Emulsion Scanning Facility in Nagoya

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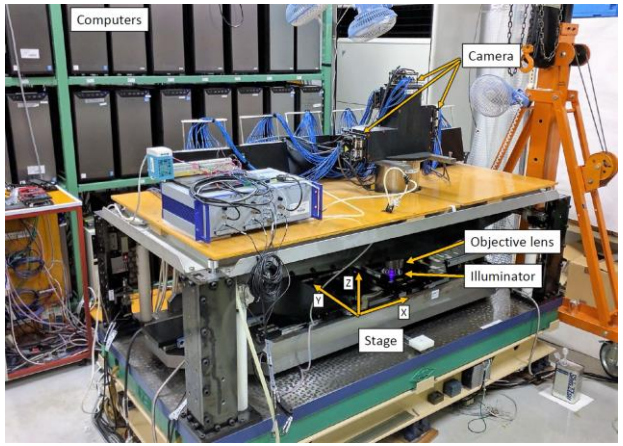
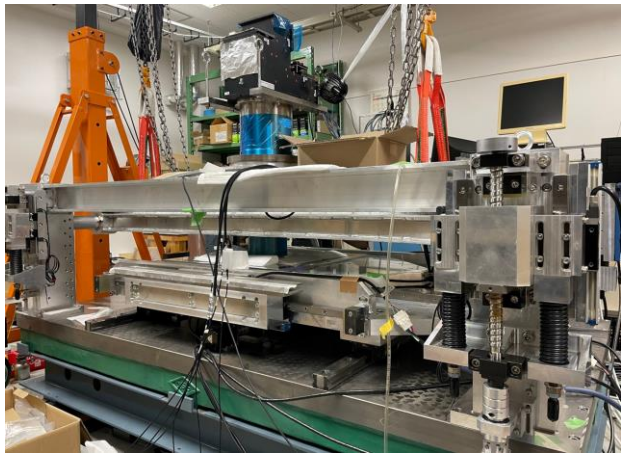


HTS1

Scanning throughput.

