

PRODUCTION OF INTENSE HIGH ENERGY GAMMA BEAM FOR LEPS2 PROJECT AT SPRING-8*

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Abstract

Construction of new beam line for LEPS2 Project at SPring-8 has been done and beam commissioning has been carried. LEPS2 is the project for high energy hadron physics using intense high energy gamma beam as probe. The gamma beam is produced by laser backward Compton scattering with injecting high power UV laser to the 8 GeV electron beam at long straight section (LSS) of SPring-8 storage ring. The target intensities of the gamma beam are $\sim 10^7/s$ for $E_\gamma < 2.4$ GeV, $\sim 10^6/s$ for $E_\gamma < 2.9$ GeV. For these purpose, new beam line with new frontend laser injection system is constructed. Some chambers and absorbers of storage ring are modified from regular type to get enough aperture for laser injection. The laser monitor system is also installed at the LSS for tuning the laser injecting direction. The beam commissioning has been carried by injecting 355 nm UV laser of total 56 W to stored electron beams of 100 mA operation and about $7 \cdot 10^6/s$ gamma ray has been obtained successfully.

LEPS2 PROJECT

LEPS2 Project is the science program for the hadron physics studied by fine experiments with intense high energy gamma beam and large acceptance high resolution detectors. The intense gamma beam is produced by the reaction of laser backward Compton scattering; the elastic scattering of laser photon and stored electron of 8 GeV storage ring of SPring-8. The maximum energy of the gamma is 2.4 GeV when 355nm UV laser is used, and 2.9 GeV when 266nm DUV laser is used. The target intensities are $\sim 10^7/s$ for the gamma beam of $E < 2.4$ GeV and $\sim 10^6/s$ for $E < 2.9$ GeV. This target is one order higher than the case of BL33LEP/SPring-8[1] which is the beam line also for high energy hadron physics and constructed about ten years ago. With this new project, more fine or brand new experiments for detail studies of hadron physics like studies of penta-quark state, etc. can be performed.

LASER INJECTION AND FRONTEND

For the LEPS2 project, new beam line named BL31LEPS2 is constructed at the one of the four LSSs of SPring-8 as shown in Figure 1. The electron beam divergence at LSS is so small that produced gamma beam divergence is also small, and then the large experimental building consists with large acceptance high resolution detectors can be constructed outside of storage ring building where is far from the reaction point of laser backward Compton scattering. It is also possible to obtain very high energy gamma beam by X-ray backward Compton scattering with undulator and soft X-ray mirror as a future plan.

Laser is introduced into reaction point inside of the ultrahigh vacuum chamber of LSS by Al coated Si mirror (M1 mirror) via quartz window at the frontend of BL31LEPS2. The schematic view of frontend and laser injection system is shown in Figure 2. Four lasers are used for producing highly intense gamma ray, these laser rays are injected via different quadrants of M1 mirror to avoid mutual interference as shown in Figure 3. These four laser rays are controlled by several mirrors in experimental hall of SPring-8 storage ring building and go to the M1 mirror through the hole on the concrete shielding wall of accelerator hall. The M1 mirror has horizontal slit of 3mm height not to be irradiated by synchrotron radiation (SR) from bending magnet (B1) of BL31LEPS2 and cooled from behind by Cu block with water channel not to be heated by SR halo. SR mask and Al window of 2mm in thickness are placed downstream of M1 mirror. Produced gamma ray goes out to air through this window and comes into beam pipe connected to experimental building with medium vacuum soon again not to be the e+e- pair due to interaction with air. The e+e- pair due to the interaction with the Al window or Pb collimator is rejected by sweep magnet shown in Figure 2. For the purpose of polarization measurement of injected laser, monitor mirror (M0 mirror) is installed upstream of M1 mirror. The M0 mirror has SR absorber behind and is movable by air cylinder.

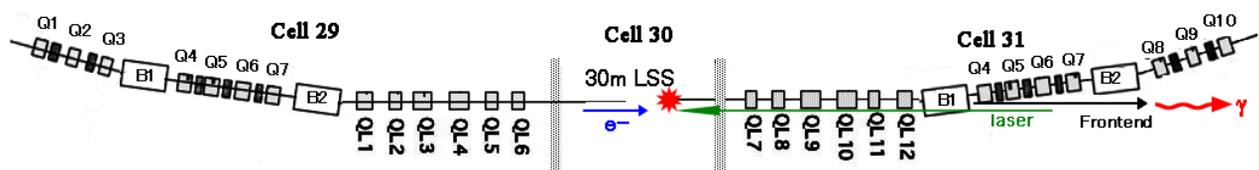


Figure 1: Schematic view of storage ring around BL31IS. Q1~10 and QL1~12 stand for quadrupole magnet and B1, B2 for bending magnet. Frontend of BL31IS is installed downstream of B1 of Cell 31.

