P05 for J-PARC 50 GeV Proton Synchrotron

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

T. Nagae

KEK

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66 members
from 21 institutes

Proposed Experiment

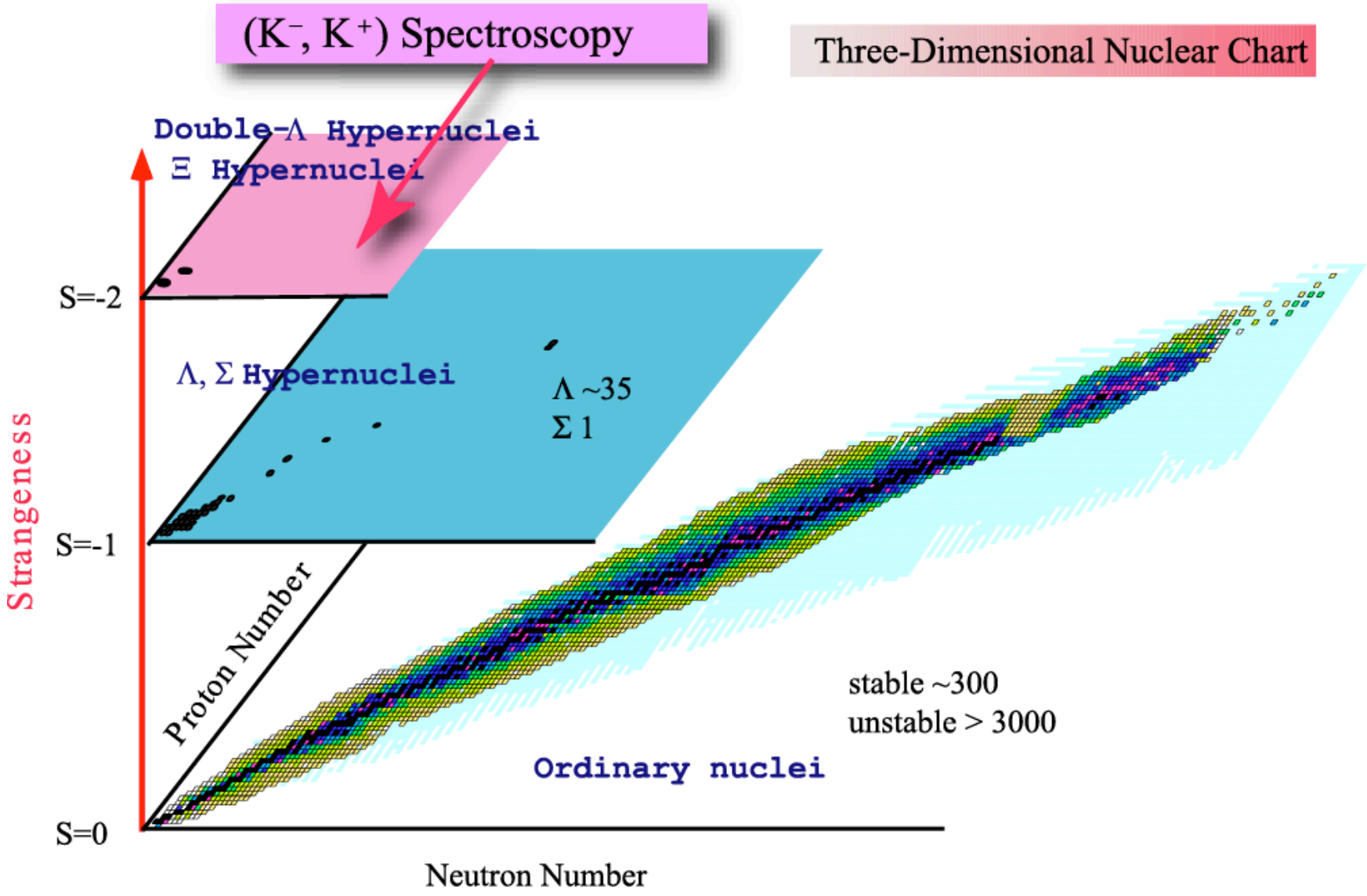
- Discovery of Ξ-hypernuclei
  - Measurement of Ξ-nucleus potential depth and width of $^{12}_{\Xi}$Be
- Beam: K^- @ 1.8 GeV/c, 1.4×10^6/spill
  - CH_2 ~2 g/cm^2 : 2 weeks for tuning and calibrations
  - ^{12}C 5.4 g/cm^2 : 4 weeks
- Setup: K1.8 & SKS+

Unique experiment at J-PARC :
No other place can do this experiment !

