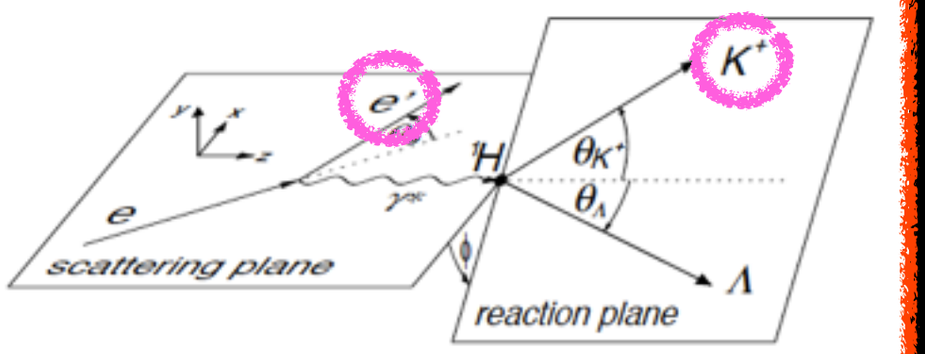
Prototype Plastic Scintillator Testing for KAOS experiment@Mainz

September 8, 2010

Satoshi Hirose (Tohoku),
KAOS Collaboration

Kaon production by electromagnetic interaction

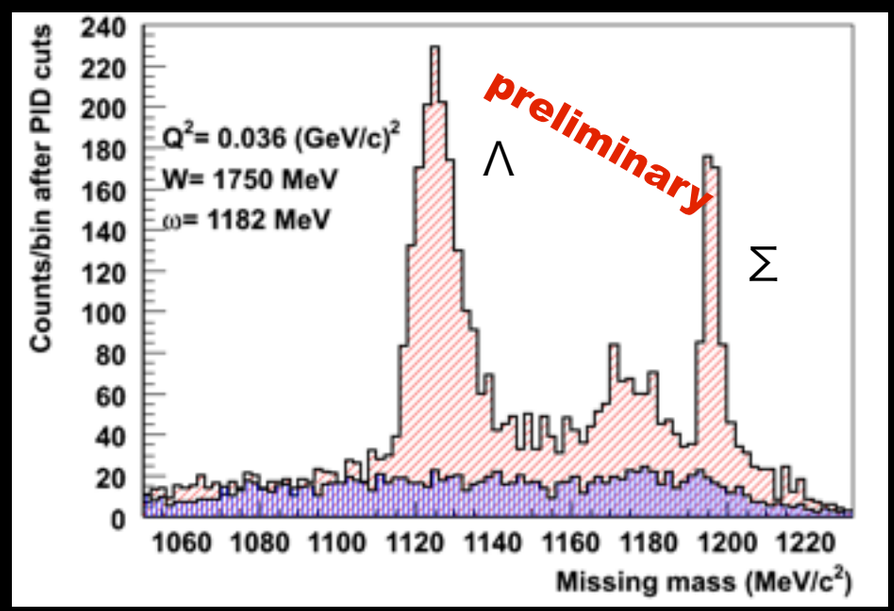


$$E_X = E_e - E_{e'} + M_{targ} - E_K = \omega + M_{targ} - E_K,$$
$$\vec{P}_X = \vec{q} - \vec{p}_K,$$

$$M_X = \sqrt{(\omega - E_K + M_{targ})^2 + p_K^2 - 2p_K|\vec{q}|\cos\theta_K - Q^2}$$

$e + p \rightarrow e' + \Lambda + K^+$

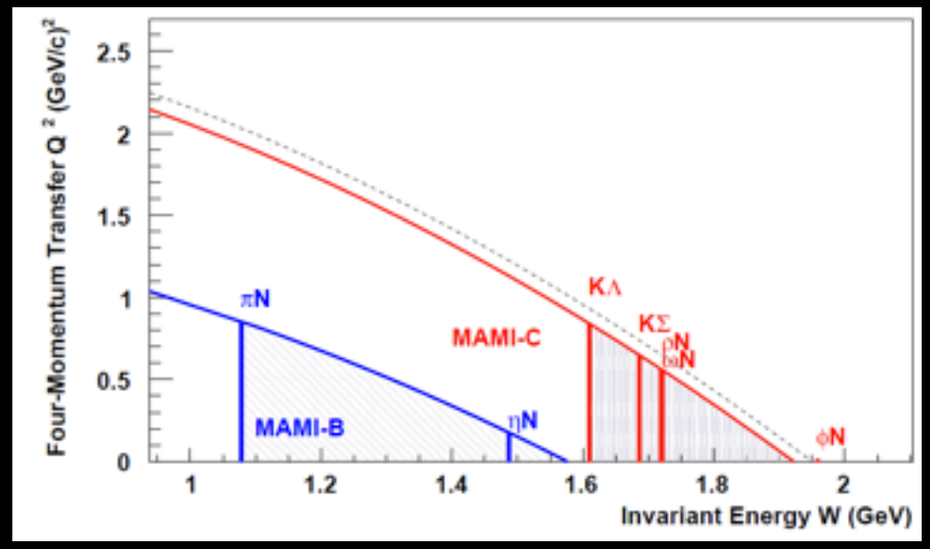
・Missing Mass
・Cross-section



[KAOS at MAMI 2009: preliminary analysis]

Motivation & advantage of KAOS

・ In 2007, MAMI (Minzer Microtron) has been upgraded to 1.5GeV electron beam energy (MAMI-C), crossing the energy threshold for open strangeness production.

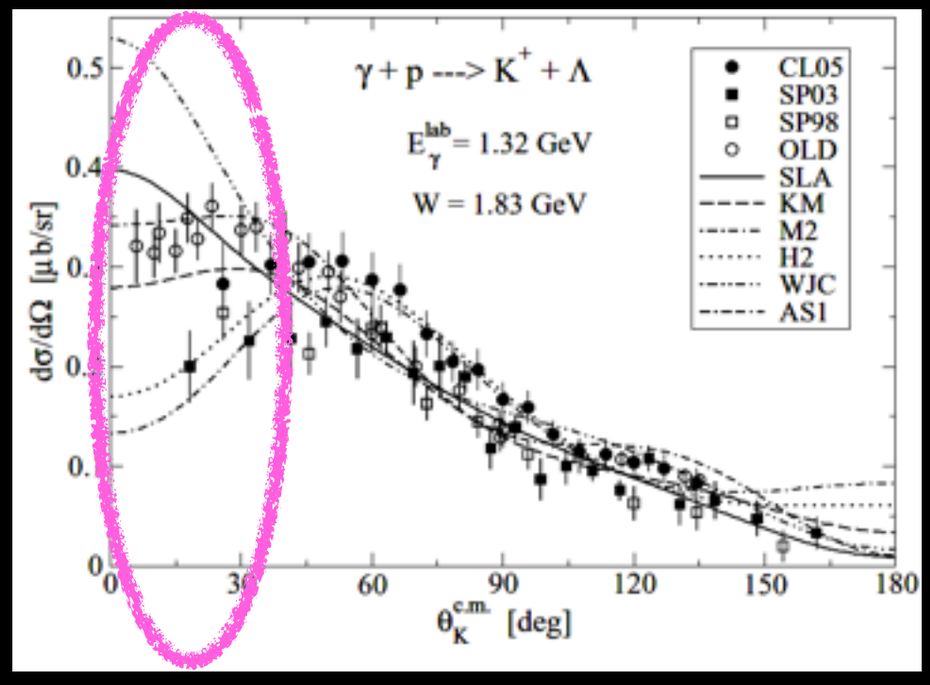


・MAMI-C is suit for researching low momentum transfer in the threshold region.

・be able to create Light Hypernucleus with cryo-target. (ex. ${}^{4}_{\Lambda}\mathrm{He}$)

・Decay pion spectroscopy

・Flexible beam time

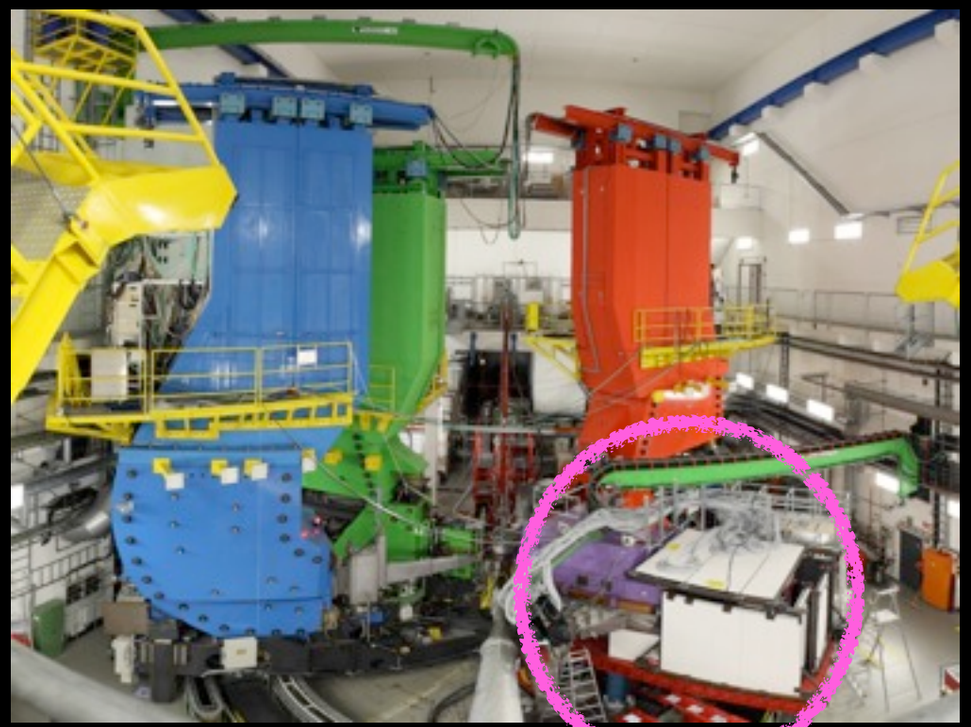


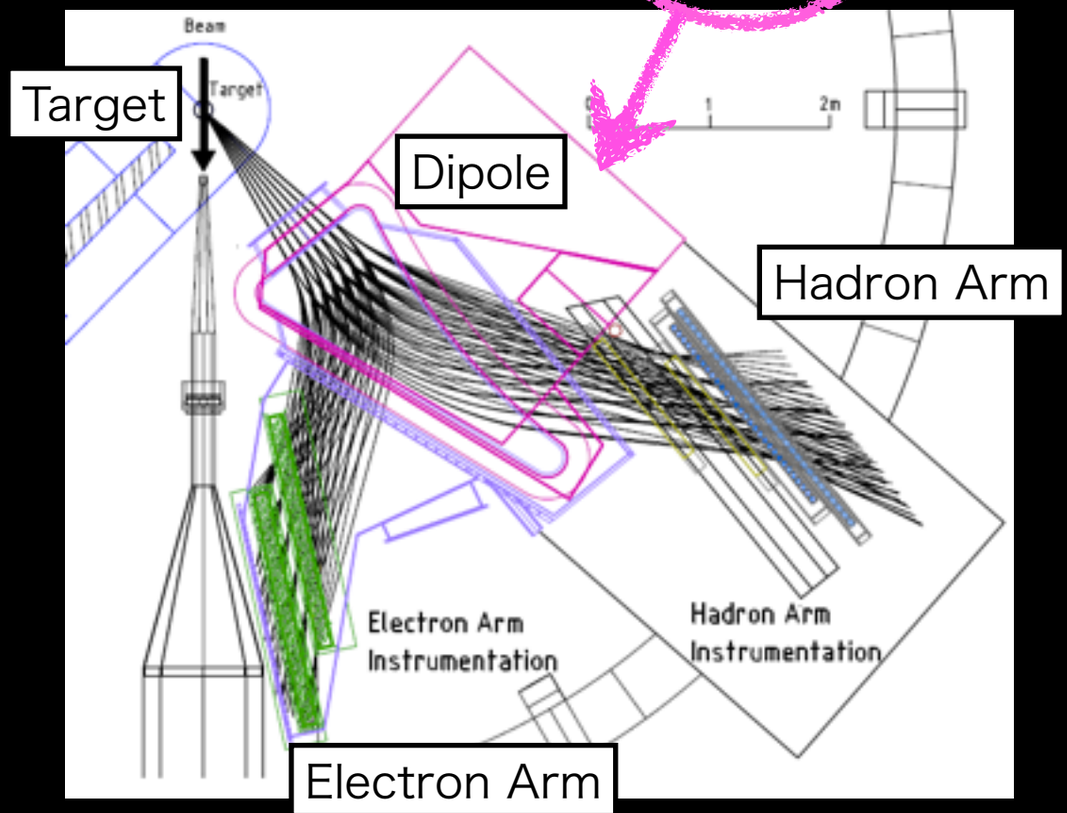
[T. Mart and A. Sulaksono, *Phys.Rev.C 74,055203 (2006).*]

