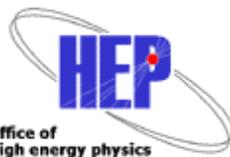


# RSVP – AGS Role

DOE HEP Review  
Brookhaven National Laboratory  
27-28 April 2005  
Phil Pile



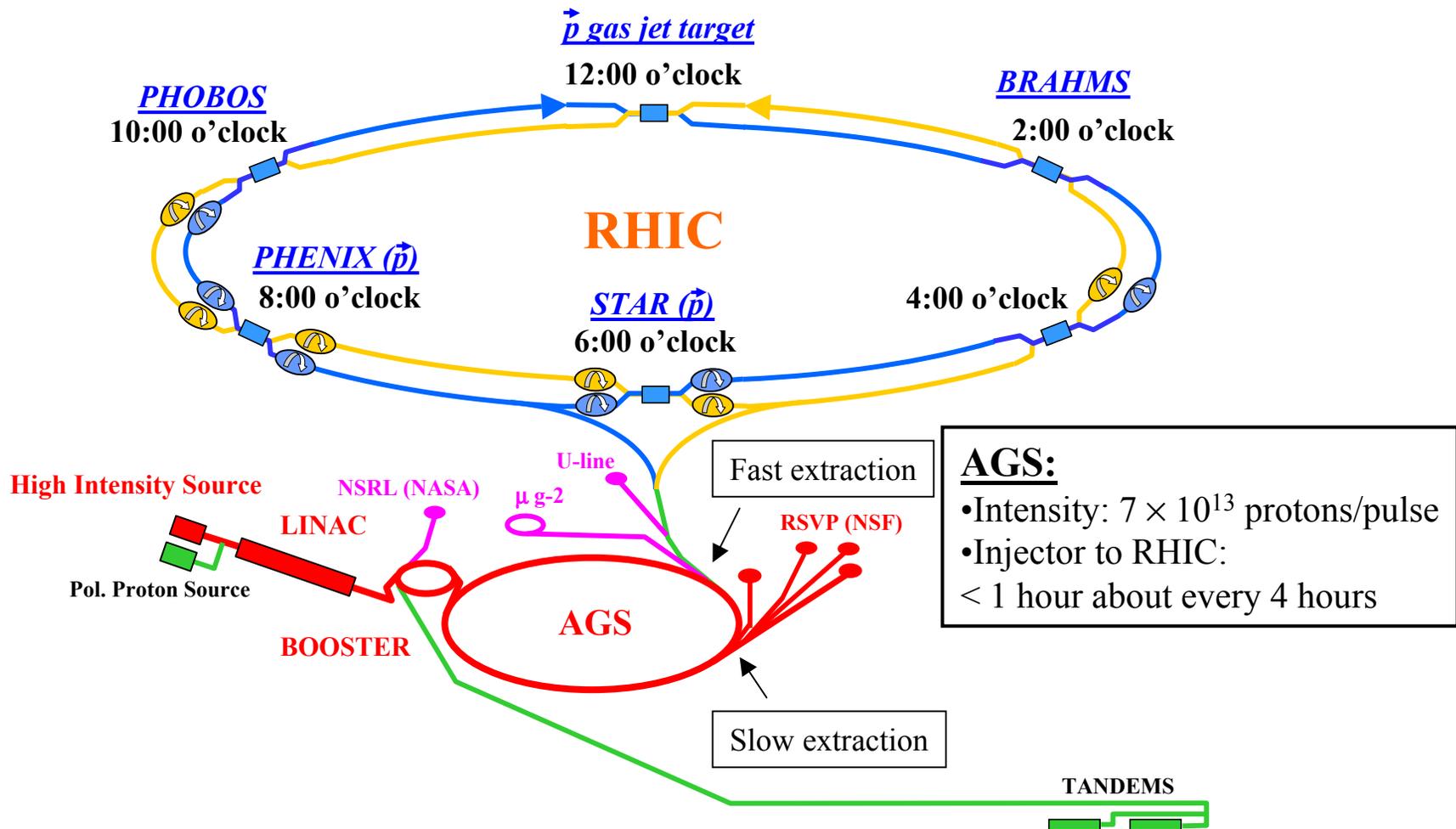
# **BNL/AGS RSVP Upgrades Project**

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## Outline

- **AGS Complex**
- **RSVP AGS Project**
- **Construction costs and labor estimates**
- **Final comments**

# AGS/RHIC Accelerator Complex



# AGS Experimental Area

*FY2006+ Experiments*

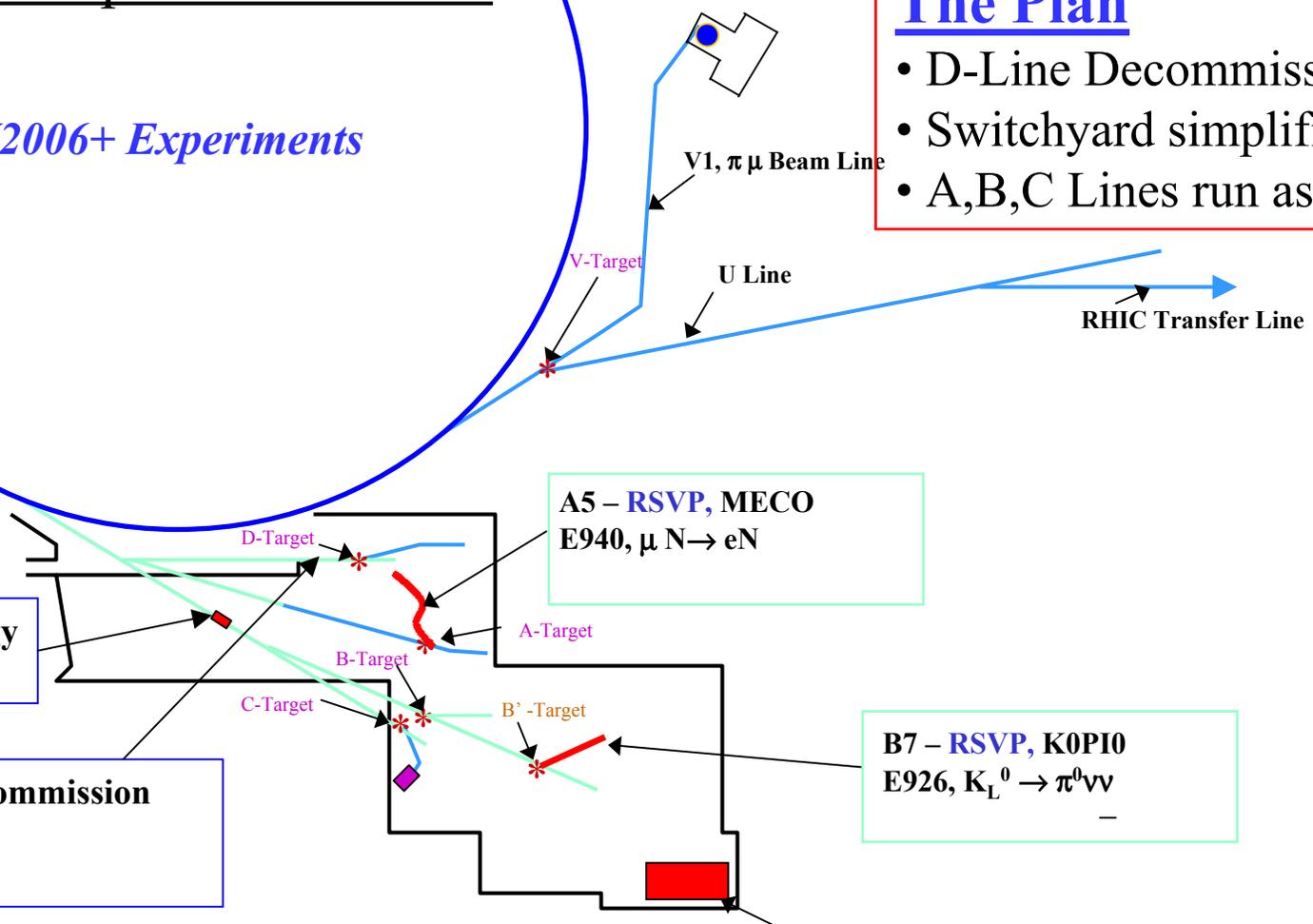
## The Plan

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

NASA Radiobiology

D-Line: Decommission  
FY2006

RHIC  
eCooling Test Facility (under construction)



