2nd Annual SRF/RF/Cryo Workshop

Arne Freyberger

Welcome and Workshop Goals

- The purpose of this one day workshop is to review progress in SRF/RF/Cryo operations since last year's workshop. Review plans to achieve 12GeV operations in the Fall of 2015 and future gradient maintenance plans.
- Gradient maintenance
- Performance during beam operations
  - Closing the gap between EmaxOPS and GMES.
- R&D
  - Identifying the source of gradient loss.
  - Going beyond the C50 program.

Action Items from previous Workshop

```
* CEBAF SRF/RF/Cryo Workshop
 * Notes                                                    :ATTACH:...
 * TODO [4/7] Issues with Actions
  * [2/4] Dynamic Heat...
  * TODO [1/2] Upgrades to improve capability...
  * TODO [1/2] Valve related issues...
  * TODO [0/3] C100 Issues...
  * DONE [2/2] C50 related...
  * DONE [4/4] 2.2GeV Physics quality beams and gradient maintenance...
  * DONE [1/1] Access to SRF commissioning data...
  * CANCELED [1/1] Preventative Maintenance Items...
 * Comments no action expected at this time ([2014-04-14 Mon])...
```

Action Items: Dynamic Heat

```
* [2/4] Dynamic Heat
 * CANCELED MOPS Calibration and Configuration                    :RFpower:...
 * CANCELED MOPS Configuration during beam operations 2-wire or 4-wire :RFpower:...
 * INPROGRESS C100 Electric Heat Compensation Upgrade      :RFpower:ATTACH:
   DEADLINE: <2015-02-06 Fri>
   :PROPERTIES:...
   Requirements and cost estimate to upgrade the heater controls on
   the C100s have been made (attached).  The cost, labor and material, is
   about $95k direct, $38k for materials.   The specifications call for each heater
   (there is a heater for every cavity) to be controlled by an
   independent power supply.
   <2014-10-09 Thu 11:18>
   This is in progress and could be done by the 2015Winter SAD, new
   deadline assigned, was <2014-08-01 Fri> is <2015-02-06 Fri>
 * TODO Q0(E) data/functions                                          :SRF:
   DEADLINE: <2015-06-05 Fri>
   The dynamic heat depends on the Q0 of the cavity.  Q0 depends on
   the gradient set points.    Having this relationship determined
   for each cavity and used by LEM and electric heat compensation
   program will provide for more precise determination of the
   dynamic load.  SRF is to continue analysis of the SRF
   commissioning data and provide either a Q_0 vs Gradient look-up
   table or a functional form for every cavity.   While analyzing
   the data, work with Operations and High Level Applications staff
   to define the data format and API for the applications that will
   use this information.  If
   needed/requested, data reduction
   help is available within Operations for this effort.
   <2014-09-12 Fri 10:07>   This is hopelessly behind schedule.
   Raw Data files, all 70GBytes have been made available.  OPS will
   do the analysis.
   <2014-09-23 Tue 09:13>
   New deadline, assigned.  Was   [2014-08-01 Fri] changed to:
   [2015-06-05 Fri]
```

Actions: Improve Capability

```
* TODO [1/2] Upgrades to improve capability
 * DONE [2/2] Both linacs at 2K on one CHL plant                    :Cryo:...
 * TODO Expanding LEM to include other optimization parameters
   + heat load
   + field emission
   + Q_0(Gradient)
   + ????
* TODO [1/2] Valve related issues
```

Identification of the desire to operate CEBAF on one CHL turned out to be very clairvoyant.

