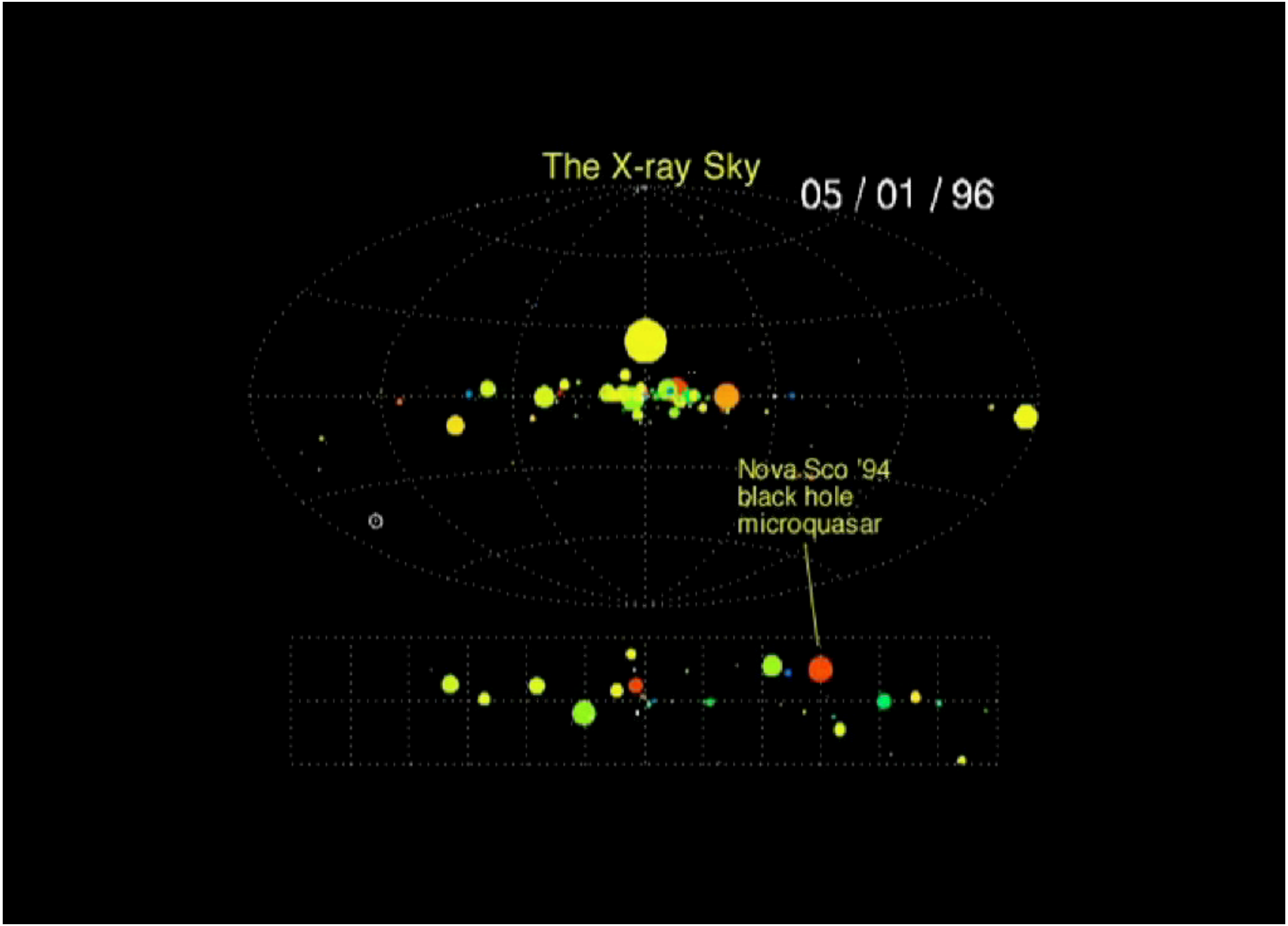
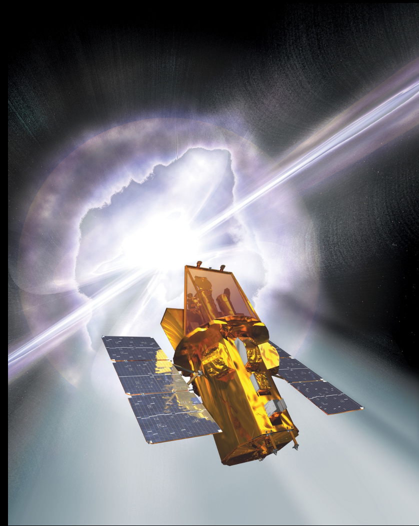
Hunting explosive events with the SKA

Anthony Rushton


The X-ray Sky
05 / 01 / 96
Nova Sco '94
black hole
microquasar

Transient hunting facilities

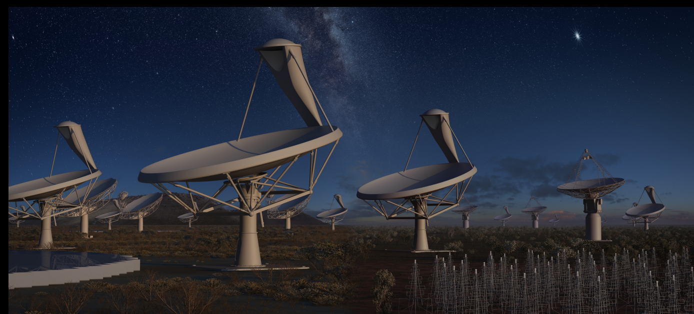


Current facilities:

- Swift-BAT (*Hard X-rays*)
- MAXI (*Soft-X-rays*)
- Palomar Transient Factor (*optical* 1.2, 7.7 Deg^2)
- Catalina Real-Time Transient Survey (*optical*, 0.5-1.5m, 1.2-8.1 Deg^2)
- Pan-STARRS (*optical*, 1.8m, 3 Deg^2)
- SkyMapper (*Optical*, 1.35m, 5.7 Deg^2)
- IceCube (*Neutrinos*)
- Advanced LIGO (*Gravitational Waves*)

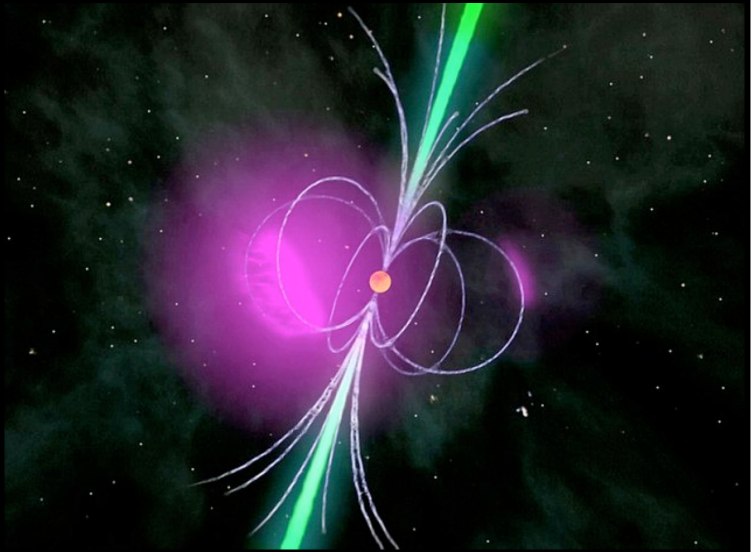
Future facilities:

- Large Synoptic Survey Telescope (*Optical*, **6.7m, 9.6** Deg^2)
- eRosita (*Soft X-rays)*
- SKA (inc. ASKAP, MeerKAT, SKA-mid, SKA-low)