- **KOPIO AGS Beam Specifications:**

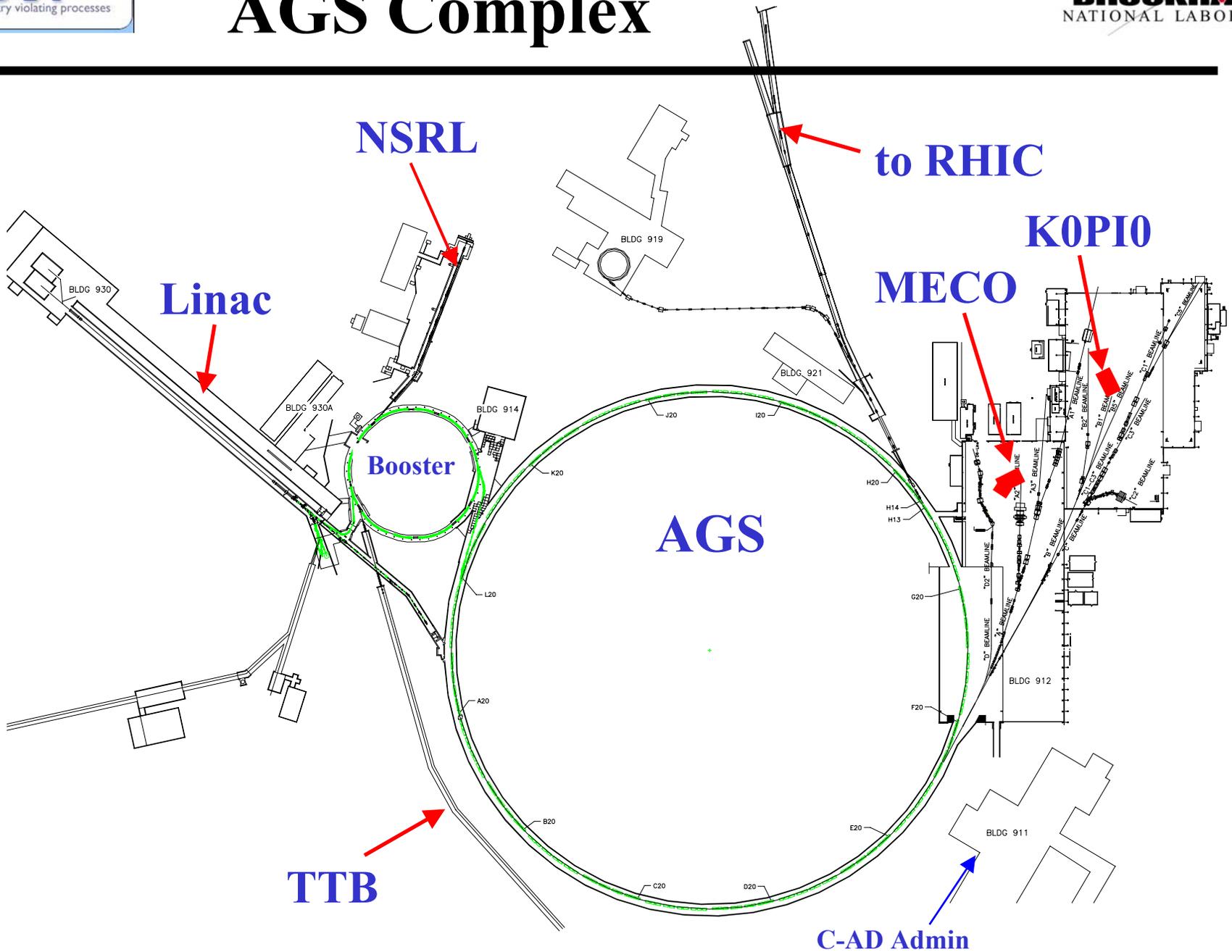
- **Momentum = 25.5 GeV/c**
- **Spill length = 4.9 sec**
  - actual spill length will be determined once rates are known and experiment optimization is complete
- **Rep rate (AGS cycle time)= 7.2 sec**
- **Intensity = 100 TP/spill**
- **Time between bunches = 40 nsec**
- **Beam bunch width =**
  - 200 psec RMS (baseline)
  - 260 psec RMS (without 100 MHz cavity)
- **Extinction between bunches = 1 x 10<sup>-3</sup>**
- **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 =  $6.0 \times 10^{20}$  (with 4.9 sec spill length)

- **MECO AGS Beam Specifications:**

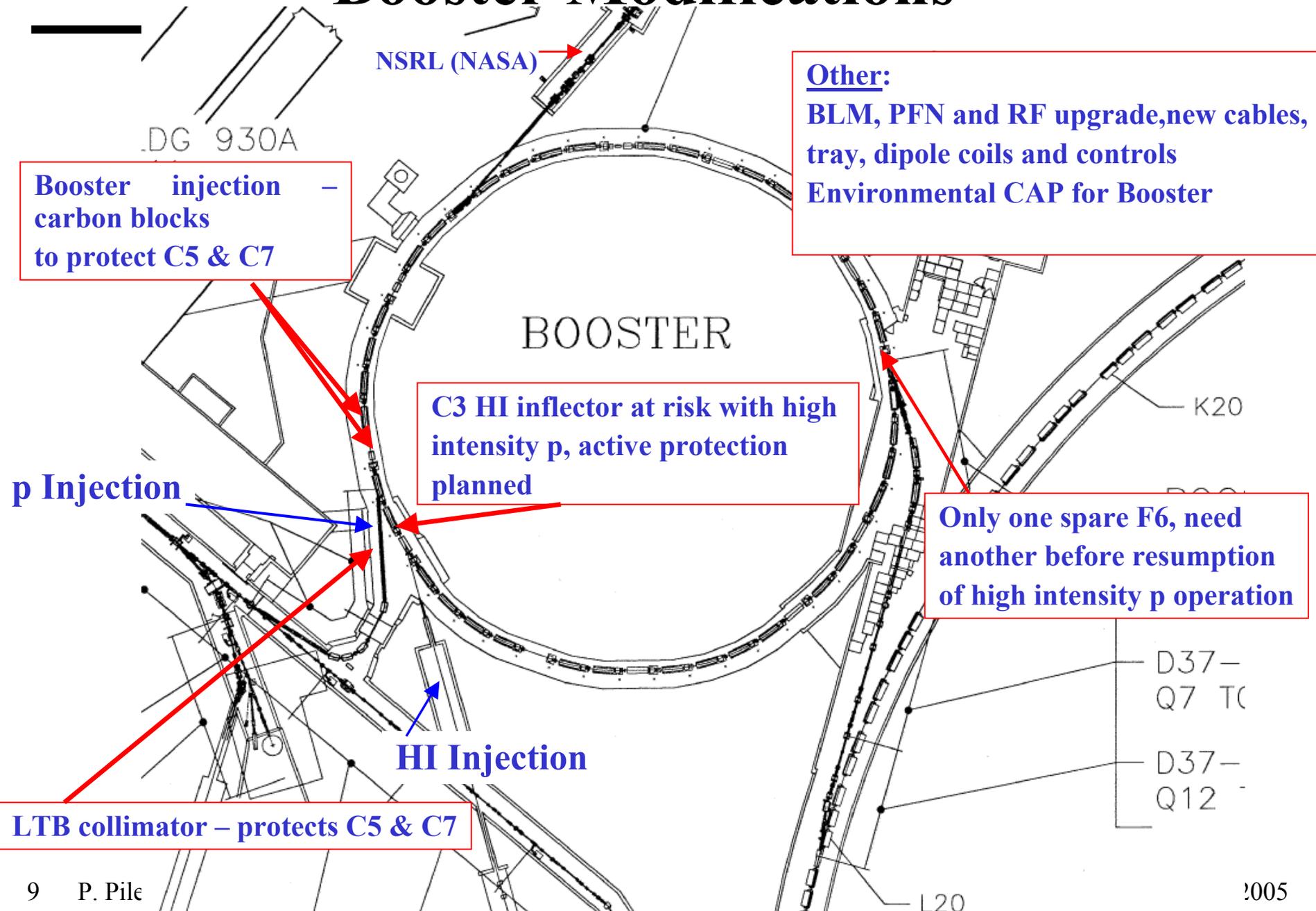
- **Momentum = 7.5 GeV/c**
- **Spill length = 0.5 sec**
- **Rep rate (AGS cycle time) = 1.0 sec**
- **Intensity**
  - **Experiment goal = Two bunches/AGS cycle 20TP/bunch**
  - **AGS base-line (achievable) = 20 TP/sec**
- **Time between bunches = 1350 nsec**
- **Beam bunch width < 50 nsec full width**
- **Extinction between bunches = 1 x 10<sup>-9</sup>**
- **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<sup>20</sup>**
  - **Run time will depend on achievable muon flux, actual background rates etc..**

- **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.**

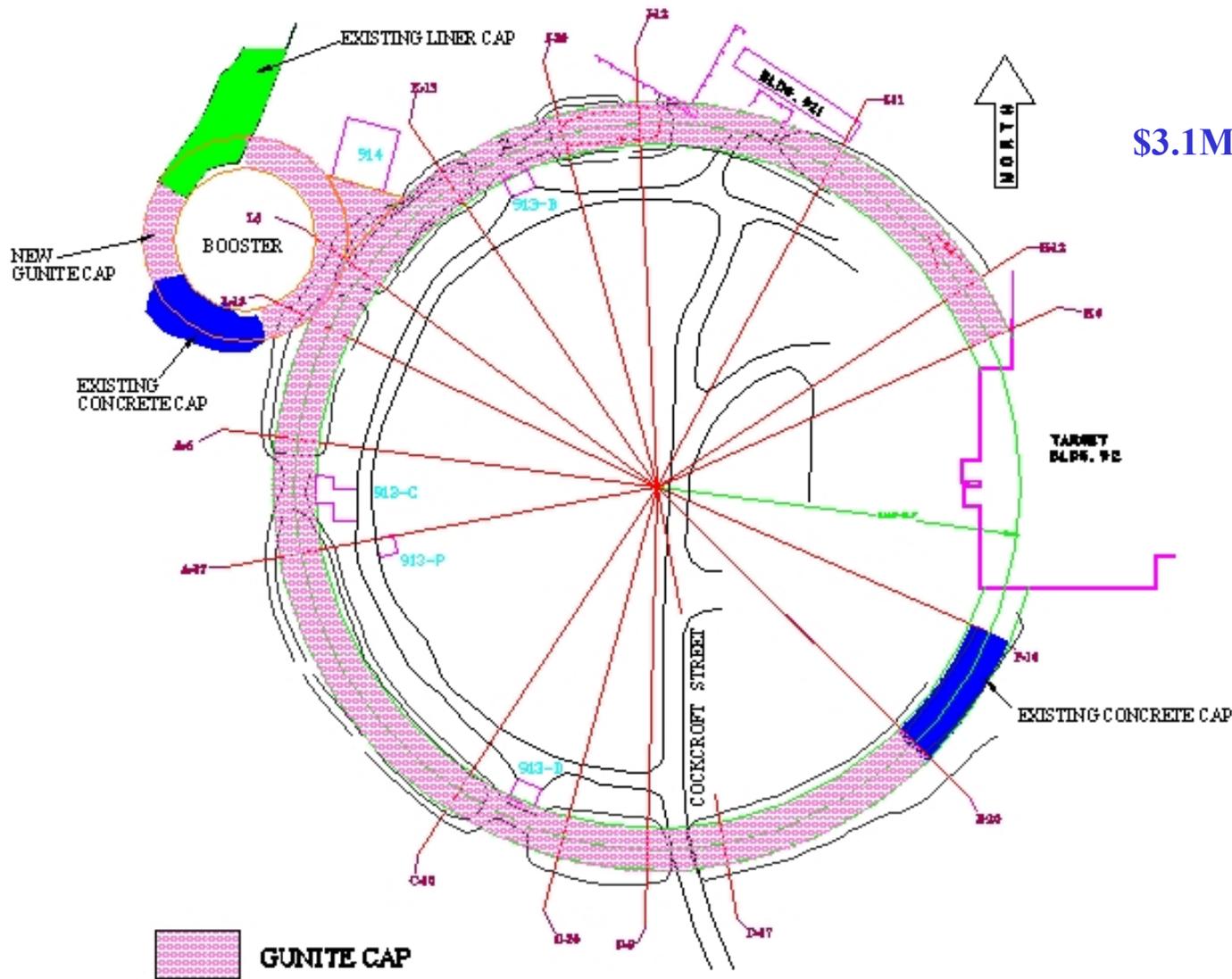
# AGS Complex



# Booster Modifications

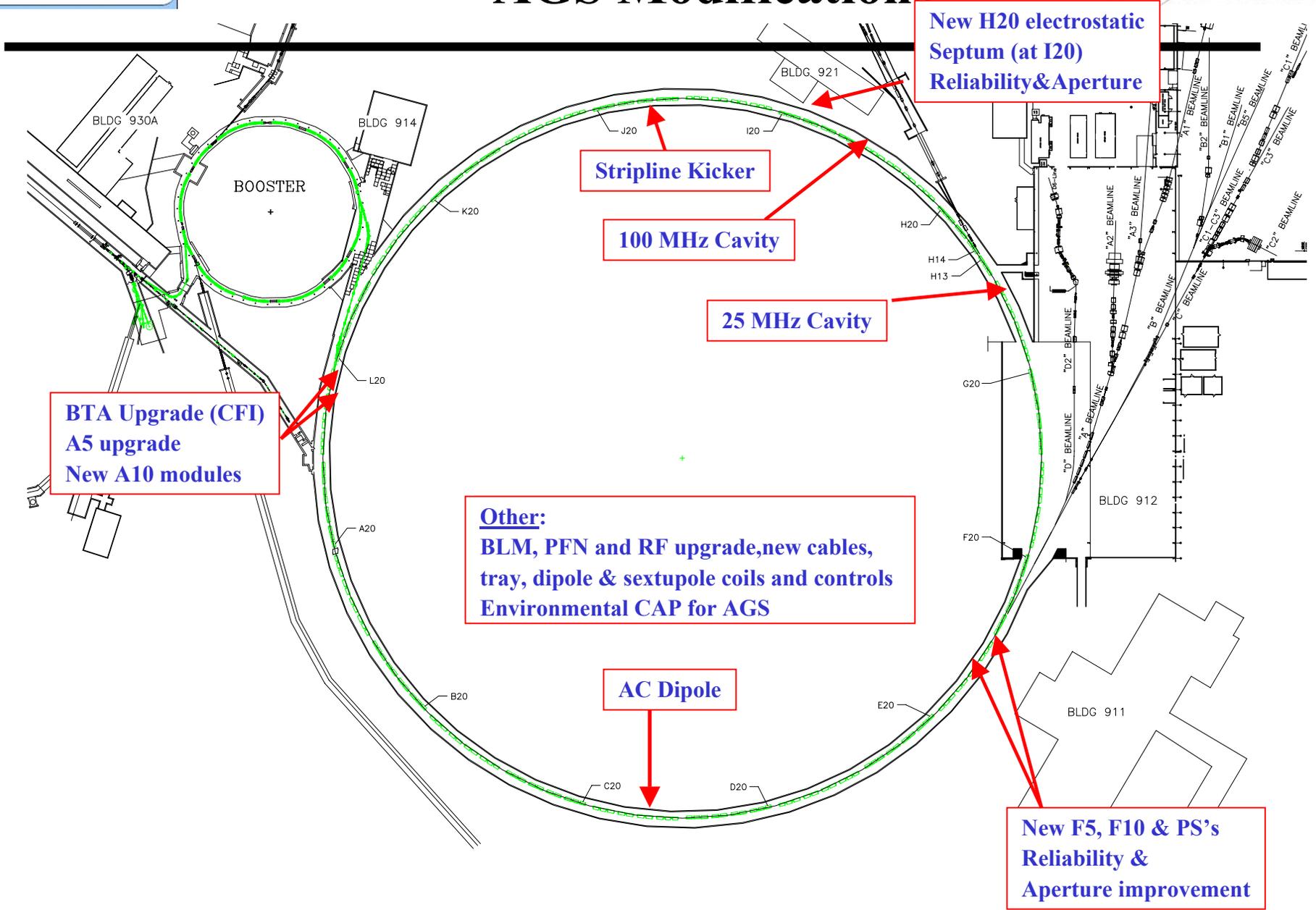


# AGS and Booster Shield Caps

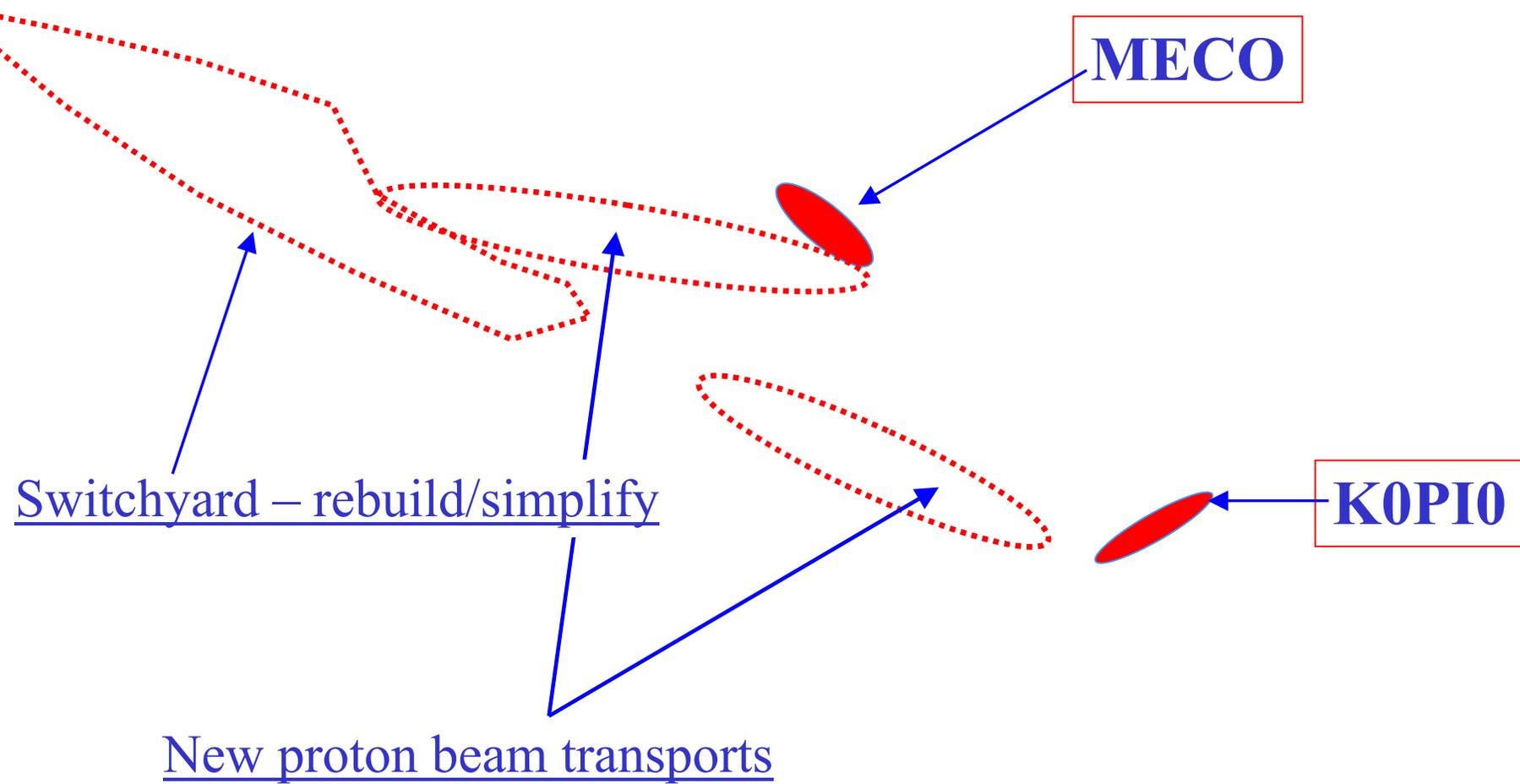


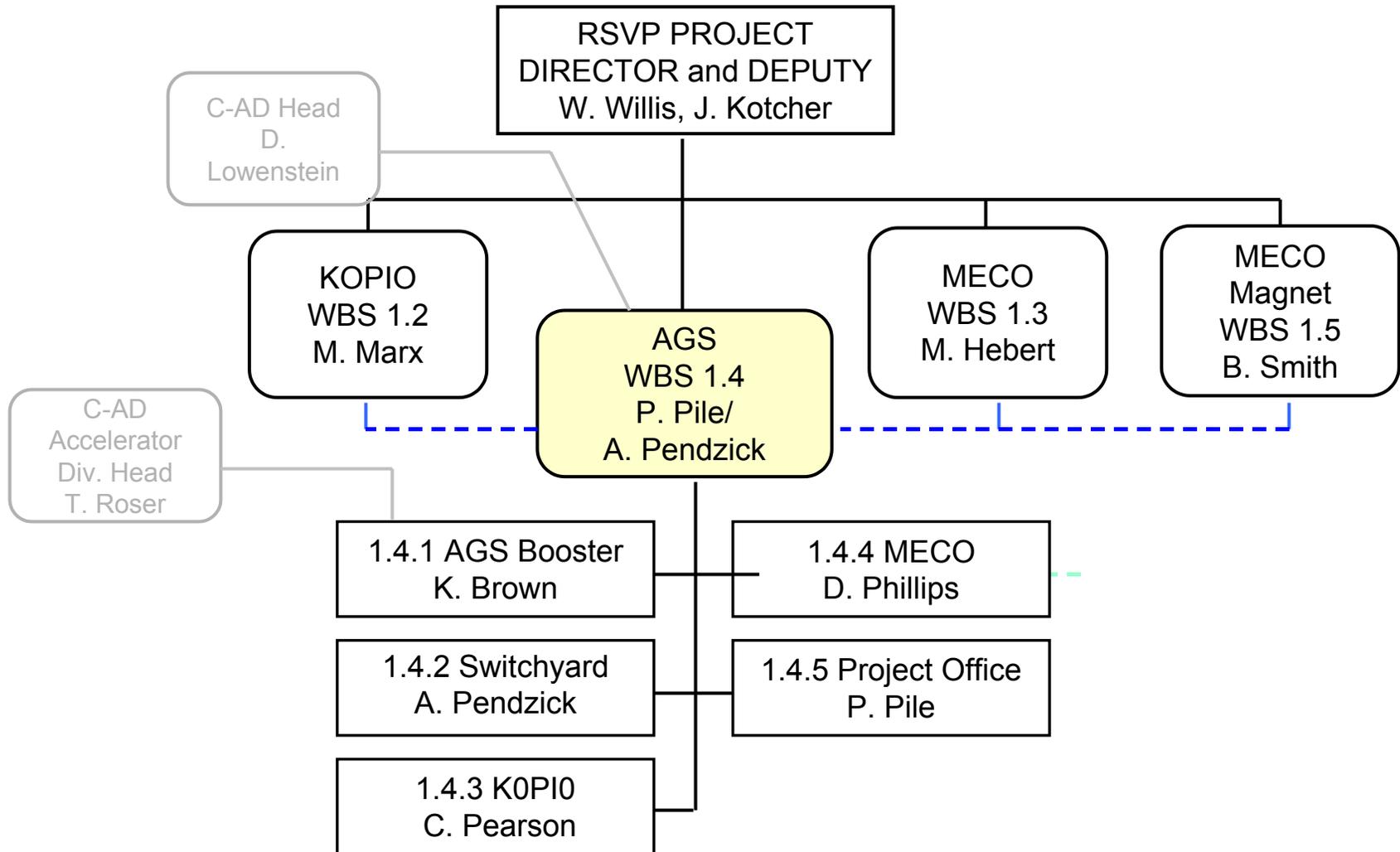
\$3.1M + 22% cont

# AGS Modifications



# Switchyard and Primary Beams (present)





(\$18.2M + 25% cont)

- **Four parts to this**
  - **AGS/Booster legacy repairs and high intensity upgrades (9.8M + 22% 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% cont)**
  - **MECO Specific Modifications (\$1.9M + 27% cont)**
    - **Beam inter-bunch extinction hardware**
  - **K0PI0 Specific Modifications (\$5.7M + 31% cont - NSF)**
    - **Beam bunching RF cavities**
    - **Booster-AGS upgrade (for intensity)**
    - **Off-project CFI contribution ~\$7.2 Canadian \$'s**
  - **AGS/Booster project support (\$0.9M + 20% cont)**

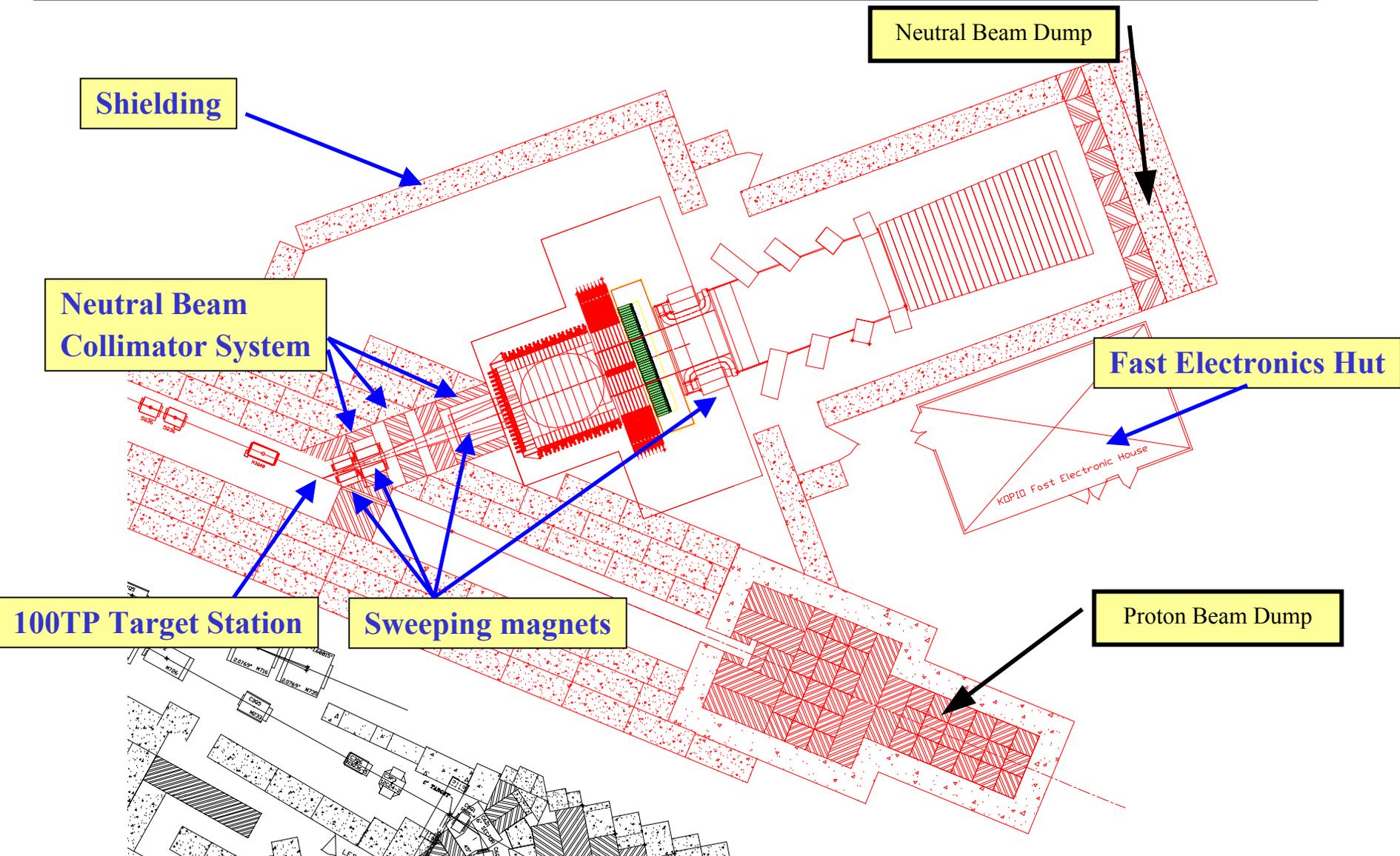
(\$2.9M + 21% cont)

- 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)

(\$8.0M + 27% cont)

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

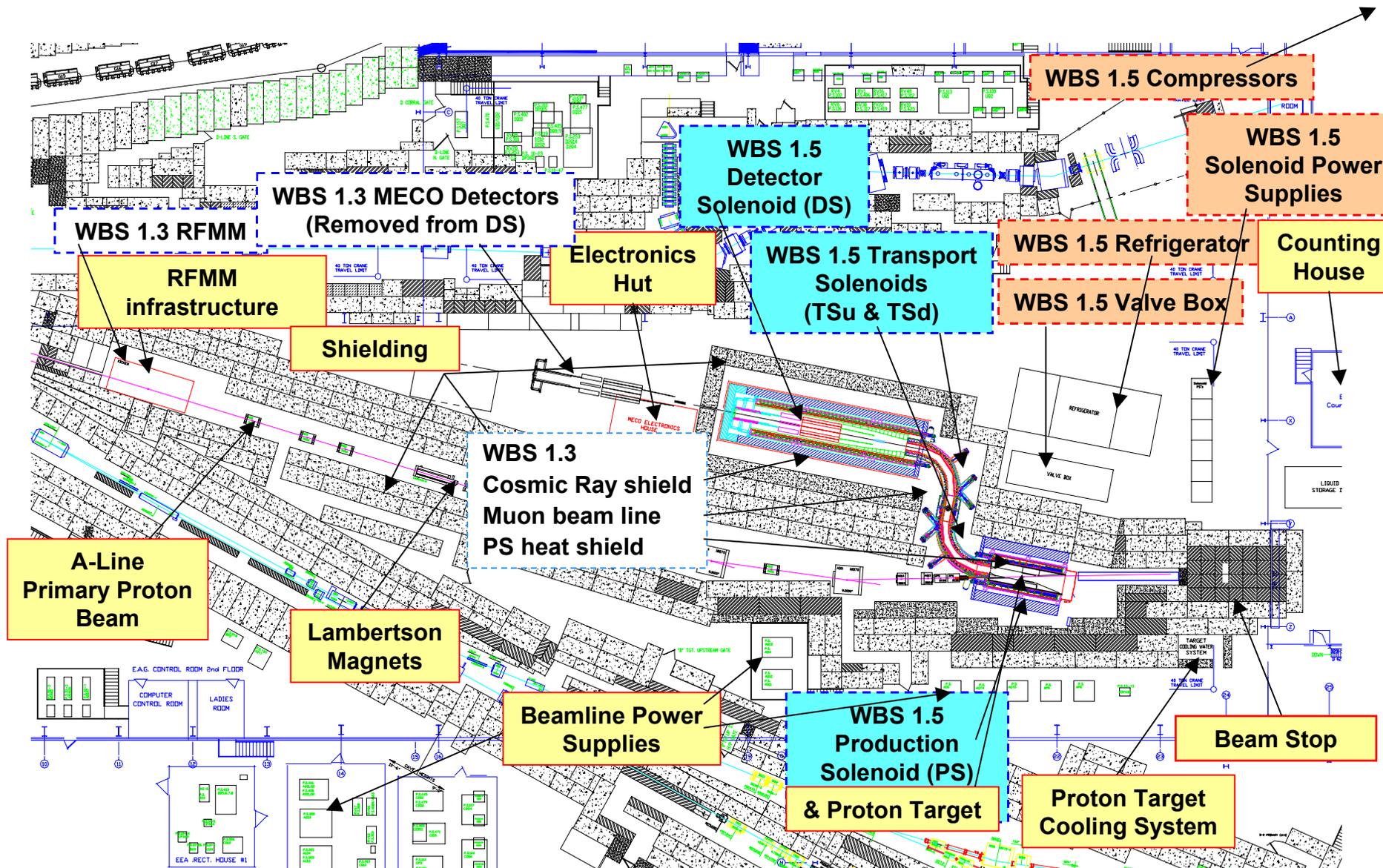
# KOPIO Neutral Beam



(\$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**

# MECO Final Installation



(\$2.3M + 20% cont)

- **Overall schedule and integration**
- **Fiscal**
- **ES&H and QA**
- **Reporting**

# WBS 1.4 Materials & Labor

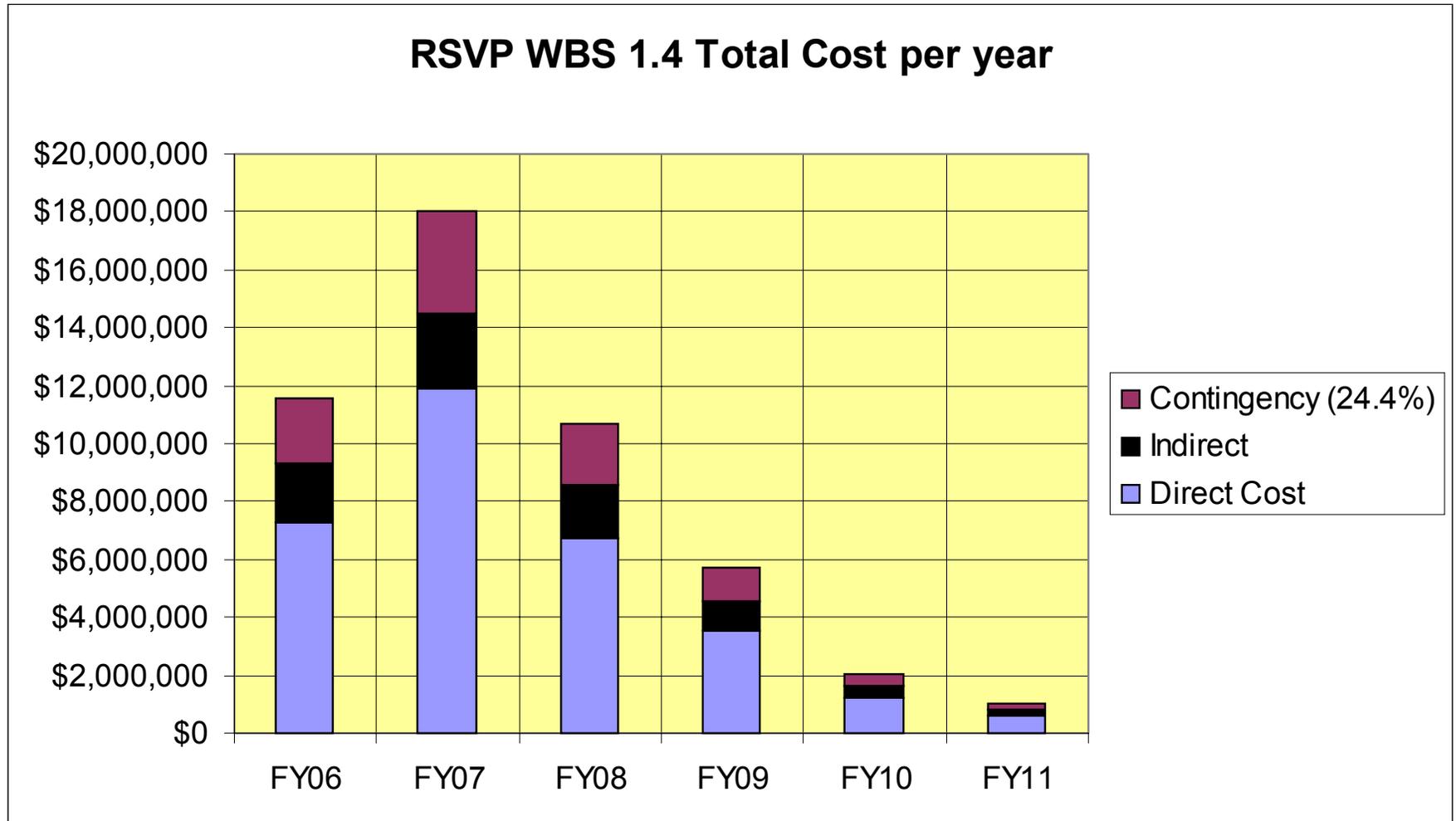
## NSF Major Research Equipment Facility Construction funds

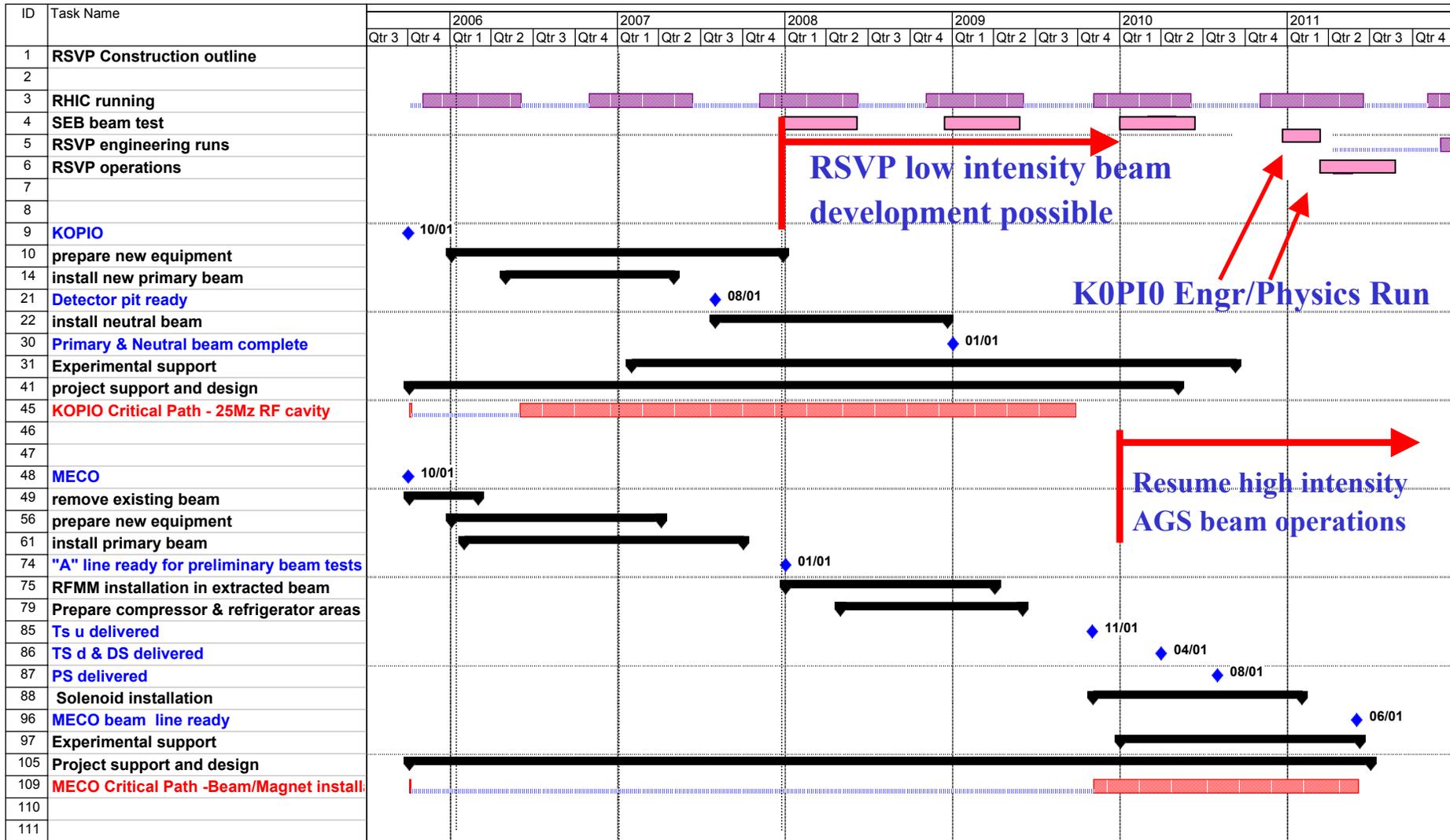
(no DOE funds used for this)

### AGS Level 3 Cost & Contingency Roll-up

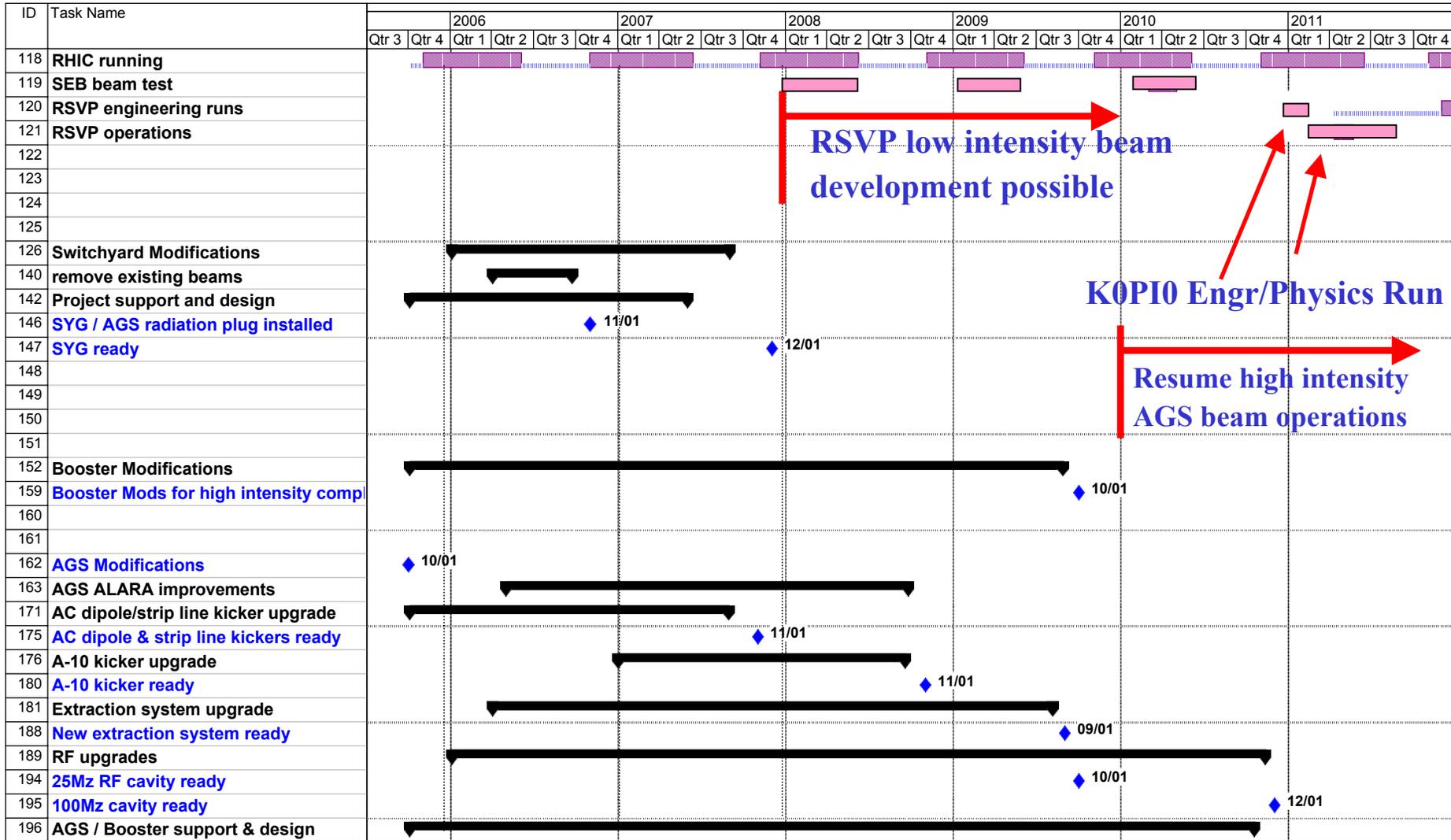
|              | System Name                      | Material Costs      | Labor Costs         | Base Cost           | Contingency Costs  | Total Cost          | FTEs         |
|--------------|----------------------------------|---------------------|---------------------|---------------------|--------------------|---------------------|--------------|
| <b>1.4</b>   | <b>AGS Upgrade Project</b>       | <b>\$15,302,238</b> | <b>\$24,072,003</b> | <b>\$39,374,241</b> | <b>\$9,588,331</b> | <b>\$48,962,571</b> | <b>146.5</b> |
| <b>1.4.1</b> | <b>Booster/AGS Modifications</b> | \$8,306,101         | \$9,892,651         | \$18,198,752        | \$4,525,773        | \$22,724,525        | 61.1         |
| <b>1.4.2</b> | <b>Switchyard</b>                | \$947,347           | \$1,966,809         | \$2,914,156         | \$596,473          | \$3,510,629         | 13.2         |
| <b>1.4.3</b> | <b>KOPIO</b>                     | \$3,914,839         | \$4,131,680         | \$8,046,519         | \$2,186,495        | \$10,233,014        | 26.0         |
| <b>1.4.4</b> | <b>MECO</b>                      | \$1,995,351         | \$5,860,208         | \$7,855,559         | \$1,807,738        | \$9,663,298         | 36.8         |
| <b>1.4.5</b> | <b>AGS Project Office</b>        | \$138,600           | \$2,220,655         | \$2,359,255         | \$471,851          | \$2,831,105         | 9.5          |

# WBS 1.4 costs (FY05\$)





# Machine construction milestones



RSVP low intensity beam development possible

KOPI0 Engr/Physics Run

Resume high intensity AGS beam operations

# Final Comments

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- **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**

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# 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.”**

**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.**

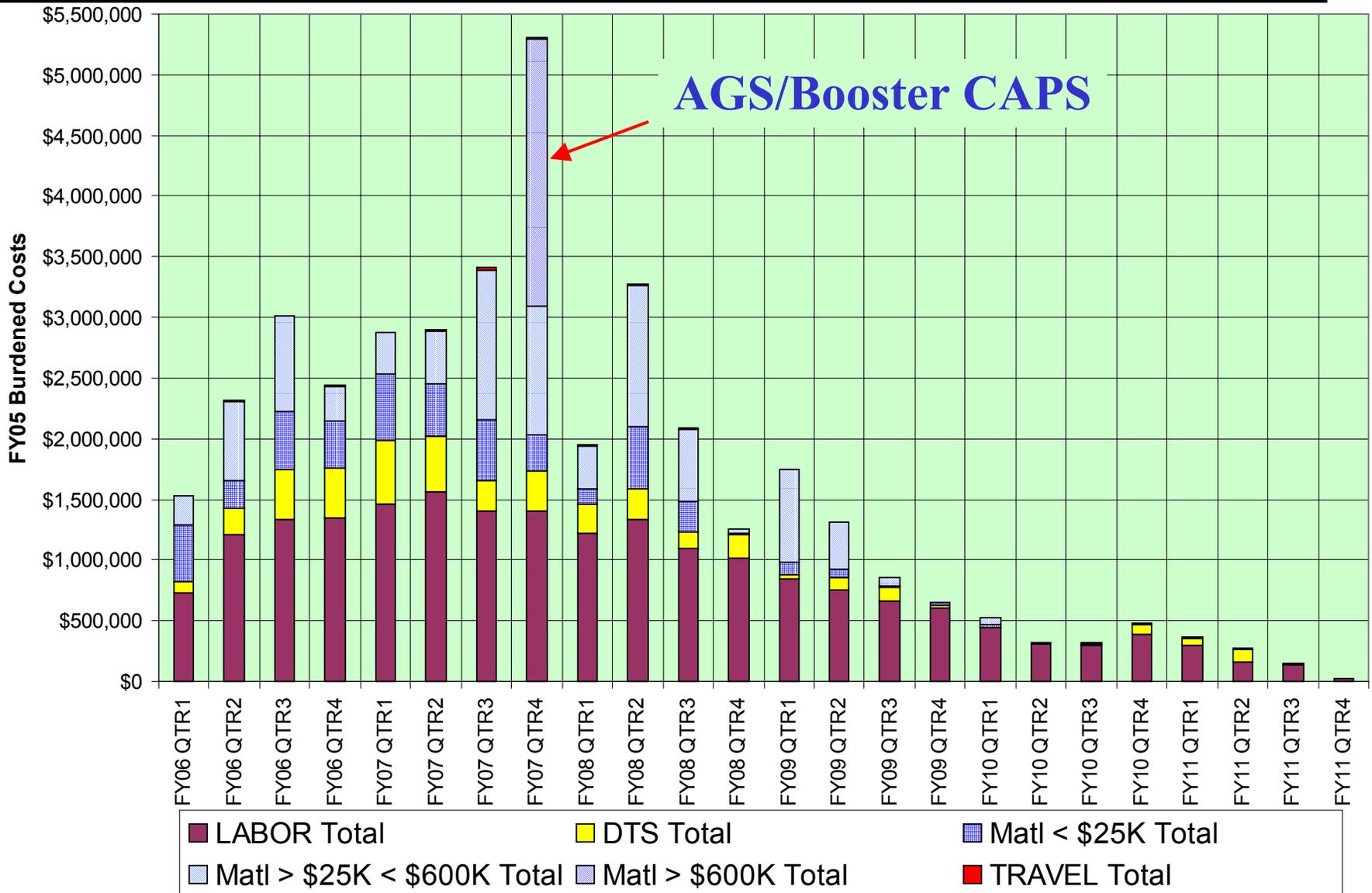
## TRIUMF Responsibility

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

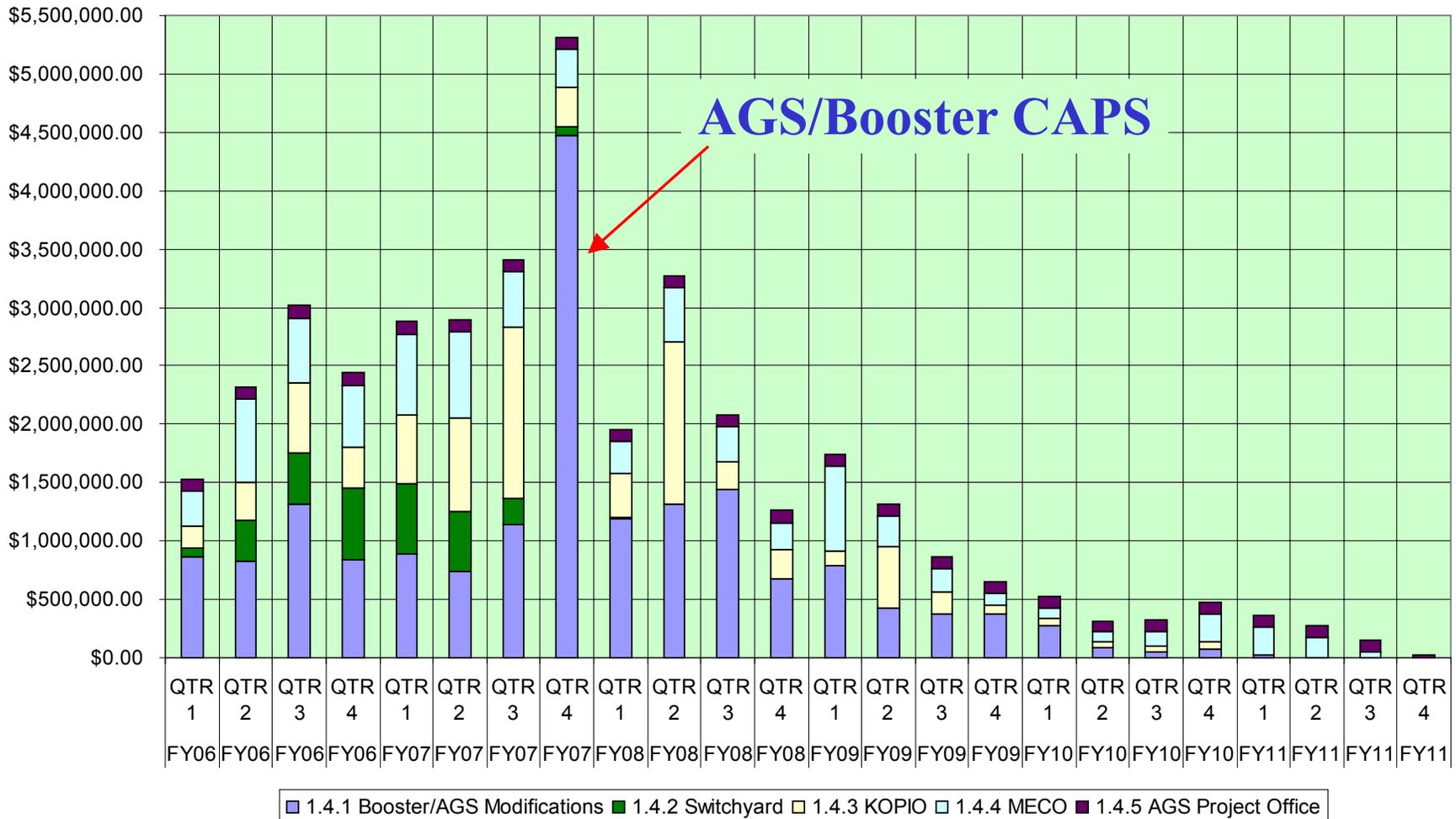
1. 25 MHz Design Collaboration and Interface/Controls
2. Injection Kickers P.S Building and Interface/Controls
3. 100 MHz RF Cavity

# WBS 1.4 SUMMARY COST



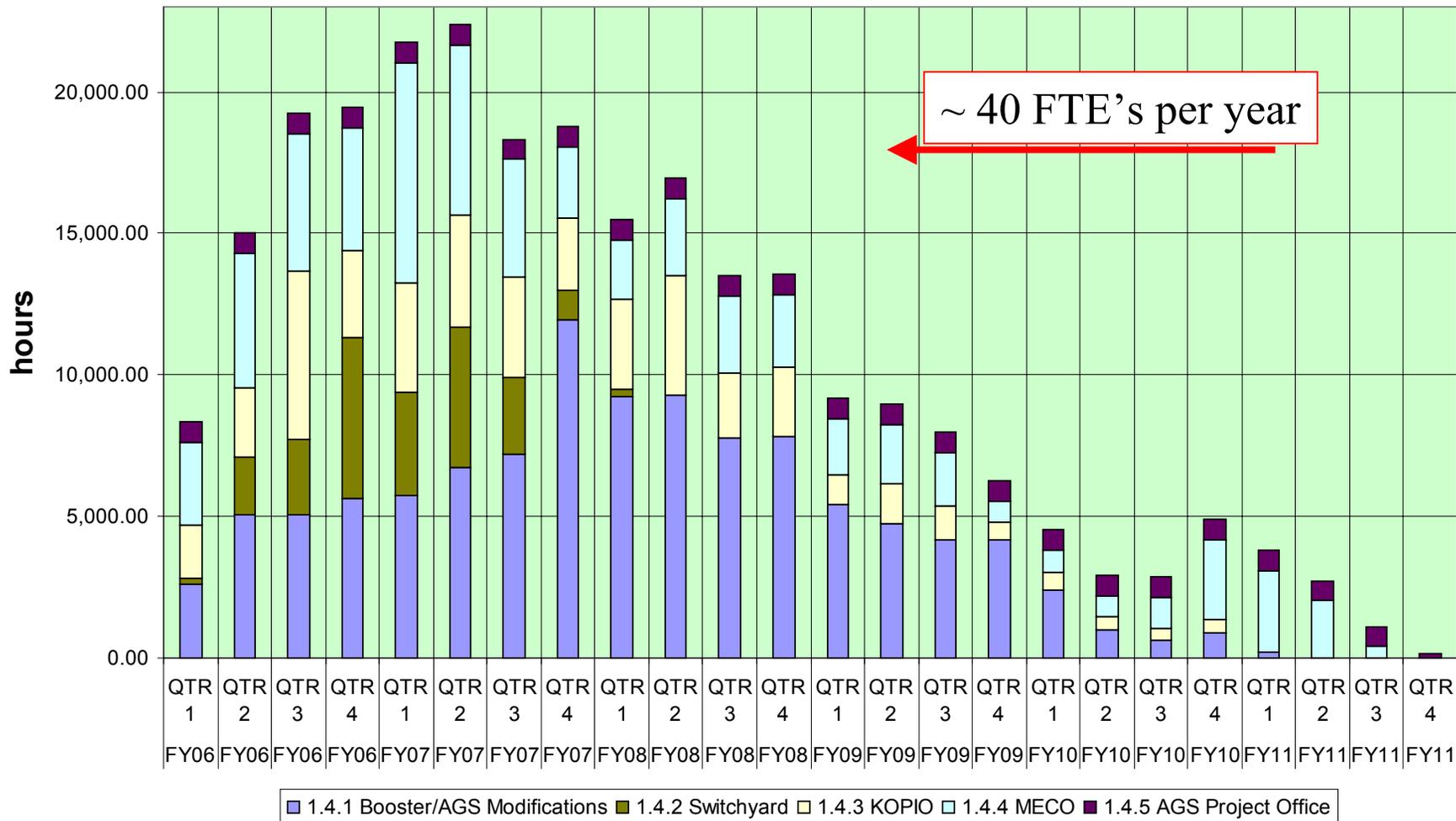
# WBS 1.4 costs (obligated)

1.4 AGS UPGRADES PROJECT  
FY05 Burdened COST



# WBS 1.4 Work

## 1.4 AGS UPGRADES PROJECT WORK



- (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  |               |               |               |               |               |               |               |
|---|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
|   | FY11#         | FY12          | FY13          | FY14          | FY15          | FY16          | FY17          |
| <b>RHIC Cryo Weeks</b>  | 27            | 27            | 27            | 27            | 27            | 27            | 27            |
| HI-HI Phys. Wks.  | 10            | 10            | 10            | 10            | 5             | 5             | 0             |
| pp, pHI Phys. Wks.  | 5             | 5             | 5             | 5             | 10            | 10            | 19            |
| Available Outside RHIC  | 10            | 10            | 10            | 10            | 10            | 10            | 10            |
| <b>TOTAL RSVP Weeks Available</b>   | 25            | 25            | 25            | 25            | 25            | 25            | 29            |
| <b>KOPIO (weeks)</b>  | 25            | 0             | 25            | 0             | 25            | 0             | 0             |
| <b>MECO (weeks)</b>   | 0             | 25            | 0             | 25            | 0             | 25            | 0             |
| <b>Outside RHIC</b>   |               |               |               |               |               |               |               |
| KOPIO   | 10            | 0             | 10            | 0             | 10            | 0             | 0             |
| MECO  | 0             | 10            | 0             | 10            | 0             | 10            | 0             |
| <b>W/RHIC HI</b>  |               |               |               |               |               |               |               |
| KOPIO   | 10            | 0             | 10            | 0             | 5             | 0             | 0             |
| MECO  | 0             | 10            | 0             | 10            | 0             | 5             | 0             |
| <b>W/RHIC pp</b>  |               |               |               |               |               |               |               |
| KOPIO   | 5             | 0             | 5             | 0             | 10            | 0             | 0             |
| MECO  | 0             | 5             | 0             | 5             | 0             | 10            | 0             |
| <b>RSVP Total Weeks</b>   | 25            | 25            | 25            | 25            | 25            | 25            | 0             |
| <b>MECO Cryo ON?</b>  | 0             | 1             | 1             | 1             | 1             | 1             | 0             |
|   | <b>FY11#</b>  | <b>FY12</b>   | <b>FY13</b>   | <b>FY14</b>   | <b>FY15</b>   | <b>FY16</b>   | <b>Total</b>  |
| <b>Personnel</b>  | \$ 2,025,632  | \$ 2,025,632  | \$ 2,025,632  | \$ 2,025,632  | \$ 2,025,632  | \$ 2,025,632  | \$ 12,153,794 |
| <b>Shift Differential</b>   | \$ 78,375     | \$ 78,375     | \$ 78,375     | \$ 78,375     | \$ 78,375     | \$ 78,375     | \$ 470,247    |
| <b>Power</b>  | \$ 3,842,748  | \$ 2,319,072  | \$ 3,842,748  | \$ 2,319,072  | \$ 3,699,948  | \$ 2,176,272  | \$ 18,199,860 |
| <b>DTS</b>  | \$ 454,914    | \$ 454,914    | \$ 454,914    | \$ 454,914    | \$ 439,637    | \$ 439,637    | \$ 2,698,930  |
| <b>SP</b>   | \$ 1,236,627  | \$ 1,236,627  | \$ 1,236,627  | \$ 1,236,627  | \$ 1,110,911  | \$ 1,110,911  | \$ 7,168,332  |
| <b>MSTC</b>   | \$ 1,910,007  | \$ 1,892,355  | \$ 1,910,007  | \$ 1,892,355  | \$ 1,883,909  | \$ 1,866,257  | \$ 11,354,892 |
| <b>MECO Fixed Costs#</b>  | \$ -          | \$ 457,328    | \$ 457,328    | \$ 457,328    | \$ 457,328    | \$ 457,328    | \$ 2,286,640  |
| <b>Indirect</b>   | \$ 3,368,746  | \$ 3,457,563  | \$ 3,451,211  | \$ 3,457,563  | \$ 3,409,989  | \$ 3,416,342  | \$ 20,561,414 |
| <b>3% FCR</b>   | \$ 387,511    | \$ 357,656    | \$ 403,705    | \$ 357,656    | \$ 393,172    | \$ 347,123    | \$ 2,246,823  |
| <b>Total</b>  | \$ 13,304,561 | \$ 12,279,523 | \$ 13,860,548 | \$ 12,279,523 | \$ 13,498,901 | \$ 11,917,876 | \$ 77,140,933 |
| Assumes energy costs are \$85/MWhr  |               |               |               |               |               |               |               |
| # Assumes MECO magnet fixed costs are paid by construction project through FY2011 |               |               |               |               |               |               |               |

# Present Switchyard Layout