KAOS@Mainz, MAMI-C

MAMI(Mainzer Microtron)
At the Institut für Kernphysik in Mainz

MAMI-C	
max energy	1,508GeV
max current	100μA





- Dipole for splitting charged particles and analyzing momentum
- Hadron arm
  - -two MWPCs for tracking
  - -TOF Walls for PID
- Electron arm
  - -Fiber Scintillation Detector

KAOS@Mainz, MAMI-C

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MAMI-C	
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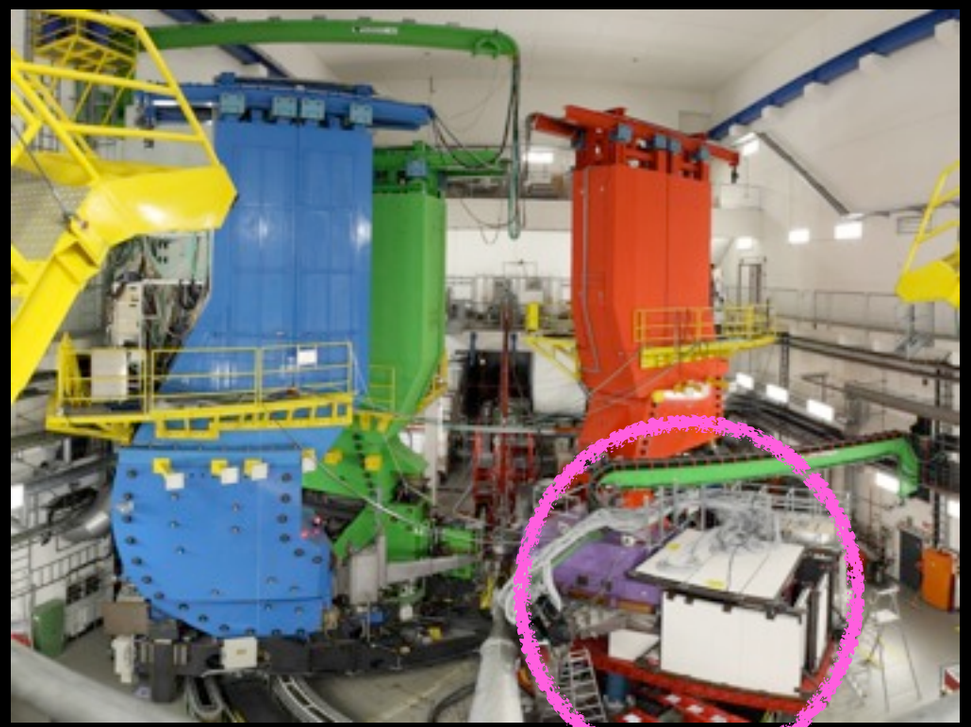

