Quarkonium Polarization in AA collisions

Round Table discussion – 16/12/2020

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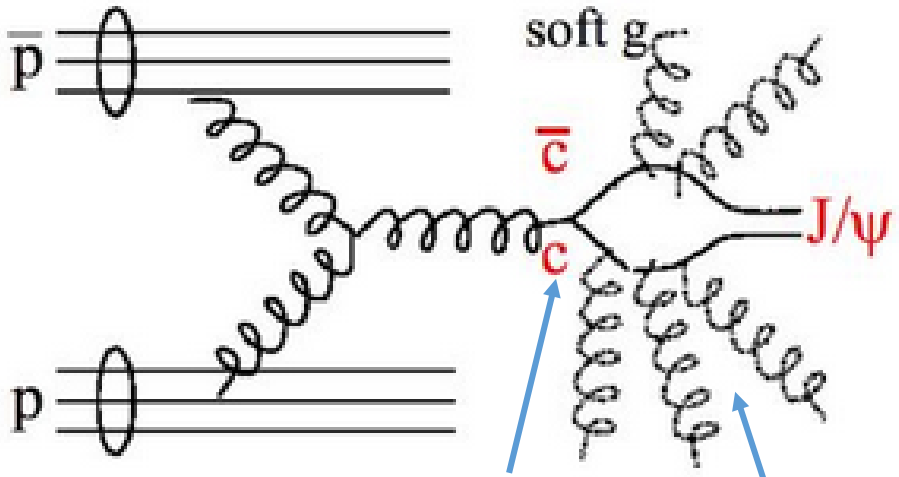
Quarkonium Polarization in AA collisions

From theory side: First requires a good understanding of production in pp (and pA), including the time scales

Reminder : formalisms dealing with quarkonia in QGP are “time ordered”

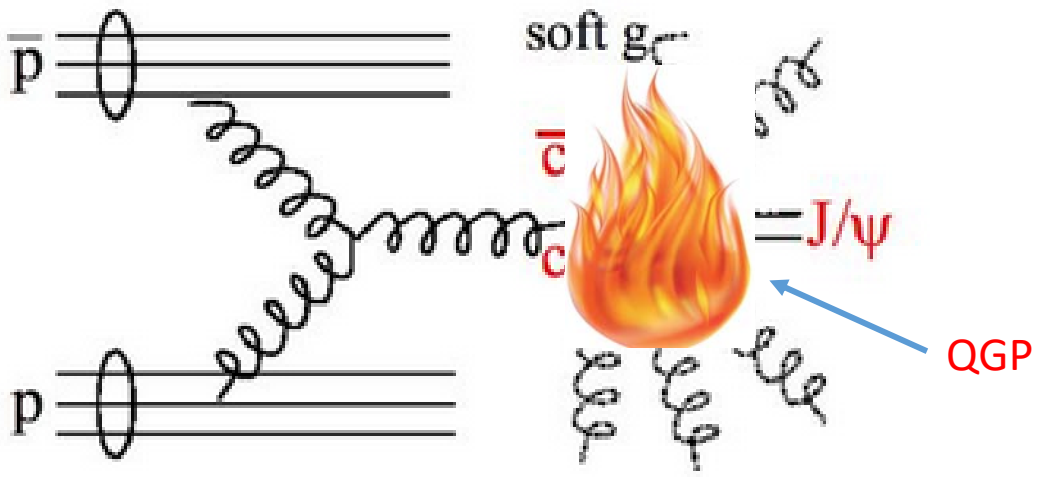


Production on short ($1/m_Q$) time scale (but boosted at high pT)

Conversion -> quarkonia on longer time scale by non perturbative LDME

Non perturbative LDME can affect the polarization of QQbar states (long ongoing story in pp). As compared to pQCD production, more in the sense of “bluring” the polarization

How universal are the LDME (wrt QGP creation)



Basic Question 1:

Do the same LDME apply for QQbar -> quarkonia production happening at the end of QGP ?

