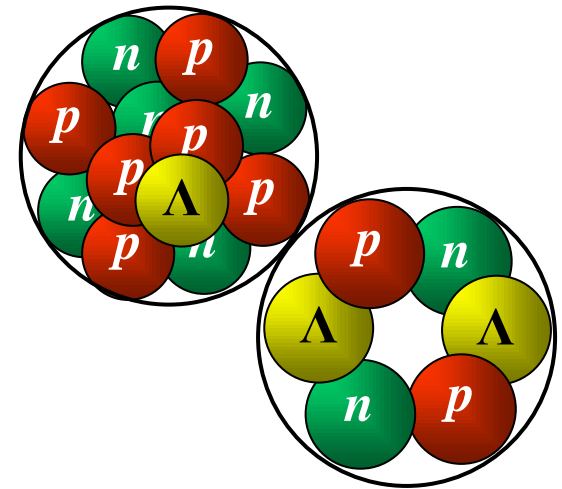


FINUDA: latest results and inheritance



7th Italy - Japan Symposium
on Nuclear Physics



November 20-23, 2012, Milano, Italy



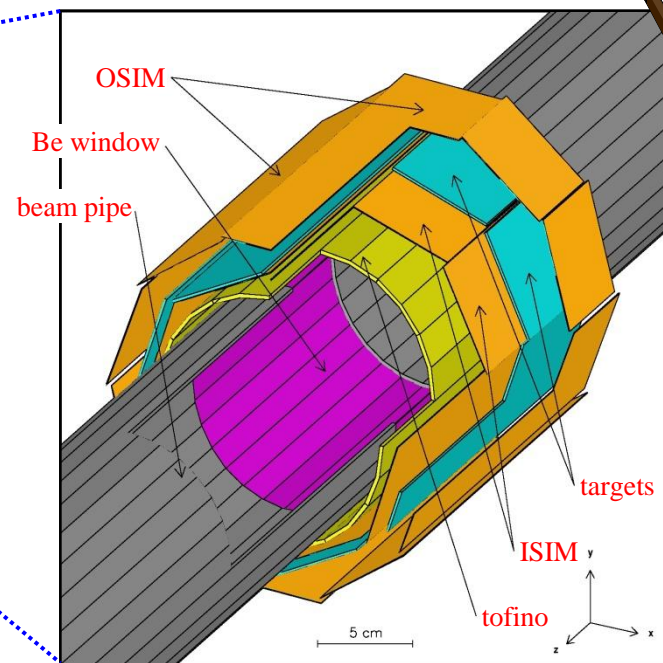
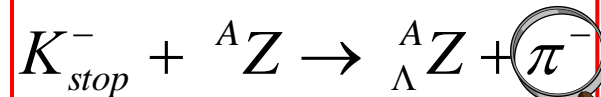
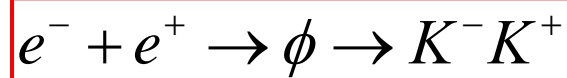
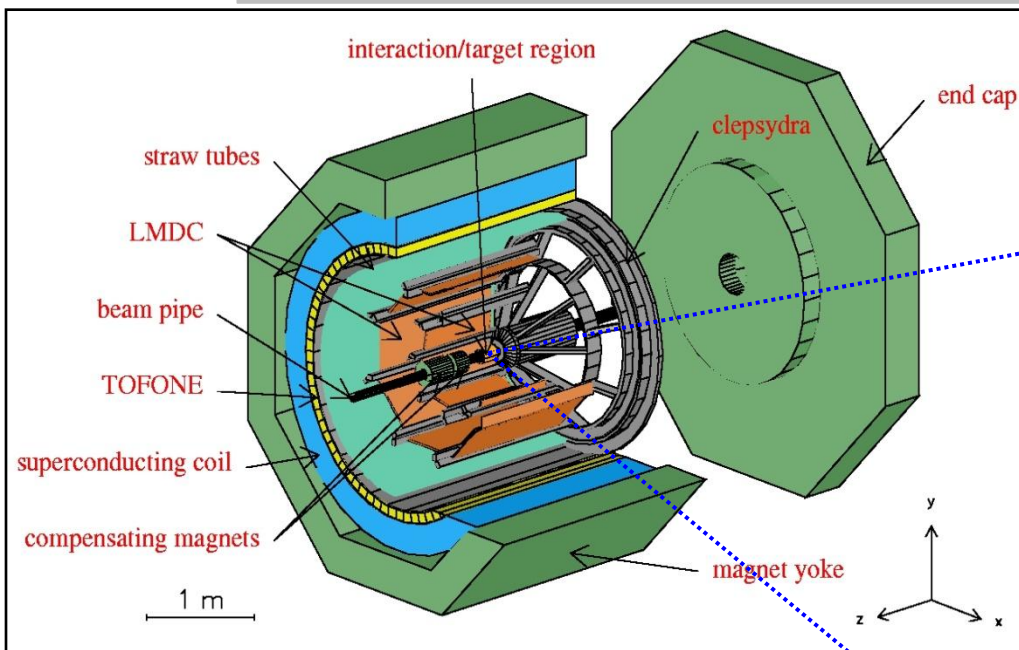
Alessandro Feliciello

I.N.F.N. - Sezione di Torino

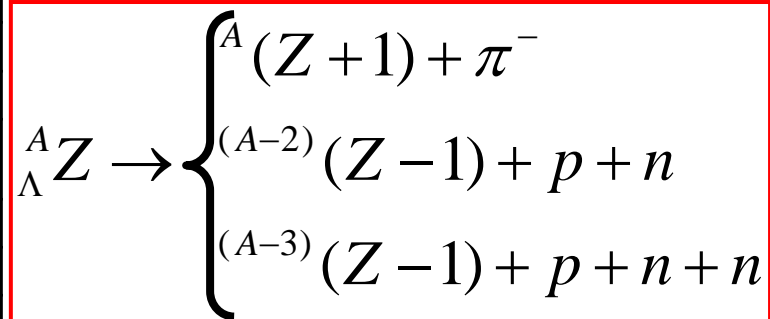


Outline

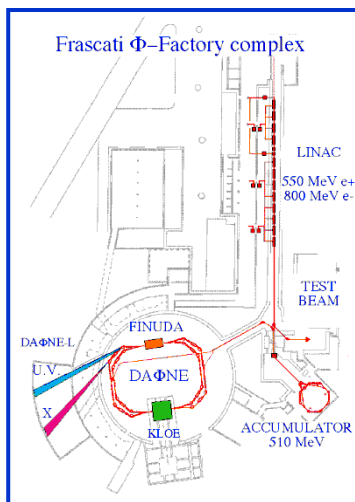
- ❖ The **FINUDA** experiment at **DAΦNE**
- ❖ hypernuclear physics results:
 - 👉 ${}^6\text{H}_\Lambda$ **neutron-rich** hypernucleus
 - 👉 **2 \mathcal{N} induced** hypernucleus weak **decay**
- ❖ Looking to the future:
 - 🗿 the **INFN ULYSSES** initiative @ **J-PARC**



energy	510 MeV
luminosity	$5 \cdot 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$
σ_x (rms)	2.11 mm
σ_y (rms)	0.021 mm
σ_z (rms)	35 mm
bunch length	30 mm
crossing angle	12.5 mrad
frequency (max)	368.25 MHz
bunch/ring	up to 120
part./bunch	$8.9 \cdot 10^{10}$
current/ring	5.2 A (max)

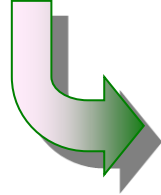


Alessandro Feliciello / 7th Japan-Italy Symposium on Nuclear Physics, Milano, Italy, November 20-23, 2012.



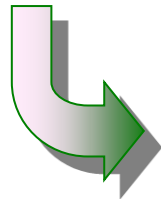


- very thin nuclear targets ($0.1 \div 0.3 \text{ g/cm}^2$)



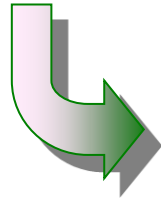
high resolution spectroscopy

- coincidence measurement with large acceptance



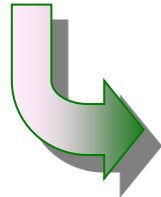
decay mode study

- event by event K^+ tagging



continuous energy and rate calibration

- irradiation of different targets in the same run

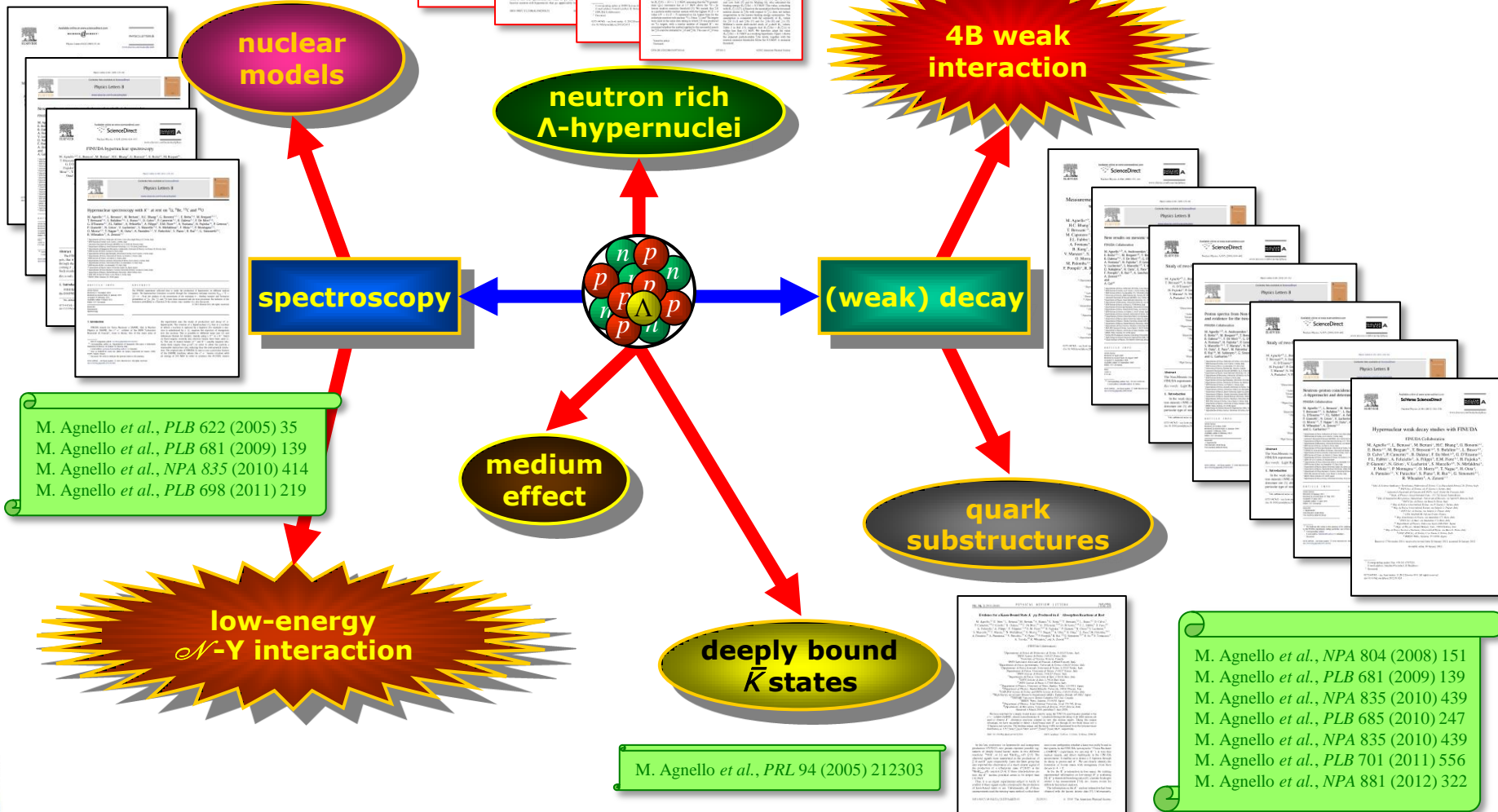


systematic error reduction

Physics output ($S = -1$)



