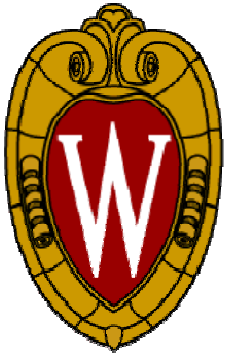


Fusion Technology Institute

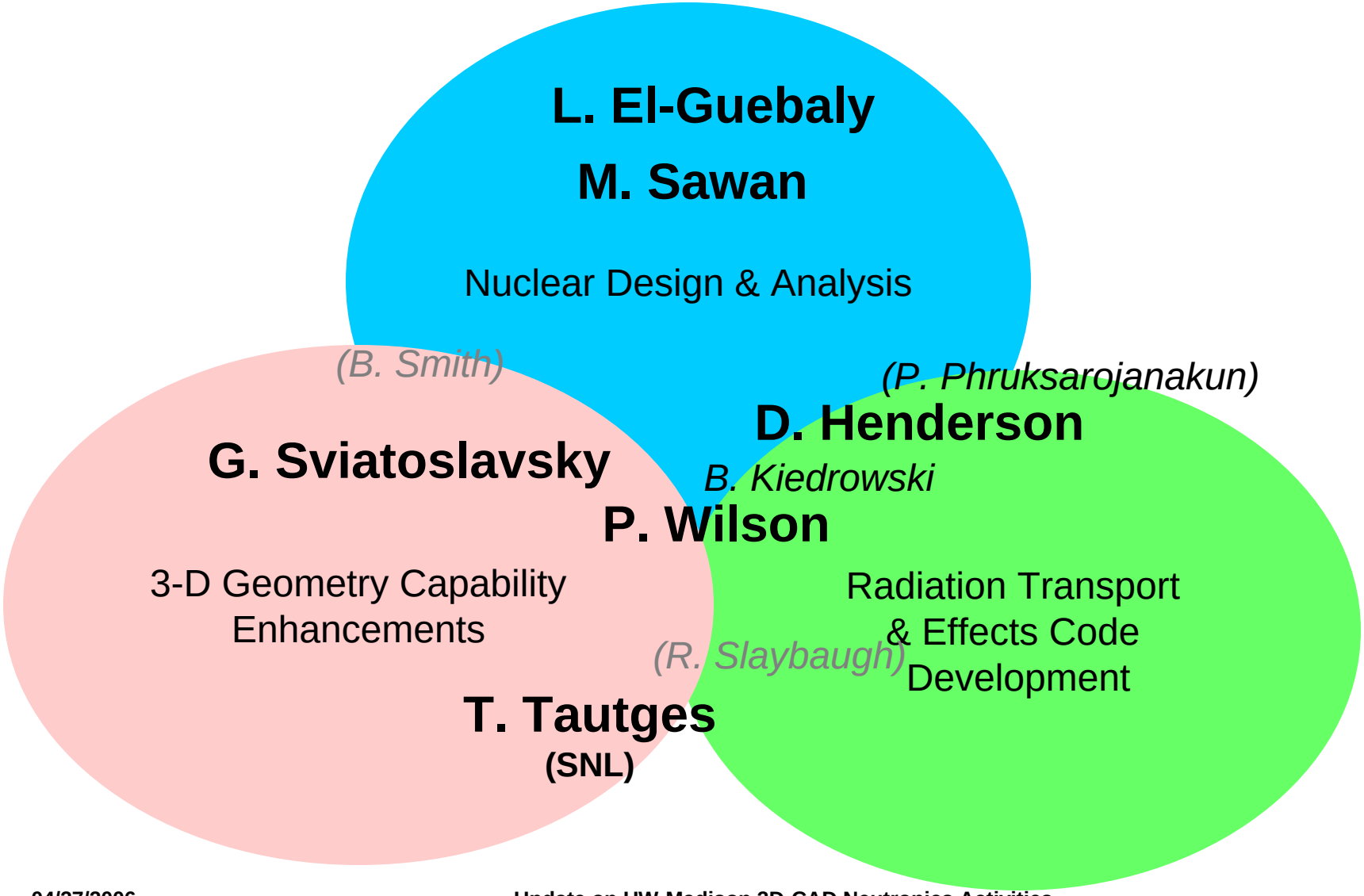
Status of CAD/MCNP 3-D Analysis

Paul Wilson
for UW-Madison Fusion Neutronics Team

April 27, 2006

THE UNIVERSITY of WISCONSIN MADISON
Fusion Technology Institute

UW-Madison Fusion Neutronics Team



Overview

- Code history & status
- Feature assessment
- Experience with ITER Benchmark
- ARIES-CS neutronics
- Issues in solid modeling

MCNP(X)-CGM History

- 2001 – began implementation of CGM in MCNPX v2.1.5
- 6/2004 – Proof-of-principle complete (50-100x performance penalty)
- 3/2005 – Oriented bounding box technology with faceted surface intersections implemented (3-12x performance penalty)
- 4/2005 – Analysis of ARIES-CS neutron transport on complex surfaces

MCNP(X)-CGM Development Plan & Progress

- Upgrade to newest versions of MCNP(X)
- Upgrade to MCNPX **v2.5.0** complete
  - MCNP compatibility enhancement
    - Forced collision variance reduction
    - Reflecting boundary conditions
    - Surface flux tally
  - Features added
    - Elimination of fatal errors from cell and surface definitions
    - Elimination of surface definitions entirely
    - Ability to define reflecting boundary conditions in CAD geometry file

MCNP(X) Compatibility

- Geometry
  - Cell volume/Surface areas – functional
  - Boundary conditions
    - Specular reflection – functional
    - White reflection – functional
    - Periodic – near term
  - Lattice/universe – long term
- Source
  - Fixed source – functional
  - Fission source – *testing*
  - Surface source write/read – long term

MCNP(X) Compatibility

- Variance Reduction
  - Cell importance – functional
  - Exponential transform – functional
  - Forced collision – functional
  - Weight windows (cell-based) – *testing*
  - Weight windows (mesh-based) – functional
  - Detector tallies - functional

