K_L Flux Monitor

**Mikhail Bashkanov**

KLF Flux monitor
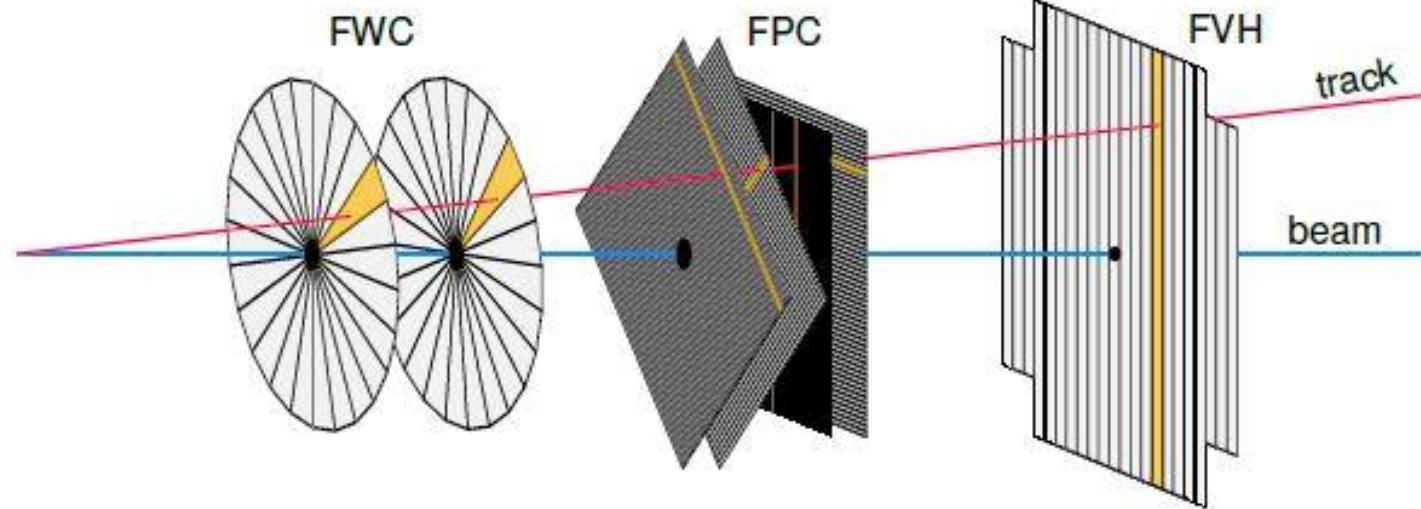
Used Wasa ToF system
Used Wasa Trackers
NO Magnet

⊕Good performance
⊕ Cheap
⊗ Limited capabilities in rare kaon decay studies

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KLF Flux monitor
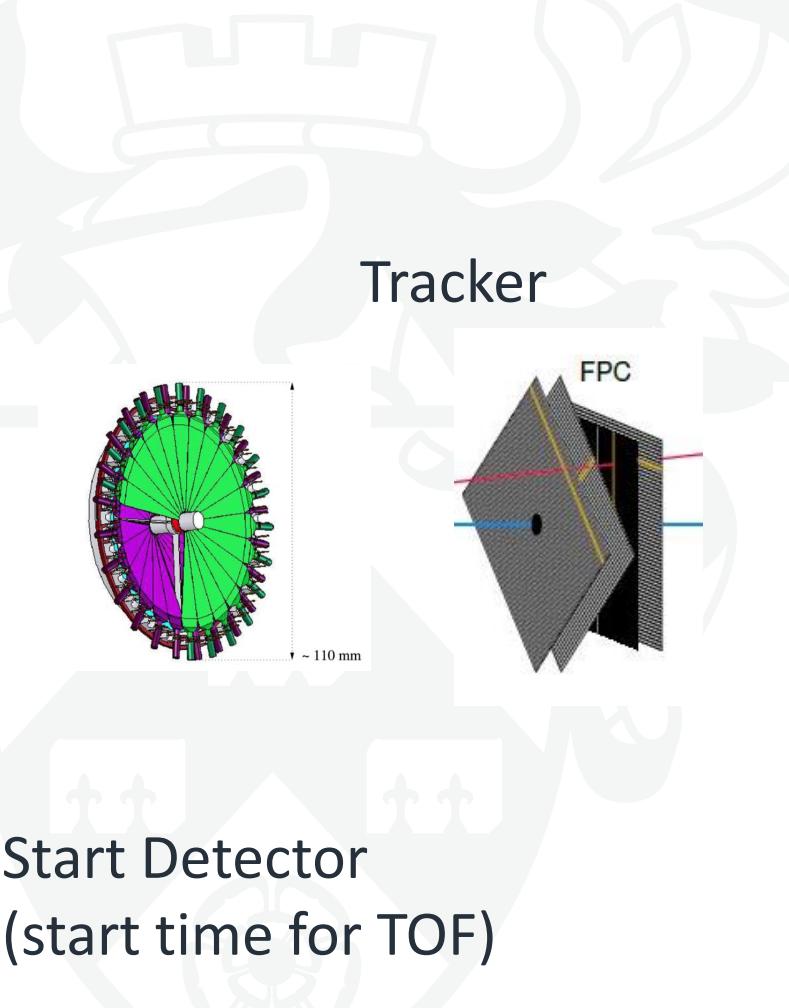
Tracker

Coarse plastic tracker

Start Detector
(start time for TOF)
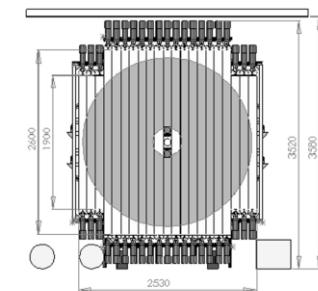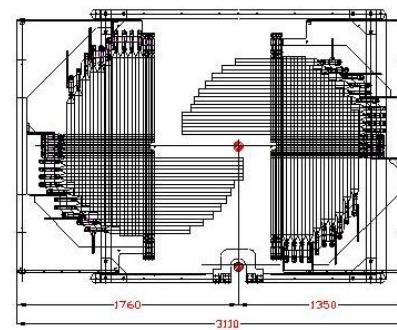
Stop Detector
(stop time for TOF)

K_L **monitoring**

$$T_{stop} - T_{start} = TOF \rightarrow \beta \rightarrow p_{K_L}$$
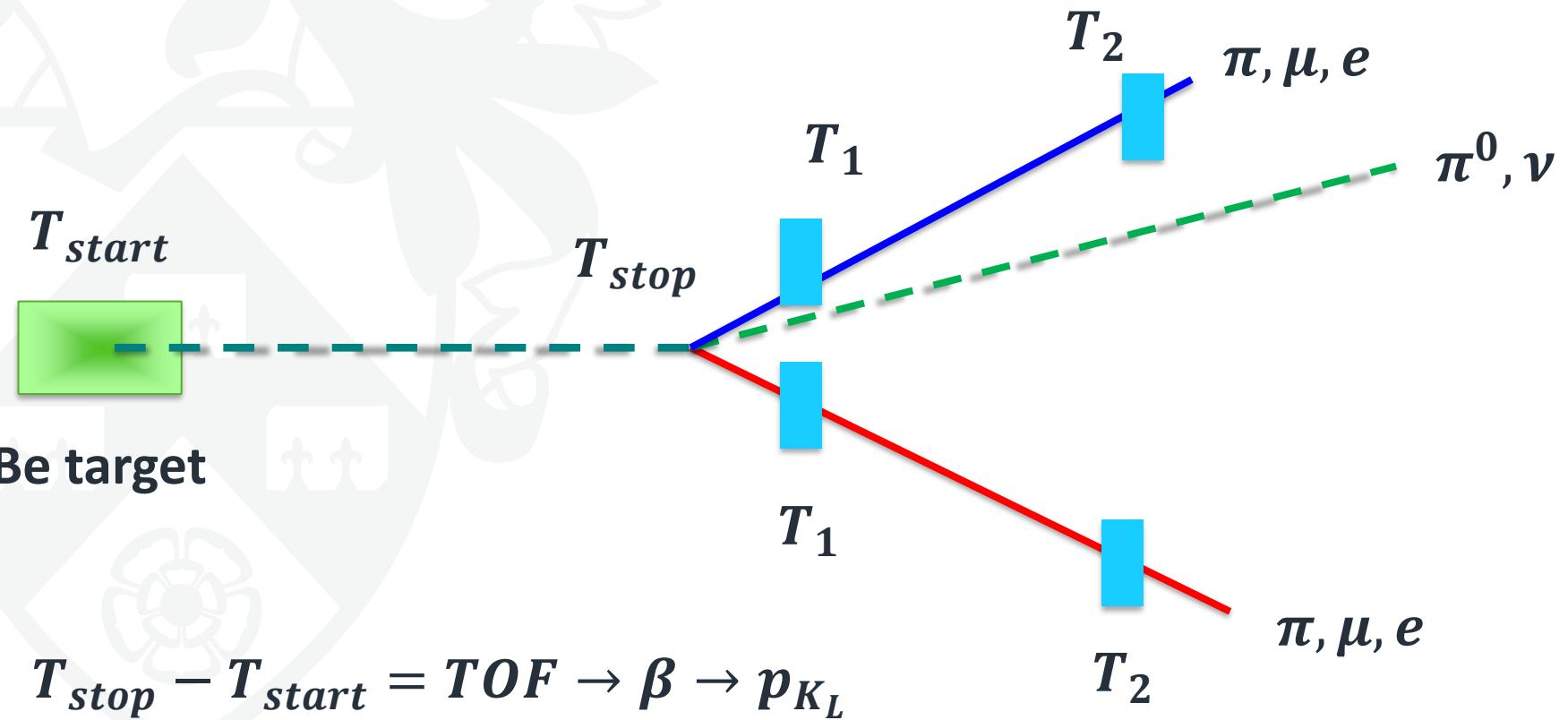
Detectors

