Scintillation Fiber Detector (SFD) for momentum dispersive focal plane

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Elastic Scattering of Protons with RI beam (ESPRI)

RIBF Detector Workshop 08 (17-18 March 2008)

Momentum tagging counter

Requirements

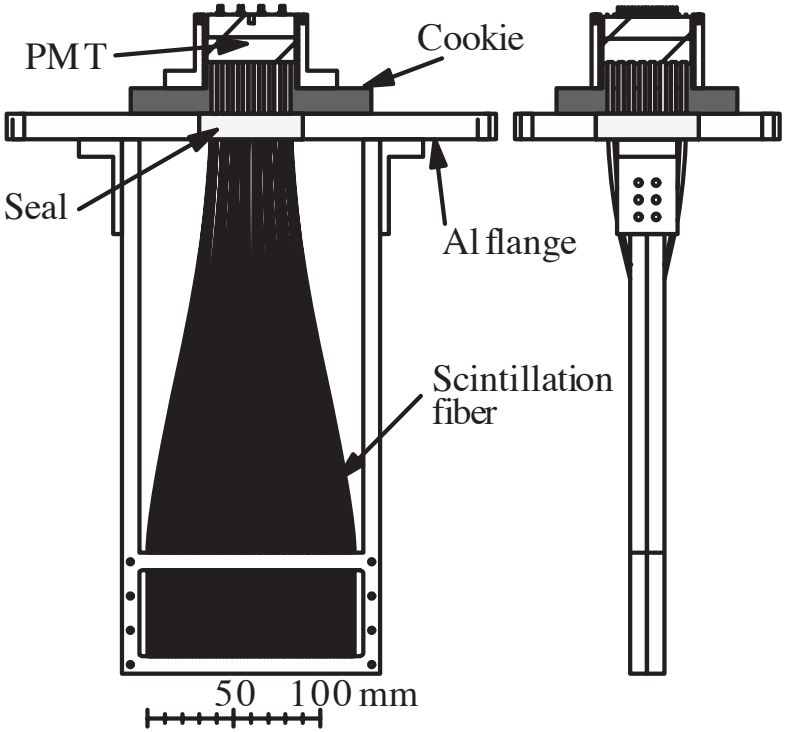
○ $\sigma_p/p \sim 0.1$ % $\Leftrightarrow$ $\sigma_x \sim 1$ mm

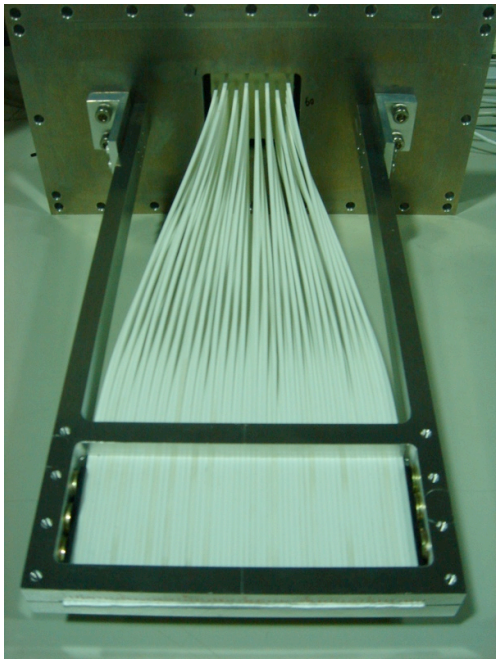
○High counting rates ($\geqq 10^6$ Hz)

○200 - 300 MeV/u, $1 \leqq Z \leqq 10$

	Position-sensitive gas detectors (PPAC, LPMWPC)	Scintillation fiber detecter (SFD)
Merit	Low-density	Safety Stability
Demerit	Gas handling safety Dependence on I_B and ΔE	High-density