MCNP(X) Compatibility

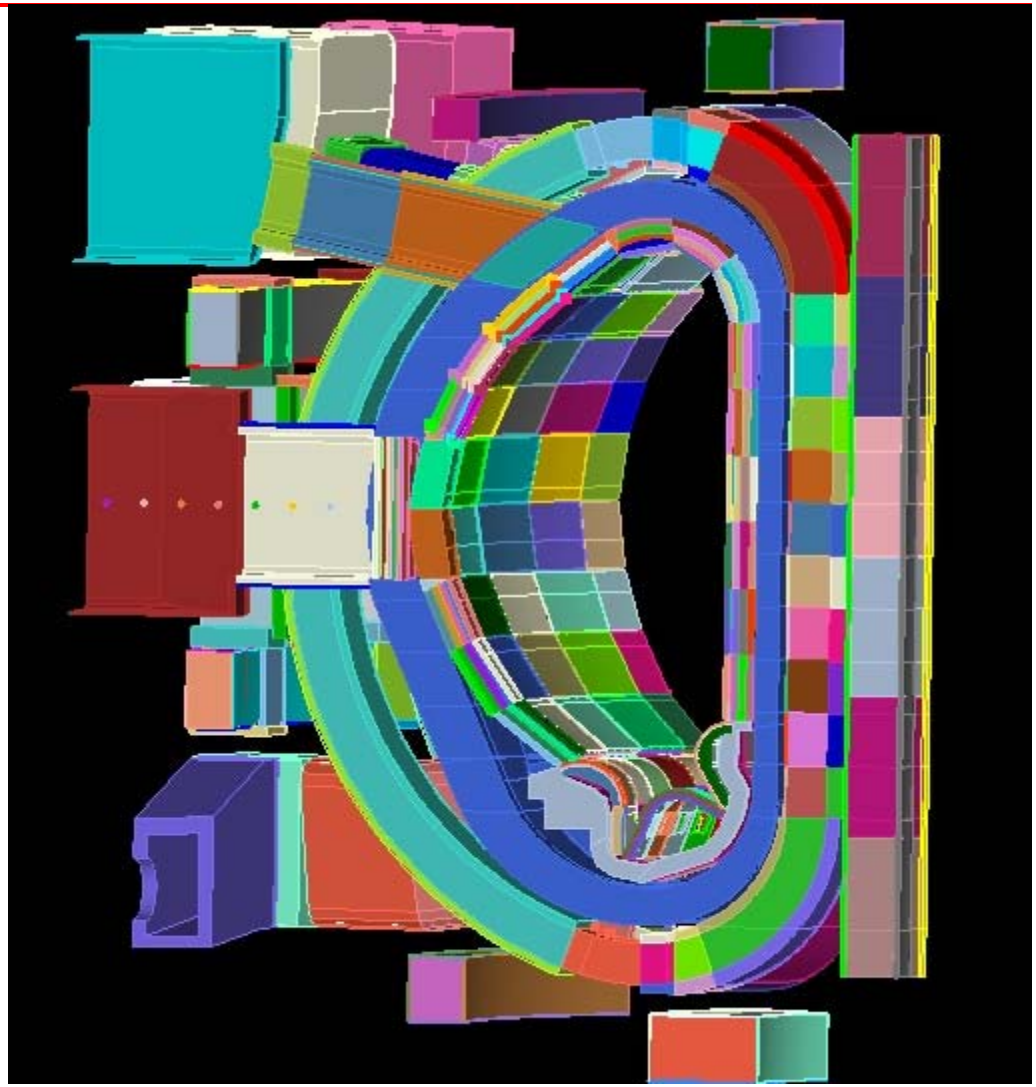
- Tallies
  - Surface current (type 1) – functional
    - Cosine bins – functional (directional ambiguity)
  - Surface flux (type 2) – functional
  - Cell flux (type 4,6,7) – functional
  - Pulse height (type 8) – testing
  - Point detector (type 5) – functional
  - Mesh tallies – functional in MCNPX
    - Note: MCNP and MCNPX have different mesh tally implementations
  - Cell flagging – functional
  - Surface flagging – functional
  - Multipliers – functional
  - Segmenting – long term ??

CGM-related Enhancements

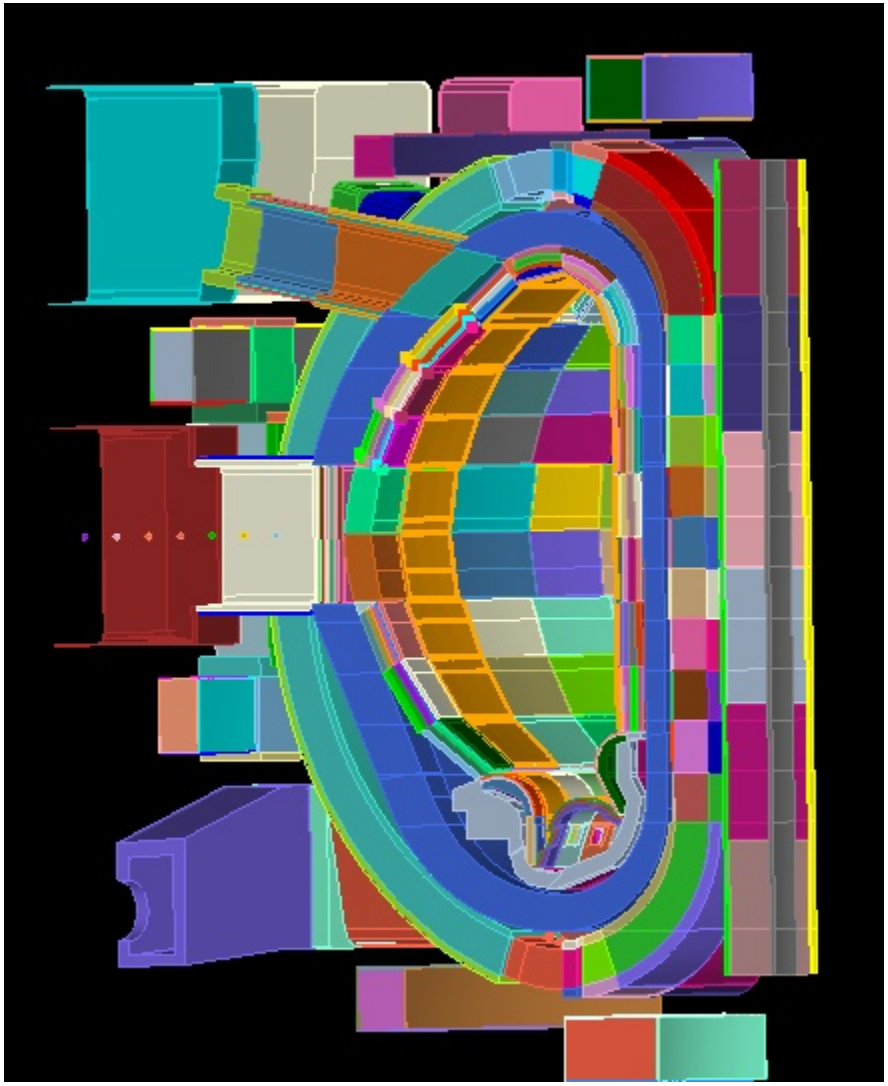
- CAD/Cubit definition of materials – near term
- CAD/Cubit definition of tallies – long term
- Further geometry-based performance enhancements

