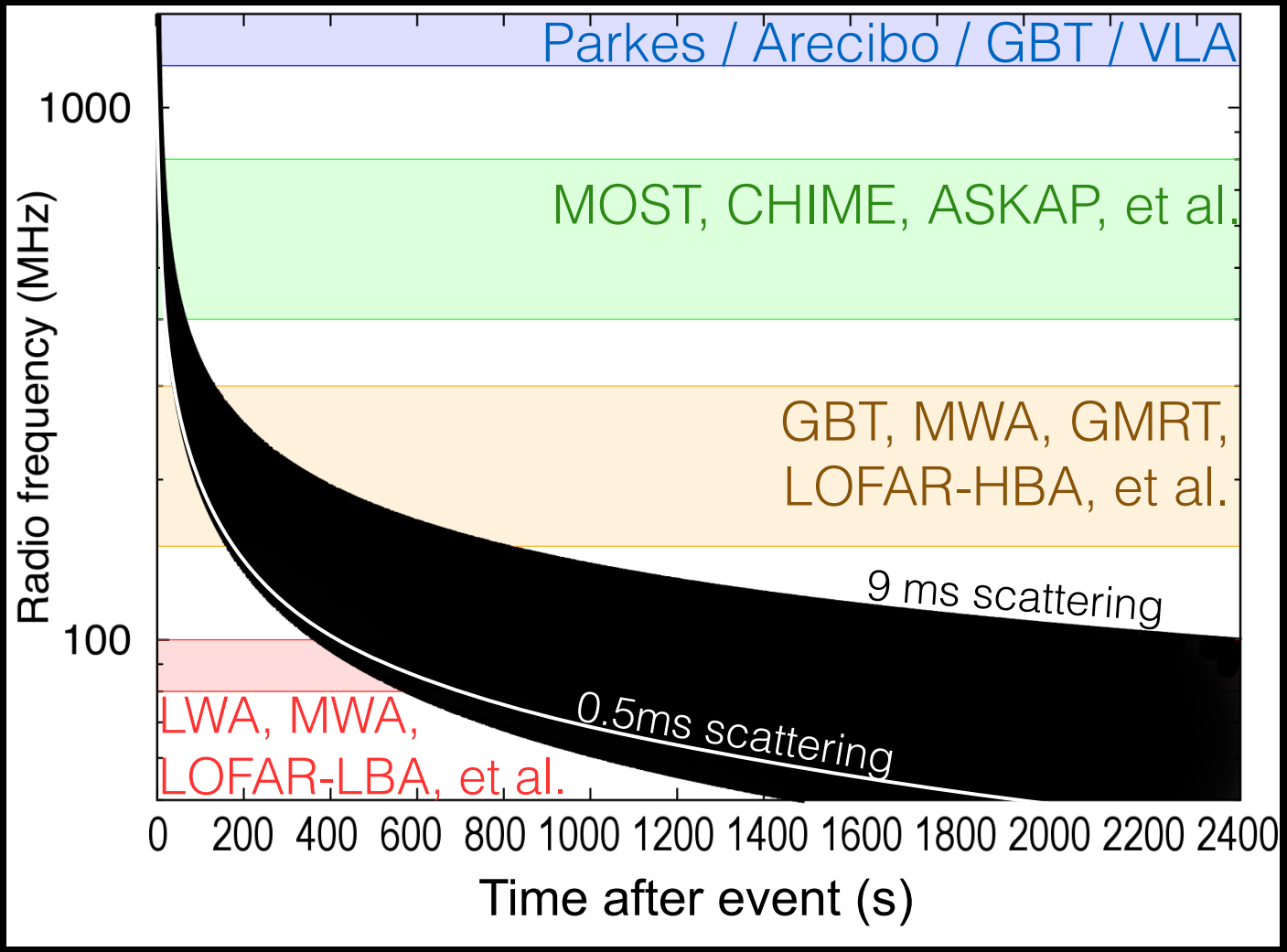
Instrumental Requirements

Instrumental broadening

$$[\text{Detected width}]^2 = [\text{Intrinsic width}]^2 + [\text{Scattering}]^2 + [\text{Sampling Time}]^2 + [\text{Dispersion error}]^2$$

