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ASYMMETRIC B FACTORY NOTE ABC-15

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SUBJECT: Asymmetric B Factory, Trip report to CERN, ESRF and DESY

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Summary:

Three main issues giving purpose to our visit to CERN, ESRF and DESY were to:

- assess the current thinking at CERN on whether Eta, the gas desorption coefficient, would continue to decrease with continued beam cleaning,
- determine if the time between NEG reconditioning could be expanded and
- acquire a knowledge of the basic fabrication processes and techniques for producing beam vacuum chambers of copper.

In conversations at CERN with Alain Poncet who spoke positively about a decreasing Eta and Yves Baconnier who supported these comments, we feel that Eta values around 10^{-6} are likely to be achieved. From Paolo Chiggiato, also at CERN, who has been doing NEG pumping experiments using ST 707 NEG strip, we obtained that increasing the NEG strip area will produce higher pumping speeds and capacities and we therefore expect longer run times between getter reconditionings.

At DESY most of our discussions with John Kouptsidis focussed on the processes and techniques for fabricating copper vacuum chambers and we were able to review this work with John in the shop where the HERA chambers were produced and where he is presently making chamber assemblies for a Doris Upgrade. Also, at both CERN and DESY, the better shielding properties and a concern for being able to manage the high heat loads dictated copper, a choice later reinforced by Brian Trickett at ESRF who had seriously considered fabricating their vacuum chambers of copper also.

Although further study and interaction will be needed to obtain more definitive information as we proceed, we conclude from our observations and discussions that a design of copper is an appropriate choice. Based in part on this information we have developed in a separate note a typical cell pumping configuration to handle the gas load for the high energy ring and includes some design options.

Detailed trip report:

CERN:

On Monday, July 16, 1990, we visited CERN and met with Gerry Chapman as Tore Wikberg, with whom we had arranged to meet, was not then available. After learning about what sort of information we were looking for, Gerry arranged for us to talk with Paolo Chiggiato about NEG pumping. Paolo led us through the basics of NEG pumping, speaking about the pumping model worked out by C. Benvenuti and others and spoke about his experiments with SAES ST 707 strip. These getters can be activated at 400 °C instead of 740 °C as for ST 101. The pumping speeds obtained at 400 and 740 °C are very similar. These getters can also be activated and reconditioned passively during a machine bakeout although the pumping speeds will be slightly lower. Paolo has been running experiments with a 15 cm dia. vessel, 3m long lined completely with getter strip. When questioned about pumping speeds and capacity with increased NEG strip per meter, Paolo said the pumping speed and capacity would be increased inferring a longer interval between getter reconditionings much the same as O. Gröbner states in reference 4 of this report.

In the afternoon we toured the LEP vacuum chamber assembly building with Gerry Chapman. Here the 12 m long aluminum beam chambers were received, inspected and leak checked. We saw the inspection and handling equipment and discussed the lead bonding process used and other ways to apply the lead to aluminum chambers such as spraying it on.

Late in the day we met Tore Wikberg who arranged a meeting with A. Poncet and Y. Baconnier on the following day.

On Tuesday, July 17, we met with Alain Poncet to whom we posed the question of whether Eta, the gas desorption rate, could be expected to decrease to about 10^{-6} molecules per photon for copper. He was direct and fairly positive about the choice to copper indicating values of 10^{-6} were obtainable and even mentioned a 10^{-7} range. Alain said we had no other choice with the high heat loads anticipated and focussed his comments more so in the thermal area. He has produced a program for calculating pressure distributions that can be run on a MacIntosh and offered to send us a copy. A later reading of his paper, Monte Carlo Simulations of Molecular Gas Flow, shows that there are some interfaces that we would need to work out to use this program but we will be following it up. Alain said a thermal analysis for the Beauty Factory at ISR had been performed by R. Valbuéna (7) with whom we were not able to meet. However, we did obtain this paper from Tore Wikberg.

