1998.9.24
H.Okuno

^{3}He Gas Detectors for Future KEK Facilities

1. JHF Spallation Neutron Source and Scattering Facilities

2. Requirements for Detectors

3. ^{3}He Gas Detectors

4. Present States and Future Directions on
   (a) Small-sized PSD
   (b) Medium-scale PSD
   (c) Large-scale PSD

5. Conclusion

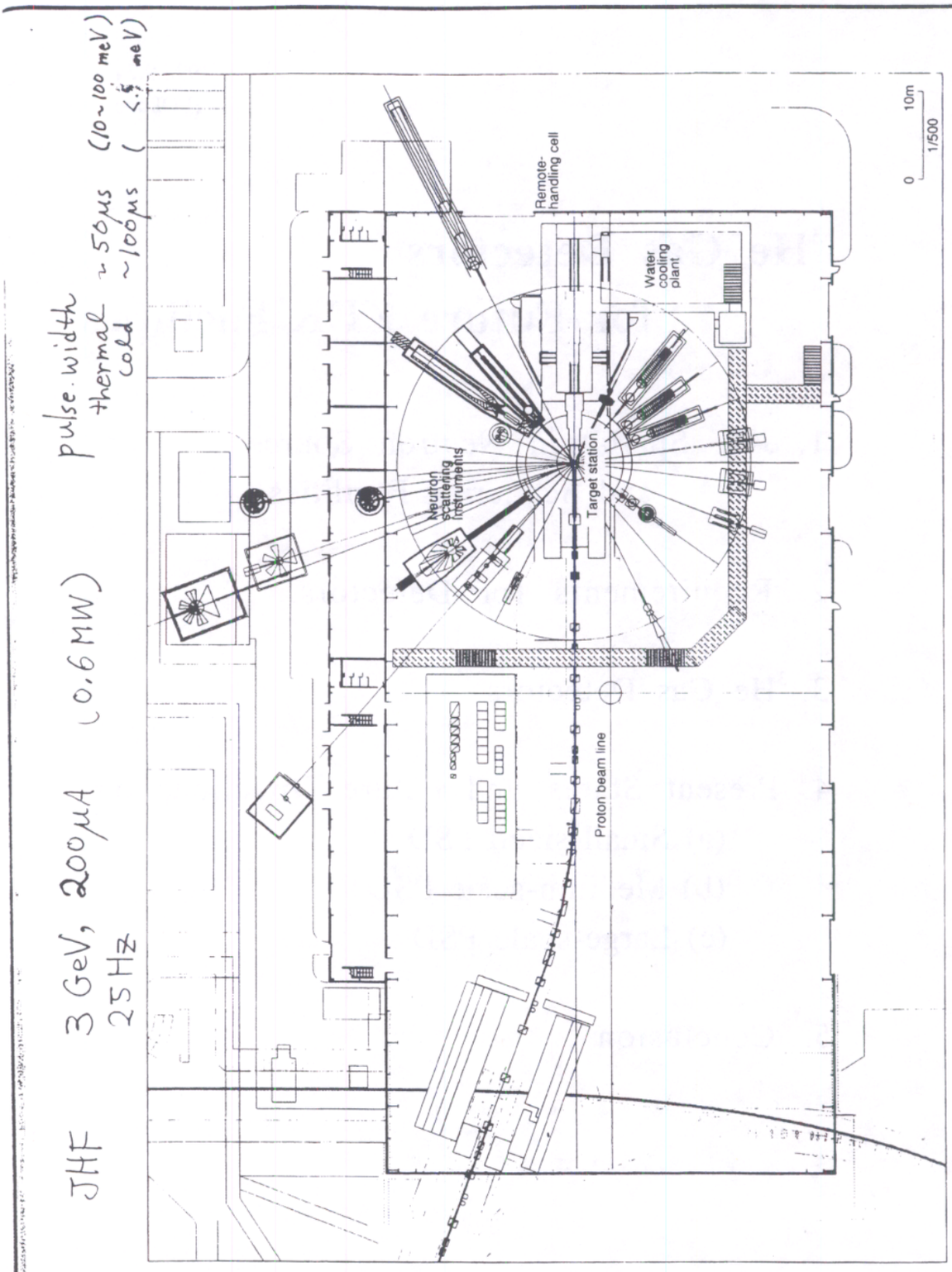
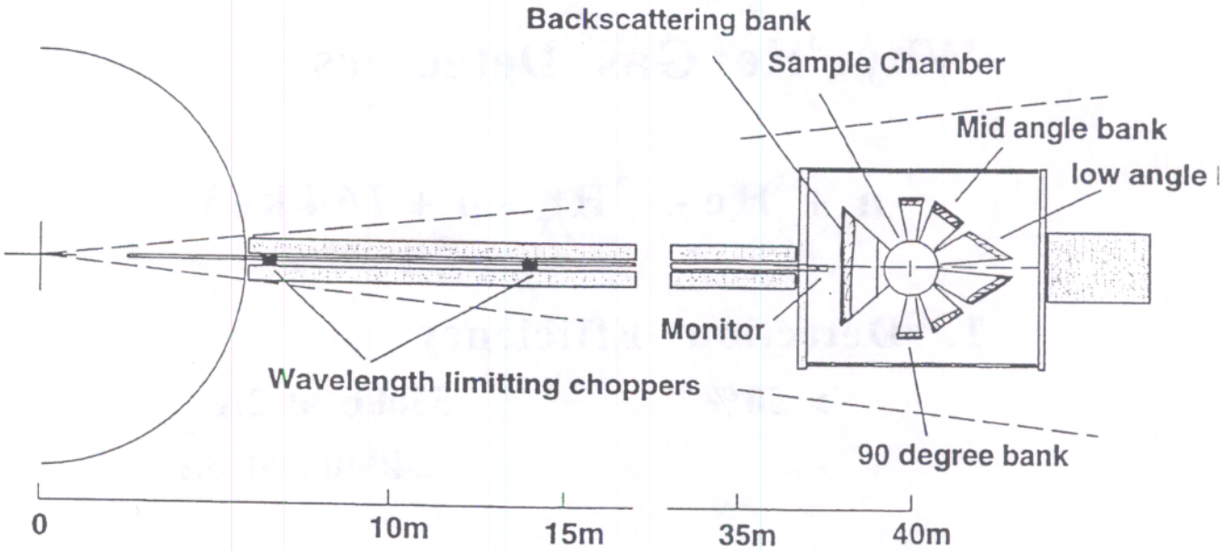
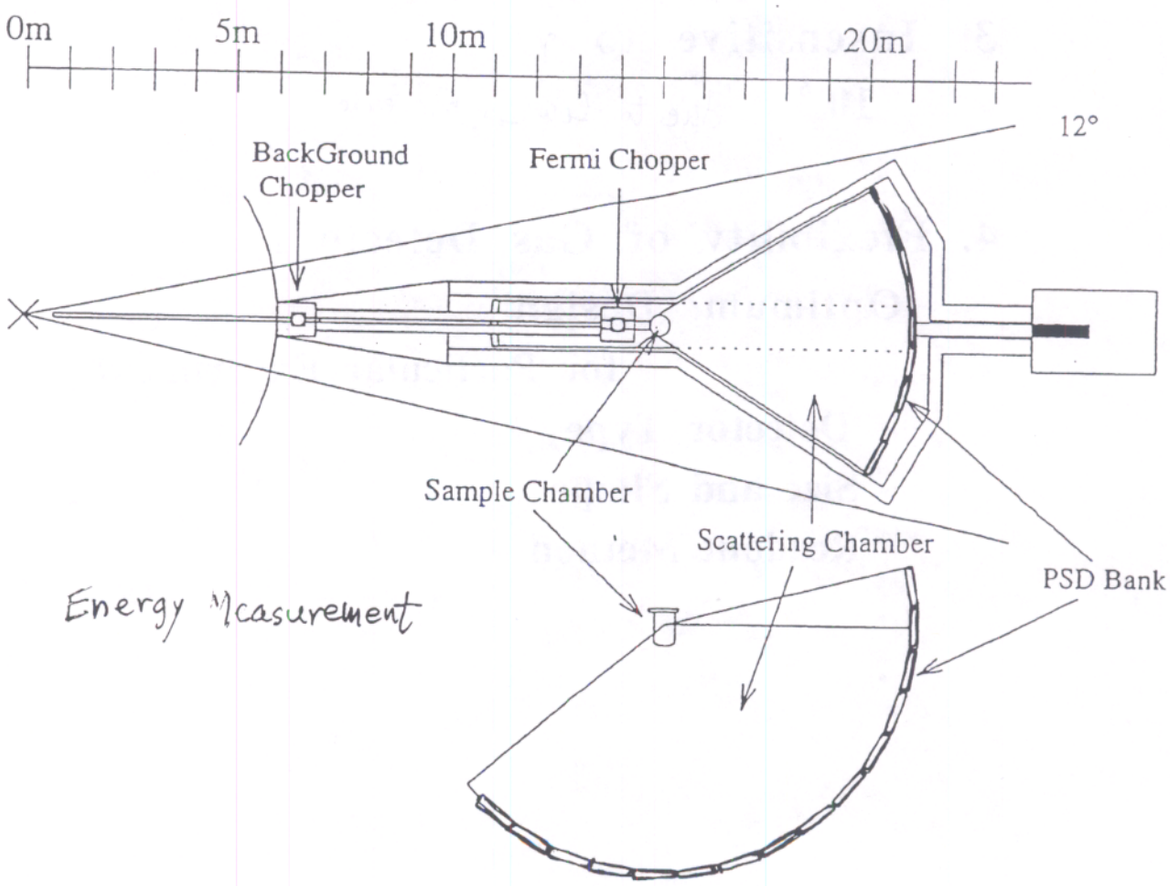