Start Detector
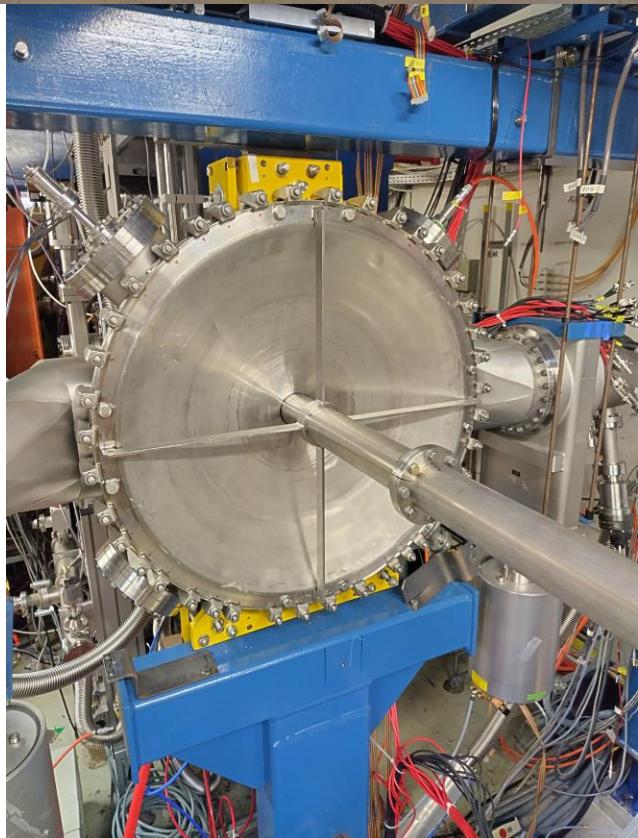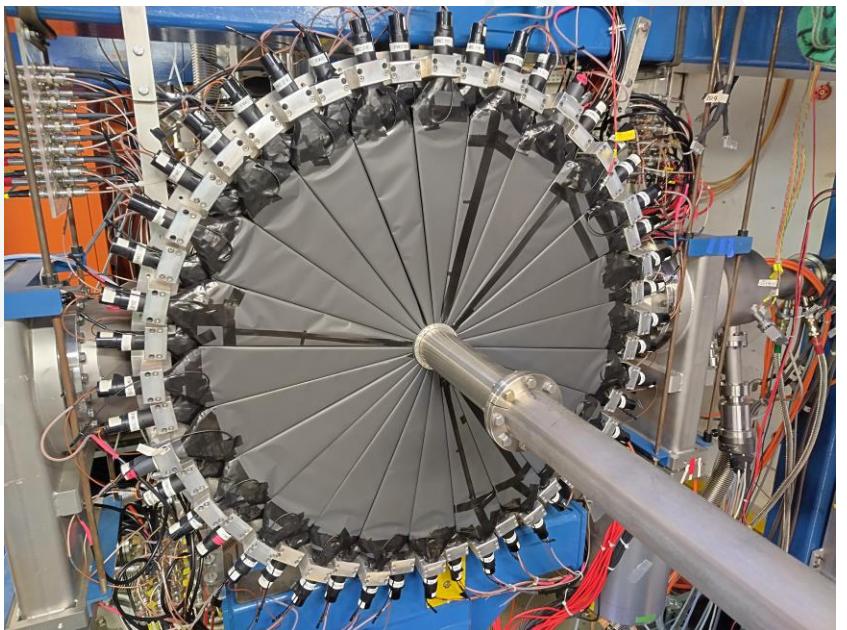
- Uninstalled
- Prepared for packing (transportation company)
- Transportation [paid Juelich]
- Paper work [ongoing]
- Delivery time JLab [Autumn 2024]

Tracker
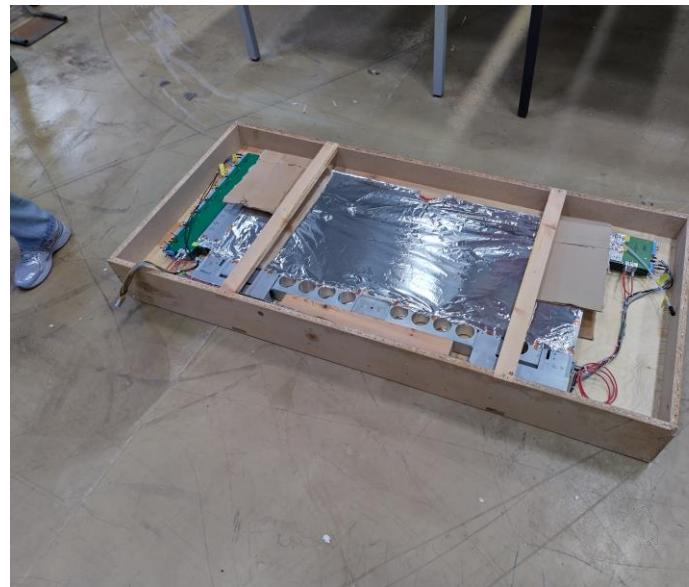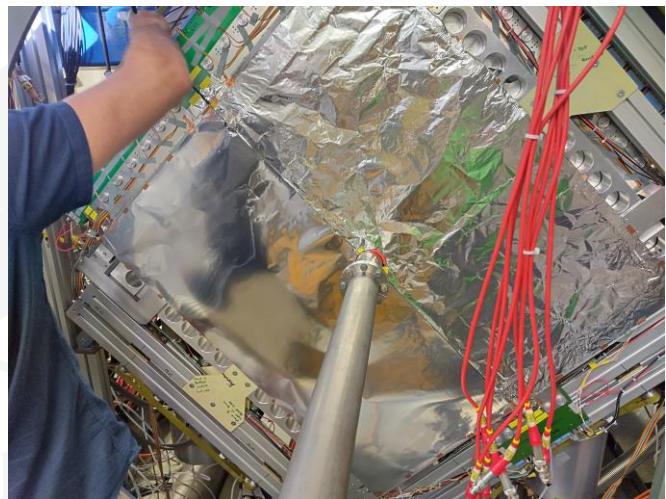
- Uninstalled and temporary boxed
- Boxes modification (transportation company)
- Transportation [paid Juelich]
- Paper work [ongoing]
- Delivery time JLab [Autumn 2024]

FRI (plastic tracker)