Later this day we met with Yves Baconnier, whom we understood was the project leader for the Beauty Factory study. In discussing the gas desorption rate for copper, Yves supported Alain Poncet's comments and added that he did not think aluminum would go much below 10^{-5}. He focussed strongly on the thermal requirements saying that their calculated linear power density was about 17 kW m^{-1} and they had calculated that their copper design could go to 40 kW m^{-1}. This gave them a safety factor of 2 but he said he would like to see a safety factor of 4. He spoke about the need for thermal testing to check out stresses and deformations in the beam chamber. He also referred us to the work of R. Valbuena and cautioned that the CERN study had been done quickly in about 4 months.

ESRF

Wednesday, July 18, 1990 we drove to ESRF (European Synchrotron Radiation Facility) in Grenoble Cedex, France to talk to Brian A. Trickett and Michael Renier. ESRF is designed to be a synchrotron radiation source for hard x-rays with about 60 beam ports on its periphery. We described our design gas and thermal loads to Brian and told him that we needed to be in the low 10^{-6} range for Eta. He did not elaborate on the Eta numbers but said he thought all materials will end up basically at the same desorption rate with sufficient beam cleaning and he also held with the view that copper gas desorption is similar to that of stainless steel. He stated they had picked stainless steel for the vacuum chamber and when they did the detailed thermal analysis decided they had to add the copper absorber bar in the chamber. They had studied a copper design and John Kouptsidis had come down to talk to them about copper. He went on to say they would likely have gone with copper if they had been able to locate a credible fabricator to make the vessels. Brian stressed the need to understand the amount of reflected power in the beam chamber as high thermal stresses could possibly cause leaks as had occurred in DORIS. Cooling tubes were added on the ESRF stainless steel portion of the chamber to reduce temperature gradients. All their pumping is lumped pumping at discrete locations using both sputter ion and NEG pumps. NEG pumps are used at the crotches, dipoles and straight sections. The NEGs on the dipoles and straight sections use 9 meters of SAES ST 707 strip and are activated or reconditioned with resistance heating.

Michael did not say how long they could run between pump reconditionings or their capacity, answering that the specifications were given to SAES who then came up with the pump sizes.

On Thursday we came back to view the full size model downstairs that Mike Renier has been working with to lay out facilities and then toured the ESRF construction site. The ring will be housed in a shielded tunnel above ground and they want to be operating a portion of the facility by mid 1992.

DESY

We met with John Kouptsidis on Monday, July 23, 1990, at DESY in Hamburg, Germany. We began by describing our B-factory parameters and the calculated gas and thermal loads and what information we were looking for. John did not comment directly on Eta values saying instead that one does the best possible job in the fabrication process and preparations and that they had run no gas desorption tests. He said their copper extrusions were made by Kabelmetal in Germany, 400 km to the south. He thought we would probably be dealing with these people also as it took a good deal of work to set this one up. The 2% amount of tin is not sacred he said, but it is the lowest amount normally offered in alloy. John said the company did a good job in keeping the other elements in the alloy within the fractions of percent they advertised and suggested we work with the company specifications. Both the beam tube and pumping tube should be specified OFHC.

On the illumination of the chamber. John said that reflection calculations needed to be done but that in total the reflected portion of the incident radiation power was about 20%.

We asked about the stiffness of the chambers after the 800 °C braze and he said that the tin provides the required stiffness as we found out later during the tour.

John said that the design effort for the HERA chambers was small but he thought the B-factory design would be more extensive.

During the tour we looked at the bellows assemblies and housings for BPMs (Beam Position Monitors). John said he would give us drawings when we got farther along. They use hydrogen peroxide and a weak sulfuric acid in their cleaning. We toured the cleaning room which is tiled and has full length solution tanks.

Examining the 12 m long chambers we found that they are stiff after furnace brazing. The pump channel is originally a box section which is machined to remove one side. The pumping slots in the beam tube are 2mm high by 8 to 9 cm long and there are 2, one above the other at a pitch of about 10 cm. The slots are machined to present an aperture to the beam gas with a flare to the pump channel. Calculations show the conductance to be over 417 l sec^{-1} m^{-1}

and similar slots are located in the entrance to the lump pumps except that there are about 6 or 7 per port. John had earlier said their pumping needed to be about 30 l sec^{-1} m^{-1} and this is provided by sputter ion pumping.

