27pHC-10

ペンタクォーク探索実験 J-PARC E19: 2nd Run Result (2)

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J-PARC E19 experiment

Pentaquark Θ^+ search experiment
with high statistics and high resolution

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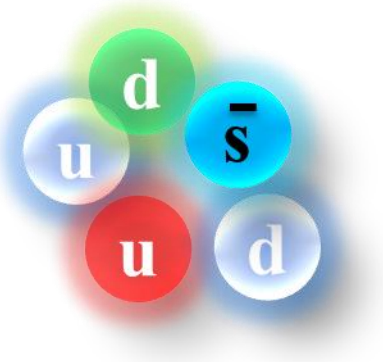
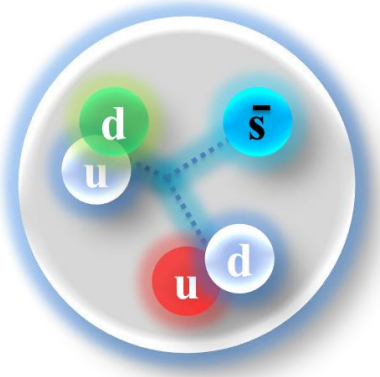


Pentaquark Θ^+

- Genuine exotic hadron (including a s^{bar} quark)
- M = ~1540 MeV/c^2 (decay $\Theta^+ \rightarrow$ KN)
- Γ < a few MeV

Extremely Narrow Width

➔ Quark (gluon) dynamics in a hadron



Diquark structure

R.Jaffe, F.Wilczek (2003)

J-PARC E19 experiment

Pentaquark Θ^+ search experiment with high statistics and high resolution

$$\pi^- + p \rightarrow K^- + \Theta^+$$

✓ **Pion induced reaction**

- **Complementary to photo-production (LEPS, CLAS etc.)**
- **Expect sizable production cross section.**