- Changed to transportation position
- Box
  (transportation company)
- Transportation [paid Juelich]
- Paper work [ongoing]
- Delivery time JLab [Autumn 2024]
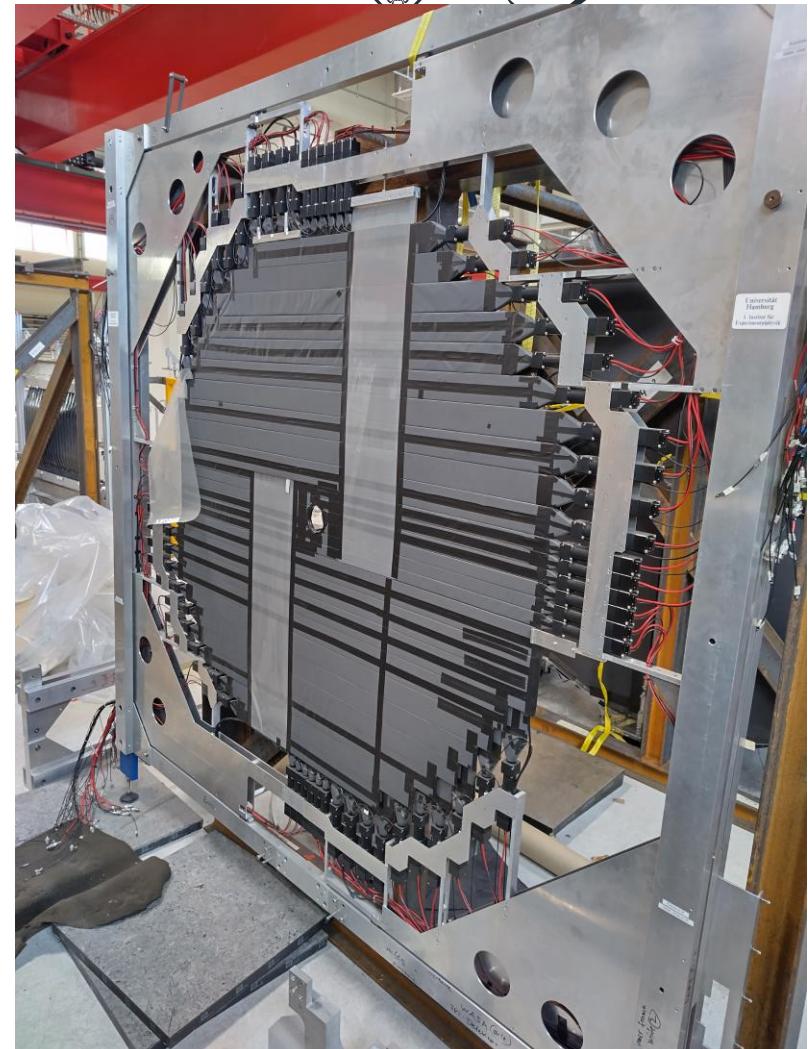
Stop detector
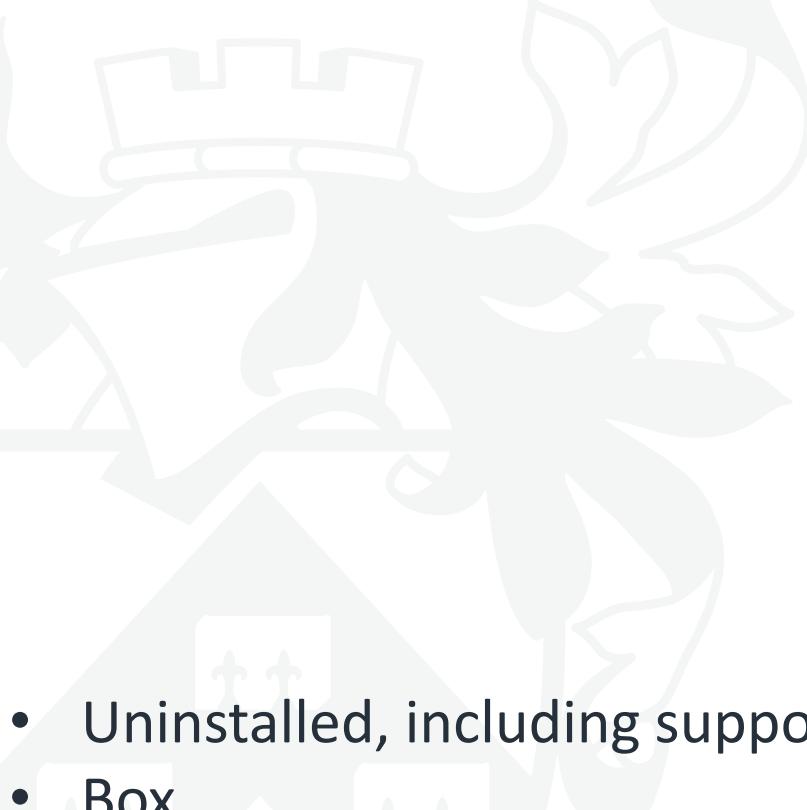
- Uninstalled, including support structure
- Box
  (transportation company)
- Transportation [paid Juelich]
- Paper work [ongoing]
- Delivery time JLab [Autumn 2024]
- Few elements needs to be reglued
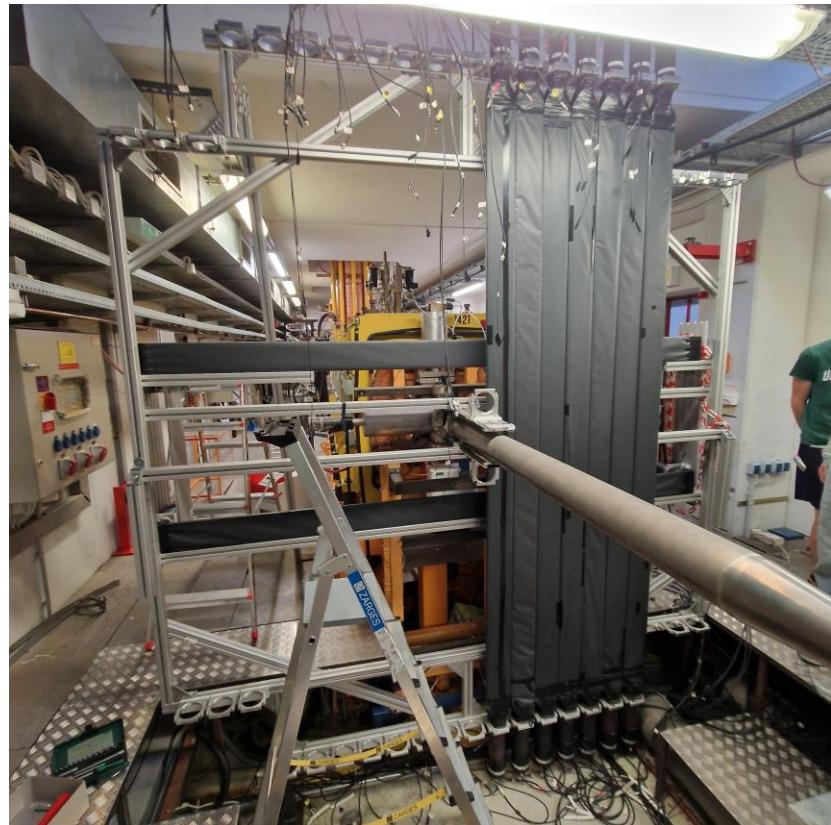
Calibration

Start detector
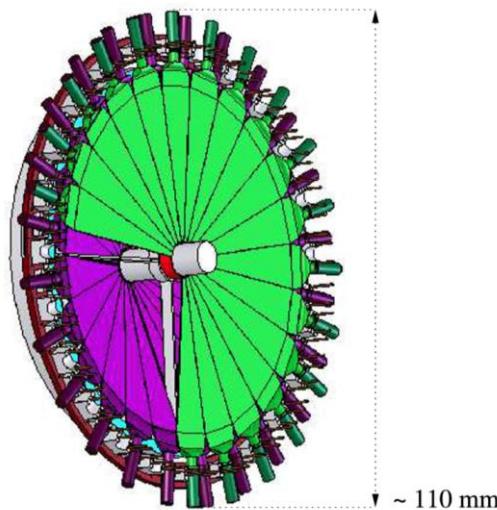
Before calibration
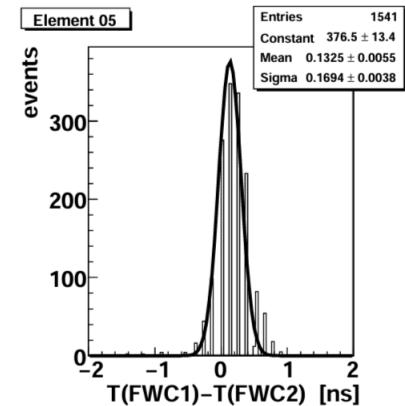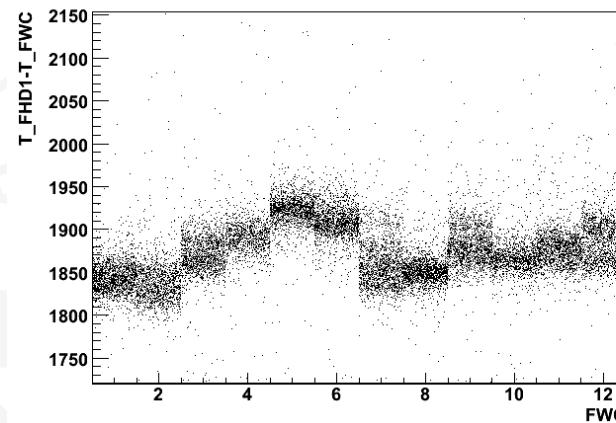
- Two layers shifted by half element
- Standalone calibration is possible with any charge tracks
  - Time
    - Offsets
    - Propagation
    - Walk
  - Energy
    - nonlinearities

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FRI (plastic tracker) FRI (plastic tracker)
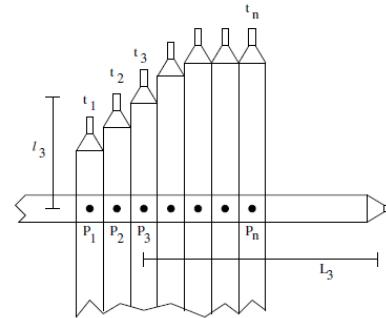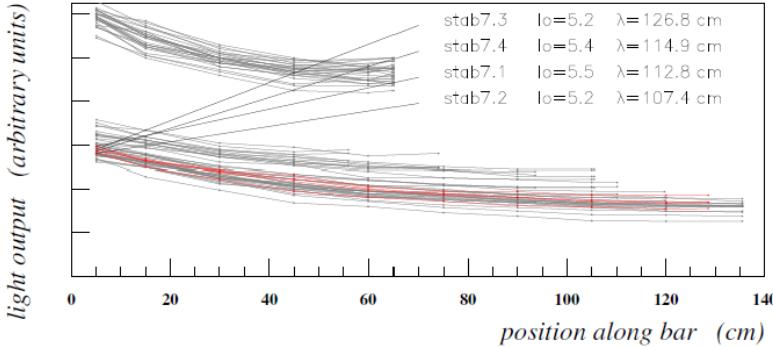
$\Delta t_n = (T - \frac{L_n}{c_{eff}}) - (t_n - \frac{l_n}{c_{eff}})$

$C_{i+1} = C_i + \frac{\sum_{j=1}^{n} \overline{\Delta t_n}}{n}$

t_n, T = TDC Hit time
C_i = Time offset for horizontal bar after iteration i
L_n, l_n = distance pixel P_n to multiplier
c_{eff} = effect. speed of scintillation light

- Two layers design
- Positioning
- Standalone calibration is possible with any charge tracks
  - Time
    - Offsets
    - Propagation
    - Walk
  - Energy
    - nonlinearities

iteration #0   iteration #3   iteration #15

mean($t_{FRI1} - t_{FRI2}$) (ns)

