Central Exclusive Production at LHCb

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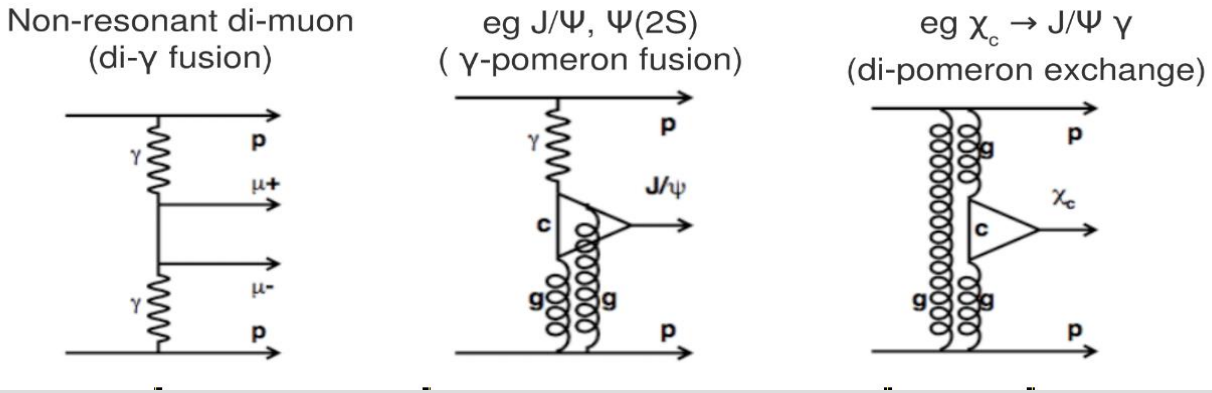
on behalf of LHCb collaboration

11.12.2k+17

9th International Workshop on Multiple Parton Interactions at the LHC
11-15 December 2017, Shimla, India

Introduction

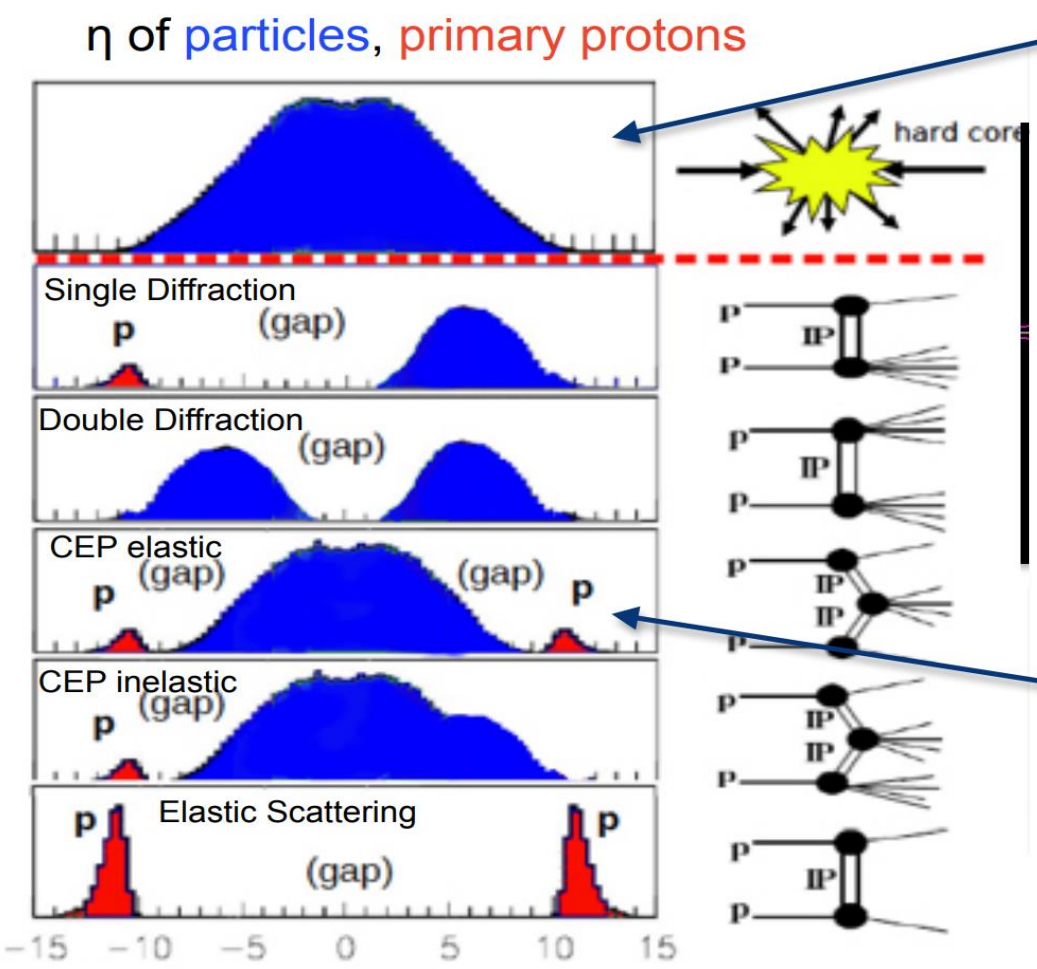
- Exchange of a colorless object: γ, *pomeron*



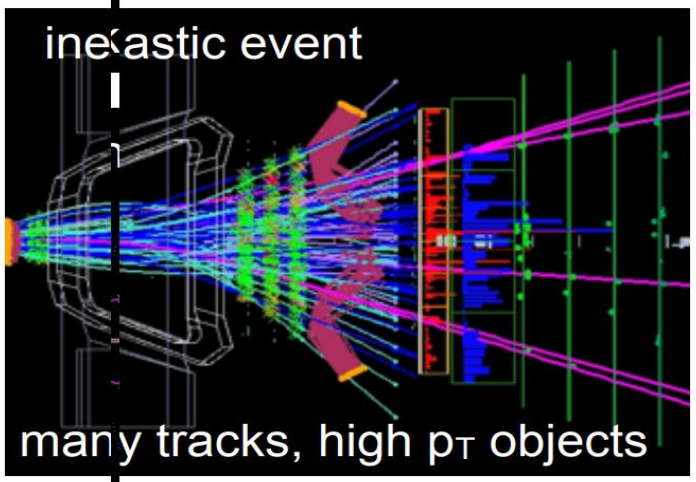
Exclusive candidates
Rapidity gap
Protons escape detection

