CENTRAL EXCLUSIVE PRODUCTION OF J/ψ MESONS IN LHCb

NNV Annual meeting

November 2nd, 2018

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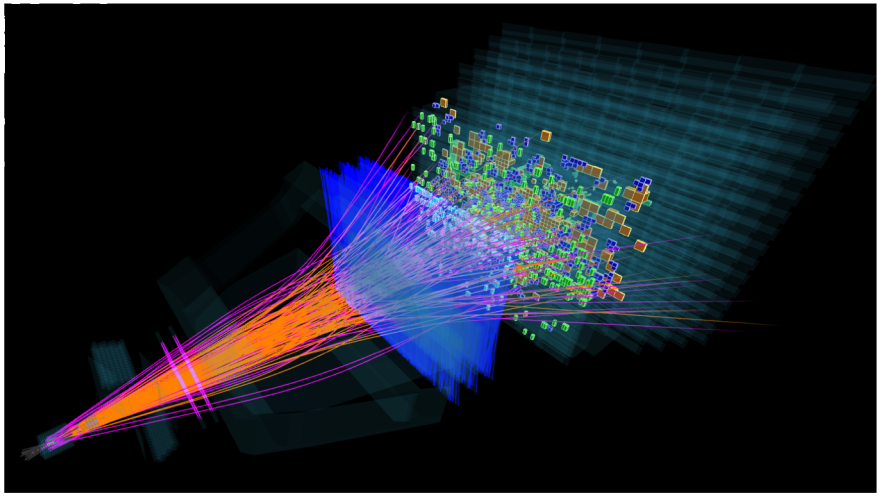
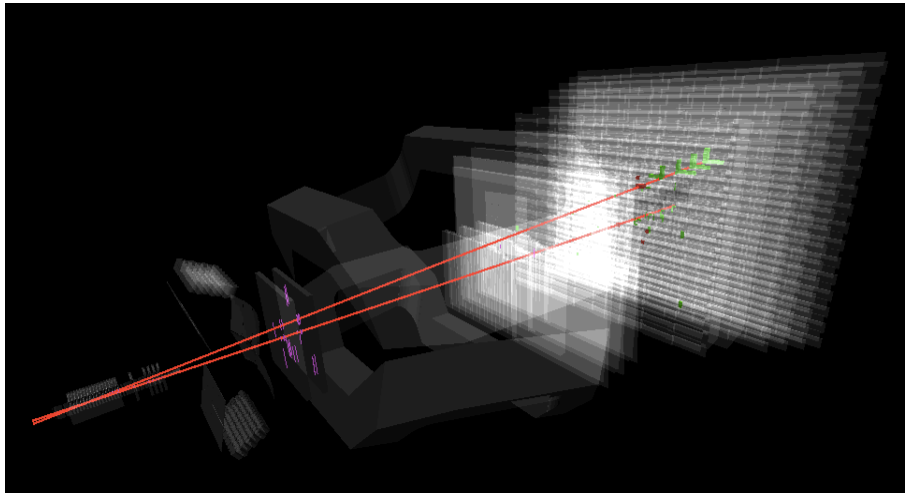
WHAT IS **C**ENTRAL **E**XCLUSIVE **P**RODUCTION?

- CEP event → diffractive process of the form $pp \to p + X + p$

- Looks like this at LHCb:



Inelastic pp collision



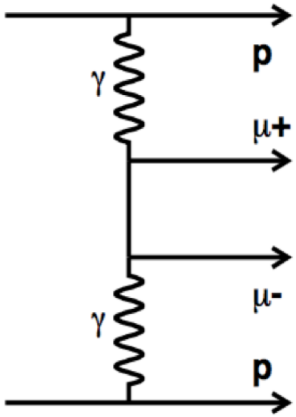
Quasi-elastic pp collision:
$\Upsilon \to \mu\mu$ CEP

WHAT IS CENTRAL EXCLUSIVE PRODUCTION?

- CEP event → diffractive process of the form $pp \rightarrow p + X + p$

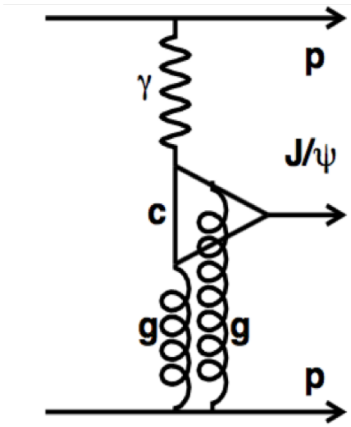
- Mediated by the exchange of a colourless object:

γ-γ fusion



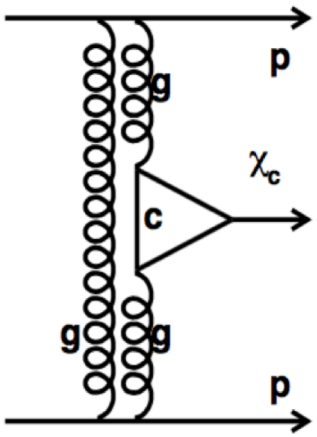
$\mu\mu, ee, \pi\pi, \ldots$

γ-pomeron fusion



$J/\psi, \rho, \Upsilon, \ldots$
$J^{PC} = 1^{--}$

di-pomeron fusion



χ_c, gg, dijet, ...
PC = + +, J = 0,1,2

- Pomeron: two or more gluons in a colour-singlet state

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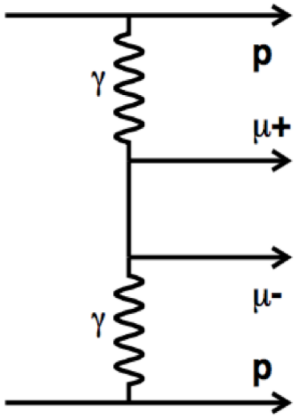

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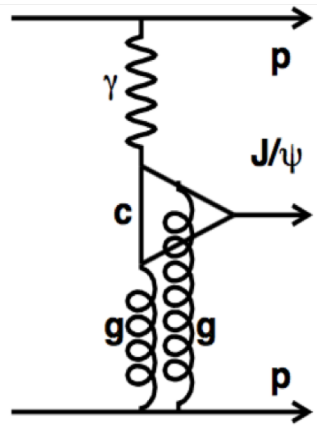

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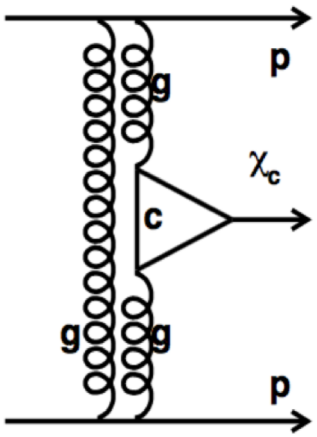

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$\mathrm{PC} = ++, \quad \mathrm{J} = 0,1,2$

- Pomeron: two or more gluons in a colour-singlet state

WHY CEP?

