R&D on a New Scanning System for the Opera Experiment

Nicola D'Ambrosio

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New Scanning System

A collaboration among different laboratories is going on (Bari, Bologna, Bern, Lyon, Münster, Napoli, Roma, Salerno)

The goal of the R&D is the development of a New Scanning System for Opera able to reach a speed around 20 cm^2/h.

I will report about our first prototype used to analyze Opera test-beam emulsion with a speed up to 11 cm^2/h

New Scanning System

Taking profit of the experience done with Chorus, we have located the *subjects* to develop for a system suitable for the Opera emulsion scanning

New Scanning System

The system has been developed using commercial components modified according to our requirement and it is strongly software-based, in a way to take advantage of any progress in technology

R&D subjects

Mechanics

(*Settling time)*

Optics

(*Large field of view)*

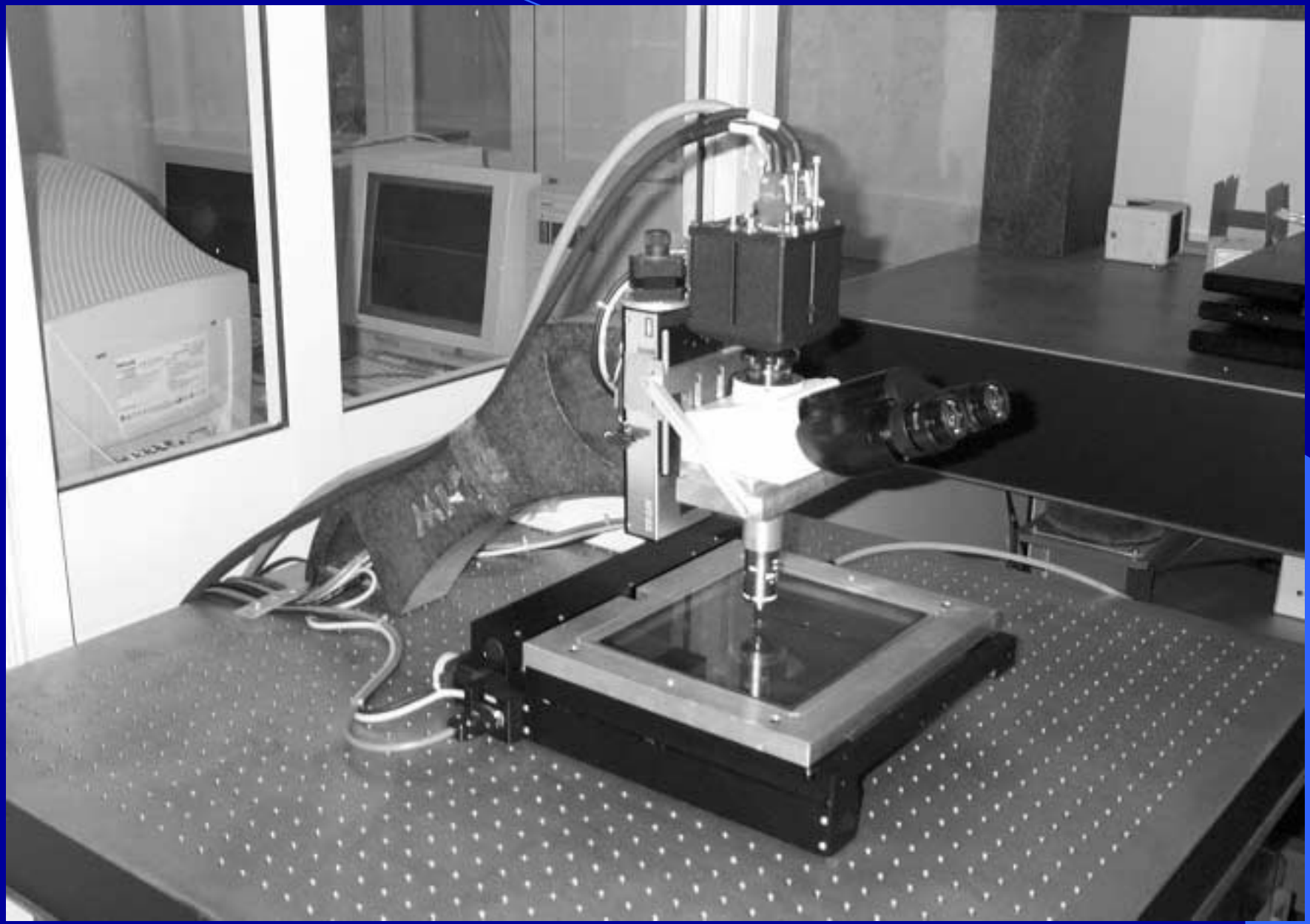
Camera

(Increasing frame rate)

Processors

(*Multi DSP*
Parallel processing)

Picture of the NSS prototype



Microscope setup
(... presently prototype)

- **Mechanics from Micos**
- **Optics from Nikon + custom**
- **Camera from DALSA mod. 1M60**
- **Processor board from Matrox**

  mod. Genesis

Mechanics

Commercial stage modified according to our requirement made by Micos

- **20 x 20 cm^2 wide working area (X,Y horizontal stage)**
- **5 cm travel length (Z vertical stage)**

- **5 phase stepper motors made by Oriental Motors (up to 125000 μsteps)**

- **Encoders provide 0.1 μm resolution**

Motor controller:
National Instruments FlexMotion (7344 PCI)

Mechanics

We have performed a fine tuning on mechanics and motor driving system to obtain a good settling time and positioning

Test condition :

Settling Time

X,Y 350 μm move and wait for oscillation damping (below 0.2 μm)

Z 200 μm move and wait for oscillation damping (below 0.2 μm)

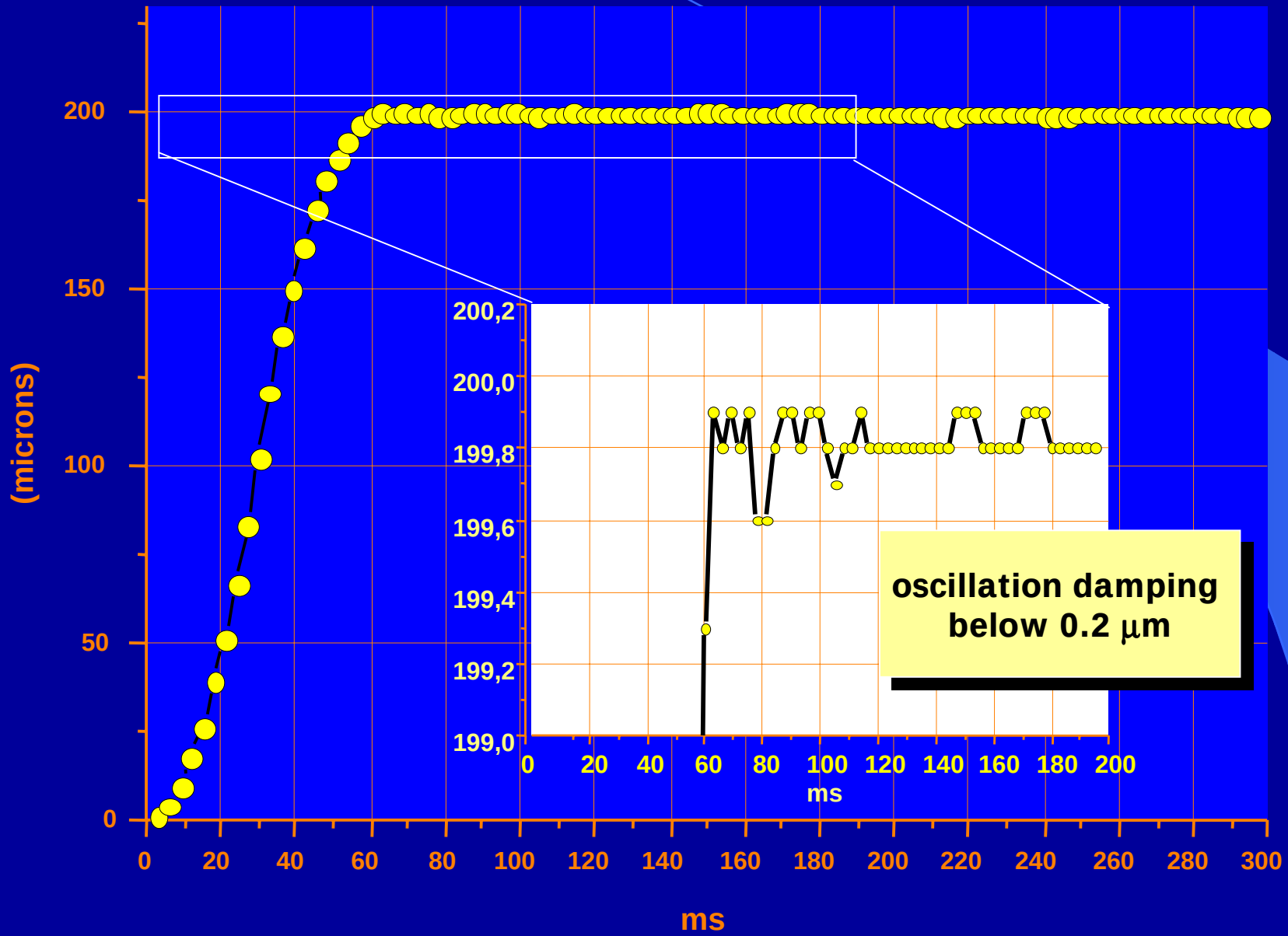
Positioning

X,Y 350 μm step on an area of 10 cm^2 simulating an acquisition
the plots show:
expected – measured position (encoder)

