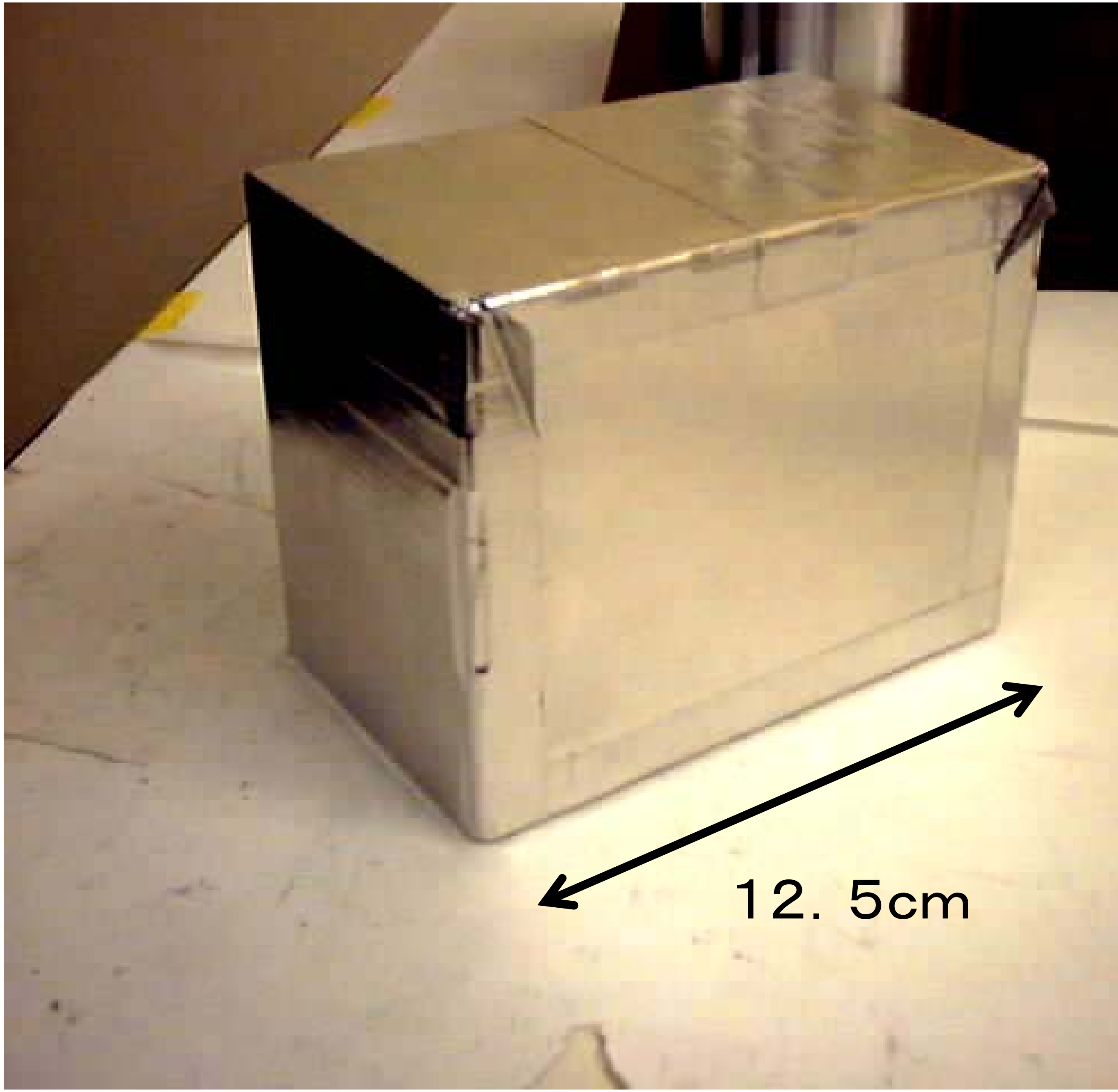
最新のEMULSION SCANNING

2007.3.17

名古屋大学　中野敏行

ECC Brick



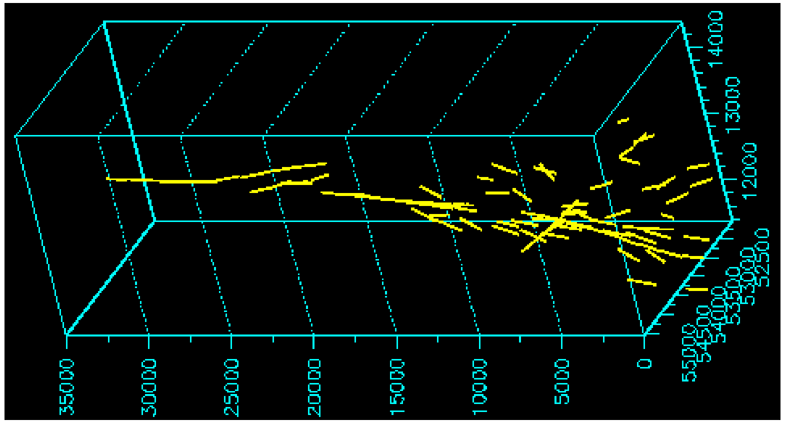
- トラッキング
  Sub-micron
- 運動量
  MCS:~10Gev/c
- e-ID, γ detection
  Shower, e-pair
- dE/dx

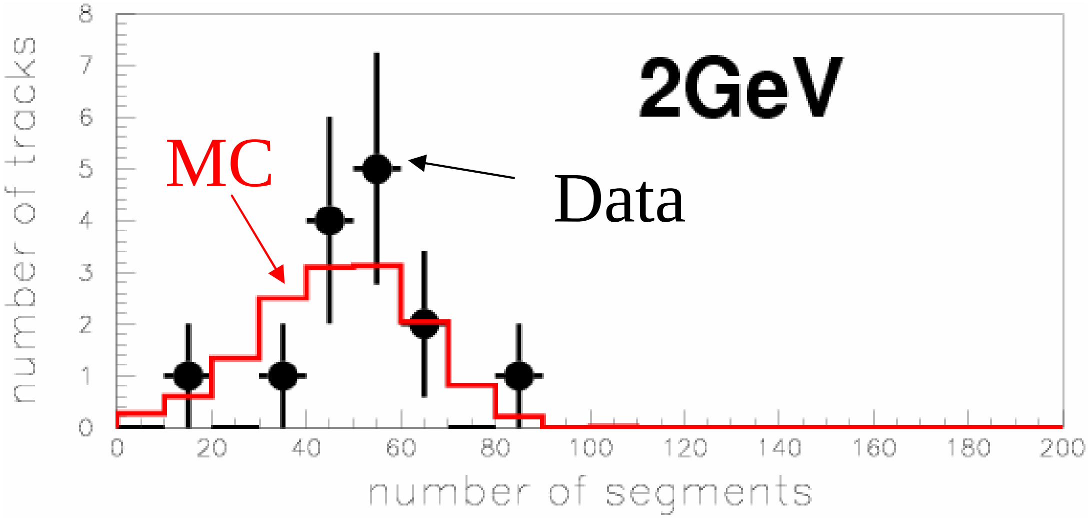
ニュートリノの同定

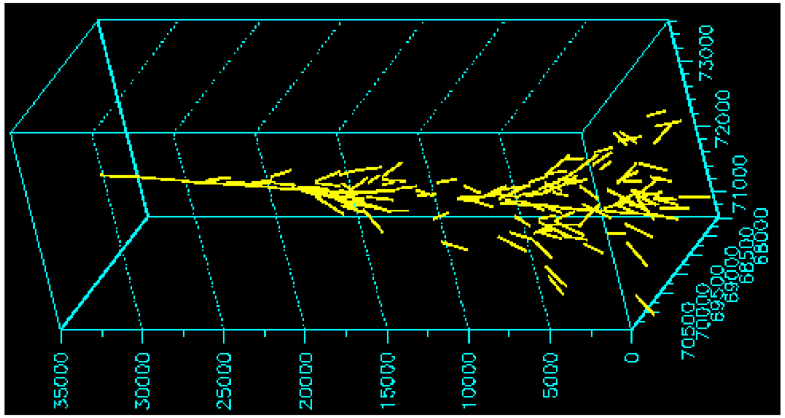
DONUT, OPERA, PEANUT, (E531, CHORUS)

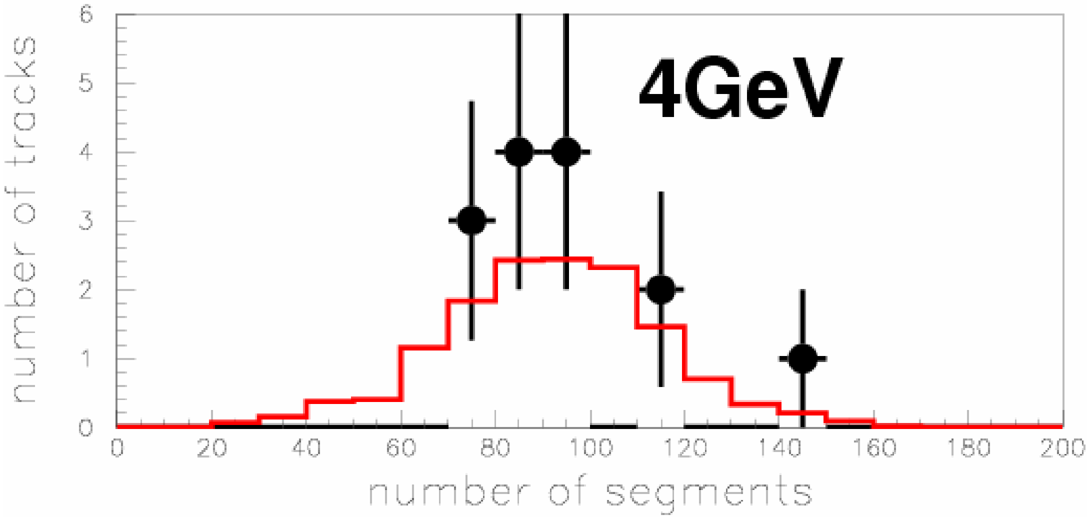
Electromagnetic shower

T.Toshito(Nagoya Univ.)
Test exp. @ CERN (May2001)
In analysis







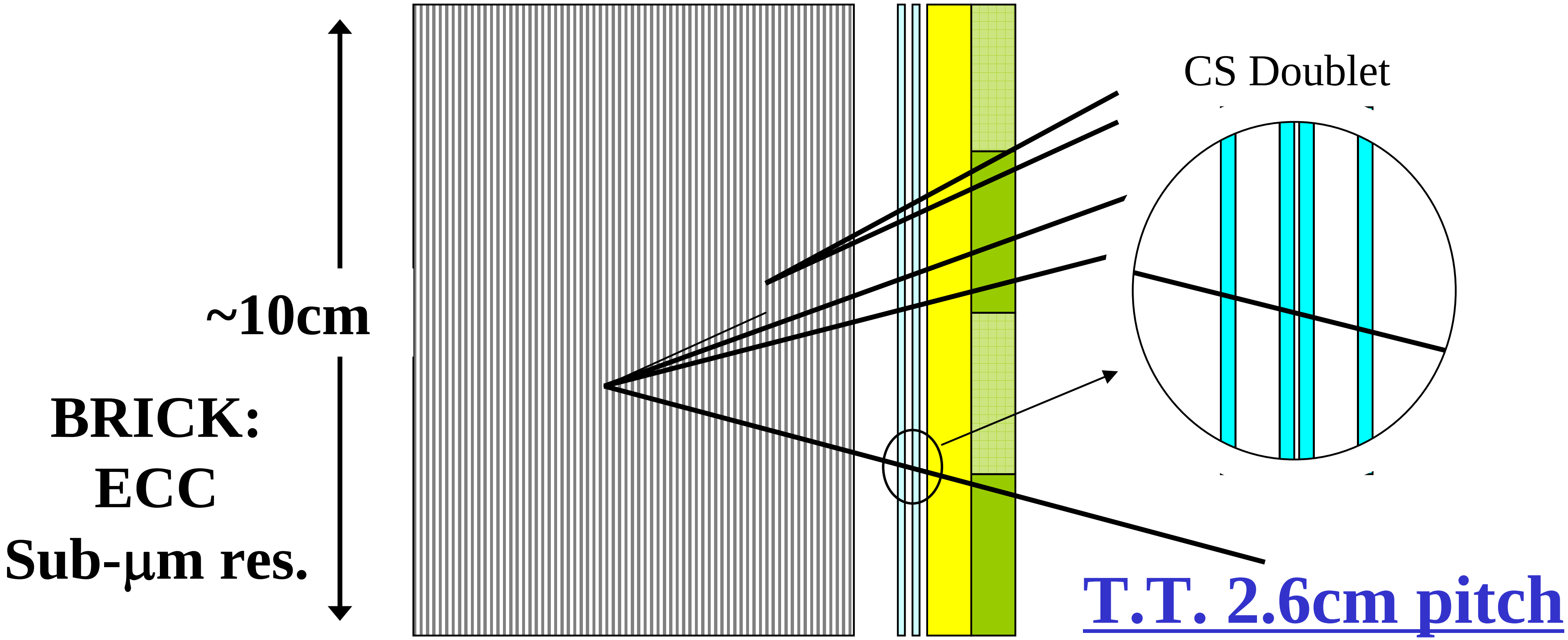


Energy determination
by calorimetric method
(in study)

$$\frac{\Delta E}{E} \sim \frac{0.4}{\sqrt{E(GeV)}}$$ @ a few GeV

Changeable Sheet

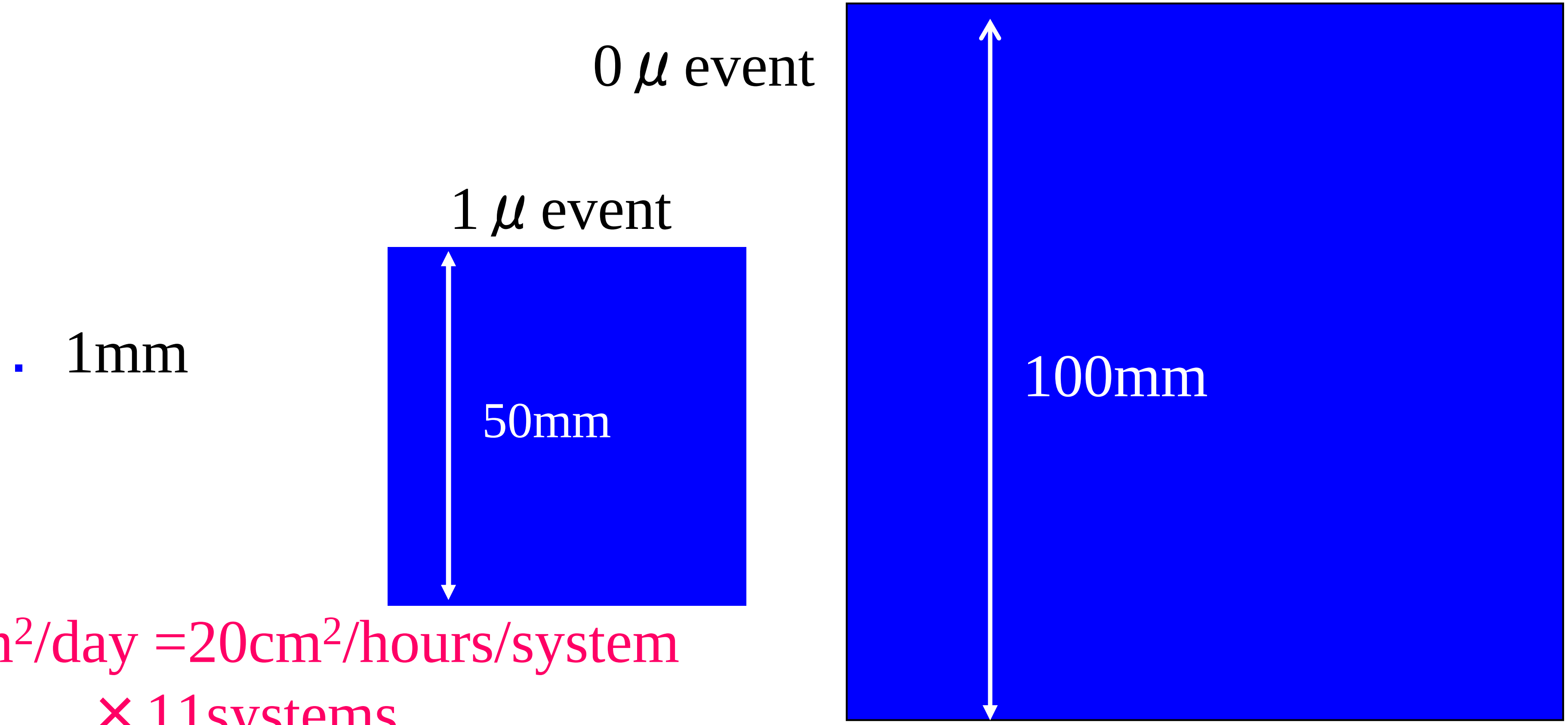
- Interface plate TT to Brick(ECC)
- Brick Tagging specially for NC-like event.



