Spectroscopic Study of Hyperon Resonances below $K^{bar}N$ Threshold via the (K^-,n) Reaction on Deuteron

H. Noumi, *Osaka Univ. RCNP*, for the E31 collaboration

S. Ajimura[1], H. Asano[1], G. Beer[2], M. Bragadireanu[8], P. Buehler[8], L. Busso[5], M. Cargnelli[4], S. Choi[3], C. Curceanu[8], S. Enomoto[14], D. Faso[5], H. Fujioka[13], Y. Fujiwara[12], T. Fukuda[9,11], C. Guaraldo[8], R. S. Hayano[12], T. Hashimoto[17], T. Hiraiwa[1], M. Iio[14], M. Iliescu[8], K. Inoue[1], N. Ishibashi[7], Y. Ishiguro[13], T. Ishikawa[12], S. Ishimoto[14], T. Ishiwatari[4], K. Itahashi[9], M. Iwai[14], M. Iwasaki[9,10], S. Kawasaki[1], P. Kienle[15], H. Kou[10], Y. Ma[9], J. Marton[4], Y. Matsuda[12], Y. Mizoi[11], O. Morra[5], T. Nagae[13], H. Noumi [1,14], H. Ohnishi[16], S. Okada[9], H. Outa[9], K. Piscicchia[8], L. Poli Lener[8], A. Romero Vidal[8], Y. Sada[1], A. Sakaguchi[7], F. Sakuma[9], M. Sato[9], M. Sekimoto[14], H. Shi[12], K. Shirotori[1], D. Sirghi[8], F. Sirghi[8], K. Suzuki[4], S. Suzuki[14], T. Suzuki[12], H. Tatsuno[8], M. Tokuda[10], D. Tomono[1], A. Toyoda[14], K. Tsukada[16], E. Widmann[4], O. Vazquez Doce[8], T. Yamaga[1], T. Yamazaki[9,12], K. Yoshida[7], H. Yim[3], J. Zmeskal[4] .

1. Research Center for Nuclear Physics, Osaka University, Japan

2. University of Victoria, Canada, 3. Seoul National University, South Korea

4. Stefan Meyer Institut fur subatomare Physik, Austria,

5. INFN Sezione di Torino, Italy , 6.Universita' di Torino, Italy

7. Osaka University, Japan, 8. Laboratori Nazionali di Frascati dell'INFN, Italy

9. RIKEN, Japan, 10. Tokyo Institute of Technology, Japan

11. Osaka Electro-Communication University, Japan, 12. University of Tokyo, Japan

13. Kyoto University, Japan, 14. High Energy Accelerator Research Organization (KEK), Japan

15. Technische Universitat Munchen, Germany, , 16. Tohoku University, Japan, 17. JAEA

$\Lambda(1405)$: $1405.1^{+1.3}_{-1.0}$ MeV (PDG Part. List'gs)

$J^P = \frac{1}{2}^-$, $I = 0$, $M_{\Lambda(1405)} < M_{\bar{K}N}$, lightest in neg. parity baryons

M. Hassanvand et al: $\pi\Sigma$ IM Spec. of $pp \rightarrow K^+\pi\Sigma$

J. Esmaili et al: $\pi\Sigma$ IM Spec. of Stopped K^- on ^4He

R.H. Dalitz et al: $\pi\Sigma$ IM Spec. in $K^-p \rightarrow \pi\pi\Sigma$ w/ M-matrix

Pole Structure of the Lambda(1405) Region

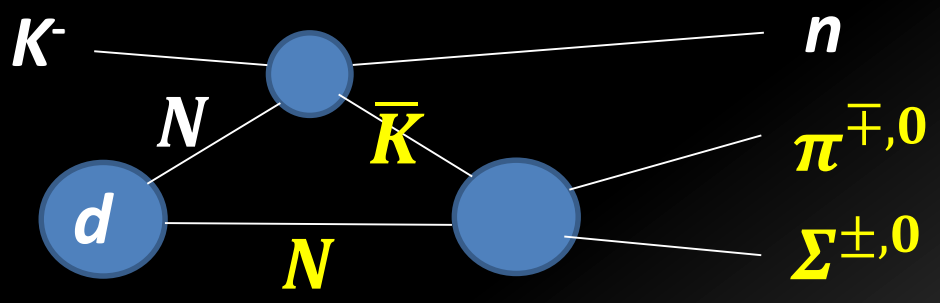
PDG Reviews: Ulf-G. Meissner and T. Hyodo (Nov. 2015)

