RSVP – AGS Role

DOE HEP Review
Brookhaven National Laboratory
27-28 April 2005
Phil Pile
BNL/AGS RSVP Upgrades Project

Outline

• AGS Complex
• RSVP AGS Project
• Construction costs and labor estimates
• Final comments
AGS/RHIC Accelerator Complex

**AGS:**
- Intensity: $7 \times 10^{13}$ protons/pulse
- Injector to RHIC: < 1 hour about every 4 hours

**RHIC**

- PHOBOS 10:00 o’clock
- BRAHMS 2:00 o’clock
- PHENIX ($\vec{p}$) 8:00 o’clock
- STAR ($\vec{p}$) 6:00 o’clock

**Fast extraction**

**Slow extraction**

- High Intensity Source
- NSRL (NASA)
- Pol. Proton Source
- LINAC
- U-line
- RSVP (NSF)

**TANDEMS**

**April 27-28, 2005**
AGS Experimental Area

**FY2006+ Experiments**

**The Plan**
- D-Line Decommissioned
- Switchyard simplified
- A,B,C Lines run as “OR’s”

**D-Line: Decommission FY2006**

**A5 – RSVP, MECO**
E940, $\mu N \rightarrow eN$

**B7 – RSVP, K0PI0**
E926, $K_L^0 \rightarrow \pi^0 \nu\nu$

**RHIC eCooling Test Facility (under construction)**

**NASA Radiobiology**
AGS Beam Specifications

- K0PI0 AGS Beam Specifications:
  - Momentum = 25.5 GeV/c
  - Spill length = 4.9 sec
    - actual spill length will be determined once rates are known and experiment optimization is complete
  - Rep rate (AGS cycle time) = 7.2 sec
  - Intensity = **100 TP/spill**
  - Time between bunches = 40 nsec
  - Beam bunch width =
    - 200 psec RMS (baseline)
    - 260 psec RMS (without 100 MHz cavity)
  - Extinction between bunches = 1 x 10^{-3}
  - Beam size on target (95%)
    - 2 mm full width vertical,
    - ~4 mm horizontal
  - Beam hours:
    - engineering run = 800 hours
    - requested physics run
      - 12000 hours at 100 TP/spill (see Littenberg talk)
    - total integrated protons for physics run = 6.0 x 10^{20} (with 4.9 sec spill length)
AGS Beam Specifications

- **MECO AGS Beam Specifications:**
  - Momentum = 7.5 GeV/c
  - Spill length = 0.5 sec
  - Rep rate (AGS cycle time) = 1.0 sec
  - Intensity
    - Experiment goal = Two bunches/AGS cycle 20TP/bunch
    - AGS base-line (achievable) = 20 TP/sec
  - Time between bunches = **1350 nsec**
  - Beam bunch width < 50 nsec full width
  - Extinction between bunches = **1 x 10^-9**
  - Beam size on target = 1 mm RMS (radius)
  - Beam hours:
    - engineering run = 800 hours
    - physics run
      - 2800 hours at 40 TP/spill (stretch goal)
      - 5600 hours at 20 TP/spill (base plan)
    - total integrated protons for physics run = **4.0 x 10^{20}**
    - Run time will depend on achievable muon flux, actual background rates etc..
General Guidelines for Modifications

- Achieve RSVP beam requirements

- Accelerators must not be activated beyond “hands-on” limits

- We must adhere to Safety & Environmental Protection Regulations and Policies
  - Protection of Ground Water
  - Minimize Occupational Radiation exposure
  - Minimize the risk of fire or electrocution

- RSVP is to have no negative impact on RHIC operations and is not to affect NASA Space Radiation Laboratory capabilities.
Booster Modifications

- Booster injection – carbon blocks to protect C5 & C7
- HI Injection – LTB collimator – protects C5 & C7
- p Injection
- C3 HI inflector at risk with high intensity p, active protection planned
- Other: BLM, PFN and RF upgrade, new cables, tray, dipole coils and controls
- Environmental CAP for Booster
- Only one spare F6, need another before resumption of high intensity p operation
AGS and Booster Shield Caps

