RHIC Polarized Jet Target Review
November 18-19, 2002
BNL Collider Center (Bldng. 1005), 3rd Fl. Conf. Room

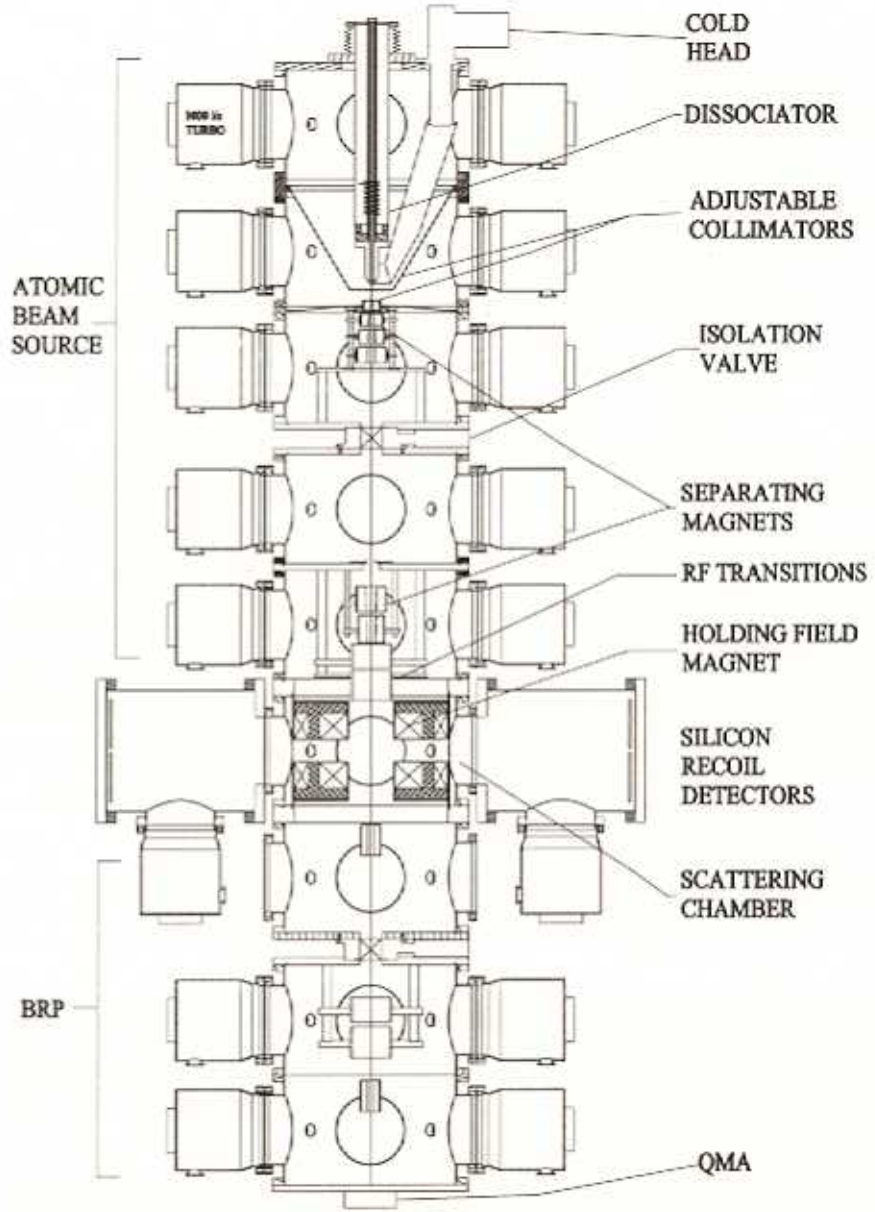
Monday November 18, 2002

08:30	Executive session	
09:00	Status of RHIC as a polarized proton collider	Thomas Roser, BNL
09:20	The Jet Target: status and plans: Response to the Review charge	Yousef Makdisi, BNL
09:50	Jet design considerations: The concept, intensity, resonances	Tom Wise, Wisconsin
10:50	Break	
11:05	The holding field magnet: Design, and fabrication plans	George Mahler, BNL
11:35	Impact on RHIC: target chamber, vacuum, RF impedance	Anatoli Zelenski, BNL
12:05	Working Lunch	
13:30	Mechanical Assemblies and Installation at 12 o'clock	John Ritter, BNL
14:00	Beam Polarization measurement with recoil arms: physics, detectors, simulations stats, syst. etc.	Alessandro Bravar, BNL
15:00	The DAQ and WFD systems	Dmitry Svirida, ITEP
15:30	Break	
15:45	Target polarization measurement: BRP stage and systematics	Tom Wise, Wisconsin
16:30	Combined measurements beam and target	Ed Stephenson, IUCF
17:00	The P-Carbon CNI polarimeters and sytemetics	Gerry Bunce, BNL
17:30	Summary and discussion	Makdisi/Bunce
18:00	Committee Executive session	
19:30	Committee Dinner (Y. Makdisi, host)	

Tuesday November 19, 2002

08:30	RHIC tour (meet at 1005)
10:00	Additional presentations if necessary
11:00	Preparing draft reports
12:00	Working Lunch
13:00	Closeout with the collaboration

Makdisi (Timeline) Resources
Bunce (Collaborative nature of Polarimetry @ AGS/RHIC


COLD HEAD
DISSOCIATOR
ADJUSTABLE COLLIMATORS
ATOMIC BEAM SOURCE
ISOLATION VALVE
SEPARATING MAGNETS
RF TRANSITIONS
HOLDING FIELD MAGNET
SILICON RECOIL DETECTORS
SCATTERING CHAMBER
BRP
QMA

The RHIC Polarized Jet Target Review

Brookhaven National Lab
November 18-19, 2002

Final Draft —— Final Draft —— Final Draft

The RHIC spin physics program has been from the beginning a unique opportunity and an important component of the overall RHIC physics program. Essential to this spin physics program are the polarized proton beams which enable the studies of spin physics phenomena in high energy collisions. The technical challenges to be faced to realize this program include the production and acceleration of the polarized beams, manipulation of the spin direction at the interaction points, and the accurate measurement of the beam polarization and related asymmetries. This review is focused on the RHIC Polarized Jet Target, which is the system chosen to provide absolute polarimetry for RHIC proton beams.

