Multiwavelength synergies in PRIMA Confusion Mitigation

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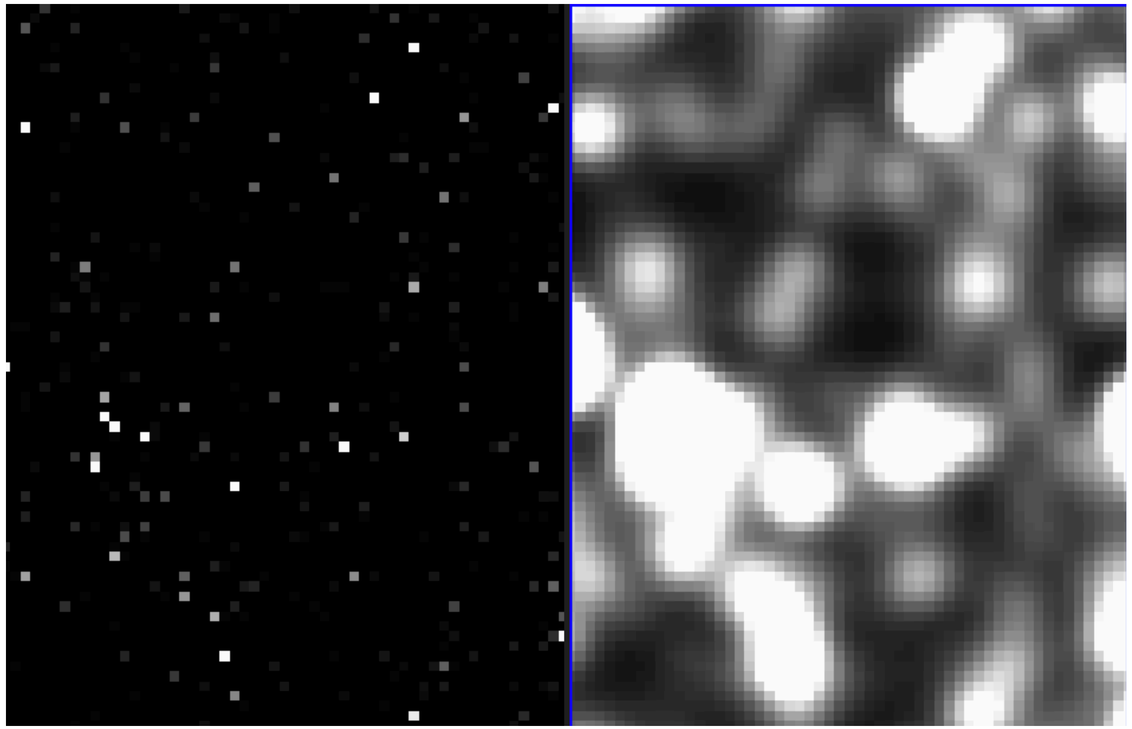
Introduction

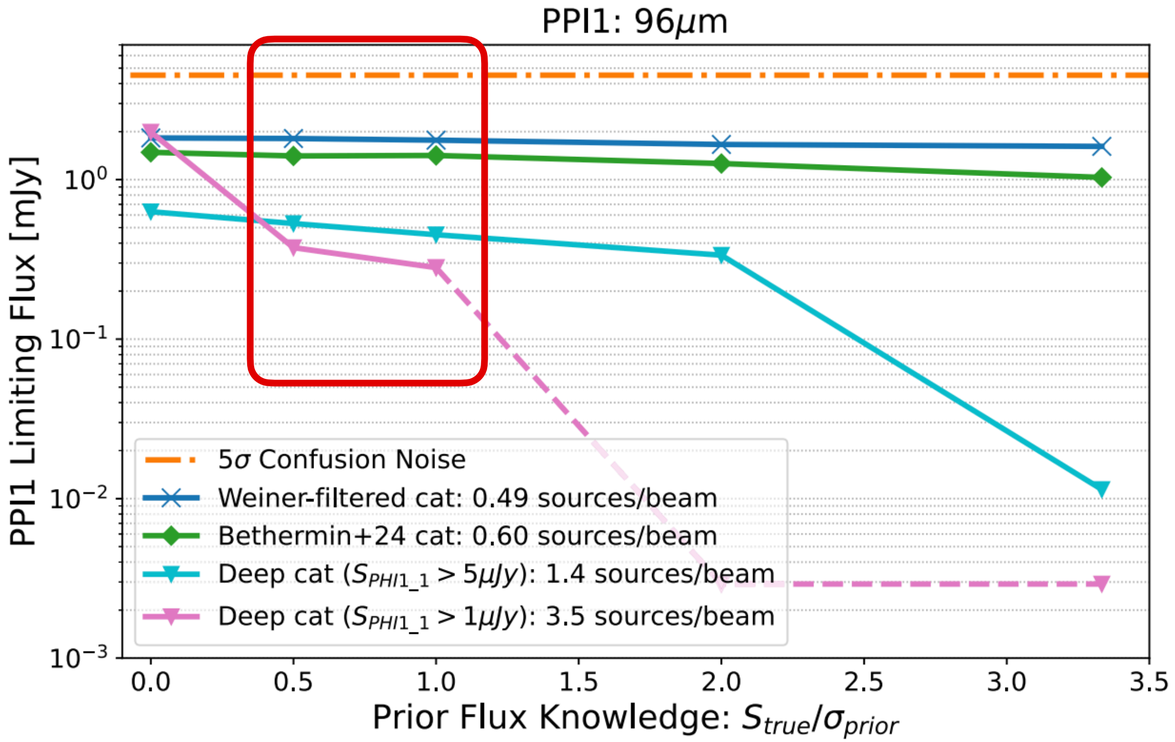
Confusion as the limiting factor in PRIMA continuum observations



- Fluctuations of sky background (dominated by faint sources of high density in extragalactic field) makes individual detection of sources with simple peak-finding/SNR threshold no longer robust below certain fluxes.
- Dominant limitation to detect faint sources in continuum observations of PRIMA
- Sources below the confusion limit could still be recovered by novel methods, i.e. XID+ (Hurley+2017, Shirley+2021).

