Sky map reconstruction in spherical coordinates From (u,v) plane to the (l,m) plane

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method

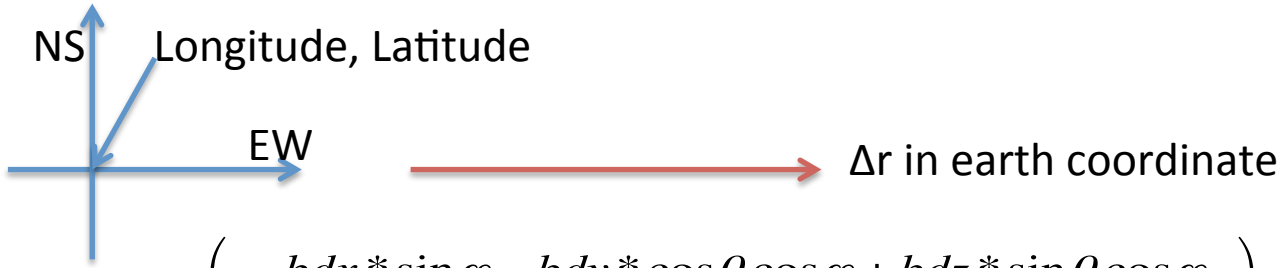
- Sky map $I(\alpha,\delta)$ reconstruction for a transit instrument from visibilities.
- α: RA East-west; $\delta = \pi/2 - \theta$: dec North-South.
- Fourier: $(\alpha,\delta) \rightarrow (u,v); I(\alpha,\delta) \rightarrow F(u,v)$

  a given pair of antenna: $(\Delta x,\Delta y) \rightarrow BeamUV(u,v)$
- θ: colatitude; φ : longitude.
- Spherical harmonics: $(\theta,\varphi) \rightarrow (m,l); I(\theta,\varphi) \rightarrow A(l,m)$

$$(\Delta x,\Delta y) + (\theta_0,\varphi_0) \rightarrow BeamLM(l,m)$$

- Spherical coordinate:

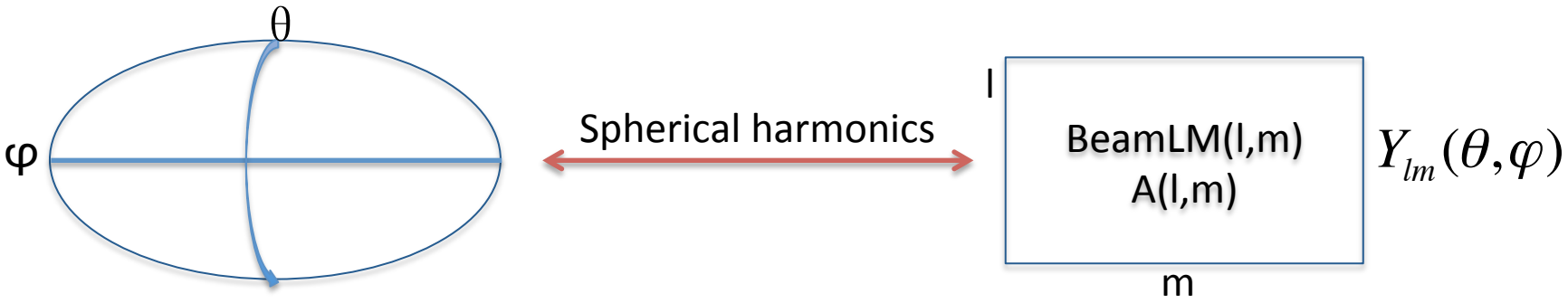
coordinate transform from local tangent plane (antenna baselines) to 3D Cartesian coordinate.



