

J-PARC: Strangeness Nuclear Physics Program

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The J-PARC Project Office

KEK

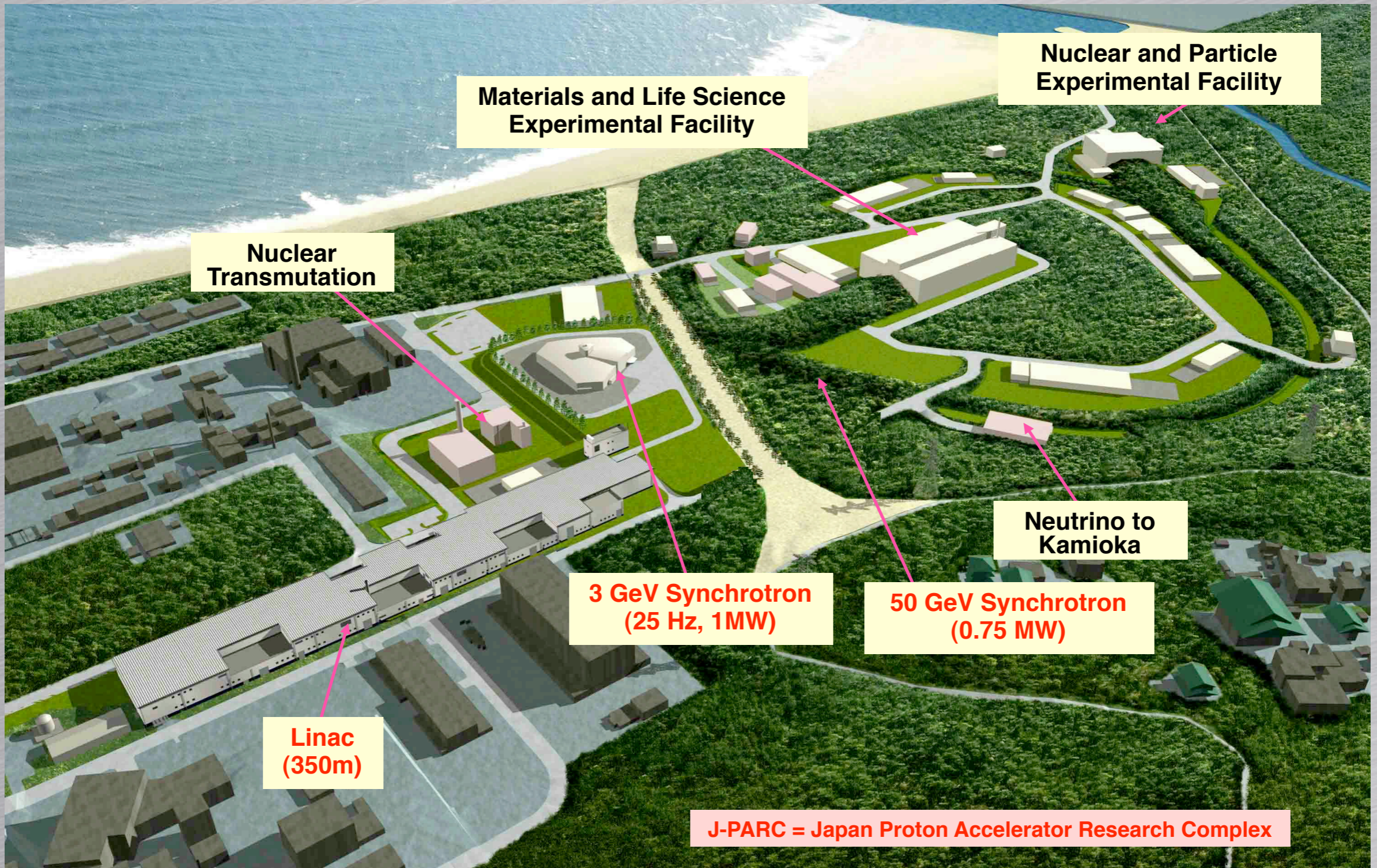
Outline

- Status of J-PARC
 - J-PARC Project Overview
 - Construction and Budget Status
- Strangeness Nuclear Physics Program
 - LOI's proposed
 - Day-1 Experiments
- NP Hall Design and R&D
- Summary

J-PARC Project

- Japan Proton Accelerator Research Complex
- Joint Project between KEK and JAERI
 - 2001: Construction started
 - approved as a 6-year project; end of this year is in the middle
- 3 accelerators and 3 research fields
 - Proton Linac: Nuclear transmutation R&D
 - 3-GeV Synchrotron: Material and Life sciences
 - 50-GeV Synchrotron: Nuclear and Particle Physics

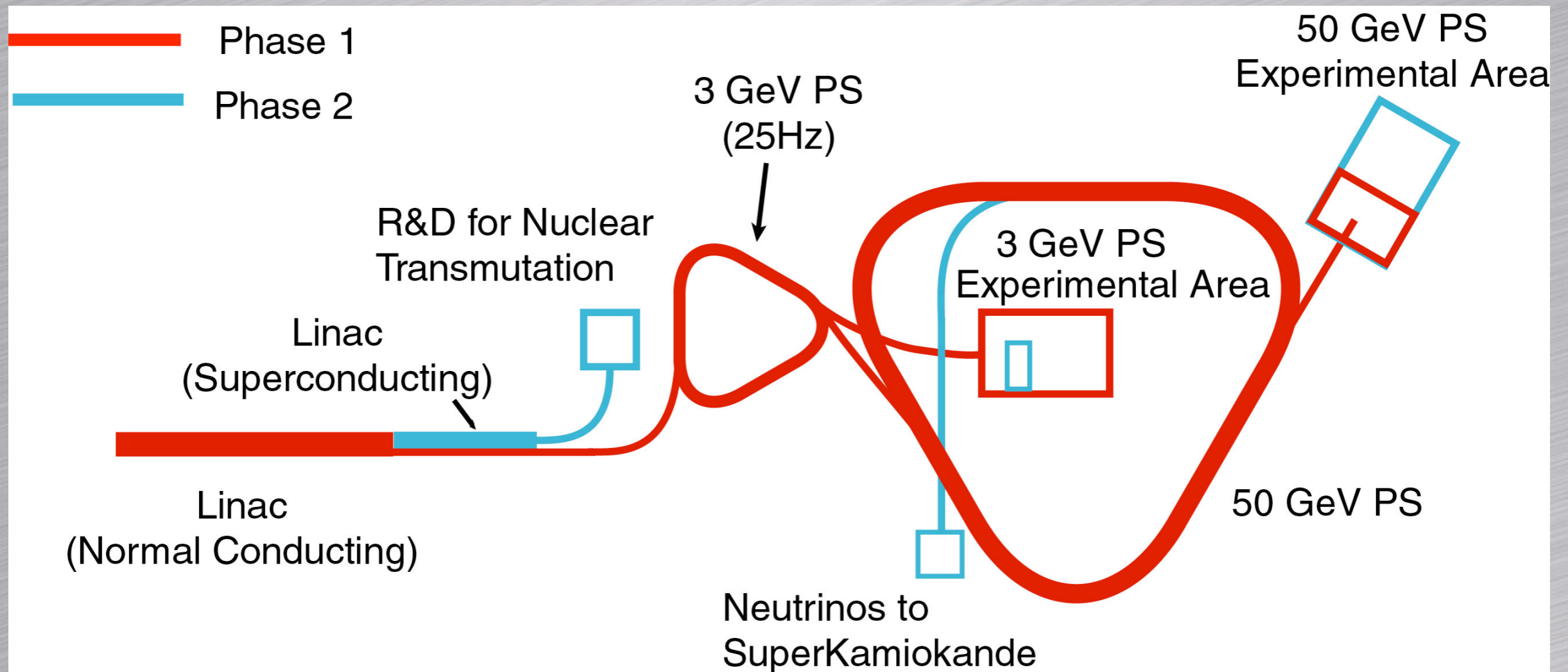
J-PARC Facility



Site View in Feb. 2003



Phase 1 and Phase 2



- Phase 1 + Phase 2 = 189 billion Yen (= \$1.89 billion if \$1 = 100 Yen).
- Phase 1 = 133.5 billion Yen for 6 years (= 2/3 of 189 billion Yen).
- Construction budget does not include salaries.

Beam Specifications

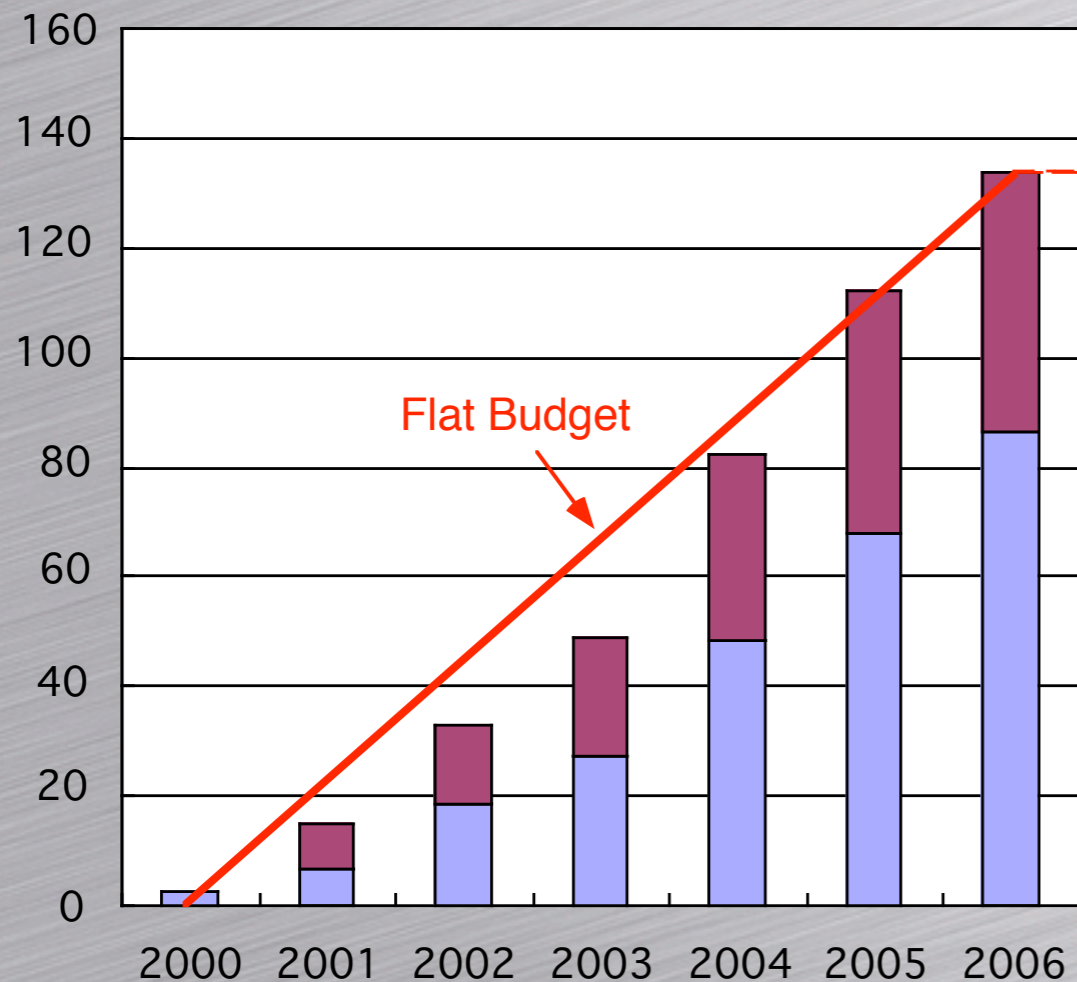
	50-GeV PS	Phase-1 ⁻
Beam Energy	50 GeV	30 GeV
Beam Repetition	3.4 s	3.4 s
Beam Width	0.7 s	1.0s
Beam Intensity	3.3×10^{14} ppp 15 μ A	2×10^{14} ppp 9 μ A
Beam Power	750 kW	270 kW

