JLab Hypernuclear collaboration meeting

Simulation Study of Grouping Trigger for HKS

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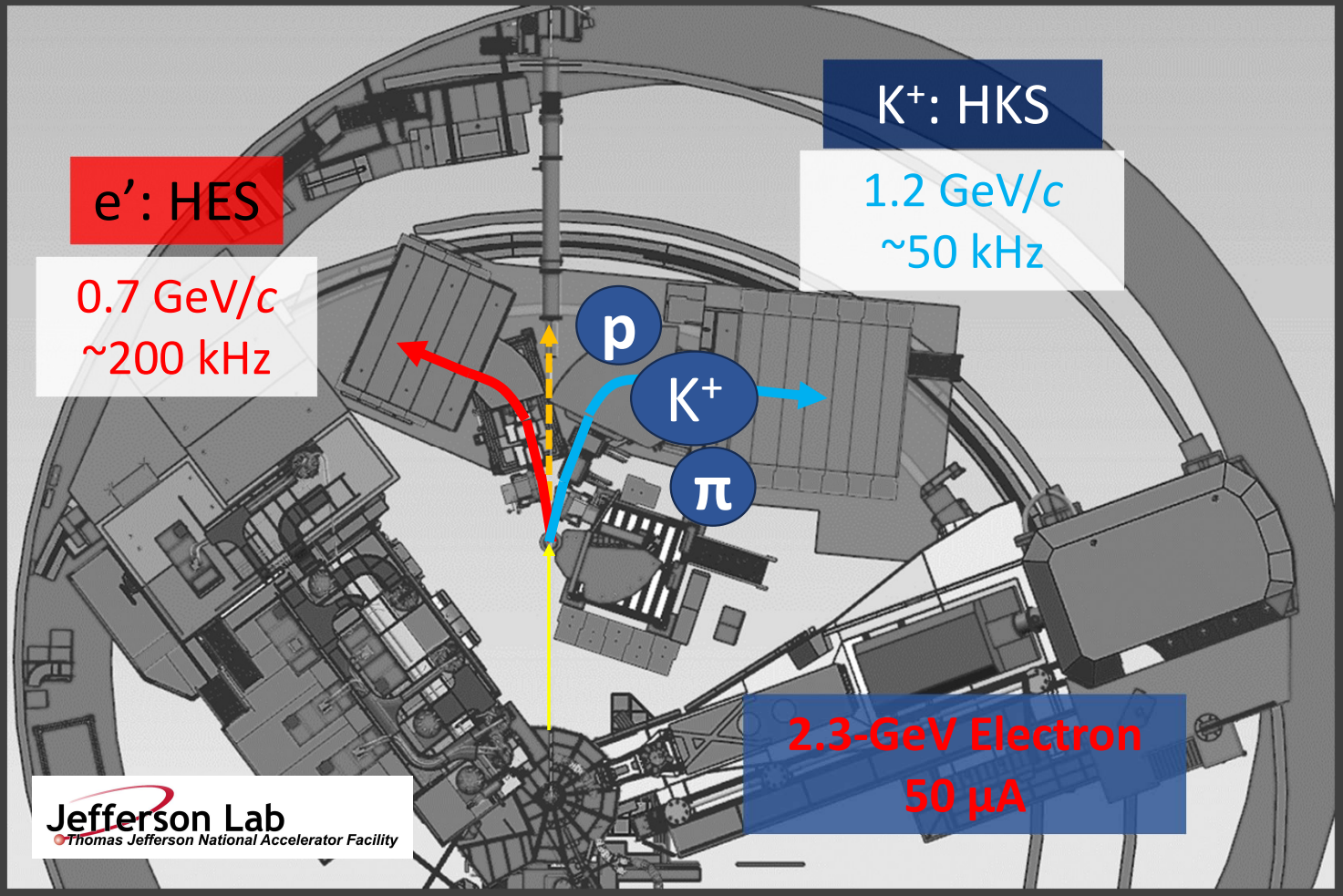
Background of HES-HKS



Estimation of background events in this experiment

- Proportional to beam current
- On the **e' side**, background is proportional to Z^2
- On the **K⁺ side**, background is proportional to A
- Since the areal density is kept constant, the physical thickness decreases as A increases

