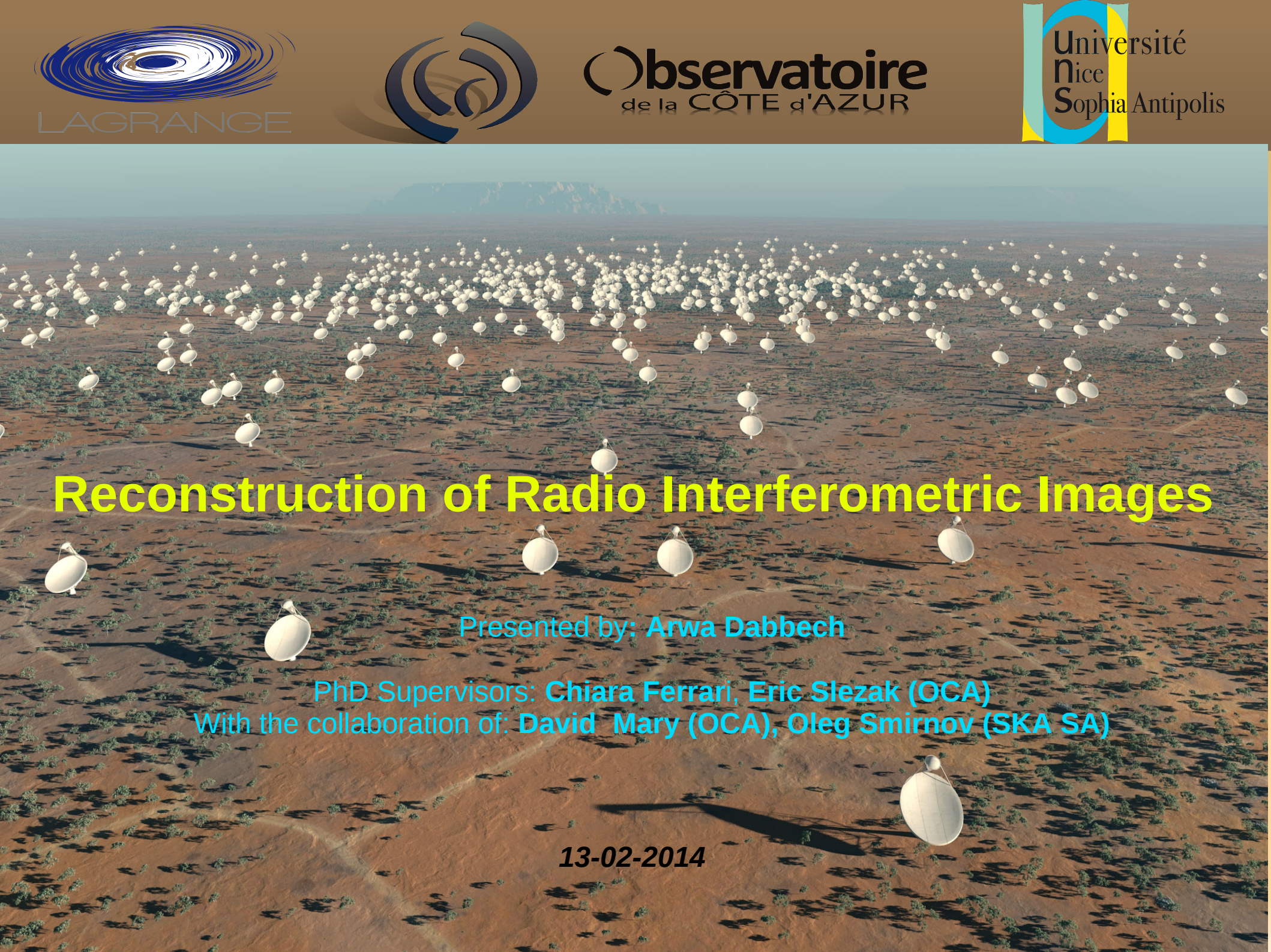


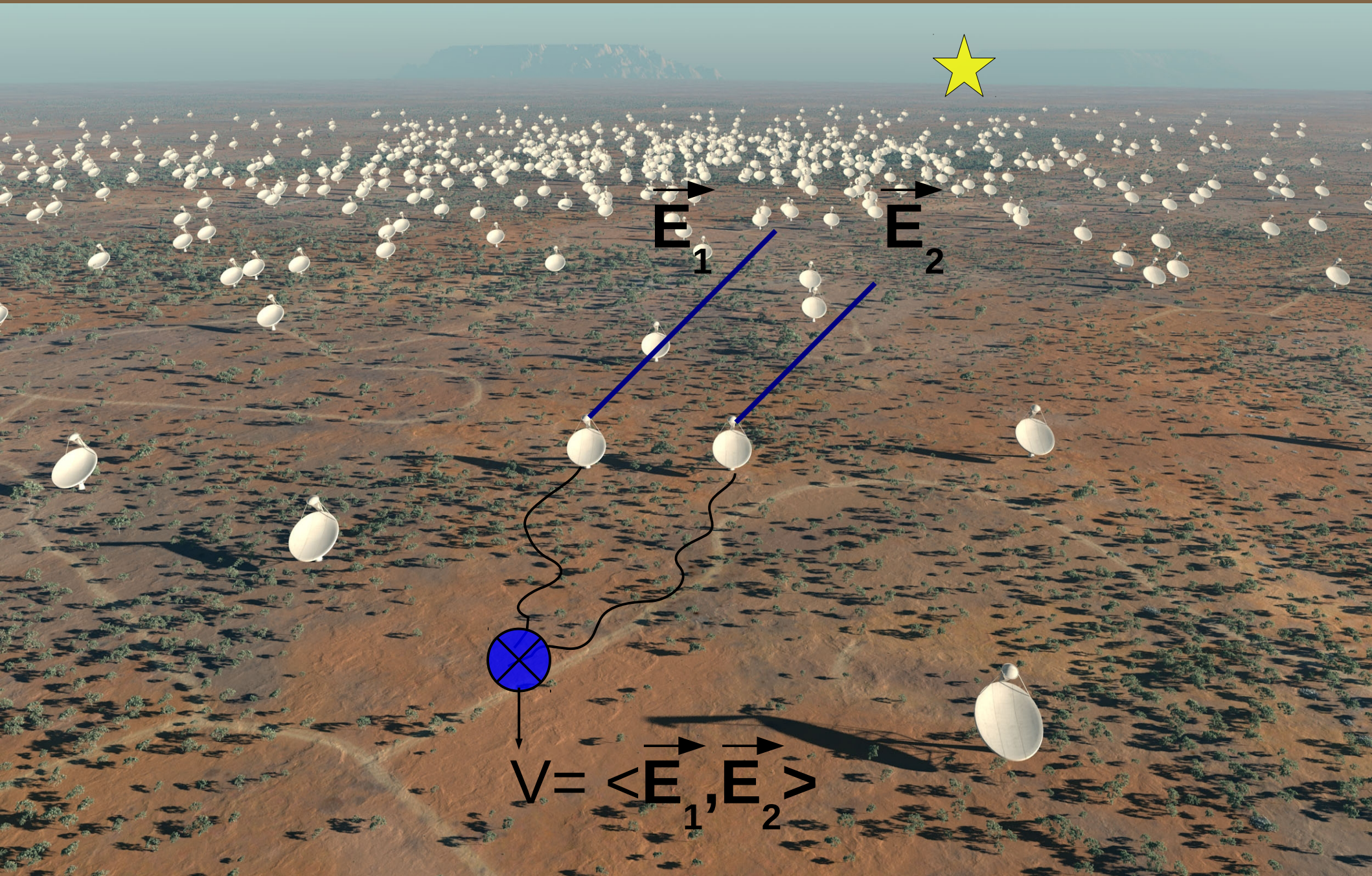
Reconstruction of Radio Interferometric Images