Linac Energy: 400 MeV \rightarrow 180 MeV

Capacity limit on Electric power and Cooling water

Construction Budget for Phase 1

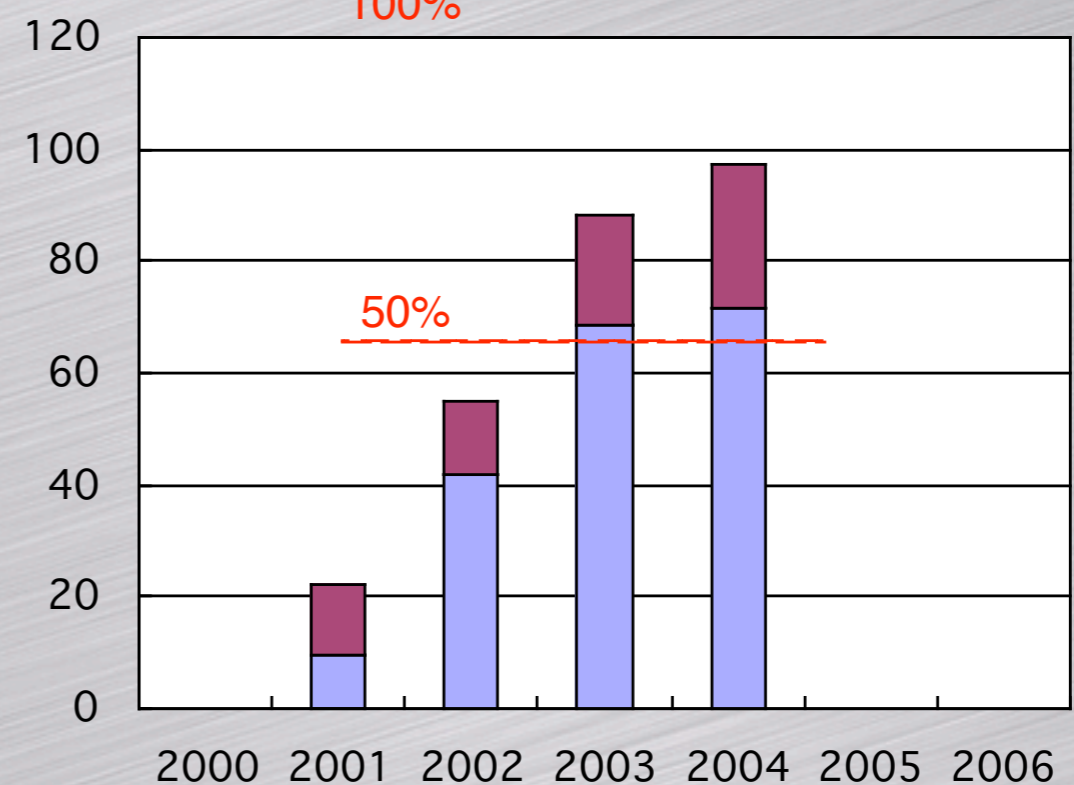
BYen Integrated Expenses (incl. future plans)



KEK
JAERI

Amount of Purchase Commitment (incl. future plans)

BYen



↑
Start

↑
Now

↑
Beam

↑
Start

↑
Now

↑
Beam



original



2003.9

Linac and 3 GeV Area



2002.12



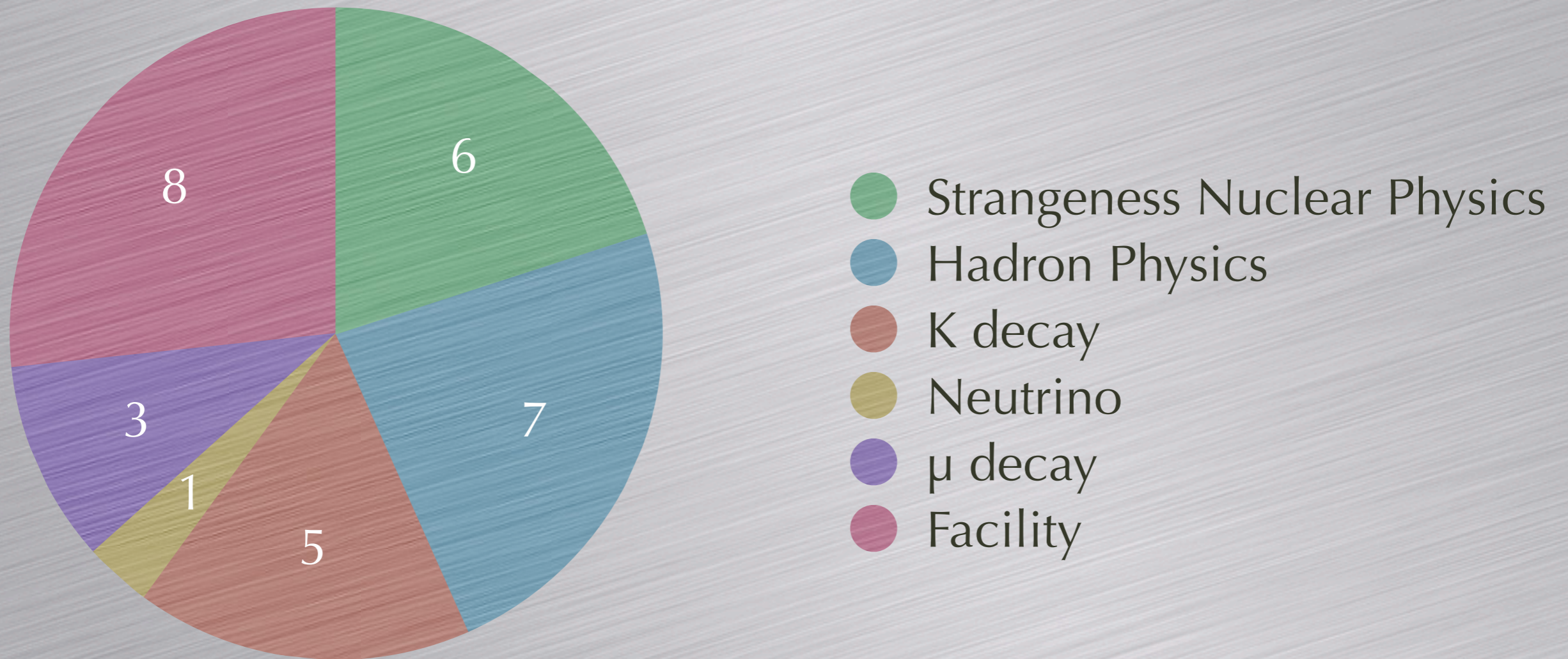
2003.9



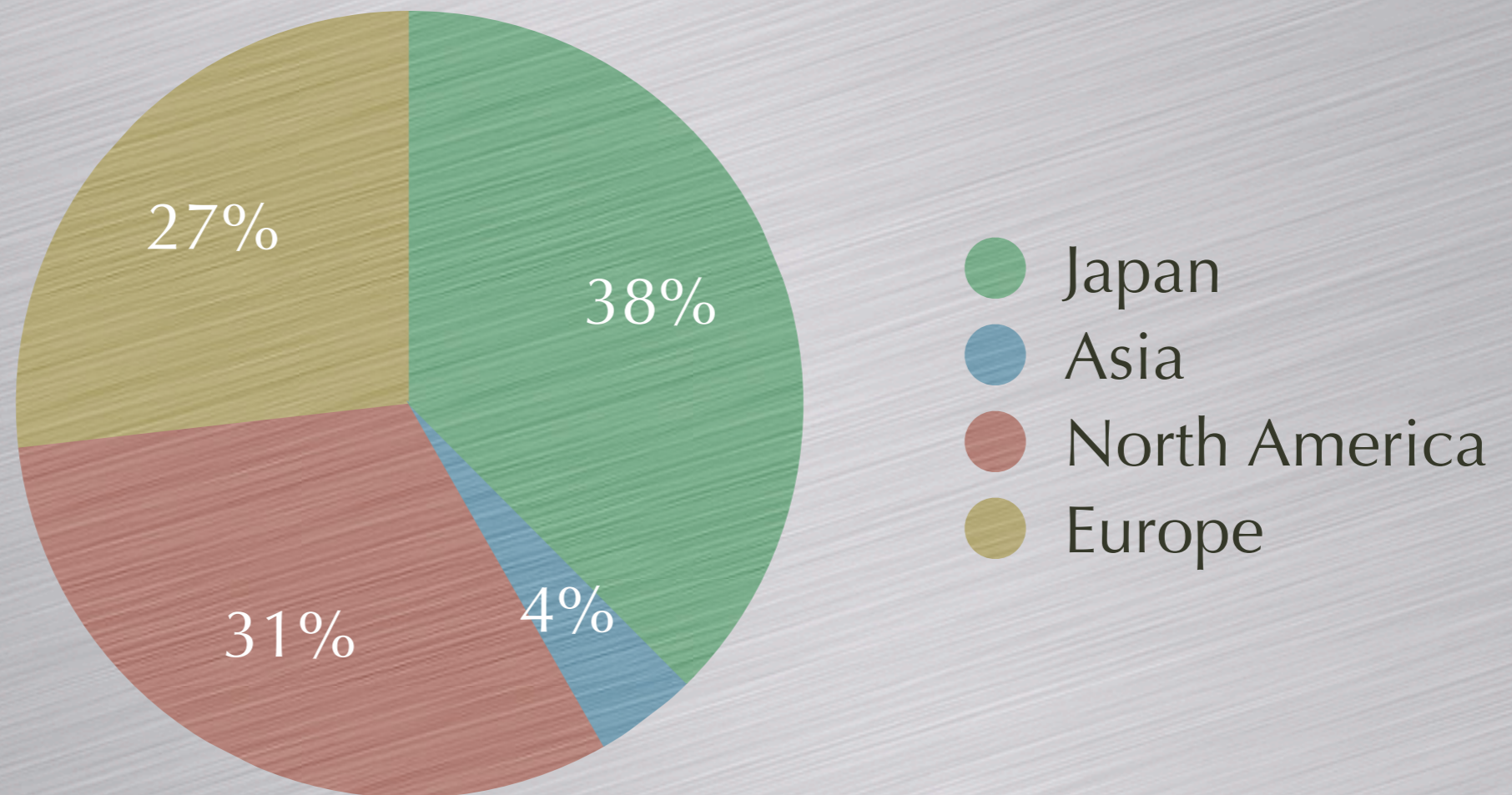
Letter of Intent

- NP01 (KEK), NP02 (Kyoto)
- July 2002: Call for LOIs
- Jan. 2003: 30 LOIs were submitted
- Nuclear and Particle physics Facility Committee (NPFC)
 - 3/22: Neutrino Exp. (L12)
 - 6/24-26: Day-1 Exp.: L06, L10 + Test Beam

What kind of LOI's ?



Nationality of Authors



LOIs in Strangeness Nuclear Physics

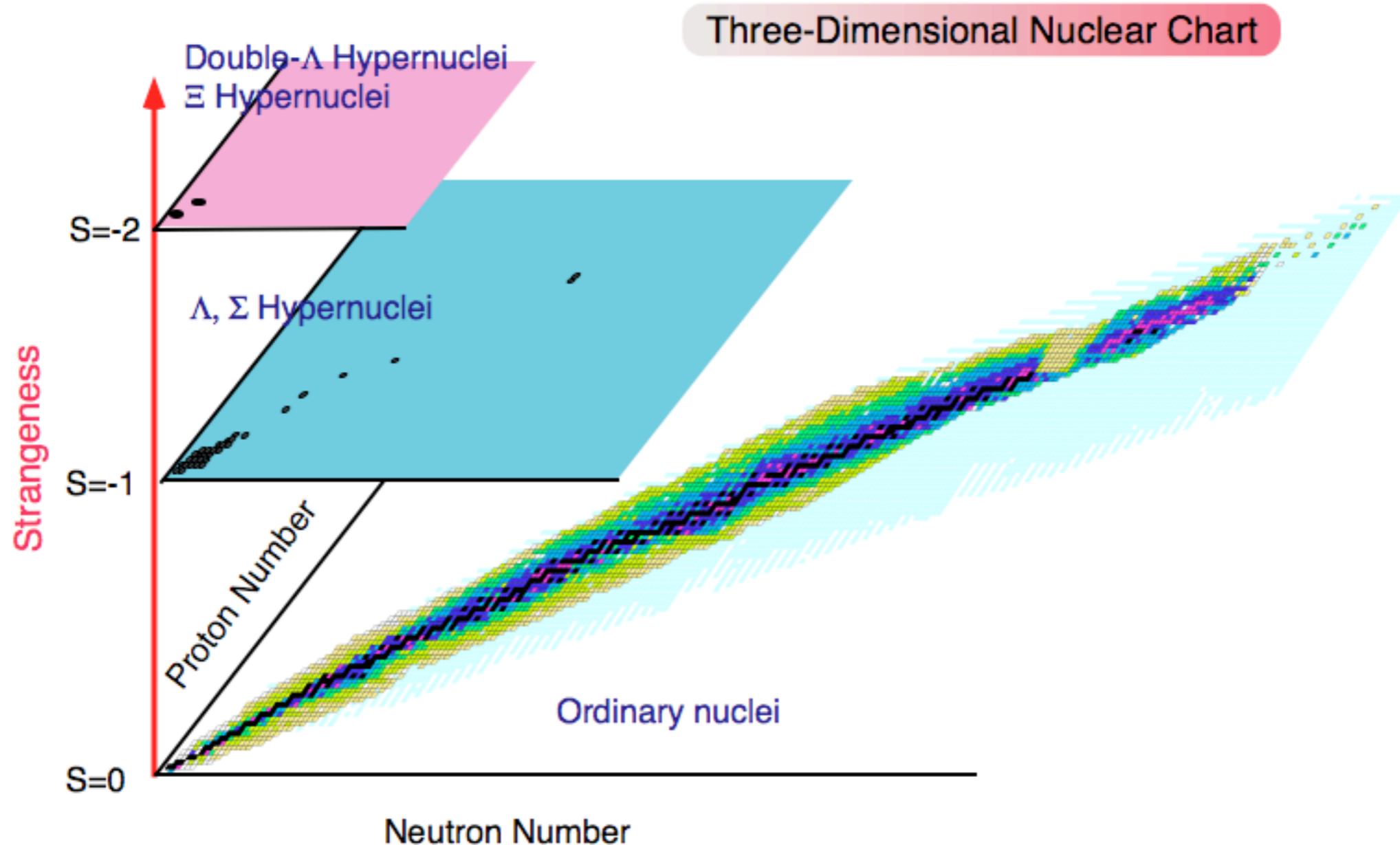
- **L06**: New Generation Spectroscopy of Hadron Many-Body Systems with Strangeness $S=-2$ and -1 (K. Imai et al.)
- L07: Hyperon-Proton Scattering Experiments at the 50-GeV PS (M. Ieiri et al.)
- L08: High-Resolution Reaction Spectroscopy of $S=-1$ Hypernuclei (H. Noumi et al.)
- L09: Neutron-rich Λ hypernuclei by the double-charge exchange reaction (T. Fukuda et al.)
- **L10**: Study of Dense \bar{K} Nuclear Systems (T. Nagae et al.)
- L21: Precise Measurement of the Nonmesonic Weak Decay of $A=4,5$ Λ Hypernuclei (S. Ajimura et al.)

