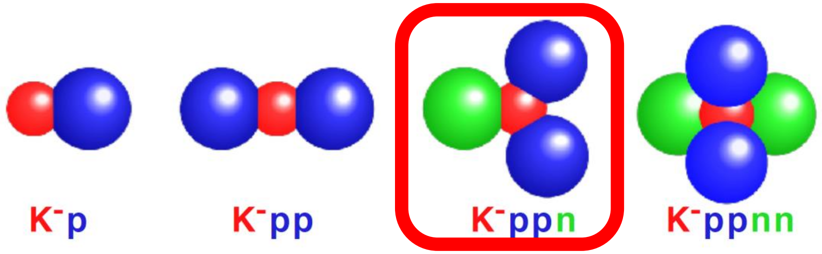
E80 Status Report

Systematic Investigation of the Light Kaonic Nuclei

– from the $\bar{K}N$ to $\bar{K}NNNN$ systems, and more –



F. Sakuma, RIKEN

on behalf of

the J-PARC E80 collaboration

42nd J-PARC PAC meeting, Jul 8 – 10, 2026

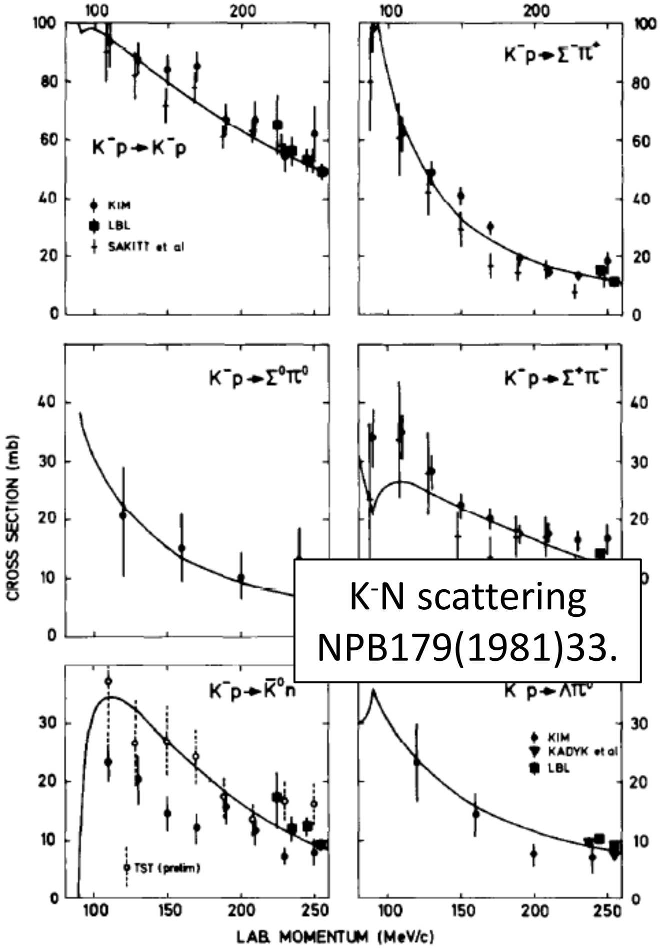
Physics Motivation

Reveal the meson properties inside nuclei via **the $\bar{K}N$ interaction**

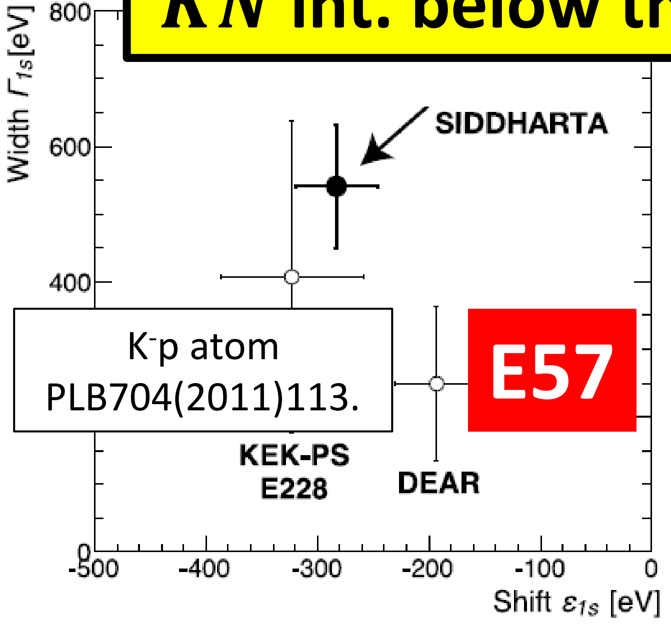
A powerful probe to understand low energy QCD

Strongly attractive in I=0 from extensive measurements

Kaonic nuclei can access $\bar{K}N$ int. below the threshold

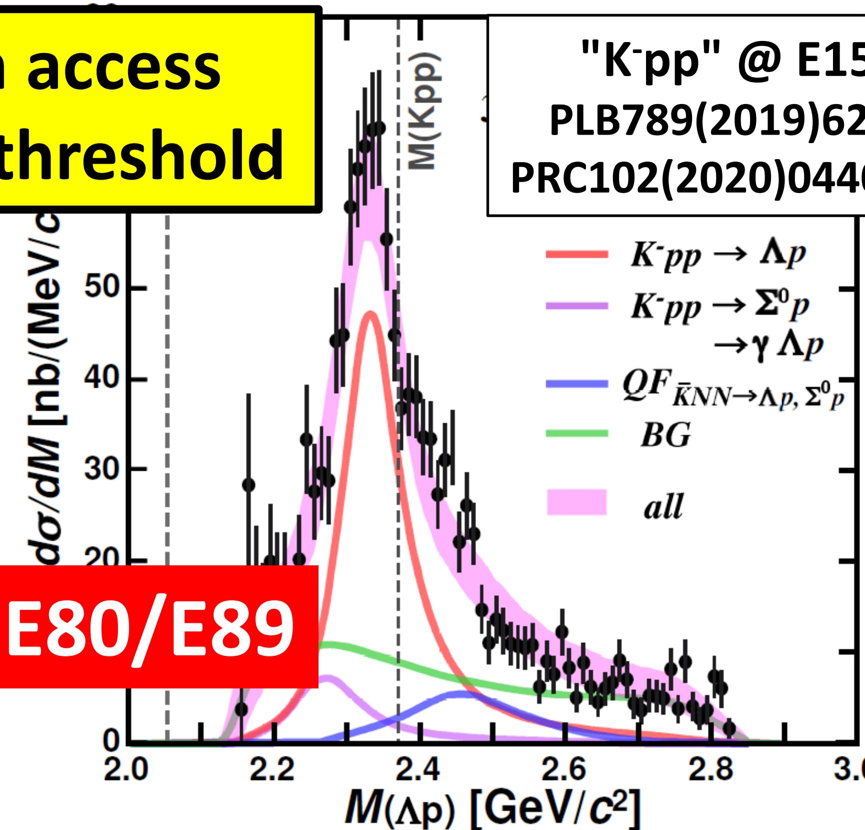


K⁻N scattering
NPB179(1981)33.



K⁻p atom
PLB704(2011)113.

E57



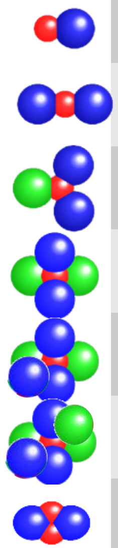
"K⁻pp" @ E15
PLB789(2019)620.
PRC102(2020)044002.

E80/E89

Systematic investigation of the light kaonic nuclei

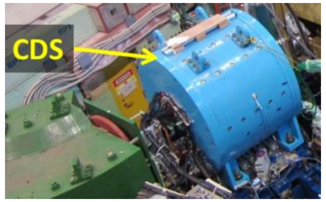
- ●Systematic measurement will be promoted
  - Mass number dependence
    - Binding energy, Branching ratio, *q* dependence, ..
  - Spin/parity determination

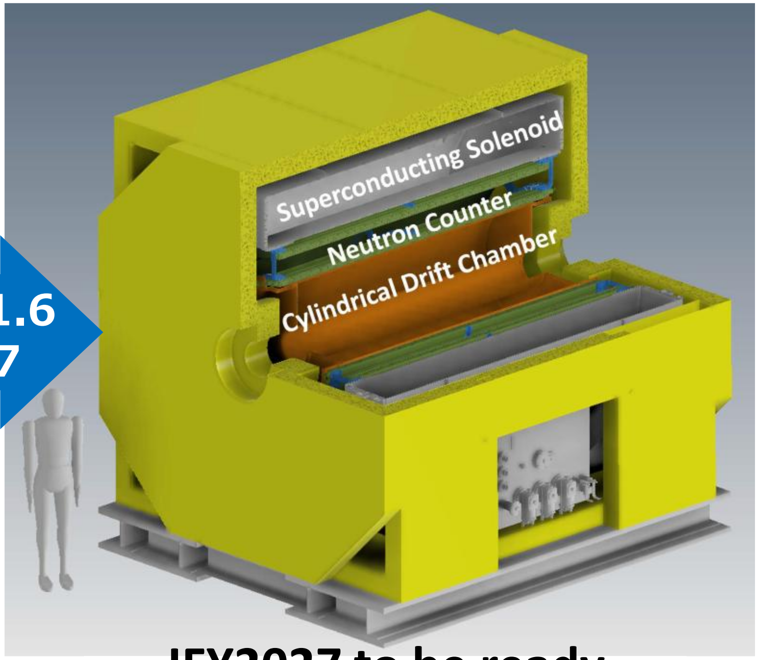
➢Extract internal structure, by combining experimental data with theoretical studies



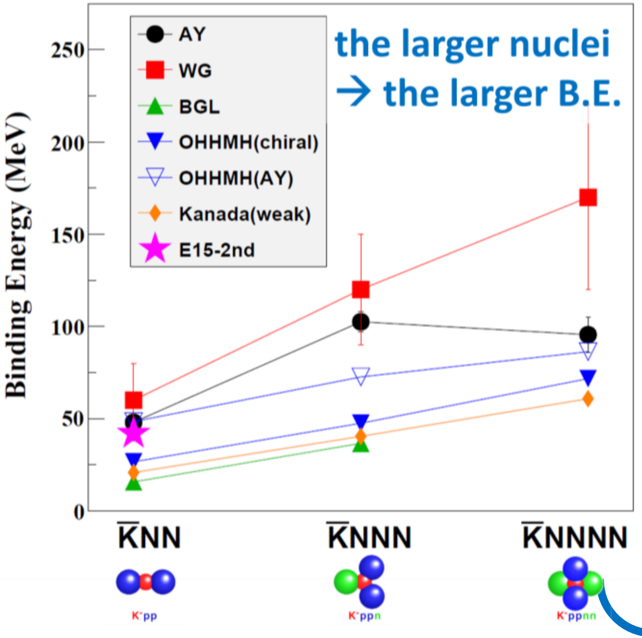
	Reaction	Decays
$\bar{K}N$	d(K⁻,n)	$\pi^{\pm 0}\Sigma^{\mp 0}$
$\bar{K}NN$	^{3}He(K⁻,N)	$\Lambda p/\Lambda n$
$\bar{K}NNN$	^{4}He(K⁻,N)	$\Lambda d/\Lambda pn$ **E80** ← first step
$\bar{K}NNNN$	^{6}Li(K⁻,d)	$\Lambda t/\Lambda dn$
$\bar{K}NNNNN$	^{6}Li(K⁻,N)	$\Lambda\alpha/\Lambda dd/\Lambda dpn$
$\bar{K}NNNNNN$	^{7}Li(K⁻,N)	$\Lambda\alpha n/\Lambda ddn$
$\bar{K}\bar{K}NN$	$\bar{p}+{}^3He$	$\Lambda\Lambda$

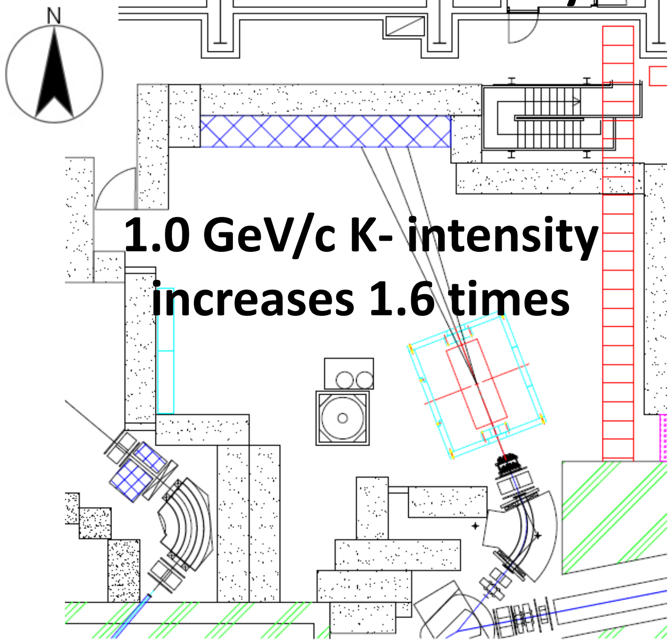
✓Solid angle: x1.6
✓Neutron eff.: x7

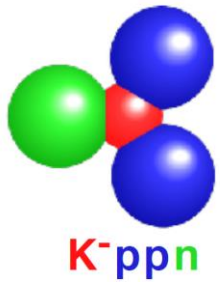




JFY2027 to be ready







a first step of the systematic investigation

$\bar{K}NNN$ @ E80

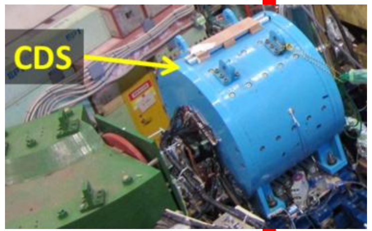
via ^{4}He(1 GeV/c K^-, n) reaction

① **Establish the existence of $\bar{K}NNN$**

- "K-ppn"→Λd 2-body decay

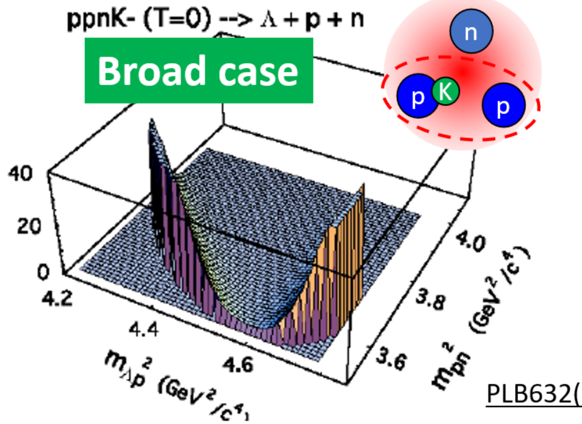
② **Study the multi-particle decay mode of $\bar{K}NNN$ toward understanding its internal structure**

- "K-ppn"→Λpn 3-body decay

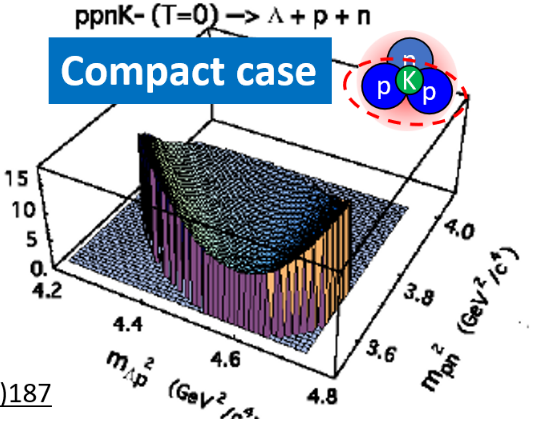


Paul Kienle [a,b], Yoshinori Akaishi [c,d], Toshimitsu Yamazaki [d,e,*]

Utilize Dalitz plots → Differences in distribution



PLB632(2006)187

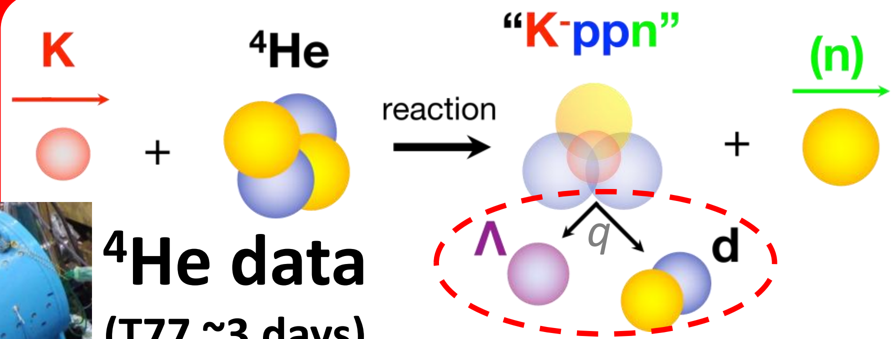


Distributed in parts of the plane

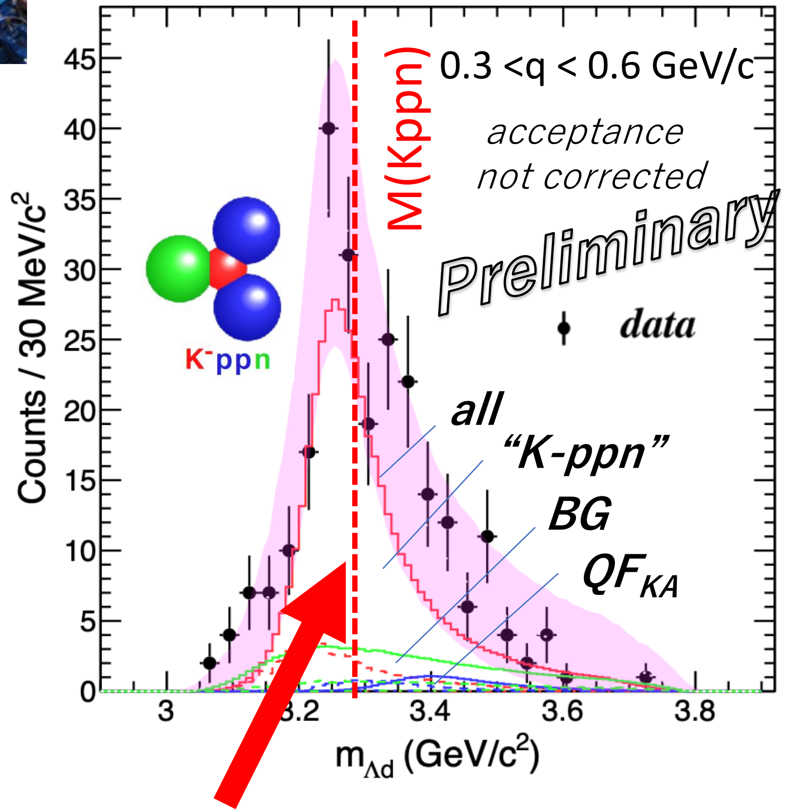
- 1 nucleon has the Fermi momentum

Widely distributed in the plane

- All particles have a momentum larger than the Fermi momentum



^{4}He data
(T77 ~3 days)



the sign of the "K⁻ppn"

Preparation Status

Timeline of E80

Original plan of Specially Promoted Research

	2022				2023				2024				2025				2026			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Magnet	–		Purchase (S.C. wires)		Construction				Test & Commissioning				Integration & Commissioning	Physics Run			Analysis & Pblication			
Polarimeter/NC	Design		Purchase & Assembly				Test & Commissioning													
CDC	Design				Construction				Test & Commissioning											
Fiber tracker	Design								Construct.		Test & Commiss.									

