Precision of the mechanical modules and improvement to the assembly station

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- **Metrology of the 8 mechanical detector-baseboard assemblies made with the version 2 of the assembly station and jigs at KEK**

- **Improvement to the station after the experience of the assembling**

Assembly station and jigs

- **Reported at the May RAL meeting**

  - A draft note is available from the web

  - Result of 3 modules was reported in the meeting

- **Mechanical detector-baseboard modules**

  - 5 more modules were assembled, total 8 modules

  - Detector: 300 μm Glass

  - Baseboard: CFRP

  - Facings: Glass

  - Photo of typical modules (from Feb. 99 presentation)

- **Metrology**

  - Fiducial marks, Dowel hole and slot

  - No flipping, through the Glass, avoiding uncertainty involved in the flipping

  - A flipping jig is under design

  - Process of describing the precision -- see drawing

  - Deviation from the ideal (design) values

1. location of the linear bearings-pins is moved to the ends of the detectors in the strip direction and in the centre axis of the detectors, in order to have a larger separation of two bearings-pins and a shorter distance to the detector's side-edges, which reduces the influence of the elastic move of the pins,
2. the axis of the linear bearings-pins is rotated 20 mrad to the x-axis of the rotation-translation and the main translation stages,
3. the dowel pins are made movable by using linear bearings-pins, so that the pins can be moved down when the base-board is taken out of the jig,
4. introducing a master gauge which defines the location of the master pins and the dowel-pins, from which the locations of linear bearings in associated jigs are copied, even to the multiple sets of jigs required for parallel operation of module assembly,
5. introducing a detector pre-alignment fixture, which eases the detector handling in an open space, simplifies the top table of the rotation stage which allows to make the assembly station concise,
6. use of disposable clean-room paper, which is porous enough to transmit vacuum, on the surface of the jigs where a detector touches, which is a common practice in a detector vendor.

The rotation-translation stage of the assembly station is shown in Figure 4, where detectors are vacuum-chucked on the rotation tables. Descriptions of the jigs are given in the next section. Most part of the jigs are made of an aluminium alloy, except the master gauge which is made of a steel alloy.

C. Jig description

1) Assembly station

An overview of the assembly station is shown in Figure 5, where the main components are a microscope-based rotation-translation stage and a video screen to display the view of the microscope. The assembly station is made of two blocks of stages: the main xy stage, x1 and y1, and an unit of rotation-translation stage, y2, x2, θ1 and θ2. The sequence of the motion stages are, from the top,

1. θ1 and θ2 -- rotation stages of two detectors, manually driven,
2. x2 -- small x-axis translation stage, manually driven,
3. y2 -- small y-axis translation stage, manually driven,
4. y1 -- main y-axis translation stage, motorized,
5. x1 -- main x-axis translation stage, motorized.

The main xy stage and the microscope unit can be any of existing equipment as long as the precision fulfils requirement. The small rotation-translation stage is a specific for the detector-baseboard alignment purpose.

The rotation-translation stage of the assembly station has linear bearings for holding master pins for the detector transfer plates. The axis of the linear bearings is rotated 20 mrad to the x-axis of the rotation-translation stage and of the main xy stage. The setting of the 20 mrad axis is described in the section of rotation-translation stage setting.

