Hypernuclear DAQ and preparation

May 16th 2025

Hypernuclear Collaboration Meeting

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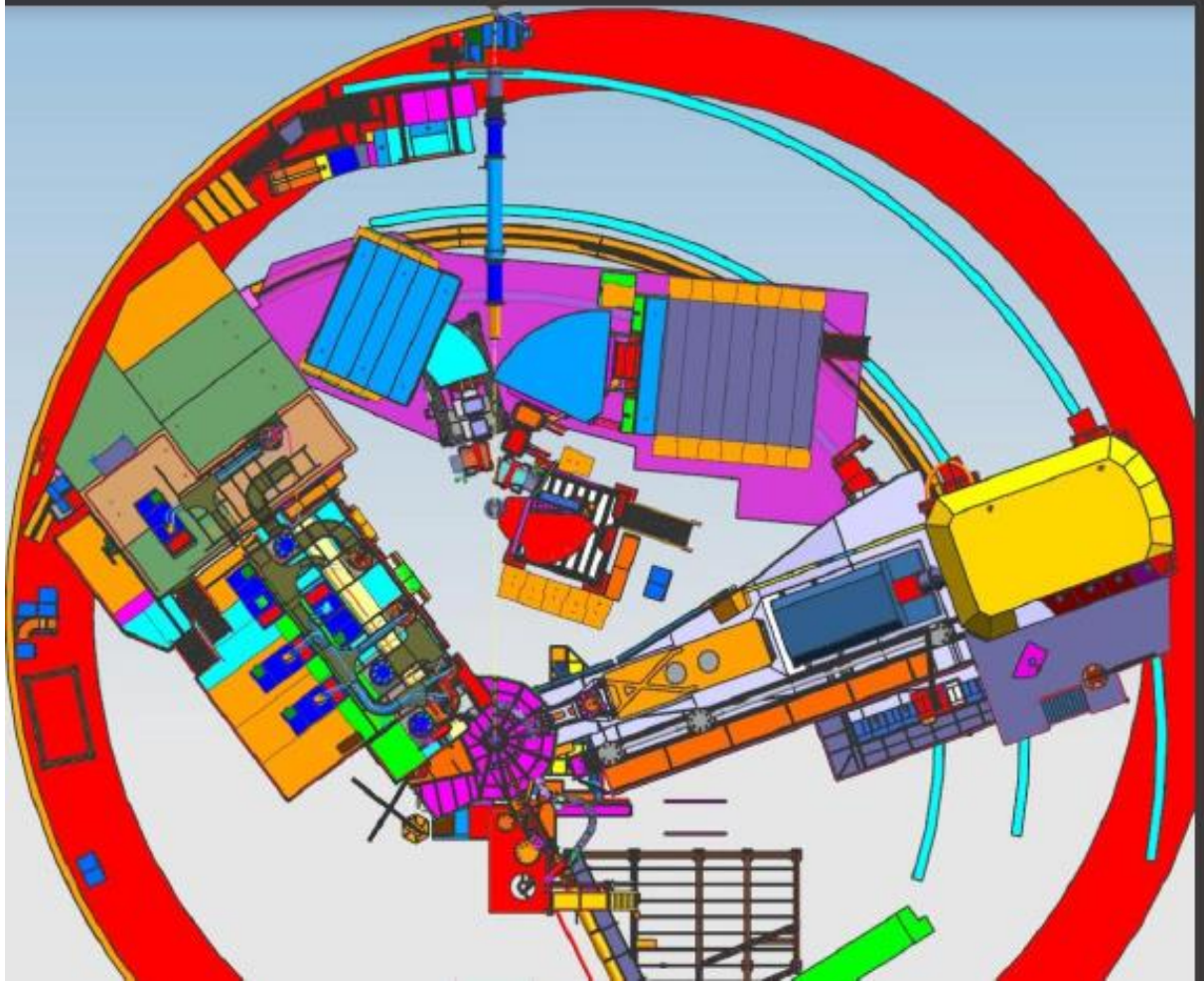
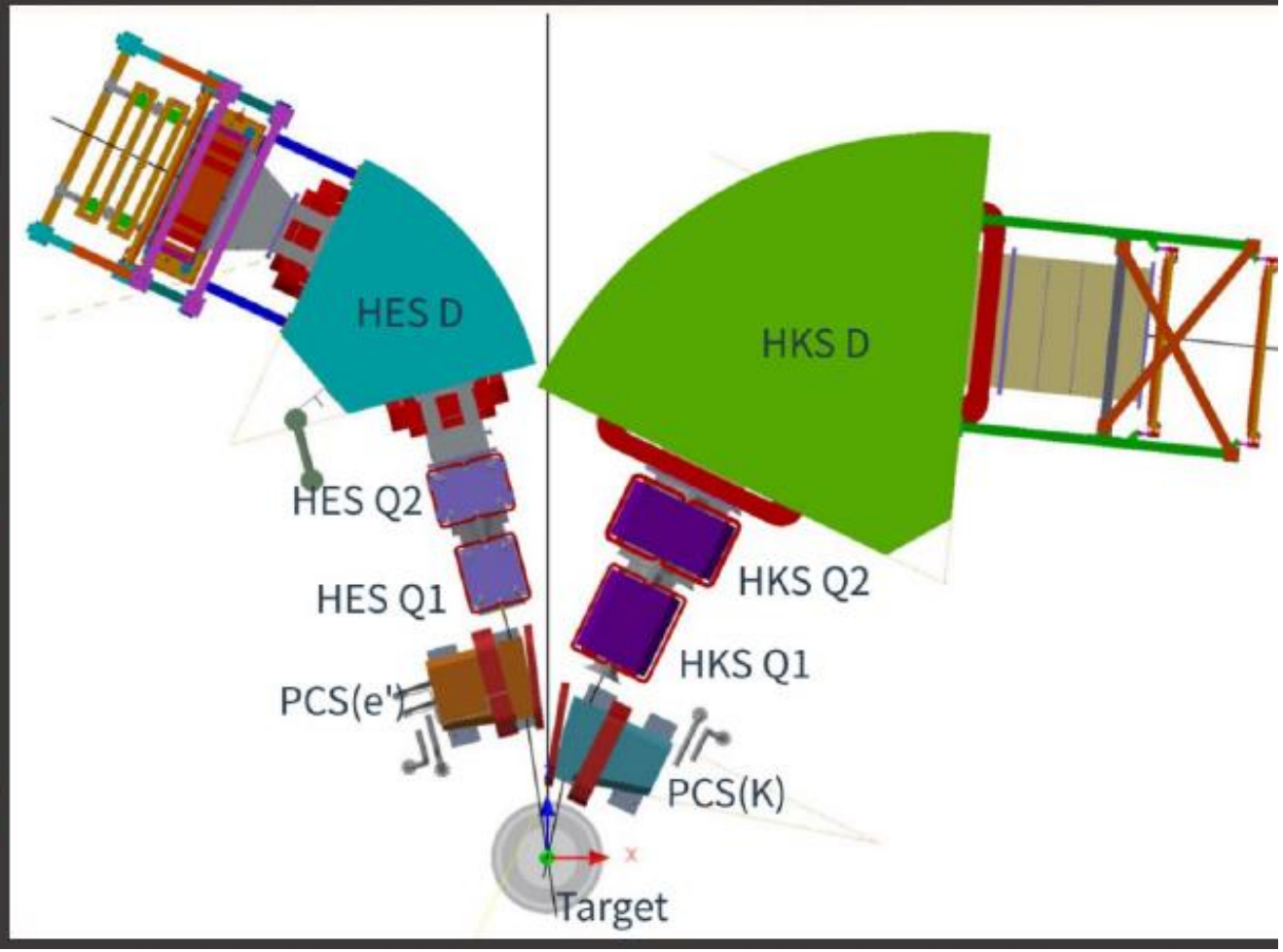
Outline