Presented by: **Arwa Dabbech**

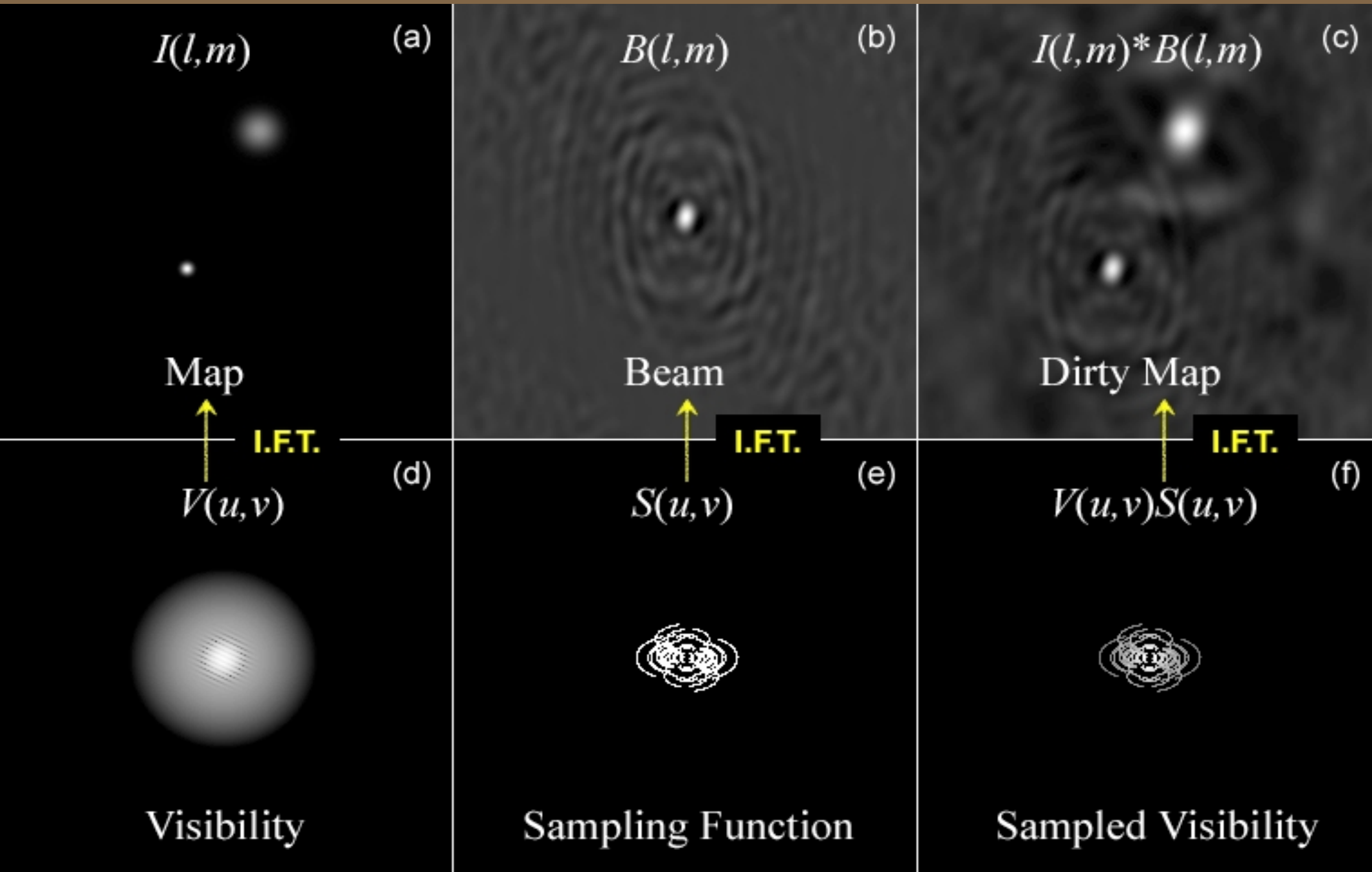
PhD Supervisors: **Chiara Ferrari, Eric Slezak (OCA)**
With the collaboration of: **David Mary (OCA), Oleg Smirnov (SKA SA)**

