Double Resonance in Dalitz plot of $M_{p\Lambda}$-$M_{K\Lambda}$ in DISTO data on $p+p \rightarrow p+\Lambda+K^{+}$ at 2.85 GeV

Ken Suzuki[1], Toshimitsu Yamazaki[2], Marco Maggiora[3], Paul Kienle[1,4†] for the DISTO collaboration

[1]Stefan-Meyer-Institut für subatomare Physik, Österreichische Akademie der Wissenschaften, [2]Nishina center, RIKEN, [3]INFN-Torino, [4]Technische Universität München

Introduction: X(2265) in the DISTO data

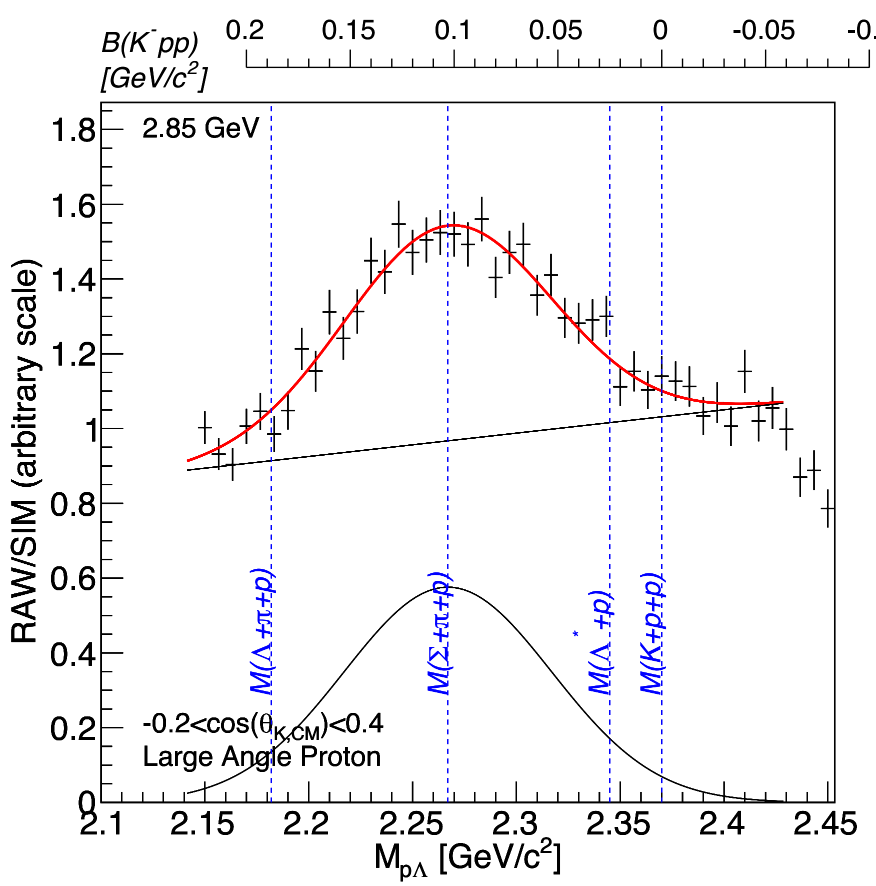
PRL 104, 132502 (2010) PHYSICAL REVIEW LETTERS week ending 2 APRIL 2010

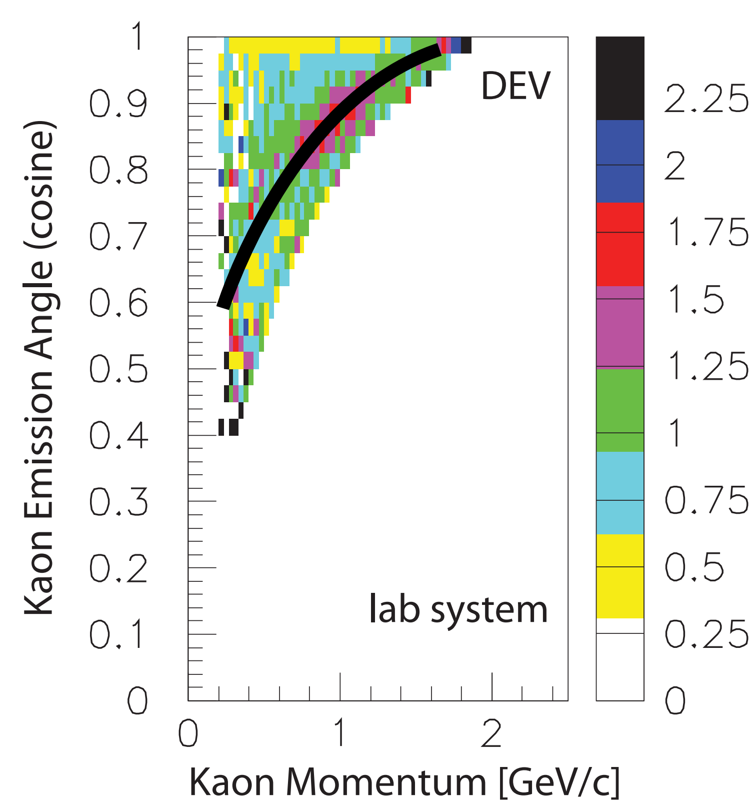
Indication of a Deeply Bound and Compact $K^- pp$ State Formed in the $pp \to p\Lambda K^+$ Reaction at 2.85 GeV

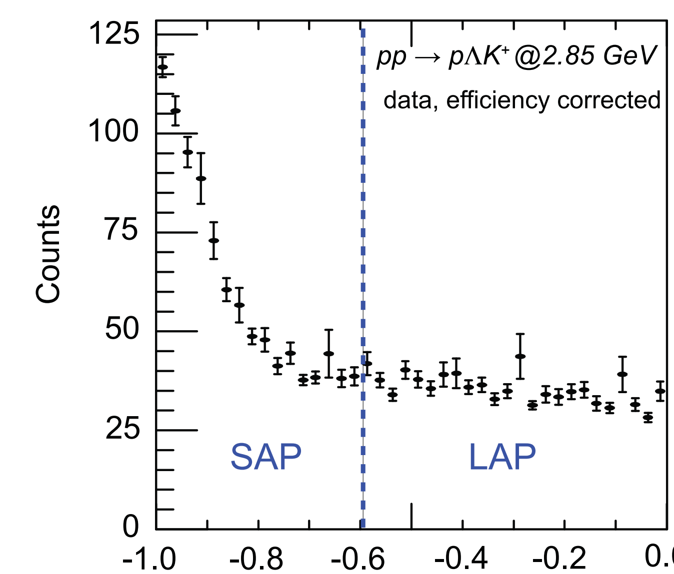
High momentum transfer:
Large angle proton cut
$\equiv |\cos\vartheta_{CM,p}|<0.6$