$3.1M + 22% cont
AGS Modifications

- BTA Upgrade (CF1)
- A5 upgrade
- New A10 modules
- New F5, F10 & PS’s
- Reliability & Aperture improvement
- New H20 electrostatic Septum (at I20)
- Reliability & Aperture improvement

Other:
- BLM, PFN and RF upgrade, new cables, tray, dipole & sextupole coils and controls
- Environmental CAP for AGS

- Stripline Kicker
- 100 MHz Cavity
- 25 MHz Cavity
- AC Dipole
- New F5, F10 & PS’s Reliability & Aperture improvement
Switchyard and Primary Beams (present)

Switchyard – rebuild/simplify

New proton beam transports

MECO

K0PI0
RSVP Project Organization (Partial)

RSVP PROJECT
DIRECTOR and DEPUTY
W. Willis, J. Kotcher

KOPIO
WBS 1.2
M. Marx

AGS
WBS 1.4
P. Pile/
A. Pendzick

MECO
WBS 1.3
M. Hebert

MECO
Magnet
WBS 1.5
B. Smith

1.4.1 AGS Booster
K. Brown

1.4.2 Switchyard
A. Pendzick

1.4.3 KOPIO
C. Pearson

1.4.4 MECO
D. Phillips

1.4.5 Project Office
P. Pile

C-AD Head
D. Lowenstein

C-AD
Accelerator
Div. Head
T. Roser
AGS/Booster – WBS 1.4.1

($18.2M + 25\% \text{ cont})

• Four parts to this
  – AGS/Booster legacy repairs and high intensity upgrades (9.8M + 22\% \text{ cont})
    • Result of internal analysis since the Jan 04 DOE Review
    • Environmental requirement - Radiation Caps (rain barriers) on AGS and Booster is largest single procurement ($3.1M + 22\% \text{ cont})
  – MECO Specific Modifications ($1.9M + 27\% \text{ cont})
    • Beam inter-bunch extinction hardware
  – K0PI0 Specific Modifications ($5.7M + 31\% \text{ cont - NSF})
    • Beam bunching RF cavities
    • Booster-AGS upgrade (for intensity)
    • Off-project CFI contribution $\approx$7.2 Canadian \$’s
  – AGS/Booster project support ($0.9M + 20\% \text{ cont})
Switchyard – WBS 1.4.2

($2.9M + 21\%$ cont)

• Existing switchyard not in condition to support high intensity operation for RSVP experiments
• Simplification/Modernization planned
  – Beam plugs to decouple construction work from beam development
  – Replace obsolete equipment
  – Minimize beam loss
  – Achromatic beam tunes to target stations
    • No beam servoing
    • No ramped magnets
  – No beam splitters
    • No beam sharing
    • No Lambertson magnets
  – Less instrumentation needed
  – Less maintenance
• NASA AGS facility relocation (A3 to Switchyard)
K0PI0 – WBS 1.4.3

($8.0M + 27% cont)

- Primary Beam up to and including target station
- Neutral Beam
- Experimental area
- Project support and integration
KOPIO Neutral Beam

- Shielding
- Neutral Beam Collimator System
- 100TP Target Station
- Sweeping magnets
- Neutral Beam Dump
- Fast Electronics Hut
- Proton Beam Dump
MECO – WBS 1.4.4
($7.9M + 23% cont)

• Primary Beam up to and including target station
• Superconducting Solenoid and refrigeration infrastructure (support role)
• Experimental area
• Project support and integration
AGS Project Office – WBS 1.4.5

($2.3M + 20% cont)

- Overall schedule and integration
- Fiscal
- ES&H and QA
- Reporting
WBS 1.4 Materials & Labor

**NSF Major Research Equipment Facility Construction funds**
(no DOE funds used for this)

AGS Level 3 Cost & Contingency Roll-up

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<tr>
<th>System Name</th>
<th>Material Costs</th>
<th>Labor Costs</th>
<th>Base Cost</th>
<th>Contingency Costs</th>
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WBS 1.4 costs (FY05$)

