Automated emulsion scanning for double-hyper nuclei experiment

(Beam pattern recognition on the emulsion plate)

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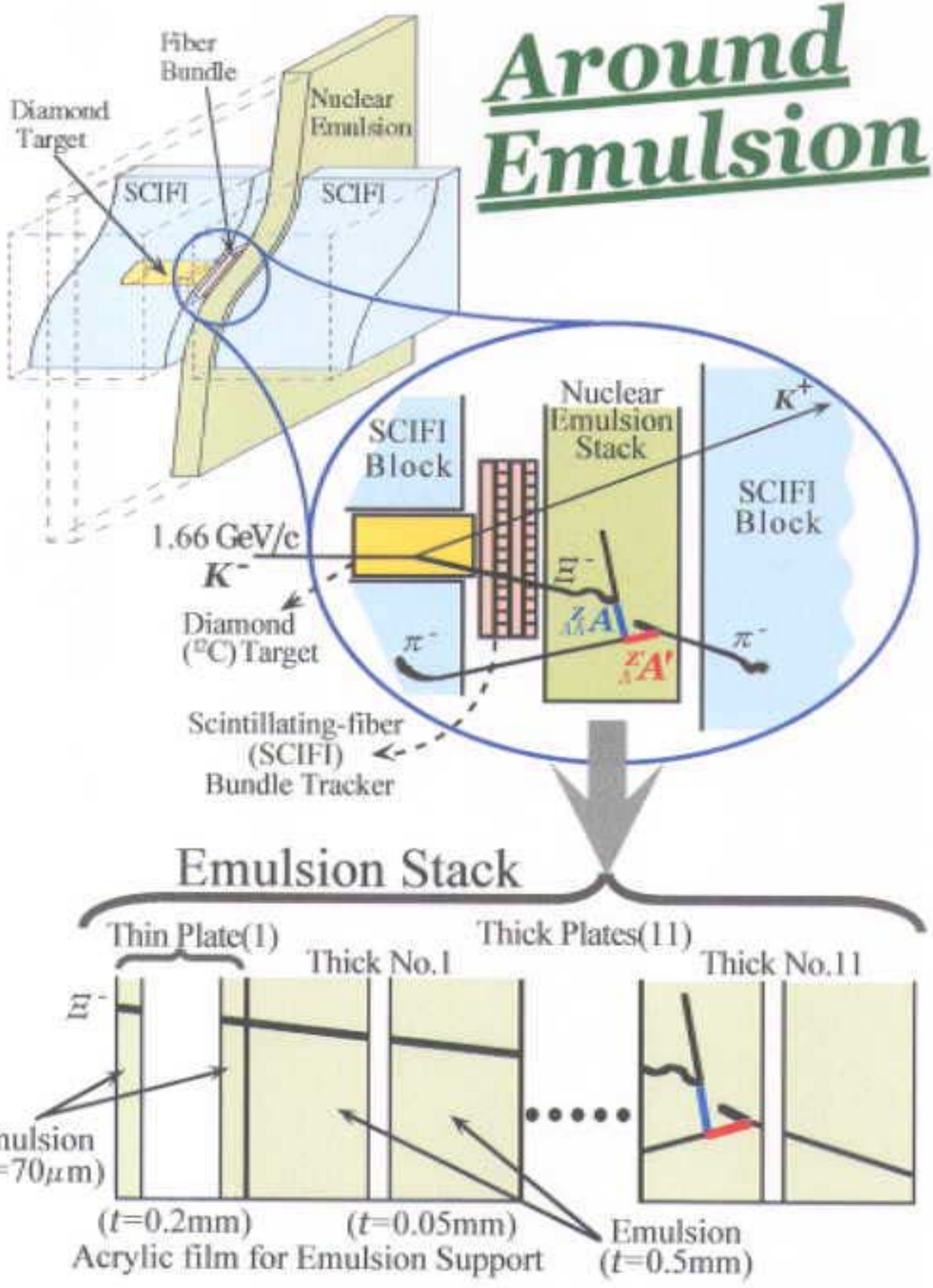
contents

1.Study of Double Strange Nuclei Emulsion-Scintillating fiber-Hybrid Method (PS-E373) Experiment

- A hybrid emulsion experiment KEK-PS E373 was carried out to study double strangeness nuclei produced via Ξ^- hyperon capture at rest

