Prediction of Heat Flux Splitting by Non-Axisymmetric Magnetic Field in the Realistic Tokamak Wall and Divertor Based on 3D CAD Model

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- **Prediction of Heat Flux Splitting by 3D Magnetic Field**
  - **Field line tracing**
    - Popularly utilized & successful qualitative analysis of experimentally observed lobe structure
    - Provide a guide to understand the role of plasma response
  - **Full consideration of 3D plasma transport**
    - High physics fidelity
   - Rich physics with atomic process, computationally demanding

- Orbit Following Simulation for Heat Flux Splitting Prediction
  - **Trace test particle full orbit motions → Collect lost particles information colliding with divertor plates → Lobe structure**
- Key Simulation Inputs
  - **Perturbed equilibrium with plasma response – GPEC**
  - **Ion profiles – Ti, ni for initialization of test particles & weight function**
  - **Pedestal structure, distinguishing L- and H-mode edge**

## 1. Schematics of Full Orbit Simulation for Divertor Heat Flux Striation
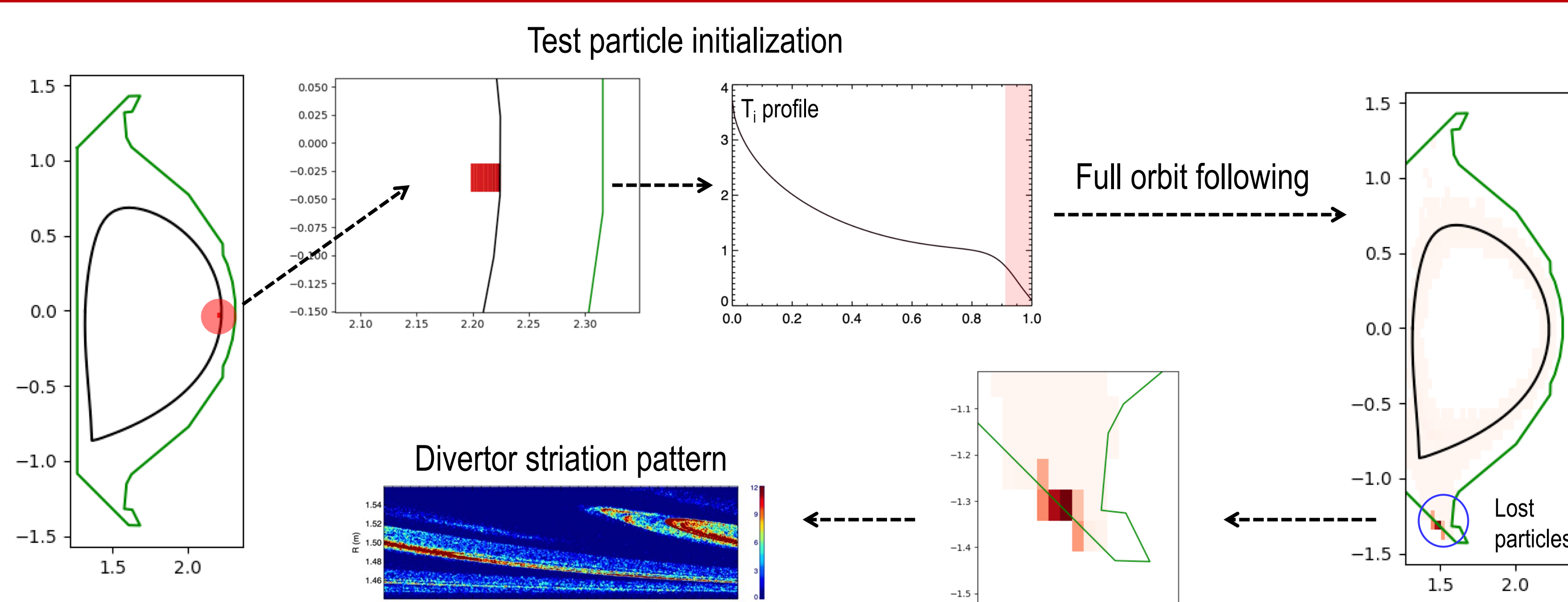
## 2. Comparison of Striation Pattern – FO vs. FLT
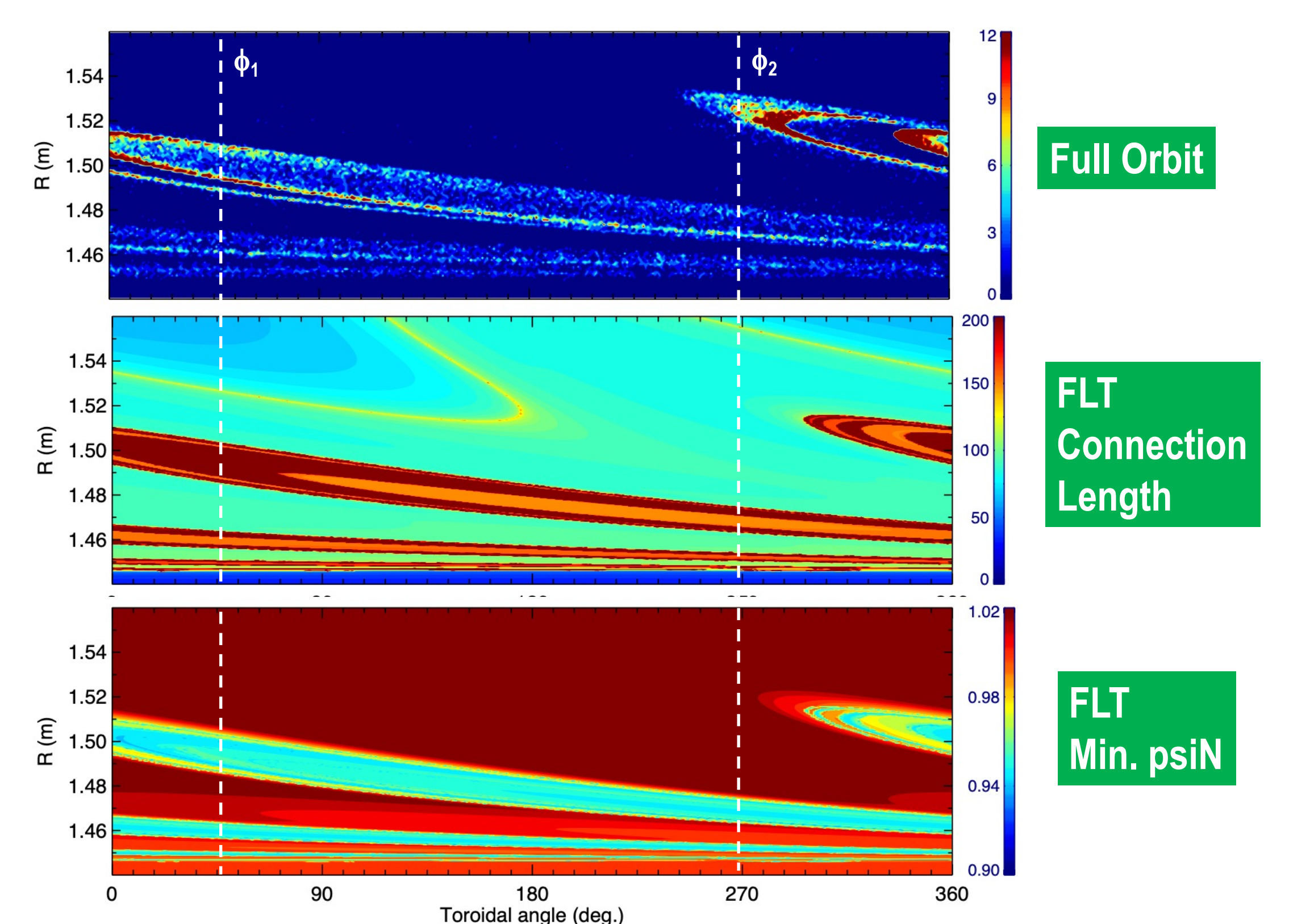
- **Both gives similar divertor striation patterns**
  - **Based on the same 3D perturbed equilibrium**
  - **Discrepancies in detailed structure**
- **Stronger striation patterns by FO**
  - **Better illustrations for relative peak amplitudes, providing heat profile-like lost particle distribution**

