

K -pp 束縛状態の探索実験 (J-PARC E15) と関連する話題

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for E15 collaboration

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1. はじめに

2. J-PARC E15 実験

3. K -pp 束縛状態の探索

3. $\Lambda(1405)$ 分光の可能性

ストレンジネス(フレーバー)核物理の取り組み

Q: “核力”について $SU_F(3)$ の枠組みで理解できるかとくに、バリオン間相互作用の短距離部分の解明
クォーク自由度の重要性

Q: “核物質”についての理解はどこまで深まるかとくに、高密度核物質の性質の解明
中性子星はハイペロン星? K 凝縮?
クォーク星、ストレンジクォーク物質?
カラー超伝導状態?

Q: 核媒質中でハドロンの性質はどのように変化するのか
カイラル対称性の(部分的)回復との関係
クォークの凝縮のなぞにせまれるか

Hadron in Nucleus

- Meson in A

π , **K**, ρ , η , ...

ϕ , ω , K^* , ...

D, D_s , ...

$m^*(\rho)$, $(U(k_F))$

$\tau(\rho)$, $(\Gamma(\rho))$

- Baryon in A

N, Λ , Σ , Ξ , ...

N^* , **Λ^*** , Σ^* , Ξ^* , ...

Δ , ...

Λ_c , Σ_c ...

$\mu(\rho)$, $Q(\rho)$

.....

Kaon in Nuclear Medium

Q: What is happen?

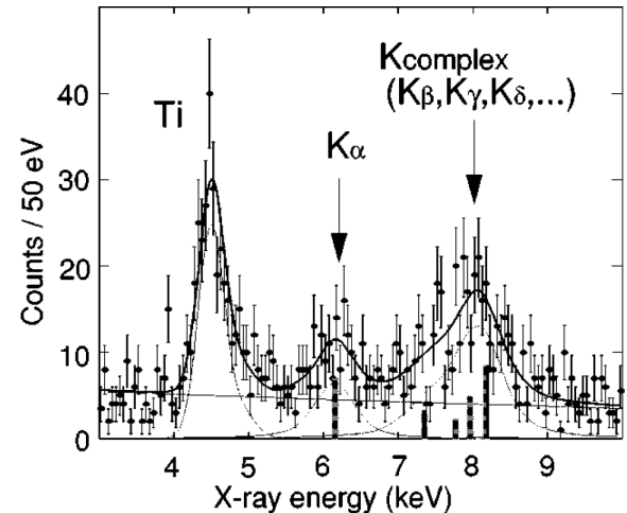
KN相互作用

- ✓ Low E K-p scattering data suggest: **引力** ($S=0$)
- ✓ K-p atomic X-ray shift : **斥力的**シフト at 1s energy reg.

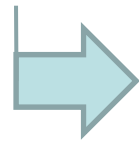
M.Iwasaki *et al.*, PRL78 (1997) 3067



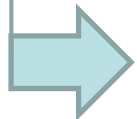
強い引力を示唆している。



“真の”1s状態は深く束縛されている！？

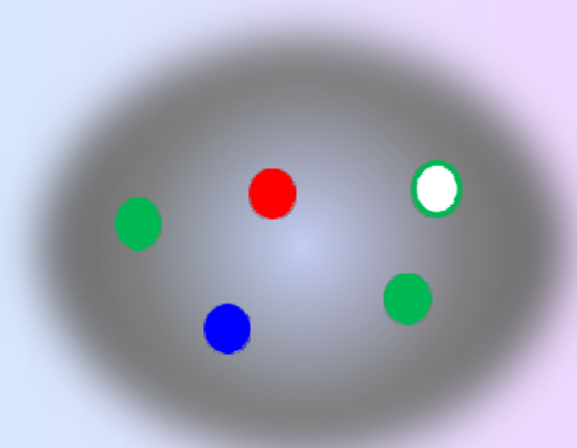
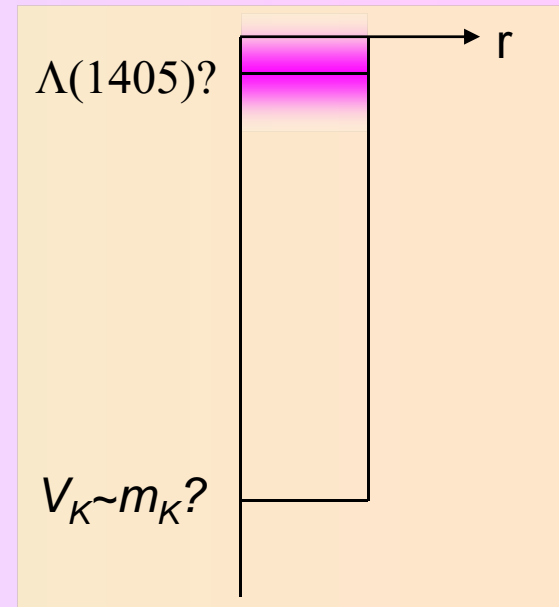
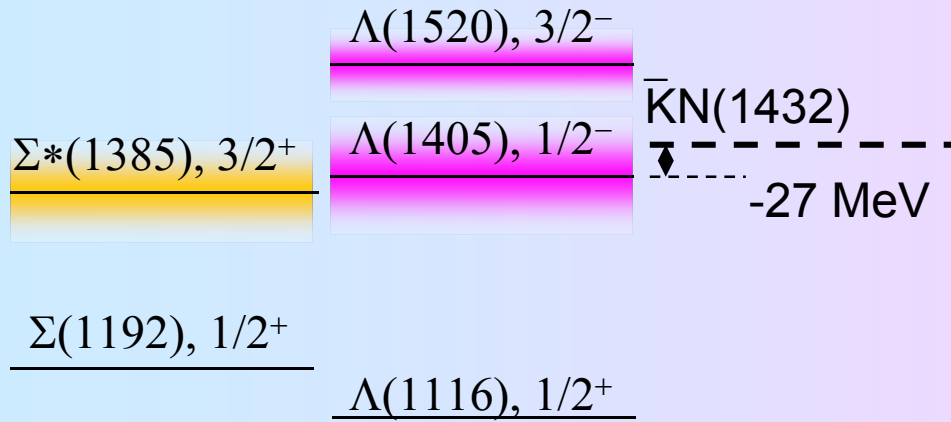
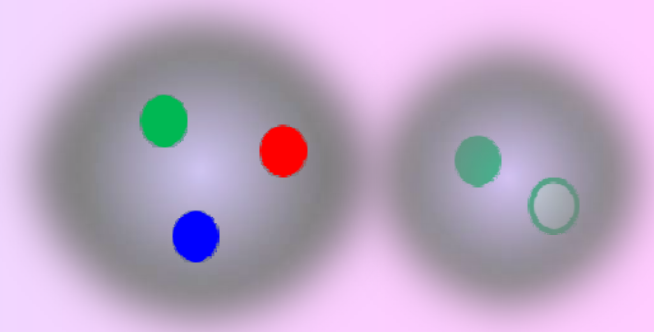


$\Lambda(1405) : S_{01}$ がそうなのか？

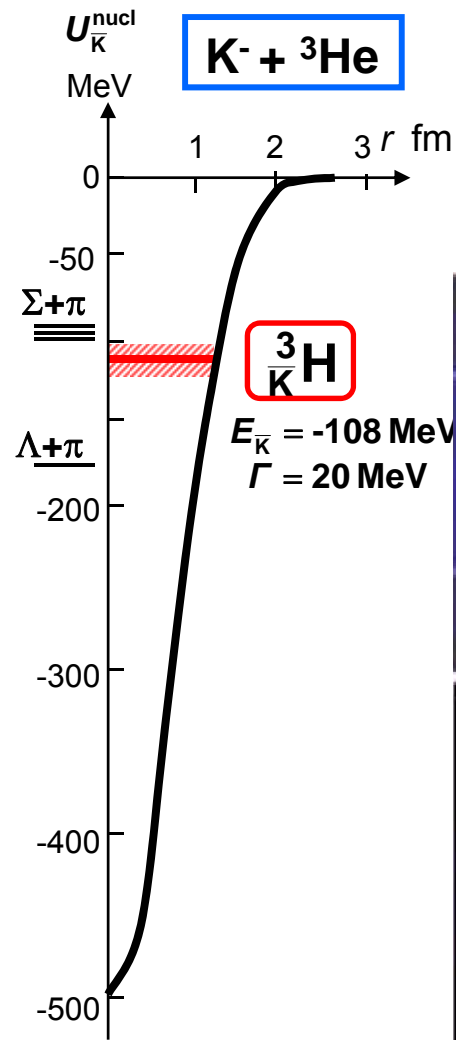
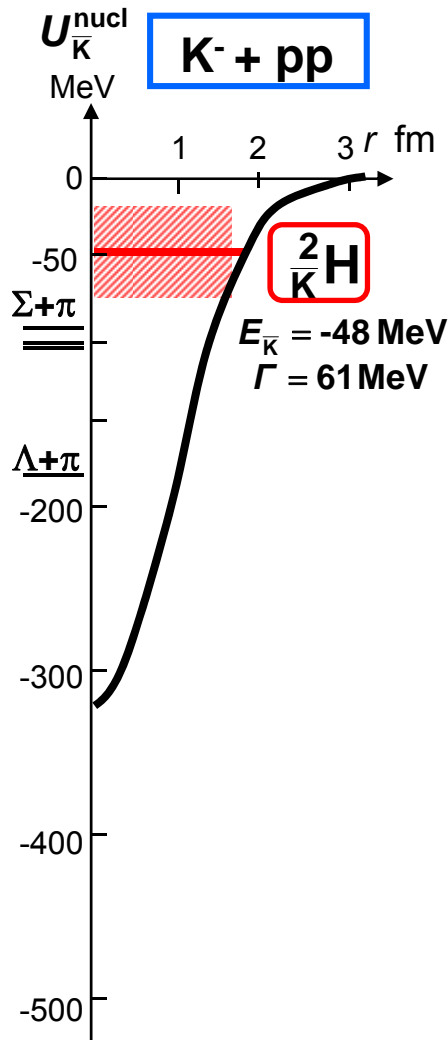
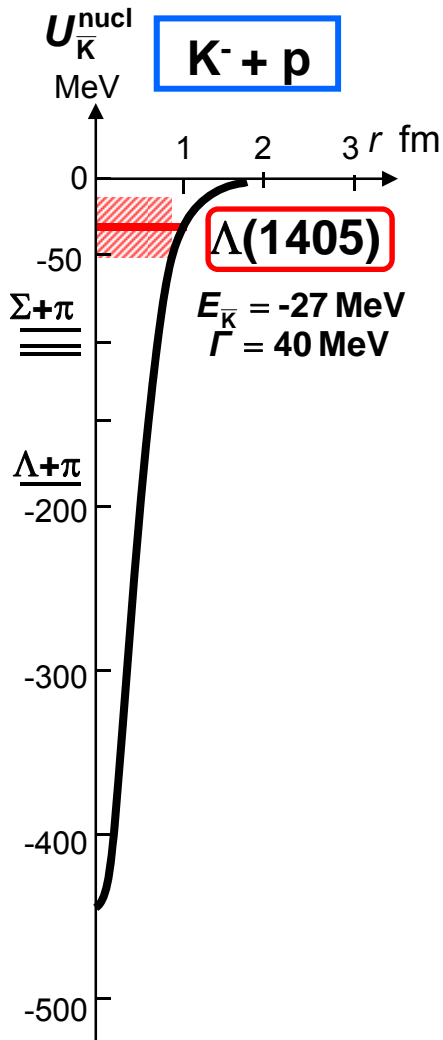


