Trigger logic for HypHI using VUPROM1

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- HypHI Phase 0 experiment
- Experimental apparatus
- Secondary vertex trigger
- TOF+ trigger
- Monte Carlo simulation
- R&D for trigger system
- Summary

HypHI Phase 0 experiment

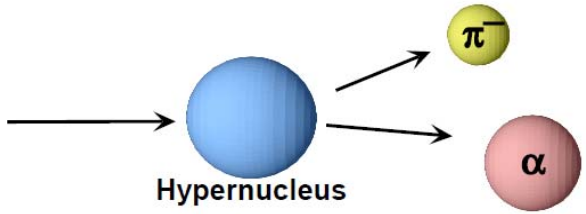
- Method
  - ^{6}Li beam with 2 A GeV in kinetic energy (E_{th} for N+N→Λ+K+N~1.6GeV)
  - Measurement of decayed particles from mesonic decay mode.

    $^{3}_{\Lambda}H \rightarrow {}^{3}He + \pi^{-}$

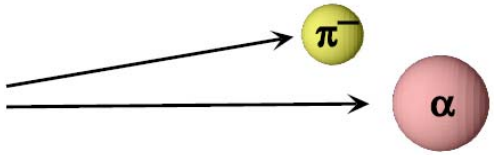
    $^{4}_{\Lambda}H \rightarrow {}^{4}He + \pi^{-}$

    $^{5}_{\Lambda}He \rightarrow {}^{4}He + p + \pi^{-}$
  - Reconstruction of secondary vertex (~20cm in average behind target)
  - Invariant mass
- Background
  - π+ ^{3}He/^{4}He : request secondary vertex behind target
  - Λ+ ^{3}He/^{4}He : reject events with ^{3}He/^{4}He at the detector just after target

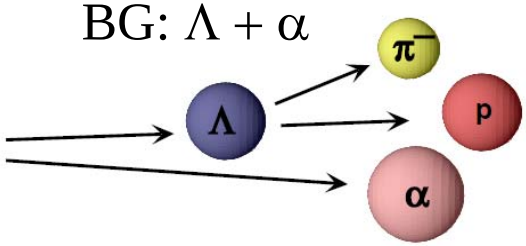
Signal: $^{4}_{\Lambda}H \rightarrow \alpha + \pi^{-}$



