

Search for structures near $J/\psi J/\psi$ & $\psi(2S) J/\psi$ mass threshold

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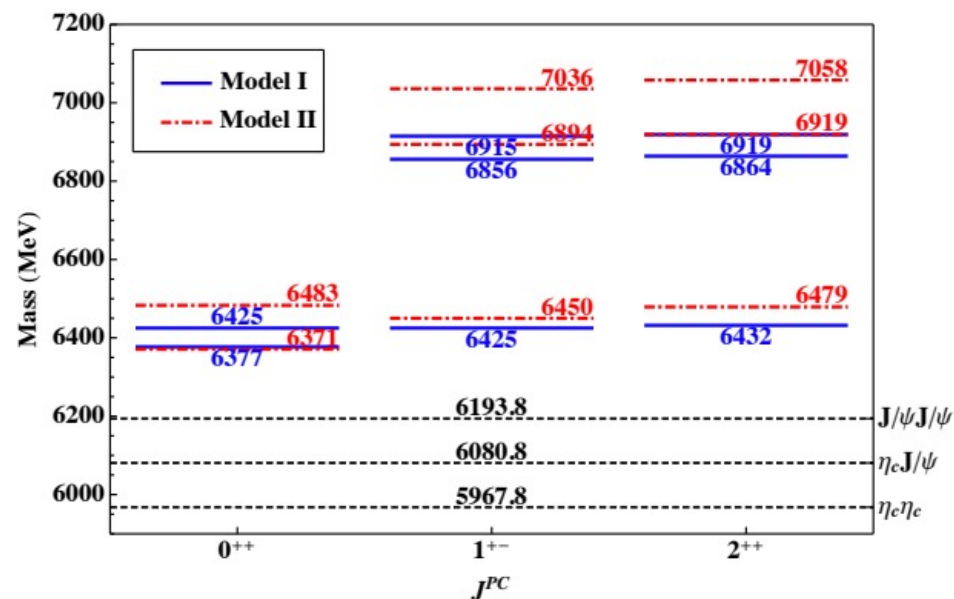
Theoretical studies: from past to today

Z. Phys. C **7** (1981) 317

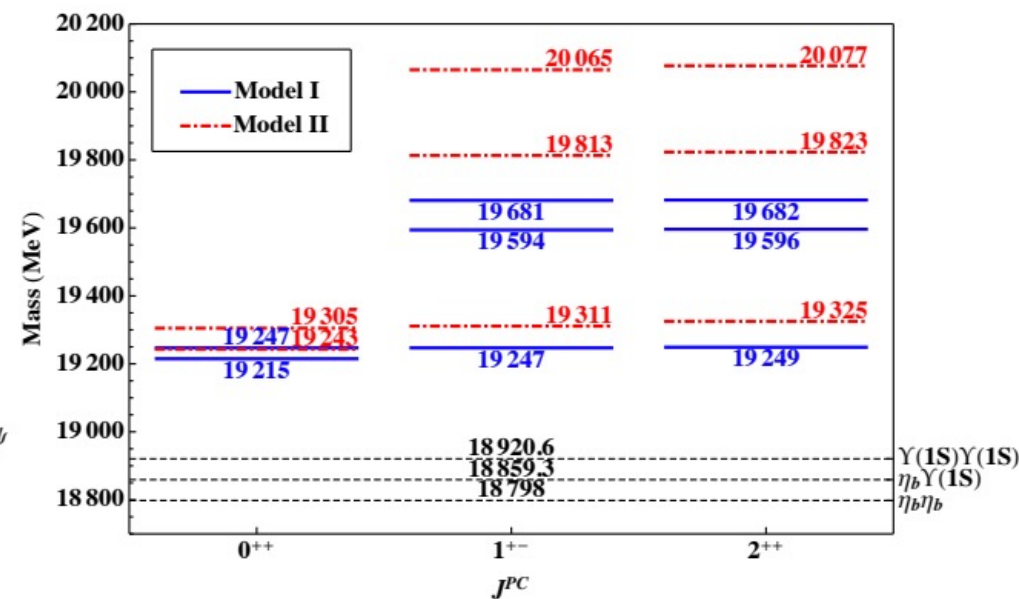
L	S	J^{PC}	Mass (GeV)
1	0	1^{--}	6.55
	1	$0^{++}, 1^{++}, 2^{++}$	
	2	$1^{--}, 2^{--}, 3^{--}$	
2	0	2^{++}	6.78
	1	$1^{++}, 2^{++}, 3^{++}$	
	2	$0^{++}, 1^{++}, 2^{++}, 3^{++}, 4^{++}$	
3	0	3^{--}	6.98
	1	$2^{++}, 3^{++}, 4^{++}$	
	2	$1^{--}, 2^{--}, 3^{--}, 4^{--}, 5^{--}$	

