Hypernuclear Physics at J-PARC

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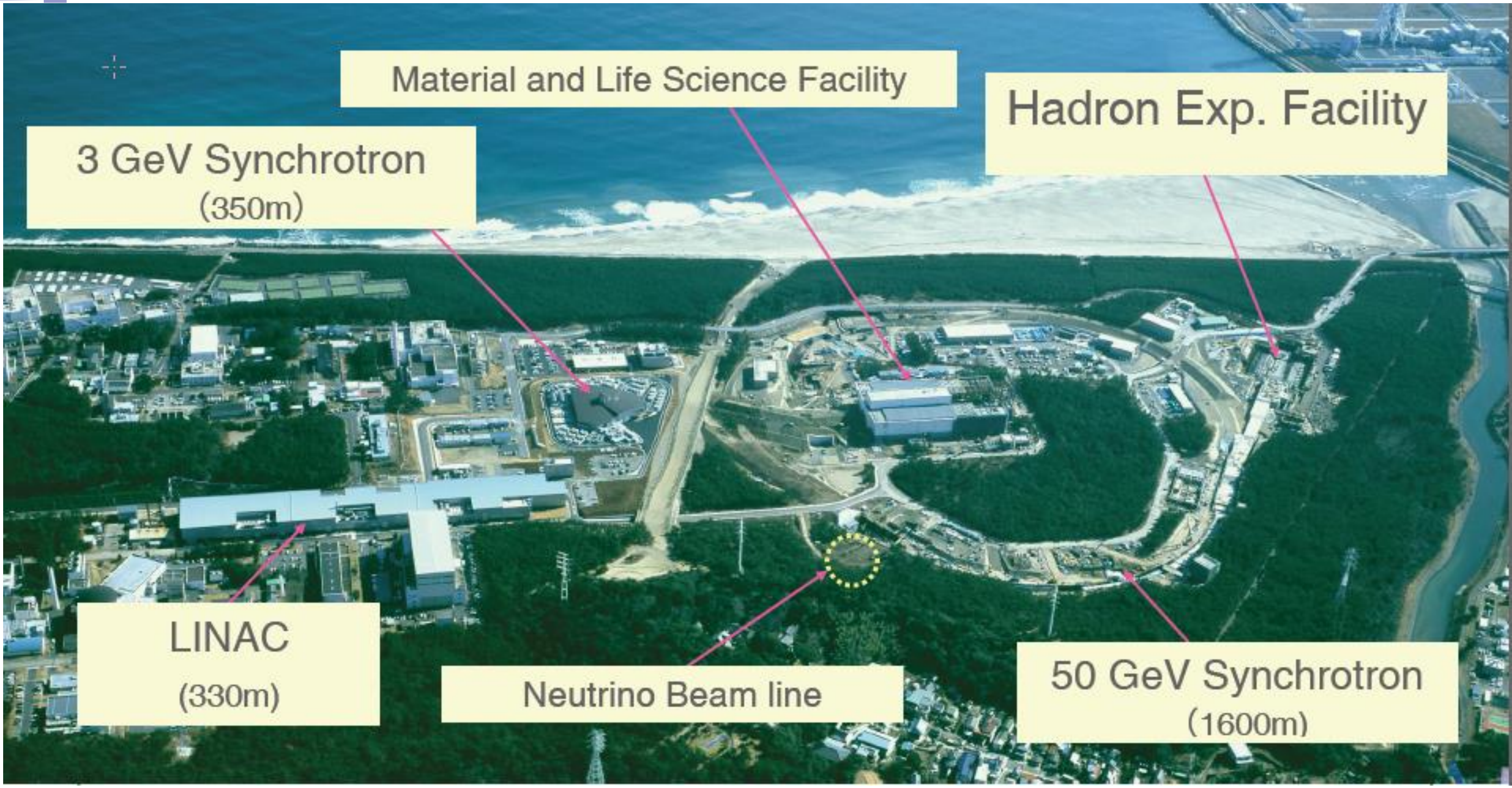
(Seoul National University)
APCTP ISBB workshop
APCTP, Nov. 14-16, 2008

I. J-PARC

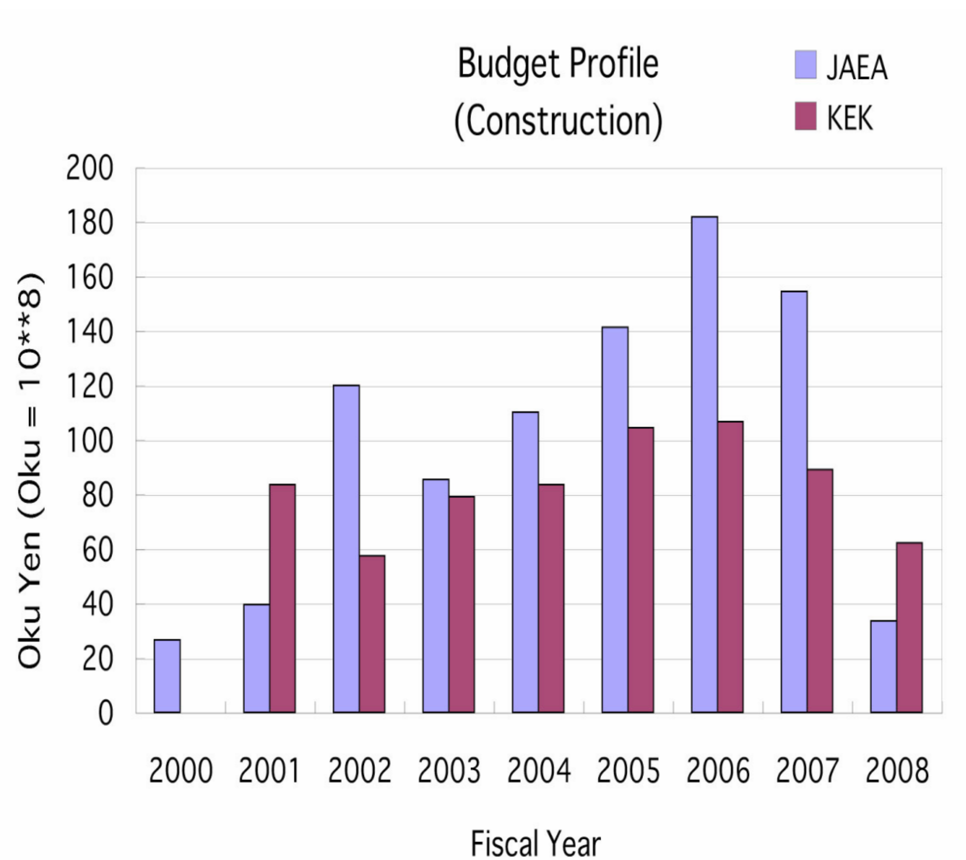
II. Hypernuclear Experiments Scheduled at J-PARC.

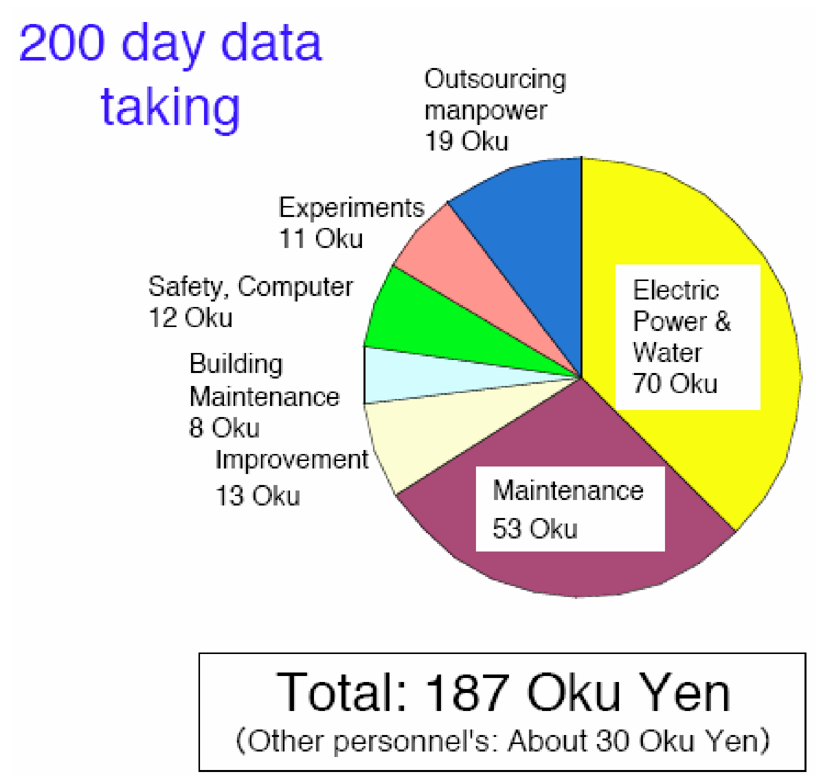
III. E18 experiment

V. Summary



- First beam at Main Ring; Dec. 13, 2008.
- Np >- 100 times that of KEK-PS
- NK at K1.8 ; 10^7 /spill(3-4sec)

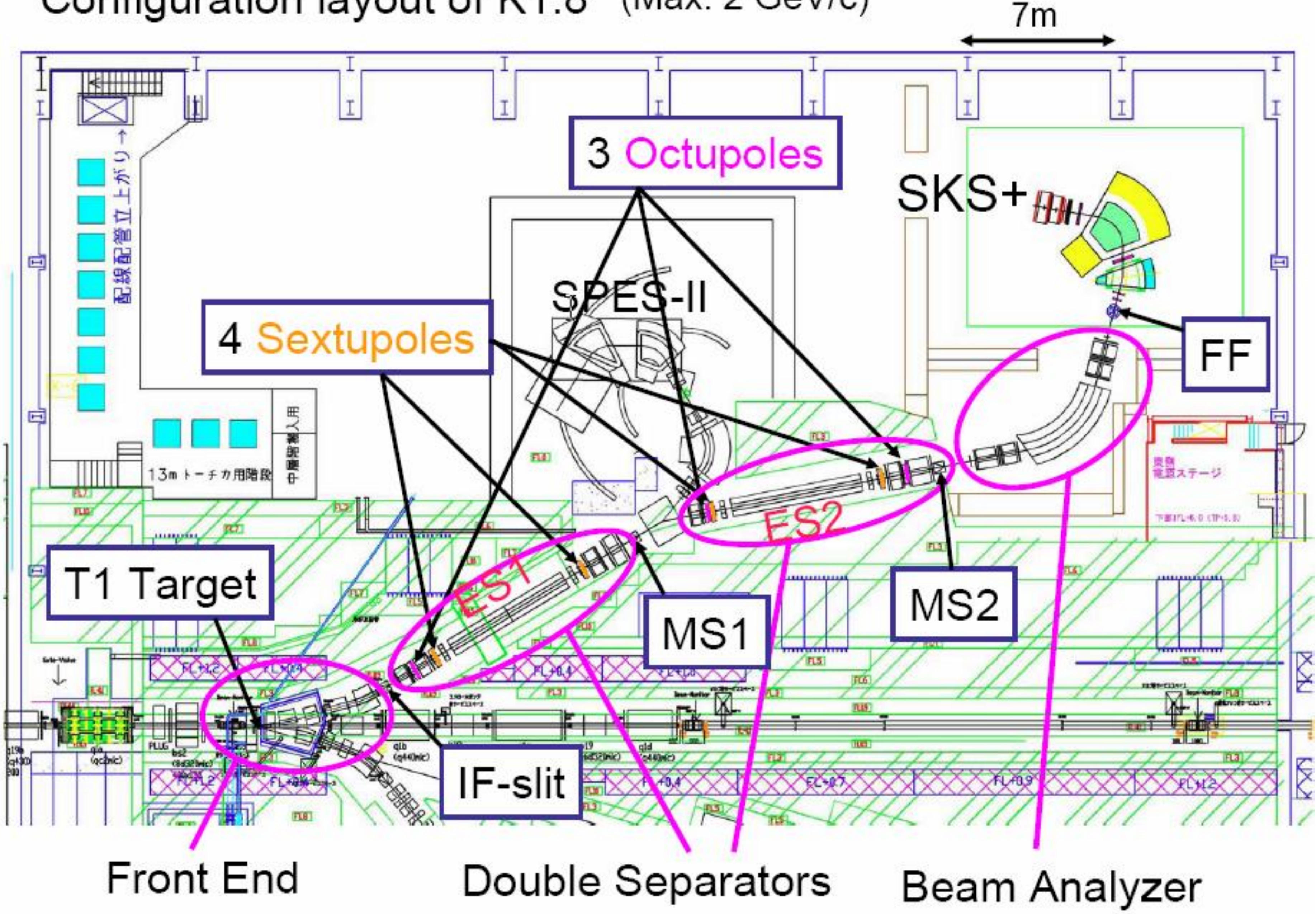




- Total budget
- 8 years construction from 2001.

- Op. fund ; 2000억/년
- Composition;

Configuration layout of K1.8 (Max. 2 GeV/c)

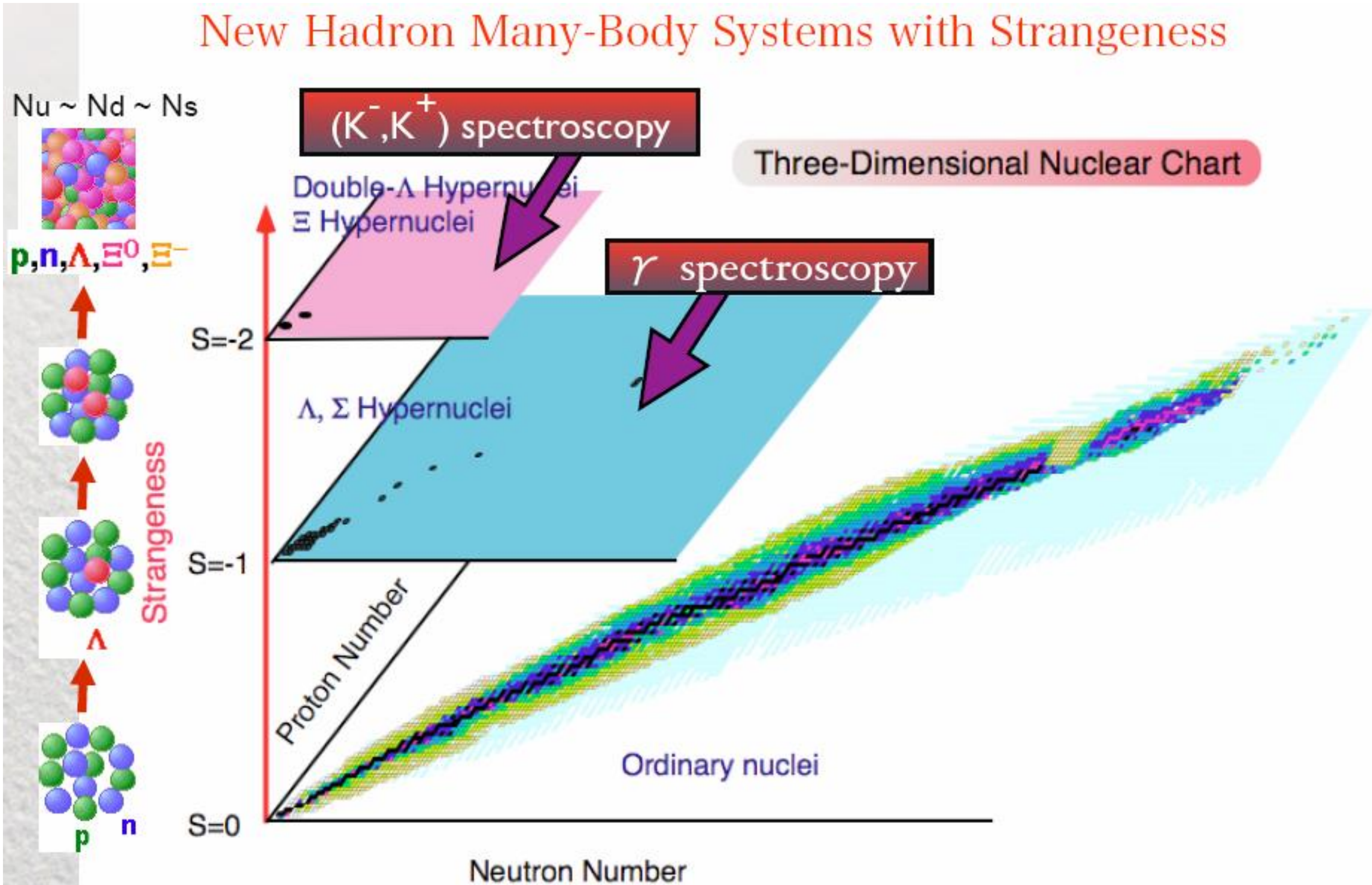


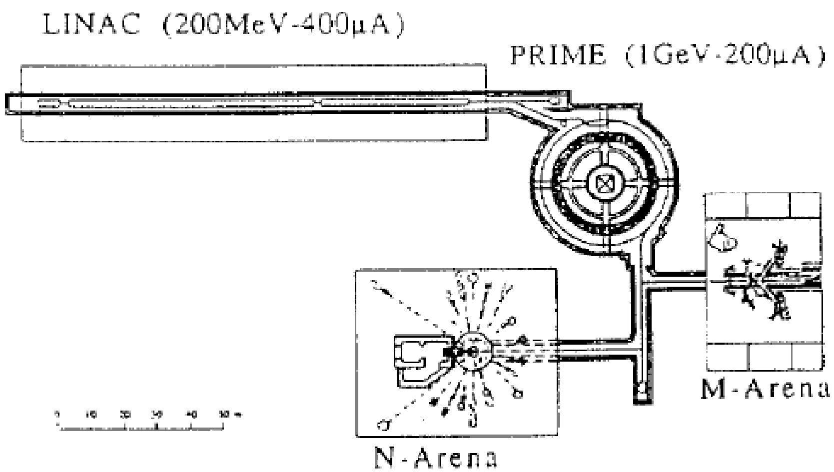
---- J-PARC PAC Approval summary after the 3rd meeting ----

