Point Source Subtraction in Visibility Space

Swiss SKA Data Challenge Team

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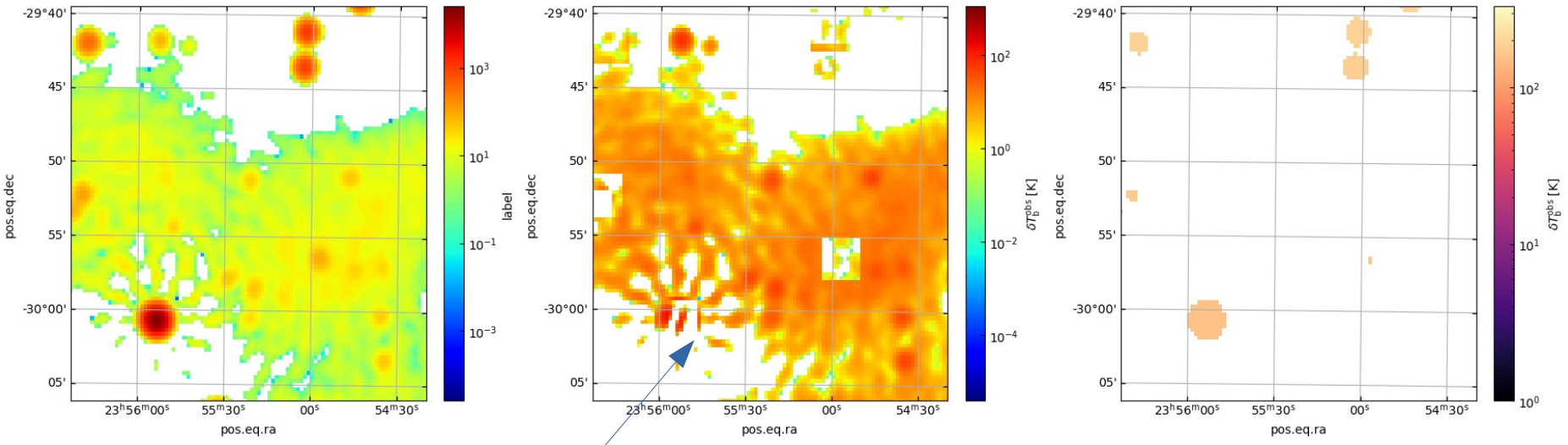
Visbility vs Image based Subtraction - Example



Artifacts near the strong sources

Visibilities in Radio Interferometry

$$V(u,v,w) = \frac{1}{2} A_e \, \Delta\nu \int\int I(l,m) \, P_N(l,m) \, e^{-2\pi i \, \{ul+vm+w(\sqrt{1-l^2-m^2}-1)\}} \frac{dl \, dm}{\sqrt{1-l^2-m^2}},$$

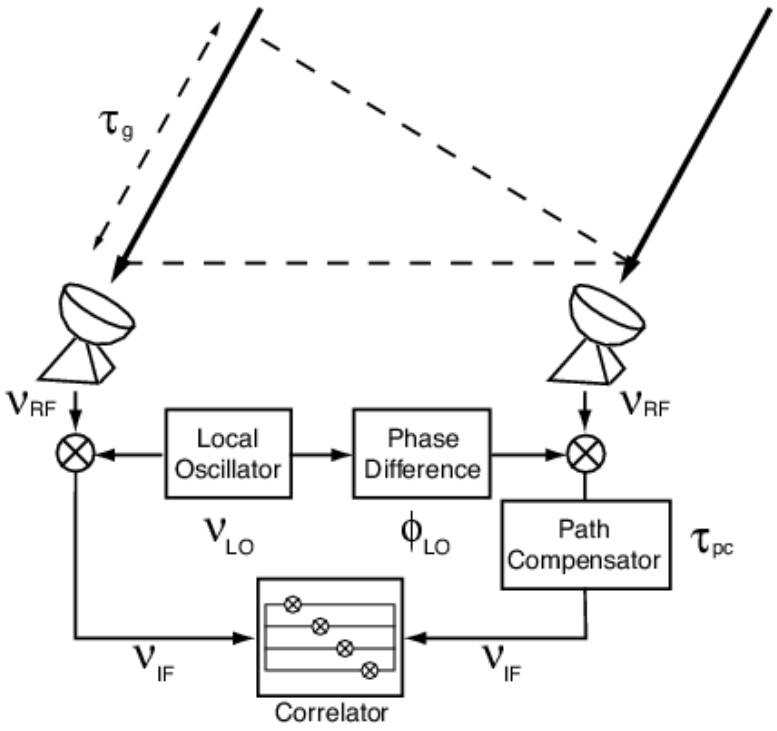
- Combine the cosine and sine responses (two independent correlator outputs) to form the complex visibility:

$$V = R_c - iR_s = Ae^{-i\phi}$$

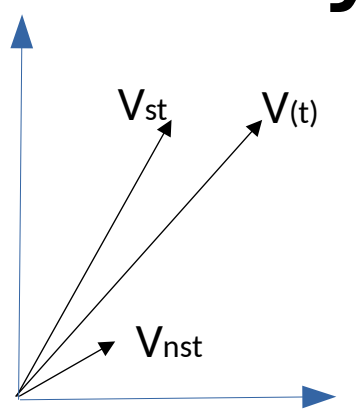
- where the amplitude is: $A = \sqrt{R_C^2 + R_S^2}$
- where the phase is: $\phi = \tan^{-1}(R_s/R_c)$

- This also gives the relationship between the source brightness, and the response of an interferometer:

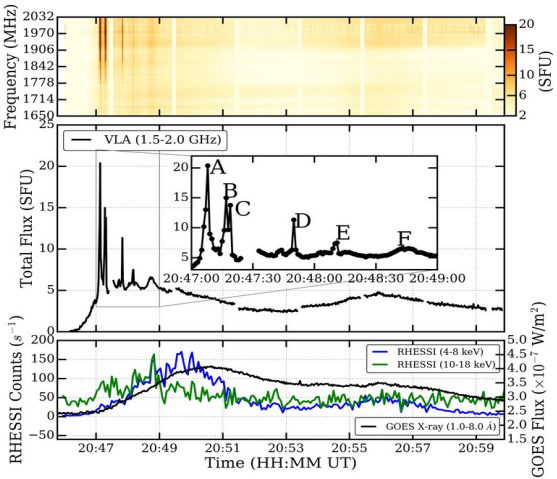
$$V(\mathbf{b}) = R_c - iR_s = \iint I_v(s) e^{-2\pi i v \mathbf{b} \mathbf{s}/c}$$

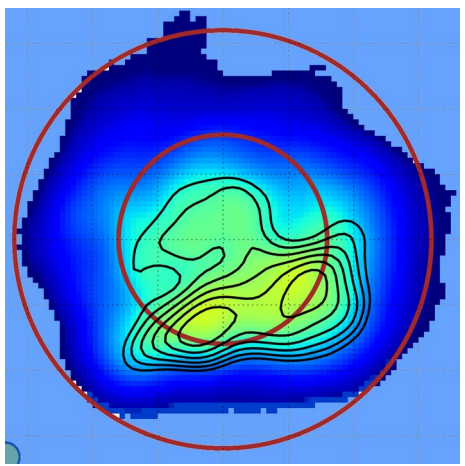


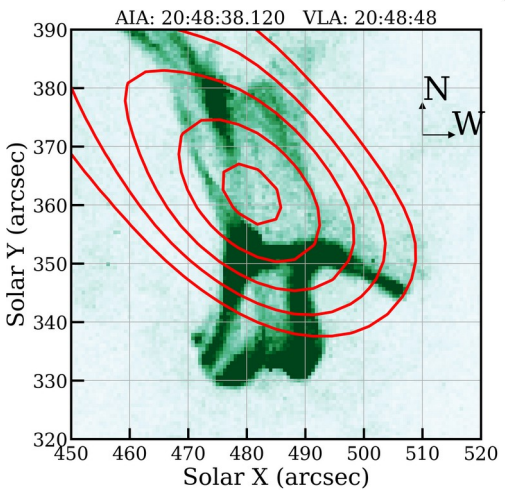
Visibility Subtraction Approach



$$\vec{V}(t) = \vec{V}_{st}(t) + \vec{V}_{nst}(t)$$







Vector subtraction in time

Stationary component

Non-stationary component

Make a model for the stationary component

Background thermal sources (Active regions)