PRIMA Confusion Mitigation with XID+

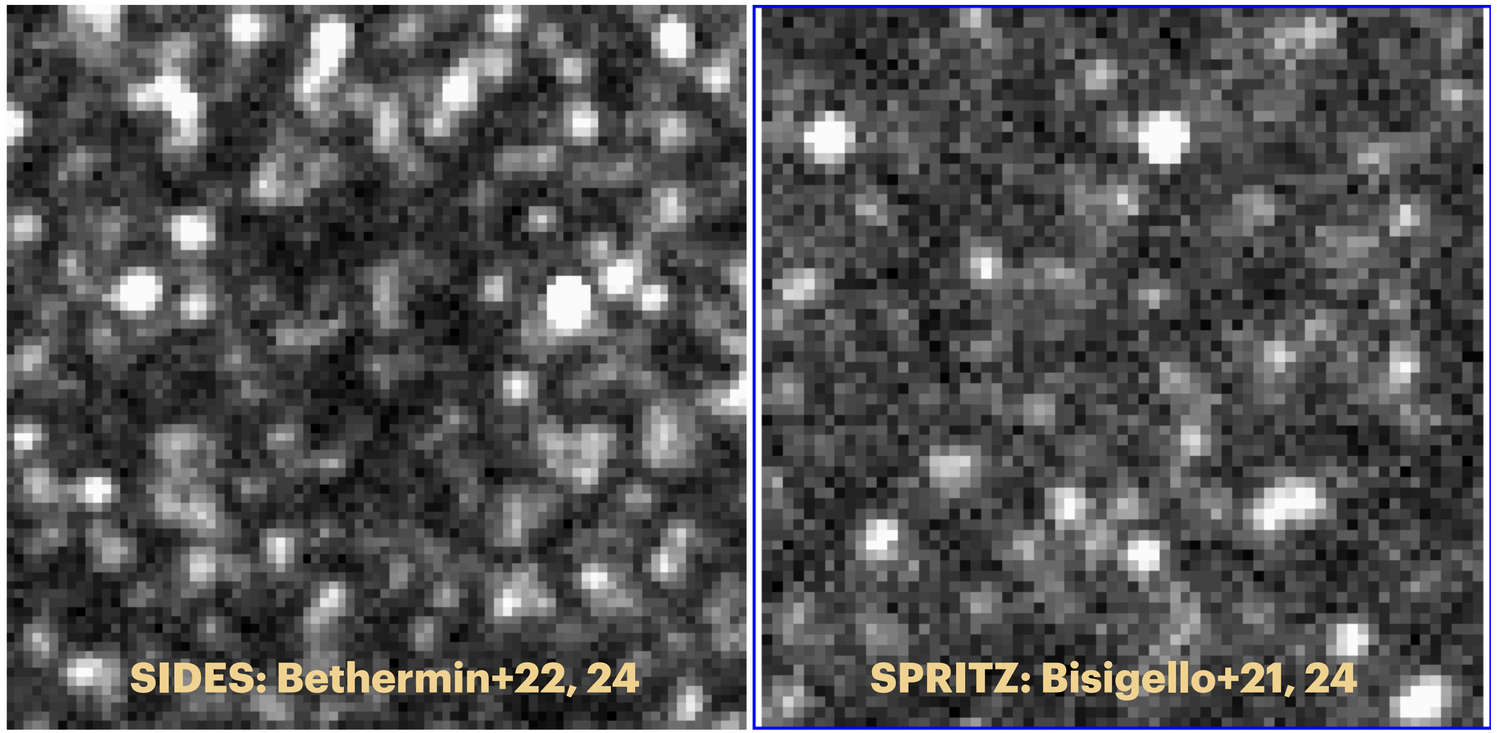
An exploration under maybe too ideal assumptions



- High-prior density + knowledge on prior fluxes —> ~10x improvement in limiting fluxes at PPI bands (Donnellan+2024).
- Prior list: Cut in mid-IR fluxes well below the detection limit, unlikely perfect in reality.
- More realistic priors: galaxy catalog from higher resolution surveys in other wavelengths, i.e Euclid, Roman, etc.

Any Proper Full-Wavelength Model?

Ideal: XID+ run on a single model from optical to mm



SIDES: 2deg^2 light cone, DM simulation + abundance matching. **Benchmark, but only in mid and far-IR, no AGN.**

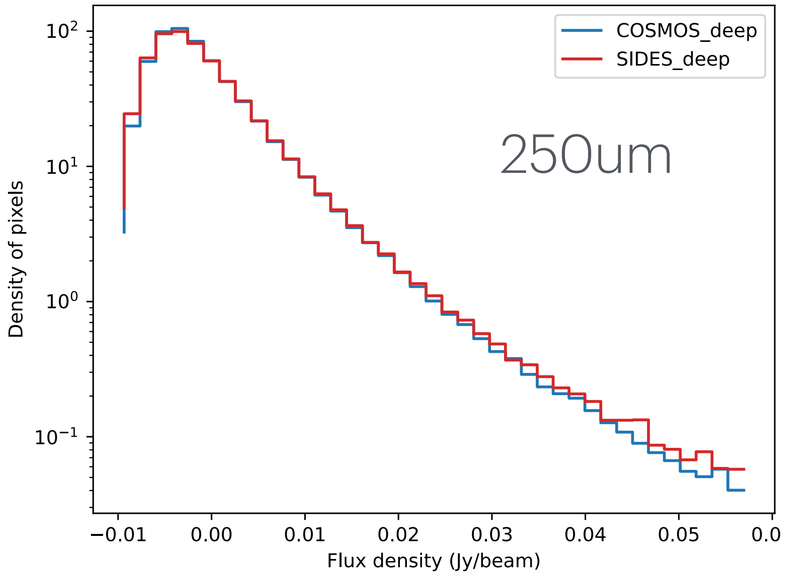
SPRITZ: light cones with various depth and area, 2-point correlation **optical to millimeter, incl. AGN**

