Presentation at the interview for the post-doctor at the IHEP

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(IHEP)

Dec. 31th, 2019

Contents

- Resume
- Research experience
  - Research activity at under graduate
  - Research activity at J-PARC
  - Research activity at IHEP
- Brief research interest for this application

My Career

- 2017(Feb.) - now, P.D. @ IHEP

- (2016 Lecturer, part-time)
- 2008~2016 P.D. Participated in J-PARC nuclear-hadron experiments

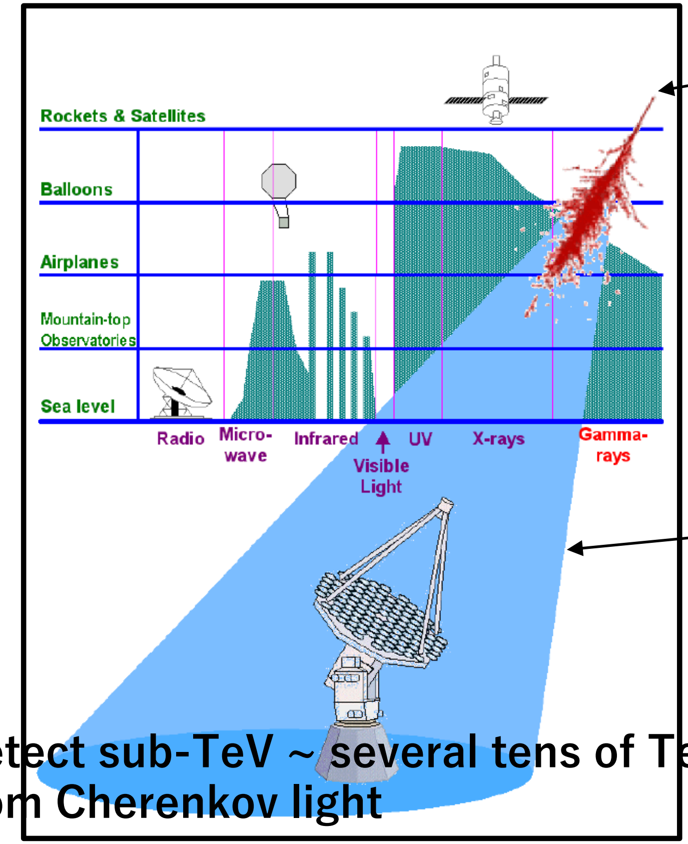
- 2003~2008 Ph. D. (& master) student at University of Tokyo (High energy astroparticle physics)

- 1998~2003 Undergraduate student at University of Tokyo

Activity & Achievement I. - - Ph.D. student

-- participated in CANGAROO-III project (Astroparticle Physics)--

Imaging **A**tmospheric **C**herenkov **T**elescope

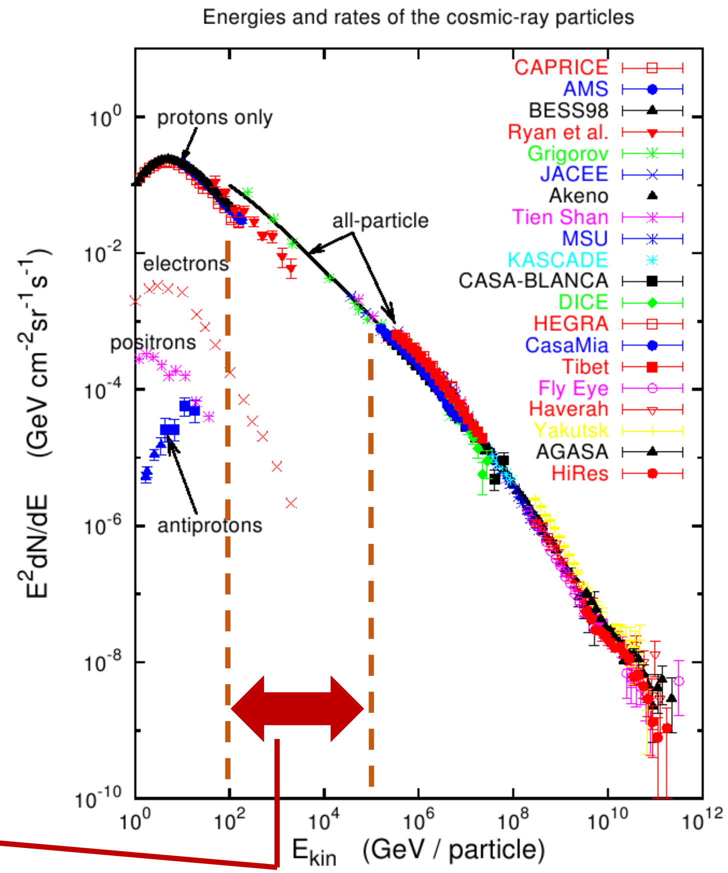


TeV γ-ray

Cherenkov light

Detect sub-TeV ~ several tens of TeV γ-rays from Cherenkov light

Cosmic-ray spectrum



Current IACTs
"MAGIC" ,
"CTA" , etc.

General goal for IACTs

To search which types of celestial objects emit such high-energy γ-ray

To explore what kinds of mechanism acts on

U.L. of the gamma-ray flux & derived limits for physical parameter around the cluster of galaxies

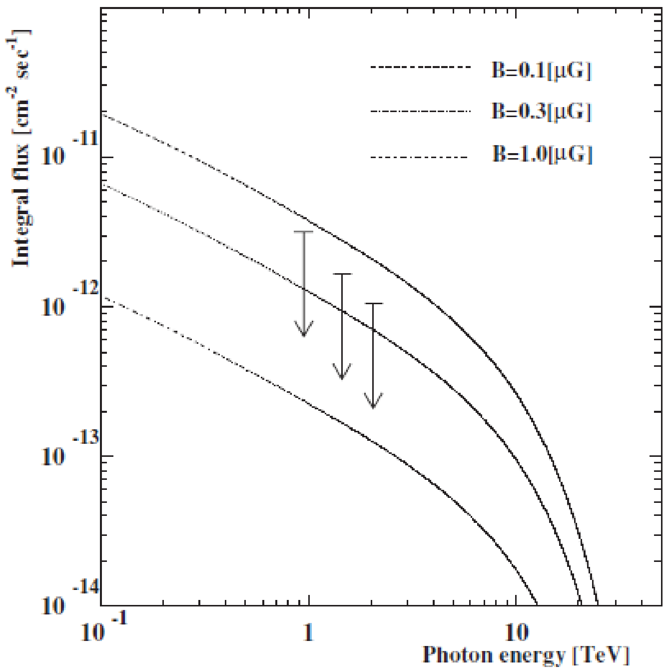


Figure 4. Derived gamma-ray flux upper limits from the *NW Relic* region of Abell 3667 (filled squares) with the predicted gamma-ray fluxes by Inoue et al. (2005). The model was scaled with the mass and the distance of Abell 3667 to that of a Coma-like cluster, and is shown in the case of magnetic fields of 0.1 μG, 0.3 μG, and 1.0 μG.

B (magnetic field) ＞0.1 μG

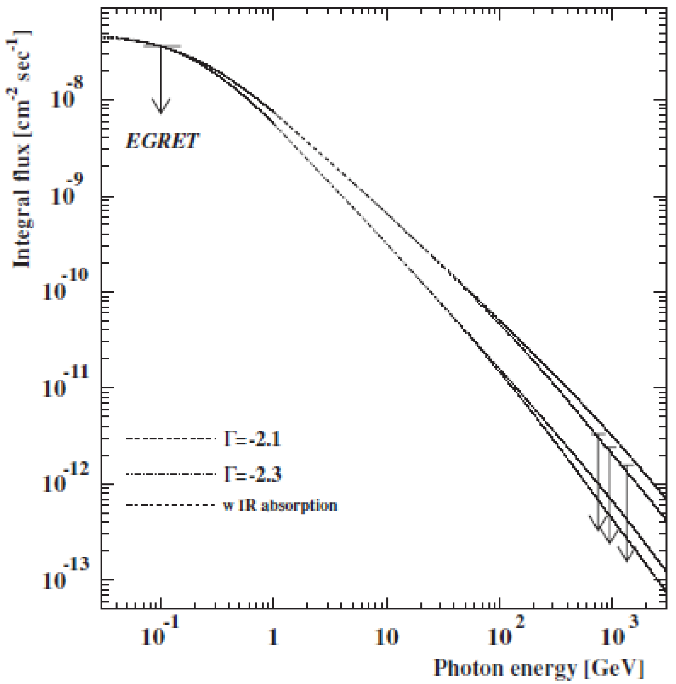
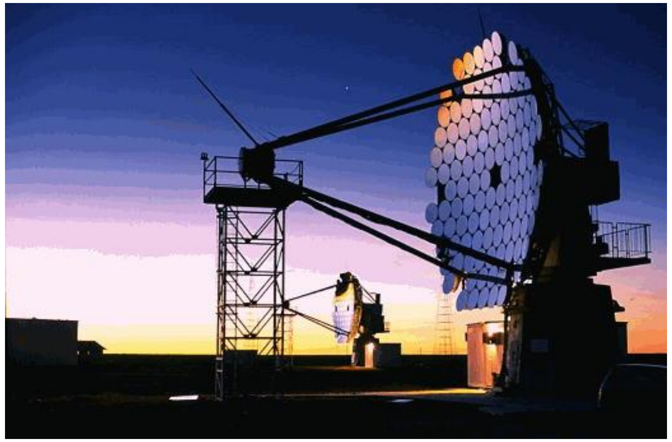


Figure 5. Derived gamma-ray flux upper limits from the *Cluster Core* region of Abell 4038 with the gamma-ray emission spectrum via π^0-decay process, normalized to the EGRET upper limits (Reimer et al. 2003). The EGRET upper limits are indicated by arrows at 100 MeV, and the lines are the gamma-ray spectrum from the proton power-law indices of $\Gamma = -2.1$ and -2.3 with an energy cutoff of 200 TeV. The gamma-ray absorption effect by IR photons are represented by dot-dashed lines, where the P0.4 model in Aharonian et al. (2006) is adopted.

Cosmic-ray density ＜30 eV/cc



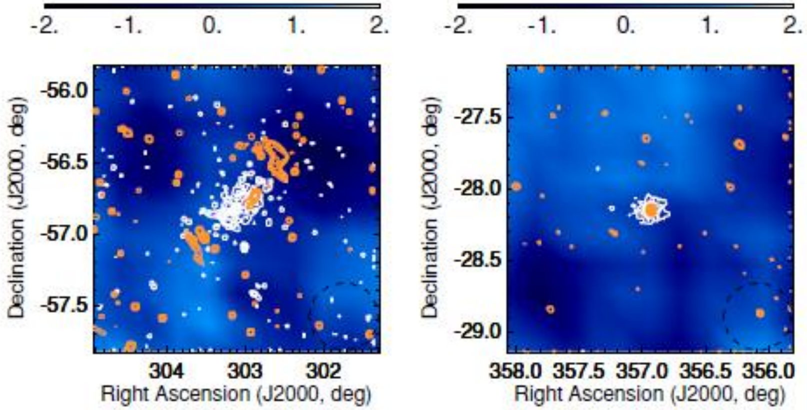


Fig: γ-ray significance map around the clusters of galaxies

Published as R. Kiuchi, . *et al.*, Astrophys. J., 704, 240-246 (2009)

