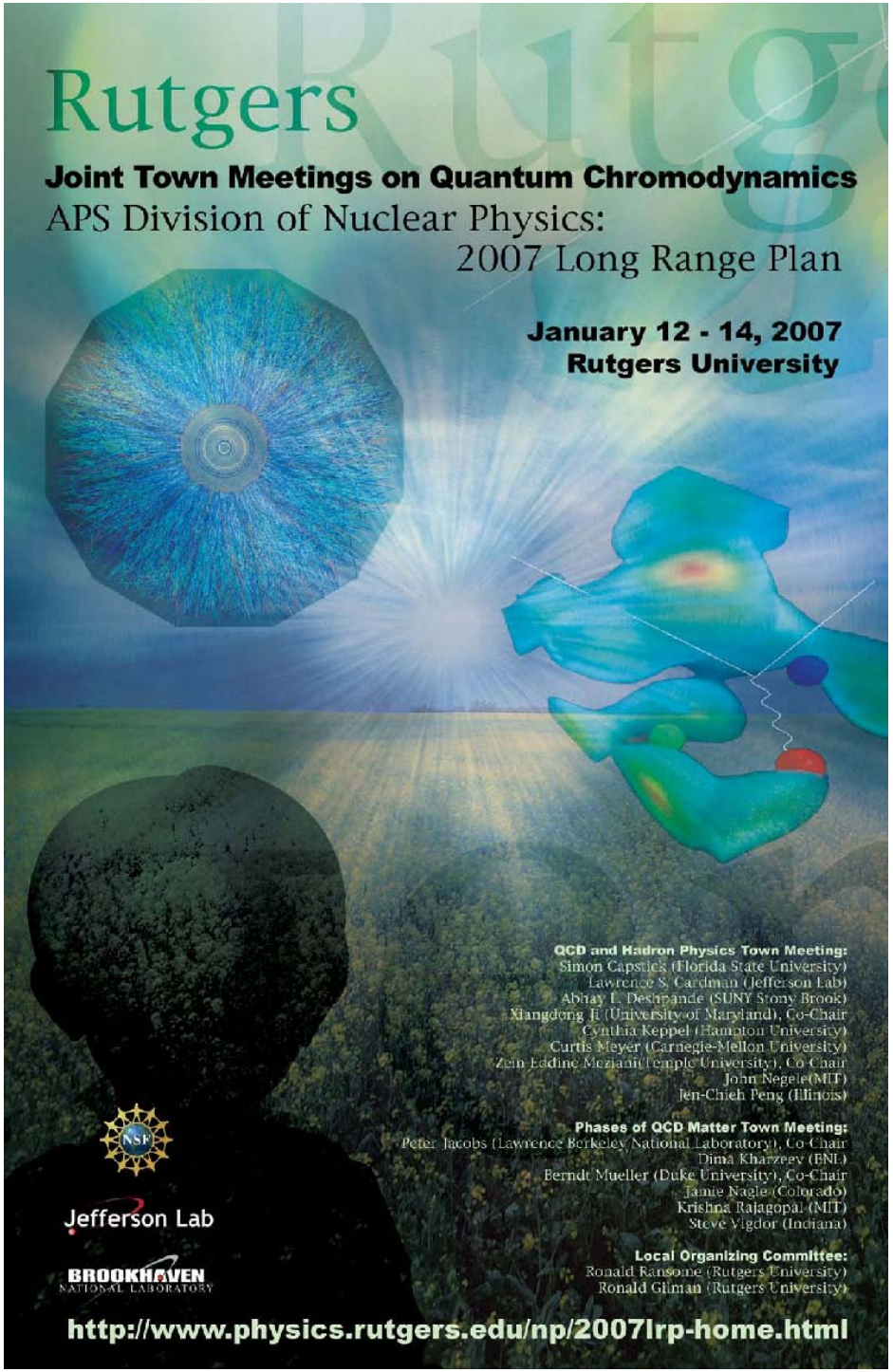

QCD and Hadron Physics

S. Capstick L. Cardman, A.Deshpande,
X. Ji, C.Keppel, C. Meyer, Z. Meziani,
J. Negele, J.-C. Peng

Phases of QCD Matter

P. Jacobs, D. Kharzeev, B. Mueller,
J. Nagle, K. Rajagopal, S. Vigdor

Thomas Ullrich

on behalf of the *Phases of QCD*
organizers & White Paper authors

NSAC Meeting, March 8-9, 2007

Joint Town Meetings on QCD
Rutgers University, January 12-14

Parallel meetings:

- Phases of QCD Matter (~RHIC heavy ion community)
- QCD and Hadron Physics (~JLab and RHIC spin communities)

Joint session on middle day (Saturday):

- RHIC II and JLab 12 GeV upgrades
- International facilities: LHC, JParc, FAIR
- Electron-Ion Collider (EIC)