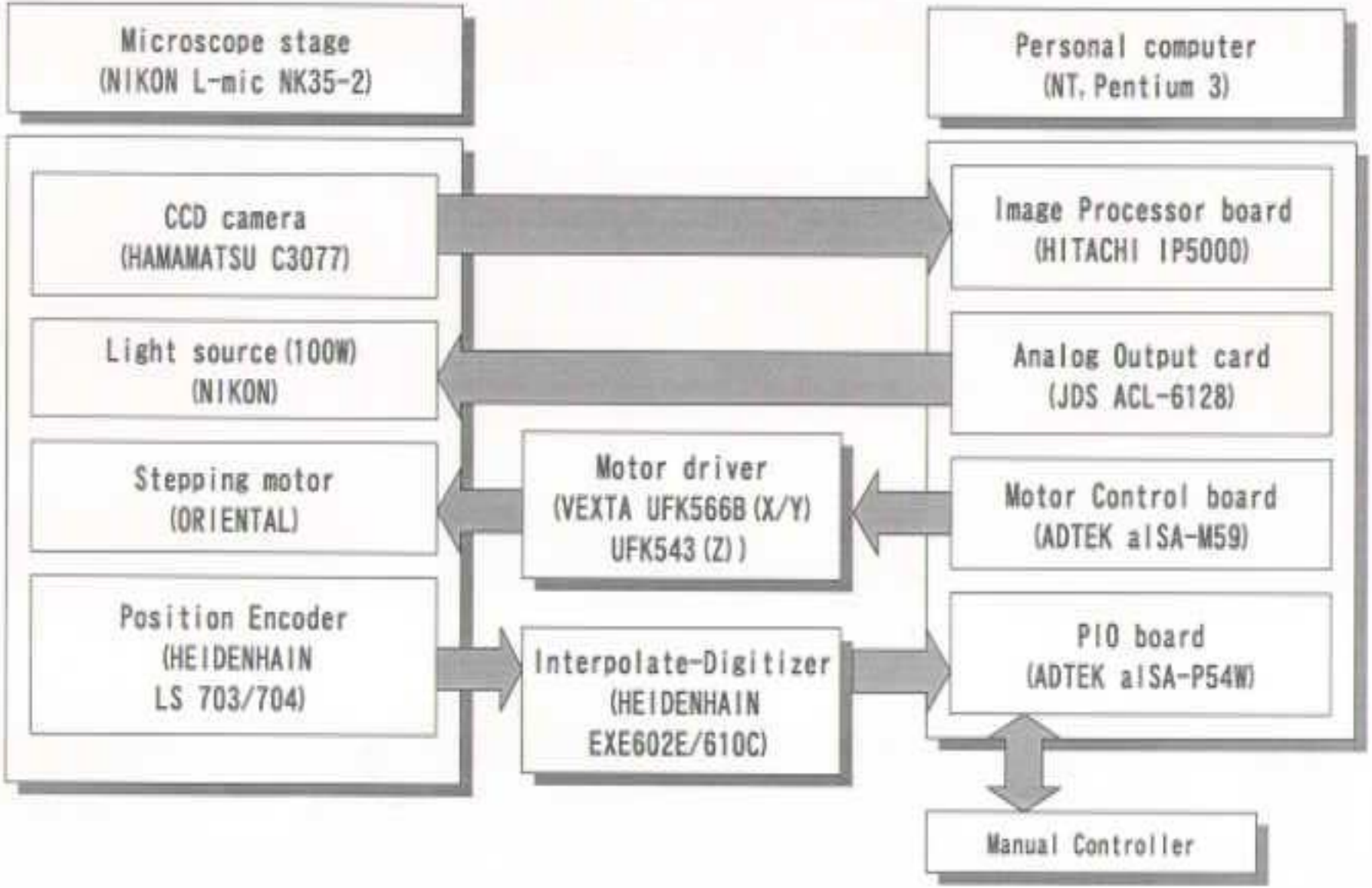
Around Emulsion



2. Auto stage Scanning System used in PS-E373

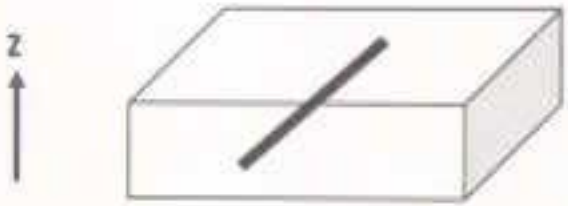
picture of scanning stage in gifu University

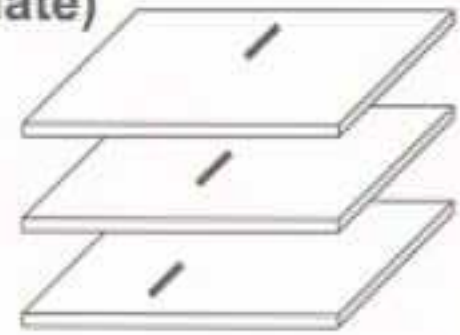
2.1 Hardware configuration



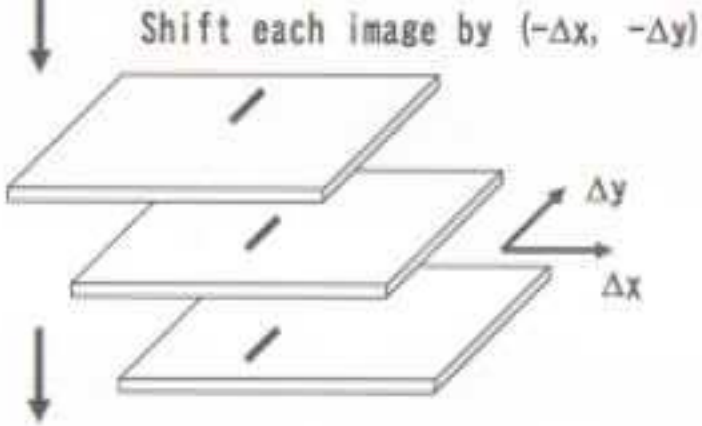
2.1.1 Concept of the track finding method

- Take pictures at different z(focusing) position
  (z : perpendicular to the emulsion plate)





1) Brightness adjustment
2) Recognition of gel position
3) Measurement of the grid mark
4) Acquisition of picture
5) Track finding



•Make superimposed image

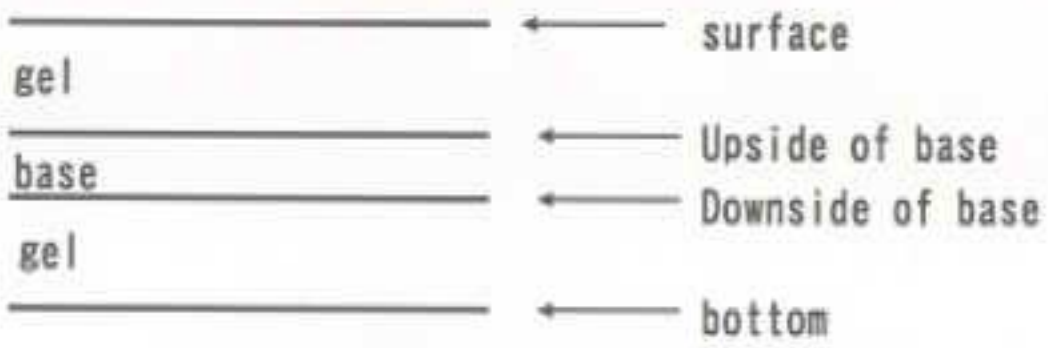
1) Brightness adjustment

- Transparency of the emulsion is different in different plate and different positions in the same plate
- The brightness and the voltage obey fallowing relation approximately