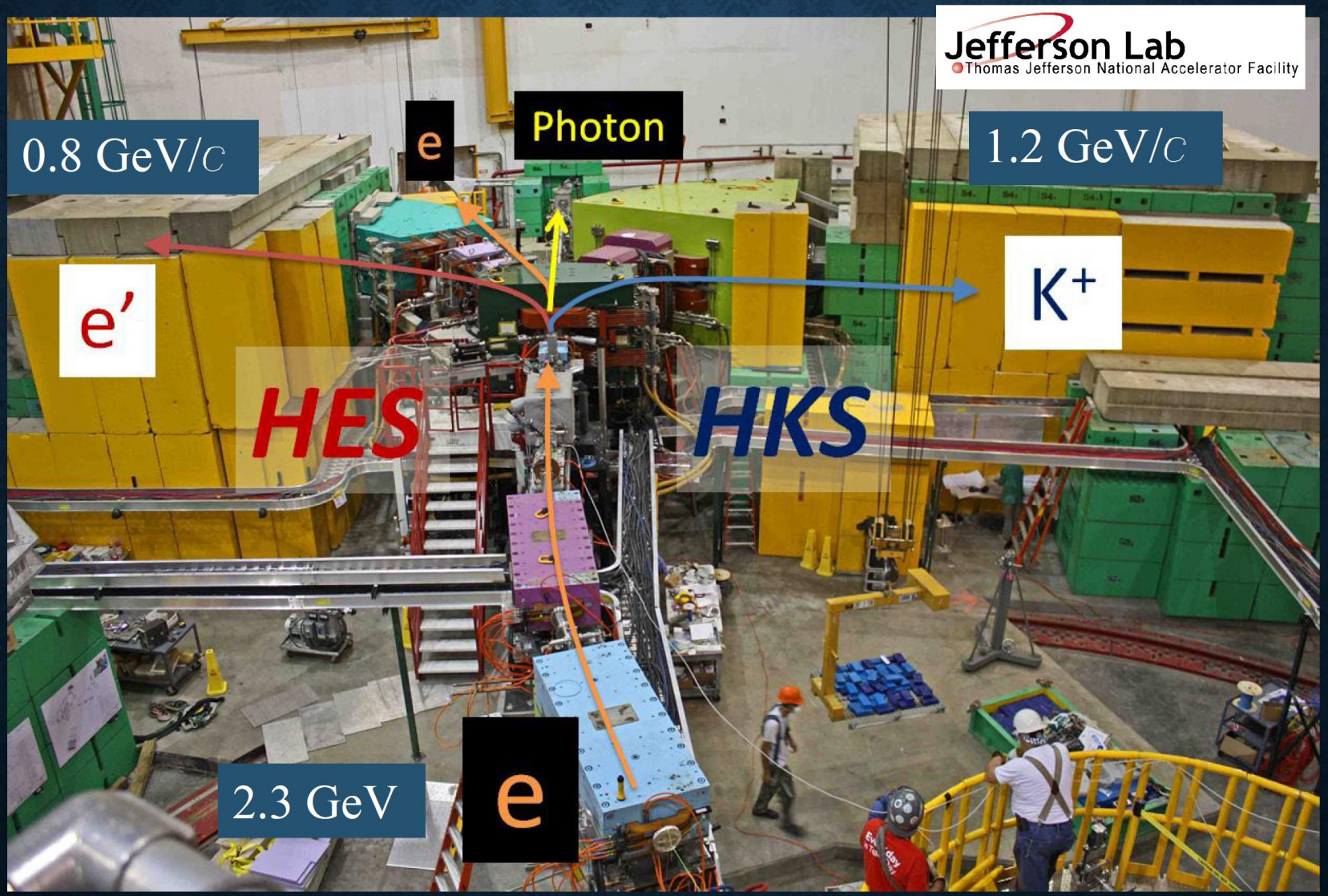
- Experiment overview
- Channel count
- Trigger overview and trigger rates
- Data rates
- SuperBigbite experiment
- Cable layout
- To do
- Labor
- Conclusion