		(Co-)Spokespersons	Affiliation(*)	Title of the experiment	Approval status	Slow line priority		3rd PAC Recommendation
						Day1?	Day1 Priority	
P01		V. Sumachev	Petersburg Nulear Physics Institute	Proposal on measurements of the spin rotation parameters A and R at the J-PARC in the resonance region of π-N elastic scattering	Rejected			
P02	LoI	P. Aslanyan	Laboratory for High Energy, JINR	Study of Exotic Multiquark States with Λ-Hyperons and K^0_S Meson Systems at JPARC	–			–
P03		K. Tanida	Kyoto U	Measurement of X rays from Ξ^- Atom	Stage 1			–
P04		J. C. Peng; S. Sawada	U. of Illinois at Urbana-Champaign; KEK	Measurement of High-Mass Dimuon Production at the 50-GeV Proton Synchrotron	Deferred			–
P05		T. Nagae	KEK	Spectroscopic Study of Ξ-Hypernucleus, $^{12}_{\Xi}$Be, via the ^{12}C(K$^-$, K$^+$) Reaction	Stage 2	Day1	1	–
P06		J. Imazato	KEK	Measurement of T-violating Transverse Muon Polarization in $K^+ \to \pi^0 \mu^+ \nu$ Decays	Stage 1			–
P07		K. Imai, K. Nakazawa, H. Tamura	Kyoto U., Gifu U., Tohoku U.	Systematic Study of Double Strangeness System with an Emulsion-counter Hybrid Method	Stage 2			–
P08		A. Krutenkova	ITEP	Pion double charge exchange on oxygen at J-PARC	Stage 1			–
P09	LoI	T. Nakano	RCNP, Osaka U	Study of Exotic Hadrons with S=+1 and Rare Decay $K^+ \to \pi^+ \nu$ ν-bar with Low-momentum Kaon Beam at J-PARC	–			–
P10		A. Sakaguchi, T. Fukuda	Osaka U	Production of Neutron-Rich Lambda-Hypernuclei with the Double Charge-Exchange Reaction (Revised from Initial P10)	Stage 1			Stage 2
P11		K. Nishikawa	KEK	Tokai-to-Kamioka (T2K) Long Baseline Neutrino Oscillation Experimental Proposal	Stage 2			–
P12	LoI	S. Choi	Seoul National University	Study of Parton Distribution Function of Mesons via Drell-Yan Process at J-PARC at High-p beamline	–			–
P13		T. Tamura	Tohoku U.	Gamma-ray spectroscopy of light hypernuclei	Stage 2	Day1	2	–
P14		T. Yamanaka	Osaka University	Proposal for $K_L \to \pi^0 \nu$ ν-bar Experiment at J-PARC	Stage 1			Stage 2
P15		M. Iwasaki, T. Nagae	RIKEN, KEK	A Search for deeply-bound kaonic nuclear states by in-flight 3He(K-, n) reaction	Stage 2	Day1		–
P16		S. Yokkaichi	RIKEN	Electron pair spectrometer at the J-PARC 50-GeV PS to explore the chiral symmetry in QCD	Stage 1			–
P17		R. Hayano, H. Outa	U. Tokyo, RIKEN	Precision spectroscopy of Kaonic ^{3}He 3d->2p X-rays	Stage 2	Day1		–
P18		H. Bhang, H. Outa, H. Park	SNU, RIKEN, KRISS	Coincidence Measurement of the Weak Decay of $^{12}_{\Lambda}$C and the three-body weak interaction process	Stage 1			–
P19		M. Naruki	RIKEN	High-resolution Search for Θ^+ Pentaquark in $\pi^- p \to K^- X$ Reactions	Stage 2	Day1		–
P20	LoI	Y. Kuno	Osaka U	An Experimental Search for μ^--e^- Conversion at Sensitivity of 10^{-18} with a High Intense Muon Source, PRISM	–			–
P21	LoI	Y. Kuno	Osaka U	An Experimental Search for μ - e Conversion at a Sensitivity of 10^{-16} with a Slow-Extracted Bunched Beam	–			–
P22		S. Ajimura, A. Sakaguchi	Osaka U	Exclusive Study on the Lambda-N Weak Interaction in A=4 Lambda-Hypernuclei (Revised from Initial P10)	Stage 1			–
–	LoI	T. Kajita	ICRR, Tokyo	A letter of Intent to extend T2K with a detector 2 km away from the JPARC neutrino source	–			–
–	LoI	K. Itabashi	RIKEN	Spectroscopy of eta mesic nuclei by (pi-,n) reaction at recoilless kinematics	–			–

More than half of the proposals are on Strangeness Nuclear Physics!!.

New Hadron Many-Body Systems with Strangeness





- 1987; INS first proposal

. . . 10 years development.

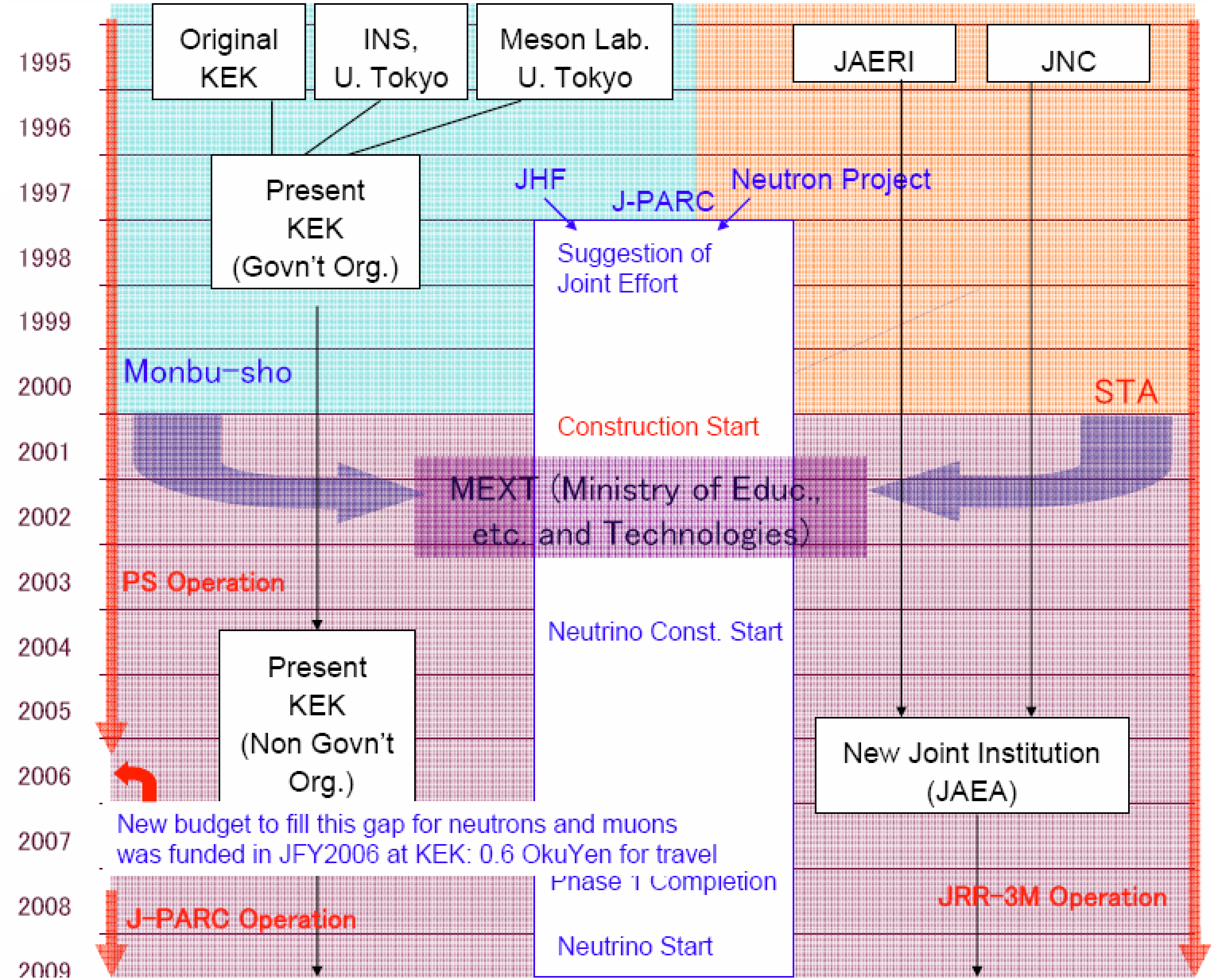
-'90/91;KEK-PS New K-spectrometers.

Successful SNP program extablished. K-arena was added.

- 1997; current J-Parc config.

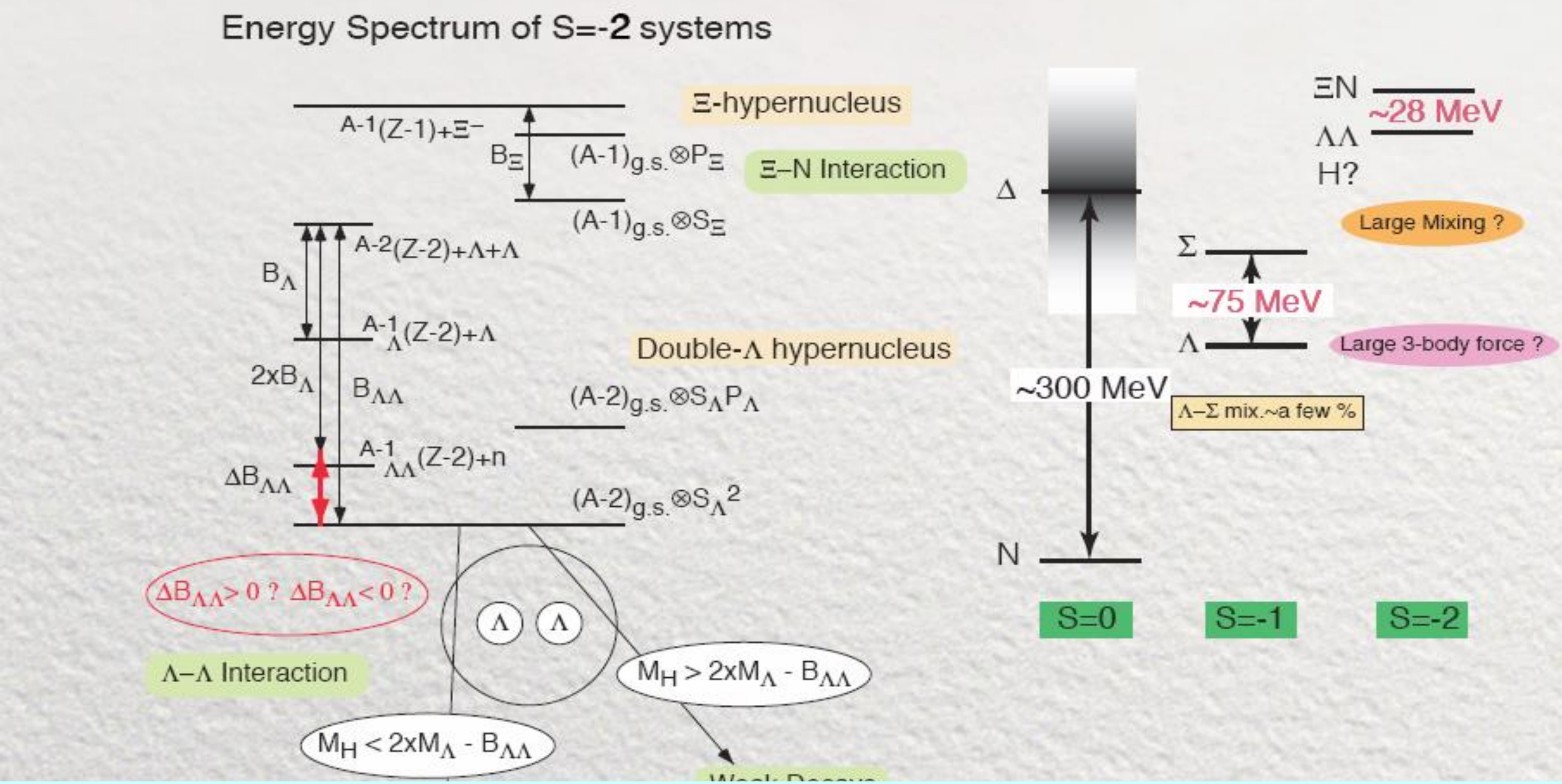
- INS-KEK 합병

- KEK-JAEA; JHF-OMEGA→ J-PARC



1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Original KEK
INS, U. Tokyo
Meson Lab. U. Tokyo
JAERI
JNC
Present KEK (Govn't Org.)
JHF
J-PARC
Neutron Project
Suggestion of Joint Effort
Monbu-sho
STA
Construction Start
MEXT (Ministry of Educ., etc. and Technologies)
PS Operation
Neutrino Const. Start
Present KEK (Non Govn't Org.)
New Joint Institution (JAEA)
New budget to fill this gap for neutrons and muons
was funded in JFY2006 at KEK: 0.6 OkuYen for travel
Phase 1 Completion
J-PARC Operation
JRR-3M Operation
Neutrino Start

S=-2 World

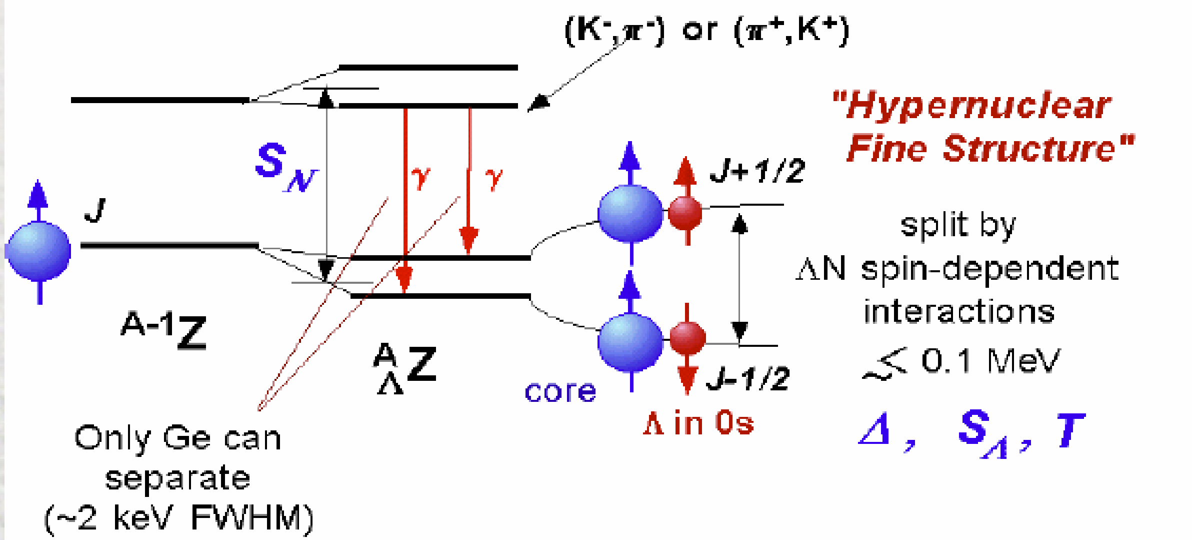


- E03 (K. Tanida); Measurement of X-rays from Ξ^- atom
- E05 (T. Nagae); Spectroscopic study of Ξ^-Hypernucleus, $^{12}{}_{\Xi}$Be via 12C(K-,K+) Reaction.
- E07 (K. Imai, K. Nakazawa, T. Tamura); Systematic Study of Double Strangeness System with an Emulsion-counter Hybrid Method

E13 (H. Tamura); Gamma-Ray Spectroscopy of Light Hypernuclei

γ spectroscopy and ΛN Interaction

- Low-lying levels of Λ hypernucleus



- 2-body ΛN effective interaction

$$V_{\Lambda N}^{eff} = V_0(r) + V_\sigma(r)\,\vec{s}_\Lambda \vec{s}_N + V_\Lambda(r)\,\vec{l}_{\Lambda N} \vec{s}_\Lambda + V_N(r)\,\vec{l}_{\Lambda N} \vec{s}_N + V_T(r)\,S_{12}$$

Δ S_Λ S_N T

p-shell : 4 radial integrals for $p_N\, s_\Lambda$ w.f.

