SIMULATIONS FOR A FIXED TARGET EXPERIMENT

AFTER @ LHC

Laure Massacrier,

Laboratoire SUBATECH Nantes,
Soon at LAL/IPN Orsay

On the work of B. Trzeciak, R. Mikkelsen, Z. Yang and AFTER simulation group

Rencontres QGP France 2014,
15-18 Septembre 2014
Etretat, France

Subatech

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

IPN INSTITUT DE PHYSIQUE NUCLÉAIRE ORSAY

OUTLINE

- **Simulations of a proton beam (7 TeV) on a proton target ($\sqrt{s}$ = 115 GeV)**

  - Charged particle multiplicity (minimum bias)

- **Quarkonium yields in pH, pA ($\sqrt{s_{NN}}$ = 115 GeV), PbA ($\sqrt{s_{NN}}$ = 72 GeV)**

- **Simulations of a proton beam (7 TeV) on a proton target ($\sqrt{s}$ = 115 GeV)**

  - Fast simulations for quarkonia using LHCb reconstruction parameters (minimum bias)

- **Simulations of a proton beam (7 TeV) on a Pb target ($\sqrt{s_{NN}}$ = 115 GeV)**

  - Full simulations using LHCb detector reconstruction (minimum bias)

TALKS ON SIMULATION DURING AFTER WORKSHOPS

3-13 february 2013 (Trento) :

https://indico.in2p3.fr/conferenceTimeTable.py?confId=7326#20130204

- **Tools for Simulations, S. Porteboeuf-Houssais**
- **Aliroot for AFTER, I. Hrivnacova**
- **Summary of WG on simulations, A. Rakotozafindrabe**

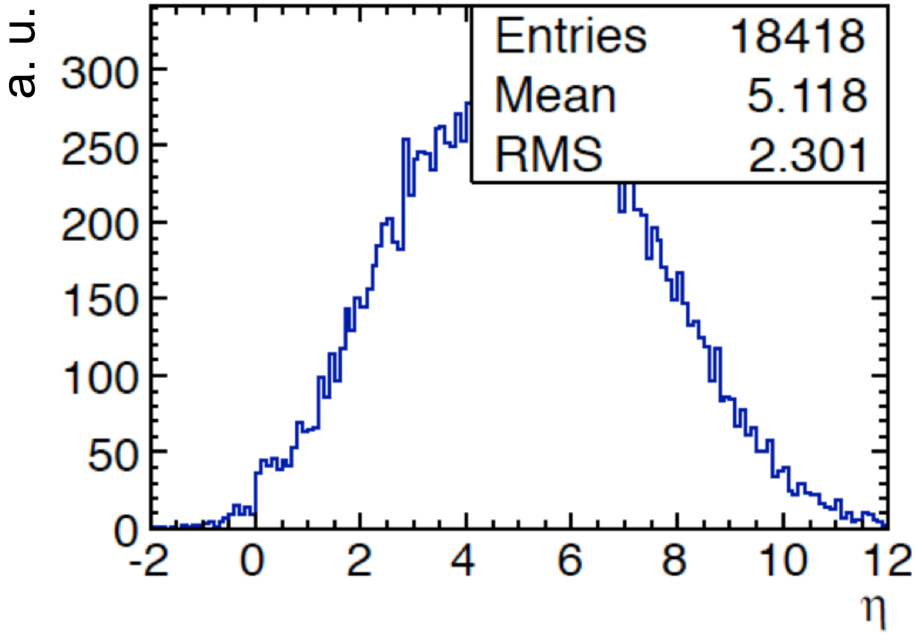
12-17 januray 2014 (Les Houches)

https://indico.in2p3.fr/conferenceTimeTable.py?confId=8591#20140112

- **AFTER@LHC in a few figures, C. Hadjidakis**
- **Overview of MC tools, L. Massacrier**
- **First simulations with a LHCb-like forward detector for AFTER, Z. Yang**
- **Summary of WG on simulations, C. Hadjidakis**