13-02-2014

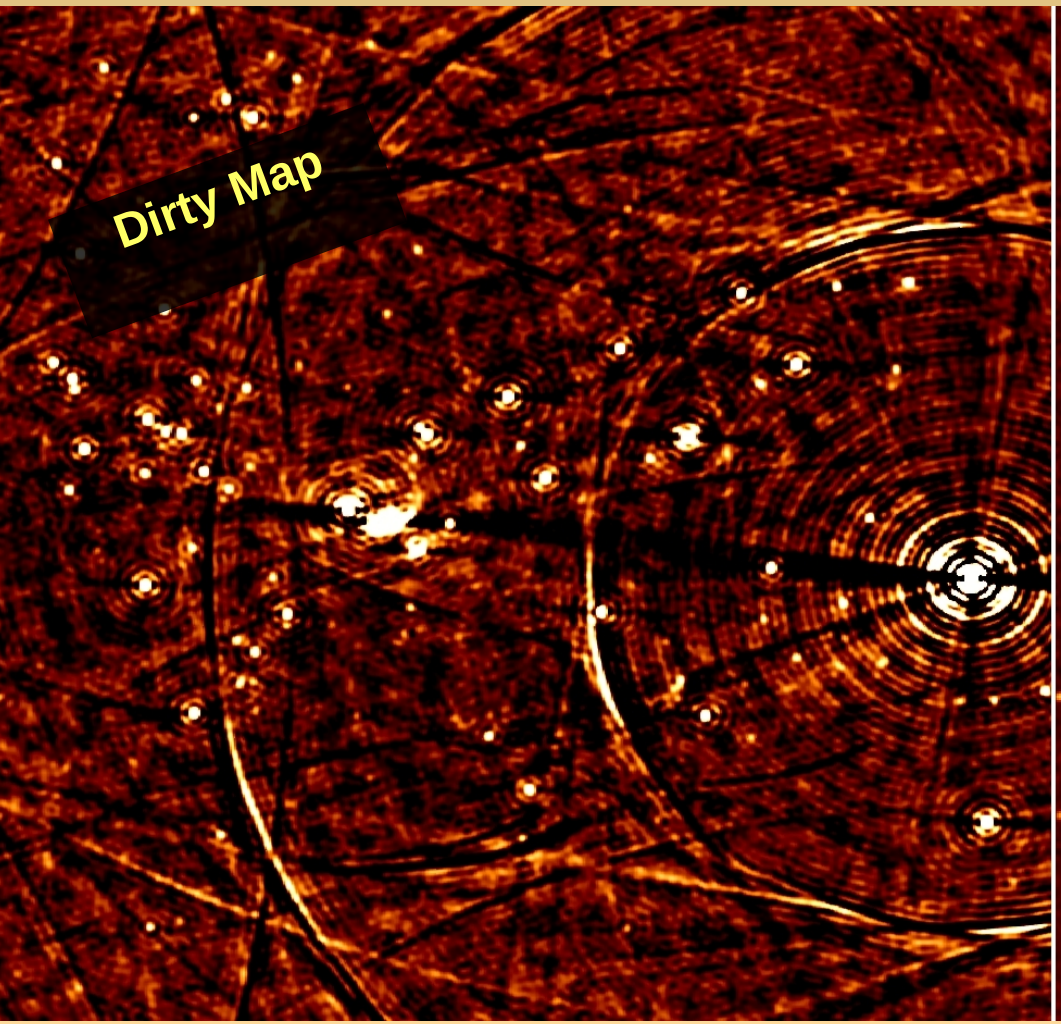
Radio Measurements

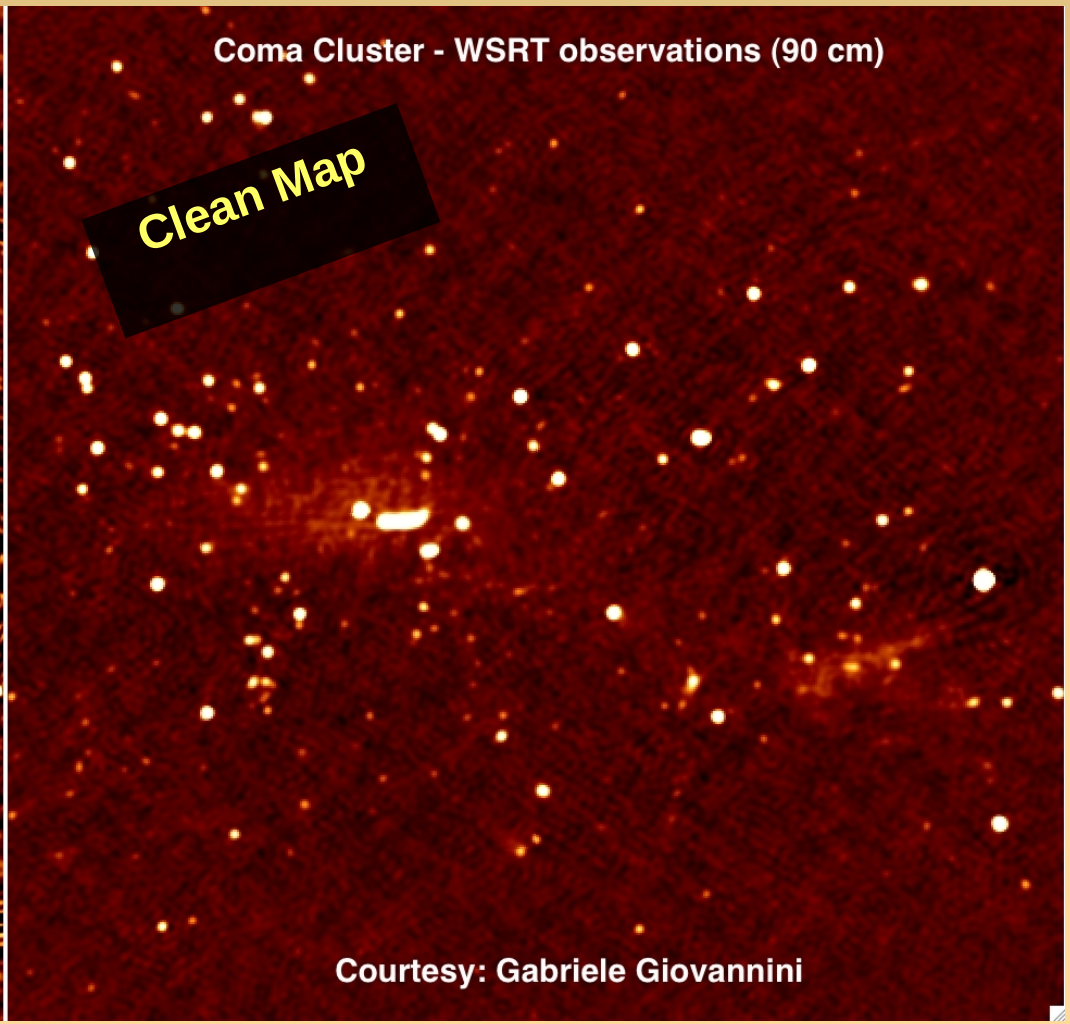


Radio Data

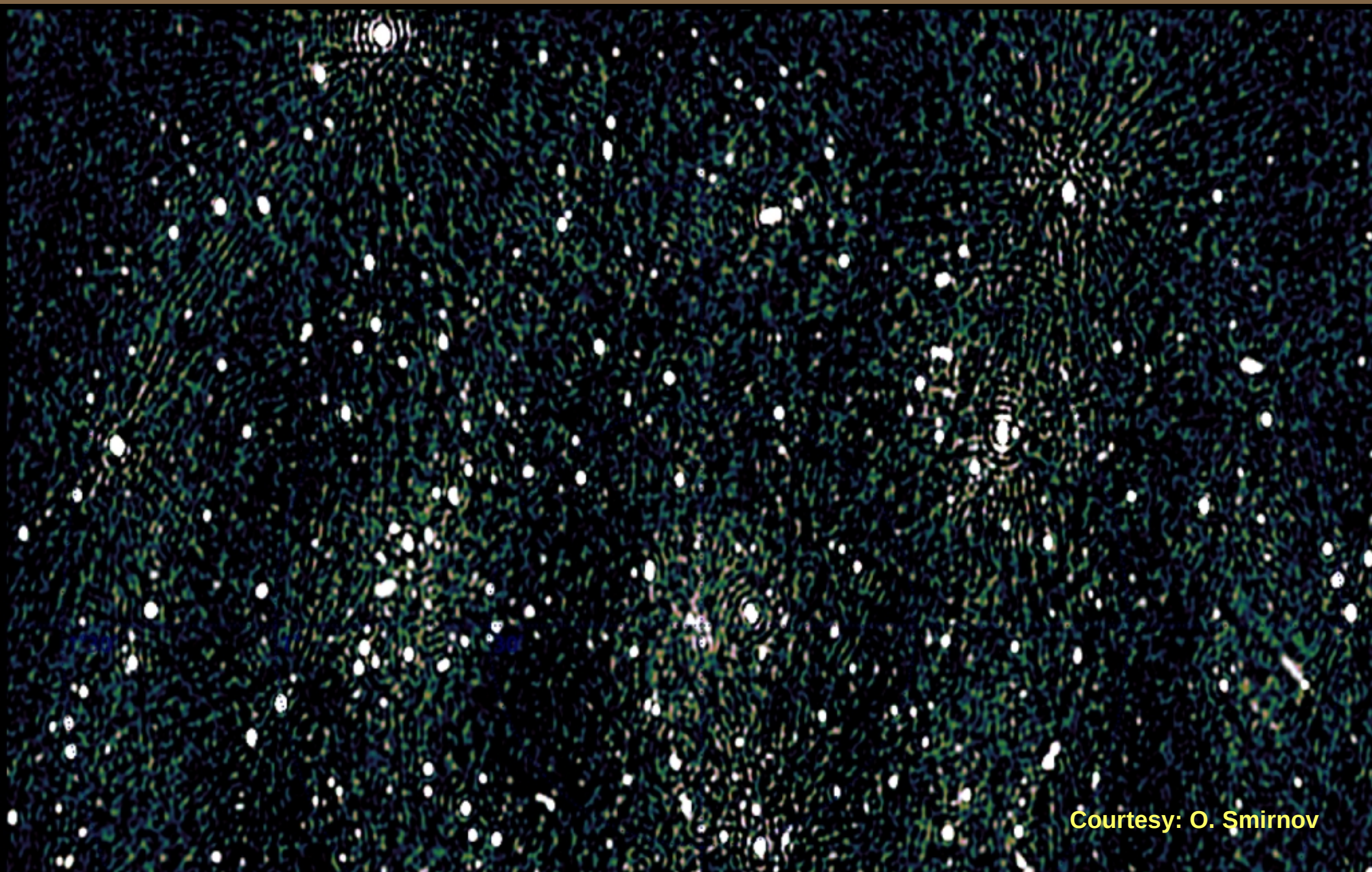

I(l,m)
(a)
Map
I.F.T.
V(u,v)
(d)
Visibility
B(l,m)
(b)
Beam
I.F.T.
S(u,v)
(e)
Sampling Function
I(l,m)*B(l,m)
(c)
Dirty Map
I.F.T.
V(u,v)S(u,v)
(f)
Sampled Visibility

Radio Data: Galaxy Clusters





Deconvolution issues

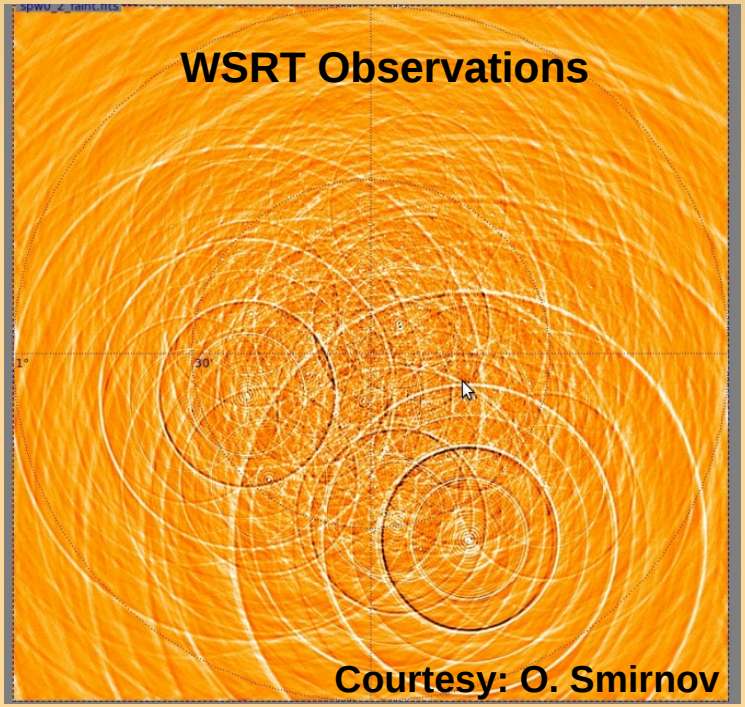


Courtesy: O. Smirnov

Radio Interferometric Problem

Radio Interferometric model (1D)

$$\mathbf{y} = \mathbf{H}\mathbf{x} + \mathbf{n}, \ \mathbf{n} \in \mathbb{R}^N$$

