CERN/NIKHEF microscopes

Microscope optics

CCD camera & readout

DSP image processing

Prediction tracking

General tracking

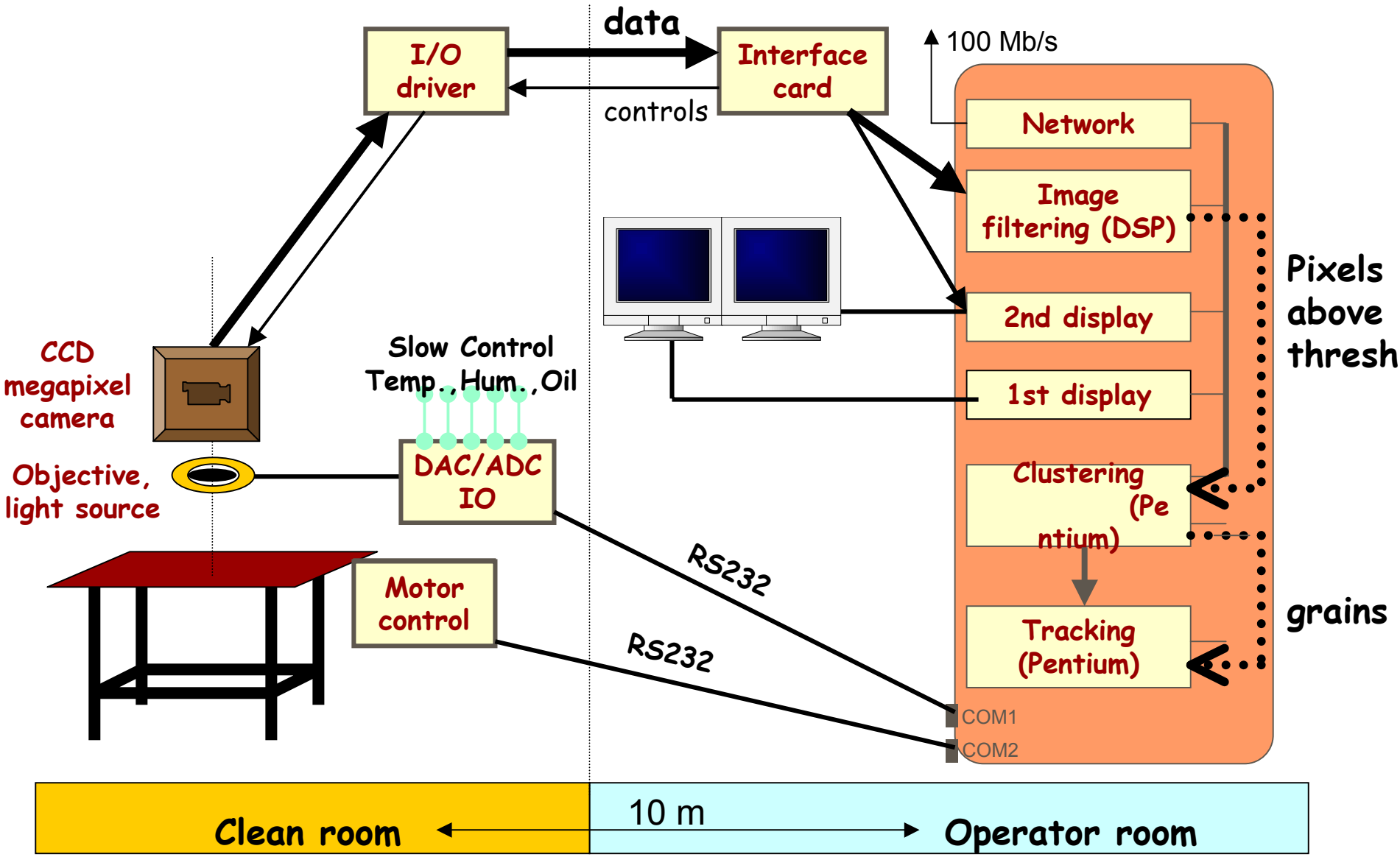
Data acquisition

B. Van De Vyver,
I.M.Papadopoulos,
J.Uiterwijk,
Ph.D. theses

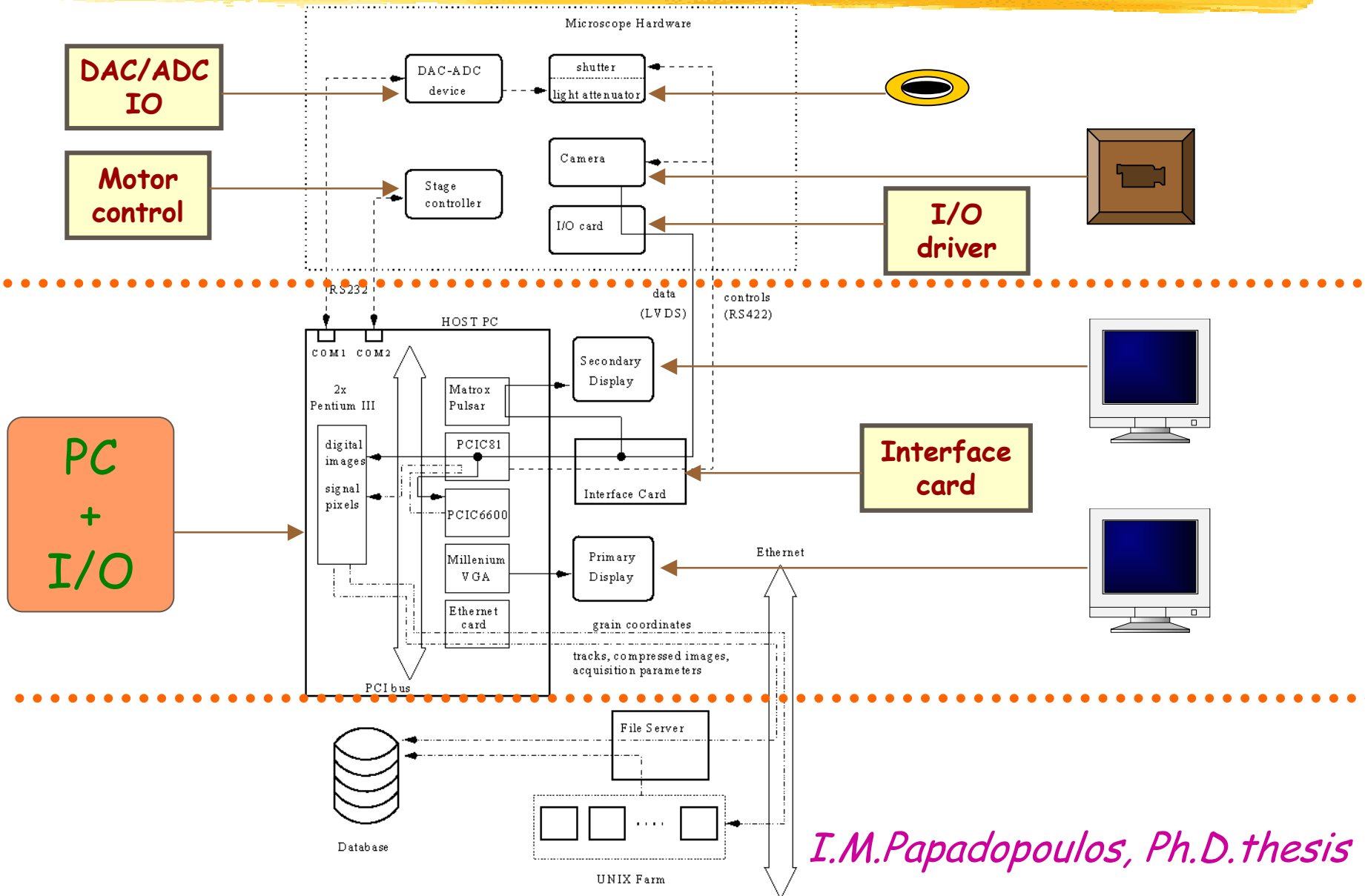
J. Panman, CERN
2nd Emulsion WS
Nagoya

Http://choruswww.cern.ch/CERN-Microscope

Microscope layout



Layout of Controls



I.M.Papadopoulos, Ph.D.thesis

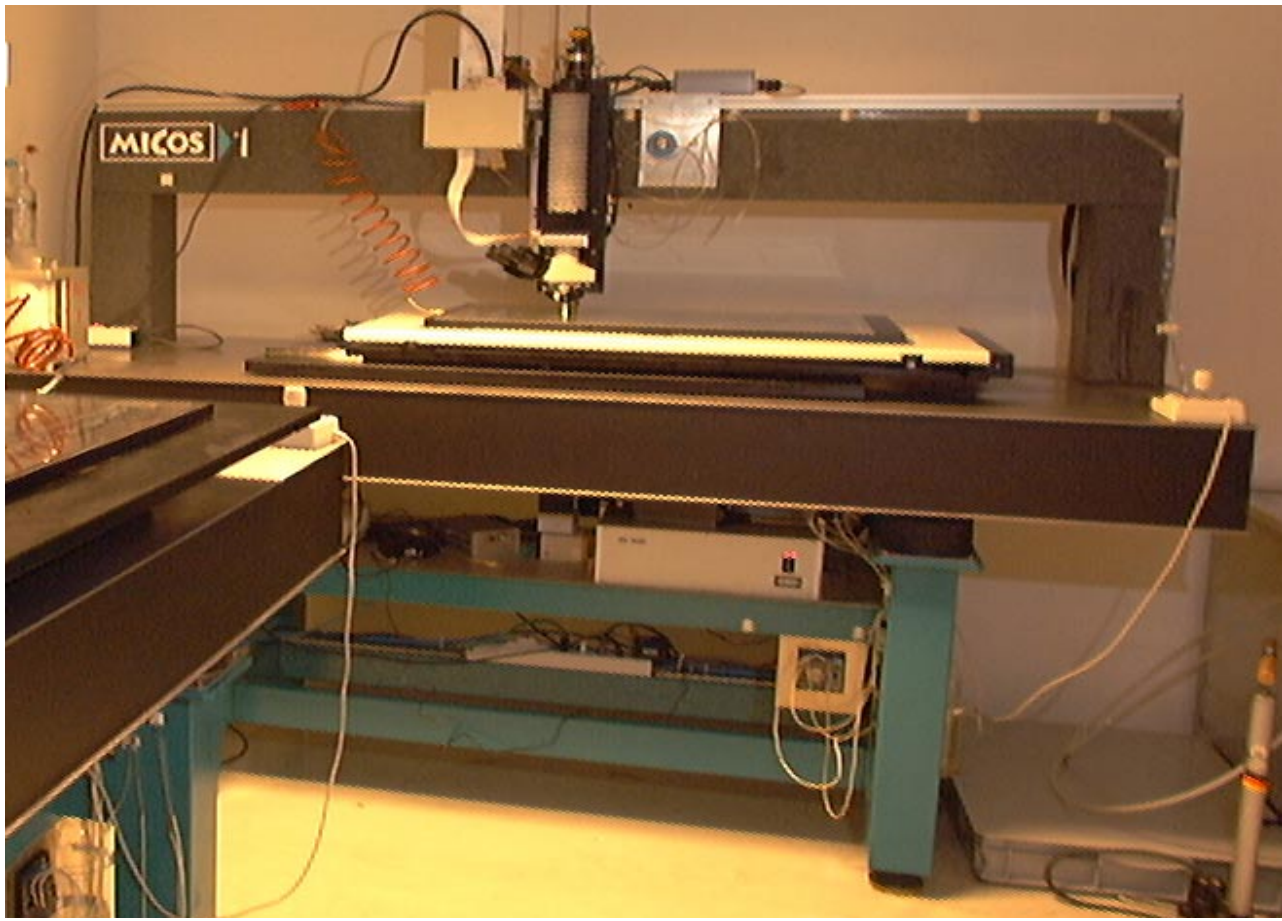
Mechanical stages

MICOS (Germany)

X-Y movement:
- 800x400 mm²
- micro-step motors
- glass-scales
- feedback loop

Z movement:
- 200 mm
- micro-step motors
- glass-scales
- feedback loop

recent new controllers:
- new firmware
- fast serial interface
- ethernet interface

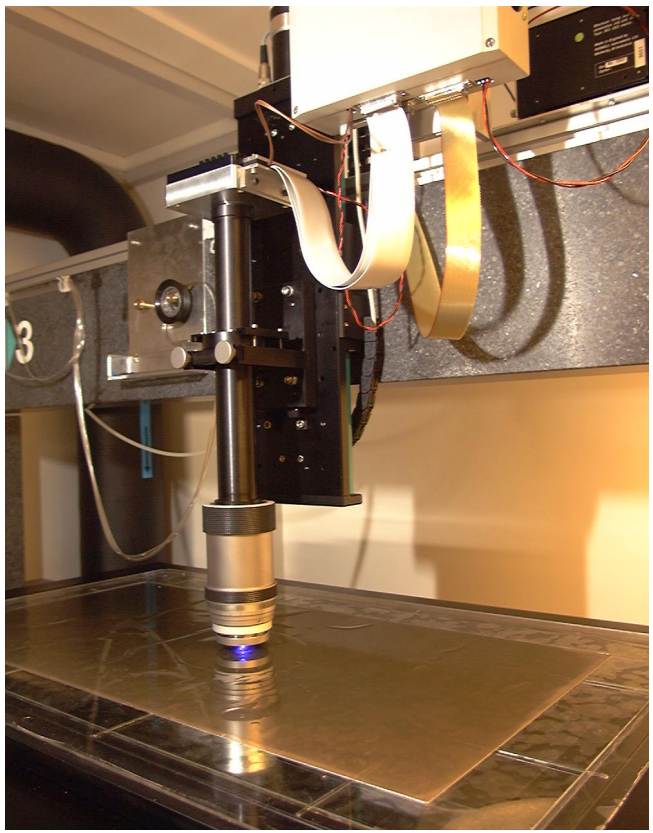


W. Flegel , J-P. Dupraz

Microscope optics

Objective

∅ FOV	0.5 mm
DOF	1.2 μm
FWD	1.2 mm
NA	1.05
M	28x 40x (60x,80x)