Kは原子核中でさらに深く束縛するか！？

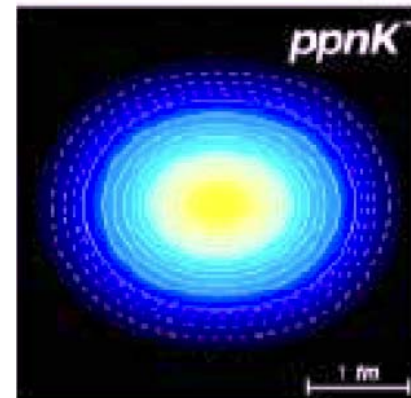
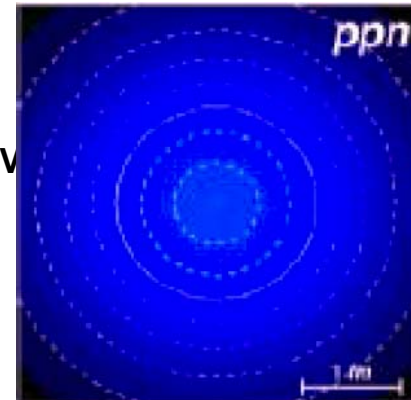
What is $\Lambda(1405)$?



Deeply Bound K-Nucleus System ?



Dote et al.

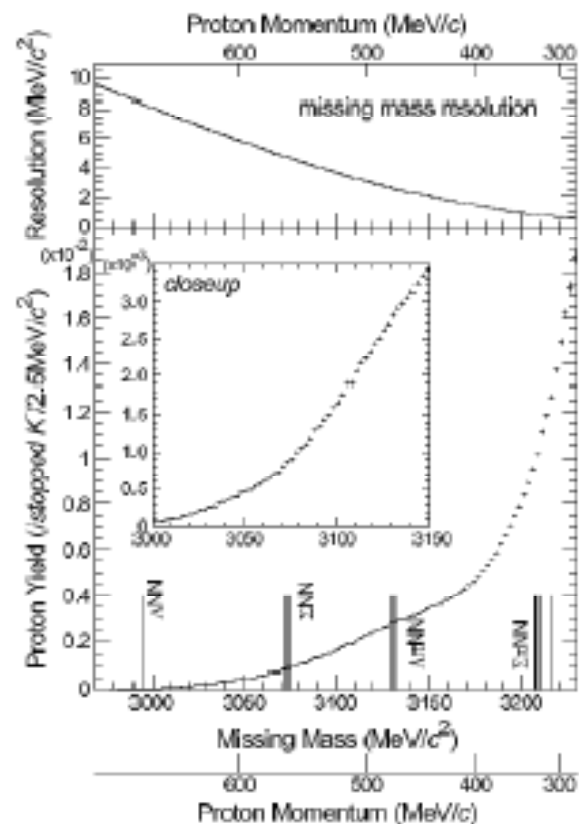
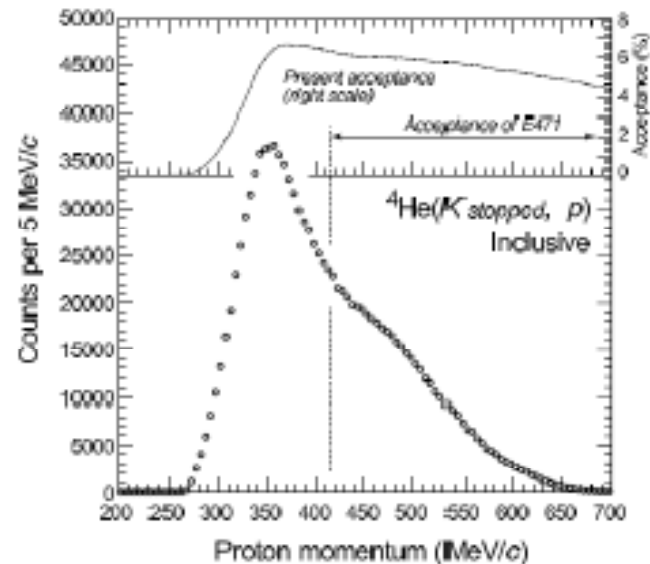
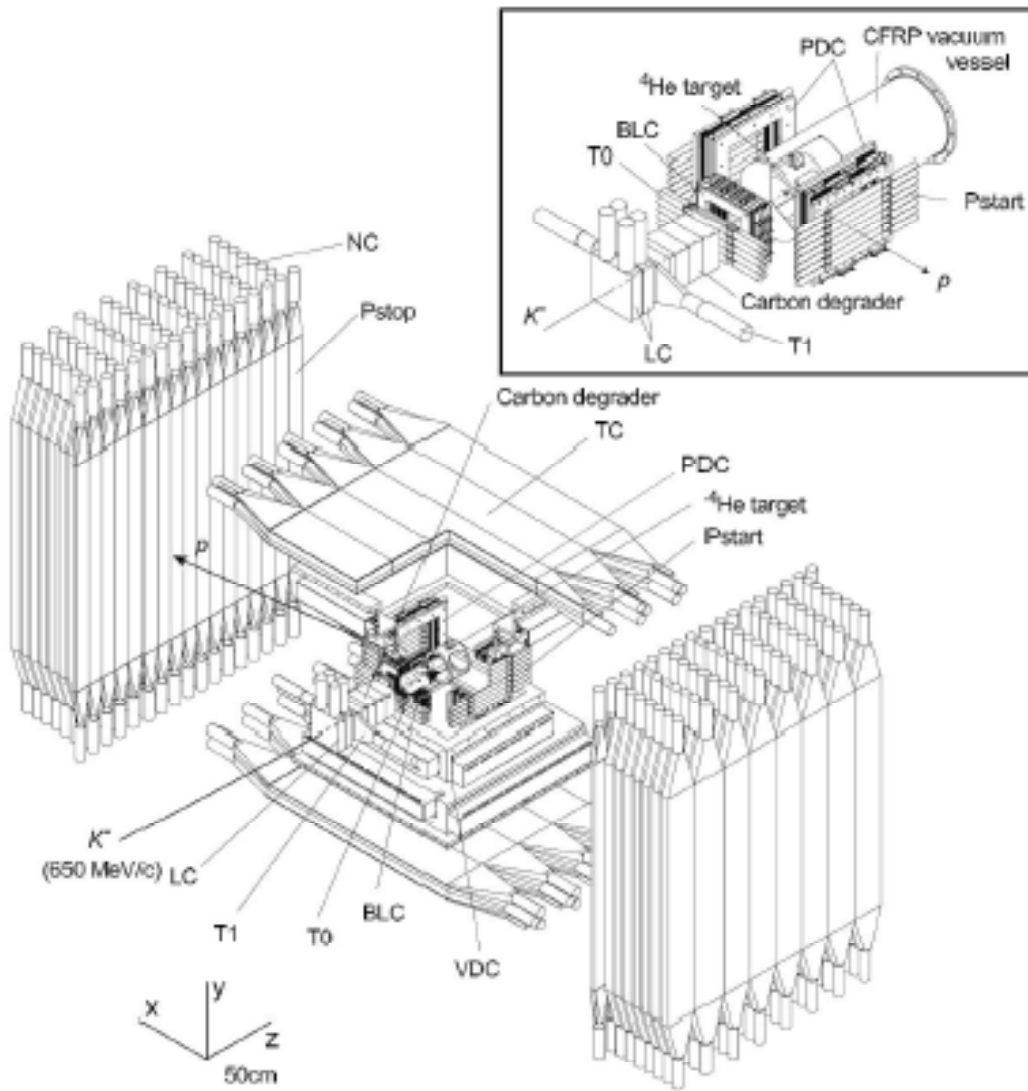