BG: π + α



BG: Λ + α



Experimental apparatus

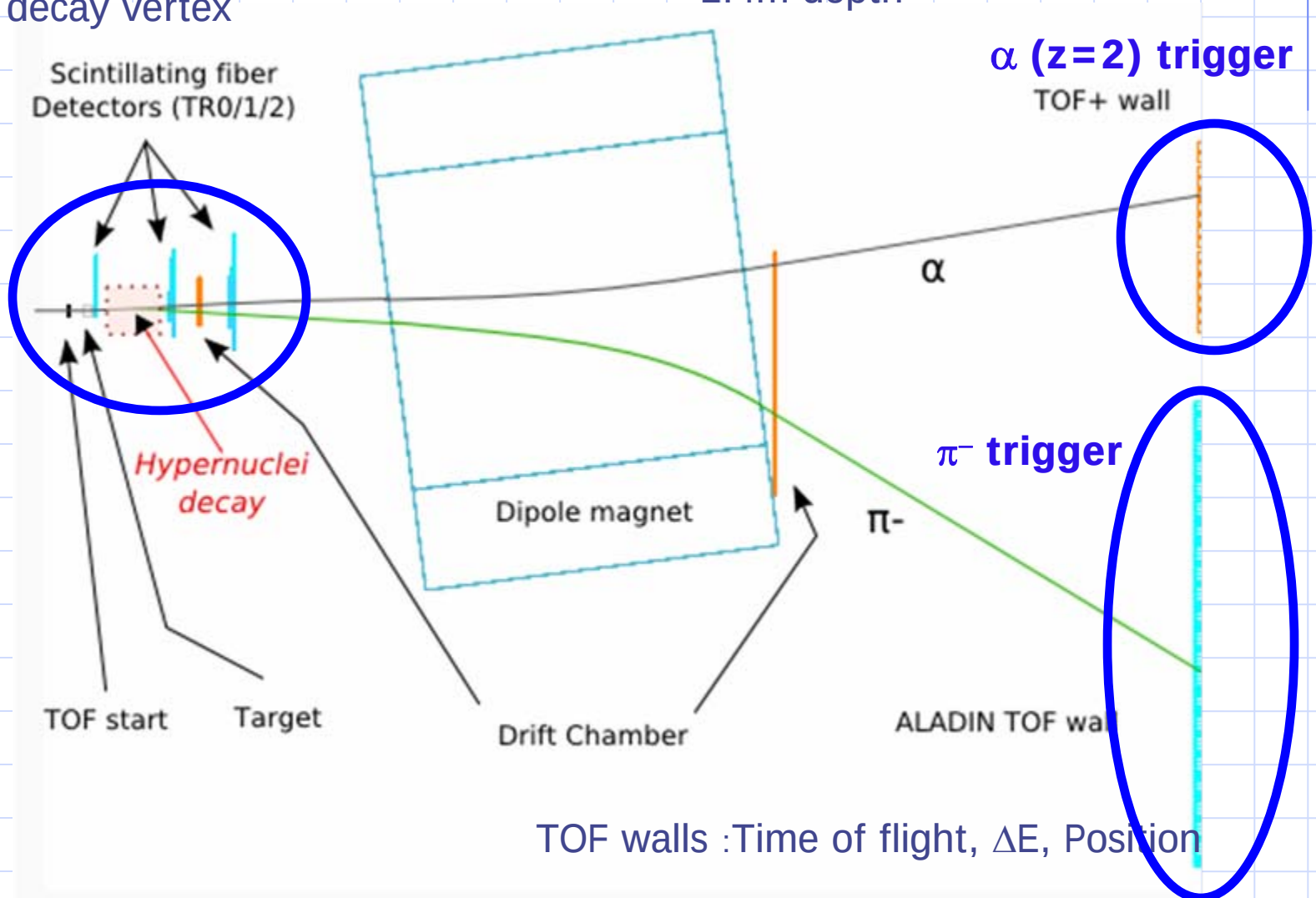
Fast trigger
<300nsec

Target: 12C with 8g/cm^2

TR0: primary vertex, ΔE

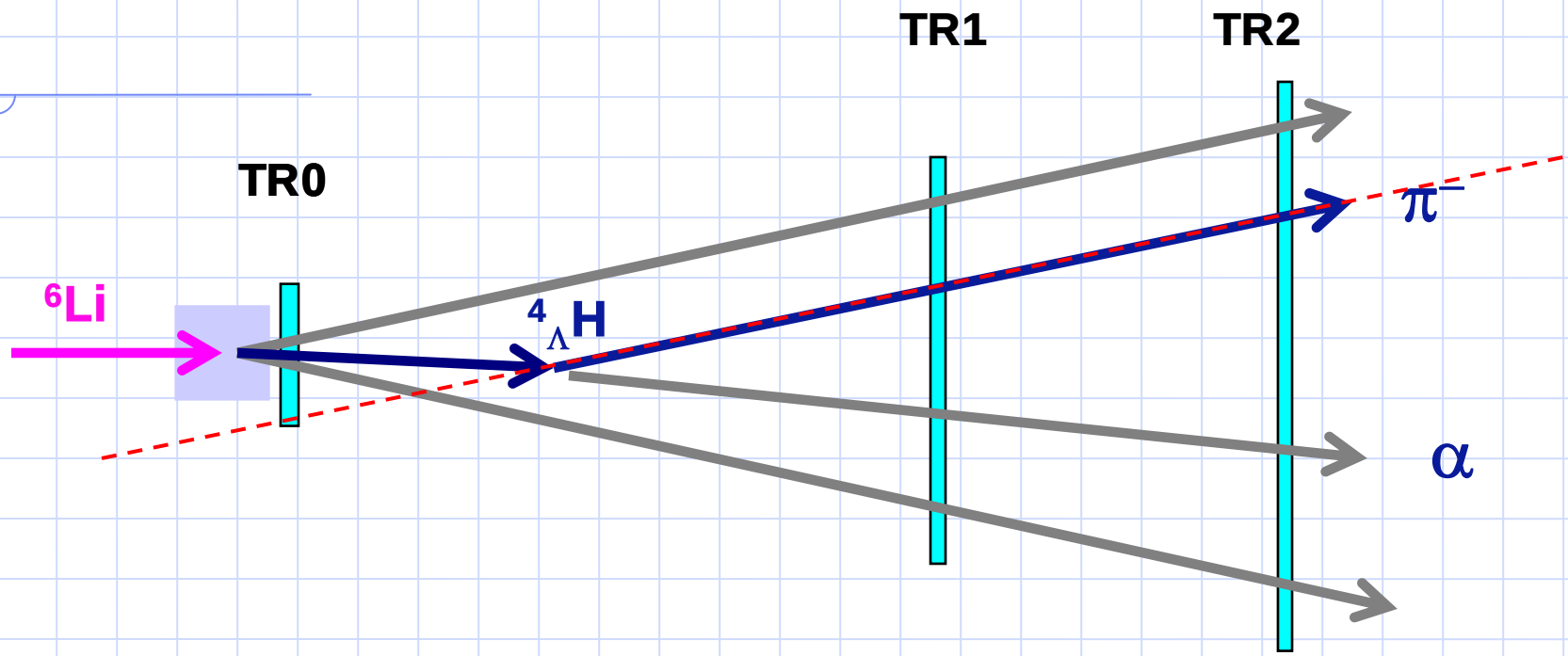
TR1,TR2 : decay vertex

Dipole magnet : 0.7 T
1.4m depth



TOF walls :Time of flight, ΔE, Position

Secondary vertex trigger



π^- from $^4_\Lambda$H makes tracks which don't cross the primary vertex

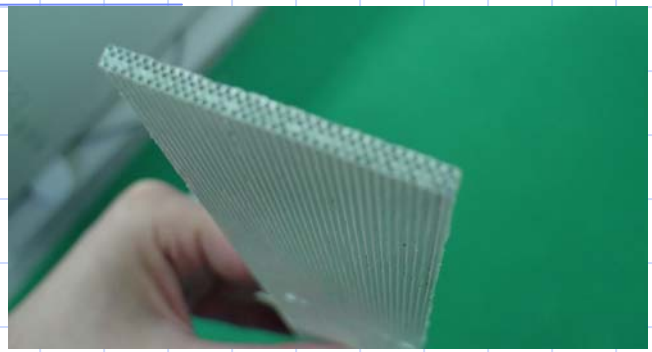
It can be identified by following procedure;

