Heavy Ion Collisions in ASCOT-EAGLE ?

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WHY ?

Why Ion.Ion at LHC ?

Why Ion.Ion in a p-p experiment?

HOW ?

How in ASCOT-EAGLE ?

Heavy Ions in ASCOT-EAGLE

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How to propose in a short time a plan for a short chapter of LOI about HI in ASCOT-EAGLE ?

In principle : many difficulties

- This subject was never discussed before
  - ← our priority is p-p physics
  - ← HI frighten particle physicists
- We are full depending on the technical choices retained for p-p
- We have no time for precise calculations or simulations
- A serious HI working group is not yet organized

... so, my point of view will be surely biased !

Indeed, we are able at present to precise our general approach for the LOI,

... by specifying that precise simulations will constitute our future task:

- no special difficulties
- we need only time and people (The next year at Clermont-Ferrand)

WHY HI at LHC?

← very attractive physical challenges:

- the search of QGP in the best thermodynamical conditions
- the study of statistical physics thanks to the very high multiplicity

WHICH is the weight of HI physics at LHC?

- HI at LHC? ∿ 10% of the LHC running time

The political weight is likely higher

- HI in ASCOT-EAGLE?

∿ 20% of the usual signatures of QGP (mainly the behaviour of high mass dileptons)

→ ASCOT-EAGLE optimized for signatures left-out by the dedicated HI experiments

WHY ION-ION at LHC ?

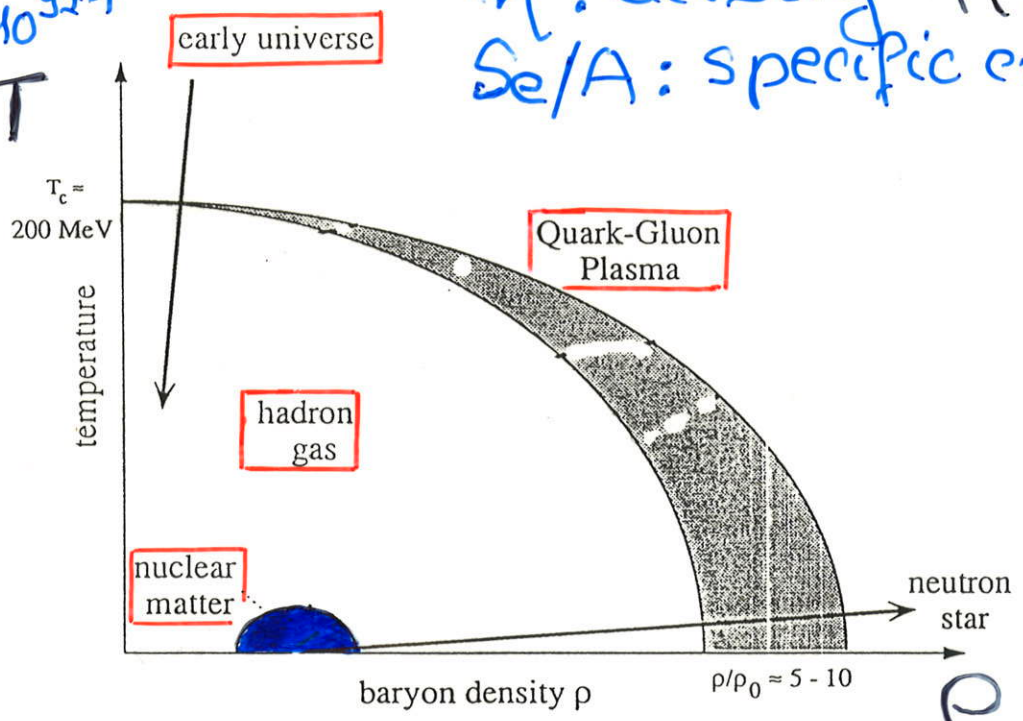
a well known answer:

to create, then to observe
an ideal QGP
in a selected Δy window
with the conditions of
a "mini big-bang"

macroscopic observables
- language of thermodynamics
- possible for extended system (A)