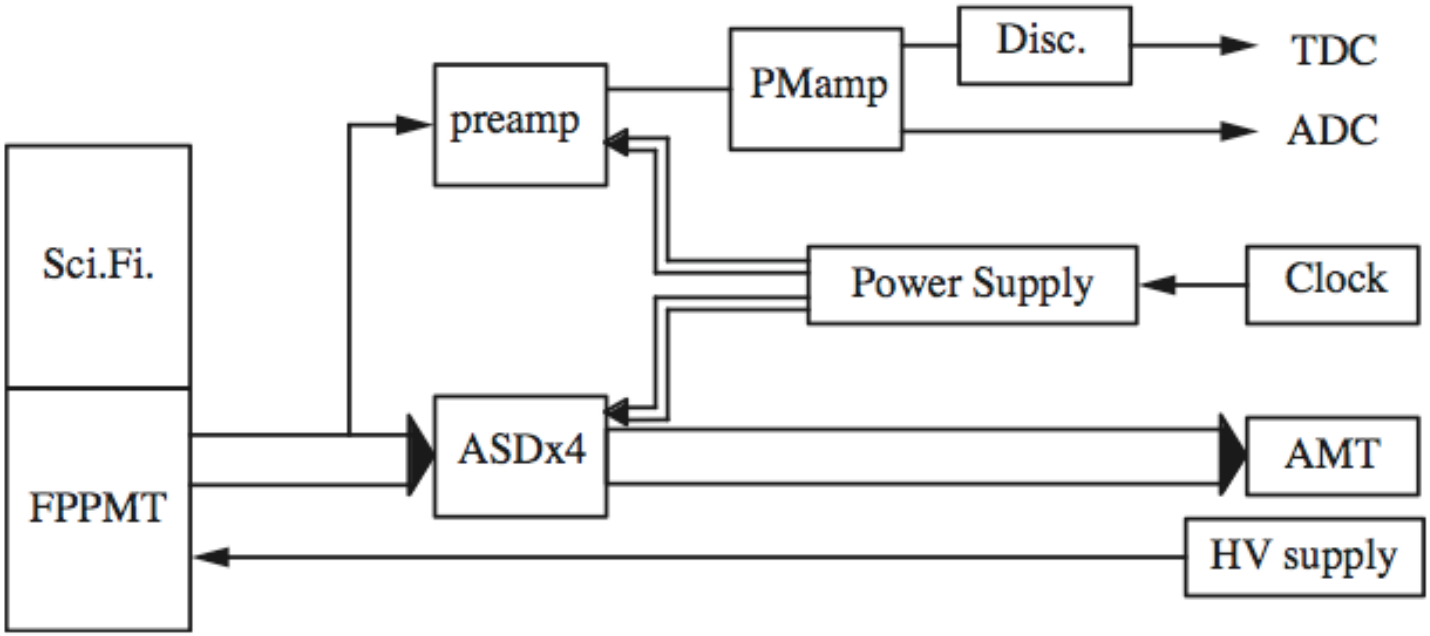
Scintillation fiber detecter





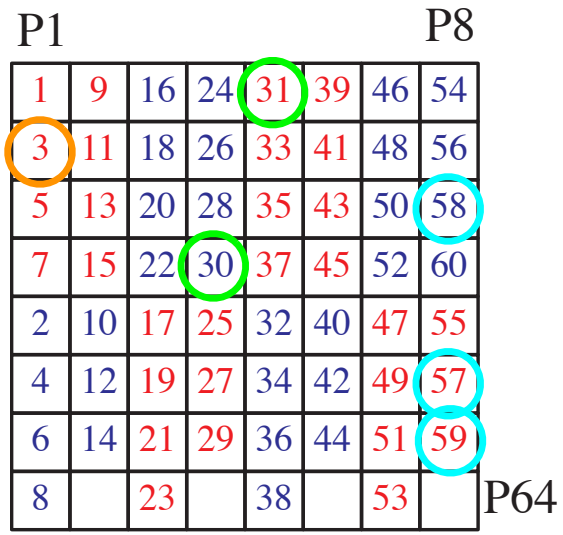
Sci.Fi.	BCF-12、 2 mm square, 60 rows
Effective area	120 mm x 50 mm

Circuit



PMT	H8500 (HAMAMATSU)	64ch Multi-anode PMT, Transistor base
ASD	GNA-180 (GNomes Design)	C_fR_f = 16 nsec
TDC	64ch AMT-VME TDC (AMSC)	0.78 nsec/bit, multi hit TDC
Preamp	TGC ASD chip	C_fR_f = 16 nsec, 0.8 V/pC

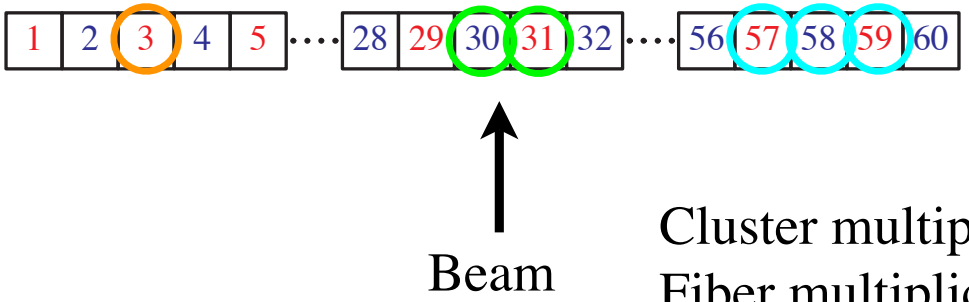
Definition of multiplicity



$$\epsilon_{c_i} = \frac{C_i}{\sum_{k=0}^{\infty} C_k}$$

$$\epsilon_{M_i} = \frac{M_i}{\sum_{k=0}^{\infty} M_k}$$

$$\epsilon_{\text{Total}} = 1 - M_0$$



Cluster multiplicity = 3 (C_3)

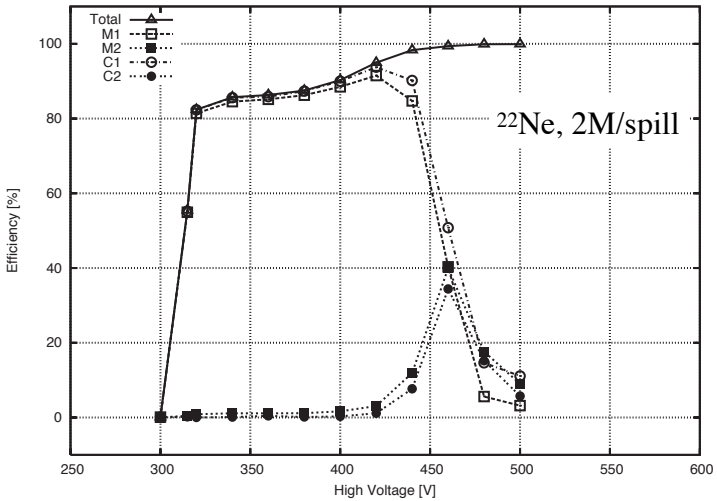
Fiber multiplicity = 6 (M_6)

