FINAL DESIGN OF THE APS-UPGRADE STORAGE RING VACUUM SYSTEM

Advanced Photon Source Upgrade

NAPAC2019

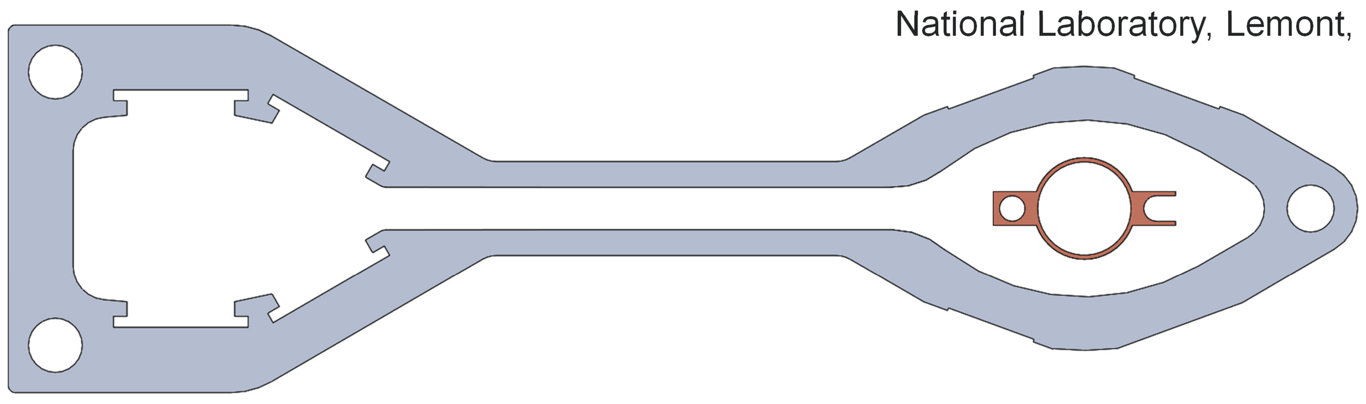
NORTH AMERICAN PARTICLE ACCELERATOR CONFERENCE

Jason Carter on behalf of the APS-Upgrade Storage Ring Vacuum System Design Group

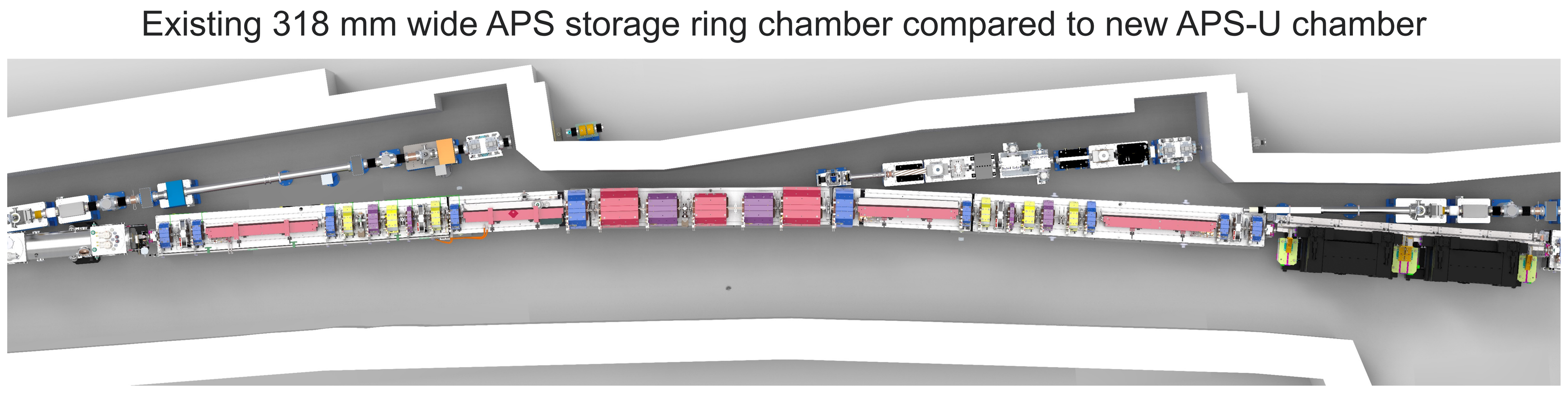
APS-U & VACUUM SYSTEM REQUIREMENTS

- **APS-Upgrade project:** 6 GeV, 200 mA multi-bend achromat retrofit to existing 1.1 km circumference storage ring
- **Pre-installation:** 40x total sectors each broken down into 5x modules of magnets, vacuum chambers & supports
- **Installation with 1 year APS dark time**: 6 month tunnel installation + conditioning
- **Vacuum conditioning**: achieve 2 nTorr average total pressure @ 200 mA by 1000 A*hrs