Table 1: Comparison of the pole positions of $\Lambda(1405)$ in the complex energy plane from next-to-leading order chiral unitary coupled-channel approaches including the SIDDHARTA constraint.

approach	pole 1 [MeV]	pole 2 [MeV]
Refs. 11,12, NLO	$1424^{+7}_{-23} - i\,26^{+3}_{-14}$	$1381^{+18}_{-6} - i\,81^{+19}_{-8}$
Ref. 14, Fit II	$1421^{+3}_{-2} - i\,19^{+8}_{-5}$	$1388^{+9}_{-9} - i\,114^{+24}_{-25}$
Ref. 15, solution #2	$1434^{+2}_{-2} - i\,10^{+2}_{-1}$	$1330^{+4}_{-5} - i\,56^{+17}_{-11}$
Ref. 15, solution #4	$1429^{+8}_{-7} - i\,12^{+2}_{-3}$	$1325^{+15}_{-15} - i\,90^{+12}_{-18}$

E31 aims at:

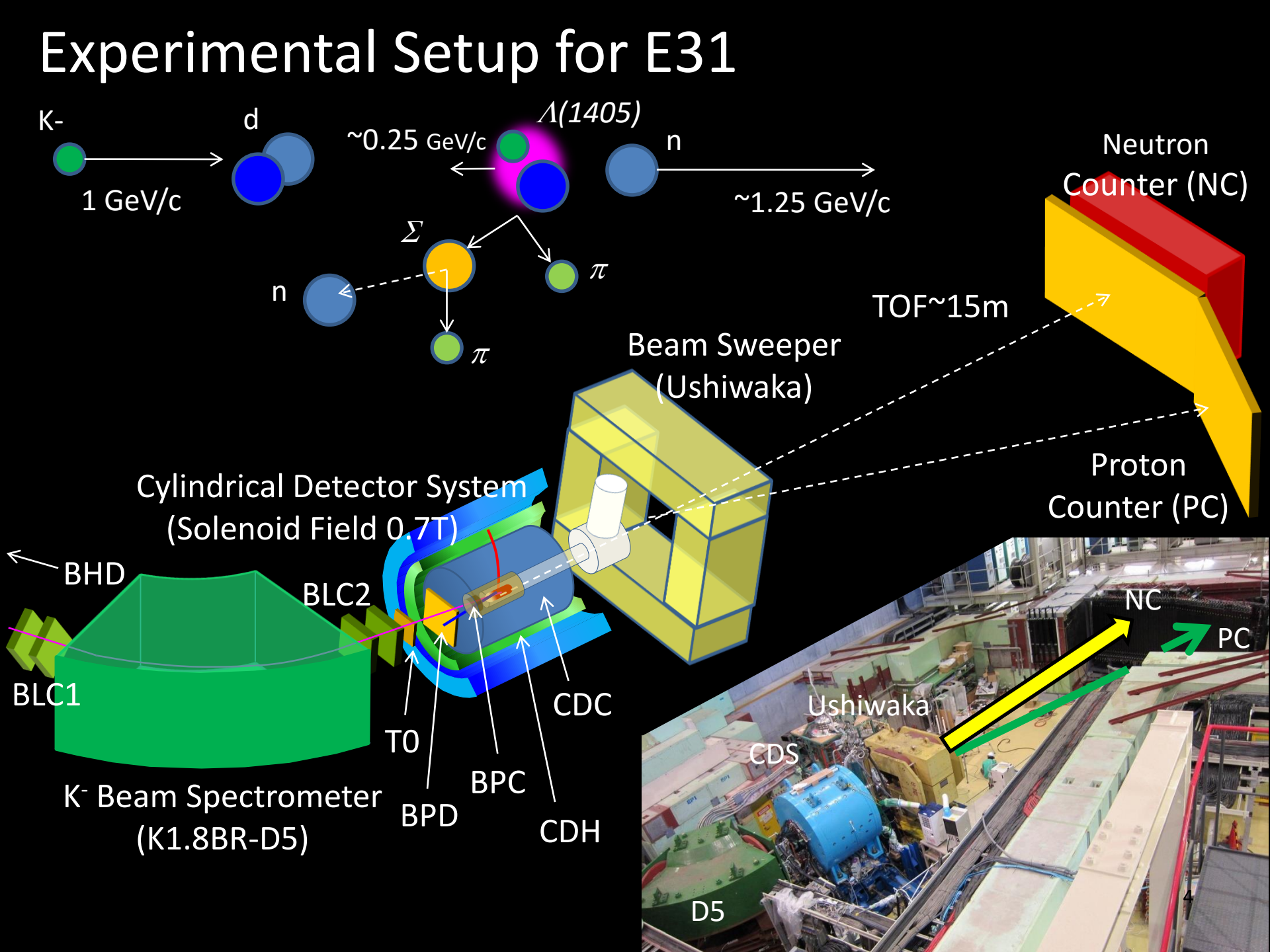
- measuring an *S*-wave $\bar{K}N \rightarrow \pi\Sigma$ scattering below the $\bar{K}N$ threshold in the $d(K^-,n)\pi\Sigma$ reactions at a forward angle of *n*.