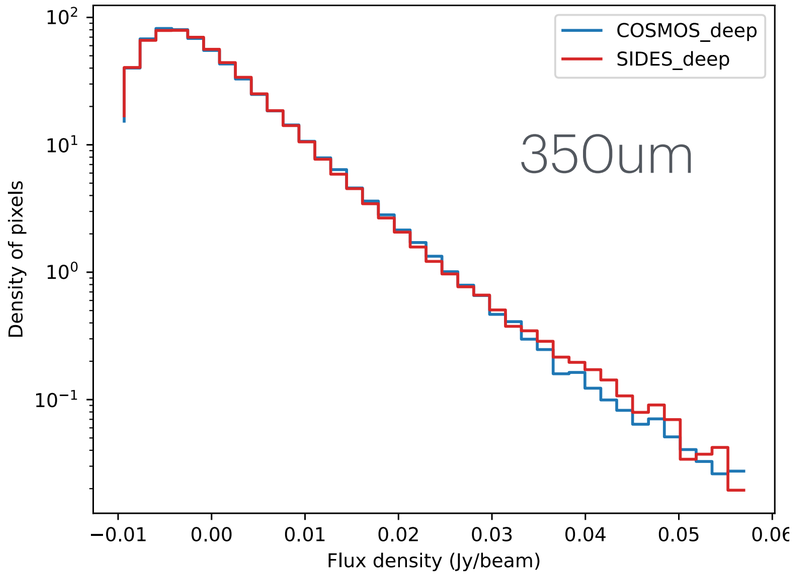
Catalog —> Pixelization —> Maps, SPIRE bands under HERMES depth

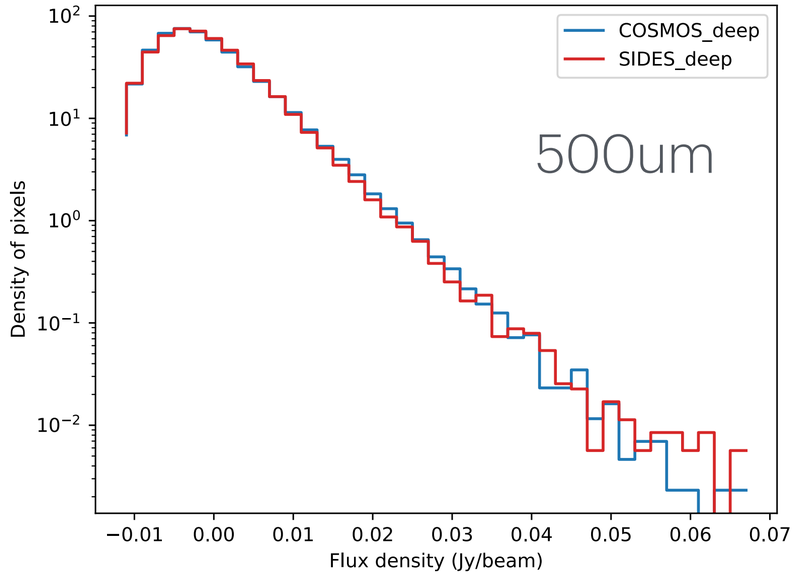
- For confusion mitigation, proper confusion in far-IR is our priority.
  Pixelized flux histogram as a metric of comparing models and data (which is P(D) analysis based on)

Any Proper Full-Wavelength Model?

P(D): SIDES vs HERMES data







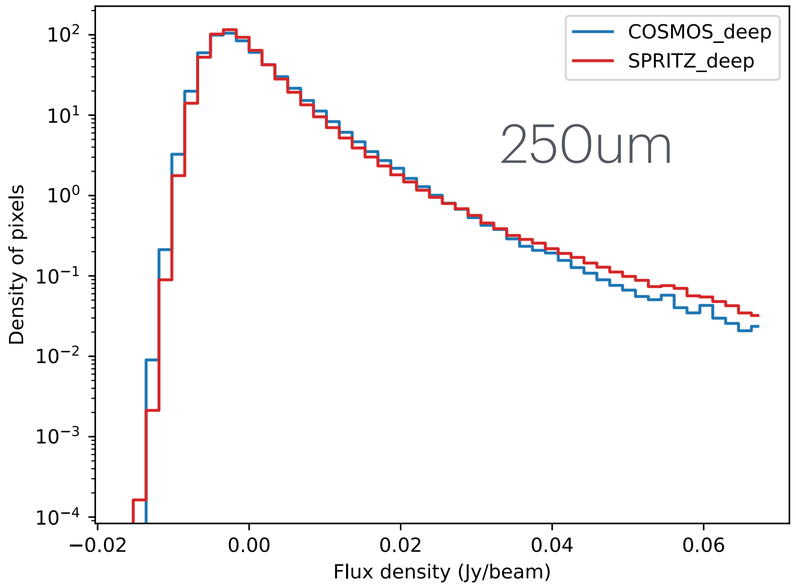
	SPIRE 250	SPIRE 350	SPIRE 500
HERMES-COSMOS	5.6 mJy/beam	6.7 mJy/beam	6.6 mJy/beam
SIDES 2 deg^2	5.6 mJy/beam	6.4 mJy/beam	6.2 mJy/beam

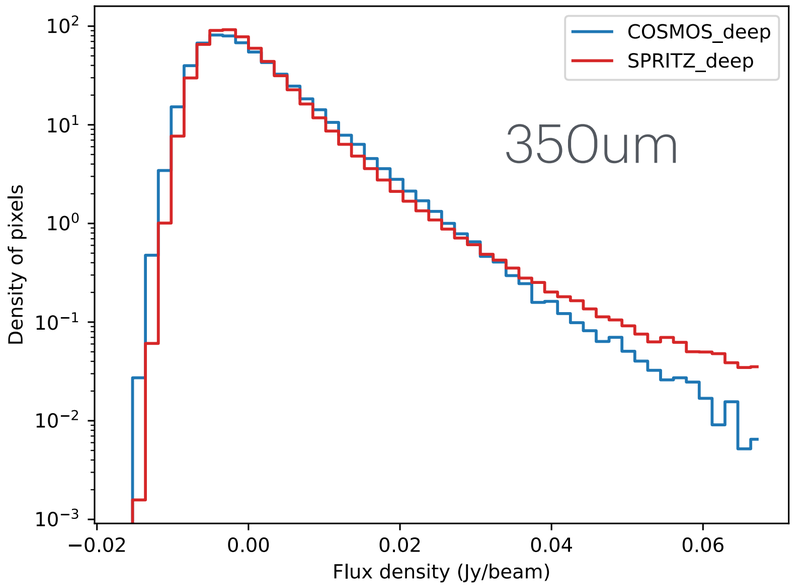
Confusion level from standard deviation of maps after iterative 5σ clipping (Bethermin+24)

