A Low Energy Program at RHIC

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- Summary of the workshop
- "Can we find the QCD critical point at RHIC?"
- @BNL March 9-10, 2006

WS Objective

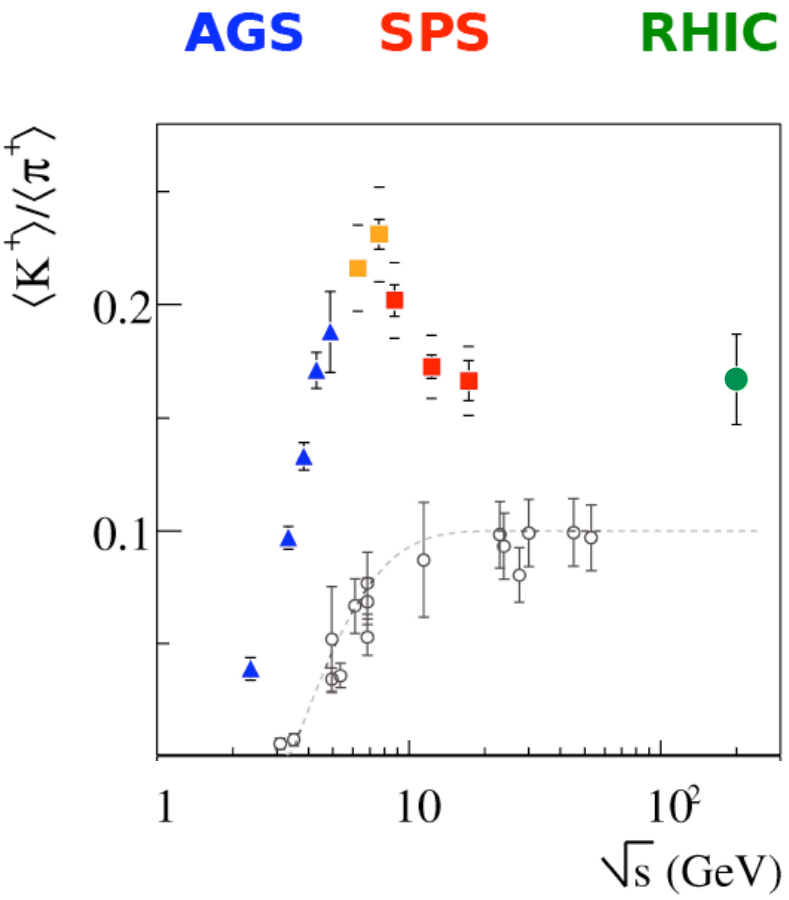
…. a growing body of theoretical and experimental evidence that the critical point on the QCD phase diagram, if it exists, should appear on the QGP transition boundary at baryo-chemical potential ~100 – 500 MeV, corresponding to heavy ion collisions with c.m. energy in the range 5 – 50 GeV/u.

… the possibility of an experimental search of this region, using the RHIC colliding beams and the STAR and PHENIX detectors. The WS will examine such a program, bringing together theorists, experimentalists, and accelerator scientists.

