DESIGN OF THE TARGET DUMP INJECTION SEGMENTED (TDIS) IN THE FRAMEWORK OF THE HIGH LUMINOSITY LARGE HADRON COLLIDER (HL-LHC) PROJECT

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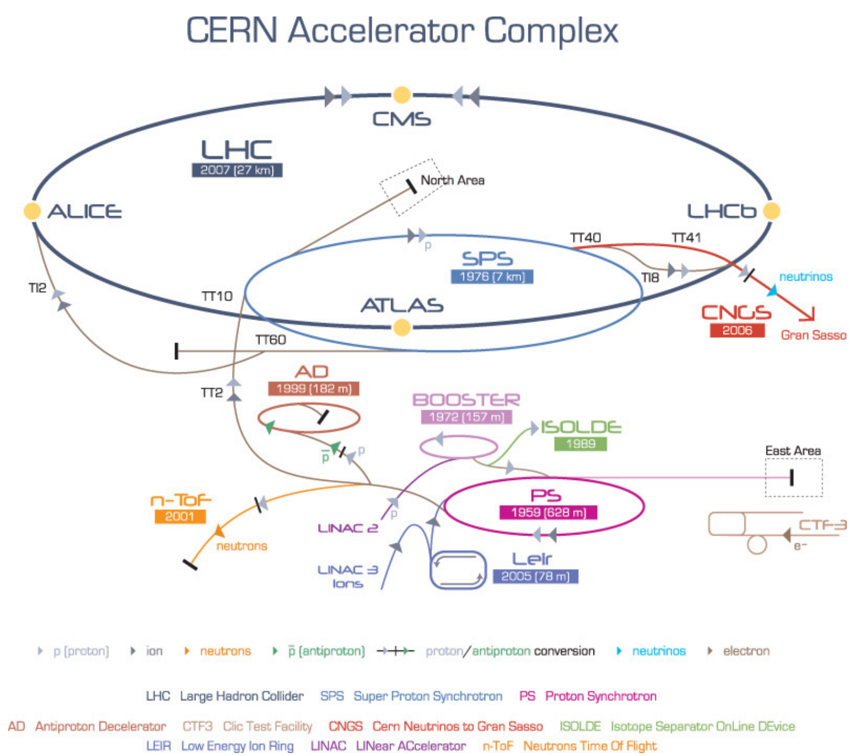
CERN | EN ENGINEERING DEPARTMENT
STVDIVM VRBIS
INFN Istituto Nazionale di Fisica Nucleare

Turn On The Light!

$$\mathcal{L} = \frac{N_1 N_2 f N_b}{4\pi\sigma_x\sigma_y}$$

LHC Injectors Upgrade

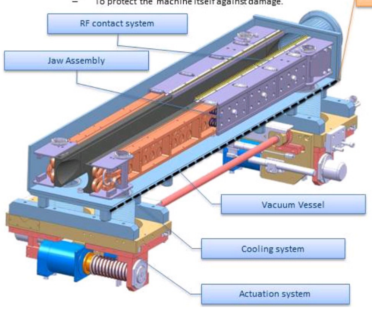


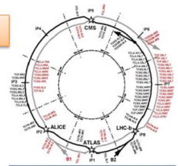
HiLumi
HL-LHC PROJECT

Beam Intercepting Devices (BIDs)

Collimators

- In all types of linear and circular accelerators, collimators are required to narrow the beam of particles. Owing to differences in the construction of the various types of accelerators, there are various approaches to beam collimation. In Linac's it is important to collimate the beam before the target or before or within the transfer line. In this type of machine, the beam interacts with the collimating system only once. In contrast, in synchrotrons and accumulator rings, the collimating system affects the beam parameters continuously and the proper selection of collimator locations is a more complicated problem.(2)
- In general, tasks of collimation system are:
  - To clean the beam;
  - To protect the machine itself against damage.





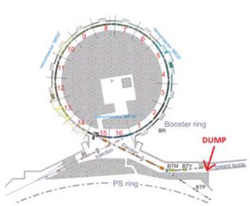
LHC collimation system layout

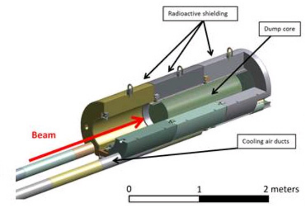
Collimator Family and main function

TCP: Beam cleaning and general protection (stage 1)
TCSG: Beam cleaning and general protection (stage 2)
TCT: Protect the triplets (stage 3)
TCLA: Intercept the cleaning-induced shower
TCLP: Catch the showers induced by experiments (p-p collisions)
TCDI: Injection collimation
TCLI (A&B): Active injection protection
TCAPx: Passive absorbers
TCTP: TCT with BPM, replaces all TCTs in Pt 1, 2, 5 and 8
TCSP: TCSG with BPM (replaces TCSG in Point 6)

Beam Dumps

- Beam dumps are devices used to dispose of the beam whenever this action is required for the operation of the accelerator complex. They are designed to continuously absorb the energy of the beam circulating in the upstream accelerator or transfer line. The energy of the beam is absorbed completely or partially, in such a way that the eventually remaining unabsorbed energy, by the primary or secondary beam, is minimised and guarantees (on a case by case basis) the required level of machine protection.(1)



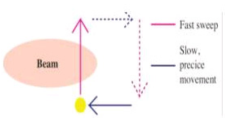


Schematic layout of PSB beam dumping system (3)

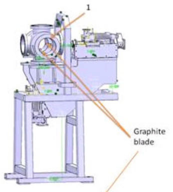
Part of the beam dump system are absorber blocks which consist on a block of material that is brought on the beam passage to stop remaining electrons in the beam. As the electrons loose energy in the material, they will not

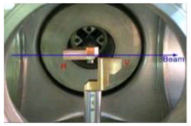
Scrapers

- Beam scrapers are useful for measuring beam properties, removing beam halo and reduce the beam size.
- The scrapers consist of two one-sided copper jaws, one for each of the transversal planes. Scraping is always conducted by sweeping one or both jaws quickly through the beam. (4)



Scraper at LSS1



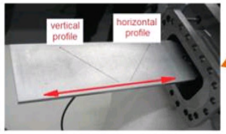


10mm thick Graphite blade

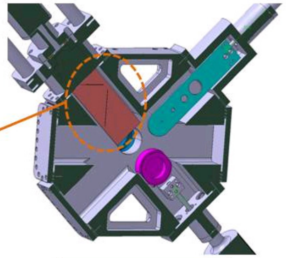
Schematic view of the movement of the SPS scraper jaw during operation: tails outside desired amplitude are cut off by means of a fast movement through the beam, starting from the parking position (marked by the yellow spot).

Slits

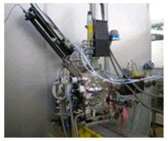
- A typical method for measuring the transverse emittance consists in a slit and grid system. For each slit position, the narrow aperture allows the passage of a beamlet populated by particles that have an almost equal position and a certain angular distribution. In the following drift space, the beamlet angular distribution is transformed into a position distribution and sampled using a profile monitor.(5)



Scanning Slit



Diagnostic box



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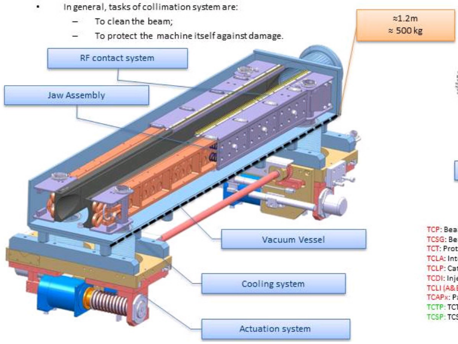

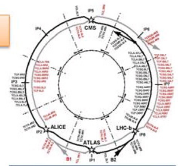

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They Have To Deal With Two Intensity Related Phenomena...

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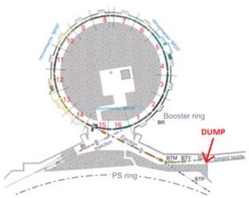

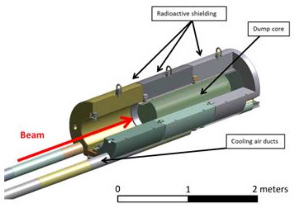

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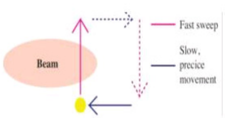

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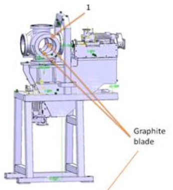

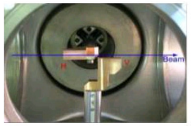

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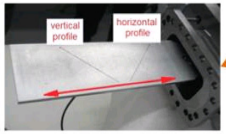

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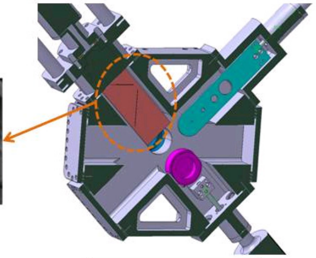

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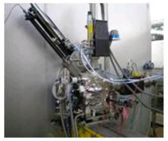

Slit/grid emittance meter

Beam Devices Interactions

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Nuclei Matter Interaction

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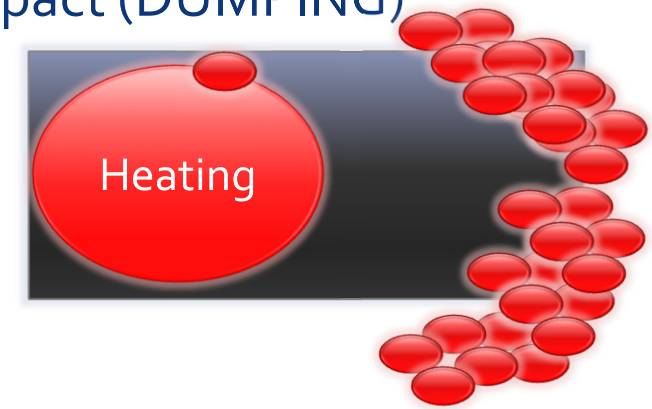
Nuclei Matter Interaction

- Beam Impact (DUMPING)



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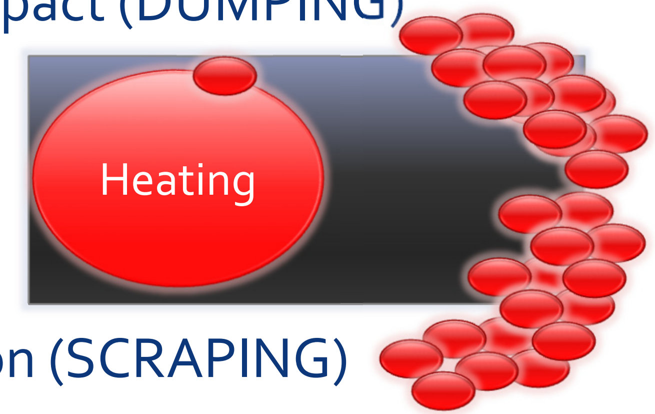
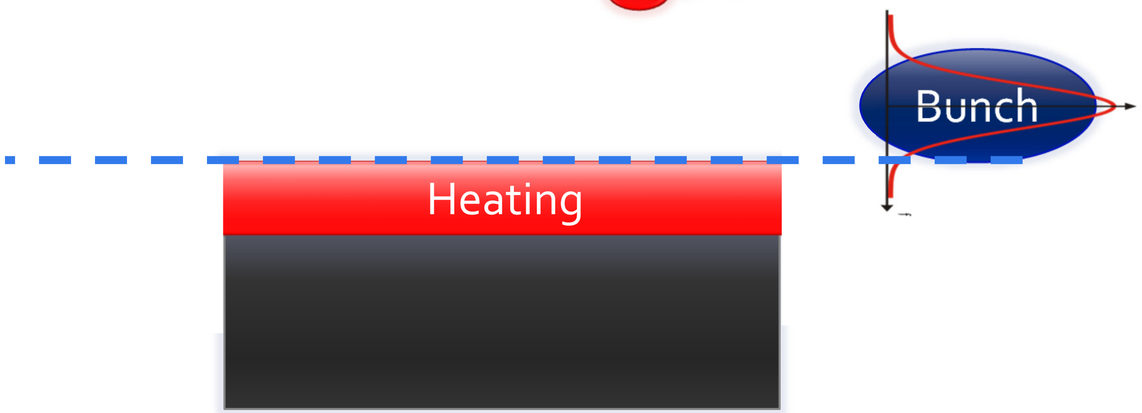


- Irradiation (SCRAPING)



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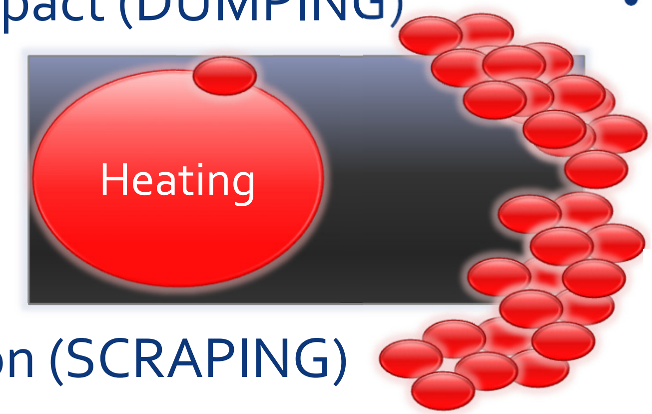

