Measuring the $J/\psi \rightarrow \mu^+\mu^-$ production cross section with CMS

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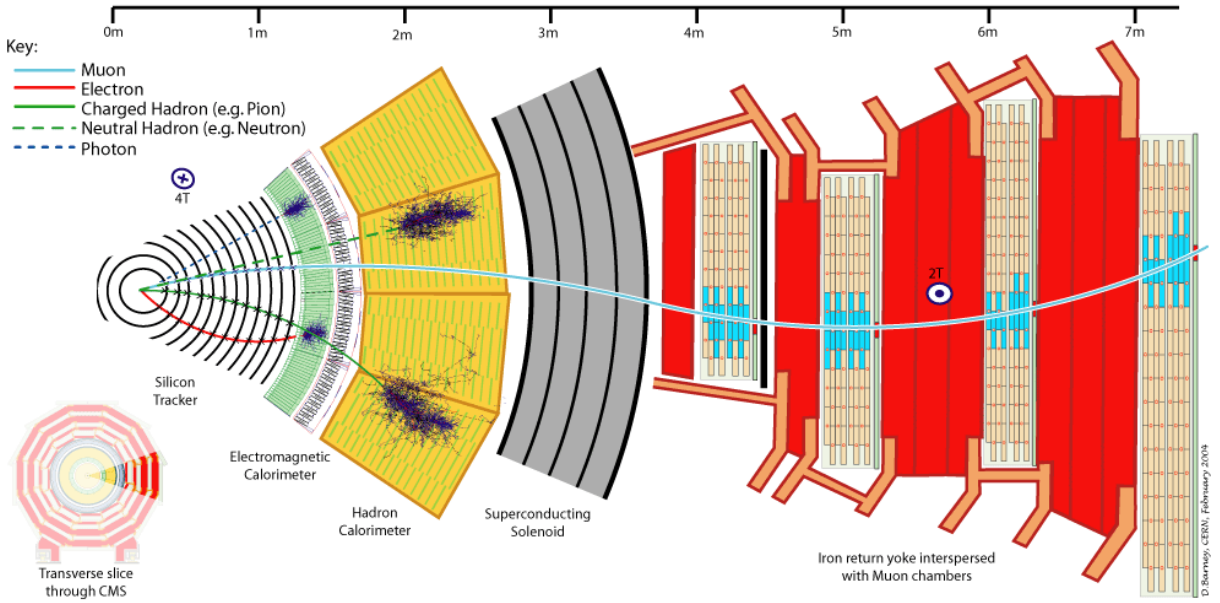
Motivations

- **LHC will produce large yields of J/ψ particles in the next few months thanks to the high collision energy and luminosity**
  - **CMS will probe J/ψ high momentum regions, extending the test of the different production mechanisms in regions never probed before**
- **CMS precision tracking will permit to distinguish prompt J/ψ's from those from B-hadron decays**
  - **Allowing to determine also the B-hadron cross section**
- **J/ψ differential cross section measurement is also an excellent test for CMS:**
  - **Monitoring detector performance (calibration and alignment)**
  - **Tuning muon reconstruction and identification**



Inclusive J/ψ Cross Section

$$\frac{\Delta\sigma(J/\psi)\cdot Br(J/\psi\to\mu^+\mu^-)}{\Delta p_T}=\frac{N_{fit}^{J/\psi}}{A\cdot\varepsilon\cdot L\cdot\Delta p_T}$$