- Measure the $J/\psi \to e^+e^-$ differential cross-section at $\sqrt{s} = 13\ \mathrm{TeV}$

→ **Have a high precision measurement of the electron reconstruction for future analyses at LHCb** by measuring $R_{J/\psi} = \frac{d\sigma(J/\psi \to \mu^+\mu^-)}{dy} \Big/ \frac{d\sigma(J/\psi \to e^+e^-)}{dy}$ ($\sigma_{J/\psi \to \mu^+\mu^-}$ already measured, [LHCB-PAPER-2018-011])

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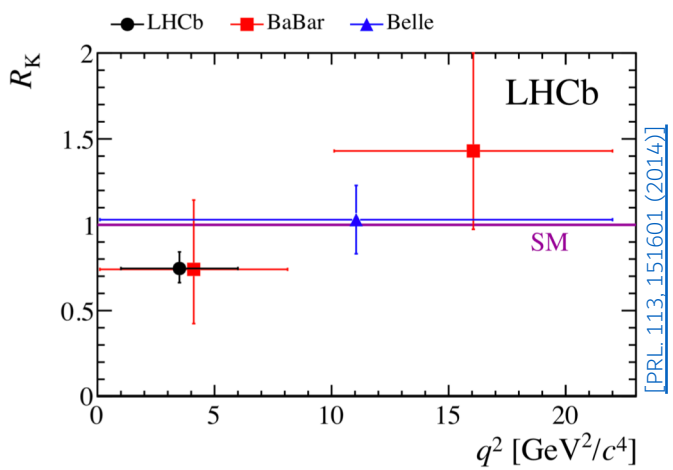
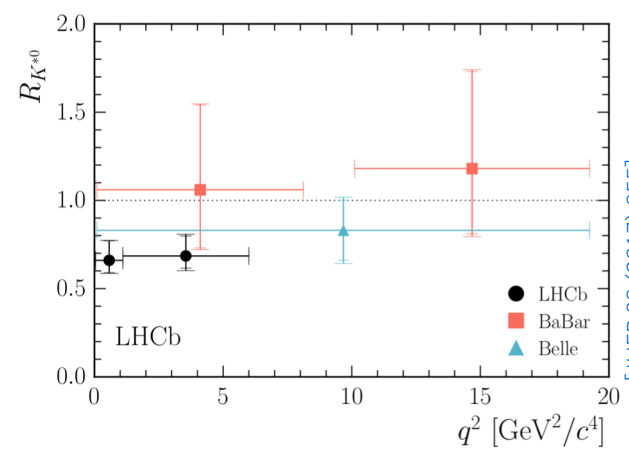
- Recently: hints of lepton flavor universality violation in $B^{+(*)} \to K^{+(*0)}ll$ $(l = e, \mu)$



[PRL. 113, 151601 (2014)]

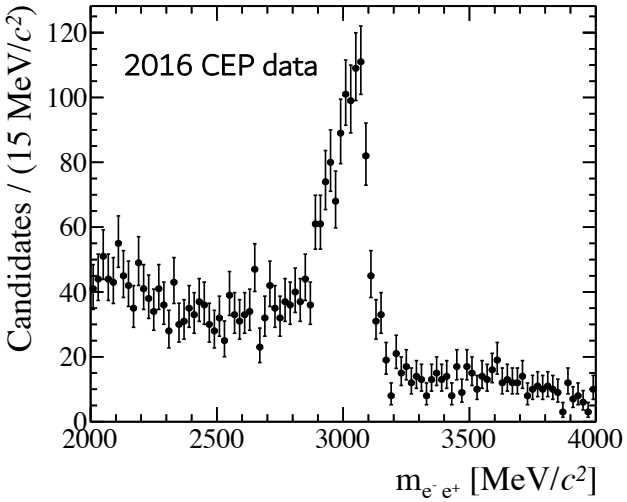


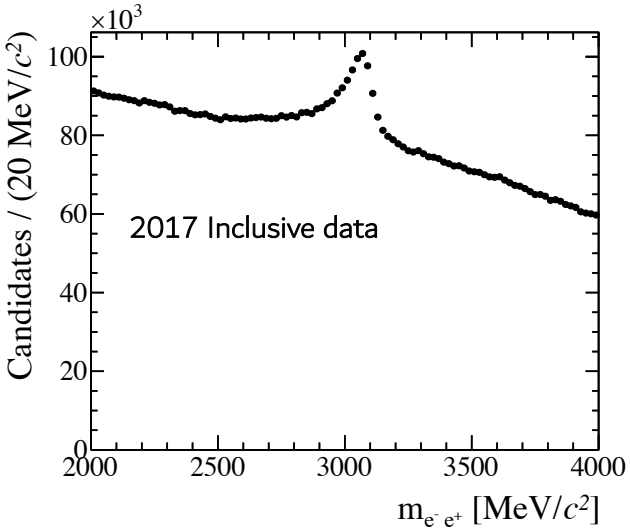
[JHEP 08 (2017) 055]

$$R_{K^{*0}} = \frac{\mathcal{B}(B^0 \to K^{*0}\mu^+\mu^-)}{\mathcal{B}(B^0 \to K^{*0}J/\psi(\to \mu^+\mu^-))} \Big/ \frac{\mathcal{B}(B^0 \to K^{*0}e^+e^-)}{\mathcal{B}(B^0 \to K^{*0}J/\psi(\to e^+e^-))}$$

WHY CEP?