4,500cm^2/h

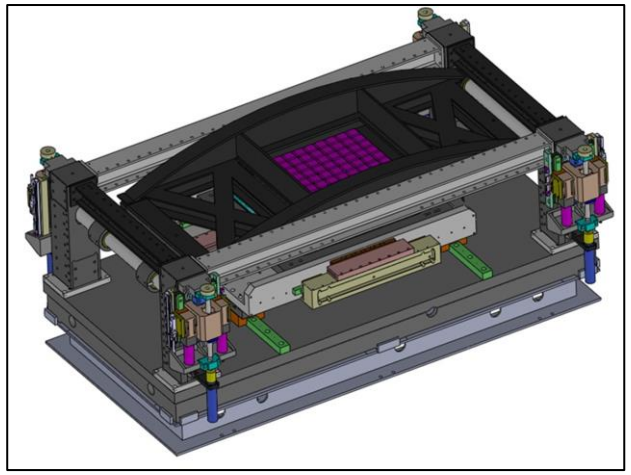
Bench mark system



HTS2

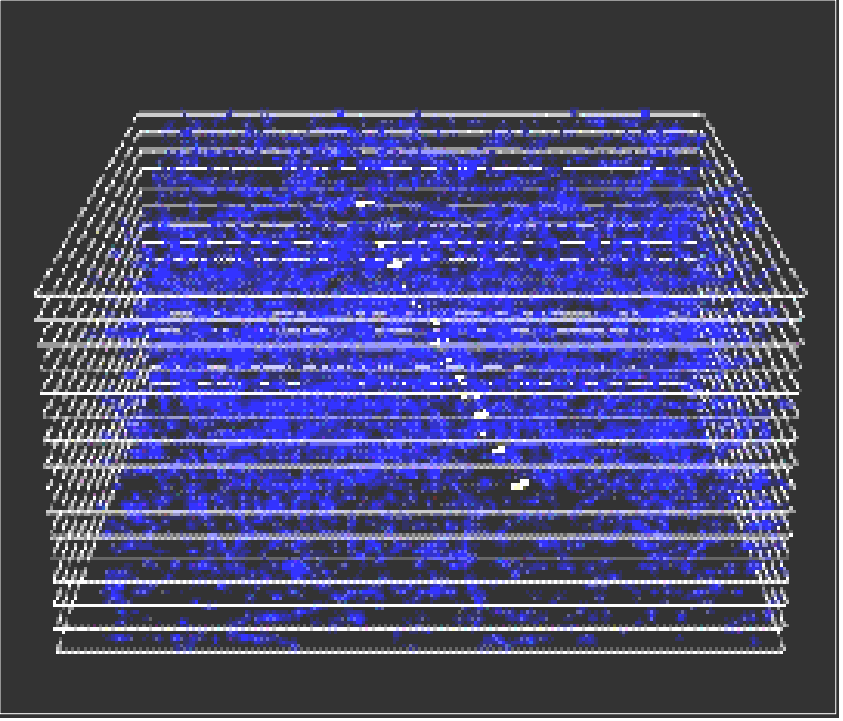
9,000(step) -

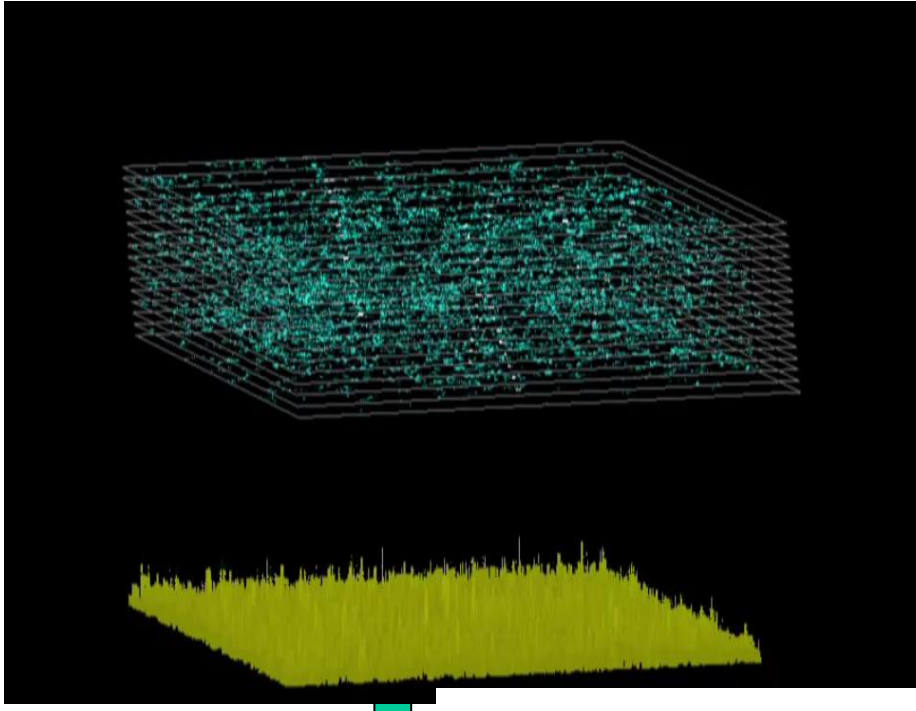
25,000(cont.)cm^2/h



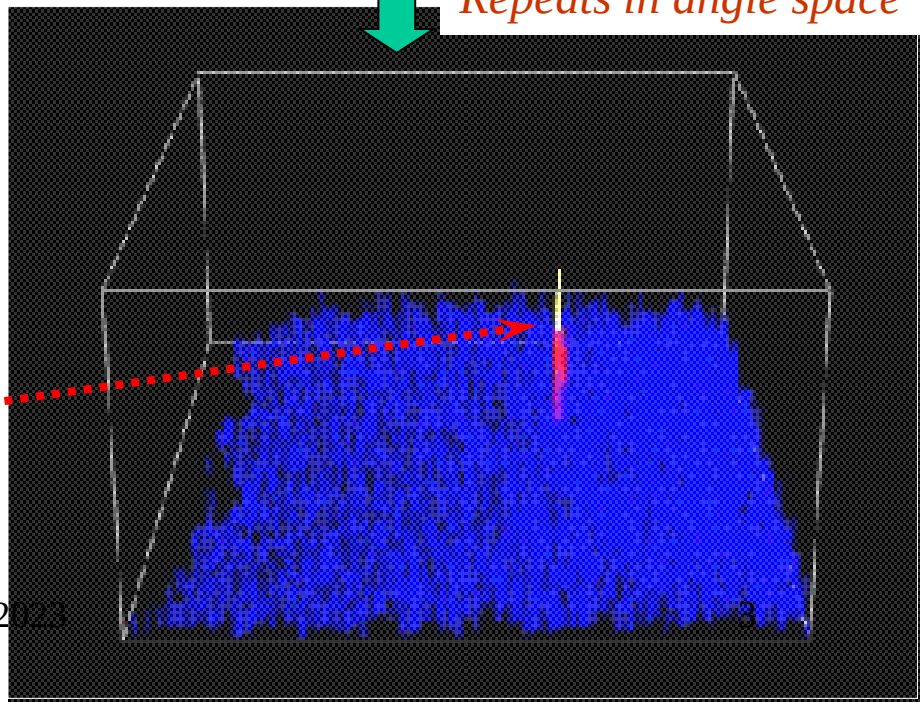
HTS3

>48,000cm^2/h



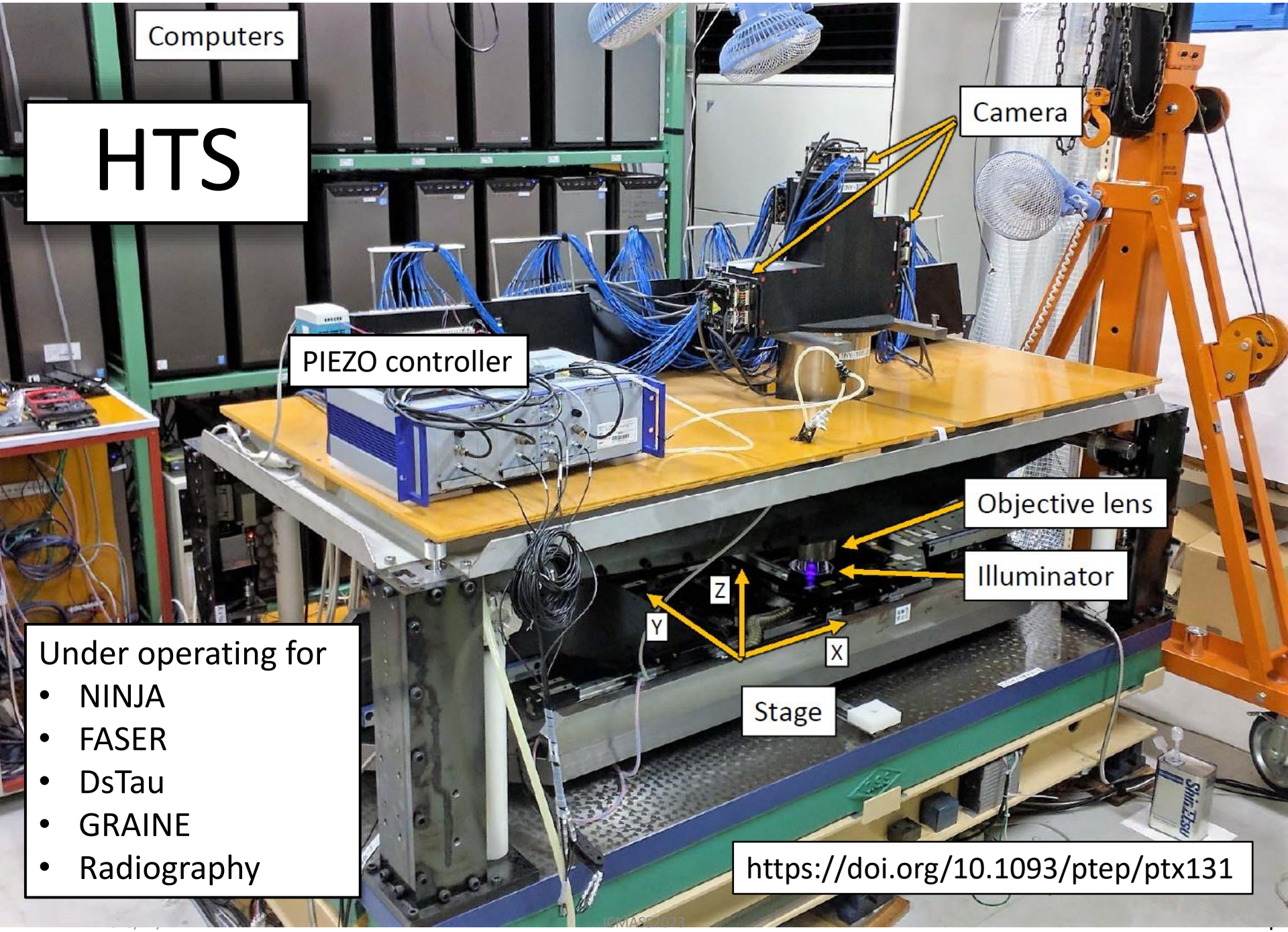


Repeats in angle space



- Take 16 tomographic images by microscope optics.
- Shift images to aim at specific angle tracks
- Sum up 16 images to examine coincidence.
- Find signal of tracks.

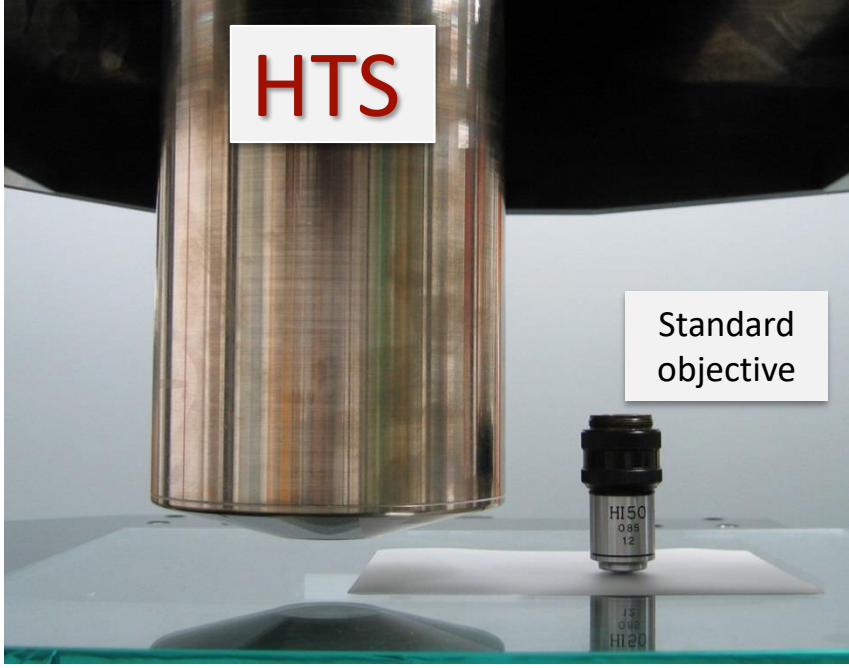
Invented by K.Niwa in 1974


Computers
HTS
Camera
PIEZO controller
Objective lens
Illuminator
Z
Y
X
Stage
Under operating for
• NINJA
• FASER
• DsTau
• GRAINE
• Radiography
https://doi.org/10.1093/ptep/ptx131

HTS series

- Very large field of view
  ex. 9 x 5.5 mm^2 (HTS2)
- Quick and Uniform velocity stage using linear motors and counter mass.
- GPGPU based image processing

