

Extrapolation of J/ψ cross sections
from p-p 7 TeV to p-p 2.75 TeV
in LO CEM

F. Bossù, M. Gagliardi

INFN & Università degli Studi Torino

Outline

- Color Evaporation Model
- $d\sigma/dy$ for J/ψ in pp at 7 and 2.75 TeV
- Rescaling factors for total and y-differential cross sections: PDF and μ_F dependence , evaluation of systematics
- Comparison with LO CSM
- Conclusions and outlook
- Perspectives for a pp run at 2.75 TeV

Motivation

One of the main observables for quarkonia suppression studies: the nuclear modification factor R^{AA}

$$R_X^{AA}(c) = \frac{\sigma_{inel}^{pp}}{\sigma_X^{pp}} \cdot \frac{N_X^{AA}(c)}{N_{coll}(c)}$$

$X = J/\psi, \Upsilon \dots$

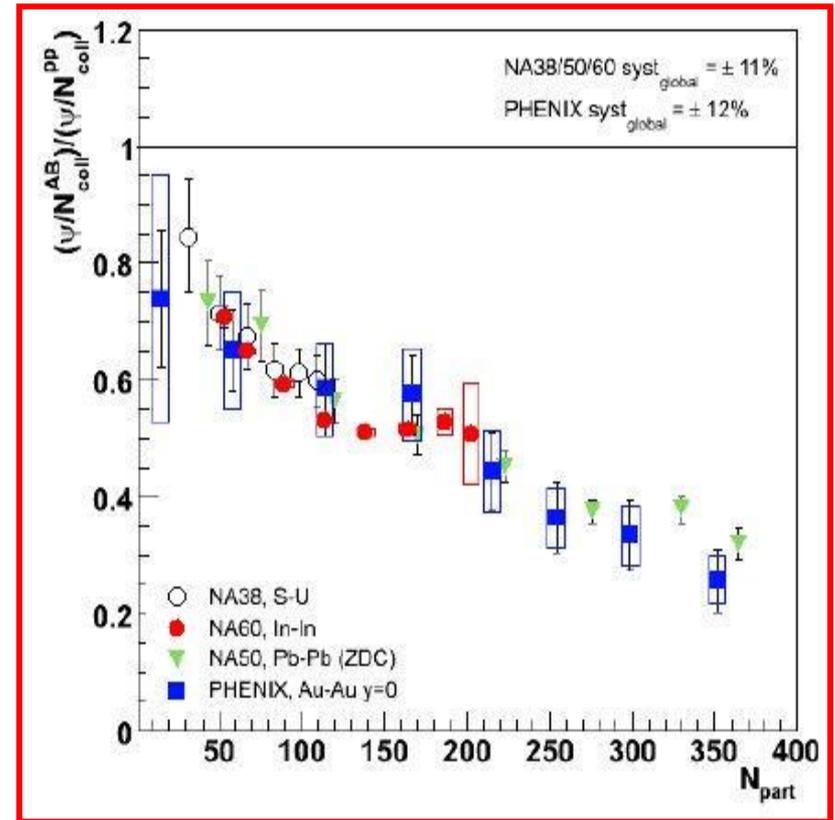
$c =$ a centrality-related quantity

At the **LHC startup**:

Pb-Pb: $\sqrt{s}_{NN} = 2.75$ TeV

p-p: $\sqrt{s} = 7$ TeV

R^{AA} meaningful if: $\sqrt{s}_{NN} = \sqrt{s}_{pp}$



Task: evaluate $\sigma(pp \rightarrow X)$ at

$\sqrt{s}_{pp} = 2.75$ TeV

MEASUREMENT?

EXTRAPOLATION?

Leading Order Color Evaporation Model

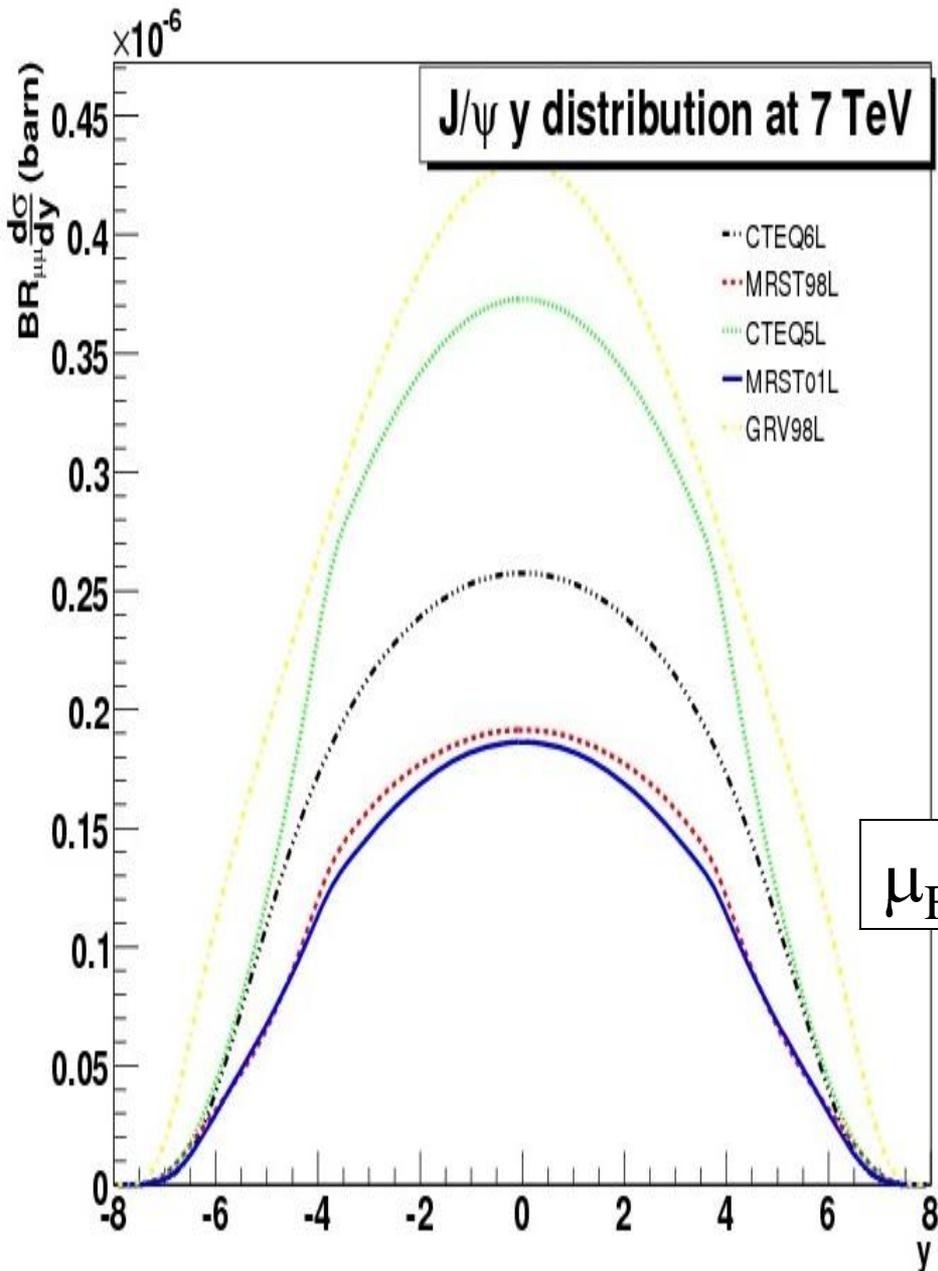
$$\sigma^{CEM} = F \sum_{i,j} \int_{4m_Q^2}^{4m_H^2} d\hat{s} \int dx_1 dx_2 f_{i,A}(x_1, \mu^2) f_{j,B}(x_2, \mu^2) \hat{\sigma}_{ij}(\hat{s}) \delta(\hat{s} - x_1 x_2 s)$$

