

I ran the ALMA configurations from Boone, Kogan/Conway and Webster to get my standard set of statistics and beam plots. My program uses normalized dimensions, i.e. the linear dimensions are divided by the antenna dia, 12m, and the magnification. I forced all configurations to the same magnification of 14. The magnification is the ratio of the primary beam width to the synthesized beam width. The Conway/Kogan had a natural magnification of 14 while the Webster array was expanded by 14/12 and the Boone array was shrunk by 14/19 (while still enforcing the close packing limit). The angular scale is normalized to the primary beam width.

The synthesized beam has been multiplied by a Gaussian beam  $\sqrt{2}$  wider than the primary beam. This is what I think is appropriate for evaluating the array for imaging wide fields filling the primary beam [ALMA memo 389 section II.B]. This is based on using the idea of orthogonality of UV measurements and doesn't depend upon any particular imaging algorithm. The problem I had in thinking about working in image space is in understanding exactly what the various algorithms do to reconstruct the wide field image from the UV data. The antennas multiple the true image by the primary beam pattern, but then do the algorithms divide by this primary beam to try and reconstruct an image from the synthesized image. Also you can convolve the model UV data with the FT of the primary beam before comparing to the measured data, etc. All of these imaging issues made my head spin, so I just stuck with my measurement orthogonality arguments. As will be pointed out below, none of this makes much difference anyway.

The results are presented in the following figures. The beam plot color scale covers 1-7%. The theoretical prediction for the sidelobe distribution is shown as a dashed line. The most useful plot is probably the plot of the peak sidelobe as a function of radius. The theoretical prediction for pseudo-random and best possible optimum are shown as dashed black and magenta lines. The black dotted line is the average sidelobe and can be thought of as what the sidelobes will be for a 12hr track on a polar source, ignoring projections effects.

Adrian's compact configuration had not been optimized and has some large sidelobes. I took the liberty of running this configuration through my sidelobe optimization program. The results of this optimization are shown in the last figures. The RMS shift of the antennas is  $<1\text{m}$  with a maximum shift of only 3m. The resulting configuration has significantly smaller sidelobes, consistent with the other configurations.

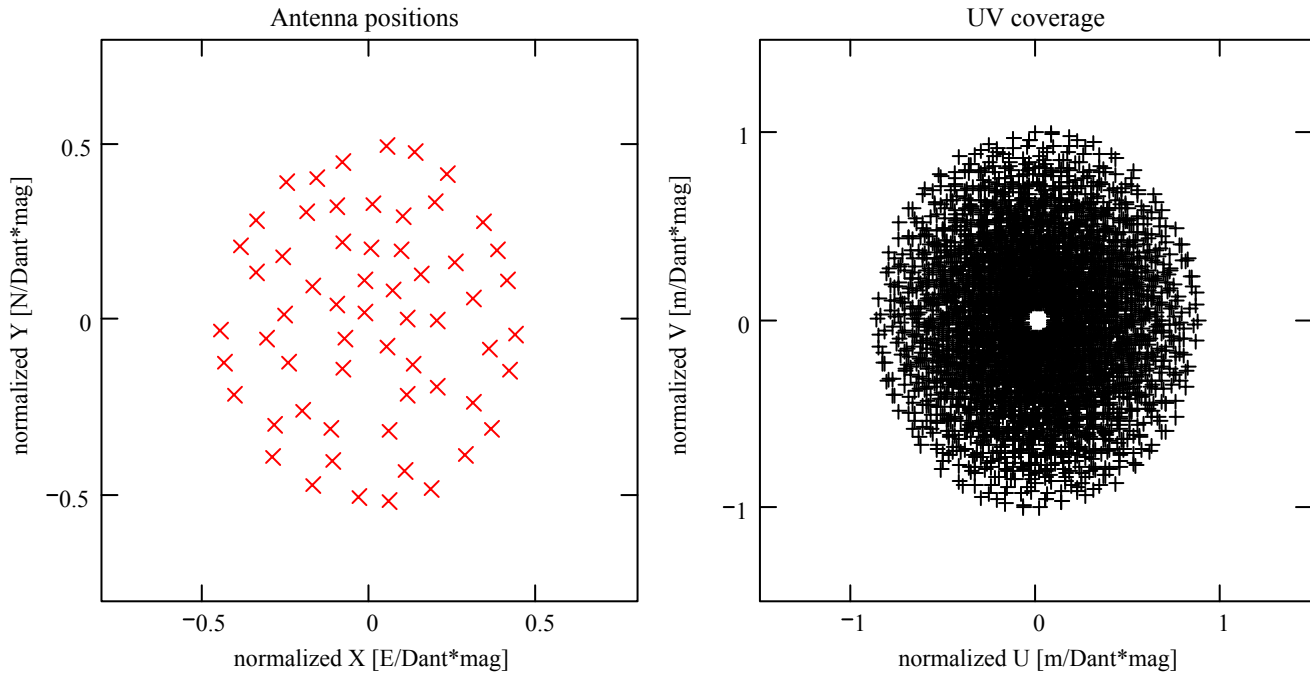
The results for the three configurations, Boone, Kogan and optimized Webster are very similar, but do have differences that are meaningful. Notably the Boone algorithm which seeks to fit a truncated Gaussian target UV distribution has smaller near sidelobes than the Kogan configuration that strived for brightness sensitivity, i.e. close packing, with sidelobe minimization. This is just what I would expect for these two strategies. Thus there is a choice between brightness sensitivity (closest packing) and well behaved near sidelobes (bell shaped UV distribution). I personally think that even people wanting brightness sensitivity will end up weighting their data to give better beams. Only pure cosmologists actually want all the raw data and work entirely in UV space. This is where actual mosaic image reconstruction tests can give us guidance.

The far sidelobes are not a big problem and minimizing them out to several times the primary beam is easy and no particular design strategy will be worse than any other in this respect. As has been demonstrated in ALMA memo 390, you can work on the far sidelobes without hurting the nearer sidelobes. As you go out the antenna shifts just become smaller and have no significant effect on the near sidelobes. This very fine tuning is justified only if the compact configuration is on a flat plane, which presumably it will be. Any of the arrays can be fine tuned to reduce the very far sidelobes with no significant effect on packing or accessibility. Even Webster's compact array which had significant sidelobes within the primary beam was fixed by shifts of less than 1m.