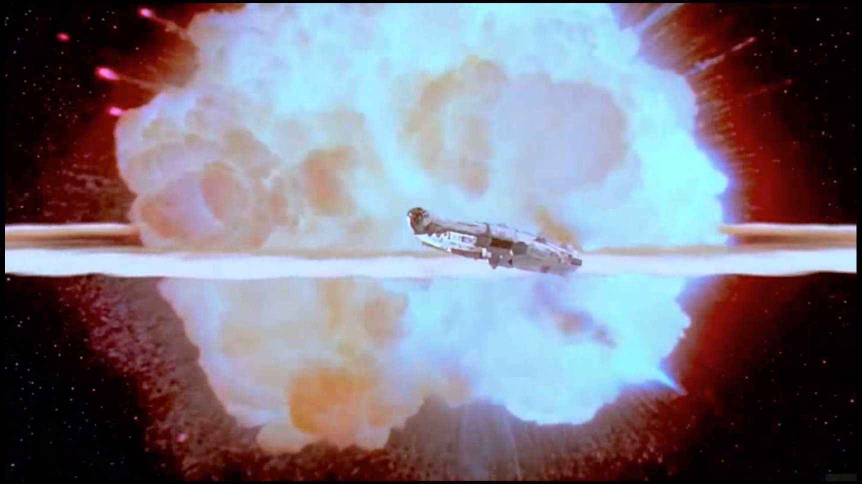


Known Radio Transient Sky

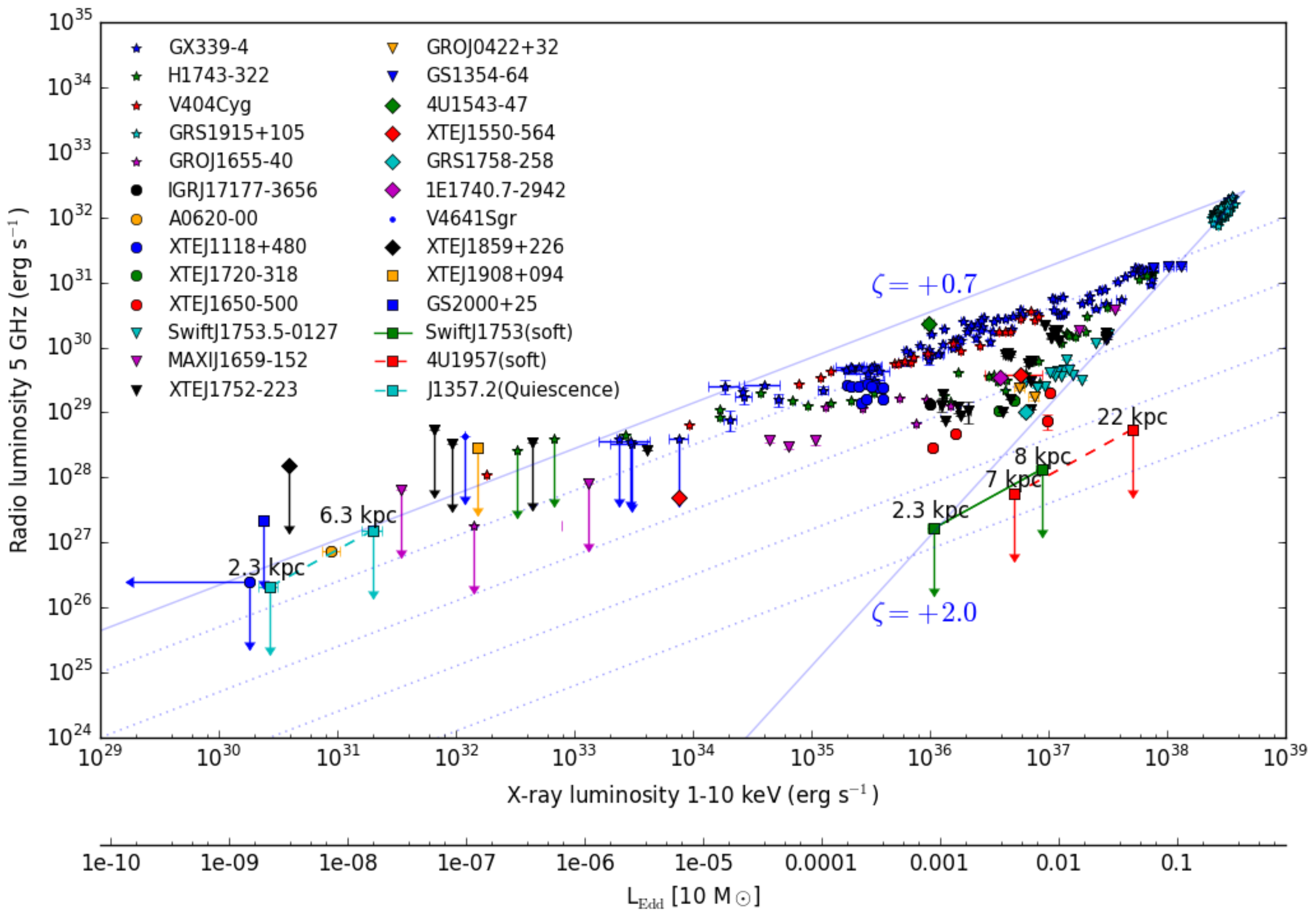
- Pulsars (inc. RRATS, Giant Pulses, Transitional XRBs, Magnetars)
- Fast Radio Bursts
- Exoplanets/Brown Dwarfs
- Flare Stars
- Cosmic rays (Lunar interactions)



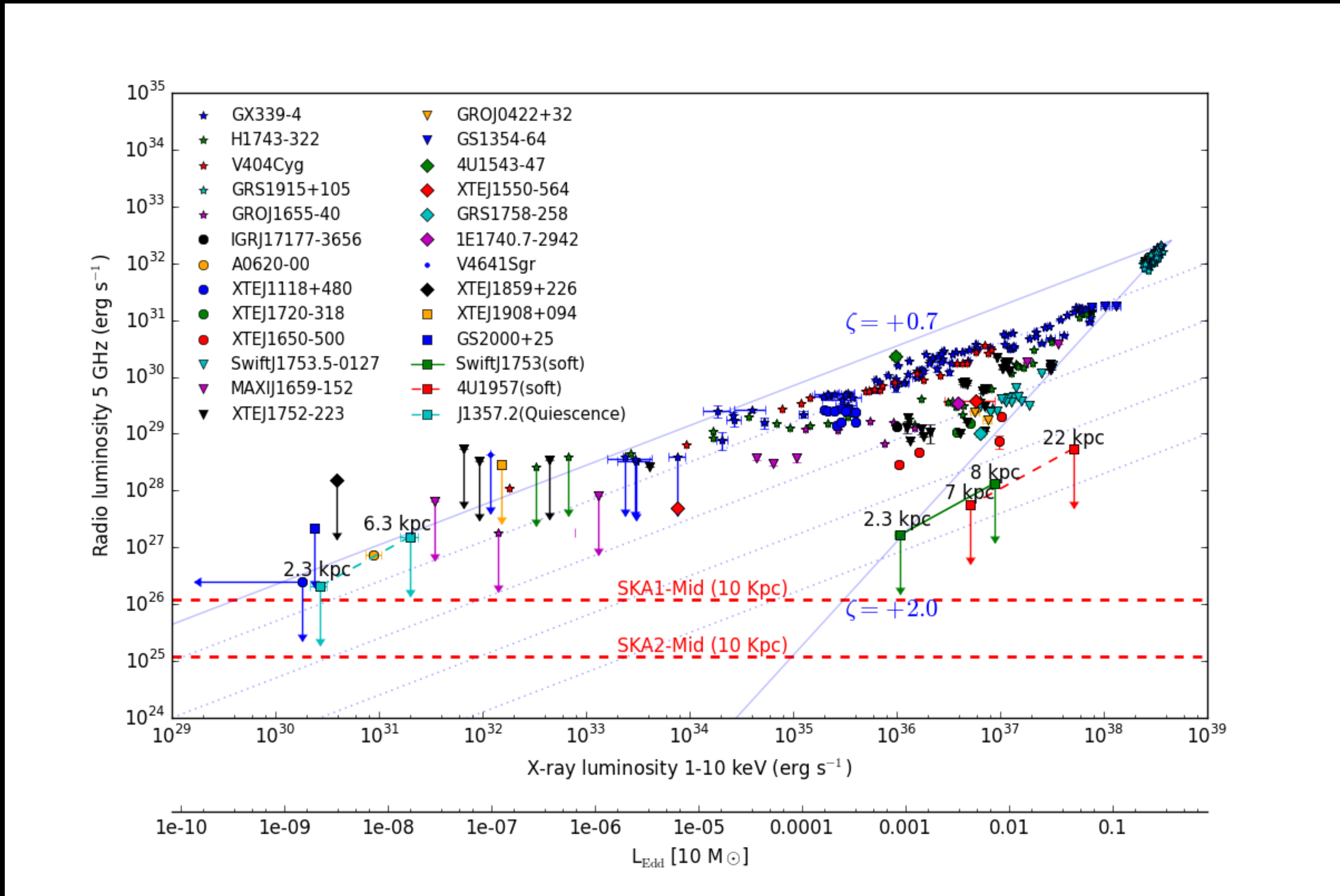
- CVs
- X-ray binaries
- ULXs
- Tidal Disruption Events
- Intra-day variables/Extreme Scattering Events
- After glows (Supernova, GRBs, FRBs?, Gravitational Waves?)



