Features

- PS実験: Spill 0.5s + Interval 2.5s
  Memory Buffer
- Collider: Synchronous, but recently DC- like in High Luminosity (Belle)
- Non-Acc. Exp.: Asynchronous, Burst (υ, γ)
  All detectors are concerned to Trigger logic & TDC, ADC, Scalor etc,,,
- Photo count Imaging: huge continuous data flow (no-trigger, asynchronous -> synchronous by high frequent clock)

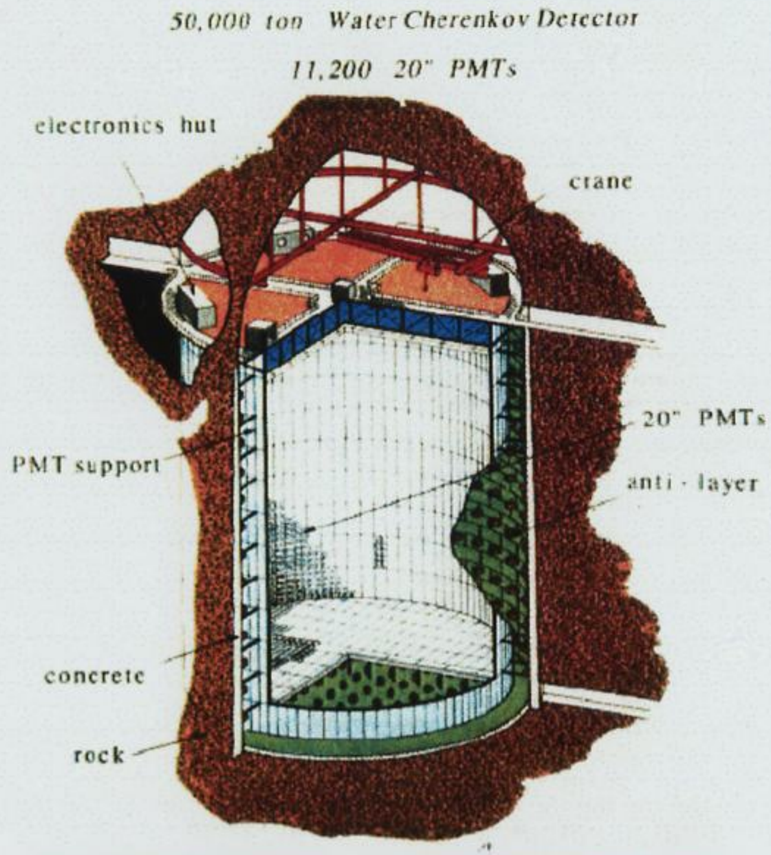
DAQ in my Experience

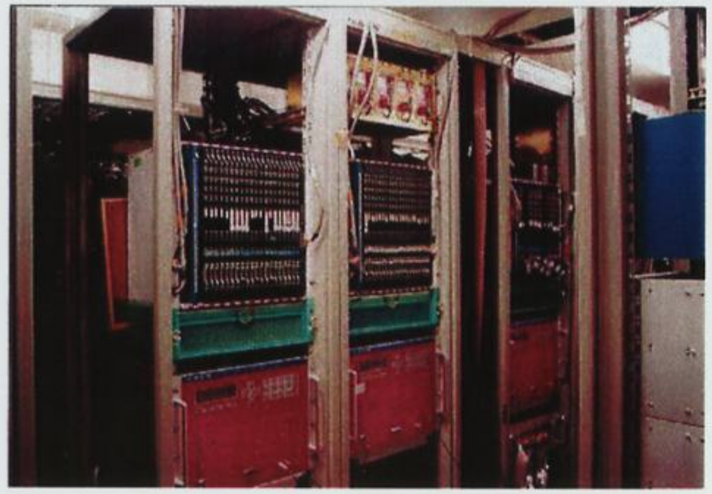
Exp.	Hardware, Data Bus	Computer	OS
PS (80~86)	CAMAC	PDP, μVAX	
Kamioka Super-Kam (86~94)	VME TKO, CAMAC,	μVAX, Sun	Sun-OS Unix-Onlineの開発
CANGAROO (87~ Now)	VME, CAMAC, TKO VME only	Sun, Intel	OS9, Solaris Linux
BELLE (92 ~97)	VME, TKO, Event-Builder	Motorolla ? Sun	VX-Works Solaris
X,γ Imaging (95~ Now)	VME, VT, FPGA-direct	Sun, Intel	Solaris, Linux, Compact-PCI

Non-Acc.(Kamiokande & Cangaroo)

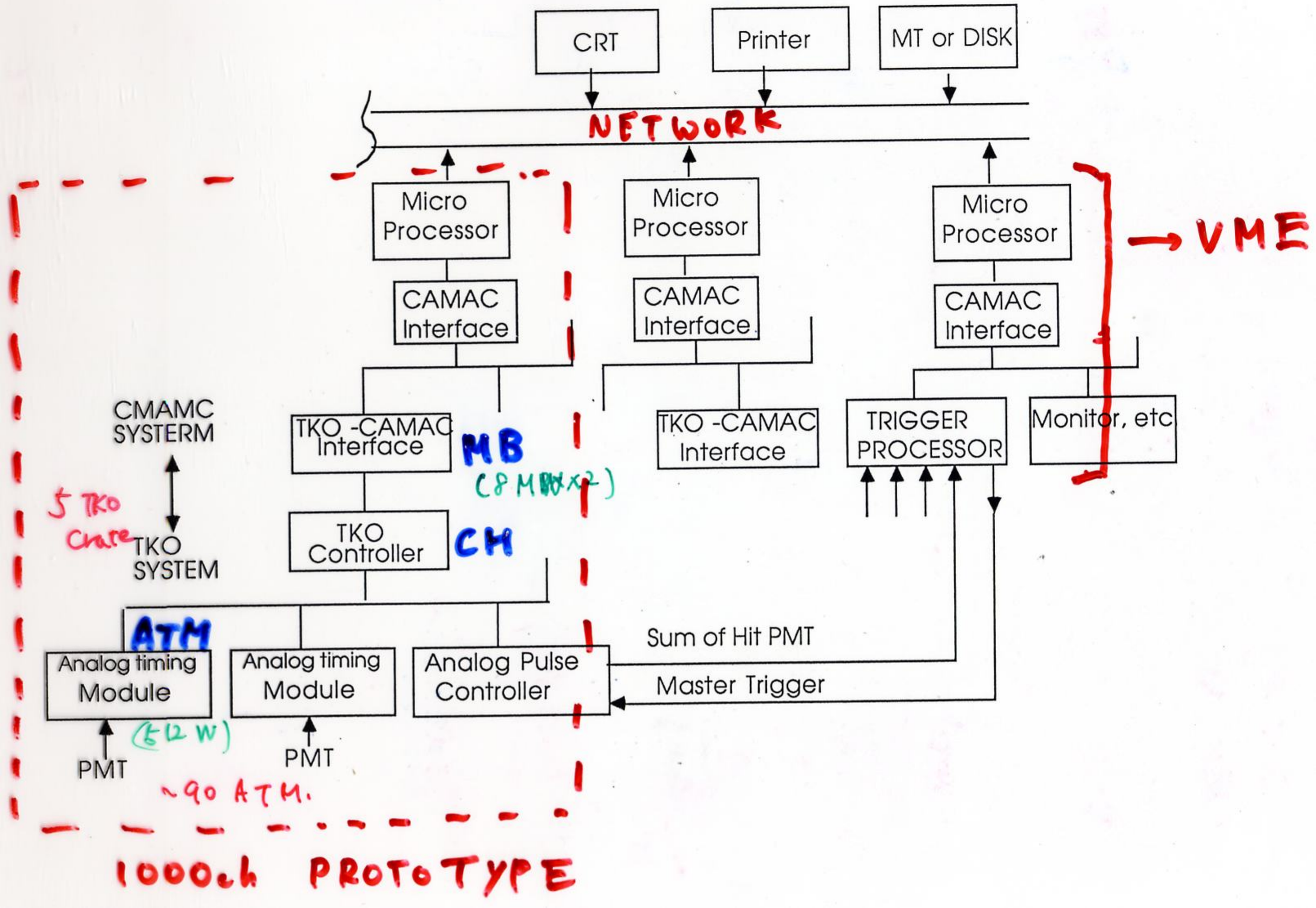
- Electronics: All in one Analog-Timing Module (ATM) TKO + VME (Special GONG)
- Distributed system
  Net-work Connection
  Unix-ON-line ->
  Sun +Solflower(S-bus to VME)
- VAX -> OS9, Vxworks(68XXX),
  Realtime UniX-like OS

- Switching Network ->
  Event Building
  (Multi-Telescopes)

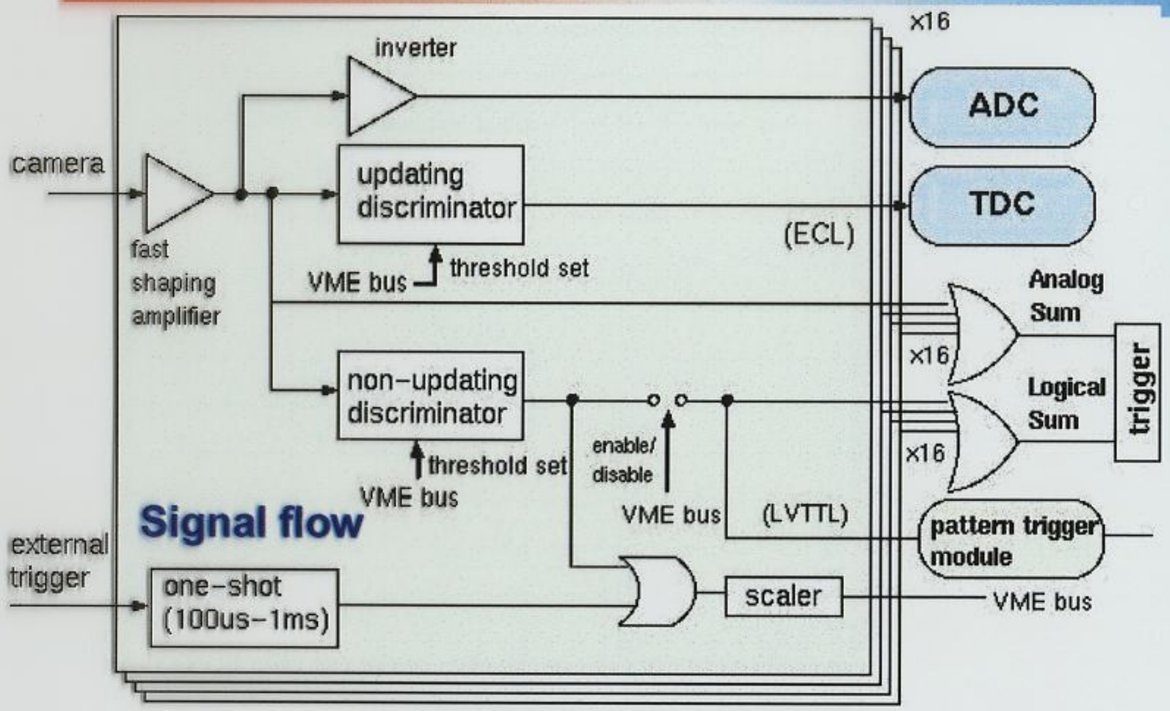




Super-KAMIOKANDE. ELECTRONICS



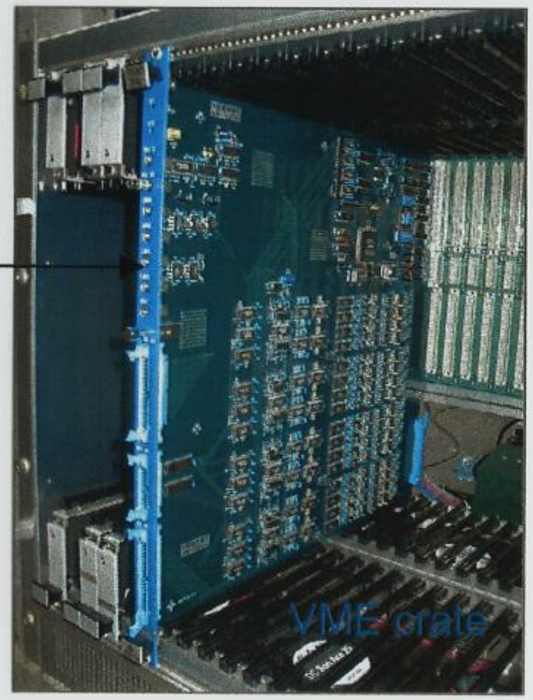
Electronics(1) front-end data acquisition



