

AUTOMATIC SCANNING FOR NUCLEAR EMULSION

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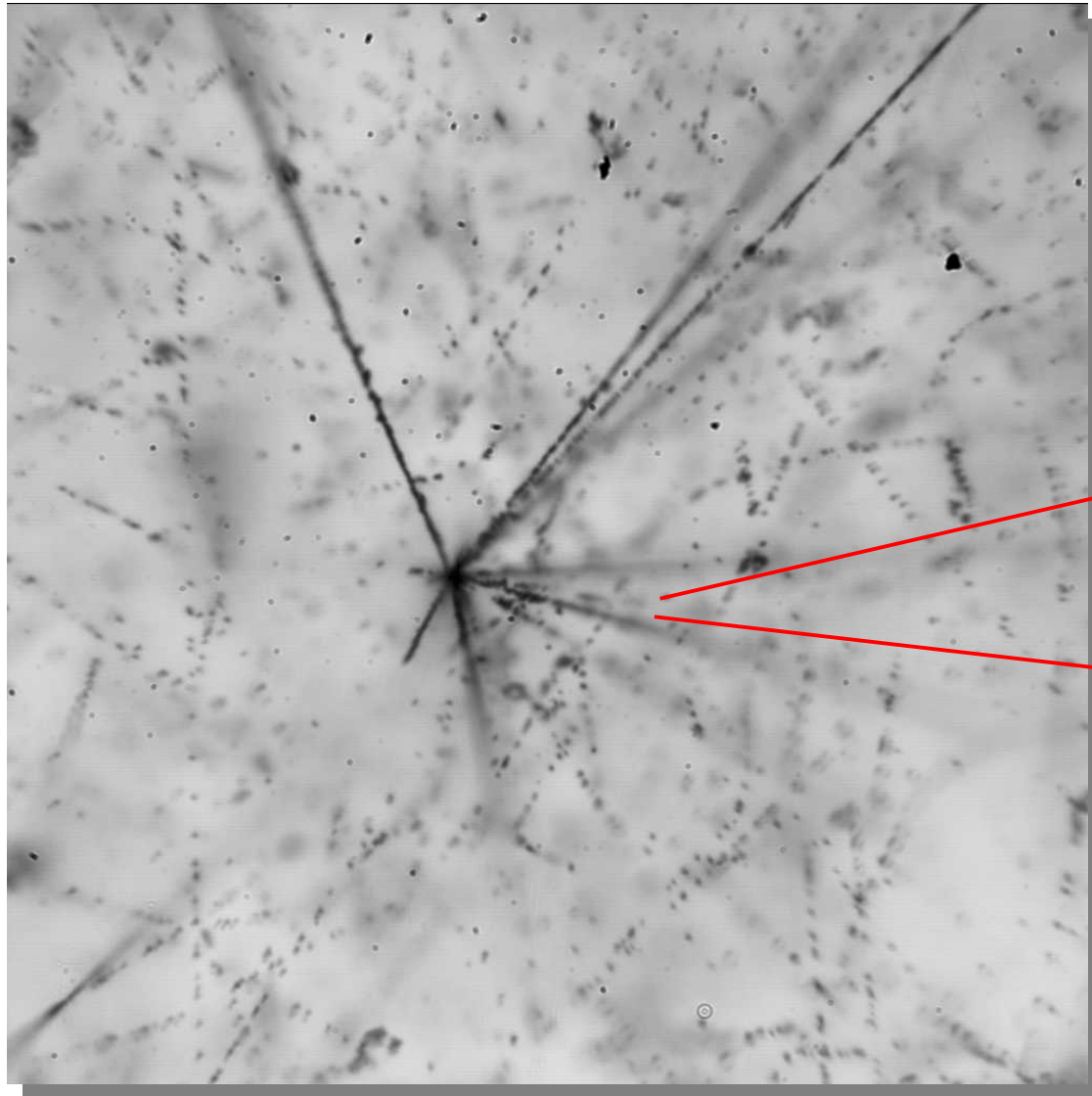
(CHORUS collaboration)

NUCLEAR EMULSIONS

PROVIDE:

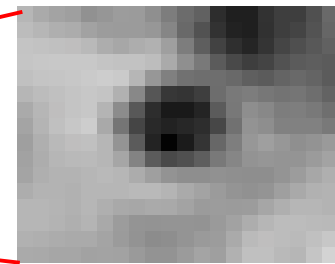
- **THREE-DIMENSIONAL SPATIAL INFORMATION**
- **EXCELLENT RESOLUTION ~ 1 μm**
- **HIGH HIT DENSITY ~ 300 hits/mm**

