## ABSTRACT

- The Advanced Photon Source Upgrade (APS-U) is to replace the existing storage ring with a multi-bend achromat (MBA) accelerator lattice.
- A three-point semi-kinematic vertical mount for the magnet modules is considered as the best approach for the APS-U removal and installation. The current planning calls for a 12-month shutdown and test period, prior to resumption of operations. The assembly and installation alignment tolerance of 100 microns RMS for girder-to-girder alignment is specified [1].
- The APS-U specifies 9 nm RMS as magnet-to-magnet vibration tolerance and 30 microns RMS as magnet-to-magnet static tolerance within a girder [1]. These require structure optimization. Parametric studies are performed during optimization.
- This poster details the structure optimization, including three-point positioning, material selection, and topology optimization.

## SPACING OPTIMIZATION OF VERTICAL SUPPORTS

- Initial geometry of FODO girder: 5.568 (L) × 1.1 (W) × 0.16 (T) m³.
- Three supports: φ0.1 m and 0.2 m (L), one at central of one side, two symmetrically at the other side.
- The span along the short side: Maximized and preferred from the point of view of stability and the rolling mode of vibration.
- The span along long side: Optimized. Maximum value of displacement vs. span: 2.6 or 4 m span.

## MATH FORMULA

\[ \text{Volume} = 3.3 \rightarrow 2.1 \text{ m}^3 \]

## REFERENCES


## NEXT STEPS

- The preliminary prototype is under test.
- In case that the current prototype does not meet the specifications during test, the 2nd topology optimization results would be realized in design.
- Further iteration of optimization includes topology optimization to give optimized thickness and geometry, and material selection to further increase the girder mode frequency.

## PROTOTYPE OF PRELIMINARY DESIGN

- Preliminary design is based on the optimized geometry in conceptual design phase.
- 0.6 m thick & 3 m span.
- Ductile cast iron, A536, GR 60/40/18.
- Design flexibility, low cost, vibration damping properties.
- Airloc 414-KSKC wedge jacks as vertical supports [2].
- Maximum figure of error 14 microns along beam path [2].
- 1st mode frequency of assembly: 39 Hz [2].

## 1ST TOPOLOGY OPTIMIZATION

- Software: Genesis® Topology for Ansys Mechanical (GTAM) [4-6].
- Constraint – 1: Minimize strain energy.
  - Minimize in-plane deflection at points along beam path.
- Constraint – 2: Maximize frequency response.
- Girder material: Cast iron.
- Boundary conditions: Cups sit on fixed balls.
- Optimized parameters:
  - Top plate 50 mm thick
  - Total thickness 600 mm
  - Volume 3.3 → 2.1 m³.

## REFERENCES

- Work supported by the U.S. Department of Energy, Office of Science, under Contract No. DE-AC02-06CH111377.
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## CONCLUSIONS

- Structure optimization plays an important role in the conceptual design phase. It leads to the right direction for preliminary design in terms of mass reduction and sound performance.
- Spacing optimization of vertical supports are performed. It leads to a guidance for next step.
- Topology optimization is performed. The material utilization is maximized.
- Parametric studies are performed for FODO girder design and optimization. The design specifications are met.

## SPACING OPTIMIZATION OF VERTICAL SUPPORTS

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## REFERENCES


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### OPTIMIZATION FOR THE APS-U MAGNET SUPPORT STRUCTURE*

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* Work supported by the U.S. Department of Energy, Office of Science, under Contract No. DE-AC02-06CH111377.