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TRANSIENT ELECTROMAGNETIC ANALYSIS OF SELECTED OUTBOARD BLANKET MODULES OF THE ITER BLANKET SYSTEM DUE TO PLASMA DISRUPTION SOFE 2013

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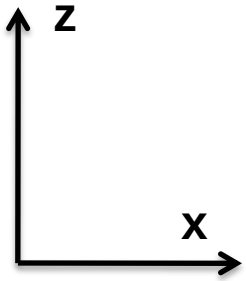
Overview

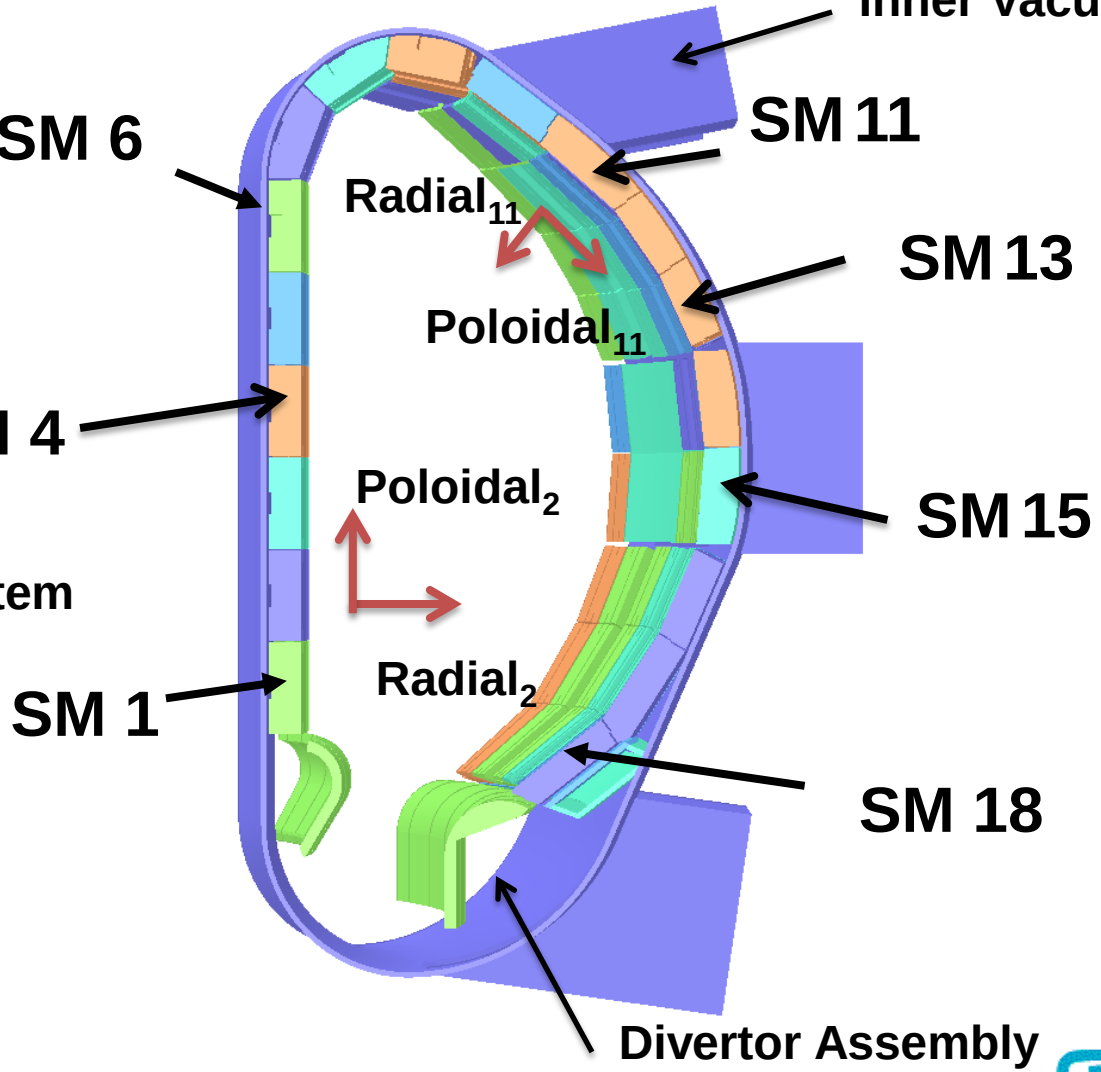
- ITER Device
  - Overall System Model
  - Typical Blanket Model
- Blanket module modeling
  - BM11
  - BM15
- Plasma Disruption Scenarios
  - Basic description
  - Modeling procedure
- Results
  - Torques for the different blanket modules and disruption cases.
- Conclusions

ITER Device

20 degree sector



Model Coordinate system



SM – shield module
No First Wall

Toroidal – out of paper

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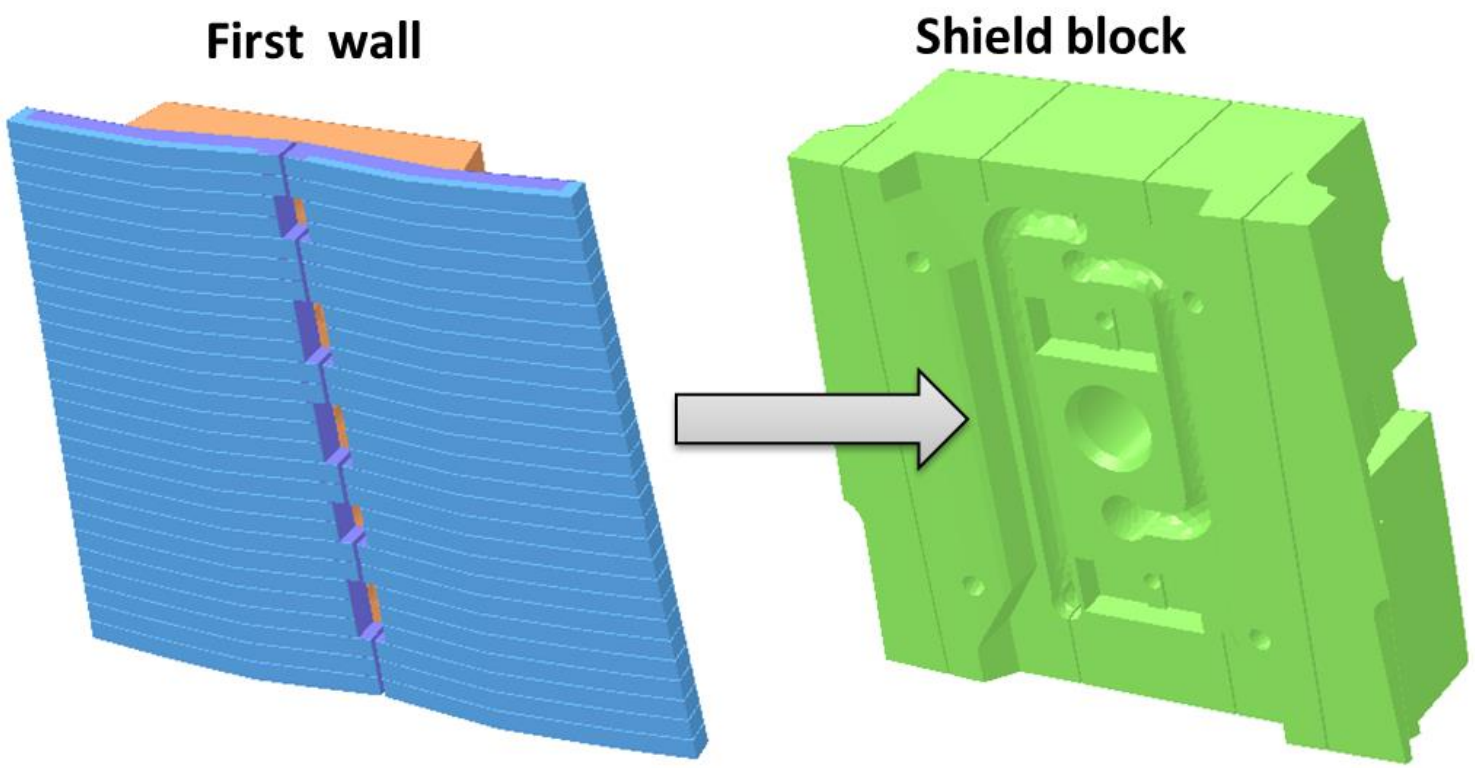
Example Blanket Module

