

```

;; -*-idlwave-*-

;print, 'charsize: ', !P.CHARSIZE
!P.CHARSIZE= 0.6      ;;

;; unit: meter
wavelength  = 20e-9      ;; 20e-9
sourcedist   = 72        ;; 72
waist        = 66e-6      ;; 66mu gives about 8mm in 72 m
sizez        = 8e-3       ;; 8e-3 hor size
sizey        = 15e-3      ;; 25e-3 vert size
fzp_offset   = -5.5e-3    ;; -5.5e-3
source_offset = fzp_offset+ 7.9e-3
Nz           = 3          ;; 301
Ny           = 5*177147    ;; 3^11=177147 } max. grid for idl

emf=initphase()  ;; needed just once

;; source
emf->gaussbeam, dist=sourcedist, sizez=sizez, sizey=sizey, w0=waist, $
wavelength=wavelength, nz=nz, ny=ny, y_off=source_offset

title = 'source in ' + string(sourcedist, FORMAT="(f6.1)") + 'm'
mywindow,2,1
1 emf->plotintensity, title=title+ ' (intensity)', charsize=!P.CHARSIZE
2 mywindow,2,2
emf->plotphase, /phunwrap, title=title+ ' (phase /phunw)', charsize=!P.CHARSIZE
emf->statistics, /nofit

2b ;; rectangular aperture
emf->aperture, type=1, p1=4.8e-3, p2=4.8e-3, p3=0, p4=source_offset
emf->statistics,/nofit

;; fzp
f= 0.08                ;; focal length
d= 20.6e-3             ;; diameter
emf->fzp, f=f, d=d, y_off=fzp_offset      ;; fzp

title = 'after FZP'
mywindow,3,1
3 emf->plotintensity, title=title+ ' (intensity)', charsize=!P.CHARSIZE
4 mywindow,3,2
emf->plotphase, title=title+ ' (phase /phunw)', charsize=!P.CHARSIZE, /phunwrap
emf->statistics, /nofit

4a ;; drift
drift= 1.0*f
print, 'drift=', drift
emf->propagate, drift=drift

title = 'Propagated to ' + string(drift,FORMAT="(f6.2)") + 'm'
mywindow,4,1
5 emf->plotintensity, title=title+ ' (intensity)', charsize=!P.CHARSIZE
6 mywindow,4,2
emf->plotphase, title=title+ ' (phase /phunw)', charsize=!P.CHARSIZE, /phunw
7 mywindow,4,3
emf->plotprofile, title=title+ ' (profile)', /ylog
emf->statistics, /nofit

7a

```



```

IDL> @flashfzp.idl
gaussbeam called
wavelength (m) = 2.0000000e-08
Nz = 3, Ny = 885735
sizez (m) = 0.0080000004, sizey (m) = 0.015000000
z_off (m) = 0.00000, y_off (m) = 0.00240000
w0 (m) = 6.6000001e-05, dist (m) = 72.000000
z0 (m) = 0.68423889 (Rayleigh Range= +/- z0)
w (m) = 0.0069452565, w2 (m^2) = 4.8236588e-05
eta (rad) = 1.5612933, Ri (1/m) = 0.013887635
call myphunwrap
get raw phase
PHI DOUBLE = Array[3, 885735]
myphunwrap called
PHI DOUBLE = Array[3, 885735]
we do not fit- we search fwhm
=====
intensity statistics
=====
z fwhm= 0.0080000004 m
y fwhm= 0.0081774041 m
z0 = 0.00000000 m
y0 = 0.0023999925 m
zmin, zmax (m) = -0.0040000002 0.0040000002, nz= 3
ymin, ymax (m) = -0.0074999998 0.0074999998, ny= 885735
wavelength (nm)= 20.000000
max intensity (W/m^2) = 7631.5443
total intensity (W) = 0.50000000
max intensity (photons/m^2) = 4.7697154e+22
total intensity (photons) = 3.1250001e+18
=====
aperture called
type = 1
FIELD DCOMPLEX = Array[3, 885735]
Z_VEC DOUBLE = Array[3]
Y_VEC DOUBLE = Array[885735]
T DOUBLE = Array[3, 885735]
fill emfield structure
aperture End
we do not fit- we search fwhm
=====
intensity statistics
=====
z fwhm= 0 m
y fwhm= 0.0047999850 m
z0 = 0.00000000 m
y0 = 0.0023999925 m
zmin, zmax (m) = -0.0040000002 0.0040000002, nz= 3
ymin, ymax (m) = -0.0074999998 0.0074999998, ny= 885735
wavelength (nm)= 20.000000
max intensity (W/m^2) = 7631.5443
total intensity (W) = 0.13565148
max intensity (photons/m^2) = 4.7697154e+22
total intensity (photons) = 3.4782175e+17
=====
** Fresnel zone plate **
=====
focal length f (m) = 0.079999998
diameter D (m) = 0.020600000
wavelength (m) = 2.0000000e-08
outerm. zone width (m) = 7.7669899e-08
inner zone rad. r1 (m) = 4.0000001e-05
number of zones N = 66306.254
spatial resolution (m) = 9.4757279e-08
numerical aperture = 0.12875001
DOF +/- (m) = 6.0326133e-07
dlambda must be (m) < 3.0163067e-13
our grid dz (m) = 0.0040000002
our grid dy (m) = 1.6935107e-08
=====
call myphunwrap
get raw phase