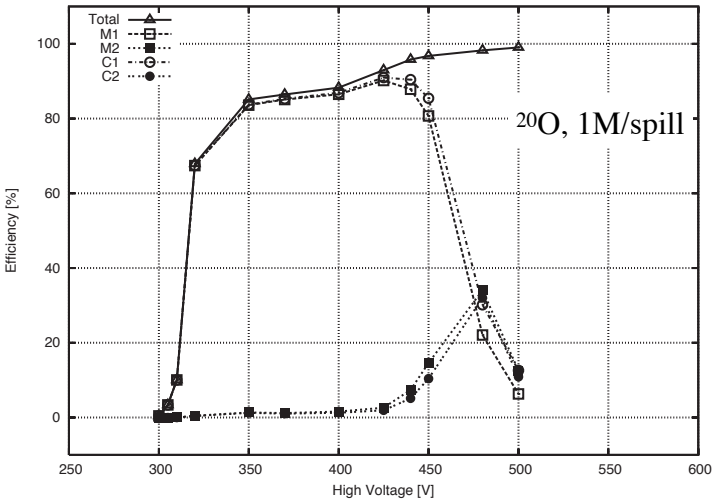
Intensity dependence of efficiency (perpendicular incidence)

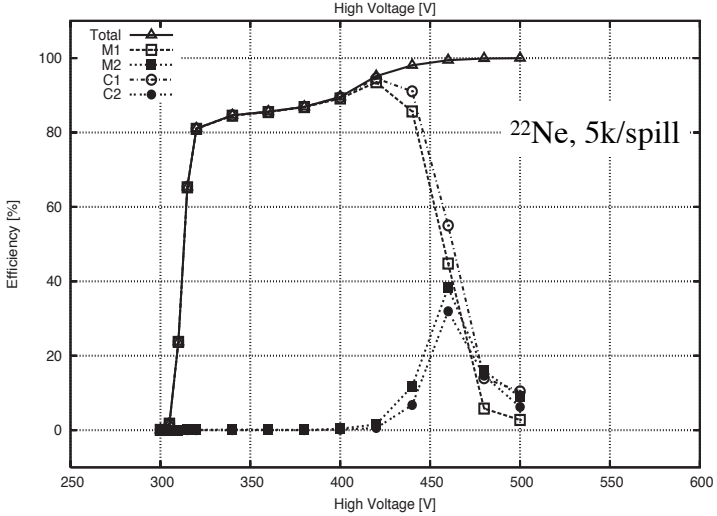
^{22}Ne	390 MeV/u	4k - 1M/spill
^{20}O	300 MeV/u	5k - 2M/spill

