# Multiplicity dependence of $\sigma_{\psi(2S)}/\sigma_{J/\psi}$ in $p$Pb collisions at $\sqrt{S_{NN}} = 8.16$ TeV

IFT meeting

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# Results

1. Prompt ratio decreases in *p*Pb collisions.

2. No trend for non-prompt ratio found in *p*Pb or Pb*p* collisions.

3. Prompt ratio with Br: $\mathcal{B}_{\psi(2S)}\sigma_{\psi(2S)}/\mathcal{B}_{J/\psi}\sigma_{J/\psi}$:

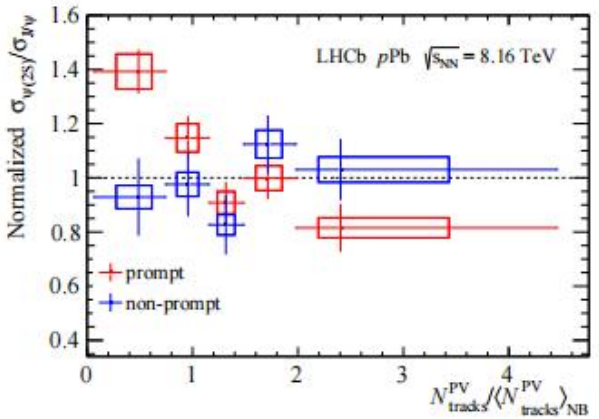
   Pb*p*: $(1.353 \pm 0.090)\%$

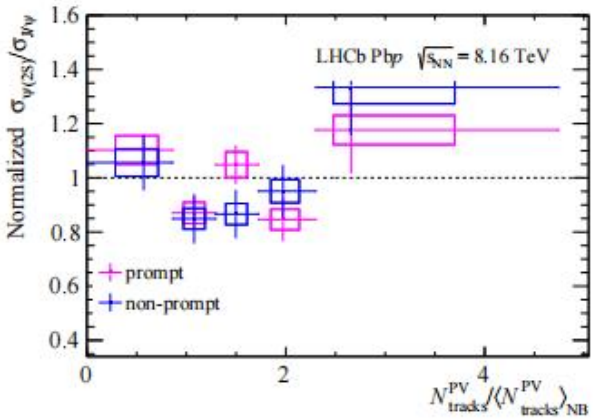
   *p*Pb: $(1.705 \pm 0.098)\%$

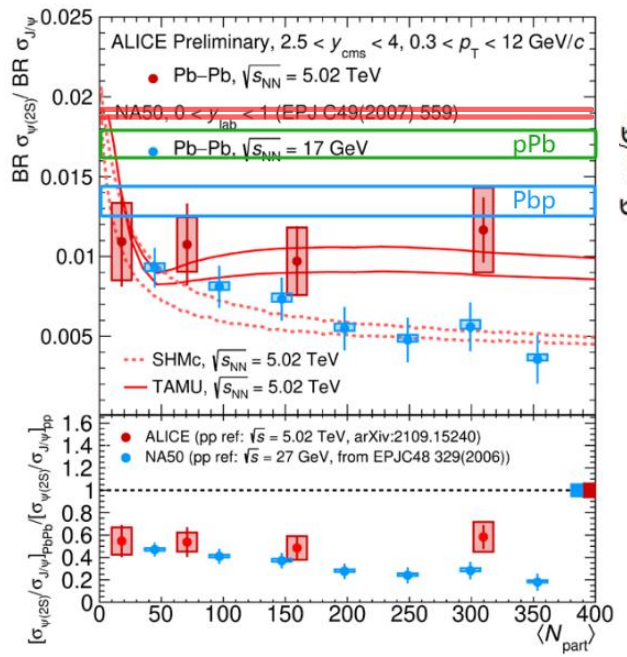
   However, no decreasing trend is found for prompt ratio in Pb*p* collisions.

