Hard Probes & jet quenching

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@CASSalgado @HotLHC

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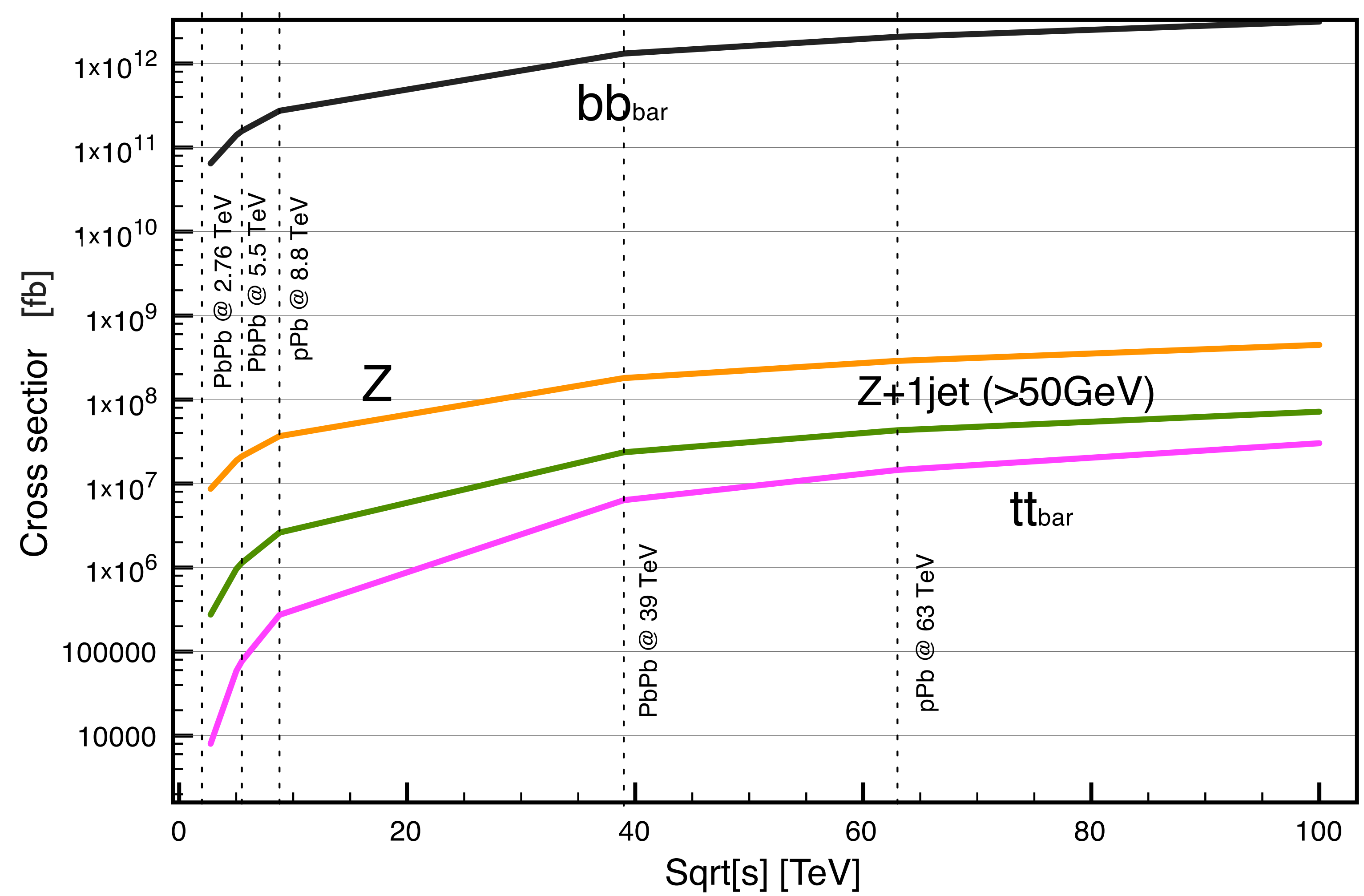
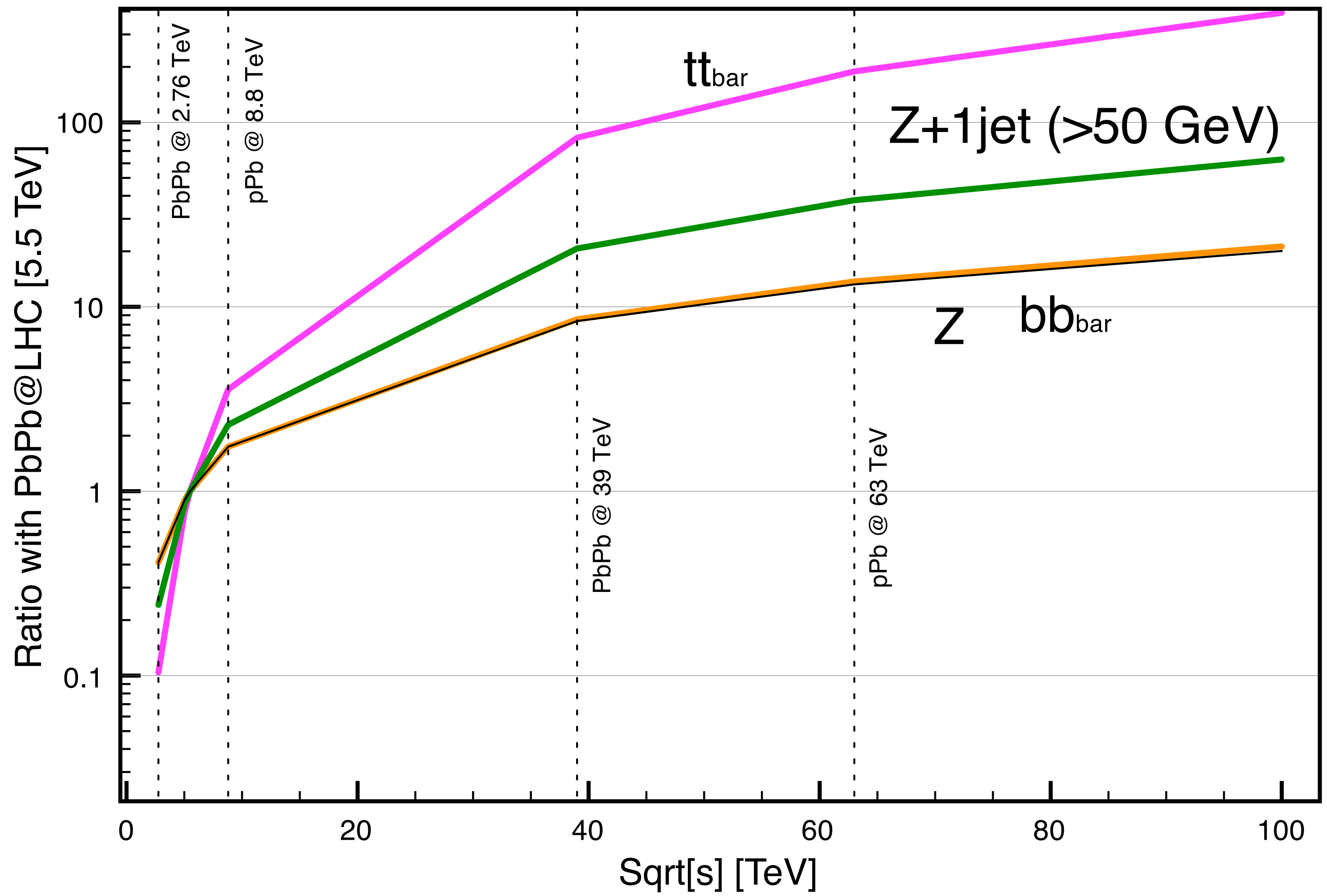
Cross Sections