Advanced Photon Source at Argonne National Laboratory, Lemont, IL USA



Existing 318 mm wide APS storage ring chamber compared to new APS-U chamber



Developing design of typical APS-U sector

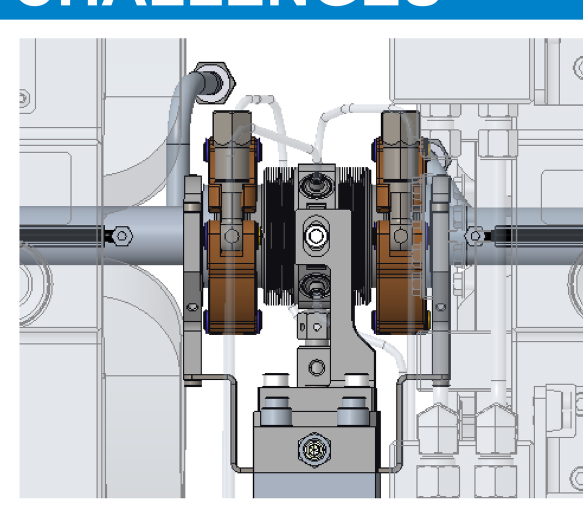
INTERFACES & DESIGN CHALLENGES

Magnets: ~1 mm clearance between poles
- Vacuum chambers must pass strict go/no-go gauges

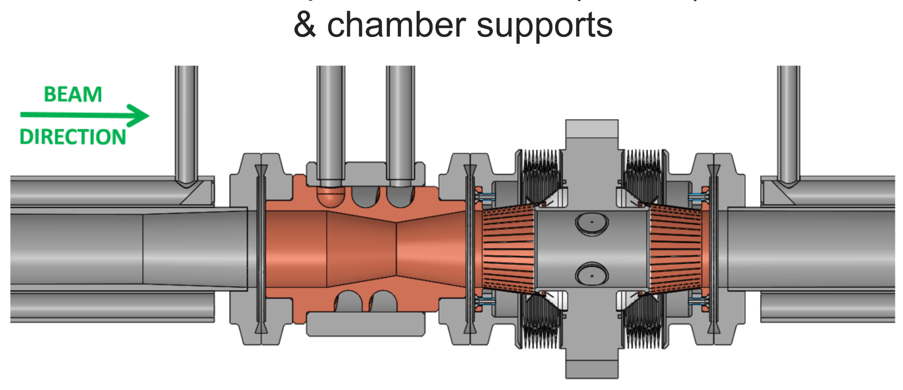
Installation: limited access to joints, BPMs
- QCF chain clamps where possible for ease of installation

Accelerator physics: minimize losses due to impedance
- Single piece RF sealing gasket within compact flange joints
- Vacuum crosses designed with machined pumping liners
- Photon absorbers with subtle transitions

Shadowing uncooled components:
- Water-cooled vacuum chambers with internal absorbers to shadow BPM/bellows & flange joints
- Ray tracing assuming misalignment & missteering



