Peering towards Cosmic Dawn
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Average radio spectral energy distribution of highly star forming galaxies

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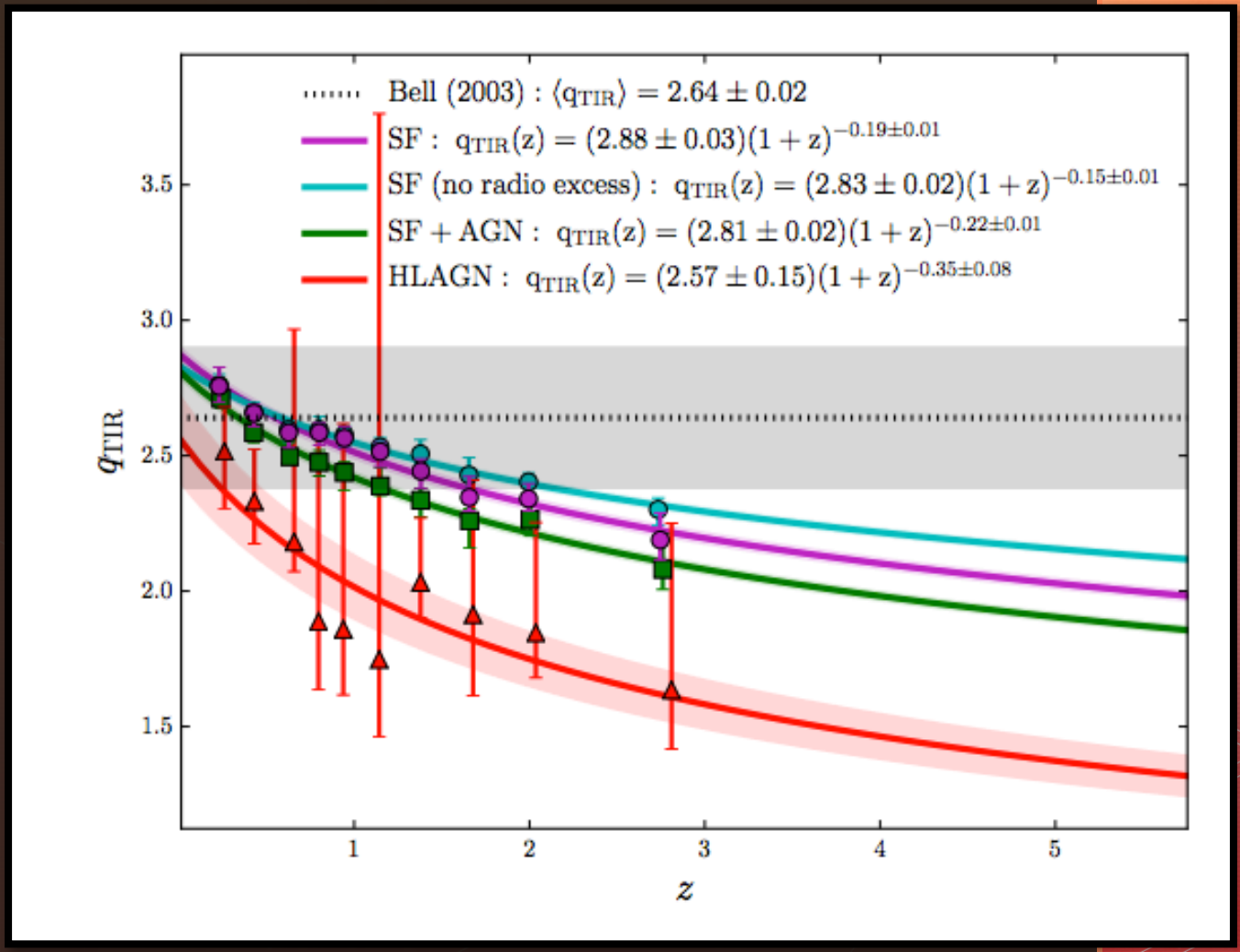
Motivation

- Better SEDs
- Better K - corrections
- Better understanding of IRRC (a.k.a. q)
- Radio luminosity as an SFR tracer

Delhaize+ 2017

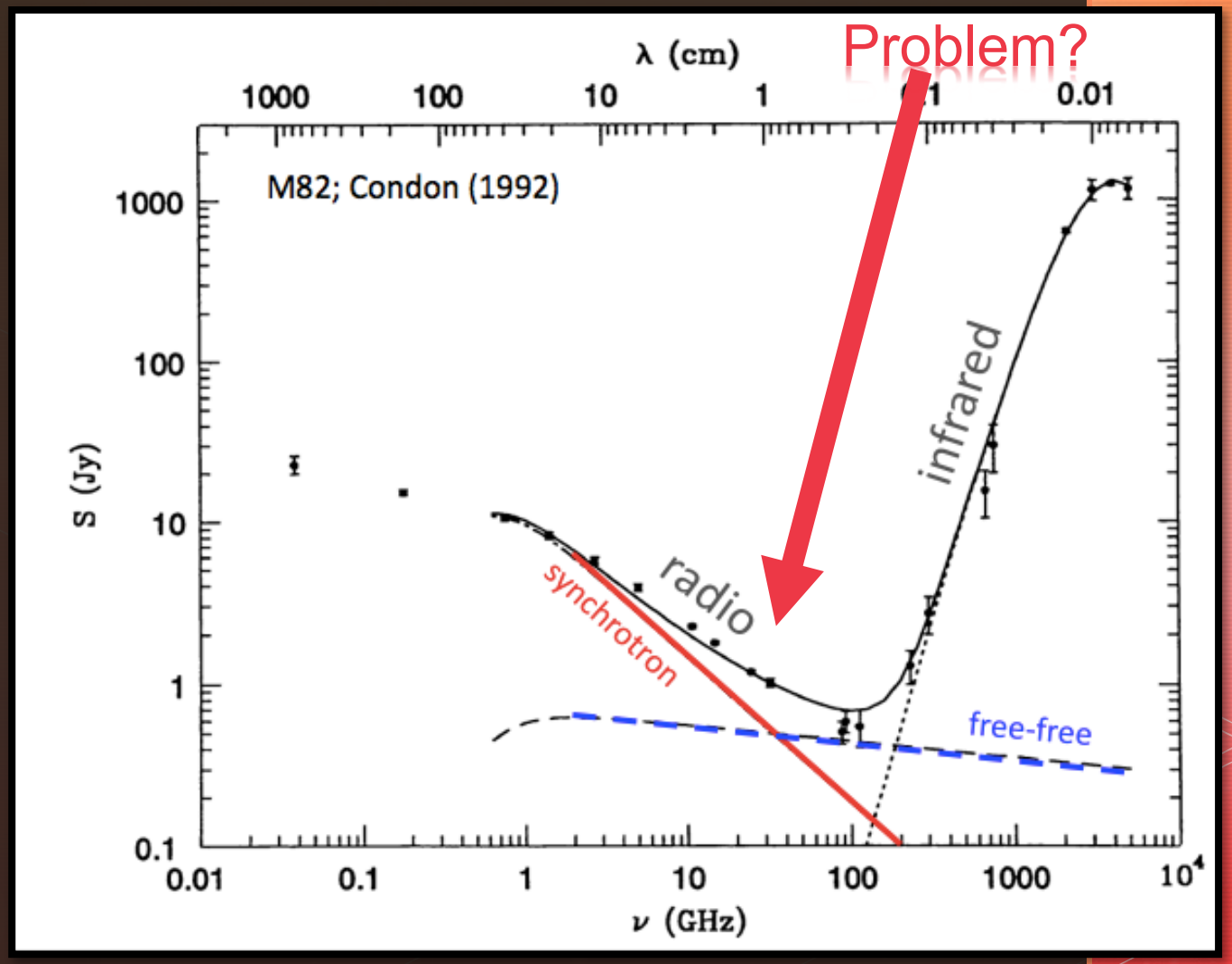


Radio spectral indices - Previous studies

Niklas+ 1997	Clemens+ 2008	Leroy+ 2011

• Non-thermal
• Sa
  • α=0.74
• Sb
  • α=0.85
• Irr
  • α=0.74
	• v < 4.8 GHz
	  • α=0.5
	• v < 8.4 GHz
	  • α=0.7
	• v > 8.4 GHz
	  • α=0.8
		• C - band
		  • α=0.67