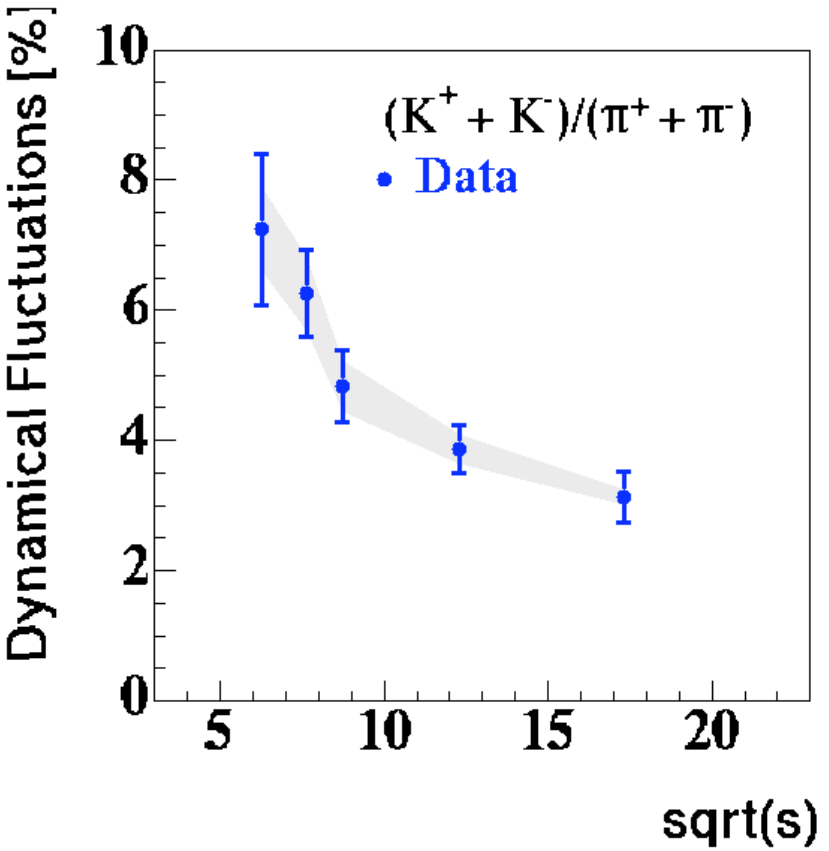
Contributions from

- Accelerator:
  - Satogata, Tsoupas, Drees, Fedotov, Roser
- Experiments and detectors:
  - Roland, Steinberg, Nayak, Xu
- SPS & FAIR:
  - Seyboth, Gazdzicki, Senger, Appelshaeuser, Stock
- Theory of CP location:
  - Karsch, Fujii, Fodor
- Theory and signals:
  - Rajagopal, Stephanov, Shuryak, Hatta, Nonaka, Redlich, Antoniou, Koch, Randrup, Stoecker, Rafelski