T : temperature
η : density (ρ)
Se/A : specific entropy

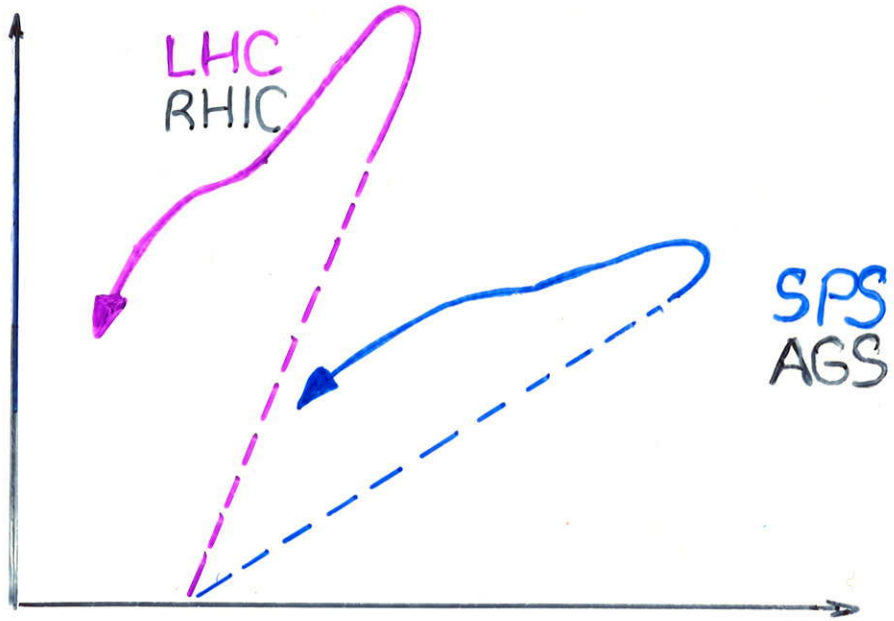
$\frac{Se}{A} \sim 10^{q \pm 1}$



ρ (η)

Lattice QCD → critical values for deconfinement / chiral symmetry restoration

$T_c \sim 200$ MeV
$\eta_c \sim 1.5$ GeV.fm^{-3} $\rho \sim 5\text{-}10\ \rho_0$



LHC $\Longrightarrow$ $T \gtrsim 2\,T_c$

$\varepsilon \gtrsim 10\,\varepsilon_c$

$Se/A \gg 10^3$

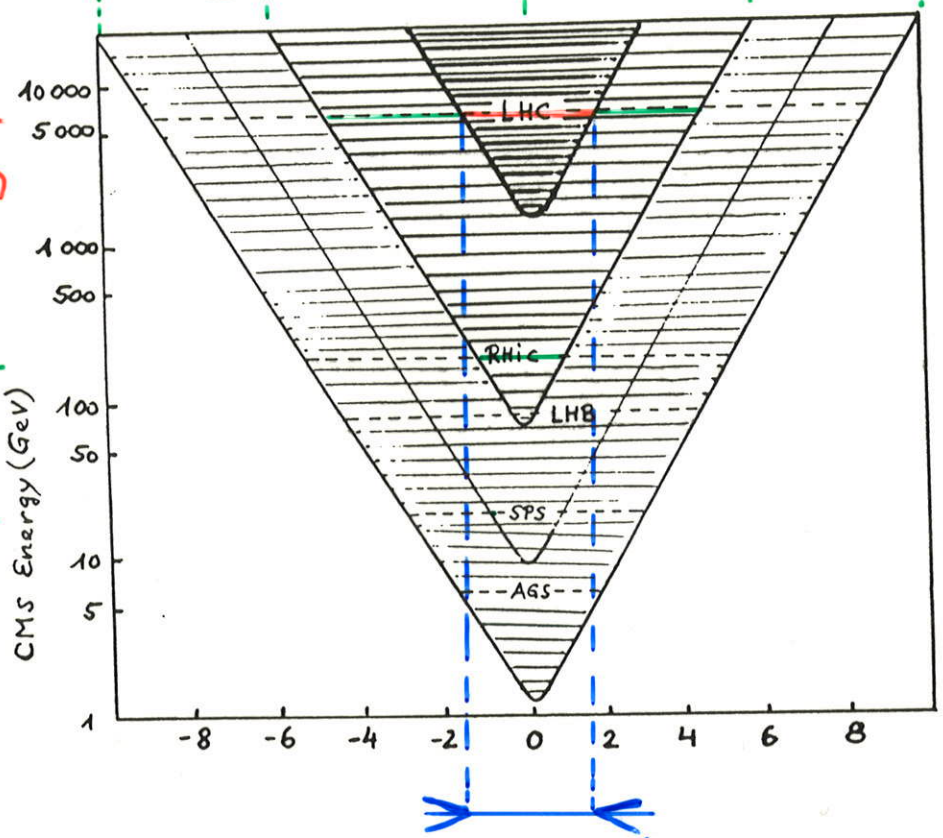
ν Ideal gas of gluons and three flavours of "massless" quarks

