

Ultra-peripheral heavy ion results from CMS

CMS Experiment at LHC, CERN

Data recorded: Fri Nov 18 03:24:41 2011 CEST

Run/Event: 181969 / 18812570

Lumi section: 520

muon 1,
 $p_T = 1.28 \text{ GeV}/c$
 $\eta = -2.296$
 $\phi = 0.493$

Maximum HCal Tower,
 $E_T = 0.90 \text{ GeV}$
 $\eta = -0.305$
 $\phi = 1.614$

Maximum ECal Tower,
 $E_T = 0.58 \text{ GeV}$
 $\eta = -3.226$
 $\phi = -3.054$

muon 0,
 $p_T = 1.87 \text{ GeV}/c$
 $\eta = -1.840$
 $\phi = -2.100$

UPC J/ψ Candidate
 $m = 3.062 \text{ GeV}/c^2$

Michael Murray, DIS2015, 29th April 2015

CMS: HIN-12-009: <http://cds.cern.ch/record/1971267>



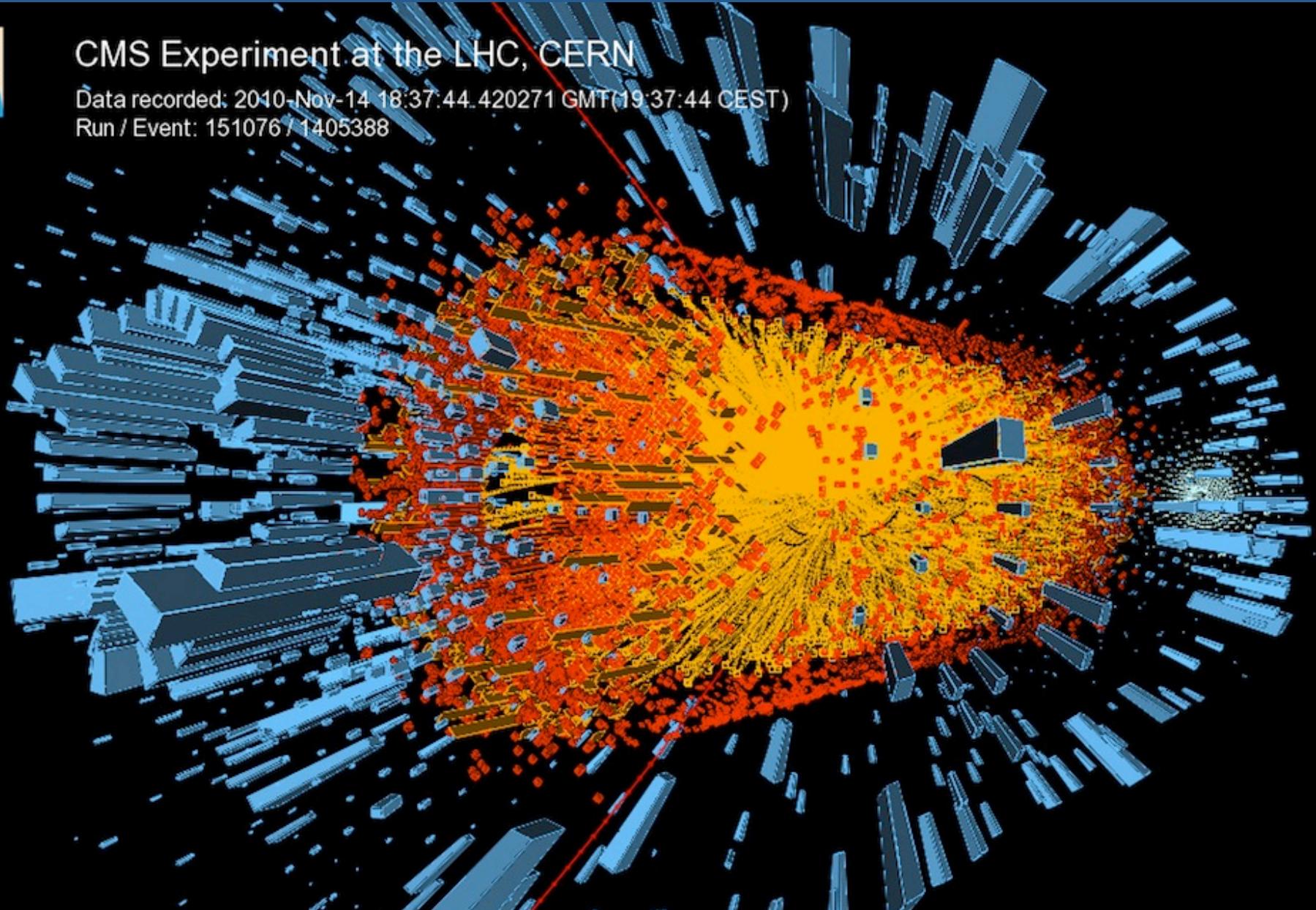
A typical heavy ion event



CMS Experiment at the LHC, CERN

Data recorded: 2010-Nov-14 18:37:44.420271 GMT (19:37:44 CEST)

Run / Event: 151076 / 1405388



3 big questions in heavy ions

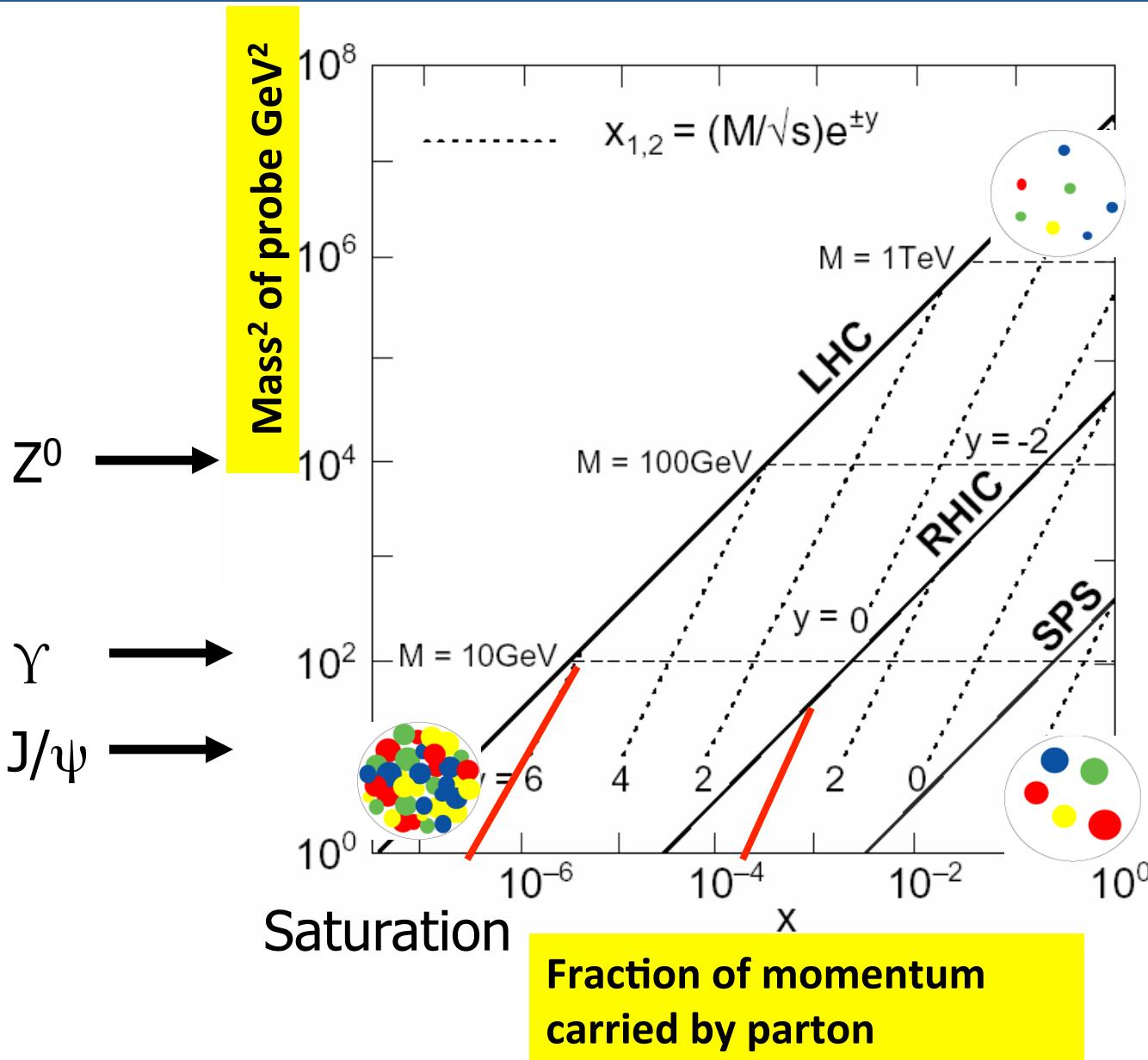
The matter produced in heavy ion collisions seems to flow like an almost perfect fluid of deconfined quarks and gluons. But big questions remain.