Thomas Ludlam convened the Review Panel on November 18-19, 2002 to review the status of the RHIC Polarized Jet Target project. The charge given to the Panel asked us to assess:

1) The design criteria and technical issues associated with the development of the polarized hydrogen jet target. This is to include progress attained so far, engineering design and integration, installation plans, impact on the RHIC luminosity performance, schedules and cost estimates.

2) The proposed plan to measure the polarization of the atomic hydrogen jet and the circulating proton beam as well as the expected backgrounds and the resulting systematic errors. Is the goal of a 5% absolute proton beam calibration at a beam energy of 100 to 250 GeV feasible, and is this sufficient to carry out the proposed physics program?

The Committee was chaired by Charles Prescott (SLAC), with the following panel members: Thomas Clegg (North Carolina/TUNL), Dieter Eversheim (Bonn), David Lynn (BNL), Hans-Otto Meyer (IUCF), and Hal Spinka (Argonne). The schedule of talks presented to the Panel is appended to this report.

SUMMARY AND RESPONSE TO CHARGES

For the Review Panel, this meeting was the first opportunity to see the plans for the Polarized Jet Target Project. It also offered the Panel a chance to see the status of the RHIC program and to meet and talk to the collaboration members involved in this program. In the past 20 years, polarized targets have been implemented at a number of facilities around the world. Brookhaven has considerable experience with the technologies involved and with other types of polarimeters,

and with the help of experienced collaborators from outside institutions, has pulled together an optimal design for a RHIC polarimeter.

With regard to the first part of the Charge, serious work on building the systems started in early 2002. Design of the many components of the target required first optimizing the specific geometry, positioning, and sizes of the internal components. Magnetic fields and field elements were also optimized for the RHIC requirements. This work was largely done at Wisconsin. Although this work held up making design choices, the result looks very promising (in simulation) for significantly increasing the atomic beam density over that obtained in previous similar targets. RHIC polarimetry will benefit considerably if these gains are realized.

