20aSA-2

ペンタクォーク探索実験 J-PARC E19: 2nd Run Result (3)

森津　学

for the J-PARC E19 collaboration

（阪大RCNP、他）

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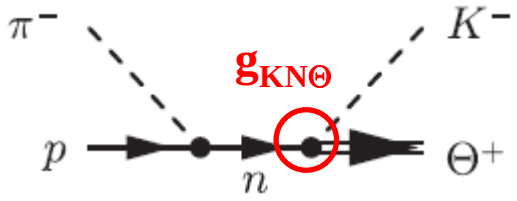
Contents

1. Introduction
   - J-PARC E19 experiment 2nd run
2. Result of E19-2nd
   - Updated analysis result from previous JPS meeting
3. Discussion
   - On Θ^+ decay width
4. Summary

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	7.8×10^{10}
2012/02 **2nd RUN**	new data at the highest beam momentum at K1.8	2.00 GeV/c	1.7 M /spill	8.7×10^{10}

Aim of the 2nd run



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

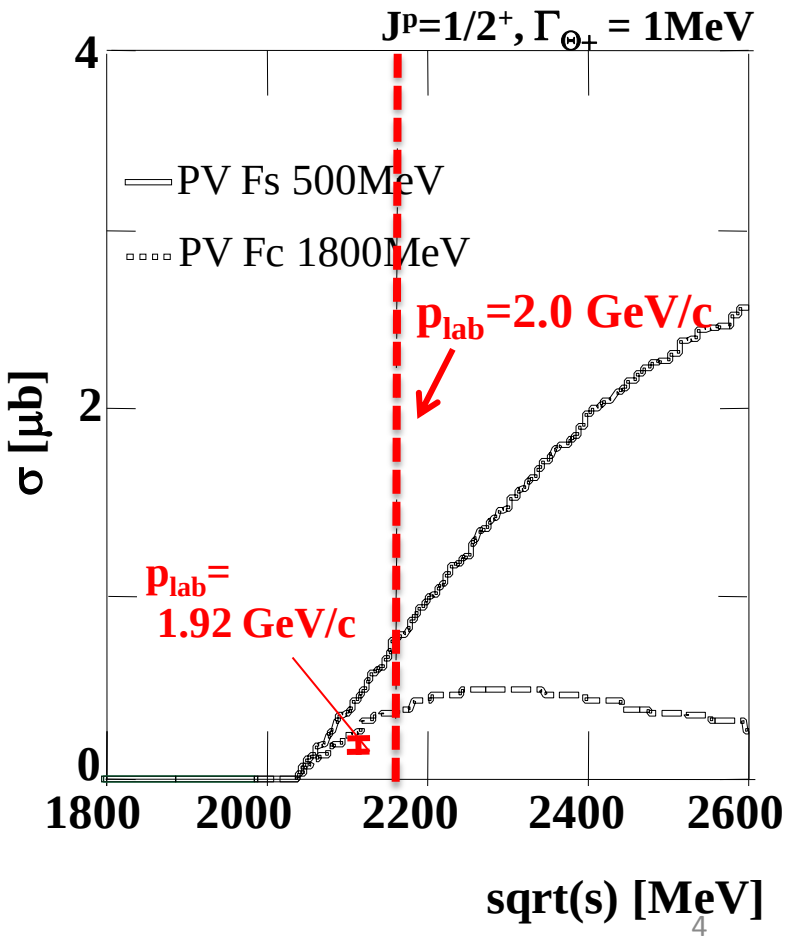
- Higher beam momentum provides higher sensitivity.