1. Identify hits by particles come from the primary vertex
2. Veto the hits selected by 1st step
3. Reconstruct tracks with surviving hits after 2nd step

Scintillating fibre detector

SCSF-78M -.83D. NON S-type by Kuraray

Diameter is 0.83mm with 2 clads



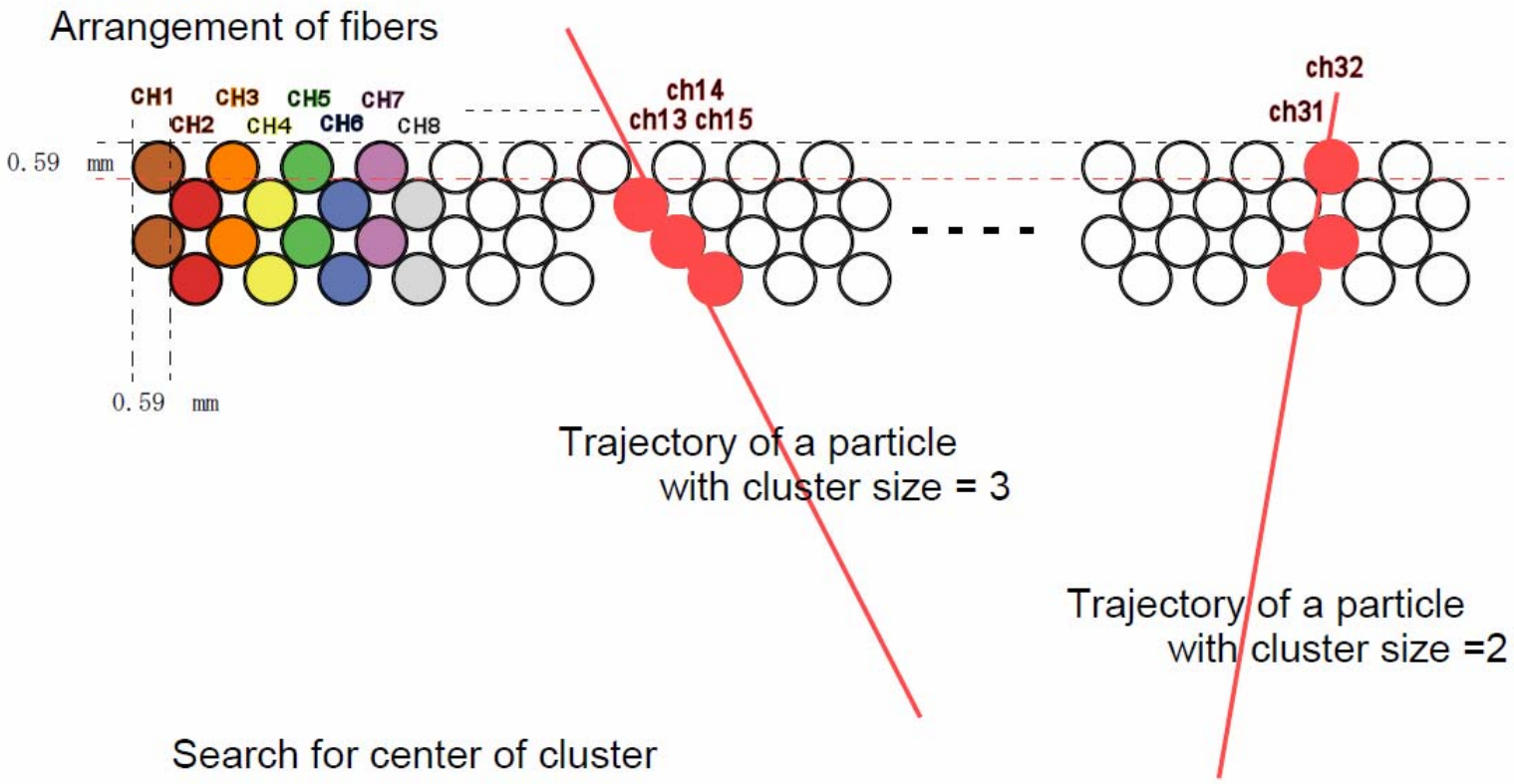
H7260 (32ch multi-anode PMT by HAMAMATSU)

name	width	No. of ch	No. of fiber	length	No. of PMT
TR0y	38mm	64	64 x 4	40mm(+20cm)	2
TR1y	76mm	128	128 x 4	130mm(+20cm)	4
TR2y	113mm	192	192 x 4	245mm(+20cm)	6
all y		384			12
TR0x	38mm	64	64 x 4	40mm(+20cm)	2
TR1x	132mm	224	224 x 4	75mm(+20cm)	7
TR2x	245mm	416	416 x 4	115mm(+20cm)	13
alll x		704			22
all		1088			34