M. Agnello *et al.*, *PLB* 640 (2006) 145
M. Agnello *et al.*, *PRL* 108 (2012) 042501
M. Agnello *et al.*, *NPA* 881 (2012) 269
M. Agnello *et al.*, *PRC* 86 (2012) 057301



nuclear models

neutron rich Λ -hypernuclei

4B weak interaction

spectroscopy

(weak) decay

medium effect

quark substructures

low-energy N - Υ interaction

deeply bound \bar{K} states

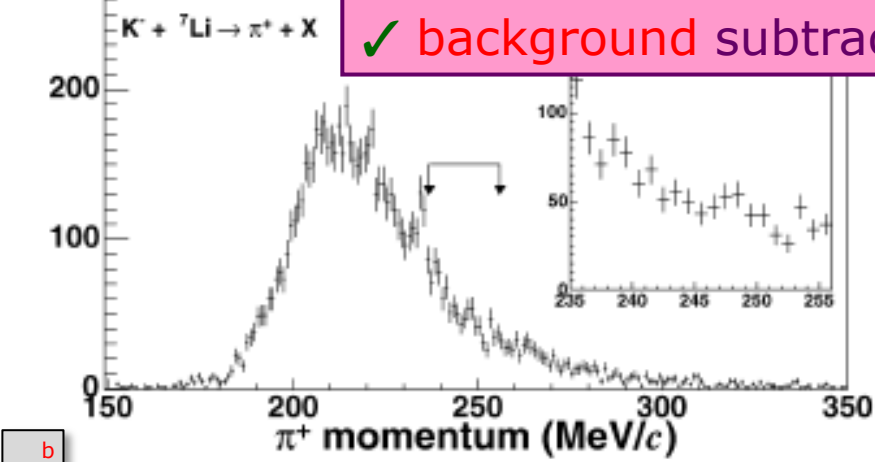
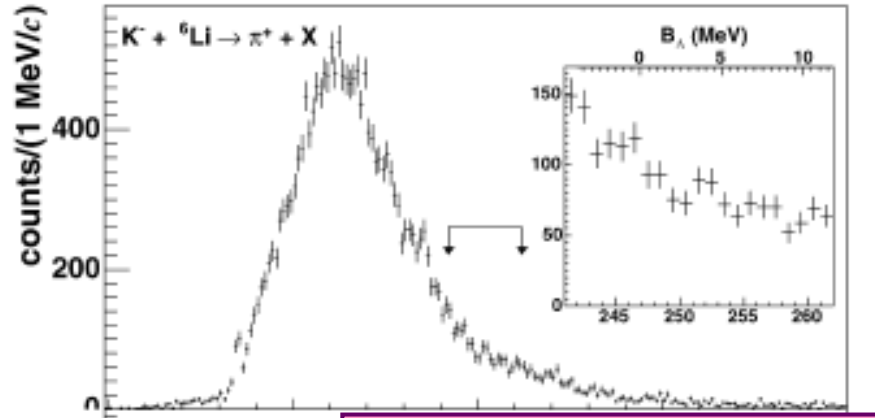
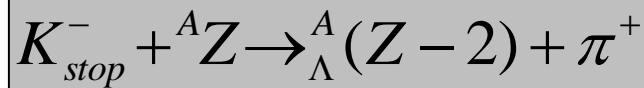
M. Agnello *et al.*, *PLB* 622 (2005) 35
M. Agnello *et al.*, *PLB* 681 (2009) 139
M. Agnello *et al.*, *NPA* 835 (2010) 414
M. Agnello *et al.*, *PLB* 698 (2011) 219

M. Agnello *et al.*, *PRL* 94 (2005) 212303

M. Agnello *et al.*, *NPA* 804 (2008) 151
M. Agnello *et al.*, *PLB* 681 (2009) 139
M. Agnello *et al.*, *NPA* 835 (2010) 439
M. Agnello *et al.*, *PLB* 685 (2010) 247
M. Agnello *et al.*, *NPA* 835 (2010) 439
M. Agnello *et al.*, *PLB* 701 (2011) 556
M. Agnello *et al.*, *NPA* 881 (2012) 322

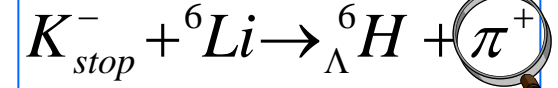


The background issue

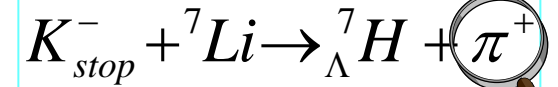
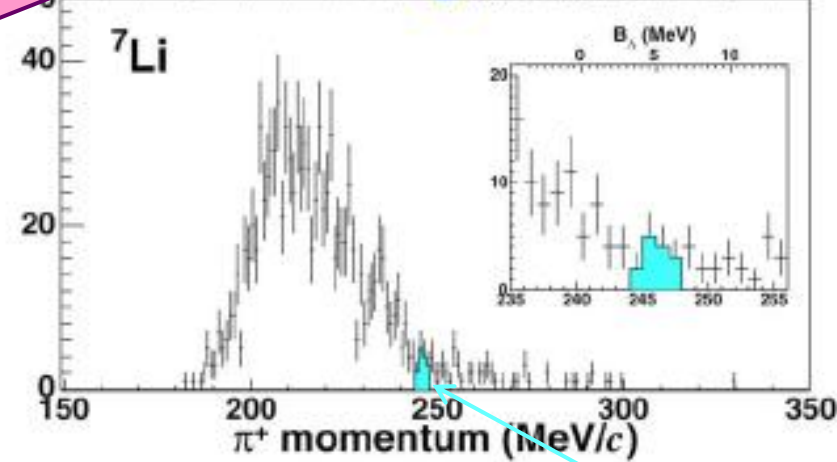
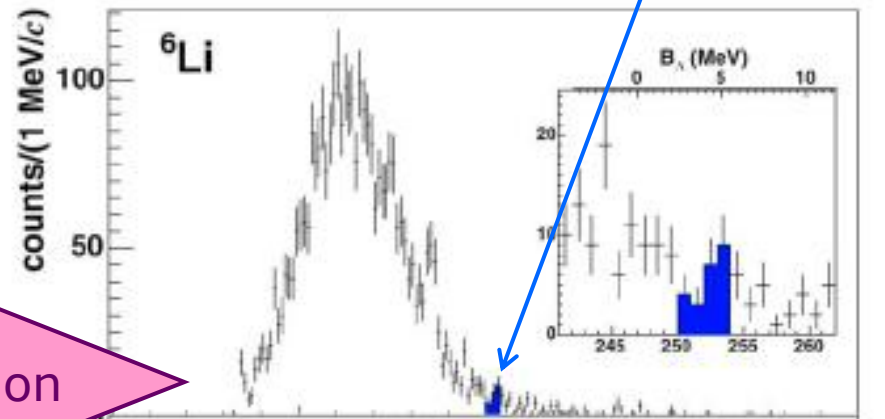


✓ background subtraction

- $K^- + p \rightarrow \Sigma^+ + \pi^-$
↳ $n + \pi^+$ ($\sim 130 < p_{\pi^+} < \sim 250$ MeV/c)
- $K^- + pp \rightarrow \Sigma^+ + n$
↳ $n + \pi^+$ ($\sim 100 < p_{\pi^+} < \sim 320$ MeV/c)



${}^6_{\Lambda}\text{H}({}^6\text{Li}) : u.l. = (2.5 \pm 1.4) \cdot 10^{-5} / K_{stop}^- @ 90\% c.l.$



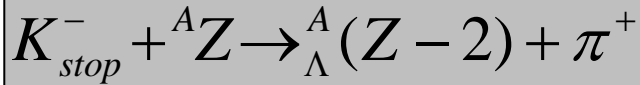
$\mathcal{L}_{int} \approx 220 \text{ pb}^{-1}$

M. Agnello et al., PLB 640 (2006) 145



background

The status of the art



- | | | | |
|---|--|--------|---------------|
| • $K^- + p \rightarrow \pi^0 + \Lambda,$ | $\pi^0 + p \rightarrow \pi^+ + n:$ | 2-step | (S-EX + C-EX) |
| • $K^- + p \rightarrow \bar{K}^0 + n,$ | $\bar{K}^0 + p \rightarrow \Lambda + \pi^+:$ | 2-step | (C-EX + S-EX) |
| • $K^- + p \rightarrow \pi^+ + \Sigma^-,$ | $\Sigma^- + p \rightarrow \Lambda + n:$ | 1-step | (S-EX) |

experimental results

KEK

INFN-LNF

- | | |
|--|--|
| • ${}_{\Lambda}^9 He({}^9 Be): u.l. = 2.3 \cdot 10^{-4} / K_{stop}^-$ | • ${}_{\Lambda}^6 H({}^6 Li): u.l. = (2.5 \pm 1.4) \cdot 10^{-5} / K_{stop}^-$ |
| • ${}_{\Lambda}^{12} Be({}^{12} C): u.l. = 6.1 \cdot 10^{-5} / K_{stop}^-$ | • ${}_{\Lambda}^7 H({}^7 Li): u.l. = (4.5 \pm 1.4) \cdot 10^{-5} / K_{stop}^-$ |
| • ${}_{\Lambda}^{16} C({}^{16} O): u.l. = 6.2 \cdot 10^{-5} / K_{stop}^-$ | • ${}_{\Lambda}^{12} Be({}^{12} C): u.l. = (2.0 \pm 0.4) \cdot 10^{-5} / K_{stop}^-$ |

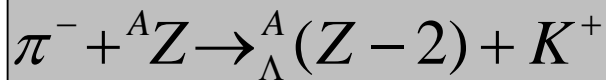
K. Kubota *et al.*, *NPA* 602 (1996) 327

M. Agnello *et al.*, *PLB* 640 (2006) 145

theoretical predictions

$$10^{-6} \div 10^{-7} / K_{stop}^-$$

T.Y. Tretyakova *et al.*, *NPA* 691 (2001) 51c



- | | | | |
|---|---|--------|-------------|
| • $\pi^- + p \rightarrow \pi^0 + n,$ | $\pi^0 + p \rightarrow K^+ + \Lambda:$ | 2-step | (C-EX + AP) |
| • $\pi^- + p \rightarrow K^0 + \Lambda,$ | $K^0 + p \rightarrow K^+ + n:$ | 2-step | (AP + C-EX) |
| • $\pi^- + p \rightarrow K^+ + \Sigma^-,$ | $\Sigma^- + p \rightarrow \Lambda + n:$ | 1-step | (AP) |

experimental results

KEK

theoretical predictions

$${}_{\Lambda}^{10} Li({}^{10} B): d\sigma/d\Omega = 11.3 \pm 1.9 \text{ nb/sr}$$

P.K. Saha *et al.*, *PRL* 94 (2005) 052502

T.Y. Tretyakova *et al.*, *PAT* 66 (2003) 1681

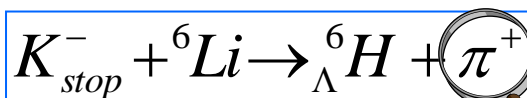
The new NRH search strategy



$\Delta\mathcal{L}_{int} \approx 960 \text{ pb}^{-1}$



coincidence measurements



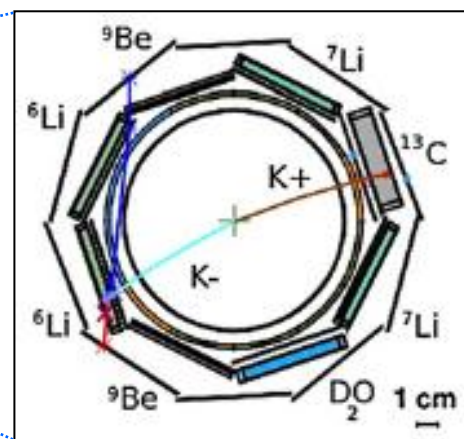
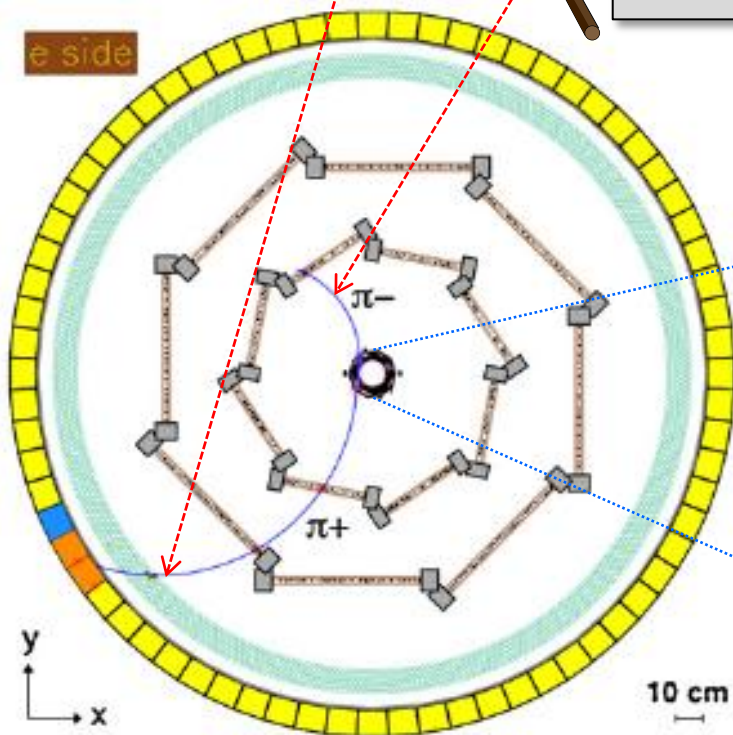
double C-EX
p $\sim 252 \text{ MeV}/c$



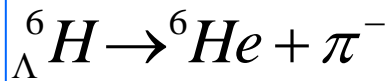
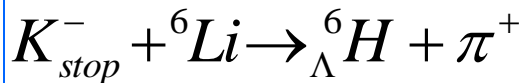
n.m. decay
p $\sim 134 \text{ MeV}/c$

apparatus capabilities:

- selective trigger (based on fast scintillator detectors)
- precise K^- vertex identification $< 1 \text{ mm}^3$ (PID + spatial resolution + K^- tagging)
- π , K , p , d , ... separation (OSIM & LMDC dE/dx)
- high momentum resolution
6‰ FWHM π^- @ 270 MeV/c
6‰ FWHM π^- @ 110 MeV/c (tracker performance + He bag + thin target)