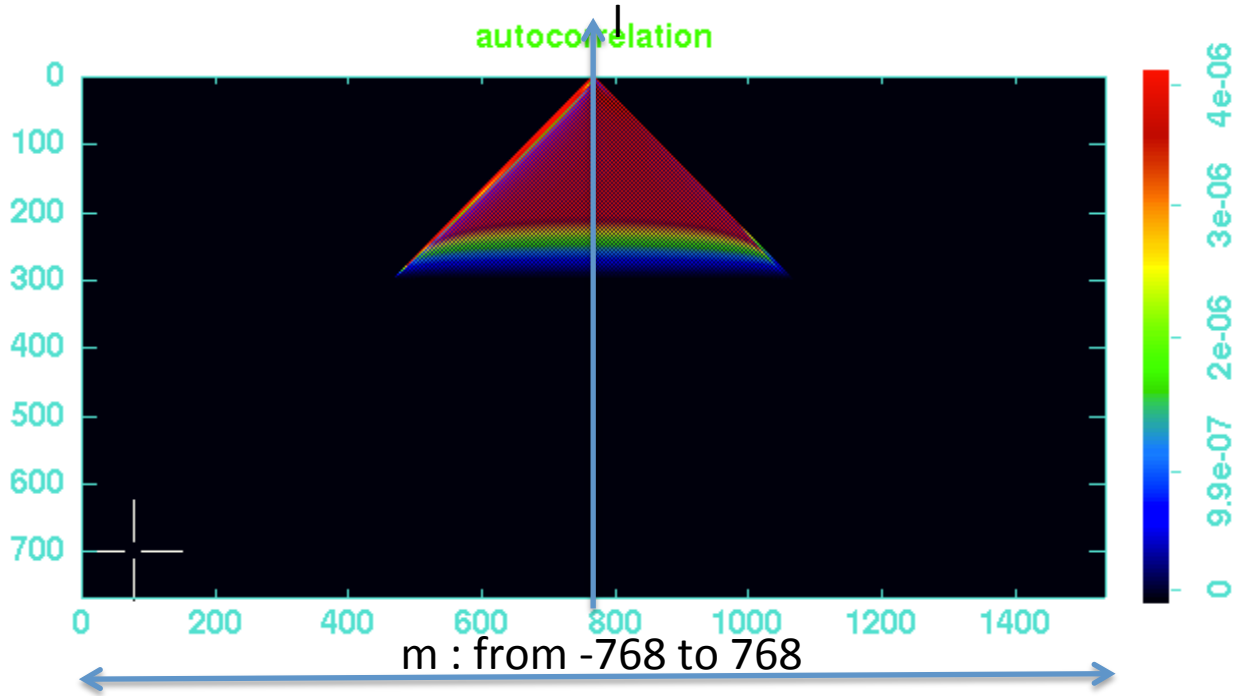
$$\overrightarrow{\Delta r} = \begin{pmatrix} -bdx * \sin\varphi - bdy * \cos\theta\cos\varphi + bdz * \sin\theta\cos\varphi \\ bdx * \cos\varphi - bdy * \cos\theta\sin\varphi + bdz * \sin\theta\sin\varphi \\ bdy * \sin\theta + bdz * \cos\theta \end{pmatrix}$$

- We can express beam as

$$Beam(\theta,\varphi) \times e^{i\vec{k}\times\overrightarrow{\Delta r}} \rightarrow BeamLM(l,m)$$

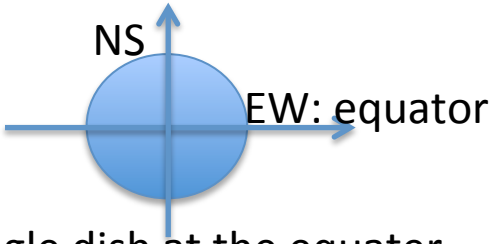


Few examples of BeamLM(l,m)