Cross section for prompt quarkonia production: **some fraction F** of the $Q\bar{Q}$ cross section below the **open heavy flavour meson threshold**. **F independent** of kinematics, process, \sqrt{s} . CS not explicitly required

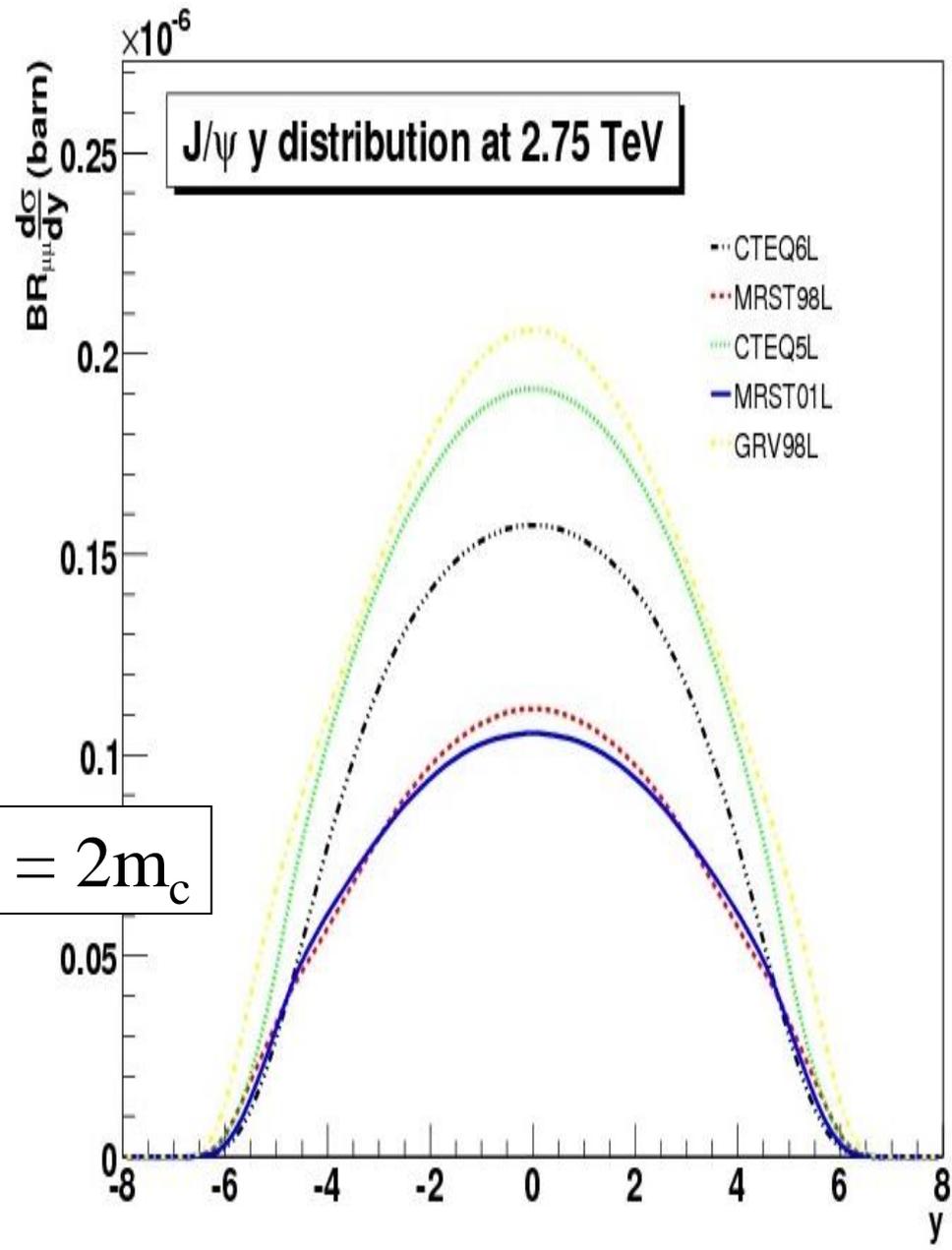
$$x_{1/2}^{L.O.} = \sqrt{\frac{\hat{s}}{s}} e^{\pm y} \Rightarrow \frac{d\sigma_{CEM}^{L.O.}}{dy} = \frac{F}{s} \sum_{i,j} \int_{4m_Q^2}^{4m_H^2} d\hat{s} \hat{\sigma}_{ij}(\hat{s}) f_{i,A}\left(\sqrt{\frac{\hat{s}}{s}} e^y, \mu_F^2\right) f_{j,B}\left(\sqrt{\frac{\hat{s}}{s}} e^{-y}, \mu_F^2\right)$$

LO formulae for the rapidity distributions can be used to estimate **uncertainty** related to the choice of **PDF set** and of μ_F . Dominant diagram **gg** \rightarrow $Q\bar{Q}$ only. Assuming no μ_R dependence of ratios of cross sections at LO