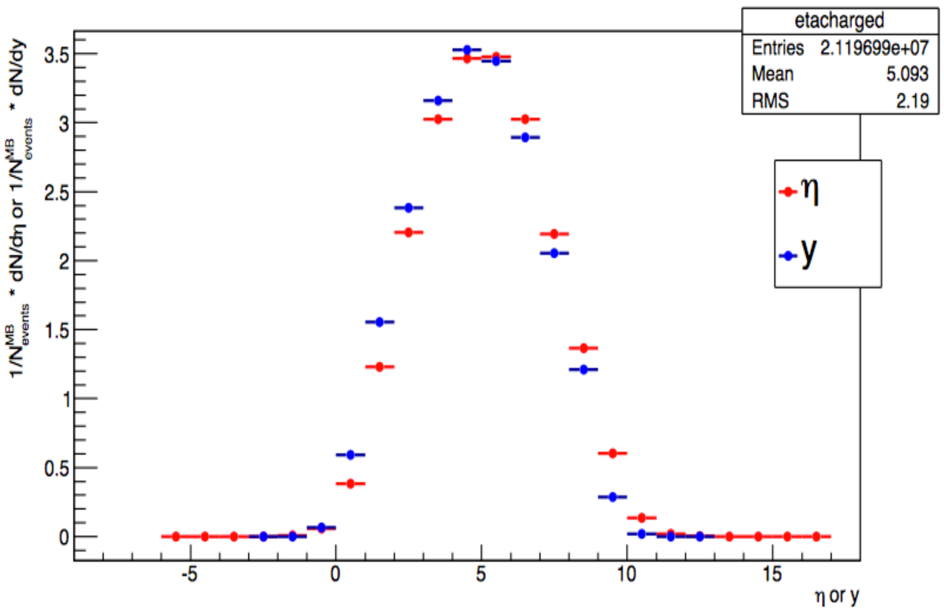
NUMBER OF CHARGED PARTICLES IN MB pp @ $\sqrt{S}$ = 115 GEV

AFTER workshop les Houches, January 2014
AFTER simulation group



EPOS 1.6.5
Number of generated events: 1000

$dN_{ch}/d\eta\,|_{\eta=0} \sim 3$



PYTHIA 8.170
Number of generated events: 10^6

$dN_{ch}/d\eta\,|_{\eta=0} \sim 3.5$

Rapidity shift: $\Delta y = \tan^{-1}\beta \approx 4.8$
$y_{CM} = 0 \rightarrow y_{lab} \approx 4.8$

QUARKONIUM YIELDS

In pH and pA (115 GeV/c)

Target	$\int \mathcal{L}$ ($fb^{-1}.yr^{-1}$)	N(J/Ψ) yr^{-1} = $A\mathcal{L}B\sigma_\Psi$	N(Υ) yr^{-1} = $A\mathcal{L}B\sigma_\Upsilon$
1 m Liq. H_2	20	4.0 10^8	8.0 10^5
1 m Liq. D_2	24	9.6 10^8	1.9 10^6
LHC pp 14 Tev (low pT)	0.05 (ALICE) 2 LHCb	3.6 10^7 1.4 10^9	1.8 10^5 7.2 10^6
RHIC pp 200GeV	1.2 10^{-2}	4.8 10^5	1.2 10^3

Target	$\int \mathcal{L}$ ($fb^{-1}.yr^{-1}$)	N(J/Ψ) yr^{-1} = $A\mathcal{L}B\sigma_\Psi$	N(Υ) yr^{-1} = $A\mathcal{L}B\sigma_\Upsilon$
1cm Be	0.62	1.1 10^8	2.2 10^5
1cm Cu	0.42	5.3 10^8	1.1 10^6
1cm W	0.31	1.1 10^9	2.3 10^6
1cm Pb	0.16	6.7 10^8	1.3 10^6
LHC pPb 8.8 TeV	10^{-4}	1.0 10^7	7.5 10^4
RHIC dAu 200GeV	1.5 10^{-4}	2.4 10^6	5.9 10^3
RHIC dAu 62GeV	3.8 10^{-6}	1.2 10^4	18

In PbA (72 GeV/c)

Target	$\int \mathcal{L}$ ($nb^{-1}.yr^{-1}$)	N(J/Ψ) yr^{-1} = $AB\mathcal{L}B\sigma_\Psi$	N(Υ) yr^{-1} = $AB\mathcal{L}B\sigma_\Upsilon$
1 m Liq. H_2	800	3.4 10^6	6.9 10^3
1cm Be	25	9.1 10^5	1.9 10^3
1cm Cu	17	4.3 10^6	0.9 10^3
1cm W	13	9.7 10^6	1.9 10^4
1cm Pb	7	5.7 10^6	1.1 10^4
LHC PbPb 5.5 TeV	0.5	7.3 10^6	3.6 10^4
RHIC AuAu 200GeV	2.8	4.4 10^6	1.1 10^4
RHIC AuAu 62GeV	0.13	4.0 10^4	61

pp : 1000 times more statistics than at RHIC ($\sqrt{s}$ = 200 GeV) and comparable statistics to LHCb with a 1m H_2 target
pA: 100 times more statistics than at RHIC (dAu $\sqrt{s}$ = 200 GeV) with a 1cm Pb target

PbA: similar statistic as at RHIC (Au-Au $\sqrt{s_{NN}}$ = 200 GeV) and 2 order of magnitude larger than at RHIC (Au-Au $\sqrt{s_{NN}}$ = 62 GeV) with a 1cm thick Pb target

