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RECENT PROGRESS OF SHANGHAI LASER ELECTRON GAMMA SOURCE (SLEGS) BEAMLINE IN SSRF*

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Abstract

Shanghai Laser Electron Gamma Source (SLEGS) beamline, based on laser Compton scattering (LCS), as one of beamlines of Shanghai Synchrotron Radiation Facility (SSRF) in phase II project, has been constructed and started test commissioning from July 2021. The results of the commissioning already show a steady experimental proof that SLEGS can produce gamma rays with adjustable maximum energy by consecutively changing the interaction angle between laser beam and electron bunches [1].

In this paper, the recent progress of SLEGS is given. The newly measured gamma-ray's spectra and flux are presented. The resolution of the gamma-rays is improved with the application of external collimator. A gamma spot monitor is setup to measure the spatial distribution of LCS gamma ray. A 4π flat-efficiency ^{3}He neutron detector (FED) array and the neutron time-of-fight (TOF) spectrometer are also designed and installed. Some preliminary results of these devices is introduced.

GAMMA-RAY SPECTRA

There are two operation mode in SLEGS. One is backscattering mode, which will make the laser and electron bunch collide at 180 degrees, the high energy end of the generated γ spectra is 21.7MeV. The other mode is slanting mode [2], which mainly inherits the design used in the prototype [3], and it can produce gamma-ray with high energy end from 0.66MeV to 21.1MeV. The resolution of the gamma-rays can be adjusted using a collimator system [4]. The laser transport system [5] is tuned carefully to acquire the gamma-ray in demand.

Improved Simulation Code

The original simulation code [6] is improved and take the divergence of laser photons' angle and the jittering of electron orbit into account. The simulated gamma ray spectra of SLEGS now agree better than before with the experimental data. (Fig. 1)

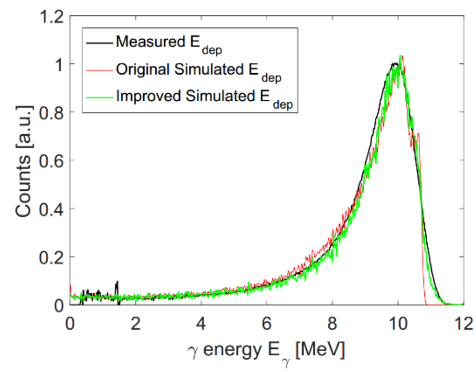

Figure 1: Comparison between the spectra calculated by improved simulation code and the original one.

Experimental Data

The electron energy of SSRF [7] is about 3.5 GeV, means the γ factor is 6849, which makes the energy change rapidly within a 300 μrad collimation angle. In order to obtain good gamma ray resolution a 200mm thick Pb collimator with 2mm diameter is setup about 40m downstream to achieve a full collimation angle of 50μrad for recent tests. We found that with this external collimator, the resolution (FWHM) of the collimated gamma-ray simulation is about 4% for backscattering case (green line in Fig. 2).

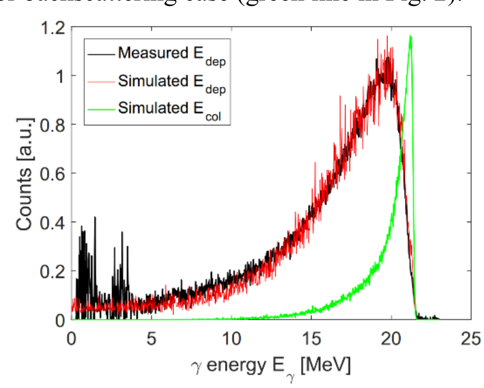

Figure 2: Backscattering gamma-ray energy spectra.