L	S	J^{PC}	Mass (GeV)
1	0	1^{--}	6.82
2	0	2^{++}	7.15
3	0	3^{--}	7.41

Width: tens of MeV



(a) $cc\bar{c}\bar{c}$

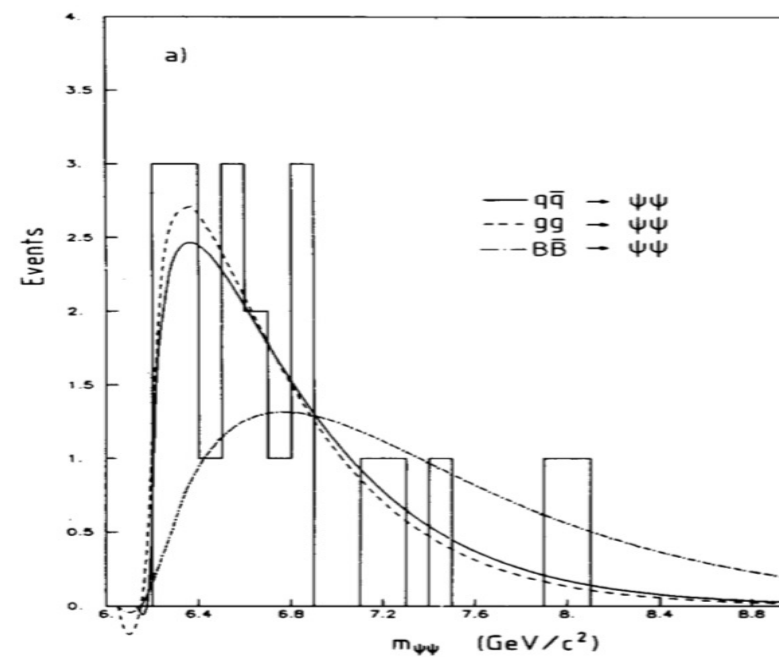
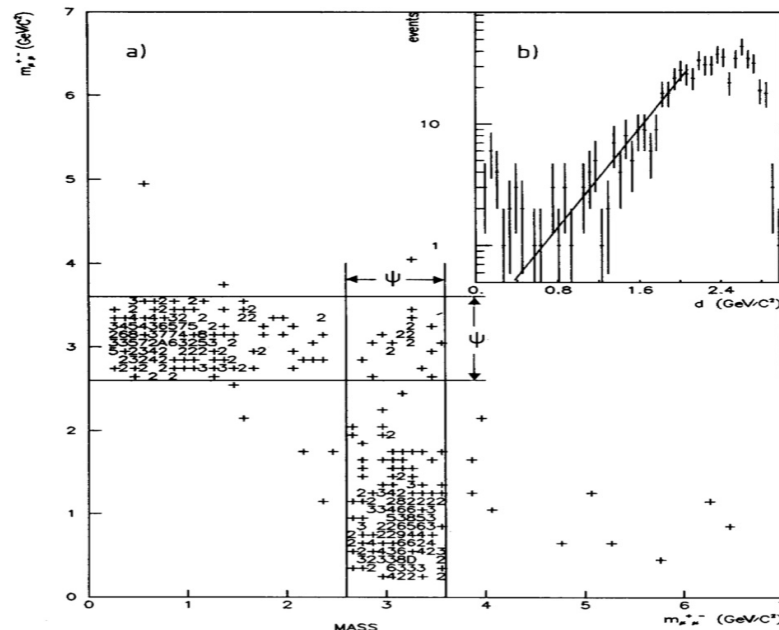


(b) $bb\bar{b}\bar{b}$

PRD 100.096013

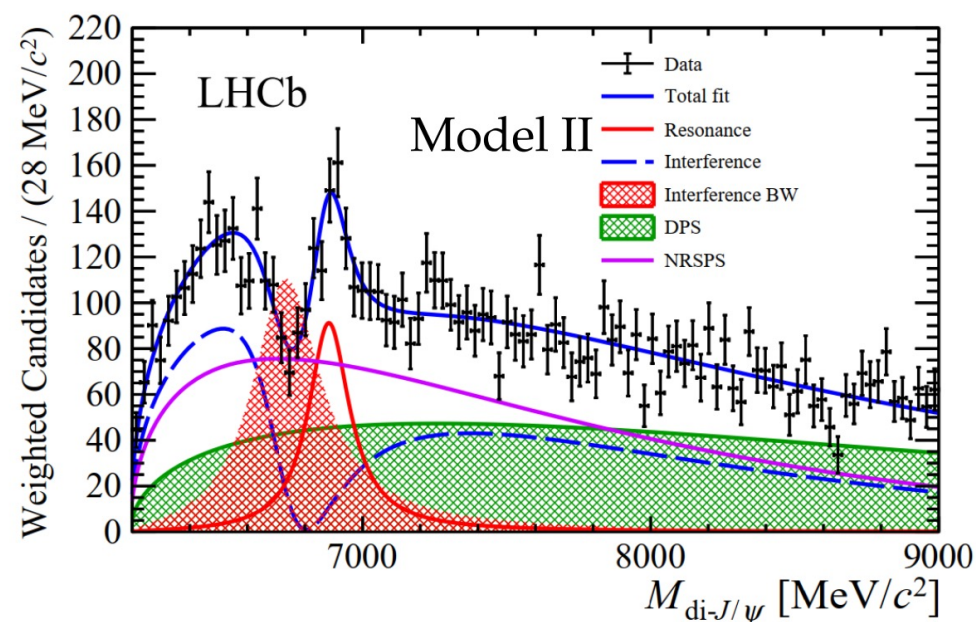
- Many studies on $(c\bar{c}c\bar{c})$, $(b\bar{b}b\bar{b})$, & $(b\bar{b}c\bar{c})$, controversial on the existence of bound states
- Relative consistent on the existence of resonance states.