1. What are the degrees of freedom of the plasma
2. What is the viscosity of the medium
3. Is the nuclear wavefunction a gluon condensate?

Photo-nucleus collisions probe the initial state of the nucleus. This is a vital boundary condition for hydrodynamic studies of the viscosity



Searching for color glass

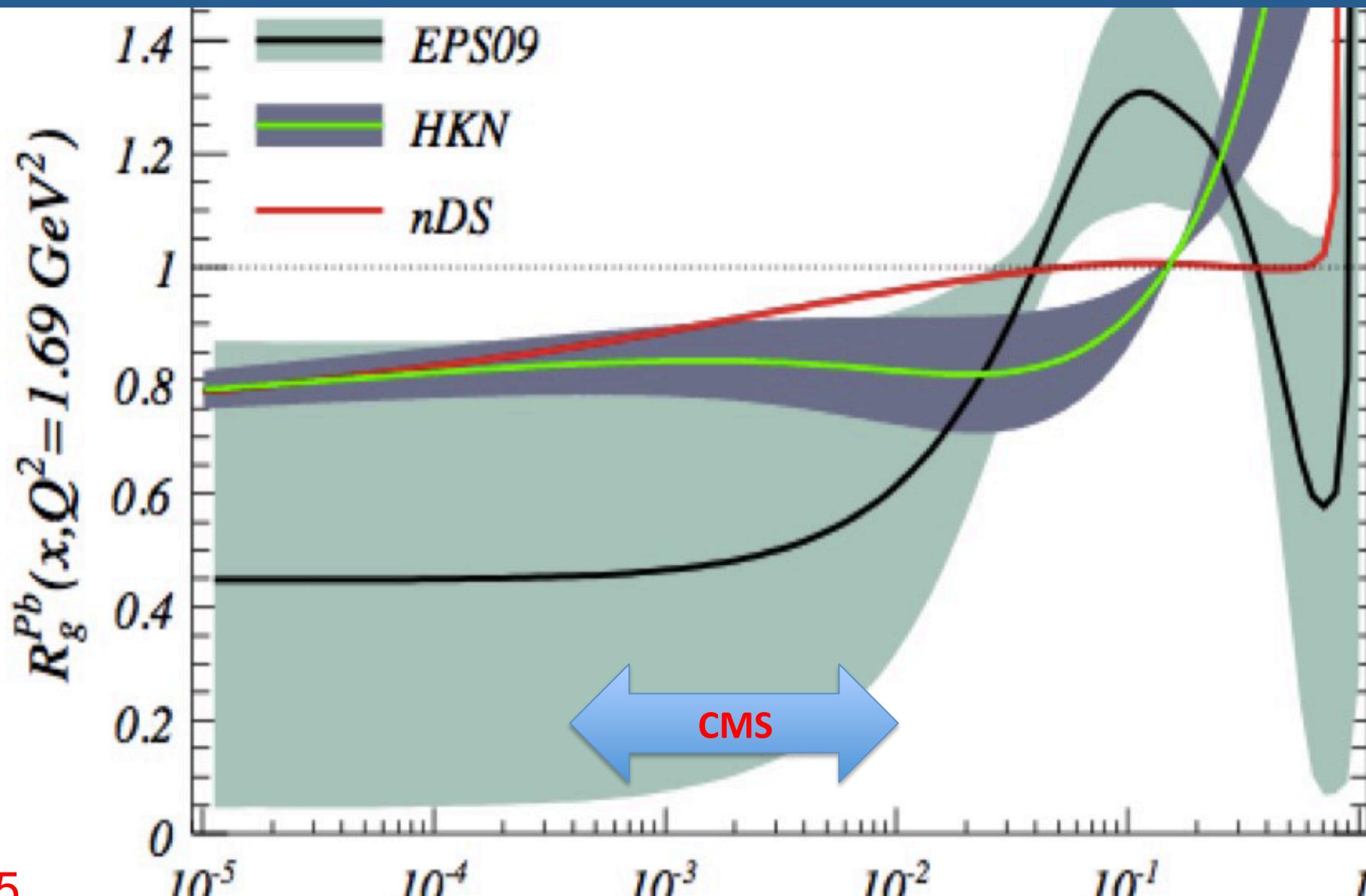


Access to widest range phase space