All calculations for pp collisions, computed with MCFM

- *Large enhancements for larger masses*

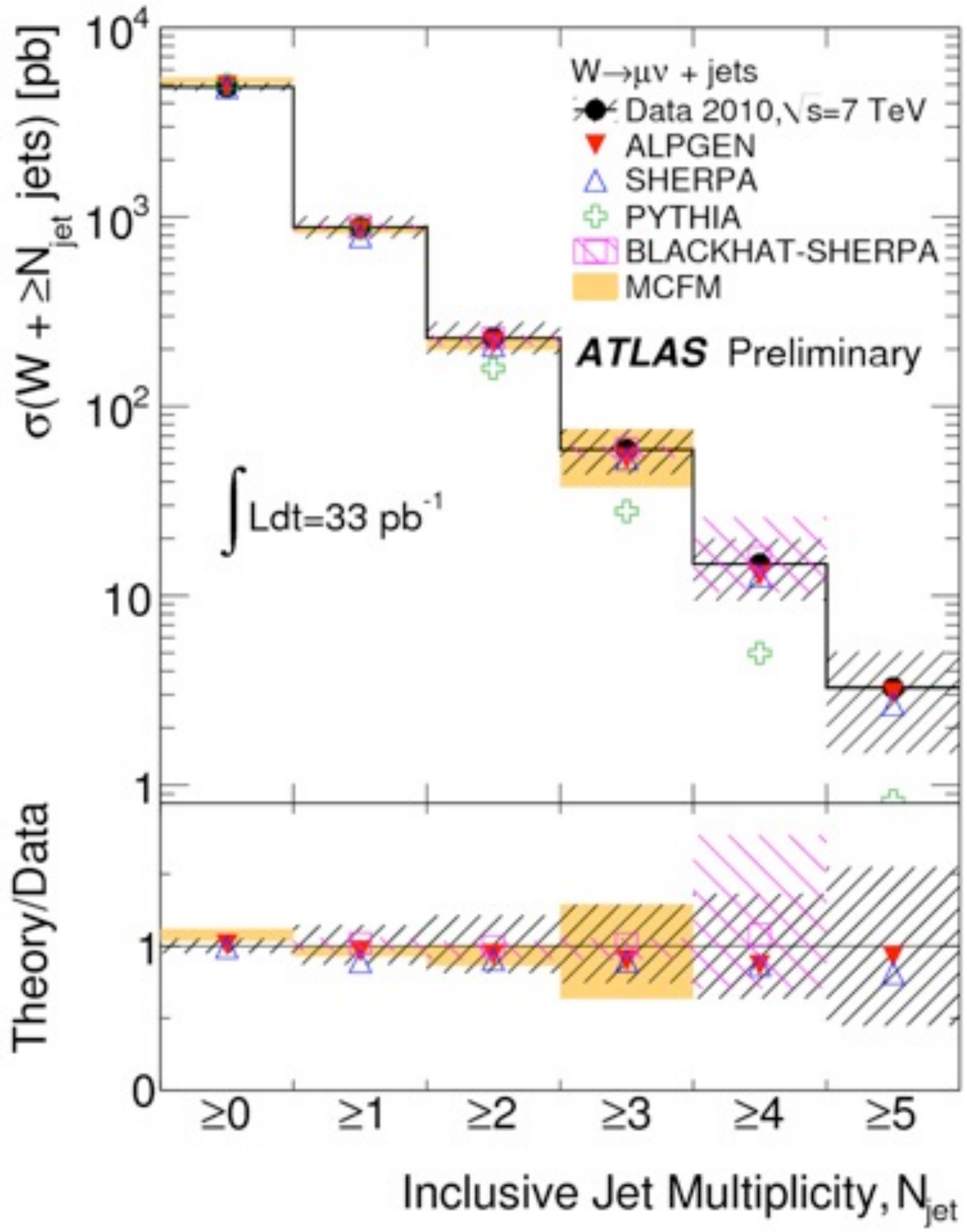
Ratios to 5.5 TeV



All calculations for pp collisions, computed with MCFM

- *Large enhancements for larger masses*
- *80x for ttbar; 40x for Z+1jet (pt>50 GeV); 20x for bbar or Z*

