Parallel Operation of the G2 and G3 Hutches

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We are seeking approval of the operation of the G2 side-bounce test stand as an x-ray beam splitter during the intermediate operation of G-line from May 2002 to the upcoming larger down period in spring 2003. This way, both the G2 and the G3 hutch can be supplied with photons simultaneously and experiments can be performed in parallel. The proposed mode of operation is covered by the current interlock set-up and no change of the safety system cabling will be required.

First commissioning experiments in the approved mode of operation have been conducted in the G2 hutch. We found that the two Be single crystals have a transmission of 65% at 8.3 keV photon energy, and that the Bragg-reflected beam has about 1.5% of the intensity of the incident beam, in compliance with our expectation (see appendix).

1) We would like to leave a side-bounce crystal for long-term use in the beam. This way there would be no turnover time between G2 and G3 experiments, since all components in G2 (side-bounce monochromator, transfer pipe) were fixed. We are seeking approval for this set-up.

2) We would like to use the photon beams in the G2 and G3 hutches simultaneously.

Radiation Safety

The proposed simultaneous operation is fully covered by the existing safety systems and procedures. The only additional radiation safety aspect is, that the beam would be used in two hutches at the same time. Because of the present arrangement of shutters, one of the user groups would be the master user who decides access to the hutches, while the parasitic users would have to co-ordinate with the master users, for hutch access and beam.

Specifically this means:

A) If the G2 team are the master users, they can access the G2 hutch, whenever they wish. In doing so they would shut off the beam for G3.

B) If the G3 team are the master users, the parasitic G2 users can only close the G2 shutter to access the G2 hutch, when the G3 team is ready for an interruption of their experiment (the present G2 shutter stops the beam for both G2 and G3).

C) Personal safety is ensured at all times in the proposed mode.

D) Master and parasitic users will need to work together cooperatively.

Remaining safety issues

Safety issues with the proposed set-up other than Radiation Safety are:

A) Oxidation of the Be crystal
B) Monitoring of the He flow in the x-ray beam transfer pipe
C) Ozone production in the remaining air paths

A) Oxidation of the Be crystal

Oxidation of the Be crystal is prevented by keeping the crystal in a helium environment. We will use the existing He flow panel to control the flow of He gas through the crystal shroud. A He flow monitor in the exit line of the shroud will ensure that there are no significant leaks in the He lines and the Kapton windows, and that the Be crystal is thus kept in an oxygen-free environment. The He flow sensor will be interlocked with the G2 shutter using existing patch panels.

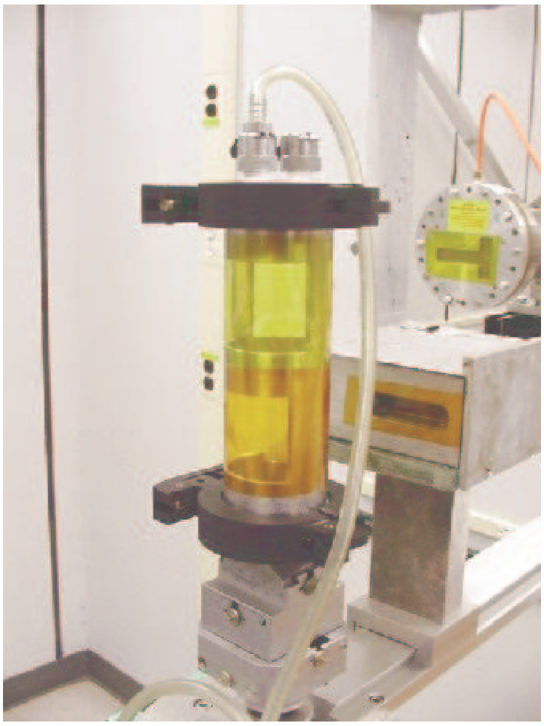
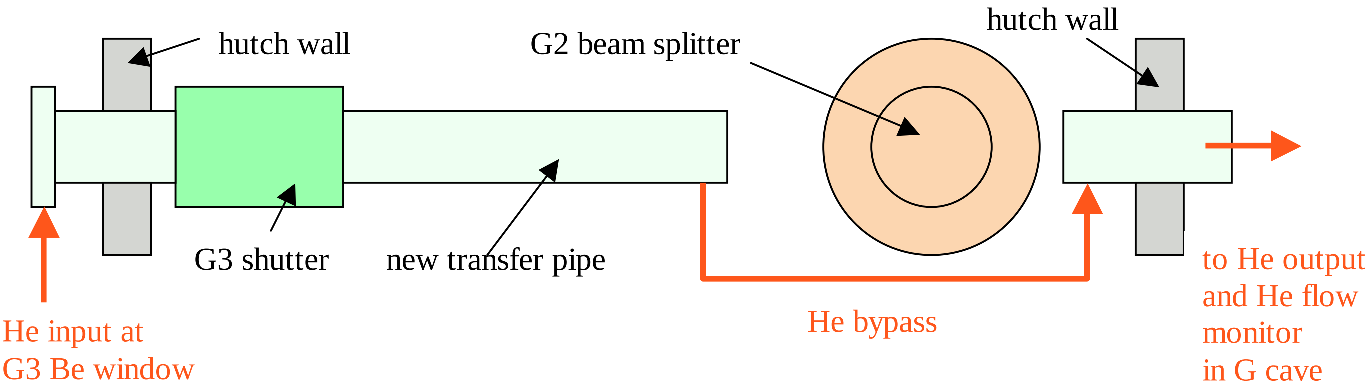