Performance study by using cooled CCD camera

-- my master thesis's works --

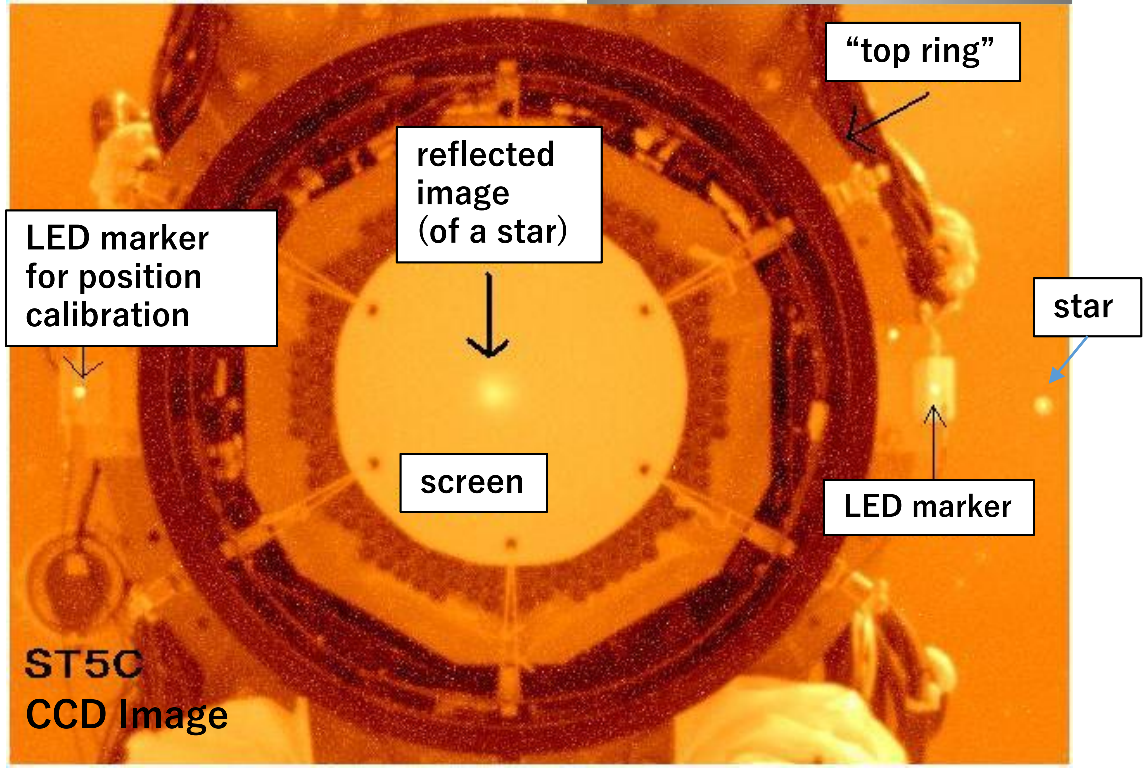
Main contribution

- Update the cooled CCD readout system
- Calibration scheme for the
  CCD (LED/dark frame/flat frame)
- Update of the data analysis procedure
with the calibration data

Evaluation

- Pointing accuracy of the telescope
- Reflectivity of the reflector (mirrors)
- Air transparency
- Estimation of background noise due to the
night sky light

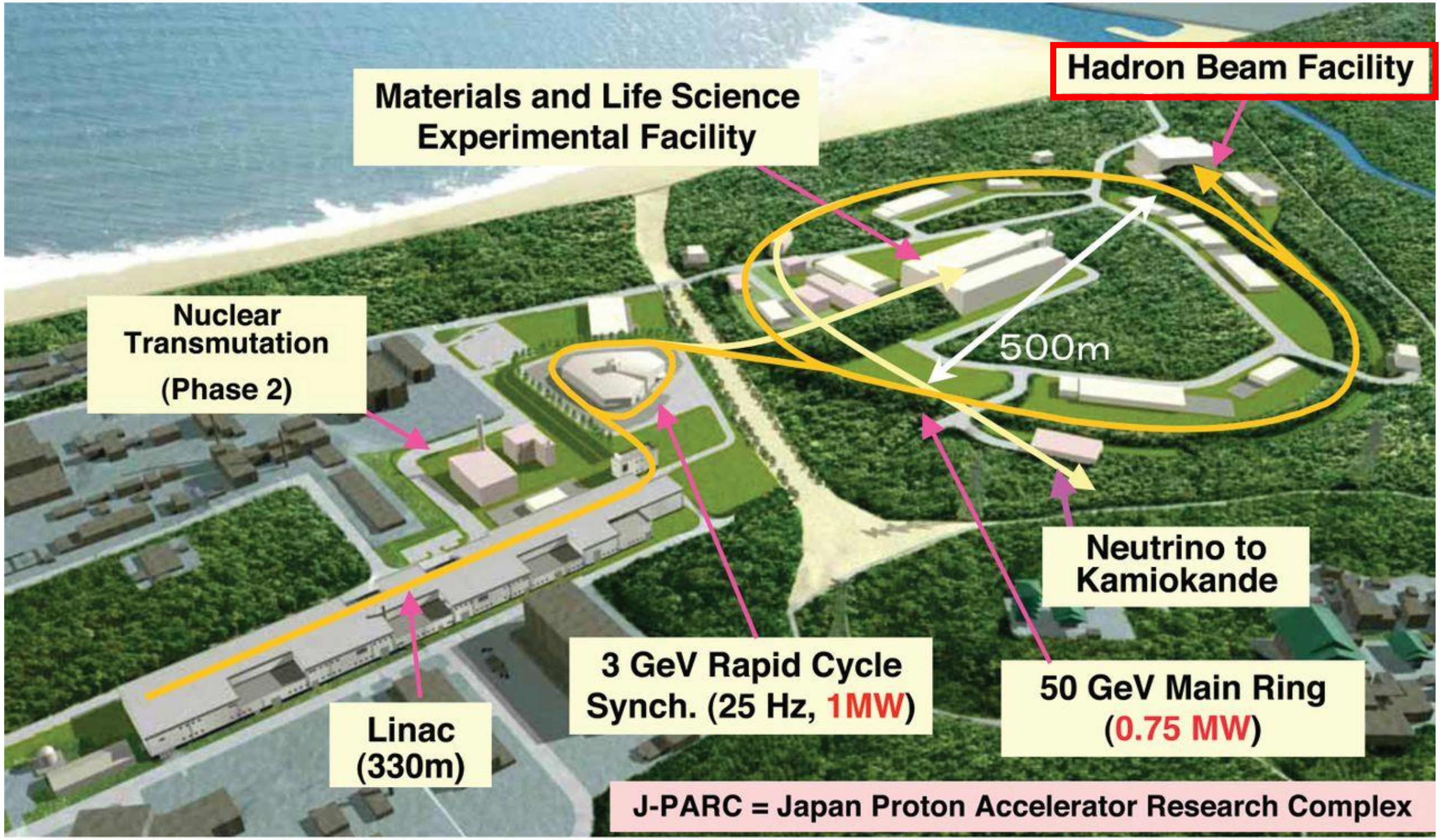
Presentation/Proc. 29th International
Cosmic Ray Conference 2005



An image taken by the cooled CCD camera

Activity & Achievement II. - - P.D. Fellow at the J-PARC

I have joined the J-PARC nuclear-hadron experiments,
search for new (exotic) hypernuclei, to study the Y-N interactions



Operation of the Main Ring starts from 2008 ~

The hadron hall consist of many area. One of them is "K1.8" area where I was working.

"K1.8" area is designed to deliver secondary Kaon beams centering around 1.8 GeV with maximum intensity. (but we have utilized pion/electron/proton beams too.)

Physics goal is to generate hypernuclei of strangeness 1 or 2, with high precision spectrometers to study Y-N interaction

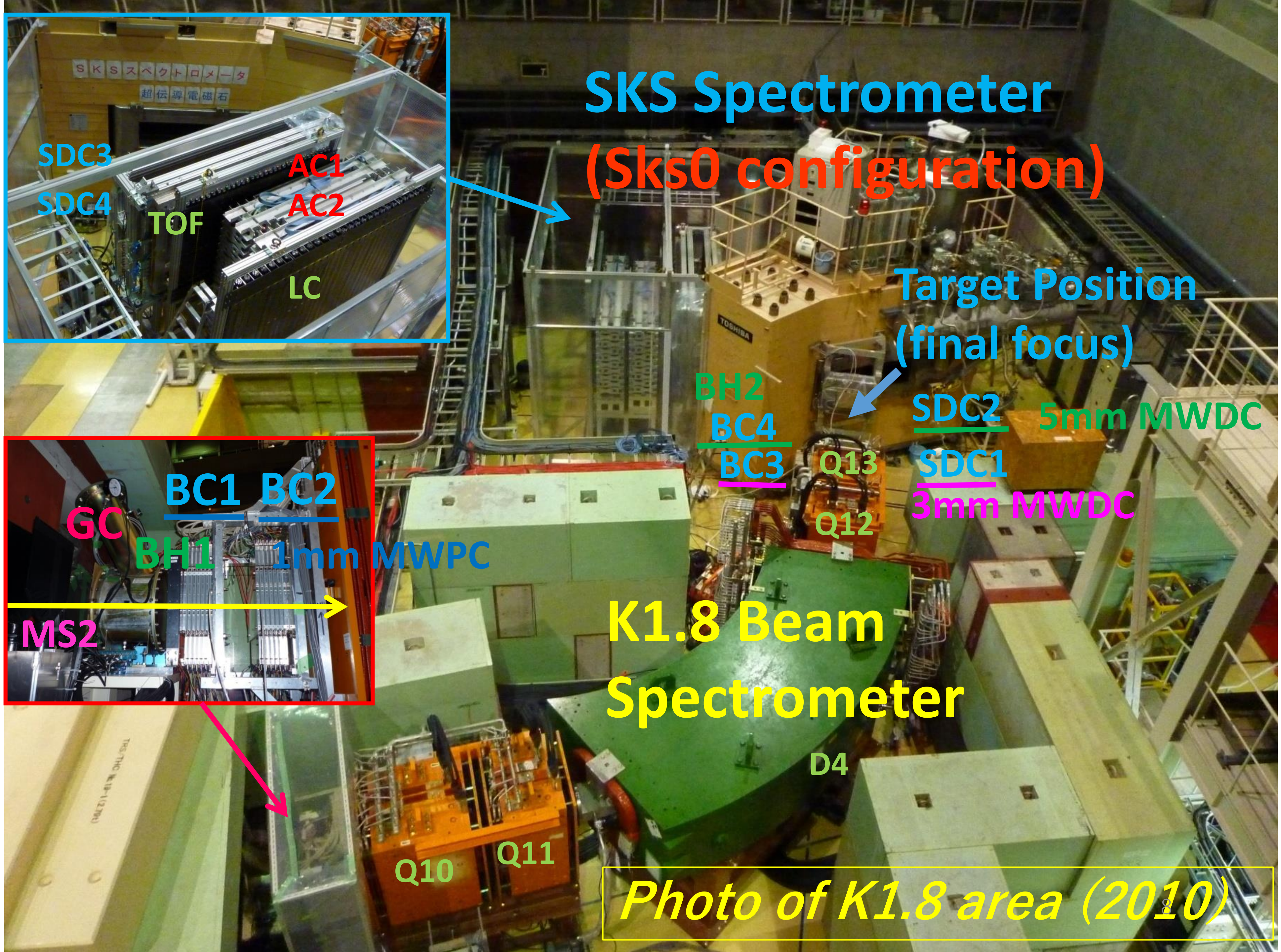


Photo of K1.8 area (2010)

K^- yield measurement (-- from 02.17.2010 run)

This results are from the very initial beam tuning work. (right after the installation)

This is very important to verify the kaon intensity with the information of π-K ratio, i.e. even the Kaon yield is high, but it is dangerous if the pion contaminates a lot, say, one/two order high, from the issue of detector/trigger capability.