➢ **2.0 GeV/c**

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

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

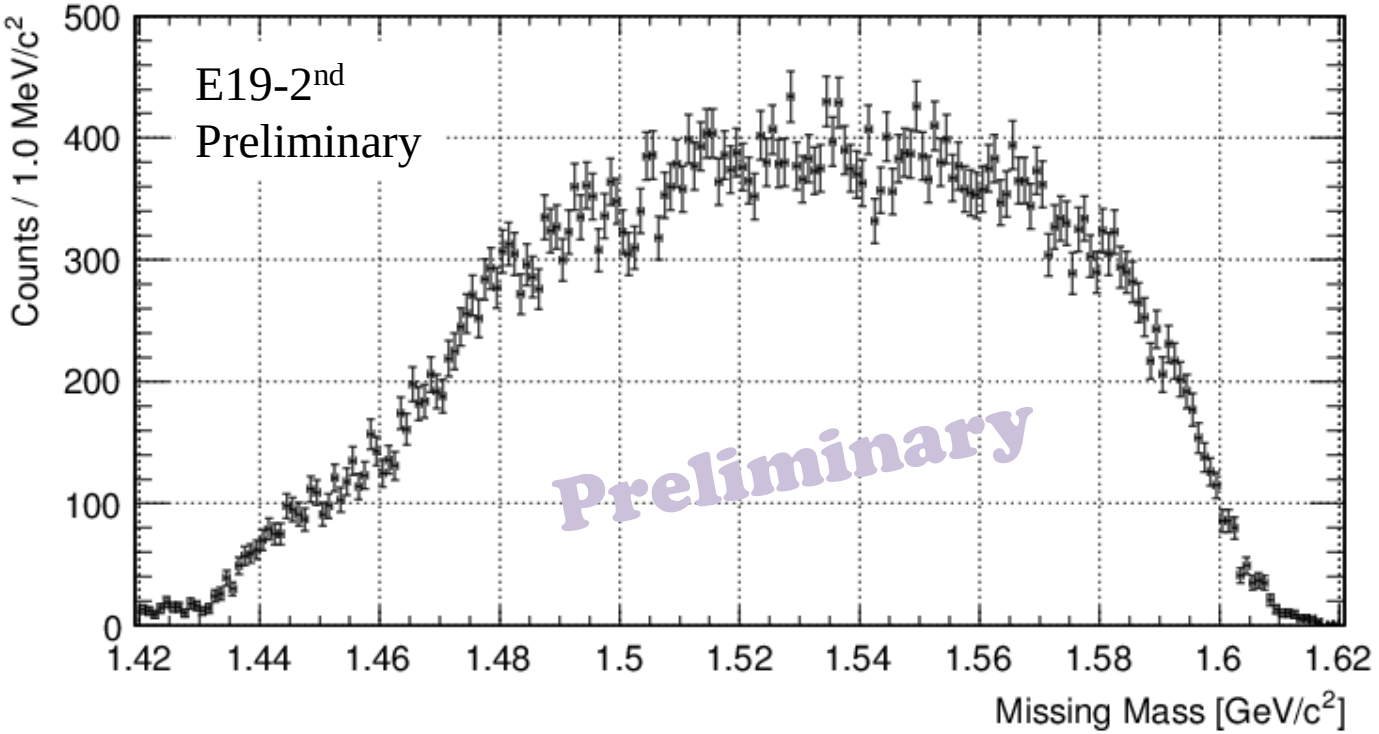
Theoretical calculations :
T. Hyodo et al., PRC 72, 055202 (2005),
PTP 128, 523 (2012).