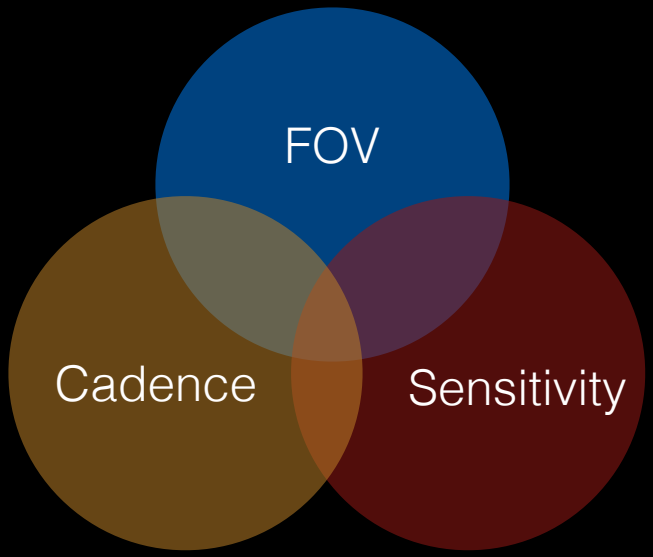


Dispersion:
1000 pc/cc



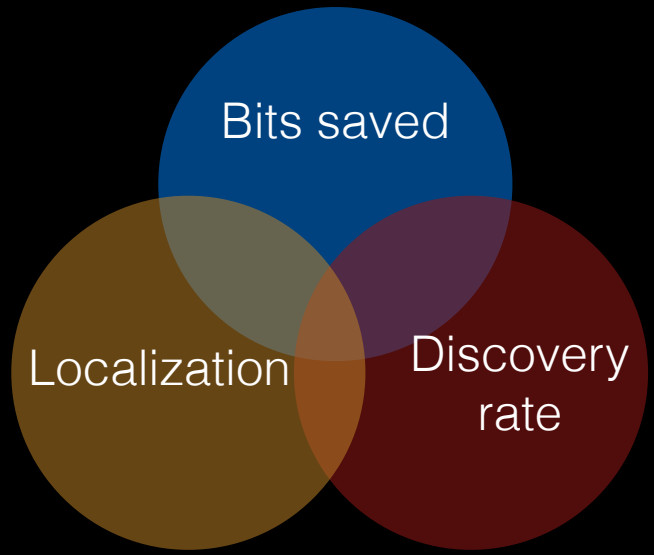
Science Optimization

General transients:



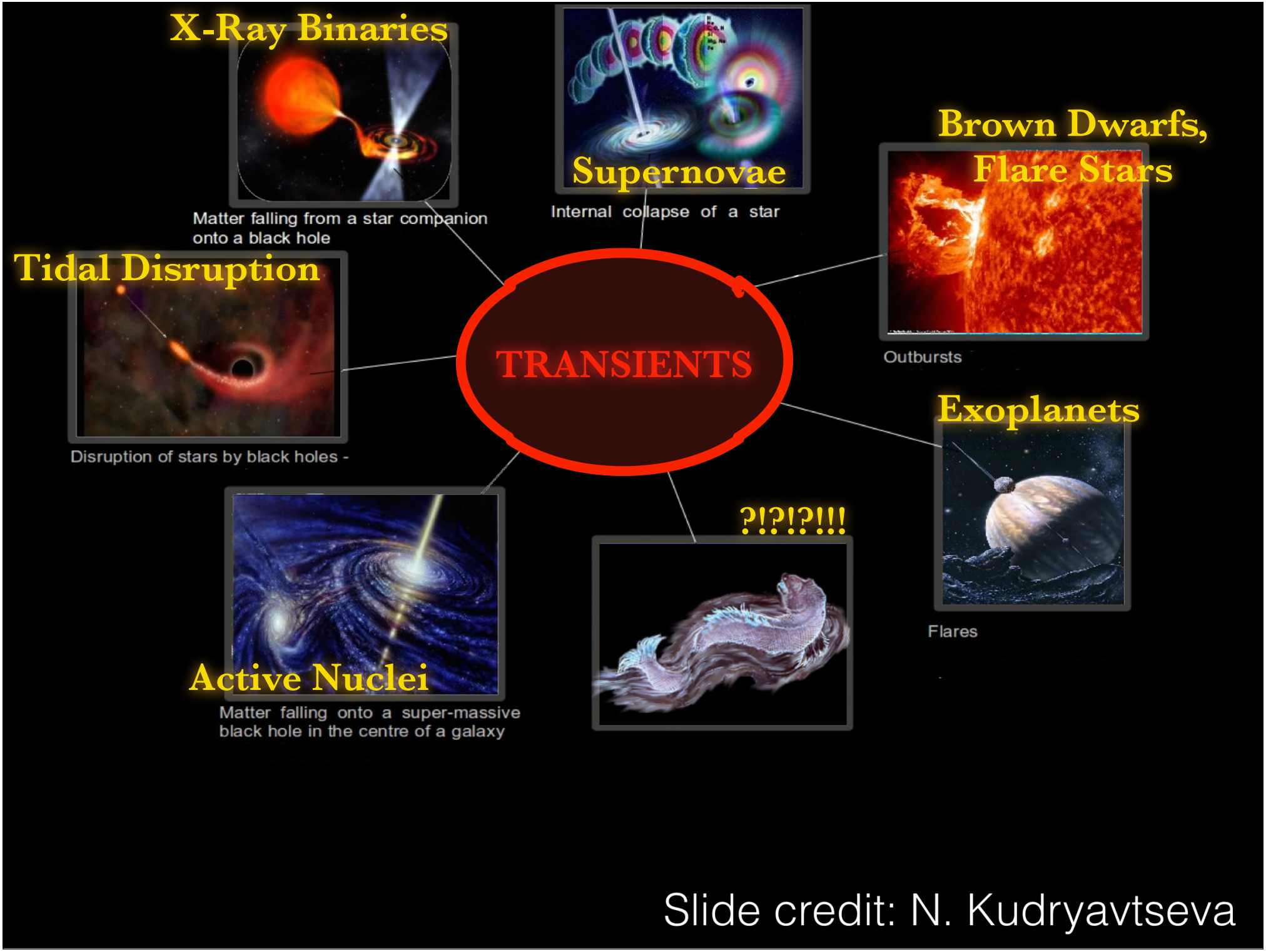
- FOV
- Sensitivity
  - Bandwidth
  - Collecting area
  - Freq. selection
- Cadence

Fast transients:

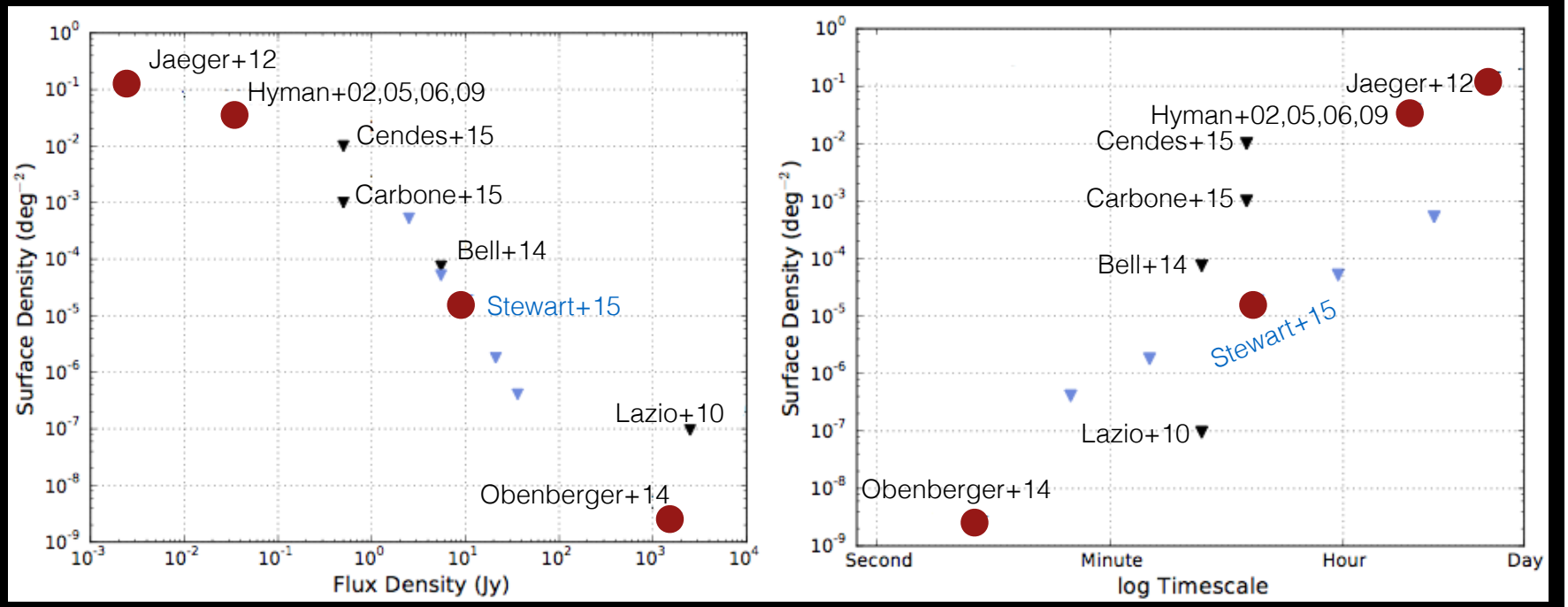


- FOV
- Sensitivity
  - Bandwidth
  - Collecting area
  - Freq. selection
  - Sample time
  - Channelization
- Polarization
- Localization
- Huge supercomputer

So what do we know so far?


X-Ray Binaries
Matter falling from a star companion onto a black hole
Supernovae
Internal collapse of a star
Brown Dwarfs, Flare Stars
Outbursts
Tidal Disruption
Disruption of stars by black holes -
TRANSIENTS
Exoplanets
Flares
?!?!?!!!
Active Nuclei
Matter falling onto a super-massive black hole in the centre of a galaxy
Slide credit: N. Kudryavtseva

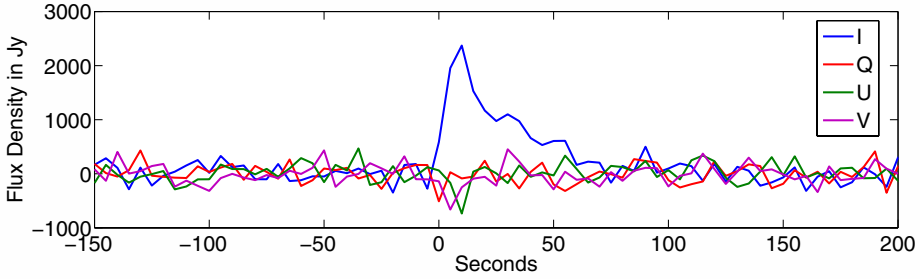
Blind Discoveries!



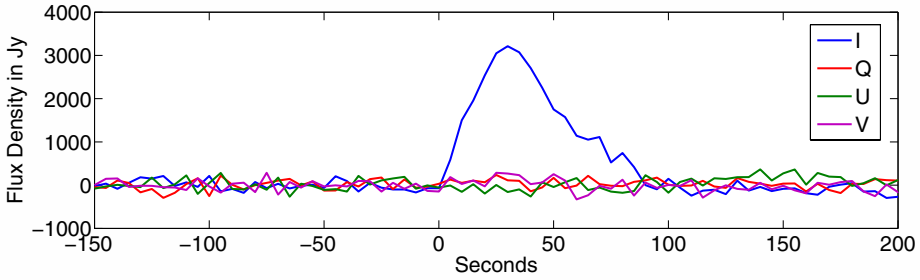
Stewart et al. (2015)

Blind

37.9 MHz
DM<450pc/cc

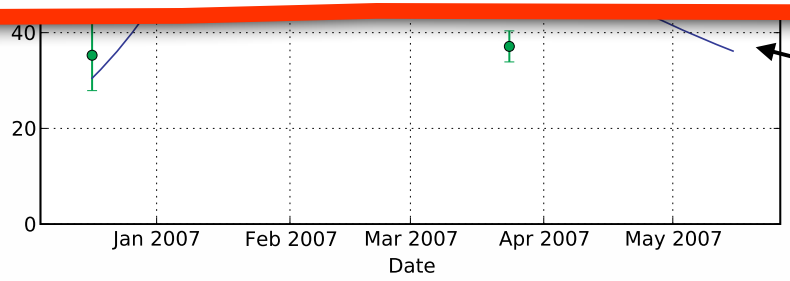


29.9 MHz
DM<250pc/cc



Obenberger et al.(2014)