12
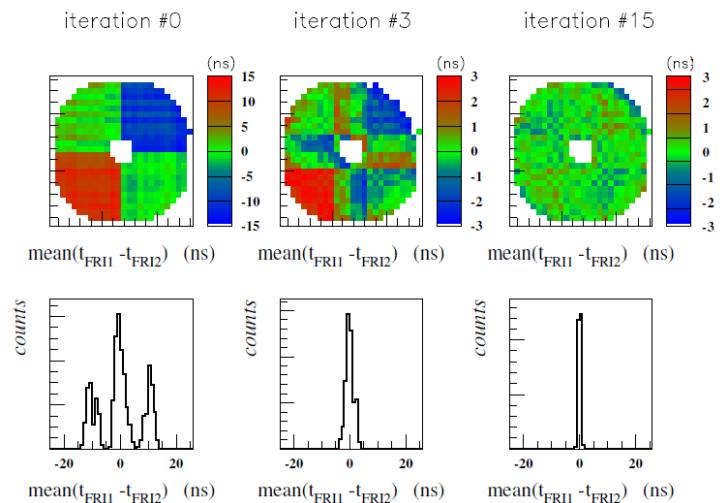
Stop detector
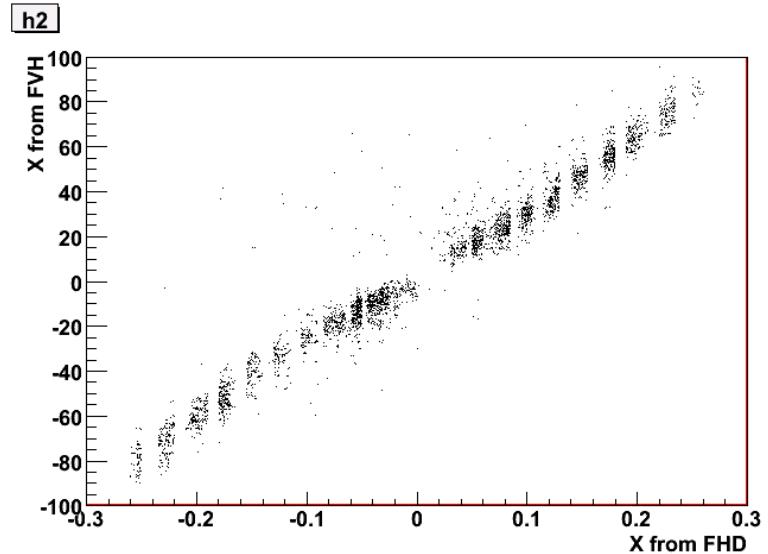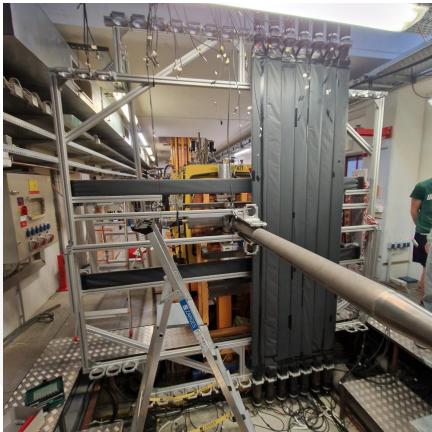
- Two-side readout
- Extra "calibration" elements
- Standalone calibration is possible with any charge tracks
  - Time
    - Offsets
    - Propagation
    - Walk
  - Energy

Absolute Normalisation

K_L monitoring

T_2

π, μ, e

T_1

π^0, ν

T_{start}

T_{stop}

Be target

T_1

π, μ, e

T_2

$$T_{stop} - T_{start} = TOF \rightarrow \beta \rightarrow p_{K_L}$$

$K_L - K_S$ regeneration

T_2

π^-

T_1

T_{start}

K_L

K_S

Be target

Tungsten foil

T_1

T_2

π^+
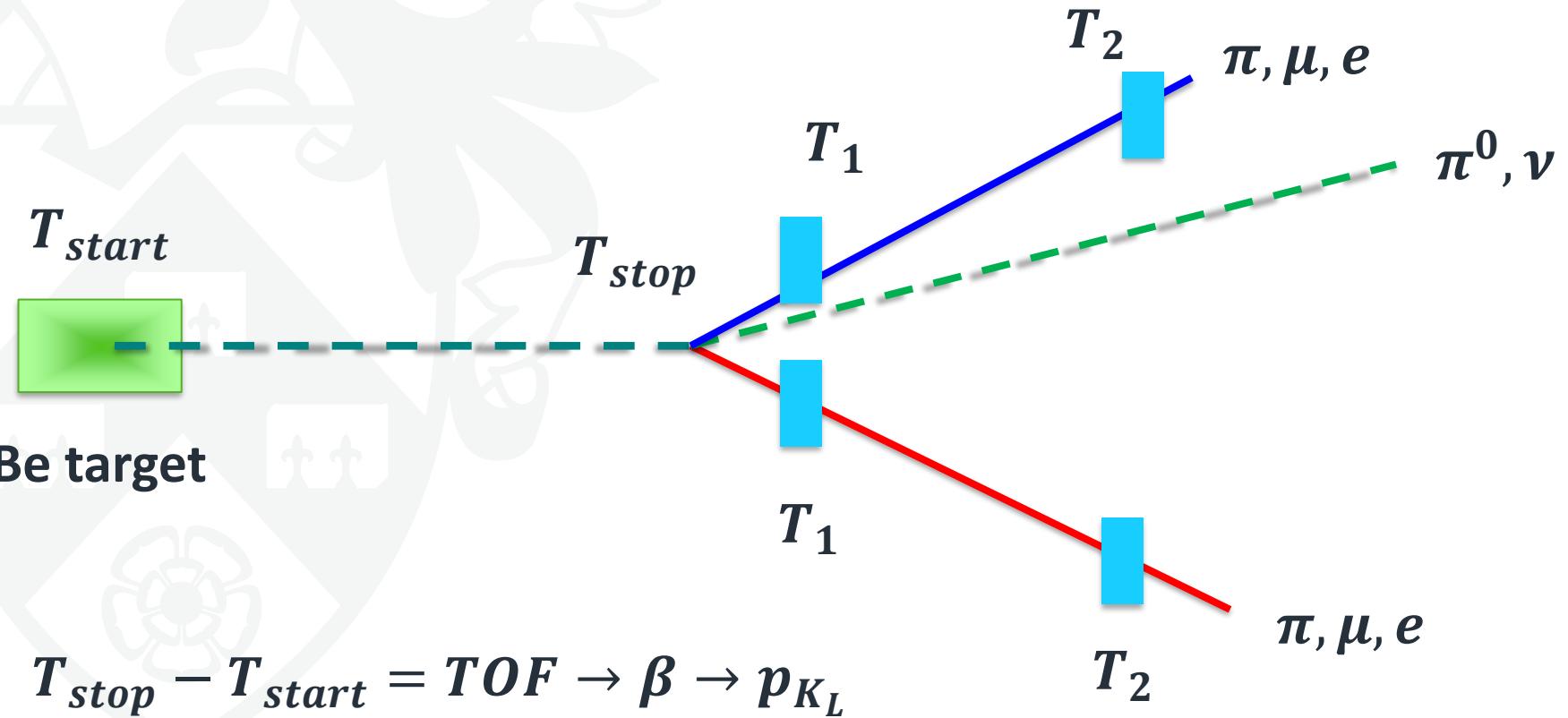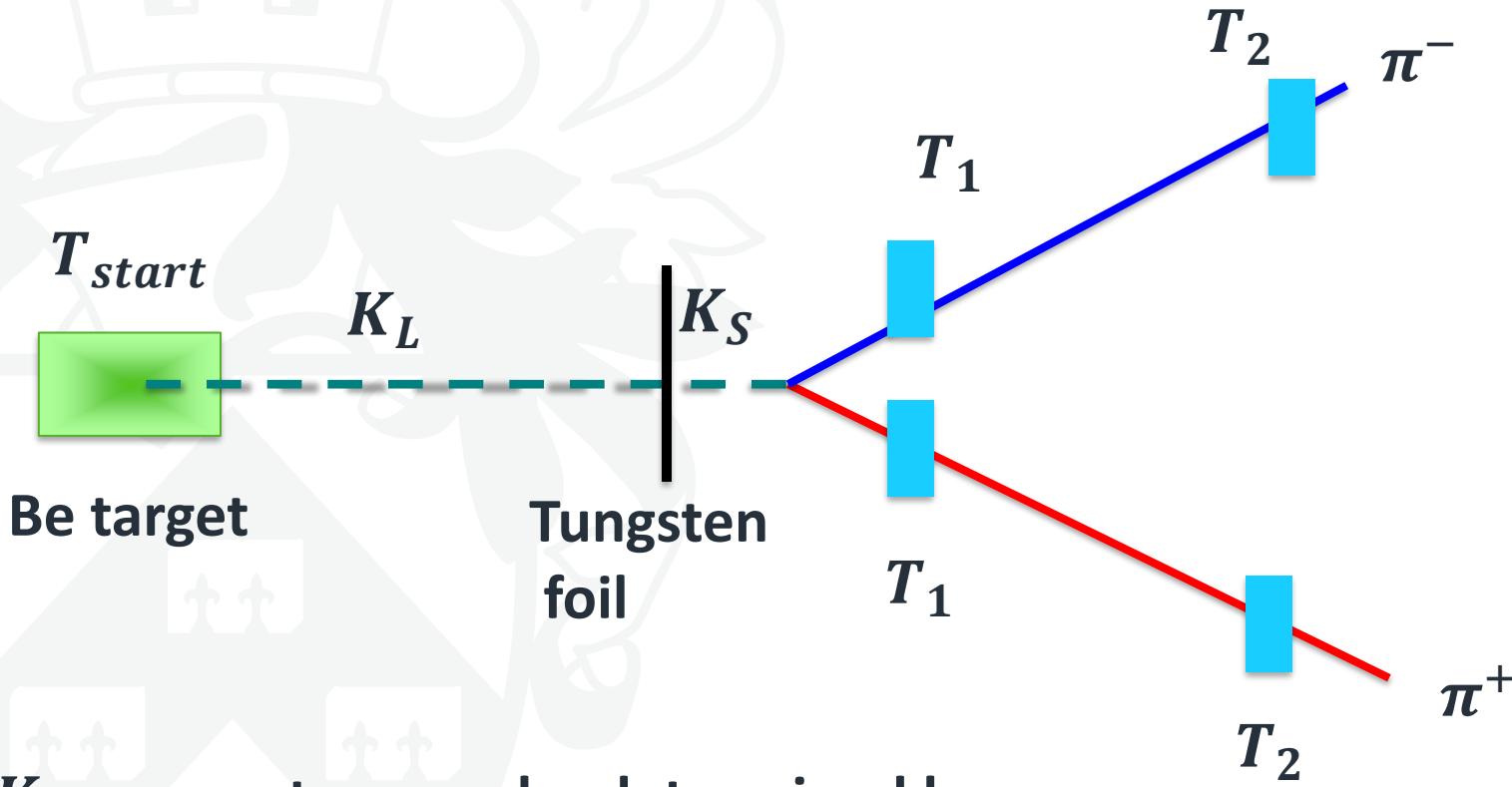
K_L **momentum can be determined by**