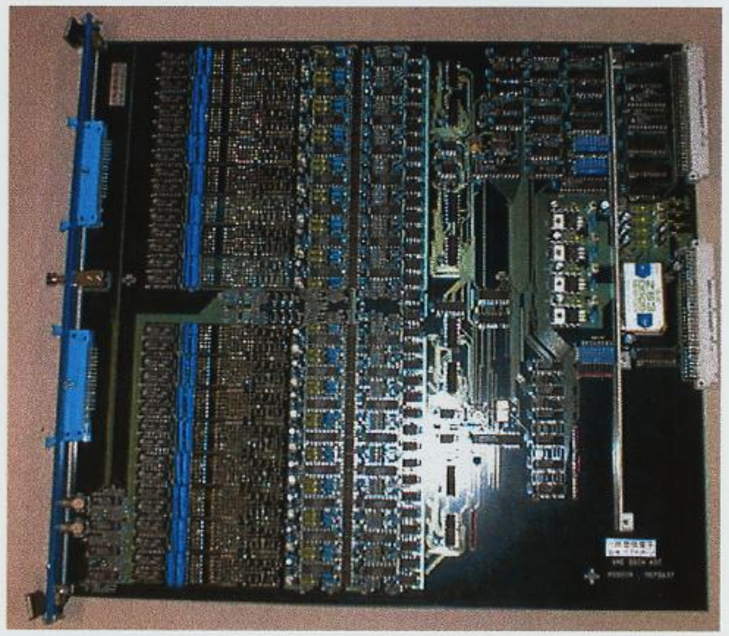
VME-based modules

- Front-end
  Discriminator/scaler
- Charge ADC
  16bit ADC chip for each channel
  Readout time:10-20μsec/board
- TDC
  1ns resolution

Custom-built VME-base front-end module



- **9U32ch.ADC**
  - **12 bit**
  - **4ch/pC**
  - **Min. 50ns gate**
  - **150ns internal delay**
- **VME-9U, A24/A32, D16**



CAMAC

CPU

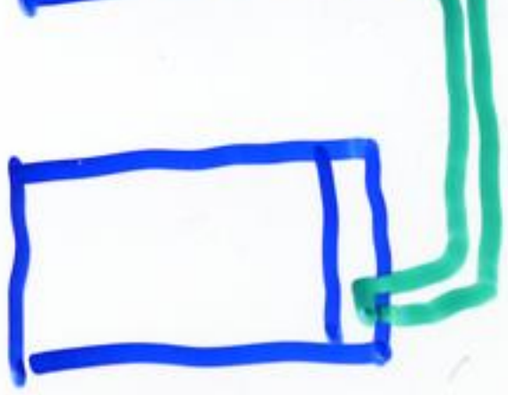
DC.

ADC

TDC

...

E131.

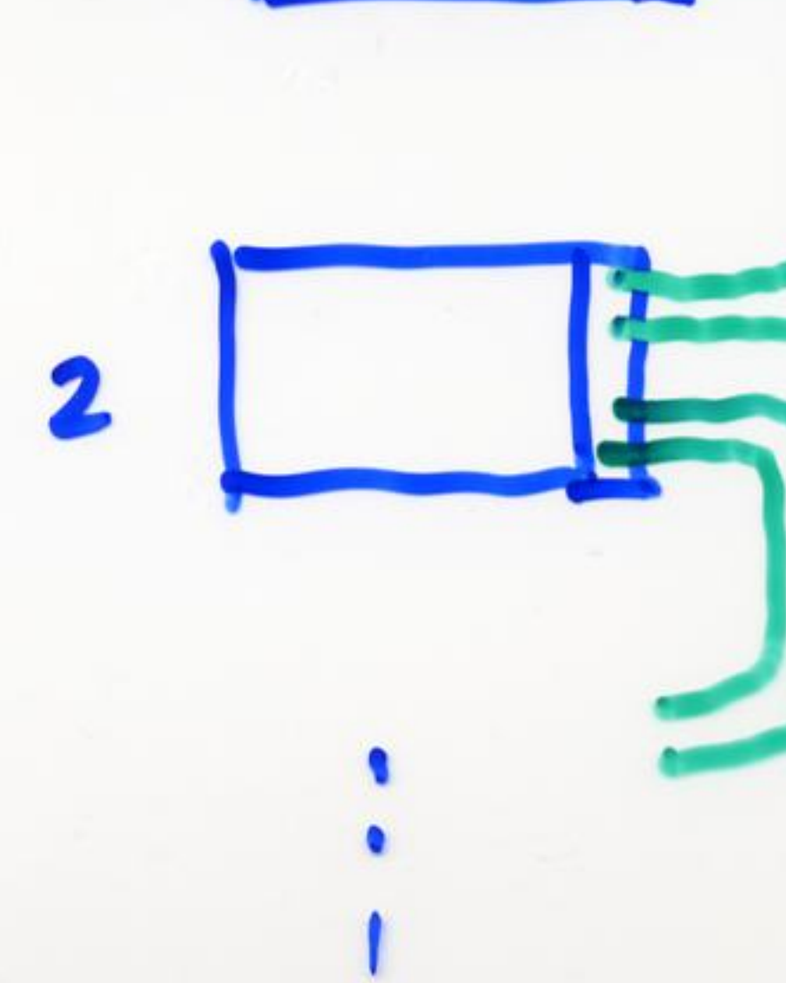


CAMAC

1

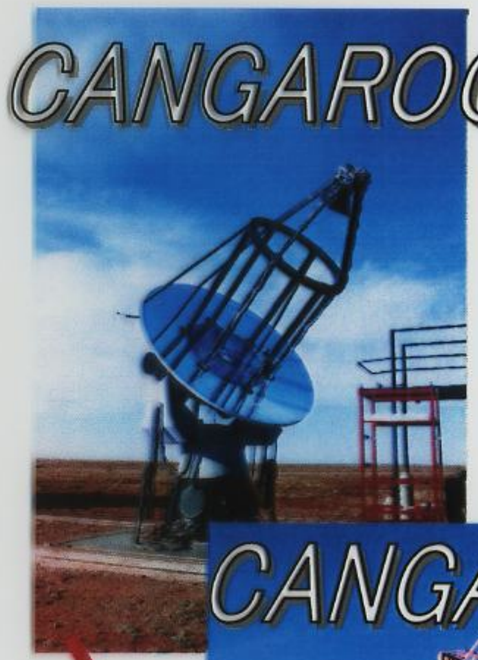
2

7



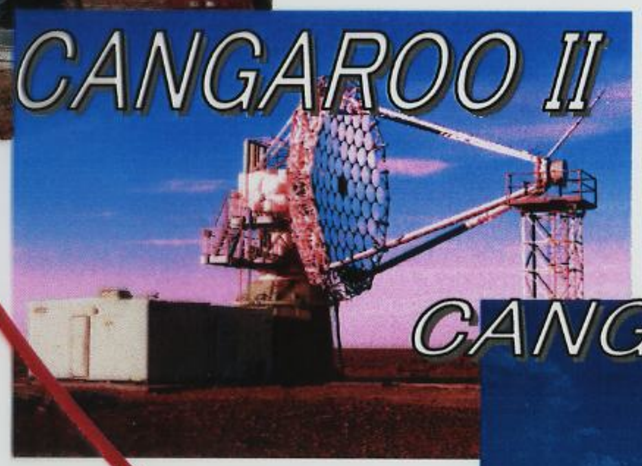
従来.

CANGAROOにおけるDAQの変遷

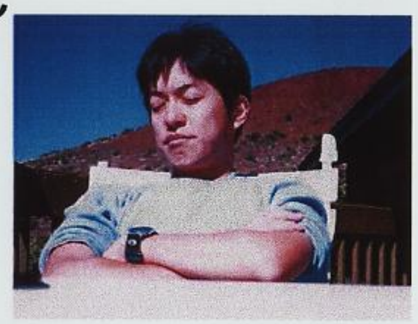


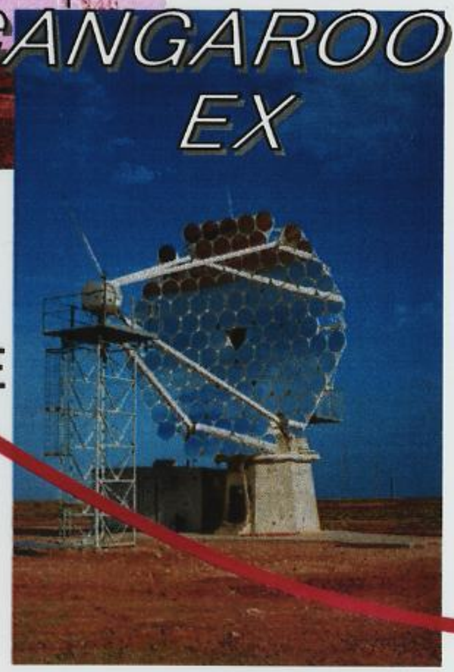
a. TKO,CAMAC
b. SUN OS
c. Workstation
d. 1Hz

a. 使用回路規格
b. 使用OS
c. 計算機
d. データ収集能力

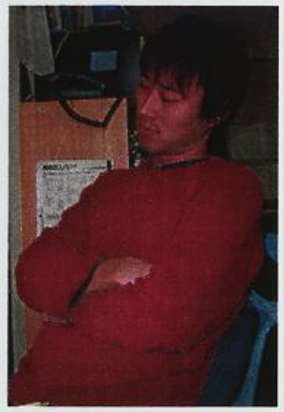


a. TKO,CAMAC
b. Solaris
c. Board PC
d. 30Hz





a. TKO,CAMAC,VME
b. Linux 2.2
c. PC
d. 80Hz



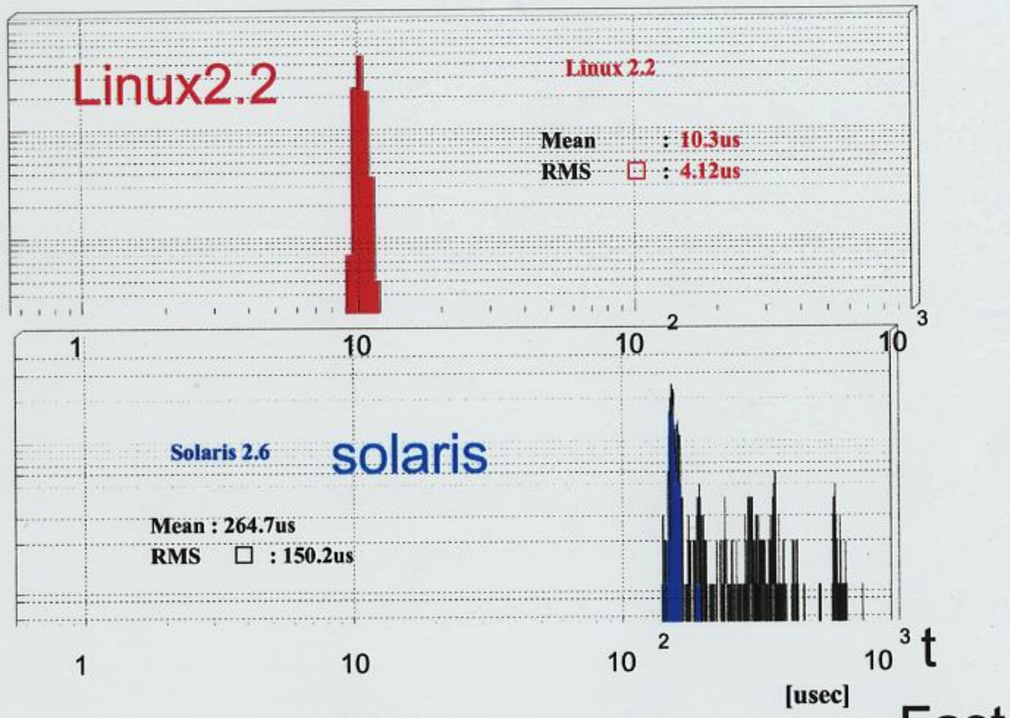
a. VME
b. Linux 2.4
c. Board PC
d. 400Hz