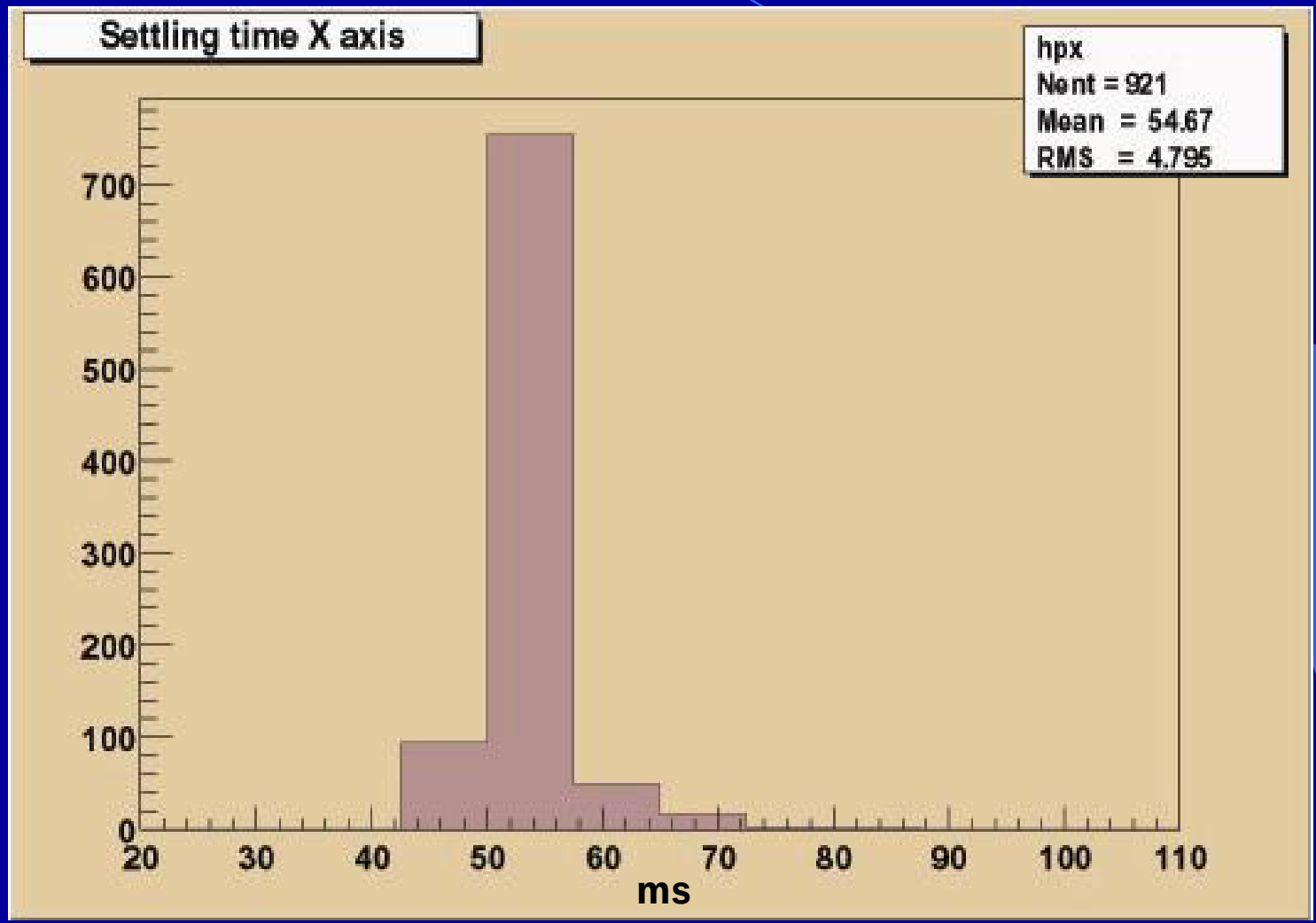
Constant speed

Z 100 μm stroke at 100 μm/s and at 200 μm/s

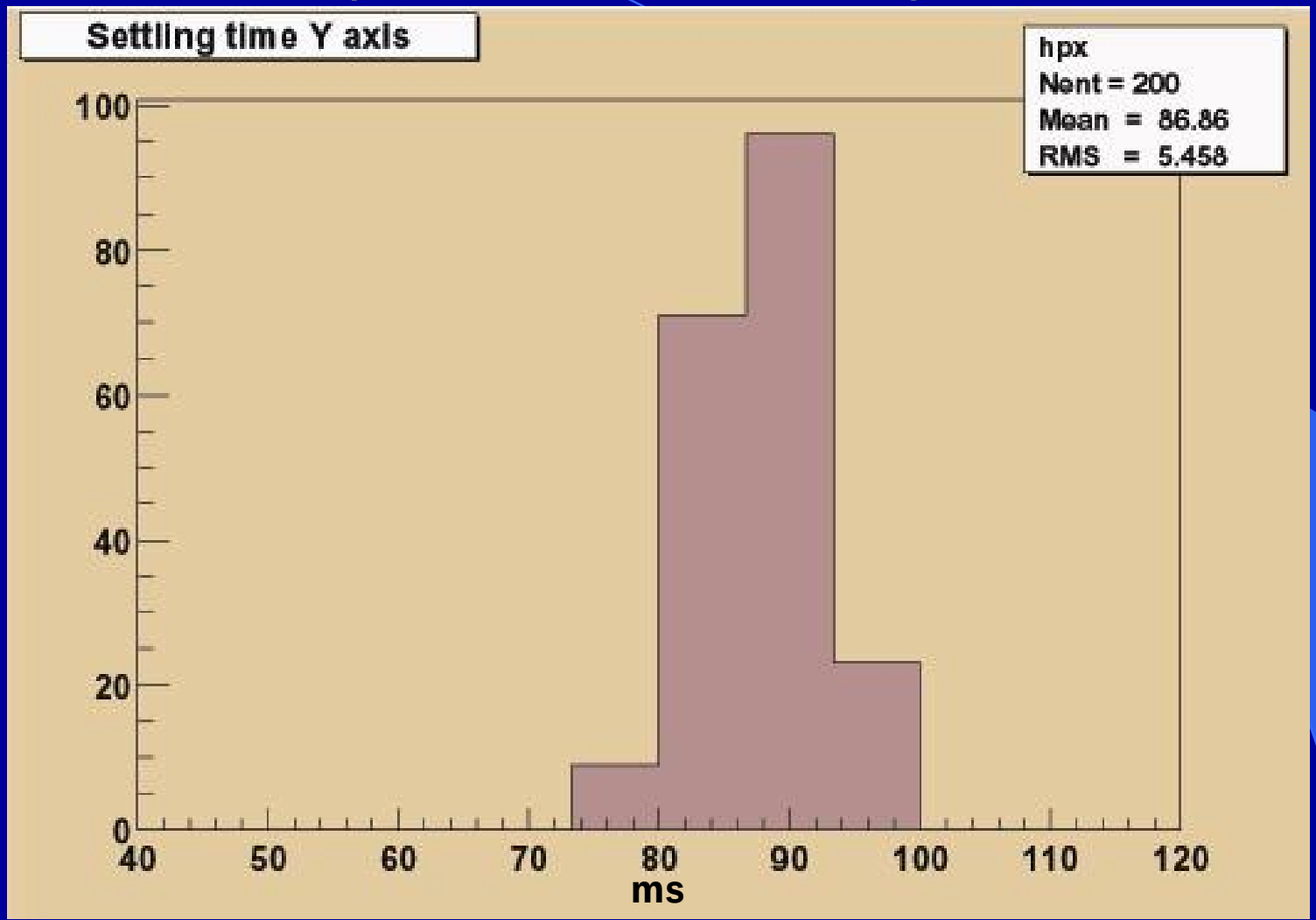
Settling time measurement (Z)



