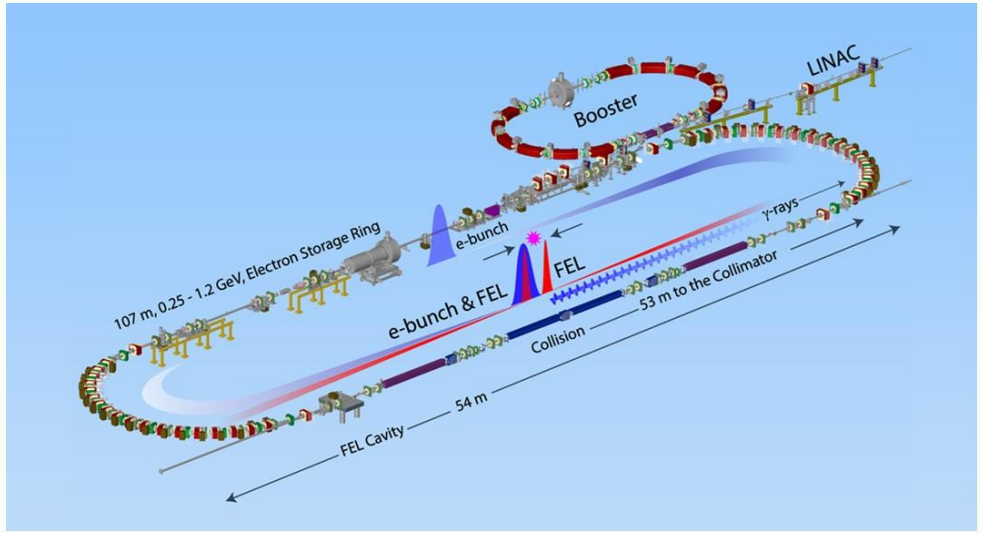
Forty Years of Accelerator Alignment at Duke University Free Electron Laser Laboratory (DFELL)