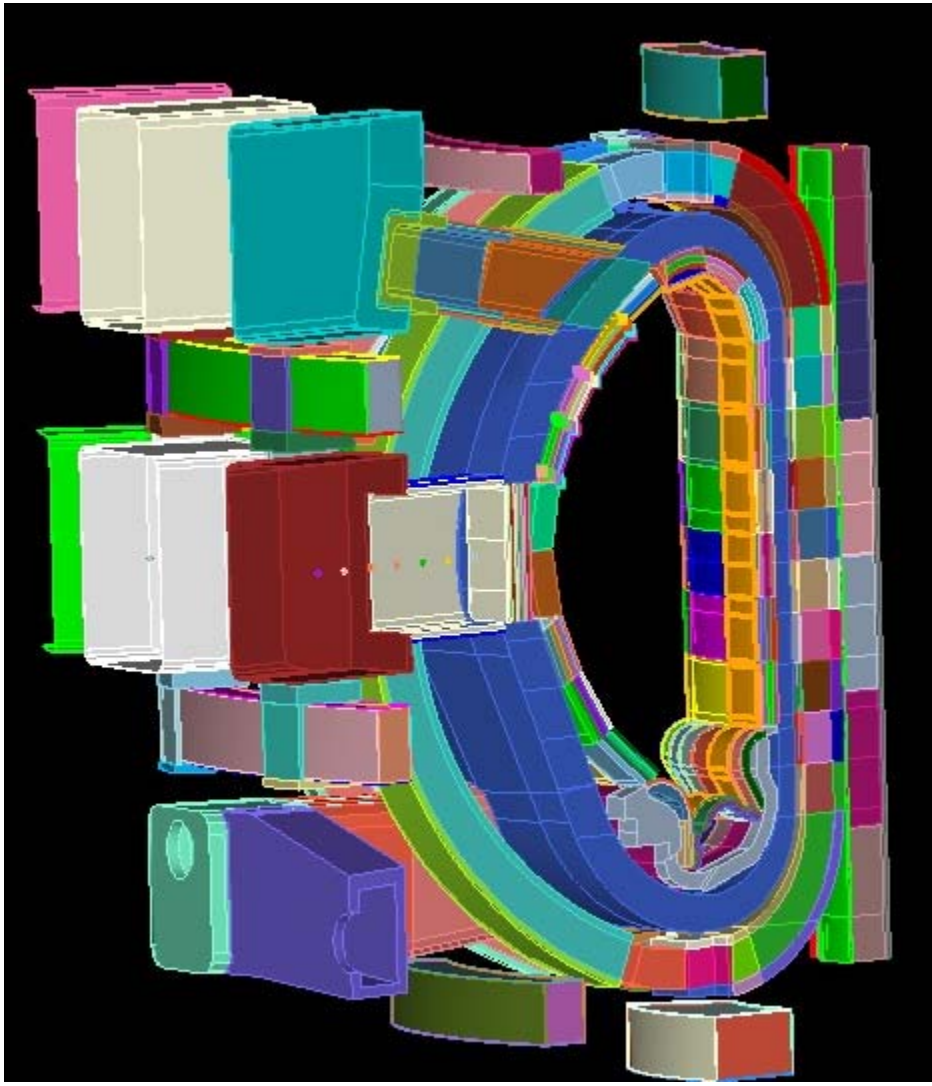
ITER Model

- 40° toroidal segment
- Source defined on 40x40 R-Z grid
- 774 volumes
- 18116 surfaces

