Trigger and Data acquisition for Hypernuclear HKE,HES and ENGE

June 5th 2026

HKS ERR

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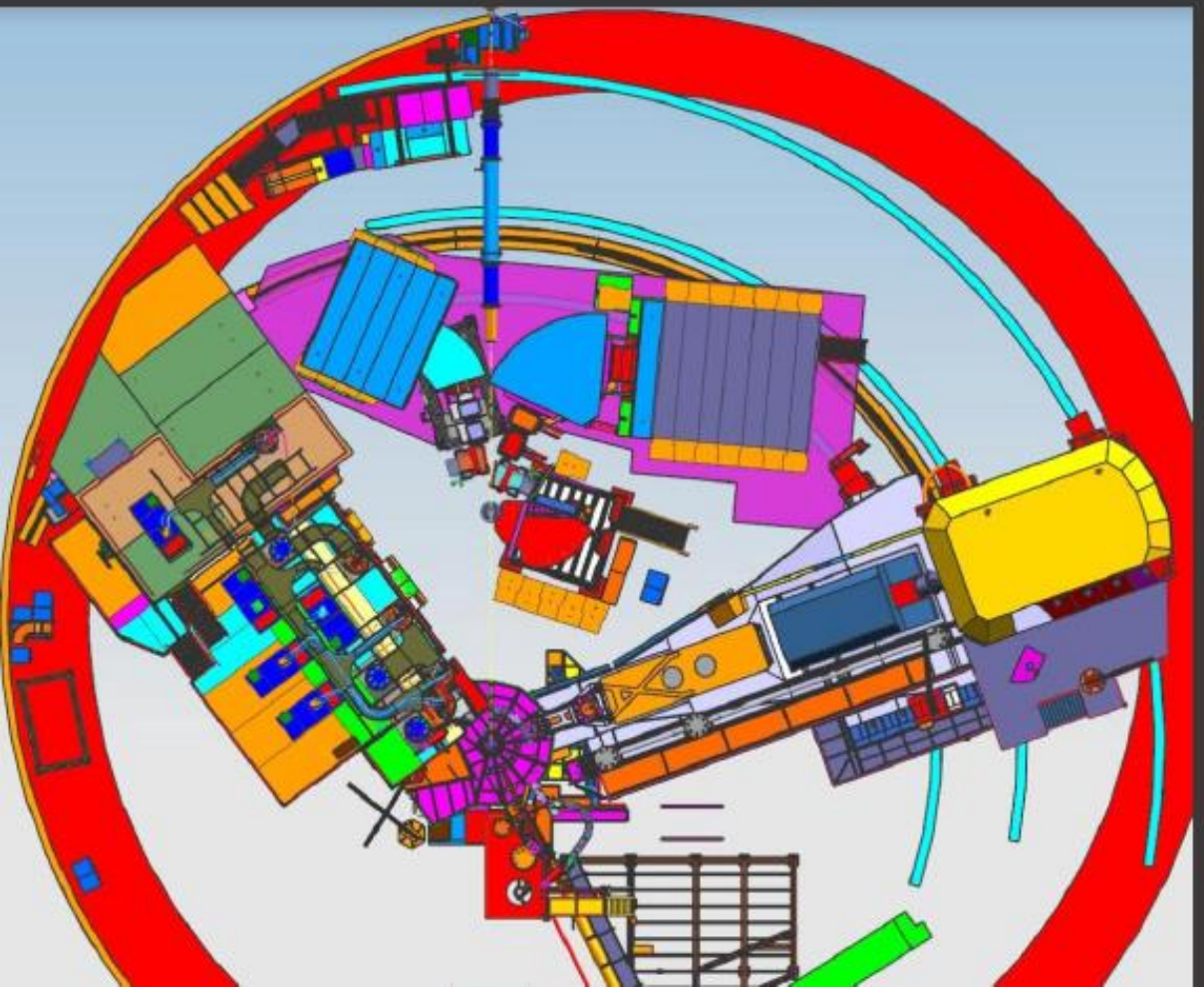
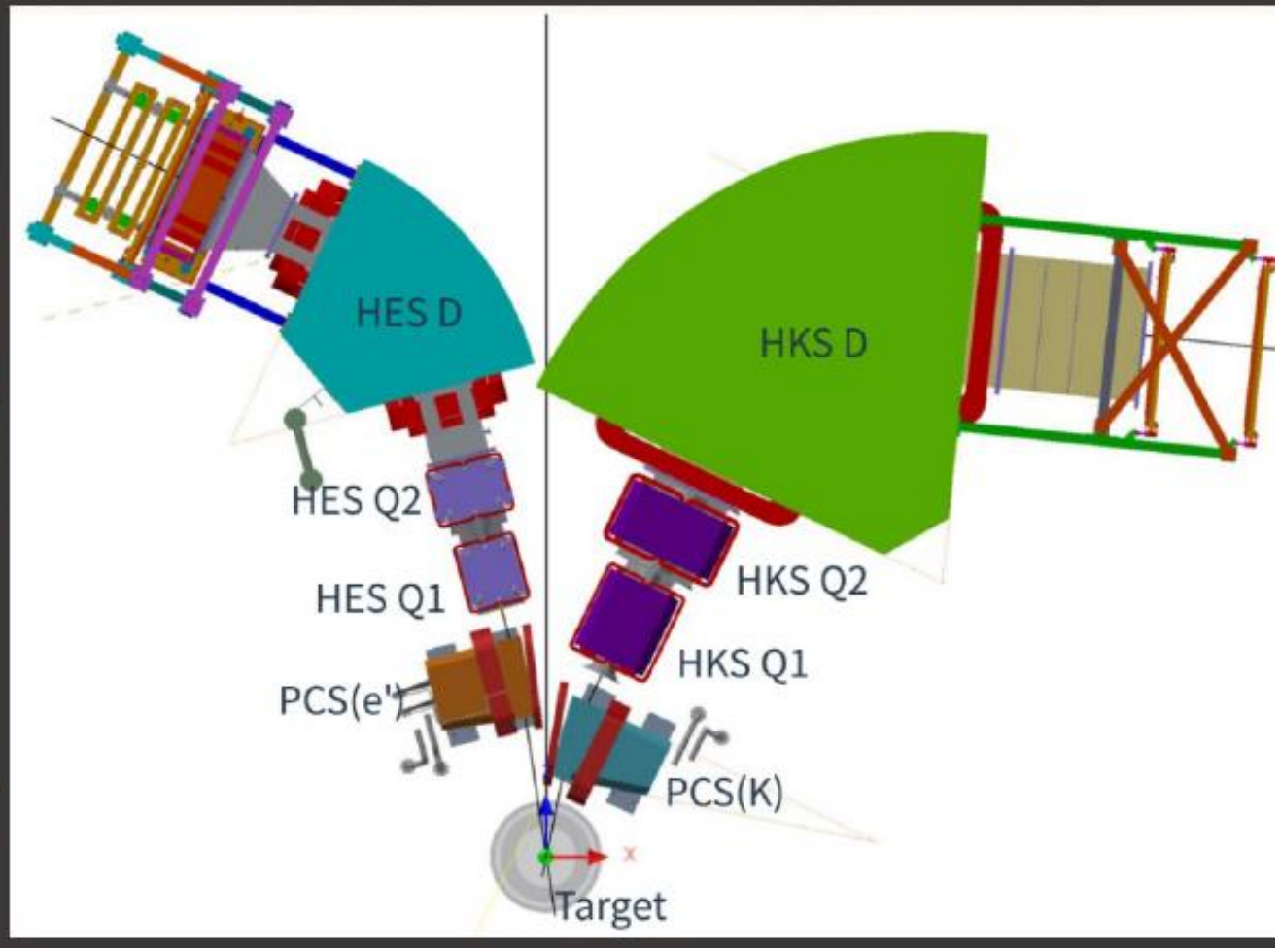
Outline