- Must be low back ground -> Doublet, Refreshed in GS
- Must be high efficiency
- Very huge Scanning load -> 5100cm^2/day

Required Scanning Power for IP(CS)

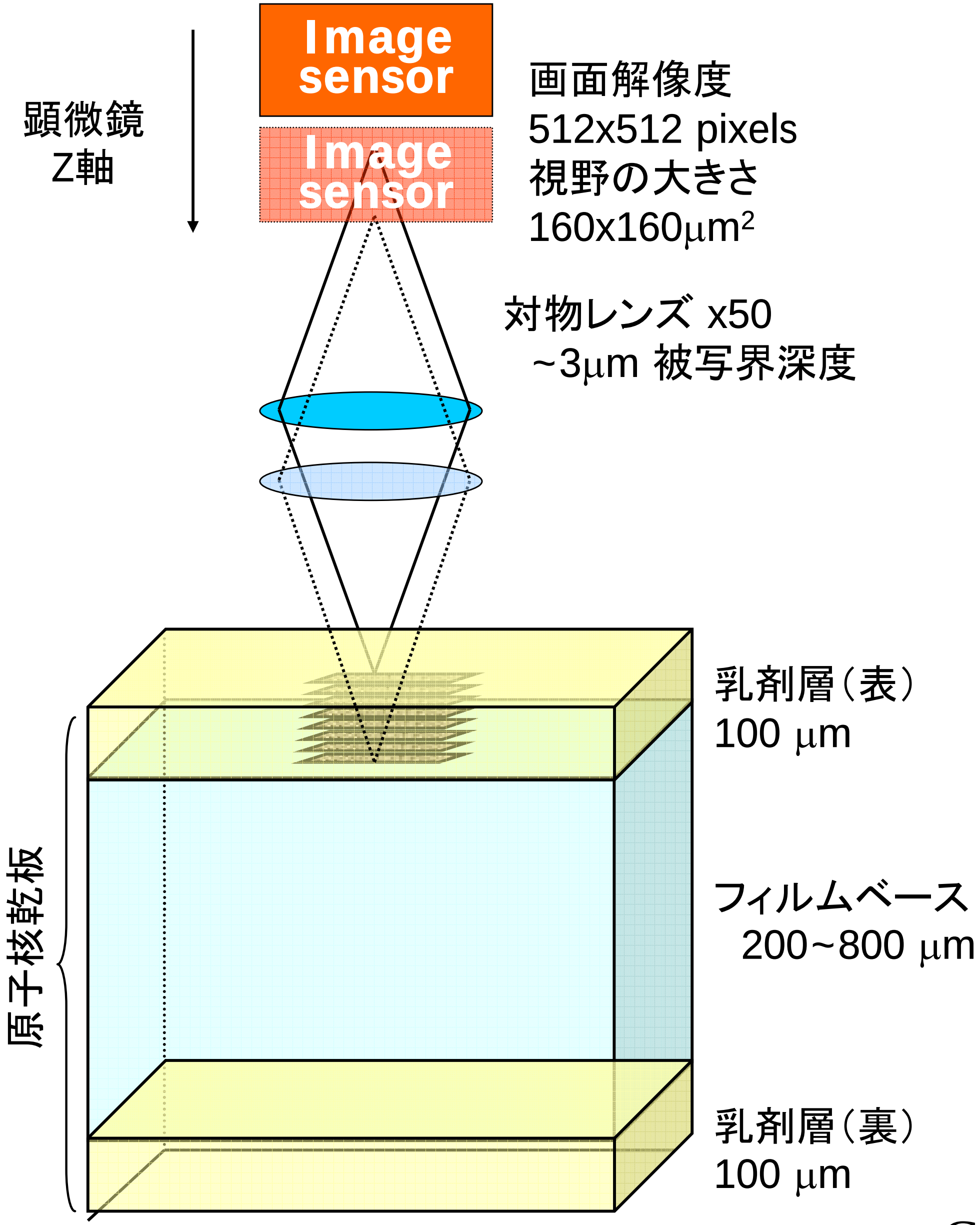
	Area to be scanned	Events /day	Scanning area cm^2/day	
CHORUS	1mm×1mm×2	1000	20	
OPERA 1μ	5cm×5cm×4	23	2300	Total 5100
OPERA 0μ	10cm×10cm×4	7	2800	



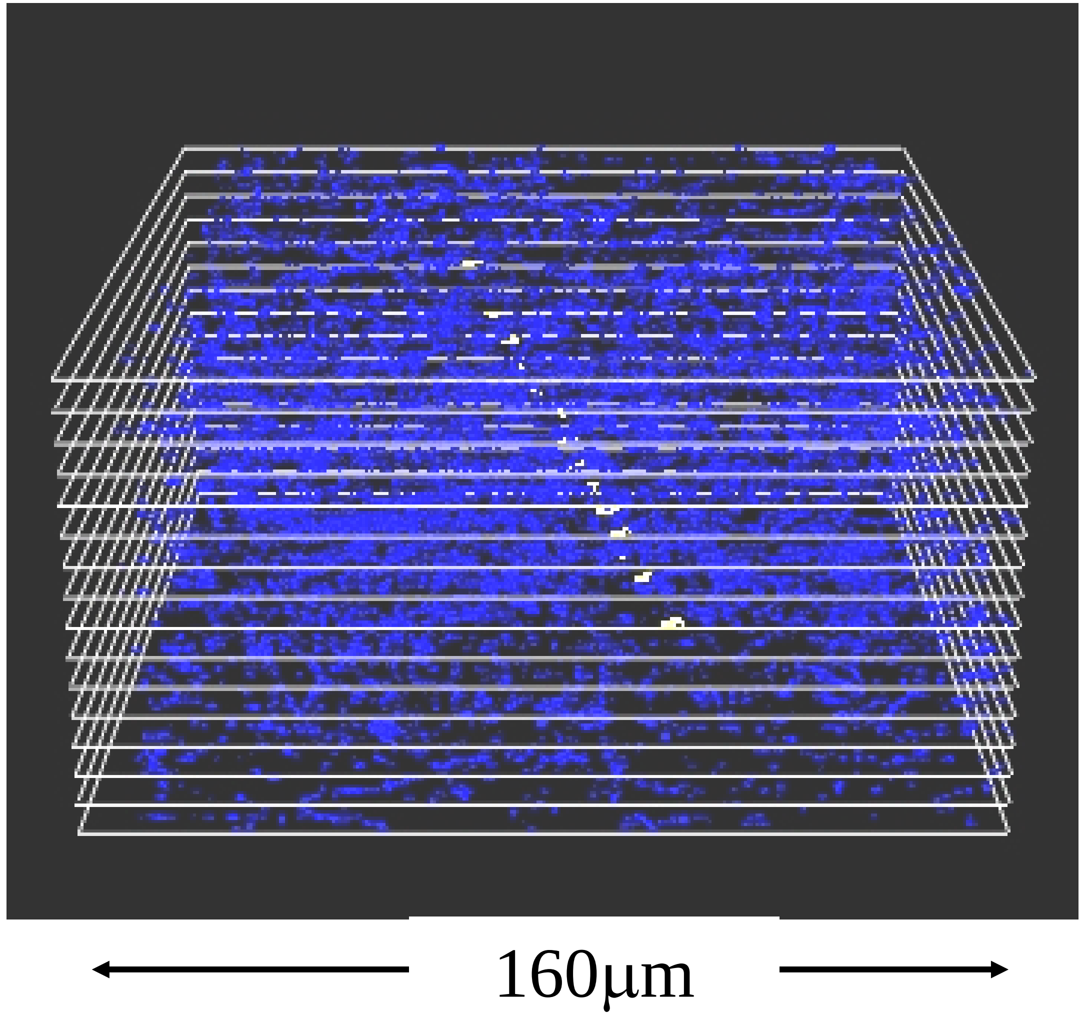
5100 cm^2/day =20cm^2/hours/system ×11systems

Automatic Emulsion Scanning System
“S-UTS 1”

Digitizing Nuclear Emulsion Films

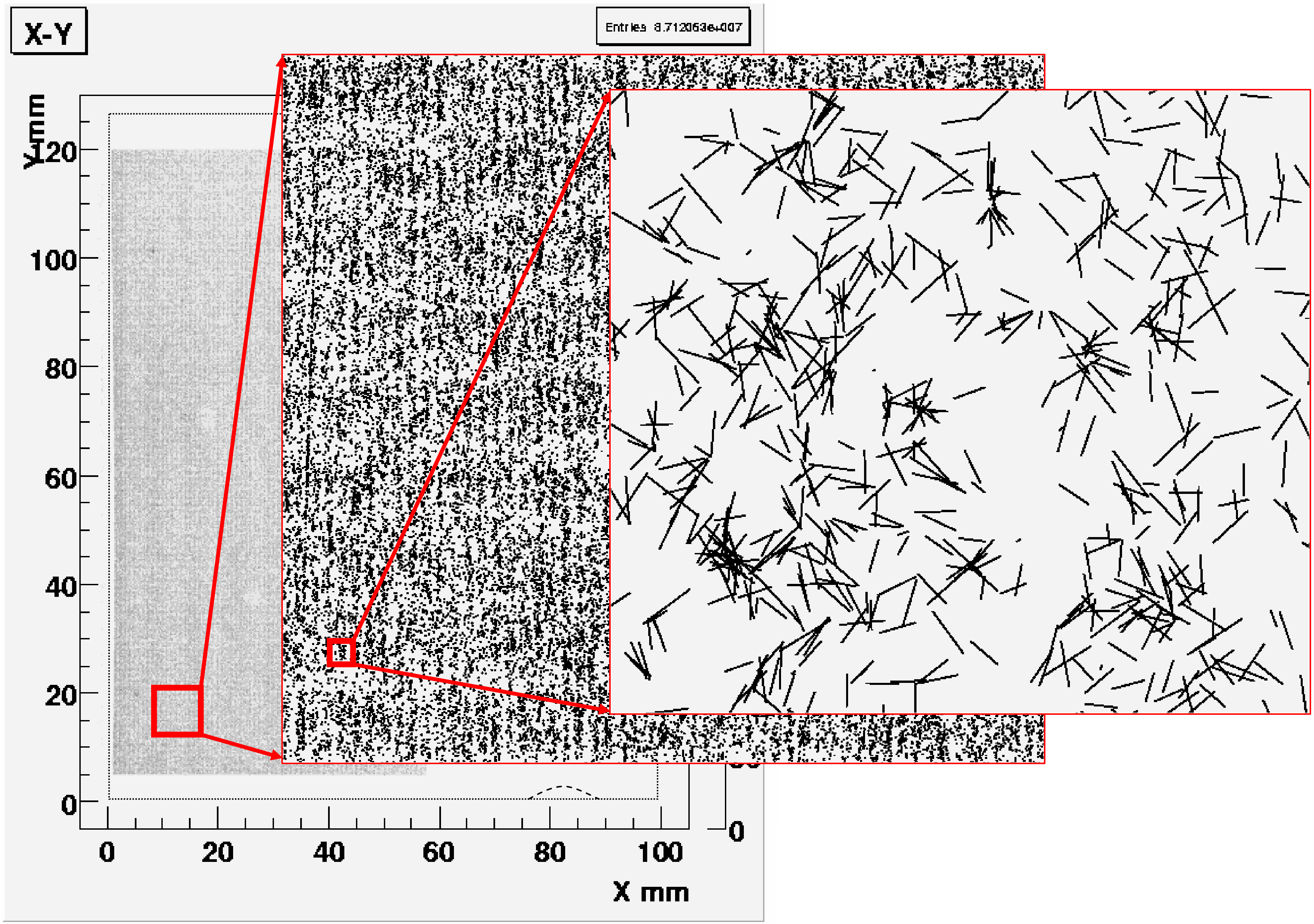


フィルム1枚あたり4×10^{12}pixel (両面)



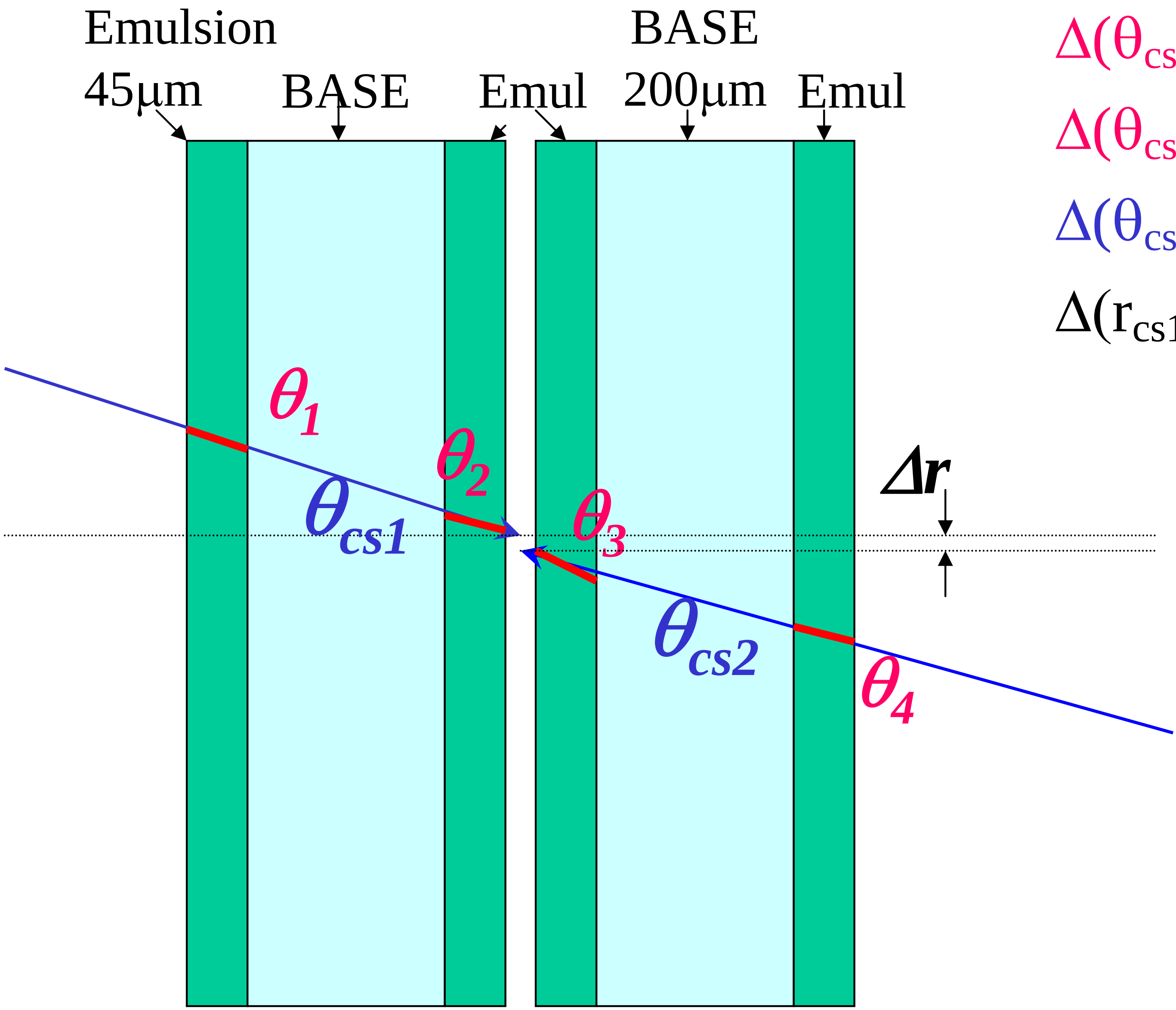
Grain Density ~15 (/45μm), FOG>3000 grain(/view)

174969 2-20-1-1 87,120,627 Micro Track Readout



Fourfold coincidence

CS Doublet cross section



Reconstruction Conditions Ex.:

$\Delta(\theta_{cs1}-\theta_{1,2}) < 0.070$ rad

$\Delta(\theta_{cs2}-\theta_{3,4}) < 0.070$ rad

$\Delta(\theta_{cs1}-\theta_{cs2}) < 0.010$ rad

$\Delta(r_{cs1}-r_{cs2}) < 10\ \mu m$

+ Eye Scan

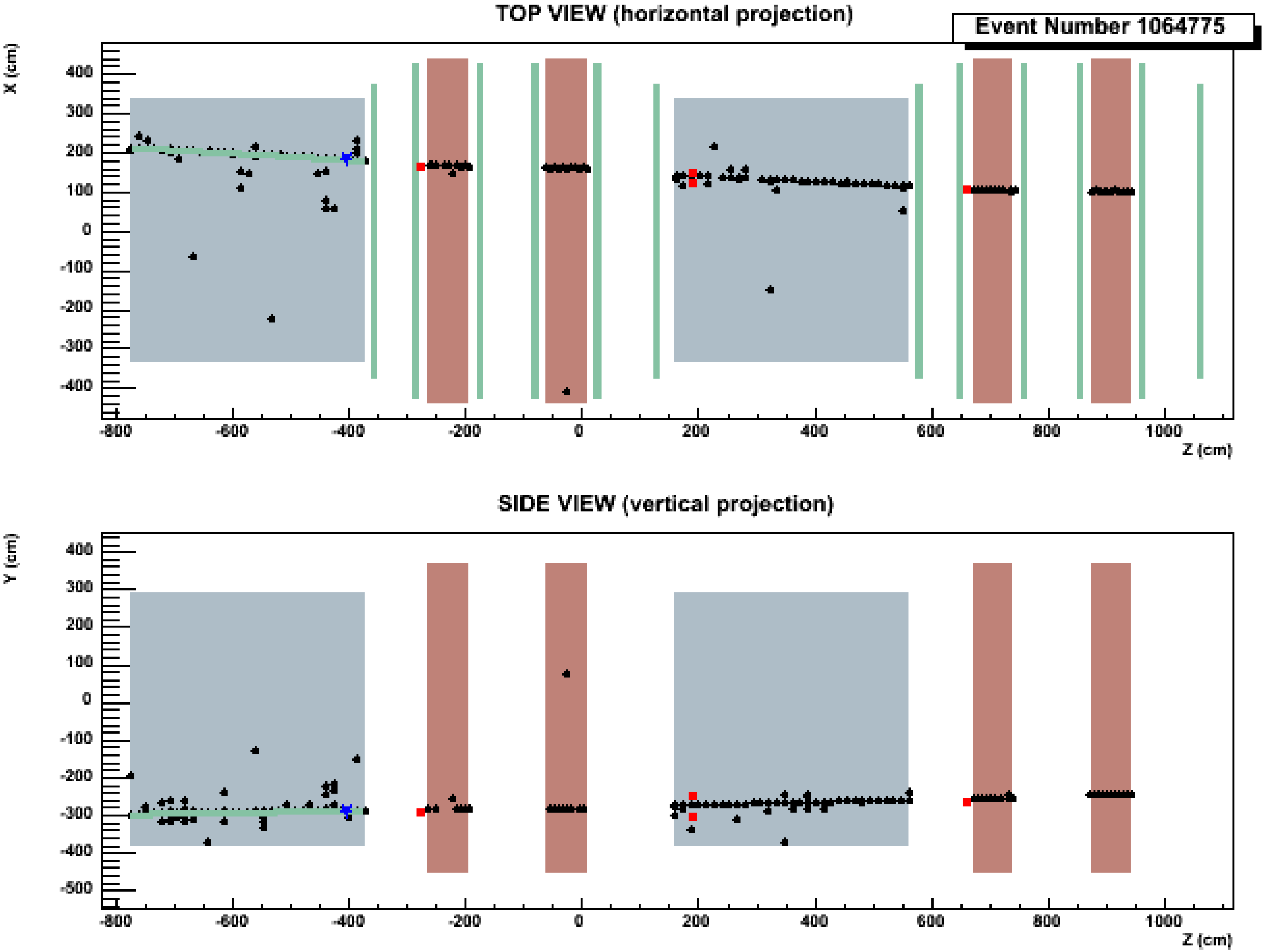
Reduce random coincidence of low momentum tracks (Compton electron, fog, etc.)

Event number: 1064775 CSD ID: 3000370

Brick location: W29/RW9/COL12, rock side

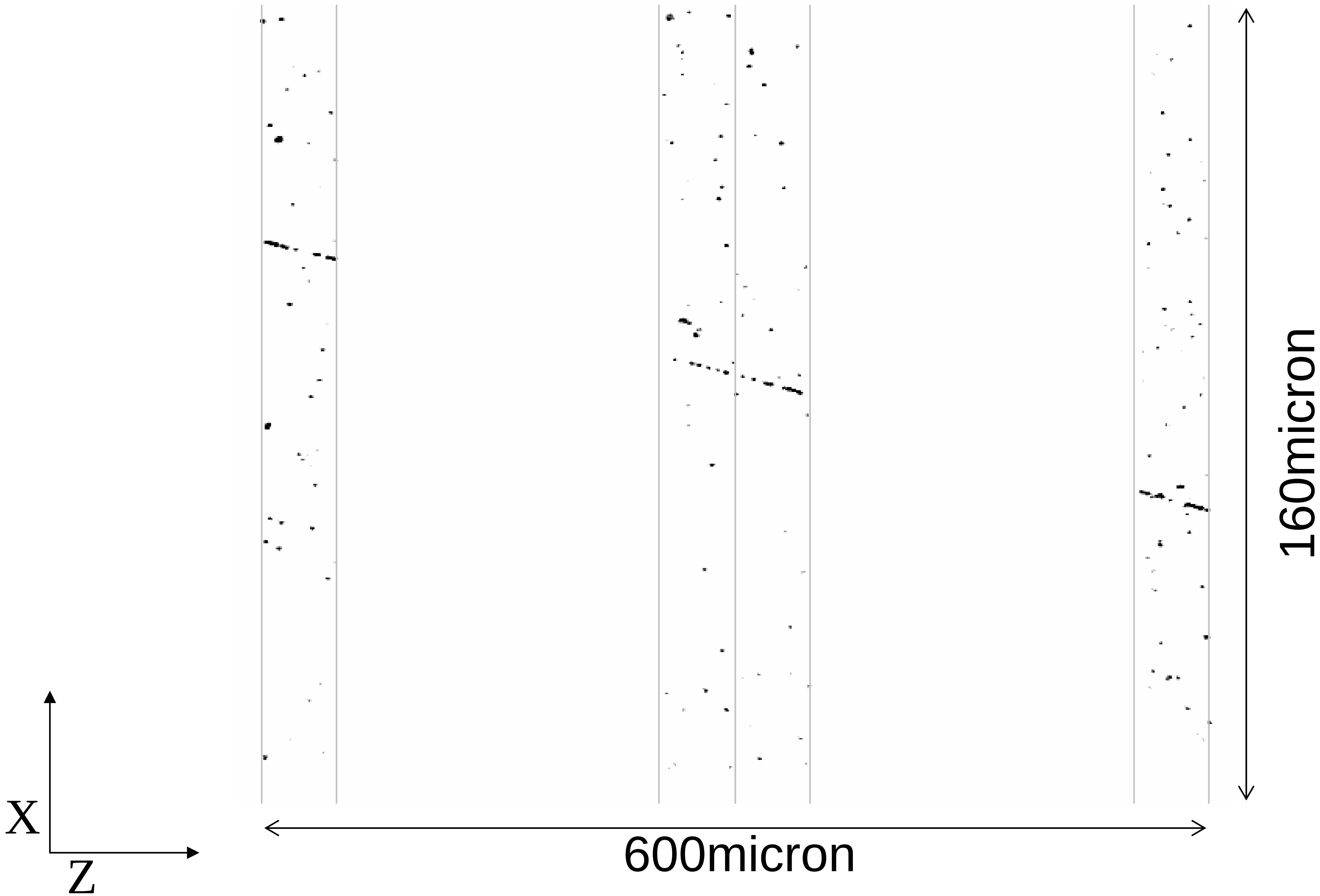
SX = -0.0839 ± 0.0013 SY = 0.0259 ± 0.0012

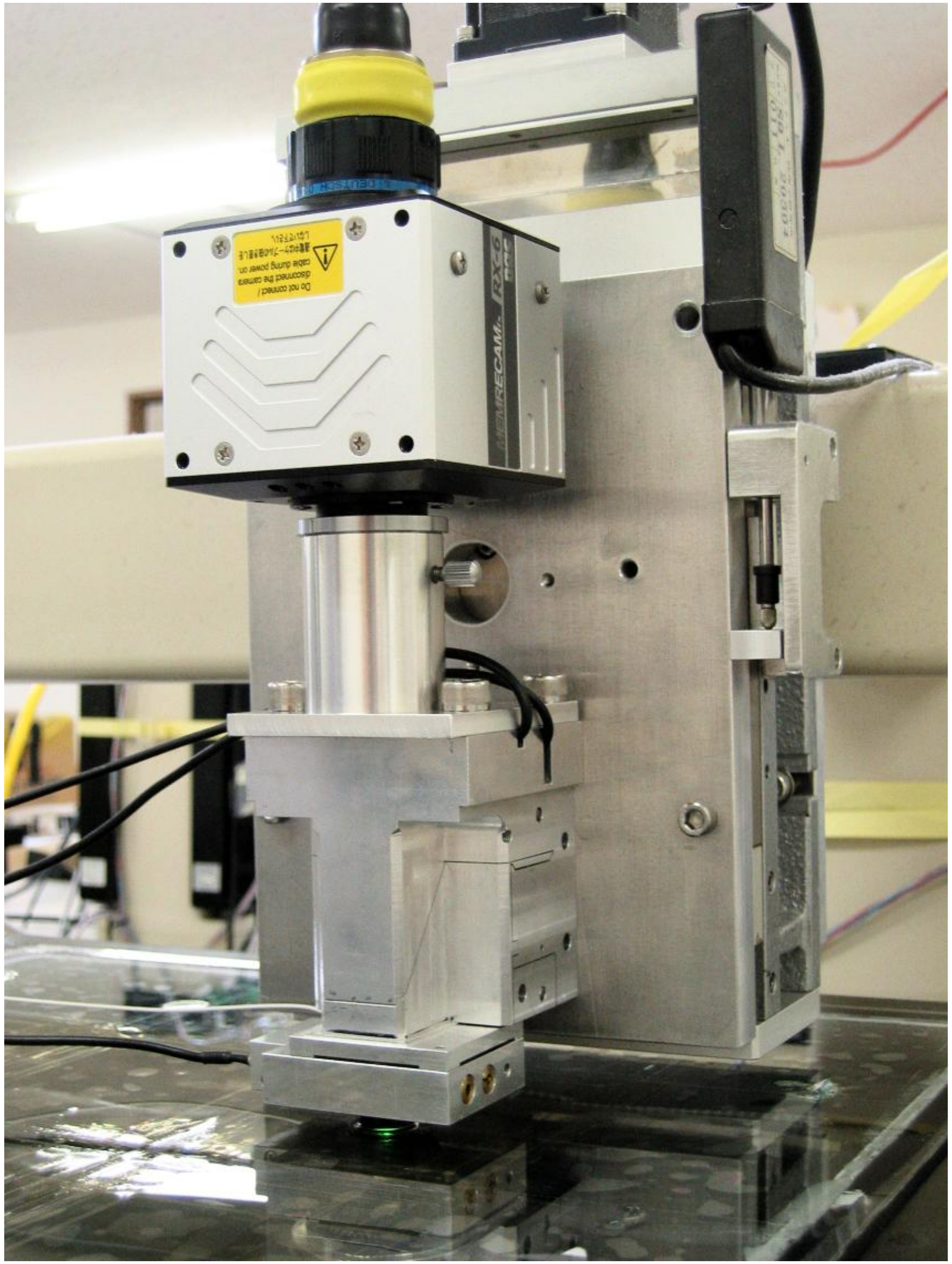
PX = 181.54 ± 0.27 cm PY = -288.03 ± 0.25 cm PZ=-401.82 cm

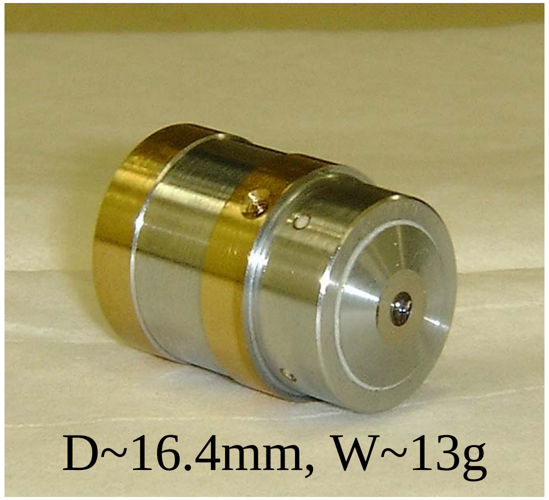


with Dario and Antoine

Found track in CSD



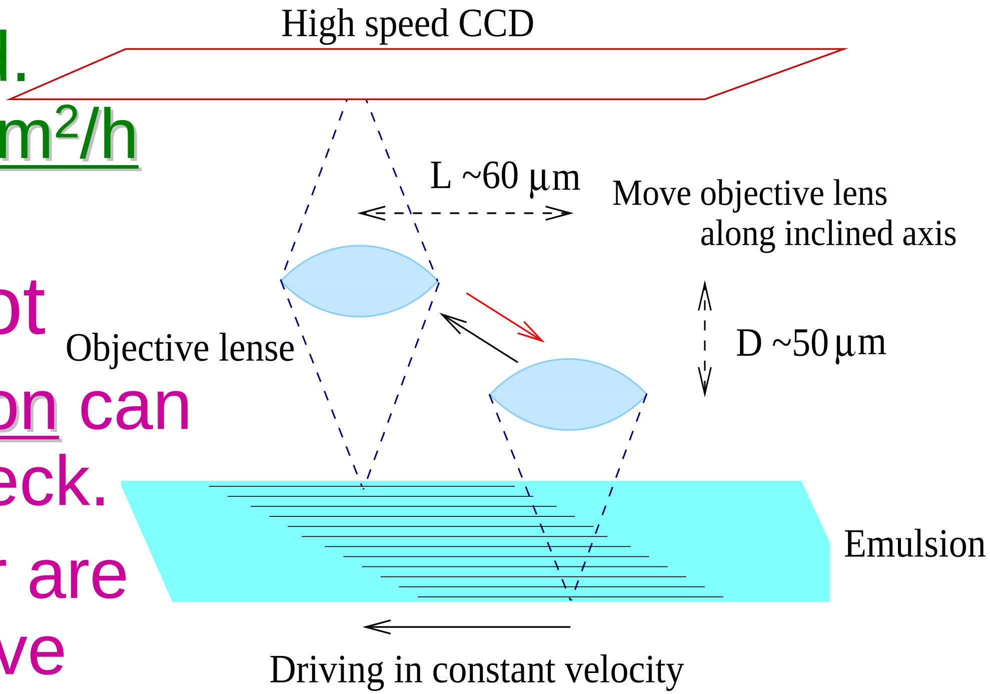




Piezo driven Optics

No step and repeat image taking (follow shot method)

- Use Ultra High Speed Camera
  - Up to 3k frames per second.
    → Max 90views/sec〜60cm²/h



- Image taking by follow shot
  - No step and repeat operation can avoid a mechanical bottleneck.
  - FOV displacement and Blur are canceled by moving objective lens