- Almost background-free events

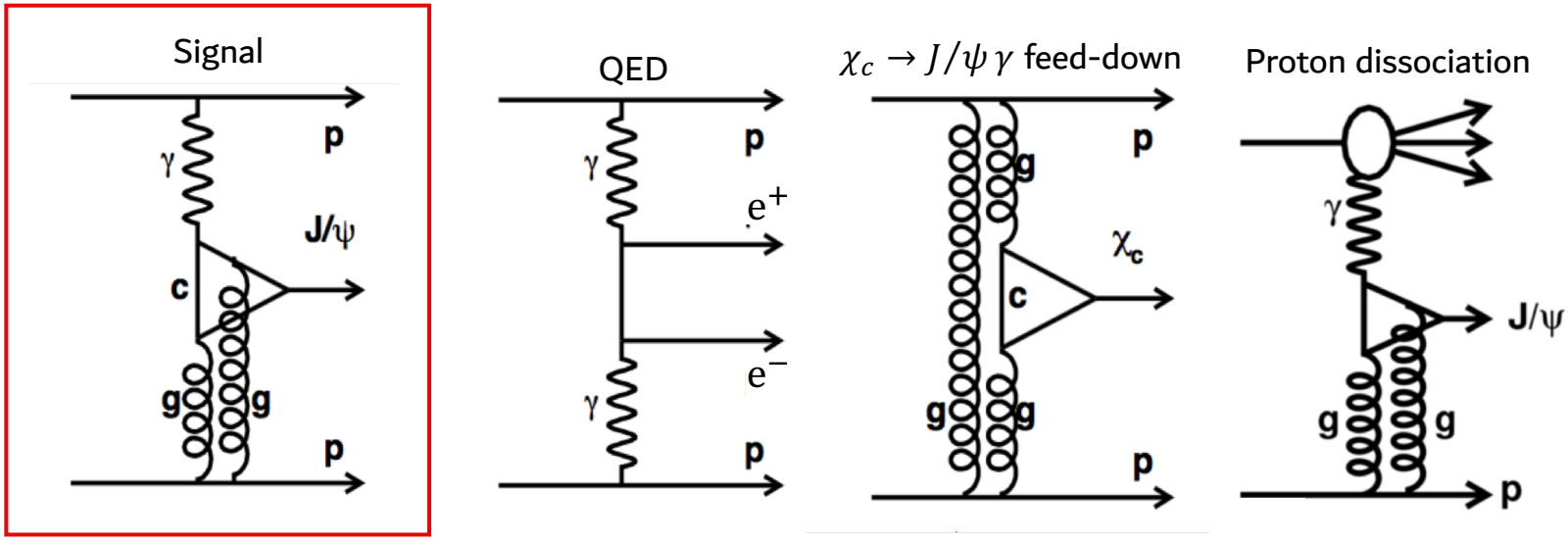




- Allows for investigation on the electron reconstruction and Bremsstrahlung recover algorithm

$J/\psi \to e^+e^-$ IN CEP: Backgrounds

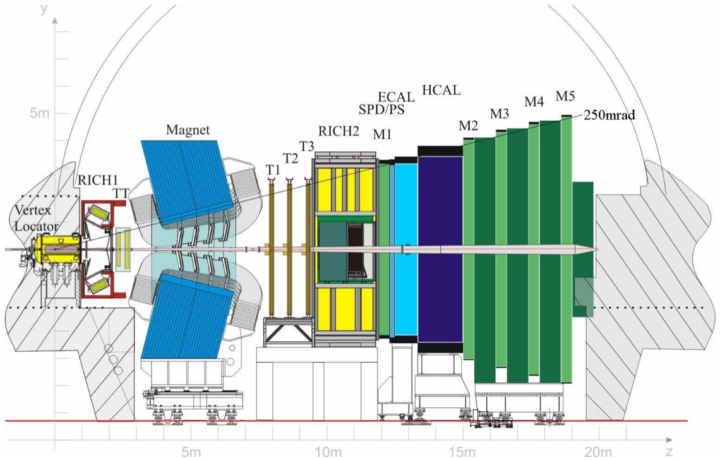
- Three main types of background:

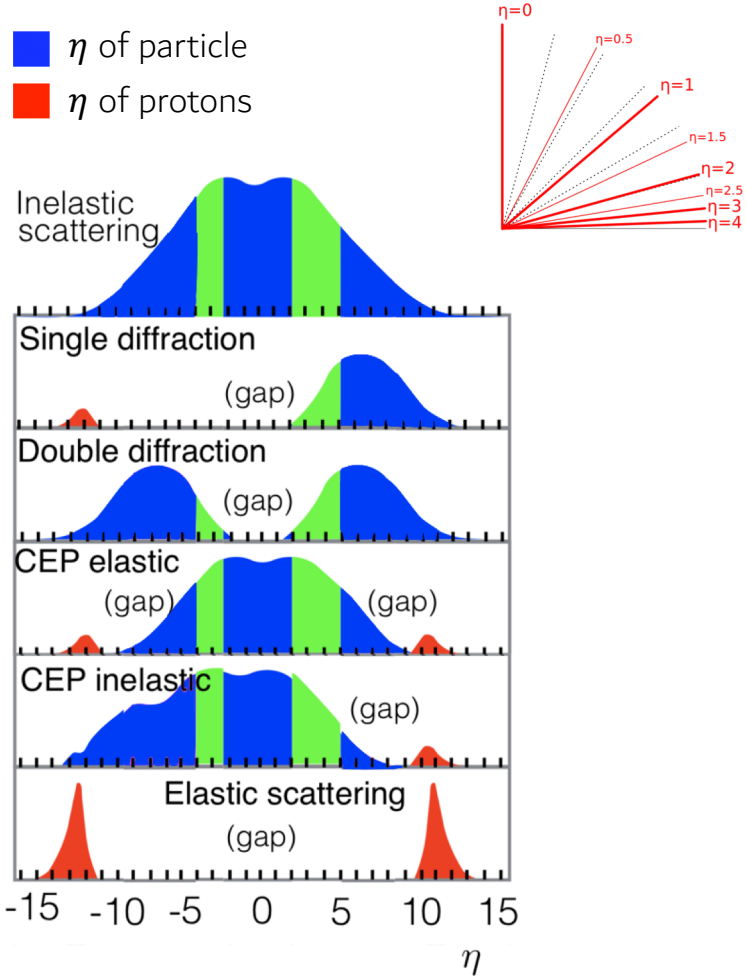


$J/\psi \to e^+e^-$ IN CEP: HeRSCheL

- **LHCb**: full coverage in $2 < \eta < 5$, partial for $-3.5 < \eta < -1.5$

[2008 JINST 3 S08005]





