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DESIGN, FABRICATION, AND ASSEMBLY OF A 3 POLE WIGGLER DEVICE

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Abstract

In this paper, ADC will discuss the design and construction of the three pole wiggler which will be used to monitor the beam emittance and provide a broadband source for the National Synchrotron Light Source II at BNL.

OVERVIEW

The 3 pole wiggler is constructed of 4 large magnets and 6 pole pieces, as shown in Figure 1 below. 2 magnets and 3 poles on top face the same configuration below. There is no girder. The magnets and poles are held together with tie rods and mounted to the strong-back by the magnet holders. The design allows for adjustment of the magnets and poles in XY translation and rotation.

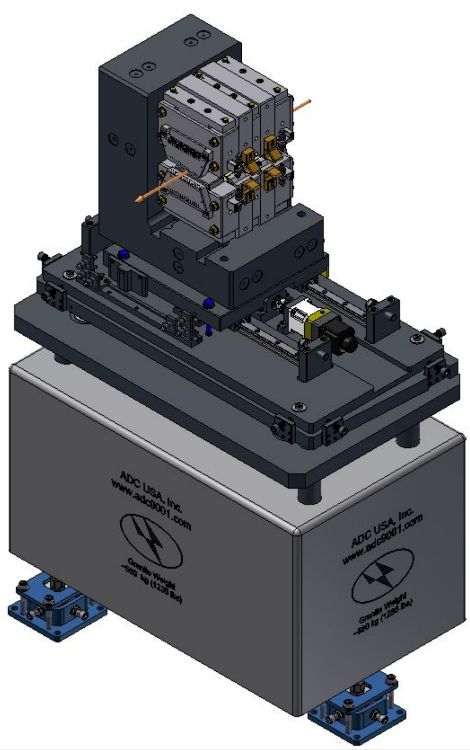

Figure 1: 3D model of the 3 pole wiggler

This system will be installed at the National Synchrotron Light Source II Department of Brookhaven National Laboratory. NSLS II is a medium energy storage ring of 3 GeV electron beam energy with sub-nm rad horizontal emittance and top-off capability at 500 mA. The three pole wiggler (3PW) will be used to monitor the beam emittance and produce the broadband radiation which is similar to what NSLS bending magnets produce. An installed view is shown in Figure 2, below.

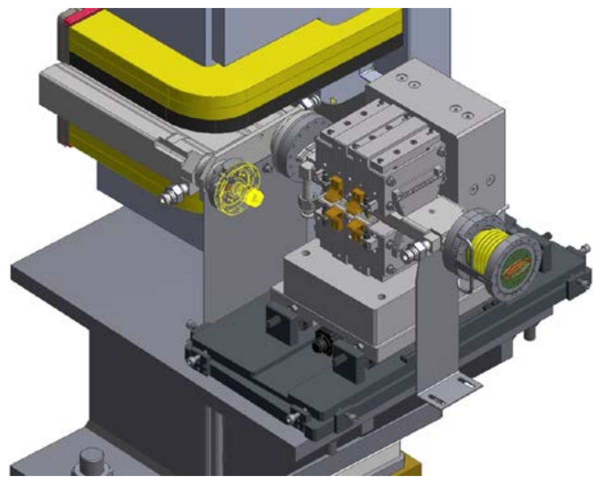

Figure 2: Installed view

MECHANICAL-LINEAR STAGE

The 3 pole wiggler consists of one motorized stage that provides 200 mm translation in the X direction, as shown in Figure 3 below.

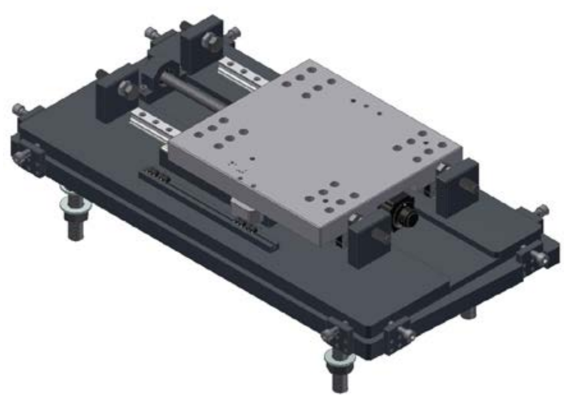

Figure 3: Mechanical linear stage

The stage is equipped with a Renishaw Tonic Encoder (with .1 um resolution and +/- 1 um accuracy) and Omron high repeatability (+/- 1 um) limit switches. A split base plate design allows manual adjustments for pitch, roll, yaw, and X translation in the upper plate, while the lower plate provides adjustment to the system in the Y and Z direction. The threaded studs attach the assembly to the girder. These studs and have a nut on both the top and bottom to lock the assembly in place. Adjustable hard stops have been added in front and behind each rail.