fragmentation of Ion 1

fragmentation of Ion 2

$2(y_0 - 2\Delta y)$

$-y_0$ $2\Delta y$ $2\Delta y$ $+y_0$



6300 — /nucleon

150 —

20 —

$y_0 \simeq \log \frac{\sqrt{s}}{M_p}$

$\Delta y \simeq 2$ for p-A $A \sim 200$

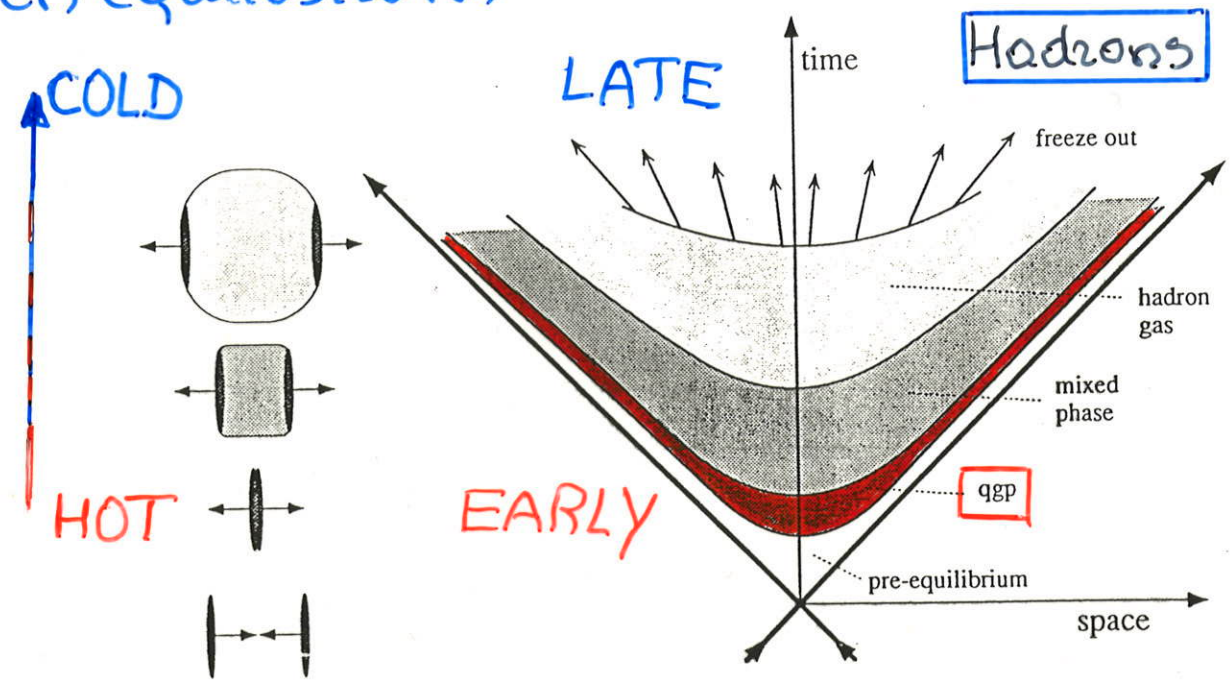
$\Delta y_0 \sim \pm 1.8$

no baryon

.. simulations (larger fluctuations) BB production...