Detailed study of quarkonium production and CNM effects

Detailed study of quarkonium states

FAST SIMULATIONS FOR QUARKONIA (pp $\sqrt{s}$ = 115 GeV) USING LHCB RECONSTRUCTION PARAMETERS

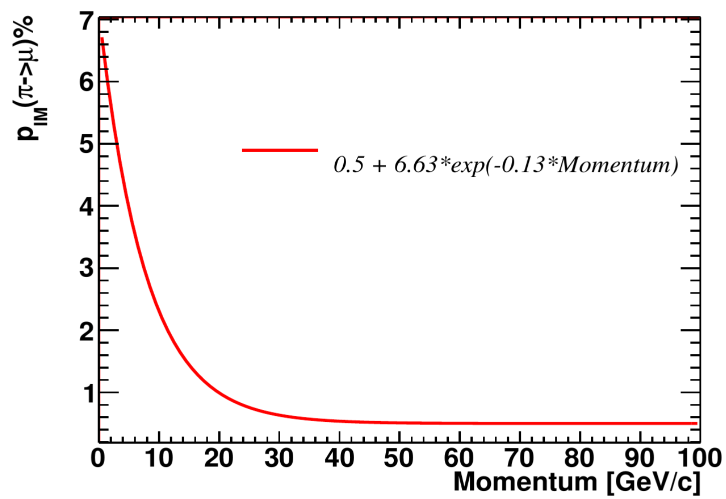
- Simulations with Pythia 8.185
- LHCb detector is NOT simulated but LHCb reconstruction parameters are introduced in the fast simulation (resolution, analysis cuts, efficiencies…)

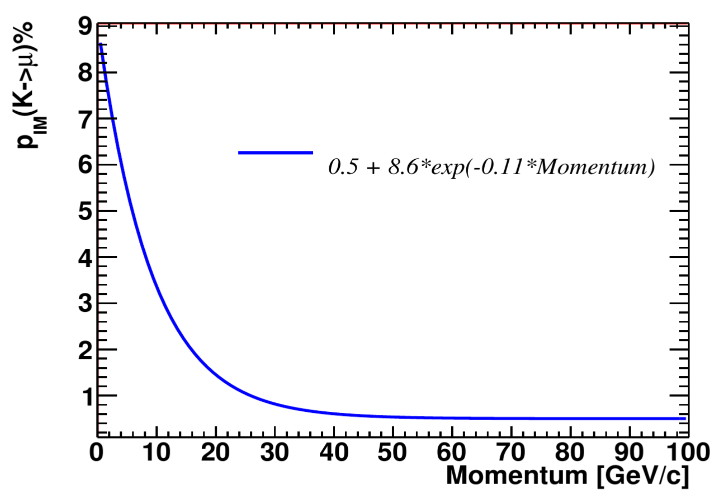
Requirements
Momentum resolution : $\Delta p/p$ = 0.5%
Muon identification efficiency: 98%

Cuts at the single muon level
$2 < \eta_\mu < 5$
$p_T^\mu > 0.7$ GeV/c

Muon misidentification
If π and K decay before the calorimeters (12m), they are rejected by the tracking
Otherwise a misidentification probability is applied

[Performance of the muon identification at LHCb, F. Achilli et al, arXiv:1306.0249]