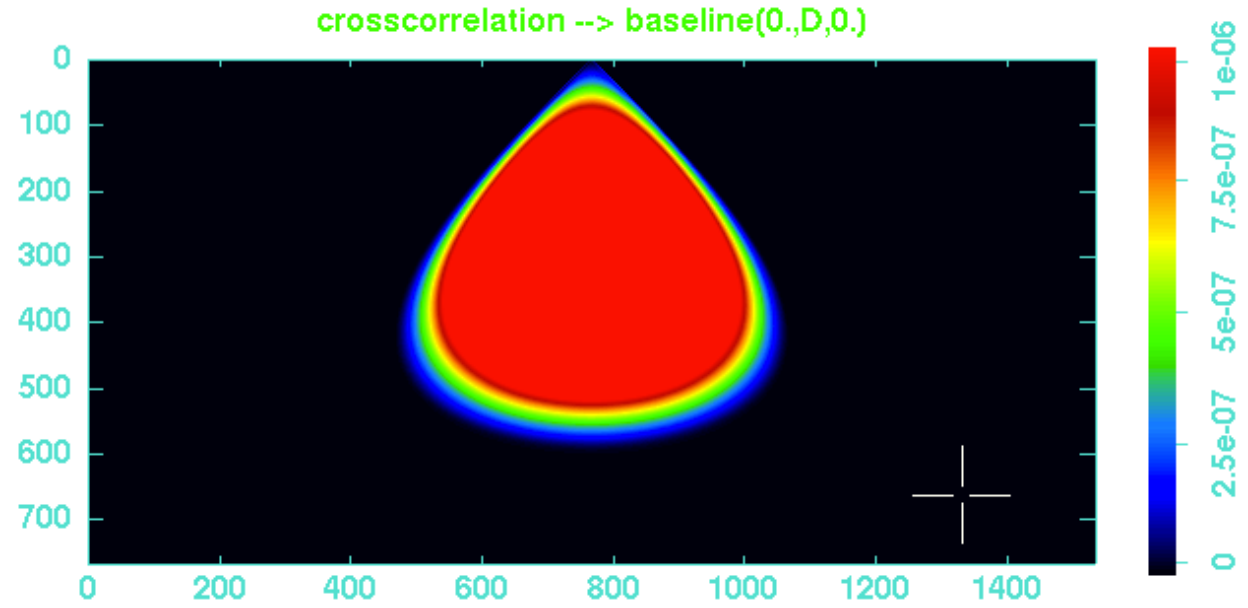


D=10m; lmax=768

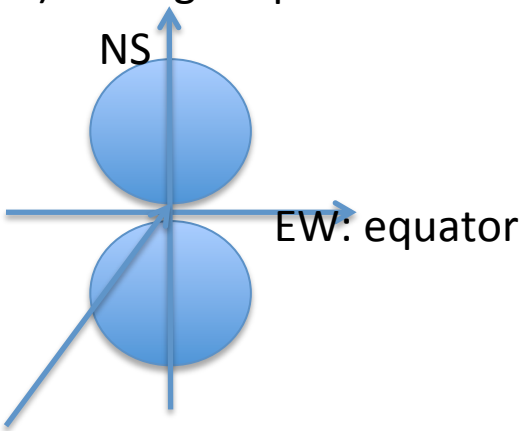
Autocorrelation
Baseline (0.,0.,0.)



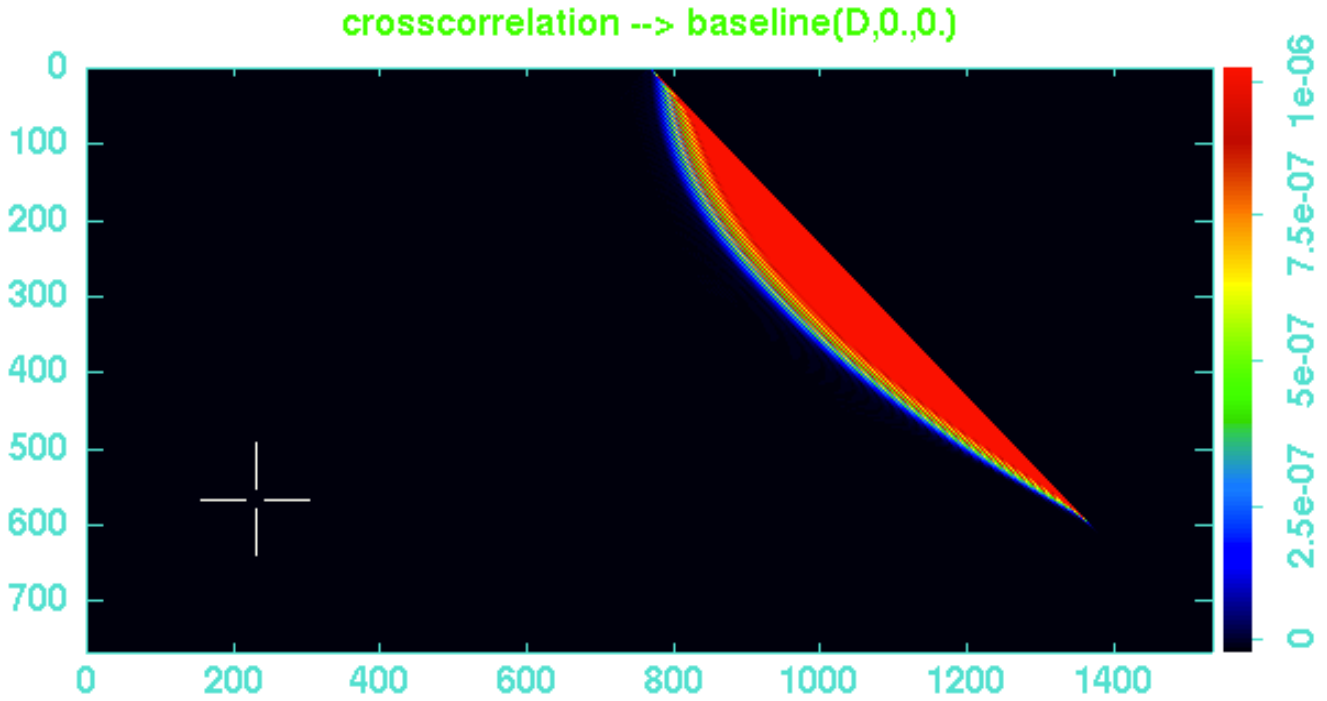
Single dish at the equater,
$\theta=\pi/2$; $\varphi=0$



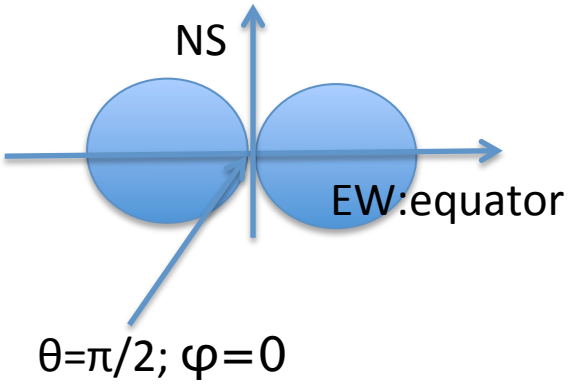
Crosscorrelation: Baseline
(0.,D,0.) in tangent plane