Y. Akaishi & T. Yamazaki, Phys. Rev. C65 (2002) 044005.

Y. Akaishi & T. Yamazaki, Phys. Lett. B535 (2002) 70.

2 Experimental Method

$^4\text{He}(K^- \text{ stopped}, N)$



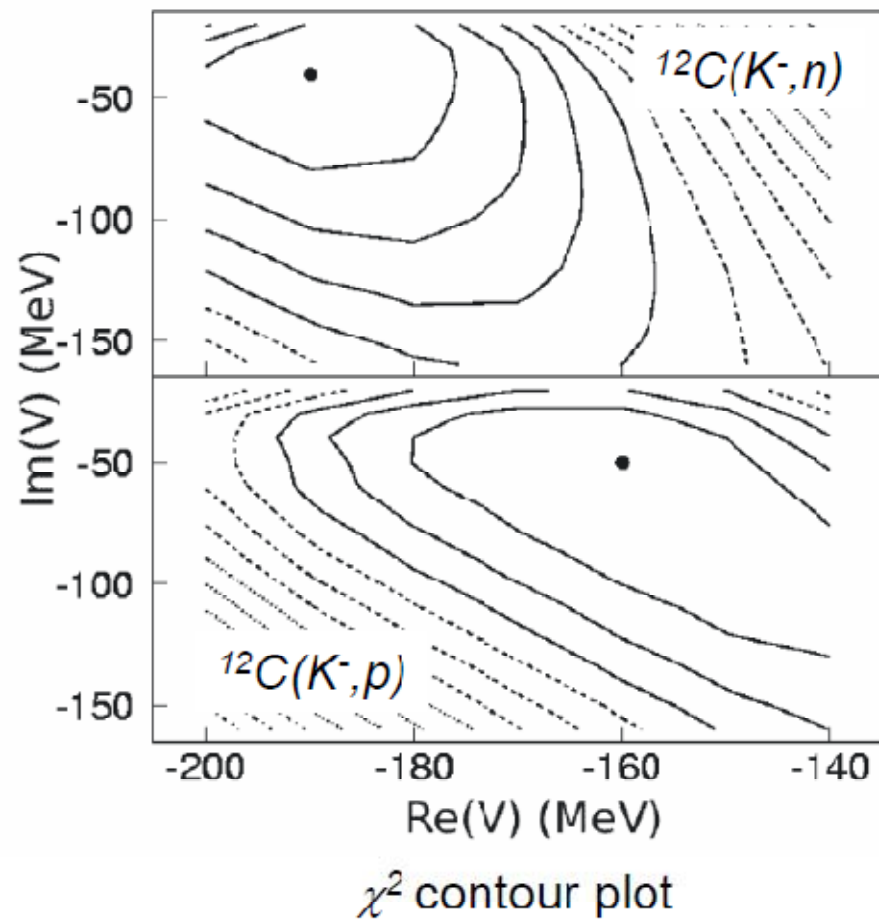
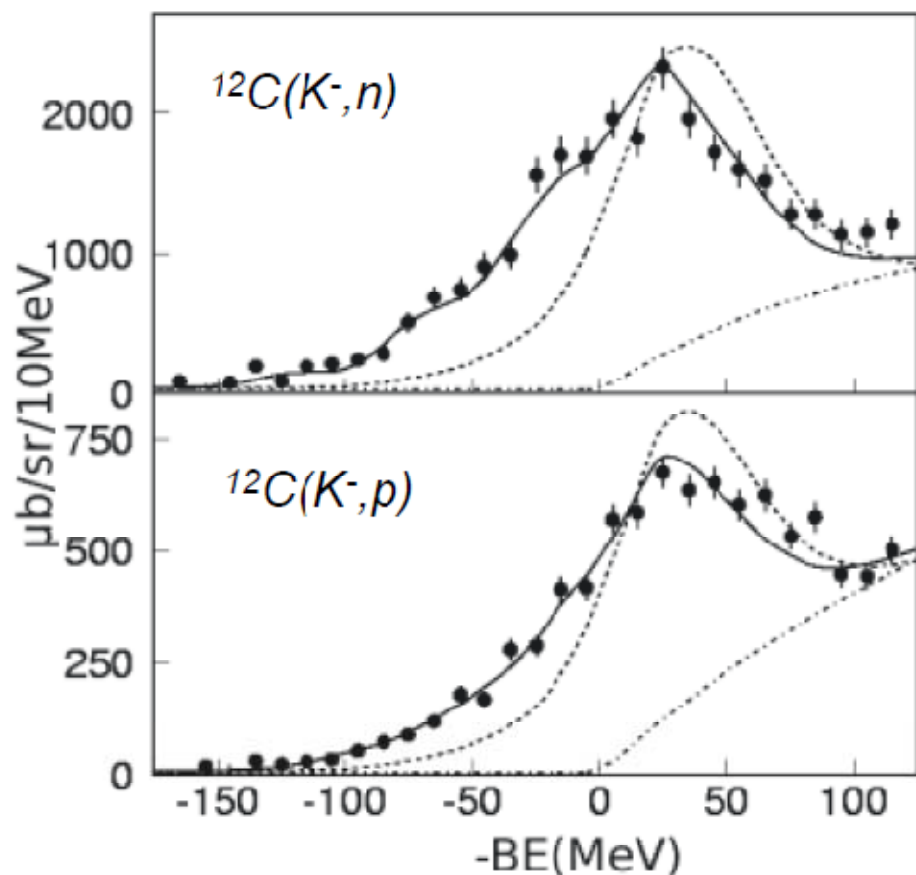
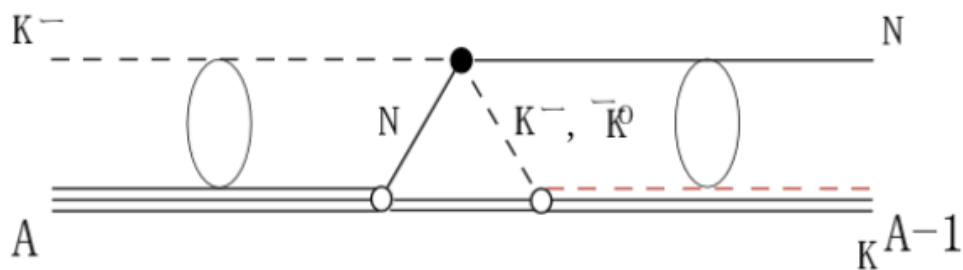
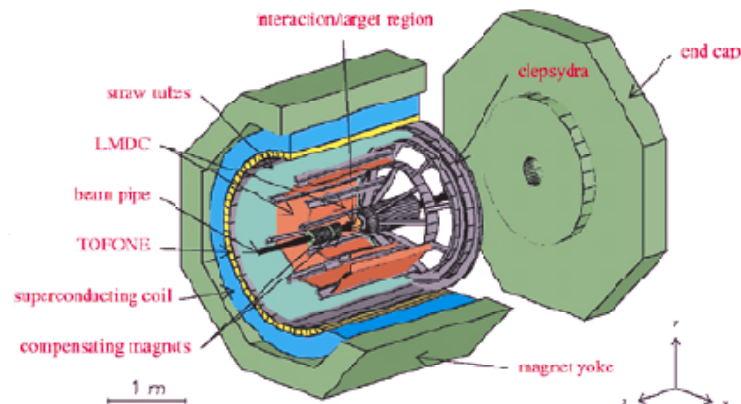
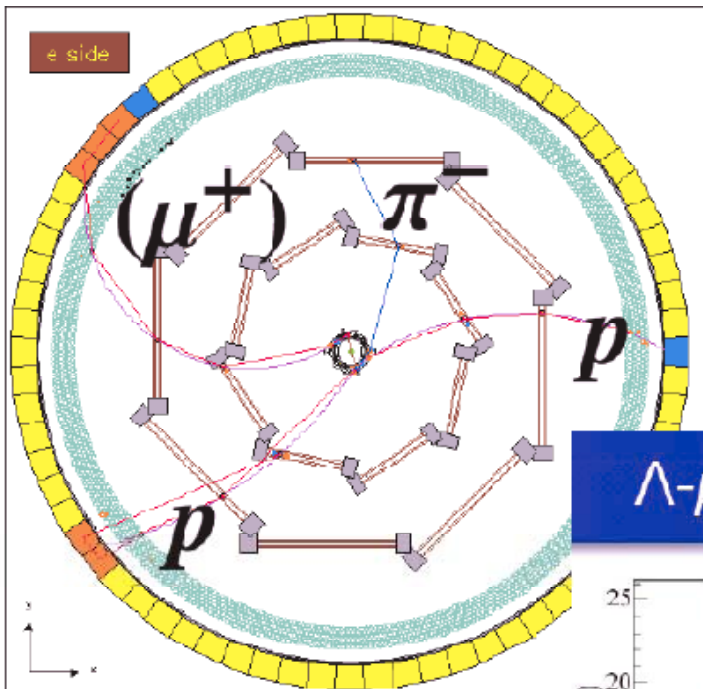


Fig. 1. Missing mass spectra of the $^{12}\text{C}(K^-,n)$ and $^{12}\text{C}(K^-,p)$ reactions are shown. Solid lines are calculated best fit $\text{Im}(V) = -40$ MeV (upper) and $\text{Re}(V) = -160$ MeV (lower) related spectra for $\text{Re}(V) = -60$ MeV and $\text{Im}(V) = -40$ MeV process (see text).





Λ -p invariant-mass

YKIS06 藤岡氏のトークより

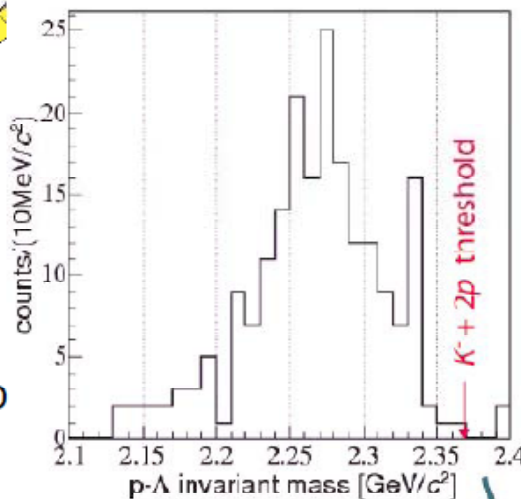
FINUDA実験

K⁻ stopped on "pp" in A
going to back-to-back Λ p

indicating
deeply bound K-pp system!?

