Changing Gears:

Transition from Shutdown to Operational Modes at RHIC

BROOKHAVEN NATIONAL LABORATORY

a passion for discovery

U.S. DEPARTMENT OF ENERGY | Office of Science

Background:

- RHIC (Relativistic Heavy Ion Collider) is part of the CAD (Collider Accelerator Department) at Brookhaven National Laboratory, Upton New York, USA.
- The facility is comprised of two pre-injectors (Proton LINAC and Tandem for ions), a Booster, a post booster (the AGS) and RHIC itself.
- In addition to the primary purpose of providing beam for injection into RHIC, injectors provide beam for various secondary users throughout the complex
  - Brookhaven Lab Ion Production (BLIP): Protons from 200 MeV LINAC
  - NASL Space Radiation Lab (NSRL): Ions from 2 GeV Booster
  - Proton Radiography (PTR): protons from 30GeV AGS


GORBEL
1000
Down Stream

RHIC

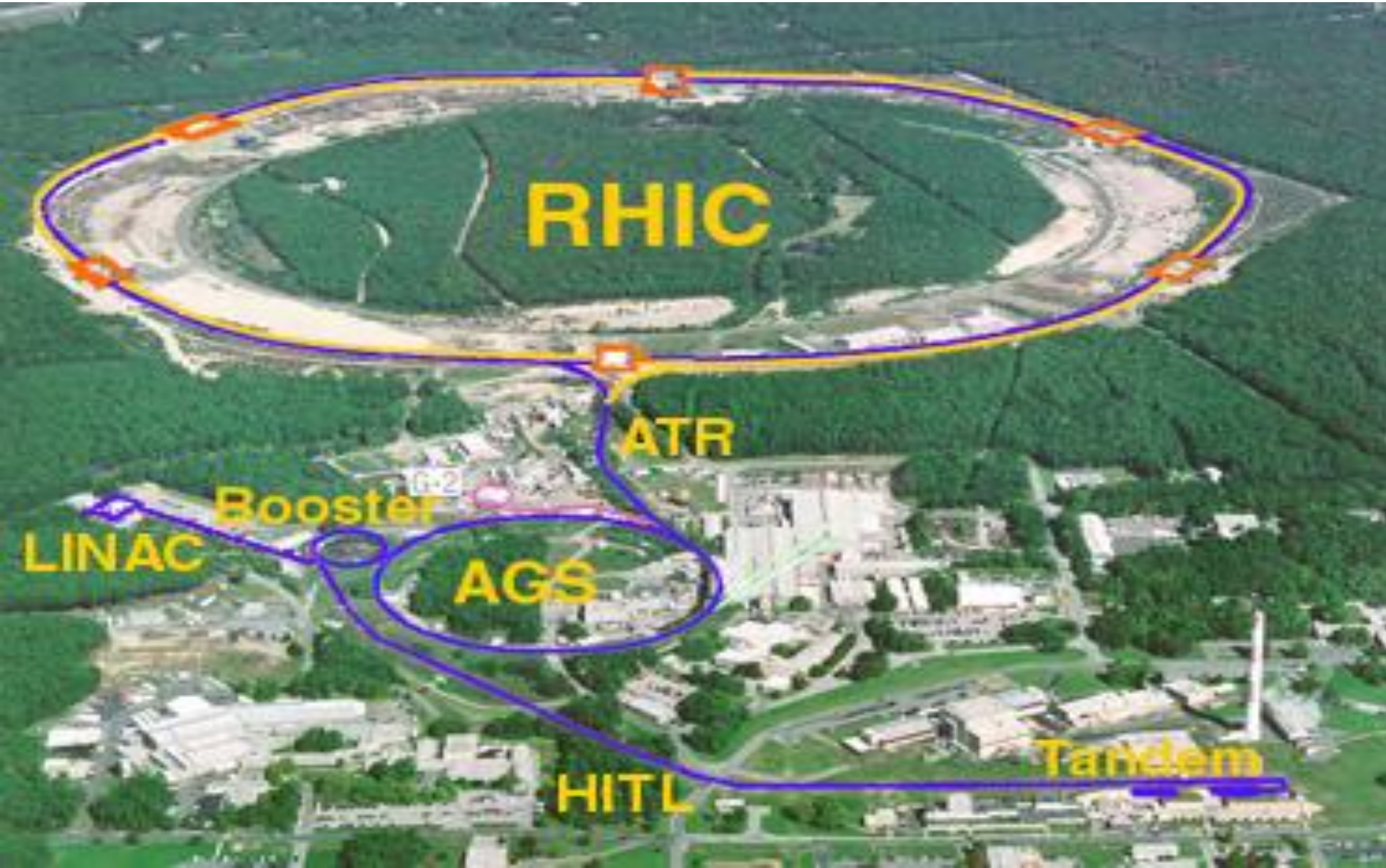
- RHIC is an accelerator and collider
  - Circumference = ~3.8km
  - Main ring consists of ~2200 main SC magnets
  - Cooled by 4k Helium gas
  - Max Dipole field = ~3.6T
  - Injection Momentum = ~30GeV (protons)
  - Max Collision = 500GeV CM (protons)
  - Cycle time varies with species and energy (nominally 10 minutes to ramp and 4-12 hours at store)
  - Capable of colliding Polarized Protons and ions through Au.

Experiments at RHIC

- Six collision points
- RF, Jet polarimeter + 4 experiments possible
- PHENIX and STAR are the two major experiments that presently run at RHIC

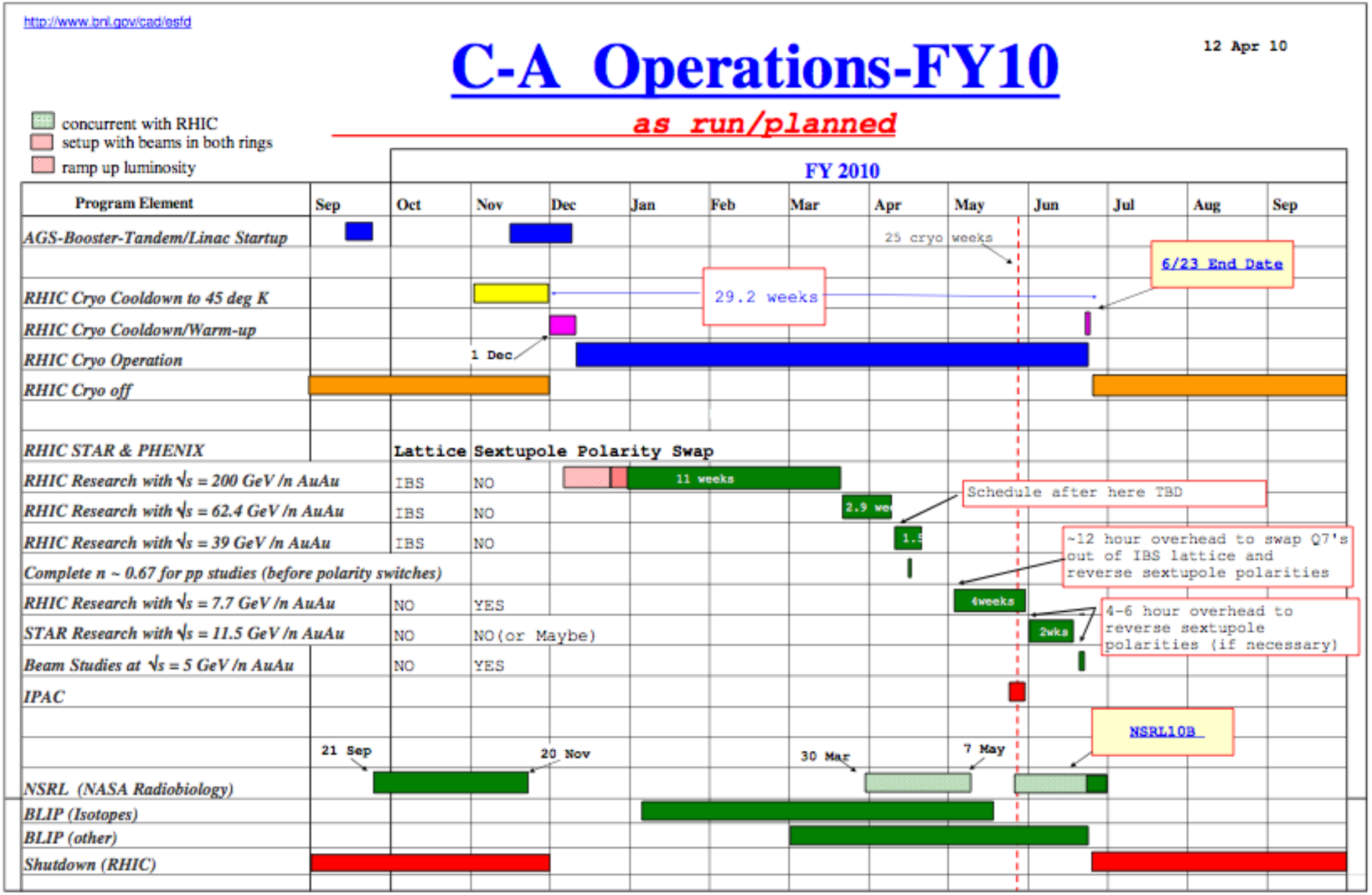
STAR and PHENIX

CAD complex at Brookhaven National Lab



The running season:

- Typically, RHIC has a single multi-month run each fiscal year.
- The run will normally start late in the fall and continues until the end of June.


http://www.bnl.gov/cad/esfd
C-A Operations-FY10
12 Apr 10
as run/planned
concurrent with RHIC
setup with beams in both rings
ramp up luminosity
FY 2010
Program Element
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
AGS-Booster-Tandem/Linac Startup
25 cryo weeks
6/23 End Date
RHIC Cryo Cooldown to 45 deg K
29.2 weeks
RHIC Cryo Cooldown/Warm-up
RHIC Cryo Operation
1 Dec
RHIC Cryo off
RHIC STAR & PHENIX
Lattice
Sextupole Polarity Swap
RHIC Research with √s = 200 GeV /n AuAu
IBS
NO
11 weeks
RHIC Research with √s = 62.4 GeV /n AuAu
IBS
NO
2.9 we
Schedule after here TBD
RHIC Research with √s = 39 GeV /n AuAu
IBS
NO
1.9
~12 hour overhead to swap Q7's out of IBS lattice and reverse sextupole polarities
Complete n ~ 0.67 for pp studies (before polarity switches)
RHIC Research with √s = 7.7 GeV /n AuAu
NO
YES
4weeks
STAR Research with √s = 11.5 GeV /n AuAu
NO
NO(or Maybe)
2wks
4-6 hour overhead to reverse sextupole polarities (if necessary)
Beam Studies at √s = 5 GeV /n AuAu
NO
YES
IPAC
NSRL10B
21 Sep
20 Nov
30 Mar
7 May
NSRL (NASA Radiobiology)
BLIP (Isotopes)
BLIP (other)
Shutdown (RHIC)

Transition to shutdown

- Configuration of the accelerators is quite different during shutdown periods.
- Machines are secured:
  - Higher level of LOTO.
  - RS LOTO is applied.
  - Water and AC systems are secured or modified.
  - Controls hardware is secured or modified.
- Areas secured during the run are unlocked for free access.
  - Berms, rooftops and other areas.
  - Radiation and other signage removed, covered or modified.
  - Road gates are opened.


Low Speed Fan #5
Caution
Verify lockout of additional
fan #5 disconnect prior to
servicing fan.

Scope of work defined

- During each shutdown major projects for upgrade and improvement projects are executed
- Prior to shutdown, group project priorities are set and individual work schedules developed
- Group schedules and workloads are then submitted, reviewed
- A departmental meeting is held where overall project priorities are discussed and set with upper management accord
- Individual groups then re-adjust their schedules for projects and PM accordingly.

Tracking and planning tools

- The status of shutdown work is:
  - On a Web based display
  - Viewable by all in the department, general pages viewable the world
  - Displayed on CCTV throughout the lab
- Job and project progress data stored in a database
  - Display tools used to view individual job data
- During Startup
  - Global access schedule
  - Startup progress schedule
  - Weekly detailed schedule
  - Startup and maintenance elogs
- Annual Shutdown Post Mortem/ Shutdown preview department wide assembly

General Access page

2009 CAD Shutdown Progress

Version November 4, 2009 P. Sampson

- ***Shutdown 09 began July 6th 2009 for RHIC***
- ***Work is progressing and at this time is scheduled to be completed in time for the scheduled Dec 1, 2009 startup.***
- ***First injection into RHIC is Dec 4th***
- ***The Booster Shutdown '09 work has been completed***
- ***NSRL experiments are presently running***
- ***Subsystems for the AGS are presently being brought on line***
- ***AGS will begin setup for RHIC injection Nov 16th at which time all shutdown work will be completed***

The table below outlines Access Modes in the accelerator enclosures:

Accelerator Access status key

No Access	
Controlled Access	
Restricted Access	

TTB Crossover						
LINAC	LINAC to run starting Jan 1					
Booster						
AGS						
AtR						
RHIC						
DATE		Nov 12	Nov 16	Nov 23	Dec 2	Dec 4

Overview with links to specifics

Follow the links below to view the timeline for completion of many of the RHIC systems as they progress through this shutdown
The General View gives an overall summary of the present situation
Items in red may extend beyond the shutdown and be completed on Maintenance Days

Group	Date Critical work is complete	Percent Complete	Comments
Vacuum	Mon 12/4/09	65%	Awaiting some parts for Stochastic, cooling vacuum and Awaiting SC some component installation. Spin Flipper work has begun. EBIS Buncher install TBD
Instrumentation/ Beam Components	Thu 12/4/09	65%	Schedule delayed awaiting some parts. Working to finish on schedule
Power supply and MMPS Maintenance/Upgrade	Mon 12/01/09	75%	Should be on time. Critical path job is valve box renovati Old MMPS systems and hardware are available as fallba
Cryo and Ring Mechanical	Tue 12/10/09	80%	On schedule.
RF Group	Fri 12/04/09	80%	On schedule
Stochastic Cooling Installation	Fri 12/04/09	55%	Awaiting completion of assembly and delivery componer
Access Controls	Fri 12/04/09	80%	On schedule.
Electricians	Fri 12/01/09	80%	Working overtime on essential jobs, delays presently bei Some delays awaiting parts

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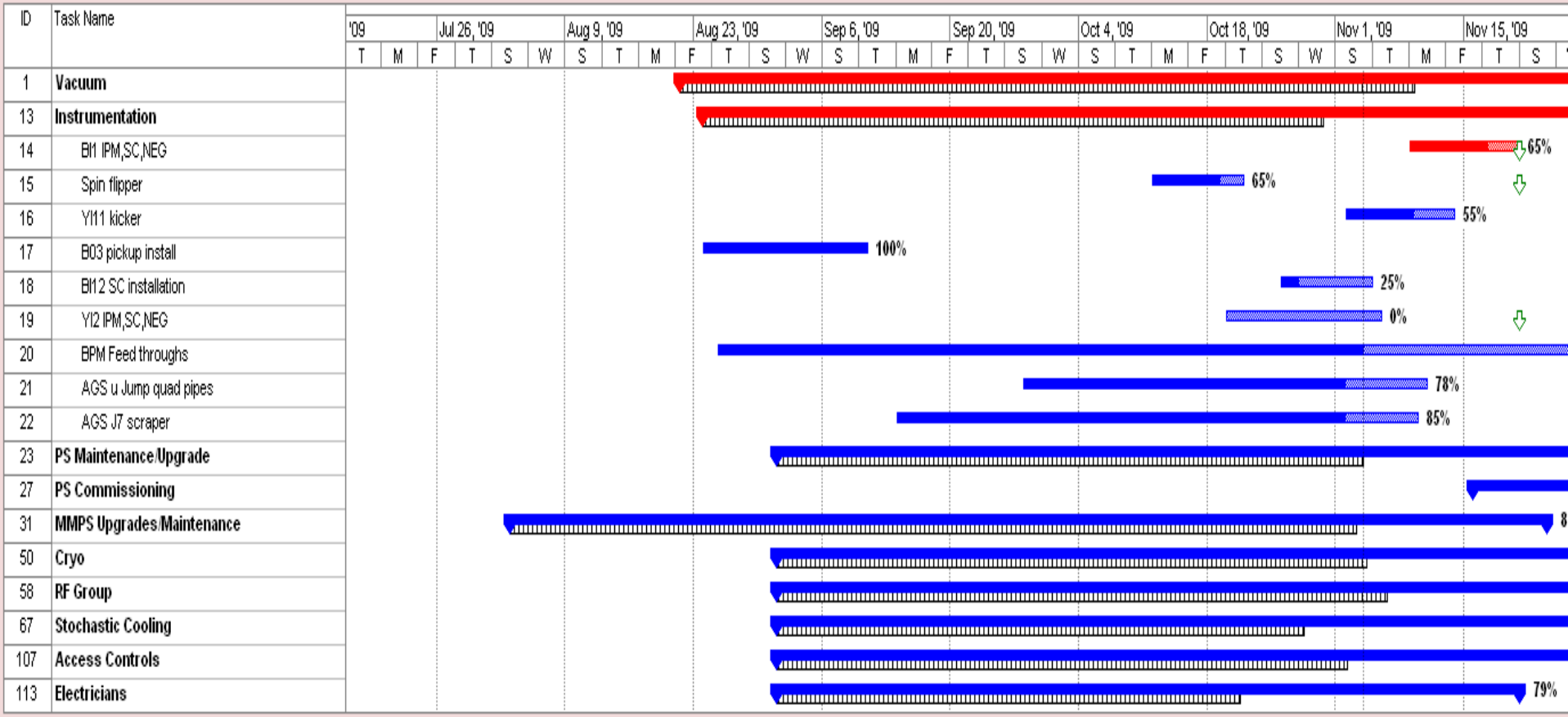
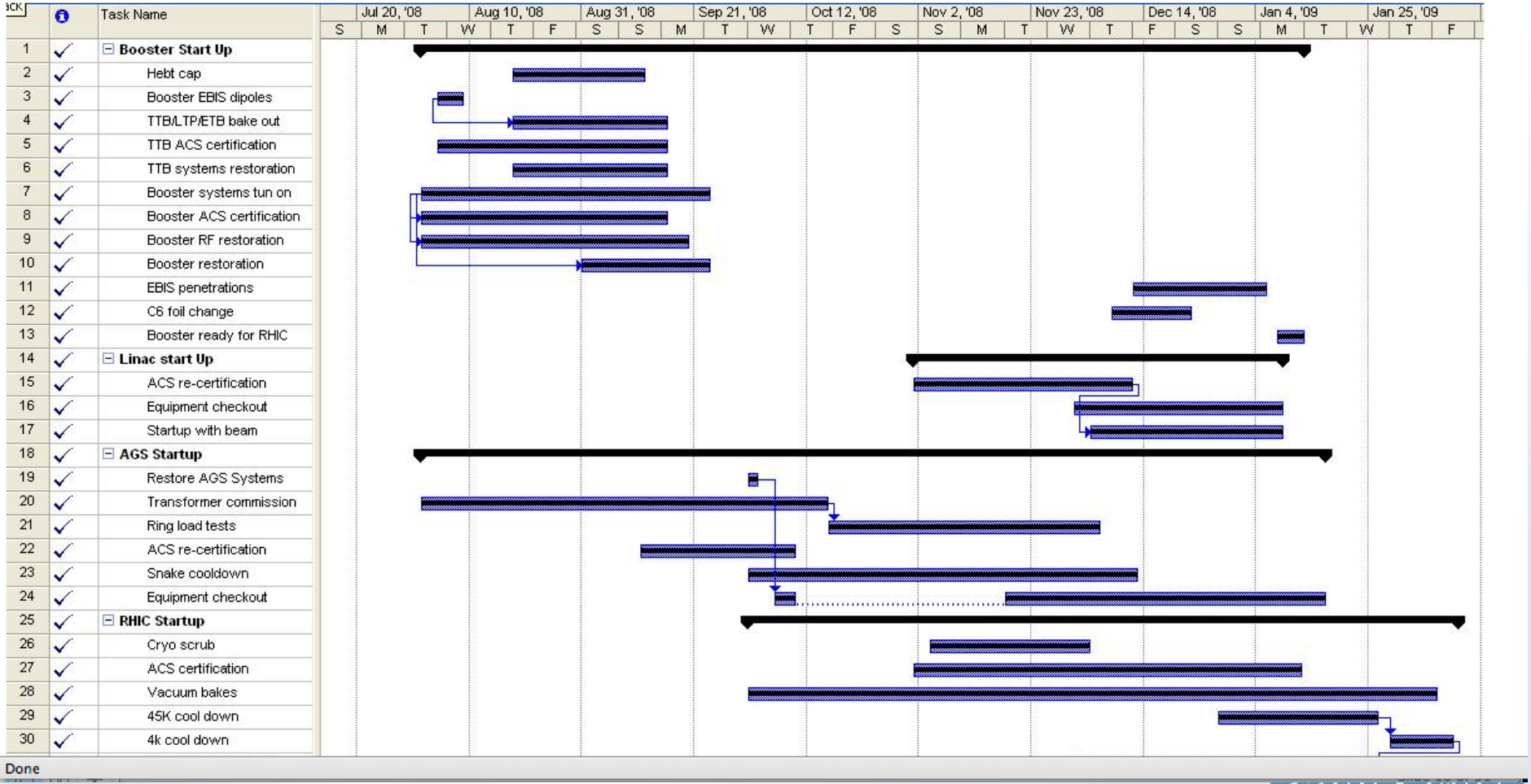
Group progress by job…

Instrumentation



Overall Startup Progress by Machine

RHIC Startup 09 COMPLETE
ver February 25, 2009 pws



By individual job or task

Linac/HEBT

Job #	Group	Job Title	Time Required	Status	Ring Access
213	Beam Components & Instrumentation	Laser Profile Monitor - Install New System	TBD wks	N	Linac
214	Beam Components & Instrumentation	EBIS Diagnostics (Linac Side) - Installation/Setup/Test	TBD hrs	N	N/A
215	Beam Components & Instrumentation	EBIS Power Supplies - Installation	TBD hrs	N	N/A
39	Beam Components & Instrumentation	C-A Video System Repairs	5 dys	C	N/A
40	Beam Components & Instrumentation	Group NRTL Related Work	15 dys	C	Linac, Tandem, Booster, AGS, BZ1, BZ2, BZ3, All RH
212	Beam Components & Instrumentation	Upgrade Linac Video System	5 dys	RS	N/A
216	Beam Components & Instrumentation	LTB Multiwire Testing - Investigate Possible Bad Wires	16 hrs	C	Linac, Booster
187	Beam Components & Instrumentation	Chipmunk Calibrations and Recertification	90 dys	C	U-Up, 1z1, 2z2, 4z1, 5z1, 6z2, 7z1, 8z2
217	Beam Components & Instrumentation	LTB Multiwires - Convert Electronic Crates to Integrator Type	TBD hrs	RS	Linac, Booster
218	Beam Components & Instrumentation	LTB Multiwires - Modify Crates for Remote Control Gain	TBD hrs	RS	Linac, Booster
219	Controls	Converting CSTs to CFEs	12 dys	N	N/A
417	Controls	Reconfiguration of Computer Room	5 dys	C	N/A
418	Controls	Operations Sybase Database shutdown	4 hrs	C	N/A
428	Controls	Control System Upgrade Configuration Installation	8 hrs	C	N/A
220	Linac	Change supplies	2 wks	RS	N/A
221	Linac	Hv Door latches	1 wks	RS	N/A
222	Linac	Rfq phase shifter	2 wks	RS	N/A
223	Linac	Replace hebt quad measure flows	1 wks	RS	Linac
224	Linac	Flush 8618 filament water lines	1 wks	RS	N/A
225	Linac	Argon Leak	16 hrs	RS	Linac
250	Linac	Installing & testing Ebis RF	8 dys	IP	N/A
226	Linac	Polarimeter work	1 wks	IP	Linac
227	Linac	Add new cables for steering magnets	4 wks	C	Linac
228	Linac	Datacon Controller Fans	5 dys	RS	Linac
229	Linac	Adjust tank quad currents and log	1 dys	RS	N/A
230	Linac	Reset all local control settings	1 dys	RS	N/A

During the shutdown:

- Systems undergo PM, upgrades, modification and testing.
- New components and systems are installed, some old systems may be removed or upgraded.
- Most of the commissioning and testing is performed during a well defined startup period.
- In order to complete these tasks effectively:
  - Sub-systems restored may need to be restored (water, cooling power etc.)
  - Specific controls must be made operational
  - Other items such as interlocks, vacuum valves, heaters, building AC…

Transition to Operations:

- There are many challenges posed by the transition of the accelerator complex from shutdown mode to operational mode.
- After several months of free access and major works, it is necessary to change not only equipment and systems but culture.
  - Workers tend to get into “Shutdown Mode” and can get frustrated when reverting to “Operations Mode”.
- In addition, many systems have been put into a power savings mode and need to be tested at full power before routine operation.
  - Scheduling power usage is a critical part of shutdown/start up and can save (or cost) big $$

Access Changes

- Many of the larger shutdown projects need the entire shutdown period (+) for completion.
- At times, materials or components arrive late causing a last minute scramble for installation and testing.
- Critical steps in the end stages of a shutdown project may include:
  - Final component installation
  - Controls and instrumentation installation and connection
  - Bake out/leak check for High vacuum
  - Final pre-beam testing
  - Final safety inspection and certification
- Most of these activities require free access to the ring and/or other areas normally secured during operations.

Site wide changes

- Postings for radiation and ODH restrict access to some areas
  - Film badges/SRDs
  - Changes to access roads – gates closed and locked
- Limits on ring access when ring >50K- ODH1
  - ODH training must be current
  - Escape packs and ODH monitors
- Current limits in the main ring
  - No Access in the tunnel for currents in the Main PS above 500A.
- Cool down activities in the tunnel
  - Thermister calibration
  - Power supply work

Live testing periods

- Access limited
- No Access to areas during Access Controls re-certification tests (~50hrs/year for RHIC)
- Safety concerns
  - Testing permits, supplemental LOTO
- Power consumption- peak power usage
- Assessment and Reaction
  - Adjustment
  - Repair
  - Reconfiguration
  - “Back out” plans

Dry Runs:

- As they become ready for a scheduled running period, each accelerator undergoes a dry run which is utilized to complete a final checkout before beam activities commence.
- During this period:
  - Access not normally permitted
  - All equipment is energized
  - All subsystems are on and in normal running configuration
  - All controls are in operational configuration
  - Expected initial super-cycles device settings, timing and system functions are loaded

Early beam studies:

- If it is desirable to complete beam studies before the scheduled run one or more of the injectors.
  - Before scheduled running
  - Special setup?
  - Special permissions?
- Have proven to be helpful for the run
  - Early detection of potential major problems
  - Decrease likelihood of delays in scheduled start up
- Impact on other work:
  - No access
  - Some equipment testing is not compatible (cause beam crash)
  - Shift in workforce focus (reduced efficiency)

Run delays avoided when starting early

- Booster cooling water flow restrictor replacement:
  - Measure flows dislodged after water pressure low (cooling water off)
  - 2 weeks to repair/restore cooling (>350 devices replaced)
- Booster MMPS transformer oil leak
  - 2 days for replacement
- AGS Main Magnet Water system
  - Leaking diaphragm valves:
  - 1 week for removal and restoration of MMPS cooling
- Main Magnet in AGS Ring short
  - 5 days for repair (in place rebuild)


UP

Other complications

- Late definition of running parameters
  - Species, energy, optics etc.
- New systems:
  - Inspection
  - Testing/Commissioning
  - Integration
- Commissioning:
  - EBIS (Electron Beam Ion Source)
    - Require parts of LINAC and Booster ready for beam
  - ERL (energy Recovery LINAC) power consumption and safety- Monitoring necessary.

Comments on other users:

- Normally run on alternate schedules
- Must resolve clashes with main (RHIC) agenda
- May use resources and/or personnel otherwise available for RHIC
- Limits shutdown and duration in some cases (NSRL)
- May force early startup
  - Some priorities many need re-assessment
- Allows for early diagnosis and rectification of problems that possibly avoiding a delay in RHIC startup.

Conclusions:

- Smooth transition from shutdown is a key element of any successful run and can be achieved by:
  - Planning and flexibility
  - Communication between groups, divisions, departments and the rest of the world
  - Early definition of running parameters
  - Scheduling
  - Taking advantage of early turn on
  - Contingency plans

Thank you