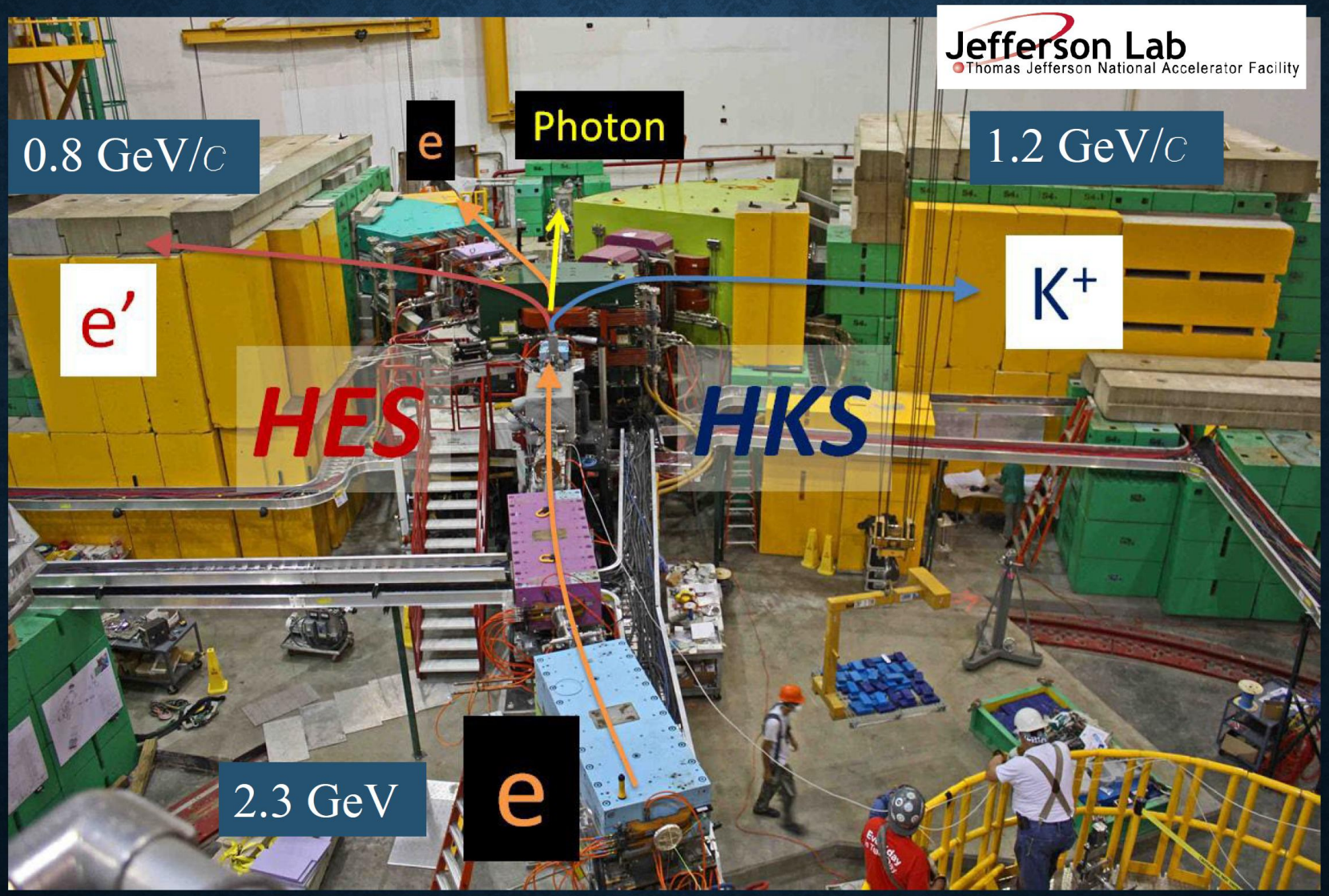
- Experiment overview
- Channel count
- Trigger overview and trigger rates
- Data rates
- To do
- Labor
- Conclusion