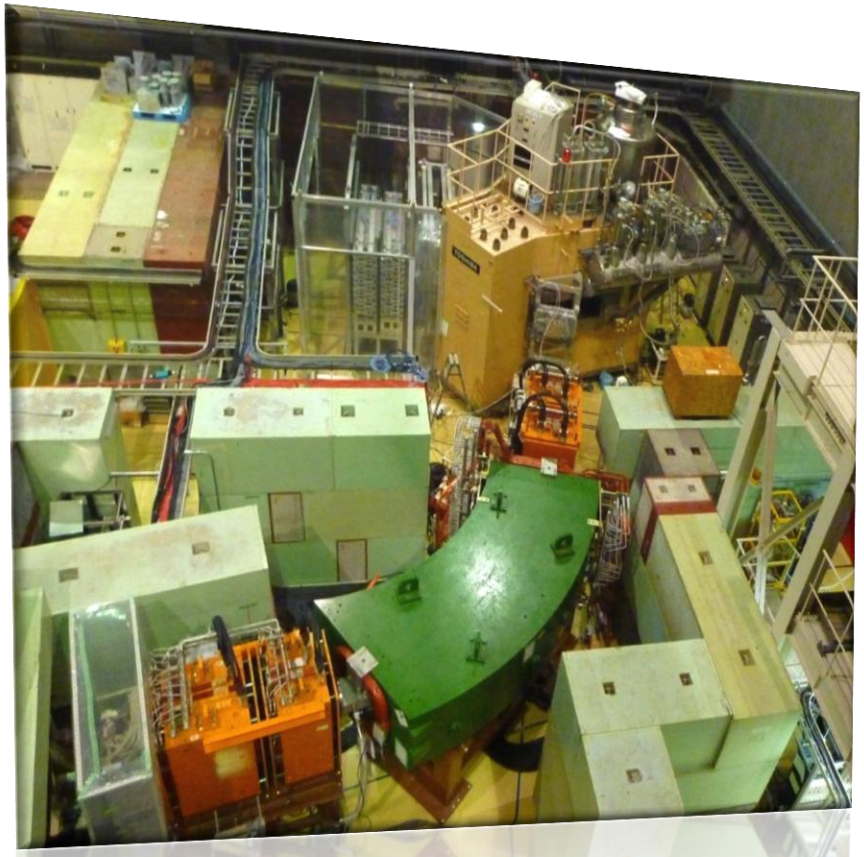
J-PARC E19 experiment

Pentaquark Θ^+ search experiment with high statistics and high resolution

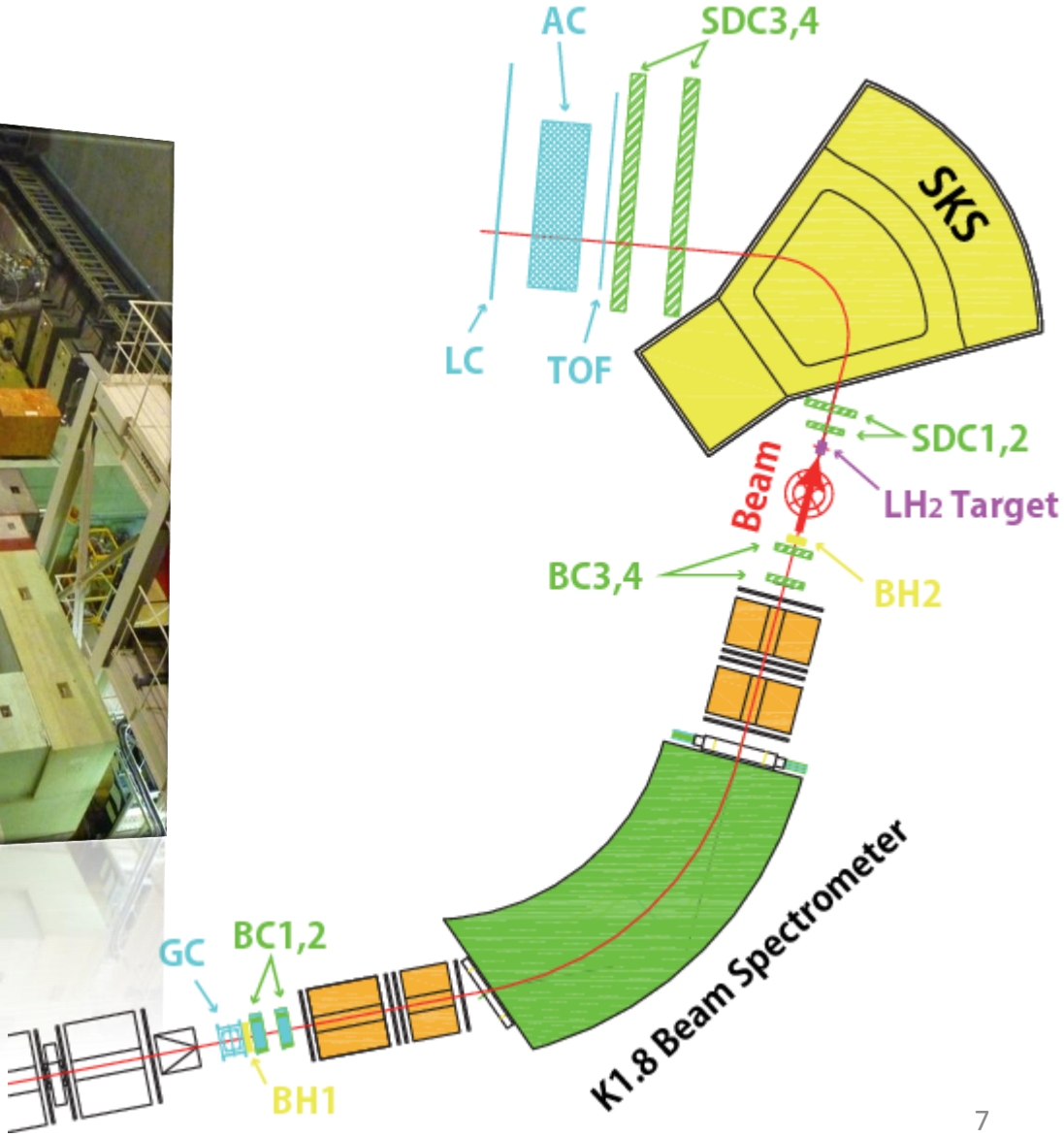
- ✓ **High resolution missing mass spectroscopy**
  - **K1.8 beam line & SKS = $\Delta M < 2$ MeV (FWHM)**