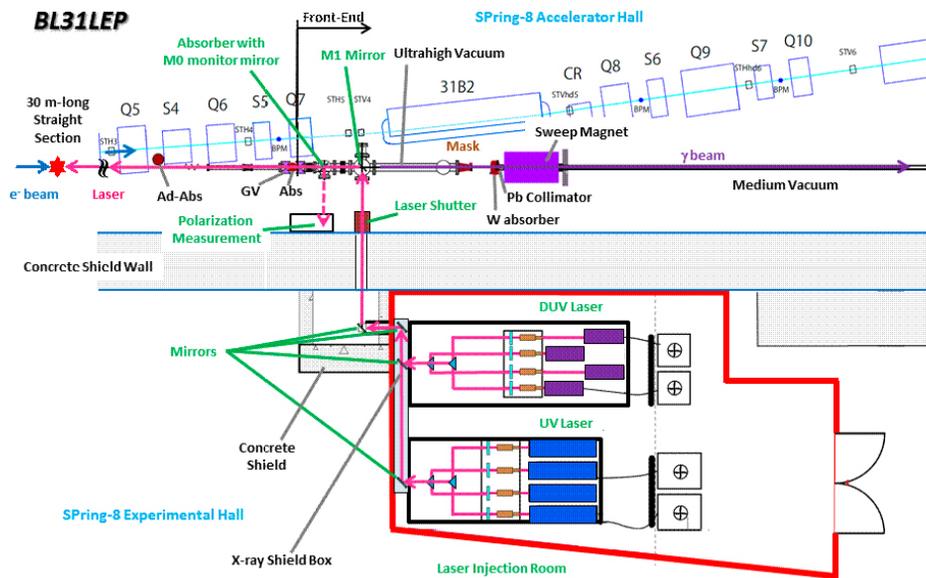


Figure 2: Frontend and laser injection system.

MODIFICATION OF CHAMBERS AND ABSORBERS

Figure 4 shows the required aperture for four laser injection. In order to enhance the aperture for the laser injection track, some chamber modifications have been done. Slot for the antechamber of B1 is hollowed along the laser tracks. The junction of photon duct to front end and storage ring straight chamber between B1 and B2 is also enhanced.

Regular crotch absorber is replaced by two separated absorbers as shown in Figure 5. The absorber inner side of storage ring receives high power SR from B1, so the receiving surface is sloped with the angle of 7.5 degree

against the SR direction. The outer absorber receives very low power only and existing regular absorber is used here. Slit with thin window for recoil electrons of Compton scattering is made inner side of absorbers' chamber and tagging counter measuring the electrons is installed downstream of the window. Additional absorber also installed at the junction of straight chamber to avoid that photon duct is irradiated by SR as the result of replacement of crotch absorber and enhancement of aperture. This additional absorber has fin structure to receive SR and not to obstruct laser at the same time as shown in Figure 3.

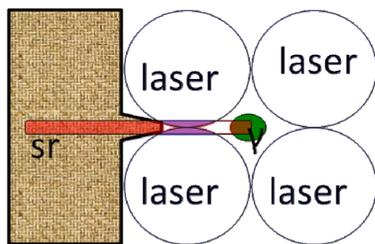


Figure 3: The relation between each shape of injected laser, SR light from BM1 and produced gamma on orthogonal plane to beam axis. the block with fin structure shows the additional absorber.

LASER MONITOR

The direction of injected laser is monitored by laser monitor installed at ~7m upstream of the reaction point as shown in Figure 4. The monitor system consists with aluminium mirrors, alumina fluorescent plates and CCD cameras as shown in Figure 6. The mirrors are installed near the electron beam track. coming to alumina fluorescent plates through quartz windows. These windows are shielded by laser slits made of stainless steel against the RF due to electron beam. Course tuning of laser injecting direction is done by this monitor and fine tuning is done with seeing the produced laser backward Compton gamma intensity.