- **IDEAL TO DETECT SHORT-LIVED PARTICLES
(CHORUS, OPERA)**



150 μm

**VIDEO IMAGE
OF NEUTRINO
VERTEX**



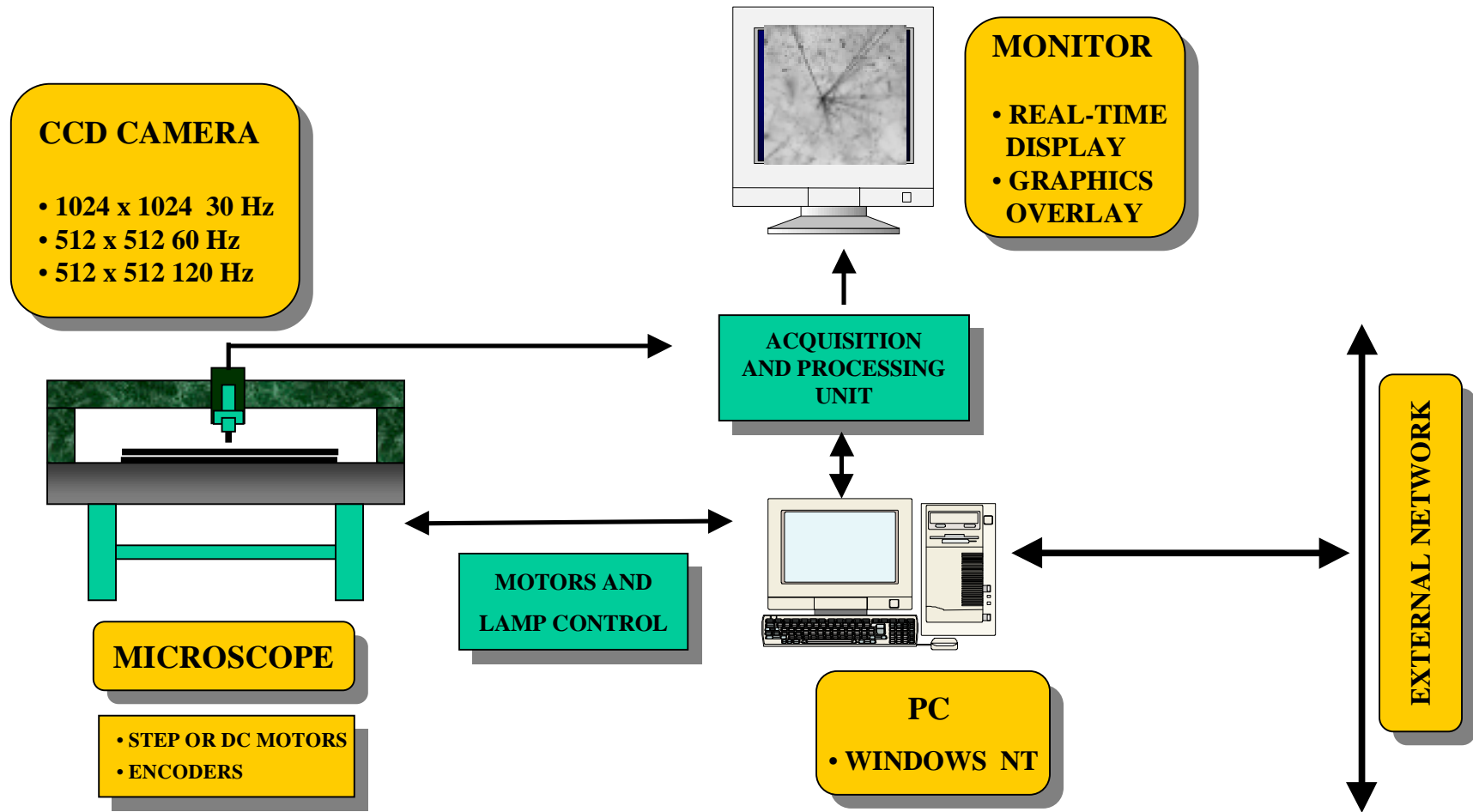
3 μm

TYPICAL GRAIN SIZE
~ 1 μm
FOCAL DEPTH
~ 2.5 μm
(with 50X objective)

AUTOMATIC SCANNING SYSTEMS

- **PIONEERING WORK MADE BY THE GROUP OF NAGOYA STARTING FROM '70s**
- **FIRST COMPLETE APPLICATION OF THE AUTOMATIC SYSTEM WITH CHORUS DATA ANALYSIS (TRACK SELECTOR DEVELOPED BY NAGOYA GROUP)**
- **CURRENTLY AUTOMATIC SCANNING SYSTEMS ARE UNDER DEVELOPMENT BY SEVERAL GROUPS OF CHORUS COLLABORATION (CERN, MÜNSTER,NAGOYA,NAPOLI, NIKHEF,SALERNO)**