- ID's all the final states to decompose the I=0 and 1 ampl's.

$\pi^{\pm}\Sigma^{\mp}$	**I=0, 1**	**Λ(1405) (I=0, S wave),** non-resonant[I=0/1] **(Σ(1385) (I=1, P wave) to be suppressed)**
$\pi^{-}\Sigma^{0}$ $[\pi^{-}\Lambda]$	I=1	non-resonant (Σ(1385) to be suppressed) $d(K^-,p)\pi^-\Sigma^0$ $[\pi^-\Lambda]$
$\pi^{0}\Sigma^{0}$	**I=0**	**Λ(1405) (I=0, S wave)**, non-resonant

Experimental Setup for E31



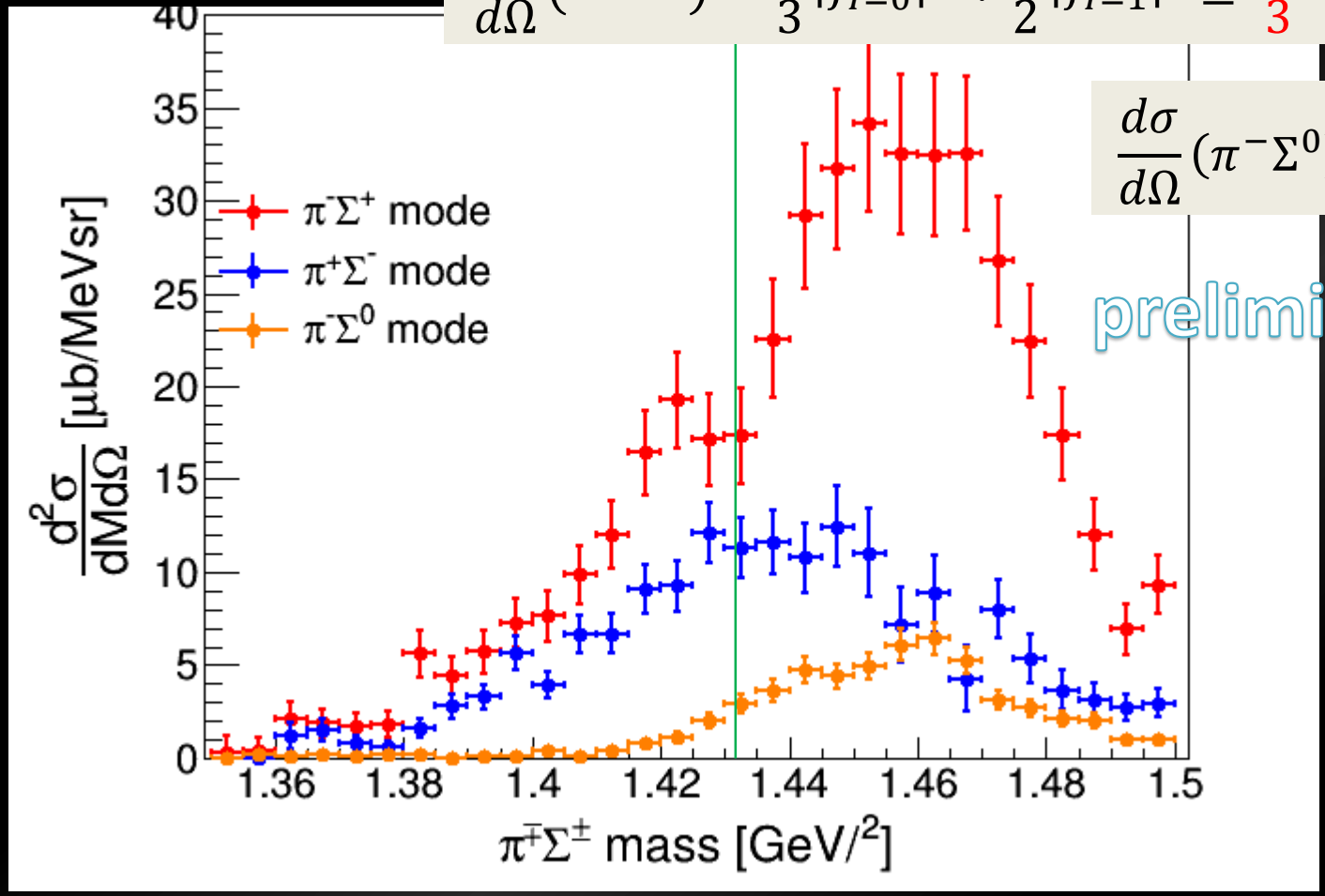
E31 Run Summary

E31 run		Beam Power	Beam Time	Executed/ Proposed
pre	May 2015	27 kW	2.2d	~5%
1st	May-June 2016	43 kW	~7d	~30%
2nd	Apr.2017	44 kW	0.5d(start up)	~30%
2nd'	Winter 2017	45 kW (Expected)	~20(+1.5)d (request)	100%

$\pi^+\Sigma^-/\pi^-\Sigma^+$ Mode ($I = 0, 1$) vs $\pi^-\Sigma^0$ Mode ($I = 1$)

$$\frac{d\sigma}{d\Omega}(\pi^{\pm}\Sigma^{\mp}) = \frac{1}{3}|f_{I=0}|^2 + \frac{1}{2}|f_{I=1}|^2 \pm \frac{\sqrt{6}}{3} Re(f_{I=0} f_{I=1}^*)$$