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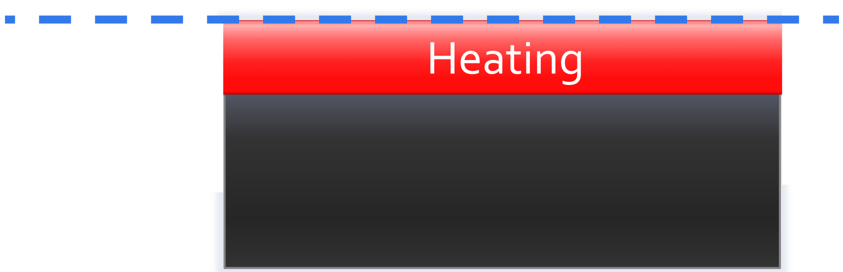
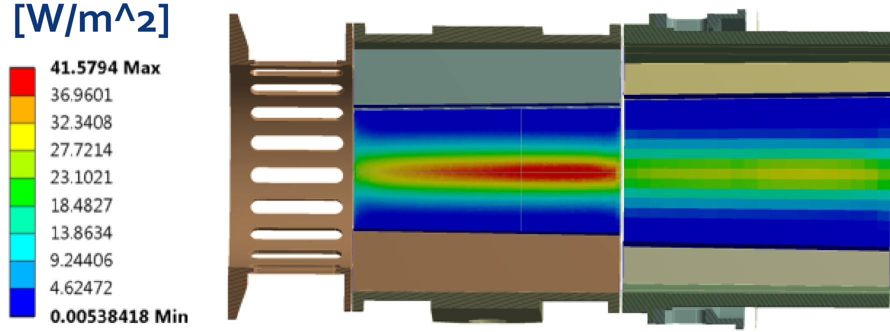


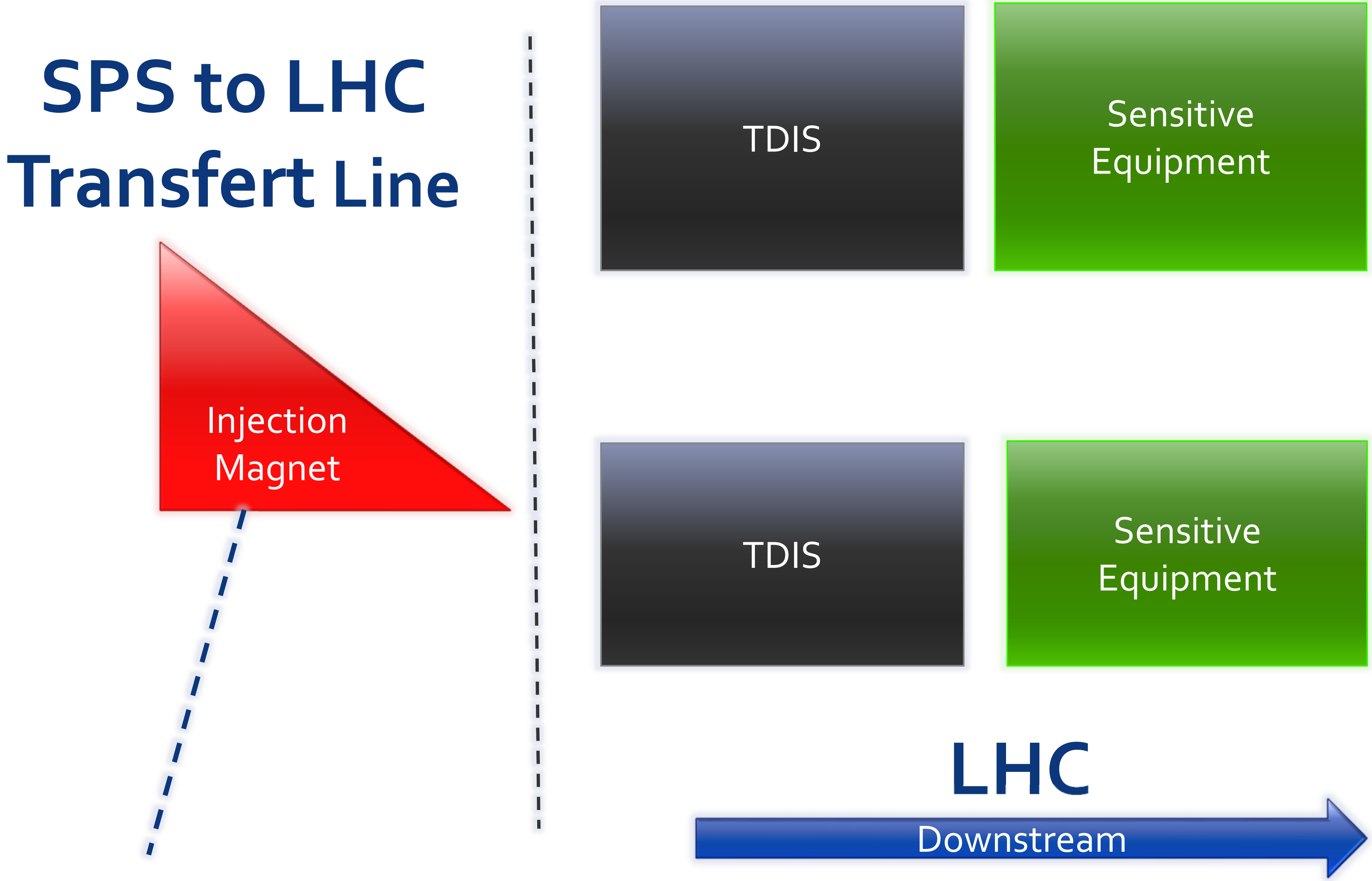
Electromagnetic Beam Device Interactions

- RF-Heating

Deposited Power [W/m^2]



The TDIS: Scope



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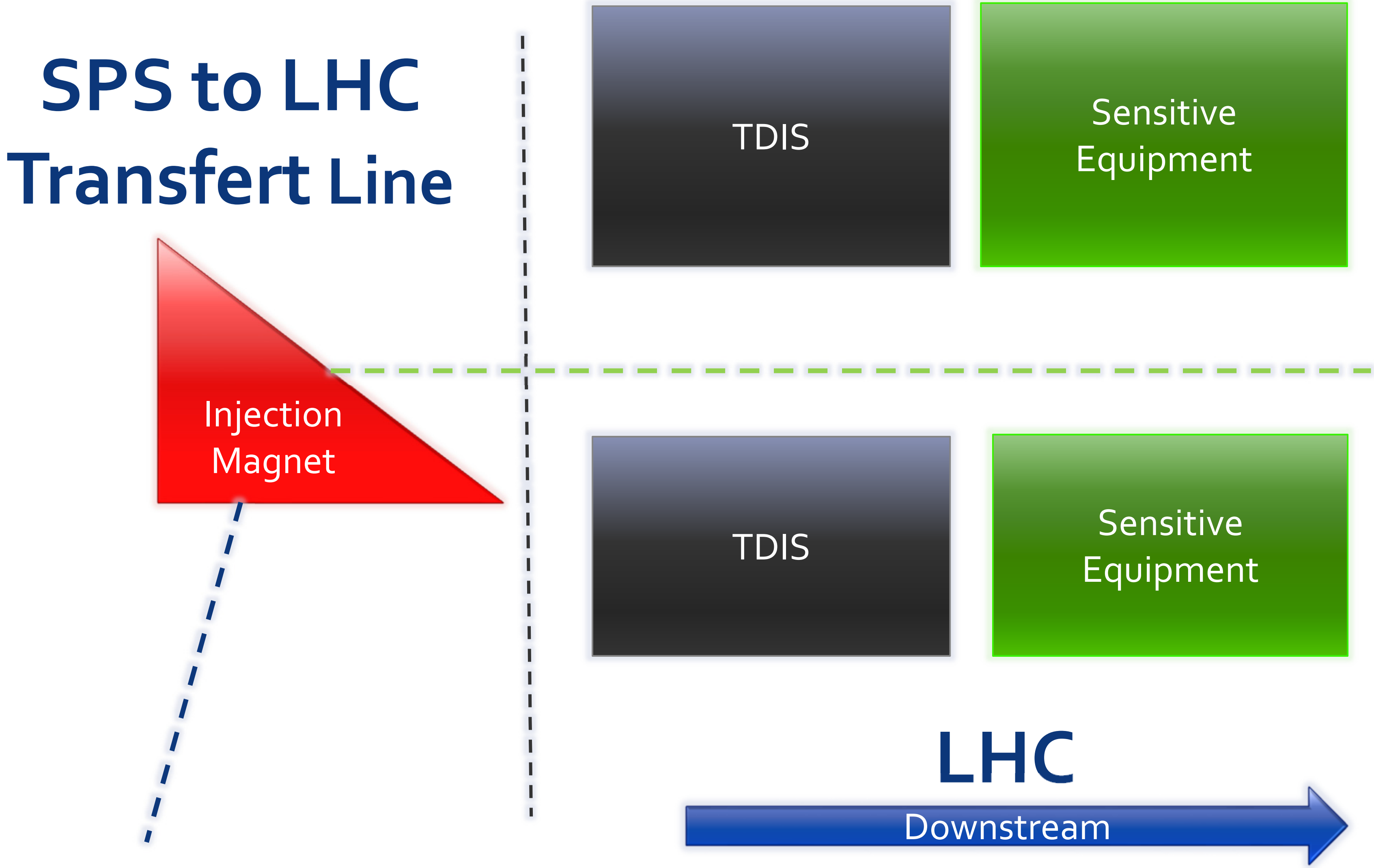

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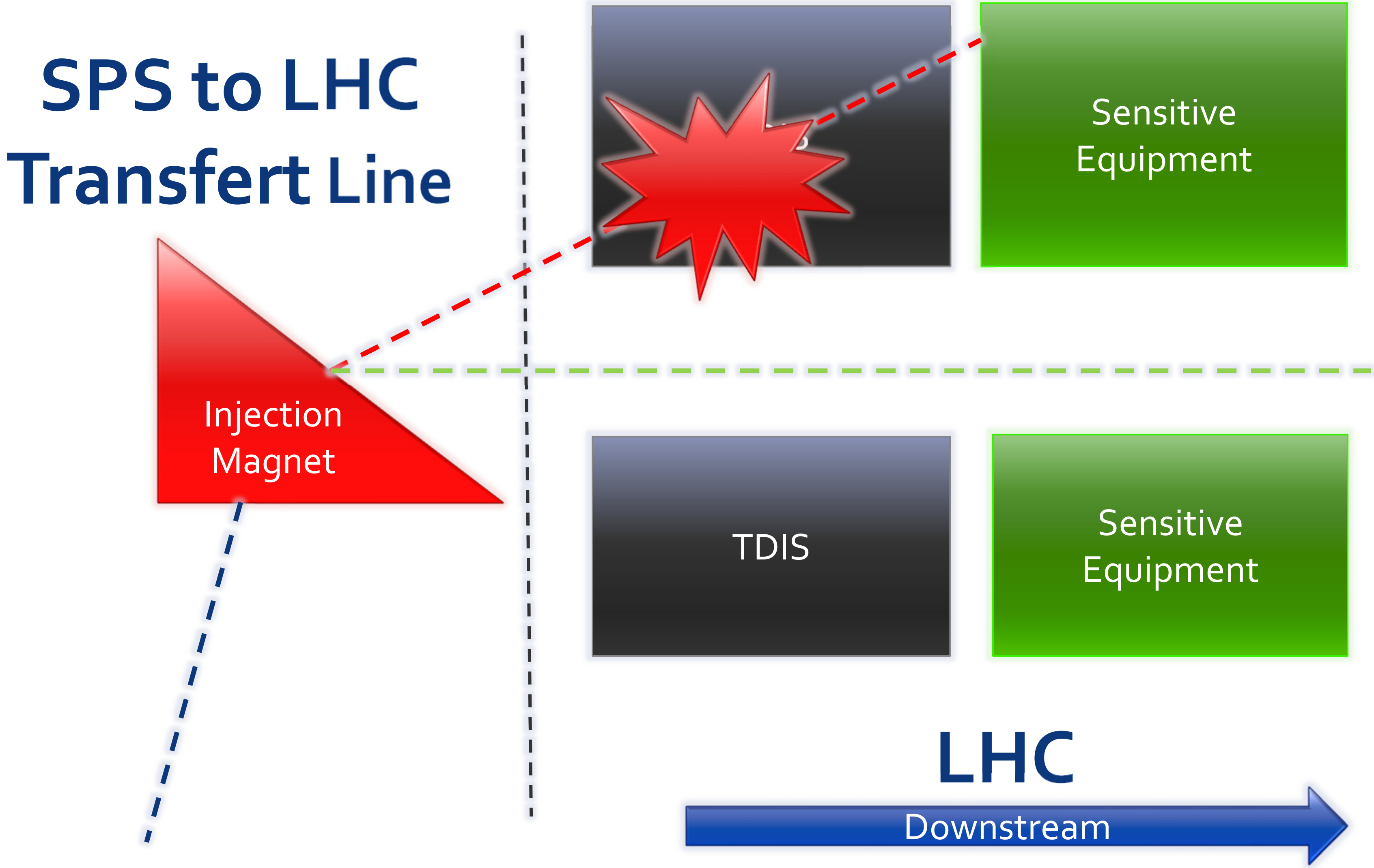