Motivation - Exp

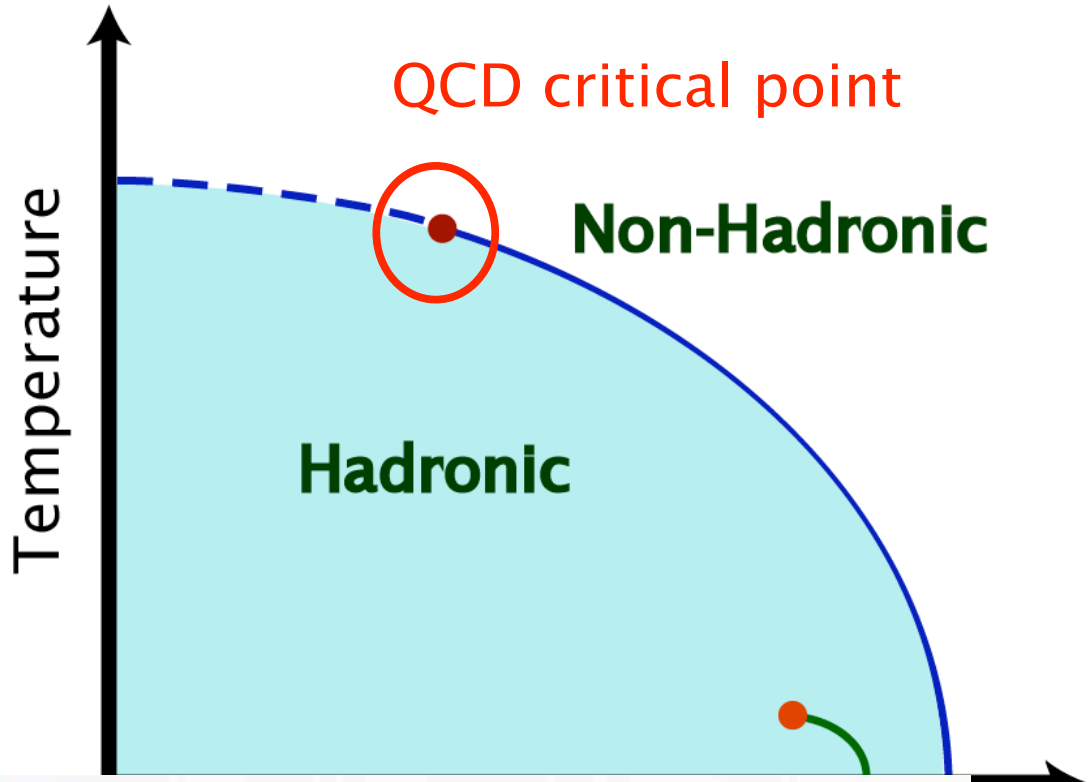


Talk of M.Gazdzicki



Talk of C.Roland

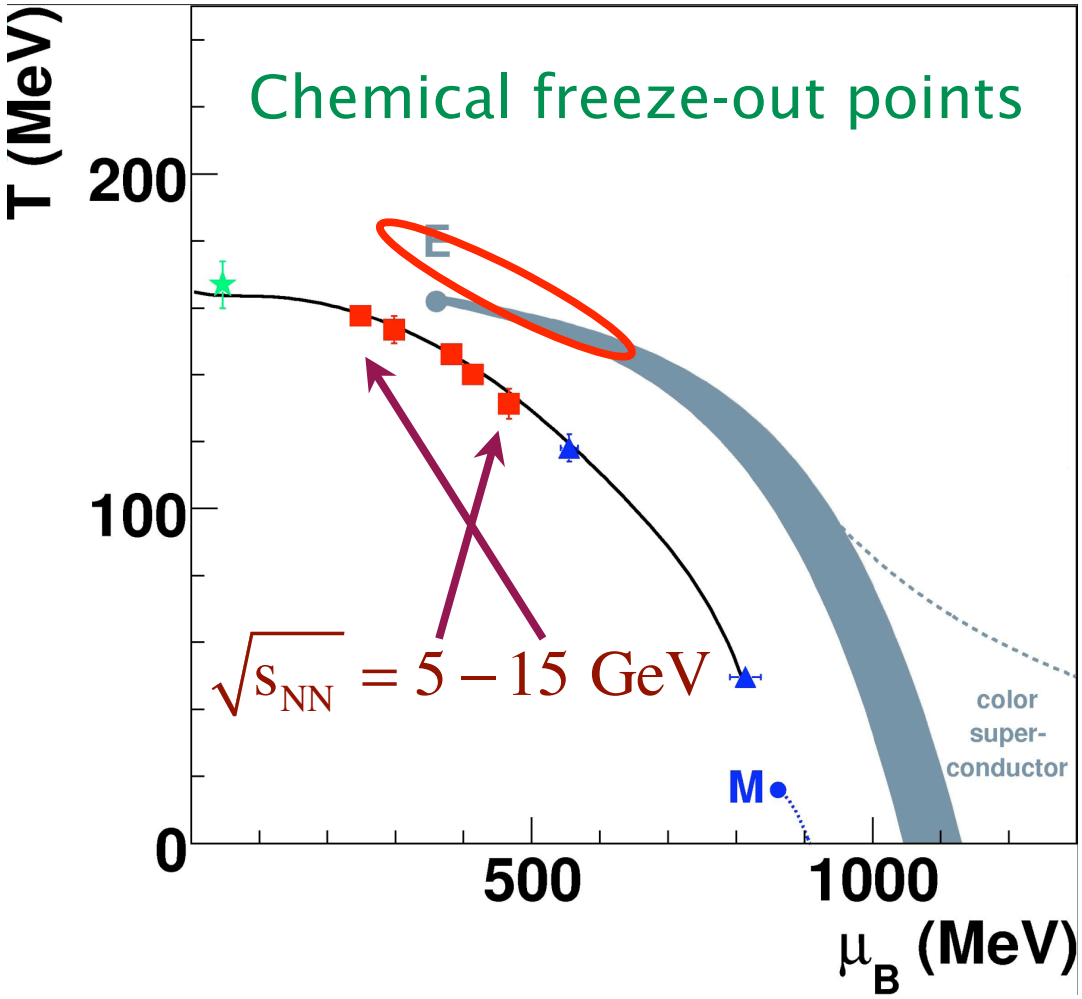
QCD Critical Point



Mapping the phase diagram. Finding the landmark that would go in any future book on QCD. Can RHIC do this

