Challenges to puzzles in hadron production

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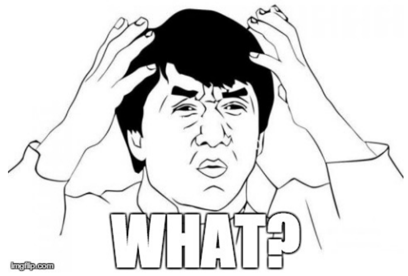
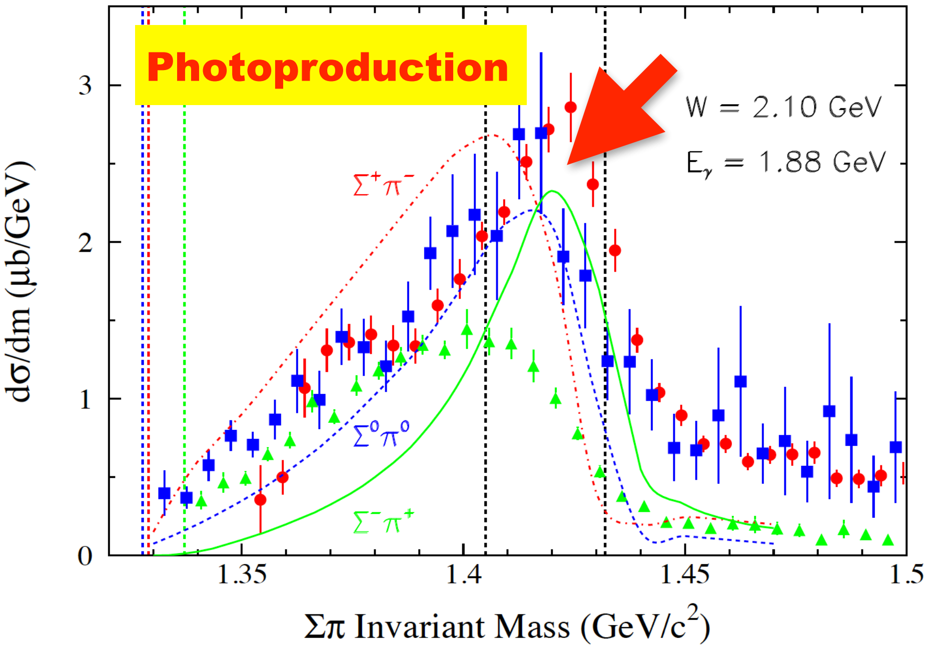
Puzzles in hadron productions

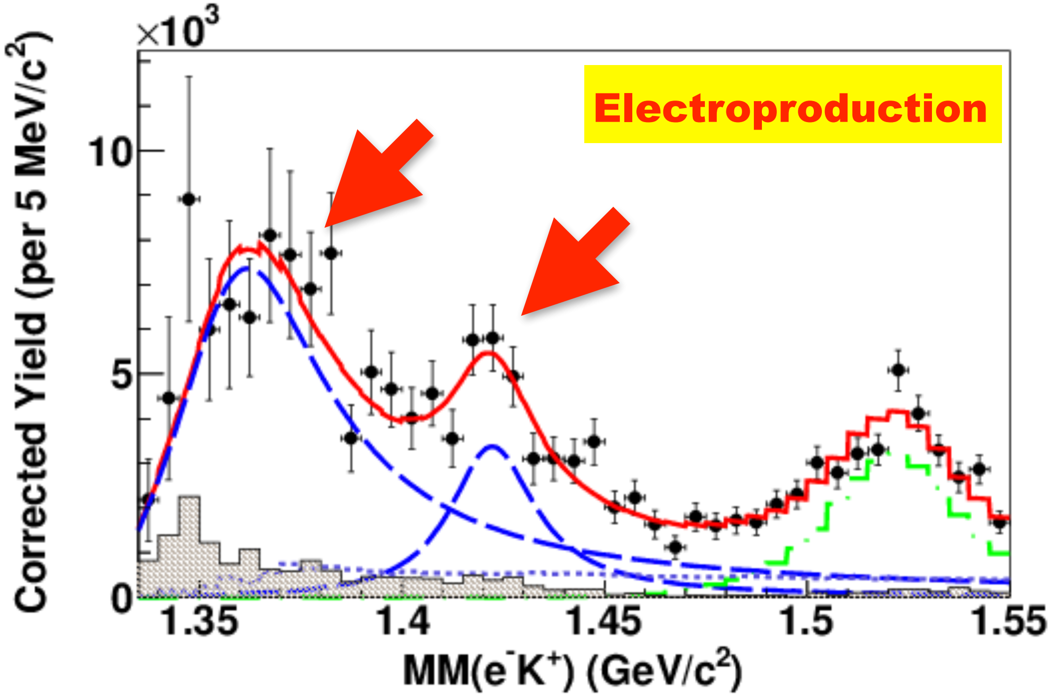
1. Internal structure of $\Lambda(1405)$
2. Bump (or dip) shown in $\sigma(\gamma p \rightarrow \phi p)$
3. Systematic studies in terms of flavors
4. Strong and EM Form factors
5. etc…