X-ray/radio correlation of XRBs



X-ray/radio correlation of XRBs



The radio luminosity is related to the power of the jet

$$L_{\rm Radio} \propto Q_{\rm jet}^{17/12}$$

Blandford & Konigl (1979)

Assume the jet forms a linear inter-dependency with the mass accretion rate

$$Q_{\rm jet} = q\dot{m}c^2$$

Falcke & Biermann (1995)

We therefore can use the compact jet to scale the **mass accretion rate**

$$\dot{m} = \dot{m}_0 \left(\frac{L_{\rm Radio}}{L_{\rm Radio,0}}\right)^{12/17}$$

A geometrically thin disk can efficiently radiate heat

$$L_X \propto \dot{m}_{in}$$

Bolometric luminosity is linearly proportional to mass accretion rate

Shakura & Sunyaev (1973)

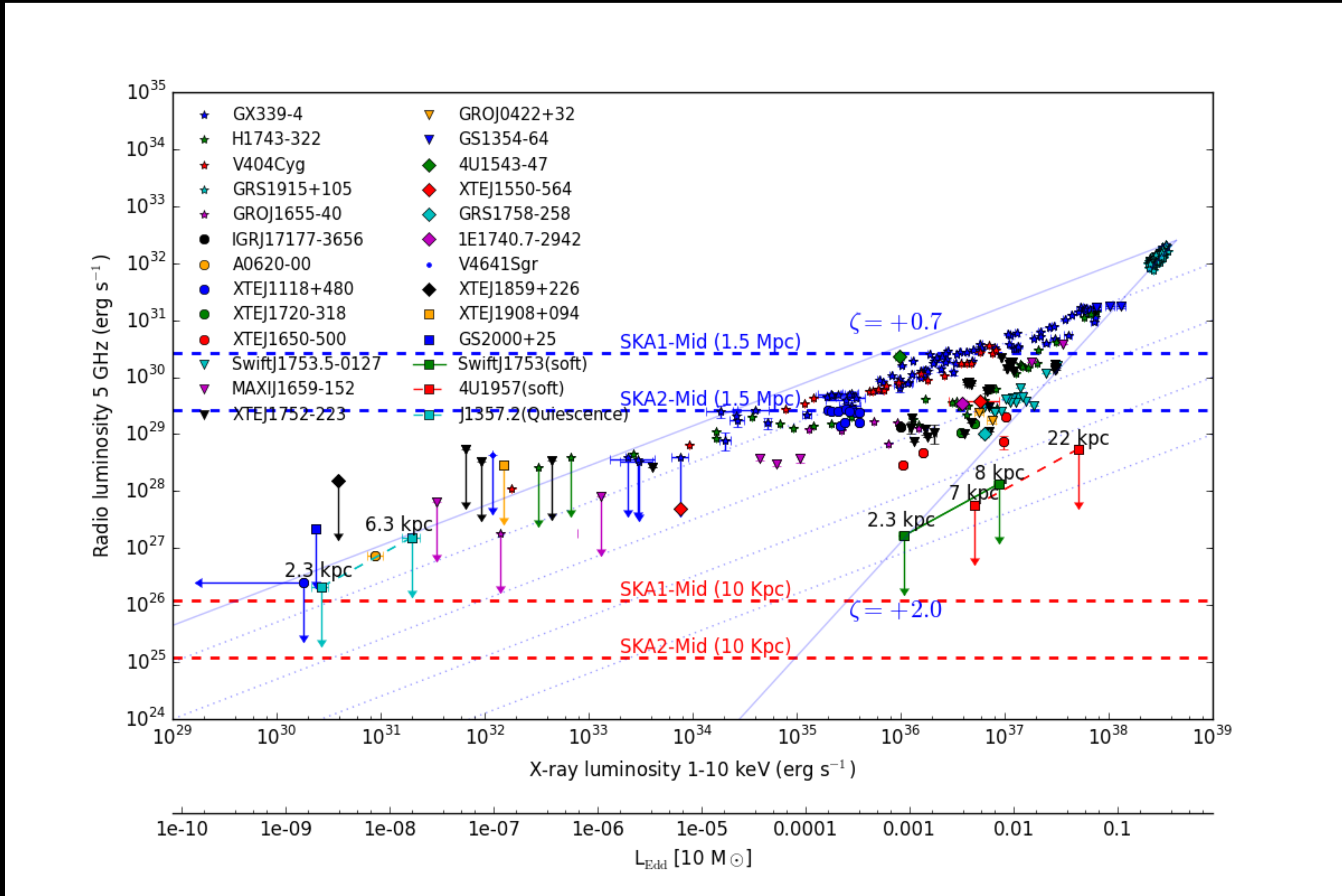
Alternative accretion models have been used to describe low/hard state in XRBs

$$L_{X-ray} \propto \dot{m}_{in}^2$$

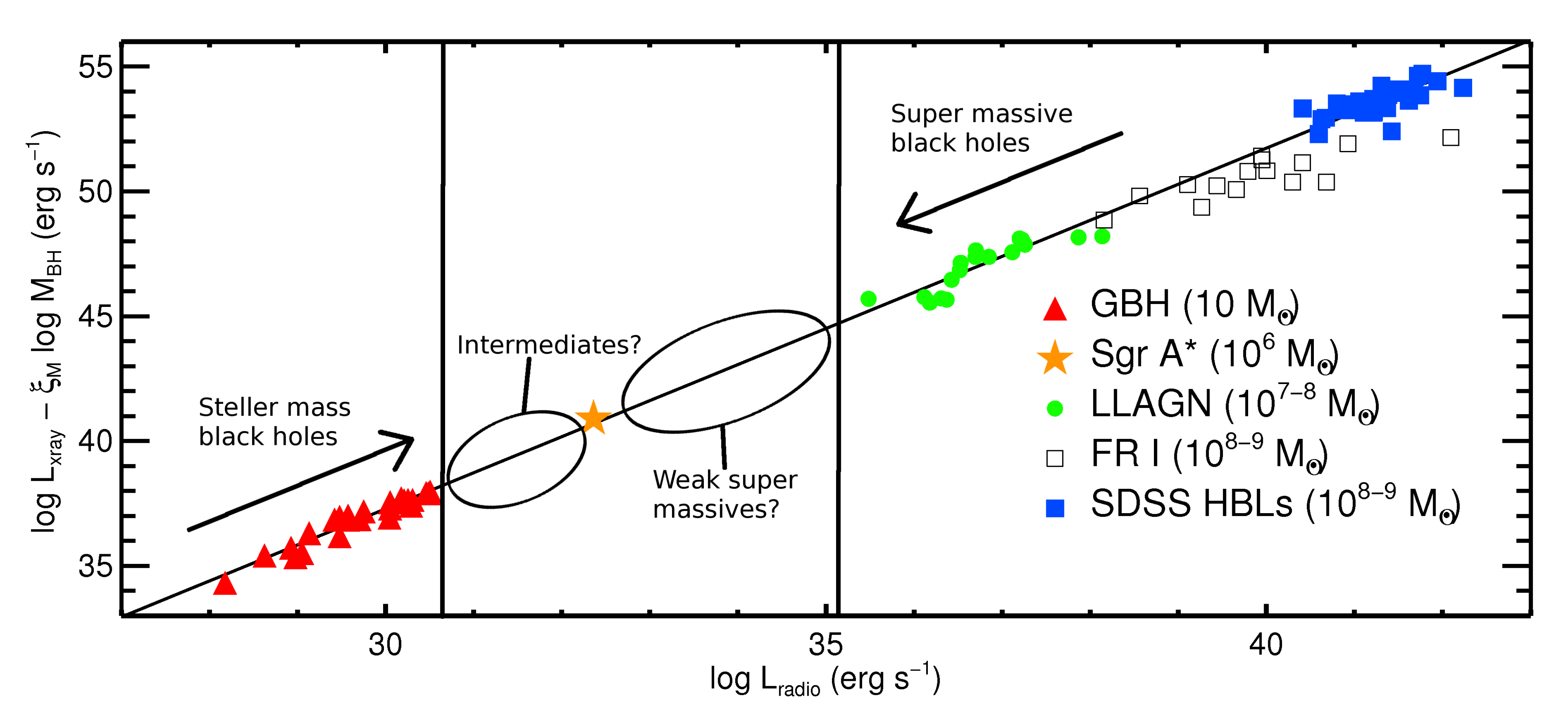
Geometrically thick disks heat energy is lost through *Radiatively inefficient accretion flows (RIAFs)*

Rees et al. (1982);
Abramowicz et al. (1995)