L06: New generation spectroscopy of hadron many-body systems with strangeness $S=-2$ and -1

- K.Imai, M.Nakamura, H.Funahashi, M.Yosoi
- T.Nagae, M.Ieiri, H.Noumi, H.Outa, M.Sekimoto, H.Takahashi, Y.Sato, A.Toyoda
- T.Fukuda, P.K.Saha
- K.Nakazawa
- K.Yamamoto, T.Yoshida
- O.Hashimoto, K.Maeda, H.Tamura, S.N.Nakamura, T.Takahashi, Y.Fujii, H.Kanda
- T.Kishimoto, A.Sakaguchi, S.Ajimura, Y.Shimizu, S.Minami, T.Itahashi, T.Hayakawa
- M.Iwasaki, K.Itahashi, K.Tanida, Y.Matsuda
 - Japan
- J.S.Song, I.G.Park, C.S.Yoon, S.H.Kim
- J.Y.Kim
- M.Y.Pac
- J.K.Ahn, I.K.Yoo
- H.Bhang, M.Youn
 - Korea
- S.Zhou, L.Zhu
 - China
- B.Bassalleck
- L.Tang
- P.Markowitz, B.Raue, J.Reinhold
- M.May, R.E.Chrien, A.Rusek, P.H.Pile
- S.Choi
- Ed.Hungerford
- G.Franklin, R.Schumacher, B.Quinn
 - USA
- T.R.Saitoh, A.Banu
 - Germany
- J.Arviex
 - France
- P.Kienle, M.Cargnelli, J.Marton, J.Zmeskal
 - Austria
- S.Marcello, T.Bressani
- M.Agnello
- A.Feliciello
 - Italy
- P.Tlusty
 - Czech

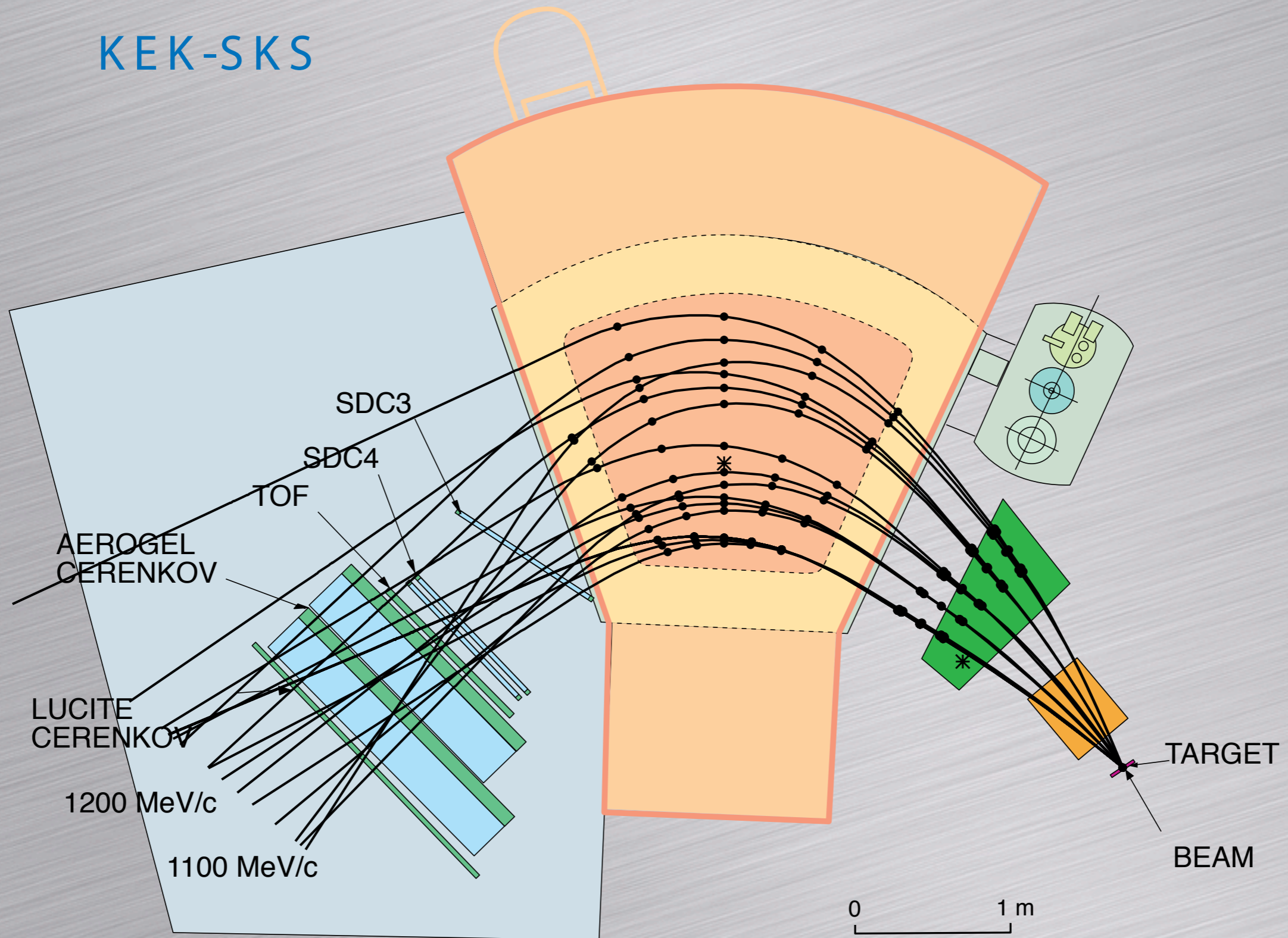
Strangeness Nuclear Physics

New Hadron Many-Body Systems with Strangeness



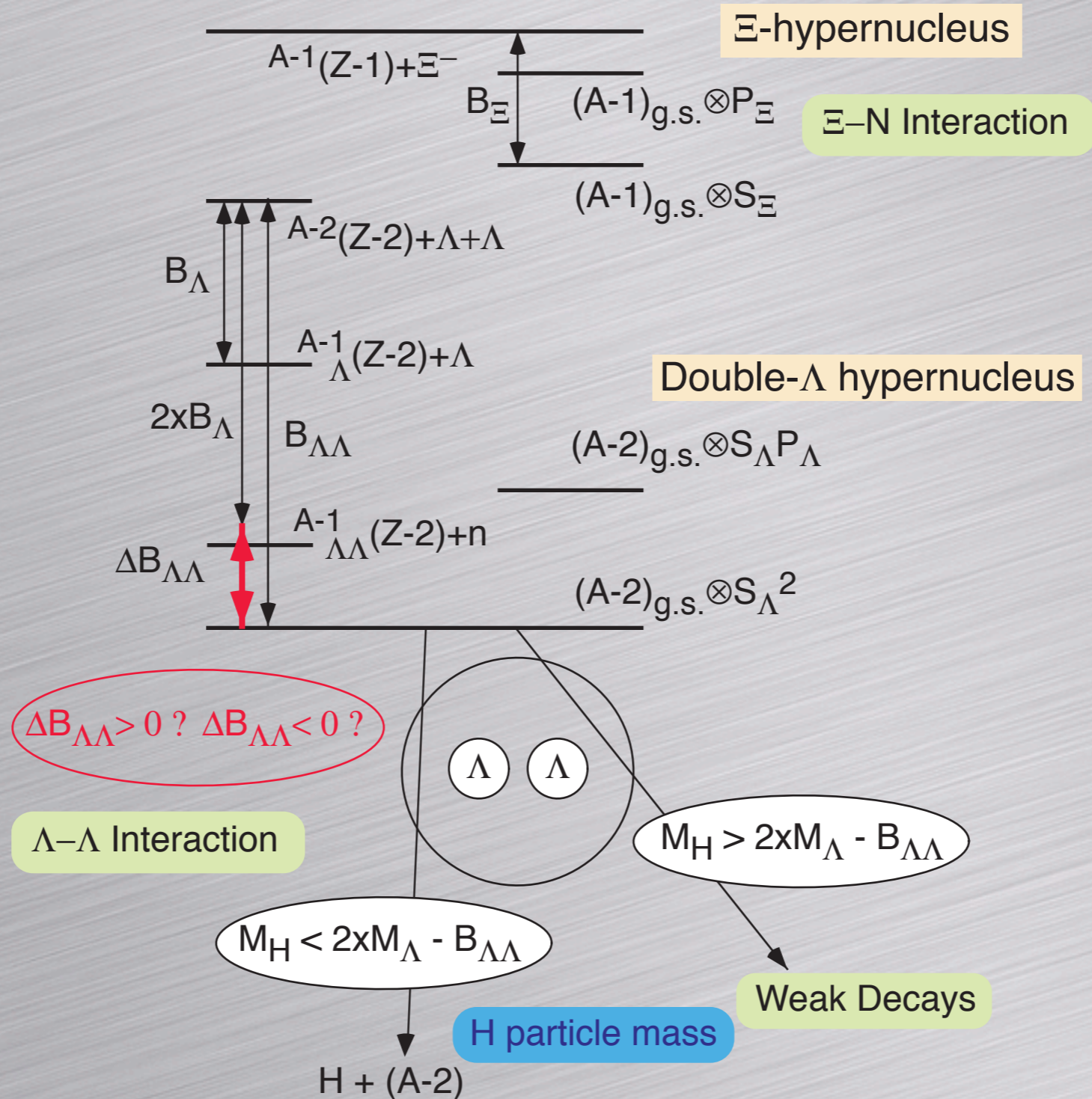
Ξ Hypernuclei with (K^-, K^+)

KEK-SKS



S=-2 World

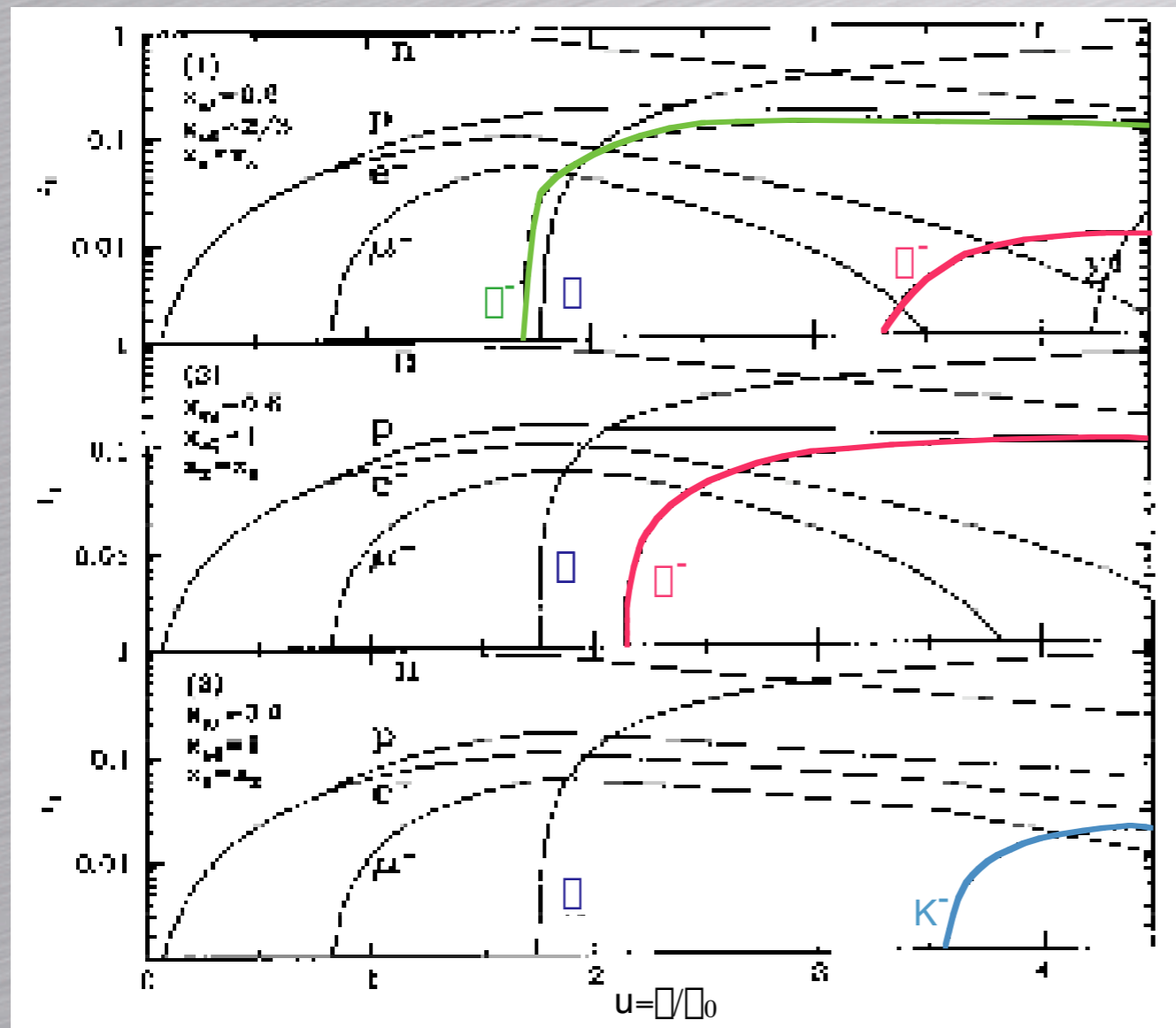
Energy Spectrum of S=-2 systems



Ξ hypernuclei potential ?

