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Memo

DATE: *January 21, 2002*

TO: RHIC E-Coolers

FROM: *Ady Hershcovitch*

SUBJECT: **Minutes of the January 18, 2002 Meeting**

Present: Ilan Ben-Zvi, Ady Hershcovitch, Jorg Kewisch, Satoshi Ozaki, Stephen Peggs, Triveni Srinivasan-Rao, Dong Wang, Jie Wei.

Topics discussed: RF Cavities.

RF Cavities: Ilan gave a rather comprehensive talk on RF cavities. TESLA cavities are a good option to pursue, since they are highly optimized, well characterized, there are a number of manufacturers, and CW operation with vertical cryostat at high gradients was achieved (well over 20 MV/m). TESLA cavities have a residual resistance 3 nΩ, which is equivalent to a Q of 10^{11}. The cavities are optimized towards higher electric fields, not Q. As a function of electric field, Q is constant (including for gradients exceeding 20 MV/m). Conservatively, a Q of 1.5×10^{10} is chosen. If cavities are kept clean and connected properly, they operate well. Ilan showed a number of cavity pictures and construction of a cavity string.

Based on input from Bernd Petersen of the DESY Cryo group, the heat load limit of a TESLA cryostat is determined by the heat flow density (1.38 W/cm^2 at 2K or 1.42 W/cm^2 at 1.8K), and by the surface area of the cryostat connection pipe. Conservatively, if we take 1 W/cm^2 and the DESY connection pipe surface area of 23 cm^2, we obtain a maximum heat flow of 23 W. However, cryostat modification to increase heat flow is simple, as it was done in Rossendorff. At RHIC, 26 W of refrigeration power may be needed.

In other topics that were covered, Ilan showed that energy recovery does indeed work and that high order mode (HOM) power is not a problem for the RHIC E-Cooler. Cavities are well understood due to substantial experience at JLAB, DESY, and industry.

Chosen cavity parameters are: 1.038 meter long, Q of 1.5×10^{10} at 2K, 20 MV/m, refrigeration power of 26 W/structure.

Options for the RHIC E-Cooler are a two-cavity system with 20 MV/m and a cooling power of 26 W/cavity, or a three-cavity system with 15 MV/m with a total cooling power of 44 W.

Below are selected viewgraphs from the presentation (courtesy of Ilan and Dong).

TESLA Accelerator Structure

- Highly optimized, well characterized
- A number of manufacturers
- Ongoing improvements
- CW operation in vertical cryostat at high gradients, well over 20 MV/m (Dieter Proch)

Heat load limit of TESLA cryostat
Bernd Petersen, DESY Cryo group

- Stay within HeII regime
- Heat flow density limited to:
  - 1.38 W/cm^2 at 2K
  - 1.42 W/cm^2 at 1.8K
  - Take conservatively 1 W/cm^2
- TESLA cryostat connection pipe 23 cm^2 thus maximum heat flow 23 W.
- Modification of cryostat is simple (done in Rossendorff)

The Superconducting
Electron Linac

- Extremely well known (JLAB, DESY, industry). Assume TESLA cavities:
- R/Q=1036Ω, L=1.038m
- Take conservatively $Q_0=1.5\times10^{10}$ at 2K, 20MV/m,
- Refrigeration power 26 W/structure
- HOM power: (Merminga et. al., LINAC2000) At RHIC, due to the ~20 ps pulse length, this is not a problem.

Main Parameters of relevant Linacs

		TESLA 500	JLAB-ERL	RHIC e-cool
Linac energy	MeV	250,000	38	~52
Accelerating gradient	MV/m	20~25	~10	15~18
RF frequency	GHz	1.3	1.5	1.3
No. of cavities/linac		~10500	8 (5-cell)	3(9-cell)
No. Klystrons/linac		~300	8	TBD
Klystron power	W	9.5M (peak)	64k/tot (ave)	<100 k/tot. (ave)
Repetition rate*	Hz	5~10(RF)	4~75 x 10^6 (b)	9.4 x 10^6 (b)
RF pulse length	ms	1.37		
Beam pulse length	ms	0.95		
No. of bunches/pulse		2820		
Bunch spacing	ns	337	20 ~ 400	105
Electron per bunch		2×10^{10}	8×10^{8}	3×10^{10}
Average current	mA	0.18	5	~50
Power per beam	MW	11.3	0.2	2.5
Electric power/linac	MW	48.5	0.5	TBD

TESLA cavity heat load

1 cryostat module:
8(test) cavities (~11m)
12(TESLA) cavities (16~17m)
+ magnet package (quads, correctors, BPM, pickup, etc.)

2K Heat load:

TESLA Test 8-cavity cryostat module:
11 W (5 Hz dynamic + static), including HOM, etc.

RHIC e-cool 2-cavity cw-mode: (assume $Q=1.5 \times 10^{10}$ at up to 20 MeV/m)
~2x 26W (at 20MeV/m)
= 3 cavity 45 MeV requires 15 MV/m, thus load is 44 watts.

Solution for test facility: pulsed operation (like TESLA? ~1% duty factor)
Cryostat from Germany / cryogenics here: need to discuss the details

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Cost Data
Stanford - 215k$/m,
DESY – (larger quantity) – 170k$/m

- Structure with LHe vessel $85k.
- Vacuum / LN_2 $20k
- RF feed-through $10k.

Quantity cost for 1-3: $70k

- 10 KW 1.3 GHz klystron with focus magnet and power supply $55k.
- Misc. hardware $35k