RSVP WBS 1.4 Total Cost per year

Contingency (24.4%)
Indirect
Direct Cost
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RSVP low intensity beam development possible

K0PI0 Engr/Physics Run

Resume high intensity AGS beam operations
# Machine construction milestones

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**RSVP low intensity beam development possible**

**K0PI0 Engr/Physics Run**

**Resume high intensity AGS beam operations**

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24  P. Pile  DOE HEP Review  April 27-28, 2005
Final Comments

• With help from the NSF, a new era in AGS Fixed Target experiments is set to begin with routine operation of the AGS for fixed target experiments, concurrent with RHIC operations

  With a different approach

• Multiple AGS experiments, running simultaneously with shared beams, will no longer be supported

• The full capabilities of the AGS will be directed toward only one experiment at a time with the AGS configured for optimal support of the experiment being served
Supplemental Material
• **Programmatic risk for RHIC**
  – Low risk – RHIC priority will be maintained
  – High intensity operation of Booster/AGS could lead to component failure and impact RHIC operations
    • Mitigated by pre-emptive component replacement and staying within acceptable RSVP operations parameters.

• **The Jan 2004 “DOE Review of RSVP Activities at BNL” had as a principal charge “to review impact of RSVP work on RHIC operations”**
  – Quote from findings:

  “In summary, the Committee concluded that the RSVP experiments will have minimal impact on the Nuclear Physics program at BNL. Plausible solutions exist for potential higher failure rates or longer repair times. The overall management structure of the project was found to be in the initial stages of development.”
CFI Collaboration

The costs associated with the AGS upgrade for KOPIO are partly being covered by the Canadian collaboration, under a Canadian Foundation for Innovation (CFI) grant.

TRIUMF Responsibility
1. 25 MHz RF Cavity and Power Amplifier
2. AGS injection kicker magnet upgrades (A10 modules)
3. Beam and accelerator physics studies (simulations)

BNL Responsibility
1. 25 MHz Design Collaboration and Interface/Controls
2. Injection Kickers P.S Building and Interface/Controls
3. 100 MHz RF Cavity
WBS 1.4 costs (obligated)
WBS 1.4 Work

1.4 AGS UPGRADES PROJECT
WORK

~ 40 FTE’s per year
Guidelines/assumptions for Example RSVP Operations

(1) AGS not available for RSVP during 1st 7 weeks of RHIC operations and for 4 weeks/additional beam during a given year

(2) Last week of RHIC operations is considered running outside RHIC operations since this is cryo warm-up week (injectors not running)

(3) AGS is available for RSVP the balance of the time after reserving 15 weeks for shutdown work

(4) 80 full intensity hours/week are available for RSVP experiments during RHIC Operations

(5) 120 full intensity hours/week are available for RSVP experiments outside RHIC Operations

(6) 20 TP/sec available for MECO at 7.5 GeV/c, linear ramp-up from 10-17.5 TP in FY12, 17.5-20 in FY14

(7) 100 TP/4.9 sec spill every 7.2 seconds available for K0PI0, linear ramp-up from 30-75 TP in FY11, 75-100 in FY13

(8) RHIC Cryo Operations based on "Constant Effort" budget - 27 weeks per year

(9) Assumes K0PI0 construction ends in FY2010 followed by 8 week engineering run in FY2011 followed by physics run

(10) Assumes MECO construction ends in FY2011 followed by 8 week engineering run in FY2012 followed by physics run
### Example Operations Plan

#### Example RSVP Operations Plan

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<thead>
<tr>
<th></th>
<th>FY11#</th>
<th>FY12</th>
<th>FY13</th>
<th>FY14</th>
<th>FY15</th>
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**Personnel**

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Assumes energy costs are $85/MWhr

# Assumes MECO magnet fixed costs are paid by construction project through FY2011
Present Switchyard Layout
Switchyard Modified for RSVP