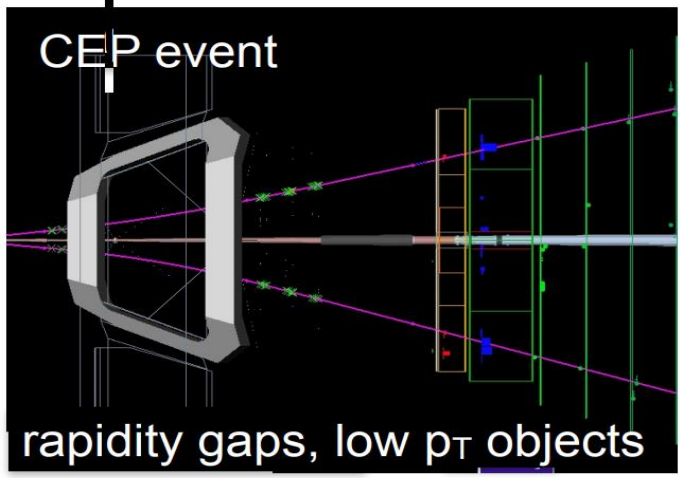
- Test of QCD, *pomeron* in clean environment
- Search for *odderon* and *saturation*
- Resonance production : sensitivity to gluon distribution at *extra low-x* $O(5\times10^{-6})$
- Non-resonance production: pure QED, well known
  - luminosity calibration
- Measured at HERA + Tevatron:
  - different kinematic ranges

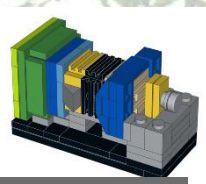
Rapidity gap



examples from LHCb







Fully instrumented in forward region $2<\eta<5$
Some capability in backward region $-3.5<\eta<-1.5$

Very flexible trigger:
ability to trigger for low momentum, low multiplicity

RICH Detectors:
95% $\varepsilon(K^{\pm})$ @5% $\pi \to K$ misID

Muon:
$\varepsilon(\mu^{\pm})$=97%@1-3% $\pi \to \mu$ misID

pp-interaction point

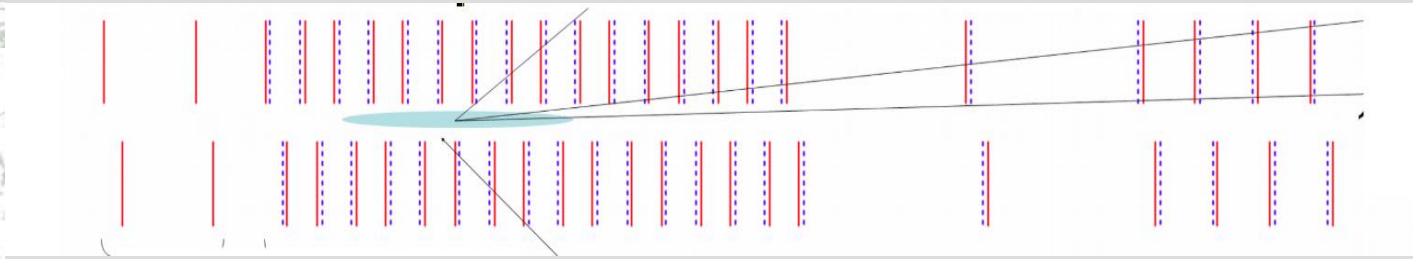
Vertex Locator
O(50fs) resolution for B
The most precise τ(B)

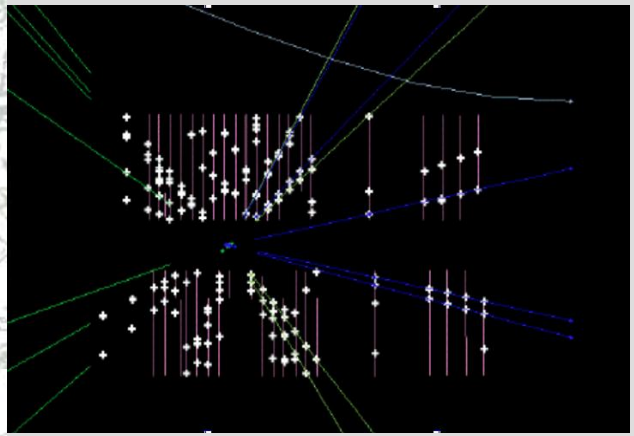
ECAL: $\sigma_m(\pi^0)=7 MeV/c^2$

Tracking:
$\Delta p/p$ =0.5-0.6% for 5<p<100 GeV/c
The most precise B-masses

LHCb Vertex Locator (VELO)

Silicon strip (r,ϕ) detector
Surrounding interaction region
no magnetic field





Forward: $1.5 < \eta < 5$
Backward: $-3.5 < \eta < -1.5$ (no momentum info)

Rapidity gap:
- forward: 3.5
- backward: 1-2 (depending on the vertex position)