3. Schematics of Collision Detection Algorithm
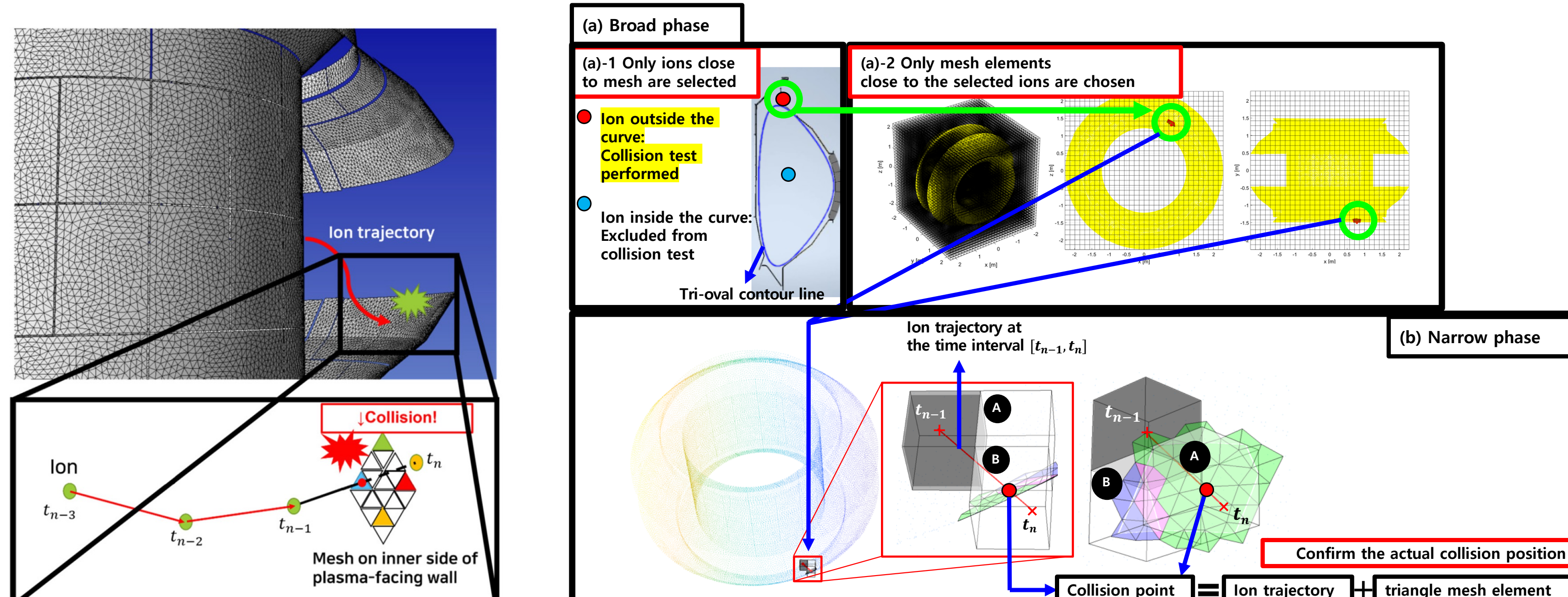
- **Integration with POCA full orbit following simulation**
  - **More accurate tracing of full particle orbits in the realistic 3D geometry, incorporating detailed segmental structures of the wall and divertor of KSTAR**