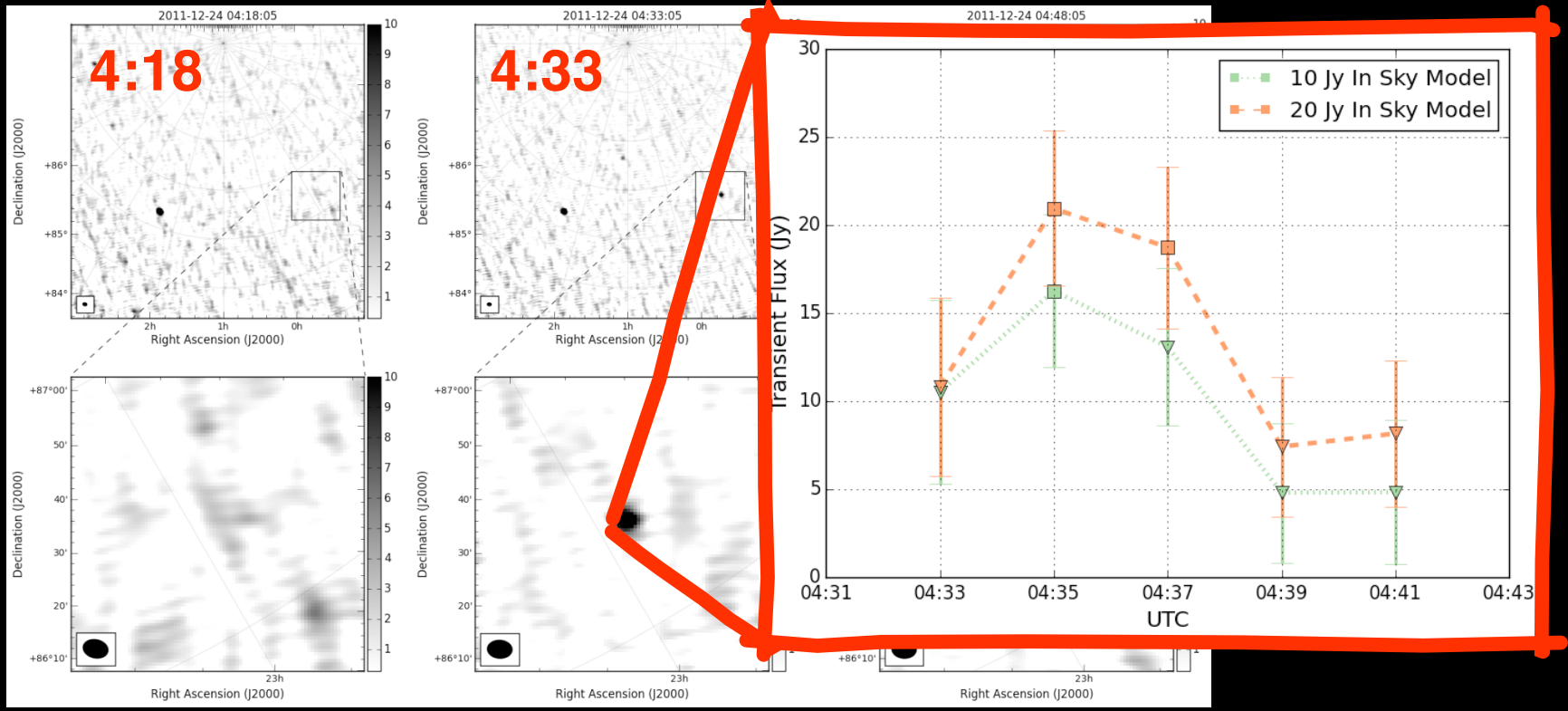
Hyman+ GC surveys



GCRT 1742-3001:
Six-month variable; steep spectrum

400MHz-Claus

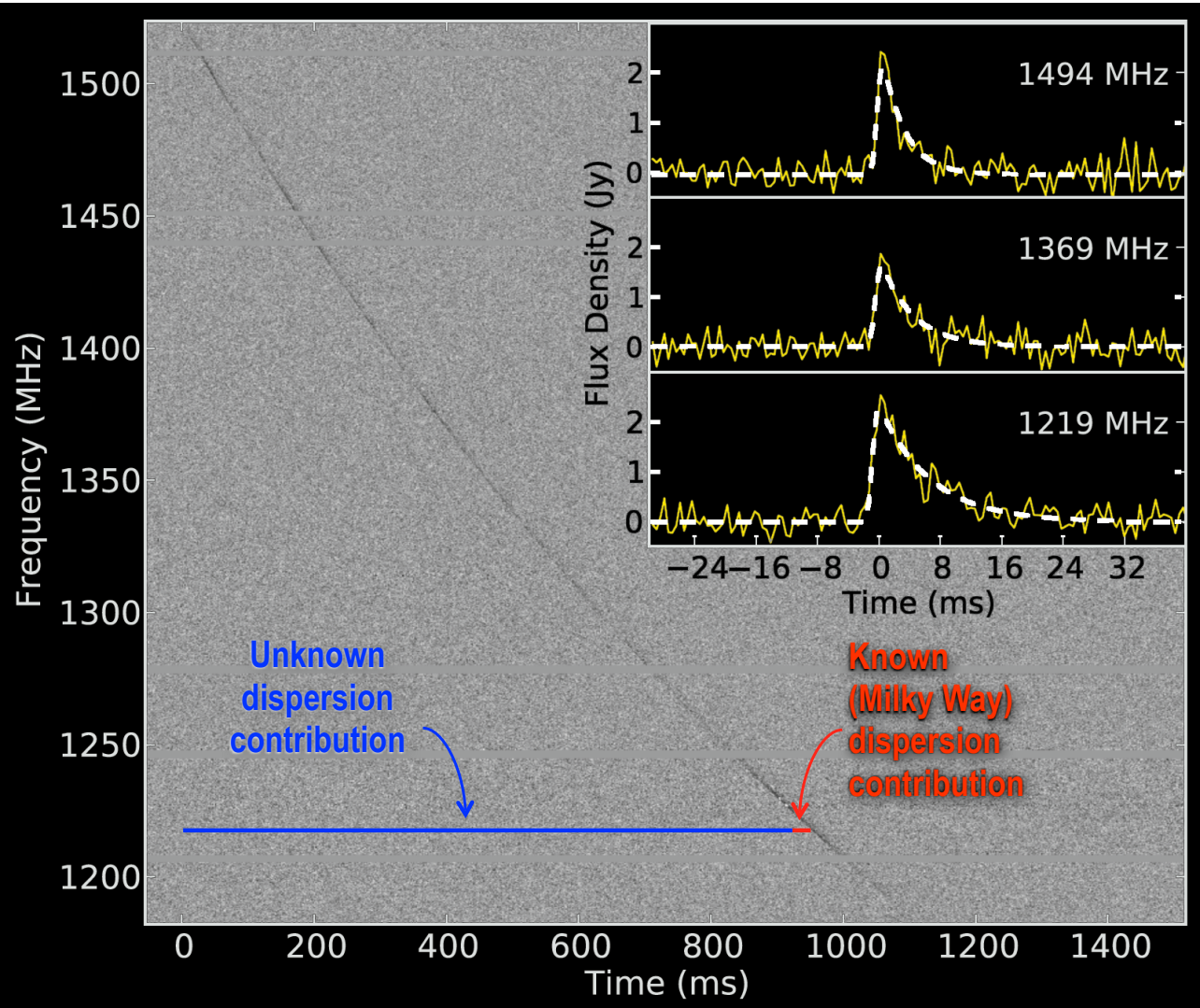
Christmas eve 2011, North (celestial) Pole



Stewart et al. (2015)

The future…

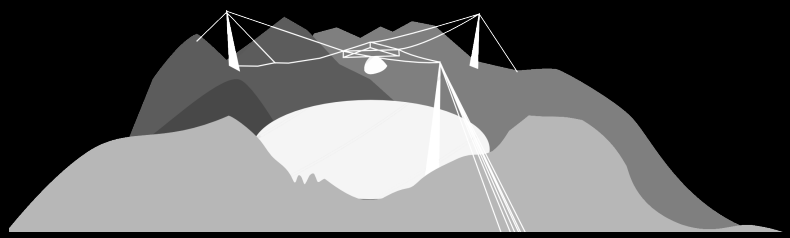
Fast Radio Bursts (FRBs)