DISTO?

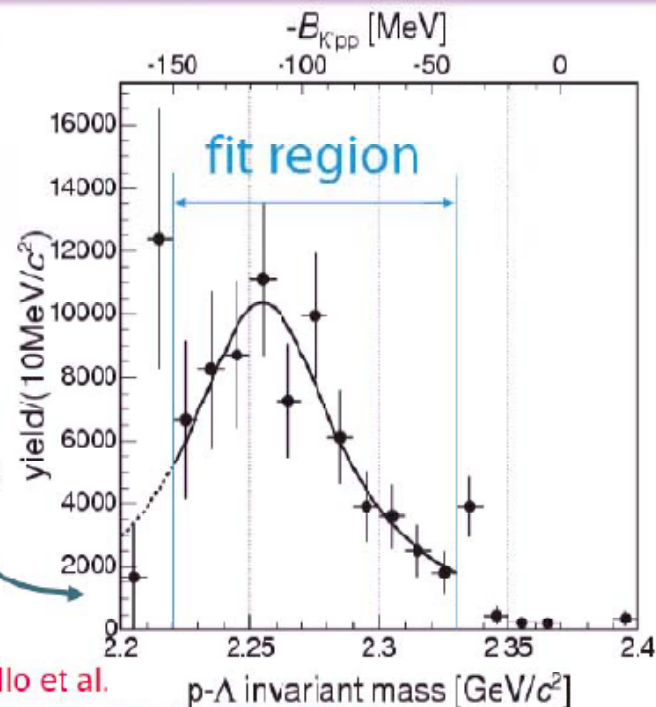
pp \rightarrow K⁺ Λ p (EXA08)



acceptance correction

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

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



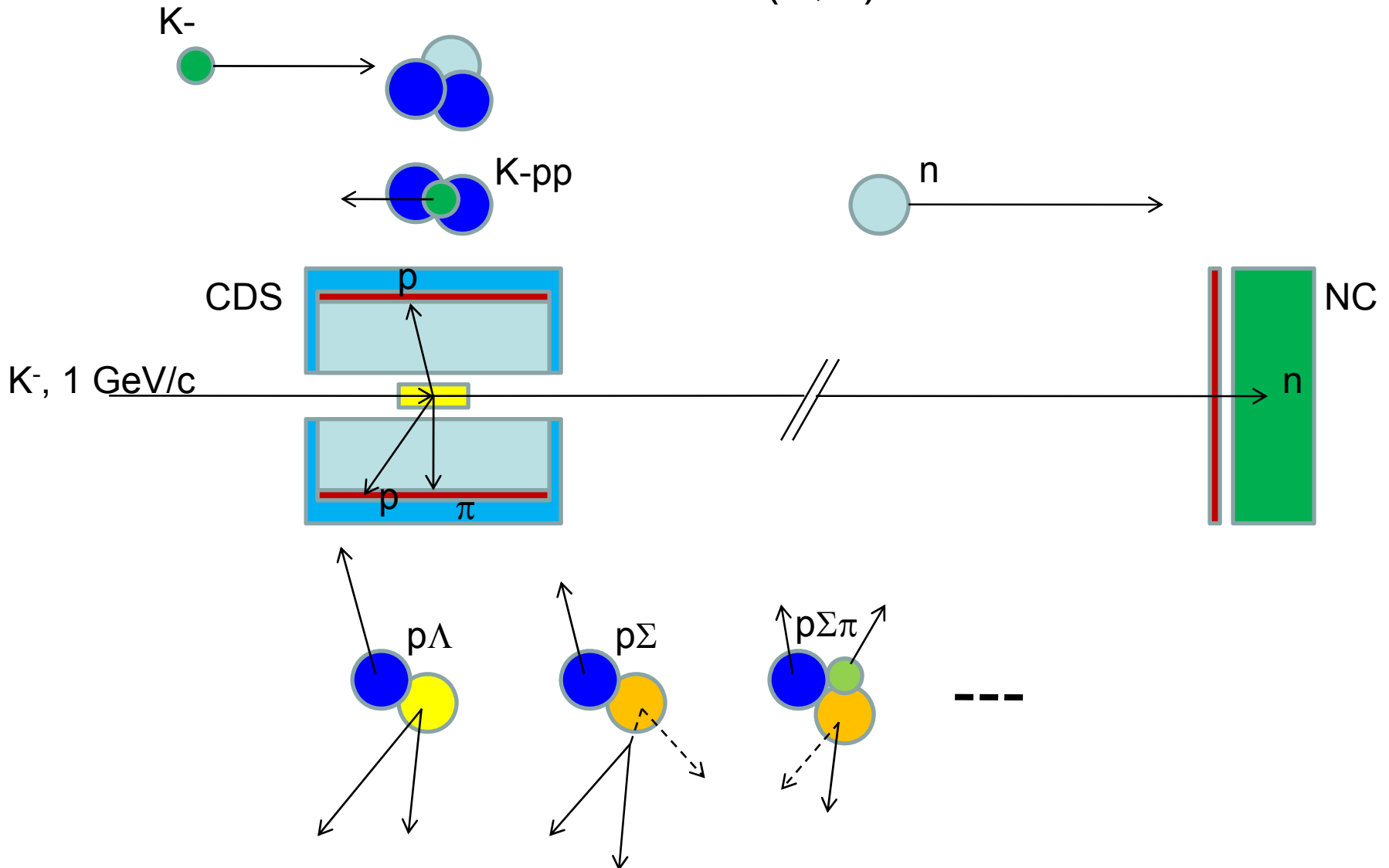
M. Agnello et al.

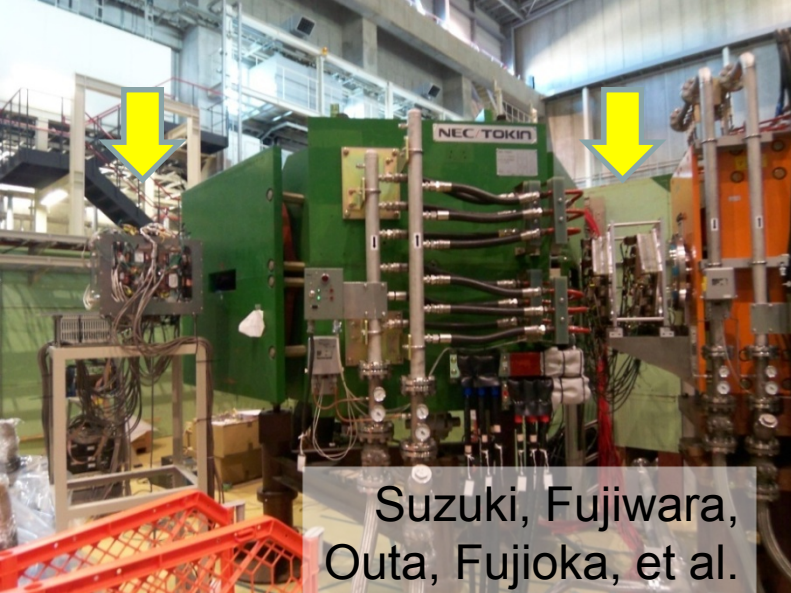
[Phys. Rev. Lett. 94, 212303 (2005)]

2. J-PARC E15実験

Exclusive Measurement of K-pp system

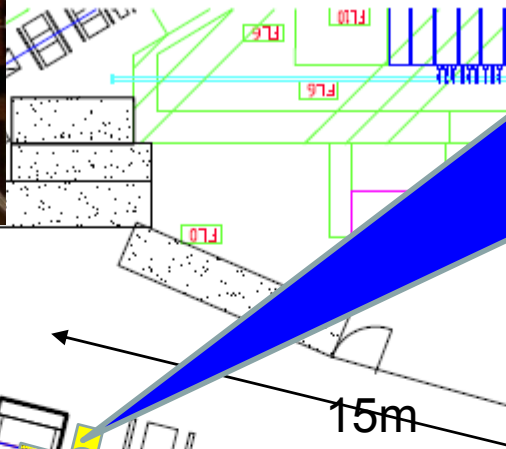
via the (K,N) reaction on ^3He



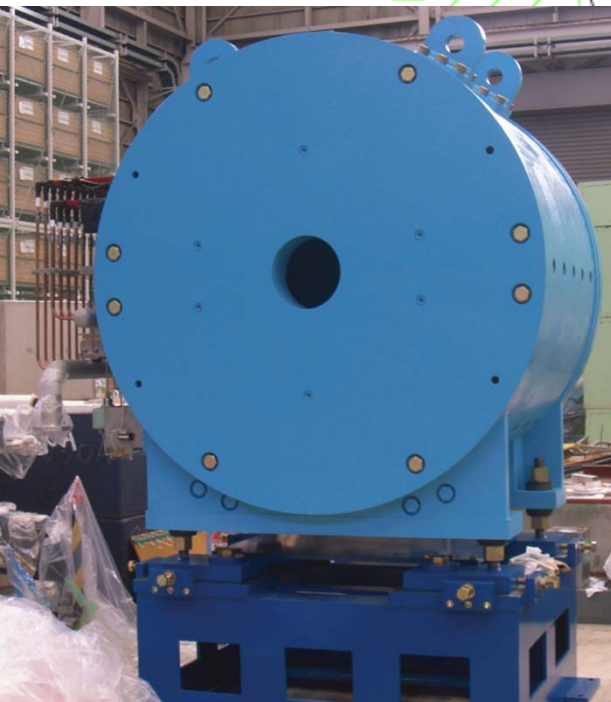


Suzuki, Fujiwara,
Ota, Fujioka, et al.