Result from the 2nd run

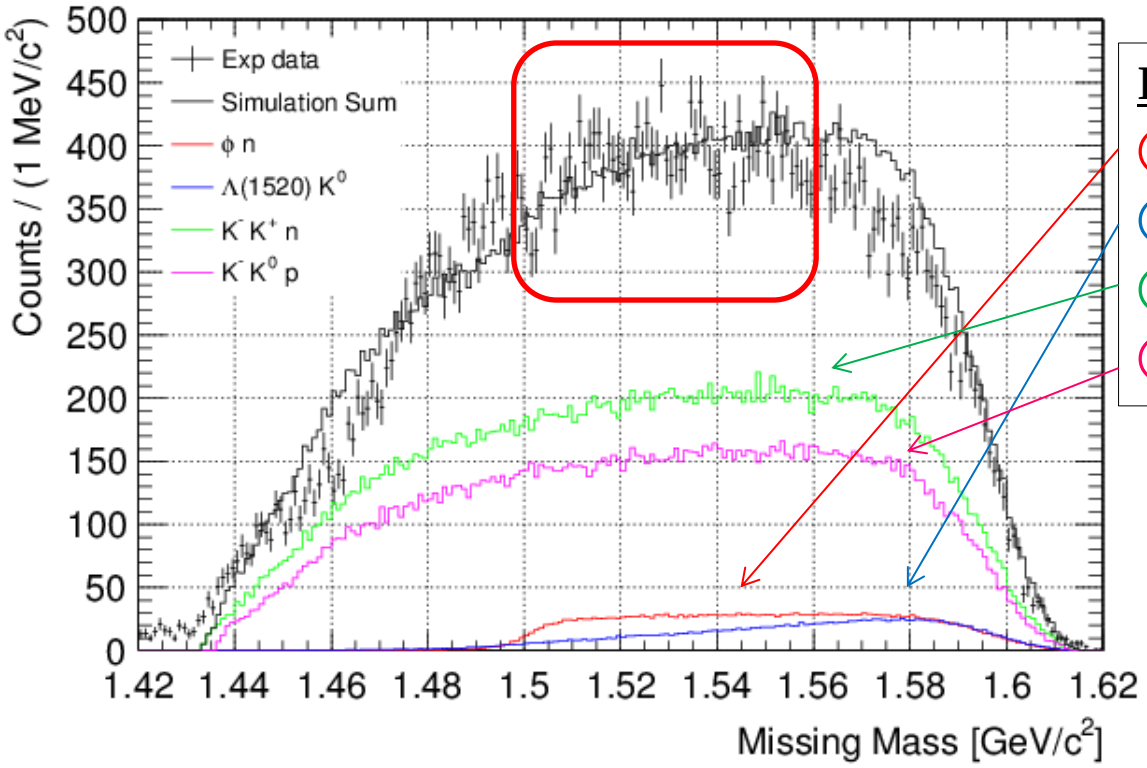
Missing Mass of Θ+ run

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



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

Comparison with BG simulation



BG processes

① $\pi^- p \rightarrow \phi n \rightarrow K^- K^+ n$

② $\pi^- p \rightarrow \Lambda(1520) K^0 \rightarrow K^- K^0 p$

③ $\pi^- p \rightarrow K^- K^+ n$ (nonresonant)

④ $\pi^- p \rightarrow K^- K^0 p$ (nonresonant)

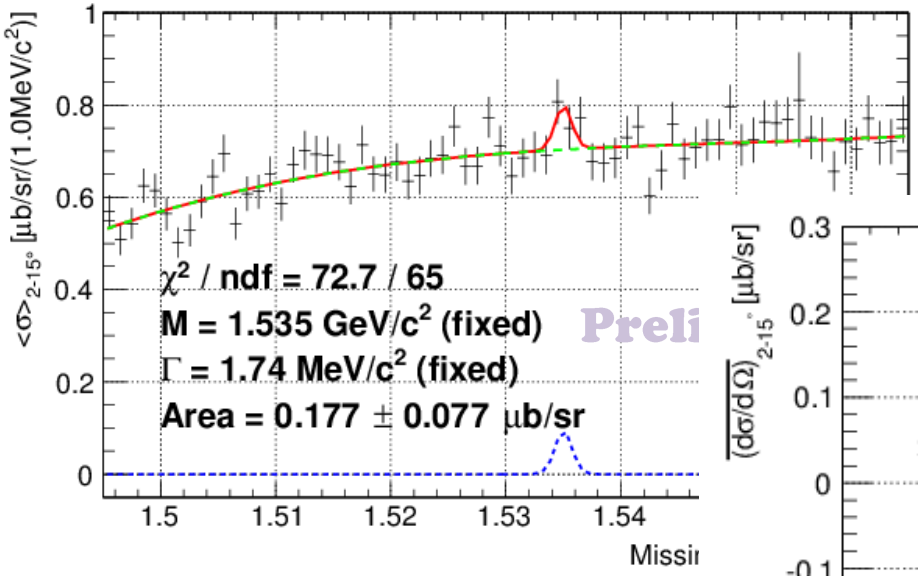
Cross sections and angular distributions are referred from precedent exp.
Scale was normalized to exp. data.

O.I. Dahl et al., PR 163, 1377 (1967)
H. Courant et al., PRD 16, 1 (1977)

- **Data can be reproduced by BG simulation.**
- **BG distribution has no structure in Θ^+ sensitive region: 1.50—1.56 GeV.**
- **[Note] This BG shape is not used in estimation of upper limit because of large uncertainty of the referred data.**