Condon+ 1992



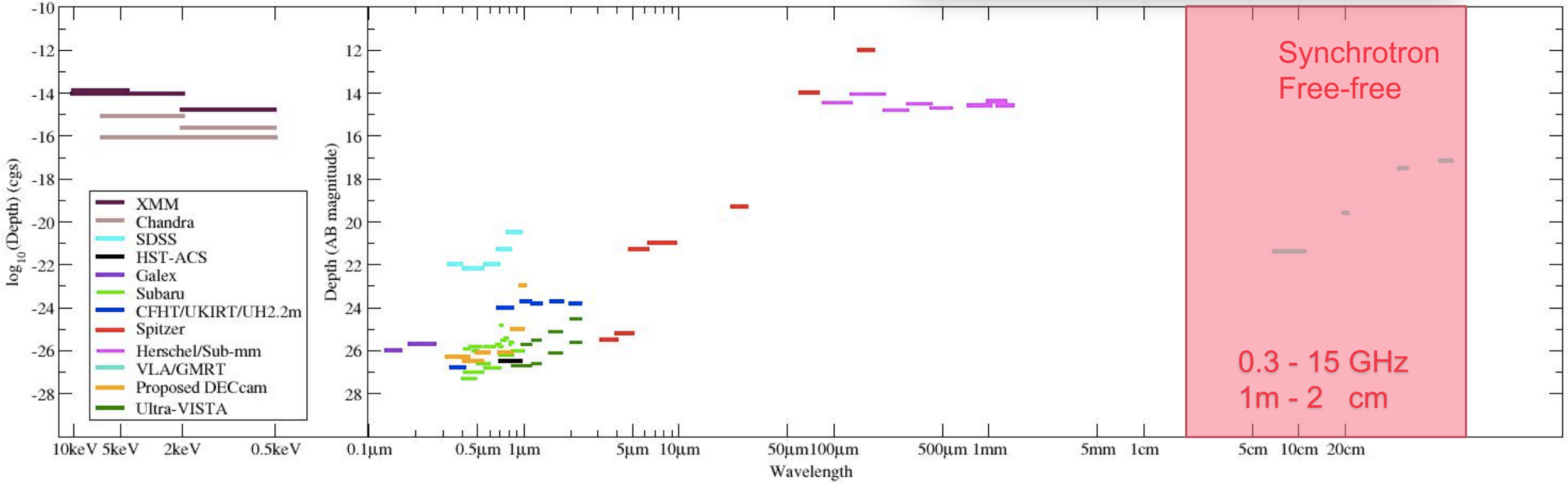
Data
And the Sample

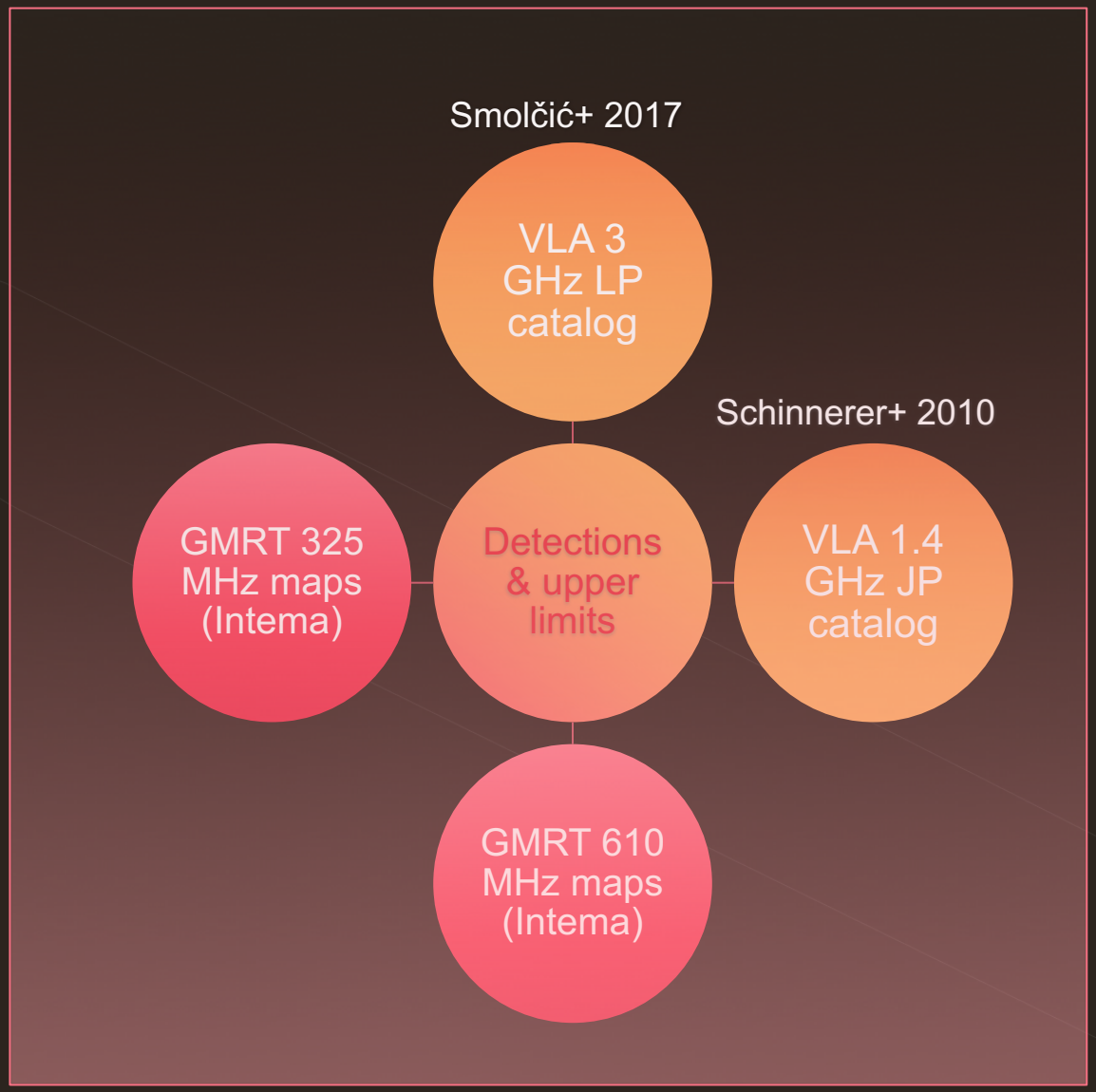
- Introducing COSMOS
- Sample
- GMRT data