  <30ms @tanθ<1.6 (Geforece RTX2080)



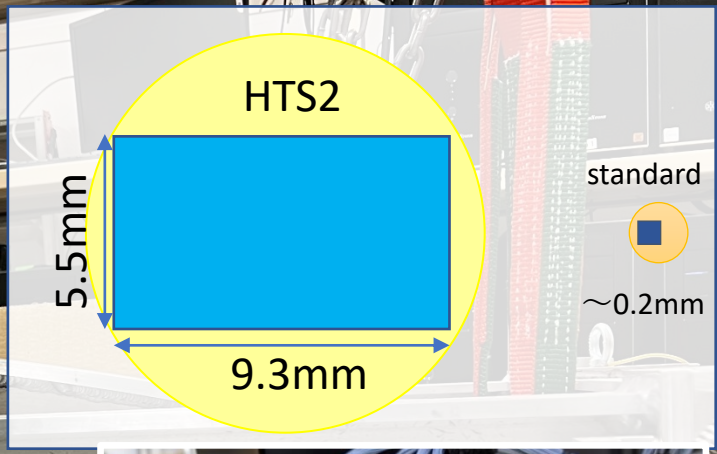
	FOV	View Cycle	Scan speed
SUTS	0.04mm^2	50Hz	72cm^2/h
HTS (running)	**25mm^2**	**5Hz**	**4,500cm^2/h**
HTS2 (under commissioning)	50mm^2	15Hz equiv.	25,000cm^2/h
HTS3	> 132mm^2	10Hz	48,000cm^2/h

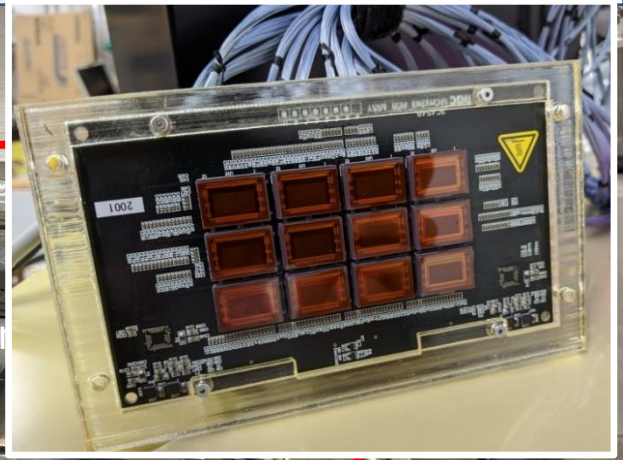
HTS2

CMOS imagers (72)

