

VO, FRBS & PWNS AT LOW FREQUENCIES

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Fast Radio Bursts

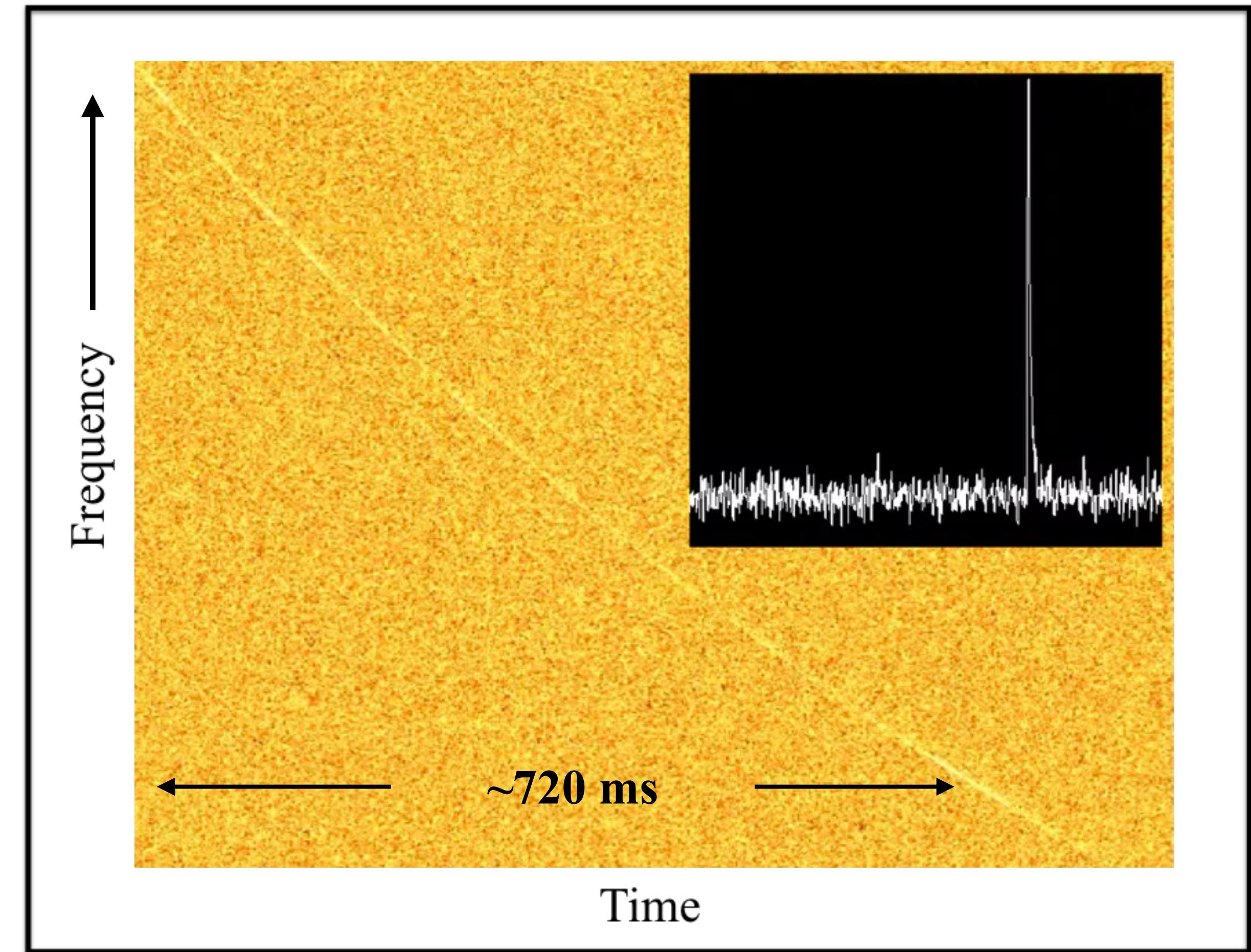
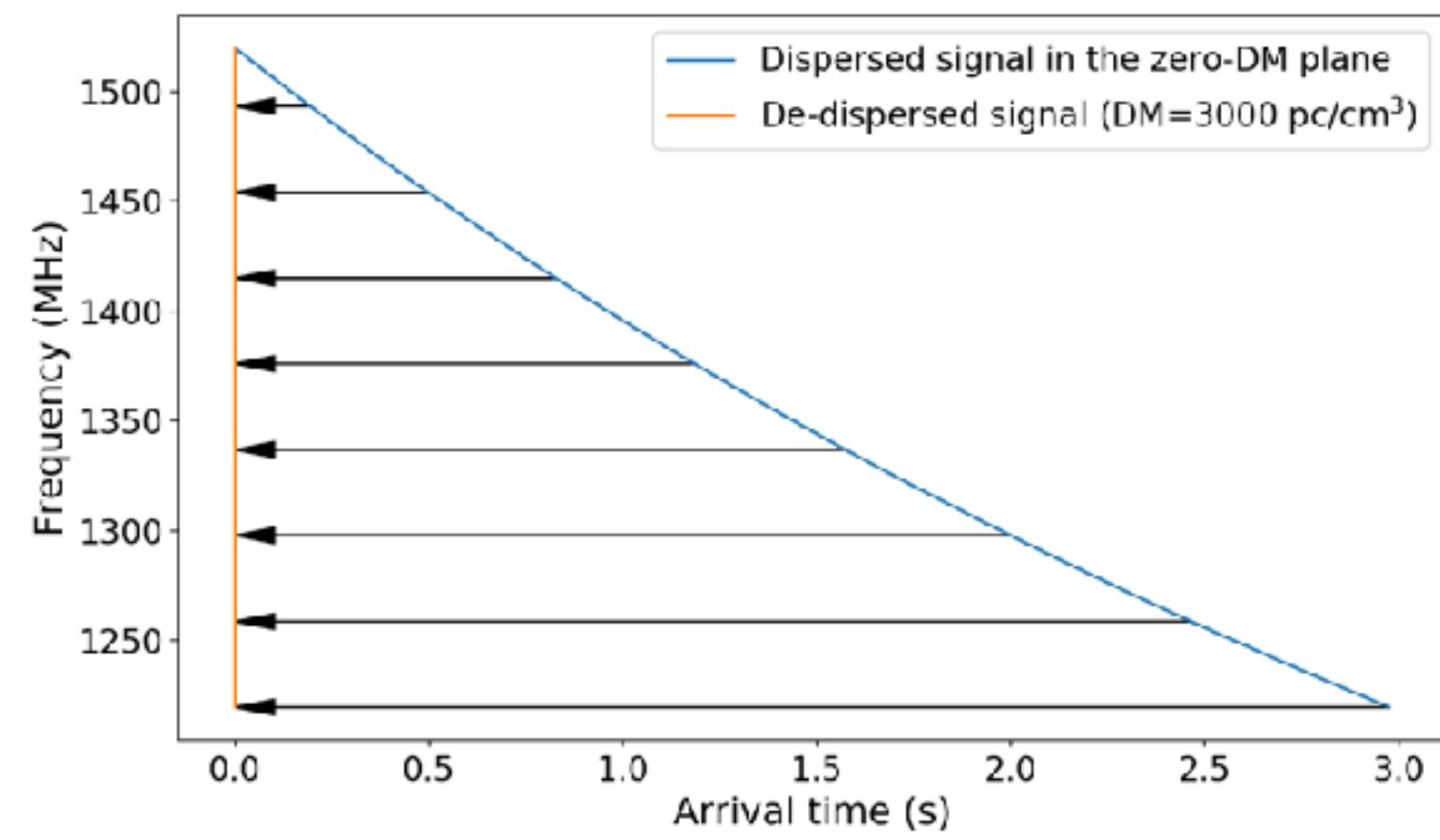
~10us-10ms duration

Extragalactic / cosmological

~ 10^3 day $^{-1}$ sky $^{-1}$

Dispersion measure (DM) > DM expected from MW

- Delay in arrival time of low frequencies with respect to high frequencies
- Due to propagation through ionized plasma