- $\Lambda, \Sigma^-, \Xi^-, K^-$ in Neutron Star Core ?

- Chemical Potential: $\mu_B = m_B + \frac{k_F^2}{2m_B} + U(k_F)$



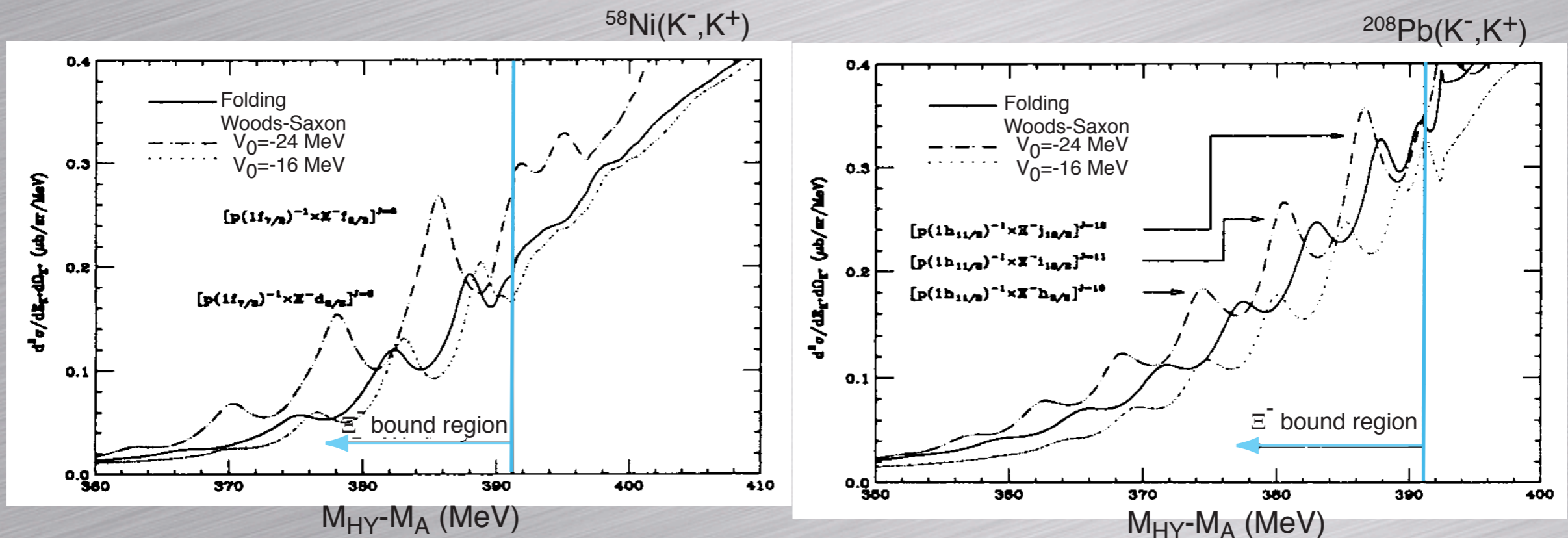
$$U_\Sigma < 0, U_\Xi < 0$$

$$U_\Sigma > 0, U_\Xi < 0$$

$$U_\Sigma > 0, U_\Xi > 0$$

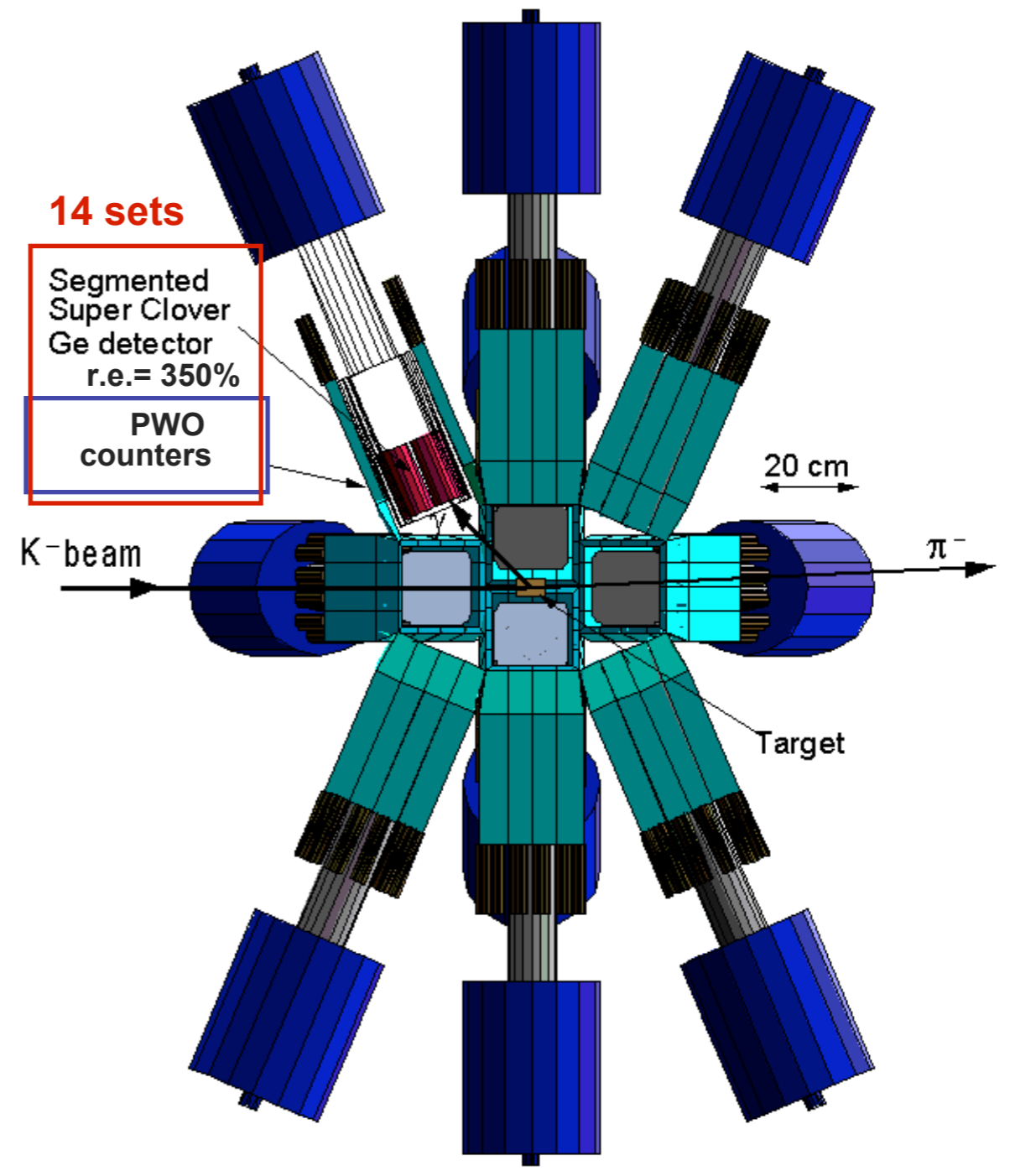
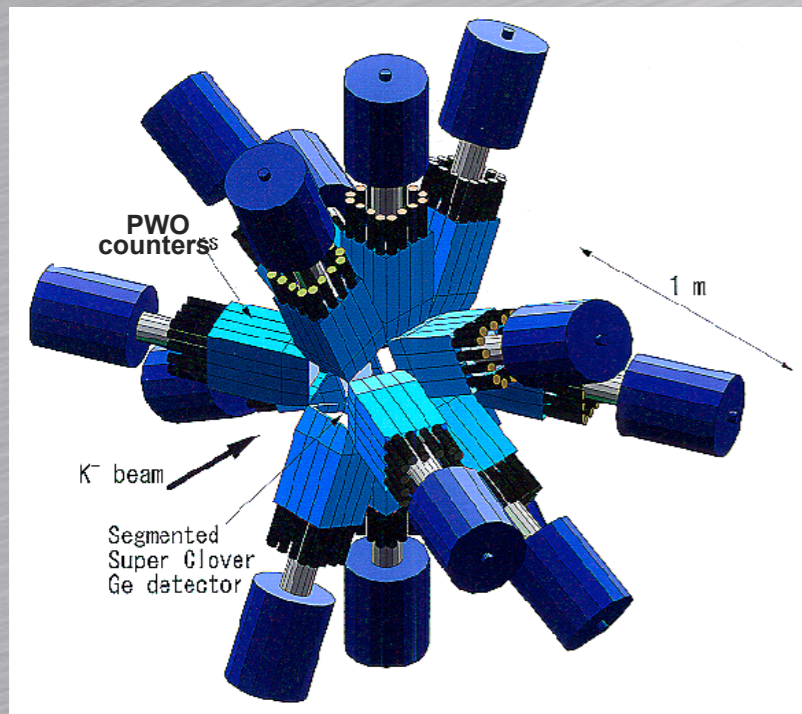
(K^- , K^+) Spectroscopy

- **2 MeV** FWHM resolution
- ~ 6 events/day/MeV for 50 msr, 2g/cm²-thick Pb \longrightarrow ~ 20 days

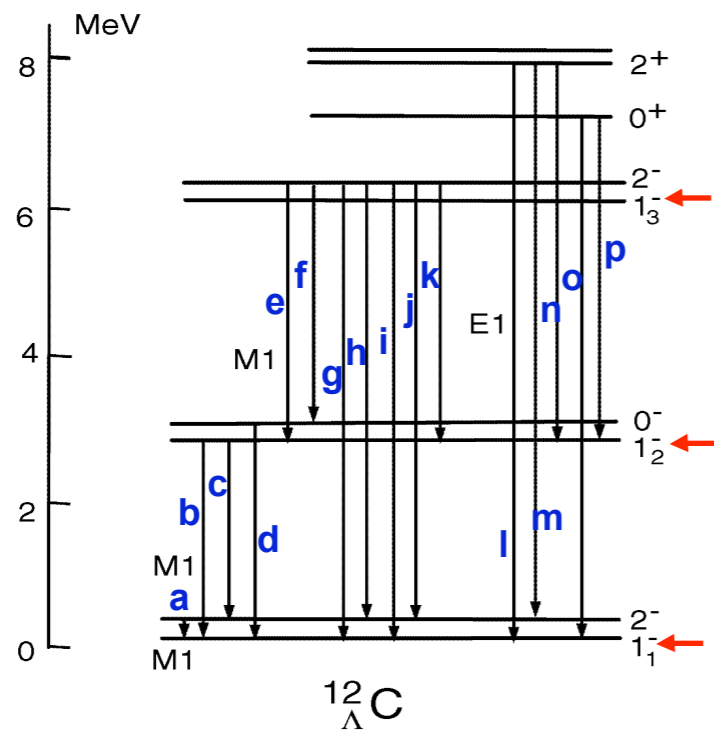
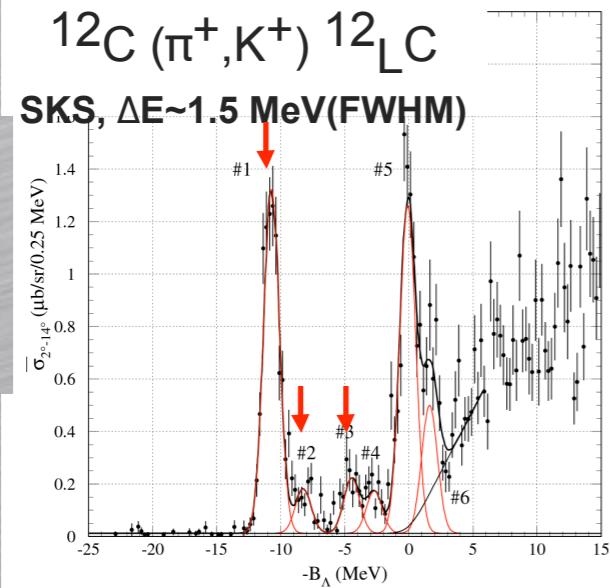