Fig. III.2.2 Schematic layout of N-arena

Powder Diffractometer



Inelastic Scattering Spectreometer



Why ^{3}He Gas Detectors

$$n + {}^3He \rightarrow {}^3H + p + 764\ keV$$

1. Detection Efficiency

   > 50% 5500b at 2Å

   24000b at 8Å

2. Finite Energy Deposit

   Discrimination of Background

3. Insensitive to γ

   10^{-6} due to low Z materials

4. Flexibility of Gas Detectors

   Optimum Design

   for Particular Experiment

   Detector Type

   Size and Shape

   Readout Method

   .

   .

Requirements for PSD

Typical Spectrometers

1. Small-angle Scattering

$\Delta x \fallingdotseq$ 2-5 mm

$\Delta t \fallingdotseq 10\ \mu s$

Rate $\fallingdotseq$ 10 ev/μs, 10^6-10^7ev/s in total

2. Powder Diffraction Scattering

$\Delta x \fallingdotseq$ 1-2 mm

$\Delta t \fallingdotseq 1\ \mu s$

Rate $\fallingdotseq 10^2$-10^3 ev/μs

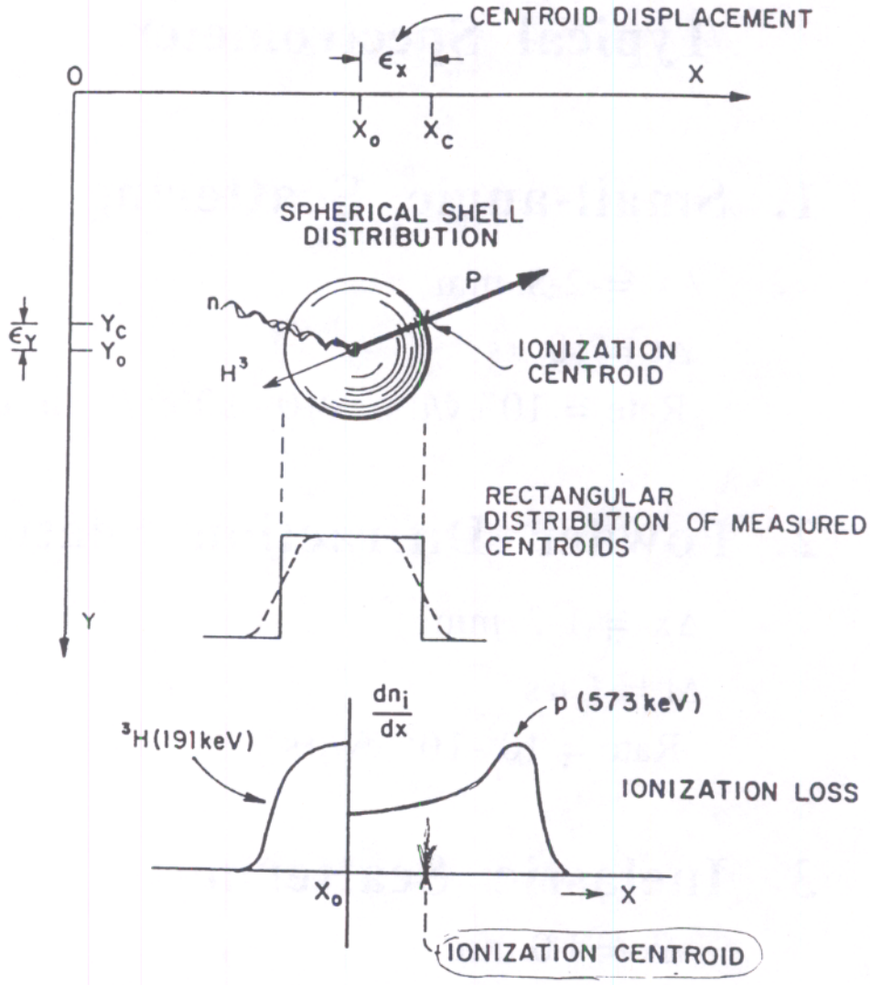
3. Inelastic Scattering

$\Delta x \fallingdotseq$ 10 mm

$\Delta t \fallingdotseq 1\ \mu s$

Rate $\fallingdotseq$ 1 ev/μs

Limitation of ^{3}He Gas Detectors due to Ranges of Final-state Particles



(a) Position Resolution

