



Poster THPAB077

# MAGNETIC SHIMS STUDIES FOR APS-U HYBRID PERMANENT MAGNET UNDULATORS\*

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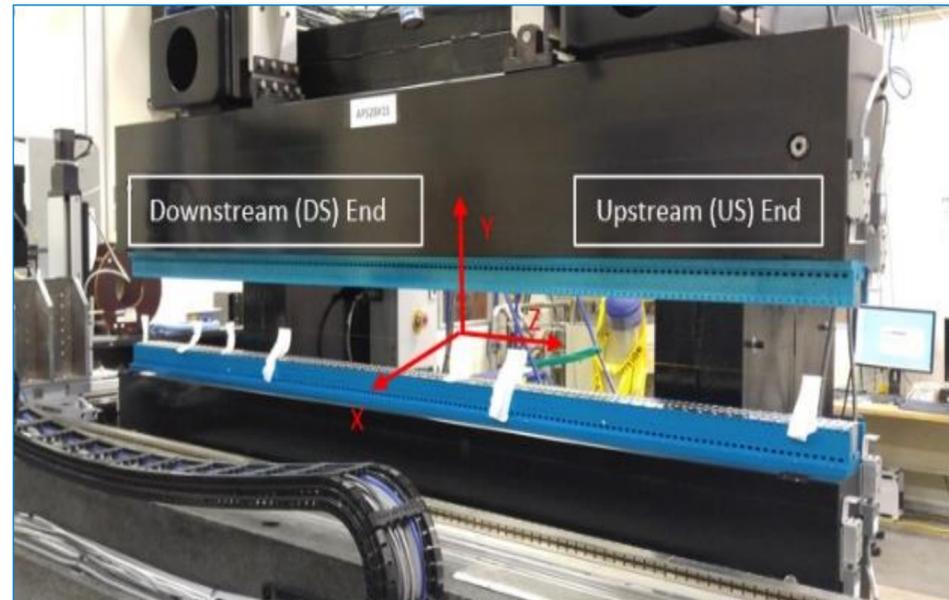
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## ABSTRACT:

- For the newly designed and fabricated APS Upgrade (APS-U) hybrid permanent magnet undulators (HPMUs), the development of magnetic shims has been critical to successfully tuning the undulators to meet the tight APS-U physics requirements
- Different types of side and surface shims have been developed and applied for this purpose.
- The side shims are primarily used for trajectory tuning, and the surface shims are for phase and multipole tuning as well as trajectory tuning.
- Current design, applications, and measurement of the shims for the newly designed and fabricated APS28 (28 mm period) undulators are presented in this paper.

## INTRODUCTION:

- New undulators and new physics requirements for APS-U storage ring. The first article of APS28 undulator on measurement bench:



- Development of new shims is critical to for tuning new APS28 undulators. Key factors: gap dependent signatures and magnetic stability.