Fast Radio Bursts

~10us-10ms duration

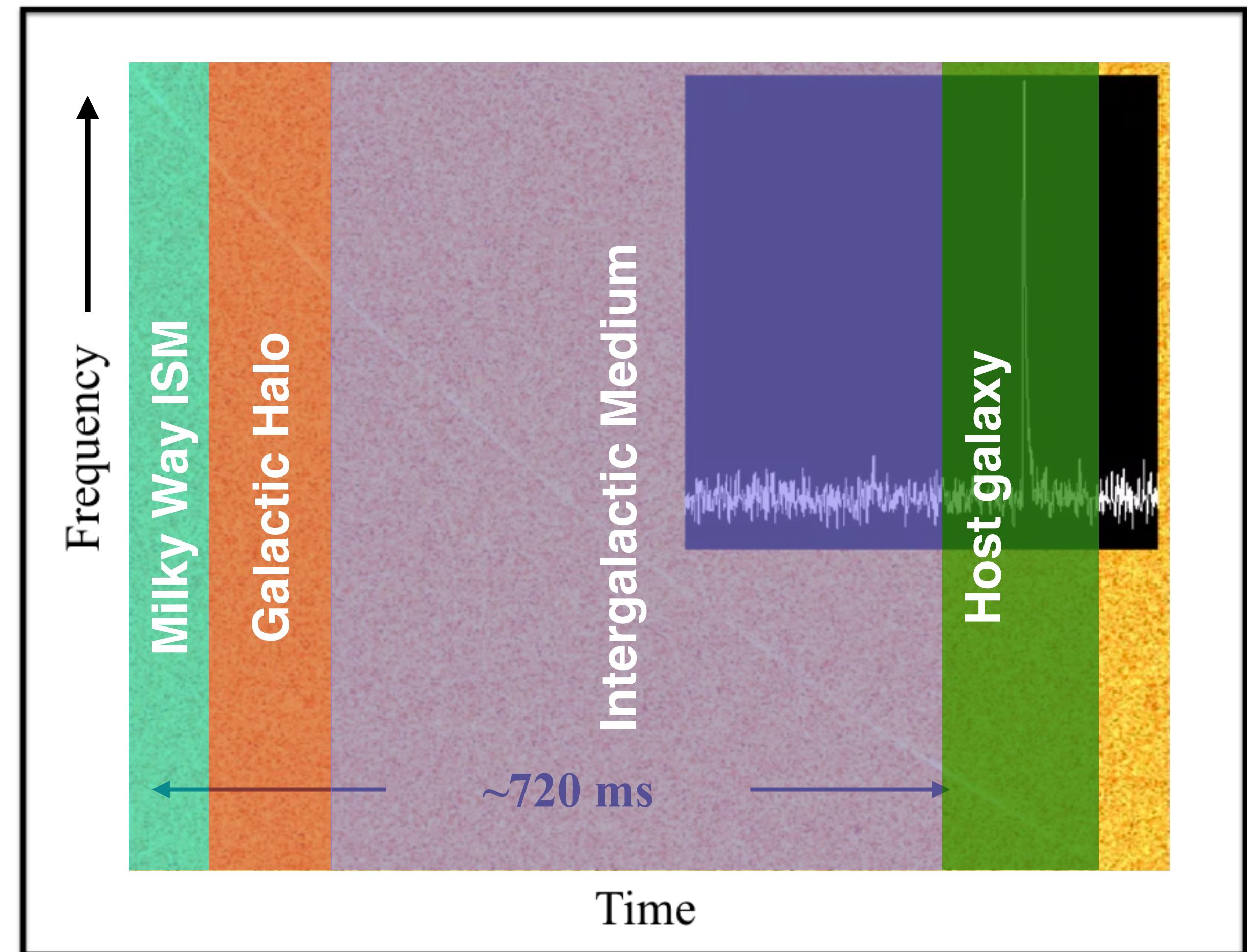
extragalactic / cosmological

~ 10^3 day $^{-1}$ sky $^{-1}$

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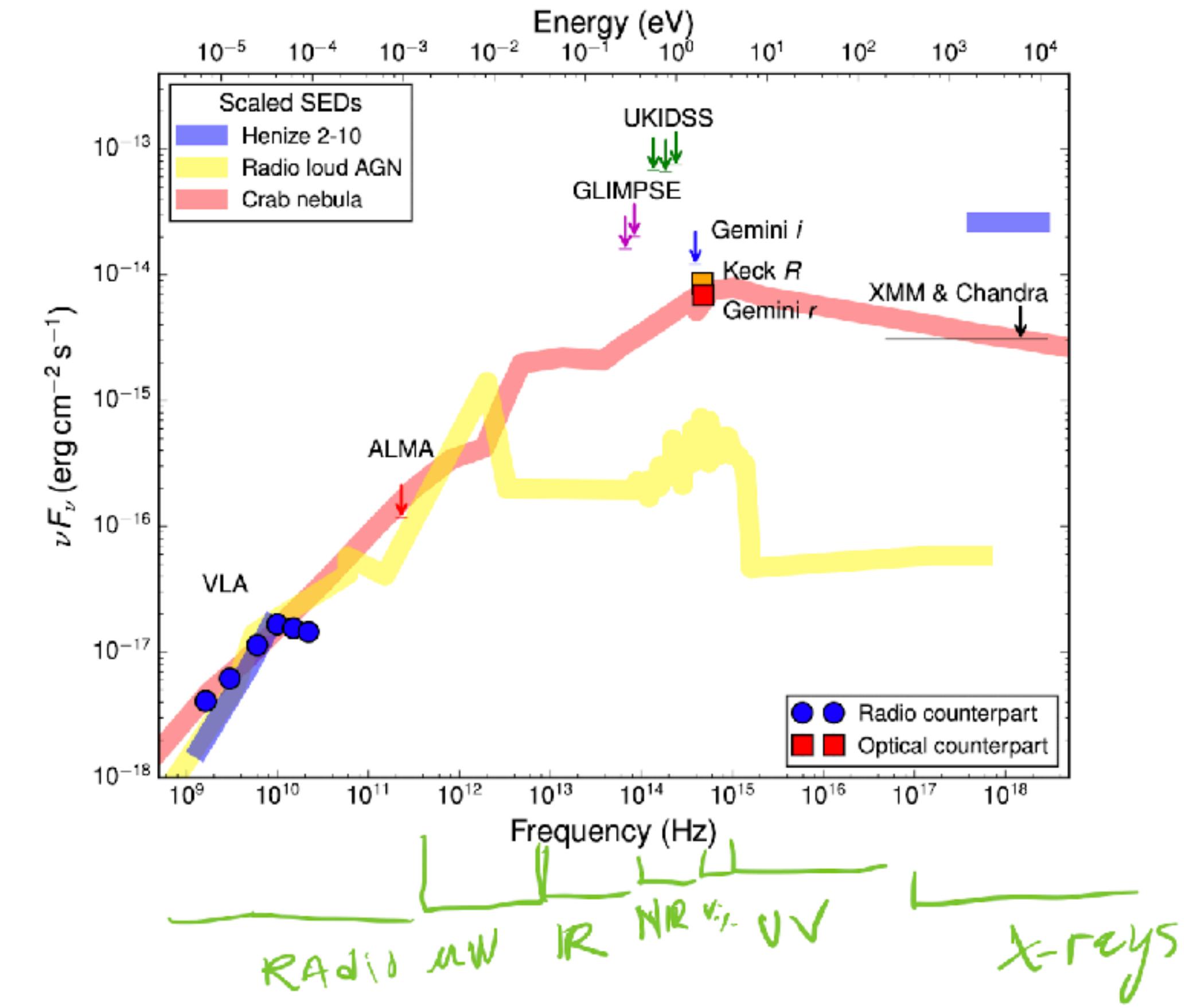
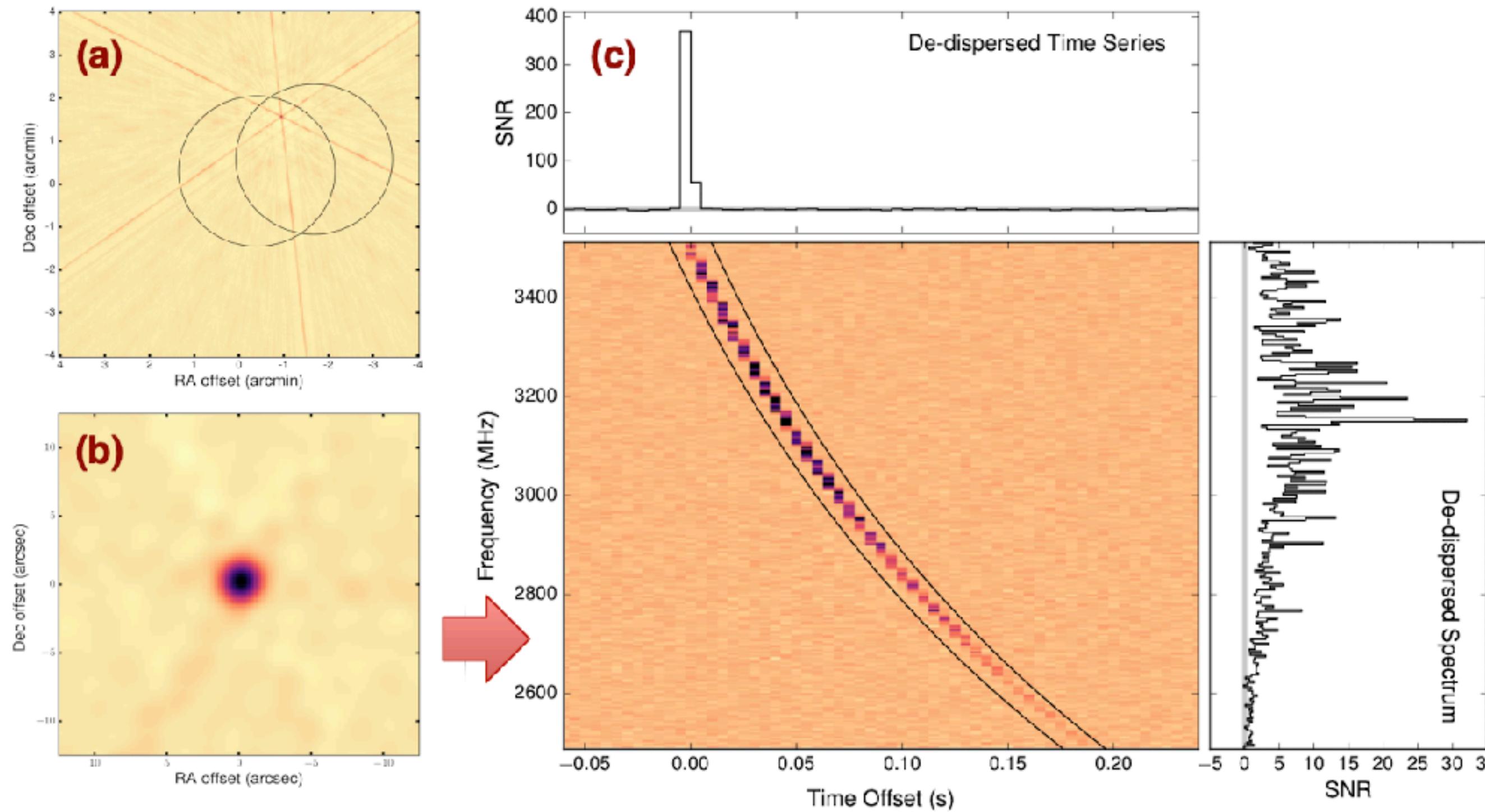
$$DM_{\text{total}} = DM_{\text{MW}} + DM_{\text{Halo}} + DM_{\text{ISM}} + DM_{\text{Host}}$$