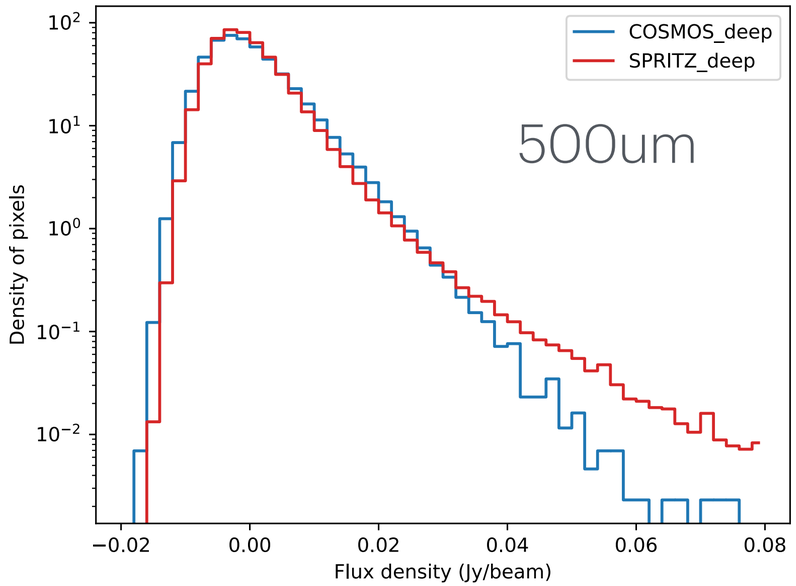
SIDES:
Well reproduced confusion at all SPIRE bands

Any Proper Full-Wavelength Model?

P(D): SPRITZ vs HERMES data







	SPIRE 250	SPIRE 350	SPIRE 500
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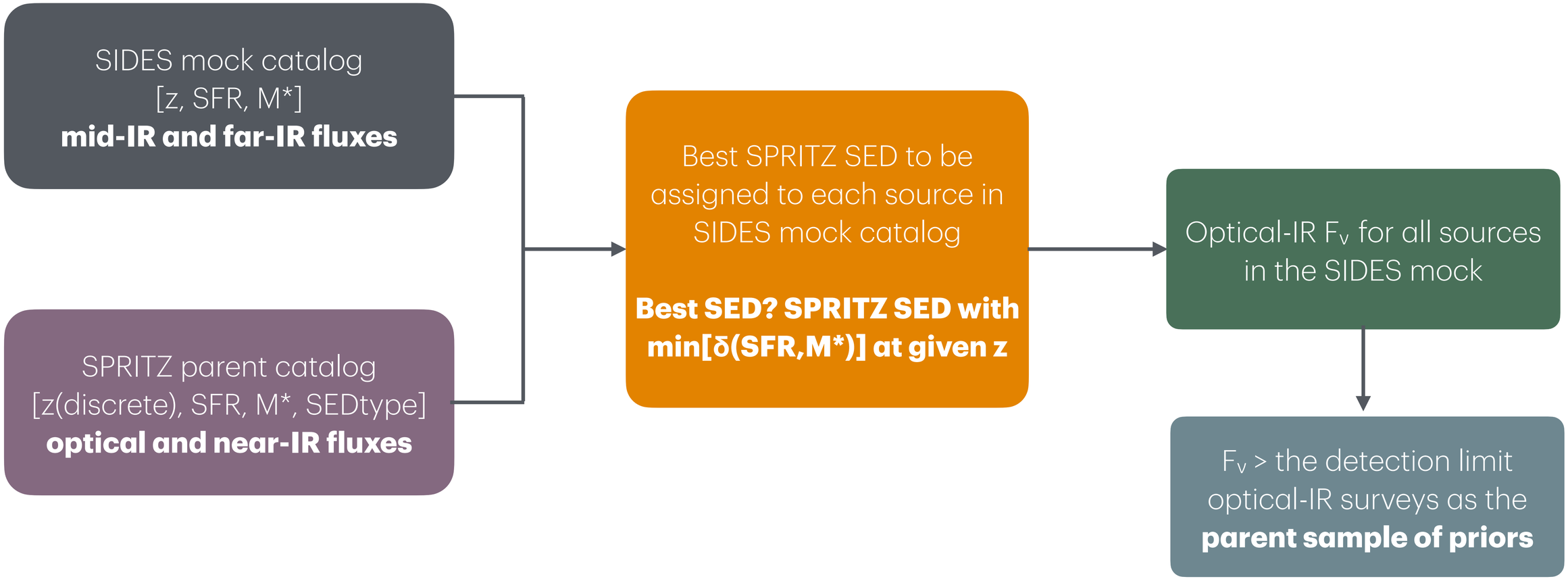
SIDES 2 deg^2	5.6 mJy/beam	6.4 mJy/beam	6.2 mJy/beam
SPRITZ (SPICA-DS)	4.9 mJy/beam	5.7 mJy/beam	5.6 mJy/beam