1. Yes !
2. No ! (only the singlet at freeze out will matter)
3. Yes … but not the same ! (they should correspond to the state of matter at Tc)

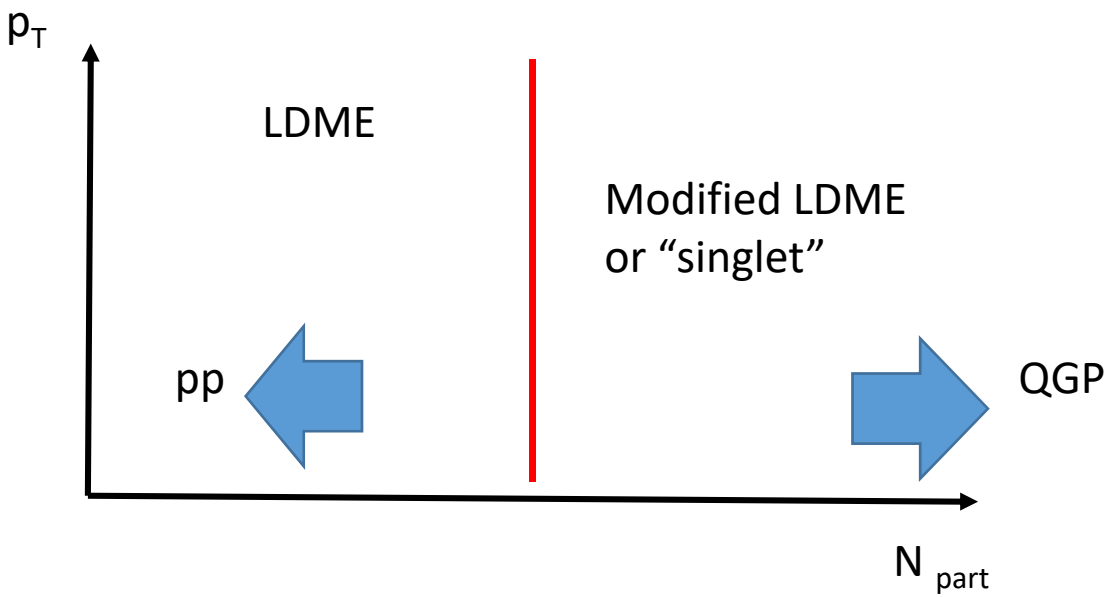
If your answer is 2 or 3, then interesting physics for the polarization : the "bluring" observed in pp might not occur => possible increase of the polarization !!! Kharzeev and Ioffe (2003)… irrespective of the various decay contributions from direct -> prompt…

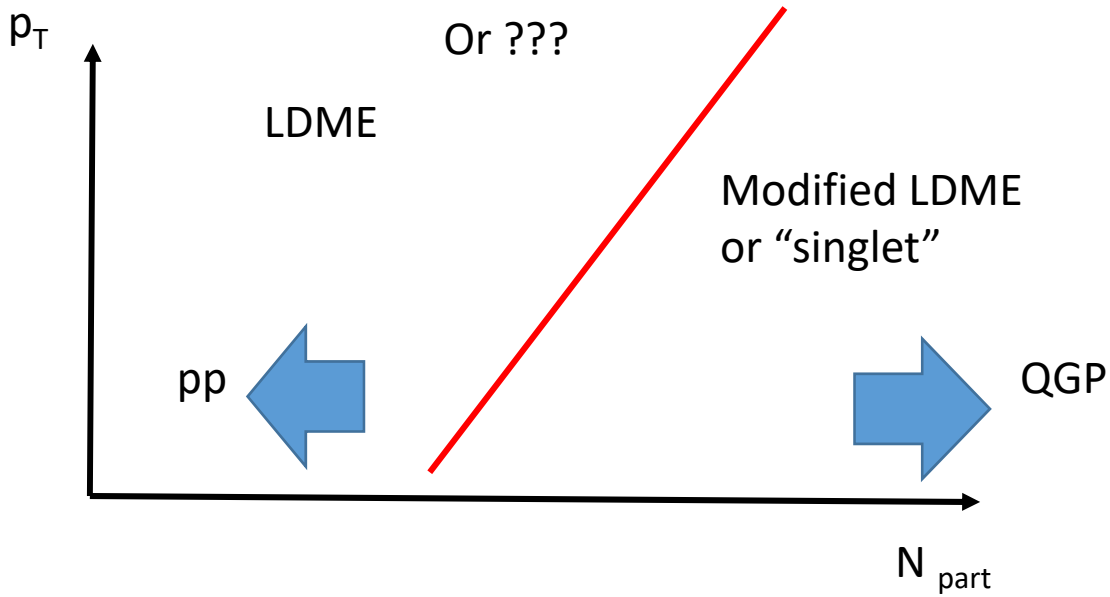
Counterpart: the QQbar-QGP interaction -> spin-flip (especially at low pT) => loss of polarization