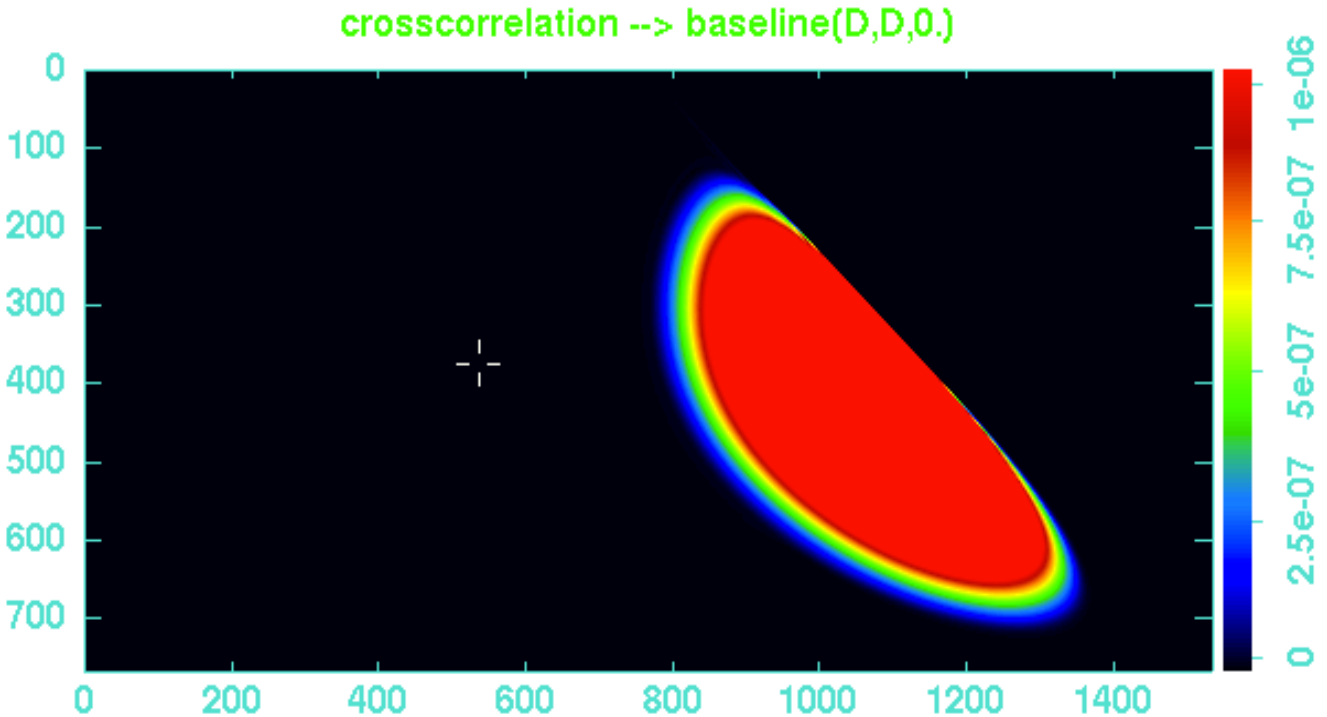


$\theta=\pi/2$; $\varphi=0$

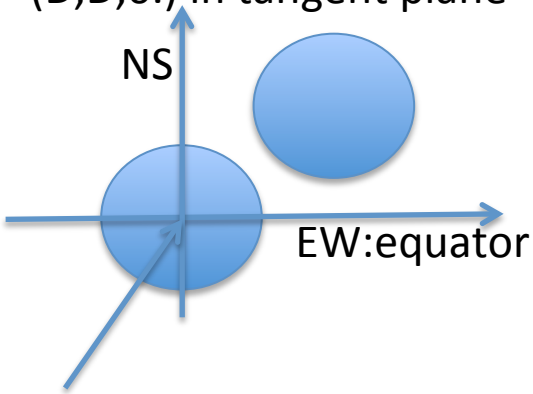


Crosscorrelation : Baseline (D,0.,0.) in tangent plane





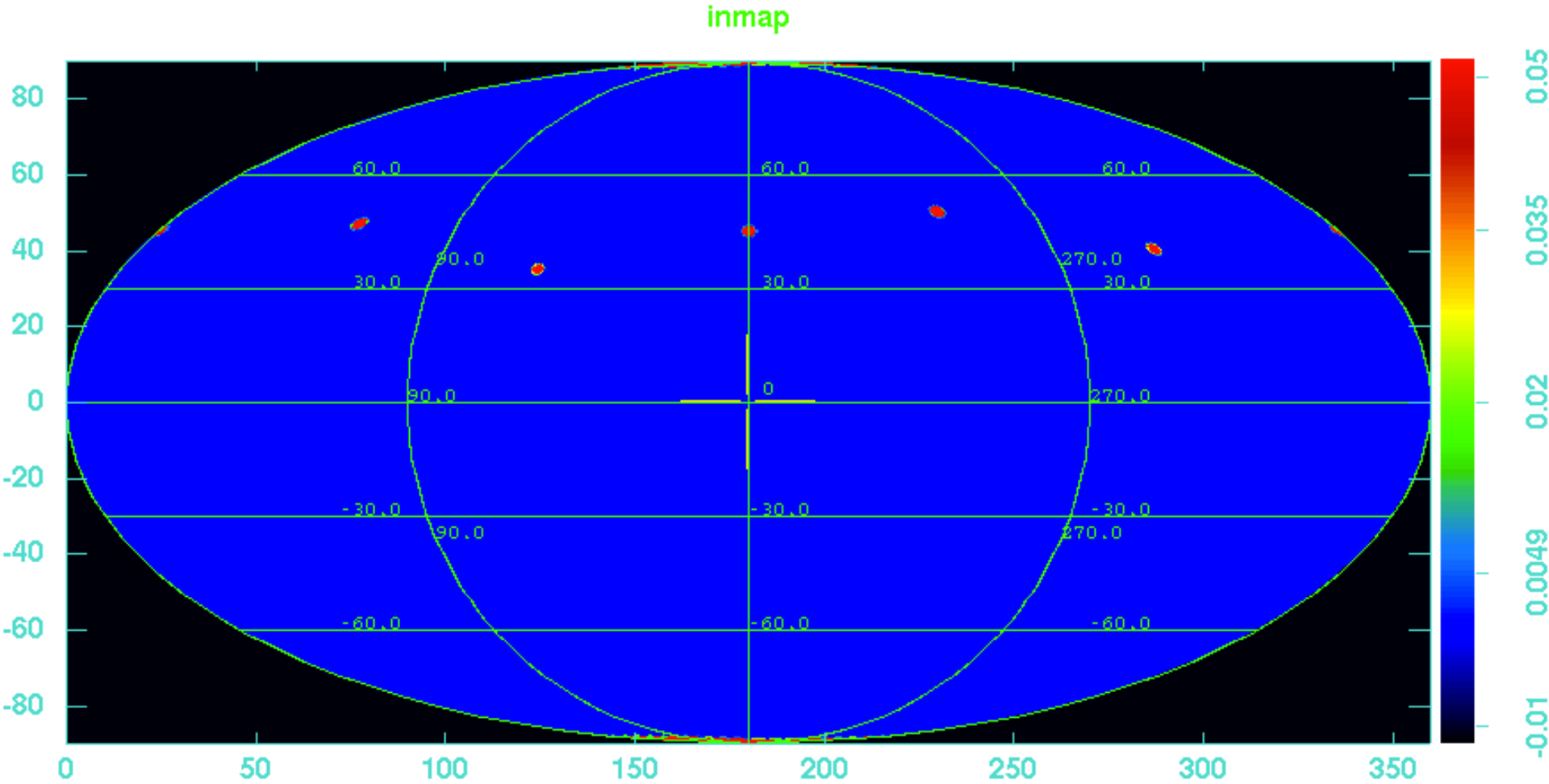
Crosscorrelation : Baseline (D,D,0.) in tangent plane