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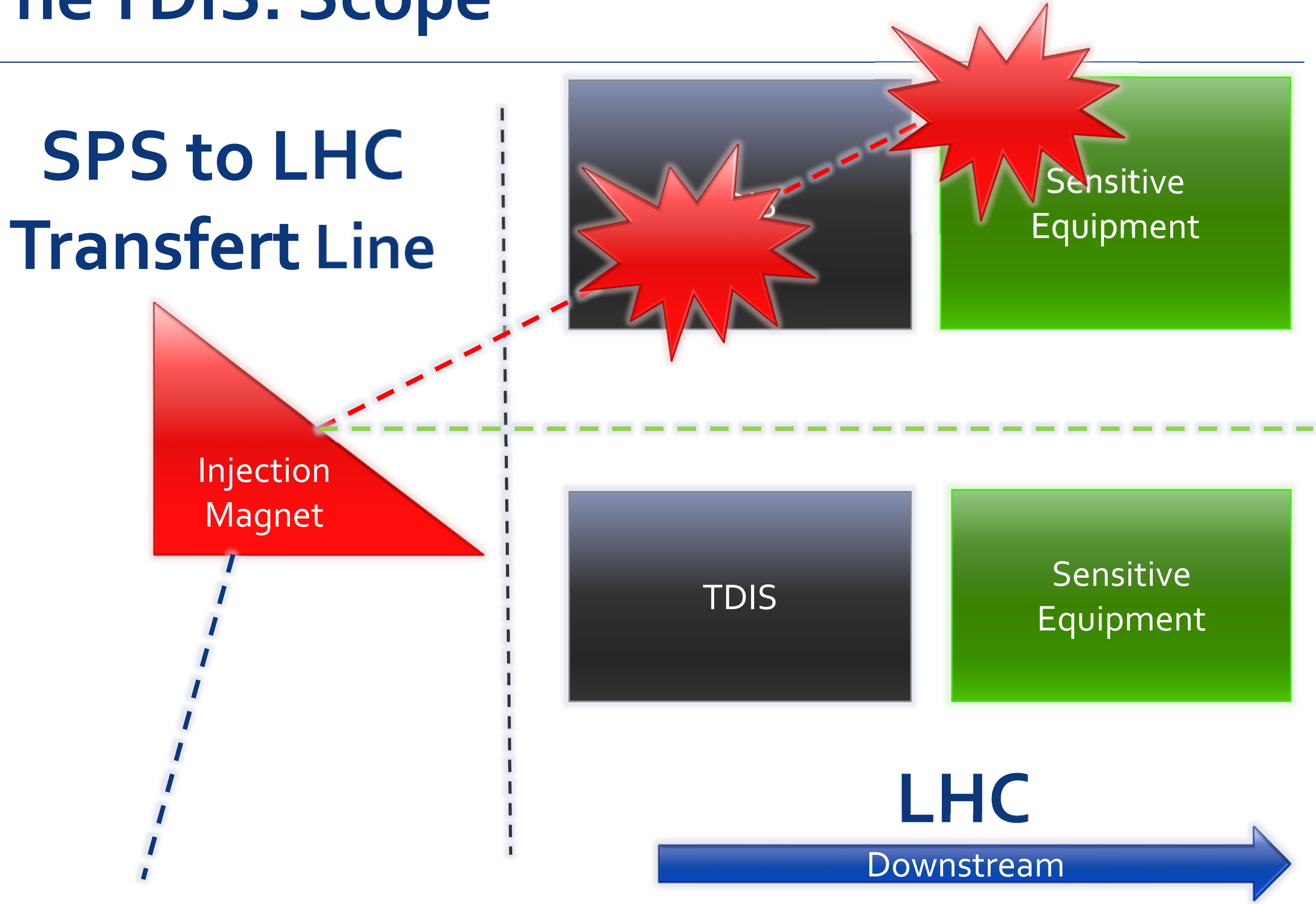
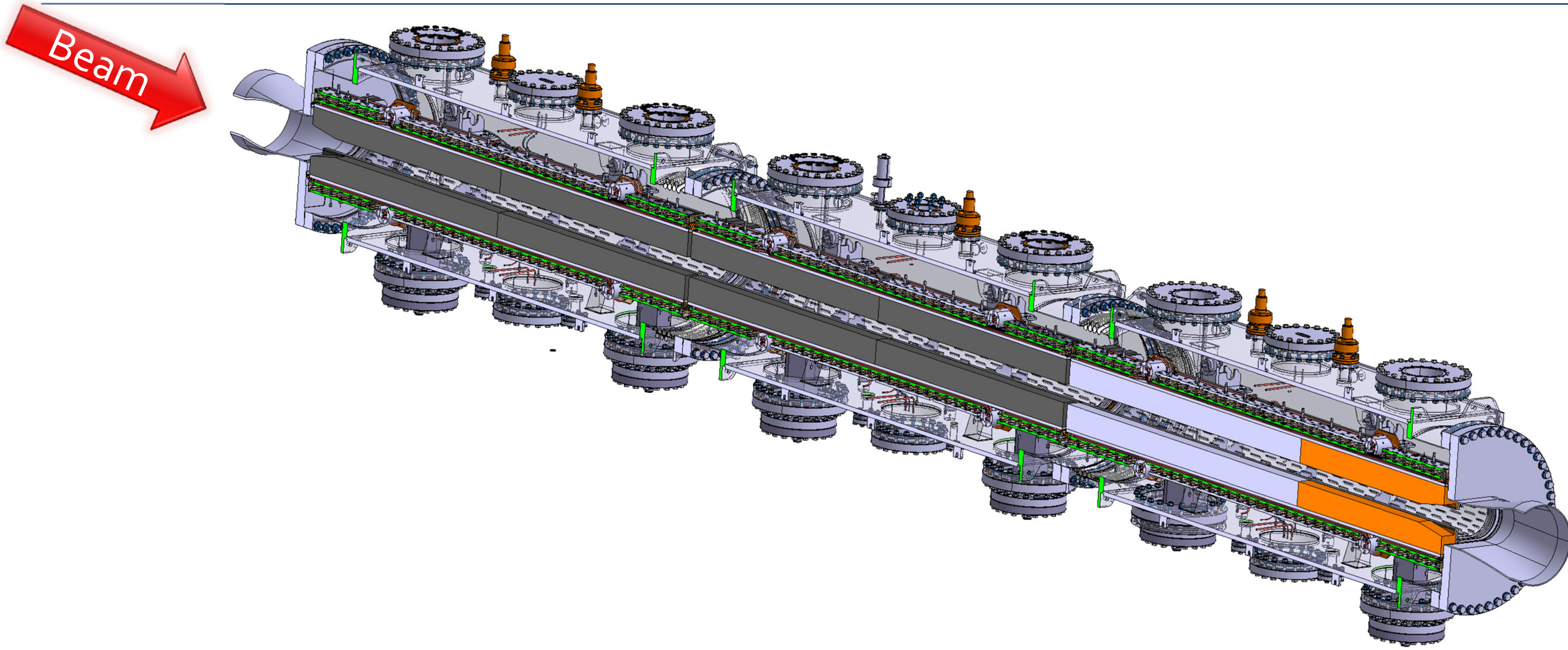
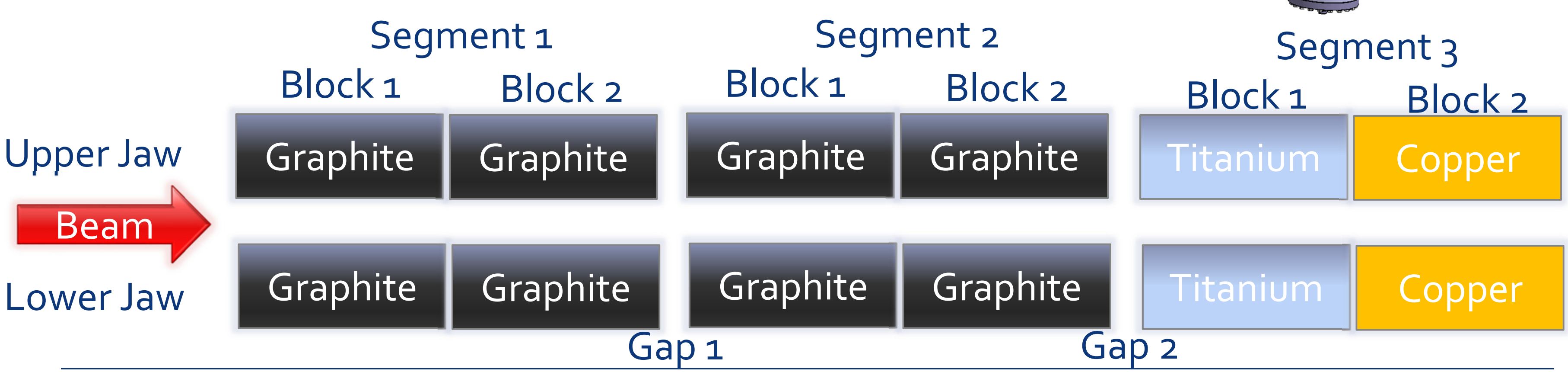


The TDIS: Geometry





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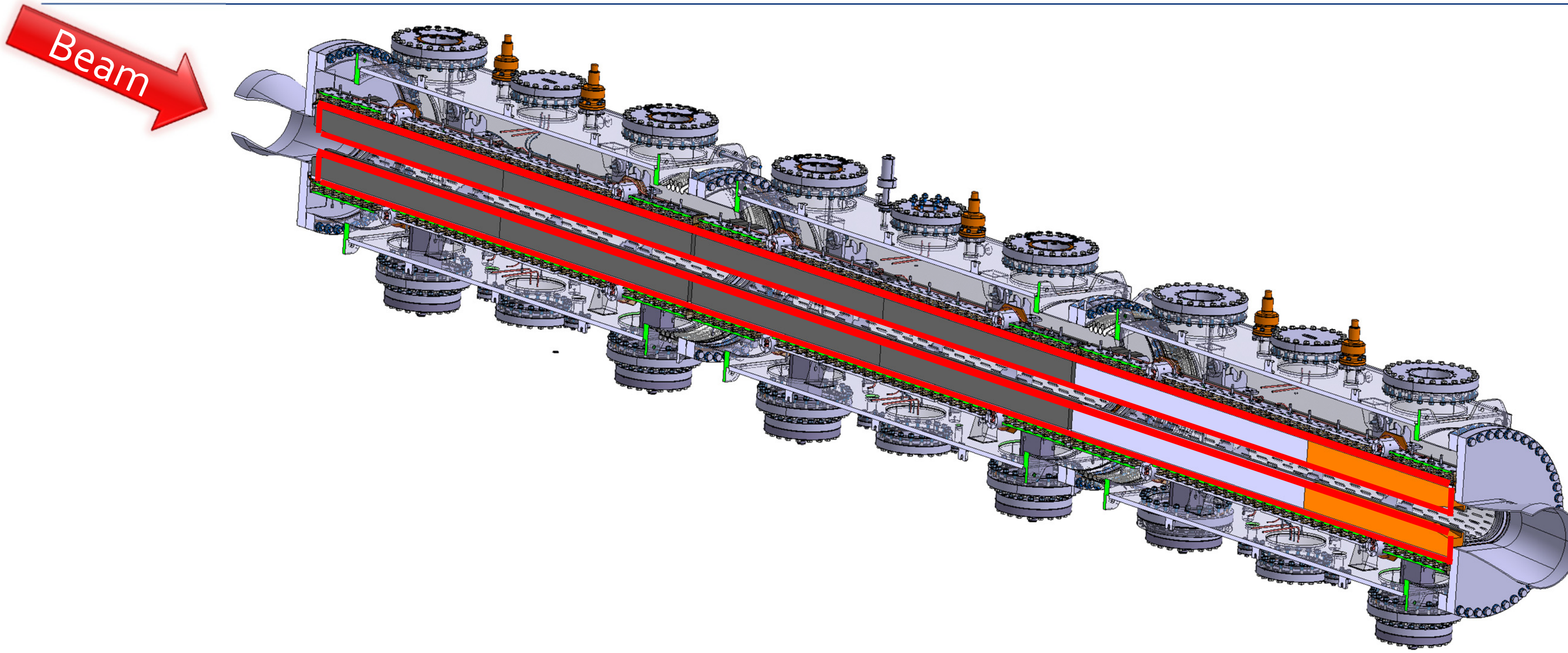