- **TOF**
- **$\pi^+ - \pi^-$ opening angle**

# $K_L - K_S$ regeneration

Fig. 3. Forward regeneration amplitude (left scale) and interference phase $\varphi_{+-} - \varphi_f(p)$ (right scale) as functions of momentum. The curve labelled $\varphi_{+-}^{SW} - \varphi_f^{opt. \, model}$

Cross-section is large

$$\Theta_{K_L} \cong \Theta_{K_S}$$
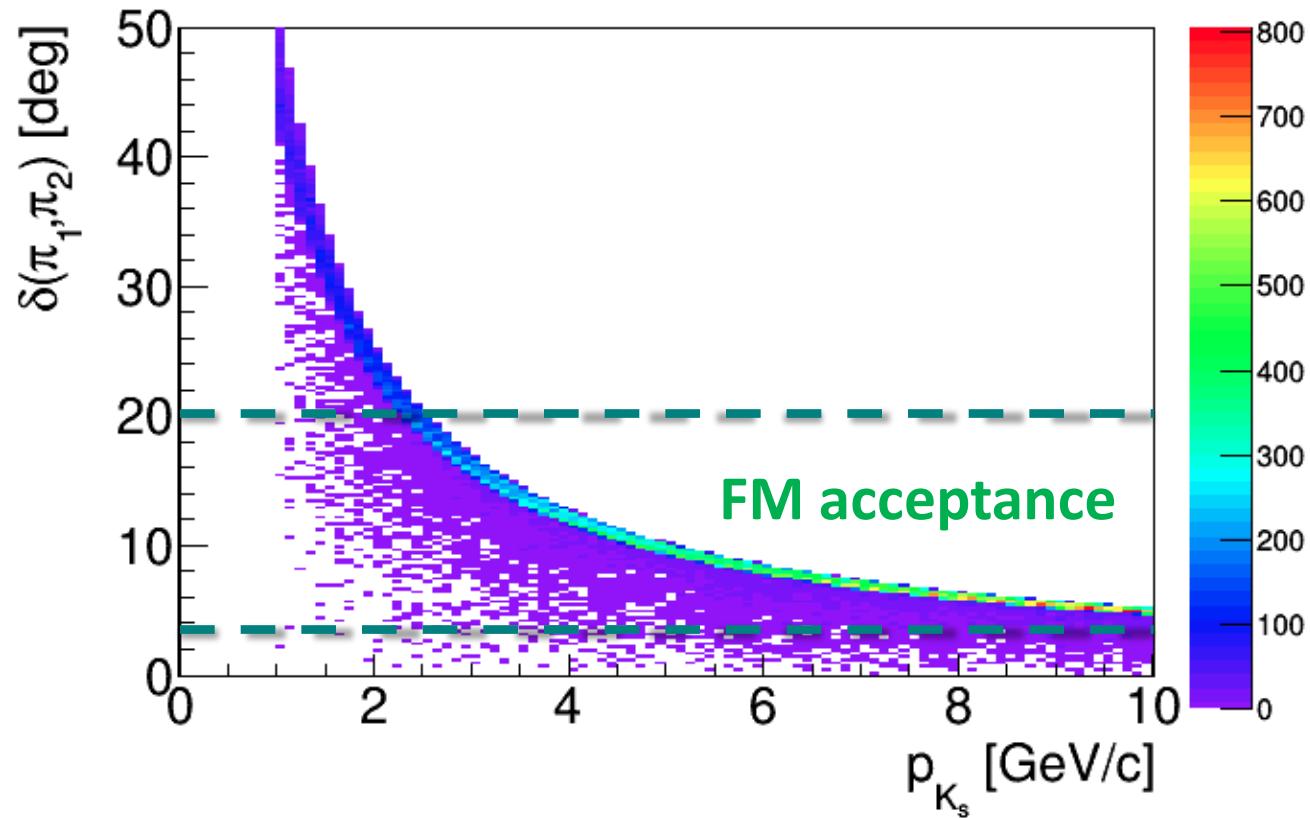
$K_L - K_S$ regeneration

- Absolute time calibration via $\delta_{\pi\pi}$ vs TOF
- Alternative method to extract kaon flux – systematics
- Reliable way to monitor high-energy K_L flux

$K_L - K_S$ regeneration
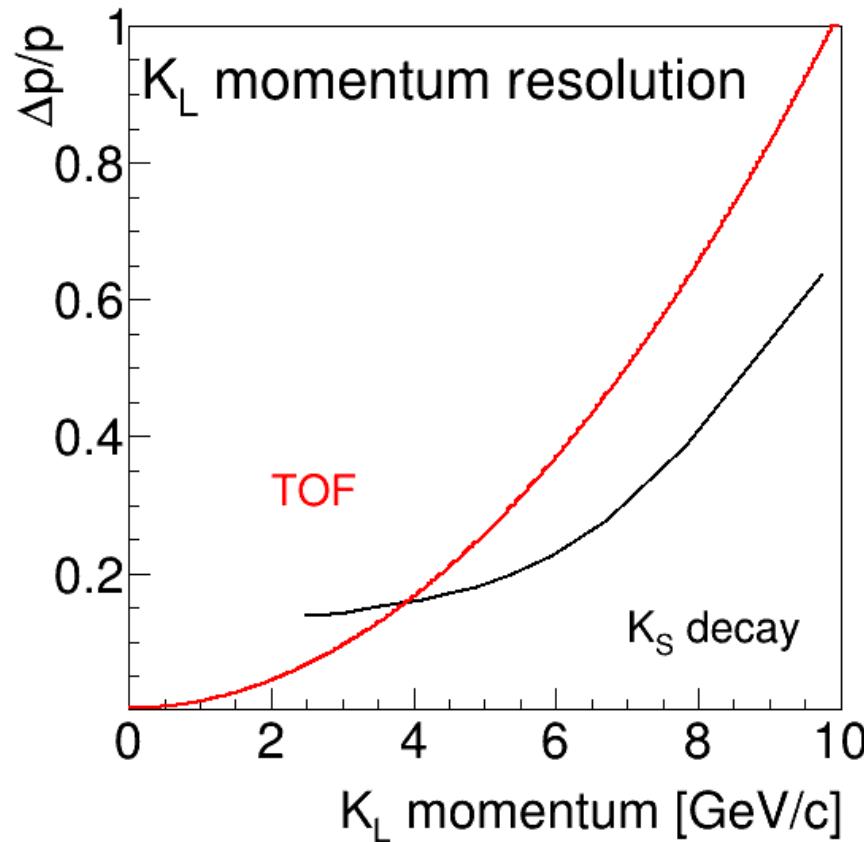
- $K_S \to \pi\pi$ about 1 event per second with ~ 1mm thick W foil
- Highest kaon flux around 4 GeV/c

$K_L - K_S$ regeneration rates an backgrounds

Relative K_S/K_L rates in Flux monitor

| Condition	K_S	K_L
Total	1	25
Coplanarity $< 5^o$	1	1
Vertex+ Coplanarity	1	0.03

- $K_S \rightarrow \pi\pi$ selection is clean

Status

- Hardware
  - Ready to be transported
- Electronics and readout
  - Hall-D
- Relative Calibration
  - Standalone for each plastic detector (multilayer design)
  - Tracker – relative to start
- Absolute calibration
  - K_s