Experimental setup at Hall C





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



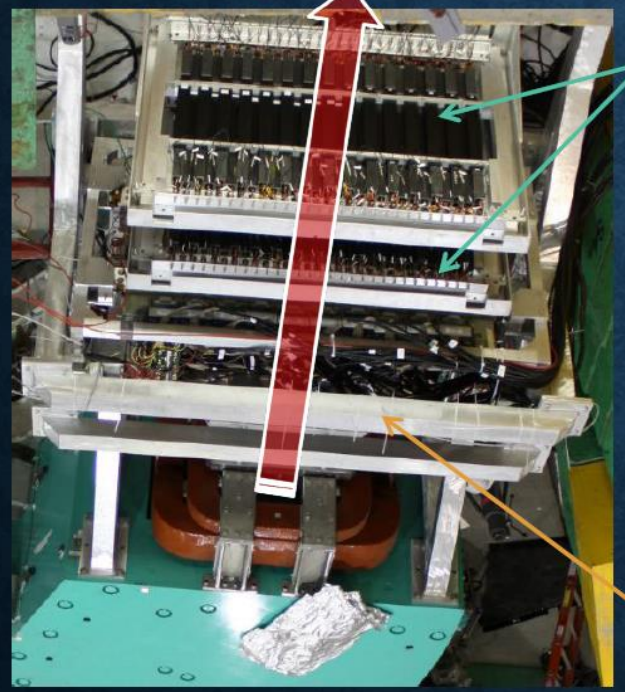
PARTICLE DETECTORS

HES

e^-

HKS

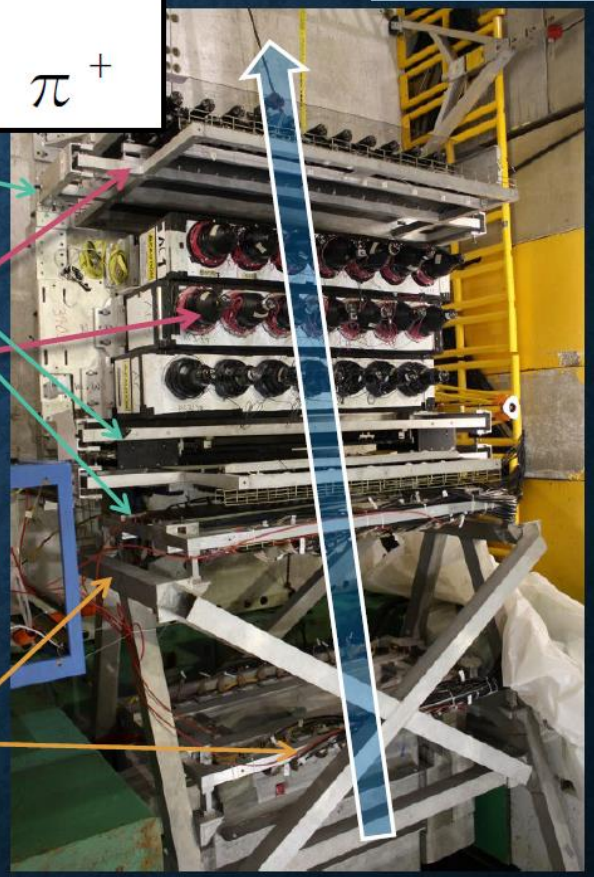
K^+
p, π^+



TOF walls
(Plastic scintillators)

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

Drift chambers



Detectors channel count

System	Detector	FADC	Low Resolution TDC	High Resolution TDC	VETROC	VETROC	FADC F250
HKS	**KDC**		**1280**		**7**		
	TOF	88		88		1	6
	AC	42					3
	WC	48					3
HES	**EDC**		**1120**		**6**		
	TOF	116		116		1	8
ENGE	**PDC**		**640**		**4**		
	TOF	54		54		1	4
	SciFi		1024		6		
Total					**23**	**3**	**24**

- 5 VXS crates with VTP and SD from SBS TI and CPU from SBS/SoLID
  - 24 FADCs for PMT readout in 2 VXS crates
  - 24 vfTDC in 3 VXS crates for DC

HES Trigger

7.1. Trigger condition

7.1.1. HKS-HES trigger

The trigger condition is a coincidence between HES and HKS,

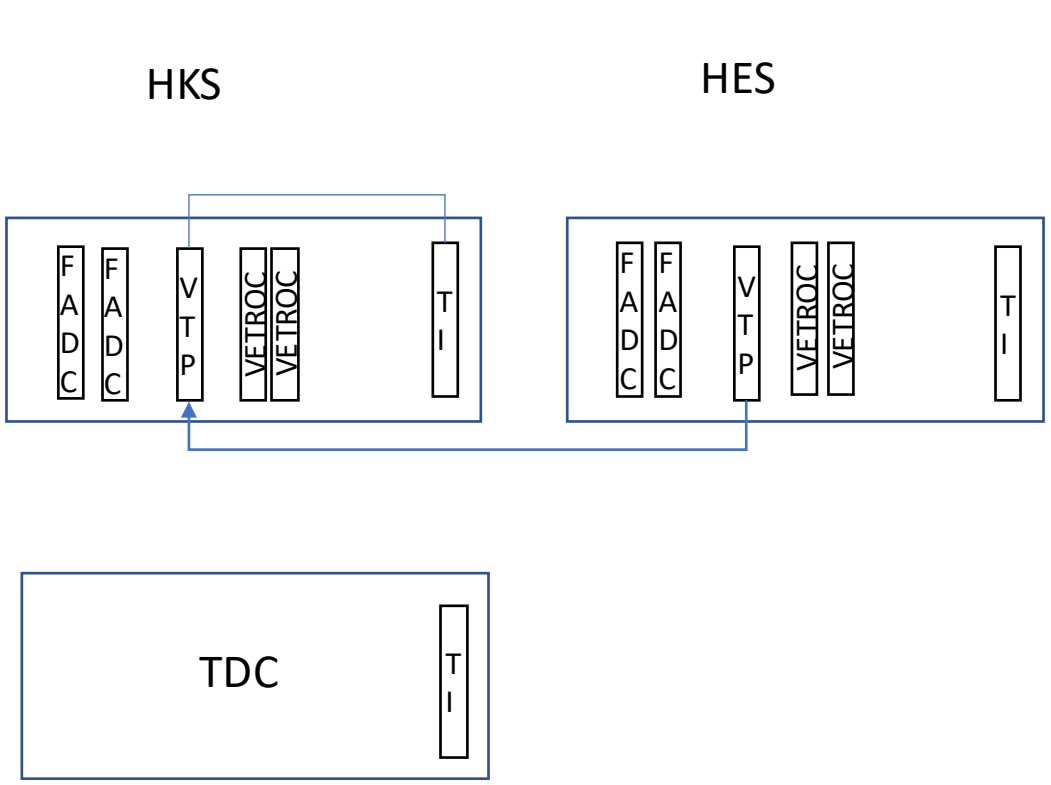
$$HES \otimes HKS \quad \text{Eq. (7.1)}$$