λ	436 nm
n (emulsion)	1.48-1.54



Light source

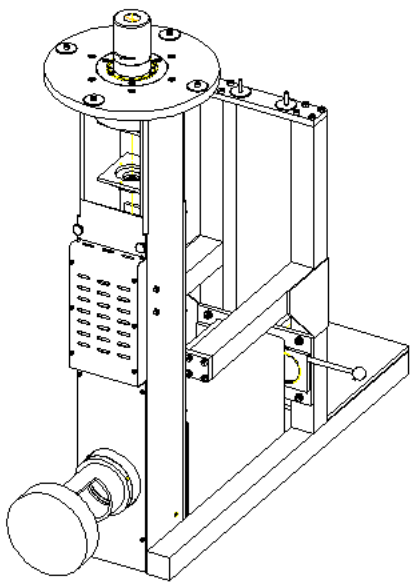
∅ FOV	> 0.6 mm
NA	0.95
shutter (LCD)	up to 120 Hz
intensity range	1:30

350 x 350 μm/view

J-P. Fabre , B. Van De Vyver, P. Zucchelli

Jenoptik

Spring 97 : specifications
Fall 97 : call for tenders
Summer 98 : first system
Fall 98 : three systems

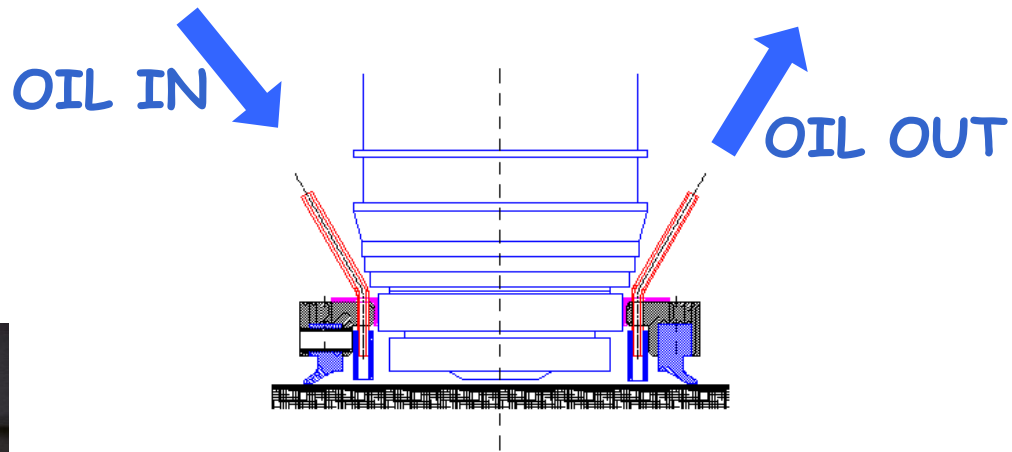


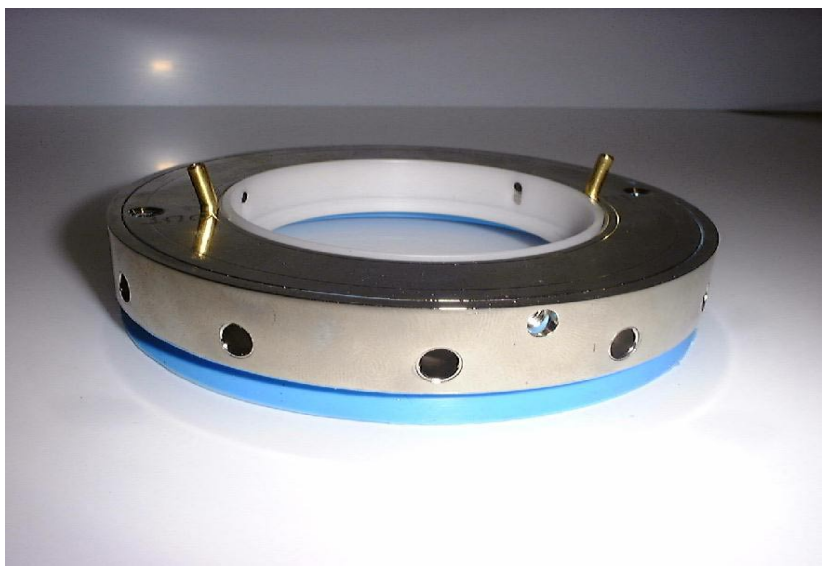
SPIE 44th annual meeting, Denver, paper 3779-43

Oil system

Almost closed circuit
(no dirt absorbed by the oil)

Reduced oil consumption
Continuous filtering
Easy plate changing



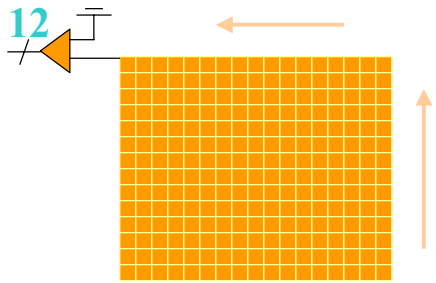


P. Zucchelli , G. Van Beek

CCD camera

Still 2 stages: 15 Hz

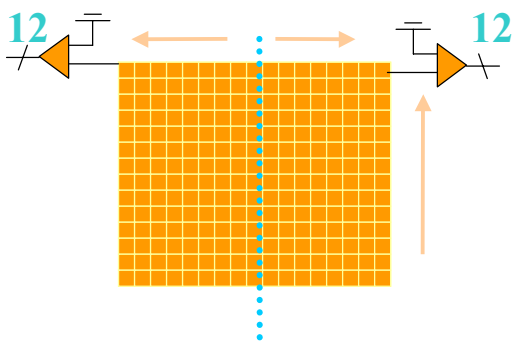
LCD shutter
exposure control C81
on-line filtering C620



8 bits

According to specs: 30 Hz

on-line filtering C620
mark finding
problem : noise !