Motivation



Obvious difference between Λ(1405) invariant masses from photo- and electro-production in experiments: **Why??**





K. Moriya et al. [CLAS], PRC87, no. 3, 035206 (2013)

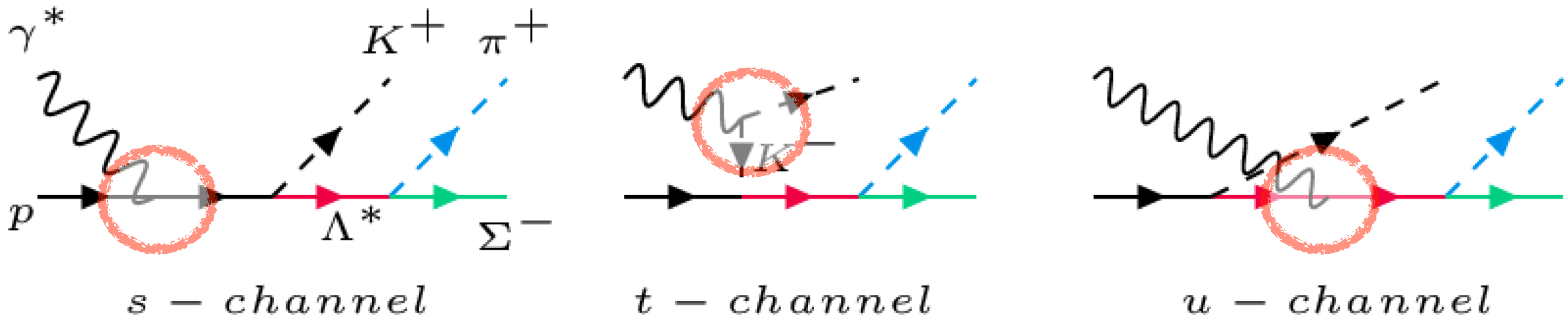
H. Y. Lu et al. [CLAS], PRC88, 045202 (2013)

Single peak vs. Double peak

Theoretical framework

Hadron EM form factors for electroproduction

Where hadron EM form factors appear?



Proton, Kaon, and Λ(1405), three EM form factors necessary

Theoretical framework

EMFF for Λ(1405): **Less known so far. So How to model it?**

How can we construct Λ(1405) EMFF???

1) It's neutral so possibly similar structure to neutron EMFF

2) EM charge rms radii relates to EMFF

cf) Galster parameterization

$$G_E^n(Q^2) \simeq -\frac{a\mu_n\tau}{1+b\tau}G_D(Q^2)$$

$$\langle r^2\rangle_E^{H,L} = -6\frac{dG_E^{H,L}(Q^2)}{dQ^2}\Big|_{Q^2=0}, \quad \langle r^2\rangle_M^{H,L} = -\frac{6}{\mu_{H,L}}\frac{dG_M^{H,L}(Q^2)}{dQ^2}\Big|_{Q^2=0},$$

$$G_E^{H,L}(Q^2) = -\frac{\langle r^2\rangle_E^{H,L}}{6}Q^2F_K(Q^2)\left[\frac{1}{1+Q^2\langle r^2\rangle_M^{H,L}/12}\right]^2, \quad G_M^{H,L}(Q^2) \approx \mu_{H,L}\left[\frac{1}{1+Q^2\langle r^2\rangle_M^{H,L}/12}\right]^2$$

M.M.Kaskulov, P.Grabmayr, EPJA 19, 157 (2004).