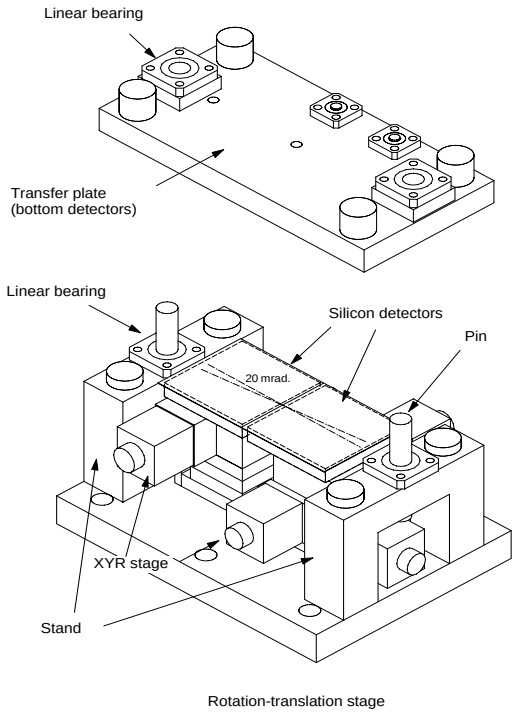


Figure 2: Conceptual view of the second version module assembly jigs

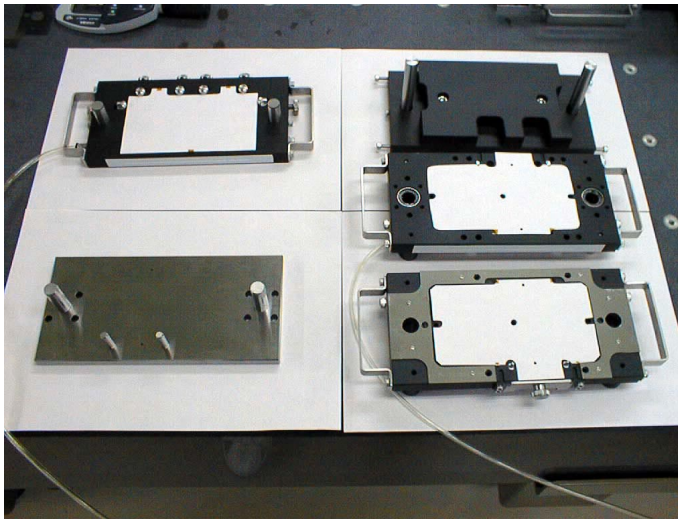
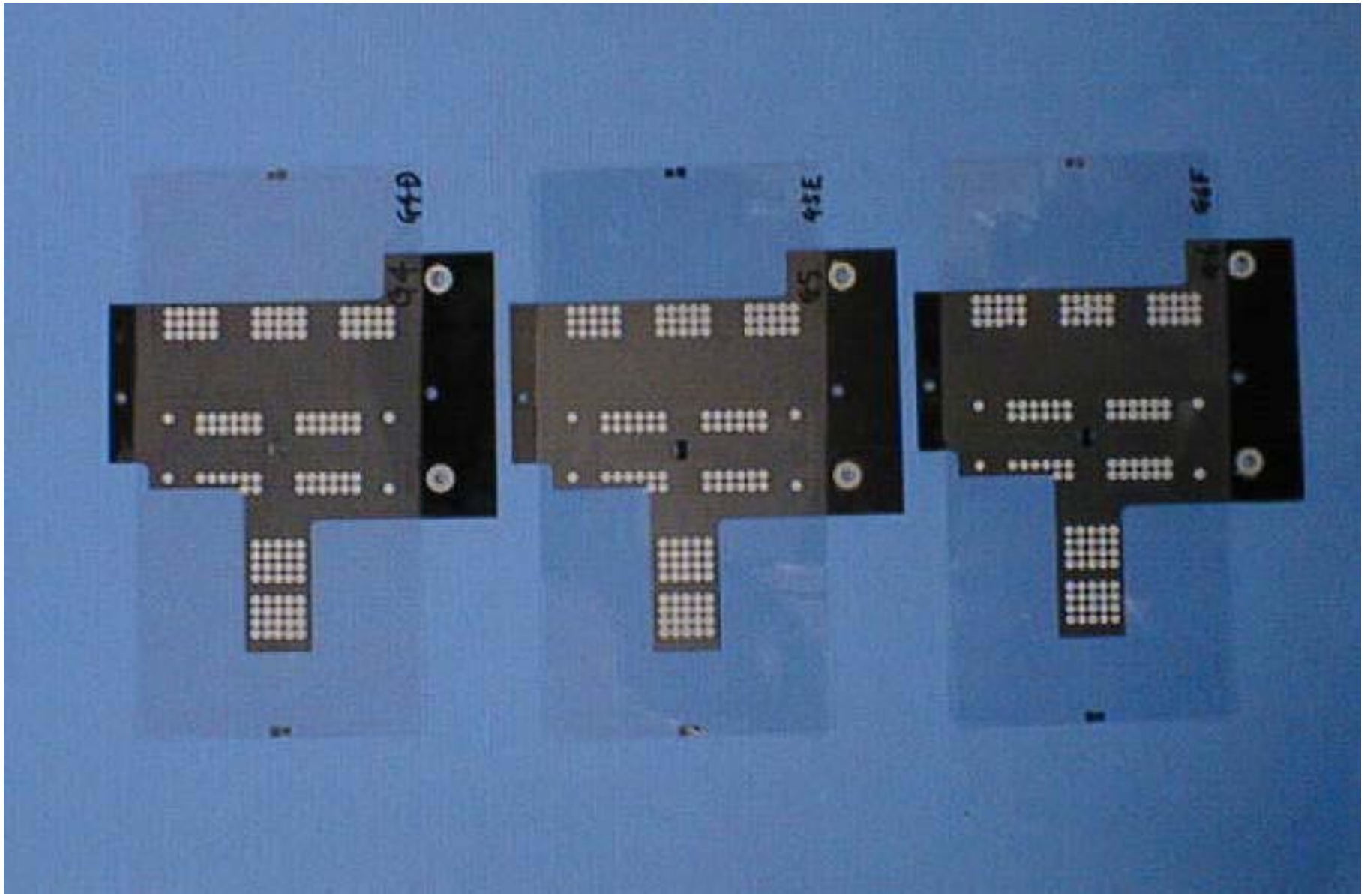
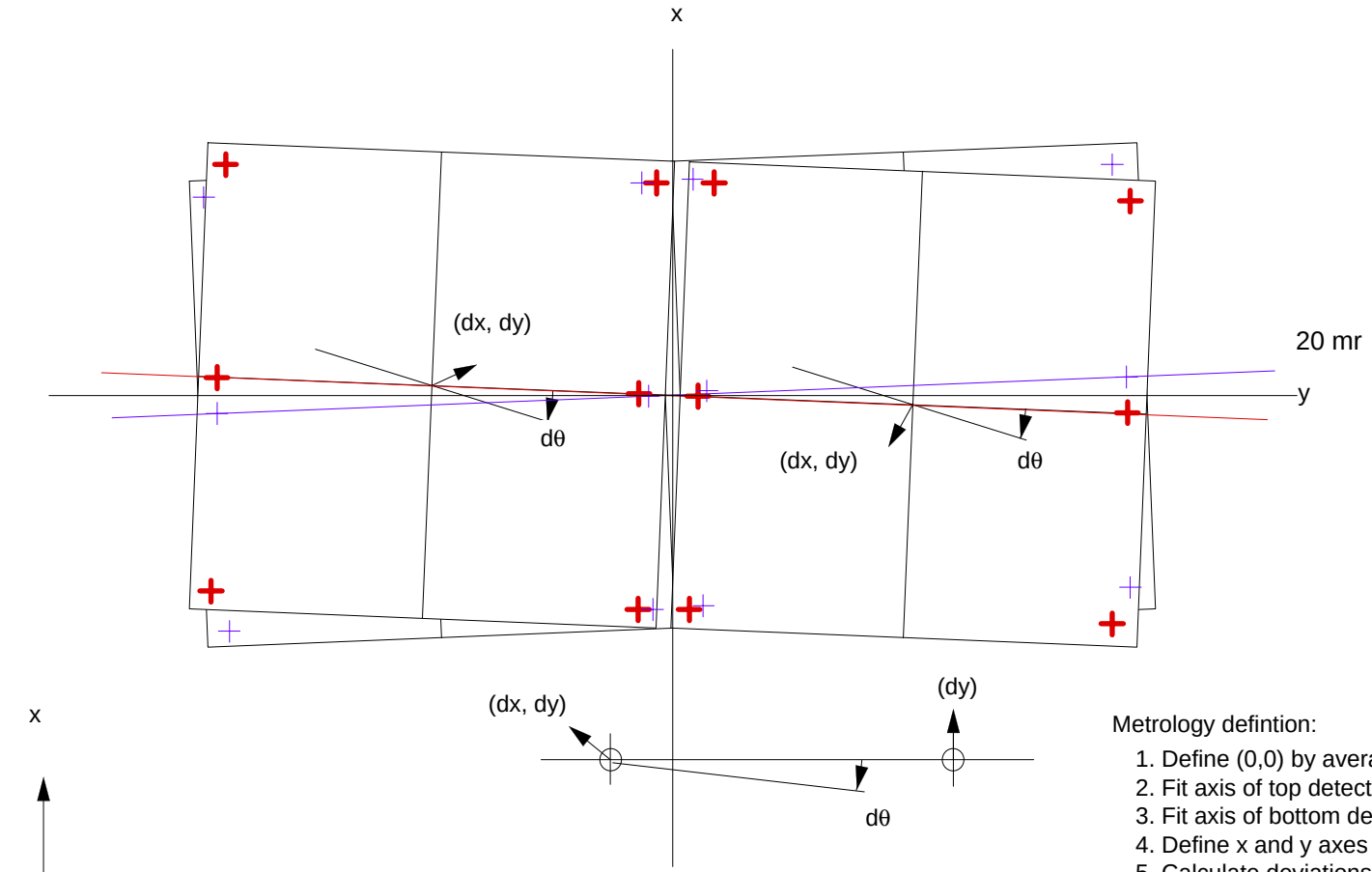