T1DAQ(80Hz) から T2DAQ へ

DAQの不感時間(dead time)の3要素

●データ転送時間

Telescope 1 (CAMAC base) ～10msec → Telescope 2 (VME base) ～1msec



●インタラプト遅延

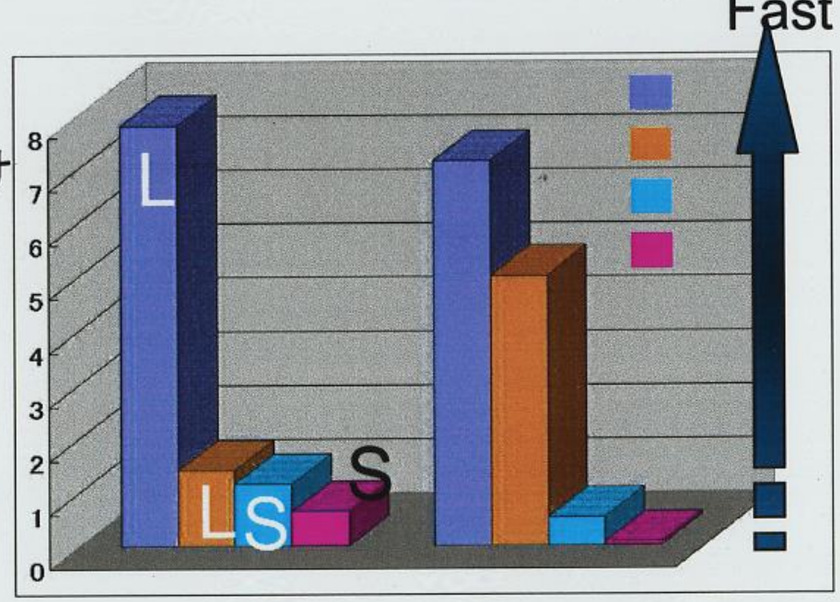
Trigger がかかってから実際にCPUに割り込みがうけつけ

Linux OS を使うことで現在でも十分に短い (～10usec)　　ref: 修士論文

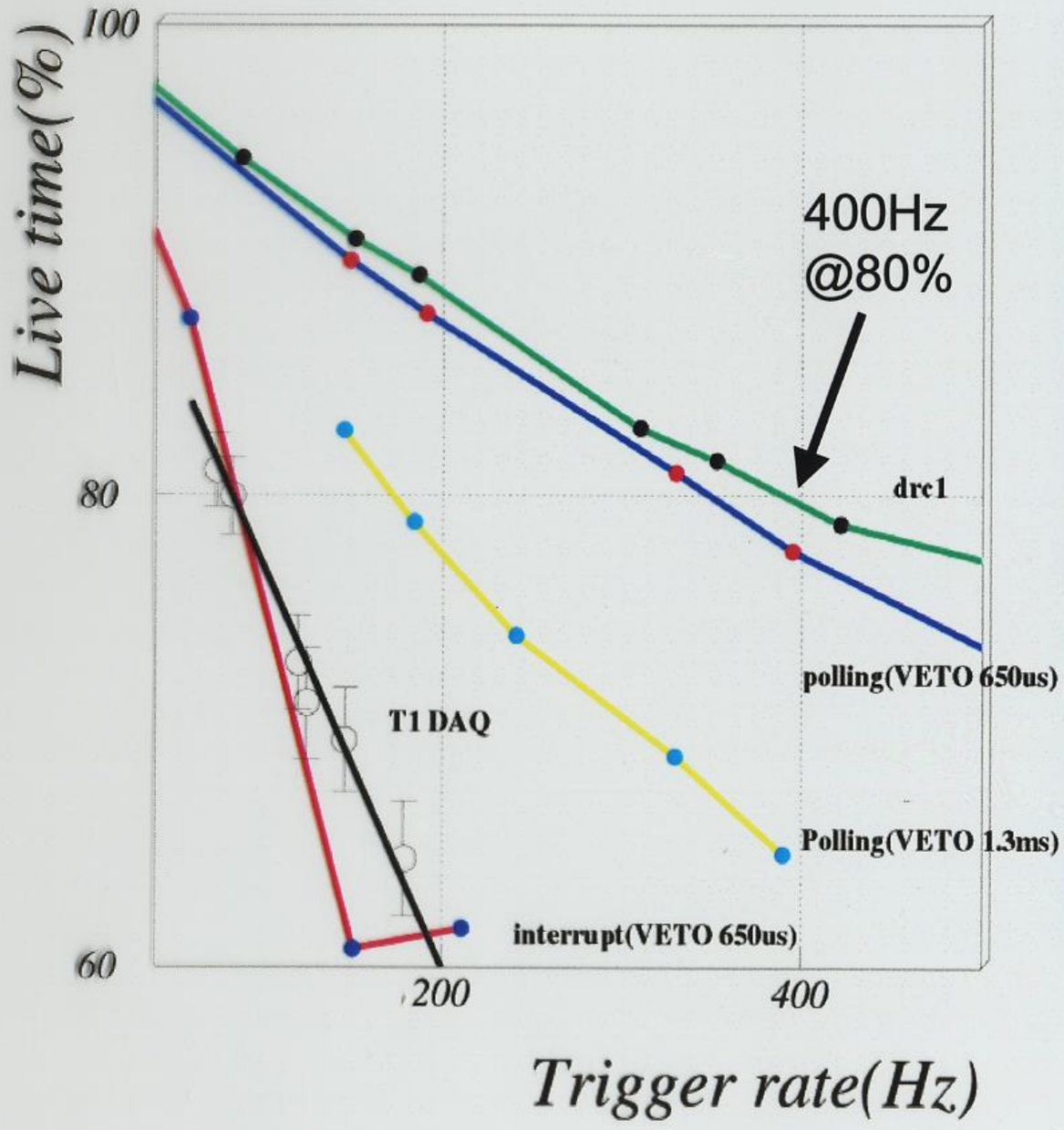
●スレッド切り替え時間

各スレッド(プロセス)が切り替わる際に生まれる待ち時間

Linux OS を使うことで現在でも十分に短い (Solaris使用時の3～5倍)　ref: 修士論文



PCI bridge vs On-board CPU



★On board CPU (model drc1)

- ADC: 1.7 us/access
- TDC: 1.2 us/access

VETO (read out time):

224 x1.7 + 200 x1.2= 620usec

448ch * 1/2

100hit * 2

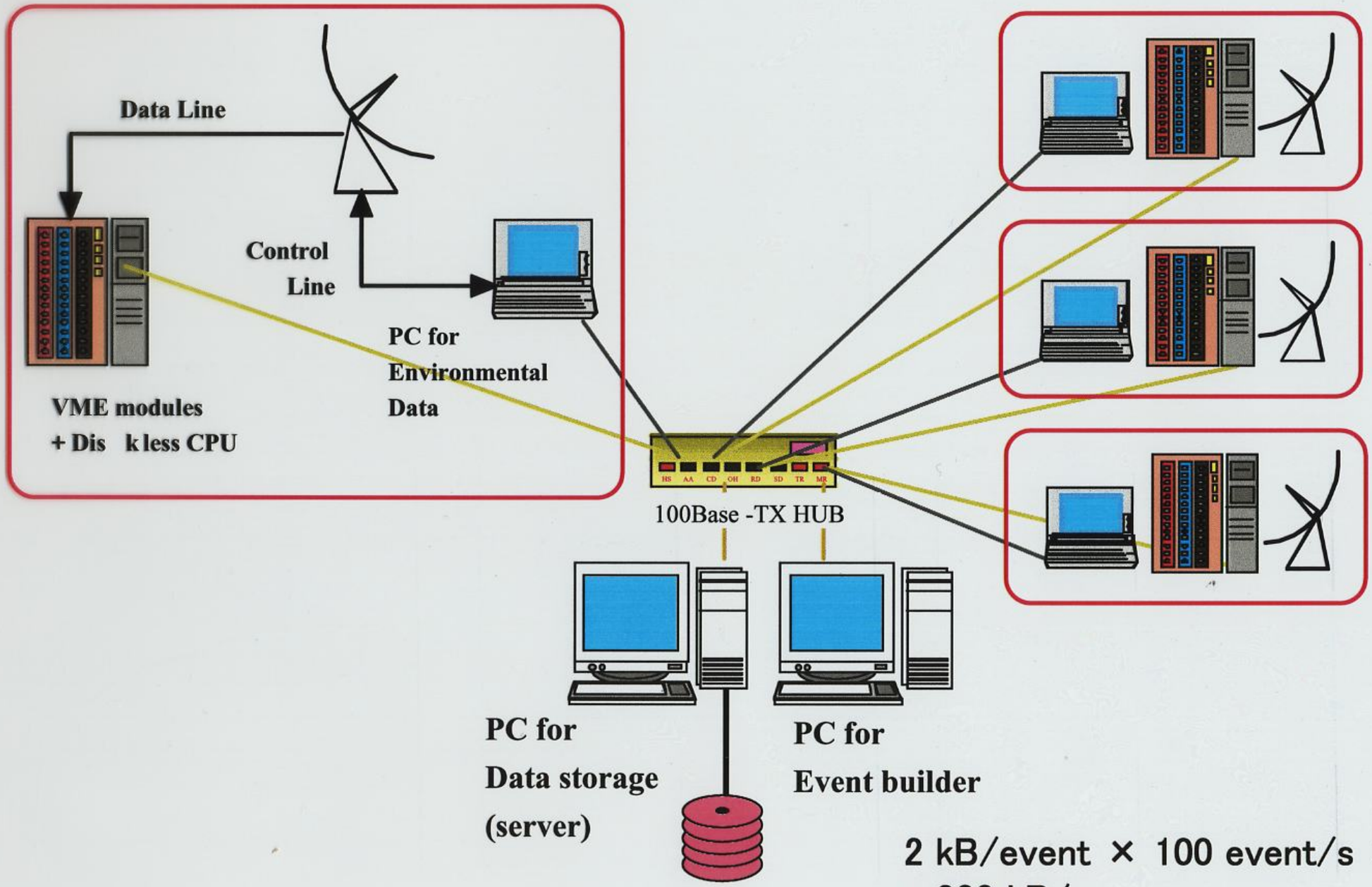
★PCI-VME bridge (model Bit3)

access speed: 1/2

→ VETO: 1300 usec

Winner: On board CPU

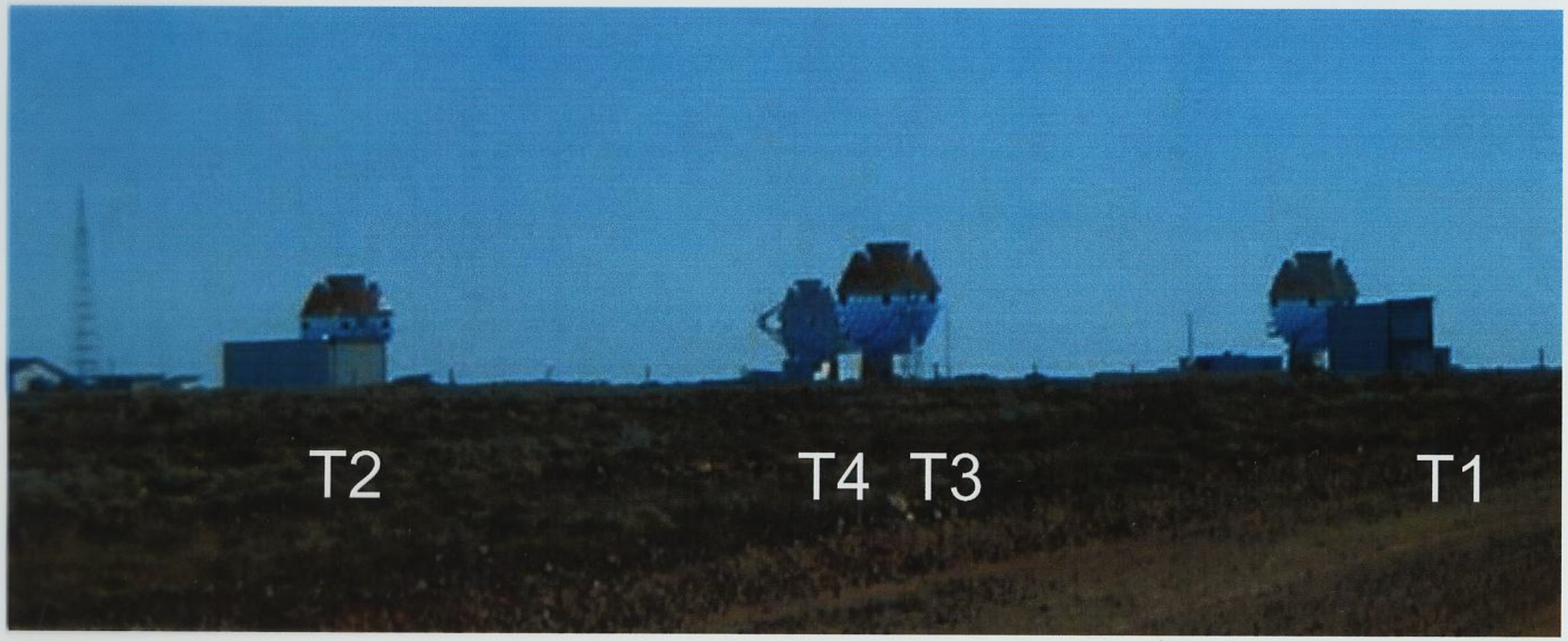
Network Overview



2 kB/event × 100 event/s × 4台
= 800 kB/s
(各望遠鏡PMT 80hit 時)