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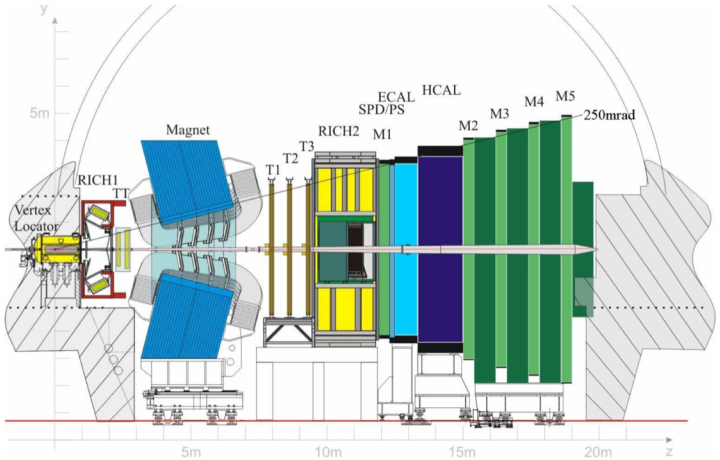
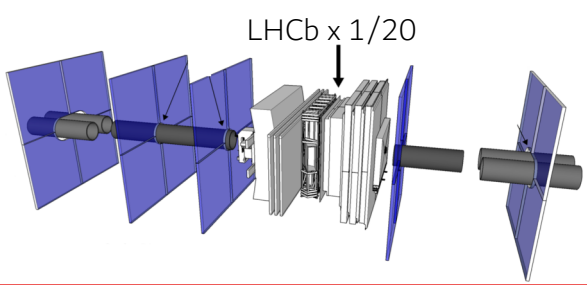
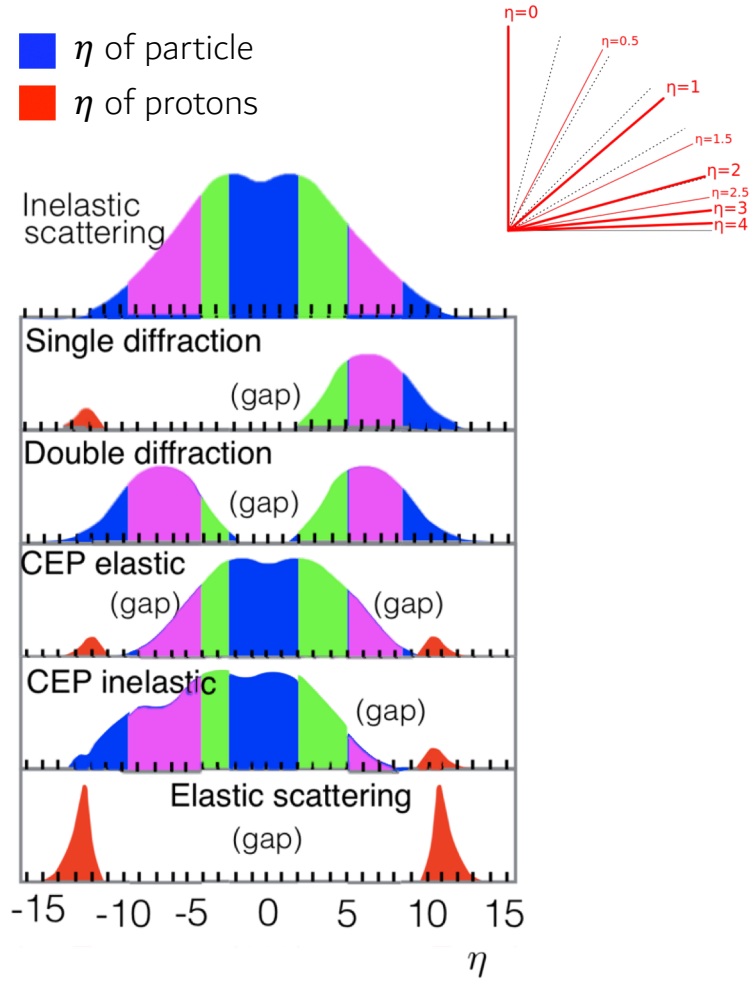


- **HeRSCheL**: coverage in $-10 < \eta < -5$, $-3.5 < \eta < -1.5, 1.5 < \eta < 10$

[JINST 13 (2018) no.04, P04017]

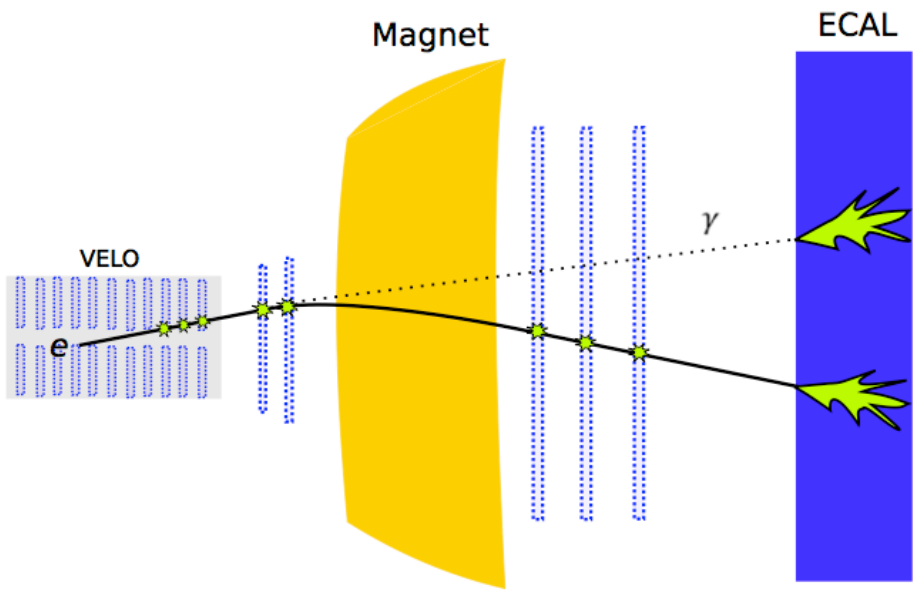


(HeRSCheL: High Rapidity Shower Counters for LHCb)