Wasa detectors

~ 110 mm
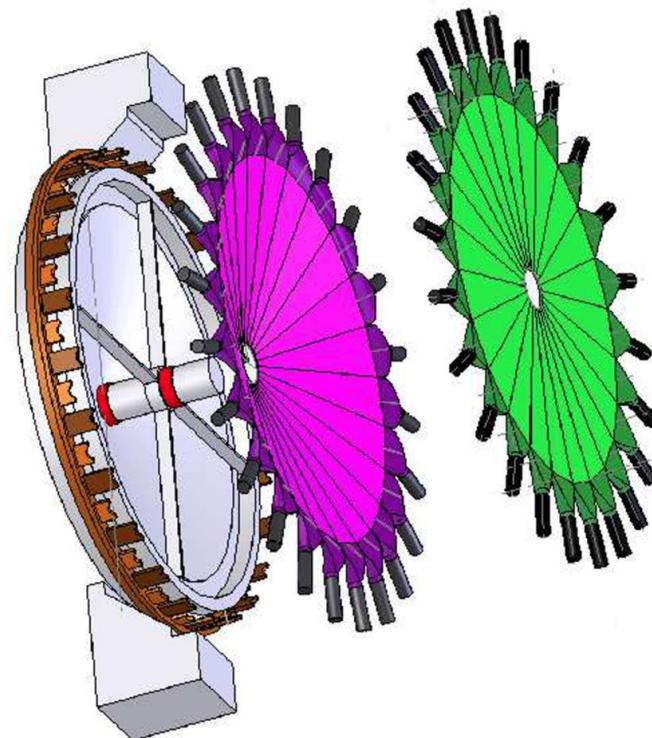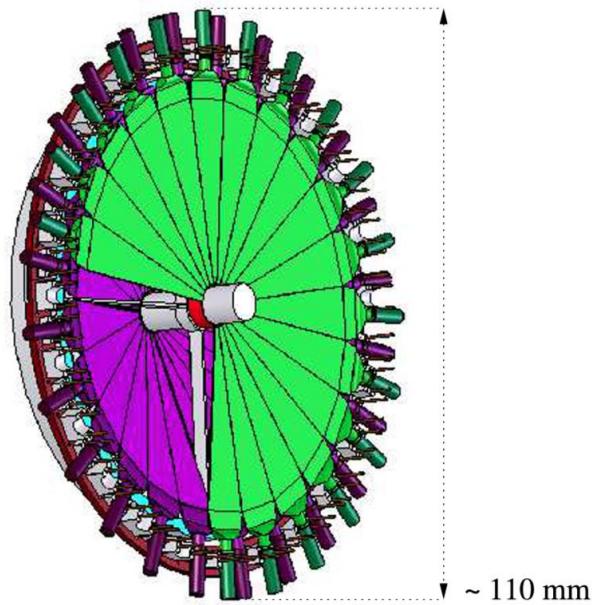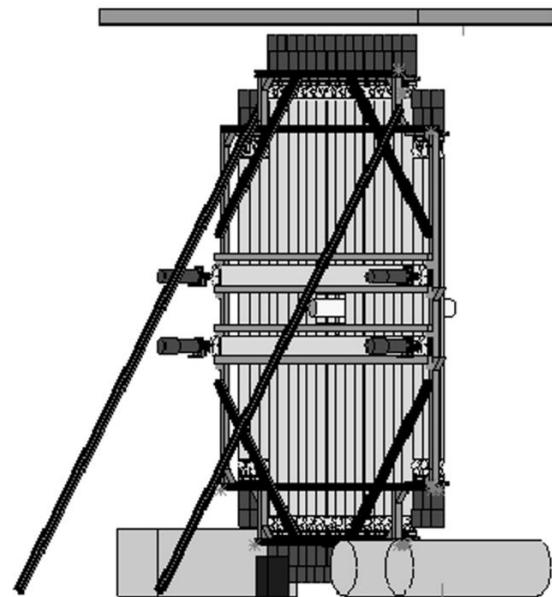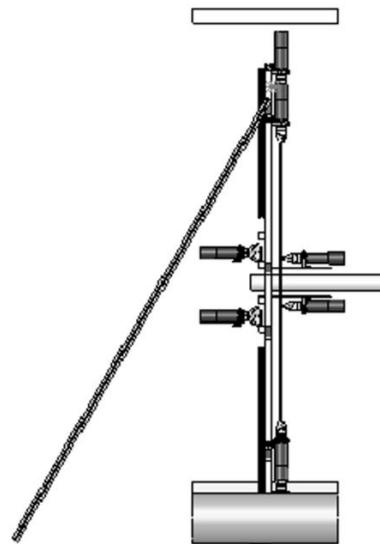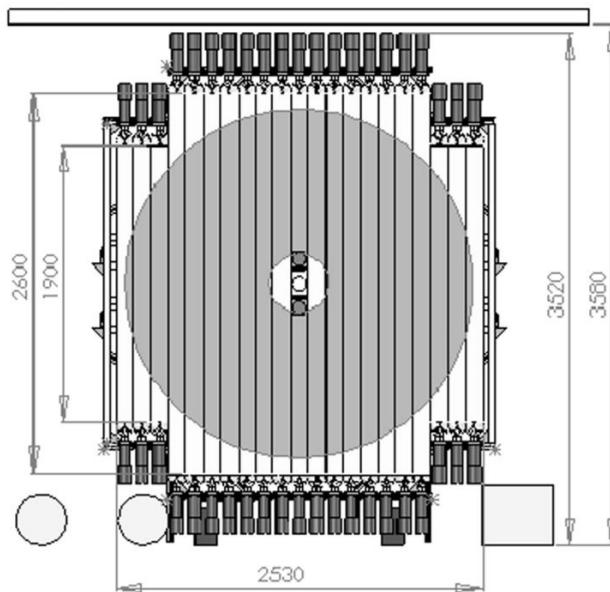
# Wasa detectors

Wasa detectors

Wasa detectors
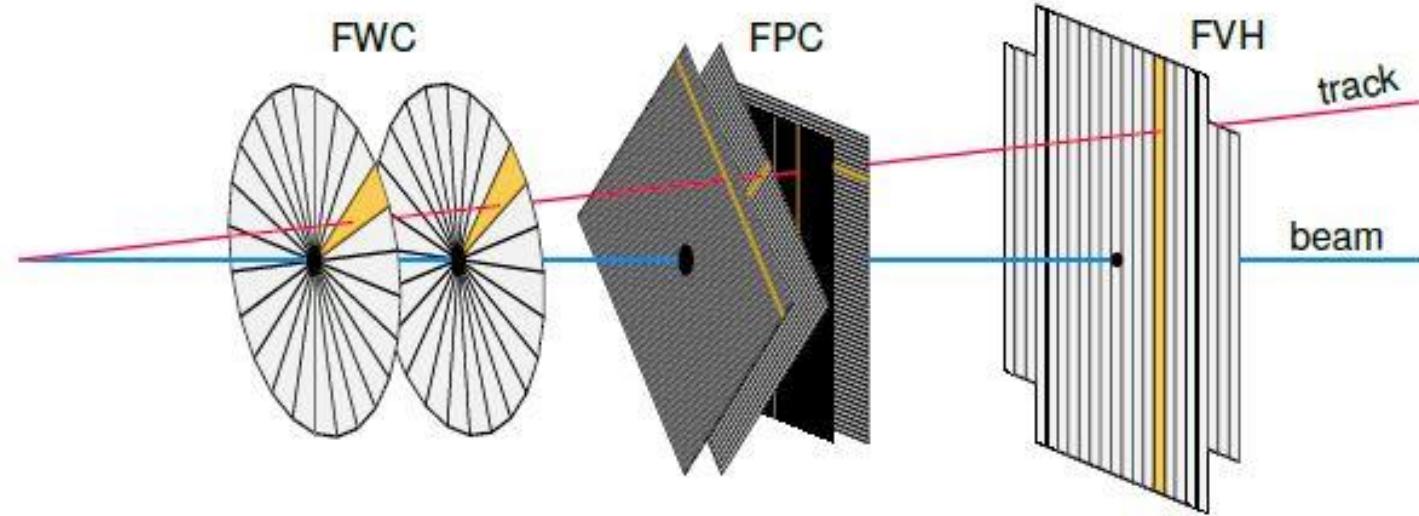
Used in TOF mode for the isospin violating $dd \rightarrow {}^4He\pi^0$ experiment

Wasa detectors
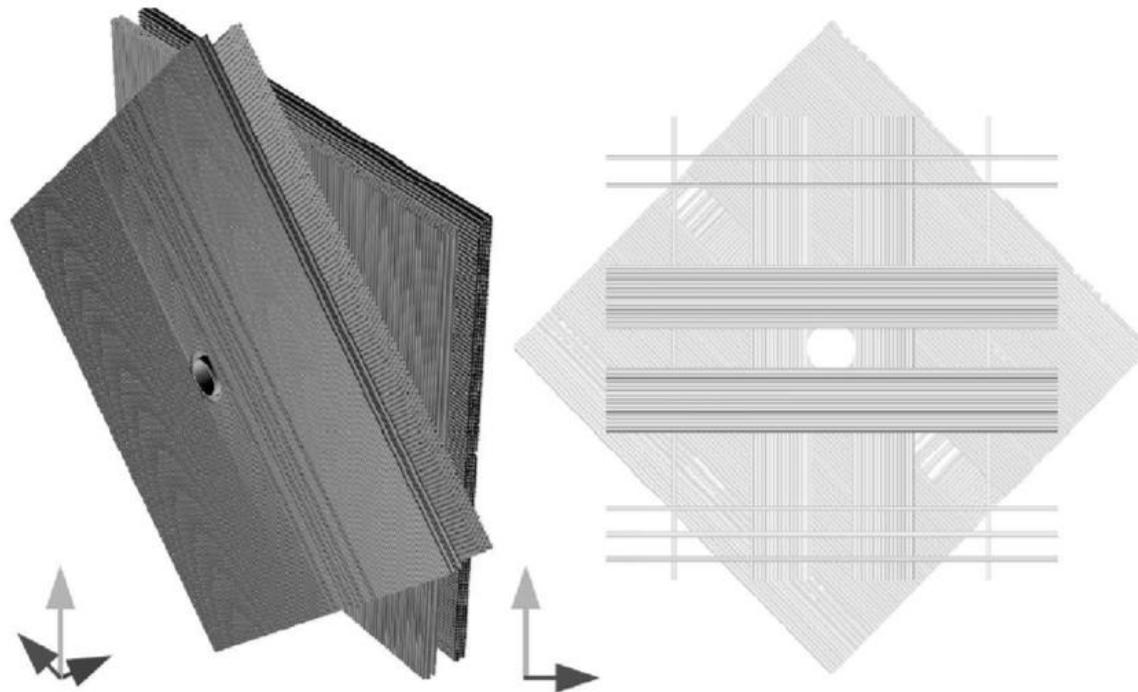
(b) Forward Proportional Chamber FPC