Hyperball-3

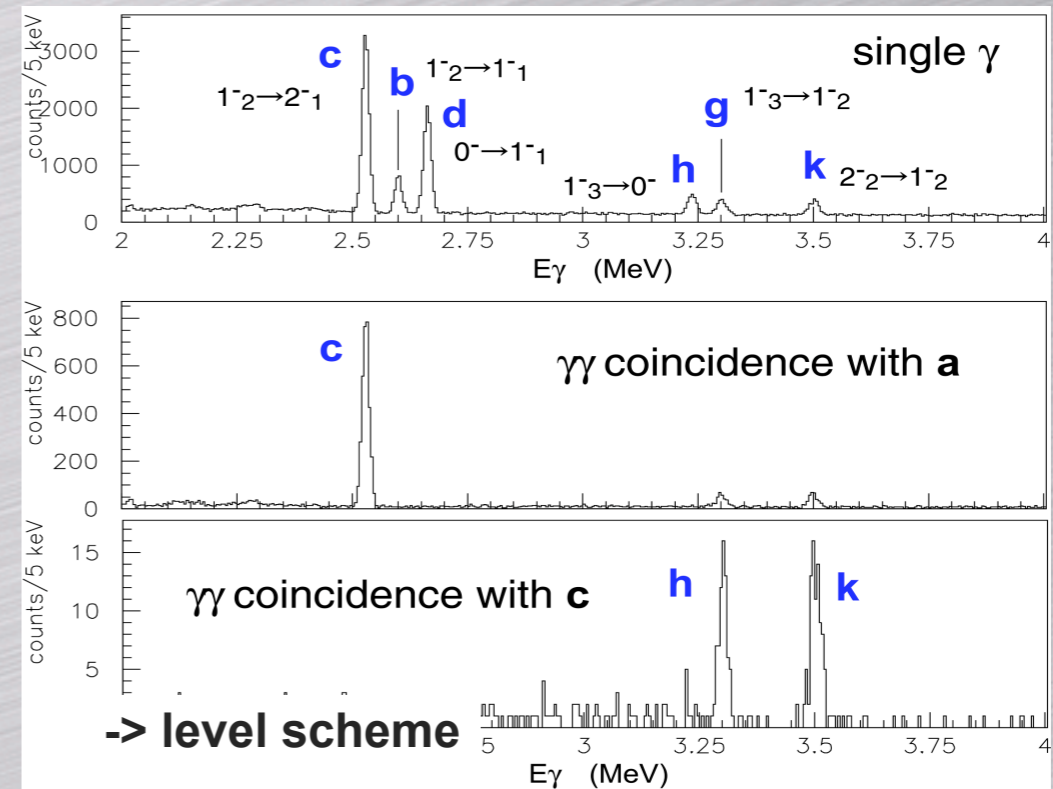
- effic. $> 10\%$ at 1 MeV
(x4 of Hyperball)
- Rate limit
 $\sim 2 \times 10^7$ particles /s (x5)
- Yield: x20 for single γ
x80 for $\gamma\gamma$



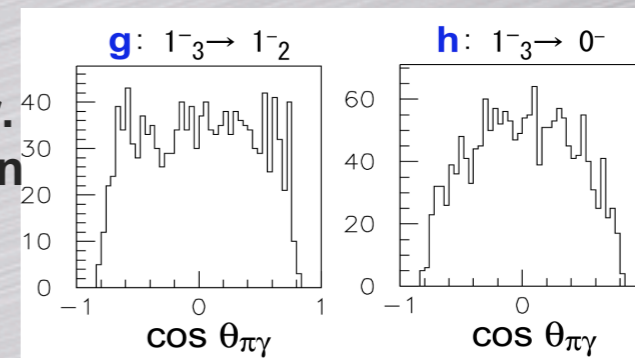
(1-b) Light hypernuclei-- $^{12}_{\Lambda}C$ case



Simulation: K1.1, 10g/cm^2 , 120 hours



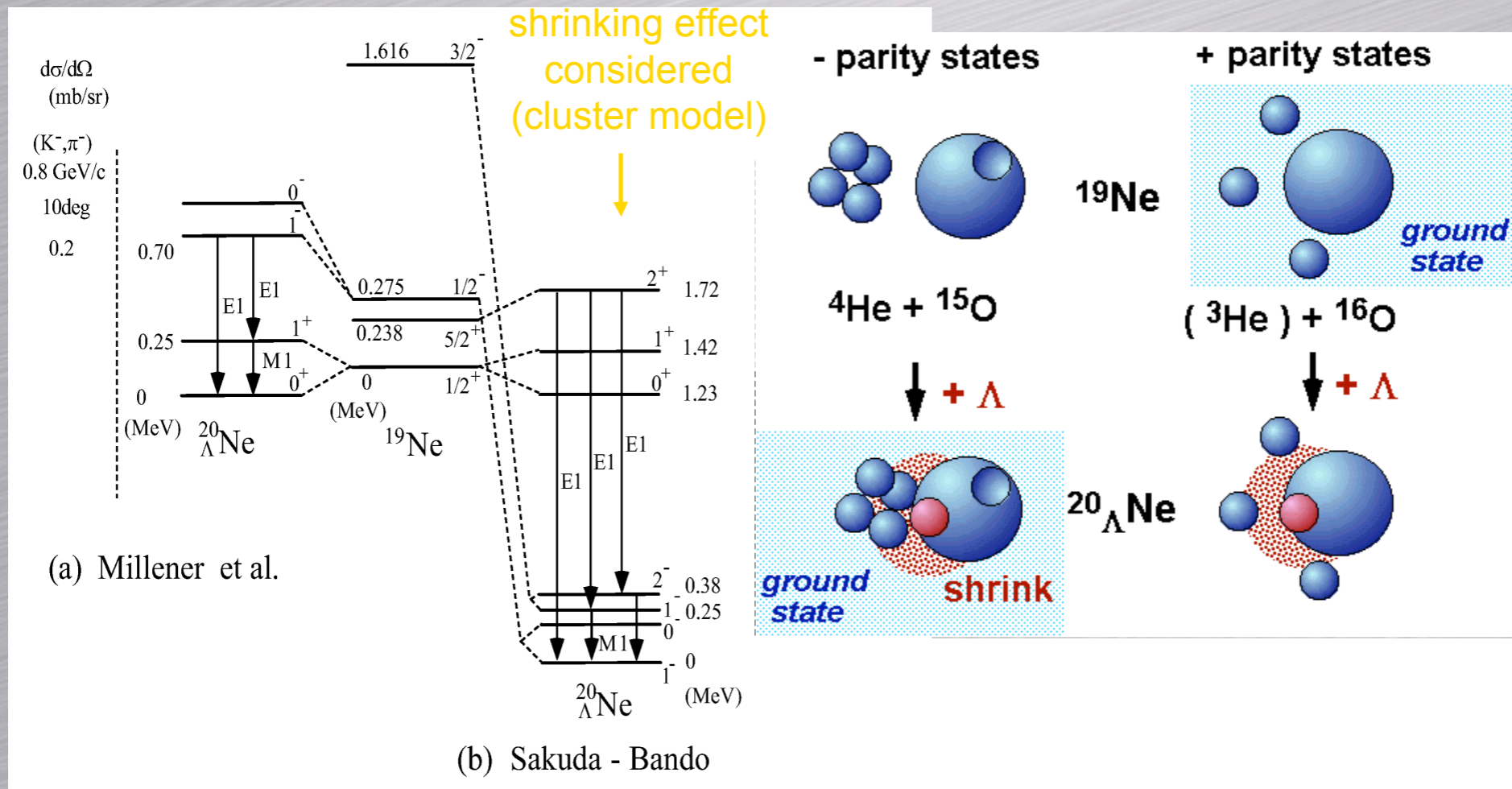
Angular corr.
 \rightarrow spin assign



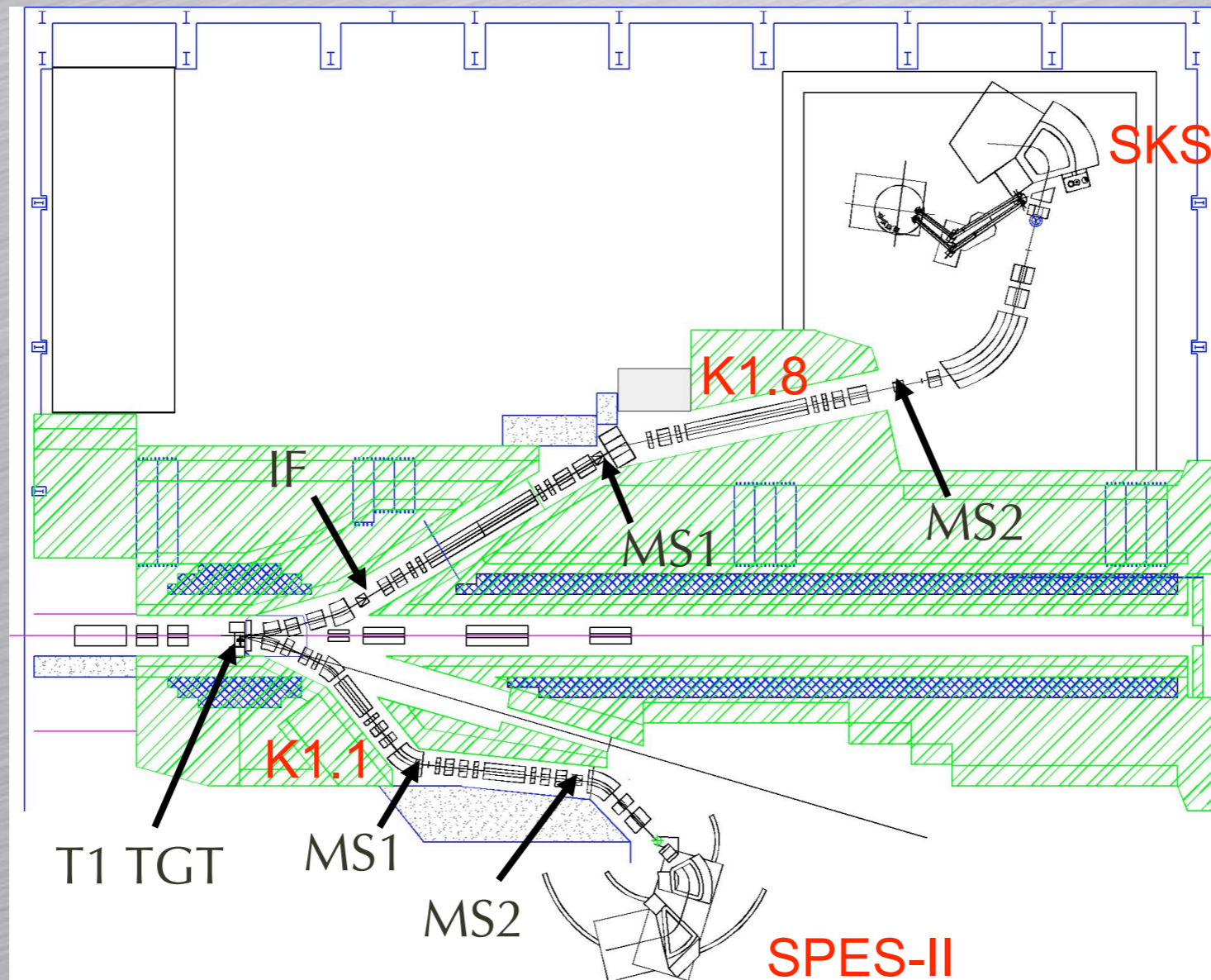
(1-b) Light hypernuclei

Impurity effect

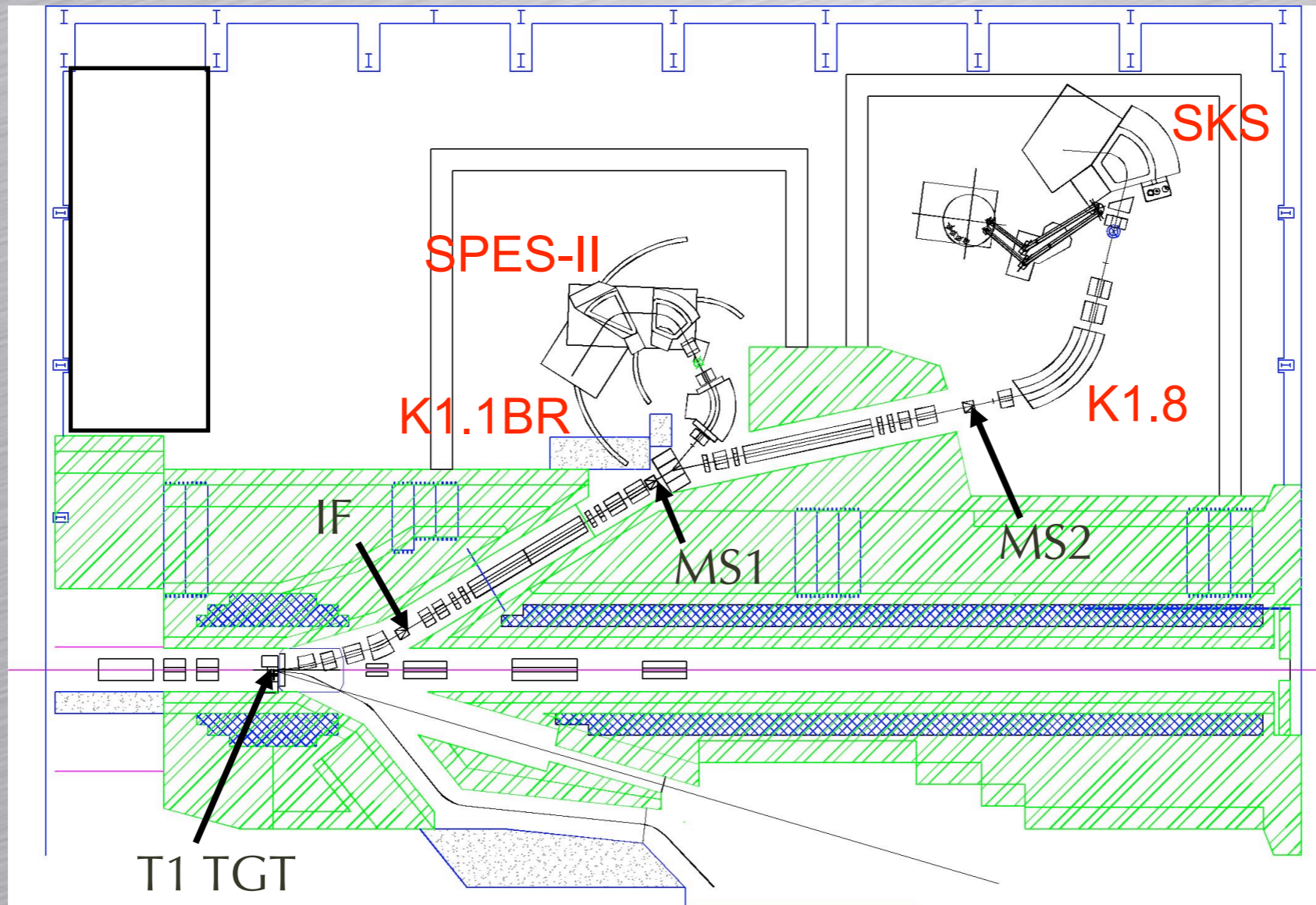
example of $^{20}_{\Lambda}\text{Ne}$: change of cluster structure