Figure 3: Overview of the second version barrel module assembly jigs: Master gauge (bottom-left), Detector pre-alignment fixture (top-left), Bottom fixture (top-right), Bottom detector transfer plate (bottom-right), and Top detector transfer plate (middle-right)



PROJECTION

ISSUE DATE 99/9/20



Metrology defintion:

1. Define (0,0) by averaging all fiducials
2. Fit axis of top detectors
3. Fit axis of bottom detectors
4. Define x and y axes from the fit axes
5. Calculate deviations from the ideal positions
6. Calculate abstracted deviations:
   - Centres and rotations of each detectors
   - Rotation of Dowel x-axis

ITEM NO.	TITLE	MATERIAL	QUANTITY	REMARKS

DESIGNED Y. Unno	SCALE	TITLE Module metrology	
DRAWN			
CHECKED	PAPER SIZE A4	DRAWING NO. MM990920-1013A	

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Metrology results

- **Precision of detector alignment**

  - Two fiducial marks along the axis per detector

- **dx, dy, dθ's of the centres of all four detectors**

  - Extremes of the samples (Spec?)

  - dx: centre ~ 0 μm, width ~ +- 3 μm (+-5 μm?)

  - dy: centre ~ 0 μm, width ~ +- 4 μm (+-5 μm?)

  - dθ: centre ~ 0.01 mrad, width ~ +- 0.04 mrad (+- 0.08 mr?)