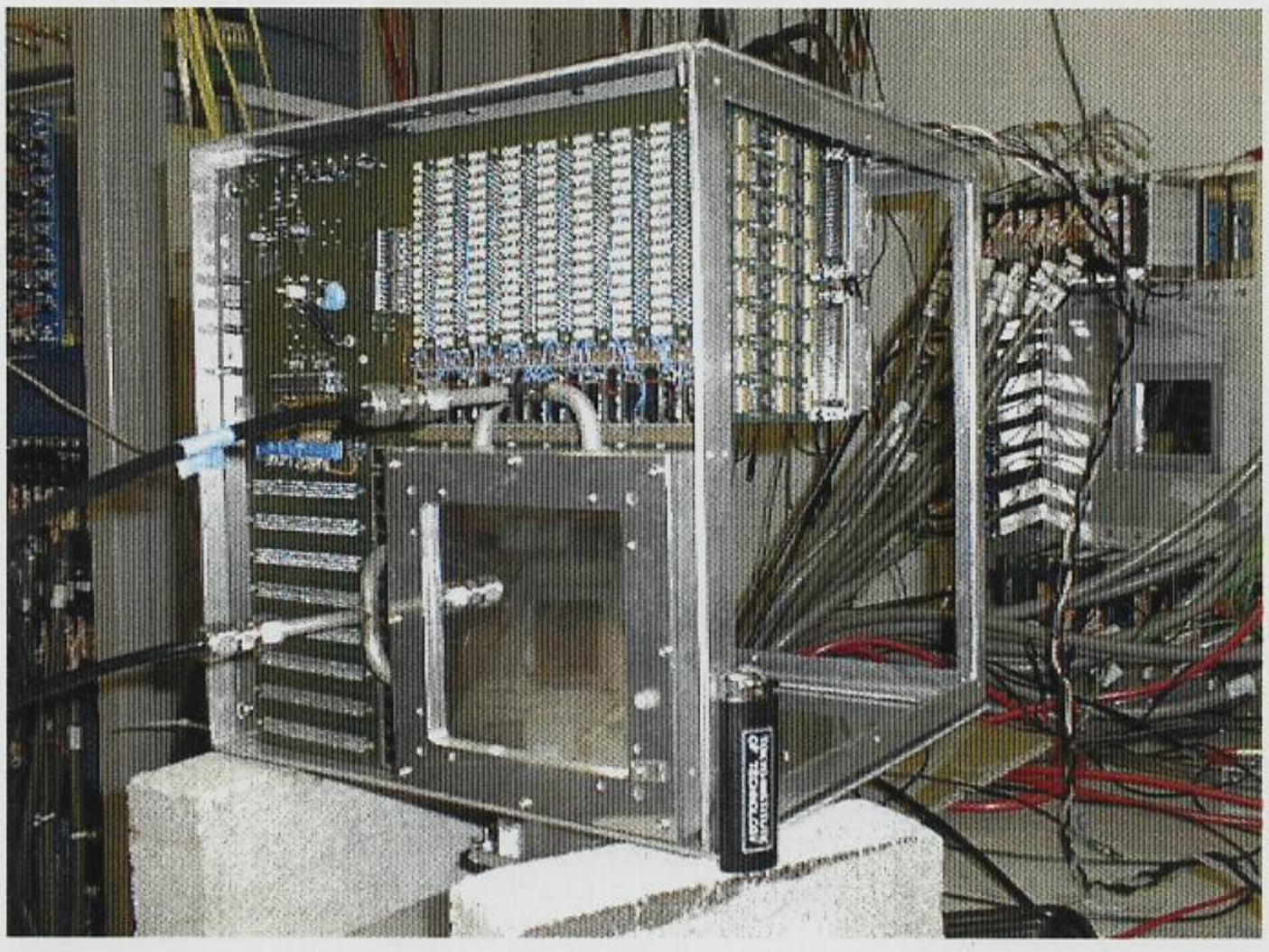
Present status of CANGAROO
Four 10m telescopes in Woomera

CANGAROO III



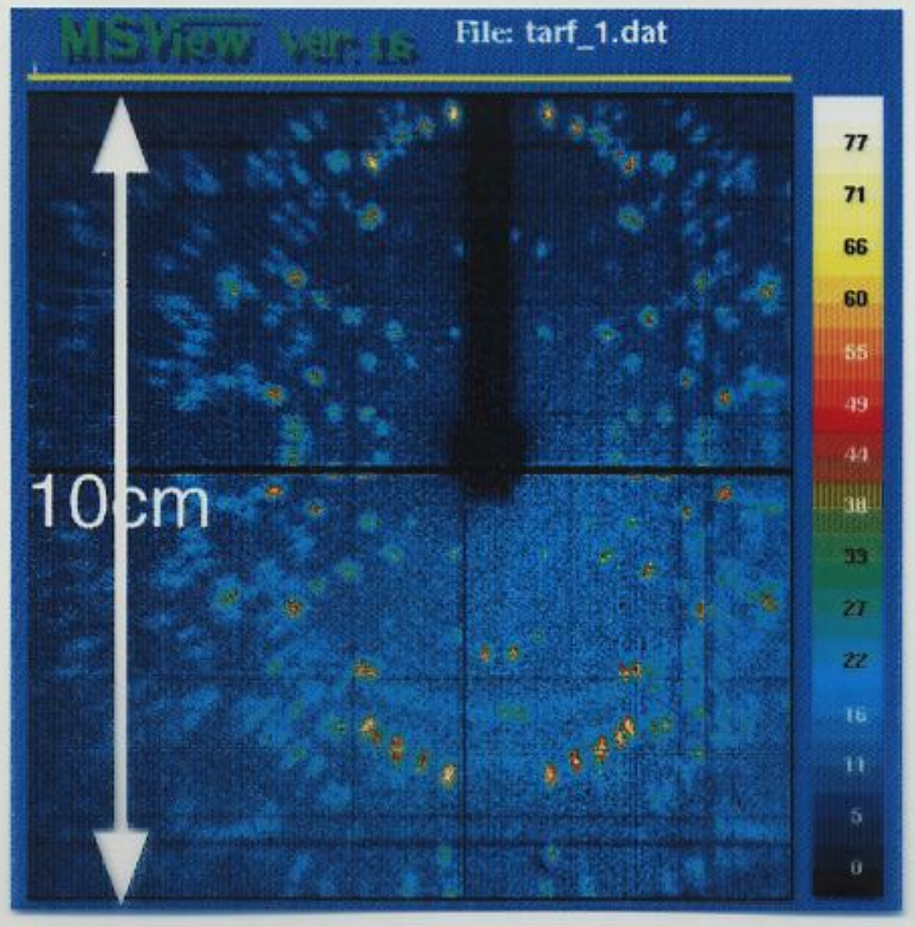
Dec/02 T1, T2 Stereo → Nov/03. Full Operation