COSMOS

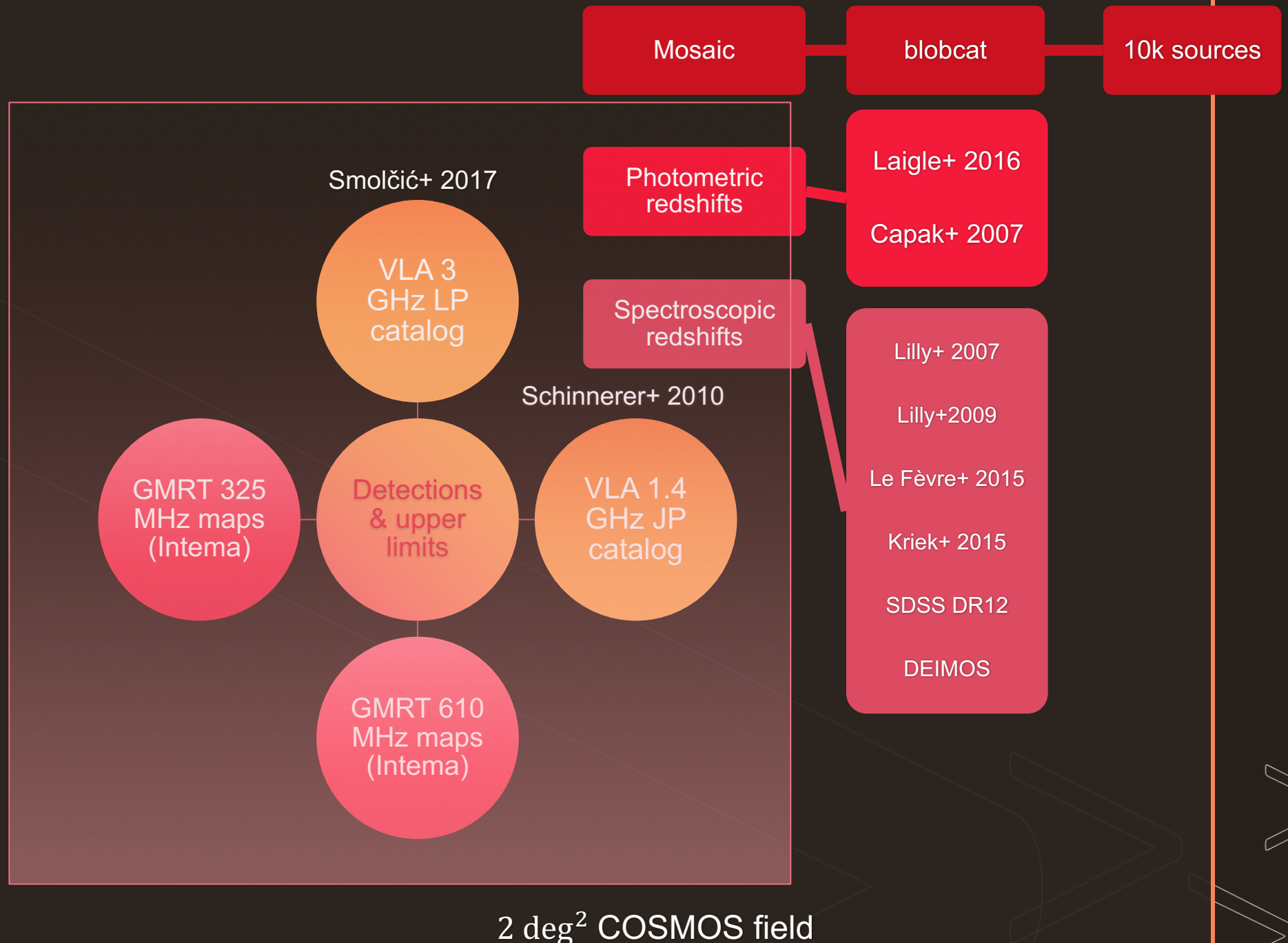
COSMOS

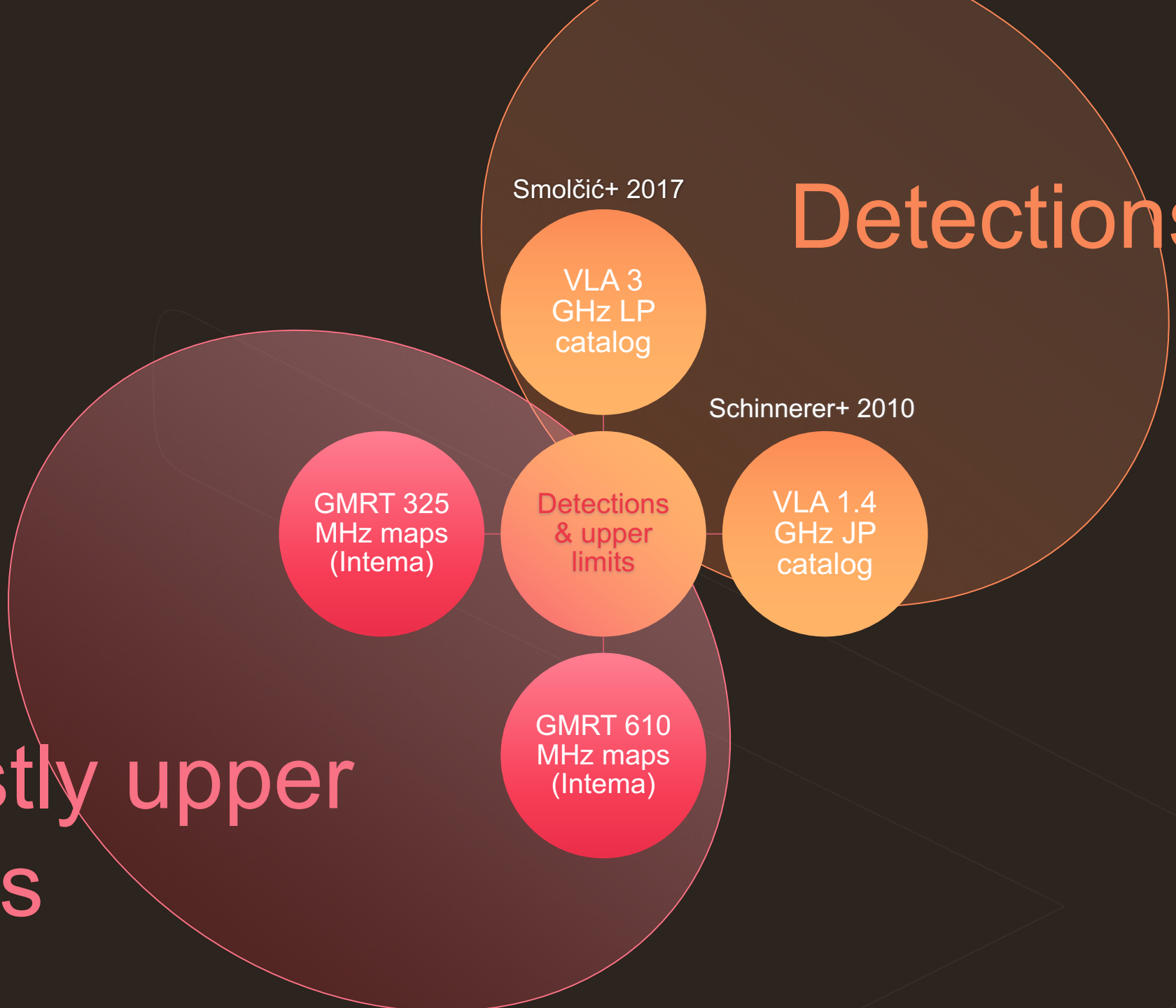
http://cosmos.astro.caltech.edu/

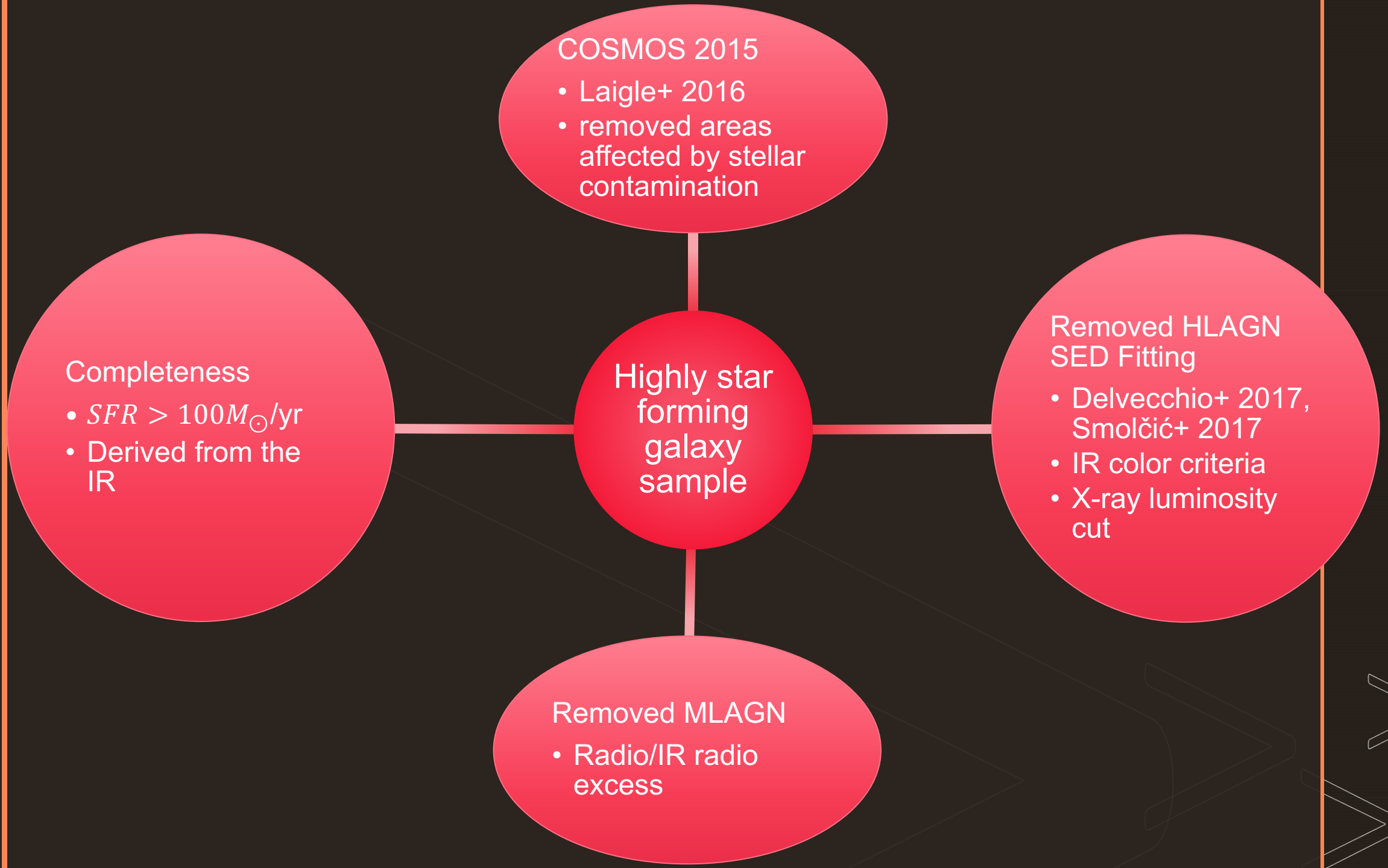




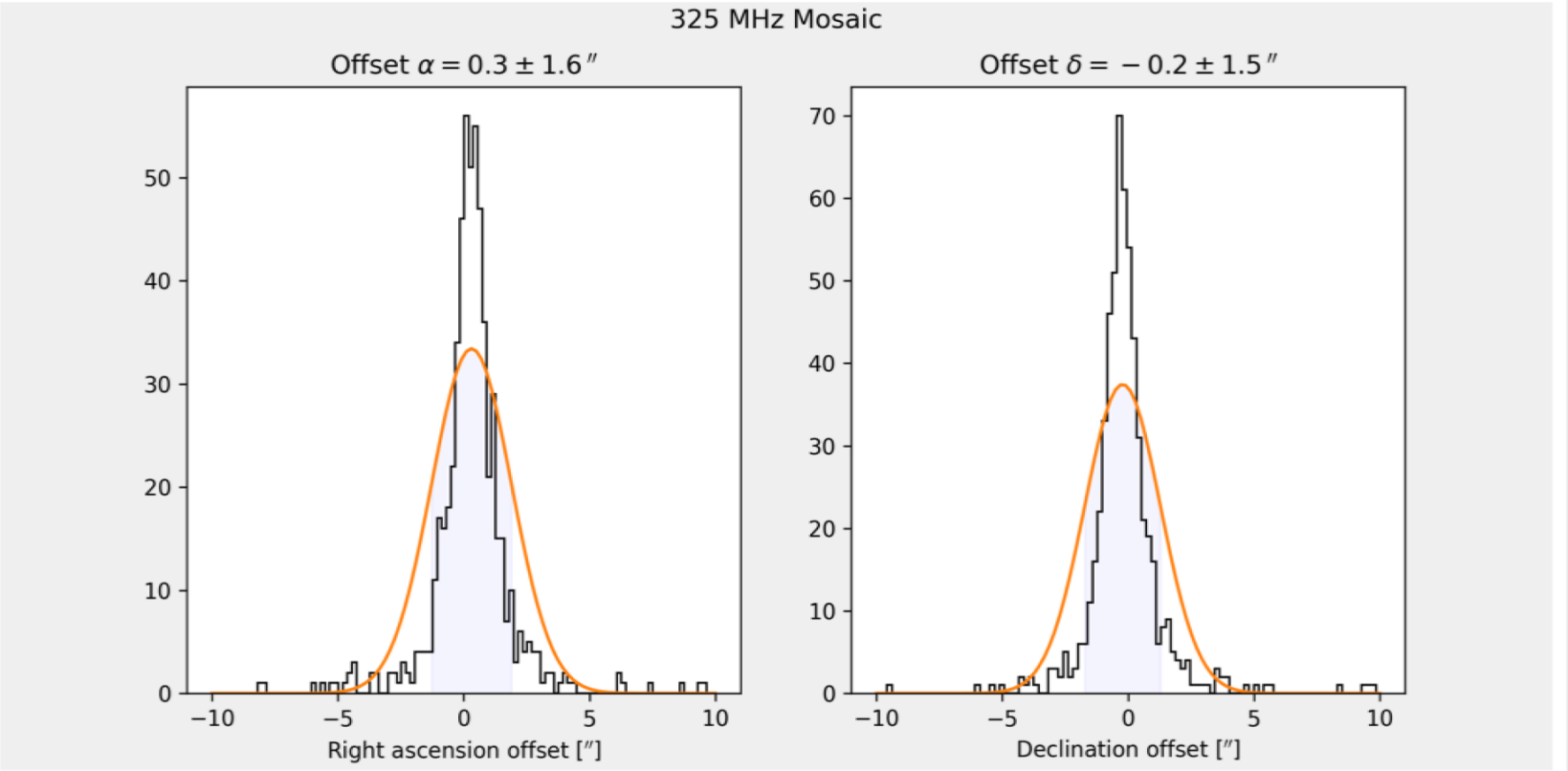
2 deg^2 COSMOS field

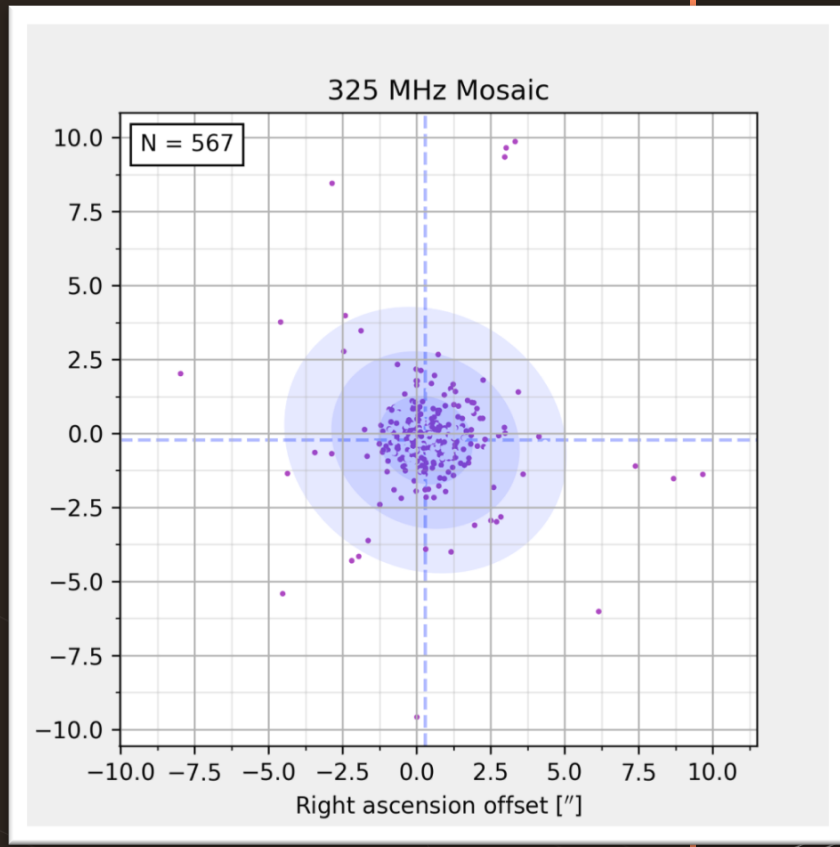

Mosaic
blobcat
10k sources
Smolčić+ 2017
VLA 3 GHz LP catalog
Photometric redshifts
Laigle+ 2016
Capak+ 2007
Spectroscopic redshifts
Lilly+ 2007
Lilly+2009
Le Fèvre+ 2015
Kriek+ 2015
SDSS DR12
DEIMOS
Schinnerer+ 2010
GMRT 325 MHz maps (Intema)
Detections & upper limits
VLA 1.4 GHz JP catalog
GMRT 610 MHz maps (Intema)
2 deg^2 COSMOS field


