CSpad alignment

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- Alignment using optical measurement
- Fast algorithm for alignment using images
- Alignment of tilted ASIC pairs in quad
- CSpad quad alignment w.r.t. the beam center

Optical measurement data

Table from Christopher Kenney

Point	X	Y	Z	SB	Pad X	Pad Y
1	0	0	0	15L		
2	43970	7	44	15L		
3	43978	21427	9	15L		
4	4	21427	20	15L	547	21846
5	17	23461	28	15s		
6	43996	23218	17	15s		
7	44117	44667	2	15s		
8	134	44906	24	15s	690	45312
9	632	47000	39	26L		
10	1137	90967	62	26L		
11	22579	90723	52	26L	22975	90179
12	22071	46766	30	26L		
13	24031	46694	25	26S		
14	24413	90681	62	26S		
15	45851	90478	39	26S	46253	89931
16	45471	46506	55	26S		

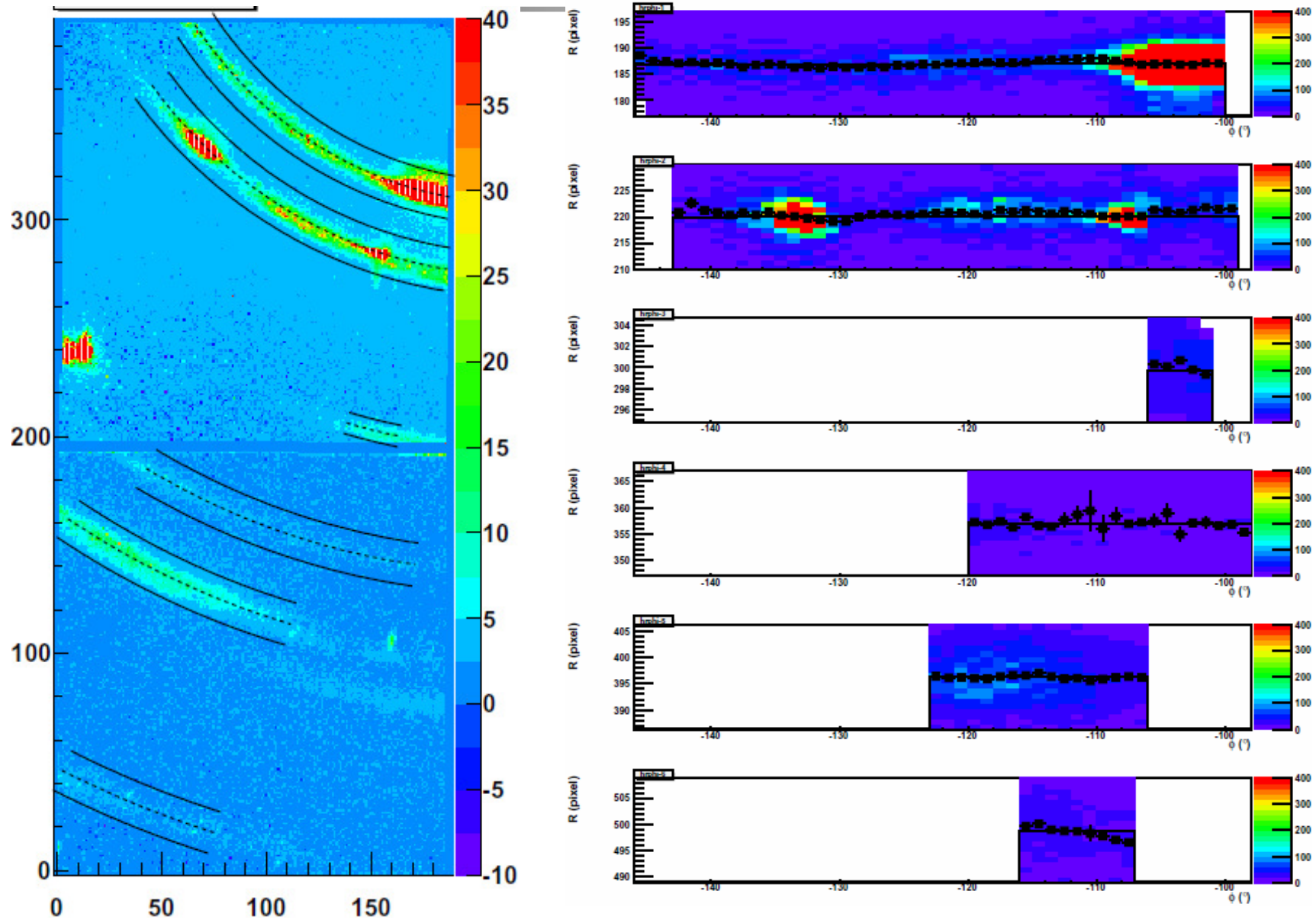| Point	X	Y	Z	SB	Pad X	Pad Y
17	47761	90117	52	27L		
18	91725	89497	63	27L		
19	91425	68067	44	27L	90871	67667
20	47454	68689	34	27L		
21	47401	66724	32	27S		
22	91369	66127	41	27S		
23	91078	44700	5	27S	90523	44299
24	47107	45286	3	27S		
25	44135	-701	42	30L		
26	44389	43268	19	30L		
27	65838	43131	23	30L	66245	42592
28	65577	-829	30	30L		
29	67520	-911	38	30S		
30	67786	43050	24	30S		
31	89220	42921	2	30S	89628	42372
32	88952	-1040	51	30S		