Objective

Stage

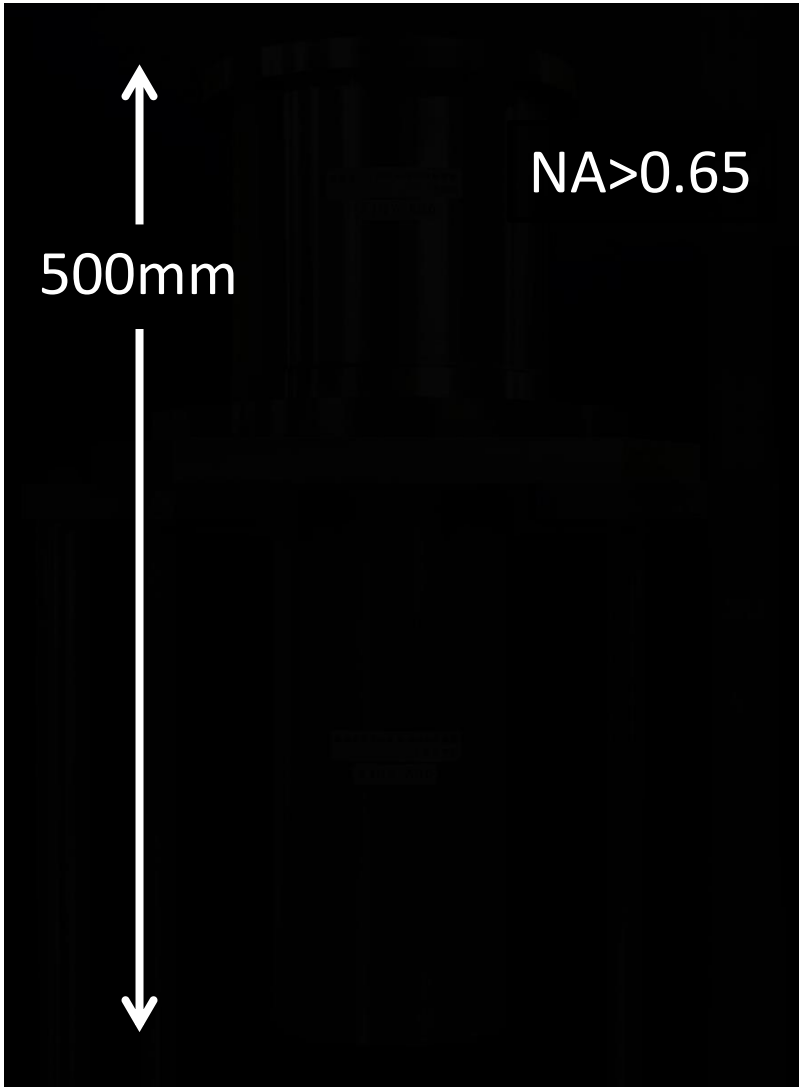




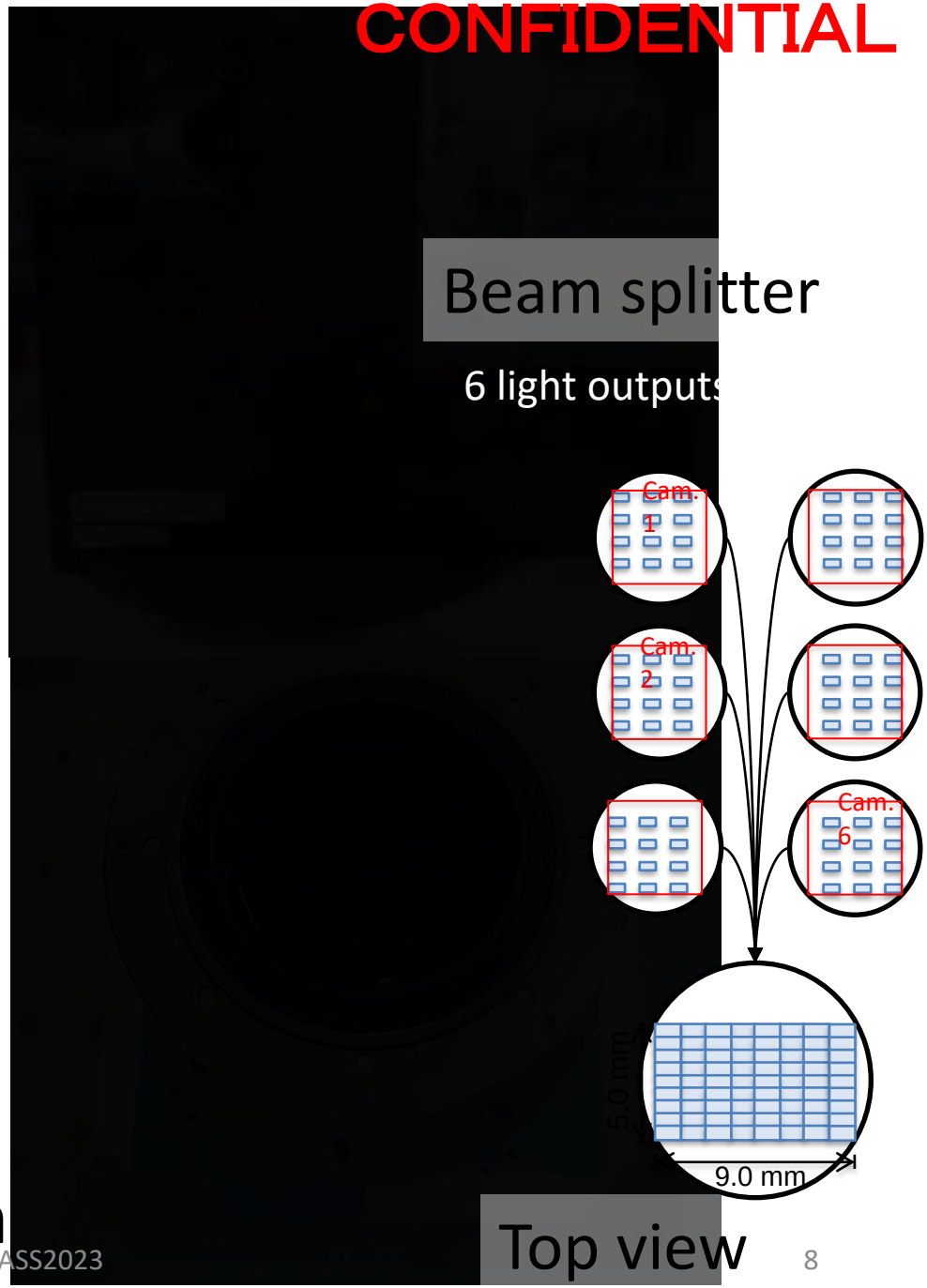
40cm

40cm

HTS2 objective lens



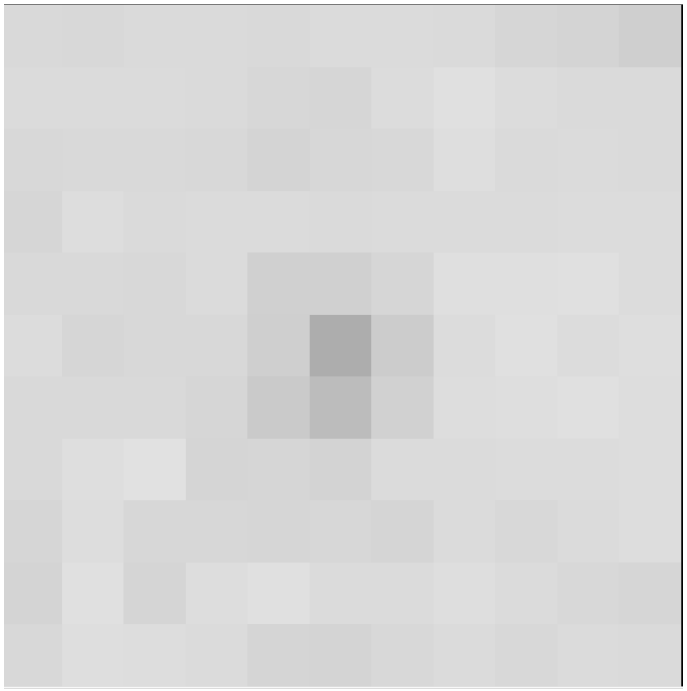
FOV : 9.33mm × 5.25mm



Reducing the effects of lower magnification

Implemented resizing image with a standard interpolation algorithm.

HTS2 raw image of grain (cropped)



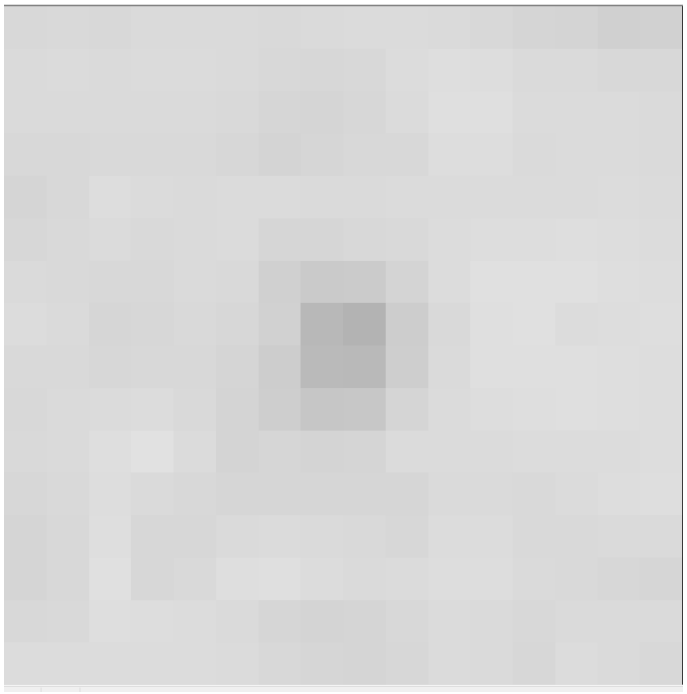
7um

1pixel ≃ 0.63 um

Ref. Minami's Poster
A1-P4 0145

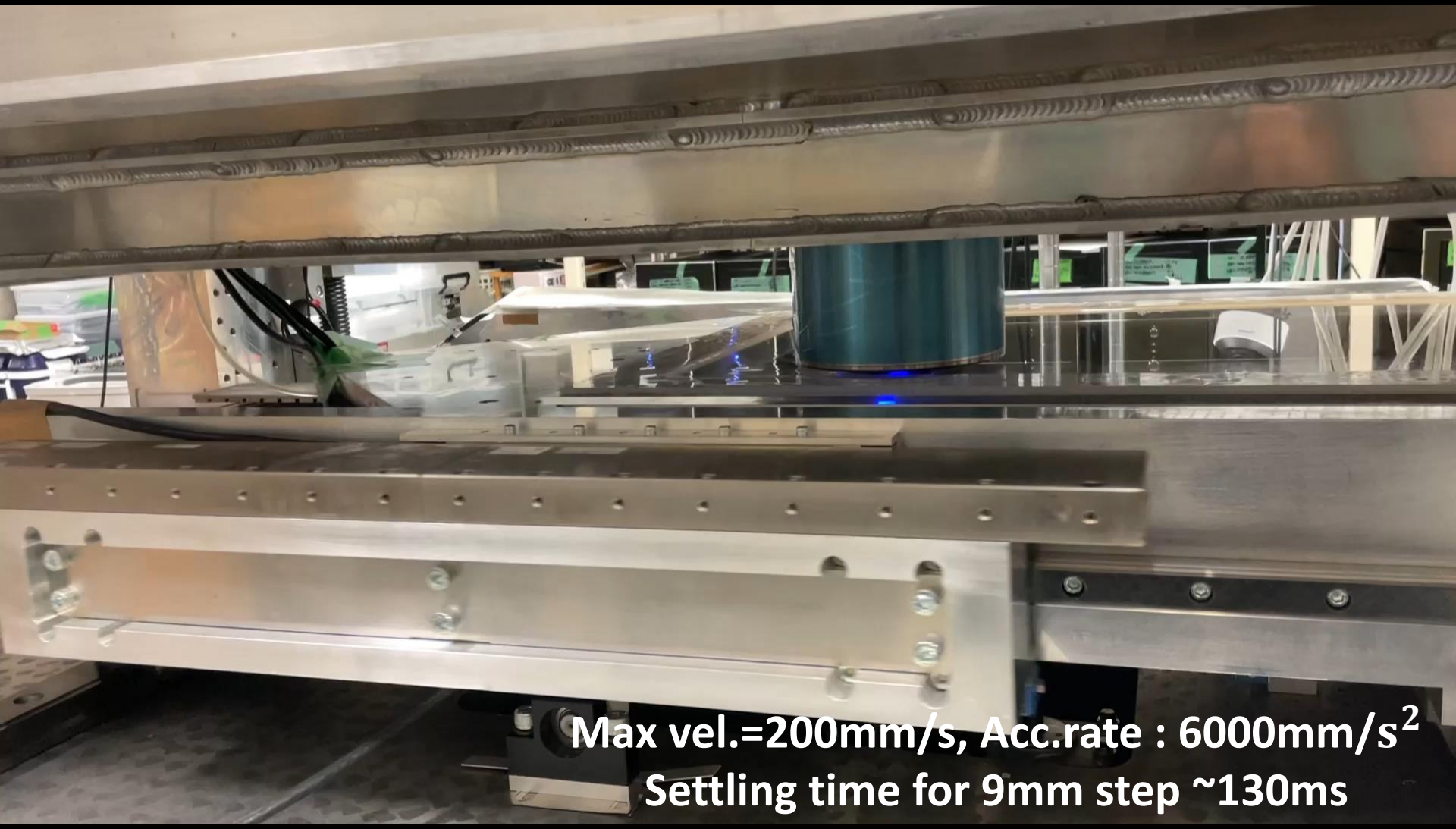
Image size per sensor
: 2048 × 1088 pixel
to
2896 × 1539 pixel
with bicubic interp.
(OpenCV, cv::gpu::resize)