Analysis technique

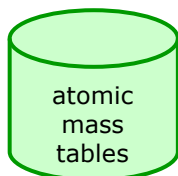


$(\tau({}^6\text{He}) \approx 801 \text{ ms})$

if ${}^6\text{H}_{\Lambda}$ is a **stable** system \Rightarrow 2 **independent** two-body **reactions**:
decay **at rest**

$$M(K^-) + 3M(p) + 3M(n) - B({}^6\text{Li}) = M({}^6_{\Lambda}\text{H}) + T({}^6_{\Lambda}\text{H}) + M(\pi^+) + T(\pi^+)$$

$$M({}^6_{\Lambda}\text{H}) = 2M(p) + 4M(n) - B({}^6\text{He}) + T({}^6\text{He}) + M(\pi^-) + T(\pi^-)$$



$$\sqrt{M^2({}^6\text{He}) + p^2(\pi^-)} - M({}^6\text{He})$$

$$\sqrt{M^2({}^6_{\Lambda}\text{H}) + p^2(\pi^+)} - M({}^6_{\Lambda}\text{H})$$

$$M({}^6_{\Lambda}\text{H}) = M({}^5\text{H}) + M(\Lambda) - B(\Lambda)$$

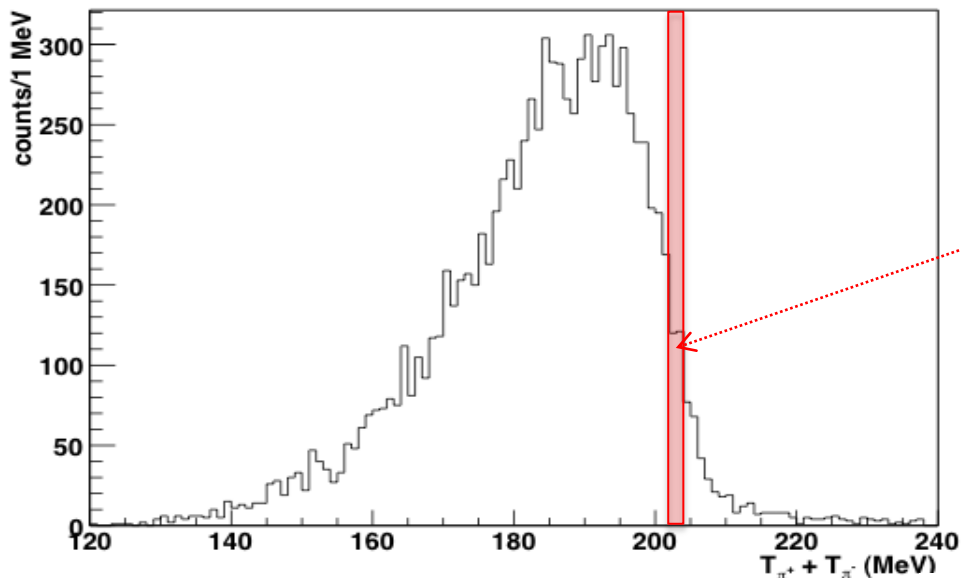
$$T(\pi^+) + T(\pi^-) = M(K^-) + M(p) - M(n) - 2M(\pi) - B({}^6\text{Li}) + B({}^6\text{He}) - T({}^6\text{He}) - T({}^6_{\Lambda}\text{H})$$

$$= 203.0 \pm 1.3 \text{ MeV}$$

(203.5 \div 203.3 MeV with $B_{\Lambda} = 0 \div 6 \text{ MeV}$)

cut on $T(\pi^+) + T(\pi^-)$: 202 \div 204 MeV

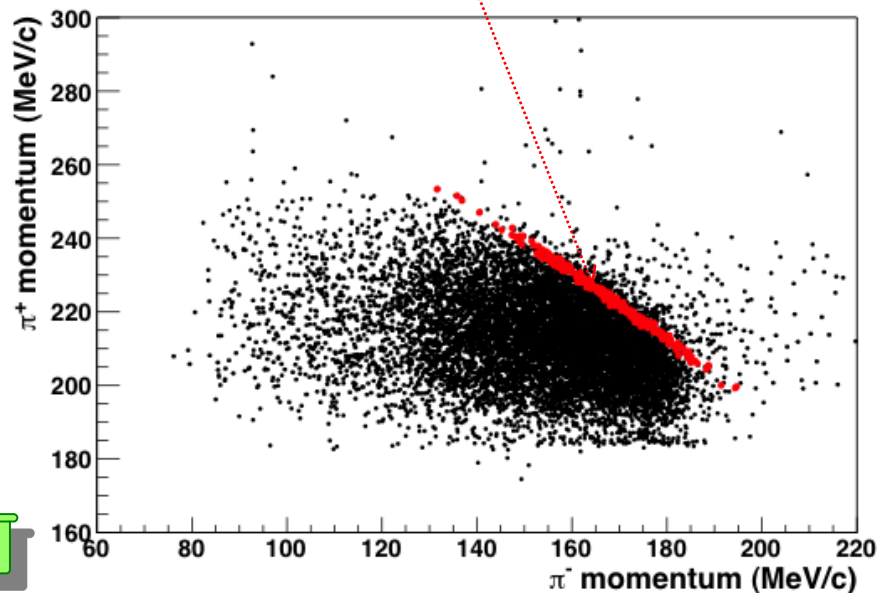
Data selection



$T(\pi^+) + T(\pi^-)$: 202 ÷ 204 MeV

absolute energy scale:

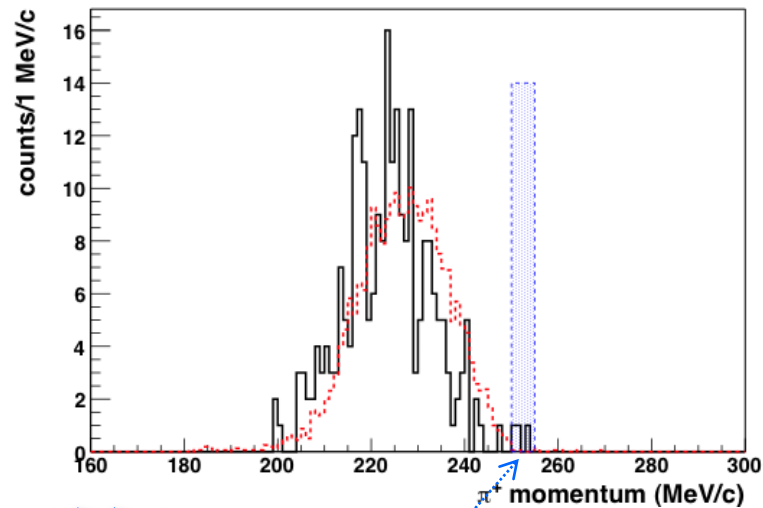
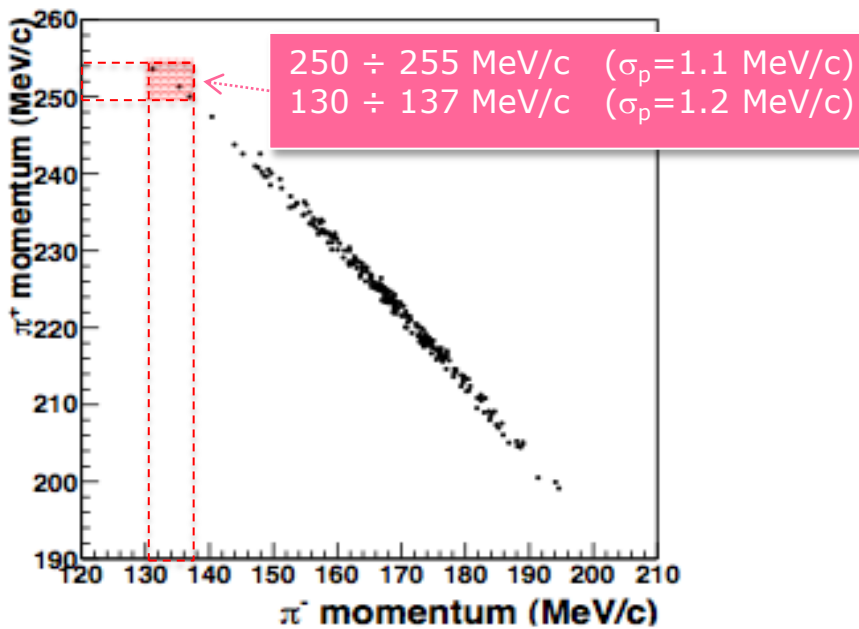
- μ^+ (235.6 MeV/c) from $K_{\mu 2}$
 $\Delta_p < 0.12$ MeV/c
 - π^- (132.8 MeV/c) from ${}^4\text{H}_\Lambda$
 $\Delta_p < 0.2$ MeV/c
- } systematic errors
- $\sigma T_{\text{sys}} = 0.17$ MeV
- $\sigma T(\pi^+) = 0.96$ MeV, $\sigma T(\pi^-) = 0.84$ MeV
 - $\sigma T_{\text{exp}} = 1.3$ MeV
 - $\sigma T = 1.3$ MeV



FINUDA Coll. And A. Gal, *NPA* 881 (2012) 269



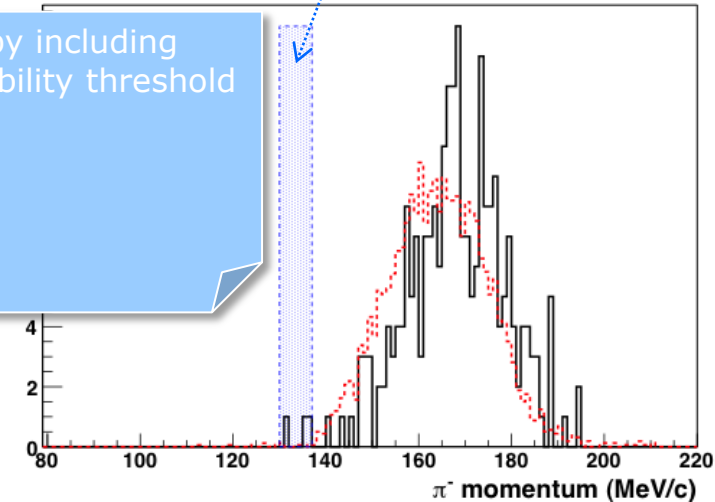
Data selection



3 candidate events
 (out of $2.7 \cdot 10^7$ stopped K^- event)

${}^5\text{H} + \Lambda$		0.0 MeV
${}^3\text{H} + 2n + \Lambda$		-1.7 MeV
${}^4\text{H}_\Lambda + 2n$		-3.74 MeV

selection range fixed by including ${}^6\text{H}_\Lambda$ lowest particle stability threshold
 $p_{\pi^+} = 251.9$ MeV/c
 $p_{\pi^-} = 135.6$ MeV/c
 $B_\Lambda = 1.5 \div 6$ MeV



Production rate



background sources

- accidentals: π^+ (250 \div 255 MeV/c) and π^- (130 \div 137 MeV/c) 0.27 ± 0.27 ev. BGD2
- $K_{stop}^- + {}^6\text{Li} \rightarrow \Sigma^+ + \pi^- + {}^4\text{He} + n$ 0.16 ± 0.07 ev. BGD1
 $\hookrightarrow n + \pi^+$
 end point ~ 190 MeV/c
 end point ~ 282 MeV/c
- $K_{stop}^- + {}^6\text{Li} \rightarrow {}^4_\Lambda\text{H} + n + n + \pi^+$ negligible
 $\hookrightarrow {}^4\text{He} + \pi^-$
 end point ~ 252 MeV/c
 $p(\pi^-) = 133$ MeV/c

production rate

- total background on ${}^6\text{Li}$: $\text{BGD1} + \text{BGD2} = 0.43 \pm 0.28$ ev.
- Poisson statistics: 3 events **DO NOT belong** to pure background @ **C.L. = 99%**

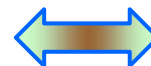
$$R * BR(\pi^-) = (3 - \text{BGD1} - \text{BGD2}) / [\varepsilon(\pi^-)\varepsilon(\pi^+)(n. K_{stop}^- \text{ on } {}^6\text{Li})]$$

$$BR(\pi^-) {}^4_\Lambda\text{H} = 0.49$$

$$R * BR(\pi^-) = (2.9 \pm 2.0) 10^{-6} / K_{stop}^-$$

H. Tamura *et al.*, *PRC* 40 (1989) R479

$$R = (5.9 \pm 4.0) 10^{-6} / K_{stop}^-$$



$$(2.5 \pm 0.5^{+0.4}_{-0.1}) \cdot 10^{-5} / K_{stop}^-$$

FINUDA Coll. and A. Gal, *PRL* 108 (2012) 042501

M. Agnello *et al.*, *PLB* 640 (2006) 145



Kinematics and binding energy

T_{tot} (MeV)	p_{π^+} (MeV/c)	p_{π^-} (MeV/c)	$M({}_{\Lambda}^6\text{H})$ prod. (MeV)	$M({}_{\Lambda}^6\text{H})$ decay (MeV)	$M({}_{\Lambda}^6\text{H})$ mean (MeV)	$\Delta M({}_{\Lambda}^6\text{H})$ (MeV)
202.6 ± 1.3	251.3 ± 1.1	135.1 ± 1.2	5802.33 ± 0.96	5801.41 ± 0.84	5801.87 ± 0.96	0.92 ± 1.28
202.7 ± 1.3	250.1 ± 1.1	136.9 ± 1.2	5803.45 ± 0.96	5802.73 ± 0.84	5803.09 ± 0.96	0.72 ± 1.28
202.1 ± 1.3	253.8 ± 1.1	131.2 ± 1.2	5799.97 ± 0.96	5798.66 ± 0.84	5799.32 ± 0.96	1.31 ± 1.28