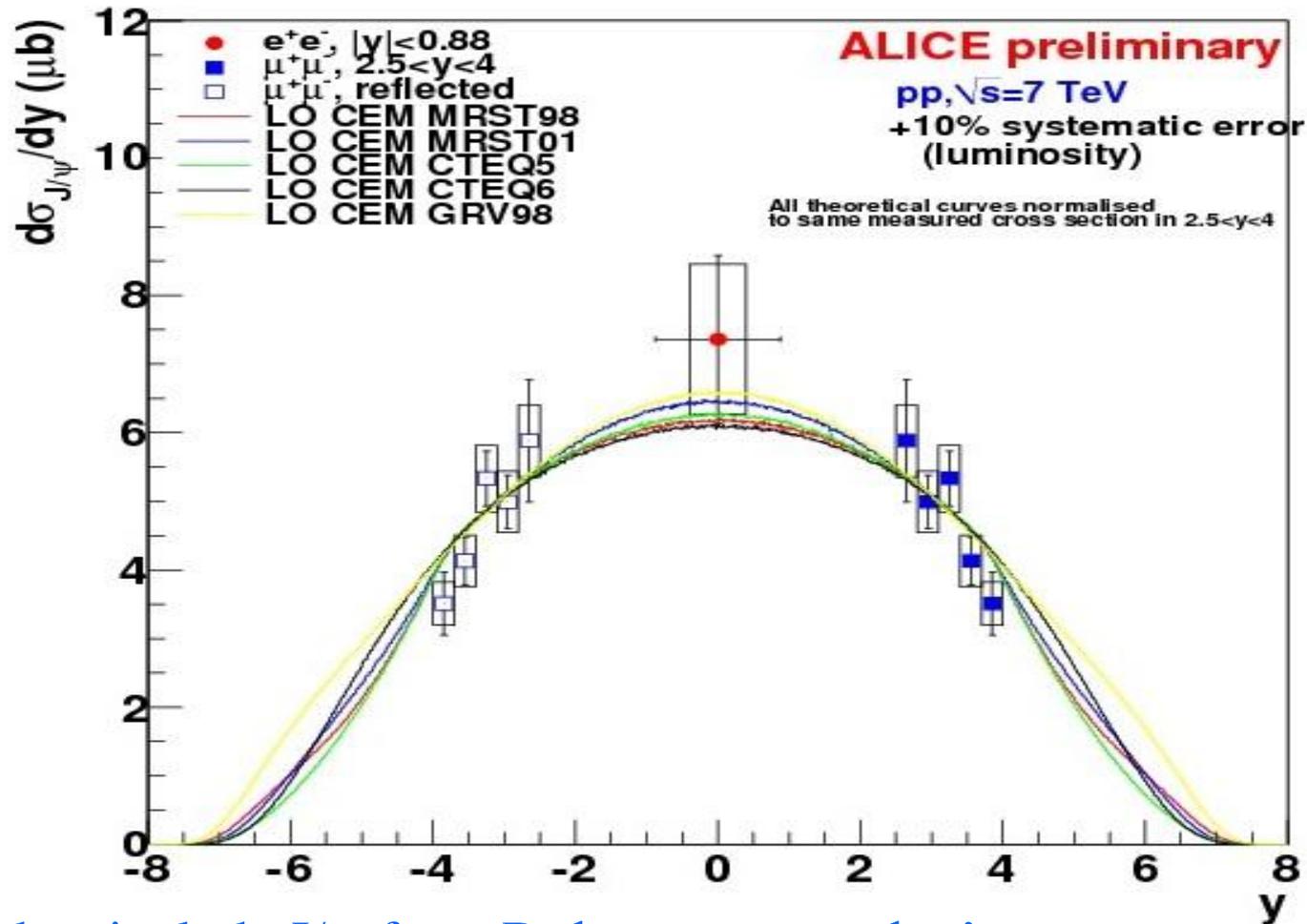
Prompt J/ψ rapidity distributions in LO CEM



$$\mu_F = 2m_c$$



J/ψ rapidity distributions in LO CEM (2)



Caveat 1: data include J/ψ from B-decay, curves don't

Caveat 2: curves are normalised to same integral in $2.5 < y < 4$ (= measured σ)