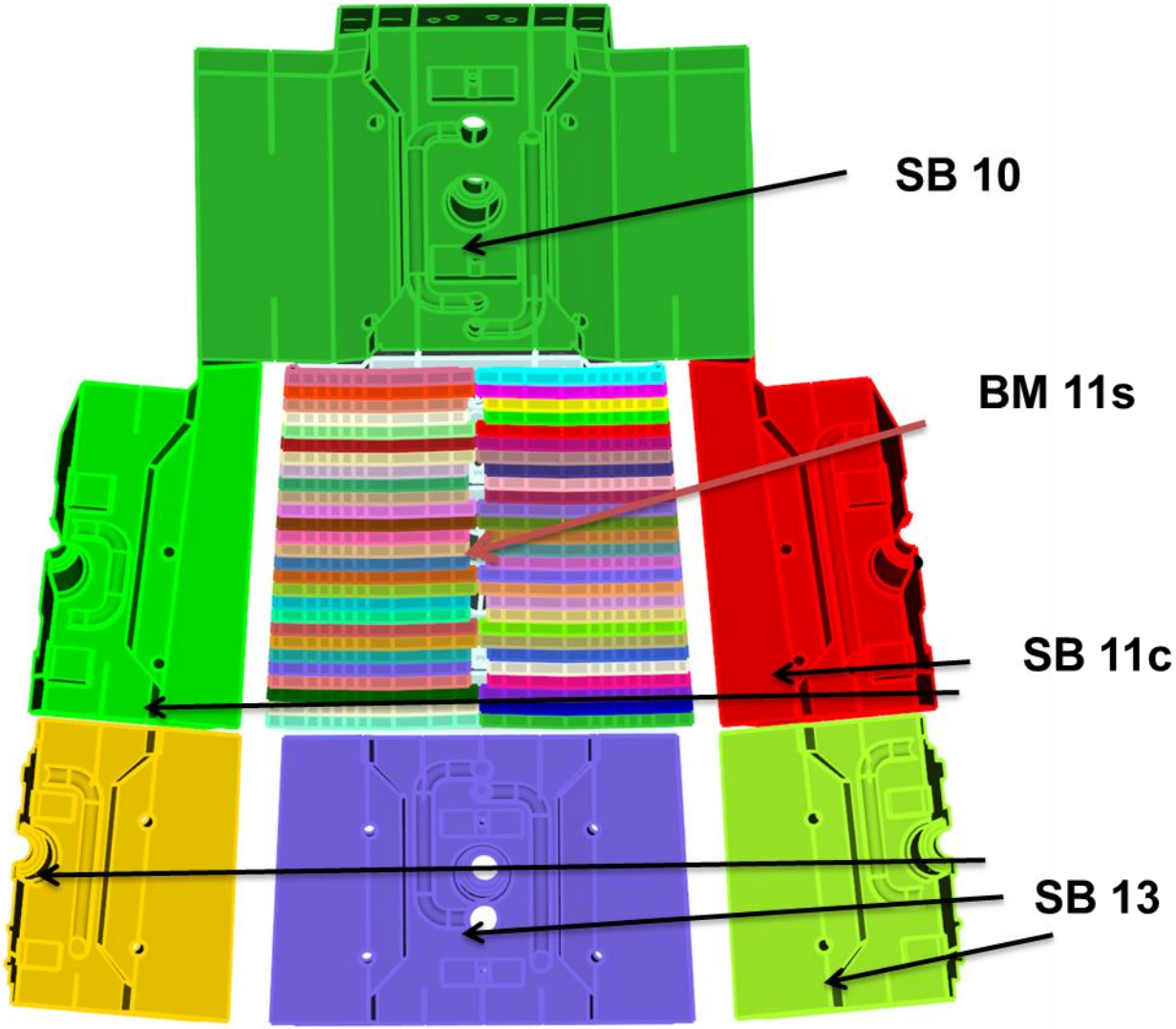


Key features – model contains cooling channels and eddy current slits

BM – shield module with First Wall Assembly

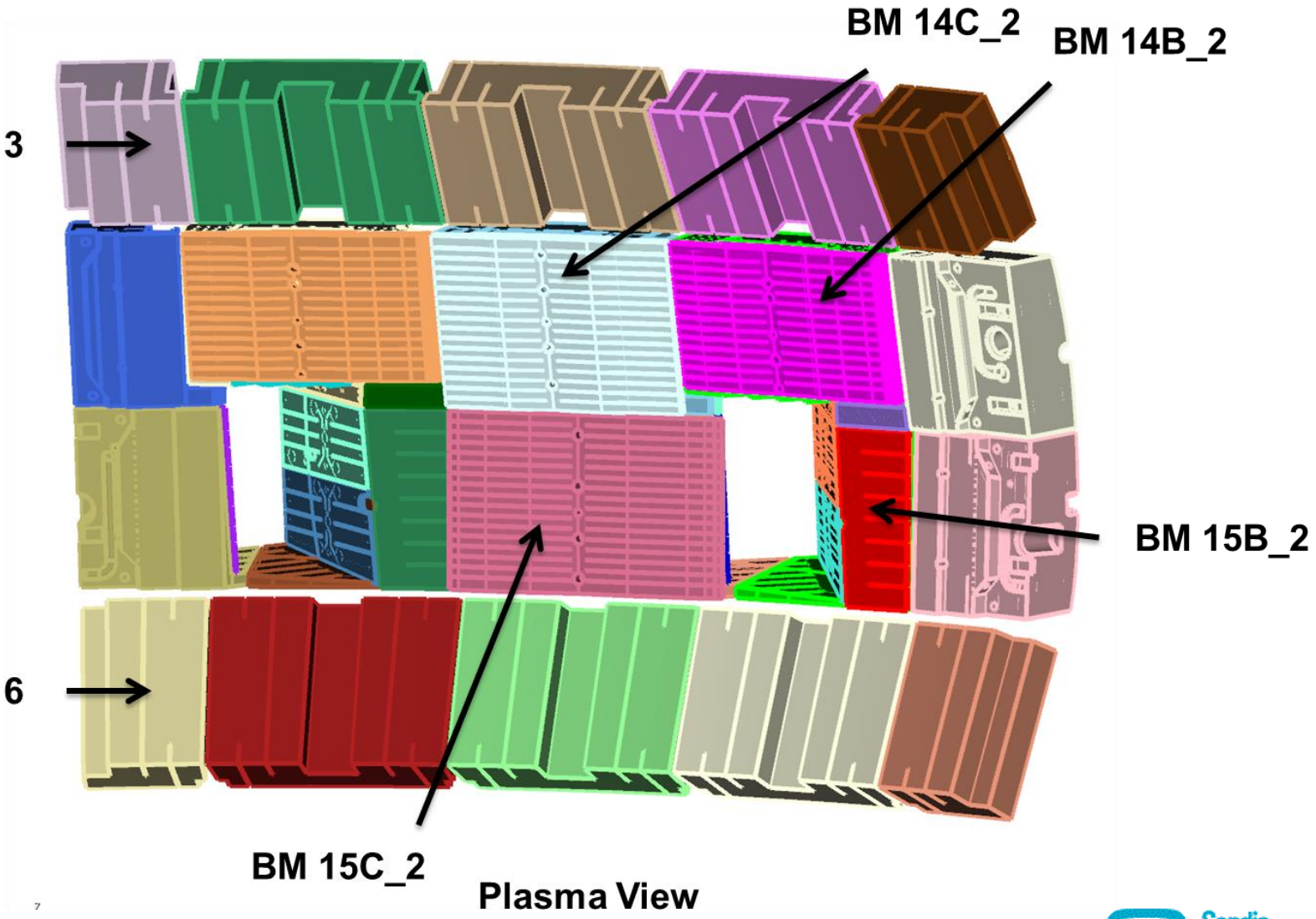
First wall assembly consists of CuCrZr face, SS fingers, SS beam

