CHAIRMAN: G .'t Hooft

Scientific Secretaries: B.Guerzoni, A. Silenzi

DISCUSSION I

- *A. Nikiforov:*

Do you remember what is the cell size of the electromagnetic calorimeter in the PHENIX experiment?

- *M. J. Tannenbaum:*

Yes, I do!

- *A. Nikiforov:*

And what is it?

- *M. J. Tannenbaum:*

(laughs)

- *A. Nikiforov:*

and can you tell me how much is it compared to the Moliere radius?

- *MJT:*

Oh, Compared to the Moliere radius the cell is larger, it's 0.01 x 0.01 radian and the cell 5.5 x5.5 cm^2 at 5 m and the moliere radius order of 1cm. See NIMA 499 (2003) 521—536.

- *A. Nikiforov:*

But, how can you measure π^0 up to 25 Gev as you stated in the talk?

- *MJT:*

They merge at 25 GeV/c, they are one cell apart. And right now our main problem is that at 18 GeV they start merging, but we have 2 calorimeters one is lead glass and one is lead scintillator with different segmentation so they can be compared. The π^0 decay that gives you problem is when they decay symmetrically because you will have for a 20 GeV $\pi 0$ two 10 GeV photons; but you also have decays with 1 photon with 19 Gev and 1 photon with 1 GeV which are far apart so they can be resolved, but I think direct photons has more problems with the merged $\pi 0$ background.

- *H. Johansson:*

You say that QCD might not be flavour blind, as an explanation of heavy quark suppression as you observe, does this mean that hadrons with 2^{nd} and 3^{rd} generation of quarks can decay through a flavour changing strong process, rather than a weak process?

- *MJT:*

Well, I'm an experimentalist, I'm not a theorist. What I said referred to what happens in the color charged medium, but the quarks decay outside the medium. We are talking of a high pT di-quark embedded in a volume the size of a nucleus with quark and gluons deconfined, in principle according to what Nino says the quark masses can be equal, and I think that they both must be light because there is no other way of explaining light quark radiative energy loss.. The second thing is that we could have the same cross section for . production of light

and heavy quarks in the medium if they both have the same mass. You have a lot of b quarks in the medium but you detect them outside of it, unless they decay inside the medium, but they don't. When the b quarks get outside the medium they return to their correct mass before they decay and that selects, due to quantum mechanics, only a small sample of the b quarks that could have been produced in the medium with low mass. That's why, in my opinion , Nino's idea on quark masses works. Serban Protopopescu of BNL told me that top quarks decay in the medium, which would mean a 10^{-24} s lifetime. I don't know if it has been measured but the theory is good and I saw this value in the particle data book. So at LHC there would be a large number of zero mass top quarks decaying semi-leptonically in the medium, and therefore a huge number of 90 GeV/c leptons coming out, depending on the semi-leptonic branching ratio This could be quite an unexpected discovery at the LHC-Ions if Nino's idea about all quarks having the same mass in the QGCW are correct.
[Added after returning home and thinking: The top quark cannot decay in the medium in this scenario because it has zero mass and hence a typical light-quark semi-leptonic lifetime.]

- *Y. Klopot:*

Could you please comment on the causes of the large azimuthal anisotropy in heavy ion collisions in contrast to anisotropy in pp collisions?

- *MJT:*

Well, it's easy! There is no way we have thought of yet for finding anisotropy in the pp collisions. The only thing you can say is that the proton is composite. The multiplicity in pp collisions is so small that there is no obvious way of measuring the reaction plane to high precision. Maybe LHC could do that, but I don't know...

- *S. Nicotri:*

Do you think it is possiblke to study the color superconductive phase of QCD at RHIC? Or will it be possible to study it in the near future?

- *MJT:*

I don't think we can make it in a laboratory. You see the problem in the phase diagram: the superconductive phase proposed is at very low temperature, very high baryon chemical potential, μ_B. Maybe some astronomer can see them, but they are not accessible in lab.

- *E. Gazis:*

In the last part of your presentation. it was shown the specific role QGCW and the specific experimental technique you have shown to confirm it. My question is if in that object proposed (QGCW) the QCD study effects for the quarkonia have been taken into account. (i.e. quark internal motion, glueballs, color octet states)

- *MJT:*

No, that's a theorist's job. In this field we find a new phenomenon and five minutes later twenty theorists claim they have the right answer. The point is that if you predict something I have seen and also something I didn't see yet, I will go and measure it. If we find the effect that the b-quark energy loss is the same as the light quark energy loss we can then worry if this means that their masses are low or whether there is some other explanation other than radiative for energy loss in a medium.

- *R. Baldini Ferroli:*

Long time ago I heard that in heavy ion collisions J/ψ should be suppressed and the ϕ enhanced. Is it still true?

- *Y. Akiba (COMMMENT):*

comparing the binary scaling the ϕ is suppressed at intermediate pt.

- *MJT:*

We measured J/ψ suppression the same as at CERN fixed target energy. But the phi is suppressed nearly the same as a $\pi0$, for pT>5 GeV/c, a factor of 5. At lower pT the phi suppression is a bit less than $\pi0$ similar to Kaons.