σ (FWHM) ~ 0.8 R_p

(b) Signal Formation Time

~ μs/cm

(a) Small-sized PSD

Better Position Resolution

BNL : < 400 μm(FWHM) ~6 atm C_3H_8

5 cm x 5 cm Wire Chamber

Main limitation is due to the Range of Protons

Range of 550keV Protons

Gas	Range(cm) at 1 atm	Pressure(atm) 100μm range
^3He	4.85	485
Ar	1.05	105
Xe	0.60	60
CH_4	0.94	94
C_3H_8	0.38	38
CO_2	0.62	62

How to go to the 100μm range ?

High-pressure Heavy Gas ?

Low-temperature ^3He ?

Low Temperature ^3He

$^3He + ^4He$

Critical Point	^3He	^4He	Ar
T_c (K)	3.33	5.22	150.68
P_c (atm)	1.15	2.27	48.00

^4He 6 K, 5 atm $\rightarrow$ $\rho / \rho_{(300K, 1atm)} \doteqdot \underline{\underline{561}}$

(Ar : to get $\rho / \rho_{(300K, 1atm)} \doteqdot .100$, $T = 155K$
$P = 35$ atm)

Conversion Layer 100 ~ 200 μm !

Ionization Mode ?

$\sim 3 \times 10^4 e$

For Small-sized Detectors,

New Generation of Gas Detectors developed for X-rays can be applied

MSGC(Microstrip Gas Counters)

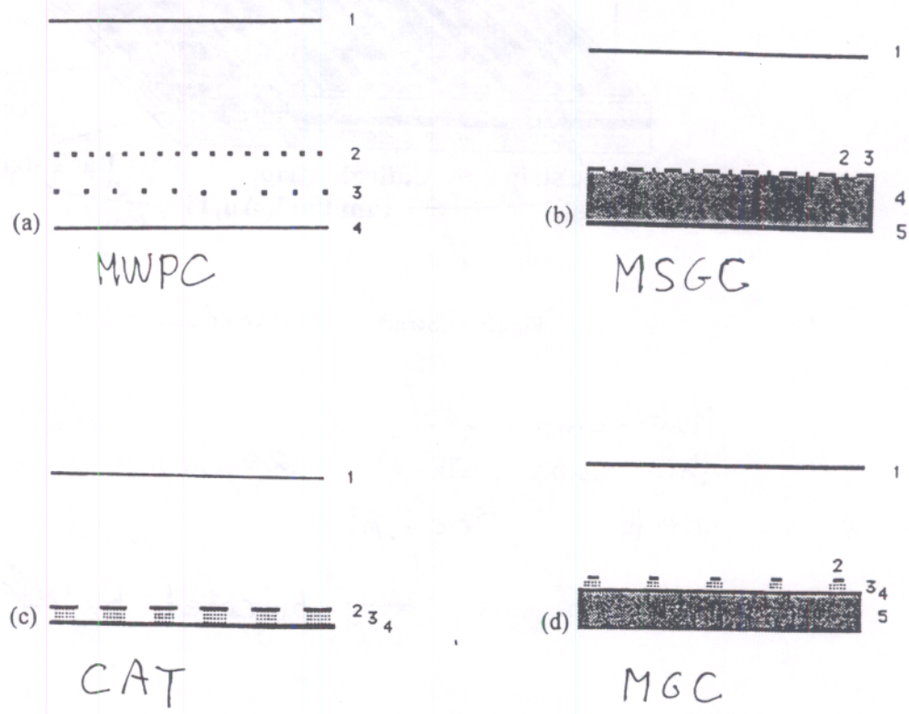
MGC(Micro-Gap Chambers)

MICROMEGAS

(Micro-mesh gaseous structure)

CAT(Compteur A. Trous)

.....