Gluon density has to saturate at low x

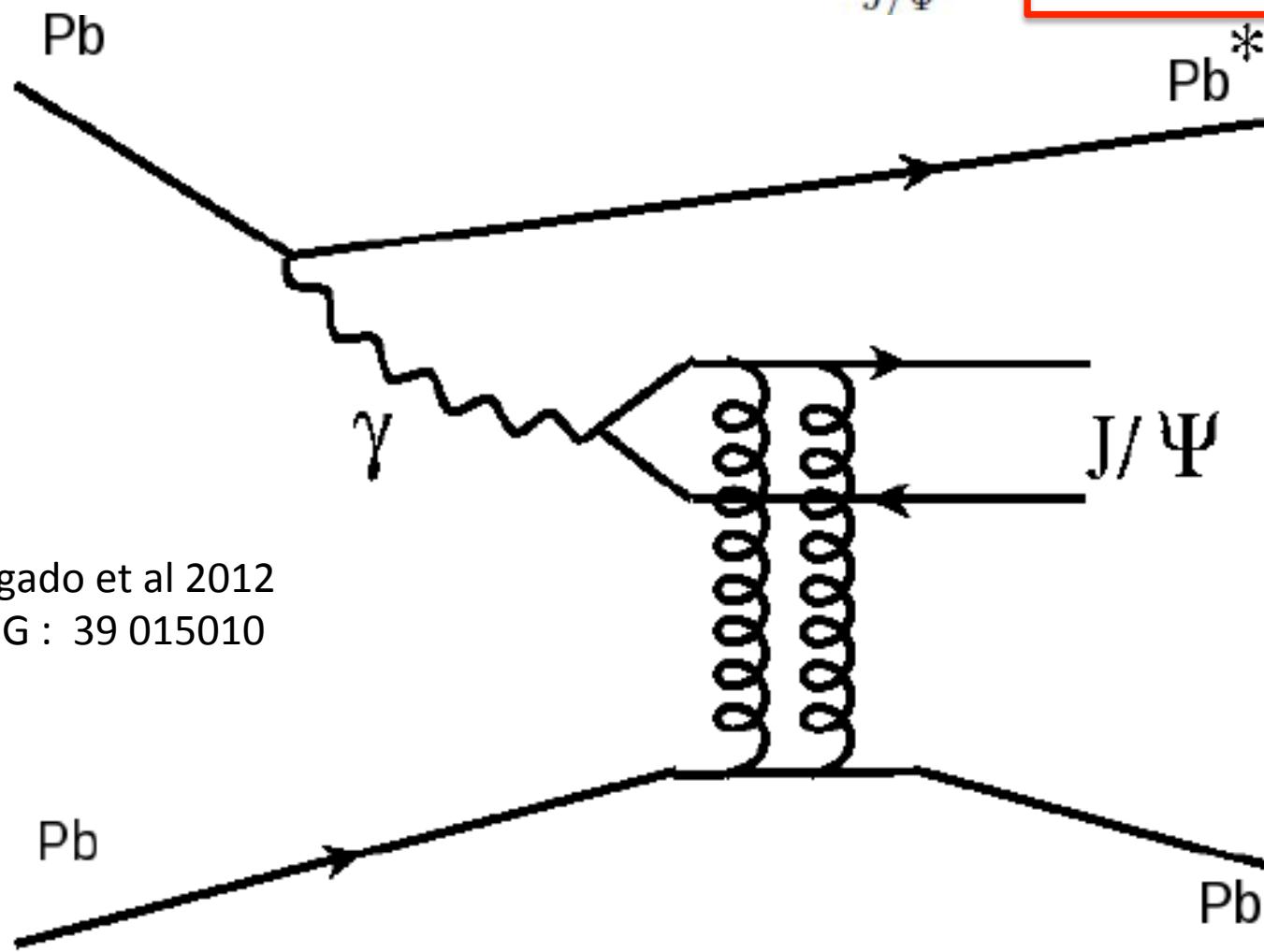


Uncertainties in nuclear PDFs



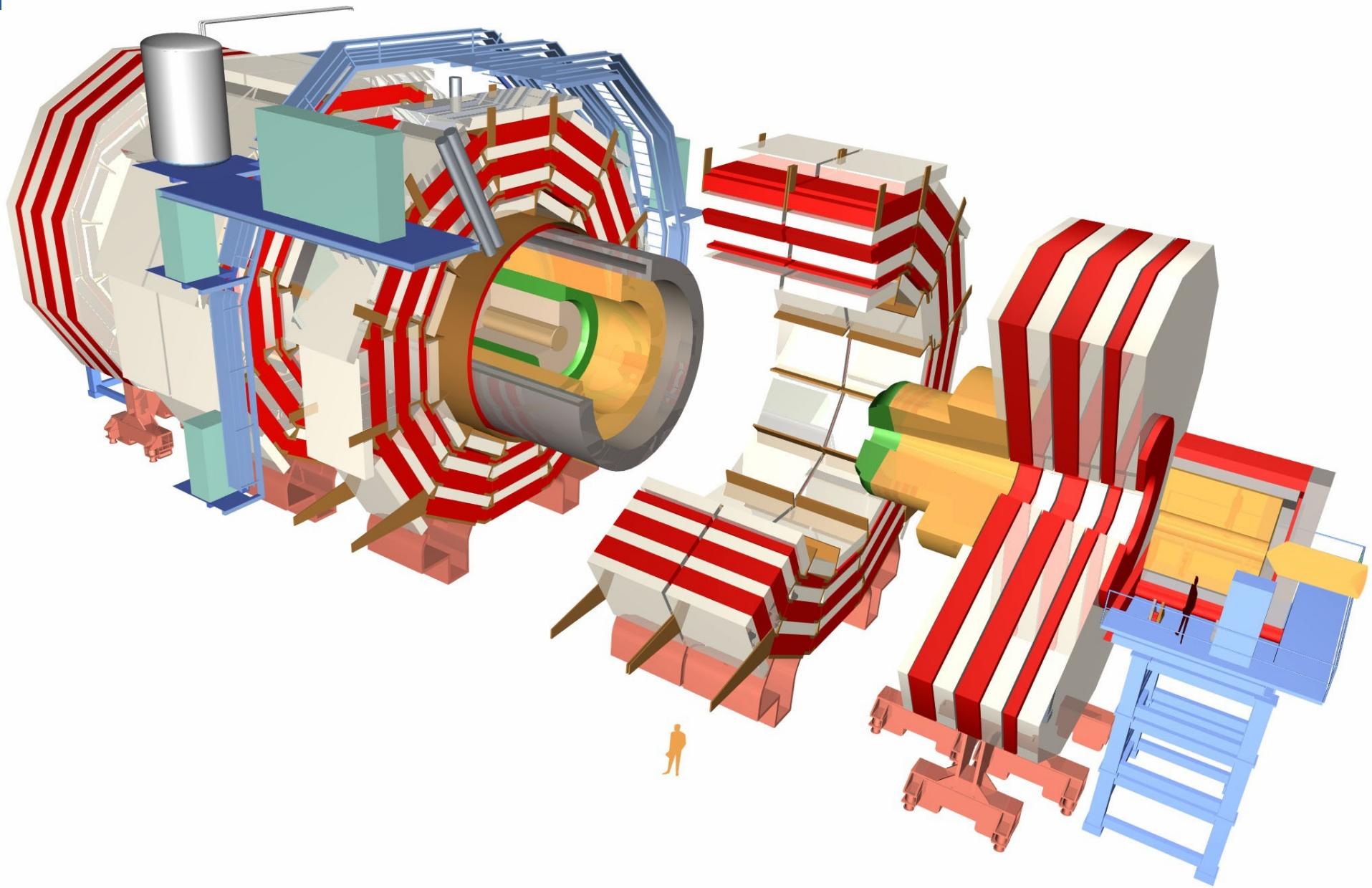
Coherent J/ ψ scales with (gluon density) 2

$$\frac{d\sigma_{\gamma A \rightarrow J/\Psi A}}{dt} \Big|_{t=0} = \xi_{J/\Psi} \left(\frac{16\pi^3 \alpha_s^2 \Gamma_{l+l^-}}{3\alpha M_{J/\Psi}^5} \right) [xG_A(x, \mu^2)]^2$$