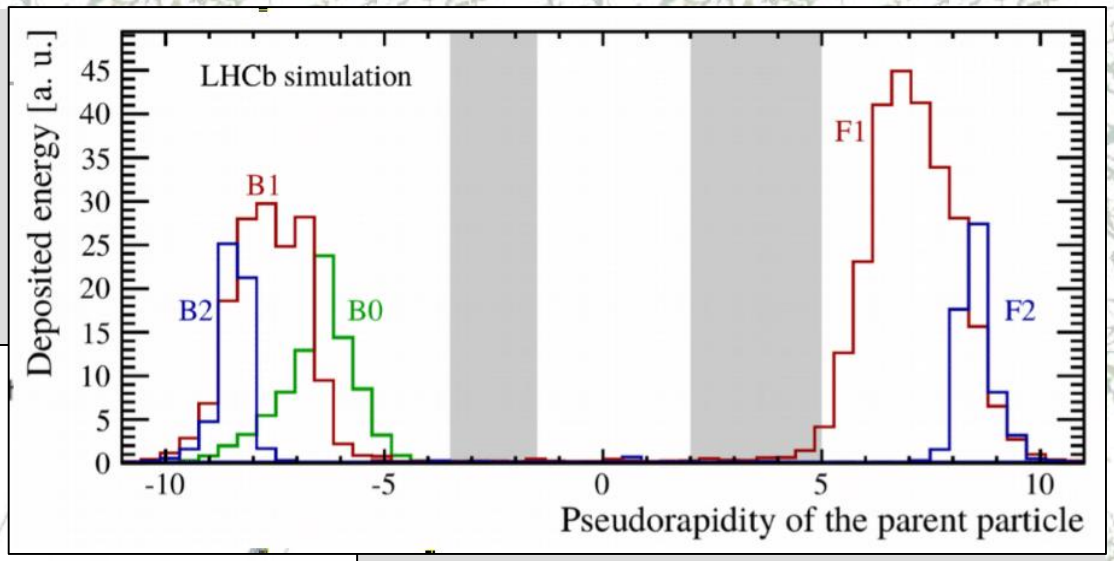
Run-II (2015-…) : Herschel

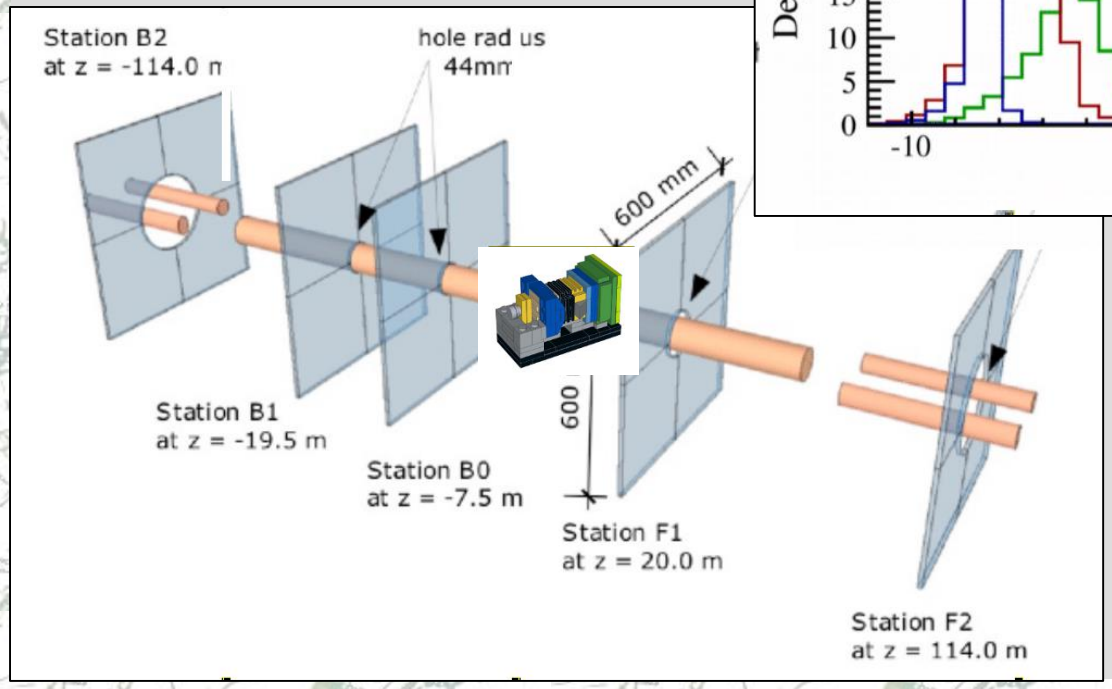
High Rapidity Shower Counters for LHCb

Additional scintillator planes

$-8.0<\eta<-1.5$

$5.0 < \eta < 8.0$





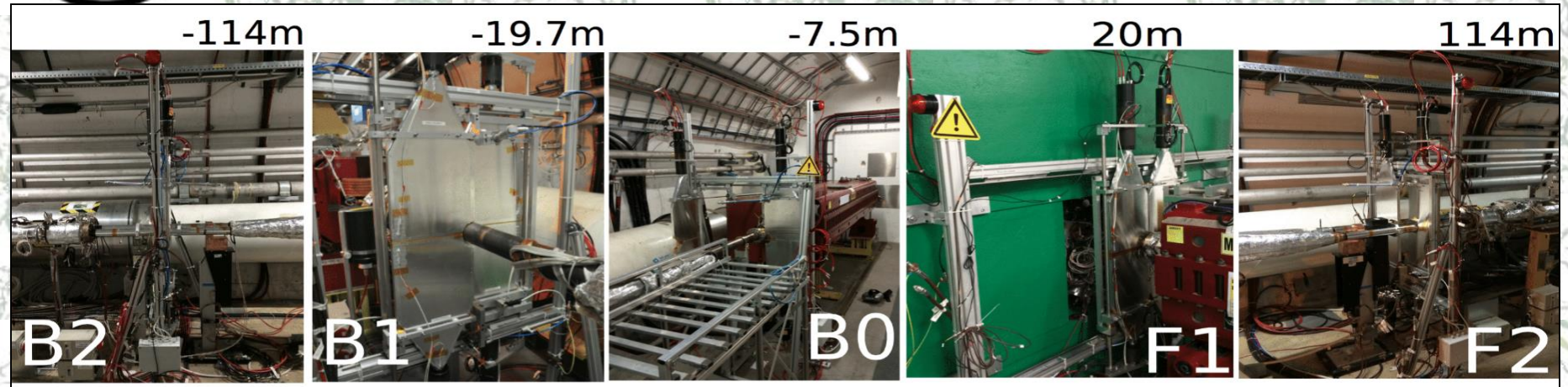
Five stations:

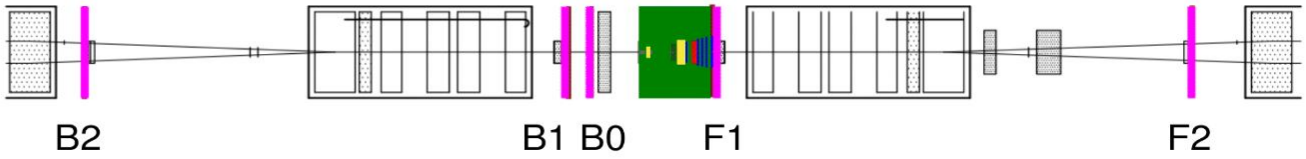
- 3 backwards
- 2 forward

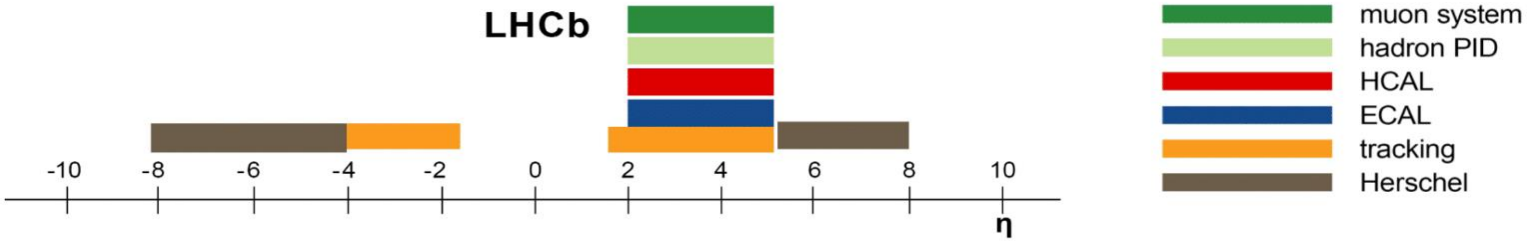
20mm of scintillator

Improve trigger **and** background rejection for CEP

Herschel



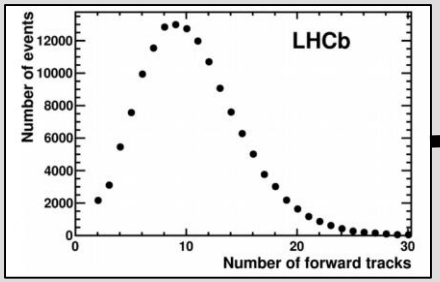




HeRSCheL pseudorapidity coverage: $-8.0 < \eta < -3.5$, $5.0 < \eta < 8.0$
LHCb (run II) $-8.0 < \eta < -1.5$, $2.0 < \eta < 8.0$