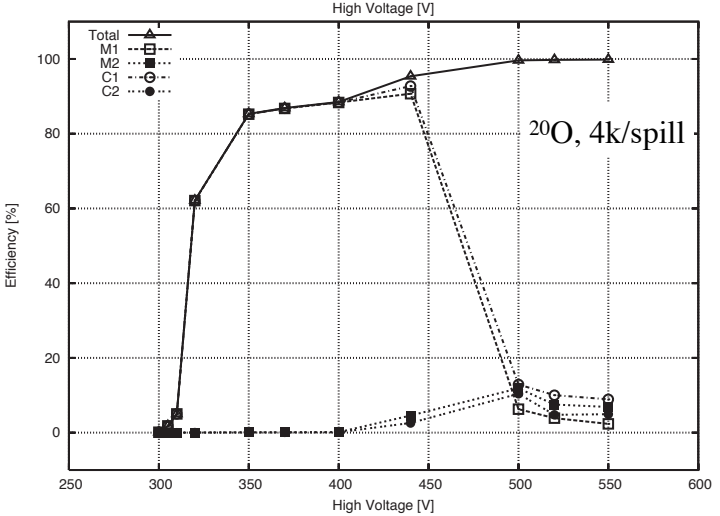
@ NIRS-HIMAC

1 spill = 1.2 sec/ 3.3 sec , Vth= -300 mV



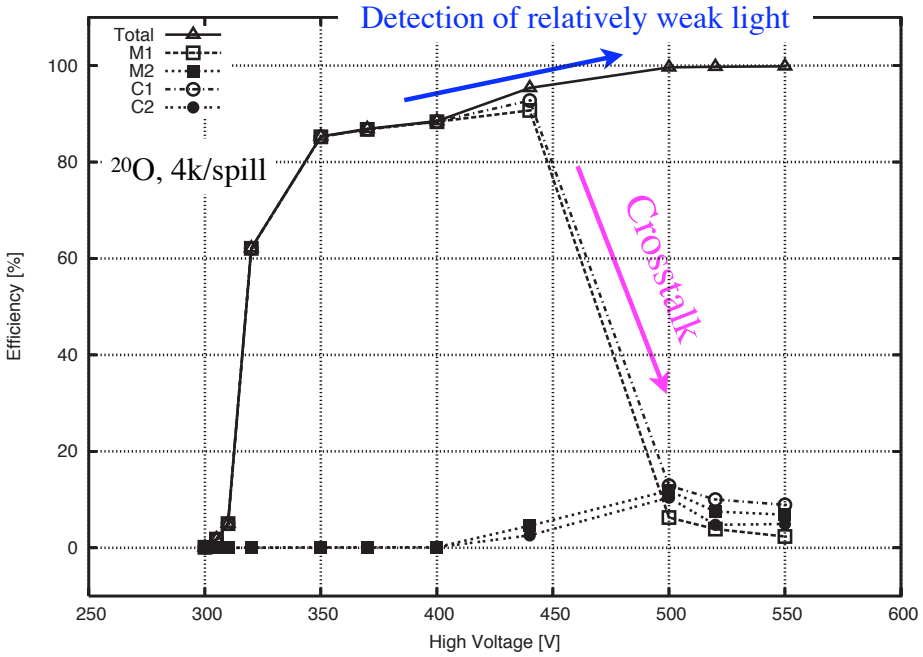


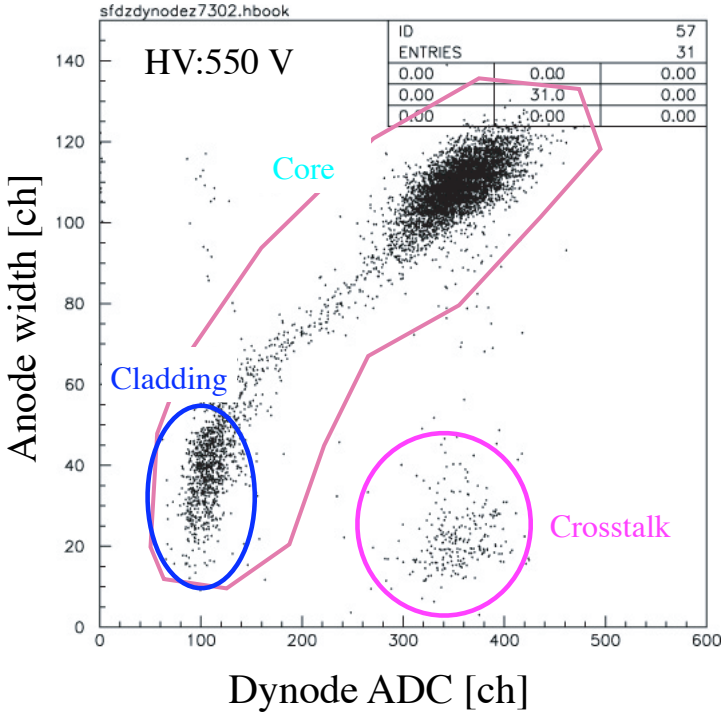


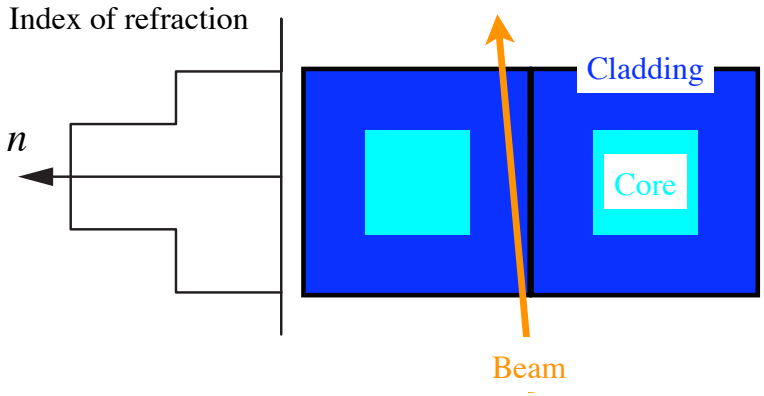


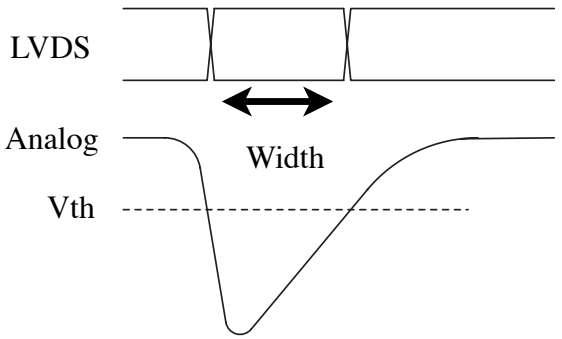
unchanged

HV dependence of efficiency (perpendicular incidence)