A series of gamma flux is measured consecutively with the coarse collimator's diameter of 2mm. The flux of corresponding simulation is also consistent with the measured one (see Fig. 3)

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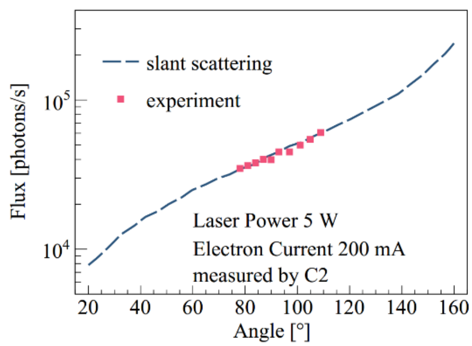

Figure 3: Measured and simulated gamma-ray flux of a series of interaction angles, C2 is short for 2mm coarse collimator.

We also measured the energy spectra of a set of various angles and collimator with different diameters, and a systematic analysis will be summarized and published in the near future.

EXPERIMENTAL DEVICES

The experimental hutch is equipped with several devices to perform measurement that users may require. Some of them has been tested recently. The results are listed below:

Gamma Spot Monitor

A gamma spot monitor is built using a LYSO crystal plate and a shimmer camera. Its spatial resolution can reach 1.25lp/mm. (Fig. 4). It can help us achieve preliminary alignment of the external collimator.

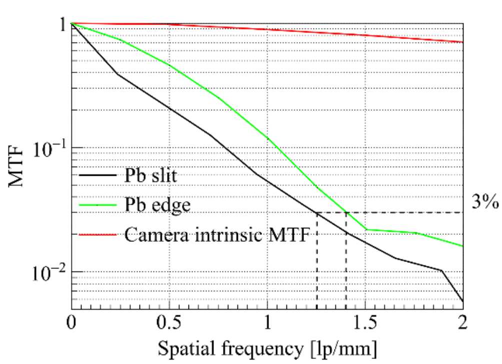

Figure 4: Module transfer function (MTF) of GSM.

The spot size is approximately 8×10mm, and we have taken a few radiographs and a simple CT test with it (Fig. 5). A more detailed systematic testing of GSM is summarized and published later.

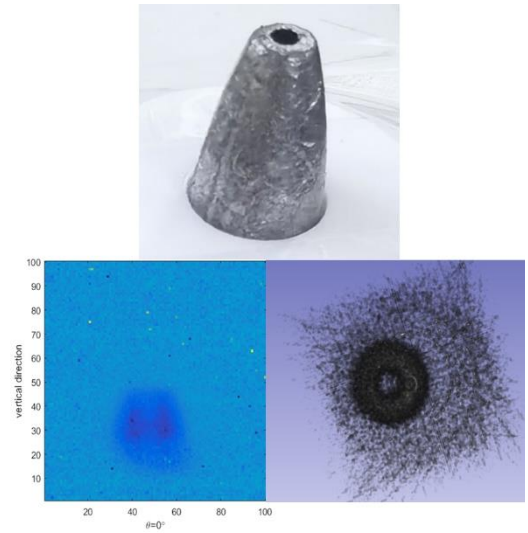

Figure 5: The CT test result of a Hollow cone (top: photo, down left: radiograph, down right: CT reconstruction model).

At the same time, we observed the phenomenon of the shape of the gamma ray spot rotating with the rotation of the incident polarization direction angle (Fig. 6). This is consistent with the prediction of theory [8]. The expose time of 90 degree is not as long as the latter two. To reduce the fluctuation, we merged more pixels. And some pixels with abnormal value make its colormap deviate from the normal range. We will investigate this deeper to see if there is anything unusual.