- **<u>2020 Jun : E80 proposal</u>**
- **<u>2021 Jan : E80 stage-1</u>**
- 2021 Jun : E89 proposal
- 2021 Jul ~ 2022 May : MR long shutdown (power-supply upgrade)
- 2022 Apr : Start of Specially Promoted Research
- 2023 Apr : Fire at the MR Second Power Supply Building
- 2023 Jun : Fire at the Hadron Power Supply Building → **~6-Month Delay**
- 2024 May : MR BM Coil Short and Other Issues
  (~1-Month Shutdown, E73 Run Split) → **~6-Month Delay**
- 2024 Jul : Fire at the Linac Building
- 2024 Apr : Start of JSPS Grant-in-Aid for Scientific Research (S)
- **<u>2024 Jul : E80 stage-2</u>**
- 2025 Jan : E89 stage-1
- 2026 Mar: Regulatory approval for the area upgrade
- 2026 Apr : KEK budget approval for the area upgrade
- 2026 Apr : Fire at the MR High-Voltage Switchboard → **~6-Month Delay**

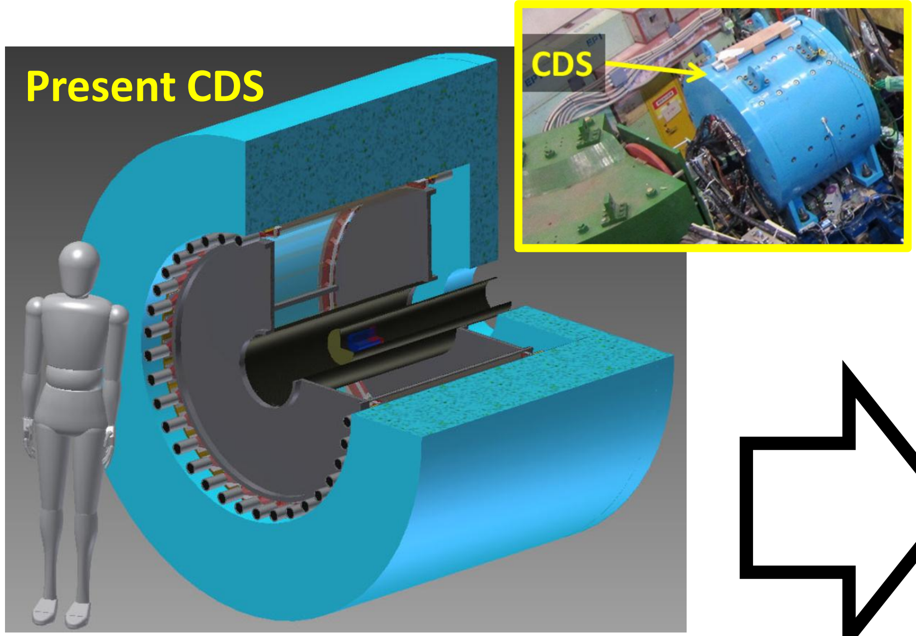
【Request to 34th-PAC (Aug 2022)】
- FY2024 Area Upgrade (after E72)
- FY2025 E80 Ready

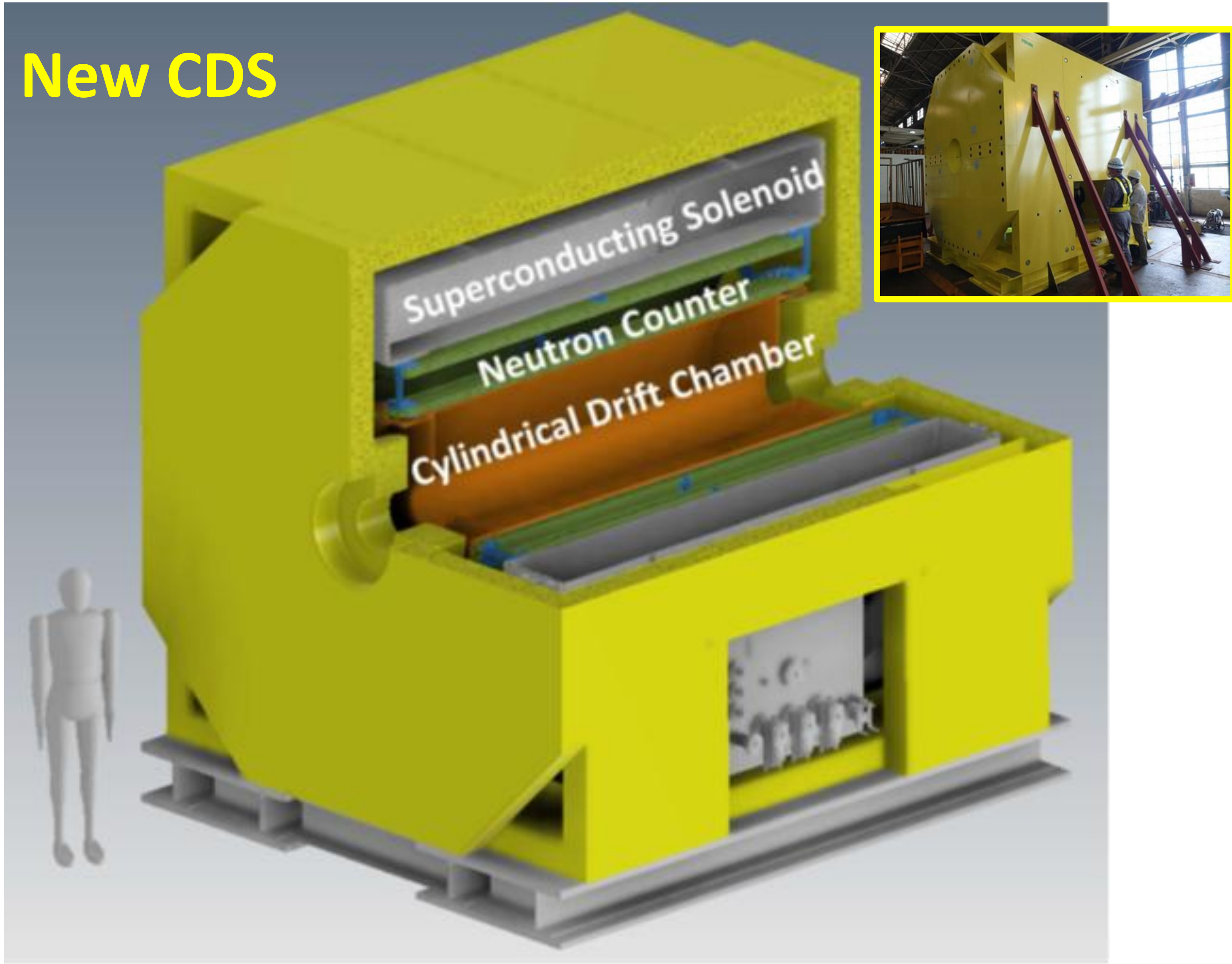
【Request to 37th-PAC (Jan 2024)】
- FY2025 Area Upgrade (after E72)
- FY2026 E80 Ready

→ **(due to regulatory approval, budget constraints,**
→ **and facility incidents)**

- FY2026 Area Upgrade
  (after E72/E104/E45)
- FY2027 E80 Ready

New Cylindrical Detector System (CDS)





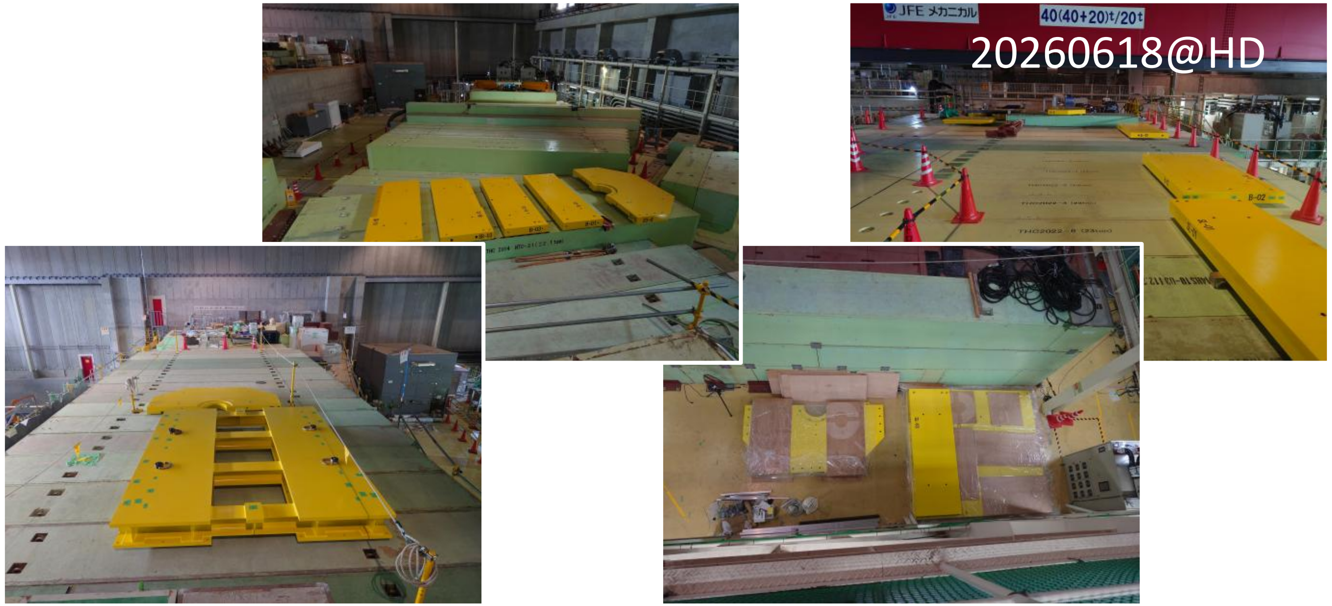
✓**Solid angle: x1.6** (59% → 93%)

✓**Neutron eff.: x7** (3% → 12%x1.6)

Superconducting Solenoid Magnet

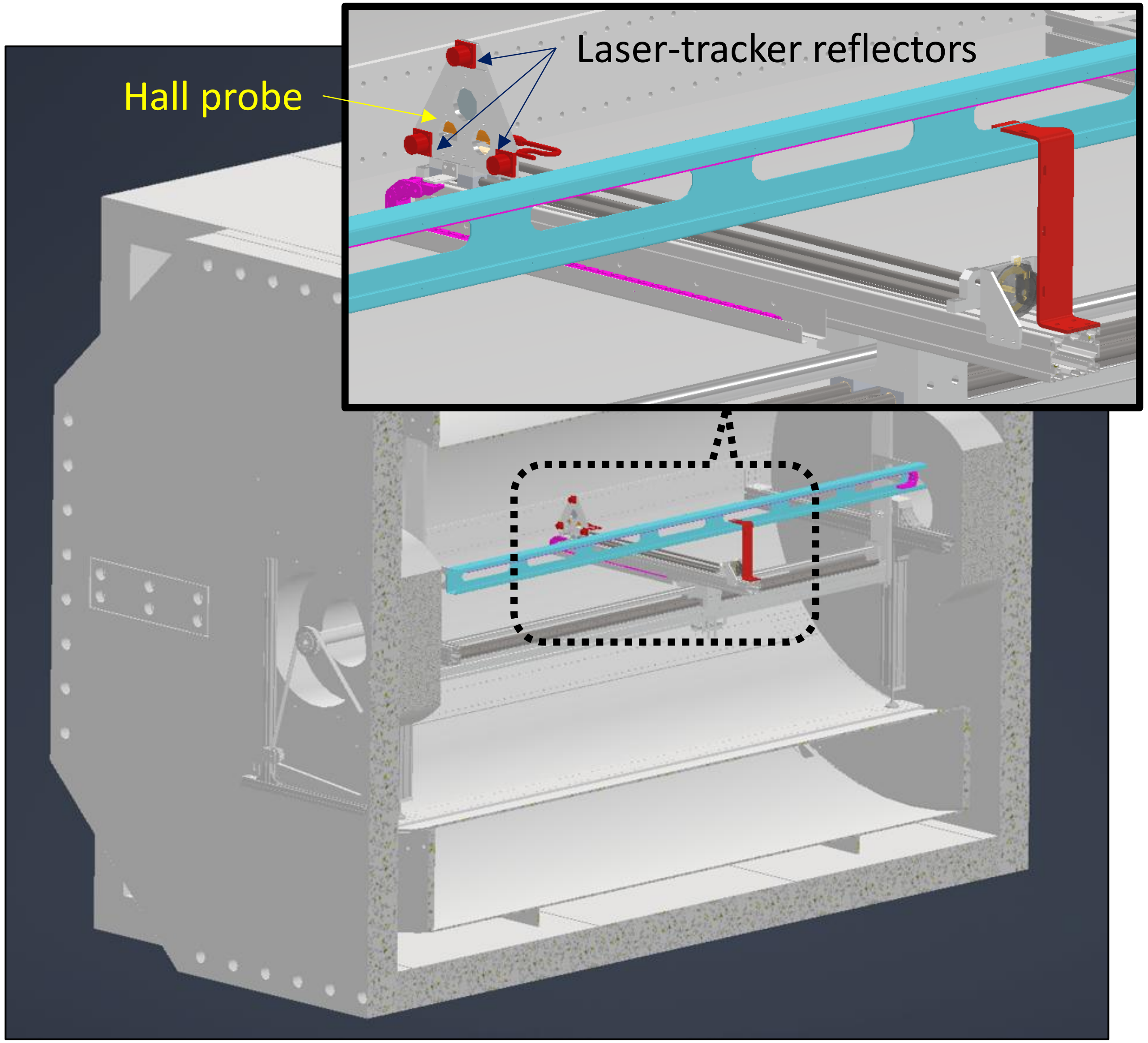
- Yoke: moved to J-PARC in June 2026
- Solenoid: ready to transfer to J-PARC

Ready to construct at K1.8BR



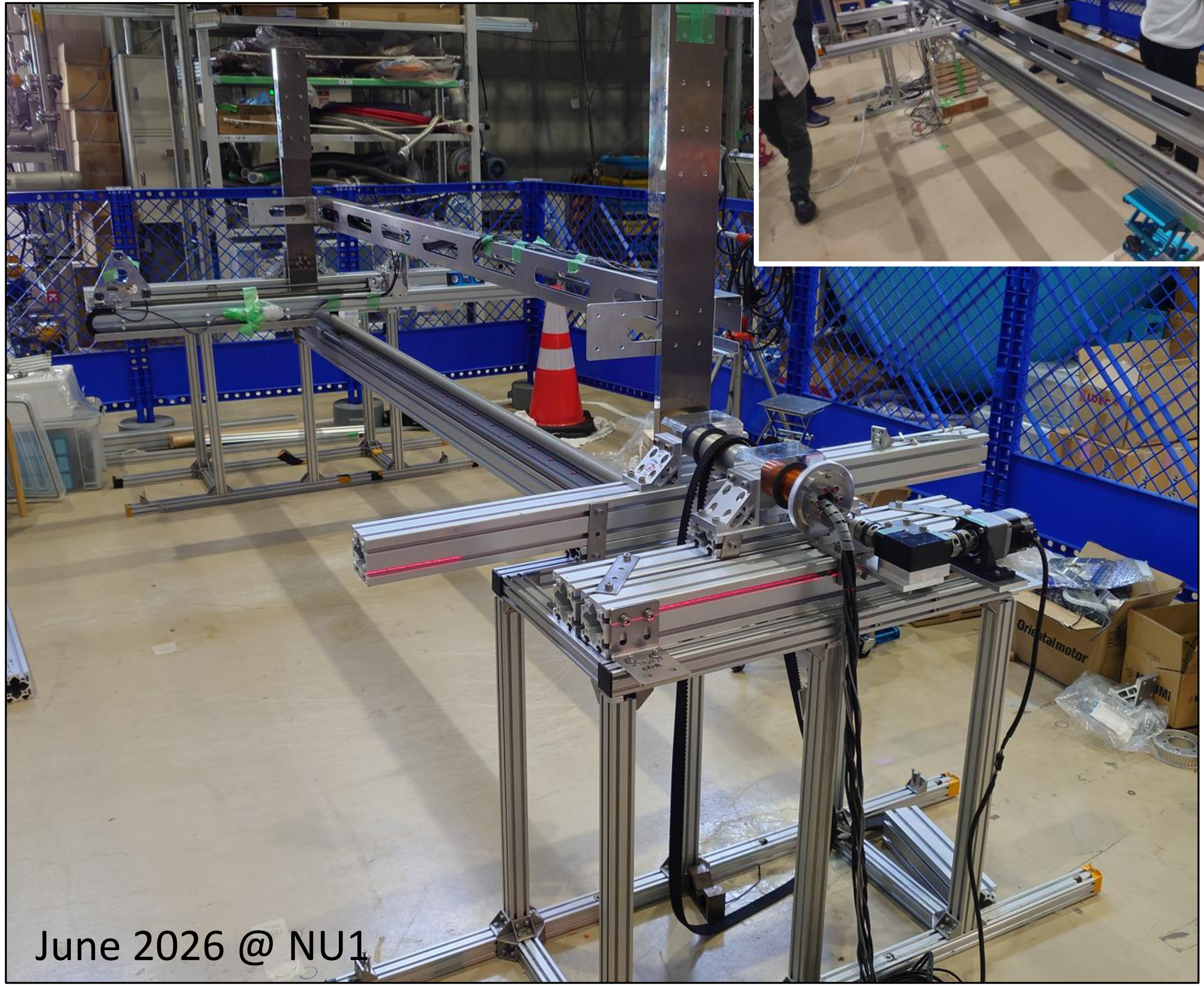
Magnetic Field Mapping System

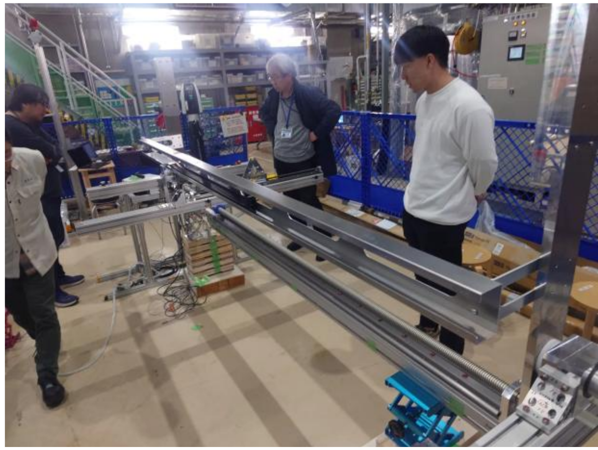
- 3D field mapping using a movable three-axis positioning system
- **The field-mapping system is being jointly developed with the COMET group**
  - Probe positions are calibrated with a laser tracker before installation of the end-caps
  - Magnetic field mapping is performed with a 3D Hall probe after installation of the end-caps



Magnetic Field Mapping System

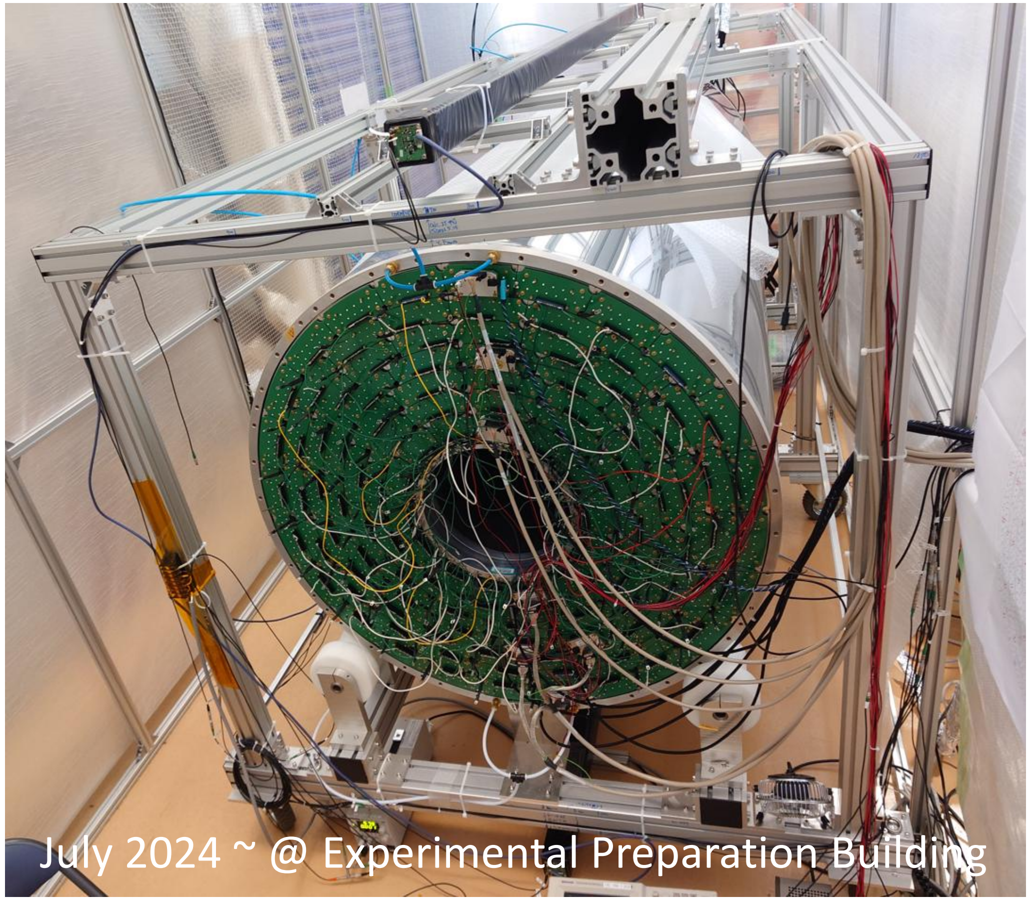
- The system has been assembled and tested at NU1
- Installation in COMET-DS is scheduled for July, followed by the measurement
  → Field mapping measurement will be established
- **The magnetic field mapping for E80 is planned at K1.8BR following the commissioning run**