Layout Option - K1.8 and K1.1



Layout Option - K1.8+K1.1BR

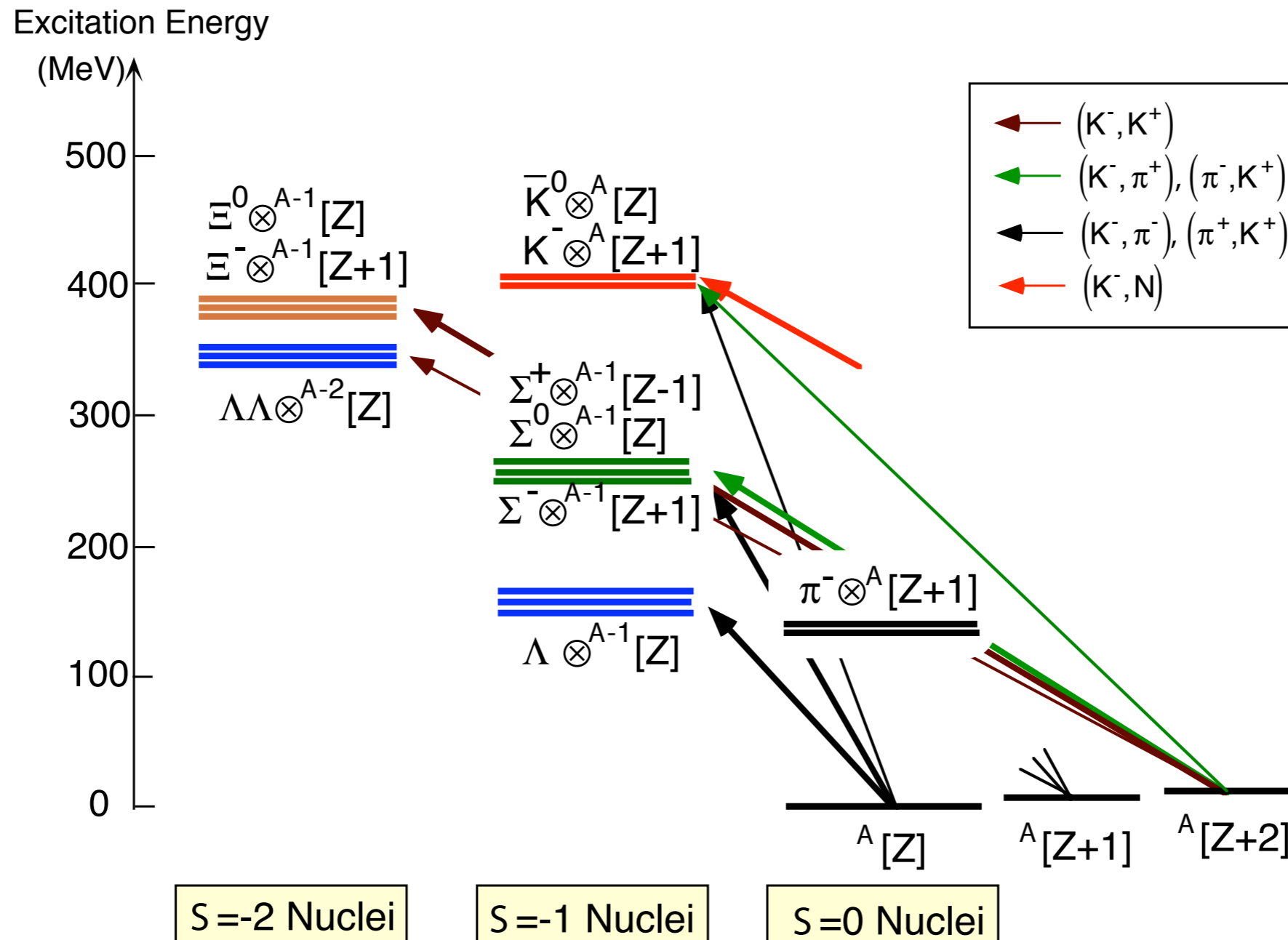


Beam Line Specification

by H. Noumi

	K1.8	K1.1	K1.1BR
Length (m)	46.4	24	26.9
Acceptance (msr.%)	2.7	16.5	4.9
Intensity (ppp)			
1.8 GeV/c	1.0E+07		
1.1 GeV/c	4.9E+05	4.1E+07	1.0E+07
Electro-static Separator	6m-7.5MV/m ×2	2m-7.5MV/m ×2	6m-5MV/m ×1
Separation/Size(rms)	10.8	4.2	6.5
Beam Mom.Resol.(%)	0.07	-	0.05

L10: Study of Dense Kbar-Nuclear Systems



$\bar{K}N$ Bound States

- Prediction by Akaishi and Yamazaki

- $\bar{K}N$ scattering lengths

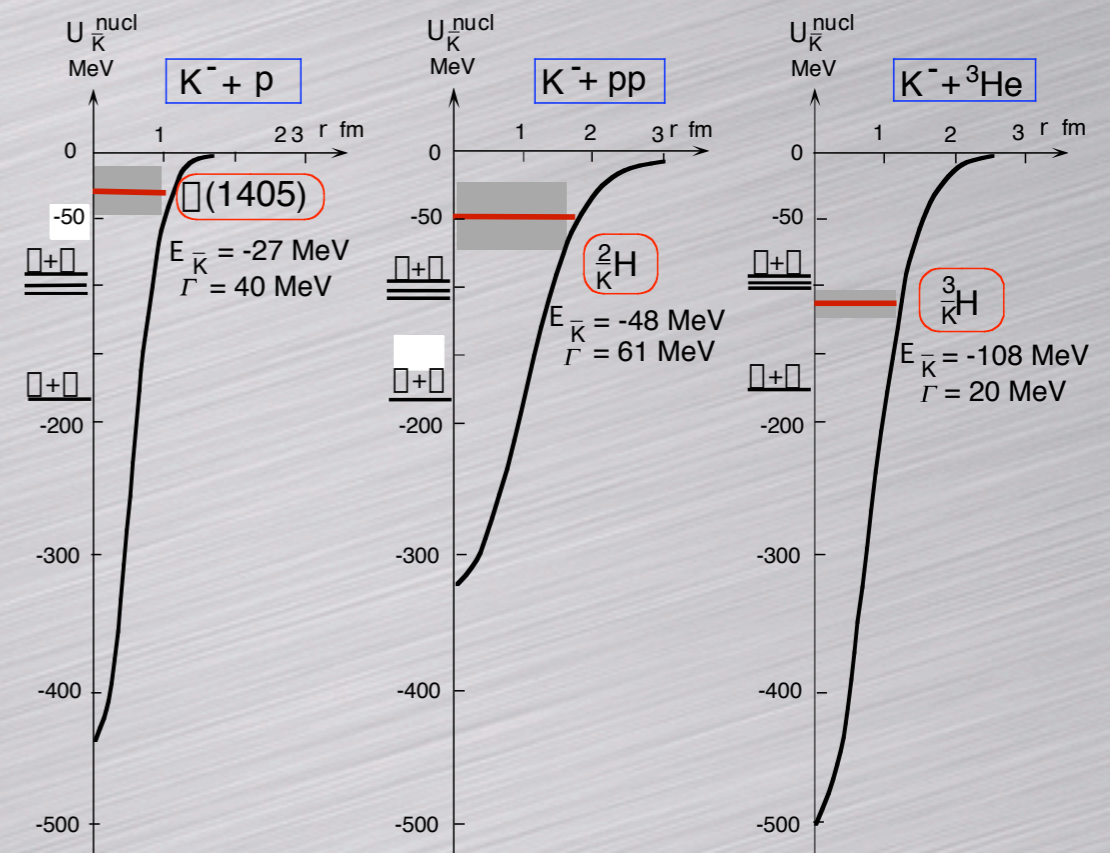
- K -p atomic shift (KEK E228)

- Mass & width of $\Lambda(1405)$

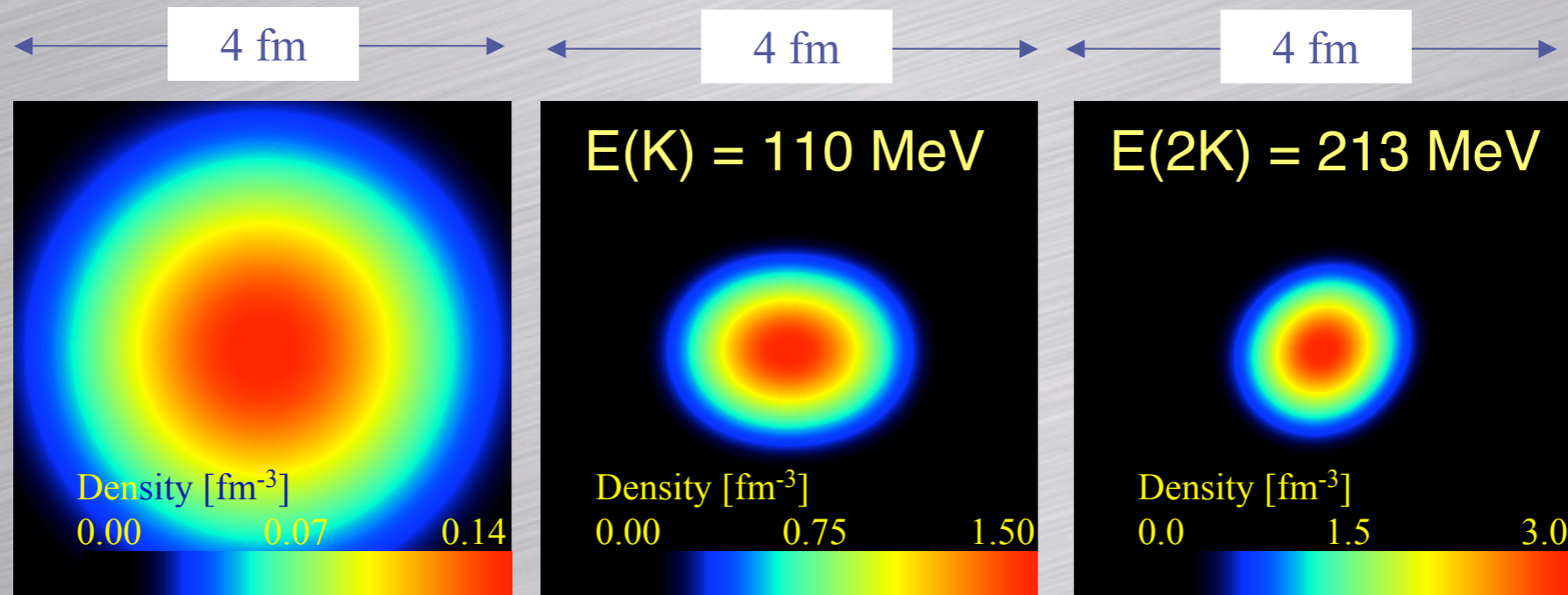


- **Strong attraction in $l=0$ $\bar{K}N$ interaction**

- K -pp, K -ppp, K -pppn, ...