Smolčić+ 2017
Detections
VLA 3 GHz LP catalog
Schinnerer+ 2010
GMRT 325 MHz maps (Intema)
Detections & upper limits
VLA 1.4 GHz JP catalog
GMRT 610 MHz maps (Intema)
Mostly upper limits

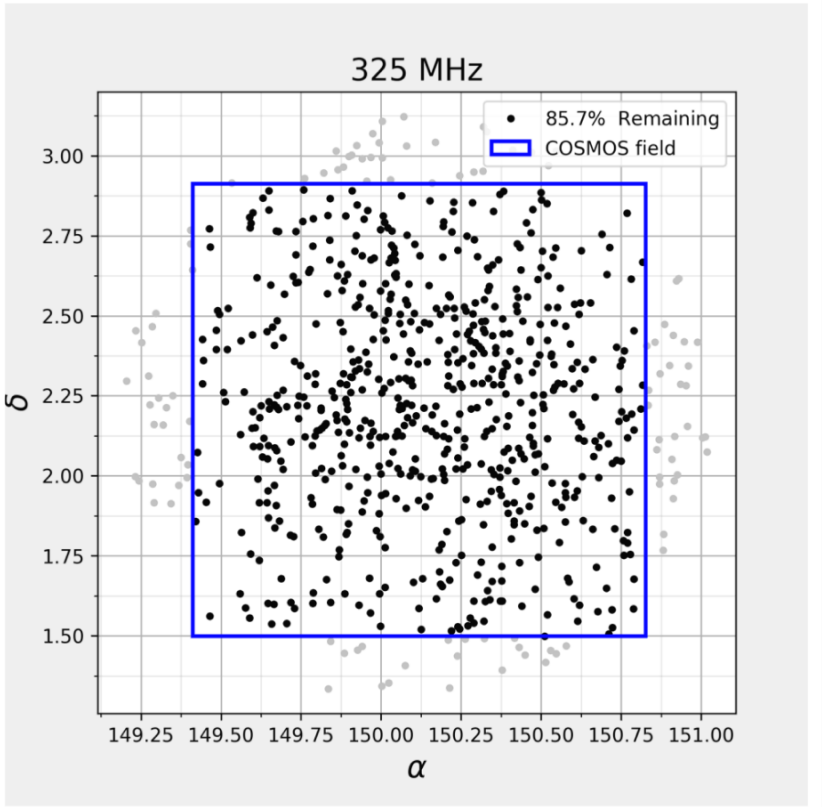

COSMOS 2015
• Laigle+ 2016
• removed areas affected by stellar contamination
Completeness
• $SFR > 100 M_{\odot}$/yr
• Derived from the IR
Highly star forming galaxy sample
Removed HLAGN SED Fitting
• Delvecchio+ 2017, Smolčić+ 2017
• IR color criteria
• X-ray luminosity cut
Removed MLAGN
• Radio/IR radio excess

