Day-1 Physics at RHIC

- nuclear matter at high temperature and density
- the great step offered by RHIC
- accelerator and experiments on Day-1
- what we may expect from the first year's program

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highly excited stongly interacting matter

- energy density > that inside a nucleon
  0.65 GeV/fm^3
  QCD -> quark deconfinement
  at ~ 2-3 GeV/fm^3
  QGP existed for first μsec after big bang

- create such matter, study phase transition

- symmetry breaking, origin of particle masses

- determine properties of hot, dense matter
  whether or not QGP is demonstrated
  at high T the qq (QGP vacuum) melts
  what happens?

use heavy ions to create large volume at high energy density - maximize lifetime and signals of new physics

cartoon of heavy ion collision

experimental observables

Characterize the conditions in the collision

- global observables
  - energy density: charged particles, Et
  - baryon density: proton rapidity distribution
- is system equilibrated?
  - thermal: hadron distributions
  - chemical: particle ratios
- high pressure -> fast expansion?
  - single hadron distributions
  - two particle correlations

search for evidence of new physics

- leptons, photons
  - decouple early, reflect early stage
  - rate, distribution reflect initial temperature
- enhanced production of s, c quarks
  - T_{init} near strange quark mass
    - measure kaons, lambdas
  - charm from gluon fusion
    - D meson decays
- QGP medium effects
  - suppression of bound c-cbar pairs
  - jet quenching
    - modified spectra of high pt hadrons
  - chiral symmetry restoration
- signals from hadronization transition
    - long lived mixed phase? (HBT)
    - droplets of QGP in hadron gas?
      - fluctuations in hadron number
- are there special events?
    - event-by-event analysis

what is known from AGS & SPS heavy ion studies

- conditions are nearly dense and/or hot enough already
  - energy density 1 - 3 GeV/fm^3
  - hadronic system at or near equilibrium
  - large expansion of dense hadronic system
- tantalizing hints of new physics
  - J/ψ suppression
  - strangeness enhancement
  - low mass lepton pair enhancement
    - chiral symmetry restoration?
- quark gluon plasma has yet to be discovered unambiguously

J/psi suppression

low mass lepton pairs

RHIC will answer the questions!

- reach ~ 10 times higher energy density
- systematics in ε, system size
- careful comparison to pp, pA collisions

RHIC in year-1

- start with Au + Au at s = 200 GeV
  - eventually 500 GeV for p+p collisions
  - also will collide polarized protons, p + A
- luminosity
  - 2×10^{26} /cm^{2}sec for Au + Au
    - year 1 will go from 1% to 10%
  - 10^{31} /cm^{2}sec for p+p, 10^{29} for p+A
- commission summer 1999
  - physics run begins October 1999
  - aim for 37 weeks operation
    - 50% machine studies, decreasing over the run
- event rate
  - Au + Au collision each 100 μsec (full L)
    - central Au + Au every millisecond
    - smaller on day-1; data rate still huge!
      - experiments write 10's of MB/sec

4 Experiments to cover all observables

- PHOBOS
  - hadrons at low p_t
  - DCC search on Day-1
  - full coverage multiplicity measurement
- BRAHMS
  - identified hadrons over wide y, p_t range
- PHENIX
  - leptons, photons and global quantities
  - sample hadrons to characterize collisions
  - high rate to study rare processes
- STAR
  - full azimuth acceptance for hadrons, jets
  - triple differential cross sections
  - event-by-event analysis
- zero degree calorimeter to provide common event selection

cross correlate signatures

STAR layout

STAR status

PHENIX layout

PHENIX status

BRAHMS layout

PHOBOS layout, status

Satoshi’s slide

conditions on Day-1

- RHIC will build luminosity 1% ->10%
- STAR will begin with
  TPC, 10% of EMCAL
  trigger hardware
- PHENIX will begin with
  MVD, 1 central arm, 1 muon arm
  triggers