Processing of optical data
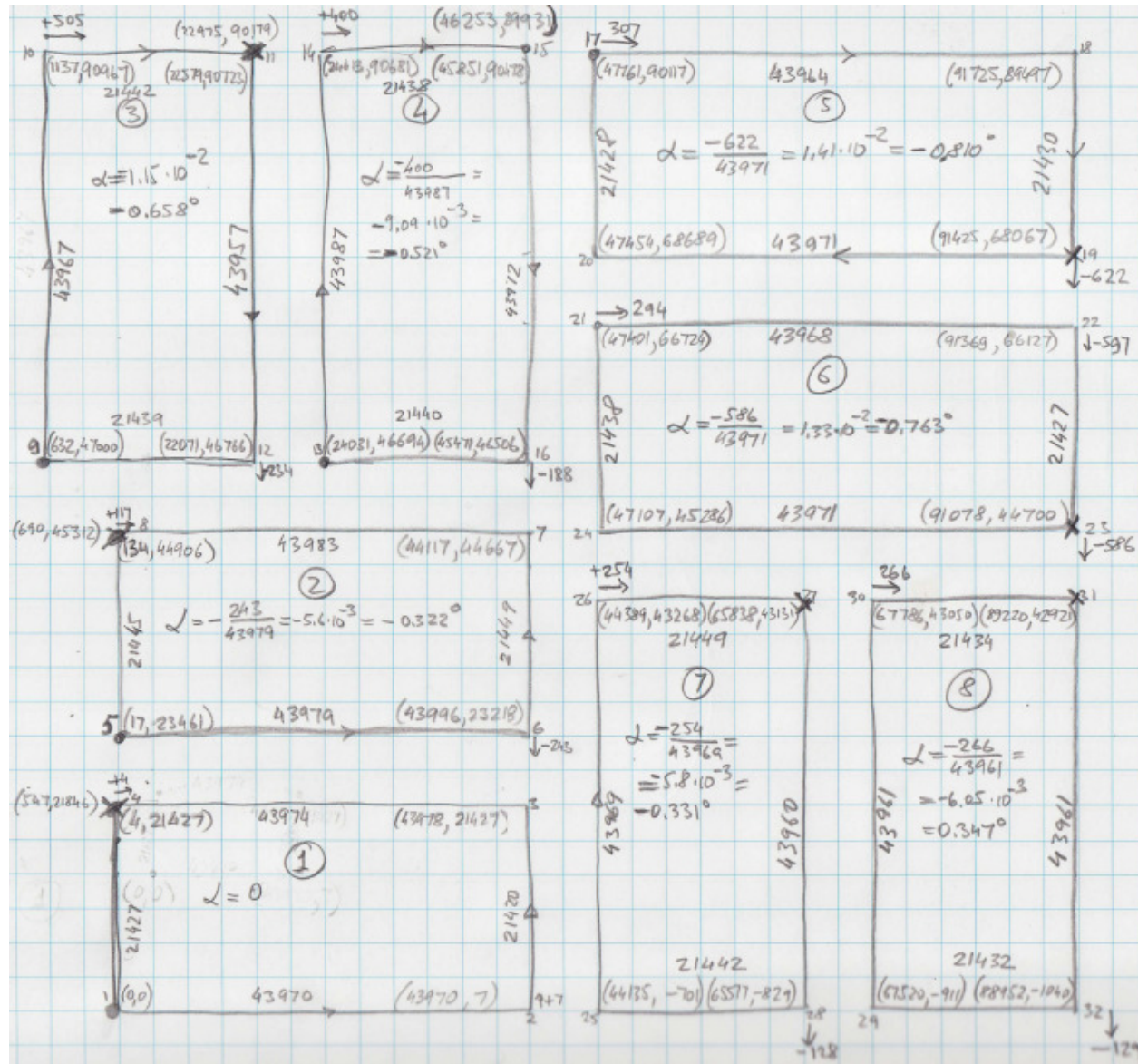
Derived parameters of pads