X-ray/radio correlation of XRBs

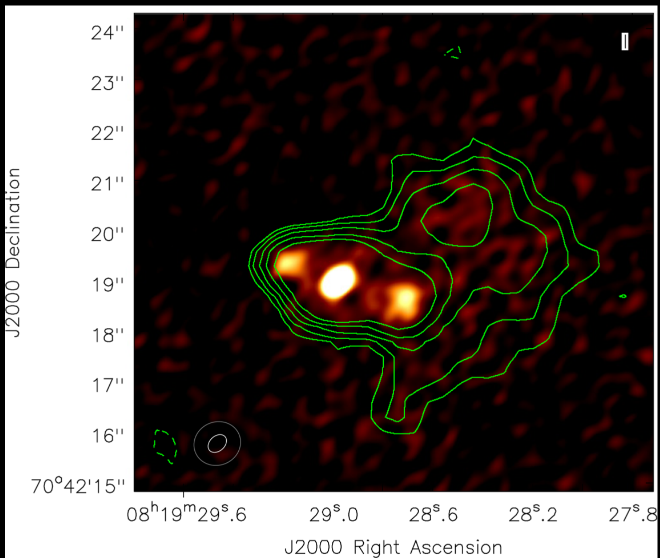


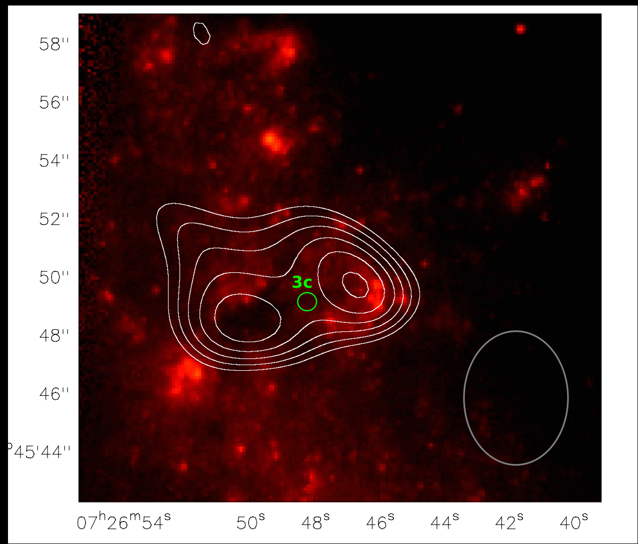
If the radio Vs X-ray correlation is a function of mass, where are the intermediates?



Plotkin et al. (2012)

Ultra-Luminous X-ray sources (ULXs)





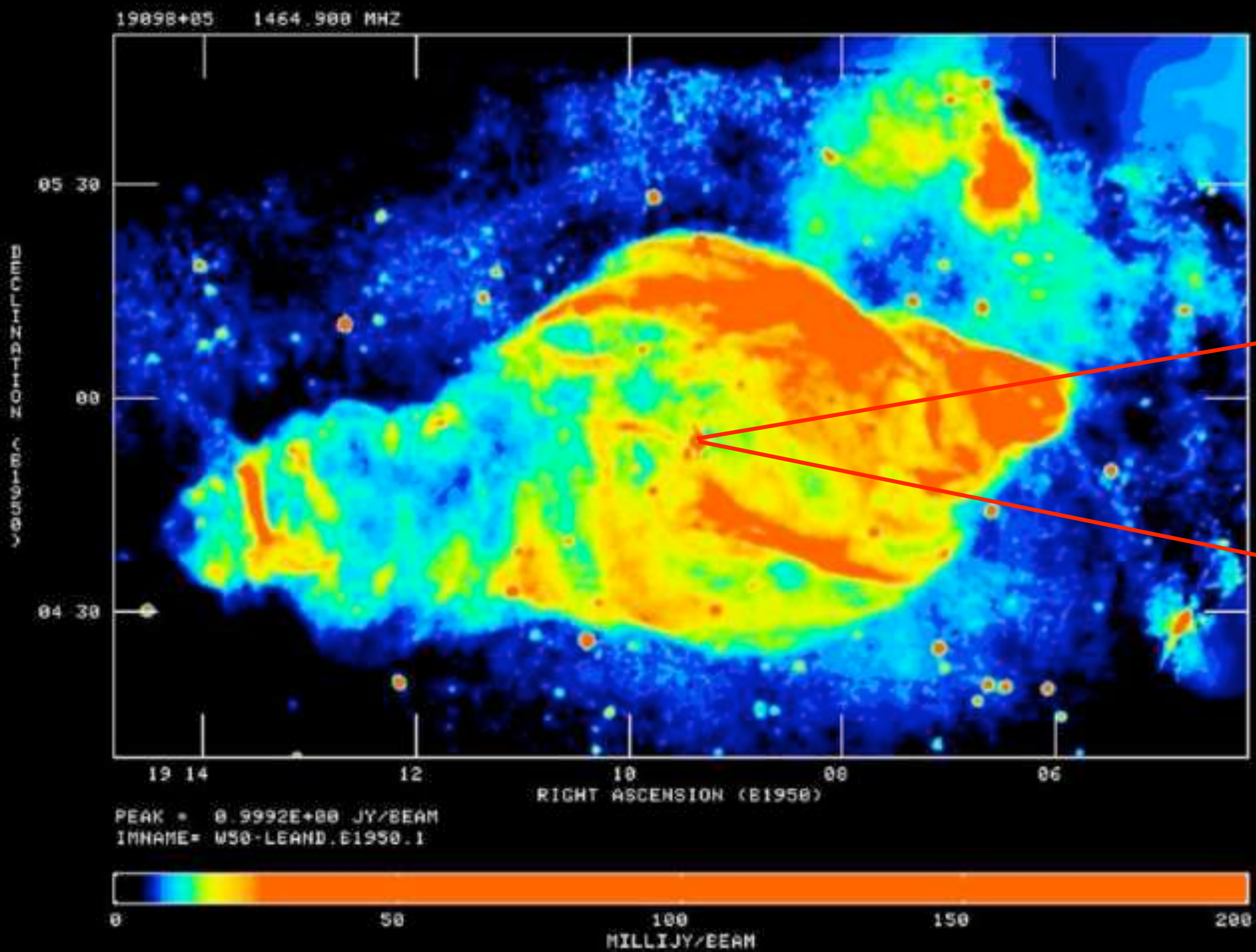
ULX Holmberg II X-1

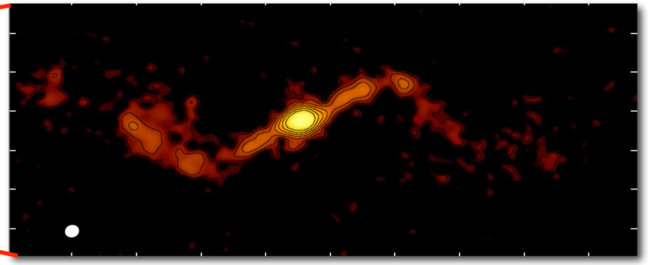
NGC 2276 ULX-3

Cseh et al. (2014)

Mezcua et al. (2013)

Analogous to a Super Eddington SS433/W50? (>1 L_{Edd})



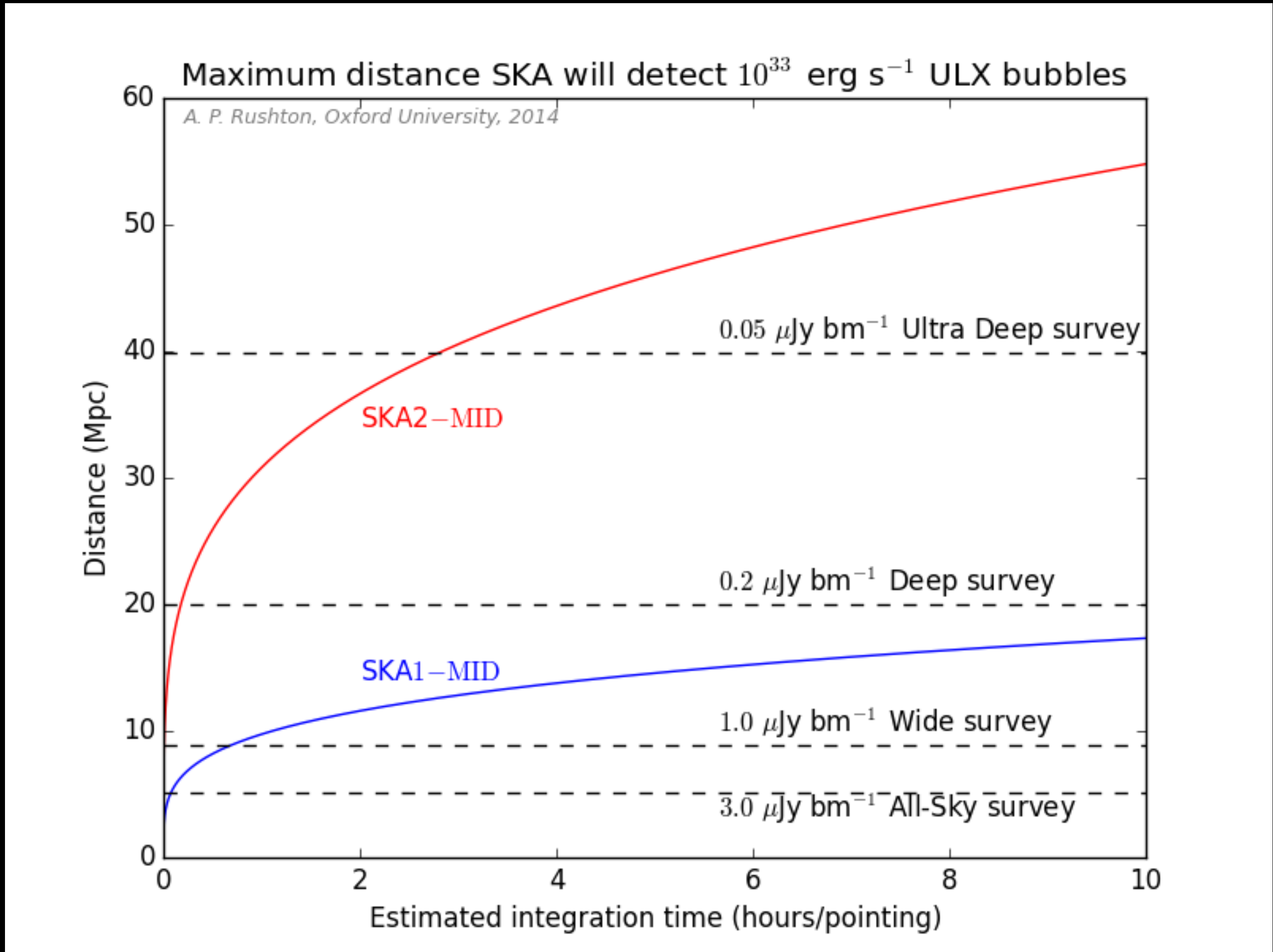


Galactic black hole SS433 (JVLA 43 GHz)