- **dx, dy's of individual fiducials**

  - dx: very good

  - dy: no sudden jump of two detectors, well in the straight lines

  - There is a (very) small offset of angle, which is also seen in the above

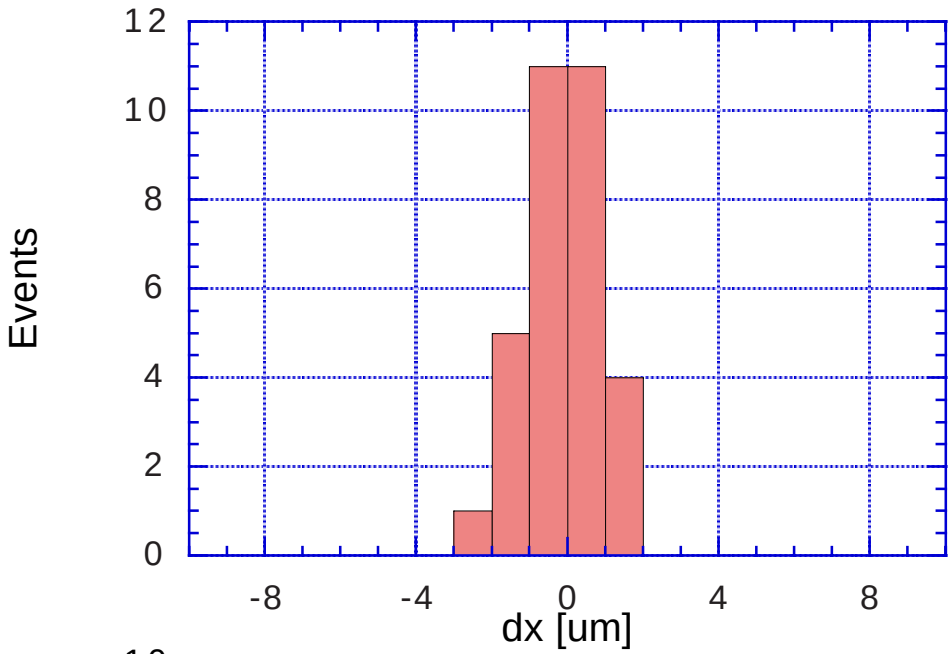
- **Dowel hole and slot**

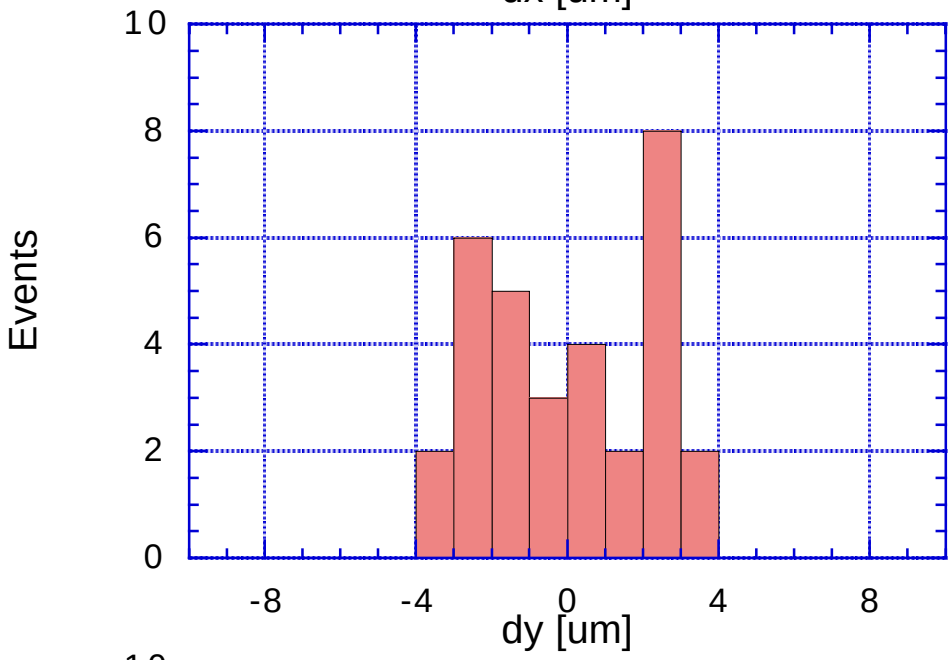
  - dx: centre ~ 2 μm, width ~ +- 4 μm (+-20 μm?)