Feasibility Study of Low-Bias Trigger

Simulation-based estimation(HES 30 ns, HKS 200 ns)

Target	Target thickness /(mg/cm^2)	Beam current /μA	HES rate /kHz	HKS rate /kHz			Accidental coincidence /kHz
			e'	p	K^+	π^+	
^{6}Li	100	50	99	25	0.24	20	1.0 ± 0.3
^{9}Be	100	50	110	23	0.23	19	1.1 ± 0.2
^{11}B	100	50	130	23	0.22	18	1.3 ± 0.3
^{27}Al	150	50	500	30	0.29	24	6.0 ± 0.5
^{40}Ca	150	50	770	29	0.27	23	9.0 ± 0.4
^{48}Ca	150	50	650	28	0.27	22	7.4 ± 0.6
^{208}Pb	150	25	1200	11	0.11	9	5.3 ± 0.5

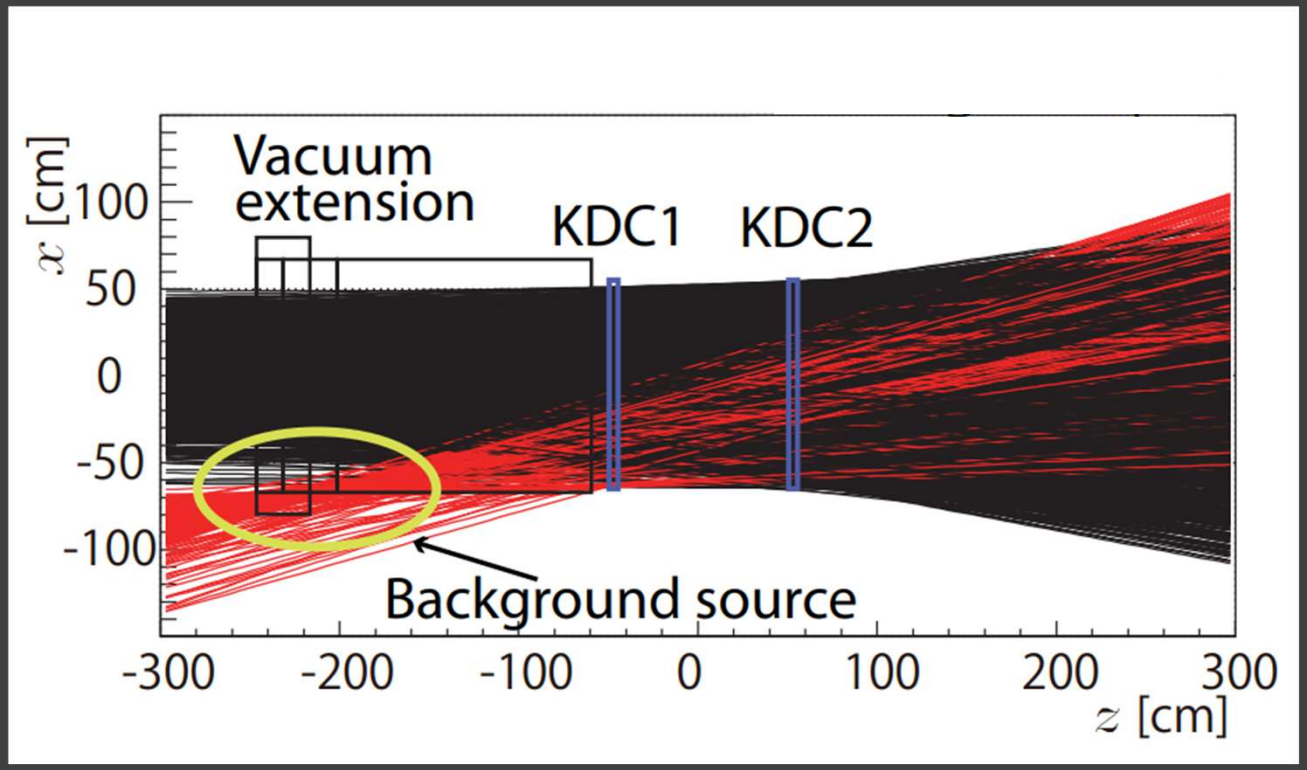
DAQ System Rate Limit: 200 kHz

$\mathrm{CP_{HES}} \otimes \mathrm{CP_{HKS}}$

CP: charged particle

Within DAQ Capacity

Importance of rejecting events outside the optical acceptance



e^+e^- Background from Bremsstrahlung (2018)