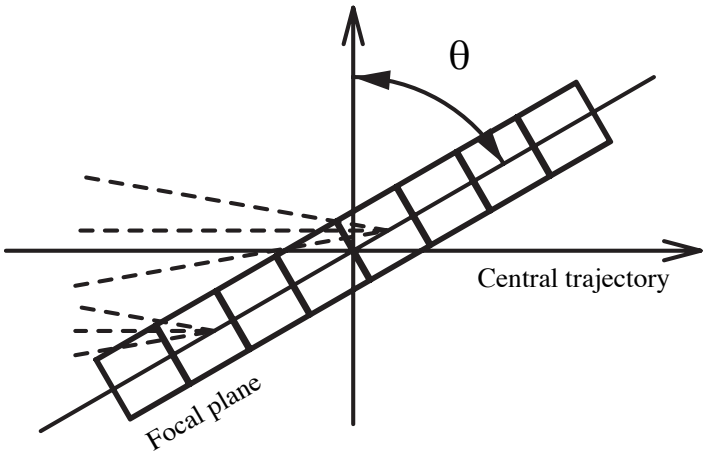


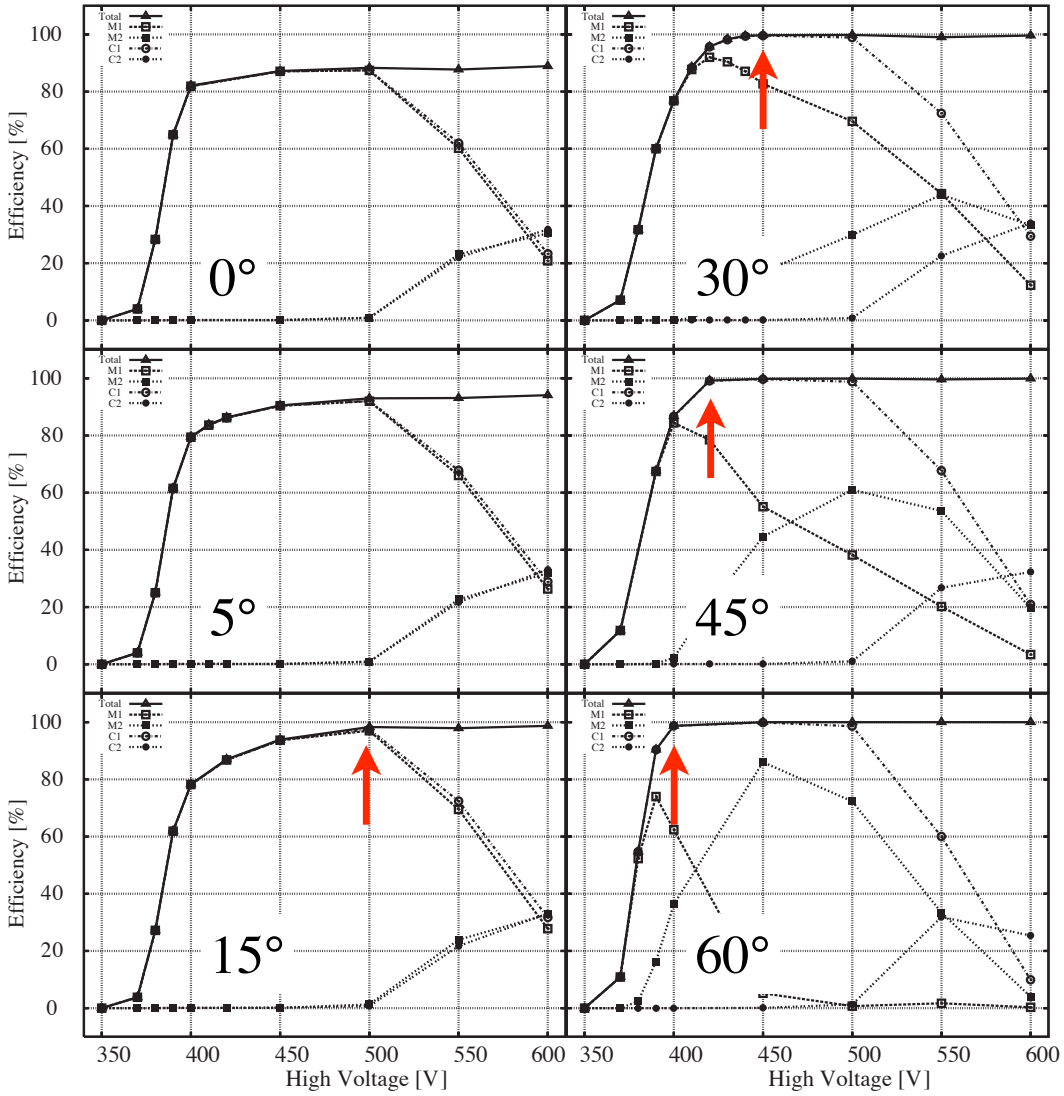


HV dependence of efficiency (oblique incidence)