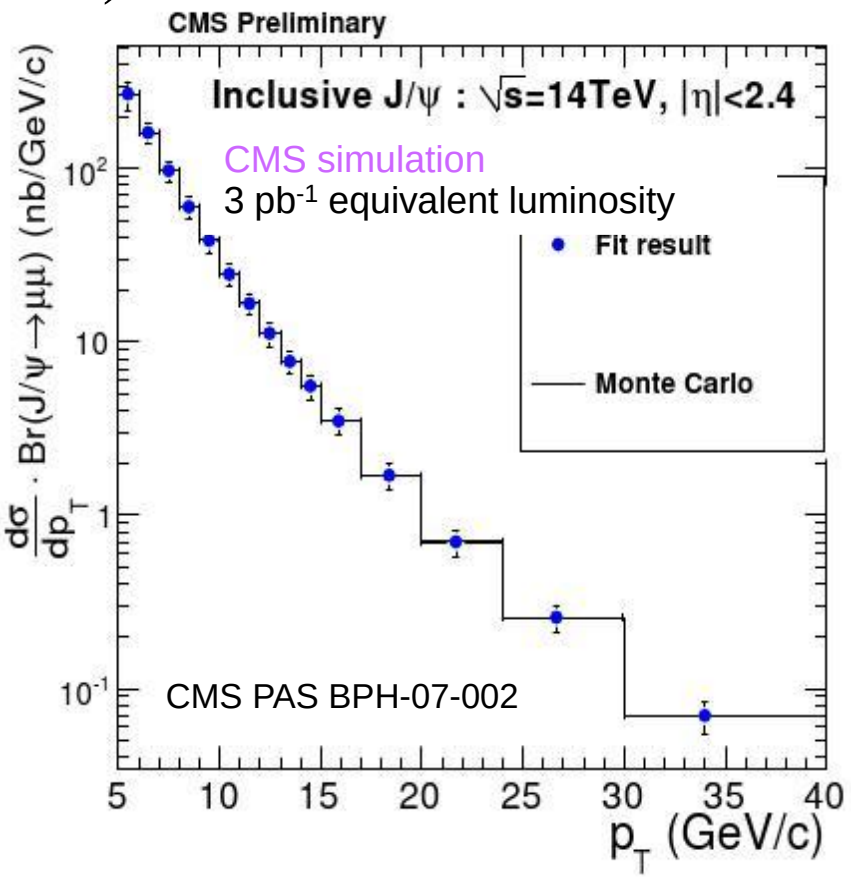
$N_{fit}^{J/\psi}$ = Number of reconstructed J/ψ in a given p_T bin (**fit on invariant mass**)

A = CMS Geometrical and Kinematical Acceptance (**Monte Carlo methods**)

ε = CMS Trigger and Reconstruction Efficiency (**Monte Carlo** and **Tag & Probe methods**)

L = Integrated Luminosity

Δp_T = Transverse Momentum bin size



The observed J/ψ yield results from:

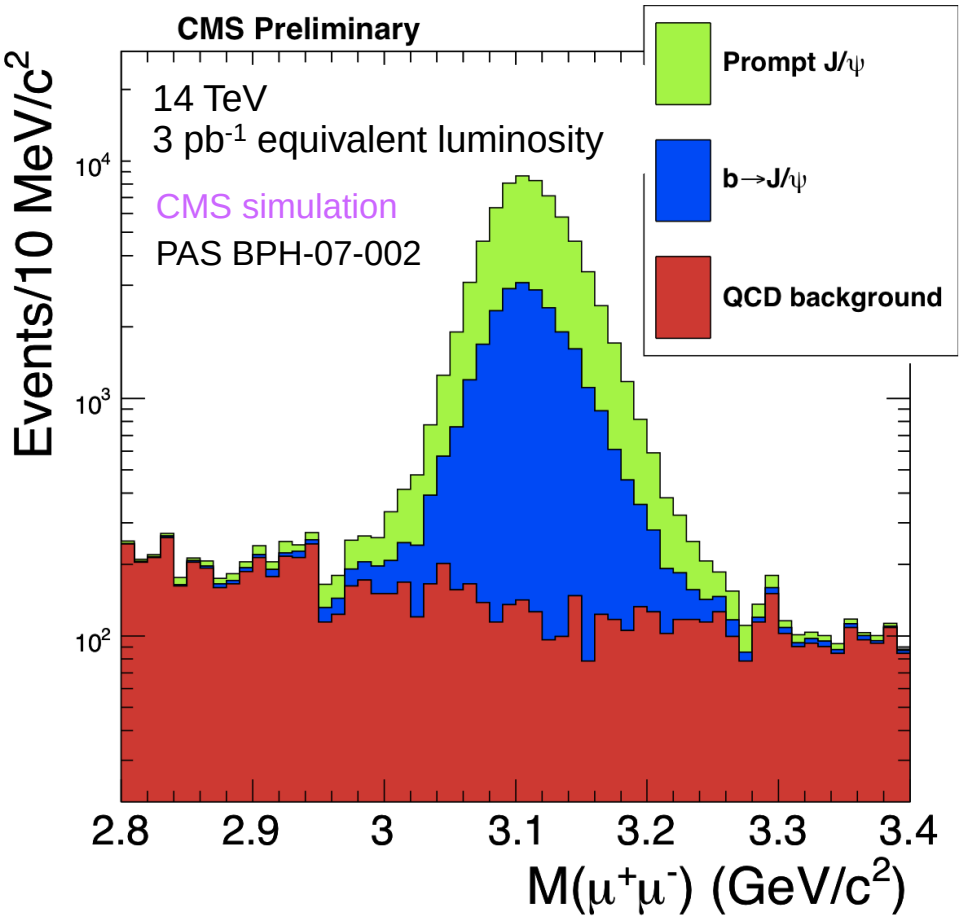
- direct production
- decays from heavier charmonium states
- decays from B hadrons (non-prompt)