Secondary vertex trigger

1000 ch → Logic module (VUPROM1) based on FPGA/DSP

Clustering for the tracking trigger



Search for center of cluster

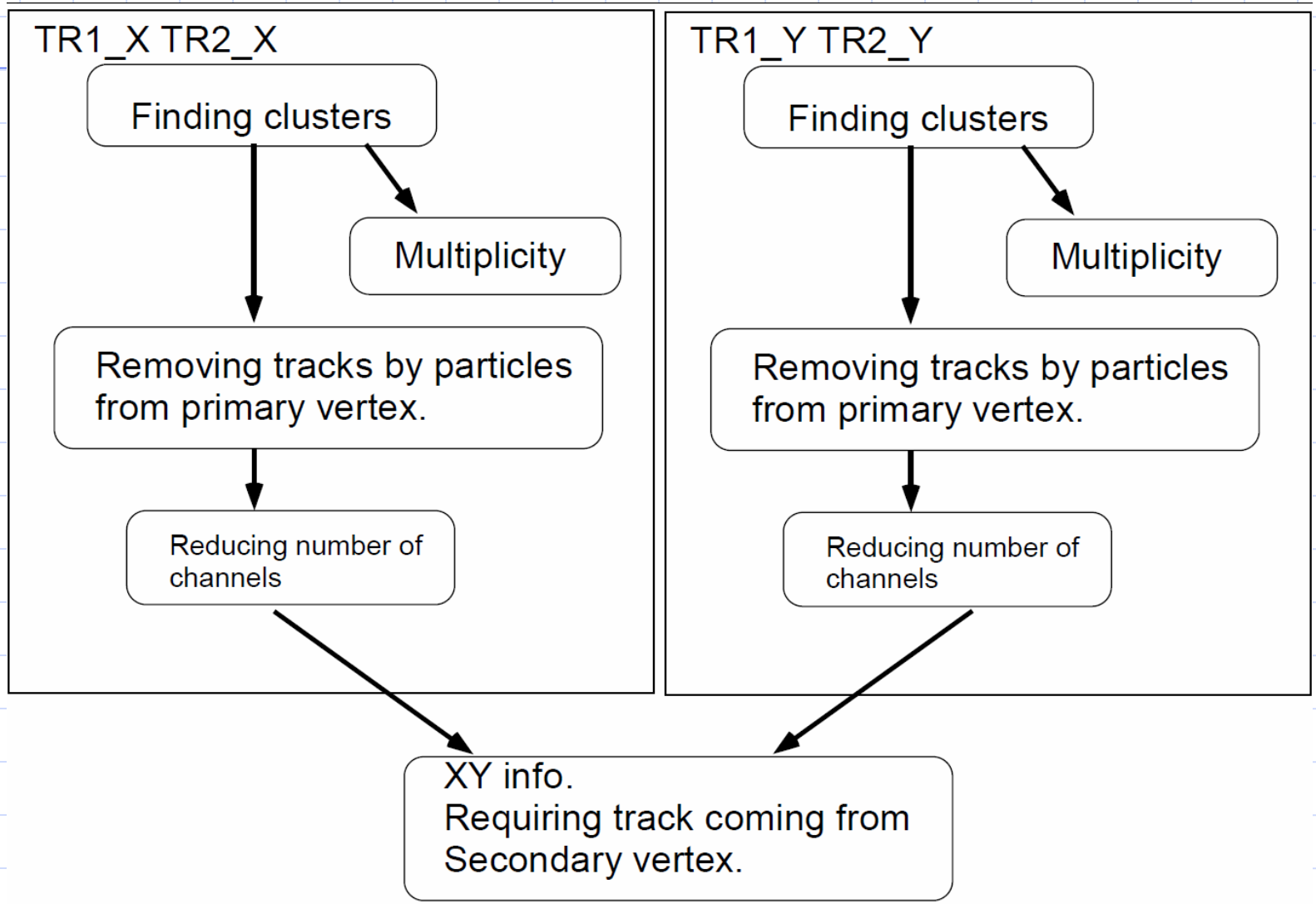
ID of fibers
red: with hit

10	11	12	13	14	15	16	17	.....	29	30	31	32	33	34

ID of fibers
red: center
of cluster

10	11	12	13	14	15	16	17	.....	29	30	31	32	33	34
10.5	11.5	12.5	13.5	14.5	15.5	16.5	.....		29.5	30.5	31.5	32.5	33.5	

Algorithm for Secondary vertex trigger



Monte Carlo Simulation

- Tools: Geant4 and Ultra Relativistic Quantum Molecular Dynamics calculations(UrQMD)
- The beam intensity of 10^7/sec
- 40% of the beam expected to interact at the target.

