LANSCE User Group Meeting

Accelerator Operations & Technology: Performance & Proposed Schedule

November 2, 2015

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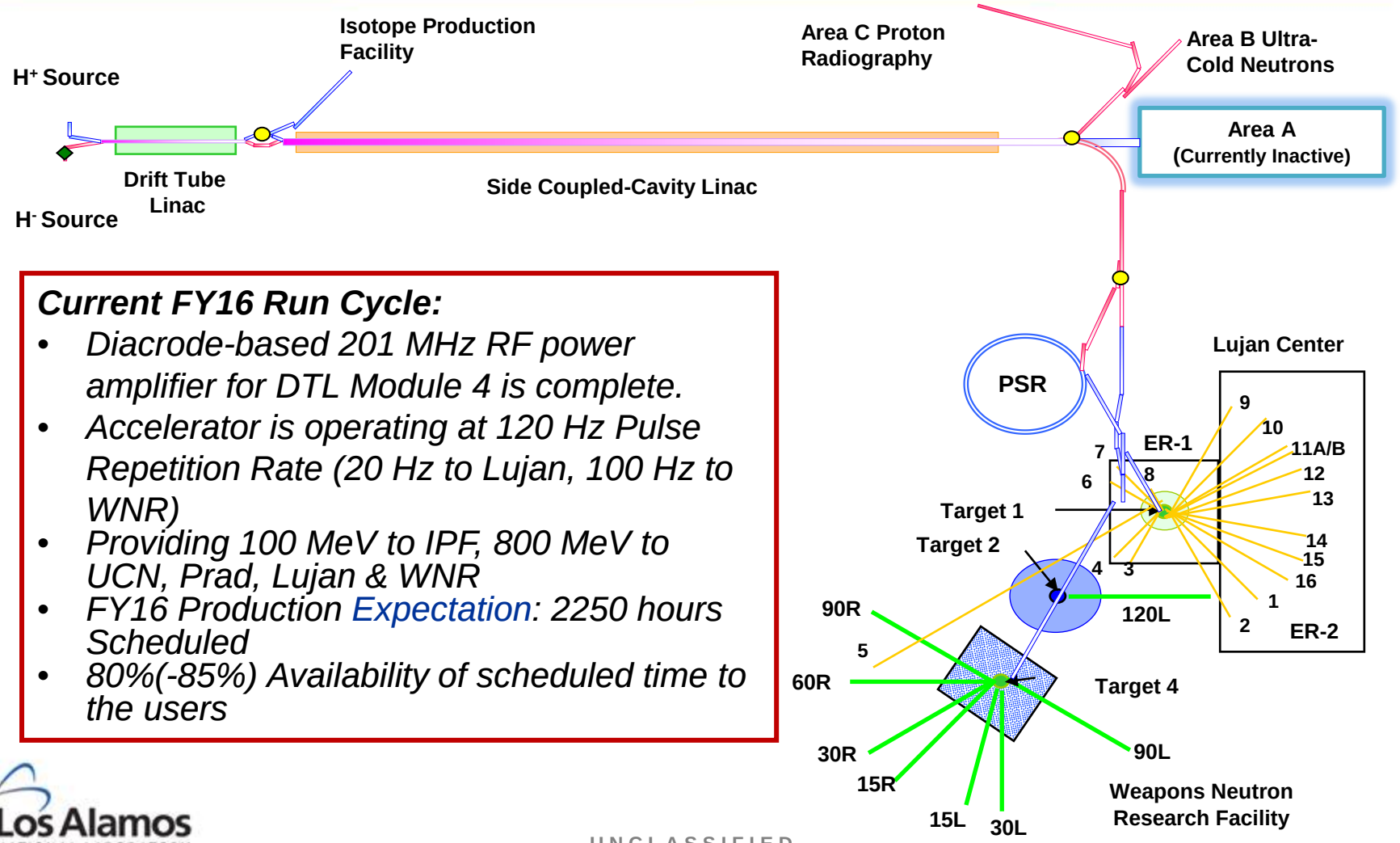
LA-UR-15-28406