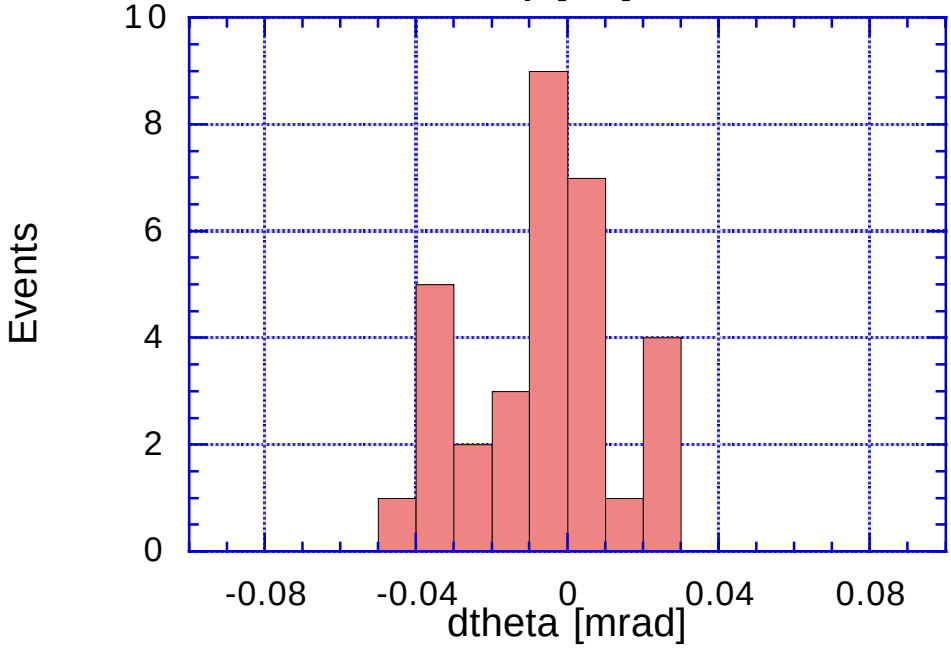
  - dy: centre ~ - 6 μm, width ~ +- 4 μm (+-20 μm?)

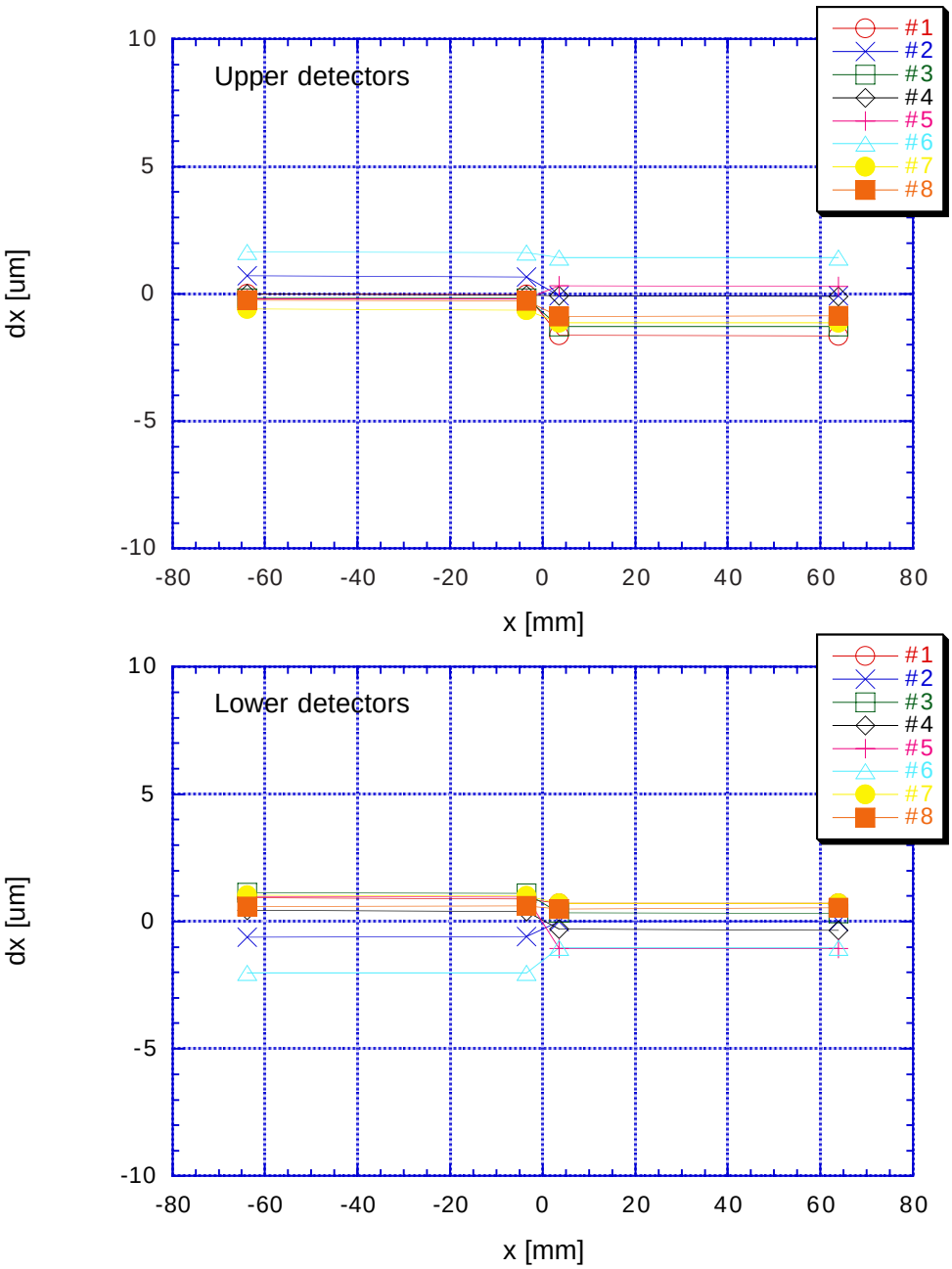
  - dθ: centre ~ 0.03 mrad, width +- 0.07 mrad (+-0.8 mrad?)