Actions: Valve related issues

```
* TODO [1/2] Valve related issues
 * INPROGRESS Gate Valve closure upon entry                    :Controls:SRF:
   At the SRF CEBAF workshop Thursday there was a consensus,
   endorsed by Andrew, that the present approach which closes
   the linac gate valves upon every entry to the tunnel was causing
   harm and not preventing possible damage given that a catastrophic
   vacuum failure would cause them to close.  Accordingly, during
   the summer down the valves will be prevented from closing upon
   normal operational entries into the accelerator enclosure (by
   disconnecting the signal generated from the PSS system state).
   The valves will be closed
   manually as a new step in the _Accelerator Shutoff Checklist_
   which is executed prior to an extended holiday or prolonged off
   time.
   <2014-10-09 Thu 11:14>
   This is in progress

 * DONE Vacuum thresholds for valve closure                    :Controls:SRF:...
* TODO [0/3] C100 Issues
```

Review of whether or not the gate valve closure is an issue should be revisit. Expect discussion on this subject during Rongli's presentation this afternoon.

Actions: C100 (part one)

```
* TODO [0/3] C100 Issues
 * TODO Field emission monitoring                          :OPS:SRF:Radcon:
   DEADLINE: <2015-09-30 Wed>
   Develop requirements/specifications for continuous monitoring of
   field emission in the C100 and C50 modules during beam
   operations.
   A detailed plan should be on hand with sufficient detail such
   that the project will be part of the FY16 AWP.    The system
   shall provide enough information to monitor changes in field
   emission during nominal beam operations as well as provide an
   additional knob in optimizing the C100/C50 performance.  System
   should be incorporated within EPICS so that the signals can be
   integrated into the accelerator control system.
   <2014-10-09 Thu 11:14>
   New deadline, was <2014-09-30 Tue>, new fiscal year was FY15 and
   is now FY16
```

Actions: C100 (part two)

```
* TODO [0/3] C100 Issues
 * TODO Field emission monitoring                          :OPS:SRF:Radcon:...
 * TODO Piezo on C100-1,2,3 and R100                              :LLRF:
   DEADLINE: <2015-01-30 Fri>
   Develop a plan to explore if piezo tuners can be used to
   mitigate the microphonic sensitivity of the first 3 C100 and
   R100 cryomodules.   This includes installing the appropriate in
   advance of the Fall2014 run.   Submit (beam) test plans to
   optimize the
   C100/R100 performance in terms of ability to withstand a higher
   level of microphonic activity than the present capability.
   <2014-09-23 Tue 09:16>
   Plan has not been developed, but the piezo are in-place.
   Considering marking this task as canceled or done.
   <2014-10-09 Thu 11:07>
   Move the deadline from <2014-08-29 Fri> to <2015-01-30 Fri>
 * TODO Cabling                                  :Cryo:IandC:RFpower:SRF:
   DEADLINE: <2015-09-30 Wed>
   Work on an integrated effort to improve the in tunnel cable routing of
   all cables (RF, magnet, cryo, instrumentation) near and inbetwenn
   the C100/R100 modules.   New routing scheme should attempt to
   improve cabling such the maintenance (short, near and long term)
   issues are minimized.   Keep in mind the radiation field from
   field emission when developing new cable routes.
   <2014-10-09 Thu 11:21>
   New deadline was: <2014-09-12 Fri> is <2015-09-30 Wed>
```

Actions: C50 related

```
* DONE [2/2] C50 related
 * DONE Understanding C50-11 Q0 distribution                    :SRF:
   DEADLINE: <2014-05-01 Thu>
   Need alignment within SRF on what magnetic/non-magnetic
   material got installed on C50-11.   Alignment is needed before
   IPAC14 as data is being presented there on C50-11.
   <2014-06-17 Tue 11:36>
   Nice paper from Rongli for IPAC2014.   The cavities with the
   non-magnetic springs show a much better Q0 retention than the
   cavities without the springs.
 * DONE [2/2] C50-12                                           :SRF:
  * DONE C50-12 Timeline...
  * DONE Leave HOM loads to 40K shield?                  :OPS:FEL:SRF:...
```

The C50-12 timeline has shifted due to budgetary constraints. More about this at the end of the day.

