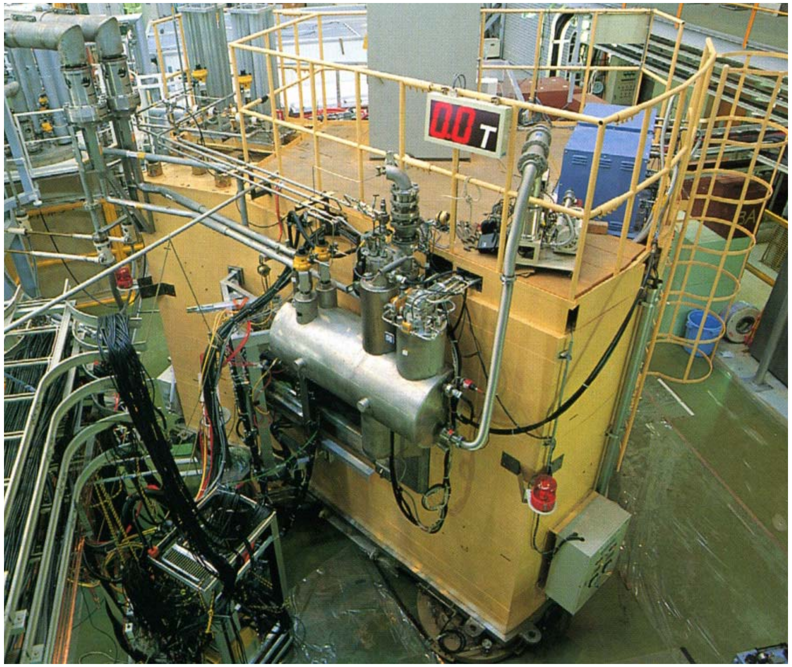
SKS@J-PARCでのハイパー核実験

研究会「広い意味での核反応研究のこれから」
2009.2.21
高橋俊行(KEK)

私が今この場にいる理由、、

M２の時に坂口さんとSKSプロジェクト
に参加したから、、です。

パイオン弾性散乱実験(E269)
　実はSKSの最初の実験
その後、E140a（ハイパー核分光）
　　　　E352（パイオン準弾性散乱実験）
をいっしょに行いました。

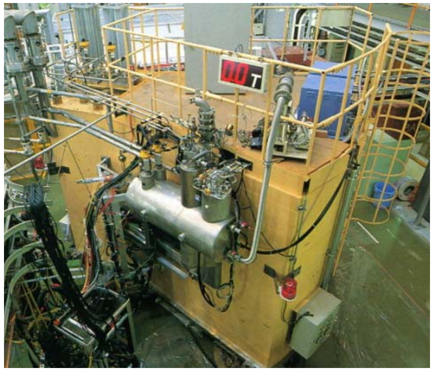


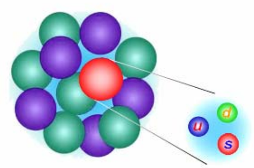
SKS	
高分解能	Δp/p ~0.1%
	ΔM~2MeV
大立体角	100msr