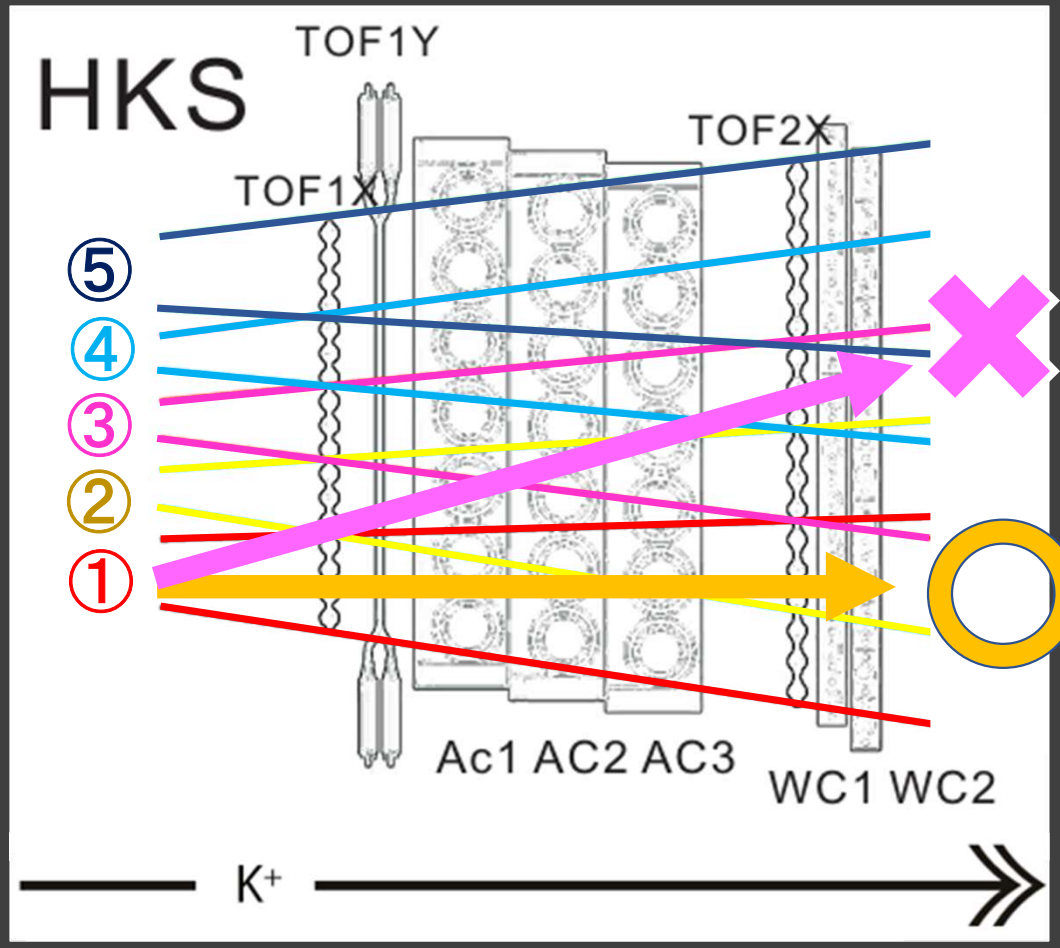
There were unexpected background that occurred in the previous experiment

The problem is resolved by implementing PCS!