2) EM information of Λ(1405) from ChUM: EM charge rms radii

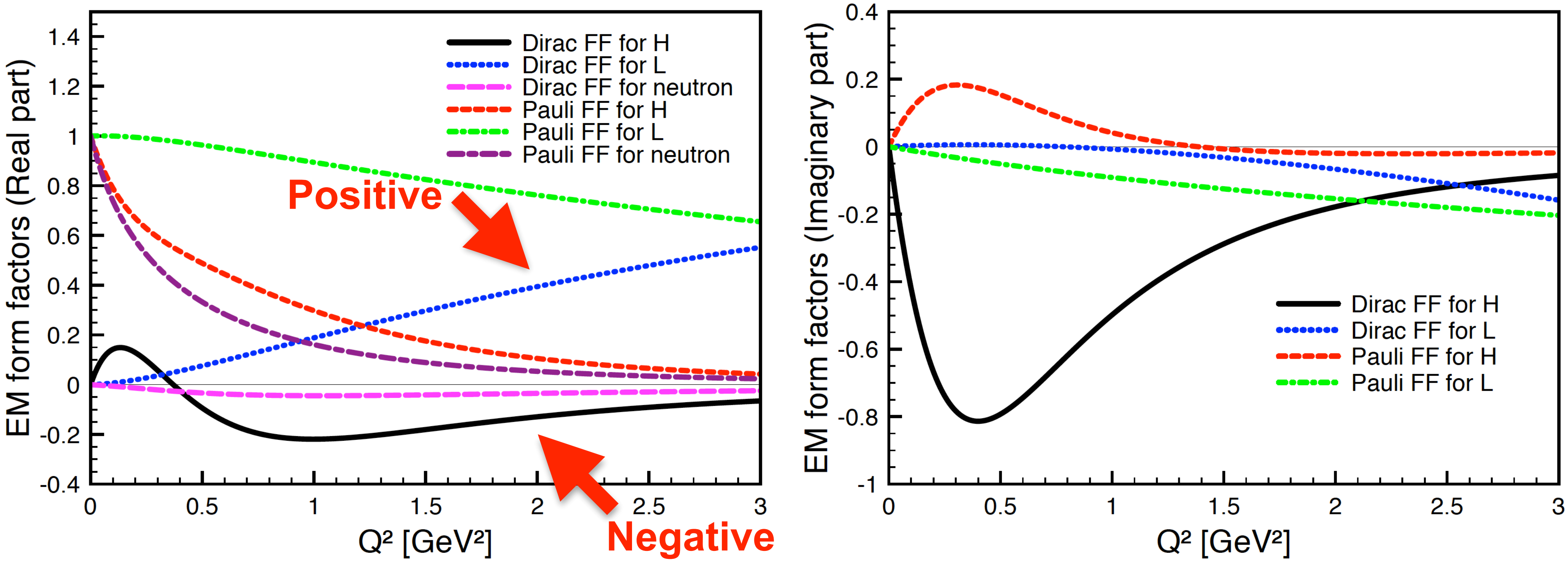
Neutron EMFF + Charge rms radii from ChUM ≈ Λ(1405) EMFF