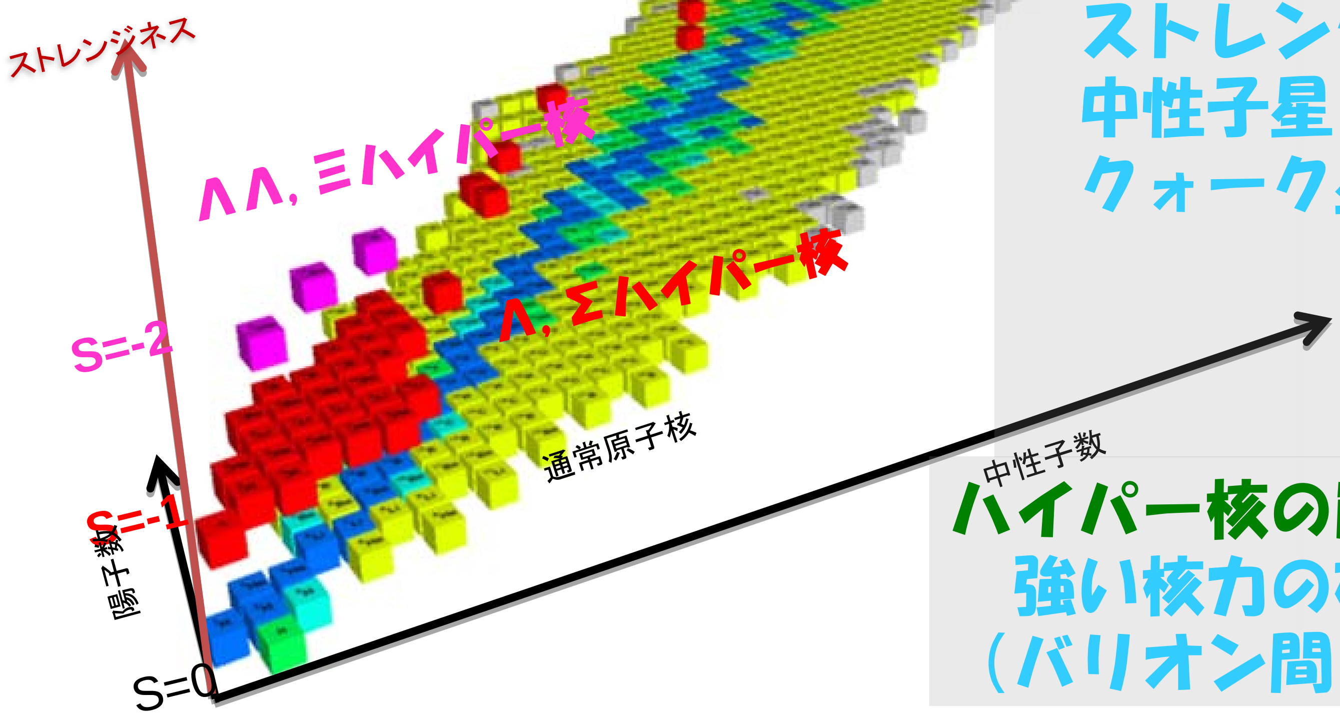
そのSKSもJ-PARCへ移設され、J-PARCでの実験に向けて準備が進められています。

ストレンジ・クォークを含む
ハドロン多体系(ハイパー核)の研究

K1.8ビームライン(大強度K⁻ビーム)とSKS(高分解能分光装置)で行う研究







強い核力の統一的理解

原子核はなぜ固い?

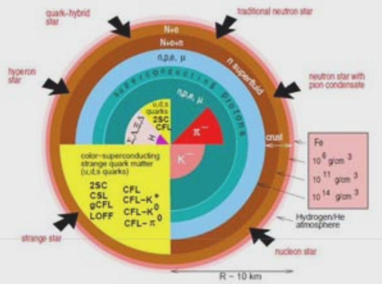
魔法数の起源?

高密度核物質の状態は?

ストレンジネスが出現!?

中性子星コア

クォーク星!?



