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Successes and Failures with Hard Probes

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The two major pillars of searches for the Quark Gluon Plasma have been: J/Ψ suppression, proposed in 1986, and apparently observed at both SPS fixed target energies and at RHIC; and, more recently, the suppression of π^0 with $p_T \geq 3$ GeV/c by a factor ~ 5 in Au+Au central collisions, observed at RHIC in 2001, which had been predicted in advance as a consequence of Landau-Pomeranchuck-Migdal coherent (gluon) bremsstrahlung by the outgoing hard-scattered partons traversing the medium. However, new effects were discovered and the quality of the measurements greatly improved so that the clarity of the original explanations has become obscured. For instance: J/Ψ suppression is the same at SpS and RHIC. Is it the QGP, comovers, something else? QCD provides beautiful explanations of π^0 and direct γ measurements in p-p collisions but precision fits of the best theories of π^0 suppression barely agree with the Au+Au data. Better data are needed for $10 < p_T < 20$ GeV/c, systematic errors are needed in theory calculations, the values of parameters of the medium such as $\langle \hat{q} \rangle$ derived from precision fits are the subject of controversy. Baryons are much less suppressed than mesons, leading to an anomalous $\bar{p}/\pi$ ratio for $2 \leq p_T \leq 4.5$ GeV/c, but beautiful theoretical explanations of the effect such as recombination do not work in detail. Heavy quarks seem to be suppressed the same as the light quarks, naively arguing against the bremsstrahlung explanation and suggesting exotic, possible transformational explanations. Di-hadron correlations reveal a trigger side ridge, possible Mach cones on the away side, vanishing and reappearance of away jets, both wide and normal jet correlations with and without apparent loss of energy. Can this all be explained consistently? Preliminary results of direct γ production in Au+Au appear to indicate a suppression approaching that of π^0 for $p_T \approx 20$ GeV/c and a possibly thermal component for $1 \leq p_T \leq 3$ GeV/c. What are the implications? Are fragmentation photons a problem? Regeneration of direct γ by outgoing partons is predicted, leading to negative v_2—is there evidence for or against it? STAR and PHENIX have different observations relevant to the existence of monojets in d+Au collisions. Will new data clarify the situation? When? etc. These and other issues will be discussed with a view to identify which conclusions are firm and where further progress towards real understanding is required.

QCD for π^0 direct-γ in p-p.

Jet suppression in AA π^0, charged don't agree $\Rightarrow$ precision π^0 excellent theory precision tests: theory barely agrees, flat is better, need better systematic errors on theory, need better data $10 < p_T < 20$ GeV/c. Fragility concept is fragile, $\langle\hat{q}\rangle$ in PQM is too large show Baier.

Jet suppression turns on > 22.4 GeV.

Direct photon suppression. If direct γ are suppressed equal to π^0 at $p_T = 20$ GeV/c, what does it mean? Detector weakness? ionization-like energy loss not visible for $p_T \sim 20$ GeV/c $\Rightarrow$ initial state effect. $\Rightarrow$ LHC is CGC factory.

photon regeneration by outgoing partons negative v2, where is it?

Fragmentation photons: few at RHIC Vitev should use Frixione cone cut to kill his inclusion of frag photons in p-p denominator which no experimentalist would do.

Monojets in CGC—PHENIX no, STAR yes. New data?

Great success measurement of dir γ down to 1 GeV in p-p and AuAu-c.f. Drell Yan (kaplan fit) significance of thermal photons.

NA60–latest explanation almost makes sense to me $\pi^+\pi^-$ annihilation below rho, more like $q - \bar{q}$ above rho: Bjorken Weisberg?

Baryon anomaly–great theory but it fails 2 pX plots same and away side enhancement STAR RAA p formation time cold matter effects. Star 'gluon' measurement no different in g and c quenching or non understanding of baryon produciton.

heavy quark suppression. Dead cone is indeed dead. Brought String Theorists into the game (is success or failure?) Transformational possibilities transport properties of light and heavy quarks same in medium.

Away jet vanishes: Good PR not such good science as jet is there if you look in the right place— Wide Jet if Mach cone then why does star get different answer in 2 and 3 particle correlations, why does PHENIX get the same value of the cone angle for all centralities while RAA changes dramatically. Solution measurement w.r. reaction plane–show STAR and PX QM prelim, 2 kinds of mixed events.

MJT failure: 'everything $\Rightarrow$ almost everything' $\Rightarrow$ new formula which works. why doesn't everybody use it instead of IAA, Works for di-hadrons but prelim PHENIX gamma jet doesn't agree. Better data needed. Also criticize star QM2008 data, show TTWW plot.

Punch through jets– clear break in STAR QM06 data (publication) BH vs. LPM where is jet broadening, Surface effect–why energy dependent? Complicated surface issues $\Rightarrow$ 3 particle correlations (w.r. reaction plane)

So it doesn't whistle.