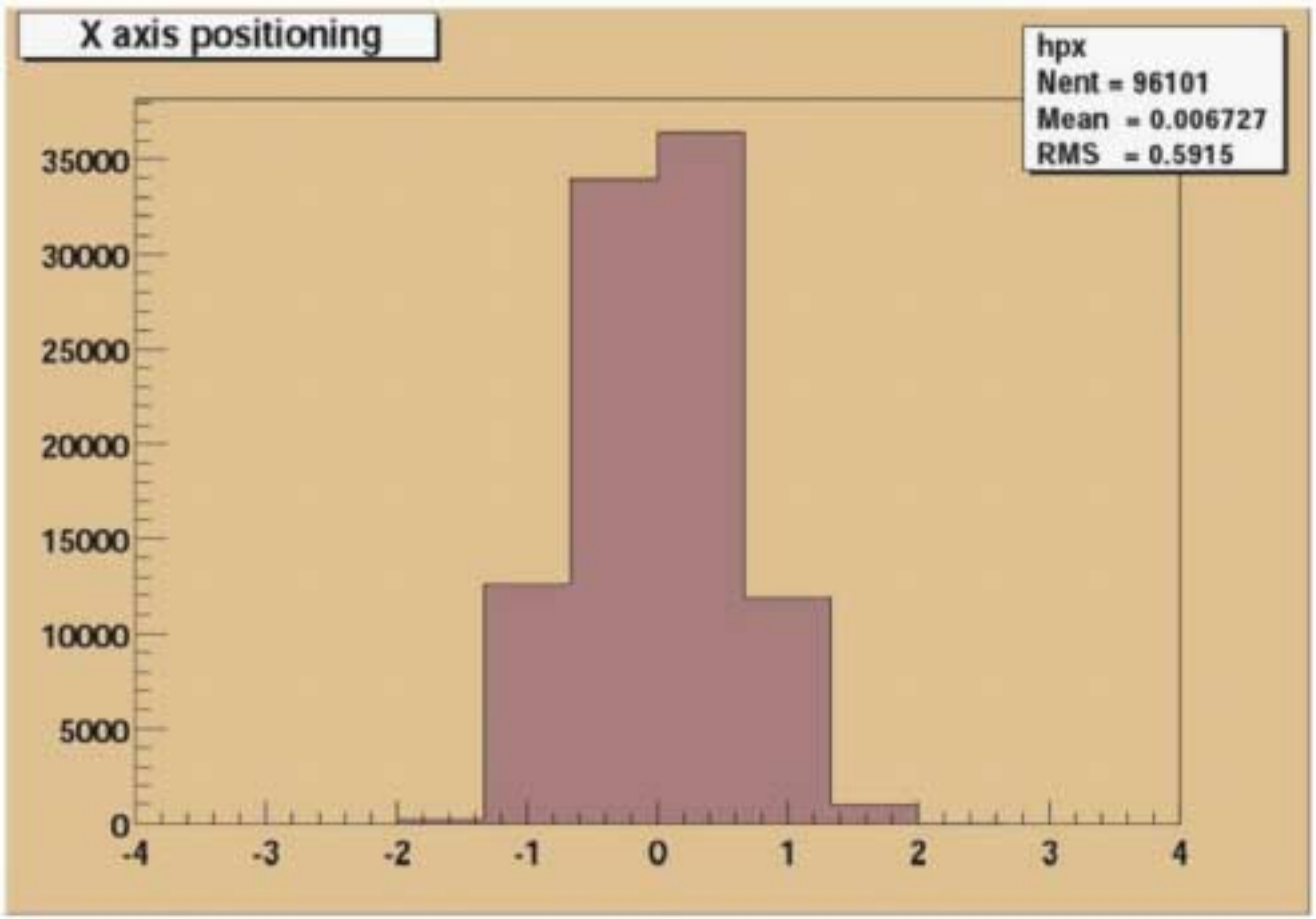
Mechanical performances: Displacement + settling time



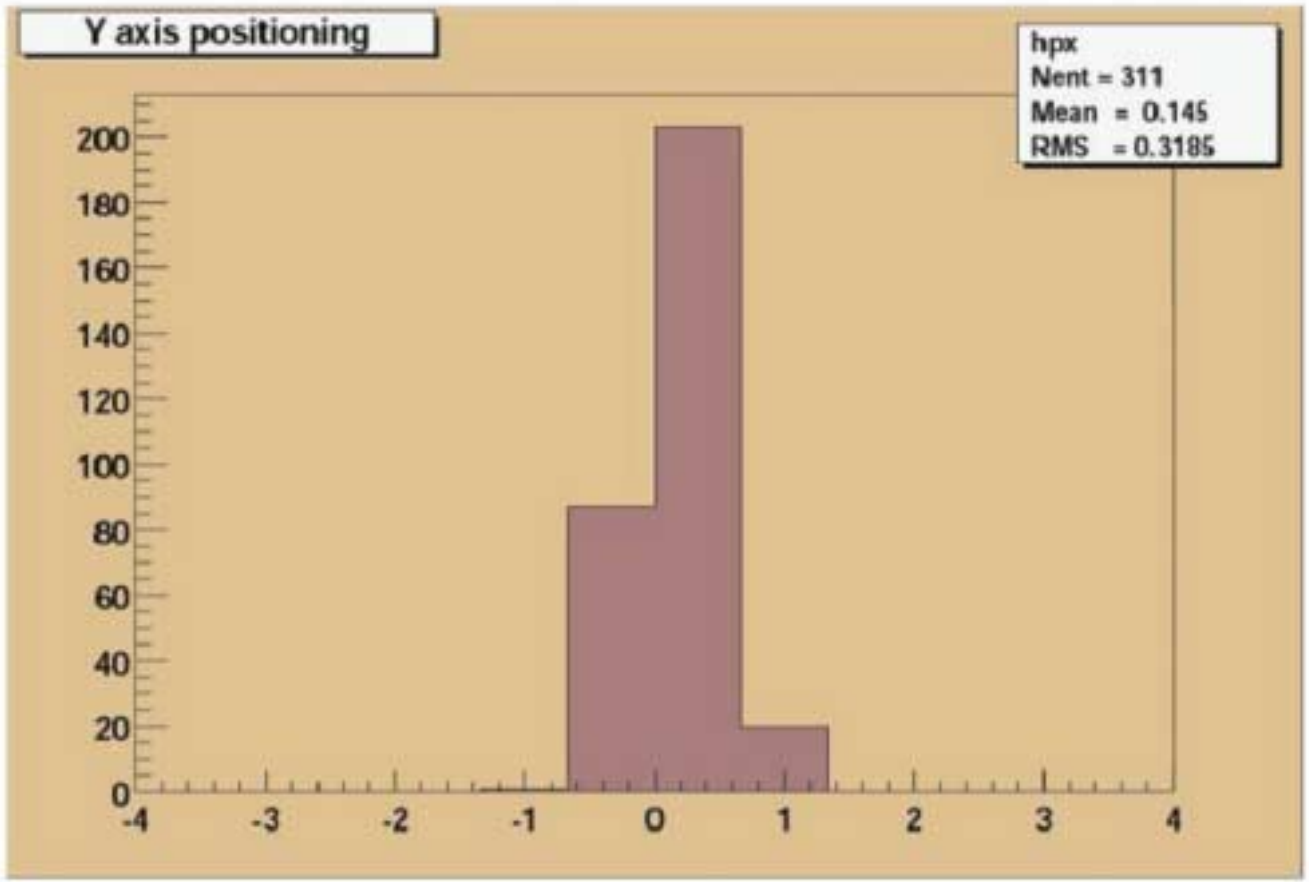
Mechanical performances: Displacement + settling time



