LOOKING FOR THE UNEXPECTED IN THE ORDINARY AT THE LHC

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(HEPHY Vienna)

in collaboration with

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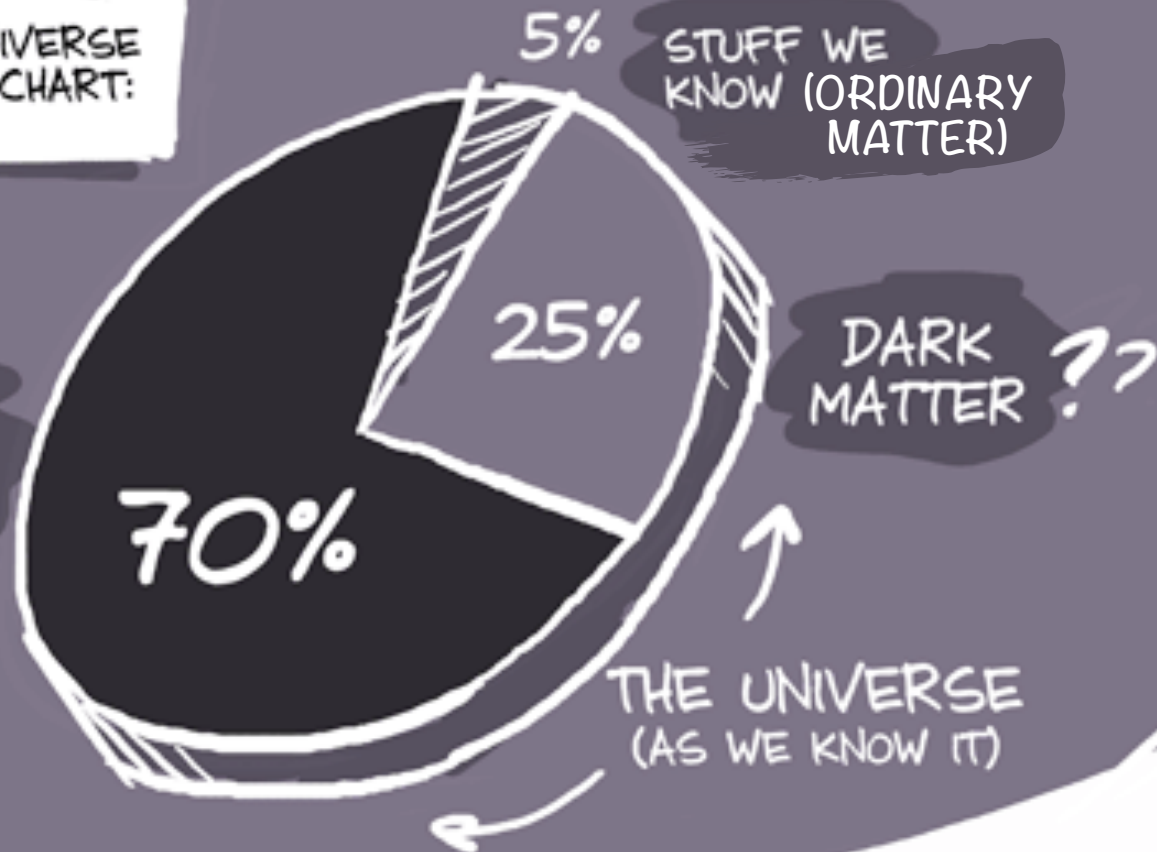
Humboldt Kolleg
Kitzbühel
25 June 2019

HEPHY
INSTITUT FÜR HOCHENERGIEPHYSIK

CONTENT OF THE UNIVERSE

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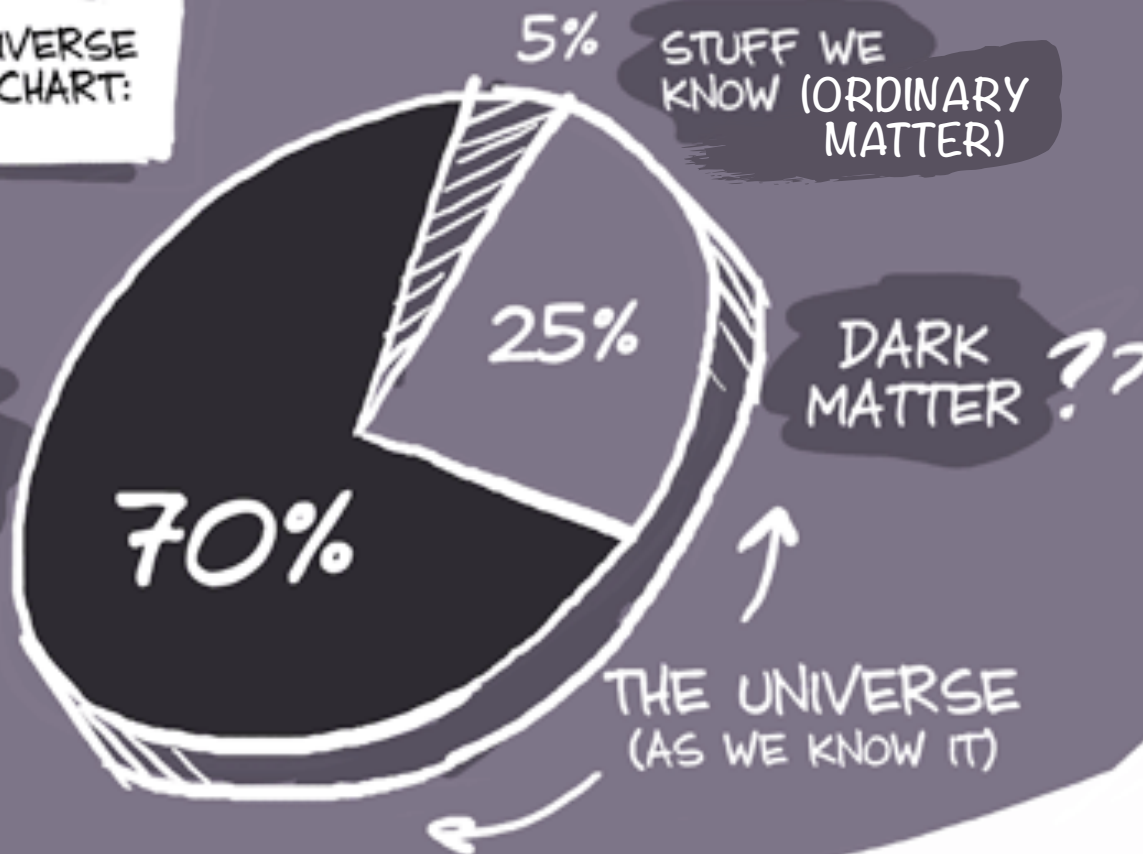
Yes, we know the content!

But we still do not understand how the strong force binds quarks

How can we study hadron formation?