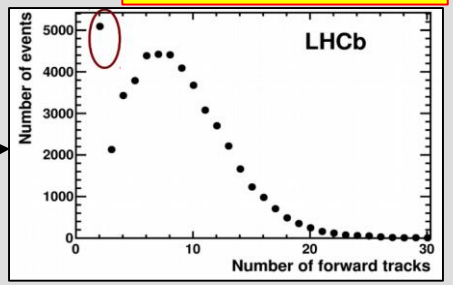
Measure of exclusivity @LHCb

- Number of tracks



No backward tracks

LHCb-CONF-2011-022

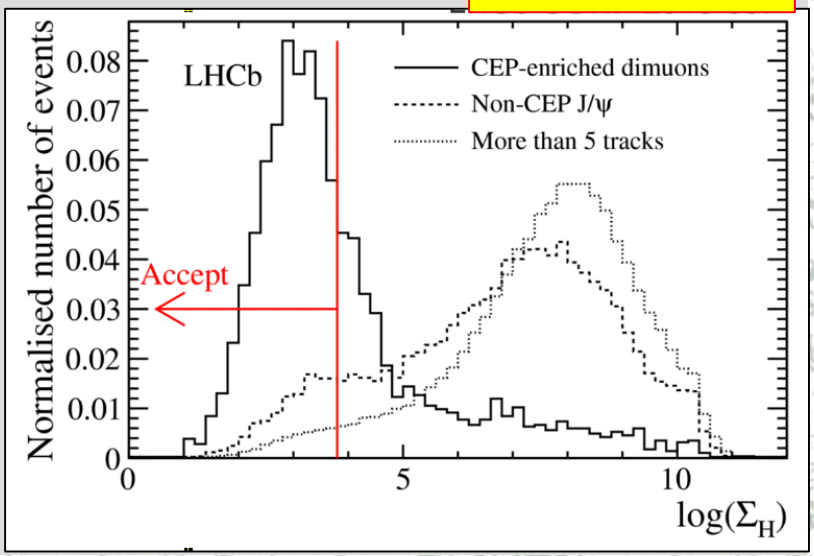


- #hits in SPD detector
- Herschel activity

$$\Sigma_H = \sum_{i=1}^{20} \left(\frac{ADC_i}{2.5 RMS_i} \right)^2$$

- Very small p_T^2

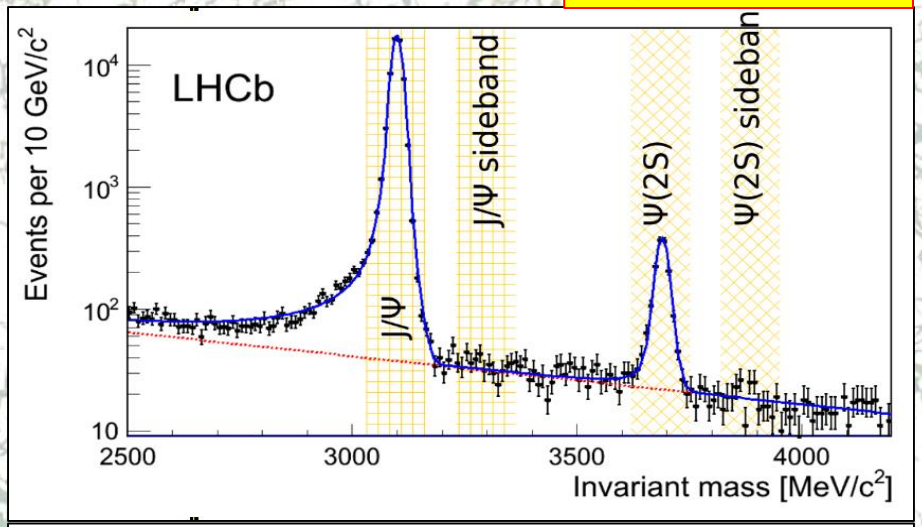
LHCb-CONF-2016-007

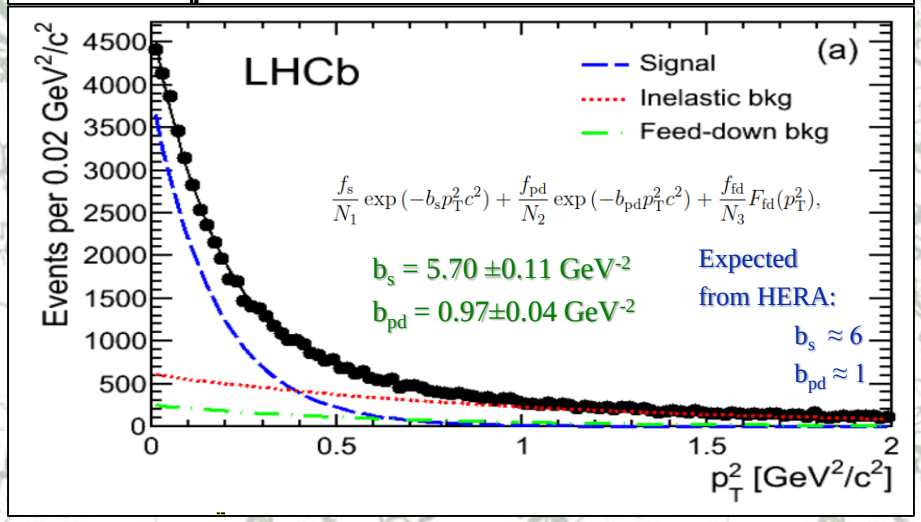


J/ψ, ψ' @ 7TeV

J.Phys.**G41**(2014) 055002

- 1fb^{-1}
- 2 muons
  - no other activity
- Backgrounds:
  - Non-resonant
    - J/ψ:1% , ψ' :17%
  - Feed-down
    - J/ψ: 10%, ψ' 2%
  - Inelastic – dominant
    - 40% (from p_T^2 fit)