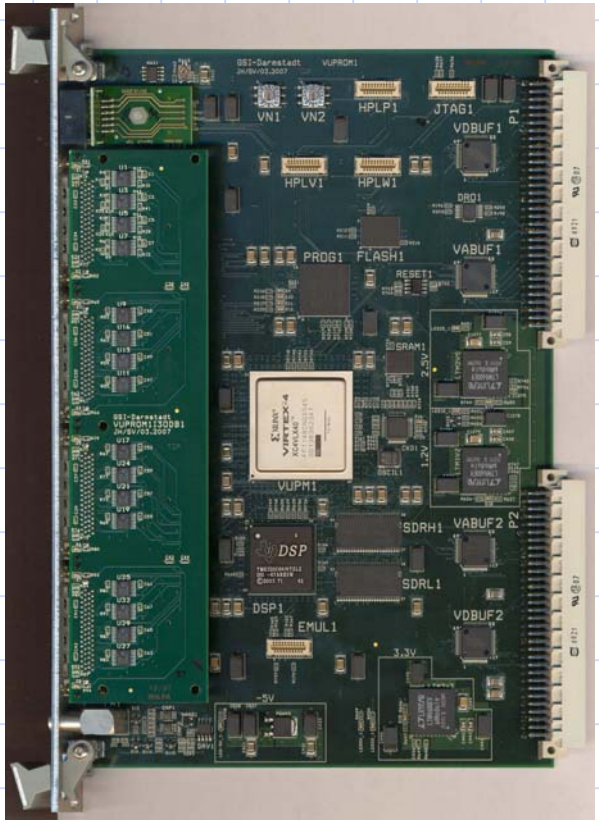
Table 1 Efficiency and reduction factor of the each trigger condition.

	Trigger	${}^{4}_{\Lambda}\mathrm{H}$ Efficiency (%)	Background Reduction (%)
1	Vertex trigger by x-plane	34.	10.
2	Vertex trigger by y-plane	30.	8.0
3	1 & 2	14.	1.7
4	ALADIN-TOF has hits	28.	15.
5	TOF+ has hits by particle with z=2	94.	14.
6	1 & 2 & 4 & 5	7.0	0.017

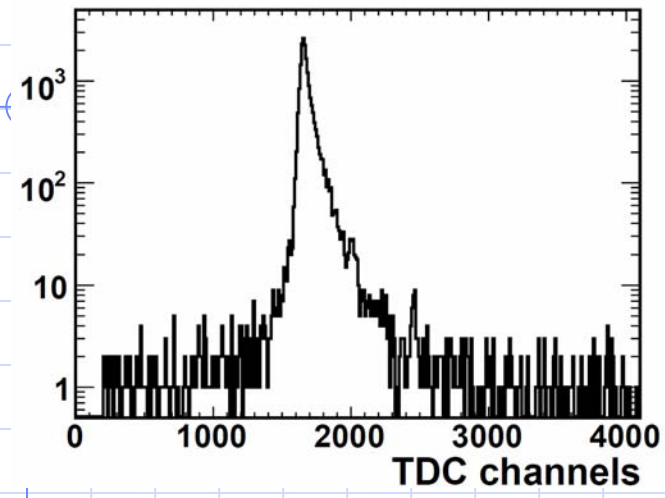
- Full function of the trigger 0.017%, trigger rate is expected to be 0.7kHz.
- This value fulfils the requirement by the DAQ system which expected to accept up to 3kHz.