only LHC with such a window

difficulty : system evolving in equilibrium ⟹ its memory is erased



⟹ we need signatures of "QGP" which decouple at different times from the evolution

+ global observables

⟹ centrality of reaction

- geometry (b: impact parameter)
- rapidity

E_T : transverse energy

E_0 : forward energy

M : charged particle multiplicity

WHY ION-ION in a p-p experiment?

The signatures?

characteristic evolution of special observables, in accordance with the values of global observables

{ global ~ conditions of formation
{ special ~ signal

LATE

Transverse momentum distribution (hadrons)

Bose-Einstein interferometry

Dynamical fluctuations and fractal mechanism

Strangeness production

Thermal photon production (real or virtual)

Dilepton production

- e^+e^- (low mass $\leq \psi'$)
- $\mu^+\mu^-$ (high masse $\leq \Upsilon''$)

dedicated heavy ion experiment

Heavy ion in a p-p experiment

EARLY

WHY this partition?

LHC heavy ions :

Low luminosity

$\mathcal{L} \sim 1.8 \times 10^{27} cm^{-2} s^{-1}$ < $\mathcal{L}$ (SPS NA38) $\sim 10^{28}$

Low frequency

Bunch spacing = 105 ns > "p-p" values

Low radiation

< SPS NA38

$\sim 10^{-3}$ "p-p" values

High multiplicity

$(dN/dy)_{central} \sim 2000-8000$

$\gg$ 35-40 p-p

$\sqrt{s} = 6250$

$\Rightarrow$ Dedicated heavy ion experiments (HI)

Low rates $\Rightarrow$ a loose trigger (1/10 - 1/100)

$\Rightarrow$ almost everything recorded

but : 10^{-3} J/ψ for 10^{+3} π^-

and $\sim 10^{-5}$ Υ

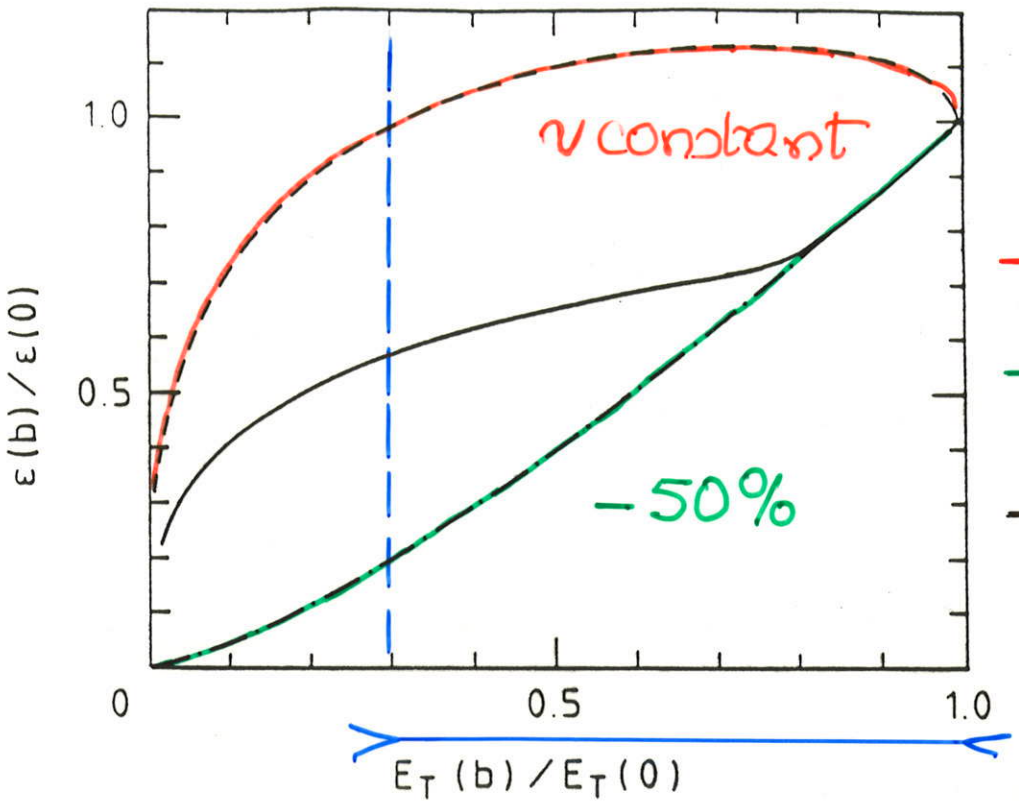
$\Rightarrow$ Complementarity of ions in a p-p experiment