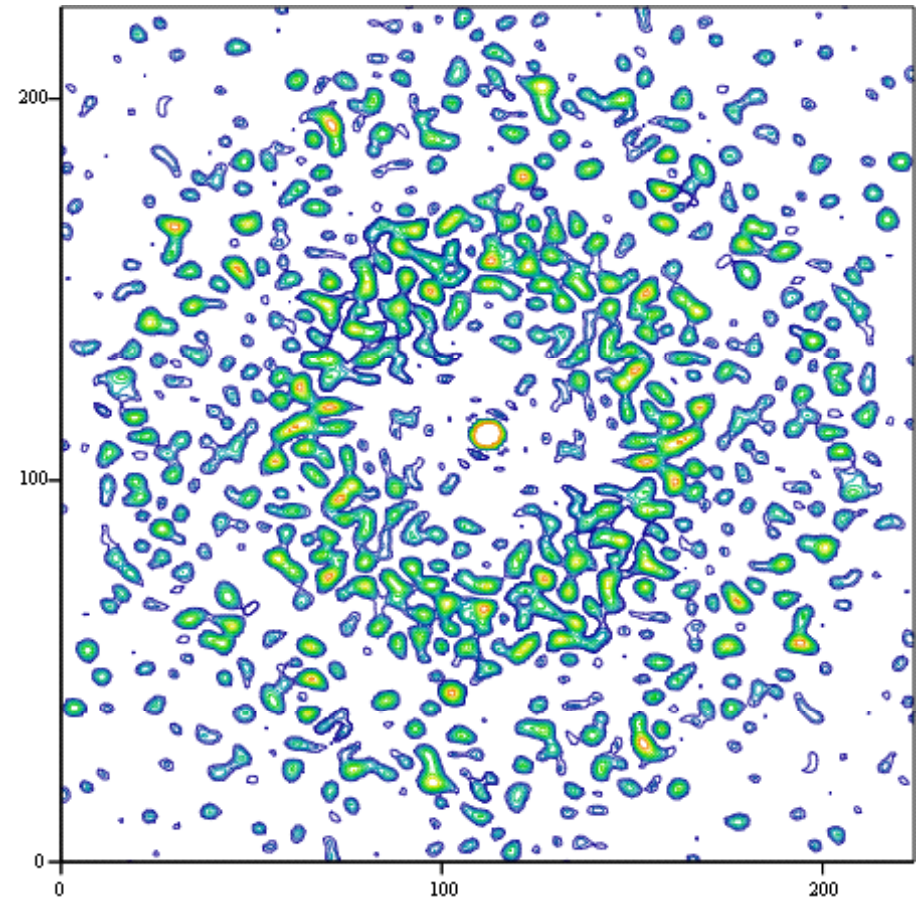
The main issues in my mind are close packed vs. excellent central PSF beam, shadowing, extreme declinations, and accessibility. The mosaic imaging studies should answer the first question and geometry will answer the next two questions and interaction with the transporter design will answer the last question.

# Boone compact

file = "Boones configs ascii.txt"      ifig = 1    mag = 14    Random perturbation.    fRan·Dant = 0    nless = 0  
xX := Re(xconfig)    xY := Im(xconfig)  
X := Re(config)    Y := Im(config)    uvdata := UV(config)    XYscale = 84      U := Re(uvdata)      V := Im(uvdata)



mag = 14    N3dB := 1      grdext := 4·N3dB    samp := 2·mag  
psf := PSFin(aconfig, samp, grdext,  $\sqrt{2}$ ·mag)    modify mag to account for the wider effective beam  
psfplot := PSFlog(psf, .01, .07)    PSF plot    required for mosaicing. mag->sqrt(2)\*mag



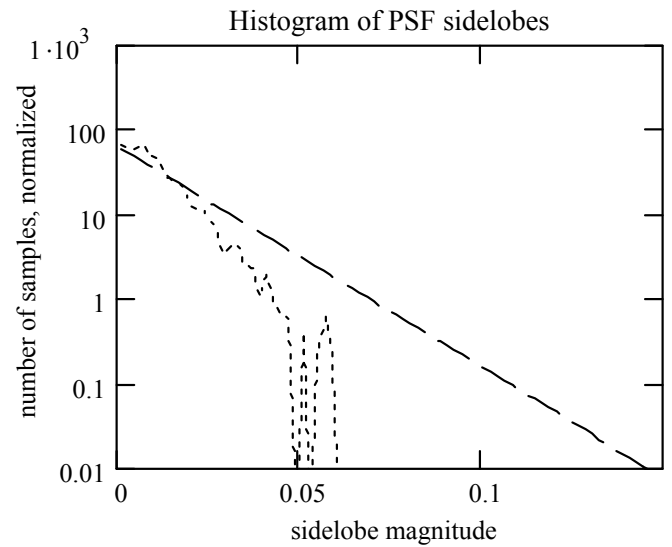
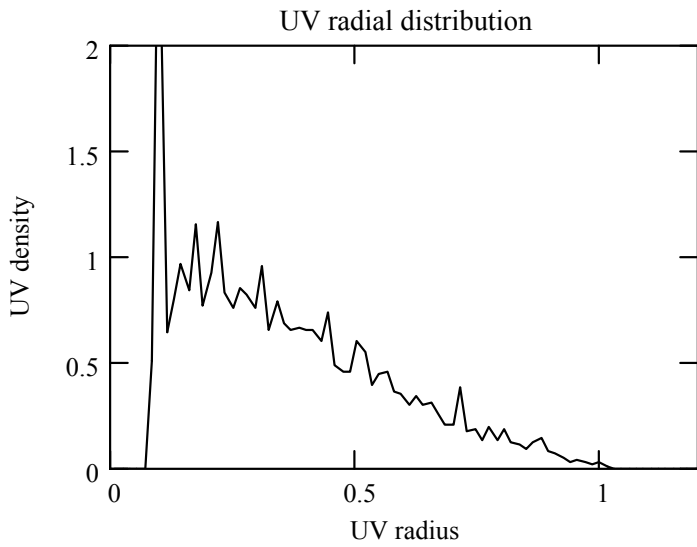
psfplot

# Boone compact

file = "Boones configs ascii.txt"      ifig = 1      mag = 14      random perturbation.      fRan·Dant = 0      nless = 0