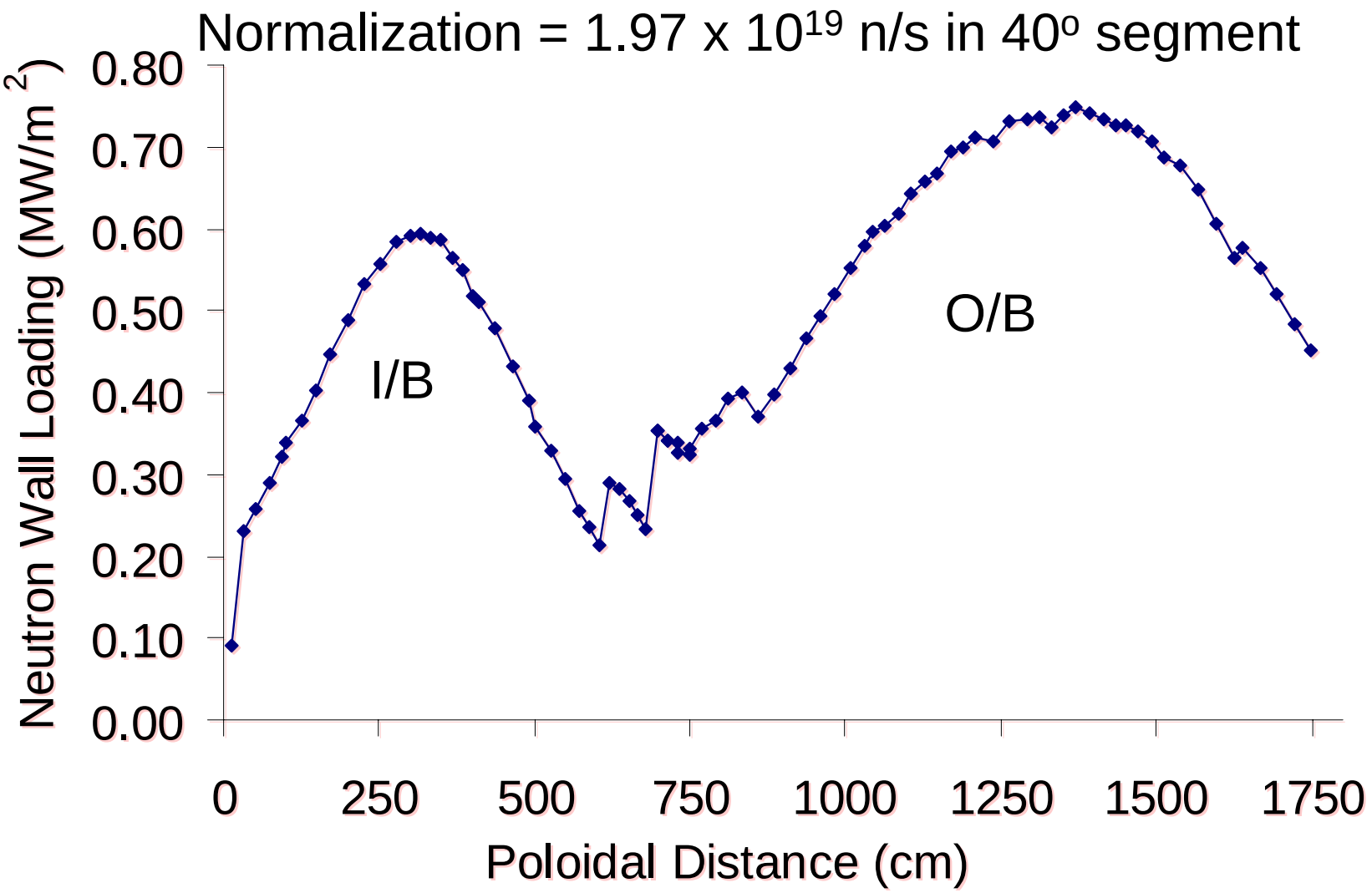


Neutron Wall Loading



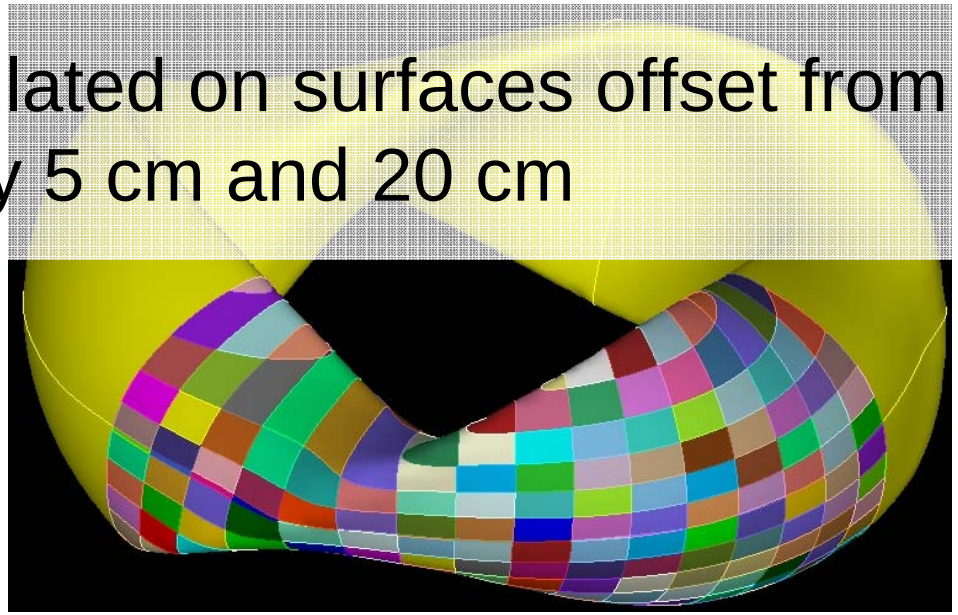


Neutron Wall Loading



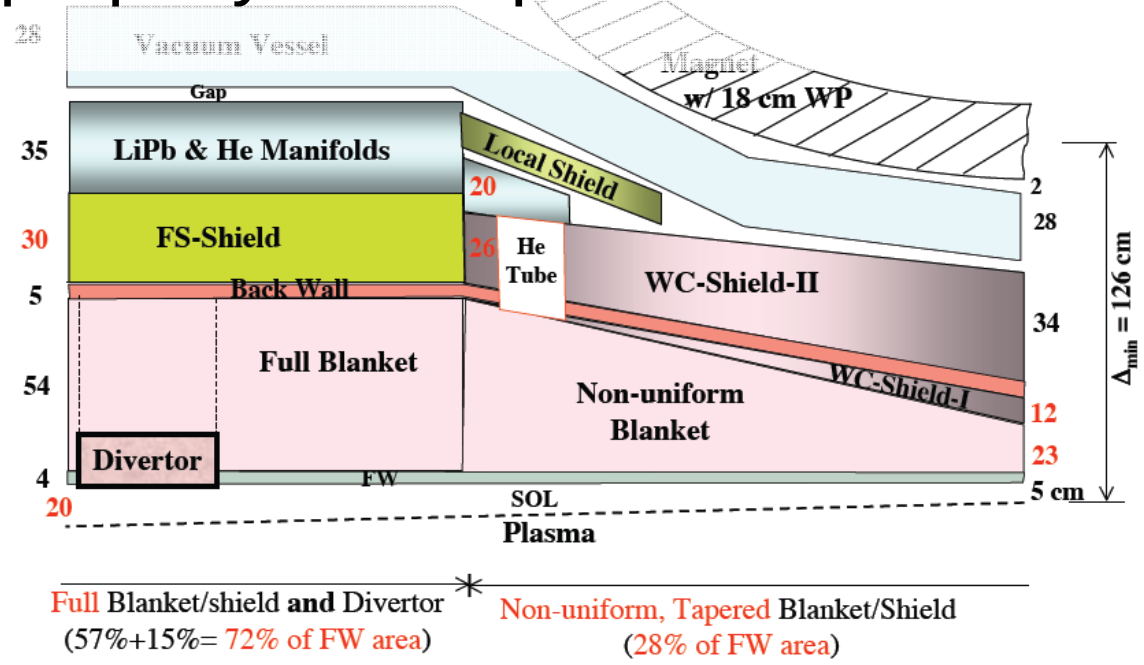
3D Neutronics for ARIES-CS

- Neutron wall loading
  - Previous work demonstrated capability BUT
    - Used incorrect interpretation of n-source distribution
    - Enhanced geometry capability drives enhanced n-source definition
  - NWL will be calculated on surfaces offset from plasma surface by 5 cm and 20 cm



3D Neutronics for ARIES-CS

- Nuclear analysis of 3-D ARIES-CS design
  - Including standard fusion power plant components
  - Important to properly develop CAD models



CAD Issues Requiring "Repair"