MicroStrip Gas Chamber

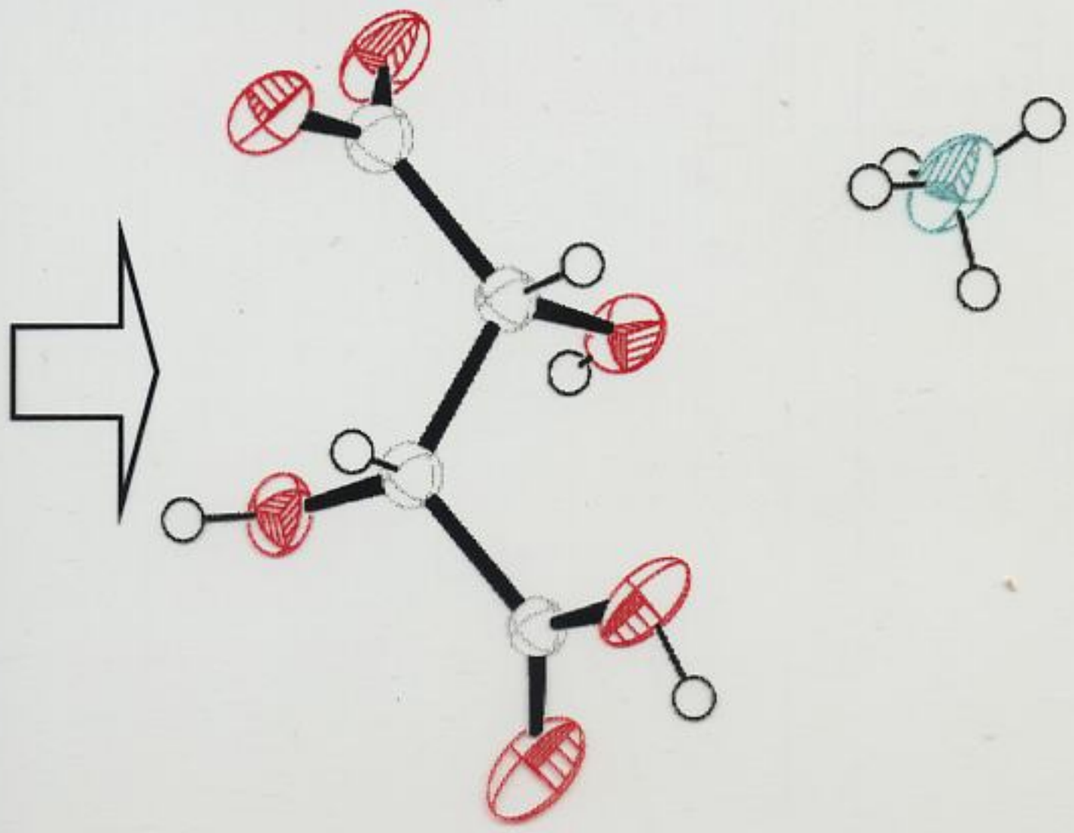


Over view of MSGC

Crystal structure analysis using time resolved diffraction data

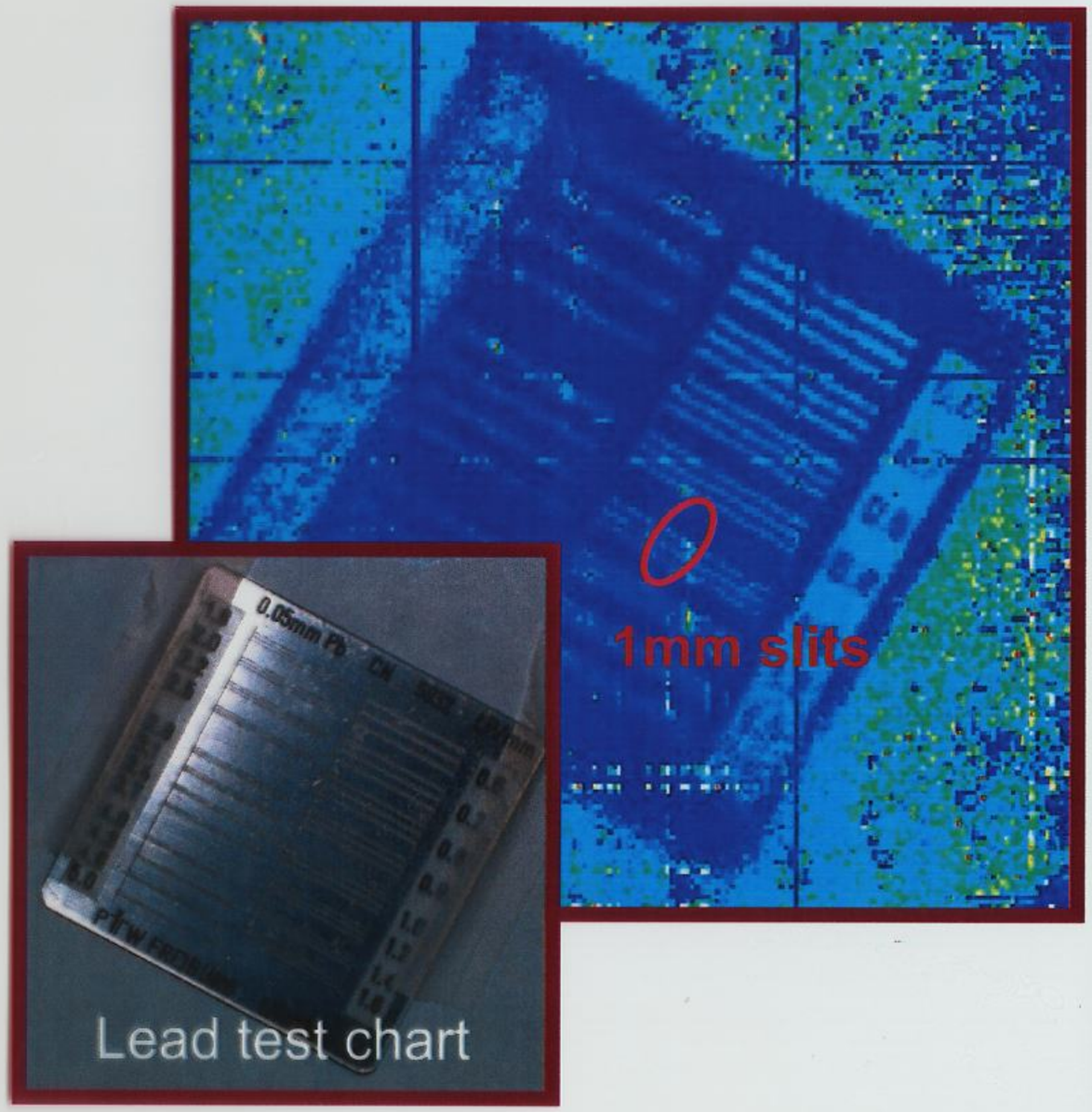


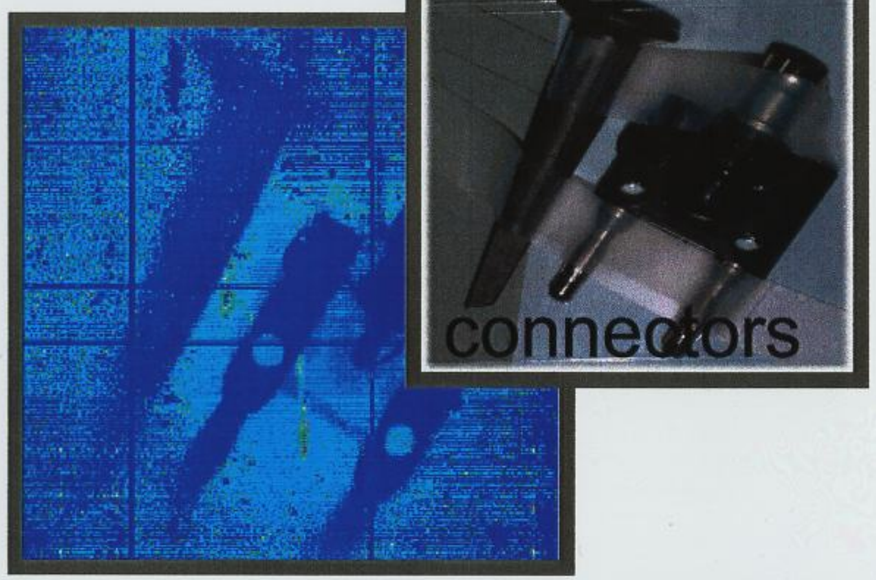
X-ray Image of MSGC

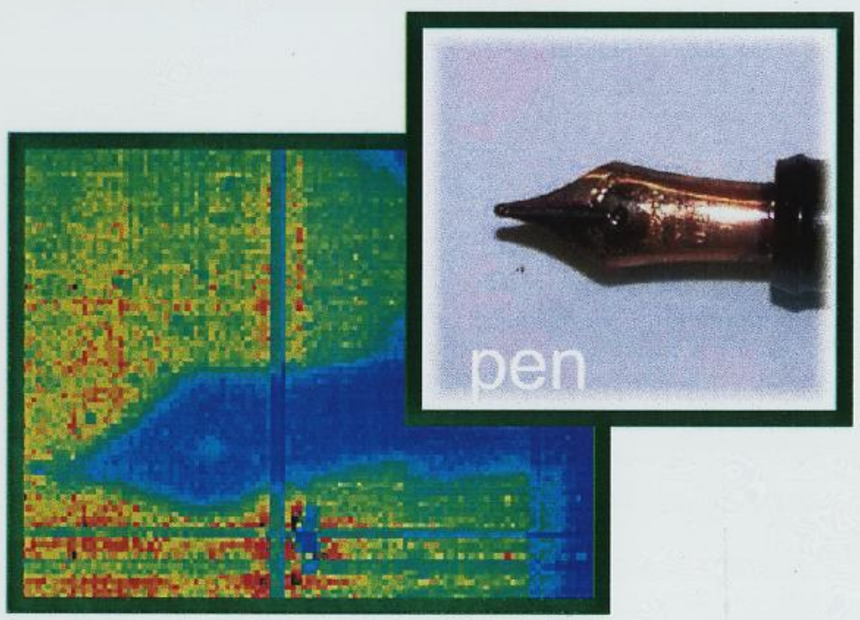


Crystal structure using 17sec. data

2D X-ray images (Xe:C_2H_6 ,1atm,2mm drift length)



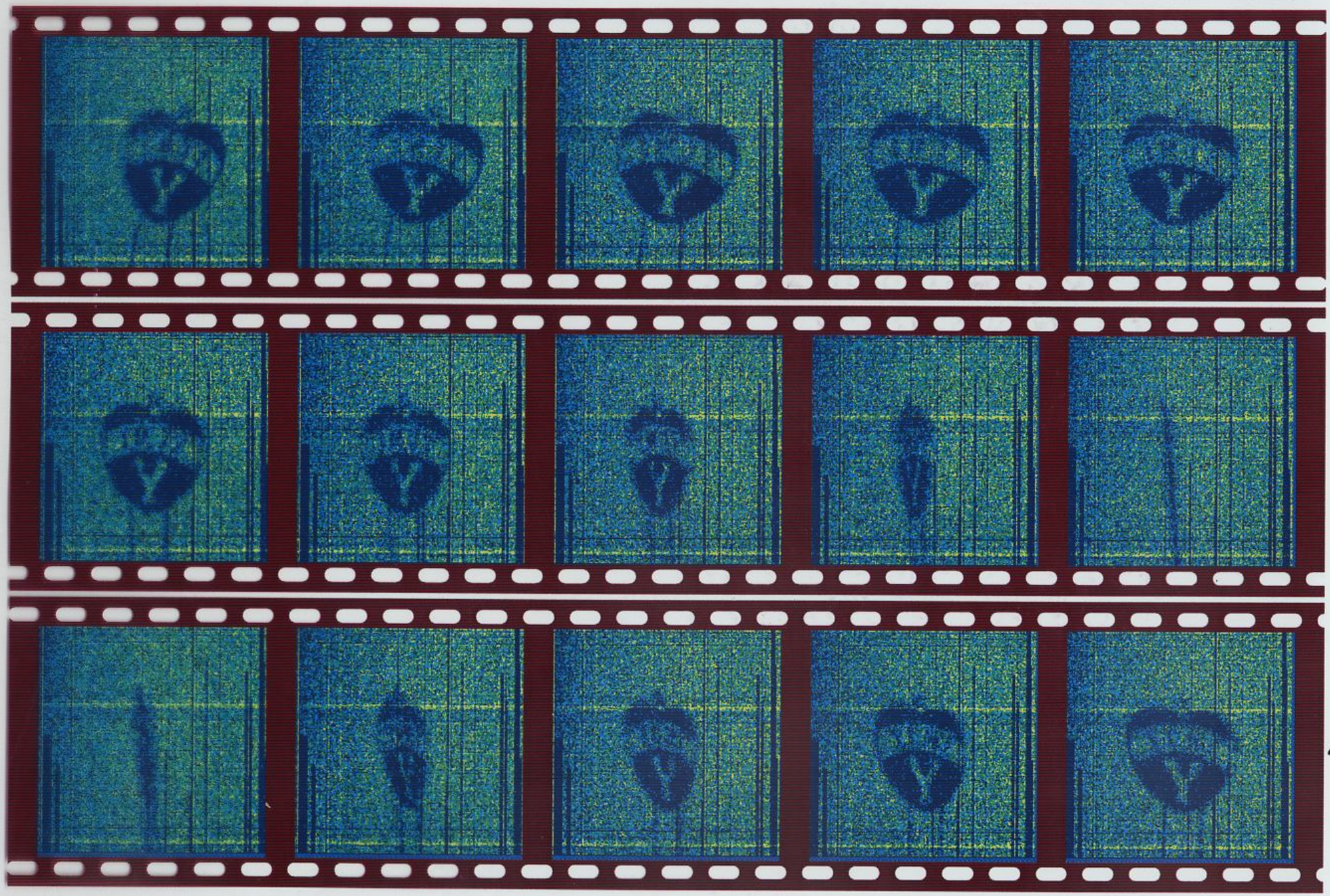


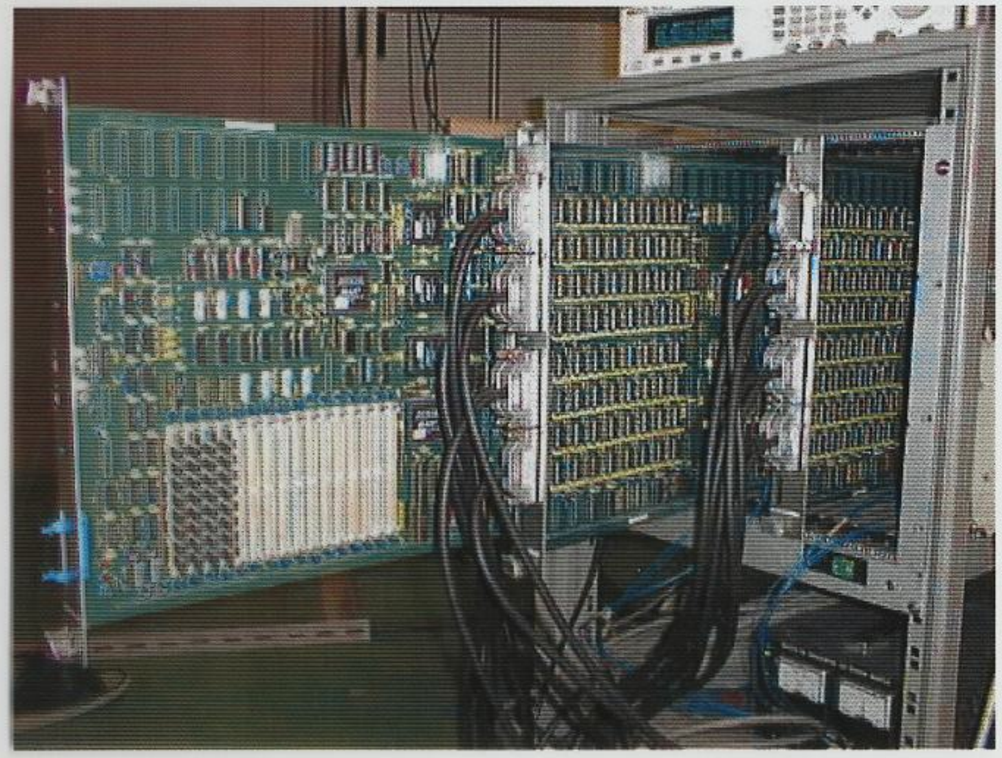


K.Miuchi et al, 2002 IEEE Trans.Nucl.Sci.2002

Realtime X-ray Imaging

40msec/frame ~75kevt/frame





Specifications

Detector

Area: 10cm X 10cm

Pitch: 200μm

Gas: Xe(70%) C_2H_6(30%)

