What have we missed, where should we go: some personal thoughts pbm, QM04, Oakland

• Soft probes

the 'horn' question correlations and fluctuations strongly decaying resonances low mass dileptons

• Hard probes

jets and quenching quarkonia and open charm photons

Main advice

- Luminosity
- Luminosity
- Luminosity

The 'horn'



- 3-4 sigma from thermal model
- No easy way to adjust

Another Ratio

Thermal model predicts also strong peak



Structure qualitatively described, 'modulation' of the freeze-out curve

An interesting and provocative data set

- Needs experimental confirmation by second experiment
- CERES: reanalysis of 40 and 160 GeV data
- No coverage of 20-30 GeV region (until GSI SIS 300)
- Connection to chiral susceptibility peak (see Karsch, Eijiri, Bielefeld LQCD)?

Search for Critical Point in the Phase Diagram

- Could be anywhere between mu=700 MeV and mu=0 MeV
- Steps of delta-mu=50 MeV sufficient

Collision energy dependence of mean $\boldsymbol{p}_{\scriptscriptstyle T}$ fluctuations



Collision energy dependence of net-charge fluctuations

- v_{dyn} corrected for charge conservation
 - Decreasing tendency at SPS
 - Little change from SPS top energy to RHIC
- UrQMD and RQMD are consistent with the observed fluctuations



Search for critical point

- No evidence so far
- Need 3 more points above SPS energy and 1 below to complete coverage
- Maybe study particle ratio or baryon number fluctuations?

Is critical point visible?

- Can fluctuations survive the phase transition?
- Does mixing near T_c destroy abnormal fluctuations?
 - -- see pbm, stachel, wetterich, nucl-th/0311005
 -- multi-meson interactions near T_c drive system towards rapid equilibration
 - -- high density phase with large collectivity when crossing T_c from above ('sticky molasses' scenario by Brown, Shuryak, Zahed)

Strongly decaying resonances

- beautiful set of data
- no clear picture emerging
- rho and Delta too high
- K* and Lambda(1520) too low
- phi is ok

Thermal fit for central Au-Au

e.g.: brand new @ RHIC 200

 $T_{ch} = 160 \pm 10 \text{ MeV}$ $\mu_B = 24 \pm 5 \text{ MeV}$

(STAR Preliminary)



relative particle abundances well described in grandcanonical system, <u>even for rare, multi-strange particles</u>



Thermal Models - II



Strongly decaying resonances

- Need much more detailed centrality dependence especially for the rho in central AuAu collisions
- Why are these resonances not or only little shifted in mass?
- Need effects of last rescattering in models
- 'the rho is always special' (Gerry Brown)

Low Mass Dileptons

- Continuum enhancement between 200 and 700 MeV established at SPS energies
- Focus now on resonance region
- Theories need to simulate experimental trigger conditions

First phi signal from CERES

ϕ meson yields



First Φ signal from NA60



To do list

- For CERES:
- Improve S/B and significance (up to factor of 2 expected) in e+e-
- Get phi-->KK and phi-->e+e- yields in same experiment

- For NA60
- Get results as function of centrality
- phi-->KK would be beautiful

Get low mass dileptons at RHIC

Direct Photons

- Beautiful new results from PHENIX
- Results consistent with pQCD calculations
- Need much higher precision (statistics, systematics) to see photons from plasma
- Window of opportunity between 2.5 and 6 GeV in p_t

New Results Central 0-10%



Theory curves include PHENIX $\gamma_{\text{expected background}}$ calculation based on π^0 : ($\gamma_{\text{direct}} + \gamma_{\text{exp. bkgd.}}$) / $\gamma_{\text{exp. bkgd.}} = 1 + (\gamma_{\text{direct}} / \gamma_{\text{exp. bkgd.}})$

- Many of my questions answered at this meeting
 * quenched energy stays in the cone
 * quenching <--> thermalization
- First indications of modified fragmentation function

Disappearance (at mid-rapidity) is dominated by final state effect(s)! *Jet Quenching*





p_T Distribution in Away-Side Jet



Jets – Questions and Comments

- Questions

 trigger bias on near side?
 - -- can fragmentation function be extracted?
- Need data with identified leading hadrons (charm?)up to higher p_t
- Comments -- calorimetry mainly useful as trigger -- the real 'beef' is in the fragmentation function (calorimetry + tracking to 0 p t) -- gamma – jet coincidences at high p t (high Luminosity)

Quarkonia and Open Charm

- Quarkonia -- new data on d-Au at RHIC -- first peaks from NA60 on In-In \rightarrow exciting results to come (but probably not PbPb) at SPS -- new data on psi' from SPS
- Open Charm

 reconstructed D
 mesons (STAR TPC!)
 consistency STAR PHENIX

Open charm reconstruction in STAR



Use PYTHIA for extrapolation to full phase space



PHENIX cross section lower than STAR but within (large) erors consistent

Flow of Charm?



S. Batsouli, S.Kelly, M.Gyulassy, J.Nagle Phys.Lett. B557 (2003) 26-32

The measurement of v_2 of charm is a way to discriminate between these contrasting dynamical scenarios



Poster by Shingo Sakai PHENIX

Open Charm

- D mesons reconstructed in STAR TPC (dAu) (need also D+/-)
- Cross sections from single electron analysis and D measurements agree (large uncertainties)
- Precision measurements of charm also in Au-Au (energy loss, flow, enhancement, ...) needs order of magnitude more luminosity
- Si vertex trackers

Quarkonia

- New data from dAu
- chi_c data from HeraB

χ_c to J/ ψ production ratio from HeraB



 Δm (GeV/c²)

Analysis of 2002/03 data:

- Comb. background by event mixing
- Carbon target
- In 15% of $\mu^+\mu^-$ statistics we find about 1300 χ_c
- •Expect N(χ_c) ~ 15k for full sample

$R(\chi_c) = 0.21 \pm 0.05$

Would imply: only about 21 % of J/psi from chi_c decay!!

Quarkonia—Comments

- Input from theory: J/psi melts only above 1.7 T_c (need non-quenched calculation soon)
- If HeraB estimate correct, J/psi suppression is not dominated by melting of chi_c
- No new insight into J/psi and QGP until high statistics J/psi measurements in Au-Au at RHIC
- Highly desirable: psi' and chi_c measurements in Au-Au
- Need J/psi p_t spectrum to nail partonic vs hadronic flow

Quarkonia continued

- New PHENIX d-Au data show indications of shadowing at forward rapidities
- Connection to 'BRAHMS' effect?