Status

- FWC (TOF start) and FVH (TOF stop)
  - Agreed on use
  - Available from Q42023
- Tracker
  - Agreed on use (Uppsala, TJ)
  - Available from Q42023

Wasa detectors
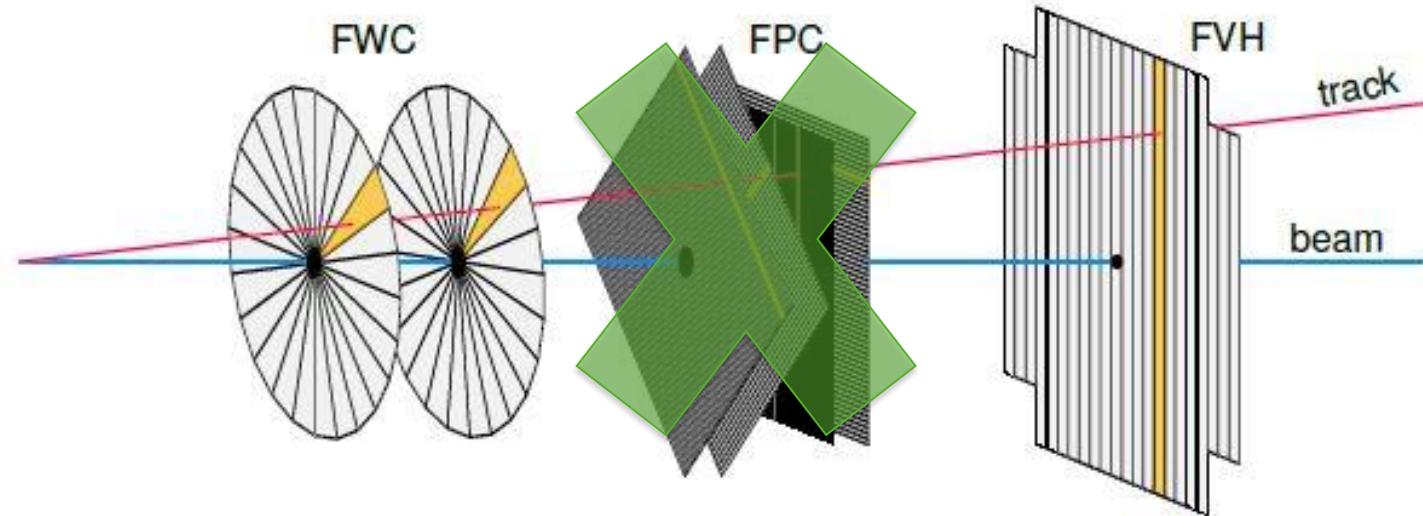
K_l time resolution due to position in Be

Be Target

γ

K_L

γ

K_L
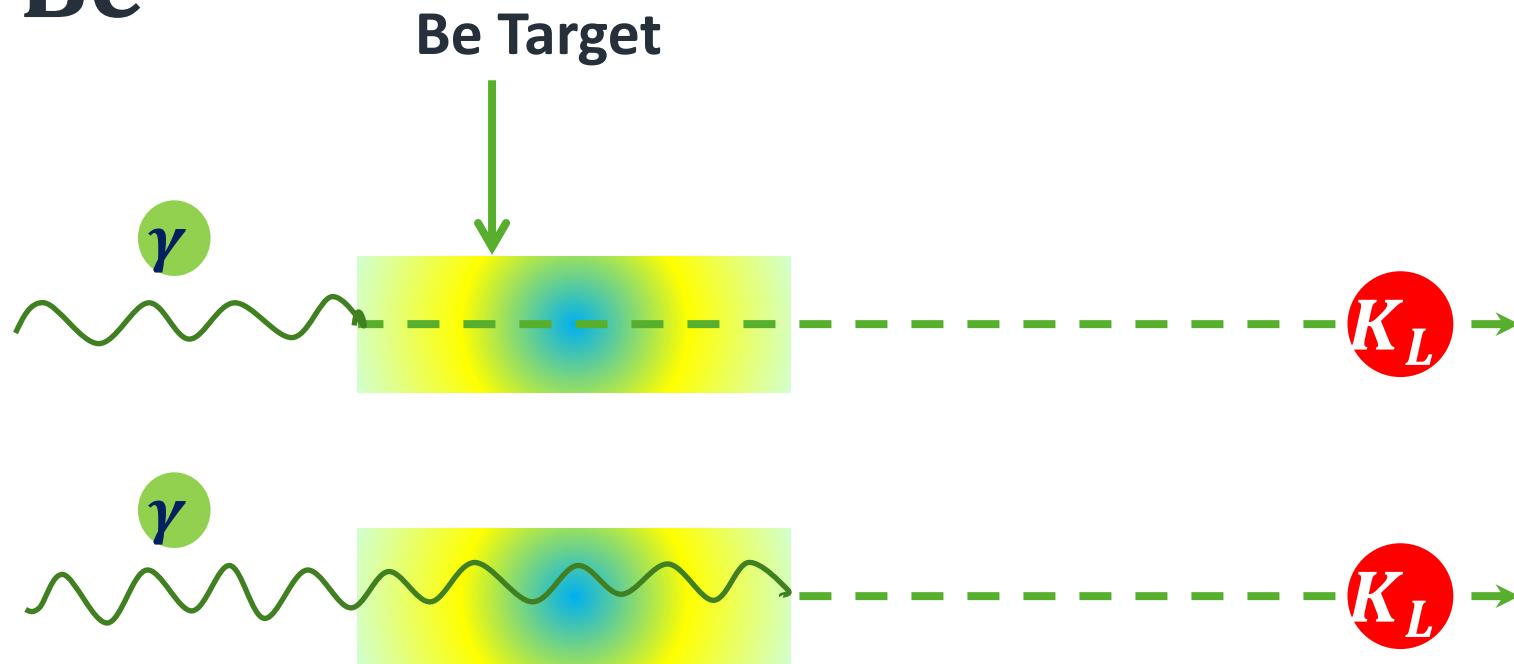
$$\Delta t = \frac{L}{c\beta_{K_l}} - \frac{L}{c} = \frac{L}{c}\left(\frac{1}{\beta_{K_l}} - 1\right)$$