$(N + Y) / Z({}_{\Lambda}^6\text{H}) = 5 \gg N / Z({}^8\text{He}) = 3$

formation mass values systematically higher than the ones from decay

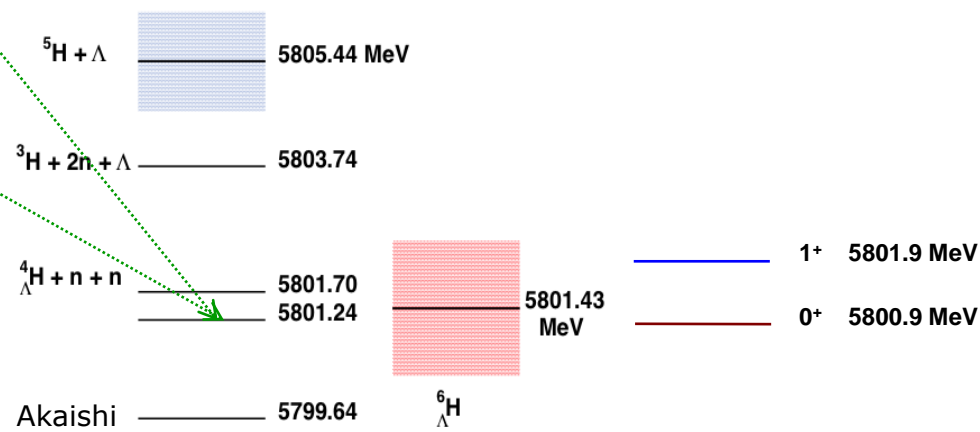
(0.98 ± 0.74) MeV
excited states production

theoretical predictions

- $B_{\Lambda} = 4.2$ MeV (R.H. Dalitz and R. Levi Setti, *NC* 30 (1963) 489)
- $B_{\Lambda} = 4.2$ MeV (L. Majling, *NPA* 585 (1995) 211c)

$\bar{M} = (5801.4 \pm 1.1)$ MeV

${}^4_{\Lambda}\text{He}$ 2.39 Λ	${}^6_{\Lambda}\text{He}$ 3.12 Λ	${}^8_{\Lambda}\text{He}$ 4.18 n 0.17 xxx	${}^7_{\Lambda}\text{He}$ 5.23 n 2.92 halo	${}^8_{\Lambda}\text{He}$ 7.16 n 1.49 xxx	${}^9_{\Lambda}\text{He}$ (8.5) n 3.9 halo
${}^3_{\Lambda}\text{H}$ 0.13 Λ	${}^4_{\Lambda}\text{H}$ 2.04 Λ	${}^5_{\Lambda}\text{H}$ (3.1) π -1.8 xxx	${}^6_{\Lambda}\text{H}$ (4.2) $2n$ -5 xxx	${}^7_{\Lambda}\text{H}$ (5.2) $3n$ 0.4 xxx	



$B_{\Lambda} = (4.0 \pm 1.1)$ MeV (${}^5\text{H} + \Lambda$)

~~$B_{\Lambda} = 5.8$ MeV (${}^5\text{H} + \Lambda$)
 $\Lambda\text{NN force} \equiv 1.4$ MeV~~

FINUDA Coll. and A. Gal, *PRL* 108 (2012) 042501
FINUDA Coll. and A. Gal., *NPA* 881 (2012) 269

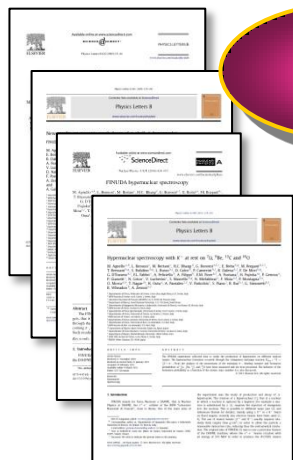
nrh prod. rate: $\sim 10^{-2}$ hyp. prod. rate in (K^-_{stop}, π^-)



Physics output ($S = -1$)



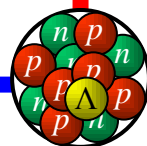
M. Agnello *et al.*, *PLB* 640 (2006) 145
 M. Agnello *et al.*, *PRL* 108 (2012) 042501
 M. Agnello *et al.*, *NPA* 881 (2012) 269
 M. Agnello *et al.*, *PRC* 86 (2012) 057301



nuclear models

spectroscopy

neutron rich Λ -hypernuclei



(weak) decay

4B weak interaction



medium effect

quark substructures

M. Agnello *et al.*, *PLB* 622 (2005) 35
 M. Agnello *et al.*, *PLB* 681 (2009) 139
 M. Agnello *et al.*, *NPA* 835 (2010) 414
 M. Agnello *et al.*, *PLB* 698 (2011) 219

low-energy N - Y interaction

deeply bound \bar{K} states

M. Agnello *et al.*, *PRL* 94 (2005) 212303



M. Agnello *et al.*, *NPA* 804 (2008) 151
 M. Agnello *et al.*, *PLB* 681 (2009) 139
 M. Agnello *et al.*, *NPA* 835 (2010) 439
 M. Agnello *et al.*, *PLB* 685 (2010) 247
 M. Agnello *et al.*, *NPA* 835 (2010) 439
 M. Agnello *et al.*, *PLB* 701 (2011) 556
 M. Agnello *et al.*, *NPA* 881 (2012) 322

$2\mathcal{N}$ induced weak decay

❖ **relevance** first pointed out by:

W.M. Alberico *et al.*, *PLB* 256 (1991) 134

❖ **key role** in data interpretation



many theoretical **predictions**

E. Bauer
G. Garbarino
A. Parreño
A. Ramos

❖ importance of the effect: $\sim 20-25\%$ of the total **NMWD width**

❖ several **experimental evidences**, but **indirect**

Ref.	Γ_2/Γ_Λ	Γ_2/Γ_{NM}	Notes
BNL-E788 [47]		≤ 0.24	${}^4_\Lambda\text{He}$, n and p spectra
KEK-E508 [48]	0.27 ± 0.13	0.29 ± 0.13	${}^{12}_\Lambda\text{C}$, nn and np spectra
FINUDA [8]		0.24 ± 0.10	$A = 5-16$, p spectra
FINUDA [9]		$0.21 \pm 0.07_{\text{stat}} \begin{smallmatrix} +0.03_{\text{sys}} \\ -0.02_{\text{sys}} \end{smallmatrix}$	$A = 5-16$, np spectra

consistent within large errors

E. Botta, T. Bressani, G. Garbarino, *EPJA* 48 (2012) 21

"smoking gun" evidence missing!

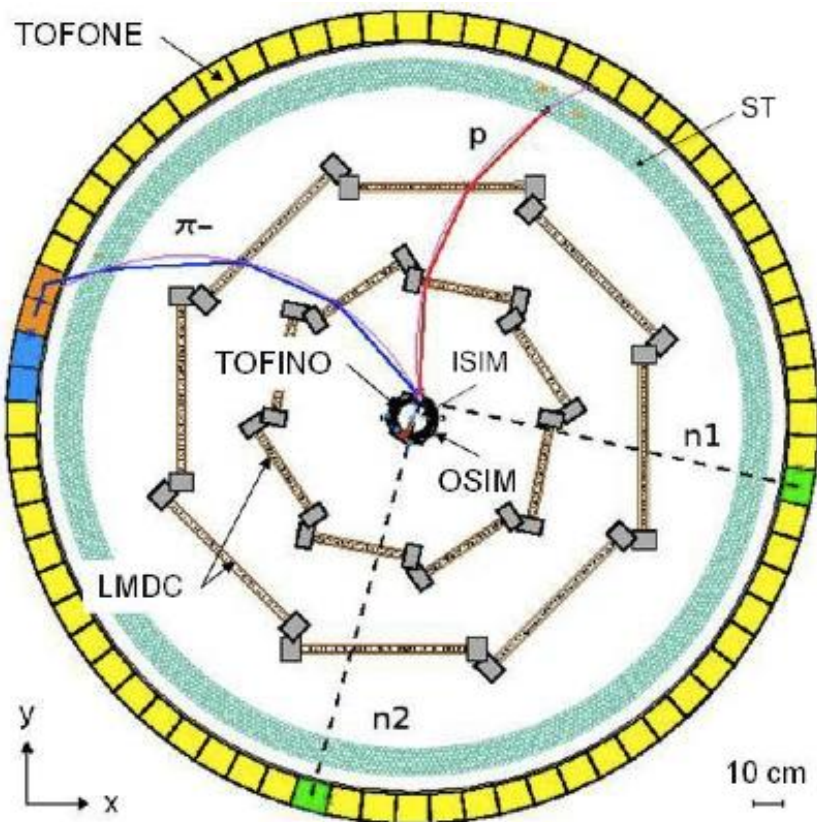
❖ experimental **hardness**: **3 nucleons** emitted from Λ -hypernucleus g.s.
4-fold coincidence measurement (π^- , p , n , n)

$2\mathcal{N}$ induced decay exp. evidence



triple coincidence: $(n + n + p)$ events

exclusive $\Lambda np \rightarrow nnp$ decay event: ${}^7_{\Lambda}\text{Li} \rightarrow {}^4\text{He} + p + n + n$



$$\begin{aligned} p_{\pi^-} &= 276.9 \pm 1.2 \text{ MeV}/c \\ p_{\text{miss}} &= 217 \pm 44 \text{ MeV}/c \\ E_{\text{tot}} &= 178 \pm 23 \text{ MeV} \\ \text{MM} &= 3710 \pm 23 \text{ MeV}/c^2 \end{aligned}$$

$$\begin{aligned} E(n1) &= 110 \pm 23 \text{ MeV} \\ E(n2) &= 16.9 \pm 1.7 \text{ MeV} \\ E(p) &= 51.11 \pm 0.85 \text{ MeV} \end{aligned}$$

$$\begin{aligned} \vartheta(n1 \ n2) &= 94.8^\circ \pm 3.8^\circ \\ \vartheta(n1 \ p) &= 102.2^\circ \pm 3.4^\circ \\ \vartheta(n2 \ p) &= 154^\circ \pm 19^\circ \end{aligned}$$

no n-n or p/n scattering

${}^7_{\Lambda}\text{Li}$	MM (MeV/c ²)
${}^4\text{He}$	3727.4
${}^3\text{He} + n$	3748.0
${}^3\text{H} + p$	3747.2

first direct, experimental evidence

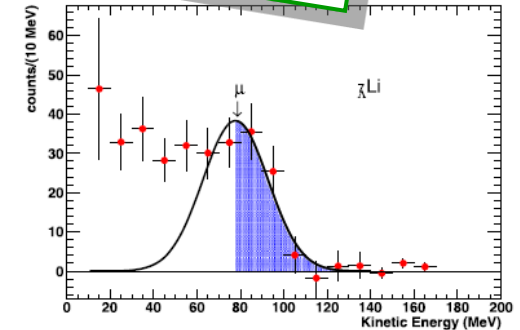
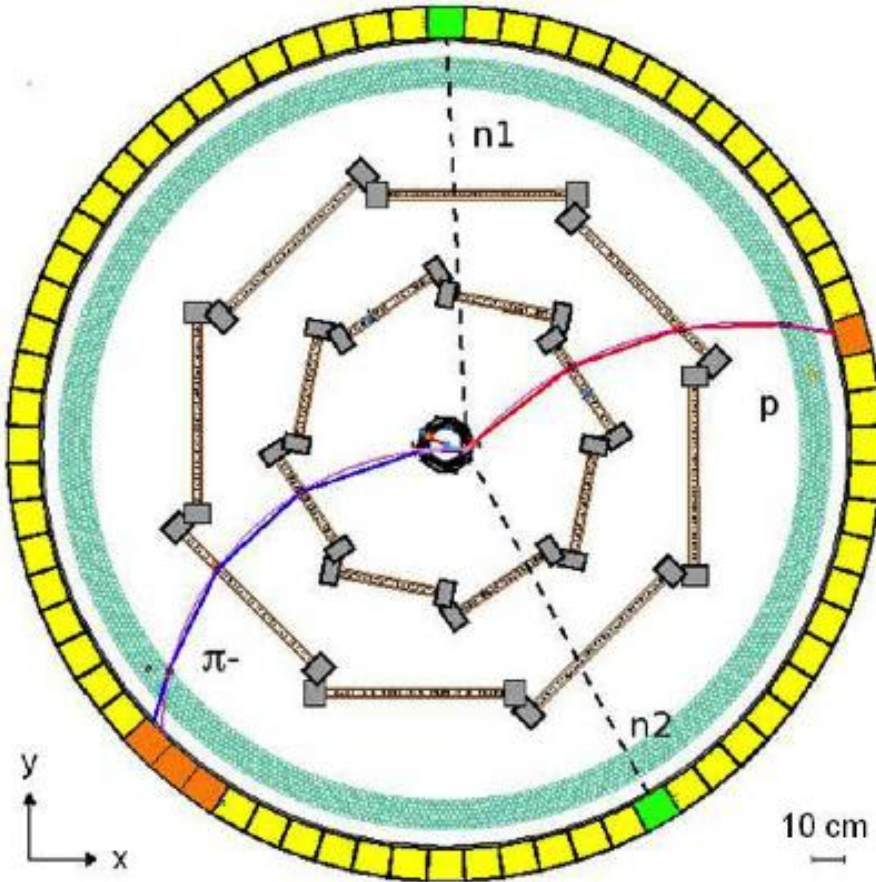
2N induced decay exp. evidence



triple coincidence: ($n + n + p$) events

exclusive $\Lambda np \rightarrow nnp$ decay event: ${}^7_{\Lambda}Li \rightarrow {}^4He + p + n + n$

cut on E_p released



$$\begin{aligned}
 p_{\pi^-} &= 276.5 \pm 1.2 \text{ MeV}/c \\
 P_{\text{miss}} &= 447 \pm 18 \text{ MeV}/c \\
 E_{\text{tot}} &= 147.1 \pm 4.2 \text{ MeV} \\
 MM &= 3720.3 \pm 4.7 \text{ MeV}/c^2
 \end{aligned}$$

$$\begin{aligned}
 E(n1) &= 21 \pm 2.0 \text{ MeV} \\
 E(n2) &= 35.3 \pm 3.6 \text{ MeV} \\
 E(p) &= 90.83 \pm 0.50 \text{ MeV}
 \end{aligned}$$

$$\begin{aligned}
 \vartheta(n1 \ n2) &= 126.5^\circ \pm 5.4^\circ \\
 \vartheta(n1 \ p) &= 53.5^\circ \pm 4.3^\circ \\
 \vartheta(n2 \ p) &= 124.6^\circ \pm 3.9^\circ
 \end{aligned}$$