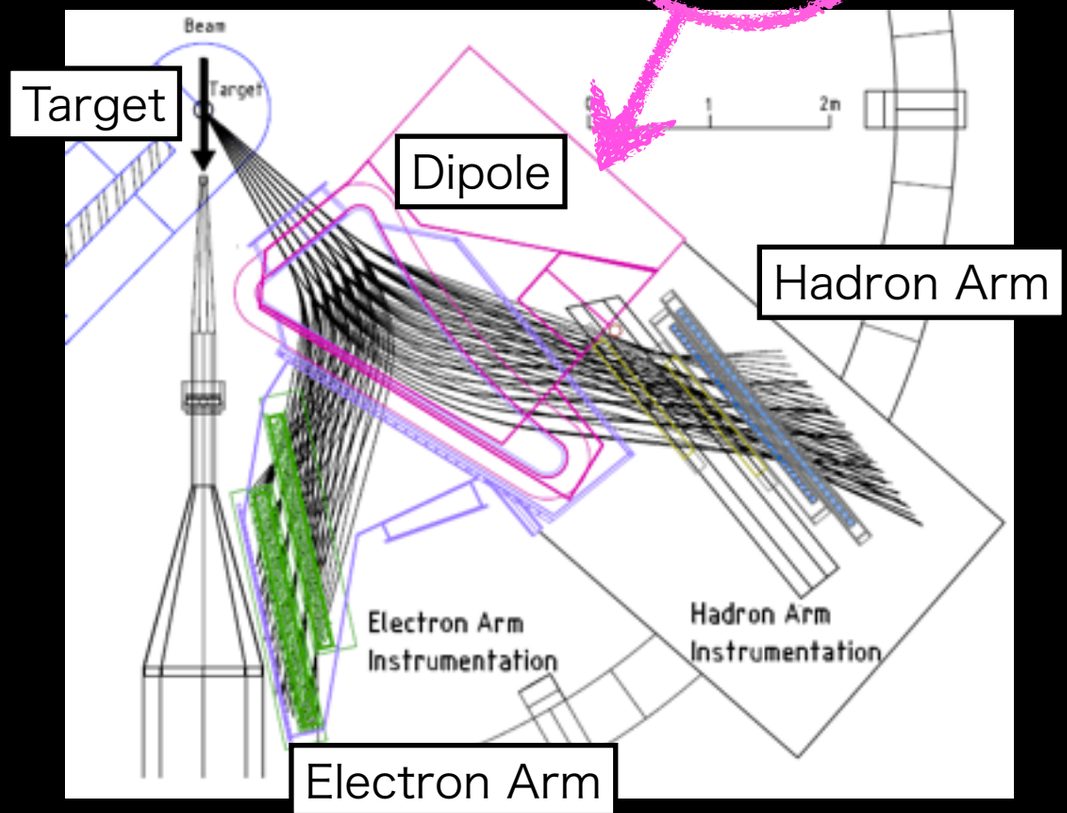

- Dipole for splitting charged particles and analyzing momentum
- Hadron arm
  - -two MWPCs for tracking
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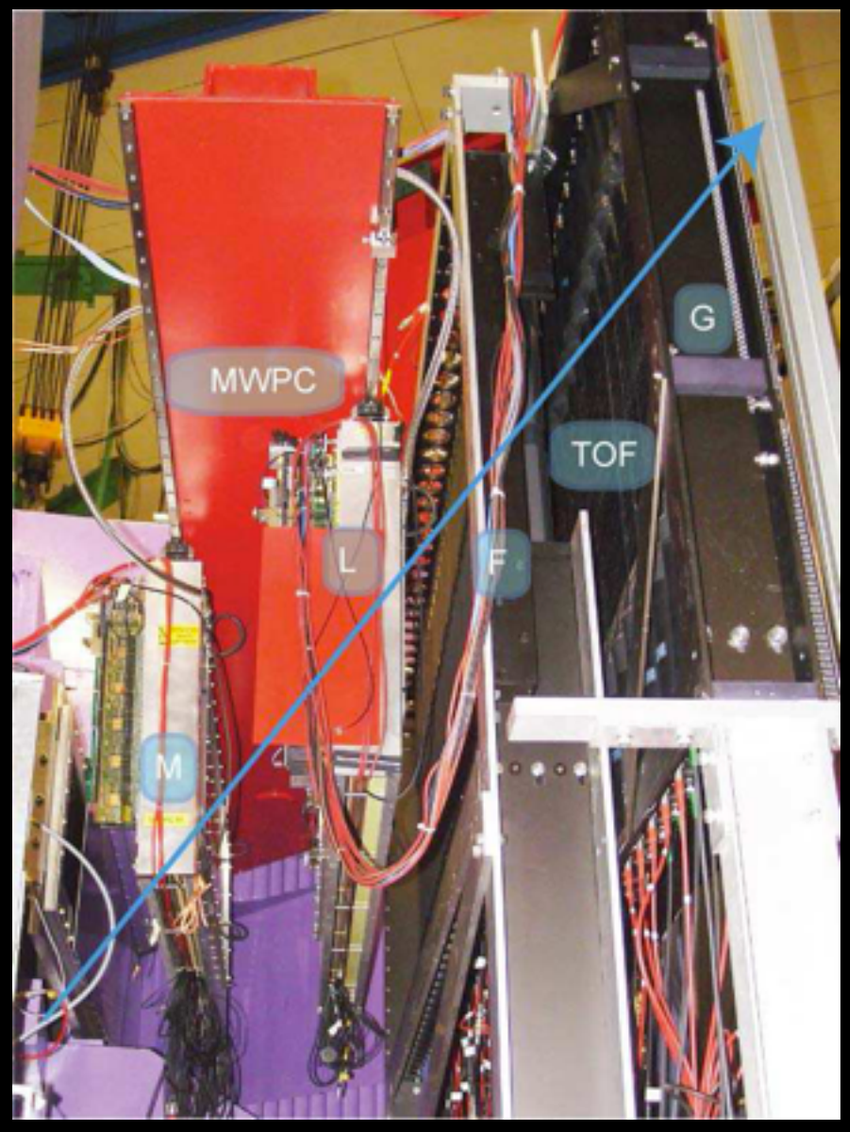
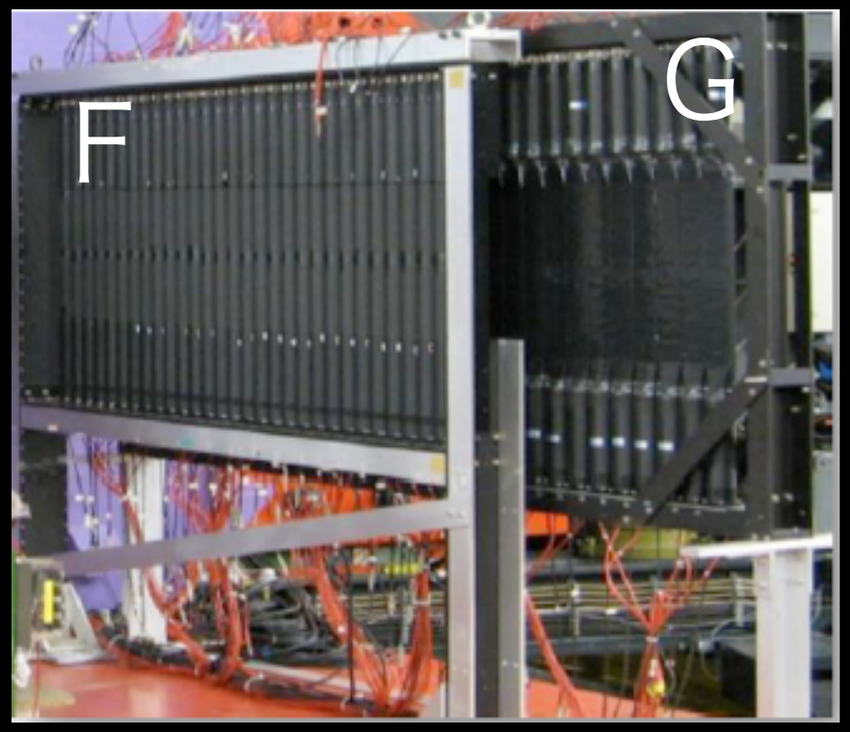
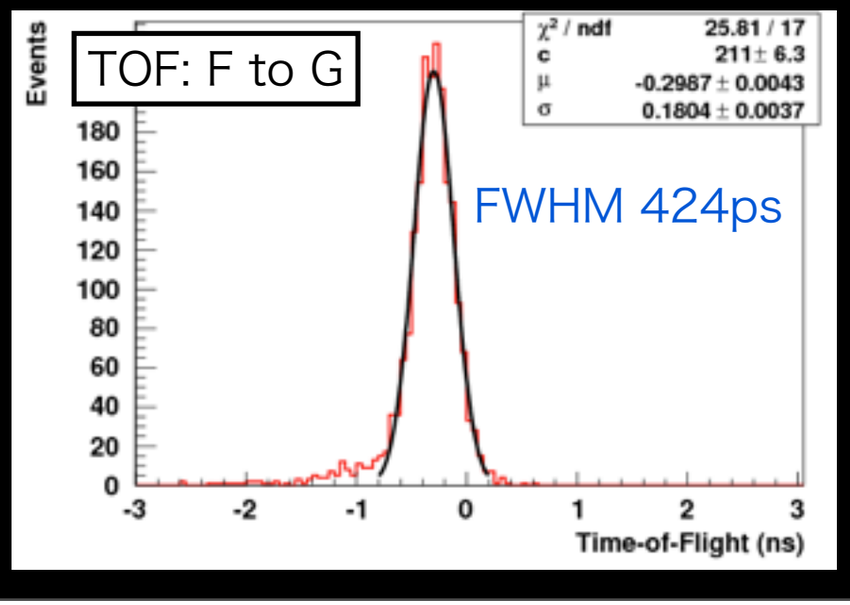
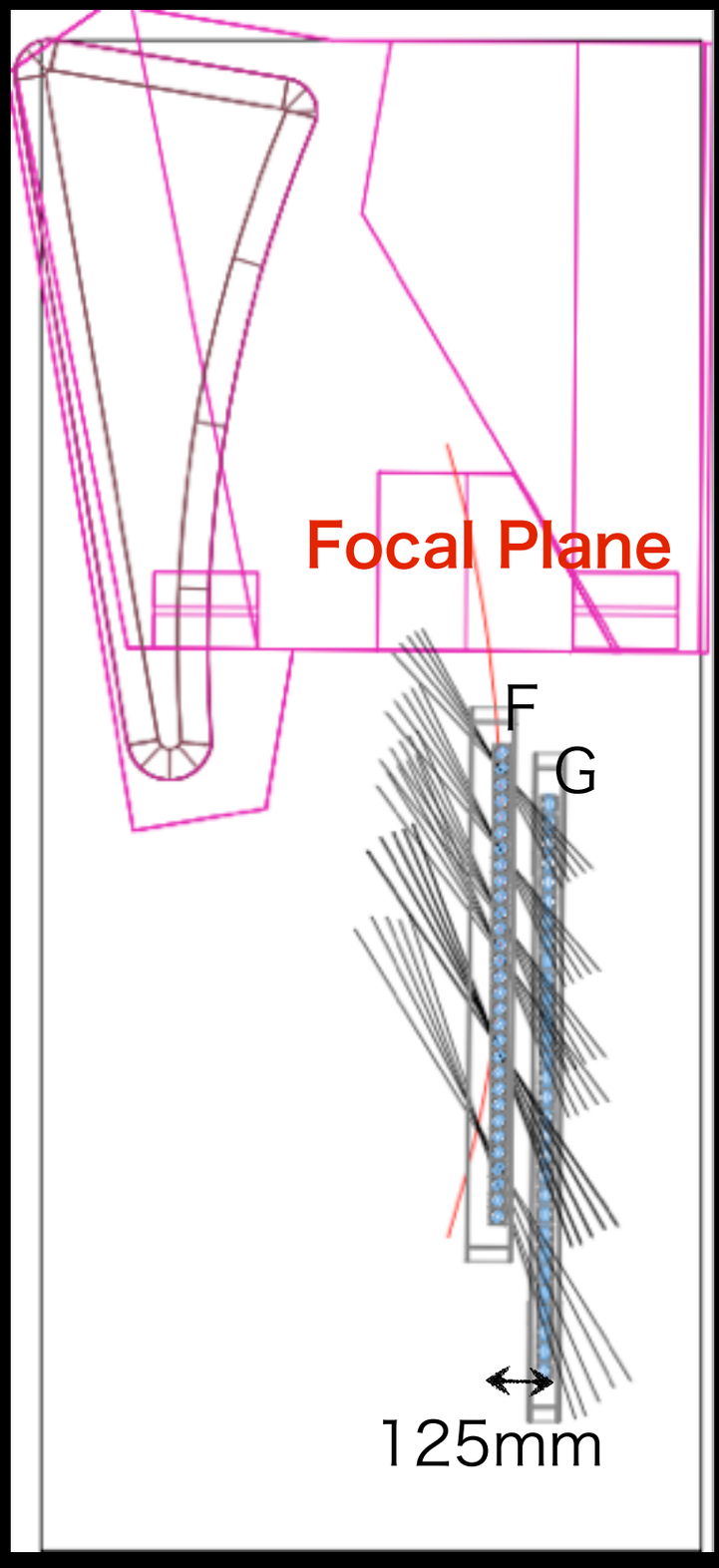
Hadron arm - TOF walls, MWPCs

Each wall consists of
30 plastic scintillators.









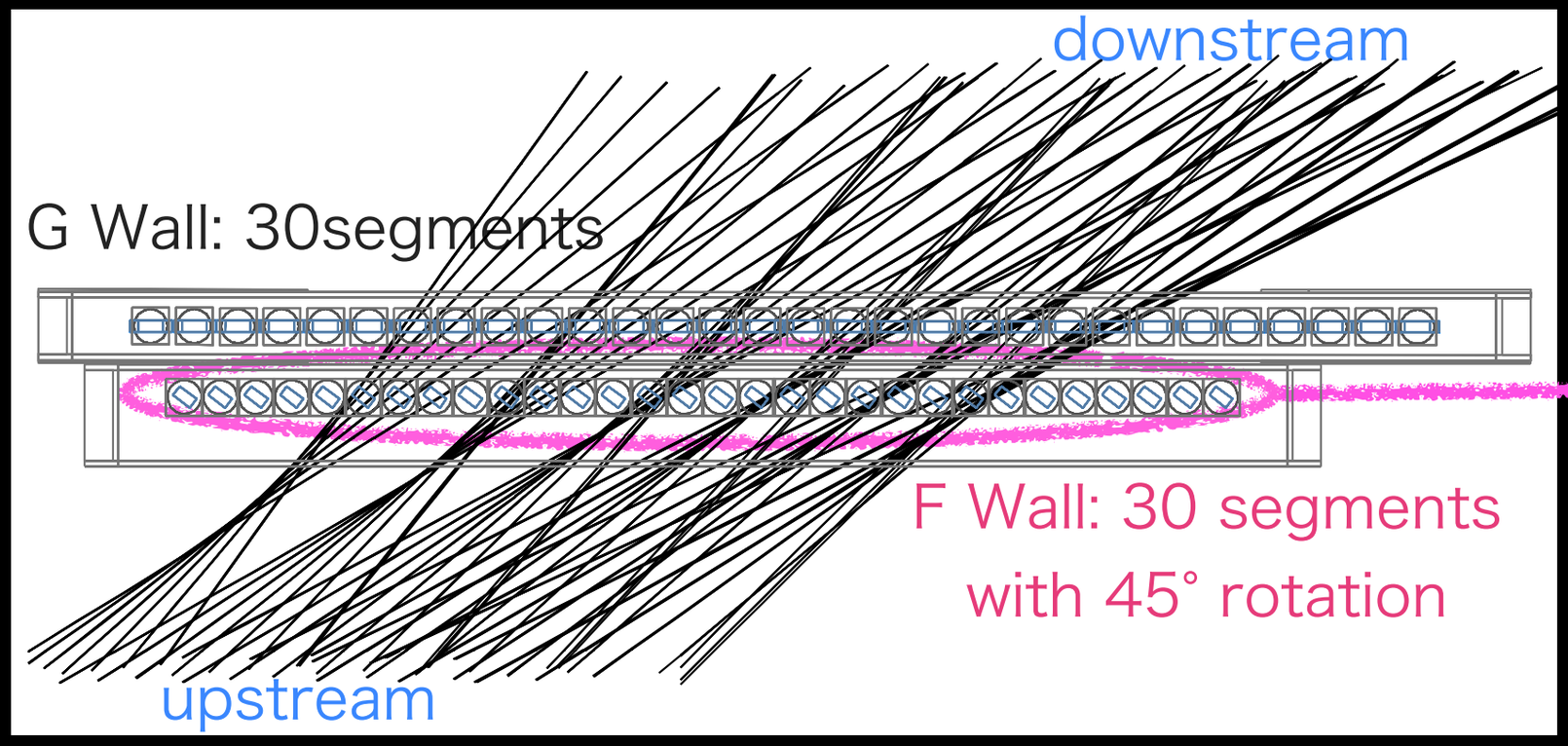
Room of improvement in Hadron arm

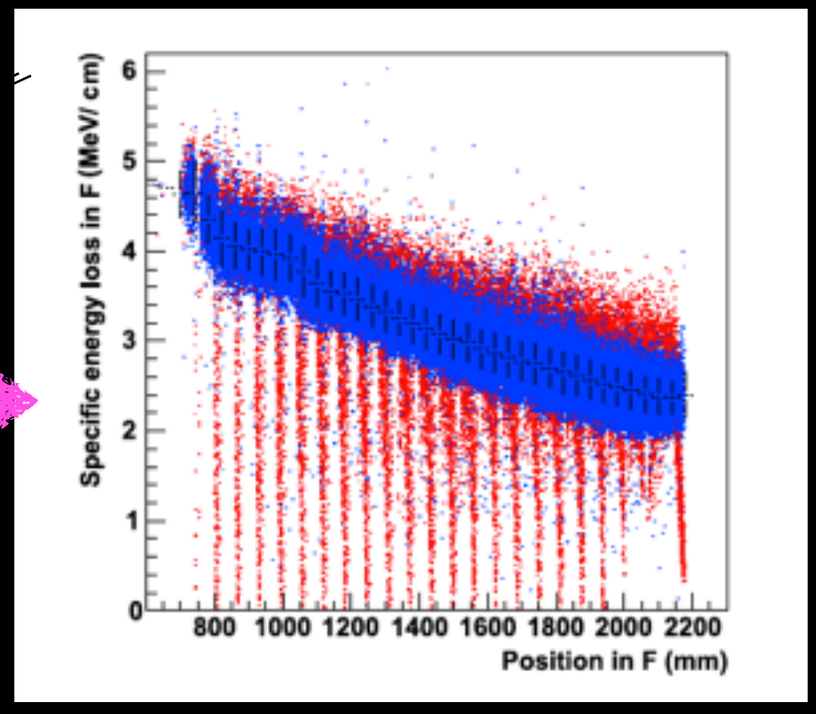
- dE/dx resolution

  Because of the aging of the material, the absorption of the scintillation light inside the scintillator is strong.

- Apertures in F wall

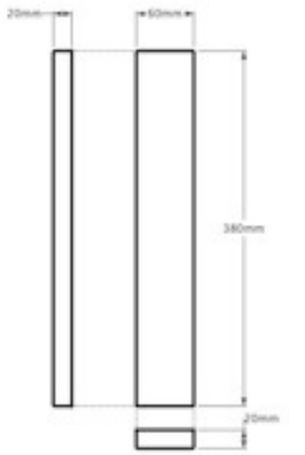
  Scintillators are rotated in order to make the pass length the same length, but particles pass through the apertures.