Experimental studies: from past to today



[PLB 158, no. 1, 85-91](#)

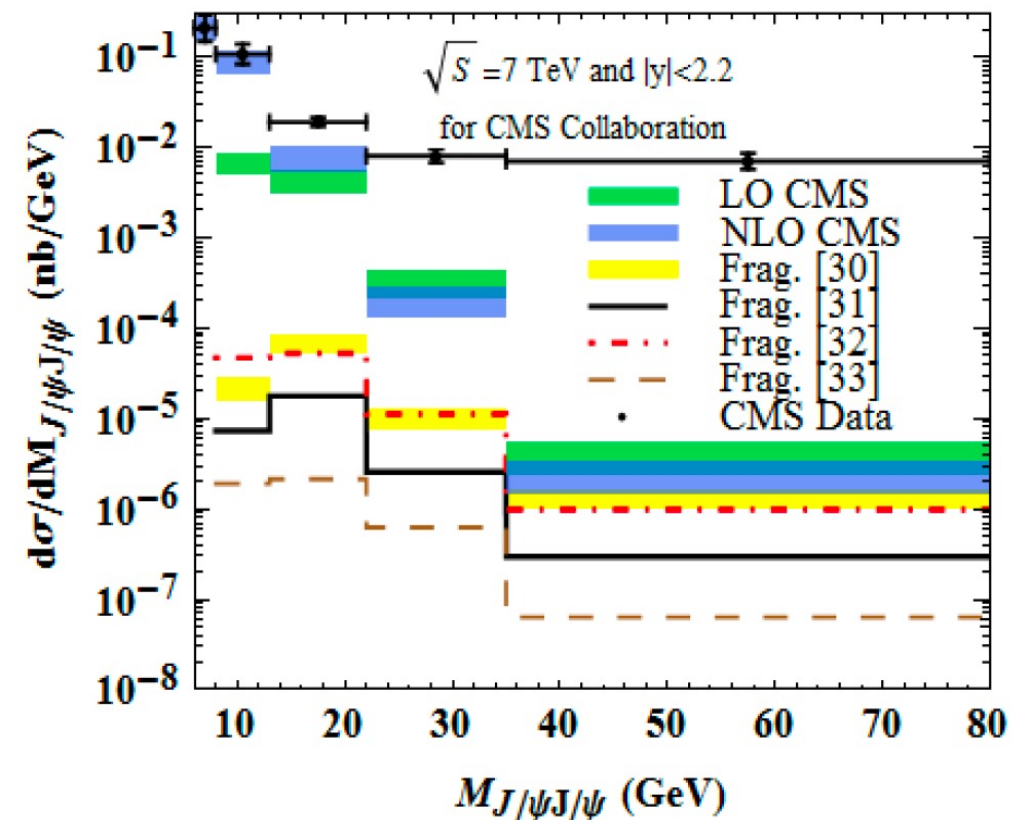
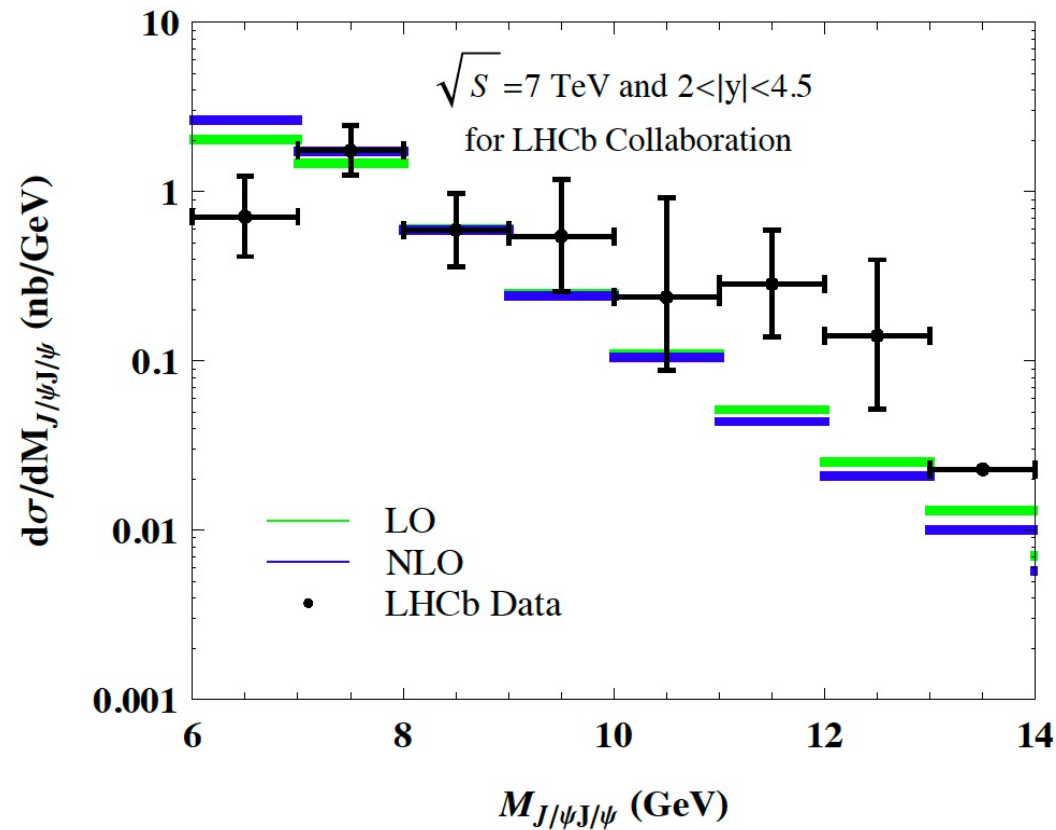
Something is going on



[arXiv:2002.06393](#)

- LHCb [claimed](#) a structure as X(6900)
- X(6900) may decay to $J/\psi J/\psi$ or $J/\psi\psi(2S)$
- Confirm using CMS Run II data in $J/\psi J/\psi$ and $J/\psi\psi(2S)$ channel?