Quarkonia

Charming

Beautiful

Characterized by quantum numbers for spin S, orbital angular momentum L and total angular momentum J
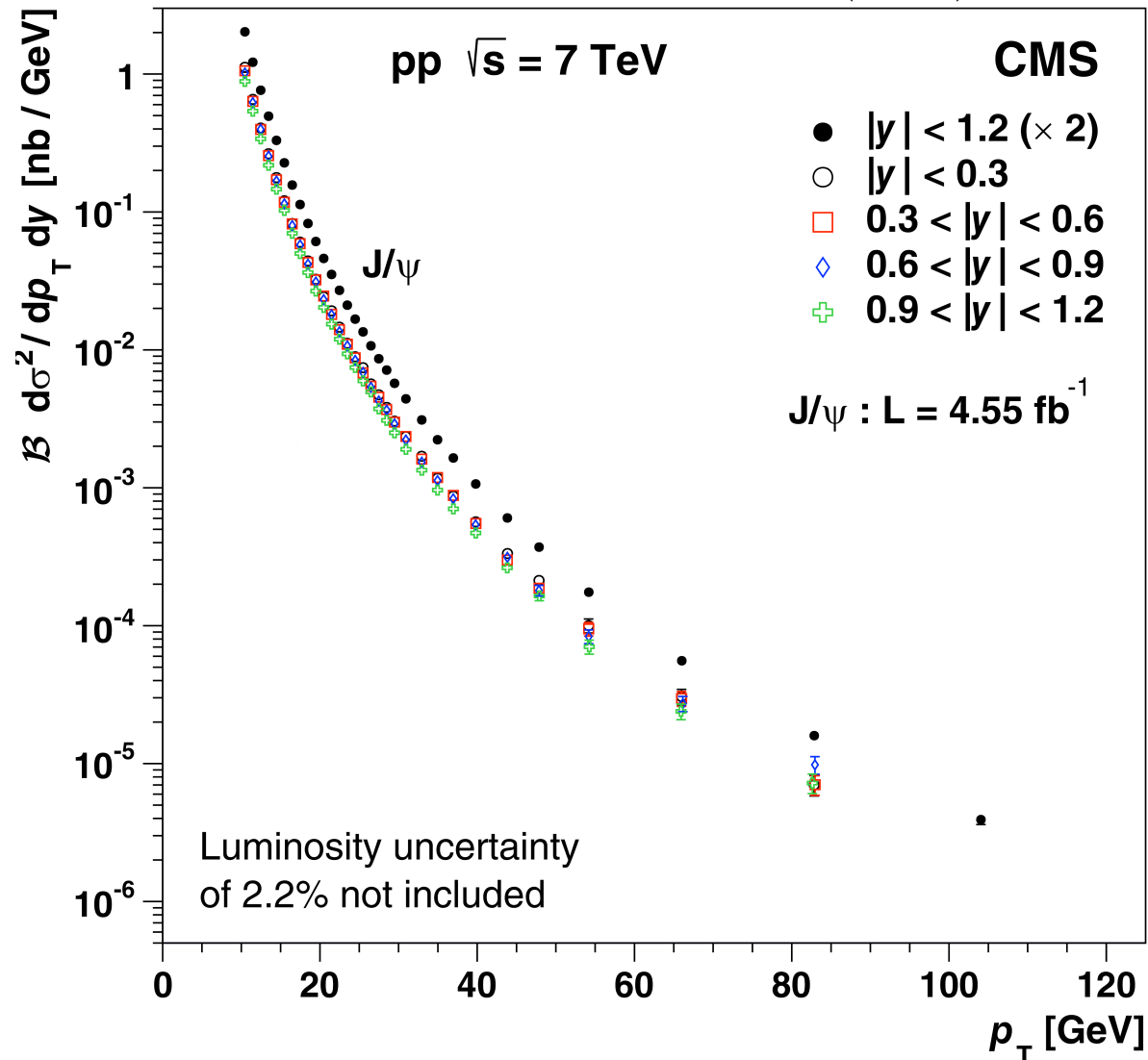
How can we study hadron formation?
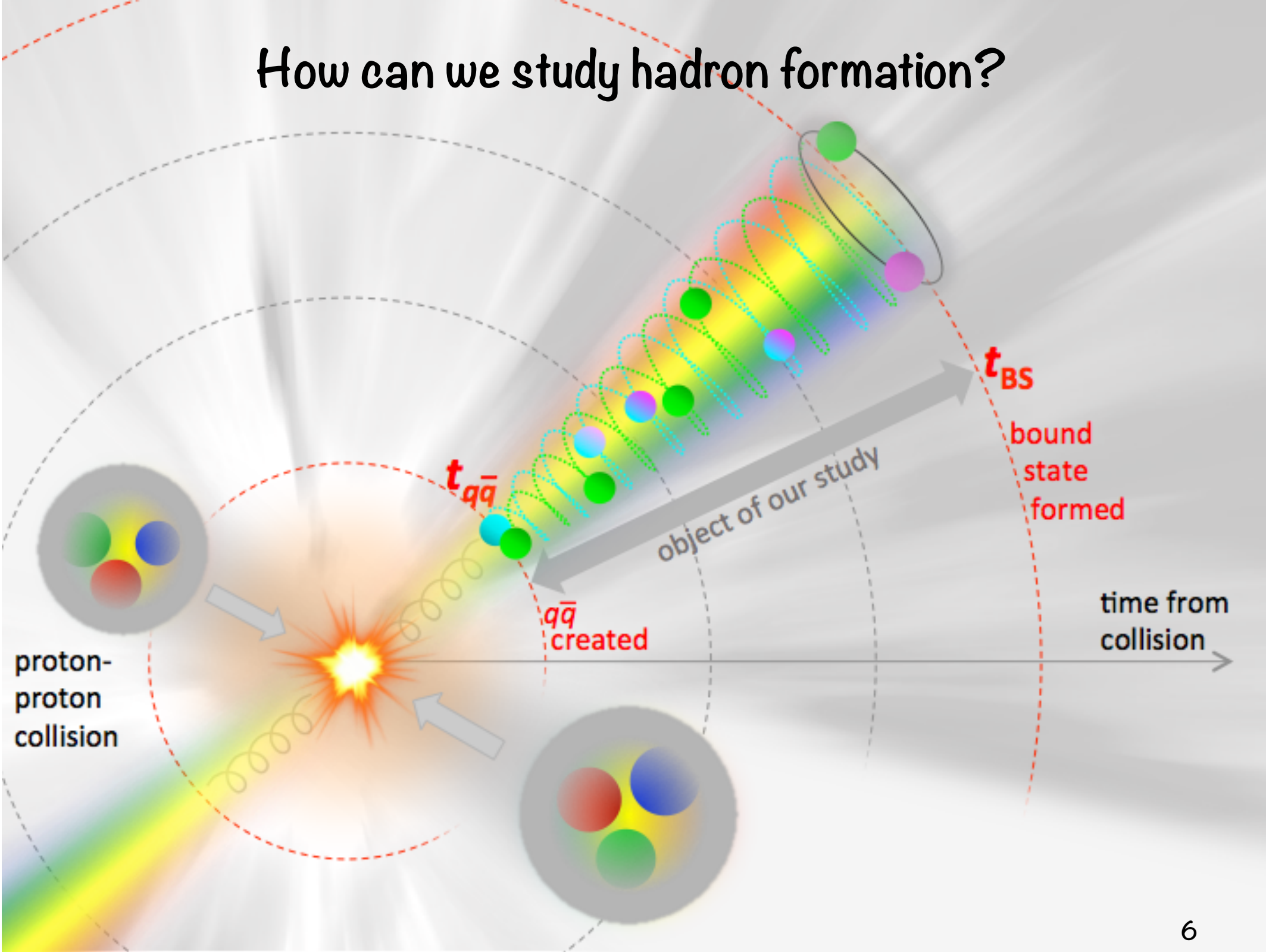
Quarkonium production
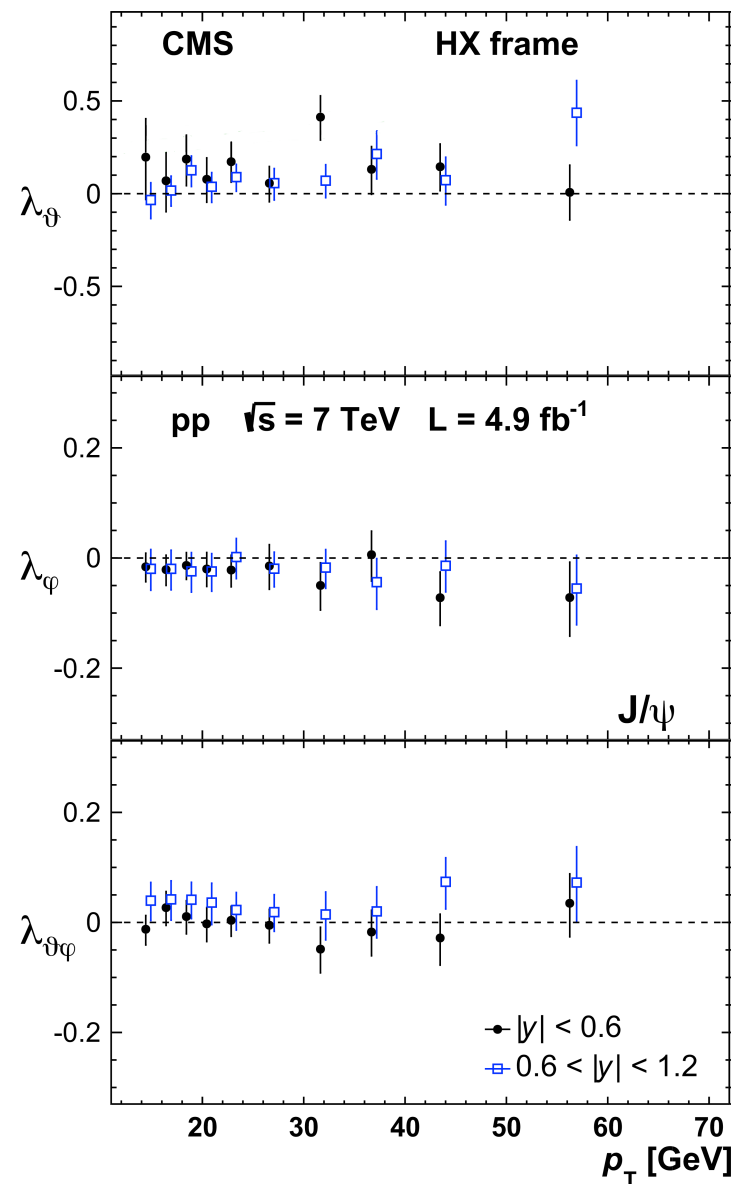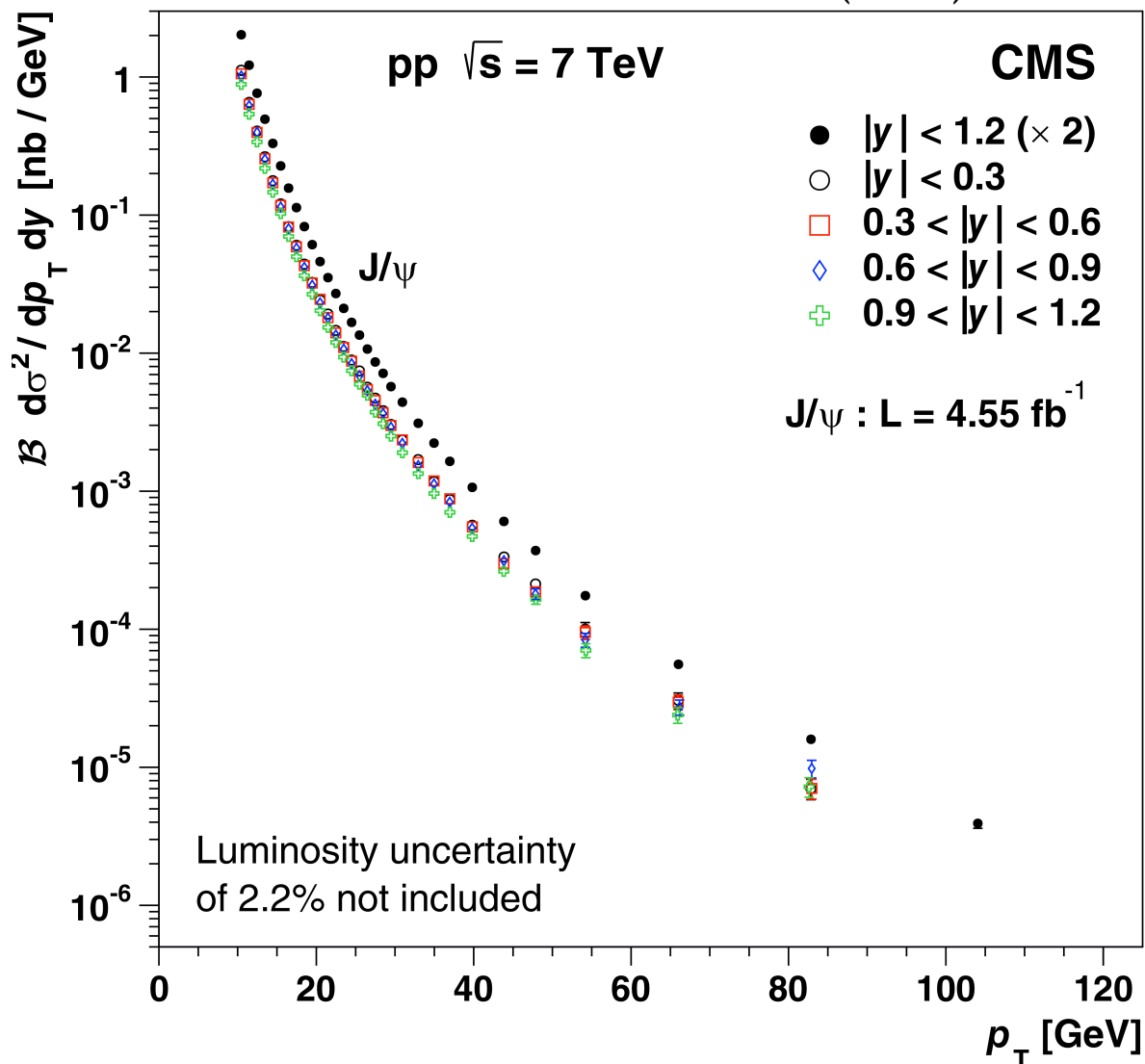
Quarkonium production

Cross section

Quarkonium production

Cross section and polarization
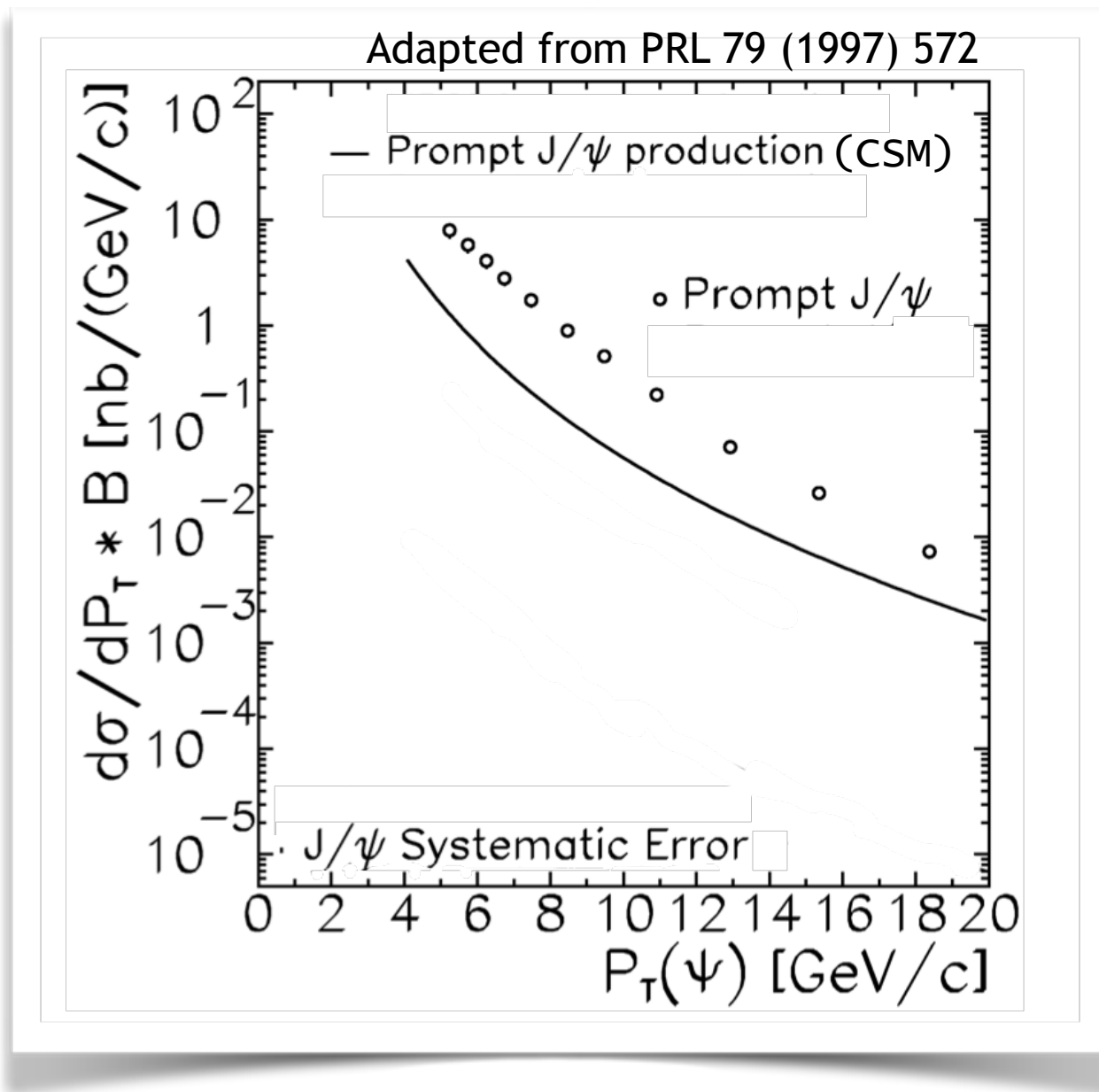
Quarkonia

