RHIC Five-Year Beam Use Proposal
The STAR Collaboration

September 2, 2003

Executive Summary

The multi-year beam use proposal presented in this report has been developed by the STAR Collaboration in response to a letter from the Associate Laboratory Director for High Energy and Nuclear Physics of Brookhaven National Laboratory, Dr. Thomas B. W. Kirk. In his letter of July 23, 2003 (Appendix 1), Dr. Kirk charged STAR with preparing a document to communicate its vision of a science driven beam use plan until 2008 under two scenarios: a 27 week constant effort scenario and an "optimum" 37 week scenario. The information contained in this document is intended to provide a snapshot of the status of the ongoing STAR scientific program, and to give a brief description of the expected progress up to 2008. A comprehensive discussion of the scientific goals of the STAR Collaboration during this period, as well as the upgrades needed to accomplish them may be found in the STAR Decadal Plan.

The first three runs at RHIC have allowed STAR to accumulate a wealth of data from p+p, d + Au, and Au + Au collisions on event-by-event observables, inclusive spectra for strange, non-strange, and charmed mesons, baryons, and resonances, and the spectra of leading hadrons from hard-scattered partons. These results have led quickly to the discovery of qualitatively new behavior, not previously observed, indicating the formation of a strongly interacting dissipative medium in central Au + Au collisions at RHIC. The primary goal of the STAR scientific program in Run IV will be to determine whether these results indicate a new phase of matter with bulk properties which are partonic has been discovered. Key questions that remain to be answered include whether the observed dissipation and collective behavior occur at the partonic stage, and whether a phase transition to a system which is deconfined and thermalized has taken place. To address measurements focused on these questions, assuming a 27 week scenario for Run IV, a period of 5 + 14 weeks of heavy ion running is requested. During this period, in addition to addressing the above questions STAR will also continue its seminal program of two-photon measurements in heavy ion interactions.

The first polarized proton runs at RHIC using beams of transversely polarized protons have led to important new results from STAR indicating a large analyzing power for the single spin asymmetry of neutral pions produced at large Feynman x and moderate p_t. In addition to first physics results, significant progress has been made in constructing and deploying the hardware and infrastructure needed for the present and future STAR spin physics program. To continue steady progress, improved machine performance for luminosity and polarization is essential. In a 27 week constant effort scenario, the STAR Collaboration proposes 5 weeks of dedicated spin physics machine development time in Run IV. Given sufficient improvement in machine performance (polarization 40-50% and luminosity ~ 1-2 pb^{-1}/week) during this five week period, the STAR Collaboration intends to strongly request an additional 3 weeks of physics data taking to take advantage of an important scientific opportunity: a significant measurement of the contribution of gluon polarization to the spin of the proton by studying A_{LL} for mid-rapidity jet production in collisions of longitudinally polarized protons.

The STAR heavy ion program envisioned up to 2008 requires an energy scan with Au beams as well further full energy Au+Au running and extended runs with different species. To carry out the STAR spin physics program during this period an increase of luminosity by a factor of approximately 20 (of order 10-20 pb^{-1}/week) over that presently achieved up to the RHIC enhanced design value will be required. A corresponding increase in polarization by a factor of 2 to ~ 70% will be required on the same timescale.

An important and clear conclusion that has resulted from this exercise is that a nominal annual running period of 27 weeks per year up to 2008 is not adequate to accomplish the heavy ion and spin physics goals of the STAR Collaboration on the timescale driven by the urgency of the science to be addressed.

1. Report on Data Acquisition in Run III (2002 - 2003)

The beam use request by STAR in the 2002-2003 run (Run III) was for 16 weeks of d +Au collisions at $\sqrt{s_{NN}}$ = 200 GeV and 8 weeks of polarized protons collisions with transverse and longitudinal polarization at $\sqrt{s}$ = 200 GeV. The specific luminosity targets were:

Minimum Bias Requirement	Lav _min > 1 μb^{-1}/ day, 70 days, 40% uptime; $\int$ Lmin > .033 nb^{-1} (delivered)
High p_t Trigger Requirement	$\int$ Lmin > 25 nb^{-1} (delivered)
Spin Physics Requirement	$\int$ Lmin > 3 pb^{-1} (delivered), P > 40%, Longitudinal $\int$ Lmin > 1 pb^{-1} (delivered) , P > 40%, Transverse

For d + Au running these luminosity targets were expected to yield 70M minimum bias events recorded and high p_t $h^{\pm}$ spectra out to 20-30 GeV/c by triggering on high p_t π°s and jets. The main scientific and technical goals for Run III were:

- Measurement of high p_t ("calibration") spectra and leading particle correlations in d + Au, and pp for comparison with AuAu; first results on shadowing and Cronin effect
- Measurement of comparison data for soft physics observables in d+Au
- Robust measurement of forward pi zero asymmetries in transverse p↑ + p↑
- First attempt to measure A_{LL} (ΔG) for mid-rapidity jet production in long. p↑ + p↑
- Commissioning of an EMC high p_t trigger
- Establishing the means to tune the STAR spin rotators for longitudinal polarization
- Engineering runs for the endcap electromagnetic calorimeter, the silicon strip detector, and the MRPC TOF Barrel Tray prototype

For d+Au running, the luminosity target set by STAR was substantially met. For polarized proton operation, there was a significant improvement in the value of the polarization over that achieved in Run II (the average polarization was increased to ~ 30%). The luminosity target set by STAR for polarized proton running in Run III was not achieved, although essential progress was nevertheless made and most of the goals of the STAR spin program for Run III were met. A question that is under study is the sensitivity to A_{LL} that was achieved with the integrated luminosity that was delivered. A significant factor in achieving several important spin physics goals was the extension of the running time by 2 weeks. Table I shows the data acquired by STAR during Run III (R = recorded; D = delivered).

Table I

Energy (GeV)	Trigger	System	Events or Integrated Lum Acquired	Goal
$\sqrt{s_{NN}}$ = 200	Min Bias	dAu	38.2M	70M
$\sqrt{s_{NN}}$ = 200	High p_T	dAu	2.6 nb^{-1}(R) 5.1 nb^{-1}(D)	25 nb^{-1} (D)
$\sqrt{s}$ = 200	Min Bias	pp	6 - 8 M	
$\sqrt{s}$ = 200	FPD^{+} (Trans. Pol)	pp	391 nb^{-1}; P ~ 35%	1000 nb^{-1}; P ~ 35%
$\sqrt{s}$ = 200	EMC, High Tower	pp	373 nb^{-1}; P ~ 35%	3000 nb^{-1}; P ~ 35%

With the above data set, all STAR scientific and technical goals for Run III were substantially met.

2. Report on Scientific Progress from Runs I – III

Heavy Ions

A major accomplishment in Run III, made possible by the reduced size of d+Au events, was analysis of the d+Au dataset in real time. Combined with the results from the analysis of AuAu data from Run I and Run II, the d+Au measurements have led to the discovery of qualitatively new behavior, not previously observed. The results indicate the creation of a dense, dissipative medium which is strongly interacting. Strong pressure gradients and collective behavior are evident in the early stage of the collision.

Comparison of inclusive yields of high p_t charged particles and the correlation of back-to-back leading charged hadrons has shown[1,2,3,4,5] (Figure 1) that inclusive high p_t particle production and "away side" leading hadrons are strongly suppressed in central Au+Au collisions relative to the yields in p+p, peripheral Au+Au, and central d+Au collisions. These studies show that the strong suppression (a factor of 5) observed in central Au+Au collisions is due to final state interactions in a dense, dissipative medium produced during the collision and not to the initial state wave function of the Au nucleus. The picture which emerges is that energetic partons traversing the medium produced in head-on Au+Au collisions lose sufficient energy that only those streaming outward from near the surface of the system produce observed jets.

Measurement of the elliptic flow, v_2 (the second fourier coefficient of the azimuthal anisotropy of the transverse momentum distribution), for a wide range of strange and non-strange mesons, baryons, and resonances[6,7,8] (Figure 2) has shown that the early stage of the collision is characterized by the buildup of large pressure gradients, and that the matter is strongly interacting and exhibits collective behavior during this stage. The behavior of v_2 as a function of p_t above ~ 2 GeV/c supports the conclusion that a dense, dissipative medium has been formed, the magnitude of the elliptic flow saturating (Figure 3) and staying constant out to transverse momenta (~ 6 GeV/c) where fragmentation from jets is expected to dominate.