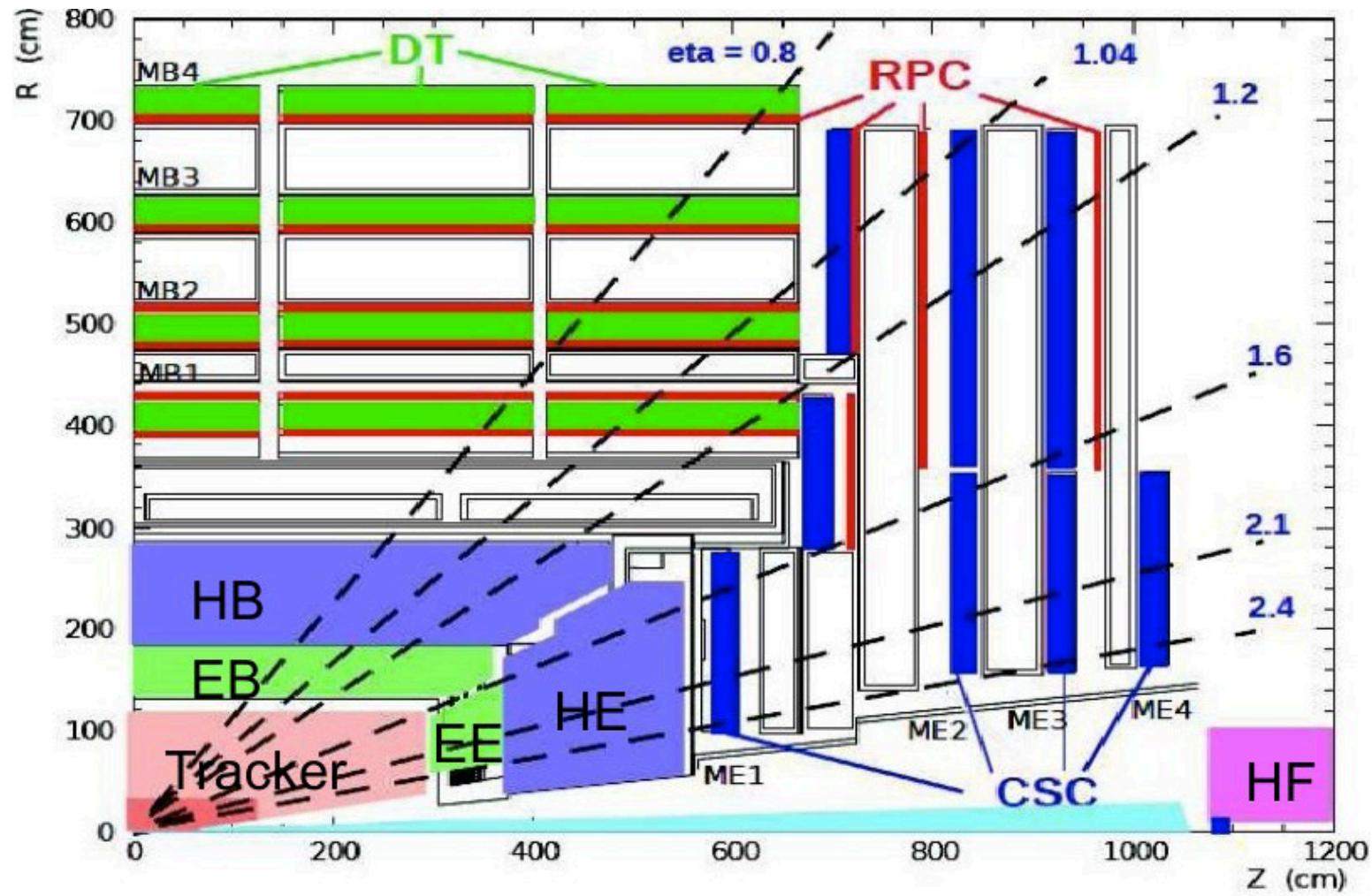
C. A. Salgado et al 2012
J. Phys . G : 39 015010