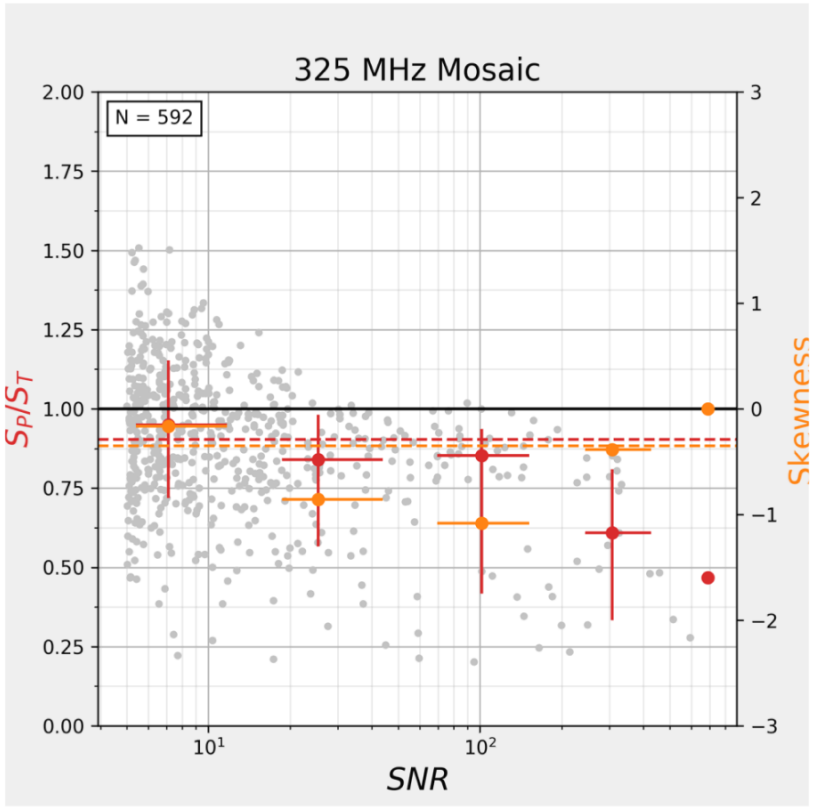
GMRT 325 MHz Astrometry

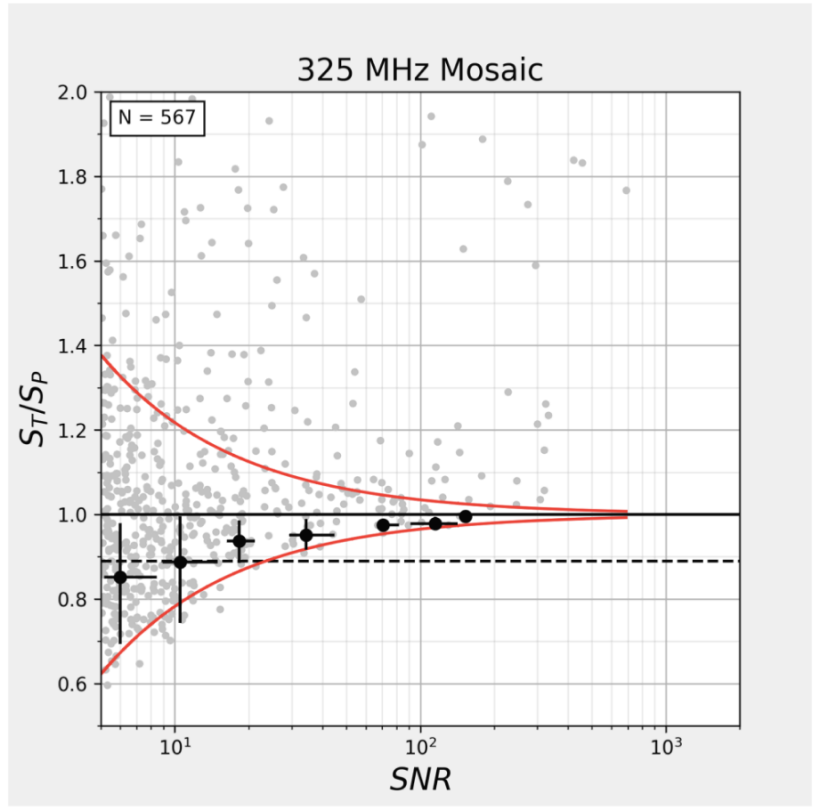




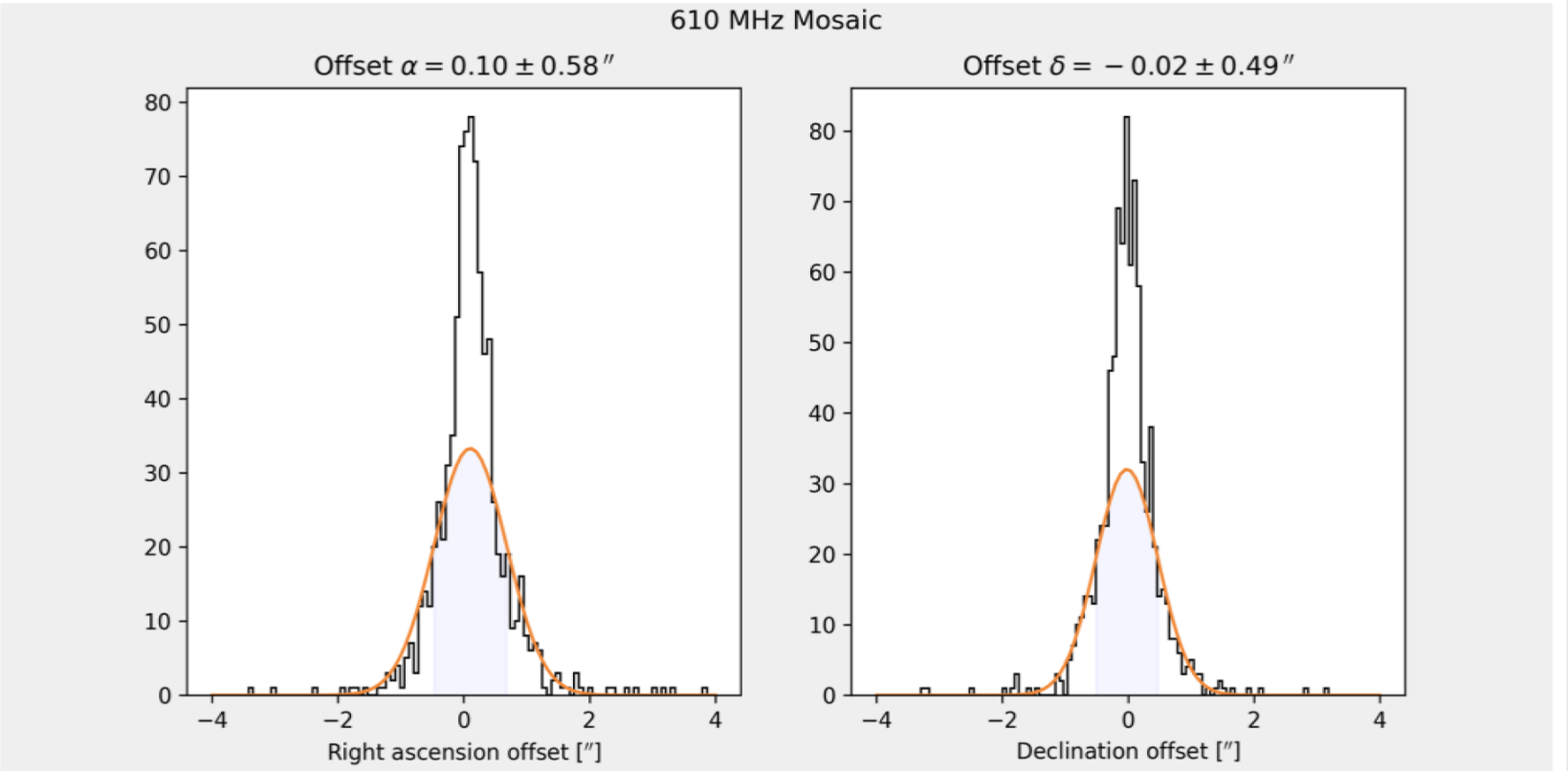
GMRT 325 MHz Sources

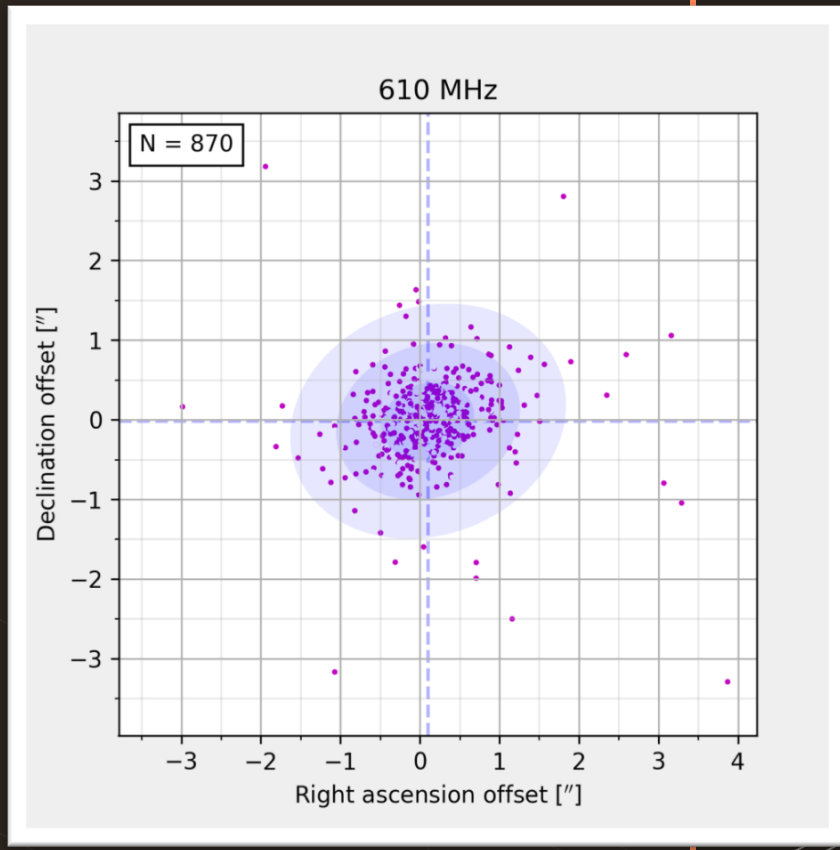




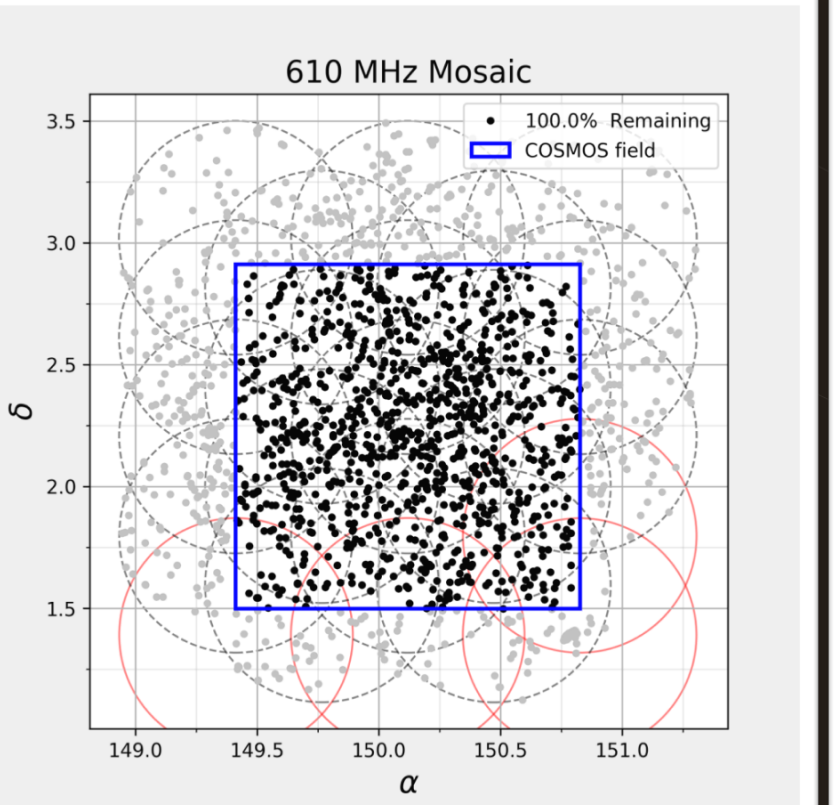


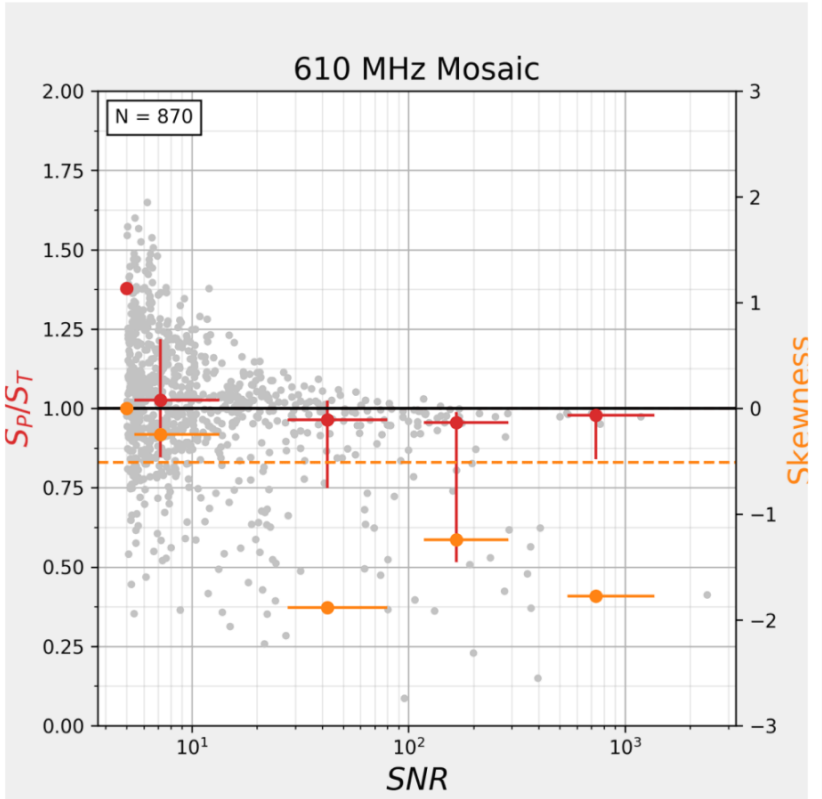
GMRT 610 MHz Astrometry

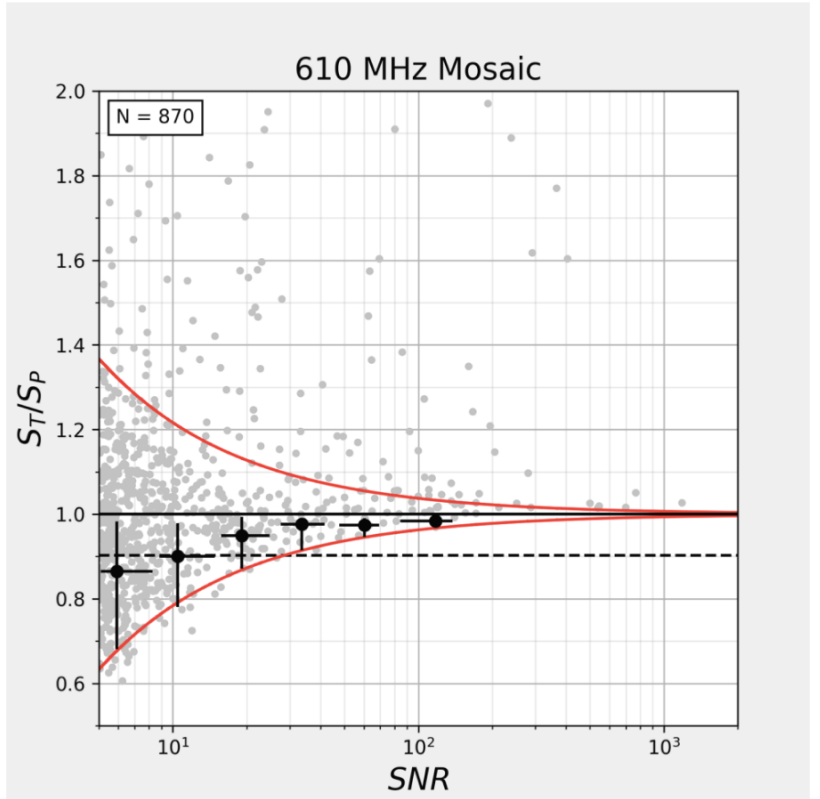




GMRT 610 MHz Sources





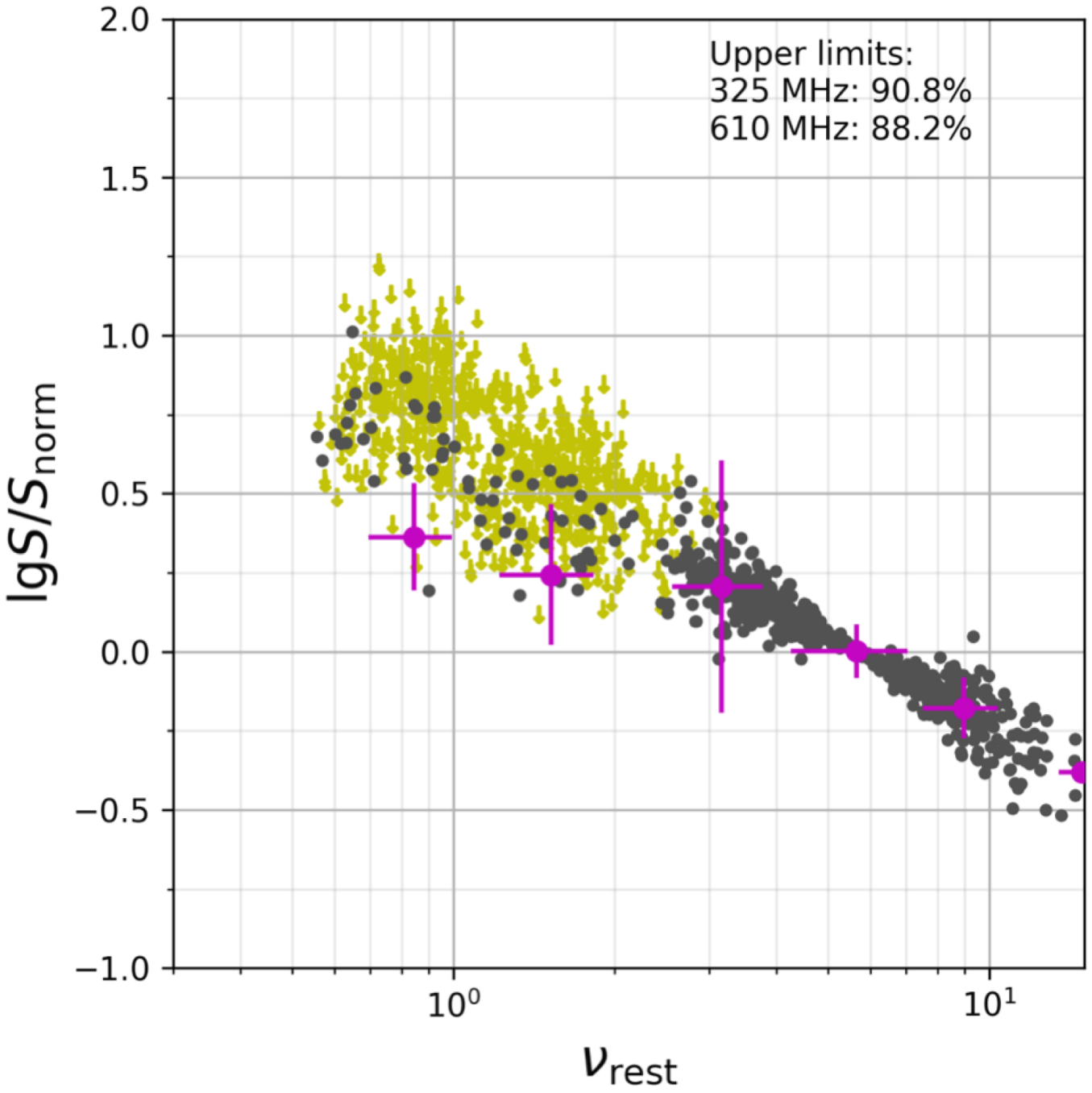