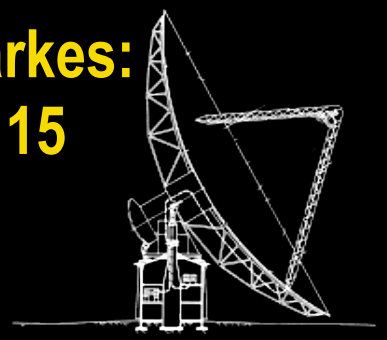
FRB fast facts

GBT: 1

Arecibo: 1

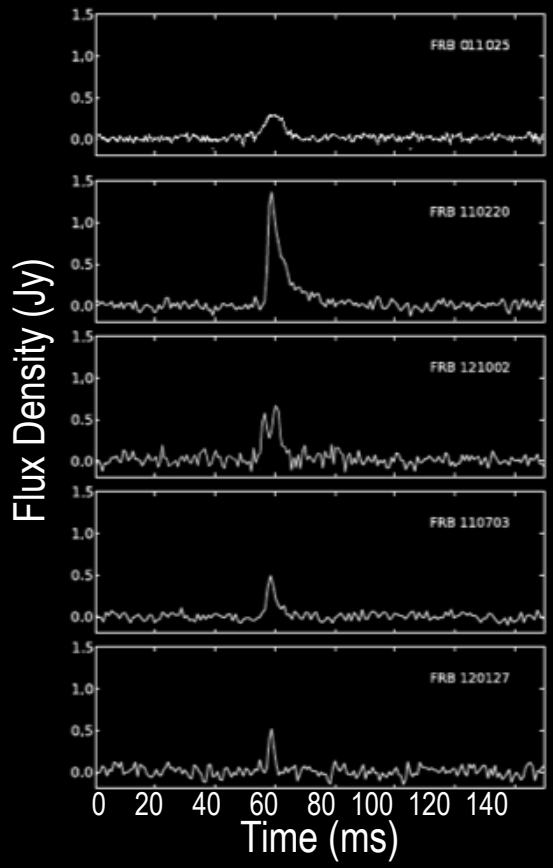


Parkes: 15

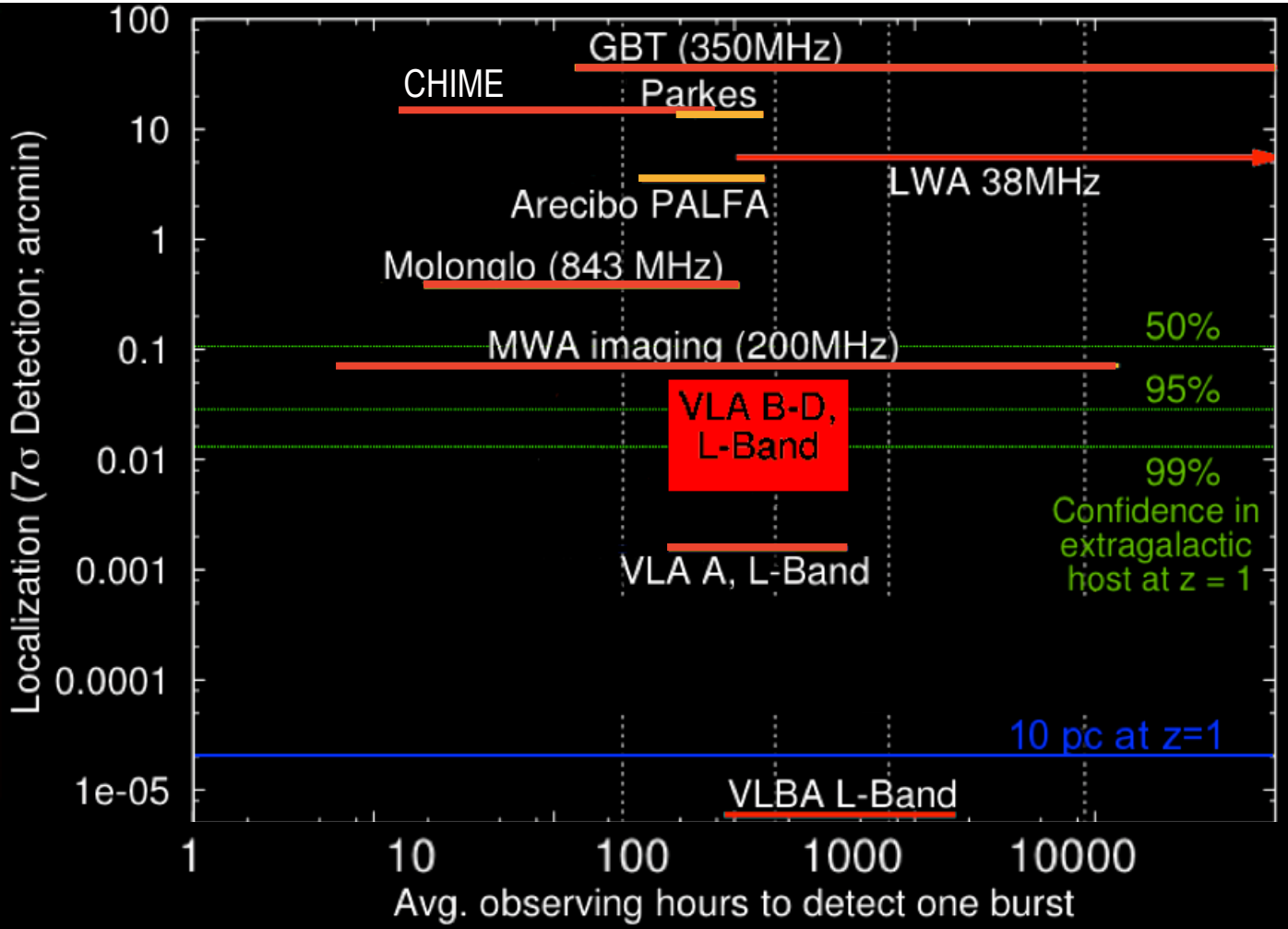


AT 1 GHz:

- ★ 17 detected (10 published)
- ★ f = 0.7 - 1.5 GHz
- ★ 2500-10000/sky/day
- ★ Extragalactic
- ★ ~50% scattered, $\langle\tau\rangle$ ~ 7 ms

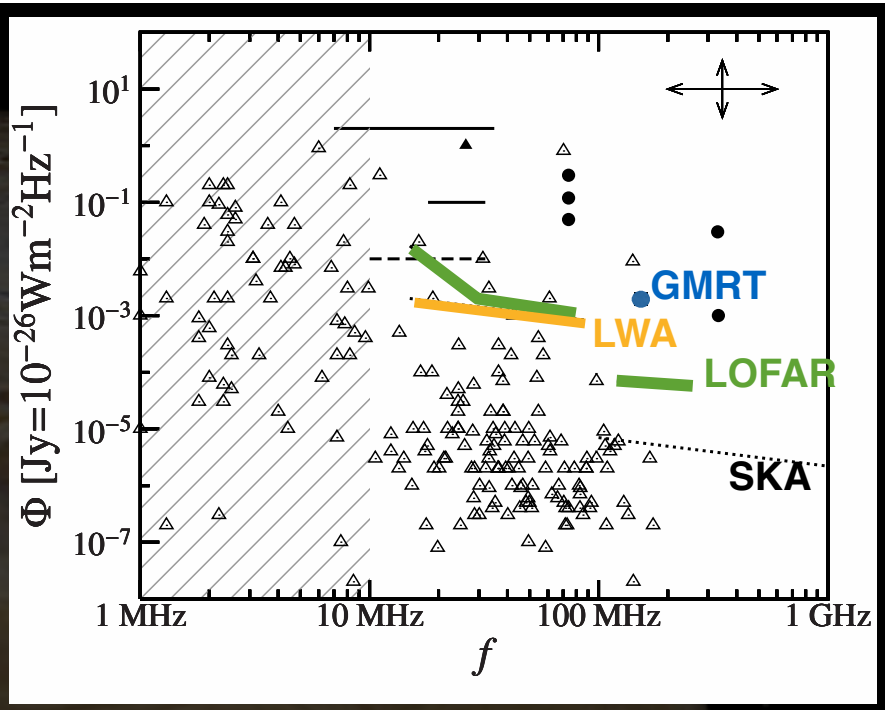


FRB optimization



Future: Hot Jupiters

- Jupiter: magnetospheric cyclotron masers
- Extrasolar planets: same processes?



Greissmeier et al. (2007)

Future: Multi-messenger

- LIGO/Virgo: detects a signal
- Prompt radio signal delayed by up to minutes, hours
- NS-NS merger, Cosmic string cusps

Yancey et al. (2015)

Conclusions

- Transient science
  - Huge range of targets
  - Afterglows, jet phenomena, exoplanets, intergalactic medium, and more
- Discoveries are commencing!
- Unexplored parameter space:
  coherent one-off events at any distance