Development of Vector Following Mesh Generator(VEGA); Improvement to Adapting General Magnetic Flux Configuration

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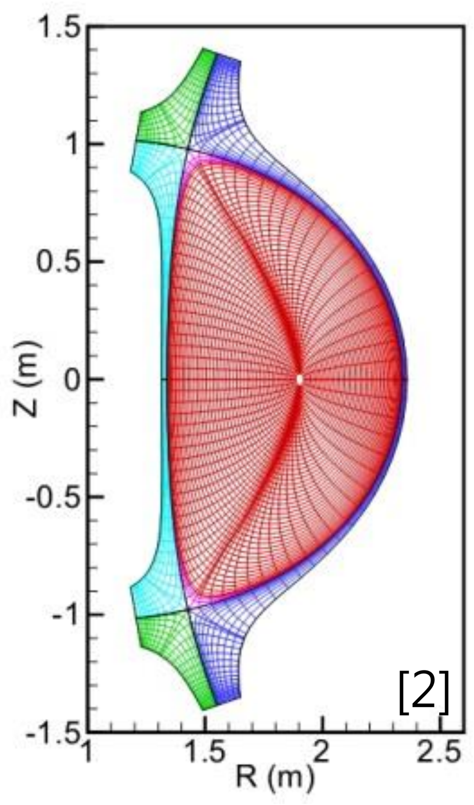
Abstract

- VEctor-following Grid generator for Adaptive mesh(VEGA) developed in SNU has been upgraded.
- It has been modified to deal with the general magnetic configuration including Discrete Double Null (DDN).
- It has been translated to C++ and some constraints and algorithms have been modified.

1. Introduction

- **Time Varying Plasma Simulation in 2D Geometry**
  - In time varying simulations, a plasma can be reconstructed its equilibrium states due to L mode to H mode[1] transition, Edge-Localized Mode (ELM) event, etc.
  - This changed plasma equilibrium affects simulations in CORE region 2-dimensionally.
  - But, in most of plasma transport codes CORE is treated in 1D and Edge/SOL in 2D.
  - And, the initial given grid wouldn't change in a whole simulation.
    → NEED general mesh generator such as VEGA[2]