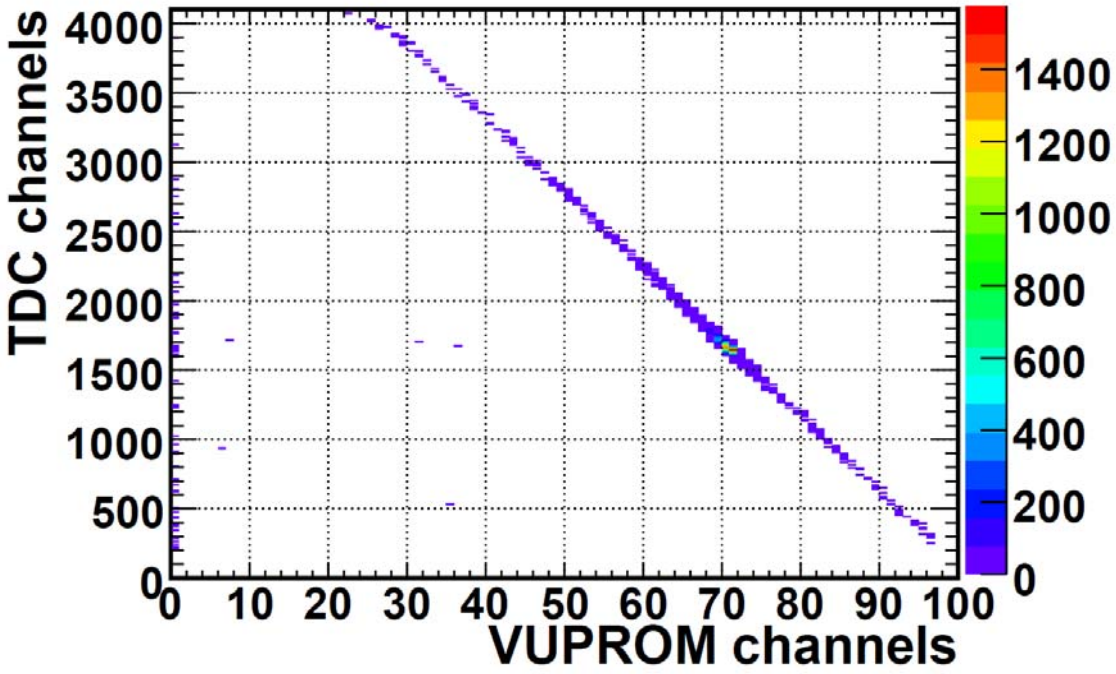
R & D for trigger system

- Logic module (VUPROM1) based on FPGA/DSP
  - Fast trigger (<300ns)
    with No. of channels >1000ch
    (Secondary vertex & time over threshold)
  - TDC for the scintillating fibre detectors
    with 2.5 ns granularity
    VUPROM1 developed by GSI EE
    1-unit wide VME 6U
    256 LVDS I/O by High Density connector (VHDCI)
    Fast Programmable Logic Device
    Xilinx Virtex-4
    (max. clock freq. 400MHZ)



TDC by VUPROM1 (Sep. 2007)





