TECHNICAL REPORT n. 76

GAIA PERFORMANCE ON BRIGHT STARS FULL RESOLUTION READOUT

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1. Introduction

In a previous document[1] we have given a summary of the results obtained in the past months about the simulations performed to estimate the astrometric error at the level of one single CCD transit. This has been done for different possible operation options, including readout modes, windowing schemes, optimising the centring algorithm. In the same document we suggested as next step the implementation of the least square algorithm applied to the full resolution readout in the saturated case, i.e. without the use of gates. In this working note we give an update of the first preliminary results, already given in a draft working note (WN n. 06) and which require a major change due to improvement of the location algorithm.

2. Simulation setup

Simulation setup is the same we used in the simulations discussed in the cited document.

Parameter	Value	Notes
PSF	Aberrated	
Algorithm	ILSA	
Sample size	900	No phase shift between sample elements
Windowing	12 x 12 px²	UnBinned PSF No Gates
Saturation	Yes, at 1,9 10^5 el	CCD linear until saturation occurs

Table 1

3 Results

Table 2 shows the new results. The simulation have been performed for three different points in the field of view, which coordinates are

- Field position n. 1: (along scan, across scan) = (0.0276,0.5300)degrees²
- Field position n. 2: (along scan, across scan) = (0.3276,0.5300)degrees²
- Field position n. 3: (along scan, across scan) = (0.6276,0.5300)degrees²

For each magnitude considered, and reported in the first column, and for each field position three numbers are given. They are:

- The number of saturated pixels (full resolution PSF)
- The difference between the star position given by the estimation algorithm and the star nominal position, in microarcseconds
- The Astrometric error in units of microarcseconds

Figure 1, 2 and 3 show the saturation limit for each PSF pixel for the three Field position respectively. For each pixel of the PSF we give the saturation magnitude.

Finally, figure 4, 5 and 6 give a graphical representation of the astrometric error results comparing the four method combinations:

- Solid line: BINNED, GATES
- Dotted line: UNBINNED, GATES
- Diamonds: BINNED, NO GATES
- **Asterisks: UNBINNED, NO GATES**

[1] D.Gardiol, "GAIA performance on bright star", GAIA_ML_025, 30.04.2005

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Mag	Field position n. 1			Field position n. 2			Field position n.3		
	N. sat. pixel	Diff nom position	Astrometric error	N. sat. pixel	Diff nom position	Astrometric error	N. sat. pixel	Diff nom position	Astrometric error
13.0	0	1.2	85.6	0	1.3	81.5	0	-1.0	84.7
12.8	0	-1.9	79.9	0	-1.2	67.4	0	0.4	81.8
12.6	0	1.7	66.4	0	-1.1	59.8	0	-0.8	71.6
12.4	0	0.1	67.1	0	1.3	57.5	0	1.3	68.7
12.2	0	-0.8	60.8	0	-0.1	47.3	0	-0.6	53.7
12.0	0	0.1	50.5	0	-0.8	48.8	0	-0.0	47.6
11.8	1	-0.1	44.1	2	-0.3	48.9	1	-0.6	45.1
11.6	2	-0.1	43.2	2	-0.6	39.4	2	-0.1	43.9
11.4	2	-0.0	37.4	4	0.5	42.0	2	0.0	35.0
11.2	3	1.5	42.1	4	-0.9	35.2	3	0.5	36.0
11.0	5	0.5	46.8	4	1.0	33.4	5	-0.6	40.9
10.8	6	-0.5	45.6	4	-0.2	30.3	6	0.9	49.8
10.6	6	0.2	42.2	4	-0.5	27.5	6	-0.4	46.1
10.4	7	0.6	41.6	4	0.1	26.8	7	-0.3	36.9
10.2	7	1.1	33.4	7	-1.1	29.6	7	0.2	32.7
10.0	7	-1.1	29.8	9	1.7	35.1	7	0.3	28.8
9.8	9	0.8	31.7	10	0.3	42.7	9	-0.2	28.6
9.6	9	-0.4	25.3	10	-1.0	40.5	9	0.2	26.5
9.4	10	0.9	24.9	10	-1.1	32.7	10	0.4	24.0
9.2	12	-1.3	23.2	12	1.3	33.4	12	-1.3	24.7
9.0	13	-0.7	27.5	13	-0.5	27.8	13	1.3	23.3
8.8	16	-0.7	30.3	14	2.0	45.9	16	0.8	33.3
8.6	18	-0.4	31.3	15	-1.7	32.6	18	0.8	29.9
8.4	19	1.0	26.8	16	-1.1	28.8	19	-1.7	35.0
8.2	20	0.5	28.9	17	1.4	25.8	20	-0.4	26.2
8.0	22	0.2	23.5	24	0.2	26.8	22	-1.0	22.9
7.8	26	-0.0	25.4	28	-0.5	29.1	26	-0.7	27.7
7.6	31	0.6	30.6	31	1.4	26.2	31	-3.0	31.9
7.4	35	1.6	29.6	33	1.2	21.1	35	5.0	28.7
7.2	39	1.0	29.4	35	2.2	22.0	39	1.2	25.9
7.0	45	-0.8	26.9	39	0.0	19.3	44	0.4	28.5
6.8	48	-0.3	25.8	43	0.6	17.7	46	-0.4	27.9
6.6	52	-0.9	21.4	46	1.2	17.4	50	-1.9	24.2
6.4	59	-1.2	23.1	54	-0.9	21.8	57	0.3	22.6
6.2	67	0.0	26.1	61	0.7	25.3	64	0.8	24.5
6.0	69	-0.2	24.0	63	0.3	24.8	66	3.4	27.4