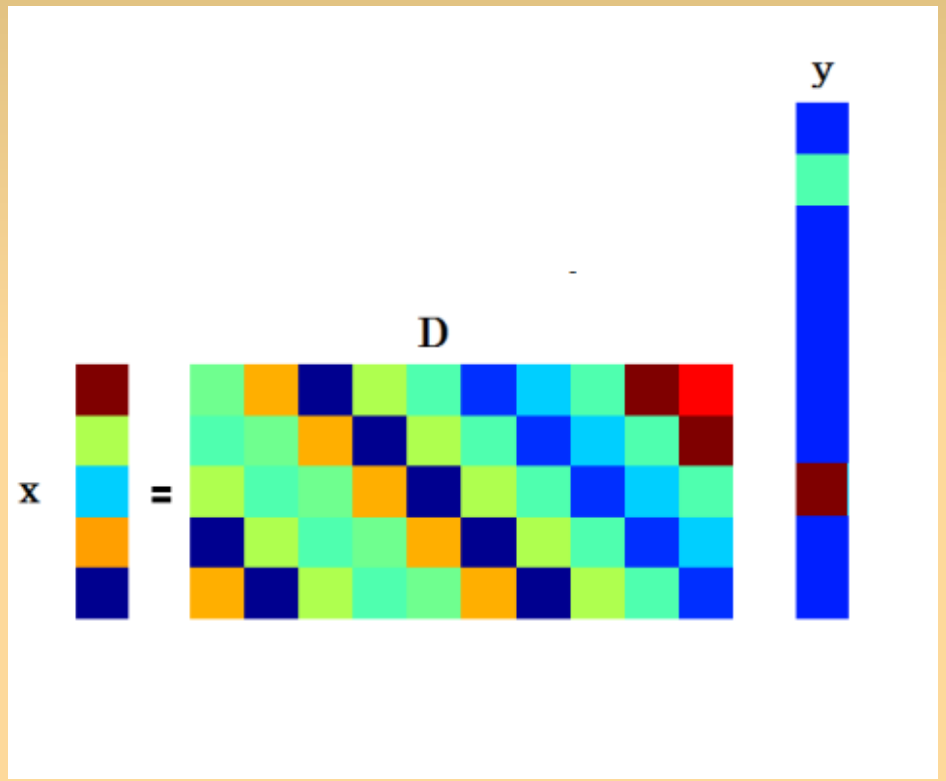


Problem ill posed due to the missing information in the uv coverage

Infinity number of skies that can fit the Dirty map

Sparse Representations

- a **sparse** signal: most of its coefficients equal zero.
- a **dictionary**: a data representation space where the signal can be sparsified.
- an **atom**: a column of a dictionary of the same size as the signal.



Sparsity Promoting approachs

- **Synthesis** Approach

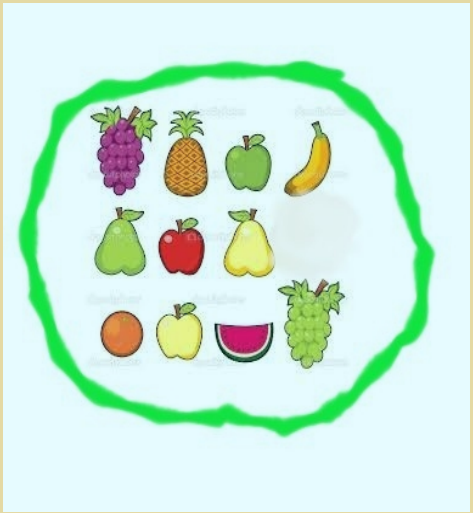
  The signal **x** is a linear combination of only **few** atoms of a given dictionary **S.**

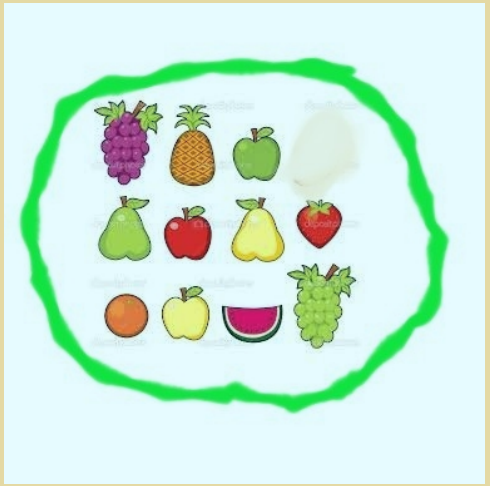
  $\mathbf{x} = \mathbf{S}\gamma$, γ (*synthesis coefficients vector*) is sparse

- **Analysis** Approach

  The projection of a signal **x** in a given dictionary **A** is **sparse.**

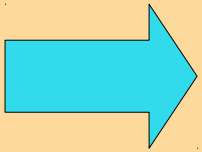
  $\mathbf{A}^T\mathbf{x} = \mathbf{a}$, $\mathbf{a}$ (*analysis coefficients vector*) is sparse





Sparsity Promoting approaches

- **Synthesis** Approach
  - \+ Intuitive design
  - \- Time consuming
- **Analysis** Approach
  - \+ Robust to false detection
  - \- Time consuming



Hybrid approach : iterative analysis then synthesis of the signal by **packets** of atoms in a greedy manner