AUTOMATIC SCANNING SYSTEM



AUTOMATIC SCANNING SYSTEMS

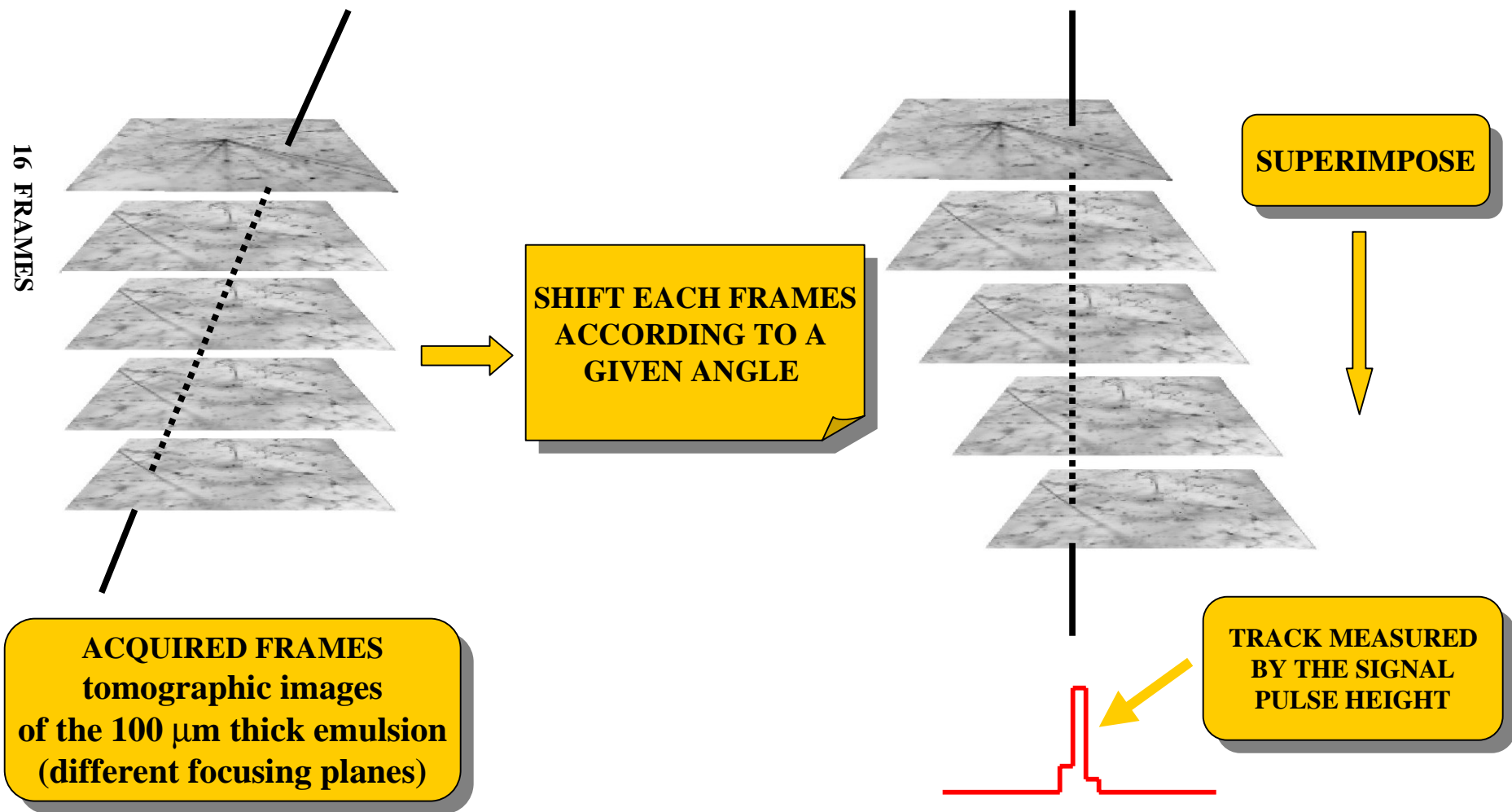
- **NEW TRACK SELECTOR SYSTEM (NTS)**

- **FPGA + FAST MEMORY**
- **120 Hz CCD ~ 4 ms 512 x 512 pixel**
- **PARALLEL PROCESSING**
- **DESIGNED TO DETECT TRACK WITH
A PREDICTED ANGLE**

- **MULTI-TRACK SYSTEM (MTS)**

- **FRAME GRABBER WITH DSP + FAST MEMORY**
- **30 to 120 Hz CCD ~ 4 ms 512x512 to 1024 x 1024 pixel**
- **PARALLEL PROCESSING**
- **DESIGNED TO DETECT ALL THE TRACKS
IN THE VIEW WITH AN ANGLE FROM 0 TO 400 mrad**

PRINCIPLE OF THE TRACK SELECTOR



ULTRA TRACK SELECTOR (UTS)

- **PARALLEL PROCESSING**
 - ~ 40 processor/system
 - **FPGA + 120 MHz SSRAM**
 - **Zero suppressed image**
- **PIPE-LINED PROCESSING**
Image taking and Track recognition in parallel

- **CCD 512 x 512 pixel**
FAST SHUTTER (~ 1 ms to 10 ms)
120 Hz FRAME RATE
FIELD OF VIEW ~ 200 x 200 μm