Table 2

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				6.2	6.6	6.4					
				6.4	7.2	7.0	6.0				
			6.2	7.8	8.8	8.8	7.6				
	6.4	7.0	7.4	9.8	11.0	11.0	9.2	7.2	7.0	6.2	
6.4	7.0	7.8	8.0	10.4	11.8	11.6	9.4	7.8	7.6	6.8	6.4
6.2	6.6	7.4	7.8	9.8	11.2	10.8	9.0	7.6	7.2	6.4	6.2
		6.2	6.6	8.4	9.2	8.6	7.6	6.4	6.0		
				7.6	8.8	8.6	6.8				
				7.4	8.2	8.0	7.0				
				6.6	7.4	7.2	6.2				
				6.2	7.0	6.8					

Figure 1 – saturation magnitude for PSF pixels, Field n. 1

				6.2	7.6	7.2					
				7.0	8.4	8.0	6.0				
				7.2	8.6	8.2					
		6.2	6.4	8.8	10.0	9.8	7.8	6.2	6.2		
6.6	7.0	7.8	8.0	10.2	11.8	11.4	9.2	8.0	7.4	6.8	6.4
6.6	7.0	7.8	8.0	10.2	11.8	11.4	9.2	8.0	7.6	6.8	6.4
		6.4	6.6	9.0	10.2	10.0	8.0	6.4	6.2		
				6.4	8.0	7.8	6.0				
				6.2	7.6	7.4					
					7.0	6.8					
					6.8	6.4					
					6.4	6.2					

Figure 2 – saturation magnitude for PSF pixels, Field n. 2

				6.6	7.4	7.2	6.2				
				7.4	8.4	8.0	7.0				
				7.6	8.8	8.6	6.8				
		6.2	6.6	8.4	9.2	8.6	7.6	6.4	6.0		
6.2	6.6	7.4	7.8	9.8	11.0	11.0	9.2	7.6	7.2	6.4	6.2
6.4	7.0	7.8	8.0	10.4	11.8	11.6	9.4	7.8	7.6	6.8	6.4
	6.4	7.0	7.4	9.8	11.2	10.8	9.0	7.2	7.0	6.2	
			6.2	7.8	8.8	8.8	7.6				
				6.4	7.2	7.0	6.0				
				6.2	6.6	6.4					