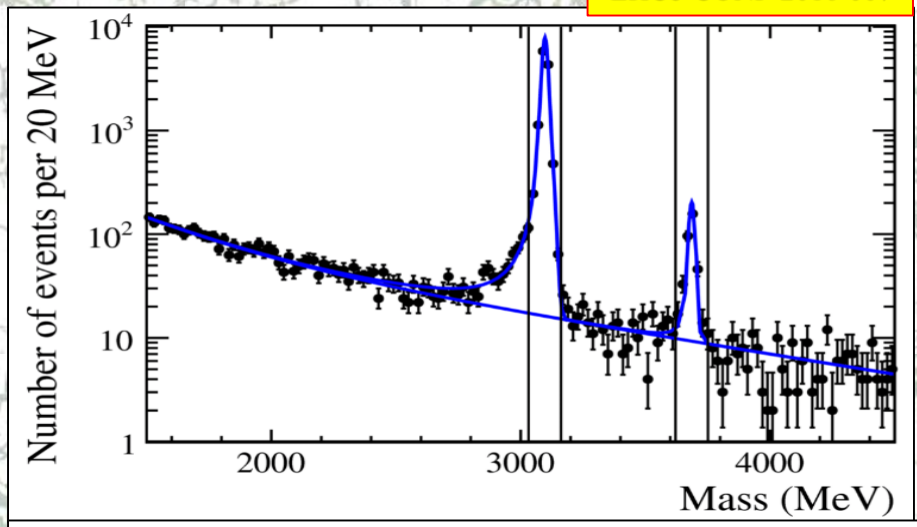


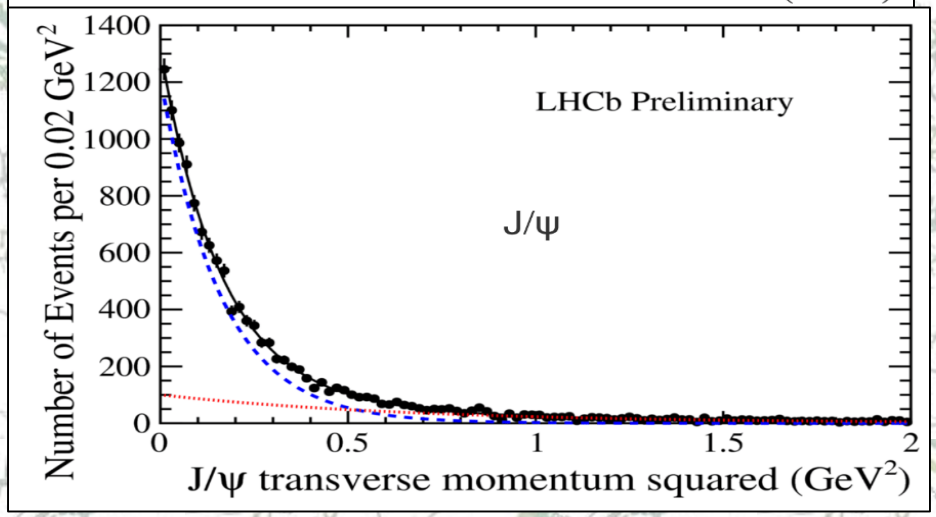


J/ψ, ψ' @ 13TeV

- 0.2fb^{-1} (2015)
- 2 muons
  - no other activity
  - **Herschel veto**
- Backgrounds:
  - Non-resonant
    - J/ψ:1% , ψ' :18%
  - Feed-down
    - J/ψ: 6%, ψ' 2%
  - Inelastic – dominant
    - 20% (from p_T^2 fit)

LHCb-CONF-2016-007

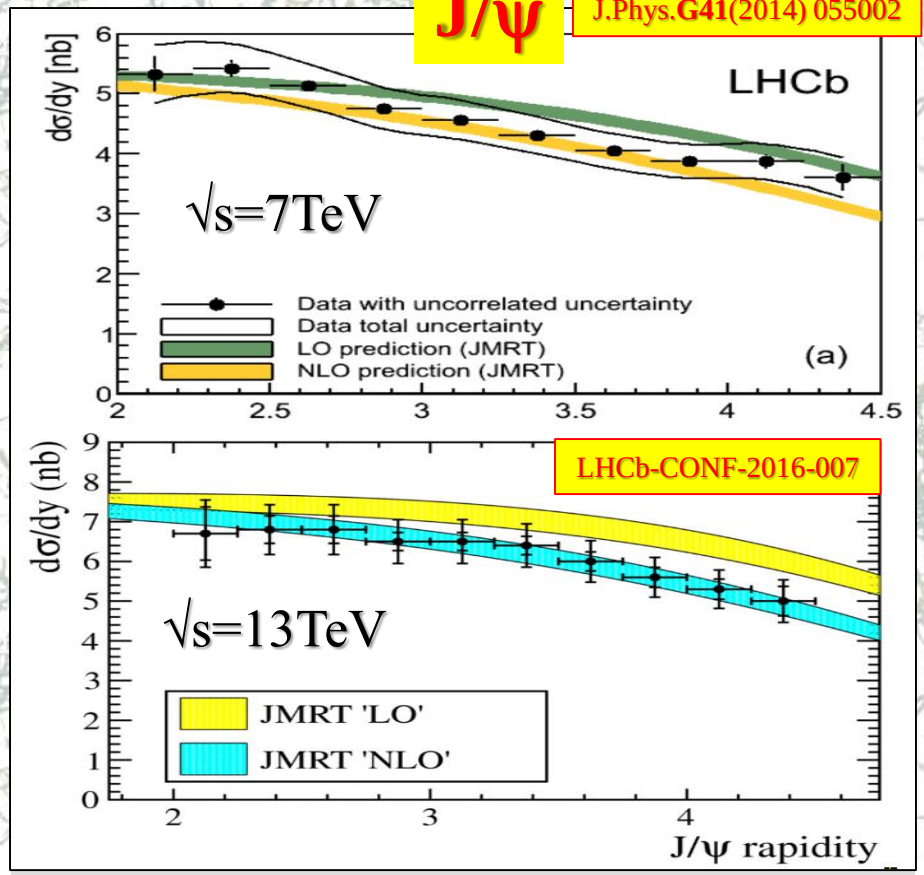




J/ψ, ψ' @ 7&13TeV

J/ψ

J.Phys.G41(2014) 055002



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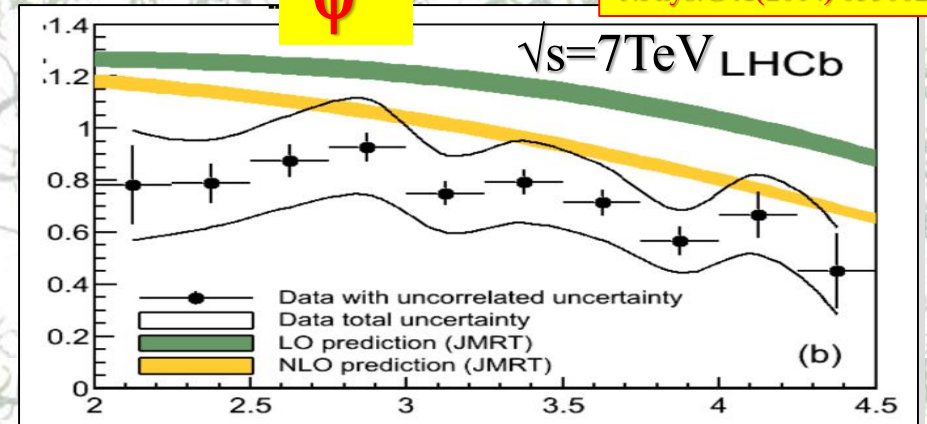
ψ'