Model for BM 11s



20 degree sector

Model for BM 15 NBI Region



40 degree sector

Model Notes

- **For accurate results for a blanket module:**
  - **Nearest neighbors are included.**
- **Inner and outer vacuum vessels are included.**
- **Simulations performed with Opera-3d software.**
  - **Finite element model**
    - **20 degree sector ~19 million elements**
    - **40 degree sector ~35 million elements**

Plasma Disruption

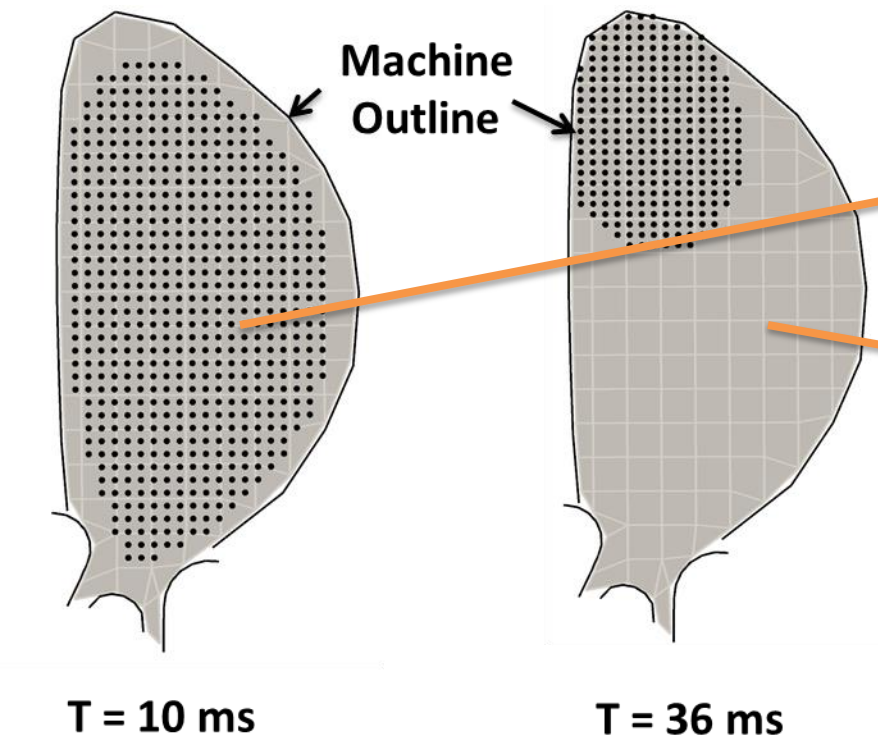
- **A 15 MA plasma current is flowing in the device, toroidal direction.**
- **Plasma drifts then disrupted.**
  - **Due to impurities**
  - **Loss of stability**
- **Plasma current starts to decrease.**
  - **Centroid of this plasma moves - eddy currents are induced.**

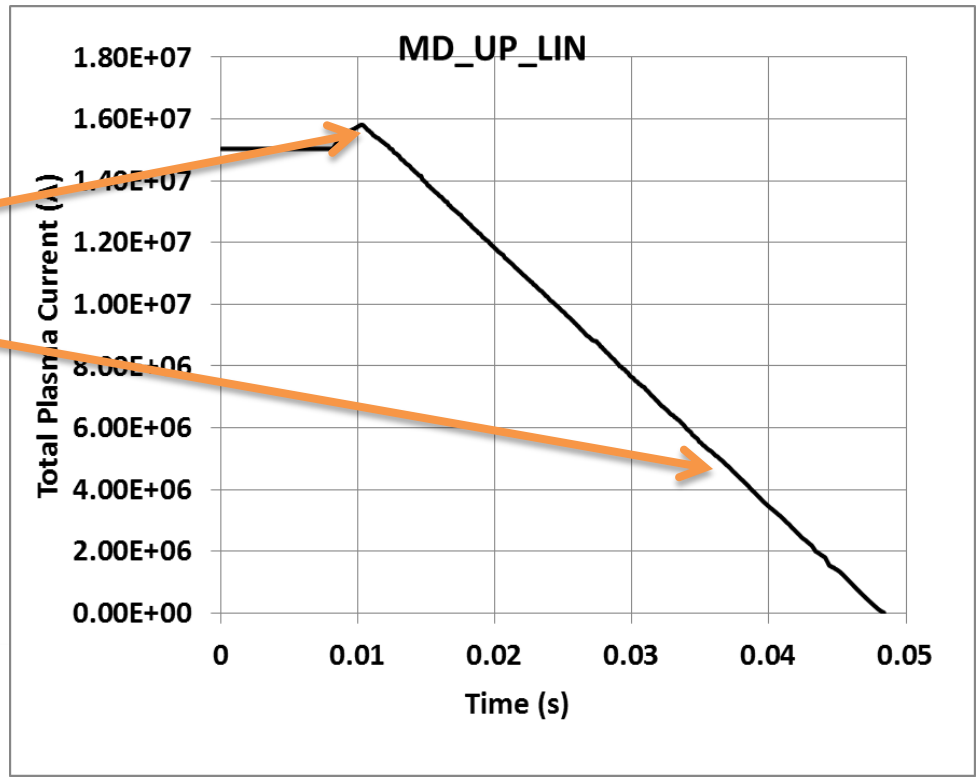
Plasma Disruption Modeling
for Eddy Currents

- From DINA Simulations
  - Prescribed by the International Organization
  - 20 different scenarios
    - MD – Major Disruption
    - VDE – Vertical Displacement Event
      - Plasma direction down(DW) or up (UP)
      - Plasma current decay linear (LIN) or exponential (EXP)
        - » MD_UP_LIN - Major disruption, upward moving, linear current decay