Purpose of the experiment

- First Spectroscopic Study of S=-2 systems in (K^-,K^+) reaction
  - Ξ-hypernuclei → double-Λ hypernuclei
  - Ξp-$\Lambda\Lambda$ mixing
  - First step for multi-strangeness baryon systems
- ΞN Interactions: almost no information
  - Attractive or repulsive ? → potential depth
  - $\Xi p \rightarrow \Lambda\Lambda$ conversion ? → conversion width
  - Isospin dependence ? → Lane term($\tau_\Xi \bullet \tau_C / A$)

Strangeness Nuclear Physics



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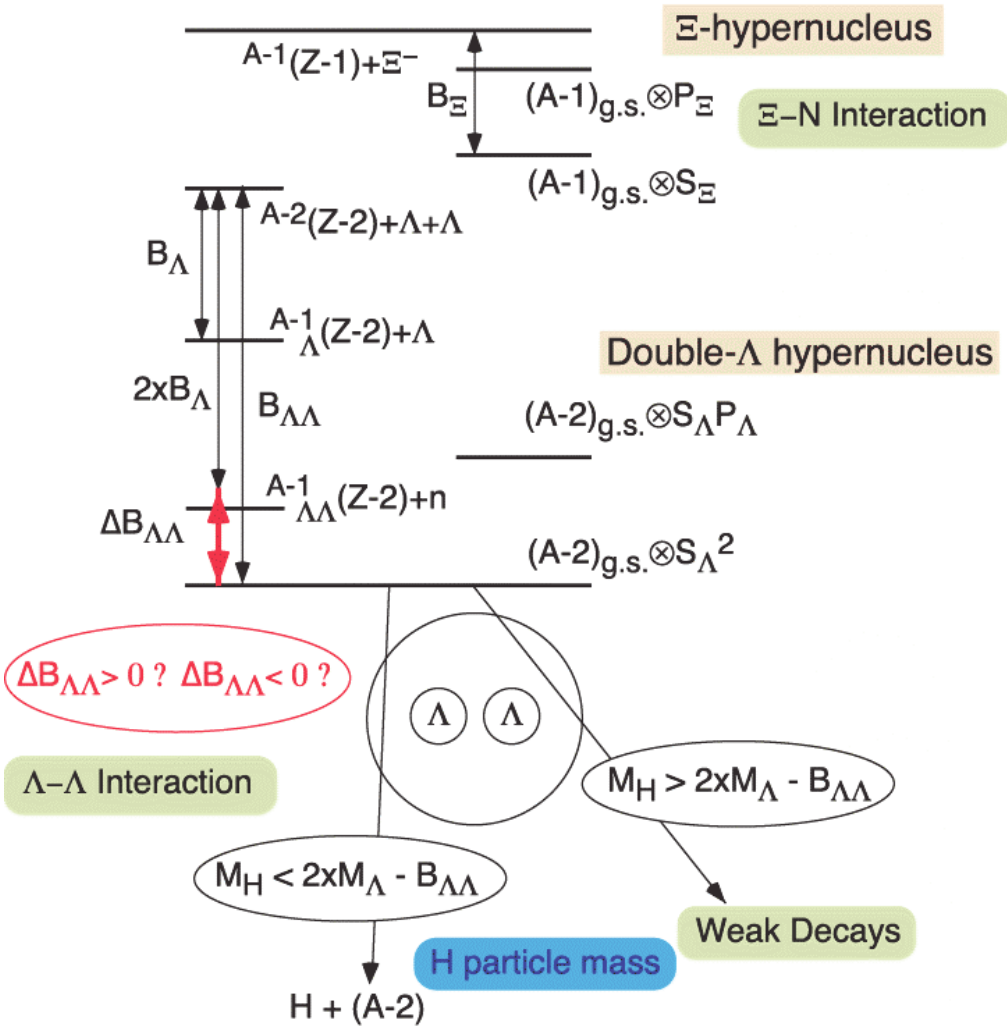
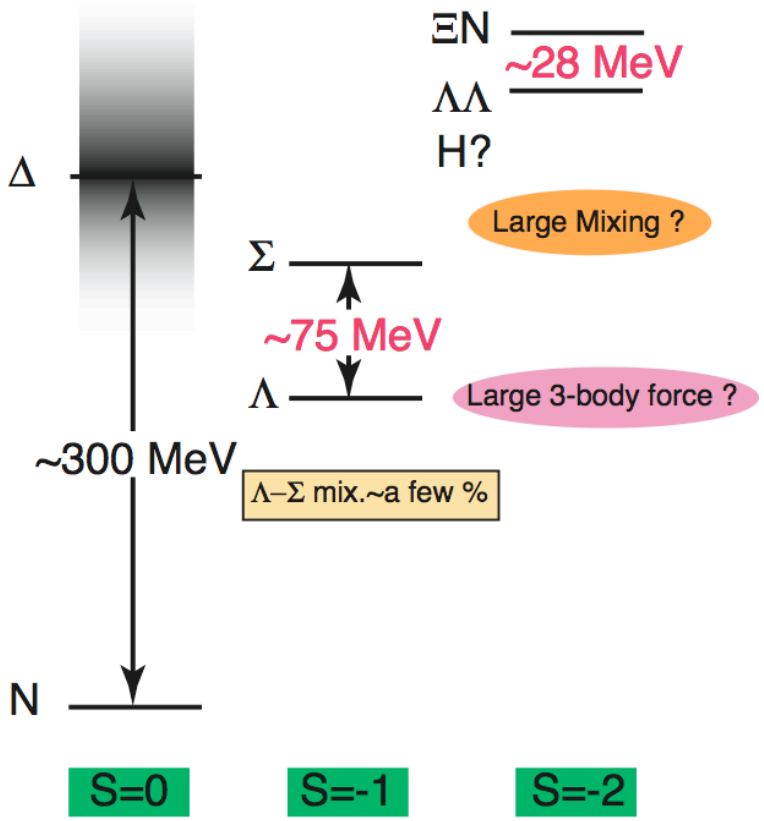
S=-2 Baryon Systems