On the other hand, construction has been slow to get started. At the request of the Panel, an updated schedule was generated on the evening of the first day and provided the next morning for discussion. The schedule shows work on the numerous components going on in parallel. Many components must be scheduled for fabrication and delivery in the next several months. This work needs close watching to assure meeting the stated goal of commissioning beginning in May 2003 and installation in RHIC for a dry run in November 2003. Strong management oversight is required.

The main recommendation is therefore:

Identify a full-time Polarized Jet Target Manager to start immediately and carry the project through to initial operation.

Regarding costs, the Panel was shown a list of technical components and estimates of their costs. Without more detailed information, we were not able to assess the accuracy of these estimates. The contingency is set at 19%, which appears to the Panel to be low. This part of the cost probably should be raised. The understanding of the costs and the budget should be an early task of the project manager. The usual approach to a cost review would be to look at the Work Breakdown Structure, in which the major systems are broken down into the lower levels of detail. Cost contingency is assigned to each subsystem component according to its status in the design phase, procurement phase, etc.

A second recommendation is therefore:

The RHIC management should call for future reviews of the Polarized Jet Target Project, at 6 months and 12 months from now. These reviews should be primarily focused on cost, schedule and progress toward the timely completion of construction and the commissioning of the project.

With regard to the second part of the Charge, the physics goals establish the required level of accuracy and precision needed in the spin physics program. There have been many studies of spin physics with polarized protons. Over the past ten years and more, the understanding of the spin structure of a polarized proton has been evolving. Scattering of leptons (electrons or muons) at high energies have revealed the spin content contributed by the quarks to be considerably smaller than at first expected. The role of the gluon in the proton spin structure naturally comes into question, and RHIC can directly study this topic. Present information from lepton scattering is limited because charged leptons do not scatter from the (uncharged) gluons, and only through structure function evolution with Q^2 do we see hints of large gluon contributions to the spin. Errors are 50-100% on these "hints". The spin structure community has been waiting for the commissioning of RHIC to gain further understanding of this puzzle. Measurements at the 10% level or better are both desired and possible. To reach this goal, the absolute beam polarization must be known to $\approx 5\%$.

Large asymmetries from transversely polarized beams on unpolarized targets have long been known to exist, based on Fermilab data (E704). Recent theoretical and experimental interest in these unexplained phenomena has increased considerably. Accurate measurements, at the 10% level, using polarized RHIC beams would raise considerable attention and would stimulate further theoretical work to understand the asymmetries. To carry out such studies, accurate and reliable polarimetry is required. At this time, RHIC features two efficient polarimeters based in small-angle p-carbon scattering ("pC CNI polarimeters"). Since their analyzing power is based on a theoretical estimate only, an *absolute* calibration is needed.

The Polarized Jet Target system has been designed to meet this goal. Based on the experience from recent systems of similar design, the parameters have been thoroughly studied and optimized. The atomic beam source intensity appears in simulation studies to exceed previous designs by a factor of ≈ 4, while meeting the requirements for beamline operation at RHIC. Accuracy at the 5-6% level appears feasible and would be sufficient for the physics program to achieve its goals. The target specialists felt this level of accuracy would not be achieved in the first year of operation, but with experience and tuning, should be reached quickly thereafter.

Because polarimeters are so important to the spin physics program, and because effective coordination of the RHIC polarimeters with the experimental groups is crucial, a liaison person will be needed by the time commissioning is underway.

A third recommendation is therefore:

A full time BNL staff physicist should be identified who will be responsible for hardware, operations, and data analysis of all the

RHIC polarimeters, and for liaison to the experimental groups.

Discussion and Comments

Management and Project Organization

The declared goal of the RHIC Polarized Jet collaboration is that a physically complete jet system exist and be ready to support the experimental program by the end of FY 2004. Their interim goal is that Polarized Jet hardware be complete and installed in the 12 o'clock IR by no later than November 2003 for an early systems test in the RHIC ring.

A PERT chart covering January 2002 to December 2003 has been distributed. This chart was drawn up on short notice at the request of the Panel. The list shows both jobs that were completed during 2002, as well as the future job sequence needed to reach the 11/03 goal. This future job list represents a very aggressive schedule.