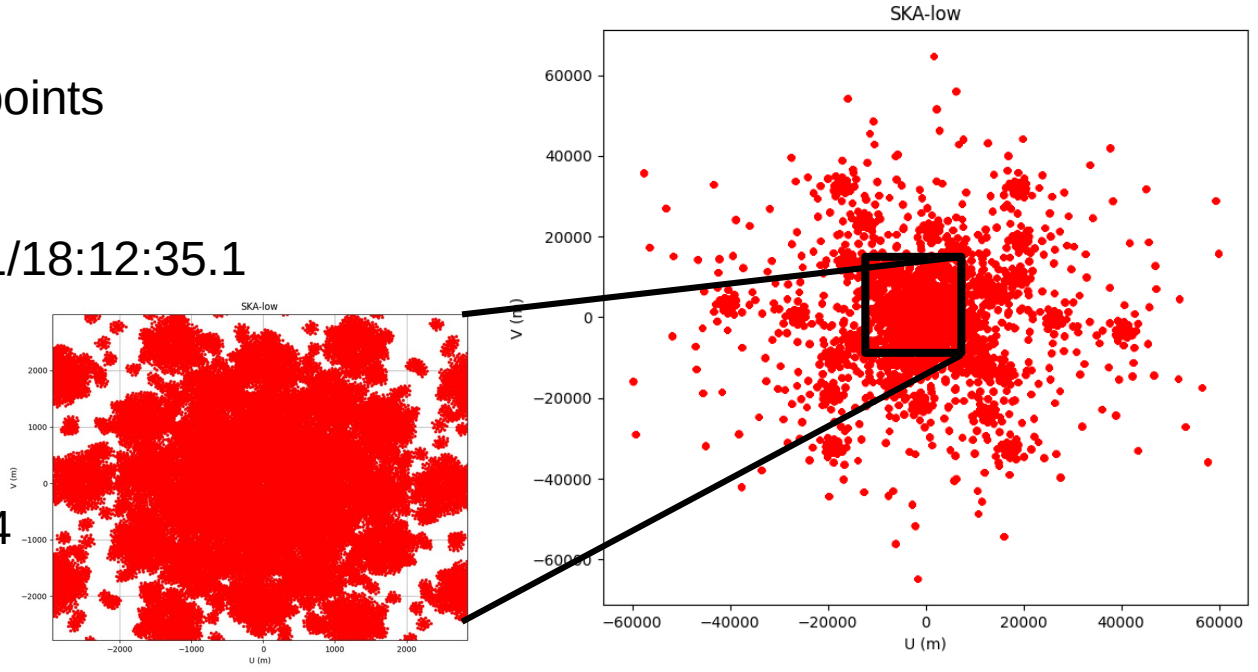
Solar flare source – compact

Time-variable

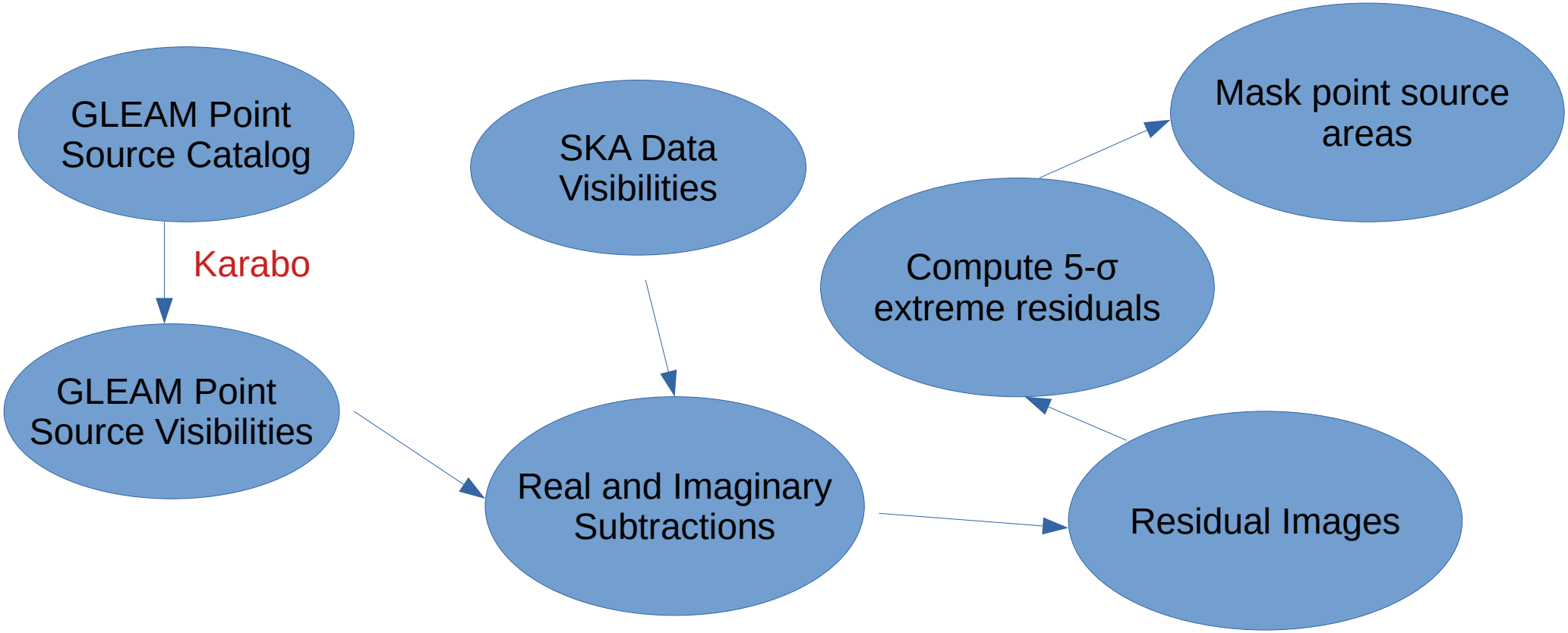
AR slowly varying component

SKA DC Data

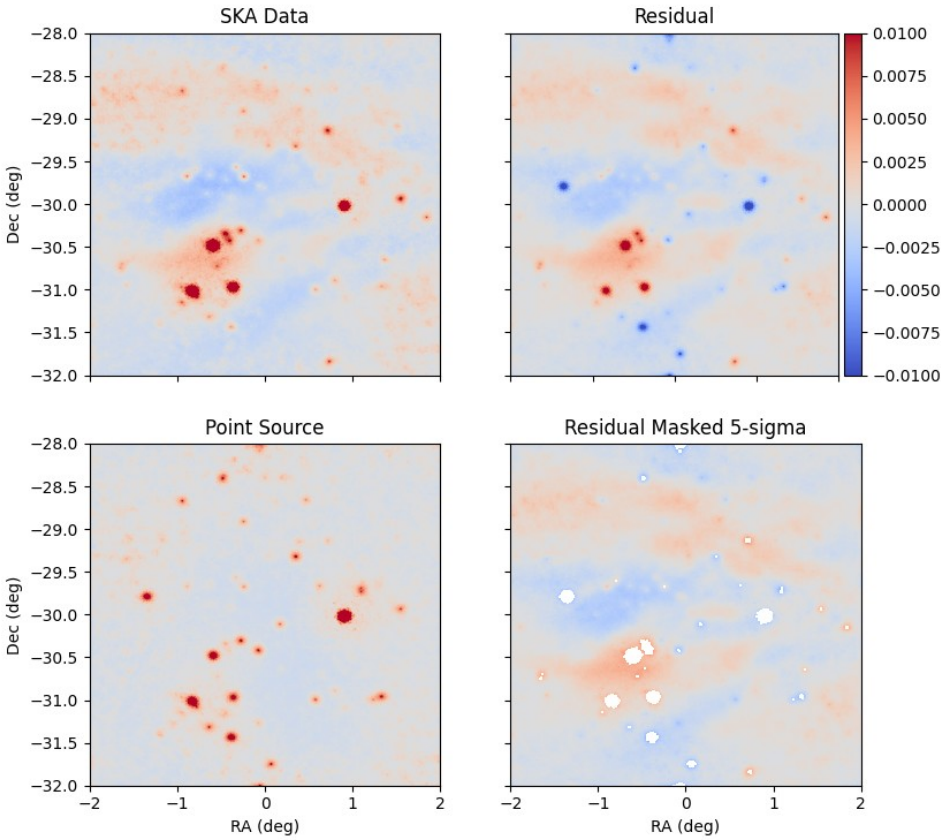
+ 512 Stations
+ 130816 instantaneous UV points
+ Total time slices: 1440
+ Simulation time: 4 hours
21-Sep 2021/14:12:35.1-2021/18:12:35.1
+ Channel Width 100kHz
+ RA: 0 deg Dec: -30 deg
+ Time resolution: 10 sec
+ Polarization: XX
+ Number of Sources: 417604
+ Data records: 188375040