Overview of the LANSCE Accelerator & Beam Delivery Complex Serving Multi-Beam Operations



Current FY16 Run Cycle:

- *Diacrode-based 201 MHz RF power amplifier for DTL Module 4 is complete.*
- *Accelerator is operating at 120 Hz Pulse Repetition Rate (20 Hz to Lujan, 100 Hz to WNR)*
- *Providing 100 MeV to IPF, 800 MeV to UCN, Prad, Lujan & WNR*
- *FY16 Production Expectation: 2250 hours Scheduled*
- *80%(-85%) Availability of scheduled time to the users*

LRM had significant impact, but we will still make investments to fully realize the operational improvements.

New 201-MHz RF System (Diacrode-based system)

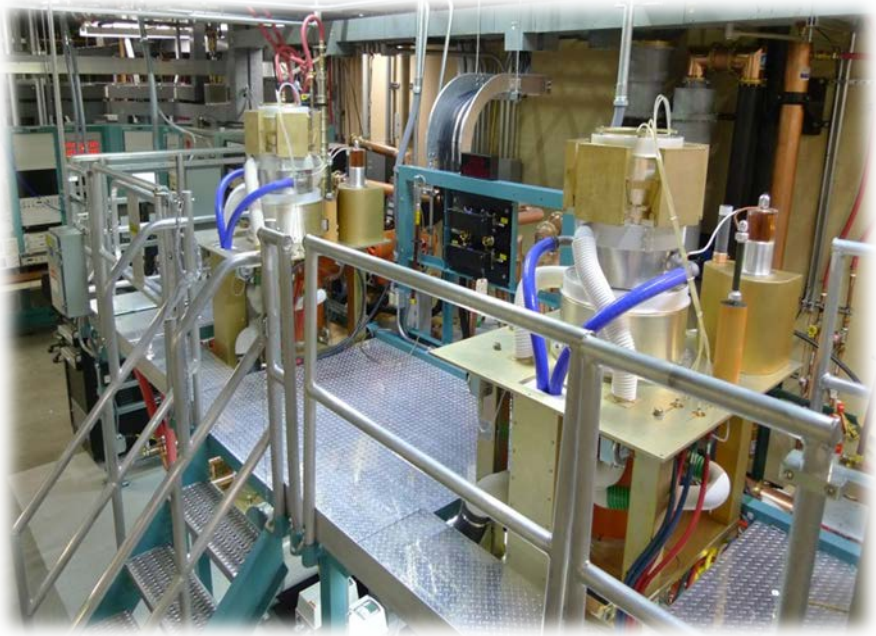
- **LINAC Risk Mitigation investments were designed to:**
  - ***Refurbish the 201 MHz and 805 MHz RF systems to regain reliable RF power system operation***
  - ***Restore sustainable 120 Hz linac operation***
  - ***Implement a modern, maintainable EPICS-based control system***
  - ***Refurbish beam transport and front-end injector systems (RFQs)***

Elements were de-scoped from LANSCE-R/LRM and remain to be addressed by future project priorities.

Linac Risk Mitigation has made significant investments in upgrades and improvements at LANSCE.

- FY14 Accomplishments
  - Installed new high-power diacrode amplifier in Module 2
  - Procured Module 4 high-power amplifier components 4 for installation in FY15
  - Installed new computer controlled water cooling systems on Module 2
  - Significant building electrical upgrades in Sector A
  - Installed new RICE and industrial controls systems in Sector A and in the 805 linac
  - Facility improvements to support new Low-Level Radio Frequency control systems throughout the 201-MHz Drift-Tube Linac and parts of the 805 linac
- FY15 Accomplishments
  - Completed Sector-A facility electrical upgrades
  - Completed high-power diacrode amplifier in Module 4
  - Procured high-power amplifier components for Module 3 to be installed in FY 2016

201-MHz, High-Power Amplifier installed on DTL Module 2 in FY14

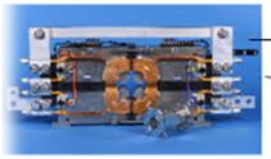


New computer controlled water cooling system installed on DTL Module 2 in FY14

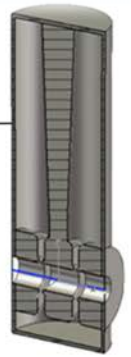
DTL Module 4 LRM Diacrode Amplifier installation in FY15

CW injectors will eventually be replaced with RFQ accelerators.

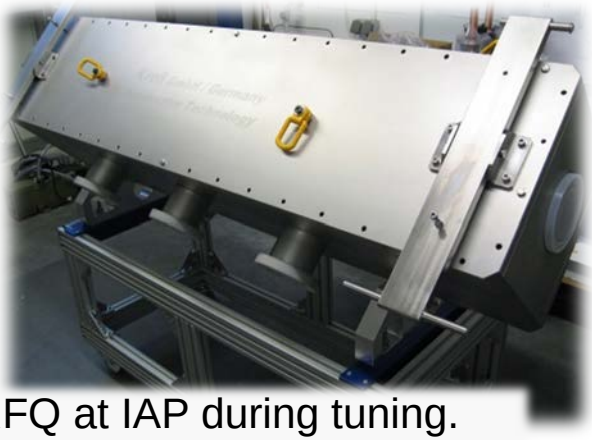
Conceptual design layout showing new H⁺ RFQ based injector (upper left) merging with existing 750 keV H⁻ LEBT (lower left) into existing common LEBT.



SNS style MEBT quadrupole.



Compact 201 MHz ¼-wave buncher cavity measures only 8 cm along beam axis.



LANSCE 4-rod H+ RFQ at IAP during tuning. Delivered to TA-53 last December.

LANSCE H+ Cockcroft-Walton Injector

Operational improvements to beam delivery performance and to enhance capabilities are on-going.

- **Feschenko Bunch Length Monitor** – allows measurement of beam longitudinal phase space; improved linac beam tuning; installation expected CY16
- **Real-Time Simulator** – goal is to use fast desktop GPU computing to model and control accelerator performance in real-time; prototype being benchmarked now
- **Improving H^- Source Performance** – higher peak output current; extending source lifetime
- **Improved H^- Chopper Rise Time and Phase Control** – improves beam to WNR, pRad, and Lujan
- **H^- Debuncher** – decouples two-beam bunching and capture; could improve peak current to WNR and pRad by up to 50%
- **PSR/1L Target Options** – pulse stacking, moderator modifications for fast neutrons
- **Revitalization of Beam Delivery to Area A** – multiple beam applications

$5.2M Office of Science investment in IPF Accelerator Improvement Project – Goals / Deliverables

Summary of Key and Ultimate Performance Parameters.		
Focus area	Key Performance Parameters	Ultimate Performance Parameters
Beam Window	Capable of **operation up to 300 μA** with new temperature and/or window deflection indications.	Capable of operation up to 450 μA with new temperature and window deflection indications.
Active and Adjustable collimator	New design with four electrically isolated sectors for beam spill monitoring and with active cooling for thermal management.	Active and Adjustable Collimator with an aperture of 1.4" to 2.3" that accommodates target sizes between 1.5-2.5 inches based upon present beam window design. Capable of handling high intensity beam spills – additional guard ring as backup.
Beam Raster	Provide **selectable circle raster patterns** with one, two or three circles each.	New system is capable of generating alternate raster types (e.g. spiral) including concentric circle patterns containing up to 100 circles.
Beam Profile Monitor/Emittance Measurement	**Capable of profiling unrastered beams** near target bulk shielding **with 1 mm or better resolution**; capability to measure beam emittance in beamline section following final IPF dipole IPBM01.	Additional capability of real-time monitoring of low average-power rastered beams.
Beam Current Measurement	**Measurements with 1% accuracy or better** over a range from 100 nA to 500 μA.	Additional capability of near real time (second time scale) beam current monitoring with 5% accuracy or better at low beam currents.
Beam Energy Monitoring	**Real-time energy monitoring** for 100-MeV beam with a resolution of 50 keV.	Additional real-time energy monitoring for 41- and 72-MeV beams with a resolution of 50 keV.

What's driving the FY16 to FY20 budget request?

The 5 year to MaRIE plan

- FY10 through FY14, the integrated LANSCE facility had stable operations and LRM funding at ~$77M/yr.
- In FY15, with the completion of Phase 1 of LRM, the LRM budget was reduced 50%. In addition, the M&O budget was reduced 4.3%. Effective allocation was $63.6M.
- LANSCE accommodated these cuts in FY15 by:
  - *Reducing scheduled operations by 10% - effectively reduced available pRad time by 25%*
  - *Effectively halted LRM work except for 201-MHz Module 4 RF replacement and Module 3 procurement + limited IC&D procurements*
- The FY16 budget enables a return to historical on-call posture, returning the 10% cut to the Users.

Stable FY16 thru FY20 operations are important considerations as we position ourselves for MaRIE.

We have developed a five-year operations plan with a transition to MaRIE with defined decision points.

Total yearly burdened operation costs (RTBF-equivalent) of $75M (FY16)

- Drives linac at 120 Hz with beam delivery to the present 6 targets.
- No procurement or construction of a new 1L target – that decision should be evaluated within 2 years.
- Continues critical investments in Linac infrastructure to maintain facility research availability and to prepare the proton linac for MaRIE.
  - *201-MHz power amplifier work is completed in FY16 (Module 3)*
  - *Includes $3M in sustainability investments in Linac including critical spares*
- Maintains accelerator operations expertise and infrastructure until needed for MaRIE construction (CD-2 activities begin in FY21)
- Phases LANSCE operations budget with MaRIE construction “heavy-lift” ($200M) in FY21

Additional critical investments will be required to sustain operations and maintain high availability.

Critical Spares

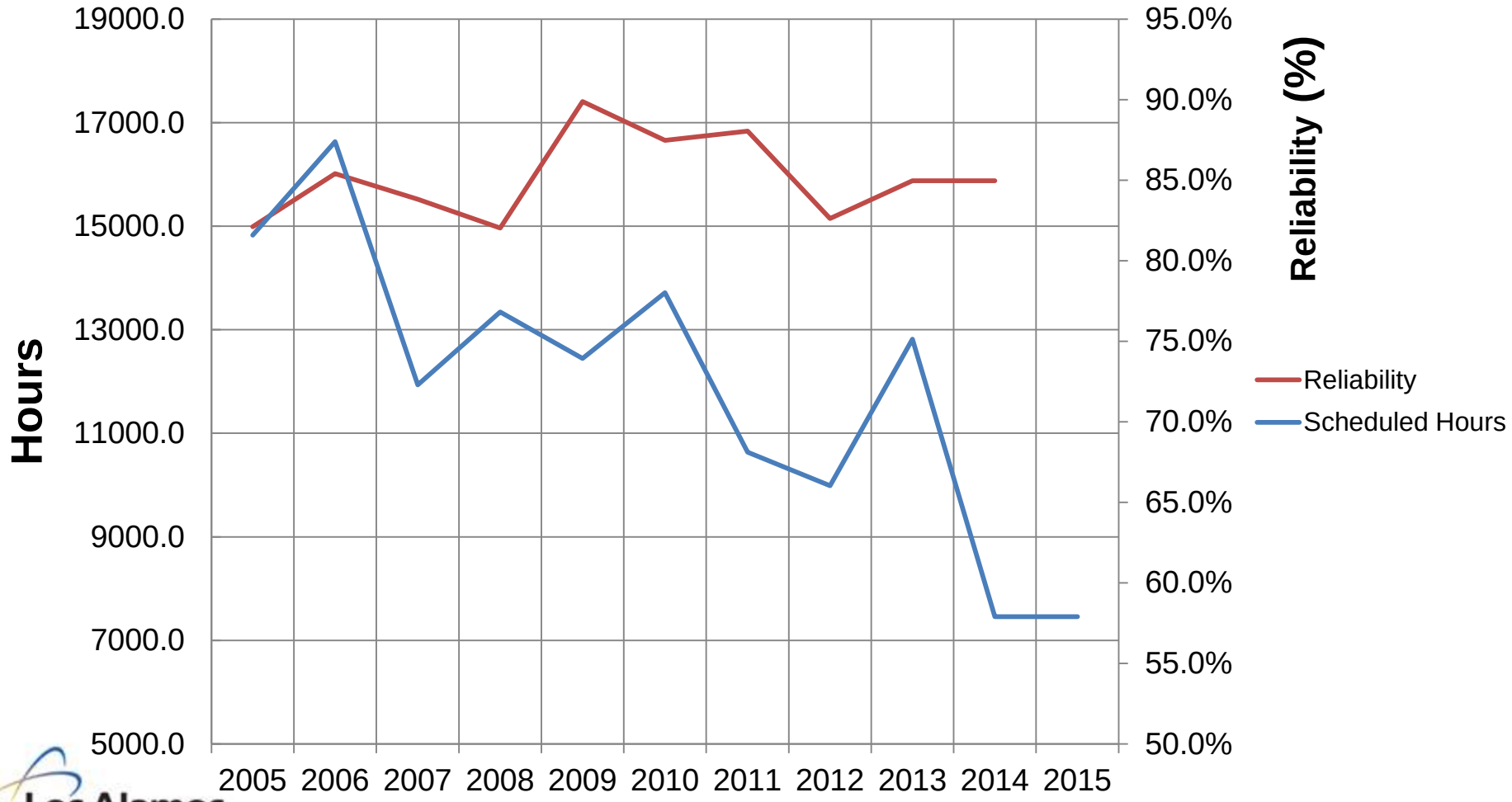
- Module 2-4 Diacrode Systems Spares
- Vacuum Ion Pump Arrays
- Modulator Decks
- Beam Position Monitors
- Magnet Power Supplies

Sustainability and Availability

- High-Voltage IVR Rebuilds
- Wire Scanners
- Rice to EPICS Controls Conversion
- LLRF Controls Replacement
- DTL Tank-1 Water System Upgrade
- Module 1 7835 System Spares

Includes significant work scope impacted by loss of LRM funding.

LANSCE Complex Integrated Hours and Reliability (2005-2015)



Reliable beam was delivered to all LANSCE experimental areas in FY15.

Area	Delivery Dates	Scheduled	Delivered	Reliability
IPF	01/07/2014 08:00 02/03/2014 08:00 & 10/11/2014 16:00 12/22/2014 08:00	110553 min. (1842 hrs.)	97165 min. (1619 hrs.)	87.9%
Lujan	01/07/2014 08:00 02/05/2014 08:00 & 10/19/2014 08:00 12/22/2014 08:00	100224 min. (1670 hrs.)	80430 min. (1340 hrs.)	80.2%
pRad	01/07/2014 08:00 02/04/2014 17:00 & 10/12/2014 07:00 12/20/2014 17:00	22068 min. (368 hrs.)	17877 min. (298 hrs.)	81.0%
UCN	01/07/2014 16:00 02/04/2014 08:00 & 10/16/2014 00:00 12/22/2014 08:00	59752 min. (996 hrs.)	55379 min. (890 hrs.)	89.3%
WNRT2	01/28/2014 16:00 02/04/2014 08:00 & 12/20/2014 08:00 12/22/2014 16:00	10163 min. (169 hrs.)	8934 min. (149 hrs.)	87.9%
WNRT4	01/07/2014 08:00 01/17/2014 16:00 & 10/19/2014 16:00 12/19/2014 16:00	71051 min. (1184 hrs.)	48527 min. (809 hrs.)	68.3%

Target problems while in production.

CY 2014 Beam Reliability Summary

Reliability Goals:

- Lujan - 80%
- WNR – 80%-85% (Programs)
- IPF, pRad, UCN – on-demand; expected high

CY 2015 Beam Reliability Summary (Jan-Feb, Oct-Present)

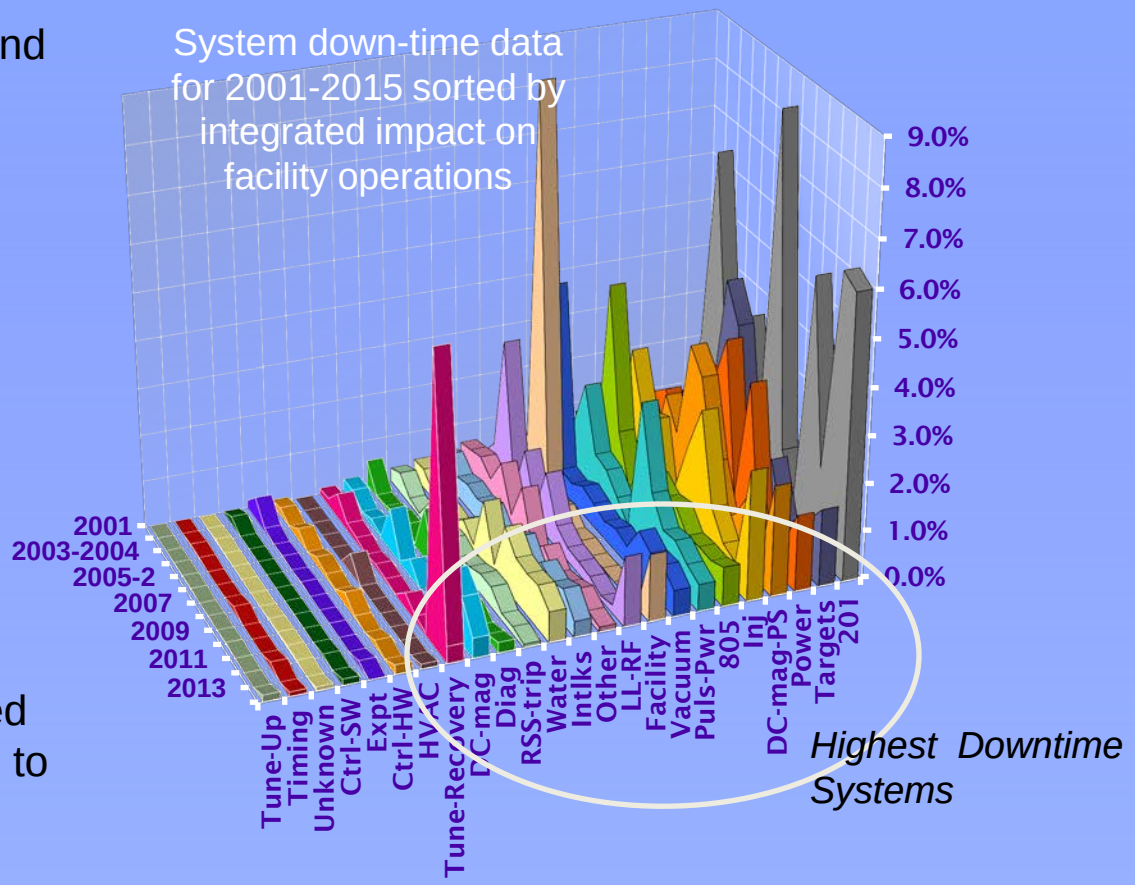
Area	Reliability
IPF	89.1%
Lujan	76.8%
pRad	90.8%
UCN	83.4%
WNR T2	N/A
WNR T4	79.1%

Careful system evaluation and accounting of downtime was used to prioritize risk mitigation focus.

Unreliable, end-of-life, and obsolete systems were identified:

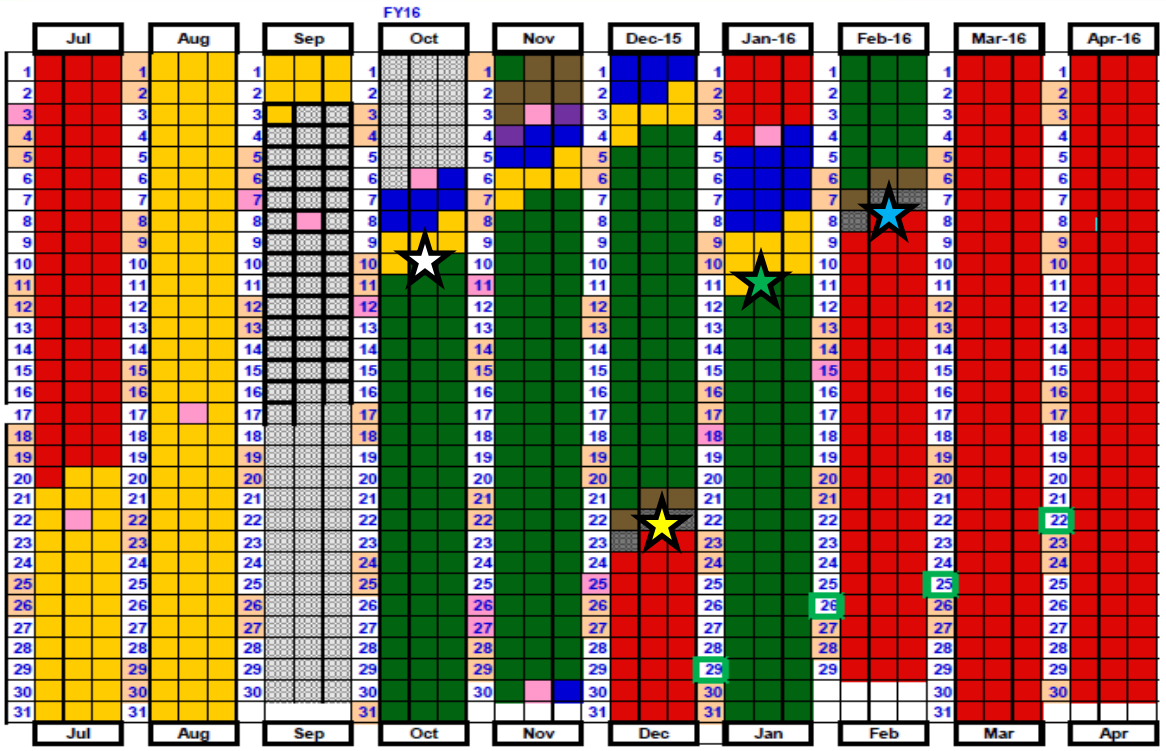
- RF systems
- DTL water system
- Controls
- Linac diagnostics
- DTL drift tubes
- Front-end injector systems

Significant progress has been made but continued investments are needed to ensure sustainable and reliable operations.



CY 2015/2016 LUF Operating Block Schedule v 3.0

- ***Oct 10 - FY16 Production***
- ***Dec 23 - Holiday Shutdown***
- ***Jan 11 - Return to Production***
- ***Feb 16 – CY 2016 Maintenance Outage Starts***

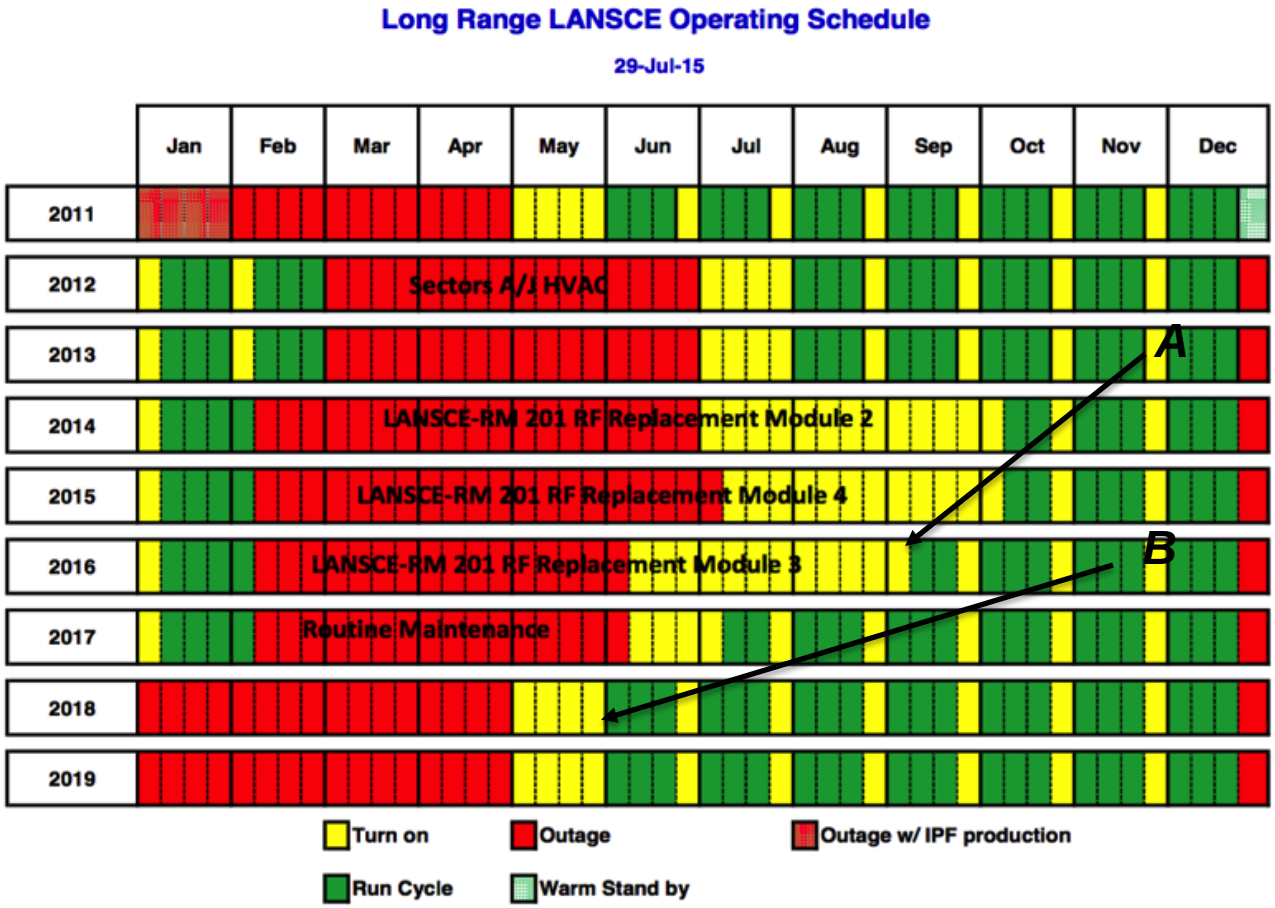


Legends:

General operations

- Outage maintenance all areas
- Scheduled maintenance all areas
- Development
- Production to all areas
- 201 Systems integration, commissioning and turn on other areas
- IPF 40 MeV sole use run
- Day for day schedule slip
- Close Sector A for 201 conditioning
- Ion source recycle/scheduled maintenance
- Documentation/Shutdown
- # Holiday and/or laboratory closure
- # Weekend
- Production beam to IPF
- Tgt 2 Linac Beam, Production other areas
- pRad production contingency, production all other areas

Proposed CY 2015-19 LUF Run Schedules as we come out of the 201-MHz Diacrode upgrades:



Between A & B, we will implement a transition back to Standard Outages/Production during CY17 back to 4 months maintenance, 1 month start-up, 21 weeks of production.

Summary

- Overall LANSCE accelerator operational reliability remains high.
- The LANSCE Linac Risk Mitigation strategy was to ensure the continued long-term reliability and availability of the LANSCE accelerator.
- The FY16 to FY20 budget request is designed to ensure appropriate funding for sustainable operations.
- Continued investments need to be made to sustain reliable operations for the long-term (*5 years to MaRIE*).
- Reliable future LANSCE operation is critical to the success of MaRIE as a multi-probe dynamic test facility.