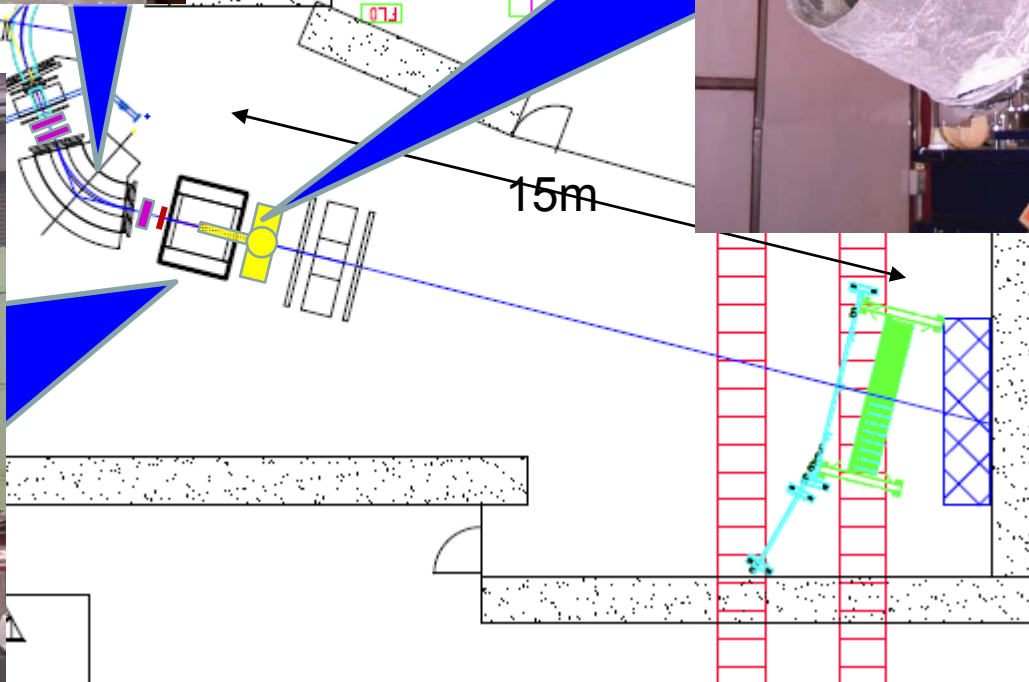
K1.8BR



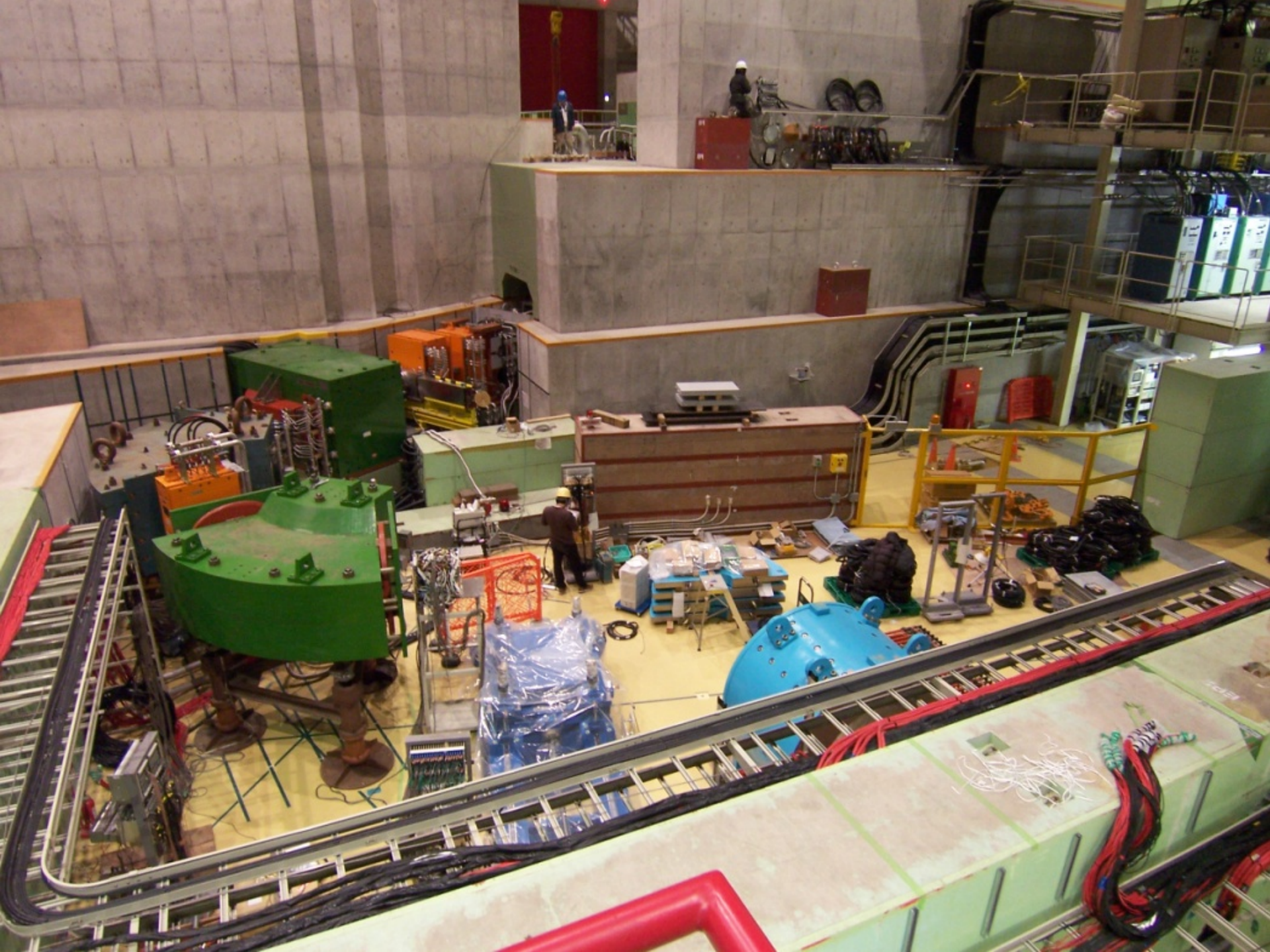
Ishimoto, Iio, et al.

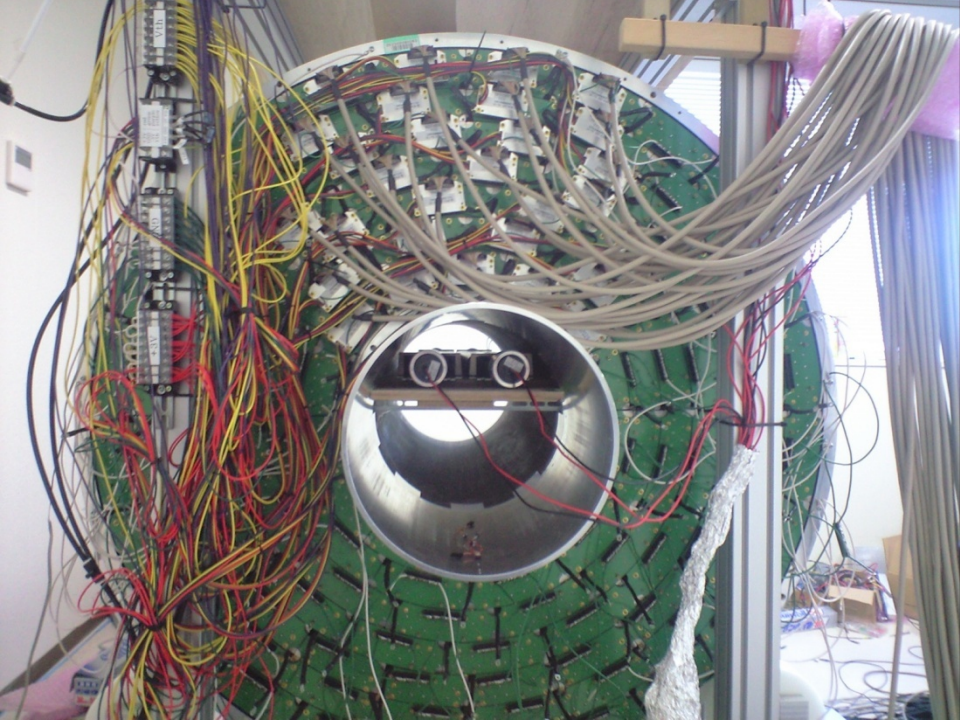


Ohnishi, Sakuma, et al.