Hyperball (Tohoku/ Kyoto/ KEK, 1998)

- Large acceptance for small hypernuclear γ yields

  Ge (r.e. 60%) x 14

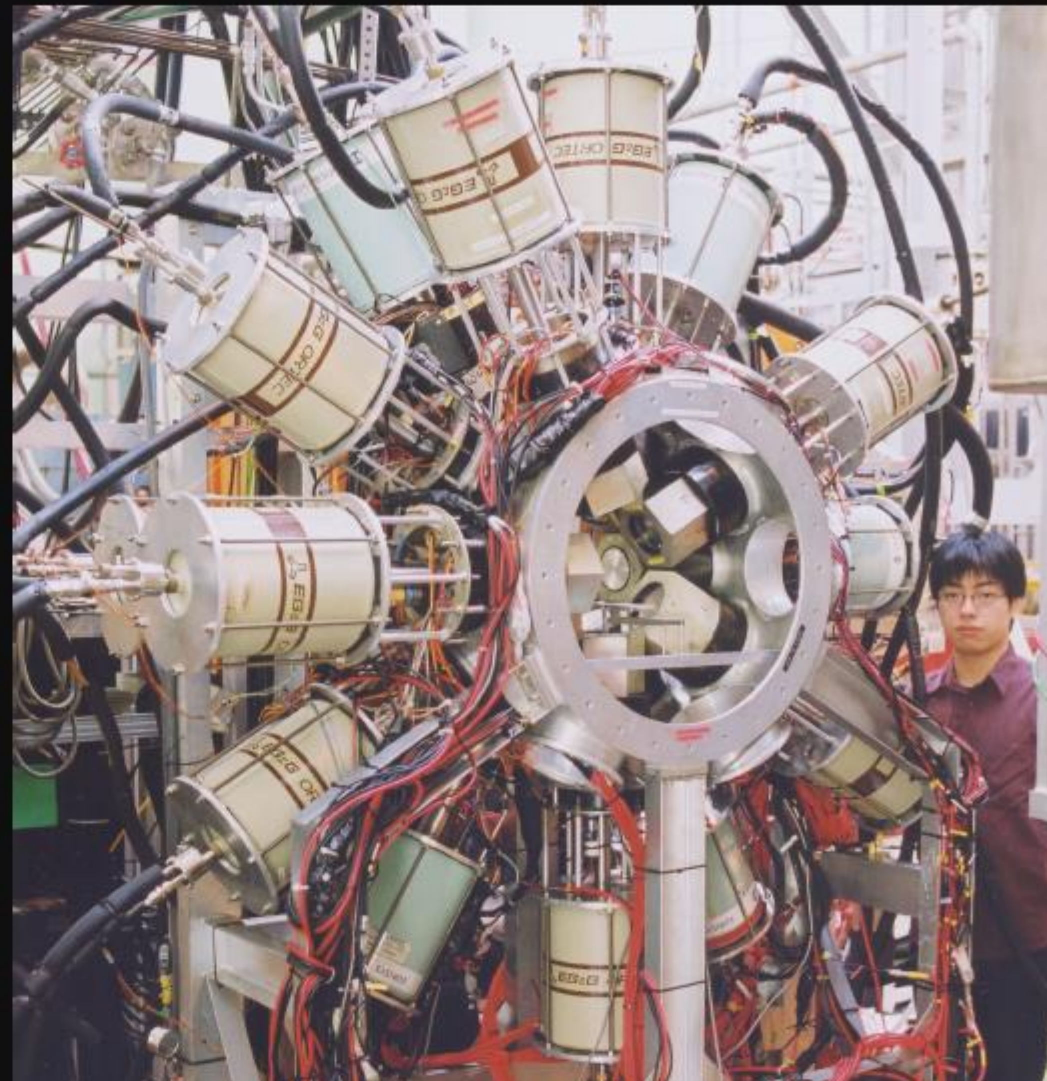
  $\Delta\Omega$ ~ 15%

  η_{peak} ~ 3% at 1 MeV

- High-rate electronics for huge background

  1 TeV/sec, 100 kHz

- BGO counters for π^0 and Compton suppression

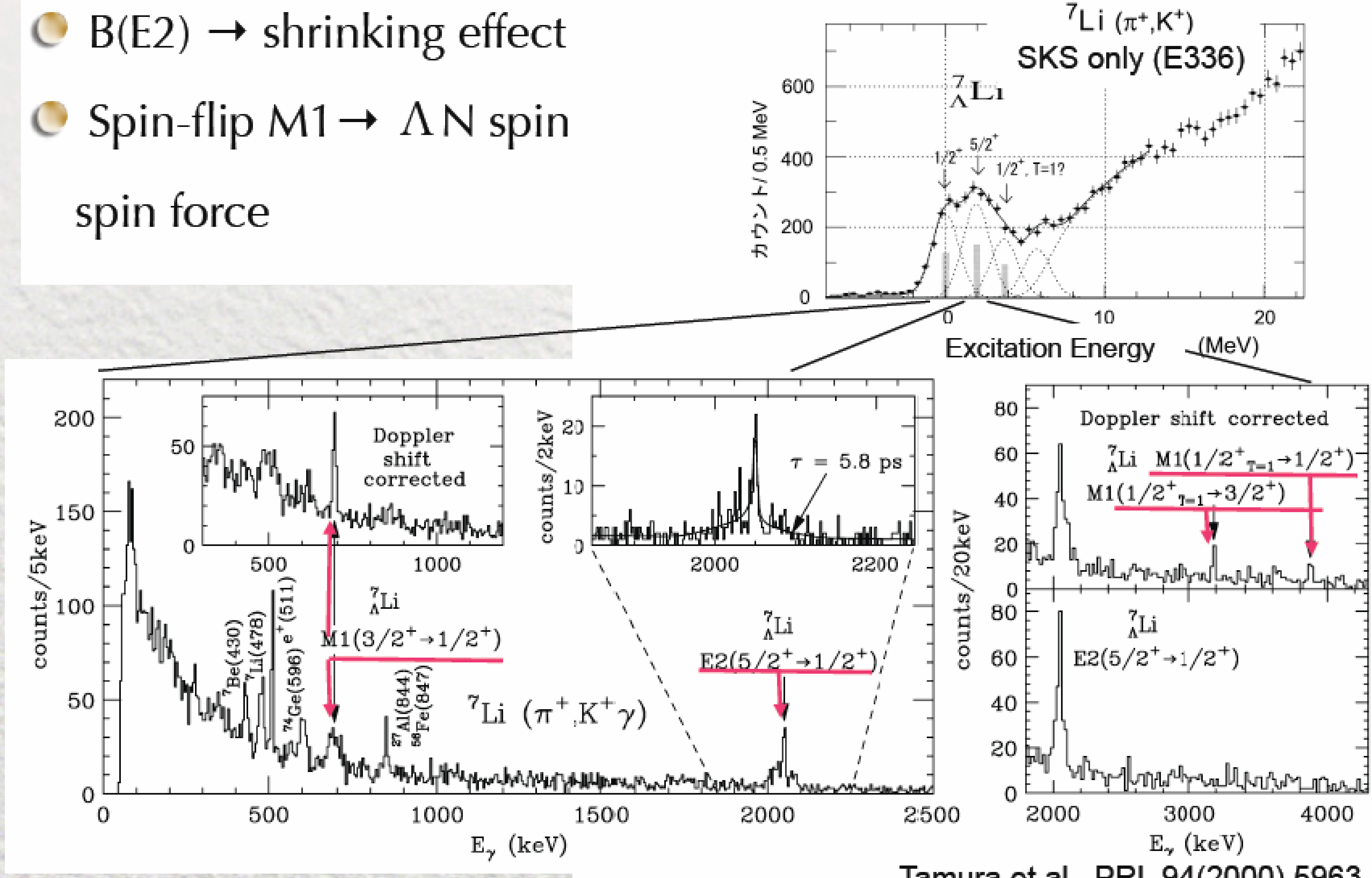


Resolution of hypernuclear spectroscopy

1 MeV → 2 keV FWHM

E419: SKS+Hyperball $^{7}Li(\pi^+,K^+\gamma)^{7}_{\Lambda}Li$

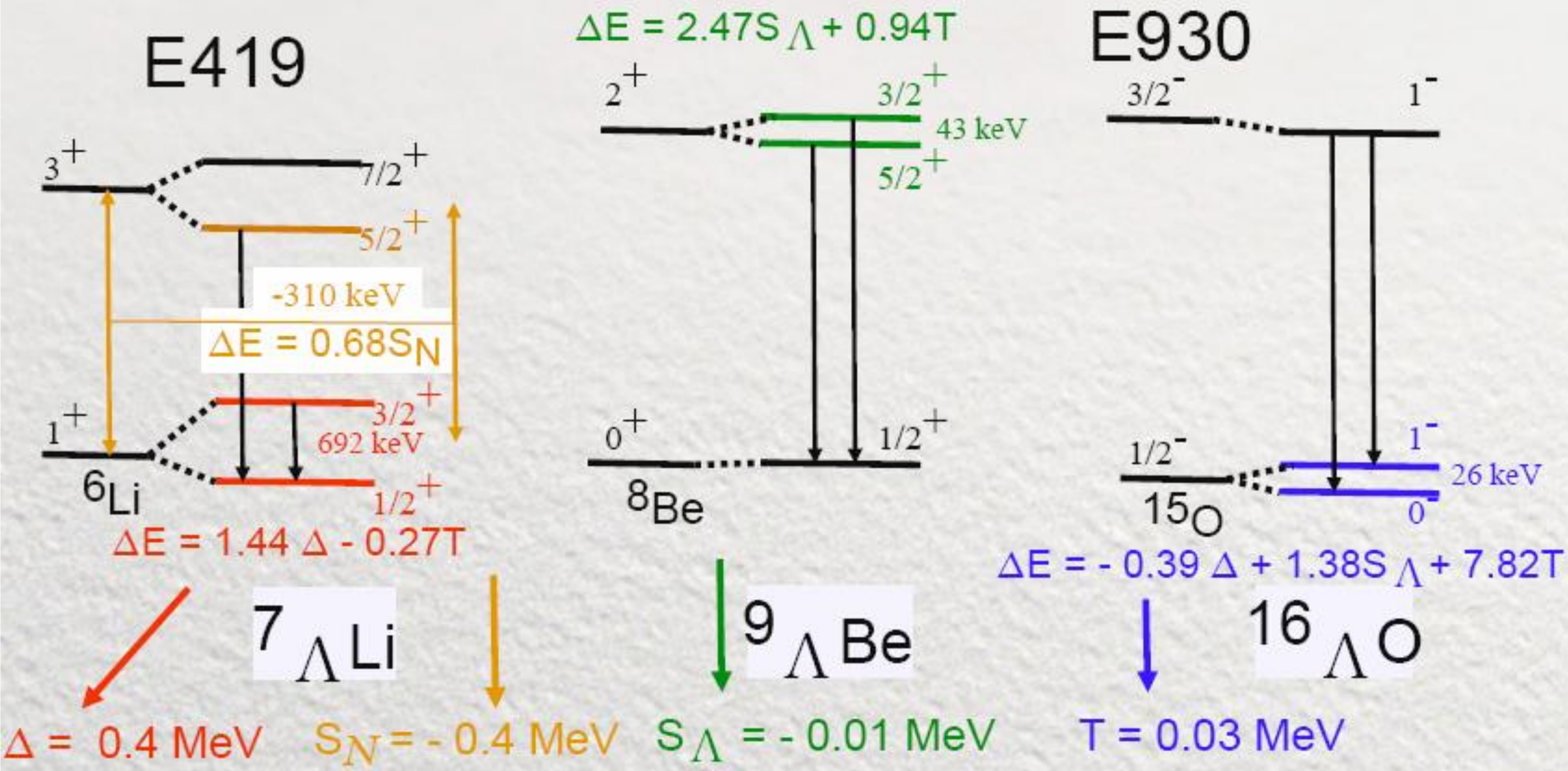
- First exp. with Hyperball
- B(E2) → shrinking effect
- Spin-flip M1 → ΛN spin spin force



Tamura et al., PRL 94(2000) 5963

Results on ΛN interaction by E419+E930

"Hypernuclear Fine Structure"



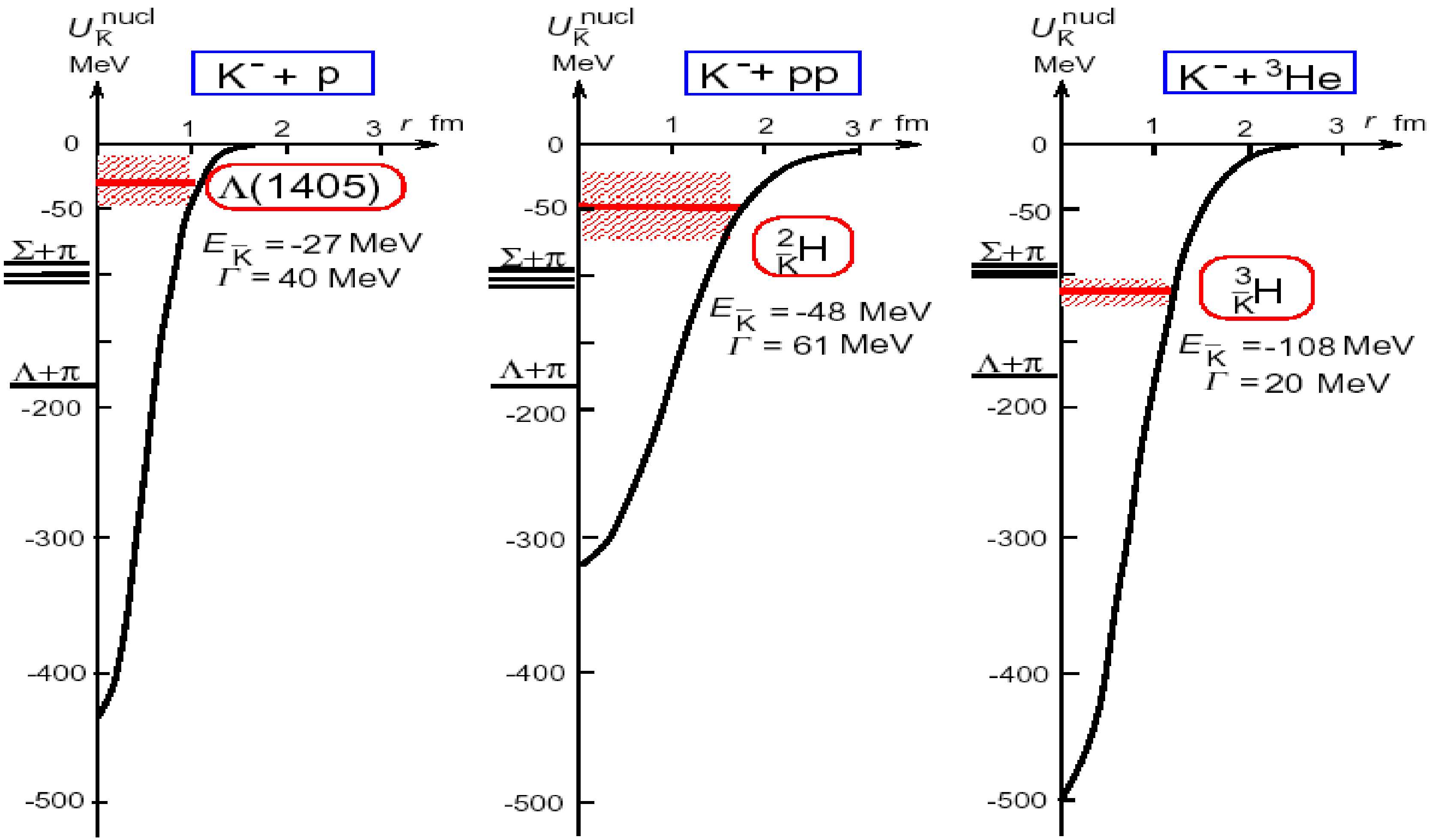
All the spin-dependent force parameters determined.