ハイパー核の崩壊

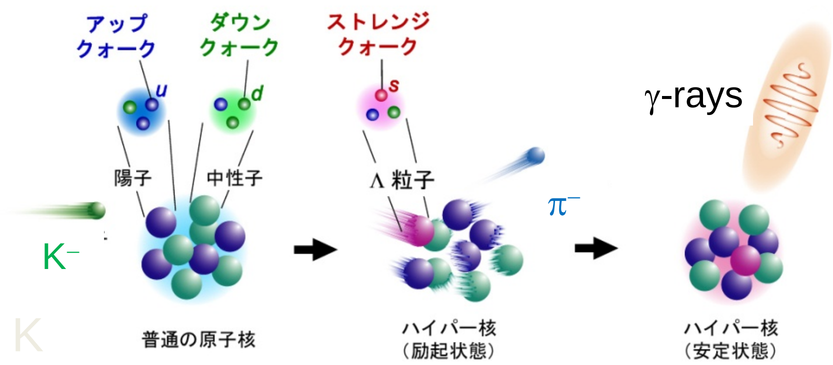
強い核力の存在中で

(バリオン間)の弱い相互作用

Approved Experiments
— K1.8 beamline —

	Spokesperson	Title	Status	Beam	
E19	M.Naruki **SKS**	High-resolution search for Θ^+ pentaquark in $\pi^- p \to K^- X$ reactions	Stage-2	π^- (~2.0)	160 hours
E10	**SKS** A.Sakaguchi	Study on Λ-hypernuclei with the charge-exchange reactions	Stage-2	π^+ (1.2)	6 weeks
E13	H.Tamura	Gamma-ray spectroscopy of light hypernuclei **SKS(SksMinus)+HyperBall**	Stage-2 Day-1	K^- (1.5)	1000 hours
E07	K.Imai, K.Nakazawa, H.Tamura	Systematic study of double strangeness system with an emulsion-counter hybrid method	Stage-2	K^- (1.7)	(150+600) hours
E05	T.Nagae **SKS+D (SksPlus)**	Spectroscopic study of Ξ-hypernucleus, $^{12}_{\Xi}$Be, via the ^{12}C(K^-,K^+) reaction	Stage-2 Day-1	K^- (1.8)	(2+4) weeks
E03	K.Tanida	Measurement of X rays from Ξ^- atom	Stage-1	K^- (1.8)	(20+100) shifts
E08	A.Krutenkova	Pion double charge exchange on oxygen at J-PARC **SKS+D (SksPlus)**	Stage-1	π^+ (1.1-2.13)	(3+10) days
E18	H.Bhang, **SKS+ ...** H.Outa, H.Park **SKS+ ...**	Coincidence measurement of the weak decay of 12LC and the three-body weak interaction process	Stage-1	π^+ (1.05)	(28+72) shifts
E22	S.Ajimura, A.Sakaguchi	Exclusive study on the Lambda-N weak interaction in A=4 Lambda-hypernuclei	Stage-1	π^+ (1.1)	4 weeks

E13: γ-ray spectroscopy of Λ hypernuclei



- Study of ΛN interaction from hypernuclear structure
  - spin dependence
  - charge symmetry breaking
  - ΛN–>ΣN coupling force
  - radial dependence p-shell to sd-shell hypernuclei

$^{4}_{\Lambda}$He, $^{10}_{\Lambda}$B, $^{11}_{\Lambda}$B, $^{19}_{\Lambda}$F

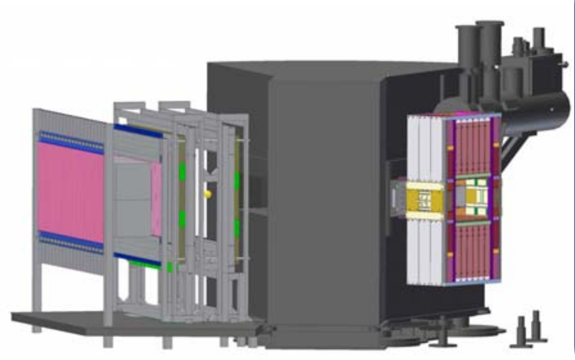
Understanding B-B int. based on SU(3)$_f$

meson-exchange picture .vs. quark-based model

- In-medium properties of Λ
  - g-factor of bound Λ from B(M1) $^{7}_{\Lambda}$Li (3/2$^+$ –> 1/2$^+$)

$^{7}_{\Lambda}$Li

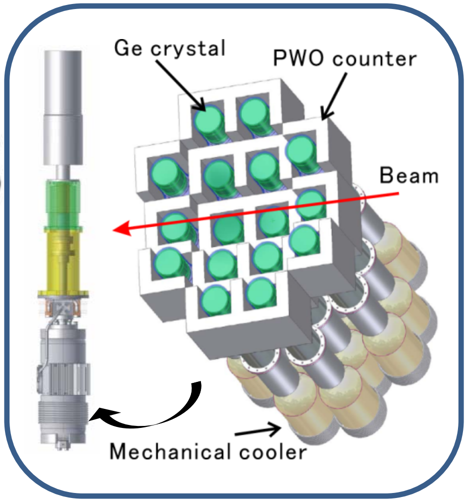
Origin of hadron mass ...