Real-time Image Filtering and Packing Processor

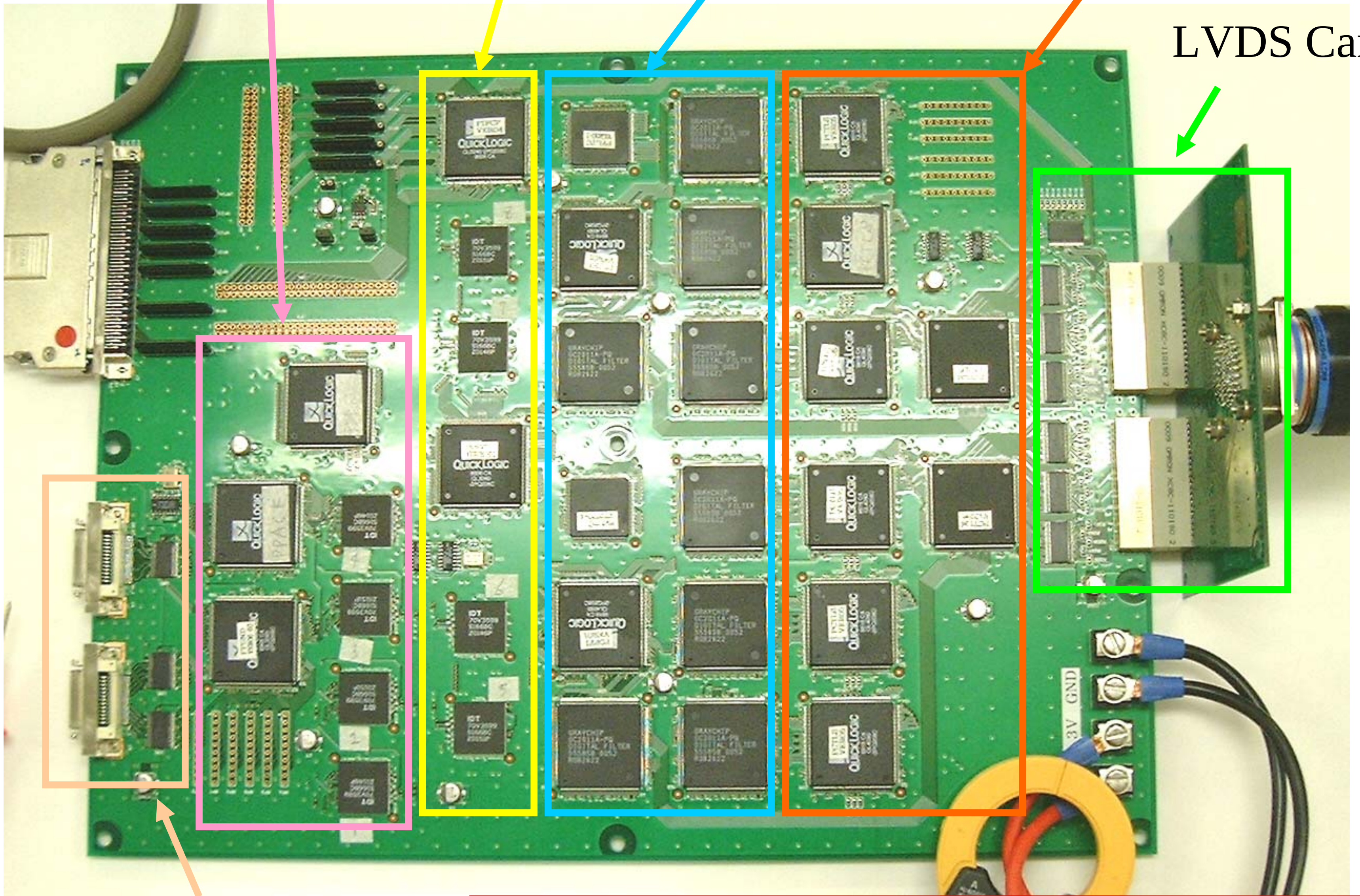
Spatial filter and Pixel Packing

Ring frame buffers

FIR filters

Arrange readout segments to lines

LVDS Camera Interface

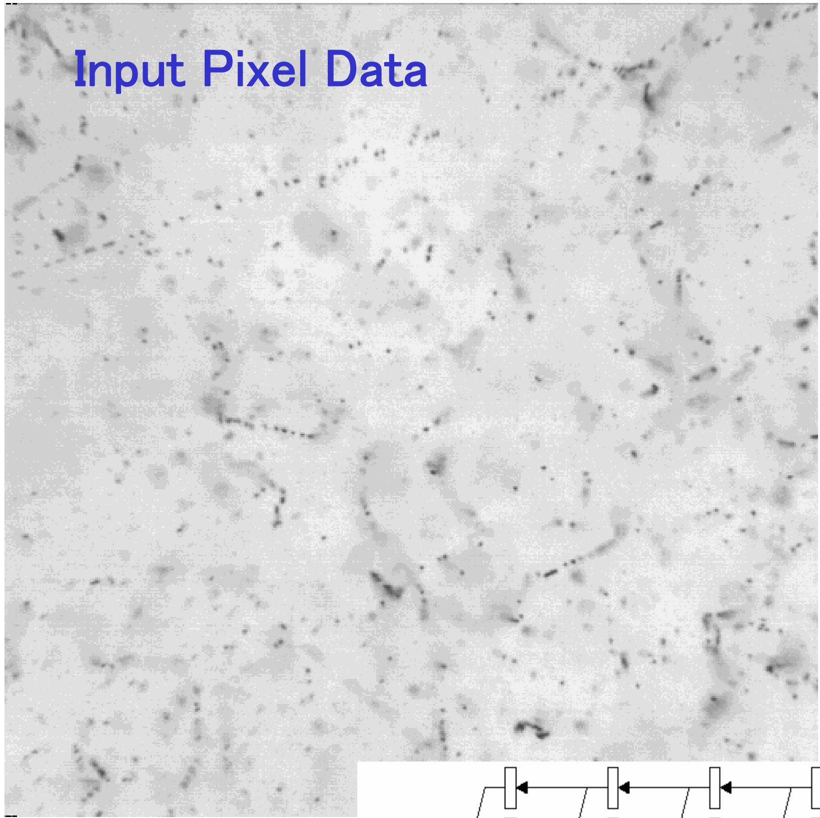


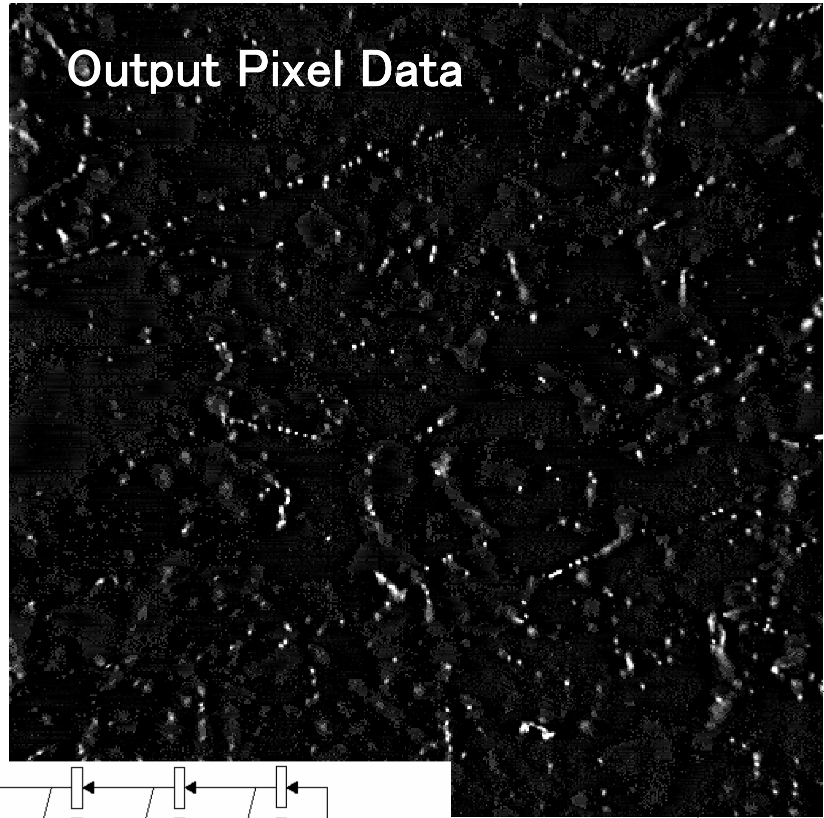
Camera In

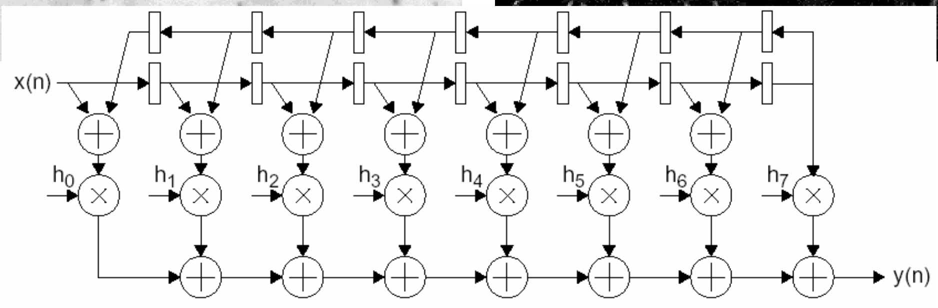
LVDS Output Interface

DATA Reduction : ~1G byte/s ⇒ 10-100M byte/s

Pre-processing before track recognition

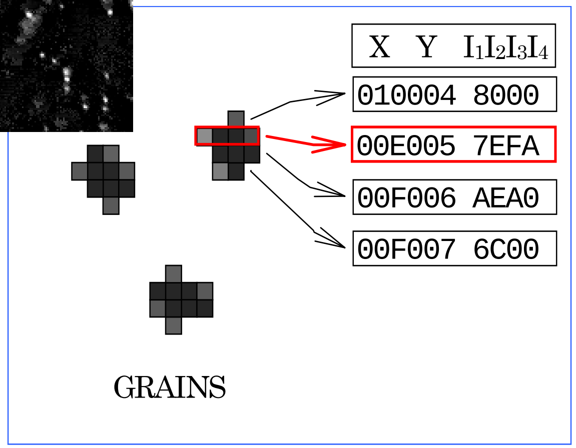






(c) 15 TAP ODD SYMMETRY FILTER

Ref. GC2011A 3.3V DIGITAL FILTER CHIP DATASHEET, GRAYCHIP, INC.

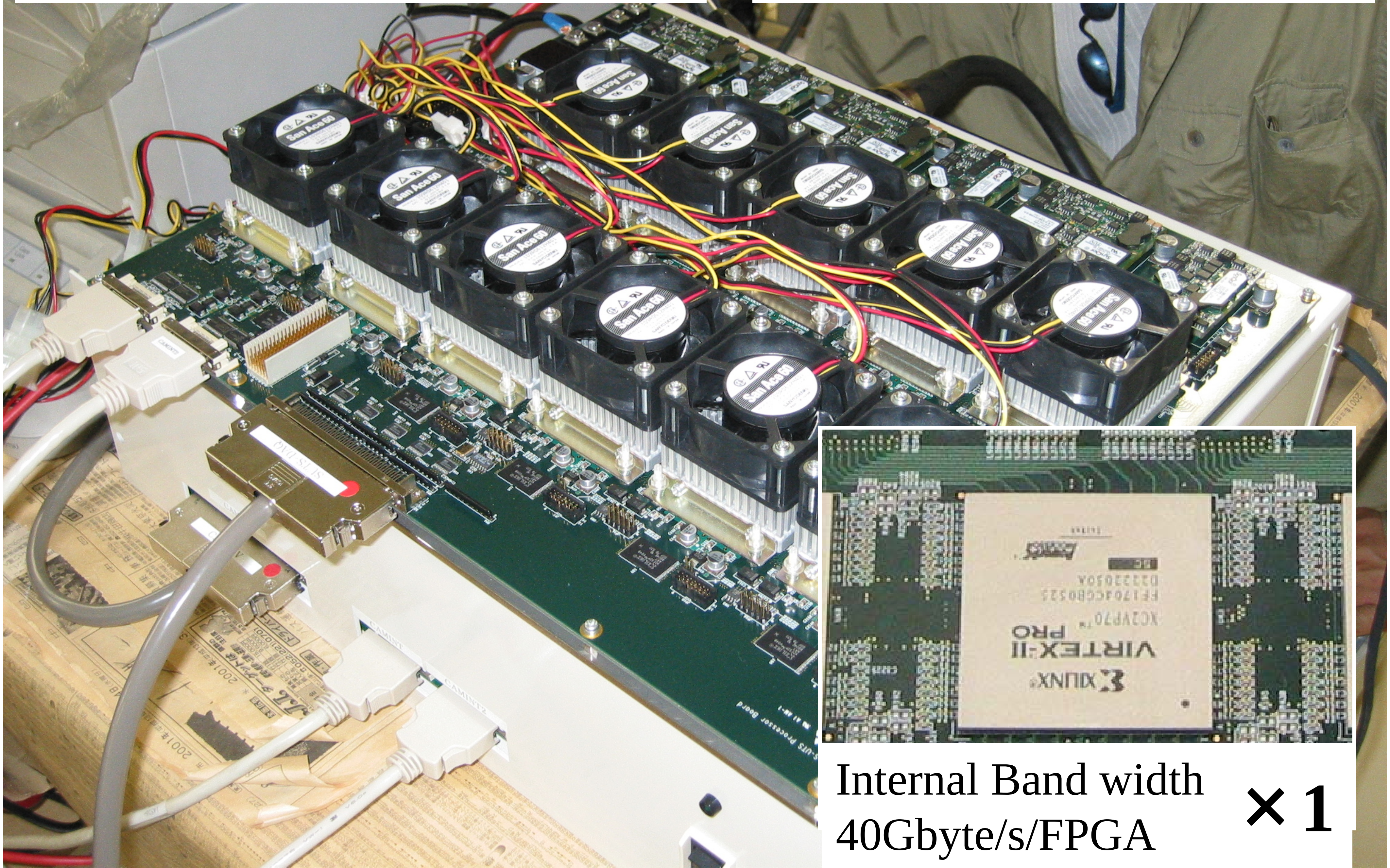


Subtract DC and LF component, like defocus grains.

Zero suppression (Record only pixels over the threshold with address)