June 2026 @ NU1

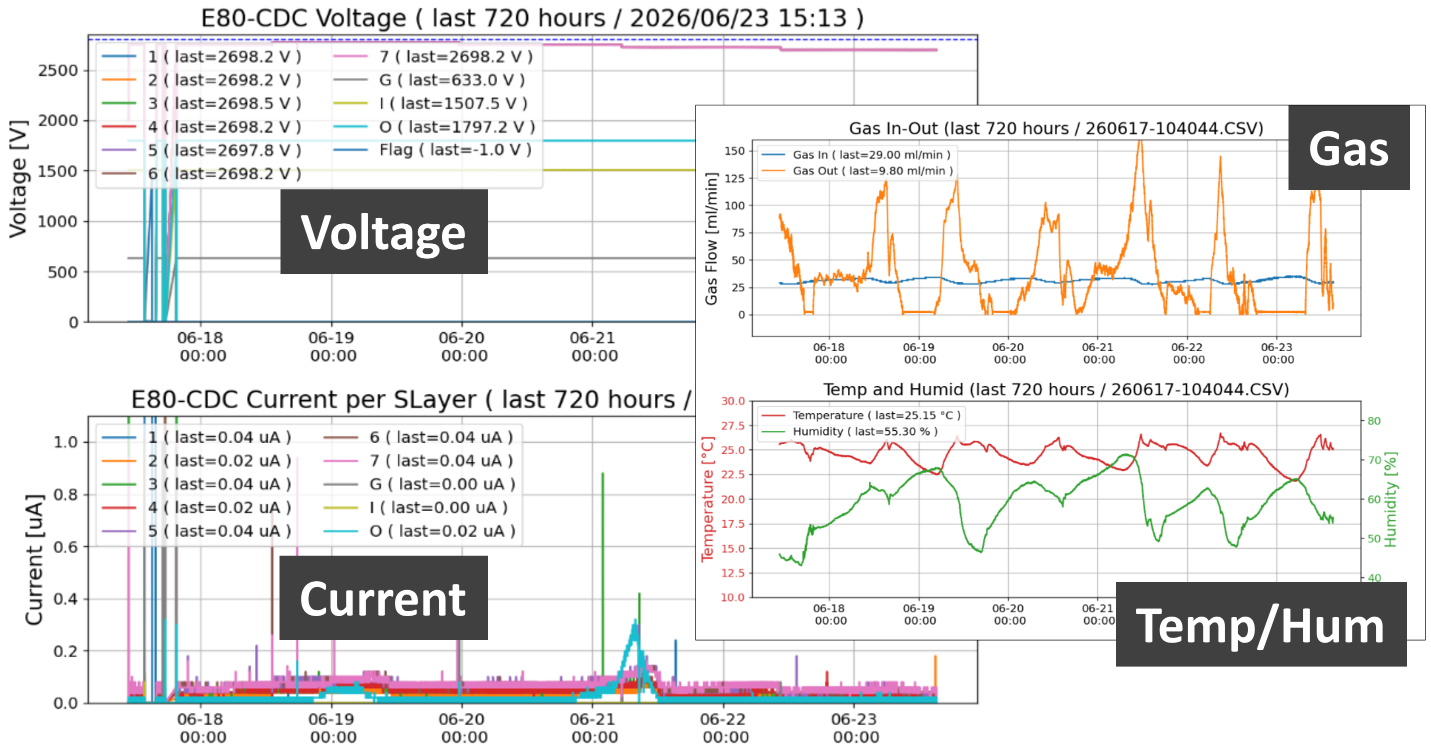


Cylindrical Drift Chamber (CDC)

- Commissioning is ongoing at J-PARC
  - Stable operation at the nominal voltage and gain has been confirmed.

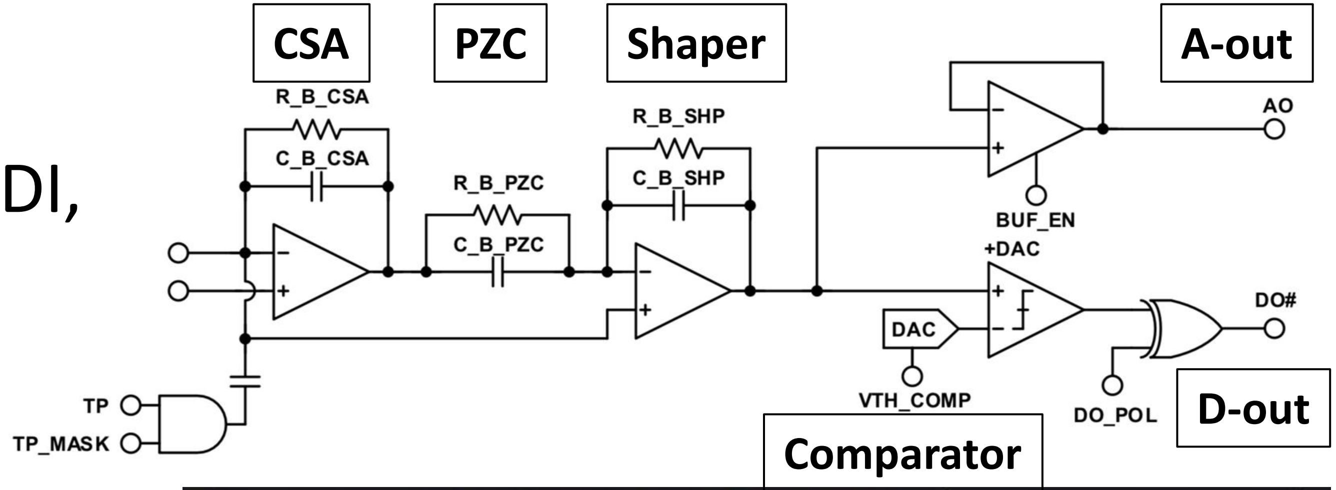


E80-CDC: Trends

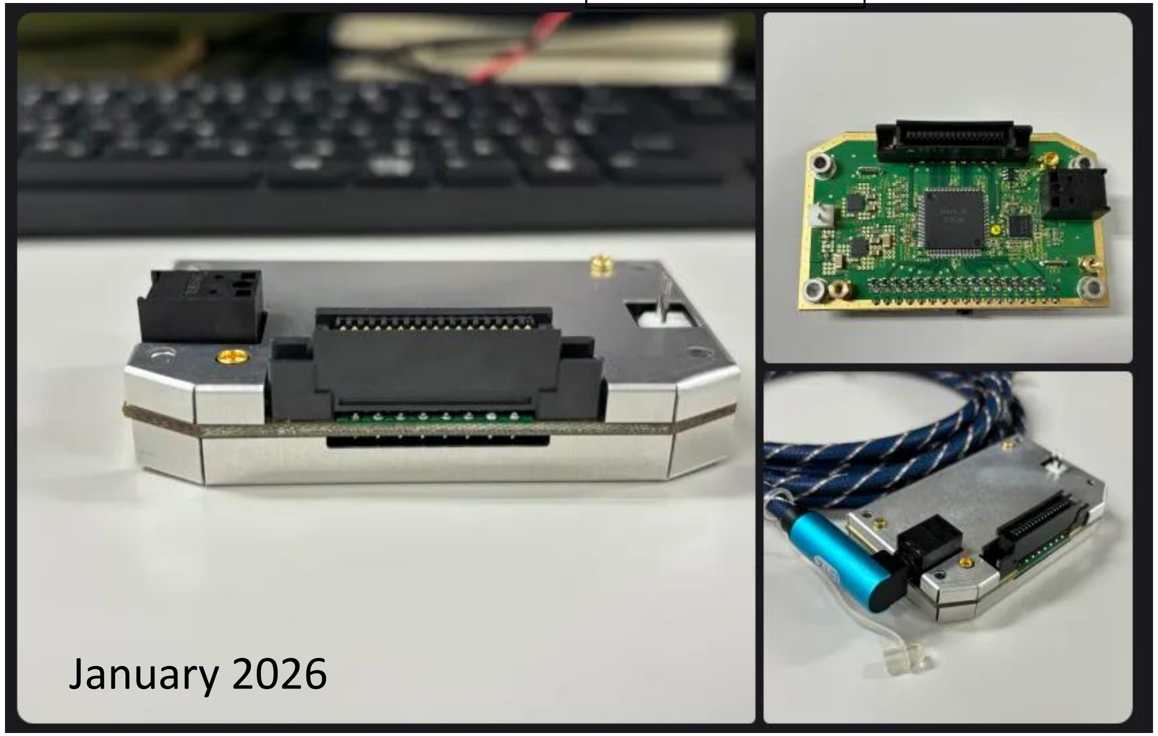


Stable operation over one month

New Preamplifier Card (ASAGI) for the CDC

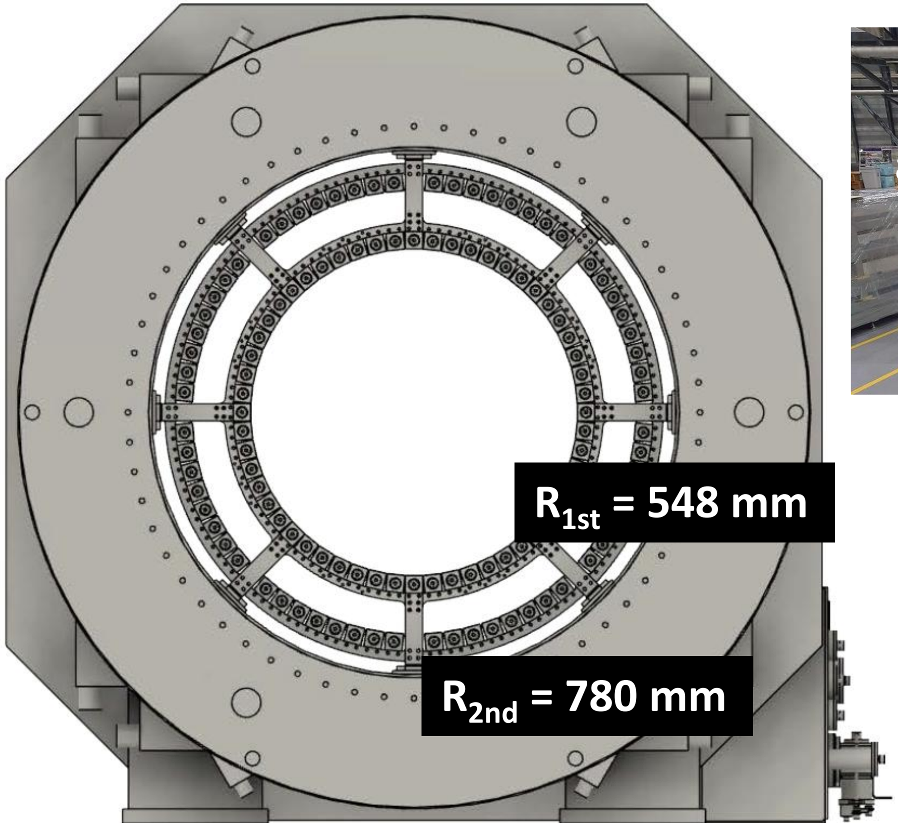


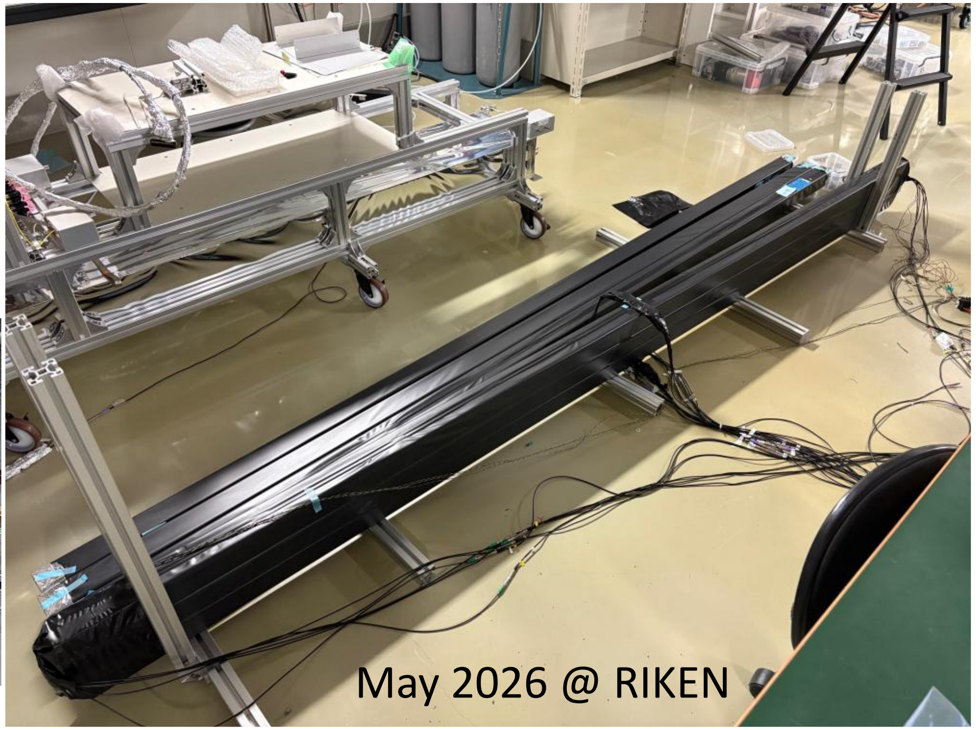
- Developing a new preamplifier card, ASAGI, in collaboration with the SPADI, E50, and NEOLITH groups
  - Variable gain and shaping time
  - Lower noise than the SONY ASD
- **Good performance of the new card has been confirmed**
  - Second prototype production with minor modifications is ongoing
- <u>Mass production is planned for summer 2026</u>

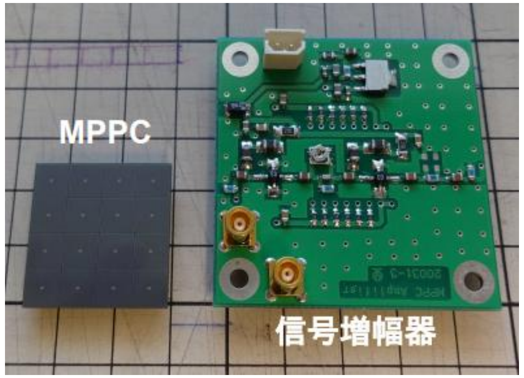


Cylindrical Neutron Counter (CNC)

- Scintillators and MPPCs have been procured
- **The required performance of the new AD8000-based preamplifier card has been confirmed**
- <u>Mass production of the preamplifier card is planned for summer 2026</u>







Time resolution:

σ_{CNC} ~ 80ps

K1.8BR Upgrade

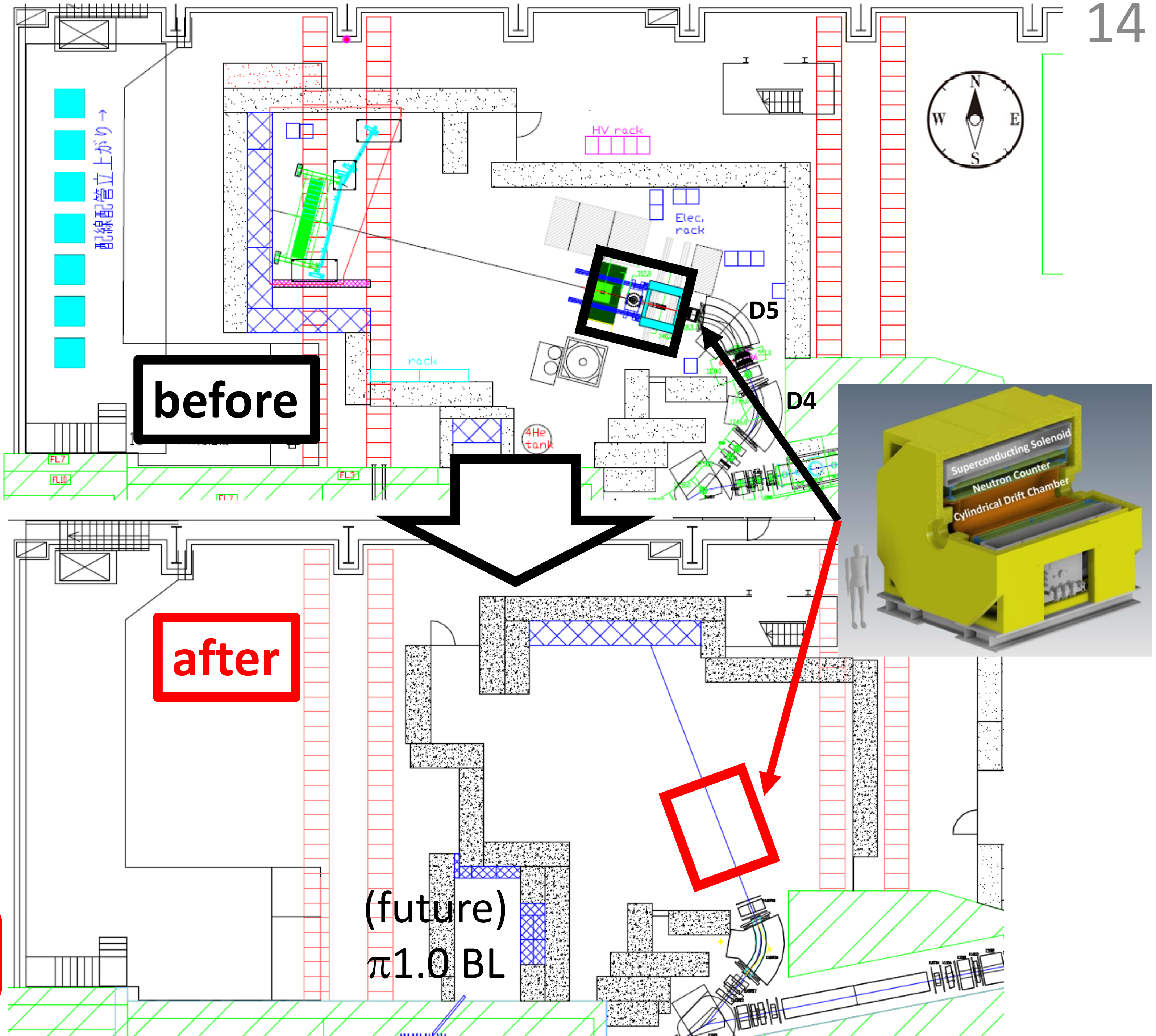
- The K1.8BR area upgrade is scheduled to start in Jan 2027

Shorten the beamline (~3.7m) by removing the final D5 magnet

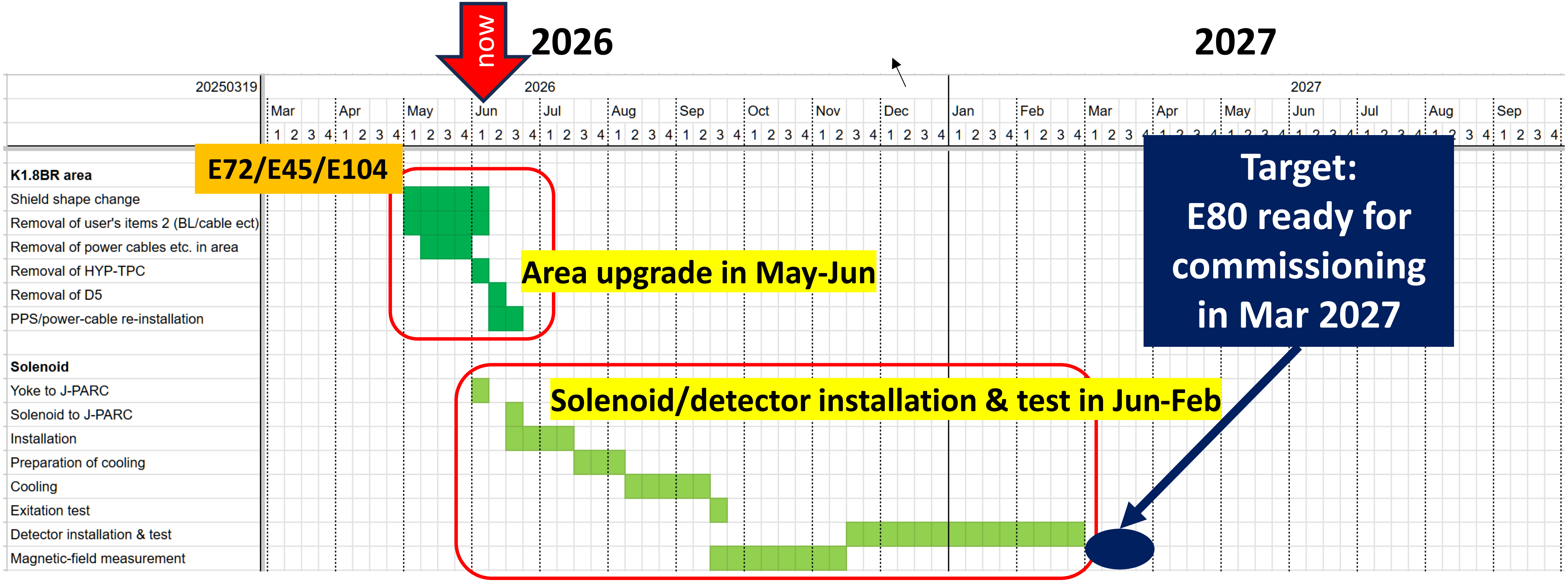
➢1.0 GeV/c K^- intensity increases 1.6 times

with $\pi/K \sim 2$

Relative beam-line length (beam yield)	D4+D5	D4
Present CDS	0 (x1)	-3.7m (x1.6)
New CDS	+1.2m (x0.9)	**-2.5m (x1.4)**