Energy Spectrum of S=-2 systems





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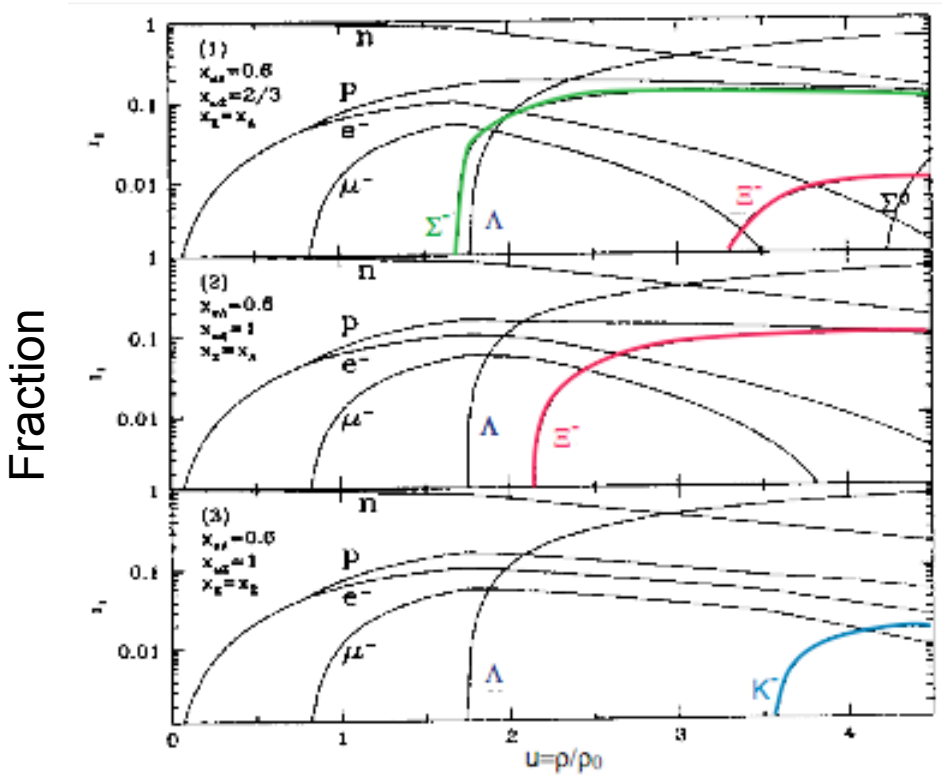
Ξ hypernuclei potential ?

- Λ, Σ^-, Ξ^-, K^- in Neutron Star Core ?
  - Chemical Potential: $\mu_B = m_B + \frac{k_F^2}{2m_B} + U(k_F)$



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

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

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

Purpose of the experiment -cont.

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U_Ξ and Partial Wave Contributions in Nuclear Matter

(MeV)

Model	T	$^1S_0$	$^3S_1$	$^1P_1$	$^3P_0$	$^3P_1$	$^3P_2$	U_Ξ	Γ_Ξ
NHC-D	0	−2.6	0.1	−2.1	−0.2	−0.7	−1.9		
	1	−3.2	−2.3	−3.0	−0.0	−3.1	−6.3	−25.2	0.9
Ehime	0	−0.9	−0.5	−1.0	0.3	−2.4	−0.7		
	1	−1.3	−8.6	−0.8	−0.4	−1.7	−4.2	−22.3	0.5
ESC04d*	0	6.3	−18.4	1.2	1.5	−1.3	−1.9		
	1	7.2	−1.7	−0.8	−0.5	−1.2	−2.8	−12.1	12.7

- OBE (NHC-D, Ehime)
  - odd-state attraction
  - strong A-dependence of V_Ξ
- ESC04d*
  - strong attraction of $^3S_1$(T=0)