Fig.3 Helium-filled shroud with Kapton windows for the Be single crystal. The crystal will be seated in the center of the bottom window.

B) Monitoring of the He flow in the x-ray beam transfer pipe

A modified transfer pipe is to be installed between side-bounce monochromator and G3 shutter. We will continue using the existing He gas inlet in the G3 hutch. An outlet in the new G2 transfer will feed He gas into the existing inlet of the G2 transfer pipe, thus creating a bypass for the monochromator. The He flow will be monitored and interlocked as before in G cave.



C) Ozone production in the remaining air paths

Ozone production will be minimized by using He filled flight paths wherever possible. The ventilation within the G2 hutch amounts to 165 CFM and should be sufficient to control the ozone production in the remaining air path of about 0.5 m for multiplayer beam (the situation would be similar to A2 hutch).

An estimate for the upper limit of ozone production in the hutch is provided in Appendix B. This calculation is consistent with Jeff White's ozone measurement in G1 reported in Appendix C.

Appendix: Interim side-bounce monochromator in the G2 hutch

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In the full-fledged version of G-line there will be a transparent beam splitter in the G2 hutch, supplying G2 with monochromatic beam while most of the broad bandwidth beam from the main multiplayer monochromator passes on to the G3 hutch. In order to get some first experience with beam splitting crystals, the G2 team is presently setting up a monochromator test station in the G2 hutch, for which we are seeking safety approval.

A side view of the monochromator set-up is presented in Fig 1:

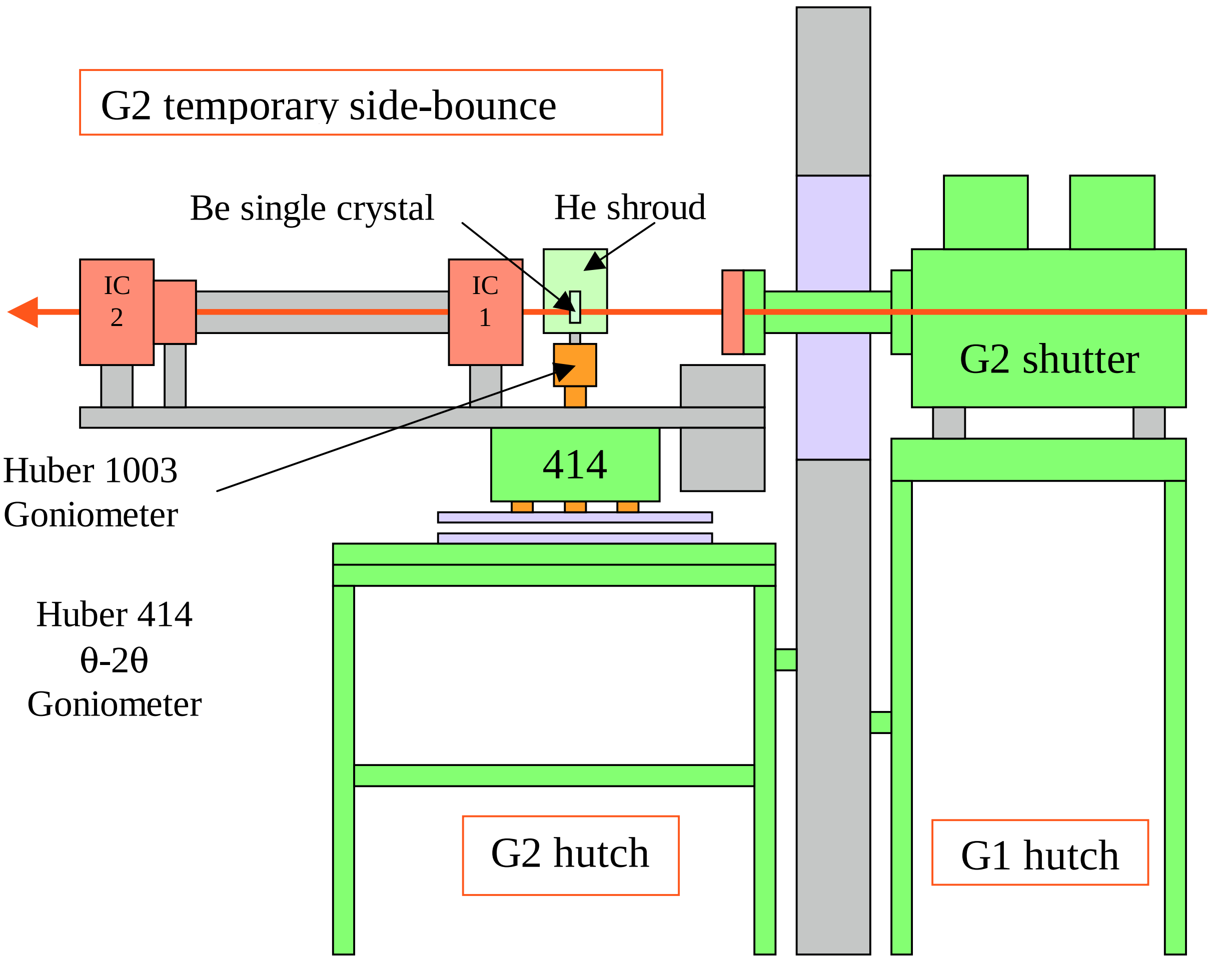

Fig 1. Side view of the side bounce monochromator set up in G2.

The beryllium single crystal is mounted on a Huber 1003 goniometer head, which in turn is mounted on a Huber 414 analyzer stage. The crystal is covered with a helium-filled shroud consisting of a KF40 nipple with Kapton windows. The function of the helium environment is to prevent oxidation of the crystals by ozone produced in the intense monochromatic incident beam. A top view of the set-up is presented in Fig. 2