A32D32

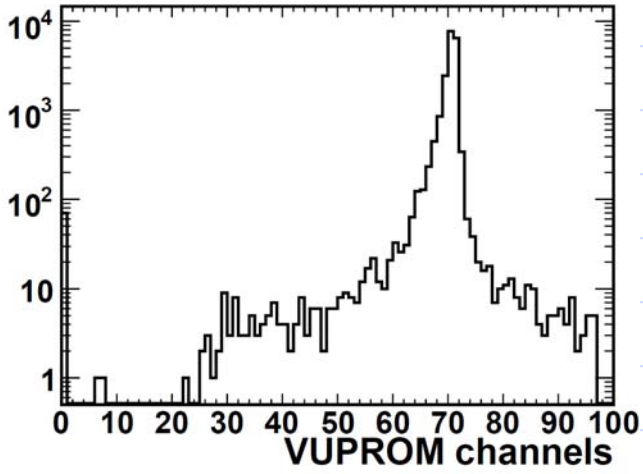
8 bit wide data

2.5 nsec granularity

Full range is adjustable

from 0x01 to 0xFF

Common stop

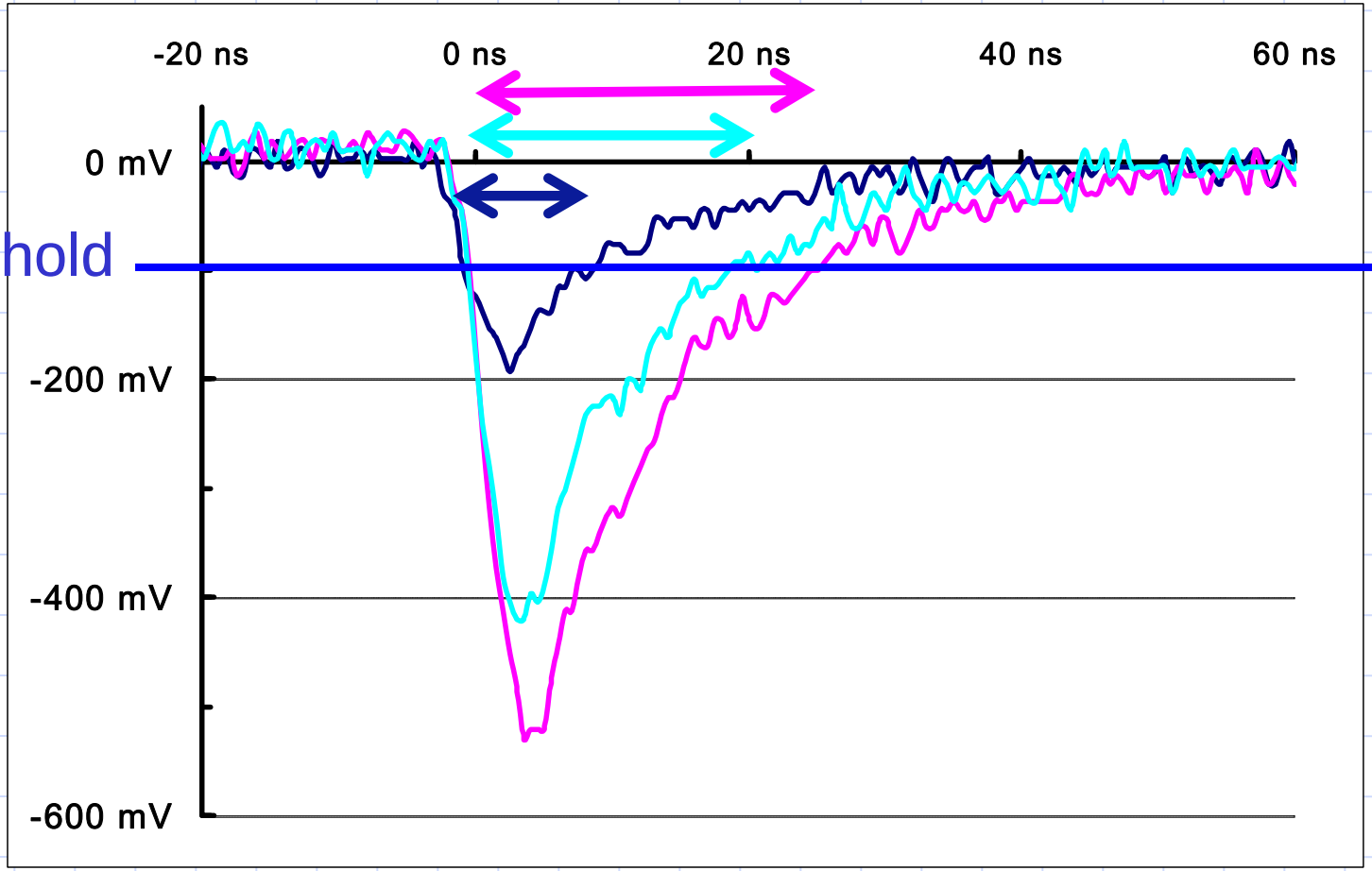


Clustering by VUPROM2 (prototype) at Mar. 2007

Fiber ID	TDC	ADC	Raw Waveform	Position	Clustered Waveform
0	0	-20.3	000000000000000000000000	0.0	000000000000000000000000
				0.5	000000000000000000000000
1	0	-9.5	000000000000000000000000	1.0	000000000000000000000000
				1.5	000000000000000000000000
2	0	-24.1	000000000000000000000000	2.0	000000000000000000000000
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
13	0	-6.6	000000000000000000000000	13.0	000000000000000000000000
				13.5	000000000000000000000000
14	0	-1.8	000000000000000000000000	14.0	000000000000000000000000
				14.5	000000000000000000000000
15	0	-8.2	000000000000000000000000	15.0	000000000000000000000000
				15.5	000000000000000000000000
16	59	84.5	000000001111100000000000	16.0	000000000000000000000000
				16.5	000000000000000000000000
17	60	487.3	000000001111111110000000	17.0	000000001111111111000000
				17.5	000000000000000000000000
18	60	456.4	000000001111100000000000	18.0	000000000000000000000000
				18.5	000000000000000000000000
19	0	-2.7	000000000000000000000000	19.0	000000000000000000000000
				19.5	000000000000000000000000
20	59	141.4	000000001111100000000000	20.0	000000000000000000000000
				20.5	000000001111100000000000
21	59	0.4	000000001111100000000000	21.0	000000000000000000000000
				21.5	000000000000000000000000
22	0	0.1	000000000000000000000000	22.0	000000000000000000000000
				22.5	000000000000000000000000
23	0	18.3	000000000000000000000000	23.0	000000000000000000000000
				23.5	000000000000000000000000
24	0	-7.4	000000000000000000000000	24.0	000000000000000000000000
				24.5	000000000000000000000000

TOF+ He trigger by time over threshold

- Amplitude of pulse height; proton:He:Li ~ 1 : 4 : 9
- Plastic BC408: 2.5 (T) x 4.5(W) x 100(L) cm^3
- PMT Hamamatsu H7415mod: Size 9/8”, Rise Time 1.7ns



Discriminator from BNL-E949

- PLD: EPF10K50E-1
- Board Size: CAMAC
- Input: 12 analog (front) , 16 ECL (optional on board)
- Output: 16 ECL (front) , 16 ECL(optional on board)
- Common threshold

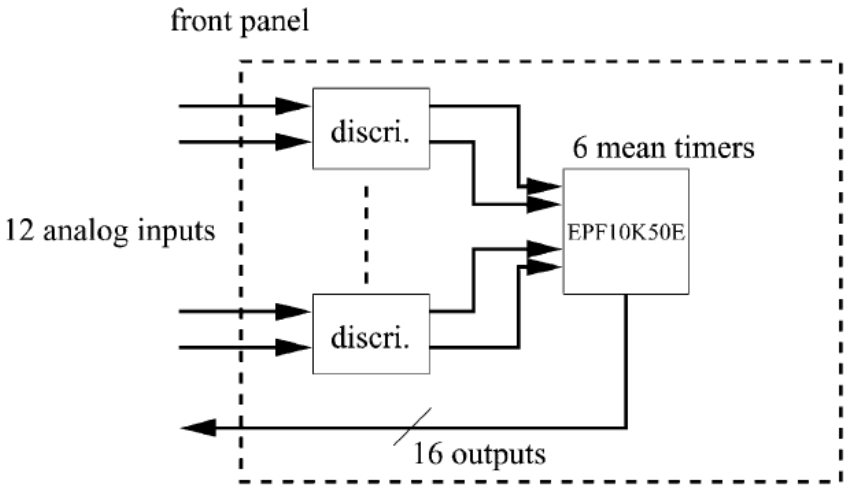
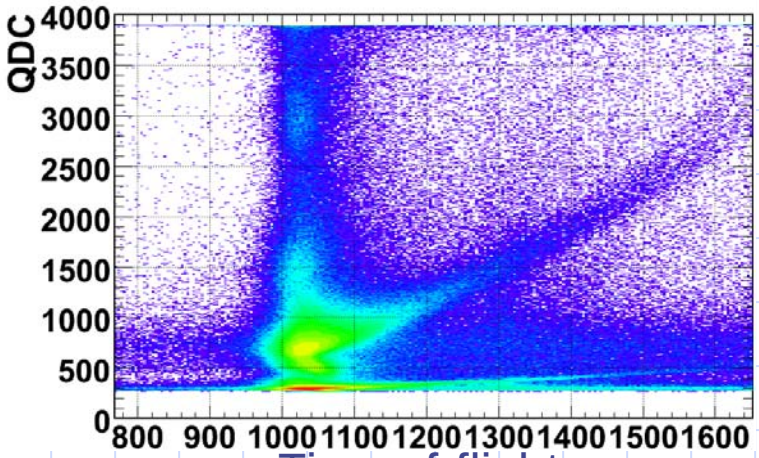


Fig. 2: 12 channel intelligent discriminator.