K. Rajagopal

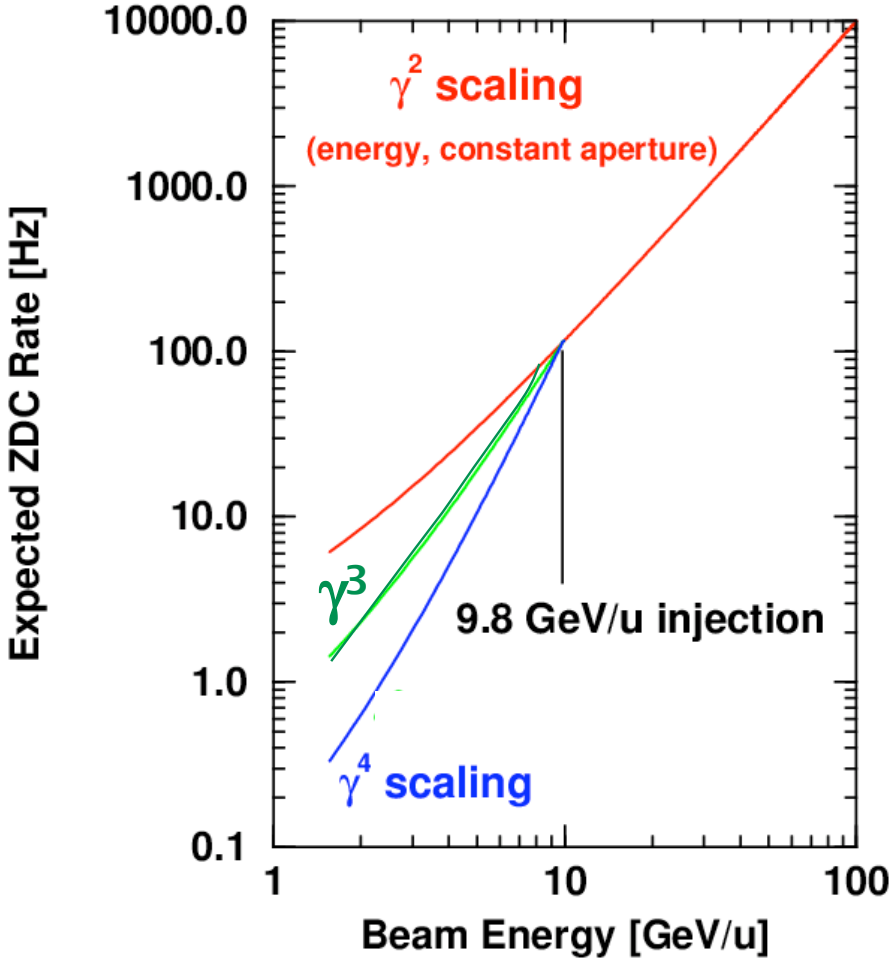
How do we get there?



Talk of M.Gazdzicki

AGeV	√ s	E_{beam}
11.6	4.86	2.43
20	6.27	3.13
30	7.62	3.81
40	8.77	4.38
80	12.3	6.15

Accelerator Capabilities



No apparent show-stoppers but low current field quality and power supply stability need to be checked

Electron cooling could improve rate enormously:
Estimated factor 100
Also:
Factor 10 by cooling in AGS

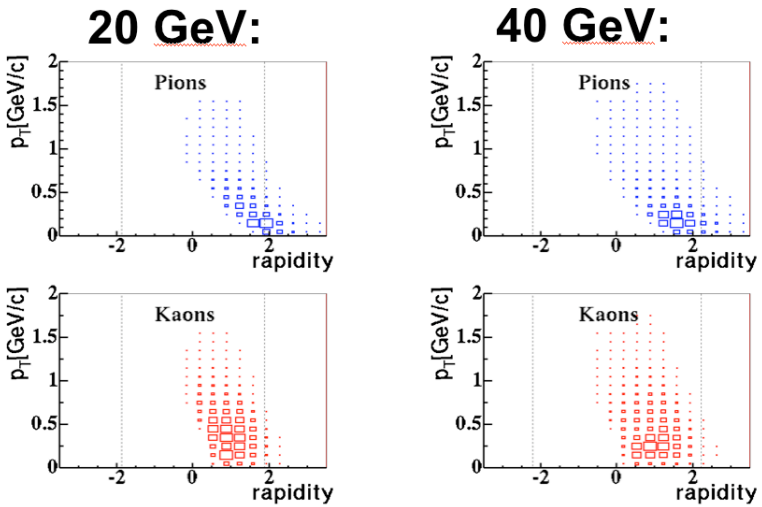
Modest investment (<1M$)