16 bits

Usually with x40 optics
(14 micron square pixels)

B. Friend

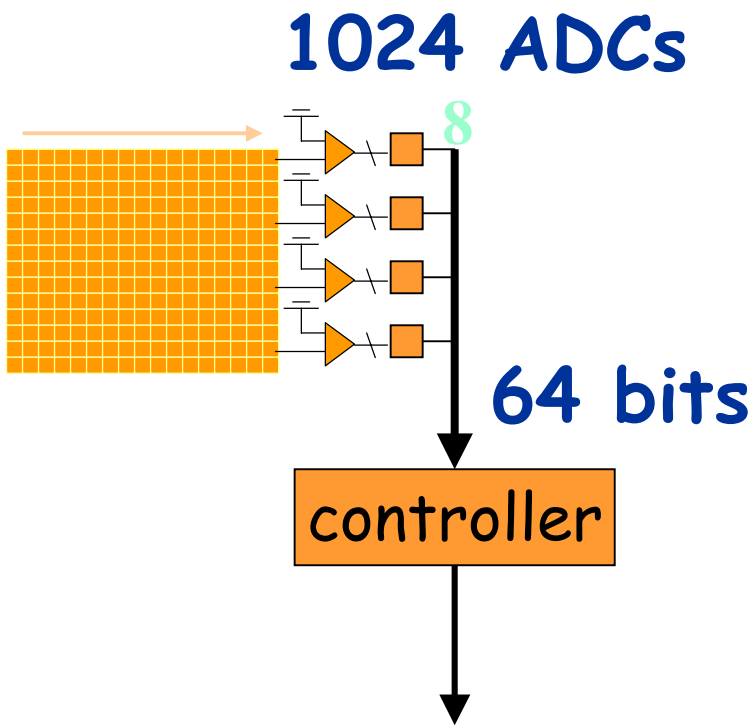
CMOS camera

One stage just implemented

Chip:
500Hz capability
Camera:
100 Hz capability

data transfer limitation 50 Hz
on-line filtering C620x2:
system limitation 40 Hz

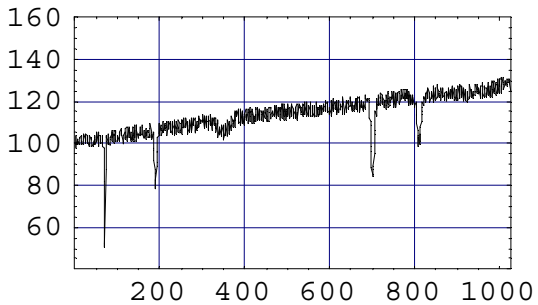
Usually with x28 optics (smaller pixel size, 10 micron)



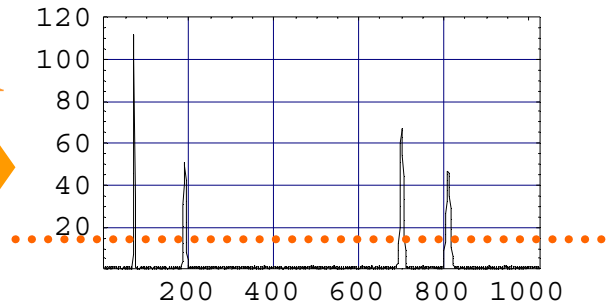
32 bit transfer to DPIO interface

B. Friend

Digital filters

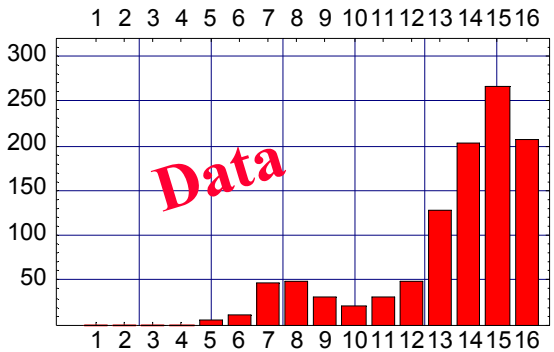


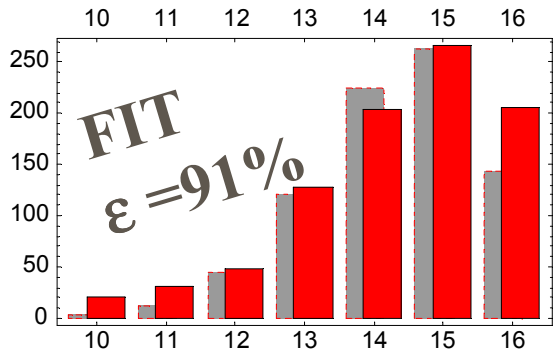
IIR



Concepts :
Chorus note 97/27

Number of layers hit out of 16 (on tracks) normal operation: 20-25 frames





5 cycles/pixel

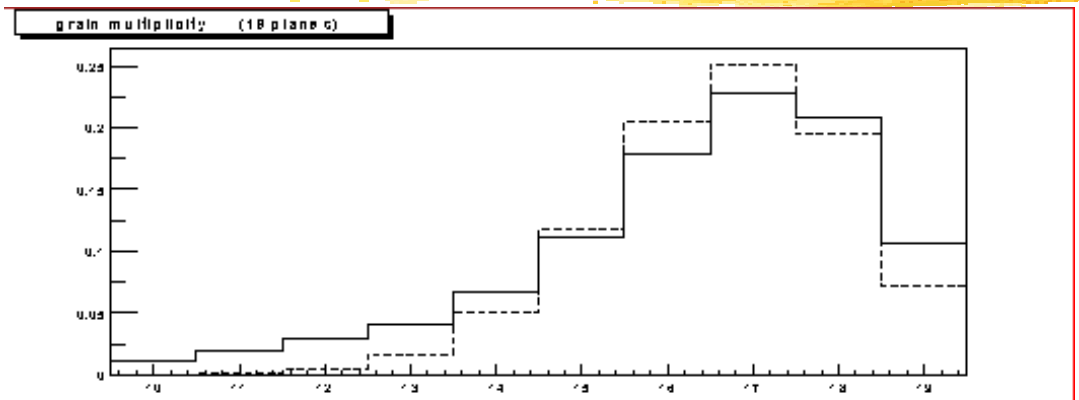
⇒ 2x40 Mpixel images/s

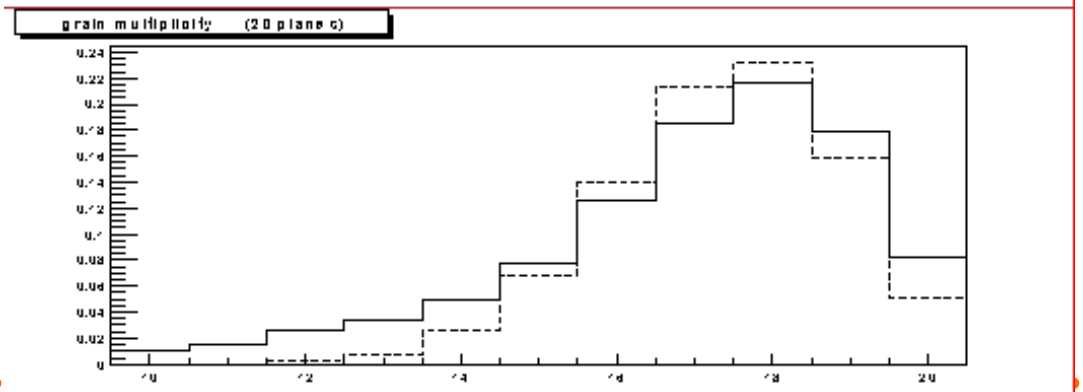
35 assembler instructions on C620 (VLIW)

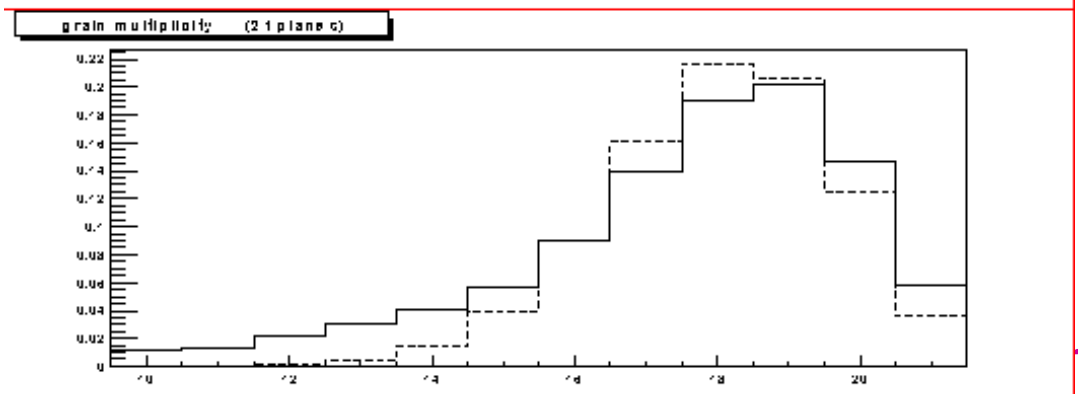
C620 implementation :
Chorus note 98/9

I.M.Papadopoulos, M. Chizov

Number of grains on a track







Number of layers (on tracks) hit out of:

19 frames

20 frames

21 frames

I.M.Papadopoulos, Ph.D.thesis

Prediction tracking

RT control

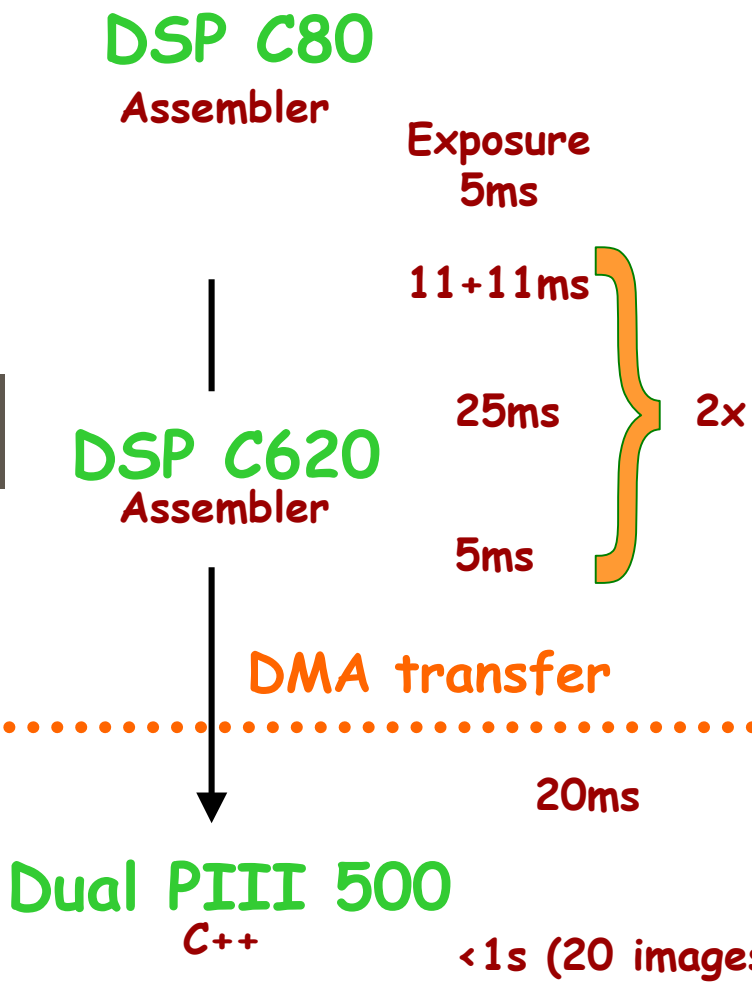
image capture

Digital filter (3-pole IIR)