p	45 MeV	1k/spill

@ CYRIC, Tohoku Univ.
Vth= -300 mV

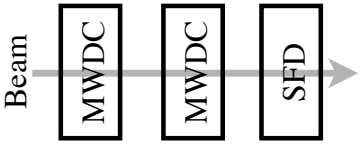


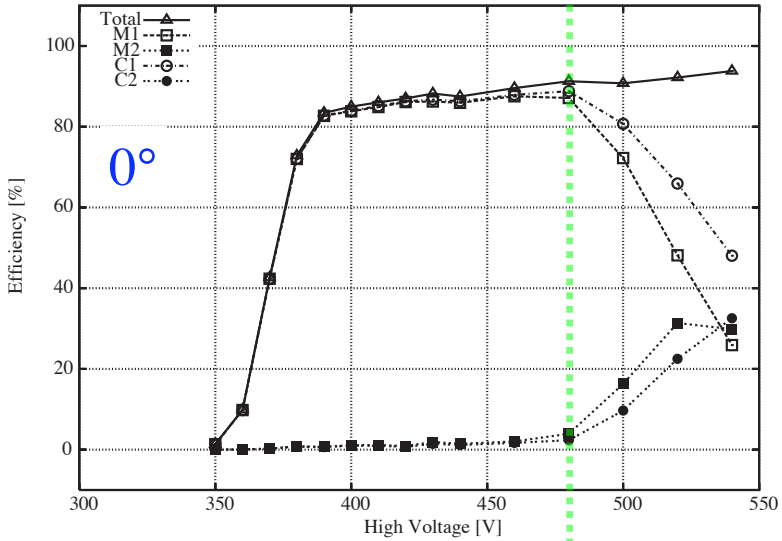


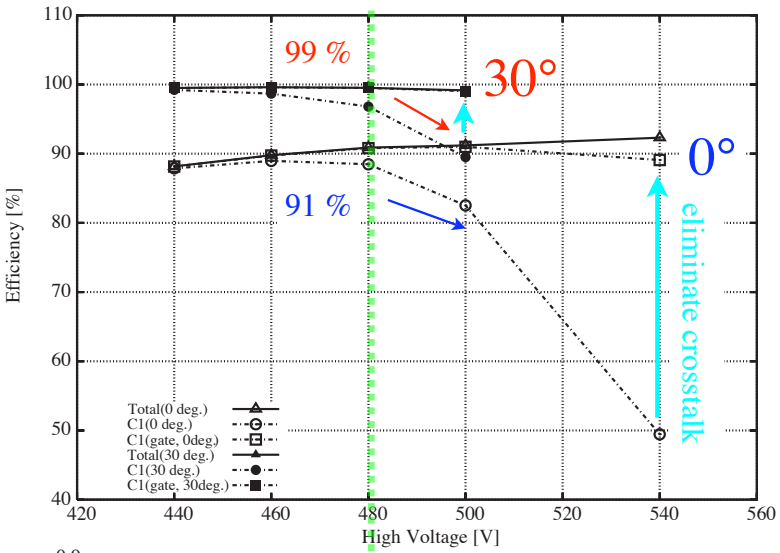
Position resolution

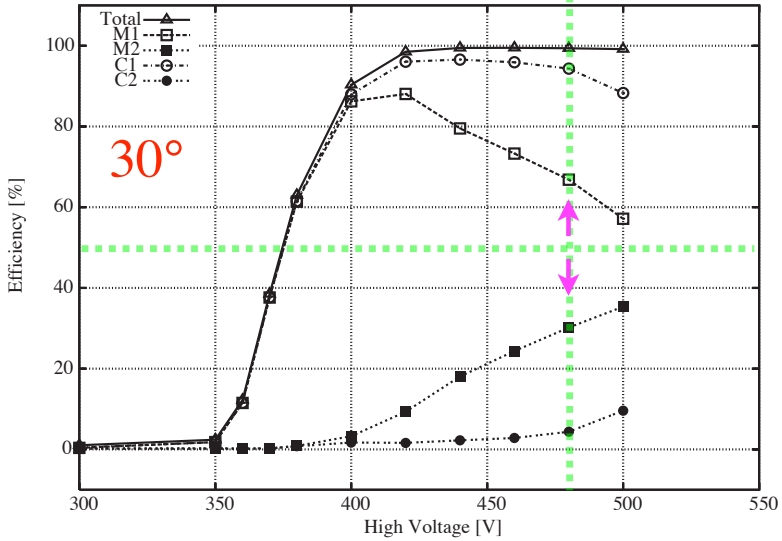
^{4}He	230 MeV/u	10k/spill