to search rare events left out by HI

MAINLY : dileptons

- EARLY SIGNALS !
- ALREADY OPTIMIZED !

E_T dependence of $\mathcal{E}$

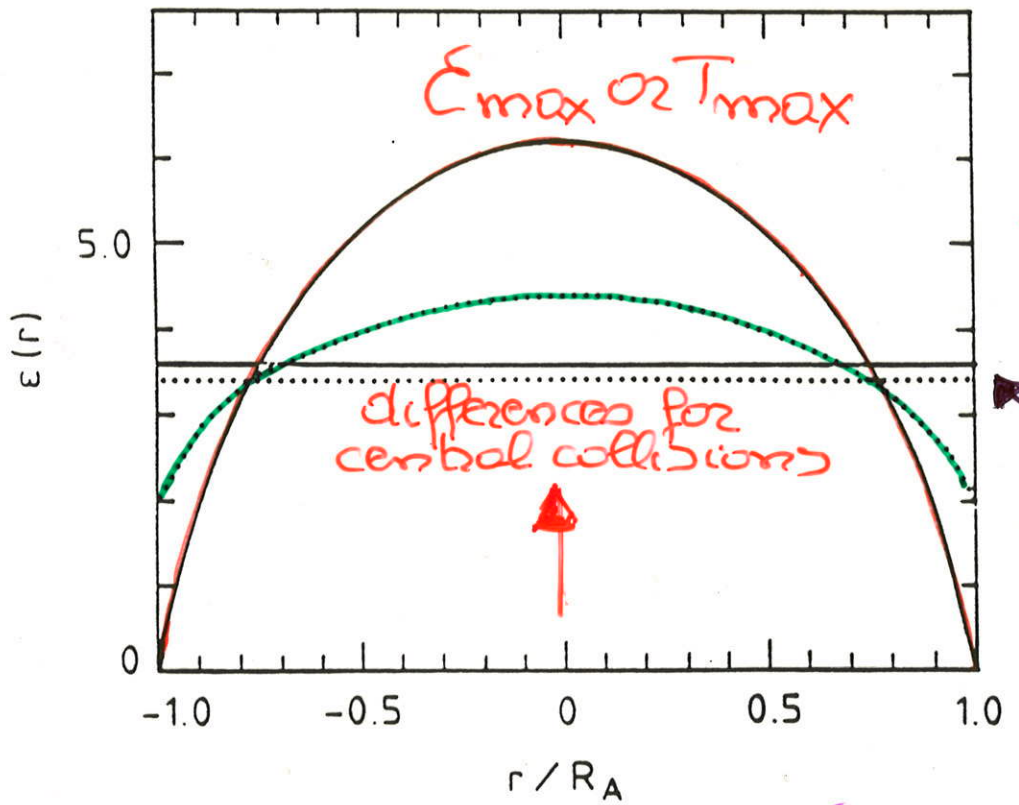


— A-A

— A-B
A≪B

—

Profile dependence of $\mathcal{E}$



— A-A

— A-B

↖ mean values

differences between { symmetric / asymmetric } cases

The interest of heavy quarkonium states ?