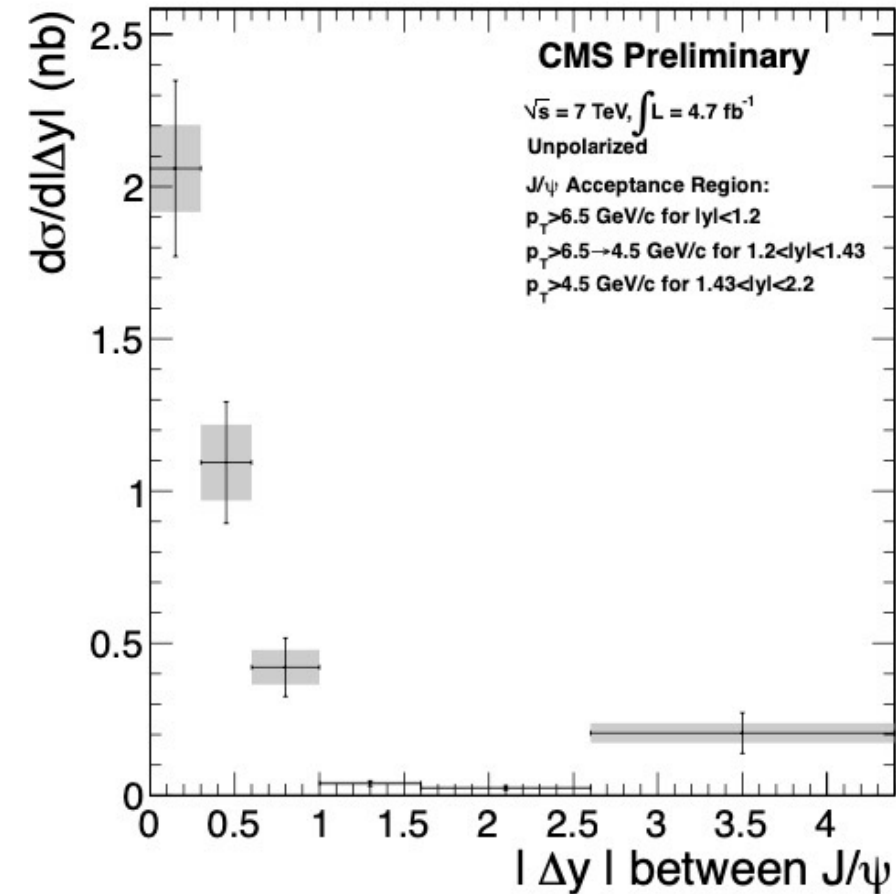
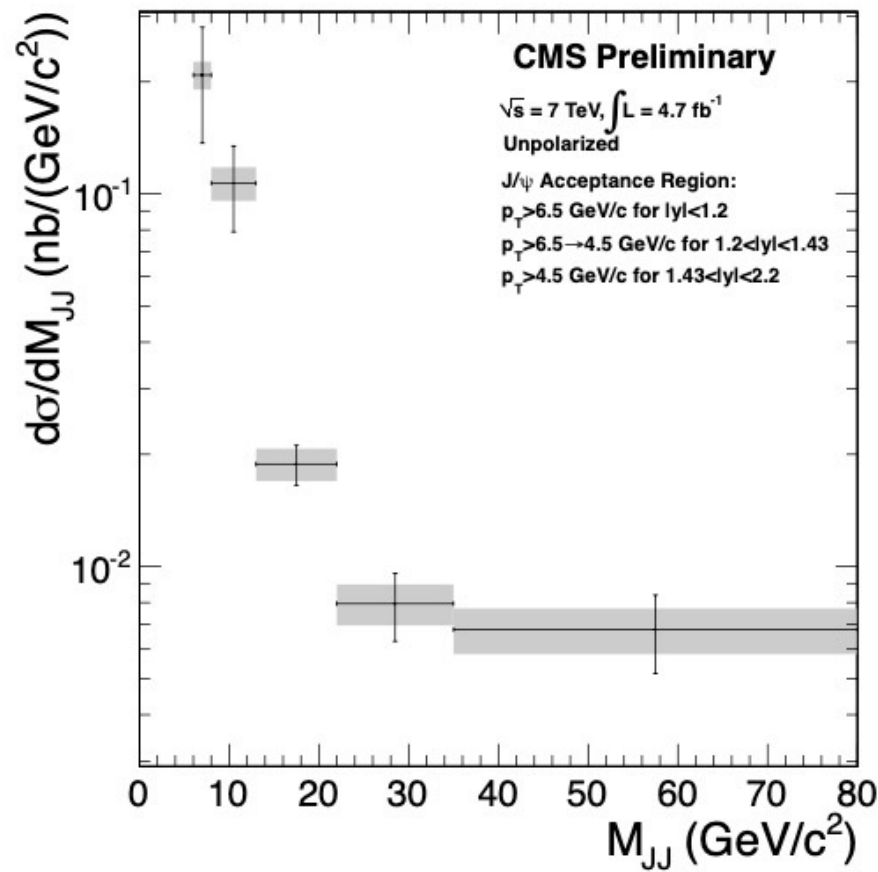
J/ ψ pair production—experiment and theory