- Optical measurement precision is 8μm
- That gives tilt angle precision 0.011°
- My tilt angle alignment (precision 0.1°) is consistent with optic measurement

Sequence of measu.	ASIC pair	Pad length L (μm)	Pad width W (μm)	αL (μm)	Tilt angle α (∘)	$\alpha - \overline{\alpha}$ (∘)	My (∘)
1	02-03	43970	21420	7	0 ± 0.011	0.469	0.7
		43974	21427				
2	00-01	43979	21449	−243	-0.322 ± 0.011	0.147	0.2
		43983	21445				
3	06-07	43967	21442	−505	-0.658 ± 0.011	−0.189	0.1
		43957	21439				
4	04-05	43987	21438	−400	-0.521 ± 0.011	−0.052	−0.1
		43972	21440				
5	10-11	43964	21430	−622	-0.810 ± 0.011	−0.341	−0.4
		43971	21428				
6	08-09	43968	21427	−586	-0.763 ± 0.011	−0.294	−0.4
		43971	21438				
7	14-15	43969	21449	−254	-0.331 ± 0.011	0.138	0.1
		43960	21442				
8	12-13	43961	21434	−266	-0.347 ± 0.011	0.122	0.1
		43961	21432				
Mean		43969.6	21436.3		-0.469 ± 0.011	0	
Dispers.		8.3	8.4		0.272	0.272	

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Fast algorithm for alignment

Ring shape in r-φ frame

- Approximate beam/ring center (x_0, y_0)
- Precise ring center (x_c, y_c)
- Ring constrain eqn. $(x - x_c)^2 + (y - y_c)^2 = R^2$
- Point on the ring

$$x = x_0 + r\cos\phi,$$
$$y = y_0 + r\sin\phi.$$

$$r(\phi | x_0, y_0, x_c, y_c, R) = -B \pm \sqrt{B^2 - C}$$

$$B = \Delta x \cos\phi + \Delta y \sin\phi, \quad C = \Delta x^2 + \Delta y^2 - R^2$$

$$\Delta x = x_0 - x_c \text{ and } \Delta y = y_0 - y_c$$

Alignment results

Fit #	ASIC	x_c	y_c	Ring and radius
1	08-09	220.52±0.12	493.28±0.20	R1 = 185.77±0.23
				R2 = 219.03±0.23
				R3 = 298.60±0.23
				R5 = 355.84±0.26
				R6 = 395.12±0.23
				R7 = 497.71±0.27
2	12-13	269.018±0.007	303.502±0.001	R1 = 186.91-fixed
				R2 = 219.95-fixed
				R3 = 299.72-fixed
				R4 = 328.49±0.02
				R6 = 396.24-fixed
3	10-11	414.25±0.09	512.08±0.11	R4 = 328.49-fixed
				R6 = 396.24-fixed
				R7 = 500.92±0.06
				R8 = 562.01±0.06

…

Configuration parameters

ASIC	orientation (o)	x_c (pixel)	y_c (pixel)
00	0 +0.1	15.76	932.65
01	0 +0.1	15.76	932.65-gap
02	0 +0.6	-200.19	930.88
03	0 +0.6	-200.19	930.88-gap
04	270 −0.2	422.26	716.34
05	270 −0.2	422.26-gap	716.34
06	270 +0.0	412	926
07	270 +0.0	412-gap	926
08	180 −0.5	220.84	494.37-gap
09	180 −0.5	220.84	494.37
10	180 −0.5	414.12	512.26-gap
11	180 −0.5	414.12	512.26
12	270 +0.0	26.95	303.53
13	270 +0.0	26.95-gap	303.53
14	270 +0.0	11.13	517.40
15	270 +0.0	11.13-gap	517.40