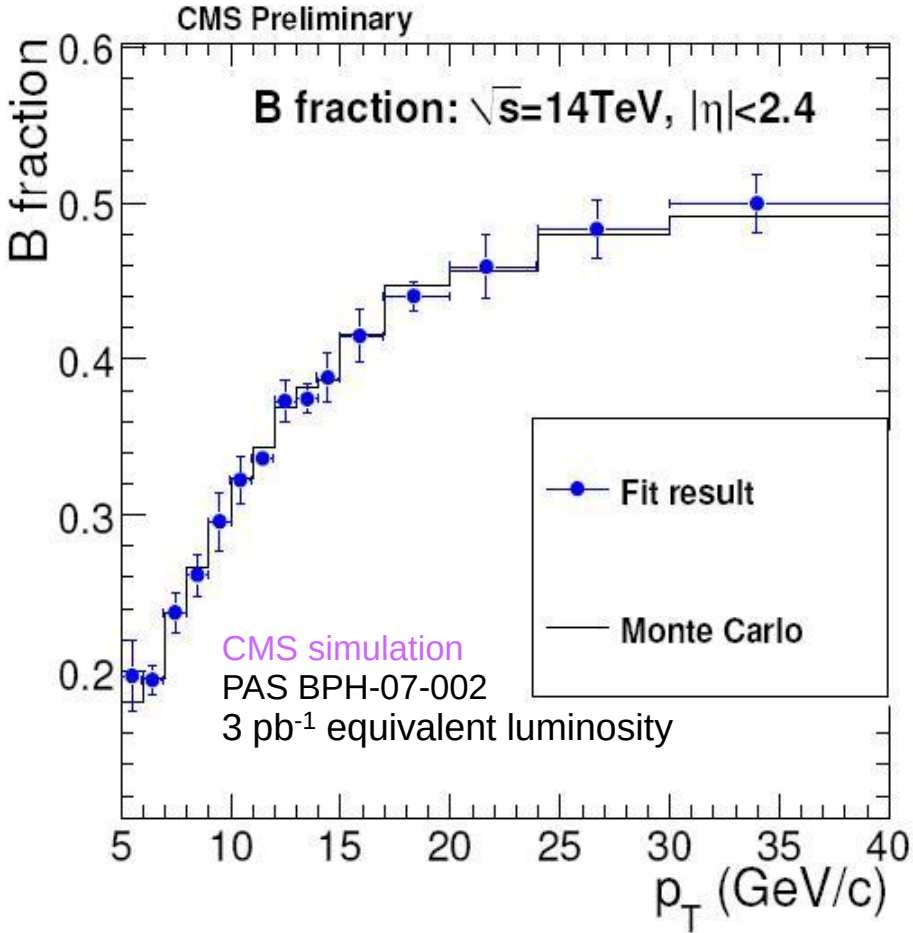
Fitting functions take into account:

- Resolution
- Final state radiation
- Background yield

Fit and *B*-fraction

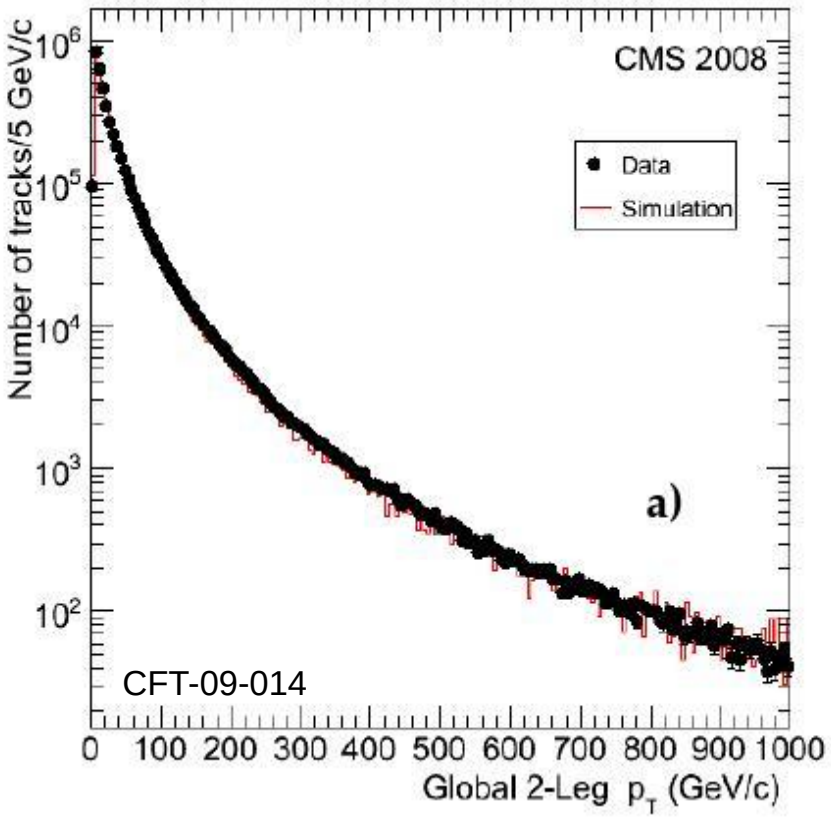
- Because of the increasing material thickness traversed by the muons and the different level-arm, the dimuon mass resolution changes with pseudo-rapidity
  - from ~17 MeV at η~0 to ~40 MeV at η~2.4
- To extract the non-prompt fraction:
  - **Simultaneous fit** of invariant mass and decay length