  - There were (small) offsets, which can be adjusted in the jig (if we know the offset beforehand)

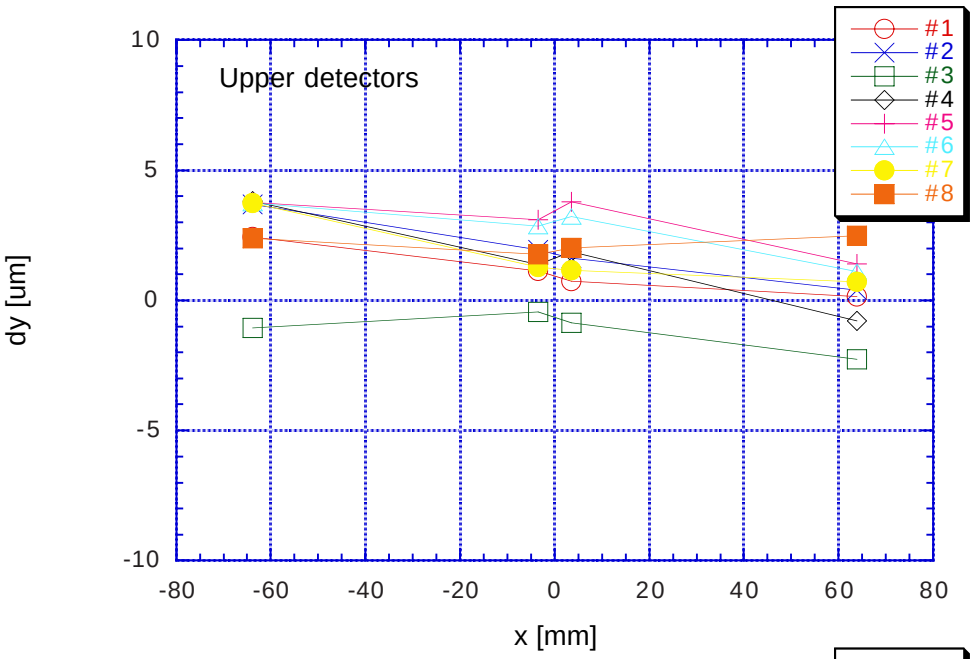

Events
12
10
8
6
4
2
0
-8
-4
0
4
8
dx [um]

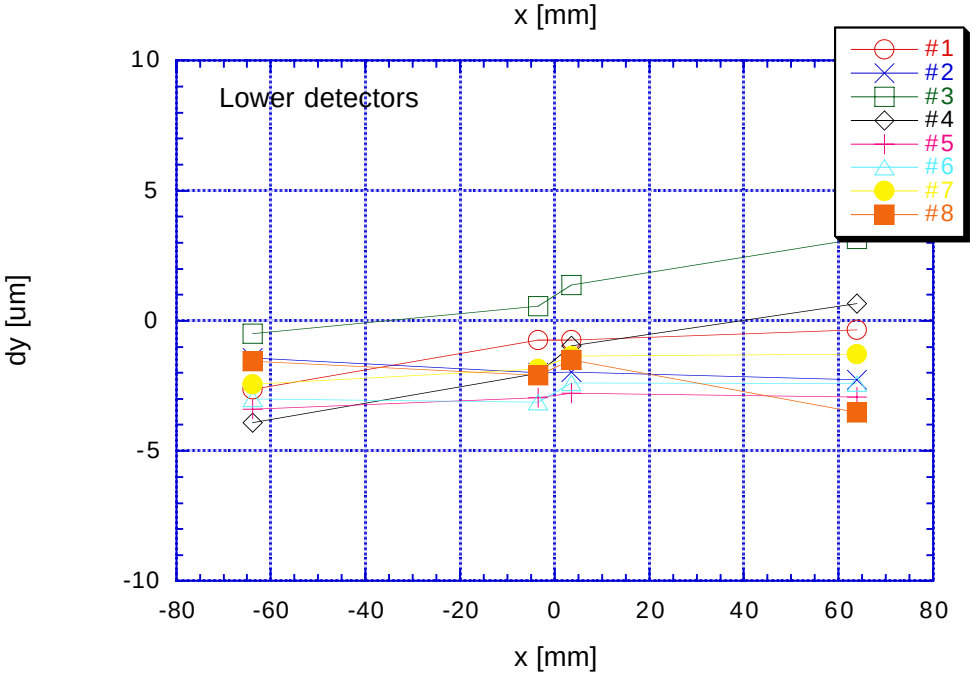

Events
10
8
6
4
2
0
-8
-4
0
4
8
dy [um]