Data do not seem to prefer nor discard any of these curves

Rescaling factors for cross sections in ALICE acceptance

Central Barrel

$$\sigma^{CB} = \int_{-0.9}^{0.9} \frac{d\sigma}{dy} dy$$

$$S^{CB} = \frac{\sigma^{CB}(7TeV)}{\sigma^{CB}(2.75TeV)}$$

PDF	S^{CB}
CTEQ5L	1.99
CTEQ6L	1.69
MRST98L	1.79
MRST01L	1.86
GRV98L	2.16

$$\mu_F = 2m_c$$

Muon Spectrometer

$$\sigma^{MS} = \int_{2.5}^4 \frac{d\sigma}{dy} dy$$

$$S^{MS} = \frac{\sigma^{MS}(7TeV)}{\sigma^{MS}(2.75TeV)}$$

PDF	S^{MS}
CTEQ5L	2.22
CTEQ6L	1.96
MRST98L	2.11
MRST01L	1.97
GRV98L	2.36

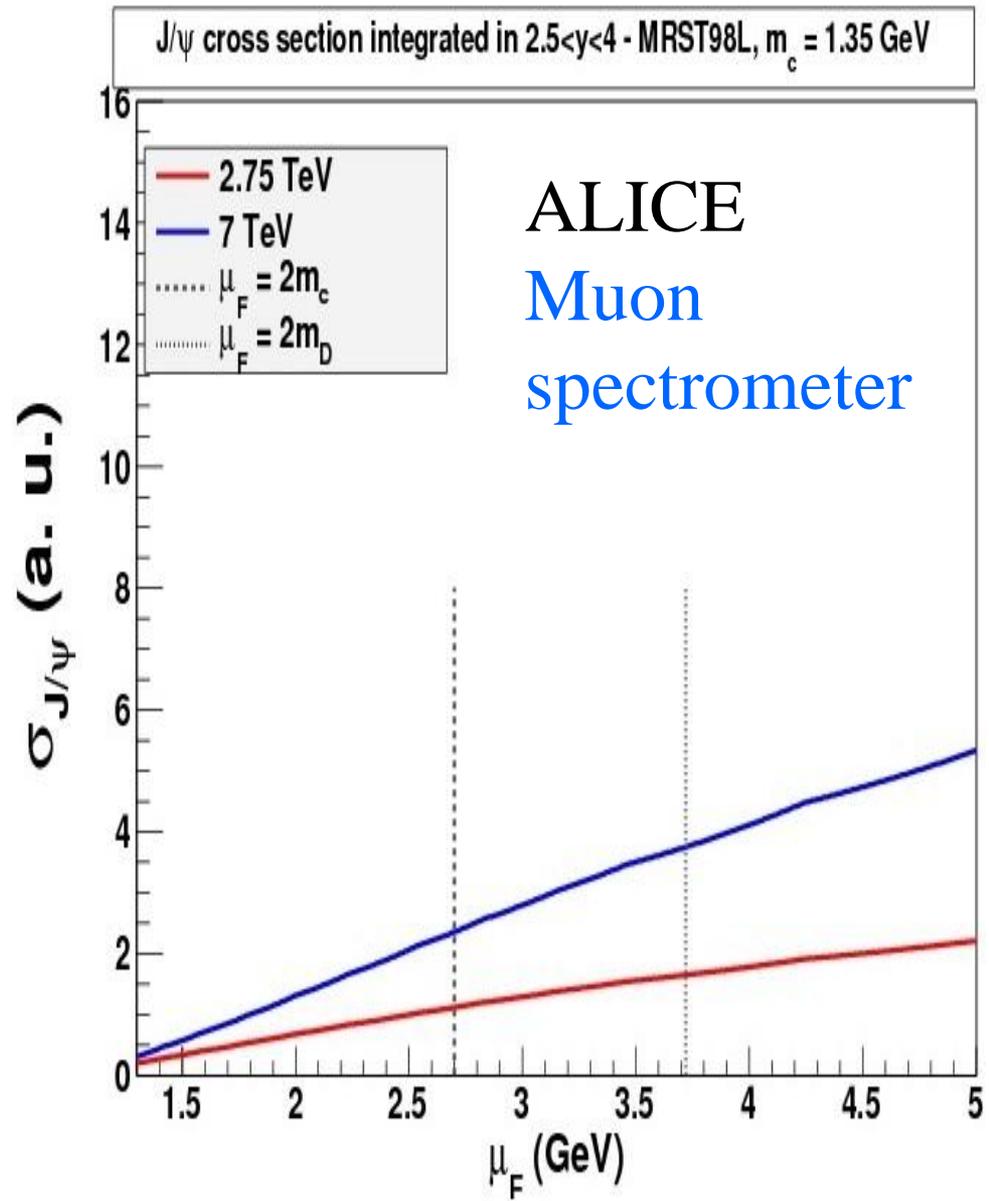
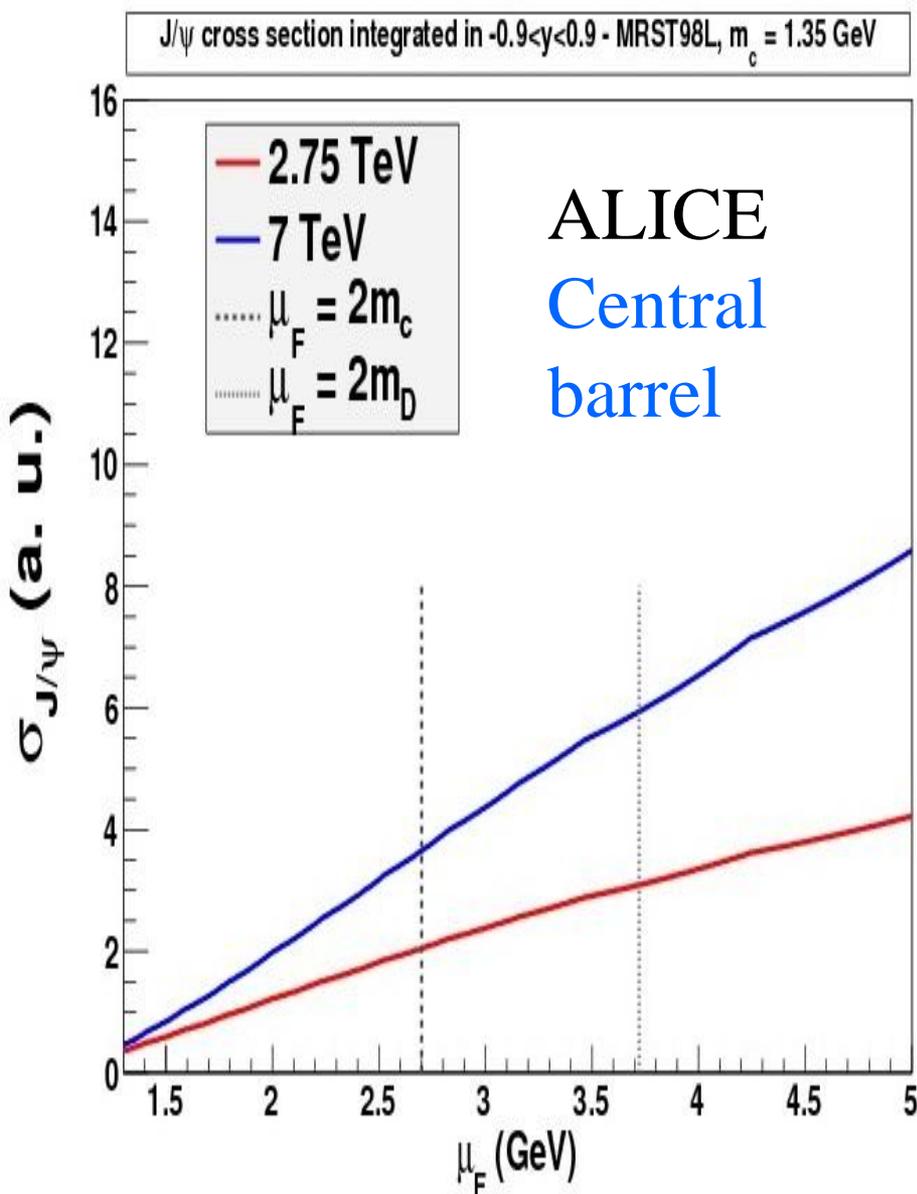
Spread / median