For L=40cm and $p_{K_l} > 800 MeV/c, \Delta t < 150 ps$

K_l time resolution due to position in Re

δt vs p
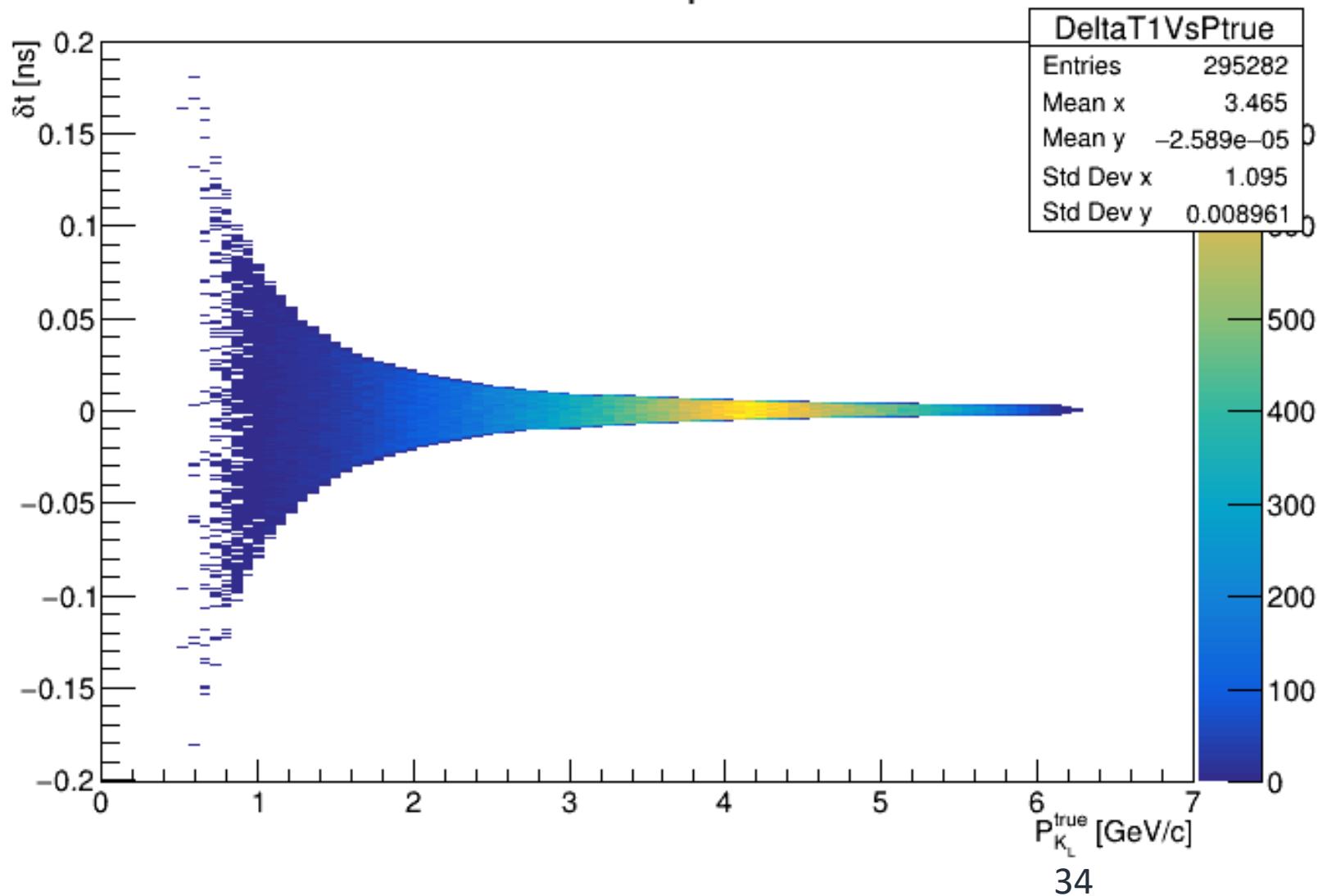
"No tracker" K_l time resolution

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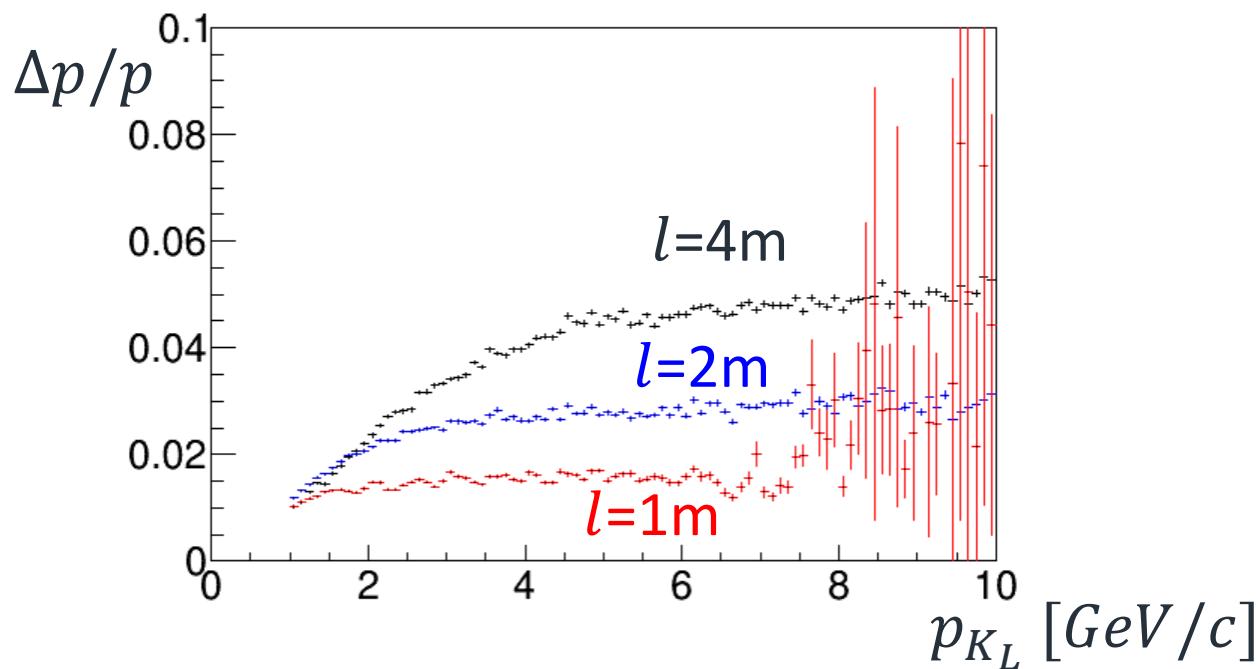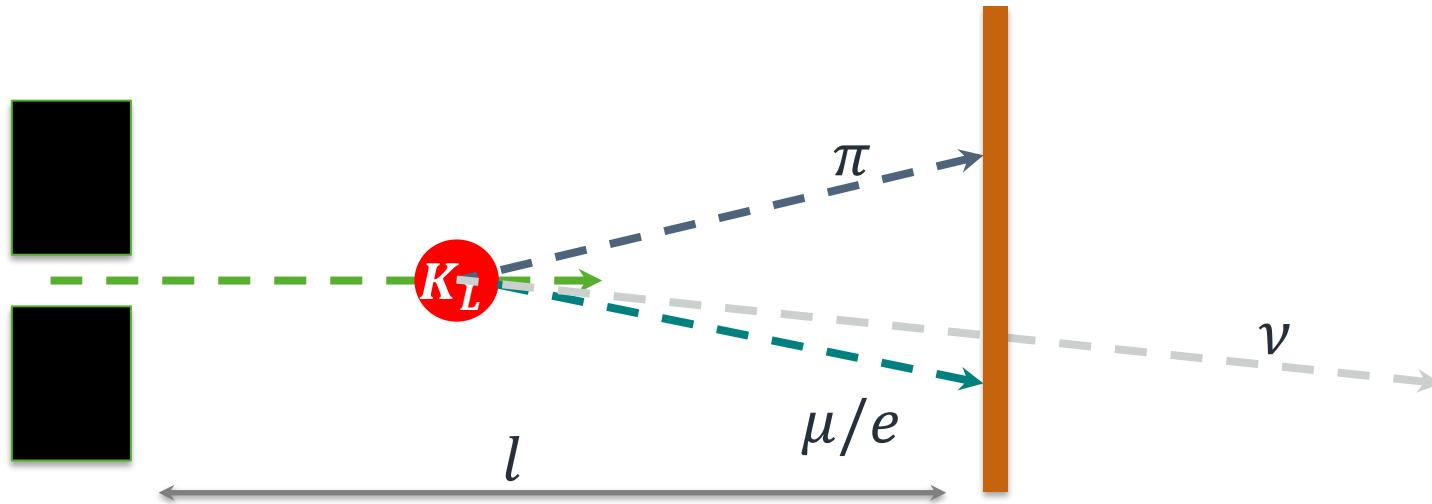
Status

- 3 options for the Flux monitor
  - Price
  - Performance
  - Byproduct research (rare decays)
  - Background suppression

KLF FM Readiness questions

- What is the status of the conceptual design of the Flux Monitor (KFM)?

KLF FM Readiness questions

- What is the status of the conceptual design of the Flux Monitor (KFM)?
  - ➔ Conceptual design is ready

K_l flux monitor location

Be target

LH2/LD2 target

24 m
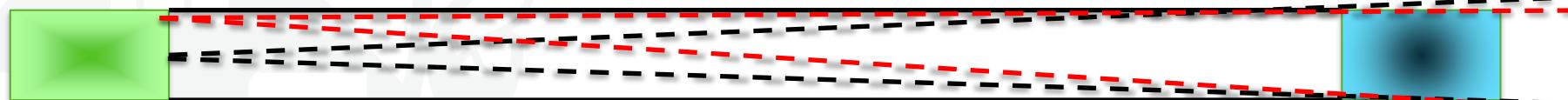
Flux Monitor

K_L decays

|	Br, %
$K_l \rightarrow \pi^{\pm} e^{\mp} \nu_e$	40.55
$K_l \rightarrow \pi^{\pm} \mu^{\mp} \nu_\mu$	27.04
$K_l \rightarrow \pi^+ \pi^- \pi^0$	12.54
$K_l \rightarrow \pi^0 \pi^0 \pi^0$	19.52

- **~ 21% of kaons decays in flight**
- **Any decay with charged particles can be used**

K_l flux monitor location

HALL D
WEST WALL

−849.272
HIGH GRANULARITY
PAIR SPECTROMETER
(C)

−810.973
(LOW GRANULARITY)
PAIR SPECTROMETER
UPSTREAM CORNER
CLOSEST TO BEAMLINE)

PAIR SPECTROMETER

BEAM TUBE
2.62 OD X .065 WALL

BEAMLINE

128.443
[3 m 26.244 cm]

6 m

2 m
kaon decay
range

1 m
Start station

2 m MRI
(optional)

1 m
Stop station

−940.677
(WINDOW − C)

−1137.217
(PAIR SPECTROMETER−C)

BEAM TUBE
1.50" OD X .065 WALL

(COIL 1−C)

FDC

CDC

BCAL

TARGET

START COUNTER

FOR

TIME

Ø185cm

Ø376cm

2.4" WINDOW
.005" THK

65.000
(TARGET−C)

174.400
(FDC−U)

−50.800
(SOLENOID−U)

Flux monitor location