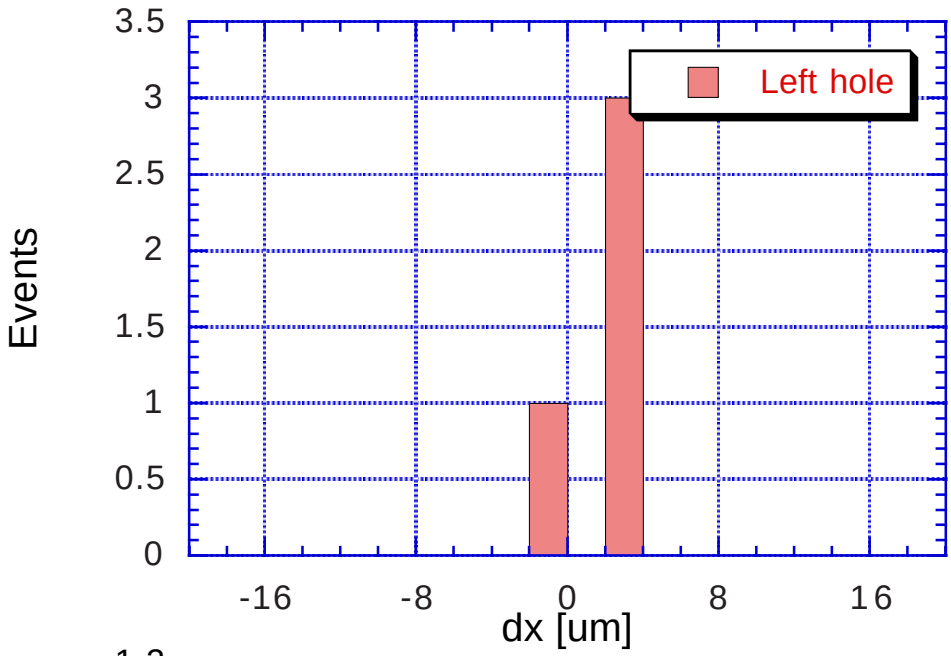

Events
10
8
6
4
2
0
-0.08
-0.04
0
0.04
0.08
dtheta [mrad]

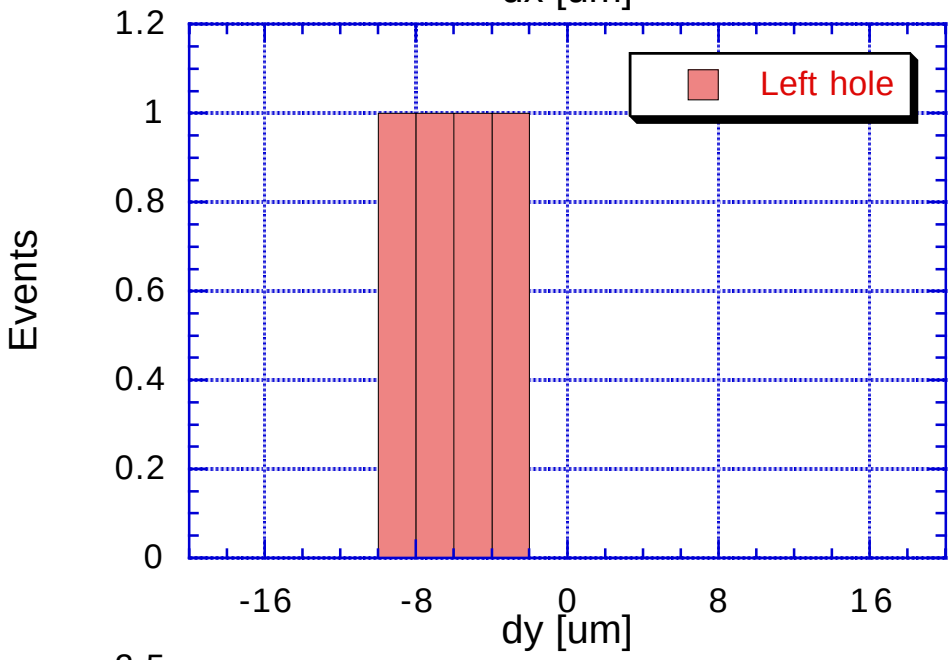

Upper detectors
#1
#2
#3
#4
#5
#6
#7
#8
dx [um]
x [mm]
10
5
0
-5
-10
-80
-60
-40
-20
0
20
40
60
80