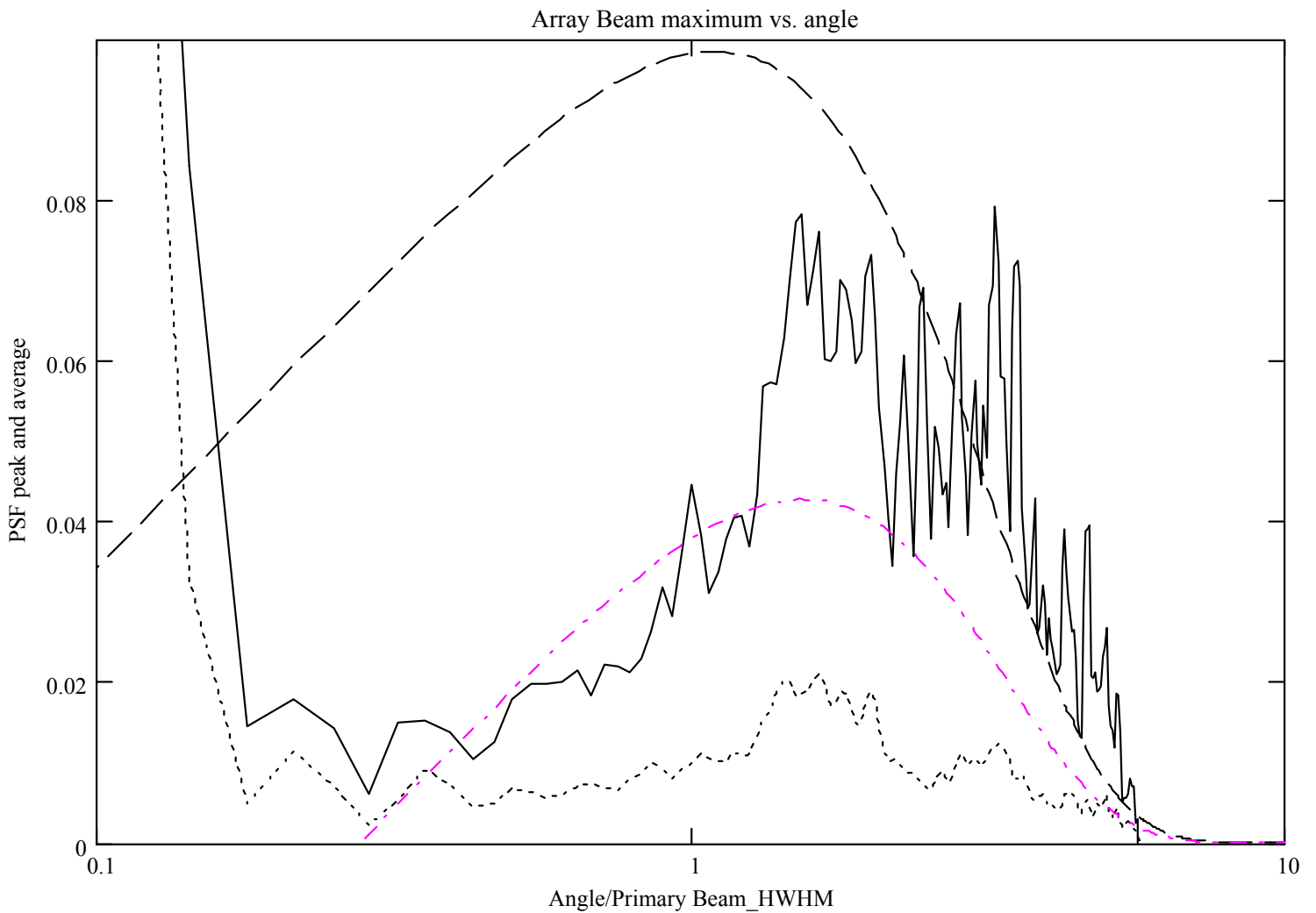
HistPlot := PSFhisto  $\left( \text{psf}, 1.5 \cdot \text{grdext}, 1 \cdot \text{grdext} \cdot \frac{\sqrt{2} \cdot \text{mag}}{2}, 500 \right)$       LPlot := Rbeam(psf)      LargeSL(LPlot, grdext) = 0.07922

nbins := 100      uvrdist := Nrdist(uvdata, nbins, 1.5)      j := 0..nbins      k := 0..200