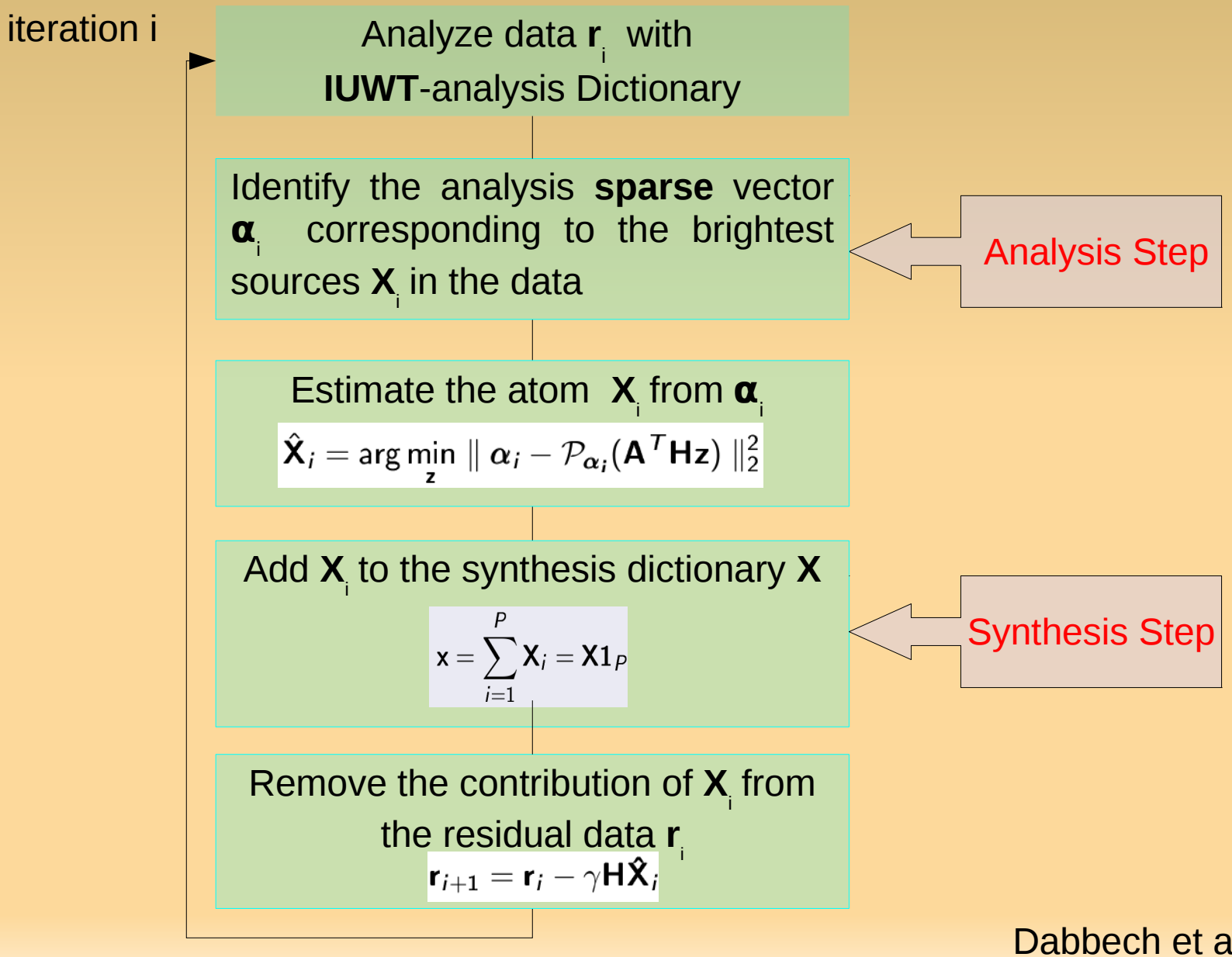
The Model

$$\mathbf{y} = \mathbf{H}\mathbf{x} + \mathbf{n} = \mathbf{H}\mathbf{X}\mathbf{1}_P + \mathbf{n}, \text{ with } \mathbf{X}_i \geq \mathbf{0}, \forall i \text{ and } P << N,$$

sparse synthesis problem with **unknown** atoms.

Dabbech et al. in prep

Analysis by Synthesis Approach



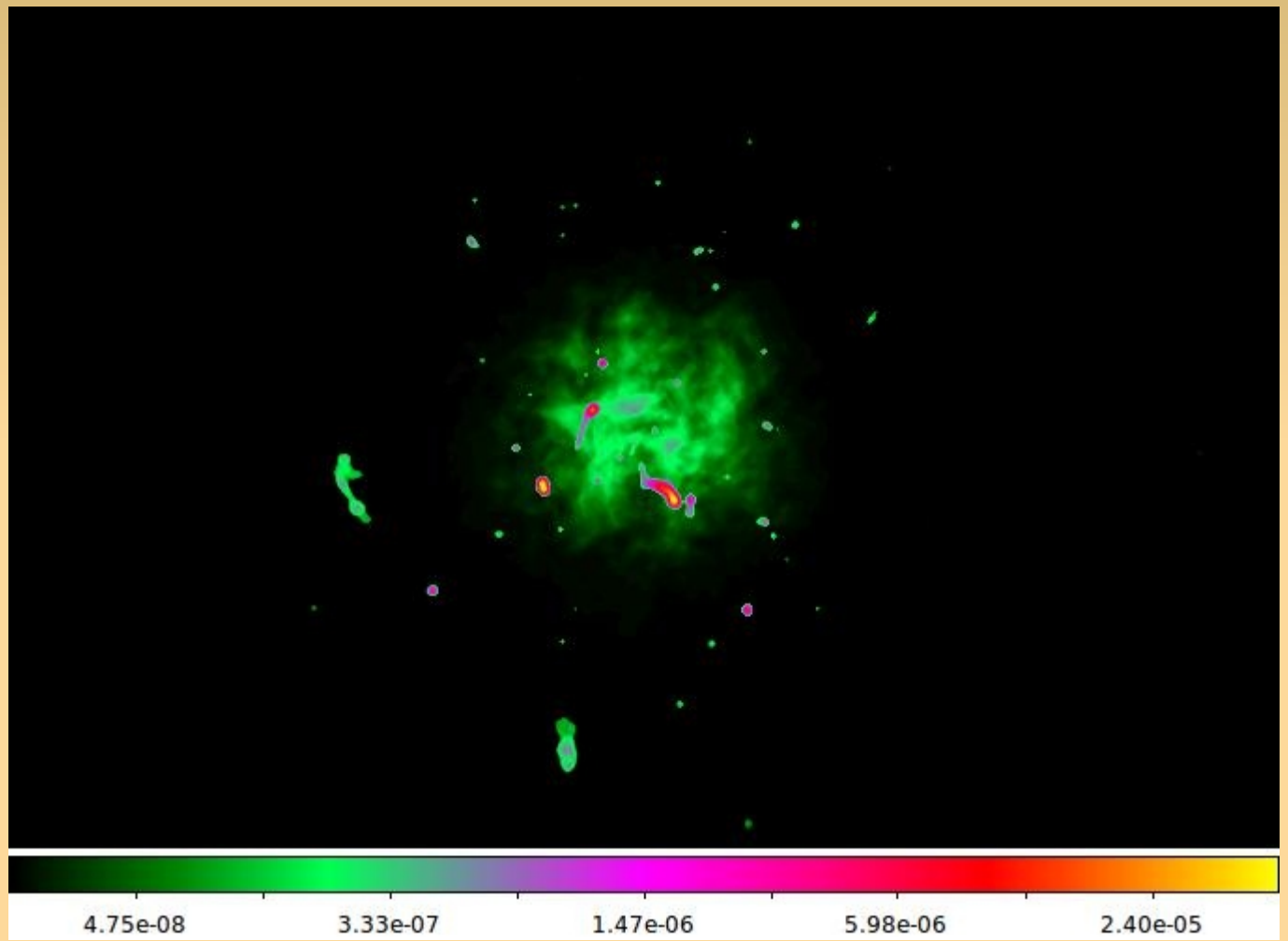
Dabbech et al. in prep

Simulations & Results

- Simulations using MeqTrees software by (O. Smirnov)