After resize image with interpolation

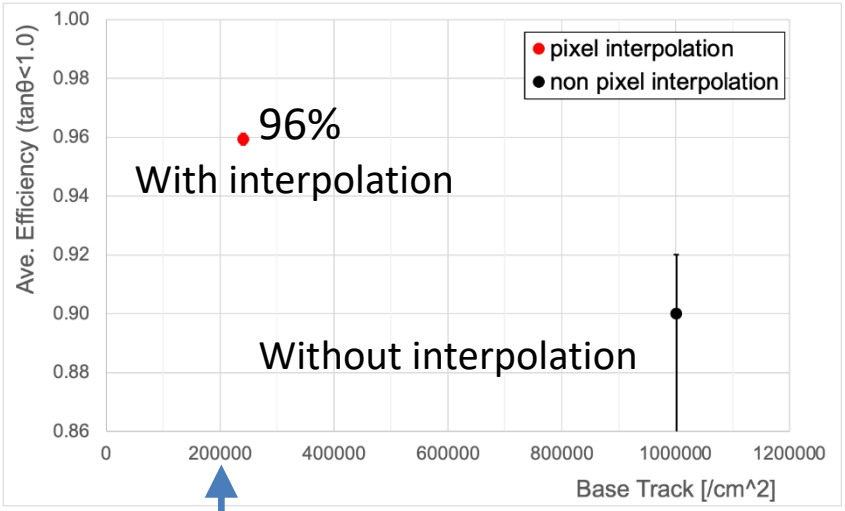


1pixel ≃ 0.45 um
Equivalent to HTS

HTS2 SCANNIG TEST (STEP mode)