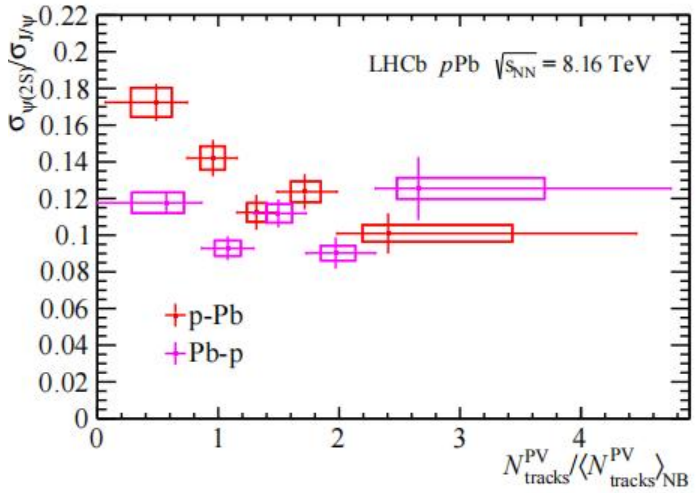
4. From the perspective of prompt ratio v.s. multiplicity:

   - *p*Pb collisions is more like *pp* collisions
   - Pb*p* collisions is more like PbPb collisions (measured by ALICE and CMS)



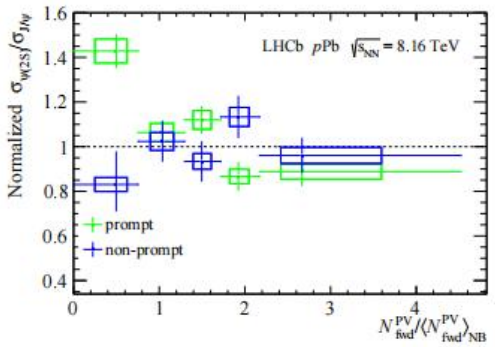



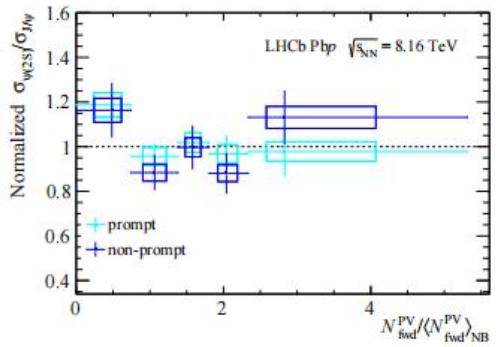



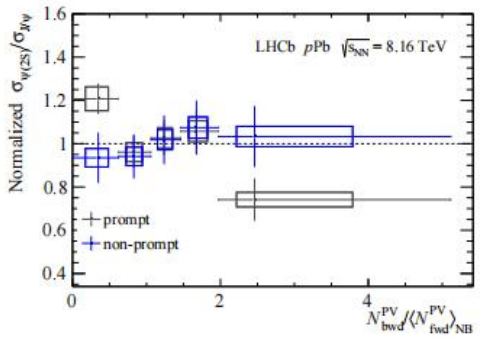

*[EPJ Web Conf. 276 (2023) 02002]*

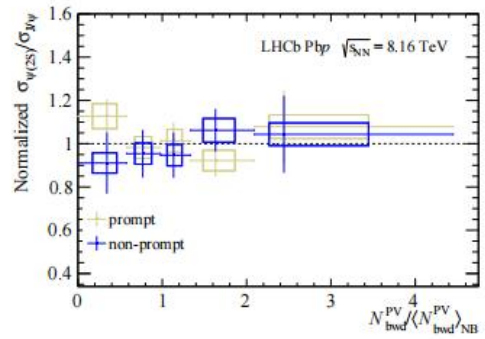
# Results

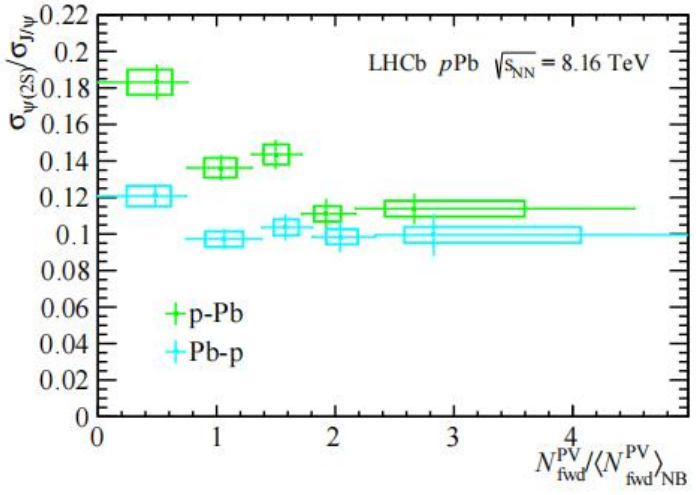
- Same conclusions holds for $N^{\mathrm{PV}}_{\mathrm{fwd}}$ and $N^{\mathrm{PV}}_{\mathrm{bwd}}$:

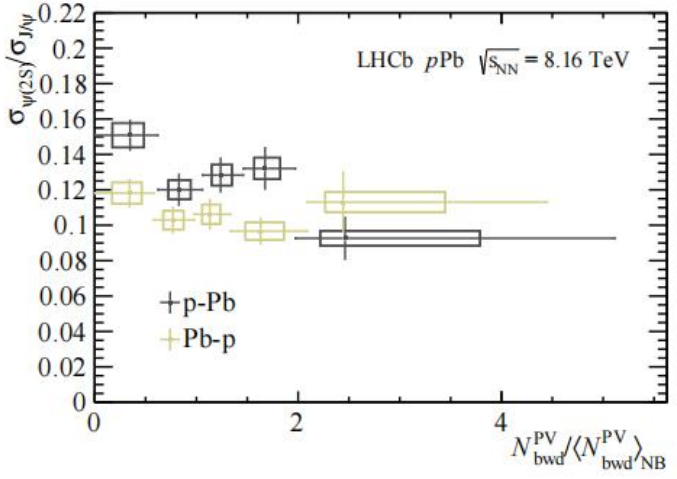


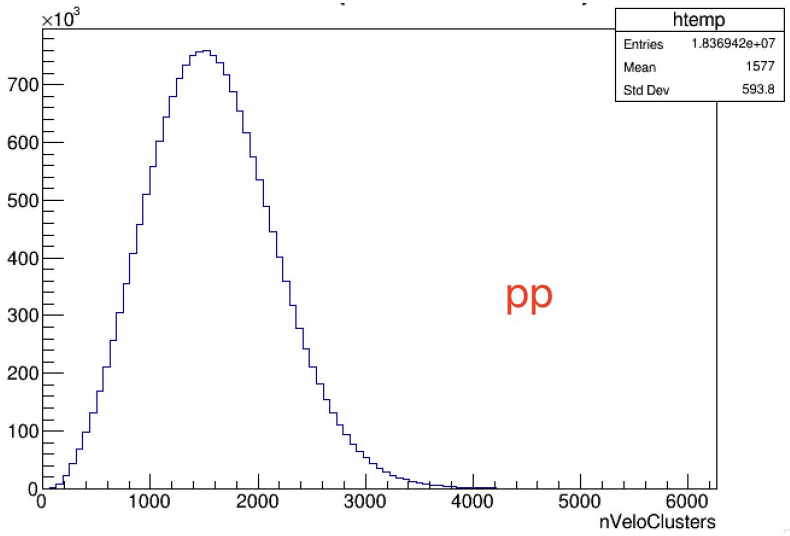



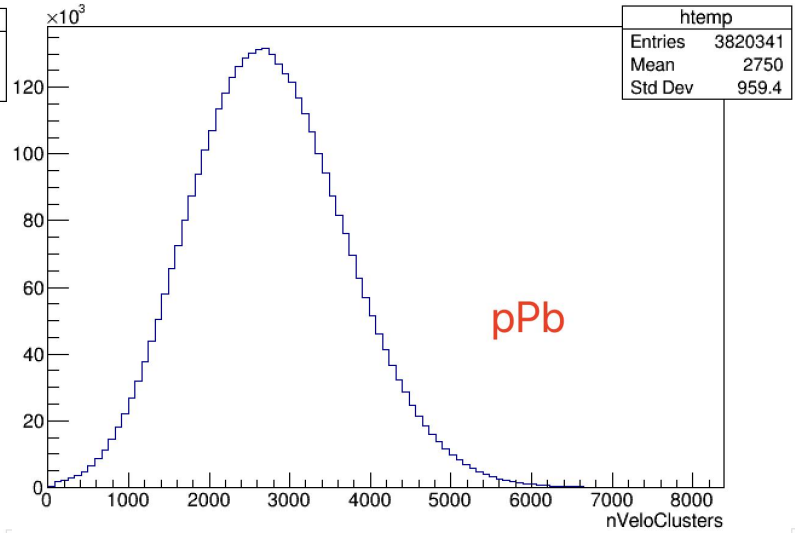

One more conclusion: prompt ratio decrease slower with $N^{\mathrm{PV}}_{\mathrm{bwd}}$ yhan $N^{\mathrm{PV}}_{\mathrm{fwd}}$ in *p*Pb, similar to *pp* collisions