Talk of T.Satogata

Talk of A.Fedotov

Detector Capabilities - I

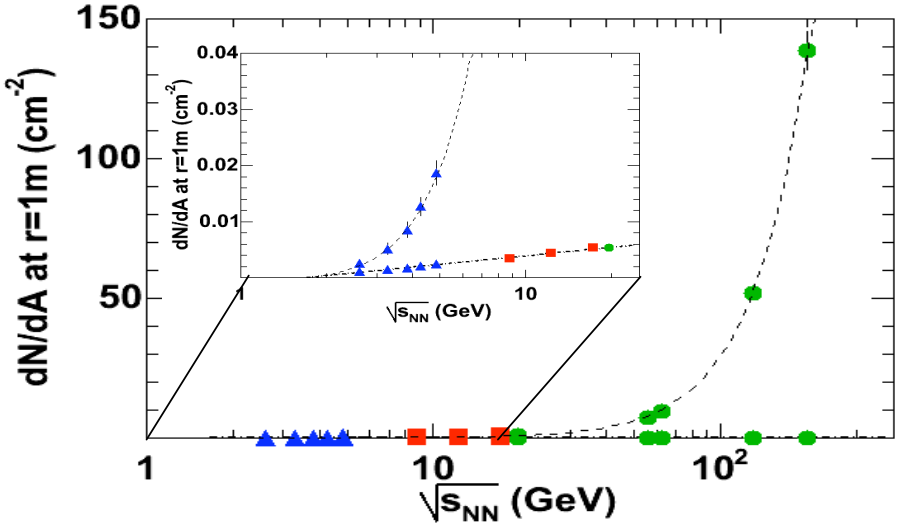
NA49 acceptance



Talk of M.Gazdzicki

Big advantage that occupancy for collider detectors is much less dependent on beam energy

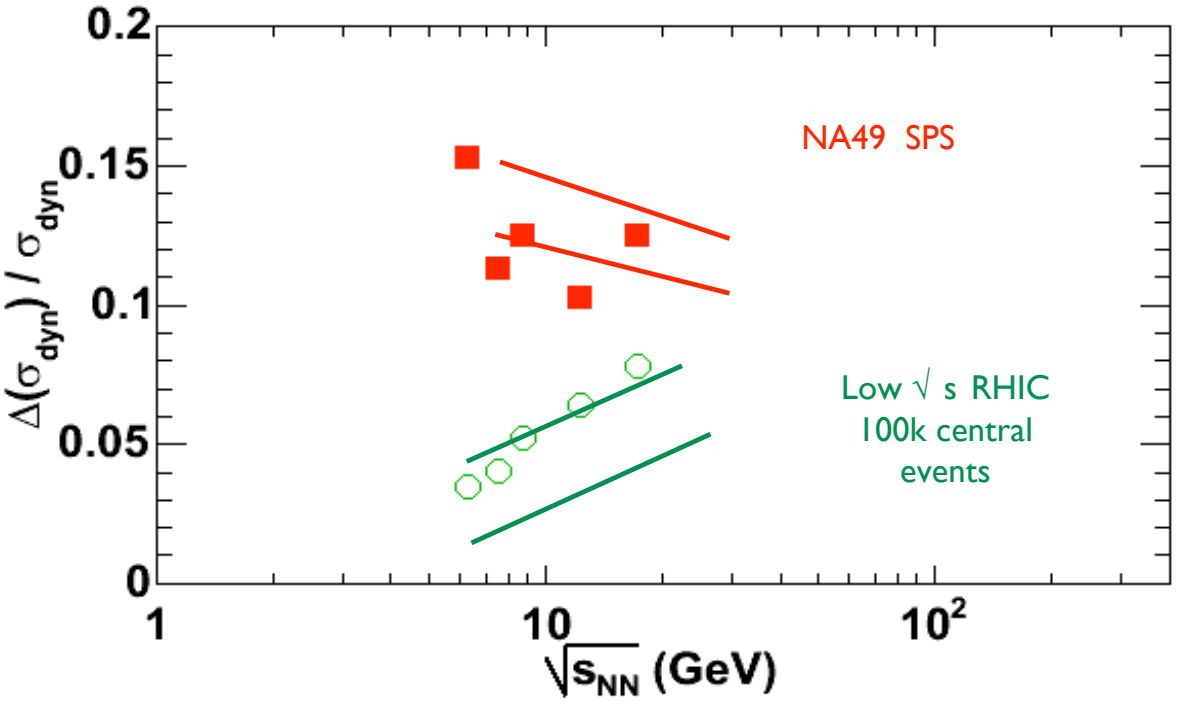
Big advantage that acceptance for collider detectors is totally independent of beam energy