SksMinus spectrometer

ΔΩ ~ 150msr

production of hypernucleus
ΔE ~ a few MeV



HyperBall-J

measure γ-ray transition
ΔE ~ a few keV

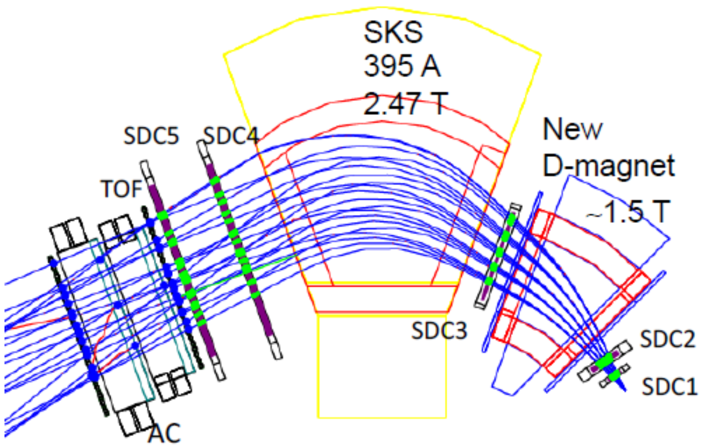
E05: Reaction spectroscopy of Ξ-hypernucleus

$^{12}_{\Xi}$Be via the ^{12}C(K$^-$,K$^+$) at 1.8 GeV/c

Missing mass spectroscopy with high resolution of 3MeV & high statistics

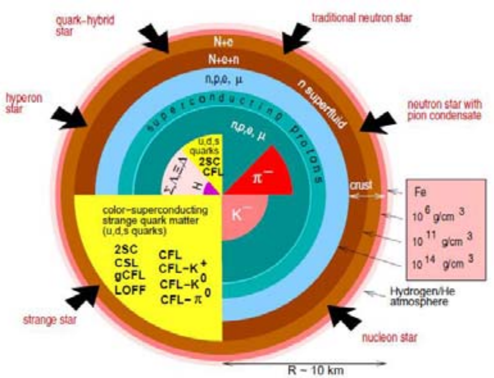
- Do Ξ-hypernuclear states exist ?
  - ΞN interaction
    attractive or replusive ?
  - ΞN –> ΛΛ conversion
    Width of hypernuclear states

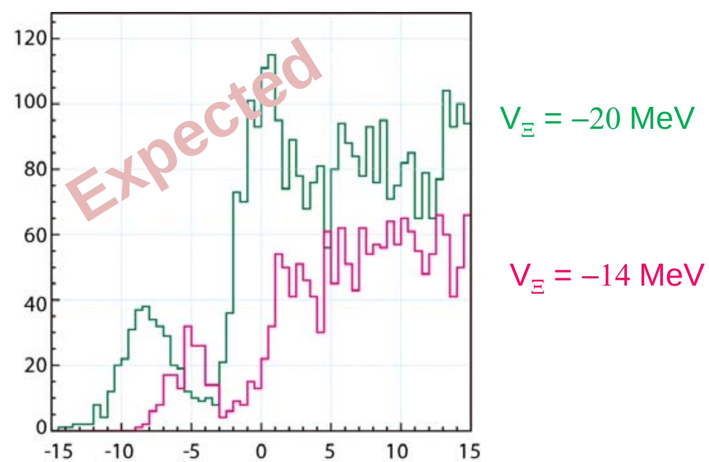
B-B interaction in the S=–2 system



SksPlus spectrometer

- Hyperonization in the high-density nuclear matter
  - Ξ$^-$ may appear in the core of neutron star
    Ξ Nucleus potential