E15 (M. Iwasaki): A Search for Deeply-Bound Kaonic Nuclear States by In-Flight 3He(K-,n) Reaction

- Believed to be non-existing:
- However, Akaishi-Yamazaki (2002) predicted:
  - K^--p interaction so strong
  - strongly bound states
  - shrinks nuclei --> deeper bound states
  - deep enough:
    the main decay channel KN-->ΣN closed
- BE > 100 MeV: narrow bound states
- High nucleon density: $\rho \sim (4\text{-}7)\ \rho_0$
  - chiral symmetry restoration?
  - deconfined quark-gluon phase?

K^- POTENTIALS AND BOUND STATES

- Y. Akaishi and TY, PRC (2002) Narrowing mechanism: $E_K < \Sigma\pi$ threshold
- TY and Y. Akaishi, PLB (2002)

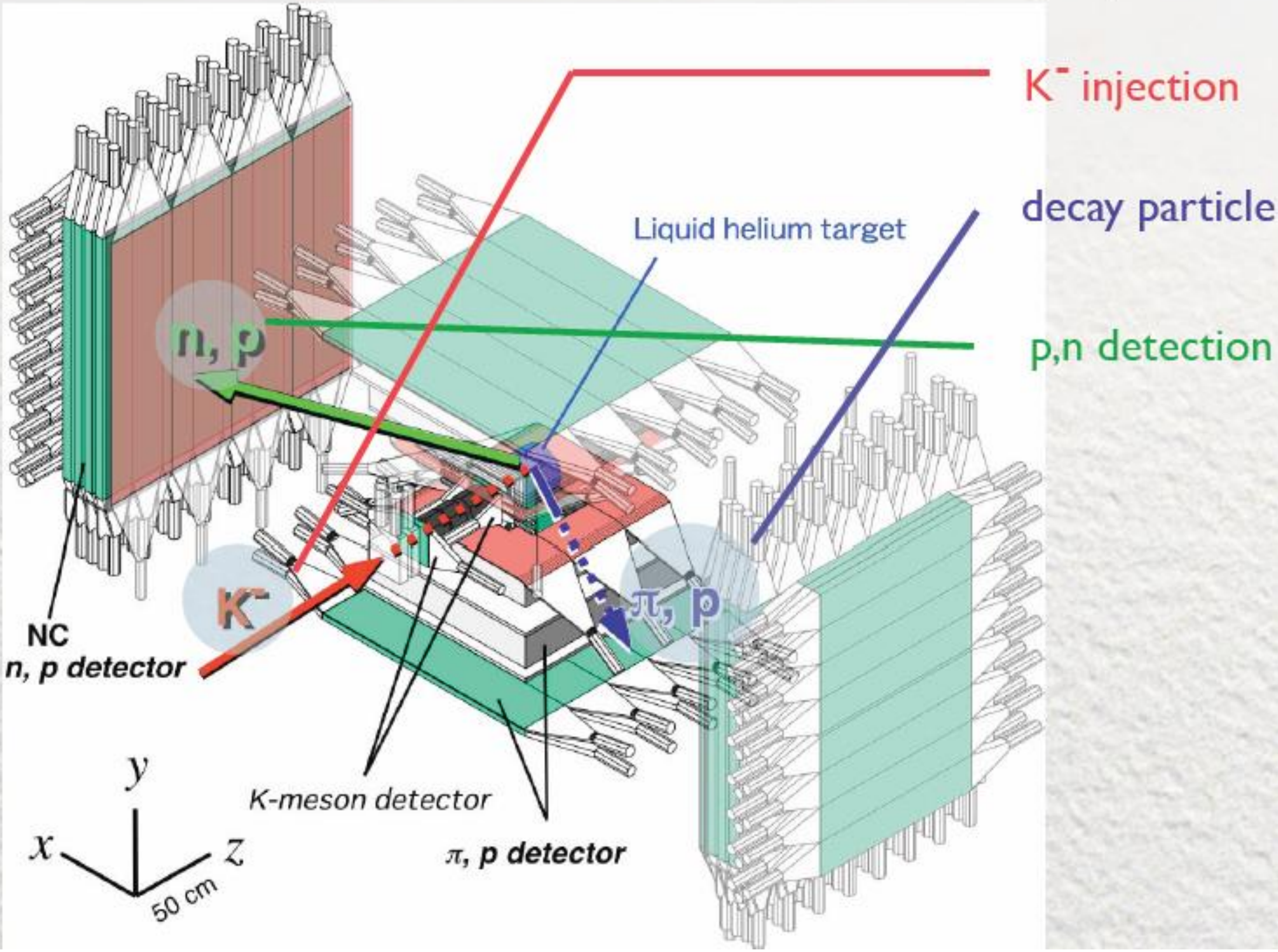


Detection Methods (1)

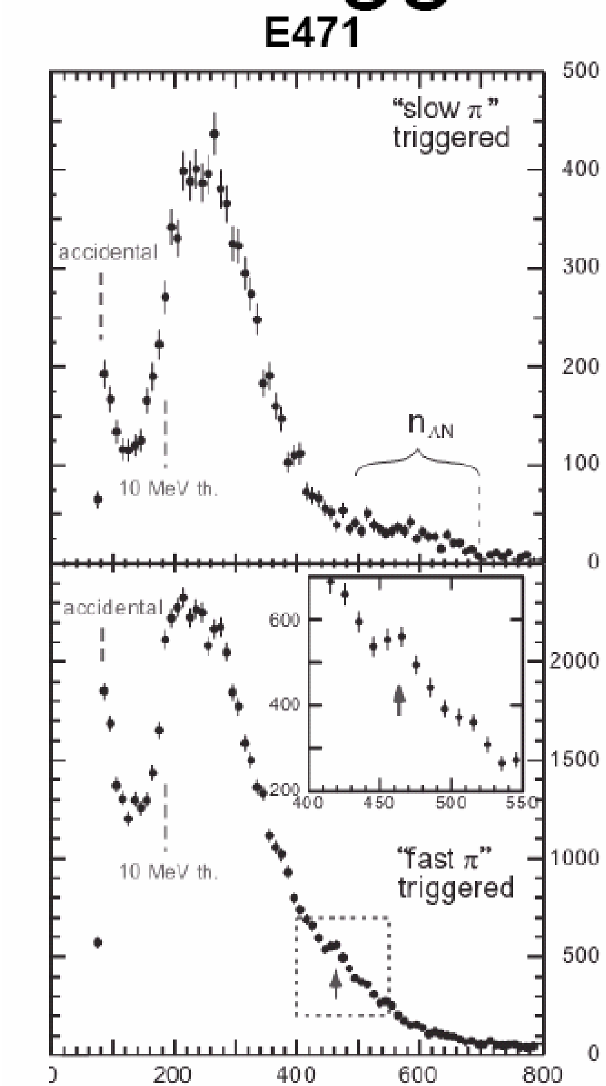
- **Missing-mass spectroscopy**
- $(K^-_{stop}$, n or p) … KEK-PS E471/E549, **FINUDA**
  - $^4He(K^-_{stop}$, n)$S^+(3140)$ …K^-ppn ? (169MeV bound)
  - $^4He(K^-_{stop}$, p)$S^0(3115)$ …K^-pnn ? (193MeV bound)
- $(K^-$, n or p) … BNL-AGS E930 / KEK-PS E548
  - $^{16}O(K^-, n)^{15}OK^-$ … B_K= 130, 90, (50) MeV
- (K^-, π^-), (π^+, K^+) … J-PARC

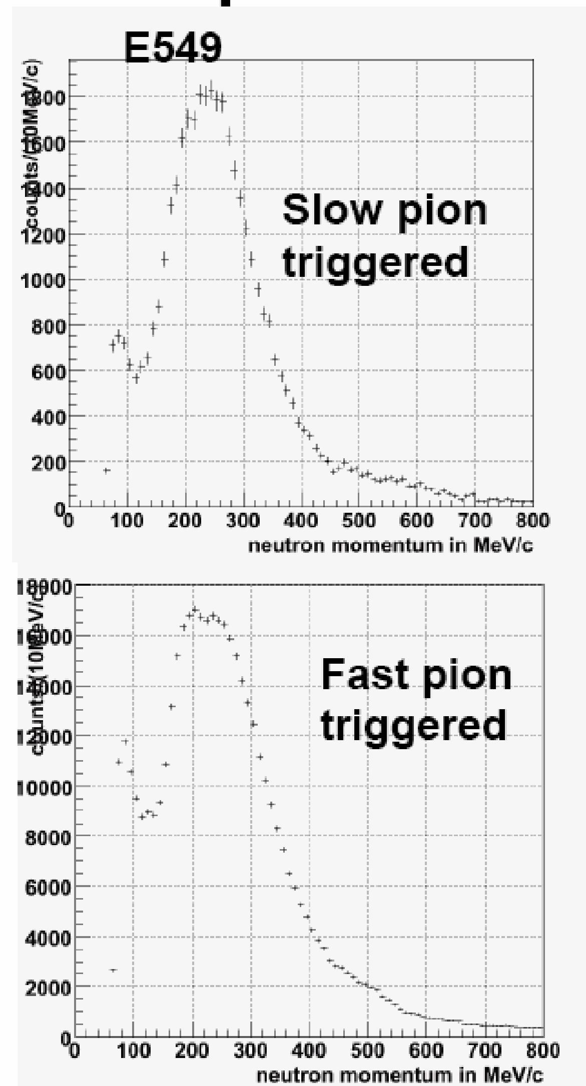
KEK E471

M. Iwasaki *et al.* : NIM A473 (2001) 286-301



Pion triggered neutron spectrum





4He(K⁻stop,n) reaction

Detection Methods (2)

- **Invariant-mass spectroscopy**
  - Heavy-ion collision … GSI-FOPI
  - K^- absorption at rest in a nucleus … **FINUDA**

$$K^- pp \rightarrow \Lambda + p, \quad \Lambda \rightarrow p + \pi^-$$

three final particles to be detected

$$K^- pn \rightarrow \Lambda + n \;,\; \Sigma^- + p$$

$$K^- ppn \rightarrow \Lambda + d$$

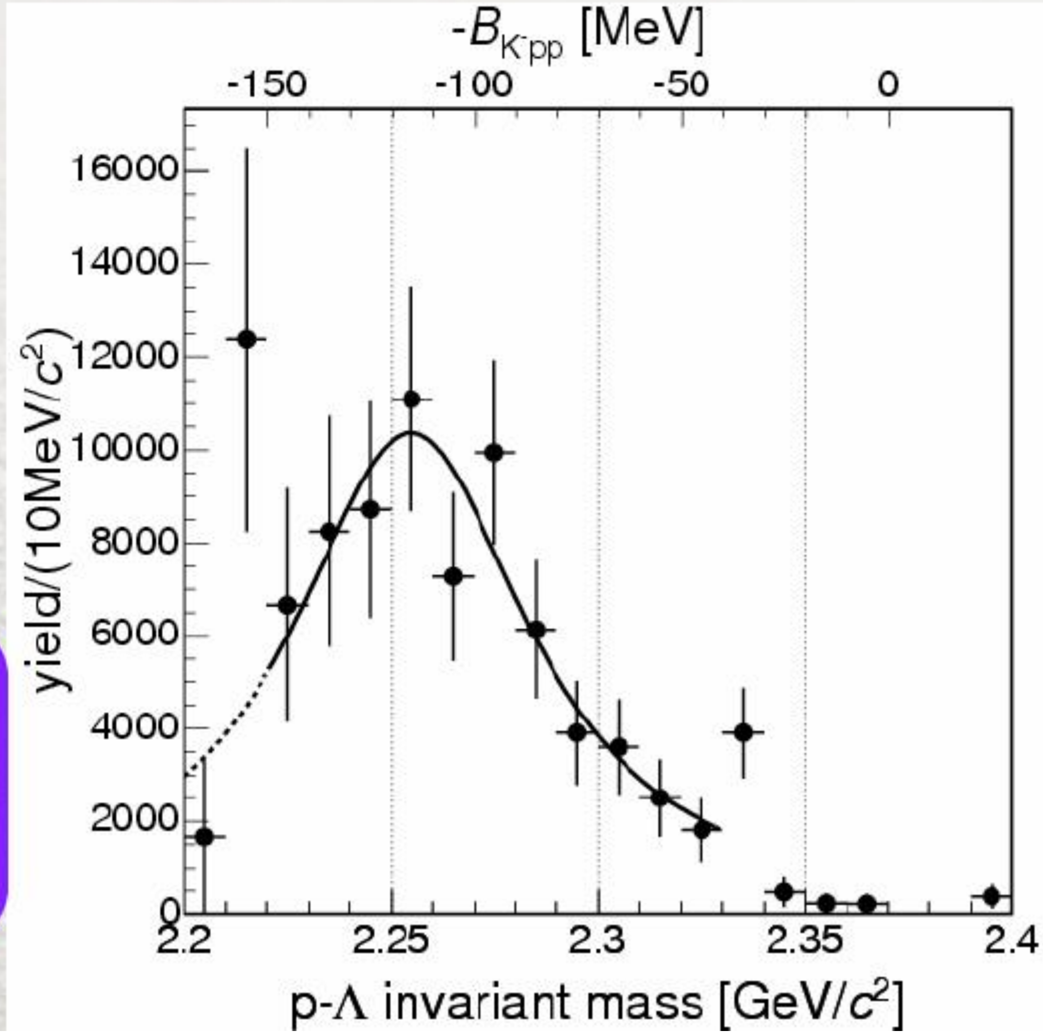
Observation of a $K^{-}pp$ bound system

Detector resolution :

$$\sigma = 4\,\mathrm{MeV}/c^2$$

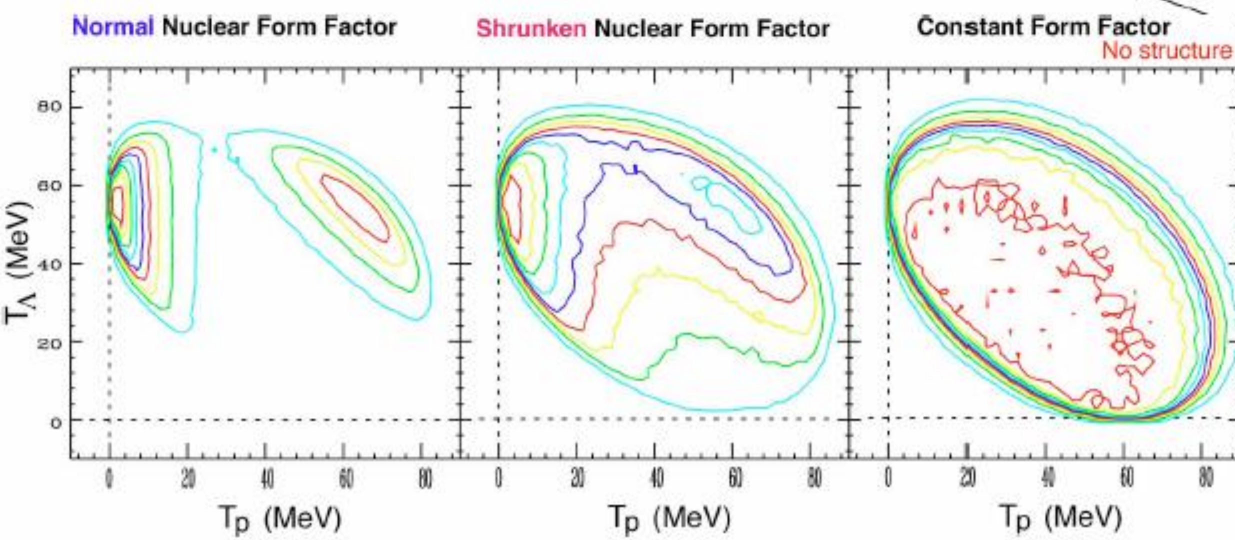
$$B = 115\,^{+6}_{-5}\,^{+3}_{-4}\,\mathrm{MeV}$$

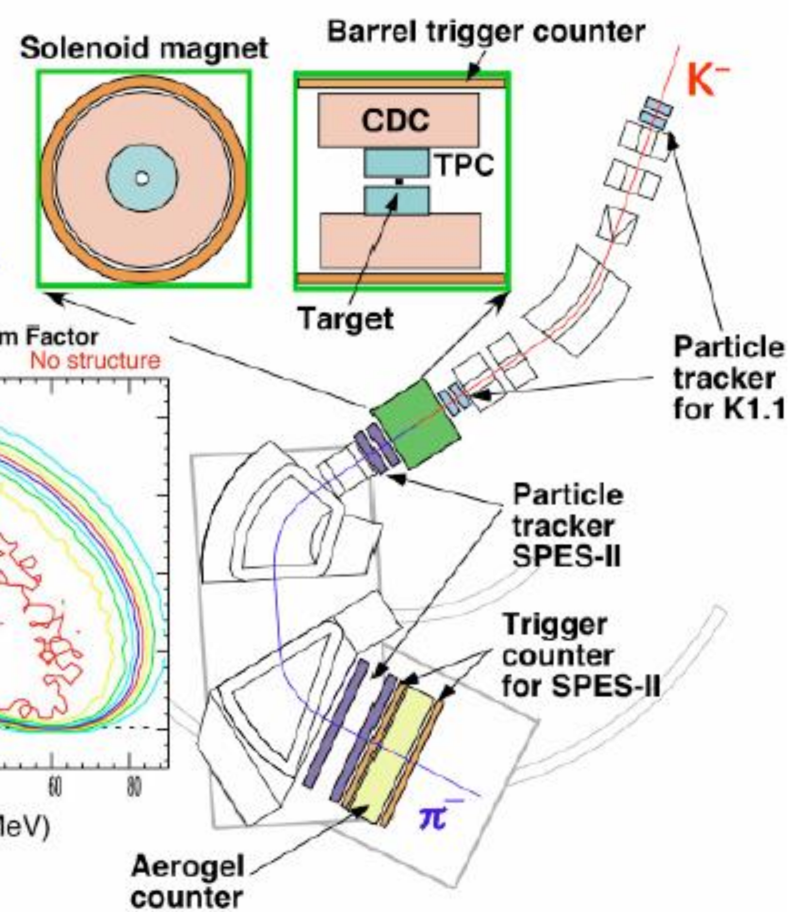
$$\Gamma = 67\,^{+14}_{-11}\,^{+2}_{-3}\,\mathrm{MeV}$$



Measurement at J-PARC

Detect all particles in
production & decay
= decay with charged particles



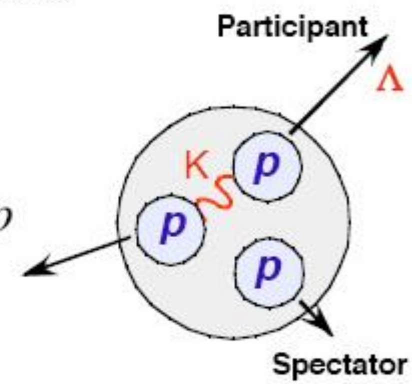


- ^{3}He Target

$$K^- + {}^3\mathrm{He} \to \langle K^- ppp \rangle + \pi^-$$

$$\langle K^- ppp \rangle \to \Lambda p + p \to pp\pi^- + p$$

Spectator?