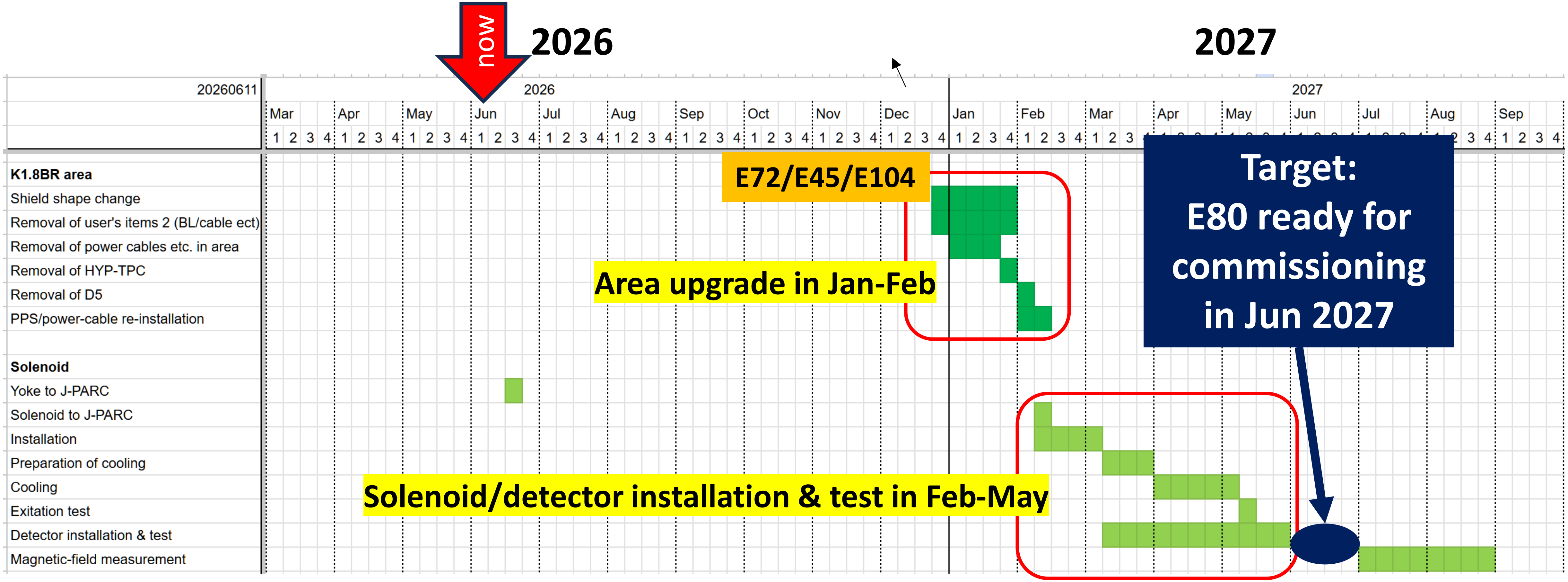


Original Timeline for E80 Readiness
(Presented at the 40th PAC, July 2025)



Area upgrade and solenoid/detector installation are scheduled from May 2026 to Feb 2027

Updated Timeline for E80 Readiness



Area upgrade and solenoid/detector installation are scheduled from Jan to May 2027

Run Plan

- **Dec 2026 (1 shift, 8h): Beamline Study** **←New Request in this PAC**
  - Beamline tuning without D5
  - Smooth transition to the 2027 commissioning run

- **Jun 2027 (1 week): Commissioning Run** **←New Request in this PAC**
  - Detector and DAQ commissioning with a ^{4}He target
  - Collection of pilot physics data focusing on the Λd channel
  - Expected yield: ~2k "K^-ppn" → Λd events

  → One Ph.D. thesis and one physics publication expected

- **After Summer 2027, before HK operation (3+1 weeks): Production Run + H2 Calibration Run**
  - High-statistics measurement with a ^{4}He target
  - Investigation of "K^-ppn" via Λd, Λpn, and mesonic decay channels

  → More than 5 physics publications expected

Scope of Publication

1. **Λdn final state:**
   - ✓Measurement of the "K^-ppn" bound state in the $^4He(K^-,n)$ reaction via the Λd decay channel
   - ✓Search for the "K^-pn" bound state in the $^4He(K^-,d)$ reaction via the Λn decay channel
2. **Λpnn final state:**
   - ✓Study of the internal structure of "K^-ppn" via the Λpn three-body decay channel in the $^4He(K^-,n)$ reaction
   - ✓Measurement of "K^-pp" production in the $K^- + {}^4He$ reaction through the Λp invariant-mass spectrum
   - ✓Search for the "K-pnn" bound state in the $^4He(K^-,p)$ reaction via the Λnn decay channel
3. **Mesonic final states :**

   e.g., $(\pi Y)^0dn/(\pi Y)^0pnn/(\pi Y)^-ppn$ final state
   - ✓Study of mesonic decay channels of "K-ppn" in the $^4He(K^-,n)$ reaction
4. **$(\pi\Sigma)^0X$ final state:**
   - ✓Study of Λ(1405) production in nuclei through the $(\pi\Sigma)^0$ invariant-mass spectrum
5. **Systematic and unified study of the $\bar{K}N$, $\bar{K}NN$, and $\bar{K}NNN$ systems to clarify the evolution of the $\bar{K}N$ interaction in few-body nuclei**

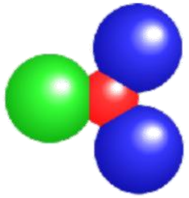
>5 physics publications are expected

Summary

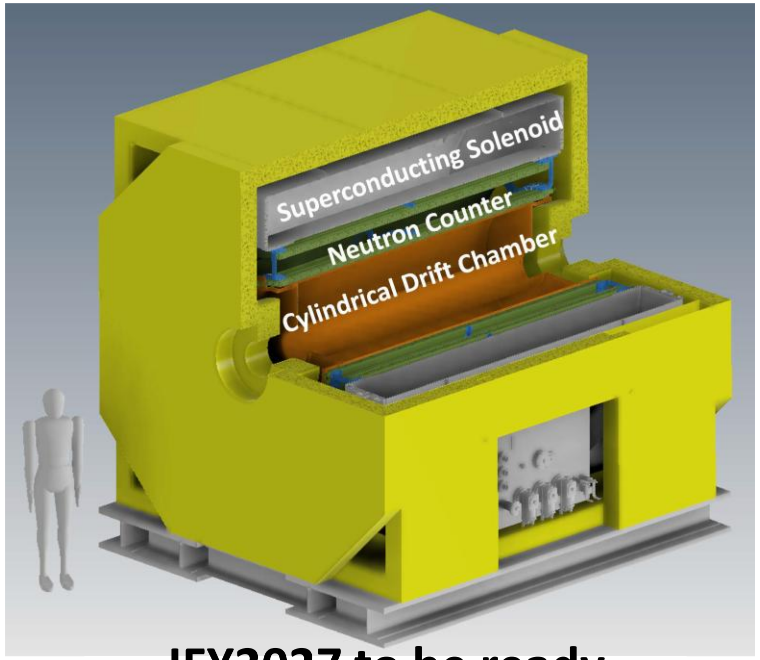
E80 investigates the **"K⁻ppn"** bound state as a first step toward the systematic study of kaonic nuclei

- K1.8BR upgrade is scheduled to start in Jan 2027
- E80 will be ready in Jun 2027
- More than 5 physics publications are expected

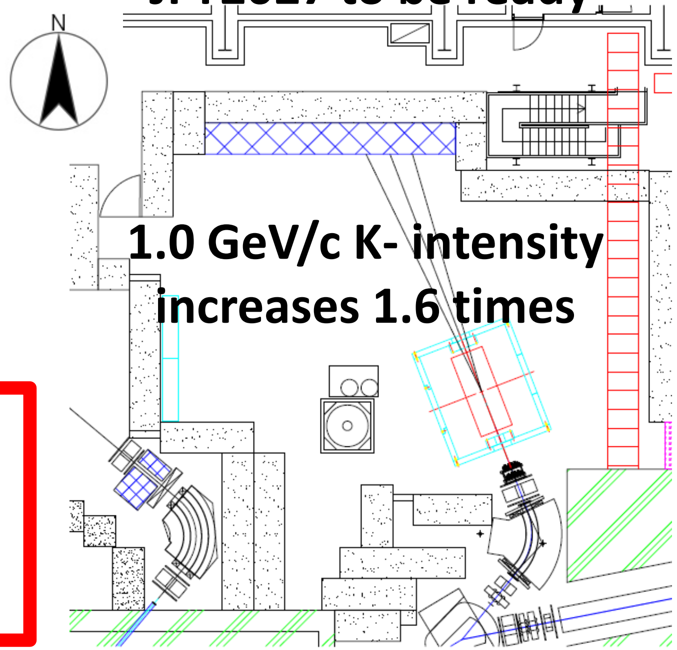
Beam intensity	90kW
Beam time	**1+1+3 weeks**



K^-ppn



JFY2027 to be ready



E80 will provide the first systematic study of the $\bar{K}N$, $\bar{K}NN$, and $\bar{K}NNN$ systems

J-PARC E80 Collaboration

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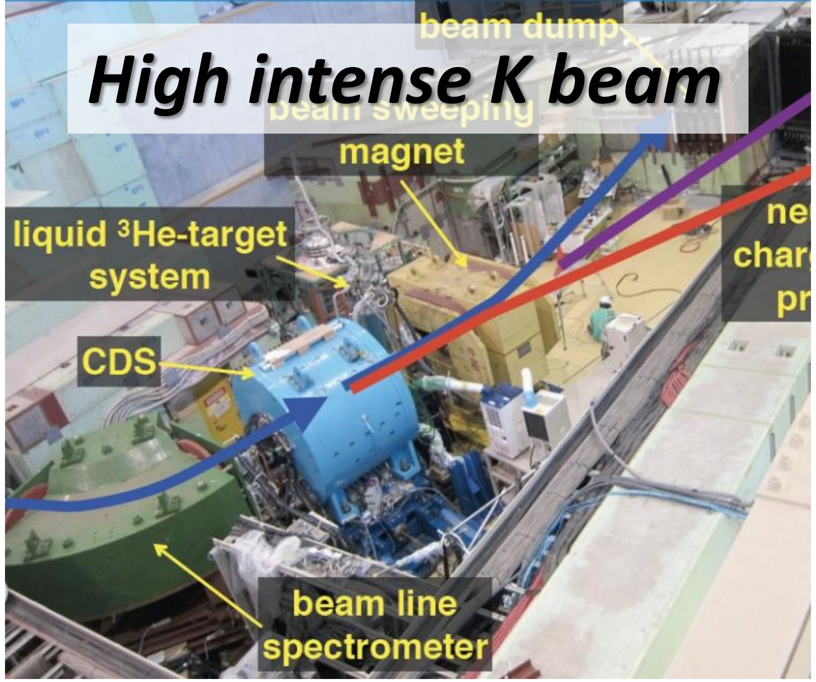
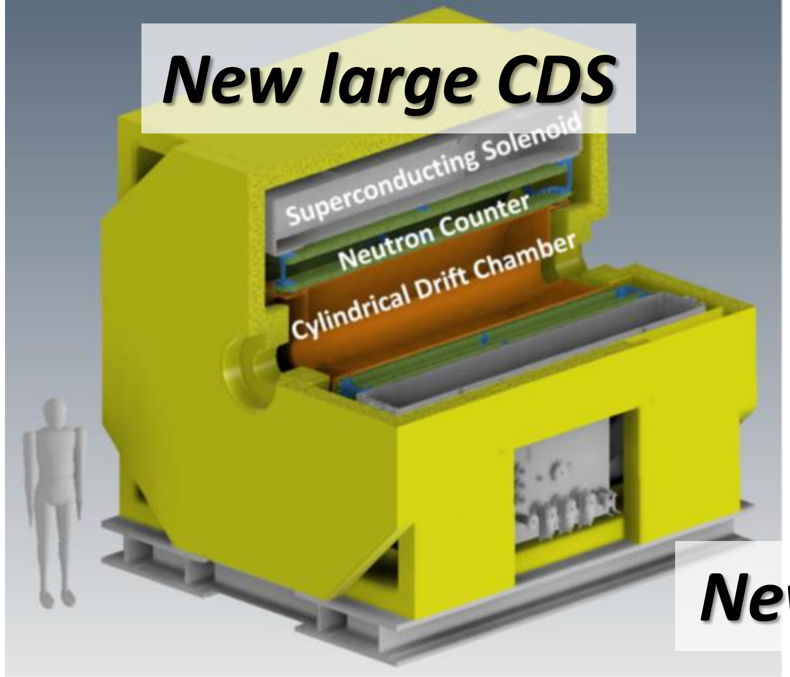
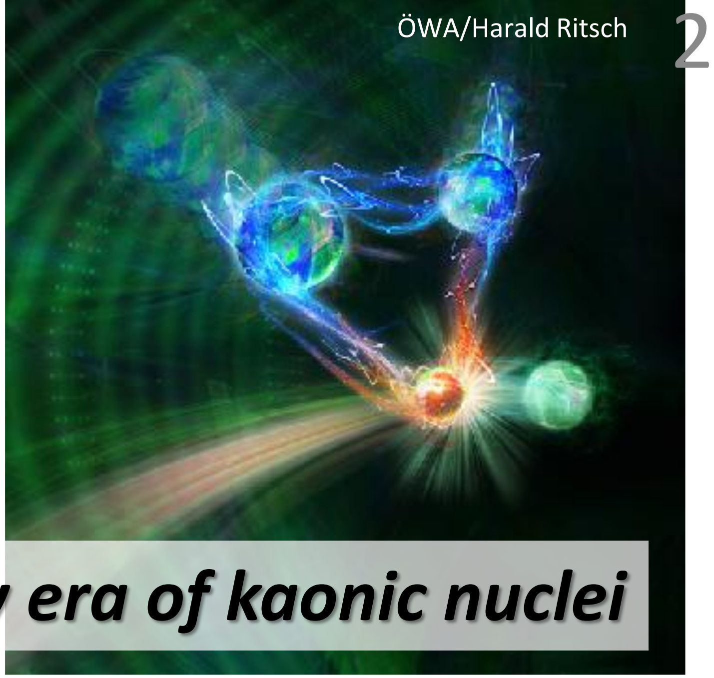
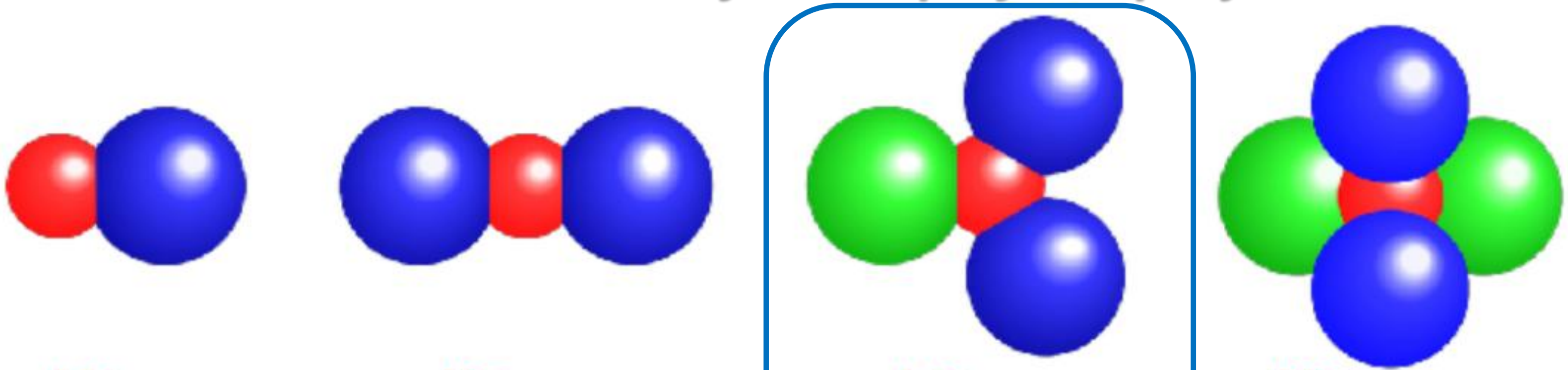






Thank you for your attention!

A first step of the project

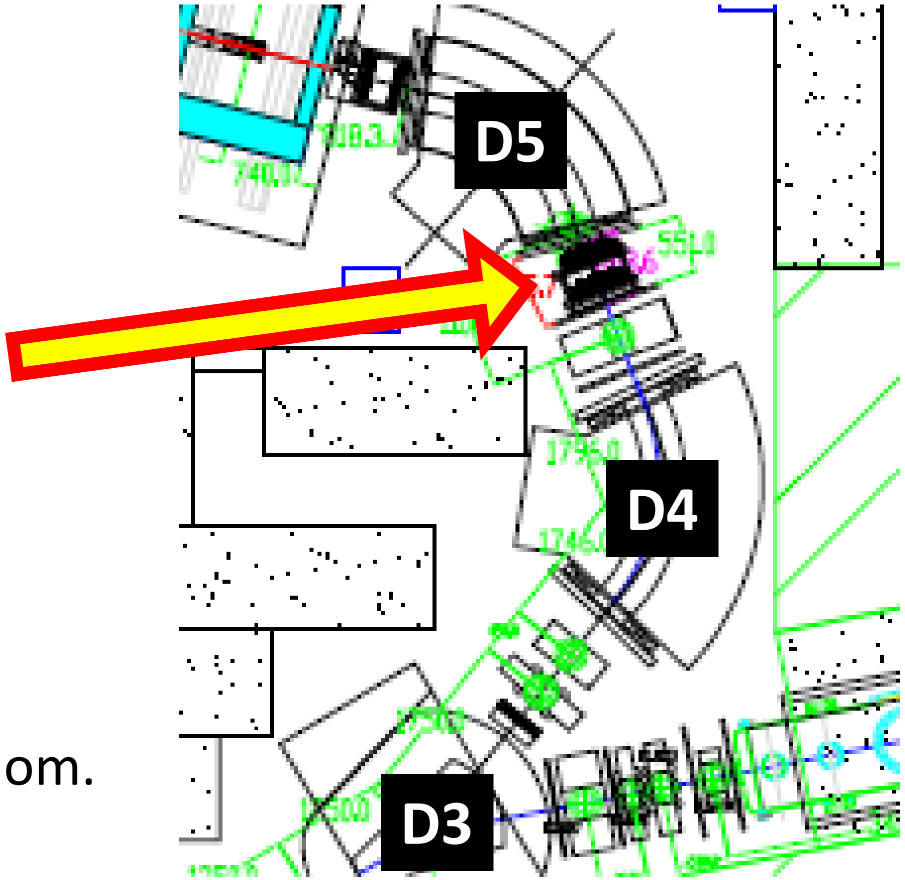


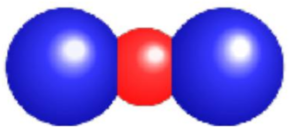
K^-p K^-pp K^-ppn K^-ppnn

via in-flight $^4He(K^-,N)$

Beamtime Request in Nov/Dec 2026 ~8 hours

- **Main purpose:**
  - beam tuning w/o D5: profile & K yield
    - 0.735 GeV/c, 1.0 GeV/c, and 1.2 GeV/c (if possible)
    - Newly developed counter study (e.g. new AC for CDS)
- **Detector Setup:**
  - BPM(Beam Profile Monitor)+AC between BLC1a and BLC1b
    - BPM: W33 x H260 x T8 x 8 segments
    - AC: W25 x H100 x T20 x 8 segments
- **Run plan:**
  - Detector&DAQ commissioning: ~ 1 hour
  - Beam tuning (CM, slit, steering): 30min x 3 mom.
  - Profile measurement with 10 magnet settings ~ 1hour x 3 mom.
  - Slit study: 1 hour x 1 mom.
  - Momentum change 15min x 2
  - Spare 1 hour





K⁻pp

$\bar{K}$NN @ E89

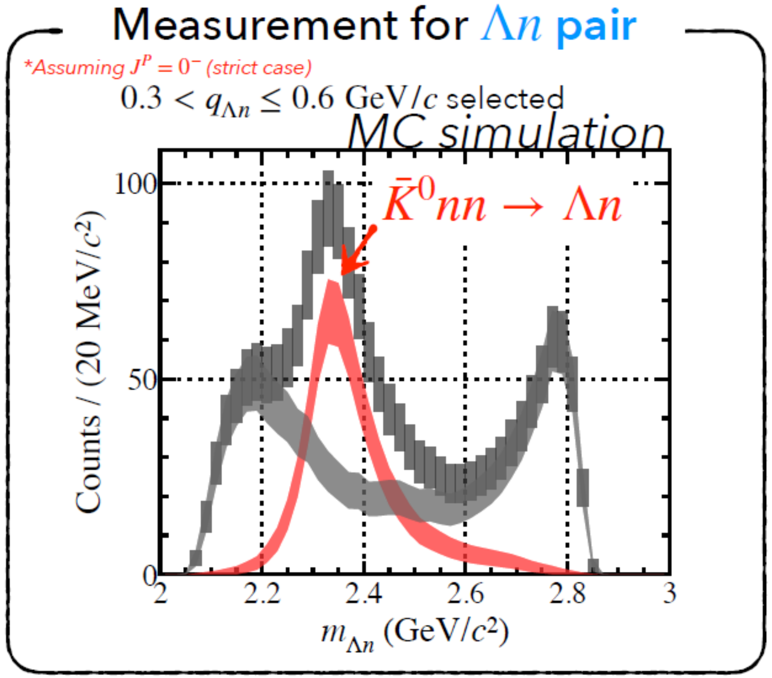
via ^{3}He(1 GeV/c K⁻, n) reaction

① Search for "$\bar{K}^0$nn", isospin partner of "K⁻pp"

- "$\bar{K}^0$nn"→Λn/Σ⁻p

② Determine the spin/parity of $\bar{K}$NN

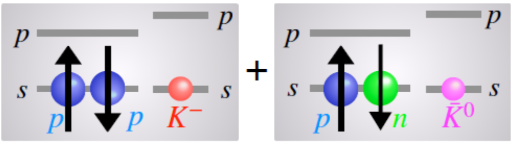
- spin-spin correlation measurement of "K⁻pp"→Λp



There are two possible configurations for the $\bar{K}NN$ ground state.