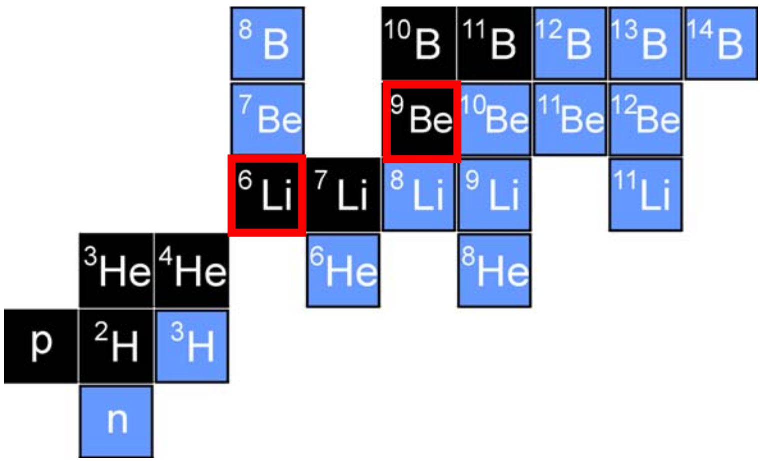




E10: Study on neutron-rich Λ hypernuclei

Produce N-rich Λ hypernuclei by DCX (π^-,K^+) reaction ~1.2GeV/c

Ordinary nuclei (target)

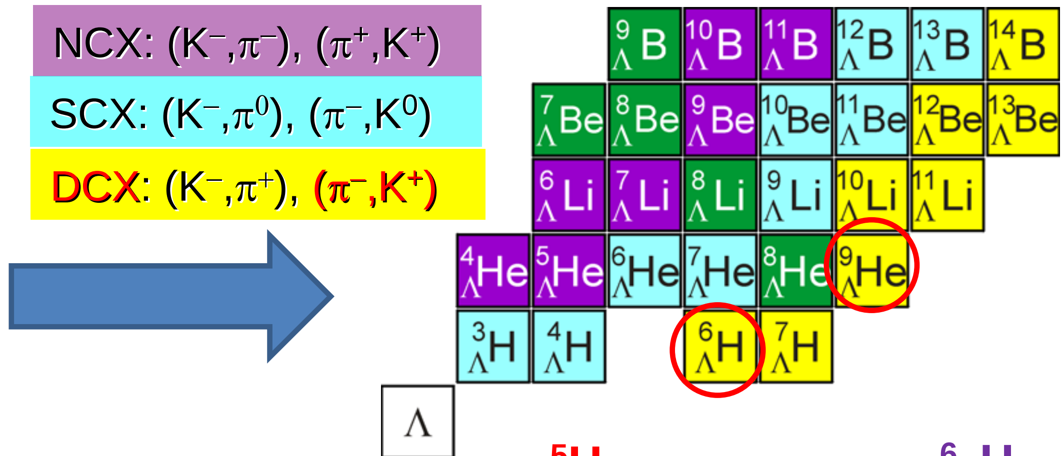


NCX: (K^-,π^-), (π^+,K^+)

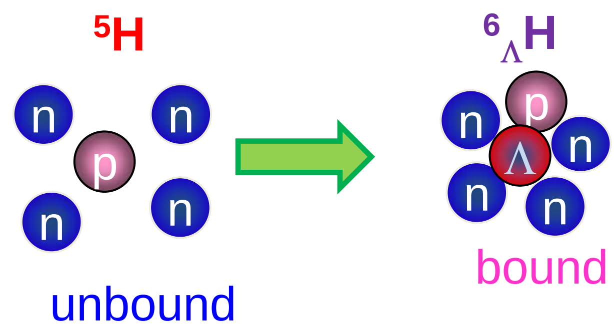
SCX: (K^-,π^0), (π^-,K^0)

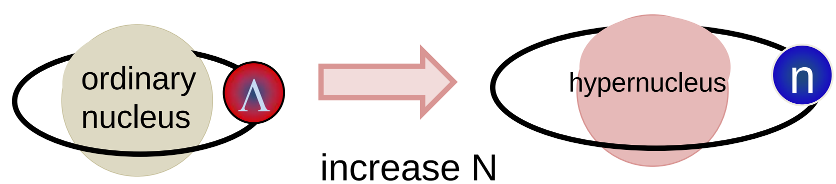
DCX: (K^-,π^+), (π^-,K^+)

Λ hypernuclei



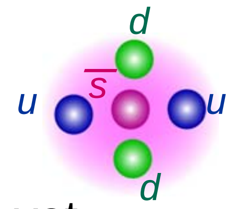
- **Glue-like role of Λ**
  - unbound (^{5}H) –> bound ($^6{}_{\Lambda}$H)
- **Change of the structure**
  - ordinary nucleus core + Λ
    –> hypernuclues + n halo
- **ΛN interaction in the n-rich environment**
  - core of neutron star
  - ΛN –> ΣN coupling effect