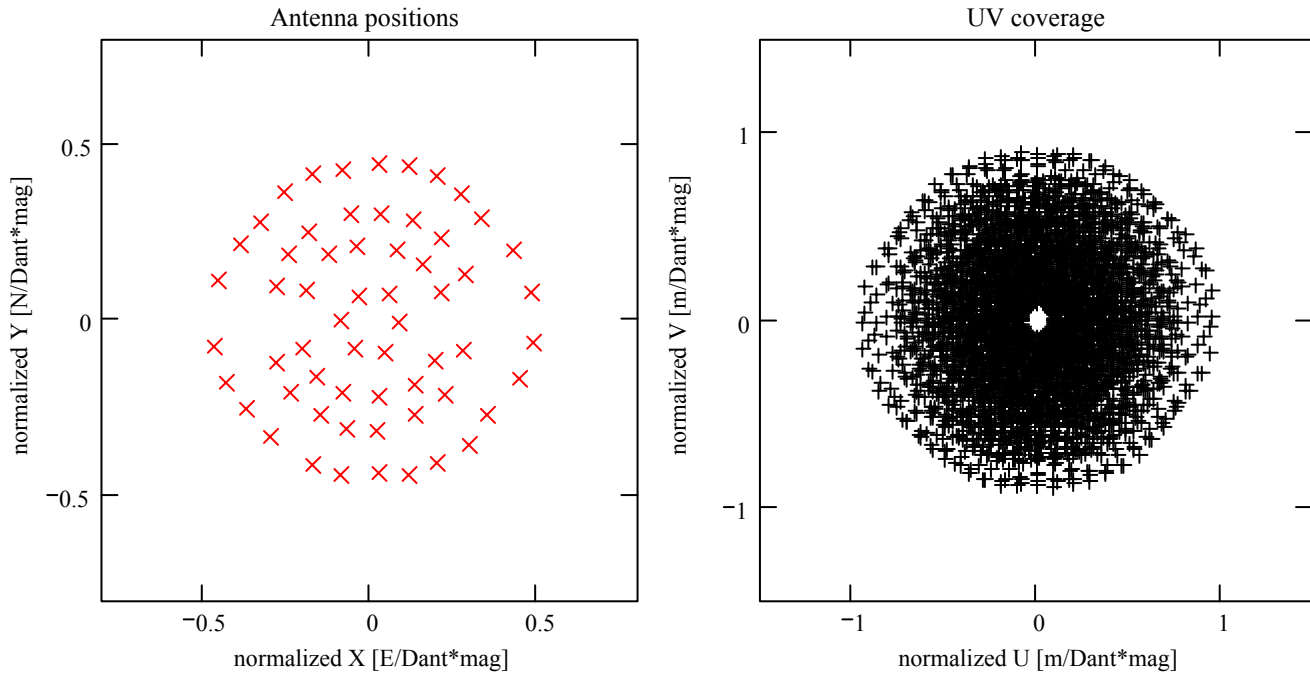
i := 0..1000

PSF for mosaics,  $\sqrt{2} \cdot \text{mag}$

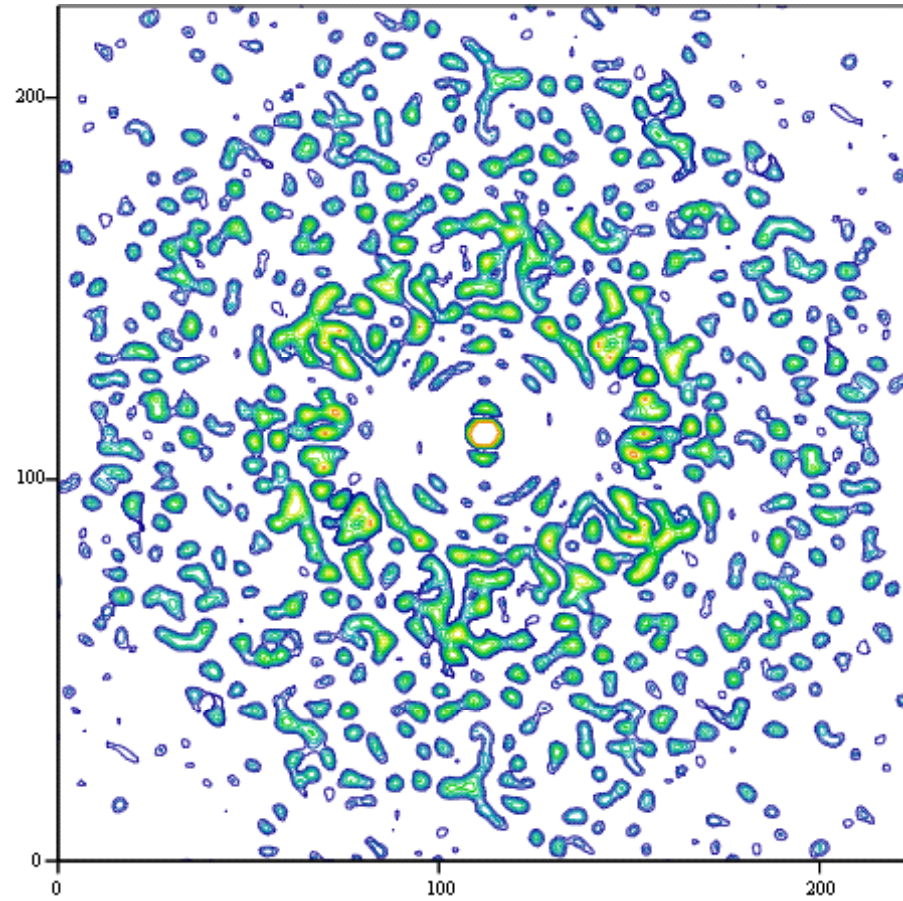


# Kogan/Conway compact

```
file = "Conways configs ascii.txt"   ifig = 1   mag = 14   Random perturbation.   fRan·Dant = 0   nless = 0  
xX := Re(xconfig)   xY := Im(xconfig)  
X := Re(config)   Y := Im(config)   uvdata := UV(config)   XYscale = 84   U := Re(uvdata)   V := Im(uvdata)
```



```
mag = 14   N3dB := 1   grdext := 4·N3dB   samp := 2·mag  
psf := PSFin(aconfig, samp, grdext, sqrt(2)·mag)   modify mag to account for the wider effective beam  
psfplot := PSFlog(psf, .01, .07)   PSF plot   required for mosaicing. mag->sqrt(2)*mag
```



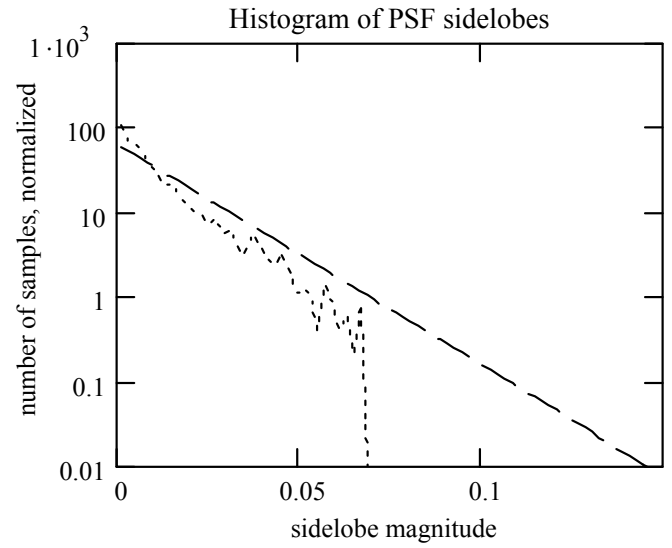
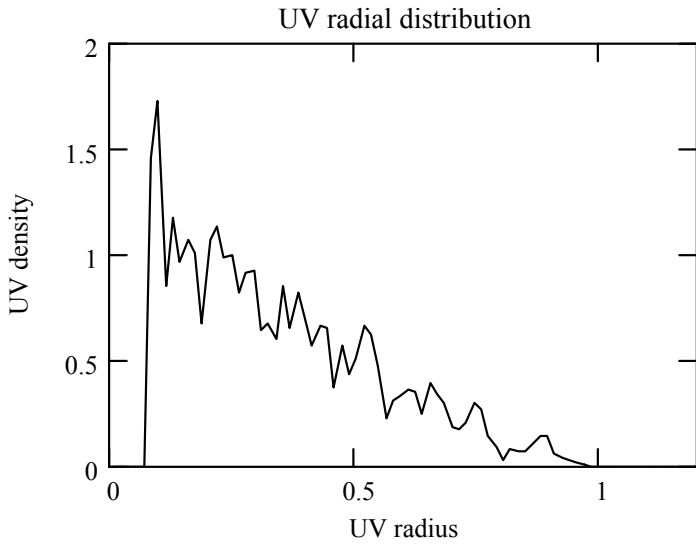
psfplot

# Kogan/Conway compact

file = "Conways configs ascii.txt" ifig = 1 mag = 14 random perturbation. fRan-Dant = 0 nless = 0