High sensitivity for the Θ^+ search

Experimental setup



J-PARC K1.8



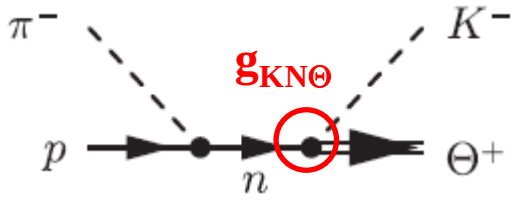
History of E19

	Comment	Beam Momentum	Beam intensity	π's on Target
2009/10 ~	K1.8 beam line & detector commissioning start			
2010/10-11 1st RUN	**examine the 2.6σ bump structure observed in E522**	**1.92 GeV/c**	**1.0 M /spill**	**7.8 x 10^{10}**
2012/02 2nd RUN	**new data at the highest beam momentum at K1.8**	**2.0 GeV/c**	**1.7 M /spill**	**8.7 x 10^{10}**

Shirotori et al., PRL 109, 132002 (2012).

This presentation

Θ+ decay width



- ✓ s-channel dominance
- ● $\Gamma_\Theta \propto g^2_{KN\Theta} \propto \sigma_{tot}$

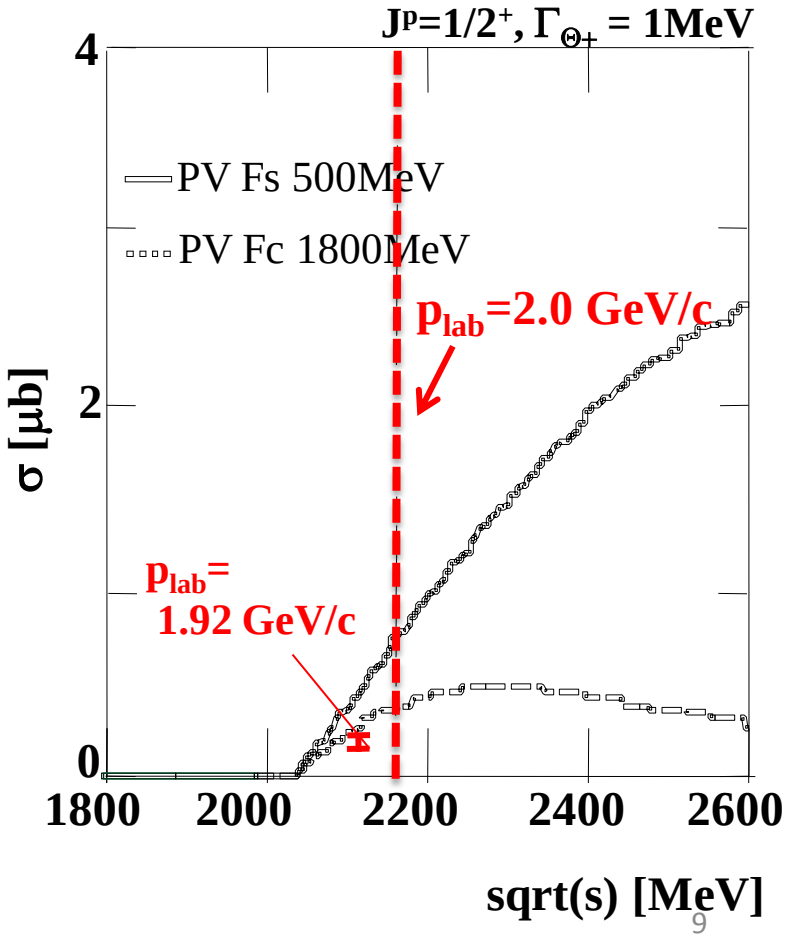
- Higher beam momentum provides higher sensitivity.

➢ **2.0 GeV/c**

(= Max. of K1.8 B.L.)

✓ Even if no peak, stronger constraint on the Θ+ decay width will be obtained.

Theoretical calculations :
T. Hyodo et al., PRC 72, 055202 (2005),
PTP 128, 523 (2012).