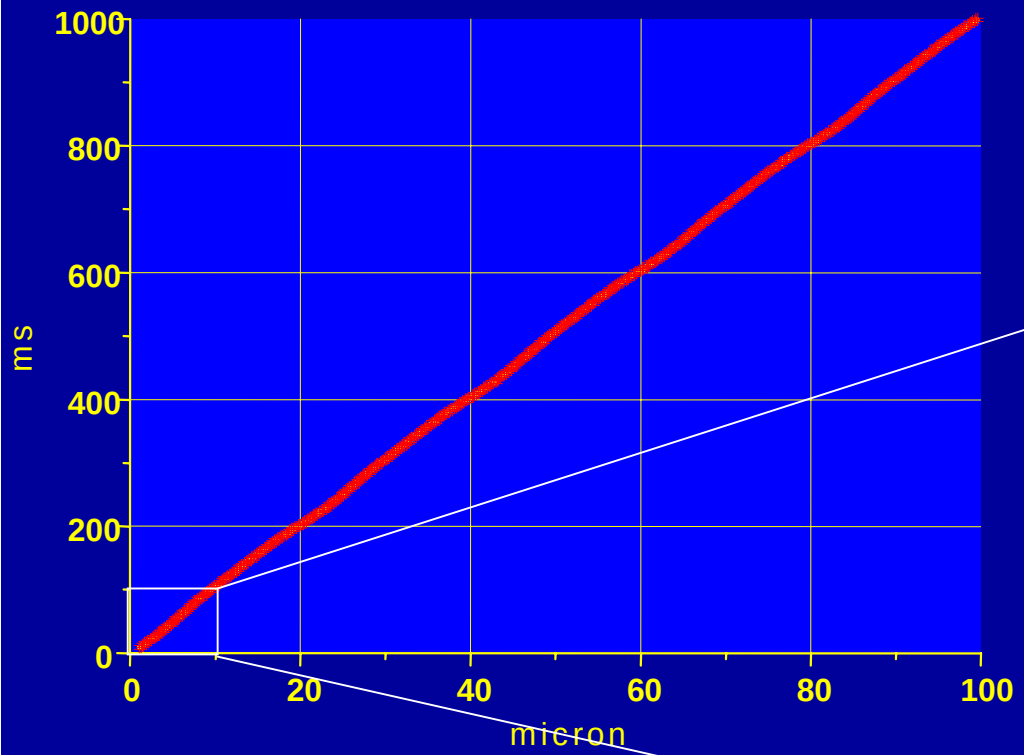
Mechanical performances: positioning

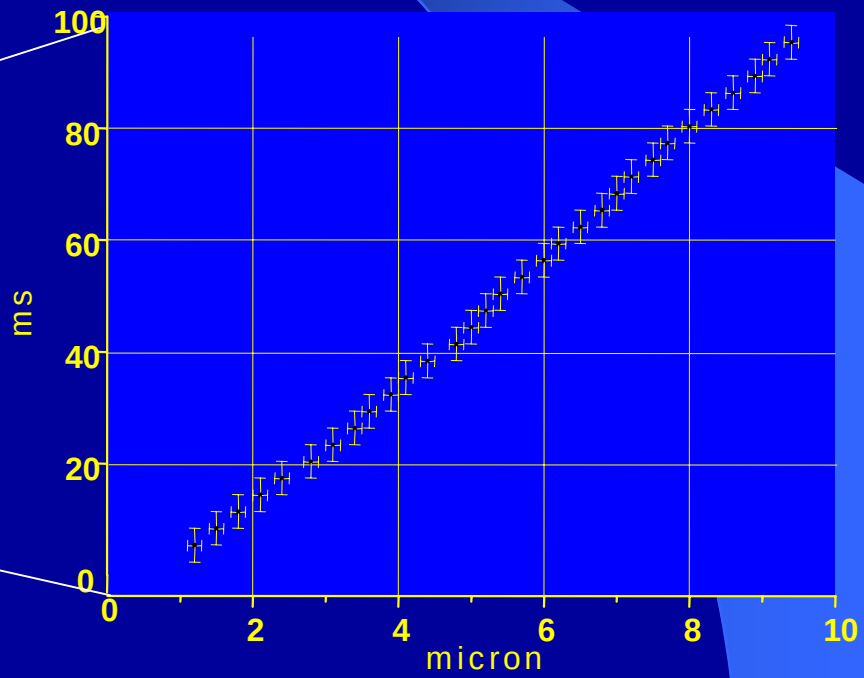


Mechanical performances: positioning



Mechanical performances: constant speed (Z)





Optics

Commercial + custom optics :

- **Nikon microscope optics system for infinite type objective**
- **Custom optics made by Optec s.r.l. (Milan) based on our specs**

Objectives

Nikon 40× (dry)
Nikon 50× (oil)

Objective specification

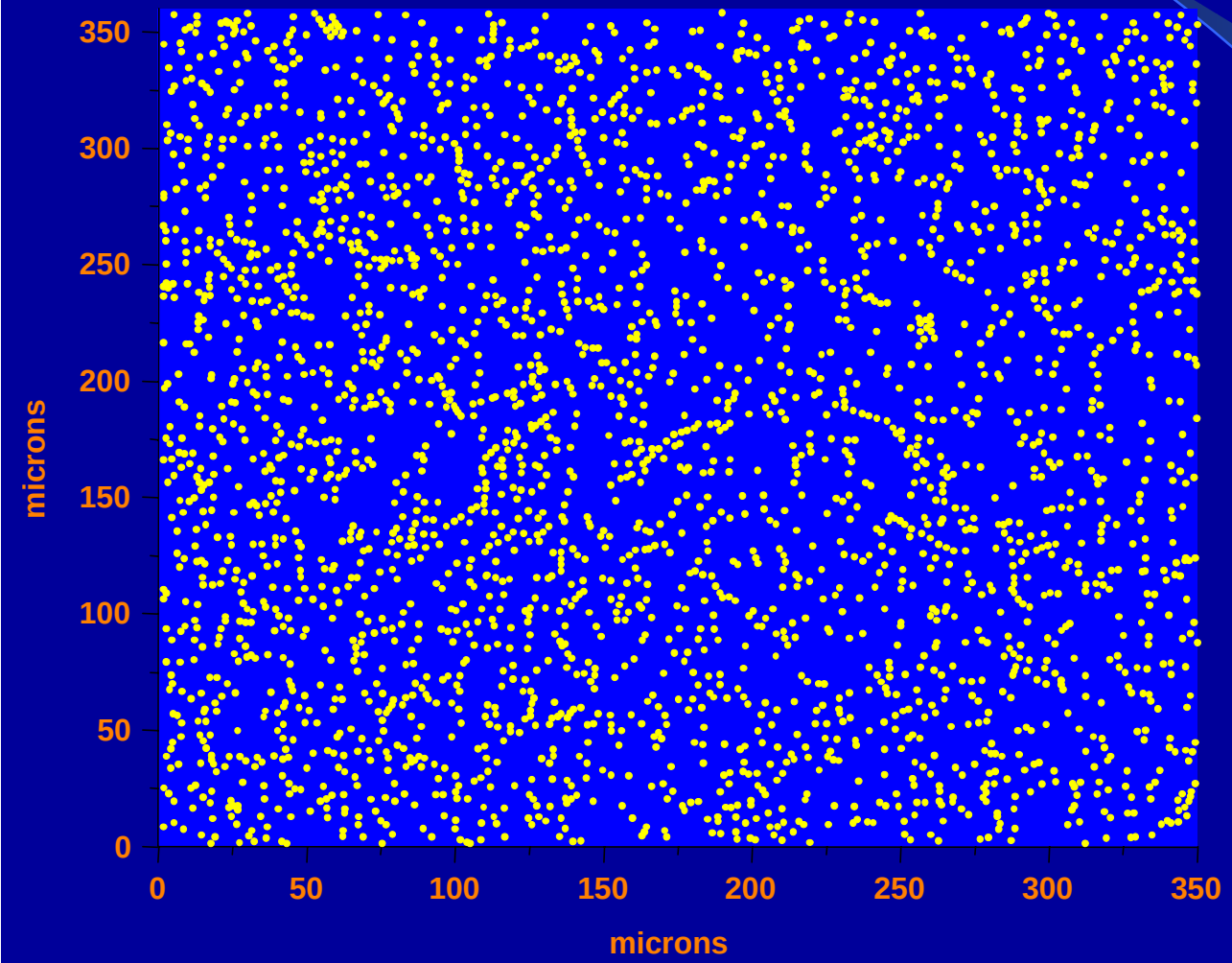
Objective	N.A.	Focal (mm)	Focus depth (mm)	Working distance (mm)
CFI Plan Fluor ELWD (Long working distance) 40× (dry)	0.60	5.0	0.76	3.7-2.7
CFI Plan Achromat 50× (oil)	0.90	4.0	0.52	0.4