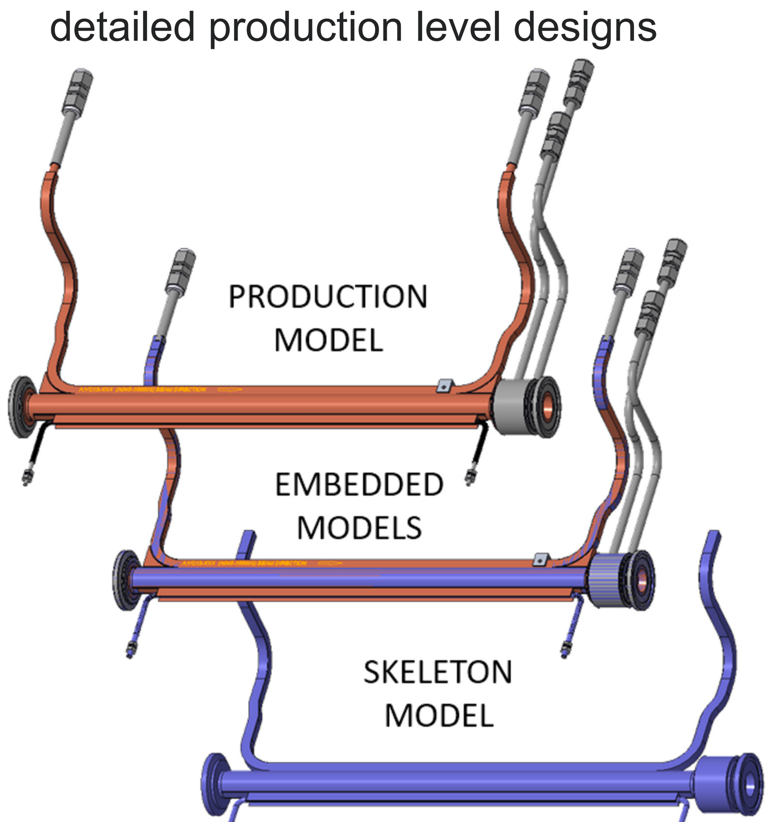
Beam position monitor (70 mm) & chamber supports

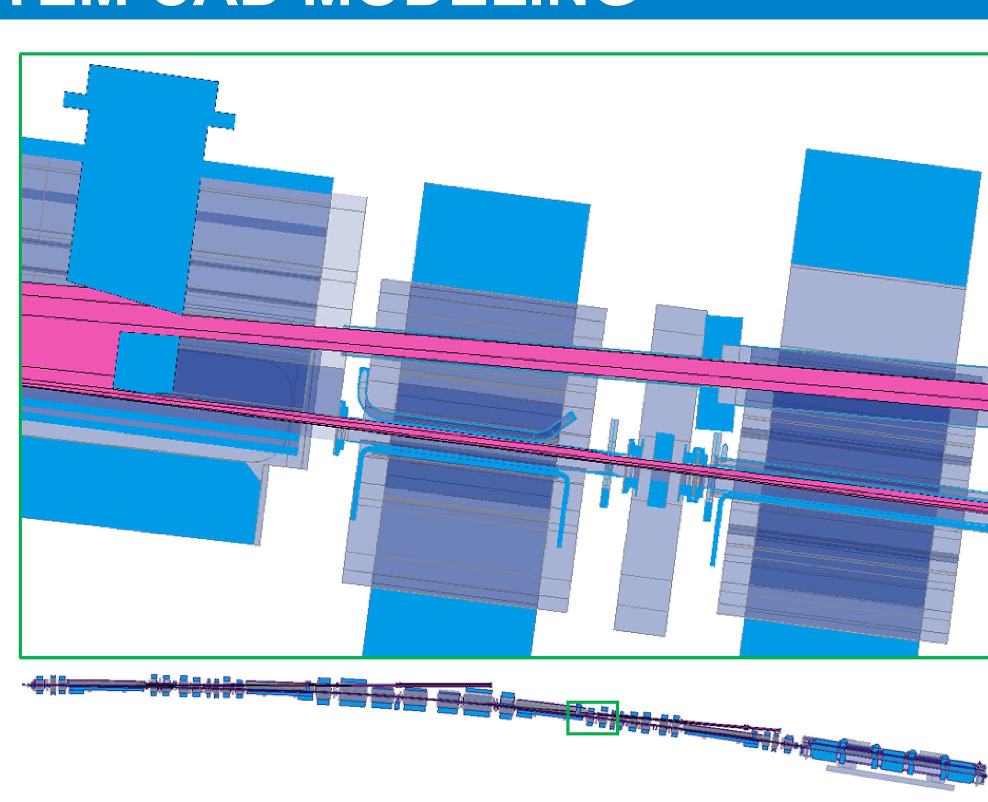


Top cross section of typical APS-U vacuum sequence

VACUUM SYSTEM CAD MODELING

'Skeleton' approach to 3D CAD modeling
- Simplified models capture critical details, allow for efficient high level assembly analysis
- All APS-U groups participate in approach
- Skeleton models embedded within detailed production level designs