Analysis result of the 2nd run

Analysis Strategy

1. **Consistency check with 1st run**
   - **$\pi^+ + p \rightarrow K^+ + \Sigma^+$ @ 1.37 GeV/c**
   - **Same reaction and same momentum with 1st run.**
2. **Calibration for 2nd run**
   - **$\pi^- + p \rightarrow K^+ + \Sigma^-$ @ 1.45 GeV/c**
   - **Same K momentum as Θ^+ run @ 2.00 GeV/c**
   - **Evaluate Θ^+ missing mass resolution.**
3. **Θ^+ run analysis**

Consistency check with 1st run

- ✓ $\pi^+ + p \rightarrow K^+ + \Sigma^+$ @ 1.37 GeV/c
- ✓ **Missing mass resolution:**

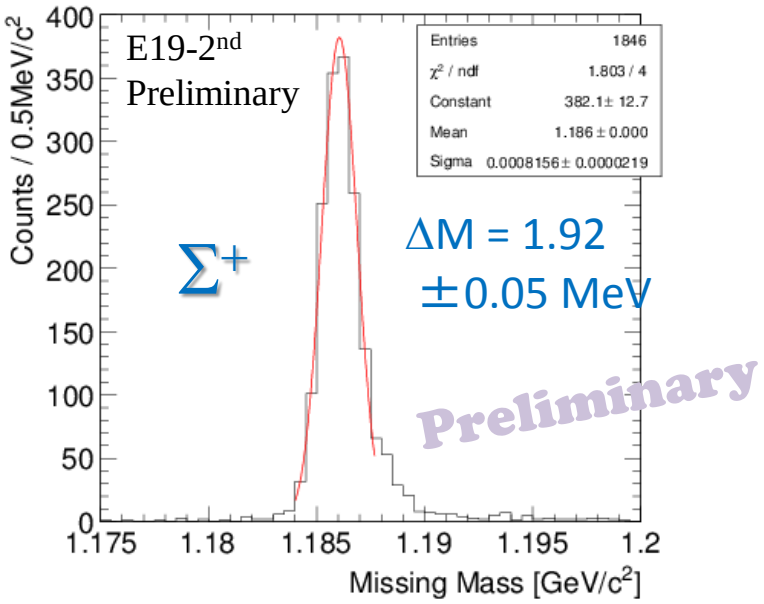
  ΔM_Σ = 1.92 MeV (FWHM)

  – **Equivalent to the 1st run.**

  Cf.) 1.86±0.08 MeV @ E19-1st

Σ^+ Missing Mass

$\pi^+ + p \rightarrow K^+ + \Sigma^+$ @ 1.37 GeV/c



Consistency check with 1st run

Σ^+ Differential Cross Section

$\pi^+ + p \rightarrow K^+ + \Sigma^+$ @ 1.37 GeV/c

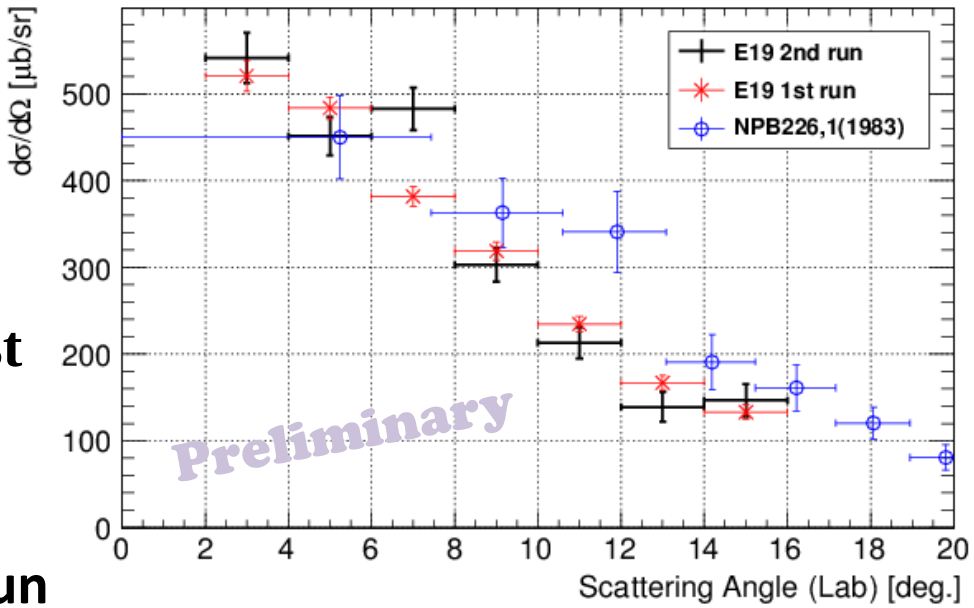
- ✓ $\pi^+ + p \rightarrow K^+ + \Sigma^+$ @ 1.37 GeV/c
- ✓ Missing mass resolution:

  $\Delta M_\Sigma = 1.92$ MeV (FWHM)

  – Equivalent to the 1st run.