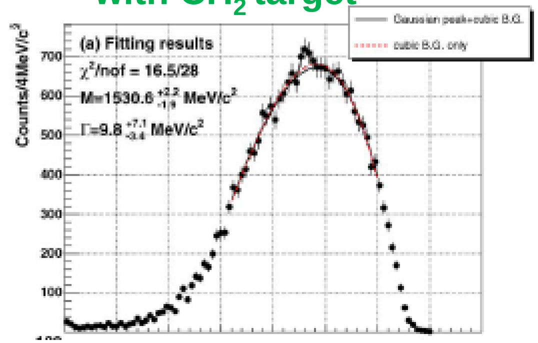
E19: Search for pentaquark, Θ^+, by $\pi^- p \rightarrow K^- X$ reaction ~2GeV/c

- Exotic five quark state (qqqq$\bar{q}$)
  c.f. meson(q$\bar{q}$), baryon(qqq)



KEK-PS E522

with CH_2 target

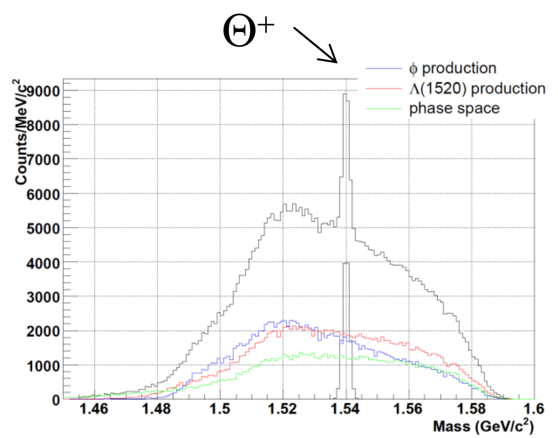


PLB635(2006)72

- Existence/No existence is not established yet.
  - Positive results at low energy
    LEPS, etc
  - Negative results at high energy
  - Acceptance is different . LEPS .vs. CLAS

- Very narrow width. Why ?

Expected spectrum



Search for Θ^+ by hadronic reaction,

$\pi^- p \rightarrow K^- \Theta^+$ channel with Liq. H_2

high resolution of ~2MeV

high statistics of 62σ

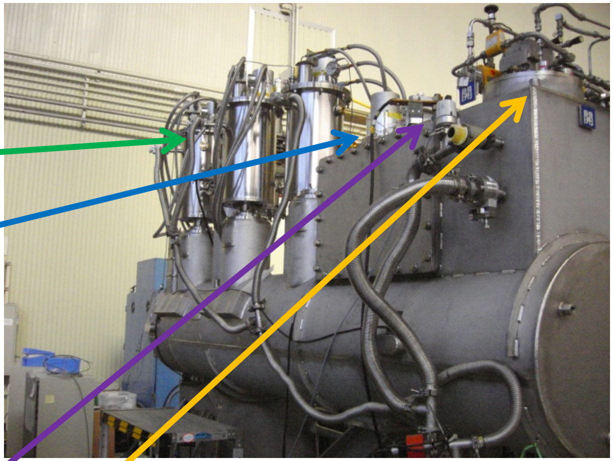
1 week data-taking with 10^7/spill beam
based on KEK-E522 result

SKS Magnet @ J-PARC

- Modification of cooling system
  - 300W refrigerator –> 3.5W GM-JT cooler x 3
    - keep Liq-He
  - Normal current lead –> Hi-TC C.L. with GM cooler
- Magnet position of each experiment determined by K1.8 users group
  - SKS0 E10/E19/E18/E22 same as PS-K6
  - SksMinus E17/(E08)
  - SksPlus E05/E08
  - no use (KURAMA) E07/E03

New cooling system for SKS magnet

Replace a large refregirator of 300W to



- 3 GM-JT Cryo-coolers
  10W cooling power in total
- Shield cooler for GM-JT
  GM-JT Power .vs. shield temp.
  3.1W @ 71K
  3.6W @ 41K
- Anti-convection device for GM-JT
- Hi-TC current leads + Cryo-cooler
- Shield Cryo-cooler (70K)
  previously used

GM-JT Cryo-cooler

To cool down, 5000L Liq-He were required at the factory.