Condition

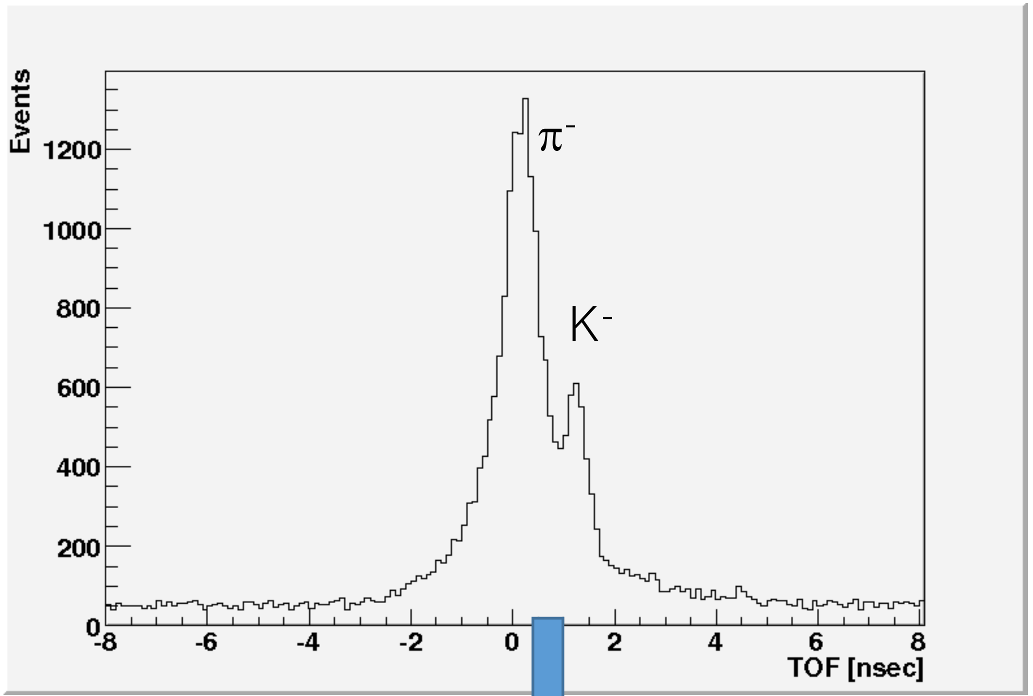
- IFH : ±130 (Full open)
- IFV : 0 ~ 4
- Mom : ±180 (Full open)
- MS1 : ±2.35
- MS2 : ±2.5
- ESS #1,2: ±200kV

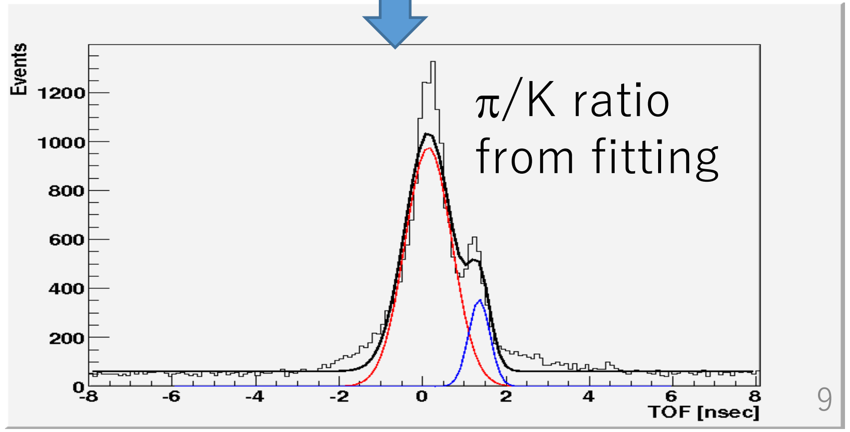
MR Intensity

2.5×10^{12} ppp

Scaler counts (/spill)

ESS #1,#2	π	K	T.M.
ON/ON	877,355	104,065	109,707





Participated Experiments @ K1.8 area

info. @ 2016

First experiment@K1.8, setup/beam tuning/(initial)physics analysis

- **E19** High-resolution Search for Θ^{+} Pentaquark in $\pi^{-}p \rightarrow K^{-}X$ Reactions (π^{-}、K^{-})

- **E27** Nuclear $\overline{K}$ bound state($K^{-}pp$) in the d(π^{+}, K^{+})

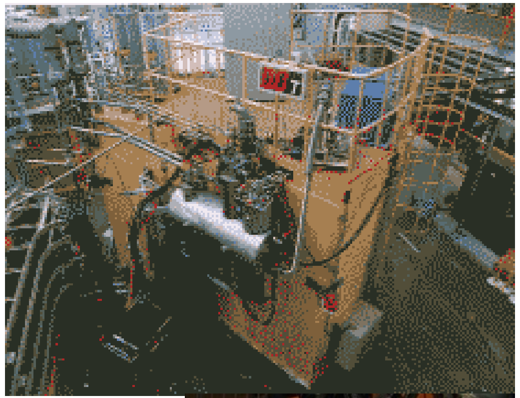
- **E10** Production of Neutron-Rich Λ-Hypernuclei with the Double Charge-Exchange Reactions (π^{-}、K^{+})

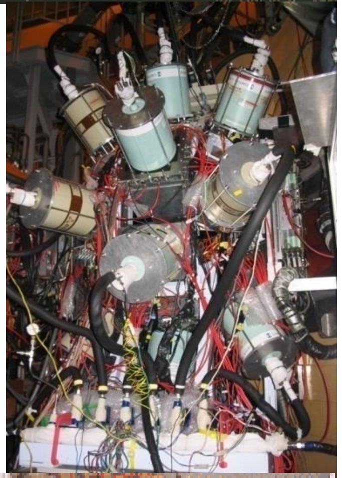
- **E13** Gamma-ray spectroscopy of light hypernuclei (K^{-}、π^{-})

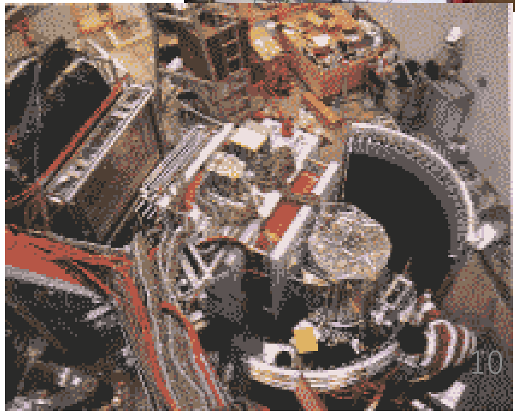
- **E05** Spectroscopic Study of Ξ-Hypernucleus ${}_{\Xi}{}^{12}Be$, via the ${}^{12}C(K^{-}, K^{+})$ Reaction (K^{-}、K^{+})

- **E07** Systematic Study of Double Strangeness System with an Emulsion-Counter Method (K^{-}、K^{+})

<u>I worked for development of SSDs</u>



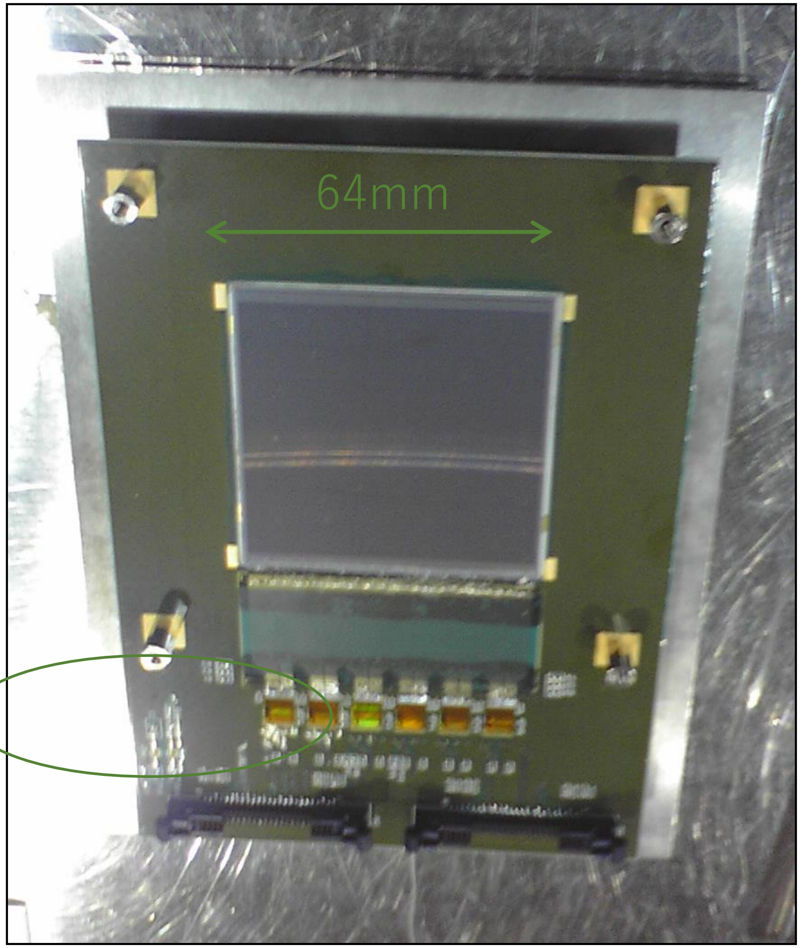




SSD used at E10 experiments

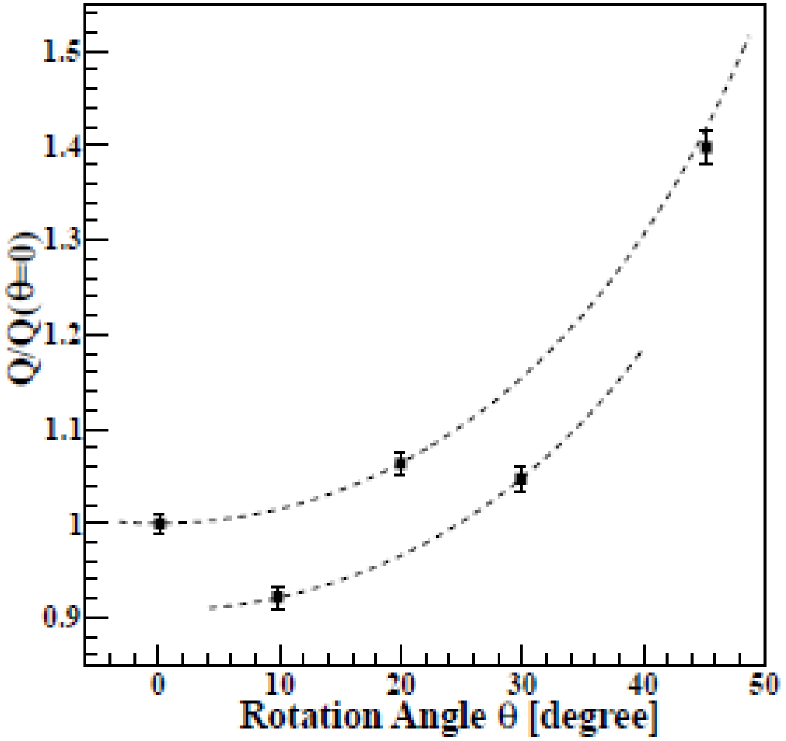
We have developed SSDs as a tracking detector under high intensity beam, and this detector is a first step for us!

- (Single Side) Silicon Strip Detector
  -- developed 2009~2012
- Sensor
  -- ATLAS sensor
  -- Strip : 768ch , 80μm pitch
  -- effective area 64mm
  -- radiation tolerance >3*10^{14}
  -- (typical operation voltage) ~ +80V
- Readout chip
  -- APV25-s1 chip (developed by CMS)
  -- Each chip has 128 ch of pre-amp and shaper and use serial transfer by a multiplexer



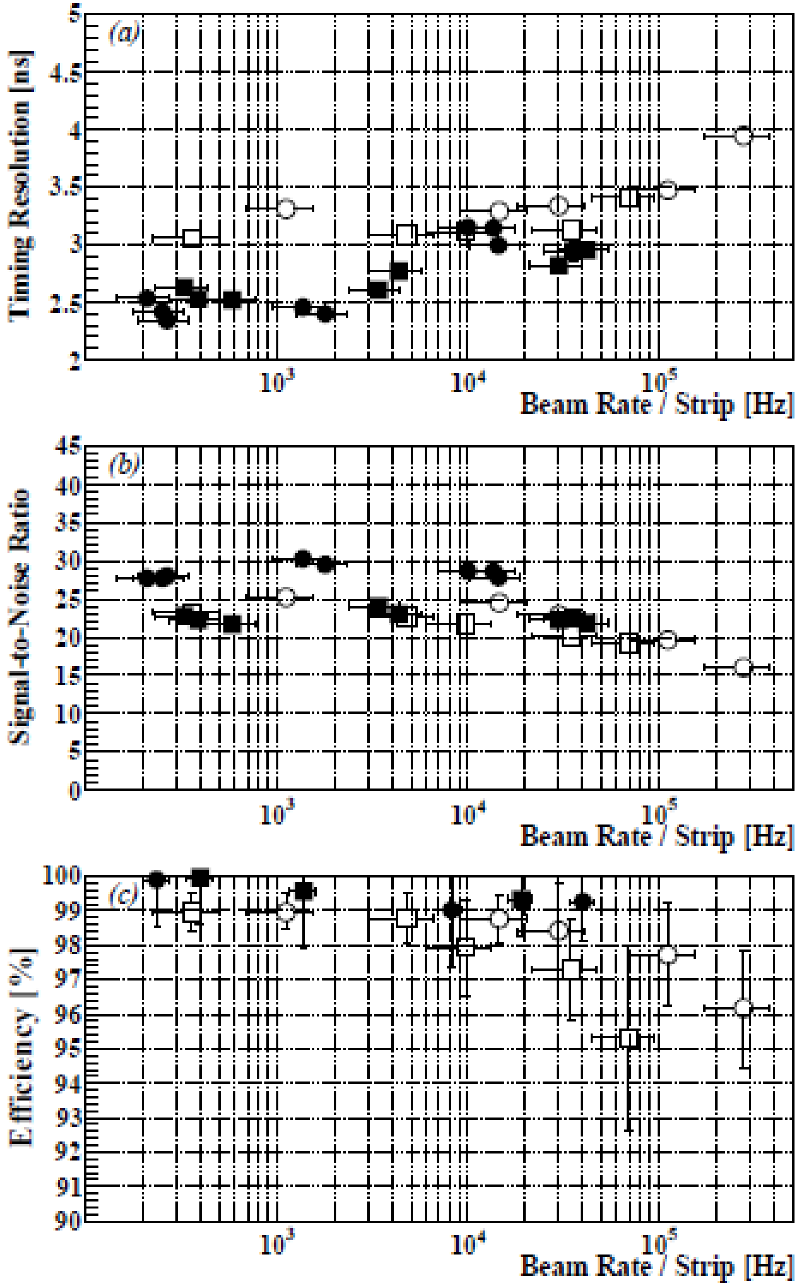
Performance of the SSD (used in E10)