Zero suppression

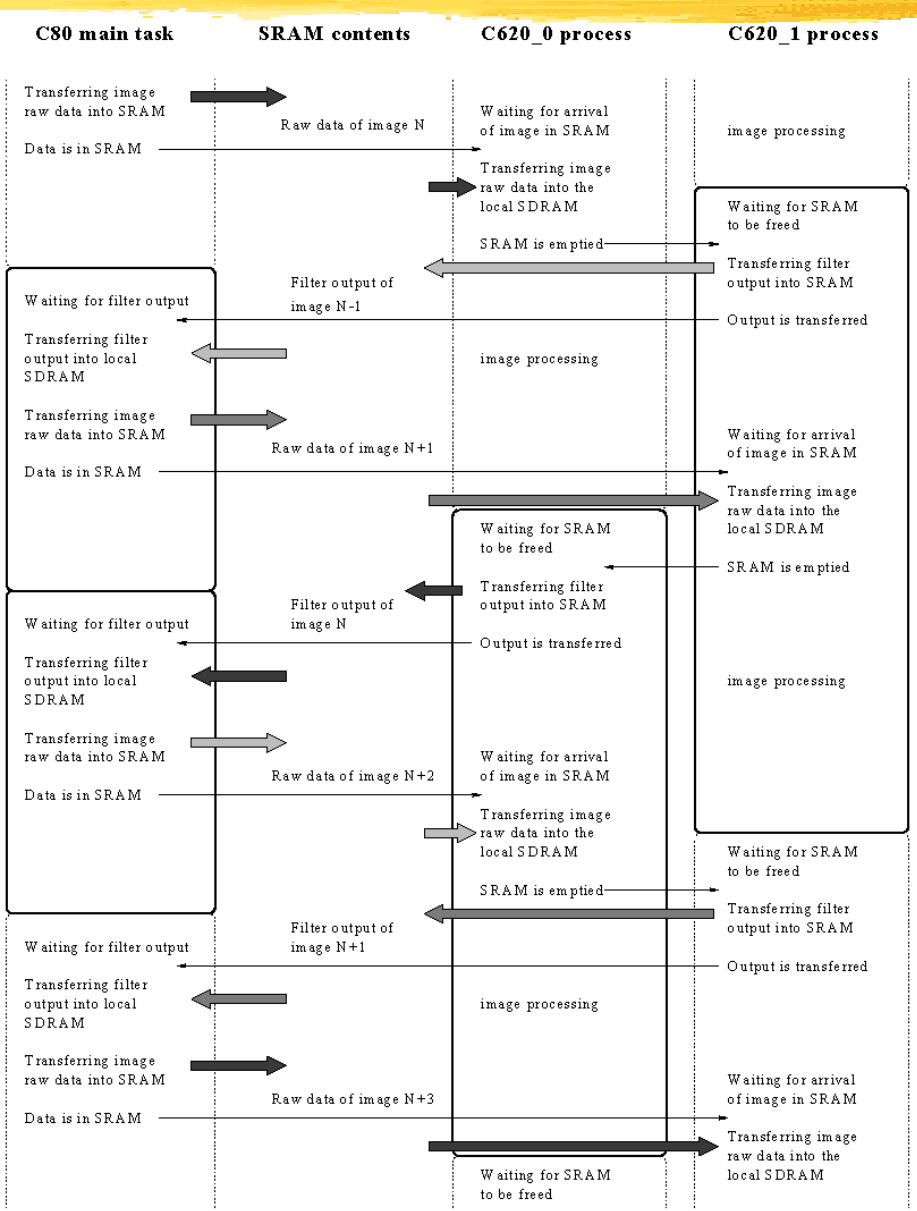
Clustering

Predicted angle tracking



I.M.Papadopoulos, Ph.D.thesis

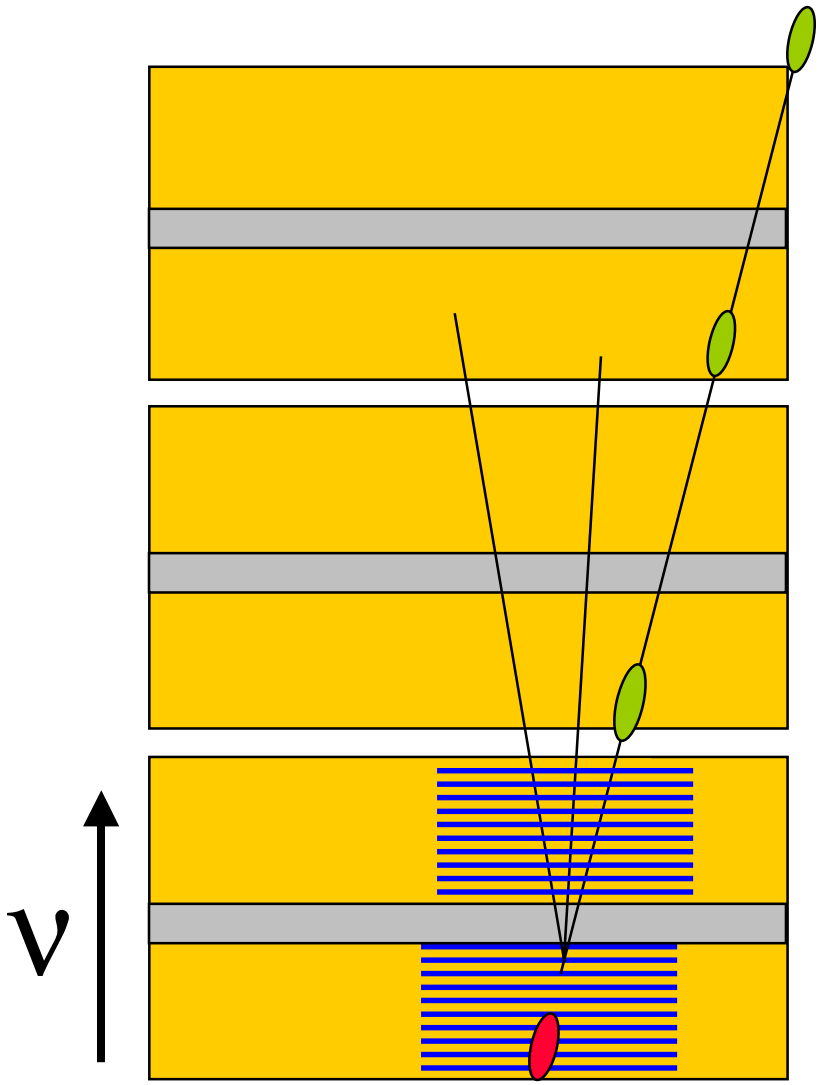
Flow control



Real-time flow control between C80 and dual C620

I.M.Papadopoulos, Ph.D.thesis

Flow diagram



Scanback

25 images
100 micron thickness
predicted angle

Net scan

25 images
100 micron thickness
all angles up to 400 mrad

Vertex analysis

2 x 60 images
2 x 350 micron
all angles up to 400 mrad

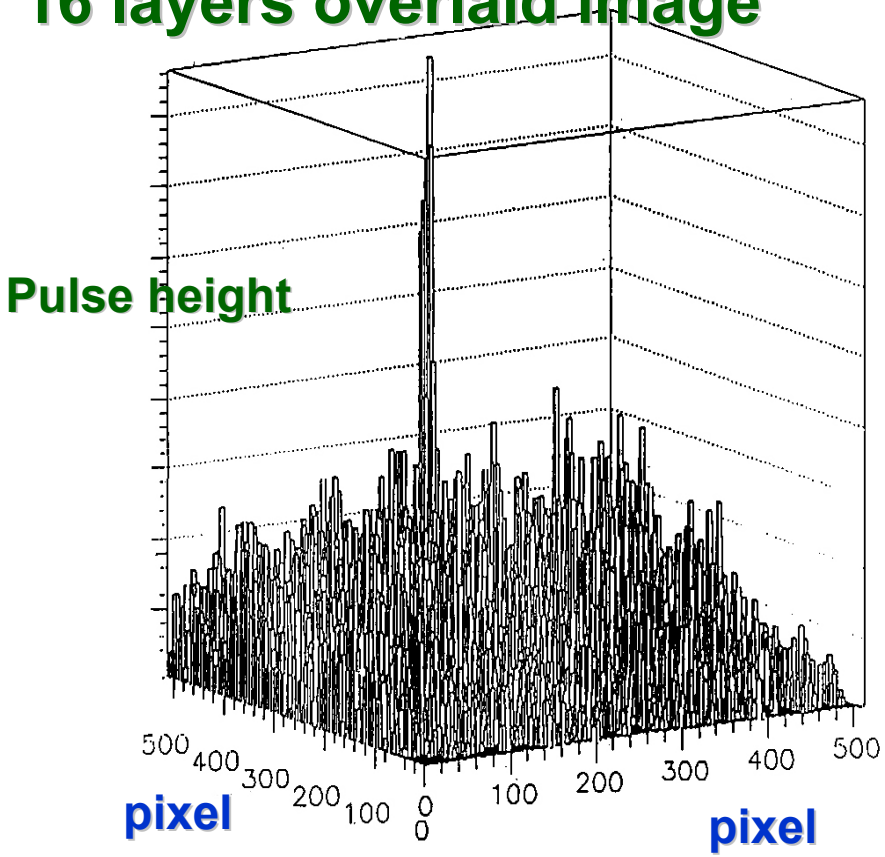
Nagoya TS principle

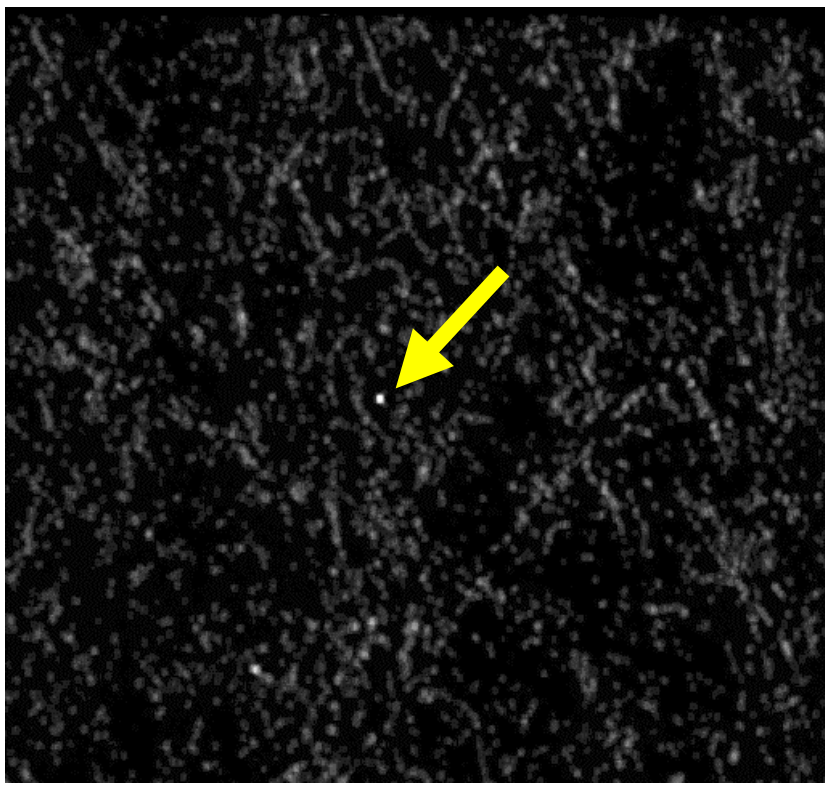
Filter images and accumulate in frame memories

Shift each frame according to the predicted angle

Take the sum of the superimposed signals

16 layers overlaid image





White spot is ‘track signal’

Software implementation

Design goal: use commercial DSP/PC hardware

Track Selector principle:

efficient for hardware implementation

but slow in software implementation

Tracking algorithms more efficient as software implementation

Two types of tracking used:

Prediction tracking (around predicted angle)

on-line; two step process

General tracking (all angles)

off-line

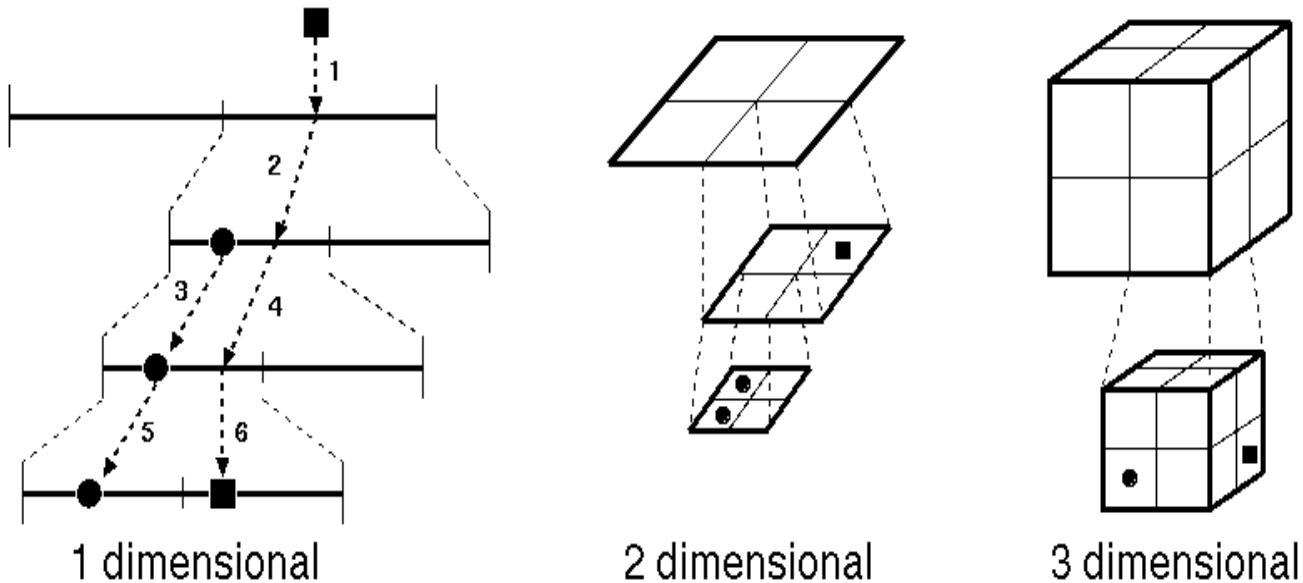
J.Uiterwijk, Ph.D. thesis, in preparation

Fast Lookup: Binary tree

Prediction tracking: 25 planes with ~2500 grains each

General tracking: volume with 100-200k grains

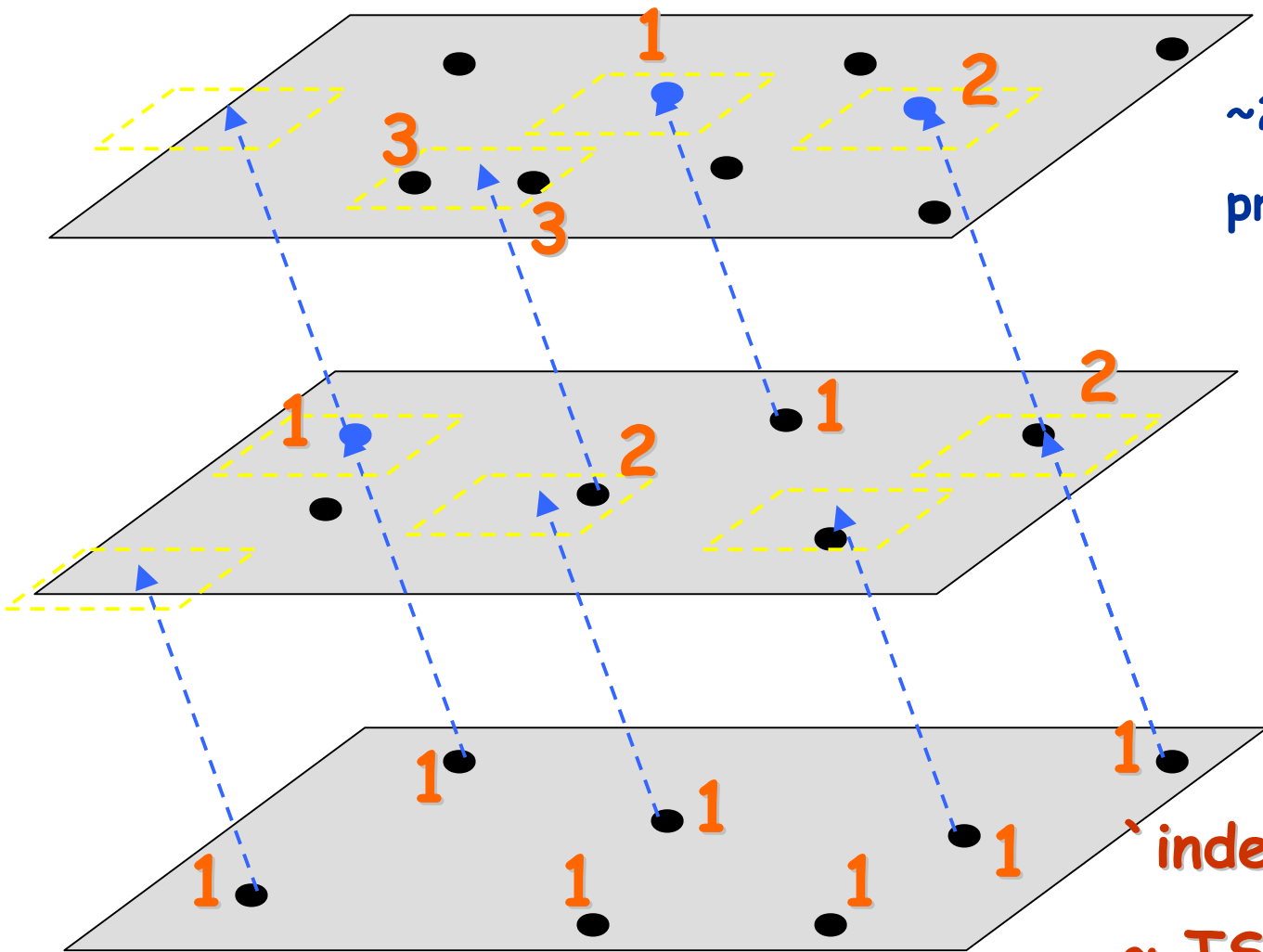
TBinaryTree<Datatype, VolumeType, dimension>