The CMS detector



$\frac{1}{4}$ slice tracker, calorimeter and muons

Tracker & calorimeter cuts ensure exclusivity, muons reconstruct J/ ψ

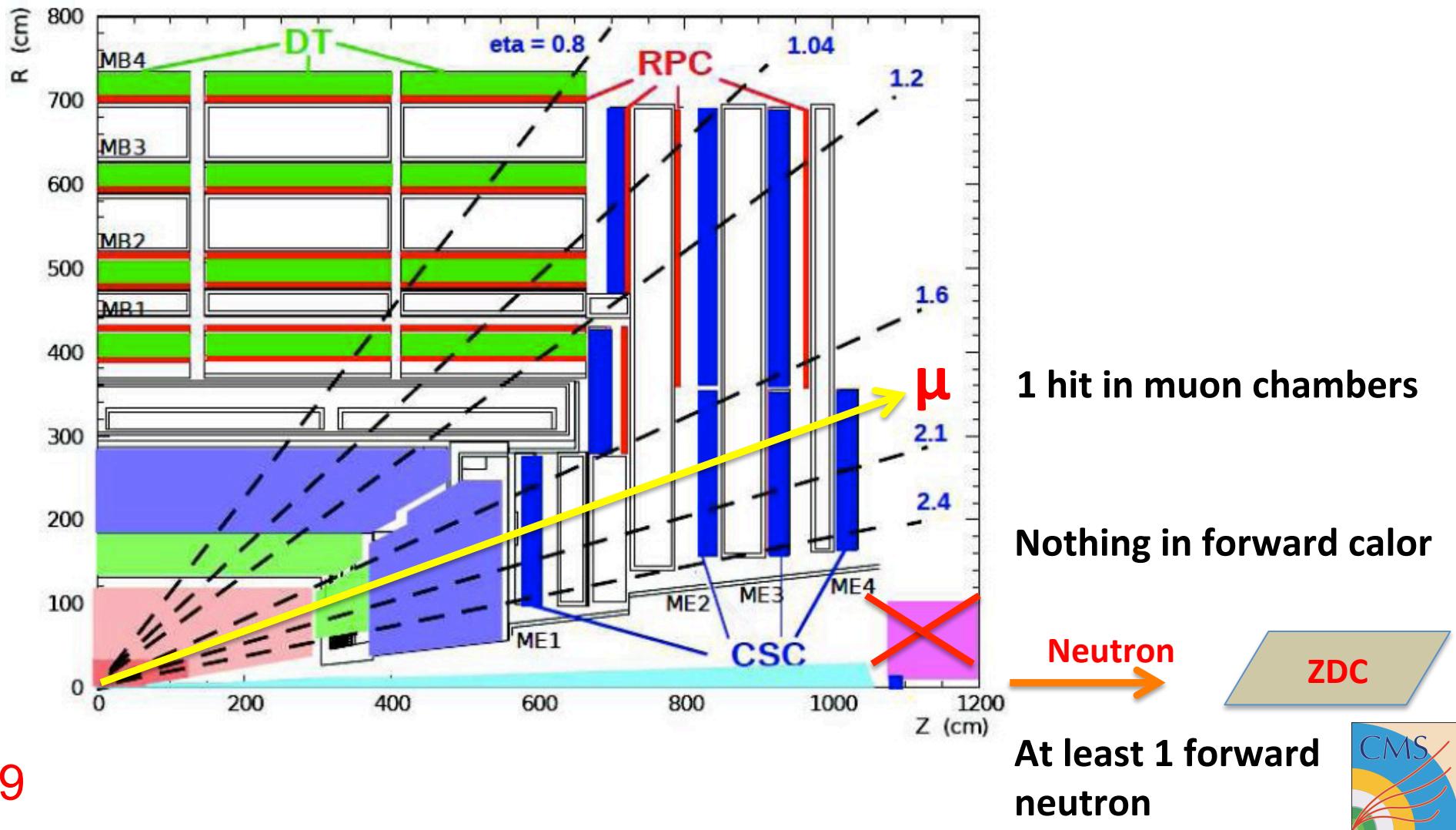


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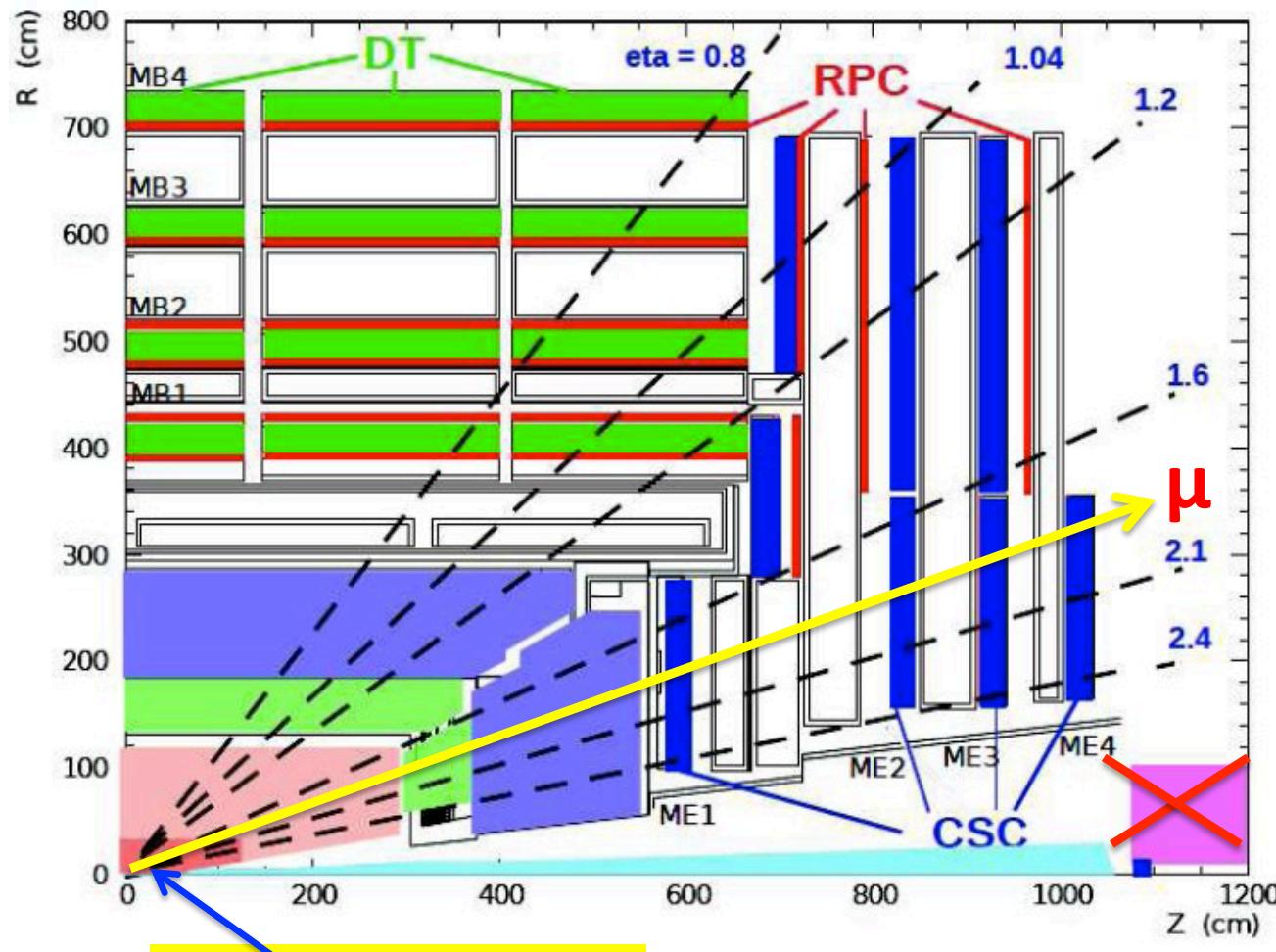
P_T resolution 1-2%, trigger collects about 95% of PbPb luminosity