PRL 33 (1974) 1404, PRL 33 (1974) 1406
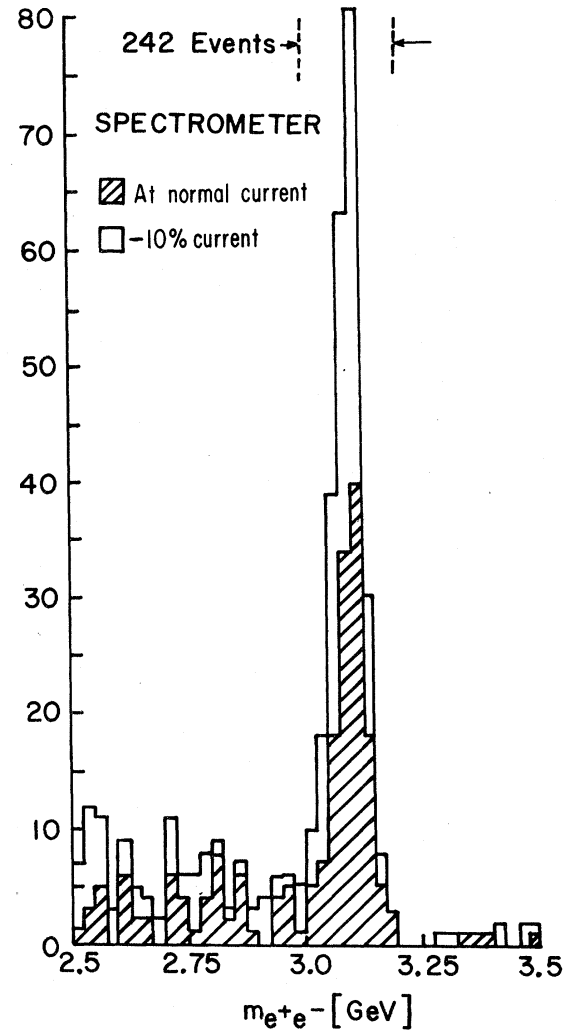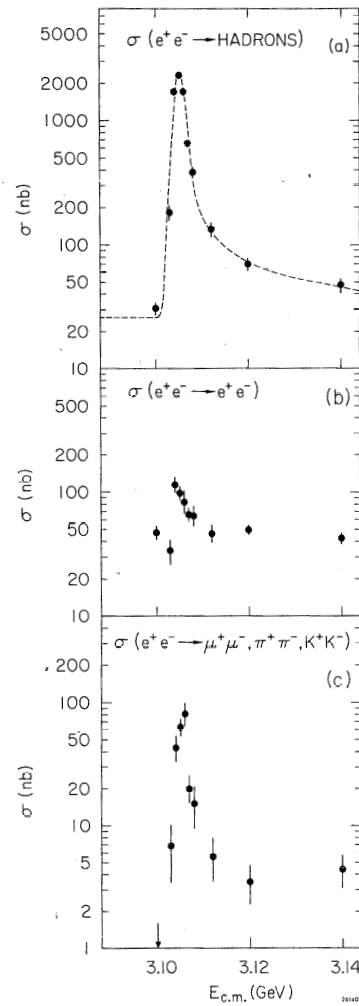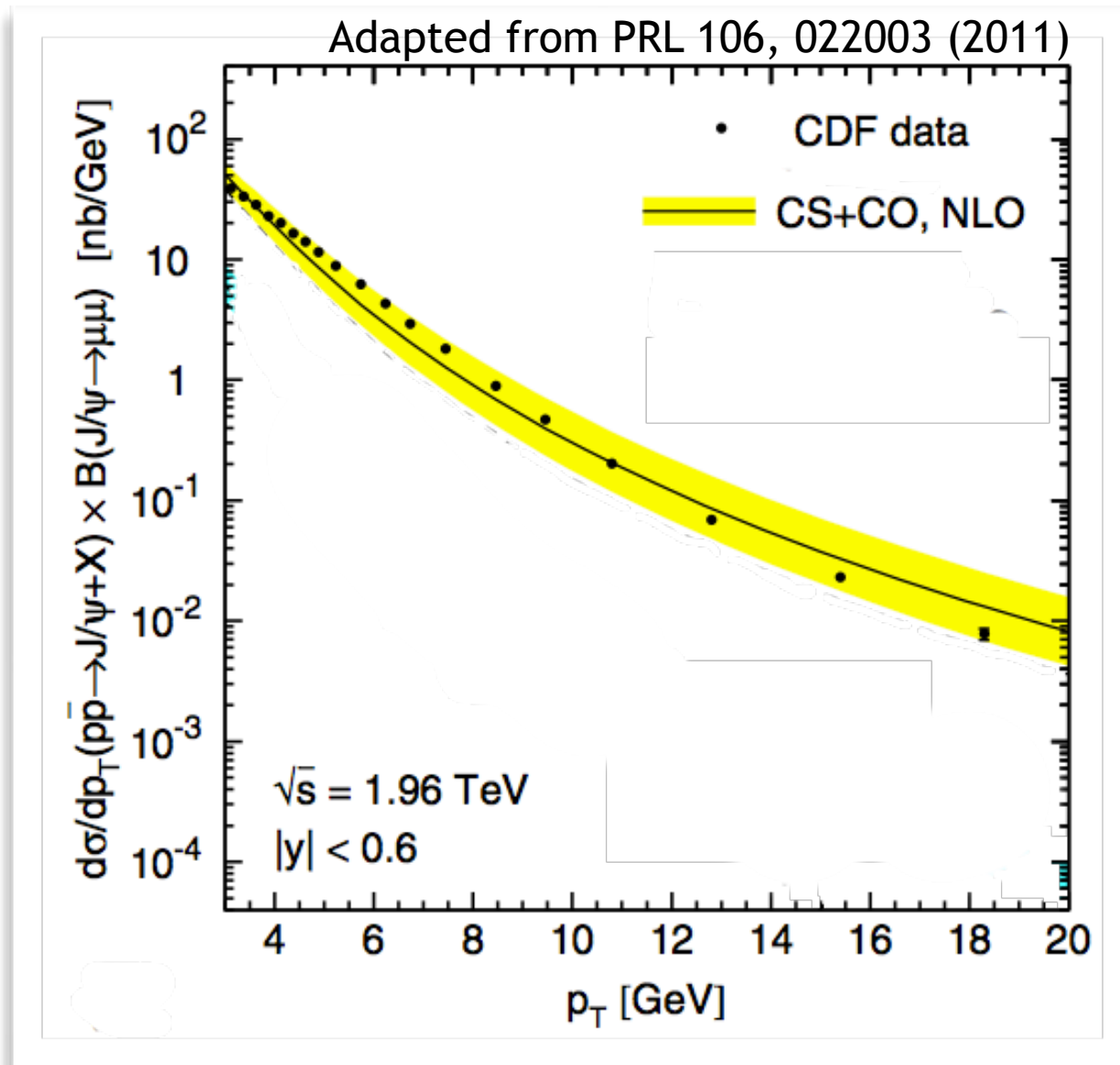
First states discovered in the 70ies

Over 40 years of quarkonium studies

Over 40 years of quarkonium studies

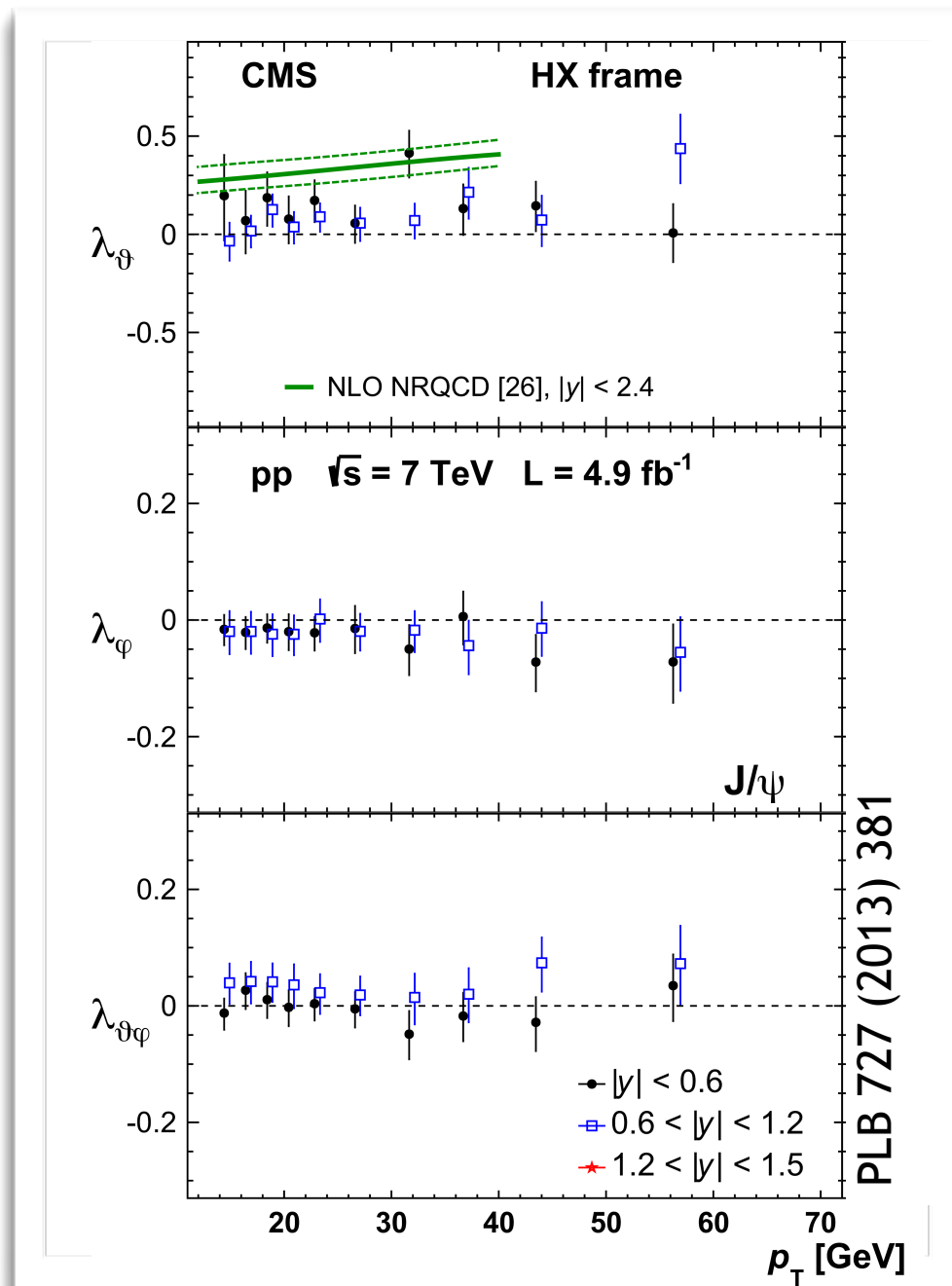
Adapted from PRL 106, 022003 (2011)

Improved theory:
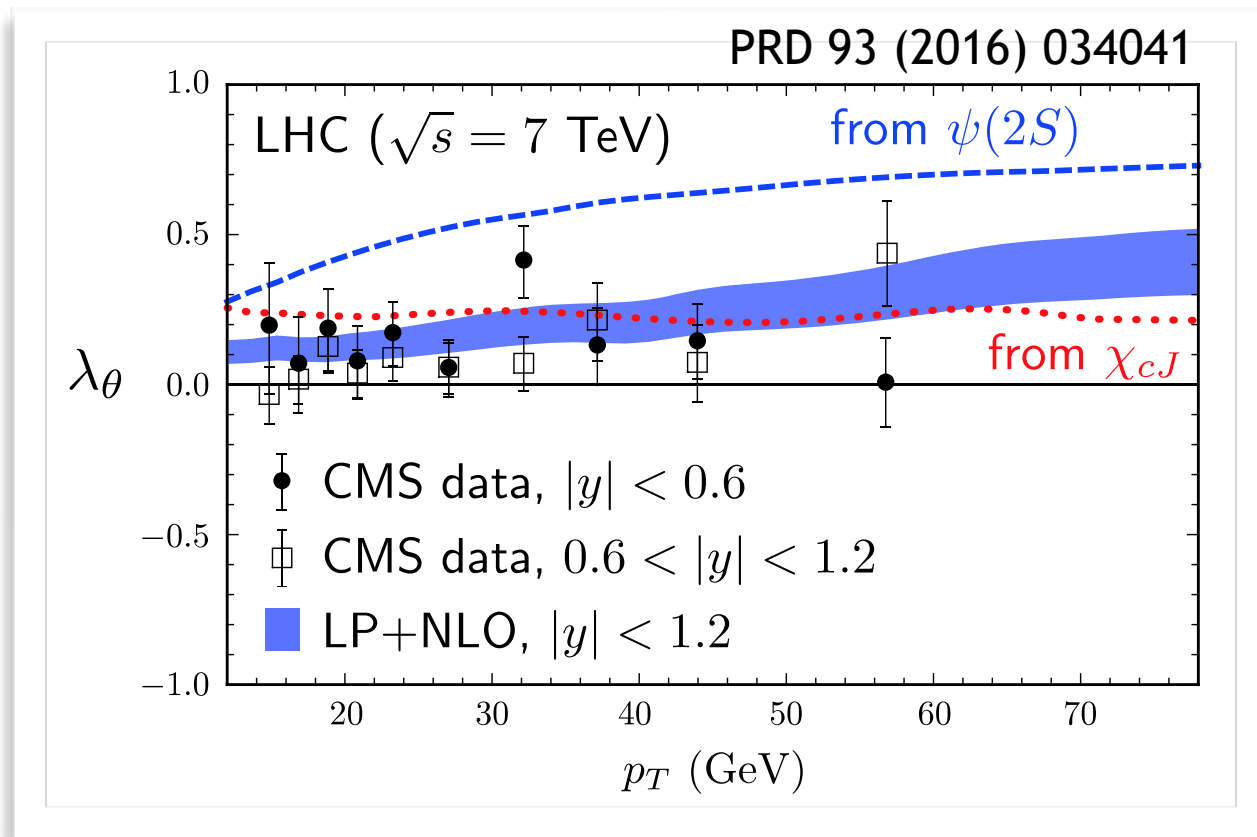Non Relativistic QCD
(NRQCD)

Over 40 years of quarkonium studies

Unpolarized quarkonia
measured at the LHC!

UNEXPECTED!

# Over 40 years of quarkonium studies

Improved theory predictions

PRD 93 (2016) 034041

LHC ($\sqrt{s} = 7$ TeV) — from $\psi(2S)$

λ_θ

from χ_{cJ}

- ● CMS data, $|y| < 0.6$
- ☐ CMS data, $0.6 < |y| < 1.2$
- ▨ LP+NLO, $|y| < 1.2$

p_T (GeV)

So we know everything about quarkonia and their production?