Relation of injection angle to the SSD and de/dx



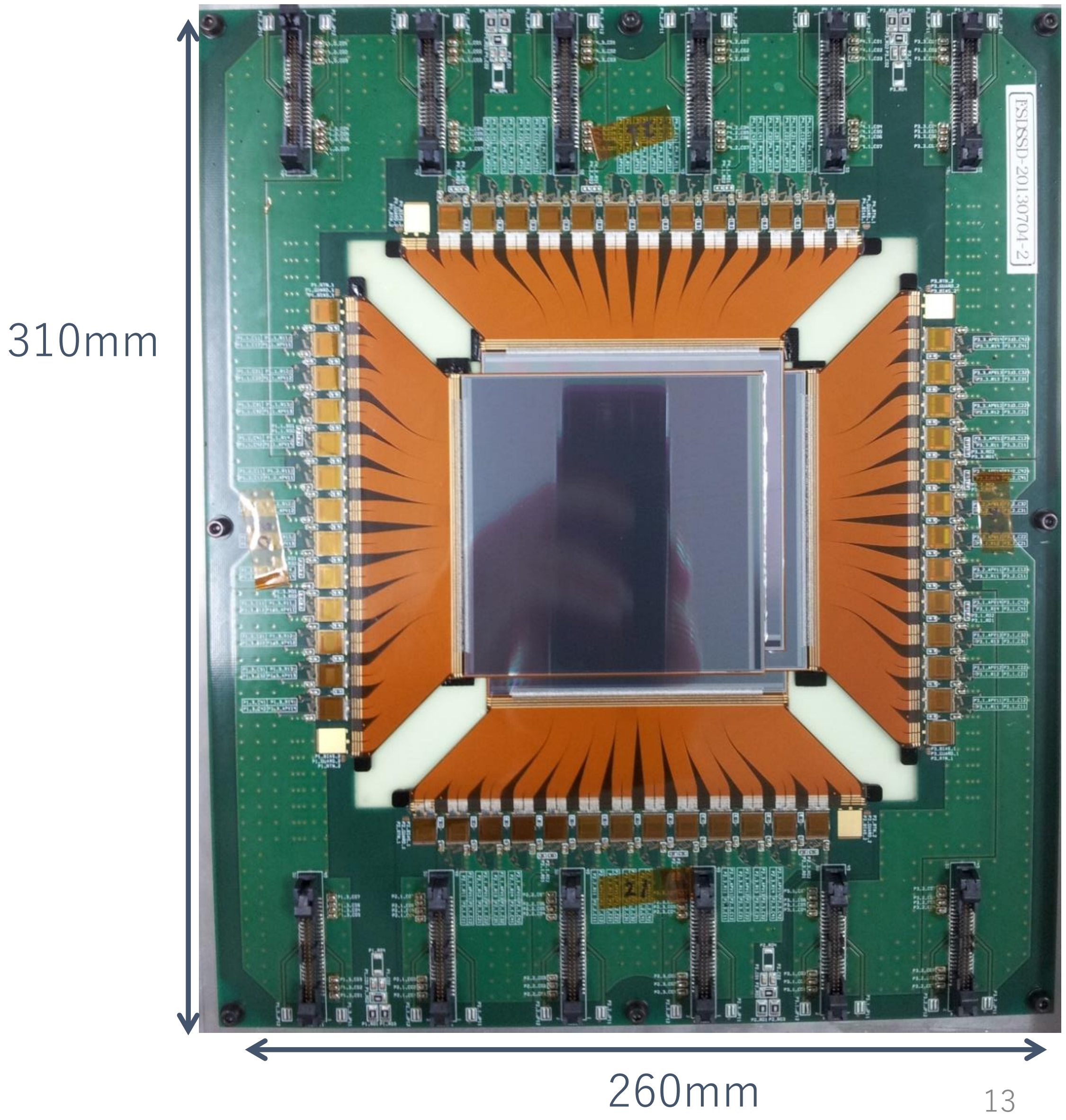
R. Kiuchi et.al, NIMA, 763 (2014) 399-403

Injection particle rate & various performance



SSD Board (E07 sensor)

- Single-sided silicon strip detector
- Composition : ***X-Y-X-Y (4 layers)***
- Strip Pitch 50 μm
- Number of strips : 1536 ch
- Effective area ~ 76 x 76 mm^2
  (where all 4 layers cover)
- Operation bias voltage : ~ 80 V
- Readout chip : APV25-s1
  (the same as the E10 SSD)



Activity & Achievement III. - - P.D. @ IHEP

- Have applied and kindly accepted as a post doctor position in the IHEP in the end of 2016.

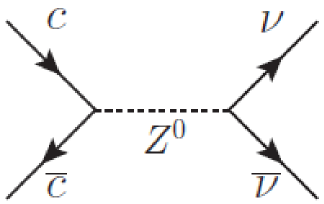
- Officially, my position began from Feb. 2017, but the documentation works, in particular, getting the working visa took long time. Almost half year I have spent.

- From June 1st in 2017, I became able to stay with the working visa here. (another one month I needed to complete the process regarding “居留许可” at Beijing)

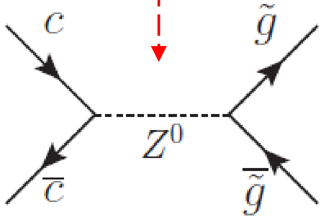
photograph (October 2016) when I have visited the IHEP for the first time

BES-III data analysis

[BES-III : Search of invisible decay of J/ψ]



the SM decay



One of predictions of the BSM decay

- Invisible decays of quarkonium offer a window into what may lie beyond the SM.
- The only decay mode of J/ψ predicted by the SM is J/ψ →νν, therefore, it implies the physics beyond the SM, if the invisible decay rate is observed to have larger Br. than the SM prediction,

$$\frac{\Gamma(\mathrm{J}/\varphi \to \nu\bar{\nu})}{\Gamma(\mathrm{J}/\varphi \to \mathrm{e}^{+}\mathrm{e}^{-})} = \frac{27\mathrm{G}^{2}\mathrm{M}^{4}_{\mathrm{J}/\varphi}}{256\pi^{2}\alpha^{2}}\left(1-\frac{8}{3}\sin^{2}(\theta_{\mathrm{W}})\right)^{2} = 4.54\times10^{-7}$$

(L. N. Chang, O. Lebedev, and J. N. Ng, Phys. Lett. B 441, 419 (1998))

- This analysis(BESIII) was started by C. Zhang et. al., and we (IHEP/PKU) take over and proceed further by adding new data set.

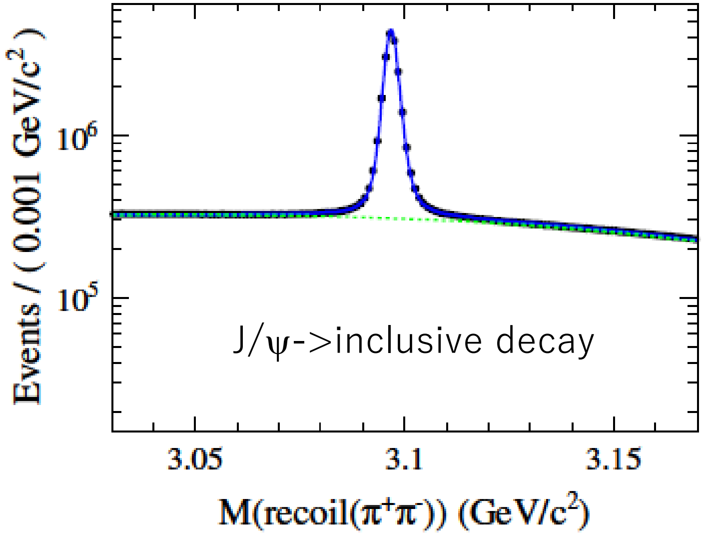
[My contribution]

- Update its systematic uncertainties, fix some bugs in previous study, reproduce a channel (J/ψ->inclusive decay) to be used for bg. estimation

BES-III data analysis

[Milestones]

- Gave a presentation at the BESIII collaboration meeting in June 2017.
- Update the analysis memo v1.1 accordingly
- Join part of analysis work for 2012 $\Psi(2S)$ data (and take over to S. Xiao (IHEP))



Updated tables (in memo v1.1) of systematics

Table 10: Summary of the relative systematic uncertainties (%) in the peaking background estimation.

Sources	$J/\psi \to \mu^+\mu^-$	$J/\psi \to e^+e^-$	$J/\psi \to n\bar{n}$	$J/\psi \to p\bar{p}$
N($\pi^+\pi^- J/\psi$) statistics	0.03			
Fit in N($\pi^+\pi^- J/\psi$)	0.44			
$N_\gamma = 0$	1.90			
Trigger	0.12			
$\mathcal{B}(J/\psi \to 2B)$	0.55	0.54	7.66	1.37
MC statistics	0.33	0.33	0.40	0.62
$N_{\text{extra trk(shower)}} = 0$	0.5	0.6	41.5	1.3

Table 11: Summary of the relative systematic uncertainties (%) in the yield extraction.

Sources	$J/\psi \to$ invisible	$J/\psi \to$ anything	$J/\psi \to \mu^+\mu^-$
Fitting range	0.43	0.35	
Signal shape	0.06	0.15	
BG shape		0.01	
Bin size		0.23	
μ track-finding			0.2
E/p ratio cut			0.03
Mass window on $M_{\mu^+\mu^-}$			0.31
Mass window on $M^{rec}_{\pi^+\pi^-}$			0.32
Background components in counting			0.02
Total	0.43	0.44	0.49

Development for the CMOS sensor

[Development for the CMOS pixel sensor, "Jadepix1"]

- The CMOS pixel sensors were fabricated as a prototype of the vertex detector for the CEPC, which we call it as "Jadepix1"

- Construct readout chain and evaluation of the sensors were the steps to be done

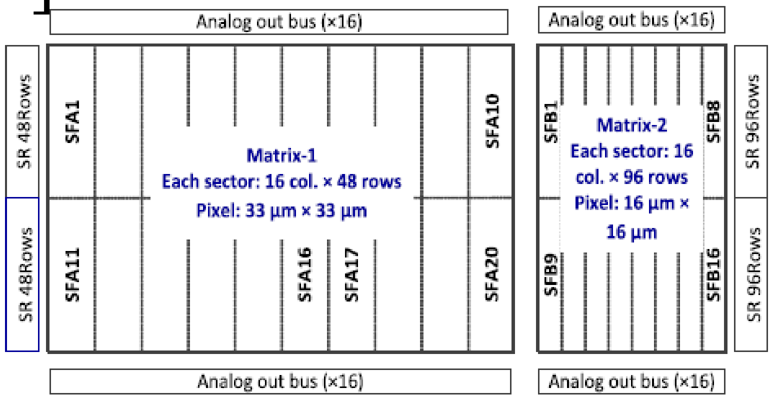
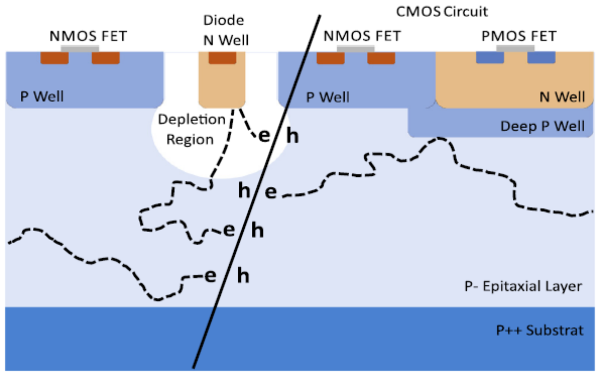


Fig. 7. Floorplan overview of the prototype.