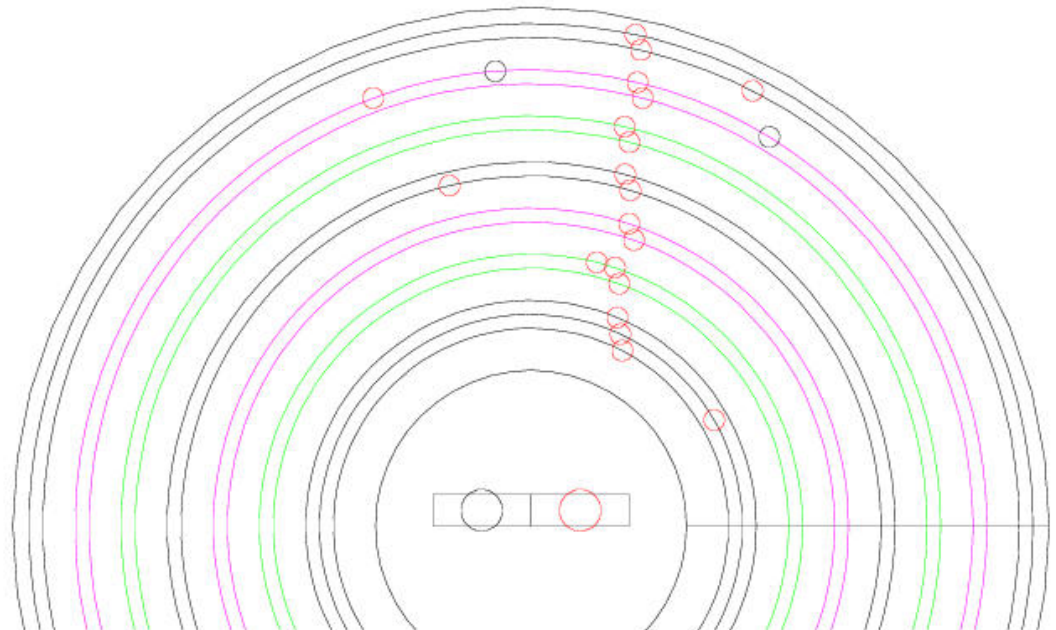




80 EVENT

151

Tsukada, Hiraiwa



3. $\Lambda(1405)$ 分光の可能性

藤岡宏之, 佐田優太, 榎本瞬, 野海
と E15 実験グループ

Motivation : Two poles?

T. Hyodo:
presented in SNP04

There are two poles of the scattering amplitude around nominal $\Lambda(1405)$ energy region.

- Cloudy bag model

J. Fink, *et al.*, PRC41, 2720

- Chiral unitary model

J. A. Oller, *et al.*, PLB500, 263

E. Oset, *et al.*, PLB527, 99

D. Jido, *et al.*, PRC66, 025203

T. Hyodo, *et al.*, PRC68, 018201

T. Hyodo, *et al.*, PTP112, 73

C. Garcia-Recio, *et al.*, PRD67, 076009

D. Jido, *et al.*, NPA725, 181

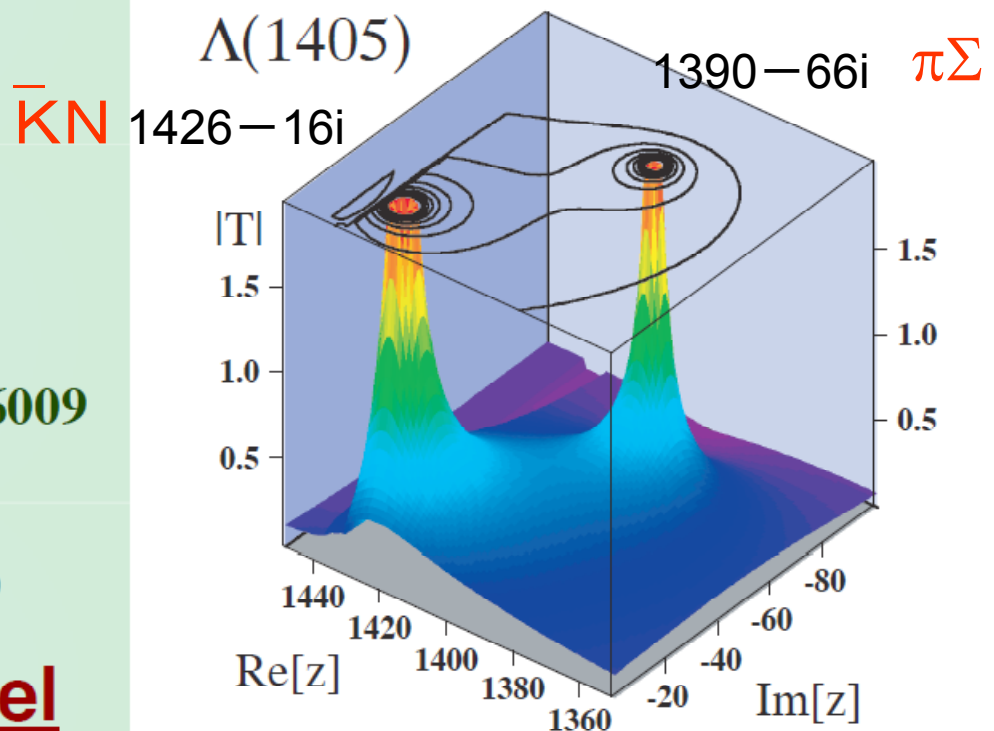
T. Hyodo, *et al.*, PRC68, 065203

C. Garcia-Recio, *et al.*, PLB582, 49

- Correlated quark model

A. Zhang, *et al.*, hep-ph/0403210

$\Lambda(1405) : J^P = 1/2^-, I = 0$

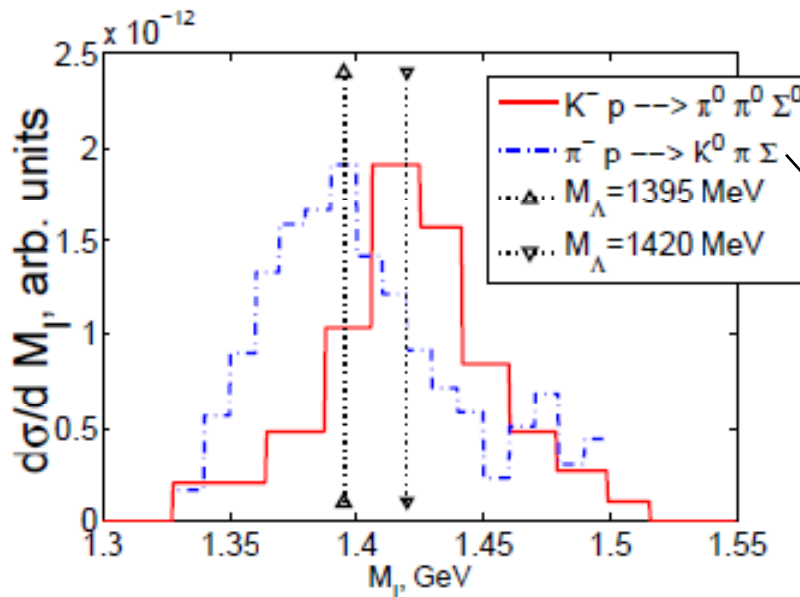
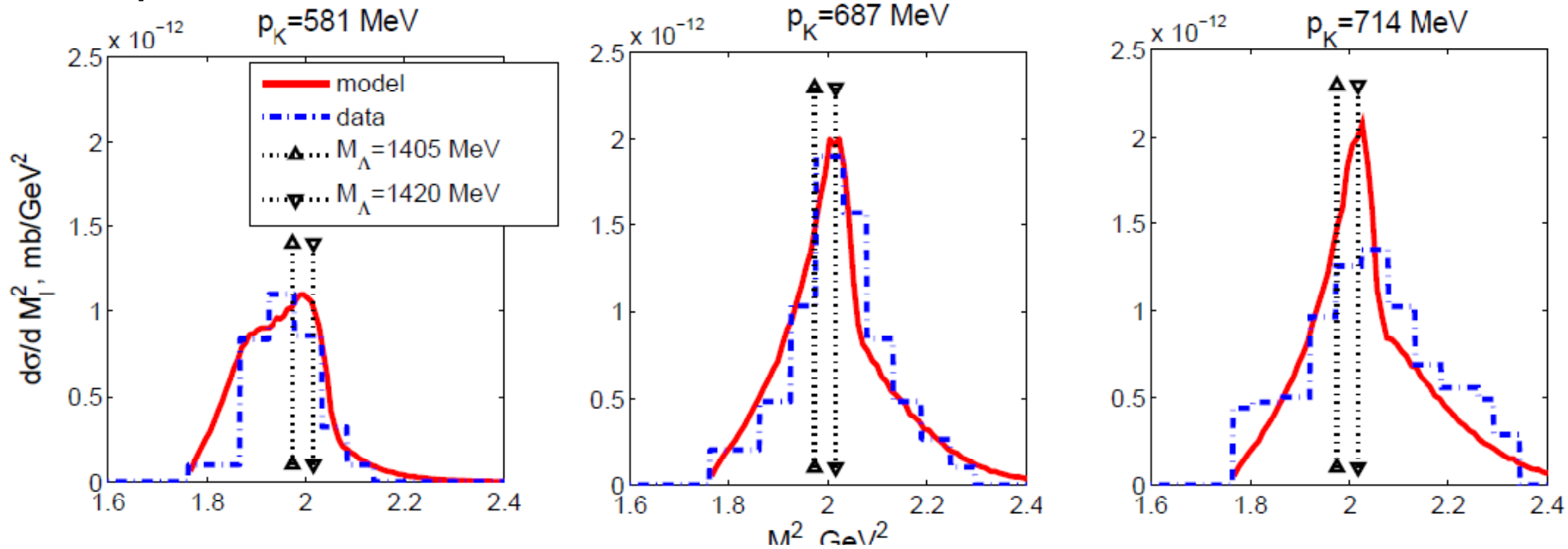


ChU model, T. Hyodo

Evidence for the Two Pole structure of $\Lambda(1405)$!?

$$K^- p \rightarrow \pi^0 \pi^0 \Sigma^0$$

V.K. Magas, E. Oset, A. Ramos, PRL95, 052301(2005)