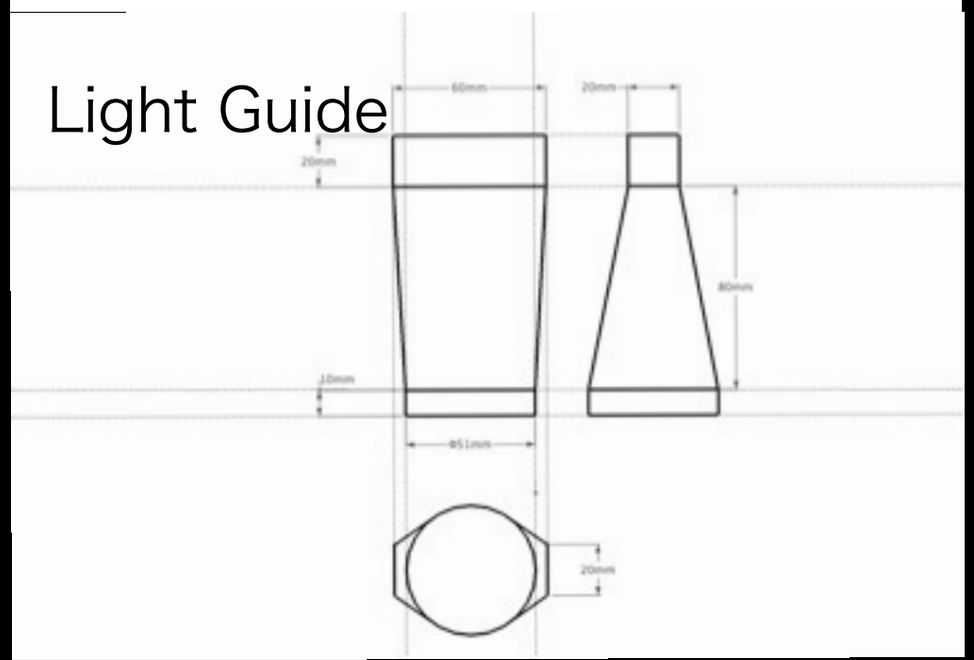


Prototype Plastic Scintillator

Scintillator



Light Guide



Scintillator dimensions	380×60×20mm^2
Material	Bicron BC-408
Fish tail length	110mm
Fish tail diameter	51mm
PMT type	Hamamatsu H1949

Technical Data

Physical Constants of SGC Plastic Scintillators

Scintillator	Light Output % Anthracene[1]	Wavelength of Maximum Emission, nm	Decay Constant, Main Component, ns	Bulk Light Attenuation Length, cm	Refractive Index	H:C Ratio	Loading Element % by weight	Density	Softening Point °C
BC-400	65	423	2.4	250	1.58	1.103		1.032	70
BC-404	68	408	1.8	160	1.58	1.107		1.032	70
BC-408	64	425	2.1	380	1.58	1.104		1.032	70
BC-412	60	434	3.3	400	1.58	1.104		1.032	70
BC-414	68	392	1.8	100	1.58	1.110		1.032	70
BC-416	38	434	4.0	400	1.58	1.110		1.032	70
BC-418	67	391	1.4	100	1.58	1.100		1.032	70
BC-420	64	391	1.5	110	1.58	1.100		1.032	70
BC-422	55	370	1.6	8	1.58	1.102		1.032	70
BC-422Q	11	370	0.7	<8	1.58	1.102	Benzephenone,1%*	1.032	70
BC-428	36	480	12.5	150	1.58	1.103		1.032	70
BC-430	45	580	16.8	NA	1.58	1.108		1.032	70
BC-436	52	425	2.2	NA	1.61	0.960 D:C	Deuterium,13.8%	1.130	100
BC-440	60	434	3.3	400	1.58	1.104		1.032	99
BC-440M	60	434	3.3	380	1.58	1.104		1.039	100
BC-444	41	428	285	180	1.58	1.109		1.032	70
BC-444G	34	490	285	180	1.58	1.109		1.032	70
BC-452	32	424	2.1	150	1.58	1.134	Lead,5%	1.080	60
BC-454 5%	48	425	2.2	120	1.58	1.169	Boron,5%	1.026	60
BC-480	**	425	—	400	1.58	1.100		1.032	70
BC-482A	QE=.86	494	12.0	300	1.58	1.110		1.032	70
BC-490	55	425	2.3	NA	1.58	1.107		1.032	70
BC-498	65	423	2.4	NA	1.58	1.103		1.032	70

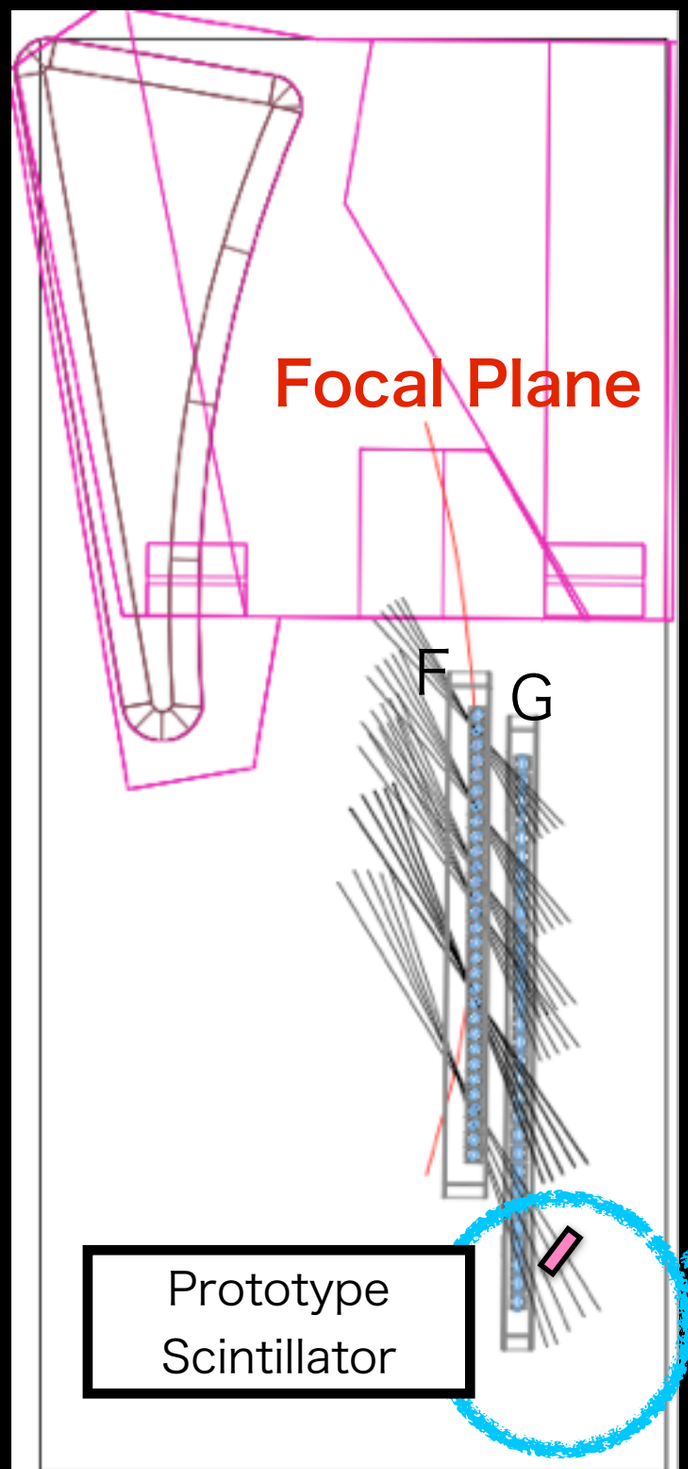
[1] Anthracene light output = 40-50% of NaI(Tl)

* 0.1 to 5 weight % also available

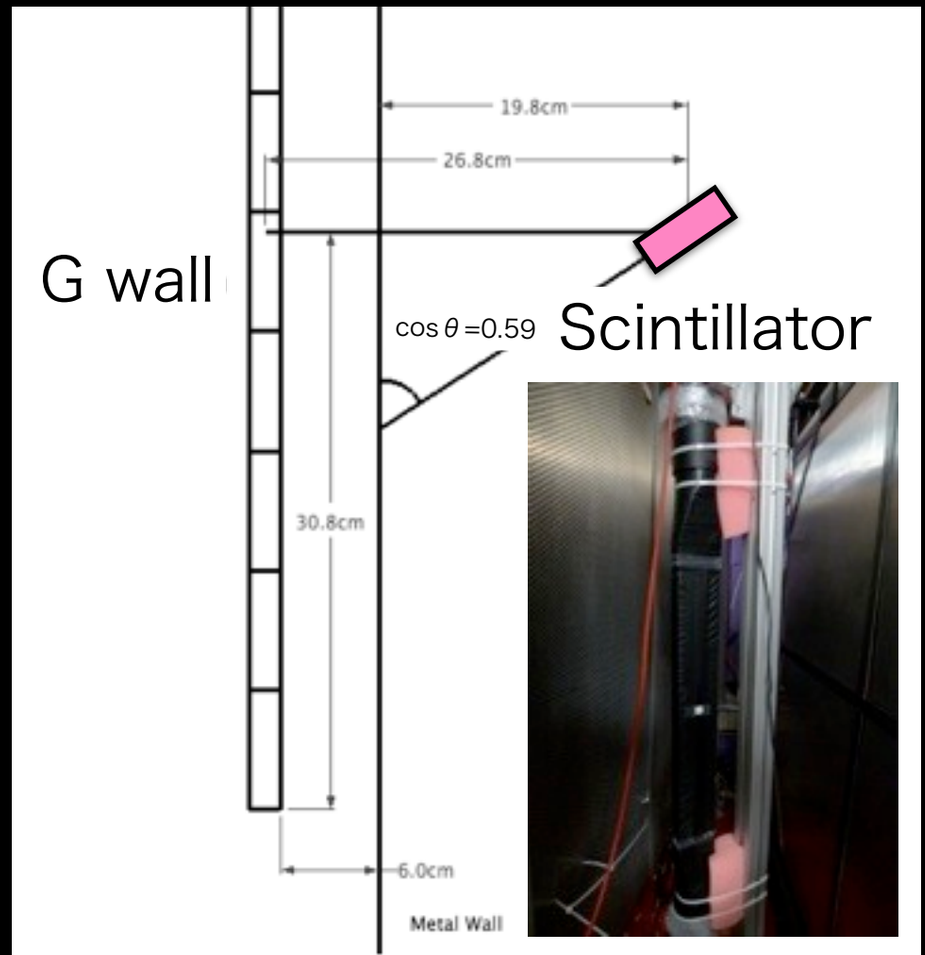
** Ratio of Cerenkov light to scintillator light = 10:1

Setup of test beam time

(August 24 - 29, 2010)