SUTS
Track recognition board

Processing speed :
>40cm^2/h/board



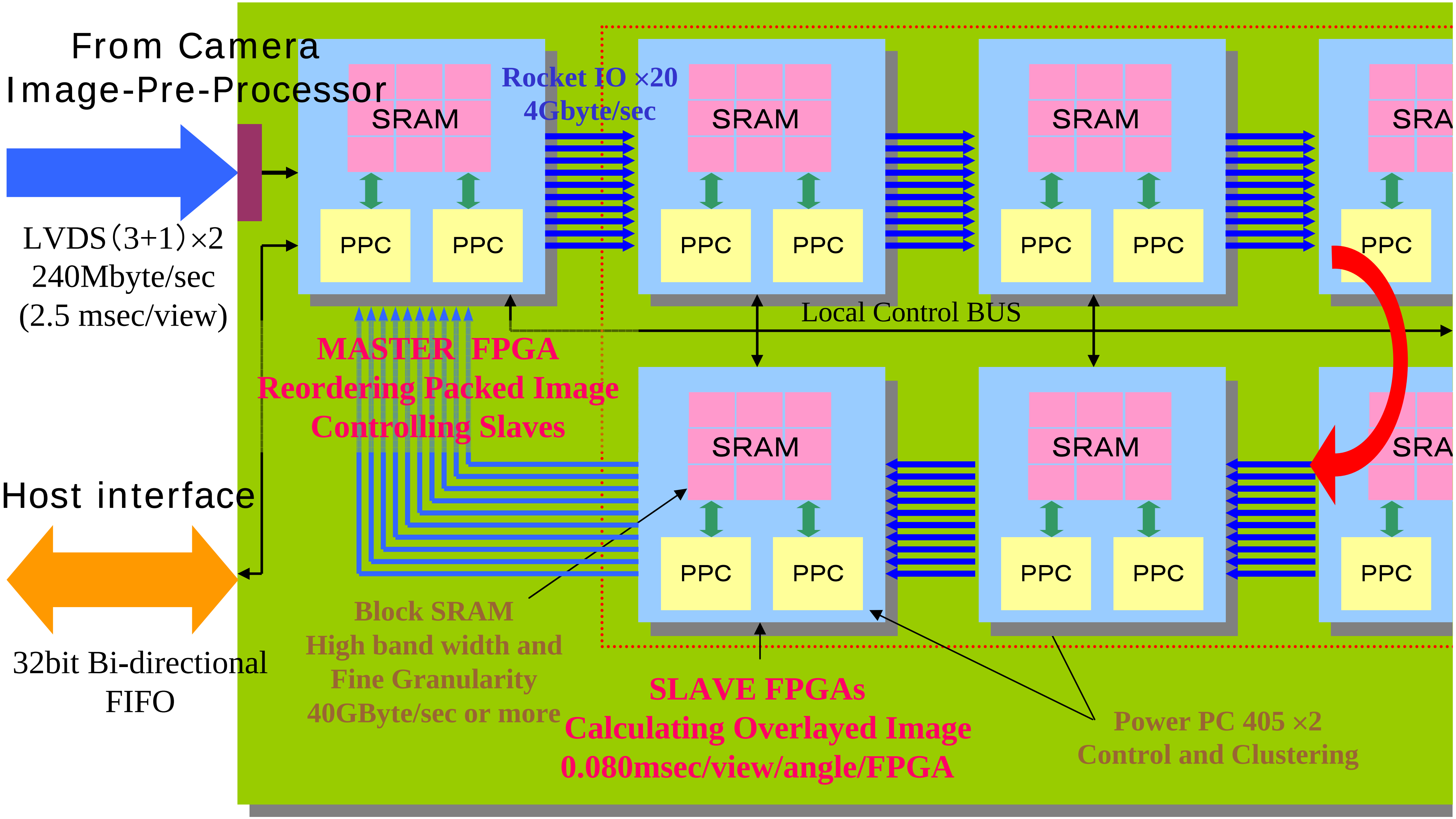
Internal Band width
40Gbyte/s/FPGA

×1

Track Recognition in SUTS

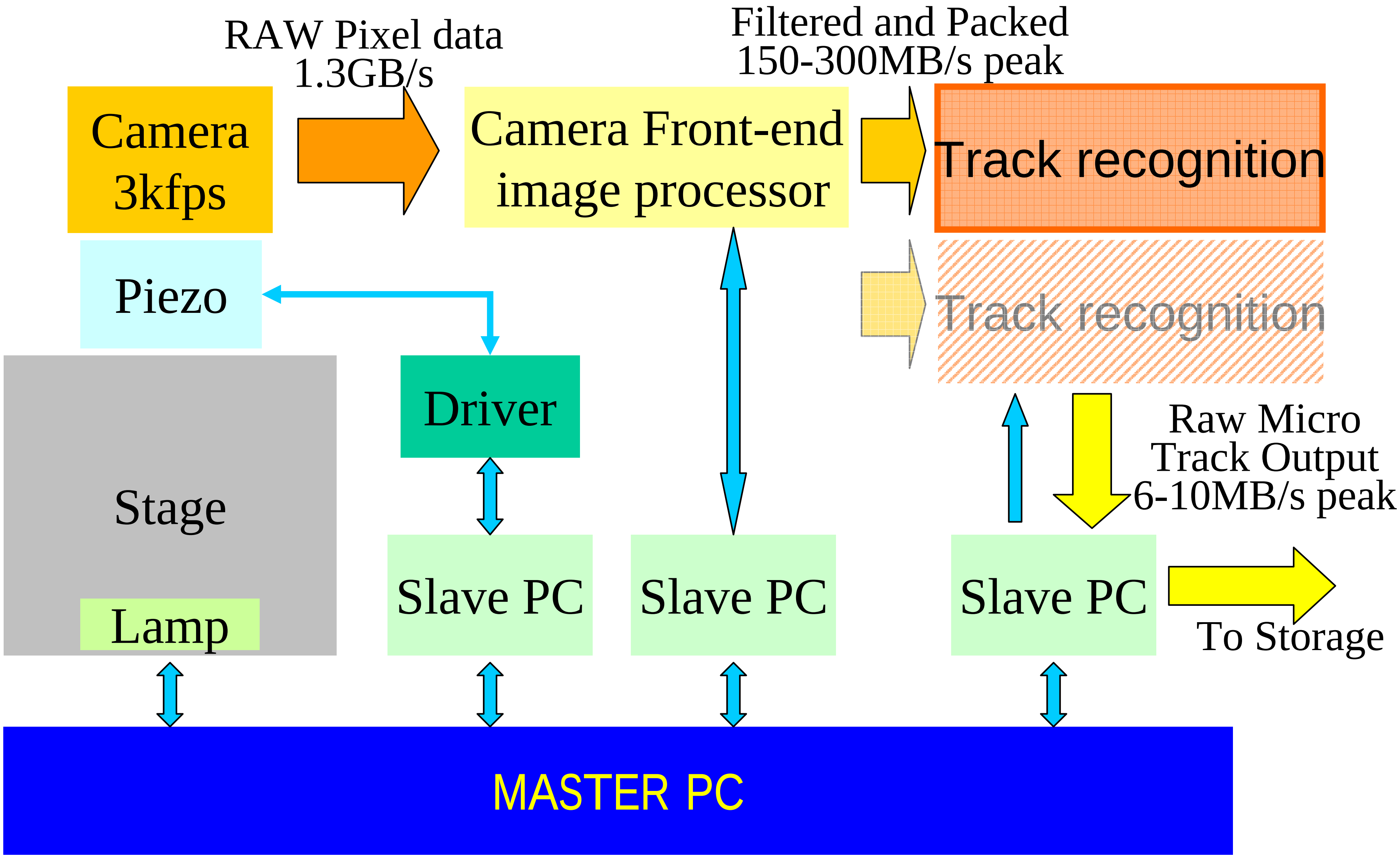
- 飛跡認識アルゴリズムは UTS を継承する。
- 目標処理能力は $100cm^2/h$ (多ユニット化による並列処理を考慮）
  - ×50 対物レンズとセンサーから期待されるのは$60cm^2/h$であるが、広視野化に対処.
- 大規模 FPGAによる高並列化による高速飛跡認識を行う。

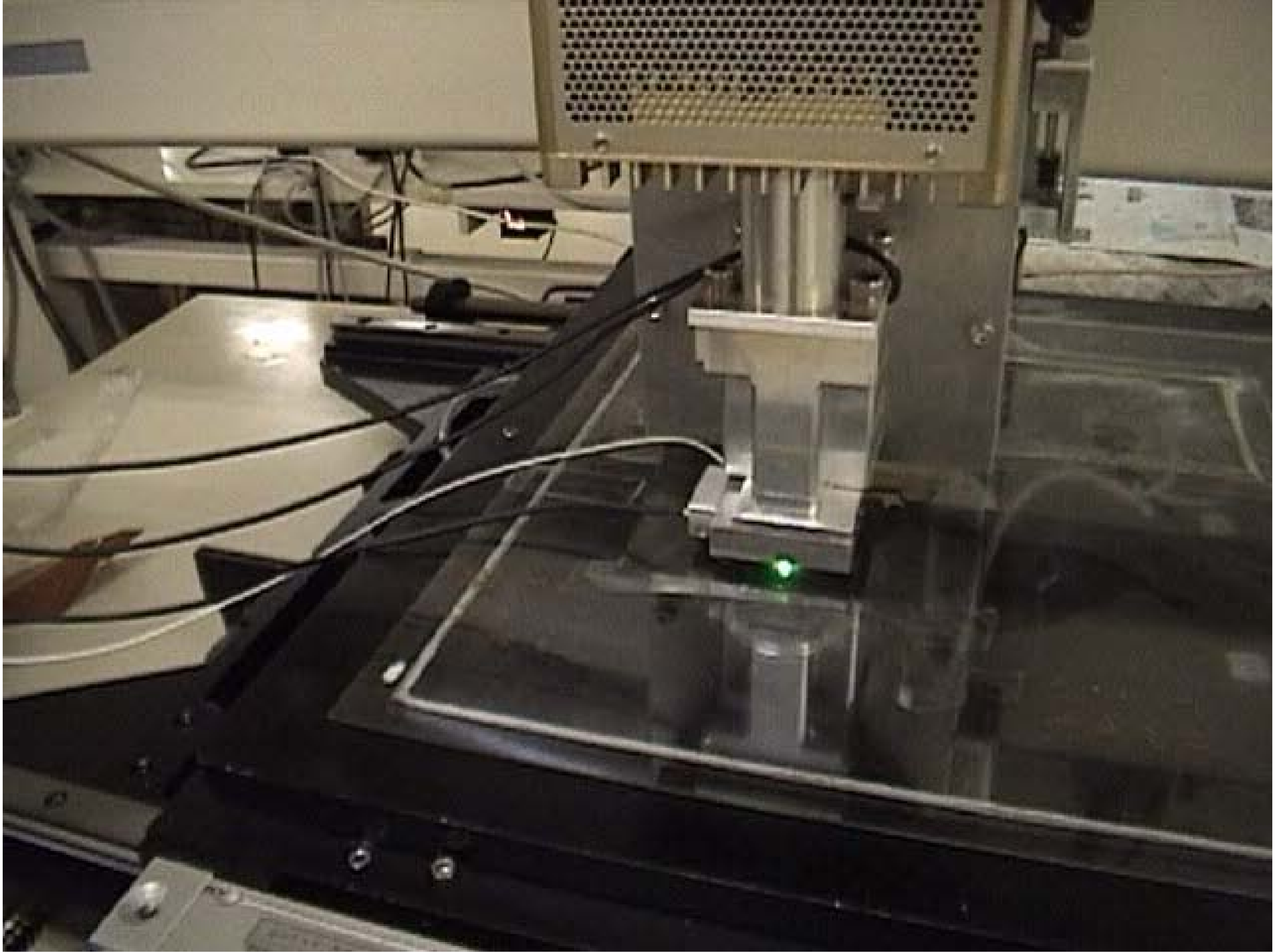
	2VP70(SUTS)	QL3060(UTS)
Logic Cell	74,448	1,584
On-die Memory	5,904kbit	N/A
On-die CPU	PPC405×2	N/A
Max Frequency (16bitCNT)	348 MHz	97MHz
Inter FPGA data transfer rate	40Gbit/sec	1.2Gbit/sec
Memory Band Width in FPGA	40GByte/sec	0.5GByte/sec



S-UTS Track Recognition Block diagram (revised)