SPRITZ: Underestimated confusion at all SPIRE bands

Constructing A Full-Wavelength Model

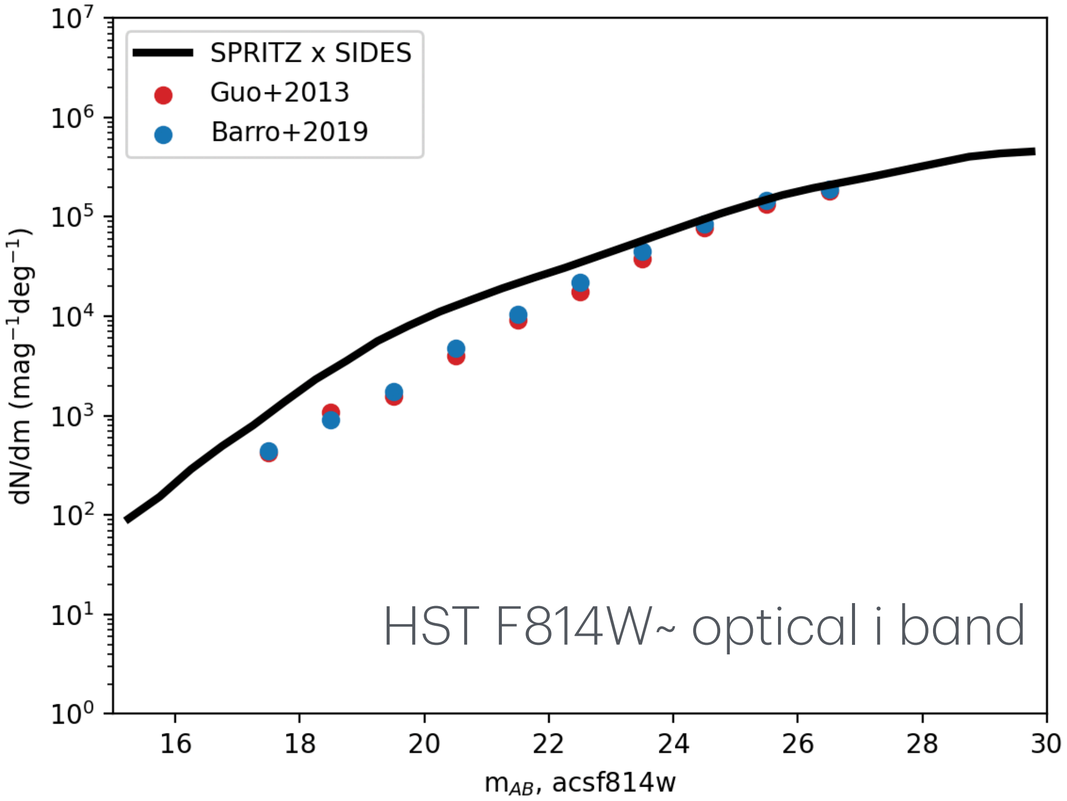
SIDES x SPRITZ on SFR/M* plane

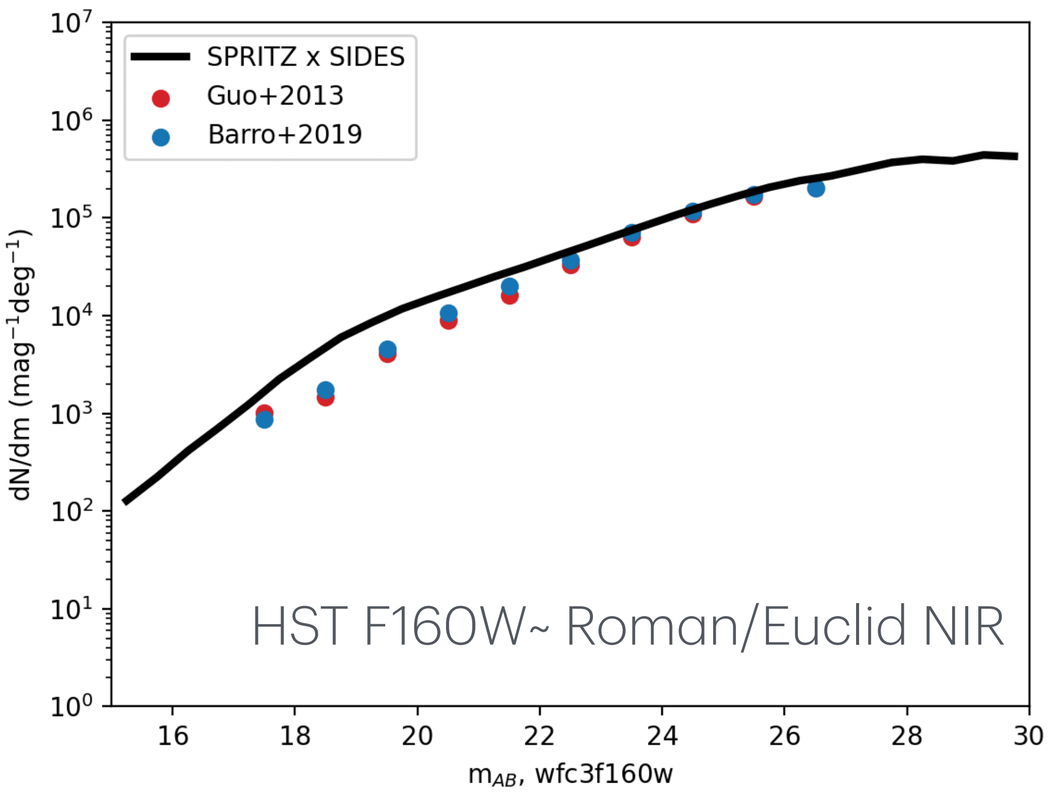


Assigned optical-IR flux + Survey depth —> Source could be detected in optical-IR surveys

Constructing A Full-Wavelength Model

Optical-IR number counts reproduced



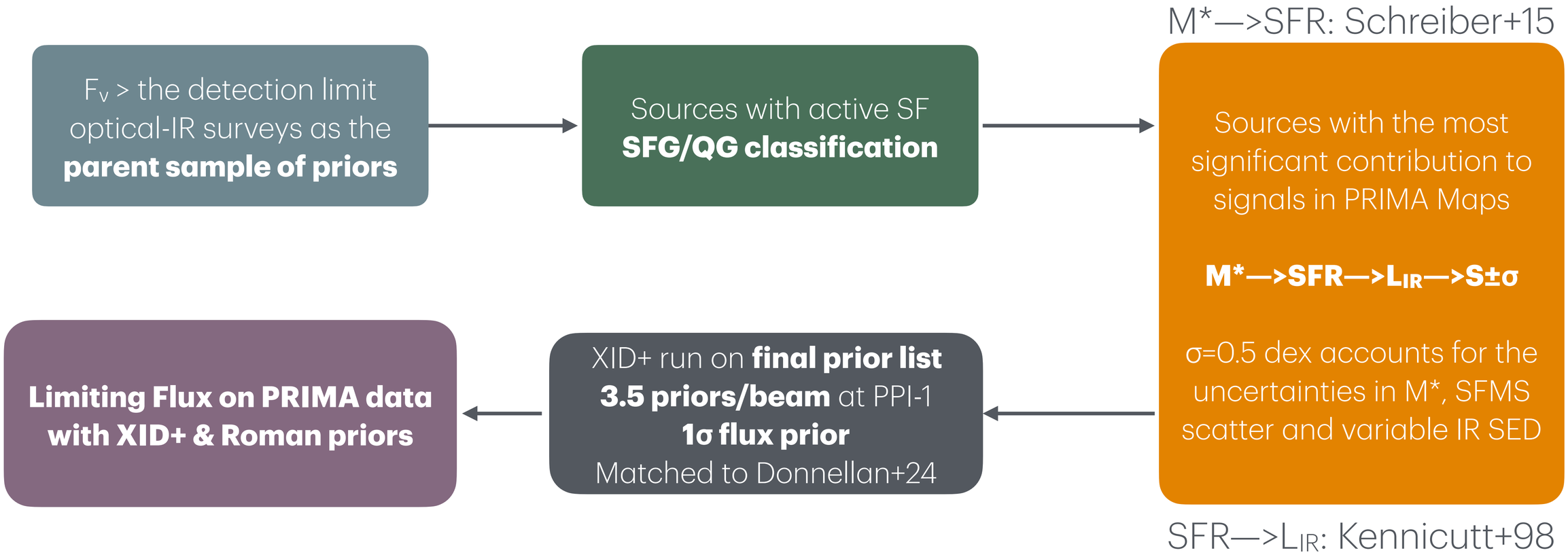


Overproduction of bright sources at ~19 m_{AB}. Good consistency at the faint end (>24 m_{AB}).