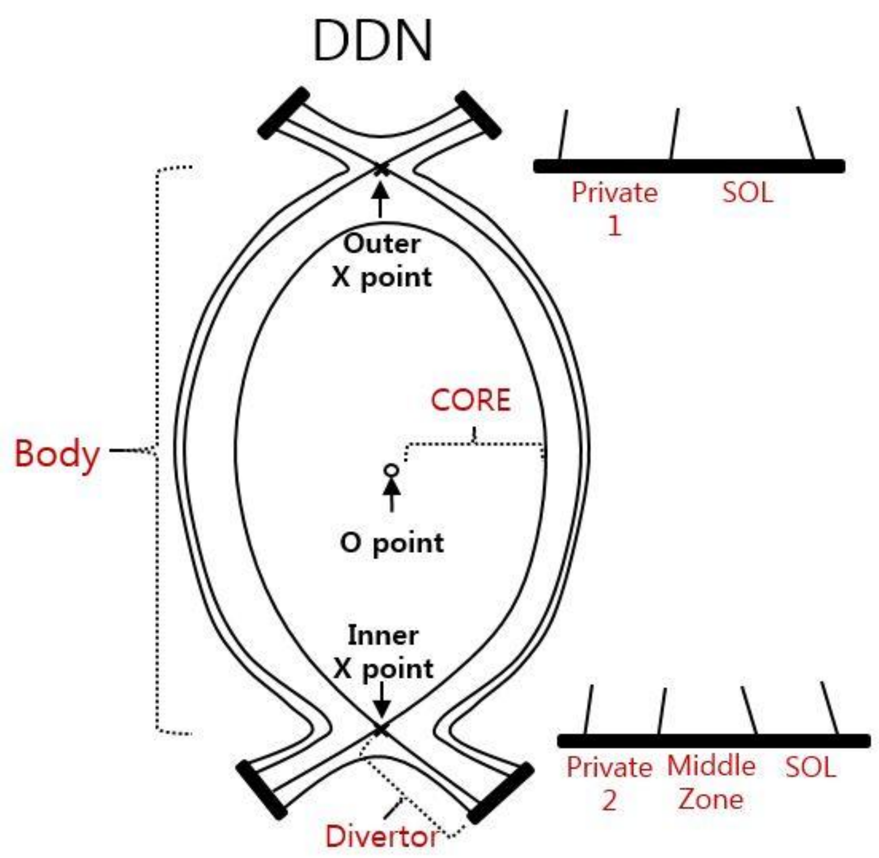
2. VEGA

- **VEGA (VEctor-following Grid generator for Adaptive mesh)**
  - Field aligned quasi-orthogonal structured mesh generator
  - Non-uniform grid distribution (User define)
  - Flexible mesh generation (Automatic determination of plasma configuration)
  - Available magnetic geometry (Single Null (SN), Connected Double Null (CDN))
- **Limitations**
  - programmed in MATLAB
    → Poor performance when linking with other simulation codes.
  - Limited magnetic geometry configurations
    → Disconnected double null (DDN) geometry, more common than the connected double null (CDN) case in real plasma experiment, not covered
  - Not verified in other TOKAMAK devices except KSTAR.

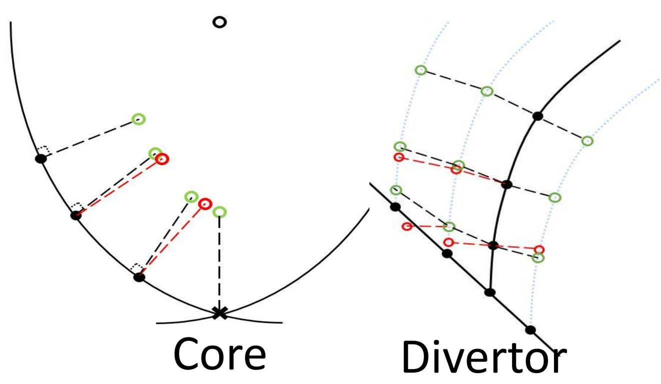
3. Expansion of VEGA

- **C++ Translation**
  - C++ language is chosen because it is widely used in many transport solvers.
  - VEGA perform faster and it can be linking with the transport solvers easier.

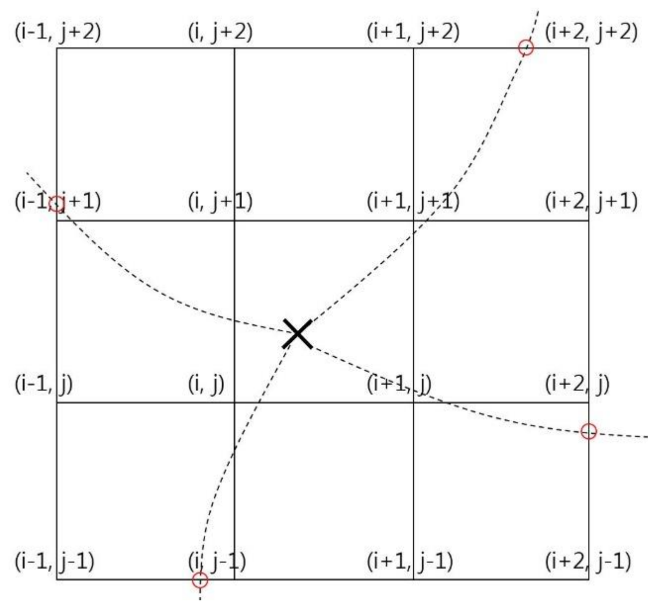
- **Covering All Magnetic Configurations Including DDN Geometry**
  - DDN magnetic configuration is more commonly formed because it is hard to yield the same value at both X points in double null geometry[3].
  - DDN is formed in following situations[4].
    - Structural machine asymmetries
    - The vertical displacement of the plasma
    - Bias induced edge currents
    → In this paper, we assumed that a plasma moves vertically.
  - New VEGA determines DDN geometry that the psi difference between the two X points is bigger than a certain value (i.e. a step size of the core mesh).
  - The mesh specifications are calculated for DDN from that of CDN automatically.