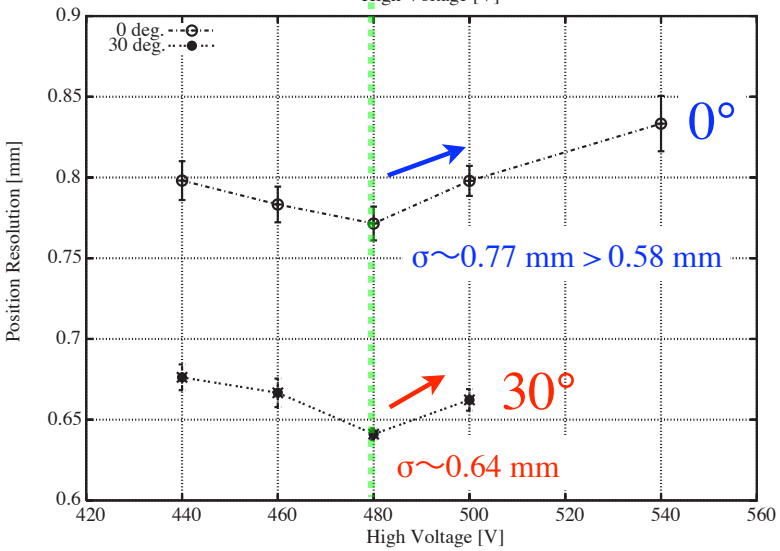
@ NIRS - HIMAC, Vth= -350 mV







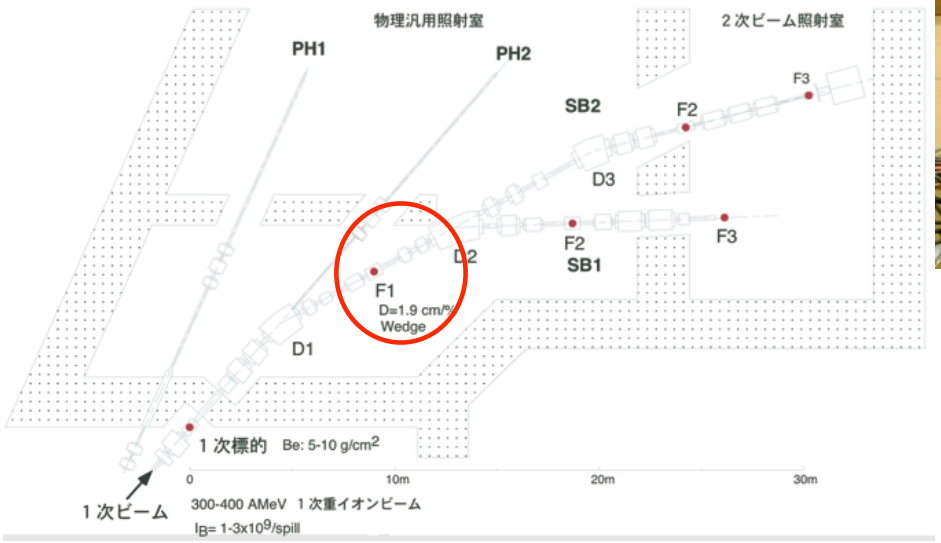


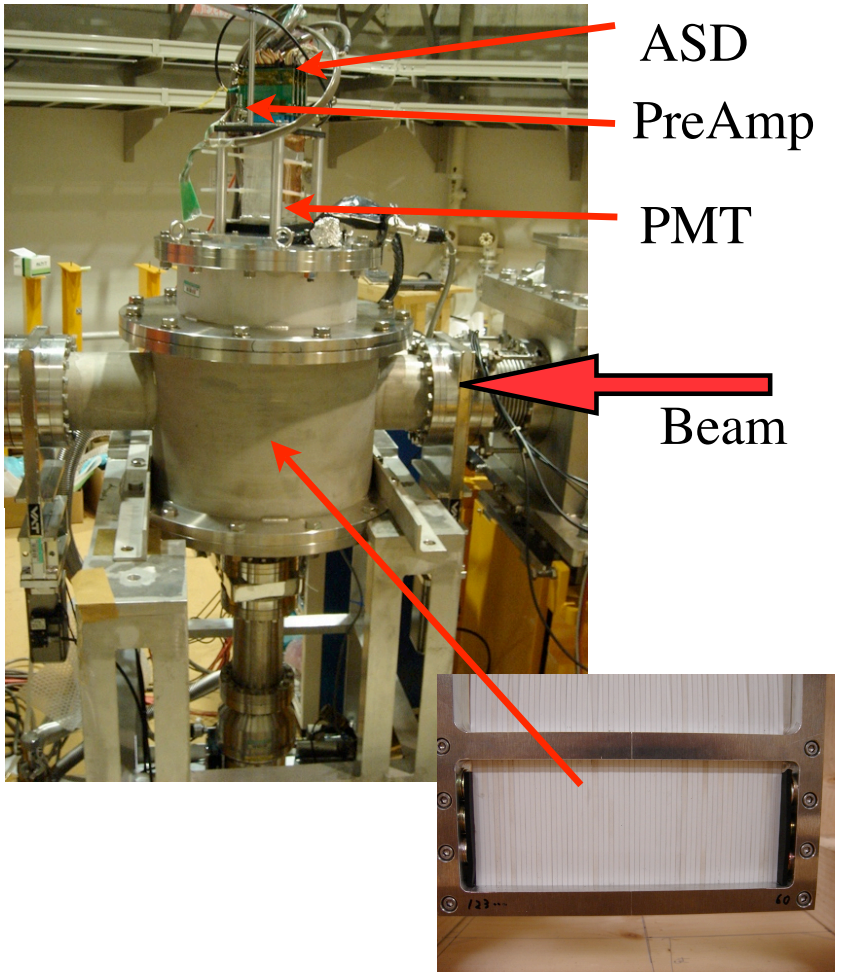


Practical use

Installed along the tilted momentum-dispersive focal plane of the SB course at NIRS-HIMAC .