SUTS block diagram

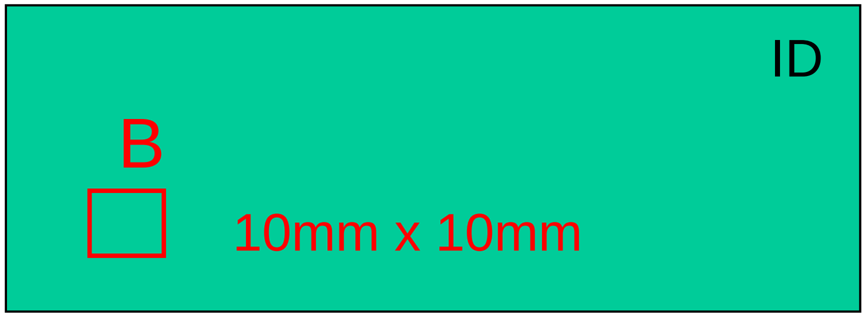


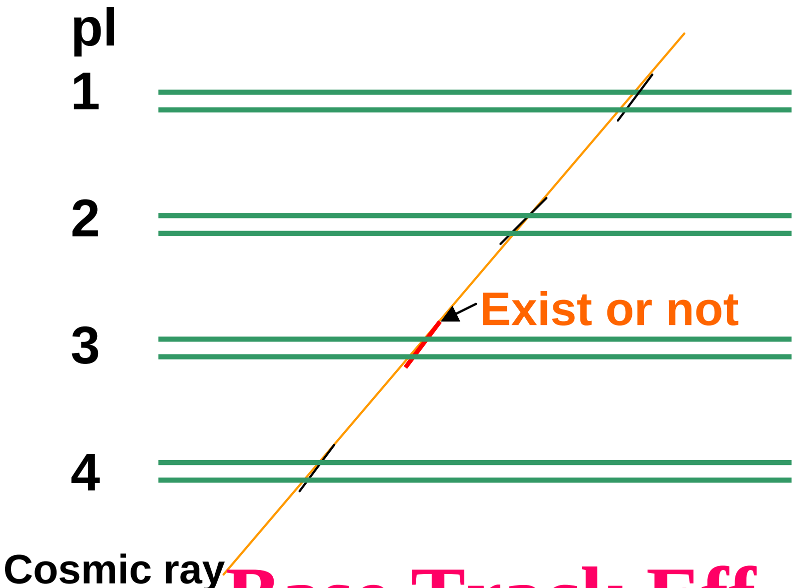


Scanning Efficiency Check

Sample : double refreshed half size OPERA film exposed cosmic rays

Scanning area

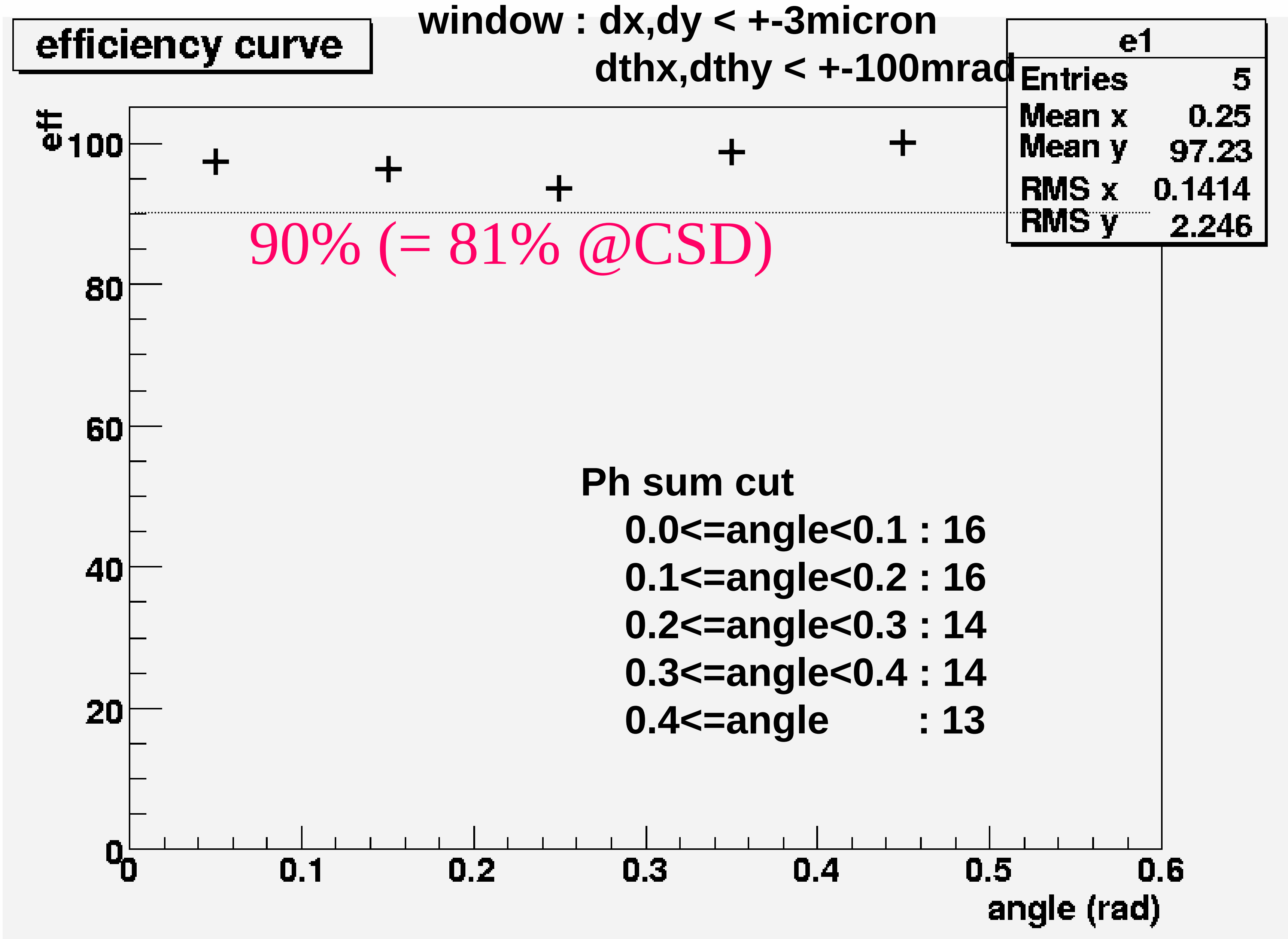




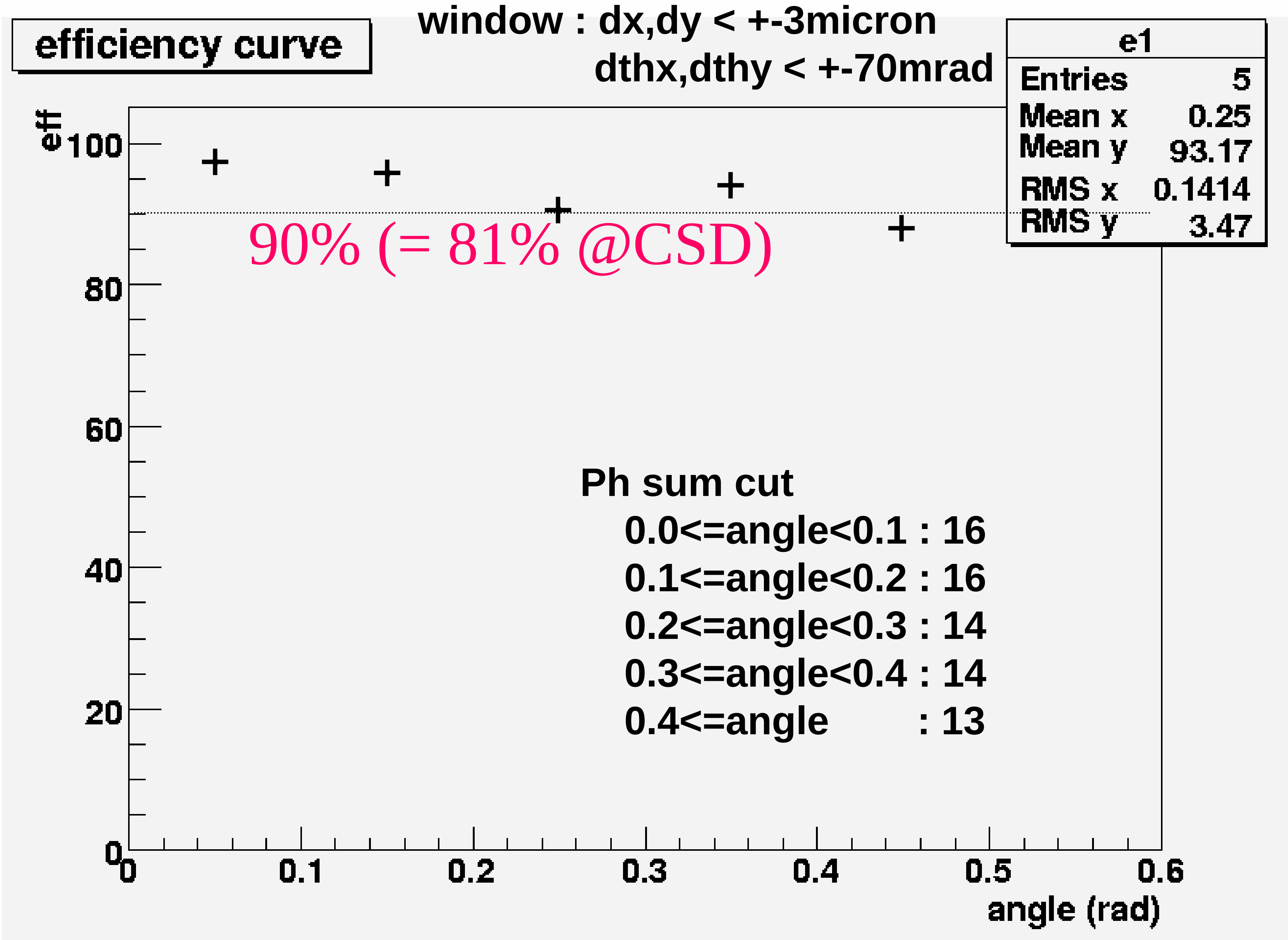
1. **Pick up prediction tracks (pl1-pl2-pl4)**
2. **Search pl3 for basetrack (2sufaces)**
   window : dx,dy < +-3micron
   dthx,dthy < +-100mrad

Base Track Eff. Corresponds to sqrt of CSD eff.