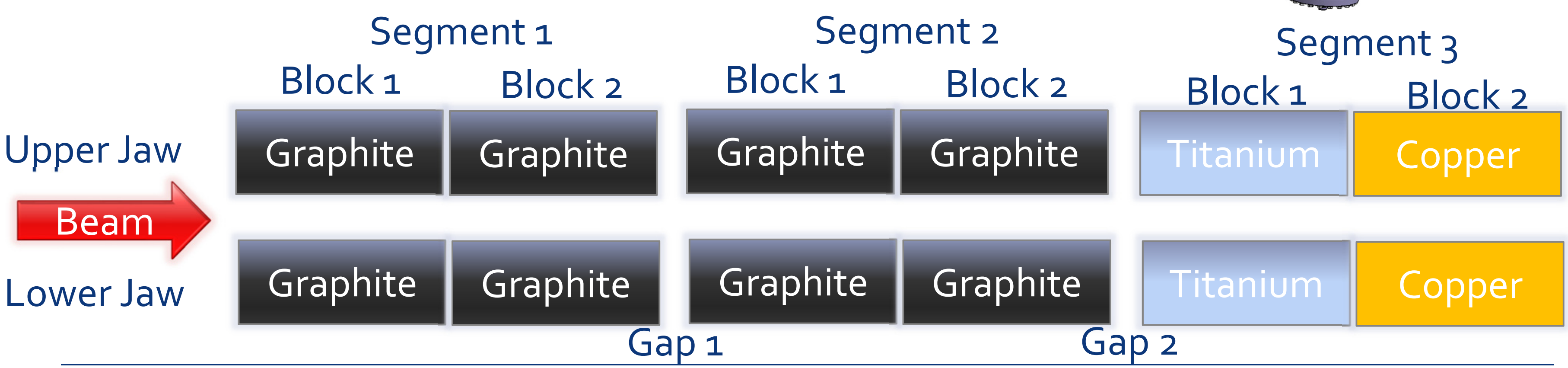

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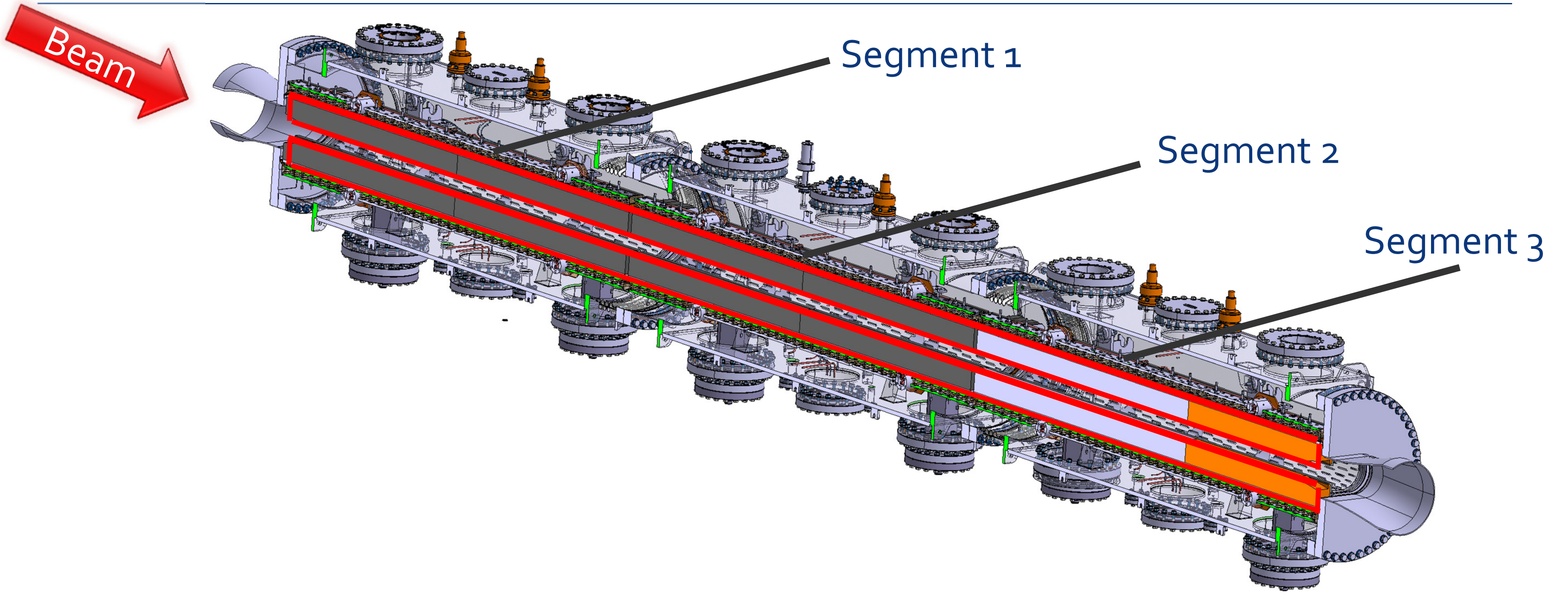

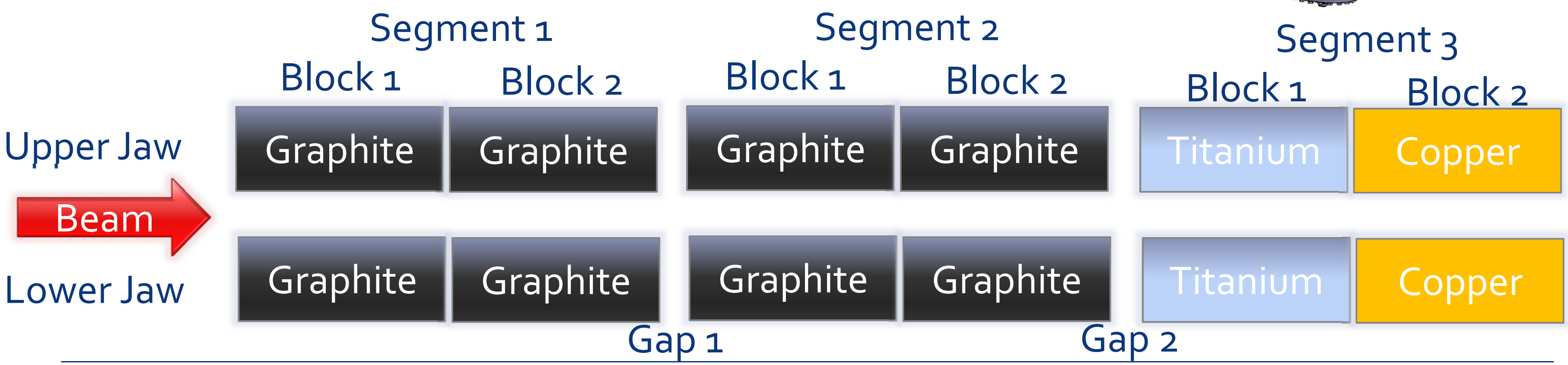

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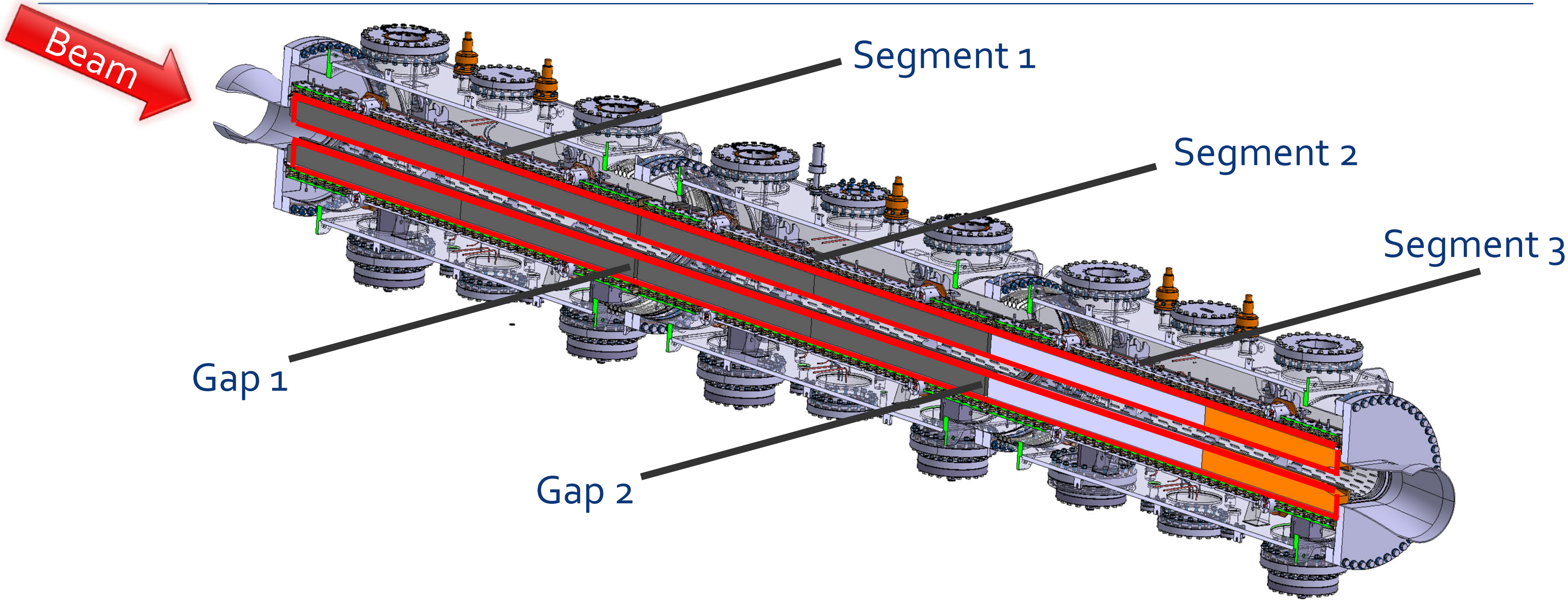
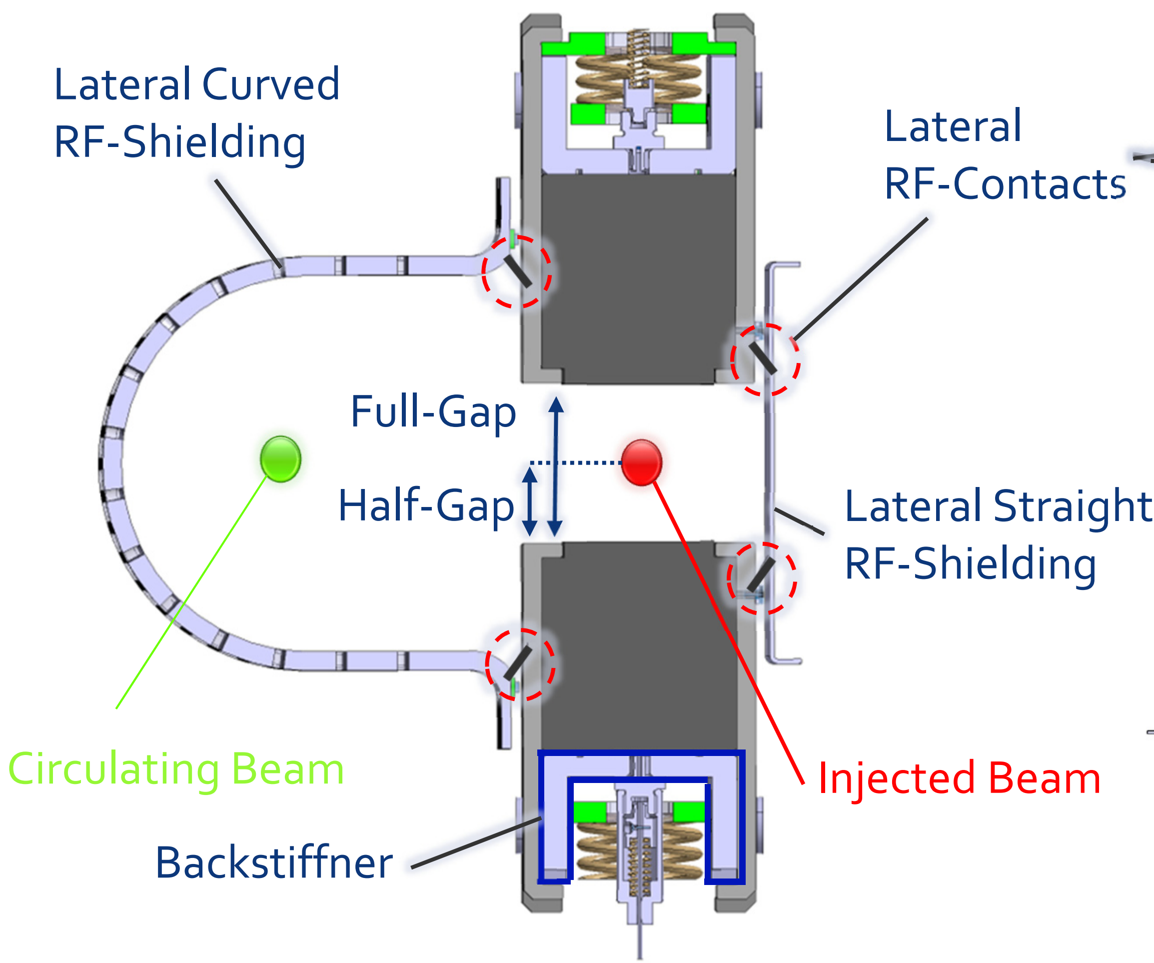