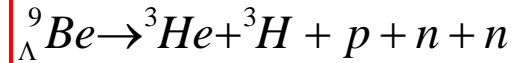
no n-n or p/n scattering

2N induced decay exp. evidence

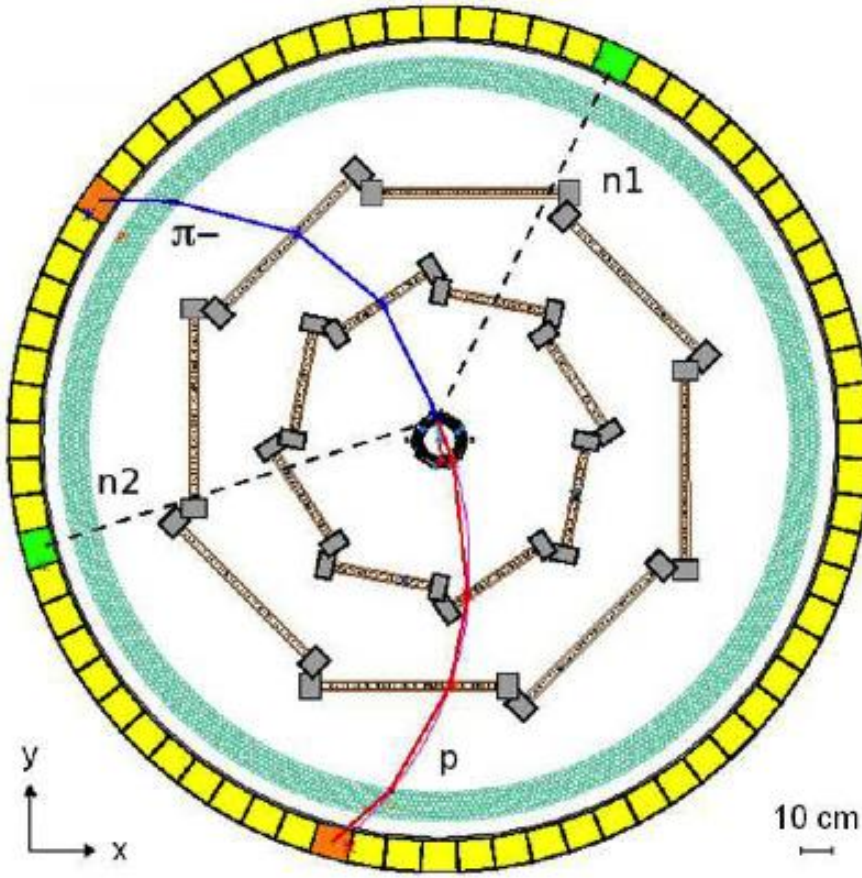


triple coincidence: $(n + n + p)$ events

exclusive $\Lambda np \rightarrow nnp$ decay event:



cut on E_p released



$$\begin{aligned}
 p_{\pi^-} &= 286.7 \pm 1.2 \text{ MeV/c} \\
 P_{\text{miss}} &= 253 \pm 18 \text{ MeV/c} \\
 E_{\text{tot}} &= 123.5 \pm 4.9 \text{ MeV} \\
 MM &= 5617.3 \pm 5.0 \text{ MeV}/c^2
 \end{aligned}$$

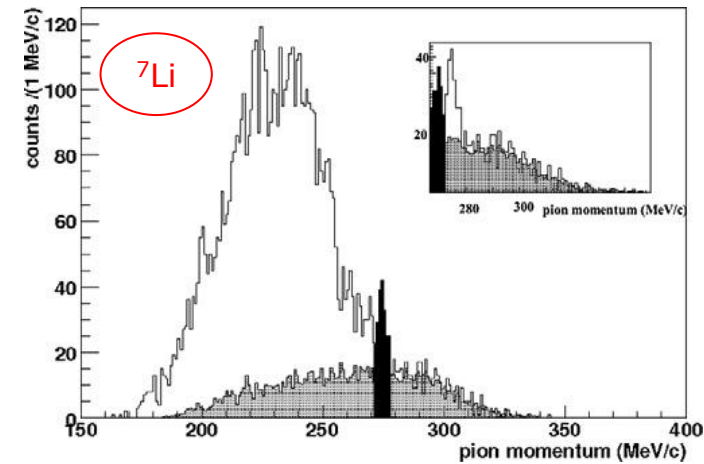
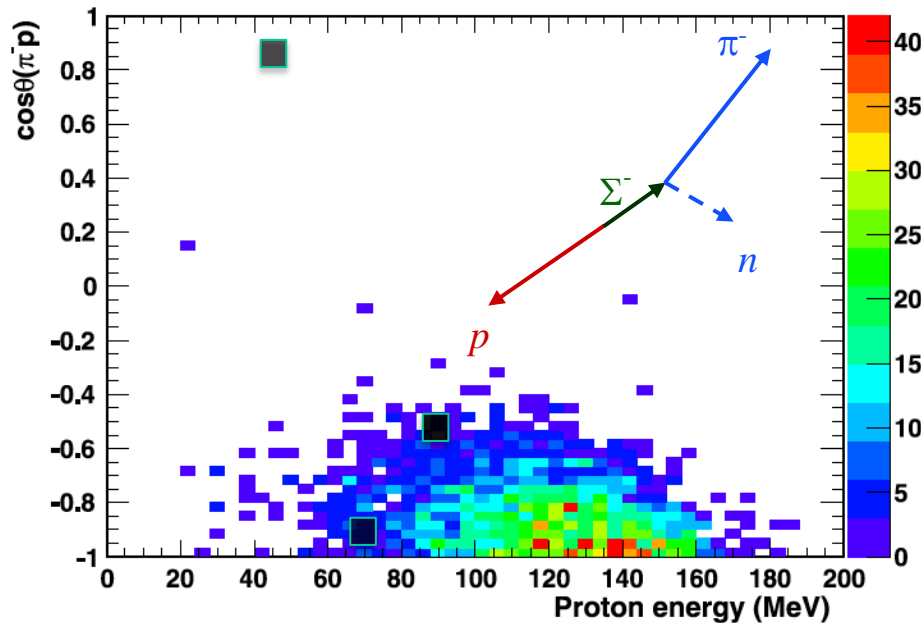
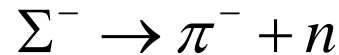
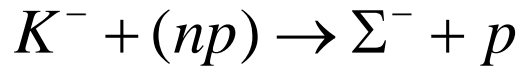
$$\begin{aligned}
 E(n1) &= 20.2 \pm 2.5 \text{ MeV} \\
 E(n2) &= 31.5 \pm 4.2 \text{ MeV} \\
 E(p) &= 71.77 \pm 0.80 \text{ MeV}
 \end{aligned}$$

$$\begin{aligned}
 \vartheta(n1 \ n2) &= 133.6^\circ \pm 7.5^\circ \\
 \vartheta(n1 \ p) &= 128.5^\circ \pm 5.5^\circ \\
 \vartheta(n2 \ p) &= 95.4^\circ \pm 3.6^\circ
 \end{aligned}$$

no n-n or p/n scattering

${}^9_{\Lambda}Be$	MM (MeV/c ²)
6Li	5601.5
${}^5Li + n$	5607.2
${}^4He + d$	5603.0
${}^3He + {}^3H$	5617.3

Background evaluation



Target	$\vartheta(\pi^-p)$	E_p (MeV)
${}^7\text{Li}$	$33.4^\circ \pm 3.7^\circ$	51.11 ± 0.85
${}^7\text{Li}$	$121.7^\circ \pm 3.2^\circ$	90.83 ± 0.50
${}^9\text{Be}$	$159.3^\circ \pm 5.9^\circ$	71.77 ± 0.80


- ❖ significant **back-to-back** correlation \rightarrow this feature **rules out** completely the **first event** on ${}^7\text{Li}$
- ❖ the correlation between $\cos\vartheta(\pi^-p)$ and E_p was studied for the simulated background: **major contribution** from this source when π and p are **emitted** nearly **back-to-back** and $E_p \geq 100$ MeV
- ❖ evaluation of the number of **simulated events** surviving to a 3σ cut on $\cos\vartheta(\pi^-p)$ and E_p on ${}^7\text{Li}$ and ${}^9\text{Be}$: $\sim 10^{-3}$ events were found for both targets

the 2 $\Lambda np \rightarrow nnp$ real events **DO NOT** belong to background to a **confidence level $\geq 99\%$** .

2008 scenario

The 6th Japan-Italy symposium on Heavy-Ion Physics
 -ASR2008: Perspective in Nuclear Physics-
 November 11-15, 2008
 Tokai, Japan

TOPICS
 Nuclear Structure
 Nuclear Dynamics
 Nuclear Astrophysics
 Facility & Instrumentation
 Nuclear Application

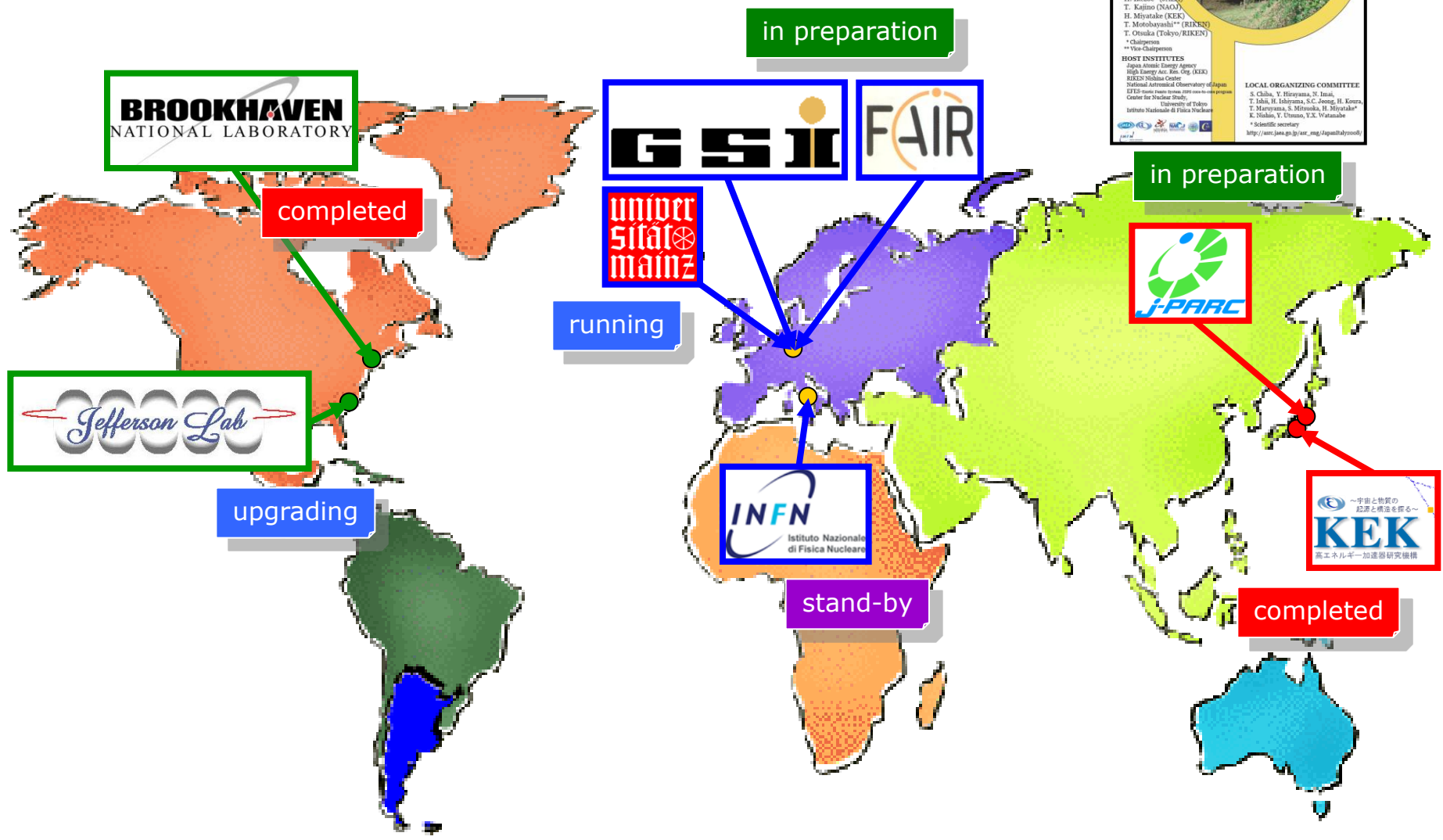


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 T. Otsuka (Tokyo/RIKEN)