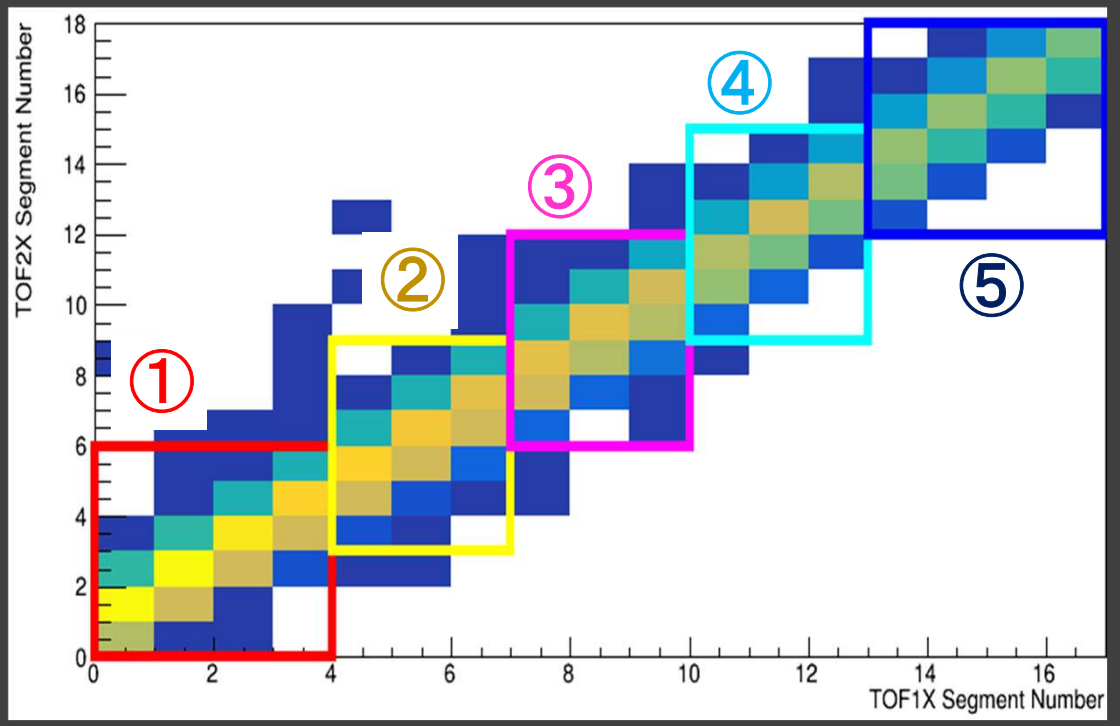
There is a **possibility of unexpected background**.

→ It is important to make **preliminary preparations** for background rejection.