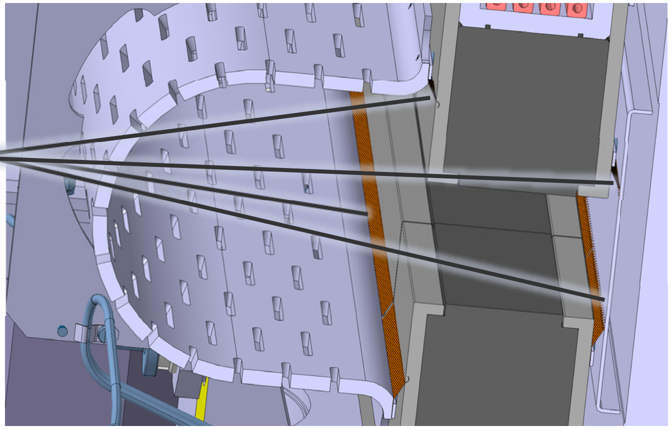
	Segment 1		Segment 2		Segment 3	
	Block 1	Block 2	Block 1	Block 2	Block 1	Block 2
Upper Jaw	Graphite	Graphite	Graphite	Graphite	Titanium	Copper
Beam →						
Lower Jaw	Graphite	Graphite	Graphite	Graphite	Titanium	Copper