Experimental setup at Hall C





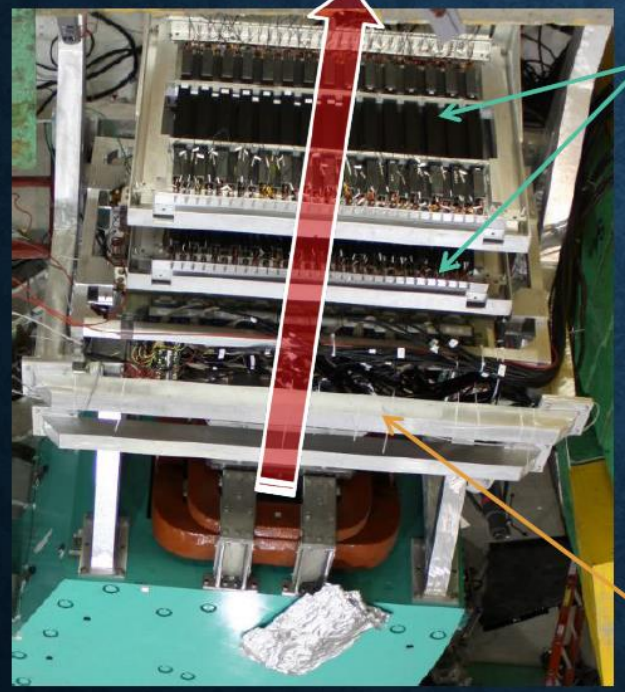
Experimental setup for E05-115 (2009) at JLab Hall C



PARTICLE DETECTORS

HES

e^-



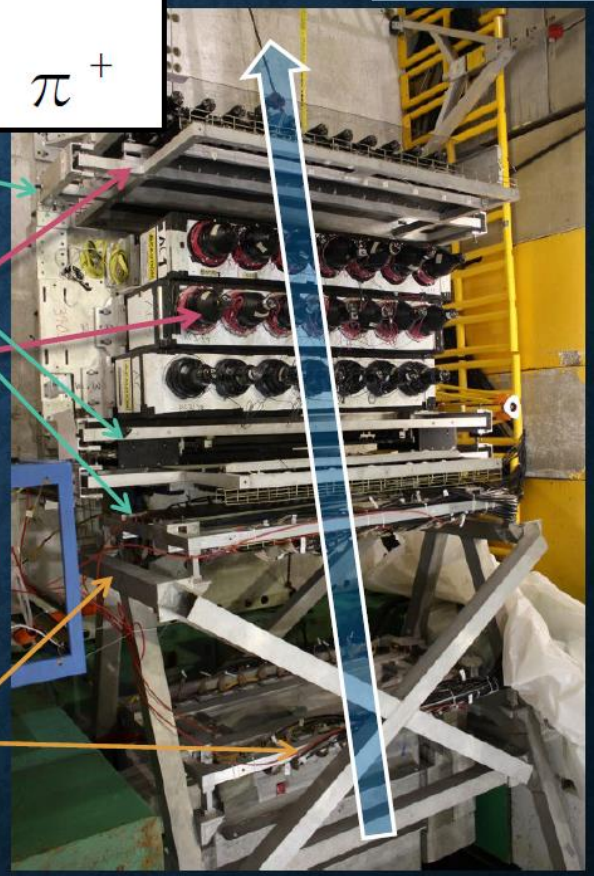
TOF walls
(Plastic scintillators)

Cherenkov detectors
- Aerogel (n=1.05)
- Water (n=1.33)

Drift chambers

K^+
p, π^+

HKS



ENGE spectrometer channels

Spectrometer	Detector	ADC	TDC
ENGE	Fiber tracker	-	832
	Drift chamber	-	360
	Timing counter	-	96
Number of total channels		0	1416

EASIROC : Time and Time over threshold for SciFi and TOF
12 V1190 or 8 VETROCs

Channel count

	Detector	Current status	No. of channels		Ready?
			ADC	TDC	
HKS	Drift Chambers	To be tested	N/A	360 + 360	
	TOF counters	All PMTs were checked	88	88	
	Aerogel Cherenkov	Test done	42	42	Yes
	Water Cherenkov	New boxes under construction	48	48	
HES	Drift Chambers	To be tested	N/A	1098+360	
	TOF counters	To be tested	116	116	

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FADC = 88 + 42 +48 +116 = 294 channels = 19 FADCs = 2 VXS crates (NPS)
V1190 = 2268 channels = 18 V1190 = 1 VME64X crate (HMS/SHMS/SBS could use CDET VETROC)
TOF = 204 channels = 3 VETROC
ENGE = 1416 TDC channels = 8 VETROCs
Will be running during Moller : NPS,SBS,SoLID hardware available
Can use HMS/SHMS electronics
BPM rasters : 2 FADC
Total : 18 V1190 (HMS/SHMS) 11 VETROC (Cdet) and 19 FADCs (SBS BigBite, Ecal, SoLID :~ 3000 channels)
4 VXS crates