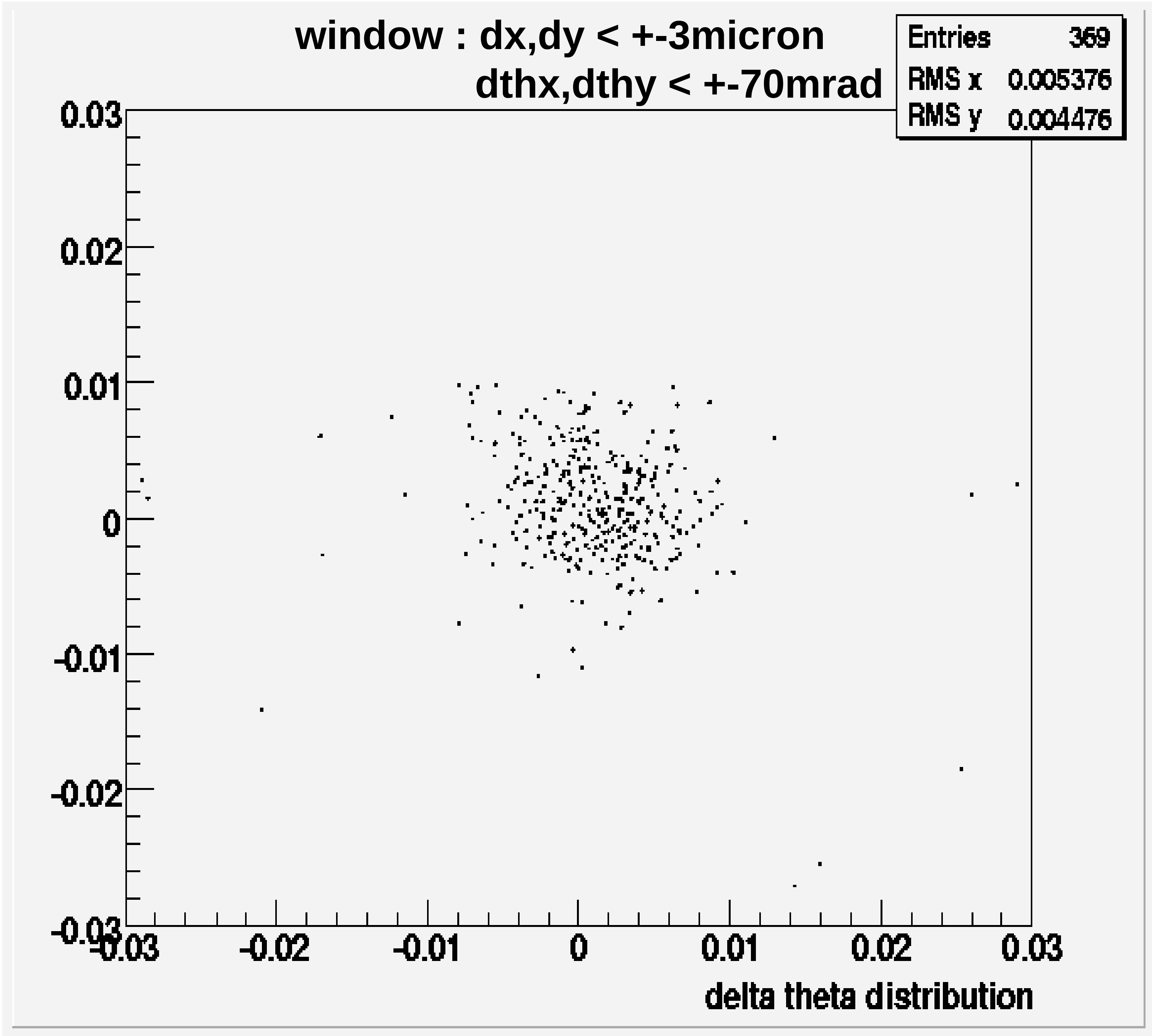
Base Track Efficiency



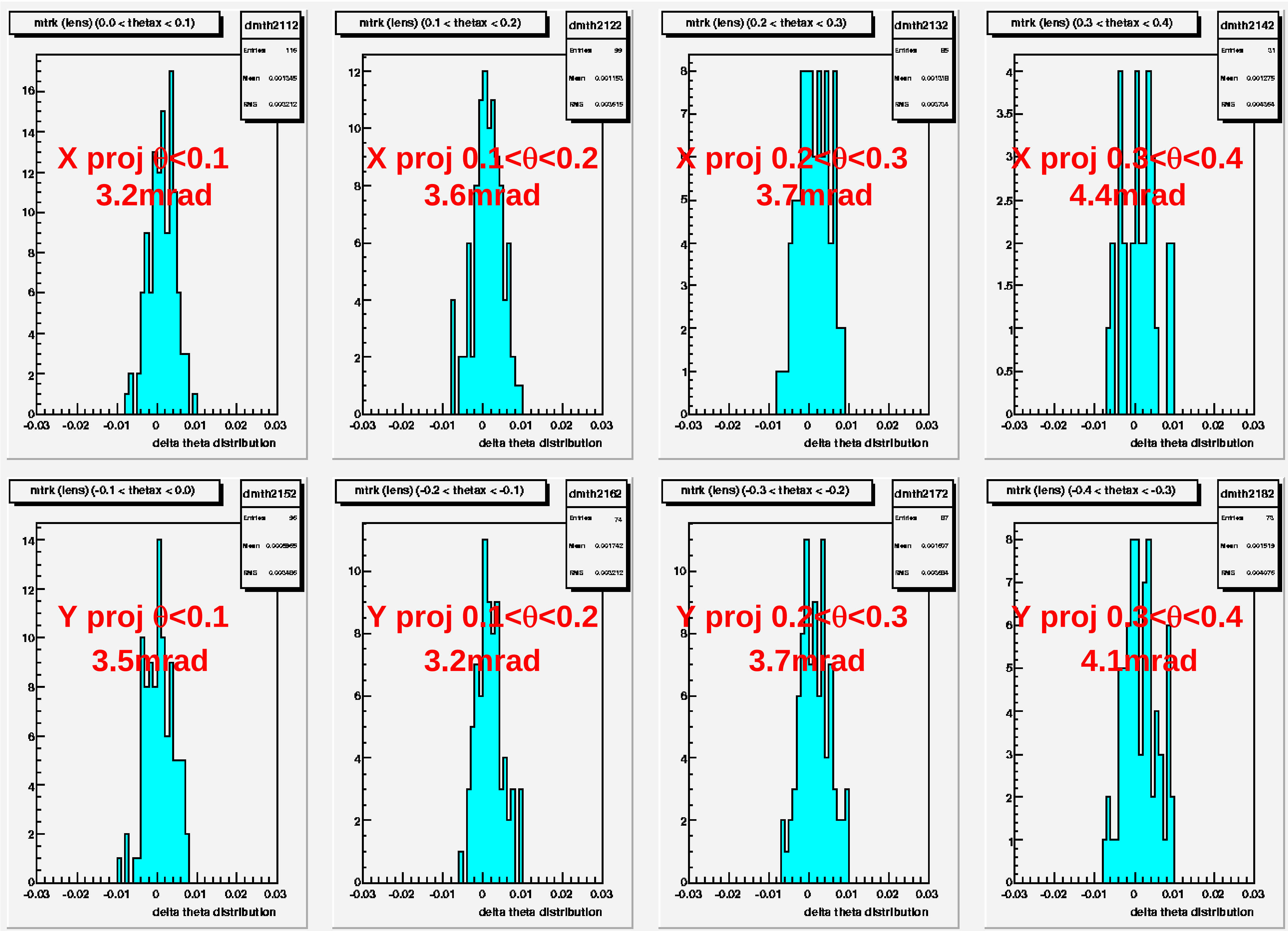
Base Track Efficiency



Angle displacement

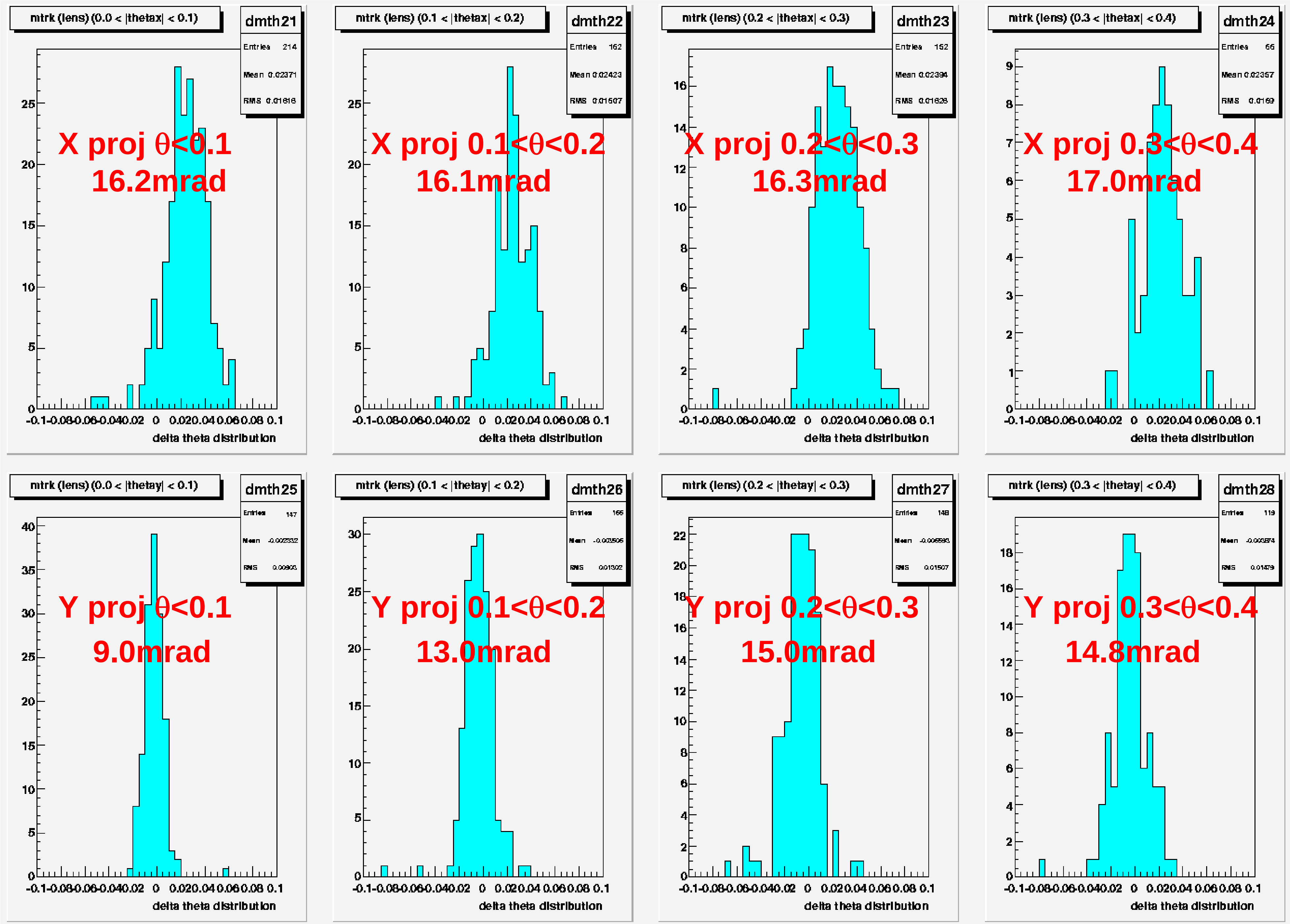


Base Track angle resolution



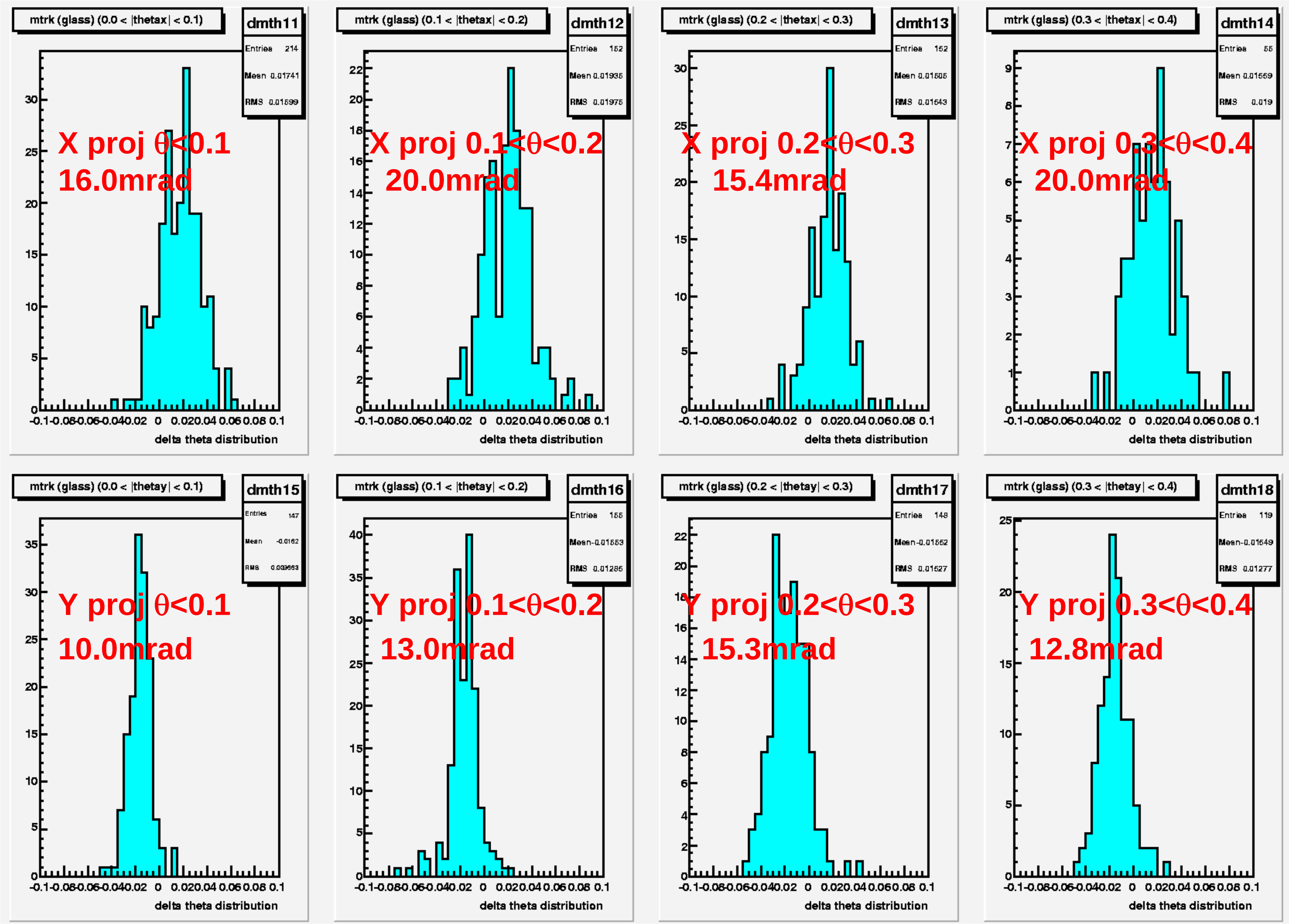
Lens side

Micro track angle resolution

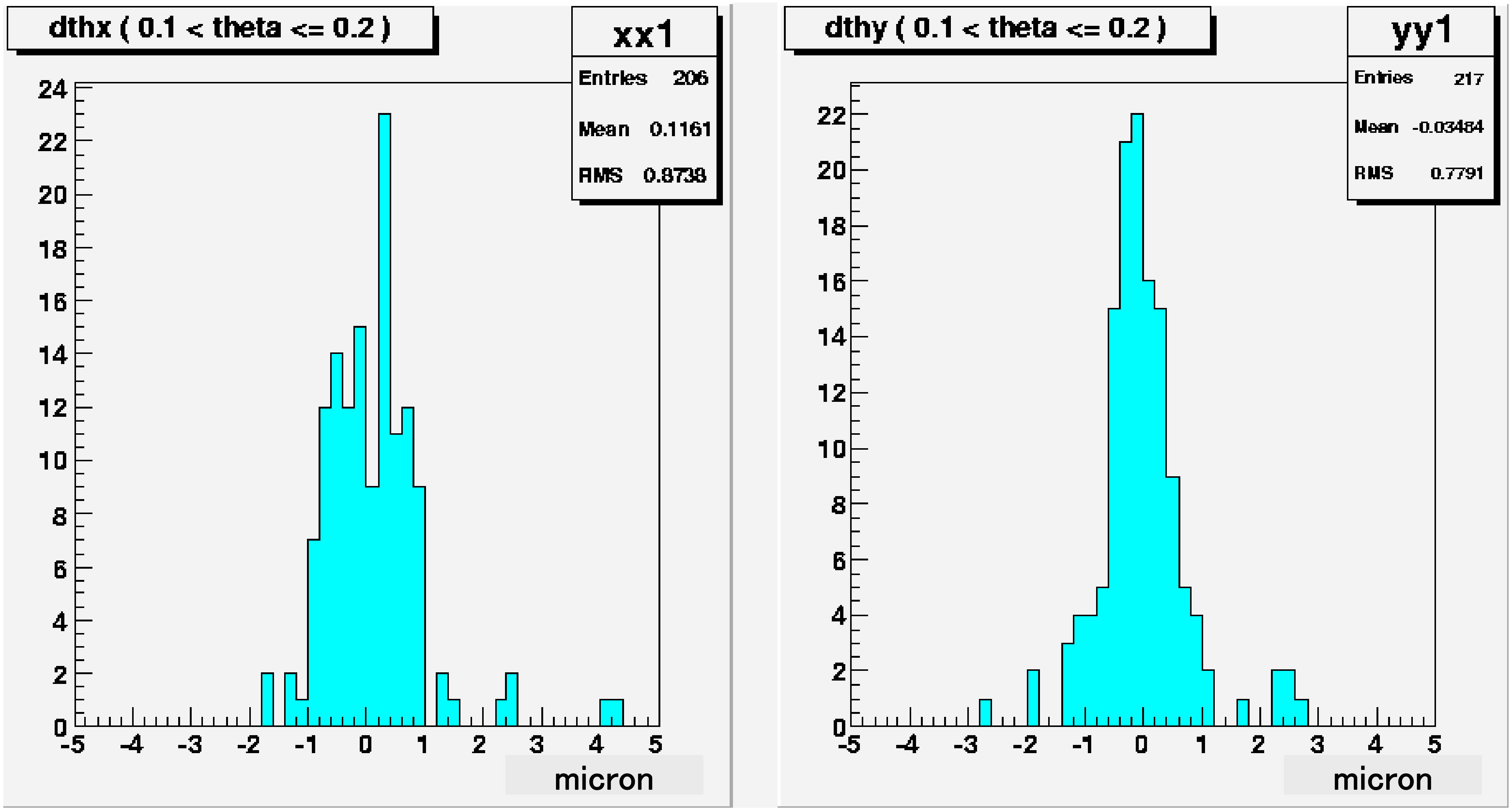


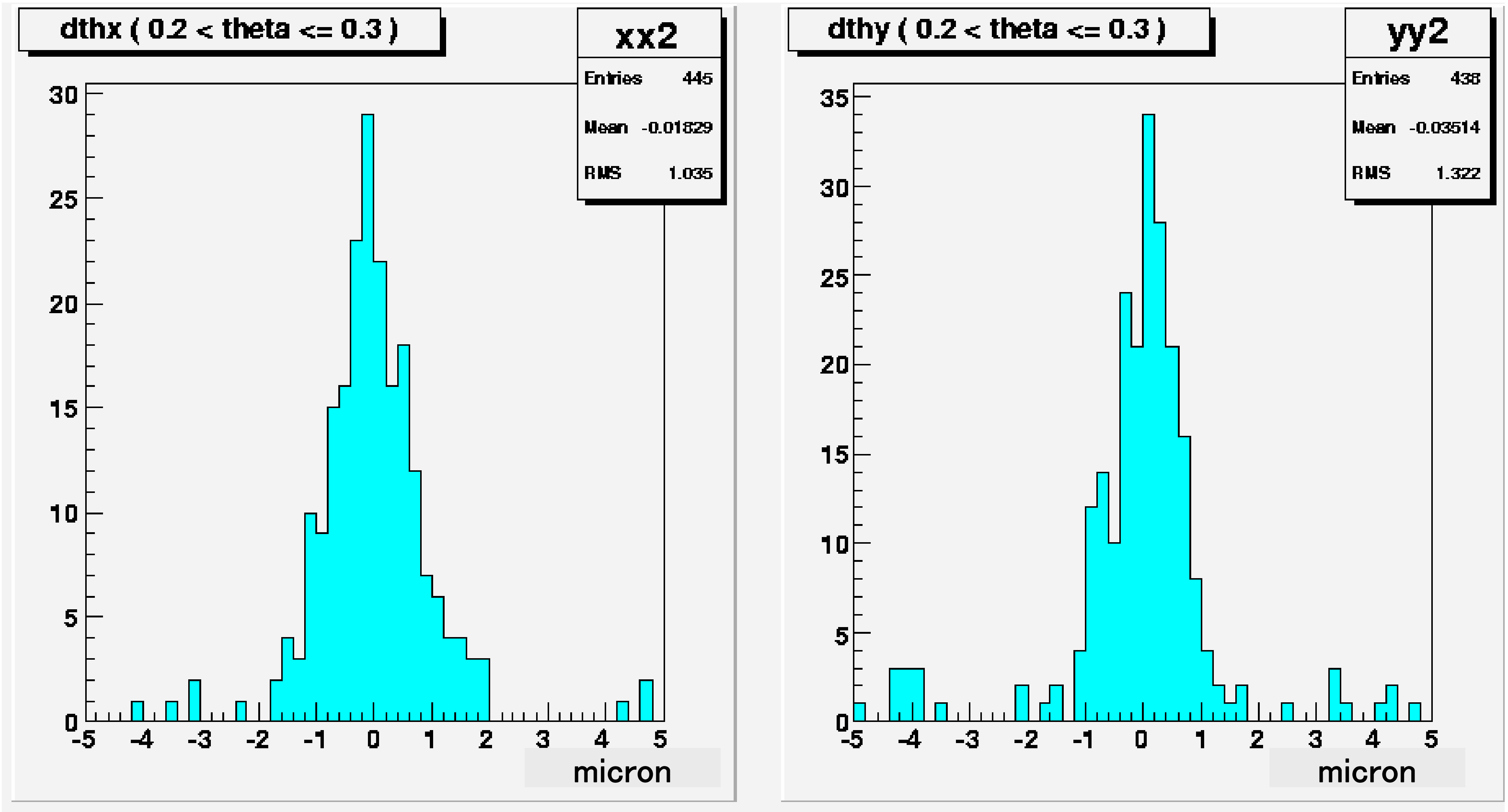
Micro track angle resolution

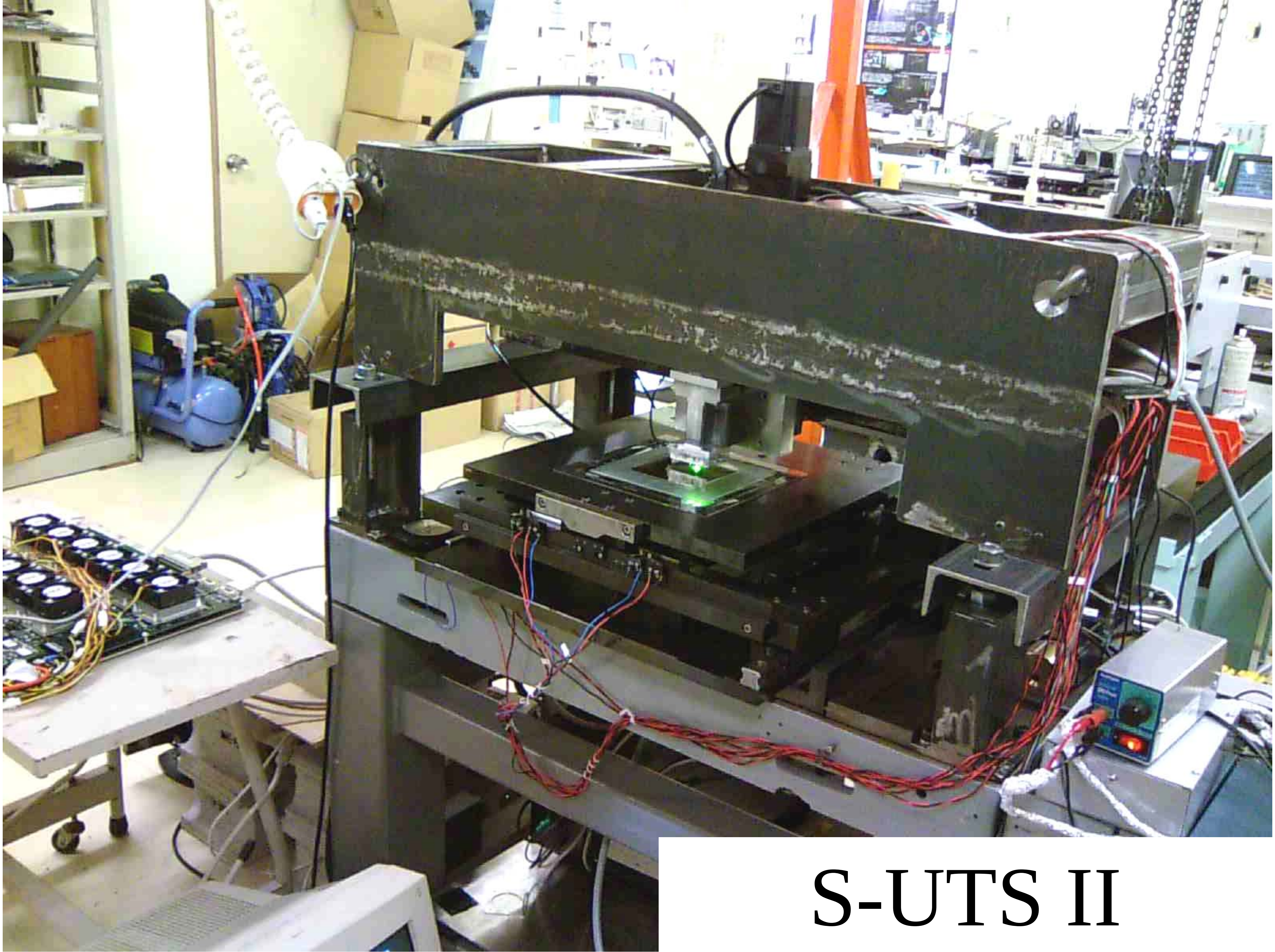
Stage side



Base Track position resolution

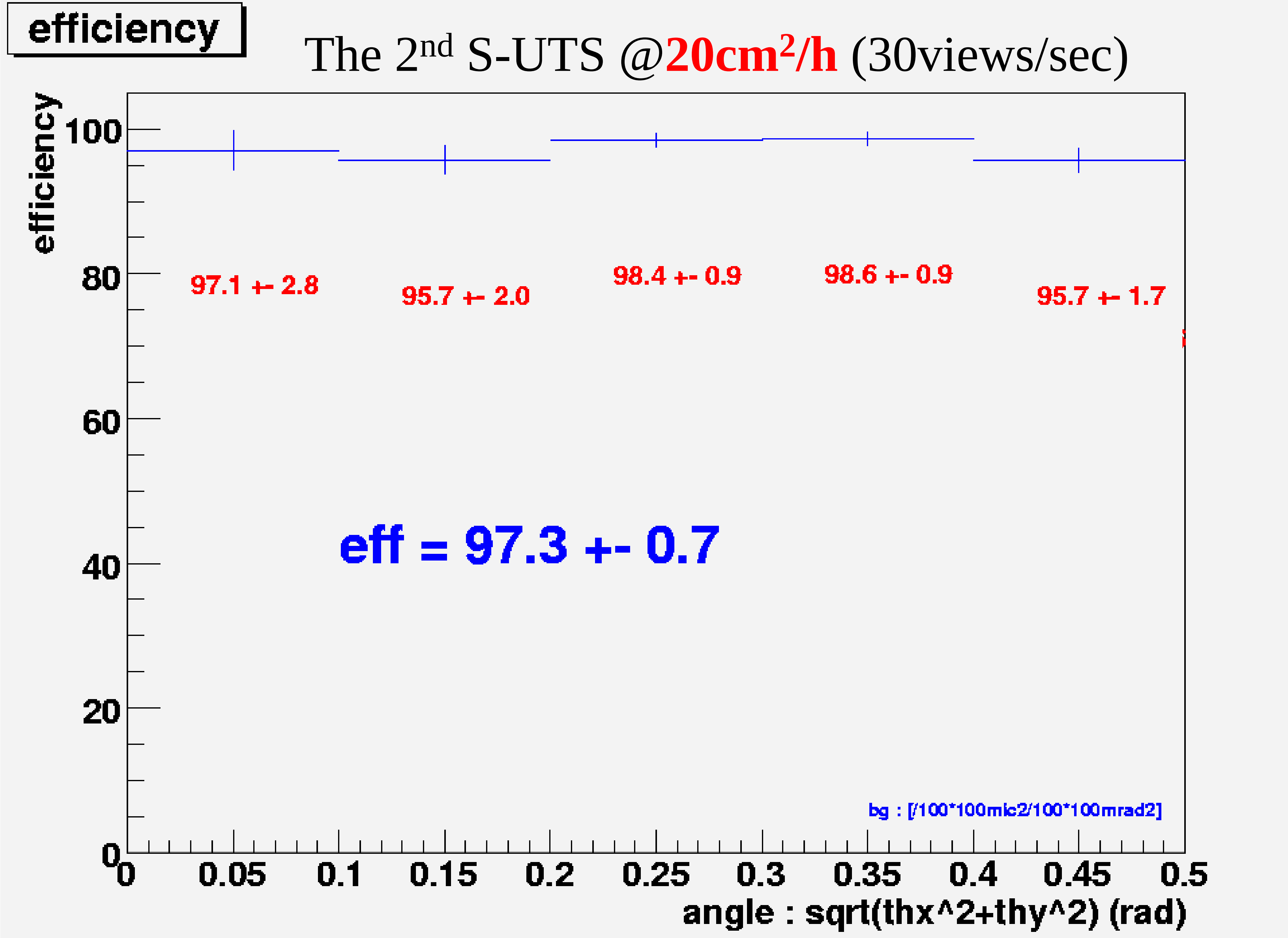



dthx (0.2 < theta <= 0.3)
xx2
Entries 445
Mean -0.01829
RMS 1.035
micron
dthy (0.2 < theta <= 0.3)
yy2
Entries 438
Mean -0.03514
RMS 1.322
micron