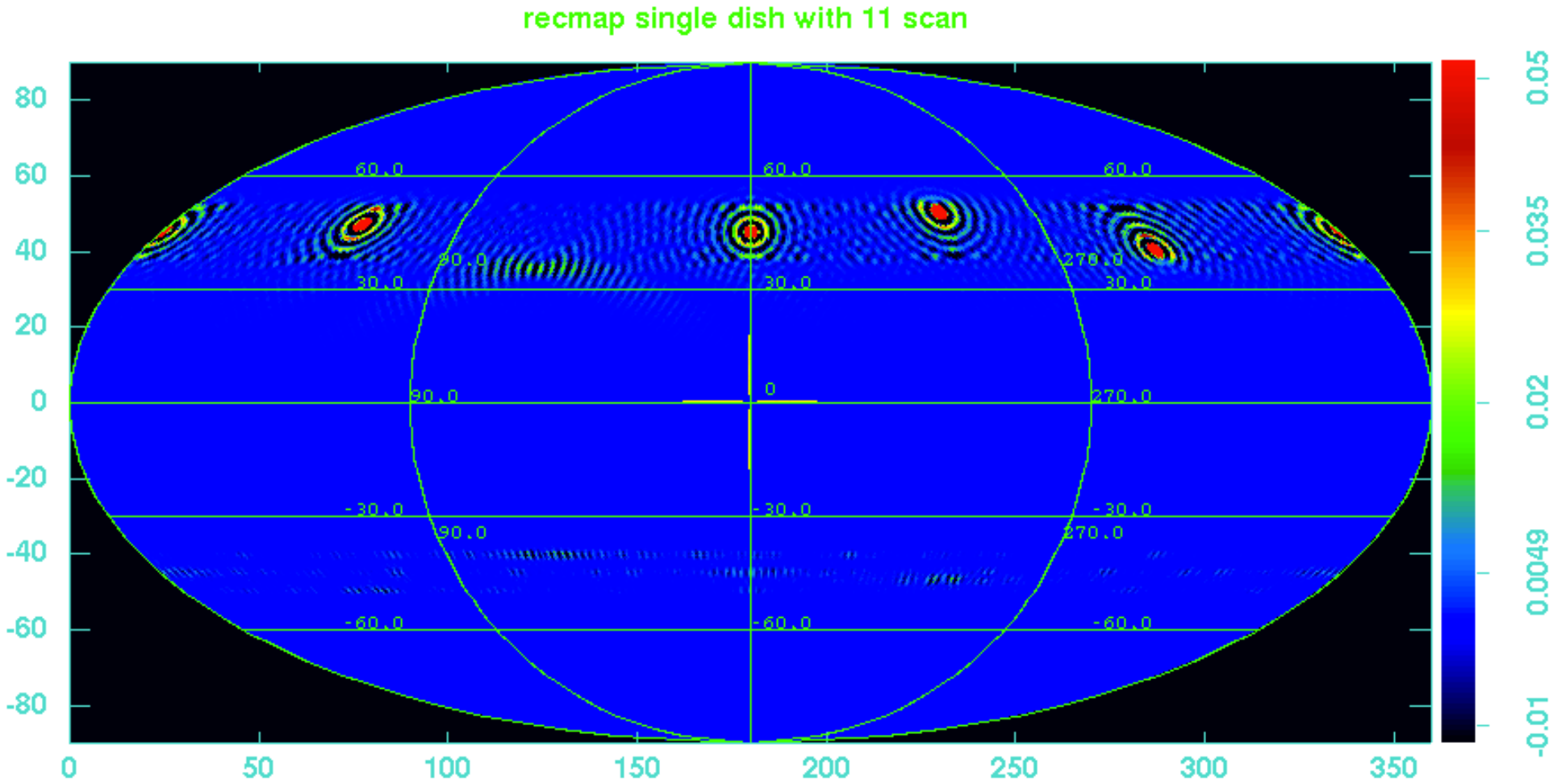
Sky map reconstruction in spherical harmonics

$$\tilde{V}_m^{ij} = \sum_{l,m} a_{lm} * B(l,m) + noise_m^{ij}$$: Calculate Alm from Visibilities and BeamLM(l,m)