HES Trigger

7.1. Trigger condition

7.1.1. HKS-HES trigger

The trigger condition is a coincidence between HES and HKS,

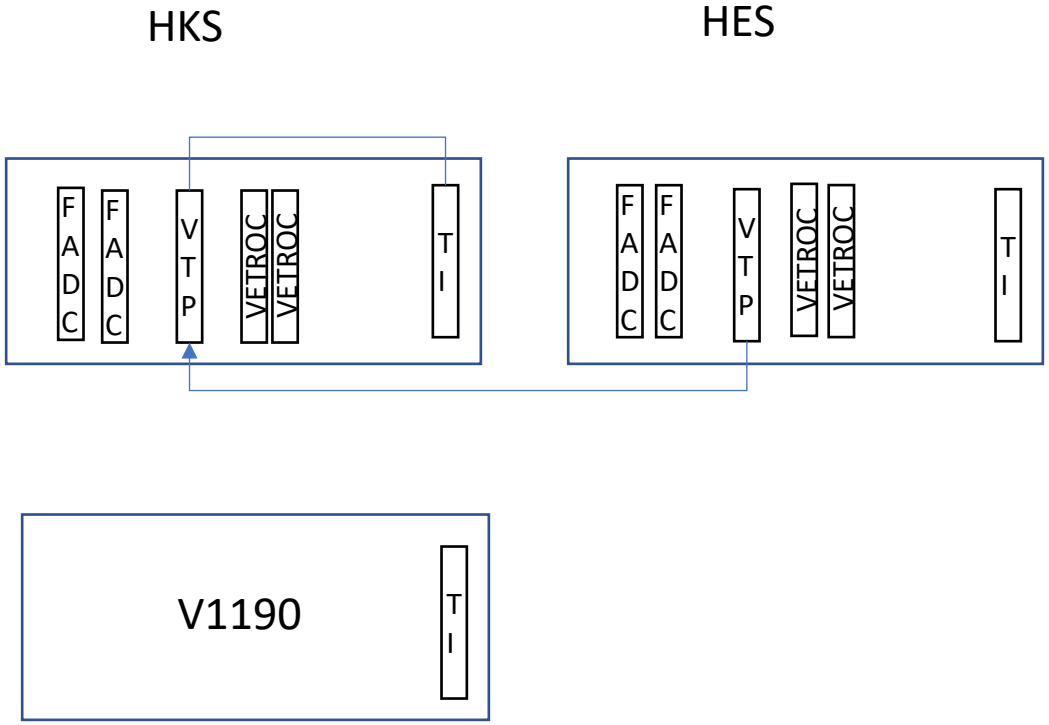
$$HES \otimes HKS \quad \text{Eq. (7.1)}$$

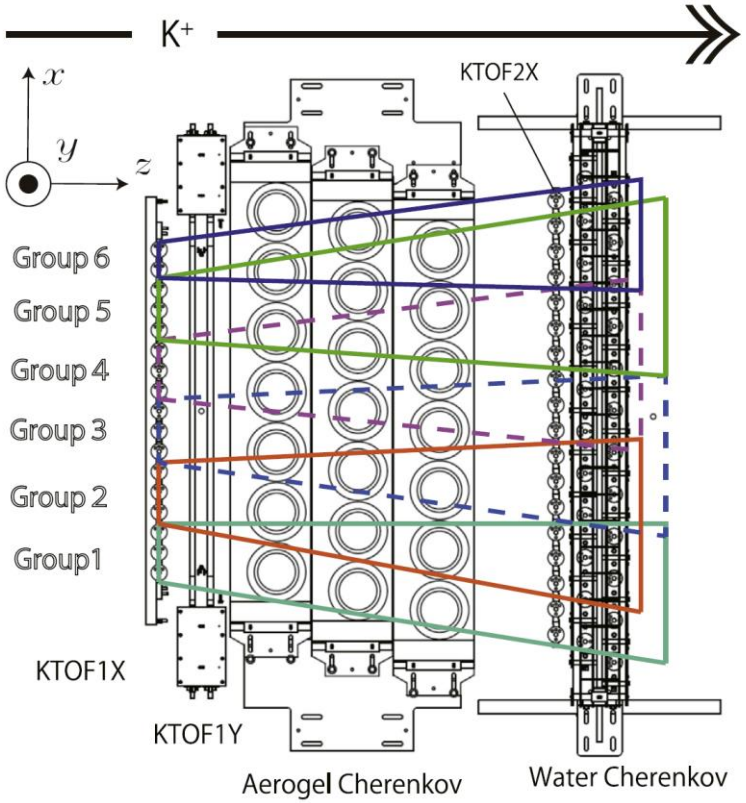
where,

$$HES = EHODO1 \otimes EHODO2, \quad \text{Eq. (7.2)}$$

$$HKS = KTOF1X \otimes KTOF2X \otimes KTOF1Y. \quad \text{Eq. (7.3)}$$

HKS readout and trigger





Use FADC data going to VTP to makes coincidences between the groups
Can program VTP for coincidences between scintillators
If use VETROC instead of V1190 could add Drift Chamber to trigger
Tests crate with FADC and VTP setup in ESB, deploying VETROC

Drift chamber testing

- Fastbus system available
- Need to revive system

- Can install VETROC or more Fastbus crates to test more chambers

Trigger rates HKS/HES and DAQ rates

Target	Areal density [/(g/cm²)]	Beam intensity (/ μA)	HES rate (/kHz)	HKS rate (/kHz)			Accidental coincidence(*) (/kHz)
			e'	π^+	K^+	p	
^{6}Li	100	50	120	22	0.27	28	**1.0**
^{9}Be			140	21	0.26	27	**1.8**
^{11}B			170	21	0.25	26	**2.1**
^{27}Al			930	20	0.24	25	**10.5**
^{40}Ca	150		1100	26	0.31	33	**14.8**
^{48}Ca			940	25	0.31	32	**13.8**
^{208}Pb		20	1300	8.2	0.24	10	**4.9**

(*) Assuming,
HES: 30 ns width
HKS: 200 ns width

Maximum rate 15 kHz

ENGE spectrometer

Target	$\mathcal{R}_{\mathrm{HKS}}$ (kHz)	$\mathcal{R}_{\mathrm{Enge}}$ (kHz)	$\mathcal{R}_{\mathrm{Trigger}}$ (Hz)	$\mathcal{R}_{\mathrm{Spectrum}}$ (Hz/MeV)
^{6}Li	45	20	90	5.6×10^{-6}
^{9}Be	25	21	50	3.0×10^{-6}
^{12}C (Graphite)	41	20	80	5.2×10^{-6}
^{27}Al	54	31	170	1.0×10^{-5}
^{40}Ca	52	31	160	9.5×10^{-6}
^{208}Pb	20	15	30	1.9×10^{-6}