Theoretical framework

EMFF for Λ(1405): **Less known so far. So How to model it?**

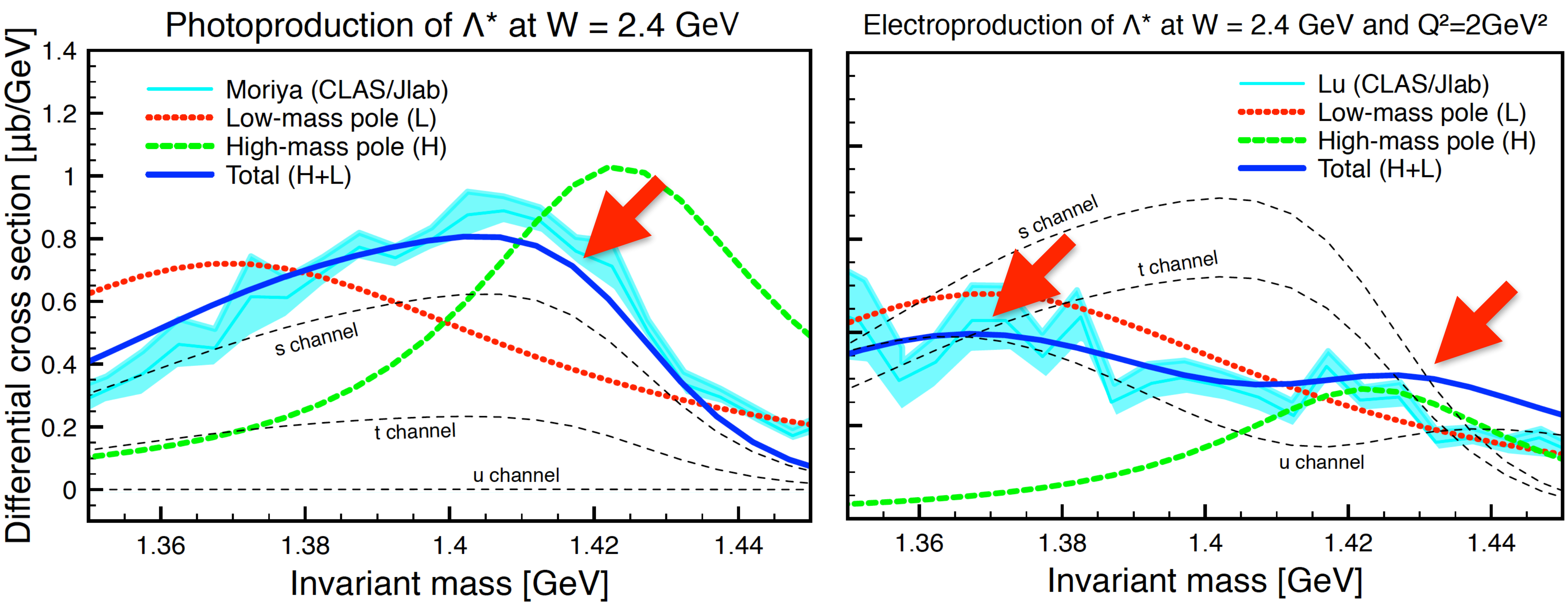
T. Sekihara, T. Hyodo and D. Jido, Phys. Lett. B 669, 133 (2008).

$\langle r^2\rangle_E^H$	$\langle r^2\rangle_M^H$	$\langle r^2\rangle_E^L$	$\langle r^2\rangle_M^L$	$\langle r^2\rangle_E^n$
$-3.365+7.783i$	$6.859-10.455i$	$0.462-0.051i$	$-0.334+0.539i$	-2.877 ± 0.077



Theoretical framework

Invariant mass plots: Full calculations



Destructive interference for photoproduction ⇒ Single pole

vs.

Constructive interference for electroproduction ⇒ Double pole

Suggests for confirming Λ(1405) structure

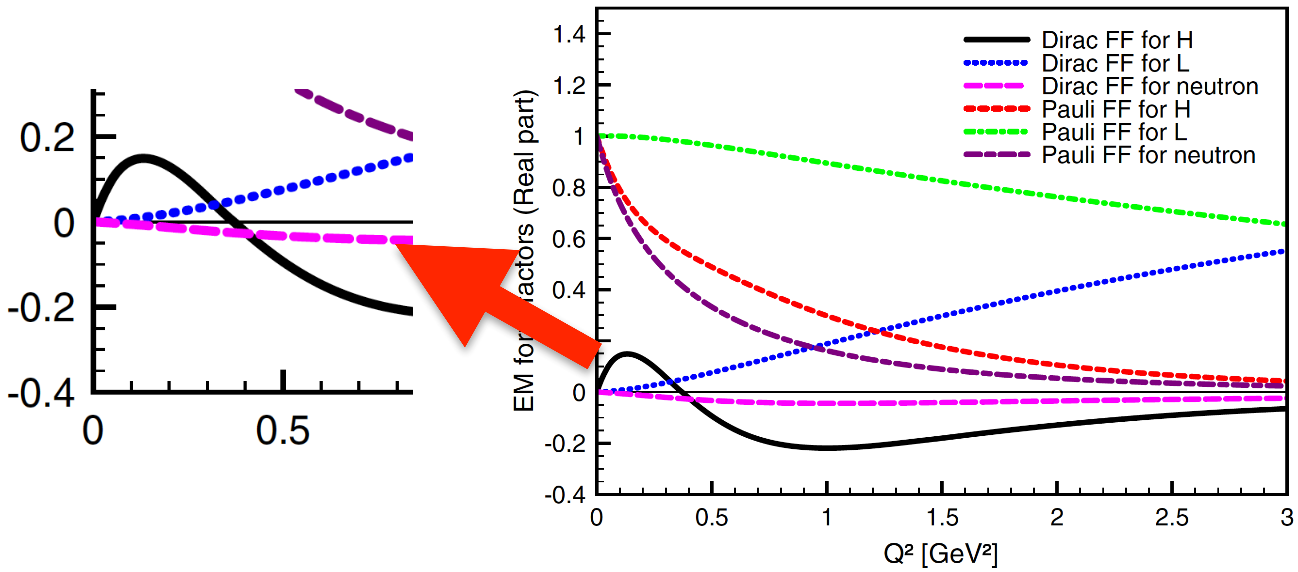
Possible suggests for experiment and lattice QCD