Density Measurement !

P. Kienle

E18; Non-Mesonic Weak Decay (NMWD) & Issues

1. **B-B Weak Interaction ;**

$$\Lambda + N \rightarrow N + N \quad (\Delta S=1 \text{ B-B W.I. })$$

- So far the only means of exploring this weak interaction.

2. Γ_n ,Γ_p measurement; Γ_n/Γ_p puzzle problem.

3. **Asymmetry ;** The current concern.

4. **$\Delta I=1/2$ Rule ;** JPARC-PS E22

5. **The 3-body interaction process, 2N-NMWD:** JPARC E18

- Not experimentally identified yet, though predicted to be a significant component of NMWD.

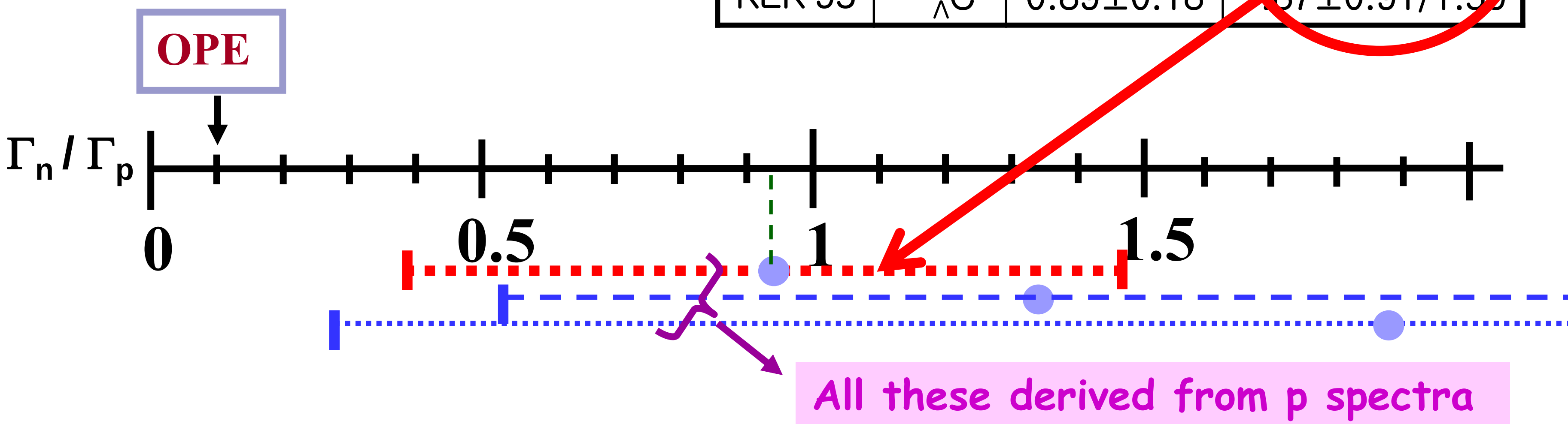
Γ_n/Γ_p puzzle and the previous searches

1. Γ_n/Γ_p Puzzle :

$\Gamma_n/\Gamma_p^{exp} >> \Gamma_n/\Gamma_p^{th}$ (OPE)

~ 1 ~0.1

	Hyp. Nuc.	Γ_{nm}	Γ_n/Γ_p
BNL	$^5_\Lambda$He	0.41±0.14	.93±0.55
	$^{12}_\Lambda$C	1,14±0.2	1.33±1.12/0.81
KEK'95	$^{12}_\Lambda$C	0.89±0.18	1.87±0.91/1.59



2. Recent Development of $\Gamma_n/\Gamma_p^{theory}$: 0.3 ~ 0.7

K.Sasaki (Direct Quark), Nucl. Phys. A669 (2000) 371

D. Jido (Heavy Meson Exc), Nucl. Phys. A694 (2001) 525

Coincidence Measurement (KEK-PS E462/E508)

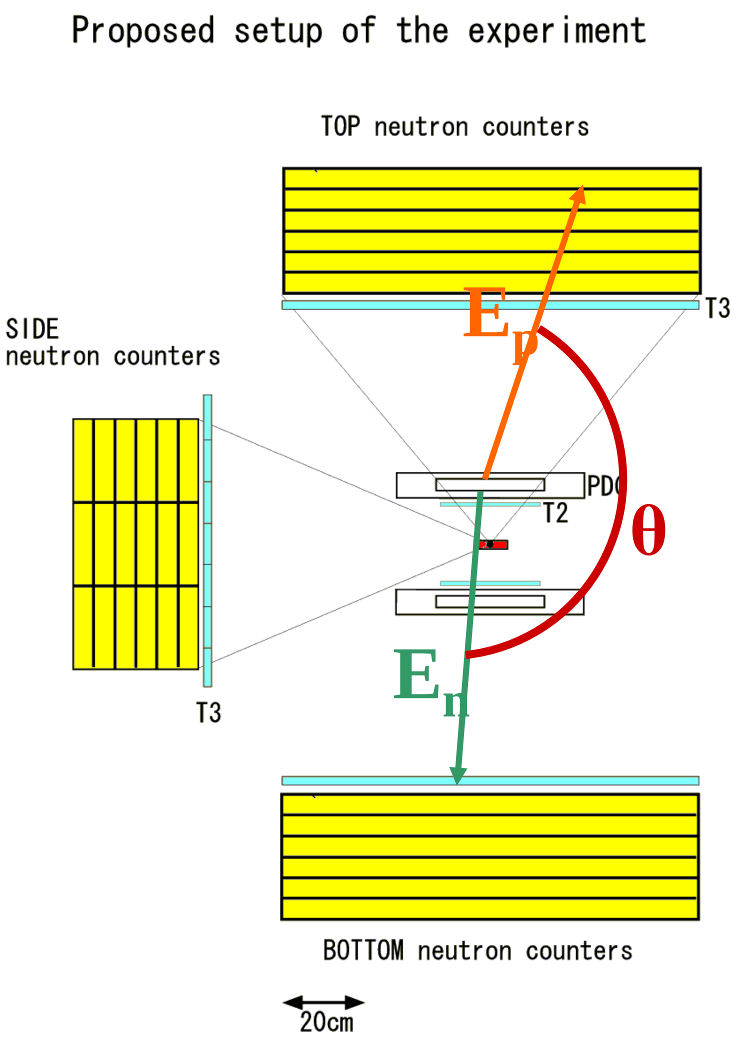
To exclude FSI effect and

3-body decay in Γn/Γp and

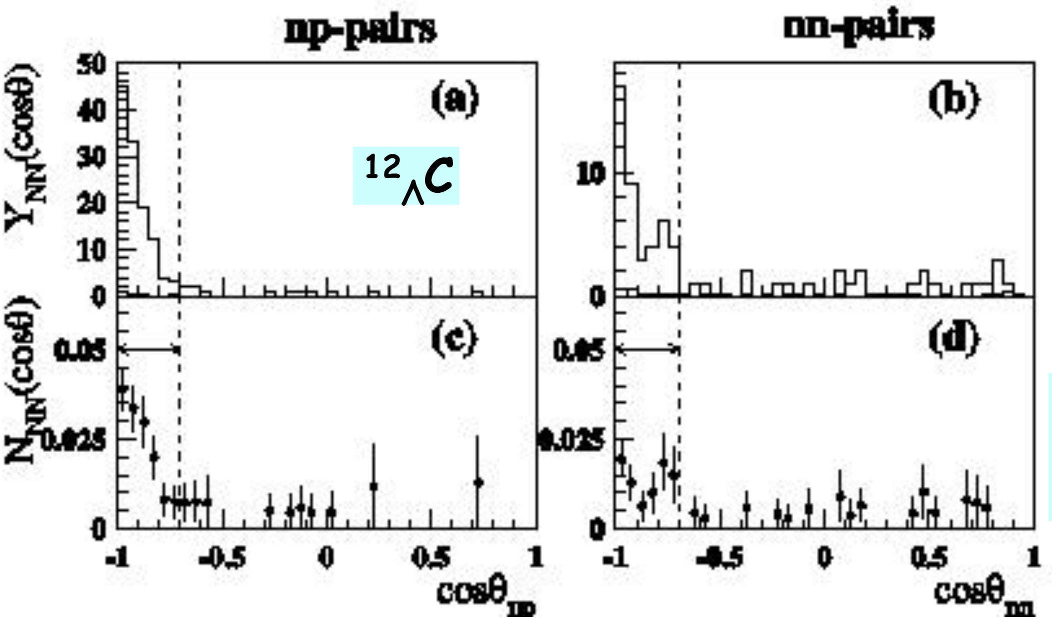
to identify 2N channel,

→ Exclusive measurement of

each decay channel.

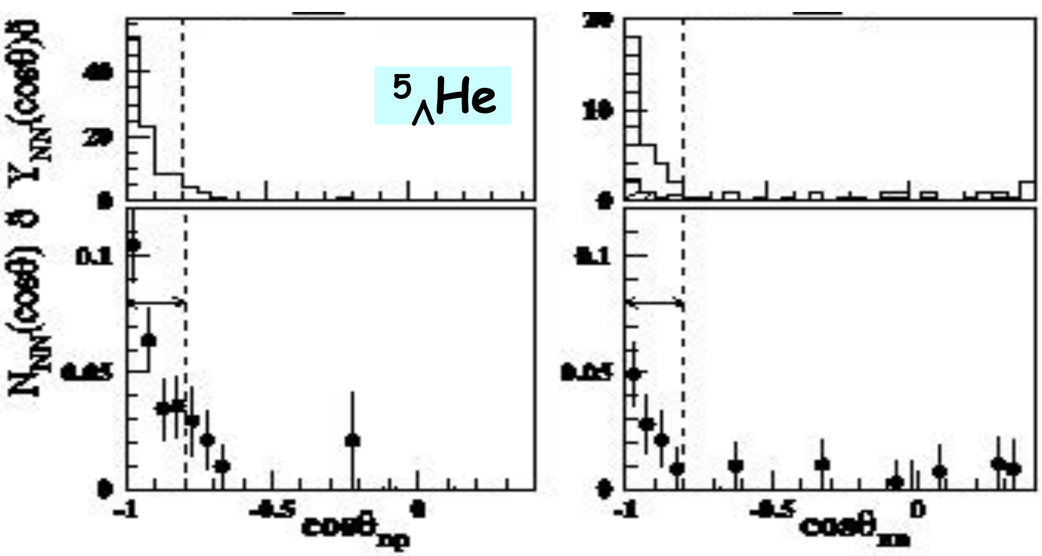


Coincidence Yields (NN correlations)



Γ_n/Γ_p = 0.51 ± 0.13 ± 0.0

M. Kim et al., PLB ('06)

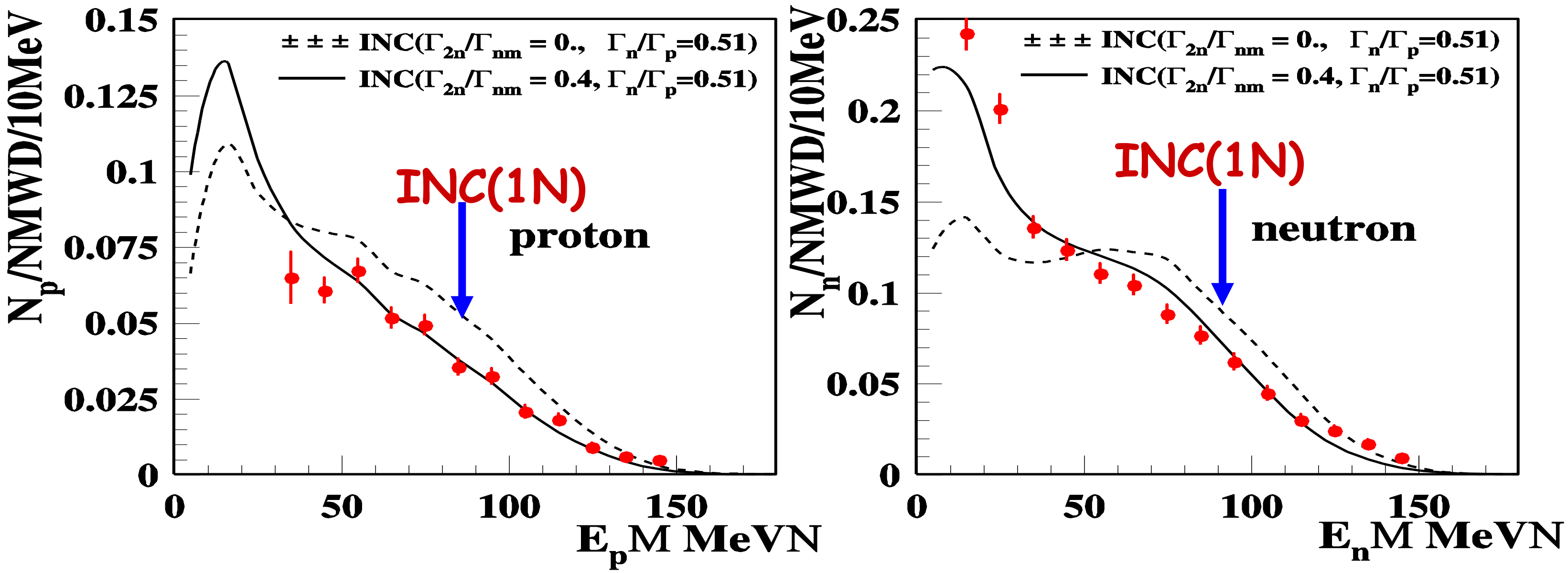


Γ_n/Γ_p = 0.45 ± 0.11 ± 0.03

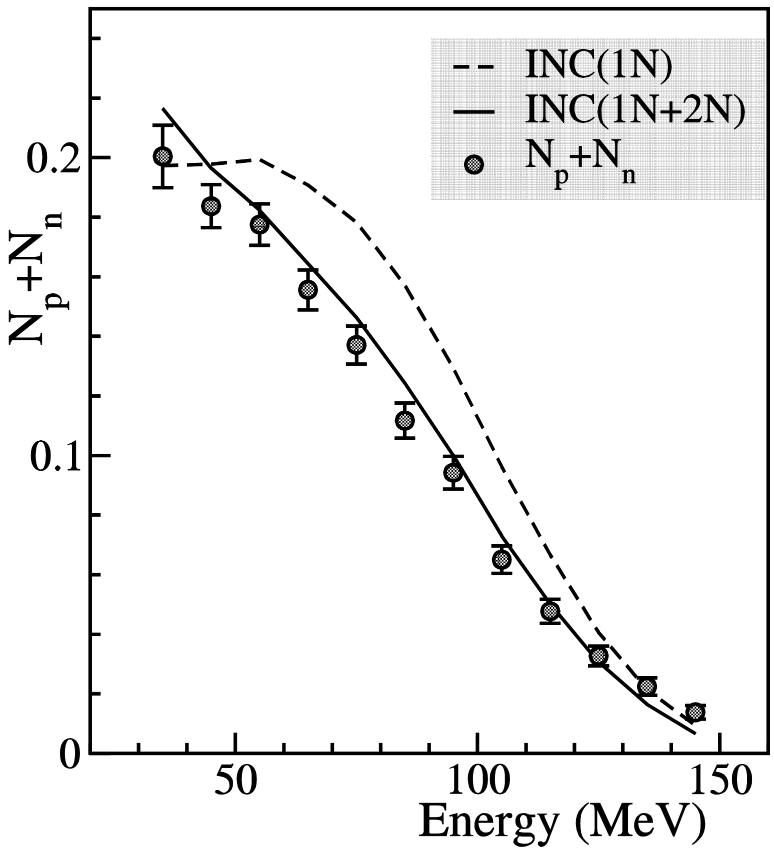
B.Kang et al., PRL 96 ('06)