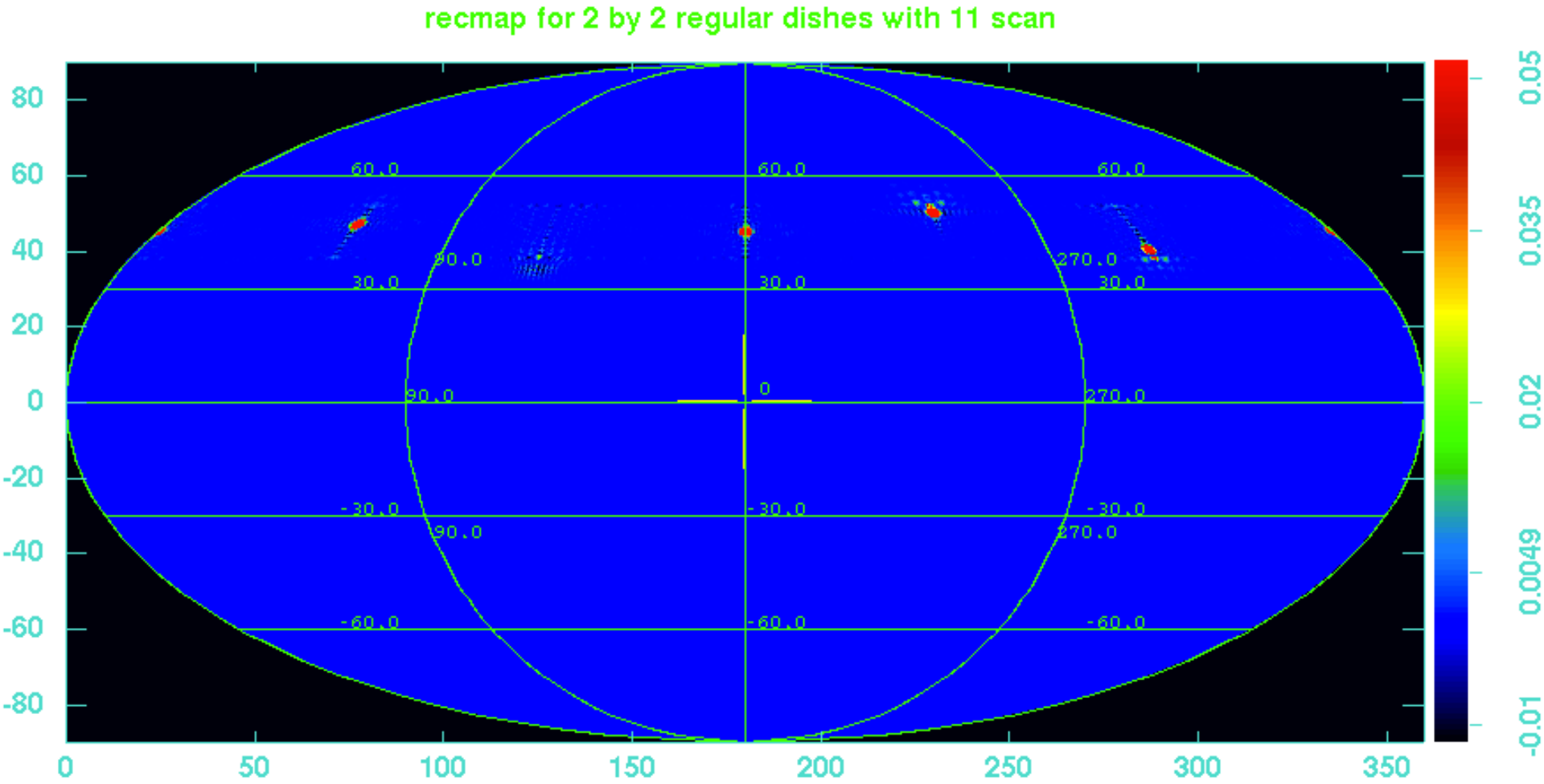
Input 8 expended source : 1 north pole, 1 south pole, 6 around latitude 45 degrees;
Scan strategy : 11 scan per 1 degree centered at 45 degrees.