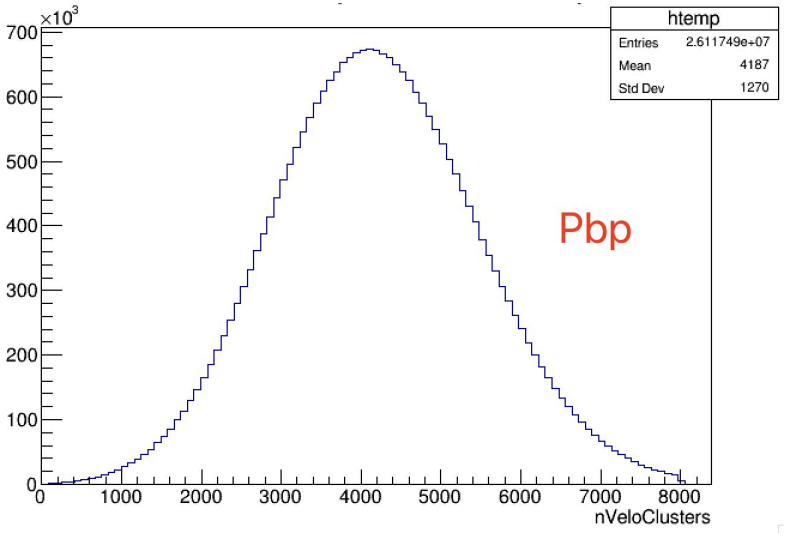
# Global cut on multiplicity

- 2016 pp collisions: nVeloClusters < 6000
- 2016 pPb collisions: nVeloClusters < 8000

However, to keep the global cut consistent, high-multiplicity events will be cut off, that's where we want to explore. So we just keep them different.



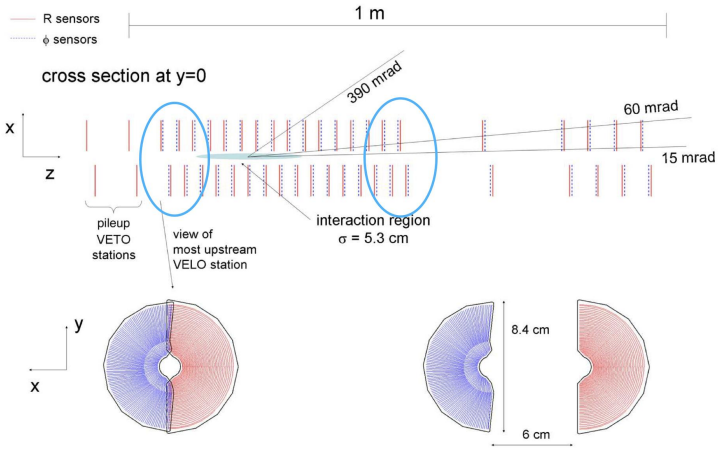
# Global cut on nPVs = 1

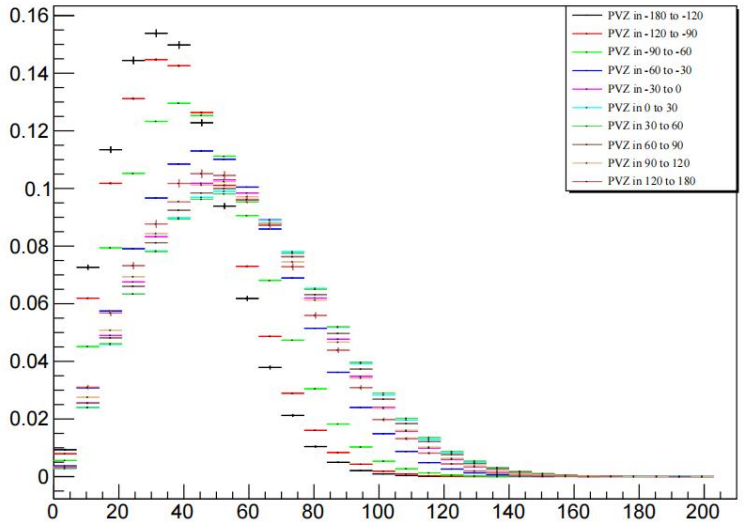
- Reason for avoiding pile-up
  - It can become challenging to distinguish and isolate the signals from the primary interaction of interest, from the signals of additional, overlapping interactions.