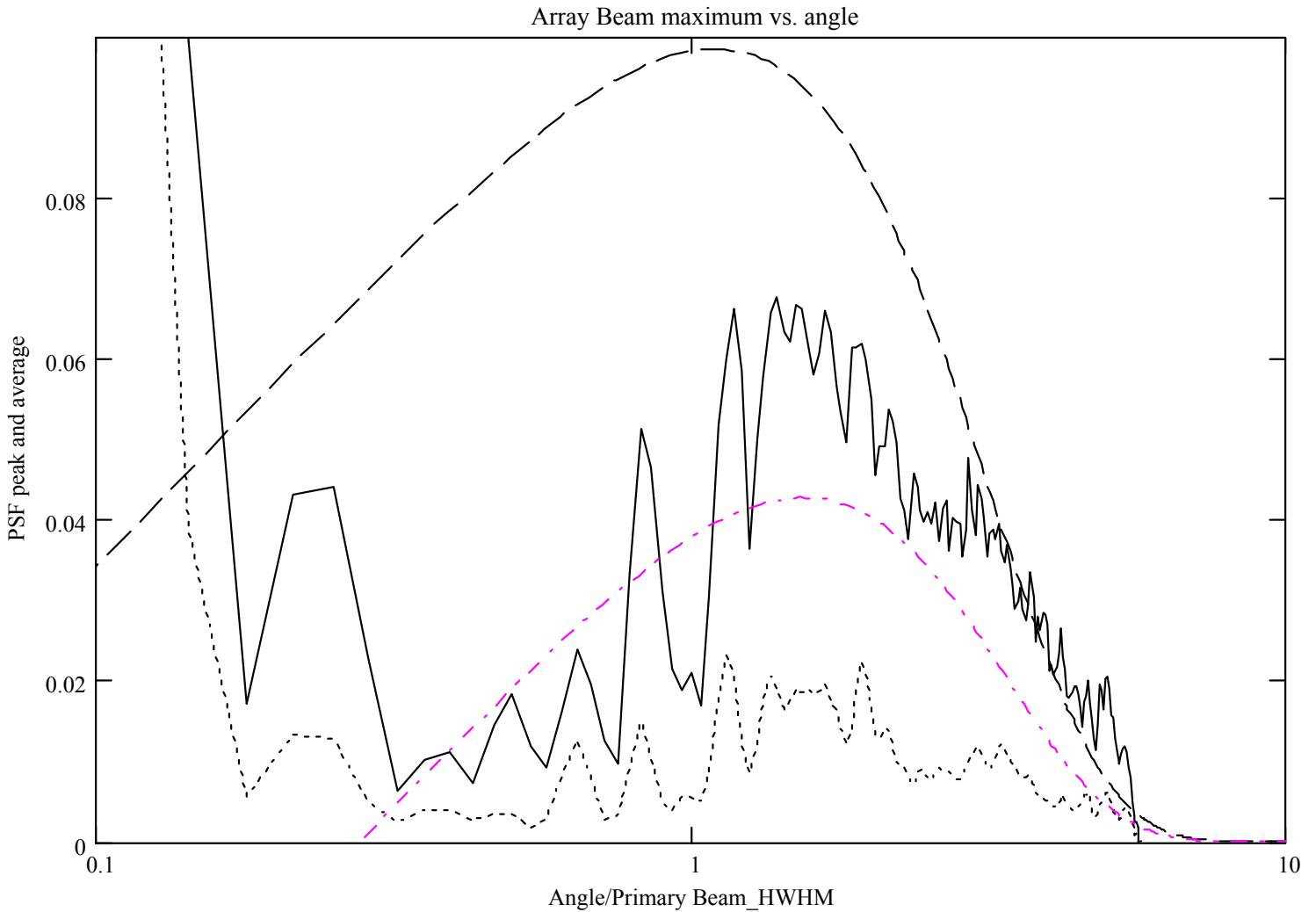
HistPlot := PSFhisto  $\left( \text{psf}, 1.5 \cdot \text{grdext}, 1 \cdot \text{grdext} \cdot \frac{\sqrt{2} \cdot \text{mag}}{2}, 500 \right)$  LPlot := Rbeam(psf) LargeSL(LPlot, grdext) = 0.07922

