HIGS flux performance table for high-flux, quasi-CW operation, DFELL/TUNL, Nov. 9, 2010 (Version 2.3).

HIGS Flux Performance Projection (2010 – 2011)		Total Flux [g/s] CW Operation Two-Bunch [*]	Collimated Flux ($\Delta E_\gamma / E_\gamma = 5\%$ FWHM) [#], [@]	FEL λ [nm]	Comment
No-loss Mode : < 20 MeV					Linear Pol. with OK-4 Circular Pol with OK-5
$E_\gamma = 1 – 2$ MeV	($E_e = 237 – 336$ MeV)	$1 \times 10^8 – 4 \times 10^8$	$6 \times 10^6 – 2.4 \times 10^7$	1064	Linear and Circular [a], [b]
$E_\gamma = 2 – 2.9$ MeV	($E_e = 336 – 405$ MeV)	$4 \times 10^8 – 1 \times 10^9$	$2.4 \times 10^7 – 6 \times 10^7$	1064	Linear and Circular [a], [b]
$E_\gamma = 2 – 3$ MeV	($E_e = 288 – 353$ MeV)	$2 \times 10^8 – 6 \times 10^8$	$1.2 \times 10^7 – 3.6 \times 10^7$	780	Linear and Circular [a], [b]
$E_\gamma = 3 – 5.4$ MeV	($E_e = 353 – 474$ MeV)	$6 \times 10^8 – 2 \times 10^9$	$3.6 \times 10^7 – 1.2 \times 10^8$	780	Linear [a]
$E_\gamma = 3 – 6.3$ MeV	($E_e = 353 – 512$ MeV)	$6 \times 10^8 – 3 \times 10^9$	$3.6 \times 10^7 – 1.8 \times 10^8$	780	Circular [a]
$E_\gamma = 5 – 8$ MeV	($E_e = 380 – 481$MeV)	$4 \times 10^8 – 1 \times 10^9$	$2.4 \times 10^7 – 6 \times 10^7$	540	Linear and Circular [a]
$E_\gamma = 8 – 11$ MeV	($E_e = 481 – 565$ MeV)	$1 \times 10^9 – 2 \times 10^9$	$6 \times 10^7 – 1.2 \times 10^8$	540	Linear [a]
$E_\gamma = 8 – 13$ MeV	($E_e = 481 – 615$ MeV)	$1 \times 10^9 – 4 \times 10^9$	$6 \times 10^7 – 2.4 \times 10^8$	540	Circular [a]
$E_\gamma = 8 – 11$ MeV	($E_e = 439 – 516$ MeV)	$5 \times 10^8 – 1 \times 10^9$	$3 \times 10^7 – 6 \times 10^7$	450	Linear and Circular [a]
$E_\gamma = 11 – 16$ MeV	($E_e = 516 – 624$ MeV)	$1 \times 10^9 – 2 \times 10^9$	$6 \times 10^7 – 1.2 \times 10^8$	450	Linear [a]
$E_\gamma = 11 – 18.5$ MeV	($E_e = 516 – 671$ MeV)	$1 \times 10^9 – 2 \times 10^9$	$6 \times 10^7 – 1.2 \times 10^8$	450	Circular [a]
$E_\gamma = 15 – 25$ MeV	($E_e = 533 – 691$ MeV)	$2 \times 10^8 – 3 \times 10^8$	$1.2 \times 10^7 – 1.8 \times 10^7$	350	Linear [a]
$E_\gamma = 15 – 30$ MeV	($E_e = 533 – 758$ MeV)	$3 \times 10^8 – 5 \times 10^8$	$1.8 \times 10^7 – 3 \times 10^7$	350	Circular [a]
Loss Mode: > 20 MeV					Circular Polarization only with OK-5 FEL
$E_\gamma = 21 – 54$ MeV	($E_e = 547 – 887$ MeV)	$\sim 2 \times 10^8$	$\sim 1.2 \times 10^7$	260	Circular [c]
$E_\gamma = 21 – 60$ MeV	($E_e = 526 – 901$ MeV)	$\sim 2 \times 10^8$	$\sim 1.2 \times 10^7$	240	Circular [c]
$E_\gamma = 50 – 95$ MeV	($E_e = 738 – 1030$ MeV)	$\sim 1 \times 10^8$	$\sim 6 \times 10^6$	193	Circular [c], [d]

(a) As mirrors degrade due to wiggler radiation, the gamma flux will be lower than the listed numbers. Operating in circular polarization slows mirror degradation.
(b) With new FEL mirrors, the flux of the circularly polarized gamma beam can be 1.5 to 2 times as the listed numbers.
(c) The flux is limited by the capability of sustaining a high intra-cavity power by the FEL mirrors and electron injection rate.
(d) Total flux is 1×10^7 gamma/sec as of Oct. 2010. A total flux of 1×10^8 gamma/sec is expected as early as Q2, 2012. [1]
(*) The flux numbers are projected for the high-flux operation with two symmetric electron bunches. The gamma flux will be different in other operation modes, including the high-resolution mode, and giant-pulse mode.
(#) The energy resolution of the collimated gamma beam depends on parameters of the electron and FEL beams, as well as the collimator opening aperture. The 5% FWHM flux in the table is used only for the purpose of illustrating the collimated flux. A higher resolution beam can be produced at the expense of a reduced gamma-beam flux. Using a given FEL mirror set, the portion of the flux selected by the collimator is inversely proportional to the gamma beam energy.
(@) It is critical to match the experimental sample and collimated gamma beam. A useful formula to estimate the portion of the gamma-ray beam after collimation is:

$$\frac{\text{Collimated Flux}}{\text{Total Flux}} = a * \left[\frac{\text{Ee [MeV]}}{0.511} * \frac{\text{r [mm]}}{52.8*10^3}\right]^2, \qquad a \sim 1.2 \text{ to } 1.5,$$

where Ee is the electron energy in MeV and r is the radius of the collimating aperture in mm. The distance between the collision point and the collimator is 52.8 m as of January, 2010.

Modes of HIGS Operation

1. ***High-flux, quasi-CW operation, micropules with sub-ns durations at 5.5796 MHz***
   Typical energy spread (FWHM): 4 – 10%; the flux performance is found in the above table;
2. ***High-resolution, quasi-CW operation, micropules with sub-ns durations at 2.7898 MHz (the main beam)***
   Typical energy spread (FWHM): 0.8 – 1.5%; the flux is lower by a factor of 50 – 100 compared to high-flux mode;
3. ***Pulsed operation***
   Typically, 100 – 300 microsecond macropulses are produced with a reprate of 1 to 15 Hz, depending on gamma energy, the flux performance is lower than quasi-CW modes, and with reduced stability below 10 MeV.

1 Contact for details of HIGS performance: wu@fel.duke.edu