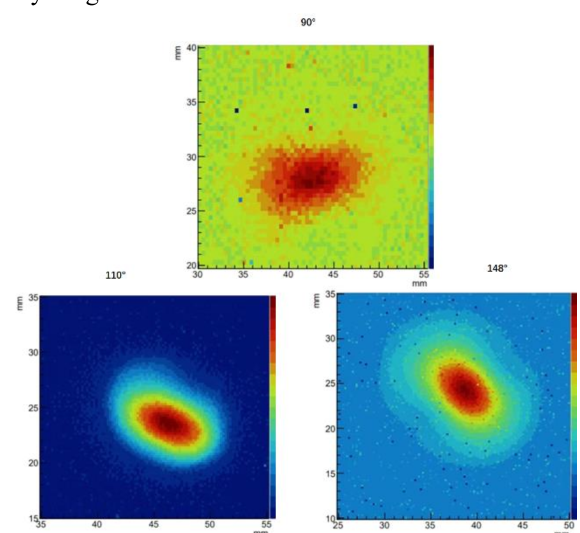

Figure 6: Gamma-ray spot change with different laser polarization angle.

Neutron Flat-Efficiency Detector (FED) Array

A 4π flat-efficiency 3He neutron detector array is built according to the design (Fig. 7) [9]. We tried to measure the (γ,n) cross section of several targets.

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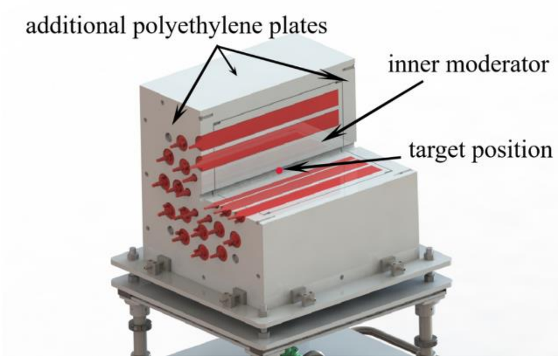

Figure 7: 3D structure of the FED.

The preliminary result with 159Tb and 197Au looks consistent with previous experiment data. The whole work details still need more time to check and will be reported to public later.

Neutron Time-Of-Flight (TOF) Spectrometer

TOF technology was used to measure the fast neutron energies. The pulse shape discrimination (PSD) capability of EJ301 detector is measured using ^{252}Cf radioactive source. The result shows a good separation between γ photons and neutrons [10].

Using the signal of $LaBr_3$ detector as the starting time and the signal of EJ301 detector as the stopping time, a coincidence time resolution was measured at a series of integral gate lengths and different distance. The result average time resolutions are close to 1.3ns.

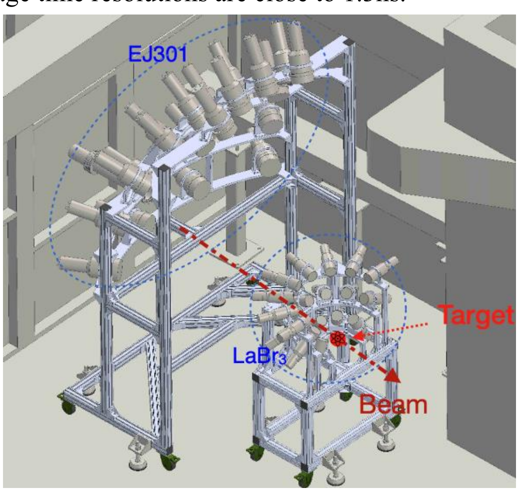

Figure 8: Structure of the TOF.

The apparatus (Fig. 8) demonstrated exceptionally good performance in collecting and distinguishing γ-rays and neutrons of GDR decay.

CONCLUSION

SLEGS is one of the several storage ring based LCS Gamma-ray sources that are in operation in the world. The innovative design of slant-scattering mode enables it to generate gamma-ray spectra with high energy end from 0.66MeV to 21.1MeV, and to generate γ-ray at a maximum energy of 21.7 MeV in backscattering mode at 180 degree. The recent commissioning results show that the qualities of gamma ray beam, such as resolution and flux, have reached the requirement of photonuclear experiment. Several experiment devices are tested and ready to serve in the research in the future. SLEGS is expected to be open to the users by the end of this year. International users from all over the world are welcomed to apply for operation hours to conduct relevant experiments in SLEGS.

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