J.Phys.G41(2014) 055002



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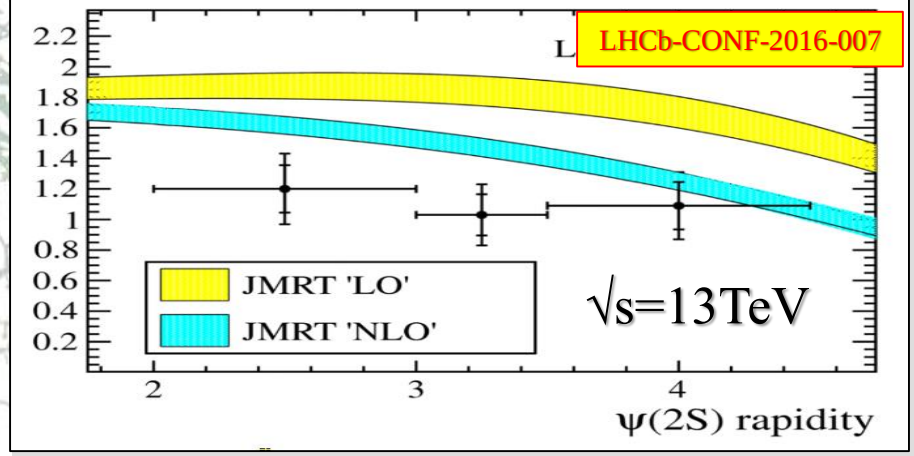


The shapes are better described by NLO predictions:

Jones,Martin, Ryskin, Teubner JHEP 1311(2013) 085

J/ψ & ψ' photoproduction

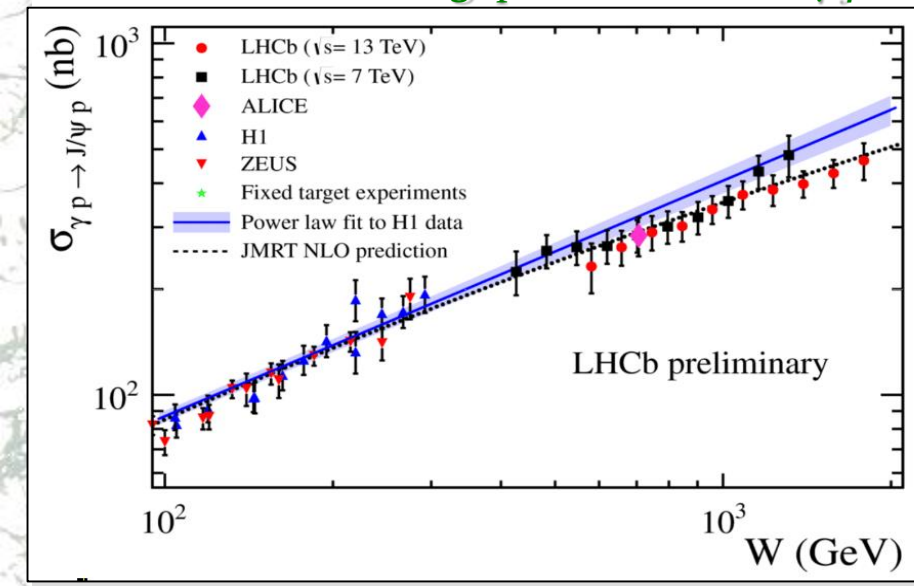
$$\sigma_{pp\to p\psi p} = r(W_+)k_+\frac{dn}{dk_+}\sigma_{\gamma p\to\psi p}(W_+) + r(W_-)k_-\frac{dn}{dk_-}\sigma_{\gamma p\to\psi p}(W_-).$$