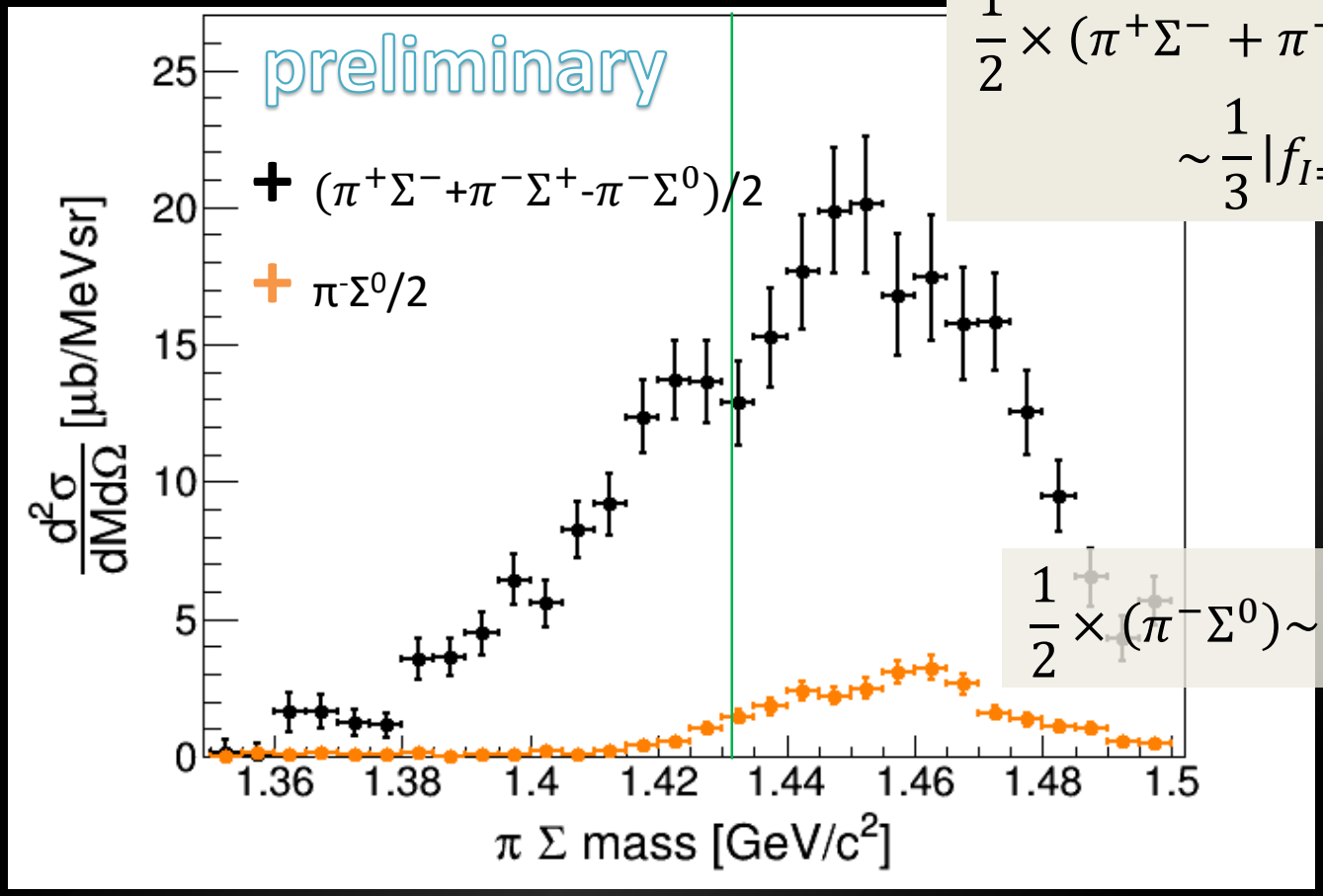
$$\frac{d\sigma}{d\Omega}(\pi^-\Sigma^0) \sim |f_{I=1}|^2$$