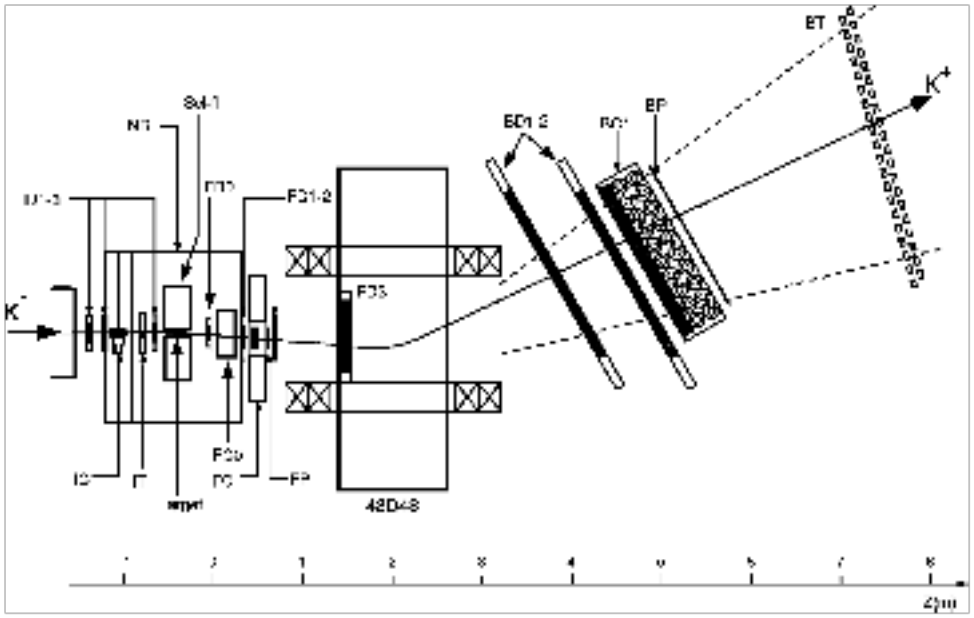
Previous Measurements on $^{12}C(K^-,K^+)$ BNL-AGS E885