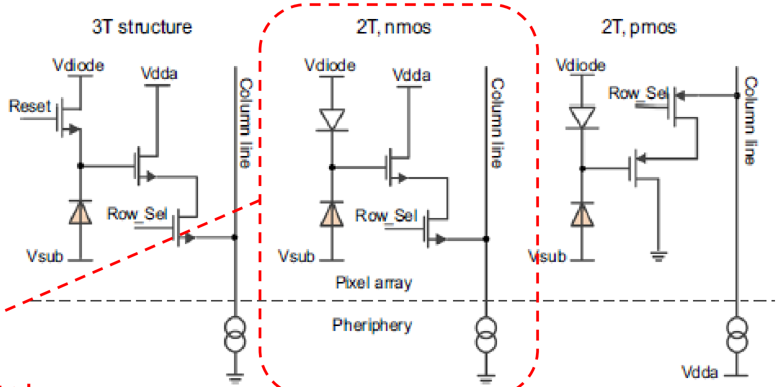


Fig. 8. In-pixel readout structures.

[My contribution]

- Development of the firmware
- Confirmation of the full chain

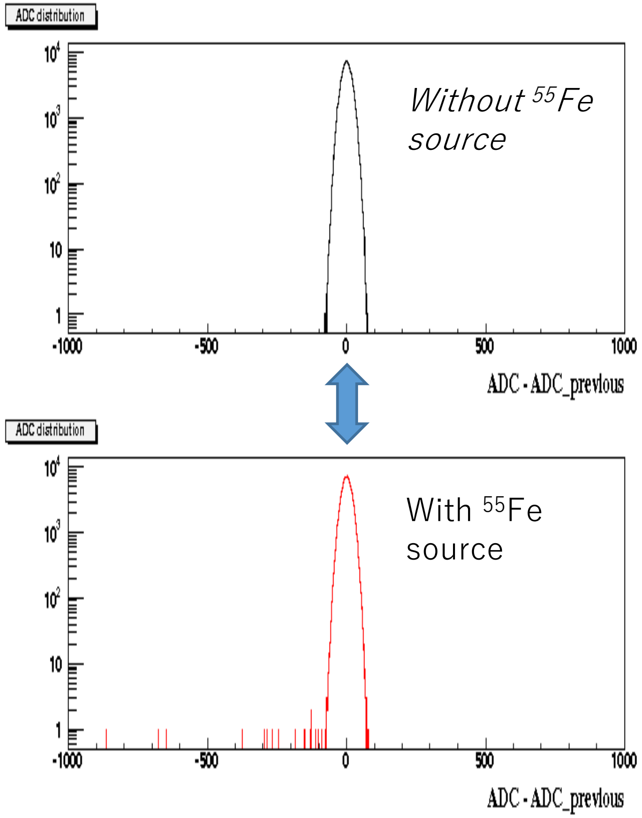
We have read pixels with "2T" structure

Figures taken from Y. Zhang, et al., NIMA 831 (2016) p99-104

Development for the CMOS sensor

[Milestones]

- Beam test @ DESY (2018 Aug.)
- A Paper is published (L.J.Chen, et. al., “Characterization of the first prototype CMOS pixel sensor developed for the CEPC vertex detector” , Radiation Detection Technology and Methods, 3, 45 (2019))



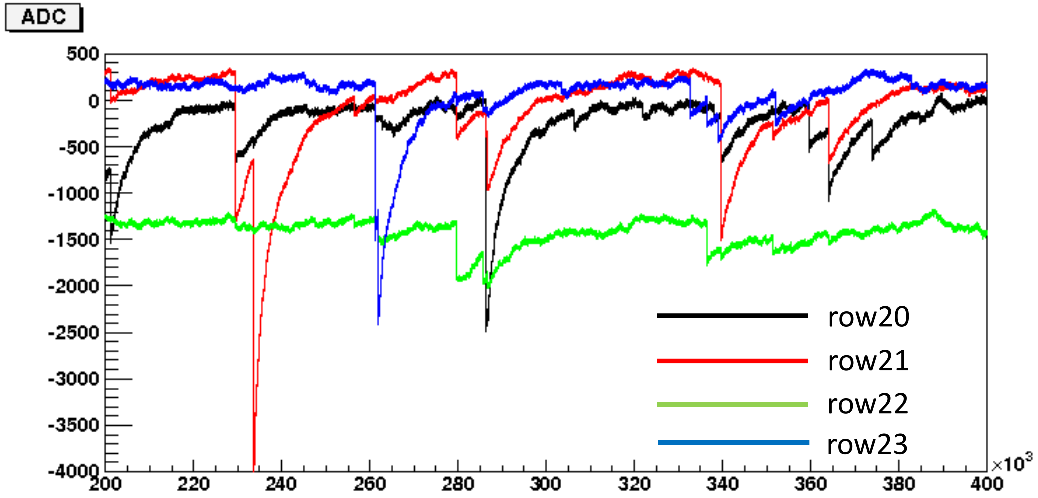


Figure : ADC(CDS) along the axis of time (unit: 24μs). four adjacent channels are shown for comparison.

The first signals confirmed by the readout system.

LGAD characterization

[**Characterization of LGAD sensor**]

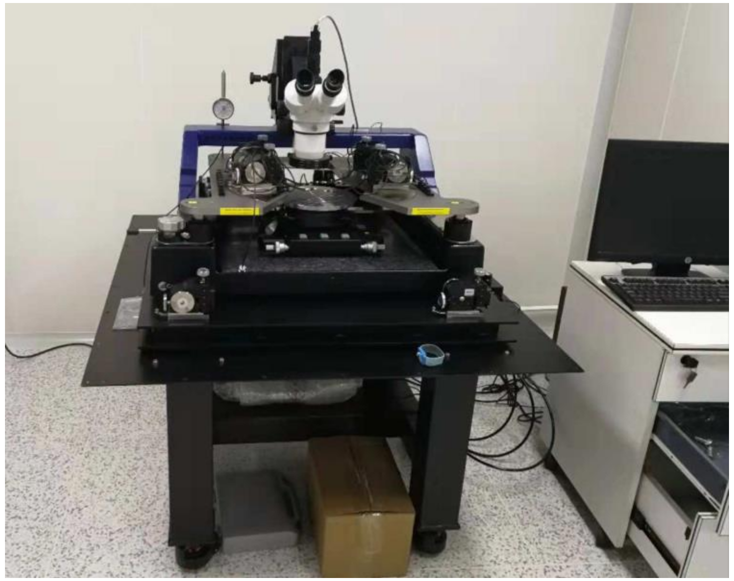
・We have started the sensor characterization for newly produced LGAD sensors for the ATLAS-HGTD

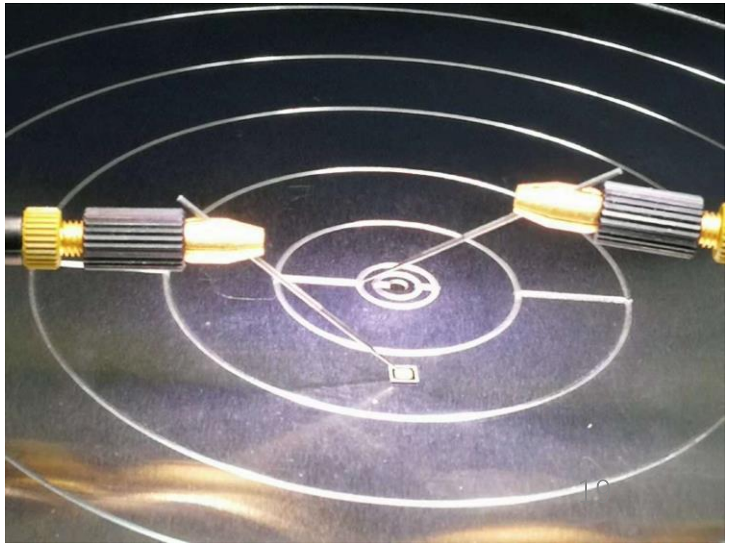
・Sensor types: single pad, 2x2, 5x5 arrays, of LGAD/PIN, made by HPK/CNM/NDL

[**My contribution**]

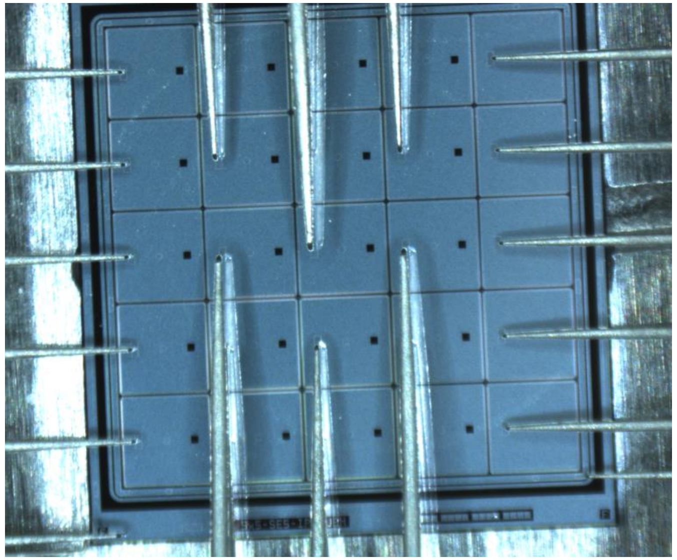
・Setup and test the measurement circuits for utilizing the probe station, including probe cards

・IV(CV) measurements on various sensors



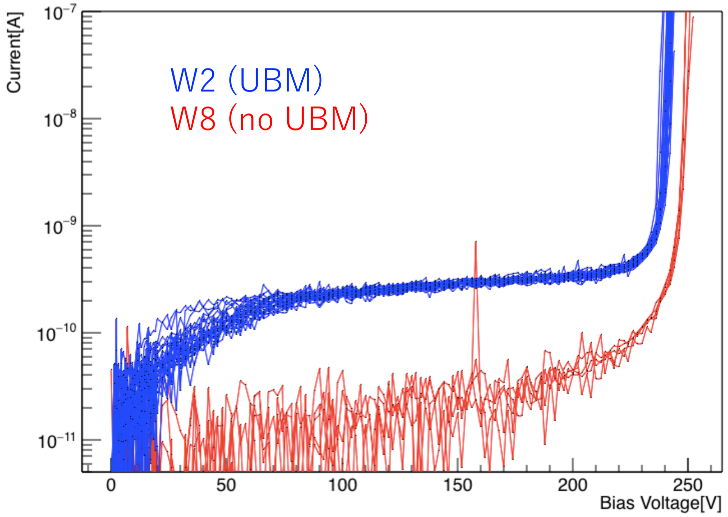


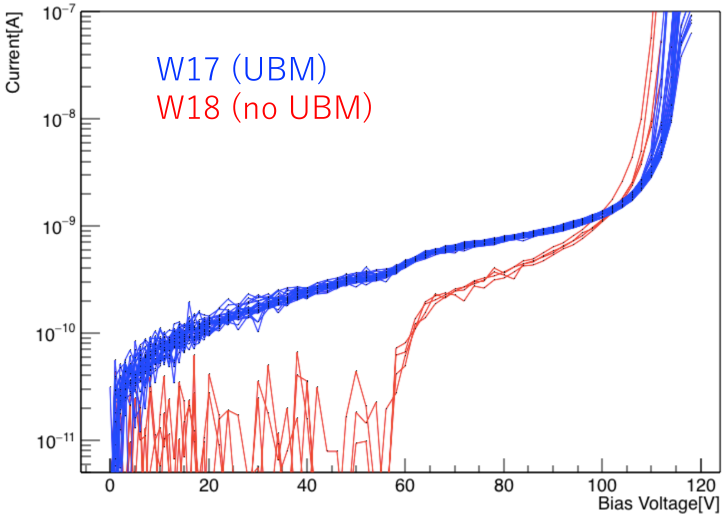
LGAD characterization

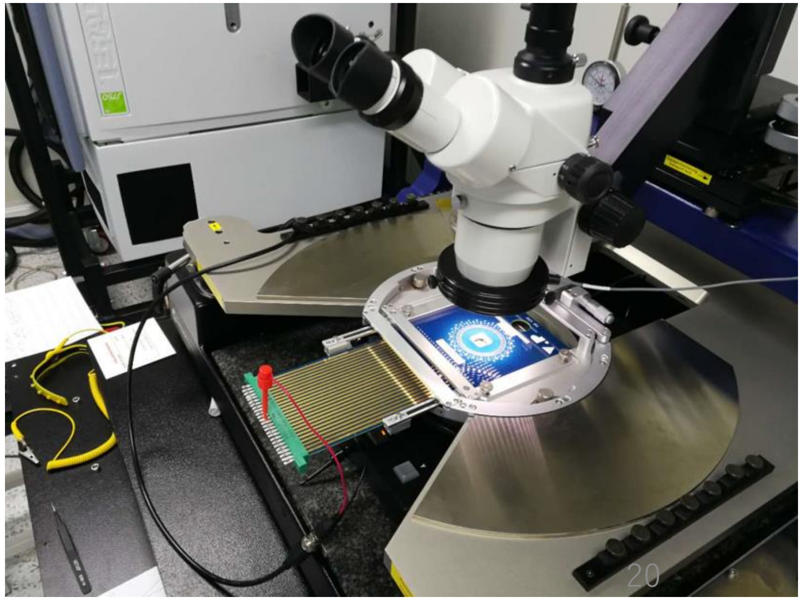


[Milestones]