- Simulations of 2h & 8h MeerKat observations

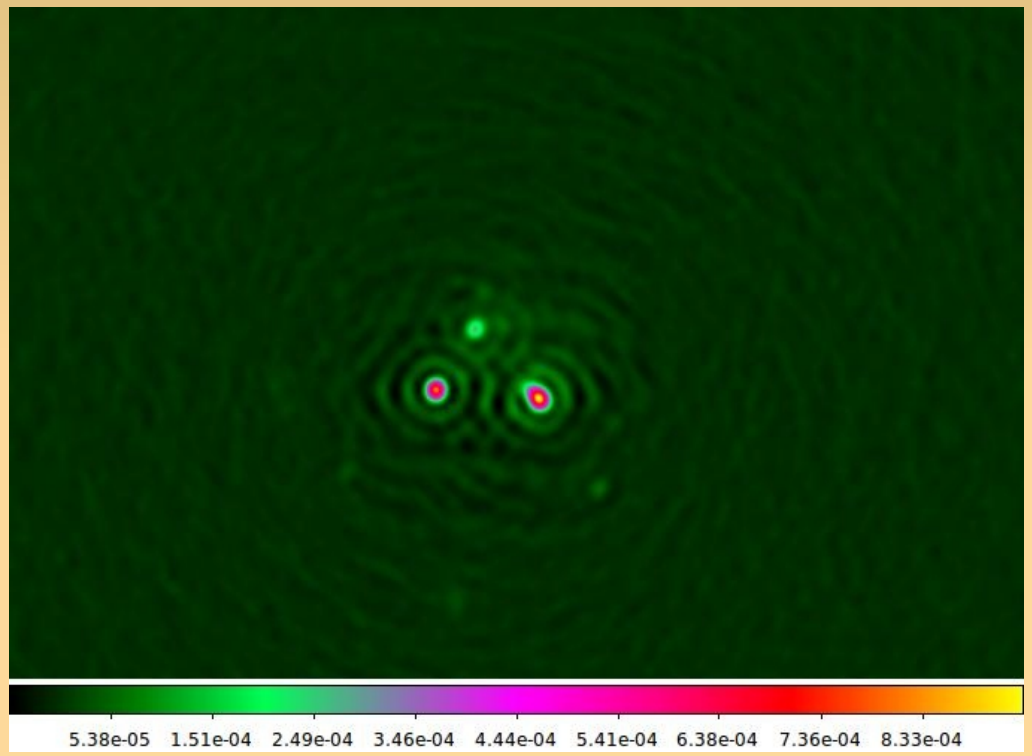
Simulations & Results



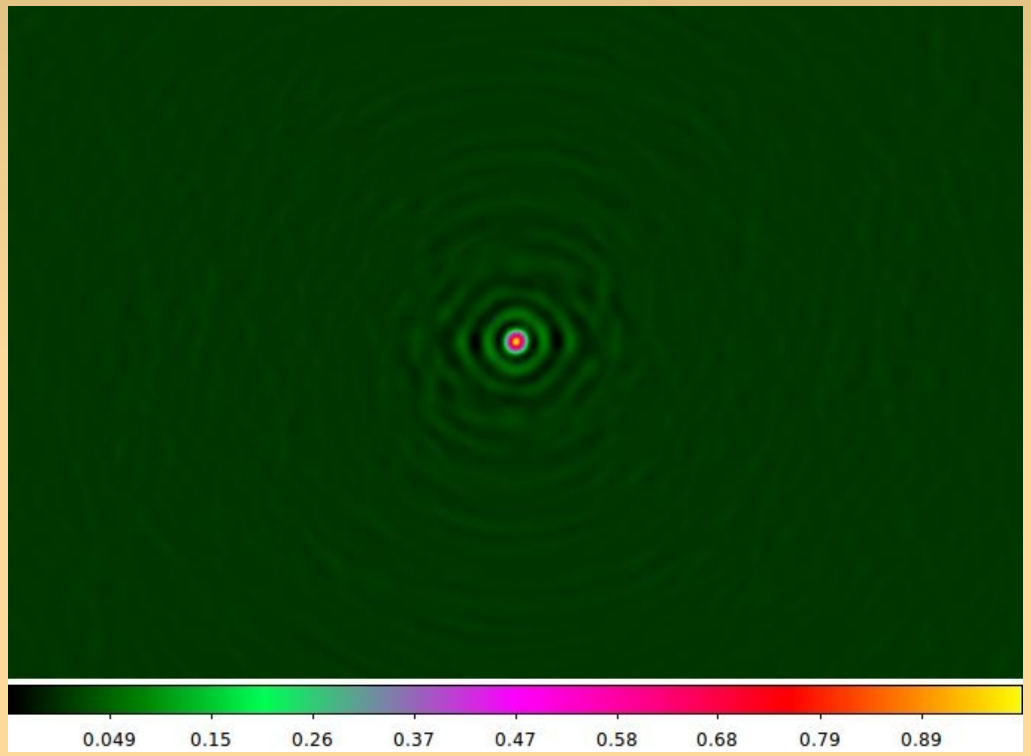
SKY: simulated galaxy cluster

Simulations & Results

MeerKat, 8h Observations

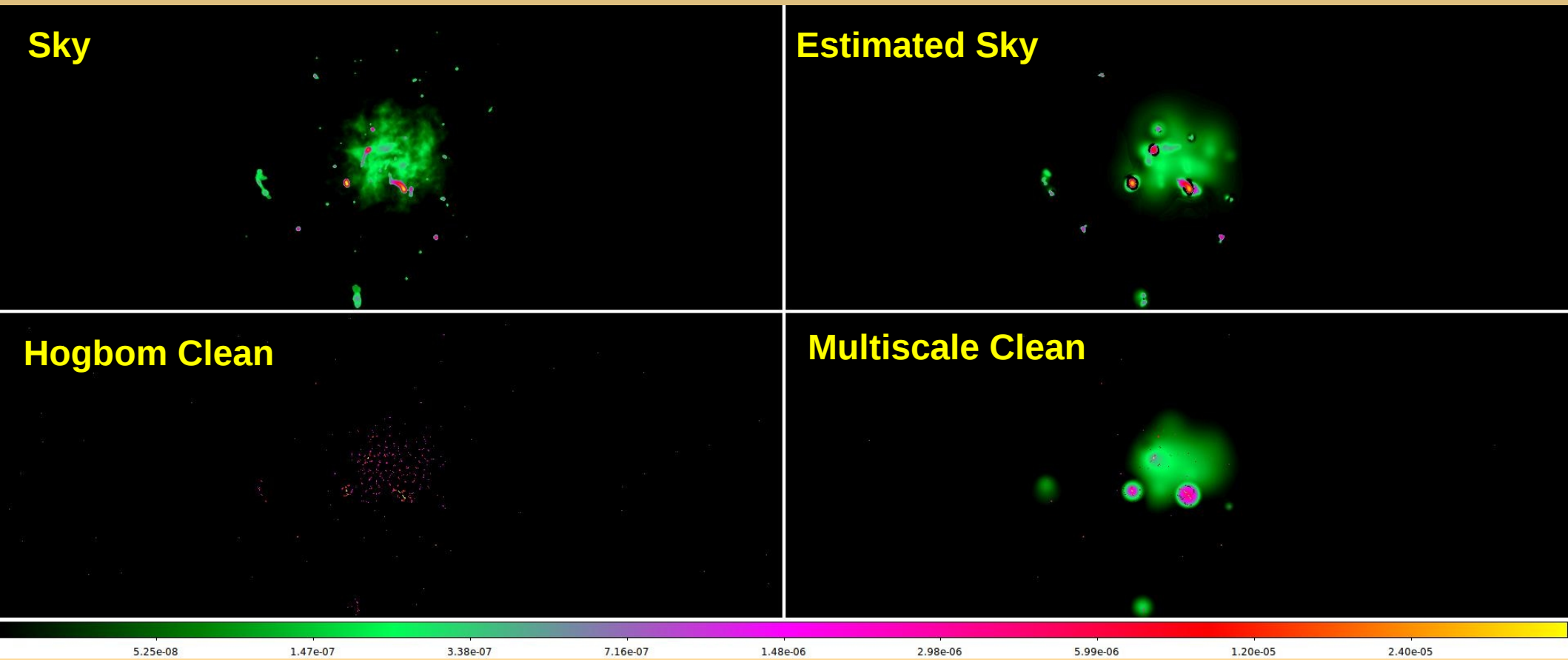


Dirty Map

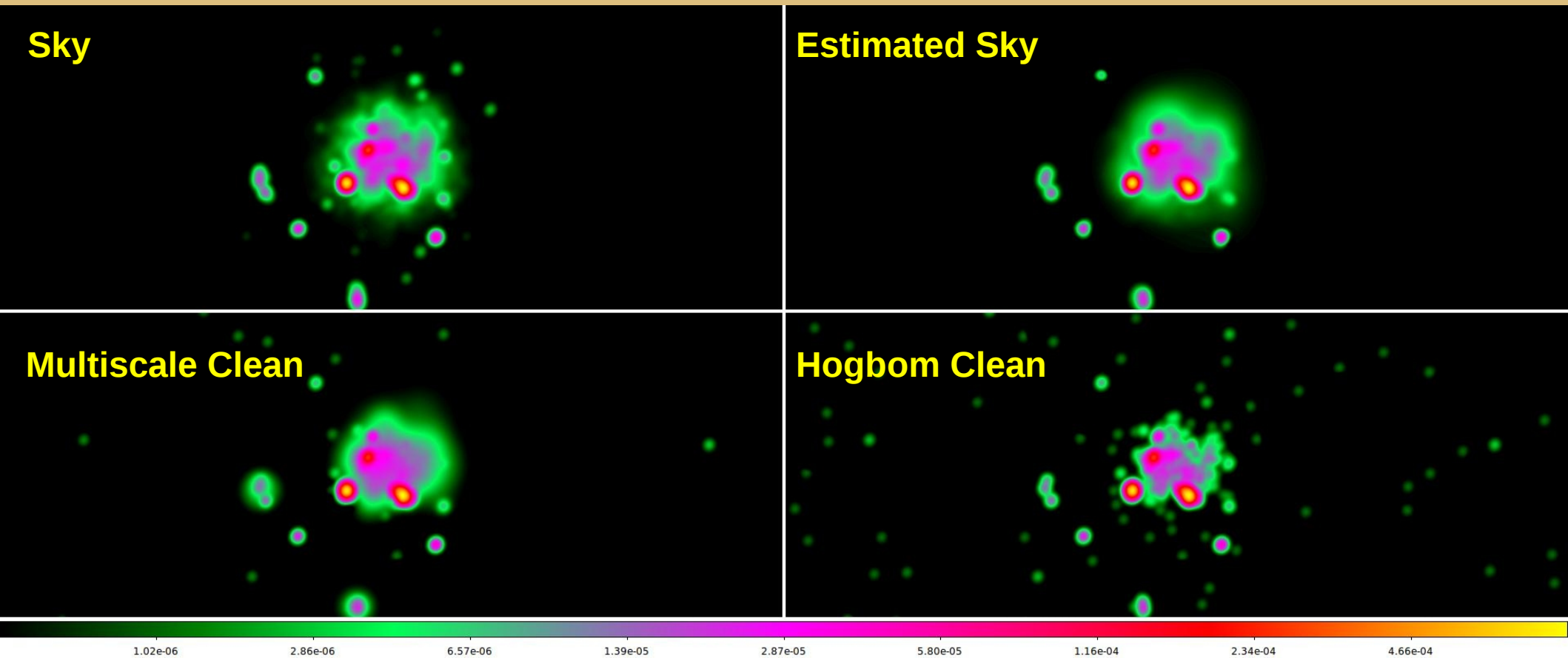


PSF