- **Modification of Old Constraints**
  - VEGA had constraints which moves a certain point to avoid mesh twists.
  - But, these sudden compression/expansion of grids affect the solution badly.
  → The grids are smoothly changed near the twist region in new VEGA.



- **First Point finding algorithm Upgrade**
  - The first separatrix points from X point are calculated manually because ,near X point, the psi values are hardly changed; $B_p = \frac{d\psi}{dx} \approx 0$
  - The first points finding algorithm in VEGA was determined to search 4 points for X point.
  - It excludes various divertor configurations such as the snowflake divertor geometry.
    → First points are now obtained up to 12 points.



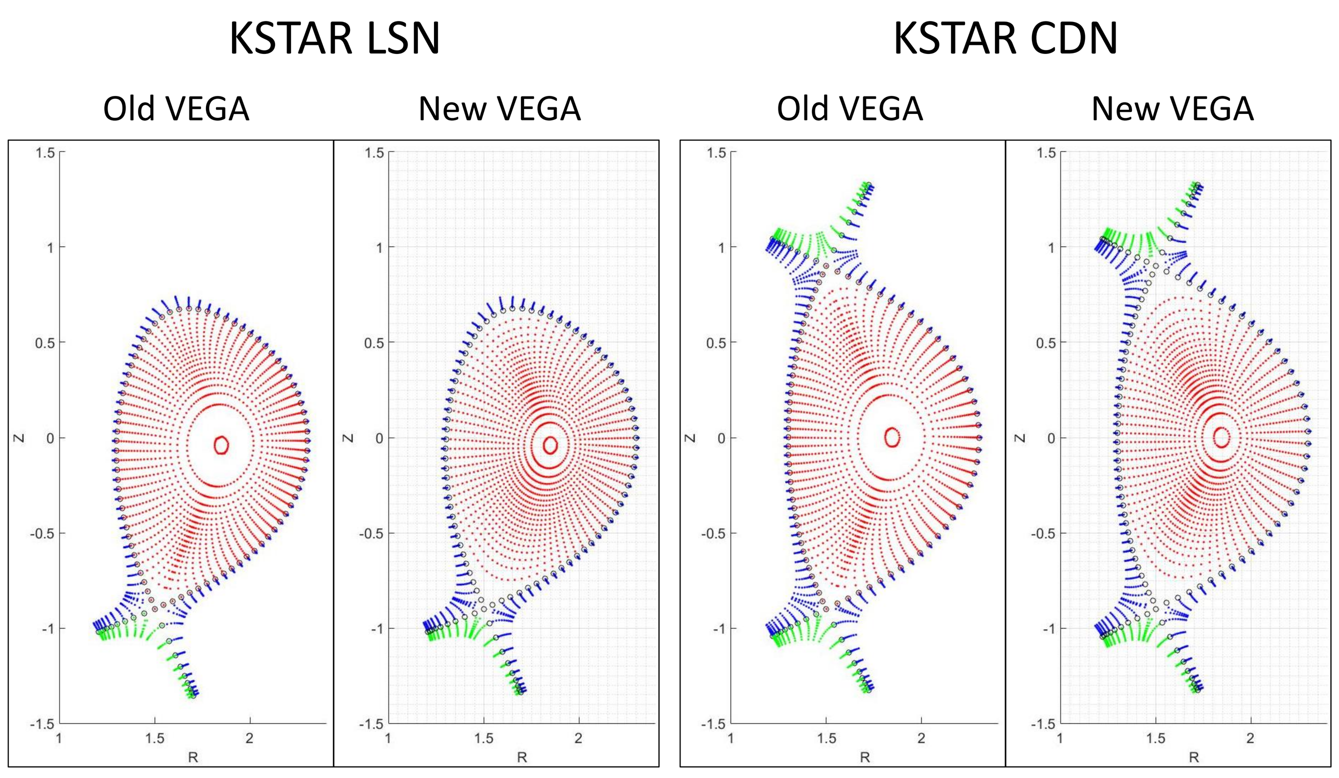
4. RESULTS

- **Grid Generator Verification**
  1. Because the whole code is modified, it is needed to verify with the previous result.
  2. DDN case is included, and verified.
  3. Old VEGA wasn't verified in other Tokamak devices.
     → New VEGA is tested the geometry from Versatile Experiment Spherical Torus (VEST)[5]