1. Measurements for Λ(1405) Dirac EMFF (How?)

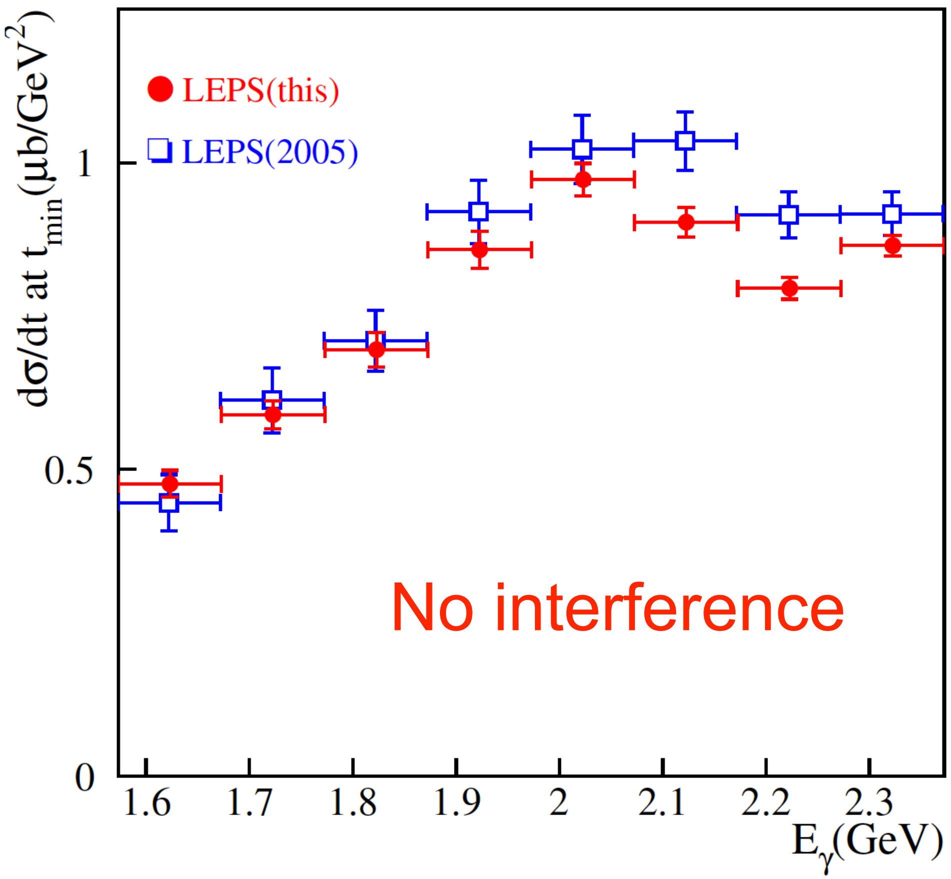
2.Invariant mass of Λ(1405) at small Q^2 region in backward scattering