- Data
- Simulations
- IRRC

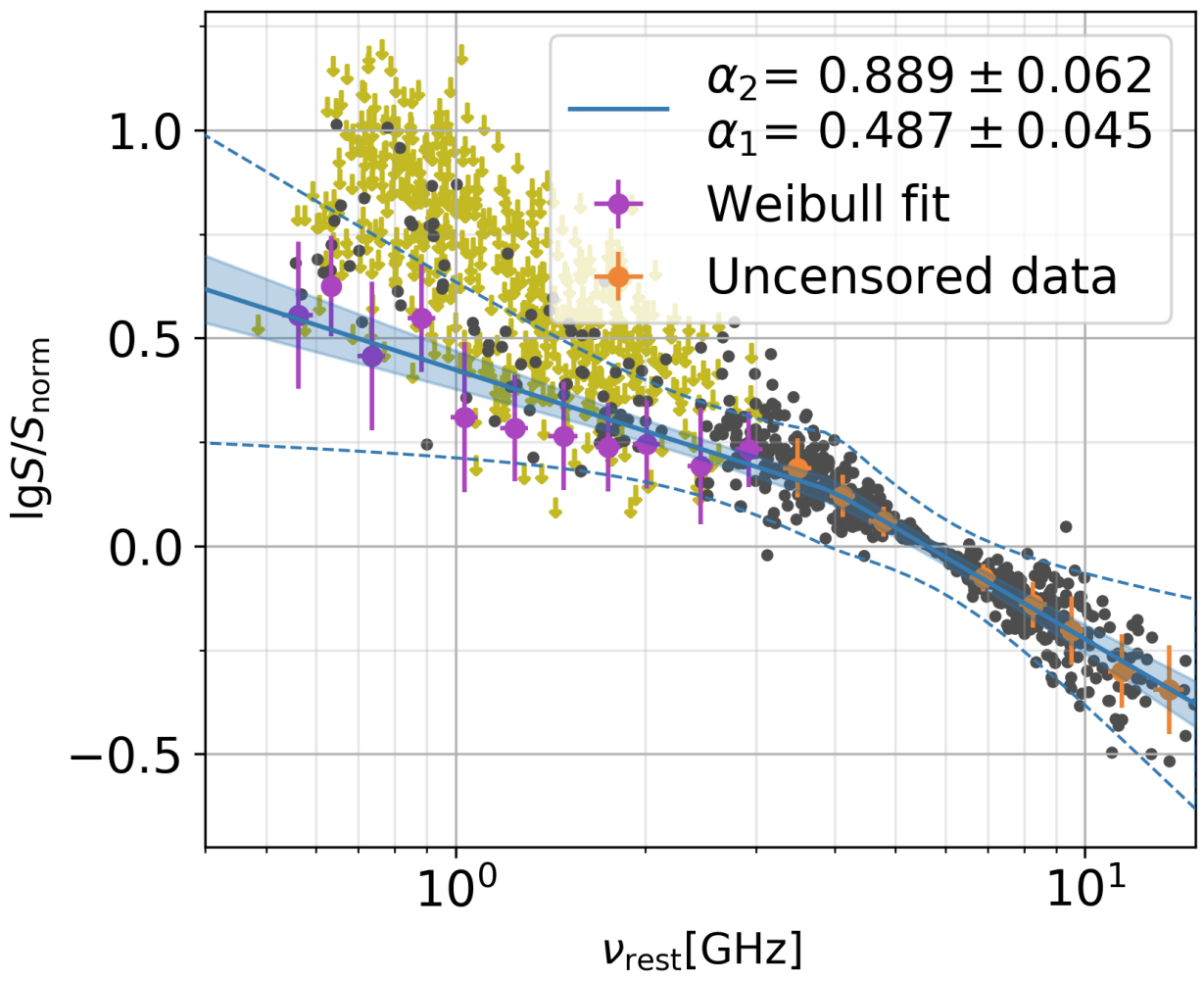
Results
And Simulations

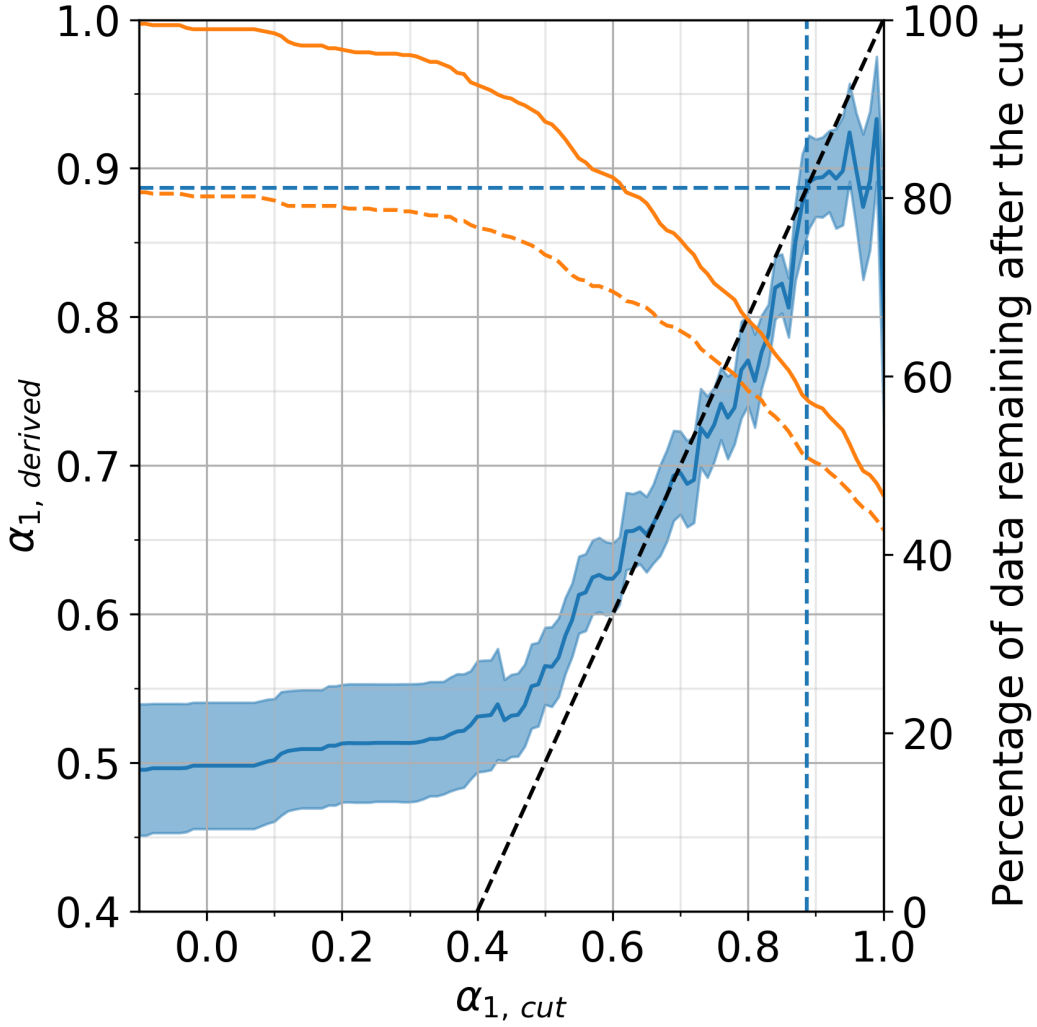
Dealing with upper limits

- Equally spaced log-rest-frame frequency bins
  - Upper limit = 5 x local RMS
- Made a Kaplan-Meier estimate
  - for each bin
- Fitted a Weibull distribution
  - to the Survival function
  - mean and standard deviation
- Fitting the with an SED