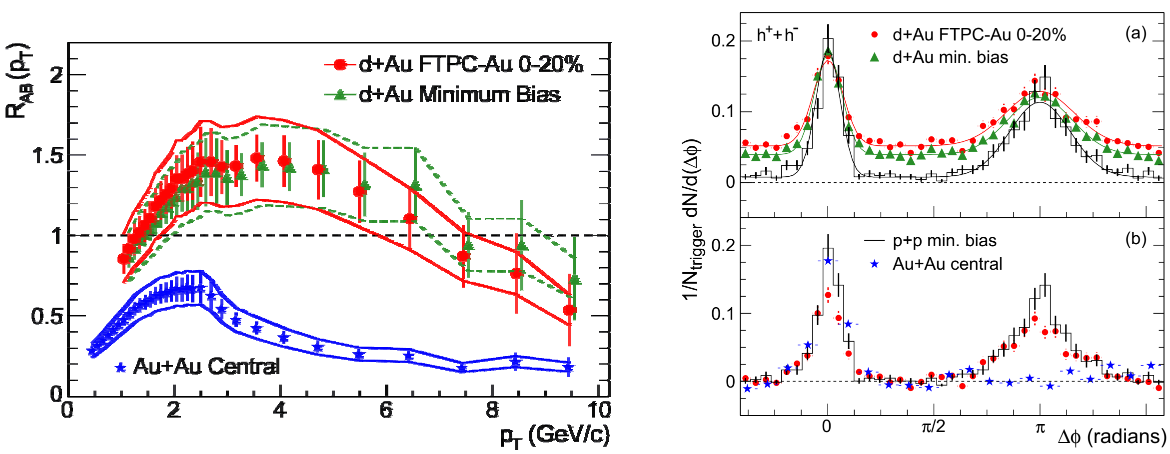


Figure 1. Left panel: Charged hadron nuclear modification factor for minimum bias and central d+Au collisions, and central Au+Au collisions. Minimum bias data are displaced 100 MeV/c to the right for clarity. There is a strong suppression (a factor or 5) of leading hadrons relative to the yields in p+p, peripheral Au+Au, and central d+Au collisions. Right panel: a) Efficiency corrected two-particle azimuthal distributions for minimum bias and central d+Au collisions and for pp collisions. The curves used to fit the data are explained in [1]. b) Comparison of two-particle azimuthal distributions for central d+Au collisions to those seen in p+p and Au+Au collisions. The respective pedestals have been subtracted.

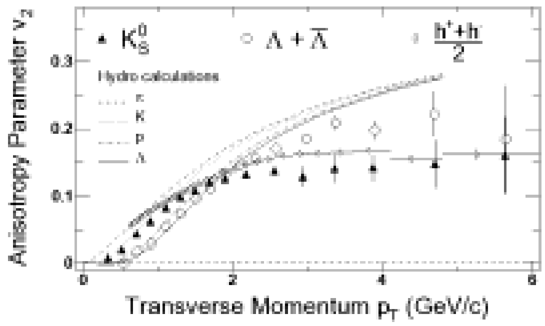


Figure 2. The minimum bias $v_2(p_T)$ for $K^0{}_S$, $\Lambda + \overline{\Lambda}$, and $h^{\pm}$. Error bars shown are statistical. Hydrodynamic calculations for pions, kaons, protons, and lambdas are discussed in [6].

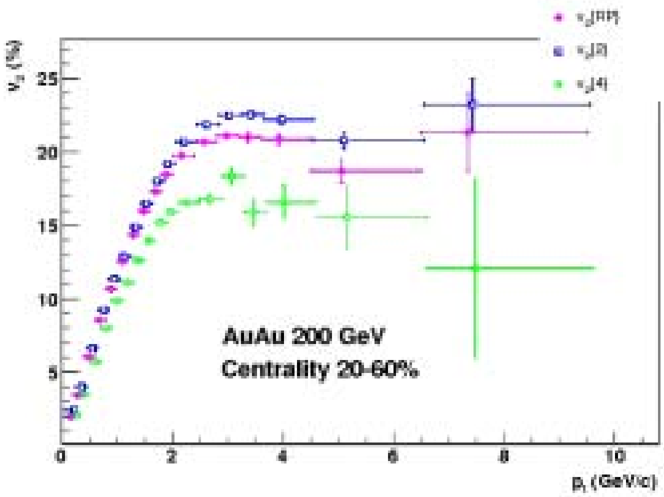
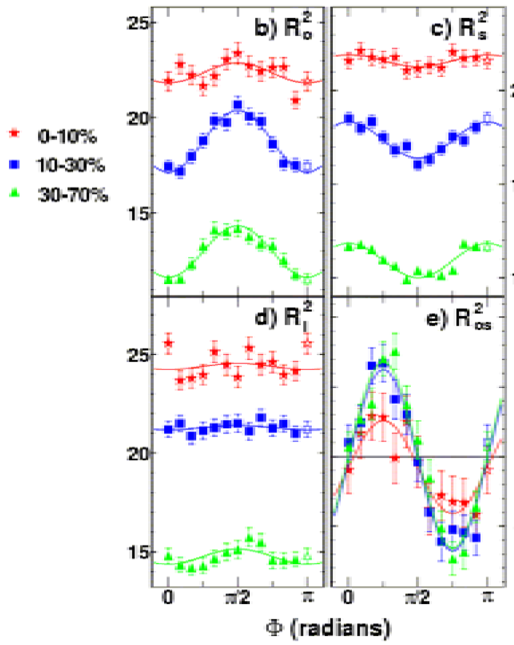


Figure 3. $v_2(p_T)$ of charged particles for AuAu collisions at $\sqrt{s_{NN}}$ = 200 GeV using the reaction plane method as well as 2 and 4 particle cumulant analyses. The results indicate that although there is some contribution from non-flow effects, significant elliptic flow persists out to the highest transverse momentum supported by the statistics of the data sample.

Further evidence supporting a picture in which the early stage of the collisions is characterized by the buildup of strong pressure gradients and collective behavior in an asymmetric region of overlap is provided by azimuthally sensitive Hanbury-Brown Twiss interferometry. The results show that second order oscillations typical of an out-of-plane extended source characterize azimuthal two-particle correlations observed in the final state[9] (Figure 4). The evolution of the overlap region is apparently sufficiently fast that the expansion of the system does not have time to quench the strong pressure gradients leading to elliptic flow. The mass dependence of particle spectra, combined with other HBT measurements show there is strong radial flow. The effect of radial flow appears to differ for multiply strange baryons (Ξ, Ω) compared to lighter particles (π, K, p)[10] possibly providing access to information on collectivity in the early partonic stage.

Extensive measurements of spectra for strange and non-strange mesons and baryons have shown that the intermediate p_t region (2-6 GeV/c)[6] (Figure 5) is complex, and that collision dynamics play a significant role in the transition from the soft to hard scattering regimes. Measurement of the complete spectrum of strange particles[11] as well as a broad range of short-lived hadronic resonances[12] (Figure 6) (many observed for the first time in relativistic heavy ion collisions) has provided the means for a detailed study of the late-stage chemical and thermal evolution of the system.



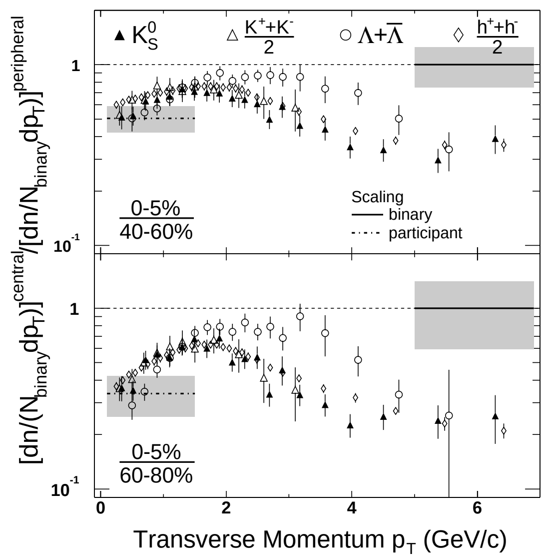


Figure 4. Azimuthally sensitive HBT radii as a function of centrality. Second-order oscillations are observed which indicate the source for particle emission is out-of-plane extended (from [9]).

Figure 5. R_{CP} for $K^o{}_s$, $K^{\pm}$, and $\Lambda + \bar{\Lambda}$ at mid-rapidity calculated using centrality intervals, 0–5% vs 40–60% (top) and 0–5% vs. 60–80% of the collisions cross section. Errors shown include Statistical and systematic errors. The width of the gray bands represent the uncertainties in the model calculations of N_{binary} and N_{part}. R_{CP} measured by STAR for $\sqrt{s_{NN}}$ = 200 GeV is also shown (from [6]).