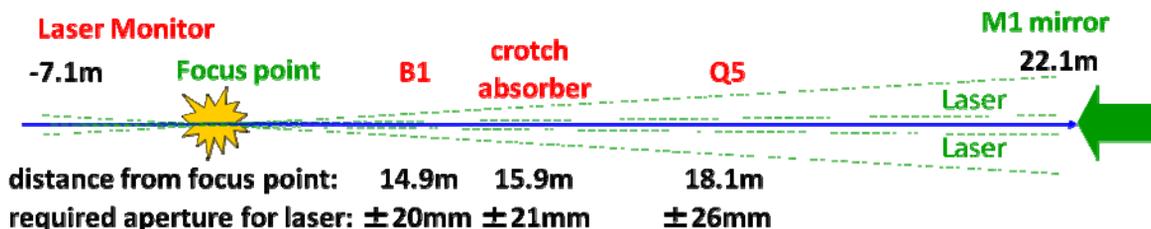


Figure 4: Required aperture for laser injection at each point.

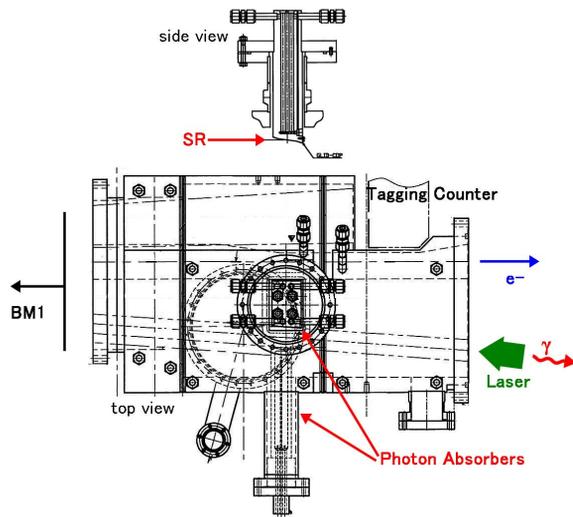


Figure 5: Layout of new photon absorbers installed as the replacement of crotch absorbers. tagging counter is installed downstream of slit for recoil electrons.

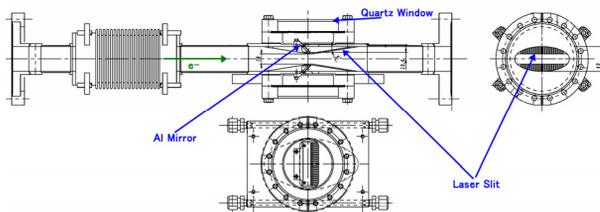


Figure 6: laser monitor system. The width of laser slits is 1 mm and thickness is 2 mm.

BEAM COMMISSIONING

Beam commissioning has been done. Two 16 W lasers and one 24 W laser of 355 nm have been used for laser injection. Fine tuning of laser injection direction has been done by seeing tagging counter rate to be maximum. Storage ring current was 100 mA. Finally about $7 \cdot 10^6/s$ laser backward Compton gamma have been obtained. This gamma intensity has been estimated from difference of the storage ring current life time between the cases of laser on and off. The gamma energy spectra also have been measured for the cases of laser on and off with storage ring current of 0.1 mA. The measurements have been done by BGO crystal calorimeter and Compton edge of 2.4 GeV is confirmed successfully as shown in Figure 7.

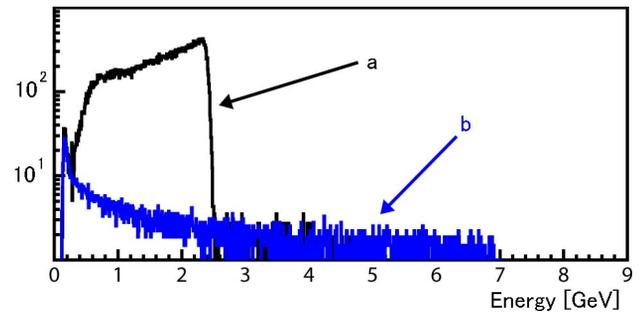


Figure 7: Obtained gamma ray spectrum measured by BGO crystal. a) the case of laser on and b) for off.

SUMMARY

Construction of new beam line for LEPS2 Project at SPring-8 has been done and beam commissioning has been carried. About $7 \cdot 10^6/s$ gamma ray has been obtained successfully by injection of two 16 W lasers and one 24 W laser to the stored electrons of 100 mA operation. More intense gamma beam will be expected when the full four laser injection would be done and the physics experiments will be performed after the detector construction to be done.

REFERENCES

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