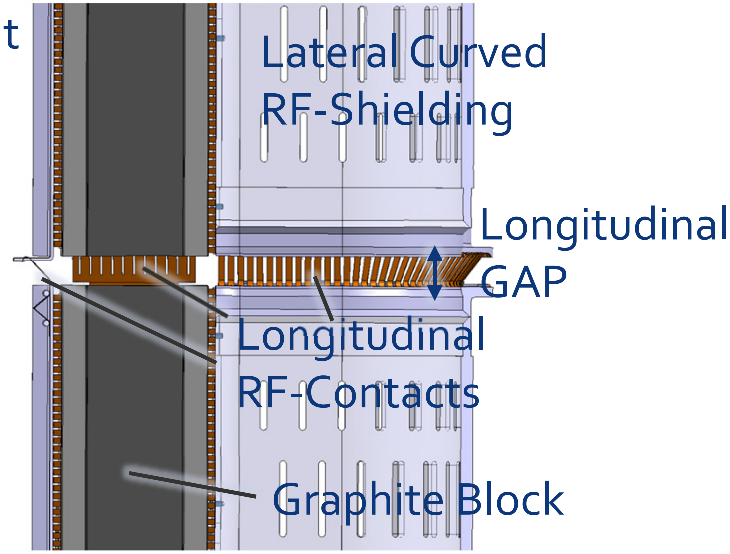
Gap 1

Gap 2

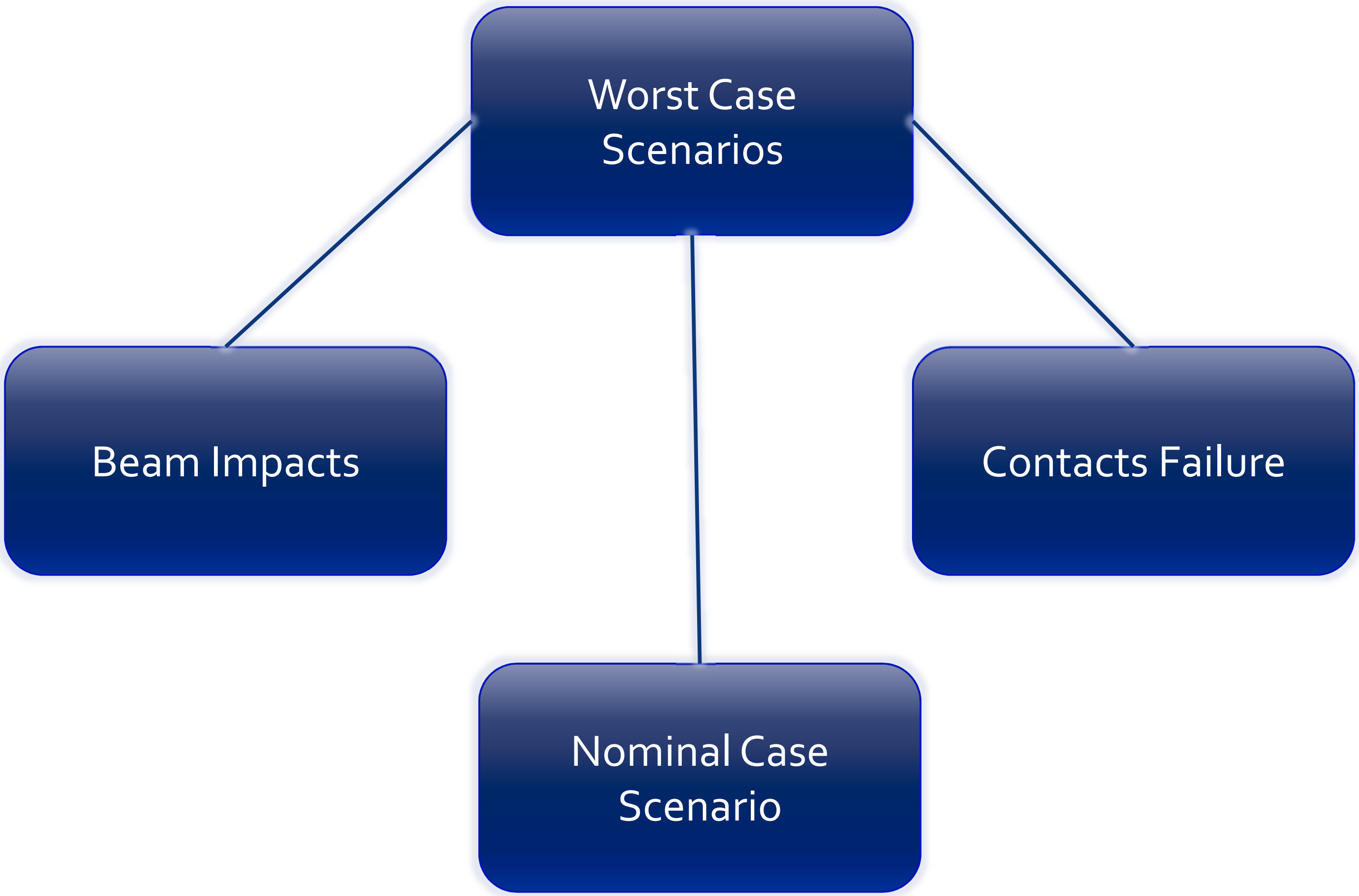
The TDIS: Geometry, the RF-System



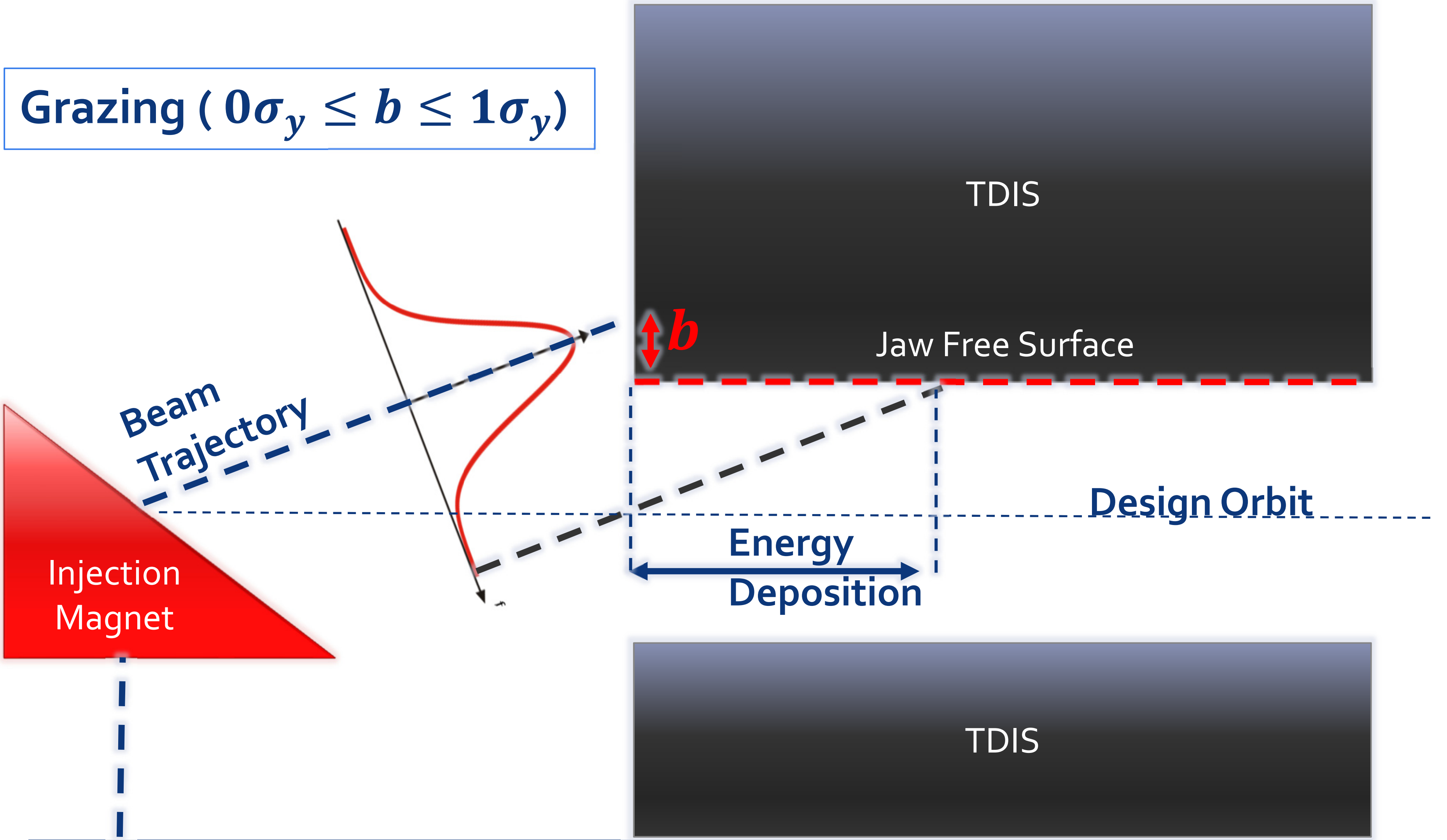




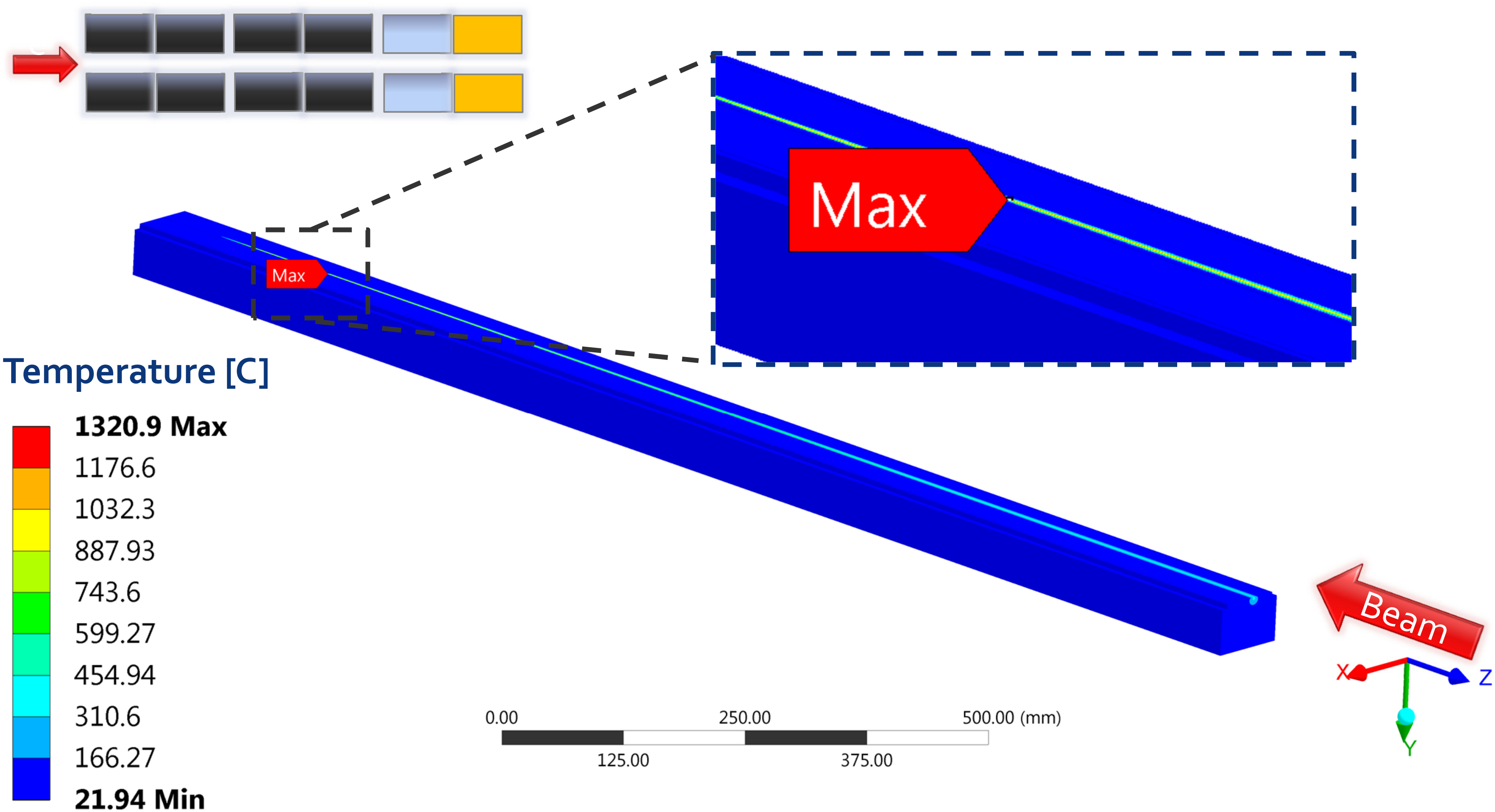
Thermo-Mechanical Analysis



Beam Impact Scenarios



Thermomechanical Simulations: Grazing



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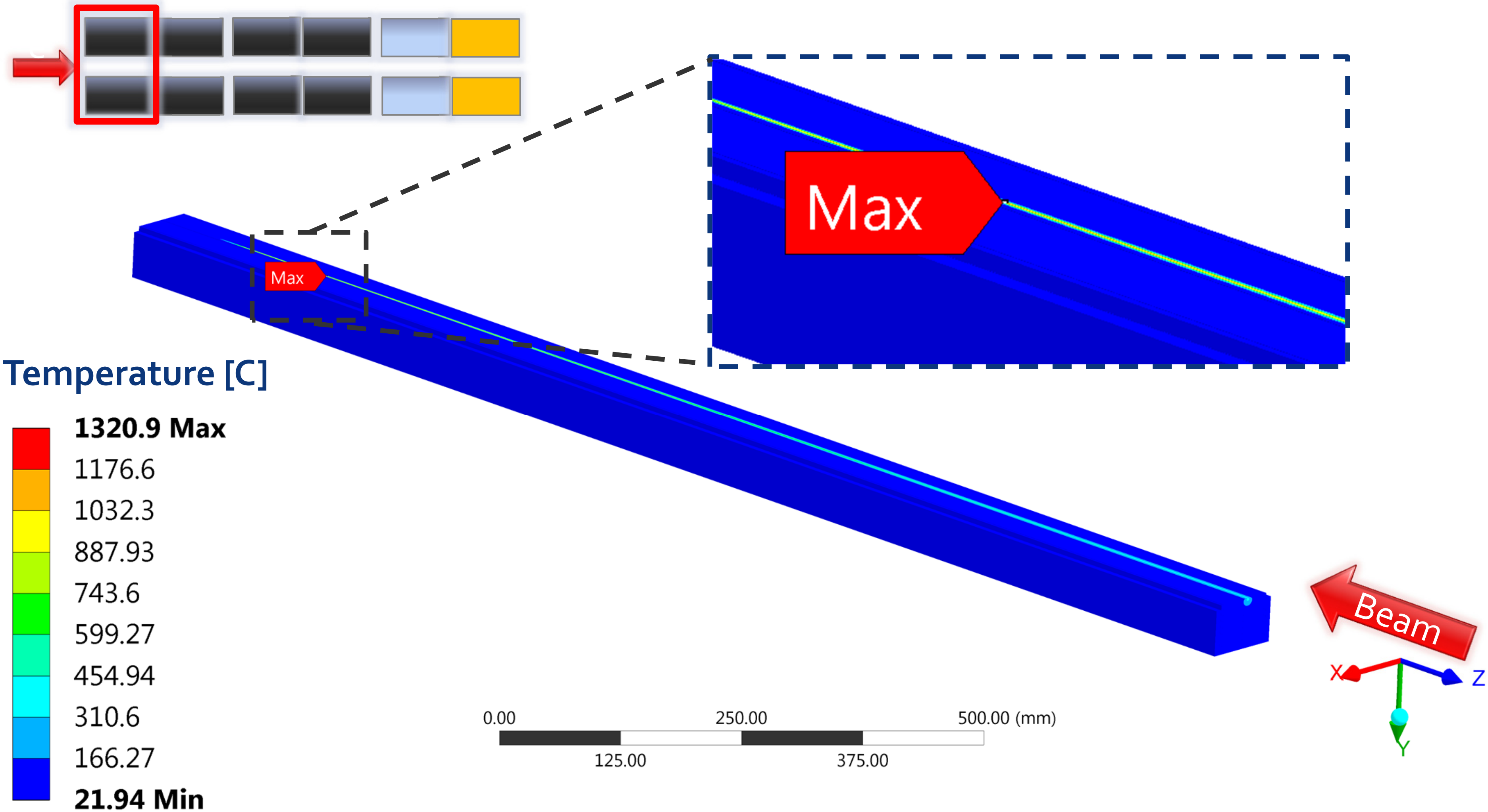

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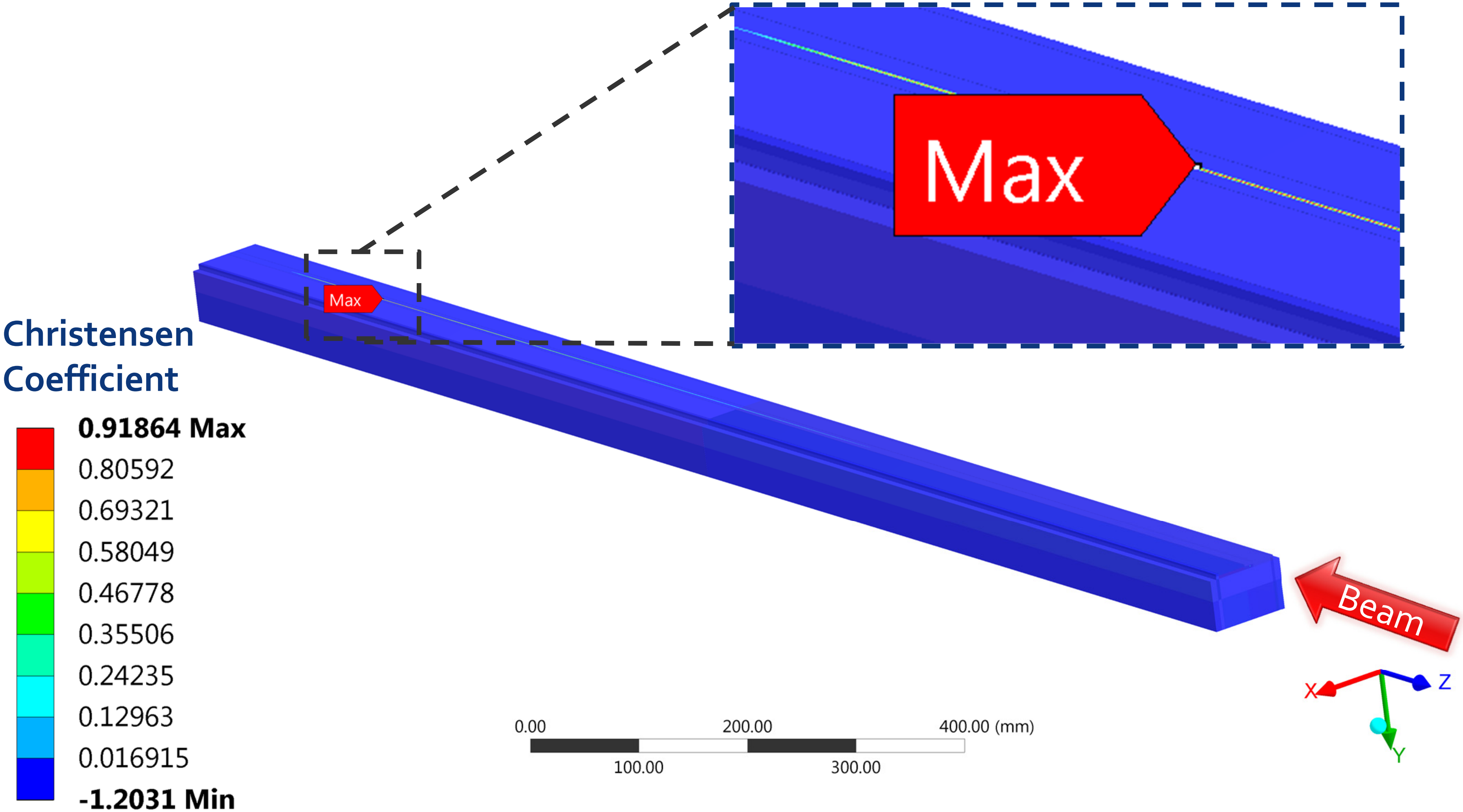

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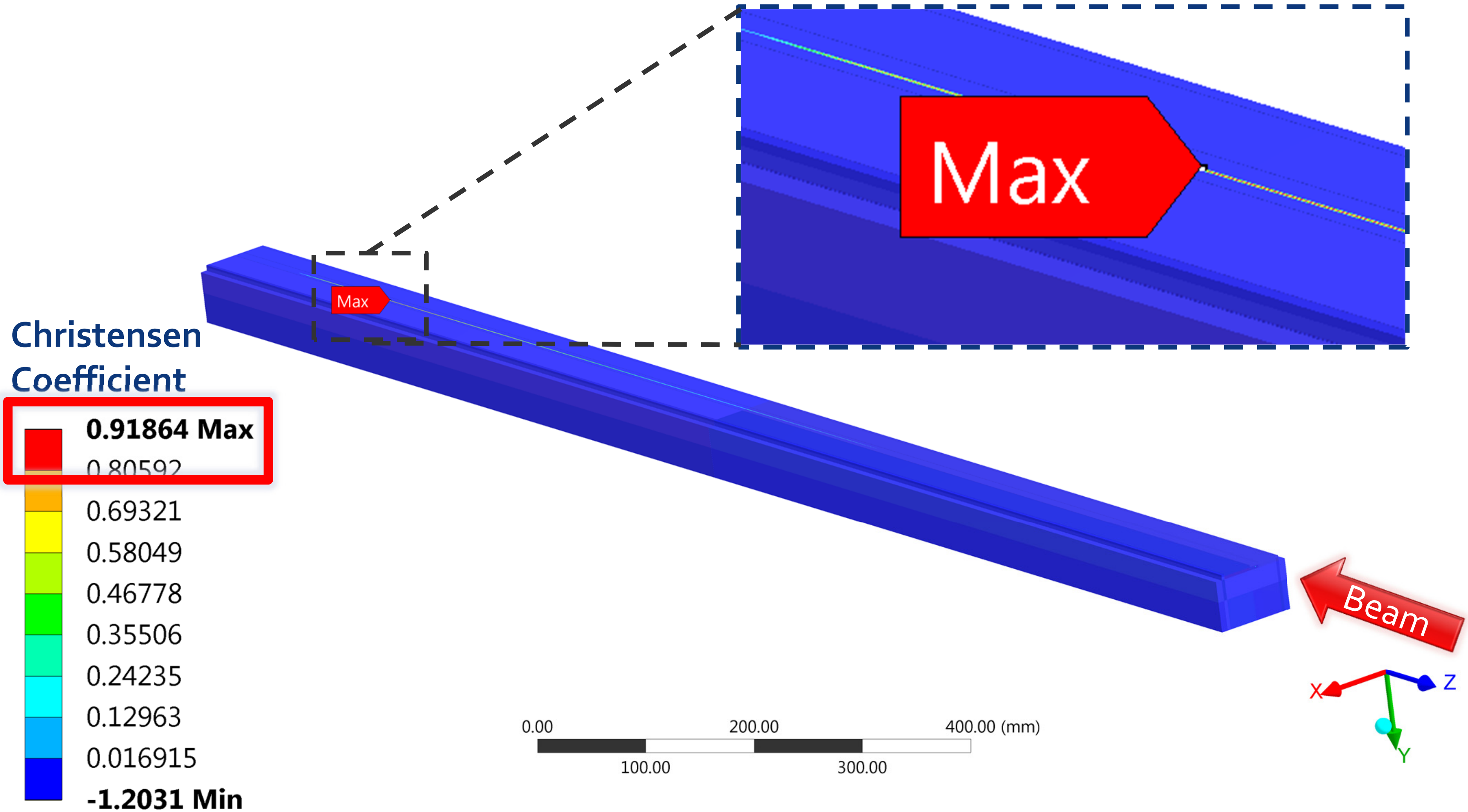