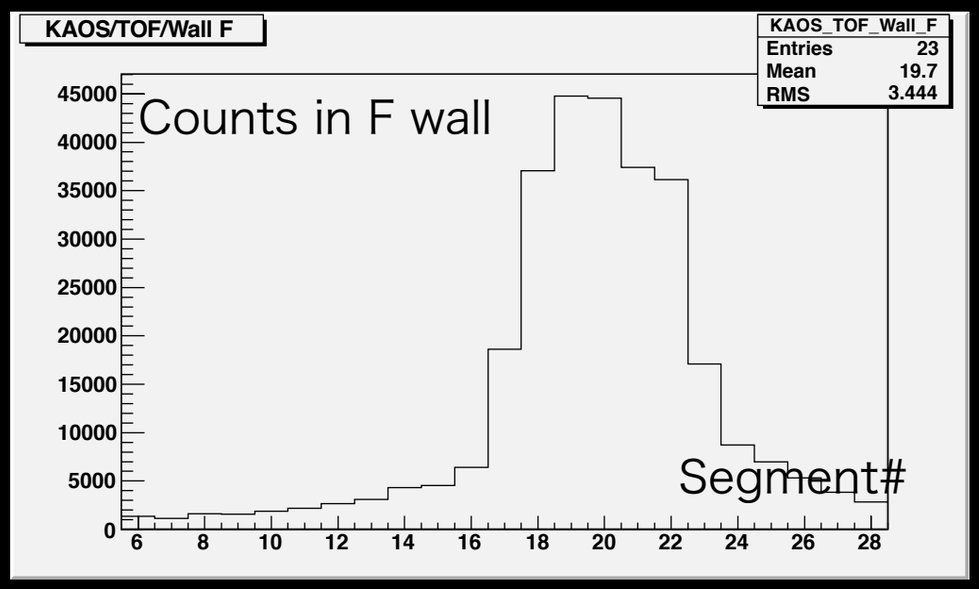


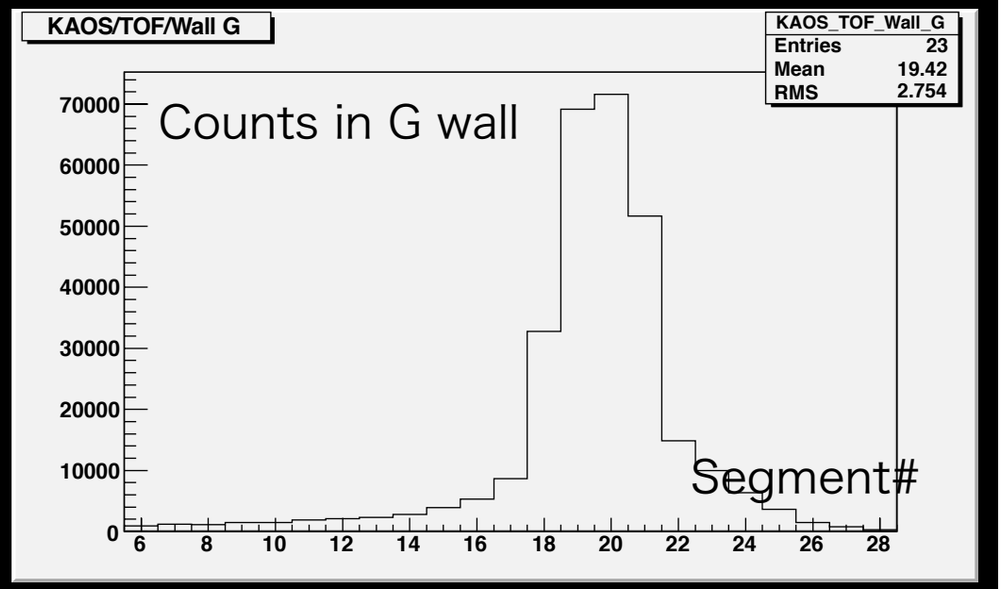
Beam energy		510MeV
Beam intensity		0.1-30uA
Target		12C: 45mg/cm^2
KAOS angle		37.5 deg.
magnetic field strength		0.718T
The center mom.		540MeV
HV of Proto Paddle's PMT		-1678V/-1699V

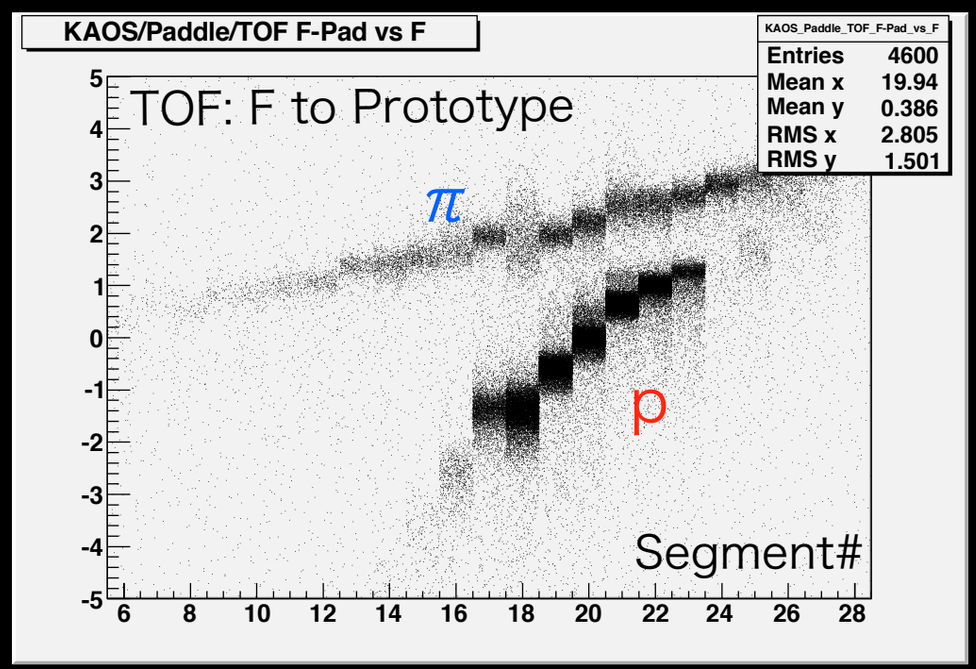


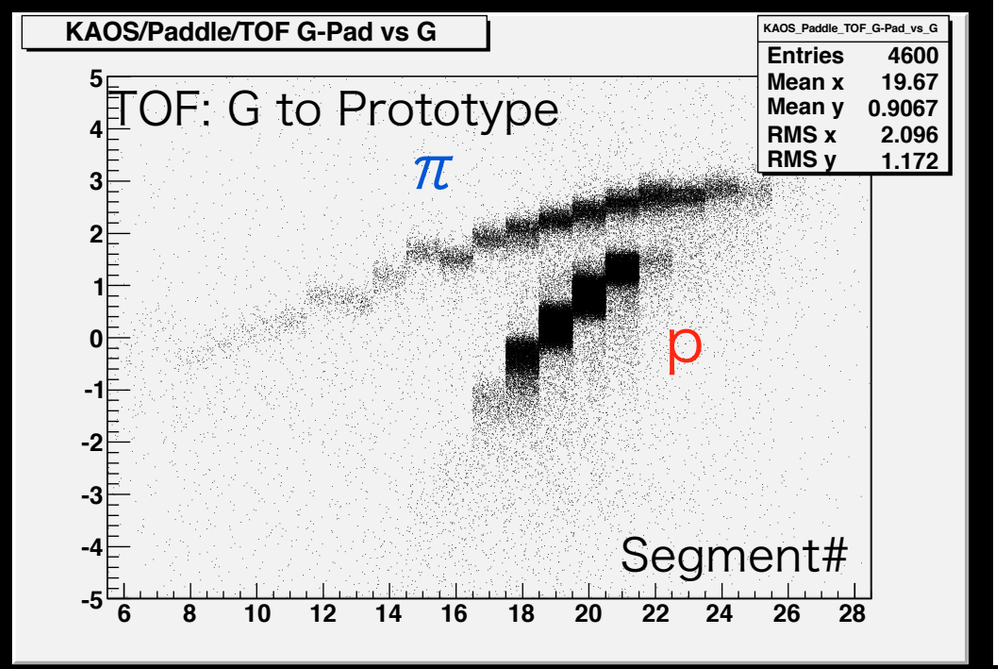
Results

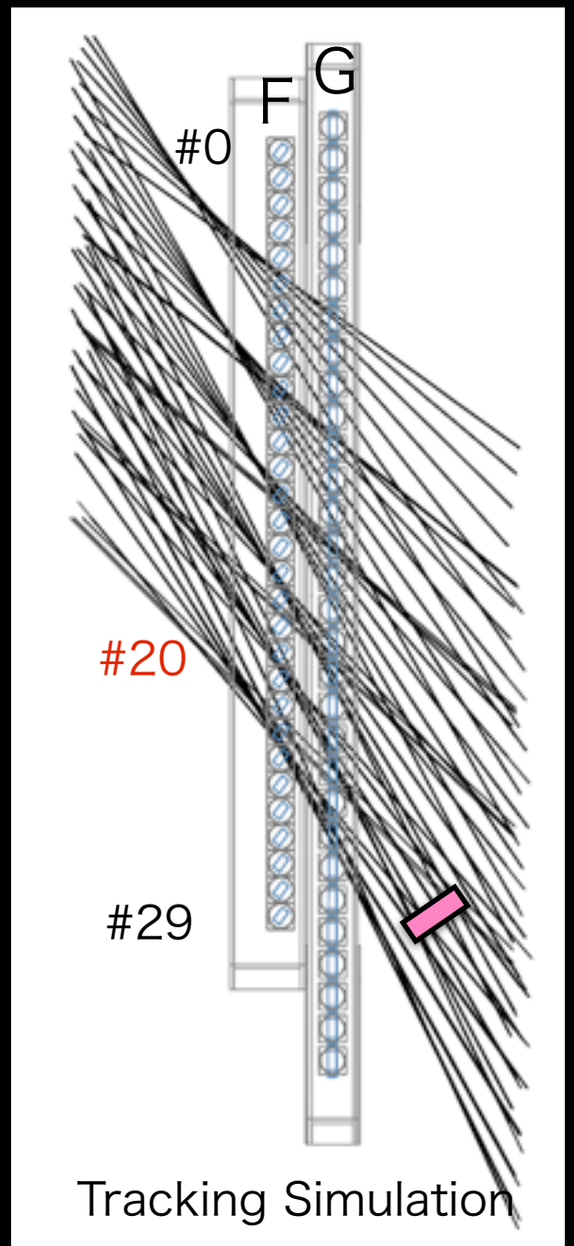
- Trigger: any F & any G & Prototype Scintillator





