TECHQM
Charge to the Working Groups

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Why TECHQM?

- There has been much work on hard probes by individuals and small groups.
  How can TECHQM go beyond these achievements and why is this needed?

- **Hard problems are soft problems**
  and soft problems are hard problems.

  There is an obvious interplay between:
  - better controlling the uncertainties in modeling geometry and dynamics of the medium produced in A+A
  - better understanding the microscopic mechanism of jet quenching
  - better characterizing intrinsic properties of the medium

There is not a single group or individual with the ability to pursue *all* aspects of this interplay with the breadth and accuracy, which is motivated by data and feasible for theory.

… why TECHQM?…

- Why becoming quantitative?
  Because quantitative control is the standard means to separate conceptually different ideas (which all may reproduce qualitative features in the data).

- How to become quantitative?
  - model all aspects relevant for a measurement in a common framework and identify and quantify the uncertainties.
  - test different dynamical pictures in the same framework (e.g. compare all e-loss models in the same geometry)

- **A proper understanding in heavy ion collisions requires understanding the dependence on beam energy.**
  To do LHC physics without asking for consistency with RHIC is as pointless as to model RHIC physics without using constraints from LHC.

What is ‘hard’?

Single inclusives

‘Medium’

R_{AA}

PID-dependent

R_{AA}

PID-independent

Jet-like correlations, jets, …

- subleading fragments of hard partons
- waves, ridges, Mach cones?
- target recoils kicked to higher pt?

Trigger particle

Beyond single inclusives, the medium-modification of the jet and the jet-modification of the medium are two manifestations of the same dynamics. Modeling task is more than interfacing existing models of soft and hard physics, it is the prerequisite for studying the dynamical relations between soft and hard physics.

Open issues concerning R_{AA}

[On purpose, this list does not start with determining qhat. Starting with qhat would presuppose that "radiative e-loss" provides a complete understanding of the microscopic dynamics underlying jet quenching. The working group should delineate first to what extent this is the case.]

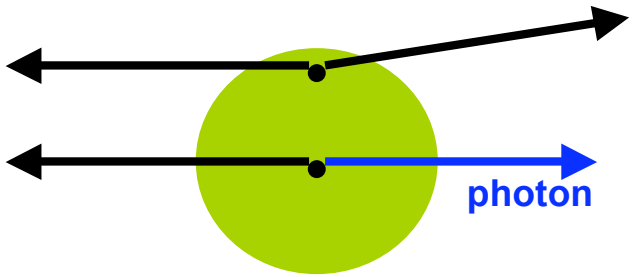
- What is the role of elastic vs. inelastic processes?
  To compare their strength, account for them in a common dynamic framework?

- How does RAA depend on mass and color charge of parent parton?
  If we quantify this question beyond specific models,
  - we have a tool to characterize microscopic mechanism (elastic vs. inelastic)
  - we have better numerical control of medium properties (such as qhat)
  - we underpin one case for future RHIC runs (separation of b- and c-)

…Open issues…

- What is the impact of geometrical and dynamical uncertainties in the dynamical modeling of the medium?

  For R_{AA}, there is some consensus about these uncertainties, but a decisive quantitative study is missing. However, e.g. for I_{AA}, the same quantitative question is likely to have qualitative implications:



Is I_{AA} dominated by back-to-back surface emission? If so, what are the prospects of photon-triggered back-to-back correlations?

- How do we understand quantitatively k_T-broadening of jet-like correlations?
  - There is a wealth of these measurements at RHIC, whose understanding is likely to require a detailed dynamical modeling of the collision and a dynamical understanding of trigger bias effects
  - Mach cones, ridges, …

Open issues concerning hydro

[On purpose, this list does not start with determining viscosity. Starting with viscosity would presuppose that hydrodynamics provides a complete understanding of the microscopic dynamics underlying bulk evolution. The working group should delineate first to what extent this is the case.]

- If different groups say 'hydro', are they solving the same set of equations with the same accuracy?
  [All collaborators should agree to a standardized set of tests.]

- What is the sensitivity of fluid dynamic simulations to initial conditions?
  - uncertainties w.r.t. geometrical profile, fluctuations
  - how can these uncertainties be constrained/quantified
    (My personal preference: vary initial conditions beyond what is reasonable to establish what is reasonable.)

- What is the sensitivity of fluid dynamic simulations to uncertainties/variations in the equation of state?
  - to what extent are dissipative processes a confounding factor for its determination?

Open issues concerning hydro

- Quantify difference between 2-dim and 3-dim simulations.

- What is the sensitivity of fluid dynamic simulations to the modeling of freeze-out?
  - can we quantify the role of a hadronic rescattering phase in terms of dissipation, duration, … ?
  - is there a physics range in which hadronic rescattering and dissipative hydro overlap in validity (would provide better basis for matching)

- Can we agree on standards of how to interface fluid dynamic simulations with hard processes?
  - this is not only a technical, but also a conceptual issue, since hydro specifies the density but not the nature of scattering partners.

- What is soft and not 'hydro'?
  (e.g. HBT? Hadrochemistry at intermediate pt?)
  Even if these issues lie beyond current abilities of quantitative dynamical modeling, we may be able to better delineate the physics underlying them.

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- There are many more open questions. We plan to compile an overview this afternoon in the two breakout sessions. Emphasis may be given to questions, which

  - are ripe for progress
  - require a TECHQM large-scale effort
  - improve our understanding of collective phenomena in and properties of hot QCD
  - have implications for future data taking

How to get TECHQM started?

- This workshop identifies amongst the many open issues those, which are ripe for progress and which require large scale collaboration.

- All those, who want to join the collaboration, state clearly what they plan contribute to its scientific program.

For instance: Urs Wiedemann
- v1.0 of a MC for final state parton shower
(main author Korinna Zapp)
- quenching weights, medium-modified fragmentation fcts
- simple models of medium-modified hadronization
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Main interest: - interfacing hard processes with realistic medium
- testing microscopic mechanisms underlying jet quenching

Today's Breakout Sessions

- The agenda of the breakout session this afternoon is

  - detailed discussion of open issues
  - drafting of short-term work plan

- Hard probes session will start with three 10-min discussions:

  Xin-Nian Wang: Open issues in hard probes
  Steffen Bass: Interfacing hard probes with 'soft physics'
  Brian Cole: Interfacing with experiments

- Soft physics session will start with slides from different groups who are not here but have specific ideas of how to get involved:

  - collaborators from Giessen (Cassing), Frankfurt (Rischke, Greiner, Xu), Warsaw (Broniowski, Chojnacki, Florkowski, Kisiel), Bielefeld (Borghini), McGill (Gale)
  - solicited contributions by: Kapusta, Lisa, Koch, Gavin, Gale