24%

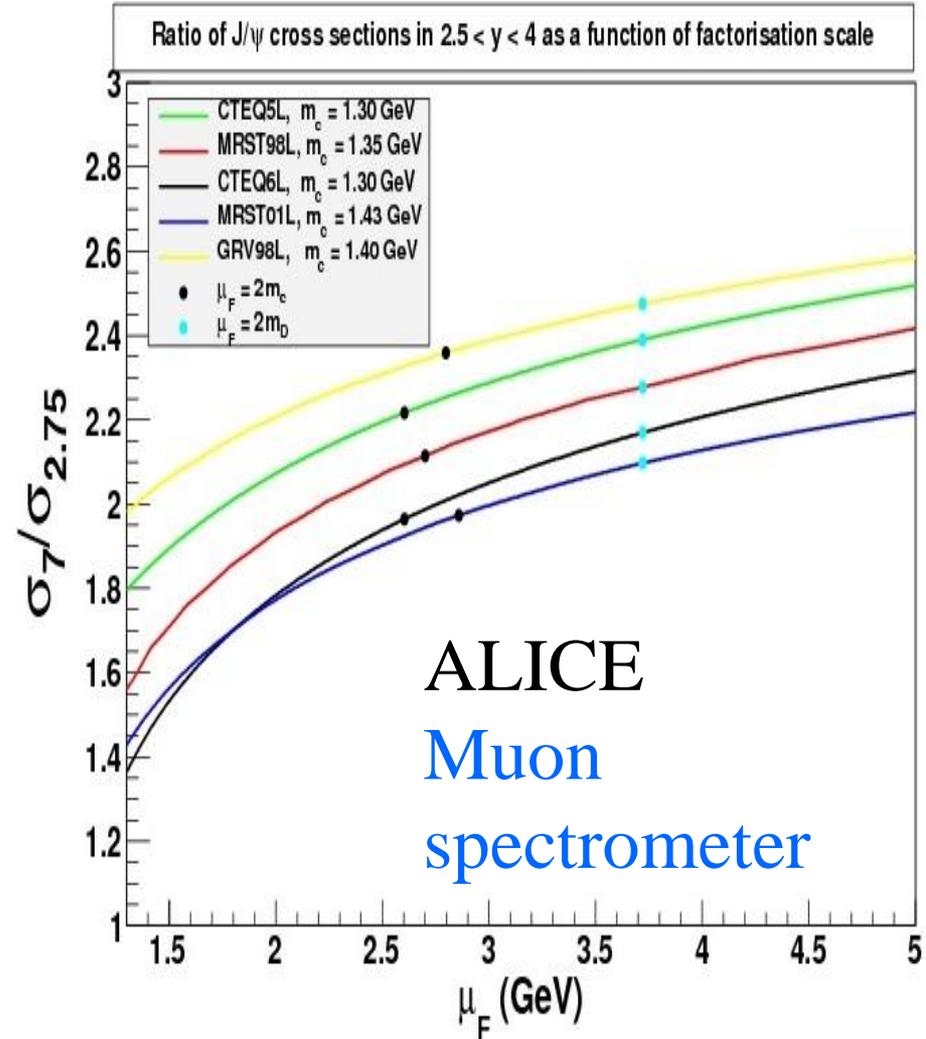
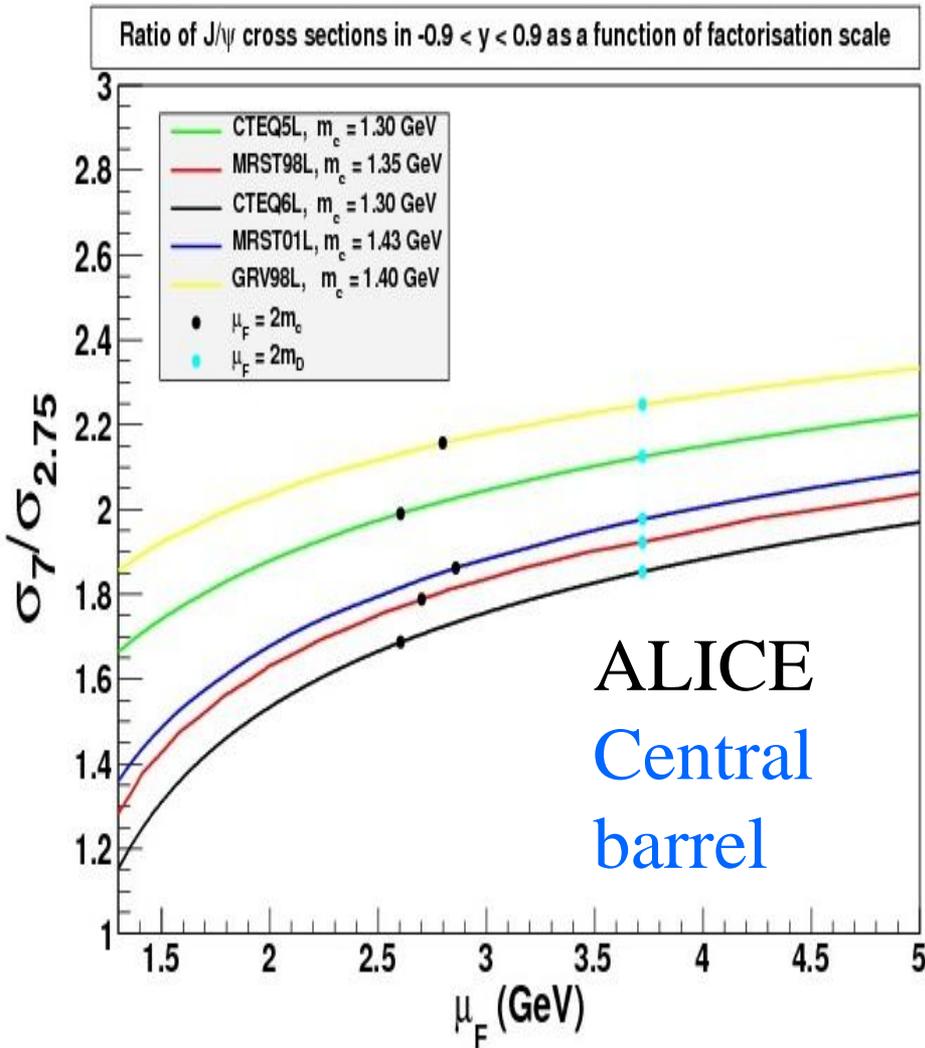
Spread / median

18%

μ_F dependence: cross sections

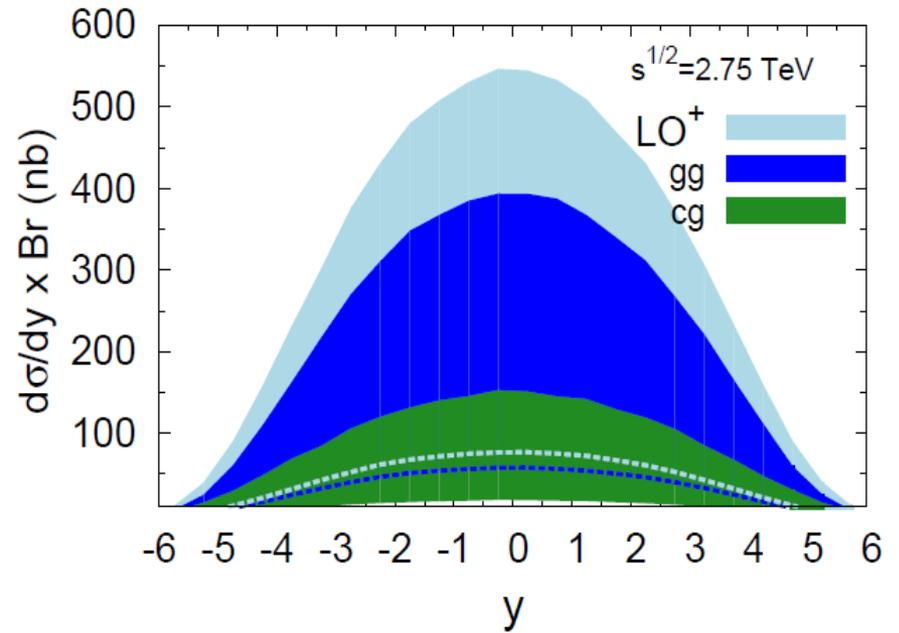
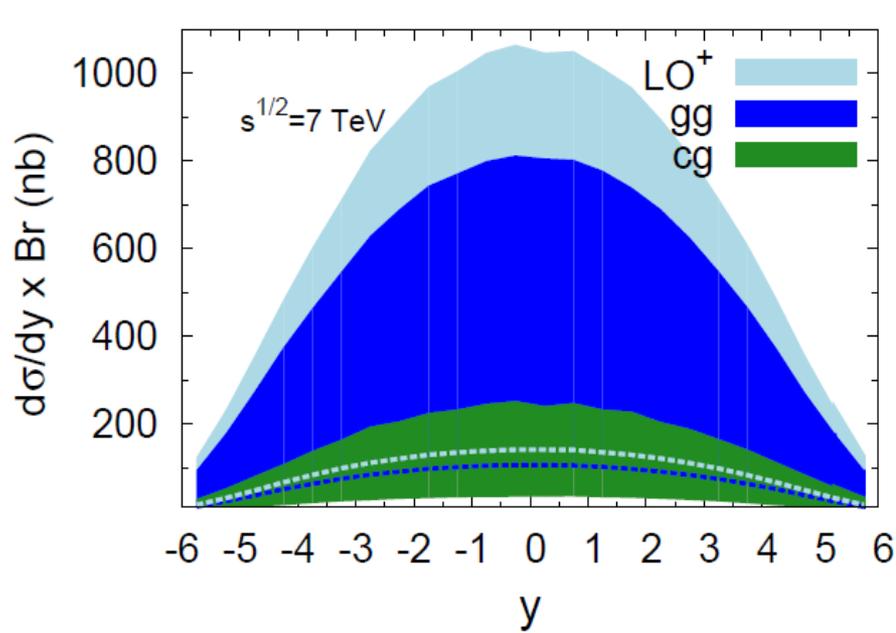