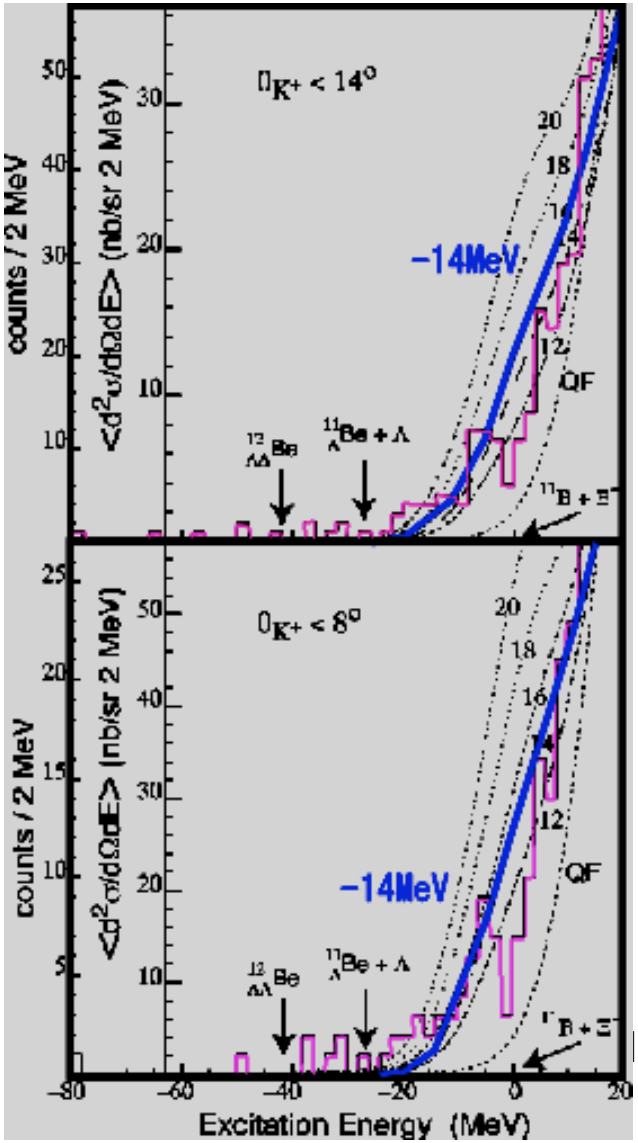
Evidence !? V_Ξ = -14 MeV

P_K=1.8 GeV/c
ΔM=9.9 MeV/c^2 (FWHM) for $p(K^-,K^+)\Xi^-$

P.Khaustov et al,
PRC61(2000)0546

$-20 < E_\Xi < 0$ MeV
89±14 nb/sr θ< 8°
42± 5 nb/sr θ<14°

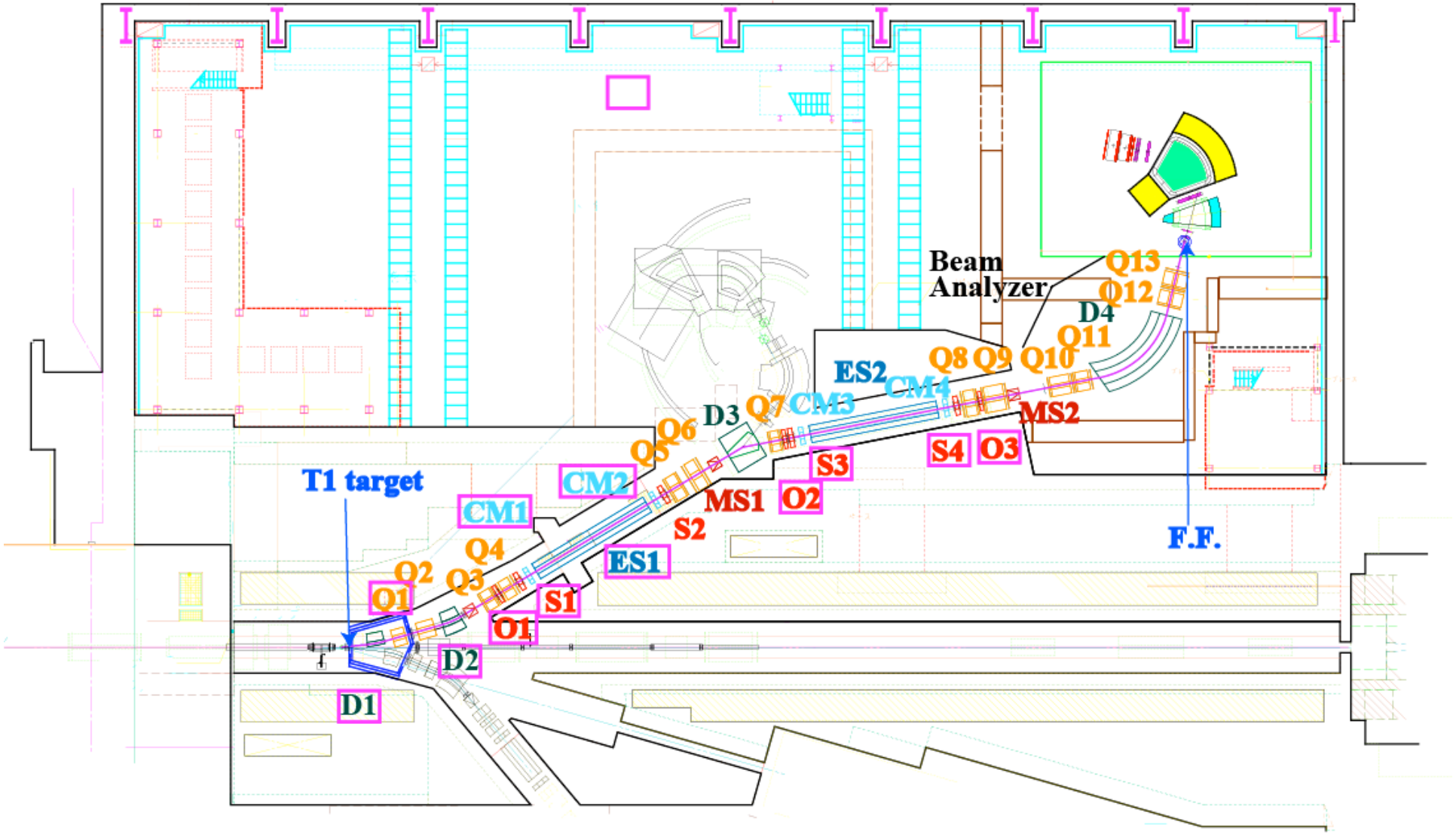




Experimental Setup

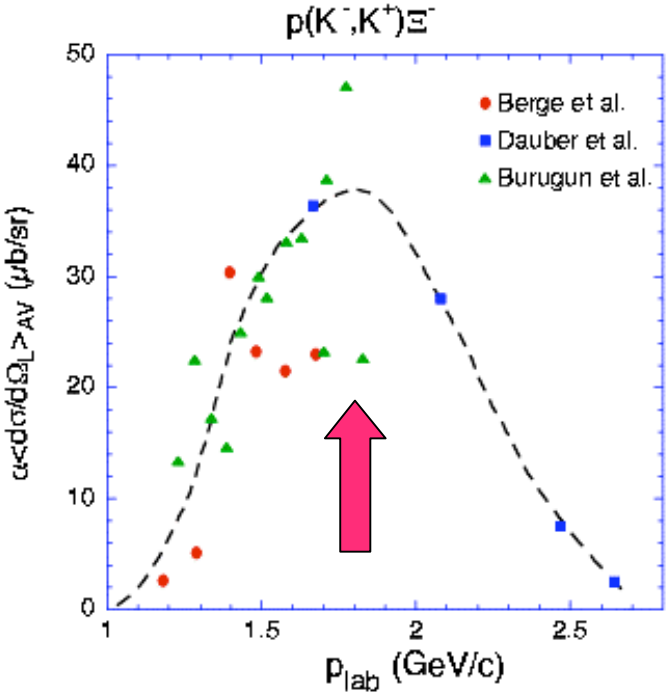
- K1.8 beam line
  - Double Electro-static Separators→$K^-/\pi^-=6.9$
  - High Intensity: 1.4×10^6 K^-/spill @ 30 GeV(9μA)
  - Beam Spectrometer (QQDQQ): $\Delta p/p=3.3\times10^{-4}$ (FWHM)
- SKS+ spectrometer
  - A new dipole magnet in front of SKS
  - Acceptance: 30 msr
  - Momentum Resolution: $\Delta p/p=1.7\times10^{-3}$(FWHM)
  - New simple cryogenics system