* Chairperson
 ** Vice-Chairperson

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 RIKEN Nishina Center
 National Astronomical Observatory of Japan
 DTLB team (from 2006 to 2008)

LOCAL ORGANIZING COMMITTEE
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 T. Ishii, M. Ishiyama, S.C. Jiong, H. Koura,
 T. Maruyama, S. Mizusaki, H. Miyatake*
 E. Nishio, Y. Onuma, Y.Z. Watanabe
 * Scientific secretary
http://www.jaea.go.jp/asr_08/asr08jap.html

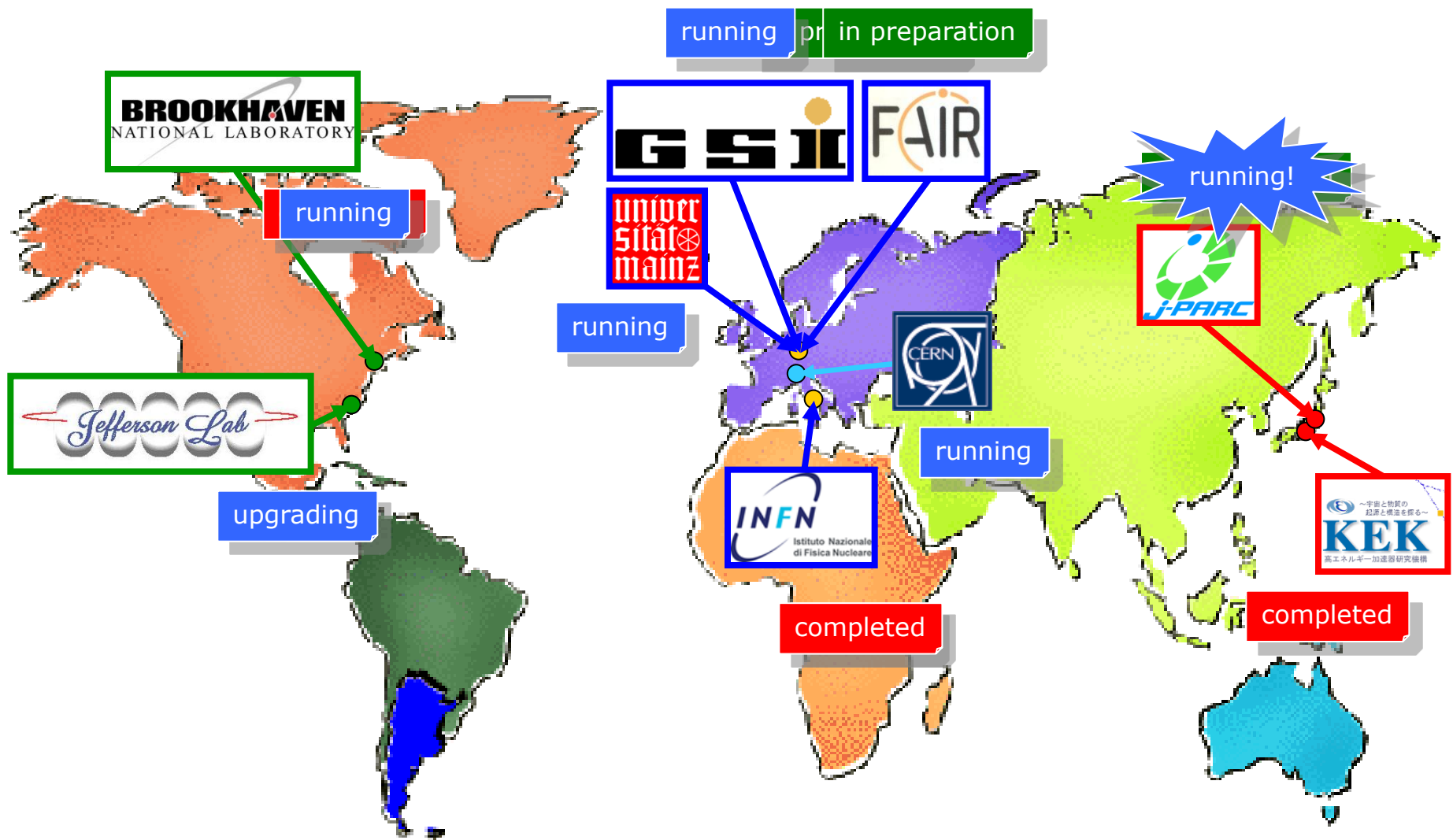


A. Feliciello / 6th Japan-Italy Symposium on Heavy-Ion Physics "Perspectives in Nuclear Physics", Tokai, Japan, November 11-15, 2008.

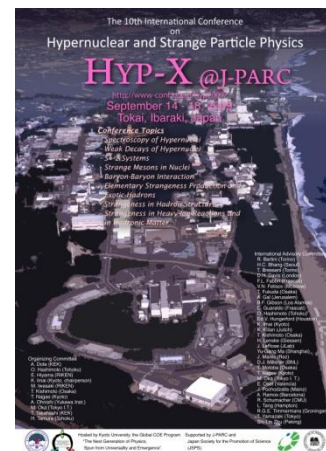


2012 scenario


Alessandro Feliciello / 7th Japan-Italy Symposium on Nuclear Physics, Milano, Italy, November 20-23, 2012.



Future speaks Japanese



XI International Conference on Hypernuclear and Strange Particle Physics




**October 1 - 5, 2012
Barcelona, Spain**
<http://icc.ub.edu/congress/HYP2012>

Conference Topics
 Production, structure and decay of hypernuclei
 Multistrange systems
 Production of strangeness
 Interactions of mesons and baryons with strangeness
 Strangeness in hadron structure
 Kaonic nuclear systems and strange mesons in nuclei
 Strangeness in astrophysics and in extreme forms of matter
 Baryonic heavy flavor systems
 Present and future facilities

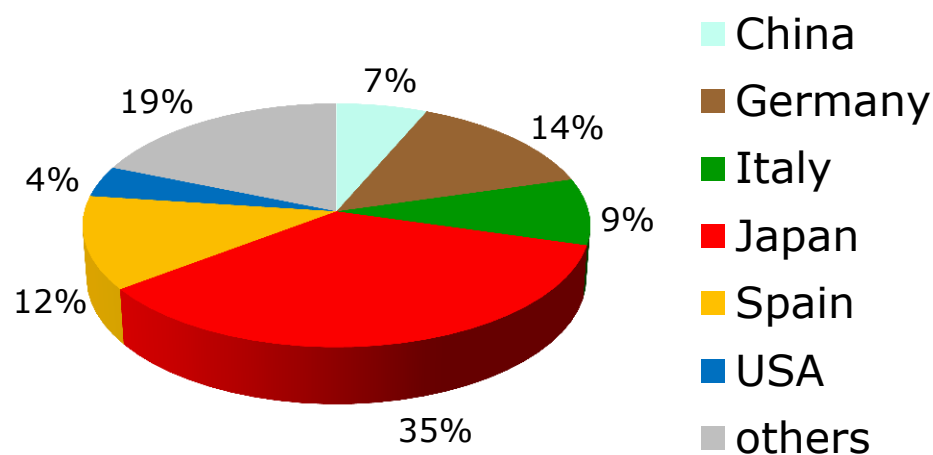
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Contact:
hyp2012@icc.ub.edu



participants (170)



next HYP: Sendai, 2015

Alessandro Feliciello / 7th Japan-Italy Symposium on Nuclear Physics, Milano, Italy, November 20-23, 2012.



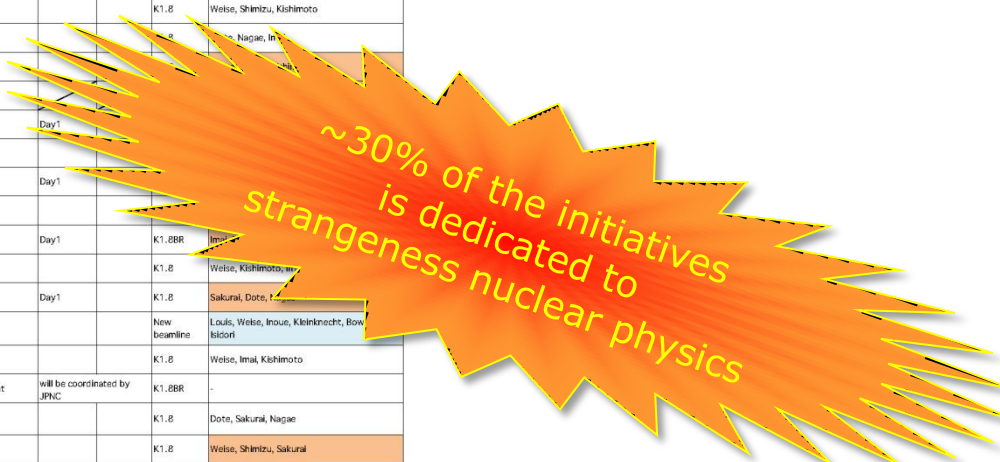
J-PARC scientific program



--- J-PARC PAC Approval summary after the 15th meeting ---

Proposals

	(Co-)Spokespersons	Affiliation	Title of the experiment	Approval status (PAC recommendation)	Slow line priority		from 2012	
					Day1 ?	Day1 Priority	Beamline	Leading References
E03	K.Tanaka	SNU	Measurement of X rays from α Atom	Stage 2			K1.8	Weise, Kishimoto, Nagae, Shimizu
P04	J.C.Feng; S.Sawada	U of Illinois at Urbana-Champaign; KEK	Measurement of High-Mass Dimuon Production at the 50-GeV Proton Synchrotron	Deferred			Primary	Nagae, Gross-Perdekamp, Imai, Dote
E05	T.Nagae	Kyoto U.	Spectroscopic Study of α -Hypernucleus, ^{12}Be , via the $^{12}\text{C}(\text{K}^+, \text{K}^-)$ Reaction	Stage 2	Day1	1	K1.8	Weise, Shimizu, Sakurai
E06	Itinatoto	KEK	Measurement of T-violating Transverse Muon Polarization in $\text{K}^+ \rightarrow \pi^0 \mu^+ \nu$ Decays	Stage 1			K1.1BR	Browder, Blucher, Kleinknecht, Iidor
E07	K.Imai, K.Nakazawa, H.Tamura	JAEA, Gifu U, Tohoku U	Systematic Study of Double Strangeness System with an Emulsion-counter Hybrid Method	Stage 2			K1.8	Weise, Shimizu, Kishimoto
E08	A.Knutenkova	ITEP	Plan double charge exchange on oxygen at J-PARC	Stage 1				Nagae, Inoue
E10	A. Sakaguchi, T. Fukuda	Osaka U, Osaka EC U	Production of Neutron-Rich Lambda-Hypernuclei with the Double Charge-Exchange Reaction (Revised from Initial P10)	Stage 2				
E11	T. Kobayashi	KEK	Tokai-to-Kamioka (TKK) Long Baseline Neutrino Oscillation Experimental Proposal	Stage 2				
E13	H.Tamura	Tohoku U	Gamma-ray spectroscopy of light hypernuclei	Stage 2	Day1			
E14	T.Yamanaka	Osaka U	Proposal for $\text{K}_L \rightarrow \pi^0 \nu \bar{\nu}$ Experiment at J-PARC	Stage 2				
E15	M.Iwasaki, T.Nagae	RIKEN, Kyoto U	A Search for deeply-bound kaonic nuclear states by in-flight $3\text{He}(\text{K}^-, n)$ reaction	Stage 2	Day1			
E16	S.Yokkaichi	RIKEN	Electron pair spectrometer at the J-PARC 50-GeV PS to explore the chiral symmetry in QCD	Stage 1				
E17	R.Hayano, H.Ohta	U Tokyo, RIKEN	Precision spectroscopy of Kaonic ^4He $3d \rightarrow 2p$ X-rays	Stage 2	Day1		K1.8BR	Imai
E18	H.Rhang, H.Ohta, H.Park	SNU, RIKEN, KRISST	Coincidence Measurement of the Weak Decay of ^{12}C and the three-body weak interaction process	Stage 2			K1.8	Weise, Kishimoto, Nagae
E19	M.Naruki	KEK	High-resolution Search for $e^+ \text{Pentaquark}$ in $n p \rightarrow \text{KX}$ Reactions	Stage 2	Day1		K1.8	Sakurai, Dote, Iidor
E21	Y.Kuno	Osaka U	An Experimental Search for $\mu - e$ Conversion at a Sensitivity of 10^{-16} with a Slow-Extracted Bunched Beam	Stage 1			New beamline	Louis, Weise, Inoue, Kleinknecht, Bowler, Iidor
E22	S. Ajimura, A. Sakaguchi	Osaka U	Exclusive Study on the Lambda-N Weak Interaction in $\Lambda \rightarrow 4$ Lambda-Hypernuclei (Revised from Initial P10)	Stage 1			K1.8	Weise, Imai, Kishimoto
T25	S.Mihara	KEK	Extinction Measurement of J-PARC Proton Beam at K1.8BR	Test Experiment			will be coordinated by JFNC	K1.8BR
E26	K.Ozawa	KEK	Search for α -meson nuclear bound states in the $\alpha \rightarrow \pi^0 \pi^0 \pi^0$ reaction and the mass modification in the in-medium $\alpha \rightarrow \pi^0 \pi^0$ decay.	Stage 1			K1.8	Dote, Sakurai, Nagae
E27	T.Nagae	Kyoto U	Search for a neutron Kbar bound state K^0 in the $d(\pi^+ \text{K}^-)$ reaction	Stage 2			K1.8	Weise, Shimizu, Sakurai
E29	H.Ohishi	RIKEN	Search for ϕ -meson nuclear bound states in the $p\text{bar} + ^2\text{Z} \rightarrow \phi + (^{A-1}\text{Z}-1)$ reaction	Stage 1			K1.1	Dote, Shimizu, Nagae, Gross-Perdekamp
E31	M.Noumi	Osaka U	Spectroscopic study of hyperon resonances below KN threshold via the $(\text{K}^+ n)$ reaction on Deuteron	Stage 1			K1.8BR	Weise, Shimizu, Imai, Kishimoto
T32	A. Rubbia	ETH, Zurich	Towards a Long Baseline Neutrino and Nucleon Decay Experiment with a next-generation 1.00 kton Liquid Argon TPC detector at Okinoshima and an intensity upgraded J-PARC Neutrino beam	Test Experiment			schedule and beam time will be coordinated by JFNC	K1.1BR
P33	H. M. Shimizu	Nagoya U	Measurement of Neutron Electric Dipole Moment	Deferred			Linac	Blucher, Louis, Gross-Perdekamp, Kleinknecht, Imai, Iidor