  Cf.) 1.86 ± 0.08 MeV @ E19-1st

- ✓ Differential cross section
  - – Almost consistent with 1st run and reference data.
  - – Good understanding of efficiencies and acceptance.



Consistency Check → OK

Calibration for 2nd run

- $\pi^- + p \rightarrow K^+ + \Sigma^-$ @ 1.45 GeV/c
- Missing mass resolution:

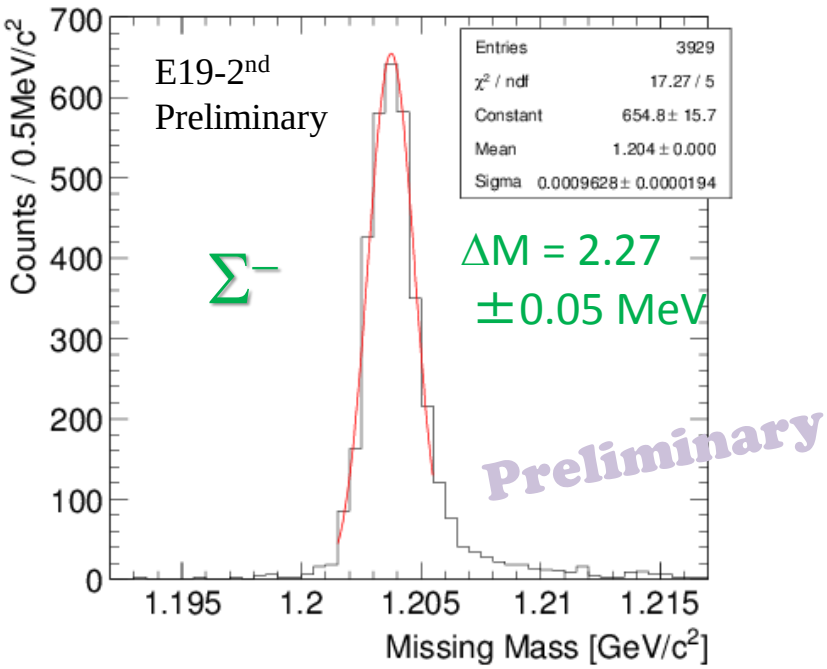
$\Delta M_{\Sigma} = 2.27$ MeV (FWHM)

- Evaluate Θ^+ missing mass resolution.
- $\pi^- + p \rightarrow K^- + \Theta^+$ @ 2.00 GeV/c

$\Delta M_{\Theta} = 1.74$ MeV (FWHM)