IWAA 2026

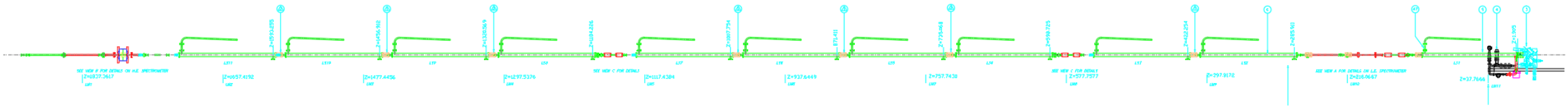
Tsukuba, Japan



Chronology and a Brief History

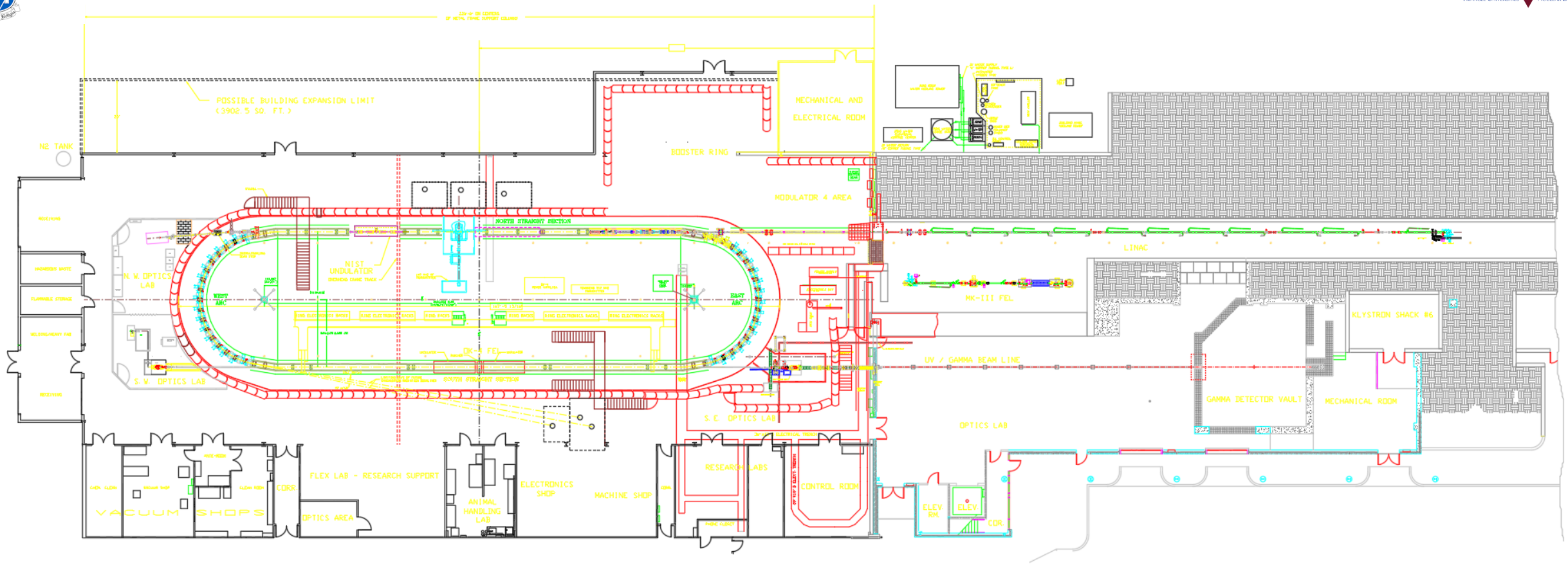
1985	*Storage Ring Based Free Electron Laser Lab at Stanford University was conceived*
1986	*Planning for technical orbital design, magnet design and alignment methodology started*
1987	*Some of the Dipoles & Quadrupoles plus the girders were fabricated and installed*
1988	*Magnets, girders, Linac accelerators plus all lab equipment were moved to Duke University*
1989	*More equipment and some of the technical and scientific staff moved to Duke University*
1989	*Planning for construction of a building for the lab at Duke was started*
1991	*Construction of the 5100 square meter Duke Free Electron Laser Lab (DFELL) was completed*
1992	*Magnetic measurement and QC under way. Installation of magnets started*
1993	*Installation of the girders completed*
1994	*Electron beam was successfully injected and stored.*





Optical instruments and alignment tools used to accomplish the task of alignment:

a. Brunson 76-RH Telescopic transit square, used to align components in a vertical plane.
b. Brunson 376-RHN Universal transit square
c. Wild precision sight level model N3, used to sight in horizontal plane and set elevations of components.
c. Wild precision optical plummet model NL, used for nadir pluming.
d. Brunson 803 invar scale extension kit, to measure distances of less than 7 meters.



Storage Ring Slab Construction

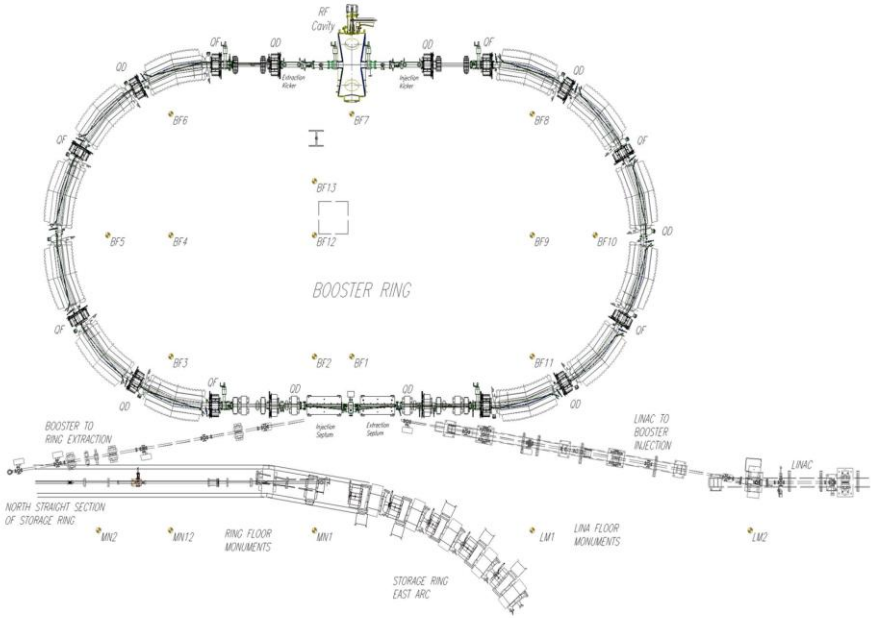
To satisfy the extraordinary stability requirements for research in the UV and γ-ray, the main storage ring's 1 meter thick slab is supported on a matrix of 32 closely spaced caissons extended to the underlying bedrock.