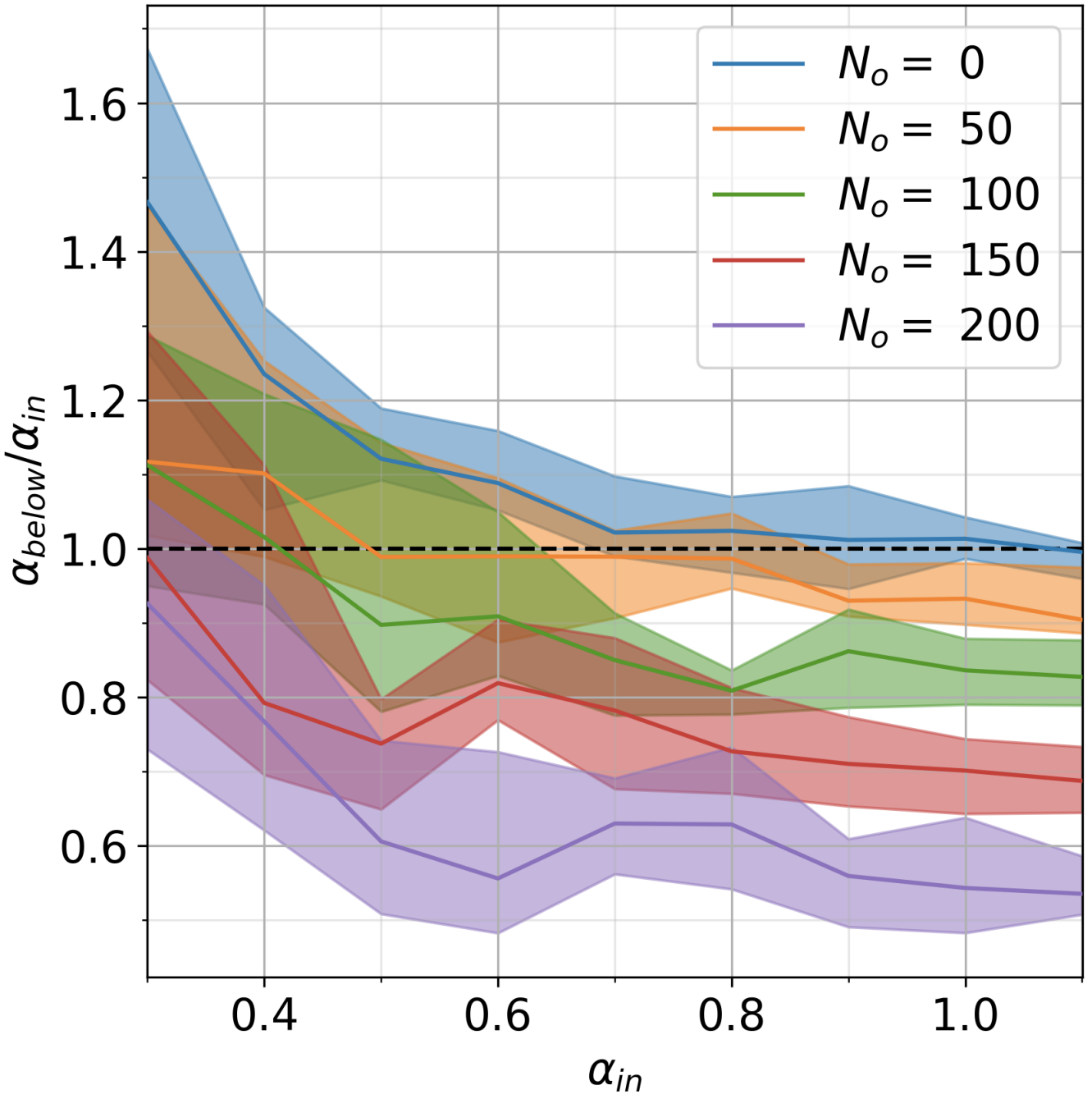
Broken power law fit & Stability





Tests – Monte Carlo Simulations

- A • α above 4 GHz
- A • Normalization
- A • Redshift
- R • Normal distribution
- R • Number of upper limits
- R • Varying α below 4 GHz
- R • Outliers with a fixed α=0.2



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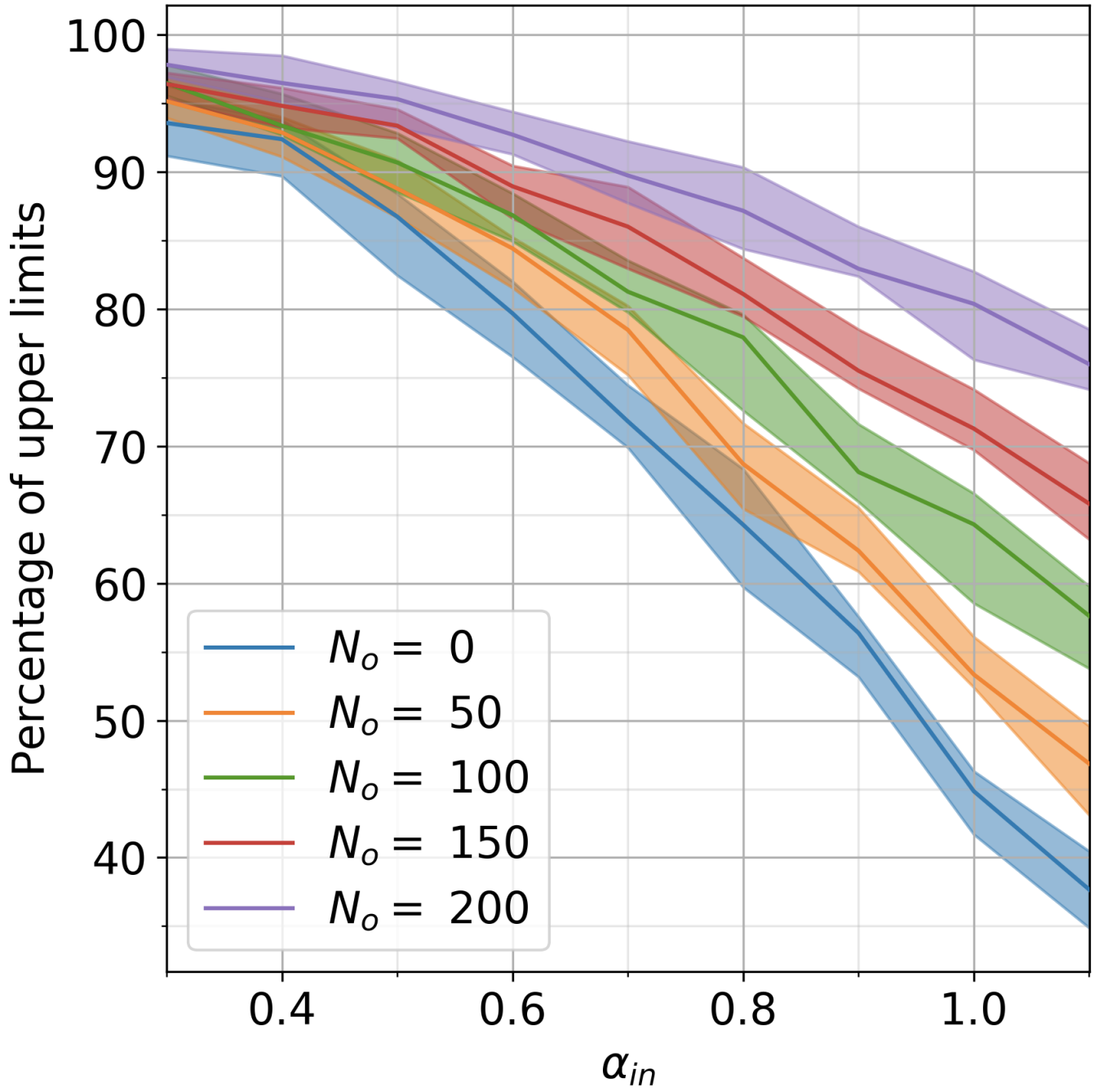

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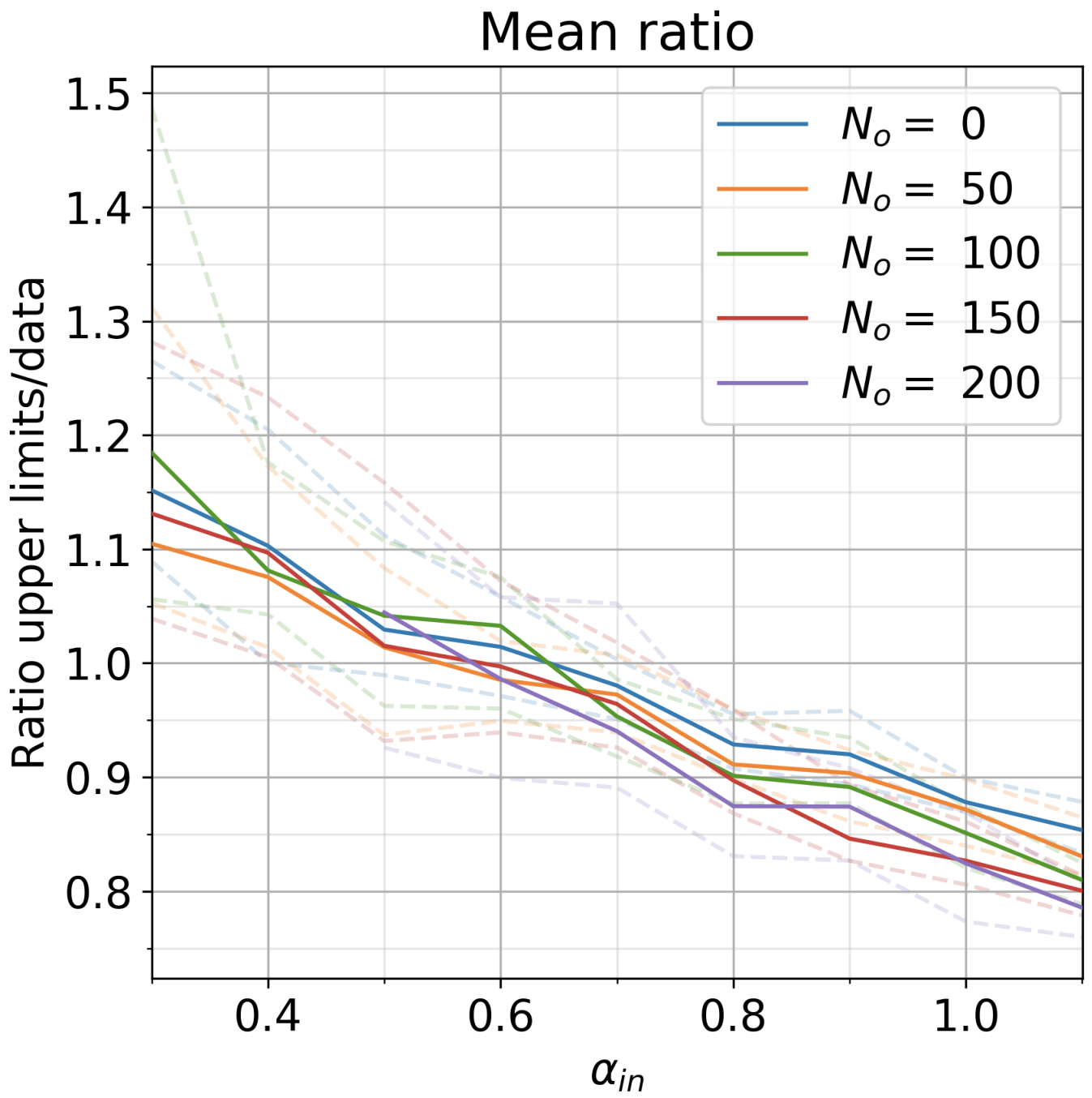