4. Heat Flux Splitting in the Realistic Wall and Divertor based on 3D CAD Model
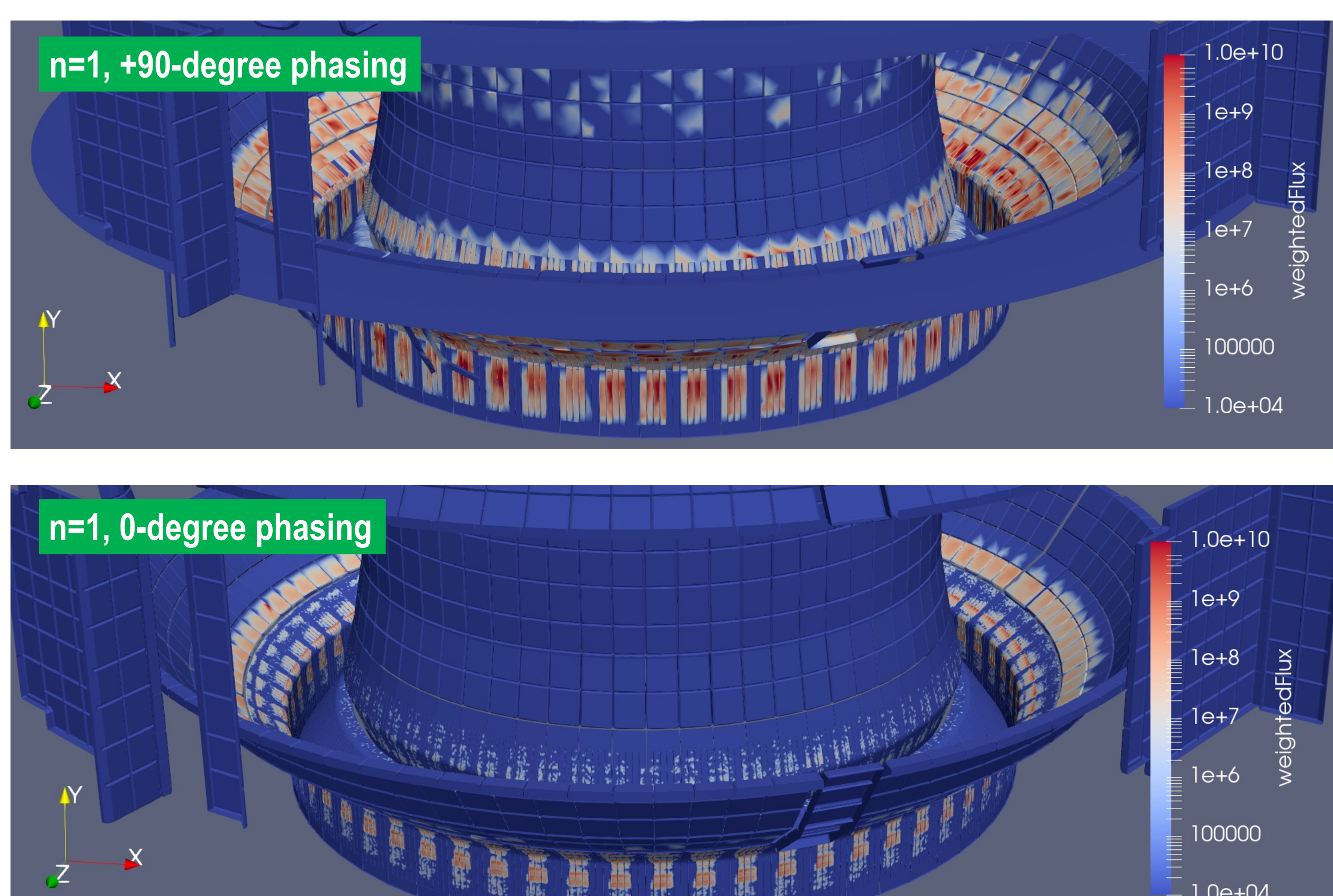
- **FO simulations with 3D CAD geometry qualitatively show clear n=1 structures**

- **Highlight detailed hot spots of intense collisions and heat deposition**

- **Physics based weight function required for quantitative comparison and prediction**

Outlook

- The newly developed simulation integrates full orbit following technique, collision detection algorithm, and 3D CAD based wall and divertor structure

- Integration into the digital twin framework is ongoing
  - **Serve as a tool for maintenance and protection of machine components in present fusion devices**

- Improvements for more physically consistent simulation
  - **Initial phase-space test particle distribution**
  - **Collisional effects**
  - **3D perturbed equilibrium**
  - **Interactions with impurities**

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