The direct localization of a fast radio burst and its host

S. Chatterjee¹, C. J. Law², R. S. Wharton¹, S. Burke-Spolaor^{3,4,5}, J. W. T. Hessels^{6,7}, G. C. Bower⁸, J. M. Cordes¹, S. P. Tendulkar⁹, C. G. Bassa⁶, P. Demorest³, B. J. Butler³, A. Seymour¹⁰, P. Scholz¹¹, M. W. Abruzzo¹², S. Bogdanov¹³, V. M. Kaspi⁹, A. Keimpema¹⁴, T. J. W. Lazio¹⁵, B. Marcote¹⁴, M. A. McLaughlin^{4,5}, Z. Paragi¹⁴, S. M. Ransom¹⁶, M. Rupen¹¹, L. G. Spitler¹⁷, & H. J. van Langevelde^{14,18}

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- First FRB localized to a host galaxy
 - High rotation measure —>
 - Found in a **dwarf galaxy**
 - Co-located to **Persistent Radio Source**
 - PRS radio not attributed to star formation
 - **SED** suggesting **Pulsar Wind Nebulae**

The direct localization of a fast radio burst and its host

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M. A. McLaughlin^{4,5}
Langevelde^{14,18}

Published online by N

FRB 190520B embedded in a magnetar wind nebula and supernova remnant: luminous persistent radio source, decreasing dispersion measure and large rotation measure

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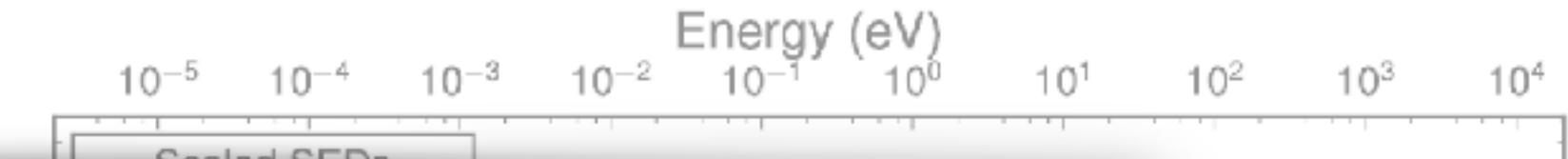
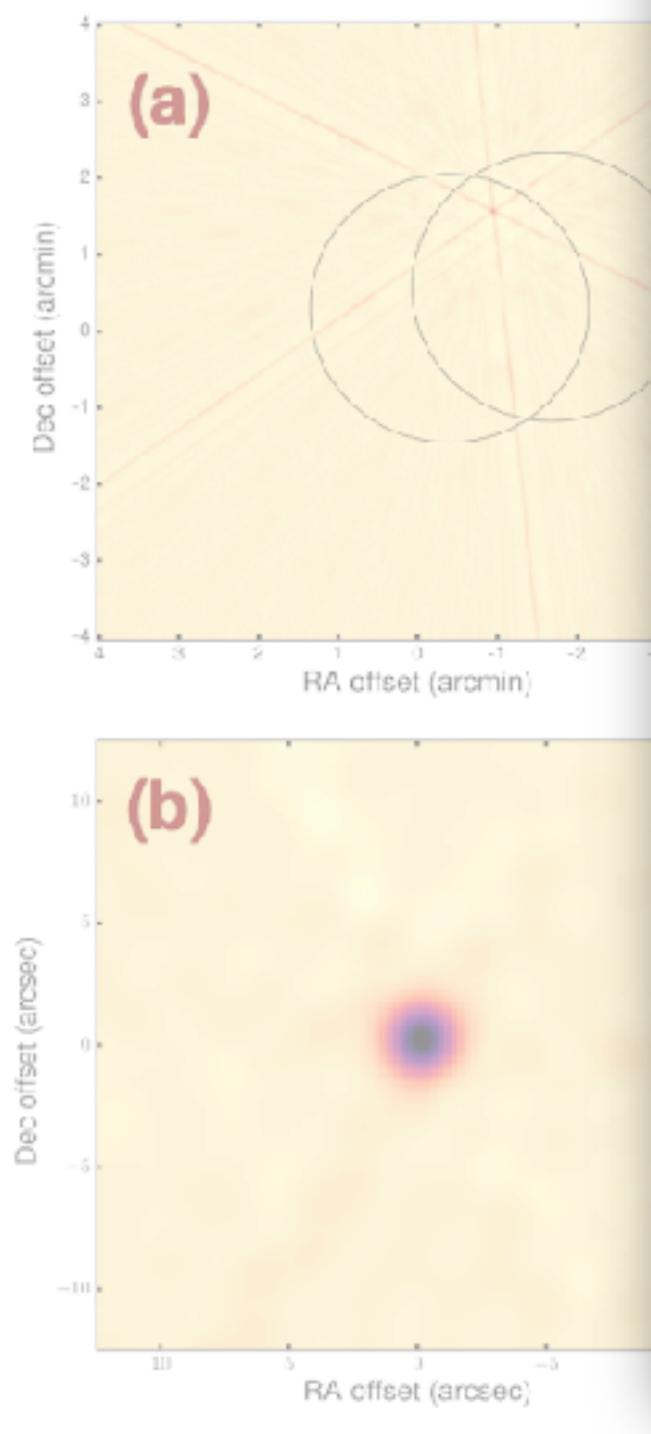
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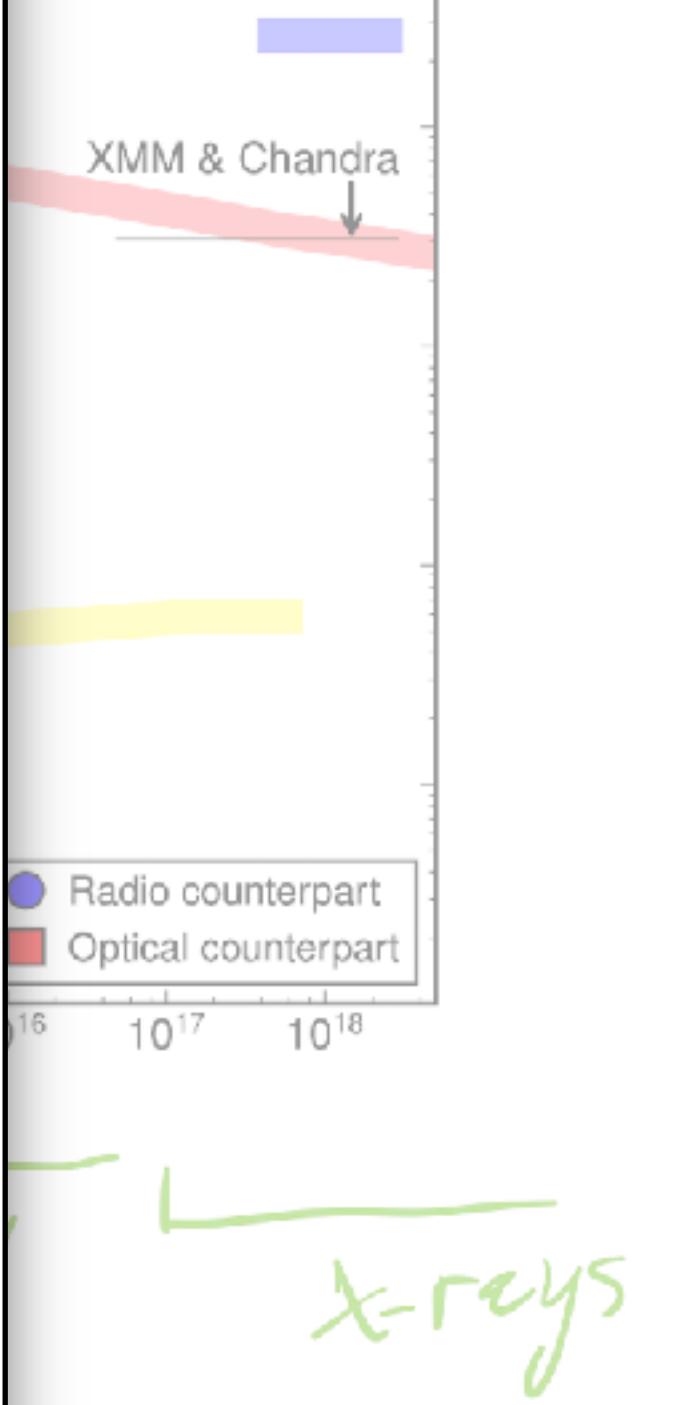
ABSTRACT