Trigger rate is very low compared to HKS and HES

ENGE readout

- EASIROC
- Send logic signal to VETROC
- Some experience with radiation test setup

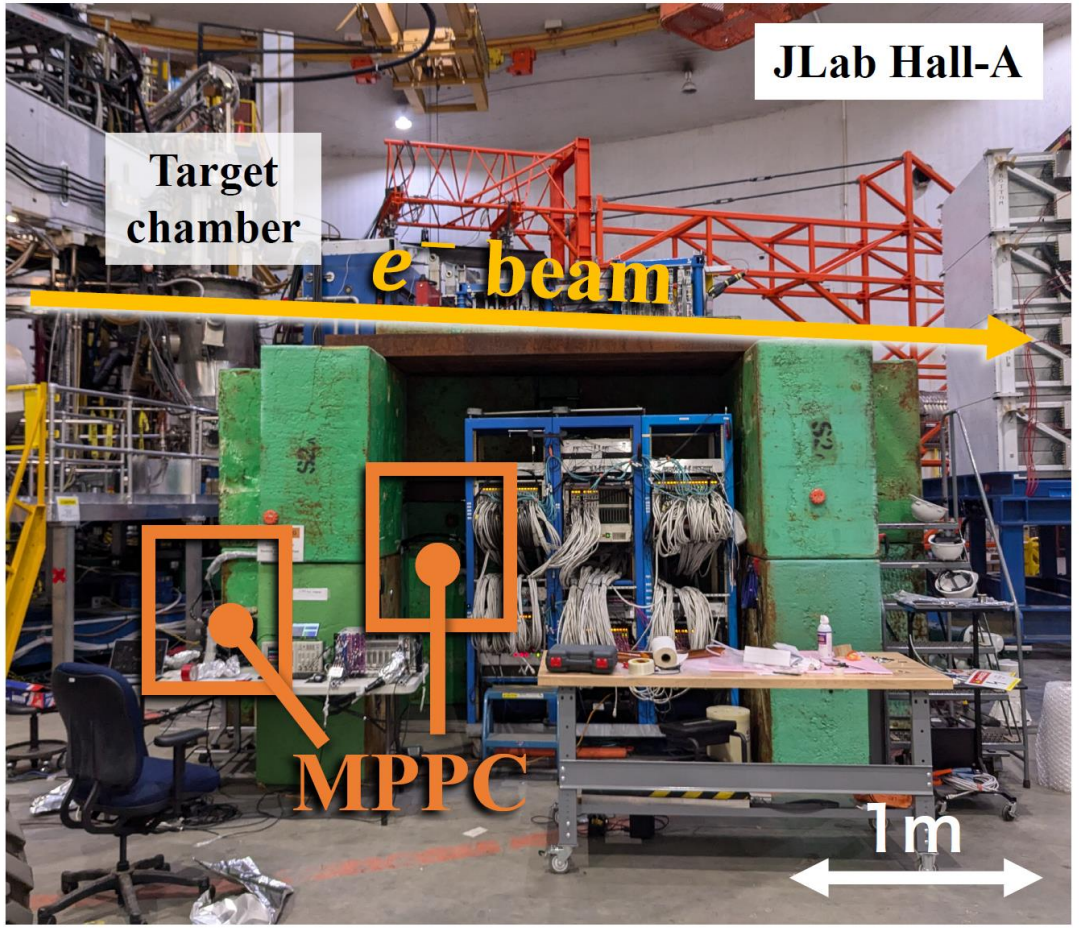
Status of MPPC radiation test

- **The 1st ERR raised a concern about radiation damage on MPPC**

- **Radiation test is ongoing in Hall-A**
  - Parasite on SBS experiment (April 9 ~)
  - Monitoring MPPC performance & radiation dose
    - Detection efficiency
    - Noise level & Gain

- **SBS experiment** (as of May 7)
  - Beam current : ~ 20 μA
  - Target : LH_2
  - Neutron flux : 100 ~ 200 mrem/h
  - Total dose : 7.4 rem (inside), 18.4 rem (outside)

