THE PEP-II Movable Collimators

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Abstract

Three movable collimators have been manufactured for installation in the PEP-II LER and HER beamlines upstream of BaBar to improve backgrounds in BaBar by a factor of 2. Each collimator has a pair of horizontally opposed, water cooled jaws with RF finger seals all around the edge of the jaws, these seals are the only sliding parts inside the vacuum chamber. Each jaw travels independently through a distance of 16.5 mm (LER) or 21mm (HER) and is supported above the collimator from motorized slideways with position feedback. The larger HER collimator has a titanium sublimation pump incorporated into the underside of the collimator, pumping through RF screens in the bottom of the chamber. Water cooled fixed ramps protect the leading and trailing edges of the jaws.

1. INTRODUCTION

The new collimators are part of a package of measures that are being introduced in the PEP-II [1] beamlines to capture the bremsstrahlung scattered beam gas particles which cause BaBar detector backgrounds and lead to radiation damage.

2. COLLIMATOR DESIGN

Dispersion strengthened copper, known by the trade name Glidcop [2] AL-15, was chosen for all the surfaces exposed to high heat loads because its of high strength at elevated temperature [3] and hence its ability to tolerate up to 200 W/linear cm of SR power during operation.

In order to provide the most rigid structure, the body was machined from a single billet of Glidcop with Glidcop transitions attached to each end of the body. The transitions are octagonal at the outer end, to match the existing beam pipe, and rectangular at the inner end, to match the collimator body, where the aperture is 5.69 cm wide x 5 cm high for the Low Energy Ring (LER) whilst the High Energy Ring (HER) collimator is 8.33 cm wide to accommodate the larger beam profile. The transition also incorporates water cooled side ramps. Stainless steel end flanges are fitted for connection to the beamline and are fitted with a standard RF omega seal.