Tanimori et al

X-ray detector

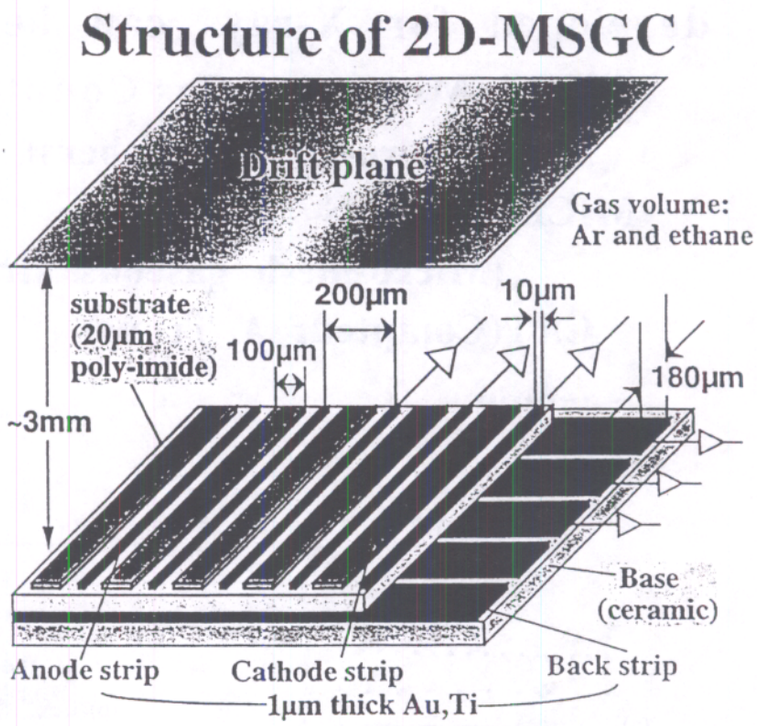


Figure 1: Structure of the two-dimensional MSGC

Multi-Chip Module
Thin substrate (~20 μm)
pitch 200 μm

← fabricated by LSI technology

→ Good results, but still need study for stable operation

→ How works for neutrons? Gas

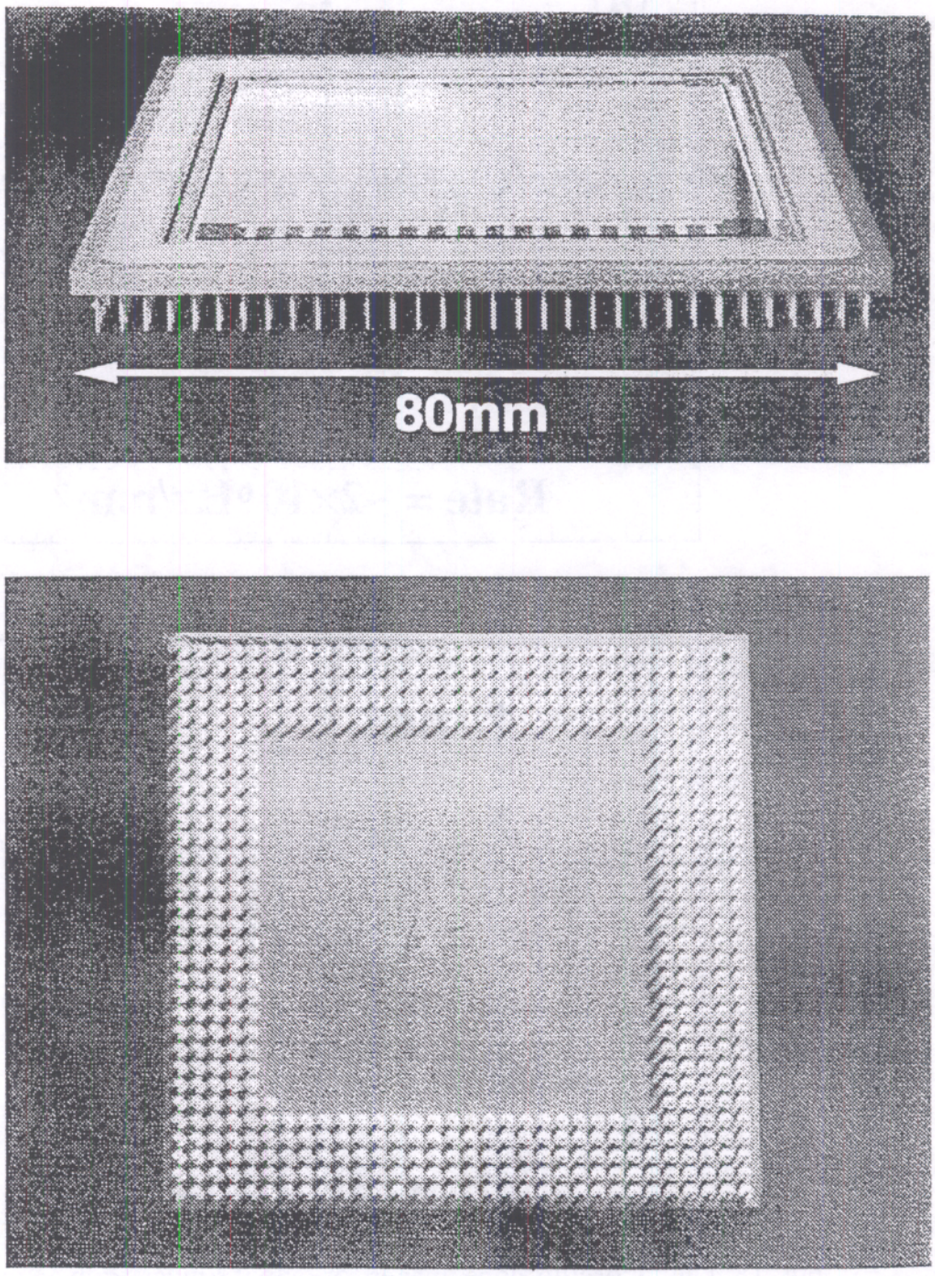


Fig. 6. Photographs of (a) the top and (b) the bottom of the MSGC