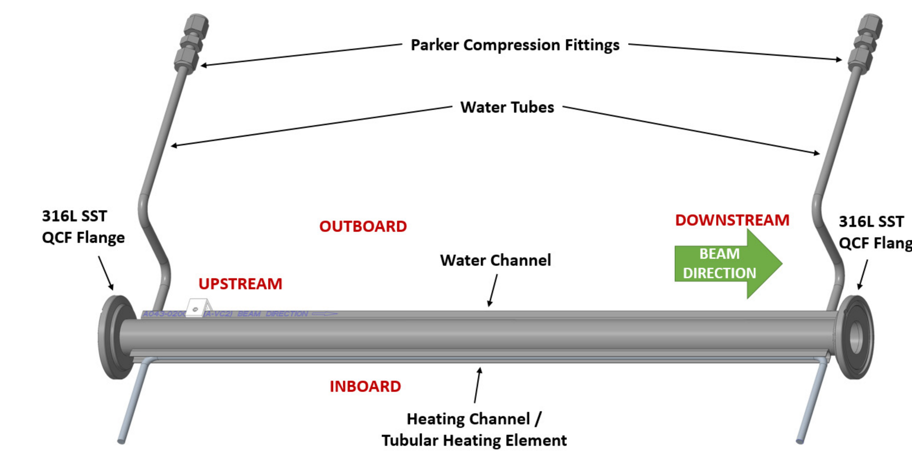


3D CAD ray trace highlighting APS-U crotch absorber

Adaptable ray trace built off skeleton assemblies
- 20 vacuum components intercept synchrotron radiation projected from 29 unique 'sub-arcs' of APS-U MBA lattice
- Stronger understanding of complex photon load distributions across chambers and absorbers

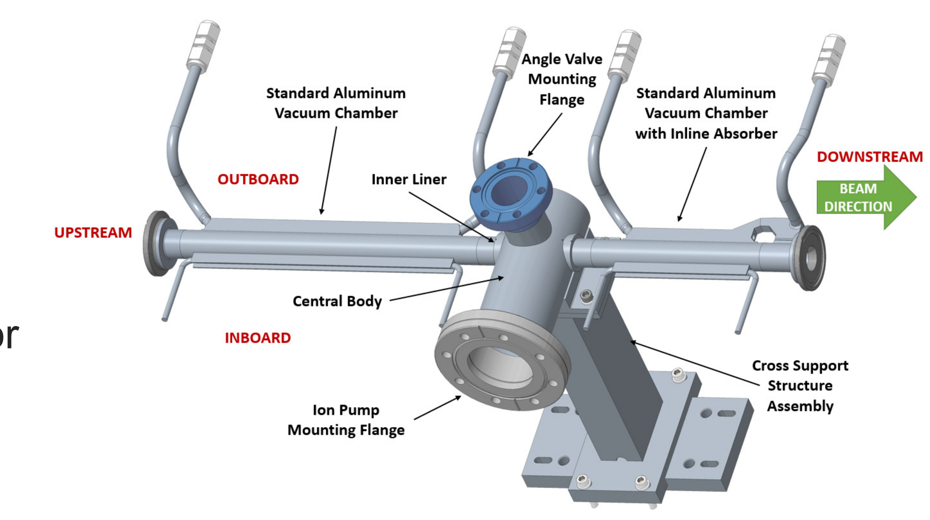
DESIGN OF VACUUM COMPONENTS

63 custom arc vacuum components per sector
- 19 NEG-coated chambers
- 14 BPMs w/ 2-sided bellows
- 5 photon absorbers
- 4 aluminum 'L-bend' chambers with antechambers
- 2 SST keyhole chambers
- 2 cross chambers
- 15 extraction line chambers & bellows