Acceptable for selecting flux-limited priors mimicking Roman/Euclid deep field catalogs (>26 m_{AB}).

Confusion Mitigation with Multi-wave Priors

A frame work with NIR position priors from a Roman-like survey

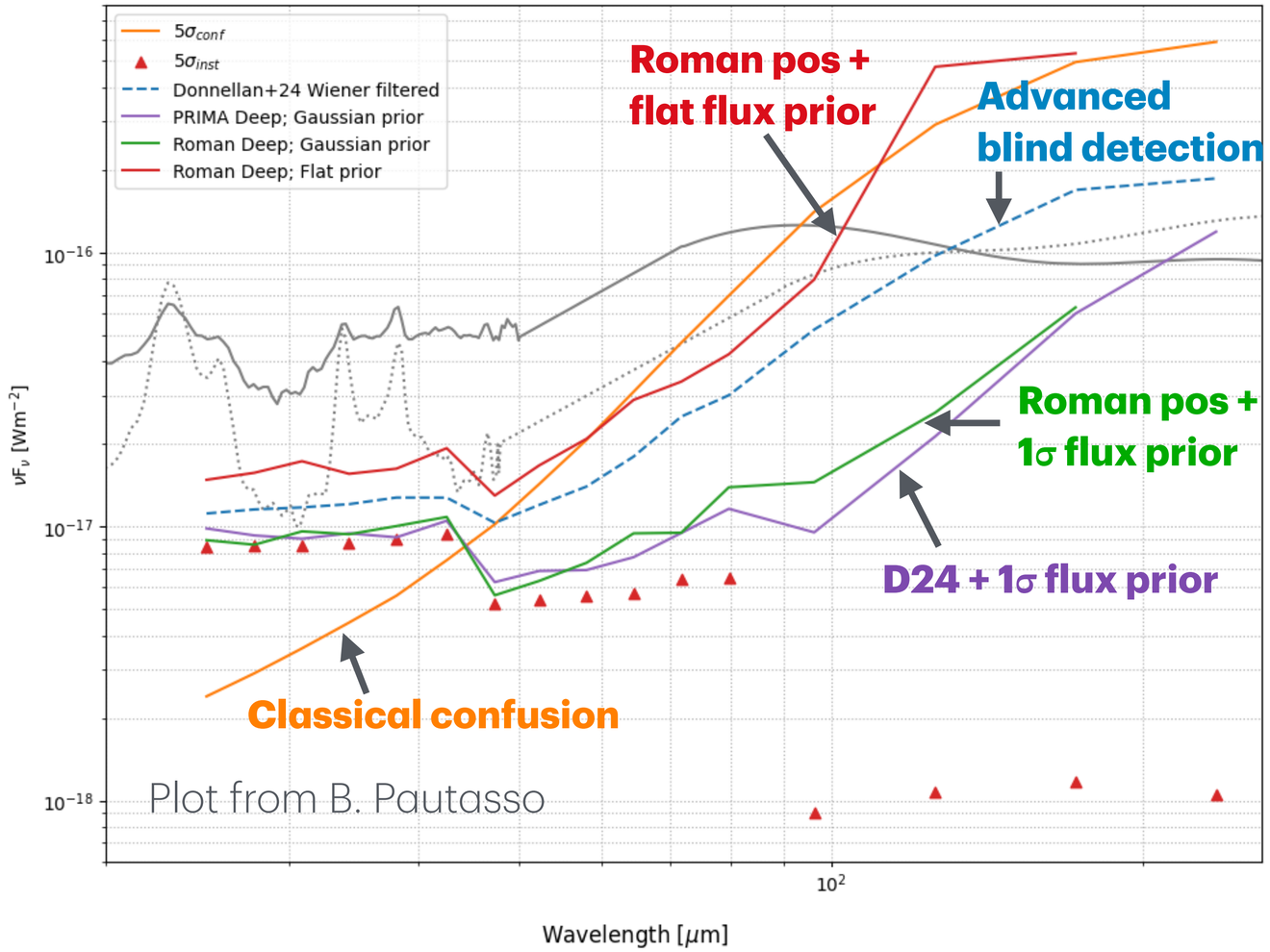


Detected source catalog —> “non-negligible” source to PRIMA data as XID+ priors

https://asd.gsfc.nasa.gov/roman/wps_2023/files/022_Yung_HLWAS.pdf

Confusion Mitigation with Multi-wave Priors

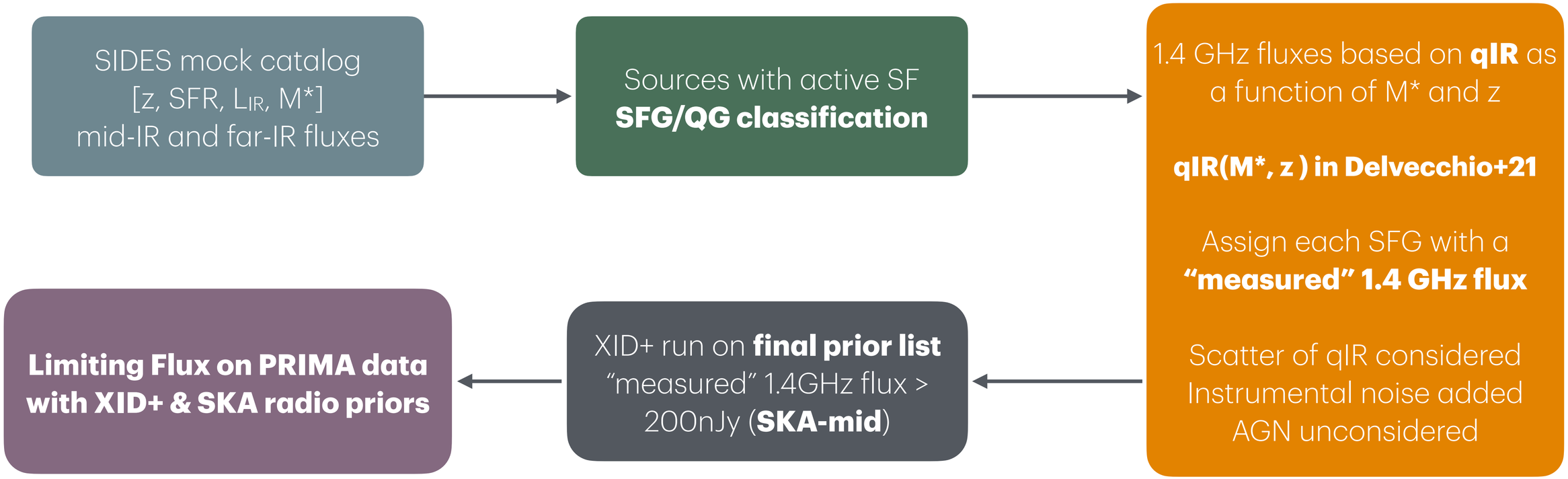
Performance of XID+ with Roman near-IR priors



- Limiting flux following the definition in Donnellan+24