Recently, FRB 190520B with the largest extragalactic dispersion measure (DM), was discovered by the Five-hundred-meter Aperture Spherical radio Telescope (FAST). The DM excess over the intergalactic medium and Galactic contributions is estimated as $\sim 900 \text{ pc cm}^{-3}$, which is nearly ten times higher than other fast radio bursts (FRBs) host galaxies. The DM decreases with the rate $\sim 0.1 \text{ pc cm}^{-3}$ per day. It is the second FRB associated with a compact persistent radio source (PRS). The rotation measure (RM) is found to be larger than $1.8 \times 10^5 \text{ rad m}^{-2}$. In this letter, we argue that FRB 190520B is powered by a young magnetar formed by core-collapse of massive stars, embedded in a composite of magnetar wind nebula (MWN) and supernova remnant (SNR). The energy injection of the magnetar drives the MWN and SN ejecta to evolve together, and the PRS is generated by the synchrotron radiation of the MWN. The magnetar has the interior magnetic field $B_{\text{int}} \sim (2 - 4) \times 10^{16} \text{ G}$ and the age $t_{\text{age}} \sim 14 - 22 \text{ yr}$. The dense SN ejecta and the shocked shell contribute a large fraction of the observed DM and RM. Our model can naturally explain the luminous PRS, decreasing DM and extreme RM of FRB 190520B simultaneously.

Keywords: Fast radio burst, magnetar, magnetar wind nebula, supernova remnant



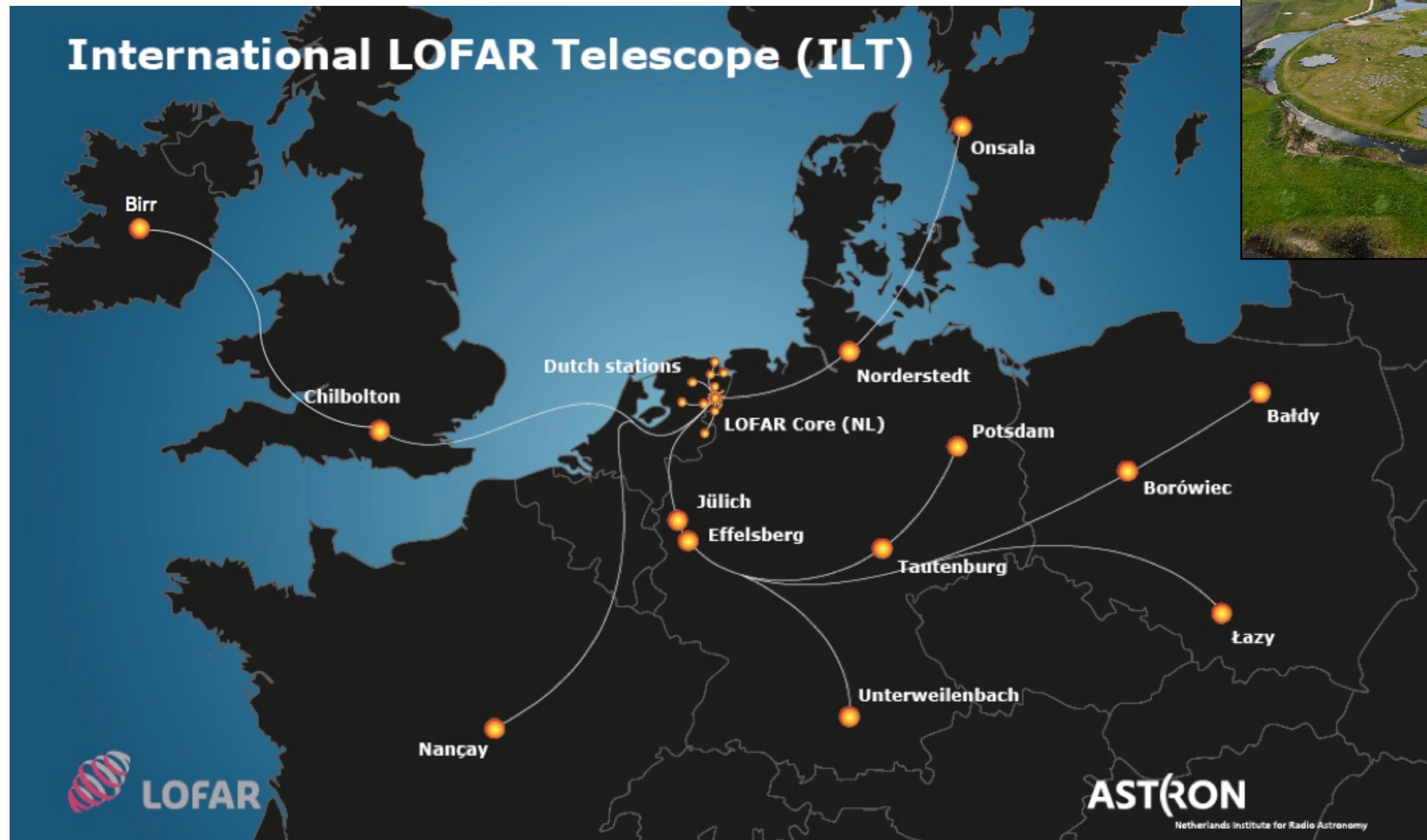
SED suggesting pulsar Wind Nebulae



radio Source
star formation
Wind Nebulae

LOFAR SURVEYS

International LOFAR Telescope (ILT)



LOFAR SURVEYS

The LOFAR Two-metre Sky Survey (LoTSS)