--- J-PARC PAC Approval summary after the 15th meeting ---

Proposals

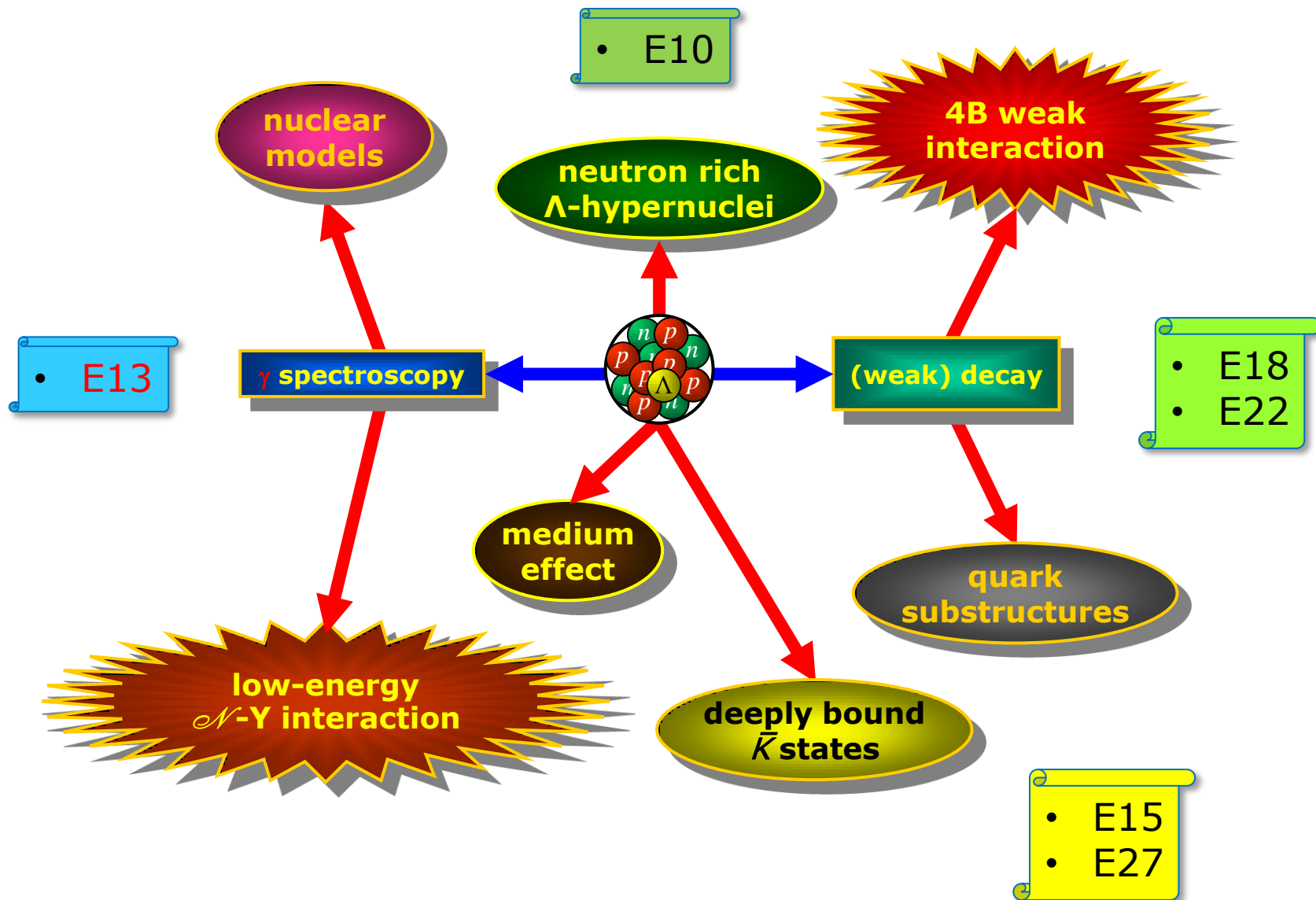
- 22 experiments
- 7 proposals
- 4 tests

E34	N. Saito, M. Iwasaki	KEK, RIKEN	An Experimental Proposal on a New Measurement of the Muon Anomalous Magnetic Moment $g-2$ and Electric Dipole Moment at J-PARC	Stage 1			MLF	Louis, Browder, Inoue, Gross-Perdekamp, Iidor
P36	M. Kohn, S. Shimizu	Hampton U, Osaka U	Measurement of $\Gamma(\text{K}^+ \rightarrow e^+ \nu) / \Gamma(\text{K}^+ \rightarrow \mu^+ \nu)$ and Search for heavy sterile neutrinos using the TREK detector system	Stage 1			K1.1BR	Browder, Blucher, Kleinknecht, Louis, Iidor
E40	K.Miwa	Tohoku U	Measurement of the cross sections of ^2p scatterings	Stage 1			K1.8	Gross-Perdekamp, Dote, Nagae, Imai
P41	M.Aoki	Osaka U	An Experimental Search for $\mu - e$ Conversion in Nuclear Fields at a Sensitivity of 10^{-14} with Pulsed Proton Beam from RCS	Deferred			MLF	Louis, Weise, Inoue, Kleinknecht, Bowler, Iidor
P42	J.K. Ahn	Pusan National U	Search for H Dibaryon with a Large Acceptance Hyperon Spectrometer	Stage 1			K1.8	Kishimoto, Dote, Nagae, Sakurai
T43	K.Aoki	RIKEN	Test of Hadron Blind Detector and GEM Tracker for the J-PARC E16 Experiment	Test Experiment			K1.1BR	
T44	T.Koike	Tohoku U	Study of in-beam performance of Hyperball-J Ge detector units with the current beam structures at the K1.1BR beam line	Test Experiment			schedule and beam time will be coordinated by JFNC	K1.1BR
P45	K.H. Hicks, H. Sako	OHio U, JAEA	3-Body Hadronic Reactions for New Aspects of Baryon Spectroscopy	Deferred			K1.8	Shimizu, Dote, Nagae
P46	K. Ozawa	KEK	EDIT2013 beam test program	(no discussion)			K1.1BR	Discussion in the sub-committee

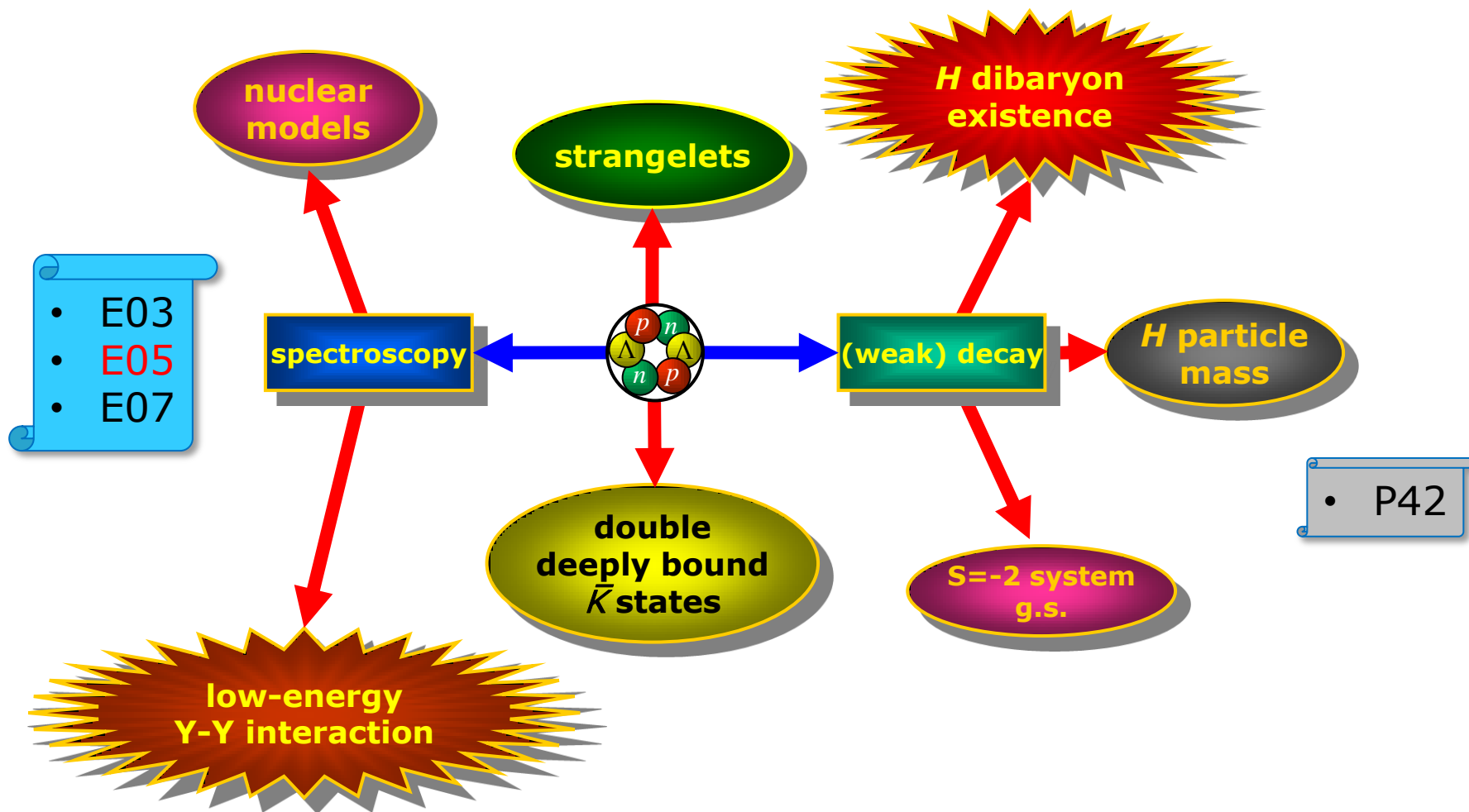
Report in PAC15
Decision in PAC15



Physics output ($S = -1$)



Physics output ($S = -2$)



The ULYSSES initiative



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E5

Proposal for J-PARC 50 GeV Proton Synchrotron

Spectroscopic Study of Ξ -Hypernucleus, ^{12}Be , via the $^{12}\text{C}(K^-, K^+)$ Reaction

K. Aoki, M. Ieiri, T. Maruta, T. Nagae (Spokesperson), H. Noumi, Y. Sato,
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High Energy Accelerator Research Organization (KEK), Japan

Y. Fujii, O. Hashimoto, T. Ishikawa, H. Kanda, M. Kaneta, T. Koike, Y. Ma,
K. Maeda, K. Shirotori, S. N. Nakamura, H. Tamura, M. Ukai, H. Yamazaki
Tohoku University, Japan