The rest of the facility including the cavity mirrors are installed on separate slabs with their thickness ranging from 12 to 32 cm.

Realignment of Duke Free Electron Laser Storage Ring
2001

In the fall of 2001, both East and West arc sections of the storage ring at the Duke Free Electron Laser (FEL) laboratory went under a major upgrade. This upgrade was necessary in order to improve the power supplies and water-cooling capabilities in the arc quadrupole magnets, and also to improve the vacuum systems in the arc sections.

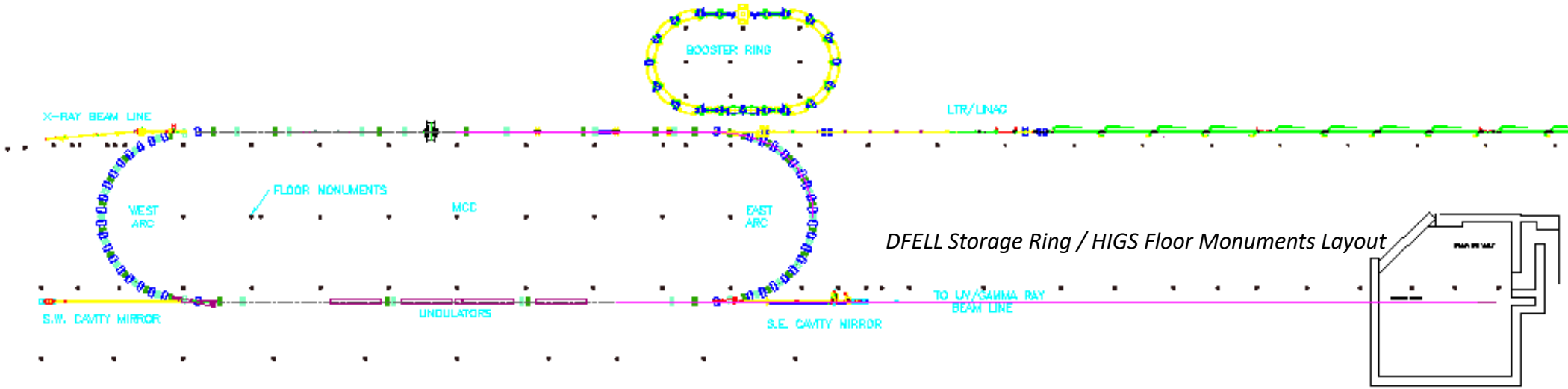
Booster Ring Installation
2006





- *Used Laser Tracker LTD500*
- *31.9 m circumference machine*
- *12 dipole magnets;*
- *8 Focusing (QF) and 8 Defocusing (QD) quadrupoles*
- *8 Sextupoles and 8 horizontal and vertical trim Dipoles*
- *One178.55 MHz RF cavity for ramping electron bunches to 1.2 GeV*
- *One injection and one extraction septum magnet; two kicker magnets*
- *Each arc in the booster ring consists of 6 magnet clusters which are supported by individual extruded aluminum strong backs.*
- *Beam energy ramping from 0.27 GeV to 1.2 GeV is accomplished in 0.6 second at 1.3 second of repetition rate.*

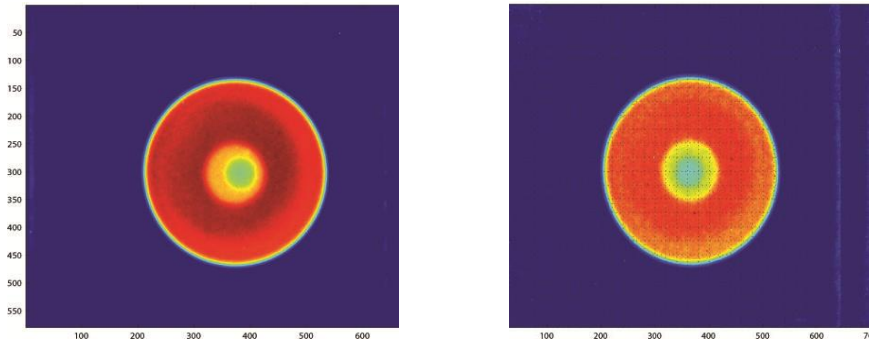
Beam Based Alignment of HIGS Targets at DFELL 2010