V. Second data release

T. W. Shimwell^{1,2*}, M. J. Hardcastle³, C. Tasse^{4,5}, P. N. Best⁶, H. J. A. Röttgering², W. L. Williams², A. Botteon², A. Drabent⁷, A. Mechev², A. Shulevski², R. J. van Weeren², L. Bester^{8,5}, M. Brüggen⁹, G. Brunetti¹⁰, J. R. Callingham^{2,1}, K. T. Chyží¹¹, J. E. Conway¹², T. J. Dijkema¹, K. Duncan⁶, F. de Gasperin⁹, C. L. Hale⁶, M. Haverkorn¹³, B. Hugo^{8,5}, N. Jackson¹⁴, M. Mevius¹, G. K. Miley², L. K. Morabito^{15,16}, R. Morganti^{1,17}, A. Offringa^{1,17}, J. B. R. Oonk^{18,2,1}, D. Rafferty⁹, J. Sabater⁶, D. J. B. Smith³, D. J. Schwarz¹⁹, O. Smirnov^{5,8}, S. P. O'Sullivan²⁰, H. Vedantham^{1,17}, G. J. White^{21,22}, J. G. Albert², L. Alegre⁶, B. Asabere¹, D. J. Bacon²³, A. Bonafede^{24,10,9}, E. Bonnassieux²⁴, M. Brienza^{24,10}, M. Bilicki²⁵, M. Bonato^{10,26,27}, G. Calistro Rivera²⁸, R. Cassano¹⁰, R. Cochrane²⁹, J. H. Croston²², V. Cuciti⁹, D. Dallacasa^{24,10}, A. Danezi¹⁸, R. J. Dettmar³⁰, G. Di Gennaro⁹, H. W. Edler⁹, T. A. Enßlin^{31,32}, K. L. Emig³³, T. M. O. Franzen¹, C. García-Vergara², Y. G. Grange¹, G. Gürkan⁷, M. Hajduk^{13,34}, G. Heald³⁵, V. Heesen⁹, D. N. Hoang⁹, M. Hoeft⁷, C. Horellou¹², M. Iacobelli¹, M. Jamrozy¹¹, V. Jelić³⁶, R. Kondapally⁶, P. Kukreti^{17,1}, M. Kunert-Bajraszewska³⁷, M. Magliocchetti³⁸, V. Mahatma⁷, K. Małek^{39,40}, S. Mandal², F. Massaro^{41,42,43}, Z. Meyer-Zhao¹, B. Mingo²², R. I. J. Mostert^{2,1}, D. G. Nair⁴⁴, S. J. Nakoneczny⁴⁵, B. Nikiel-Wroczyński¹¹, E. Orrú¹, U. Pajdosz-Śmierciak¹¹, T. Pasini⁹, I. Prandoni¹⁰, H. E. van Piggelen¹⁸, K. Rajpurohit^{24,10}, E. Retana-Montenegro^{46,47}, C. J. Riseley^{24,10,35}, A. Rowlinson^{1,48}, A. Saxena⁴⁹, C. Schrijvers¹⁸, F. Sweijen², T. M. Siewert¹⁹, R. Timmerman², M. Vaccari^{50,10}, J. Vink⁴⁸, J. L. West⁵¹, A. Wołowska³⁵, X. Zhang^{2,52} and J. Zheng^{54,23,55}

(Affiliations can be found after the references)

DR2: 4 million radio sources

Observed area: ~5500 square degrees

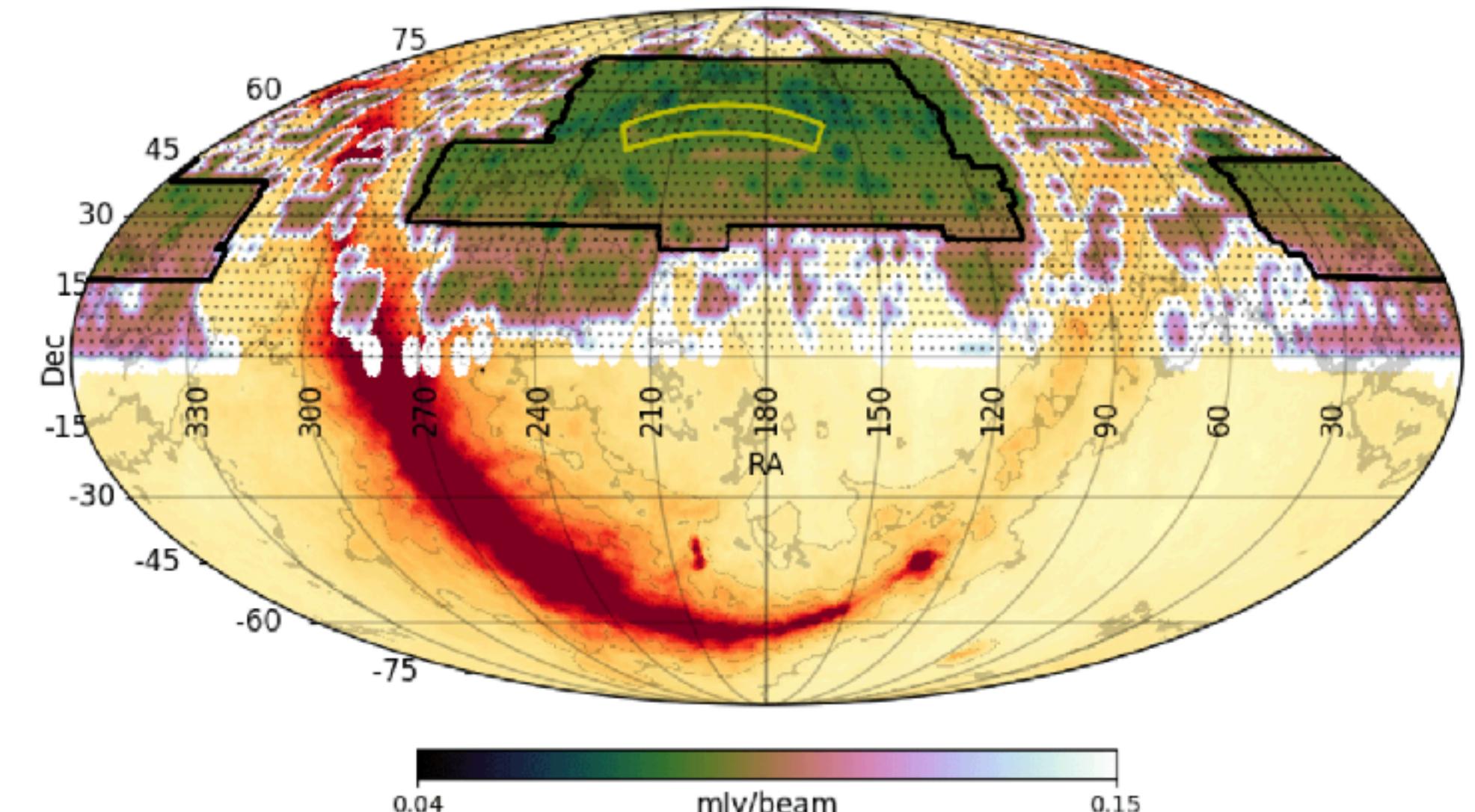
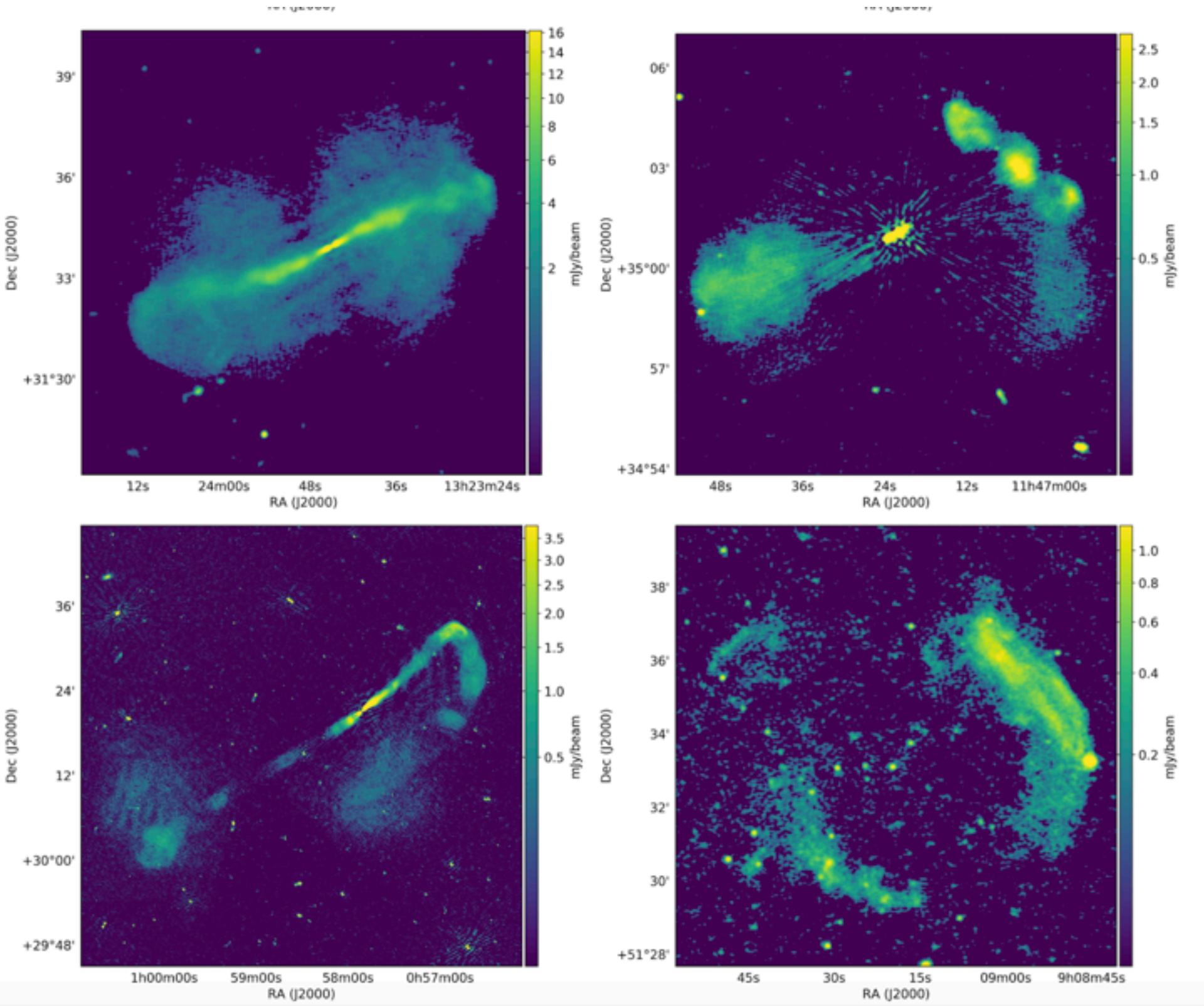
Central frequency: 144 MHz