nbins := 100 uvrdist := Nrdist(uvdata, nbins, 1.5) j := 0..nbins k := 0..200



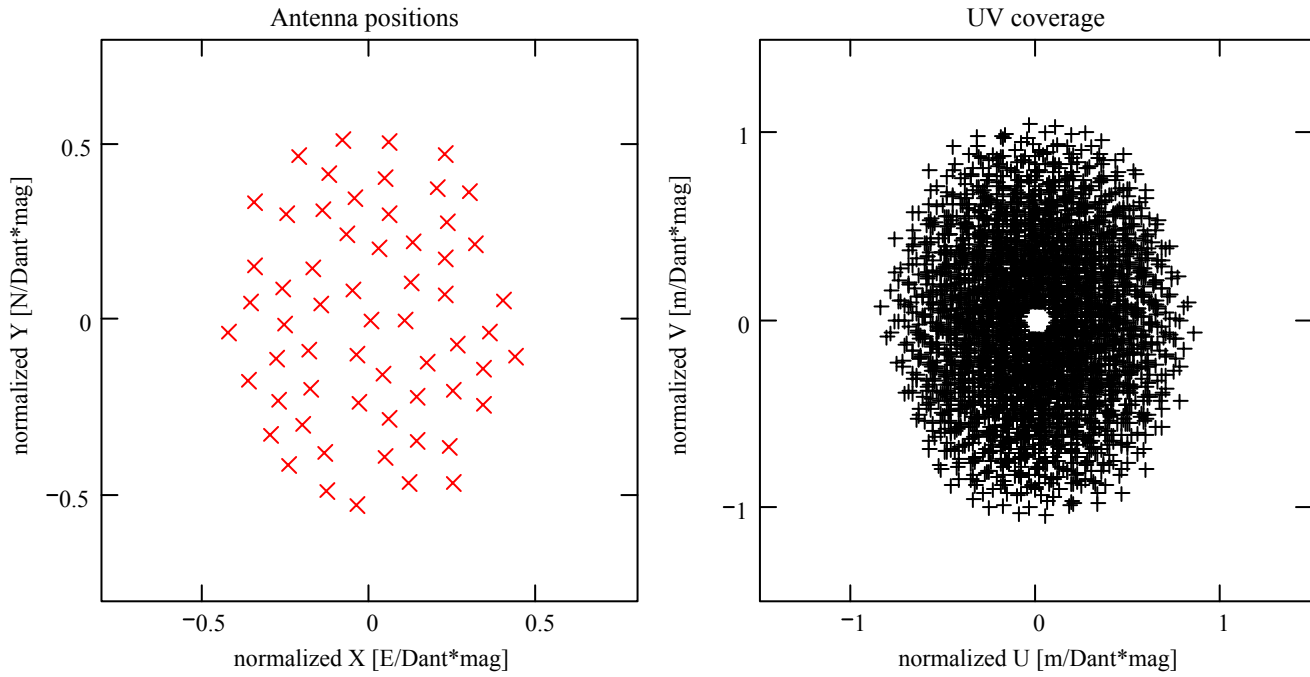
i := 0..1000

PSF for mosaics,  $\sqrt{2} \cdot \text{mag}$

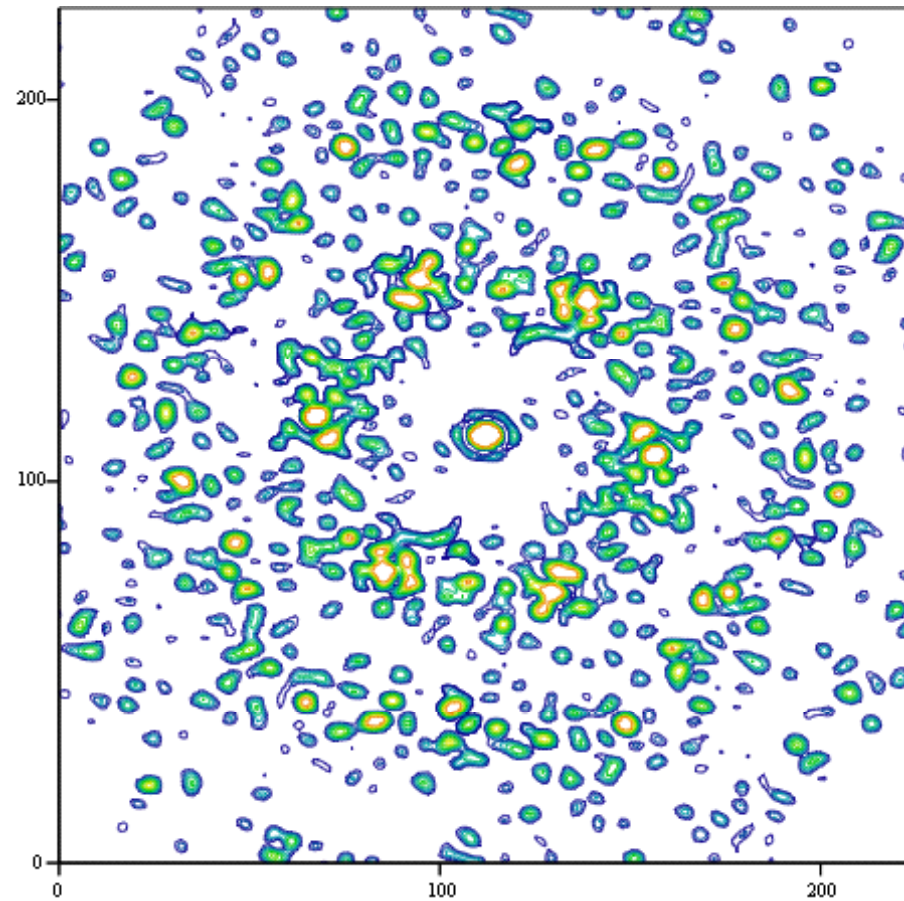


# Webster compact

```
file = "Websters configs ascii.txt"   ifig = 1   mag = 14   Random perturbation.   fRan·Dant = 0   nless = 0  
xX := Re(xconfig)   xY := Im(xconfig)  
X := Re(config)   Y := Im(config)   uvdata := UV(config)   XYscale = 84   U := Re(uvdata)   V := Im(uvdata)
```



```
mag = 14   N3dB := 1   grdext := 4·N3dB   samp := 2·mag  
psf := PSFin(aconfig, samp, grdext, sqrt(2)·mag)   modify mag to account for the wider effective beam  
psfplot := PSFlog(psf, .01, .07)   PSF plot   required for mosaicing. mag->sqrt(2)*mag
```



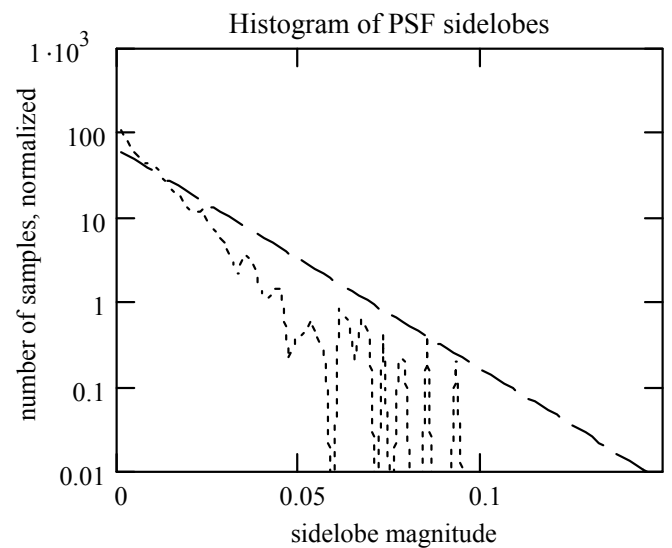
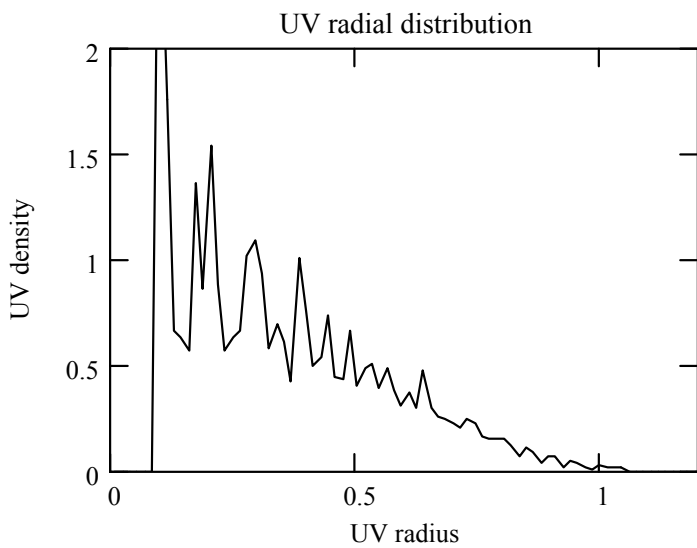
psfplot

# Webster compact

file = "Websters configs ascii.txt" ifig = 1 mag = 14 random perturbation. fRan-Dant = 0 nless = 0