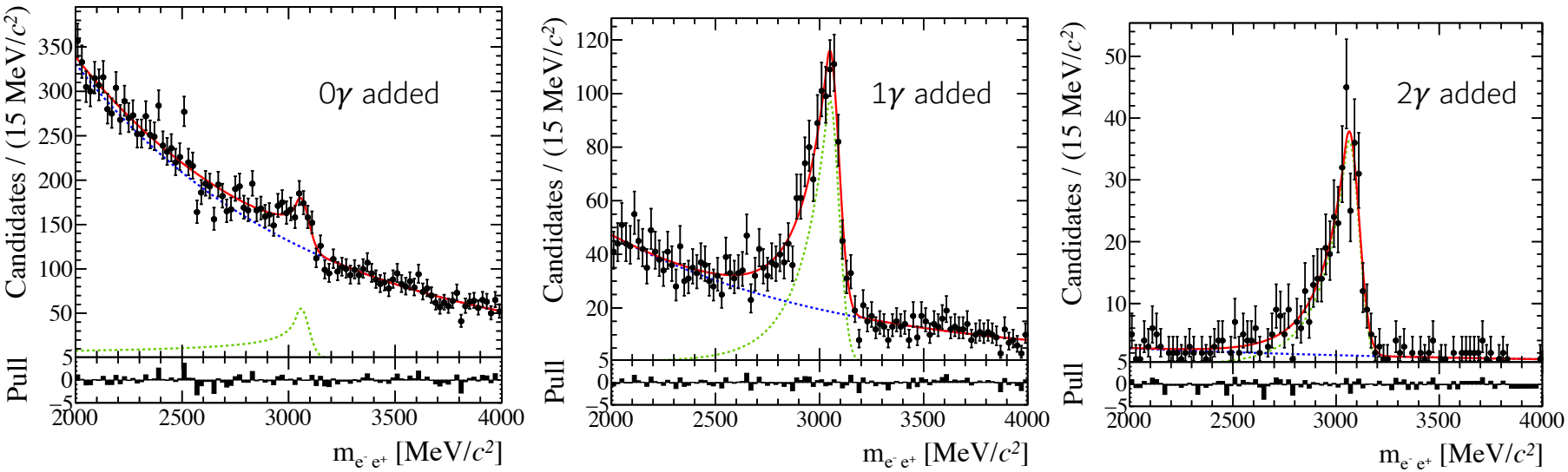
$J/\psi \rightarrow e^+e^-$ IN CEP: Bremsstrahlung

- CEP allows for investigation on the electron reconstruction and Bremsstrahlung recover algorithm



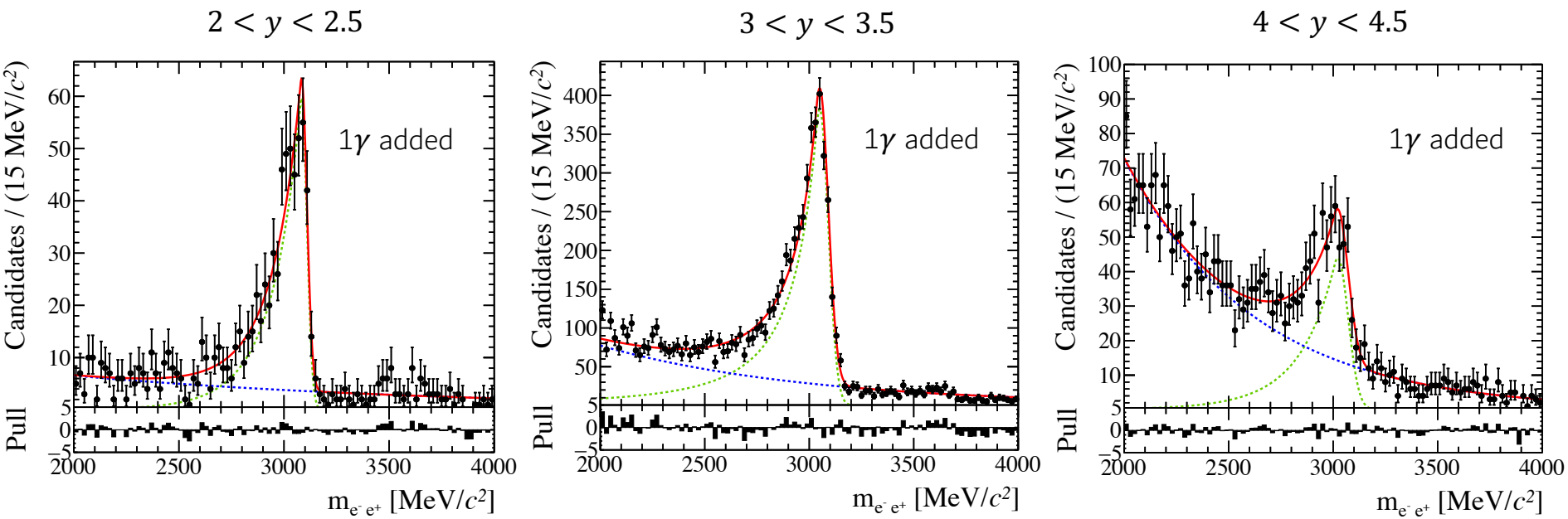
$J/\psi \to e^+e^-$ IN CEP: Bremsstrahlung

- The mass shape is dependent on the Bremsstrahlung correction
  → we split the data into three "categories"



$J/\psi \to e^+e^-$ IN CEP: Rapidity bins

- We also split the data into 10 equally spaced y bins in the range $2 < y < 4.5$

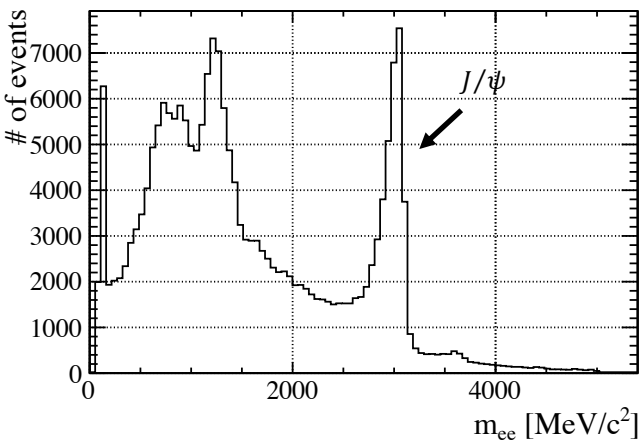


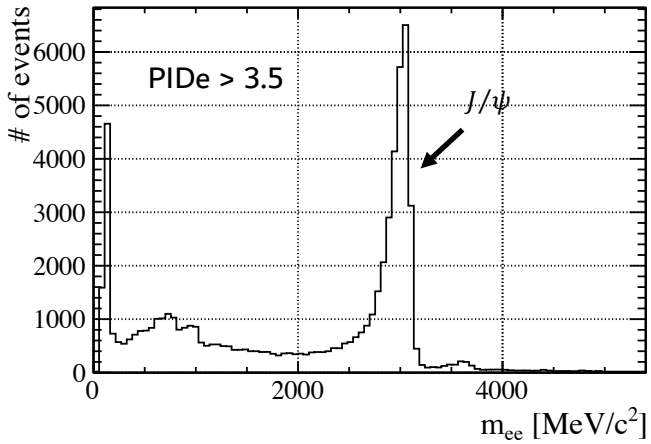
→ There are many more events in the central region