To keep to such a schedule requires that the status of all active jobs be monitored closely (on a daily basis), that the critical path be clearly recognized, and that the impact of departures from the schedule be understood. This Panel feels that without a committed, full-time project leader there is little hope to reach the 11/03 goal. The project leader should also be responsible as a liaison to the representatives of the collaboration who are carrying out some of the work at their home institutions. (see our first recommendation)

Little time and effort was spent to produce the present PERT chart. It is necessary that the jobs listed and their completion dates be consistent with available manpower. Thus the PERT chart has to be refined and combined with the names of contributing people and their respective involvement in this project. This Panel suggests that follow-up reviews of the Jet Target Project be conducted at 6 months and 12 months from now, i.e., prior to the first installation effort and after the first test in the 12 o'clock IR. The purpose of these reviews is to report the progress of this project to the RHIC management, to the Jet Target collaboration, and to the users of the RHIC polarized beams. (see our second recommendation)

Atomic Beam System (ABS)

There seem to be no real showstoppers as far as the ABS jet systems are concerned. The committee was impressed with the overall level of understanding of technical issues and challenges associated with development of the jet. Thus, the four issues highlighted below are not surprising. Generally, most have been considered already by the design group, or are acknowledged by individual group members to be worthy of further consideration.

1) One must design and map magnetic field shapes very carefully, especially around the ABS RF transitions and beam interaction regions, to assure proper spin handling and depolarizing resonance avoidance. Mutual proximity of these regions, each of which needs critically shaped electromagnetic fields to accomplish its intended physical process, is a technical challenge which will likely take time to resolve. Sufficient time must be allocated after assembly of these systems on the test stand for careful field mapping and correction of unwanted electromagnetic interactions.

2) Protection from the unlikely, but potentially damaging break of a pyrex dissociator tube dictates careful attention to interlocks and possible fast-acting valves to isolate critical regions of the source from the accelerator. Early discussion is needed with responsible parties in accelerator operations to fix the design of appropriate protection measures.

3) Desire for rapid jet target and Breit-Rabi polarimeter installation in the RHIC ring, especially during early systems development and refinement, means that rapid pumpdown capability will be advantageous. Thus, early consideration should be given to facilitating bakeout of critical Jet Target regions nearest the RHIC ring. This would likely require designs for proper heat sinks and thermal shielding of critical components like the permanent magnet sextupoles and Si detectors.

4) Minimizing the background H_2 and H_2O contributions to the expected scattering asymmetry will be very important for overall minimization of polarimetry errors. Because this is so important in reducing the overall uncertainty of the RHIC beam polarization, plans need to be in place to devote enough effort and resources, probably over an extended time period, to assure first that these background contributions can be analyzed and monitored, and later that they can be understood as well as possible.

Breit-Rabi Polarimeter (BRP)

The Breit-Rabi Polarimeter for the RHIC Polarized Jet Target is similar to the one used at HERMES, where this method has been developed to its present level of maturity and accuracy. At HERMES the BRP serves as the standard for the atomic beam polarization measurement. Systematic errors related to the target polarization measurement have been shown to be negligible except for i) the ballistic background from hydrogen gas and water; the contribution of the latter has been found at COSY to be exceptionally high (7%); and ii) the bunch field depolarization of the target by the beam.

Both effects should be checked at RHIC as soon as possible to serve as a quality control of the complete RHIC Polarized Jet Target and to give a realistic assessment of the attainable accuracy of the RHIC Polarized Jet Target polarization.

The costs for the RF-transitions are believed to be realistic assuming that there is substantial support and RF knowledge, both from and within the group responsible for building these devices.

Silicon Detectors, Readout Electronics, and Data Acquisition

The collaboration presented their plans to measure asymmetries (and thus analyzing powers) in the elastic scattering of RHIC beam protons with jet target protons, where one or both of the protons are polarized. Asymmetries are measured through detection of the jet recoil proton at scattering angles near ± 90 degrees to the beam direction and in the horizontal plane (i.e. in the direction perpendicular to both the RHIC beam and jet direction). Measurement of the scattering angle provides a measurement of $|t|$, the four-momentum transfer squared of the scattering process.