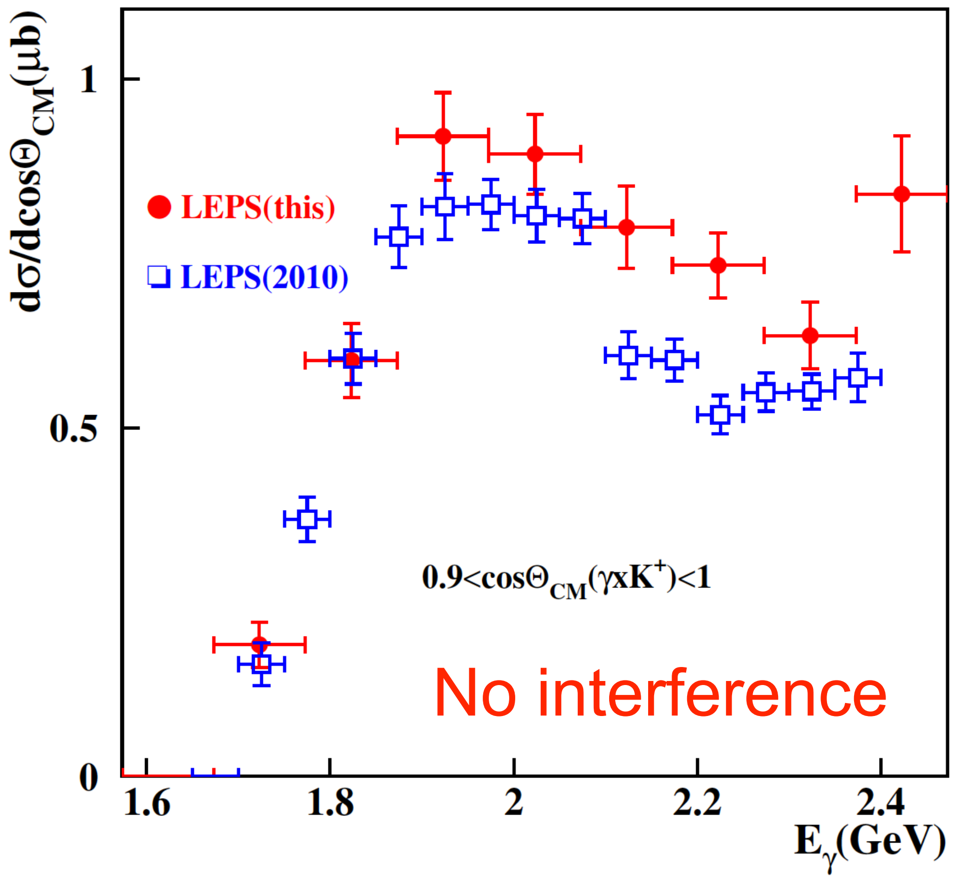
What can we expect?

Transition from
single (destructive)
to
double (constructive)
peak



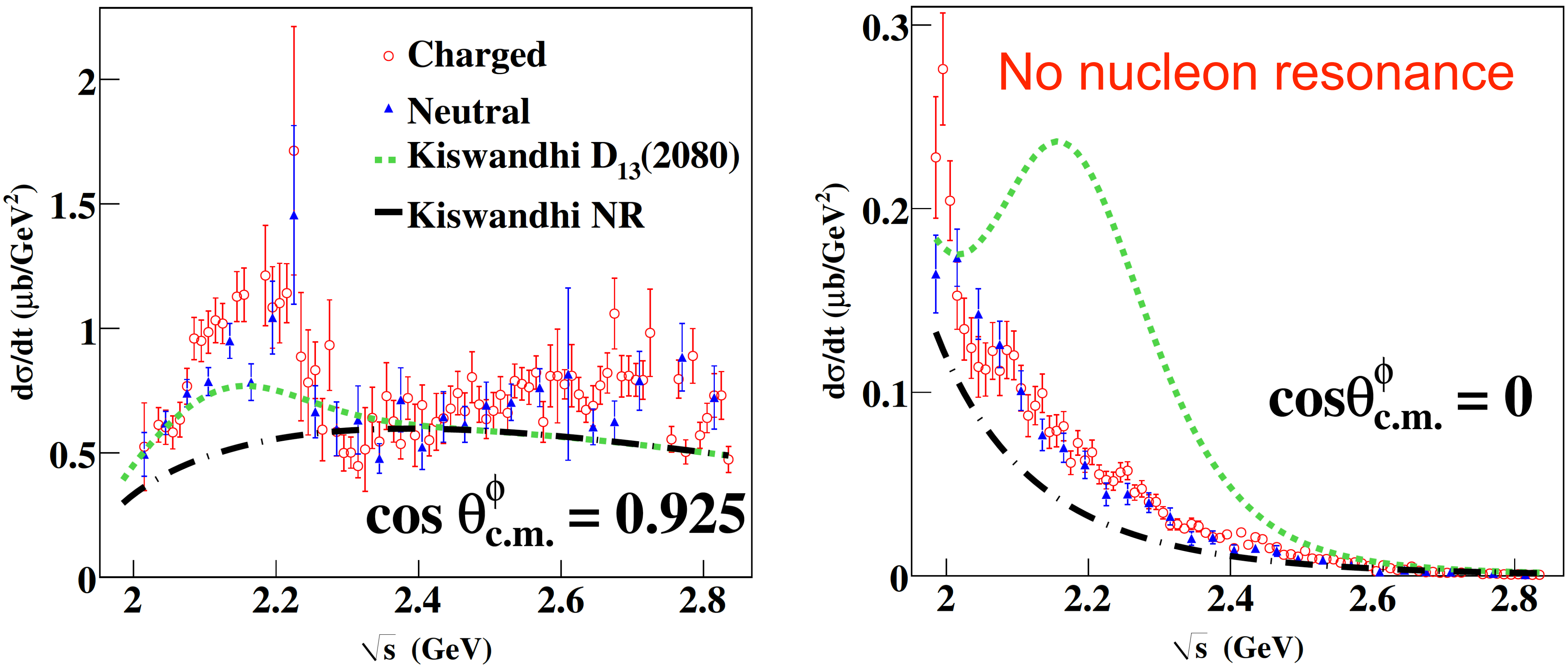
Dip shown in σ(γp→φp)