The result with Bicubic interpolation

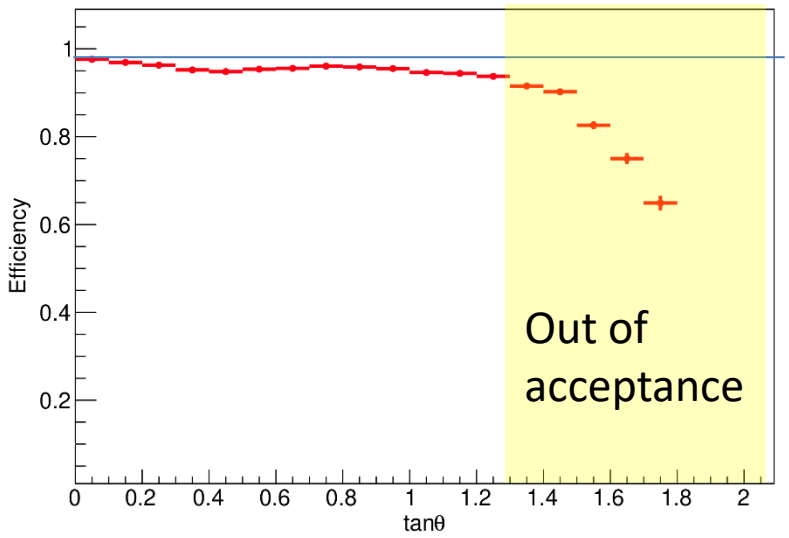


2*10^5 tracks/cm^2

Film : GRAINE2023
Developer : GR-1

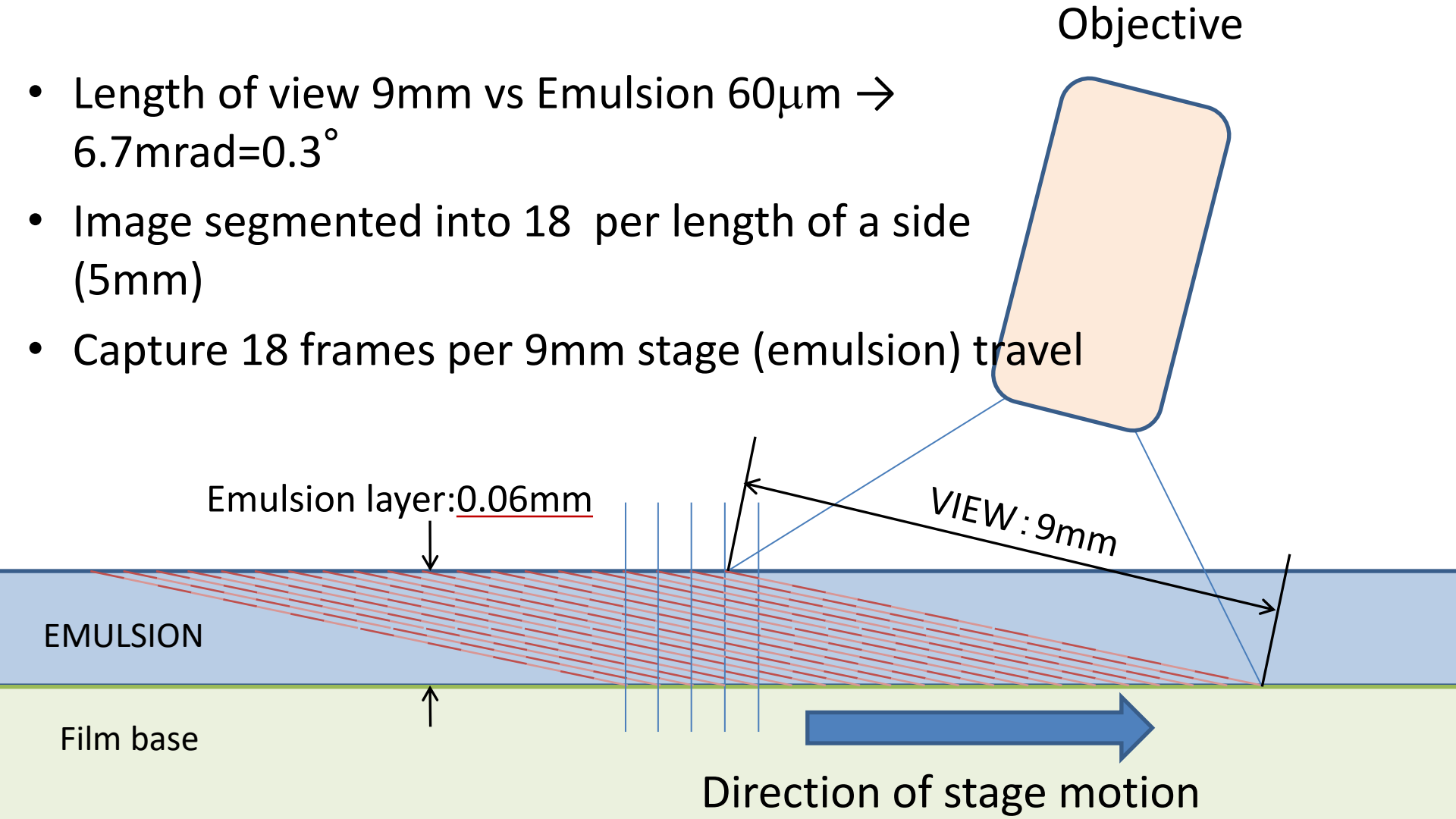
Ref. Usuda's Poster
A1-P5 0155

Efficiency vs. track slope

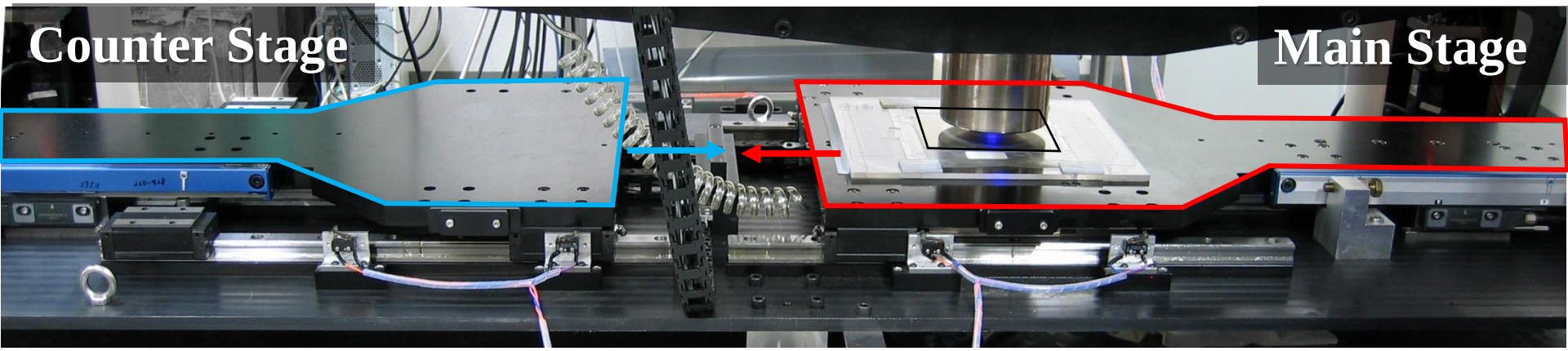


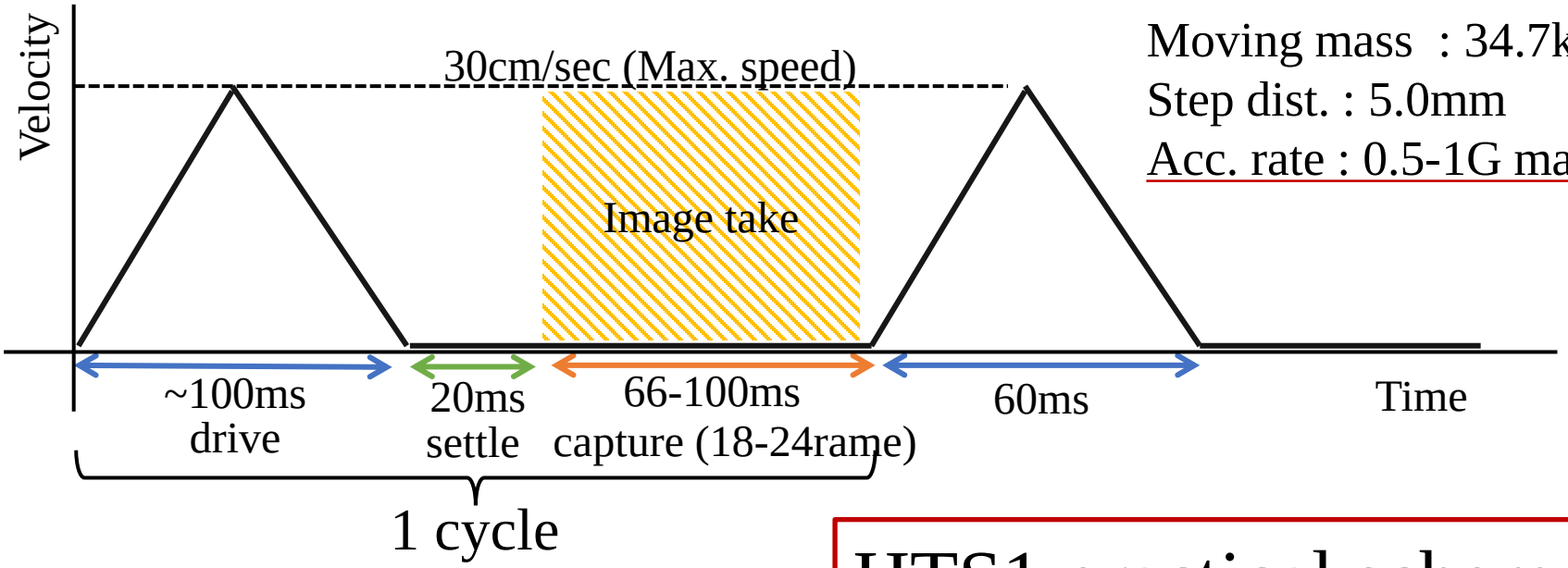
Continuous image capturing

- Length of view 9mm vs Emulsion 60μm → 6.7mrad=0.3°
- Image segmented into 18 per length of a side (5mm)
- Capture 18 frames per 9mm stage (emulsion) travel



Time chart of each cycle





Moving mass : 34.7kg
Step dist. : 5.0mm
Acc. rate : 0.5-1G max.