$J/\psi \rightarrow e^+e^-$ IN CEP: Electron PID

- Bumps around 700 and 1000 MeV/c^2 → probably not e
- Check PIDe for e^+, e^- in that region

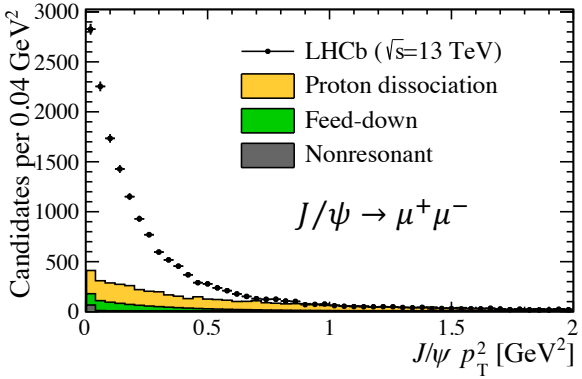
→ Perform a cut on PIDe > 3.5



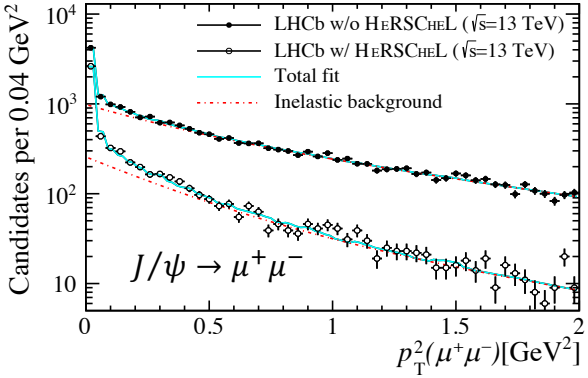


$J/\psi \to e^+e^-$ IN CEP: ${p_T}^2$

- We fit the ${p_T}^2$ distribution
- In diffractive processes, signal is expected to be $\propto \exp(-{p_T}^2)$

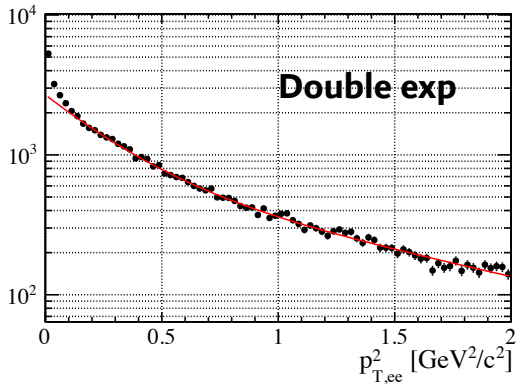


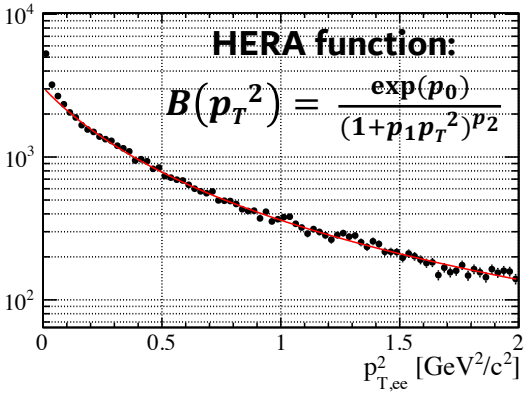
[LHCB-PAPER-2018-011]



[LHCB-PAPER-2018-011]

- We tried different curves, need to study further





OUTLOOK

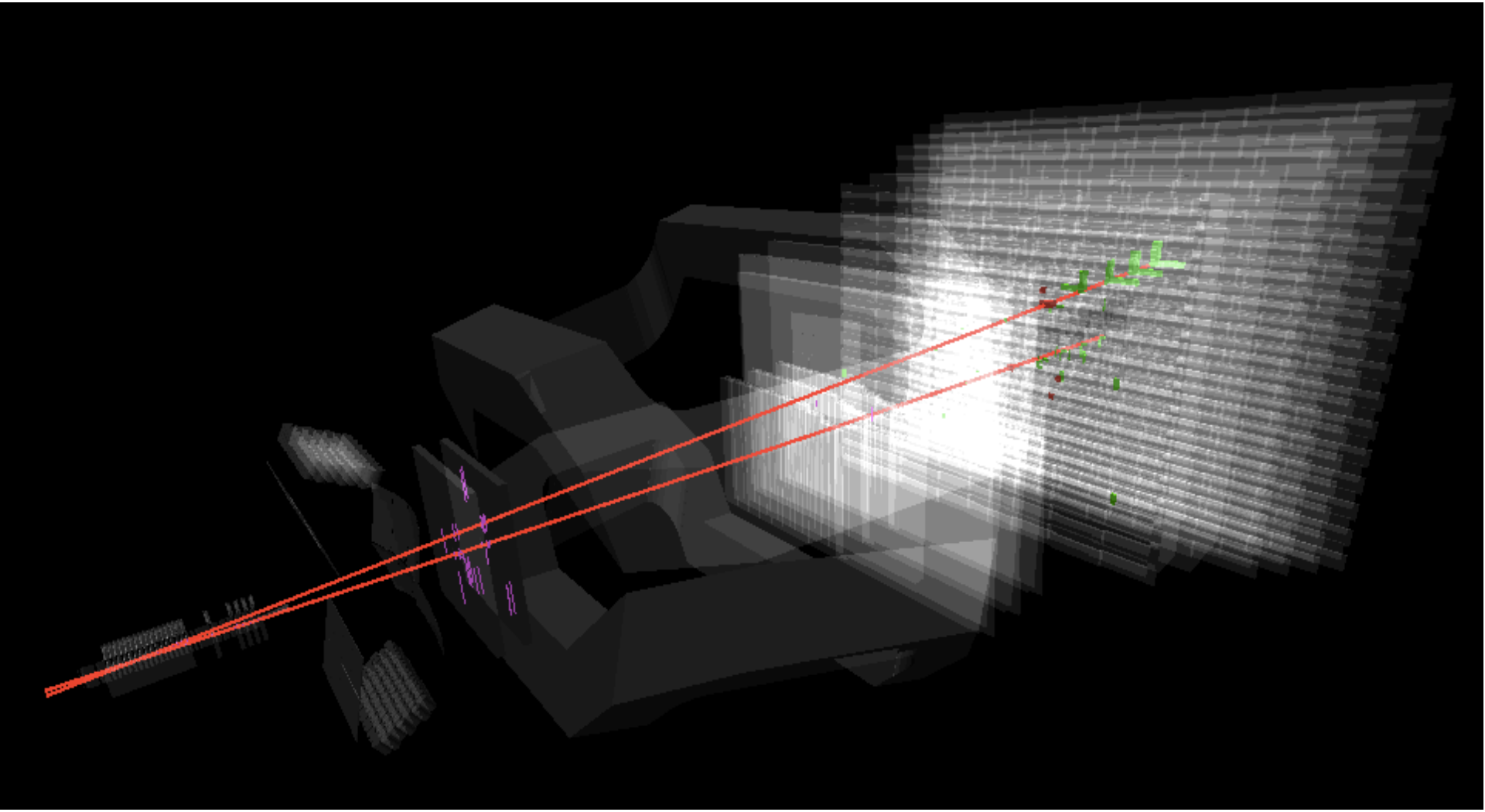
- CEP of J/ψ mesons is a great scenario for studying electron reconstruction
- More work needed until calculating

