Grid distorsion on D2am CCD cameras.

J.-F. Bérar, D2am-CRG/F, ESRF

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1 D2am 1242x1152 camera : Fiber Optic Coupled CCD.

SAXS users have noticed that distorsions on D2am CCD camera were significant and lead to some troubles when data have been collected both at high and at low Q with separate settings. Using a copper grid (holes diameter .3mm on a 3mm square lattice) etched by electronic board technics by Cyrille Rochias (LSP, Grenoble), these distorsions have been characterised and a correction procedure deduced.

The added (LSP) on the right image have been drawn to figure a perfect grid located around the "central" node.

Uncorrected grid image and corrected one.

1.1 The distorsions

As distorsions seem very weak near the center, they have been expressed by a polynomial function using the center as origin : $X = f(X - X_o) = f(x)$ The adjustement lead to a grid size of 74.9 pixels corresponding to $40.1 \mu m/pixel$ in the horizontal direction.

Following table contain the coefficients of X and Y expansions :
$X = X_o + A_x x + A_y y + A_{x^2} x^2 + A_{xy} xy + A_{y^2} y^2 + ...$

	X					Y				
scale factor on $A_{x^i y^j}$	x^0y^0					x^0y^0				
	x^1y^0	x^0y^1				x^1y^0	x^0y^1			
	x^2y^0	x^1y^1	x^0y^2			x^2y^0	x^1y^1	x^0y^2		
	x^3y^0	x^2y^1	x^1y^2	x^0y^3		x^3y^0	x^2y^1	x^1y^2	x^0y^3	
	x^4y^0	x^3y^1	x^2y^2	x^1y^3	x^0y^4	x^4y^0	x^3y^1	x^2y^2	x^1y^3	x^0y^4
1	621					576				
10^3	1000	0.00				4.70	1003			
10^5	-1.92	0.59	-1.62			-0.13	0.17	2.66		
10^8	-7.34	1.92	-5.20	-0.32		-0.01	-5.01	-0.02	-6.50	
10^{11}	1.63	-0.66	-0.19	2.39	-0.50	-0.44	2.38	-1.83	1.53	-3.60

The A_y value, 1.003 shows that the lattice is nearly a perfect square. The maximum deviation is observed in X (bottom right) is near 30 pixels, in Y (botom left) near 24 pixels.

The 246 nodes located on the grid are then adjusted with a standard error of 1.5 pixels to be compared with an error of 8.9 pixels before correction. Following pictures show the distorsions on each nodes and the remaining values after correction of the image.

The difference between the image after and before correction allows to visualise easily the effect of the correction. The following zoom on the grid corners (top, right) and (bottom, left) proof that the correction improve greatly the image quality.

The relative size of the pixels is represented in the image. It can be noticed on the figure, the size far from the center is reduced by about 20%.

1.2 Correction procedures.

The grid coefficients have been calculated using *bm2grid*. No special care have been necessary to extract the grid, the following parameters were given :

GRID_LEVEL=20 : minimum count on pixel used in grid nodes

GRID_COUNT=10 : minimum pixels number in grid nodes

GRID_ERROR=0.2 : tolerance around translation for nodes extraction

After refining the grid value, the grid parameters were output to the file *ccd1/ccd1_g0.res* whose lines can be inserted in the standard beamline procedure *bm2img* :

```
GRID_DCOR=15
GRID_XCOR=      621         1 2.10727e-07 ....
GRID_YCOR=      576 0.00470413   1.0034 -1.31391e-06 ....
```

2 D2am 1340x1300 camera : Fiber Optic Coupled CCD.

These preliminary result have been obtained with the grid image provided by Roper Scientific (about 600um) in the file "flm-4-1.SPE" (August 14th, 2002).

Uncorrected grid image and corrected one.

Due to the small translation vector in the grid 6200 nodes have been found. The small value of the translation vector (about 16 pixel) complicates the analysis and at the time the result is not satisfactory even if the distortion have strongly been decreased.

Using the same expension, the coefficents are :

axis	table scale factor	x^0y^0 x^1y^0 x^2y^0	x^0y^1 x^1y^1	x^0y^2
X	1 10^3	670 1000	0.00	
Y	1 10^3	650 -2	1002	

3 Correcting image with *bm2img* procedure

The correction of the position of the pixels is obvious when the grid is known but some problems may occur with the intensity.

3.1 Method of correction.

In a constant flux, due to the pixel size the count in each pixel are represented on the left, they are proportional to the pixel surface.

In the natural view, the intensity are shown on a regular non corrected grid and the surface distortion appear like an intensity change.

The correct way to correct the grid is to split the intensity of the real pixel in proportion of the surface common to the new pixel.
Applying this calculation, this image is obtained. There is no problem for all the inner pixel, for very sharp signal a small convolution may occurs, for the case in which the detector resolution is very important, local fit of intensity may allow a better splitting of the intensity on the new array. But pixels in the border lines may are affected by this remapping.
A solution is to extend the intensity of these pixels, if the surface concerned is not too tiny. After this operation the excluded pixel have to be redefined by generating a new mask including the effect of the distortion. change

3.2 Interaction with the flatfield correction.

When a flatfield correction is applied before the grid correction, the content of pixels changes.
Applying the normal correction lead to overestimate the pixel with small size. However the normal result can be achieved if a surface correction is applied.

3.3 Practical correction of images with *bm2img*

3.3.1 Geometrical grid parameters.

The coefficient calculated by *bm2grid* can be used to correct images in *bm2img*, this is done by writing the following tags and lines in *bm2img.ini*.

GRID_DCOR=	15			number of coefs
GRID_XCOR=	621	1	2.71678e-07	...
GRID_YCOR=	576	0.00424391	1.00337	...

To avoid typing mistakes lines writen by *bm2grid* command can be added to the *bm2img.ini* file.

4 Grid determination : *bm2grid* procedure

4.1 *bm2grid* program method

4.2 Initialisation file used for the 1242x1152 CCD

```
# bm2grid.ini   input file for grid calibration
# cvs_id =" $Id: bm2grid.ini,v 1.2 2002/07/22 12:31:40 berar Exp $ ";
#
# C Rochas grid used with 1242x1152 CCD
GRID_LEVEL=20
GRID_ERROR=0.2
GRID_COUNT=10
GRID_SIZE=3.00
```

```
@GRID_IMAGE=ccd1/ccd1_g0.edf
@GRID_OUT_NODES=ccd1/ccd1_g0.nod
@GRID_PROCESS=
@GRID_OUT_XMGR=ccd1/ccd1_g0.agr
@GRID_OUT_SURF=ccd1/ccd1_g0_surf.edf
@GRID_OUT_RES=ccd1/ccd1_g0.res
@GRID_INPUT=ccd1/ccd1_g0.res
@GRID_CHECK=ccd1/ccd1_g0.edf,1000,2
@GRID_PROCESS=
@GRID_OUT_NODES=ccd1/ccd1_g0_chk.nod
@GRID_OUT_XMGR=ccd1/ccd1_g0_chk.agr
```