DFELL Storage Ring / HIGS Floor Monuments Layout

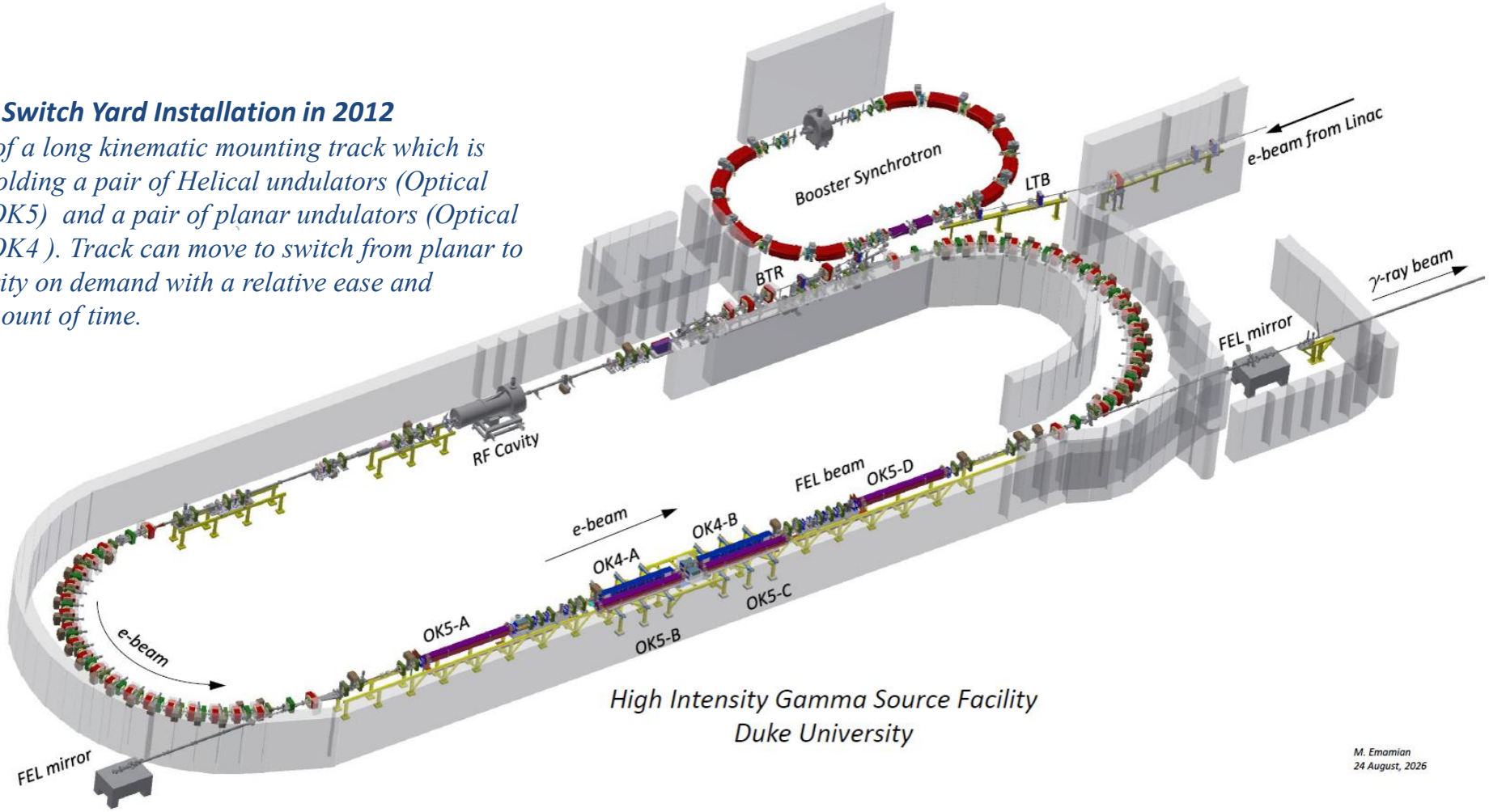
Gamma Ray BGO Imaging System and the Beam Based Alignment