The collaboration proposes to use twelve silicon detector arrays to measure the scattering angle of the recoil proton, as well as the proton energy and time of flight. The detectors are sufficiently thick to stop protons up to 8 MeV. The acceptance of the detectors around the 90 degree angle is sufficient to see elastic scattering from both the Yellow and Blue RHIC beams, but easily has sufficient resolution to identify which beam is involved in each event. It was shown that background signals primarily in the form of beam-gas interactions and diffractive proton-proton interactions are kinematically suppressed by using $|t|$ vs. scattering angle correlations.

The detectors are to be read out with an existing preamp followed by signal-shaping electronics that are currently under design. The signals are recorded with CAMAC "Waveform Digitizers" (WFD) that sample each channel at approximately 370 MHz. It is noted that the readout (preamps through the WFDs) are slight modifications of a system that has been successfully implemented in the pC CNI polarimeters at RHIC.

We see no significant technical challenges in either the silicon detectors or readout electronics. The technologies are mature and there is sufficient expertise with these technologies either directly within the collaboration or within groups assisting it.

A timeline was presented for production of the detector system beginning with a December 2002 start of silicon detector fabrication and ending with a completed system by December 2003. The proposed schedule to build the detector and readout system within a year appears to be adequate and allows some contingency. However we point out that the fabrication of silicon detectors is a process that often causes delays because of design and yield issues, as well as clean room equipment failures. As the collaboration only requires 4 working detectors in the first year to initiate a polarization measurement we believe there is sufficient contingency in the schedule to obtain these detectors. But the collaboration should carefully monitor the production to see that it proceeds in a timely fashion.

No information was presented on grounding and shielding of the detectors. We recognize that some collaboration members have experience with a similar detector system through their work on the pC CNI polarimeters. But there may be additional pickup problems arising from the jet source itself. We recommend that consideration be given to grounding and shielding before construction of the detectors and their mounting assemblies.

While bake-out of the polarimeter is not currently planned by the collaboration, we suggest that they consider in the design of the detector mounts sufficient heat sink capability to protect the detectors should a bake-out become necessary.

Systematic Uncertainties

The process of establishing a known beam polarization when only the target polarization is a priori known was described. Basically, measurement of asymmetries in two detectors (left, right) with four beam-target spin states (++,+-,-+,--) provides sufficient information to solve for the beam polarization multiplied by an analyzing power, A, and separately the target polarization times A. The ratio eliminates A, and the BRP measurement of the jet target polarization allows for determination of the beam polarization. Solid angle acceptances and luminosity factors cancel out, and other effects are minimized. A generalized matrix version of an analysis scheme was described in which no unpolarized running is required, and the spin independent luminosity for each spin state is not needed. Through calibration of the beam polarization, the pC CNI polarimeters would be calibrated at each RHIC running energy.

A summary of the expected uncertainties contributing to the knowledge of the absolute beam polarization was presented. These are all dominated by systematic uncertainties, and when combined in quadrature give $\Delta P_{beam}/P_{beam} \approx \pm 0.06$.

The three largest contributions are all about ±3% and include: a) the error in measurement of the absolute jet target polarization, dominated by the uncertainty of the fraction of water and molecular hydrogen in the interaction region, b) the systematic error in the asymmetry measured in the pC CNI polarimeter, and c) the uncertainty in the pC CNI polarimeter analyzing power when the silicon strip detectors are replaced, due to the unknown depth of the dead layer on their surface. The Panel believes that the accuracy $\Delta P_{beam}/P_{beam} \approx \pm 0.06$ is a realistic estimate, based on the results shown, and that it will not seriously impact the RHIC polarized program, which specifies an accuracy of ±0.05 for the beam polarization.

We believe (with one reservation) that the proposed detector system will be capable of measuring the analyzing power of elastic proton scattering. Our reservation concerns whether there is sufficient rejection of background signal in the detectors. Though there appears to be sufficient rejection of beam-gas and diffractive interactions (through kinematic techniques described by the collaboration), there is concern that additional sources (e.g. from scattered jet beam) may alter the measurement if these sources have a non-negligible analyzing power. However we recognize that estimation of these backgrounds (and analyzing power) is very difficult and can only be fully understood once the device is built.