Search time scales as $2^D \log N$ (offset to build tree)

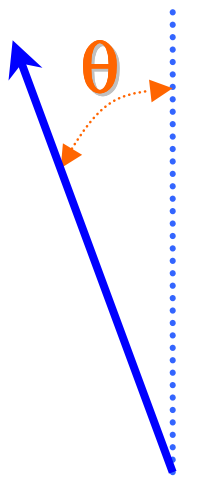
J.Uiterwijk, Ph.D. thesis, in preparation

Tracking trigger level 1



~2500 grains/layer

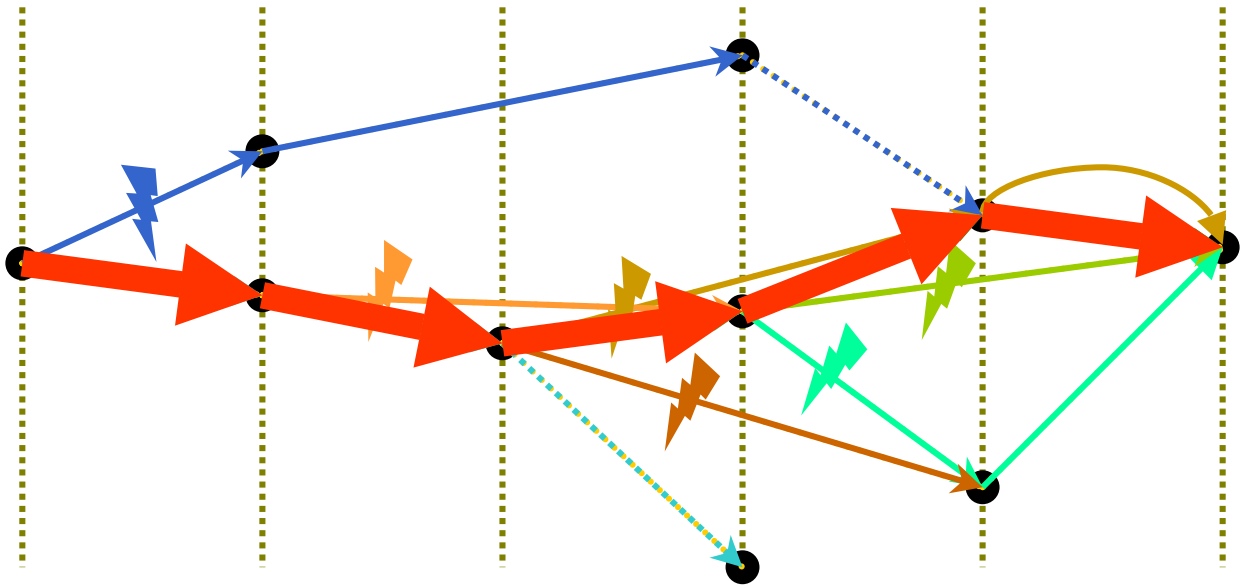
predicted angle :



`index` in last layer

~ TS sum

Tracking trigger level 2



After level 1 <10 track regions of <100 grains (>50 reduction)

Building links
Large angular acceptance
Maximum distance across link

Segment growing
On-the-fly acceptance (cone,cylinder,..)
The longer the segment, the better
The shorter the gaps, the better

Full angular coverage? Skip level 1

General tracking

CCD image capture

Digital filter (3-pole IIR)

DSP C620 — 25ms

Assembler

Clustering

Dual PII 500 (WNT) — 20ms

C++

Dispatcher and OBJY/db (100Mb Ethernet)

'Offline' Tracking

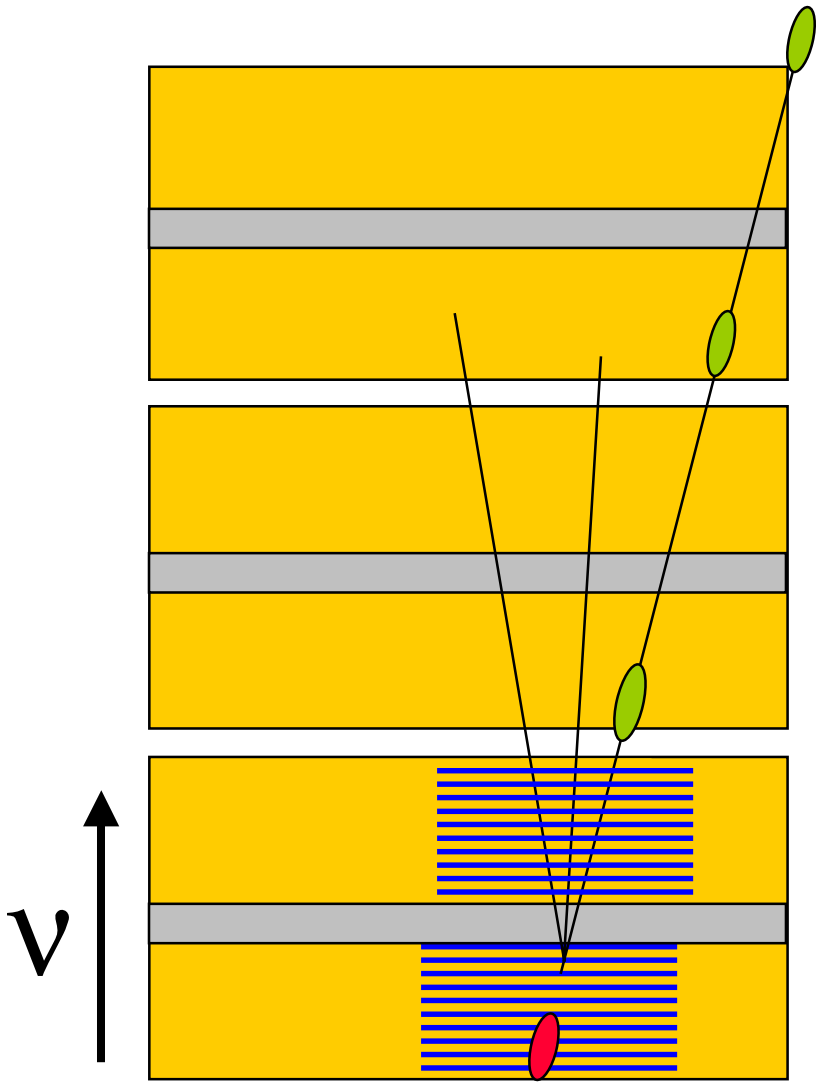
Multiple nodes

Dual PIII 860 (Linux) 1-20s ~20 images

C++

Scalable architecture !