All the tests about system performances have been done using the 50X oil objective and standard Nikon optics

Optical performances…
(Flatness, distorsion)

Distribution of grains recognized through filter response peaks

The filter output is independent of the position in the field of view



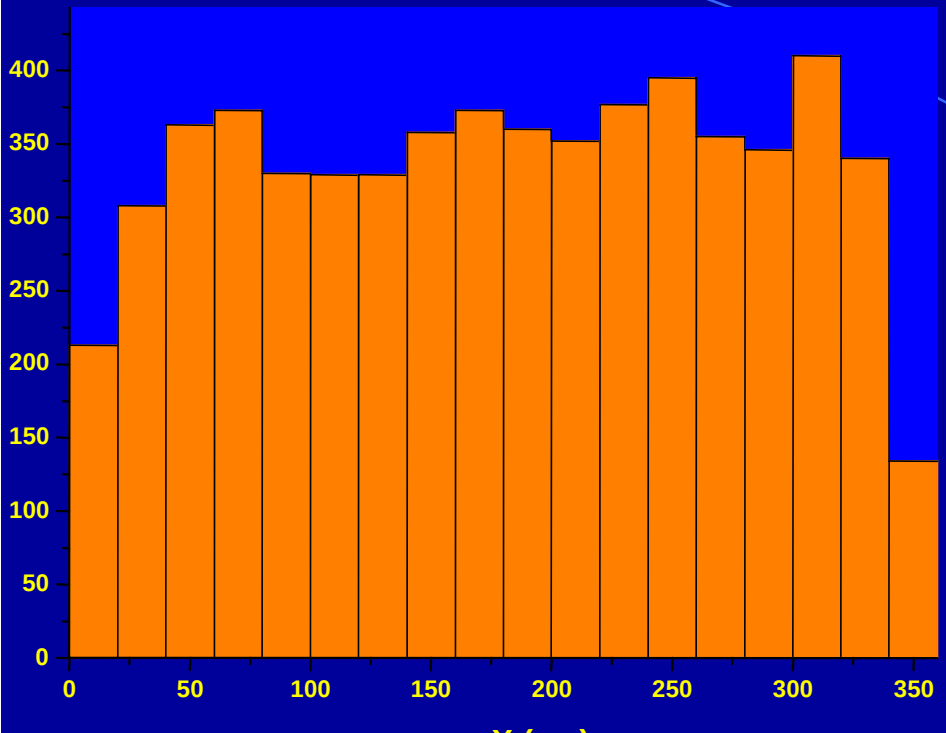
View : 350x350 μm²

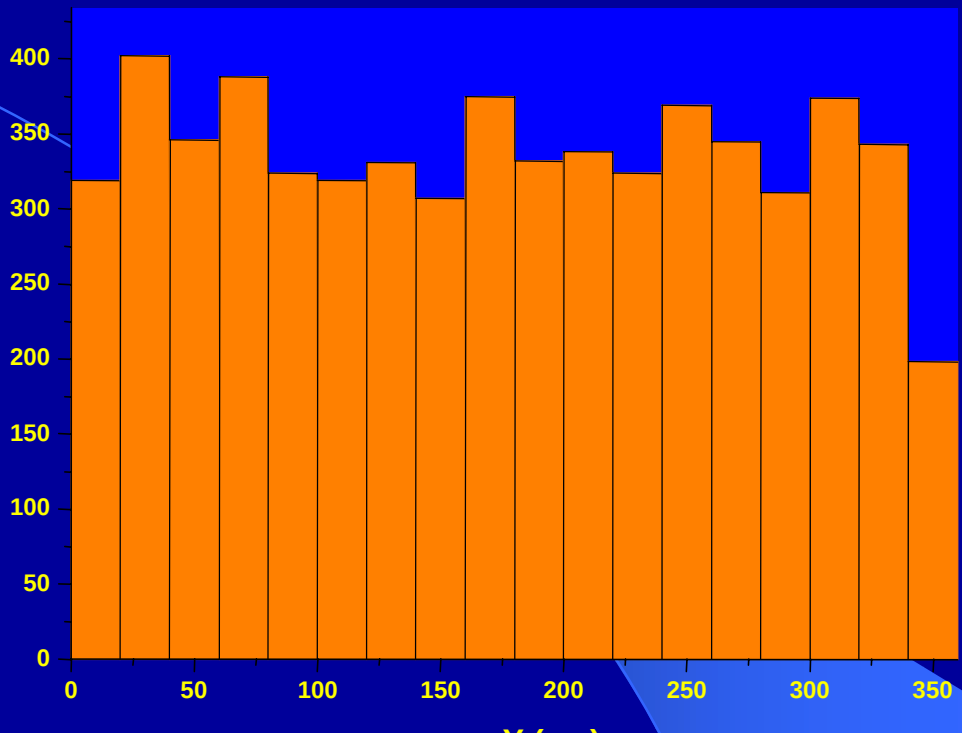
50X oil objective

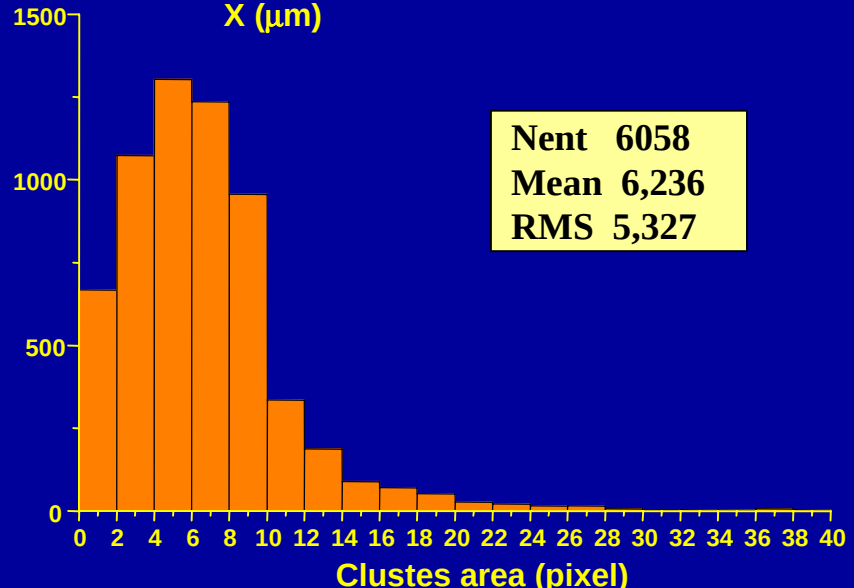
Standard Nikon optics

6X6 filter

Distribution of grains along X and Y axis







Nent	6058
Mean	6,236
RMS	5,327

Custom optics

...to work with different image sensors size and different objectives

we are developing custom optics adapter.

Presently prototype specifications:

- **Working with sensor area up to 15.5 × 15.5 mm²**
- **Continuously tunable field of view from 290 × 290 μm² to 360 × 360 μm² with 40X Dry Nikon objective**
- **Fully corrected and planar field of view**