0''.2 localization accuracy (comparable to optical surveys)

Point source completeness to 90% at 0.8 mJy/beam

HIPS previewer

- [High-resolution preview](#) (view in the Aladin app or in a web browser)
- [Low-resolution preview \(20 arcsec\)](#)



Census of the Local Universe (CLU) Narrowband Survey. I. Galaxy Catalogs from Preliminary Fields

David O. Cook^{1,2}, Mansi M. Kasliwal¹, Angela Van Sistine³, David L. Kaplan³, Jessica S. Sutter⁴, Thomas Kupfer¹, David L. Shupe², Russ R. Laher², Frank J. Masci², Daniel A. Dale⁴, Branimir Sesar⁵, Patrick R. Brady², Lin Yan⁴, Eran O. Ofek⁶, David H. Reitze¹, and Shriniwas R. Kulkarni¹

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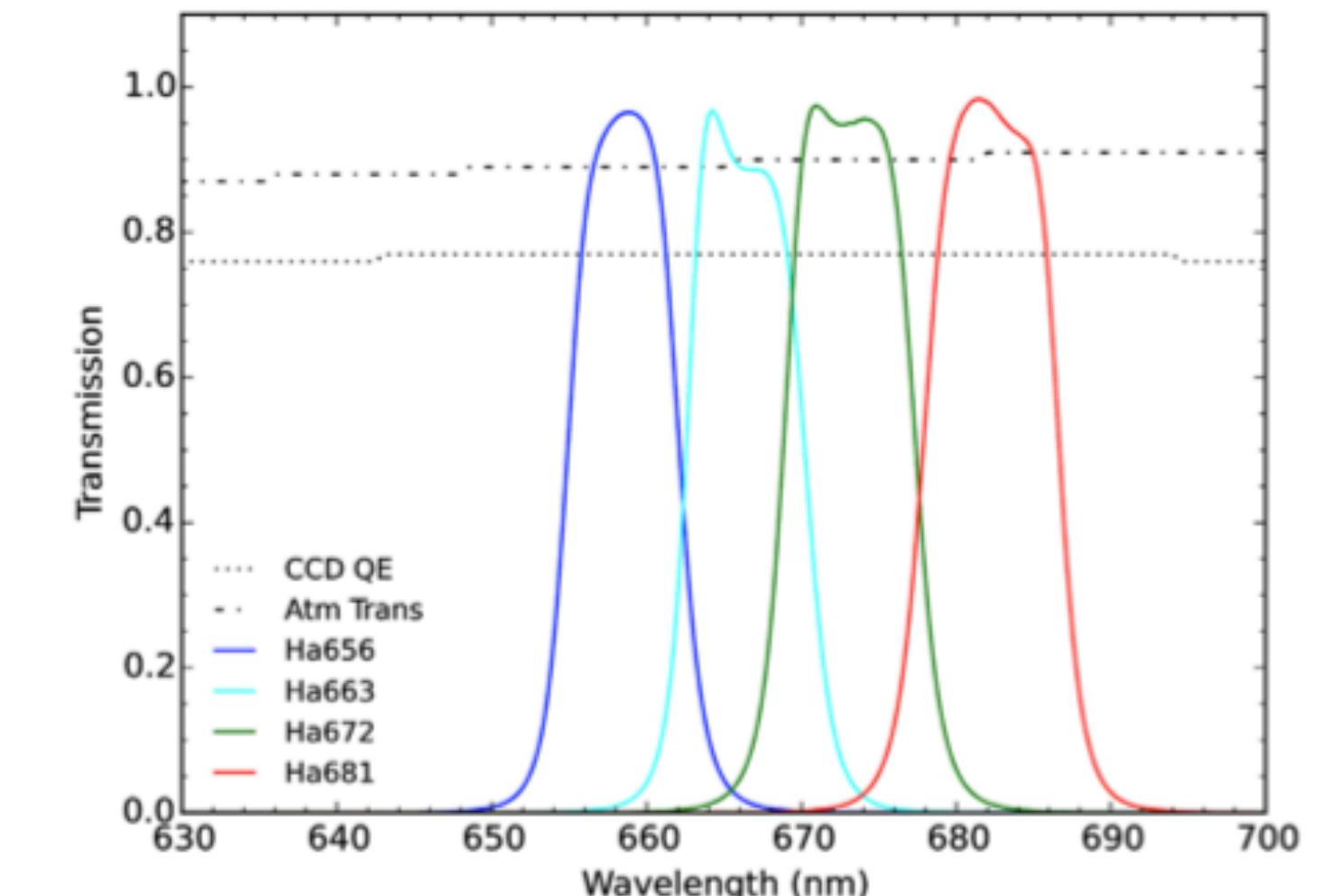


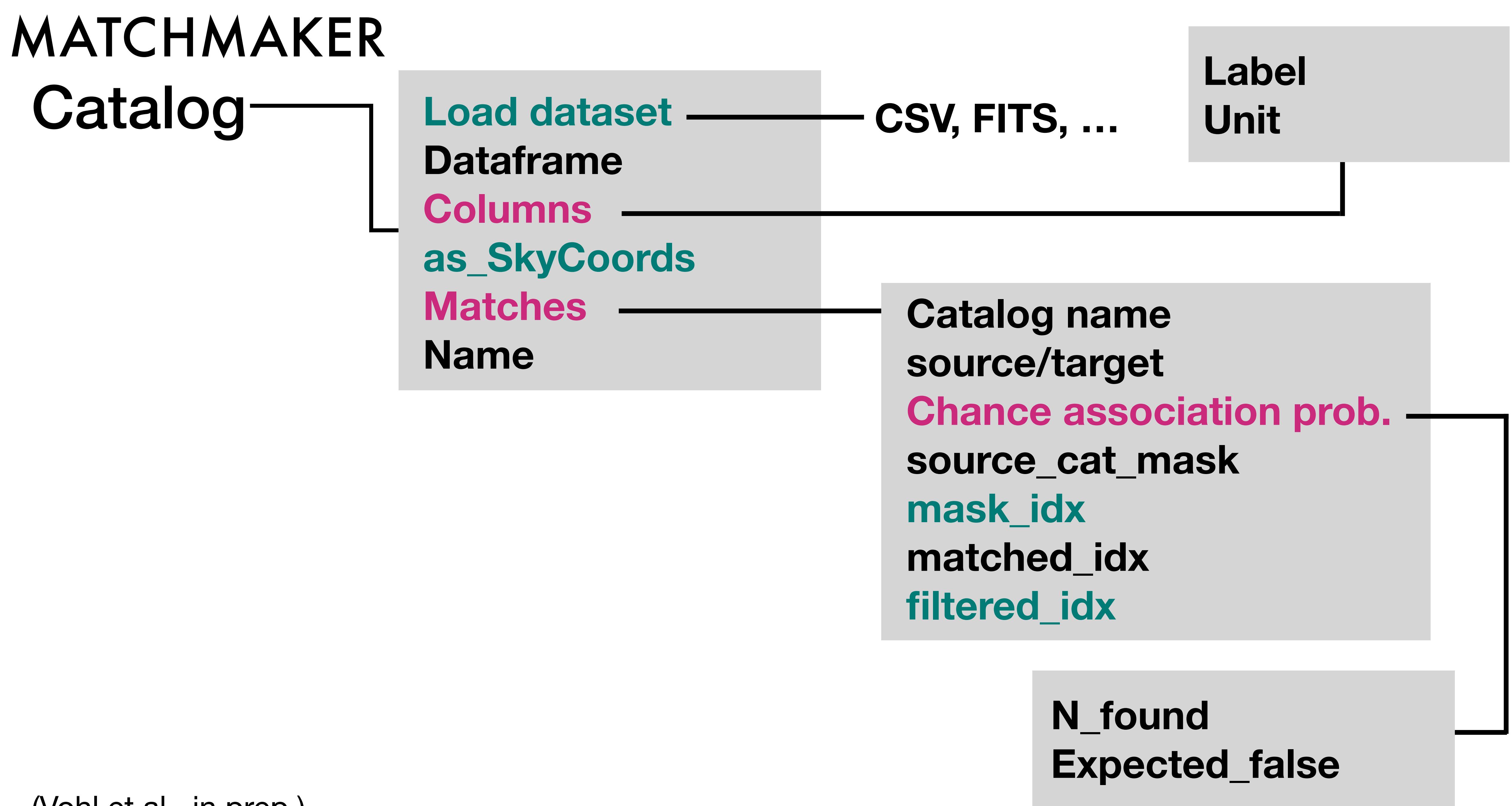
Figure 1. Measured filter transmission profiles of the four CLU-H α narrowband filters, where the blue, cyan, green, and red curves represent H α 1, H α 2, H α 3, and H α 4 filters, respectively. The horizontal dotted and dashed lines represent the CCD quantum efficiency and the atmospheric transmission at Palomar Observatory, respectively.