μ_F dependence: rescaling factors



Variation in $2m_C < \mu_F < 2m_D$: 4% to 10% (depending on PDF)

Comparison with CSM



J. P. Lansberg arXiv:1006.2750v1 [hep-ph]

LO **CSM** with CTEQ6L PDF:

$$1.87 < S^{CB} < 2.07 \quad \text{and} \quad 2.31 < S^{MS} < 2.52$$

$$S^{CB} = \frac{\sigma^{CB}(7TeV)}{\sigma^{CB}(2.75TeV)}$$

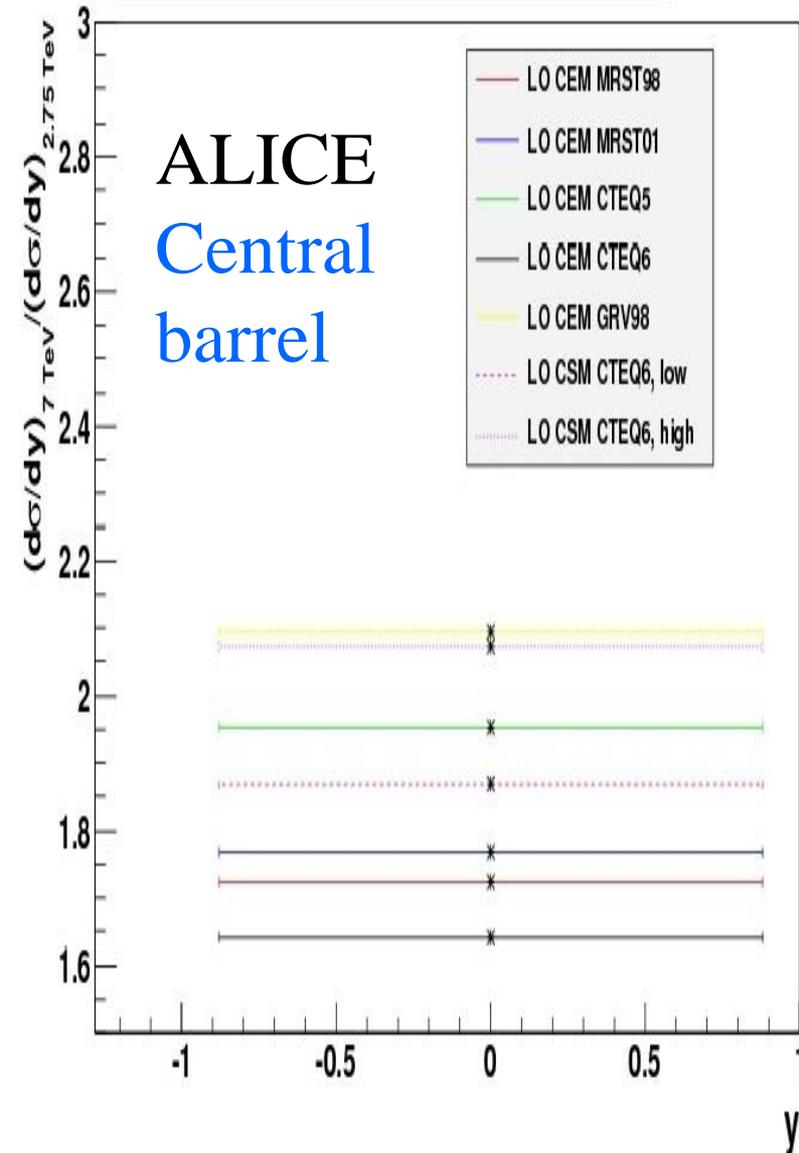
LO **CEM** with CTEQ6L PDF and $\mu_F = 2m_C$

$$S^{CB} = 1.69 \quad \text{and} \quad S^{MS} = 1.96$$

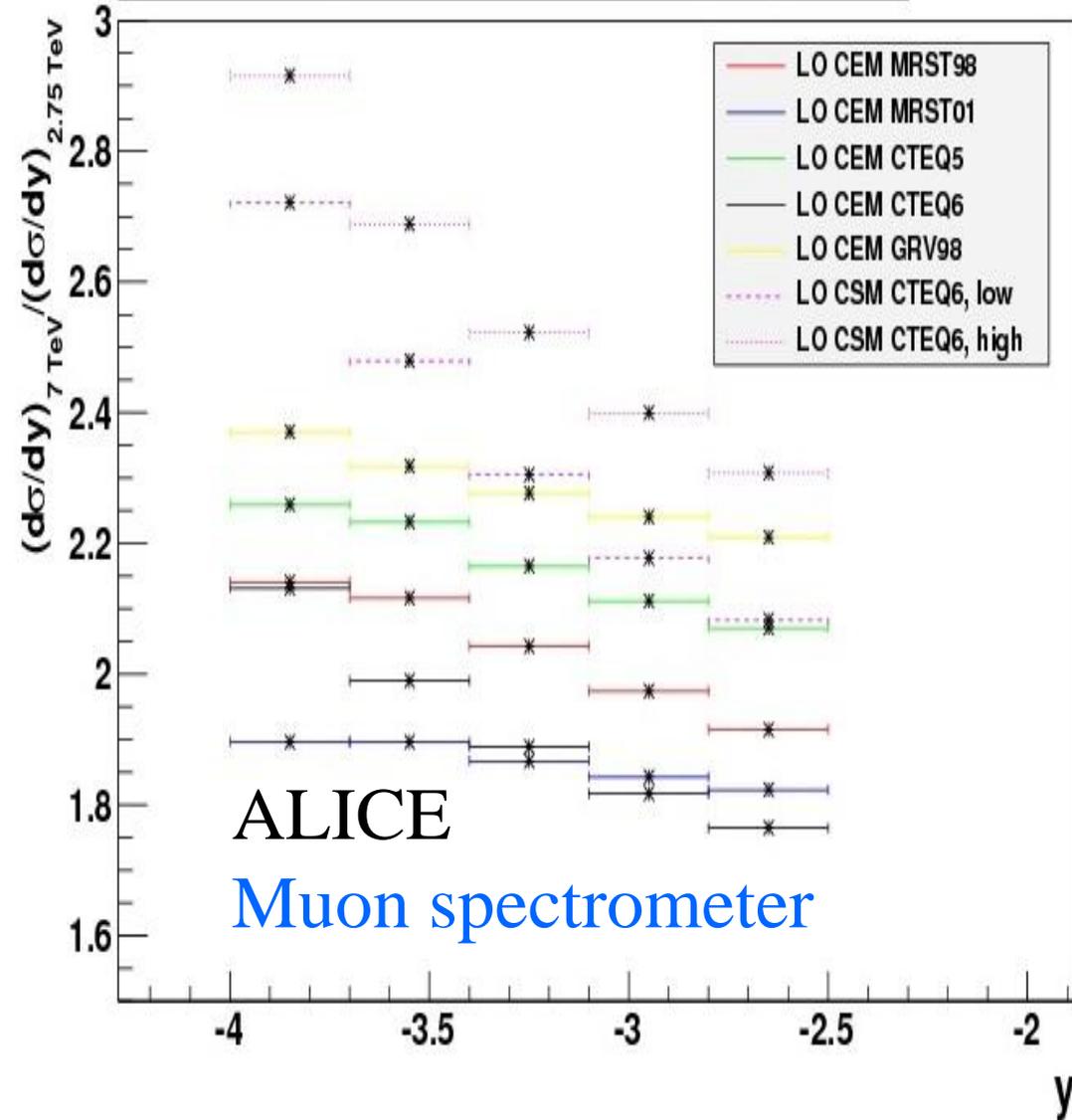
$$S^{MS} = \frac{\sigma^{MS}(7TeV)}{\sigma^{MS}(2.75TeV)}$$