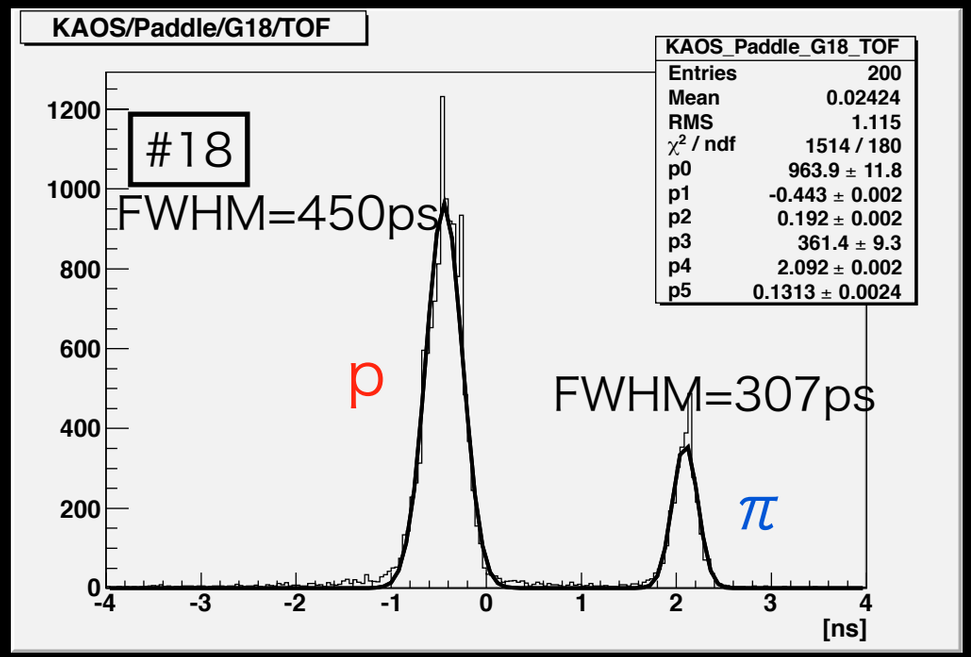


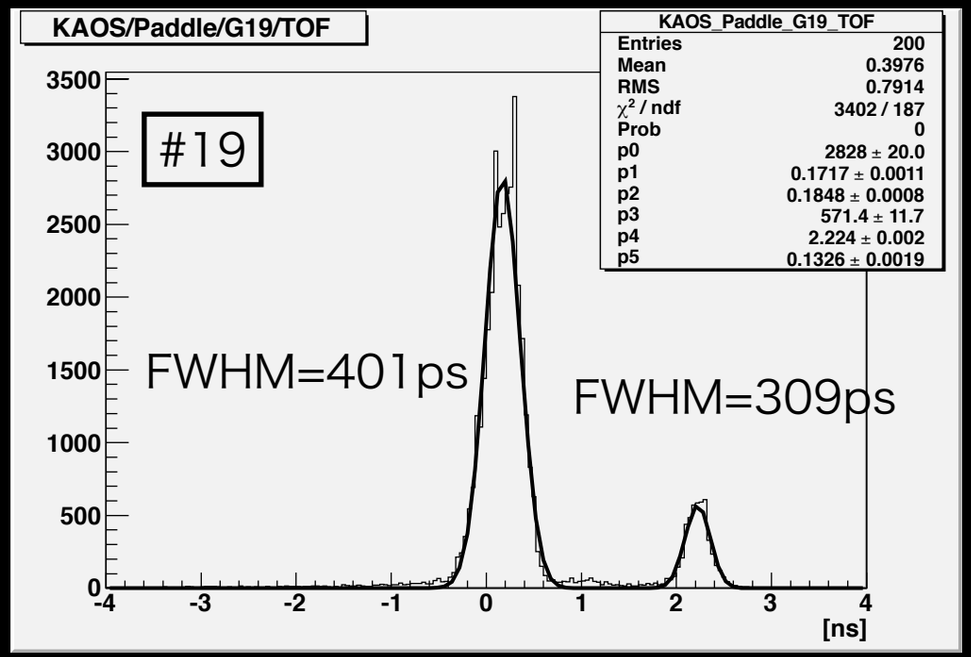


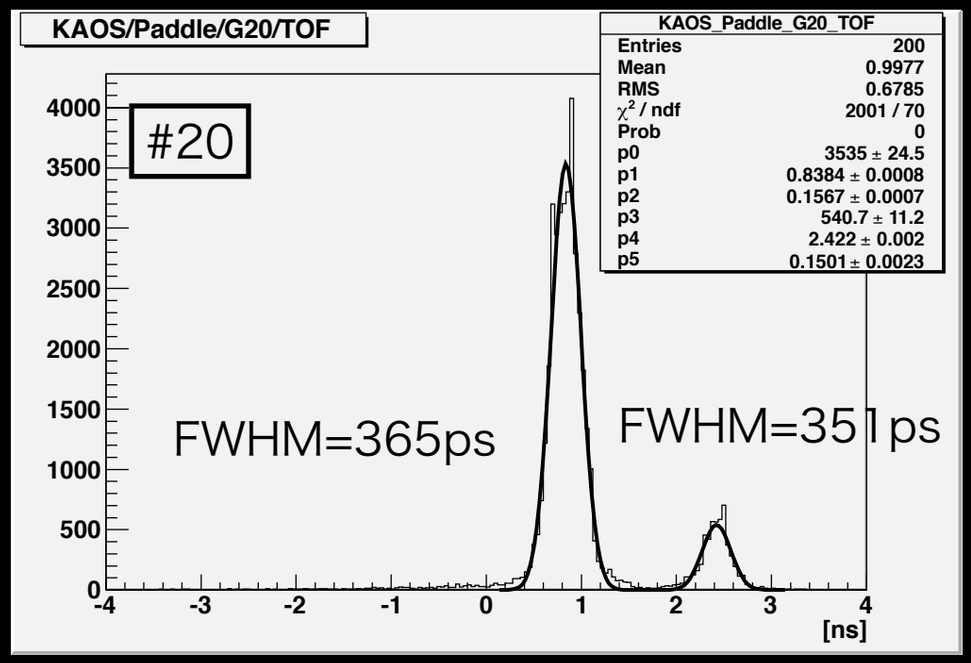


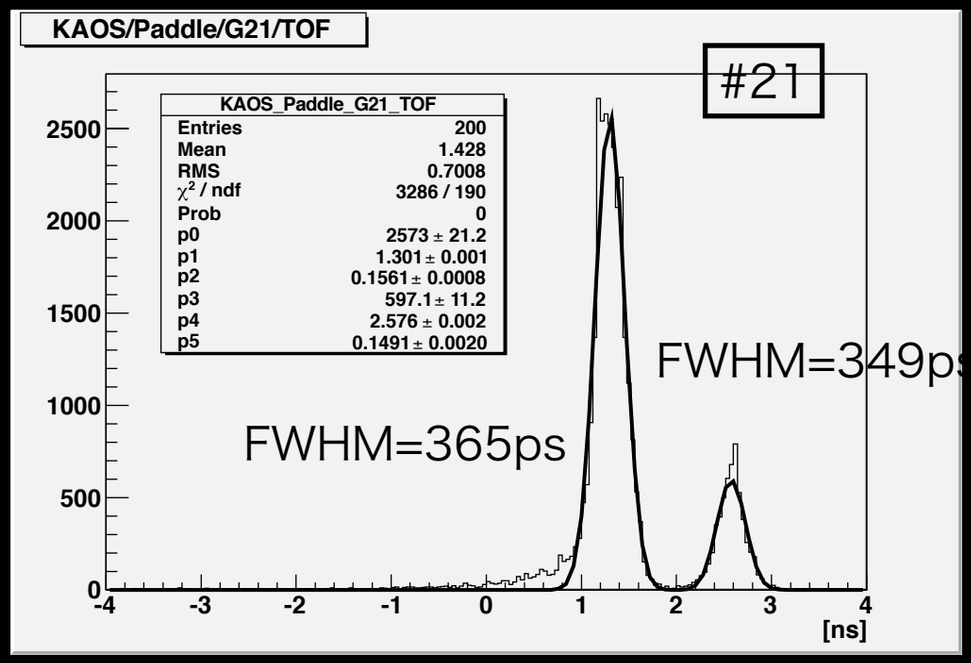
Results

TOF: each G segments to the Prototype Scintillator



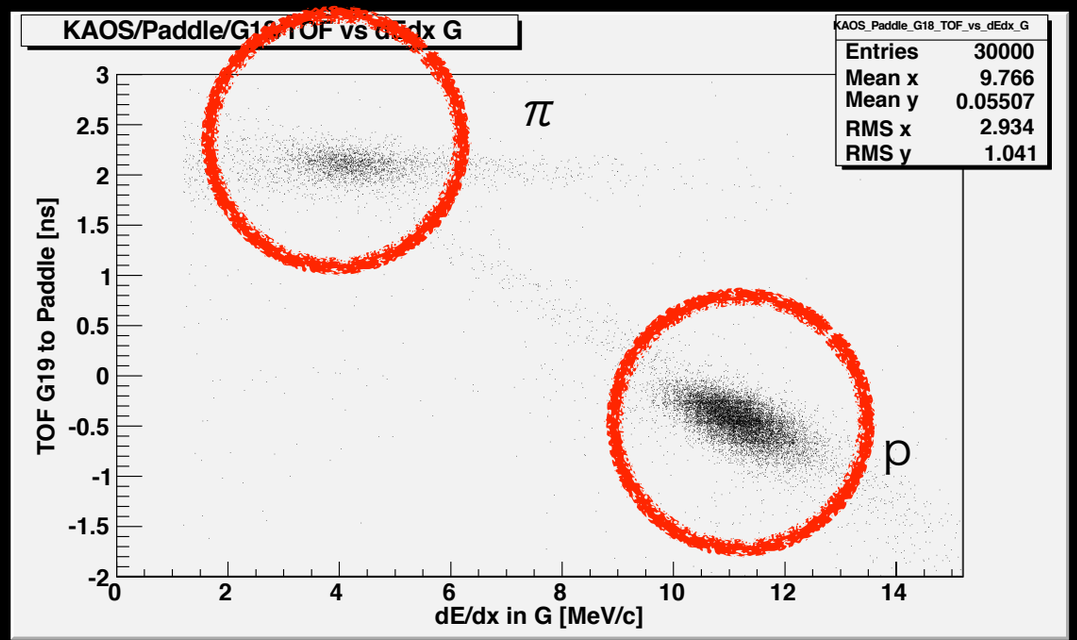




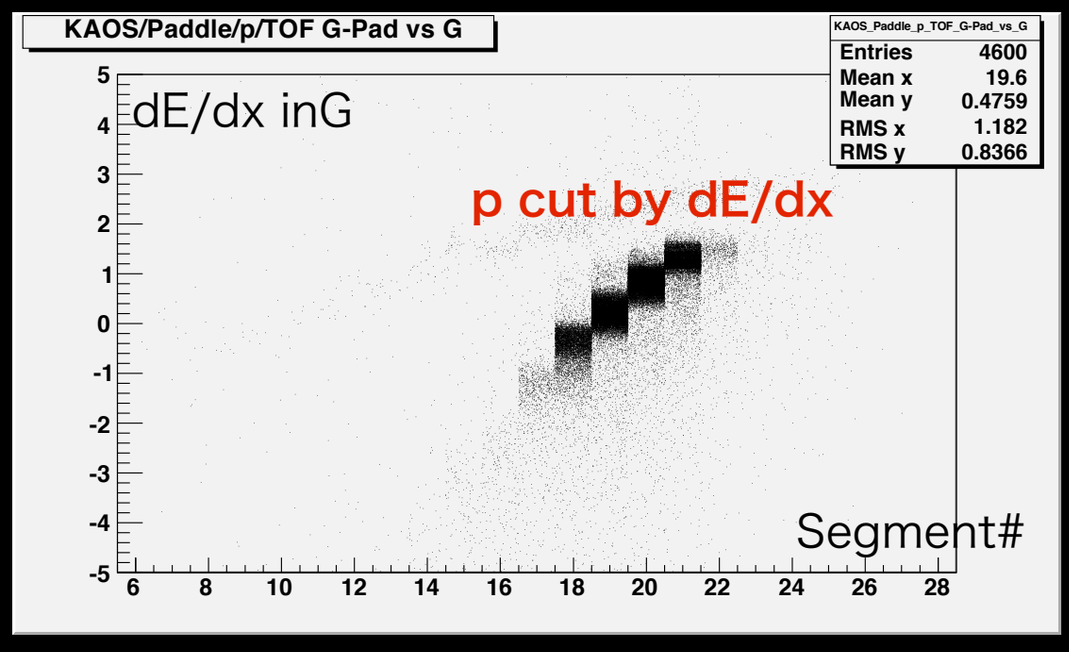


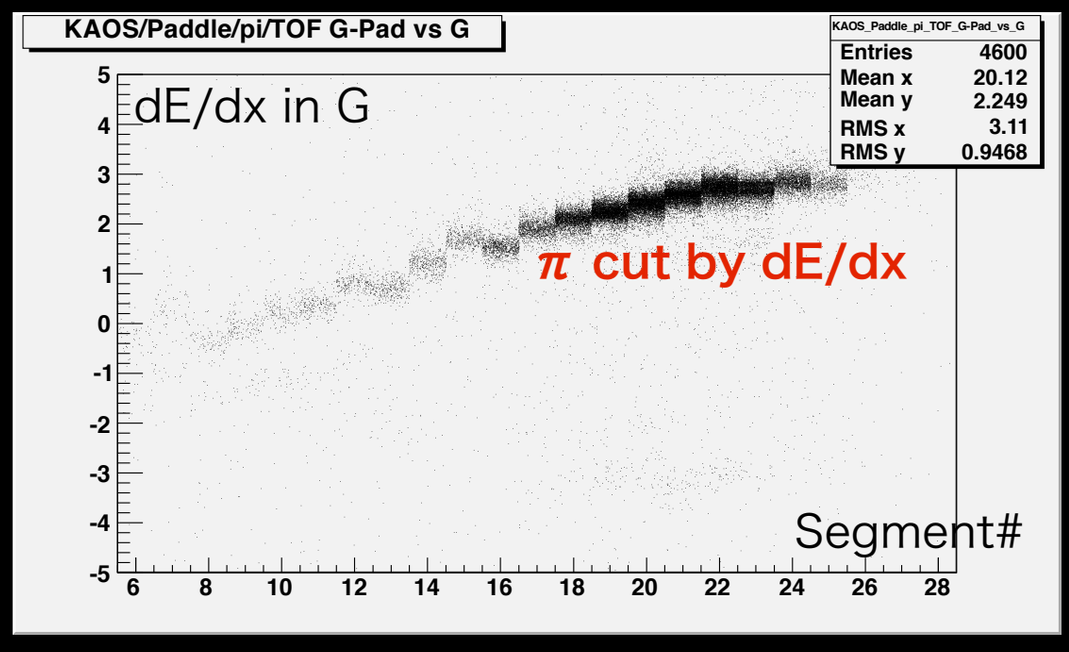
No time-walk corrections were applied yet.