Formation of High Density State



ppn

total B.E. = 6.0 MeV
 central density = 0.14 fm^{-3}
 $R_{\text{rms}} = 1.59 \text{ fm}$

ppnK⁻

total B.E. = 118 MeV
 central density = 1.50 fm^{-3}
 $R_{\text{rms}} = 0.72 \text{ fm}$

ppnK⁻K⁻

total B.E. = 221 MeV
 central density = 3.01 fm^{-3}
 $R_{\text{rms}} = 0.69 \text{ fm}$

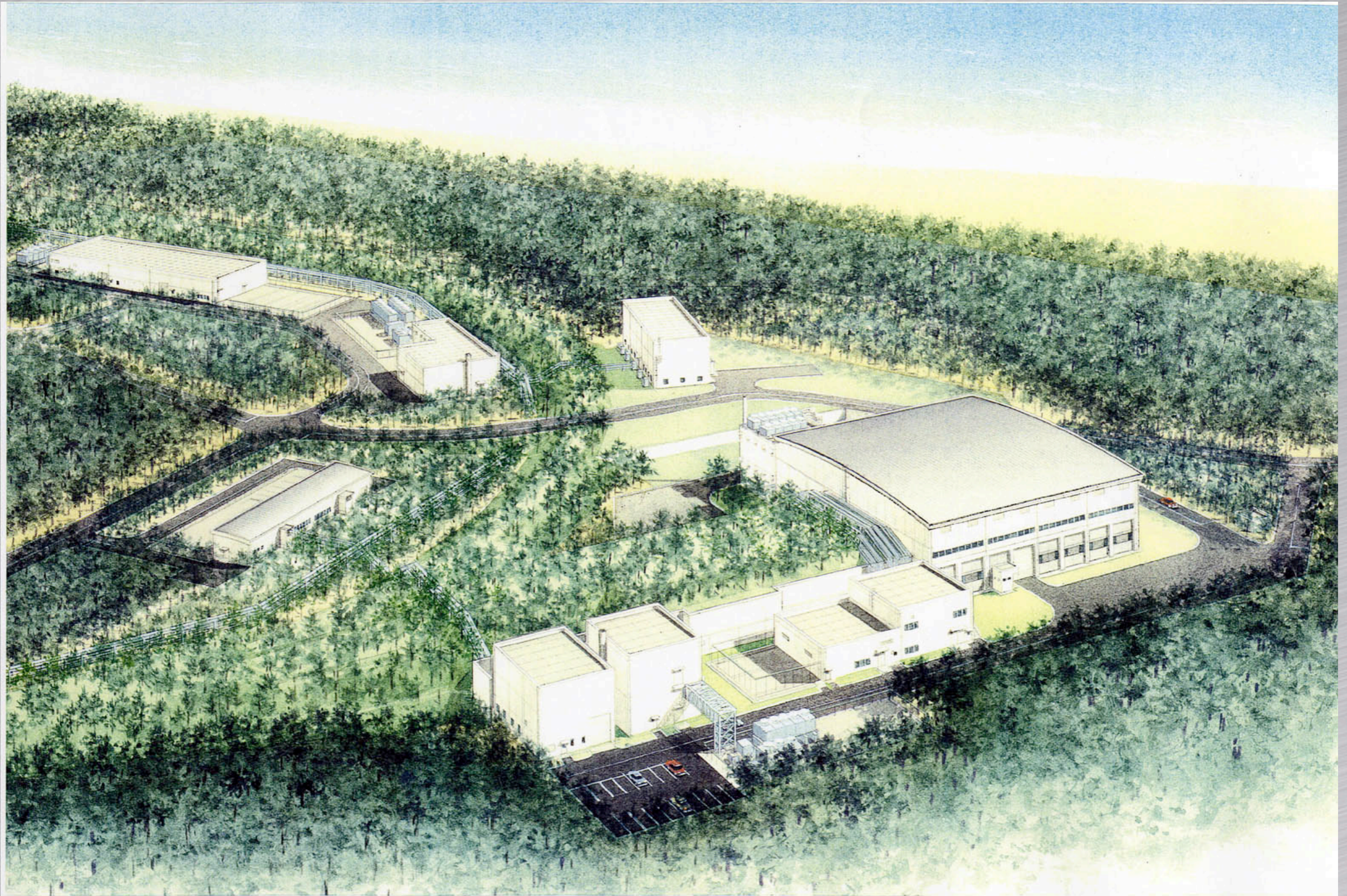
$\rho > \rho_0 \times 10 !!$

Dote et al.

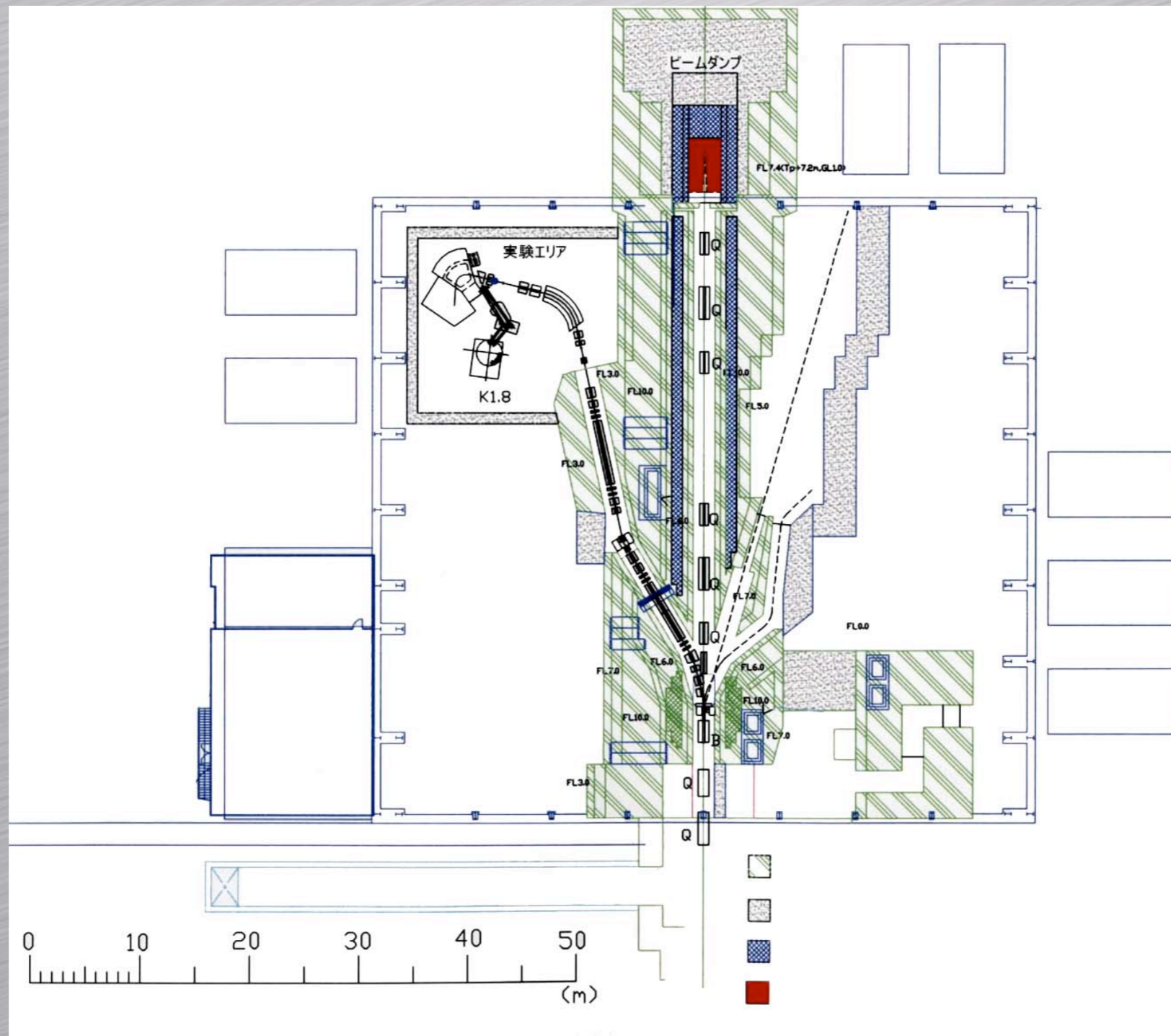
How to produce ?

- Single Kaon bound state
 - **(K⁻,π⁻) reaction: BNL P967**
 - **(K⁻,N) reaction** *Kishimoto*
 - **(Stopped K⁻,n) reaction: KEK E471**
Suzuki
- Double Kaon bound state
 - **(K⁻,K⁺) reaction**