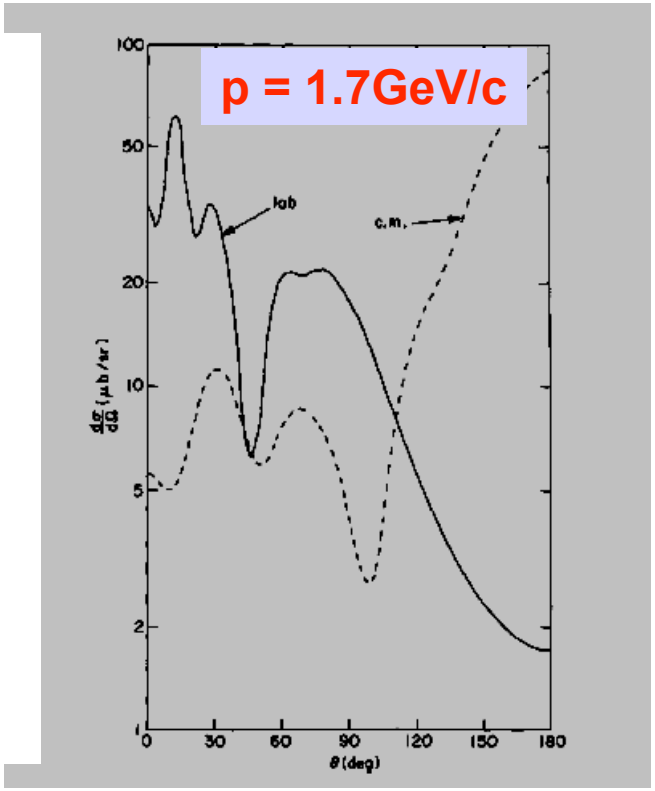
K1.8 & SKS+ in Hadron Hall



$K^- p \rightarrow K^+ \Xi^-$ Cross Section

C.B.Dover & A.Gal
Ann. of Phys. 146(1983)309

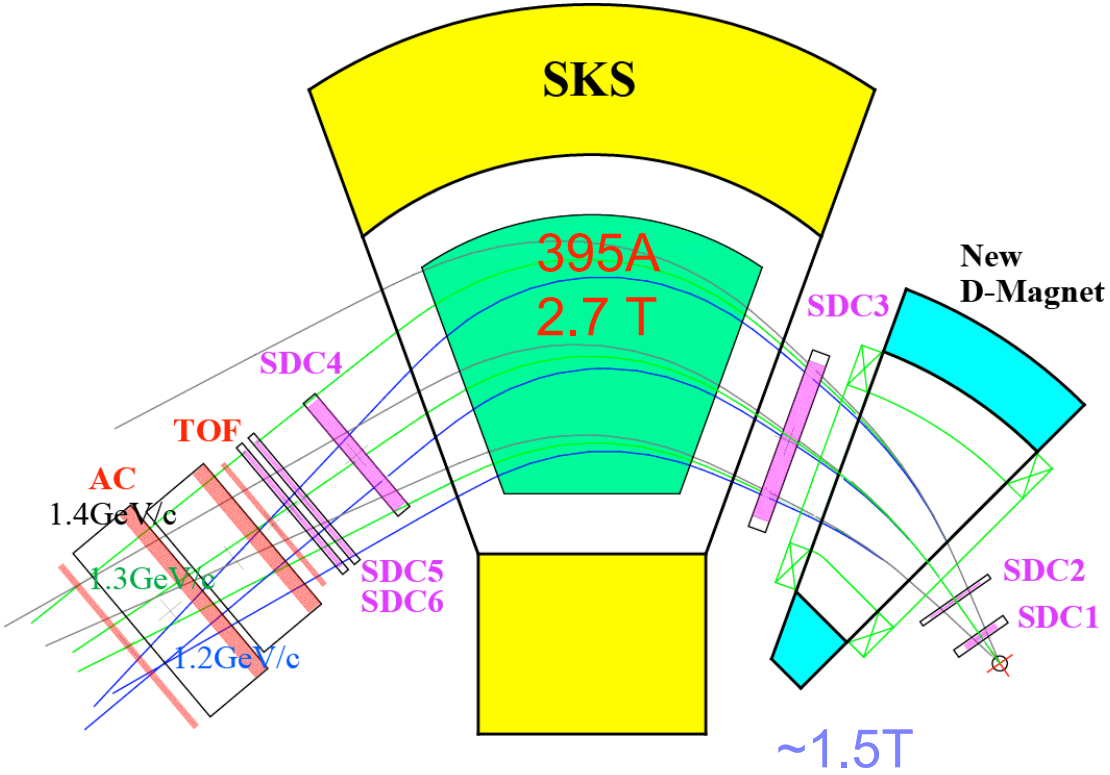


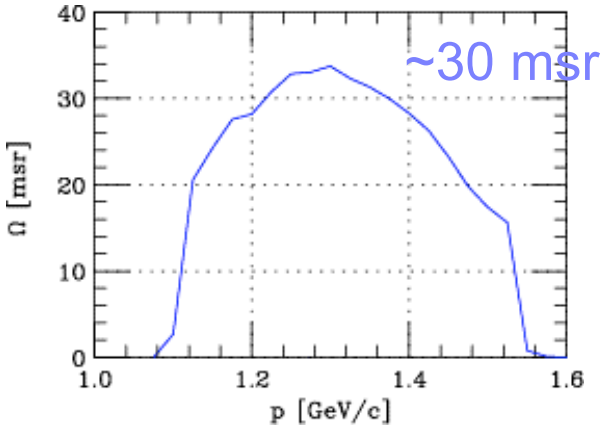


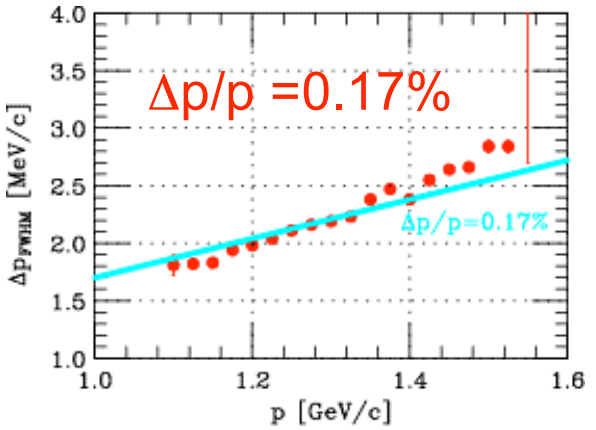
T.Iijima et al.
NPA546(1992)588

p = 1.65 GeV/c
$1.7° < \theta_{lab} < 13.6°$
35±4 μb/sr

SKS+ Spectrometer

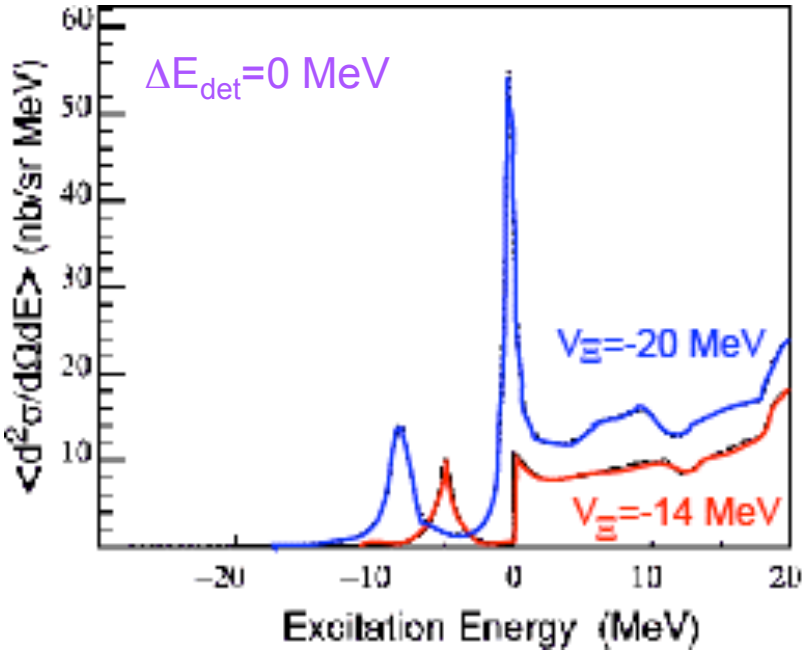






- 95°total bend
- ~7m flight path
- Δx=0.3 mm (RMS)