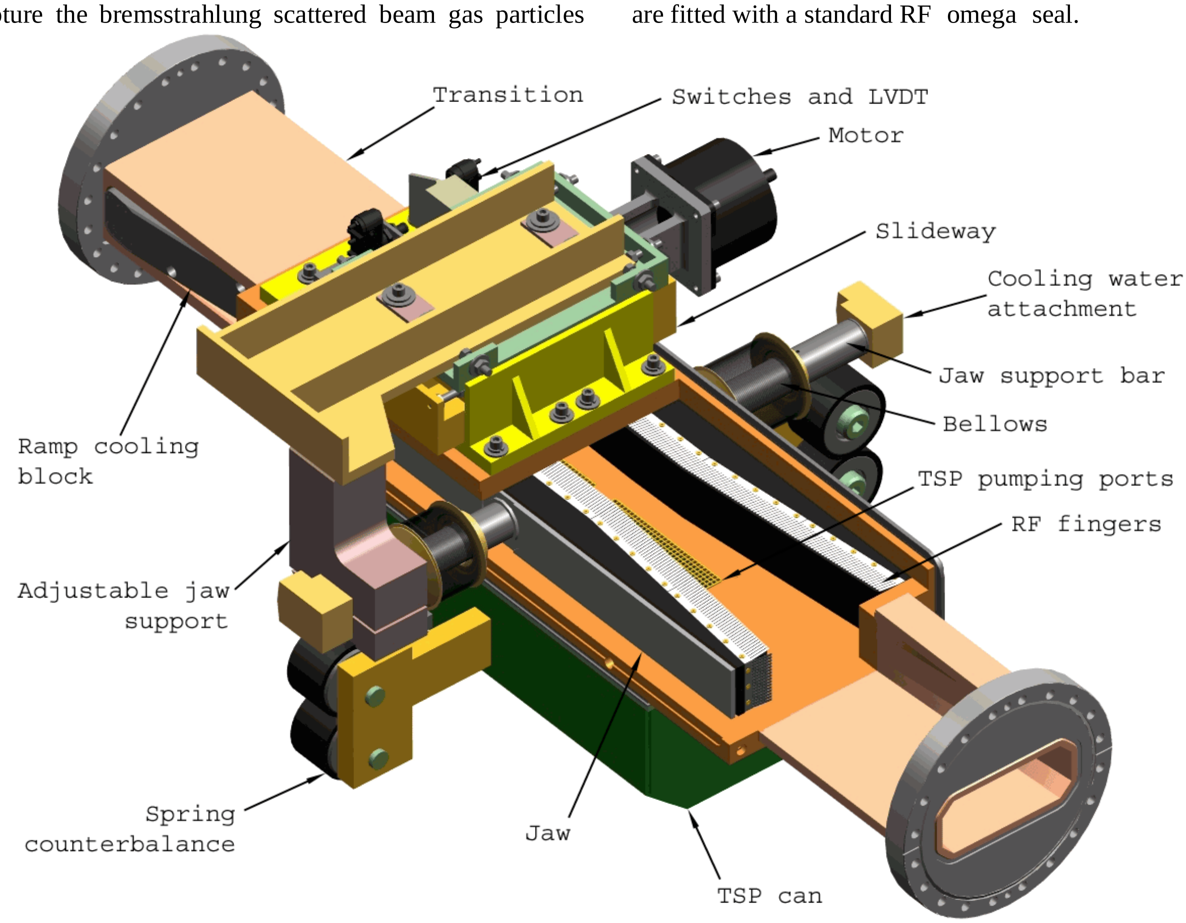

Figure 1: Cutaway view of the HER collimator

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Each Glidcop jaw is gold plated and water cooled over its entire exposed surface. They can be positioned independently, with a resolution of 0.0025 cm; the jaw travel is 1.65 cm (LER) 2.1 cm (HER). The bar attached to the back of the jaw has 3 functions: 1) it provides physical support for the jaw, 2) it contains the supply and return water passages, 3) it contains the air vents that would be used to identify a water leak within the jaw. Internally, the jaw contains brazed in stainless steel water diverters which ensure even cooling of the surface. There are no water to vacuum brazed joints, instead an air gap was fitted, which vents to 3) above. Convection analysis indicated that the water cooling requirements would be 2 gpm for each of the jaws and 0.5 gpm for each of the ramps.

figure 2: Assembling fingers on a jaw.

The RF fingers are screwed on to the jaws, simplifying replacement in the event of a damaged finger. Much development work went into the type and thickness of plating to be used on the sliding surfaces of finger and body. The chosen combination, which, under testing [4], ran for the equivalent of 10 years without failure, involved silver plating the body 0.018 mm and rhodium plating the fingers 0.0025 mm. Prior to rhodium plating, the fingers were electropolished to remove all sharp edges caused by the EDM process then nickel flashed. Other than the RF fingers, there are no moving/sliding parts in the vacuum.

The HER collimator, which is currently being manufactured, will have a single Titanium Sublimation Pump (TSP) lying horizontally in a plenum underneath the collimator. The TSP cartridge (Thermionics Sierra Inc, model SB-275-3) carries 3 Ti heating elements connected to a common power socket outside the chamber. A mask is fitted above the heating elements to ensure that Ti would not be deposited in the path of the beam, allowing regeneration to take place while the beam is still on. The total Ti covered surface will be 2200 cm^2.

There was insufficient room for a TSP underneath the LER collimators so a NEG pump and a 440l/s ion pump was fitted in the drift chamber immediately upstream of the collimators.

The area to the side of the collimators has very little space available, so the jaws are supported by slideways mounted above the collimator via rigid arms that connect the slideways to the back of the jaw. A bellows unit makes the vacuum seal. A constant force coil spring system was fitted to counterbalance the effect of vacuum at the bellows, ensuring that the motor sees the same force whilst operating in either direction.

To provide support and fine adjustment of the collimator assembly, a standard SLAC designed Sukiennicki support system, was fitted. This design uses rod ends with differential nuts with separate adjustments for each direction of motion.

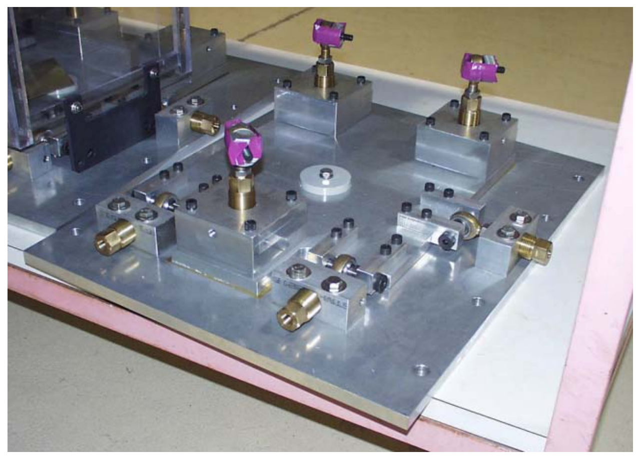

Figure 3: Sukiennicki adjustable support

Temperature monitoring is provided by 3 thermocouples and a klixon on the collimator body and water return lines. If any of these sensors detect a temperature of $66^{O}C$ (default setting) the beam abort system is triggered.

A polycarbonate cover is fitted over the top of the collimator to protect the slideway components and bellows from dust and water.

For technical specs of collimators see [5]

3. MANUFACTURE

A prototype jaw body was first manufactured from aluminum to prove the complex CAM/EDM process. The body and transition were hollowed out by a combination of milling and EDM.

Prior to brazing, each component was plated to 0.013mm with copper to minimize the diffusion of braze material into the Glidcop Cu/Al_2O_3 matrix at elevated temperatures and to improve the vacuum sealing qualities which can be a problem with Glidcop.