→ Comparable to estimated Hall-C radiation



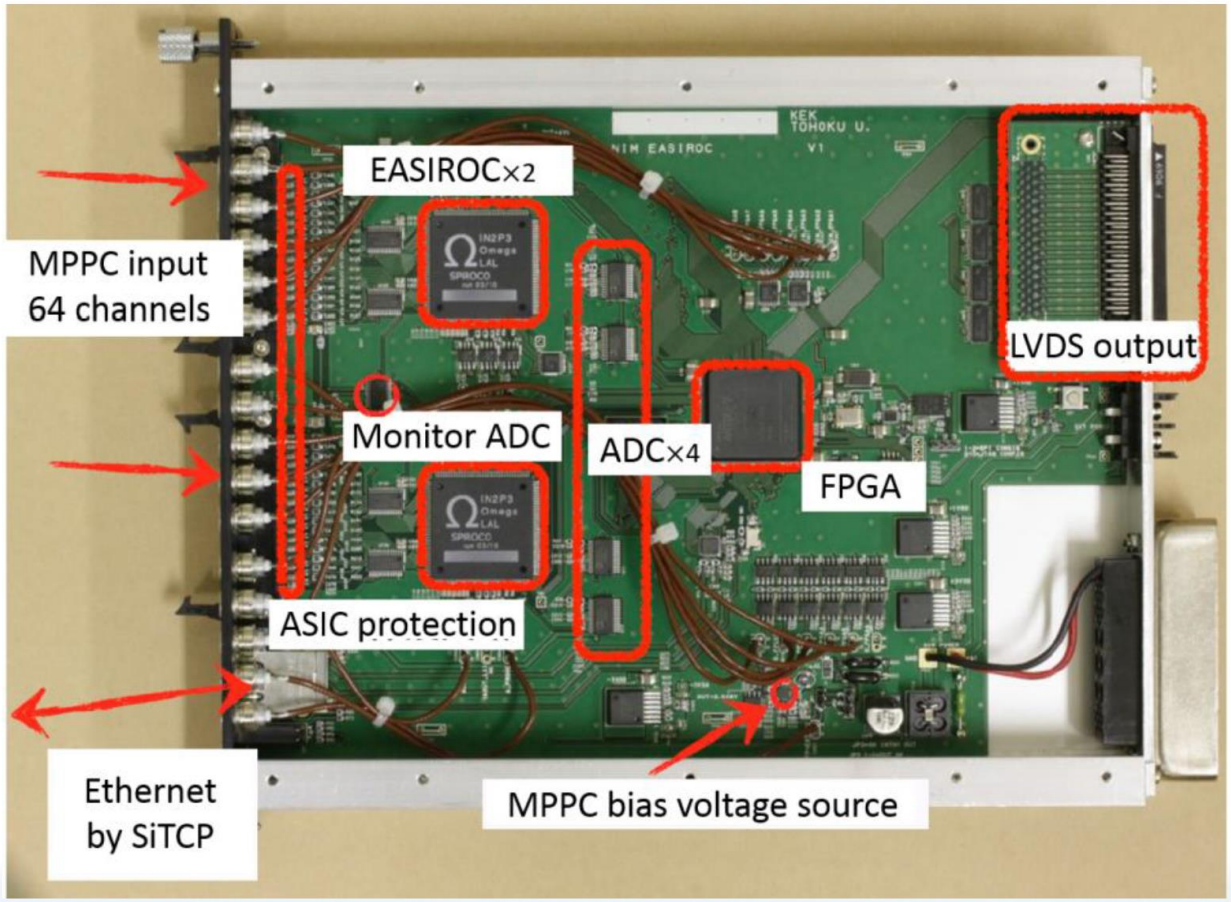
Readout – NIM-EASIROC module

EASIROC(ASIC) + FPGA + I/O module for MPPC
Developed and demonstrated for scintillating fiber detector at J-PARC

2 EASIROC ASIC
- Power : NIM crat or Cable
- 32 x 2 MPPC IN
- Preamp, Shaper
- Discriminator LVDS OUT
- 1 ns LSB Multi-hit TDC
- HV and threshold fine tuning in software

ADC
- 12-bit Pipe-line ADC
- 2 x 2

FPGA
- XC7A100T-2FGG676C



VfTDC

- Multipurpose FPGA board
- 4x32 channel front panel + 2 x 32 back panel
- 18 ps per bin

- To develop
  - VTP trigger
  - VTP readout

- Test and develop
  - Timing resolution
  - Software for vfTDC readout , offset and timewalk corrections

Data rates with time / integral

- Event size
  - 13 kB with time and amplitude 100 % occupancy
  - Estimated occupancy 5% maximum
- Max trigger rate : 15 KHz
- Max data rate : 190 MB/s
- Expected data rate : 9.5 MB/s
- Can be handled now by Hall C DAQ
- Tape : ~ 0.2 PB