J/Ψ →μ⁺μ⁻ IN MB pp @ 115 GEV

- For 1m of H target and few tens of seconds of data taking

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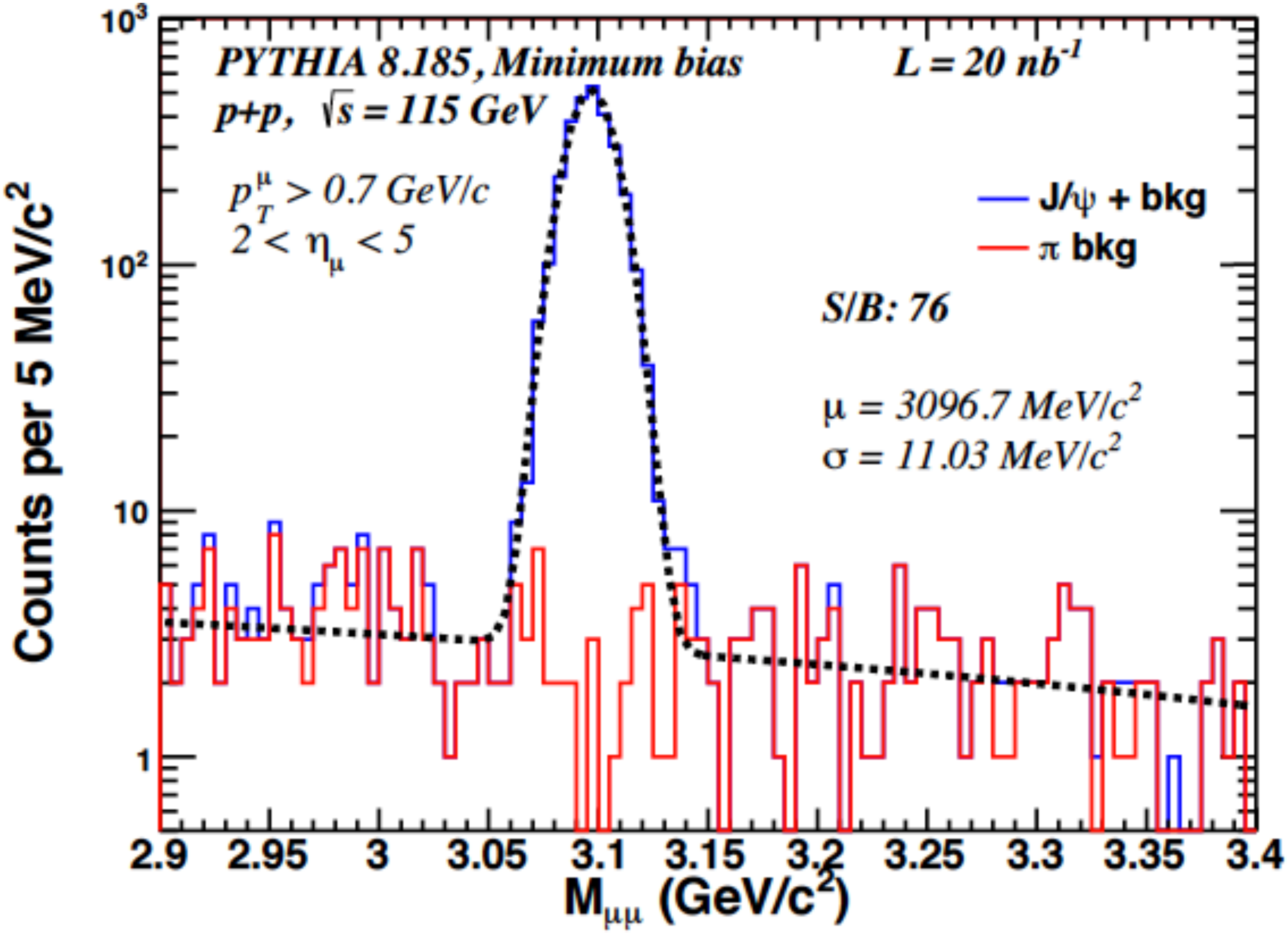

Misidentified pions is the dominant source of background

J/Ψ →$\mu^+\mu^-$ IN MB pp @ 115 GEV (BINS IN RAPIDITY)

- For 1m of H target and few minutes of data taking

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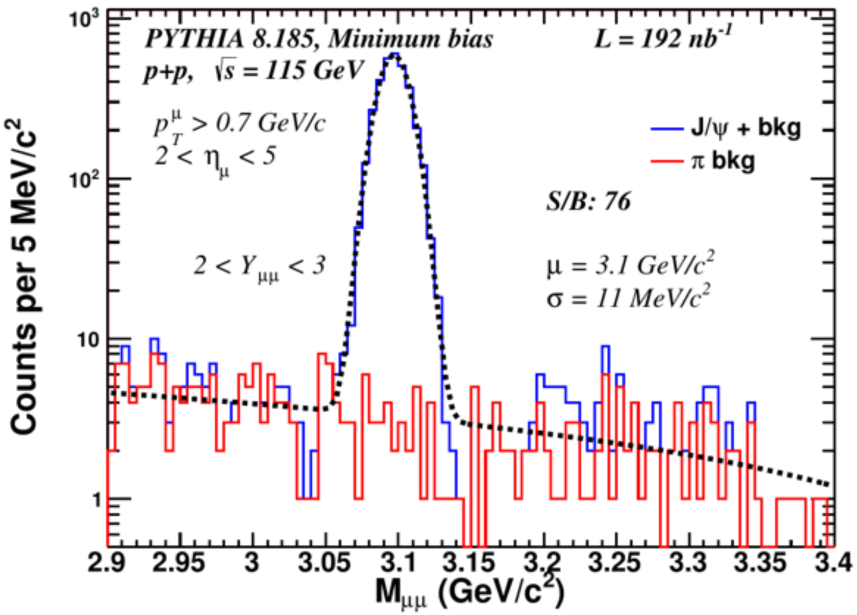