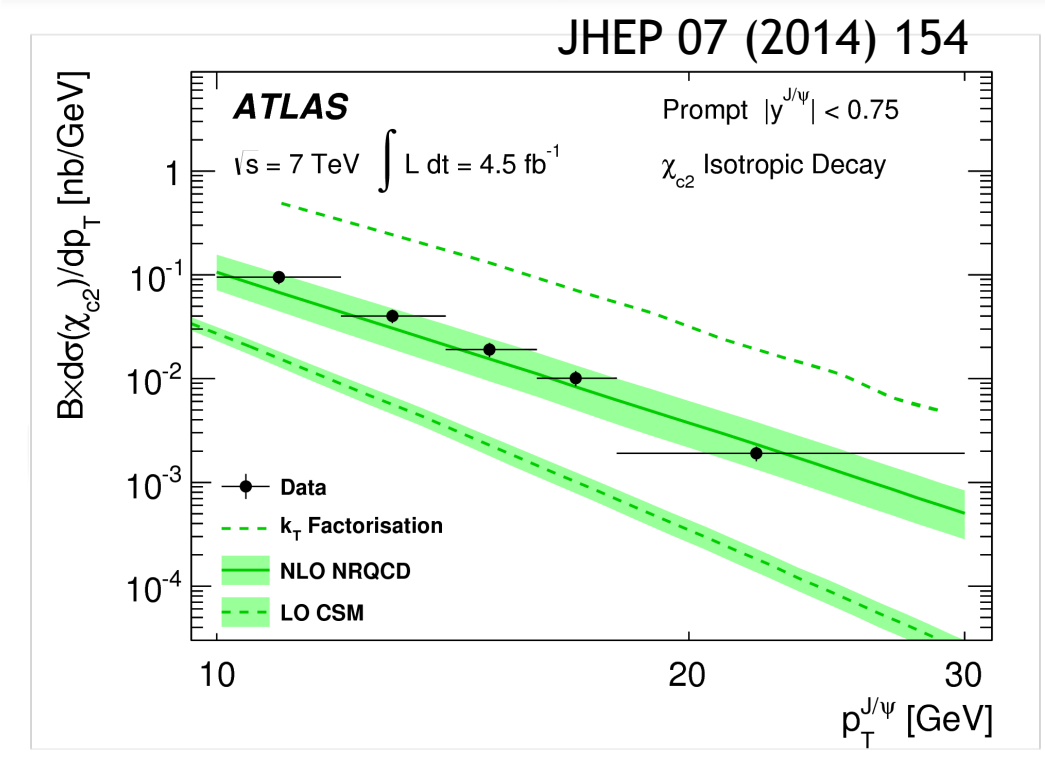So we know everything about quarkonia
and their production?

NO!

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Looking at higher angular momentum
(P-wave) charmonium states

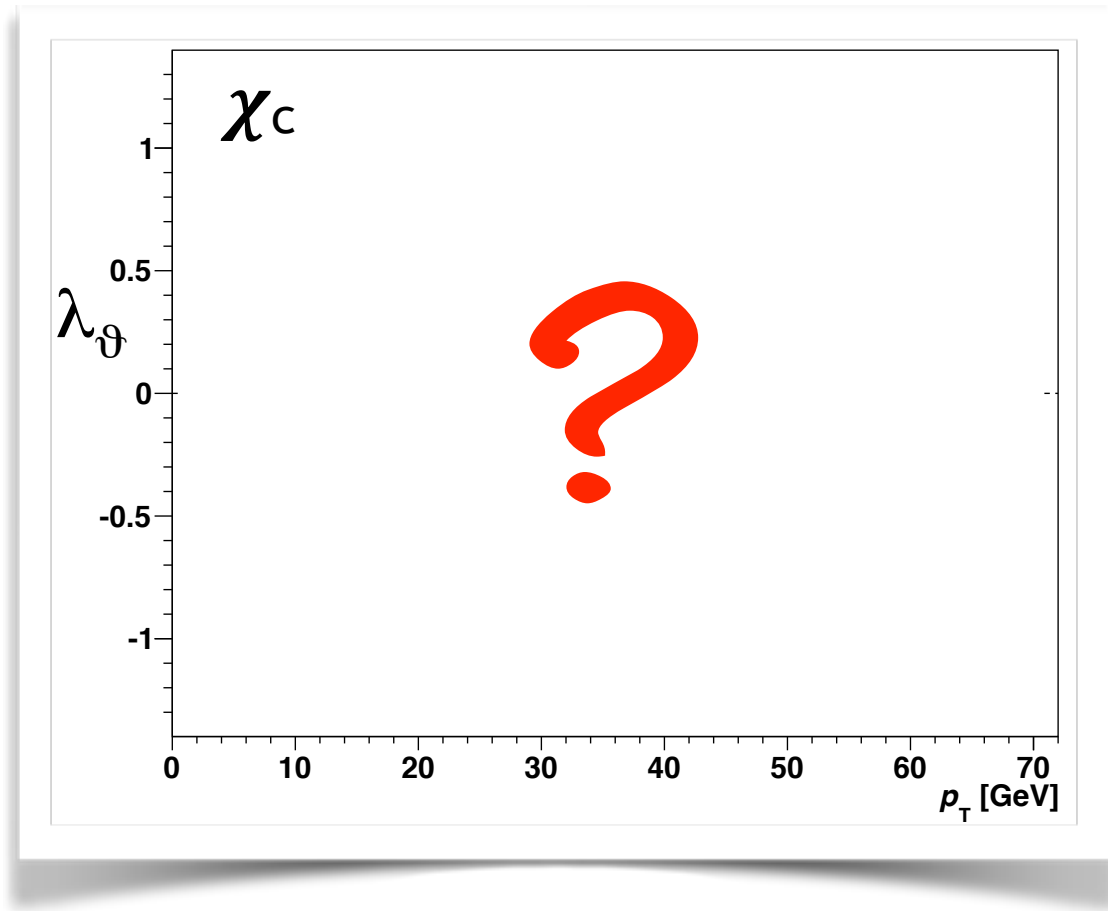Cross sections

JHEP 07 (2014) 154
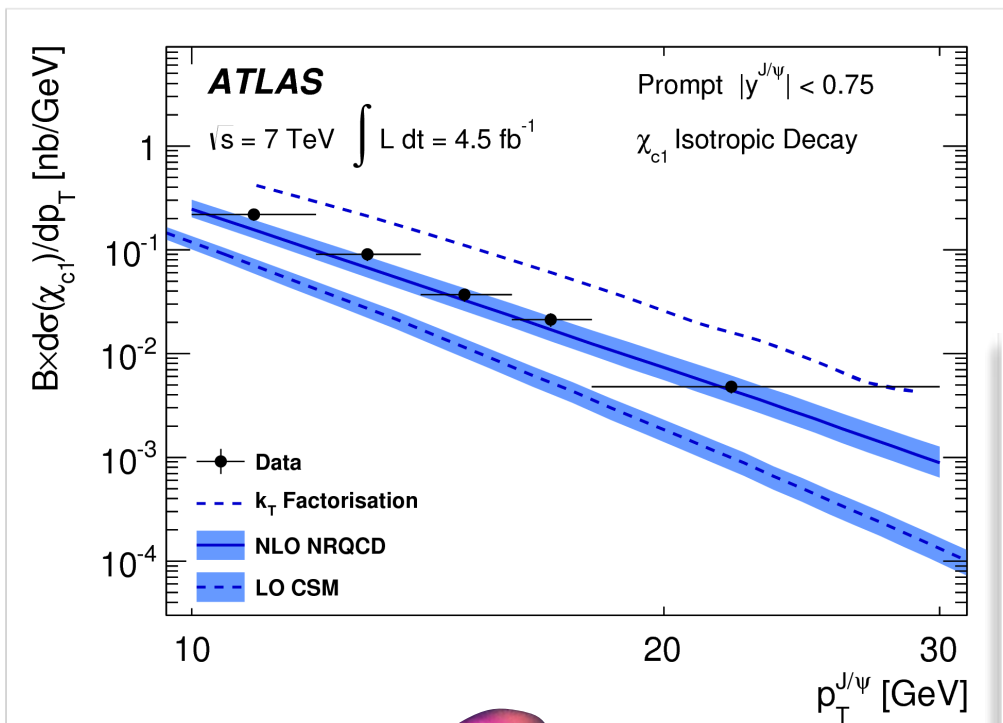
Looking at higher angular momentum (P-wave) charmonium states
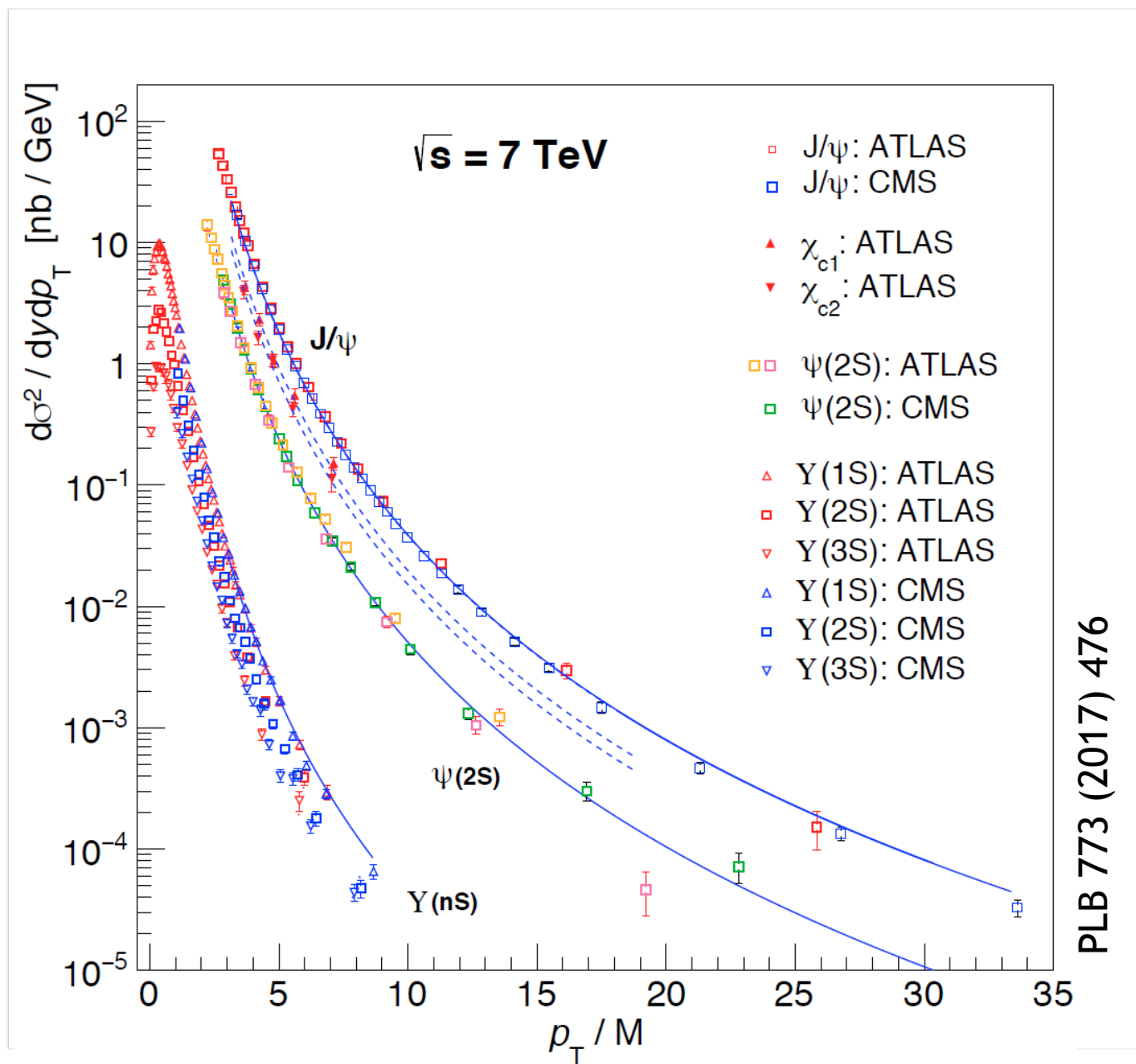
Polarizations

We have
no idea!