- 3 π of the sky : 26,470 square degrees
- Observed in four H-alpha bands
- Catalog provides various physical information

Table 1
Narrow-band H α Filter Properties

Filter Name	Filter λ (Å)	Filter $\Delta\lambda$ (Å)	Redshift Range (#)
H α 1	6584.2	76.1	$-0.0026 < z < 0.0090$
H α 2	6663.7	77.9	$0.0094 < z < 0.0213$
H α 3	6730.9	90.1	$0.0187 < z < 0.0324$
H α 4	6822.1	92.1	$0.0325 < z < 0.0471$

Note. The properties of the CLU narrowband filters, where the columns present the filter names, central wavelength, FWHM, and redshift range, are provided from left to right. The first filter (H α 1) is centered on rest-frame H α , while the last filter's FWHM extends to 200 Mpc.



```
datasets = {'clu': Catalog1,  
           'lotss': Catalog2}
```

```
datasets['clu'].df.iloc[  
    datasets['clu'].matches['lotss'].mask  
]
```

```
[36]: datasets['clu'].df.iloc[datasets['clu'].matches['lotss'].mask]
```

	index_df_clu	cluid	id_other	name	ra	dec	dm	d
652	22654	236443	585876	UGC 00384	9.592208	32.638222	34.074726	
697	23414	237984	585906	UGC 00511	12.540583	31.731250	34.331436	
800	26039	243424	499696/626011	CGCG 502-	20.571417			
					32368	252380	588779	440189 NGC 7468 345.746919 16.605246 32.304489
					32369	252387	588849	448024 UGC 12864 359.349958 30.992167 33.550587

```
datasets = {'clu': Catalog1,  
           'lotss': Catalog2}
```

```
datasets['lotss'].df.iloc[  
    datasets['lotss'].matches['clu'].filtered_idx  
]
```

• [38]: `datasets['lotss'].df.iloc[datasets['lotss'].matches['clu'].filtered_idx]`

[38]:	Source_Name	RA	E_RA	DEC	E_DEC	Peak_flux	E_Peak_f
3816151	ILTJ003822.25+323816.0	9.592726	6.584300	32.637778	8.406498	0.095541	0.0291
599728	ILTJ005009.60+314350.5	12.539993	1.436865	31.730713	1.375752	0.387253	0.0698
3616998	ILTJ012217.24+284754.1	20.571815	1.092289	28.798384	2.097363	0.384706	0.0847
1255086	ILTJ013046.51+21	3961933	ILTJ230259.25+163617.9	345.746872	0.242465	16.604986	0.357964
		3752475	ILTJ235723.92+305931.7	359.349648	0.845909	30.992164	0.414000
							0.941244
							0.1271

... ■ ■ ■

333 rows × 24 columns

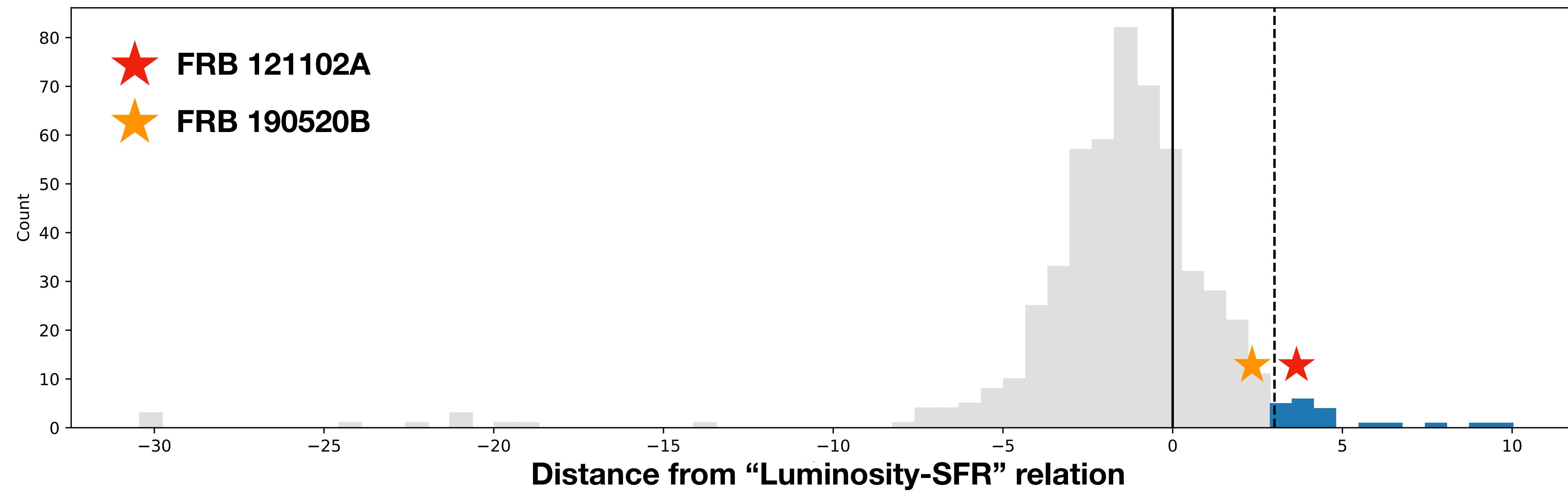
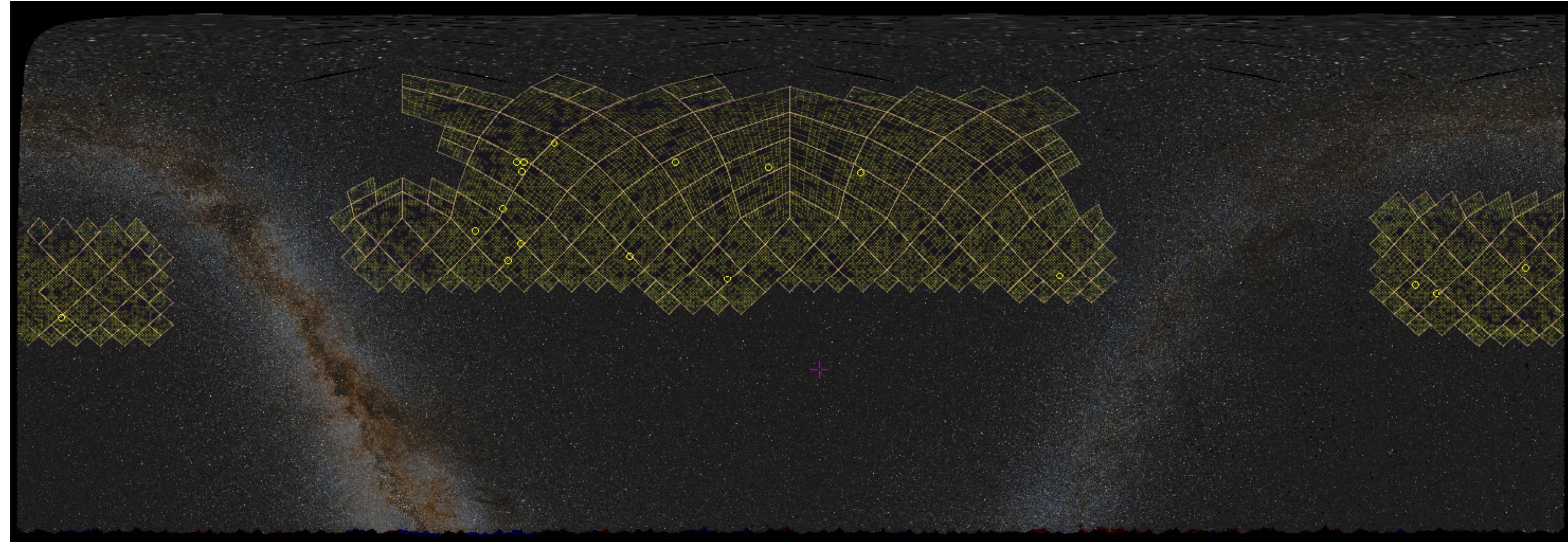
```
datasets = {'clu': Catalog1,  
           'lotss': Catalog2}
```

```
datasets['clu'].matches['lotss'].chance.total
```

```
datasets['clu'].matches['lotss'].chance.expected
```

```
[44]: datasets['clu'].matches['lotss'].chance.total, \  
      datasets['clu'].matches['lotss'].chance.expected
```

```
[44]: (333, 8.985293091946474)
```



```
for i, row in datasets['lotss'].df.iloc[mask2][['RA', 'DEC']].iterrows():
    print ("""OR 1=CONTAINS(POINT('ICRS',s_ra,s_dec),CIRCLE('ICRS',{},{},{}))""".format(
        row['RA'],
        row['DEC'],
        4*datasets['lotss'].beam['bmaj'].value
    ))
```

```
SELECT TOP 5000 [default] FROM obscore
WHERE dataproduct_type = 'spectrum'
AND (
    1=CONTAINS(POINT('ICRS',s_ra, s_dec),CIRCLE('ICRS',<RA1>, <DEC1>, <RADIUS1>))
    OR 1=CONTAINS(POINT('ICRS',s_ra, s_dec),CIRCLE('ICRS',<RA2>, <DEC2>, <RADIUS2>))
    OR ...
)
```