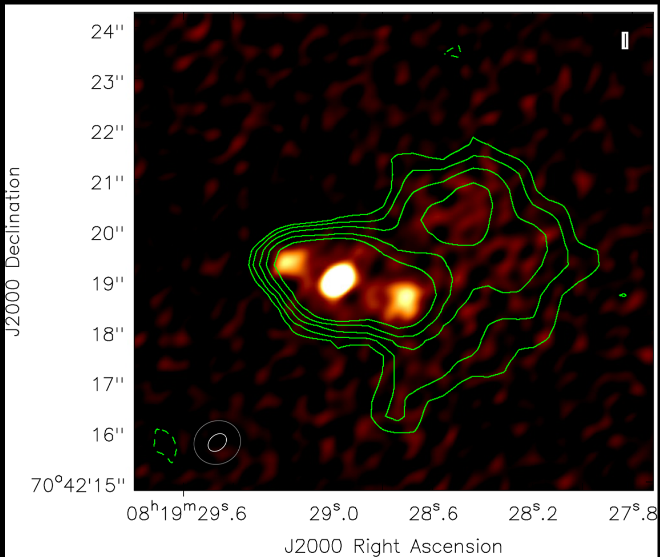
Rushton et al.

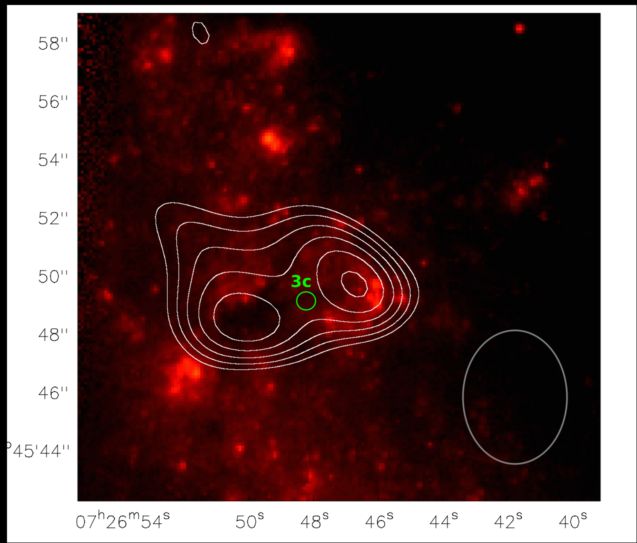
Dubner et al.

ULXs in the local universe



Ultra-Luminous X-ray sources (ULXs)





ULX Holmberg II X-1

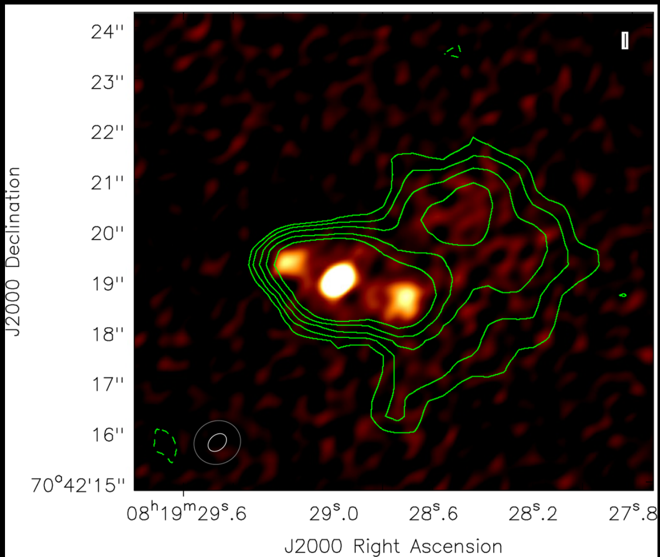
NGC 2276 ULX-3

Cseh et al. (2014)

Mezcua et al. (2013)

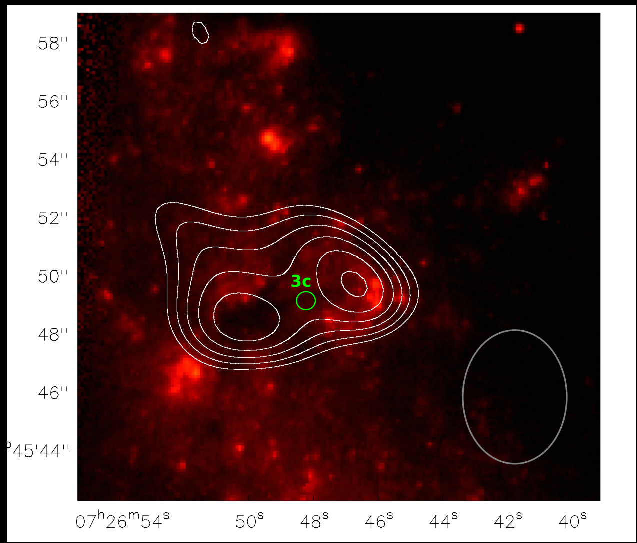
Sub-Eddington intermediate mass BHC

Super-Eddington Stellar BHs



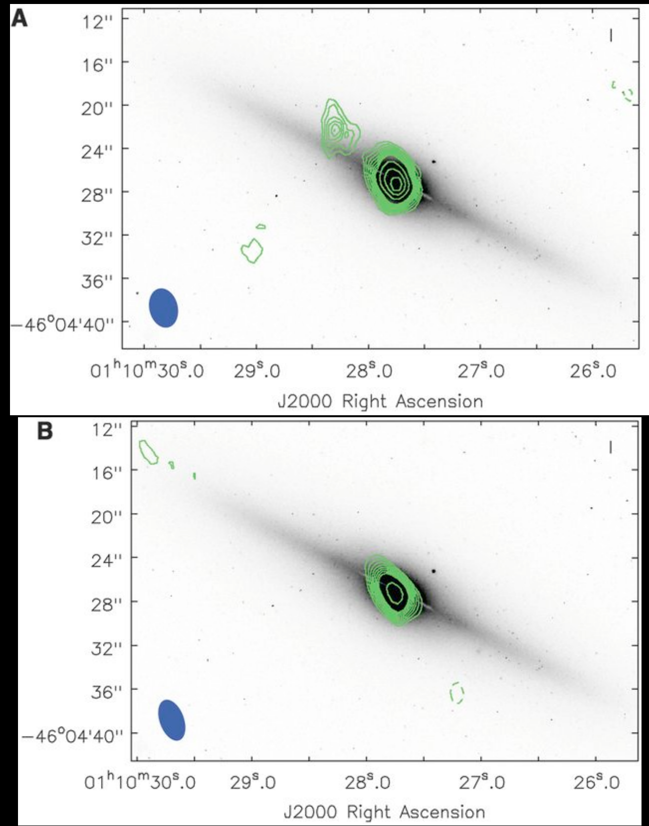
ULX Holmberg II X-1

Cseh et al. (2014)