- The analysis in *pp*, *p*Pb and Pb*p* all requires the nPVs to be exactly one.

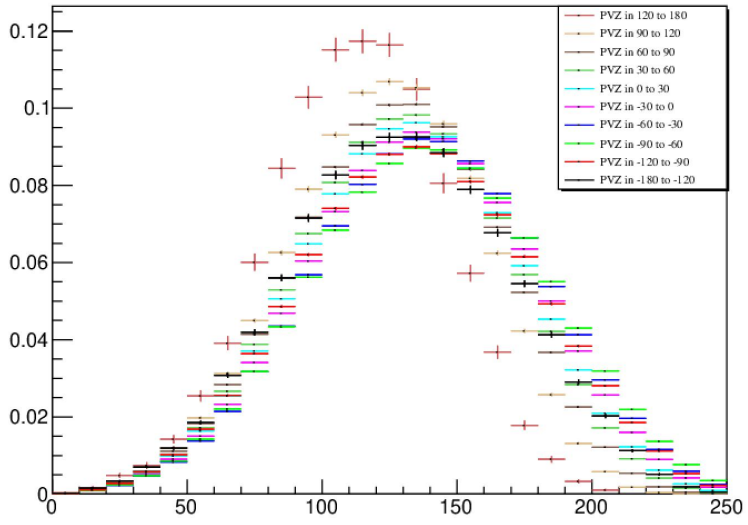
# Global cut on PVZ

- The velo acceptance is not uniform along beam axis, result in an underestimation on multiplicity. We need to cut off those events in too up- and downstream sides (blue circles), by checking the multiplicity distribution in different PVZ ranges:




$N^{\mathrm{PV}}_{\mathrm{tracks}}$ distribution in different PVZ ranges for *pp* collisions data




$N^{\mathrm{PV}}_{\mathrm{fwd}}$ distribution in different PVZ ranges for Pb*p* collisions data

# Global cut on PVZ

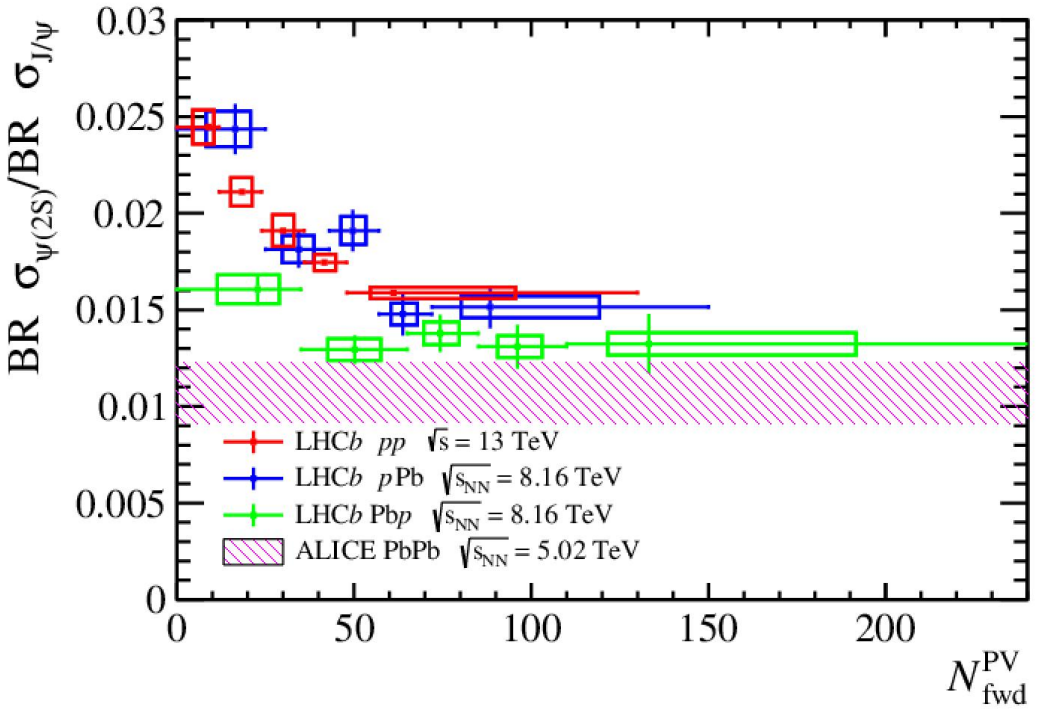
- For pp collisions:
  - When we take $N^{\mathrm{PV}}_{\mathrm{tracks}}$ as multiplicity, PVZ is restricted to be [-60,180] mm
  - For $N^{\mathrm{PV}}_{\mathrm{fwd}}$, $N^{\mathrm{PV}}_{\mathrm{bwd}}$: [-180,180] (100%), [-30,180] mm
- For pPb/Pbp collisions:

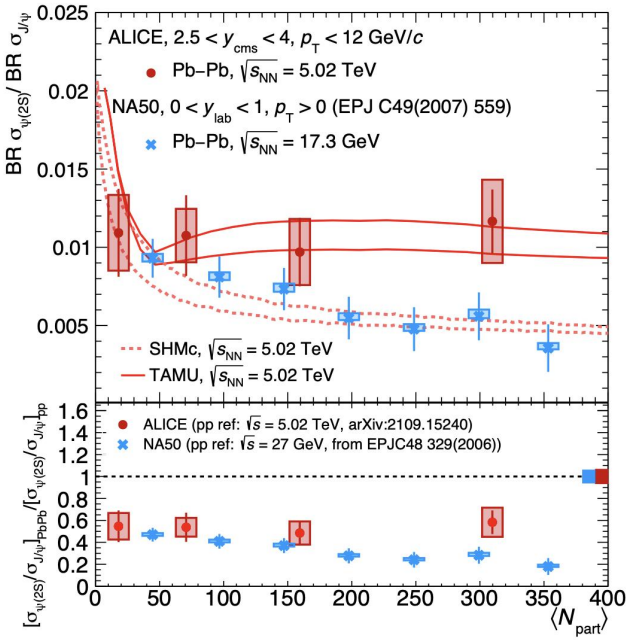
| Configuration | Mult. Variable | $z_{PV}$ | |
|---|---|---|---|
| $p$Pb | $N^{\mathrm{PV}}_{\mathrm{tracks}}$ | [-30, 180] mm | |
| $p$Pb | $N^{\mathrm{PV}}_{\mathrm{fwd}}$ | [-180, 180] mm | 100% data keeped |
| $p$Pb | $N^{\mathrm{PV}}_{\mathrm{bwd}}$ | [-30, 180] mm | |
| Pb$p$ | $N^{\mathrm{PV}}_{\mathrm{tracks}}$ | [-60, 180] mm | |
| Pb$p$ | $N^{\mathrm{PV}}_{\mathrm{fwd}}$ | [-180, 120] mm | >99.9% data keeped |
| Pb$p$ | $N^{\mathrm{PV}}_{\mathrm{bwd}}$ | [-30, 180] mm | |

We should compare the result under $N^{\mathrm{PV}}_{\mathrm{fwd}}$ scheme

# Comparison

- pp result is consistent with pPb result
- Pbp result show slower decreaing trend, and the ratio is lower than pp and pPb result
- Pbp result is close to the PbPb result measured by ALICE
- ALICE PbPb result is taken from the hepdata and fitted by a horizontal line. (right graph)

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# Resources

- Twikipage: https://twiki.cern.ch/twiki/bin/viewauth/LHCbPhysics/Psi2StoJpsiRatio8TeVpPb
- AnaNote: https://www.overleaf.com/read/mfpgrjgmdxwj#45ea55
- Tuple in EOS:  /eos/lhcb/wg/IonPhysics/analyses/psi2S_over_jpsi_vs_Mul_pPb_8TeV
- gitlab for analysis code: https://gitlab.cern.ch/lhcb-ift/psi2s_over_jpsi_vs_mul_p_pb8tev

One can reproduce the result by:

0. Download directory '0_File' from /eos/lhcb/wg/IonPhysics/analyses/psi2S_over_jpsi_vs_Mul_pPb_8TeV
1. Download all the directories in the sample place you save 0_File (DO NOT CHANGE NAMES)
2. cd 3_Scripts
3. source zTotal.sh (better run in background, it might take one or two hours)