preliminary

$$\frac{1}{2} \times (\pi^+\Sigma^- + \pi^-\Sigma^+ - \pi^-\Sigma^0) \ (I = 0)$$

v.s. $\frac{1}{2} \times \pi^-\Sigma^0 \ (I = 1)$



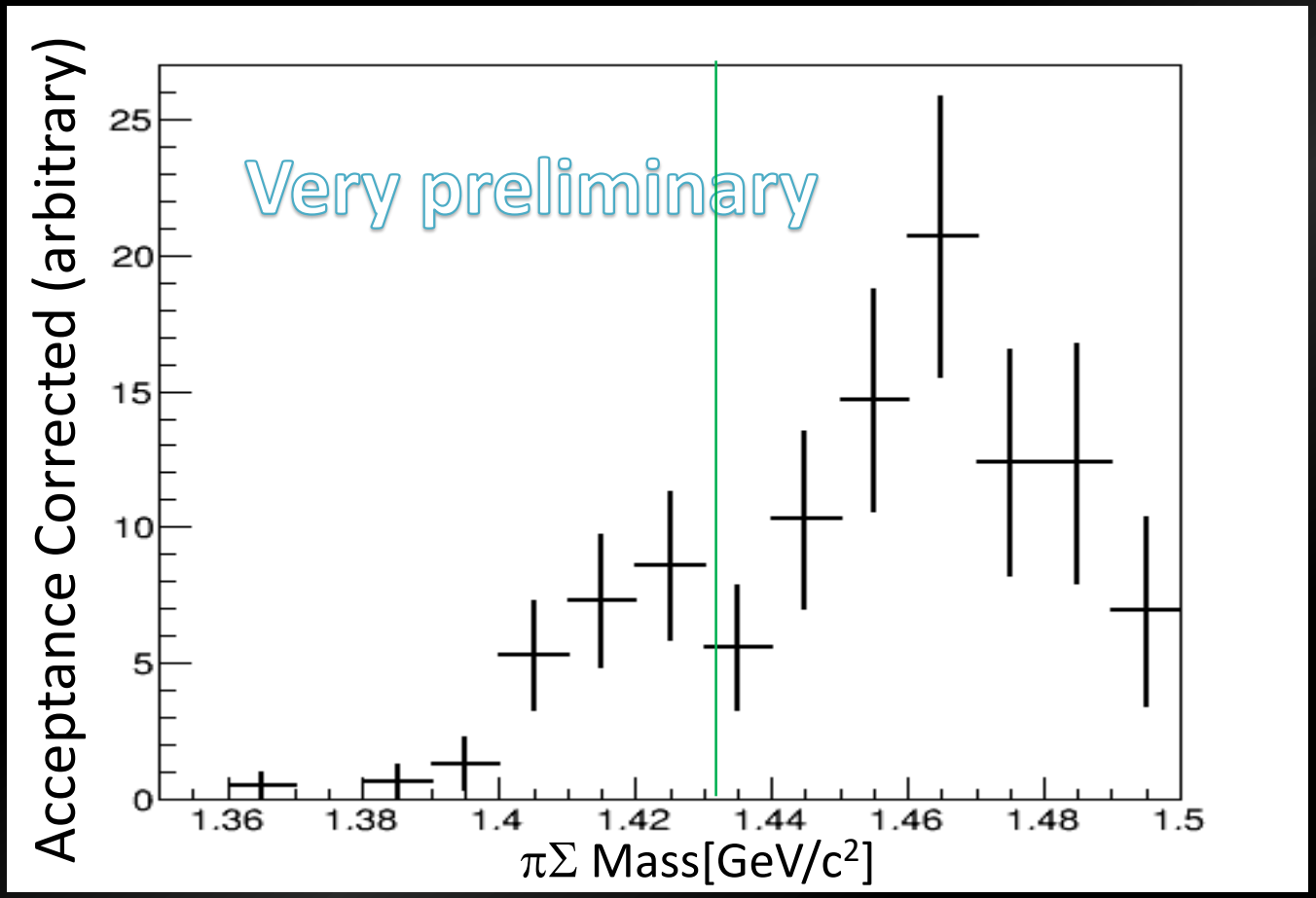
$$\frac{1}{2} \times (\pi^+\Sigma^- + \pi^-\Sigma^+ - \pi^-\Sigma^0) \sim \frac{1}{3}|f_{I=0}|^2$$