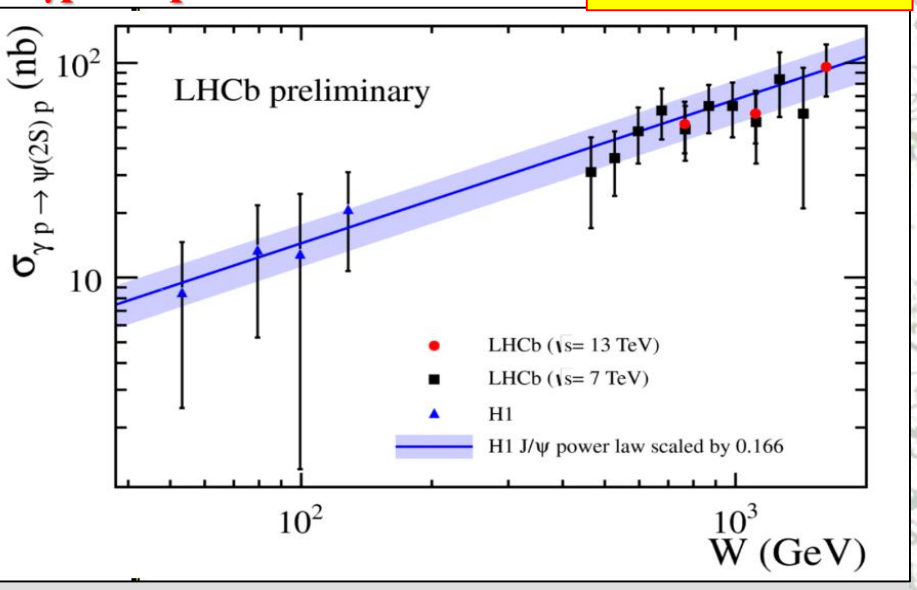
$k_\pm = m_\psi/2e^{\pm y} = E_\gamma$

$W^2_\pm = 2k_\pm\sqrt{s} = m^2(\gamma p)$

measured — *gap survival* — *γ-flux* — **γp→Vp *x-section***

LHCb-CONF-2016-007

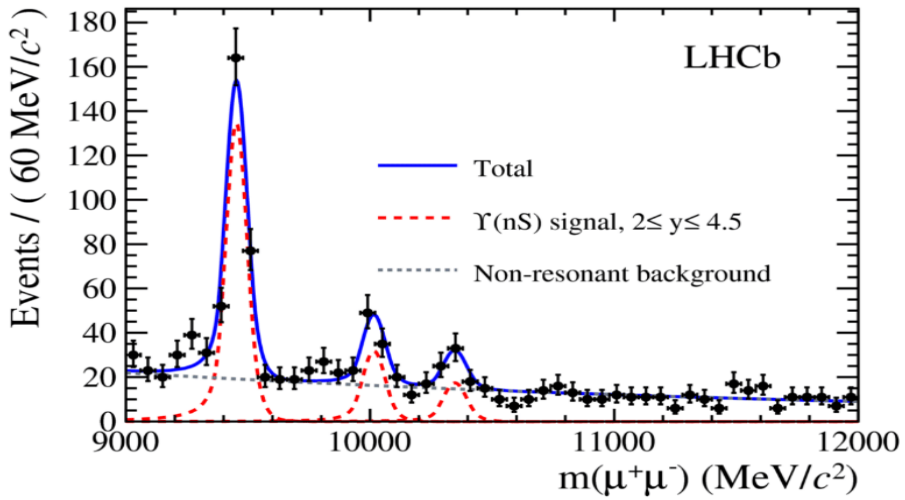


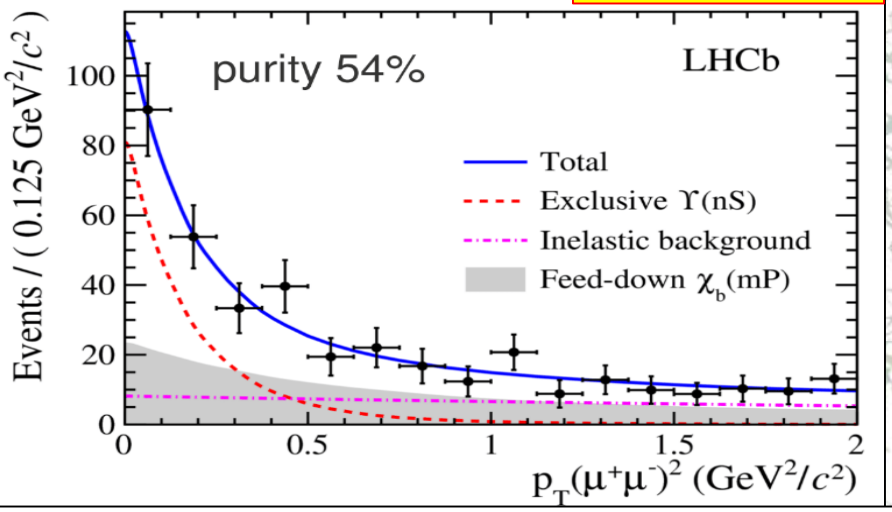


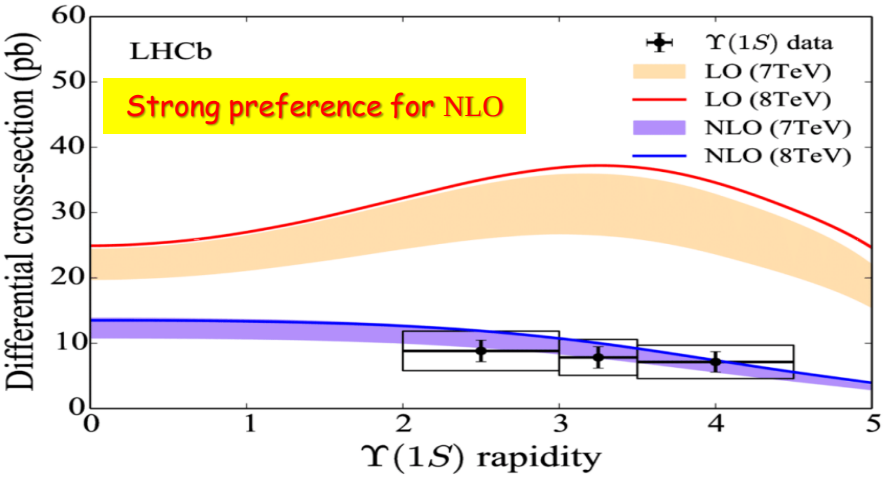
- Good agreement between √s=7 & 13TeV

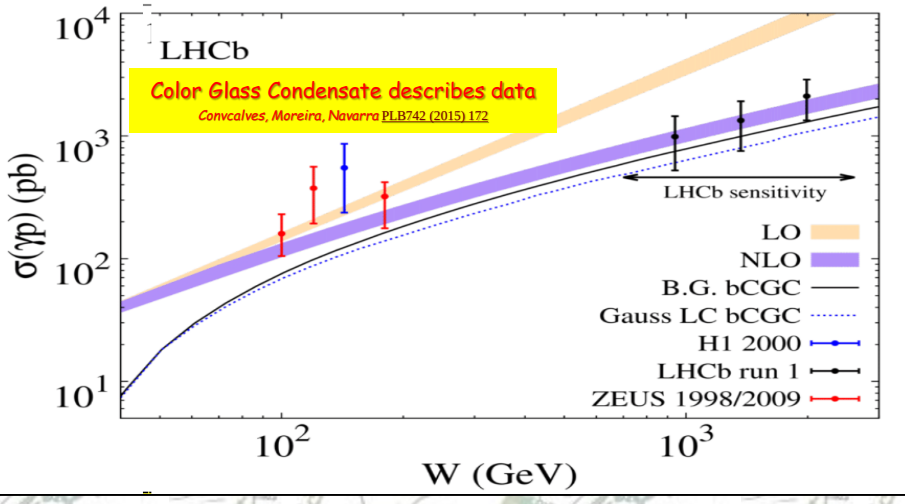
CEP of Υ at 7 and 8TeV

JHEP 1509 (2015) 084



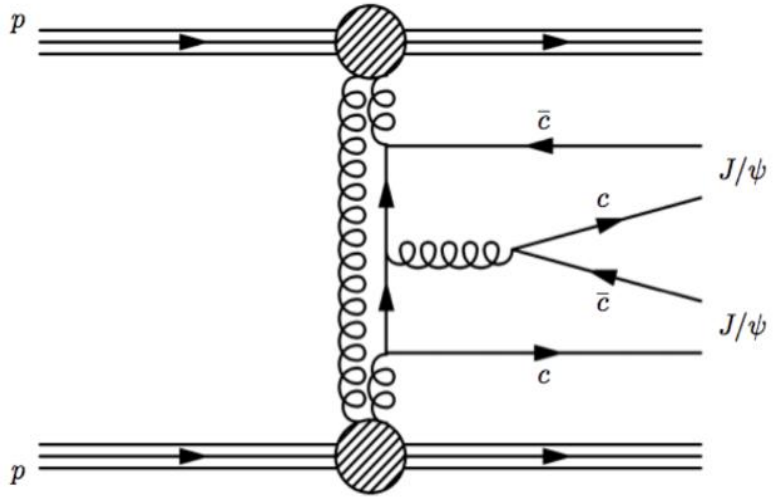


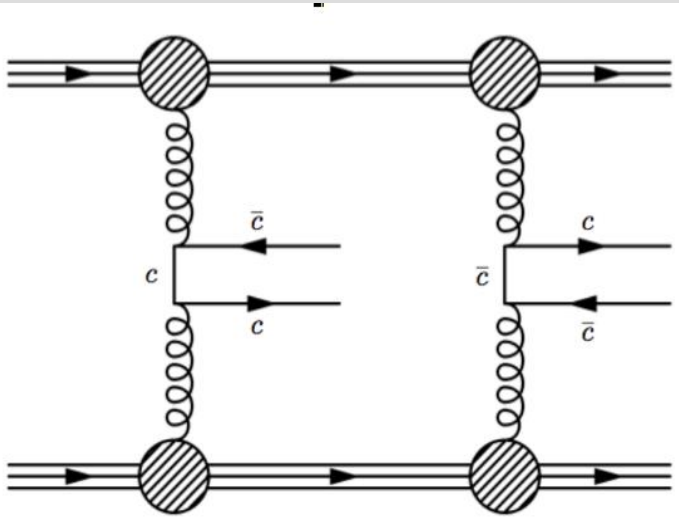




CEP: double charmonium

- Two *pomeron* exchange

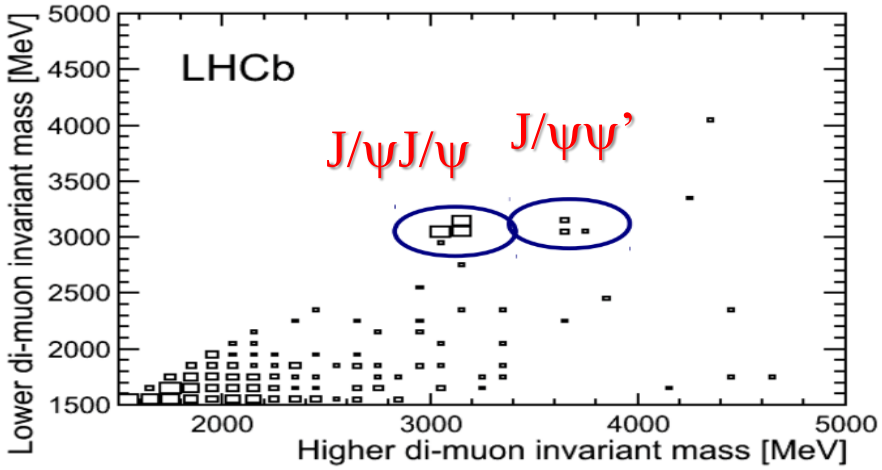


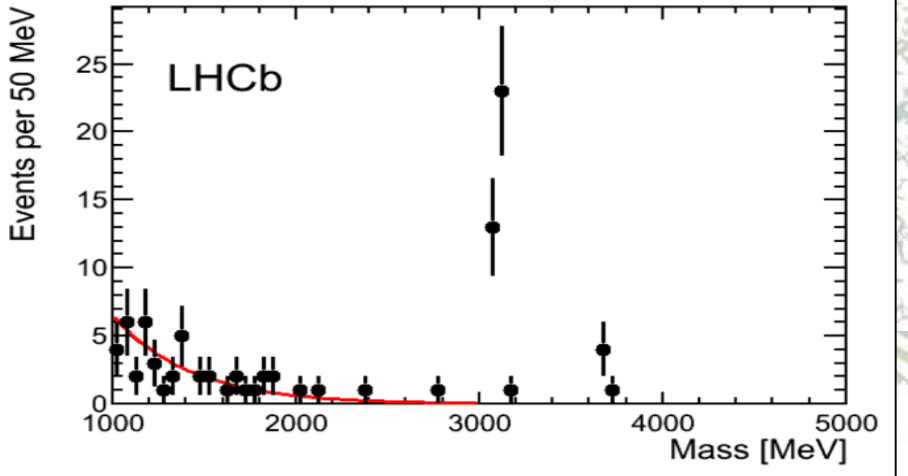