How course, some "fine tuners" depending on whether the QQbar stems from "quasi bound correlation in QGP" -- aka Y(1S) – or recombination – charmonia at low pT –

How universal are the LDME (wrt QGP creation)

Other “fine tuner” : the role of centrality and pT :





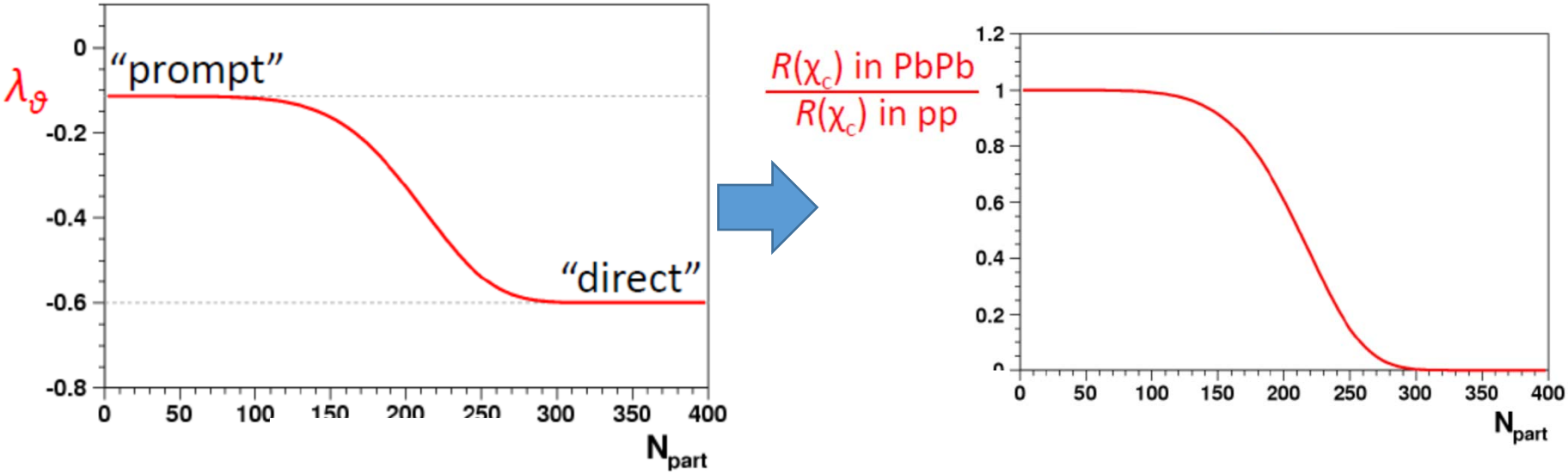
Basic Question #2 : do the LDME still apply at large pT even for central AA collision ?

The role of decay

Other idea : in pp, the decays contribute to a bluring of the polarization that would be observed in the direct state (f.i. Pietro Faccioli and Joao Seixas, PRD 85, 074005 (2012))

Hence, a reduction of the various decay contribution could result in an increase (or at least modification) of the polarization

Could then be used as an indirect measure of the chi-states suppression



Simplifying assumptions (by the authors / PBG):

- direct-J/ψ polarization is the same in pp and PbPb => pT high enough
- *normal* nuclear effects affect J/ψ and χc in similar ways
- χc1 and χc2 are equally suppressed in PbPb
- Sequential suppression acts the same way at "high pT" (as at low pT)

The role of decay

J. P. Lansberg (to be confirmed/explored) : at low pT, combination of flows + modification of decay-contribution could lead to « significant » modification of the polarization

The role of pT

Large p_T :

- Spin flip is blocked (helicity approx conservation)
- Frozen dynamics
- LDME might apply
- Expected small modification of polarization (unless large decay modification wrt pp)
- Effective theory (SCET) have been identified …
- Answer might come « soon »

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The role of pT

Low p_T (central AA)

- Spin flip is easy (ηc and J/psi are just 100 MeV apart << T)
- Long time dynamics
- => no polarization expected at the end of the QGP …
- Polarization might be recreated thanks to the combination of flow and decay
- No theory calculation available to my knowledge. Complicated to include all ingredients… but room for some model study

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- Frozen dynamics
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Two main strategies

Strategy 1: observe the « depolarization » of polarized states (in pp) and attribute this to the QGP-QQbar interaction + modification of LDMEs

Strategy 2: observe the « polarization » of unpolarized states (in pp) and attribute this to the modication of LDMEs / to the modification of decay contributions due to sequential suppression / …