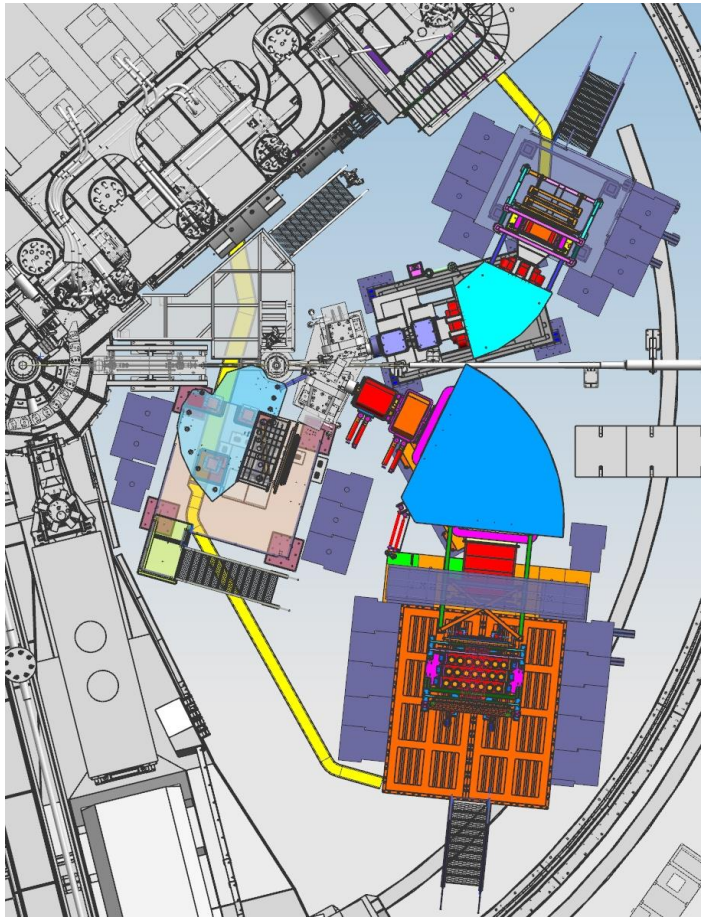
SuperBigbite experiment

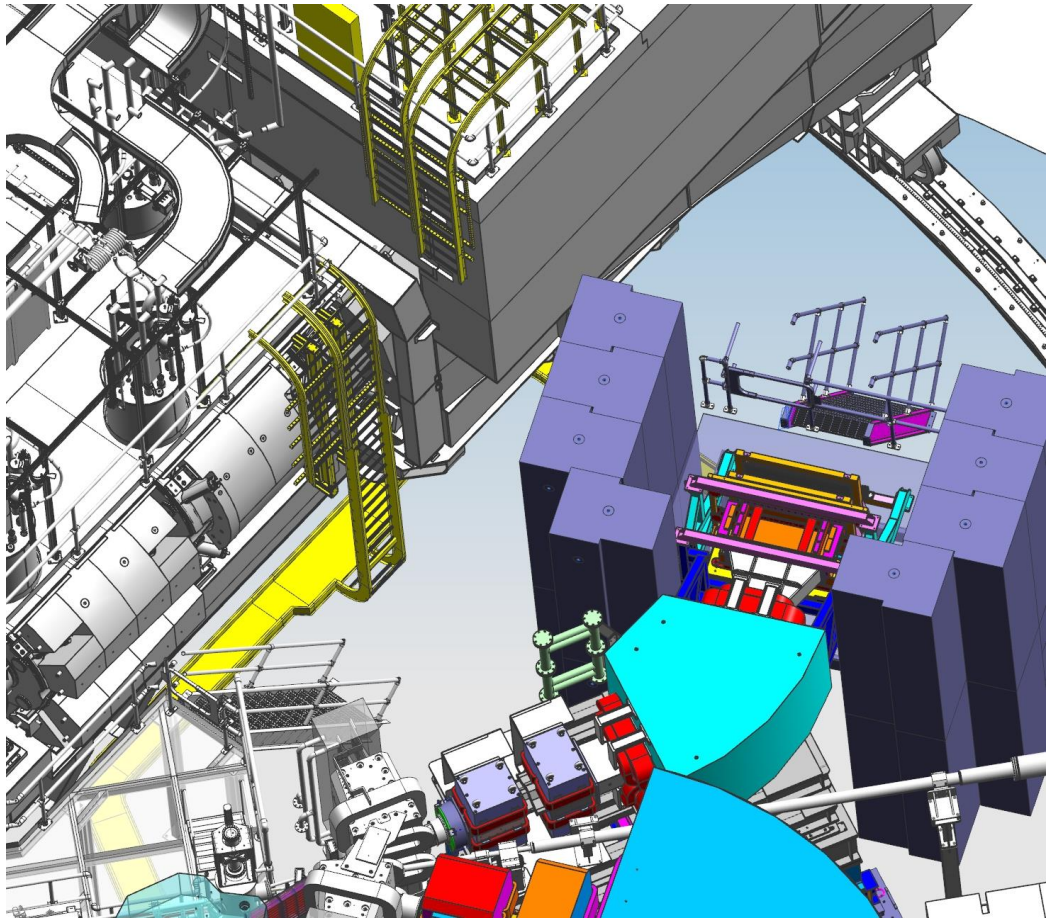
- Ecal
  - 1800 channels
  - FADC trigger and readout
  - 7 crates with 13 to 16 FADCs
  - One VTP per crate
  - 50 m and 100 m cables
- Coordinate detector
  - 2352 channel of MaPMT
  - Nino amplifier discriminator
  - 2352 / 16 = 147 ribbon cables
  - LVDS repeater
  - ~ 1 ns timing resolution
  - Software developed by CNU

Additional electronics

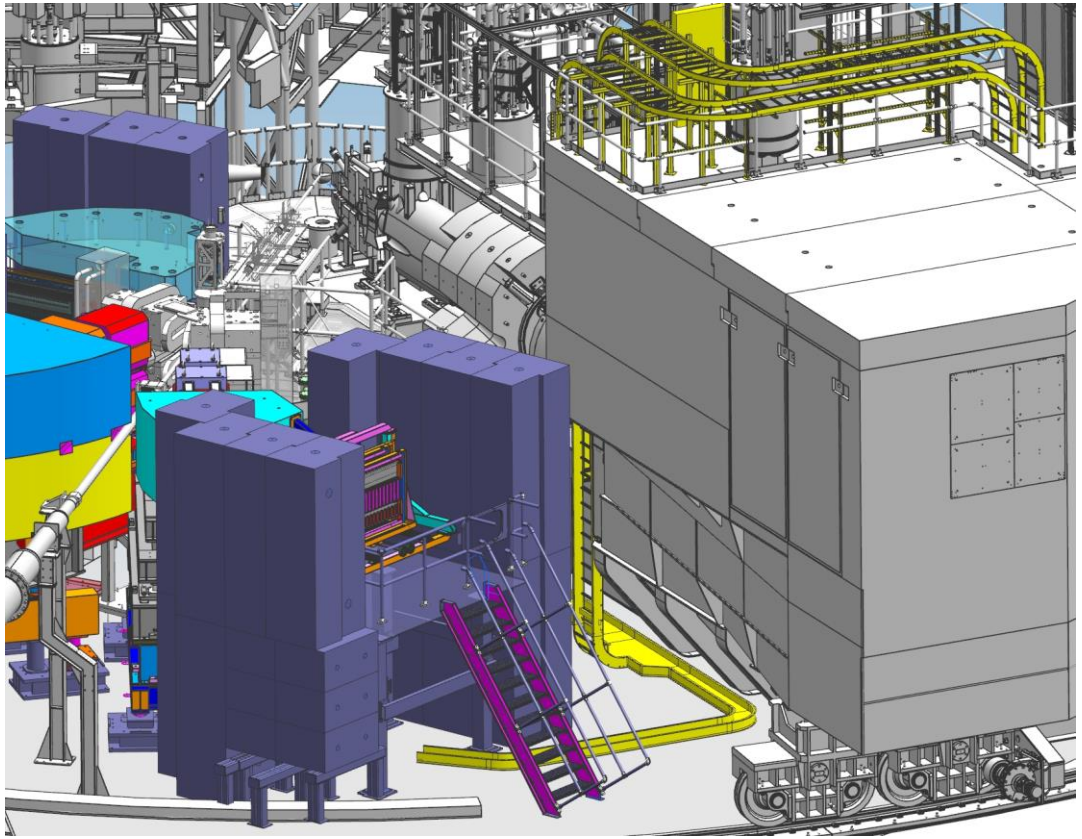
- Beamline info
  - Target and beamline BPM
  - Raster
  - 1C12 BPM