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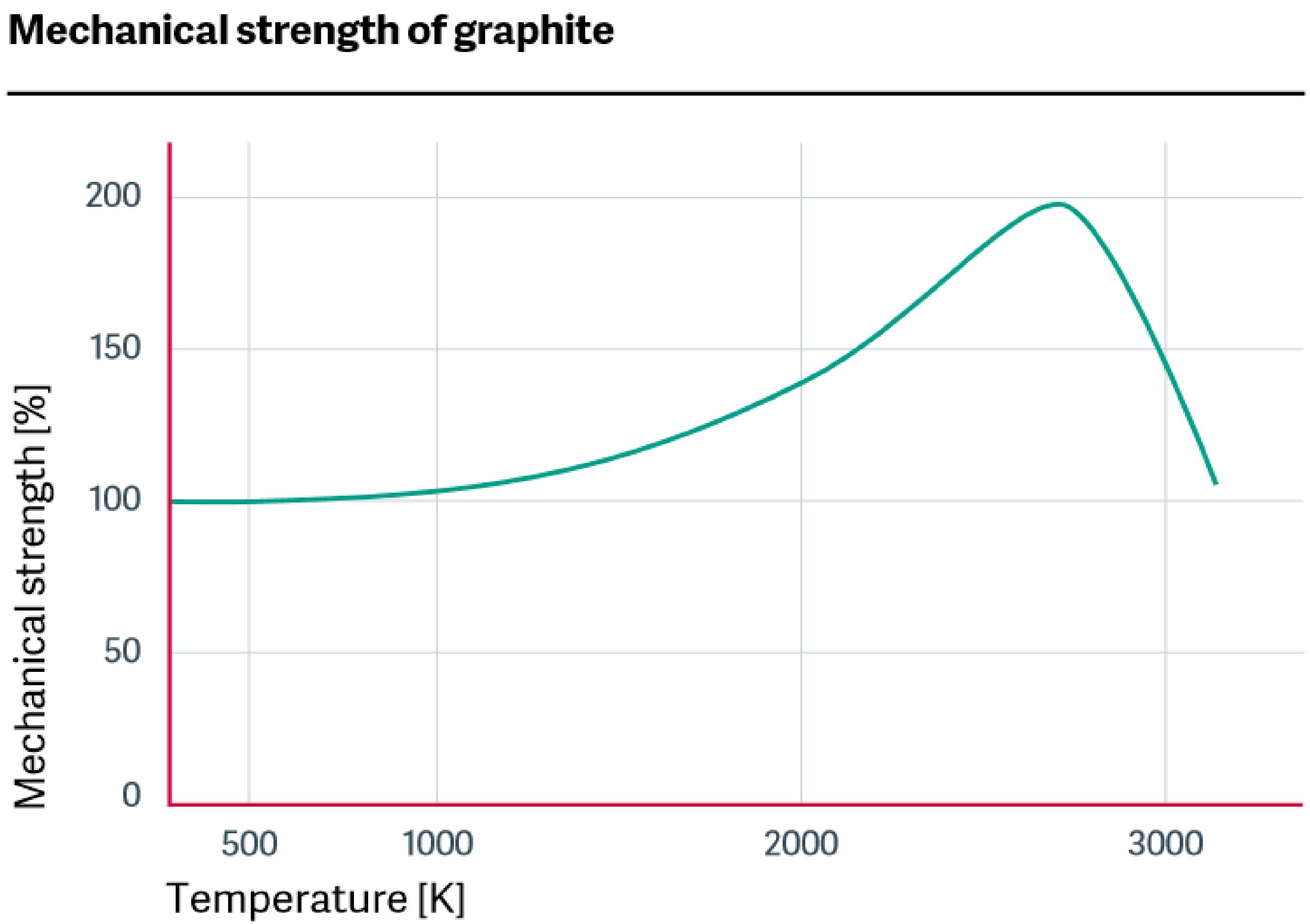

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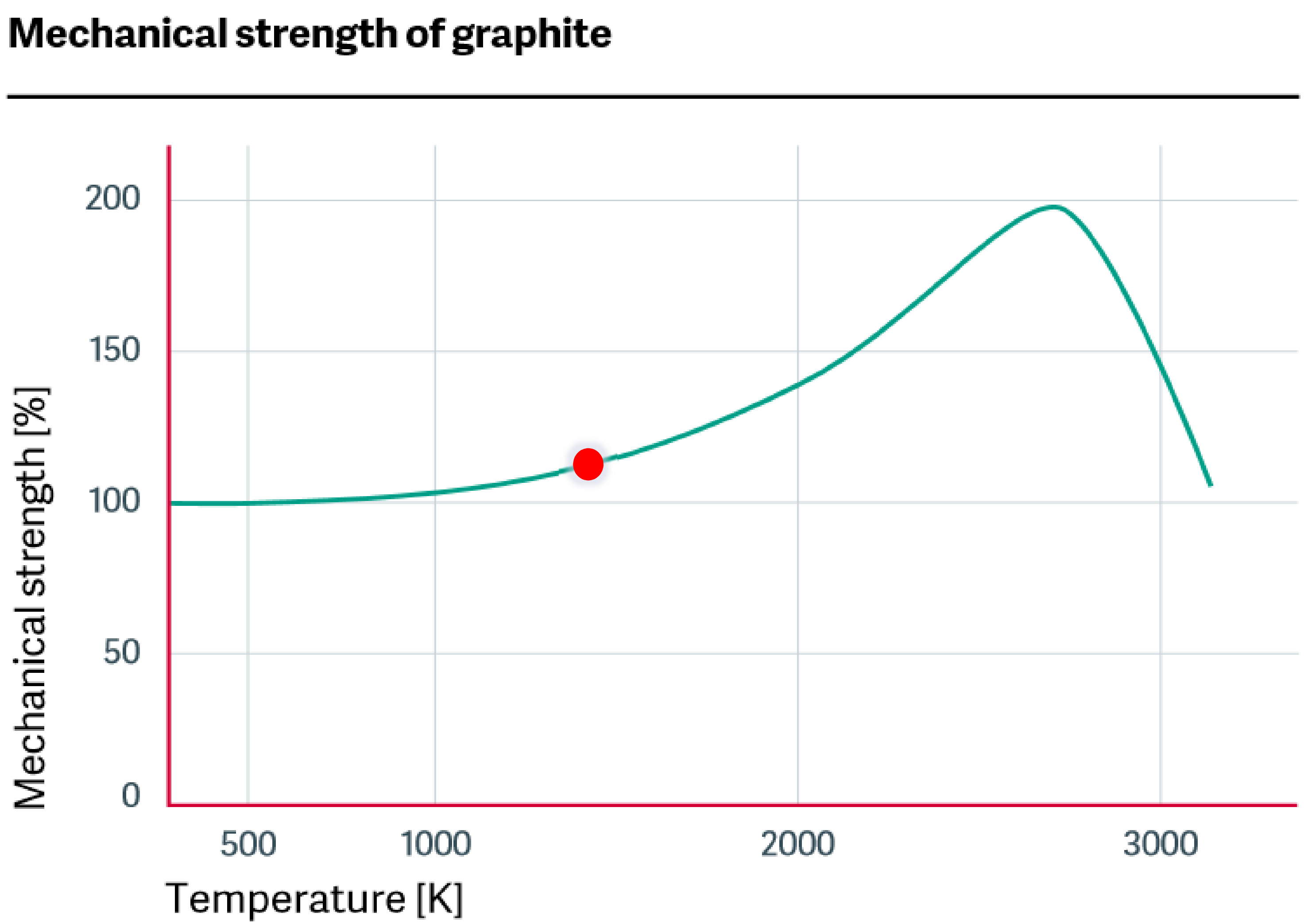
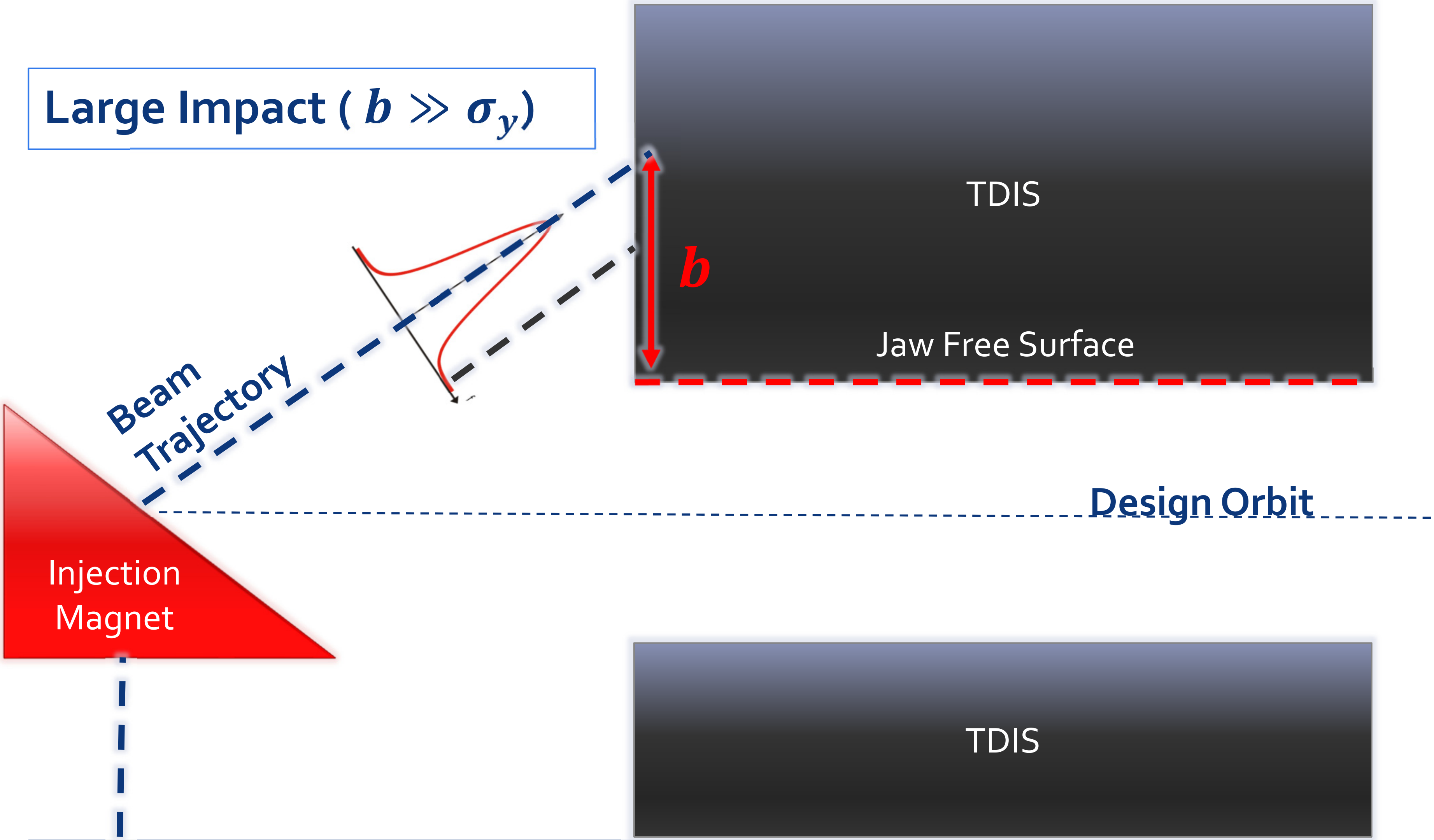


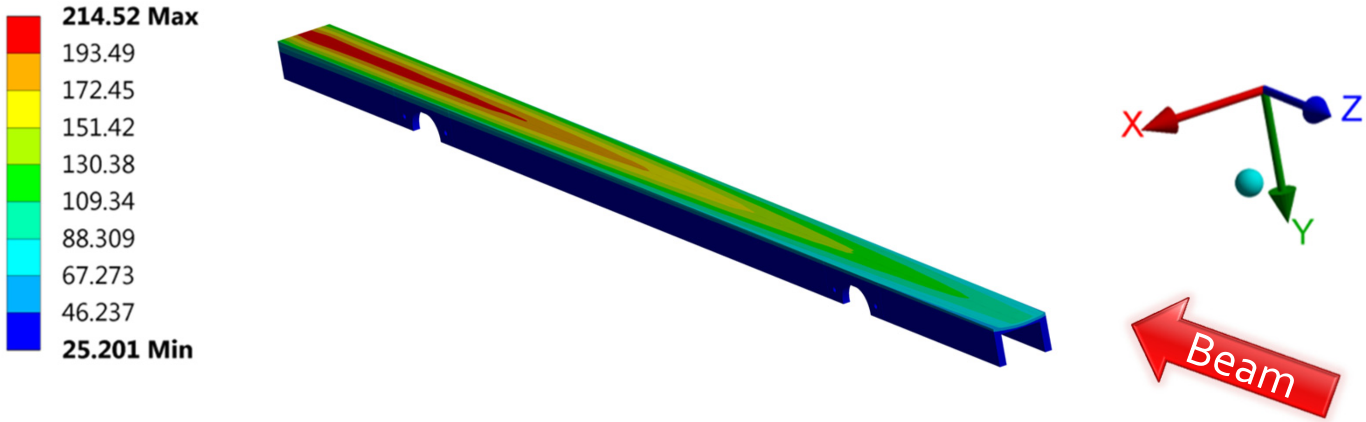
Beam Impact Scenarios

Large Impact ($b \gg \sigma_y$)