Actions: 2.2GeV related

```
* DONE [4/4] 2.2GeV Physics quality beams and gradient maintenance
 * DONE Complete integrated plan to get to 2.2GeV/pass by Fall2015 :OPS:RFpower:SRF:...
 * DONE Complete gradient maintenance plan to maintain 2.2GeV/pass :Cryo:OPS:RFpower:SRF:...
 * DONE Plasma Processing...
 * DONE [2/2] Helium Processing
  * DONE Develop a plan to Helium process CEBAF by Sept. 2015...
  * DONE Investigate the viability of Helium Processing at 4K...
```

This represents the most significant outcome/success of last years SRF/RF/Cryo workshop.

Actions: SRF data and Klystrons

```
* DONE [1/1] Access to SRF commissioning data
 * DONE Access to SRF commissioning data
   Access to the raw SRF commissioning data shall be made available
   to all Accelerator/Engineering division staff.
   <2014-10-09 Thu 11:30>
   Location of the SRF commissioning data was provided to OPS. Data
   was copied to the OPS computer network for local access and
   analysis.
* CANCELED [1/1] Preventative Maintenance Items
 * CANCELED Klystron repair contract                          :RFpower:
   DEADLINE: <2014-09-30 Tue>
   Need have 5kW klystron repair contract in place at the start
   Q1FY15 so it
   can be executed throughout FY15.   Rate of repairs should be
   at least 12 klystrons/year or at the minimum set by the vendor.
   <2014-10-09 Thu 11:15>
   This has been cut out of the FY15 budget.
```

More on klystrons and RF power later this afternoon from Rick Nelson.