$$R_{J/\psi} = \frac{d\sigma(J/\psi \to \mu^+\mu^-)}{dy} \Big/ \frac{d\sigma(J/\psi \to e^+e^-)}{dy}$$

- Extend studies on HeRSCheL data, start producing MC samples

- Thanks to Álvaro Loya Villalpando and Pieter Braat for their work during their stay as summer students ☺

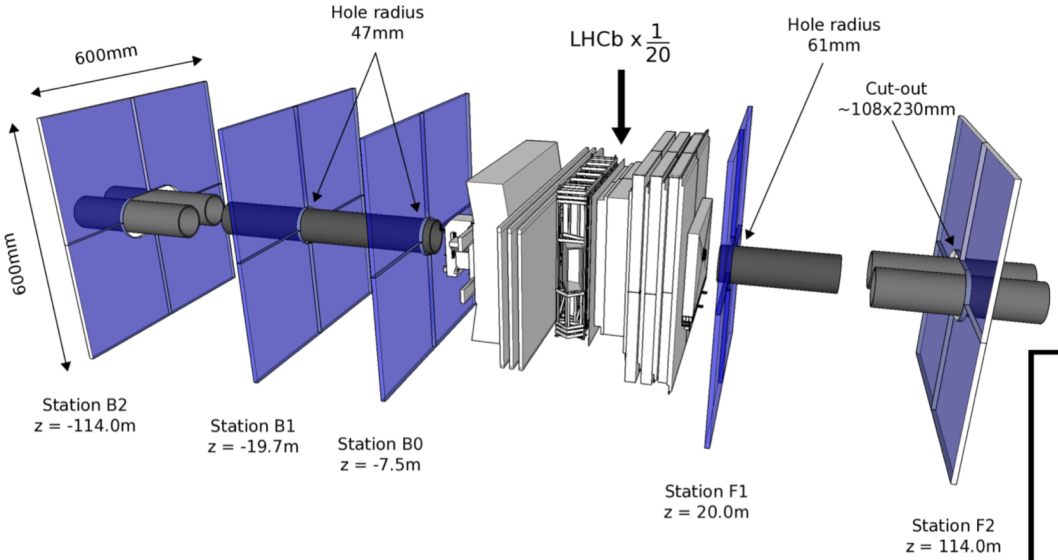
- Expect exciting results in some months!

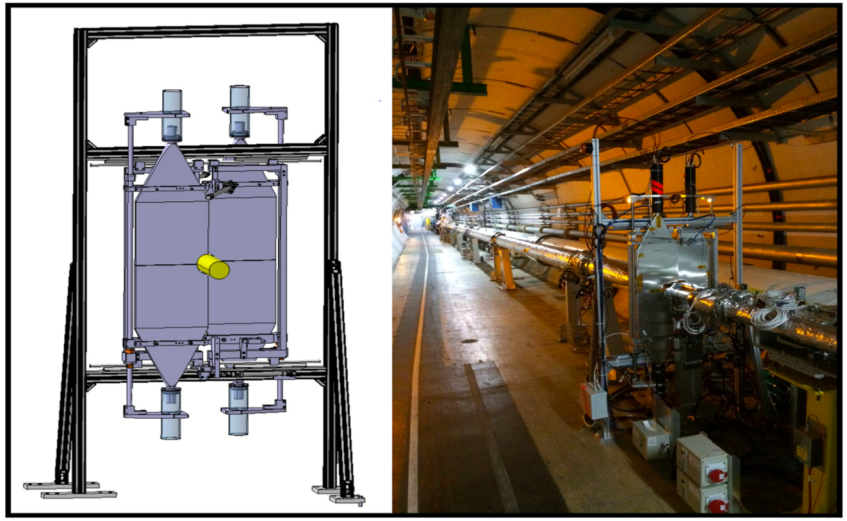


THANK YOU FOR YOUR ATTENTION!

HeRSCheL

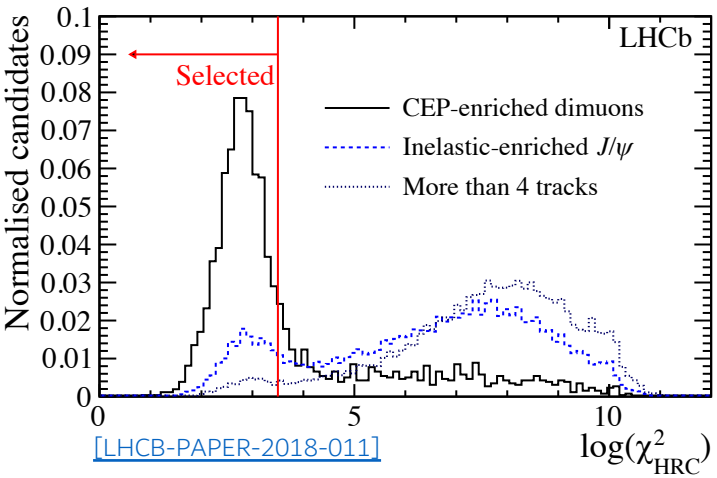
- Mission: detect high rapidity particles