- Key Features
  - Axisymmetric (2-D) description
  - Plasma current modeled by a finite number of filaments
    - Number of filaments vary with time
    - Position vary with time

Plasma Disruption Modeling





DINA Filaments

Total plasma current

NOTE: Points shown are the Dina filament currents

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Plasma Disruption Modeling

- **Modeled by 64 stationary solenoids.**
  - **Using the equivalence principle.**
- **Each has a different time history.**
- **Models the time variation of the total current behavior.**
- **Models the movement of the plasma with time.**

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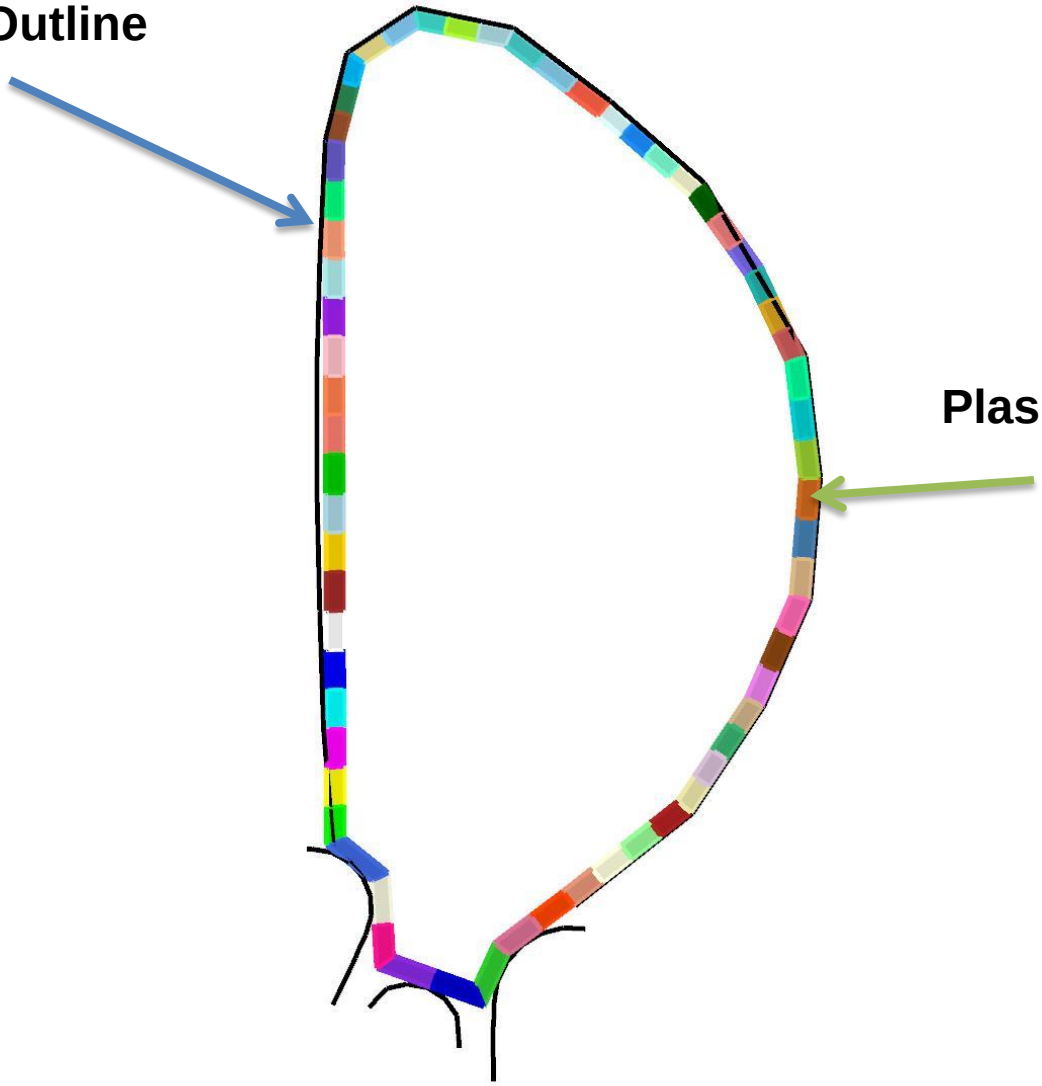
Plasma Disruption Modeling

Machine Outline



Plasma Conductors 64

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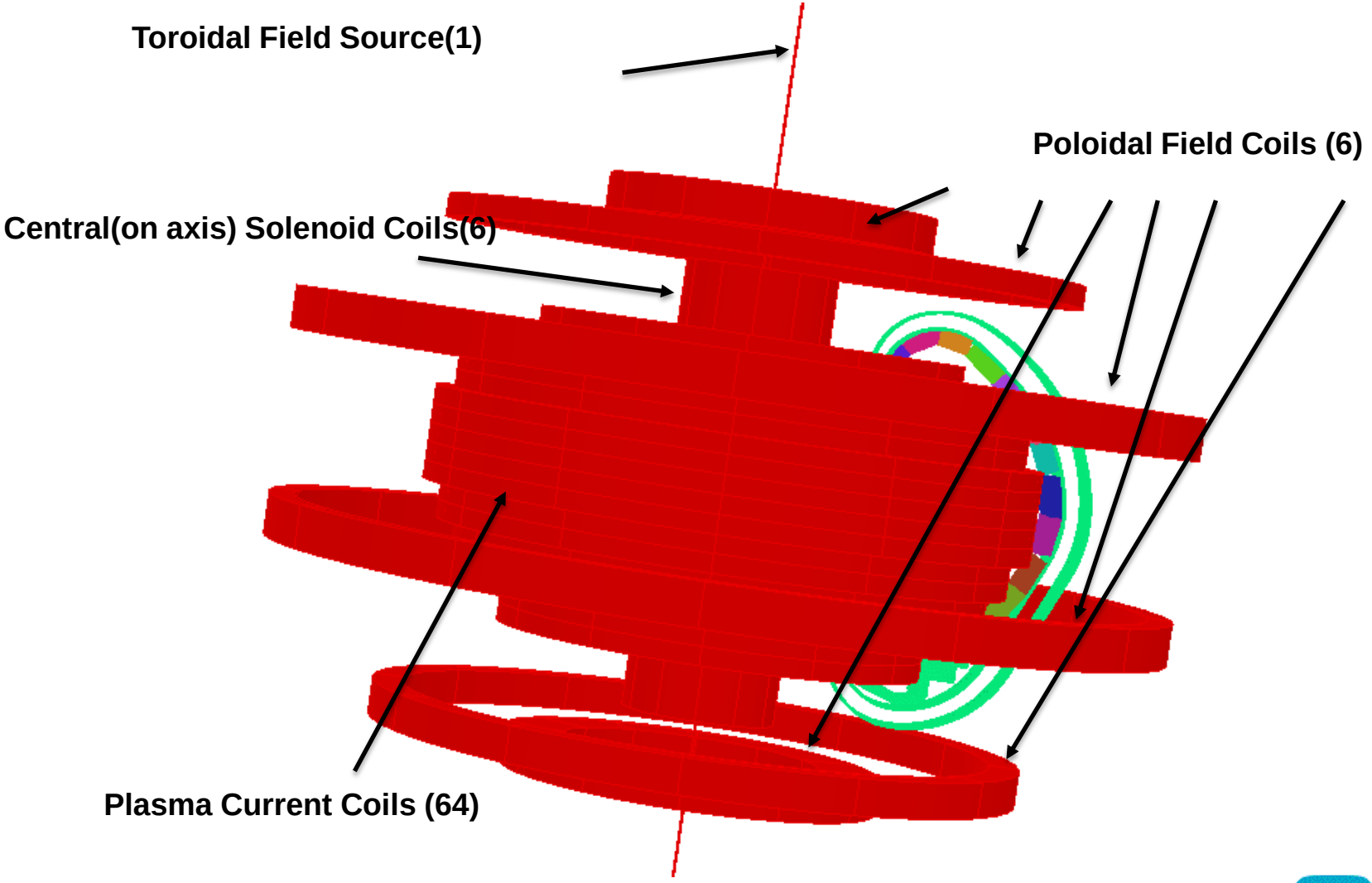
Electromagnetic Model of Plasma Currents