- An order of magnitude improvement at PPI1 if we have some unbiased knowledge (1σ) on flux, match to Donnellan+24 using an ideal prior list.
- Sensitive to the knowledge on flux. High density (3.5 source/beam at PPI-1) + flat flux prior worsen the results.

Confusion Mitigation with Multi-wave Priors

Alternative position priors from radio surveys, i.e. SKA-mid

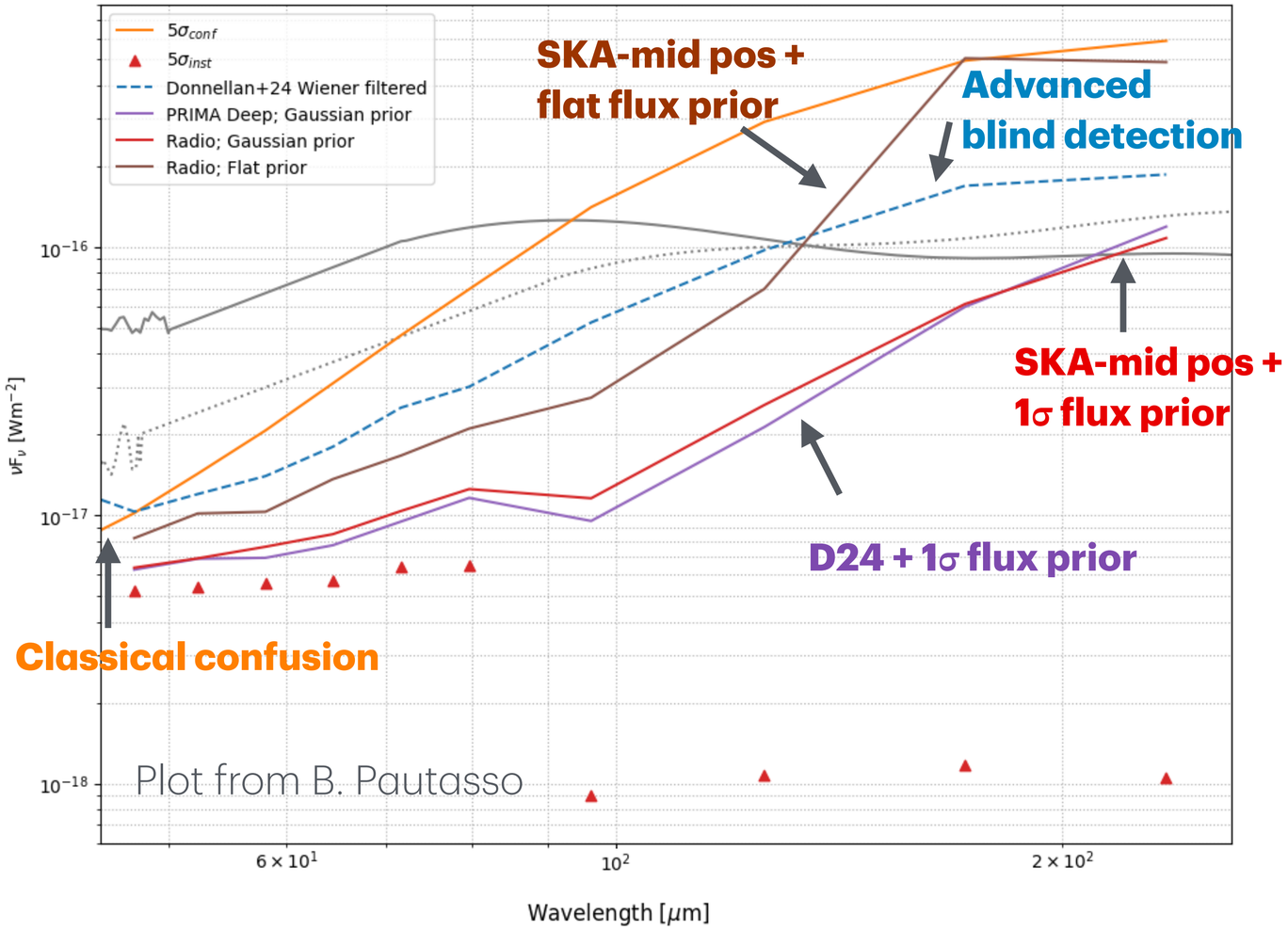


Source properties in SIDES —> detectable radio sources in SKA as XID+ priors

Do not rely on the framework assigning optical-IR fluxes from SPIRTZ to SIDES sources