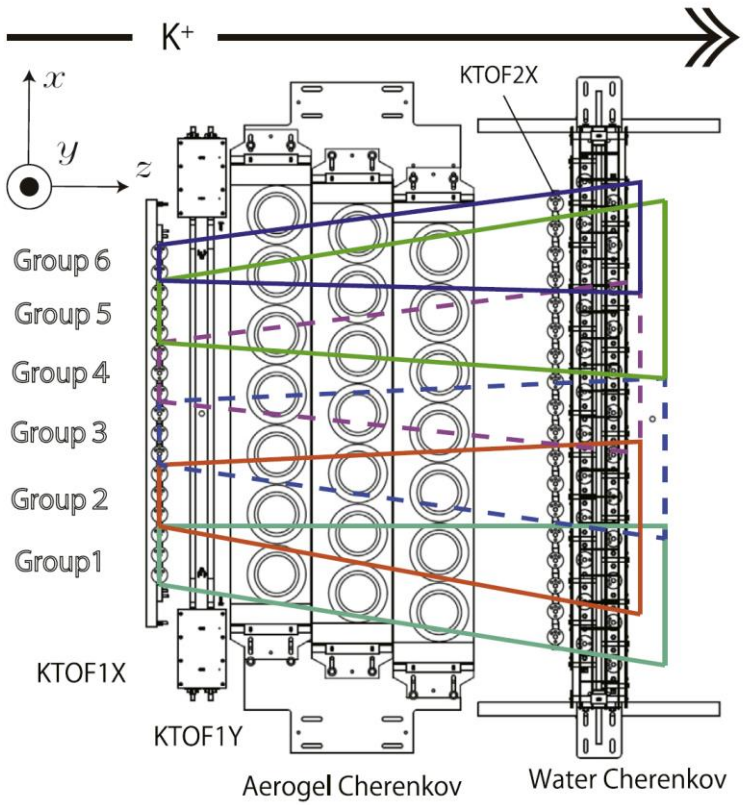
where,

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

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

HKS Trigger





Use FADC data going to VTP to makes coincidences between the groups
Can program VTP for coincidences between scintillators
Development on going and will start testing Mid 2026

Trigger rates HKS/HES

Layer Coincidence Window = 24 ns
Spectrometer Coincidence Window = 200 ns
pi rejection efficiency (HKS) = 99%

Target [thickness / mg/cm^2]	Beam current / μA	Rate / kHz												
		HES			HKS					Enge			Coincidence	
		e′	Accidental	Total	pi$^+$	K$^+$	p	Accidental	Total	pi$^-$	Accidental	Total	Coin Proton	Kaon Trigger
Graphite [100]	50	130	42	170	18	0.22	23	0.3	23	41	52	93	3.8	1.2
^{40}Ca [150]	50	770	210	980	23	0.27	29	1.5	31	52	110	160	46	6.9
^{208}Pb [150]	25	1200	1300	2500	9	0.11	11	10	21	20	1700	1700	840	18

Maximum rate 18 kHz
Other targets lower rate
Rates lower than previous HKS experiment