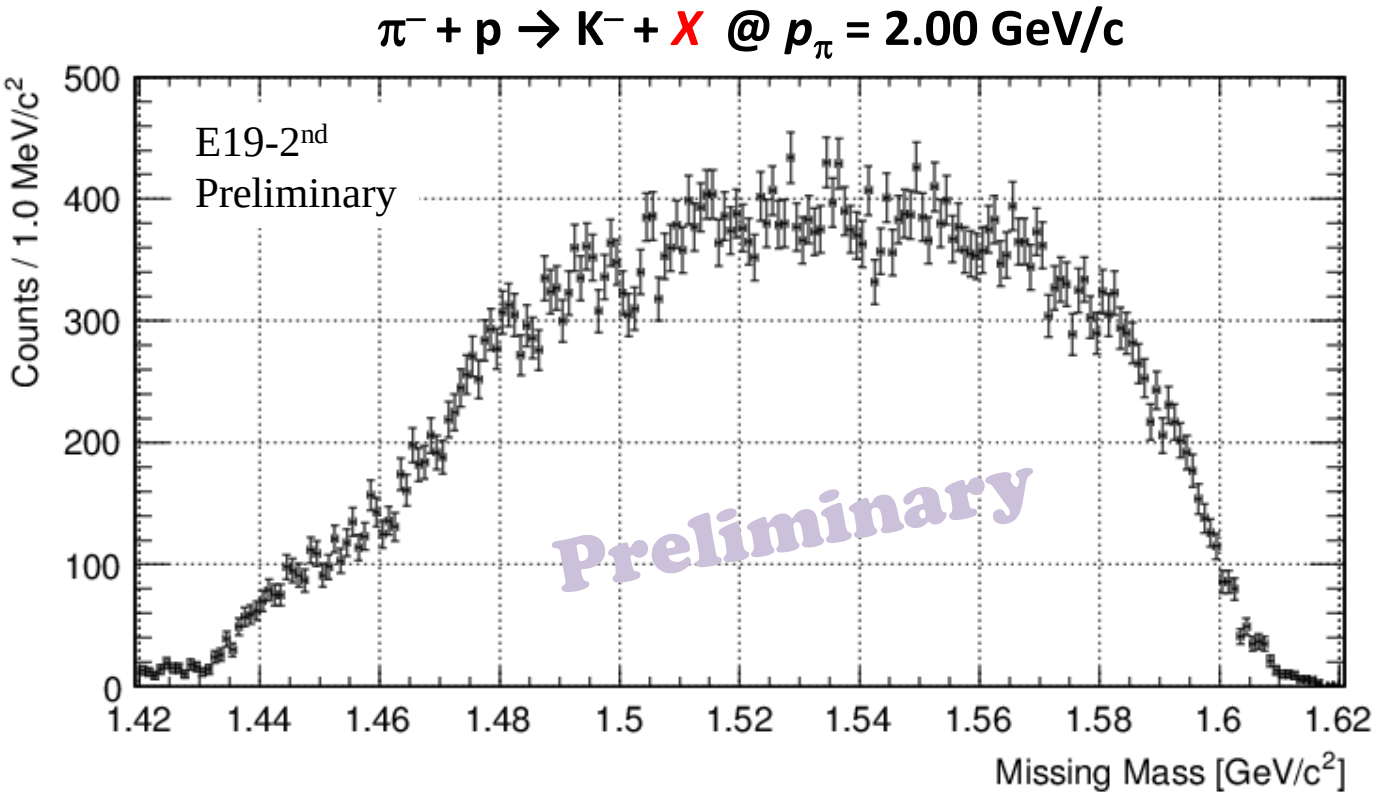
Σ^- Missing Mass

$\pi^- + p \rightarrow K^+ + \Sigma^-$ @ 1.45 GeV/c



Cf.) $\Delta M_{\Theta} = 1.44$ MeV @ E19-1st
This is affected by increase of beam momentum (1.92 → 2.00 GeV/c)

Missing Mass of Θ+ run



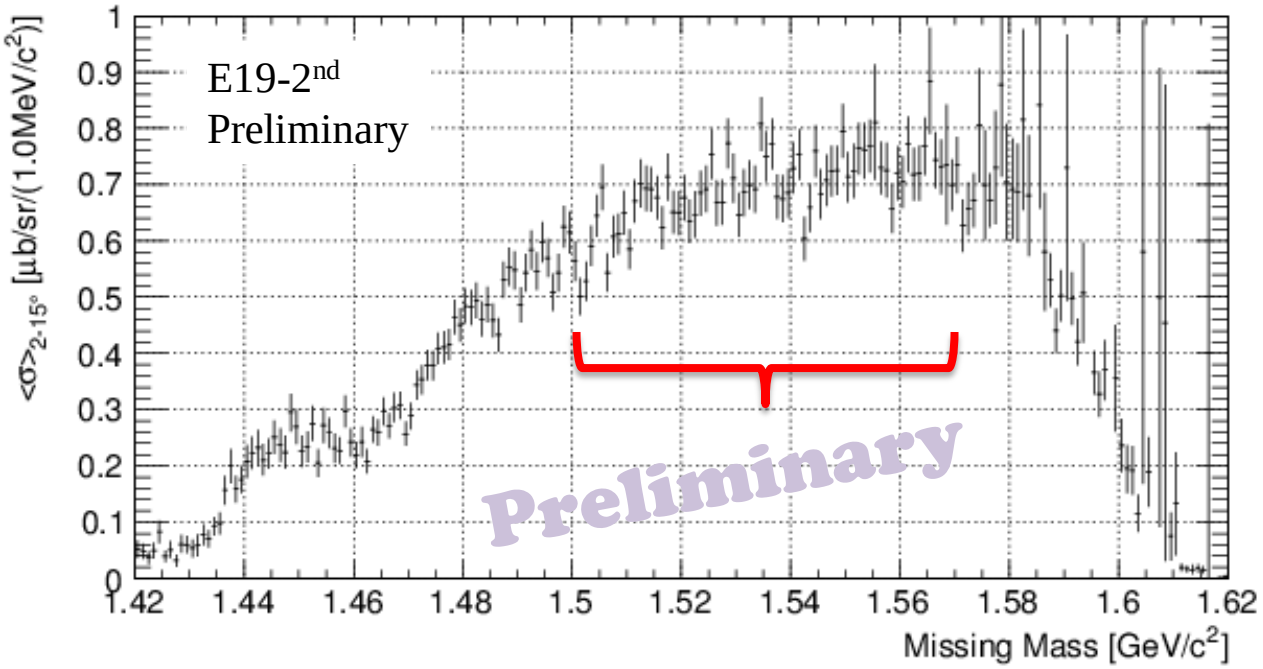
✓ **No peak structure was observed in Θ+ run.**