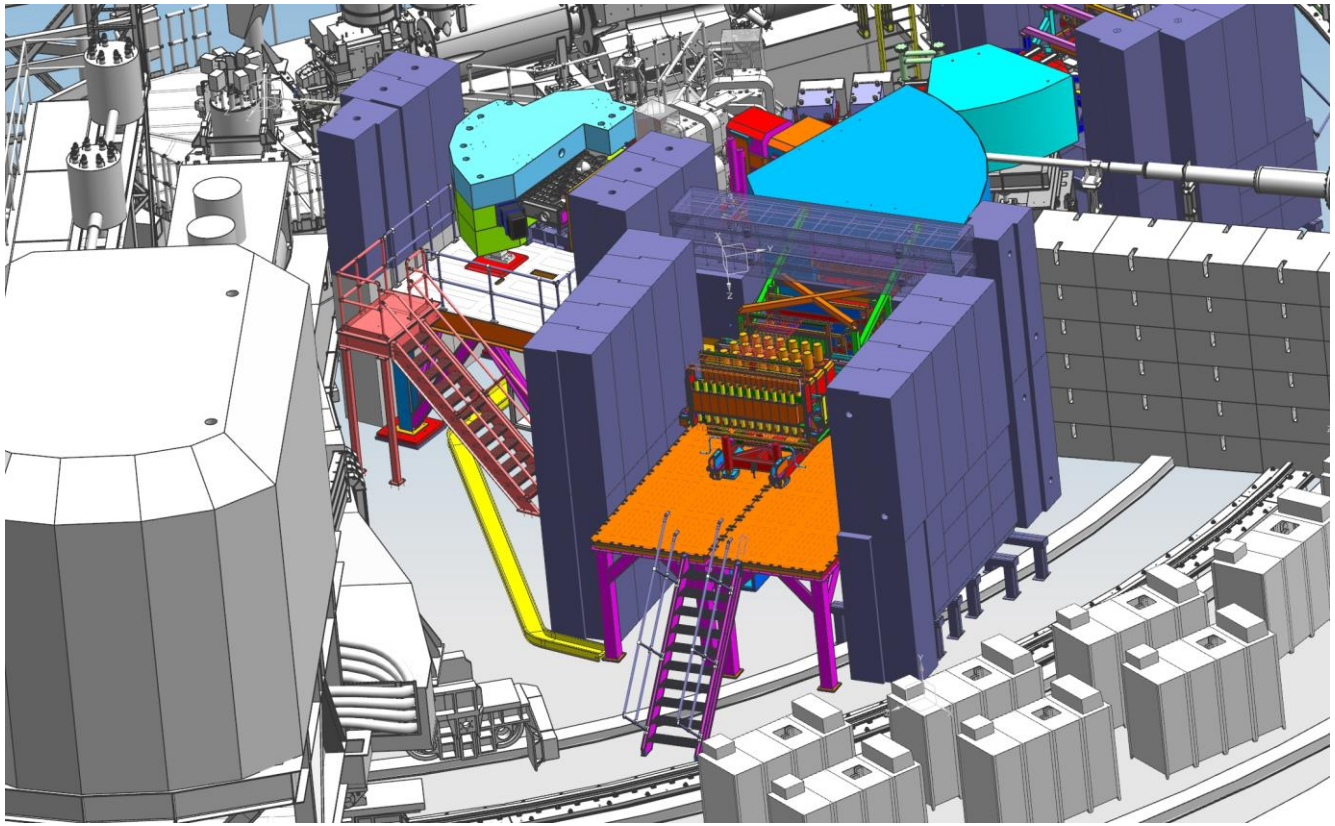
Cabling to SHMS hut





Cabling to SHMS hut





MRPC

- MRPC
  - 12 modules (3 planes x 4) to cover HKS, HES, ENGE
  - Hope to get 50 ps timing resolution – On bench 25 ps reached
  - 256 channels per module = 3048 channels of high resolution TDC = 16 VETROC
  - Default : use SBS NINO and VETROC from CDET (20 ps)
  - Other readout but need to procure (few modules to test now)
    - PicoTDC
    - NALU ASOC or AARDVARC

To do / Testing

- Bench testing and testing with detector VETROC
- Setup FADC trigger with VTP
- Setup testing in ESB
  - Cerenkov
  - TOF scintillator
  - Wire chamber
  - VfTDC test
- Setup beamline crate

Labor

- Hanjie Liu (DAQ, Trigger)
- Teppei Iwamoto (Detector, Trigger)
- Sho Nagao,Ken Nishida (ENGE SiPM, Easyroc)
- William Henry (DAQ, detectors)
- Chandan Gosh (DAQ,detectors)
- Sangwha Park (Software)
- Alexandre Camsonne (DAQ, Trigger, Beamline)
- Toshiyuki Gogami (Detector testing and setup)
- Ben Raydo (VTP)

Conclusion

- HKS,HES
  - FADC = 88 + 42 +48 +116 = 294 channels = 19 FADCs = 2 VXS crates
  - V1190 = 2268 channels = 18 V1190 = 1 VME64X crate or 2 VXS crates
  - TOF = 204 channels = 3 VETROC
  - All modules available from SHMS/HMS/NPS/SBS hardware
- CODA3 with 20 kHz trigger rate (should be able to handle 200 KHz limited by tape cost)
- Digital trigger using FADC, VTP and VETROC
- Expected rate 10 MB/s, can be handled by current Hall C DAQ
- Getting setup in ESB for detector tests

Backup

		ADC	TDC		Event size		Occupancy					
HKS												
	Drift chamber		720		2880					High resolution		204
	TOF counter	88	88		1056					Low resolution		2268
	Aerogel Cherenkov	42	42		504							
	Water Cherenkov	48	48		576							
										FADC	19	
HES	Drift Chambers		1458		5832							
	TOF counter	116	116		1392					V1190		18
										VETROC		3
ENGE	SciFi		360		2882					V1290		7
	DC		832		6658					F1		4
	TOF		96		770							
								183.6	MB/s max			
							Expected	10	MB/s		2.625333	PB
								2625333120	MB	Expected	~0.3	PB