Charmonium ($c\bar{c}$) and
Bottomium ($b\bar{b}$)
⟵ produced by prehermal interactions
(mainly hard gluon fusion)
≠ low mass quarkonium ($q\bar{q}$, $q=u,d,s$)
⟵ produced in thermal equilibrium
(hadronisation stage)

2 possibilities :

- in an ordinary medium :
physical vaccuum ≈ confining medium
point-like pair → size increases → bound state
- in a very dense medium : 2 scenarii

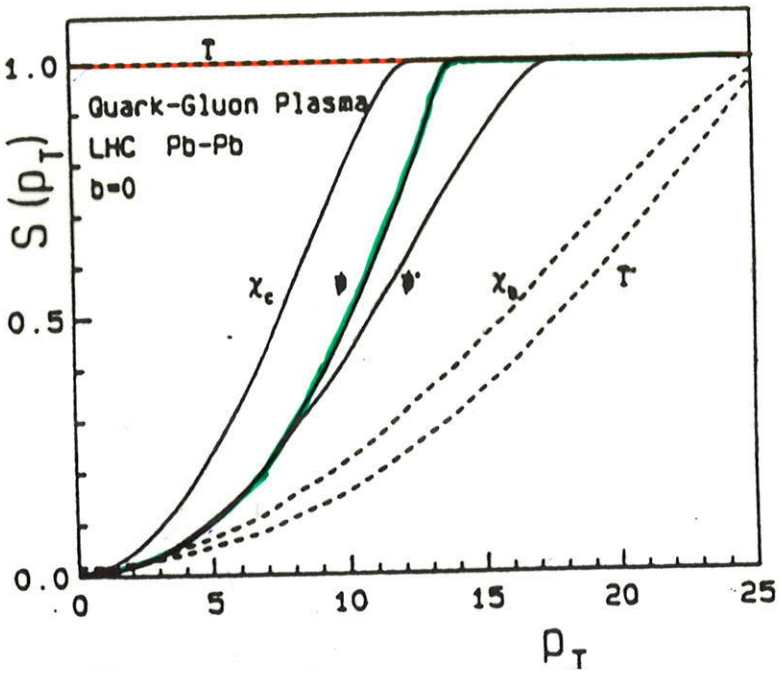
* QGP ≈ deconfining medium
point-like pair – colour screening of $q\bar{q}$ potential → no binding or dilution
global effect of the whole medium

* Absorption by the hadronic matter (mostly pion gas) → open flavours
Local effects of the hadrons