T. Yoshioka et al. IEEE Trans. Nucl. Sci. Vol. 51 No. 3 (2004) p334

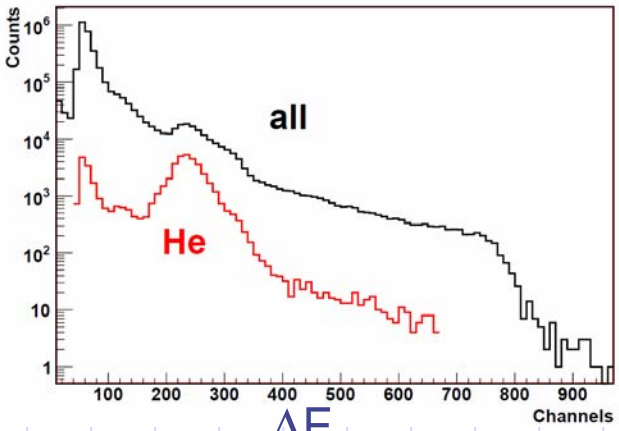
TOF+ prototype (Sep. 2007)

- Time of flight vs ΔE - 2 A GeV Ni beam scattered by C target



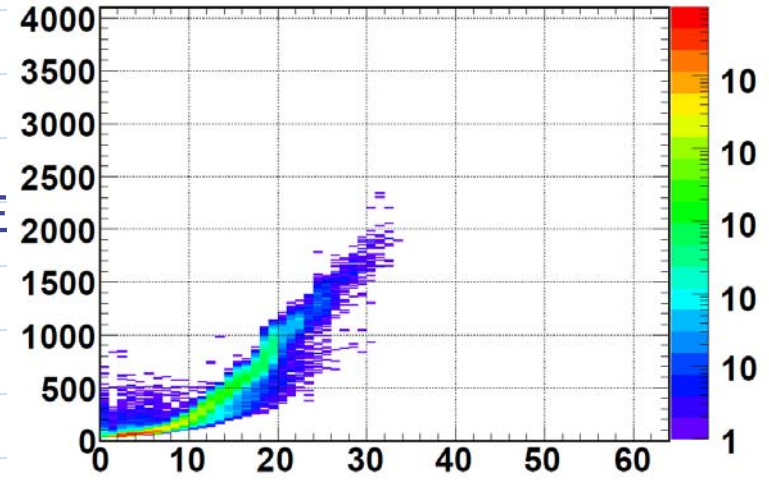
ΔE

Time of flight

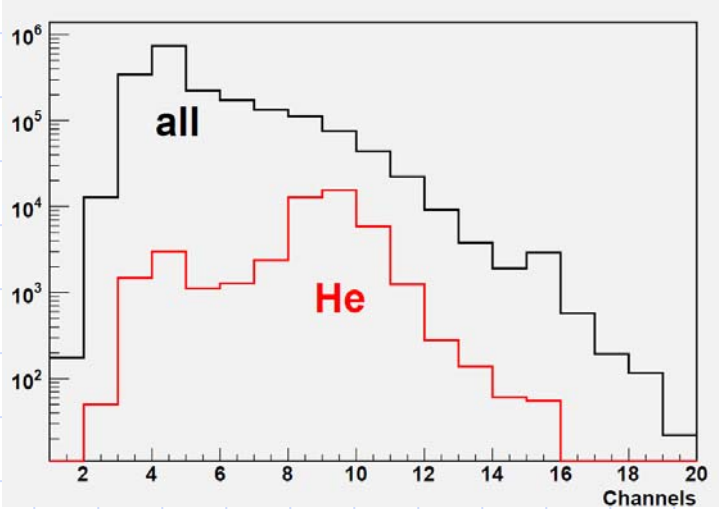


ΔE

- Time over threshold for He trigger



ΔE



Time over threshold measured by Logic module

Summary

- Fast trigger by three functions; secondary vertex trigger, TOF+ He trigger, π^- trigger have been designed for HypHI phase 0 experiment.
- Trigger rate have been studied by MC simulations and obtained results fulfils the requirement by the DAQ system.
- Logic module (VUPROM1) based on FPGA/DSP for trigger logic have been developed for the HypHI trigger
- Basic functions tested with prototype detectors and VUPROM1 shows expected performance.

Future plan

- Realistic design, again with MC simulation and experimental results.
- Beam test Aug. 2008 with full channels of Fiber Tracking detectors.
  - Wave form 1077ch -> 10 modules
  - Vertex trigger for Y plane. ->