SPEED

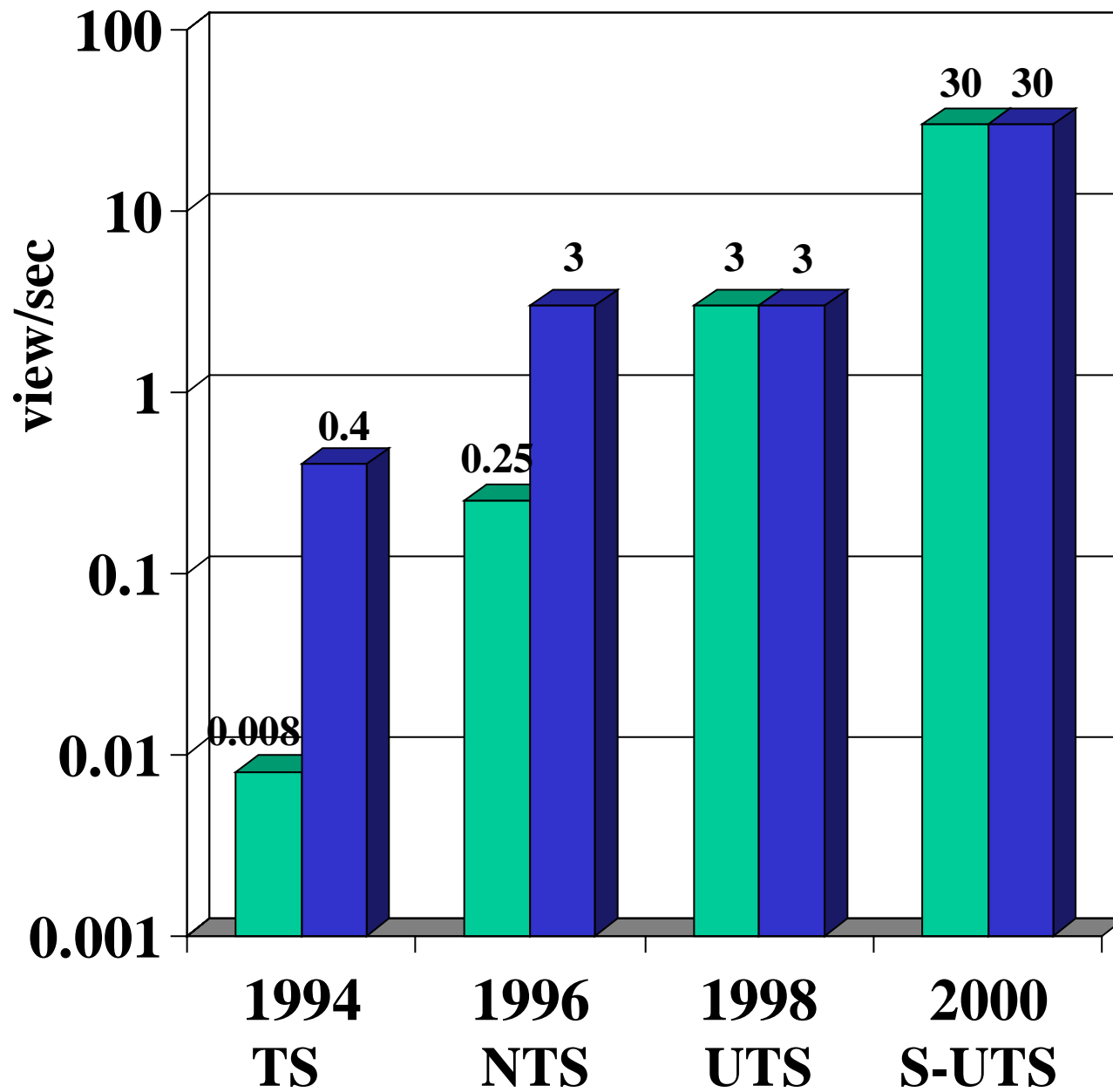
For a view 150 x 150 μm

Image acquisition ~ 0.3 s

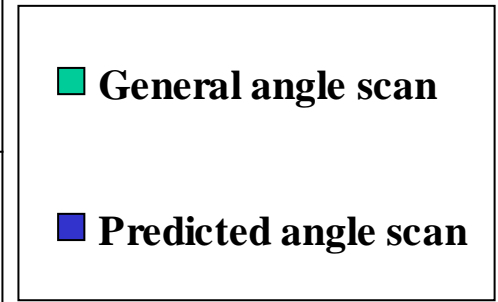
Track Recognition ~ 0.3 s

1 cm^2/hour

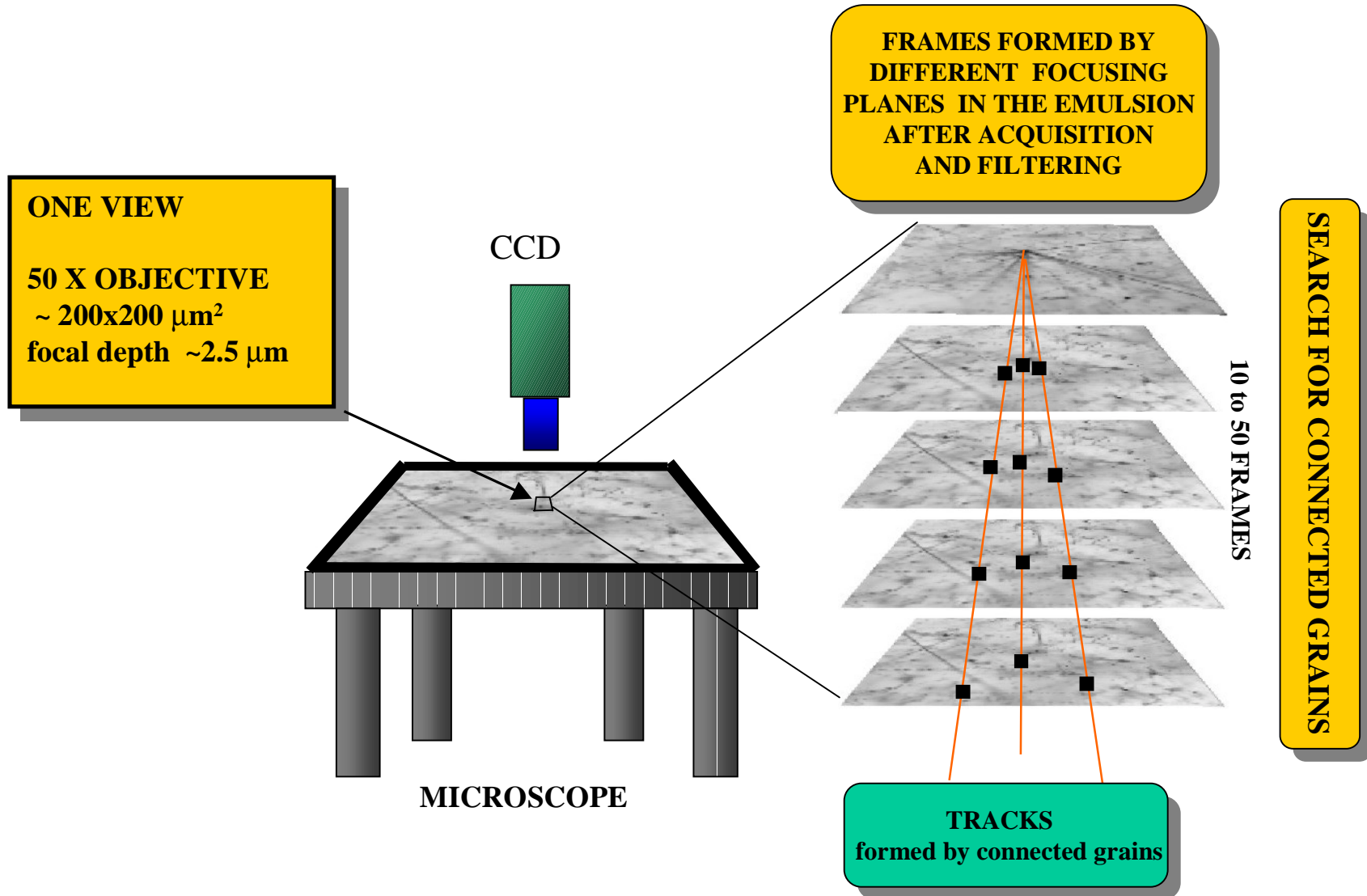
TRACK FINDING EFFICIENCY ~ 98 %



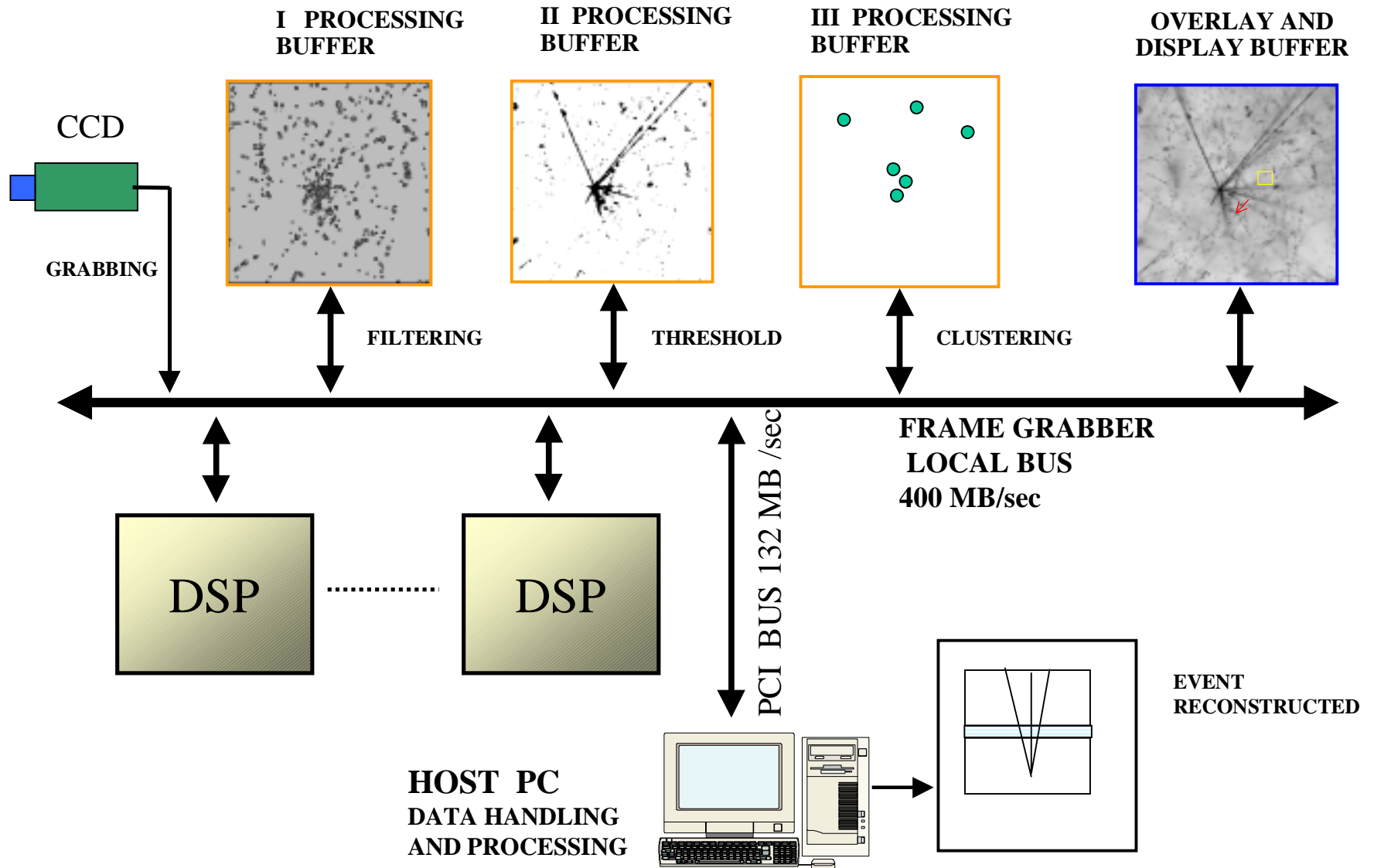
**SCANNING POWER
ROAD MAP
OF
TRACK SELECTOR
SYSTEMS**



AUTOMATIC SCANNING : PRINCIPLE OF THE MTS



MULTIPROCESS APPROACH FOR MTS USING A MULTI-DSP BOARD (PIPELINE OR PARALLEL)



MULTI-TRACK SYSTEM (MTS)

UNDER DEVELOPMENT

- **ACQUISITION MULTI-DSP BOARD WITH DEDICATED NEIGHBOUR OPERATION ACCELERATOR PROCESSOR AND FAST VIDEO MEMORY (MATROX GENESIS with DSP Texas Instruments TMS320C80 + MATROX CUSTOM PROCESSOR)**
CURRENTLY THE SYSTEM HAS 1 DSP

- **PARALLEL PROCESSING**

DSP on the acquisition board

+

HOST PC PROCESSOR

- **MEGAPIXEL CCD**
FAST SHUTTER (~ 1 ms to 10 ms)
30 Hz FRAME RATE
FIELD OF VIEW ~ 200 x 200 μm
- **CCD 512 x 512 pixel**
FAST SHUTTER (~ 1 ms to 10 ms)
120 Hz FRAME RATE