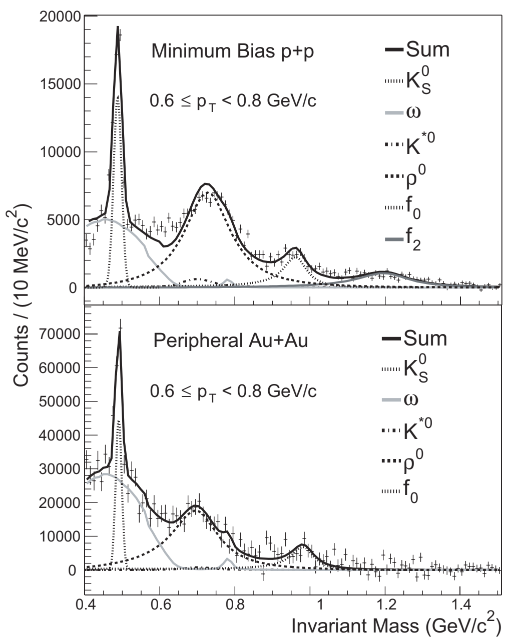


Figure 6. The raw $\pi^+\pi^-$ invariant mass distributions after subtraction of the like-sign reference distribution for minimum bias p+p (top) and peripheral Au+Au (bottom) interactions (from ref. [13]).

The first large-acceptance measurement of < p_t > fluctuations at RHIC by STAR[14] **(**Figure 7) has revealed intriguing deviations from a central limit theorem (CLT) statistical reference. A striking 17 ± 2% (stat+syst) *rms* excess of charge-independent fluctuations is observed in $\sqrt{n}(\langle p_T \rangle - \hat{p}_T)/\sigma_{p_T}$ (extrapolated to 100% of primary charged particles in the acceptance for the 15% most-central events). A possible interpretation being studied is that this effect may result from hierarchical p_t production —initial-state scattering followed by parton cascade— in the early stage of the collision.

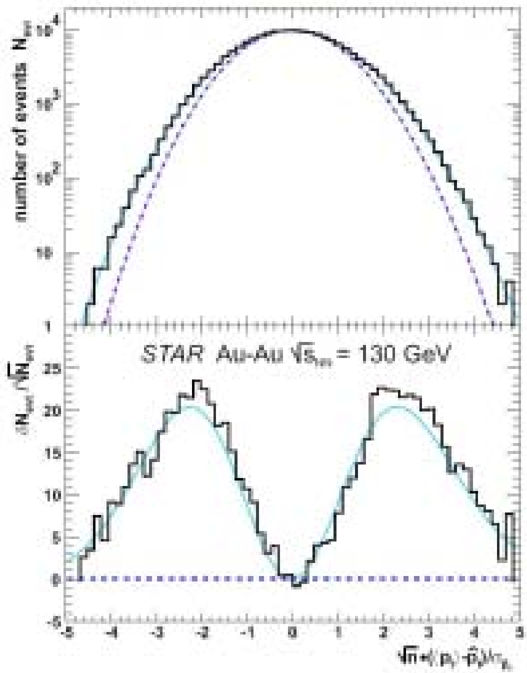


Figure 7 Upper panel: Event-number distribution on $\sqrt{n}(\langle p_T \rangle - \hat{p}_T)/\sigma_{p_T}$ for 80% of primary charged hadrons in |η| < 1 for 183k central events (histogram) compared to CLT gamma reference (dashed curve). Monte Carlo CLT reference (solid curve underlying gamma reference) and broadened gamma distribution (solid curve underlying data)[15]. Lower panel: difference in upper panel between data and gamma reference (histogram) or between broadened gamma and gamma reference (solid curve) divided by Poisson error.

These and other results from the initial survey performed by STAR have shown that the matter being produced exhibits features qualitatively different from those observed before in collisions of heavy nuclei. The following picture emerges.

The system is highly dynamic and the evolution is fast; characteristic features include:

- Transverse expansion with an average velocity of ~ 0.55 c
- A large degree of anisotropic flow (v_2) suggesting hydrodynamic expansion and high pressure at early times in the collision history
- The duration of hadronic particle emission appears to be very short
- Near side correlations show that the fragmentation properties of the observed jets are the same in p-p collisions and for all centralities of Au-Au collisions indicating that the fragmentation for these jets occurs in vacuum

The produced matter is opaque, exhibiting:

- Persistence of the saturation of v_2 at high p_T
- Suppression of high p_T particle yields relative to binary scaled p-p
- Suppression of away side leading particles from jets
- Large-scale correlations of net charge, total charge, and $< p_t >$

Statistical models describe the final state well as indicated by:

- Excellent fits to particle ratio data with equilibrium thermal models
- Excellent fits to flow data with hydrodynamic models that assume equilibrated Systems
- Chemical freeze-out at about 175 MeV; thermal freeze-out at about 100 MeV

Spin Physics

Although the STAR spin physics program is still in its infancy, the first polarized protons runs at RHIC have already yielded important new results. Specifically, the study of forward neutral pion production at large Feynman x and moderate p_t has indicated a large analyzing power for single spin asymmetries in collisions of transversely polarized protons (Figure 8). These exciting results suggest a strong sensitivity to aspects of the parton distributions tied to the transverse spin orientation of a proton. That covers transversity and the so-called Sivers effect, which is a preference for quark transverse momentum in a proton to be directed to one side or the other of the plane formed by the spin direction and the proton's momentum direction. In addition to first physics results, significant progress has been made in constructing and deploying the hardware and infrastructure needed for the present and future STAR spin physics program. Spin-sorted scalers have been implemented, beam-beam counters which serve as local polarimeters have been constructed and commissioned, and six of eight eventual lead glass hodoscopes (top and bottom, left and right on both ends of the STAR detector) have been installed. In Run III, an important accomplishment was the use of the beam-beam counters to commission the spin rotators on either side of the STAR intersection and demonstrate they could be tuned to provide longitudinal polarization at the STAR intersection. Progress in constructing the STAR Endcap Electromagnetic Calorimeter to provide essential kinematic coverage for the study of $\Delta G(x)$ is ongoing.

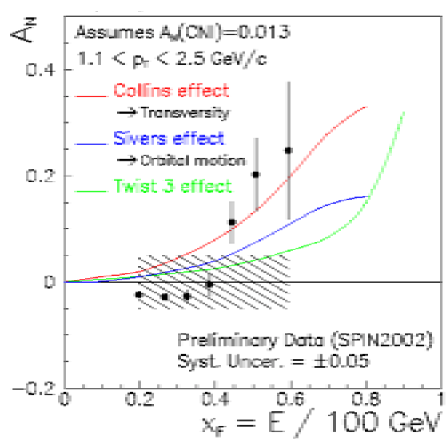


Figure 8. STAR results for the analyzing power for forward π^0 production at large pseudorapidity ($3.3 \leq \eta \leq 4.1$). The data are compared to several calculations including one based on the Collins effect, corresponding to a spin dependent fragmentation (red curve), on a twist-3 quark-gluon correlation responsible for the spin effect evaluated at p_T =1.5 GeV/c (green curve), and on the Sivers effect, where the spin effects arise from a correlation between the quark spin and its transverse momentum in the distribution function (blue curve) (from ref. [16]).

Other Important Scientific Measurements

Ultra-peripheral collisions studies in the first heavy ion runs at RHIC have demonstrated the possibility for carrying out a unique program to study coherent particle production (Figure 9).

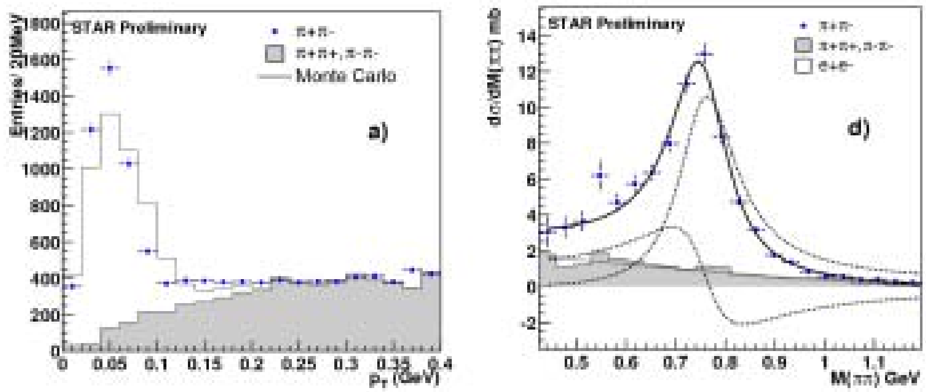


Figure 9. The p_T and π-π invariant mass spectrum of two-track events collected in 200 GeV Au-Au collisions with the minimum bias trigger, from coherent photoproduction of ρ^o and direct π-π pairs accompanied by mutual Coulomb excitation. The p_T spectrum is peaked below 100 MeV/c, as expected for a photon from the electromagnetic field of one nucleus scattering coherently from the other nucleus, emerging as a vector meson.