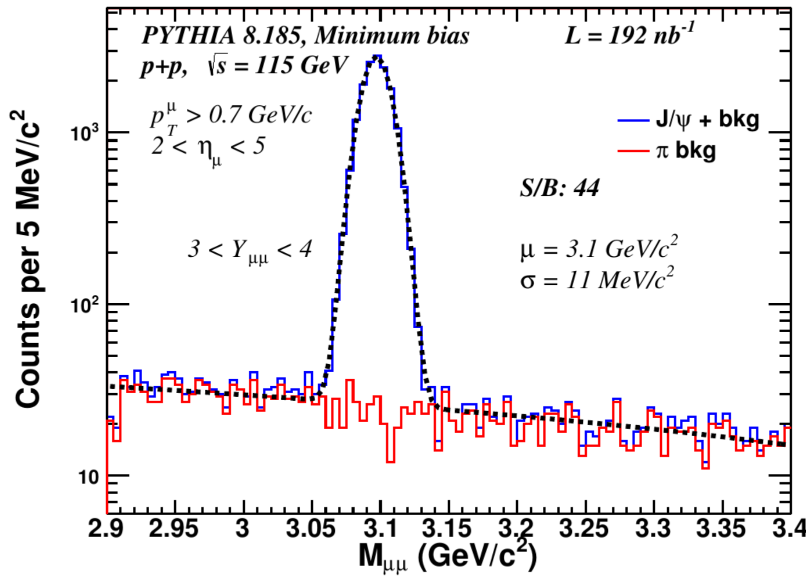

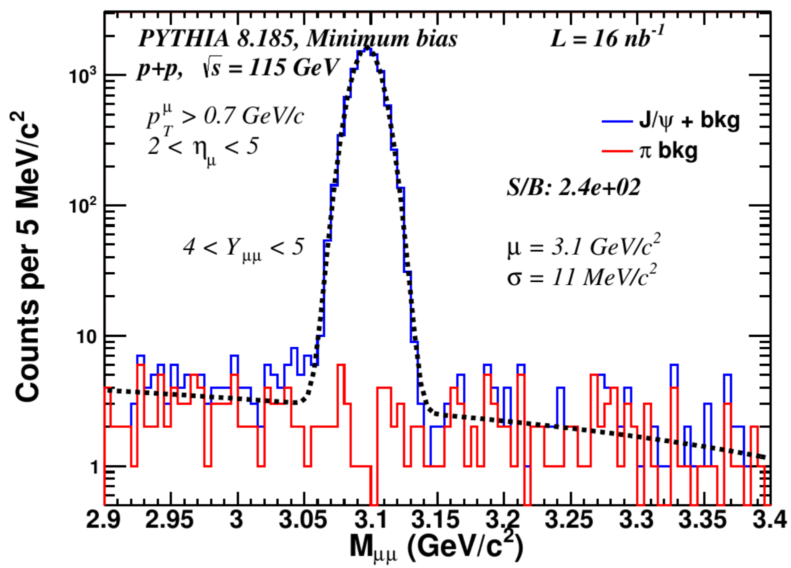

J/Ψ →$\mu^+\mu^-$ IN MB pp @ 115 GEV (Y_{LAB} AND P_T REACH)

- For 1m of H target and 2 weeks of data taking

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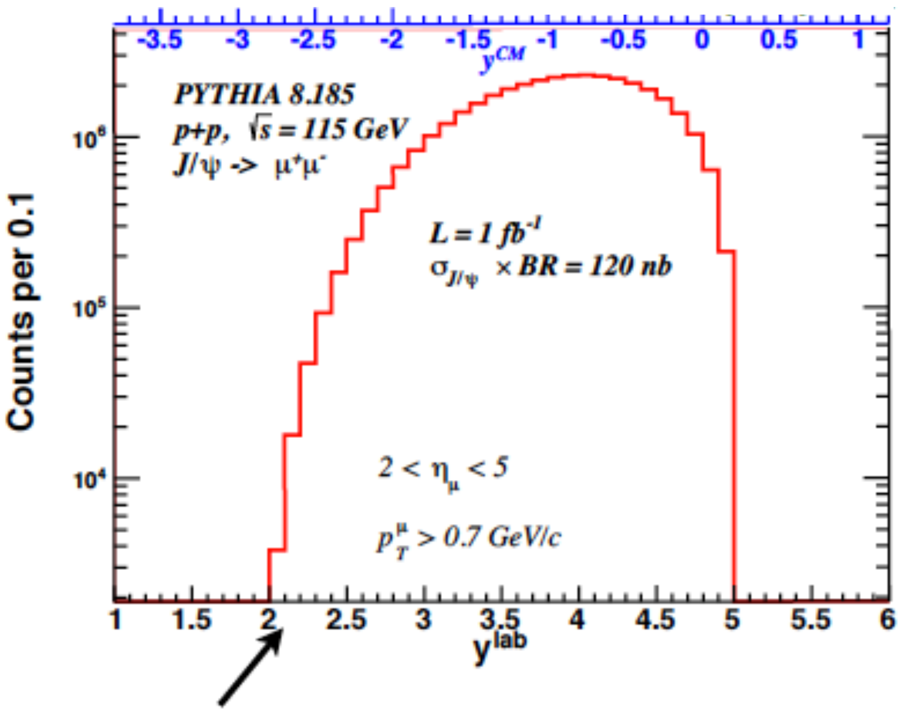
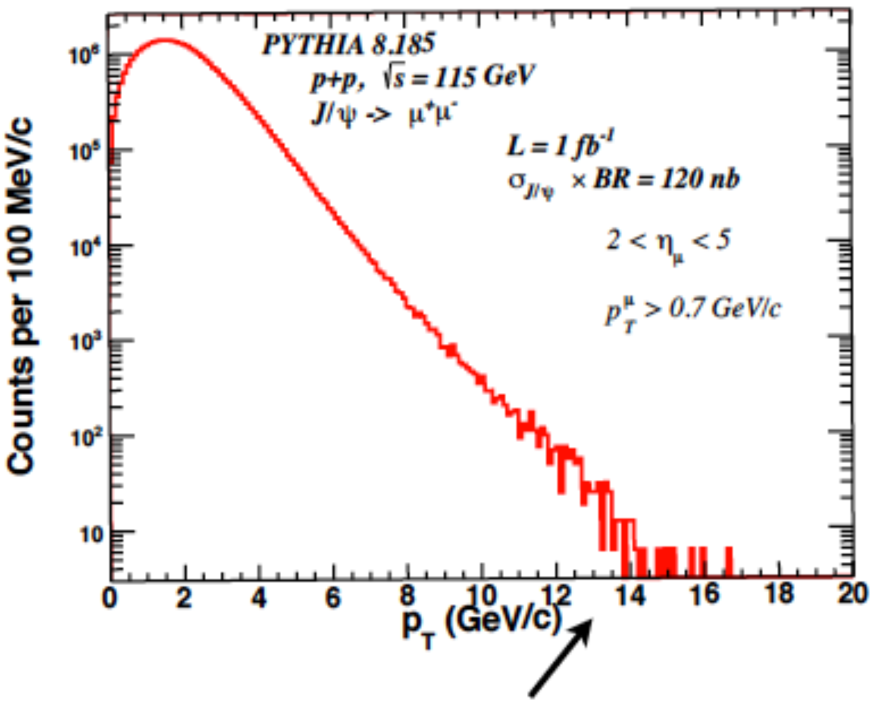




