Is LHC run III the end of exclusive physics?

Quarkonia As Tools 2022

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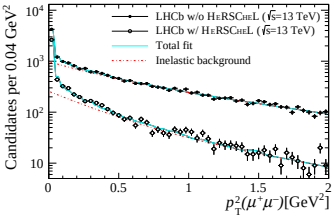
exclusive production measurements in a nutshell

- Select $J/\psi \rightarrow \mu^+\mu^-$ in an empty detector
- Extend coverage with forward shower counters (Herschel, AOD)
- This requires events with exactly one interaction
- At run III the number of simultanious interactions is increased reducing the probability of single interation events
- Even in single interaction events some non-exclusive events escape detection



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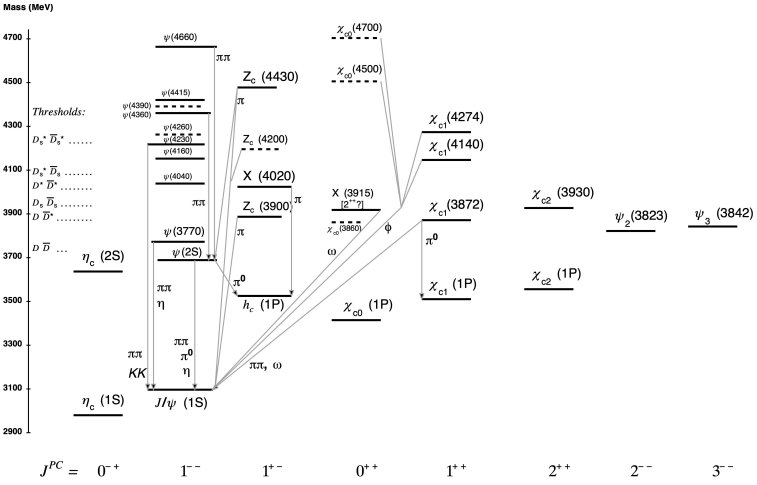
- Fit model to the p_{T} distribution
- $\|t\|$ distribution becomes unaccessible
- Measurements are model dependent
- proton tagger would be a way out (not for run III)

what can we gain in run III we couldn't get in run II?

- more statistics
  - needs a way to to use only tracks and not use calorimeters due to pileup
- different states
  - Better precision for J/ψ unlikely
- better detectors
  - Upgraded LHCb detector allows to trigger on soft hadrons
  - Utilise special runs in filling schemes
- fixed target
  - SMOG2 allows for running in *pp* luminosity production runs

This introduction has my personal viewpoint and is slightly focussed on LHCb

charmonium and friends



η_c, χ_c and h_c

There are plenty of fully charged decay channels with many tracks and low branching fraction

- exclusive η_c production probes odderon exchange
- χ_c production has already been seen at the LHC
- exclusive χ_c (3872) is still missing

Look at $\phi\phi$, $p\overline{p}$, $\Lambda\overline{\Lambda}$, $\Xi^-\overline{\Xi^+}$ and $J/\psi\pi^+\pi^-$.
More challenging final states include $2(\pi^+\pi^-)$, $3(\pi^+\pi^-)$ and $h_c \to K^0_S K^\pm \pi^\mp \pi^+ \pi^-$

With particle identification and high luminosity and good tracking efficiency new states can be measured.

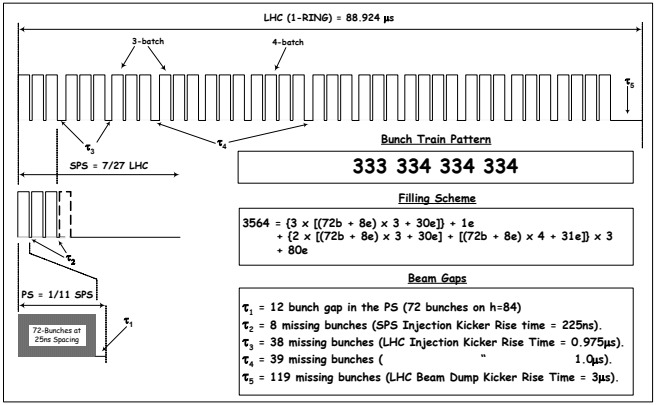
What if single interaction events are necessary?

- run II data
- special runs (minuscule luminosity)
- special bunches
- ghost charges

pilot bunches

The LHC injector chain can generate bunches in a large bunch parameter space. Intensity between $5 \cdot 10^9 - 10^{11}$ and emittance between $0.8 - 2.5 \mu\mathrm{m}$. reference Those bunches can be filled before the high intensity bunch trains are filled. They can not be placed in the LHC injection kicker rise time (the kicker ejects them) but there is a potential that they can be placed in the abort gap.

special reduced intensity bunch placement



- put the bunch in the about gap (τ_5)
- intensity is limited by machine protection limits (it will be dumped in the superconducting magnets around the beam dump kicker)
- will need RnD for the abort gap cleaning and monitoring

This scheme is not up to date but shows the concept. reference

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- there will be less single collision bunch crossings
- in special runs single collision bunch crossings can be recorded
- special bunches may be possible but require significant RnD
- model dependent, tracking based measurements will benefit from larger luminosity

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