P. K. Saha
Japan Atomic Energy Agency (JAEA), Japan

H. Fujioka, D. Nakajima, T. N. Takahashi
University of Tokyo, Japan

K. Nakazawa, T. Watanabe
Gifu University, Japan

K. Imai, K. Miwa, K. Tanida
Kyoto University, Japan

S. Ajimura, T. Kishimoto, A. Sakaguchi
Osaka University, Japan

M. Yosoi
Research Center for Nuclear Physics (RCNP), Osaka University, Japan

T. Fukuda
Osaka Electro-Communication University, Japan

P. Evtoukhovitch, V. Kalinnikov, W. Kallies, N. Kravchuk, A. Moiseenko,
D. Mzhavia, V. Samoilov, Z. Tsamalaidze, O. Zaimidoroga
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J. K. Ahn, B. H. Choi
Pusan National University, Korea

Y. Fu, C. Li, X. Li, C. Zhou, S. H. Zhou, B. Zhou
China Institute of Atomic Energy (CIAE), China

R. E. Chrien
Brookhaven National Laboratory (BNL), USA

B. Bassalleck
University of New Mexico, USA

E13

Proposal for J-PARC 50 GeV Proton Synchrotron

Gamma-ray spectroscopy of light hypernuclei

Y. Fujii, K. Futatsukawa, O. Hashimoto, K. Hosomi, H. Kanda, M. Kaneta, T. Koike, Y. Ma,
K. Maeda, A. Matsumura, M. Mimori, S.N. Nakamura, K. Nonaka, Y. Okayasu, T. Suzuki,
K. Shirotori, H. Tamura (Spokesperson), K. Tsukada, M. Ukai
Tohoku University, Japan

K. Aoki, Y. Kakiguchi, T. Nagae, H. Noumi, Y. Sato, M. Sekimoto, H. Takahashi,
T. Takahashi, A. Toyoda
High Energy Accelerator Research Organization (KEK), Japan

P. Evtoukhovitch, V. Kalinnikov, W. Kallies, N. Kravchuk, A. Moiseenko, D. Mzhavia,
V. Samoilov, Z. Tsamalaidze, O. Zaimidoroga
Joint Institute for Nuclear Research, Russia

Y.Y. Fu, C.B. Li, X.M. Li, J. Zhou, S.H. Zhou, L.H. Zhu
China Institute of Atomic Energy, China

E. V. Hungerford, A. Lan (+ a postdoc and 2 graduate students)
University of Houston, U.S.A.

T. Bressani, S. Bufalino, L. Busso, D. Faso, A. Feliciello, S. Marcello,
University of Torino and INFN, Sezione di Torino, Italy

S. Kamigaito, K. Imai, K. Miwa, K. Tanida
Kyoto University, Japan

H. Fujioka, D. Nakajima, T.N. Takahashi
University of Tokyo, Japan

P. Markowitz, J. Reinhold
Indiana International University, U.S.A.

K. Nakazawa, T. Watanabe
Gifu University, Japan

S. Minami, T.R. Saito
GSI, Germany

A. Krutenkova, V. Kulikov
Institute for Theoretical and Experimental Physics, Russia

Day-1
experiments!!!

a special thank to:



E13 experiment layout

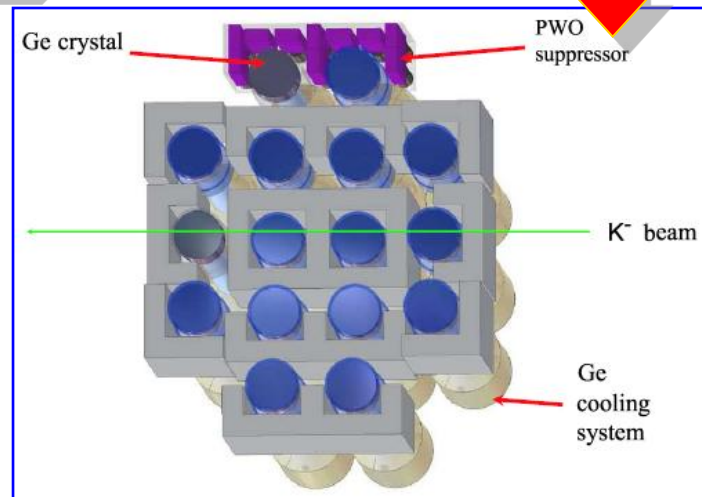


γ -ray spectroscopy of hypernuclei

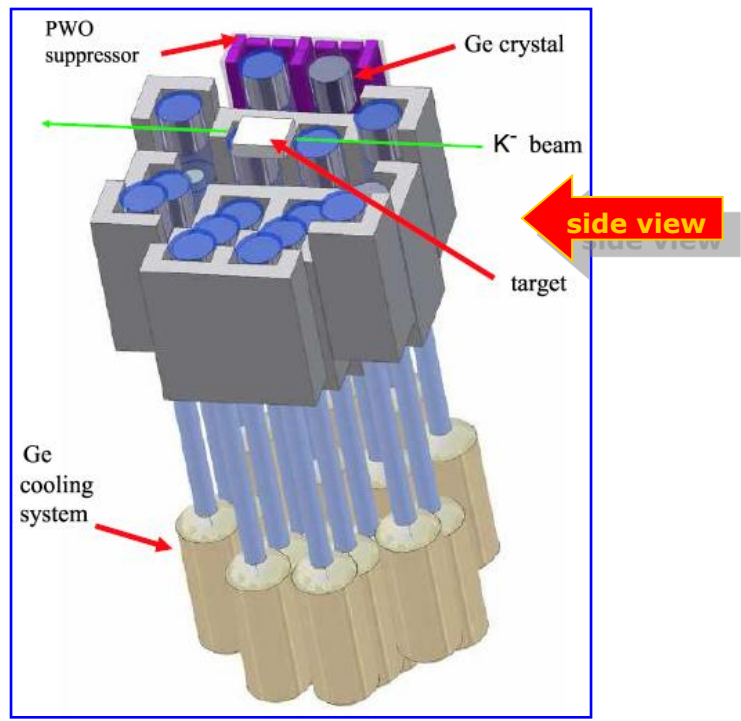
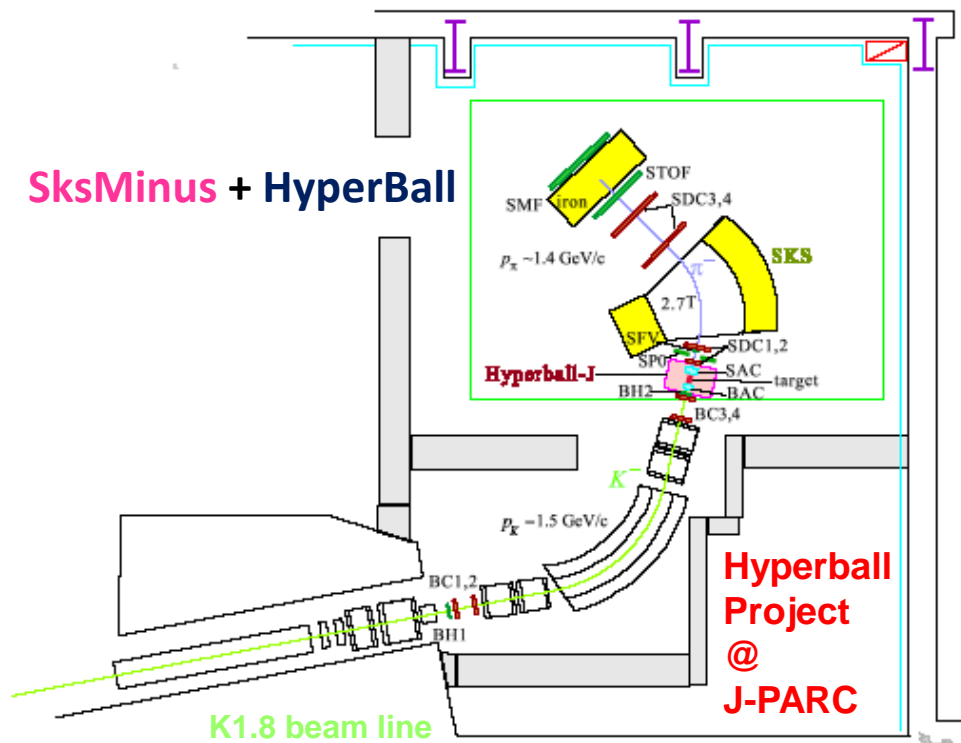
❖ further study of ΛN interaction: ${}^4\text{He}_\Lambda$, ${}^{10}\text{B}_\Lambda$, ${}^{11}\text{B}_\Lambda$, ${}^{19}\text{F}_\Lambda$

- ΛN - ΣN coupling and 3-body force
- charge symmetry breaking ($\Lambda n \neq \Lambda p$?)
- radial dependence (interaction range)

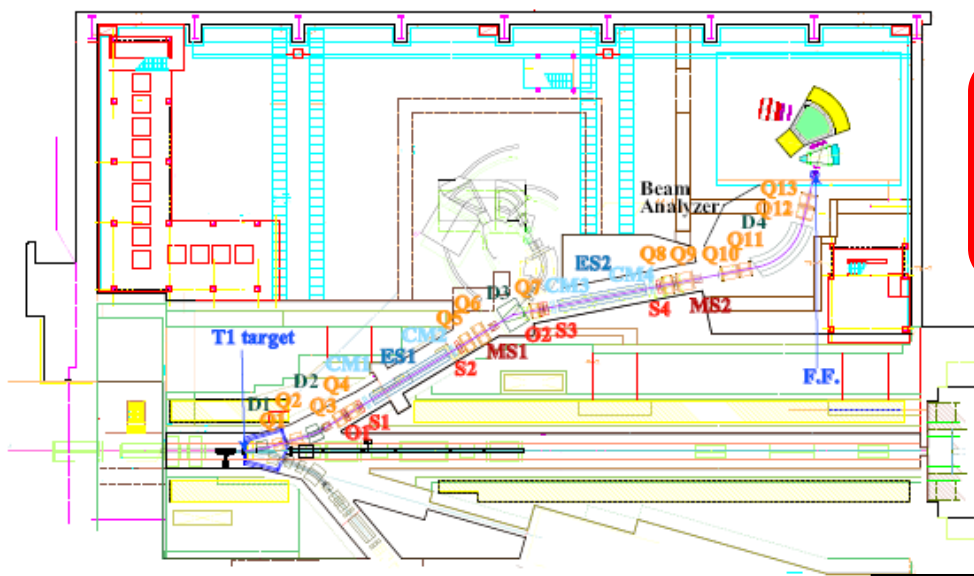
❖ g_Λ in a nucleus from spin-flip B(M1): ${}^7\text{Li}_\Lambda$



SkMinus + HyperBall

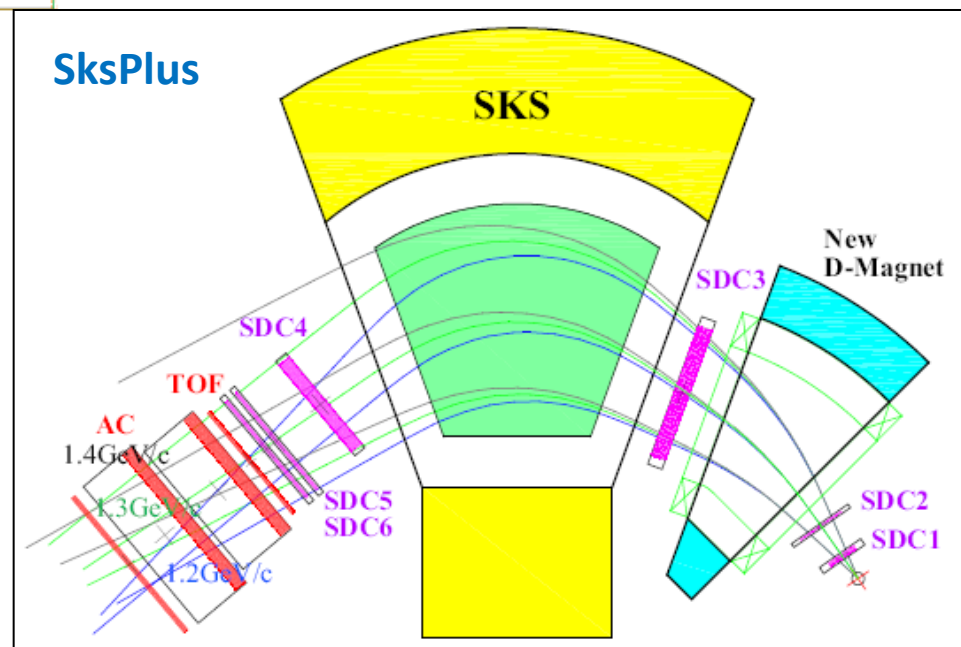


E05 experiment layout







Spectroscopic study
of Ξ -hypernucleus, $^{12}\text{Be}_{\Xi}$,
via the $^{12}\text{C}(K^-, K^+)$ reaction

- ❖ first spectroscopic study of $S = -2$ systems in (K^-, K^+) reaction
- ❖ ΞN interaction
 - ? attractive or repulsive
 - ? depth of Ξ -nuclear potential
 - ? isospin dependence
 - ? ΞN - Λ coupling force



Summary

-  Last but not least **results** from **FINUDA**:
 -  first **experimental evidence** for the heavy hyperhydrogen ${}^6\text{H}_\Lambda$
 -  first **direct observation** of **2 \mathcal{N} induced** hypernucleus weak decay

-  **FINUDA** could be considered an ideal **bridge** between the **KEK** and the **J-PARC** eras:



we are now looking forward for **new and exciting** world class **results**

Thank you!

どうも ありがとう