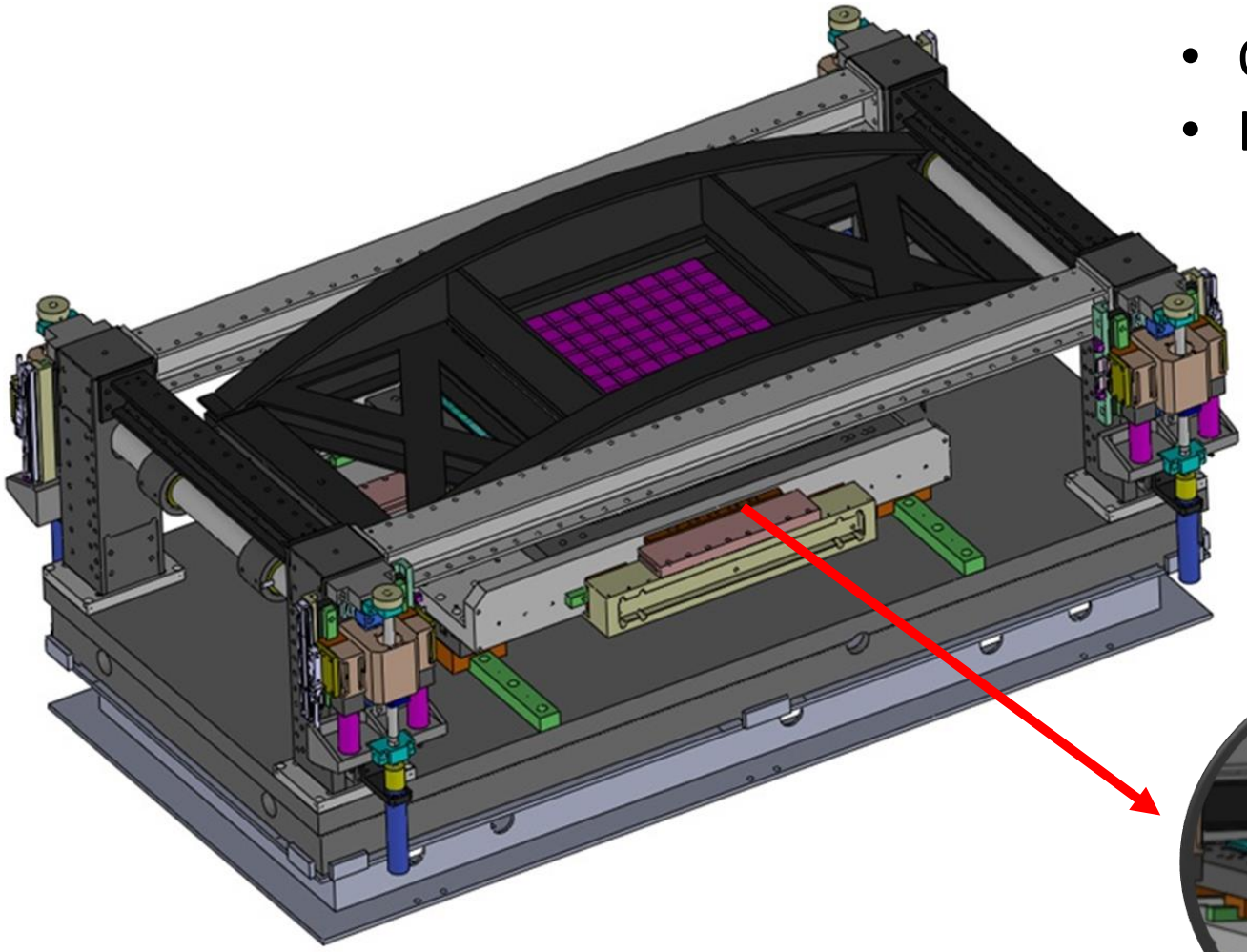
HTS1 practical scheme

HTS2 stage test drive (CONT. mode)

Beyond HTS2

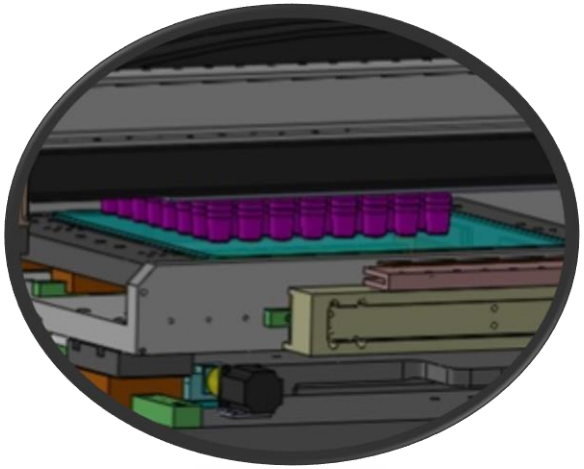
Aiming for faster and more widespread use