MECHANICAL FEA-ANALYSIS

FEA analysis was performed to determine the amount of deflection that will occur at the magnet locations. The following table, Table 1 shows the results from hand calculations prior to the FEA analysis. Table 2 shows the results of the FEA. The image in the center, Figure 4, shows the gradient of static deflection.

Hand Calculations
$F_{yield\ of\ bolt}$ = 16.5 kN (Force to permanently deform the bolt from elongation)
$t_{yield\ of\ bolt}$ = 15 kN (Force to permanently deform the bolt from shear)
$y_{magnet\ module}$ = 0.7 μm (Deflection of magnet modules)
$y_{strongback}$ = 3.1 μm (Deflection form the strong back)
y_{total} = 4.5 μm (Total Deflection)

Table 1: Hand calculations

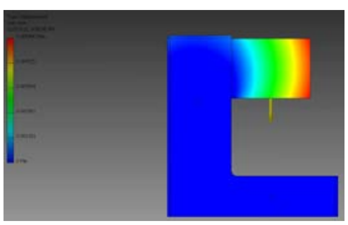

Figure 4: Gradient of static deflection

Applied Load	Deflection
2600 N	3.5 μm
7800 N (3x)	10 μm
26000 N (10x)	35 μm
130000 N (50x)	170 μm

Table 2: R- FEA Result

MECHANICAL-MAGNET ASSEMBLY

The upper and lower magnet assemblies consist of 2 NdFeB permanent magnets, 1 main pole made of Vanadium Permendur, and 2 side poles made of low carbon steel. The magnet assembly is held together by 4 stainless steel rods with M10 threaded ends, which run through the magnet holders and pole piece spacers. 8 M10 nuts are used to clamp the system together. The magnet assembly is bolted to the strong-back by the magnet holders; see Figure 5 to the right. Holders for corrector magnets are attached to the end poles. A prototype 3PW is shown in Figure 6 below.

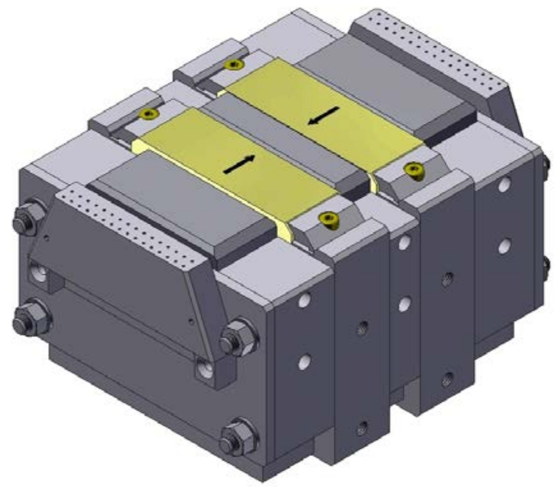

Figure 5: Lower magnet assembly

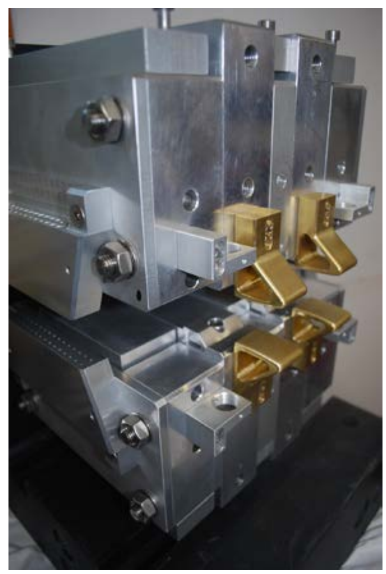

Figure 6: Prototype 3PW

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