Gas volume: 2~5 mm

Position res.: 93μm(RMS)

QE: ~10% (@17keV, 2mm)

Readout/DAQ

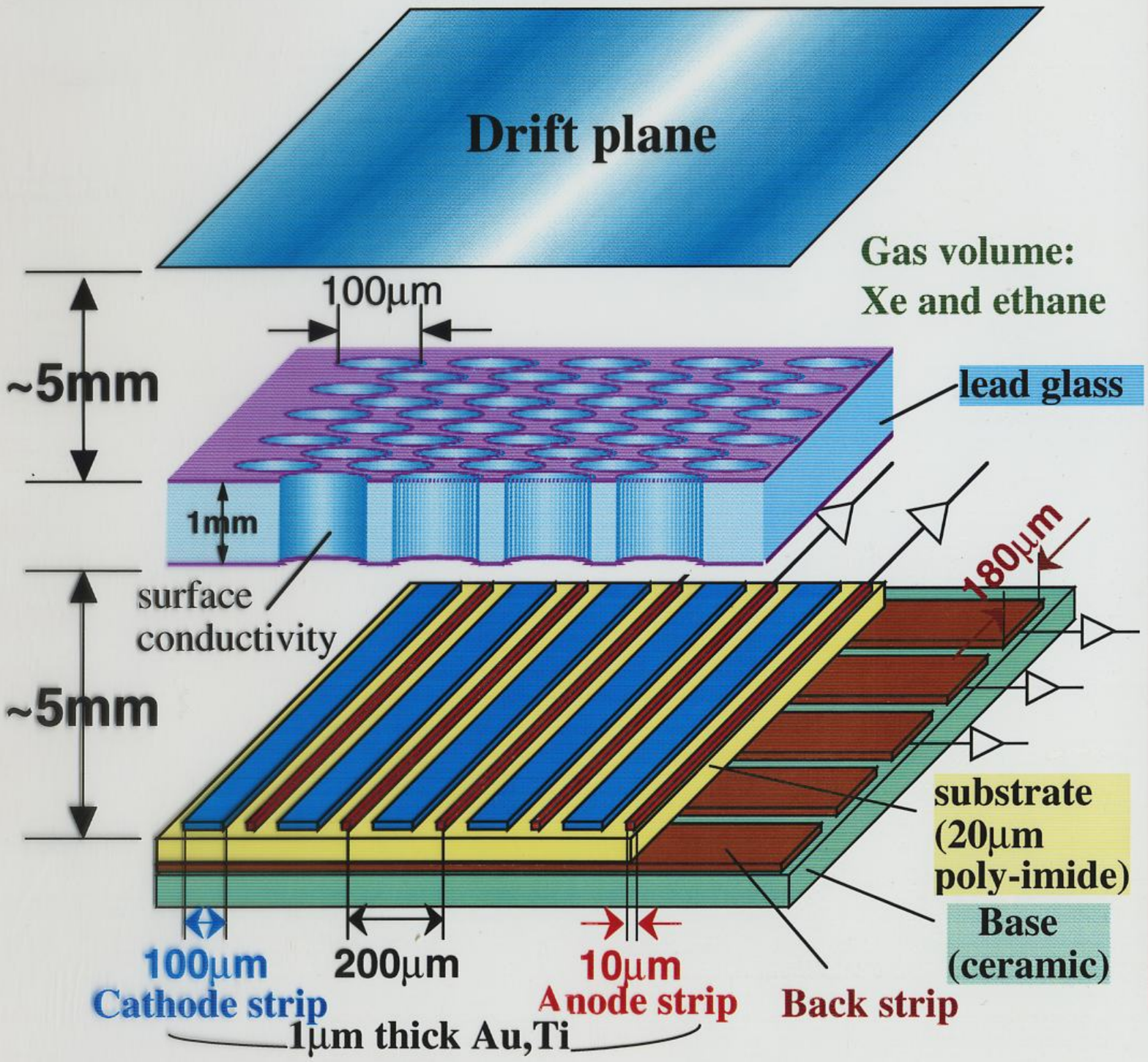
Pre-amp. : MQS104A

ADC: not use (only 1/0)

Position encode: hardware

Max. process: 3.7Mcps

MSGC with Capillary plate

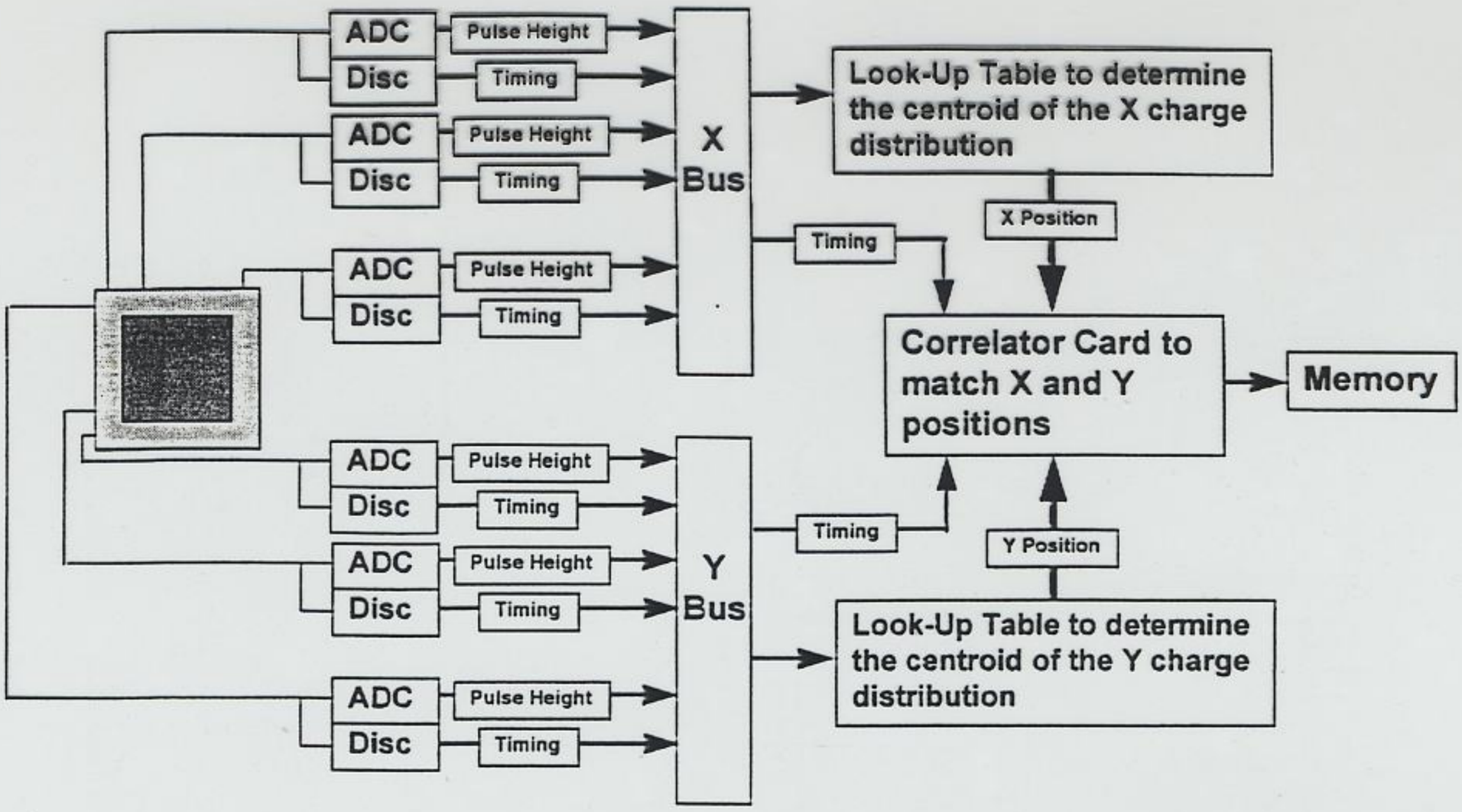


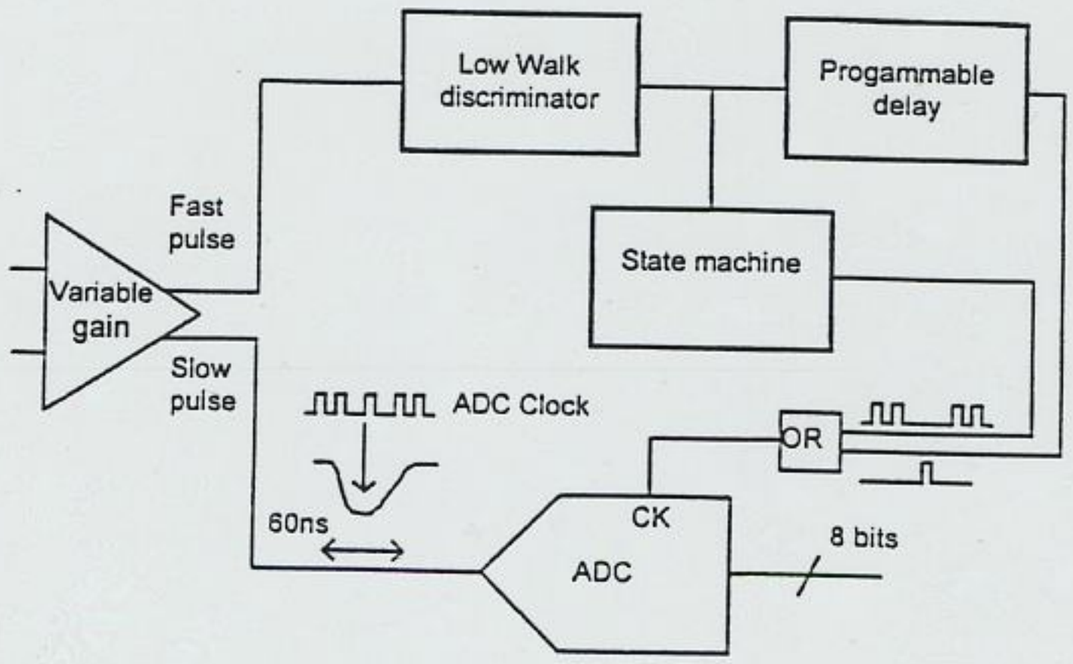
Gas amplification
- pulse counting area detector