NGC 2276 ULX-3

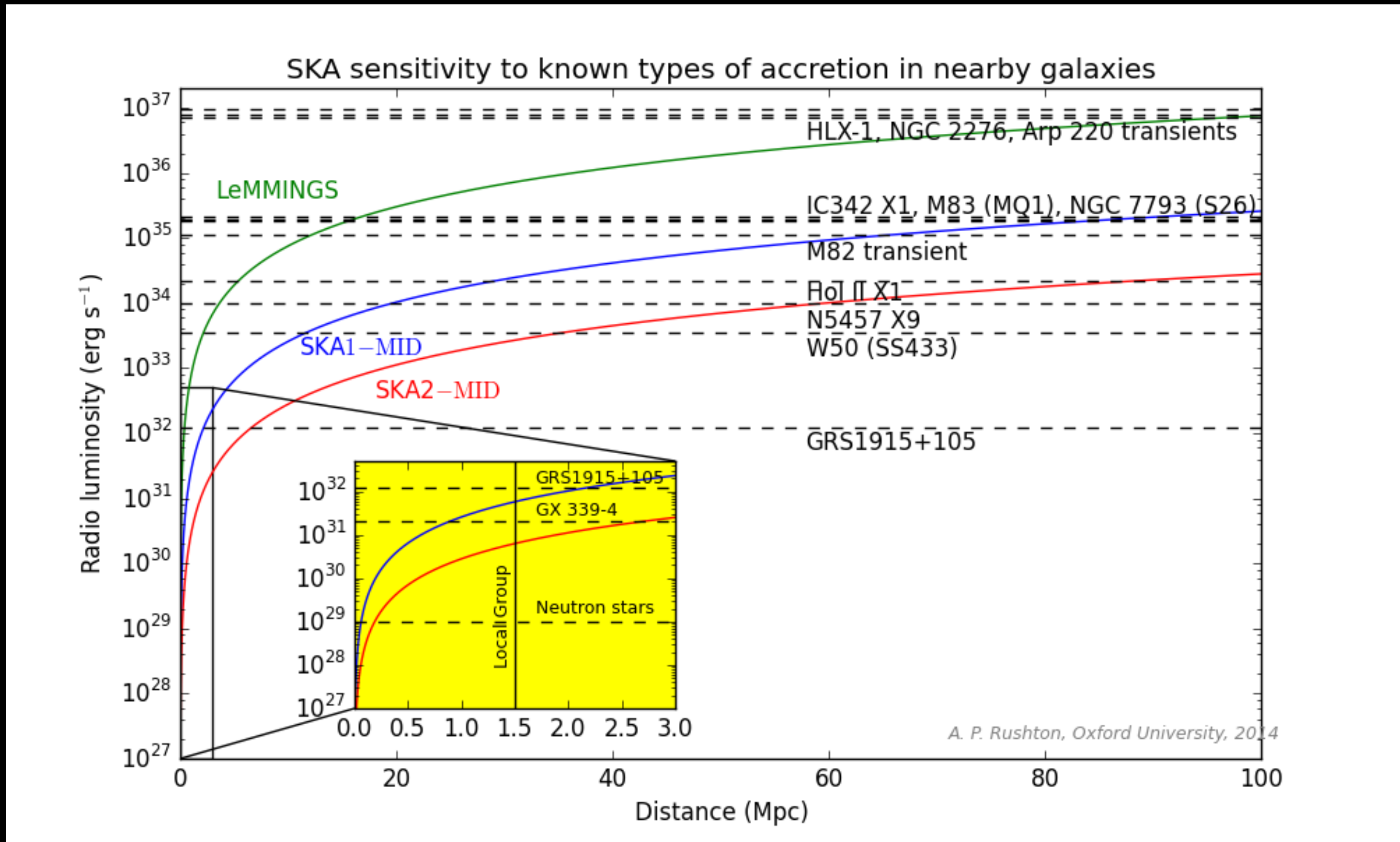
Mezcua et al. (2013)



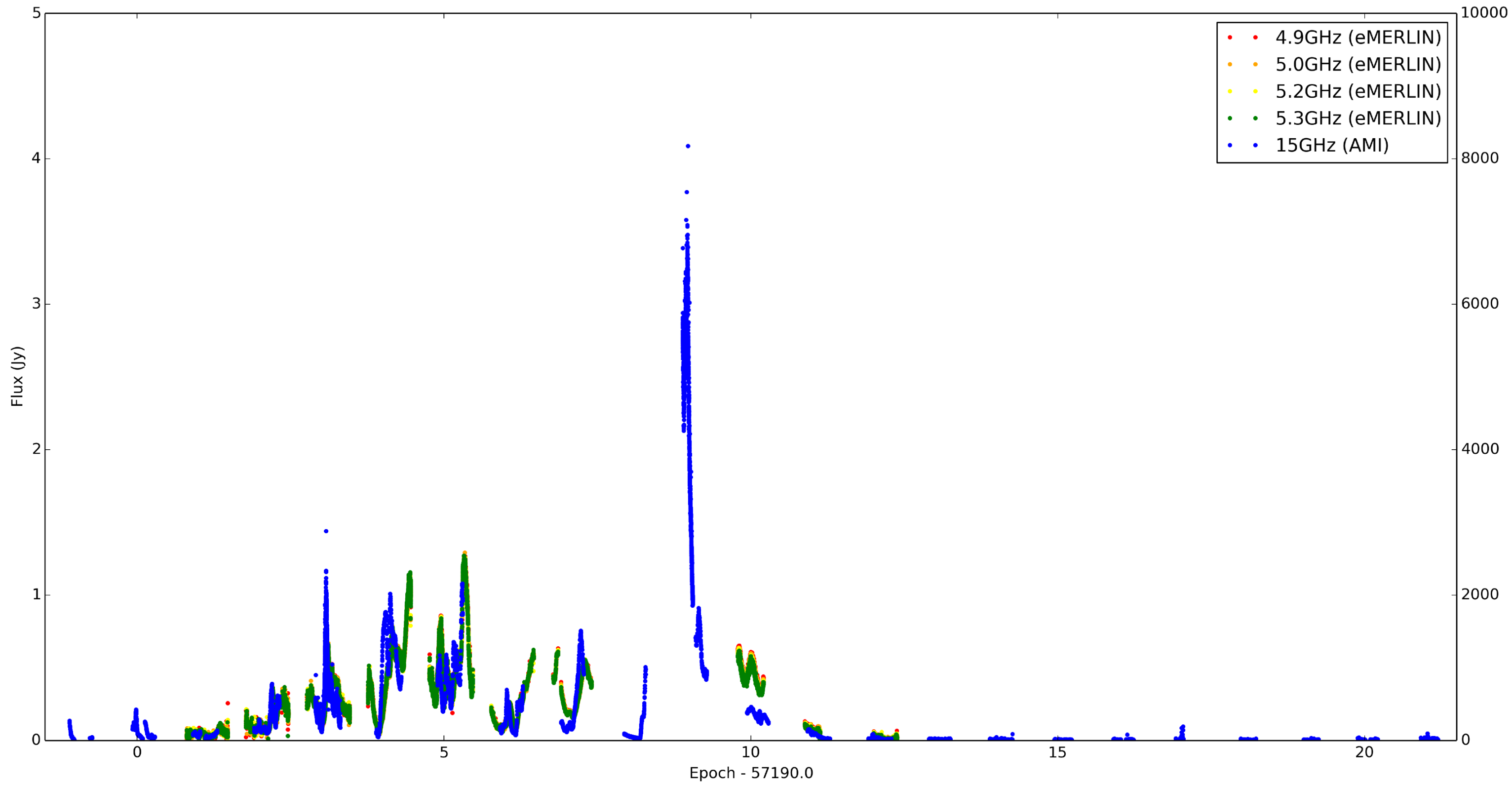
ESO 243-49 HLX-1

Webb et al. (2012)