Upper limit for Θ^+ production cross section

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

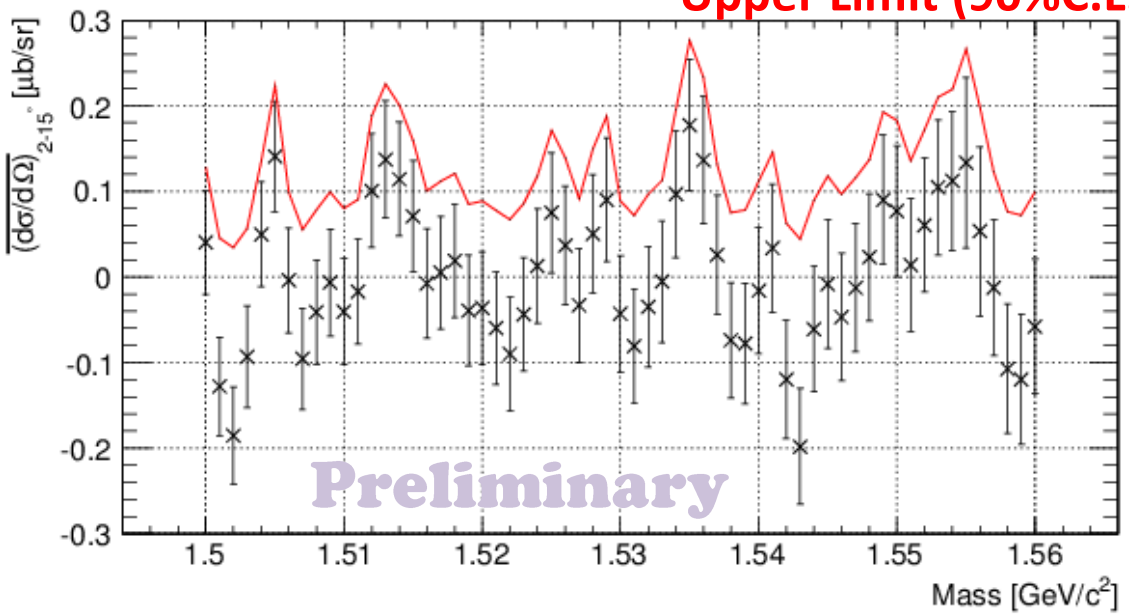


Signal: Gaussian with fixed width of 1.74 MeV

B.G.: 3rd order polynomial

Fitting results of each mass

Upper Limit (90%C.L.)



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

< 0.28 μb/sr @ 1.50 – 1.56 GeV/c^2

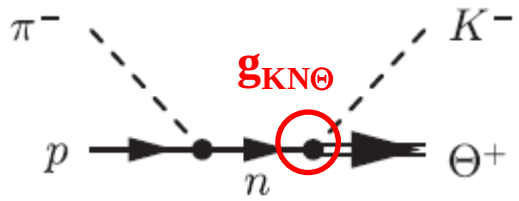
Cf.) E19-1st : < 0.26 μb/sr @ 1.51– 1.55 GeV/c^2

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

Upper limit for Θ+ decay width

We can obtain U.L. of decay width, in the same way of the 1st run.

- **0.61 MeV for ½+**
- **3.7 MeV for ½-**



$$\Gamma_\Theta \propto g^2_{KN\Theta} \propto \sigma$$

T. Hyodo et al., PTP 128, 523 (2012).

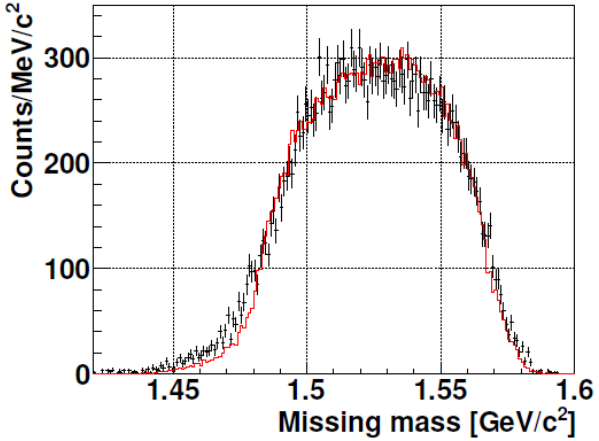
Cf.) E19-1st : 0.72 MeV for ½+, 3.1 MeV for ½-

- For ½+ case, U.L. was improved because of larger cross section of theor. calc.
- For ½- case, U.L. was not updated since cross section become smaller.