2D readout with
- anodes
- backstrips

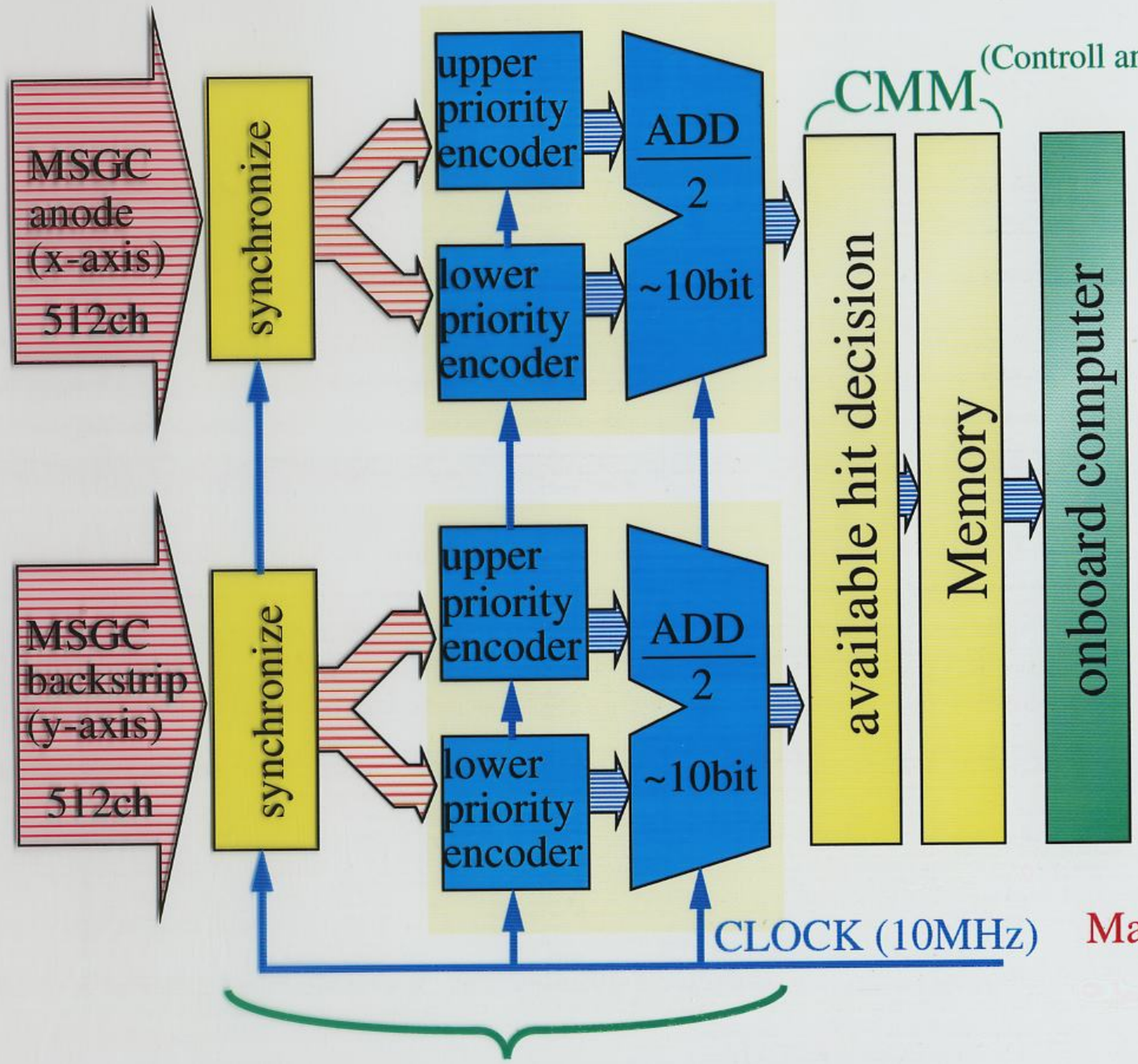
Micro structure
- low space charge
  $>10^5$cps/mm^2
- fine position resol.
  <100μm

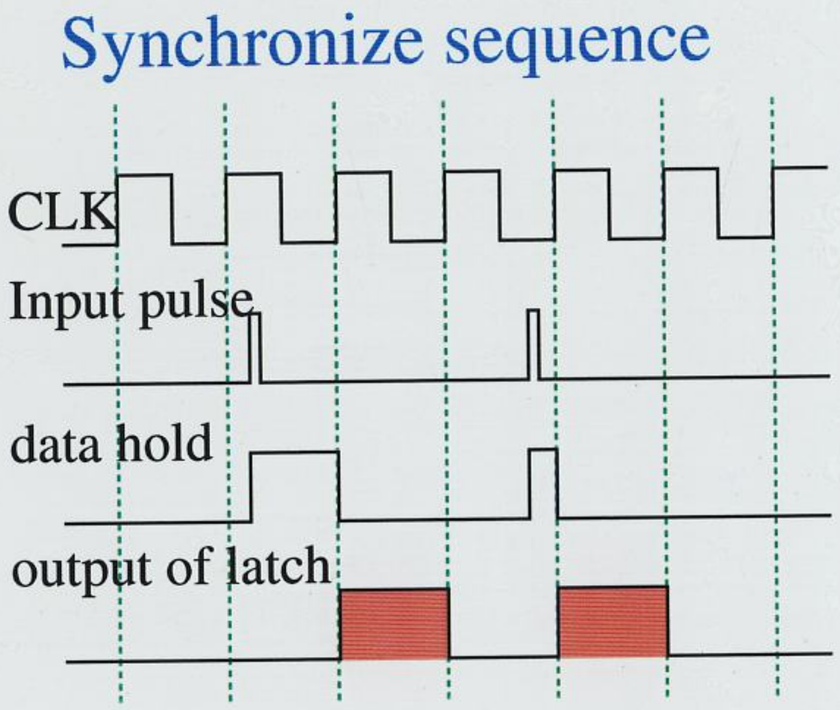
Stable and safety Operation
- Total gain > 1000


ADC
Disc
Pulse Height
Timing
X Bus
Y Bus
Look-Up Table to determine the centroid of the X charge distribution
Look-Up Table to determine the centroid of the Y charge distribution
X Position
Y Position
Correlator Card to match X and Y positions
Memory


Low Walk discriminator
Progammable delay
State machine
Variable gain
Fast pulse
Slow pulse
ADC Clock
60ns
OR
CK
ADC
8 bits

Circuits for MSGC data encoding



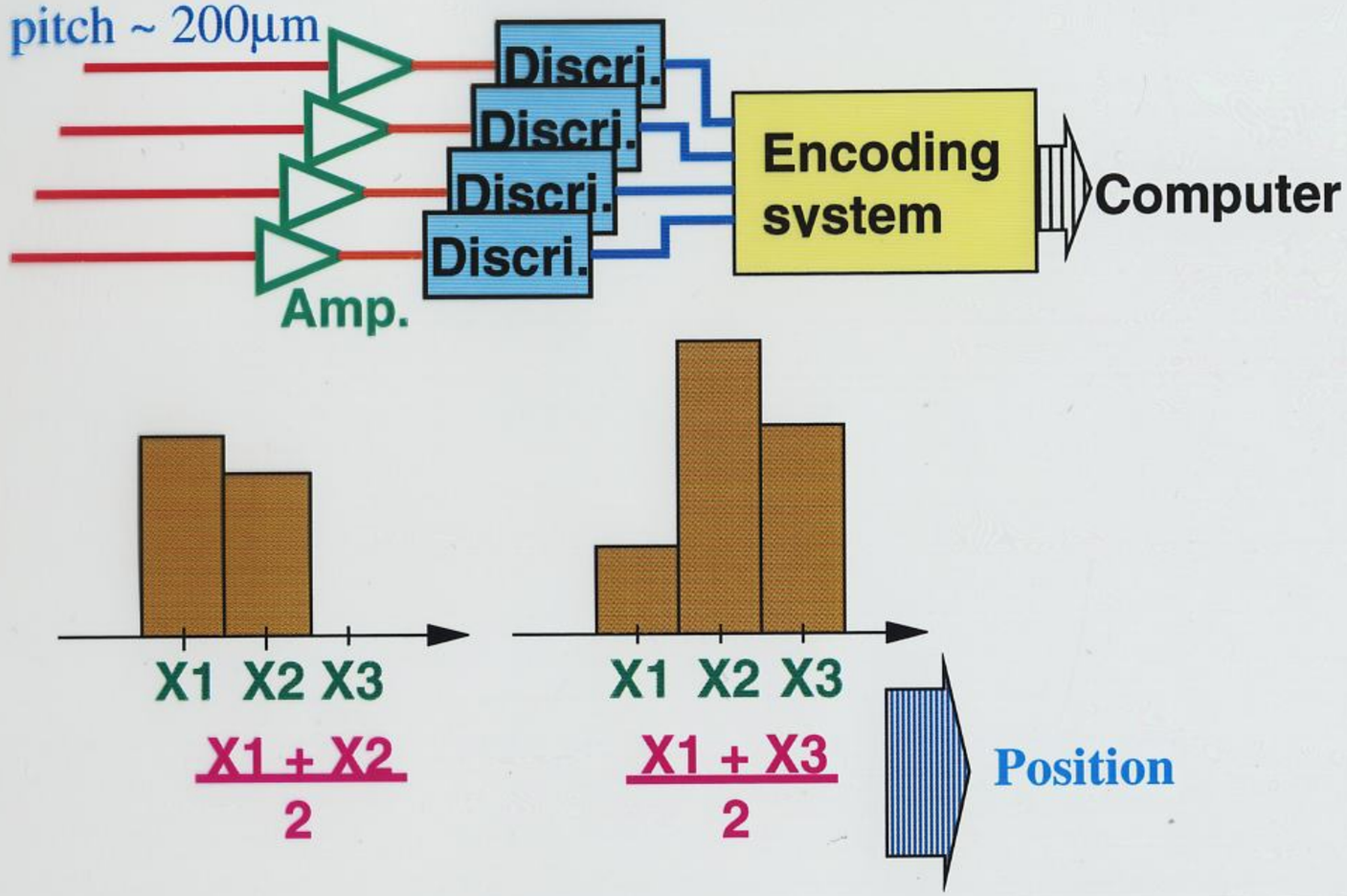


Maximum rate (simulation) = 37MHz

Complex Programmable Logic Device (CPLD)

(Altera MAX7000 series)

High resolution data taking with digital readout



	Analog	Digital
• Position resolution (RMS resolution)	~30μm	~60μm where, 200μm pitch
• Readout system	complex	simple
• Data processing	slow	fast (>10MHz)

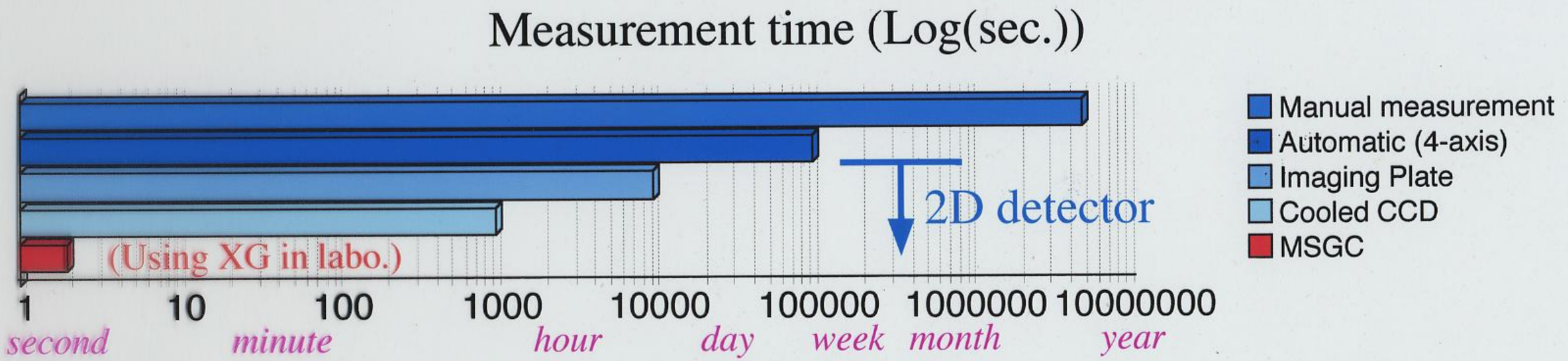
Conclusion

MicroStrip Gas Chamber and Fast DAQ system were developed
for time-resolved X-ray imaging

New crystal structure analyzing method: Continuous Rotation Photograph

Crystal structure analysis was carried out in 2 sec. using MSGC

Fastest record !!!



Crystal structure analysis will be done less than one second using SR source.