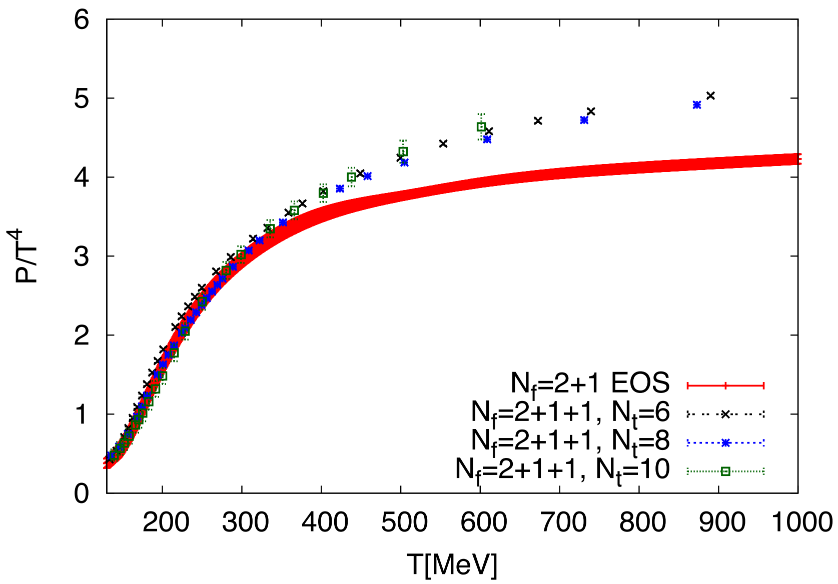
Z+jets

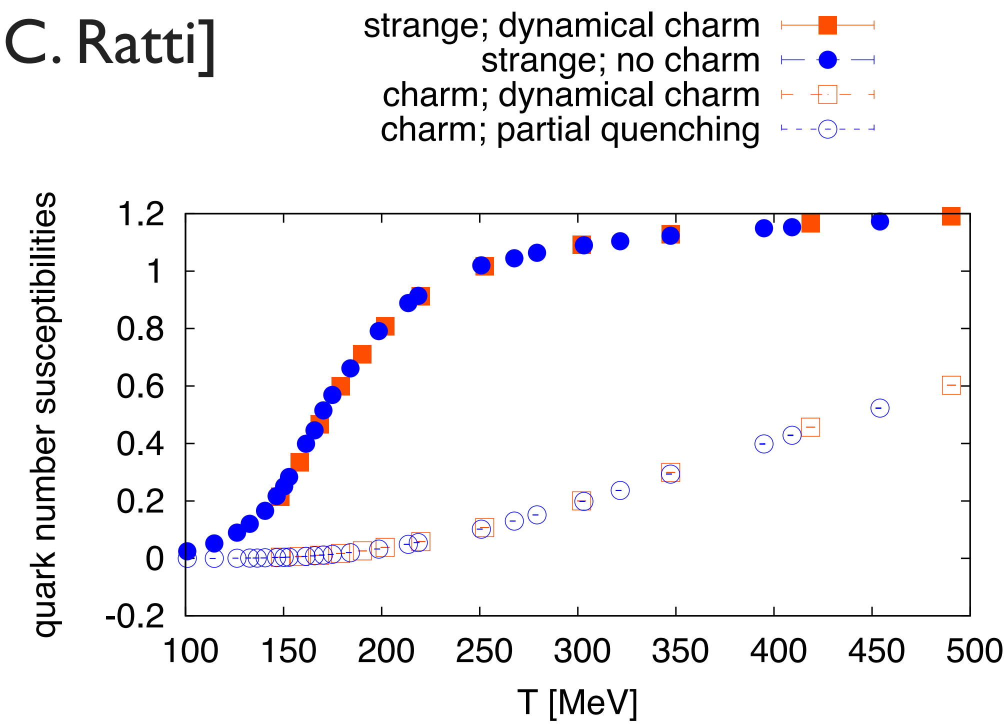


Needs to be recomputed for nFHC

Charm...

[Borsanyi et al 1204.0995 - Thanks to C. Ratti]





Flavor hierarchy? [Bellwied, Borsanyi, Fodor, Katz, Ratti 2013]

- *Charm deconfinement transition ~ 1.5 Tc [all this preliminary and speculative]*

Charm production [See also Jan Uphoff this morning]

- *In the CGC approach, charm produced as massless when Qsat >> Mcharm*

$$Q_{\rm sat,LHC} \sim 1.7 \div 2\, GeV \quad \Longrightarrow \quad Q_{\rm sat,nFHC} \sim 2.5 \div 3\, GeV$$