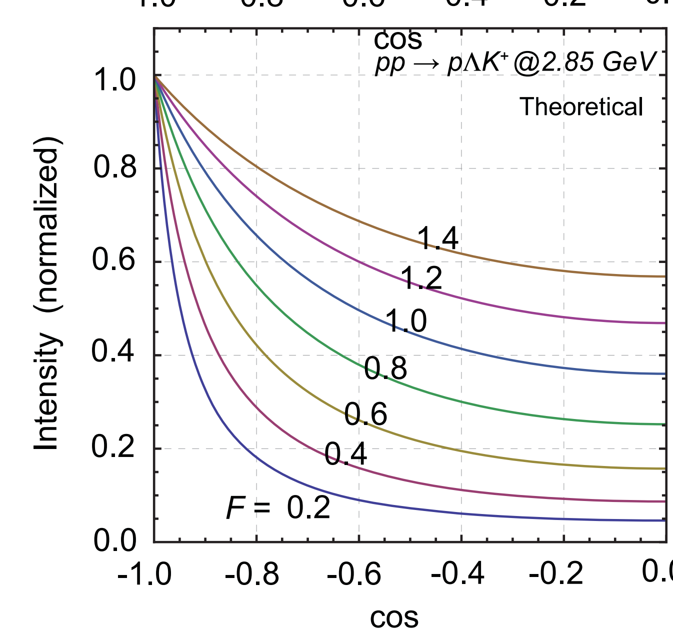
high quality, high statistics (~120k), high purity data sample of exclusive pp→pΛK+ final state (~98%)

pp→XK+ : X(2265)







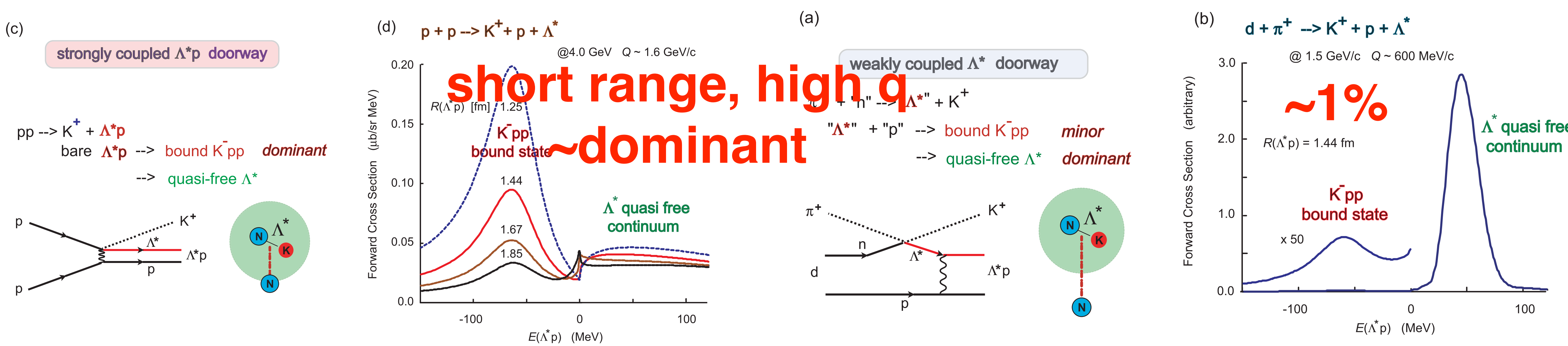


Mx=2267 MeV/c² Γx=118 MeV

$K^{-}pp$ production mechanism

$\Lambda(1405)p \rightarrow K^{-}pp$

p+p, unconventional | **(π, K), conventional**



T. Yamazaki and Y. Akaishi, PRC76 (2007) 045201.

"hard collision/formation mechanism"