Rescaling factors for y -differential cross section

Ratio of J/ψ cross sections at mid-rapidity



Ratio of J/ψ cross sections in rapidity bins



Conclusions

- Rescaling factors from 7 to 2.75 TeV evaluated in **LO Color Evaporation Model** for total and y-differential cross sections, with 5 different PDFs
- **Variation** of rescaling factors with **PDF**:
24% in ALICE **central barrel** acceptance
18% in ALICE **muon spectrometer** acceptance
- **Variation** related to factorisation scale μ_F : 4% ÷ 10% (depending on PDF) for $2m_C < \mu_F < 2m_D$
- **CSM (lower bound) vs CEM**:
10% for **central barrel**, 16% for **muon spectrometer**

NB: Variation = Full spread / median

Outlook and hints for discussion

- Take into account J/ψ from B-decay
- NLO CEM
- Newer PDFs (can we discard some of those used here?)
- Explore more models (CSM, NRQCD..)
- Should we expect theory to reduce systematics with combined use of LHC@7 TeV and Tevatron data?

A pp run at 2.75 TeV?

LHCC102 minutes (shown at LPC meeting 27/09/2010)

Finally, ALICE's request for a proton-proton run at the equivalent heavy-ion energy per nucleon was discussed. This is an important reference run for heavy-ion physics. ALICE agreed that the required beam time would be taken from the allocated heavy-ion running period.

in part (~50%)

May be scheduled in 2011 <http://indico.cern.ch/conferenceDisplay.py?confId=108493>

```
Date: Wed, 14 Jul 2010 17:13:38 +0200 (CEST)
From: Massimiliano Ferro-Luzzi <massi@mail.cern.ch>
To: Terry Wyatt <twyatt@fnal.gov>
Cc: Emmanuel Tsesmelis <Emmanuel.Tsesmelis@cern.ch>,
    LHC Programme Coordinator <lpc@mail.cern.ch>
Subject: setup time for 2.8 TeV LHC run
```

One colliding bunch in IP2

LHC Programme coordinator says:

```
The setup time for a short LHC run at 2.8 TeV center of mass
(with the assumption that we would use 2 bunches per beam of
7e10 p/bunch and 10-11 meter optics, thus staying below the
SetupBeam limit) is approximately 6 fills (with ramp).
```

```
In addition, of course, there is some offline preparation work
involved, which however does not require machine time (but does
mean some manpower).
```

```
Assuming some realistic machine availability, and assuming we
would have to run approximately 20 hours in stable beams
to allow ALICE to collect at least 30 M evts, the actual time
involved would be about one week.
```

```
Best regards
Massi
```

A pp run at 2.75 TeV? (2)

Maximum luminosity (no beam displacement)
with nominal emittances, 1 colliding bunch, 7×10^{10} p and
 $\beta^* = 3.5$ m : ~ 0.2 Hz/ μb (vdM scan)

Thus, in 20 h with $\beta^* = 10$ m we should expect (at most):
 $20 \text{ h} * 3600 \text{ s/h} * (3.5/10) * 0.2 \text{ Hz} / \mu\text{b} = 5600 \mu\text{b}^{-1}$

Using measured cross sections at 7 TeV and a rescaling
factor to 2.75 TeV of 0.5, we get:

~ 2400 J/ ψ in e^+e^- in $-0.9 < y < 0.9$

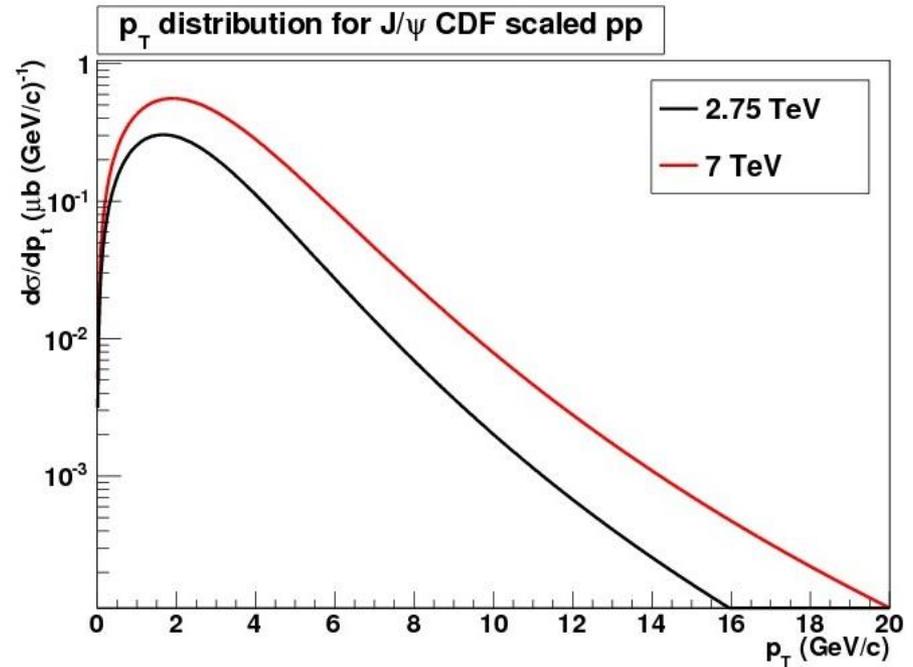
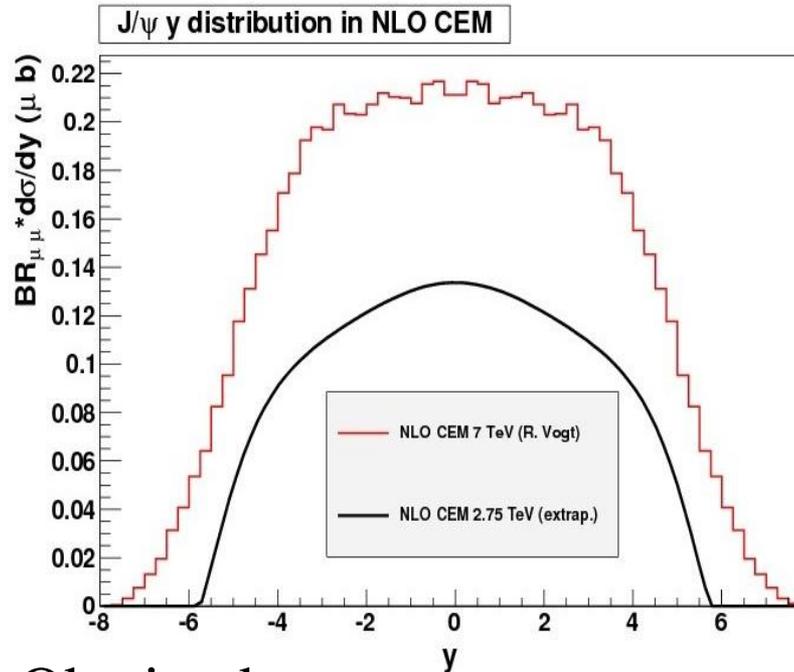
~ 1200 J/ ψ in $\mu^+\mu^-$ in $2.5 < y < 4$