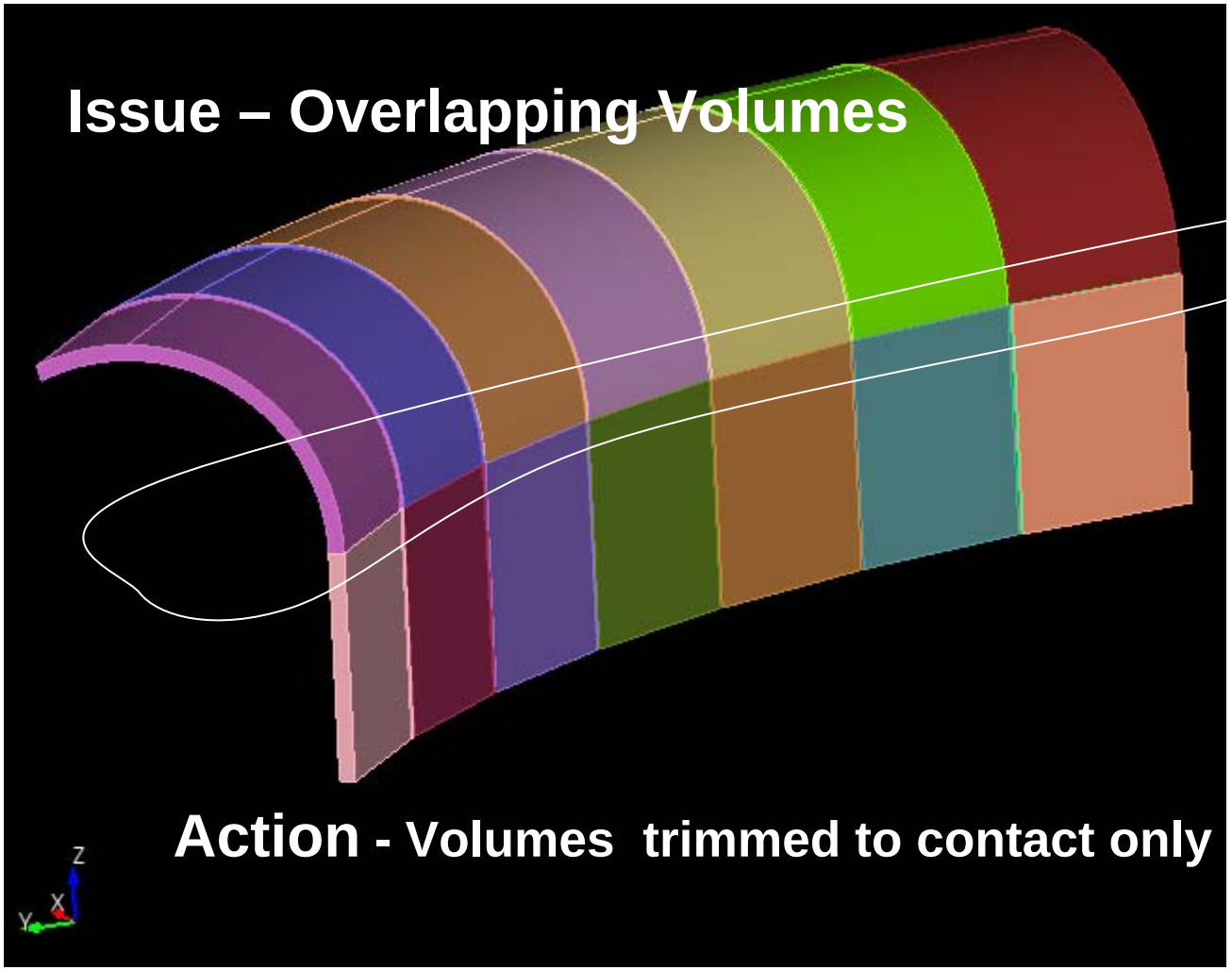
Human effort shifts from traditional MCNP model creation to CAD/Solid Model repair

- Overlapping Volumes (i.e.: clashes)
- Mating surfaces not contacting
- Slight "Misalignment"
  - Imprint generates ultra thin surfaces
  - Doesn't always require repair