Image Performance

X-ray source:

CuKα (8keV)

Gas:

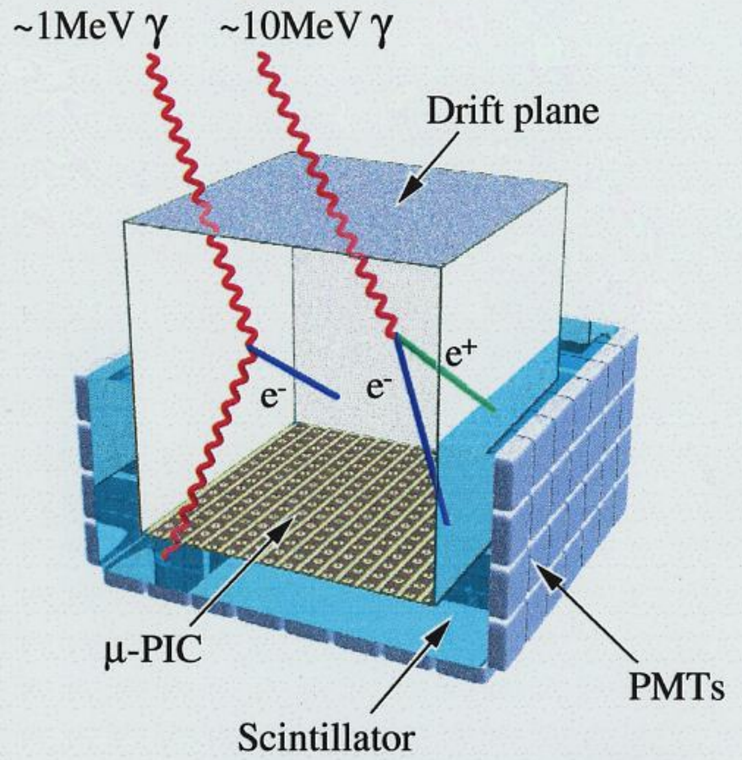
$Xe:C_2H_6 = 7:3$

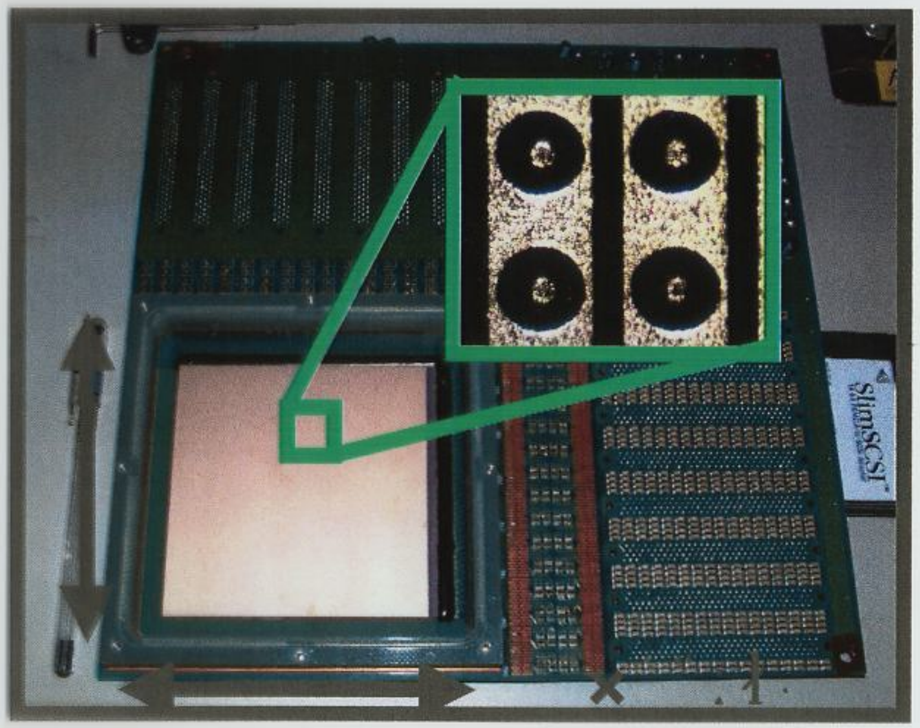
Position resolution:

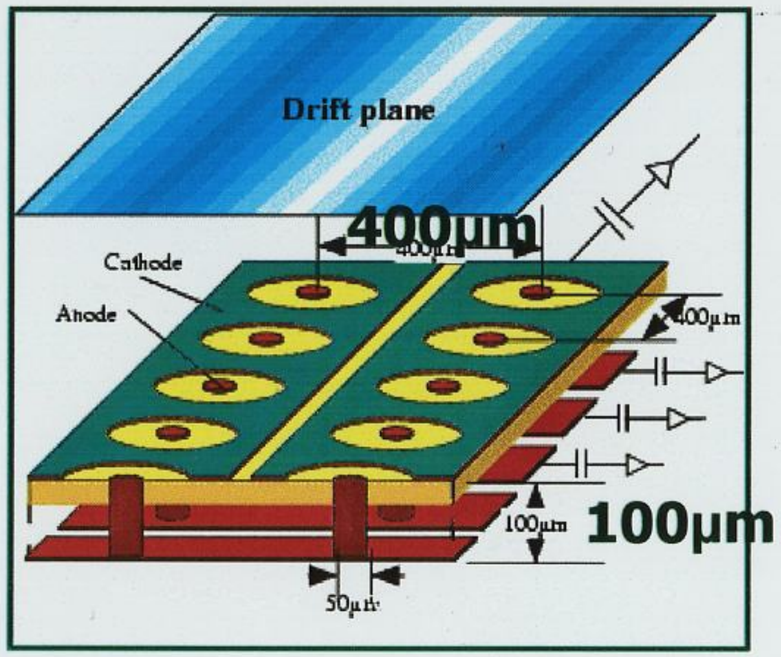
< 100μm

X-ray, Gamma-Ray Imaging

- Micro Pixel Chamber (μ–PIC)
  256anode + 256 cathode strips
- Fine position resolution
- High gain (~15000)
- Discharge damage: small
- 1000hours operation (gain~5000)



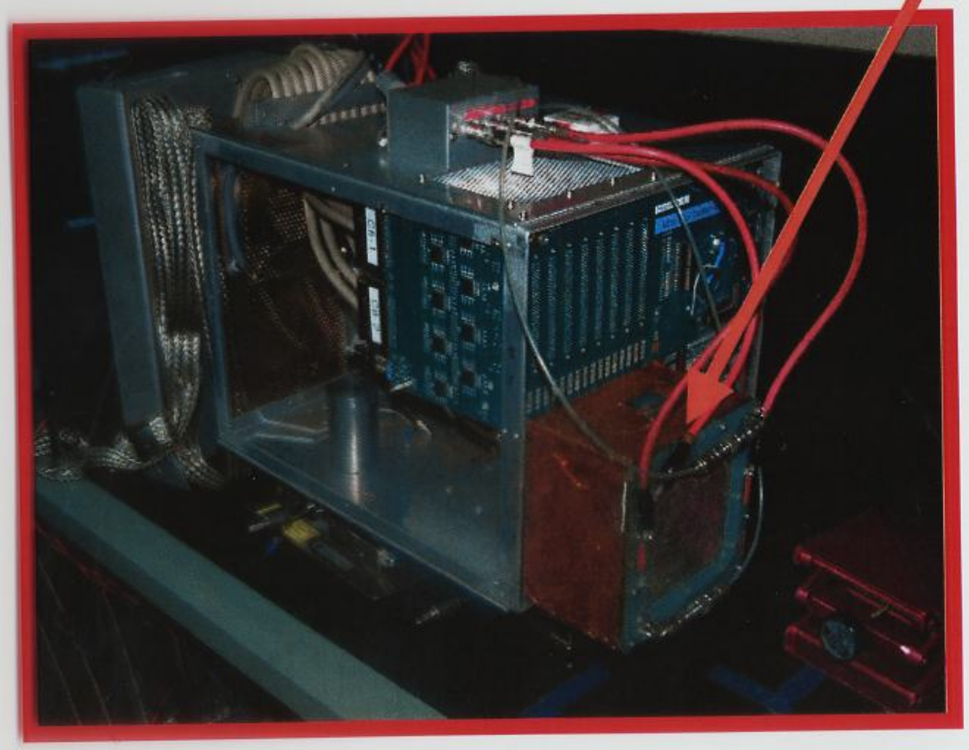


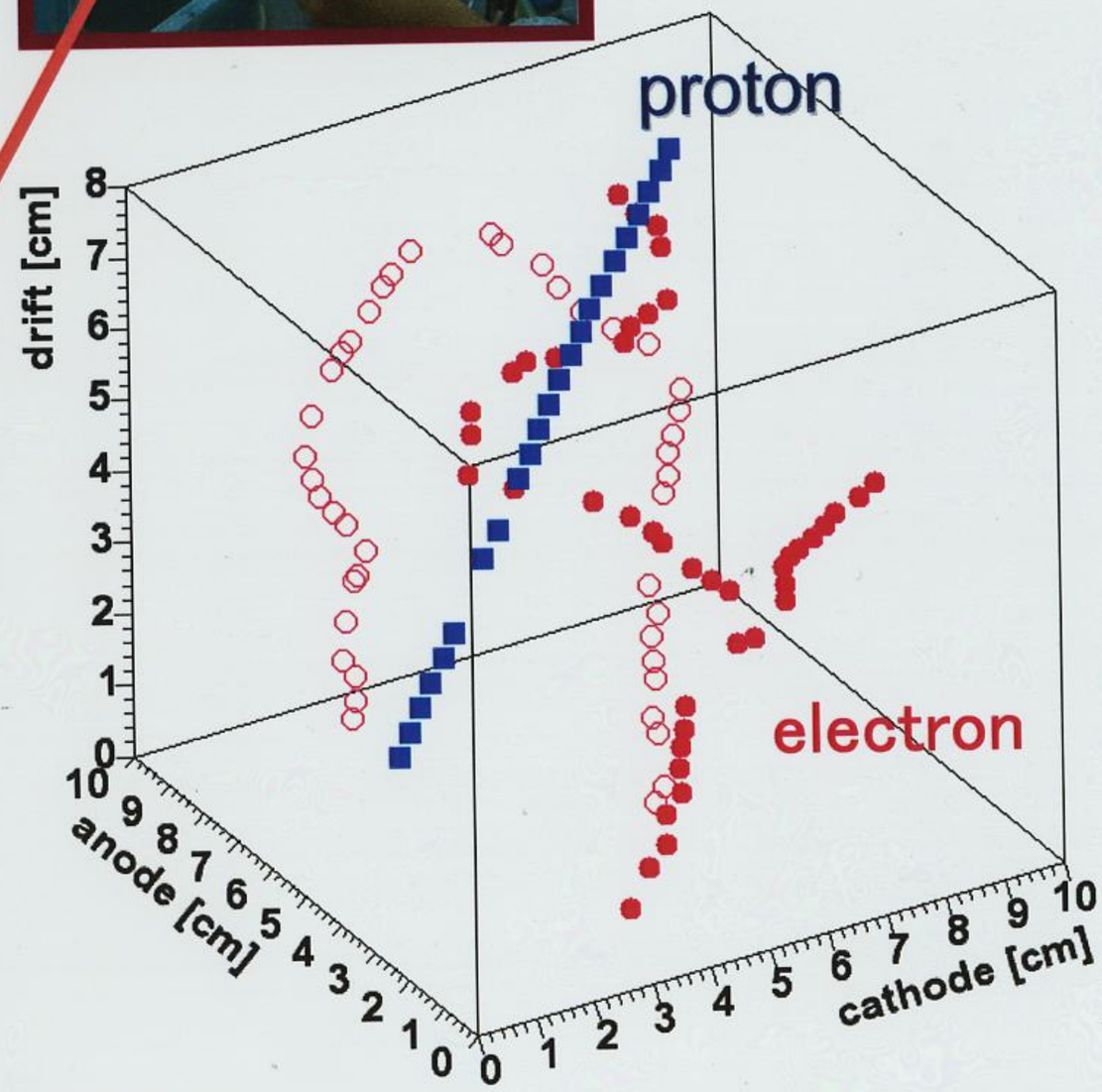


Micro-TPC(3D-Track Imaging)

- Field cage
  8cm drift length
  0.4 kV/cm electric field
  $+10 \times 10 cm^2$ μ-PIC

➡ micro-TPC





Perspectives

- On-line Soft, Off-line との差が小さくなる。
  VME, C-PCI-BUS,　Direct mapping to CPU memory
- Hardware, Software との差が小さくなる。
  FPGA, PLD, およびその将来型chip がハードの中心
  特に、 Network devices embedded in FPGA
  各検出器でデータ処理　－＞　Network

  DAQがいらない、既存のNetwork 機能がFASTEST
- Network, Programable VLSI, など最新のIT技術の
  有効利用が重要
- ADCは？？？　ひとつの解、 One-bit Solution
- Pre-amplifier, Discri. はどうする？？？？