Results



separated π and p





Summary & TO DO

- We successfully curried out detectors test beam for improving KAOS detectors.
- The result shows good resolution of prototype scintillator and complete separation of π and p.
- Plans
  - September: To order the mass production
  - December: To construct new Scintillation wall.
  - Winter: KAOS spectrometer test at zero degree with chicane

END

Back up

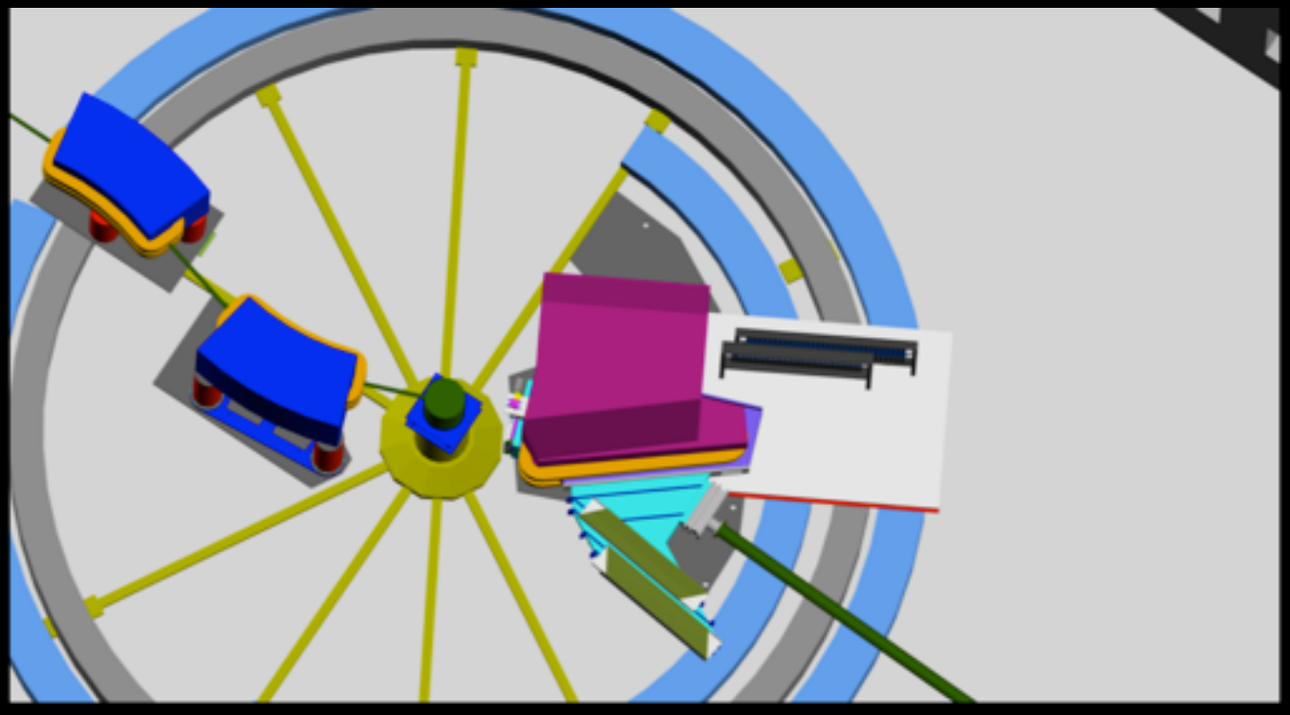
Test beam analysis

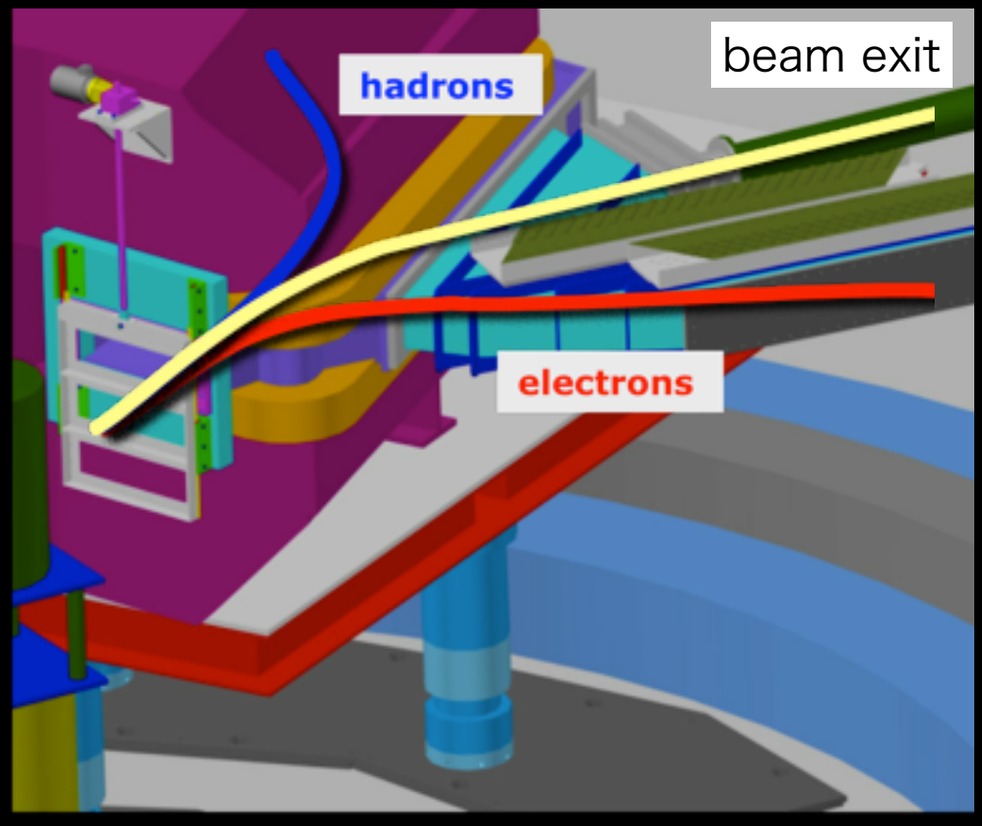
paddle no.	x (cm)	p (MeV/c)	Lorentz β		length (cm)	Δt G–P		
			π	p		π (ns)	p (ns)	π–p (ns)
18	52.8	+5%	0.97	0.52	59.2	0.65	3.18	2.53
19	45.2	+8.5%	0.97	0.53	52.6	0.52	2.57	2.05
20	37.6	+12%	0.97	0.54	46.2	0.32	1.90	1.58
21	30.0	+16%	0.98	0.55	40.2	0.17	1.44	1.27
22	22.4	+19%%	0.98	0.56	34.9	0.00	—	
23	14.8	+23.5%	0.98	0.58	30.6	-0.04	—	

Specification of KAOS dipole

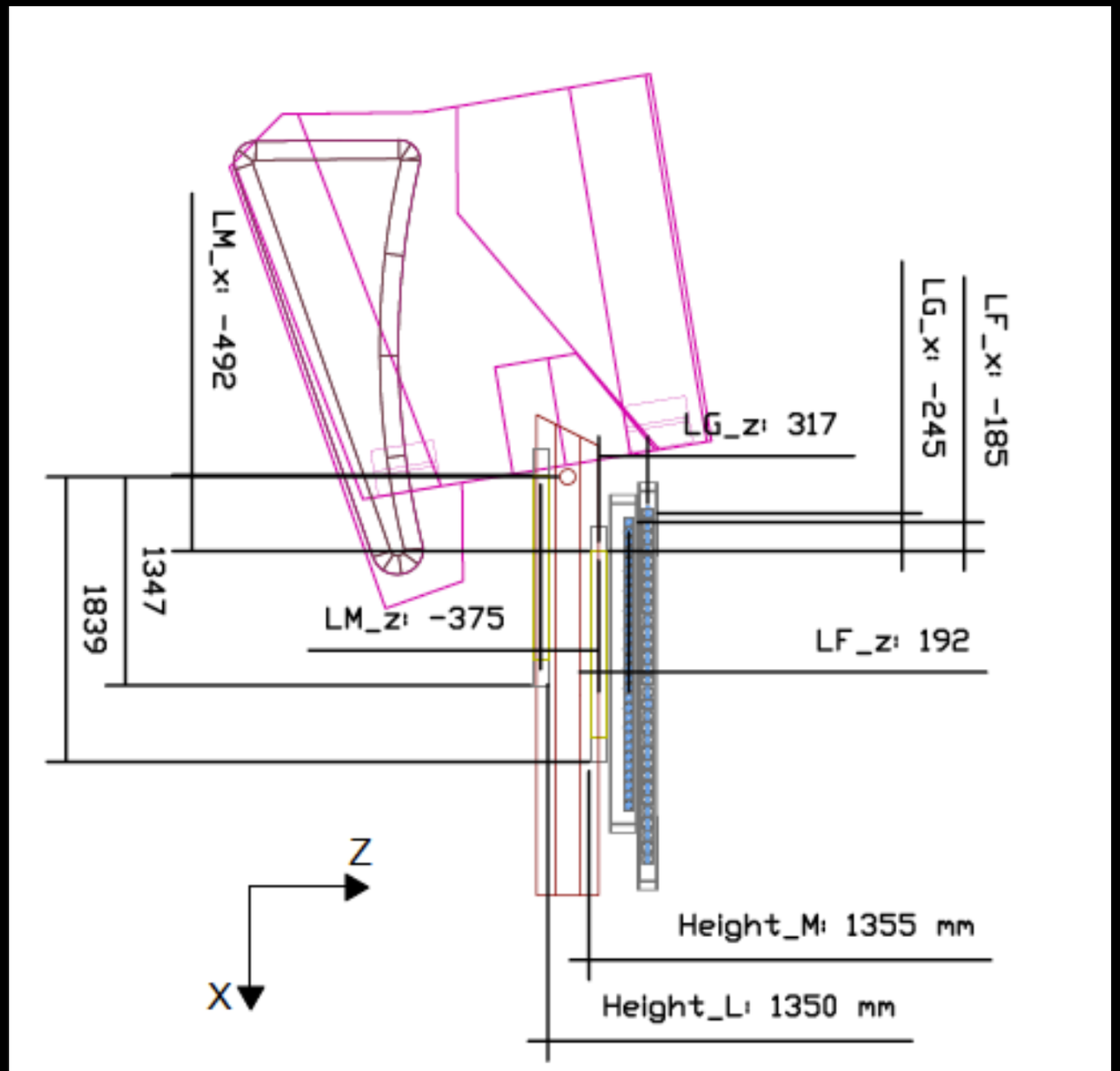
	SpekB	KAOS hadron arm
maximum momentum (MeV)	870	2 100
momentum acceptance (%)	15	50
solid angle acceptance (msr)	5.6	10.4
dispersive angle acceptance (mrad)	±70	±185
do. (°)	±4	±10.5
non-dispersive angle acceptance (mrad)	±20	±14
do. (°)	±1.15	±0.8
length of central trajectory (m)	12.03	5.3
angle of focal-surface (°)	47	~ 45
length of focal-surface (m)	1.8	~ 1.2
dispersion at central trajectory (cm/%)	8.22	2.4
magnification at central trajectory	0.85	2.0
dispersion to magnification (cm/%)	9.64	1.2
first-order resolving power	19 000	2 400
first-order momentum resolution	$< 10^{-4}$	$\sim 10^{-3}$