$$\frac{1}{2} \times (\pi^-\Sigma^0) \sim \frac{1}{2}|f_{I=1}|^2$$

- *The I=0 amplitude is dominant.*

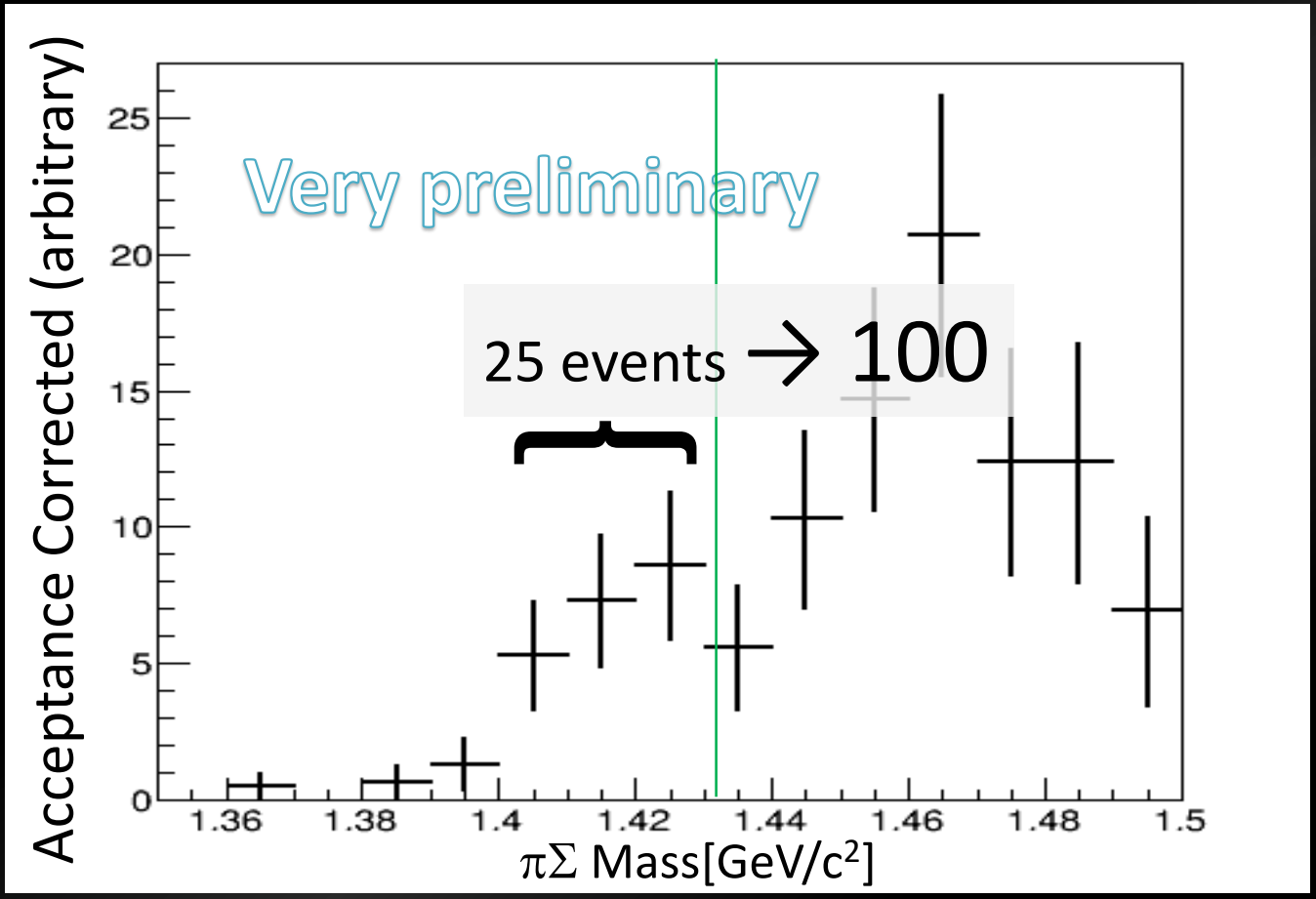
$\pi^0\Sigma^0$ Mode ($I = 0$)

$$\frac{d\sigma}{d\Omega}(\pi^0\Sigma^0) \sim \frac{1}{3}|f_{I=0}|^2$$



$\pi^0\Sigma^0$ Mode ($I = 0$)

$$\frac{d\sigma}{d\Omega}(\pi^0\Sigma^0) \sim \frac{1}{3}|f_{I=0}|^2$$



The E31 2nd Run

- We like to finish E31 to measure a complete set of all the final isospin states in high statistics (x4).
- We NEED to accumulate at least ~100 events of $\pi^0\Sigma^0$ below the K-p thres.
  - To compare with the $(\pi^-\Sigma^+ + \pi^+\Sigma^- - \pi^-\Sigma^0)/2$ spectrum, At least 10% in statistical error below the K-p threshold is necessary.
- We NEED to run for 20(+1.5 for start up) days at 45 kW.
  - As requested at the previous PAC

E31 Run Summary/Request

E31 run		Beam Power	Beam Time	Executed/ Proposed
pre	May 2015	27 kW	2.2d	~5%
1st	May-June 2016	43 kW	~7d	~30%
2nd	Apr.2017	44 kW	0.5d(start up)	~30%
2nd'	**Winter 2017**	**45 kW (Expected)**	**~20(+1.5)d (request)**	**100%**