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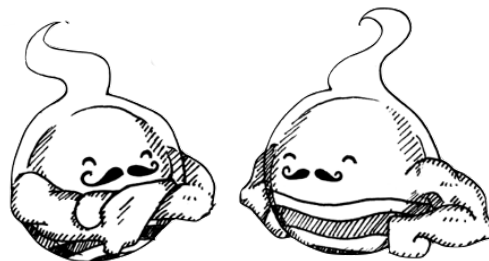
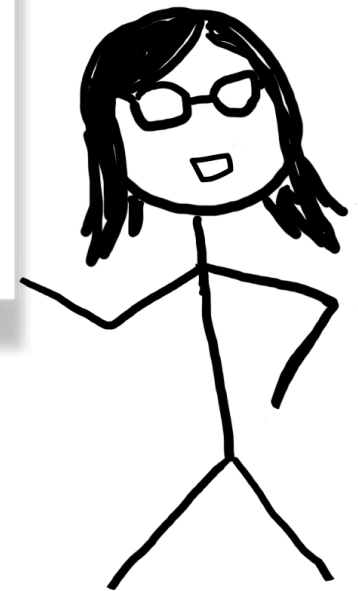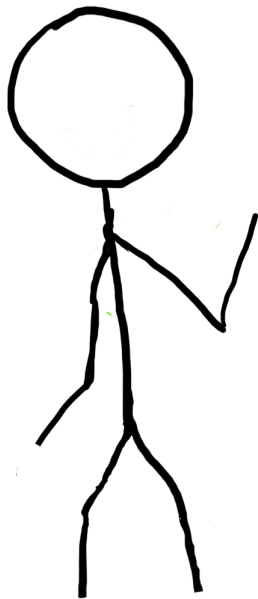# What does NRQCD say about the polarization of p-wave charmonia?
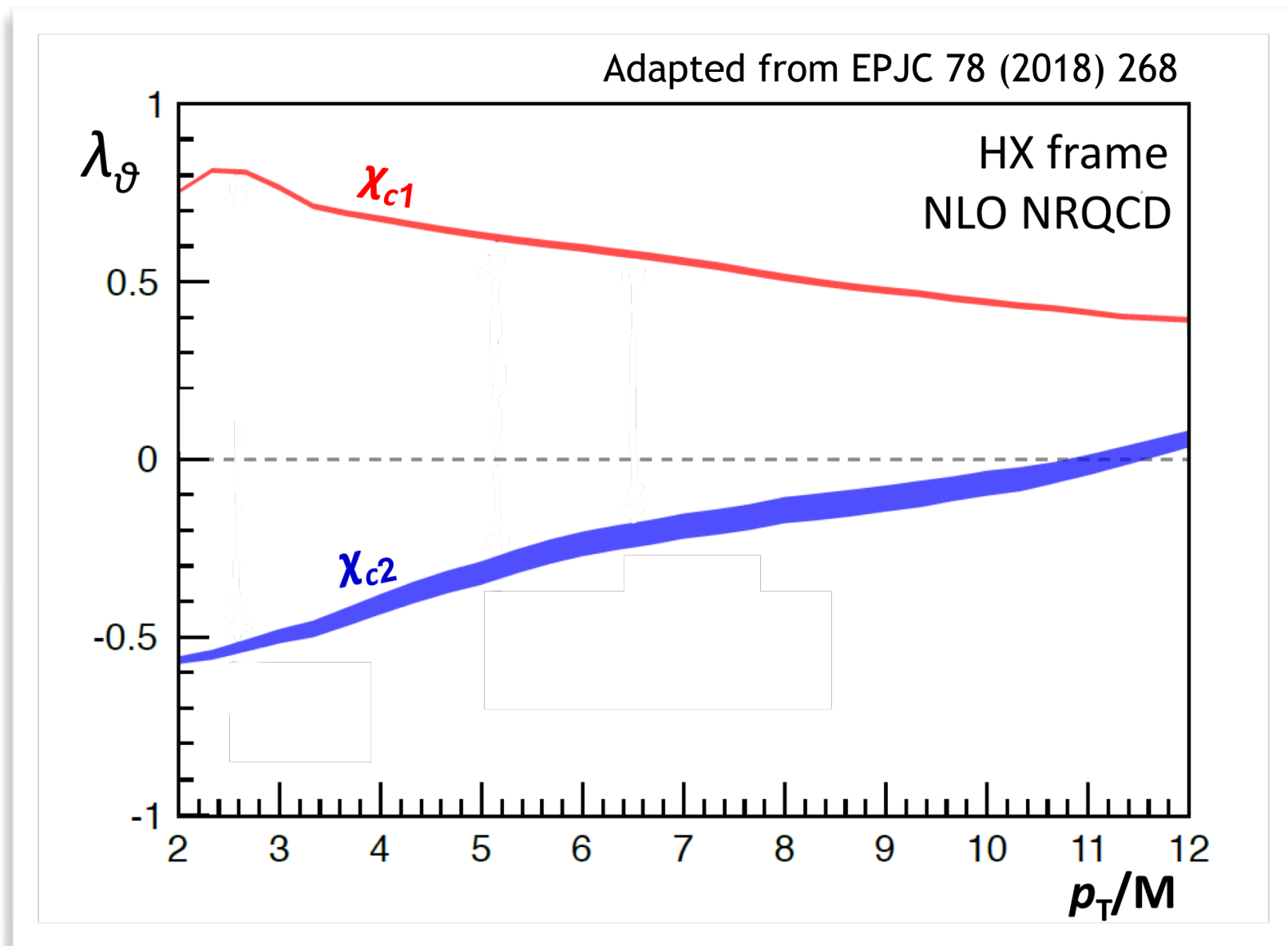
What can we learn from data?
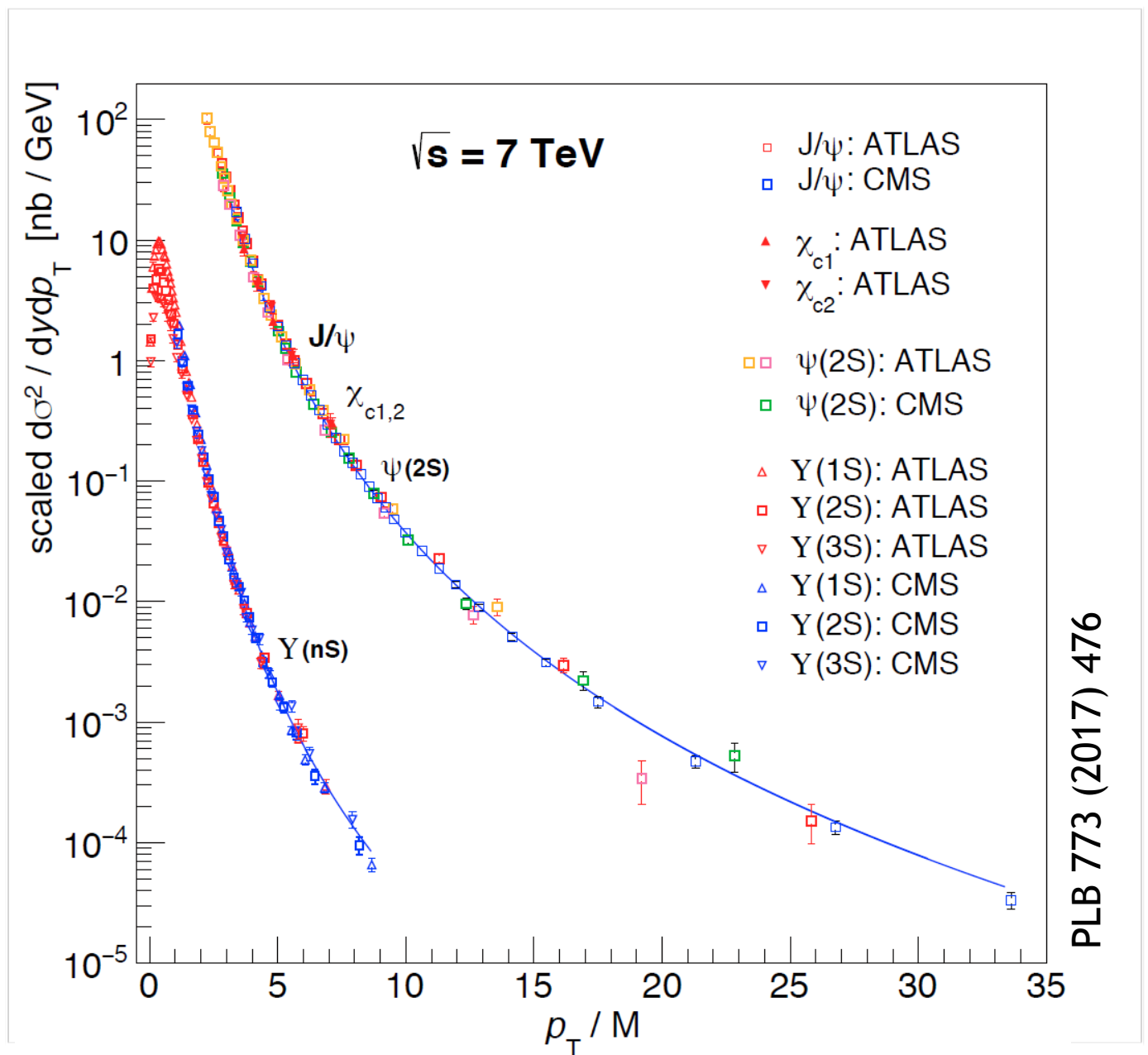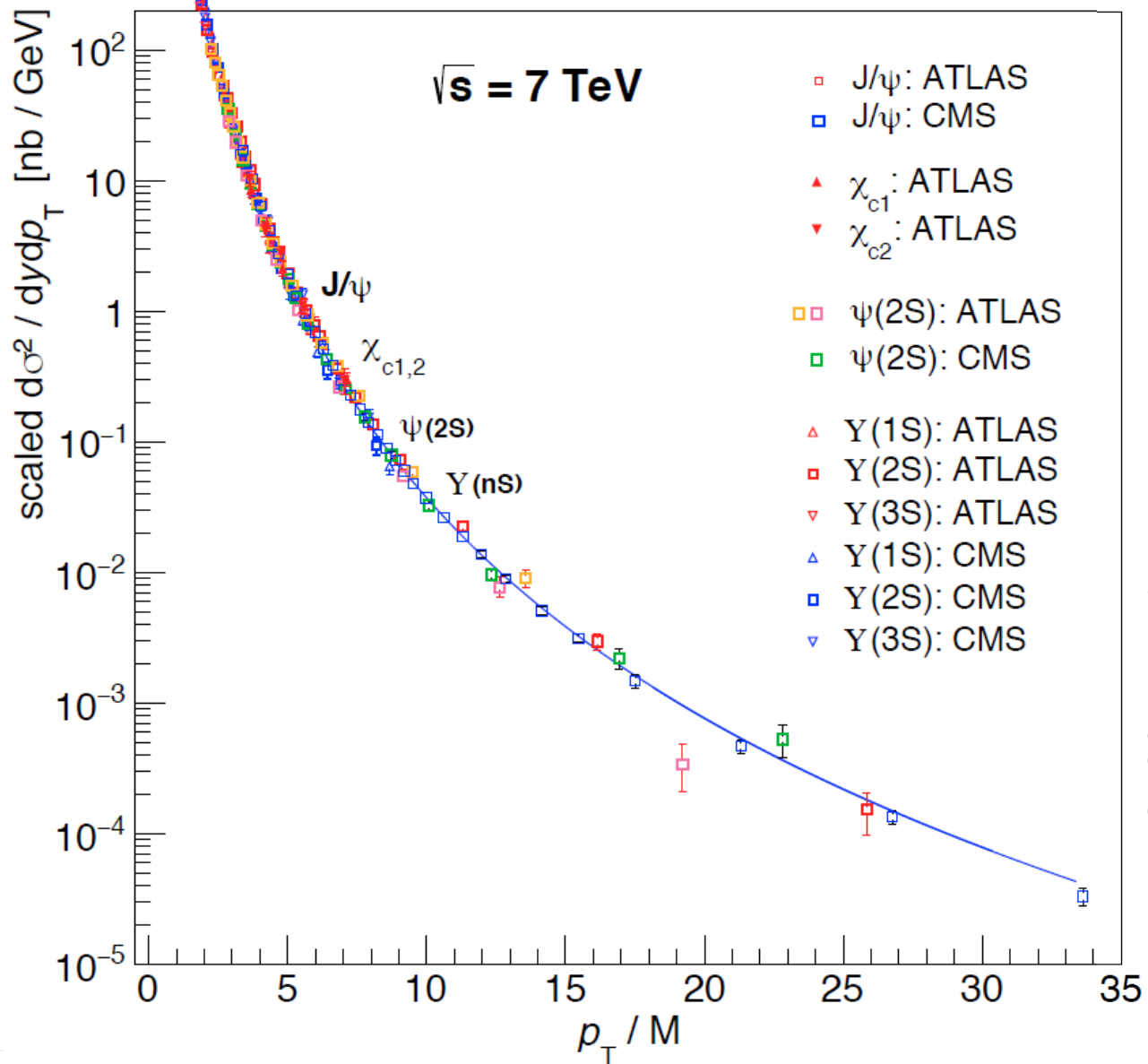
What can we learn from data?

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What can we learn from data?