DISTO

T. Yamazaki *et al.*, PRL 104 (2010) 132502

Mass 2.267±3(stat.)±5(syst.) GeV/c^2

width 118±8(stat.)±10(syst.) MeV

E27@J-PARC

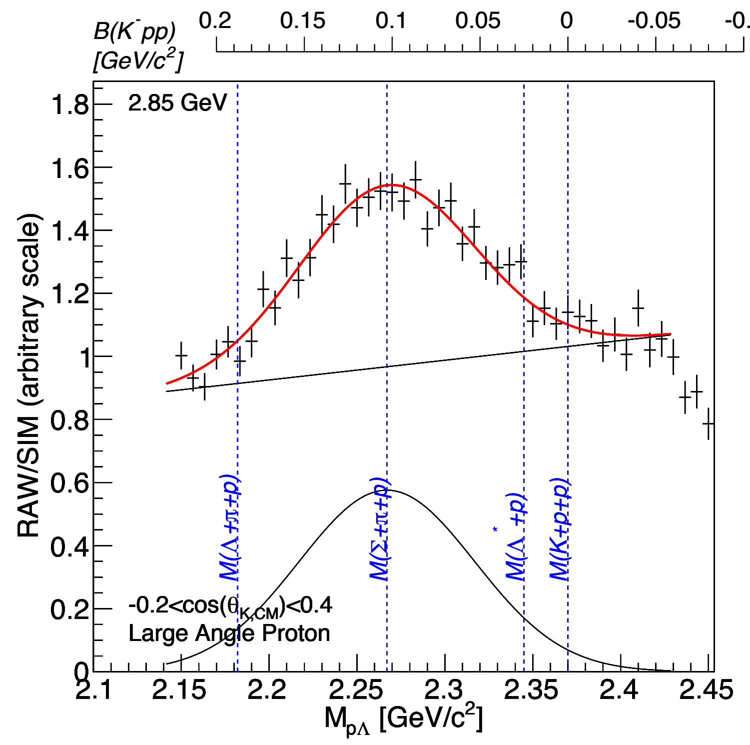
Y. Ichikawa *et al.*, PTEP 2015 021D01

Mass 2.27^{+18}_{-17}(stat.)$^{+30}_{-21}$ (syst.) GeV/c^2

width 162^{+87}_{-45}(stat.)$^{+66}_{-78}$(syst.) MeV

$K^{-}pp$ production mechanism
$\Lambda(1405)p \rightarrow K^{-}pp$

p+p, unconventional



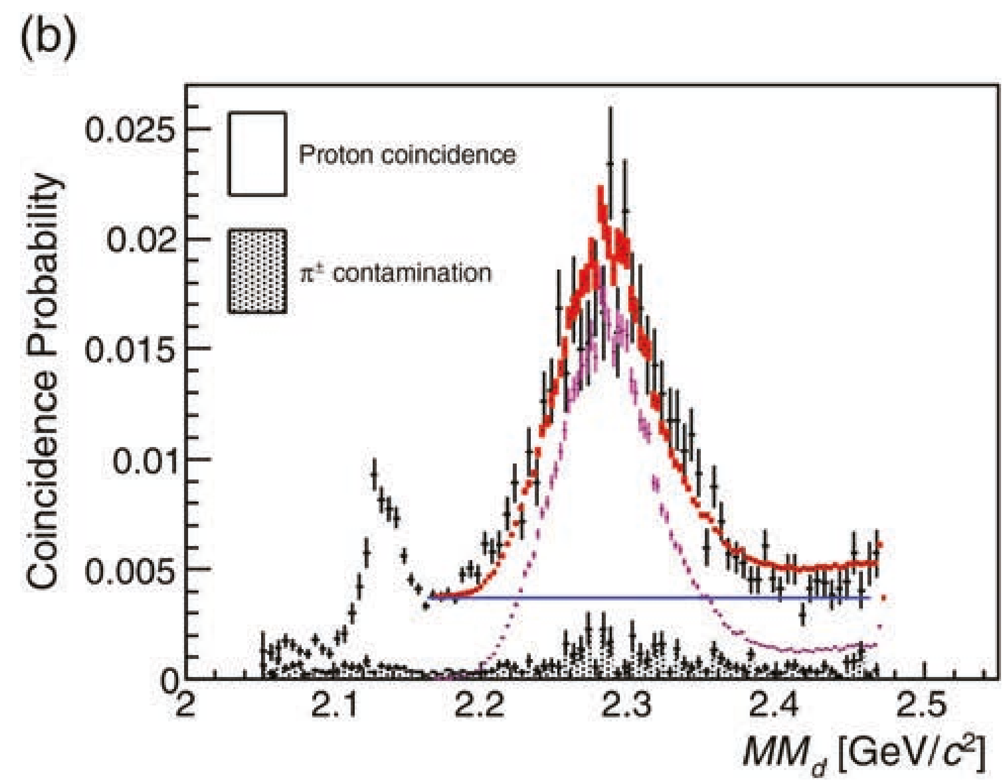
DISTO

T. Yamazaki *et al.*, PRL 104 (2010) 132502

Mass 2.267±3(stat.)±5(syst.) GeV/c^2

width 118±8(stat.)±10(syst.) MeV

(π, K), conventional



E27@J-PARC

Y. Ichikawa *et al.*, PTEP 2015 021D01

Mass 2.27^{+18}_{-17}(stat.)$^{+30}_{-21}$ (syst.) GeV/c^2

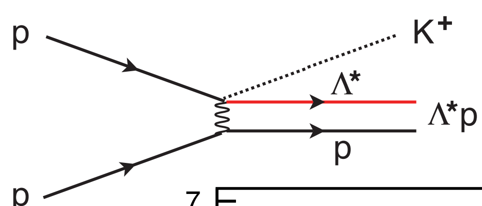
width 162^{+87}_{-45}(stat.)$^{+66}_{-78}$(syst.) MeV