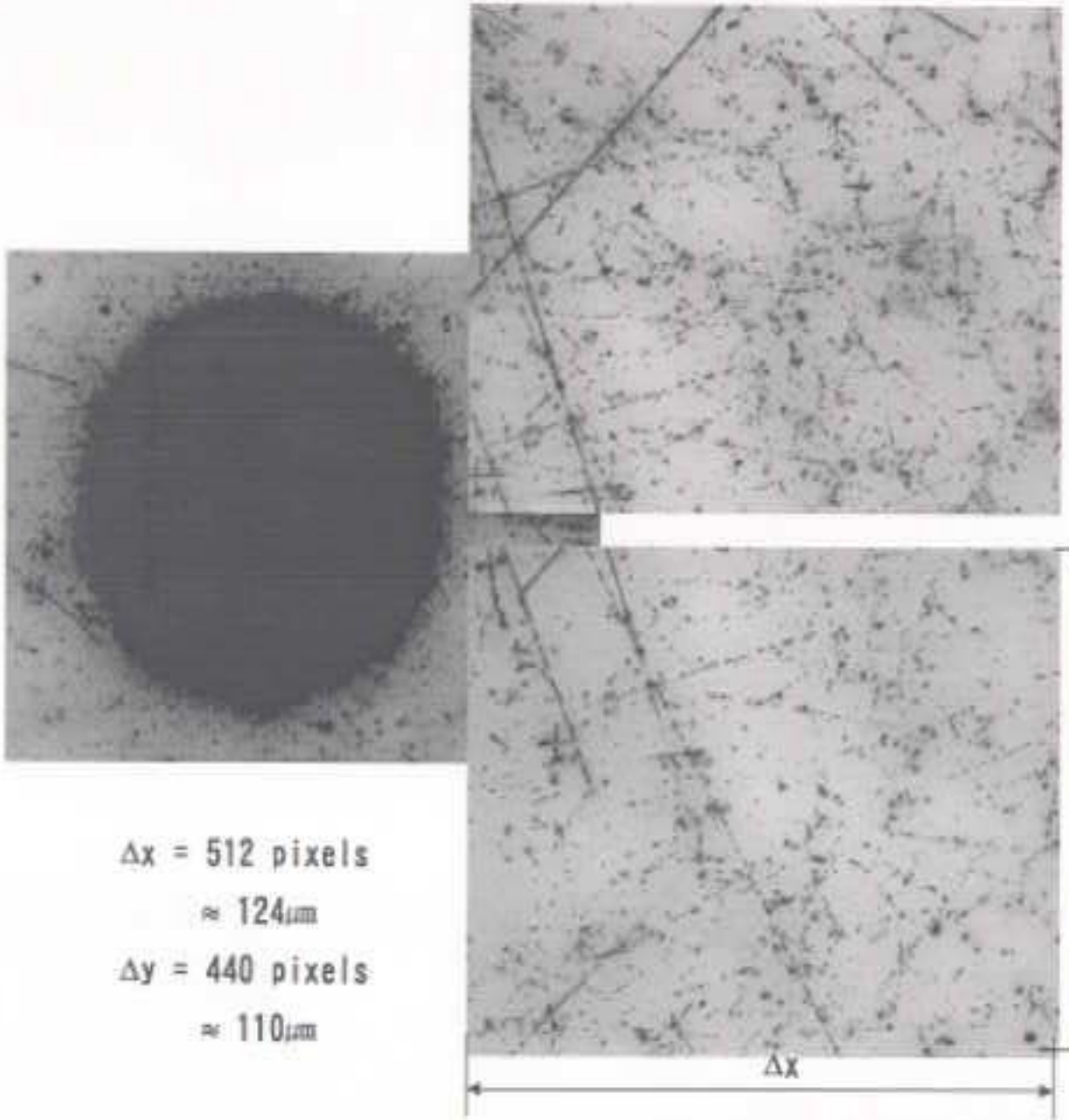
$$(\text{brightness}) = a \times \log(\text{voltage}) + b$$

2) Recognition of gel position

- measure the position of the four place



3) Measurement of the grid mark position



√ Predicted position of track
Before checking the grid mark
(x = -31.482, y = -17.784)

√ Predicted position of track
After checking the grid mark
(x = -31.466, -17.7359)

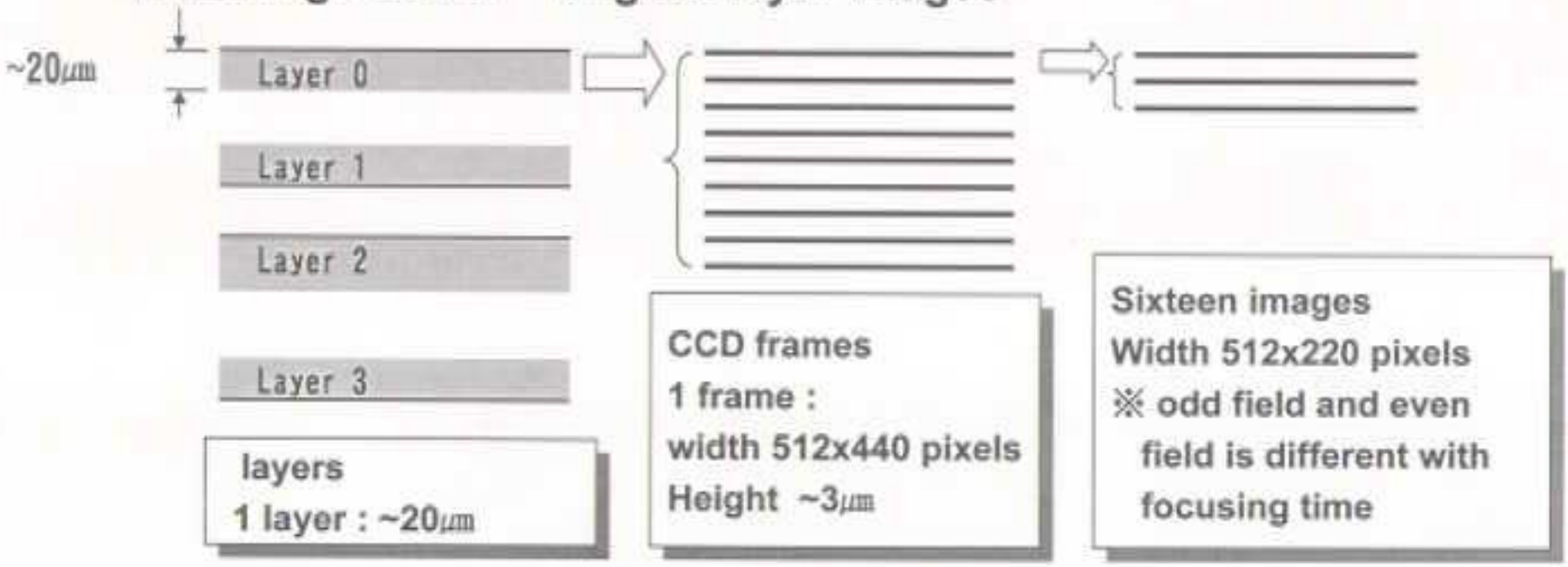
√ position of track After scan
(x = -31.4533, y = -17.7359)