PLB 773 (2017) 476

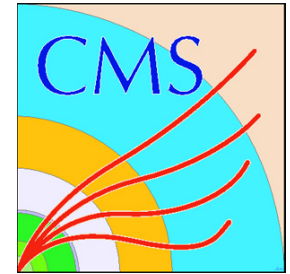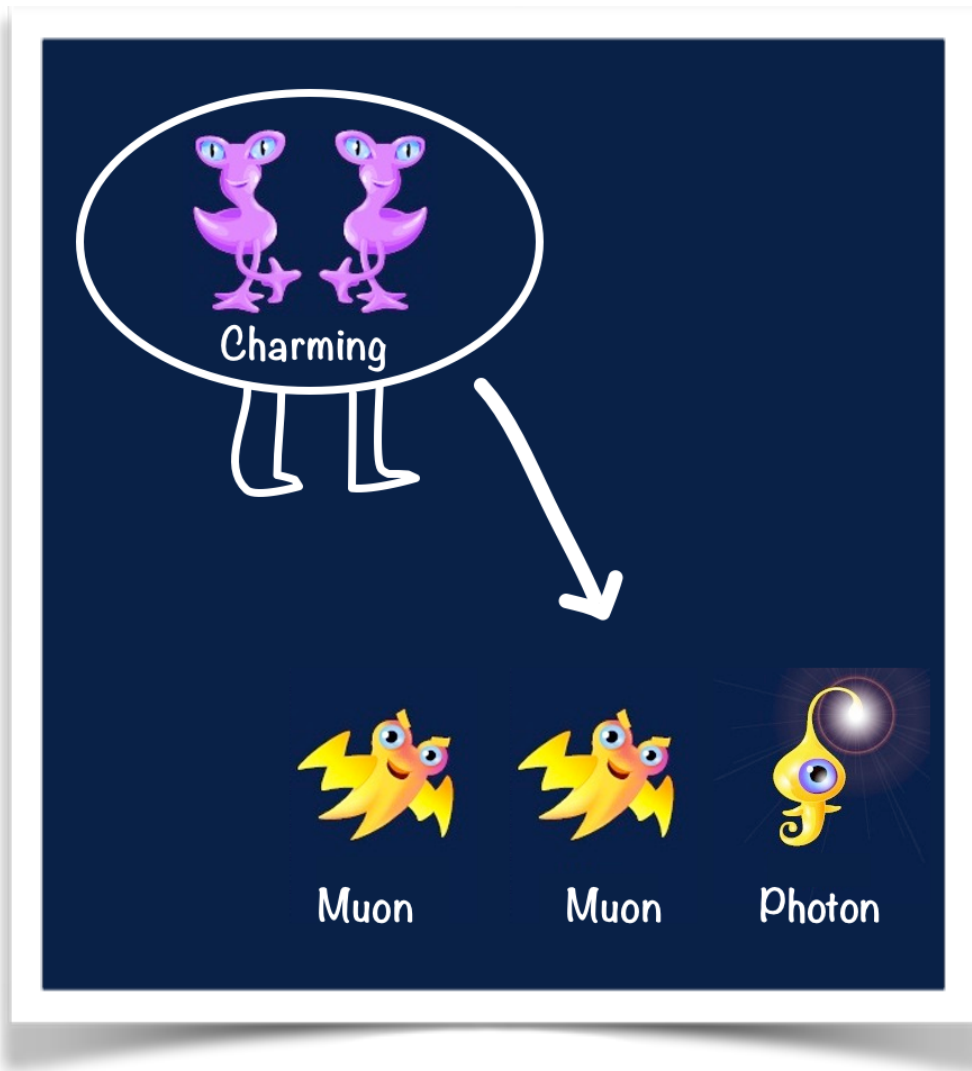Helicity frame
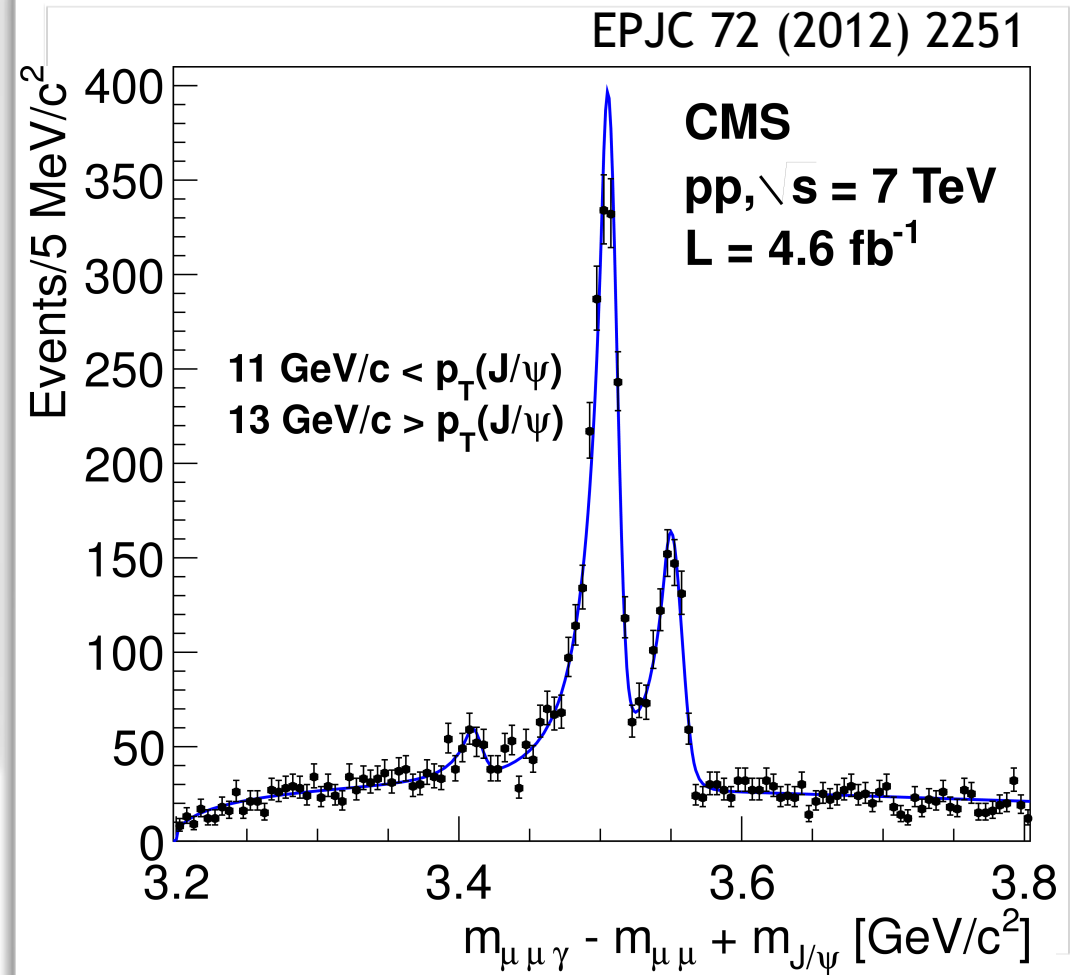
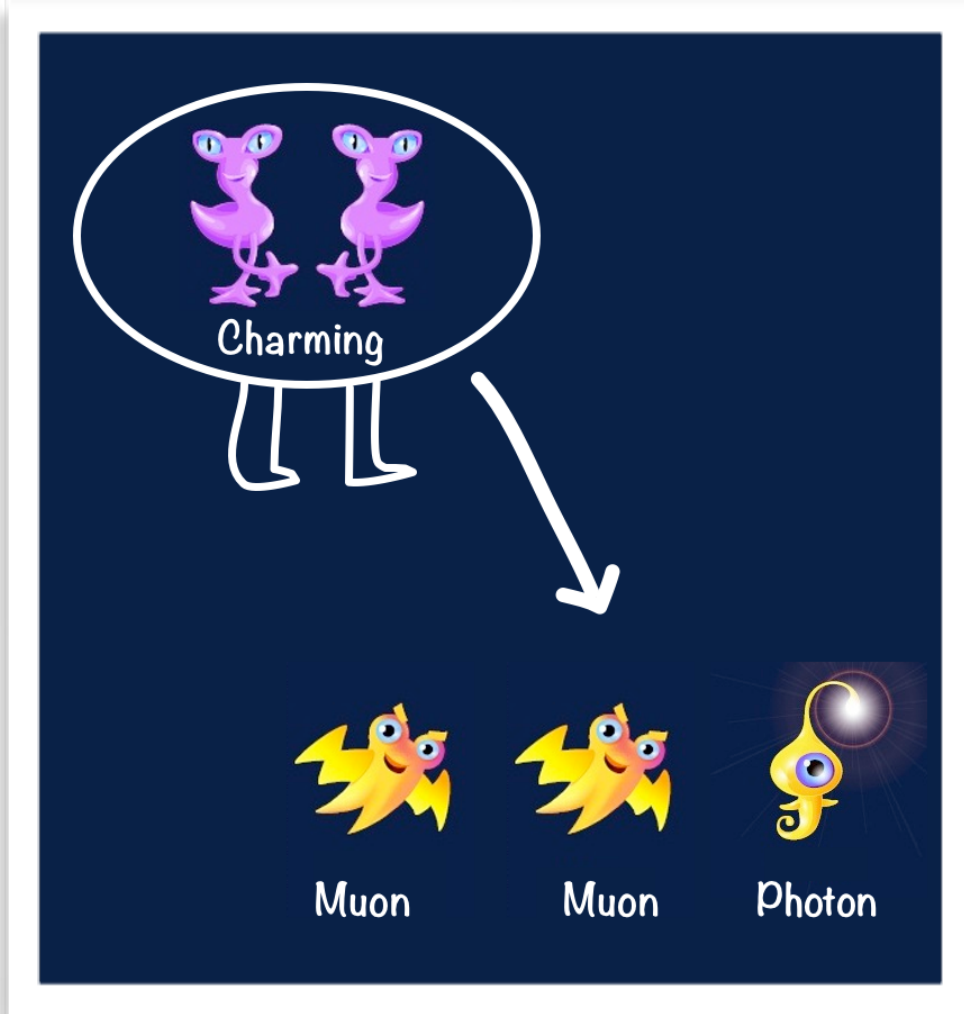- ■ J/ψ CMS
- ● ψ(2S) CMS
- □ Υ(1S) CMS

Can we measure the polarization of P-wave states?

Can we measure the polarization of P-wave states?

YES!
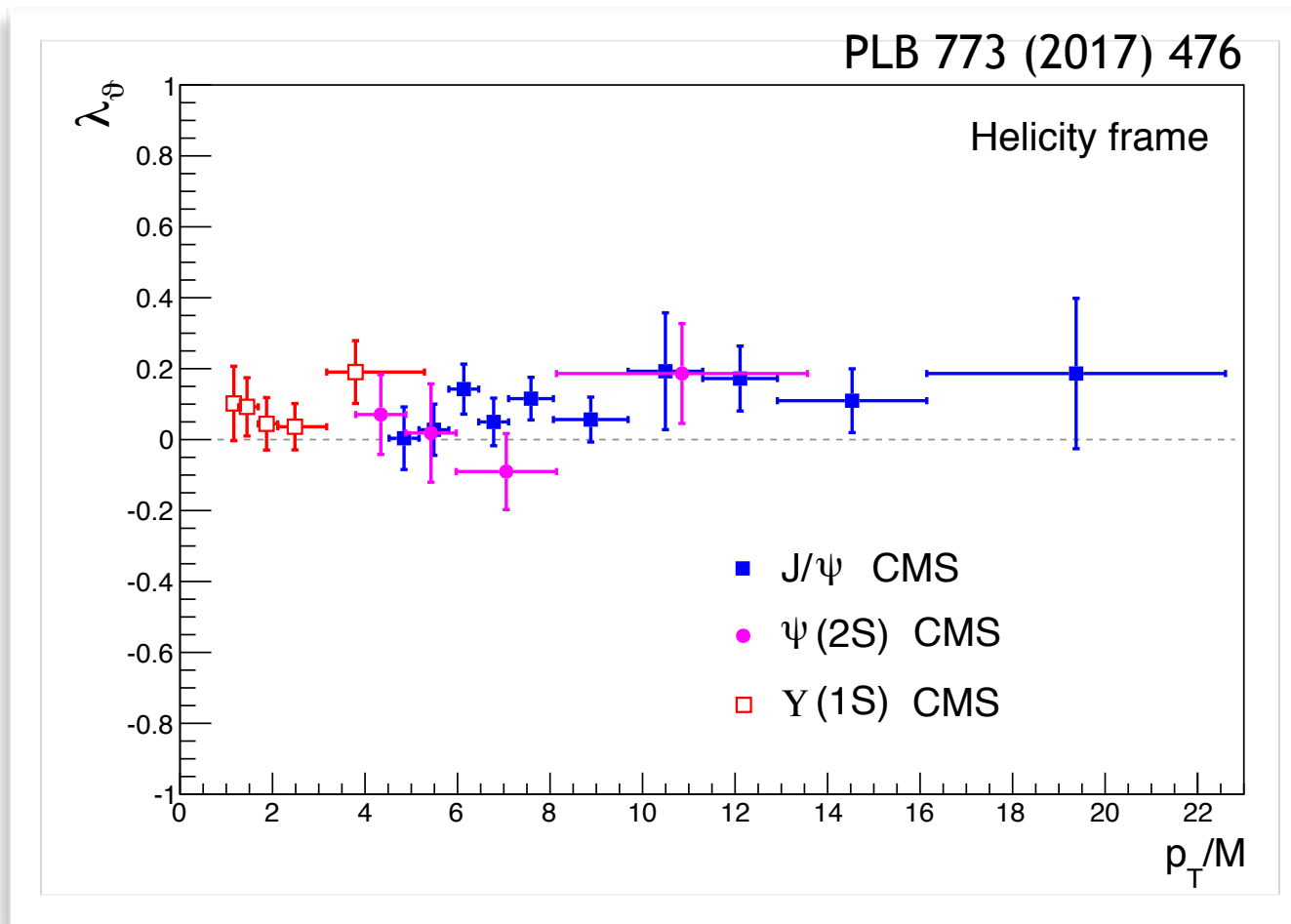
Can we measure the polarization of P-wave states?
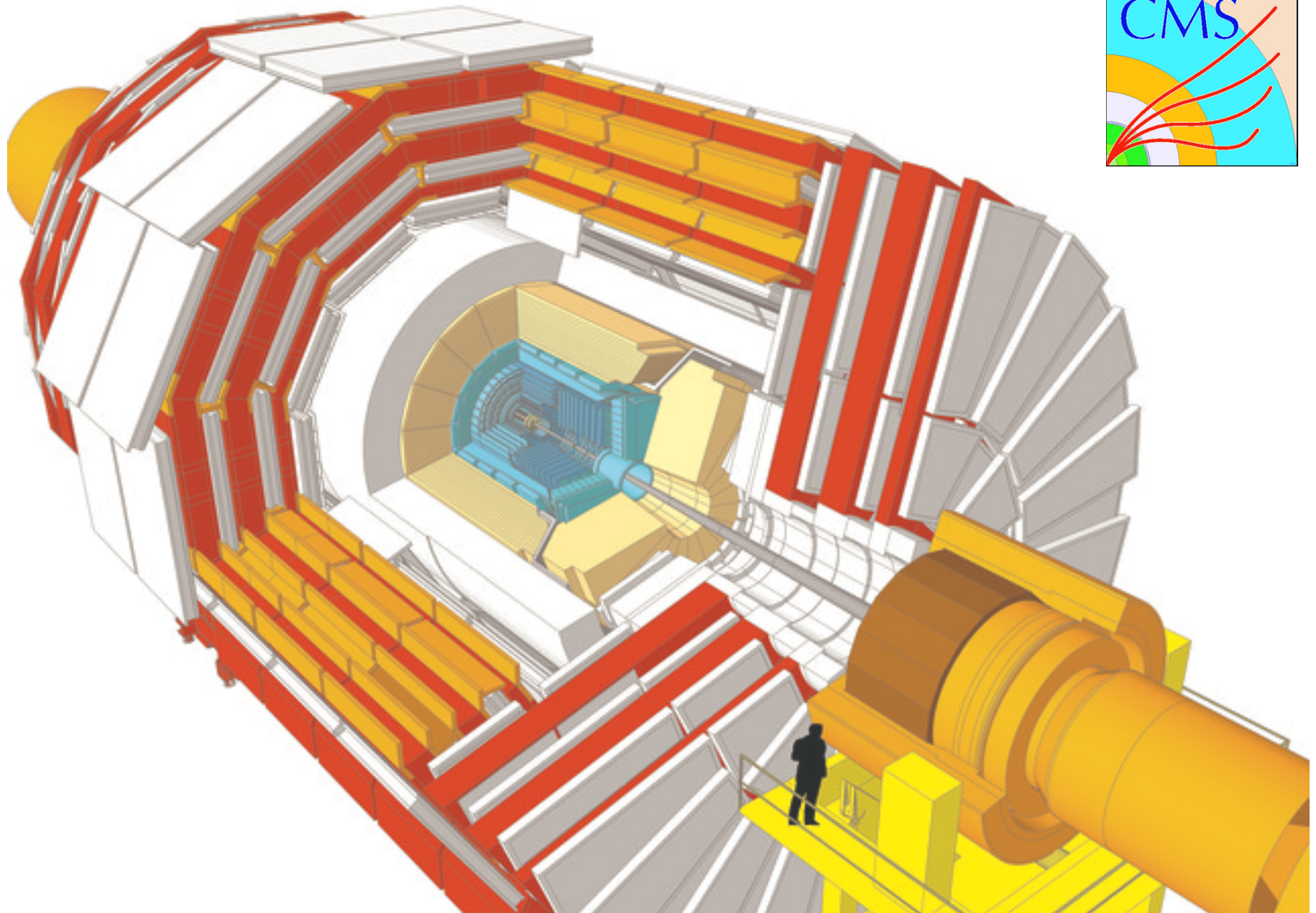
Can we measure the polarization of P-wave states?