Sensitivity to Outliers

H

- H_0: derived α= simulated α
- H_1: they are different

Combining

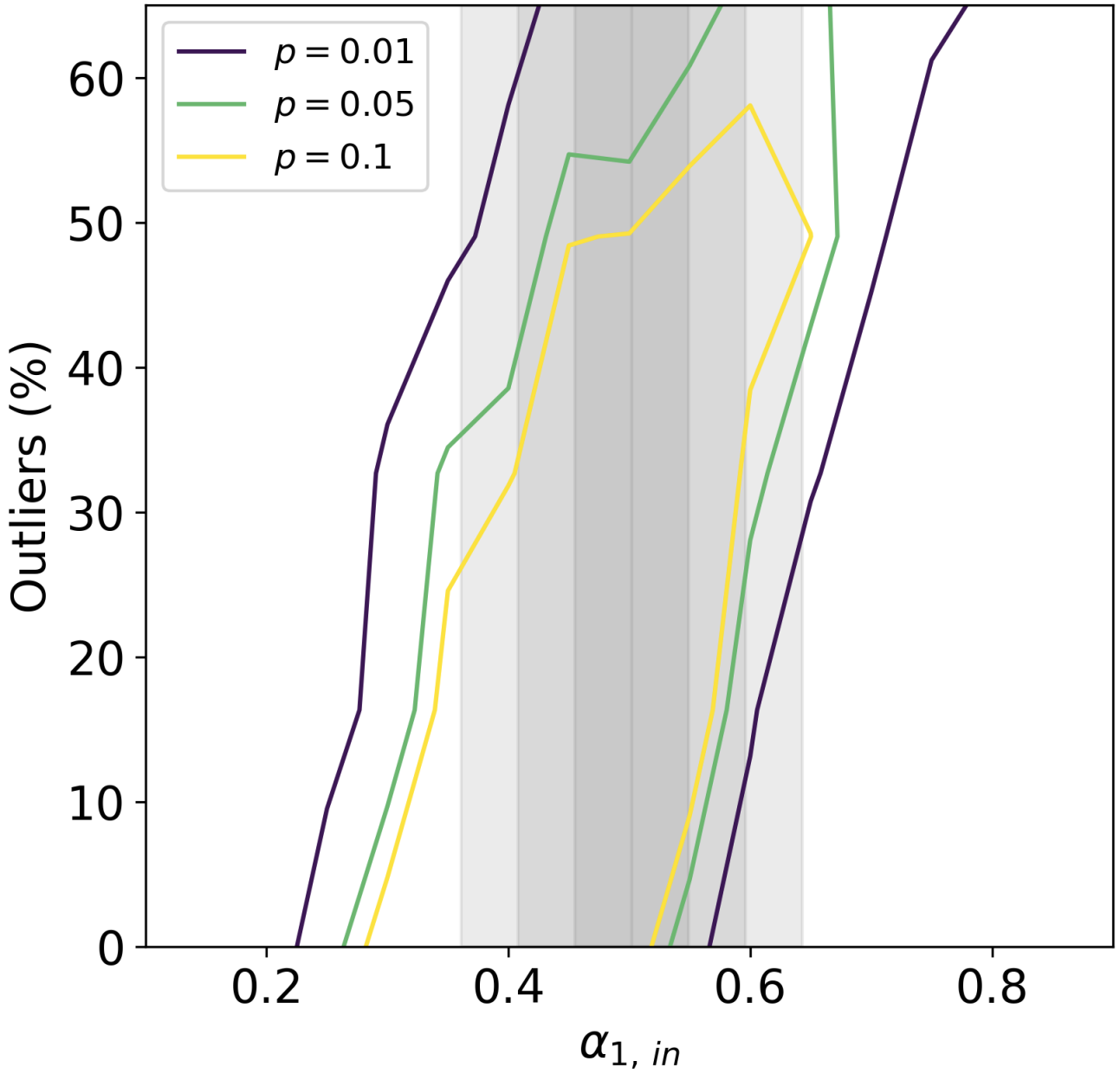
- Derived α vs. simulation-derived σ
- Percentage of upper limits
- median normalized log-Flux of upper limits /detections

?

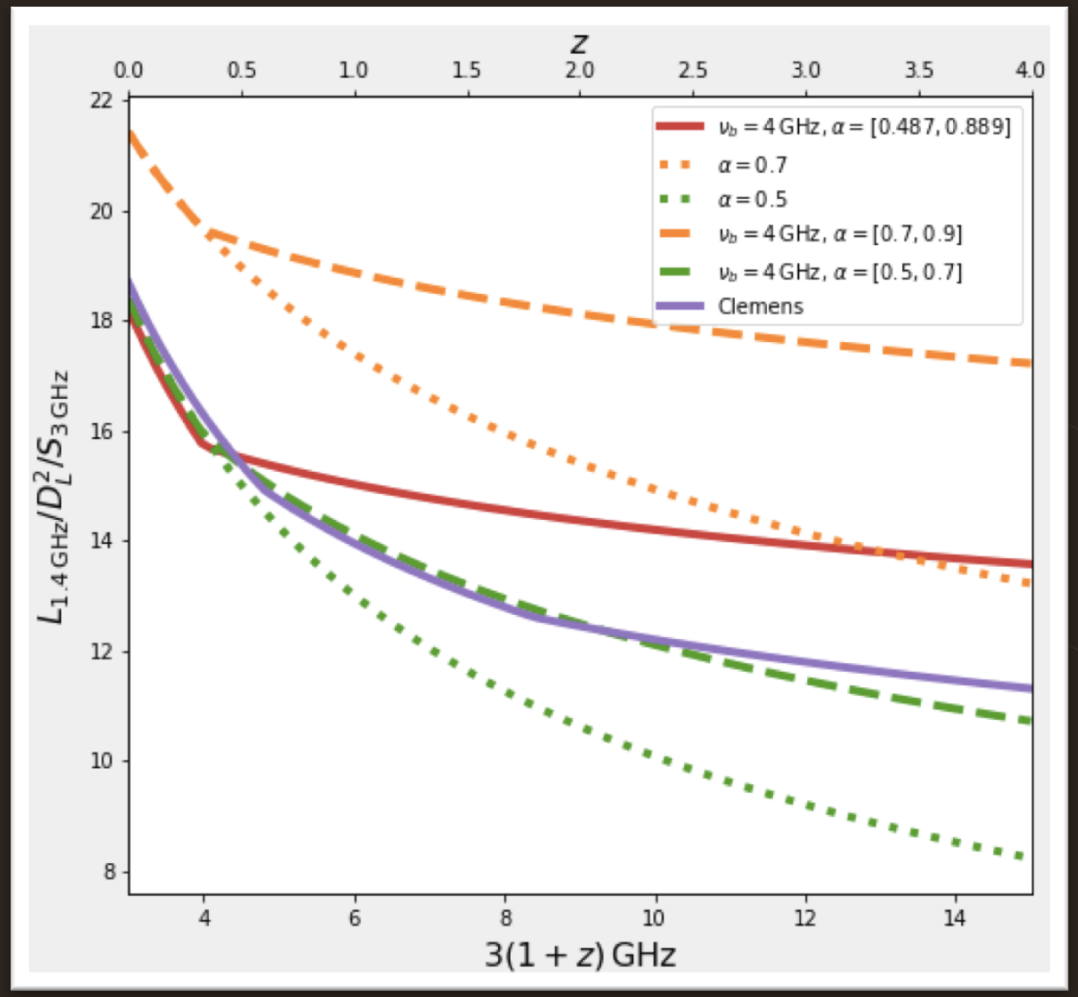
- Excluding portions of the parameter space up to a chosen p-value?

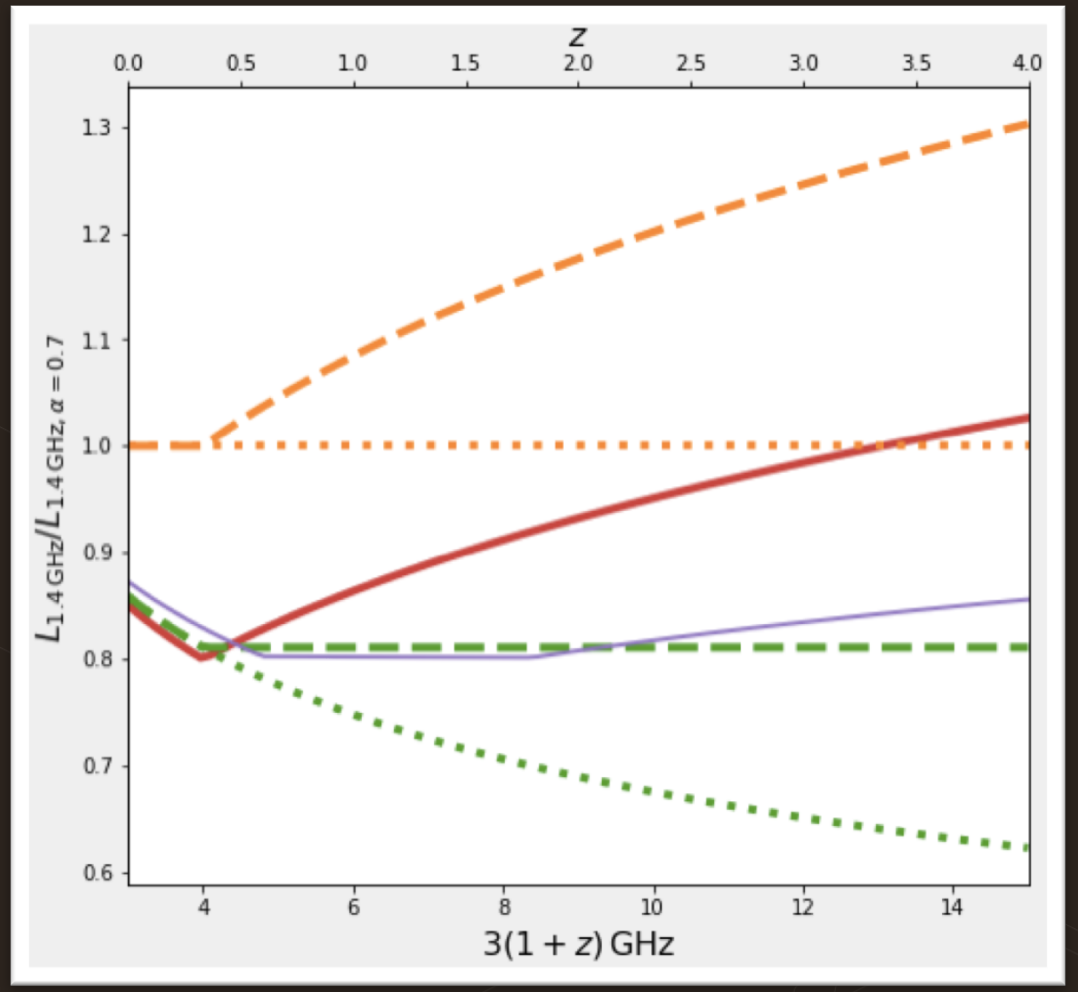
?

- Which part of it is “unresolved”?



K-corrections for broken-power laws





Summary and Outlook

Data
- Used a combined VLA 1.4 & 3 GHz sample
- Shallower GMRT 325 & 610 MHz data

Sample
- Highly star forming galaxies in the COSMOS field

SED
- Constructed an SED in the radio - broken power law
- Steeper spectrum above 4 GHz (0.9), and a flatter spectrum below 4 GHz (0.5)
  - in line with Clemens and Leroy (0.5-0.8, ULIRGs)

Outliers
- Described the influence of flat-spectrum outliers to the dataset

q
- Can we construct IRRC for highly star forming galaxies with the best-fit SED?