Data rates

HKS		ADC channels	TDC channels			ADC size bytes	TDC size bytes	Total bytes	Occupancy		Data Rate	
	Drift chamber		1280				5208	5208	0.05		5.208	
	TOF counter	88	88			760	368	1128	0.2		4.512	
	Aerogel Cherenkov	42	42			368	184	552	0.2		2.208	
	Water Cherenkov	48	48			416	208	624	0.2		2.496	
									0.2		0	
									0.2		0	
									0.2		0	
HES	Drift Chambers		1120				4560	4560	0.05		4.56	
	TOF counter	116	116			1000	480	1480	0.2		5.92	
									0.2		0	
									0.2		0	
ENGE	Drift chamber		640				2608	2608	0.05		2.608	
	SciFi		1024				4168	4168	0.2		16.672	
	TOF	54	54			472	232	704	0.2		2.816	
Total		348	4412			3016	18016	21032		Data rate	47	MB/s
								Max	420.64			

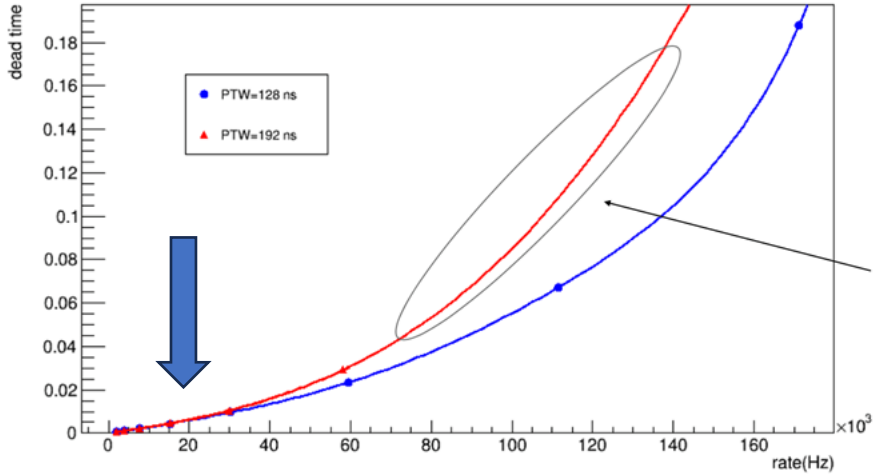
Expected rate around 50 MB/s
Maximum rate at 100 % occupancy : 420 MB/s

Data rates with time / integral

- Event size
  - 24 kB with time and amplitude 100 % occupancy
  - Estimated occupancy 5% maximum for chambers ans 20% for PMTs
- Max trigger rate : 20 KHz
- Max data rate : 470 MB/s
- Expected data rate : 50 MB/s
- Can be handled now by Hall C DAQ
- Tape : ~ 0.6 PB typical Hall C experiment

Dead time and bottle necks

- 2 VXS crates with VTP readout for FADC = 1.25 GB/s
- 3 VXS crates with VETROC = 3 x 100 MB/s
- Not bottle neck for data transfer dead time coming from front end
- Will use event blocking and buffering to get similar dead time has in Hall B or Hall D



Note: When PTW=192 ns, due to the data transfer limit (1Gb/s), the highest rate it can reach is 75 kHz;

So the projection may not be right.

Dead time for FADC with VTP readout with full waveform less than 1% at 20 KHz
Will be even lower with just time and amplitude readout

Beamline

- Beamline info in FADCs in counting house
  - Target and beamline BPM
  - Raster
  - 1C12 BPM

- In place with subset of BPMs during running experiment, will add a few more channels for all BPMs
- Readout and analysis module tested

ESB testing

- Electronics from SBS moved into ESB
  - All electronics for all detectors setup
  - Active testing of the detectors
  - Development of HKS trigger
  - Electronics test

Time line

- From now to August 2026
  - Detector commissioning in ESB
  - HKS HES trigger development and testing
- August 2026
  - Install HKS VXS crates in SHMS hut (Alexandre, William Henry) ~ 1 week
- December 2026
  - Move electronics from ESB to Hall C (Alexandre, William Henry) ~ 1 week
  - Estimate of 2 months of cabling (can be done before and in parallel)
  - Test data with full DAQ setup
    - High rate test, check for bottlenecks and dead time
    - Detector commissioning with cosmics

Labor

- Alexandre Camsonne (DAQ coordinator, Trigger, Beamline) 50 %
- Hanjie Liu (DAQ, Trigger) 10 %
- William Henry (DAQ, detectors, beamline) 50 %
- Toshiyuki Gogami (Detector testing and setup) 25 %
- Ken Nishida (Electronics and detector testing) 20 %
- Kaito Higashimoto (Electronics and detector testing) 15%
- Ben Raydo (FADC VTP trigger) 15 %
- Masaya Ichikawa (DAQ developments and testing) 20 %