Can we do something with this?

Next slides: very preliminary feasibility study
in the muon spectrometer (signal analysis only!)

Perspectives for a pp run at 2.75 TeV

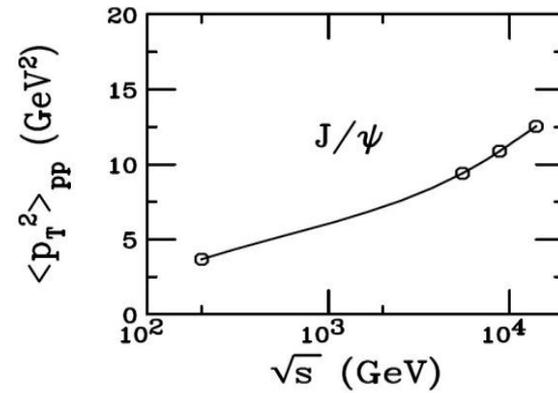
Generate 1200 J/ψ with “realistic” input distributions at 2.75 TeV:



Obtained as:

$$\left. \frac{d\sigma}{dy} \right|_{2.75}^{NLO} = \left. \frac{d\sigma}{dy} \right|_{5.5}^{NLO} * \left. \frac{d\sigma}{dy} \right|_{2.75}^{LO} / \left. \frac{d\sigma}{dy} \right|_{5.5}^{LO}$$

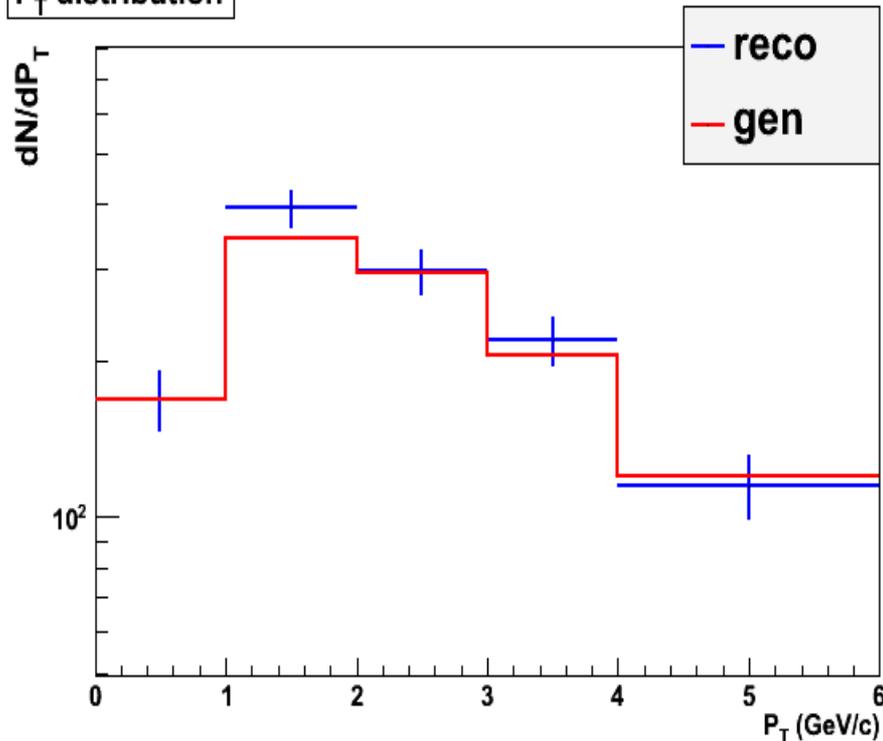
Rescaled from
CDF fit
according to
CEM
evolution



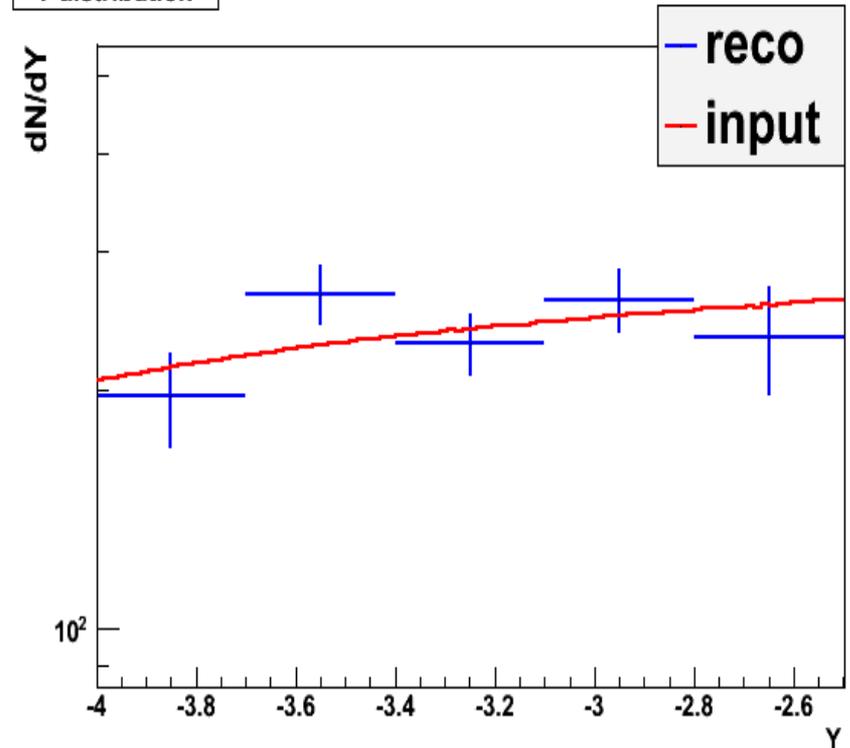
Perspectives for a pp run at 2.75 TeV

After reconstruction: about 500 detected J/ψ

P_T distribution



Y distribution



Can we appreciate the J/ψ signal in such a low statistics scenario? **Full physics performance coming soon**