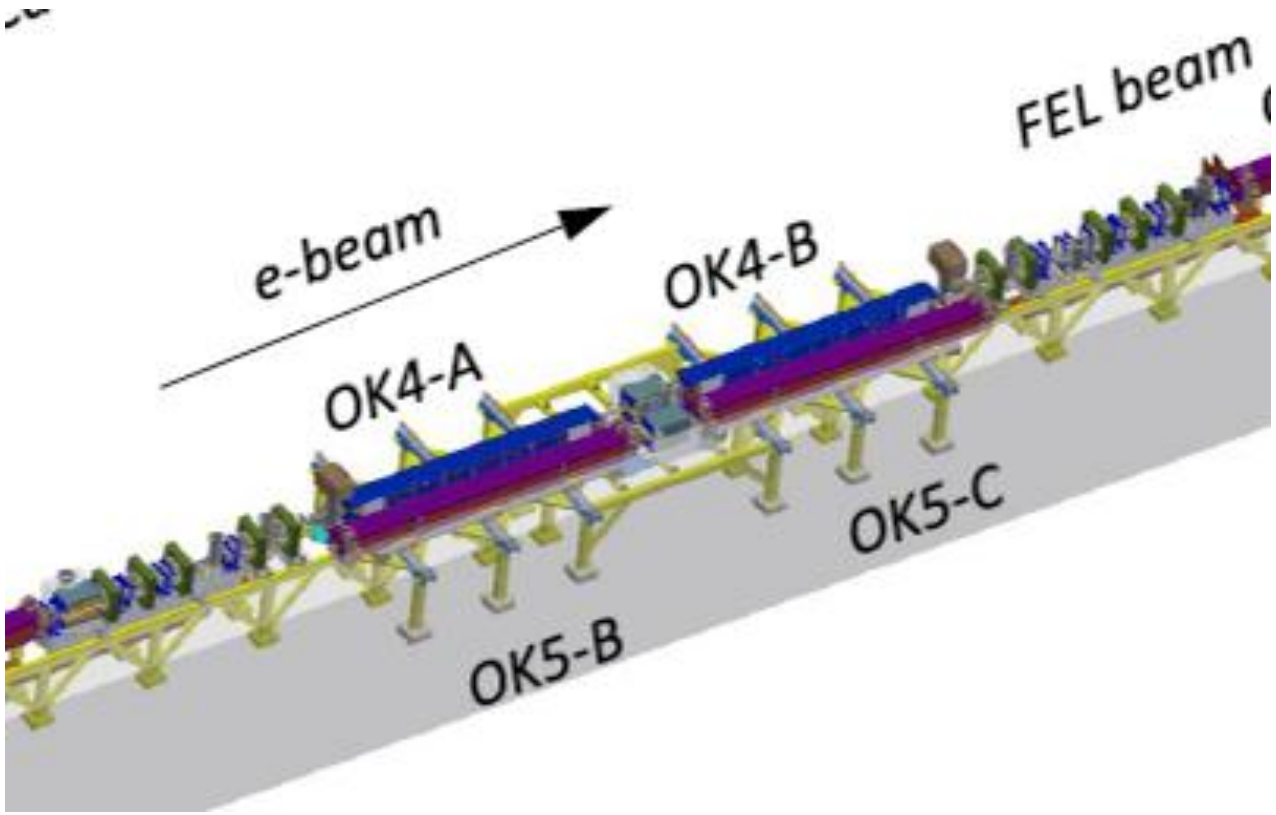
In order to rapidly and precisely image and align objects and other experimental targets which are placed in the path of gamma rays, a gamma ray imaging system was designed. Major components of this system consist of a scintillation crystal plate, Bismuth Germanium Oxide or BGO which converts gamma rays to visible lights, and a CCD based camera to capture the lights. The spatial resolution of this BGO system is in the order of 0.5 mm.



Switch Yard Installation in 2012

Installation of a long kinematic mounting track which is capable of holding a pair of Helical undulators (Optical Klystron 5, OK5) and a pair of planar undulators (Optical Klystron 4, OK4). Track can move to switch from planar to helical polarity on demand with a relative ease and minimum amount of time.




e-beam
FEL beam
OK4-A
OK4-B
OK5-B
OK5-C

Thank You For Your Attention!