S.Y.Ryu et al. [LEPS Collaboration], PRL116, 232001 (2016)

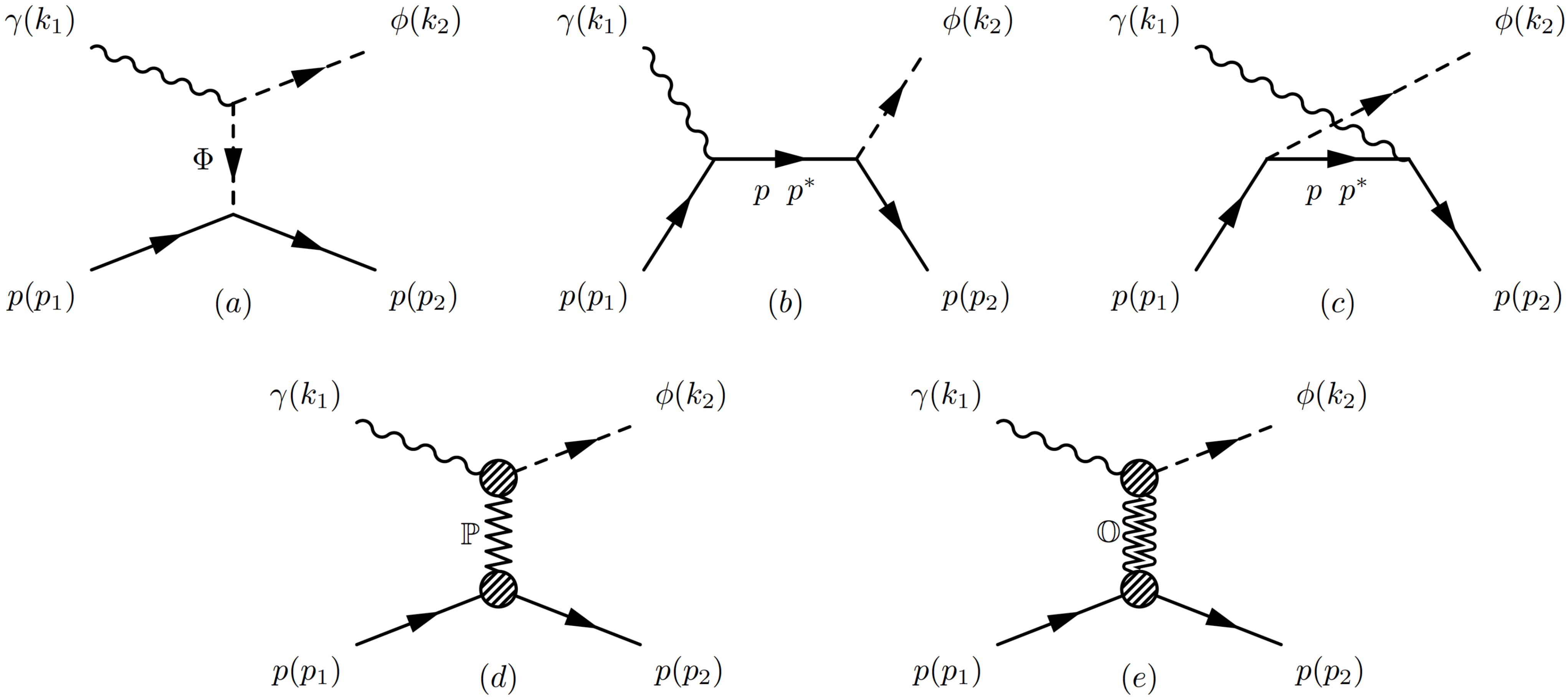
Dip shown in σ(γp→φp)



B.Dey, arXiv:1403.3730 [hep-ex].