Conclusion

- HKS,HES, ENGE
  - 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
- Digital trigger using FADC, VTP and VETROC
- Expected rate 50 MB/s, can be handled by current Hall C DAQ
- Smaller scale as NPS or SBS experiments

Backup

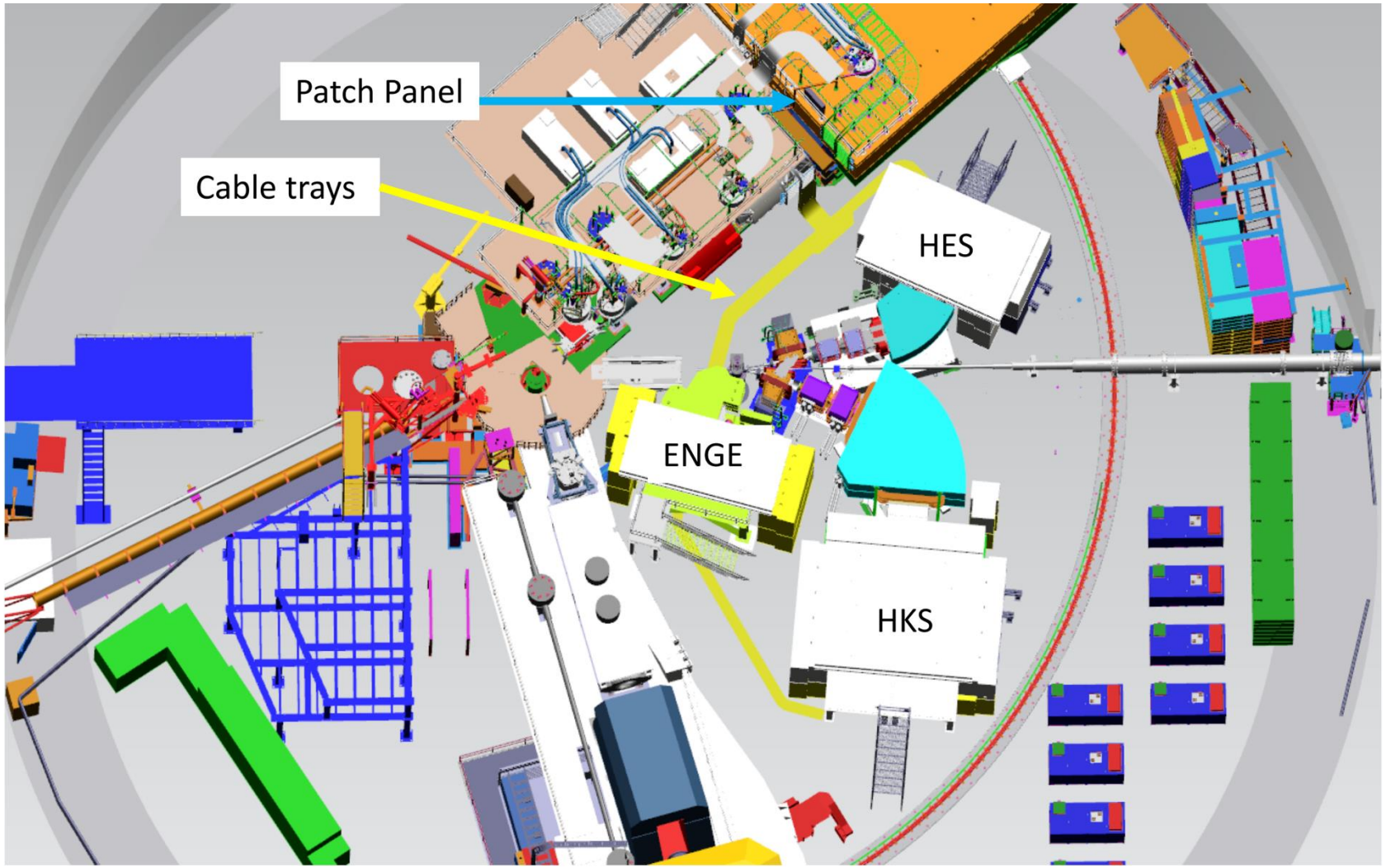
Electronics in SHMS hut

All Cables routed to SHMS patch panel

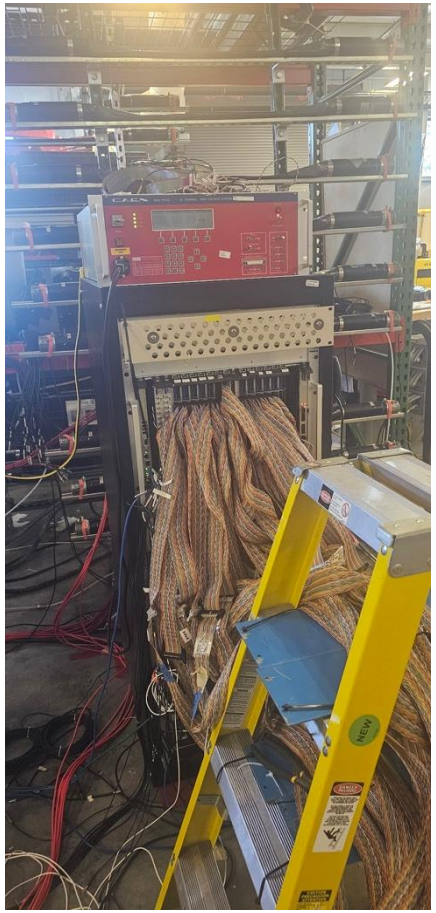
NPS handled 1080 cables
There will be 800 of the 100m and 75m length cables from Hall A's GeP experiment that can be used.

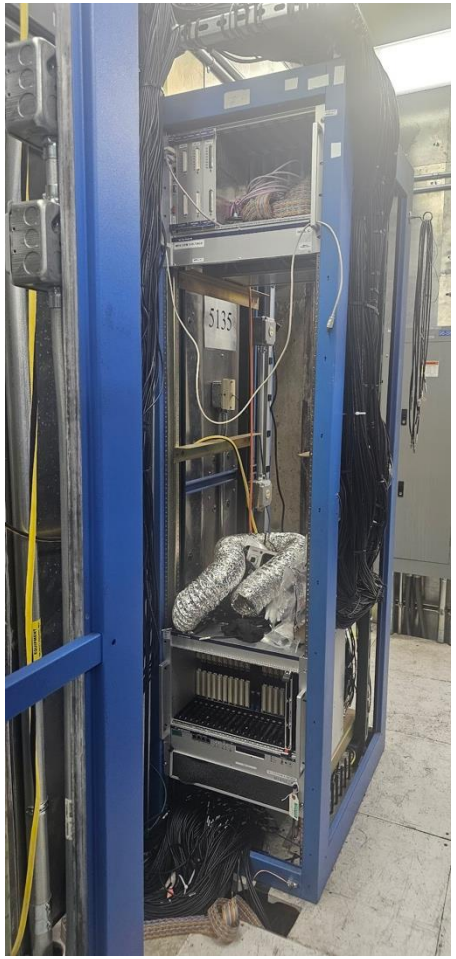
Max Cable lengths laid out along floor is 46m (150')

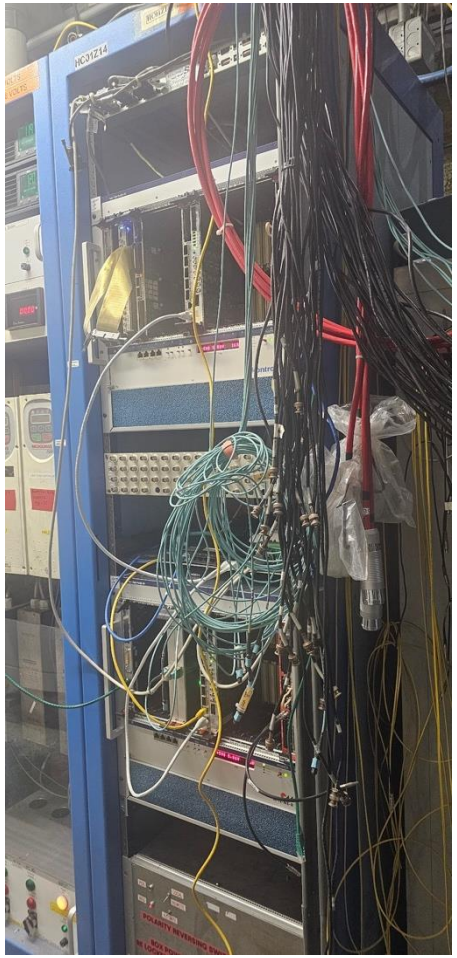
See Detector talk for more cable info



Hall C Beam







ESB test