^{20}O(p,p), E=300 MeV/u (1 M/spill)
^{9}C(p,p), E=300 MeV/u (0.8 M/spill)
^{3,4,6}He(p,2p), E=200-250 MeV/u
^{6,7,8,9}Li(p,2p), E=250 MeV/u





^{9}C(p,p), E=300 MeV/u (0.8 M/spill)

TOF resolution (F1-F3)

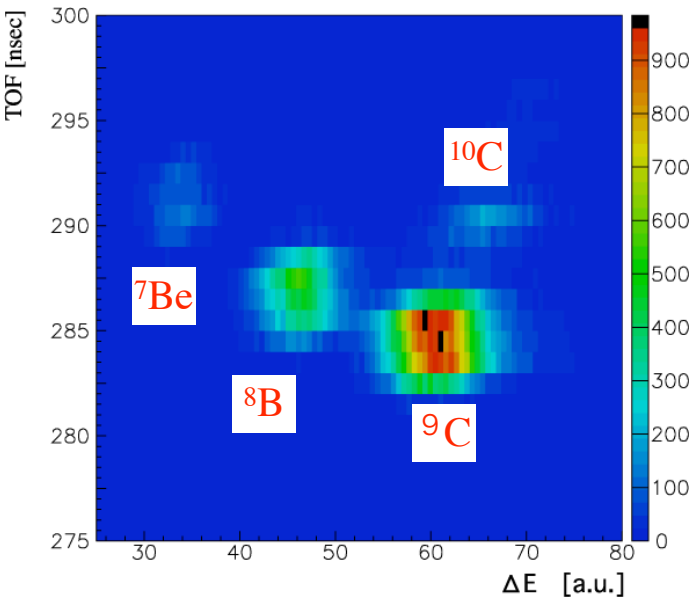
σ∼1 nsec

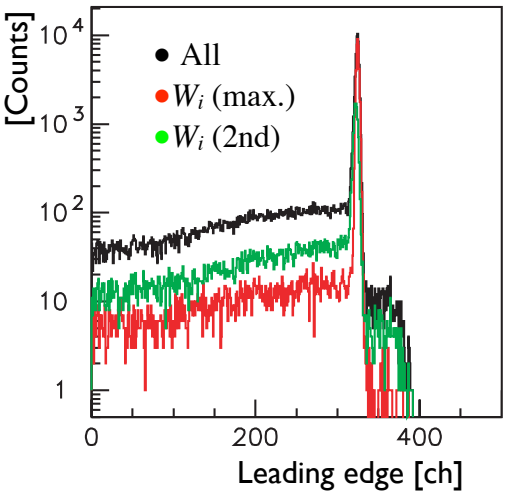
Beam particle idenfication (TOF-ΔE method)

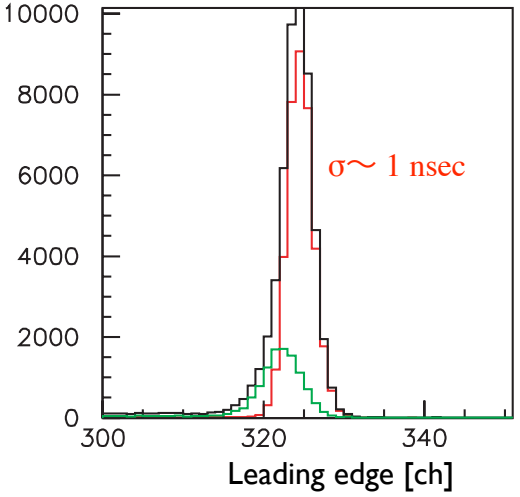
PID efficiency > 90%

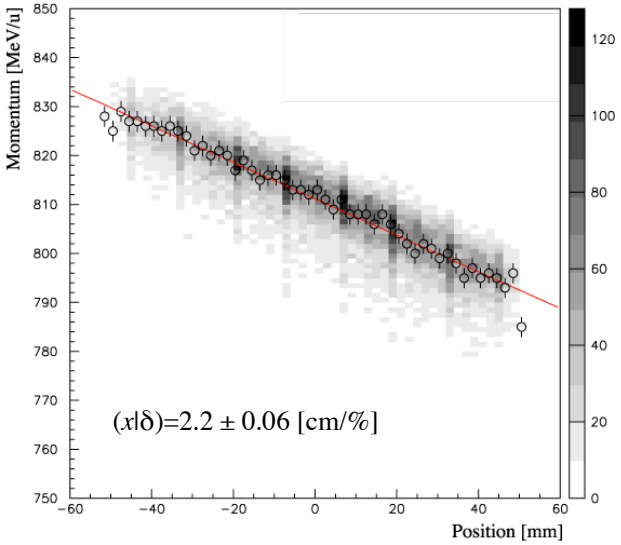
Beam momentum tagging

$\Delta p/p < 0.1$ %









Summary

☆We have developed a simple one-dimensional scintillation fiber detector.

☆Results of performance tests

- Beam intensity : unchanged at high count rate (^{22}Ne ～2x10^{6} Hz).
- Insensitive area : surface of each Sci.Fi. (ex. PMMA cladding)
- Tilt : efficiency of C1 = 100 %
- Width sum : eliminate crosstalk
- Position resolution : σ ～ 0.8 mm (0 deg.), 0.6 mm (30 deg.) ; ^{4}He 230 MeV/u
- Time resolution : σ ～ 1 nsec ; *p* 45 MeV(ΔE=2.7 MeV) ～ ^{20}O 300MeV/u (ΔE=44 MeV)
- PID efficiency : > 90 % ; ^{9}C 300MeV/u, 0.8 M/spill

☆SFD was installed along the momentum dispersive focal plane of the SB course at NIRS-HIMAC.

☆The others

Order of fibers @MAPMT, Multi-hit TDC for beam line scintillator