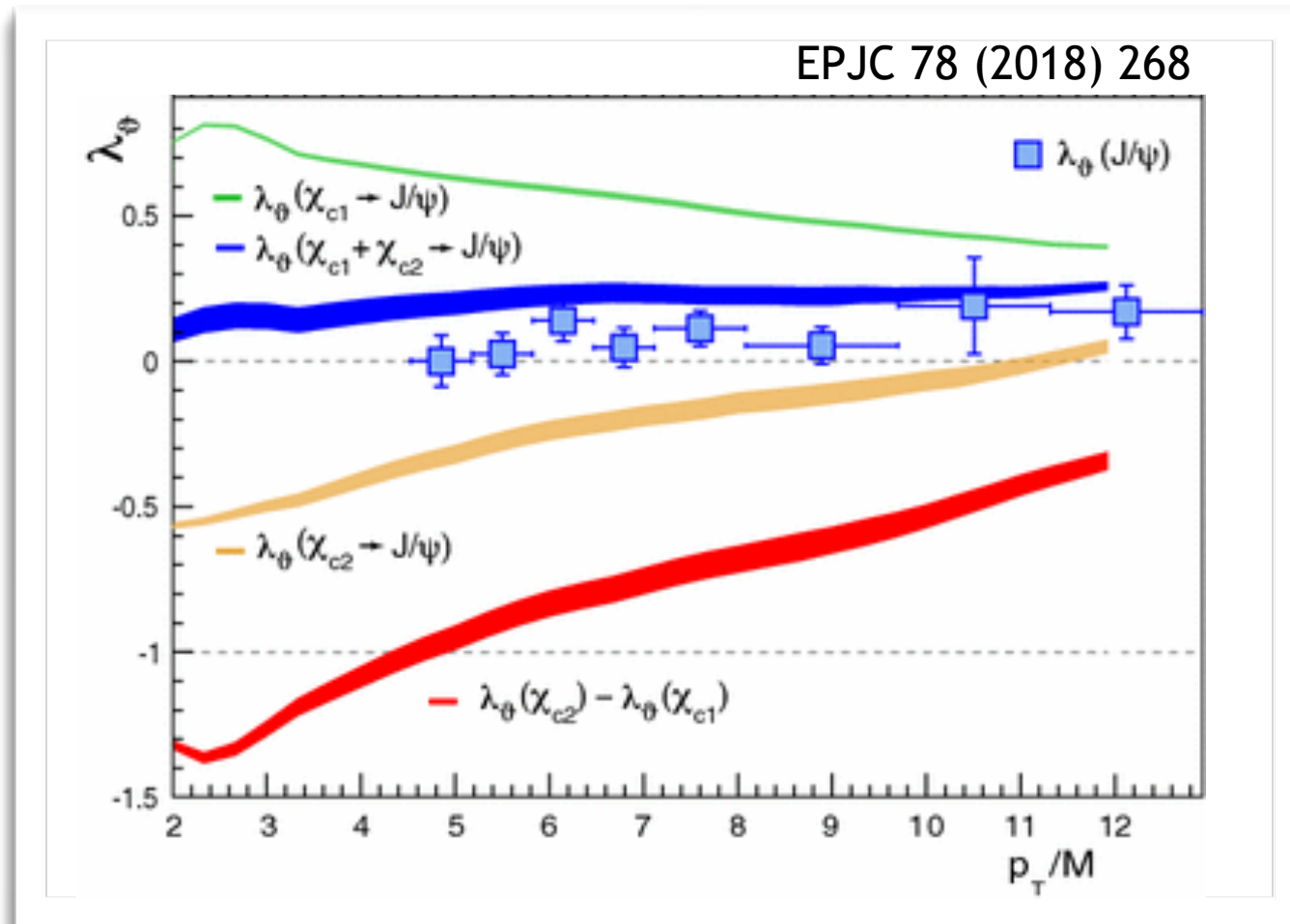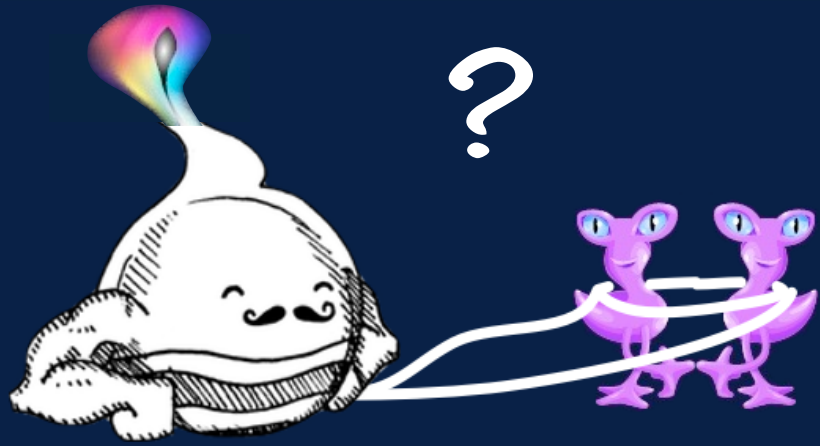# Can we measure the polarization of P-wave states?

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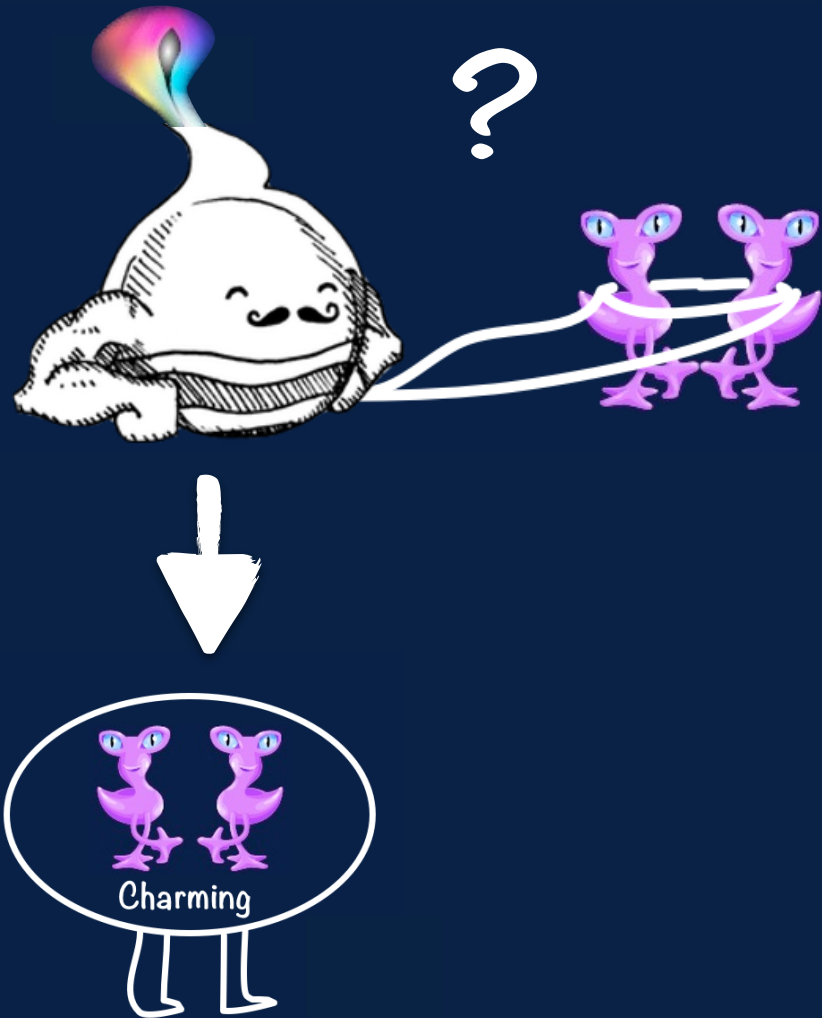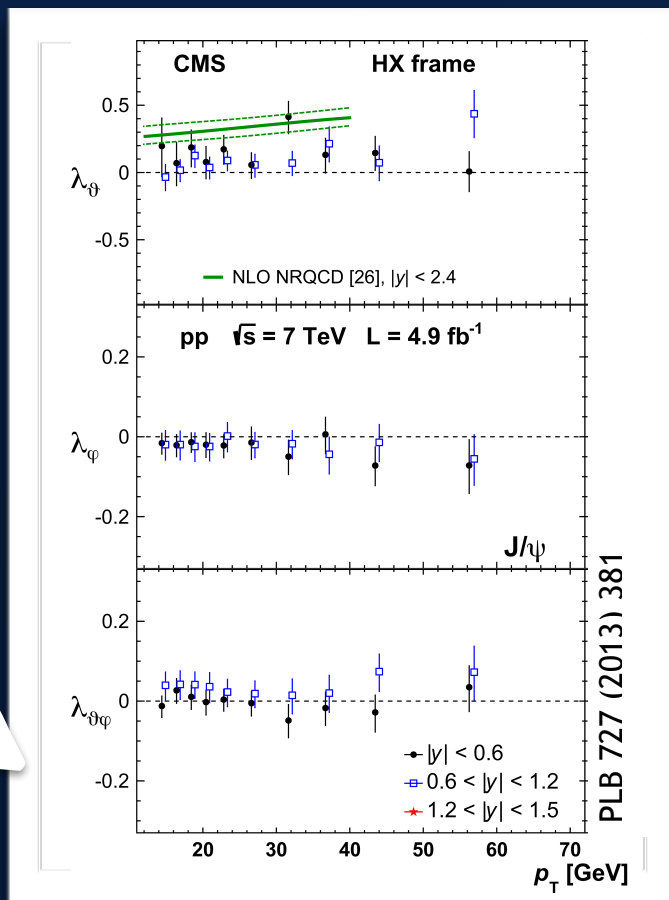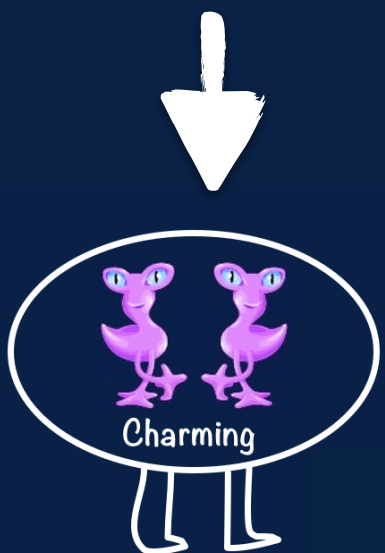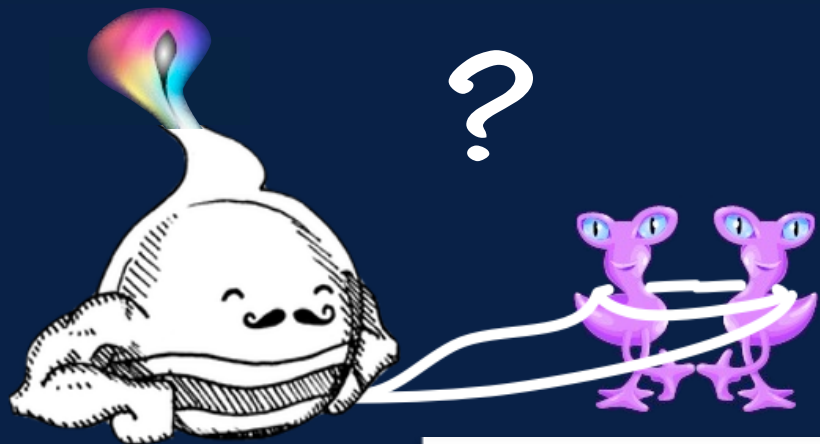Relative polarization measurement down to lowest possible transverse momentum