- Cross-section senstitive to exotics
  - Glueballs, tetraquarks

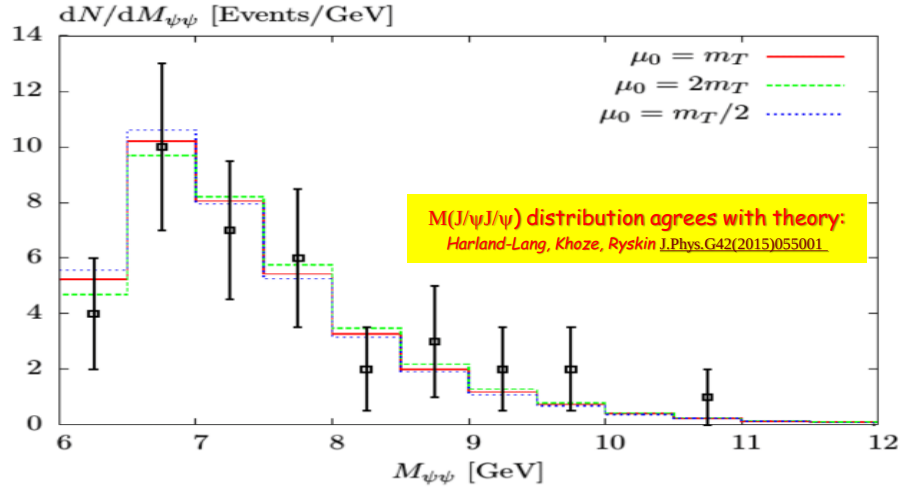
CEP: double charmonium

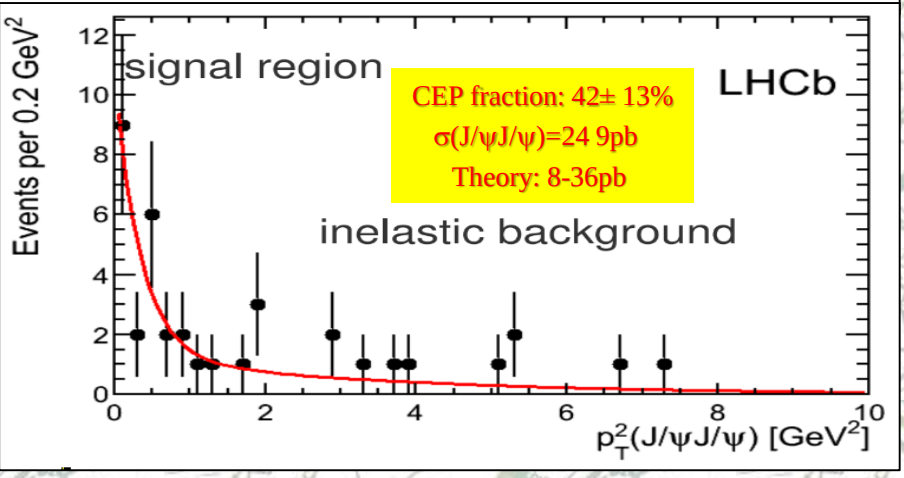
J.Phys.G41 (2014) 115002





invariant mass of 2nd di-muon pair





Conclusions

- LHCb's forward acceptance provides unique window on CEP
- Spectroscopy in a very clean environment
- QCD:
  - Very *low-x* gluon PDF
  - Nature of *pomeron*
  - Sensitivity to *glueballs, odderons, tetraquarks*
- Outlook
  - Increased sensitivity (Herschel)
  - Expect to collect $O(5\text{fb}^{-1})$ with low pileup –
    - A lot of unique and interesting measurements is expected

Stay tuned!

CEP in LHCb