- *ALL experiments will begin with minimal trigger selection*

Day-1 will already address mysteries & new signatures

- $dN_{ch}/d\eta$
  - parton cascades -> 2 or 3 times more charged particles than hadron cascades
- gluon dominated plasma?
  - $dN_{ch}/d\eta$ will give a hint
  - open charm via single high p_t leptons
    - e-μ coincidence to control background
- push p_t spectra to several GeV/c
  - jet quenching?
- J/ψ production vs. centrality
- of course, we characterize the collisions
  - hadronic observables vs centrality
- surprises surely await!

different model predictions from Flemming

Characterizing the collisions on Day-1

- multiplicity
  - all experiments
    - correlate with forward calorimeter
  - fluctuations in eta, phi?
- E_t
  - PHENIX
- hadron distributions, ratios
  - STAR, PHENIX, BRAHMS
    - 5-10K identified hadrons in ~ 1 week
    - BRAHMS to map over y, p_t to 1 GeV/c
      - program requires months
  - low p_t spectra by PHOBOS
- two-particle correlations
  - all experiments
    - focus on different y, particle ID
- survey centrality dependence; vary species?

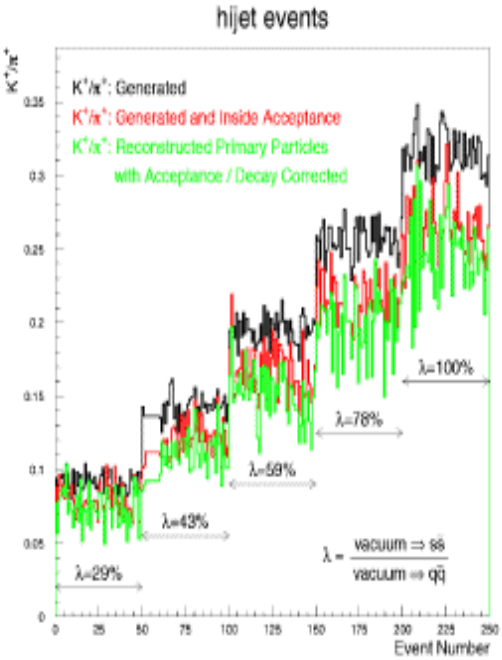
Quark-gluon plasma signatures on Day-1

- strangeness enhancement
  - STAR, PHENIX, PHOBOS, BRAHMS
    - distributions of K, Λ, ϕ
- J/ψ suppression
  - PHENIX
    - few K $J/\psi \rightarrow \mu^+\mu^-$ in central Au+Au
    - comparable to initial NA50 data
- jet quenching
  - PHENIX, STAR
    - good statistics $\pi^{0,charged}$ to 5 GeV/c
- ϕ mass, width
  - STAR, PHOBOS, PHENIX
    - decays to K+K- in year-1
- charm enhancement
  - PHENIX
    - ~100K electrons with p_t>1.5 GeV/c
- fluctuations in particle production
  - PHOBOS, BRAHMS, STAR, PHENIX

phi-> KK in PHENIX

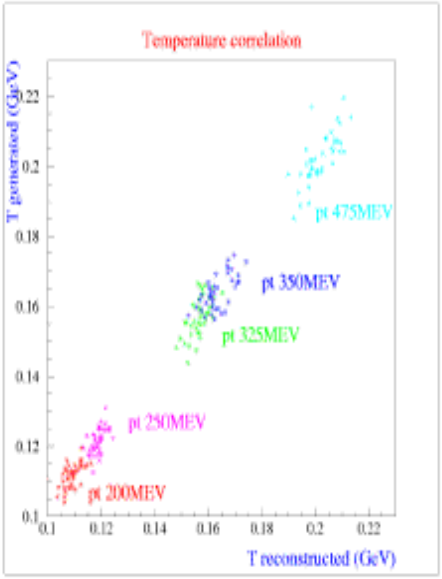
dimuons in PHENIX

Simulations: Physics Performance



FQ. Wang

Reconstructed K/π ratios



I. Sakrejda

Reconstructed slope parameters

Reconstructed physics signals: event by event

PHOBOS

- fully instrumented for Day-1
- high statistics spectra at low pt, HBT
- focus on global measurements
    - scan lighter species, pp, pA early
    - large statistics, rare processes for year-2
    - aim for minimal trigger bias

RHIC year-1 schedule