Actions Summary

```
* CEBAF SRF/RF/Cryo Workshop
 * Notes                                                    :ATTACH:...
 * TODO [4/7] Issues with Actions
  * [2/4] Dynamic Heat...
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  * TODO [1/2] Valve related issues...
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```

- Overall happy with the progress.
- Overall think the actions distilled from last years workshop were appropriate.
- High priority actions have been addressed.
- Would like to see more progress on the C100 issues, or understand why the progress has been what it is.

Energy Reach Tech-note

- 2014 Update: CEBAF Energy Reach and Gradient Maintenance Needs
  - https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-95056/14-024.pdf
  - Rama Bachimanchi, Jay Benesch, Michael Drury, Arne Freyberger, Rongli Geng and John Mammosser

Energy Reach Tech-note

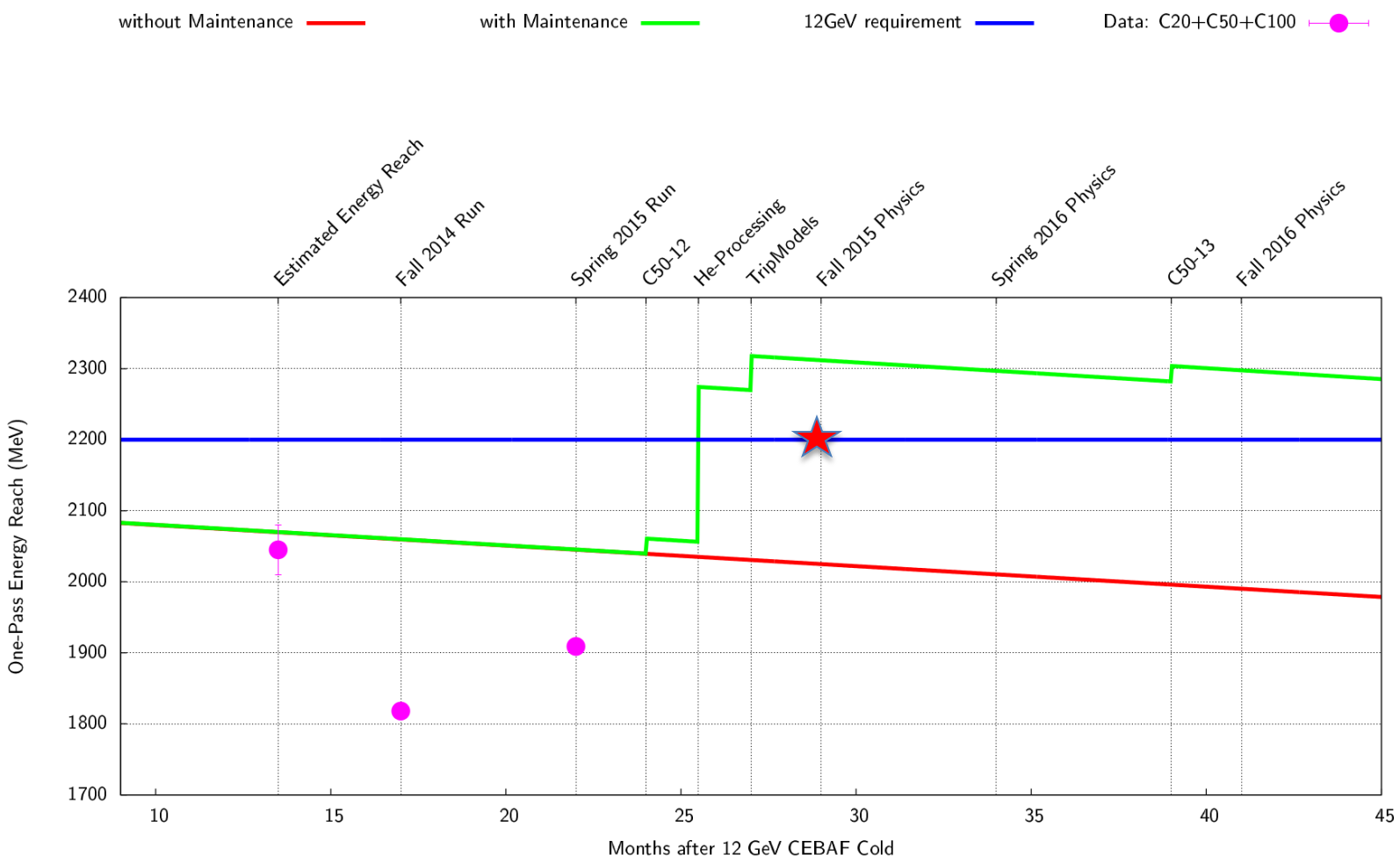
Linac	Type	<E_{maxOPS}> (MV)	2014-Feb <GMES> (MV)	2014-Feb $\frac{<GMES>}{E_{maxOPS}}$ (MV) (%)	2014-Apr <GMES>	2014-Apr $\frac{<GMES>}{E_{maxOPS}}$
NL	C20	8.61	7.19	84	5.26	61
NL	C50	11.71	11.03	94	10.11	86
NL	C100	20.86	17.59	84	17.78	85
SL	C20	9.09	7.05	78	6.70	74
SL	C50	11.55	10.06	87	9.16	79
SL	C100	19.77	16.66	84	15.90	80

Table 8: <E_{maxOPS}> commissioning values from Table 2, <GMES> values from the two sample Spring 2014 configurations (Tables 3 and 7) and their ratio.

- How do we decreasing the gap between EmaxOPS and GMES?
- What is the source of the gap?

Clyde Mounts presentation later this morning

Energy Reach Tech-note



Energy Reach Tech-note

Cavity Type	2012 Prediction (MeV)	Feb-2014 2.2GeV/pass (MeV)	Apr-2014 2.0GeV/pass (MeV)
C20	672	808	**654**
C50	379	**457**	412
C100	969	**934**	932

Table 9: Predicted energy reach from the 2012 model compared to the measured energy gain in 2014. The Feb-2014 setup had a large RF trip rate due to the excessive gradient requested from the C20 cavities. **Bold** values represent the maximum gradient for Physics quality beams.

Cavity Type	$\frac{d\mathcal{G}}{dt}$ (MV/m-yr)	$\mathcal{G}_\Delta$ (MV/m-ThermalCycle)
C25	0.14 ± 0.05	0.5 ± 0.1 or 7%
C50	0.42 ± 0.06	0.5 ± 0.1 or 7%
C100	0.00 ± 0.06	0.5 ± 0.1 or 7%

Table 11: 2014 values of the average gradients and gradients loss for the various cavity types in CEBAF. All values are identical to the 2012 values except the C50 $\frac{d\mathcal{G}}{dt}$ which was 0.71 ± 0.08 MV/m-yr in 2012. The C100 annual loss remains at zero until there is enough data to provide an estimate of this loss.

Klystrons

- Spare klystrons completely consumed by end of FY17.
- Without spare klystrons, energy reach degrades at almost twice the estimate rate.
  - Annual gradient loss due to new field emitter is 34MeV.
  - Annual gradient loss due to failed klystrons in a 30week year(8.4klystrons) is 28MeV.