from Karsch and Satz

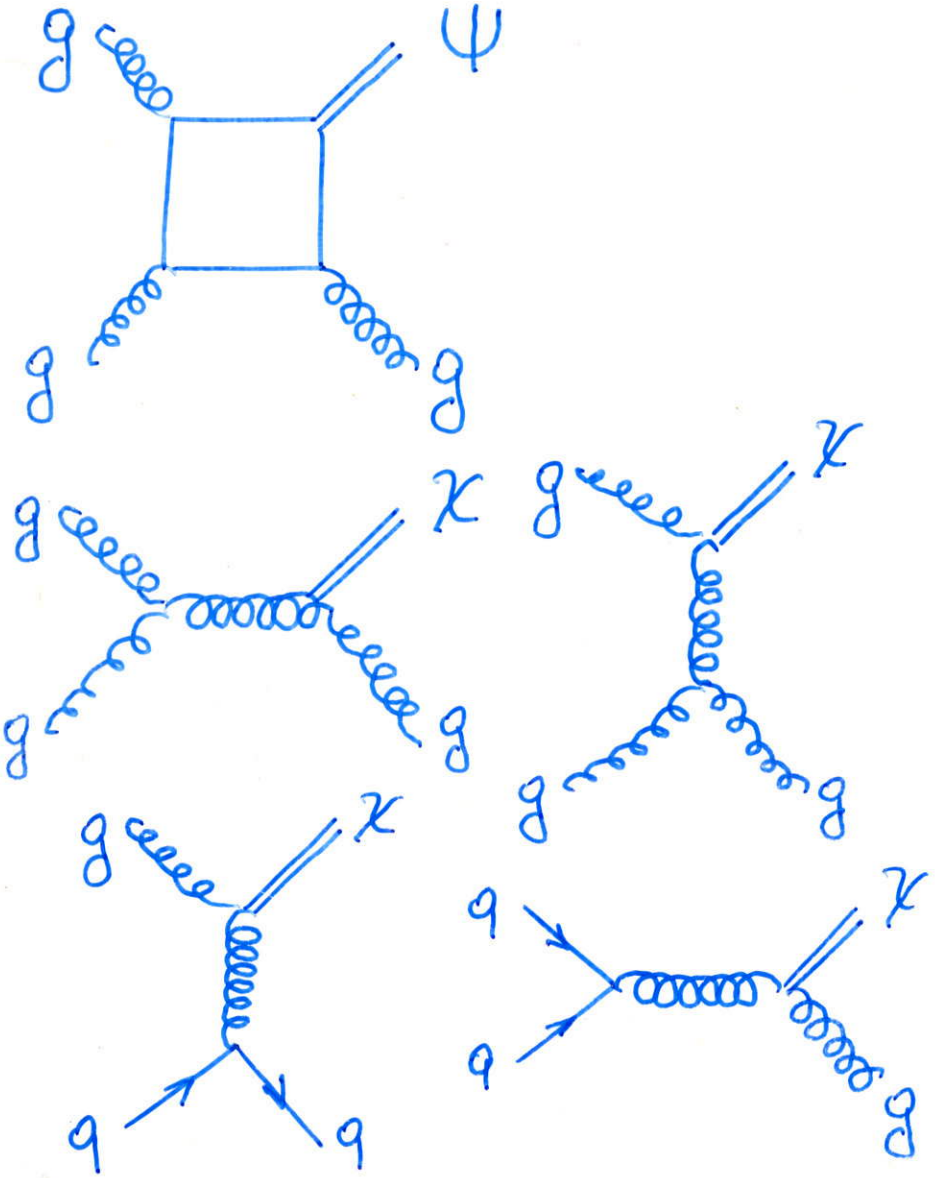
States	ψ	ψ'	Υ	Υ'
M (GeV/c^2)	3.1	3.7	9.6	10.0
τ (fm)	0.45	0.88	0.23	0.51
T_d/T_c	1.17	1.0	2.62	1.12

← no Debye screening or dissociation



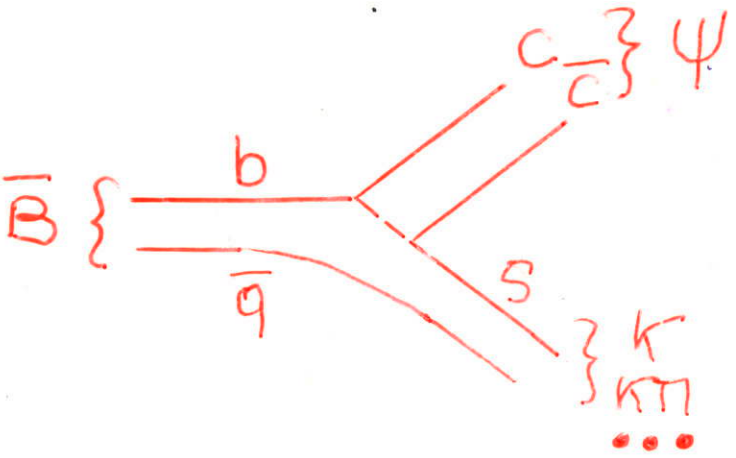
very optimistic picture from the effect of QGP only:
no suppression at all of Υ state!