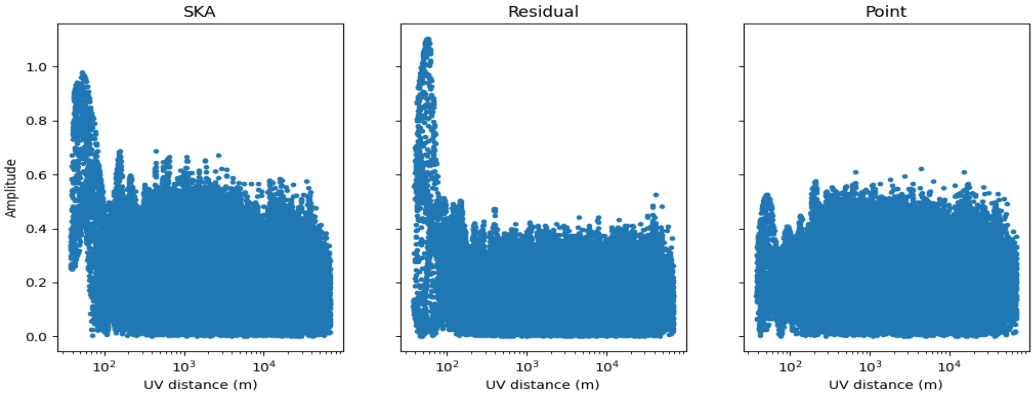


Point Source Subtraction Procedure



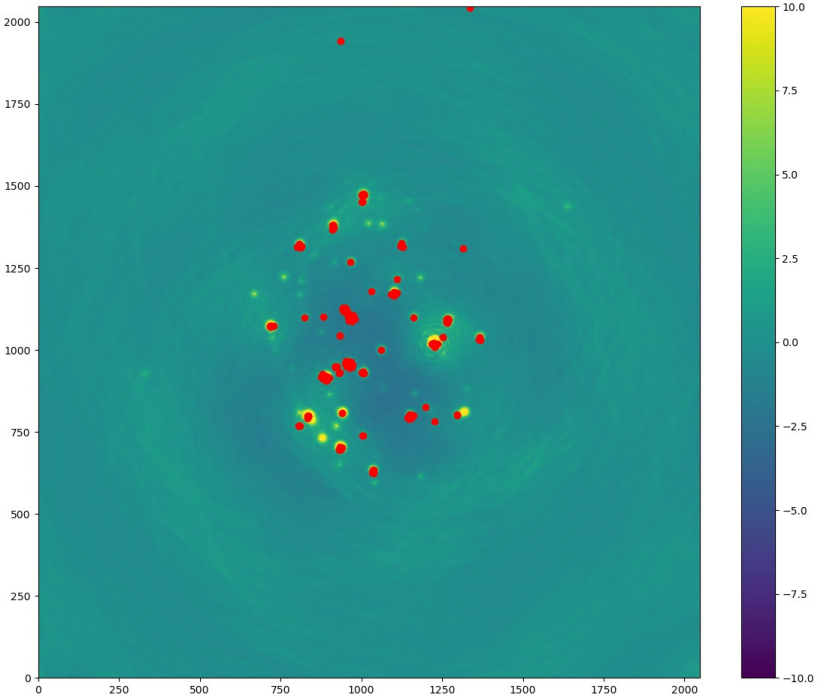
Point Sources

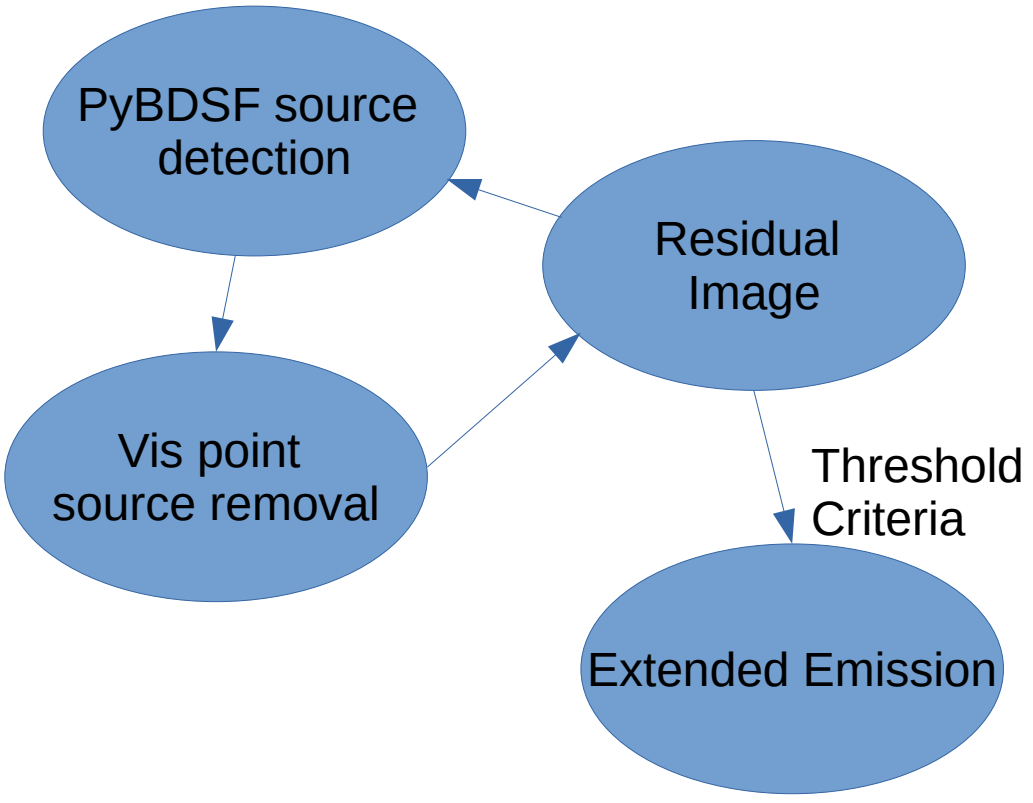




+ Extended and point source are seen
+ Significant amount of power in extended emission
+ The residuals are obtained are not perfect
+ Threshold cut-off to remove point source
Miss-match of the fluxes in the catalog and data leads to uneven subtraction

Iterative Approach to remove foreground





Summary

+ Point Source subtraction is better than image-based subtraction, if strong sources are in the FoV
+ For SKADC3, sources shows wide range of flux densities
+ Point source subtraction reduced flux densities upto ~ 70%
+ Thresholds can be used to mask the point source regions