Progress of SKS Magnet

- 2006 Measurement of the cooling power of GM-JT cryo-cooler.
- 2008 Jan. Disassemble of 2/3 of the yoke at N-hall, Tsukuba
  Coil bessel was shiped to the factory
  for modification of the cooling system.
- 2008 May All cryo-coolers were ready. shipped to the factory
- 2008 Jul. Earth fault at the upper coil. Impossible to repair.
  –> Disconnect of the 1/6 coil block.
  Max. Field 2.7 T to 2.45T (@400A)

- 2008 Sep. Transport the disassembeld yoke to J-PARC.
  Disassemble of the remaining yoke at Tsukuba.
- 2008 Dec. Cool-down test at the factory.
  3W surplus cooling power
- 2009 Jan.- Assemble of the magnet at J-PARC.
- 2009 Feb. Finish the assembly of the magnet

- 2009 Mar.- Setup of the compressor for cryo-coolers,
  magnet power supply, monitors...
- 2009 May- Cool-down & excitation test at J-PARC

まとめ

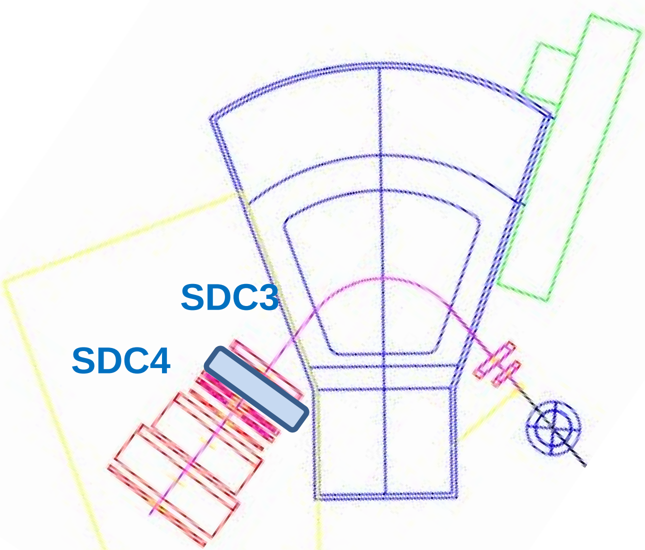
- 私が今ここにいるきっかけとなったSKSはJ-PARCへ
- ハイパー核分光などの研究を行う。
  - Λハイパー核の精密核分光
  - S=-2のハイパー核研究
  - 中性子過剰Λハイパー核、ペンタクォーク
- 今年秋（10月）からのビーム運転に向けてSKSは整備進行中