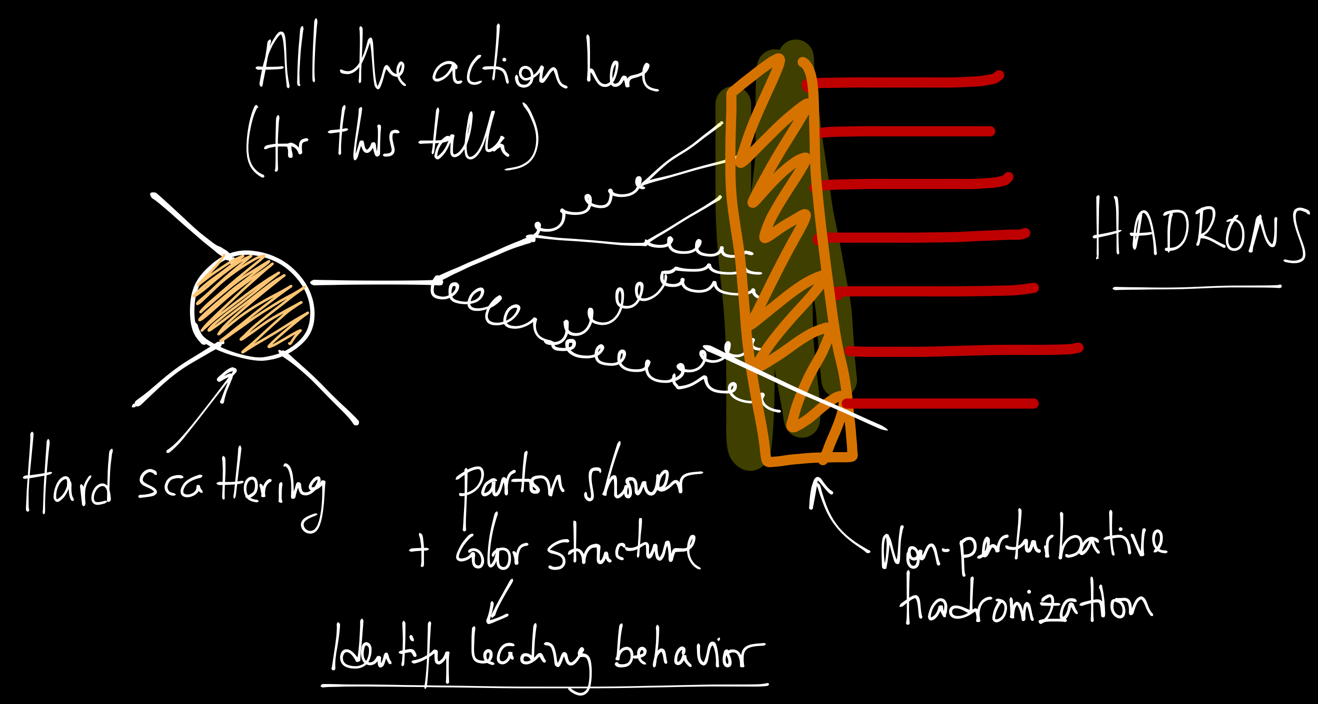
- *With large uncertainties on the actual value - a complete calculation would be needed*

Jet quenching

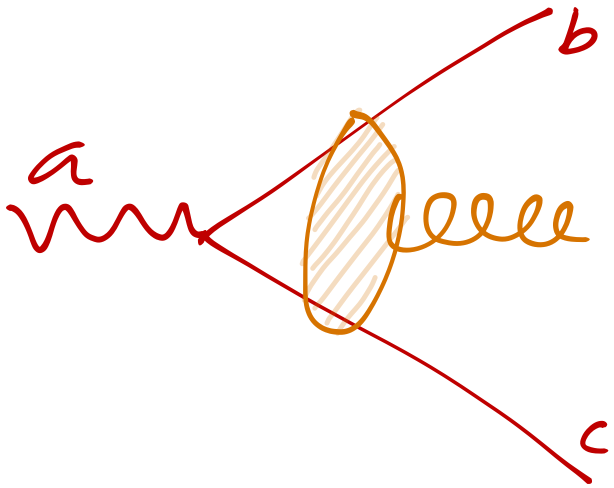
Two main questions - in my opinion

- *Space-time picture of the jet evolution / medium evolution*
- *Color structure of the jet evolution / medium evolution*