$^{12}C(K^-,K^+)^{12}_{\Xi}Be$ spectra calculated with Woods-Saxon potentials



P.Khaustov, et al.
Phys. Rev. C61(2000)054603

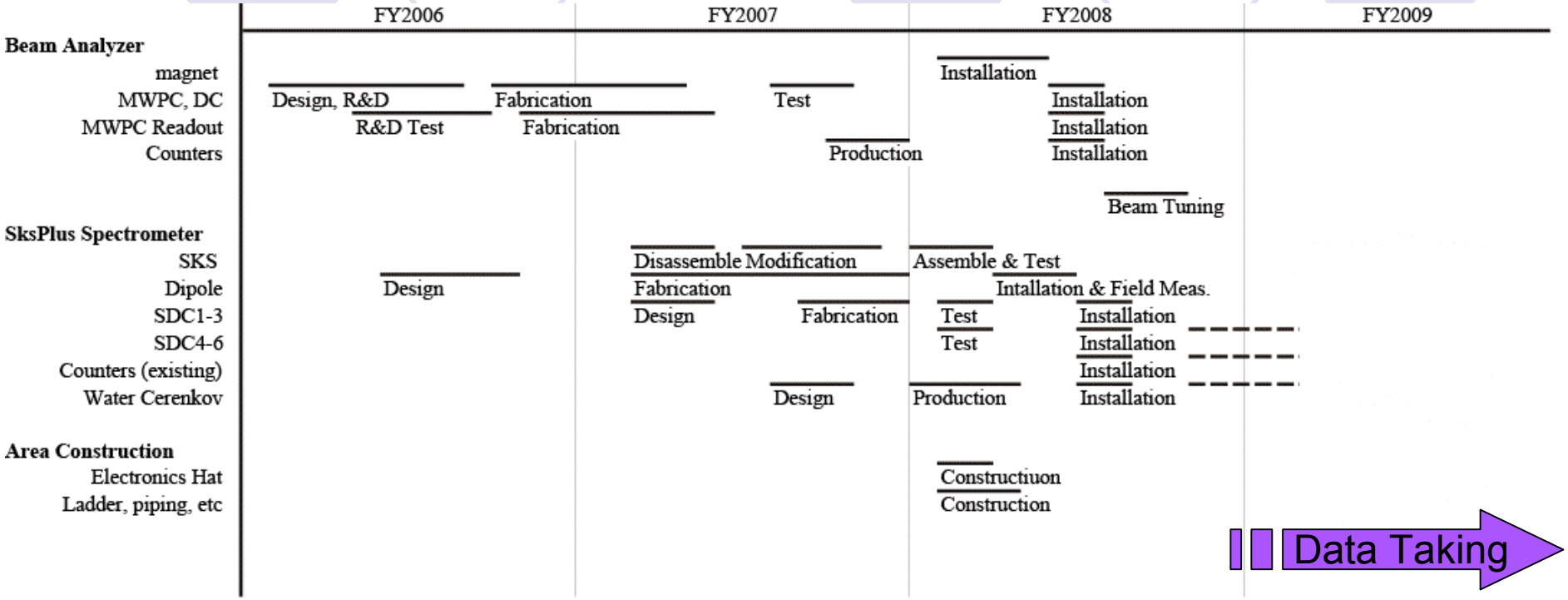
states		V^{Ξ}_0 [MeV] −24	−20	−16	−12
s-state					[nb/sr]
$0p_{3/2} \rightarrow 0s_{1/2}$	1^-	215	168	123	81
p-states					[nb/sr]
$0p_{3/2} \rightarrow 0p_{3/2}$	0^+	29	20	–	–
	2^+	164	103	–	–
$0p_{3/2} \rightarrow 0p1_{/2}$	2^+	152	93	–	–
sum		345	216	–	–

K.Ikeda, et al,
Prog. Theor. Phys. 91 (1994) 747 ;
Y.Yamamoto, et al,
Prog. Theor. Phys. Suppl. 117 (1994) 281

Expected Yield

- $Y_C = N_{beam} \times N_{target} \times d\sigma/d\Omega \times \Delta\Omega \times f_{decay} \times f_{analysis}$
  $= 3.7 \times 10^{10}[/day] \times 5.4 \times 6.02 \times 10^{-7}/12[/\mu b]$
  $\times 0.06[\mu b/sr] \times 0.03[sr] \times 0.5 \times 0.7$
  $= 6.3$ events/day
  $\sim$ 190 events/month
- Precision:
  - Peak Position: 0.1 - 0.3 MeV
  - Width: 0.2 - 1 MeV

Schedule



- Run Plan -
  - < 1 μA : CH2 spectrometer tuning etc.
  - > 2 μA : C target data taking start