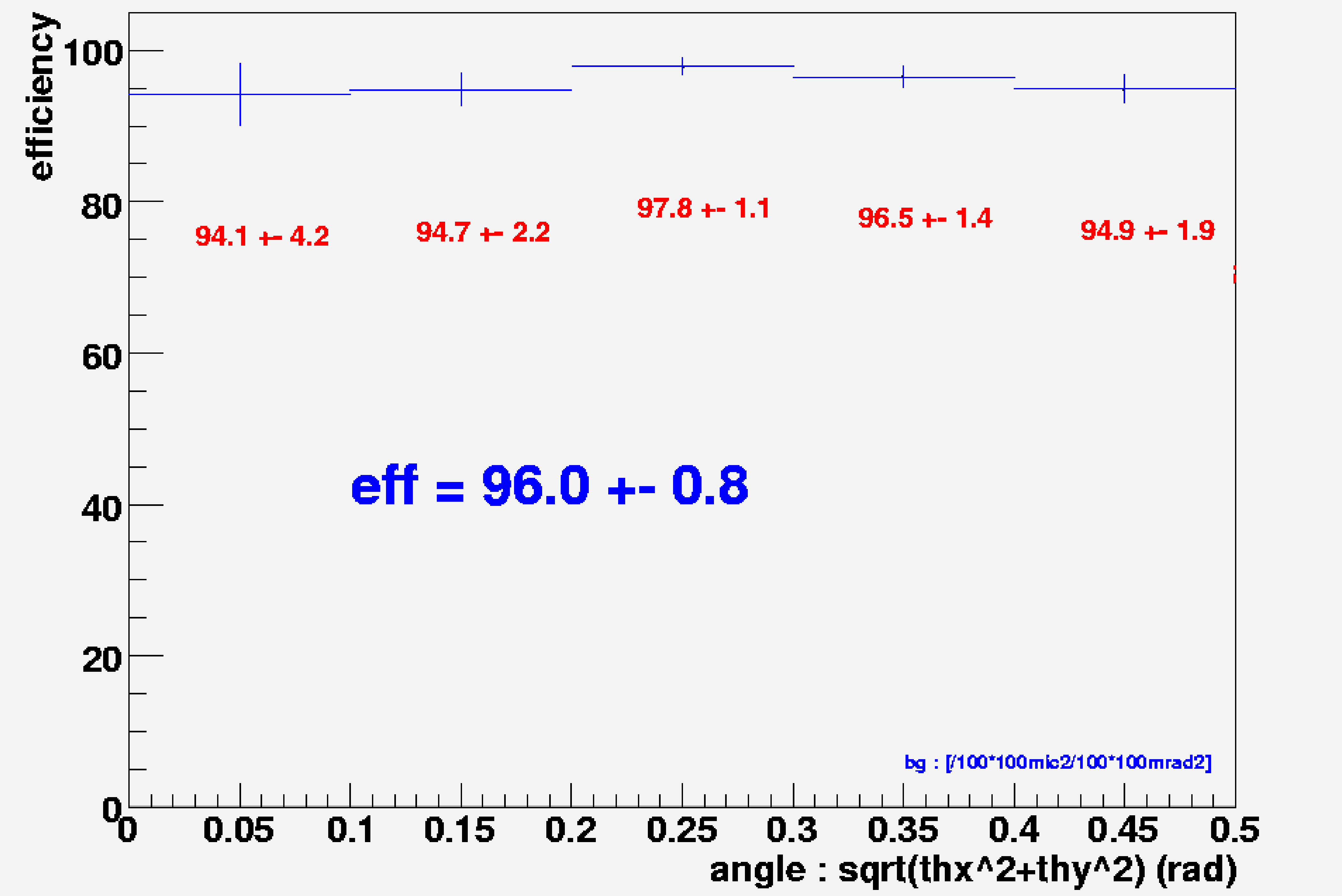


S-UTS II

The 2nd S-UTS @20cm²/h (30views/sec)



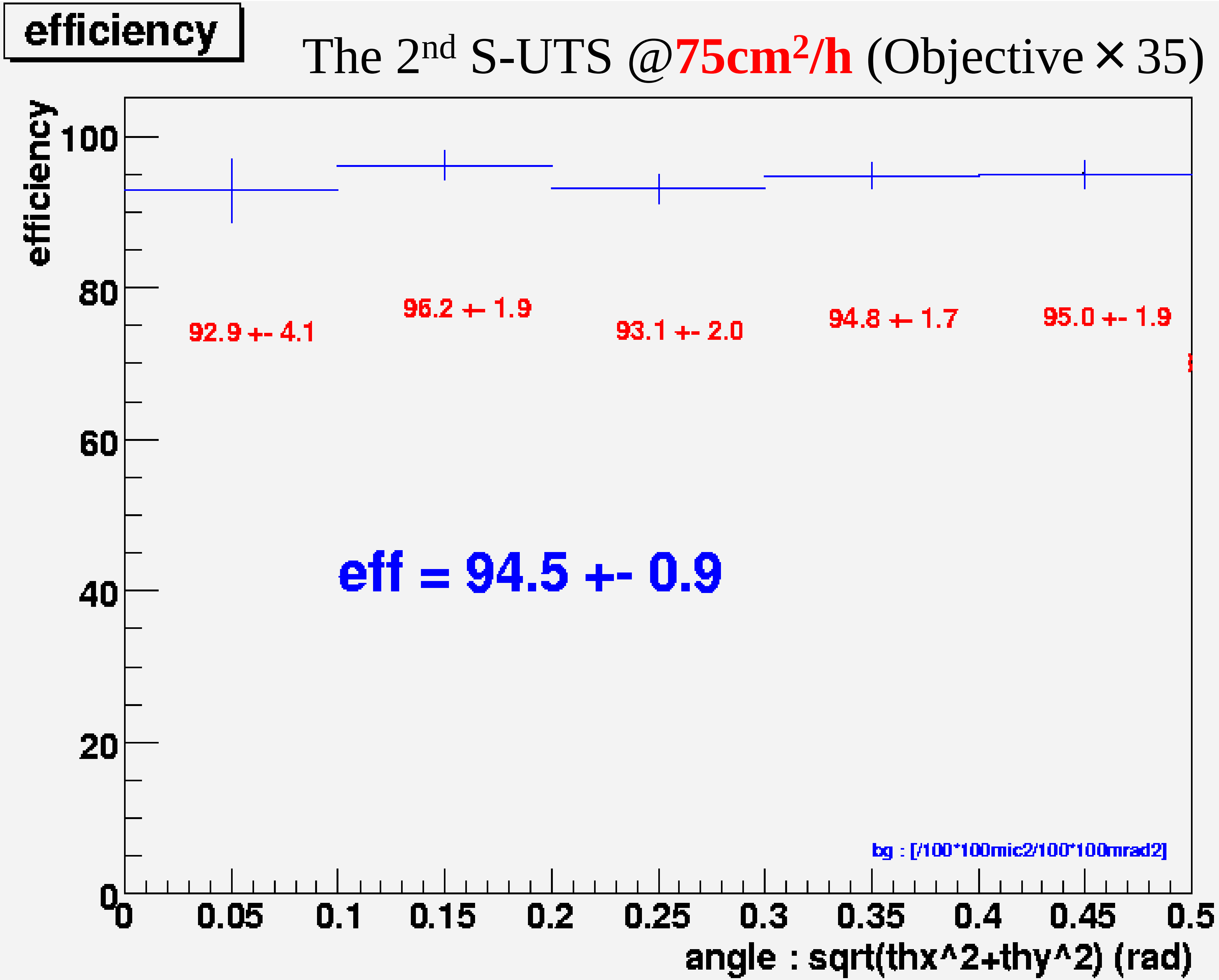
The 2nd S-UTS @**40cm²/h** (60views/sec)



改良の見込み

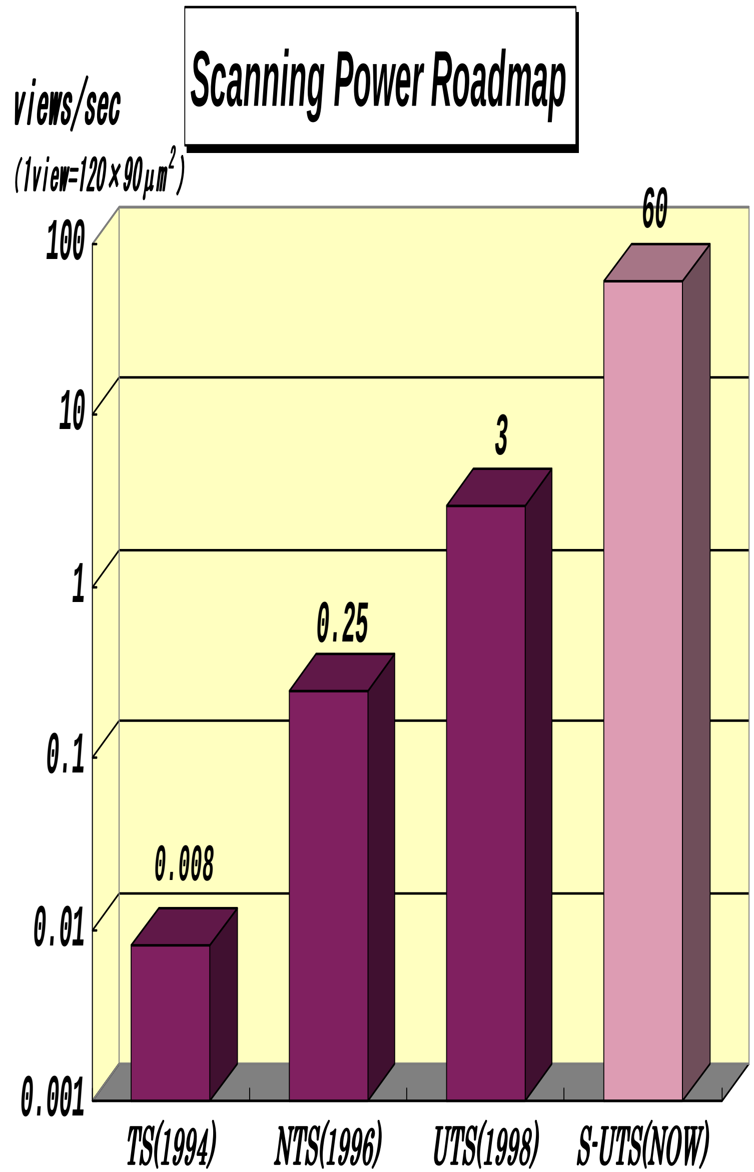
- 繰り返し周期の短縮
  - 現状 60views/s (40cm^2/h) ⇒ 90view/s (60cm^2/h)
- FPGA上のコードの最適化による処理能力の向上。
- 飛跡認識パラメーターの最適化による品質の向上
  - 角度分解能, アクセプタンス等, 光学収差の補正
- 対物レンズの低倍率化（広視野化）による飛跡読み出し速度の向上。
  - ×50から×35への変更で約2倍のゲイン
  - ×25が実現すれば4倍以上のゲイン

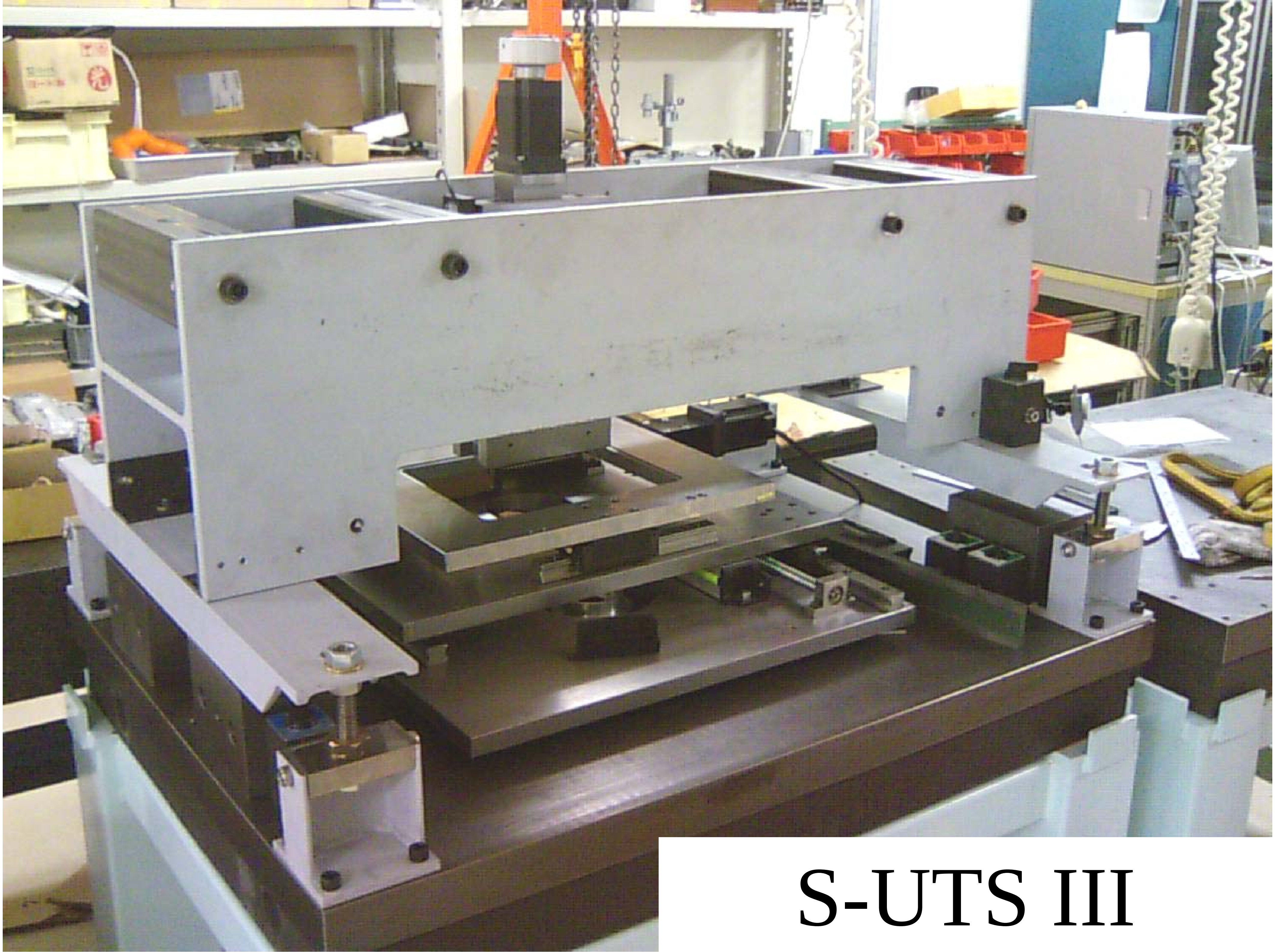
The 2nd S-UTS @75cm^2/h (Objective × 35)



まとめ

- 40cm^2/hでの飛跡読取りを実現し、最低限の性能は確保。
- Efficiency ~95%@ base track (2-fold coincidence).
- Facilityを構築しつつ性能の向上を図っている。
- 低倍率化（広視野化）による速度向上は非常に有望。100cm^2/hも目前。5 systemsで10000cm^2/day＝＞PEANUT





S-UTS III