Bursty emission in nearby galaxies



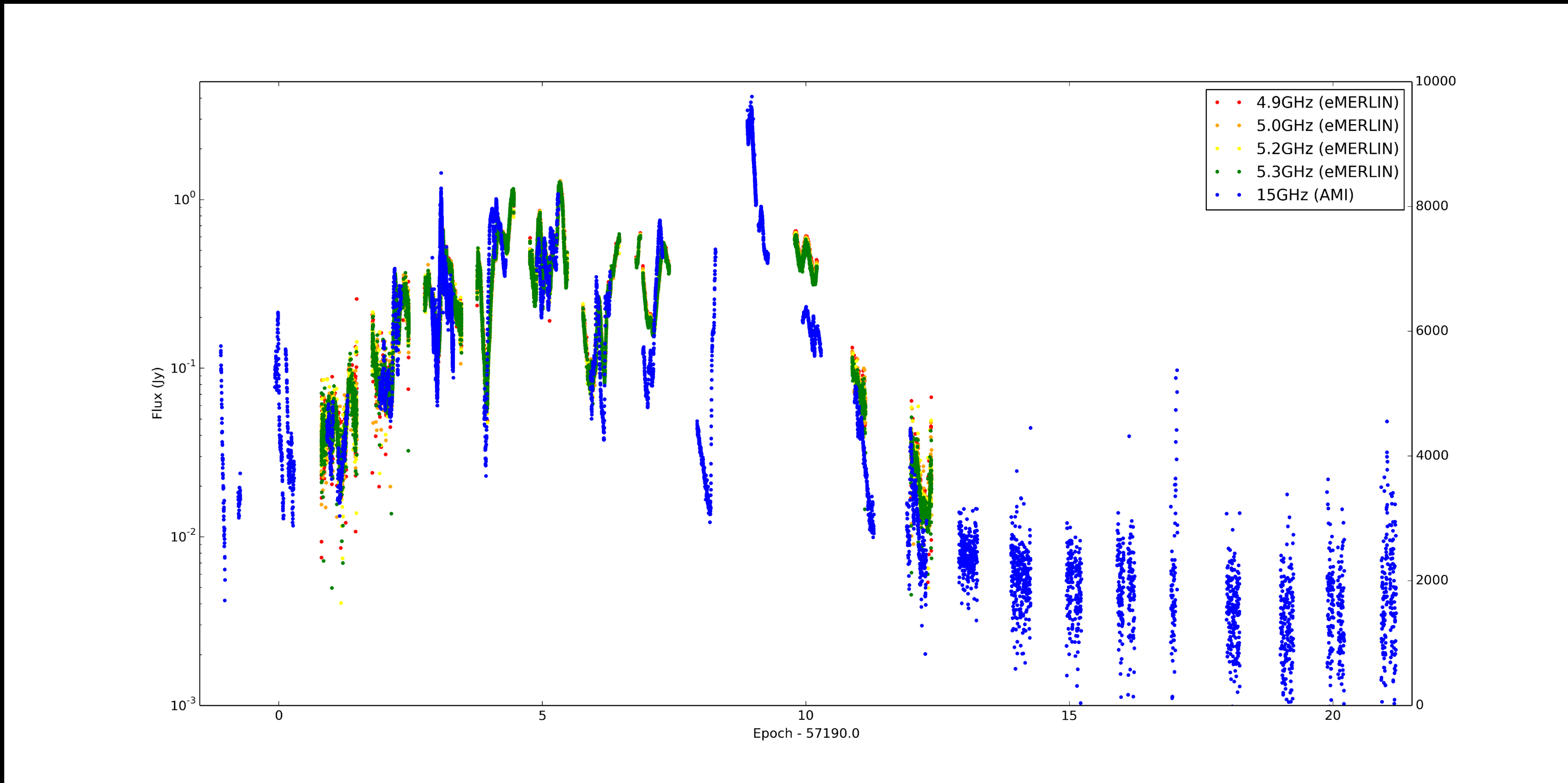
Highly Variable source: V404 Cyg



June 2015: few mJy-> few Jy in days

4 PI SKY team

Highly Variable source: V404 Cyg

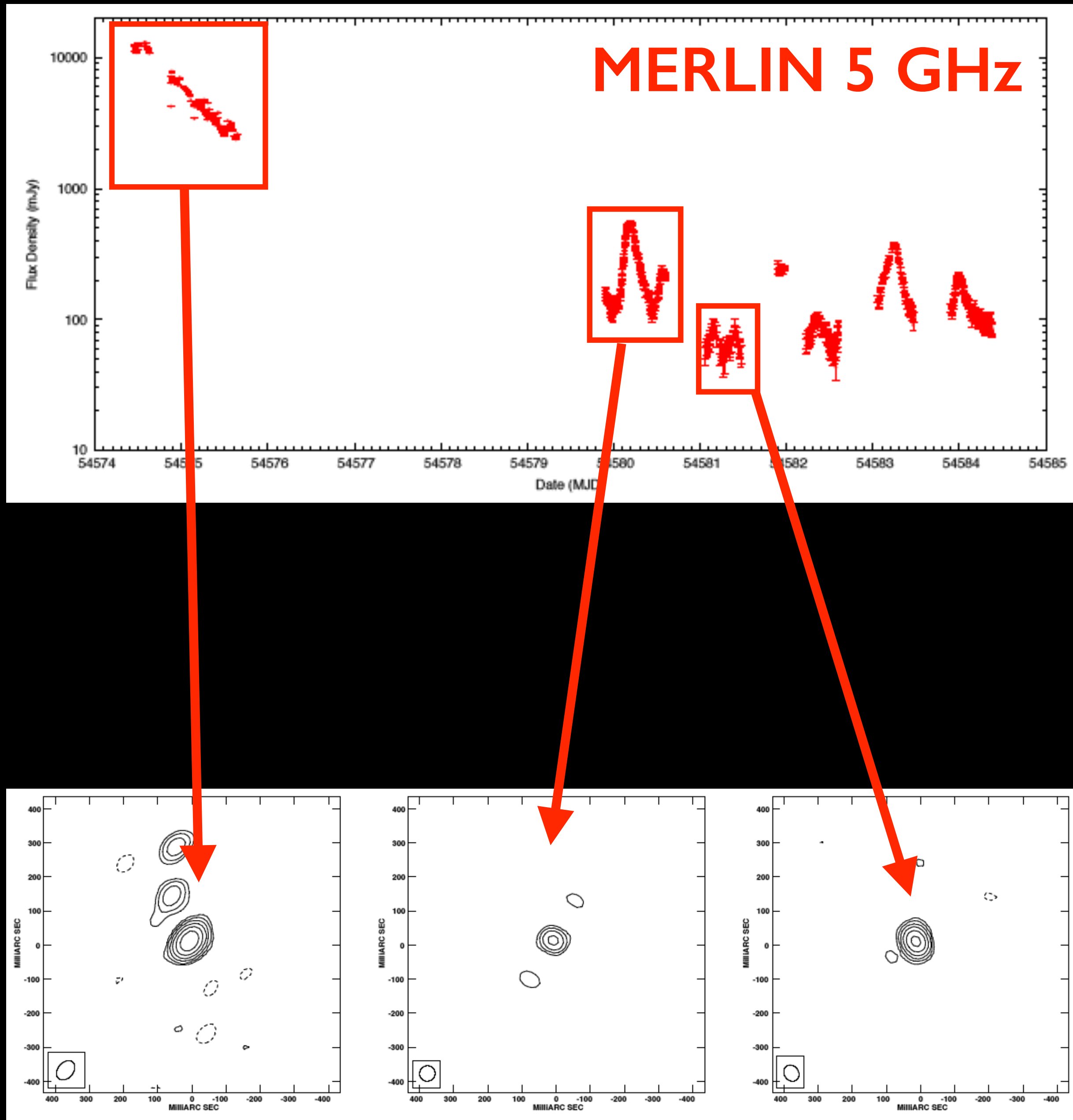


June 2015: few mJy-> few Jy in days

4 PI SKY team

Highly Variable source: Cyg X-3

Source Varied between
0.1-20 Jy on time-scales
of a few days

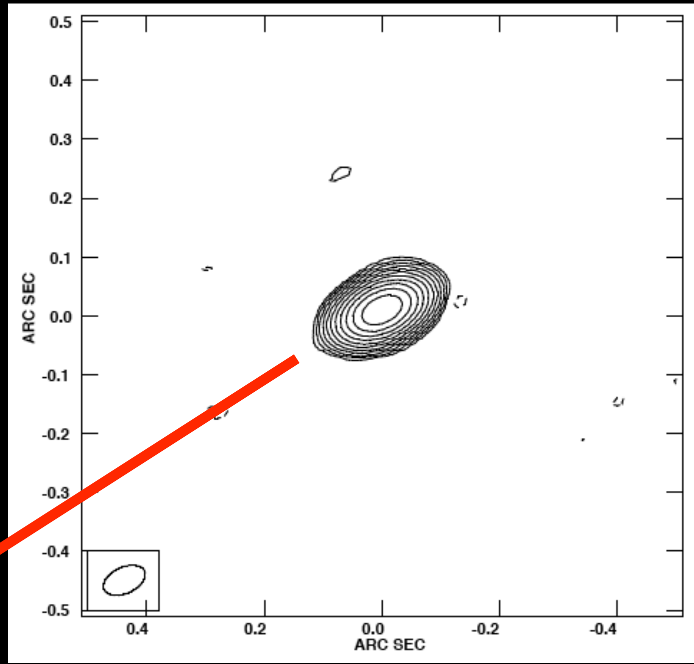


- Very poor images due to intrinsic changes in the sky brightness

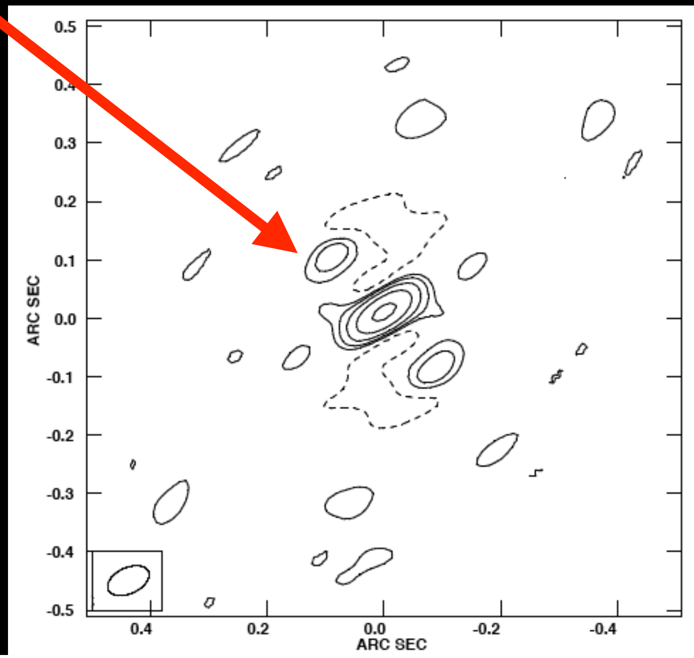
- Violating a basic assumption of aperture synthesis