Figure 3 – saturation magnitude for PSF pixels, Field n. 3

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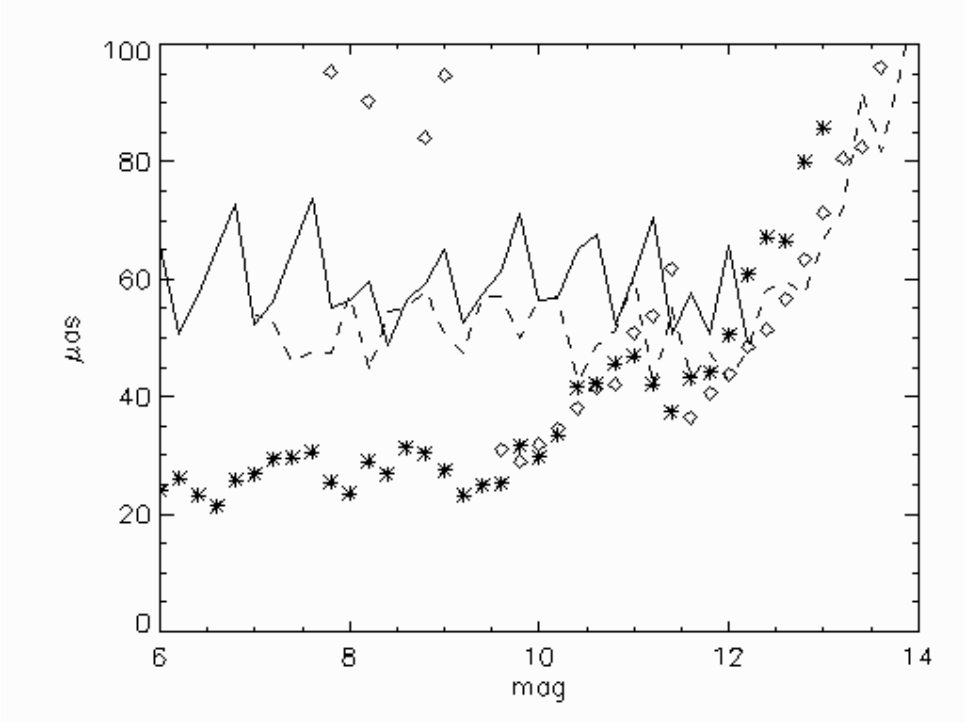