Missing Mass of Θ+ run

After acceptance correction

Cross Section averaged over 2 – 15 deg.

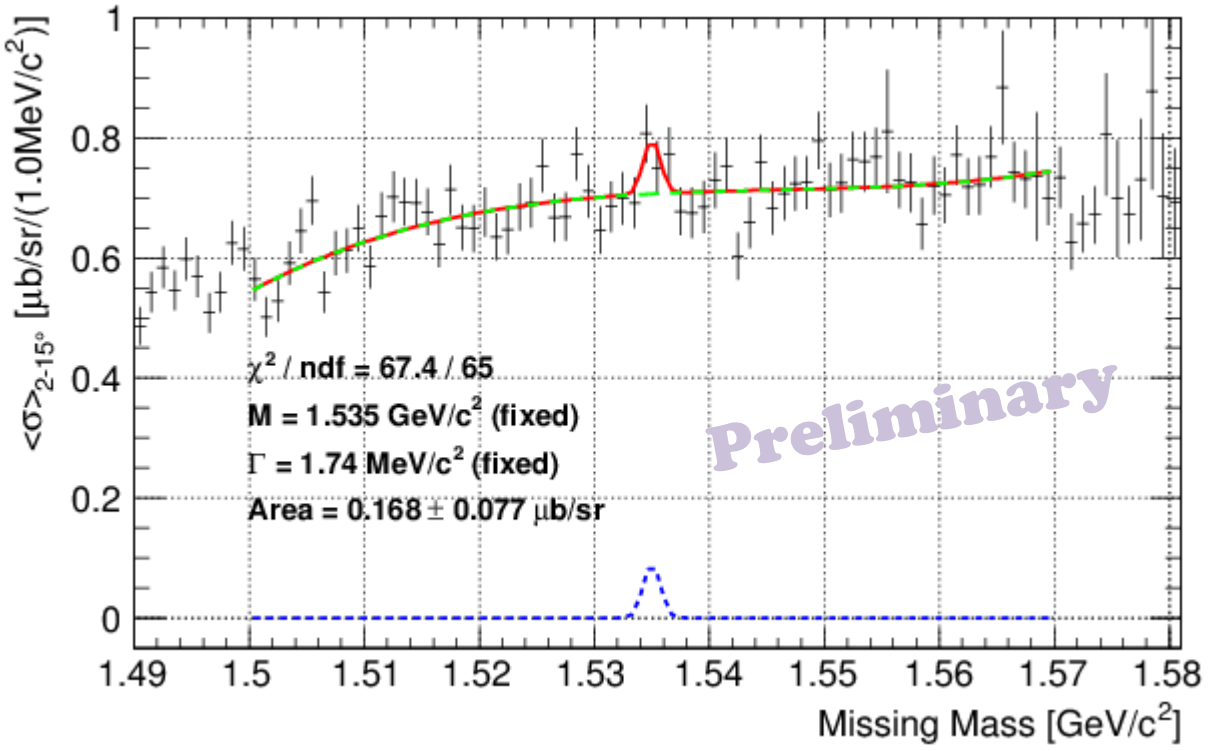
$\pi^- + p \rightarrow K^- + X$ @ p_π = 2.00 GeV/c



- For upper limit, use 1.50 -- 1.57 GeV/c^2 as flat acceptance region.