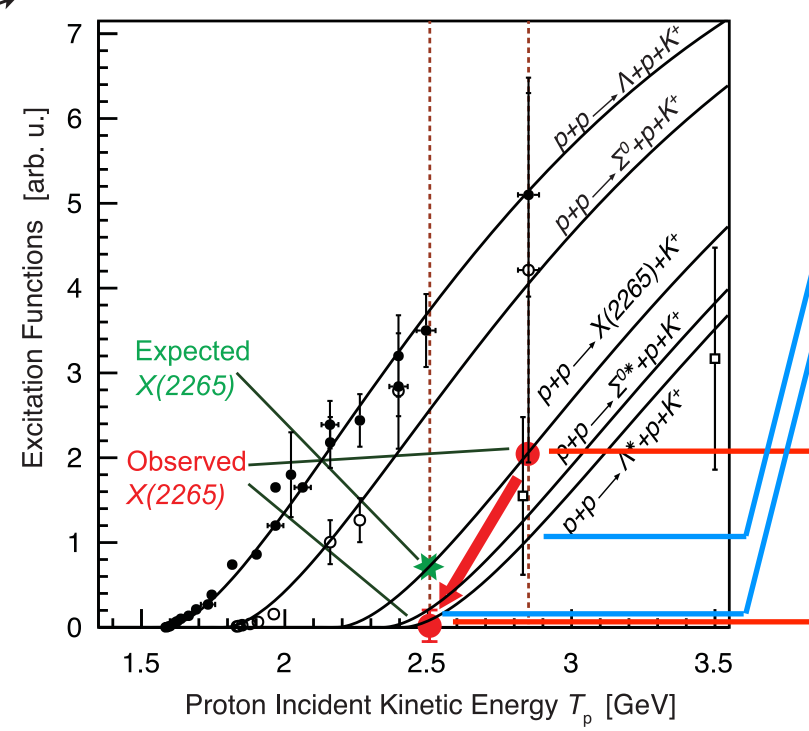
X(2265) energy dependence

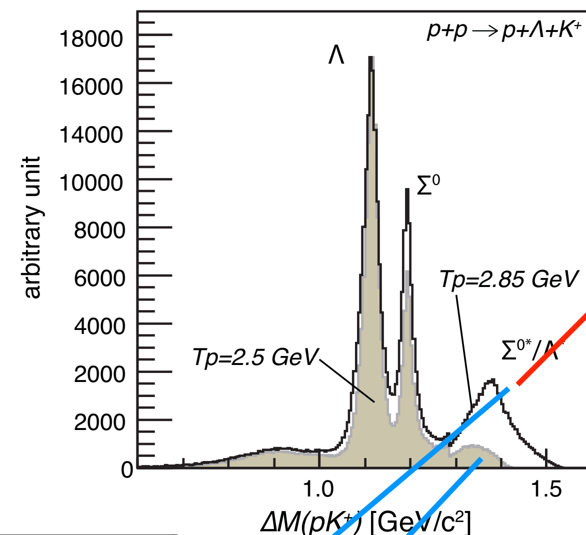
almost no Y* at T_p=2.5 GeV

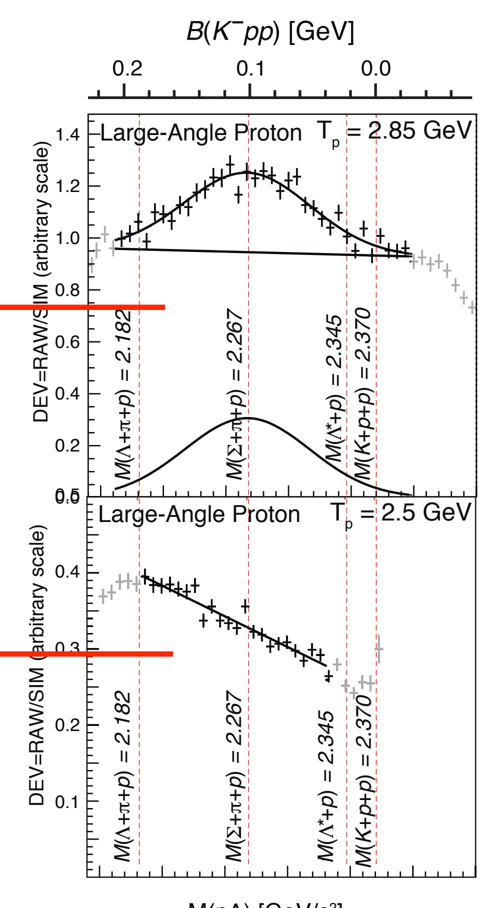
elementary process

$p+p \rightarrow p+\Lambda^{*}+K^{+}$







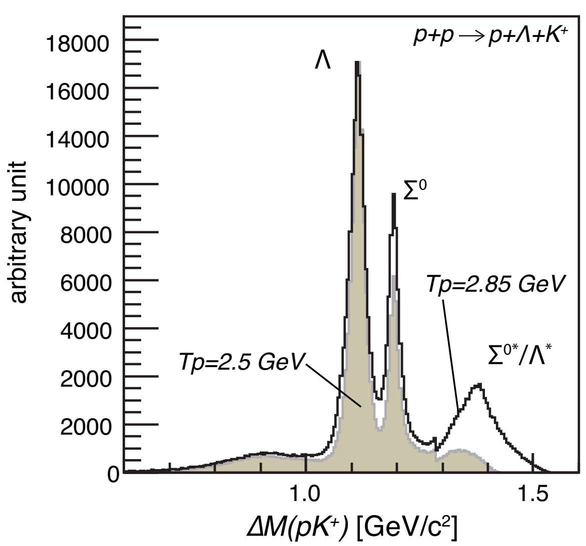


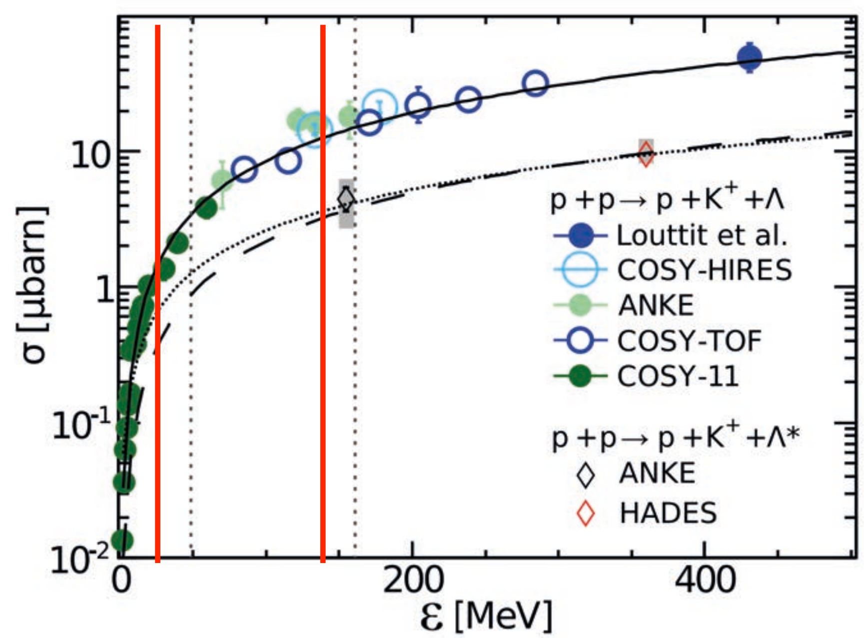
P. Kienle *et al.*, EPJ A48 (2012) 183

Λ^{*}(1405) involved in the X(2265) production mechanism

Comment on Epple/Fabbietti paper on DISTO analysis (arXiv:1504.02060v1)

“The two vertical dashed lines mark the excess energy for the Λ(1405) production for the two data sets, measured by DISTO (48.8 MeV and 161.2 MeV). …. With help of the two curves the ratio of the Λ* production cross section between the two DISTO energies was determined to be $\sigma_{pK + \Lambda(1405)}$ (2.5 GeV)/$\sigma_{pK + \Lambda(1405)}$ (2.85 GeV)=0.23, for the scaled curve and 0.3 for the curve based on the free” Epple and Fabbietti, arXiv:1504.02060v1





$p+p \to p+K^+ + \Lambda^*$ T_p = 2.85 GeV ⇔ ε = ~~139~~ MeV

$p+p \to p+K^+ + \Lambda^*$ T_p = 2.5 GeV ⇔ ε = ~~27~~ MeV

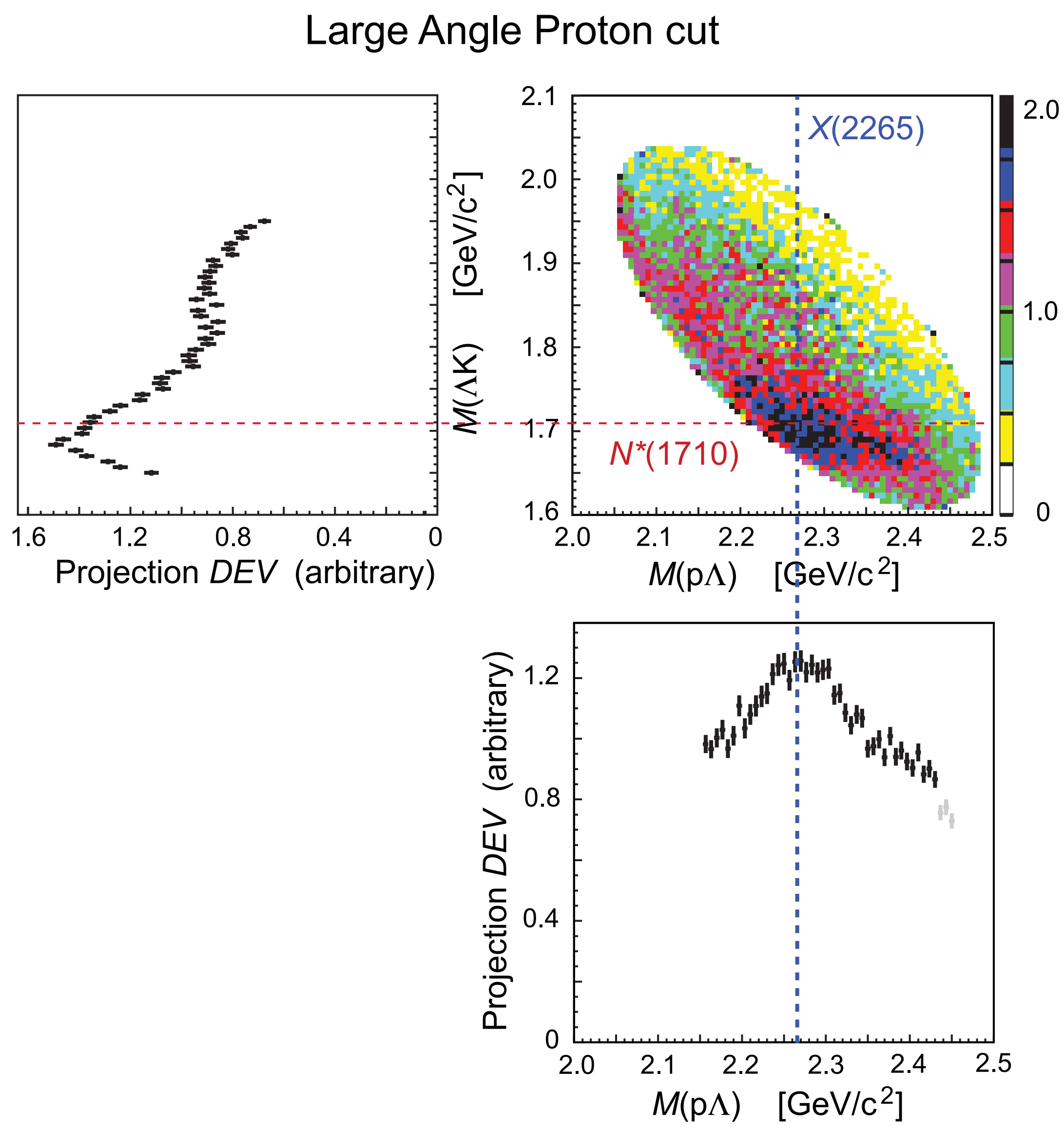
?