Electromagnetic Load Calculations

- **Calculated forces and torques transformed from the global to local coordinate system of a blanket module.**
  - **Radial direction : toward plasma**
  - **Toroidal direction : in direction of plasma flow**
  - **Poloidal direction : t x r**

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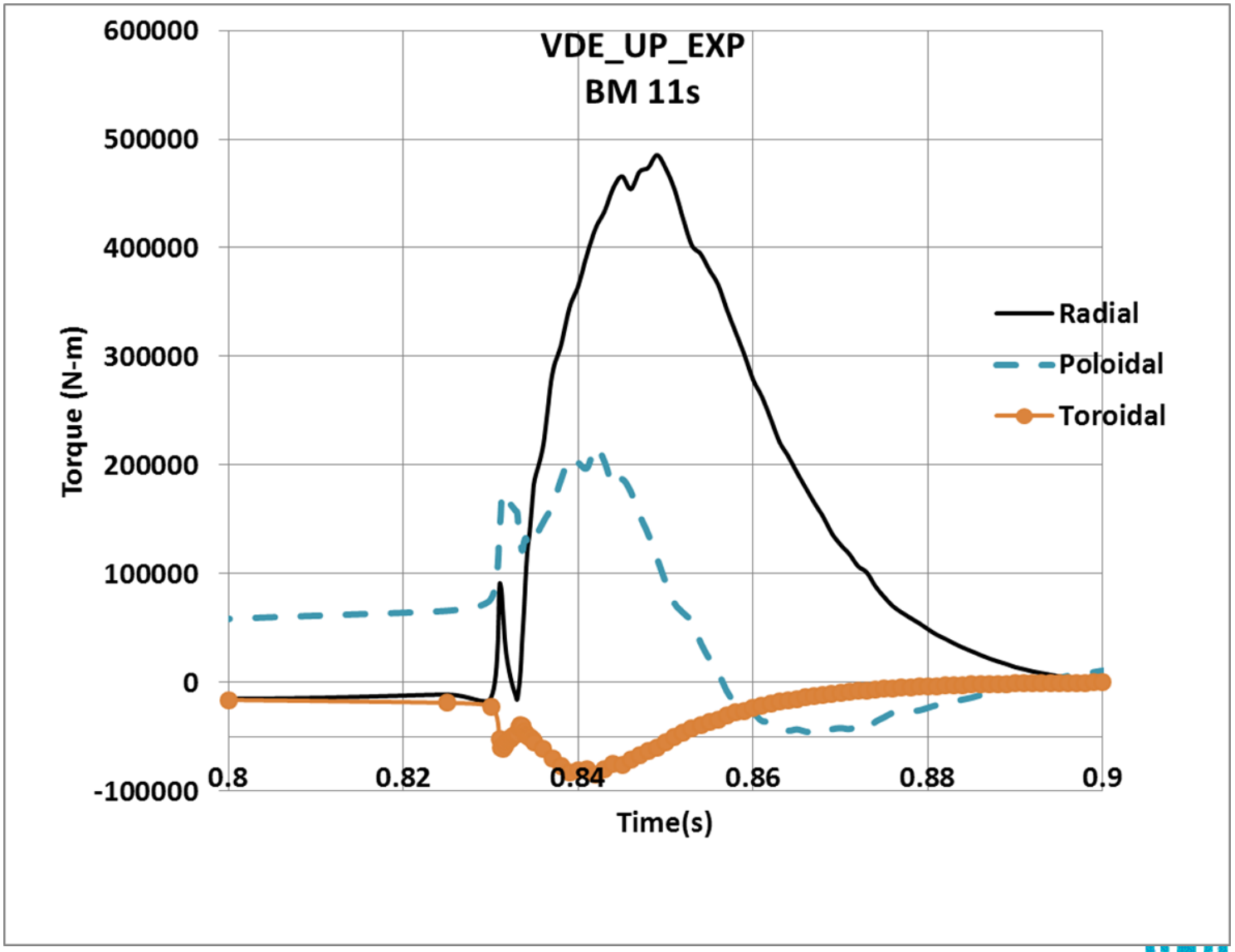
Torque Results