SPEED

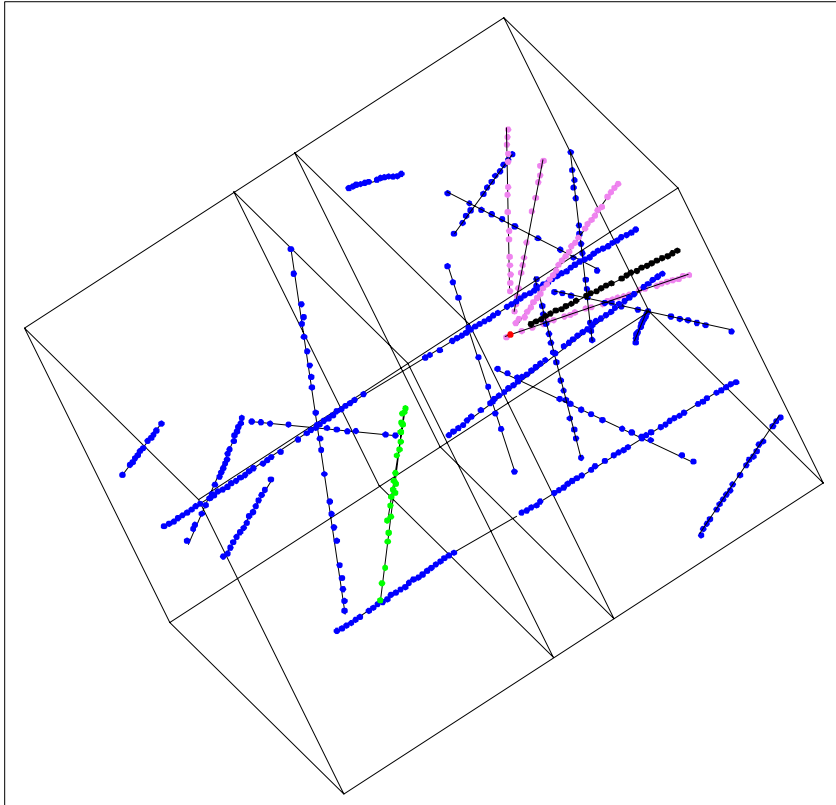
For a view 200 x 200 μm

Image acquisition ~ 0.5 s

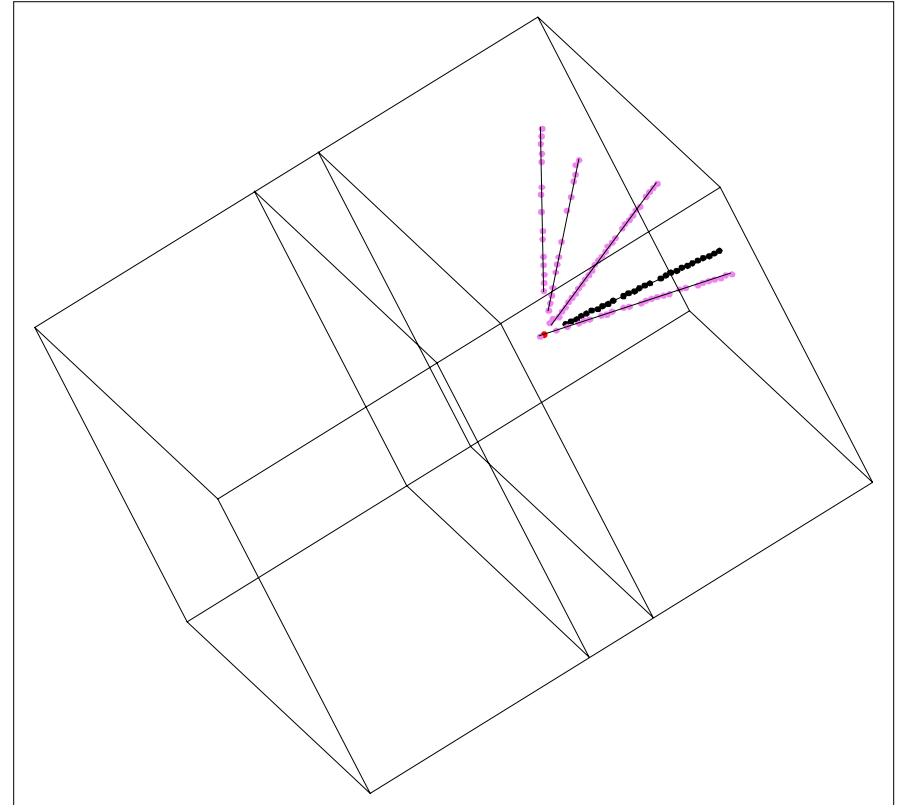
Track Recognition ~ 0.3 s

~ 1 cm^2/hour

3D RECONSTRUCTION OF ALL TRACKS IN A VIEW



3D VERTEX RECONSTRUCTION AFTER SELECTION



(150 x 150 x 800 μm) not in scale

FUTURE

- **Super - UTS**

- **~10 times faster than UTS**
- **1000 fps CCD**
- **FASTER PROCESSOR BUS**
- **IMPROVED MECHANICS**

- **MTS II**

- **~10 times faster than current system**
- **500 fps MEGAPIXEL CCD**
- **UP TO 12 DSP and 12 NOA processor**
- **IMPROVED MECHANICS and OPTICS**