" $(NN)_{(I.sym\times S.asym)} \otimes \bar{K}$ "

$J^P = 0^-$

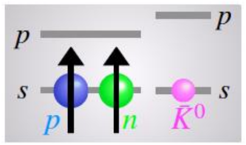


$$\frac{|I_{\bar{K}N} = 0|^2}{|I_{\bar{K}N} = 1|^2} = \frac{3}{1}$$

Deeper bound expected

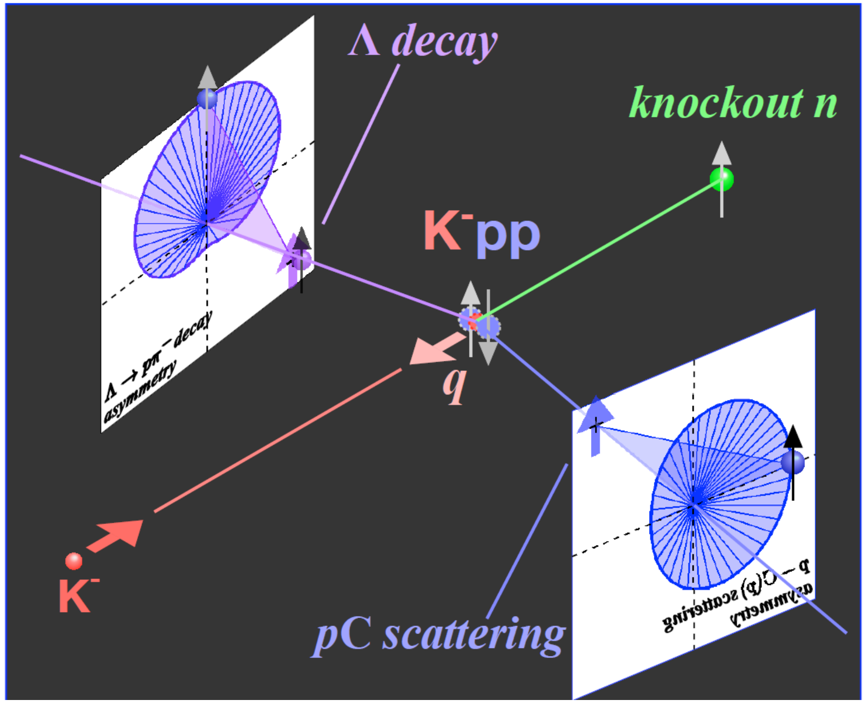
" $(NN)_{(I.asym\times S.sym)} \otimes \bar{K}$ "

$J^P = 1^-$



$$\frac{|I_{\bar{K}N} = 0|^2}{|I_{\bar{K}N} = 1|^2} = \frac{1}{3}$$

Shallower bound expected



Revised CDS Preparation Plan

● Original Plan

Jun 2026 Solenoid Installation → Magnetic Field Mapping → CDC/CNC/... Installation → Mar 2027 **Completed**

● Revised Plan

Jan 2027 Solenoid Installation → CDC/CNC/... Installation → May 2027 **Completed** → Commissioning Run

→ Jul 2027 CDC/CNC/... Removal → Summer 2027 Magnetic Field Mapping → CDC/CNC/... Installation → Winter 2027 **Completed**

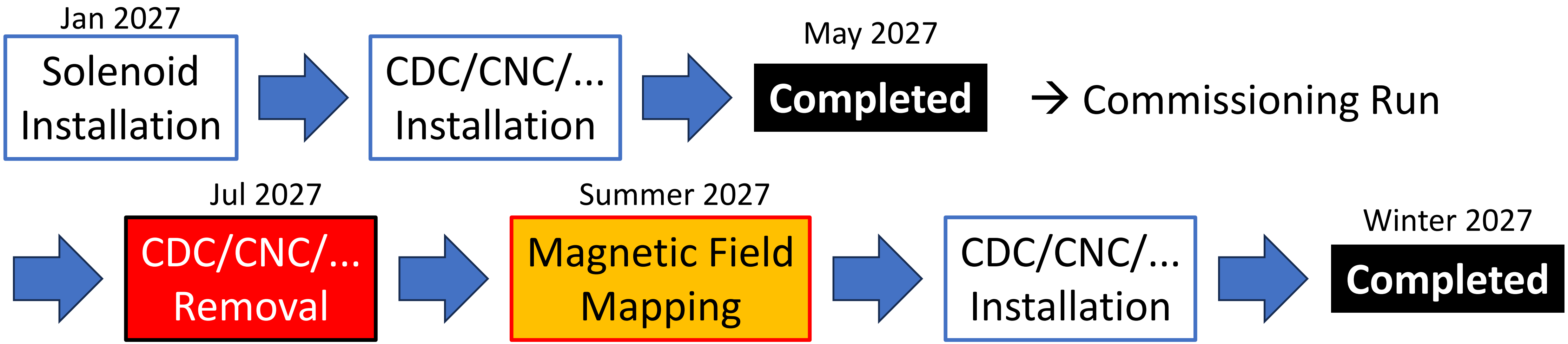
We use the field map calculated with OPERA-3D (TOSCA)

→ Magnetic field mapping is used to calibrate the calculated field map.

Revised CDS Preparation Plan

- ➢Commissioning run
  - intended to establish stable detector operation, DAQ, and beam tuning
- ➢Detector re-installation after commissioning
  - expected to be a well-established procedure

●Revised Plan



We use the field map calculated with OPERA-3D (TOSCA)

→ Magnetic field mapping is used to calibrate the calculated field map.

Revised CDS Preparation Plan

●Original Plan

Jun 2026: Solenoid Installation → Magnetic Field Mapping → CDC/CNC/… Installation → Mar 2027: **Completed**

●Revised Plan

Jan 2027: Solenoid Installation → CDC/CNC/… Installation → May 2027: **Completed** → Commissioning Run

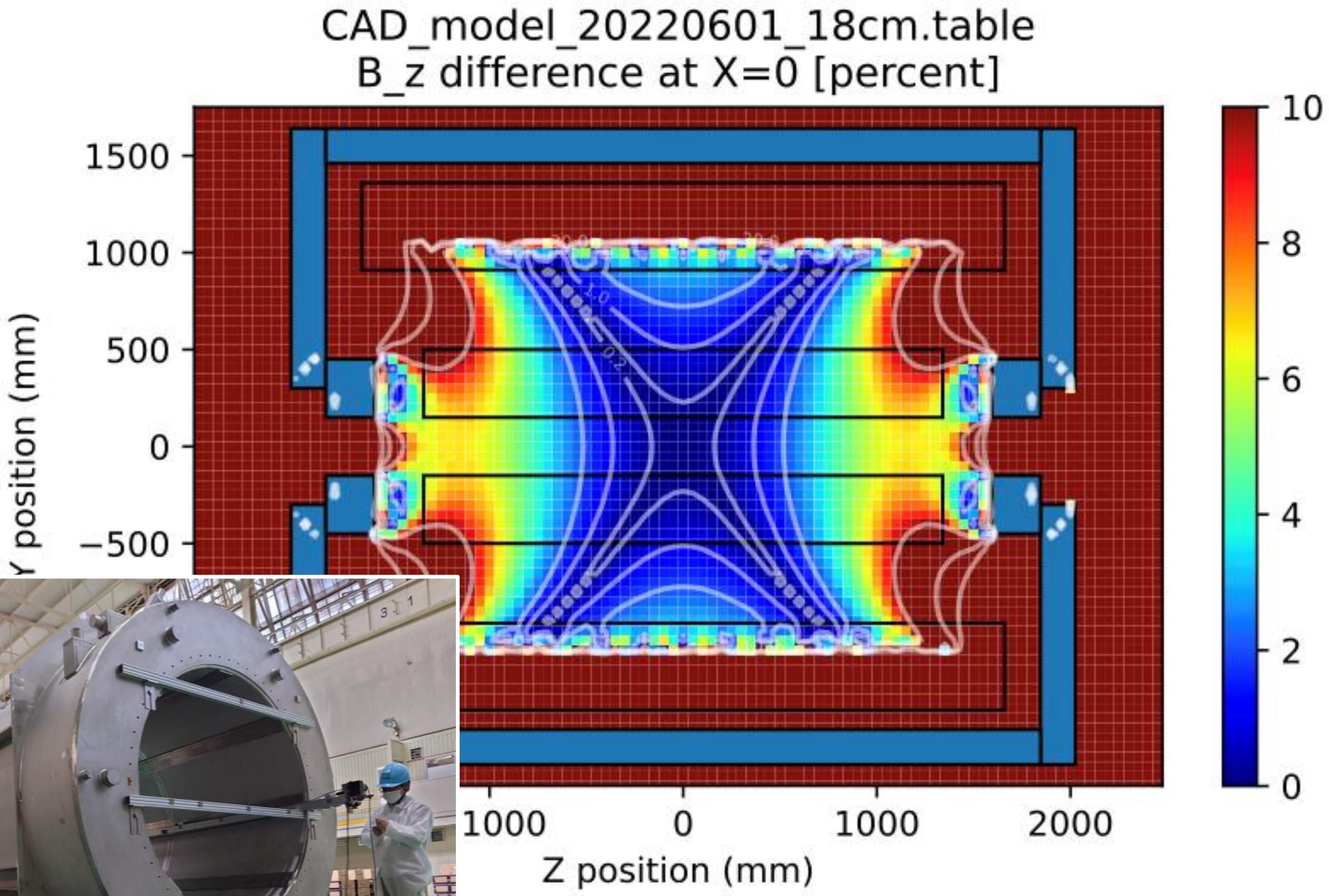
→ Partial Magnetic Field Mapping → Production Run → Magnetic Field Mapping

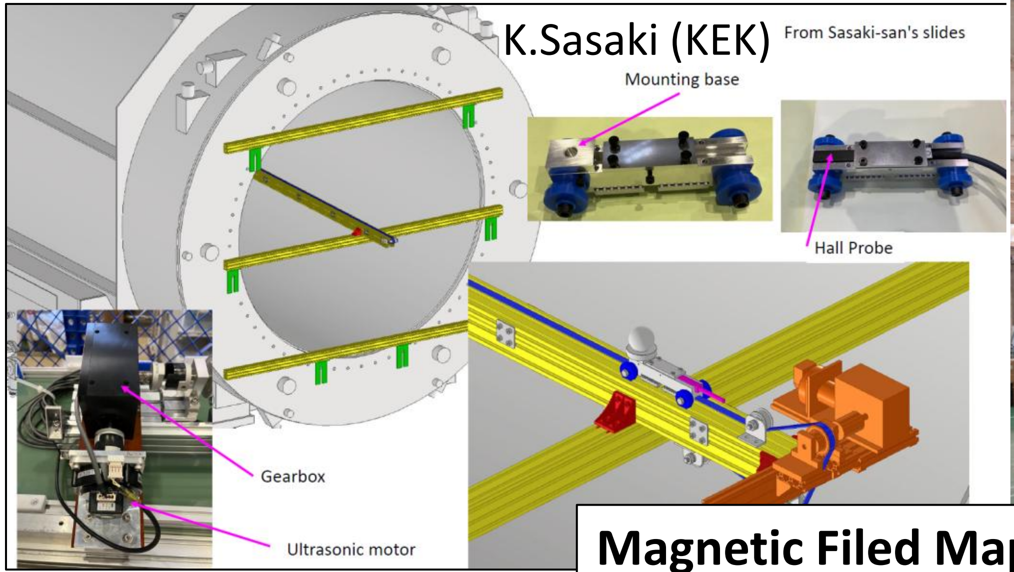
We use the field map calculated with OPERA-3D (TOSCA)

→ Magnetic field mapping is used to calibrate the calculated field map.

Partial Magnetic Field Mapping

- Following the commissioning run, magnetic field mapping will be performed in the central bore of the CDC
  - using the same method employed for the field mapping without the return yoke at Toshiba (Feb. 2025)





Magnetic Filed Mapping in Feb. 2025

The measured field will be used to validate and calibrate the OPERA-3D field map

Experiments @ K1.8BR

- **Dora CDS**
  - ✓E73 ($^{3}_{\Lambda}$H lifetime) Completed in Feb. 2025

need 9 months

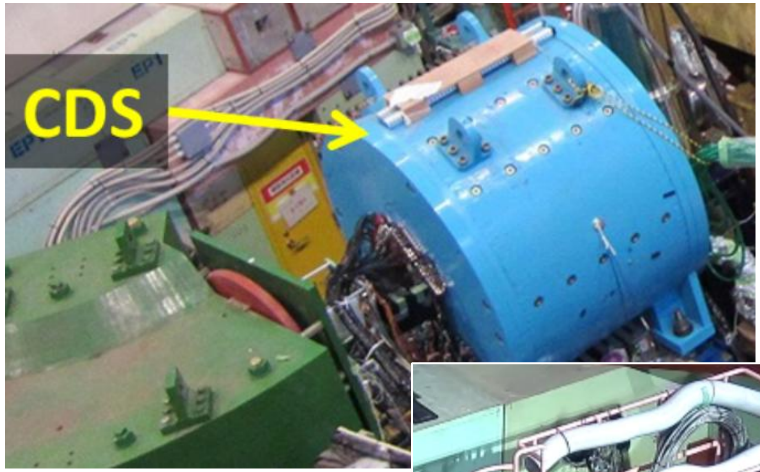
now

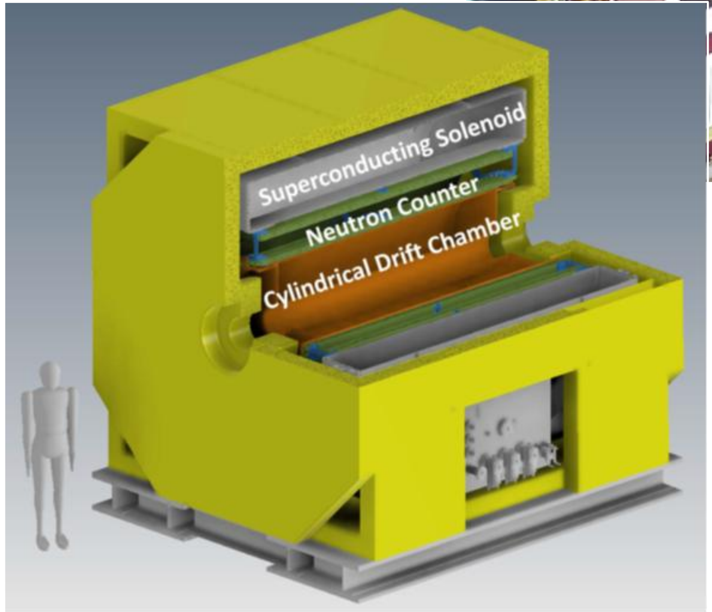
- **Hyp-TPC**
  - ✓E72 (Λ^*) 7(+6)d@90kW
  - ✓ P109 (Θ^+) 3h
  - ✓E104 ($p^{bar}p \to \phi\phi$) 10(+3)d@90W
  - ✓E45 (Baryons) 2.5+2+2.5(+4)d

K1.8BR upgrade

need ~9 months

- **Dolami CDS**
  - ✓E80 ($K^-ppn \to \Lambda d/\Lambda pn$) ~14+21d@90kW
  - ✓E89 ($J^P(K^-pp)$) 56d@90kW
  - ✓E57 (K^-d atm) 7d@80kW → ~30d@80kW





Urgency of E80

- Detectors are being completed on schedule

- New $K^{-}d$ atom results from DAFNE
  - Strong motivation to proceed with $K^{bar}N$ interaction studies at J-PARC as soon as possible

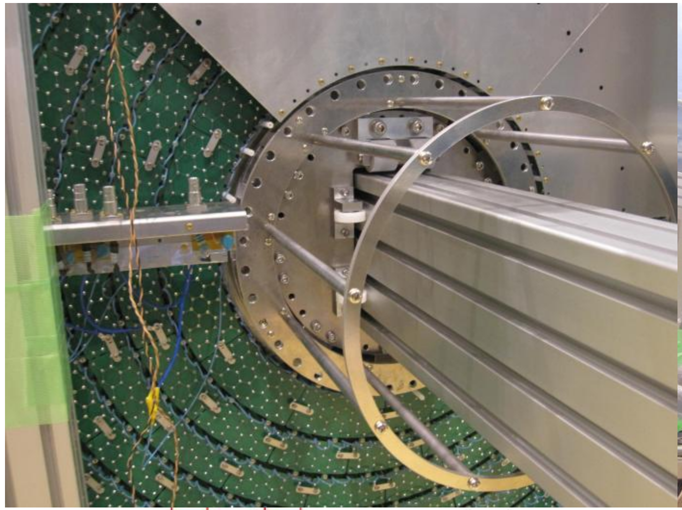
- E80 must begin within the period of the large research grant
  - Grant-In-Aid for Specially Promoted Research by JSPS (JFY2022-26)
  - Magnet assembly at K1.8BR must be completed using this grant
  - Part of the shield reconfiguration cost be covered in FY2026 using this grant

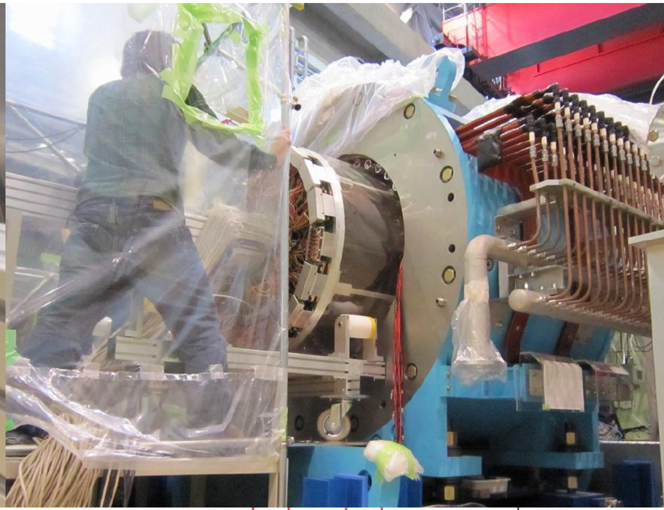
CDC Installation

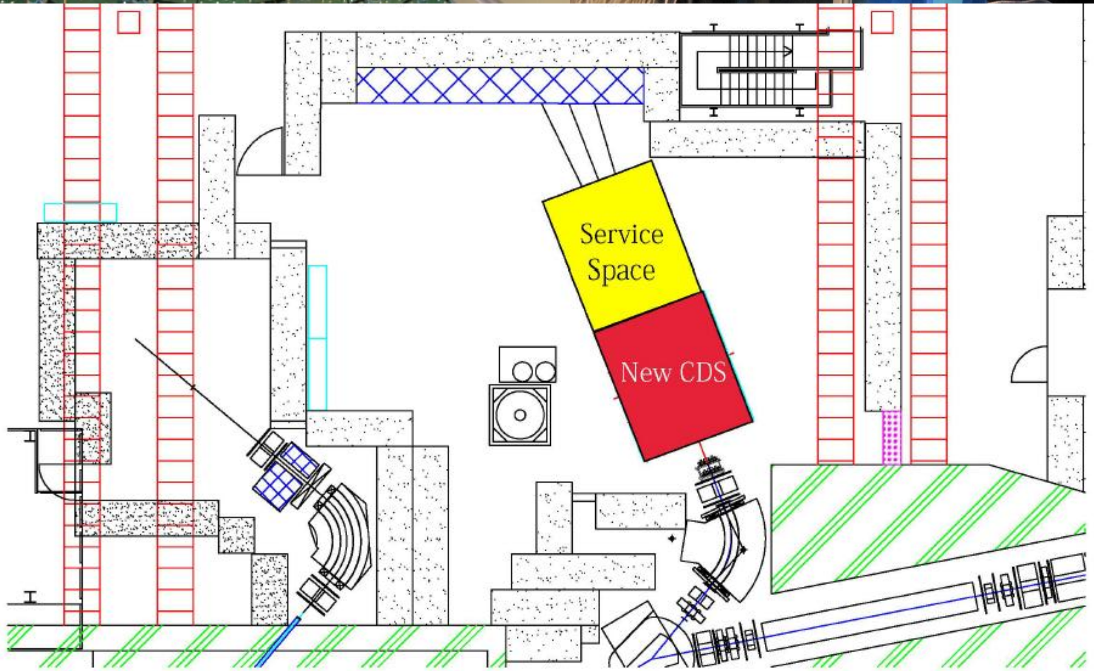
- CDC is installed by inserting a long frame bar into the center of the CDC and magnet
    - We plan to use a splittable bar twice the length of the solenoid.