Level 1 Triggering

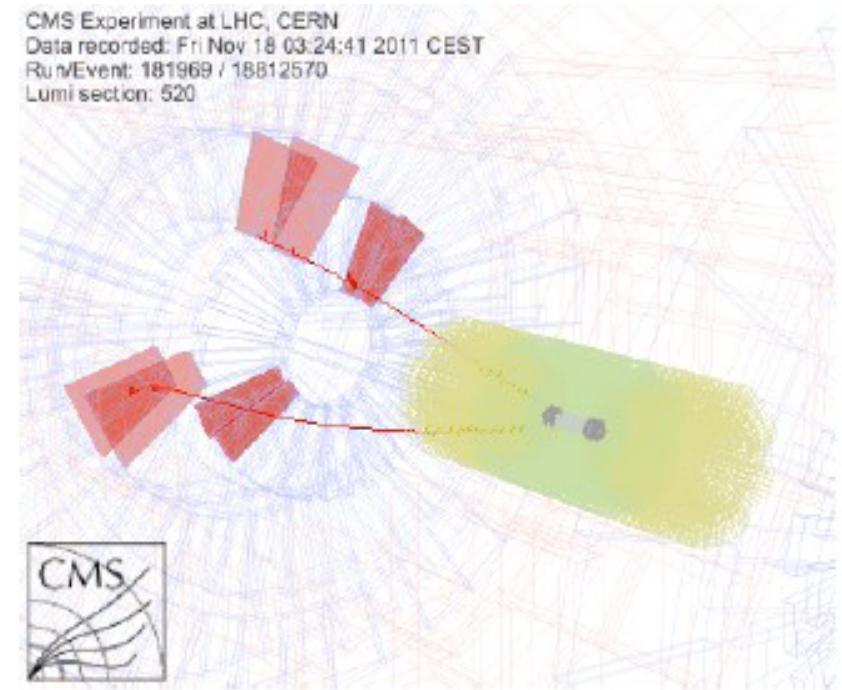


High Level Trigger



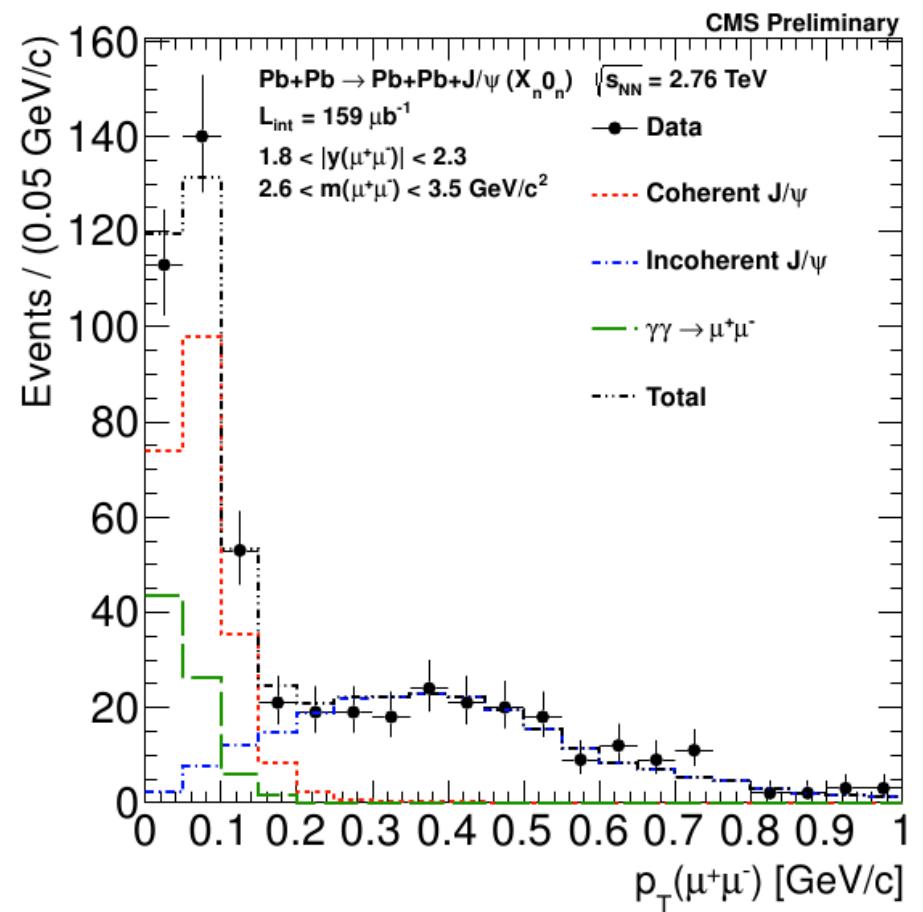
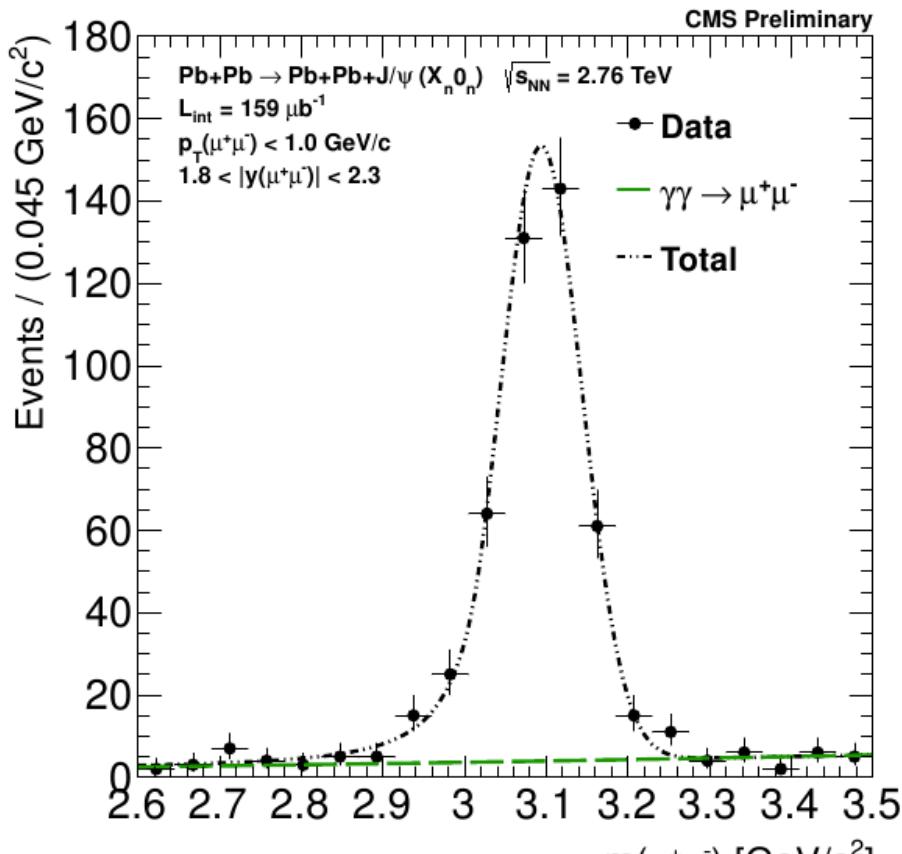
Event Selection

- Require good vertex, i.e. $\sqrt{x^2 + y^2} < 2$ cm and $|Z| < 25$ cm
- No energy in forward calorimeters, $3 < |\eta| < 5$
- 2 tracks with $\chi^2/\text{ndf} < 3$ at least 5 hits in the tracker and $< 3 \sigma$ match between tracker and muon system.
- $1.2 \text{ GeV} < p_{T\mu} < 1.8 \text{ GeV}$
- $1.2 < |\eta_\mu| < 2.4$



**517 candidate J/ψs
with $p_T < 1 \text{ GeV}/c$
and $1.8 < |y| < 2.3$**

Fit to mass and p_T to extract signal



207 ± 18 coherent J/ψ with $p_T < 0.15$ GeV

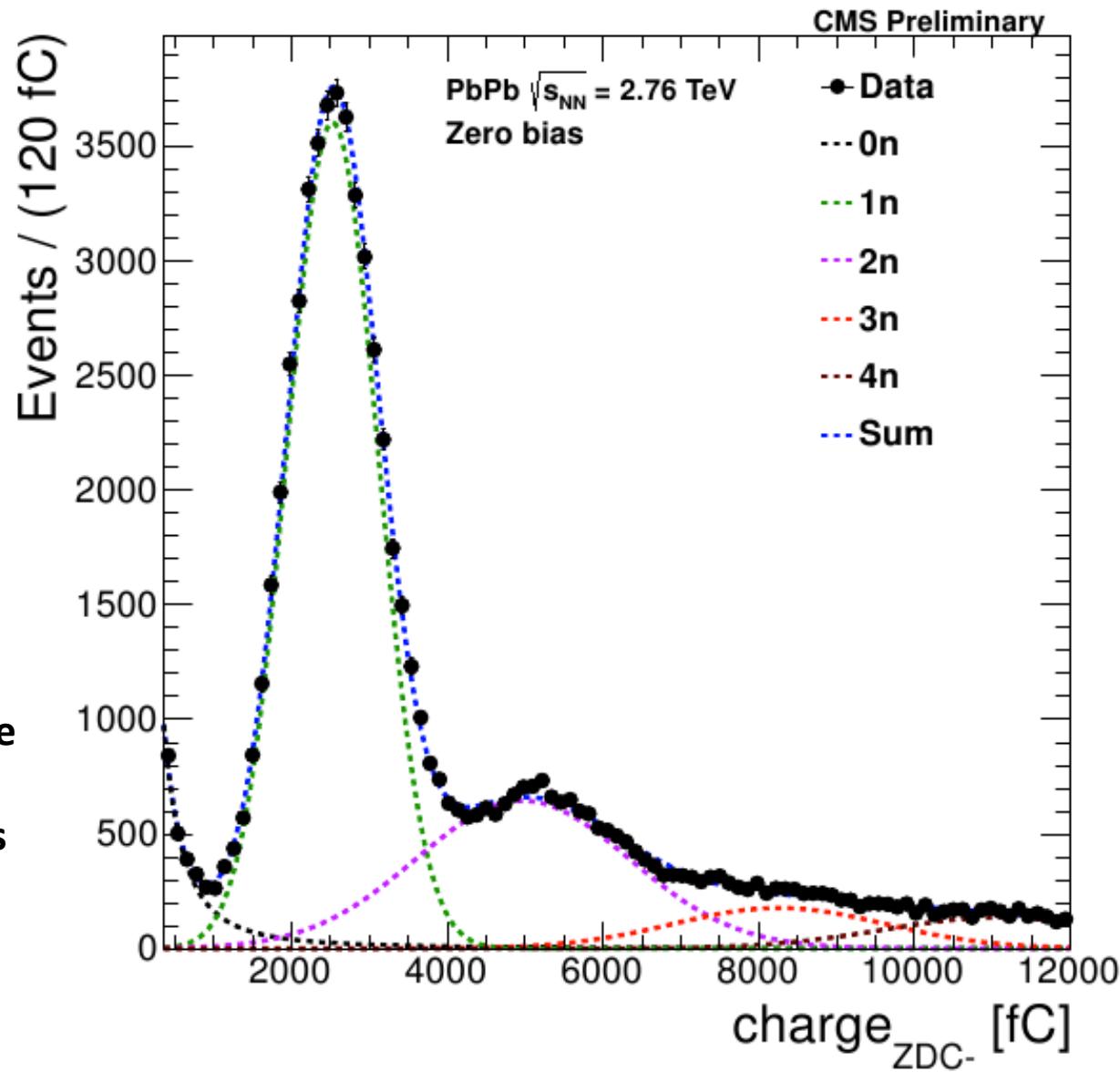
Acceptance and Efficiency Corrections

$$\frac{d\sigma_{X_n 0_n}^{coh}}{dy}(\text{J}/\psi) = \frac{N_{coh}^{\text{J}/\psi}}{BR(\text{J}/\psi \rightarrow \mu^+ \mu^-) \cdot \mathcal{L}_{int} \cdot \Delta y \cdot (A \times \varepsilon)^{\text{J}/\psi}}$$