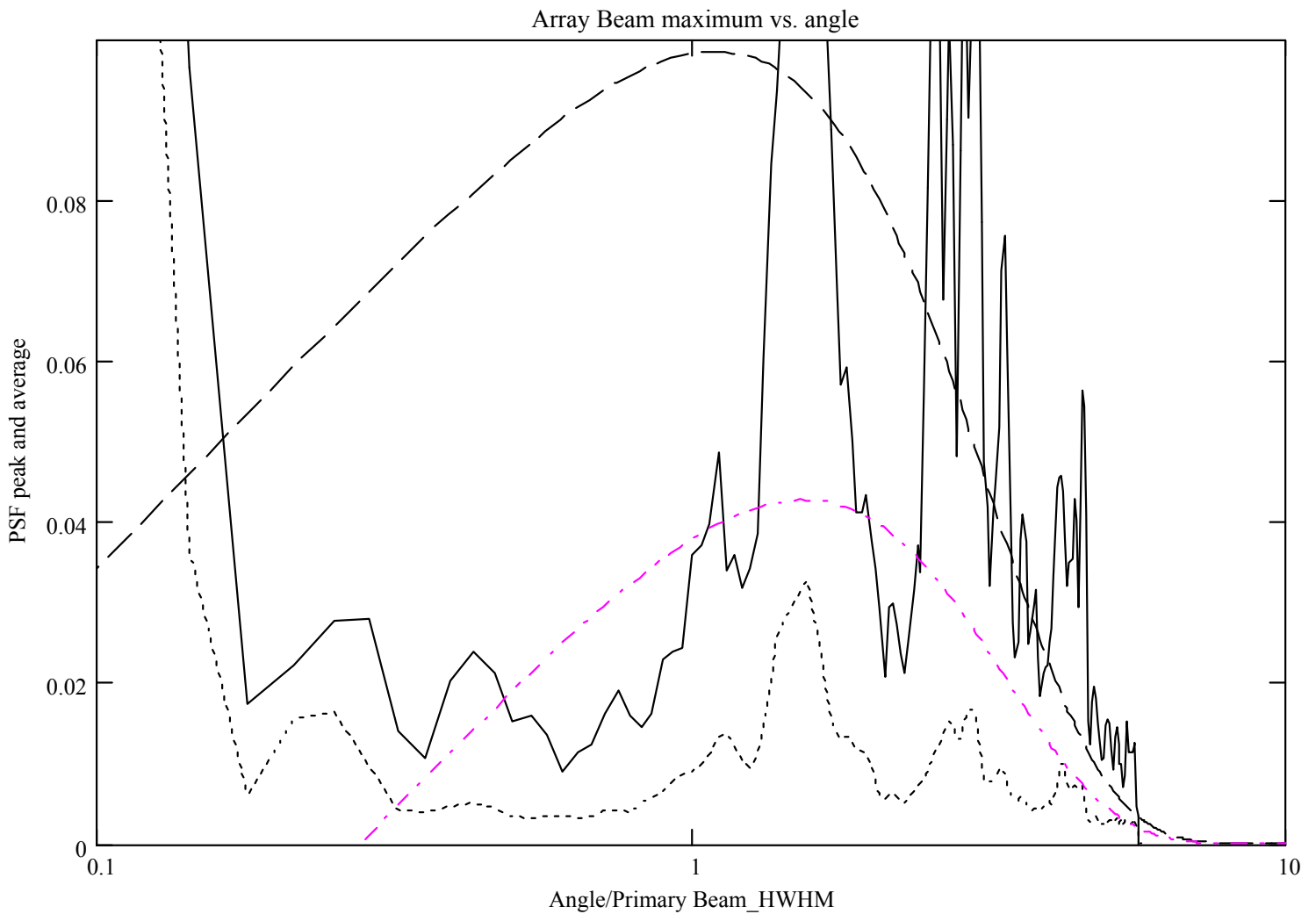
HistPlot := PSFhisto  $\left( \text{psf}, 1.5 \cdot \text{grdext}, 1 \cdot \text{grdext} \cdot \frac{\sqrt{2} \cdot \text{mag}}{2}, 500 \right)$  LPlot := Rbeam(psf) LargeSL(LPlot, grdext) = 0.07922