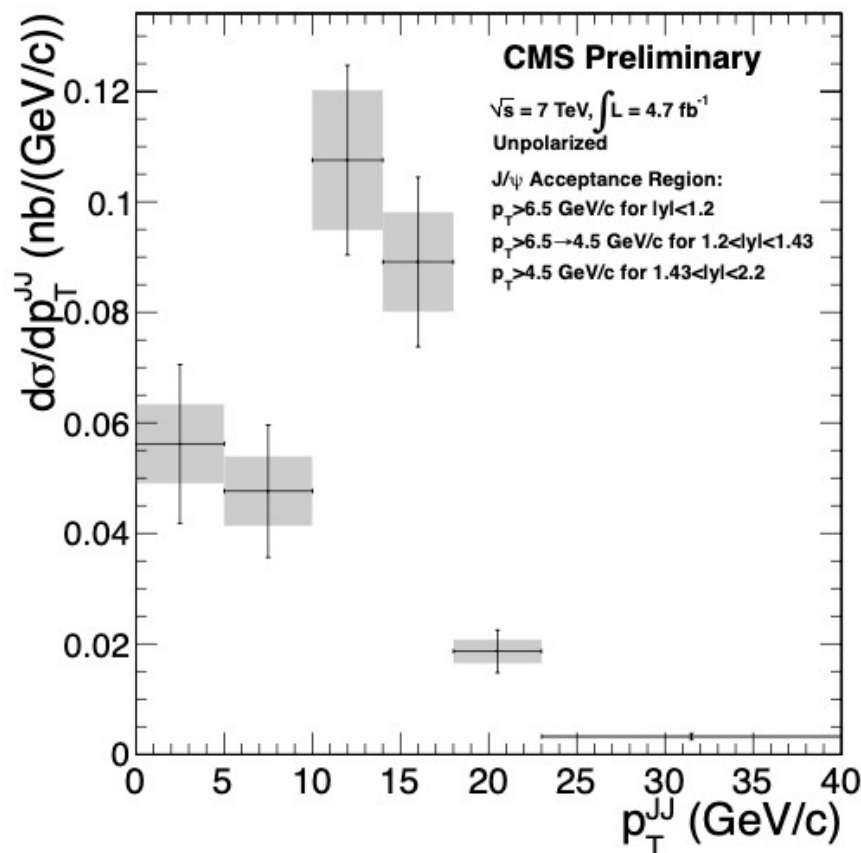
PRD 94, 074033 (2016)

- NLO result reasonably describe the LHCb J/ ψ pair cross section,
- Big difference in transverse momentum and J/ ψ pair mass—NLO+fragmentation
- Something we do not understand is going on
- Possible resonance may be part of the reasons
- Finding potential resonances can help understand the production

Double J/ψ production at CMS at 7 TeV

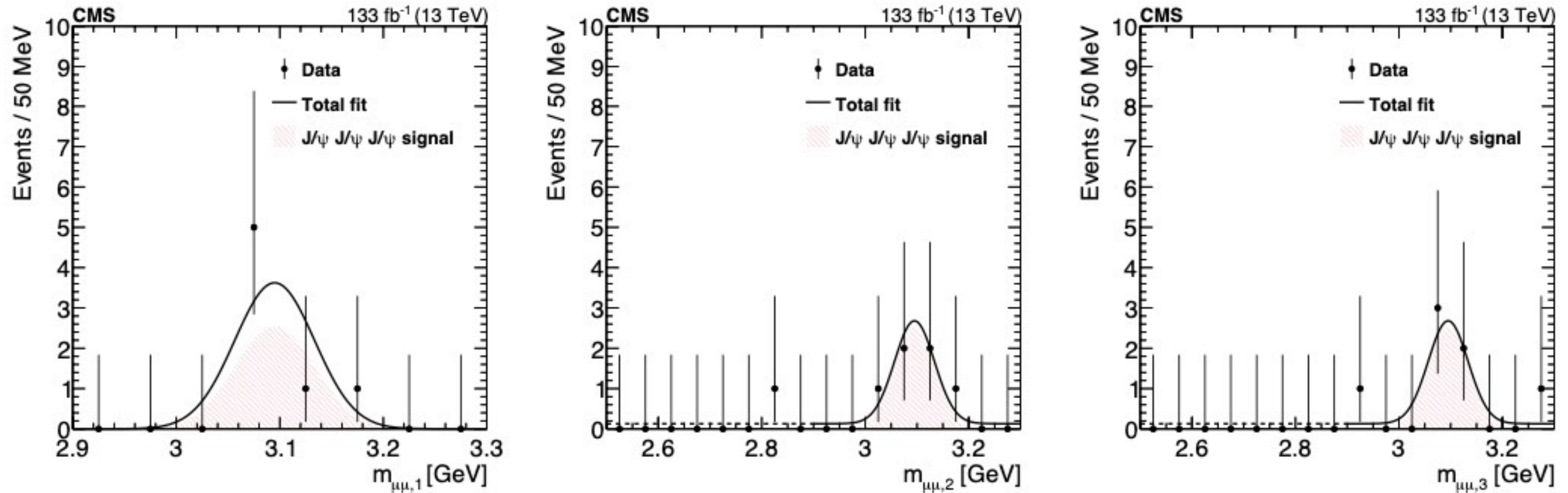


CMS-PAS-BPH-11-021



- Total cross section : $\sigma = 1.49 \pm 0.07 \pm 0.14 \text{ nb}$
- Fiducial region :
 - $p_T^{J/\psi} > 6.5 \text{ GeV/c for } |y^{J/\psi}| < 1.2$
 - $p_T^{J/\psi} > 6.5 \rightarrow 4.5 \text{ GeV/c for } 1.2 < |y^{J/\psi}| < 1.43$
 - $p_T^{J/\psi} > 4.5 \text{ GeV/c for } 1.43 < |y^{J/\psi}| < 2.2$