```

Source in 72m

after aperture

26% left

PHI DOUBLE = Array[3, 885735]

myphunwrap called

PHI DOUBLE = Array[3, 885735]

we do not fit- we search fwhm

intensity statistics

z fwhm= 0 m  
 y fwhm= 0.0047999850 m  
 z0 = 0.0000000 m  
 y0 = 0.0023999925 m  
 zmin, zmax (m) = -0.0040000002 0.0040000002, nz= 3  
 ymin, ymax (m) = -0.0074999998 0.0074999998, ny= 885735  
 wavelength (nm)= 20.000000  
 max intensity (W/m<sup>2</sup>) = 7631.5443  
 total intensity (W) = 0.067830935  
 max intensity (photons/m<sup>2</sup>) = 4.7697154e+22  
 total intensity (photons) = 4.2394336e+17

after FEP

another factor 2 lost (expected) as

drift= 0.079999998

propagate called- automatic selection of propagator

----- propfourier called -----

----- propfourier start calculation --- drift= 0.079999998

filter = 0 plot = 0  
 Nz, Ny = 3, 885735  
 z\_vec[0] = -4.0000002 z\_vec[Nz-1] = 4.0000002 mm  
 width = 8.0000004 height = 15.000000 mm  
 u: min = -124.99999 max = 124.99999

----- FT of Source field ----- exp(-i ...)

----- Propagator for free space -----

----- Propagate in Fourier space -----

----- Inverse FT to get output field ----- exp(+i ...)

fill emfield structure

----- propfourier end -----

call myphunwrap

get raw phase

PHI DOUBLE = Array[3, 885735]

myphunwrap called

PHI DOUBLE = Array[3, 885735]

FIELD DOUBLE = Array[3, 885735]

mz out of range: force profile at center

getprofile: nz, ny, mz, my, m, mindex: 3 885735 1 0  
 936353.33 354046

FIELD DOUBLE = Array[3, 885735]

mz out of range: force profile at center

getprofile: nz, ny, mz, my, m, mindex: 3 885735 1 0  
 936353.33 354046

we do not fit- we search fwhm

intensity statistics

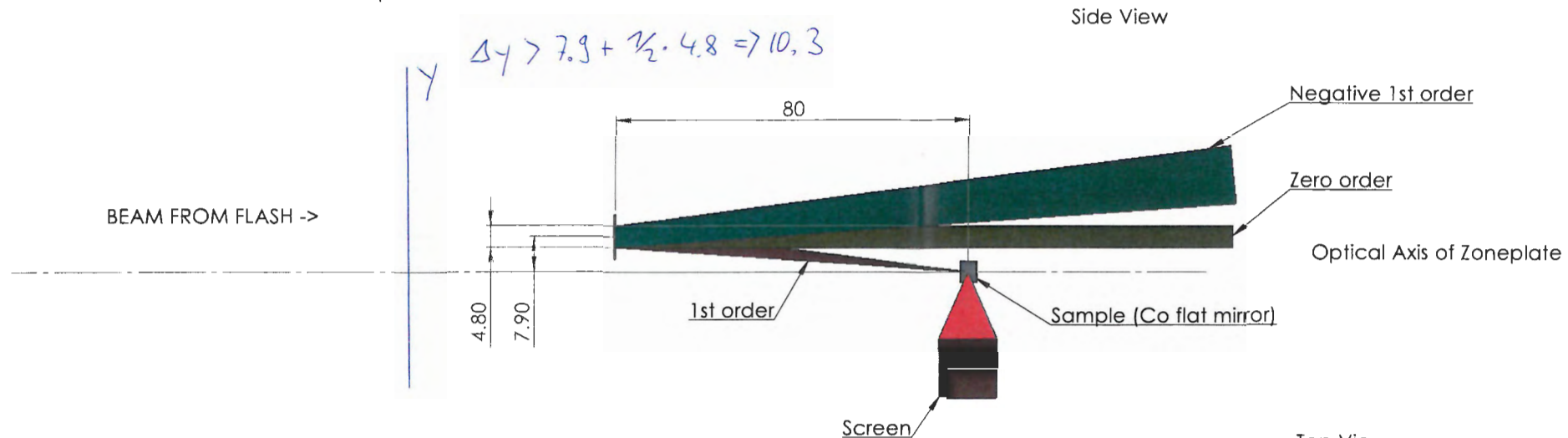
z fwhm= 0 m  
 y fwhm= 4.3015171e-06 m  
 z0 = 0.0000000 m  
 y0 = -0.0055014032 m  
 zmin, zmax (m) = -0.0040000002 0.0040000002, nz= 3  
 ymin, ymax (m) = -0.0074999998 0.0074999998, ny= 885735  
 wavelength (nm)= 20.000000  
 max intensity (W/m<sup>2</sup>) = 936353.33  
 total intensity (W) = 0.067830935  
 max intensity (photons/m<sup>2</sup>) = 5.8522085e+24  
 total intensity (photons) = 4.2394336e+17

IDL>

Incoming beam from FLASH:

- 60eV, gaussian profile, 1.5% bandwidth
- Diameter 8mm, unfocused
- Distance from undulator to zoneplate: 72m

- Simulate how non-homogeneities in the illumination of the zoneplate affect the focal spot shape.



Zoneplate parameters:

Membrane Size=4.8x4.8mm<sup>2</sup>  
 F=80mm  
 R<sub>min</sub> = 5.5mm  
 R<sub>max</sub> = 10.3mm  
 Min pitch = 153.1 nm (structure size 76.531nm)  
 Max pitch = 300.6 nm (structure size 150.3nm)

R<sub>min</sub> and R<sub>max</sub> are the curvature radius of the lowermost and the uppermost zone fitting in the 4.8x4.8mm<sup>2</sup> window as in the picture in attachment.