## SIDE SHIMS:

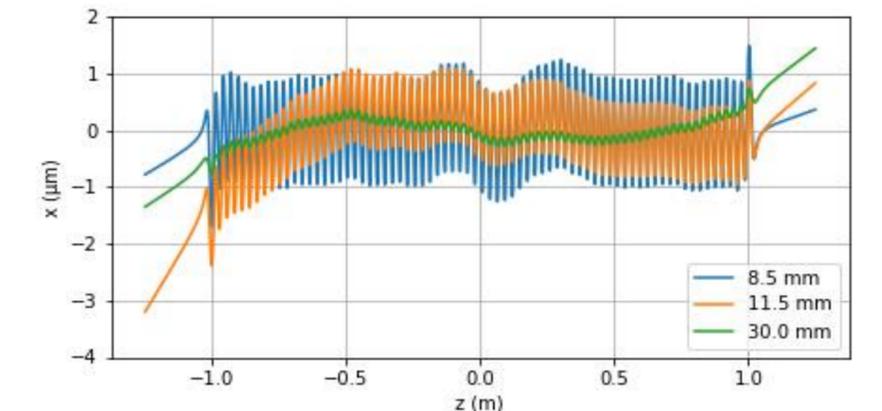
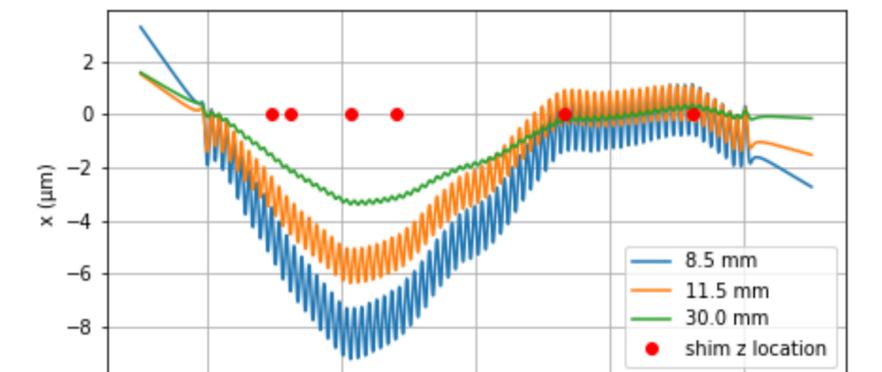
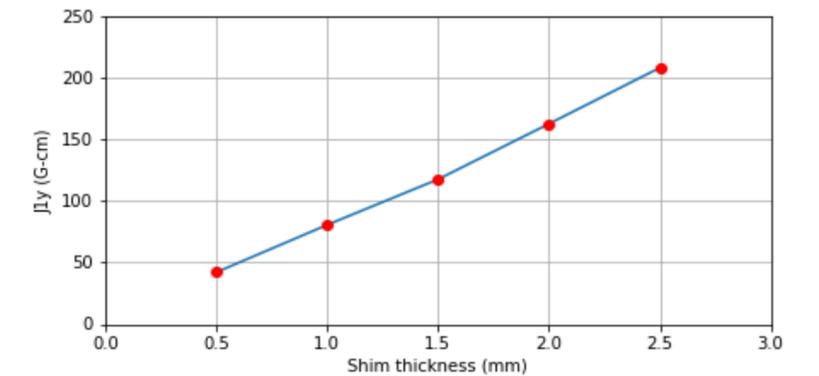
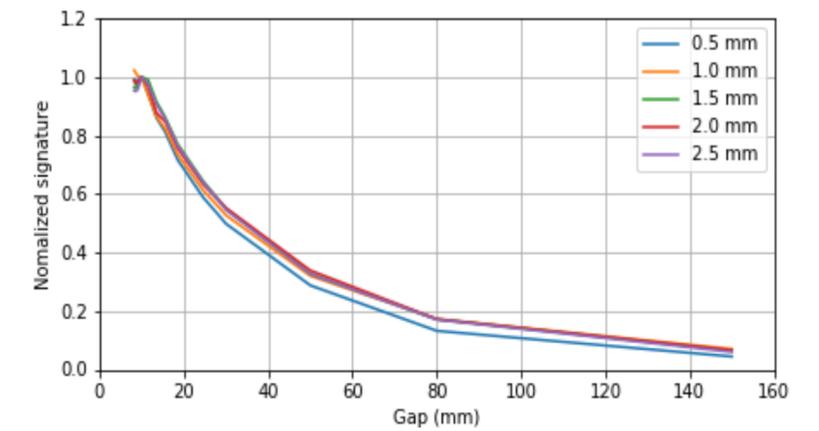
- Placed on sides of a pole
- Secured to the keeper
- Stackable 0.5-mm-thick



- Trajectory tuning (APS28#12S)
- 6 pairs of side shims
- Locations (red dots)
- Normal dipole signature

Trajectory before tuning:

Trajectory after tuning:



## SURFACE SHIMS:

- Placed on recessed magnet
- Thickness: 0.1 mm, 0.2 mm, 0.4 mm
- Length: 5 mm, 10 mm, 15 mm, 20 mm
- Multipole tuning
- Phase tuning

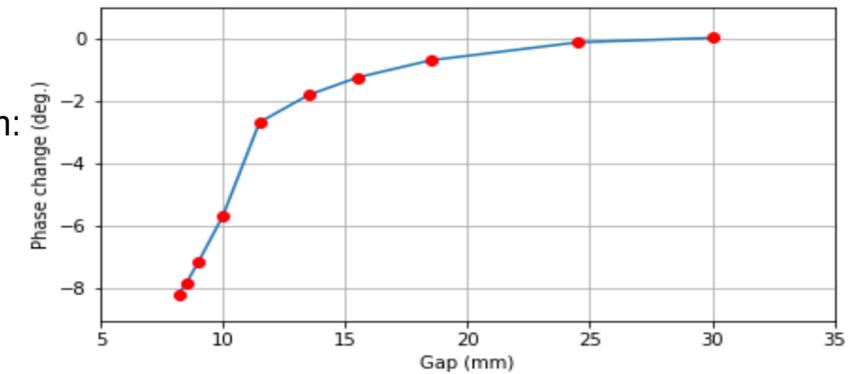
Picture of twelve 0.2-mm x 5-mm surface shims on bottom jaw of APS28#7:



## (SURFACE) PHASE SHIMS:

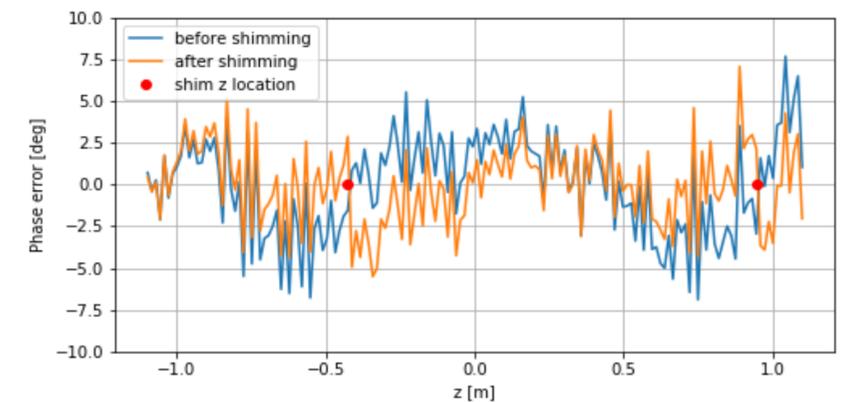
- Placed on recessed magnet
- Thickness: 0.1 mm, 0.2 mm
- Covers whole magnet width

Signature of 0.2-mm-thick shim:



Phase tuning (APS28#7):

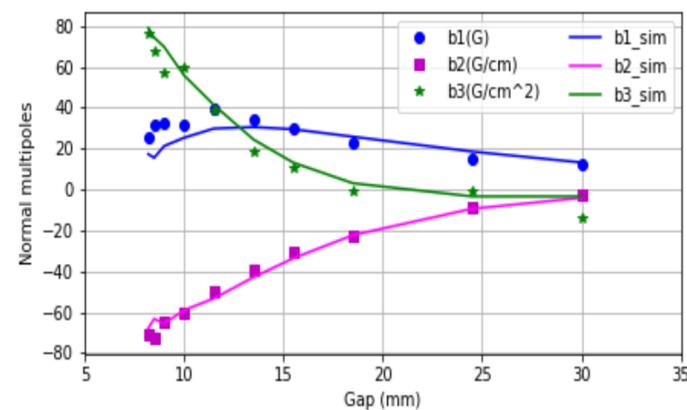
Phase errors  
(before and after tuning):



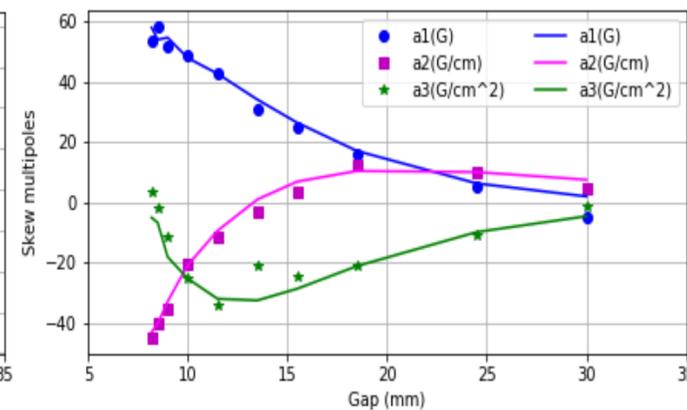
## SURFACE (MULTIPOLE) SHIMS:

- Signatures of multipoles simulated
- Signatures verified with measurements:

Normal multipoles:



Skew multipoles:



## CONCLUSION:

- After several design iterations and tests, the current design of side shims and surface shims have been proven successful.
- With a newly developed phase tuning method and an algorithm-guided tuning methodology all 13 newly fabricated APS28 undulators have been tuned to the APS-U specifications.
- The design has also been successfully extended to the shorter undulator period lengths of 25 mm and 21 mm for the APS-U.