- Have had successfully measurements on single/5x5 LGADs, some numbers among those characterization was reflected in the ATLAS HGTD TDR, the version submitted in this March







TRACS development for LGAD sensors

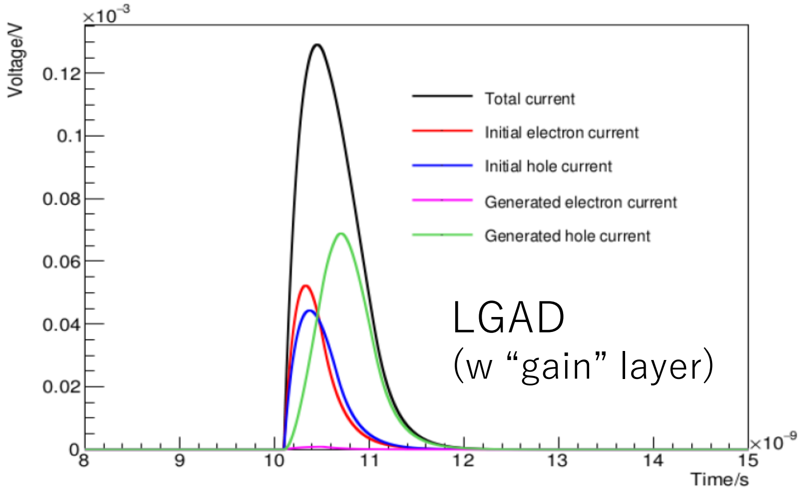
- TRACS [1] is developed for a fast simulator tool of transient currents in silicon detectors
  - Ramo's theorem for calculating the transient current
  - FEniCS solver for Laplace/Poisson equations
  - Multi-threading
  - C++11 base
- Development has been started aiming for simulating LGAD sensors to deduce and compare parameters of LGADs both of non-irradiated and irradiated one.

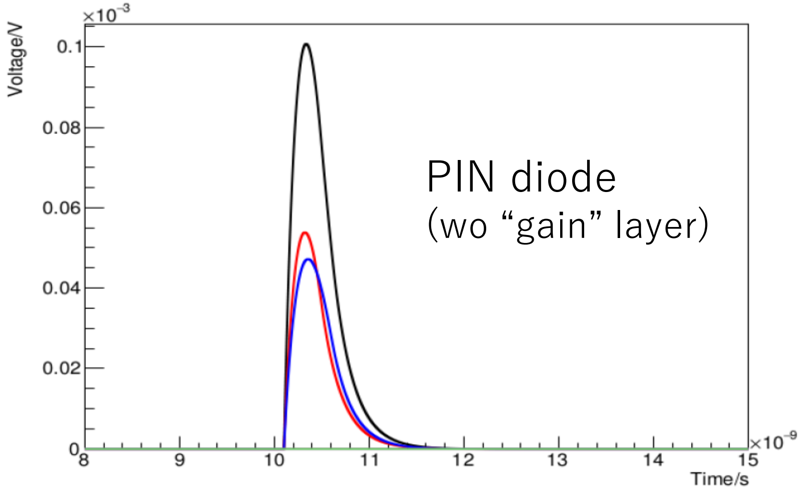
[1] J. Calvo, P. de Castro, A. Díez González-Pardo, M. Fernández García, M. Moll, U. Senica, I. Vila, Nucl. Instrum. Meth. A 917 (2019) 77.

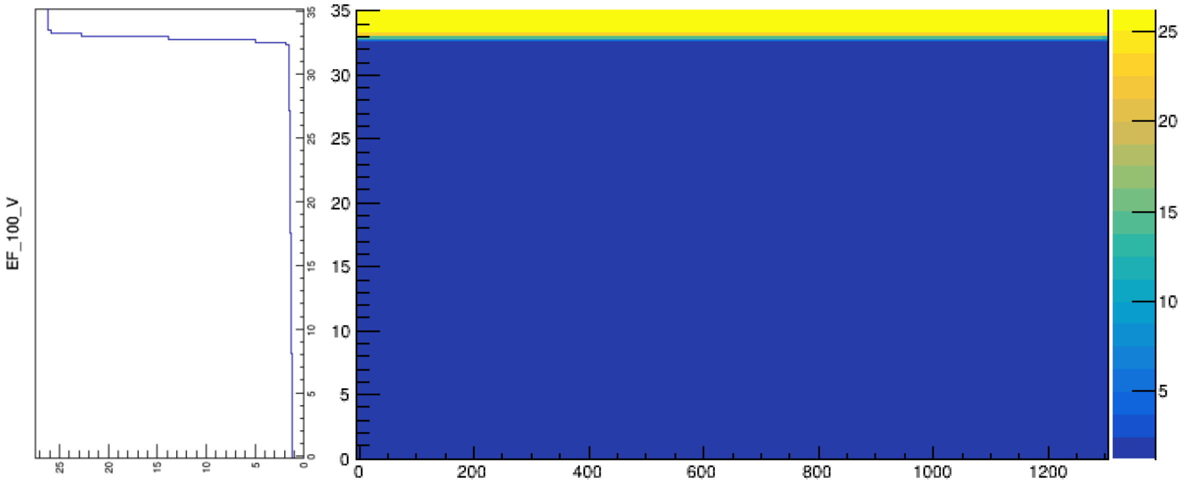
TRACS development for LGAD sensors

[**Status**]

- Implementation of the LGAD structure, introduction of avalanche region having a Gaussian effective doping profile, the impact ionization effect
- Comparison with the real TCT measurement data

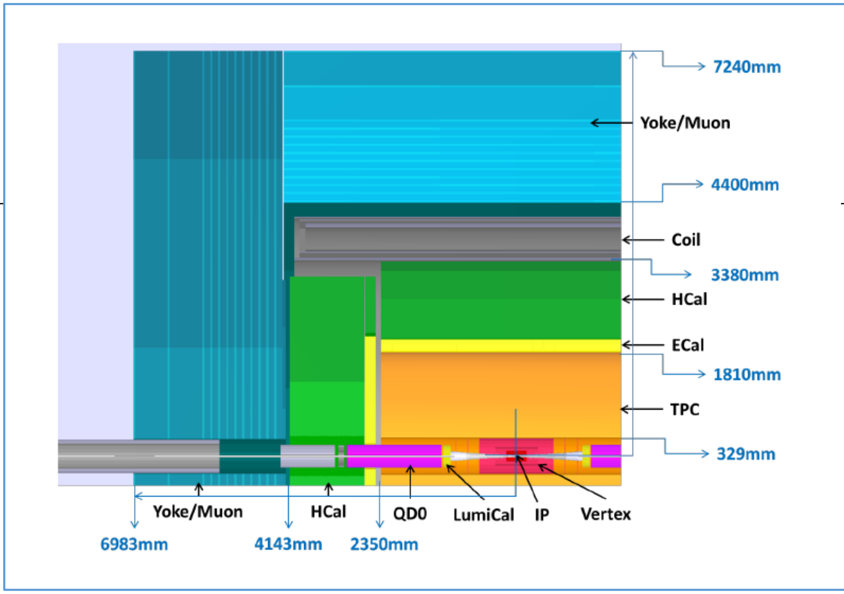






Electric-field map of single pad LGAD

CEPC HZZ analysis



[Analysis of the CEPC MC samples]

- Join the works to evaluate achievable precision of each Higgs decay mode at the CEPC

  - We keep analyzing the "HZZ" channel, a Higgs boson decaying into two Z bosons, which provides various combinations of decay products from Z bosons. (ZH→ZZZ*)

  - Previous study was based on "CEPC_v1" and now we are evaluating them on "CEPC_v4"

property	estimated Precision			
	CEPC-v1		CEPC-v4	
m_H	5.9 MeV		5.9 MeV	
Γ_H	2.7%		2.8%	
$\sigma(ZH)$	0.5%		0.5%	
$\sigma(\nu\bar{\nu}H)$	3.0%		3.2%	
decay mode	$\sigma\times$BR	BR	$\sigma\times$BR	BR
$H\to b\bar{b}$	0.26%	0.56%	0.27%	0.56%
$H\to c\bar{c}$	3.1%	3.1%	3.3%	3.3%
$H\to gg$	1.2%	1.3%	1.3%	1.4%
$H\to WW^*$	0.9%	1.1%	1.0%	1.1%
$H\to ZZ^*$	4.9%	5.0%	5.1%	5.1%
$H\to\gamma\gamma$	6.2%	6.2%	6.8%	6.9%
$H\to Z\gamma$	13%	13%	16%	16%
$H\to\tau^+\tau^-$	0.8%	0.9%	0.8%	1.0%
$H\to\mu^+\mu^-$	16%	16%	17%	17%
$\mathrm{BR}^{\mathrm{BSM}}_{\mathrm{inv}}$	–	<0.28%	–	<0.30%

from the CEPC white paper

[My contribution]

- Make a simple analysis framework for this channel

- Collaboration work with UW/USTC now

CEPC HZZ analysis

[Milestones]

- Analysis of decay channels, having two muons, two neutrinos, two quarks (ZZZ*→μμ+νν+qq) , has been done with the collaboration work.

- Gave presentations on the CEPC workshop about the status of HZZ analysis
  -- The 2019 International Workshop on the High Energy Circular Electron Positron Collider @IHEP
  -- The 1st CEPC Physics Workshop toward Physics Whitepaper and TDR @PKU)

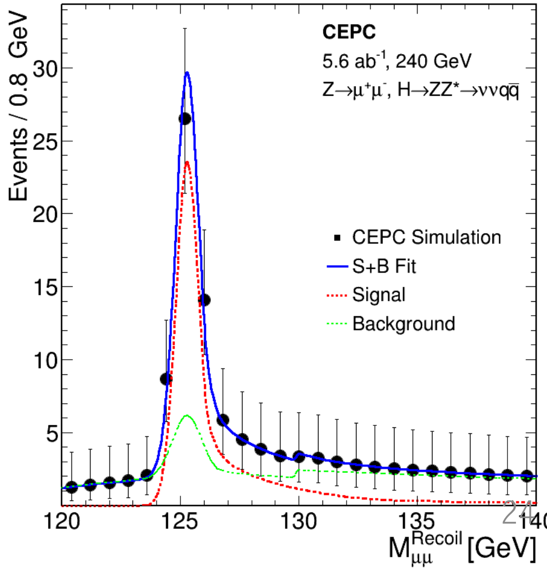
[On-going]

- Converging and composing a paper draft
- Analysis of (ZZZ*→ee+νν+qq) to increase the statistics

Expected Number of events with different objects

	Z→ll	tautau	νν	qq
H→ZZ*→4q	888	444	3.10k	9.24k
2ν + 2q	508	254	1.77k	5.29k
2l + 2q	170	85	596	1.8k
4ν	73	36	254	756
2l + 2ν	49	24	170	508
4l	8	4	28	86
X + tau	120	60	418	1246

- More than 2 jets, Await for sophisticated Jet Clustering
- Await for tau finder
- limited accuracy ~ > 50%
- Explored by H->invisible analysis -> Accuracy ~ 40%
- Promising channels
- Unexplored



Motivation/Research interests for this application

- Simulation works for the CEPC, such as study of possible detector configuration and its performance, definitely connects my recent activities, i.e. the test of CMOS sensor, the CEPC Higgs analysis, thus highly motivated to try that.