Confusion Mitigation with Multi-wave Priors

Performance of XID+ with SKA-mid radio priors

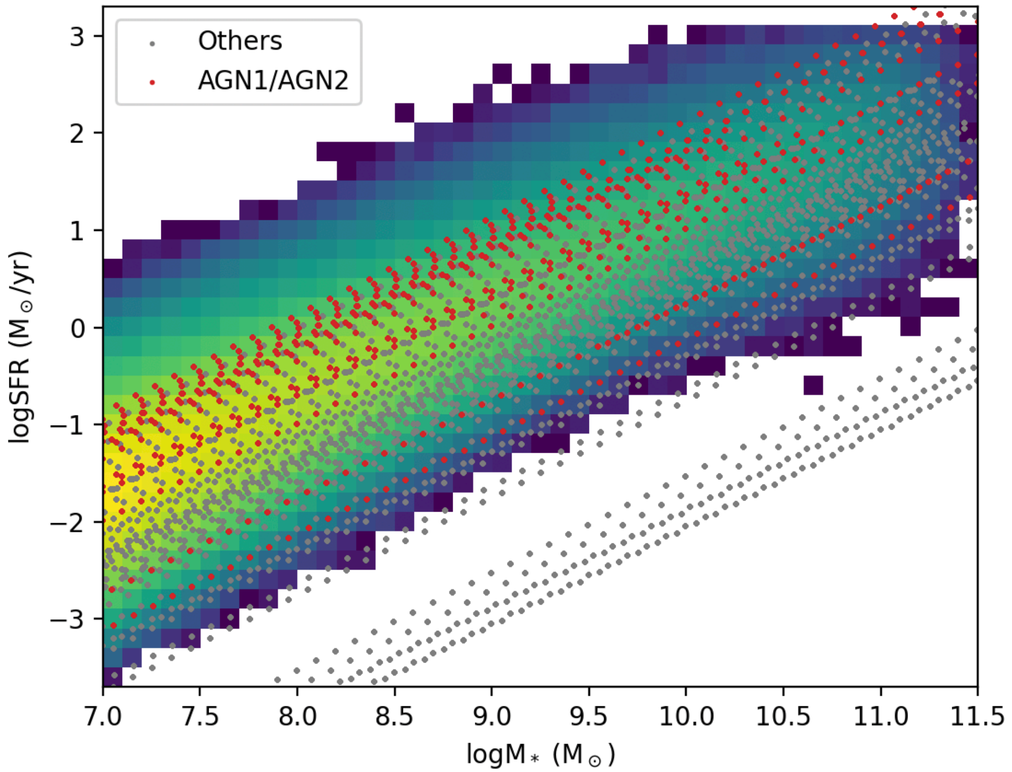


- Limiting flux following the definition in Donnellan+24
- An order of magnitude improvement at PPI1 if we have some unbiased knowledge (1σ) on flux, match to Donnellan+24 and Roman priors.
- At a lower source density (2 per beam at PPI-1), better than advanced blind detection method with flat flux prior in most bands

Conclusion

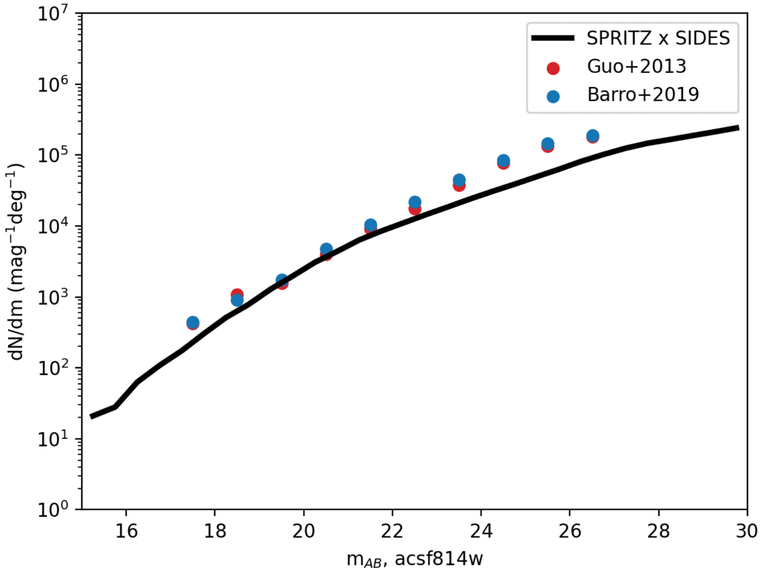
- In addition to source number counts, evaluation of far-IR mocks should also pay attention to the comparison between observed and simulated sky maps in 2D.
- PRIMA flux measurement down to an order of magnitude deeper that classical confusion is possible with XID+ and sources catalogs from near-IR surveys like Roman, if we could have a rough but unbiased knowledge on their mid and far-IR fluxes.
- Prior catalogs from deep radio continuum surveys of, i.e. SKA-mid, show a similar performance as near-IR prior catalogs in improving faint source flux measurement under XID+ framework, indicating their promising potential of synergy with PRIMA.

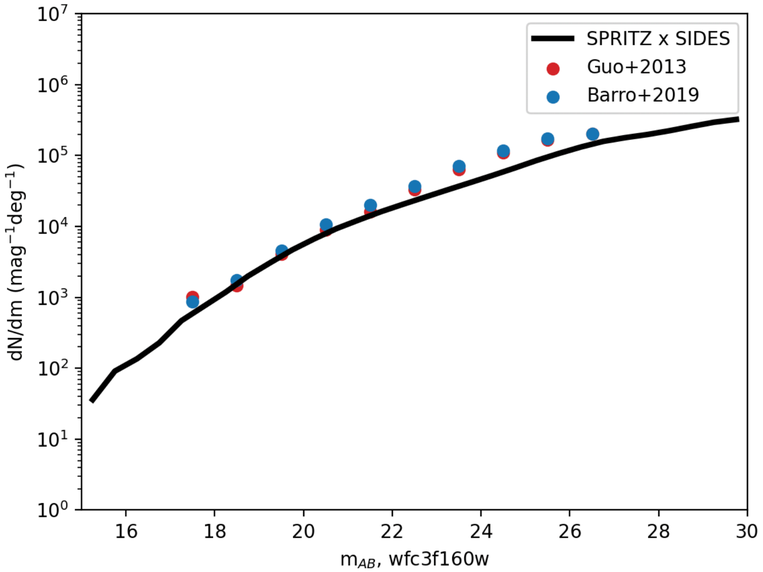
Number Counts: SFR/M* matching



Lack of starburst in SPRITZ template.

Overproduction of sources with AGN templates?





Removing a few AGN-dominated templates improves bright end number counts, but....