$\sigma_{pK + \Lambda(1405)}$ (2.5 GeV)/$\sigma_{pK + \Lambda(1405)}$ (2.85 GeV) ~ 0.1

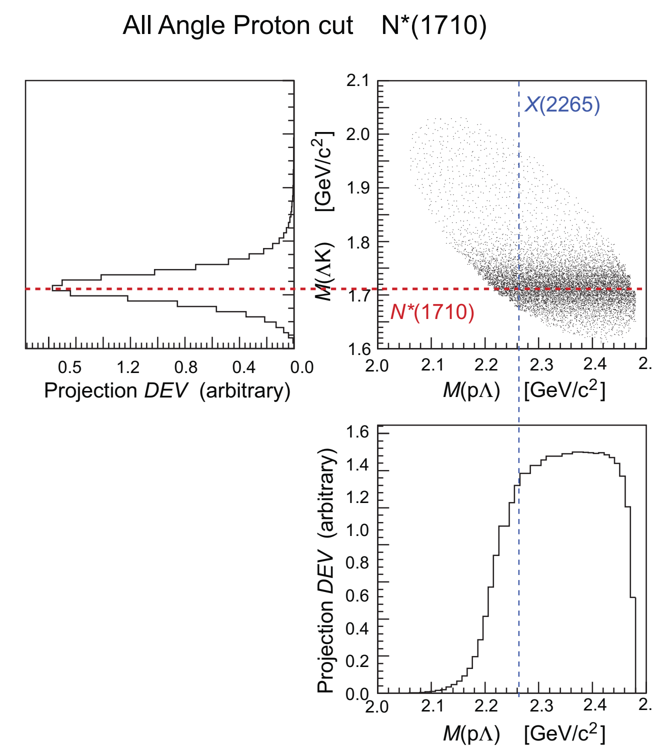
experimentally almost no population

X(2265) in a Dalitz plot

$\rightarrow p+(K^{+}+\Lambda=N^{*})\rightarrow p+K^{+}+\Lambda$



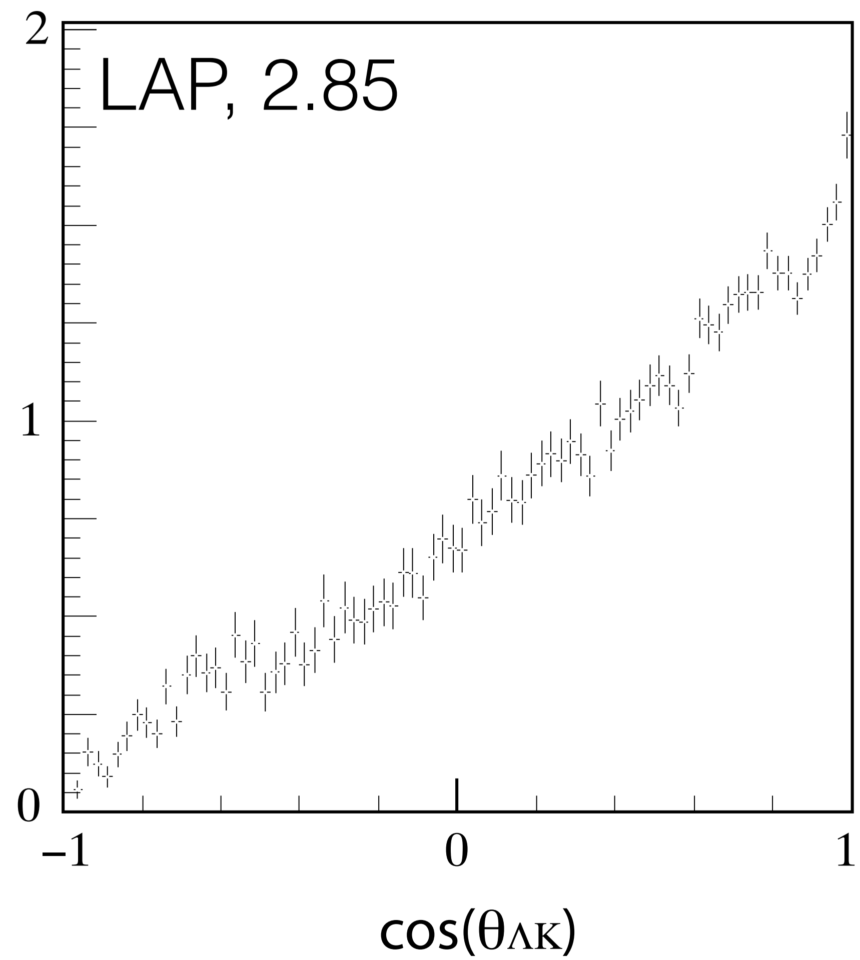
$\rightarrow K^{+}+X\rightarrow K^{+}+p+\Lambda$

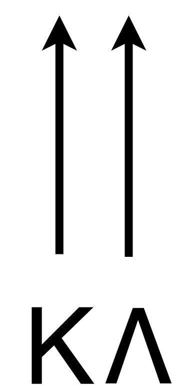


simple MC of N*(1710) and projections

Population of the X(2265) is localised at the crossing point of two resonance band, X(2265) and N*(1710) ⇒ <u>**Double Resonance**</u>