- BM 11s
  - VDE_UP_EXP
  - MD_UP_LIN
- BM 15C_2
  - MD_UP_LIN
  - MD_DW_LIN

BM 11s –VDE_UP_EXP



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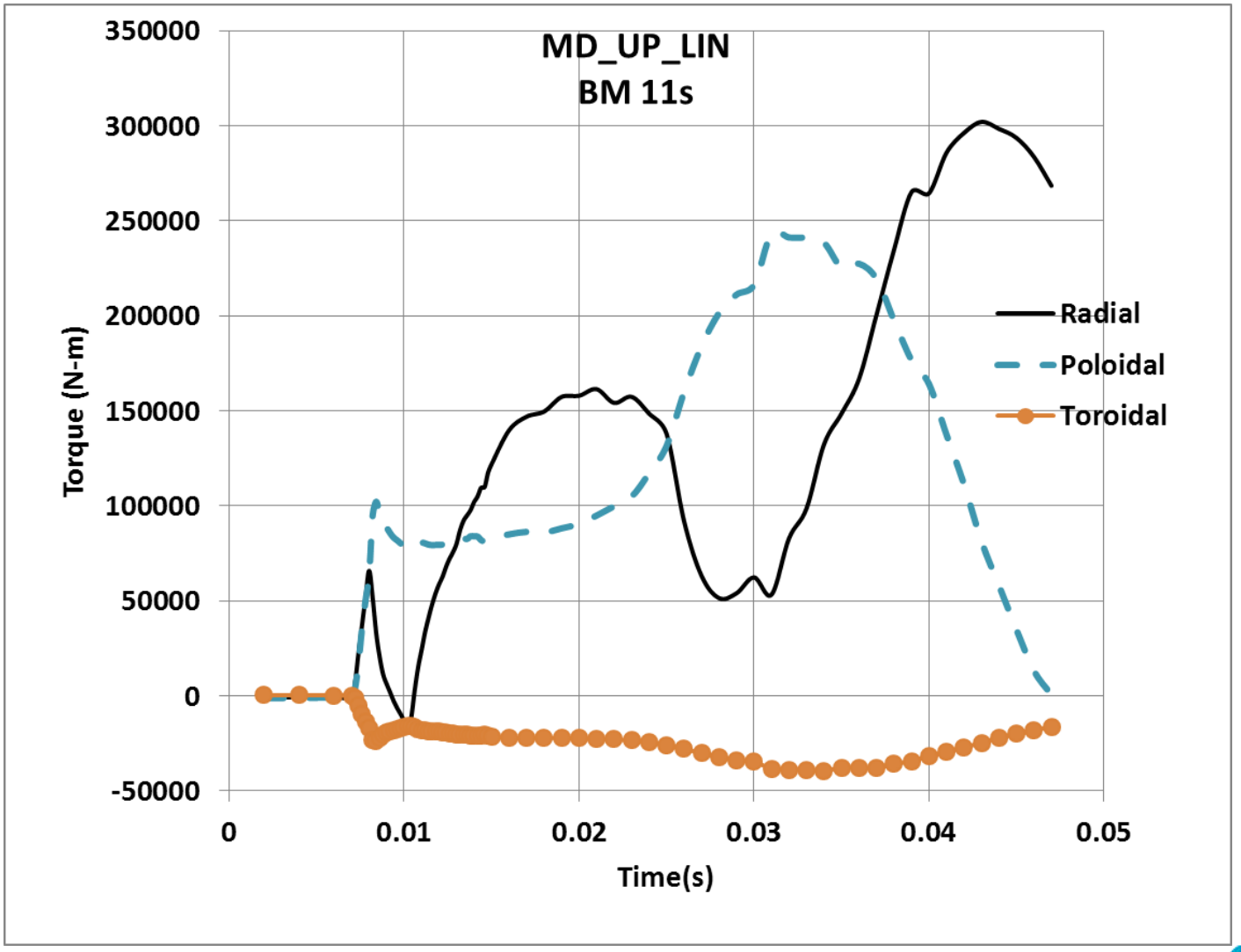
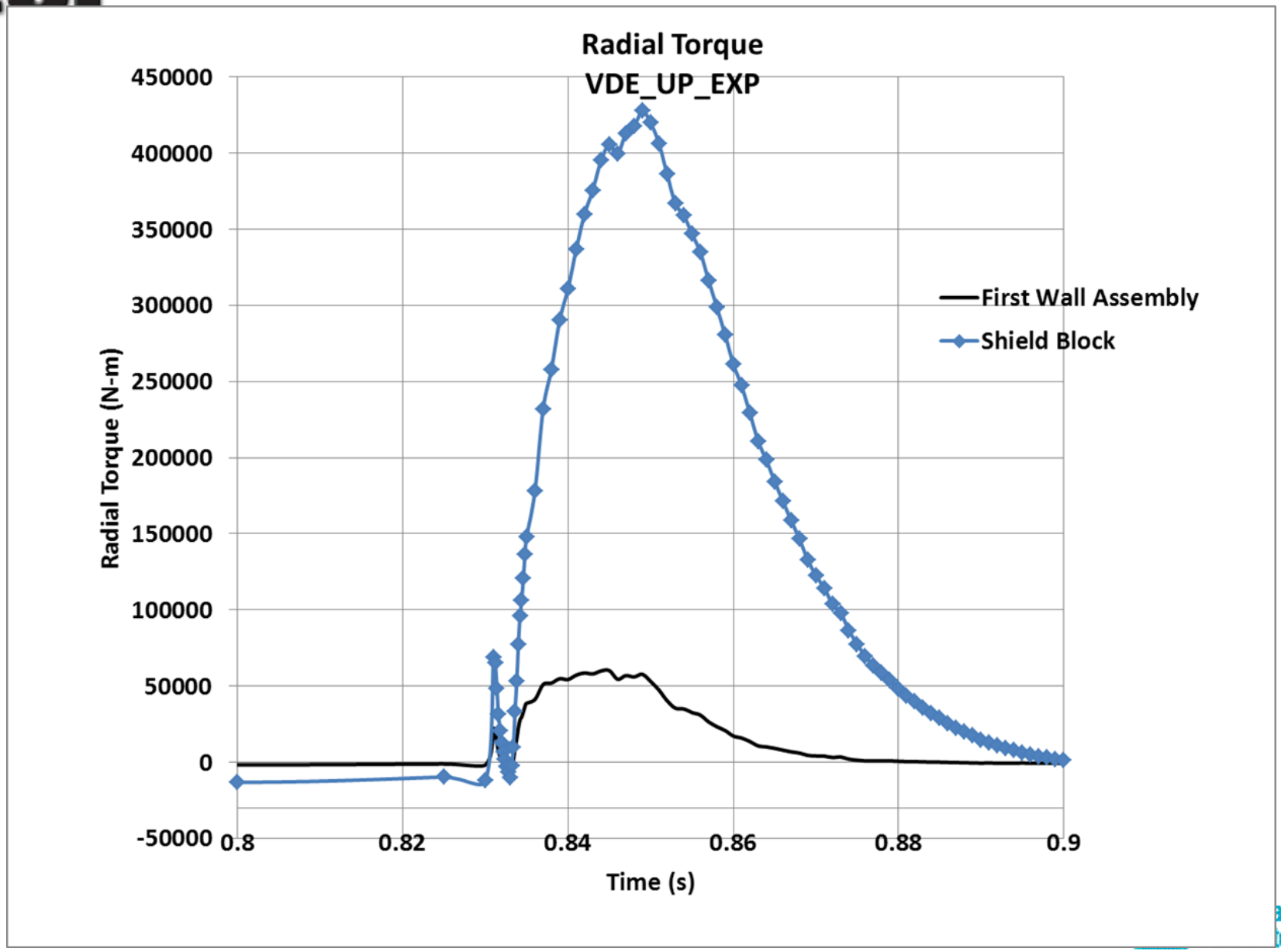
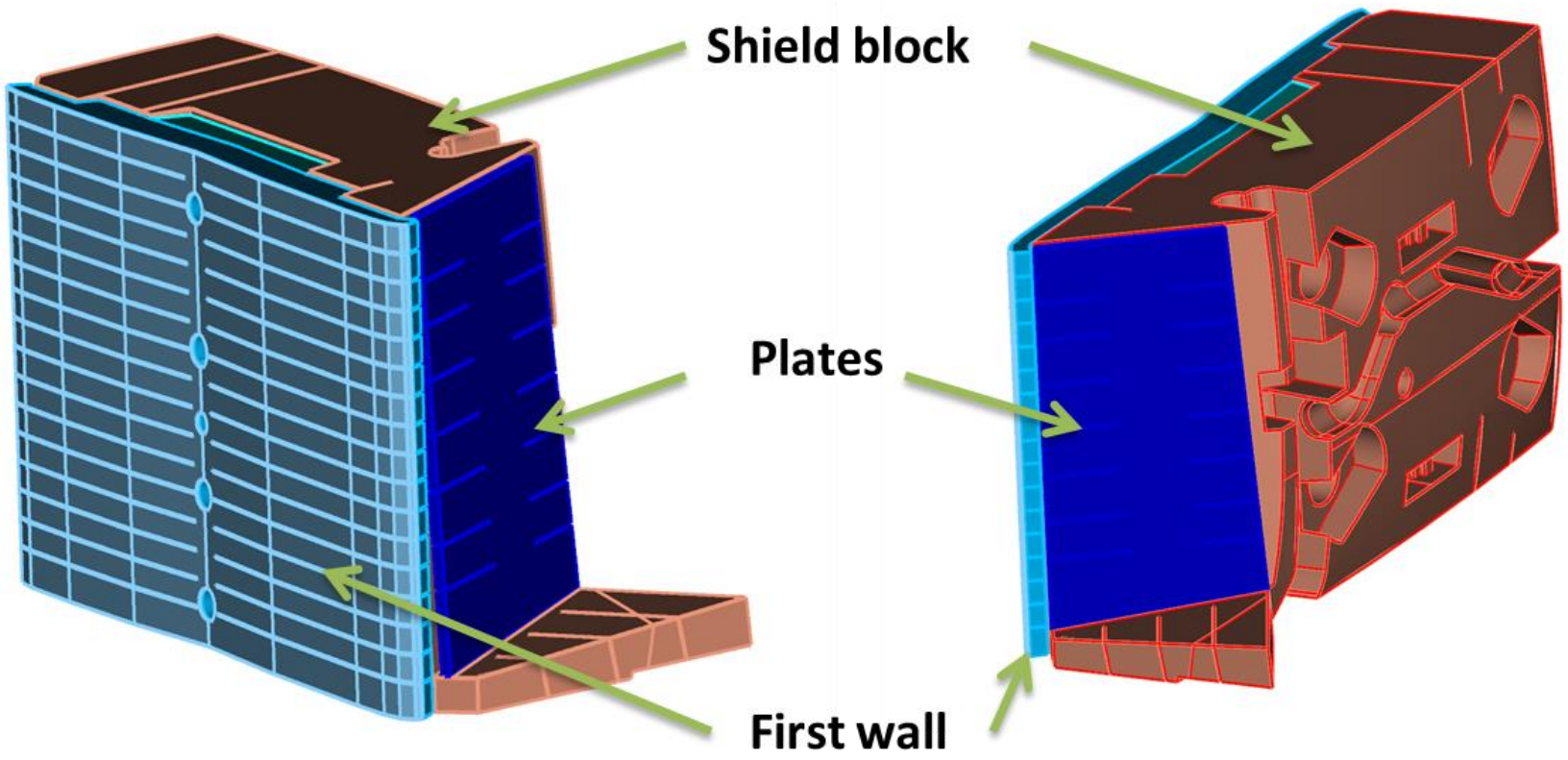
BM 11s –MD_UP_LIN