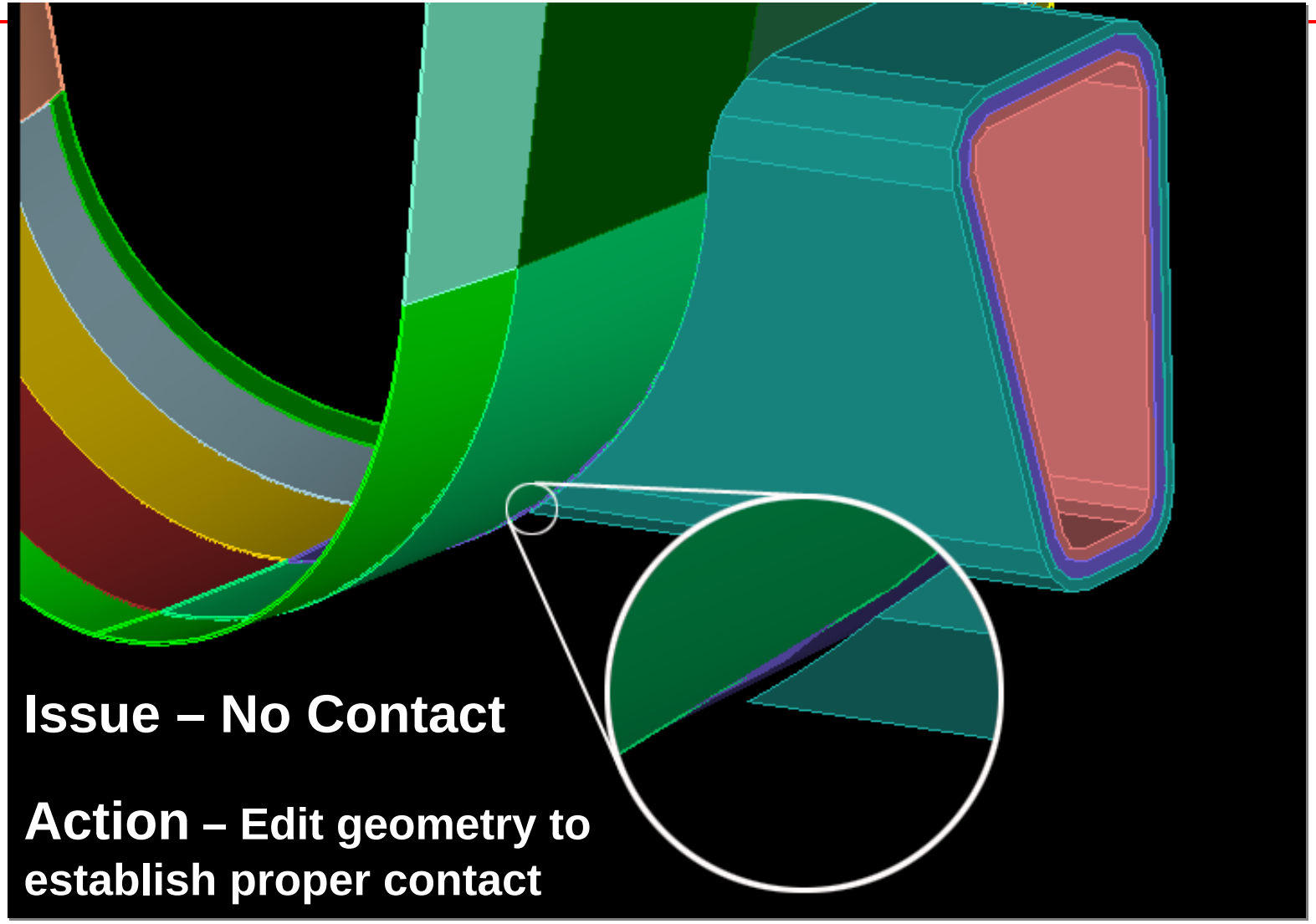
- Complex Surface Definition

Examples of Typical CAD Issues and Typical Repairs

Overlapping Volumes

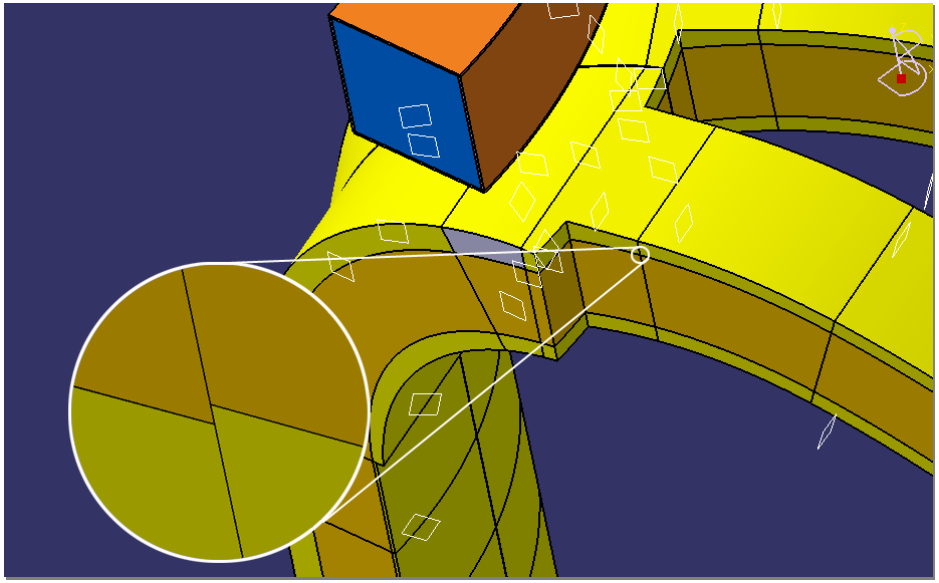


Mating Surfaces Not Contacting

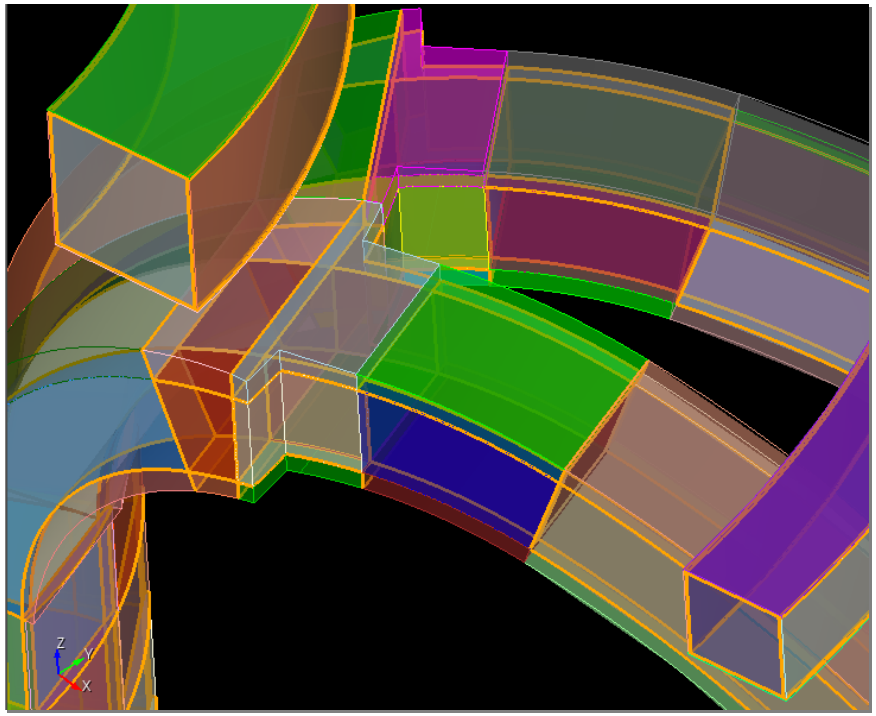


Misalignment

Issue – misalignment …

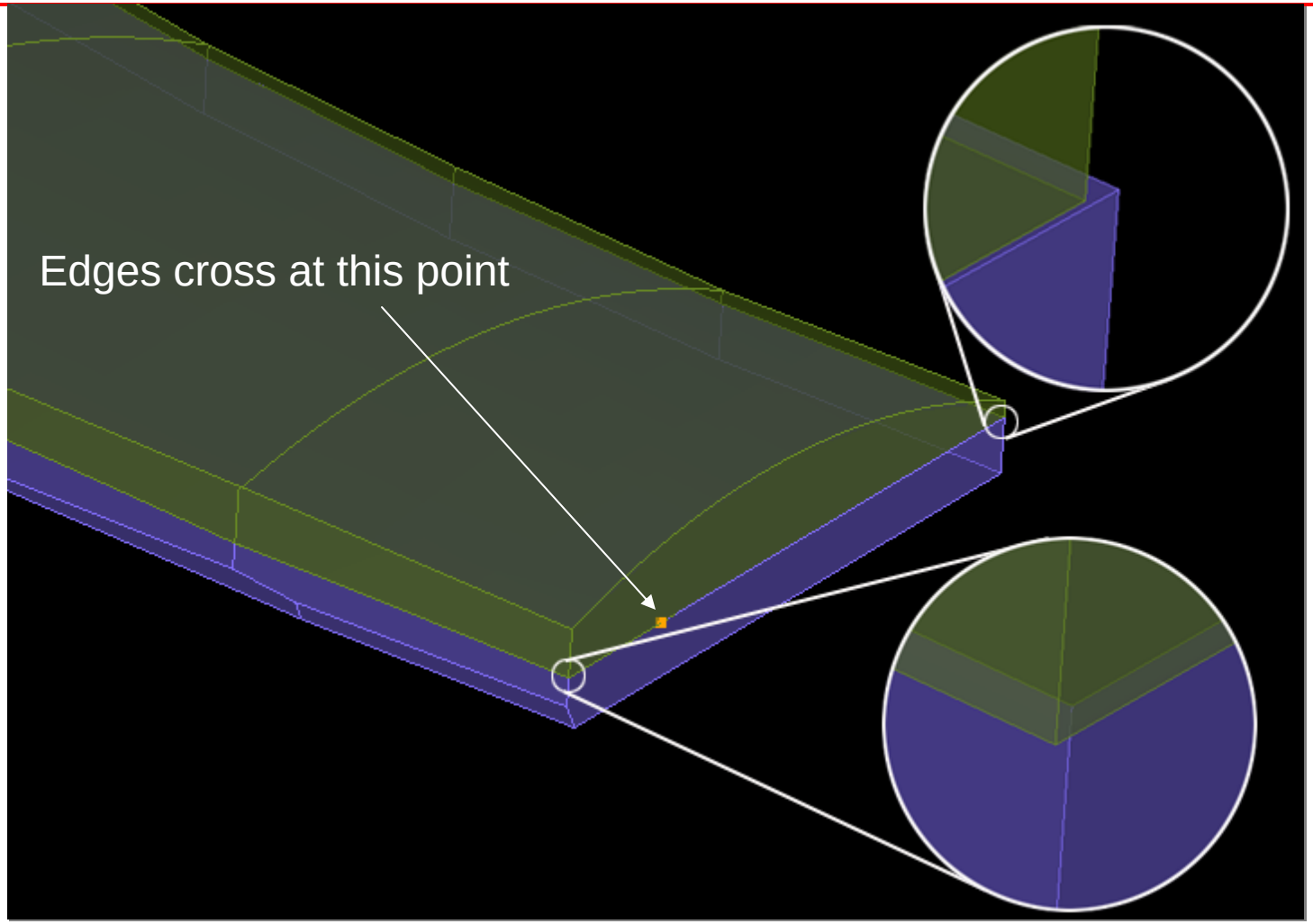


… causes imprint difficulty and therefore no merge



Misalignment

Issue – Slight Edge Misalignment