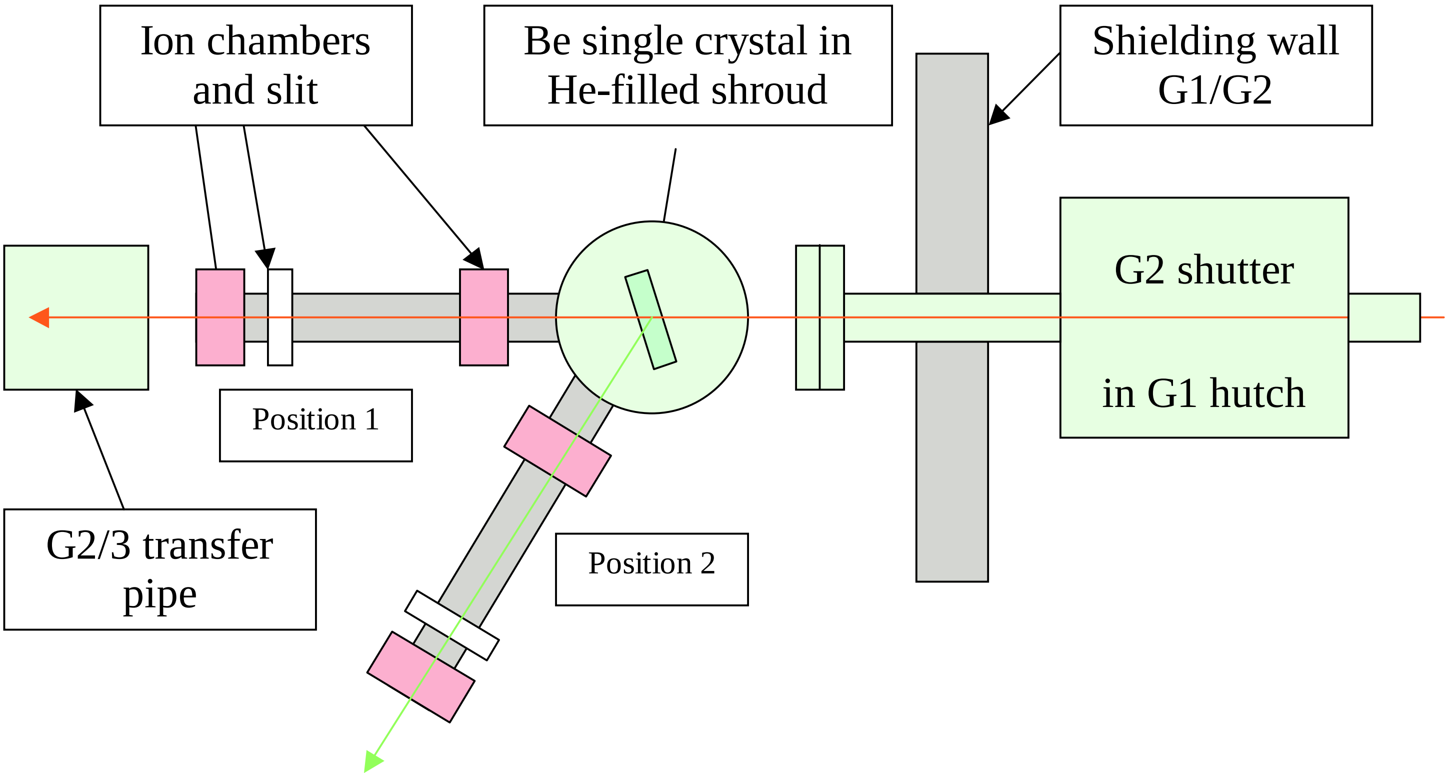

Fig 2. G2 side-bounce monochromator test stand, top view. Helium filled parts are marked light green. Position 1 of the detector arm (2θ) is used for characterizing the transmitted beam. Position 2 is used for characterizing the Bragg-reflected beam with about 0.1% band width (due to the mosaic of the Be crystal).

Appendix B: Estimated upper limit for ozone production in G2 hutch

At 8 keV photon energy we measured a photon flux of 6×10^{12} photons per second, so let us assume an upper limit of 10^{13} photons per sec. Under normal conditions there is 21% of oxygen in air corresponding to a partial pressure of 160 Torr. The x-ray absorption along a 1 m path through 160 Torr O_2 is 27% (source: CXRO web site). If we assume that all of the absorption is due to the ionization of O_2, 3×10^{14} ions would be produced per minute. Again we assume that all of these ions form ozone. Using Avogadro's number and the mol volume of an ideal gas we can then convert the number of ozone molecules to the ozone volume created per minute which amounts to 5×10^{-10} cubic feet per minute. With an air flow of 165 cubic feet per minute through the G2 hutch, the upper limit of the steady state ozone concentration in the G2 can be estimated to be 3×10^{-12}. For comparison, the TLV is 0.1 ppm and the odor threshold for humans is 0.01ppm.

Appendix C: Jeff White's ozone measurement in G1 hutch

On 5/2/02, with the full 2 mm horizontal width and full vertical width of a multi-layer x-ray beam in the G1 station, the CHESS portable ozone sensor was placed at the upstream wall of the station, directly below the location of where the multi-layer beam is entering the hutch. This was monitored while radiation surveys were conducted to determine if ozone production without a flight tube would be a problem. No signal above background was discovered on the ozone sensor.

Ozone sensor characteristics: Range 0-1ppm, Sensitivity 0.01ppm, Accuracy ~0.02ppm, Alarm level 0.2ppm

Ozone Safety information:
1) Odor threshold for most humans 0.01-0.015ppm (Short-term desensitization sometimes occurs during exposure.)
2) ACGIH Threshold Limit Value (TLV) 0.1ppm
3) Short-term exposure limit (SEL) ~2ppm (provided no respiratory infection).

Thus all indications are that ozone production won't be a problem. If ozone production would ever start up, the normal odor threshold of an individual is generally sufficient to determine, if this has changed and thus further precautions may become necessary (additional flight tubes etc.).