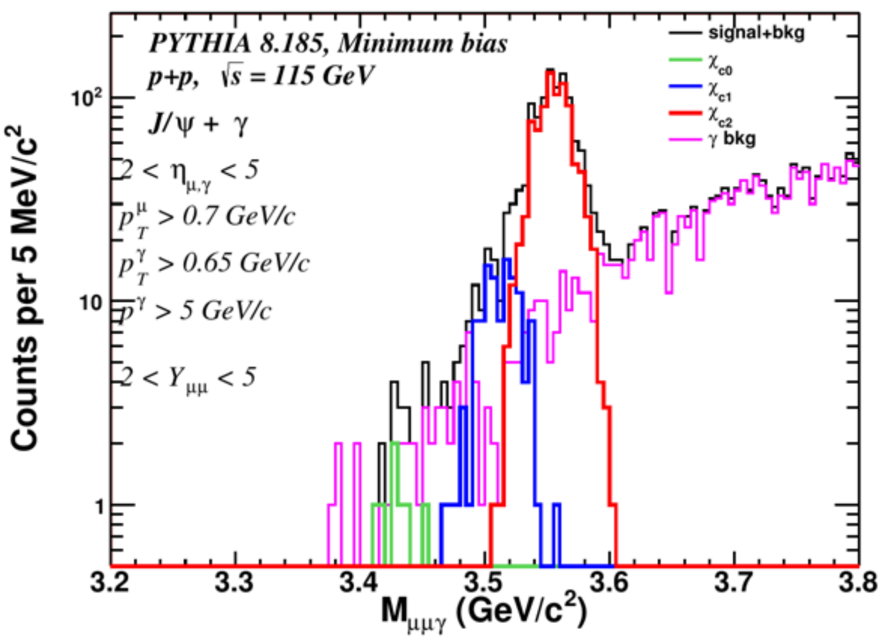
Large statistics allow one:

- To reach large p_T
- Study low y_{lab} with a statistical precision of ~3% ($2 < y_{lab} < 5$ → $-2.8 < y_{CMS} < 0.2$)