For both, large improvements at higher energies



Coherence and decoherence in the antenna



Antenna in the vacuum

$$r_\perp \sim \Theta\, t_{\rm form} \sim \frac{\Theta}{\theta^2 \omega}$$

$$\lambda_\perp \sim \frac{1}{k_\perp} \sim \frac{1}{\omega\theta}$$

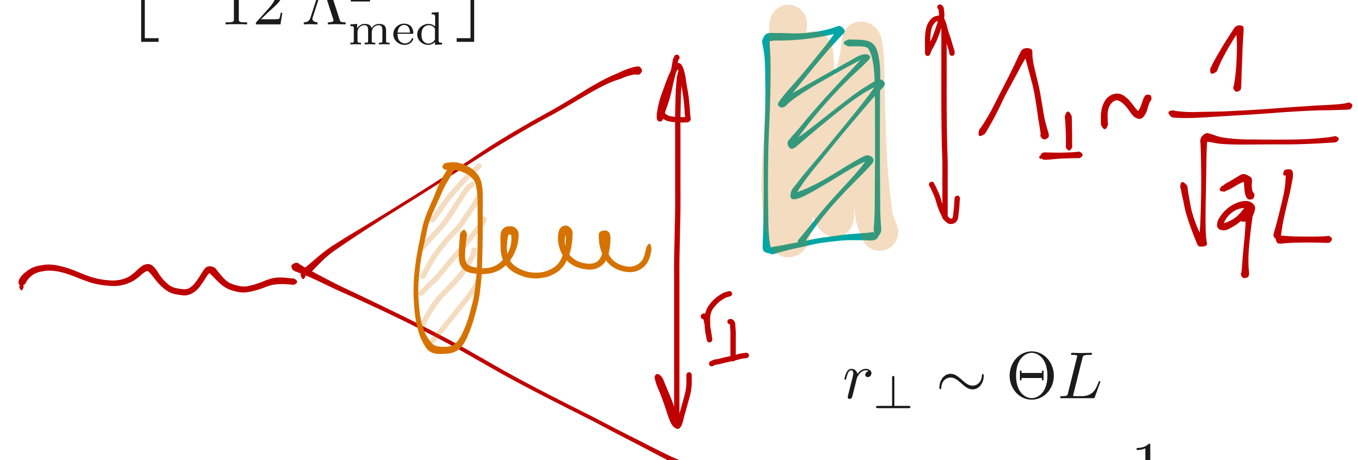
$$r_\perp > \lambda_\perp \iff \Theta > \theta$$

Coherent emission

Antenna in the medium

- Decoherence parameter

$$\Delta_{\rm med} = 1 - \exp\left[-\frac{1}{12}\frac{r_\perp^2}{\Lambda_{\rm med}^2}\right]$$



$$r_\perp \sim \Theta L$$

$$\Lambda_{\rm med} \sim \frac{1}{\sqrt{\hat{q} L}}$$

- The medium color-rotates the antenna which eventually looses color coherence

Coherence for a singlet

- Decoherence parameter $$\Delta_{\rm med} = 1 - \exp\left[-\frac{1}{12}\frac{r_\perp^2}{\Lambda_{\rm med}^2}\right]$$

- For a given time t :::

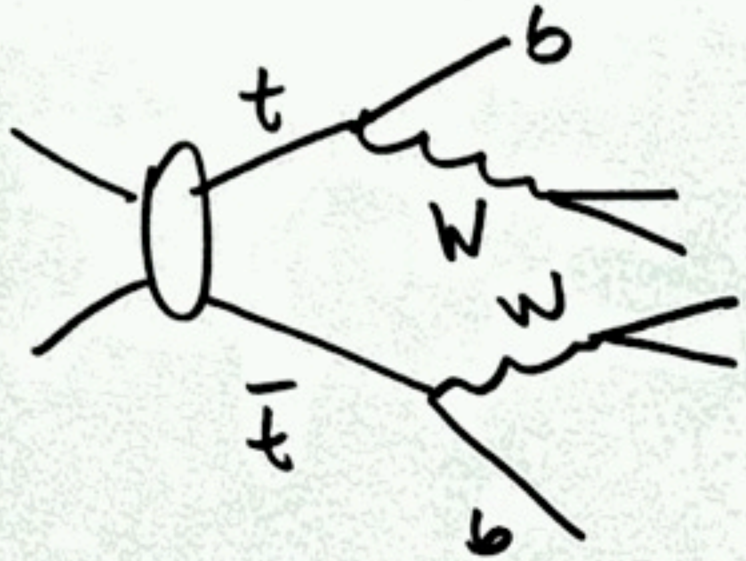
$$r_\perp \sim \Theta t$$
$$\Lambda_{\rm med} \sim \frac{1}{\sqrt{\hat q t}}$$
$$\Delta_{\rm med} \sim 1 - \exp\left[-\frac{1}{12}\hat q\, \Theta^2\, t^3\right]$$

- So, the quark-antiquark pair remains in a color singlet during the time

$$t_{\rm sing} \sim \left[\frac{12}{\hat q \Theta^2}\right]^{1/3}$$

[From discussion with Gavin Salam and Guilherme Milhano]