Will be prepared in FY2026

- Service space equivalent to the installation area of the magnet is required downstream of the magnet
    - to prepare and install the CDC by rolling it in and out of the magnet

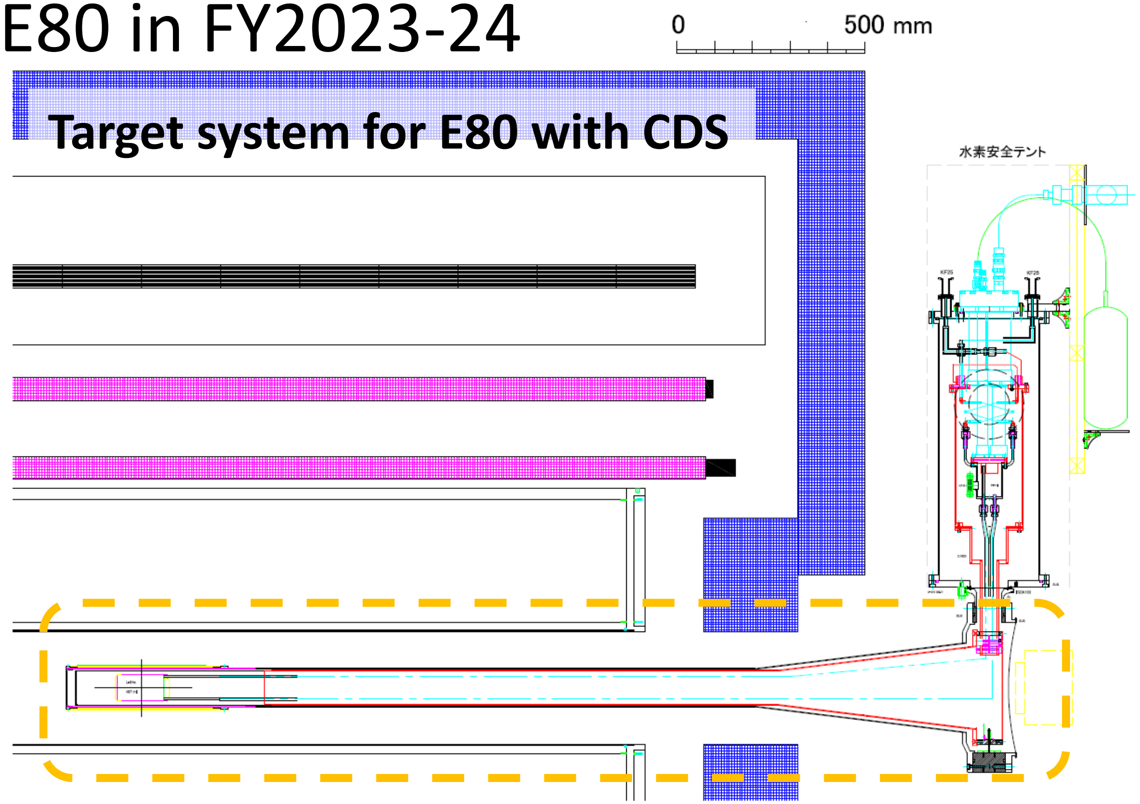






Target System

- Cool down below 3K with pulse tube (Cryomech PT410), no cryogen required
- Capable to liquefy H_2/D_2/^3He/^4He gasses [Target replacement takes a few days]
- **The system has already worked well (T77/E73)**
- The horizontal part will be extended for E80 in FY2023-24



Expected Spectrum of $K^{-}+^{4}He$

@ 3 weeks, 90kW

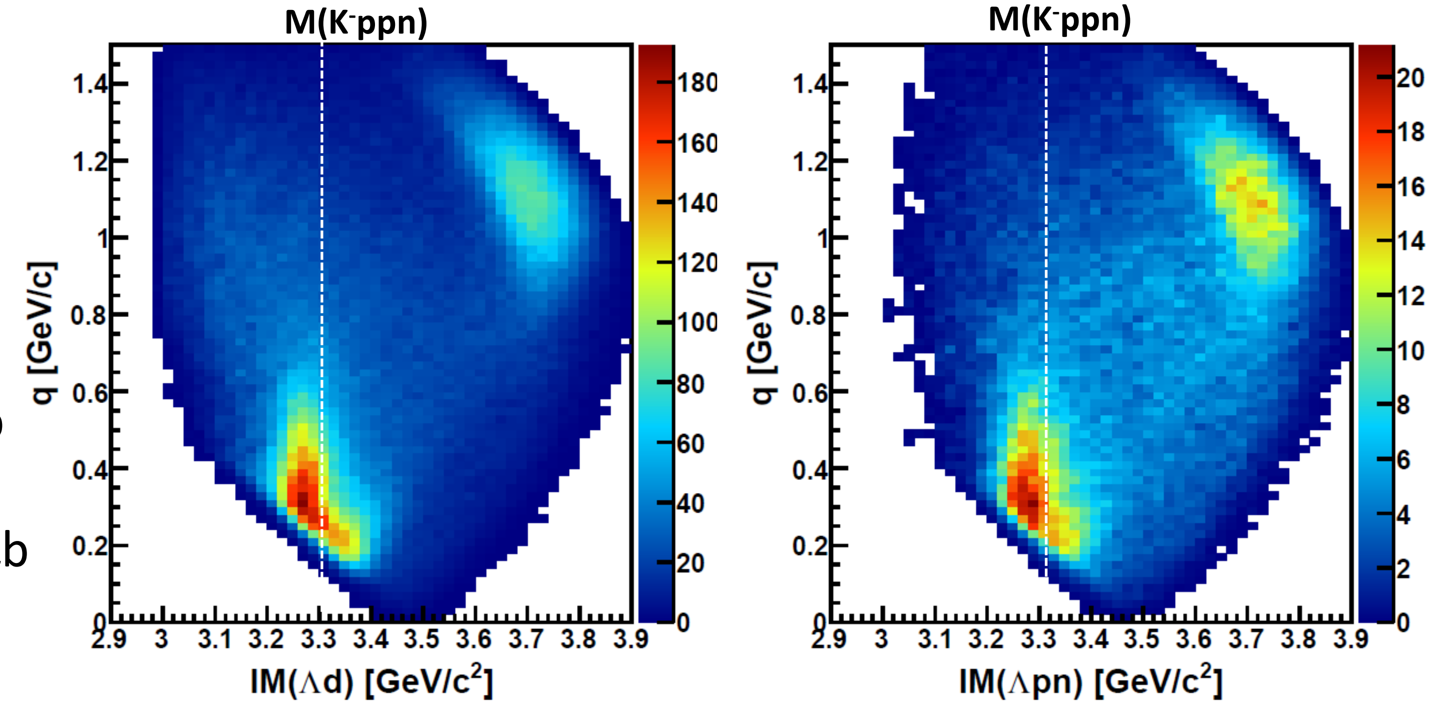
$K^{-}+^{4}He \rightarrow \Lambda d+n$ **$K^{-}+^{4}He \rightarrow \Lambda pn+n$**

B_{Kppn} ~ 40 MeV

Γ_{Kppn} ~ 100 MeV

Q_{kppn} ~ 400 MeV/c

$\sigma(K^{-}ppn)$*Br ~ 5 μb
$\sigma(QF)$ ~ 5 μb
$\sigma(BG)$ ~ 10 μb



- Similar parameters obtained with the $K^{-3}He \rightarrow \Lambda pn$ (PRC102(2020)044002.) are adopted to K-ppn/QF/BG shapes
- K-ppn signal [q-independent] can be seen clearly

Expected Spectrum of K^-+^{4}He

@ 3 weeks, 90kW

$K^- + {}^4He \rightarrow \Lambda d + n$

$K^- + {}^4He \rightarrow \Lambda pn + n$

B_{Kppn} ~ 40 MeV

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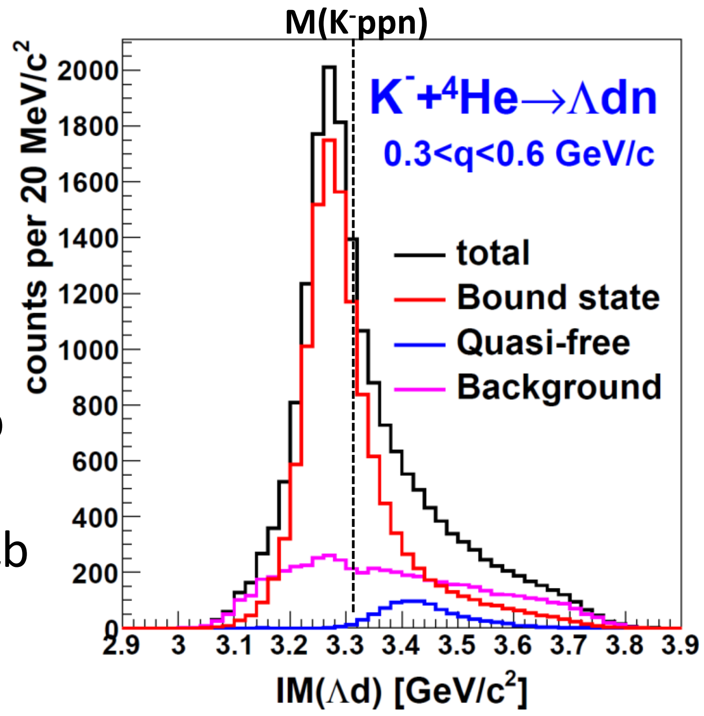
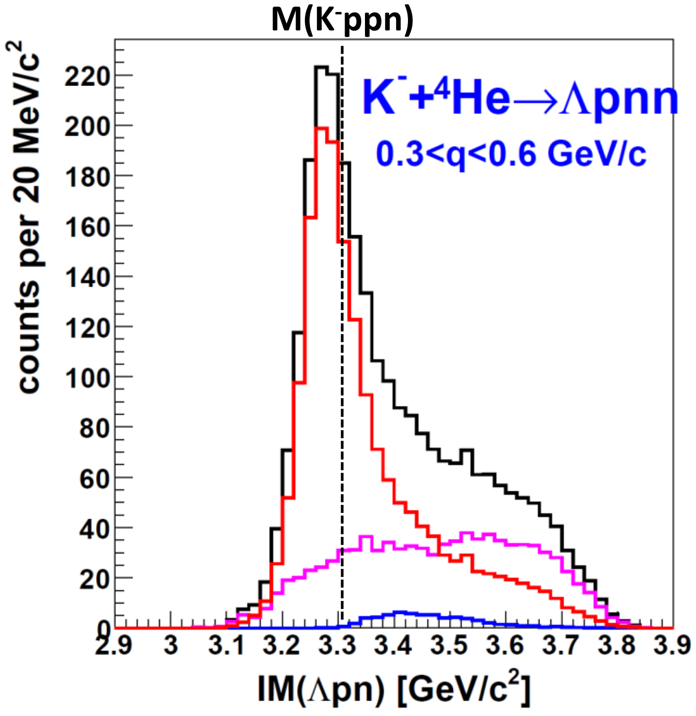




- The signals can be enhanced by selecting 0.3 < q < 0.6 GeV/c
- K-ppn signal can be seen clearly

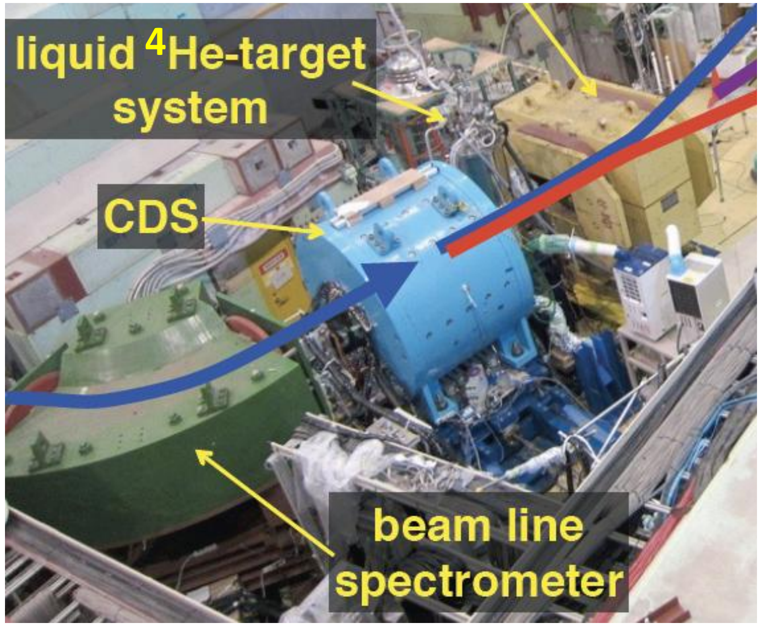
Table 2: Estimated $K^{-}ppn$ yield for a three-week data taking using the 90 kW MR beam power.

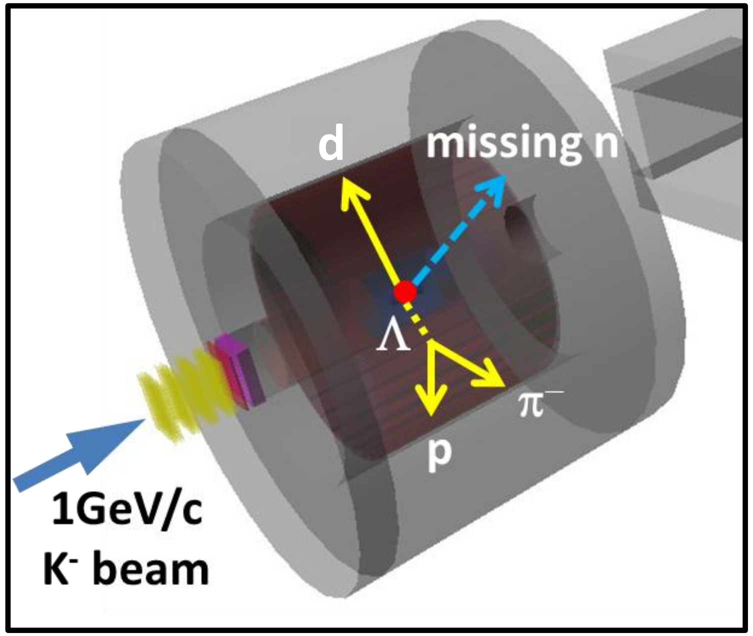
decay mode	Λd	Λpn
$\sigma^{tot} \cdot BR$	assumed to be 5 μb	
accelerator up-time	0.9	
# of K^{-} beam	155×10^{9}	
# of K^{-} on target	100×10^{9}	
# of expected yield	1.2×10^{4}	1.2×10^{3}

From TDR 2024

$K^{-4}He \rightarrow \Lambda dn$ Analysis with the T77 Data

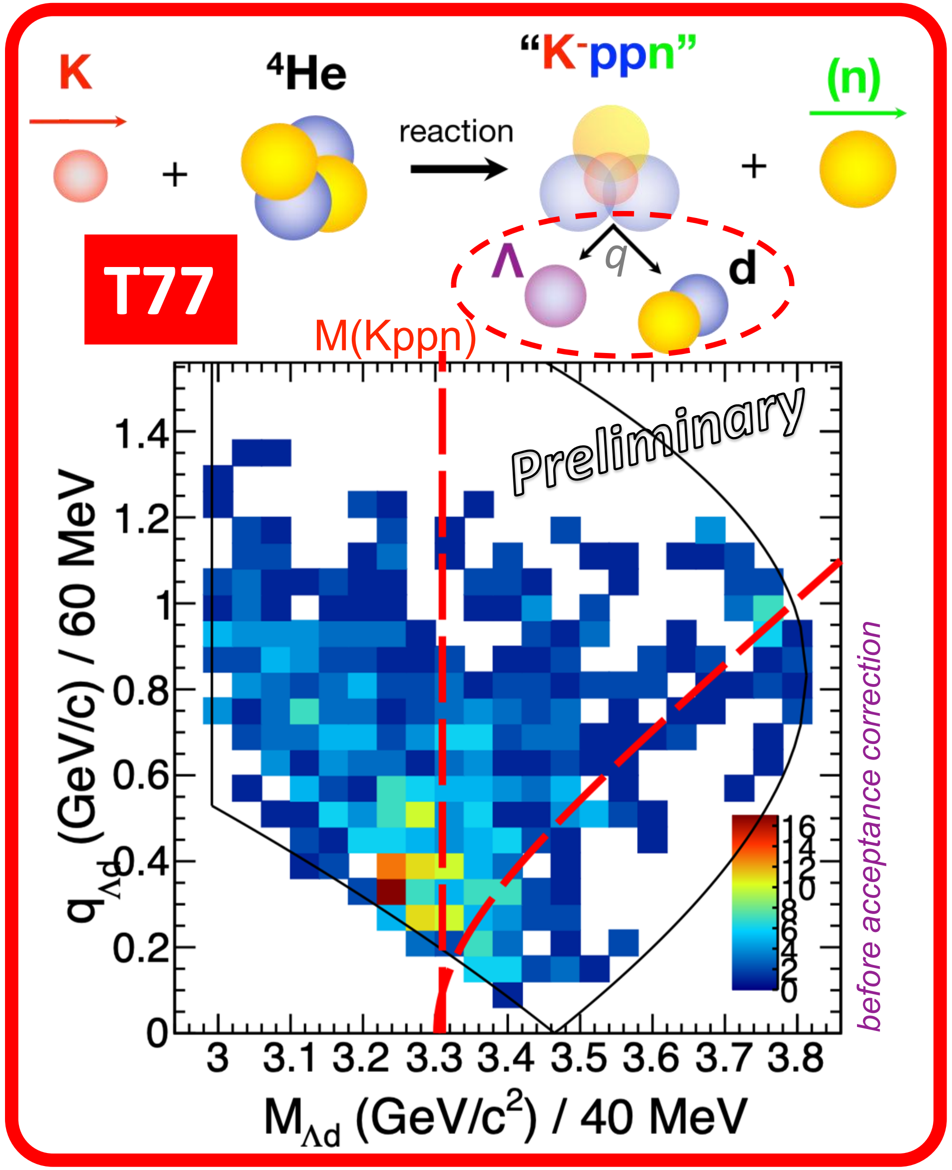
- An analysis of the **Λdn** final state with **$K^{-4}He$** reaction at **1 GeV/c** has been conducted
  - T77: lifetime measurement of $^{4}_{\Lambda}H$ in 2020
- The results will be updated with a part of the E73 controlled data
  - E73: lifetime measurement of $^{3}_{\Lambda}H$ in 2024