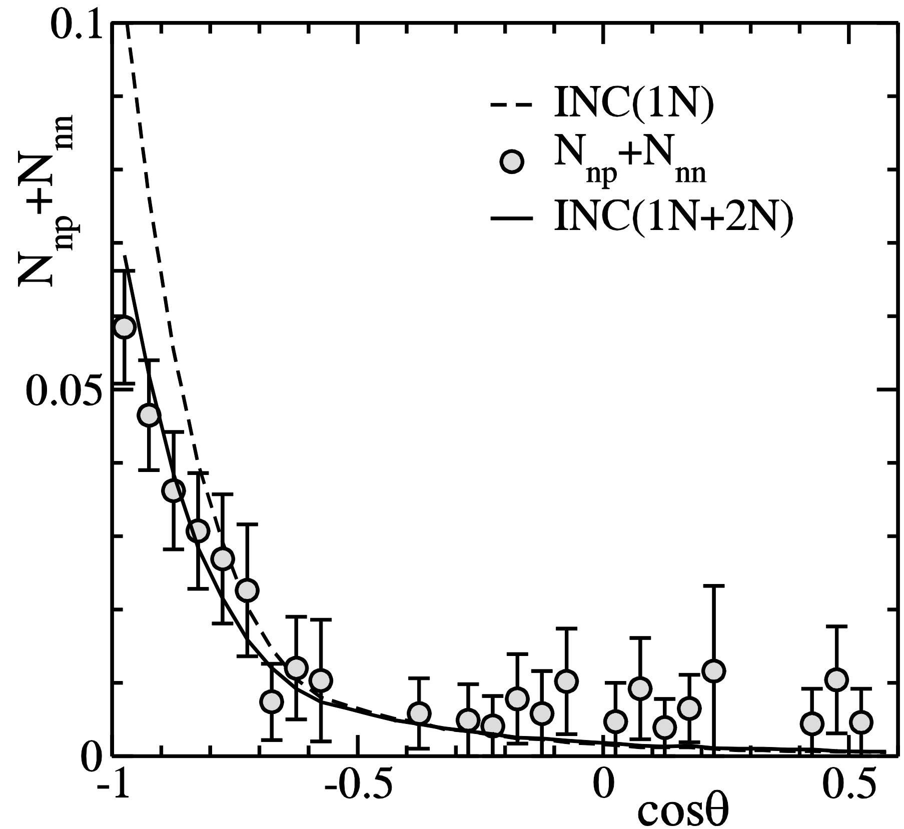
Nnn/Nnp ≈ Γn/Γp

Quenching of Singles Yield



1. Quenching in both p and n spectra from that of INC.
2. What would be the mechanism for the nucleon Quenching?
   → Stronger FSI & 3-Body process.
3. FSI ; n & p are indistingushable (isospin indep.) → HE similarity.
   LE behavior ; Cross over effect → LE p enhancement.
4. Instead, What observed → LE n enhancement.
5. What would be the source of the LE n enhancement???





The signatures of (2N)-NMWD processes were found both in the singles and coincidence data. All of them indicates fairly large Γ_{2N} comparabel to Γ_{1N}.

J-PARC E22 Experiment (ΔI=1/2 rule)

- Properties of LN weak interaction
  - study on non-mesonic weak decay (NMWD) in hyper nuclei → ΛN weak interaction
    - spin/isospin structure
    - parity information

    } determination of partial decay amplitudes
  - measurement of np-ratio (G_n/G_p) of ^4_LHe

    Λn→nn, Λp→np
- Studies toward test of "ΔI=1/2 rule"
  - "ΔI=1/2 rule" valid or not in NMWD
  - Study on A=4 hypernuclei (^4_LHe and ^4_LH)
  - 1st step for the study

$\Delta I = \frac{1}{2}$ rule

- The strangeness changing weak decay strongly favors the $\Delta I = 1/2$ transition.
- The exp ratio A(dI=1/2)/A(dI=3/2) ~ 20 in the decay of K and hyperon.
- The mechanism for the dominance of dI=1/2 is not well understood yet.

Nonmesonic decay of A=4 hypernuclei

Allowed initial states for A=4, 5 hypernuclei

hypernucleus	$\Lambda n \to nn$	$\Lambda p \to np$
${}^{4}_{\Lambda}H$	${}^{1}S_{0}$, ${}^{3}S_{1}$	${}^{1}S_{0}$
${}^{4}_{\Lambda}He$	${}^{1}S_{0}$	${}^{1}S_{0}$, ${}^{3}S_{1}$
${}^{5}_{\Lambda}He$	${}^{1}S_{0}$, ${}^{3}S_{1}$	${}^{1}S_{0}$, ${}^{3}S_{1}$

- $\Gamma p({}^{4}_{\Lambda}H)$, $\Gamma n({}^{4}_{\Lambda}He)$

$\Rightarrow$ we can measure ${}^{1}S_{0}$ amplitudes directly.

- If $\Delta I=1/2$ rule holds, $\Gamma n({}^{4}_{\Lambda}He)/\Gamma p({}^{4}_{\Lambda}H)=2$.

$\Rightarrow$ we can check the validity of the $\Delta I=1/2$ rule in B-B weak interaction.

Existing experimental results

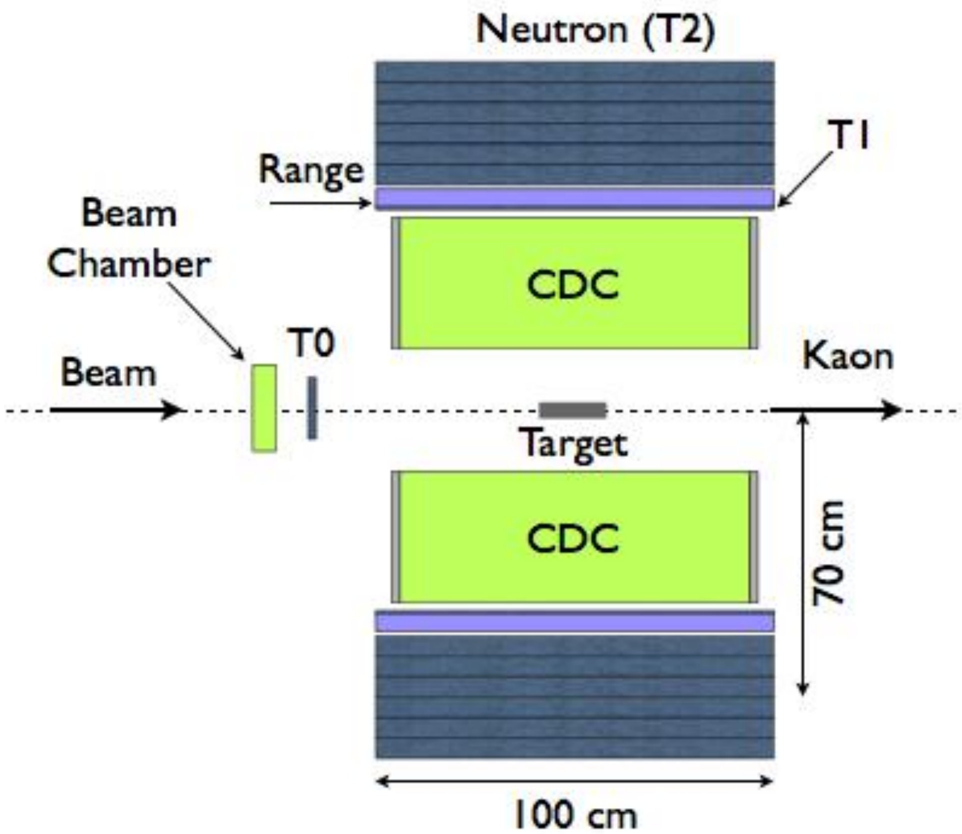
$\Gamma n({}^{4}_{\Lambda}He)/\Gamma_{\Lambda}=0.01^{+0.04}/_{-0.01}$ (KEK), 0.04 ± 0.02(BNL) NP A639(1998)261c

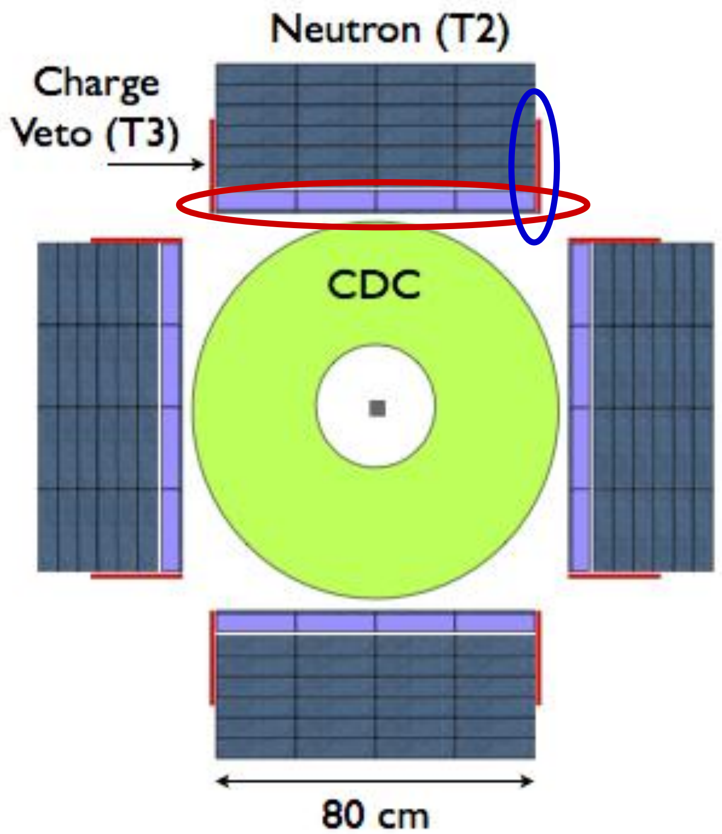
$\Gamma p({}^{4}_{\Lambda}He)/\Gamma_{\Lambda}= 0.16\pm0.02$(KEK), 0.16 ± 0.02(BNL) NP A639(1998)251c

Decay Counter Setup

Basic concepts are based on the setup of E462/E508 expeiments.

- CDC+T1(Timing for charged one)+T2(neutron)
- Side veto to reject passing through ptls
- Share most of the detection system with E22





Summary;

1. J-PARC is a unique and competitive facility located near to us and would be a very convenient place for us to do experiments.

2. It is just about to start beam extraction and Experiments will start from next year. This initial stage would be very important time for us to formulate our future fruitful activities and results from it.

3. It is desirabel to develope strong oversea research activity as one of the two pillars to support future nuclear physics. ABSI can be another pillar.

4. In order to upgrade the oversea activities, strong competitive domestic facility is absolutely necessary, directly or indirectly.

5. Therefore the domestic and oversea programs are complimentary to each other as we can see in the IL-JOO-MOON (fig).

Extra

Summary

1. The long standing Γ_n/Γ_p discrepancy problem has finally been solved in corporation of the theoretical and experimental efforts.

2. Now after the resolution, there are remaining important problems, such as Ay (asymmetry parameter) inconsistency, $\Delta I = 1/2$ rule and the contribution of the 3-body 2N-NMWD channel.

3. The signatures of 3-body NMWD processes were found both in the singles and coincidence data. All of them indicates fairly large Γ_{2N} comparabel to Γ_{1N}.

4. There are two NMWD experiments approved for J-PARC.

   1) E18 ; Γ_{2N} (3-body decay process), Γ_n ,Γ_p

   2) E22 ; $\Delta I = 1/2$ rule

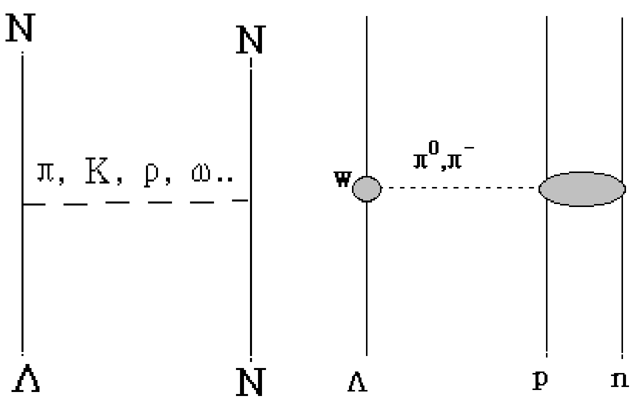
Decay Modes and Motivation

$\Gamma_{tot}(=1/\tau)$

- Γ_m
  - Γ_{π^-} ($\Lambda \rightarrow p\pi^-$)
  - Γ_{π^o} ($\Lambda \rightarrow n\pi^o$)
  - **Mesonic**, q~ 100 MeV/c
- Γ_{nm}
  - Γ_p ($\Lambda p \rightarrow np$) (1N)
  - Γ_n ($\Lambda n \rightarrow nn$) (1N)
  - Γ_{2N} ($\Lambda NN \rightarrow nNN$) (2N)
  - **Nonmesonic**, q~ 400 MeV/c

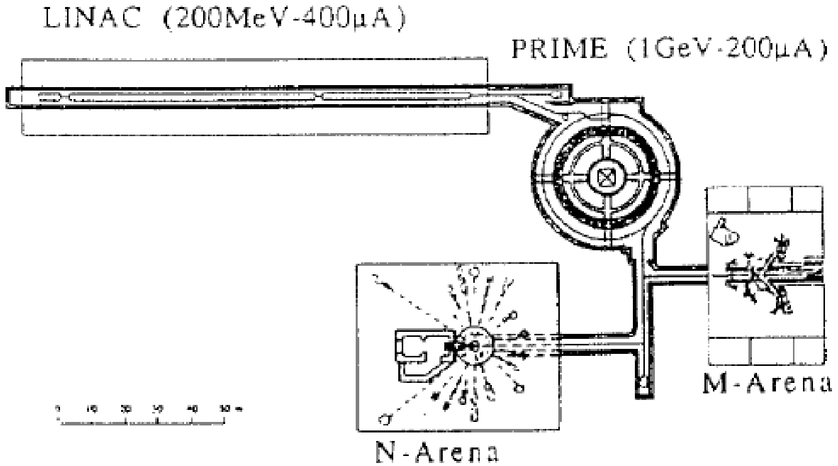
Previous Searches

3-Body Process



(2N-NMWD)