Result of alignment using ring-image
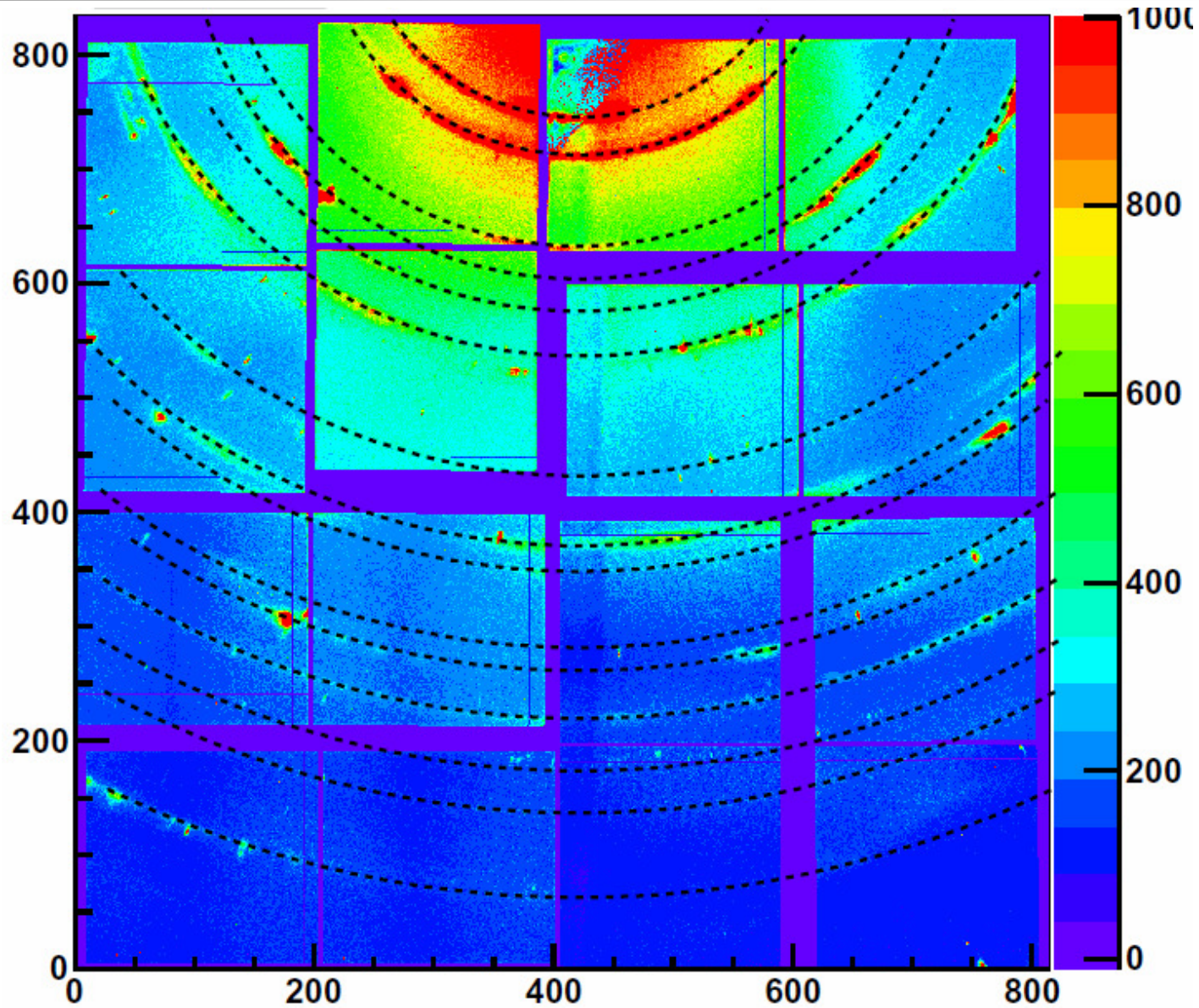
Summary

- Fast ASICs' alignment algorithm, based on ring-image, is done
- All fits for Quad2 are completed, configuration parameters are available
- Stat. precision is ~0.2 of pixel size
- Syst. uncertainty strongly depends on ring image quality. Currently it is ~1-2 pixels.
- Optic measurement has a precision of 8μm or 0.07 of pixel size
- Q: is a pad geometry stable?
- Working on extraction of configuration parameters from optic measurement.