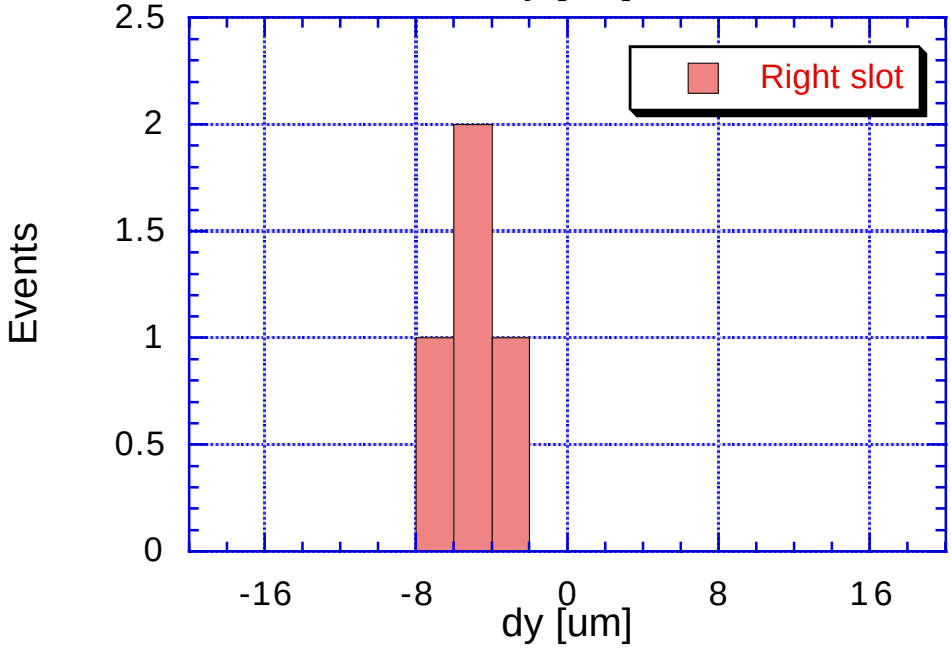
Lower detectors
#1
#2
#3
#4
#5
#6
#7
#8
dx [um]
x [mm]
10
5
0
-5
-10
-80
-60
-40
-20
0
20
40
60
80

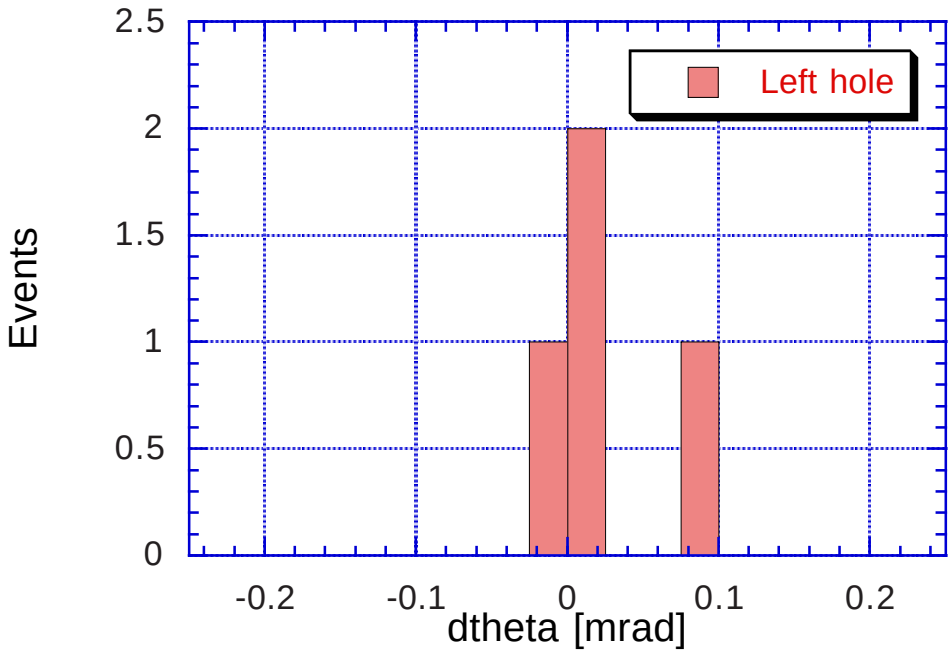

Upper detectors
#1
#2
#3
#4
#5
#6
#7
#8
10
5
0
-5
-10
-80
-60
-40
-20
0
20
40
60
80
dy [um]
x [mm]


Lower detectors
#1
#2
#3
#4
#5
#6
#7
#8
10
5
0
-5
-10
-80
-60
-40
-20
0
20
40
60
80
dy [um]
x [mm]


Left hole
Events
dx [um]
3.5
3
2.5
2
1.5
1
0.5
0
-16
-8
0
8
16


Left hole
Events
dy [um]
1.2
1
0.8
0.6
0.4
0.2
0
-16
-8
0
8
16


Right slot
Events
dy [um]
2.5
2
1.5
1
0.5
0
-16
-8
0
8
16


Left hole
Events
dtheta [mrad]
2.5
2
1.5
1
0.5
0
-0.2
-0.1
0
0.1
0.2

Improvement to the assembly station

- **Two microscopes**

  - With one microscope, the stage must be moved back-and-forth in the x axis to adjust the detectors, which was tedious and concerned to introduce error

  - With TWO microscopes, which are observing the fiducial marks simultaneously, no need to move the large x span

  - Photo of an overall view

  - Photo of an close-up view

  - Photo of the vacuum chuck jigs

- **Status**

  - Microscopes are set and ready

  - Assembly of multiple mechanical modules is to come soon

Plan for the future

- **Introduction of a pattern recognition capability**
  - **Hardware and software from industry**
  - **Default pattern recognition: Oval fitting**
- **Assessment of the need of the automated control**
  - **Two microscopes, 20 mrad offset rotation stage, preset jig, ...**
  - **Experience will tell us whether we still need the automation**
- **Then, fabricate the assembly station for the production**
  - **Production assembly station(s)**
  - **Production assembly jig(s)**