- The acceptance and reconstruction efficiency are estimated from MC and found to be 12%
- The trigger efficiency is measured from data and found to be 50%

Identifying Neutrons in the ZDCs

Thresholds are
set from
minimum bias
data



First measurement of break up modes for UPC J/ ψ

Xn0n single-sided with any number of neutrons

XnXn double-sided with any number of neutrons on either side

1n0n single-sided with exactly one neutron on just one side

1n1n double-sided with only one neutron on each side

J/ ψ with $p_T < 0.15 \text{ GeV}/c$	$X_n X_n / X_n 0_n$	$1_n 0_n / X_n 0_n$	$1_n 1_n / X_n 0_n$
Data	0.36 ± 0.04	0.26 ± 0.03	0.03 ± 0.01
STARLIGHT	0.37	N/A	0.02
GSZ	0.32	0.30	0.02

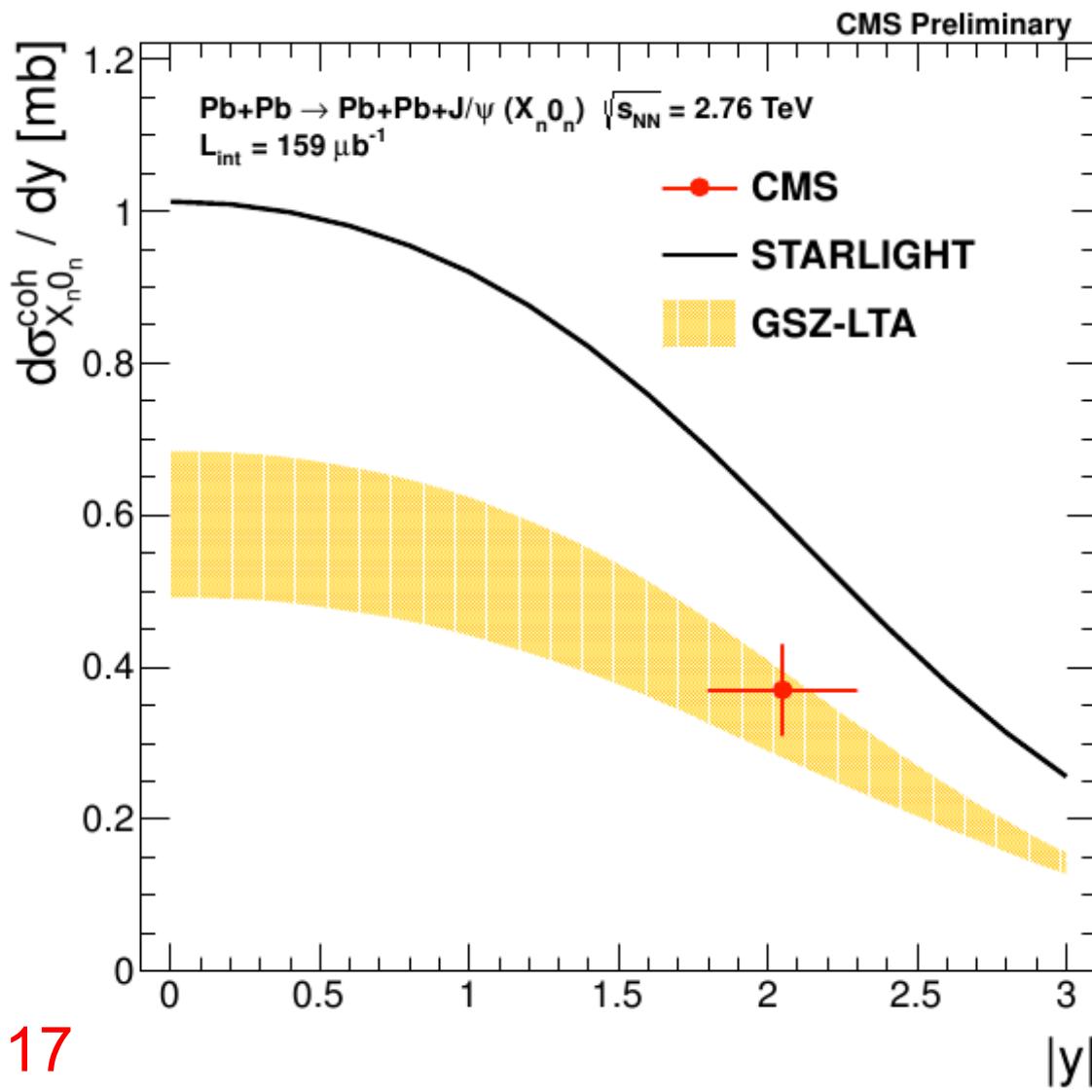
Systematic Uncertainties

Table 1: Summary of systematic uncertainties.

	Uncertainty
(1) Neutron tagging	6%
(2) HF energy cut	1%
(3) signal extraction	5%
(4) MC input	1%
(5) ZDC efficiency estimation	3%
(6) Tracking reconstruction	4%
(7) Luminosity determination	5%
(8) Branching ratio	1%
Total	11%