Δx = 512 pixels
≈ 124㎛
Δy = 440 pixels
≈ 110㎛

4) Acquisition of pictures

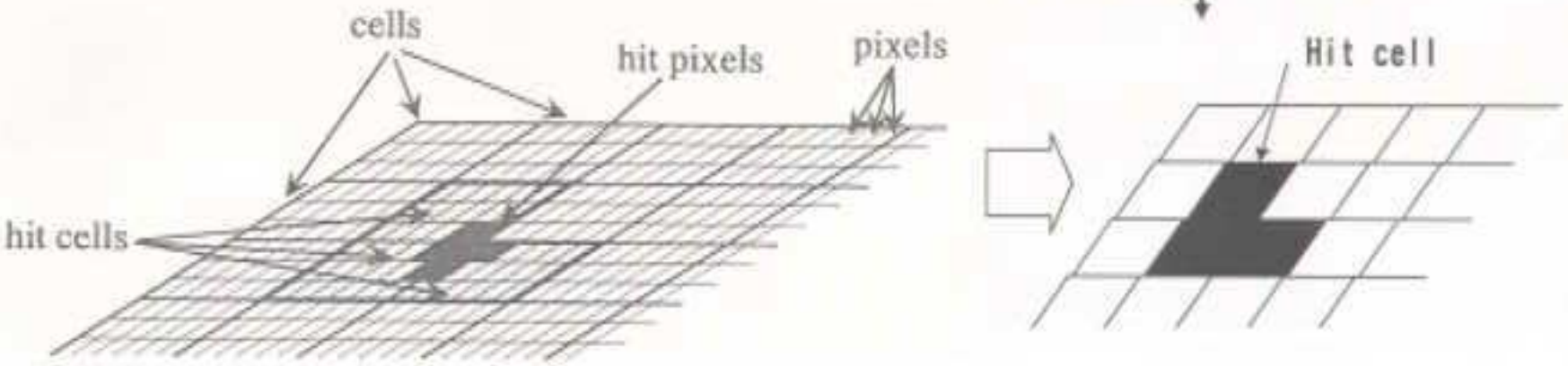
- To acquire eight CCD frames from CCD camera (240 ns)
- Get sixteen images as dividing odd field and even field
- To change images

  (• gray reverse • subtract the gray value of pixel by some value)
- This image called " original layer images"



5) Track finding

1. Angular acceptance (tanθ) is the predicted value ±0.08
2. Binary images are made from original layer images by summing every 6(H)x3(V) pixels are cell ⟹ coarse layer images



3. Select the track candidate using the principal of the Superimposed image

   The number of hitting cells ≥ threshold → track candidate

   < threshold → reject

4. Clustering to decide the size and central position of the track candidate

   >> using the "original frame images" again

5. Person check the track candidate(s) to decide whether accept as track or not

Correction the local grid coordinates

- The relative position between the plate 1 and the plate 2 was determined with the X-ray marks at the four corners of the plates
- From plate2 to plate 12 : determined by connecting tracks of charged particles in two successive plates.

  √ tracks are searched for in the angular acceptance of 0.3(tanθ) in the upstream plate, manually.

  √ three tracks are selected at every four corners of the plate

  √ the tracks are searched for in the just downstream plate automatically.

  √ By checking the position relation between these tree tracks, the real tracks are selected among the several candidates at each corner

2) Relative position of local grid marks between the plates

(1) select the three track in one position in previous plate manually doing this four plan

(2) searching those tracks in the next plate automatically

(3) save the offset value (offset_2) between the local and global grid coordinates(= local grid coordinates of plate 2)

3) Scanning the emulsion

2.2 alignment of a track

After beam exposure on emulsion

1) Make the grid marks on the each plate using by negative film

   >> 23x23 grid mark

2) Development the emulsion

3) Scanning emulsion

The precedent work before scanning emulsion plate

1) Measure the grid marks by 11x11 for correct the distortion during development

   (1) compare the negative film grid mark position (called original grid coordinates) and measured local grid marks

   (2) save the offset value between the original and local coordinates(-> offset_1)

1) Make the grid marks on the each plate using by negative film

   * 23x23 grid mark

2) Development the emulsion

3) Scanning emulsion

The precedent work before scanning emulsion plate

1) Measure the grid marks by 11x11 for correct the distortion during development

   (1) compare the negative film grid mark position (called original grid coordinates) and measured local grid marks

   (2) save the offset value between the original and local coordinates(-> offset_1)

Summary of searching track in E373 experiment

total module : 100 modules
module scanned (till now) : 31 modules
number of scanned track : 12160

- Result

  >> Two twin Λ hyper nuclei event

  >> Two double-Λ hyper nucleus

NAGARA event

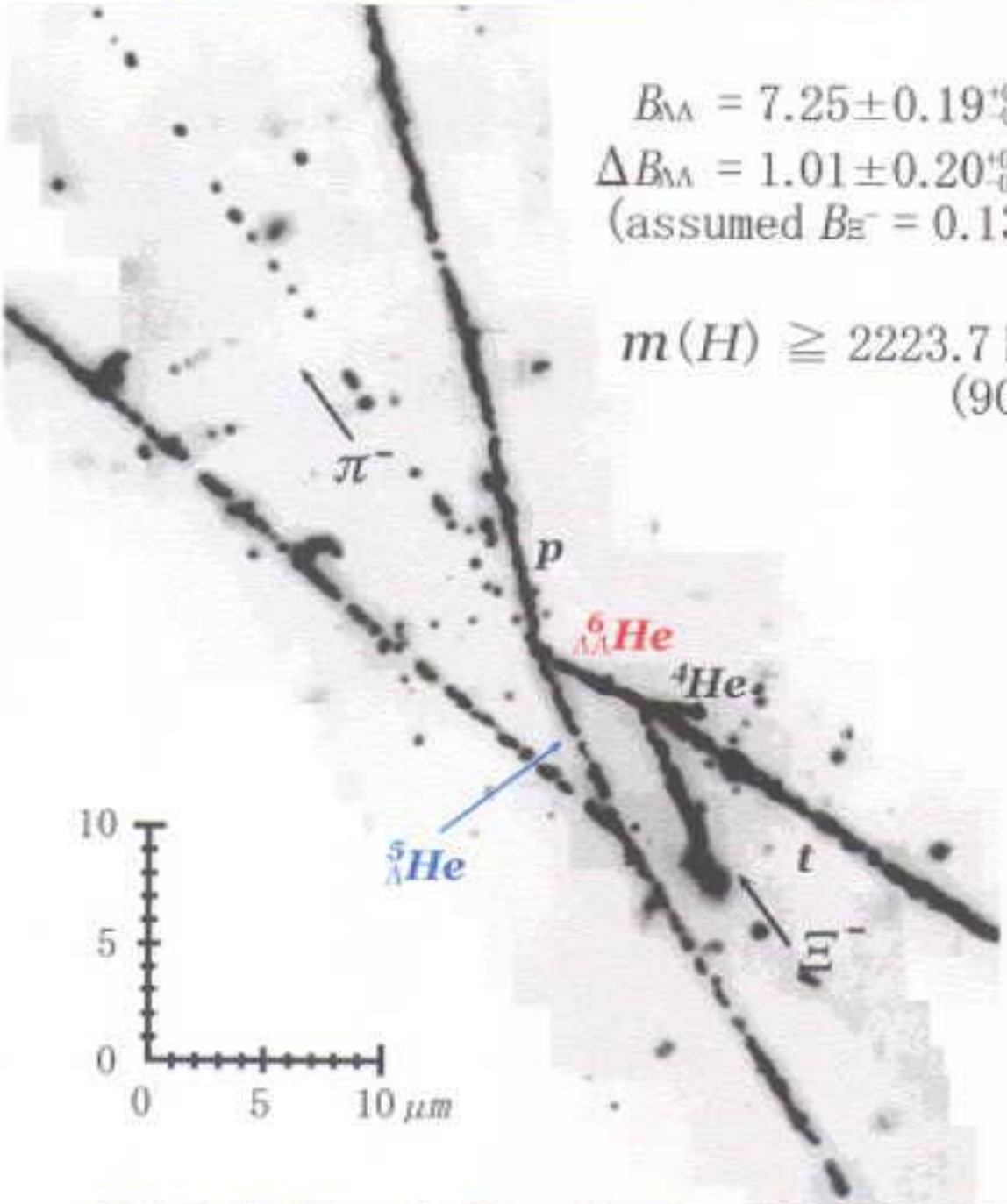
Mar. 9. 2002

${}^{6}_{\Lambda\Lambda}$He double-hypernucleus

Unique interpretation!!