package on which a 5 cm × 5 cm two-dimensional MSGC was mounted. The package is made of ceramics with a 8 cm × 8 cm size, and has 541 pins with a 0.1 in. pitch on the backside.

256 x 256 pixels

Anode Signal for X-rays

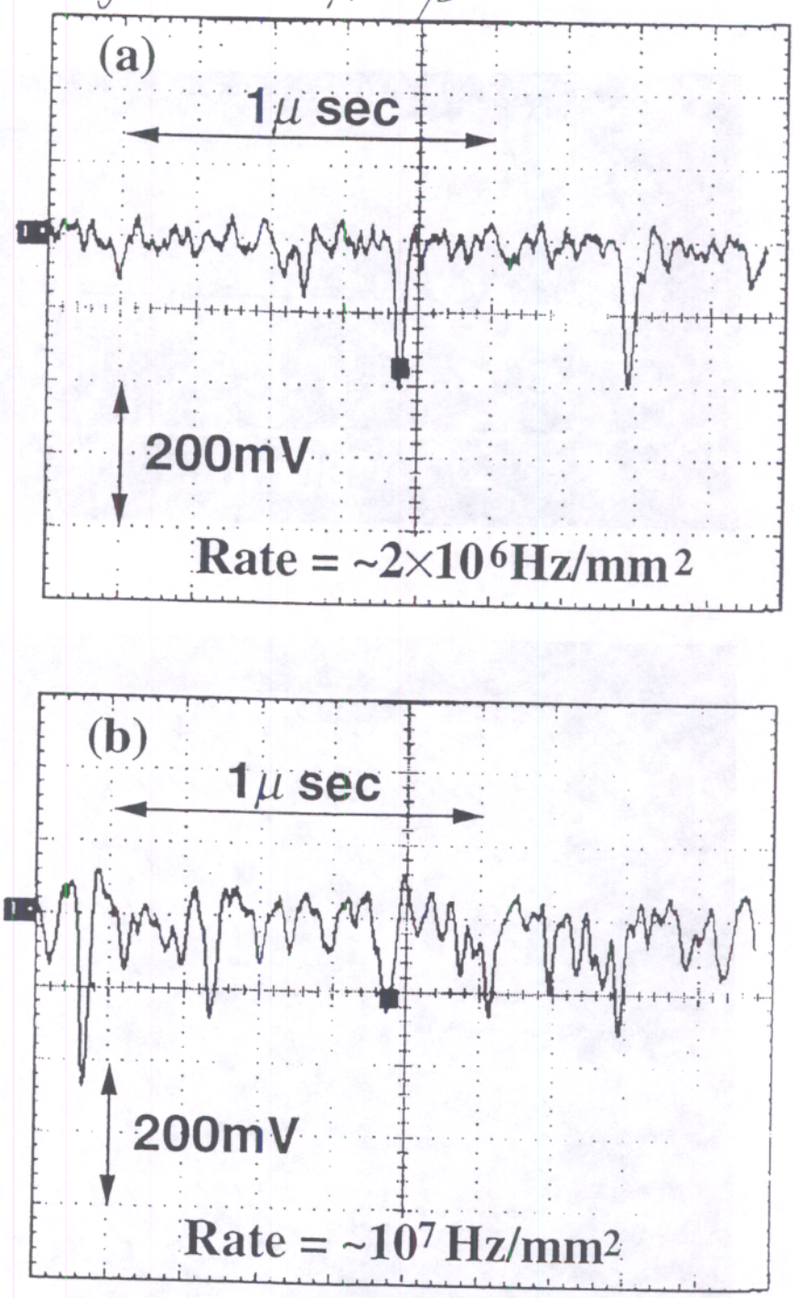


Fig. 18. Digital oscilloscope images for output singles from an anode of the MSGC at a counting rate of (a) 2×10^6 Hz/mm^2 and (b) $\sim 10^7$ Hz/mm^2.