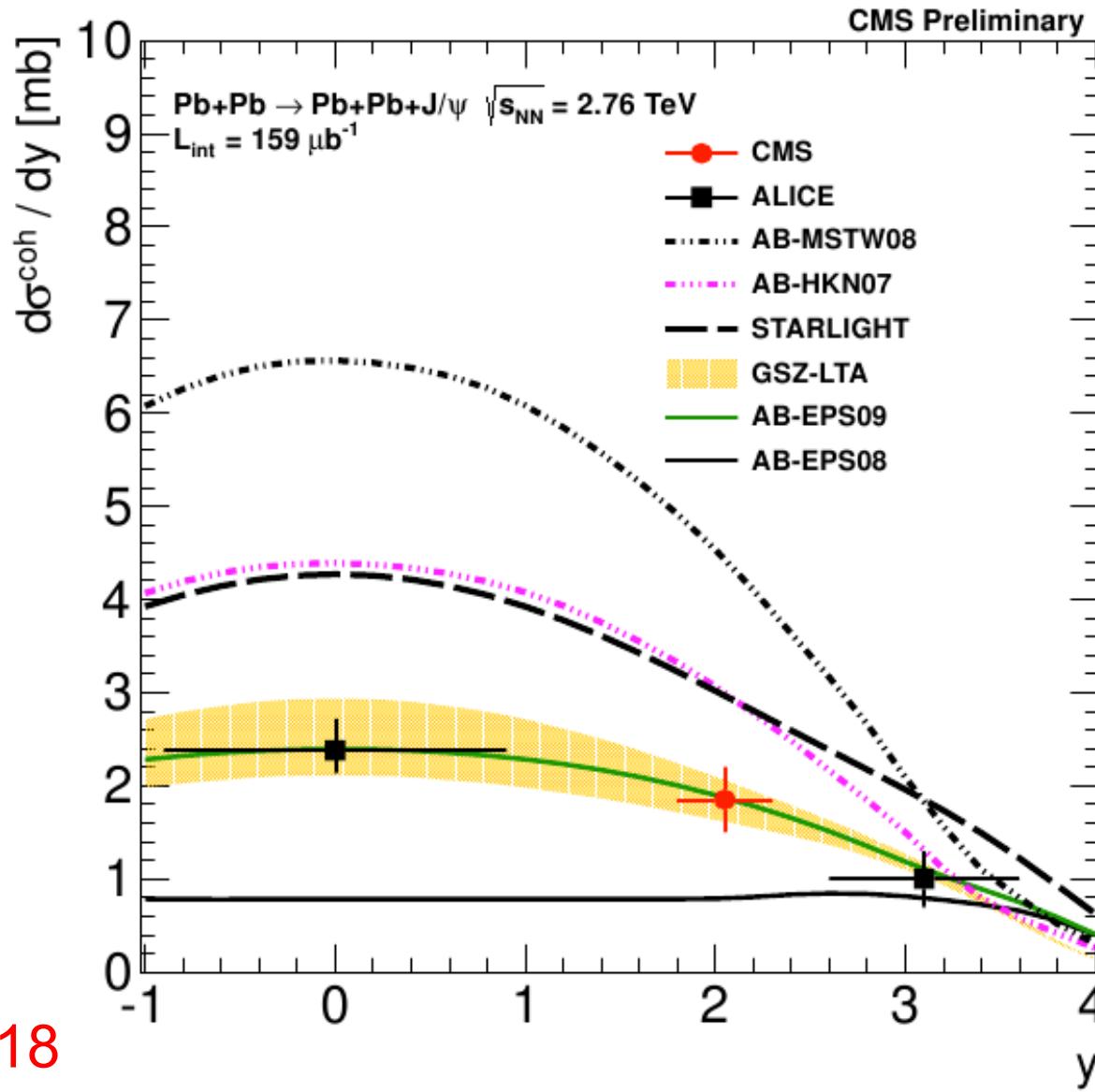


Coherent cross section for PbPb J/ψ



For the $X_n O_n$ mode the coherent cross section is $d\sigma/dy = 0.37 \pm 0.04 \pm 0.04 \text{ mb}$
This is the dominant mode that has neutron emission.

Comparisons to ALICE and models

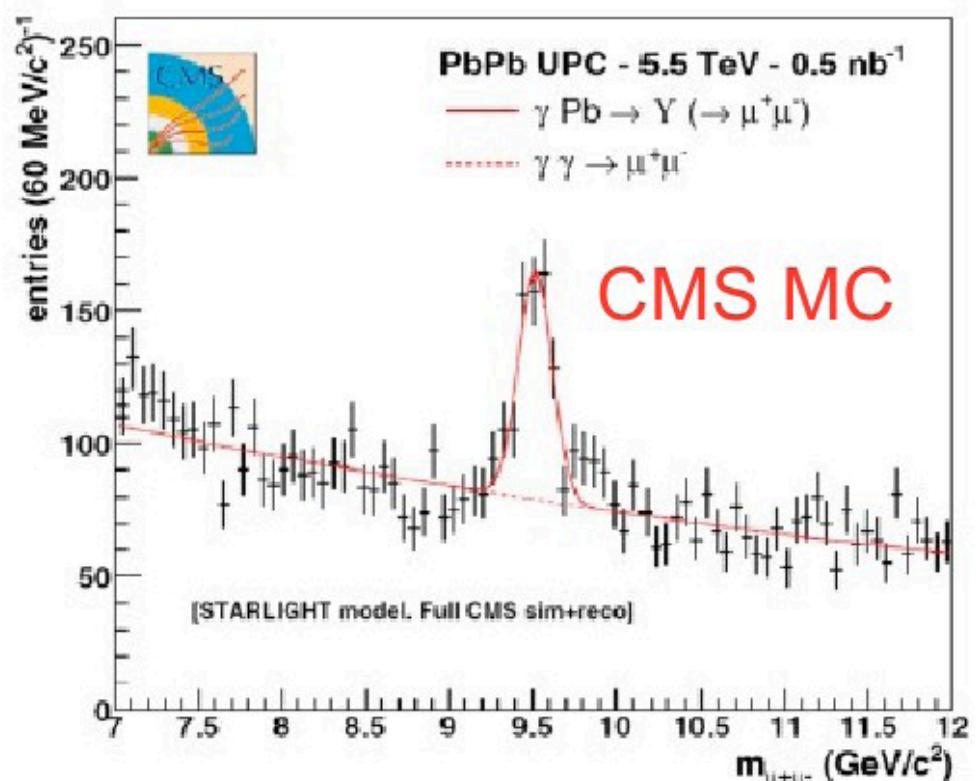
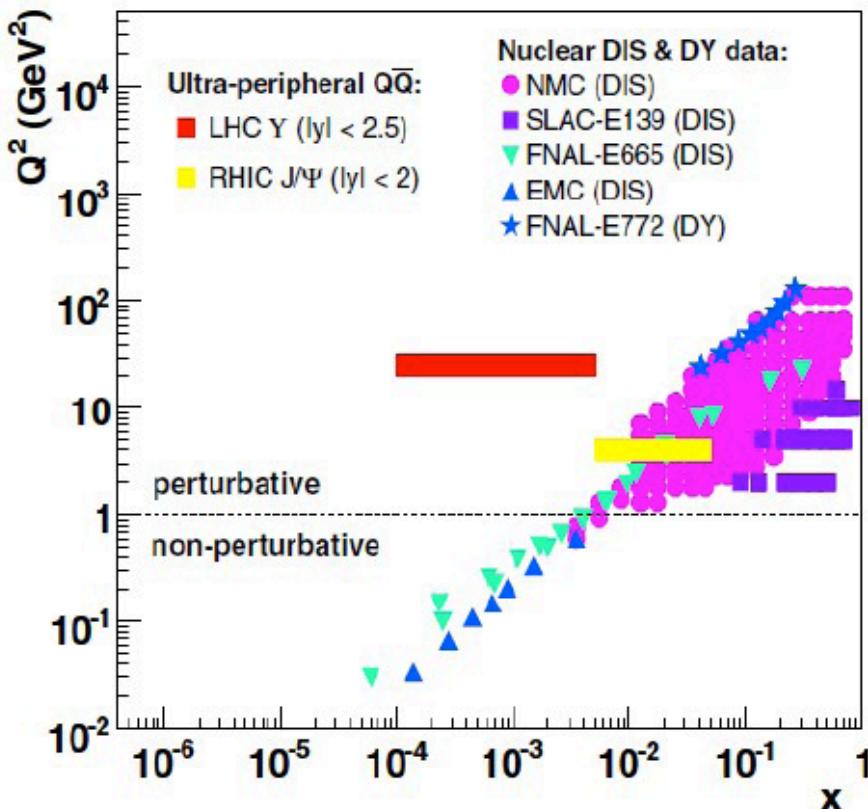


Cross section for XnOn is scaled up to the total cross section with STARLIGHT.

Data favor models containing moderate gluon shadowing

ALICE: Eur.Phys.J. C73 (2013) 2617,
Phys.Lett. B 718 (2013) 1273

Prospects for upsilon in 2015



Nuclear Physics B 179–180 (2008) 150–155

**Given increase in luminosity and energy
of 5.1 TeV we expect 200 – 1000 Υ**



Summary

- UPC quarkonia offer a clean probe of the initial state, in particular the nuclear gluon density
- CMS and ALICE coherent J/y cross sections favors theoretical models including nuclear gluon shadowing
- Break-up ratios are consistent with theoretical models using multiple photon exchange
- The 2015 run offers the opportunity to study UPC Y and potentially new objects like dijets

Backup