Upper limit for Θ^+ production cross section

An example of fitting result @ 1.535 GeV/c^2



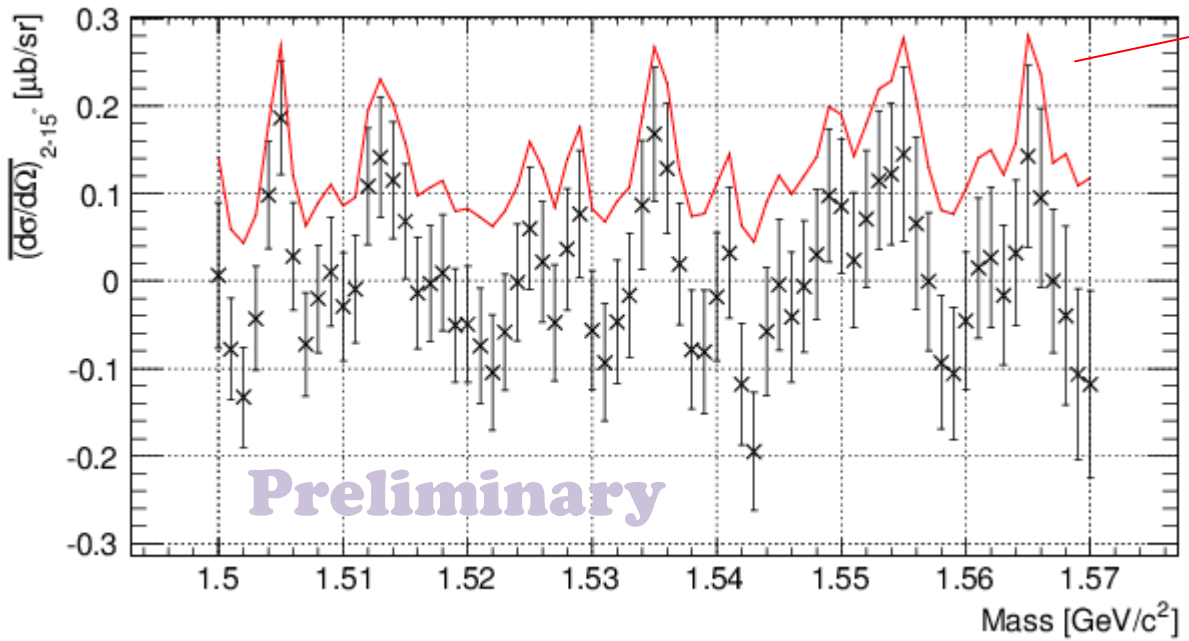
Fitting function

- **Signal: Gaussian with fixed width of 1.74 MeV**
- **B.G.: 3rd order pol.**

➢ **Search mass region from 1.50 to 1.57 GeV/c^2.**

Upper limit for Θ^+ production cross section

Fitting results of each mass and Upper limit (90%C.L.)



- Upper limit for differential cross section averaged from 2 to 15 deg:

  < 0.28 μb/sr @ 1.50 – 1.57 GeV/c^2

Cf.) E19-1st : < 0.26 μb/sr @ 1.51– 1.55 GeV/c^2

- Difference comes mainly from evaluated M.M.Resol. (1.44 → 1.74 MeV)

Summary

- J-PARC E19 is a pentaquark Θ^+ search experiment with high statistics and high resolution.
  - $\pi^- p \rightarrow K^- \Theta^+$ reaction
  - J-PARC K1.8 B.S. and SKS
- E19 2nd run result was presented. (@ 2.0 GeV/c beam)
  - Consistency with 1st run was checked. → O.K.
  - Θ^+ missing mass resolution of 1.74 MeV was evaluated.
  - No peak structure was observed in MM spectrum.
  - Upper limit for Θ^+ production cross section was obtained to be 0.28 μb/sr @ 1.50 – 1.57 GeV/c^2

✓ Next

- Compare theoretical calculation.
- Derive new upper limit for Θ^+ decay width.