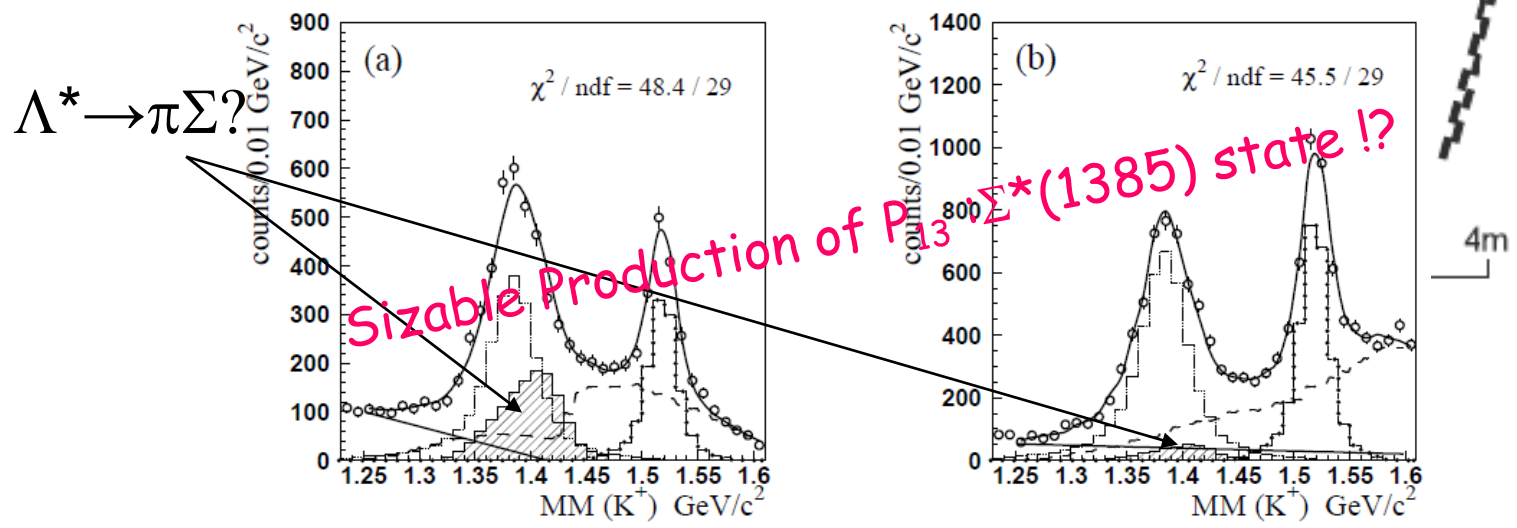
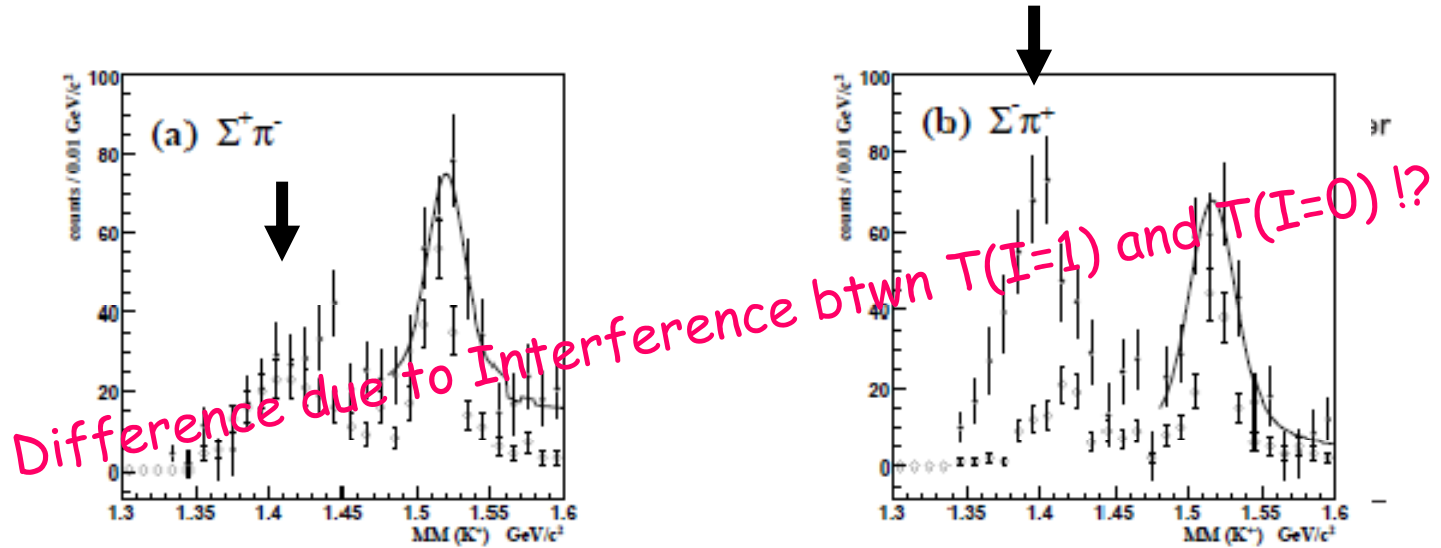
S. Prakhov et al.,
PRC70, 034605('04)

$$K^- p \rightarrow \pi^0 \pi^0 \Sigma^0$$

D. W. Thomas et al.,
NPB56, 15('73)

$$\pi^- p \rightarrow K^0 \pi \Sigma$$

LEPS EXP. for $\gamma p \rightarrow K^+ \pi^- \Sigma^+$ or $\rightarrow K^+ \pi^+ \Sigma^-$:



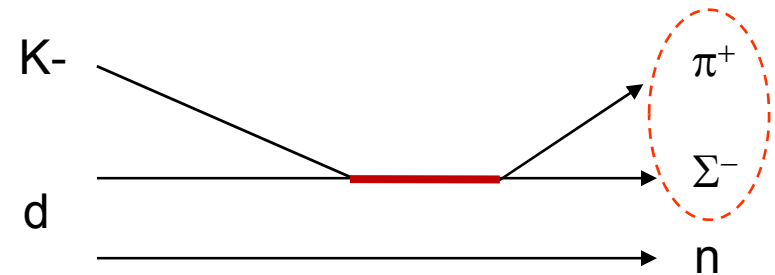
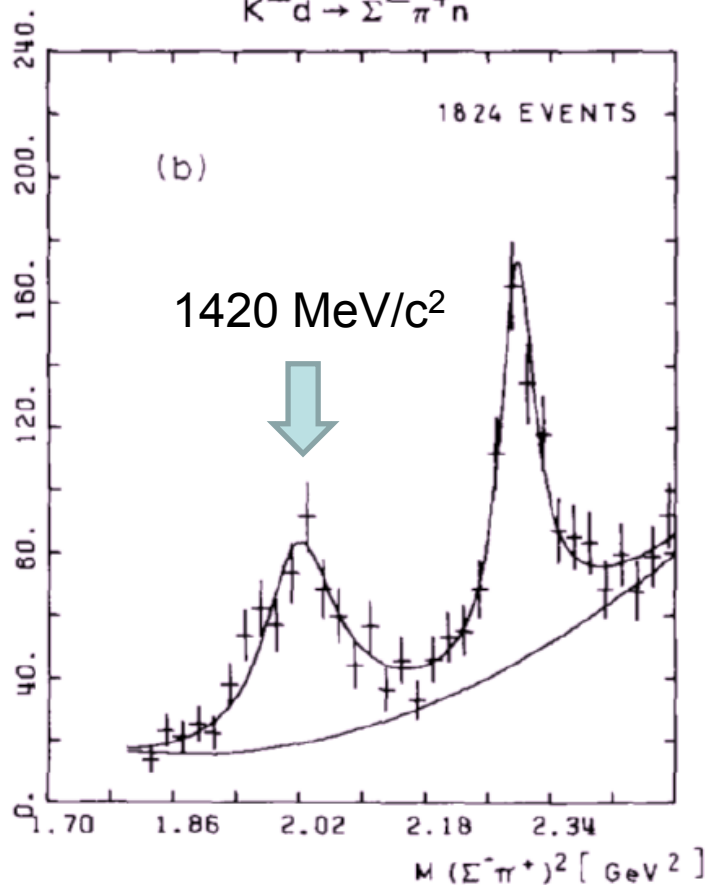
Bubble Chamber Exp. for $d(K^-\Sigma^-\pi^+)n$ at CERN