Among the three largest contributions to the total error, the Panel believes that the first has a good chance to be reduced with careful study, although it may take more than 1-2 years to achieve this reduction. The second largest contribution is caused by a presently unknown source of systematic error in the pC CNI polarimeter from the 2002 run. It is urged to pursue vigorously the source of this error, as it has the potential to be present also in the jet target polarimeter. Note that for polarized pp collisions when the jet target is collecting data, $\Delta P_{beam}/P_{beam} \approx \pm 0.04$ would be expected, and the Panel encourages significant RHIC polarized running with the jet target in order to achieve the smaller uncertainty in absolute beam polarization.

Will Come

Although a commissioning plan was not presented, it is anticipated that many systematic studies will be needed. Many of the tests for systematic errors performed for the pC CNI polarimeter should be repeated with the jet target detectors, since they are similar in design. Other tests might involve varying the spacing of the Yellow and Blue beams at the interaction region, cross checks of the pC analyzing power with a carbon beam on the polarized jet target, mapping of the polarization profile as the target is moved relative to the beam, and perhaps a cross check of the energy dependence of the analyzing power by acceleration and deceleration of the beam within a fill.

Since the polarized jet target polarimeter is anticipated to be an important instrument for future polarized proton running at RHIC, a BNL staff physicist should be responsible for its hardware, operations, and data analysis. The RHIC pC CNI

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polarimeters are complementary to the polarized Jet Target and equally important to the measurement of the polarization of the beams. The *same* staff person should oversee and coordinate work with these polarimeters. He/she should work with collaborators from the RHIC spin community to derive beam polarizations, study systematic effects, and make hardware repairs and improvements. (see our third recommendation)

Appendices:

Review Agenda

Response

- Makdisi is the Full time PM.
- Makdisi et al are preparing a MS Project management & tracking [met with Jehanne Simon Gillo this morning & she is happy with the development & progress]
- Makdisi to call JSG monthly.
- Joe Scaduto is assigned the Liaison Engineering task.
- Haixin Huang to look after the Polarimeters Liaison.

Makdisi, Yousef I

From: Fox, Brendan
Sent: Tuesday, December 03, 2002 8:40 AM
To: Roser, Thomas; Mackay, William W; Saito, Naohito; Bland, Leslie C; Goto, Yuji; Makdisi, Yousef I
Cc: Bunce, Gerry M; Heinz, Tammy A
Subject: Proposed Agenda for the next RHIC Spin Collaboration Meeting (Wed, Dec 18th)

Hi y'all,

In consultation with Gerry, I have cobbled together the following itinery for the next RHIC Spin Collaboration Meeting:

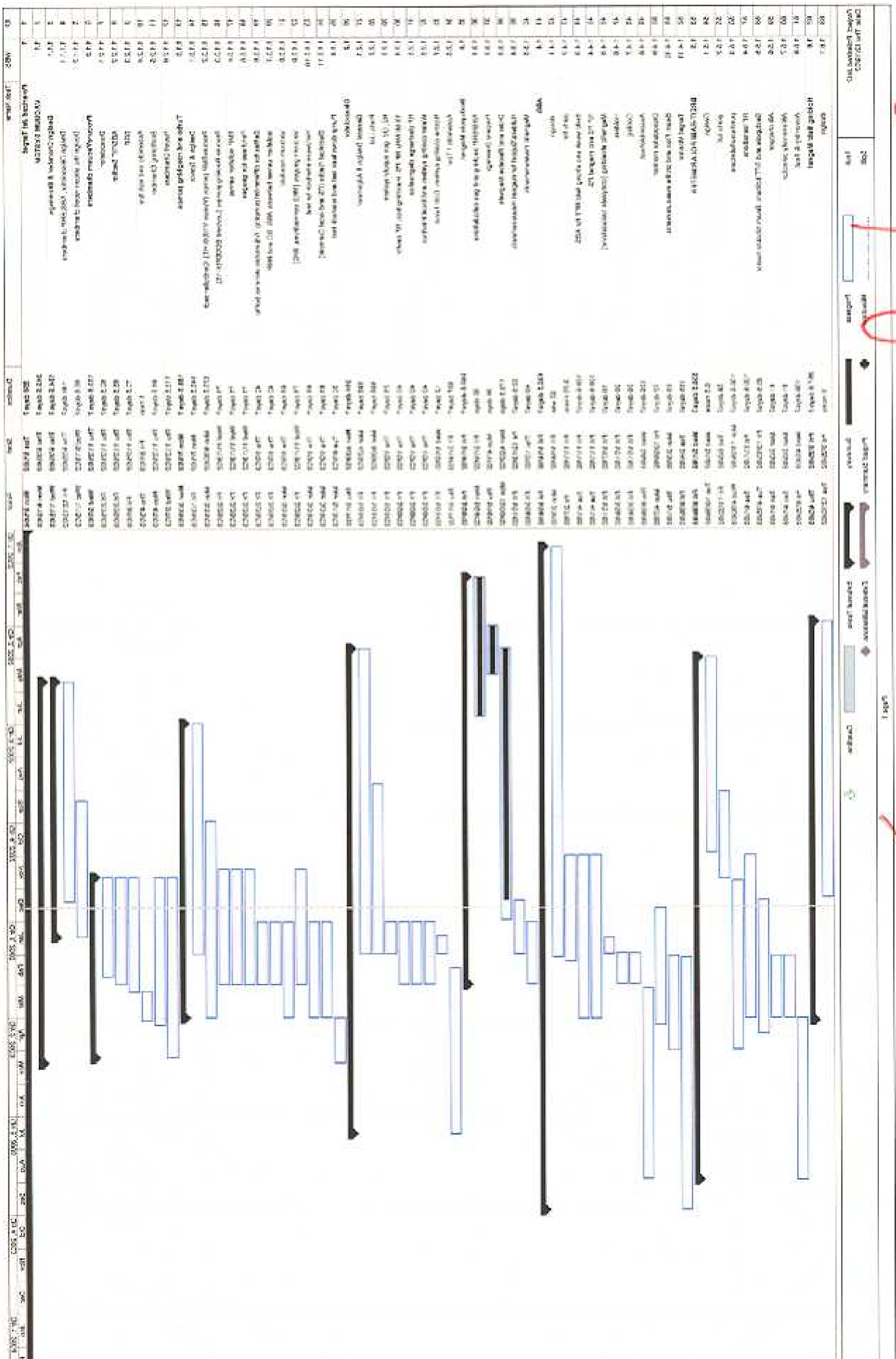
09:00 to 09:45 - Summary of the AGS Polarization Workshop
(Thomas Roser)
09:45 to 10:30 - Summary/Outcome of the Jet Target/Experiment Review
(Yousef Makdisi/TBA)
10:30 to 10:45 - Coffee Break
10:45 to 11:30 - Status Report on the Accelerator Run-03 Preparations
(Leif Ahrens)
11:30 to 12:00 - Status Report on the AGS CNI Polarimeter
(Jeff Woods)

02:30 to 02:50 - Update on PHENIX Readiness for Run-03
(Matthias Grosse-Perdekamp/TBA)
02:50 to 03:10 - Update on STAR Readiness for Run-03
(Les Bland/TBA)
03:10 to 03:30 - Update on RHIC Polarimetry Readiness for Run-03
(Osamu Jinnouchi/TBA)
03:30 to 03:45 - Coffee Break
03:45 to 04:15 - Conclusions about RHIC Polarimetry for Run-02
(Osamu Jinnouchi)
04:15 to 05:00 - Run-02 BBC Asymmetry Results from PHENIX
(Kiyoshi Tanida)