$\chi_C \rightarrow \mu^+\mu^-\gamma$ IN MB pp @ 115 GEV

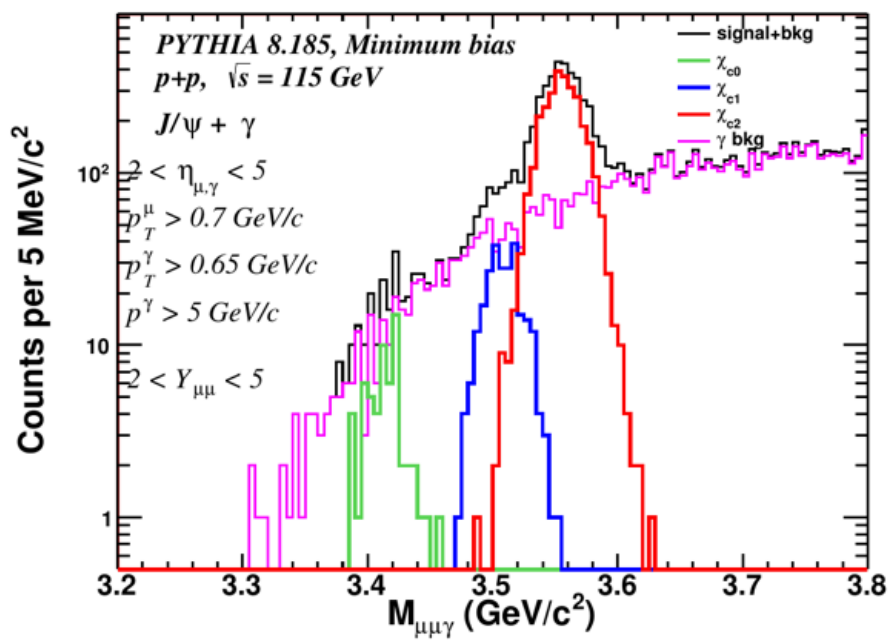
- Preliminary studies of the χ_c also started
- 100% gamma identification efficiency assumed at present

B. Trzeciak, July 2014, Orsay



Additional cuts on the photon

$p_T > 0.65$ GeV/c
$p > 5$ GeV/c



Additional cuts on the photon

$p_T > 0.5$ GeV/c
$p > 4$ GeV/c

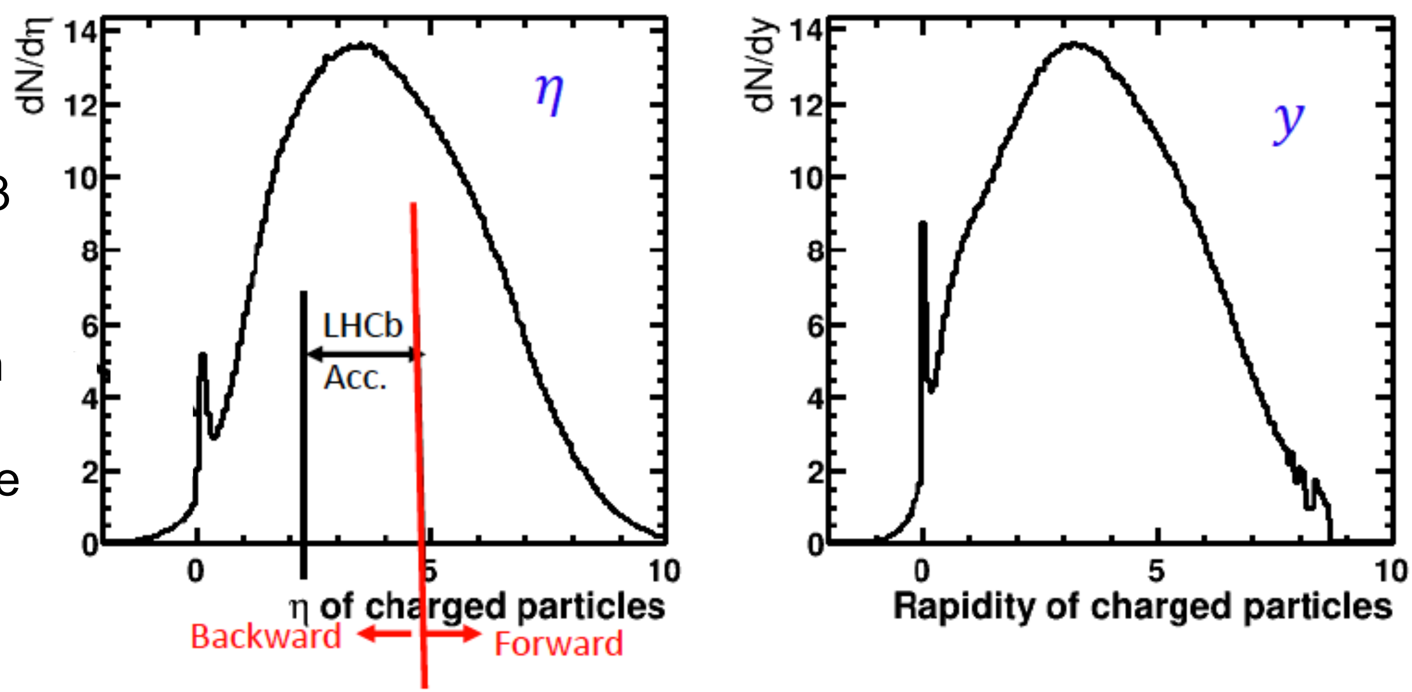
Simulations of a proton beam (7 TeV) on a Pb target ($\sqrt{s_{NN}}$ = 115 GeV)

- **Full LHCb simulation and standard reconstruction**
- Study the resolution at vertex, the occupancy in the pixels…
- Compare multiplicities in AFTER with LHCb pA run

- Simulations with HIJING version 1.383bs.2
- 10 000 events generated, no pile-up