- *Z. Marshall:*

I have been thinking about Prof. Zichichi's experiment of firing a beam throuhg the QGP, so I ask how long does the QGP live? And how could it be lengthened.

- *MJT:*

It typically lives 10 fm/c so it's 0.3 10^{-22}s. So it will be very difficult to time that beam. If Nino thinks he can do it, good luck to him. I have no idea how to do it. You can clearly send in a pulse of protons of a ns length but you will have one interaction in a Zillion. In principle if you throw enough protons one of them will hit, but I can't imagine that it can hit the A+A collision within a time of 10^{-23} second.

- *ZM:*

and there is no way to lengthen the lifetime?

- *MJT:*

I wish we could control that. Maybe with a Penning trap with Chromo Electric and Chromagnetic fields (Ha,Ha), it would be wonderful.

- *Y. Akiba:*

I wish to comment. We cannot shoot in the collision area, but we can actually study event by event the reaction frame, i.e. elliptic flow I have shown in my lecture.

- *MJT:*

b b-bar pairs are born as the medium is formed and pass through the medium on the way out. All the hard scatterring occurs in the first moment of the reaction and the di-partons are distributed throught the medium So we can study this effect with hard scattered parton-pairs.

- *L. Cifarelli:*

The basic idea is to synchronizing with the plasma and hit this object before hit has expanded, hadronized, avoiding examining the latter part of the reaction using pre-shower synchronization. I can tell they are working hard on this problem.

- *MJT:*

I think that the hard scattered partons can penetrate the plasma and it happens very quickly. A 2 GeV π can not be resolved until 20 fm which is outside the plasma while the energy loss of its parent parton has taken place inside the plasma. The soft stuff fragmenting takes place well after that time.

K. Ni- :

Is there any advantage by using Pb-Pb at LHC than using Au-Au collision like at RHIC?

- *MJT:*

When I was a particle physicist I used 5 x 10 x 20 cm lead bricks for a heavy element target [see PRL 26 (1971) 46] while nuclear physicists used gold targets that looked like gold coins. That's why I became a nuclear physicist. No, the reason is that when you make an ion source you can use any gold wire which is isotopically pure, while the standard lead brick is not isotopically pure (but of course all has the same Z). The difference between gold and lead is no big deal, Gold is 197 nucleons Lead is only 11 nucleons more. We will try to use uranium in the future, it's football shaped, so something interesting can come out.

- *C. Wen:*

How to decide to run the beam on the central collision case on under an off-central case? Is that based on some special physics purpose? What is the running-time fraction for different detector configurations?

- *MJT:*

We cannot select how the collision will take place. We squeeze the beam at the mm level but the ion is fm in size, so the centrality of the collision is just random.

- *A. Silenzi:*

You have shown that the particle yield in momentum with HI collisions decreases more steeply than with pp collisions. Is it possible to state from this feature that partons with higher energy are stopped more easily within the QGP?

- *MJT:*

Well, the energy dependence of the parton energy loss in a medium is one of the key issues of the field. In the 2 particle correlation we don't know how the energy loss by a parton in the QGP depends on its energy, although in principle we could map it out with enough data. In my opinion, if dE/E is constant we would have a constant $R_{AA,}$ just on general principles, and that's what we see. I hope that LHC will sort that out. A colleague from Brookhaven, Dima Kharzeev found the way to have energy loss ΔE proportional to E^2, you know that synchrotron radiation energy loss is proportional to E^4.

- *A. Silenzi:*

So you confirm that there is a clear energy dependence in the energy loss during QGP crossing?

- *MJT:*

Actually from a more experimental point of view it's very difficult to say anything. If you want to trigger on a jet by selecting a high pT particle you have a trigger bias: you are most likely to get a low energy jet that fragments high than a high energy jet that fragments soft because the jet spectrum falls like $1/p_t^8$ and the fragmentation function is exponential. Similarly when you look at a particle coming out of the medium: instead of having a 100 GeV jet that has lost 50 GeV in crossing the medium you will have a 50 GeV jet from the surface that have not lost much, so this tremendous surface effect make this 2-particle correlations much more complicated to understand in A+Au collisions compared to p-p collisions as an experimental channel. We have people studying 3-particle correlation and 4 particle correlations, it's alot of fun.

- *C. Bonati:*

You spoke about deconfinement in the phase transition but usually deconfinement is associated also with restoration of chiral symmetry. Could this have some experimental consequences?

- *MJT:*

Do not ask me this, I am an experimental physicist. I think that chiral symmetry gets restored in the first instant of the collision. I do not know what happens when the particles hadronize.

- *S. Dubynskiy:*

On the cartoon of strongly interacting matter as a nuclear matter and quark matter at higher density the value of 1.6 fm is related to the size of a nucleon But where does the value for 0.8 fm for quark case come from?

- *MJT:*

The answer is that if we look at the formula for gluon radiation in the color-charged medium, the minimum of momentum transfer is μ^2. This μ is the same as the debye mass, and it 0.5 GeV/c, that is 0.4 of a fm. That's why I think 0.8 fm is the radius we study.