Flow diagram



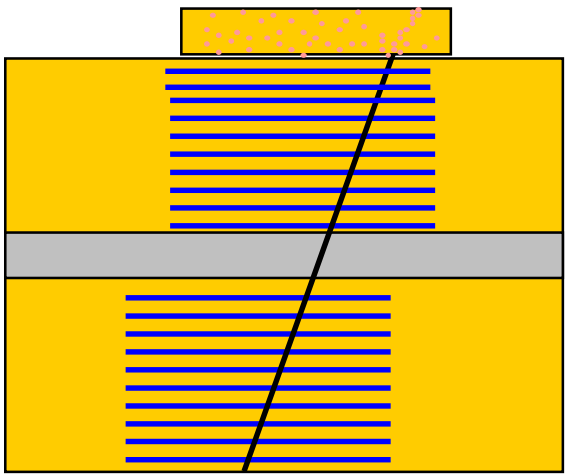
Scanback

25 images
100 micron thickness
predicted angle

Vertex analysis

2 x 60 images
2 x 350 micron
all angles up to 400 mrad

Topologies



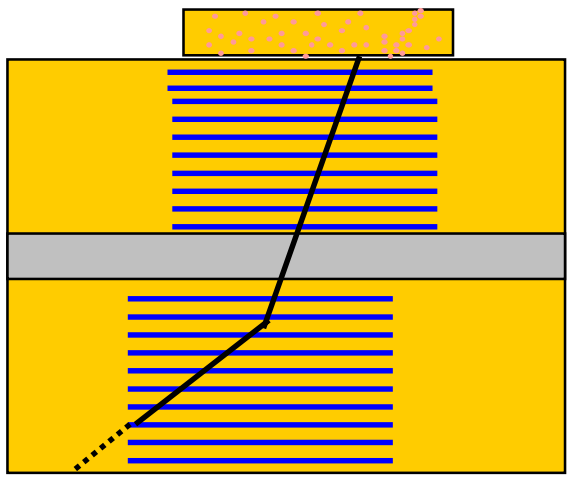
Inefficiency

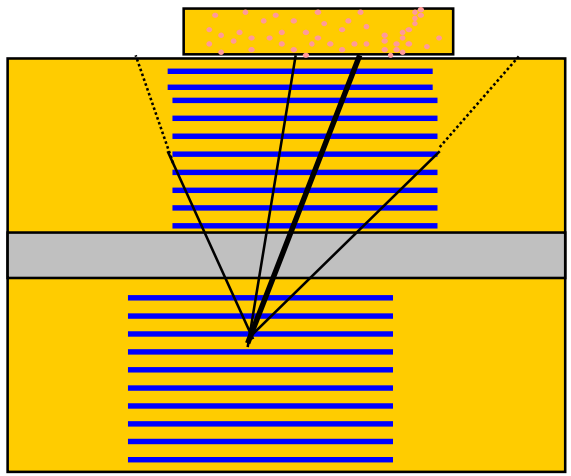
Track scanback

Long kink

Raw data

Parent scanback

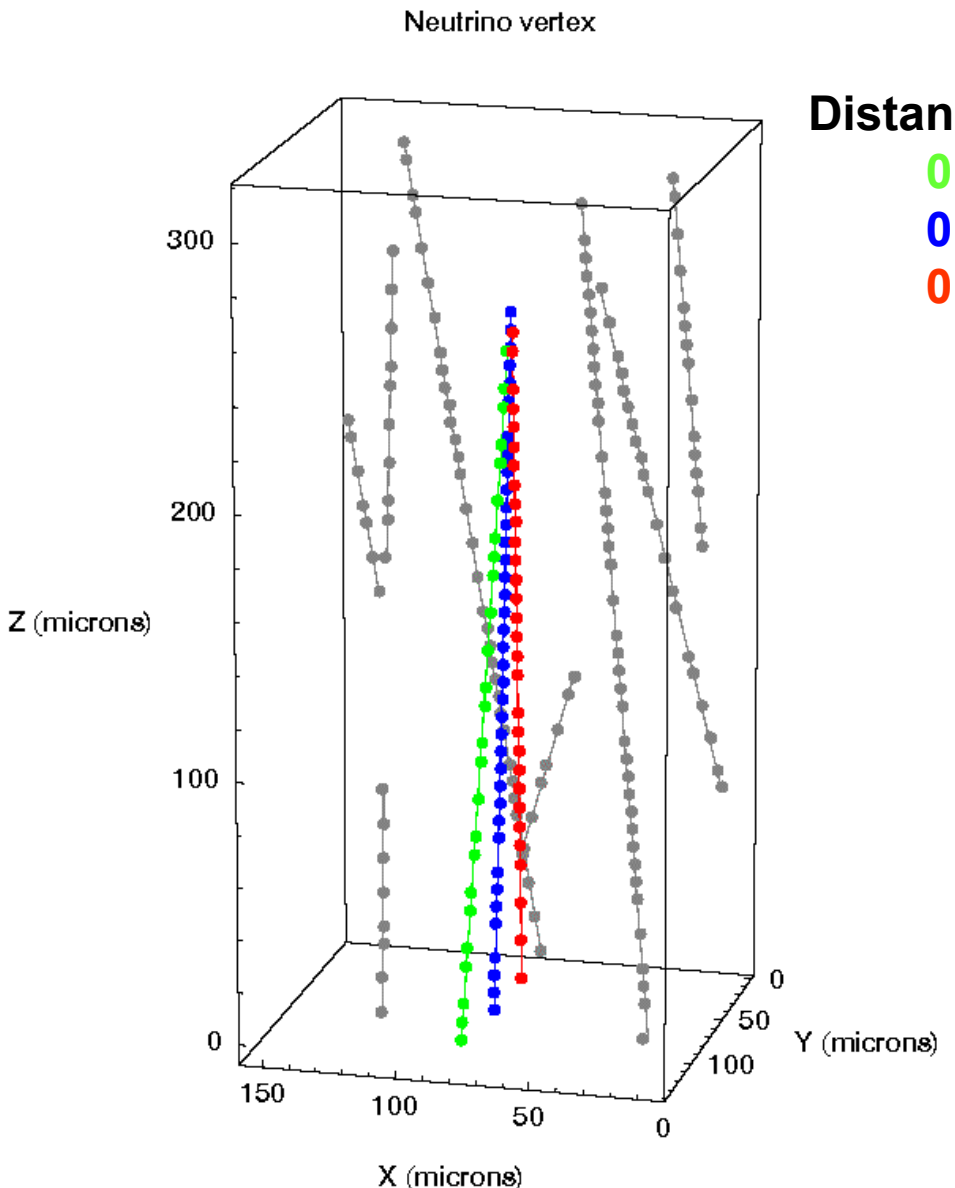




Vertex

Raw data

Tracking results

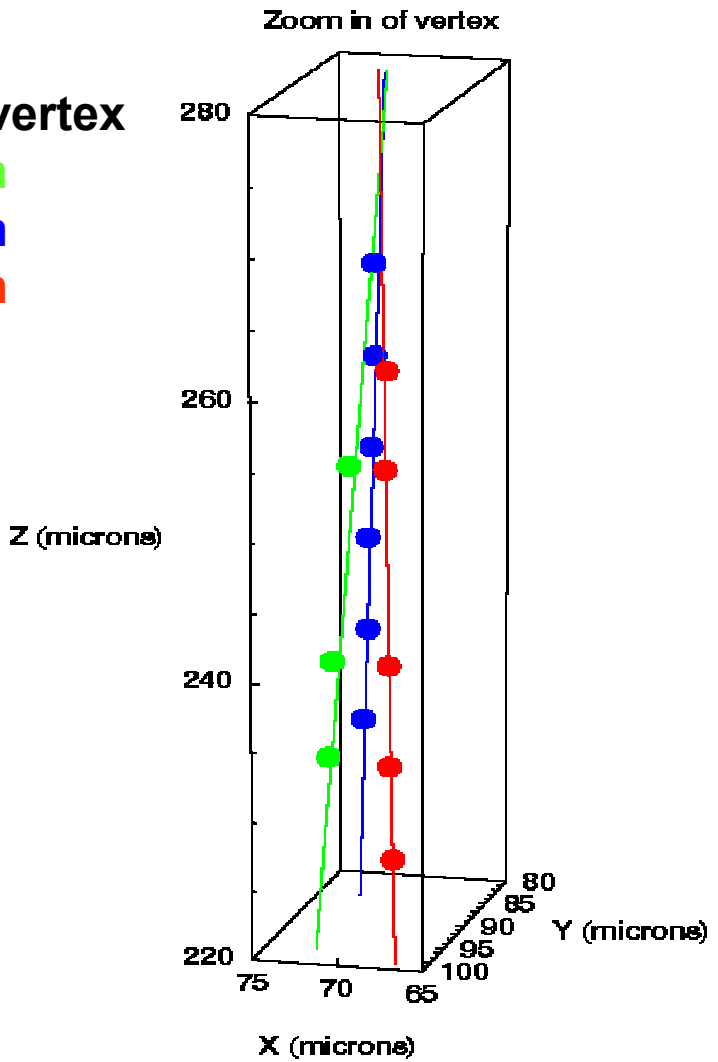


Distance to vertex

0.03 μm

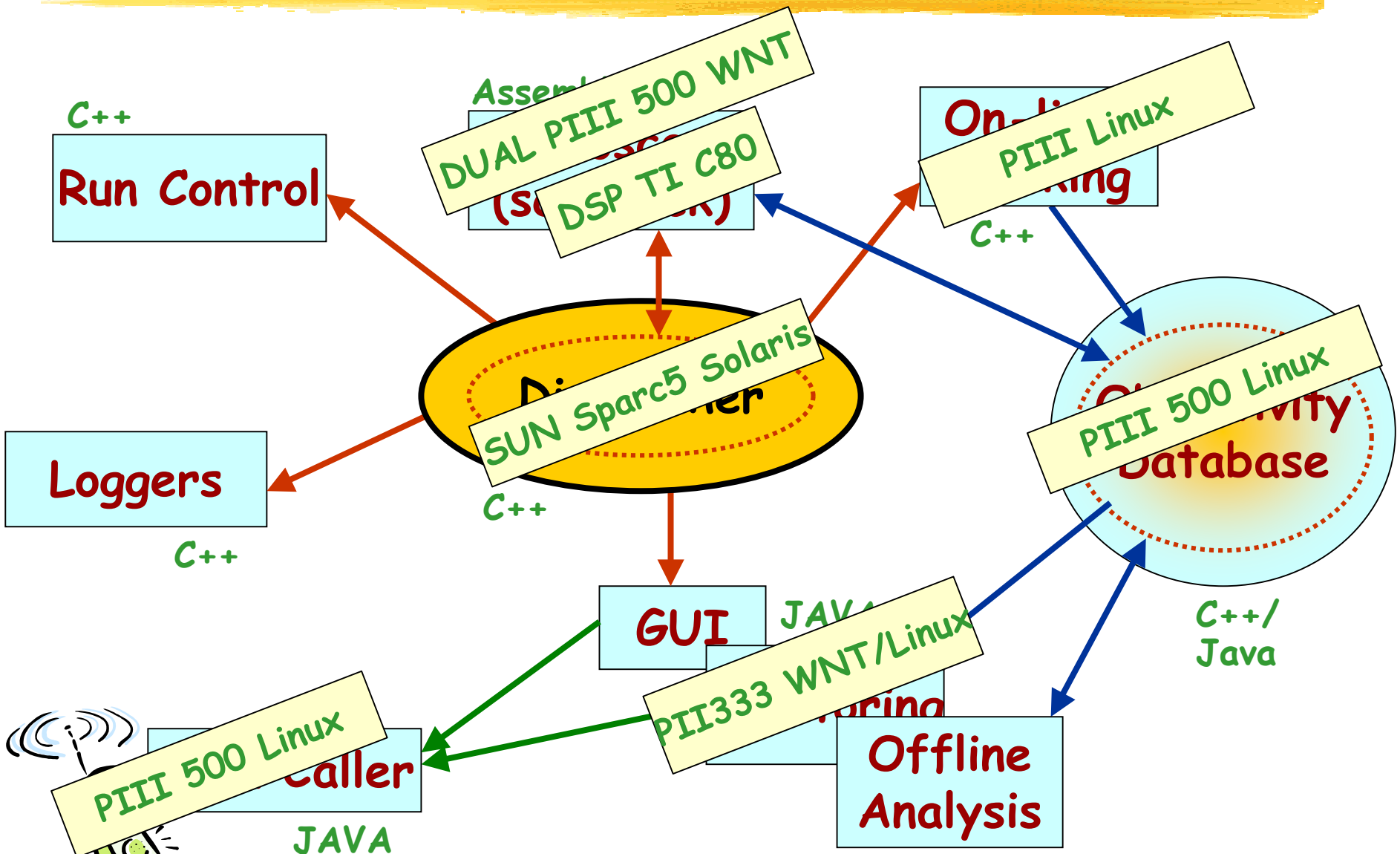
0.05 μm

0.19 μm



J.Uiterwijk et al., in preparation

Microscope DAQ at Cern

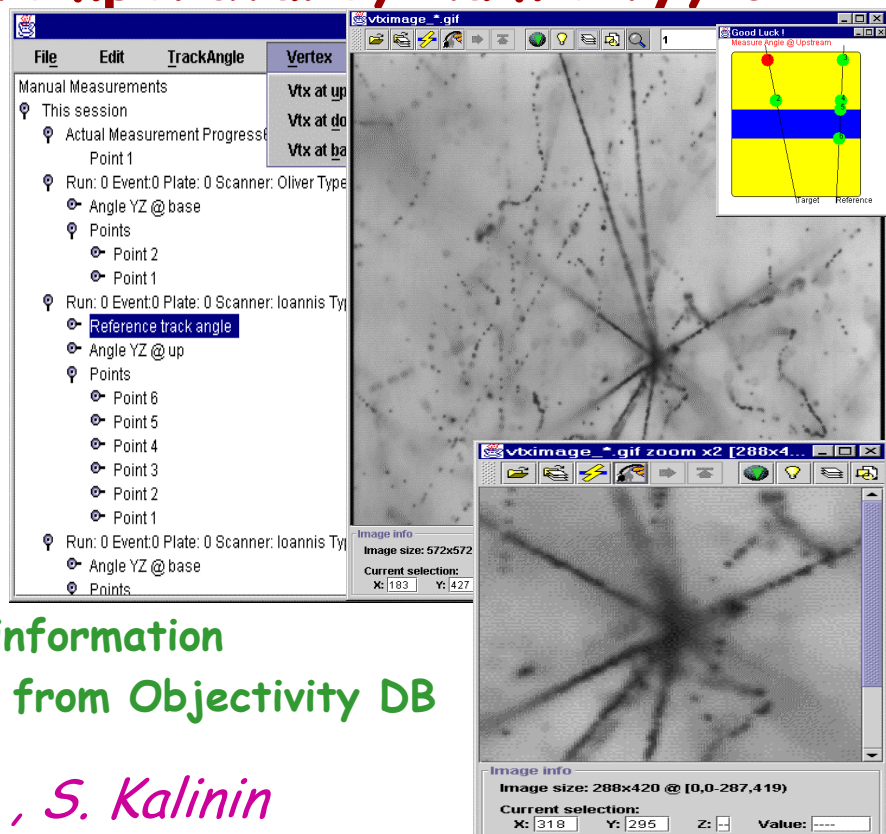


J.Uiterwijk, H. Meinhard, B. Van De Vyver

Java GUI

Java Applications for :

- **Slow control (CCD and room temperature, humidity, oil flow, …)**
  - Objectivity interaction
  - GSM portable phone messaging