nbins := 100 uvrdist := Nrdist(uvdata, nbins, 1.5) j := 0..nbins k := 0..200



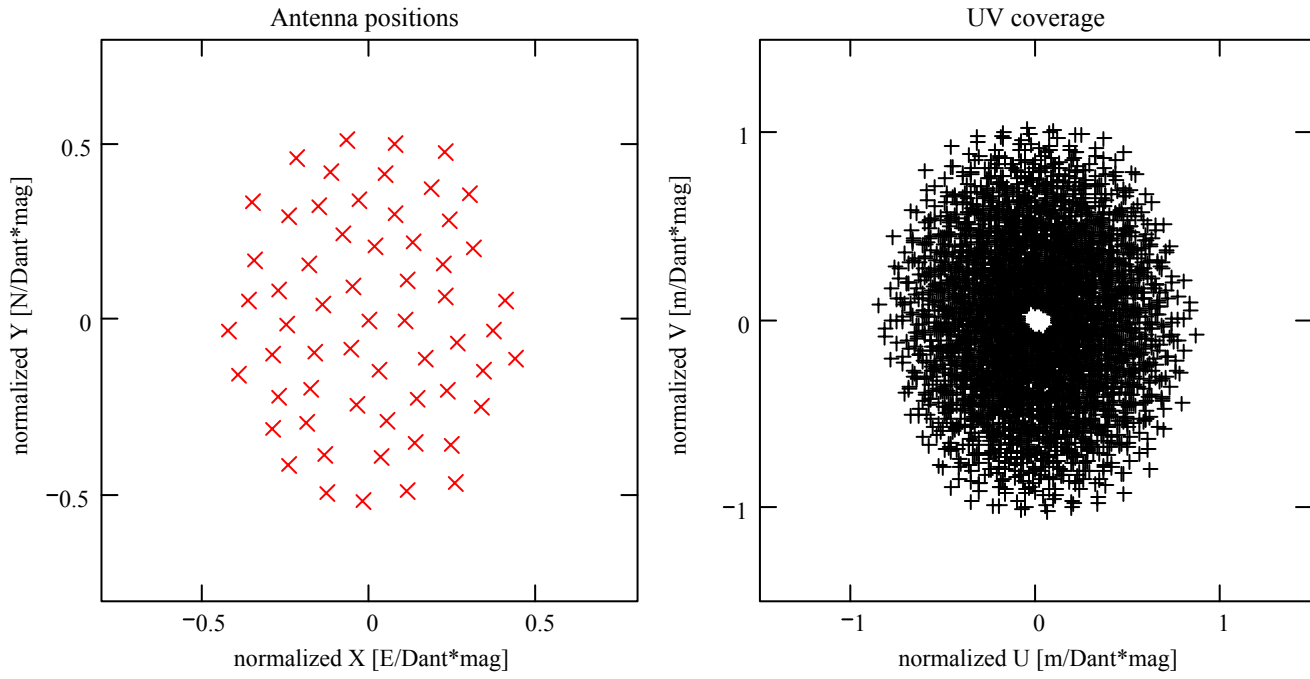
i := 0..1000

PSF for mosaics,  $\sqrt{2} \cdot \text{mag}$

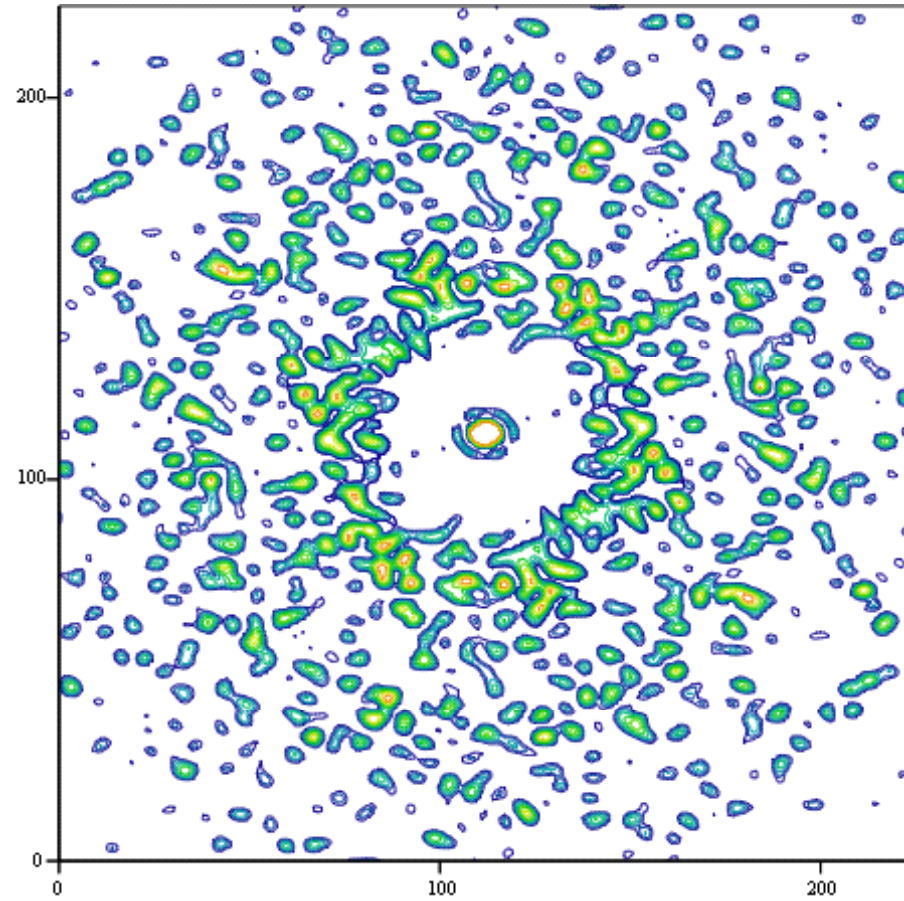


# Webster compact, optimized

```
file = "Websters configs ascii.txt"   ifig = 1   mag = 14   Random perturbation.   fRan·Dant = 0   nless = 0  
xX := Re(xconfig)   xY := Im(xconfig)  
X := Re(config)   Y := Im(config)   uvdata := UV(config)   XYscale = 84   U := Re(uvdata)   V := Im(uvdata)
```



```
mag = 14   N3dB := 1   grdext := 4·N3dB   samp := 2·mag  
psf := PSFin(aconfig, samp, grdext, sqrt(2)·mag)   modify mag to account for the wider effective beam  
psfplot := PSFlog(psf, .01, .07)   PSF plot   required for mosaicing. mag->sqrt(2)*mag
```



psfplot

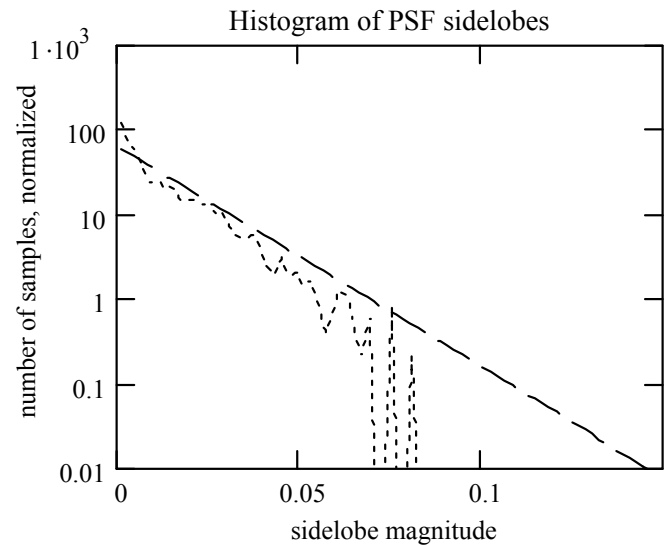
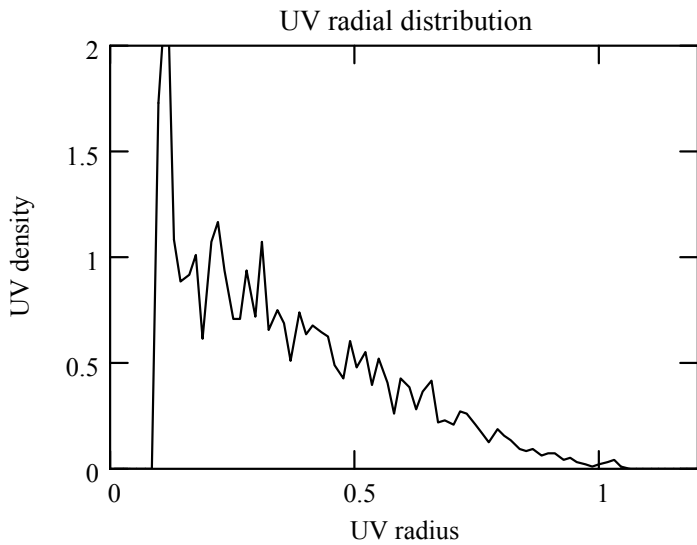


# Webster compact, optimized

file = "Websters configs ascii.txt" ifig = 1 mag = 14 random perturbation. fRandant = 0 nless = 0

HistPlot := PSFhisto  $\left( \text{psf}, 1.5 \cdot \text{grdext}, 1 \cdot \text{grdext} \cdot \frac{\sqrt{2} \cdot \text{mag}}{2}, 500 \right)$  LPlot := Rbeam(psf) LargeSL(LPlot, grdext) = 0.07922

nbins := 100 uvrdist := Nrdist(uvdata, nbins, 1.5) j := 0..nbins k := 0..200



i := 0..1000

PSF for mosaics,  $\sqrt{2} \cdot \text{mag}$