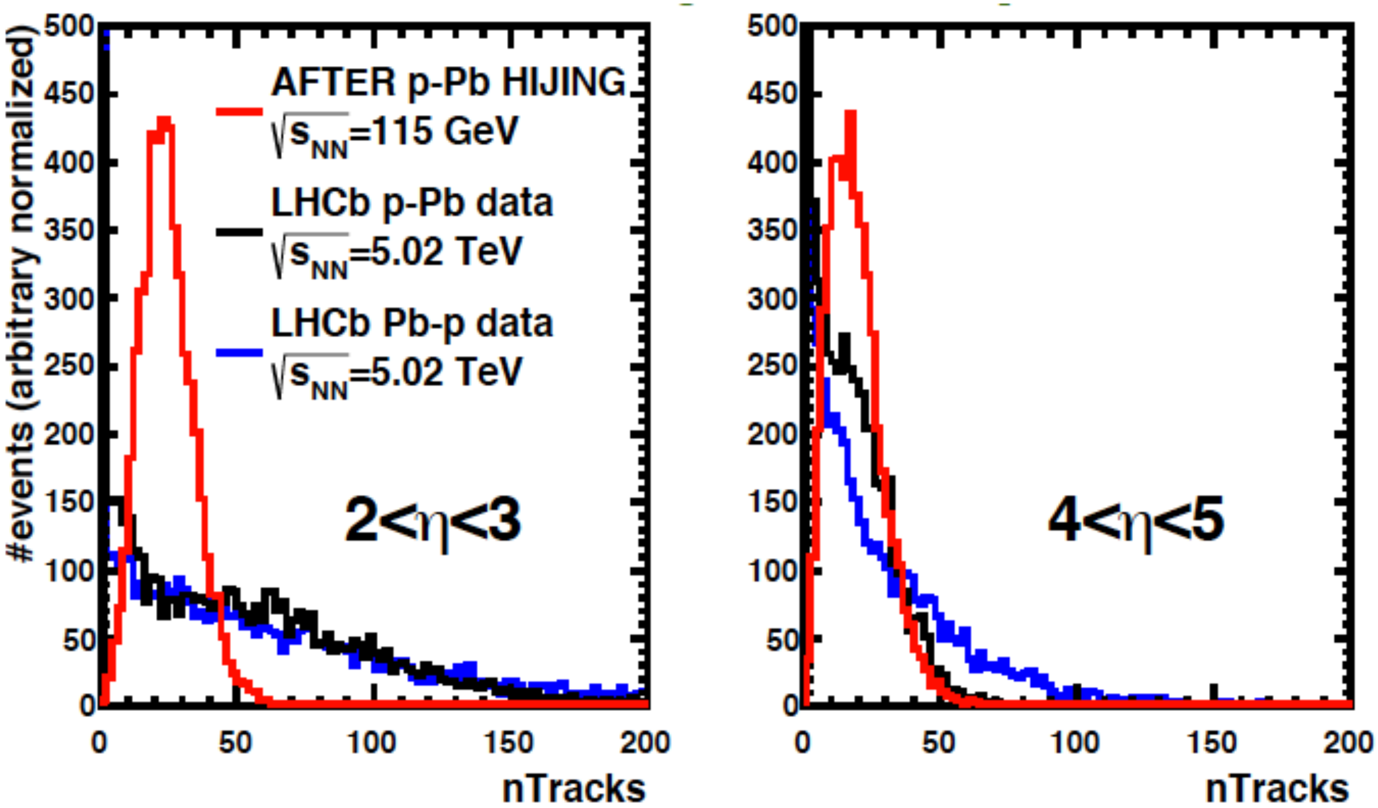
Z. Yang, AFTER workshop les Houches, January 2014

dN/dη ~ 13 Generated charged particles in LHCb acceptance



Simulations of a proton beam (7 TeV) on a Pb target ($\sqrt{s_{NN}}$ = 115 GeV)

Z. Yang, AFTER workshop les Houches, January 2014



- ❑ Track multiplicity in AFTER (pPb @ 115 GeV) is lower than the one measured by LHCb (pPb/Pbp @ 5.02 TeV)
- ❑ LHCb detector can cope with the multiplicity of pPb at $\sqrt{s_{NN}}$ = 115 GeV in 2 < η <5

SUMMARY

- **Several simulations already performed in pH, pA (115 GeV) mainly focus on quarkonia at present:**
  - Fast simulations with LHCb like parameters (y_{lab}, p_T reach for J/ψ in 2 weeks of data taking)
  - Simulations for χ_c ongoing

- **Promising results obtained in simulations with LHCb setup:**
  - Allows to study the track multiplicity, occupancy rates in a VELO like detector…
  - LHCb detector can cope with the multiplicities in AFTER (pA 115 GeV)

- **Simulations of the target in Geant4, development of a simulation framework for AFTER also ongoing**