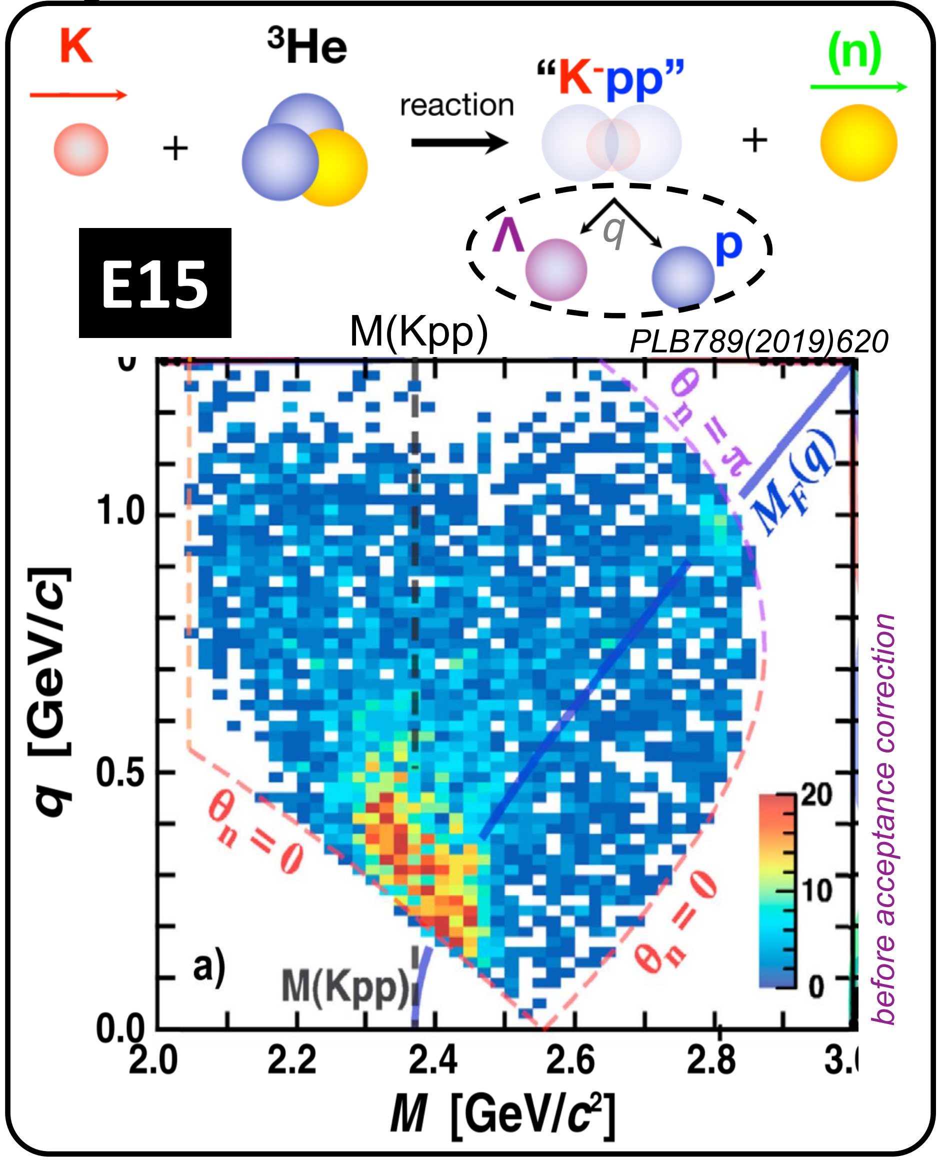




Experiment	K^- on target
E15 (^{3}He)	~42 x 10^9
T77 (^{4}He)	~6 x 10^9
E73 (^{4}He)	~6 x 10^9

Preliminary result





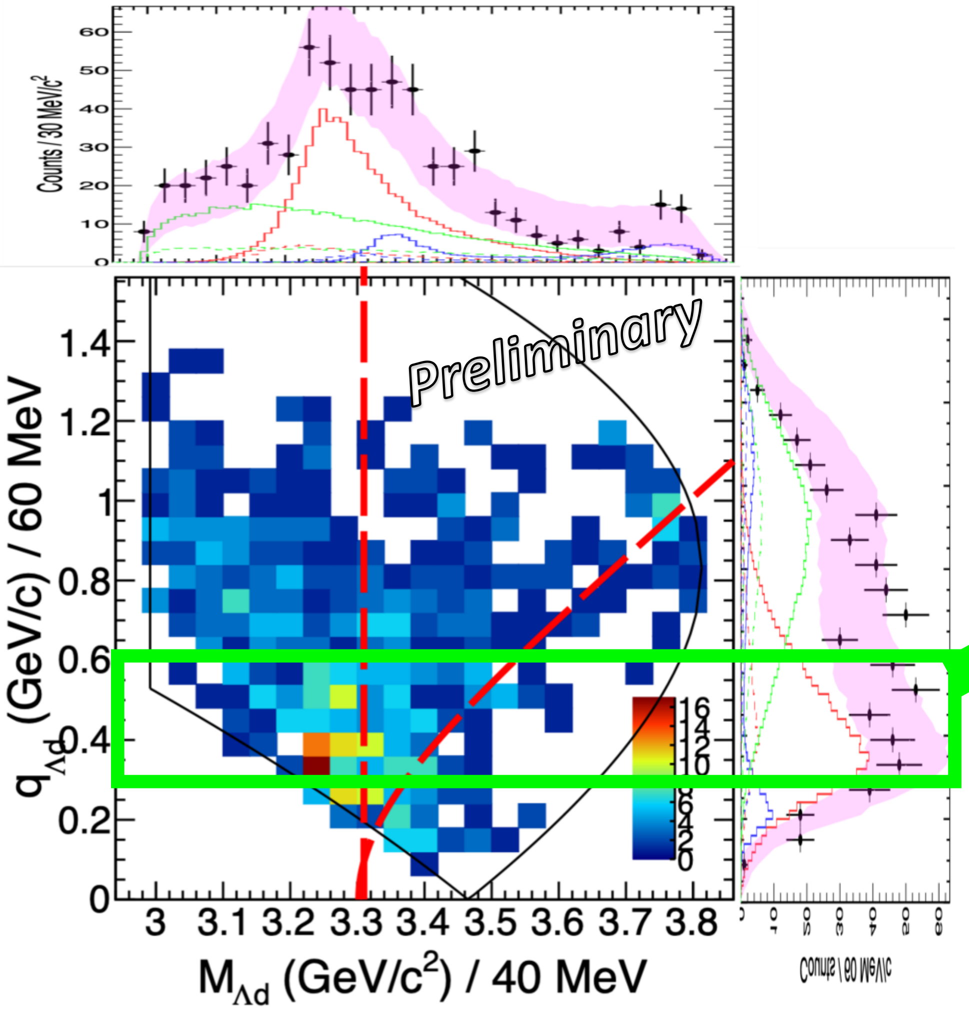
- **Two distributions are quite similar**
- structure below the threshold (**seems *q*-independent**), QF-K, BG

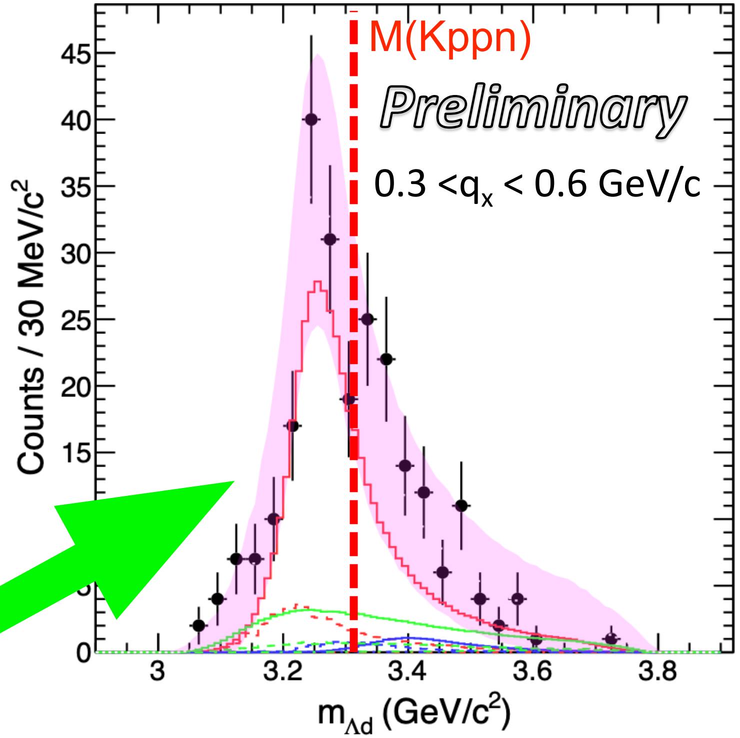
$K^{-4}He \rightarrow \Lambda dn$ Analysis with the T77 Data

2D fit on the (M,q) space with similar shapes to E15:

Breit-Wigner wtih Gaus. form factor (PWIA), QF-K^-, and Broad BG

$$\sigma(M,q) \propto \rho(M,q) \times \frac{(\Gamma_X/2)^2}{(M-M_X)^2+(\Gamma_X/2)^2} \times exp\left(-\frac{q^2}{{Q_X}^2}\right)$$





$B_X \;=\; 64 \pm 11(stat)\; MeV$

$\Gamma_X \;= \sim 100\; MeV$

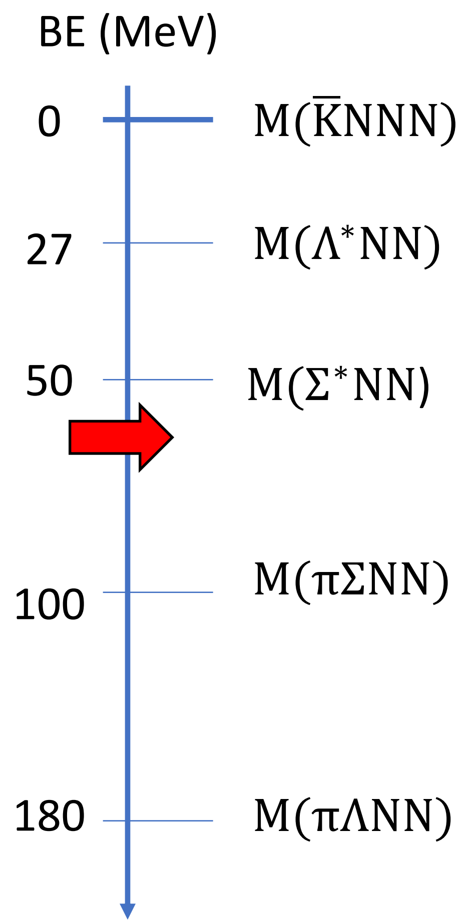
$\sigma_{X\rightarrow\Lambda d} \;\sim\; 4\;\mu b$

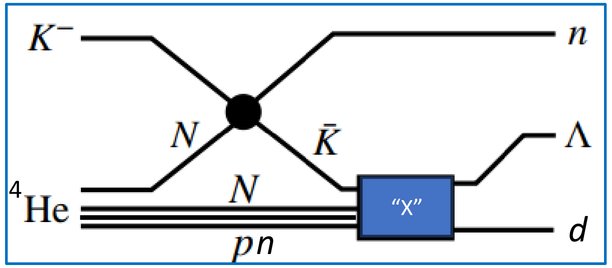
$K^{-4}He \rightarrow \Lambda dn$ Analysis with the T77 Data

What is the observed structure? [Discussion]

1. <u>"X"→Λd decay mode is unique evidence of **$I_{"X"}$ = 0**</u>
   - I(J^P) : Λ = 0(1/2+), d = 0(1+), K^- = 1/2(0-), ^3He = 1/2(1/2+) , ^4He = 0(0+)

2. <u>**"X"="K^-ppn" with $J_{"X"}$ = 1/2** would be likely, considering the isospin and spin combination in S-wave interaction</u>
   - **$J_{"X"}$ = 1/2:** ^4He initial state is I(J) = 0(0) and low-momentum intermediate $\bar{K}$ would react with remaining NNN [I(J) = 1/2(1/2)] in S-wave
   - **Exclusion of Y*(I=1)NN**: probability of "X"→Λd decay would be suppressed because spin/isospin flip is needed to reconfigure NN [I(J) = 1(0)] into deuteron [I(J) = 0(1)]
     - ➢ Λpn decay would be dominant





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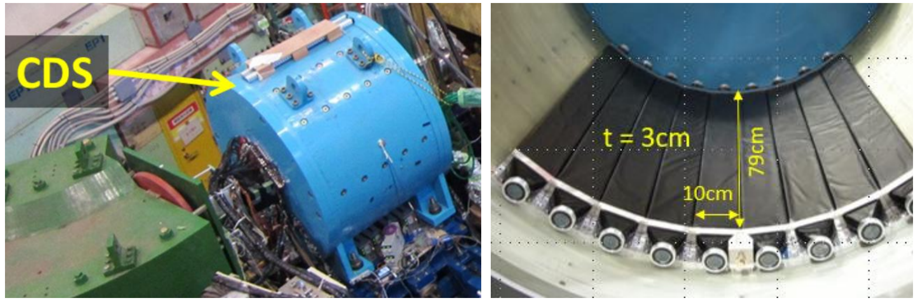
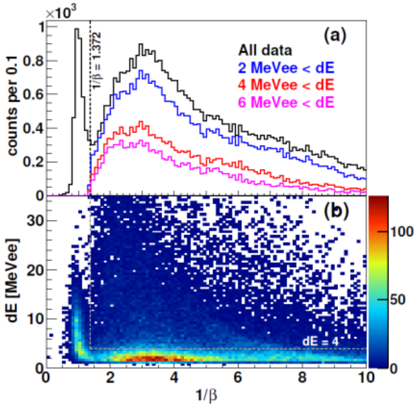
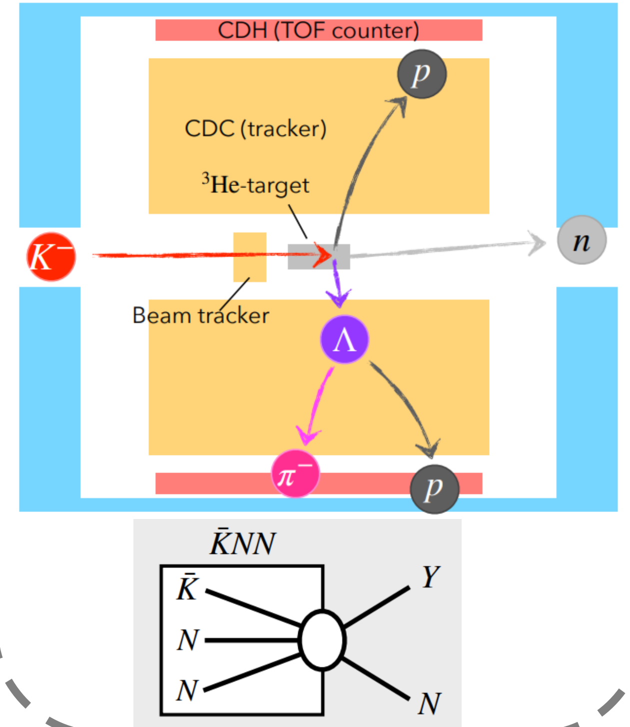
Mesonic Decay Analysis with the E15 Data

- with neutron detection using a thin scintillation counter array (CDH)
  - ☹ small efficiency (3~9%)
  - ☹ BG from the inner wall of the magnet

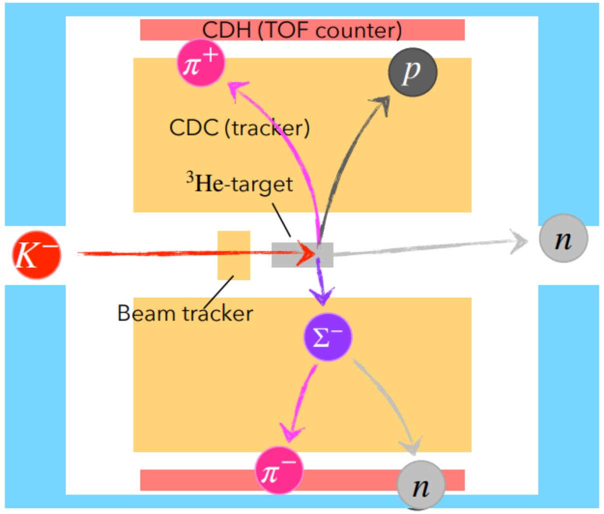




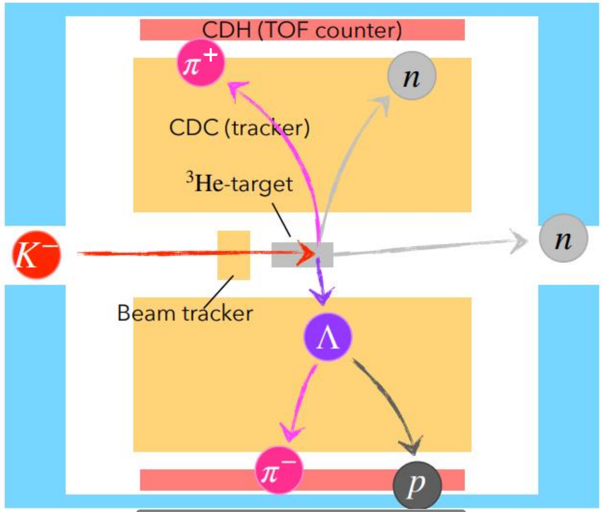
$"K^-pp" \to \Lambda p$



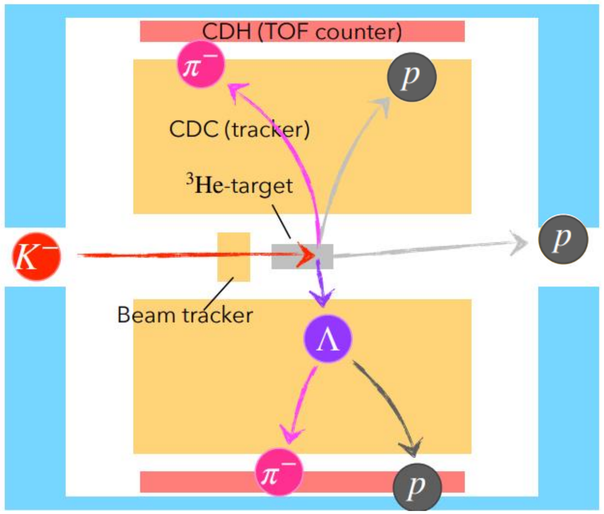
$"K^-pp" \to \pi^\pm\Sigma^\mp p$

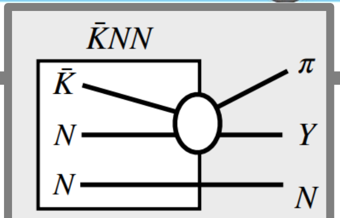


$"K^-pp" \to \pi^+\Lambda n$



$"\bar{K}^0nn" \to \pi^-\Lambda p$





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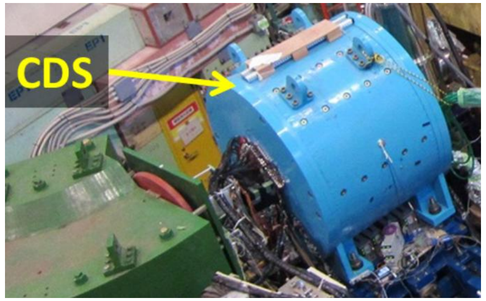