Triple J/ ψ production at CMS at 13 TeV



arXiv:2111.05370v1

- Total cross section : $\sigma = 272^{+141}_{-104}$ (stat) ± 17 (syst) fb
- Effective DPS cross section: $\sigma = 2.7^{+1.4}_{-1.0}$ (exp) ± 1.4 (theo) mb
- An amazing result

Dataset samples and triggers for $J/\psi J/\psi$ & $\psi(2S)J/\psi$

■ Charmonium dataset for Run II data.

■ $\sim 135 \text{ fb}^{-1}$ Int Lumi (2016, 2017, 2018)

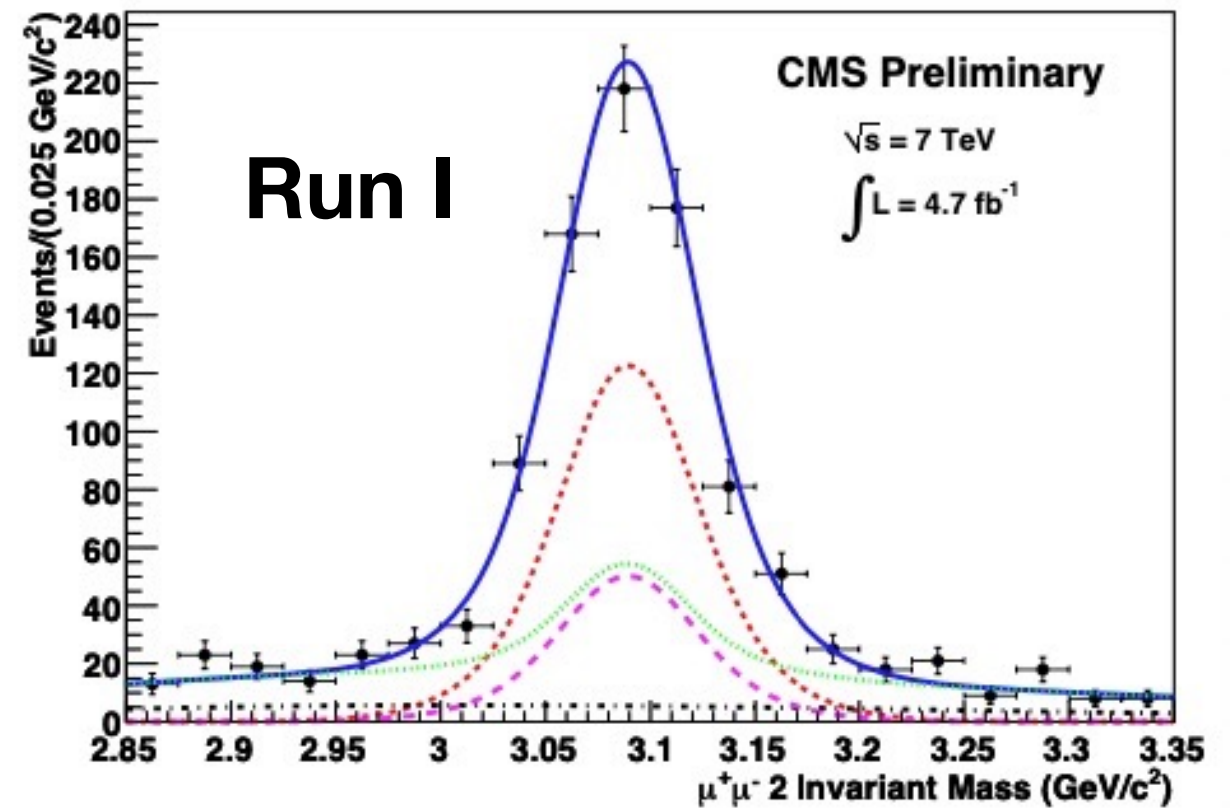
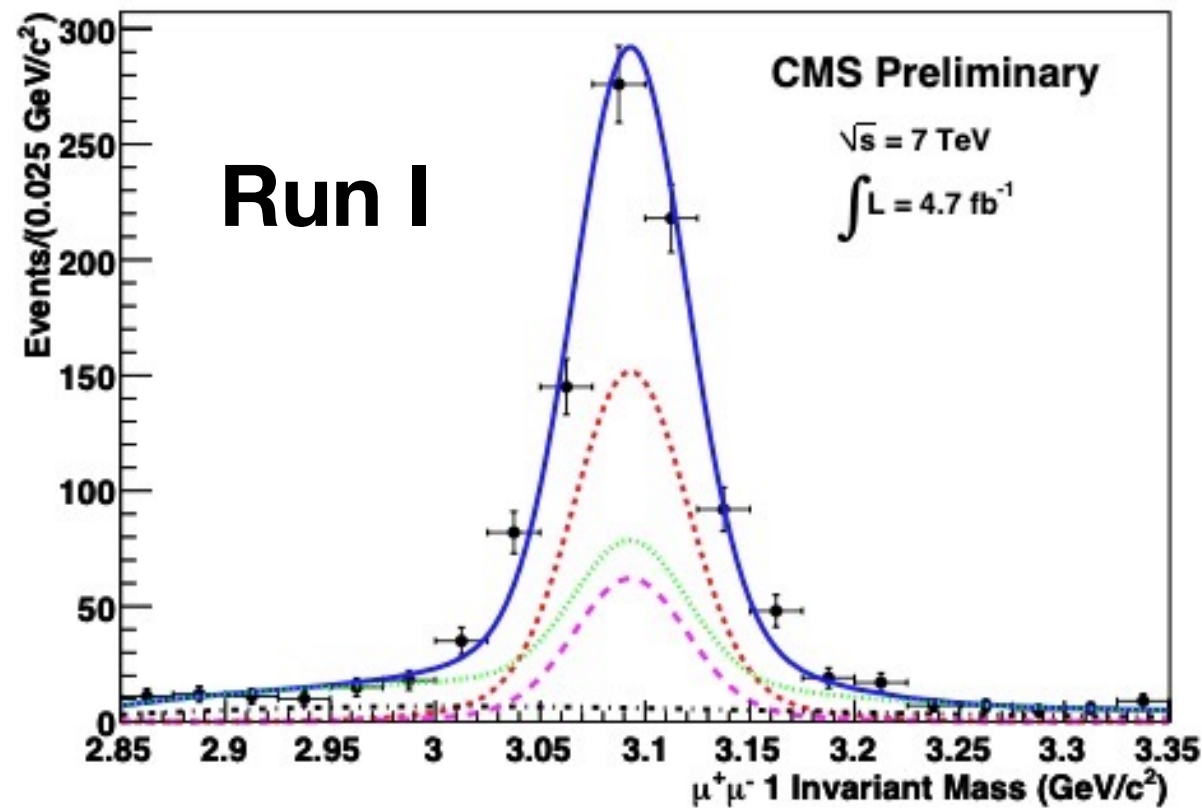
■ The triggers:

- 2016 : 3 muons without pT cut; 2 opposite charged dimuon mass in J/ψ mass region(2.7 ~ 3.4 GeV)
- 2017&2018 : 3 muons; 2 opposite charged dimuon for each muon pT greater than 3.5 GeV, mass between 2.95 ~3.25 GeV; Another muon whose pT greater than 2 GeV

Expected $J/\psi J/\psi$ & $\psi(2S)J/\psi$ yield at CMS Run II

■ CMS Run I data :

CMS-PAS-BPH-11-021



- Projections of the fit results in $M_{J/\psi 1}$ and $M_{J/\psi 2}$
- Expected $J/\psi J/\psi$ & $\psi(2S)J/\psi$ yield at CMS Run II :

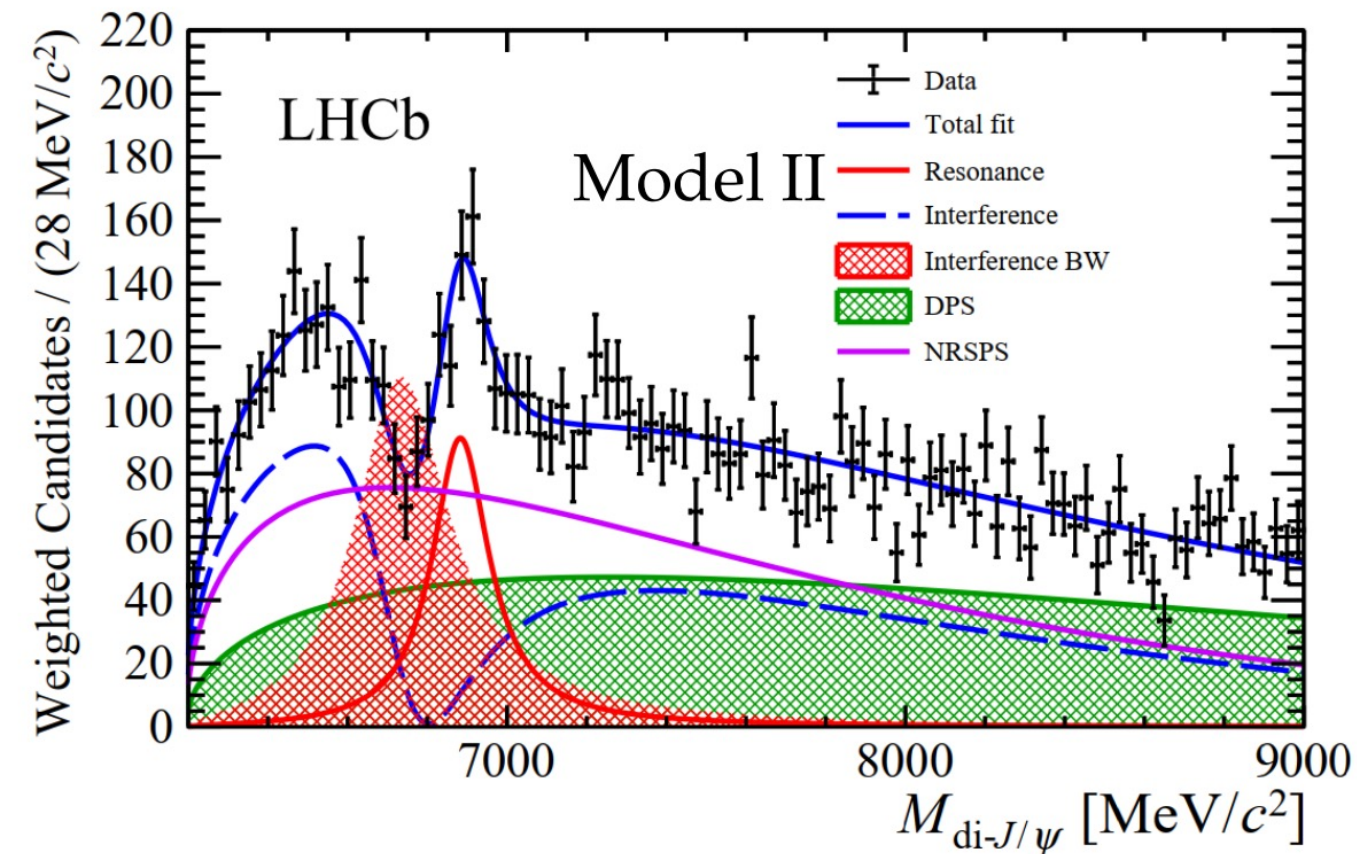
$J/\psi J/\psi$: ~25000

$\psi(2S)J/\psi$: ~200

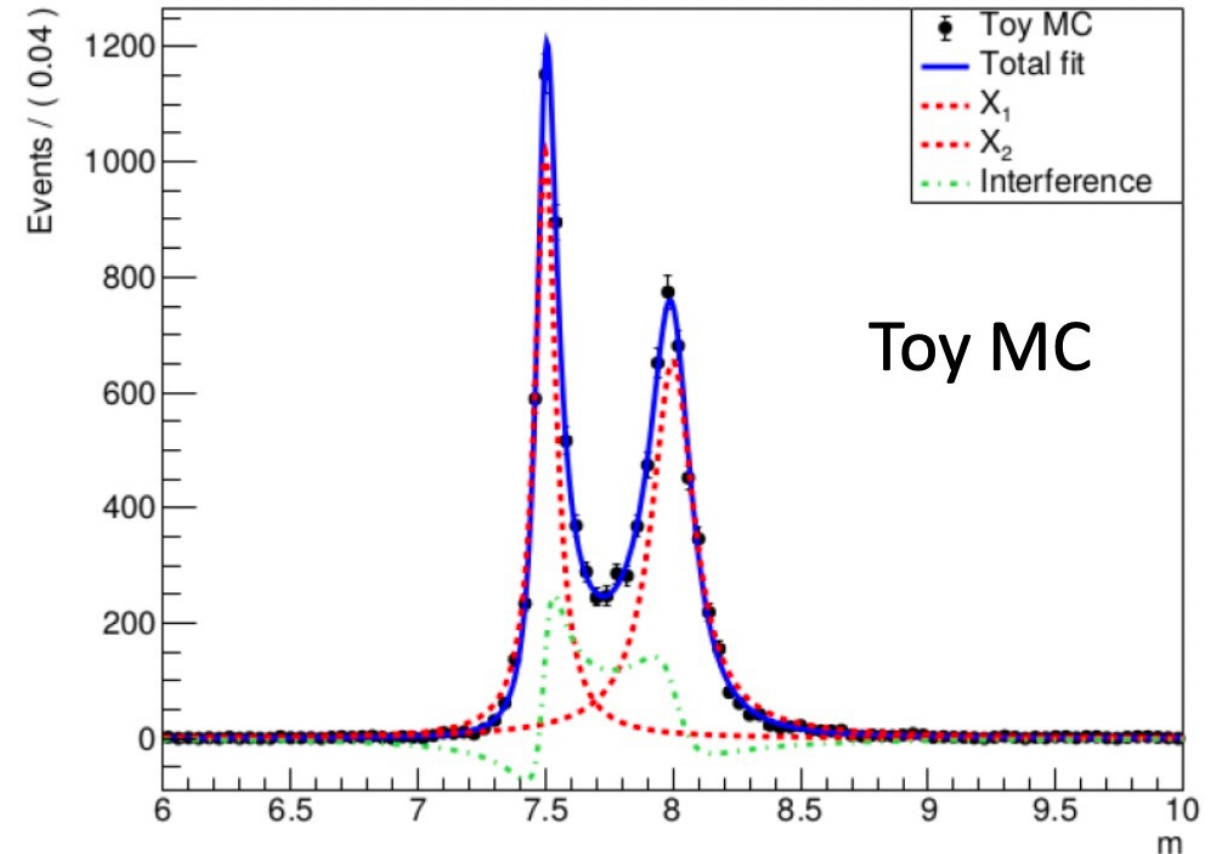
What we expect

- $J/\psi J/\psi$ analysis is going for pre-approval
 - Expect interesting results
 - $\psi(2S)J/\psi$ analysis is on the way
 - Any surprise ?
-
- Hopefully out in the coming winter conference

What we expect



[arXiv:2002.06393](https://arxiv.org/abs/2002.06393)



<https://indico.ihep.ac.cn/event/12369/session/16/contribution/100>

- Have better sensitivity
- Consider many scenarios including multiple peaks and interference between multiple peaks

Summary

- High expectation in HEP community
- CMS will play an important role in the on-going saga
- $J/\psi J/\psi$ & $\psi(2S)J/\psi$ on the way

Stay tuned!