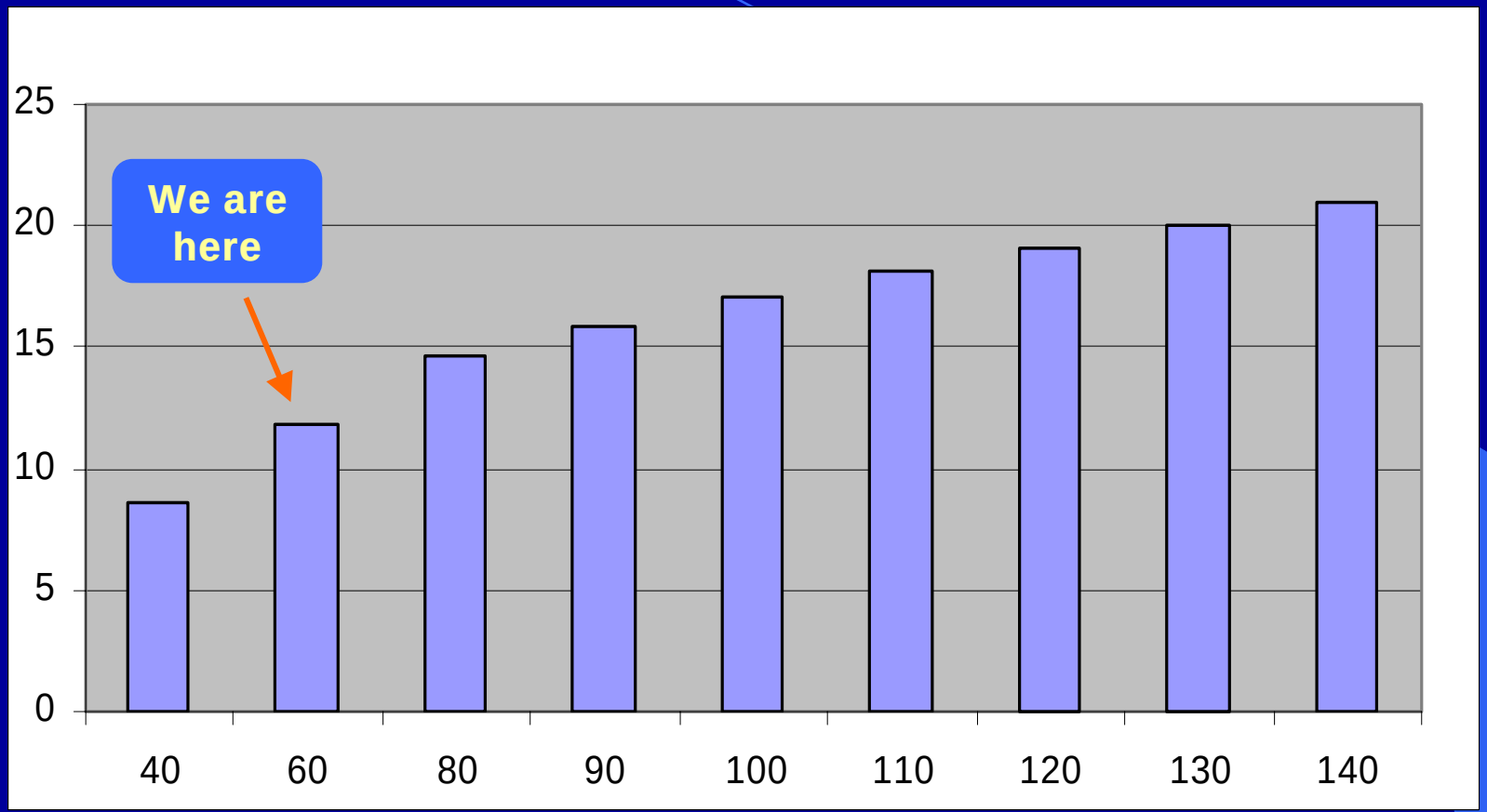
TEST IN PROGRESS

CCD Camera
… presently NSS prototype

DALSA 1M60

- **1024 X 1024 pixel**
- **Sensor area 14,3 mm^2**
- **Pixel size 14 μm^2**
- **Electronic shutter (0,5 – 10) ms**
- **12 bit (used at 8 bit)**
- **4 LVDS channels at 20 MHz**

Frame Rate Vs. Scanning Speed



- **view 360 x 360 μm² (330 x 330 μm² useful)**
- **80 ms to change view**
- **1 emulsion side - 15 layers**

CMOS Camera

1. R&D camera optimized to be interfaced with Genesis board

2. Commercial Camera made by Mikrotron

Both use the same Cmos Sensor from Photobit

CMOS SENSOR Specification:

PHOTOBIT PB-MV13	1280 × 1024 pixel	12 × 12 μm^2/pixel	fps up to 500 10 channels 66 MHz	15.4 × 12.3 Area (mm^2)

Mikrotron Cmos camera
Mod. MC1300

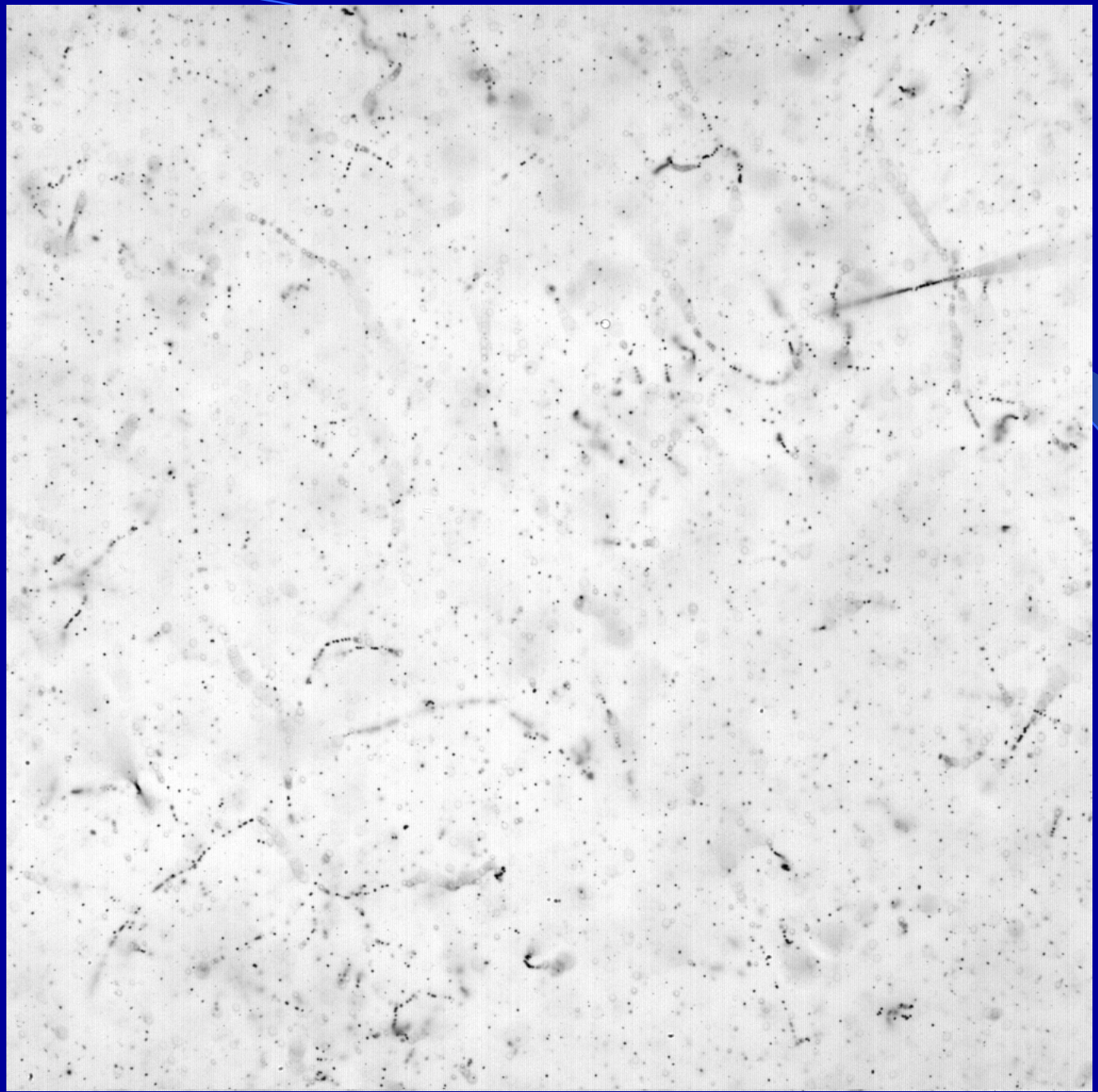
- **1280 X 1024 pixel**
- **100 fps**
- **Electronic shutter (10 μs – 20 ms)**
- **Sensor area (15,36 x 12,29) mm²**
- **Pixel size 12 μm²**
- **1 LVDS channel 16 bit (2 pixel 8 bit/pixel) at 66 MHz**

Interface with Genesis board already done

16 bit at 40 Mhz

-> 58 fps

TEST IN PROGRESS



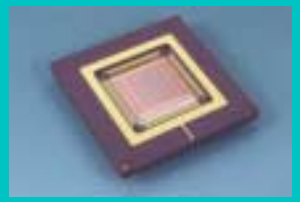
Emulsion image
Taken with
MC1300 Cmos
Camera
and 50X oil
objective

Custom CMOS Camera (R&D)