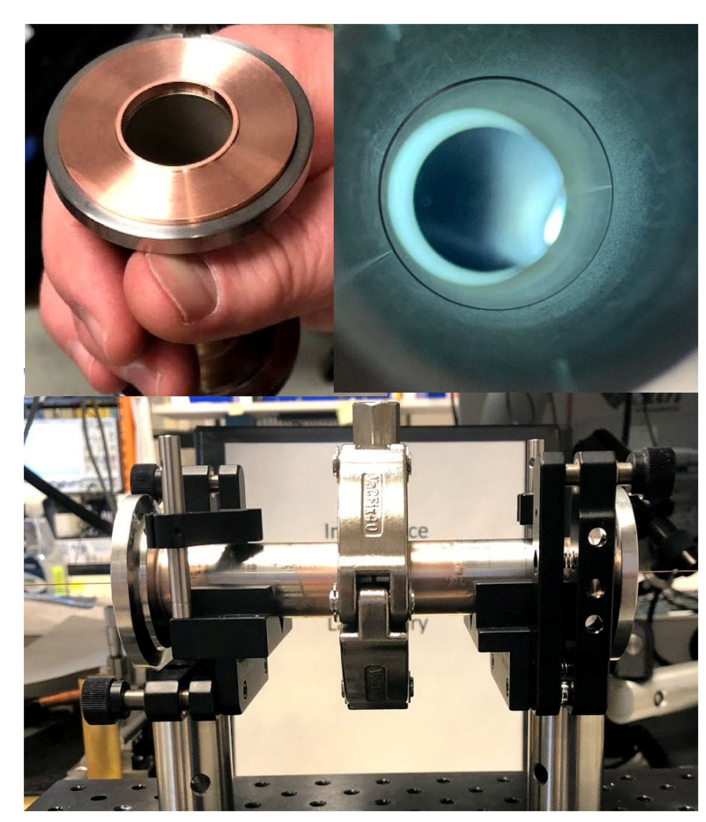


Typical NEG-coated Inconel vacuum chamber

NEG-coated vacuum chambers
- Typically built around aluminum or copper extruded tube with 22 mm ID
- Outboard water cooling channel
- Tube heater in c-shaped inboard channel
- Downstream 'inline absorber' shadowing flange joints and BPMs
- Inconel chambers passing through corrector magnets
- NEG-coating 2 copper keyhole shaped chambers



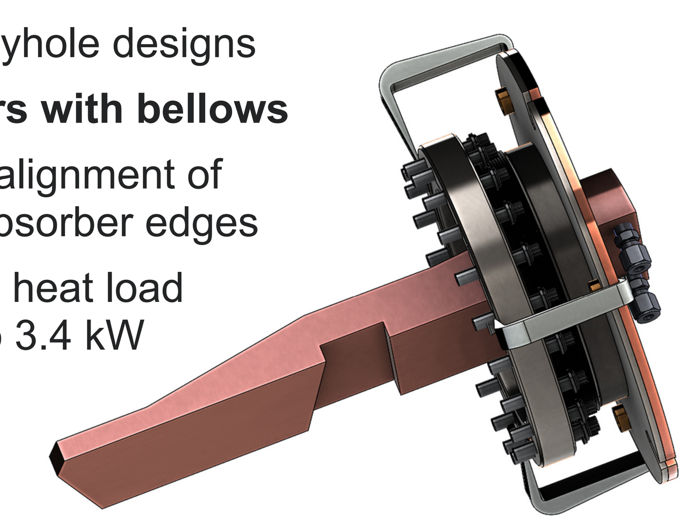
Typical NEG-coated aluminum vacuum chamber



Custom RF sealing copper gaskets test on Goubau line and in-ring installations

Single piece RF-sealing gaskets
- Demonstrated dual vacuum seal and RF seal on vacuum cross and Goubau line and recent NSLS-II in-ring tests
- Extending to keyhole designs