The J/ψ difficulties ... at LHC



Direct production

χ decay
↳ ψ



B decay
↳ ψ

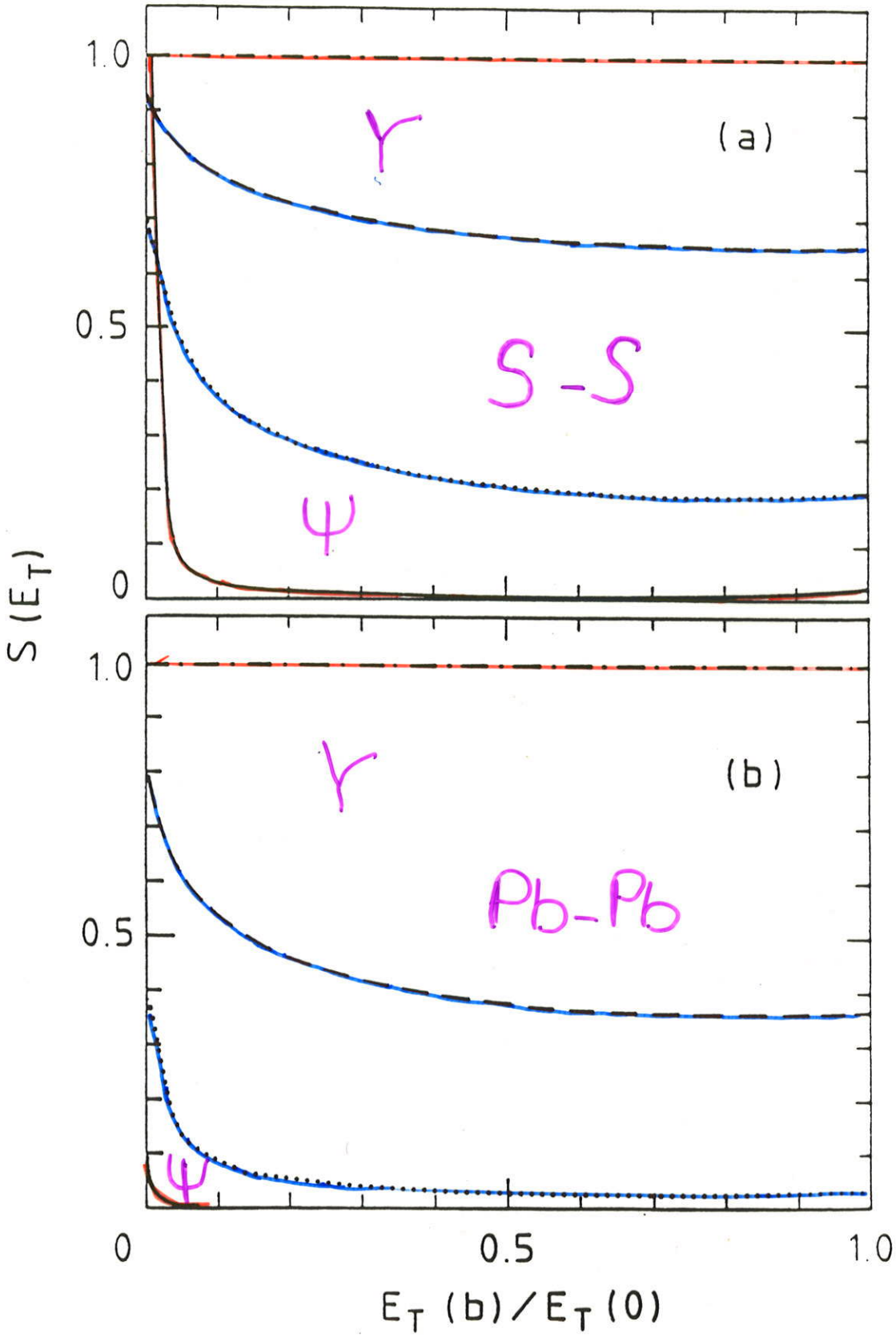
dominant at LHC

+ $\langle P_T \rangle_\psi \ll \langle P_T \rangle_\gamma$

↳ reduction due to cuts
... at least for γ

E_T dependence of ψ and Υ:

- QGP
- Absorption



P_T dependence of Υ:

- QGP only (colour screening)
- Absorption
- Initial state scattering + Absorption