$$\Xi^- + {}^{12}\mathrm{C} \longrightarrow {}^{6}_{\Lambda\Lambda}\mathrm{He} + {}^{4}\mathrm{He} + t$$

$$ {}^{6}_{\Lambda\Lambda}\mathrm{He} \longrightarrow {}^{5}_{\Lambda}\mathrm{He} + p + \pi^-$$



$B_{\Lambda\Lambda} = 7.25 \pm 0.19^{+0.18}_{-0.11}$ MeV

$\Delta B_{\Lambda\Lambda} = 1.01 \pm 0.20^{+0.18}_{-0.11}$ MeV

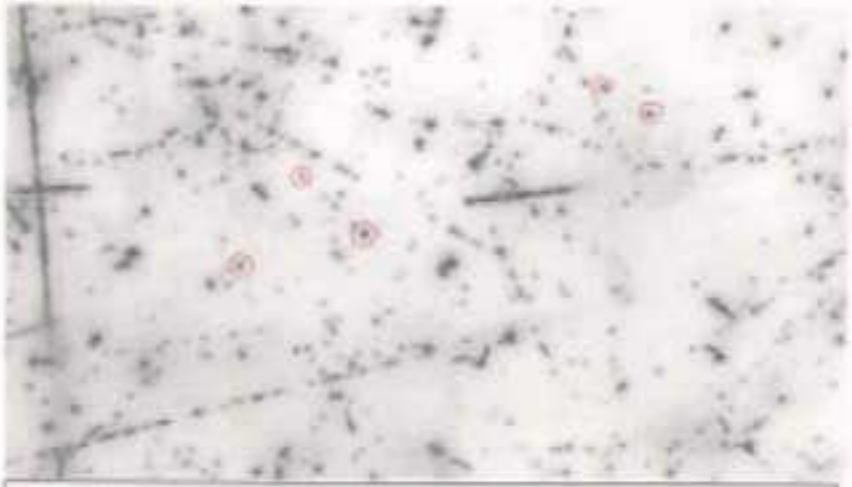
(assumed $B_{\Xi^-} = 0.13$ MeV)

$m(H) \geqq 2223.7$ MeV/c^2

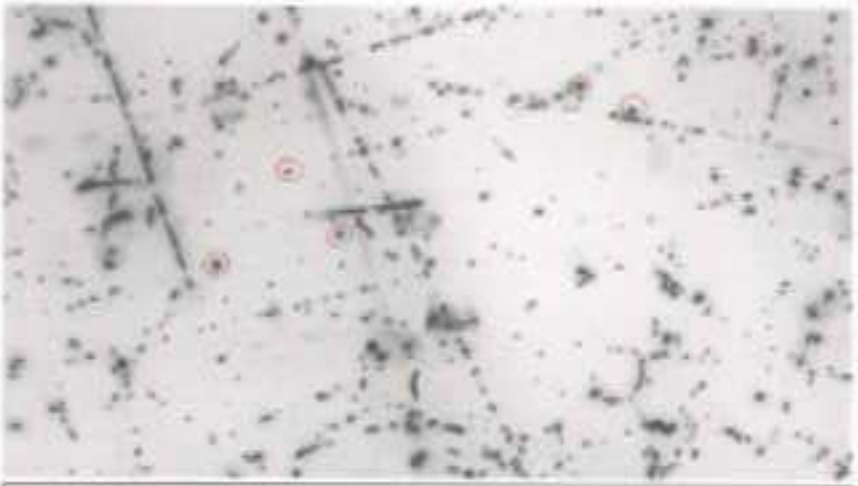
(90% C.L.)

H.Takahashi et al., Phys. Rev. Lett. 87, 212502(2001)

3. An attempt to increasing the scanning efficiency using the beam pattern



•Previous plate (ex: plate 9)



•Next plate (ex: plate 10)

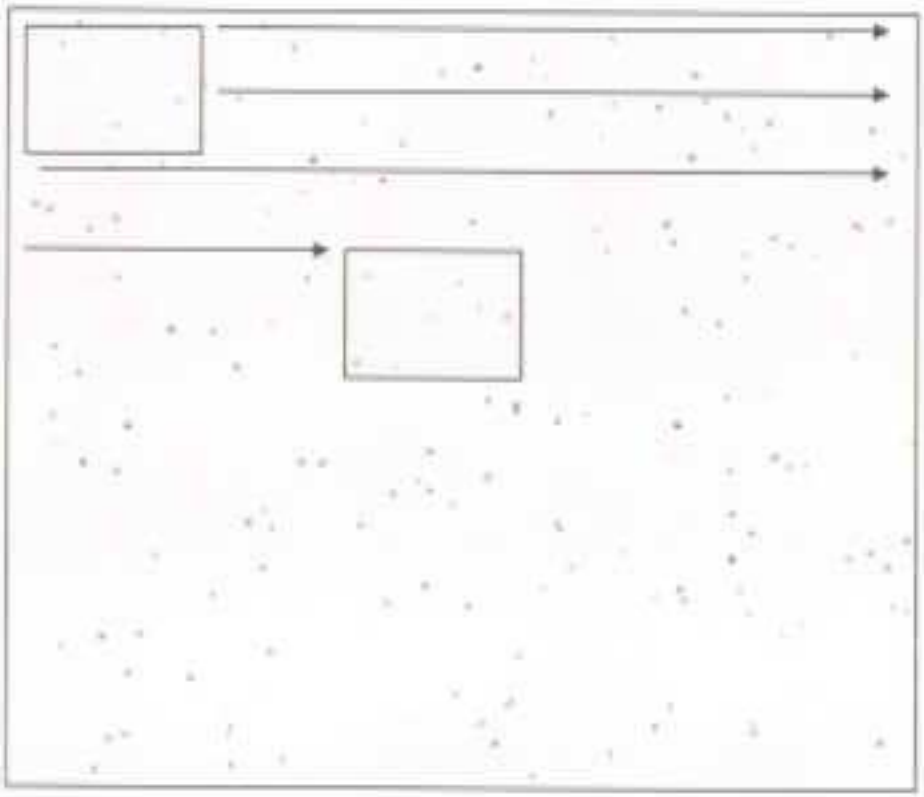
- Group A : changed the positions
- Group B : seldom changed the positions
- If we can get the beams' pattern, we will predict the position of track much correctly