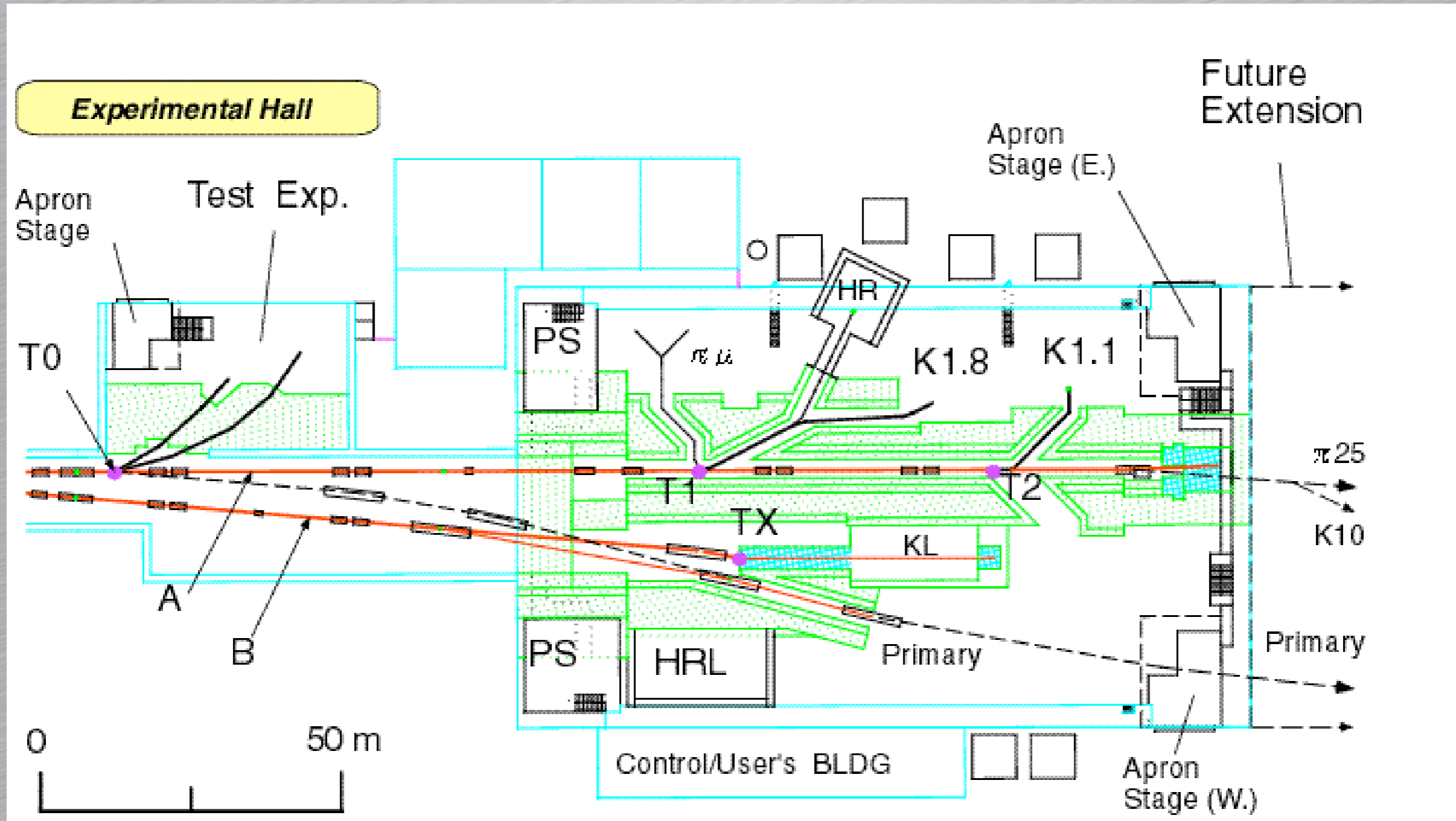
NP Hall



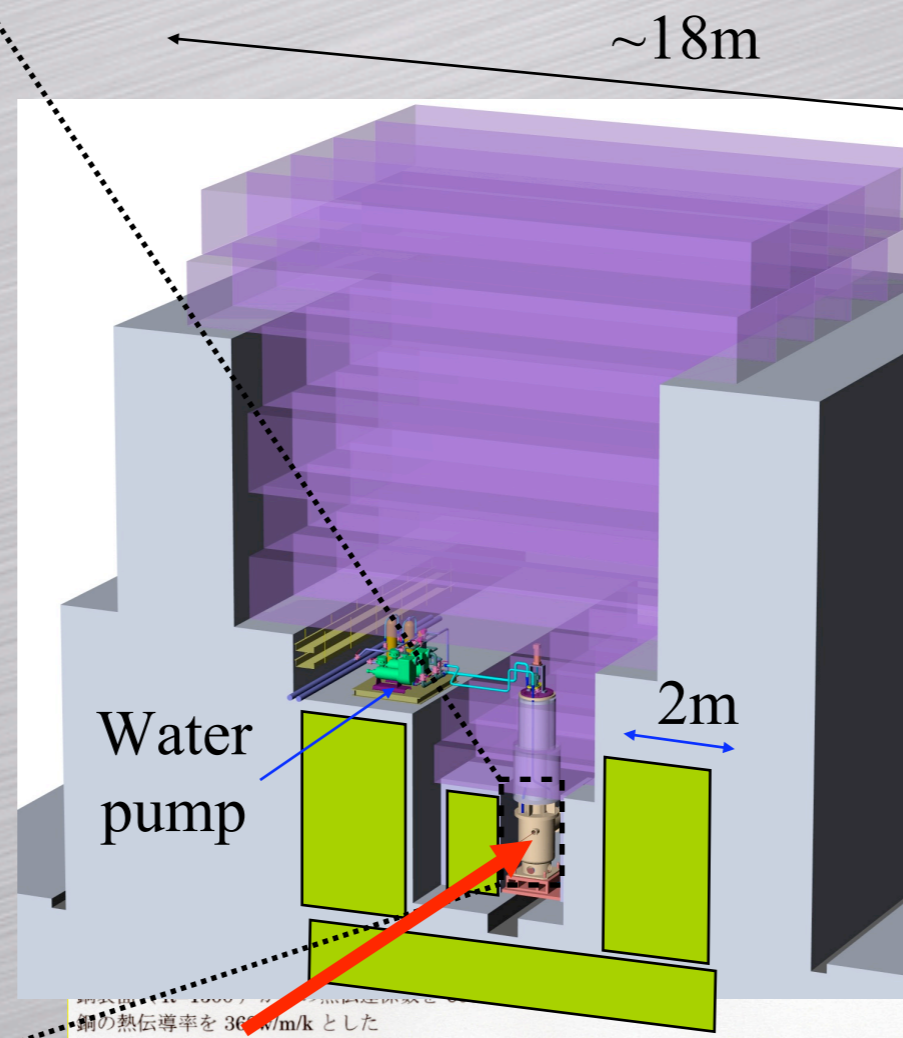
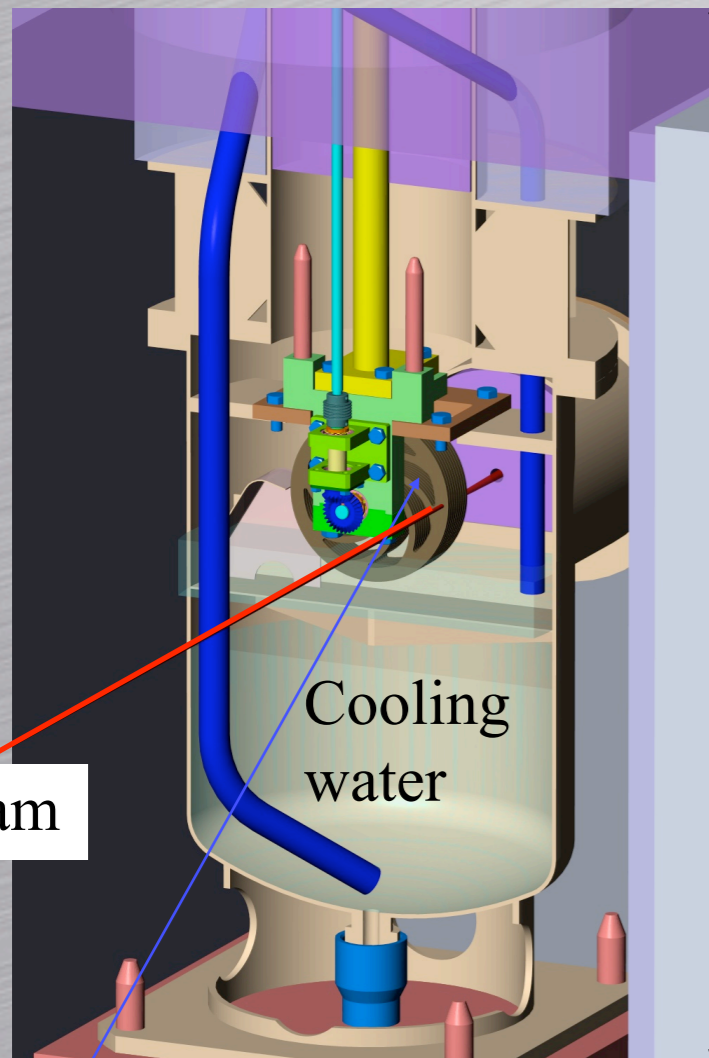
NP Hall: Phase-1



NP Hall: Phase-2



Technical Challenges

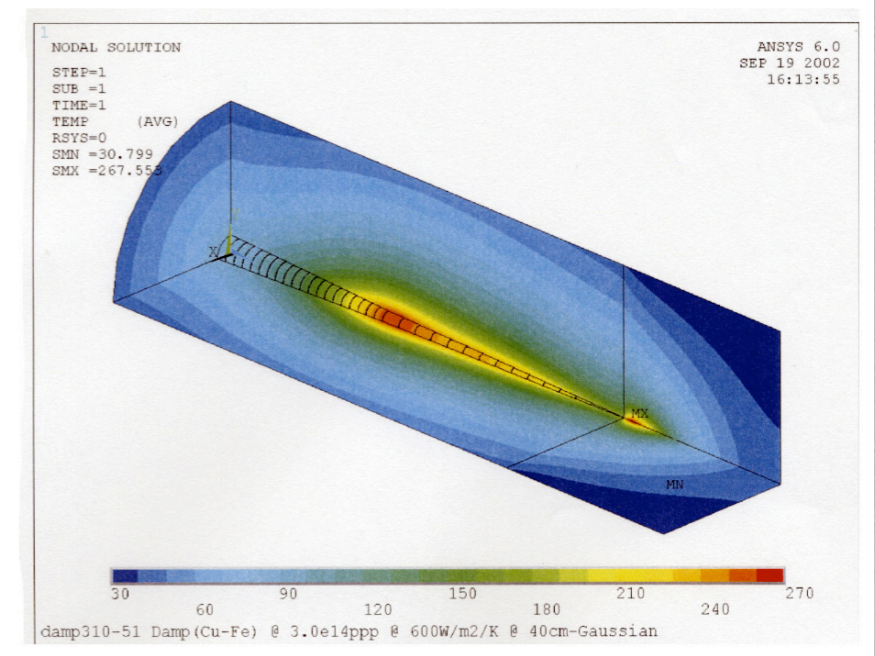
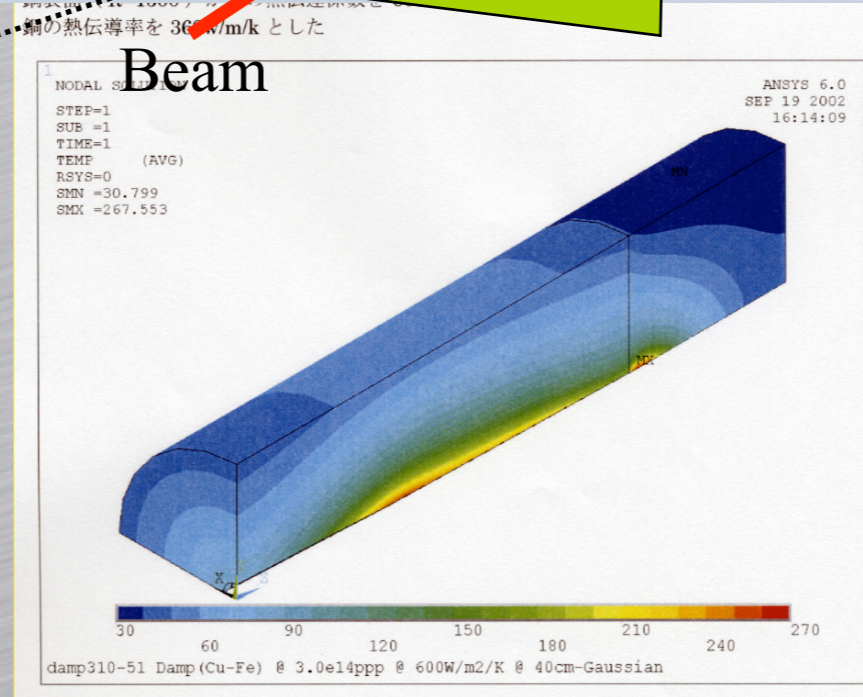


T1 Target

Beam Dump
(750kW)

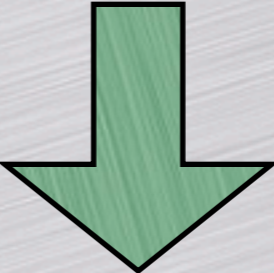
Target disk
5.4cm Thick
50cm Diam.

Noumi, Tanaka, Sato,
Takahashi, Yamanoi, ...



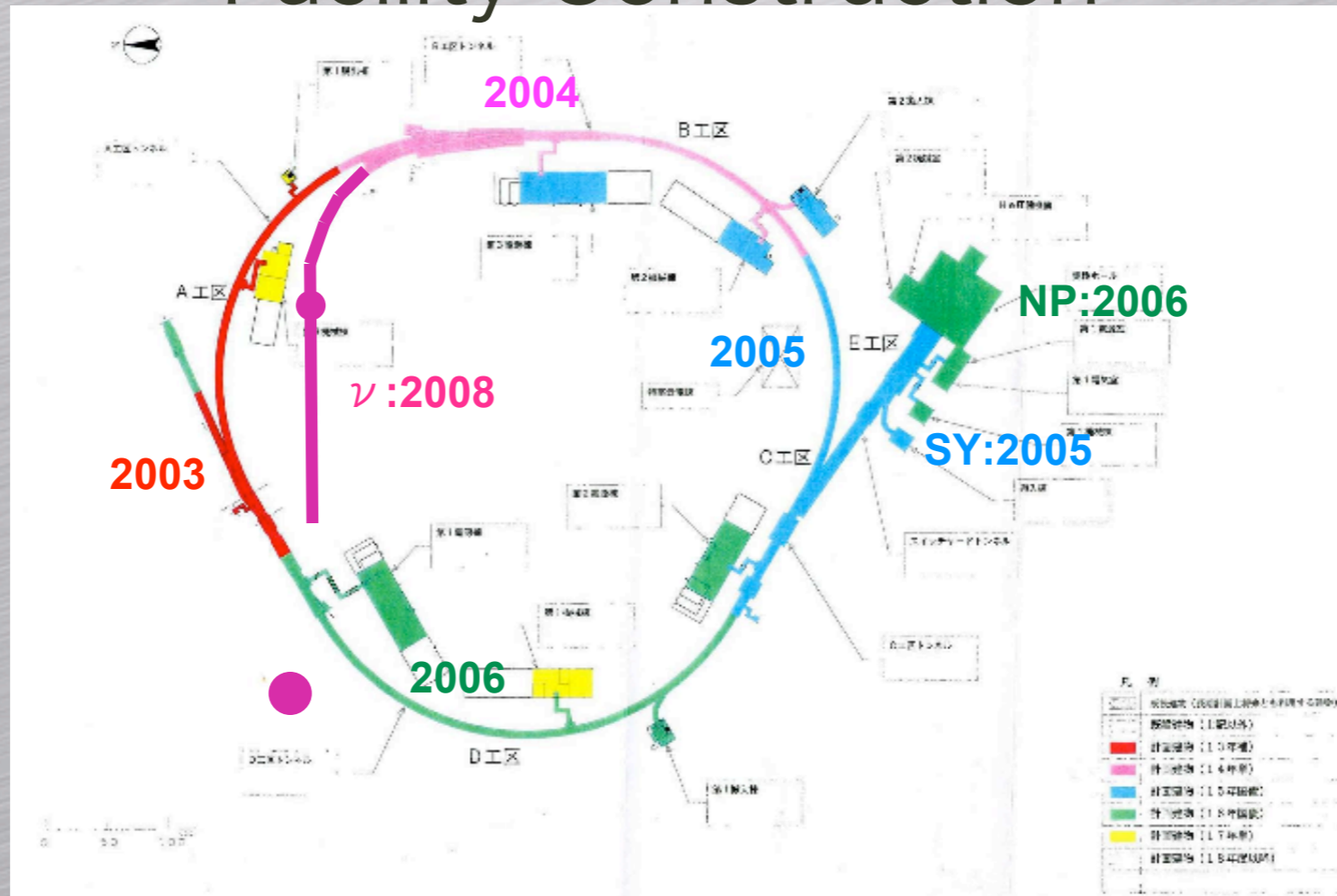
Ancient Salt Farm



- found in the 50 GeV ring area
- 11-13th century?
- 2003-2004:excavation
- 
- One year delay for tunnel construction

Construction Schedule

Facility Construction



Primary line in SY: 2006

Magnets in NP Hall: 2007

First beam at NP Hall: 2008

ν -Beam: 2009

Summary

- J-PARC is now under construction.
 - First beam@30 GeV in 2008: one year delay
 - Require extra budgets for full spec.
- Strangeness Nuclear Physics Program
 - Two LOIs (L06, L10) as Day-1 Experiments
 - K1.8, K1.1BR, and SKS', SPES-II, Hyperball-3, New CDS, etc. will be available at Day-1
- Call for Full proposals: in 2004
 - NP04: in Feb., 2004
 - <http://j-parc.jp/>