Grouping trigger concept



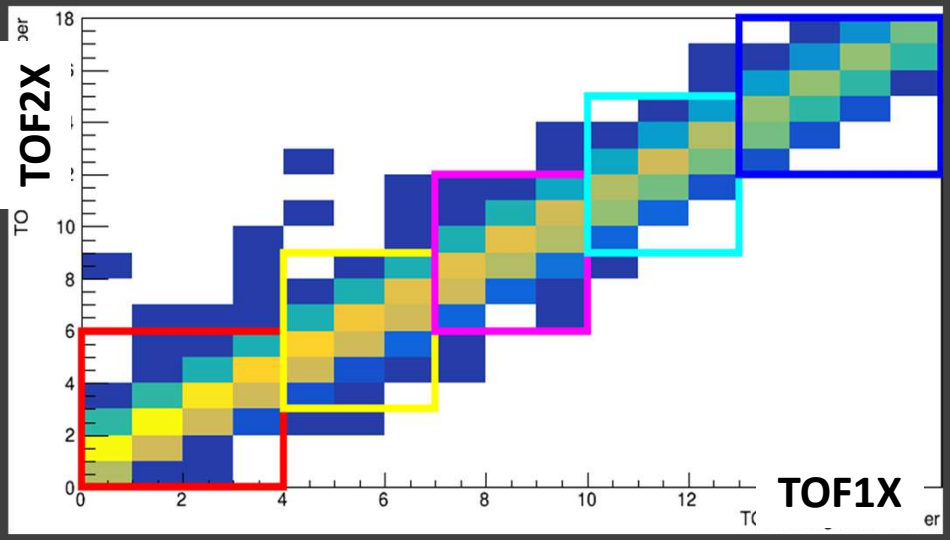
Schematic diagram of HKS detector



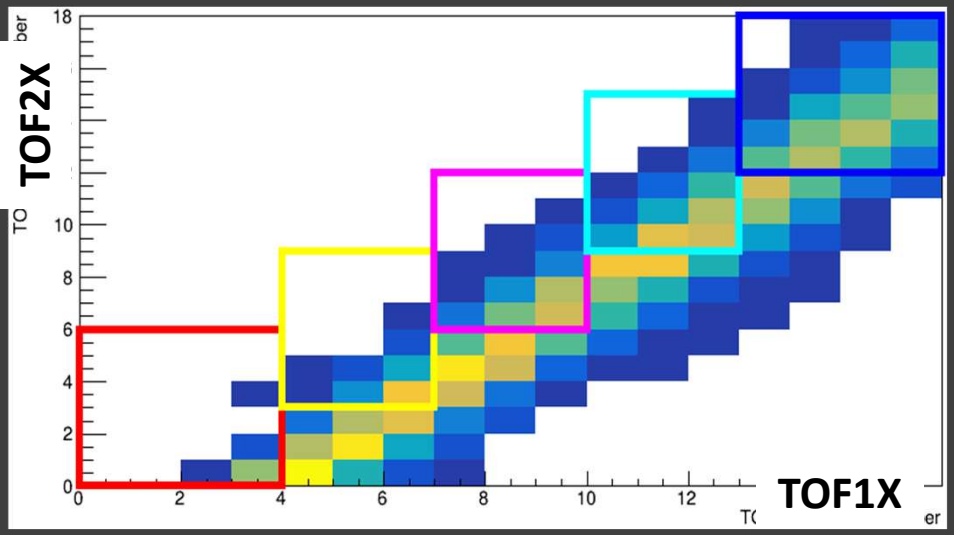
K^+ Hit Combinations of TOF1X and TOF2X from Monte Carlo Simulation