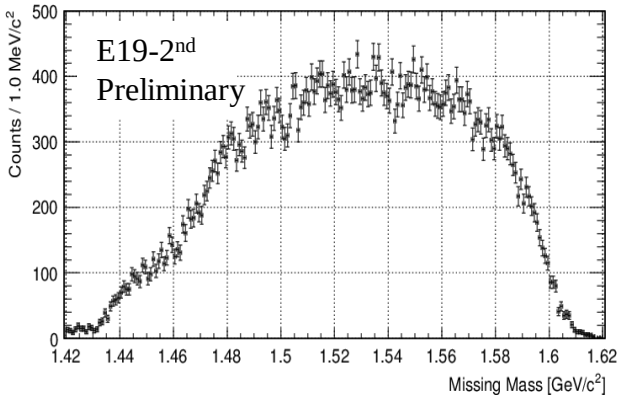
Discussion on Θ^+ decay width

Combined Analysis of 1st and 2nd run

1st run @ 1.92 GeV/c



2nd run @ 2.00 GeV/c

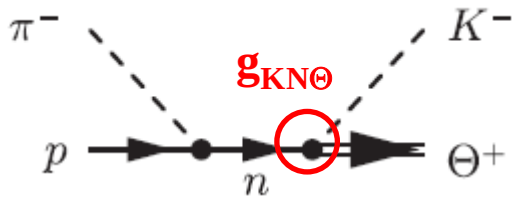


- Now, we obtained results at 2 kinds of initial momentum: 1.92 and 2.00 GeV/c.
- We performed a combined analysis based on the theoretical calculation, considering about these momentum dependence.

Theoretical calculation of meson-induced Θ^+ production

T. Hyodo et al., PTP 128, 523 (2012).

- Effective Lagrangian approach
- Less ambiguous than photoproduction

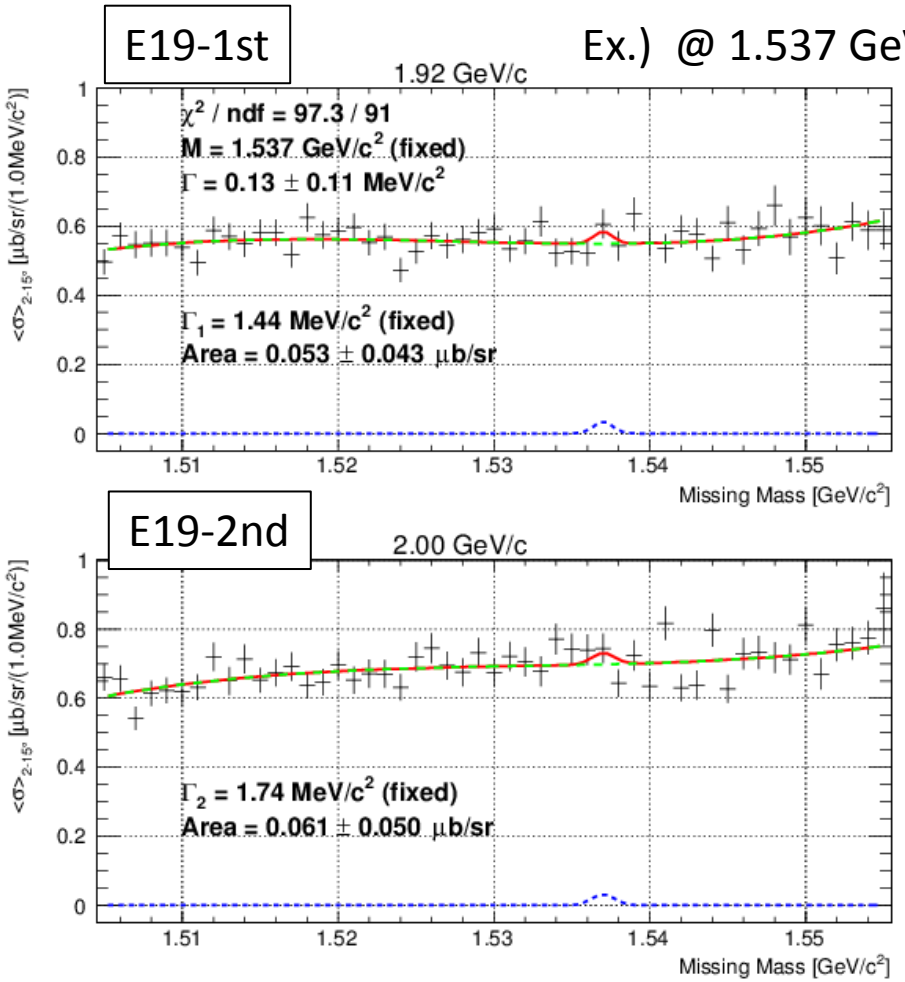


✓ Theoretical uncertainty
- Coupling scheme: PS/PV
- Form factor: static/covariant
- Form factor cutoff value was determined by hyperon prod.
- Θ^+ mass dependence was considered; 1.510—1.550 GeV

There are some ambiguity,

But we took all variations into account and adopted the "most conservative" case. This is confident for "upper limit estimation".