Joint discussions on EIC priorities at end of Saturday and noon Sunday

All talks posted at: http://www.physics.rutgers.edu/np/2007lrp-home.html

Phases of QCD: Background White Papers

Posted at: http://www.physics.rutgers.edu/np/2007lrp-home.html

- RHIC II
- Electron Ion Collider
- RHIC Theory Upgrade
- LHC:
  - ATLAS Heavy Ions
  - CMS Heavy Ions
  - ALICE-US
  - LHeC *(new proposal for electron ring in LHC tunnel)*
- Accelerator R&D

Phases of QCD: Recommendation #1

1. Our central goal is a dramatic advance in our understanding of QCD Matter, through quantitative comparison of theory and experiment to determine the properties of the strongly interacting Quark-Gluon Plasma discovered in the initial phase of RHIC operations, and through further exploration of the QCD phase diagram at non-zero baryon density where a critical point has been predicted. The essential requirements for the success of this scientific program are therefore our highest priorities:

- Effective utilization of the RHIC facility and completion of the ongoing detector upgrade program;
- The RHIC II luminosity upgrade, which will enable quantitative study of rare processes;
- Strong support for the ongoing theoretical studies of QCD matter, including finite temperature and finite baryon density lattice QCD studies and phenomenological modeling, and an increase of funding to support new initiatives enabled by experimental and theoretical breakthroughs.

Phases of QCD Recommendation #2: LHC

2. We strongly recommend significant and timely participation of U.S. groups in the LHC heavy ion program, which will study QCD matter at the highest energy densities and temperatures available in the laboratory. This program will test and extend the insights reached in the RHIC program, and has the potential to make important new discoveries about QCD Matter.

Phases of QCD Recommendation #3: EIC

Same EIC bullet will appear in "Phases of QCD Matter" and "Hadronic Physics" Summary White Papers

3. An Electron-Ion Collider (EIC) facility is the highest priority of the QCD community for new construction after the JLab 12 GeV and the RHIC II luminosity upgrades. EIC will address compelling physics questions essential for understanding the fundamental structure of matter:

- Precision imaging of sea-quarks and gluons to determine the full spin, flavor and spatial structure of the nucleon;
- Definitive study of the universal nature of strong gluon fields manifest in nuclei.

This goal requires that R&D resources be allocated for expeditious development of collider and experimental design.

Further recommendations

Still to be written:

4. Common theory bullet *(the bullet is common, not the theory)*

5. Education and Outreach

6. Accelerator R&D

Phases of QCD Matter: Summary of the Rutgers Long Range Plan Town Meeting, January 12-14, 2007 *version 1.2*

Peter Jacobs
Lawrence Berkeley National Laboratory

Dmitri Kharzeev
Brookhaven National Laboratory

Berndt Müller
Duke University

Jamie Nagle
University of Colorado

Krishna Rajagopal
MIT

Steve Vigdor
Indiana University

March 2, 2007

Contents

Common chapter with QCD and Hadron Physics White Paper

Hot QCD Outline for LRP

Members of Working Group:

T. Hallman, E. Hartouni, U. Heinz, B. Jacak[C], P. Jacobs[C], D. Kharzeev, R. Lacey[C*], B. Mueller[C], T. Roser, J. Symons, T. Ullrich[C], B. Wyslouch, G. Young, B. Zajc[[C]]

First draft of outline available ($\rightarrow$ next slide)

- Ongoing discussions …
- Major input/source: *Phases of QCD* White Paper

The Phases of QCD Matter
Exploring the Nature of Nuclear Matter at the Highest Energy Densities

1. Introduction

- The quest for new states of matter at the highest densities and temperatures
  Big picture question: "Are there new states of matter at the highest densities and temperatures?"
  (Question 7 of the Turner Report)
- Structure of QCD matter and QCD symmetries

2. The RHIC Era

- The phenomenal success of the experimental program
- Experimental discoveries
  "perfect" flow, baryon enhancement, jet quenching, hard probes of dense matter, etc.

1. **The Insights**
   - Kinetic and chemical freeze-out
   - The nearly perfect fluid (hydro, η/s)
   - Flow carried by valence quarks
   - Extreme color opaqueness
   - Initial indications for the color glass condensate
   - Response of the medium (Mach cones?)
2. **Theoretical Developments**
   - Advances in lattice gauge theory
   - From cold nuclei to hot plasma: color glass condensate and plasma instabilities
   - 3D dynamical simulations of HI collision (hydro, transport, …)
   - The strongly coupled plasma: insights from AdS/CFT correspondence
   - Scientific impact of our program beyond nuclear physics

1. The Opportunities

- RHIC II:
  a. Exploring the low energy frontier (search for the critical point)
  b. Rare probes (heavy flavor, γ-jets, quarkonia, correlations, etc.)
  c. Higher densities with U+U (flow, energy loss)
  d. Asymmetric collisions, extended phase space coverage, forward physics, etc.
- Heavy ions at the LHC
- Quantitative phenomenology: Integrating data analysis with a complete dynamical description of the collisions

2. The Needed Resources

- Facility operations and detector upgrades
- RHIC luminosity upgrade (RHIC-II)
- Increase support for theory, including new initiatives

+

Floating Pages (Introduction to Topics & Glossaries & Illustrations)