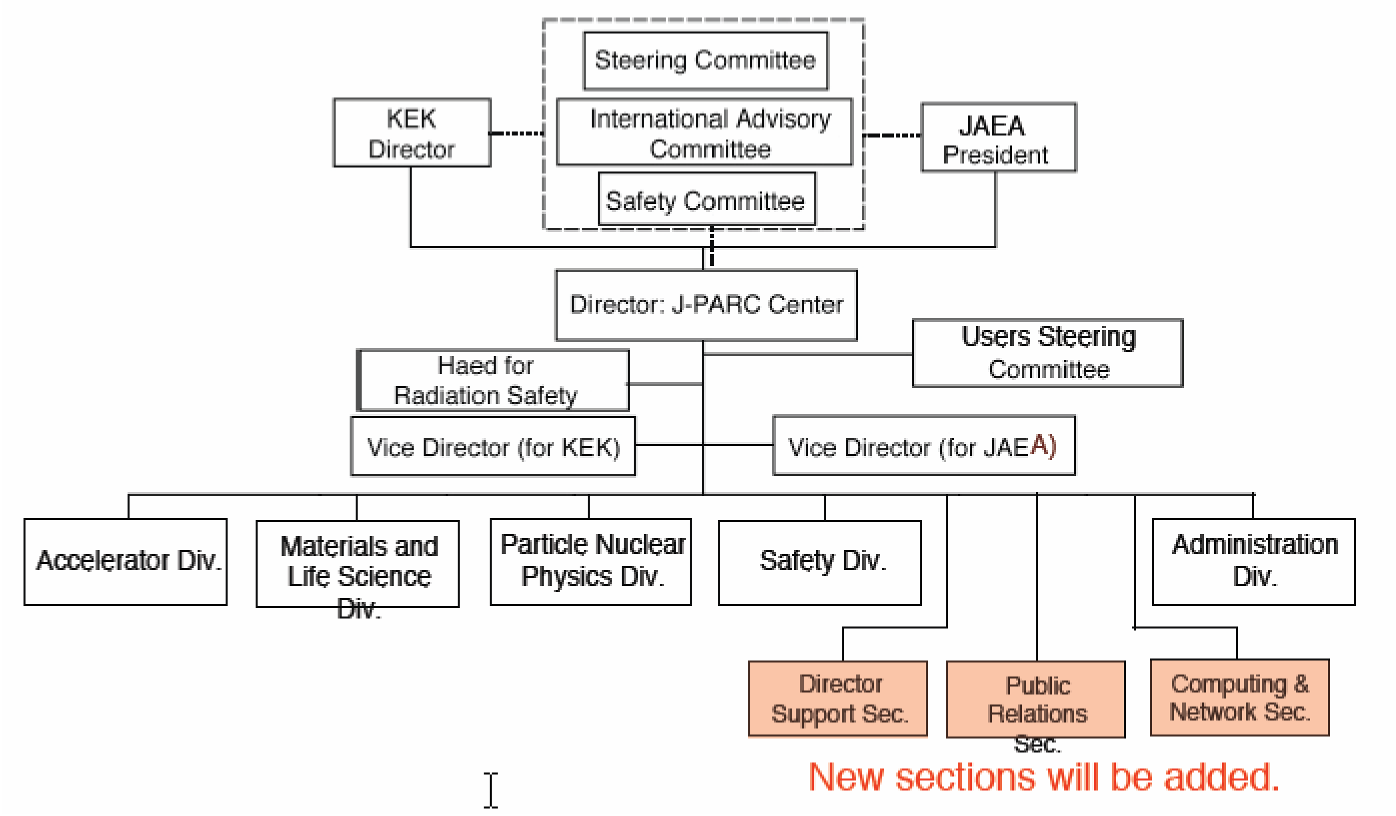
- 2N NMWD: Predicted theoretically, but not exp. idendtified yet.



- 1987; INS first proposal
. . . 10 years development.
-'90/91;KEK-PS New K-spectrometers.
  Successful program extablished.
  K-arena was added.
- 1997; current J-Parc config.
- INS-KEK 합병
- KEK-JAEA; JHF-OMEGA→ J-PARC

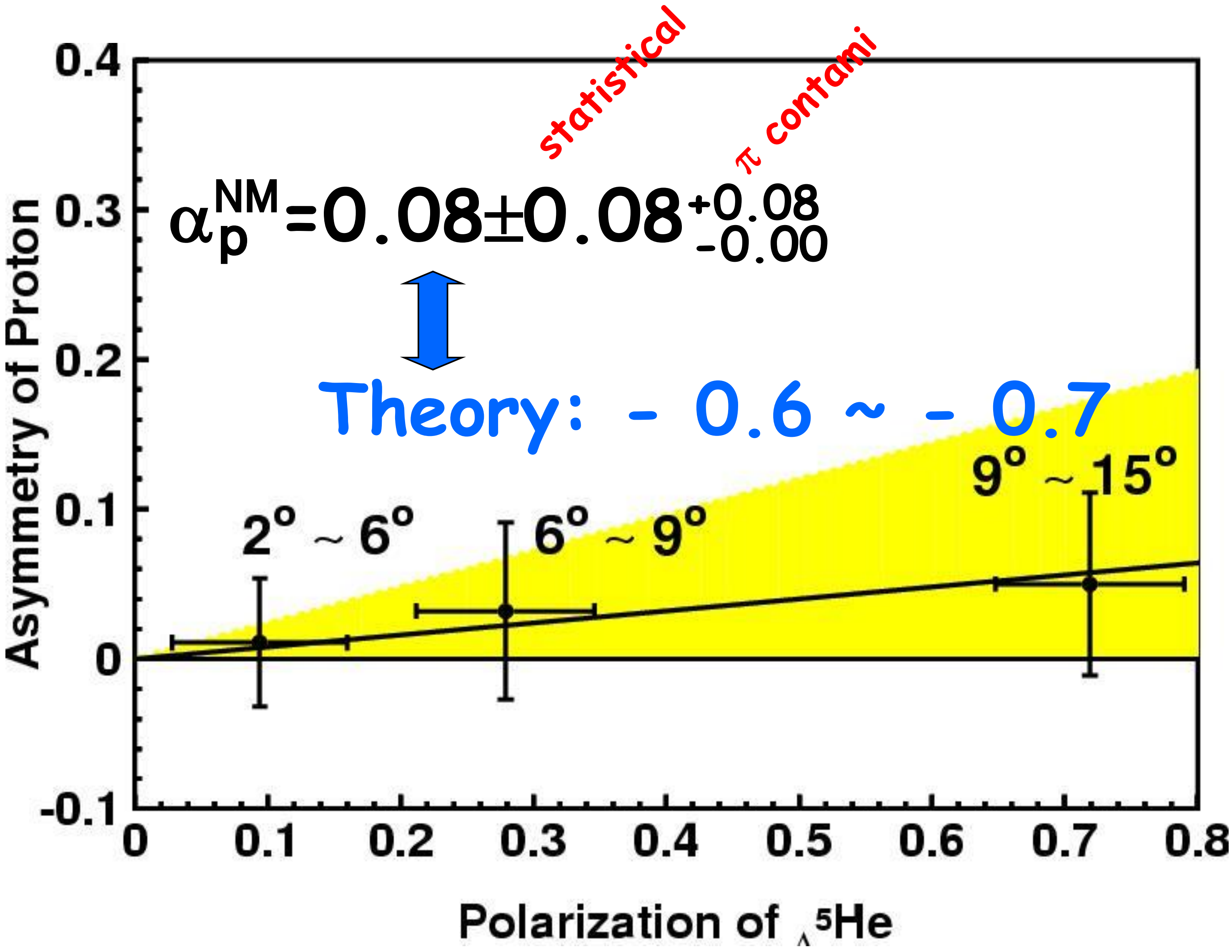
Table 1 Main beam parameters

Injected H^- beam			
Energy		200	MeV
Peak current		20	mA
Injection period		400	μsec
Width of micropulse		~ 190	nsec
Repetition rate		50	Hz
Average current		200	μA
Normalized emittance ($\varepsilon_{xn}, \varepsilon_{yn}$)		2.6	π·mm·mrad
Energy spread		± 0.1	%
Beam just after injection			
Absolute emittance	ε_x	150	π·mm·mrad
	ε_y	125	π·mm·mrad
Revolution frequency		1.3	MHz
Number of beam bunches		2	
Bunch length		~ 190	nsec
Number of particles in a bunch		1.25×10^{13}	
Beam at the extraction			
Energy		1 (1.5)	GeV
Revolution frequency		2.3	MHz
Bunch length		~ 100	nsec
Absolute emittance	Horizontal	42.9	π·mm·mrad
	Vertical	35.7	π·mm·mrad
Momentum spread		±1	%



Steering Committee
KEK Director
International Advisory Committee
JAEA President
Safety Committee
Director: J-PARC Center
Users Steering Committee
Haed for Radiation Safety
Vice Director (for KEK)
Vice Director (for JAEA)
Accelerator Div.
Materials and Life Science Div.
Particle Nuclear Physics Div.
Safety Div.
Administration Div.
Director Support Sec.
Public Relations Sec.
Computing & Network Sec.
New sections will be added.

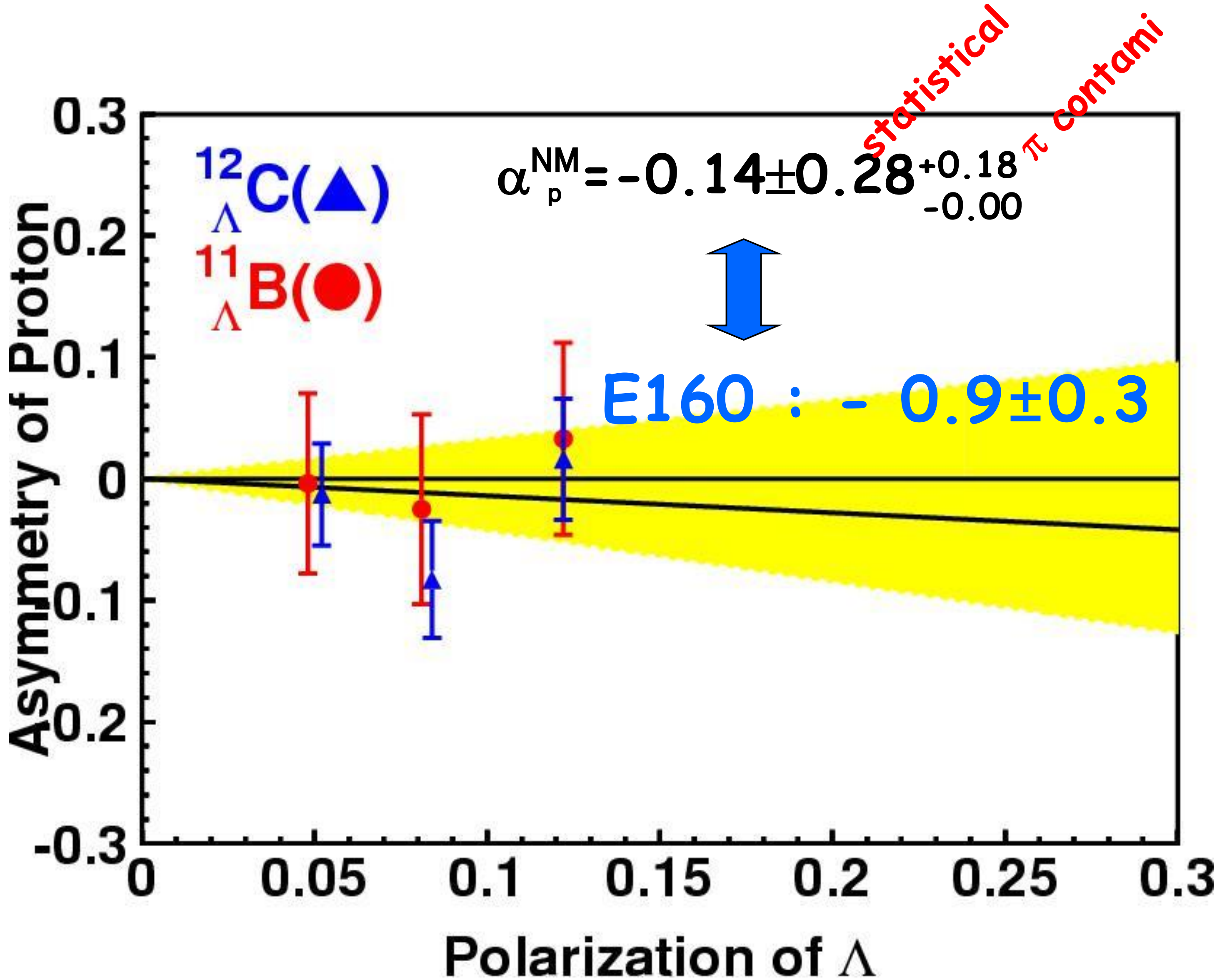
Asymmetry parameter of $^{5}_{\Lambda}He$



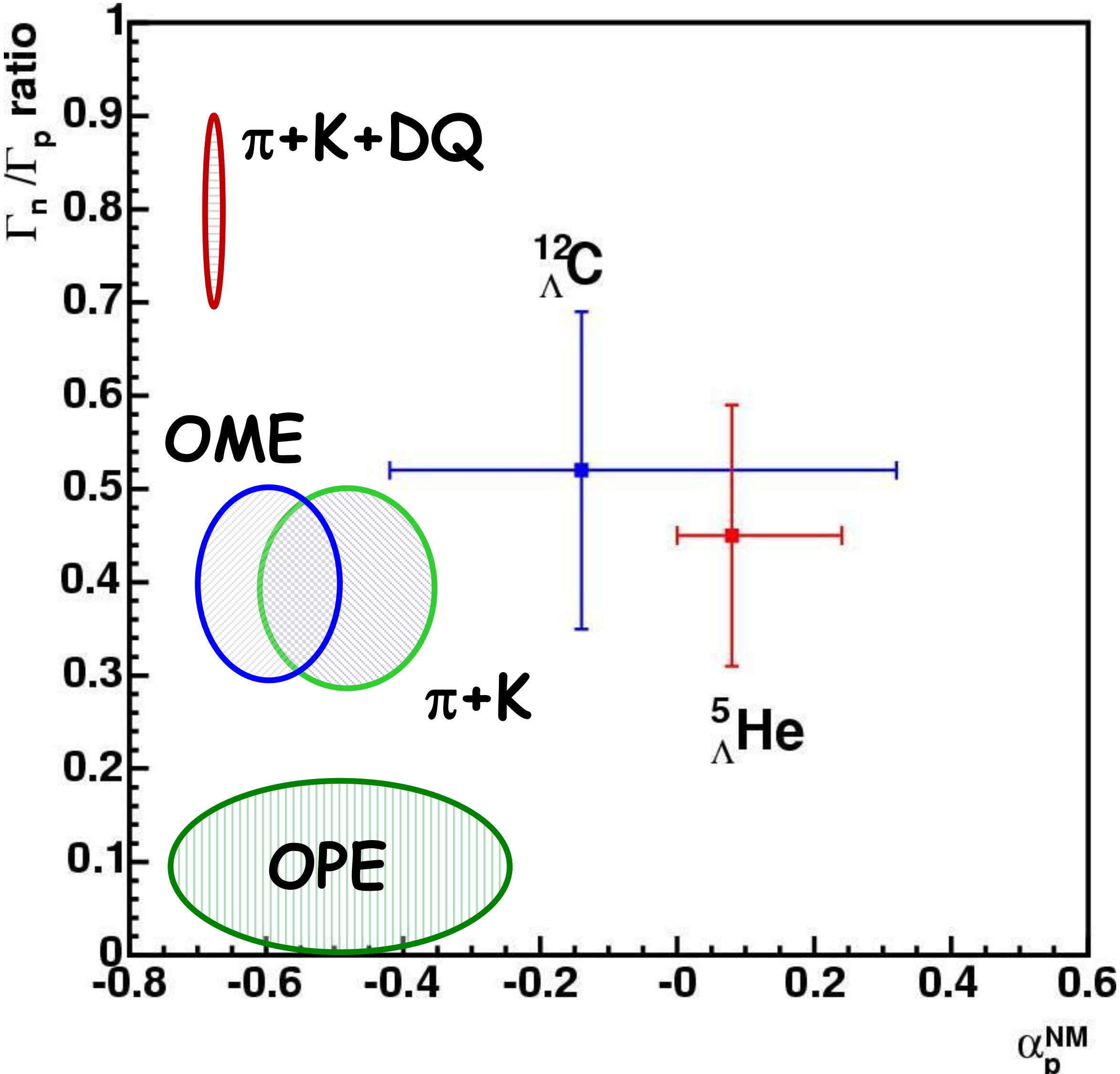
Proposal

- Main Objects :
  - To measure the 3-body decay process, namely Γ_{2N}, the 2-nucleon induced NMWD in 10% error level
  - To measure all decay widths of NMWD in 10% error level.
- Reaction : $^{12}C(\pi^+,K^+)$ at P_π=1.05 GeV/c with $10^7\pi$/spill.
- Spectrometer & Detector :
  - SKS Kaon spectrometer; 100 mSr.
  - Coincidence Detectors; 2π Sr
- Yield Estimation and Expected Results:
  - $N_{nbb}(nn)$ ~ 300 (23)
  - $N_{nbb}(np)$ ~ 375 (12)
  - $N_{bb}(pp)$ ~ 90 (8)
  - N(NNN) ~ (125) (5)

Asymmetry parameter of $^{12}{}_{\Lambda}C$, $^{11}{}_{\Lambda}B$



Comparison with recent results



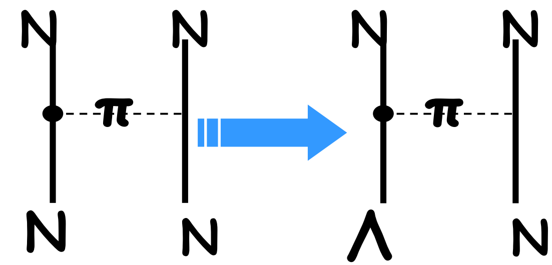
- ✓ Theoretical models, such as π+K and OME, can explain Γ_n/Γ_p ratio, but not a^{NM}.