Single dish case

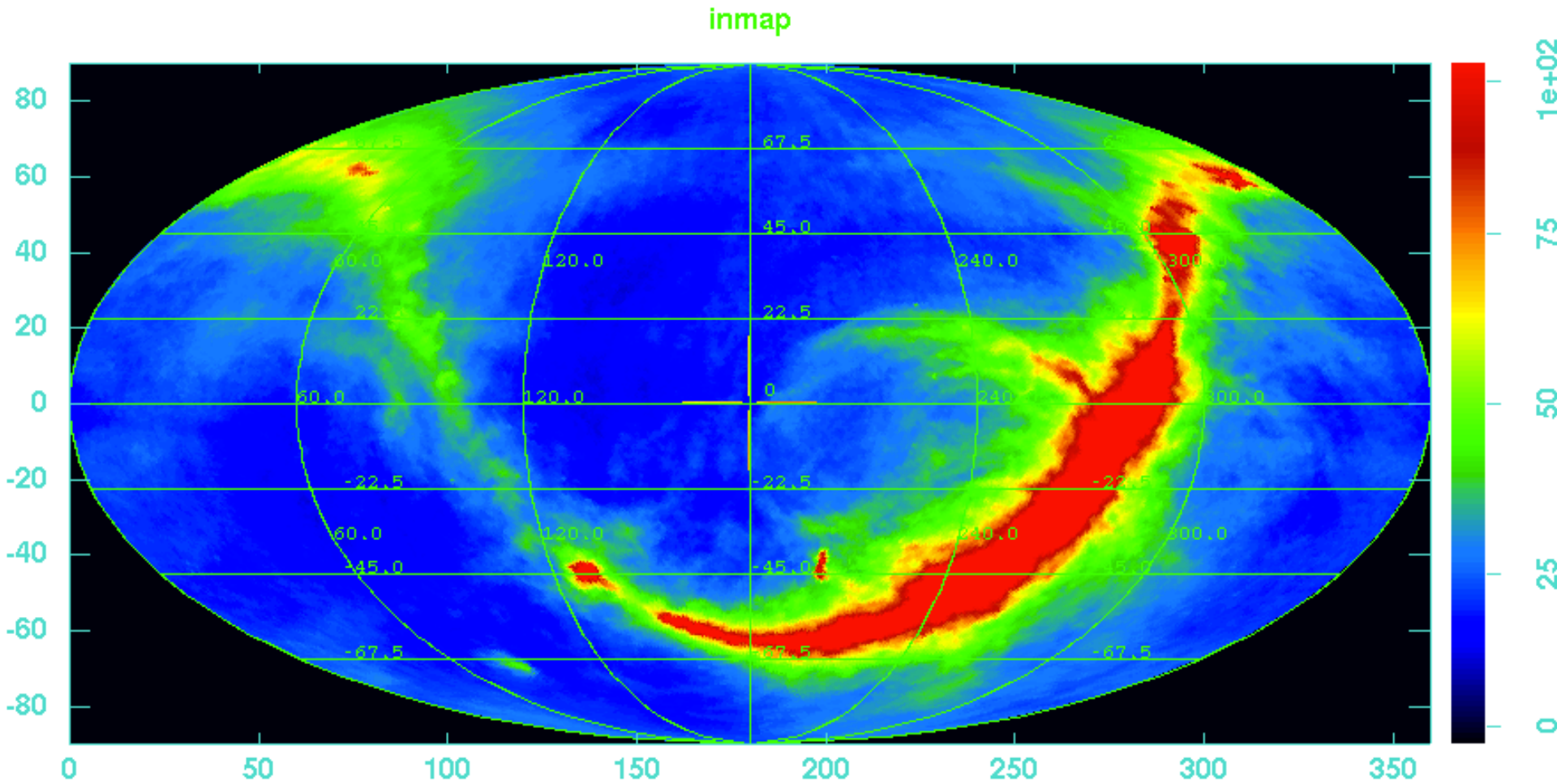


2 by 2 regular dishes case

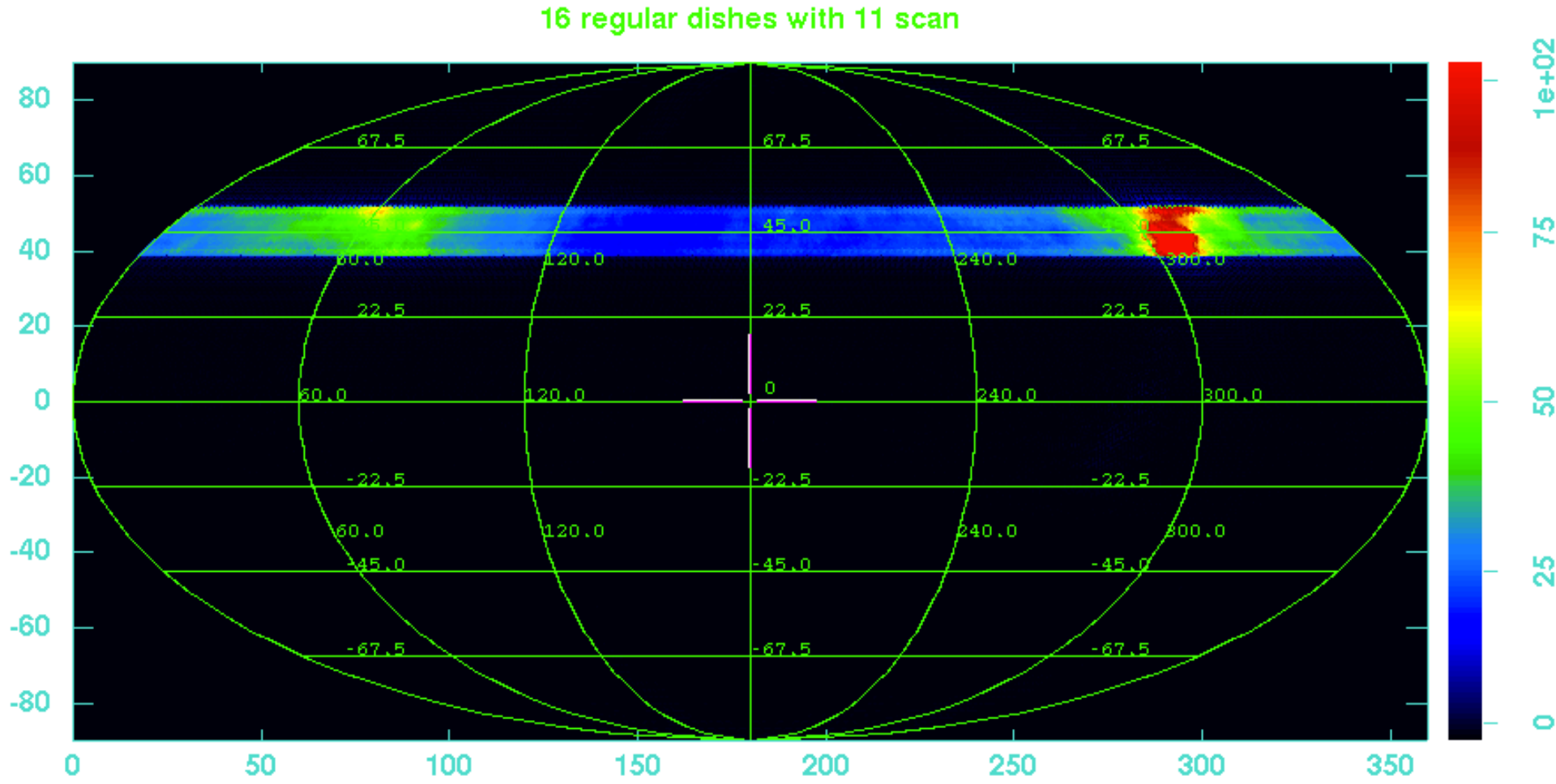


Input synchrotron map

Scan strategy : 11 scan per 1 degree centered at 45 degrees.



Interferometer : 4 by 4 regular dish array



Next steps

- Detailed study of reconstructed map properties
- Application to PAON-4 & Tianlai