3. General Summary of Status and Outlook

The question of whether or not a new phase of matter is being produced with bulk properties which are partonic is yet to be answered. It remains to be shown that the dissipation and collective behavior occur at the partonic stage, that the system is deconfined and thermalized, and that a phase transition has occurred.

The primary goal of the STAR scientific program from 2004-2006 will be to answer these questions using the full capability of the existing STAR detector, including the baseline detectors (Time Projection Chamber, DAQ, Trigger, and Magnet), detectors funded through the Additional Experimental Equipment initiative (Barrel Electromagnetic Calorimeter and Silicon Vertex Tracker), and other essential detectors provided by additional major investments: the Endcap Electromagnetic Calorimeter (NSF), Forward Time Projection Chambers (MPI), Silicon Strip Detector (IN2P3), and Photon Multiplicity Detector (VECC). Prototype detectors for an eventual Time of Flight Barrel based on multi-gap resistive plate chamber technology will also be commissioned by scientists from the United States and China.

Using this suite of detectors STAR will complete its initial survey of soft physics observables (spectra, strangeness, event-by-event fluctuations and correlations, etc.) and extend its measurement of elliptic flow to the heaviest multiply strange baryons. Exploratory studies will be performed to establish the yields of open charm, charmonium, and bottomonium and to set the stage for future studies of possible charm quark thermalization and color screening of heavy quark bound states. In addition, the feasibility of using kinematic selection of the parton-parton center of mass for di-jet events and the measurement of high transverse momentum D mesons to isolate the jet fragmentation resulting from light quarks, gluons, and heavy quarks will be studied. These partons are expected to couple differently to dense partonic matter and observation of differential energy loss for these probes will provide important information on the nature of the medium that has been produced. A key requirement for making strong progress during this period will be increased insight and guidance from nuclear theory, particularly concerning the range of phenomena possible from hadronic scenarios.

Beginning during the second half of this decade, the STAR research program will turn to a broader and deeper exploration of the fundamental properties of matter created by heating the QCD vacuum, the accompanying phase transitions, and the extremely hot, superdense states that precede the formation of a thermal plasma of quarks and gluons. These studies will address e.g., the nature of chiral symmetry breaking and how is it related to the masses of the hadrons; the relationship between the deconfinement and chiral transitions; the nature of a possible saturated gluon state in strongly interacting particles. The new matter produced at RHIC will provide a unique laboratory for a full, detailed exploration of the fundamental properties of QCD. Extensive studies of proton-nucleus and polarized proton collisions will provide essential information on the initial conditions, and the role of spin as a fundamental component of QCD.

The STAR physics program during the high luminosity era will center on precision measurements e.g., of the dynamics of heavy flavor (charm and beauty) production as a means of studying the various stages of formation and hadronization of QCD matter, detailed measurements of observables related to hard-scattering of partons in the kinematic range where perturbative QCD calculations can be reliably carried out, use of electromagnetic probes (including direct photons) to study the formation and evolution of a deconfined state, and extended capability for the study of new effects related to the spin structure of the nucleon with the RHIC Spin program.

Studies key to fully characterizing the properties of the quark-gluon plasma, and the QCD vacuum will include:

- measurement of the gluon density of the plasma using direct-photon tagged jets
- measurement of flavor tagged jets to test perturbative QCD predictions of the quark mass dependence of partonic energy loss
- measurement of spectra and yields for the Upsilon family of states to place significant constraints on the temperature in the initial stage of the collisions
- detailed unfolding of large and small scale fluctuations and correlations for identified particles to map the dynamics and evolution of the produced matter
- studying partonic collectivity by measuring bulk physics properties (e.g. spectra, elliptic flow, particle ratios, non-identical particle correlations) for particles and resonances containing light, strange, and charmed quarks
- studying the effects of chiral symmetry restoration via leptonic decays of hadronic resonances in-medium
- direct photon spectra via gamma-gamma HBT to provide information on the temperature and lifetime of the early time partonic and later stage hadronic phases using a penetrating probe

Additional studies will focus on the search for new phenomena in bulk QCD matter such as strong CP violation which is expected to be associated with the deconfinement phase transition. Such studies require very large samples of unbiased data ($>10^8$ events).

A broad spectrum of world class spin physics studies will be carried out. The contribution to the proton spin from gluons will be determined using direct photon + jet, inclusive jets, and di-jet production at moderately high p_T (> 5 GeV/c). The flavor-dependence (ubar vs. dbar) of the sea quark polarization, and thereby the mechanism for producing the sea in a proton, will be probed using parity-violating W production and decay. Additional studies of the effects of quark mass terms in the QCD Lagrangian and of quark transverse spin preferences in a transversely polarized proton will be accomplished by measuring transverse spin asymmetries for b-quark jets, for pi-zeros from forward-going jets, and for quark-quark di-jets.

To accomplish this program the STAR detector requires significant upgrades. In the past several years, a number of workshops have been held to discuss the evolution of the detector necessary to carry out this program. These discussions have indicated that the physics goals of the high-luminosity STAR program will be most effectively achieved through evolutionary upgrades to the existing STAR detector, maintaining a strong physics program through the remainder of this decade with new components being phased in during the annual shut-downs. This approach will significantly extend the physics reach of STAR in order to take full advantage of the $4 \times L_0$ phase and will enable STAR to be fully capable of exploiting the full luminosity upgrade ($40 \times L_0$) when the machine improvements for the RHIC II program are completed.

These upgrades include:

- a full acceptance TOF barrel based on multi-gap resistive plate chamber technology to significantly extend the momentum range of STAR's particle identification capabilities
- a precision micro-vertex detector capable of directly observing charm and beauty decays
- a high rate data acquisition system and corresponding TPC front end electronics upgrades to allow maximal utilization of RHIC luminosity to study bulk physics properties of the produced matter
- a forward tracking upgrade to enable reliable charge sign determination for W decay
- a new, compact fast TPC incorporating GEM readout capable of robust operation in a high luminosity (40 x present performance) environment to provide the performance required for seminal direct-photon HBT measurements and high pt tagged jet studies.

Instrumenting the forward STAR acceptance with hadron calorimetry and roman pots to extend STAR's scientific reach for spin physics and diffractive physics measurements is also being considered.

4. RHIC Run IV (2003 - 2004)

4.1 Modifications to the STAR Detector Configuration for Run IV

For Run IV, there will be several modifications to the STAR detector setup designed to extend the physics reach of STAR in the next data taking period as well as in the future.

Another 25% of the Barrel Electromagnetic Calorimeter will be installed during the 2003 shutdown. Readout will be available for half of the newly installed modules, bringing the percentage of the full barrel EMC in operation in Run IV to ~ 60%. Further installation of the readout for the remaining modules which have been installed will be accomplished during the run if possible. Both 180º segments of the Endcap Electromagnetic Calorimeter have been installed, and by the end of the 2003 shutdown, all 12 30-degree sectors of active elements, including towers, SMD, preshower and postshower layers, and readout fibers will be ready. For Run IV, complete tower readout for 12 sectors and multi-anode PMT readout and state-of-the-art FEE for 5 sectors of Shower Maxium Detector, and preshower and postshower layers is anticipated.

The increased Barrel and Endcap Electromagnetic Calorimeter acceptance available for Run IV will significantly extend STAR's ability to detect and trigger upon high pt photons, π°s, and jets and to measure neutral energy from soft hadrons in heavy ion collisions.

The STAR photon multiplicity counter will be completed for Run IV. It is located on the east end of the STAR detector at a distance of ~ 550 cm from the interaction vertex. This highly segmented detector will use gaseous detection of electron showers from photons conversions (combined with a charged particle veto) to count the multiplicity of photons in the pseudo-rapidity range $2.3 < \eta < 3.5$. These data will be used to examine the multiplicity and spatial distribution of photons on an event-by-event basis in this acceptance to search for non-statistical fluctuations and possible Disoriented Chiral Condensate behavior on an event-by-event basis. Event shapes and flow in this kinematic region will also be explored.