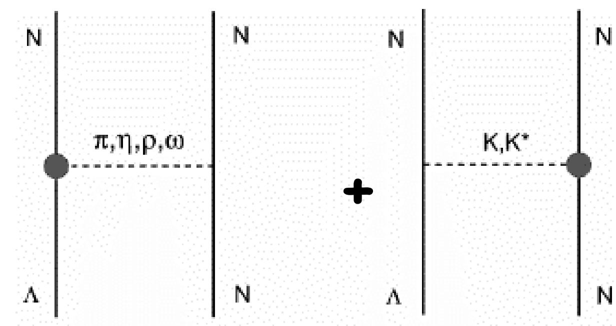
Models of ΛN→NN interaction (I)

1. **Meson Exchange Models;**

   ΔI=1/2 rule adopted.

- OPE model(1967) ; V_π by Adams.
  → Γ_{NM} OK, but very small Γ_n/Γ_p.
- Heavy meson exchange(HME) model;
  Mckeller/Gibson, Dubach, Oset, Ramos,. .
  - Extended to heavier Mesons, π, K, ρ, ω, . .
  - ΔI=1/2 rule adopted.
  - Found that π and K are the main players.
  - No drastic effect with heavyier Mesons.



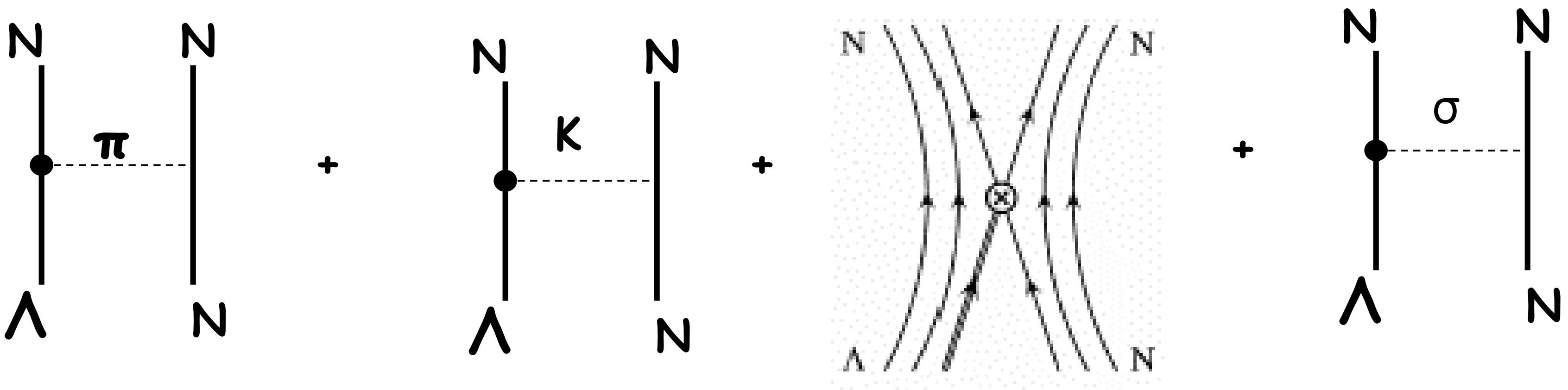


$^{12}_{\Lambda}C$	Γ_{nm}	Γ_n/Γ_p	a_{NM}
π K 2π/σ 2π ω (Jido)	0.77	0.53	
π ρ K K* ω η (Ramos, Parr)	0.55−0.73	0.29−0.34	−0.73
(Barbero et al.)	1.17	0.21	−0.53
Experiment	0.929±0.027±0.016 [29]	0.51±0.13±0.04 [28]	$-0.14\pm0.28\pm^{0.18}_{0.00}$ [30]

Models of ΛN→NN interaction (II)

2. Hybrid quark-hadron Model

- 6-q Bag model + V_π; Cheung et al.,
- Direct Quark(DQ) Mechanism; V_{DQ} + V_{ME}
  - $\Delta I=1/2$, $3/2$ both allowed.
  - Oka, Sasaki, . .
  - considerable improvement on Γ_n/Γ_p
- Recently Sigma exchange term (OSE) added.



$^5_\Lambda$He (Sasaki)	Γ_{nm}	Γ_n/Γ_p	α_{NM}
π	0.372	0.134	−0.441
π+ K	0.304	0.466	−0.362
π+ K+ DQ	0.523	0.720	−0.678
π+ K+ σ	0.392	0.548	0.571
π+ K+ σ + DQ	0.392	0.449	0.219
Experiment	0.411±0.023±0.006[29]	0.45±0.11±0.03[27]	0.08±0.08±0.08 0.00 [30]

1. π + K + DQ ; DQ model applied to light HN.

2. π + K reproduces underestimated, Γn/Γp well reproduced and the asymmetry parameter quite different from the small experimental value.

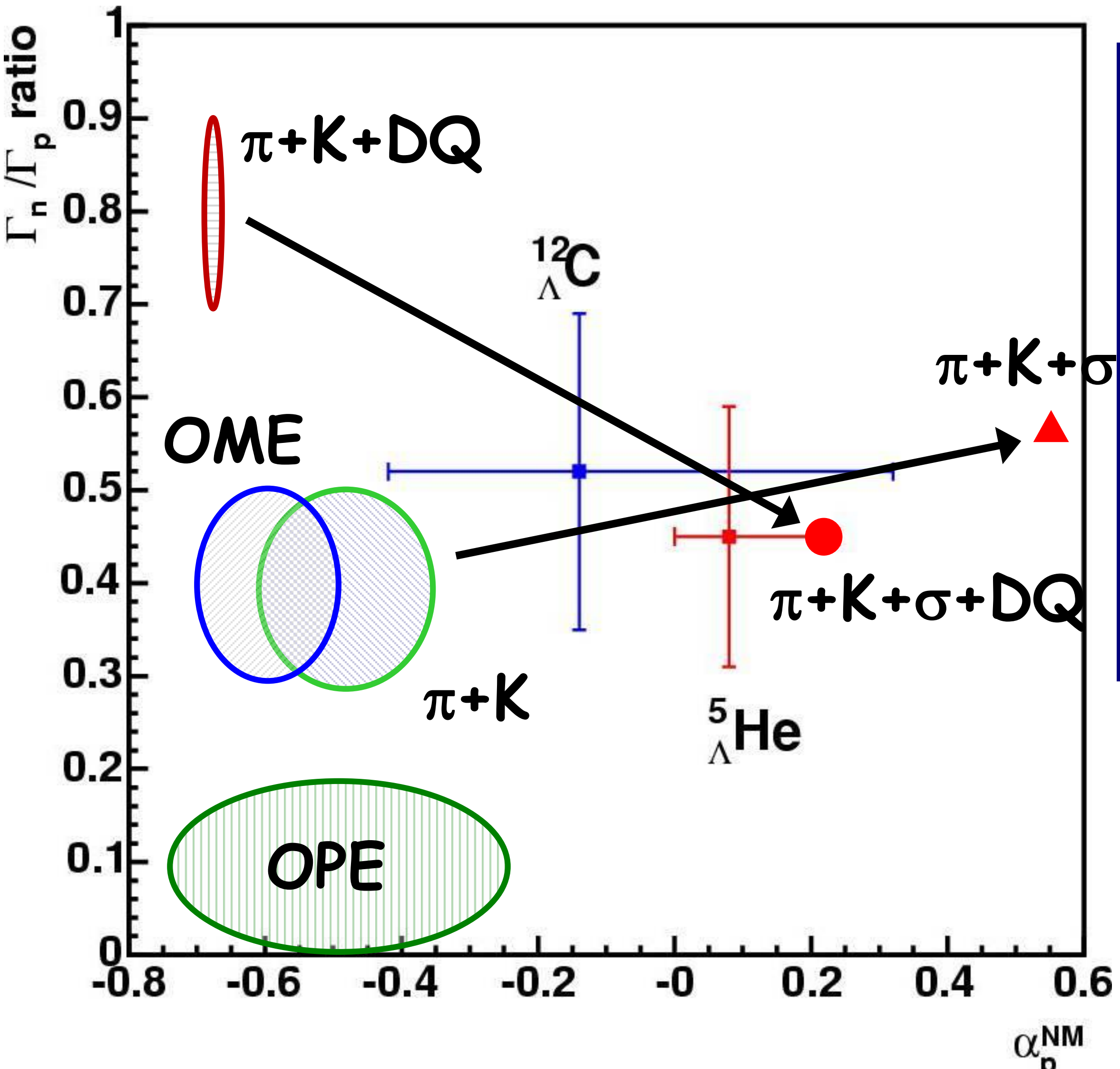
3. DQ contribute to Γnm significantly. However, the a become even worse.

4. σ included; Now it explains all the features .

5. HME and DQ reproduces similar Γn/Γp and anm, but of different isospin str.

6. One has to test the ΔI=1/2 rule experimentally. (J-PARC E22)

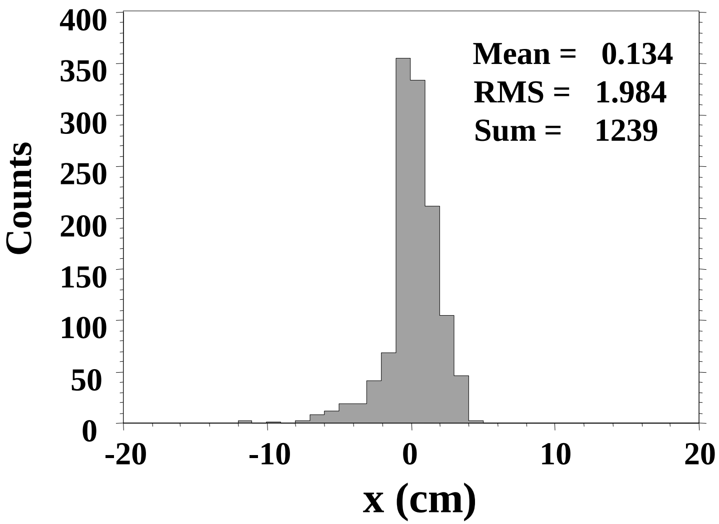
Comparison with recent results

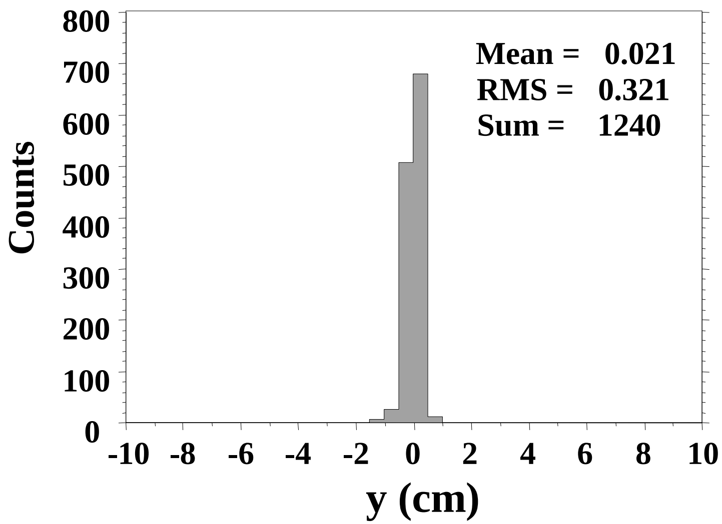


- ✓ Theoretical models, such as π+K and OME, can explain Γ_n/Γ_p ratio, but not a^{NM}.

At present, Only π+K+σ+DQ model reproduce both Γ_n/Γ_p and a^{NM}.

Kaon Beam Profile at FF of K1.8





K1.8 Performance Summary

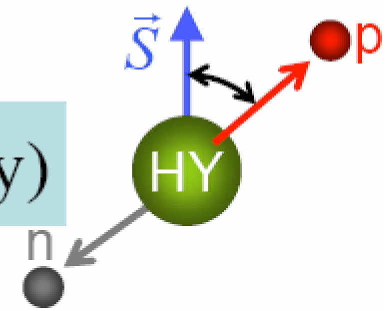
051011

	K1.8 (50 GeV-15μA)	(30 GeV-9μA)
Max. Mom. (GeV/c)	2	
Length (m)	45.853	
Acceptance (msr.%)	1.4	
$K^-(\pi)$ Intensity (ppp)#		
1.8 GeV/c	6.6E+06	1.4E+06
1.5 GeV/c	2.7E+06	0.54E+06
1.1 GeV/c	0.38E+06	0.08E+06
Electro-static Separator	750kV/10cm 6m×2	
Single Rate @ MS2 @ 1.8 GeV/c$	＞33E+06	＞8E+06
K^-/π^- @ FF @ 1.8 GeV/c	8	6.9
X/Y(rms) size @ FF (mm)	19.8/3.2	

using Sanford-Wang formula, assuming 1pulse=3.53s (0.7s flat top)

$ Signle Rate Estimation for Trigger/Tracking Devices to be placed just after MS

- A new puzzle arises
  - Decay asymmetry inconsistent



$$\alpha_p^{NM} \approx 0 \text{ (Exp.)} \Leftrightarrow \alpha_p^{NM} \approx -0.7 \text{ (Theory)}$$

Asymmetry written by amplitudes

$${}^1S_0 \times {}^3S_1 \qquad {}^3S_1 \times {}^3S_1$$

$$\alpha_p^{NM} = \frac{2\sqrt{3}Re[-ae^* + b(c - \sqrt{2}d)^*/\sqrt{3} - f(\sqrt{2}c + d)^*]}{\{a^2 + b^2 + 3(c^2 + d^2 + e^2 + f^2)\}}$$

Large contribution ?

initial	final	amplitude	isospin	parity
$^1S_0$	$^1S_0$	*a*	1	no
	$^3P_0$	*b*	1	yes
$^3S_1$	$^1S_1$	*c*	0	no
	$^3D_1$	*d*	0	no
	$^1P_1$	*e*	0	yes
	$^3P_1$	*f*	1	yes

assuming initial S state

a, b: ${}^1S_0(I=1)$

c, d, e: ${}^3S_1(I=0)$

f: ${}^3S_1(I=1)$

Non-Mesonic Weak Decay (NMWD) & Issues

1. B-B Weak Interaction ;

$$\Lambda + N \rightarrow N + N \quad (\Delta S=1 \text{ B-B W.I. })$$

- So far the only means of exploring this weak interaction.

2. Γ_n ,Γ_p measurement; Γ_n/Γ_p puzzle problem.

3. Asymmetry ; The current concern.

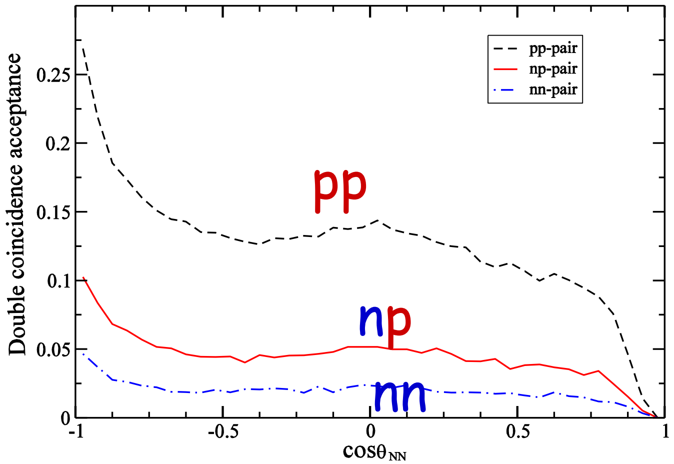
4. $\Delta I=1/2$ Rule ; JPARC-PS E22

5. The 3-body interaction process, 2N-NMWD: JPARC E18

   - Not experimentally identified yet, though predicted to be a significant component of NMWD.

Detection Efficiency of nucleon pairs and Expected Yields

	E508	E18
N_π	2×10^{12}	5×10^{12}
dN_π/dt	4×10^6/spill	10^7/spill
T(arget)	4.3g/cm^2	4.3g/cm^2
N_{HY}(g.s.)	~62K	2.5*62K
Y_{bb} (np)	116	~1160
Y_{bb} (nn)	43	~430
Y_{bb} (pp)	8	~90
Y_{nbb} (np)	12	~375
Y_{nbb} (nn)	23	~300
Y_{nnn}	3	(~45)
Y_{nnp}	2	(~80)
$\sigma_{stat}(\Gamma_n/\Gamma_p)$	28%	~10%
$\sigma_{stat}(\Gamma_{2N})$		~10%



bb: back-to-back
nbb: non-back-to-back