100 bit
10 channels
66 MHz

32 bit
4 channels
40 MHz

Photobit
CMOS sensor



XILINX
Virtex
FPGA device

Matrox Genesis

Custom CMOS Camera (R&D)

- Custom Interface between Sensor and Genesis board
- Speed: 120 fps (because of the limitation of the acquisition board)
- Electronic shutter (10 μs – 20 ms)
- Easily programmable via serial interface (…exposure, window size)
- Onboard programmable Lookup table

The Interface is flexible enough to be easily upgraded with new acquisition board

ready by the end of March

Processor Board and image handling

1 Matrox Genesis + 1 Matrox double processing node

(3 total processing nodes)

Parallel processing

2D FIR programmable Filtering

Syncronous ad Asyncronous operation

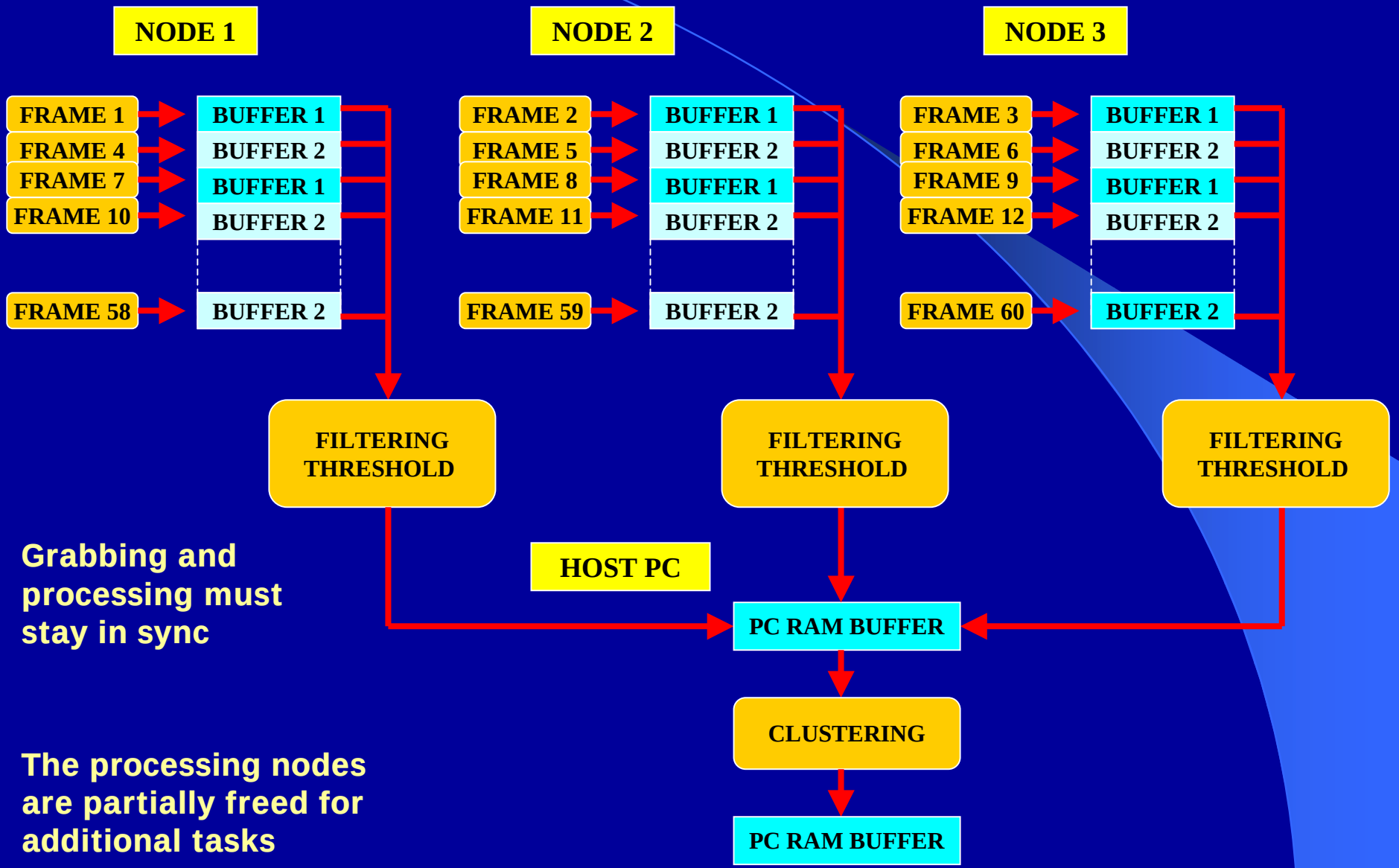
2 solutions for Multi Processor approach