Talk of G.Roland

Detector Capabilities -II

Relative error on K/π fluctuations

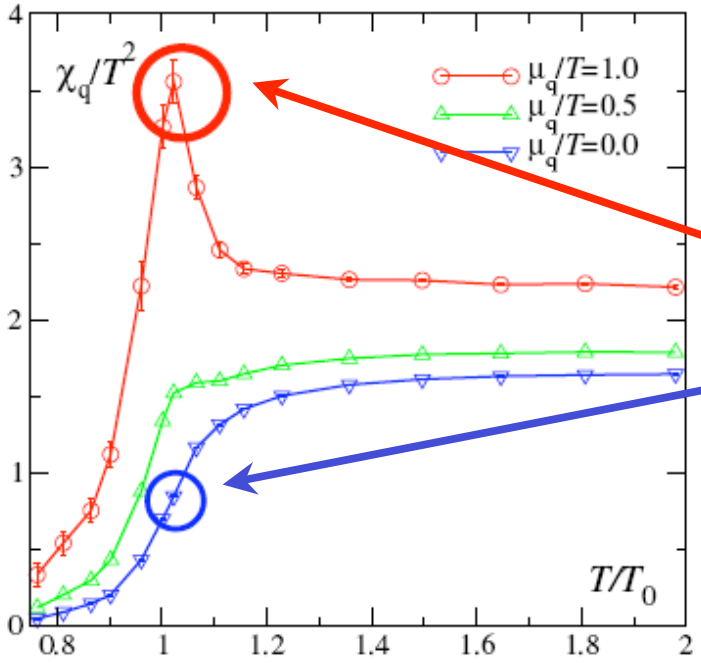


Talk of G.Roland

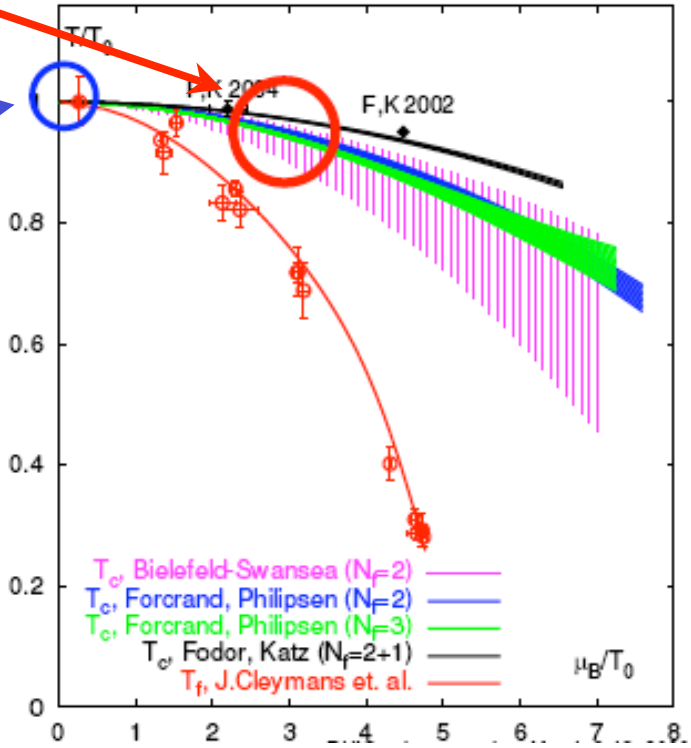
100K central events at RHIC would provide a big improvement over NA49 results (Note: requires STAR TOF upgrade)

Model Examples - I

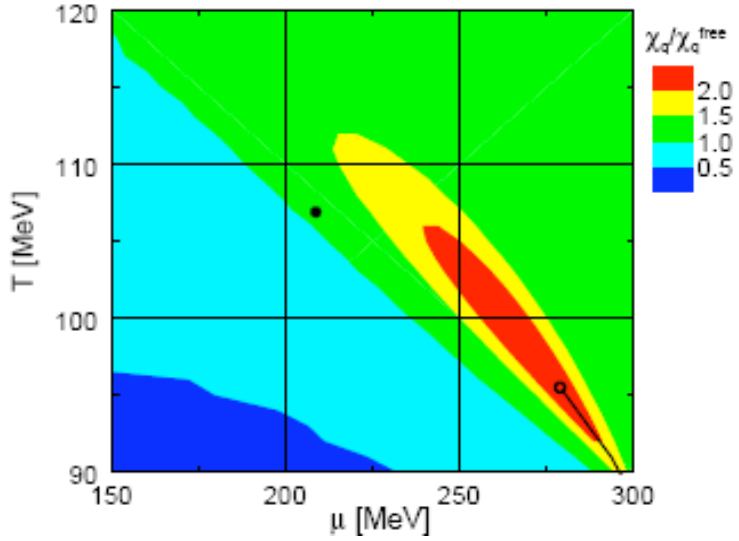
Sudden changes in susceptibility taken as evidence for critical point