STAR beam-beam counters, based on scintillator tile-fiber technology have been completed. These will be used in Run IV to provide effective triggering and vertex detection for pp, dAu, and AuAu collisions, as well as for local polarimetry in polarized proton collisions.

An upgraded, fully integrated Forward Pi Zero Detector constructed from eight lead glass arrays (top & bottom, left & right on both ends of the STAR detector) supplemented by scintillator shower maximum detectors will be completed. This detector will allow continued study of transverse spin asymmetries and will provide an additional means of establishing local polarimetry at the STAR intersection

Approximately half (10 ladders) of the STAR Silicon Strip Detector (SSD) will be installed to provide improved efficiency for secondary vertex detection and improved capability for the measurement of low momentum particles. A new tray of prototype Time Of Flight Detector modules based on multi-gap resistive plate chamber technology will be installed for testing and physics data taking.

4.2 Additional Factors Impacting STAR Beam Use in Run IV

There are several additional developments expected to impact the STAR data taking effort in Run IV. These include the commissioning of an upgraded DAQ capability (DAQ100), and a new STAR integrated tracking package, ITTF. The commissioning of high p_t and jet triggers using the STAR Barrel and Endcap Electromagnetic Calorimeters will also be continued.

The STAR DAQ100 development is designed to allow STAR to write out cluster information rather than raw data to tape. The expected gain from this development, if successful, is a significant increase in the rate at which events can be recorded (50 Hz min bias, 30 Hz central, and 50 Hz pp), as well as the speed at which they can be reconstructed. The DAQ100 software suite is ready and simulations to check the effect of its implementation on various physics observables are ongoing. During the 2003 shutdown, members of the STAR physics working groups have been charged with conducting a quality assurance exercise for STAR physics observables to insure the data taken with DAQ100 are robust before the use of DAQ100 is fully "signed off". Periodically during Run IV, runs will be taken writing out raw data (as in Runs I and II) to allow calibration and crosschecks.

Toward the end of calendar 2003, STAR will freeze its existing tracking code and begin a transition to a new integrated tracking package which has been under development for more than a year. The new code will utilize the information from all STAR detector and tracking systems. It will have improved memory management capability and will be supportable and maintainable. Some improvement in analysis speed may also be realized.

In addition, during Run IV STAR will utilize its Level I and Level II trigger abort (fast clear) capability, to incorporate higher level trigger algorithms focused on the measurement of charmonium and bottomonium (the Upsilon, and in peripheral collisions the J/ψ).

4.3 STAR Beam Use Request for Run IV (2003-2004)

Run IV: Study of Jet Quenching and High P_t Hadrons, Partonic Collectivity, Open Charm, Charmonium and Bottomomium; Possible Study of ∫ v_2 and High P_t Hadron Production at Lower Energy; Measurement of Forward π° Asymmetry; First measurement of ΔG

The STAR beam use request for a 27 week scenario in Run IV is shown in Table II:

Table II
27 Week Scenario

Beams	Au + Au	p p
Weeks	5 + 14	5*
$\sqrt{s_{NN}}$	200**	200

(** Based on performance, 2 weeks at $\sqrt{s_{NN}}$ = 63 GeV may be requested)
(* With adequate machine performance, 3 more weeks for physics data taking will be requested)

These beams will be used to provide data on soft and hard physics observables for AuAu collisions and to enable important improvements in machine performance for spin physics studies. If there is sufficient improvement in the performance of the machine for polarized protons, an additional 3 weeks will be requested for spin physics data taking.

The core goal for the heavy ion running will be to accumulate sufficient statistics with full energy AuAu running to achieve:

- 30 million central events useful for D meson spectra
- high pt triggered π° spectra out to 15 GeV/c
- > 50 million min bias events for omega v2
- of order 5-10k J/ψ and first measurement of the Upsilon in central collisions

Other goals which will also be achieved if the above are realized are:

- Sufficient statistics for detailed study of the centrality and p_t dependence of the Ω and Ξ as well as several strange resonances (Λ(1520), Σ*, and Ξ (1520)
- Extension of the p_t range for R_{cp} and v_2 studies of resonances as well as strange and rare particles.
- High statistics samples for event-by-event studies of fluctuations and correlations
- High statistics sample for non-identical particle correlations with respect to the reaction plane; π,K, Baryon HBT with respect to the reaction plane, non-identical hyperon HBT
- High statistics sample for extending UPC measures

The STAR Collaboration has set a challenge of reaching a new level of efficiency in data collection, taking every advantage of improved timing and analysis cuts, new startup procedures focused on optimal use of the beginning of stores, etc. Detailed real time analysis of a fraction of the data to accurately assess what is being collected will be carried out. If the necessary statistics to achieve the above goals can be accumulated quickly enough, STAR will make a strong request to reduce the beam energy to $\sqrt{s_{NN}}$ = 63 GeV for 2 weeks to study the dependence of the $\int v_2$ on $\sqrt{s_{NN}}$ and the influence of $< p_t >$. An attempt will also be made to study high p_t suppression (or lack thereof) and event-by-event measures for a collision system in which the hard scattering component has been significantly reduced.

Recent calculations[17] that fit the suppression of the high-p_T particle inclusive yields at 130 and 200 GeV underestimate the R_{AA} observed at the SPS by a factor of three (Figure 10). Thus, there is a possibility that the high-p_T suppression effect can be "turned off" in a controlled way through variation in collision energy. This would provide a clear signature for a fundamental change in the medium produced at RHIC relative to lower energies.

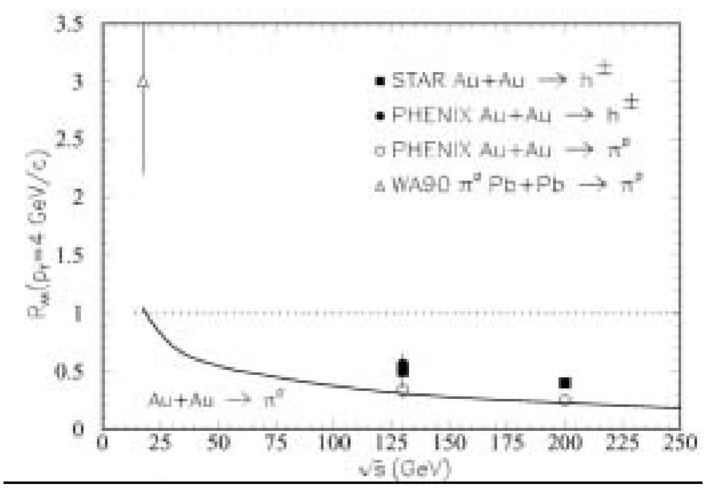
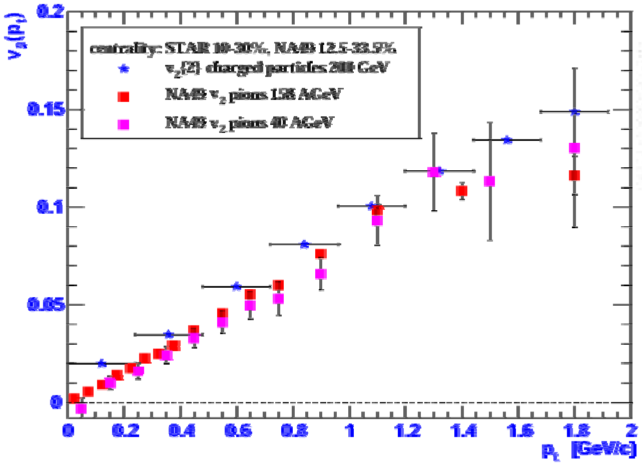


Figure 10. Theoretical calculation[18] of R_{AA} vs $\sqrt{s_{NN}}$

Another very important question concerns the interpretation of the physics underlying the observed magnitude of elliptic flow, one of the observables taken as a key indicator of strong pressure gradients and collective behavior in the early stage of the collision. An important question is the scaling of elliptic flow as a function of p_t (Figure 11): can it be verified that the increase in integrated v_2 with beam energy is simply an effect of the increase in $< p_t >$ with $\sqrt{s_{NN}}$ (Figure 12)?