- **Grid Specification**

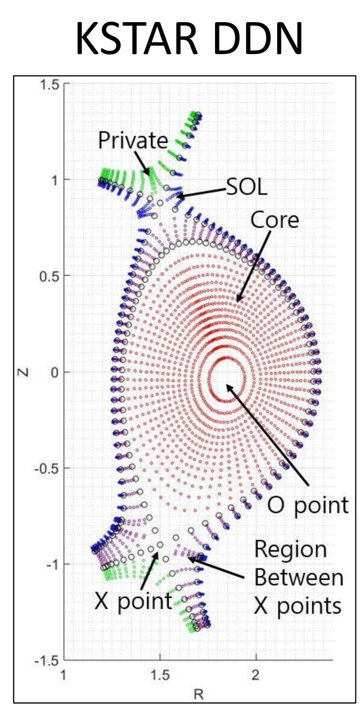
Domain	Core	SOL	Private
Node number	20 x 80	10 x 60	10 x 10
Preference	uniform	Non-uniform	Non-uniform

1. Comparing New VEGA with the Old one



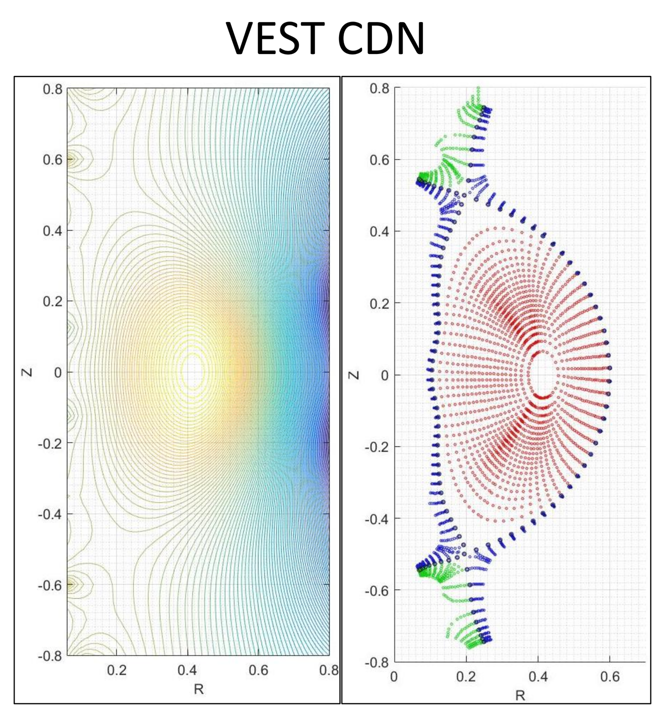
- The new VEGA shows fine performance.
  However, it is obvious that new VEGA cannot adjust radial grid distribution.

2. DDN Case



- This is a drastic DDN case.
  There are several issues such as grid distribution in the middle zone.

3. Verification with other device



- VEST device is preparing the double null divertor. Because of its uniqueness the grid in the private regions needs discussion.

5. Summary

- The Vector following Grid generator for Adaptive mesh (VEGA) has been updated.
- VEGA has been translated to C++, and the DDN magnetic configuration is included.
  In addition, grid constraints are changed for better numerical calculation and first point finding algorithm is modified for extending the code availability.
- New VEGA is verified against previous results of SN, CDN cases by comparing with old VEGA.
- New VEGA is tested for the DDN geometry and applied to the VEST device.

❖ Reference

[1] F. Wagner et al., Phys. Rev. Lett., 49, 1408 (1982)

[2] Y.J. Kim et al., Comput. Phys. Comm. 186 (2015) 31–38

[3] R. Marchand and M. Dumberry, Com. Phys. Com., 96, 232-246 (1996).

[4] R. Marchand et al., Nucl. Fusion 35 297 (1995).

[5] K. J. Chung et al., Plasma Science and Technology, Vol. 15, No. 3, Mar. 2013