Angular correlation of ΛK^+



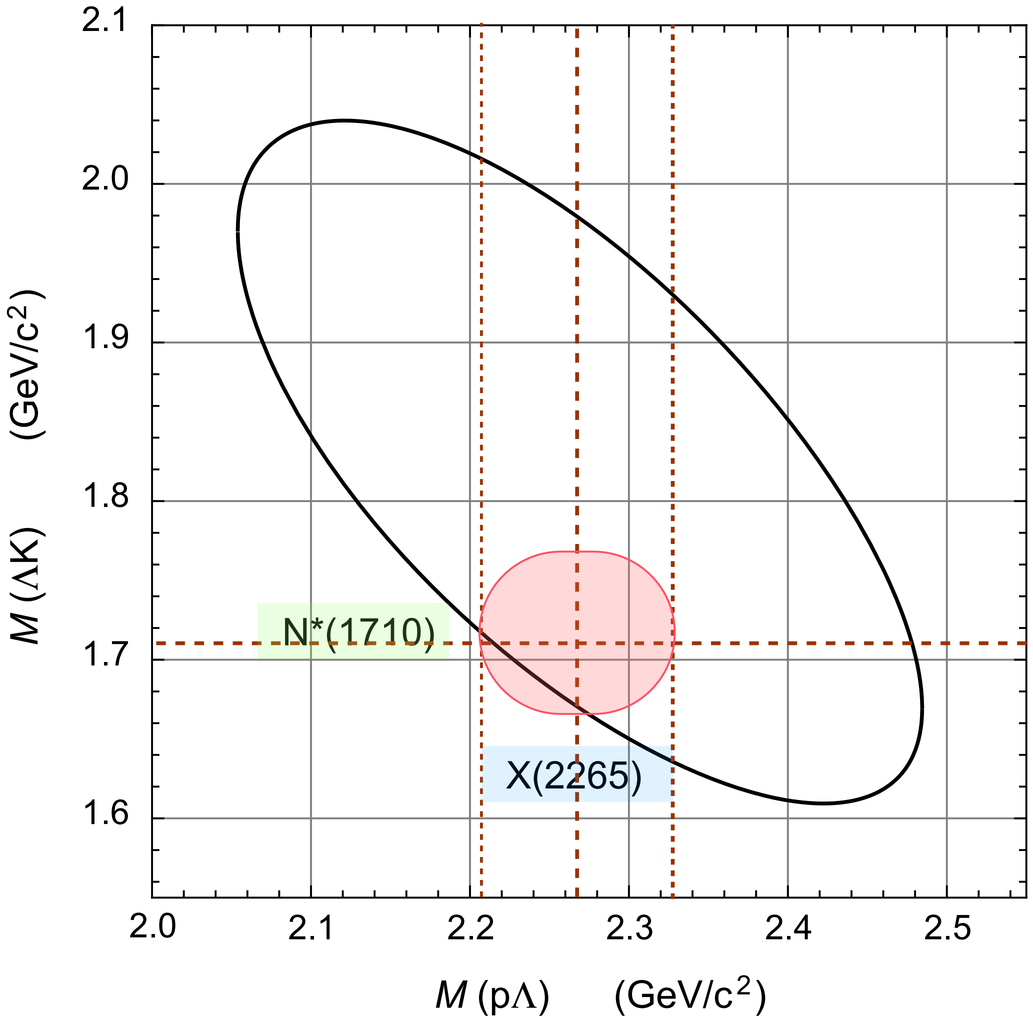


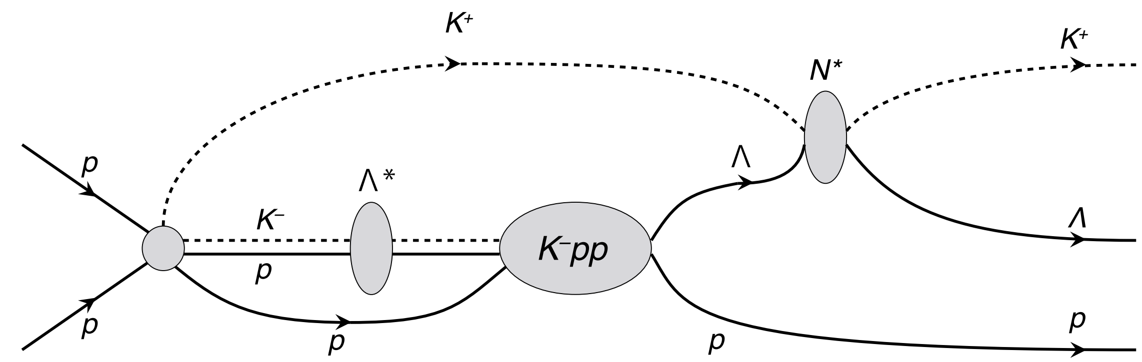
the strong attractive $K^+\Lambda$ angular correlation is related to N^* production