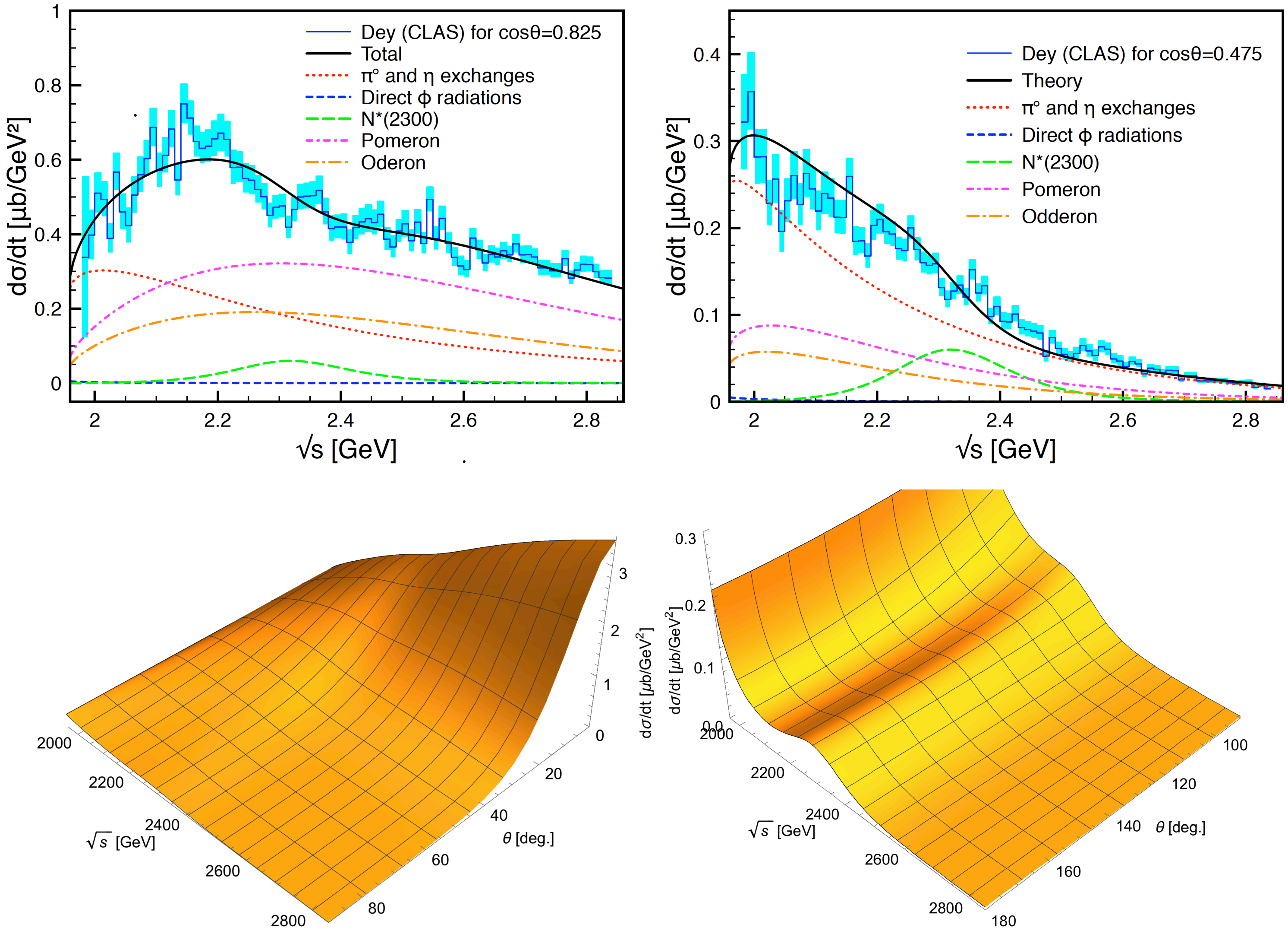
A.Kiswandhi and S.N.Yang, PRC86, 015203 (2012).

Dip shown in σ(γp→φp)



Gluonic contributions: Pomeron and Odderon

Dip shown in σ(γp→φp)



Complicated interference between Pomeron, Odderon, and N*

Thank you very much for your attention!!

We appreciate the supports from APCTP