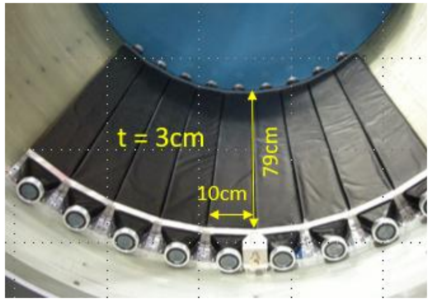

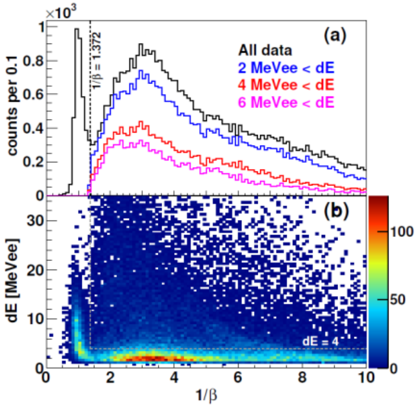

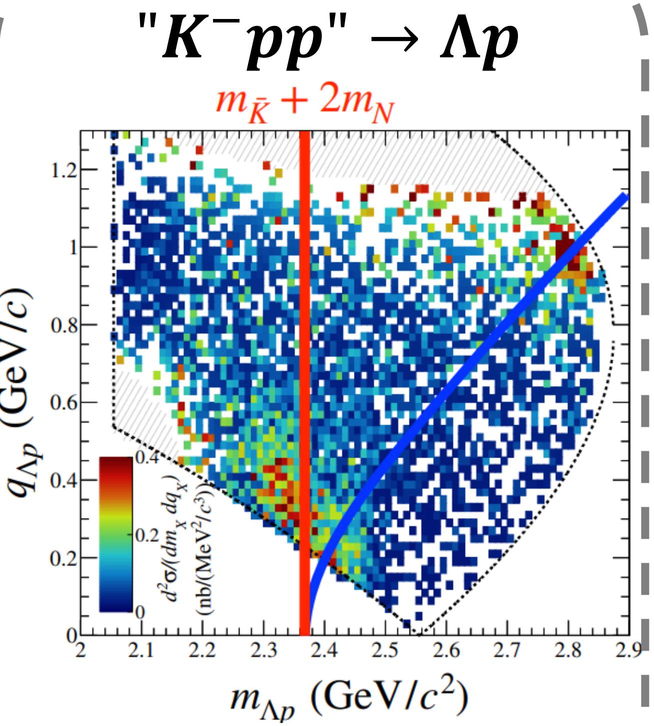

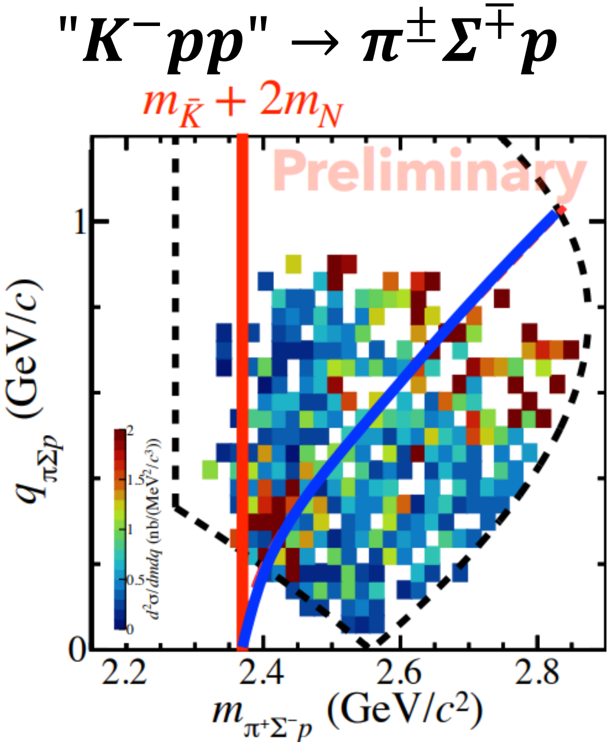

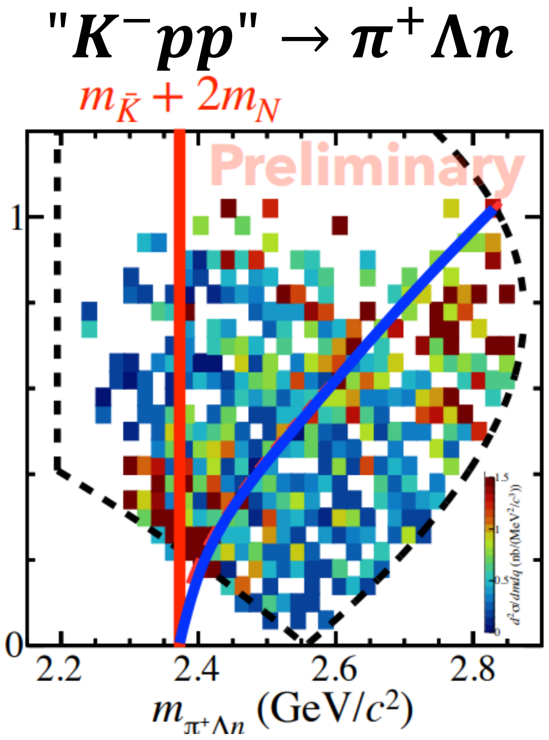

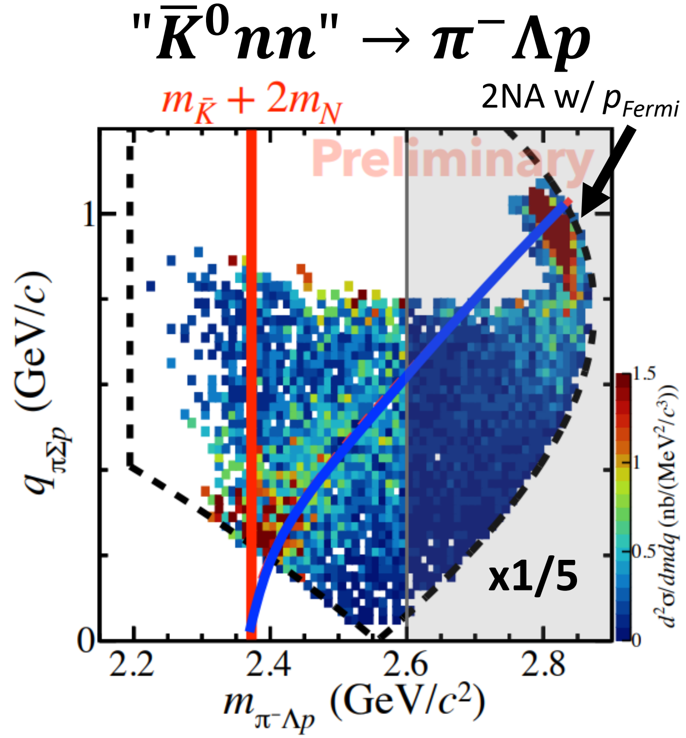

Similar but not clear peak below M(KNN) due to the phase space

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Mesonic Decay Analysis with the E15 Data

Phase space

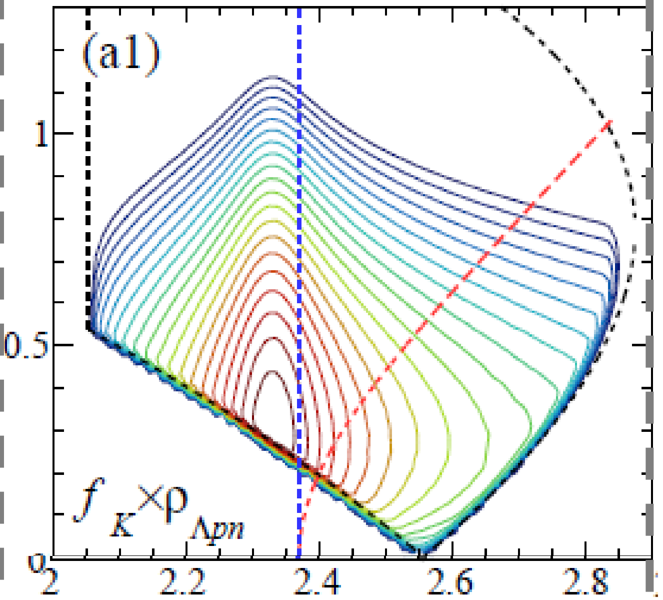
Momentum term from spatial integral

Plane Wave Impulse Approximation

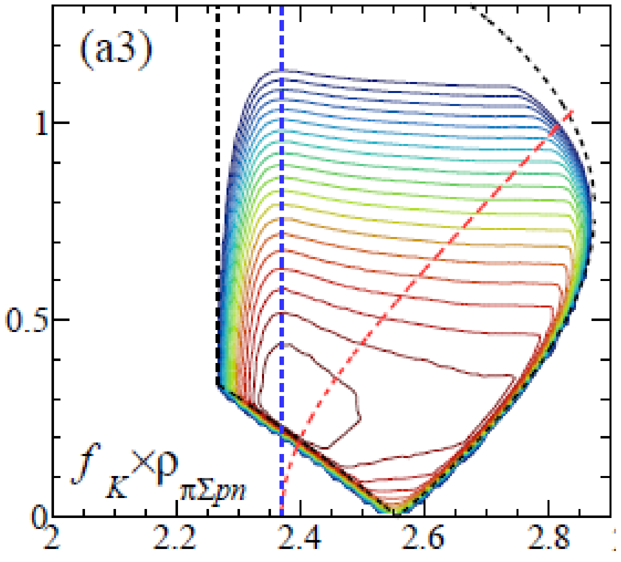
Fit with PWIA $\sigma(M,q) \propto \boxed{\rho(M,q)} \times \boxed{\frac{(\Gamma_{Kpp}/2)^2}{(M-M_{Kpp})^2+(\Gamma_{Kpp}/2)^2}} \times \boxed{exp\left(-\frac{q^2}{{Q_{Kpp}}^2}\right)}$

Energy term (BW type) from time integral

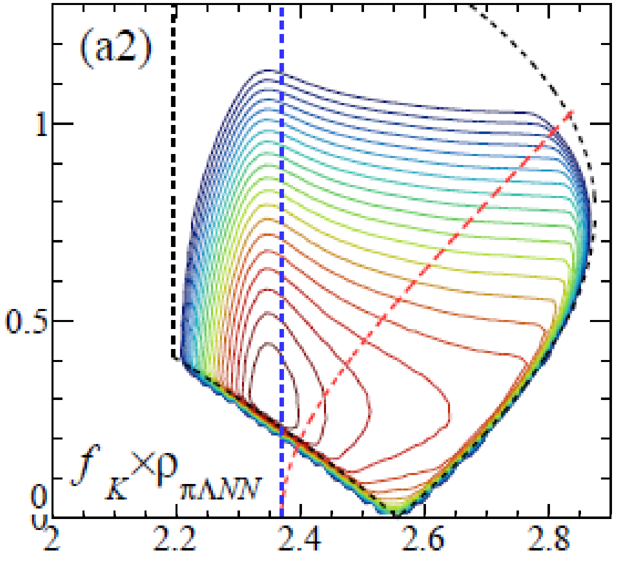
$"K^-pp" \rightarrow \Lambda p$



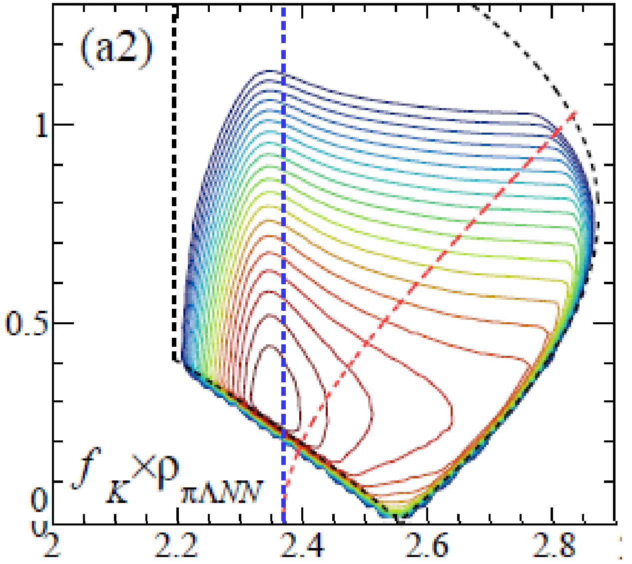
$"K^-pp" \rightarrow \pi^{\pm}\Sigma^{\mp}p$



$"K^-pp" \rightarrow \pi^+\Lambda n$



$"\bar{K}^0nn" \rightarrow \pi^-\Lambda p$



Employ the same model func. for KNN & QF, with each phase space

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Mesonic Decay Analysis with the E15 Data

Plane Wave Impulse Approximation

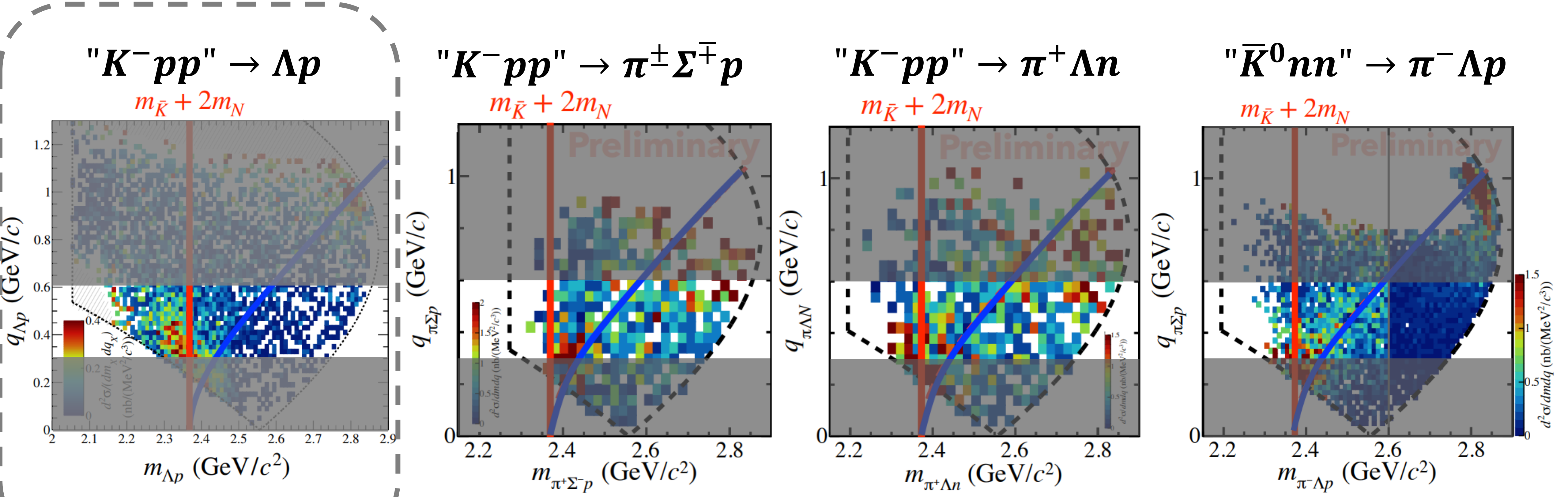
Fit with PWIA

Phase space

Momentum term from spatial integral

$$\sigma(M,q) \propto \boxed{\rho(M,q)} \times \boxed{\frac{(\Gamma_{Kpp}/2)^2}{(M-M_{Kpp})^2+(\Gamma_{Kpp}/2)^2}} \times \boxed{exp\left(-\frac{q^2}{{Q_{Kpp}}^2}\right)}$$

Energy term (BW type) from time integral



Fit the 1D spectra in 0.3<q<0.6 with the same model func.

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Mesonic Decay Analysis with the E15 Data

Plane Wave Impulse Approximation

Fit with PWIA

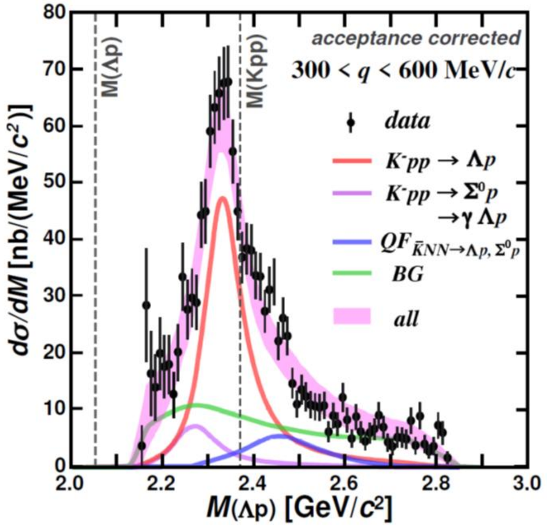
Phase space

Momentum term from spatial integral

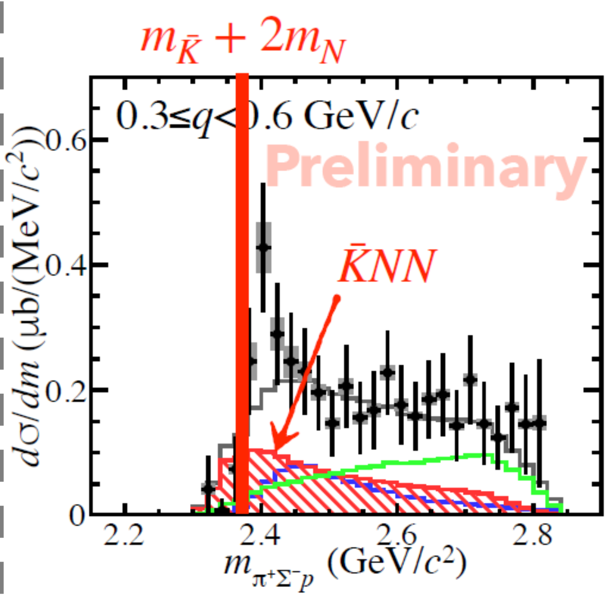
$$\sigma(M,q) \propto \boxed{\rho(M,q)} \times \boxed{\frac{(\Gamma_{Kpp}/2)^2}{(M-M_{Kpp})^2+(\Gamma_{Kpp}/2)^2}} \times \boxed{exp\left(-\frac{q^2}{{Q_{Kpp}}^2}\right)}$$

Energy term (BW type) from time integral

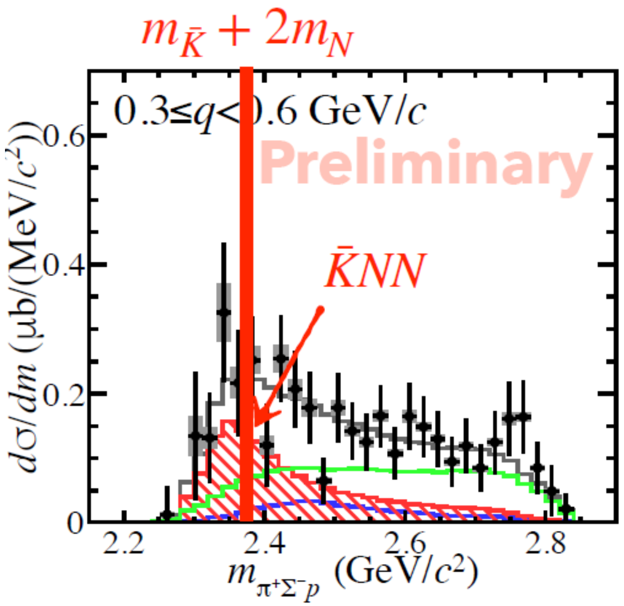
$"K^-pp" \rightarrow \Lambda p$



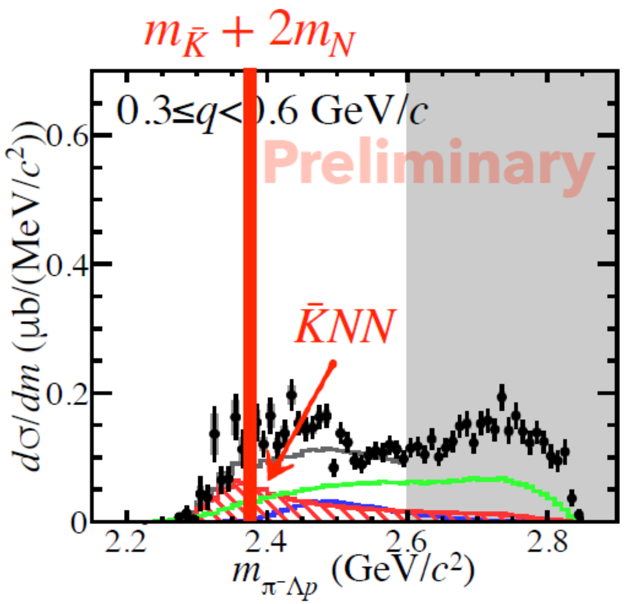
$"K^-pp" \rightarrow \pi^\pm\Sigma^\mp p$



$"K^-pp" \rightarrow \pi^+\Lambda n$



$"\bar{K}^0nn" \rightarrow \pi^-\Lambda p$



With the model func., the spectra are consistently explained.

T.Yamaga et.al., PRC110(2024)014002

Mesonic Decay Analysis with the E15 Data

- $\Gamma_{YN} << \Gamma_{\pi YN}$: mesonic decay is dominant
- $\Gamma_{\pi\Sigma N} \sim \Gamma_{\pi\Lambda N}$: significant contribution of the $I_{KN} = 1$ as well as $I_{KN} = 0$
- $\Gamma_{\pi+\Lambda n} / \Gamma_{\pi-\Lambda p} \sim 2$: if we assume $Br_{K\text{-}pp \to \pi+\Lambda n} = Br_{K0nn \to \pi-\Lambda p} \to \sigma_{K\text{-}pp} / \sigma_{K0nn} \sim 2$

$$\text{"}K^-pp\text{"} \rightarrow \Lambda p$$

$\sigma_{\bar{K}NN}^{tot} \times Br\ (\mu b) =$
$9.3 \pm 0.8^{+1.4}_{-1.0}$ [all]
$5.5 \pm 0.5^{+0.8}_{-0.6}$ [<M(KNN)]

$$\text{"}K^-pp\text{"} \rightarrow \Sigma^0 p$$

$\sigma_{\bar{K}NN}^{tot} \times Br\ (\mu b) =$
$5.3 \pm 0.4^{+0.8}_{-0.6}$ [all]
$3.1 \pm 0.2^{+0.5}_{-0.4}$ [<M(KNN)]

$$\text{"}K^-pp\text{"} \rightarrow \pi^+\Sigma^- p$$

$\sigma_{\bar{K}NN}^{tot} \times Br\ (\mu b) =$
$38 \pm 3 \pm 3$ [all]
$3.2 \pm 0.2 \pm 0.2$ [<M(KNN)]

$$\text{"}K^-pp\text{"} \rightarrow \pi^-\Sigma^+ p$$

$\sigma_{\bar{K}NN}^{tot} \times Br\ (\mu b) =$
$110 \pm 8 \pm 8$ [all]
$9.4 \pm 0.4 \pm 0.7$ [<M(KNN)]

$$\text{"}K^-pp\text{"} \rightarrow \pi^+\Lambda n$$

$\sigma_{\bar{K}NN}^{tot} \times Br\ (\mu b) =$
$62 \pm 11 \pm 9$ [all]
$15.5 \pm 2.7 \pm 2.1$ [<M(KNN)]

$$\text{"}\bar{K}^0 nn\text{"} \rightarrow \pi^-\Lambda p$$

$\sigma_{\bar{K}NN}^{tot} \times Br\ (\mu b) =$
$29 \pm 3 \pm 3$ [all]
$7.2 \pm 0.6 \pm 0.7$ [<M(KNN)]

More precise measurements and theoretical investigations are needed