Figure 1 – Field n. 1

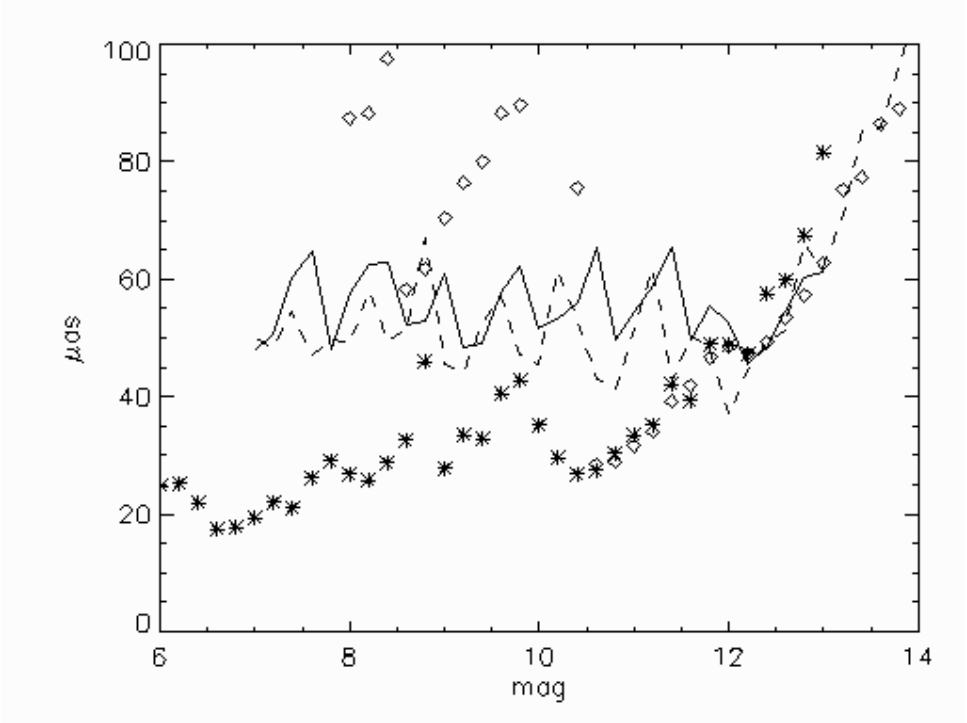

Figure 2 – Field n. 2

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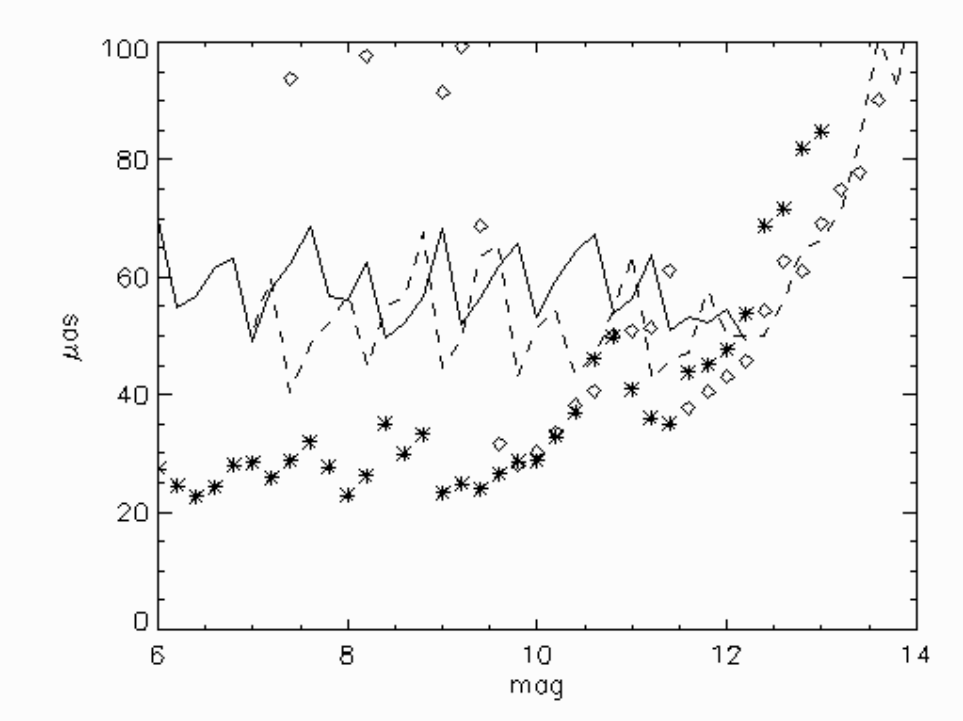

Figure 3 – Field n. 3

4 Comments

In the non saturated regime the astrometric error is roughly the same for all the four methods combination (gates vs. no gates and binned vs. unbinned), and in any case within the statistical error. It is possible that the systematic greater value for the unbinned-no gates method is due to the increased readout noise (a factor of about the square root of 11, i.e. ~3).

With regards to the number of saturated pixel at increasing magnitudes, table 2 seems to suggest that series of Fields n.1 and n.3 are rather similar, more than each one is with the serie of Field n. 2, at least up to magnitude V = 7. But even if the number of saturated pixels at a given magnitude is the same, their location on the PSF is different, as can be verified from Figures 1 and 3. This is due to two main reasons: a) the (slightly) different relative position of the PSF with respect to the CCD pixel grid and b) the (slightly) different PSF shape. The greater difference with respect to Field n.2 is originated by the same effects, where effect a) is more important than b) (saturation occurs, at least at an early stage, by couples of pixels, suggesting that the PSF maximum is located near the boundary between two adjacent pixels).

In the saturated regime, two ranges can be distinguished:

- where saturation is light, let's say less than 10 pixels are saturated, effects a) and b) produces appreciably differences between the different Field positions
- for stronger saturations, the PSF shape seems to be less important, and the error level seems to be well stabilised around the value of 30 μas.

In any case, the unbinned-no gates method keep good performances even at very bright magnitudes (at magnitude 6 the fractional number of saturated pixels is higher than 0.4).

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