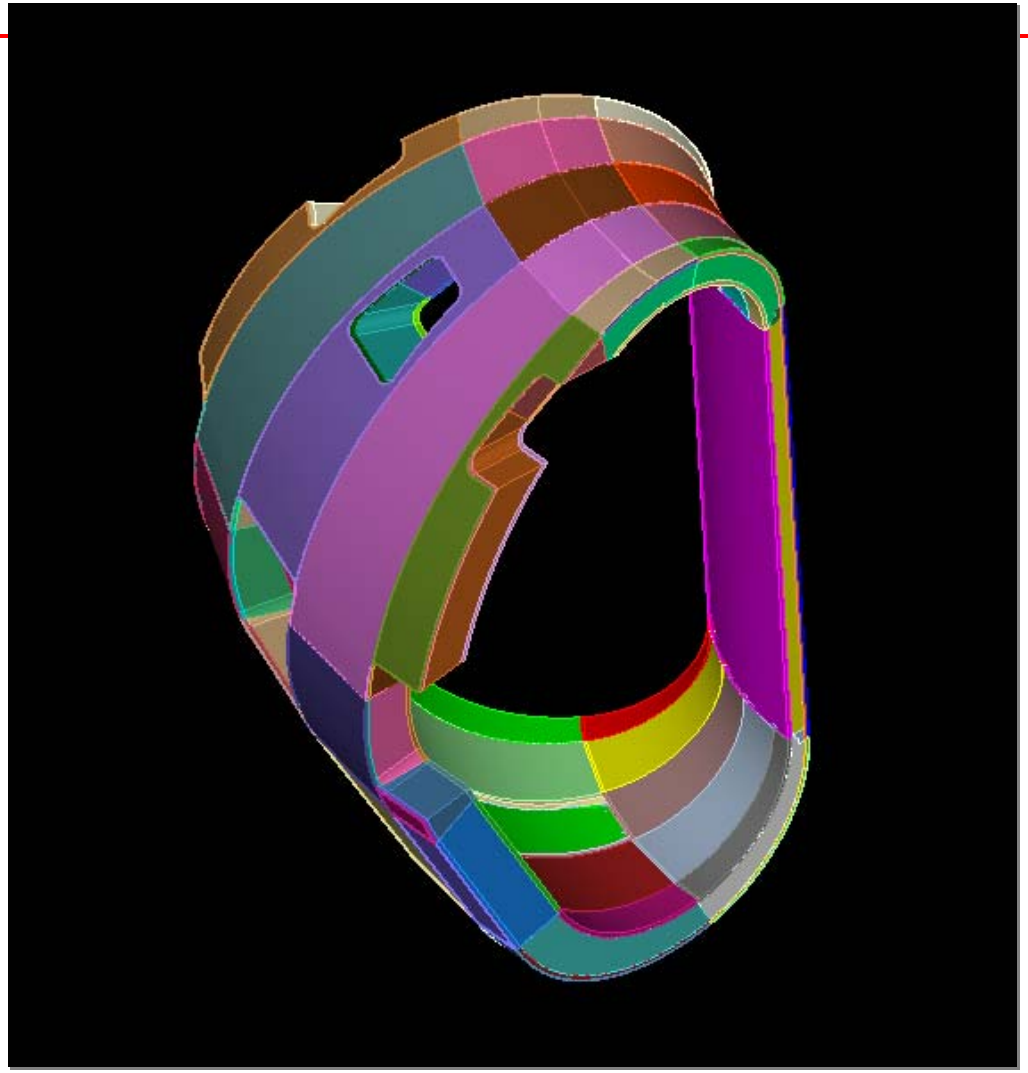


Action – MAY require recreating volume

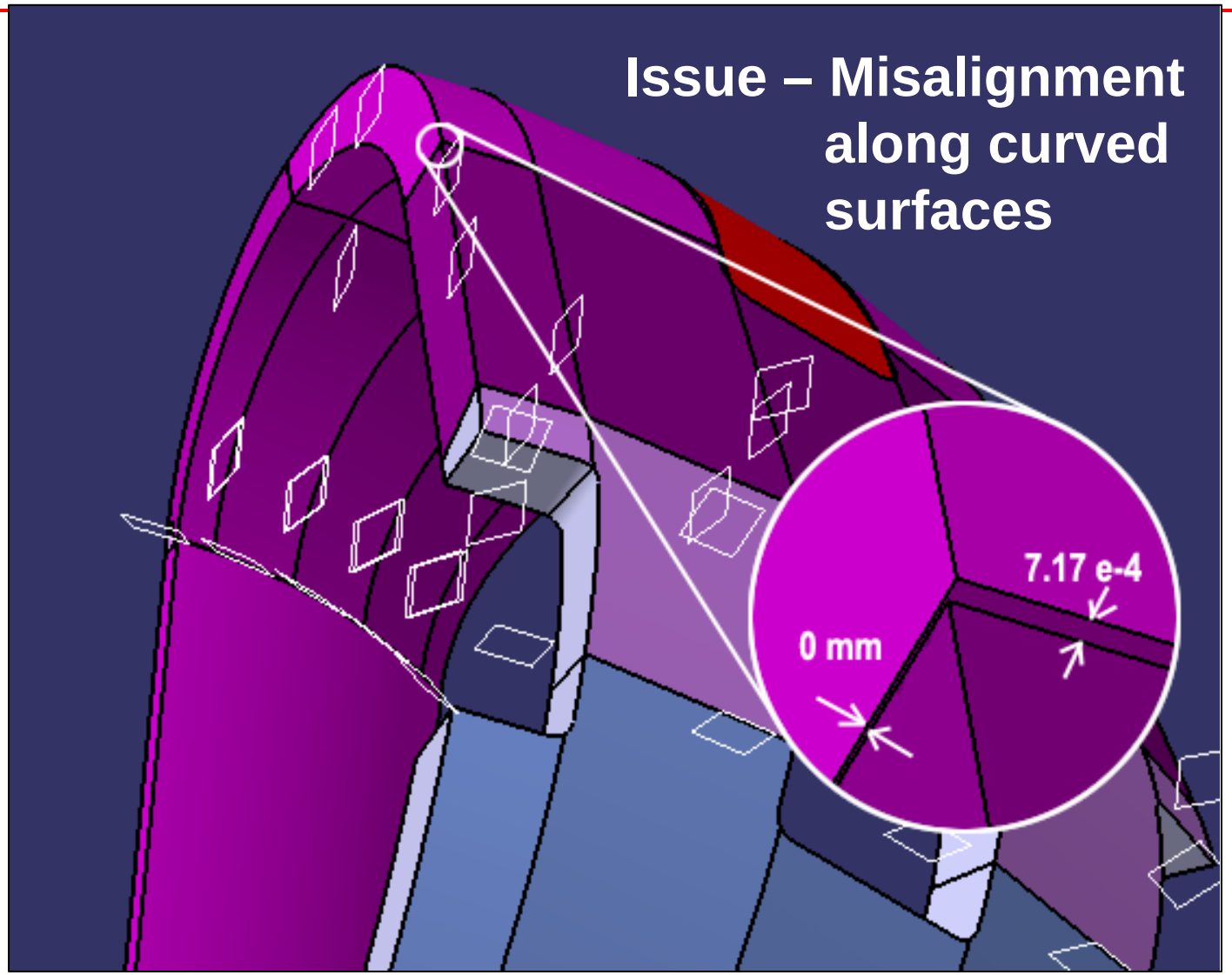
Complex Surface Definition

Issue – definition of neighboring complex surfaces differ slightly, preventing surfaces from merging

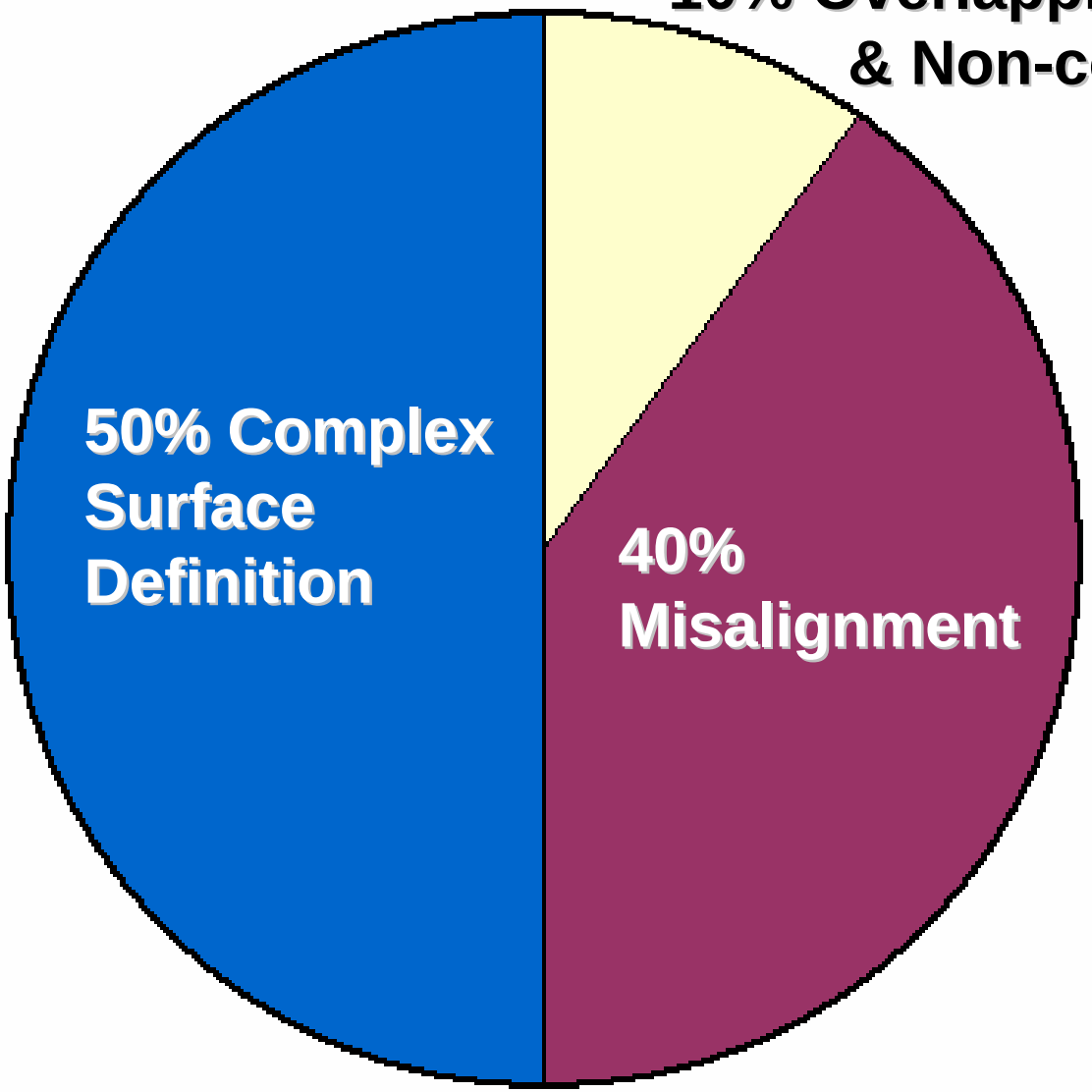
Action – Recreate geometry and/or "Unify" neighboring volumes into a single volume.



Complex Surfaces & Misalignment



Distribution of Repair Efforts



Improving the Process

- **Direct Link to CATIA (or appropriate modeler) data – eliminating possible translation issues.**
- ***Work with original ITER data – simplification process may have introduced errors***
- **Tighten design process to minimize "designer-introduced" issues**
- **Leverage prior work via configuration control - allowing future model revisions to address only those area that have changed.**

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