(b)Medium-sized PSD

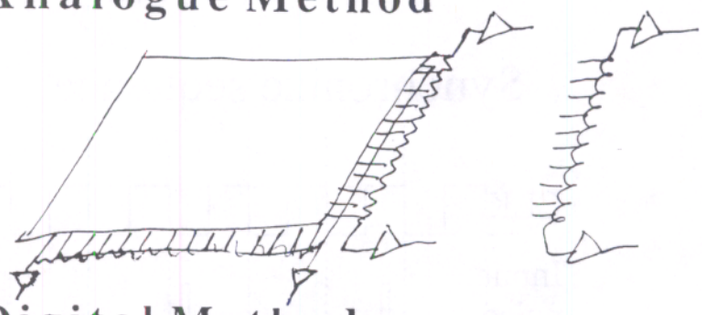
(MWPC)

50cm x 50 cm

Position Resolution 2-3 mm

Rate Capabilities are determined by Readout Electronics

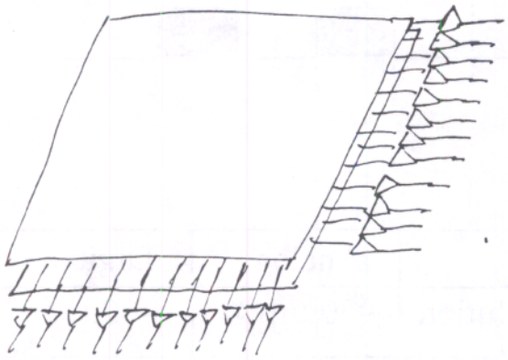
Analogue Method



$\sim 2\times10^5$/s/plane

Digital Method

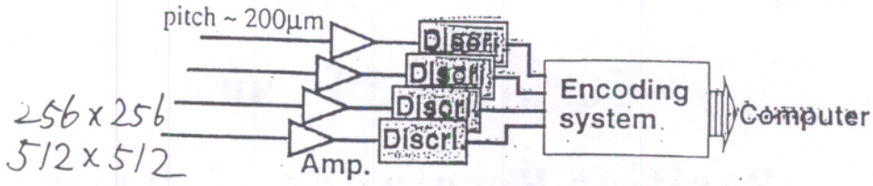
-Readout of Each Wire

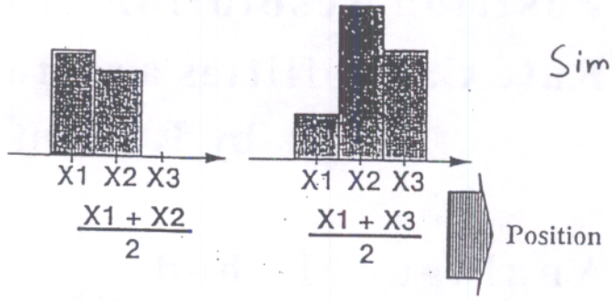


$10^6 \sim 10^7$/s/plane

Example by Tanimori et al for MSGD

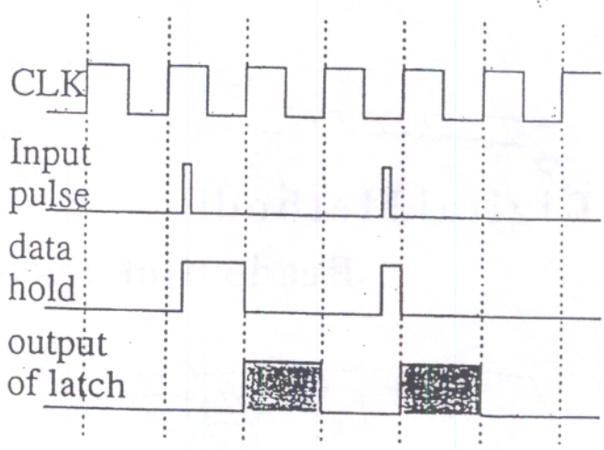
High resolution data taking with binary readout