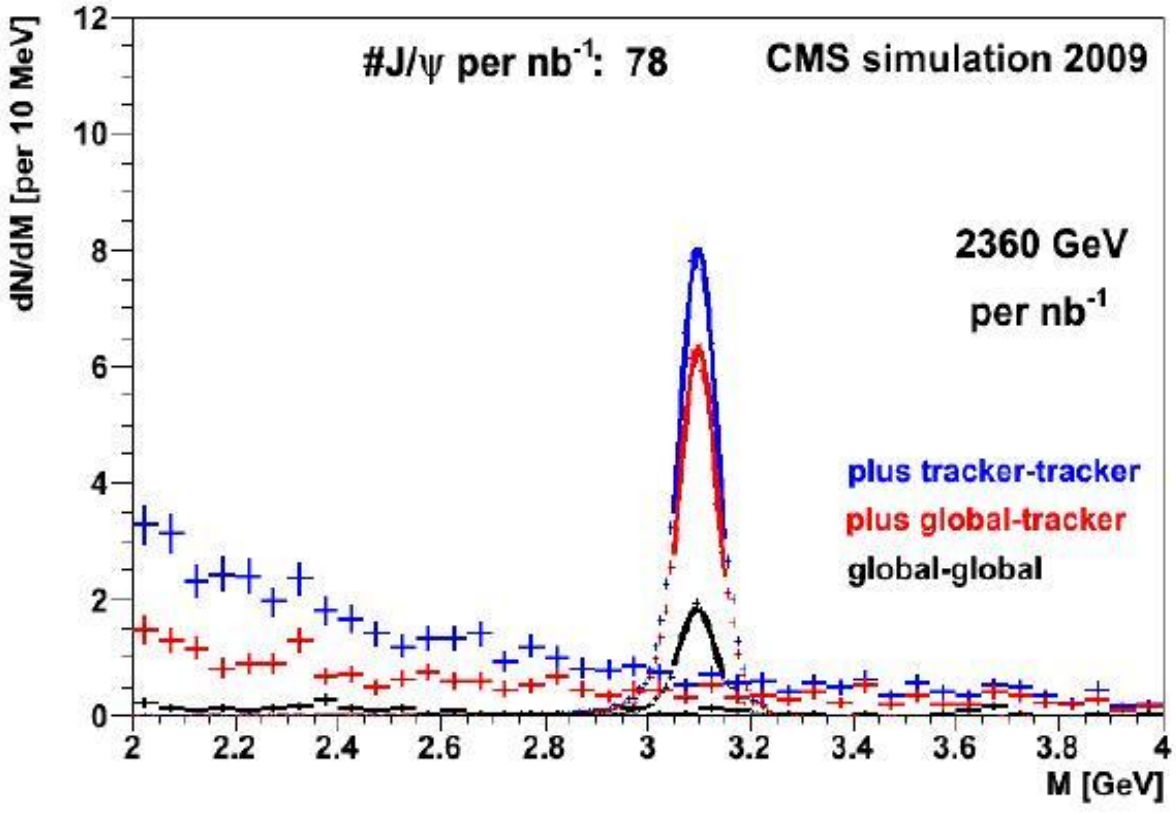




CMS now, Looking towards the 7 TeV runs

- Chosen triggers will follow LHC instantaneous luminosity to get the highest number of candidates:
  - double muon triggers with increasing muon quality and p_T thresholds
- From the cosmic and collision data acquired, improved knowledge of the detector performance
  - **Muon** performance as expected