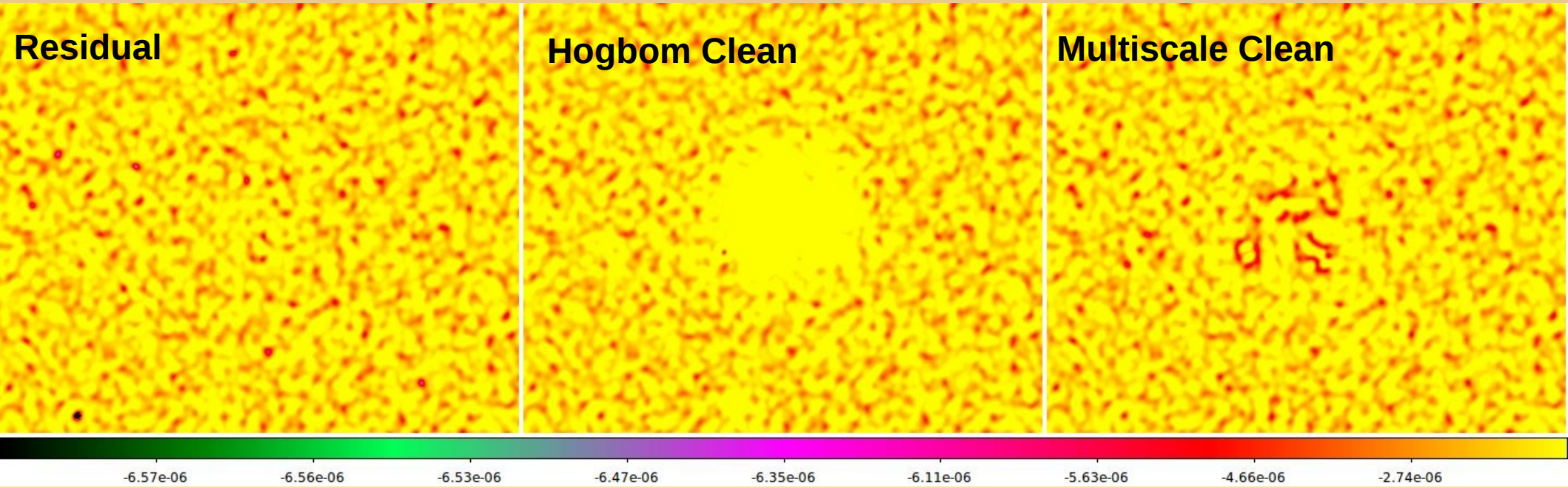
Simulations & Results



Simulations & Results

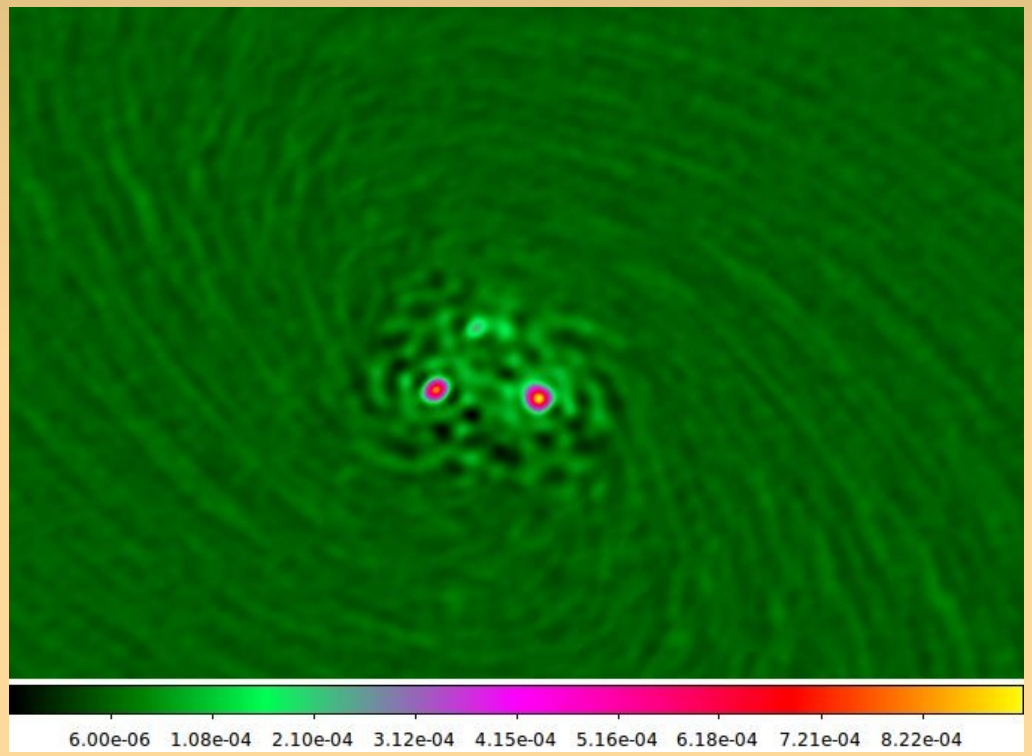


Simulations & Results

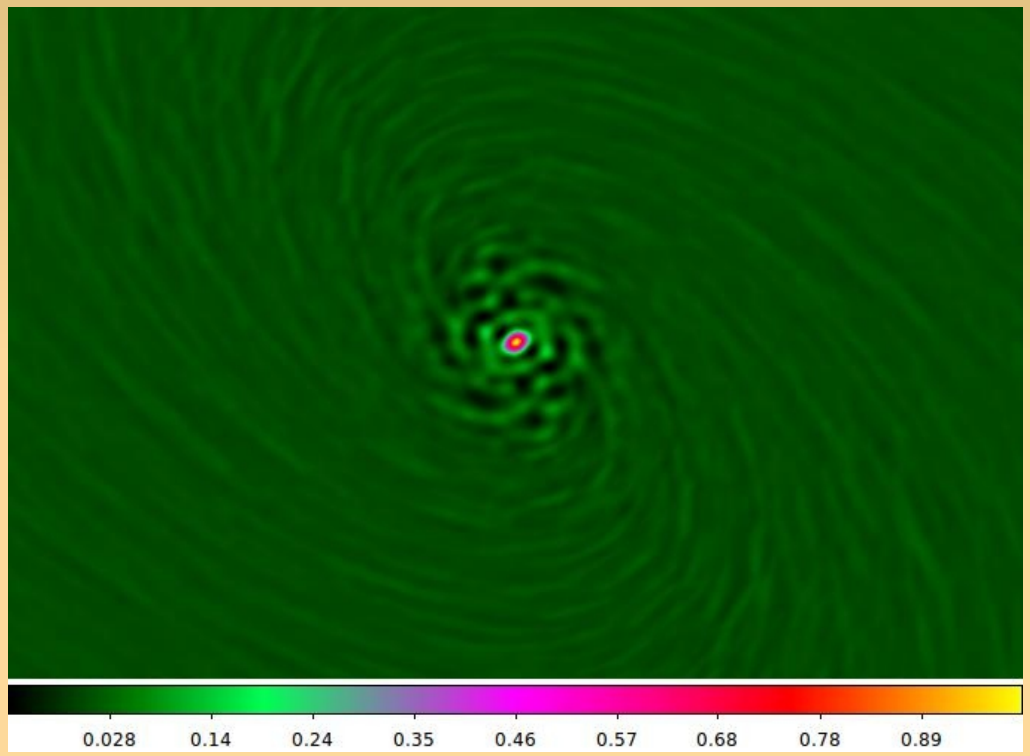


Simulations & Results

MeerKat, 2h Observations

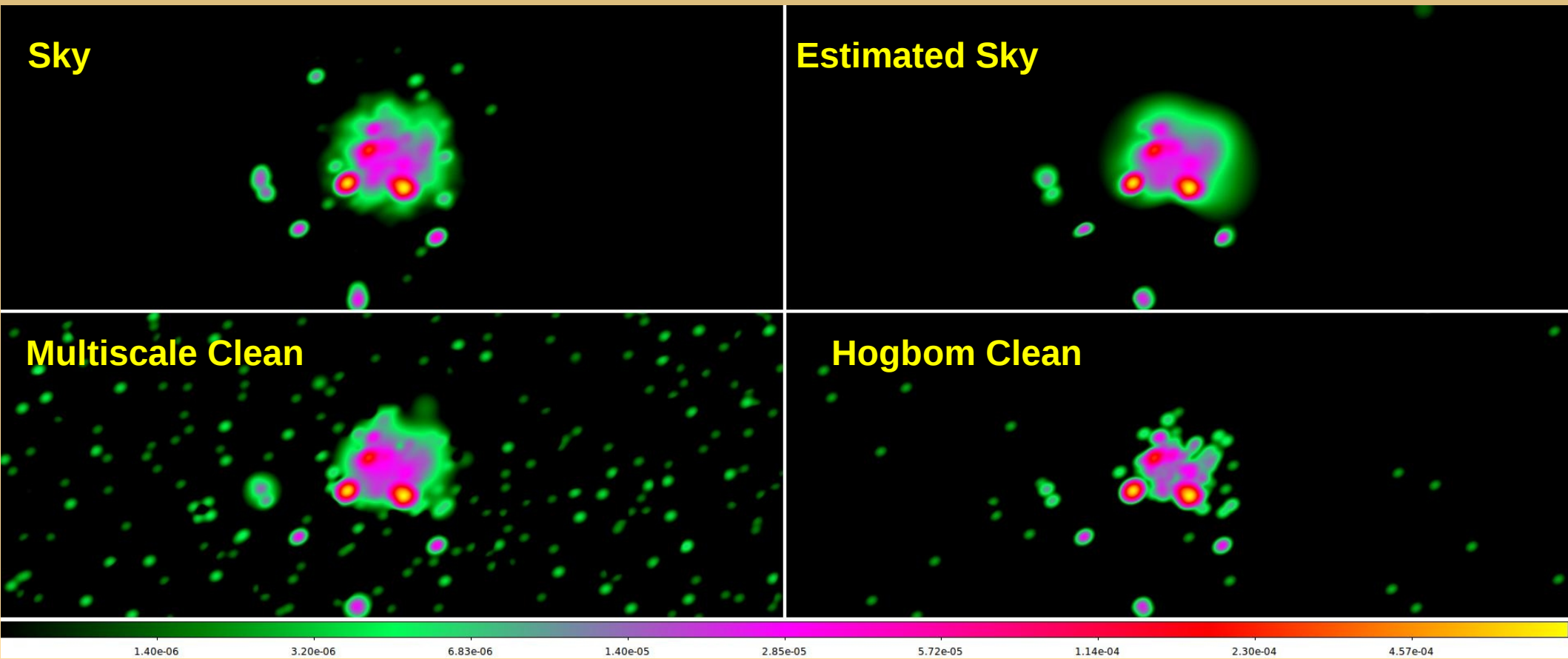


Dirty Map



PSF

Simulations & Results



Conclusions

- Results are promising!