EPJC 78 (2018) 268
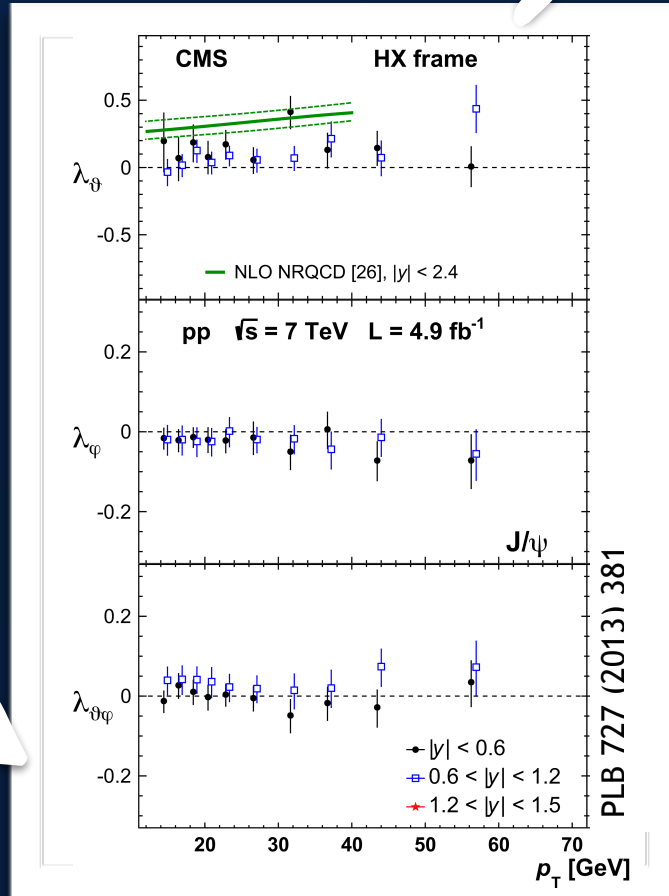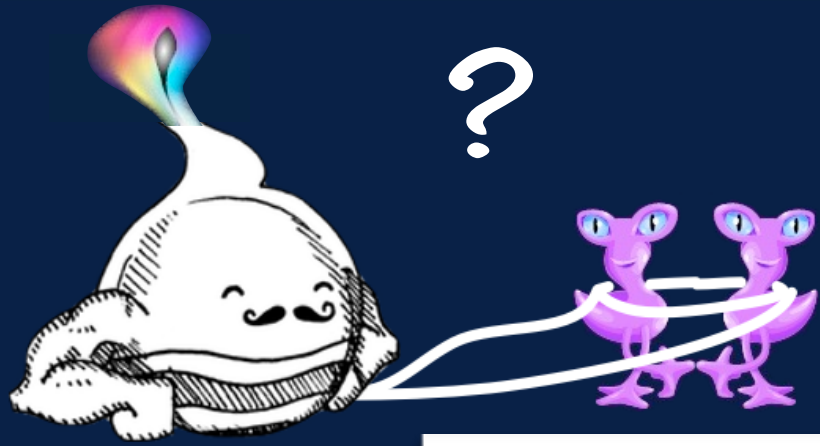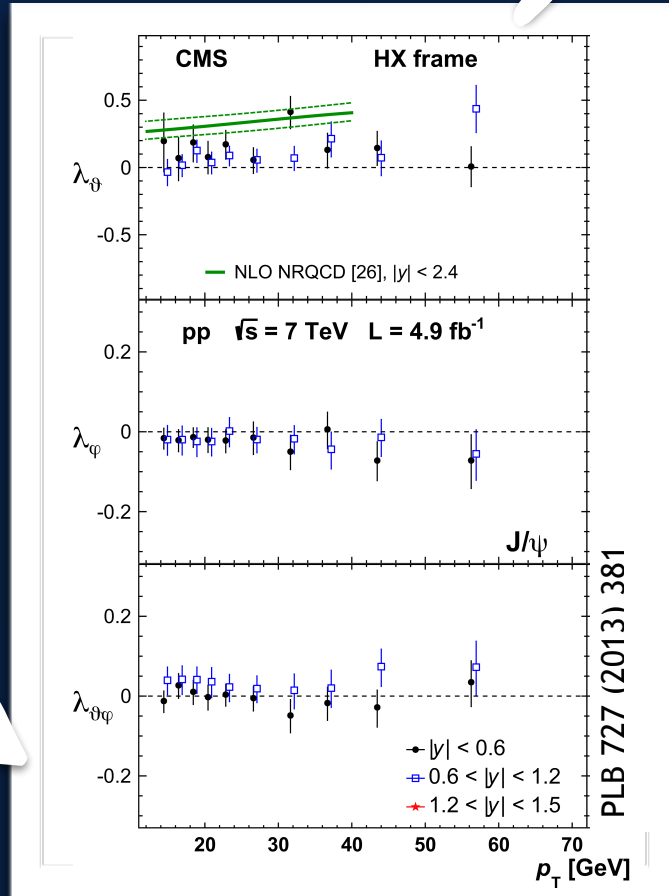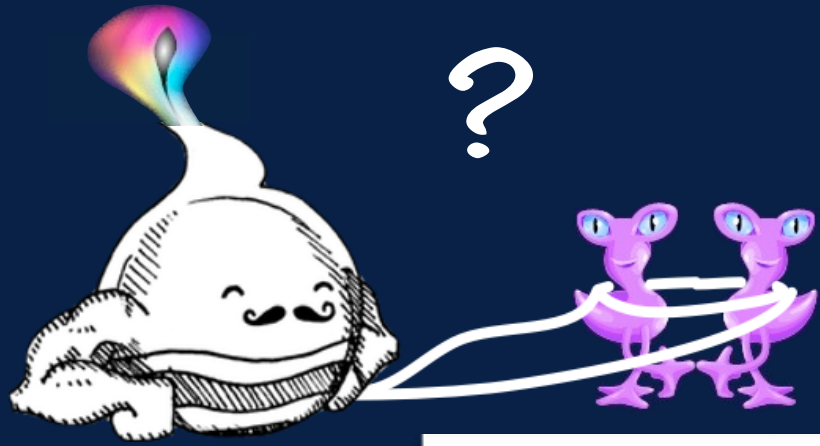
Summary and conclusions

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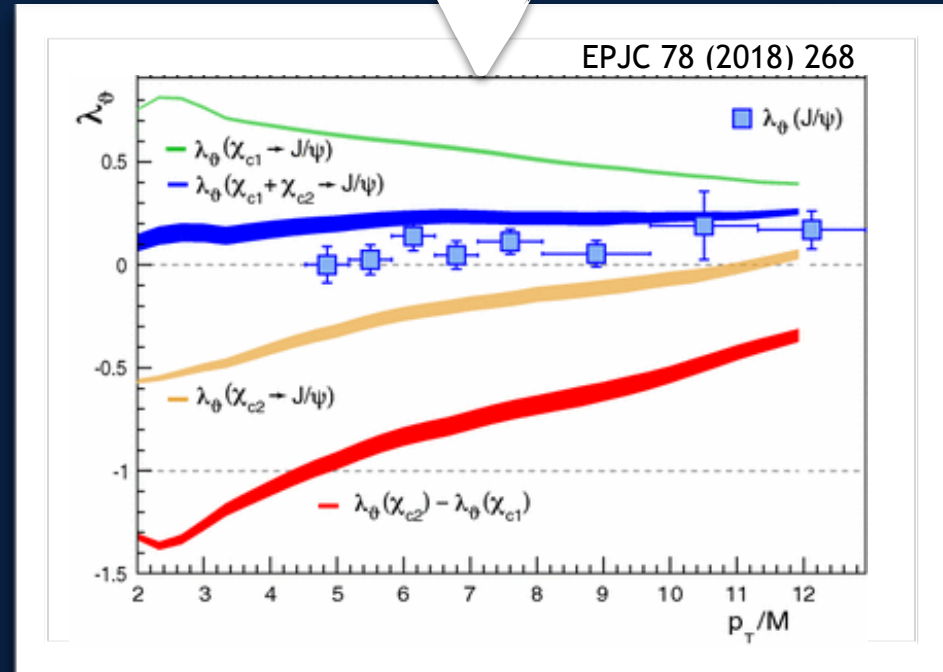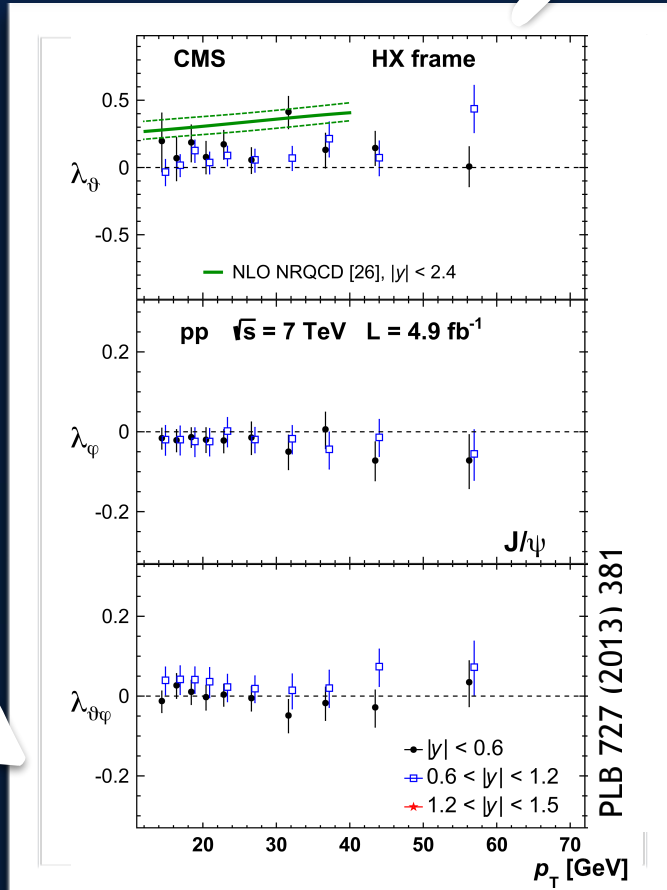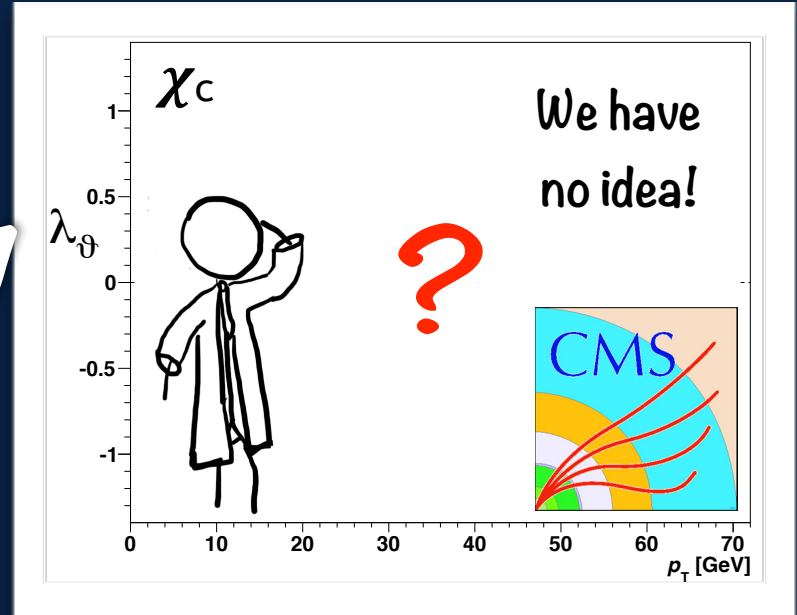
Summary and conclusions
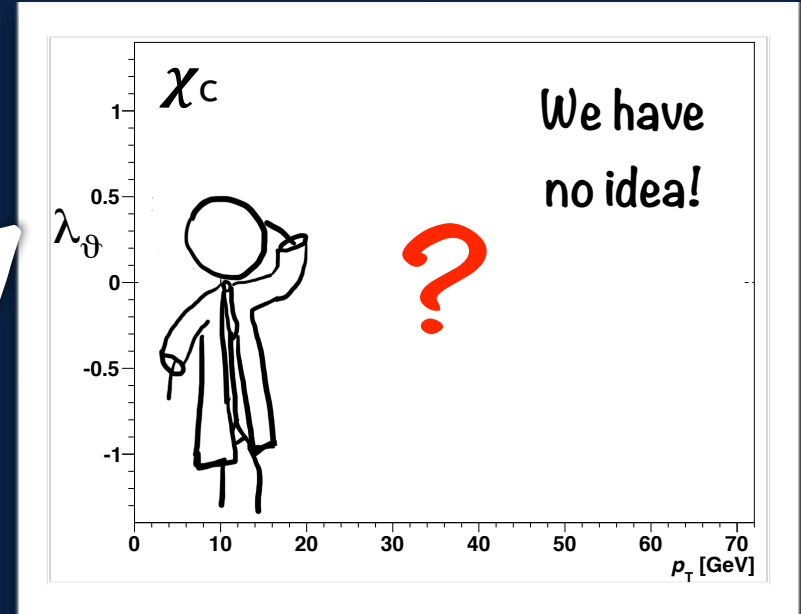
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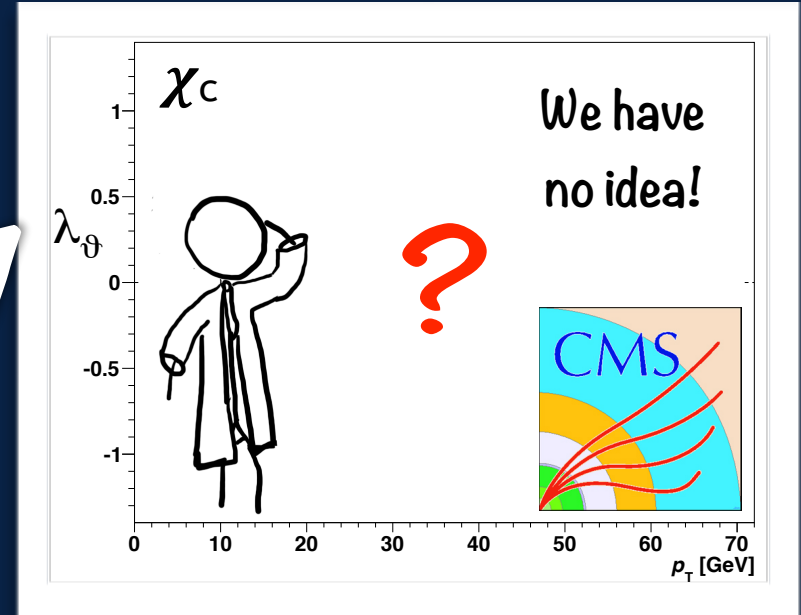
Summary and conclusions

WAITING FOR THE UNEXPECTED!