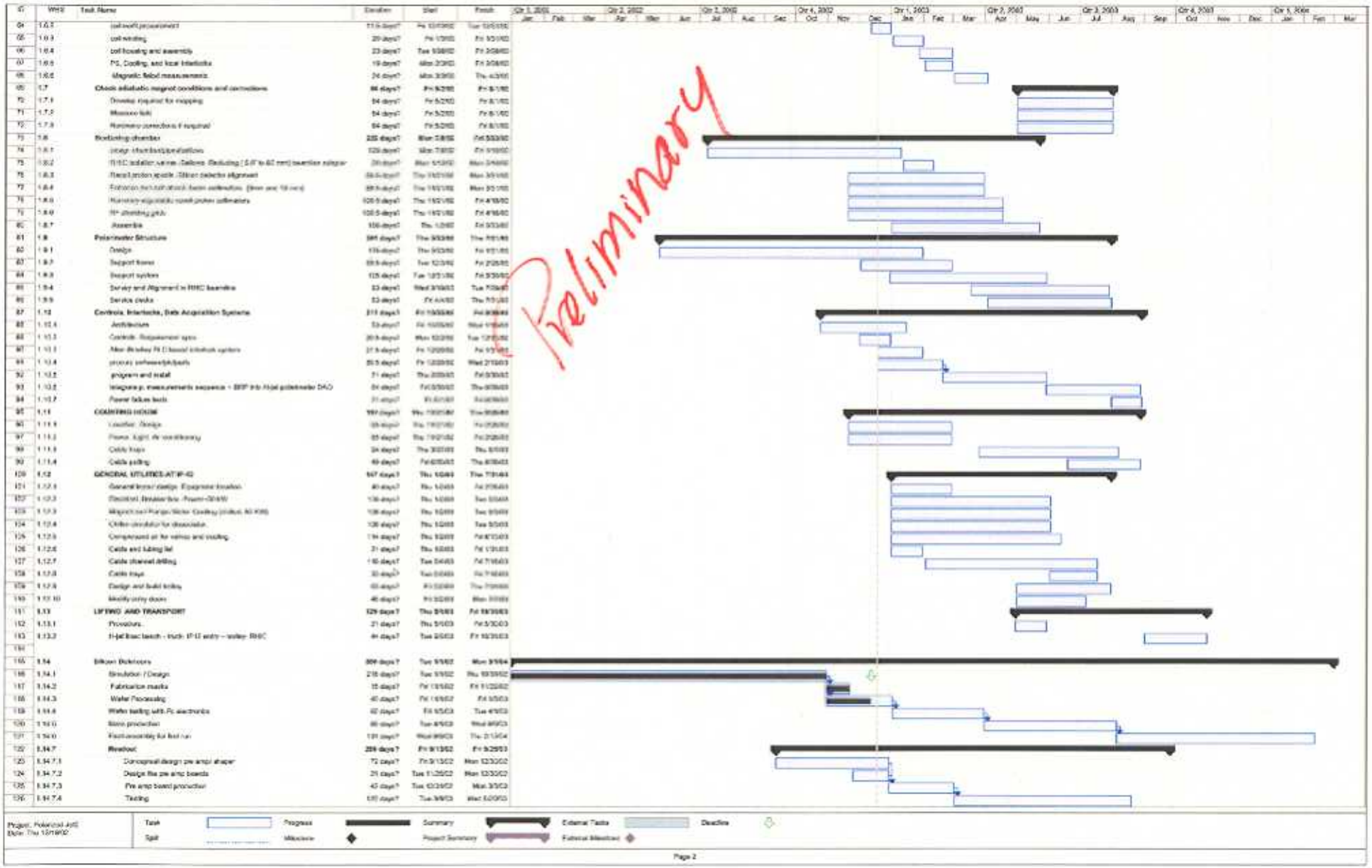
where I have indicated either speaker or, via the "/TBA" the person who I will ask to tell me who should speak on this topic.

Please let me know if there is anything additional which you feel should be covered in this meeting ... thanks ...

... brendan



In progress! Preliminary


Preliminary

ID	WBS	Task Name	Duration	Start	Finish
127	1.14.7.5	Design shaper board	40 days?	Fri 1/31/03	Fri 3/28/03
128	1.14.7.6	Shaper board prototype production	65 days?	Mon 3/31/03	Sat 6/28/03
129	1.14.7.7	WTD modification	215 days?	Mon 11/11/02	Fri 9/26/03
130	1.14.8	DAQ	178 days?	Thu 5/29/03	Fri 1/30/04
131	1.14.8.1	Hardware	95 days?	Thu 5/29/03	Fri 10/10/03
132	1.14.8.2	FPGA programming code	85 days?	Mon 10/6/03	Fri 1/30/04
133	1.14.9	Jet development commissioning and testing	150 days?	Fri 4/25/03	Fri 11/28/03
134	1.14.10	Installation dry run	46 days?	Mon 12/1/03	Tue 2/3/04
135	1.14.11	Installation for polarized Run	12.5 days?	Tue 2/3/04	Mon 3/1/04

Project: Polarized Jet
Date: Thu 1/?/03

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone