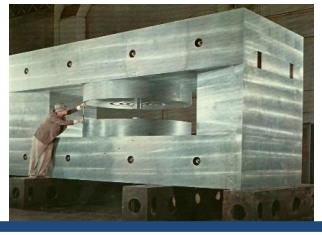
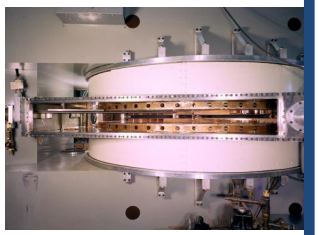
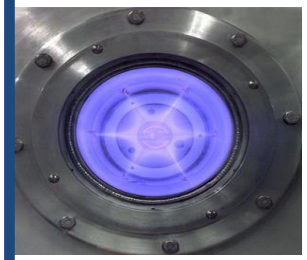
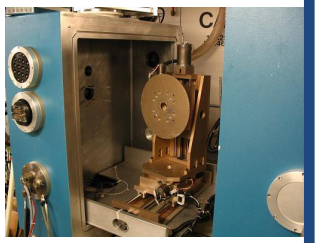
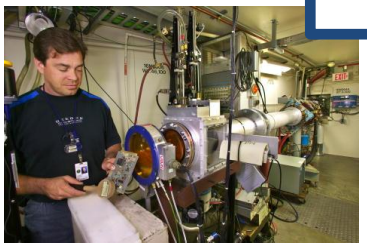
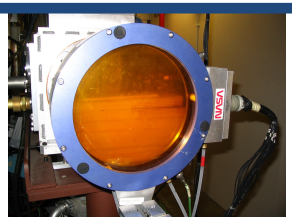
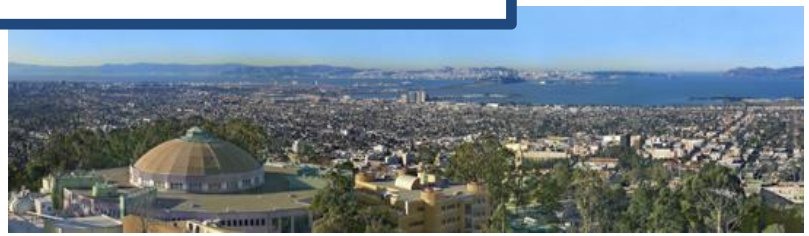
88-Inch Cyclotron Operations





BERKELEY LAB

Larry Phair

Charge

Department of Energy
Washington, DC 20585

February 20, 2020

Dr. Barbara Jacak
Lawrence Berkeley National Laboratory
1 Cyclotron Road, Mail Stop 50R4049
Berkeley, CA 94720

Dear Dr. Jacak:

The Department of Energy (DOE) Office of Nuclear Physics' (NP) Facilities and Project Management Division is in the process of organizing an Operations Review of the 88-Inch Cyclotron at Lawrence Berkeley National Laboratory (LBNL). As you are aware, the review will take place at LBNL on March 4-5, 2020.

The 88-Inch Cyclotron has experienced uncertainty in outside funding sources in the recent past which have introduced risks to facility staffing levels and operations. This review will consider actions taken to decrease the dependence of the facility on non-NP funding sources and the resources needed to implement the current NP and applied programs (Scenario 1). The 88-Inch Facility is proposing to enhance its role in the international Super Heavy Element (SHE) Research Community. While the scientific merit of that proposal will not be considered here, this review will assess the additional facility resources, capabilities, and development of beams that would be needed to implement the enhanced SHE effort (Scenario 2). Finally, this review will consider the viability of operating the Facility at full capacity and will assess the resources and capabilities needed to ensure robust operations at full capacity (Scenario 3).

In particular, the review panel will be requested to address the following questions:

1. Facility scope and risk mitigation: What is the current scope of operations in support of the Facility mission? What is the five-year vision of the Facility and are proposed initiatives well-aligned with implementing the five-year vision? Have adequate and appropriate steps been taken since the last operations review to mitigate risks resulting from uncertainties in non-DOE funding?
2. Workforce levels: Is the Fiscal Year (FY) 2020 staffing level and proposed staffing plans for Scenario 2 and 3 appropriate and optimized? What resources are required to support staffing levels in each scenario?
3. Facility performance and maintenance: Since the last operations review, has the performance of the Facility been reliable and sound, and do facility accomplishments have merit and impact? Is the Facility plan to maintain operations, including deferred maintenance and single point failures, complete and appropriate? What resources are required to support reliable operations for each of the scenarios?

4. New capabilities: Are the plans for facility developments, improvements, and new capabilities needed to implement each of the scenarios, complete, appropriate, and feasible, and in support of the Facility vision? What resources are required to implement new capabilities for each of the scenarios?
5. Rates and partnerships: Is the strategy for allocating beam-time to stakeholders over the upcoming five year period appropriate and sound? Are the proposed hourly rates for different stakeholders reasonable and ensure full-cost recovery for non-NP work? Have synergistic opportunities for partnerships amongst stakeholders been identified?

The first day will consist of presentations by the Laboratory and executive sessions. The second day will be used for presentation of homework, breakout sessions, if needed, and an executive session for preliminary report writing. A brief close-out will take place in the late afternoon. Preliminary findings, comments, and recommendations will be presented at the close-out.

Dr. James Sowinski, Program Manager for Nuclear Physics Facilities, will chair this review. He can be contacted at (301) 903-7587, or e-mail: James.Sowinski@science.doe.gov. The panel members have been instructed to contact Ms. Sandra Ritterbusch at LBNL at (510) 486-5146 or E-mail: SERitterbusch@lbl.gov regarding logistics questions. Word processing, internet connection, and administrative assistance should be made available during the review.

Each panel member is being asked to review all aspects of the 88-Inch Cyclotron program. They will be asked to write individual "letter reports" on their findings. The chairperson will accumulate these "letter reports," and compose a DOE report based on the information in the letters.

I greatly appreciate your efforts in preparing for this review. It is an important process that allows our office to understand the scope of activities and associated costs of operating the facility. I look forward to a very informative and stimulating visit.

Sincerely,

Jehanne Gillo
Director
Facilities and Project Management Division
Office of Nuclear Physics

Enclosure

Charge: 3 scenarios

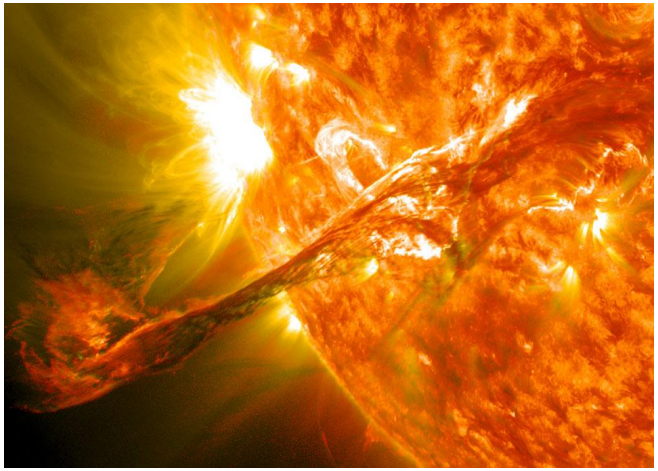
- **Scenario 1** is "now."
  - What have we done to decrease the dependence of the facility on non-NP funding sources?
  - What are the resources needed to implement the current NP and applied programs?
- **Scenario 2** is the super-heavy element (SHE) search, 2,000 hours/year. Looking for element 120, in addition to current basic science work. 4,000 hours total.
  - What additional facility resources, capabilities, and development of beams would be needed?
- **Scenario 3** is operating at full capacity (defined as 5,500 hours/year, 4,000 hours for DOE-NP and 1,500 hours other).
  - What resources and capabilities are needed to ensure robust operations at full capacity?

Charge: 5 categories

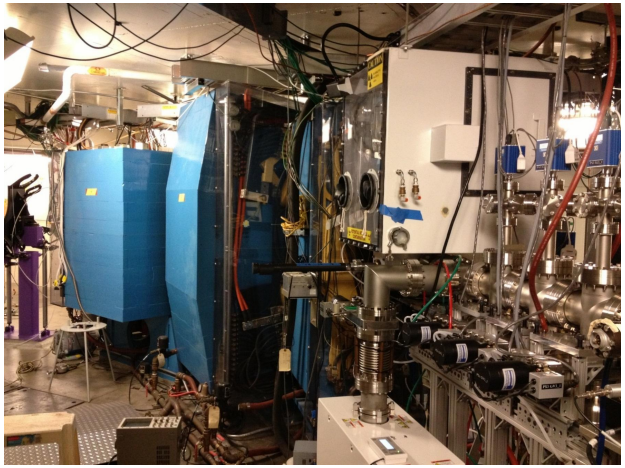
1. **Facility scope and risk**
   - A. What is the current scope of operations in support of the facility mission?
   - B. What is the five-year vision of the Facility and are proposed initiatives well-aligned with implementing the five-year vision?
   - C. Have adequate and appropriate steps been taken since the last operations review to mitigate risks resulting from uncertainties in non-DOE funding?
2. **Work force levels**
   - A. Is the Fiscal Year (FY) 2020 staffing level and proposed staffing plans for Scenario 2 and Scenario 3 appropriate and optimized?
   - B. What resources are required to support staffing levels in each scenario?
3. **Facility performance and maintenance**
   - A. Since the last operations review, has the performance of the Facility been reliable and sound?
   - B. Do facility accomplishments have merit and impact?
   - C. Is the Facility plan to maintain operations, including deferred maintenance and single point failures, complete and appropriate?
   - D. What resources are required to support reliable operations for each of the scenarios?
4. **New capabilities**
   - A. Are the plans for facility developments, improvements, and new capabilities needed to implement each of the Scenarios (1-3) complete, appropriate, and feasible, and in support of the Facility vision?
   - B. What resources are required to implement new capabilities for each of the scenarios?
5. **Rates and partnerships**
   - A. Is the strategy for allocating beam-time to stakeholders over the upcoming five-year period appropriate and sound?
   - B. Are the proposed hourly rates for different stakeholders reasonable and ensure full-cost recovery for non-NP work?
   - C. Have synergistic opportunities for partnerships amongst stakeholders been identified?

88-Inch Cyclotron Mission (1A)

2016 Bonner Prize winner I-Yang Lee working on GRETINA.



Solar filament & coronal mass ejection (CME), captured by the Solar Dynamics Observatory (SDO) in September of 2012. Parts for SDO were tested at the BASE Facility.



The Berkeley Gas-Filled Separator (BGS), used for unique national superheavy element studies.

Mission:

- A national center for heavy and super-heavy element research
- A key provider of nuclear data needed to enable and support national activities in energy, medicine, and security.
- A leading (go-to) facility for space effects measurements needed to support the US government and commercial space and aeronautics communities. This is the Berkeley Accelerator Space Effects (BASE) Facility.

Also:

- Develop world-leading ion sources.
- Train students in nuclear science.

88” Cyclotron mission history

Year	Status
2003	The 88-Inch status changes to a local user facility
Nov 2003	MOU is signed DOE, US Air Force and NRO for 2004 through 2005
Nov 2005	MOA for FY06 through FY11 is signed DOE, US Air Force and NRO
2011	Inter-agency agreement (IA) for FY11 to FY15
2016	IA for FY16-17, but only with USAF (missing half of normal funding for BASE)

- Support basic research in low energy nuclear physics and chemistry with an emphasis on training the next generation of nuclear scientists
- Facilitate R&D research program conducted at the 88-Inch facility (e.g., Nuclear Data program)
- Support national security and other US space programs in the area of radiation effects testing
- Conduct R&D directed toward ECR ion sources

Scenario 1 (now)

- What are the resources needed to implement the current NP and applied programs?

In FY18, we built a bottom up activity-based description for the facility. Apportion costs according the beam line and activity being performed. Allows for a more accurate assessment of the full cost recovery rate.

Activity-based budget. Essential changes:

- BASE technician effort completely covered by non-DOE funds
- “shared” M&S costs vs “BASE-only” M&S costs vs “DOE-only” M&S cost

DOE rate: $1,764/hour

BASE rate: $2,482/hour

- DOE-NP, IP : 2800 hours ($4.70M + 0.28M)
- NASA: 500 hours ($1.24M)
- MDA: 500 hours ($1.24M)
- WFO: (200) hours ($0.50M)

Scenario 1 continued

- What have we done to decrease the dependence of the facility on non-NP funding sources?

- Activity-based budget.
- Changed the reservation policy. If advance funding is not here within 45 days of beam time, it is sold to those on waiting list.

Scenario 3 (full capacity)

- Operating at full capacity (define). What resources and capabilities are needed to ensure robust operations at full capacity?

- DOE-NP: 4,000 hours ($5.97M)
- BASE: 1,500 hours ($3.35M)

5,500 hours is the effective “maximum” number of hours that we last ran in 2013.

See talks by B. Ninemire (reliability & maintenance), L. Phair (staffing)

Scenario 2: SHE search at the BGS

DOE-NP : 4,000 hours
BASE : 0 hours

Cost: $7.17M

What additional facility resources, capabilities, and development of beams would be needed? (See talks by R. Clark and D. Xie)

1. Facility scope and risk mitigation

1A. What is the current scope of operations in support of the facility mission?

- Scenario 1
  - DOE-NP, IP : 2,800 hours
  - NASA: 500 hours
  - MDA: 500 hours
- DOE-NP hours in support of
  - super-heavy element (SHE) phyiscs and chemistry (Clark)
  - nuclear data needed in support of national activities in energy, medicine, and security
- Ion source group provides
  - specialized beams needed for SHE work (see talks by D. Xie and J. Benitez)
  - cocktail beams for radiation effects testing (M. Johnson, J. Benitez)

Five-year vision of the Facility (1B)

1B. What is the five-year vision of the Facility and are proposed initiatives well-aligned with implementing the five-year vision?

Vision:

1) FIONA structure and chemistry experiments. (R. Clark)

2) Neutron and light ion beams for nuclear data research.

3) Completed 3 years of SHE search for element 120 (R. Clark)

4) BASE running of 1,500+ hours. (M. Johnson)

Initiatives (1B)

Example: Shared improvements of reliability (B. Ninemire)

Spare deflector rails

Spare helium compressor

Spare He refrigerator

BASE improvements (B. Ninemire, M. Johnson)

Spare Final Power Amplifier

Portable spare beamline power supply

Spare modulator

Linac booster (energy upgrade, in-air testing, D. Todd)

Cooling tower

We had a vendor bid for installed replacement for $285K

- Need to add purchasing overhead (11.8%)
- Plus ~$250K to disconnect/connect & oversee the work
- But needs include:
  - Sprinkler system on single cell tower per Fire Marshall
  - Roof lift ES&H assurance activities
  - Perceived commissioning responsibilities w/LBNL Facilities

Vendor became concerned…

Current plan: use same vendor to build custom cooling tower, other vendor to do the installation

Project plan complete and will be reviewed.

Start procurement.

Mitigate risks from non-DOE funding (1C)

1C. Have adequate and appropriate steps been taken since the last operations review to mitigate risks resulting from uncertainties in non-DOE funding?

Recommendations from last review that mitigate risk:

- Operator-tech (L. Phair and B. Ninemire)
  - hybrid position with specialized skills of both operator and technician (electrical or mechanical)
  - Can contribute to maintenance and improvement work when not on shift as operators
  - Maximize efficiency. No need to bring in additional part-time techs (from Engineering Division) during shutdowns
- Database of parts for maintenance (B. Ninemire)
- Full cost recovering using activity-based costing (developed in FY18, L. Phair)
- Schedule optimization(M. Johnson)

2. Work force levels

	Scenario 1 (now, 3800h)	Scenario 2 (SHE, 4000h)	Scenario 3 (5500 h)
Operators	5.0	5.0	6.0
Mechanical Tech	3.3	3.1	4.0
Engineers	1.7	1.7	1.9
Electrical Tech	3.8	3.8	4.7
Management	2.0	2.0	2.1
Ion Source	1.9	2.0	2.1
BASE Tech	1.0	0.0	1.0
Safety	0.8	0.9	1.0
Facilities	0.6	0.9	0.3
Eng Support	0.2	0.3	0.2
Totals (FTEs)	**20.3**	**19.6**	**23.3**
Salaries ($M)	**5.72**	**5.40**	**6.59**

2A. Is the Fiscal Year (FY) 2020 staffing level and proposed staffing plans for Scenario 2 and 3 appropriate and optimized?

2B. What resources are required to support staffing levels in each scenario? (staffing talk, L. Phair)

3. Facility performance and Maintenance

3A. Since the last operations review, has the performance of the Facility been reliable and sound? (B. Ninemire)

3B. Do facility accomplishments have merit and impact?

- Facility uptime of 92-94%, except FY19 which had vacuum problems (80%)
- VENUS development for higher charge states and intensities (J. Benitez and D. Xie)
- Neutron beams developed for Bernstein Nuclear Data experiments
- Ti beam development (D. Xie)
- MARS proposal developed and submitted (D. Xie)
- Energy upgrade concept (enables in air testing) (D. Todd)

3C. Is the Facility plan to maintain operations, including deferred maintenance and single point failures, complete and appropriate? (B. Ninemire)

3D. What resources are required to support reliable operations for each of the scenarios? (L. Phair, investment plan)

4. New capabilities

4A. Are the plans for facility developments, improvements, and new capabilities needed to implement each of the scenarios (1-3) complete, appropriate, and feasible, and in support of the Facility vision?

MARS-D (D. Xie)

Linac booster (D. Todd)

New cocktails for in-air testing (J. Benitez)

4B. What resources are required to implement new capabilities for each of the scenarios? (above talks)

5. Rates and partnerships

5A. Is the strategy for allocating beam-time to stakeholders over the upcoming five year period appropriate and sound?

5B. Are the proposed hourly rates for different stakeholders reasonable and ensure full-cost recovery for non-NP work?

(L. Phair, investment plan, full-cost recovery talk)

Summary

- Support basic research in low energy nuclear physics with an emphasis on training the next generation of nuclear scientists
- Facilitate R&D research program(s) conducted at the 88-Inch facility (e.g., Nuclear Data program)
- Support national security and other US space programs in the area of radiation effects testing
- Conduct R&D directed toward ECR ion sources

Back-up slides

Funding history

From Interagency agreement for 2010-2015

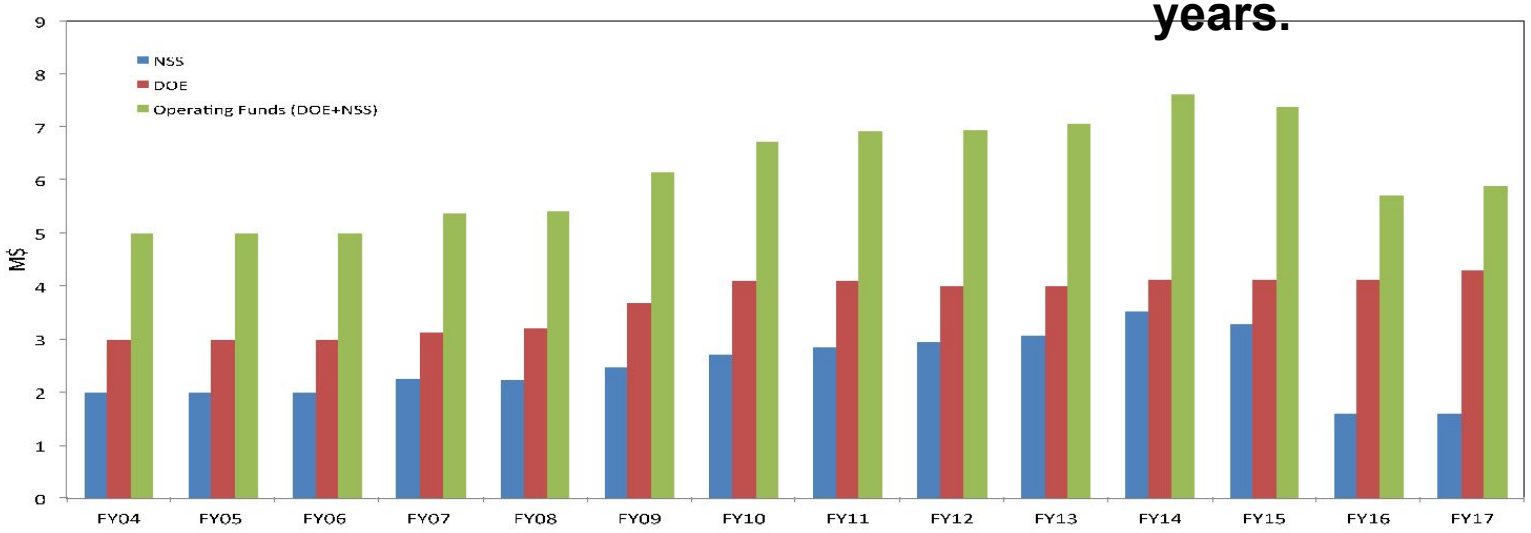
7. Projected Milestones

The DOE, the USAF, and the NRO will, within the limits of their budget priorities, include in their respective budgets for FY 2010 through 2015, their pro rata funding share (3:1:1) sufficient to support the LBNL's cyclotron annual operations costs. The dollar amounts, adjusted for inflation, corresponding to this pro rata share will be determined jointly by the DOE, the USAF, and the NRO annually during a joint program review. The current best estimate is included below (in millions):

Happening

	FY10	FY11	FY12	FY13	FY14	FY15
DOE	4.08	4.24	4.41	4.59	4.77	5.00
SMC	1.36	1.42	1.47	1.53	1.59	1.64
NRO	1.36	1.42	1.47	1.53	1.59	1.64
Total	6.80	7.07	7.35	7.65	7.95	8.27

- Cyclotron budget increases in FY09-10 were utilized to restore manpower to a healthy level and stabilize operation.
- Big cut in 2016. 50% of BASE funding.
- **BASE funding remained at 50% for the last 5 years.**



Staffing levels with the loss of NRO funding in FY16

Negotiations were active at the close of FY15. The assumptions were:

- DOE: $4.1M
- Air Force: 1,000 hours
- NRO: 500 hours guaranteed (WFO), with option to purchase more (up to 500 hours more)
- WFO: 500 hours (**New**: we had never assumed anything about WFO in previous budgets)

For 4,500 hours, the cyclotron costs are $7.3M for the year ($1,600/hour) in FY16. This was the plan.

In late January, the NRO withdrew from the plan.

- Our bottom line changed by 11%.
- It happened well into the year (so our burn rate was wrong).
- The AF price of $1,600/hour (in the IA) was not consistent with the new situation.

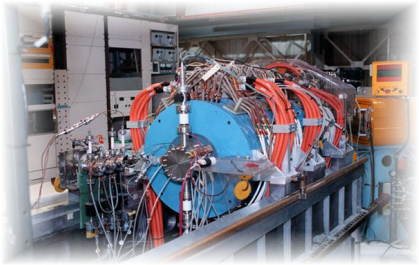
BGS was down for FIONA upgrade. We tried to do more WFO (plan A). We did not lay off staff. Reduce carryover was plan B. In the end, we had $6.9M in funding for the year (short $400k from our target).

Ion Source Development

Past (1st & 2nd)

(Normal conducting)

AECR-U (1996)
1.7 T, 2.6 kW,10+14 GHz



Talks by Janilee Benitez and Dan Xie

Present (3rd gen.)

(Super conducting)

VENUS (2001)
4.0 T, 14 kW, 18+28 GHz

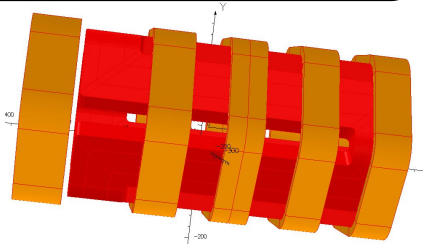
FRIB

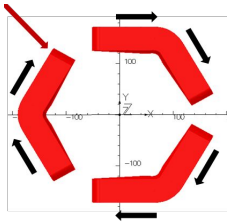
VENUS is the ion source for FRIB

Future (4th & 5th)

$NbTi$ & Nb_3Sn

MARS
(Mixed Axial and Radial field System)





Innovation: closed loop sextupole winding

Agenda

Day 1

8:00 AM	Welcome	Dr. Barbara JACAK
8:10 AM	88 Cyclotron Operations	Dr. Larry PHAIR
8:50 AM	BASE Operations	Mr. Mike JOHNSON
9:35 AM	*break*	
9:45 AM	Facility Reliability & Maintenance	Mr. Brien NINEMIRE
10:40 AM	Staffing and Work Force Level (and Analysis)	Dr. Larry PHAIR
11:20 AM	SHE search requirements	Dr. Rod CLARK
11:45 AM	*Lunch*	
1:00 PM	Investment plan, full cost recovery analysis and budget for scenarios, including carryover analysis	Dr. Larry PHAIR
1:45 PM	Safety	Mr. Jeff BRAMBLE
2:10 PM	Ion source operations	Ms. Janilee BENITEZ
2:35 PM	*break*	
2:45 PM	Ion source R&D	Dr. Dan XIE
3:15 PM	Energy upgrade	Dr. Damon TODD
3:45 PM	Executive session	Dr. Jehanne GILLO
5:50 PM	*Transportation departs from b.50 entrance*	
6:20 PM	Dinner, location TBD	
8:35 PM	*Transportation returns to Hotel Shattuck Plaza and b.50*	

picture of cooling tower