Search associated data among the VizieR catalogues

This web page is an access to the [VizieR](#) Associated data (images, spectra, timeseries, SED) which comes from publications. This tool is the result of the documentation assigned by the authors of the catalogues and supervised by the CDS documentalist team (see [the VizieR ingestion tool](#)).

VO compatibility

The meta-data and the search engine are built according to the [VO](#) framework ([SIA](#), [SSA](#), [ObsTAP](#)) and can so be queried by VO softwares. The data are gathered with the [Saada](#) engines, and the VO data model [ObsCore](#) has been chosen for the documentation.



Simple search ObsTAP Query

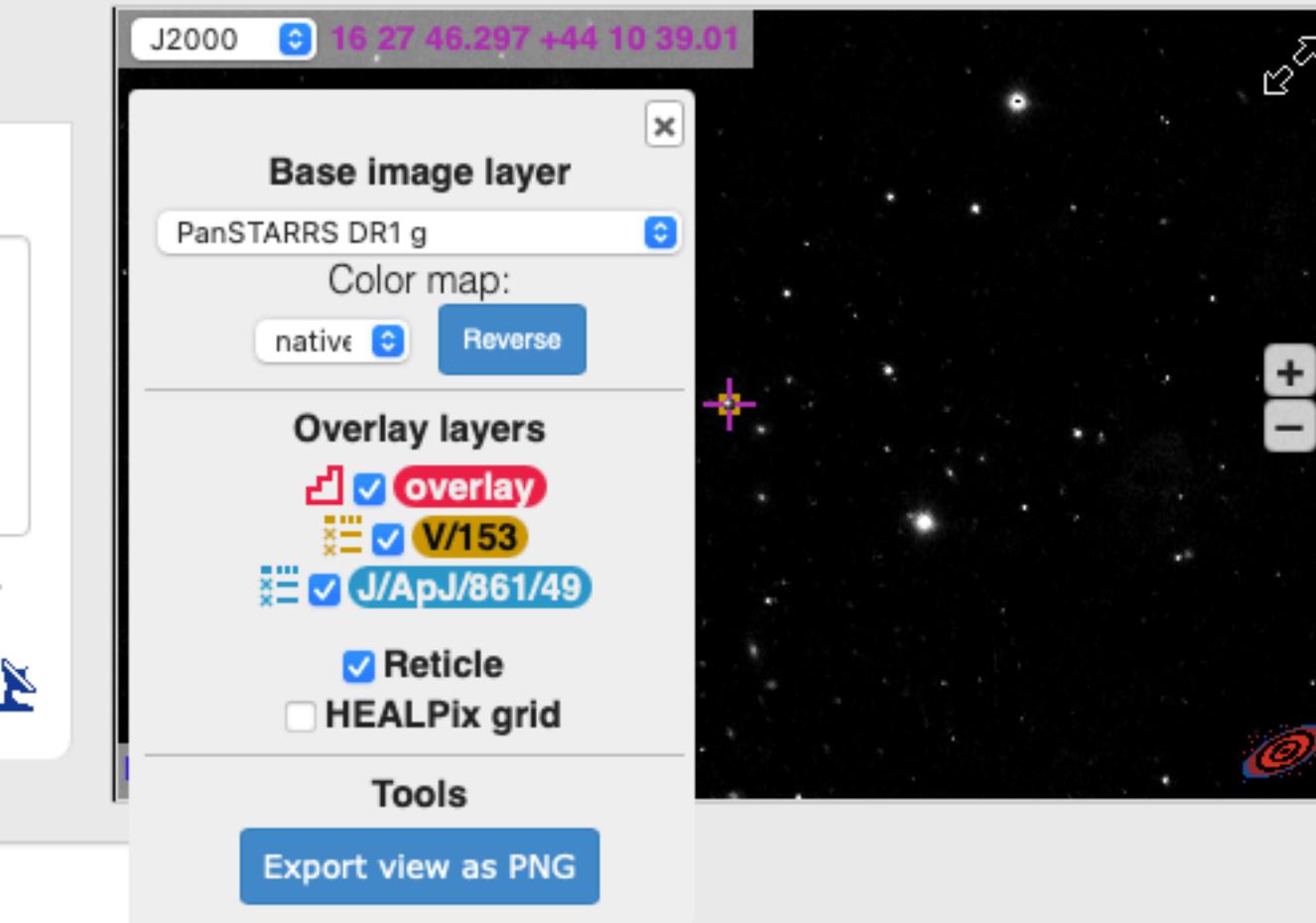
Request :

```
SELECT TOP 5000 [default] FROM obscore
WHERE dataproduct_type = 'spectrum'
AND (
1=CONTAINS(POINT('ICRS',s_ra,s_dec),CIRCLE('ICRS',
[REDACTED],0.006666668))
```

[ObsCore](#) [Refresh](#) [Download csv](#) [Download votable](#) [Tar](#)

[Search](#)

Show 10 entries Filter



Show 10 entries

5 entries

Preview	Target	Data collection	Ra	Dec	Band min (nm)	Band max (nm)	Begin time (MJD)	End time (MJD)	Facility				
AGC	[REDACTED]	J/ApJ/861/49	[REDACTED]	[REDACTED]	211,061,162.944	211,061,162.944			Arecibo Radio Telescope	Download	Search	Header	
LAMOST	[REDACTED]	V/153	[REDACTED]	[REDACTED]	369.999	909.913	57,424.043	57,424.110	LAMOST	Download	Search	Header	
LAMOST	[REDACTED]	V/153	[REDACTED]	[REDACTED]	369.999	909.913	56,802.990	56,803.051	LAMOST	Download	Search	Header	
LAMOST	[REDACTED]	V/153	[REDACTED]	[REDACTED]	369.999	909.913	56,570.074	56,570.104	LAMOST	Download	Search	Header	
LAMOST	[REDACTED]	V/153	[REDACTED]	[REDACTED]	369.999	909.913	56,570.112	56,570.142	LAMOST	Download	Search	Header	

[◀ Prev](#) p.1/1 [Next ▶](#)

Seek for spectra and photometry → Make SED where possible