As a first step to address such questions, if STAR's full energy goals can be completed quickly enough, a two week run at a center-of-mass energy of 63 GeV per nucleon pair is proposed. High quality charged-particle and π^0 inclusive spectra have been measured in p-p collisions at 63 GeV at the ISR and will serve as the reference spectra for computing the nuclear modification factor for Au-Au collisions measured at the same energy. Based on the previous performance for Au-Au collisions at 200 GeV and scaling the luminosity by γ^2, the average STAR collision rate at 63 GeV will be ~150 Hz. This rate is sufficient to saturate the DAQ bandwidth when recording minimum-bias events. Based on past experience and the DAQ100 upgrades that are underway at present, STAR should be able to record ~10M useful minimum-bias Au-Au events during two weeks of data taking if minimum-bias events saturate the available bandwidth. Based on the ISR measurements, such a dataset will be sufficient to measure the inclusive charged-particle yield to ~8 GeV/c in the 0-5% most central collisions and ~7 GeV/c in the 60-80% (peripheral) centrality bin. The p_T reach of flow and correlation studies will necessarily be lower.



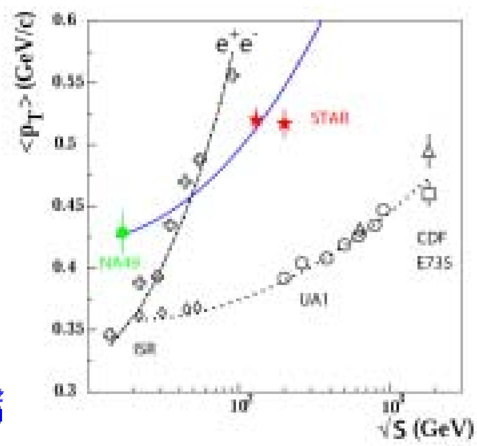


Figure 11 The scaling of elliptic flow as a function of p_t

Figure 12 $< p_t >$ vs $\sqrt{s_{NN}}$

STAR Spin Physics Goals for Run IV

RHIC Spin Commissioning: 5 weeks.

It is essential for the future of the STAR spin physics program that significant progress be made in Run IV toward improving machine performance and further commissioning of essential spin physics hardware and infrastructure. The STAR Collaboration requests that 5 weeks of dedicated spin physics machine development running be provided for this effort. The goals for this development time are to:

- commission a new working point for RHIC operation with polarized proton collisions at $\sqrt{s}$ = 200 GeV

- complete testing of NEG coated beam pipes to address vacuum breakdown problems in order to increase the proton beam intensity to 2×10^{11} per bunch.

- commission the polarized gas jet target.

- commission the RHIC AC dipole magnet to allow polarization reversal of stored RHIC beam.

Spin Physics Data Taking:

Assuming there is sufficient improvement in machine performance (polarization ~ 40-50%, luminosity ~ 1-2 pb^{-1}/week) the STAR Collaboration will strongly request an additional 3 weeks for physics data taking to address an important scientific opportunity: the accumulation of additional statistics for the measurement of A_{LL} for mid-rapidity jet production. This time will also be used to achieve several additional technical goals:

- operational tests of the new RHIC working point with longitudinally polarized proton beams in each ring

- completion of the first phase of the calibration of the beam polarization using the polarized gas jet target, achieving an accuracy $\Delta P_{beam} / P_{beam}$ ~ 10%.

-

With ~ 2 pb^{-1} of integrated luminosity and polarization > 35% the figure of merit (P_{beam}^4 $\int L\,dt$) for this data sample will be ten times larger than that obtained in Run III, increasing the sensitivity to gluon polarization and allowing for a significant first data point relating to an important scientific question of world-wide interest for more than a decade: the extent to which gluon polarization contributes to the spin of the proton.

The STAR beam use request for a 37 week scenario in Run IV is shown in Table III:

Table III
37 Week Scenario

Beams	Au + Au	p p
Weeks	5 + 19	10
$\sqrt{s_{NN}}$	200 (14), 20 (1), 63 (4)	200

In the event that there are 37 weeks of running, STAR proposes to carry out the full energy program discussed above, and make measurements at two additional energies. The first lower energy point would be at the RHIC injection energy to verify a number of soft physics measurements made at the SPS with the large, uniform acceptance provided by the STAR Detector. Although a one day period of running at RHIC injection has already been done, the statistics from that data sample are not sufficient to make firm conclusions. After that, a 4 week run at $\sqrt{s_{NN}}$ = 63 GeV proposed. At this energy the yield of jets and leading particles from hard-scattered partons remains measureable in a relatively short period of time and there is pp data at the ISR for comparison. These measurements would constitute the initial step in carrying out an excitation function to search for possible threshold behavior.

The additional time made available for polarized proton studies would be used to learn more about luminosity limitations in physics development mode. Based on C-AD projections, the data sample for the measurement of A_{LL} for mid-rapidity jet production should be 3 pb^{-1} in this case, representing a 20 times increase in figure of merit compared to Run III. It is expected that δA_{LL} ~ 0.01 for measured jet energies below 10 GeV. This precision will provide significant discovery potential for gluon polarization under many different scenarios. Additional polarization weighted integrated luminosity is ultimately desired to extend high precision A_{LL} measurements of jet production to higher p_t thereby sampling different admixtures of gg, qg and qq′ subprocesses and spanning a broader $x_{Bjorken}$ range for the initial-state partons.

5. Run V (2004-2005): Search for Possible Threshold Behavior; Study of Collisions System with Reduced Hard Scattering Component; Possible Species Comparison. Studies of Transverse Spin Effects and ΔG

The STAR beam use request for Run V in shown in Table IV:

Table IV
27 Week Scenario

Beams	AuAu or Fe-Fe	p↑ p↑
Weeks	5 + 9	5+5
$\sqrt{s_{NN}}$	20, 40, 63 or 200 (2) (3) (4) or (9)	200

- Possible scientific and technical goals:
  - Measurement of open charm and charmonium in lighter system
  - Measurement of high p_t comparison spectra
  - Measurement of elliptic flow for heavy baryons/mesons at lower $\sqrt{s_{NN}}$ or for lighter system
  - Measurement of fluctuation and correlations in system where hard-scattering component is reduced
  - Search for possible threshold behavior in soft and hard physics observables vs $\sqrt{s_{NN}}$
  - Continuation of soft physics program
  - Continued work on measurement of ΔG in $p\uparrow + p\uparrow$
  - Continued study of transverse spin effects

Heavy Ion Physics Goals for Run V

The proposed heavy ion running scenario for Run V depends on what is accomplished in Run IV and what is learned from a possible low energy data point in that run. If it is not possible to run at $\sqrt{s_{NN}}$ = 63 GeV in Run IV, STAR will strongly request a comprehensive energy scan in Run V to study possible threshold effects for high p_t particle suppression (at 63 GeV only), and the dependence of soft physics observable on $\sqrt{s_{NN}}$. The latter will likely be key to understanding the information these measurements provide concerning the bulk physics properties of the produced matter. If a lower energy point is possible in Run IV, an alternative which may be considered is to request a full energy run with a lighter system to obtain robust comparison data with a system having a smaller surface to volume ratio, and for which there is less uncertainty in determining $n_{participant}$.

The existing high-p_T inclusive suppression results indicate that R_{AA} goes smoothly from ~0.2 for the most central collisions to ~1 or above for peripheral collisions. First indications are that high-p_T observables are very similar in d-Au collisions as in peripheral (60-80% centrality) Au-Au collisions. Hence, reducing the number of participants in a collision may be a controlled means to turn the suppression off, complementary to measurements at reduced energy. However, the uncertainty in the Au-Au collision geometry increases substantially as the collisions become more peripheral, making a precise determination difficult. Also, the running time necessary to sample a large number of effective nucleon-nucleon collisions in peripheral Au-Au collisions is extremely long. These problems can be overcome through measurements of lighter systems. Ultimately, measurements will be required at 200 GeV with a series of species.

The various physical properties of the system that will be measured, such as the build-up of elliptic flow, the propagation and energy loss of hard scattered partons, the yield of strange particles, characteristics of the source(s) for particle emission, and the level of event-by-event fluctuations and correlations are all expected to depend strongly on system size and geometry. Varying the system size is best accomplished in a controlled manner by varying the beam species. The dependence of some observables may be essential for interpretation of the results from full energy AuAu interactions, and in principle it would be advantageous to have this information sooner. Practical concerns about the overhead in establishing a given running configuration, and the desire to address heavy flavor as soon as possible necessitate this measurement being deferred until Run V or Run VI

In the event a decision is taken to run with a lighter system as opposed to a comprehensive energy scan, for the first measurement in this sequence STAR proposes to study a symmetric system that is expected to demonstrate substantial high-p_T suppression, but with a much smaller effect than has been seen in central Au-Au collisions. This will provide a direct cross-calibration with Au-Au data. The STAR 200 GeV Au-Au results indicate that R_{AA}~0.5 at high p_T in the 30-40% centrality bin. The mean number of nucleon participants for this centrality is ~115, which is matched rather closely in central Fe-Fe collisions. Thus, a Fe-Fe run at $\sqrt{s_{NN}}$ = 200 GeV is proposed. STAR will investigate the same observables that have been already studied or which will be studied this coming year in Au-Au collisions – inclusive charged-hadron yields, inclusive π^0 production, near-side and back-to-back di-hadron correlations, elliptic flow. A total integrated luminosity of ~ 4 nb^{-1} will be required to achieve statistics comparable to the combined Run II and Run IV 200 GeV Au-Au data sets.