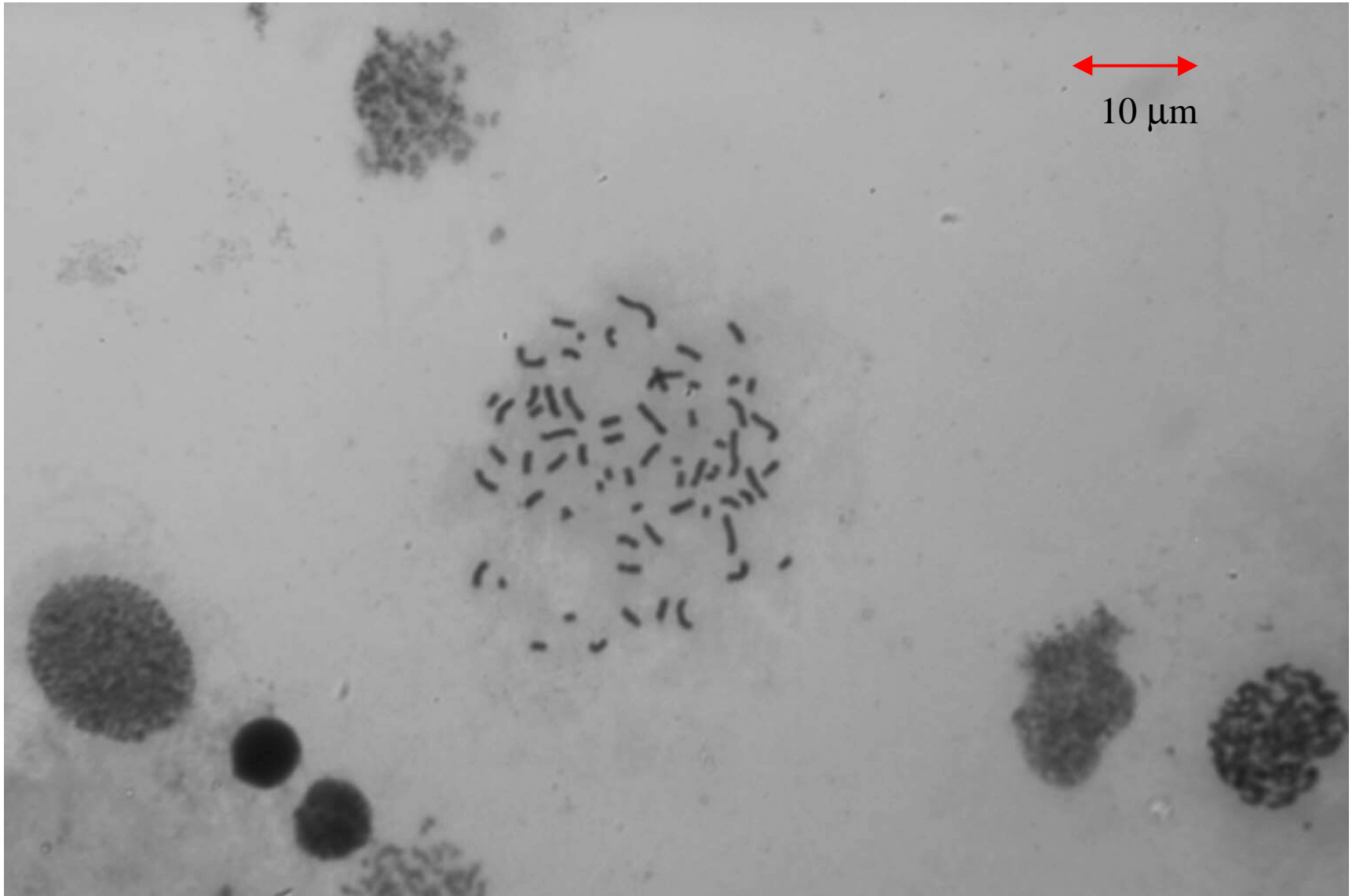
HIGH ENERGY PHYSICS :

- **CLUSTER, TRACK
AND VERTEX
RECOGNITION
(CHORUS, OPERA)**

BIOPHYSICS :

- **PATTERN RECOGNITION
(COUNTING, ABERRATION)**

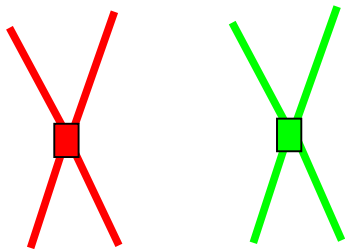
CHROMOSOME COUNTING



(One slide 2 x 4 cm) 1 view ~ 120x80 μm

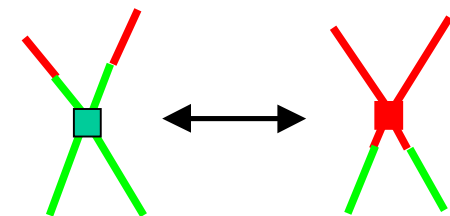
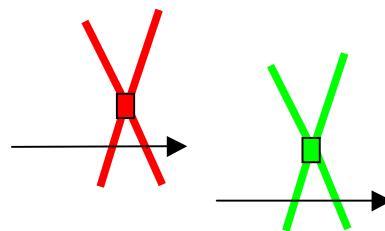
N. D'Ambrosio - London, September 1999

CHROMOSOME ABERRATION



**NORMAL
CHROMOSOME**

**BROKEN
CHROMOSOME
(E.G RADIATION)**



**ABERRATION
(WRONG RECOMBINATION)**

**BIOPHYSICS
APPLICATION**

FUTURE :

**DEVELOPMENT OF A FULL AUTOMATIC
SYSTEM FOR CHROMOSOME ABERRATION**

FINDING

(USE OF DSP PROCESSOR BOARD, NEW CCD CAMERA)

- **AUTOMATIC SEARCH FOR CHROMOSOME PATTERNS**
- **AUTOMATIC SEARCH FOR CHROMOSOME ABERRATION**

**R&D STUDIES ARE IN PROGRES IN NAPLES AND
MUNSTER LABORATORIES**

CONCLUSION

- **THE IMPRESSIVE PROGRESS OF THE AUTOMATIC SCANNING SYSTEMS TECHNOLOGIES HAS STIMULATED THE REVIVAL OF THE NUCLEAR EMULSIONS PARTICLE TRACK DETECTORS**
- **THE USE OF THESE SYSTEMS TOGETHER WITH NUCLEAR EMULSION ALLOWS THE REALISATION OF EXPERIMENTS WITH UNPRECEDENTED STATISTICS**
- **THE CURRENT SYSTEMS ARE FLEXIBLE ENOUGH TO BE USED IN ANY FIELD WHERE A FAST DIGITAL IMAGE ANALYSIS IS REQUIRED**