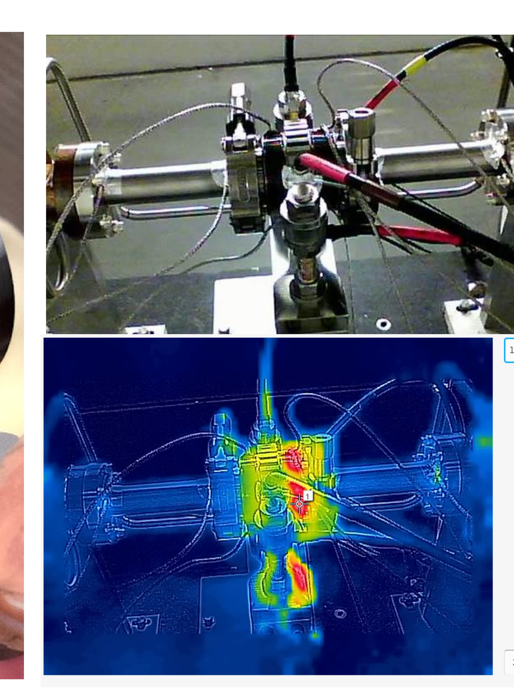
Photon absorbers with bellows
- Bellows based alignment of critical crotch absorber edges
- CuCrZr for high heat load absorbers up to 3.4 kW



CuCrZr crotch absorber with bellows for alignment

Beam position monitors
- Design improvements through prototyping lessons learned
- Recent in-ring tests at NSLS-II demonstrated button readings and met vacuum but heated at 100 mA due to RF liner being out of contact
- Follow-up in-ring tests coming at APS (September 2019) to correct installation
- Working on hard-stops to guide travel during bakeout growth and ensure RF contact

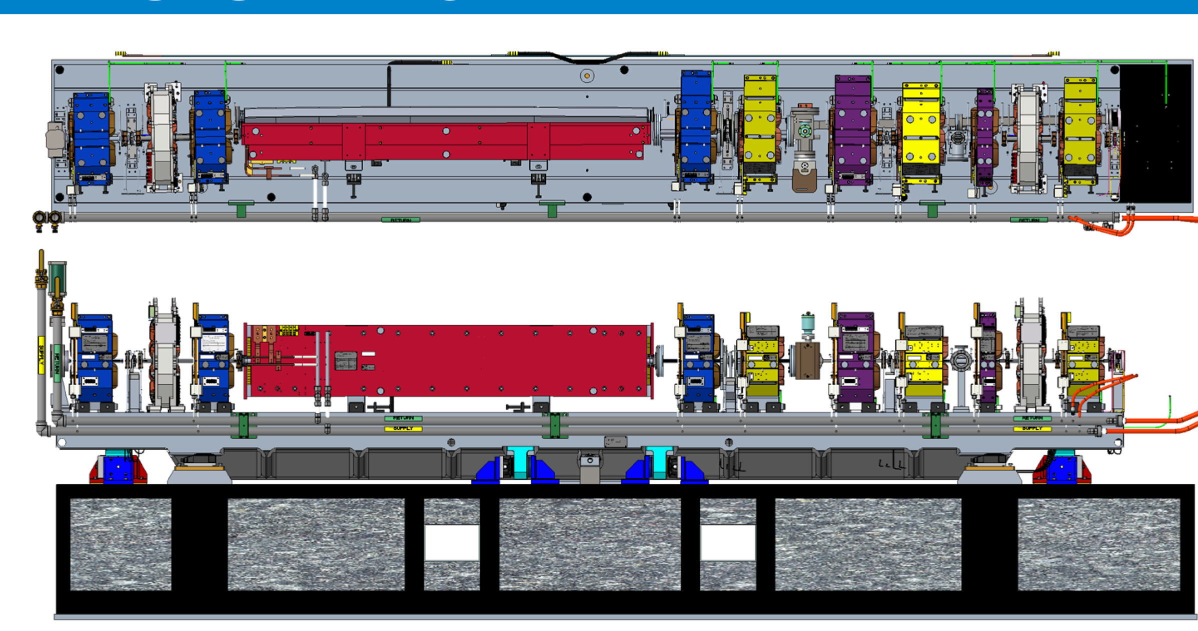
Recent prototype of APS-U beam position monitor with welded bellows



August 2019 NSLS-II in-ring test of APS-U prototype BPM

FUTURE WORK

- September 2019 APS in-ring test of APS-U BPM
- Turning final designs into procurements
- QA and vacuum certification of production vacuum equipment
- Begin pre-installation of full APS-U modules in Summer 2020
- Mockup installation of first articles of all components



Top and front views of typical APS-U module

ACKNOWLEDGMENT

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