Extreme simulated effect of source variation

A 1 Jy Gaussian component convolved with the eMERLIN beam (5 GHz)



Concatenated with a 0.1 Jy component

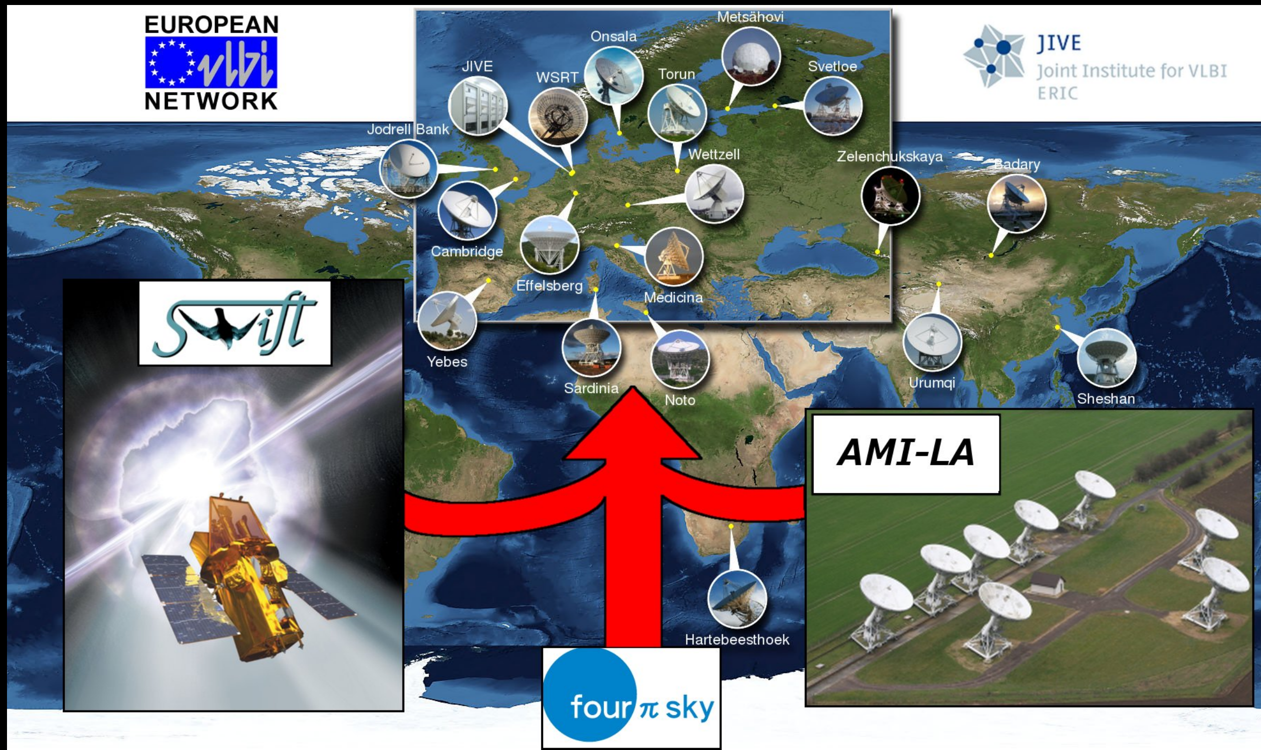


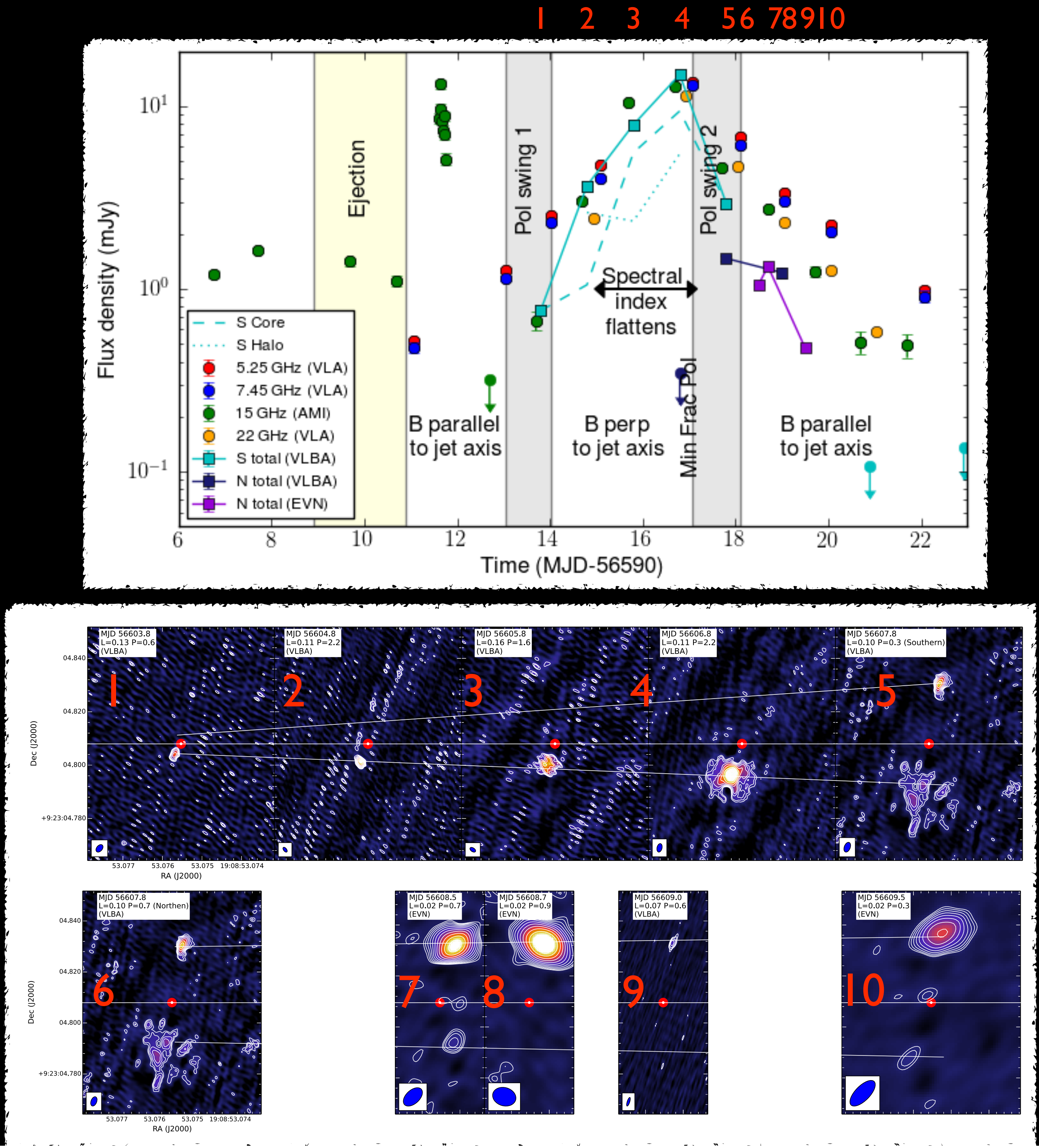
Result

- The RMS noise of the map increases by a factor of 10-100
- Bad side-lobes affects the fidelity of the map

Automatic triggering

- Monitor known transient with AMI
- Report variability via VOEvent (XML)
- Robotically respond at higher resolution (VLBI/EVN)




1 2 3 4 5 6 7 8 9 10
Ejection
Pol swing 1
Pol swing 2
Spectral index flattens
Min Frac Pol
B parallel to jet axis
B perp to jet axis
B parallel to jet axis
Flux density (mJy)
Time (MJD-56590)
S Core
S Halo
5.25 GHz (VLA)
7.45 GHz (VLA)
15 GHz (AMI)
22 GHz (VLA)
S total (VLBA)
N total (VLBA)
N total (EVN)
MJD 56603.8 L=0.13 P=0.6 (VLBA)
MJD 56604.8 L=0.11 P=2.2 (VLBA)
MJD 56605.8 L=0.16 P=1.6 (VLBA)
MJD 56606.8 L=0.11 P=2.2 (VLBA)
MJD 56607.8 L=0.10 P=0.3 (Southern) (VLBA)
MJD 56607.8 L=0.10 P=0.7 (Northen) (VLBA)
MJD 56608.5 L=0.02 P=0.7 (EVN)
MJD 56608.7 L=0.02 P=0.9 (EVN)
MJD 56609.0 L=0.07 P=0.6 (VLBA)
MJD 56609.5 L=0.02 P=0.3 (EVN)
Dec (J2000)
RA (J2000)

Thanks