3.1 general idea

3.2 selecting beams

3.3 matching beams

Concept searching for a track using beam

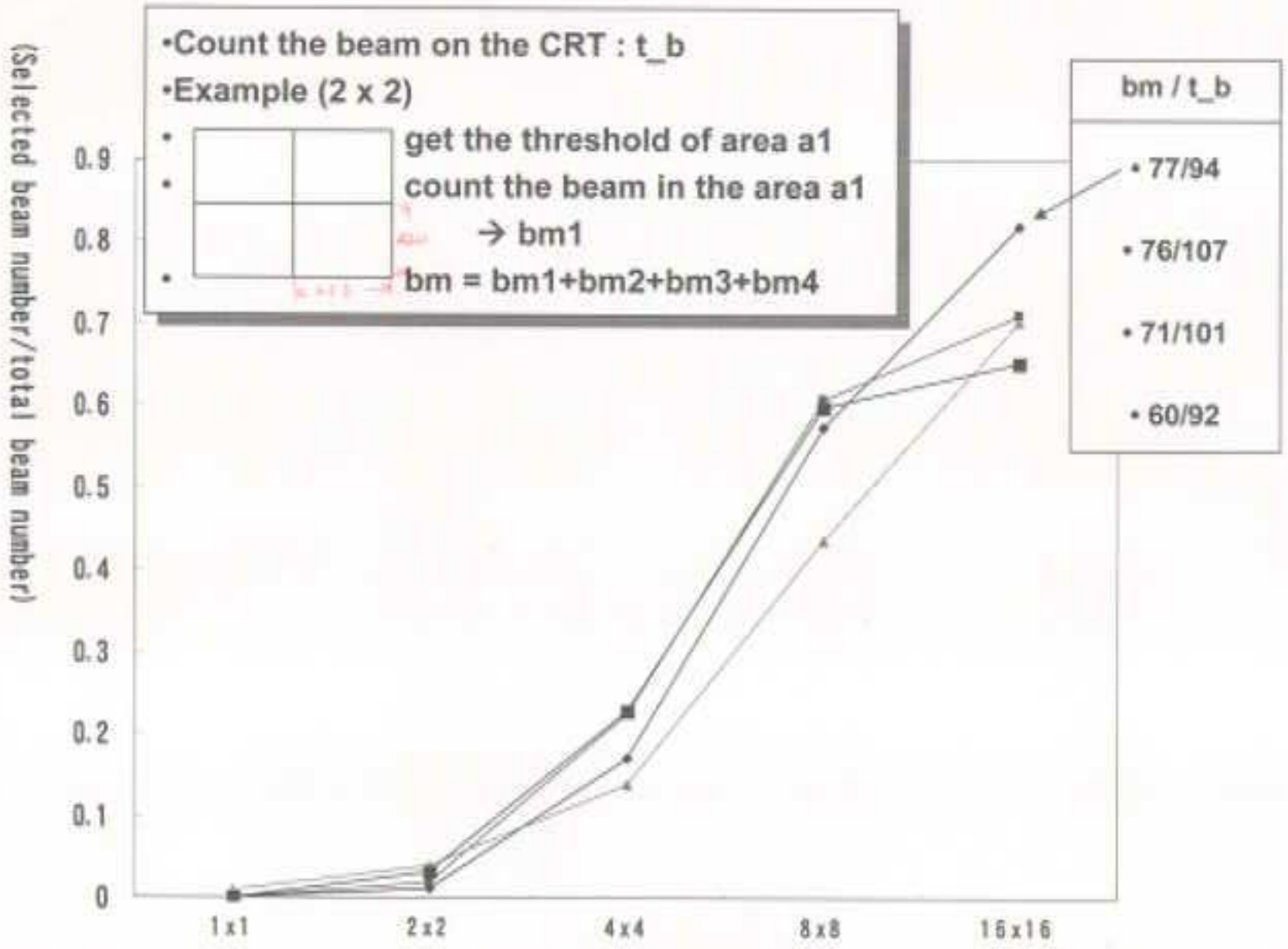


Beam gotten previous plate player 5

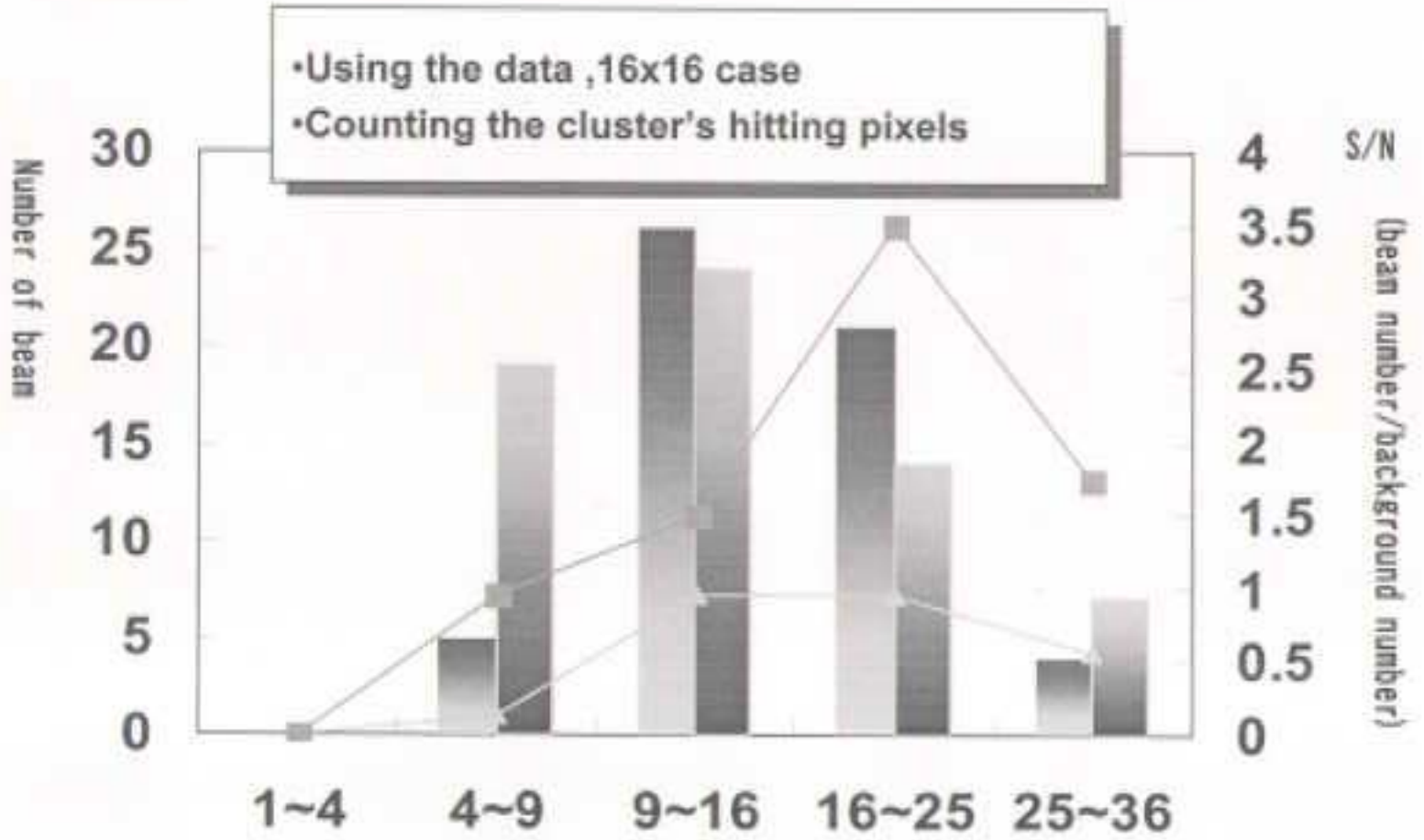
• Matching the beam pattern which was gotten at previous plate layer 5 and that of current scanning plate layer0