- **Manual Emulsion Scanning**
  - Microscope hardware control
  - Measurement tools
  - Offline Viewer
- **Wired Event Display**
  - Display of electronic detector information
  - Display of scanning information from Objectivity DB



M. Doucet, D. Raffo, O. Melzer, E. Pesen , S. Kalinin

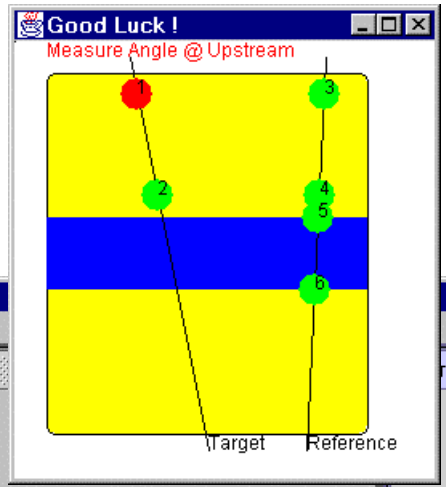
Manual scanning

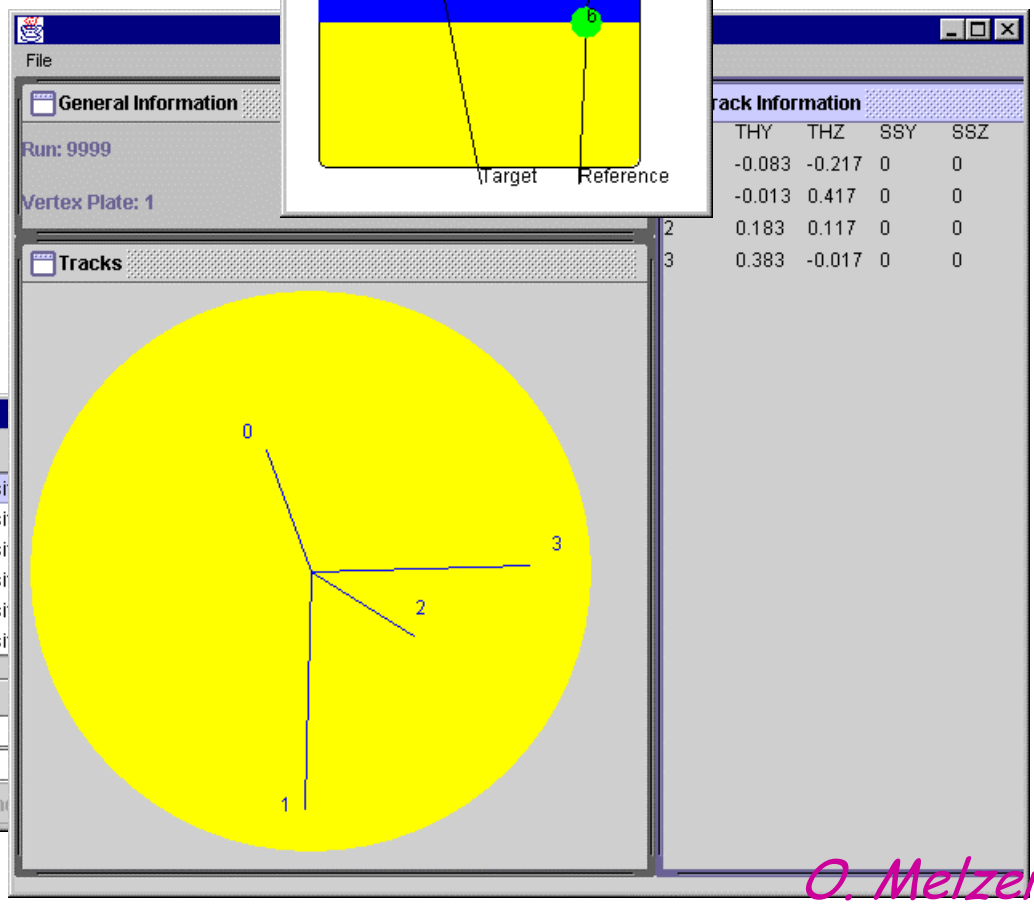
Data available off-line

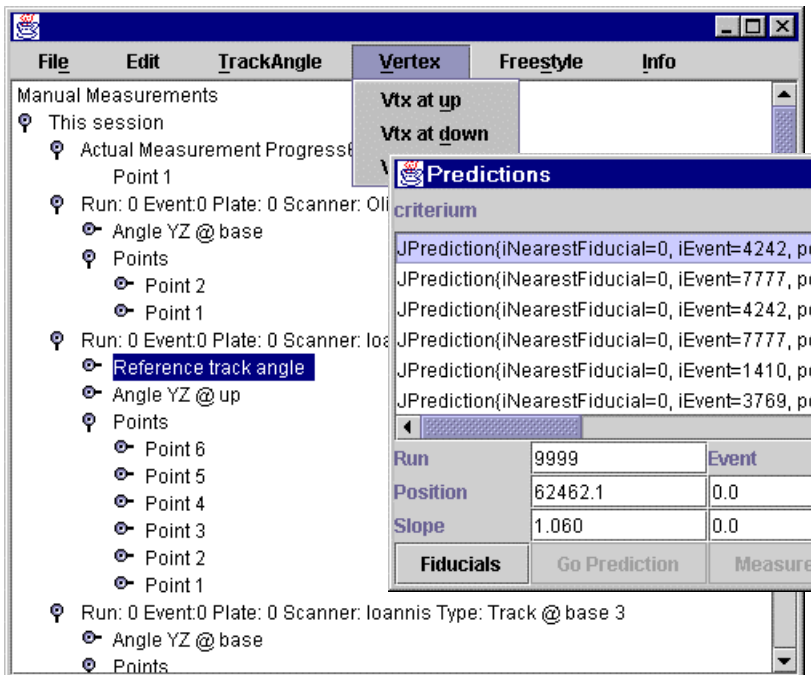
- 9 views of 350 x 350 mm = 1 mm2
- JNI interface to Objectivity/C++

User interface

- Java panel, same as 'real-life'
- Chorus event display (Wired)
- Overlay of raw data and grains







O. Melzer

Performances

CCD Camera:
15 Hz

1 view (25 frames) + movements
3.6 s

1 cm^2 / hour

independent of tracking method

CMOS Camera:
100 Hz

1 view (25 frames) + movements
2.4 s

1.5 cm^2 / hour

transfer limitation being removed:
~2 cm^2 / hour