O. Braun et al., NPB129, 1(1977)

$p_K=673\sim 834$ MeV/c

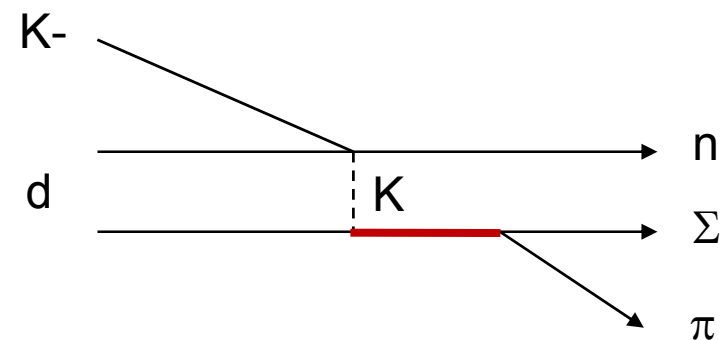
$\sigma\sim 400$ μ b

$K^-d \rightarrow \Sigma^-\pi^+n$

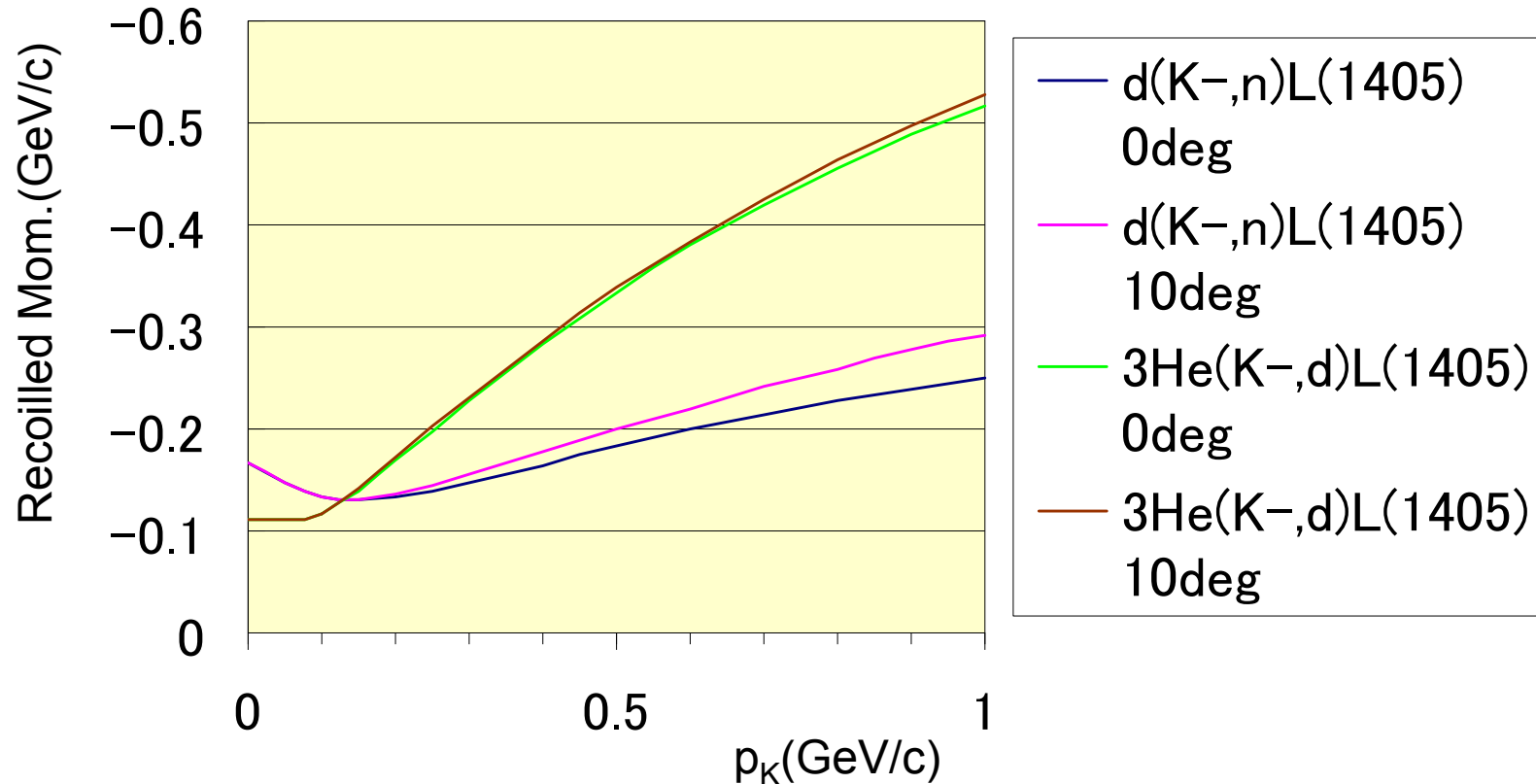
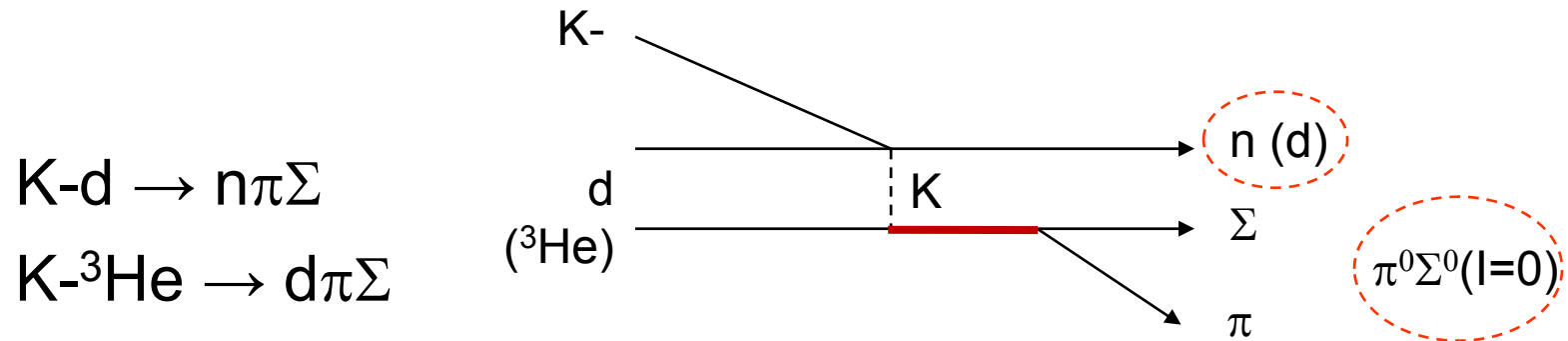


$q_n=0.6\sim 1$ GeV/c (not reported)

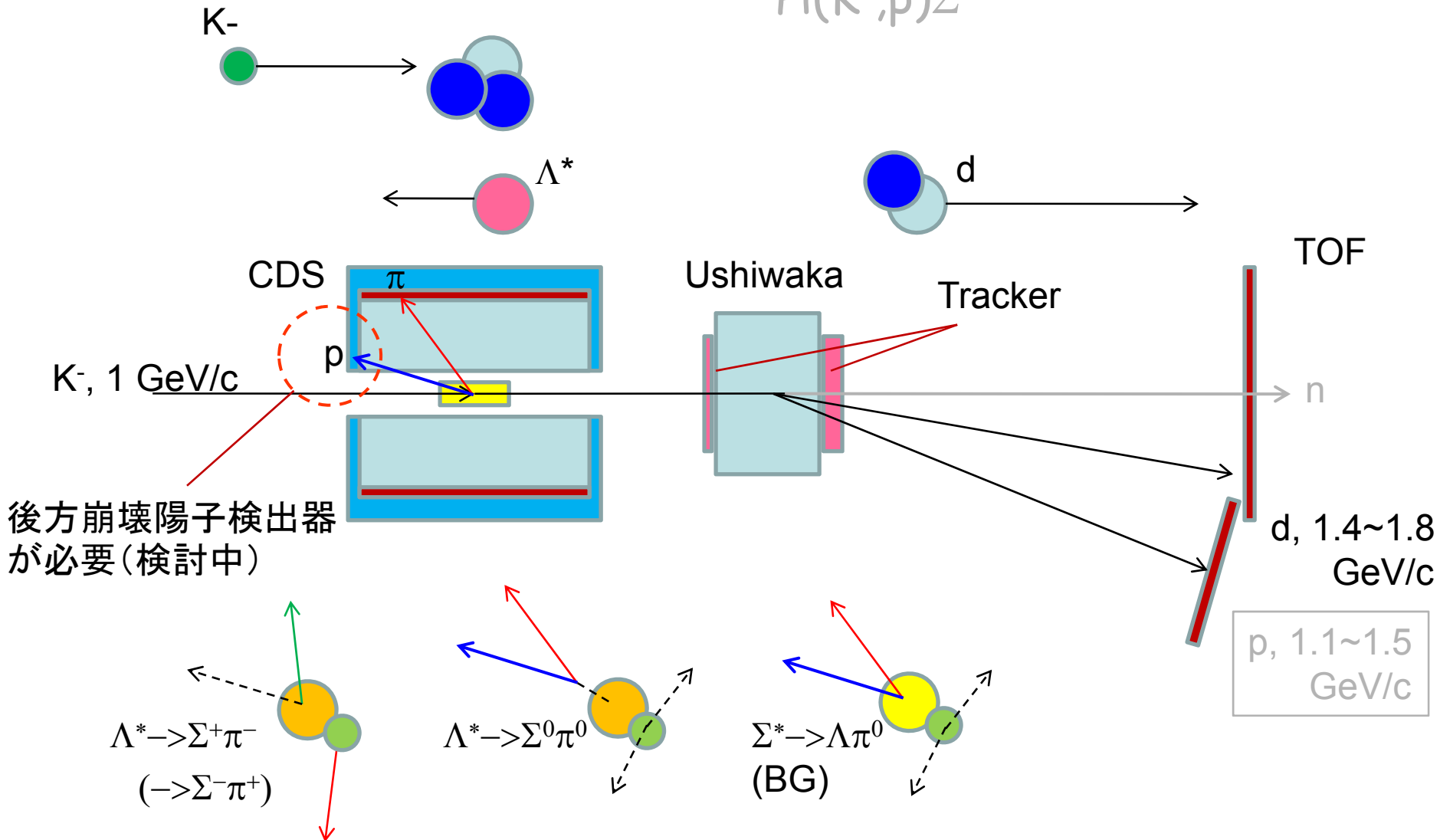
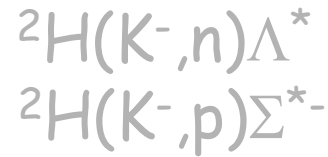
n :spectator?



Exp. to form S -Wave $\bar{K}N$ state and $I=0$ state in final state with low-E K^- Beam at J-PARC



$\Lambda(1405)$ Spectroscopy via the (K^-,d) reaction on ^3He



Summary

J-PARC E15実験:

K-pp束縛状態の探索: 生成から崩壊まで

最初のビーム(2009年1月下旬)に向けて鋭意準備中

$\Lambda(1405)$ 分光の可能性:

${}^3\text{He}(K^-,d)\Lambda^*$: S-Wave $\bar{K}N$ 結合状態の生成 ${}^2\text{H}(K^-,n)\Lambda^*$
 $\Lambda^* \rightarrow \Sigma^0\pi^0$: I=0 stateの崩壊過程

後方崩壊陽子検出器、散乱d,p用検出器群、トリガー等
実験スキームのデザイン中