- I have also interests in the hardware development for LHCb/CEPC, at which I can utilize my past experiences.

Thank you very much !

Detector Installation at K1.8 area

Since the experimental area ("K1.8") was almost empty,
common equipment, then, user's detector system should be installed

detector installation, detector alignment, cabling, electronics, checking the signals , , ,

These photographs are taken in 2009, at the very first but large installation of systems

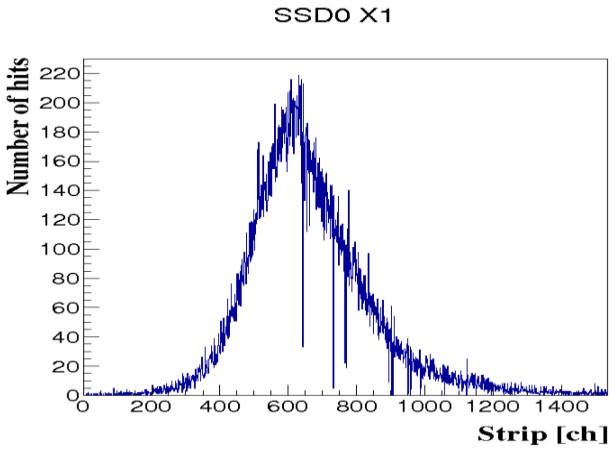
Time-line of the E07 SSD development (hardware part)

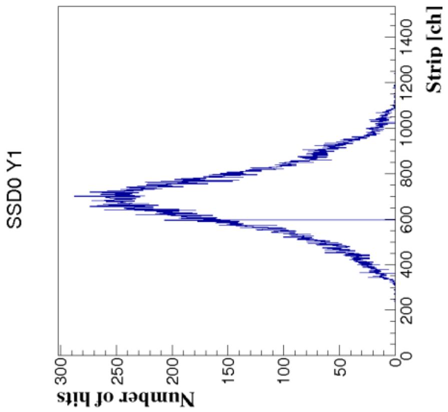
May	2013	Screening of all readout chips (APV25s1)
Summer	2013	PCB layout was made (Nagoya-University) , Start to decide the FPGA structure
Nov. ~ Dec.	2013	Wire-bonding , assembly of the board (company)
Jan.	2014	Prototype-1 (1-layer) SSD delivery
Jan ~ Mar.	2014	Examination at a test bench
May	2014	Prototype-2 (double-layer) layer SSD delivery
May ~ Sep.	2014	Examination at a test bench including a test-beam exposure
Oct ~ Nov	2014	Hardware test on a proto-supporting frame
Feb.	2015	Full spec 4 layer SSD delivery
Apr. ~ Aug.	2015	Final check of the DAQ part (especially FPGA logic)
Sep. ~ Oct.	2015	Installation & test beam exposure @ J-PARC
May~June	2016	E07 experiment (fist half) → 2017 latter half

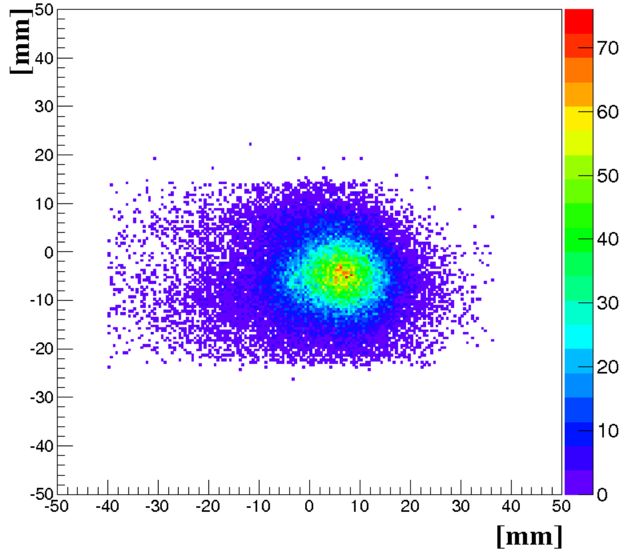
From E07 beam exposure (June 2016)

We have successfully installed & operated the silicon detectors !

2D Beam profile reconstructed from the SSD data







My main contribution -- Firmware --

Connection

CMOS pixel sensor -> ADC (on motherboard) -> FPGA(firmware) -> DAQ-PC

Task of firmware : Transfer/Process signals from the upstream (mother board) to the downstream (DAQ-PC). Also handling various control signals for both sides.

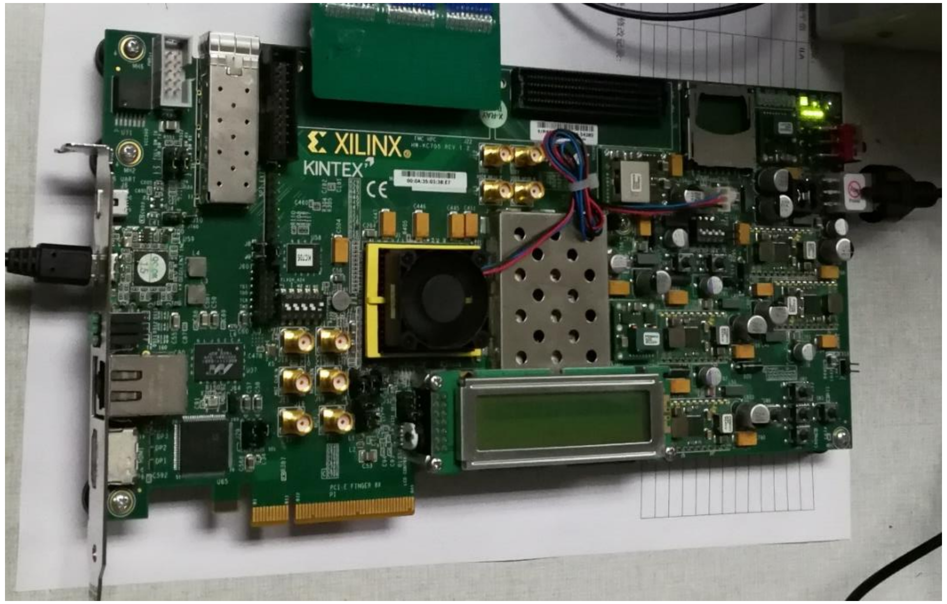
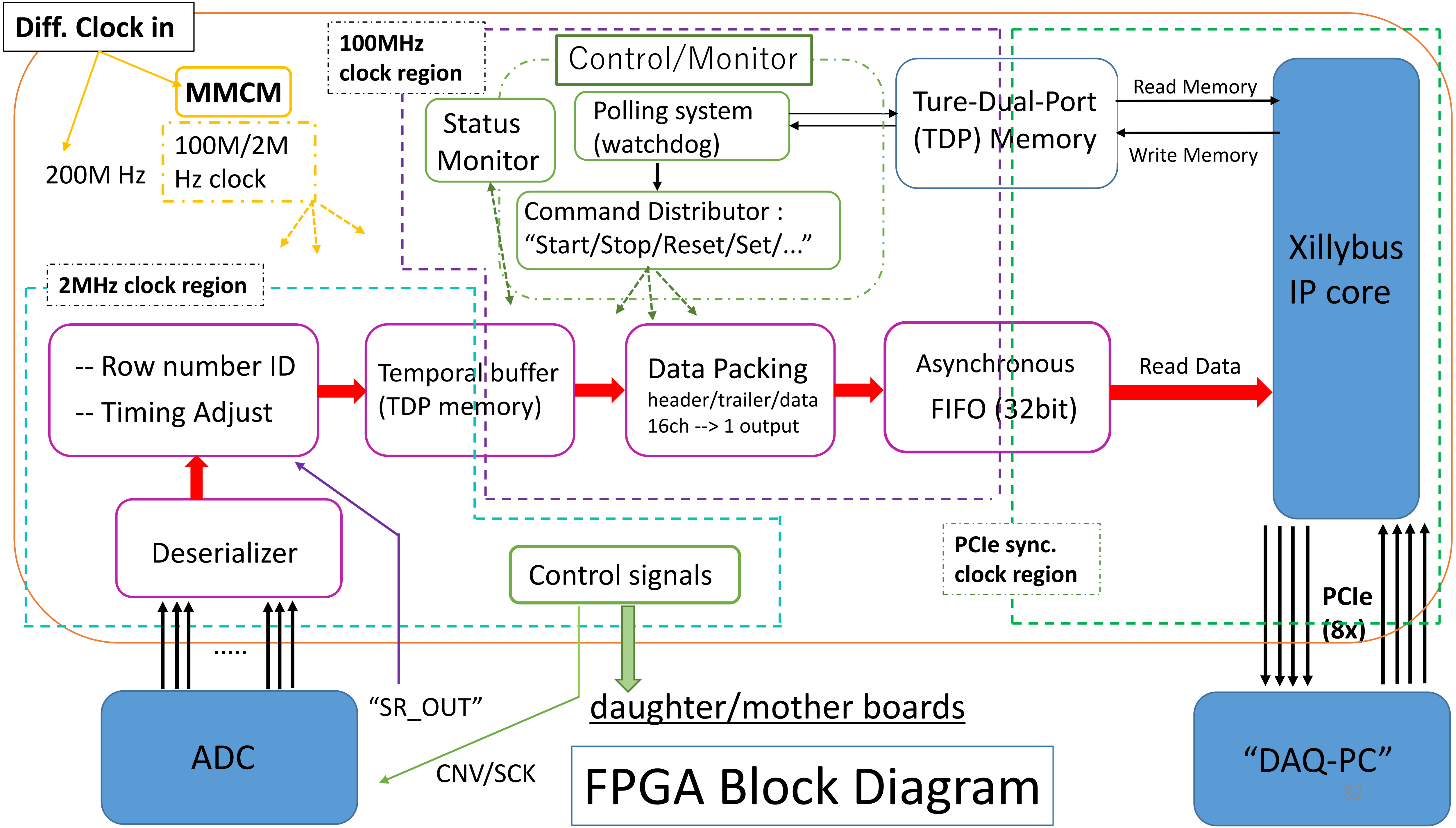


Figure : **Kintex-7 FPGA on the KC705 board**

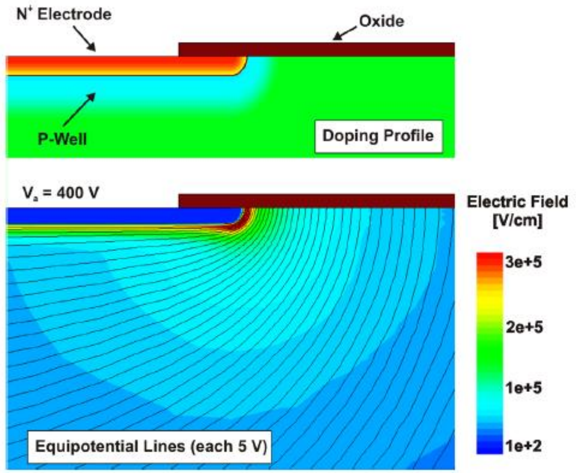
Figure : **Setup for data taking with ^{55}Fe source**