Simple Encoding

Synchronize sequence



10 MHz
↓
30 MHz

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

(c) Large-sized PSD

> 1m x 1 m

Position Sensing along
the Anode Wire for 2D-PSD
---Charge Division---

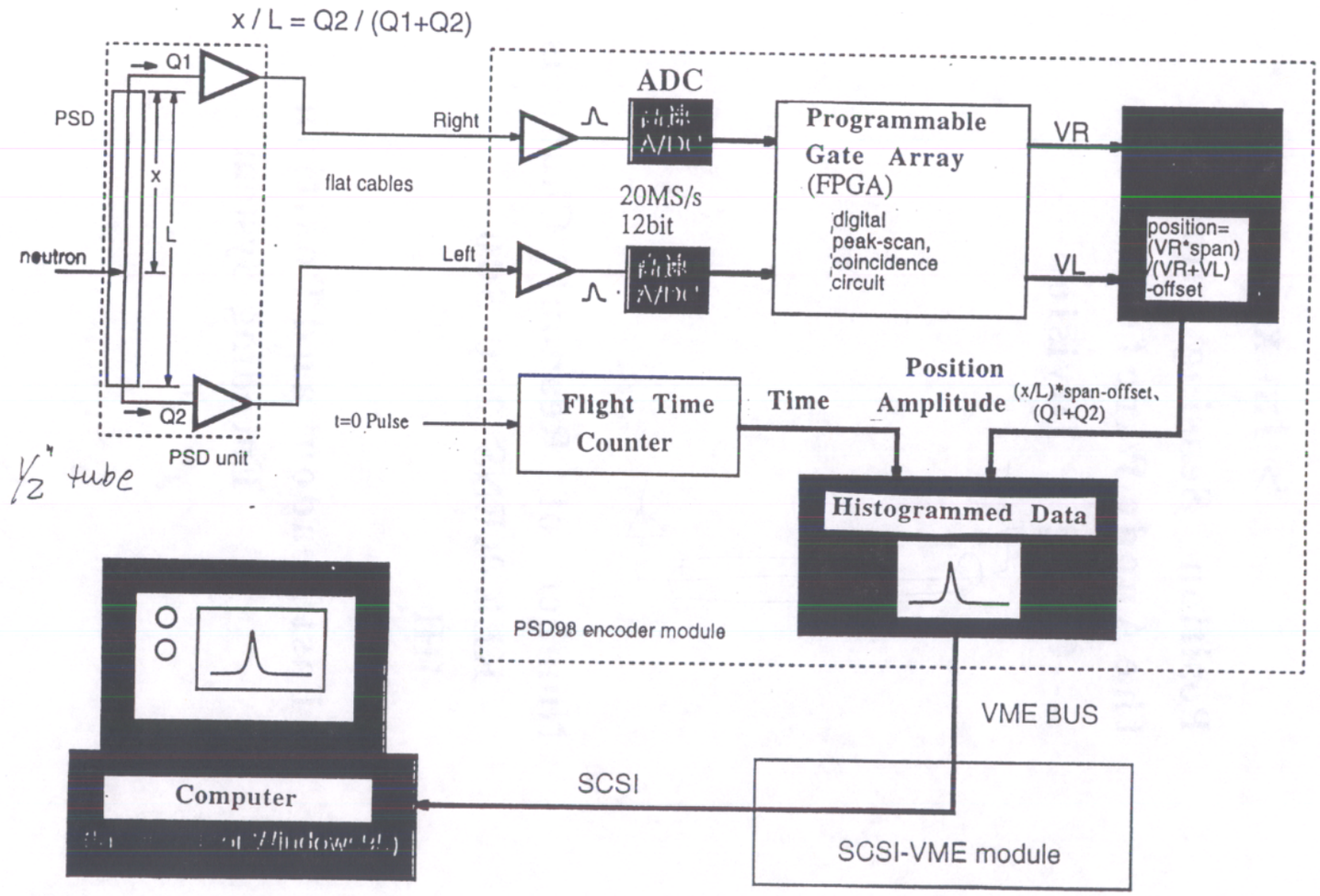
Number of Readout Channels

KEK-KENS	200-500
JHF	?

Fast Readout and Position
Encoding System

Readout Scheme of PSD98

KENS Satoh et al



Position Resolution
~5 mm

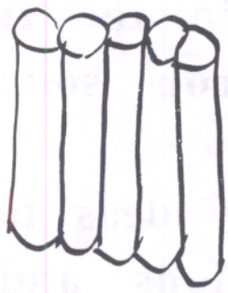
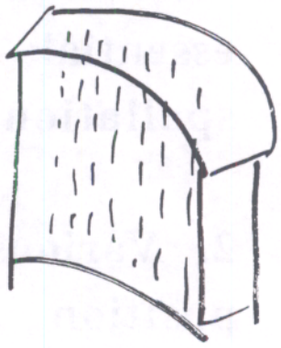
Time Resolution
125 ns
~1 μs

25 μs/event

⇩

4×10^4/wire

Mechanical Structures

	Array of Single Wire Tubes	Multi-wires in a Single Gas Volume
		
Pressure Vessel	Simple	Complex
Gas System	Closed	Circulation-type
Dead Space	some	O
Position Readout and Resolution	tube diameter	better
Flexibility	O	X
Cost Performance		

Conclusion

1. ^{3}He-based Gas Detectors of various sizes and various shapes will play essential roles in the future spallation neutron source.

2. Various novel ideas to get better position resolutions and higher counting rates should be studied.

3. Fast Data aquisition and analysis system is a key for future high-intensity neutron facilities.