  Very good recovery of both compact and extended sources on realistic simulations & on real data (VLA, Kat7) as well

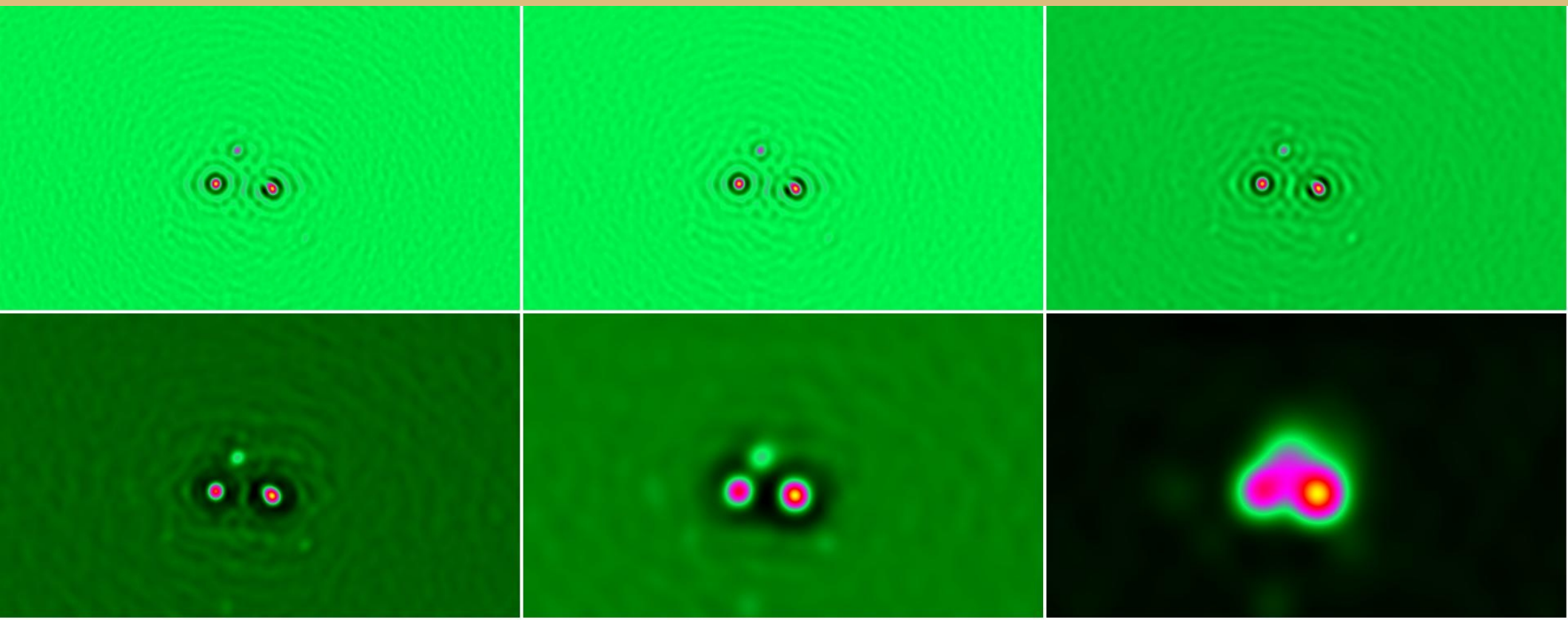
- On going work

  Taking into account the variation of the PSF in the field of view

  Source catalog as output of the code

Thanks!

IUWT-analysis vector



Thanks!

Thanks!