The integrated ion pump parts are purchased from Varian and installed into the chamber module at DESY. The furnace system consists of the 15 m furnace, a runout table, the power supply and controls and a gas bottle group of about 8. The gas is 7% hydrogen and 93% argon and during construction when 60 meters of chamber parts were produced every 24 hours, they went through all eight bottles in a week. The braze time is 8 hours at a temperature of 800°C and the vacuum in the furnace was about 10^{-5} torr achieved with a turbomolecular pump.

In the afternoon we toured HERA which is seven stories down. We saw typical cell assemblies and the progress on the Proton Super-conducting cold bore. The e-beam chamber took about 2 years to construct and after a short 2 months run has not been operated and is awaiting the completion of the cold bore before further running.

On Tuesday we met with Allen Odian who works at SLAC but is on a temporary assignment at DESY. He took us for a tour of the Zeus detector in the south hall and after a second look at the HERA electron ring we left DESY.

Papers Collected:

1. UHV Characterization of low activation temperature non evaporable getter, C. Benvenuti; P. Chiggiato, Cern, Switzerland, R. Kersevan Sincrotrone Trieste, Trieste, Italy.

2. Non Evaporable Getters: Past, Present, Future, C. Benvenuti, Cern, Switzerland

3. Design Considerations for the vacuum system of a Beauty factory in the ISR, O. Grobner, T. Wikberg Technical note AT/VA/OG, REF., Feb 8, 1990

4. Design considerations for the vacuum system of a Beauty factory in the ISR, O. Grobner, H. Schubäck, R. Valbuena, T. Wikberg, 19 April, 1990

5. Non-standard vacuum hardware for an accelerator vacuum system, W. Unterlirchner, Cern, Geneva, Switzerland, CERN/LEP-VA/89-50

6. FEM Calculations of UVH All-metal Demountable Joints For LEP, T. Wikberg, E. Dodelin, CERN-LEP-VA/89-49

7. Chambre á vide de "Beauty Factory" etude thermique et mécanique, R. Valbuéna, CERN-PS/PA-S Note 90/05 19 Avril 1990 *.

8. Monte Carlo Simulations of Molecular Gas Flow: some applications in accelerator vacuum technology using a versatile personal computer program, A. Pace, A. Doncet, CERN PS/89-49(ML)*.

9. A review of some advanced vacuum techniques for particle accelerators, A. Poncet, 6.6 1990 European Vacuum conference, May 21/25, 1990 Trieste, Italy*.

10 Ion trapping and clearing, A. Poncet, CERN/MT 90-1 (ES), Geneva, Switzerland, February 1990*.

11 ESRF Foundation phase report, February 1987, European Synchrotron Radiation Facility, Grenoble Cedex, France.

12 Status of the ESRF vacuum system, B. A. Trickett, M. Renier, European Synchrotron Radiation Facility, Grenoble Cedex, France, 1990.

13 The ESRF vacuum system, B. A. Trickett, European Synchrotron Radiation Facility, Grenoble Cedex, France, Vacuum/Volume 38, Great Briton, 1988.

14 Design of the ESRF Absorbers, Gérard Marot, European Synchrotron Radiation Facility, Grenoble Cedex, France, 11 October, 1989.

15 Differences in Synchrotron Radiation Induced Gas Desorption from stainless steel and aluminum alloy, M. Andritschky, O. Gröbner, A. G. Mathewson, P. Strubin, Cern, Geneva, Switzerland, R. Souchet, Lure, Orsay, France, B. Trickett, ESRF, Grenoble, France.

16 Performance of the SRS Vacuum System, B. A. Trickett, Daresbury Laboratory, Daresbury, Warrington, WA4, 4AD, UK, 15 August, 1986.

17 The vacuum system of the HERA Electron storage ring, R. Ballion, J. Kouptsidis etal, Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany, 1990 Gordon and Breach. Science Publishers, Inc., USA.

18 A new approach for computing diode sputter-ion pump characteristics, H. Hartwig and J. S. Kouptsidis, Deutsches Elektronen Synchrotron DESY, Hamburg, Germany, 28 August 1974 J. VAC. SCI. Technol., Vol 11, No-6 Nov/Dec 1974

*A copy of these papers are filed with the original ABC note for your review.

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