Geant4

K⁺ Signal

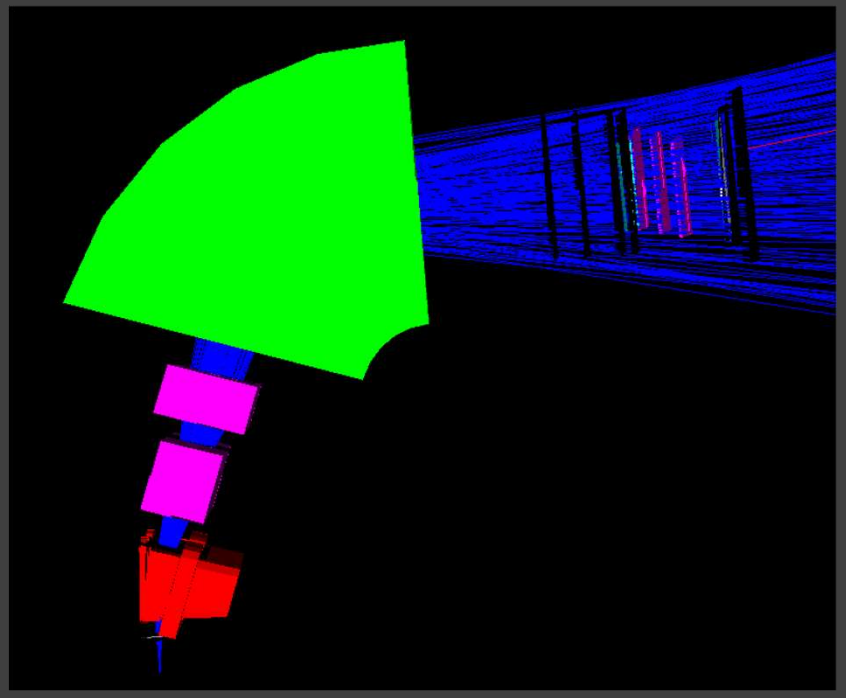


Background



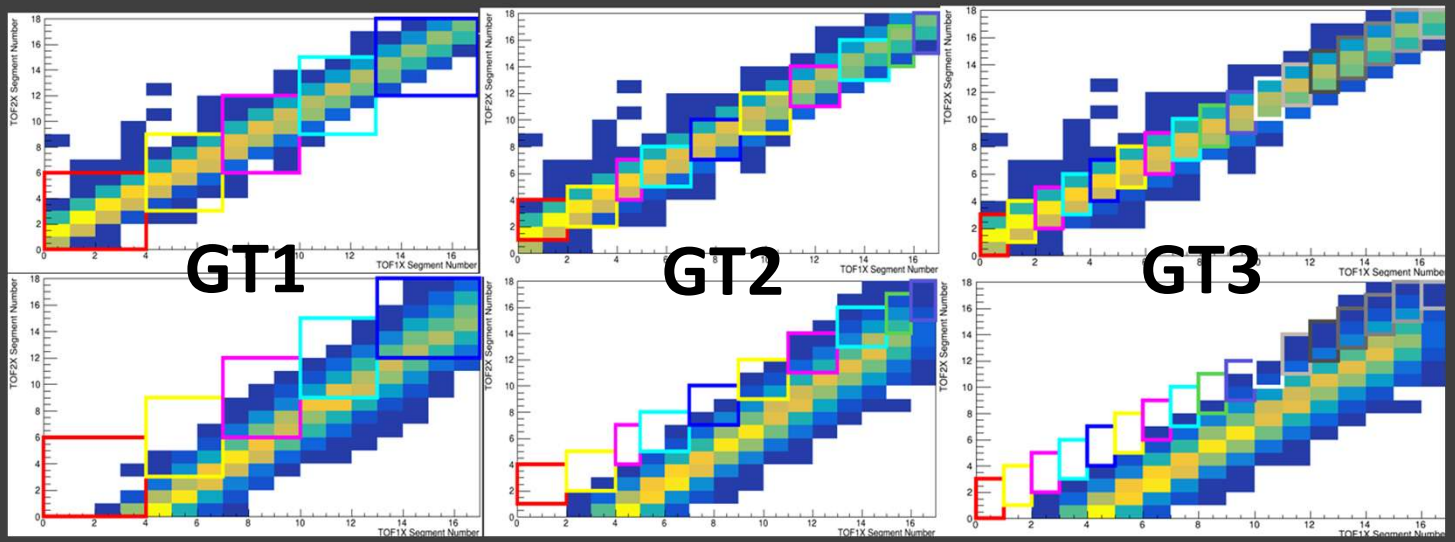
Simulation condition for signal

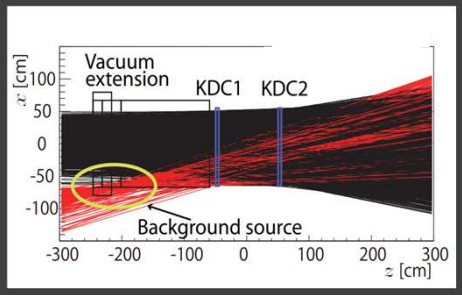
Momentum (GeV/C)	Angle	Particle	reaction	decay
1.2±0.3	12-18°	K^+	electromagnetic	off



Background was explicitly generated to mimic the previous experiment.

Geant4 Results & Discussion





To this background, survival ratio should be under **68%**

Survival ratio	GT1	GT2	GT3
Signal	99.6%	87.0%	94.5%
Background	31.1% →	9.2% →	4.5%

This result represents one possible example.

In the actual experiment, we can adapt flexibly as needed.

Cherenkov detectors can also be incorporated.

Schedule of development

FY2025

Jan. **Jun.** **Dec.**

- DAQ Construction
  - setup for detector commissioning

- Firmware development for **VTP**
  - coding on C++
  - simulation

FY2026

Jan. **Jun.** **Dec.**

- Preparing analysis
  - online analysis
  - offline analysis
  - decoder

- DAQ Construction
  - DAQ cabling
  - timing confirmation
  - check for dead channels

FY2027

Jan. **Jun.** **Dec.**

Beam start

Summary

- The estimated accidental coincidence rate is below the DAQ acceptance
- Preliminary preparation for unexpected background events

  → **Grouping trigger** is introduced as a preliminary strategy.
  - An effective trigger logic already exists
  - The system allows for further flexible adaptations based on actual conditions.
- Development and commissioning are proceeding on schedule.