The vacuum furnace brazing was done in a 2 stage process using standard SLAC procedures and tolerances. The first braze used 35Au/65Cu filler alloy at 1025 ^{O}C, soaking for 3 minutes and this was used to join the cooling bars to the body and the end flanges to the extensions. Next the assembly was brought together for the second braze using 50Au/50Cu filler alloy at 985^{O}C for 4 minutes.

Assembly of the collimator was aided by the addition of adjusting screws to finely position the jaws in the body. Also, alignment tool holders were located on jaw arms and the end flanges in order to calibrate the jaw position relative to the body.

As part of the final cleaning process, the collimator and slideways (motors, LVDT s and switches are removed) are subject to a 200 ^{O}C bakeout. In order to withstand this, the slideways, which were reconditioned having previously been kept as spares for a wire scanner, were stripped down and lubricated with Nye Synthetic Flouroether Grease type 899S-1 which is rated to 300 ^{O}C. Also the plastic roller ball guides were replaced with aluminum guides.

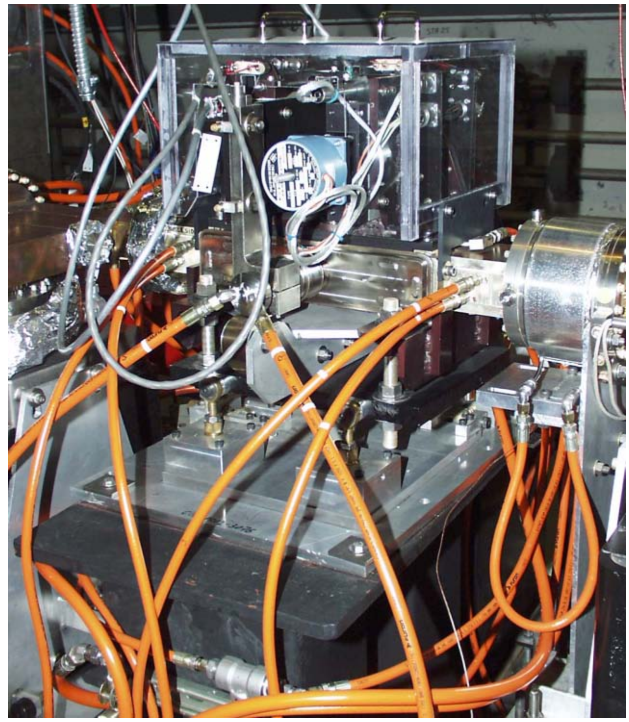

figure 4: LER collimator installation

4. CONTROL SYSTEM

The PEPII Movable Collimators Control System is a closed loop computer based system consisting of a stepper motor drive system with LVDT s (Linear Voltage Differential transducers) for positional feedback. The stepper motors are Superior Electric Slo-Syn type M091-FD-419E which are 4 phase, 6 wire, 150 oz-in DC stepper motors, designed to operate at 5.3V driving 1.6A per phase and are specially ordered with radiation resistant wiring. They are operated in 200 steps/rev. full step mode driving a 2 mm/thread screw drive assembly. This results in a step resolution of 10 μm/step. The drive rate is set at 200 steps/sec. thus moving the collimators at a rate of 2mm/sec. The motors are driven from single width CAMAC based stepper motor controllers, model SMC-24B, manufactured by Joerger Enterprises. They are L/R drive type operating in full step, power down mode. There are limit switches at both limits set approximately 0.4mm from the stops to prevent the slide assembly from being driven into the mechanical stops. Software stops are set approximately 0.25mm before the switches. The position of the collimators are fed back to the control system by the use of Daytronic corporation type DS500-S LVDTs which provide a linear voltage output proportional to the collimator position over a 1 inch range. These are also specially ordered with radiation resistant wiring. The LVDTs are controlled by Daytronics dual LVDT conditioner cards type 10A30-2X8 specially modified for SLAC and are located in a Daytronic 10K1 chassis. The output voltage from the conditioner card is taken directly from the card and fed into a SAM (Smart Analog Module) which is a single width CAMAC module.

5. EARLY RESULTS

Operation of the LER collimators has so far been restricted to a single excursion of one of the jaws and the results were very encouraging. We intend to wait for some time until the beam has been fully conditioned before operating the collimators.

6. REFERENCES

[1] PEP-II Conceptual Design Report , SLAC report 418, LBL-PUB-5379, June 1993

[2] Glidcop is a registered trademark of OMG Americas Corp., Research Triangle Park, NNC, USA

[3] R.Valdiviez et al, The use of dispersion strengthened copper in accelerator designs Los Alamos National Laboratory.

[4] Wear test. SLAC report, S.J.Metcalfe, May 2000, http://www.slac.stanford.edu/grp/ad/me/coll_fin_wear.htm

[5] J.Seeman et al, PEPII New High Power, Low Impedance, Movable Collimator , P2298, EPAC2000, June 2000