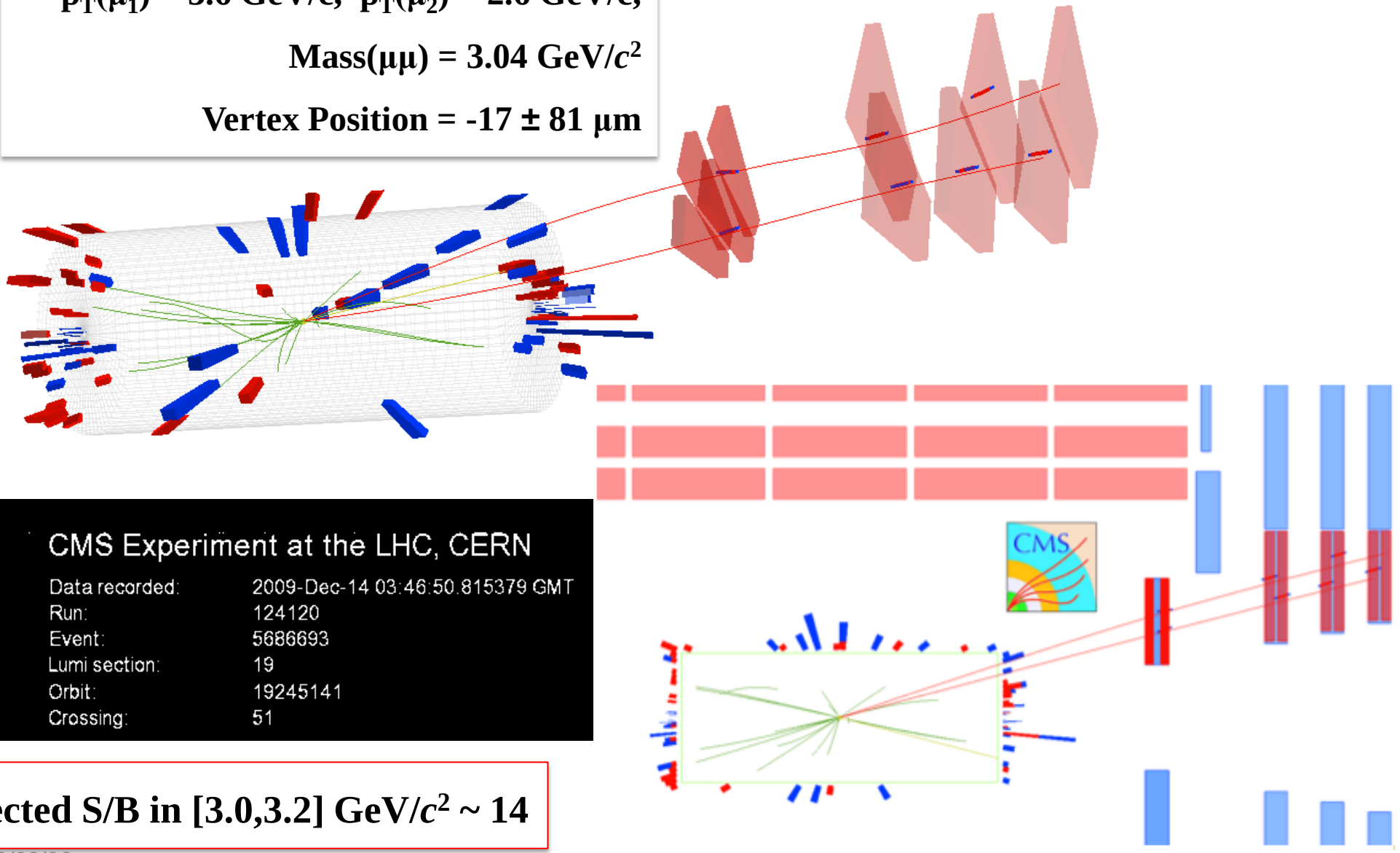


A Di-muon Event at 2.36 TeV, December '09

$p_T(\mu_1)$ = 3.6 GeV/c, $p_T(\mu_2)$ = 2.6 GeV/c,

Mass($\mu\mu$) = 3.04 GeV/c^2

Vertex Position = -17 ± 81 μm



Expected S/B in [3.0,3.2] GeV/c^2 ~ 14

Conclusions

- **CMS is ready to make the measurement of the J/ψ cross section at 7 TeV c.m.s. energy!**

- **We are expecting about 100 thousand J/ψ candidates in the next few months**

- **One suitable candidate already found in 2.4 TeV data!**

BACKUP

Muon types and selections

- **Old Analysis: Global Muons** only (muons reconstructed with both tracker and muon chambers)
  - **p_T > 3 GeV/c**
- **Now: Global Muons** and **Tracker Muons** (muons reconstructed only with tracker and identified with muon chambers)
  - **Pixel Tracker Layers > 1**
- **J/ψ vertex probability > 0.001**

Dimuon Triggers vs LHC Luminosity

- **Dimuon trigger used for the 2007 Simulation (PAS BPH-07-002):**
  - **Each global muon with $p_t > 3$ GeV/c,**
  - **J/ψ mass in [2.8,3.4] GeV/c^2**
- **Dimuon triggers for initial LHC running:**
  - **More open muon triggers, with lower momentum cuts**
  - **Cuts will be successively raised to follow instantaneous luminosity**

J/ψ Cross Section Estimation

Center of Mass Energy [TeV]	Prompt J/ψ Cross Section [μb]
7	21.8
14	32.9

from CERN-2004-009