Talk of F.Karsch

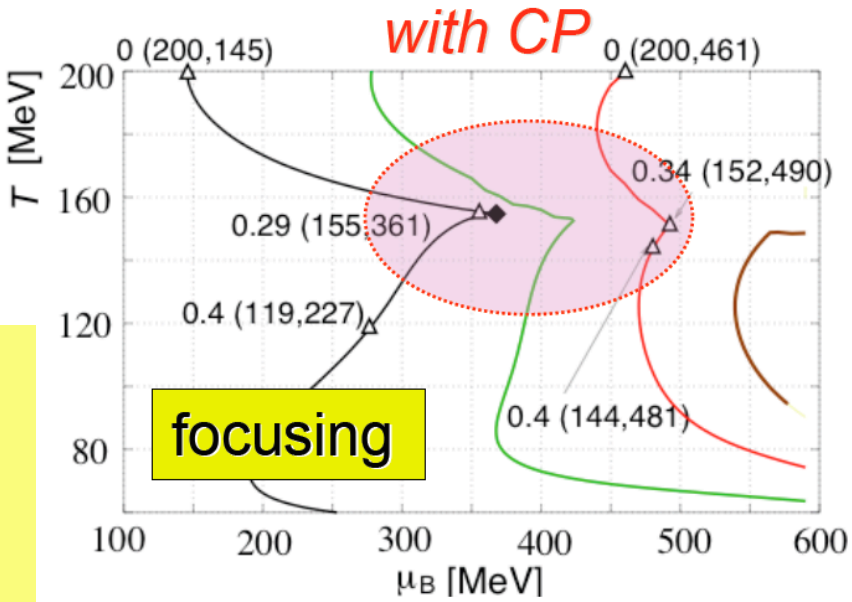


Model Examples - II



Talk of Y.Hatta

Enhanced susceptibilities over an extended region



Talk of C.Nonaka

Hydro predicts that evolution of system is attracted to critical point

Proposed Signals

- Lots of ideas, mostly qualitative as expected
  - Largely related to bulk properties, not rare probes
- Fluctuations of many varieties
  - Particle ratios, multiplicity, charge, baryon number, mean p_T, etc, etc
- Energy dependence of flow characteristics
  - Both v_1 and v_2
  - Especially pions compared to protons
- "Lumpy" final states

Overall Status

- Theory
  - Very promising but a lot of details to work out
- Accelerator
  - Very promising but a number of details to work out
- Detectors
  - Very promising but a few details to work out

- On experimental side, capability will be much better known soon

WS Summary

- Strong endorsement of carrying out machine studies at low beam energies, preferentially this run
- Suggestion to aim at an initial physics program of about 10 weeks, at energies corresponding to SPS data
- Working Group formed to help develop specific beam use proposals for presentation to BNL's PAC by the end of this summer
- Present status:
  - STAR and PHENIX endorse low energy program and are developing physics program with the goal to include in beam use request
  - Machine tests will be done in June (end of run)

Related Exp. Efforts

- RHIC @ high energy
  - Study formation and properties of "perfect liquid"
- LHC @ very high energy
  - Extend study of matter at $\mu_B \approx 0$, scaling properties of particle production and equilibration
- SPS @ similar energies
  - Continue NA49 energy scan with lighter systems
- FAIR @ lower and similar energies
  - Systematic studies, especially with rare probes

Relationship to CBM

- Establishing phase transition is part of RHIC mission
- Information from RHIC will focus CBM efforts
- Gives CBM chance to concentrate on
  - Systematic studies, especially with rare probes
  - Chiral symmetry restoration
- Complementary efforts

Conclusions

- Very exciting possibility exists for expanding the experimental exploration of a broader range of the QCD phase diagram at a short time scale
- Early theoretical and experimental indications are very promising
- RHIC has the potential to make important contributions to this area
- Machine capabilities and future experimental program are under active development
- RHIC and CBM are complementary efforts