An example of combined fitting

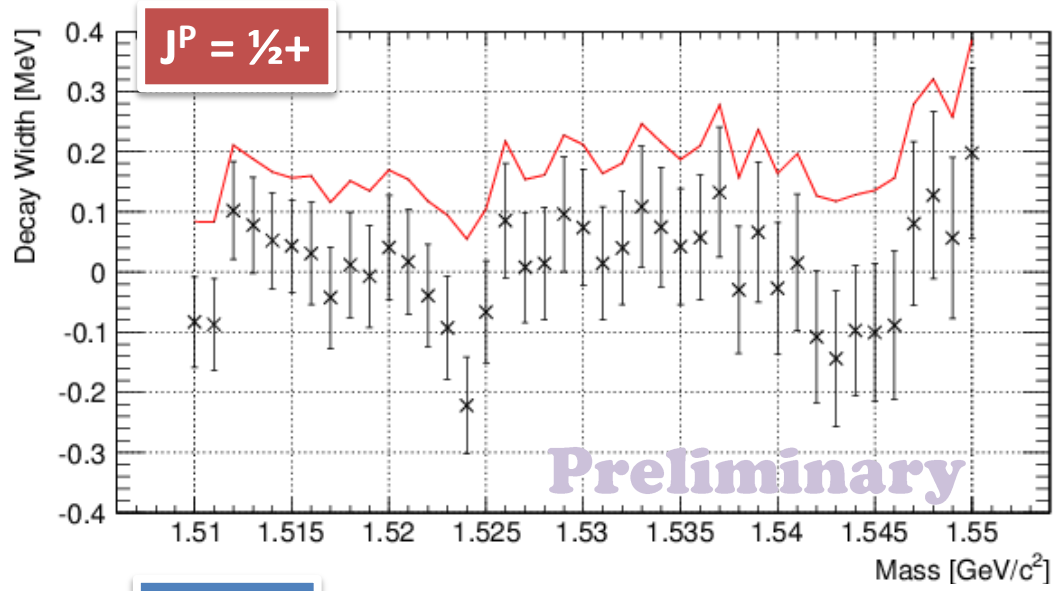


Simultaneous Fit of 1st and 2nd data:

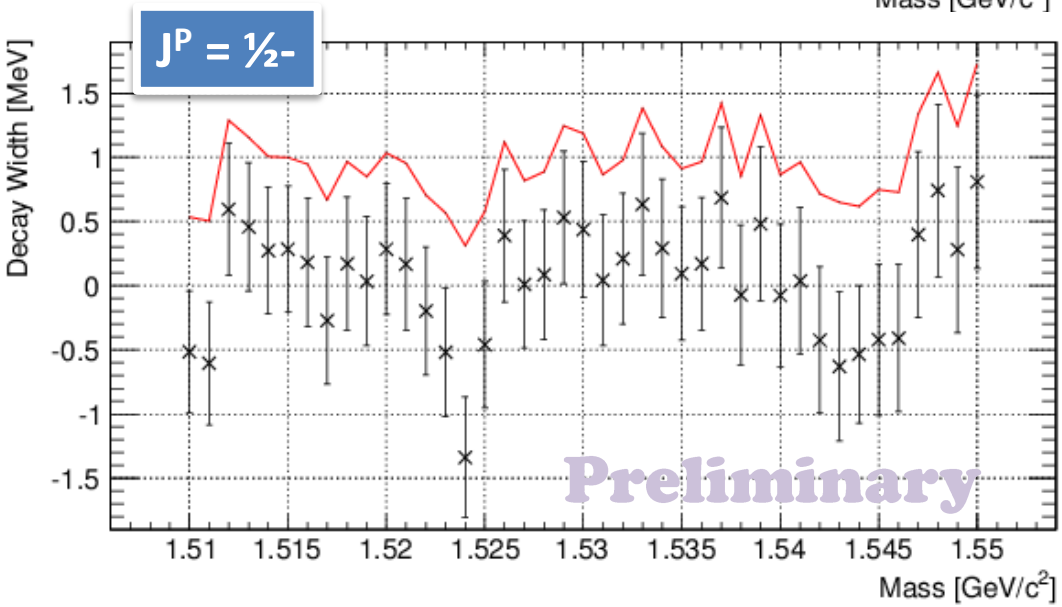
- **σ is proportional to Γ_Θ at each momentum.**
- **Γ_Θ is an unique parameter (except for coefficients of pol.).**

Upper limit on decay width

Results of combined fitting



← Upper Limit (90%C.L.)