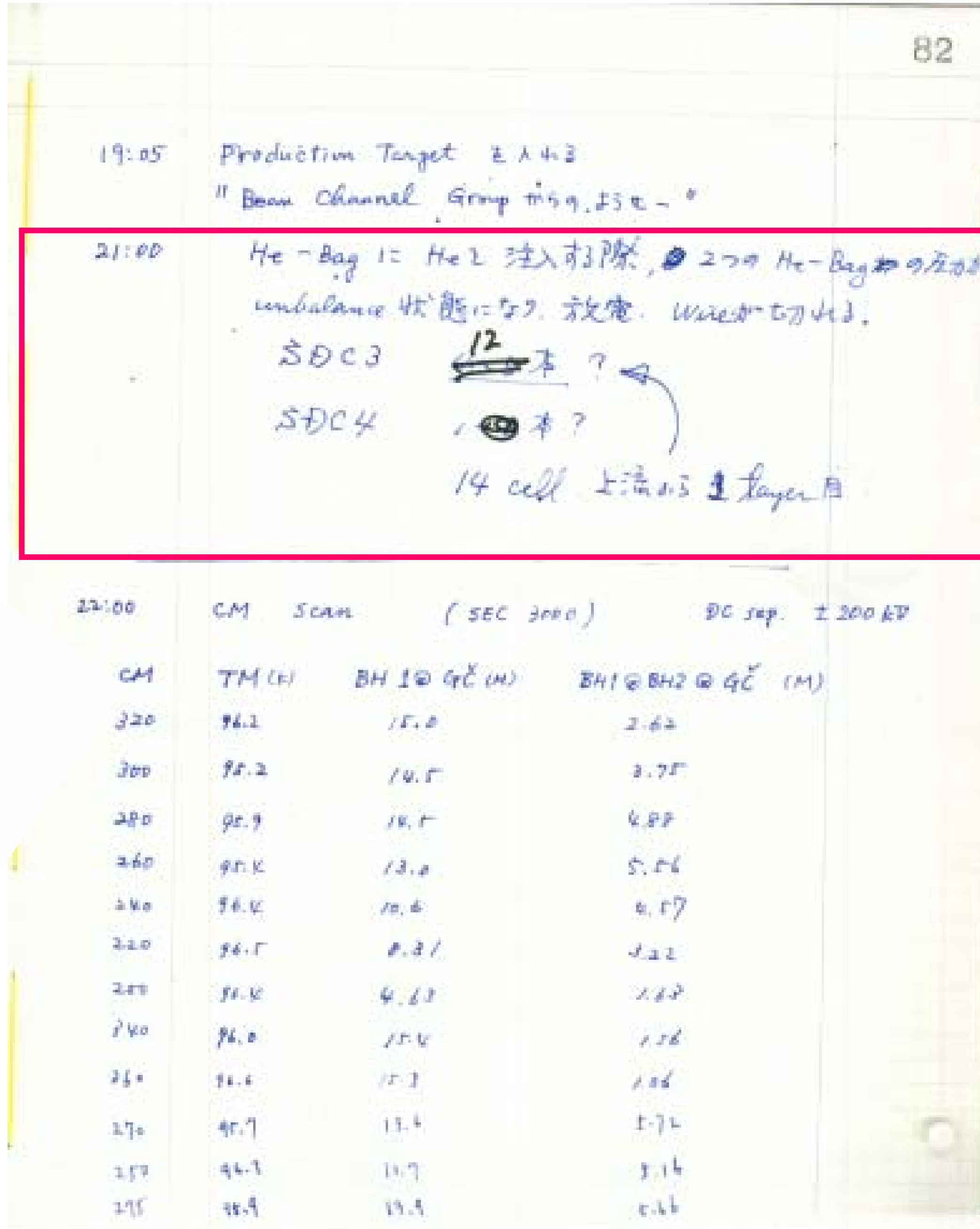
最後に
―これを紹介しないと―

1993年5月13日事件

E140a LogBook Vol.8

１９９３年５月１３日





82

19:05 Production Target を入れる
" Beam Channel Group からの [illegible] "

21:00 He-Bag に He を注入する際、2つの He-Bag の圧力が unbalance 状態になり、放電。wireが切れる。
SDC3 12本 ?
SDC4 [illegible]本 ?
14 cell 上流から1 layer目

22:00 CM Scan (SEC 3000) DC sep. ±200 kV

CM	TM (K)	BH1⊗GC̆ (M)	BH1⊗BH2⊗GC̆ (M)
320	96.2	15.0	2.62
300	95.2	14.5	3.75
280	95.9	14.5	4.88
260	95.4	13.0	5.56
240	96.4	10.6	6.57
220	96.5	8.31	4.22
200	96.4	4.63	2.82
340	96.0	15.4	1.56
360	96.6	15.3	1.86
270	95.7	13.6	5.72
257	96.3	11.7	5.16
275	95.9	13.9	5.66

5/14

SDC3, SDC4X, SDC4T

See p.82

SDC3：重傷

SDC4X：端、この sense 1本のみ？

SDC4T：不明 → はずす必要あり？

Pion intensity on target

	~~KG~~ EP1 (10^6)	~~KG~~ KG (10^6)	π (10^4)	π/K (%)	MR
92-12 cycle	3.0	2.6	4.1	1.58	
5/13 夜 (8.8 GeV)		1.6	0.8	0.5	
5/14 morning 10:16 (8.8 GeV)	2.4	2.1	2.06	1.0	7.0

Accelerator improved

Bumpsbar improved tuning

「もう来るな！」と私が言ったとされていますが、、、

私はそんなことは言っておりません。

Ｊ－ＰＡＲＣにSKSを見に来てください