The tops & the W's



BOOST: $\frac{p_T}{M}$

Andrea's estimate $L \sim 1\,\text{fm}\, p_T[\text{TeV}]$

Take: $p_T \simeq 0.5$ TeV $\Rightarrow \frac{p_T}{M} \sim \frac{1}{3}$

0 fm/c $t\bar{t}$ produced

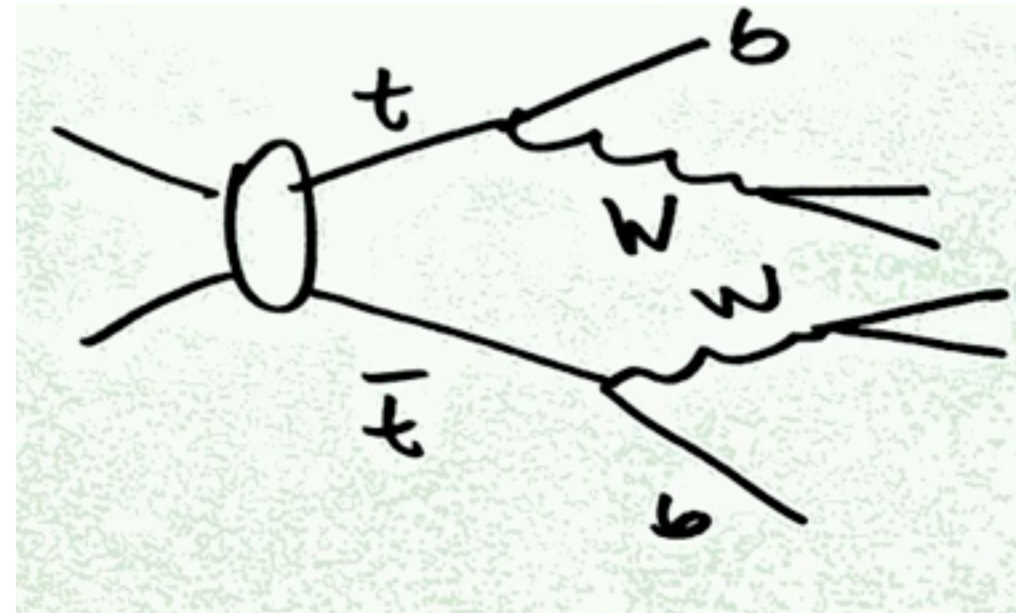
~ 0.5 fm/c each $t \to Wb$

~ 0.8 fm/c W decay

→ Take hadronic decay for one of them

$t_{min} \sim \left[\frac{12}{\hat{q}\,\theta^2_{q\bar{q}}}\right]^{1/3} \simeq 0.5\,\text{fm} \Rightarrow$ **1.8 fm $W \to q\bar{q}$ singlet**

Different boosts



	Pt=1 TeV	Pt=500 GeV
ttbat produced	0 fm/c	0 fm/c
top → W+b	1 fm/c	0.5 fm/c
W decay	1.6 fm/c	0.8 fm/c
qqbar in singlet	2.3 fm/c	1.3 fm/c

Space-time picture of the first instants of the collision accessible

- *Rates...*

Rates

- Total cross section at 39 TeV (PbPb) ~ 6.5 nb ~ 1.5 10^7 ttbar produced
- Reduction factor ~$10^{3.5}$ (Andrea, this morning based on M. Mangano) ~ 4500 with pT>1TeV

Decay channels

[From Christof this morning]

- ll+bb+MET 10%: "observation channel"
- l+bb+2jet+MET 44%
- bb+4jet 46%

- 10 nb-1 5.5 TeV PbPb collisions -> 35k ttbar events
- Branching ratio into e^+e^-, u^+u^- and $e^{+-}u^{+-}$ ~6.5% -> ~2300 ttbar
- Current CMS (pp) acc·eff ~ 23% -> ~500 pairs

- Taking a similar reduction factor but for the second decay channel ~ 250 t's with pT>1TeV
- ~ 4000 with pT>500 GeV [taking cross section 33 pb - Pythia/Gavin]

More realistic analyses needed, but that numbers seem reasonable to me

Summary

The threshold for charm mass could be passed by either (fluctuations) of temperature and/or Qsat

- *Mechanism of thermalization not known !*

Going to higher energies new tools available

- *First look to the case of tops/W's... seem reasonable to me*
- *Access to the initial stages of the collision*
- *Space-time picture (different observables)*