1. After filtering The image is binarized (reduced to 128 kB) and sent to the host PC RAM via the PCI bus

   The PC CPU recognizes the clusters in the image on the fly -> tracking

2. On board Clustering, data reduction (few KB) -> sent data to Host for Tracking operation

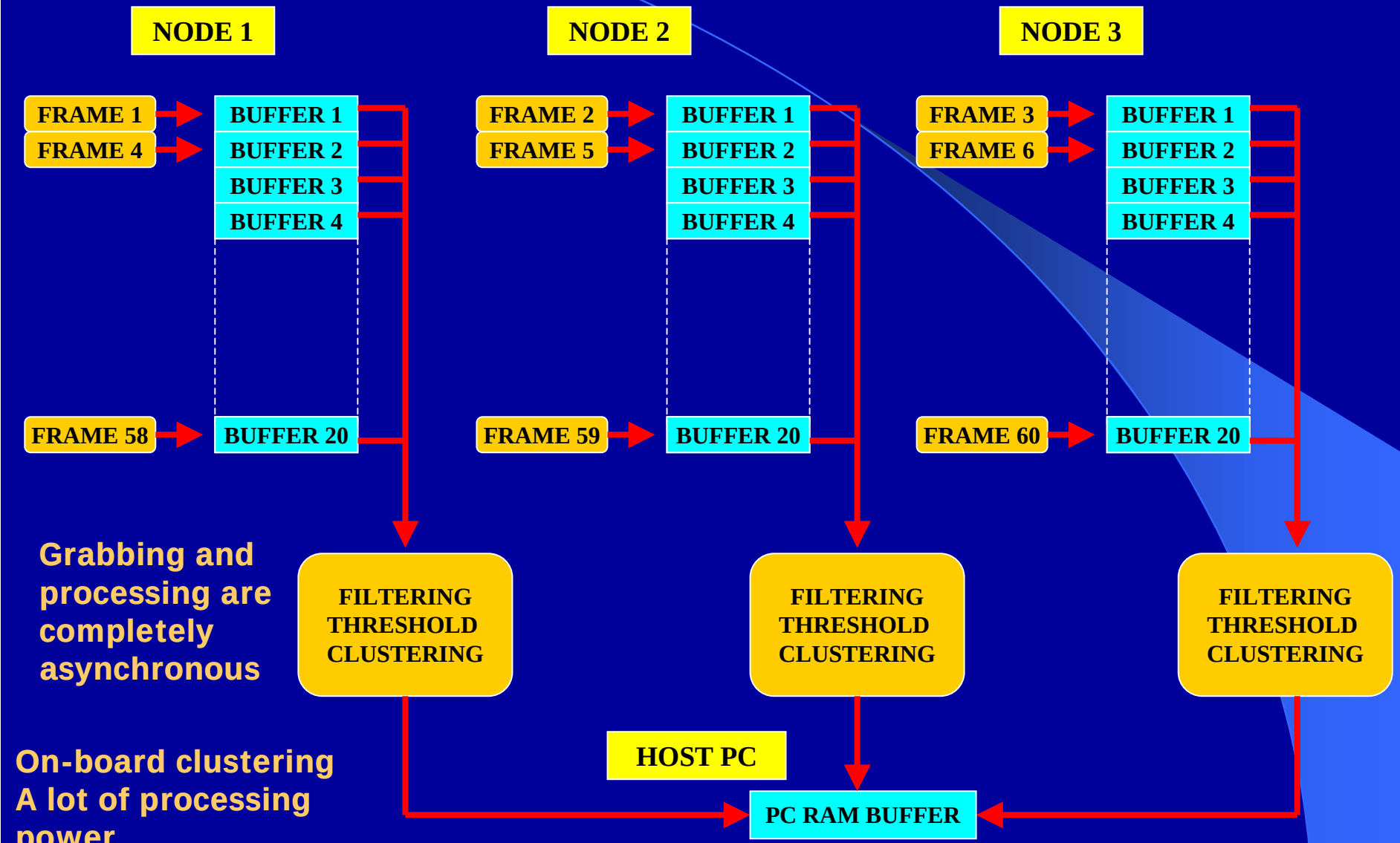
Solution #1



Grabbing and processing must stay in sync

The processing nodes are partially freed for additional tasks

Solution #2

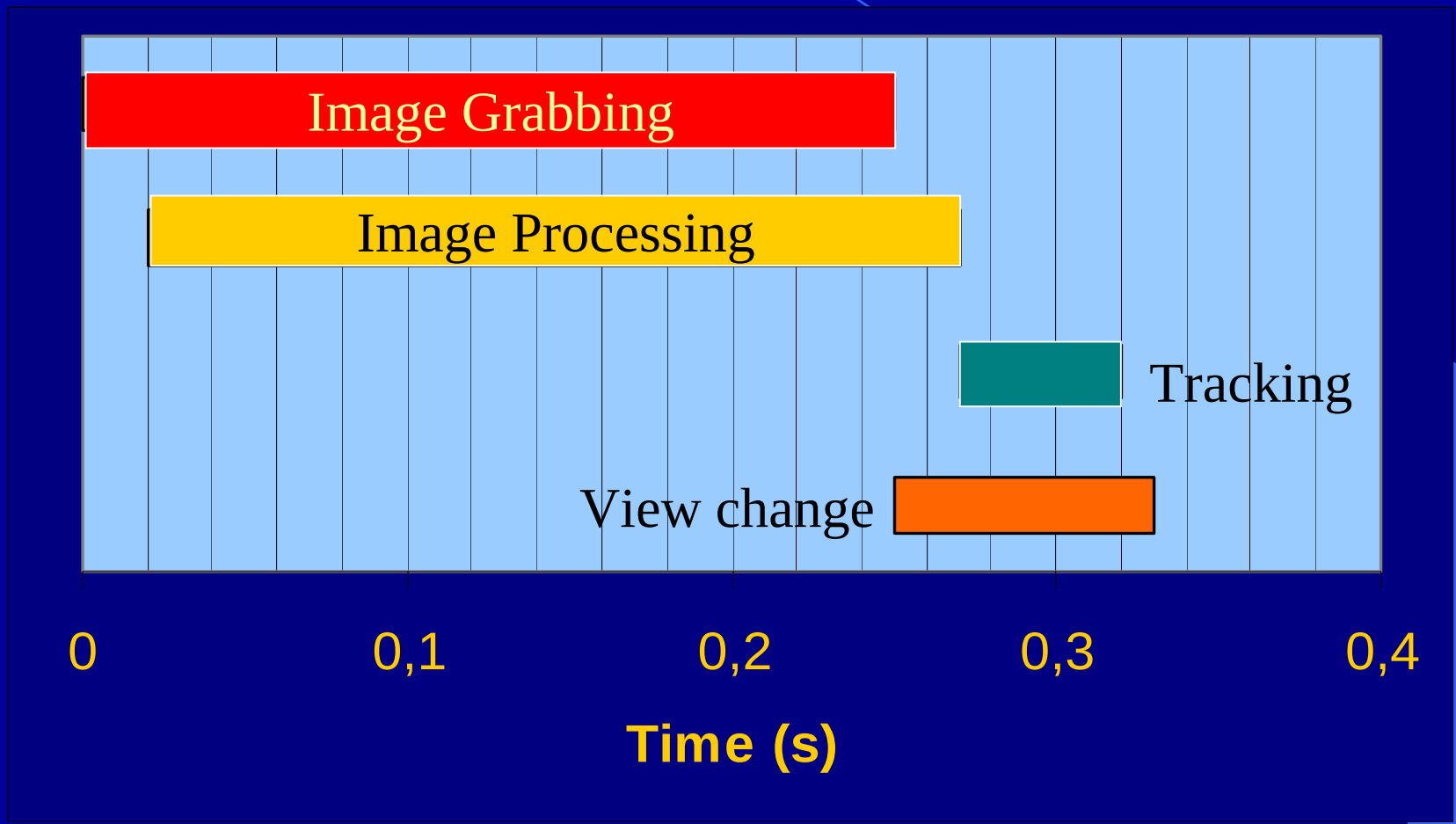


Grabbing and processing are completely asynchronous

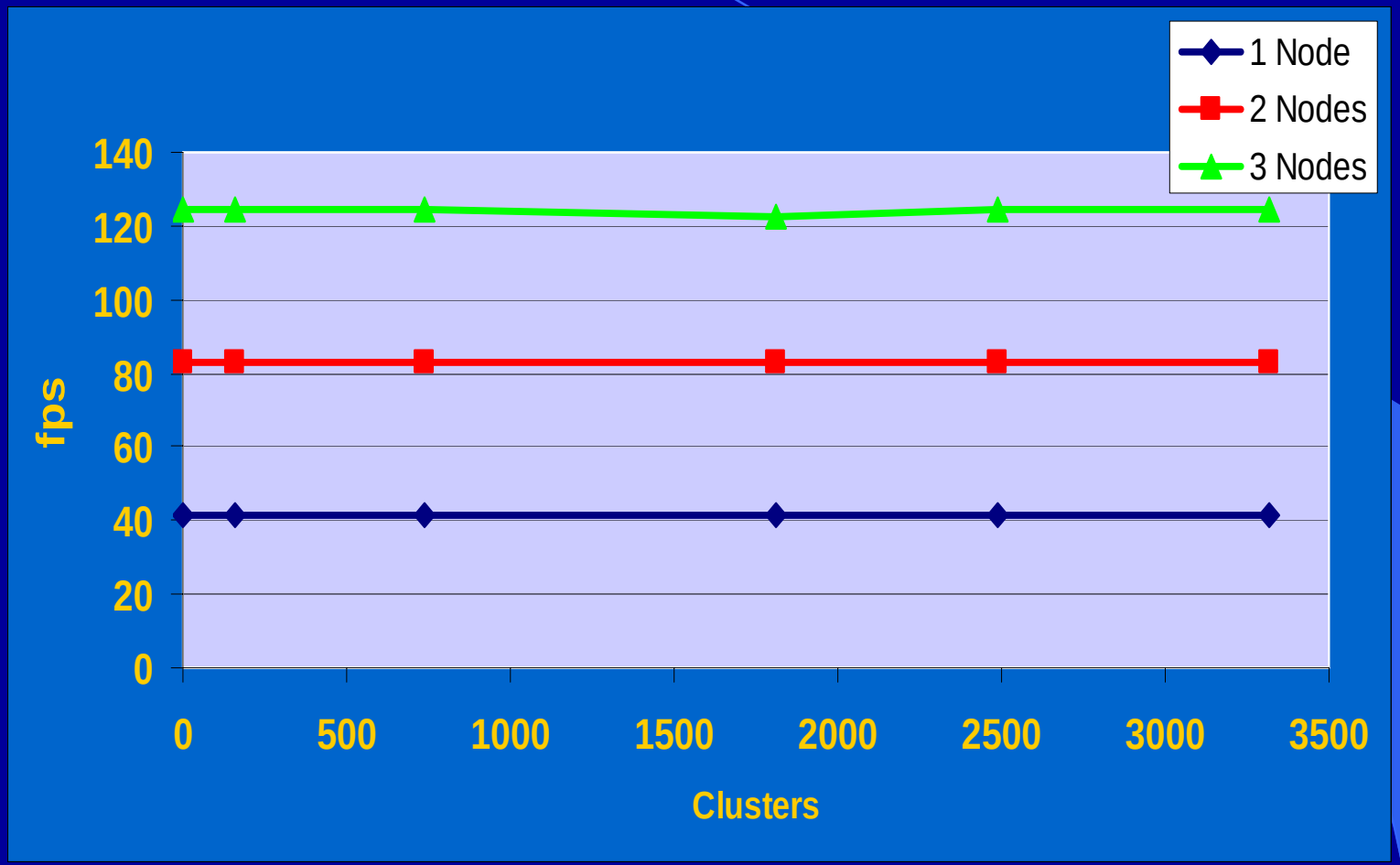
On-board clustering
A lot of processing power

The Host PC CPU is free

System Operation Timing



Cluster processing on Host PC



Conclusions

- Scanning speed of 11 cm^2/h achieved
- CMOS Camera at 120 fps forthcoming
- Dry Objective adoption in perspective
- Scanning speed of 20 cm^2/h within reach