HTS3 - Parallelized microscope

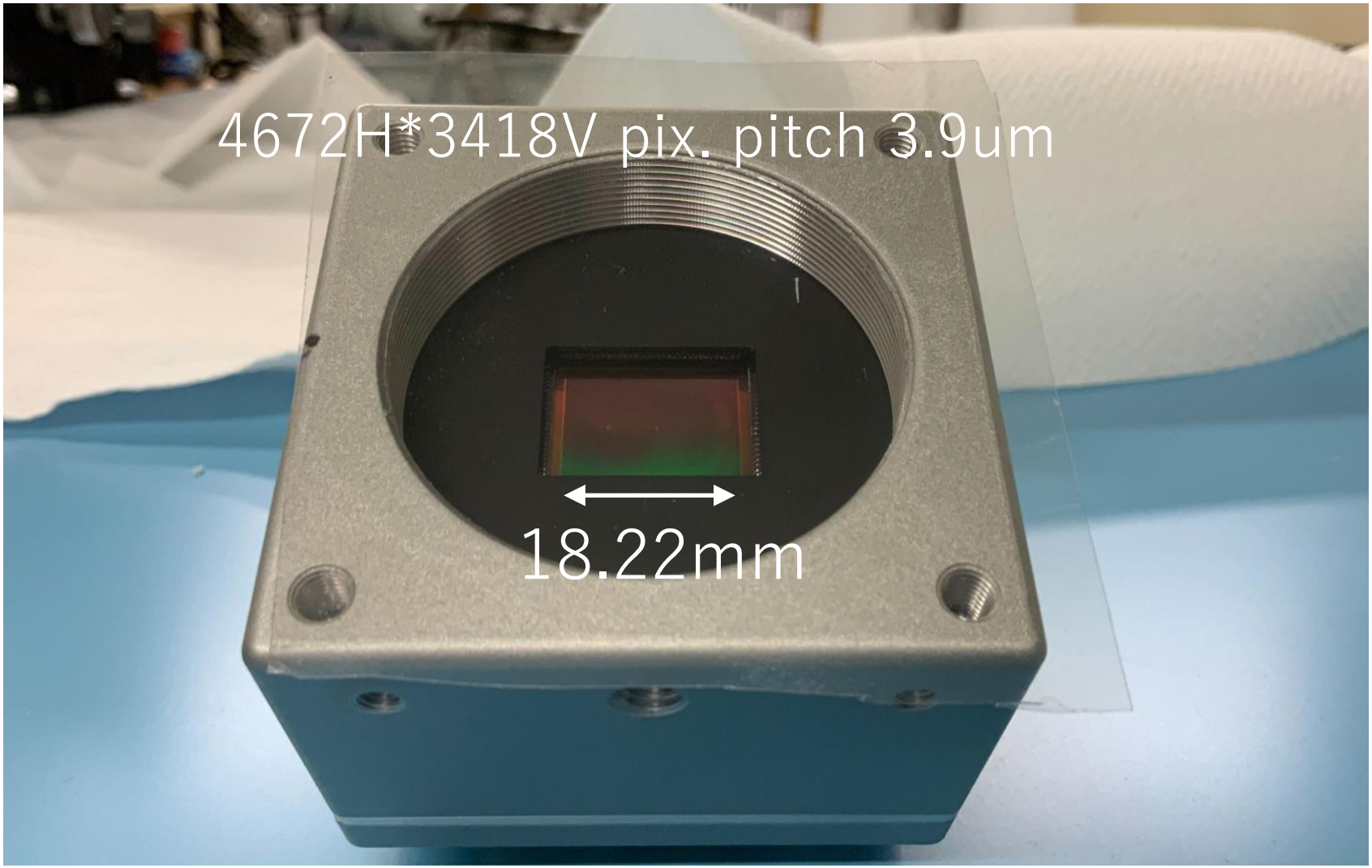


- Objective Matrix
- Large pixel imager

Gives 3x larger field of view of HTS2



ImageSensor for HTS3



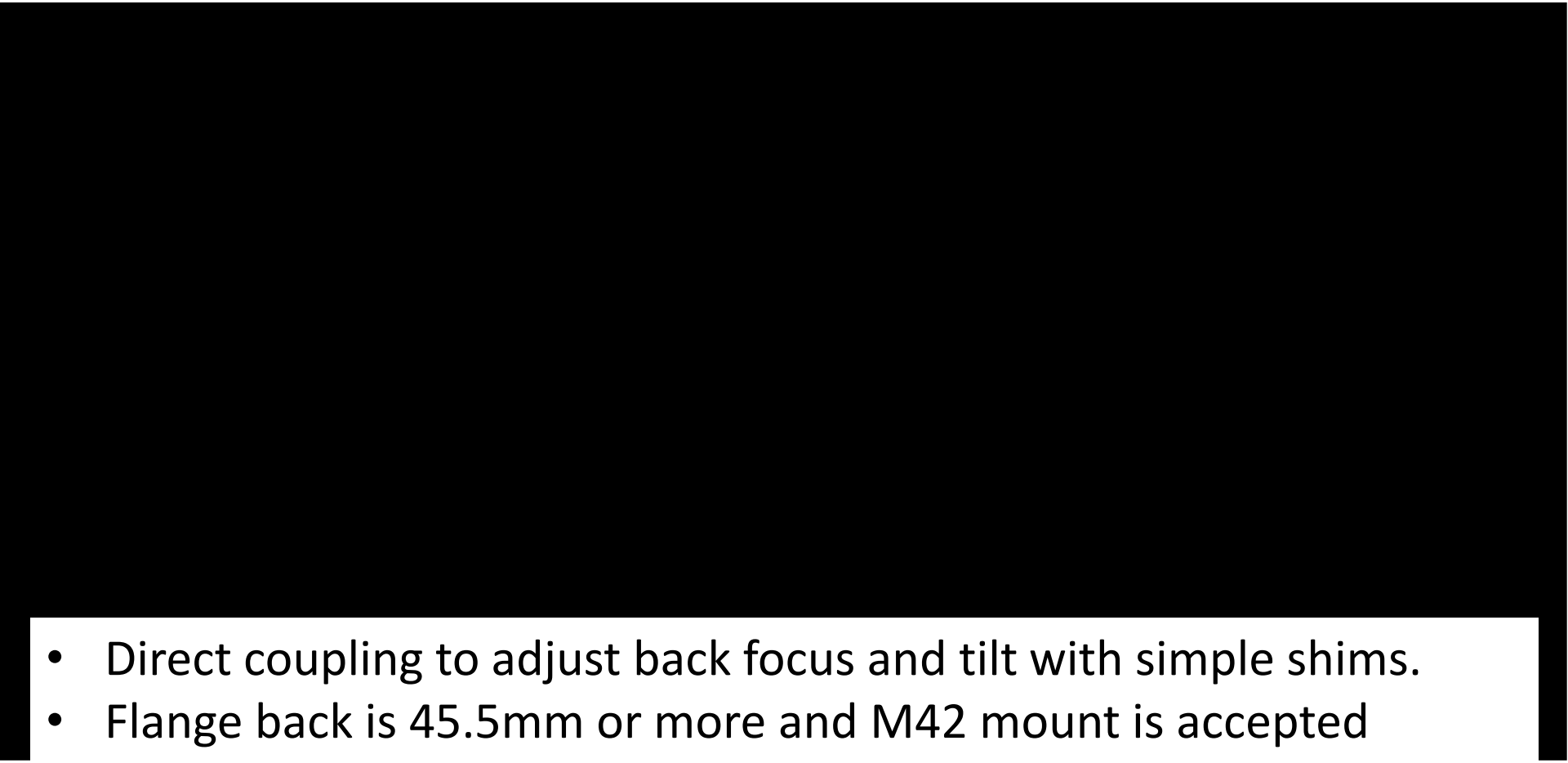
HTS3 scanning speed

- Number of pixel 4672H*3418V pix. pitch 3.9um per objective
  - Cell size(pixel pitch) of HTS1 and 2 is 5.5 um Magnification : HTS1 = x12.2, HTS2= x8.6
  - Assuming 25 optics

Objective Mag.	Pixel size (μm)	X size (mm)	Y size (mm)	FOV/obj Area(mm^2)	Total FOV Area(mm^2)	
8.67	0.45	2.10	1.54	3.24	81	HTS1-like
6.07	0.64	3.00	2.20	6.62	165	HTS2-like

- Total FOV 150mm^2 is x6 larger than HTS1 .
- If 10 Hz/100ms per view is achieved, the throughput will be 12 times faster than HTS1. = 2x speed of HTS2
  - View step become half of HTS1 and ¼ of HTS2
- If 100 objectives, -> 8 times the speed of HTS2 can be achieved

Possibility with a single objective, HTS-3S

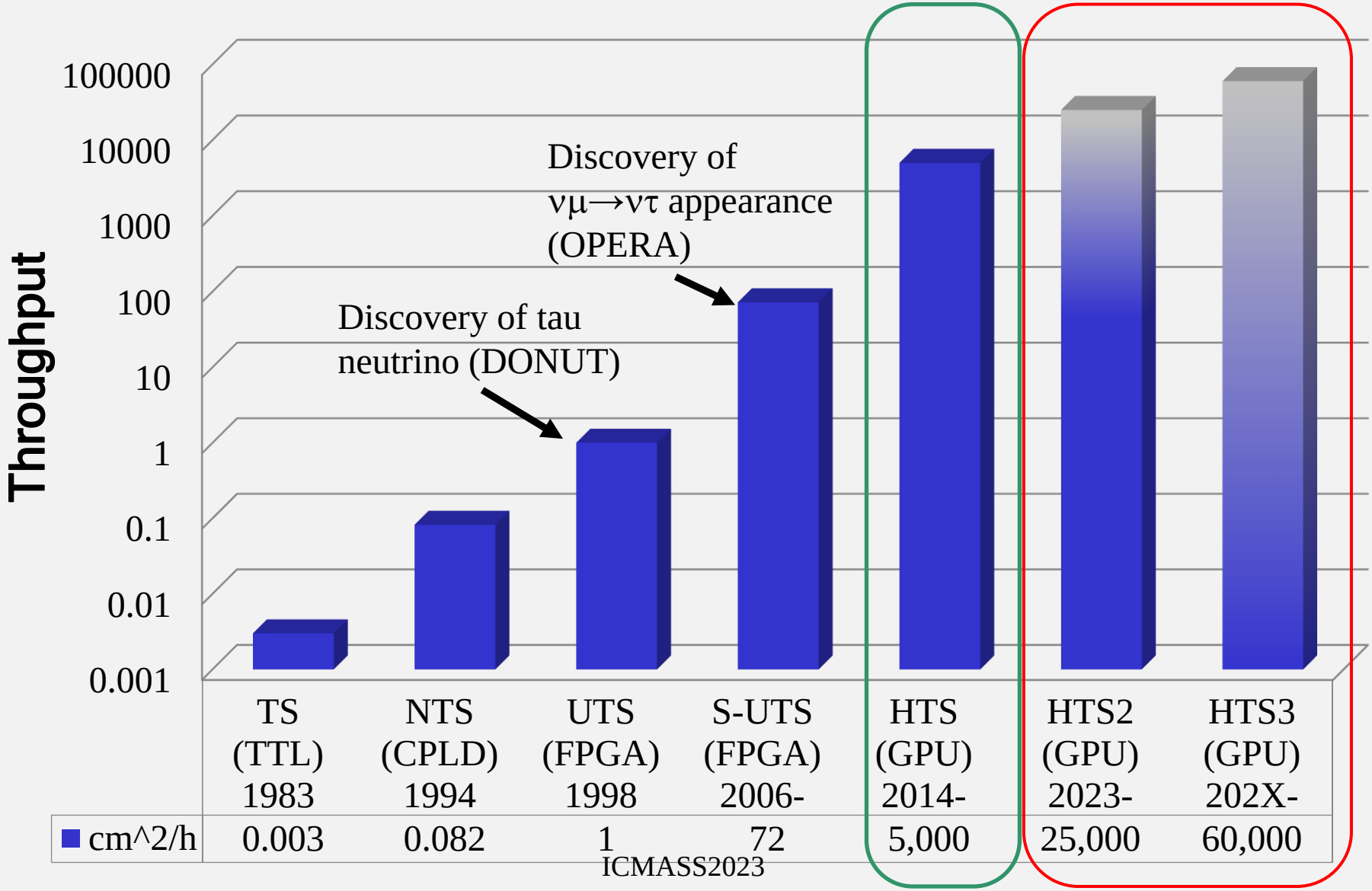


- Direct coupling to adjust back focus and tilt with simple shims.
- Flange back is 45.5mm or more and M42 mount is accepted

One objective gives about ¼ FOV of HTS1

⇒ 1000cm^2/h can be achieved with reasonable cost

Emulsion Readout History and Roadmap



Conclusion

- “HTS2” is in the practical stage.
  - Stop Go operation started.
  - Target scan speed : 2.5m^2/h
  - Accepts large emulsion films
- Constructing HTS3 - >2x HTS2, and sub system for widespread use.
- Nagoya group supports various experiments and projects which need large amount of nuclear emulsions, order of 1000m^2.
  - Muon imaging
  - Particle physics
  - Gamma-ray astronomy