Beam gotten current scanning plate layer0

1) Consider just brightness of hitting points

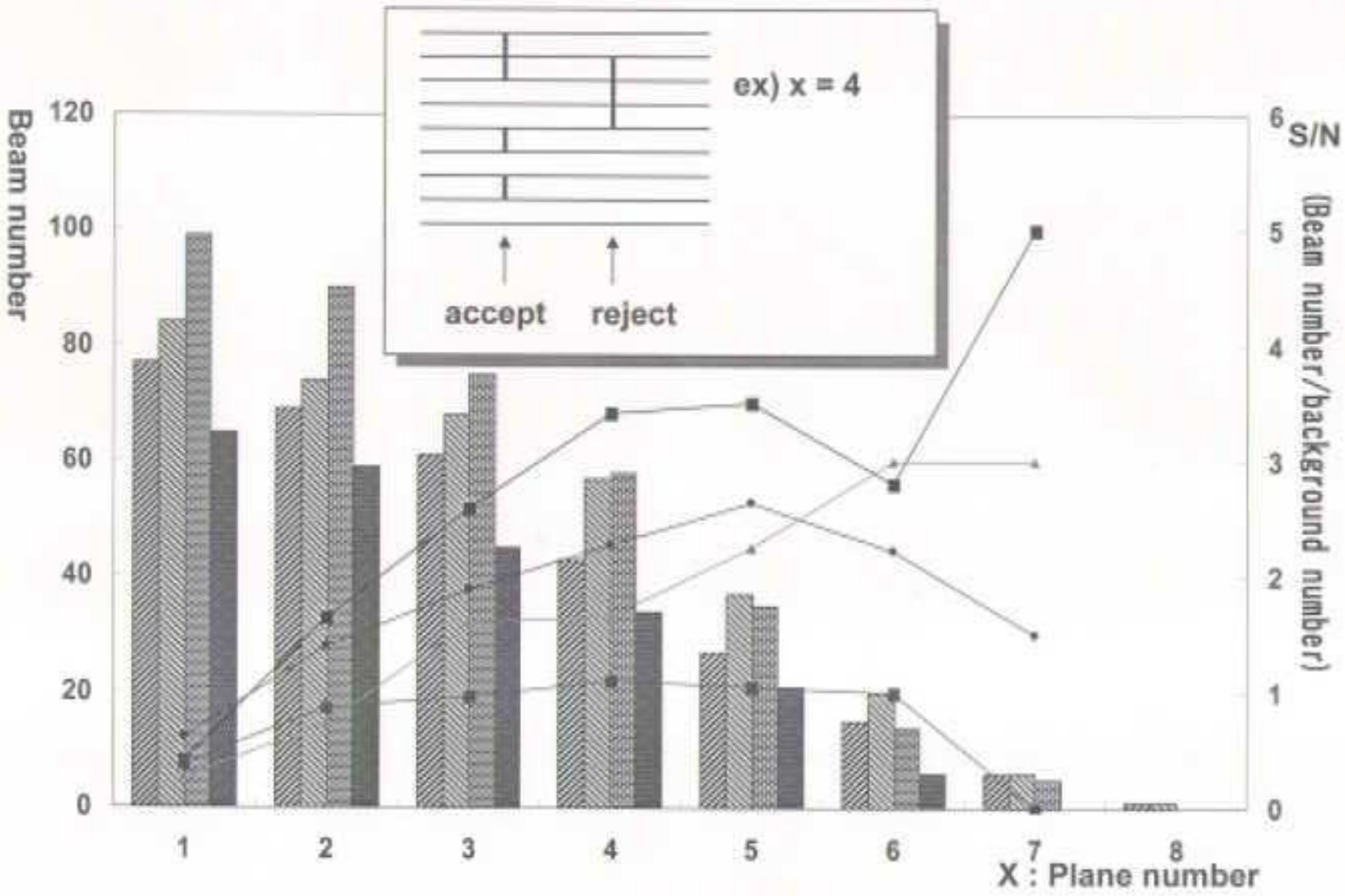


2) Consider the size of clusters

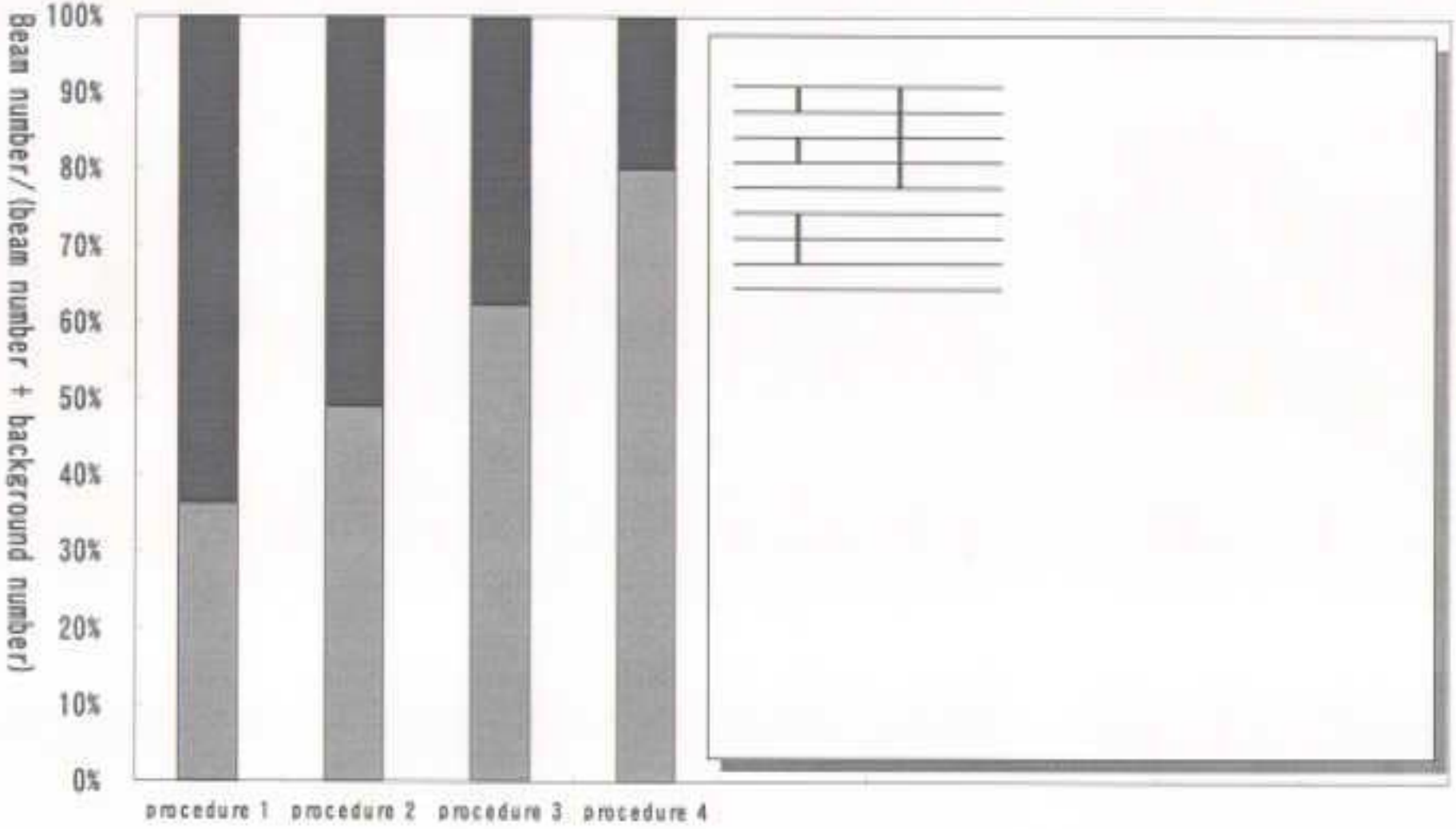


X axe : the size of the cluster (number of hitting pixels)

3) Consider how many planes(images) clusters is in?

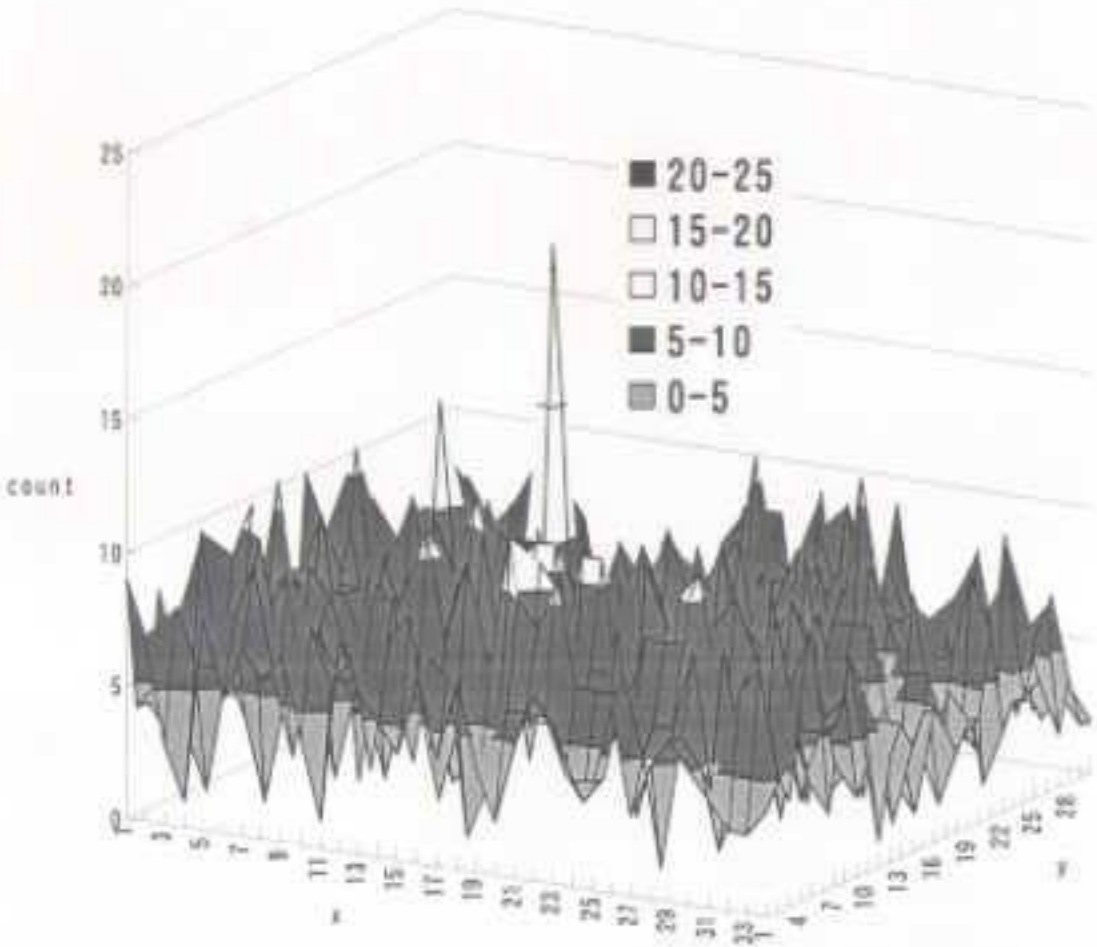


4) Reject the clusters which cannot be found on 3 planes successively and the compare



Matching the beam pattern

- This is just check the matching program – this is the previous result when we get eighty percentage



Summary of upgrade scanning system

- If we decrease the size of area predicted tracks position,
  → Increasing the scanning speed
  # current : predicted position – position found by scanning
  MEAN : 20.02 μm
  MAX : 609.10 μm (sample 100)

- Increasing emulsions in new experiment(BNL-E964)
  emulsion : ET-7D (Gel 2.4t)
  100 Double Hypernuclei event expected
  start : 2004 (if we can get financial support)