Additional pp comparison data will also be required. At present, STAR has < 0.5 pb^{-1} of EMC-triggered p-p events that include read-out of the TPC and FTPCs as reference data for comparison to measurements in more complex systems. This is not adequate to match the statistical precision expected from the heavy ion measurements and limits their physics reach significantly. For comparison, ~10 pb^{-1} of EMC-triggered p-p events would provide the same statistics that will be obtained during the long 200 GeV Au-Au run in Run IV. The existing d-Au data also lack the statistical reach that we will obtain with 200 μb^{-1} of Au-Au data or 4 nb^{-1} of Fe-Fe data, although they will serve temporarily until additional p-p data can be recorded. Run V will be the first run with completed Barrel and Endcap EMCs which will provide the capability to address the need for further pp comparison data. For this purpose STAR will seek to sample ~30 pb^{-1} using an EMC high-tower trigger.

In addition to high p_t studies, the full spectrum of soft physics measurements made for AuAu would be repeated for a lighter species to obtain comparison data essential to the interpretation of possible partonic collectivity, pressure gradients in the early stage of the collision, the extent to which the early stage of the collision is dominated by gluon-gluon interactions, etc.

STAR Spin Physics Goals for Run V

The spin physics goals in Run V are influenced by what is accomplished in Run IV. A primary goal of the STAR spin program overall is to determine the contribution to the proton spin from gluons. This will be measured using direct photon + jet, inclusive jets, and di-jet production at moderately high p_T (> 5 GeV/c). It is presumed this program will begin in Run IV with the measurement of A_{LL} for mid-rapidity jet production given adequate machine performance. In that case, the spin goals in Run V may focus more strongly on additional measurements with transverse polarization while dedicated luminosity development is ongoing as discussed below. In the event the above measurement of A_{LL} is not made in Run IV, this will need to be considered for priority in Run V. Additional key goals for Run V will be the following:

- commissioning colliding beam operations in RHIC with 70% beam polarization, made possible by use of the strong helical dipole snake in the AGS.
- commissioning RHIC for routine operation with 2×10^{11} protons per bunch for polarized proton collisions at $\sqrt{s}$ = 200 GeV.
- Completion of the calibration of the proton beam polarization at 100 GeV to achieve an accuracy of $\Delta P_{beam} / P_{beam}$ ~ 5%.

It is envisioned that dedicated luminosity development will be essential during this period so that STAR can begin measurements of A_{LL} for inclusive direct photon production at $\sqrt{s}$ = 200 GeV. This measurement will best map the nature of the gluon polarization, a primary RHIC spin physics goal. It requires luminosity which is of order 30 pb^{-1} per week. C-AD has commented that the efforts to increase the luminosity and optimize polarization need to be carried out as separate developments, so it is projected that the beam polarization may not be optimal during periods when luminosity is being developed. Given that the figure of merit depends on P_{beam}^2 for single-spin asymmetries (e.g., the analyzing power, A_N) and P_{beam}^4 for two-spin asymmetries (e.g., A_{LL}), this period is expected to be opportune for physics measurements with transverse polarization and for measurements which are dependent on the polarization of a single beam. These measurements are important for improving our understanding of the transversity structure function.

Measurements that may be carried out depending on machine performance include:

- measurements focused on understanding the dependence of the analyzing power for forward pion production on Feynman-x and p_t (separately).

- measurements to understand the degree to which the Collins effect contributes to the large analyzing power for forward neutral pion production by measurement of the forward jet accompanying the leading π°. If the spin asymmetries are strongly correlated with the Collins angle, then quantitative connections of these spin effects with the transversity structure function can result.

It may be possible to carry out the second measurement with the existing FTPC if sufficient tracking resolution can be achieved. Alternatively, this measurement may require the addition of forward hadron calorimetry to STAR to accurately measure the Collins angle (the angle between the plane defined by the leading particle momentum and the jet thrust axis and the plane perpendicular to the polarization vector). This question is under study.

A third possible measurement requires large integrated luminosity, and its realization depends on luminosity growth in Run V:

- measurement of transverse spin asymmetries for particle correlations in mid-rapidity jet production (Collins effect or interference fragmentation functions).

This running time will also be used to accumulate statistics for photon + jet coincidences, to develop analysis methods needed for production runs measuring A_{LL}. When the luminosity development succeeds in producing > 10 pb^{-1} week, and the beam polarization is optimized, further luminosity development would be continued with longitudinal beam polarization.

The STAR beam use request for Run a 37 week scenario in Run V in shown in Table V:

Table V
37 Week Scenario

Beams	AuAu and Fe-Fe	p↑ p↑
Weeks	5 + 17	5 + 7
$\sqrt{s_{NN}}$	20, 40, 63 and 200 (1) (1) (4) and (6)	200

In a 37 week scenario, STAR proposes to conduct both an energy scan and an extended measurement with a lighter species. This effectively speeds up the heavy ion scientific program by a year relative to what can be achieved in the 27 week scenario. The additional two weeks allocated to the spin physics program would provide the opportunity for further luminosity development. This would help insure that a long production run in the following year would result in a substantial integrated luminosity sample. Furthermore, STAR would use the additional time to collect a more useful initial sample of photon + jet data so that the analysis could be fully developed before the subsequent year's production run.

6. Run VI (2005-2006): Measurement of Gluon Structure Function in the Au Nucleus; First Production Run for $\Delta G(x)$ at $\sqrt{s}$ = 200 GeV

The STAR beam use request for Run VI in shown in Table VI:

Table VI
27 Week Scenario

Beams	d+Au	p↑ p↑
Weeks	5 + 9	5+5
$\sqrt{s_{NN}}$	200	200

Heavy Ion Physics Goals:

Gluon shadowing at low Bjorken *x* in heavy nuclei is an important and long-standing problem. In addition, the quark and gluon distributions within the Au nucleus are a critical input to calculations of high-p_T particle production at RHIC. Quark distributions in heavy nuclei are known to be quite different from those in the nucleon, and the same is likely true of the gluon distributions. STAR can measure the gluon distribution in the Au nucleus directly by observing the γ + jet final state characteristic of quark-gluon Compton scattering in d + Au reactions. This is the same reaction STAR will study for its ultimate determination of gluon polarization in the proton. Analysis of the existing d + Au data is underway to obtain a first look at the γ + jet final state, but the existing data are limited. The Barrel Electromagnetic Calorimeter (EMC) was only operational over the range $0< \eta <1$ during the recent d + Au run, and the preshower read-out, which is important for γ-π^0 discrimination, was not active. Once the full BEMC and Endcap Electromagtnetic Calorimeter (EEMC) are completed, STAR will be able to measure the gluon density in the Au nucleus with statistical accuracy better than 3% for $x_{BJ} > 0.03$ by comparing the γ + jet yield in a 200 nb^{-1} d +Au data sample to the corresponding yield in p+p collisions. The data will also be self-normalizing through comparisons between yields when the photon and jet both appear at positive η, sensitive primarily to the quark distribution in the deuteron and the gluon distribution in Au, and when the photon and jet both appear at negative η, sensitive primarily to the quark distribution in Au and the gluon distribution in the deuteron. STAR has also demonstrated the ability to measure small cross section differences for different centralities in d-Au collisions. Thus, this measurement will provide the first detailed information about the centrality dependence of the nuclear gluon modifications.

In the absence of guidance regarding the d-Au luminosity that might be expected in FY2006, it is unclear how much beam time this study will require. It is possible depending on machine performance this measurement may need to be done over several running periods. It would be extremely interesting to compare the d-Au results to a study of a lighter asymmetric system, such as d-C or d-Cu, in order to map out the nuclear dependence of the gluon distributions. However, large integrated luminosities are needed for both systems to make significant comparisons.