$\cos\vartheta(\Lambda\text{-}K^+)\sim1$ associated with X(2265) production

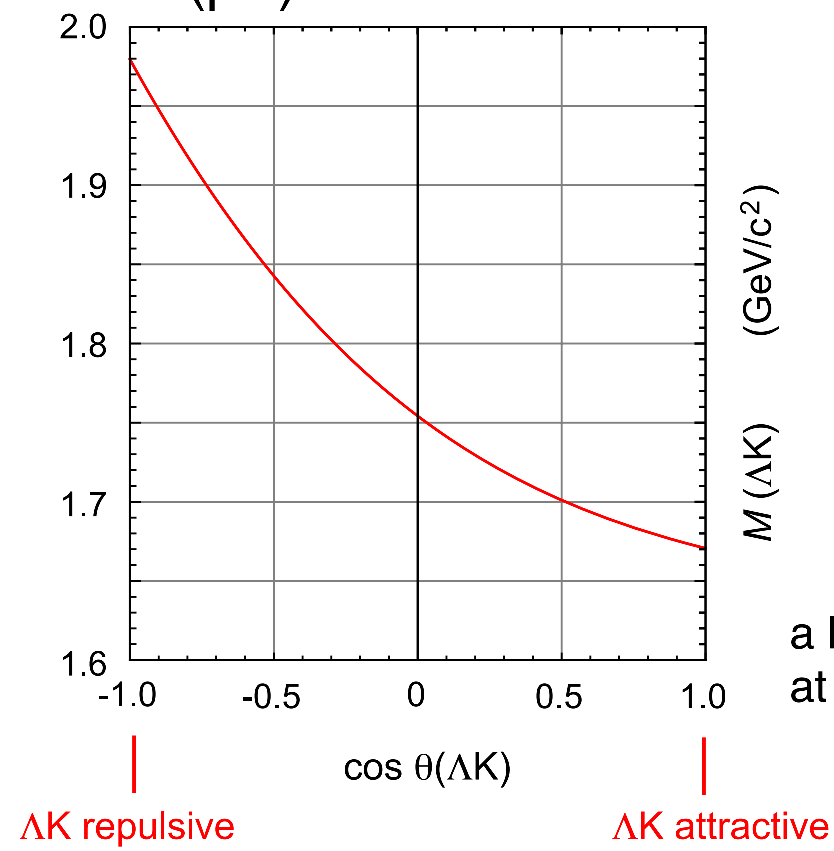
$\Lambda K^+ = N^*$ resonance and FSI

$pp \rightarrow p\Lambda K^+$ @2.85 GeV





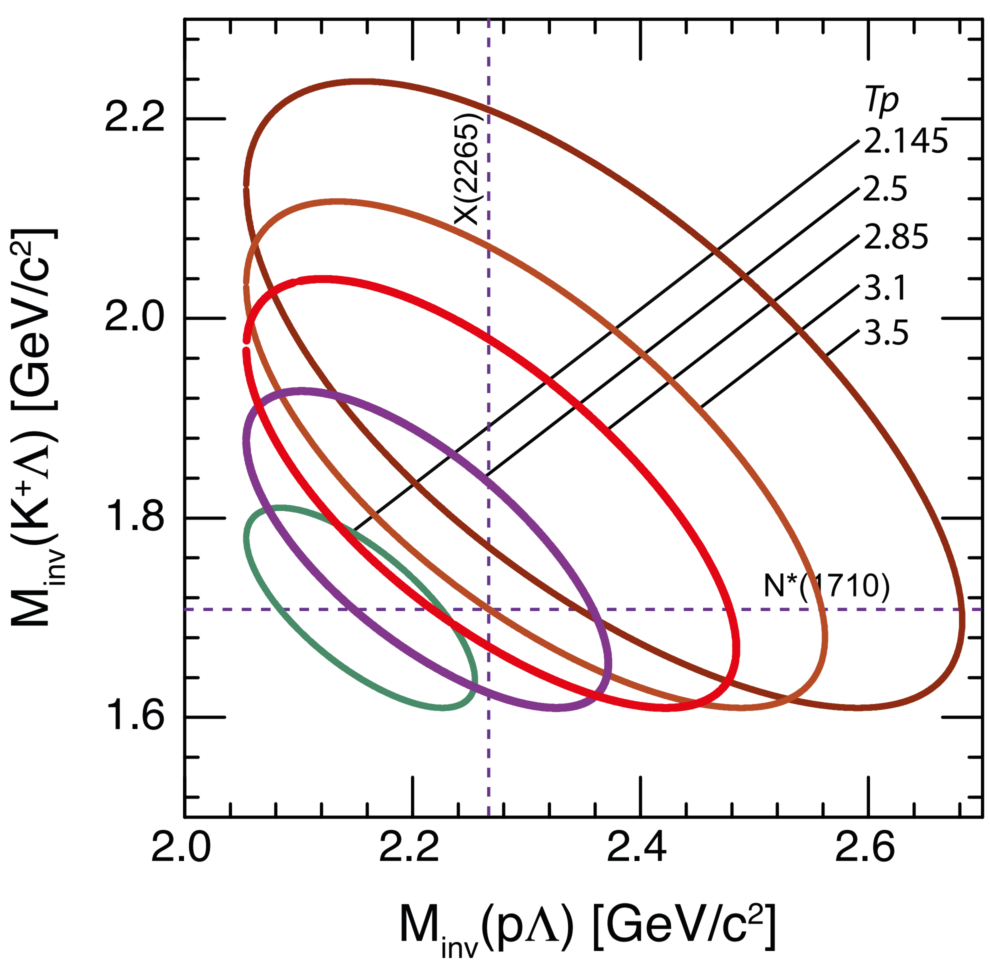
M(pΛ)=2.267 GeV/c²

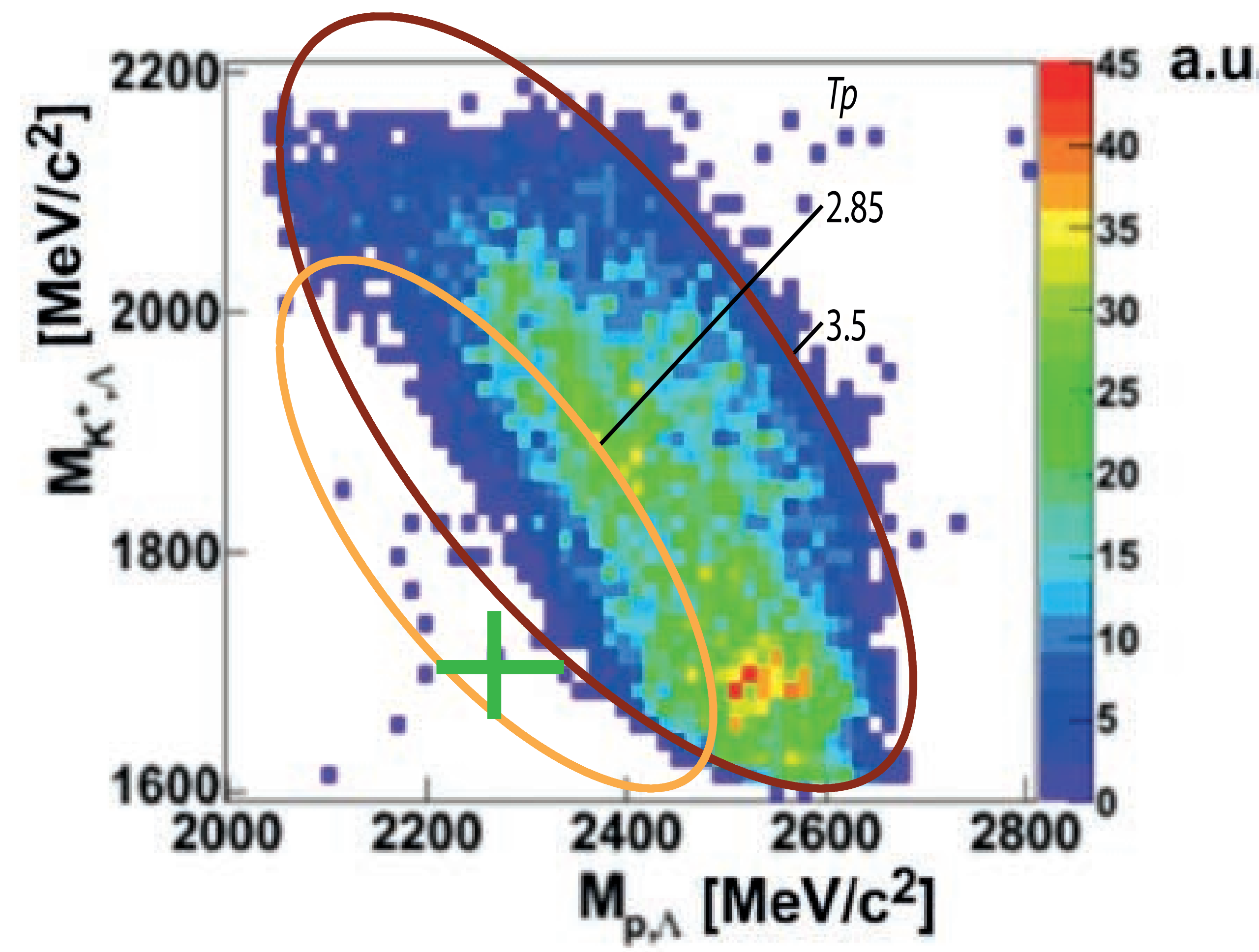


a kinematical relation of cosθ(Λ-K^+) at X_{CM} as a function of $M(\Lambda K^+)$

The resonant structure at ~1.71 GeV, located in the lower-M(ΛK^+) region of the Dalitz plot, ⇔ attractive correlation; cosθ(Λ-K^+) → 1.

Another consequence of the Double Resonance: Comment on the HADES Data at Tp=3.5 GeV