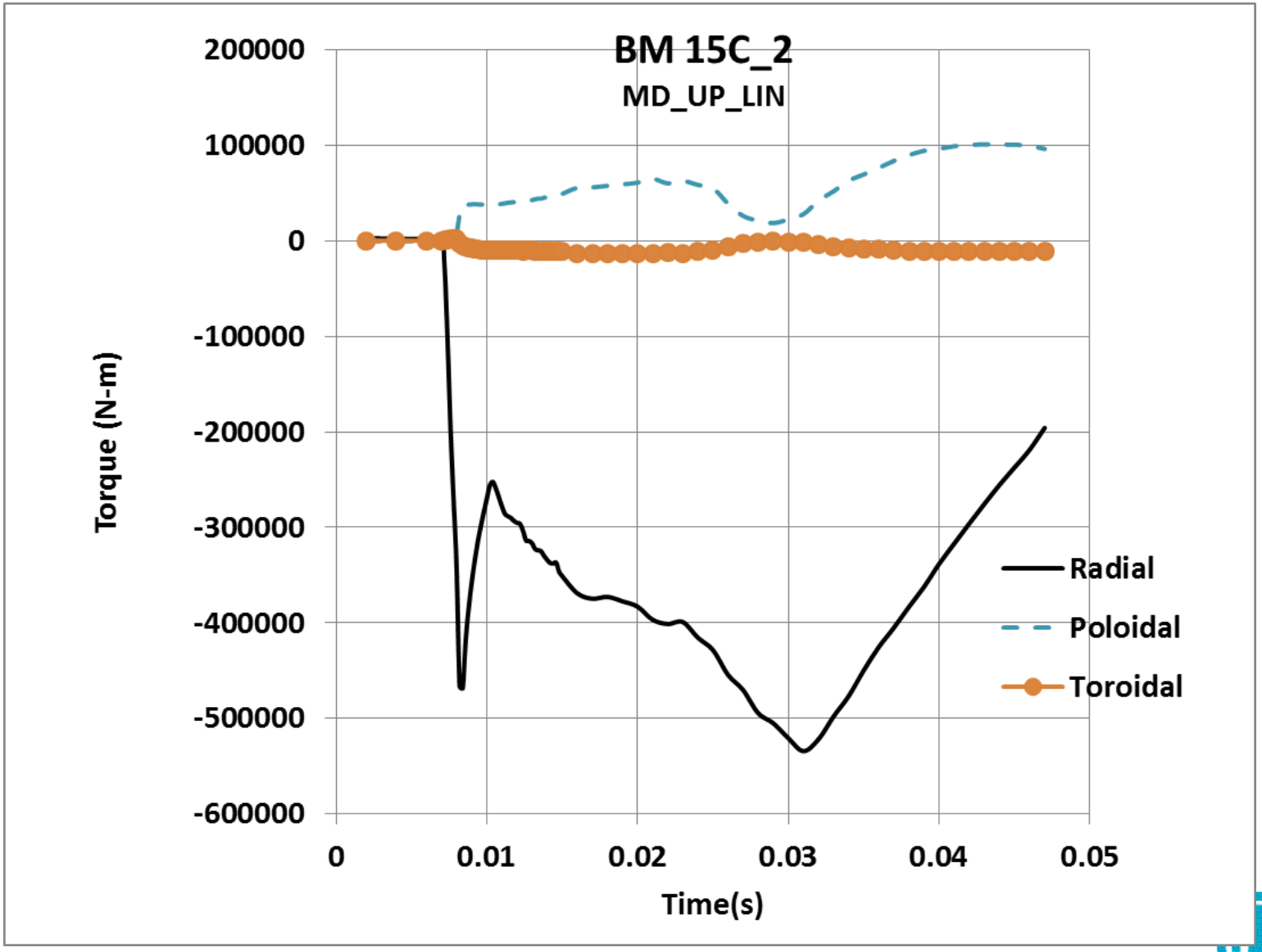
BM 11s –VDE_UP_EXP



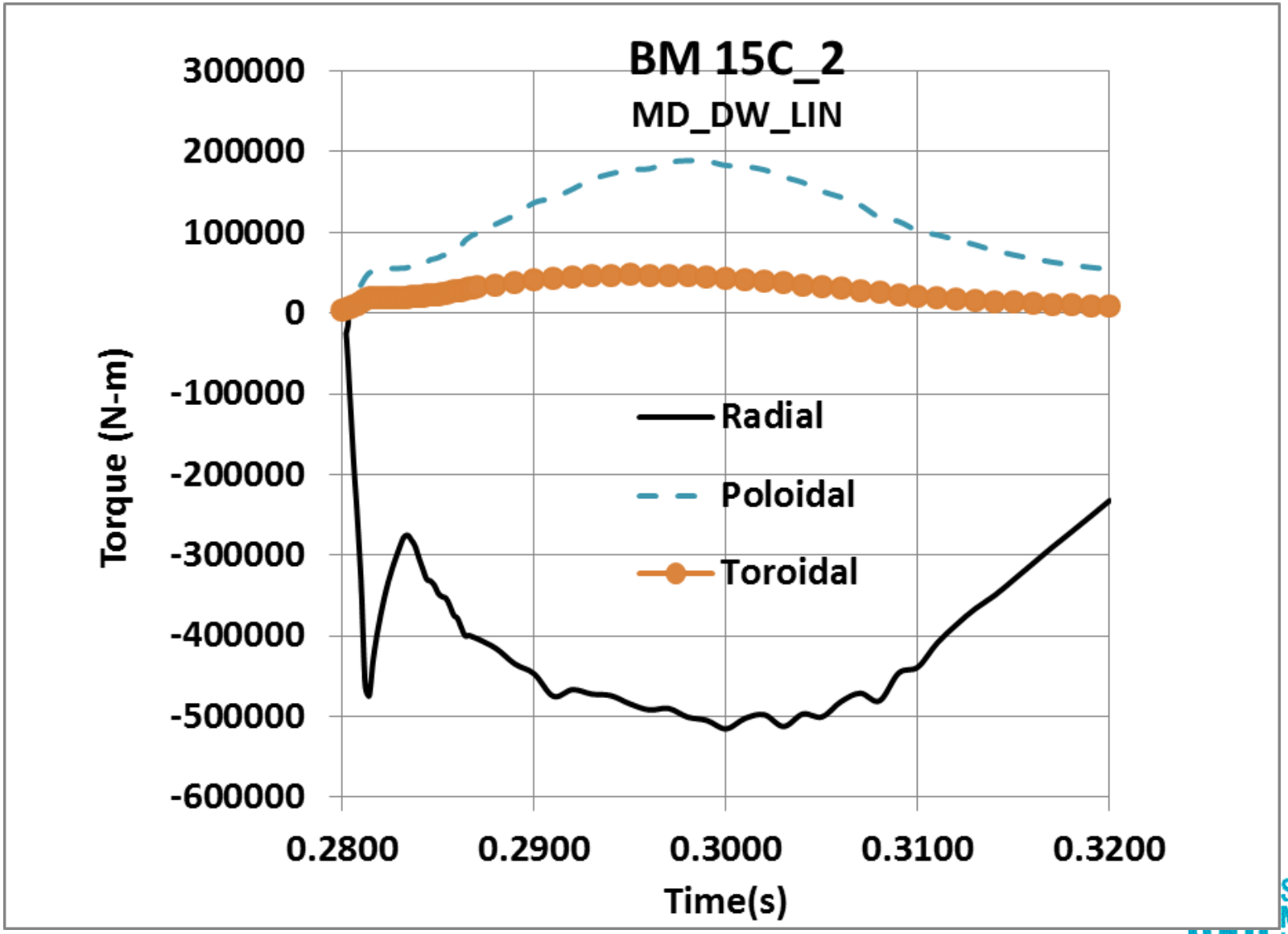
BM 15C_2



BM 15C_2 - MD_UP_LIN



BM 15C_2 - MD_DW_LIN



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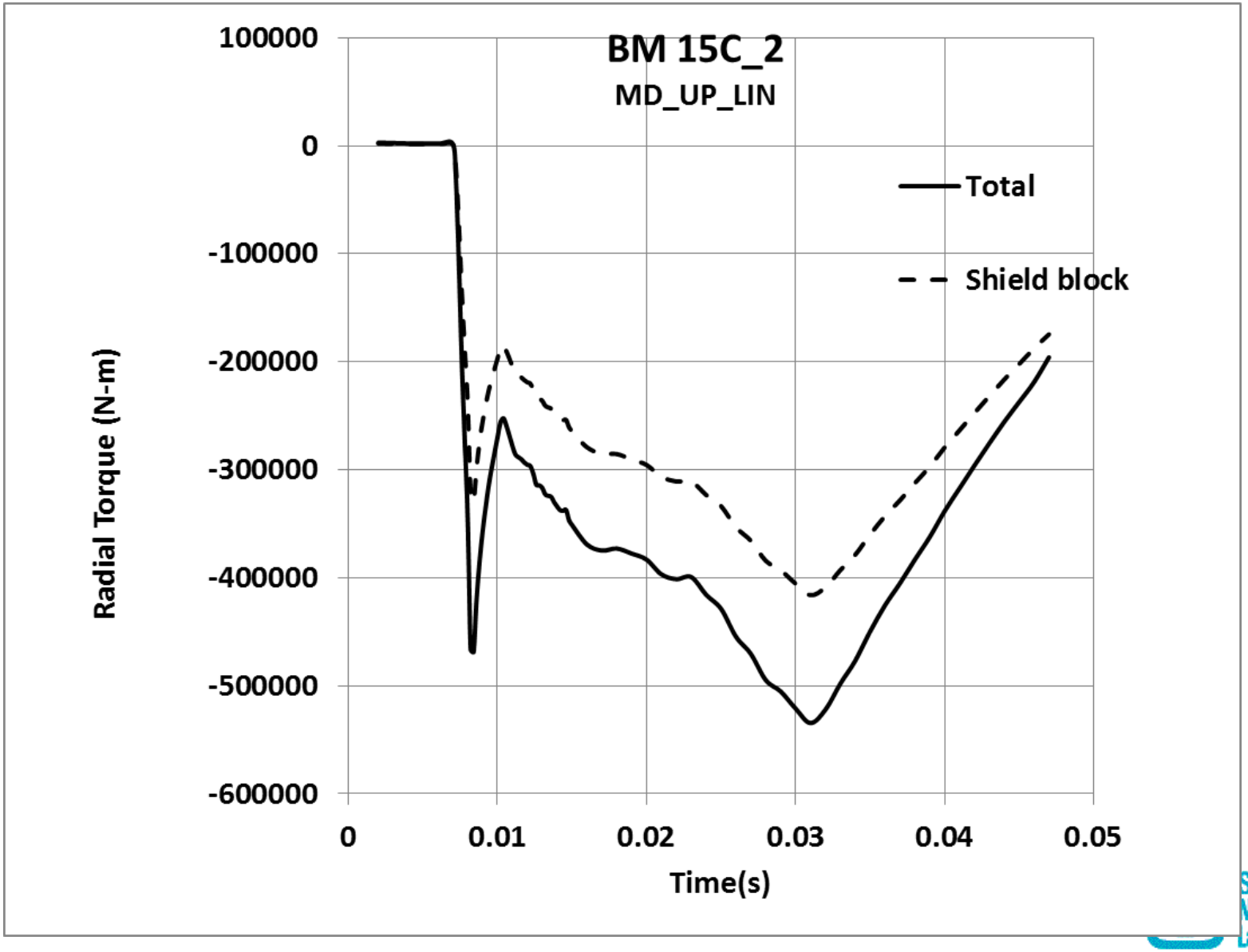
BM 15C_2 - MD_UP_LIN



Conclusions(1)

- The analysis technique used to predict the electromagnetic loads on selected outboard blanket modules has been described.
  - BM models
  - Plasma disruption modeling
- The torques have been calculated for different plasma disruption events for these modules.

Conclusions(2)

- **The predicted loads do not exceed the load limits for these blanket modules.**

- **Since each blanket module component has been separated electromagnetic loads have been calculated:**
  - **First wall to shield block**
  - **Plate attachments**