Installation of a beam chicane for the zero degrees operation





Hadron arm


LM_x: -492
LG_x: -245
LF_x: -185
LG_z: 317
1839
1347
LM_z: -375
LF_z: 192
Z
X
Height_M: 1355 mm
Height_L: 1350 mm

Trigger Rates

I (μA)	trigger type	R (kHz)
1	P	2.2
4	P & any F & any G	0.45
10	P	21.5
10	P & any F & any G	0.9
30	P	71.5
30	P & any F & any G	8.0

Run summary

	Start Time	Stop Time	measuring time	Trigger	center mom. of p	Dipole Field	Prot HV	Beam Current	PMT Threshold	TOF wall TH	Trigger Rate	Target
	run_2010-08-26-15-05-39	run_2010-08-26-15-22-41	17min	any paddle	200 MeV/c	0.26T	-2000	0.1uA		1980		C12, 45mg/cm^2
	run_2010-08-26-15-22-51	run_2010-08-26-15-26-11	4min	any paddle	200 MeV/c	0.26T	-2000	0.1uA		1980		C12, 45mg/cm^2
	run_2010-08-26-15-27-18	run_2010-08-26-15-33-06	6min	any paddle	200 MeV/c	0.26T	-2000	0.1uA		1980		C12, 45mg/cm^2
	run_2010-08-26-15-33-51	run_2010-08-26-15-35-02	2min	any paddle	200 MeV/c	0.26T	-2000	0.1uA		1980		C12, 45mg/cm^2
	run_2010-08-26-15-35-24	run_2010-08-26-15-39-55	4min	tracking (making bands)	200 MeV/c	0.26T	-2000	0.1uA		2020		C12, 45mg/cm^2
	run_2010-08-26-15-40-39	run_2010-08-26-15-51-57	11min	anyF&anyG	200 MeV/c	0.26T	-2000	0.1uA		2020		C12, 45mg/cm^2
	run_2010-08-26-15-26-25	run_2010-08-26-16-50-33	24min	anyF&anyG&prot	200 MeV/c	0.26T	-2200	0.1uA		2010		C12, 45mg/cm^2
	run_2010-08-26-16-55-38	run_2010-08-26-17-00-19	5min	anyF&anyG&prot	200 MeV/c	0.26T	-1600	4uA				C12, 45mg/cm^2
	run_2010-08-26-17-00-55	run_2010-08-26-17-06-53	6min	anyF&anyG&prot	200 MeV/c	0.26T	-1700	4uA				C12, 45mg/cm^2
	run_2010-08-26-17-07-17	run_2010-08-26-17-16-31	9min	anyF&anyG&prot	200 MeV/c	0.26T	-1800	4uA				C12, 45mg/cm^2
	run_2010-08-26-17-16-53	run_2010-08-26-17-26-02	10min	anyF&anyG&prot	200 MeV/c	0.26T	-1900	4uA				C12, 45mg/cm^2
	run_2010-08-26-17-26-39	run_2010-08-26-17-35-35	9min	anyF&anyG&prot	200 MeV/c	0.26T	-2000	4uA				C12, 45mg/cm^2
	run_2010-08-26-17-41-22	run_2010-08-26-17-50-02	9min	anyF&anyG&prot	200 MeV/c	0.26T	-2000	4uA				C12, 45mg/cm^2
	run_2010-08-26-18-00-50	run_2010-08-26-19-32-14	90min	anyF&anyG&prot	200 MeV/c	0.26T	-2000	4uA				C12, 45mg/cm^2
	run_2010-08-26-21-15-28	run_2010-08-26-21-21-55	6min	anyF&anyG&prot	450 MeV/c	0.60T	-2000	4uA				C12, 45mg/cm^2
	run_2010-08-26-21-23-10	run_2010-08-26-21-24-41	1min	anyF&anyG&prot	450 MeV/c	0.60T	-2000	4uA				C12, 45mg/cm^2
	run_2010-08-26-21-26-08	run_2010-08-26-21-29-29	3min	anyF&anyG&prot	450 MeV/c	0.60T	-2000	4uA				C12, 45mg/cm^2
	run_2010-08-26-21-30-10	run_2010-08-26-21-47-43	17min	anyF&anyG&prot	550 MeV/c	0.74T	-2000	4uA				C12, 45mg/cm^2
	run_2010-08-26-21-49-00	run_2010-08-26-21-51-10	2min	anyF&anyG&prot	568 MeV/c	0.76T	-2000	4uA				C12, 45mg/cm^2
	run_2010-08-26-21-52-37	run_2010-08-26-21-56-32	4min	any paddle	540 MeV/c	0.718T_m, 0.72T	-2000	4uA				C12, 45mg/cm^2
	run_2010-08-26-21-57-07	run_2010-08-26-22-00-18	3min	anyF&anyG	540 MeV/c	0.718T	-2000	4uA				C12, 45mg/cm^2
	run_2010-08-26-22-00-51	run_2010-08-26-22-51-08	51min	anyF&anyG&prot	540 MeV/c	0.718T	-2000	4uA				C12, 45mg/cm^2
junk	run_2010-08-26-23-24-38	run_2010-08-26-23-25-21	1min	pulser	540 MeV/c	0.718T	-2000	4uA				C12, 45mg/cm^2
pedestal run	run_2010-08-26-23-27-33	run_2010-08-26-23-28-43	1min	any paddle	540 MeV/c	0.718T	-2000	4uA				C12, 45mg/cm^2
HV Scanning	run_2010-08-26-23-29-10	run_2010-08-26-23-35-41	6min	anyF&anyG&prot	540 MeV/c	0.718T	-2000	4uA				C12, 45mg/cm^2
	run_2010-08-26-23-36-18	run_2010-08-26-23-49-56	13min	anyF&anyG&prot	540 MeV/c	0.718T		4uA				C12, 45mg/cm^2
	run_2010-08-26-23-50-18	run_2010-08-26-23-57-35	7min	anyF&anyG&prot	540 MeV/c	0.718T		4uA				C12, 45mg/cm^2
	run_2010-08-27-00-01-09	run_2010-08-27-00-02-13	1min	anyF&anyG&prot	540 MeV/c	0.718T		4uA				C12, 45mg/cm^2
	run_2010-08-27-00-02-23	run_2010-08-27-00-04-08	2min	anyF&anyG&prot	540 MeV/c	0.718T		4uA				C12, 45mg/cm^2
	run_2010-08-27-00-04-16	run_2010-08-27-00-23-34	19min	anyF&anyG&prot	540 MeV/c	0.718T		4uA				C12, 45mg/cm^2
GOOD DATA!!	run_2010-08-27-00-24-03	run_2010-08-27-00-58-24	34min	anyF&anyG&prot	540 MeV/c	0.718T		4uA				C12, 45mg/cm^2
	paddle rotation here											C12, 45mg/cm^2
	run_2010-08-27-01-37-30	run_2010-08-27-01-43-01	6min	prot	540 MeV/c	0.718T	-1680 & -1700	4uA	2000			C12, 45mg/cm^2
some mistaking	run_2010-08-27-01-43-35	run_2010-08-27-01-57-21	14min	anyF&anyG&prot	540 MeV/c	0.718T	-1680 & -1700	4uA	TOP, BOT1950			C12, 45mg/cm^2
TH Scanning	run_2010-08-27-01-57-41	run_2010-08-27-01-58-28	1min	anyF&anyG&prot	540 MeV/c	0.718T	-1680 & -1700	4uA	SUM1950			C12, 45mg/cm^2
	run_2010-08-27-01-58-51	run_2010-08-27-01-59-20	1min	anyF&anyG&prot	540 MeV/c	0.718T	-1680 & -1700	4uA	1900			C12, 45mg/cm^2
	run_2010-08-27-01-59-53	run_2010-08-27-02-00-54	1min	anyF&anyG&prot	540 MeV/c	0.718T	-1680 & -1700	4uA	1875			C12, 45mg/cm^2
	run_2010-08-27-02-01-17	run_2010-08-27-02-01-51	1min	anyF&anyG&prot	540 MeV/c	0.718T	-1680 & -1700	4uA	1825			C12, 45mg/cm^2
	run_2010-08-27-02-02-10	run_2010-08-27-02-04-09	2min	anyF&anyG&prot	540 MeV/c	0.718T	-1680 & -1700	4uA	1775			C12, 45mg/cm^2
	run_2010-08-27-02-04-12	run_2010-08-27-02-05-26	1min	anyF&anyG&prot	540 MeV/c	0.718T	-1680 & -1700	4uA	1700			C12, 45mg/cm^2
	run_2010-08-27-02-05-42	run_2010-08-27-02-14-45	9min	anyF&anyG&prot	540 MeV/c	0.718T	-1680 & -1700	4uA	1700		400Hz	C12, 45mg/cm^2
	run_2010-08-27-02-19-05	run_2010-08-27-02-19-36	1min	anyF&anyG&prot	540 MeV/c	0.718T	-1680 & -1700	10uA	1700		900Hz	C12, 45mg/cm^2
GOOD DATA!!	run_2010-08-27-02-23-01	run_2010-08-27-02-42-47	19min	anyF&anyG&prot	540 MeV/c	0.718T	-1680 & -1700	10uA	1700			C12, 45mg/cm^2
	run_2010-08-27-02-44-01	run_2010-08-27-02-44-06	1min	anyF&anyG&prot	540 MeV/c	0.718T	-1680 & -1700	10uA	1700			C12, 45mg/cm^2
	run_2010-08-27-02-44-20	run_2010-08-27-03-13-30	29min	prot	540 MeV/c	0.718T	-1680 & -1700	10uA	1700		21000Hz	C12, 45mg/cm^2
	run_2010-08-27-03-14-04	run_2010-08-27-04-00-45	46min	anyF&anyG&prot	540 MeV/c	0.718T	-1680 & -1700	1uA	1700		48Hz	C12, 45mg/cm^2
INTERESTING	run_2010-08-27-04-01-56	run_2010-08-27-04-23-37	22min	prot	540 MeV/c	0.718T	-1680 & -1700	1uA	1700		2200Hz	C12, 45mg/cm^2
	run_2010-08-27-04-26-50	run_2010-08-27-04-48-46	22min	anyF&anyG&prot	540 MeV/c	0.718T	-1680 & -1700	30uA	1700		8000Hz	C12, 45mg/cm^2
	run_2010-08-27-04-49-33	run_2010-08-27--05-24-41	35min	prot	540 MeV/c	0.718T	-1680 & -1700	30uA	1700		73000Hz	C12, 45mg/cm^2
	run_2010-08-27-05-25-29	run_2010-08-27-06-05-16	40min	any paddle	540 MeV/c	0.718T	-1680 & -1700	30uA	1700		5300000kHz	C12, 45mg/cm^2

Plans for the future

2010/2011 winter:	Possibility for in-beam tests of new scintillator wall elements. Elementary kaon electro-production measurements with the KAOS spectrometer at zero degree.
2011 spring:	First decay pion spectroscopy experiment using the new scintillator wall in the KAOS spectrometer as kaon tagger(?)
2011 summer:	First hypernuclear spectroscopy experiment using the KAOS spectrometer at zero degree and the electron arm detector for small angle electron tagging(?)