Spin Physics Goals:

Run VI will be the first run, in principle, when all the spin physics hardware and infrastructure for STAR, C-AD, and the AGS that is needed for a robust measurement of of A_{LL} ($\Delta G(x)$ using γ+jet final states (QCD Compton diagram)) in p↑ + p↑ at $\sqrt{s}$ = 200 GeV will be fully implemented and commissioned. By this time the warm bore helical dipole and strong snake will be operating in the AGS, the polarized gas-jet will be calibrated to achieve an accuracy of $\Delta P_{beam} / P_{beam}$ ~ 5%, and the STAR barrel and endcap electromagnetic calorimeters will have been completed. Triggers capable of selecting inclusive jets, dijets, and leading π°s will have been commissioned and fully implemented. Therefore, STAR proposes to give high priority in Run VI to a robust measurement of ΔG, a study which has been of world-wide interest for more than a decade, and which has the potential to elucidate the parton dynamics within the proton

A key factor determining whether a production run measurement for $\Delta G(x)$ can be successfully carried out in Run VI will be whether the machine performance has improved sufficiently. To carry out the STAR spin physics program during this period an increase of luminosity by a factor of approximately 20 (of order 10-20 pb^{-1}/week) over that presently achieved up to the RHIC enhanced design value will be required. A corresponding increase in polarization by a factor of 2 to ~ 70% will be required on the same timescale. Considering that these goals may be challenging between now and Run VI, STAR has adopted a conservative approach to carry this measurement out in Run VI and Run VII.

The STAR beam use request for Run VI in a 37 week scenario is shown in Table VII:

Table VII
37 Week Scenario

Beams	d+Au	Fe-Fe	p↑ p↑
Weeks	5 + 8	5 + 4	5+7
$\sqrt{s_{NN}}$	200	200	200

or

Table VII
37 Week Scenario

Beams	d+Au	p↑ p↑
Weeks	5 + 12	5+12
$\sqrt{s_{NN}}$	200	200

In this scenario, if an extended run with a lighter system has not already been done, STAR proposes to split the heavy ion time between an initial measurement of the gluon distribution in the Au nucleus and obtaining comparison data with a lighter system for the reasons discussed above. Some incremental time would also be allocated to the measurement of A_{LL} to improve the precision of this measurement and help insure the likelihood of a robust first production measurement. In the event a lighter species has been run during Run V, the time additional time would be split between the heavy ion and spin measurements to improve the robustness of both data samples.

7. Run VII (2006-2007): First results with MRPC Barrel TOF; Charmed Quark Studies; Studies of Resonances and Rare Particles; Measurement of $\Delta G(x)$ at $\sqrt{s}$ = 200 GeV

The STAR beam use request for Run VII in shown in Table VIII:

Table VIII
27 Week Scenario

Beams	Au+Au	p↑ p↑
Weeks	5 + 5	5+9
$\sqrt{s_{NN}}$	200	200

In Run VII it is anticipated that a significant portion of the STAR Barrel TOF detector will have been installed and commissioned. In that event STAR proposes in a 27 week scenario to have a short AuAu run at full energy to utilize the new capability of this detector for improved signal to noise and extended p_t range in the measurement of strange and non-strange resonances and rare particles as well as particles containing a charm quark. This study will provide significantly greater discrimination power in distinguishing between various models of particle production and will allow STAR to measure the ratio of various open charm states in order to study possible charm quark thermalization. The primary focus of this run will be to complete the production run measurement for $\Delta G(x)$ (A_{LL} using γ+jet final states) at $\sqrt{s}$ = 200 GeV.

The STAR beam use request for Run VII in a 37 week scenario is shown in Table IX:

Table IX
37 Week Scenario

Beams	Au+Au	Ca-Ca	p↑ p↑
Weeks	5 + 8	5 + 4	5+10
$\sqrt{s_{NN}}$	200	200	200

In a 37 week scenario for Run VII, STAR proposes to use the additional time primarily to measure comparison data for a very light system to complete a comprehensive species and energy scan prior to beginning a strong focus in RHIC II measurements.

8. Run VIII (2007-2008): First results with MRPC Barrel TOF and Microvertex Detector; Direct Photon and Flavor Tagged Jet Studies; Yields and Spectra for Particles Containing Charm and Bottom Quarks. Measurement of $\Delta G(x)$ at $\sqrt{s}$ = 500 GeV

The STAR beam use request for Run VIII in shown in Table X:

Table X
27 Week Scenario

Beams	Au+Au	p↑ p↑
Weeks	5 + 10	5+5
$\sqrt{s_{NN}}$	200	500

In Run VIII it is anticipated that STAR will propose a long full energy AuAu run to take full advantage of new capability provided by the Barrel MRPC TOF detector and a new active pixel sensor microvertex detector, as well as corresponding upgrades to the DAQ and TPC Front End Electronics. During this run, STAR will begin a number of studies made possible in the 4 x luminosity era by the extended physics reach provided by upgrades. Primary goals will be:

- measurement of the gluon density of the plasma using direct-photon tagged jets
- measurement of flavor tagged jets to test perturbative QCD predictions of the quark mass dependence of partonic energy loss
- measurement of spectra and yields for the Upsilon family of states to place significant constraints on the temperature in the initial stage of the collisions
- detailed unfolding of large and small scale fluctuations and correlations for identified particles to map the dynamics and evolution of the produced matter
- studying partonic collectivity by measuring bulk physics properties (e.g. spectra, elliptic flow, particle ratios, non-identical particle correlations) for particles and resonances containing light, strange, and charmed quarks
- studying the effects of chiral symmetry restoration via leptonic decays of hadronic resonances in-medium

Some of these measurements (e.g. direct photon and flavor tagged jets) require an additional increase in the AuAu luminosity by a factor of 10. This is expected to be accomplished sometime near the end of the decade with electron cooling of the heavy ion beams. Although these measurements can not be fully addressed without the upgraded RHIC luminosity, initial studies will be carried out in the 4 x luminosity era to establish the analysis methods and obtain initial yields, etc.

In a 27 week scenario, a short spin physics run at $\sqrt{s}$ = 500 GeV is also proposed to extend the lower bound of the x_{BJ} range measured (the gluon distribution increase rapidly as x_{BJ} decreases), and to allow a first measurement of the polarization of sea anti-quarks using parity violating W decay. This timescale is thought to be roughly consistent with that expected for a forward tracking upgrade required to improve STAR's capability for W charge sign determination.

The STAR beam use request for Run VIII in a 37 week scenario is shown in Table XI:

Table XI
37 Week Scenario

Beams	Au+Au	p↑ p↑
Weeks	5 + 14	5+10
$\sqrt{s_{NN}}$	200	500

In a 37 week scenario for Run VIII, STAR proposes to use the majority of the additional time to allow for a robust spin physics measurement at $\sqrt{s}$ = 500 GeV having the same goals as above. A long full energy AuAu would also be carried out.

9. Summary of Propose Scenarios

A summary of the configurations propose up to 2008 is provided in Table XII.

STAR BUP Summary

Table XII

Run/Weeks	Mode 1/Weeks	Mode 2/Weeks	Mode 3/weeks	Mode 4/weeks	Mode 5/ Weeks
Run IV, 27	AuAu @ 200, 5+14	p+p @ 200, 5			
Run IV, 37	AuAu @ 200, 5+14	AuAu @ 20, 1	AuAu @ 63, 4	p+p @ 200, 5+5	
Run V, 27	AuAu @ 20, 2	AuAu @ 40, 3	AuAu @ 63, 5 + 4	p+p @ 200, 5+5	or
Run V, 27	Fe-Fe @ 200, 5+9	p+p @ 200, 5+5			
Run V, 37	AuAu @ 63, 5+4	AuAu @ 20, 1	AuAu @ 40, 1	Fe-Fe @ 200, 5+6	p+p @ 200, 5+7
Run VI, 27	d+Au @ 200, 5+9	p+p@200, 5+5			
Run VI, 37	d+Au @ 200, 5+8	Fe-Fe@200,5+4	p+p@200, 5+7	or	
Run VI, 37	d+Au@ 200, 5+12	p+p@200, 5+12			
Run VII, 27	AuAu@200, 5+5	p+p@200, 5+9			
Run VII, 37	AuAu@200, 5+8	CaCa@200,5+4	p+p@200, 5+10		
Run VIII, 27	AuAu@200, 5+10	p+p@500, 5+5			
Run VIII,37	AuAu@200, 5+14	p+p@500, 5+10			

10. Collaboration Readiness

The STAR Operations Group, as well as the STAR Collaboration membership have been participating in an extensive program of shut-down activities in preparation for Run IV. STAR will be fully prepared to begin the program outlined for Run IV.

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