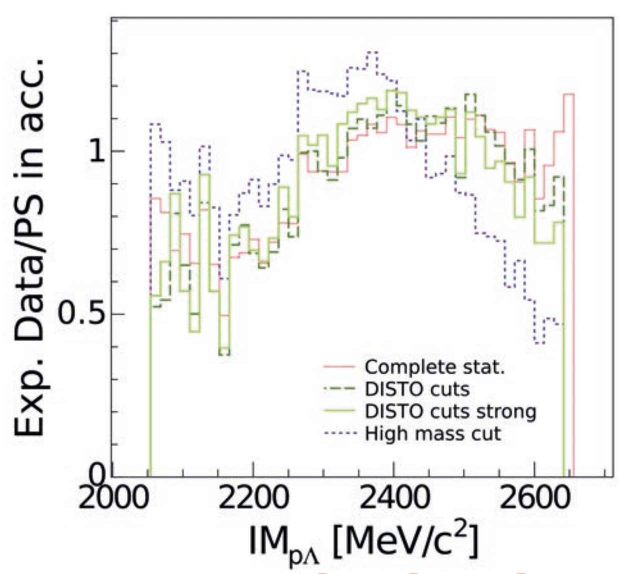


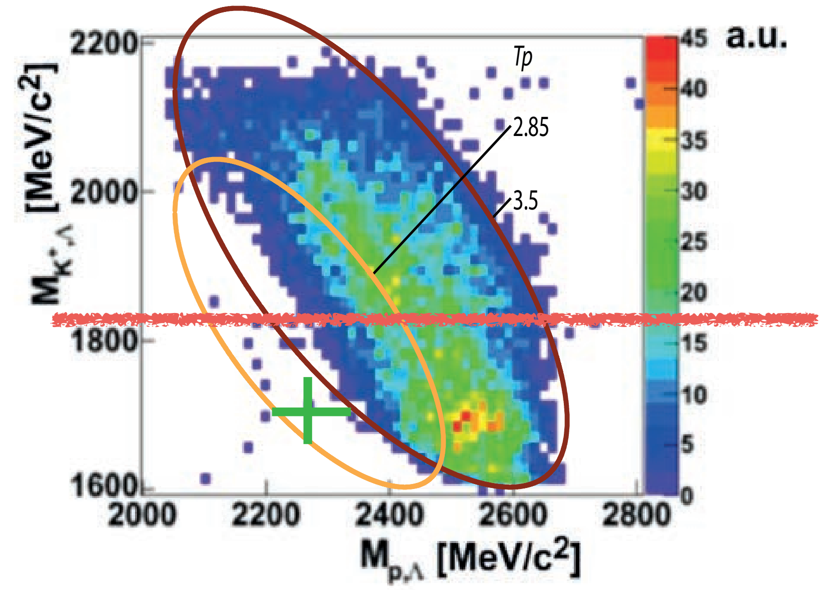
Double resonance feature of the X(2265) population set an upper limit on Tp to be ~ 3.1 GeV. At Tp=3.5 GeV the X(2265) population zone is outside the kinematically allowed area.

Comment on Epple/Fabbietti paper on DISTO analysis (arXiv:1504.02060v1)

Epple and Fabbietti, arXiv:1504.02060v1

An remarkable result (violet dashed in Fig. 2) is obtained if one only selects events where **$M_{K^+\Lambda}$ >1810 MeV/c^2.**

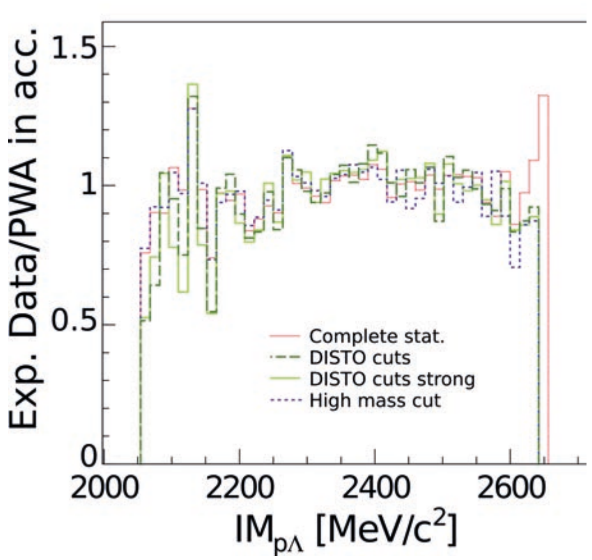




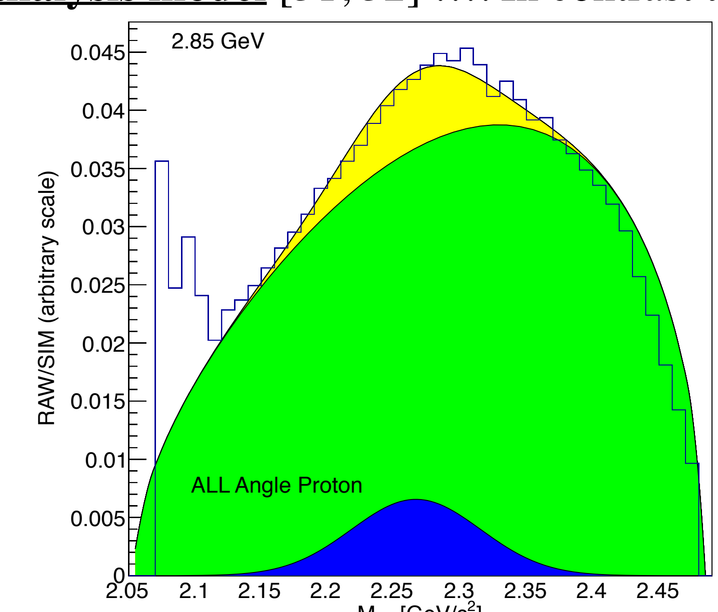
cut on a correlated distribution, especially such an drastic one, influences in its projection as a trivial consequence.

Epple and Fabbietti, arXiv:1504.02060v1

… deviation spectra that we have obtained **by dividing the measured spectra by a partial wave analysis model** [31, 32] …. In contrast to the Figs. 2 and 3, **the deviation spectra are in this case rather flat** around one and …



Our DEV plot is to see a deviation from PS distribution. If you change the denominator of divisional operation, by including something else, the results changes as a trivial consequence.



A consistent picture on production mechanisms that explains these experimental observations would be ..

- X(2265) is the $\bar{K}pp$ state
    - which is populated by the “hard collision/formation” mechanism
        - Λ(1405)-p produced in short range has a high sticking probability even at *q* as high as 1.6 GeV/c, provided the object is high density object
        - Otherwise $\bar{K}pp$ is not populated in the *p+p* reaction
- $\bar{K}pp$ population in the *pp* reaction by the hard collision/formation mechanism
    - requires minimum T_p~2.7 GeV. At T_p=2.5 GeV the Λ(1405) is not populated and thus no population of X(2265)
    - requires maximum T_p~3.1 GeV.
        - because of the Double resonance feature of its population
            - K^+-Λ emission into the same direction, indicating attractive FSI and/or N* resonance
        - X(2265) cannot be populated at T_p=3.5 GeV (HADES) because it is outside the kinematically allowed zone
    - making *p+p* reaction T_p=2.85 GeV very unique
- X(2265) population in d(π+,K+) reaction at J-PARC E27
    - the small sticking probability around 1% as observed in the J-PARC E27 is consistent with the expectation in Ref. *Yamazaki and Akaishi, PRC76 (2007) 045201*

Summary and Outlook

- Various data are by now available related the DISTO X(2265)
  - DISTO X(2265) localised at $M_{p\Lambda}$~2.265 GeV/c^2, $M_{K\Lambda}$~1.71 GeV/c^2 in the Dalitz plot
  - X(2265) production pronounced at T_p=2.85 GeV cannot be populated at higher T_p, as seen by HADES
  - suggesting the validity of the “hard collision/formation mechanism”
- Consistent with the picture, $K^{-}pp$ produced with Λ^* as a doorway, PRC76 (2007) 045201, both in $p+p$ and $d(\pi^+,K^+)$ reactions
- Full efficiency/acceptance correction coming