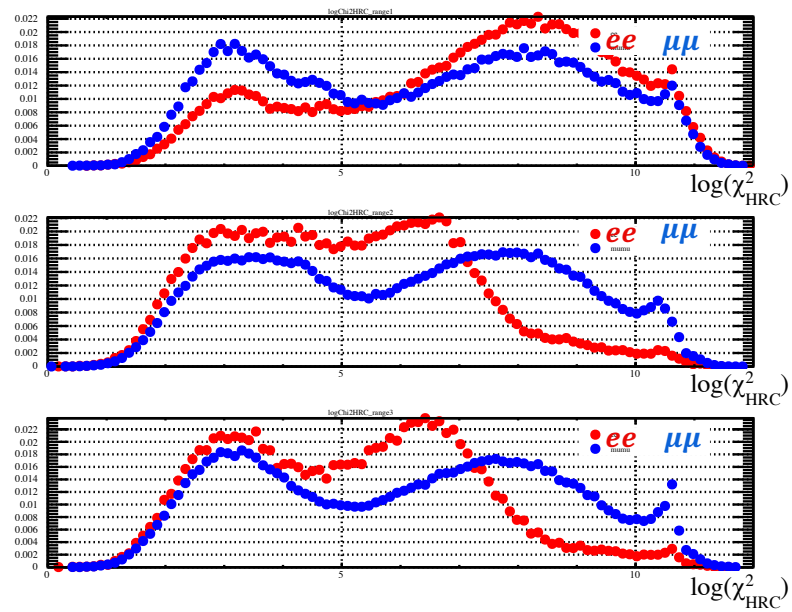
$J/\psi \to e^+e^-$ IN CEP: HeRSCheL

- Use the quantity $\log(\chi^2{}_{\mathrm{HRC}})$, where $\chi^2{}_{\mathrm{HRC}} = \sum \chi^2{}_i\,,\ \chi^2{}_i = B_0, B_1, B_2, F_1, F_2$
- For the $\sigma_{J/\psi \to \mu^+\mu^-}$ studies:



[LHCB-PAPER-2018-011]

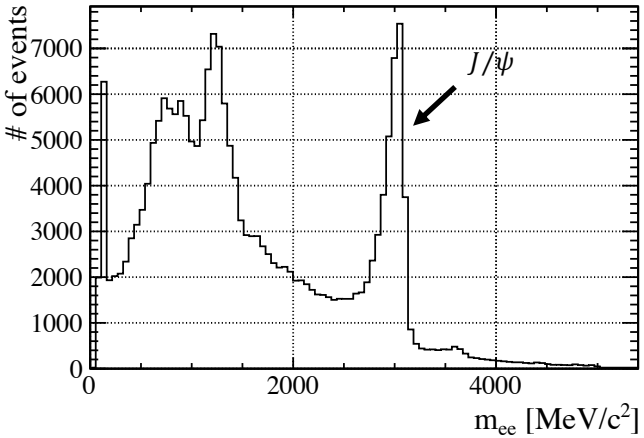
- What we see, divided in 3 run ranges:

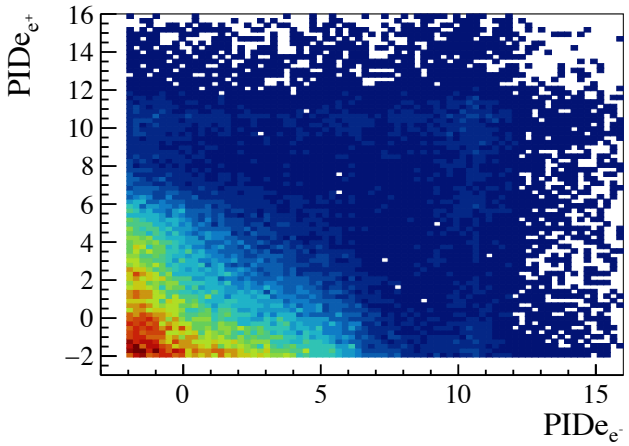


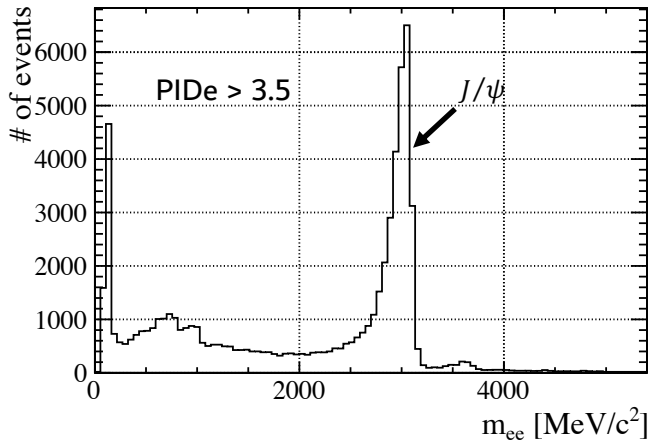
- Protons interacting outside of LHCb after triggering the detector?
- Protons interacting with beam gas before IP inside LHCb?

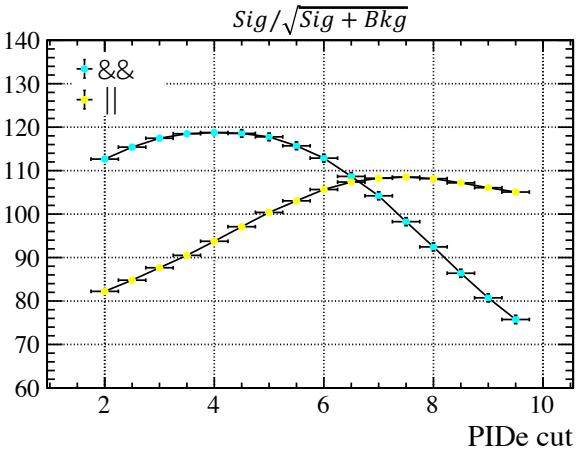
$J/\psi \rightarrow e^+e^-$ IN CEP: Electron PID

- Some unexpected bumps around 700 and 1000 MeV/c^2 → probably not e
- Check DLLe for e^+, e^- in that region









PIDe > 3.5