FPGA Block Diagram

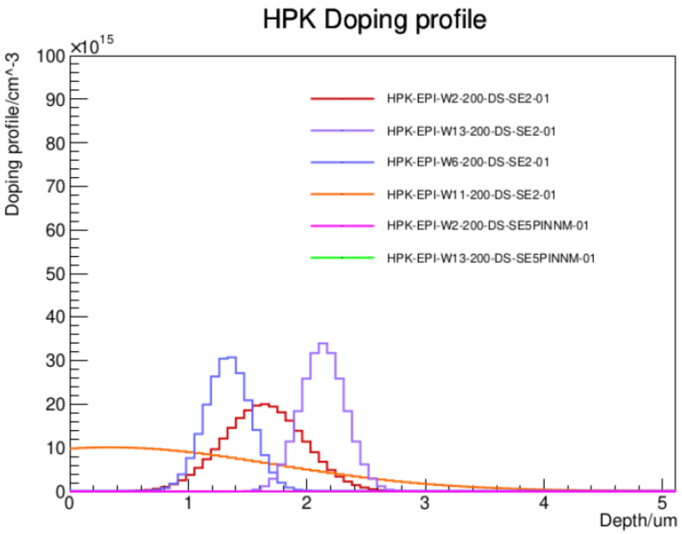


Doping Profile

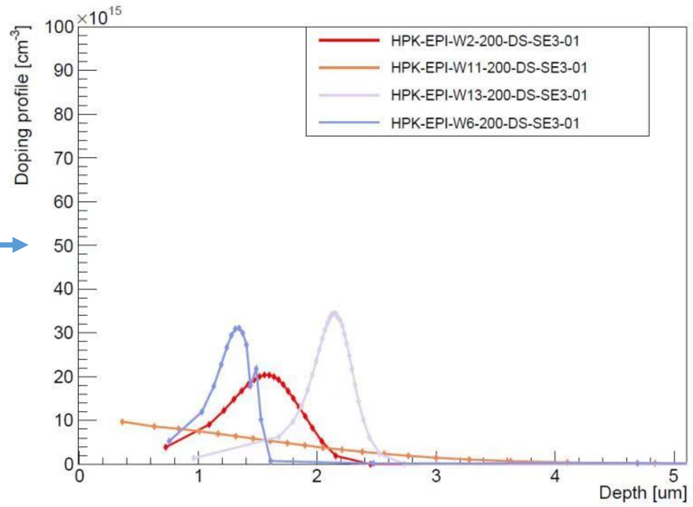
- Avalanche region in LGADs is reproduced
  - Neff parameters to set the effective doping profile
  - Simple Gaussian shape is assumed



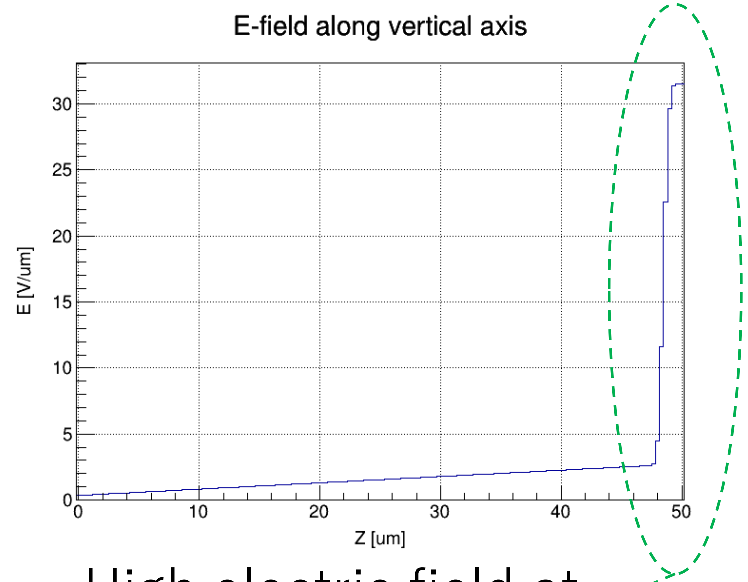
Schematic view of electric field and doping profile in LGAD [2]



Doping profile set in the TRACS simulation



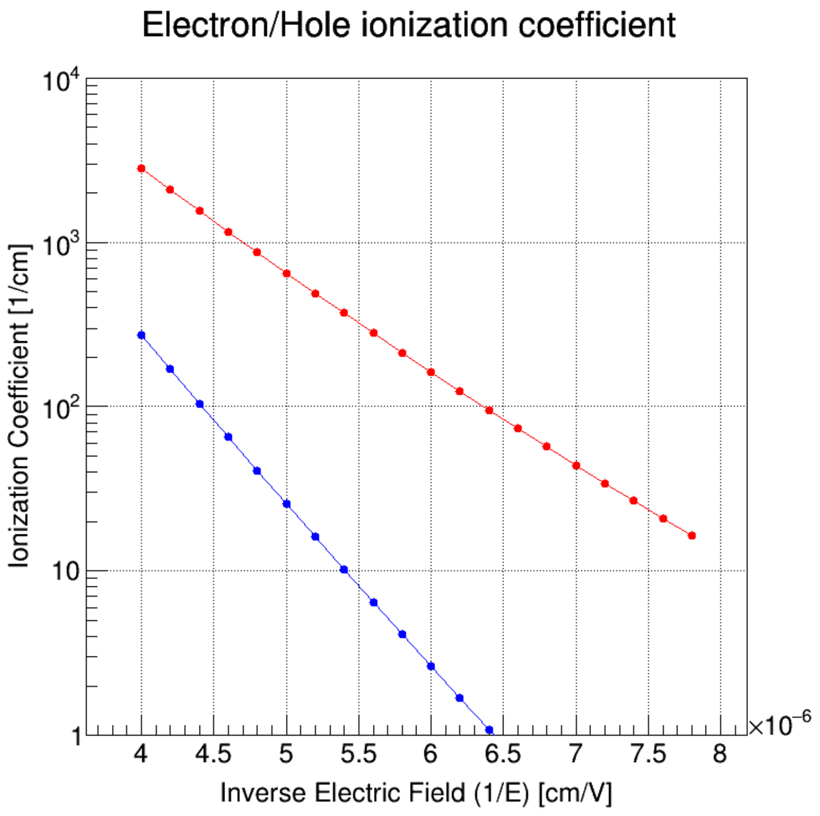
Doping profile deduced from CV measurements

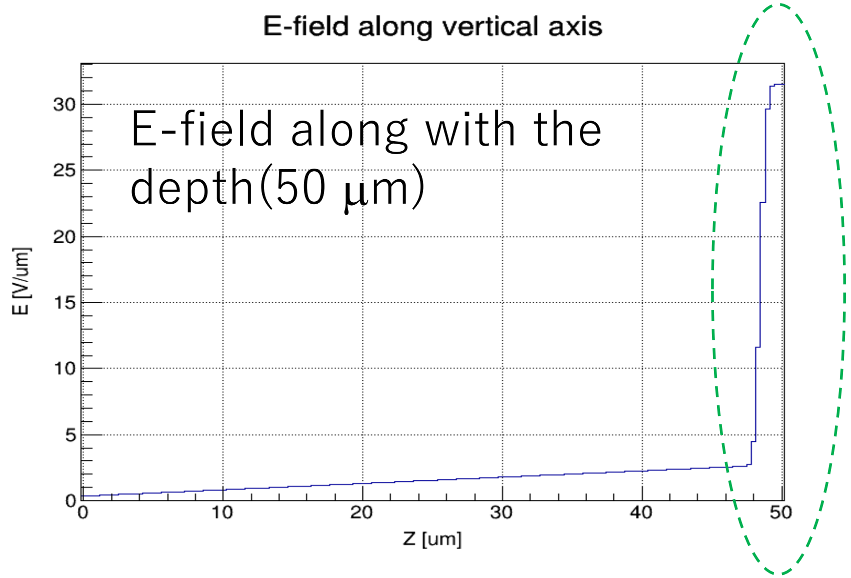


High electric field at “gain layer” in LGAD

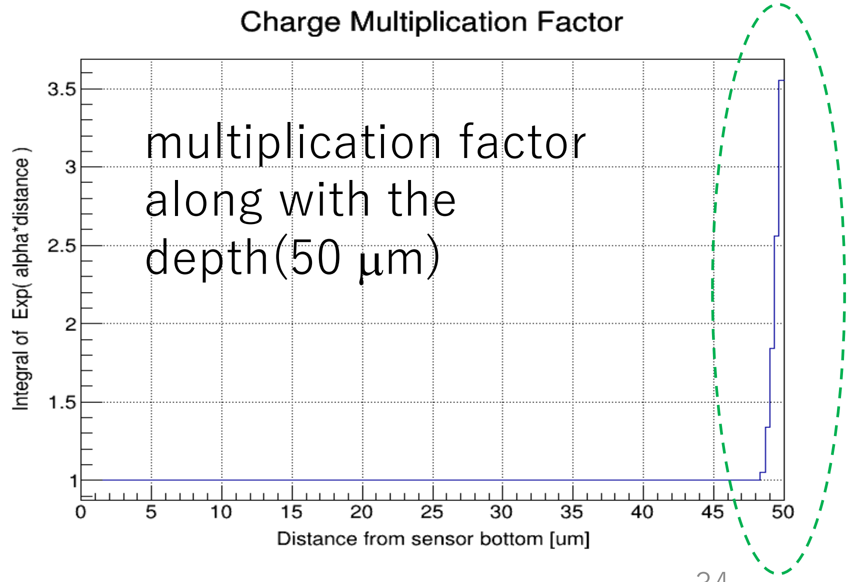
Impact Ionization Effect

- Adopt the impact ionization analytical model in [3]





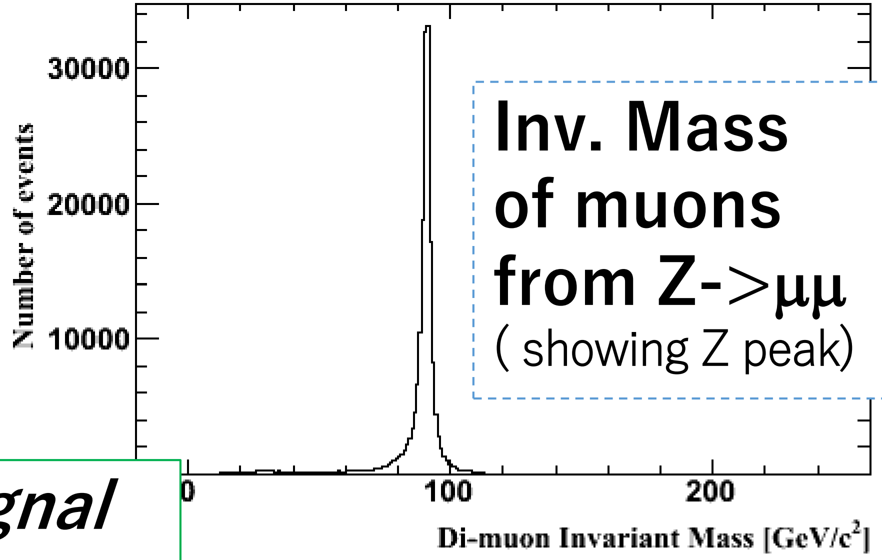
"gain layer" in LGAD



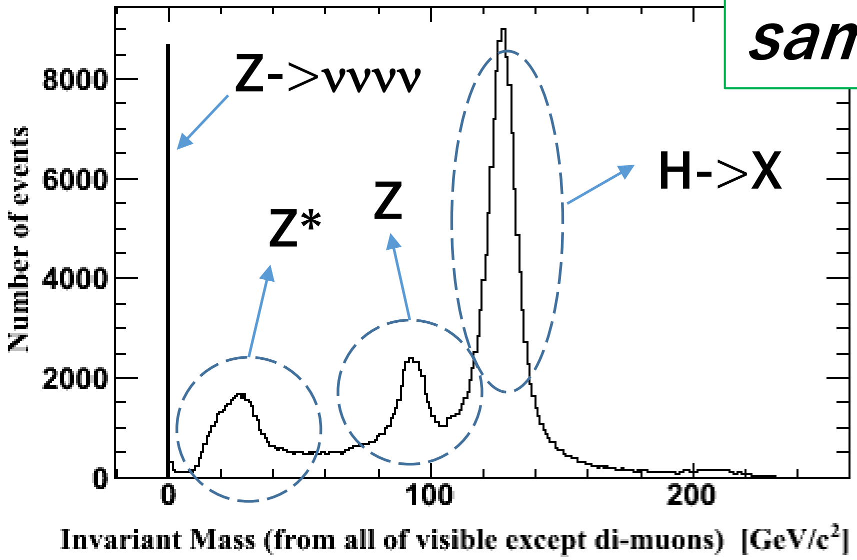
H->ZZ* analysis : Signal distribution

- Event selection for the exclusive channel: $e^+e^- \to ZH \to Z(\mu^+\mu^-)H(ZZ^* \to jj\nu\nu)$

Inv. Mass of muons from Z->μμ
(showing Z peak)



Showing only signal samples here



Rec. Mass of muons from Z->μμ
(showing Higgs peak)