- CEBAF energy reach will be below 12GeV 2.5y after FY17 (5y with klystron spares).

Recommendation

Funds be made available in FY16 and annually thereafter of ≈\$500k/year for the purchase of 6.5kW spare klystrons. This is to be continued until a three year stockpile has been accumulated.

13kW klystron purchases should be initiated once the next 13kW klystron fails (≈\$75k/each without solenoid).

FY16 and Beyond

- CEBAF should be in a position to support 2.2GeV/pass, 12GeV operations.
- Operational weeks will vary due to budgetary issues.
  - 35weeks/year maximum
  - 30weeks/year probably typical
- Present gradient maintenance plan (C50/year) is insufficient to support 12GeV operations beyond 2022.
  - What's the plan?
  - Helium process every 5 years?
  - C75?
  - Eliminate gradient loss?

Today's Agenda

	Wednesday, July 15, 2015		
	SRF/RF/Cryo		
08:15-08:30	Assemble: Coffee and Pastries provided		
08:30-10:15 1h45m	Intro & SRF Data and Cryogenics		
AM1	Chair: Geoff Krafft		
	8:30	Welcome and Meeting Goals Review action items from last years StayTreat	Arne Freyberger
	8:50	SRF CEBAF Operational Performance	Rama Bachmanchi
	9:40	CEBAF SRF Data management	Geoff Krafft
	9:55	Cryo status and plans: include info on He and N2 losses, contamination mitigation	Jonathan Creel
10:15-10:30	Break: Cold coffee and stale pastries		
10:30-12:00 1h30m	Operations		
AM2	Chair: Arne Freyberger		
	10:30	C100 microphonics update	Kirk Davis
	10:55	EmaxOPS vs Operational value	Clyde Mounts
	11:10	Gradient calibration	Jay Benesch
	11:30	MO/LO Performance Summary and Maintenance plans.	Tomaz Plawski
	11:45	RF Separation status	Mark Wissman
12:00-13:30	Lunch: On your own		
13:30-15:15 1h45m	Field Emission and Q0		
PM1	Chair: Rongli Geng		
	13:30	HeProc status and results to date	Mike Drury
	13:45	C20/C50/C100 RF Soak plans: Fault minimizing, Egain maximize	Rama Bachmanchi
	14:00	CEBAF particulate field emitter Control	Rongli Geng
	14:30	Dynamic heater controls	Tom Powers
	14:45	Q0 precision: what is required, what has been achieved?	Jay Benesch
	15:00	LEM upgrade path	He Zhang
15:15-15:30	Break: Cookies, H2O, Ice Tea? Cold soda? Warm soda?		
15:30-17:00 1h30m	Projects and R&D		
PM2	Chair: Jay Benesch		
	15:30	New ideas and approaches to raise CEBAF Q0 - initial results and proposed studies	Rongi Geng
	15:50	The C75	Bob Rimmer
	16:10	Klystrons and 20yr vision for RF power	Rick Nelson
	16:30	Obsolence and anticipated upgrades	Curt Hovater
	16:45	1/4 cryomodule and C50-12 Status update	Tony Reilly
17:00	END		

- Chairs please keep the speakers on schedule and the discussion focused.
- Speakers please respect the schedule.
- Audience please keep the discussion relevant, respectful, crisp and invigorating.
- Actions items will be distilled from the presentations and discussion. No need to solve the problem during the meeting.