In mass region 1.51—1.55 GeV/c^2
Upper limit on Γ_Θ

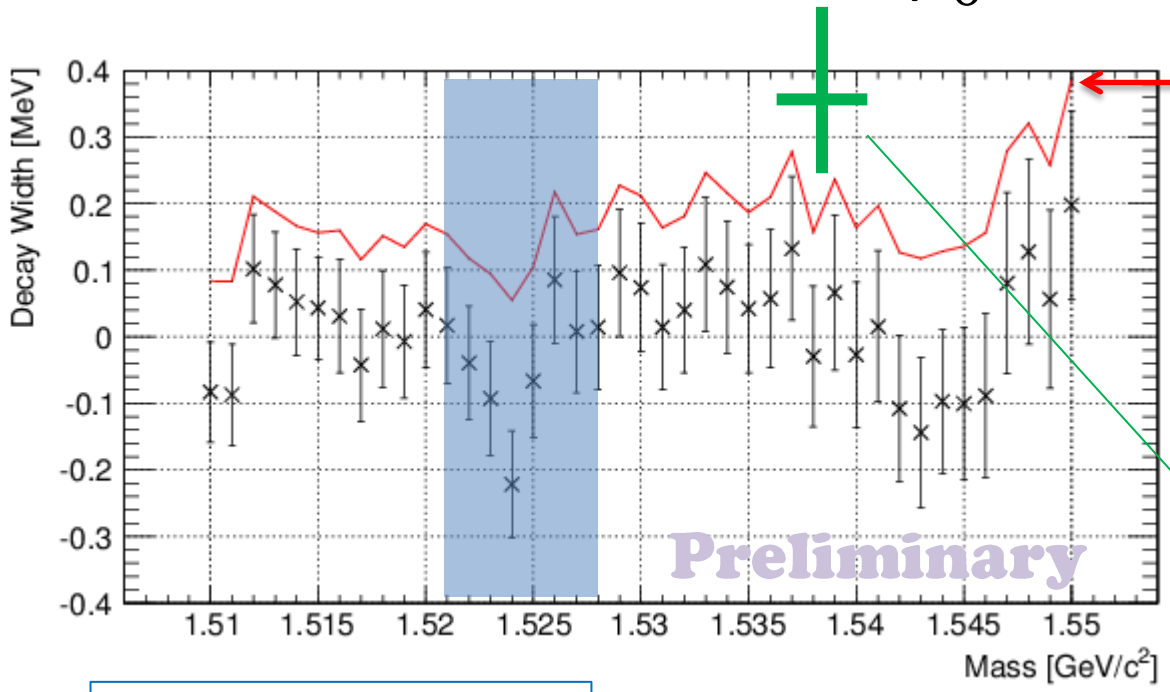
- **0.39 MeV for ½+**
- **1.7 MeV for ½-**

[Note]:
This limit is very conservative estimation.

Discussion (for ½+) comparison with other experiment

✓ **Our U.L. overcame the U.L. from Belle (Γ_Θ < 0.64 MeV).**

R.Mizuk et al., PLB 632, 173 (2006)



U.L. in mass region of 1.51--1.55 GeV,
→ **Γ_Θ < 0.39 MeV**

DIANA:
M = 1538±2 MeV
Γ = 0.36±0.11 MeV
arXiv:1307.1653

LEPS:
M = 1524±2±3 MeV
PRC 79, 025210 (2009).

For LEPS region, Γ < 0.22 MeV.

For DIANA region,
Our U.L. is comparable to their width.

Summary

- **E19 2nd run result was presented.**
  - **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 – 1.56 GeV/c^2**
  - **Upper limit on Θ^+ decay width was derived to be 0.61 (3.7) MeV for ½+ (½-).**
- **Combined analysis of 1st and 2nd run was also reported.**
  - **Based on the theoretical calculation, (conservative) upper limit on Γ_Θ was estimated to be 0.39 (1.7) MeV for ½+ (½-).**