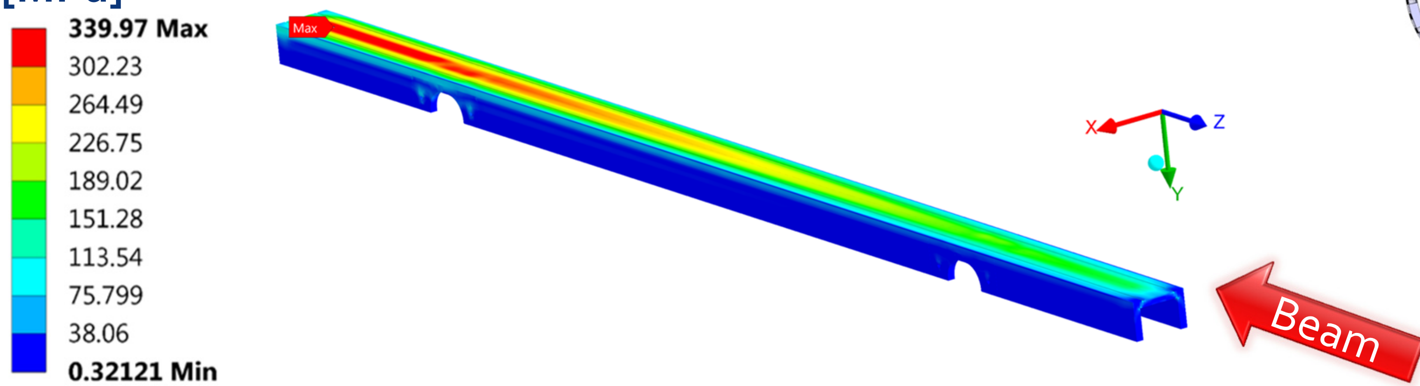


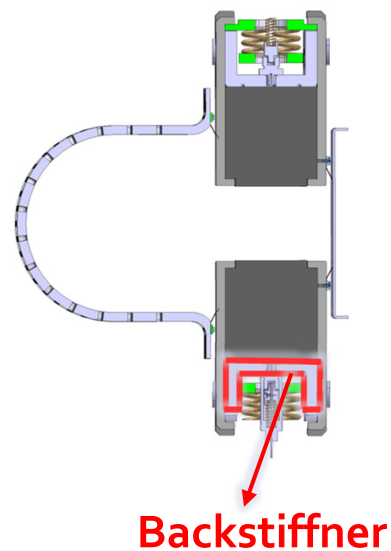
Thermomechanical Simulations: Large Impact

Temperature [C]

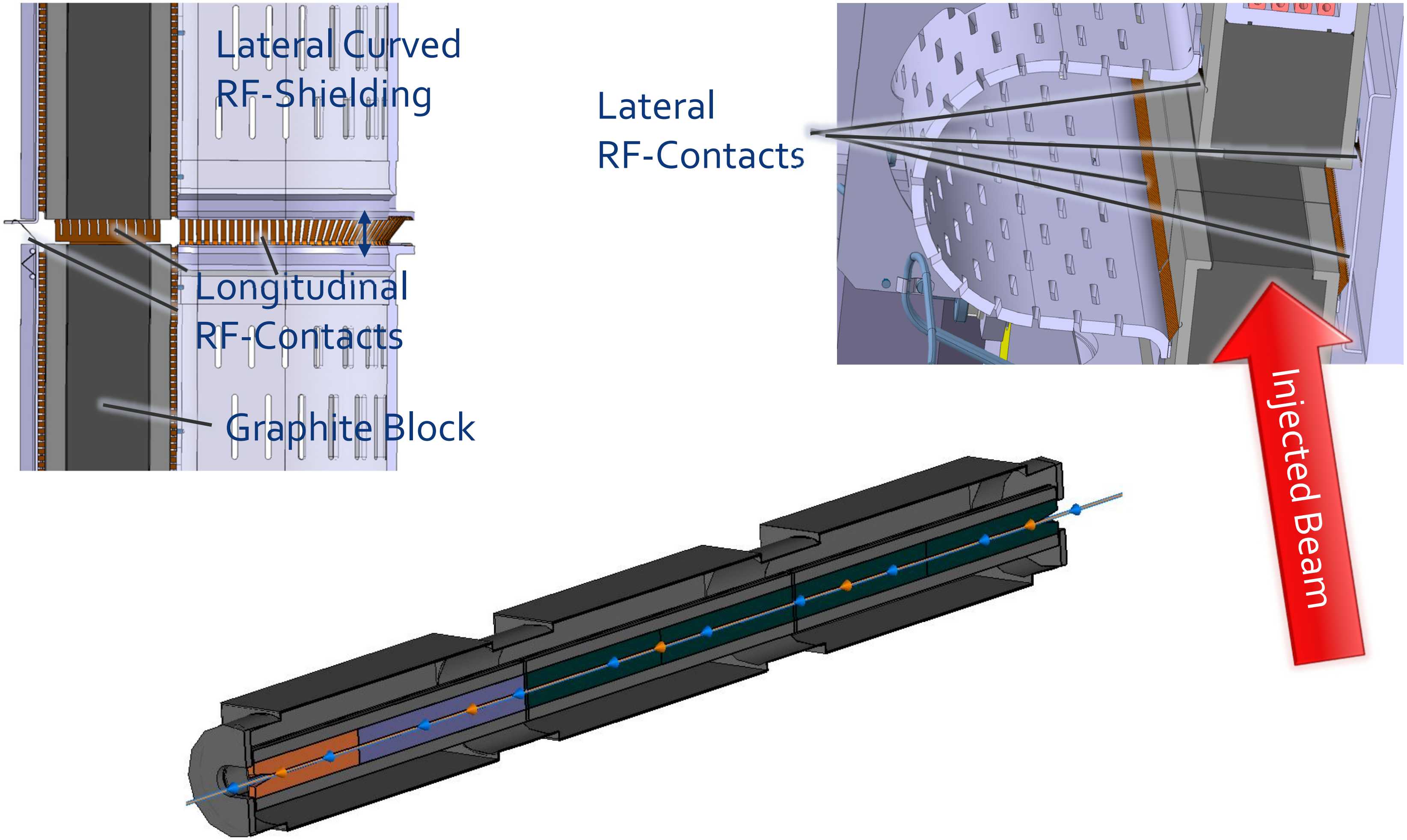


Von Mises Stress [MPa]





Complete Failure of the Longitudinal RF-Contacts Scenario



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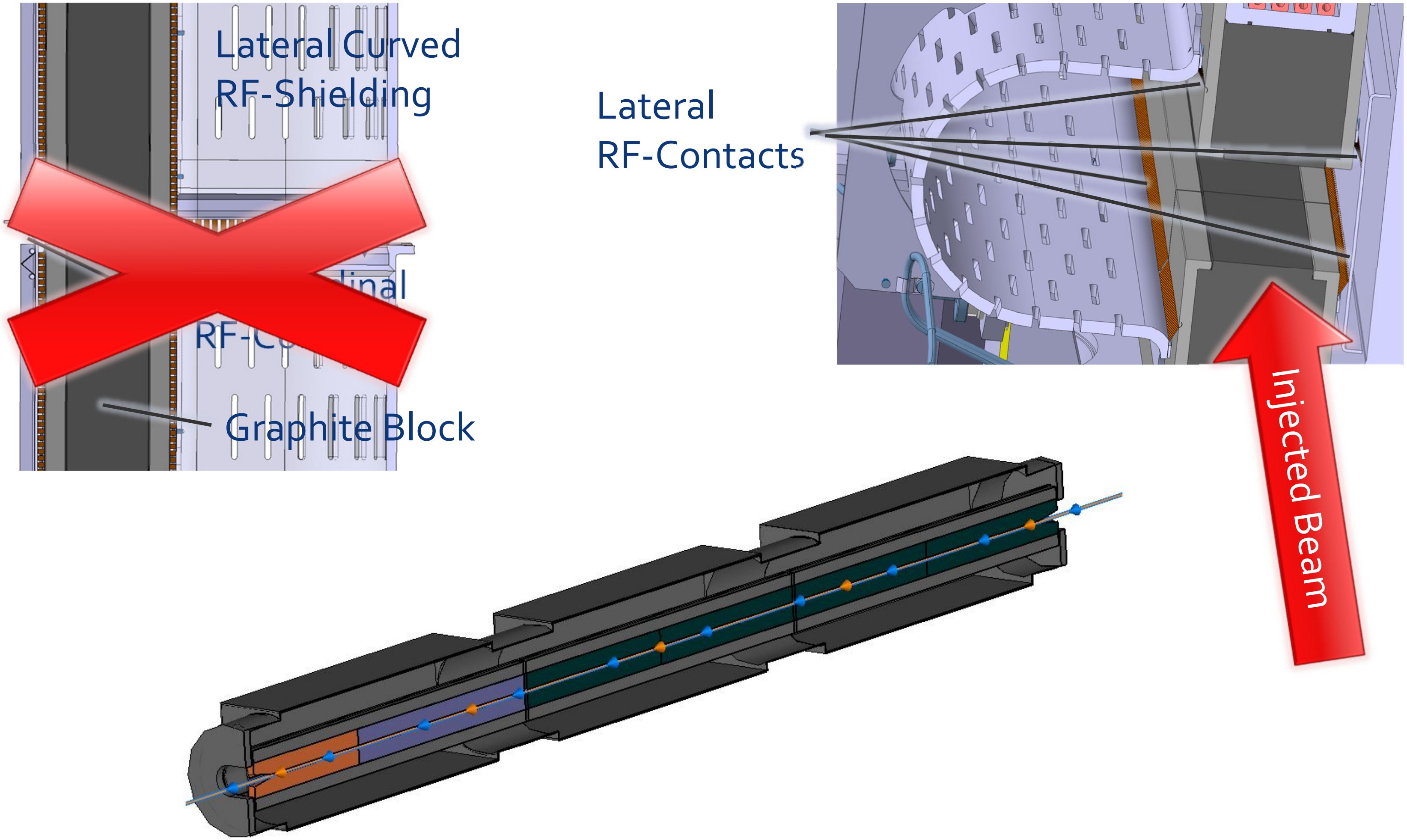

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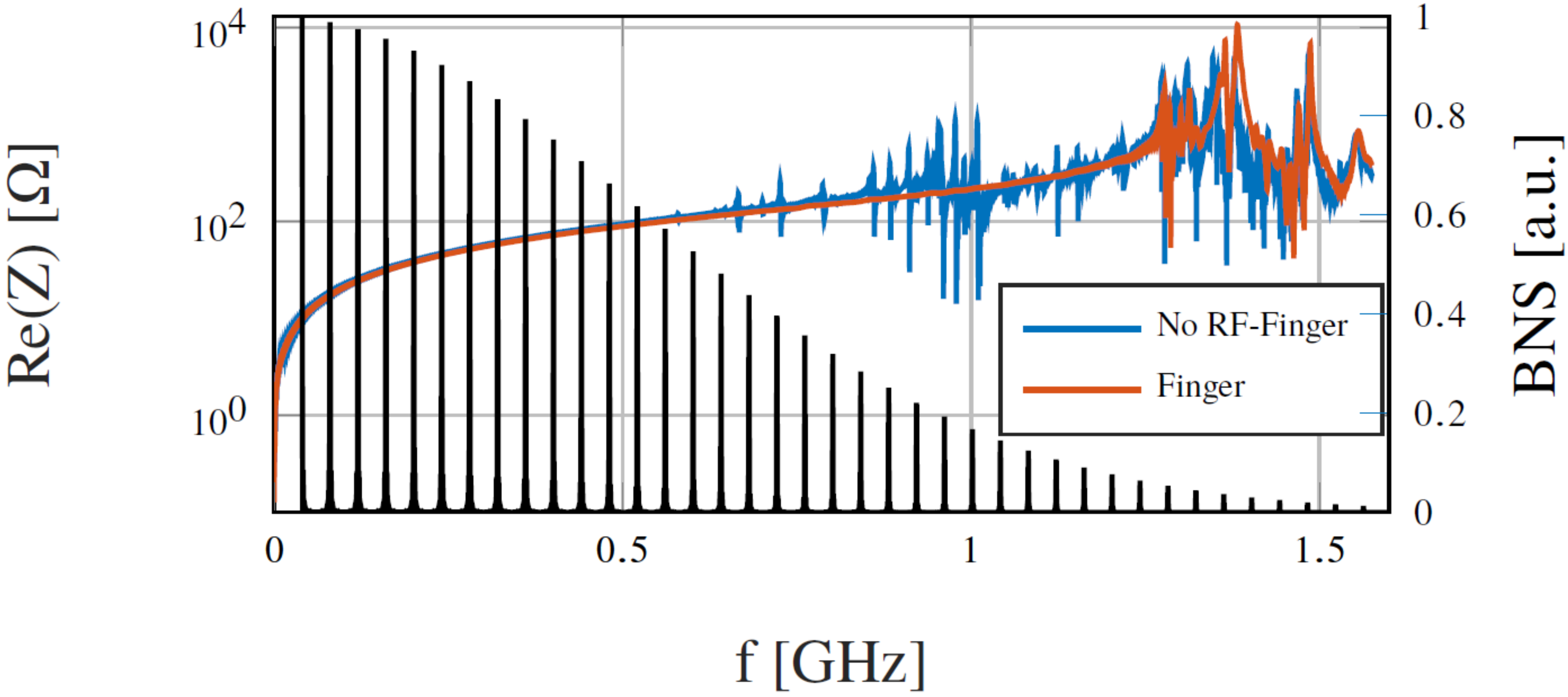
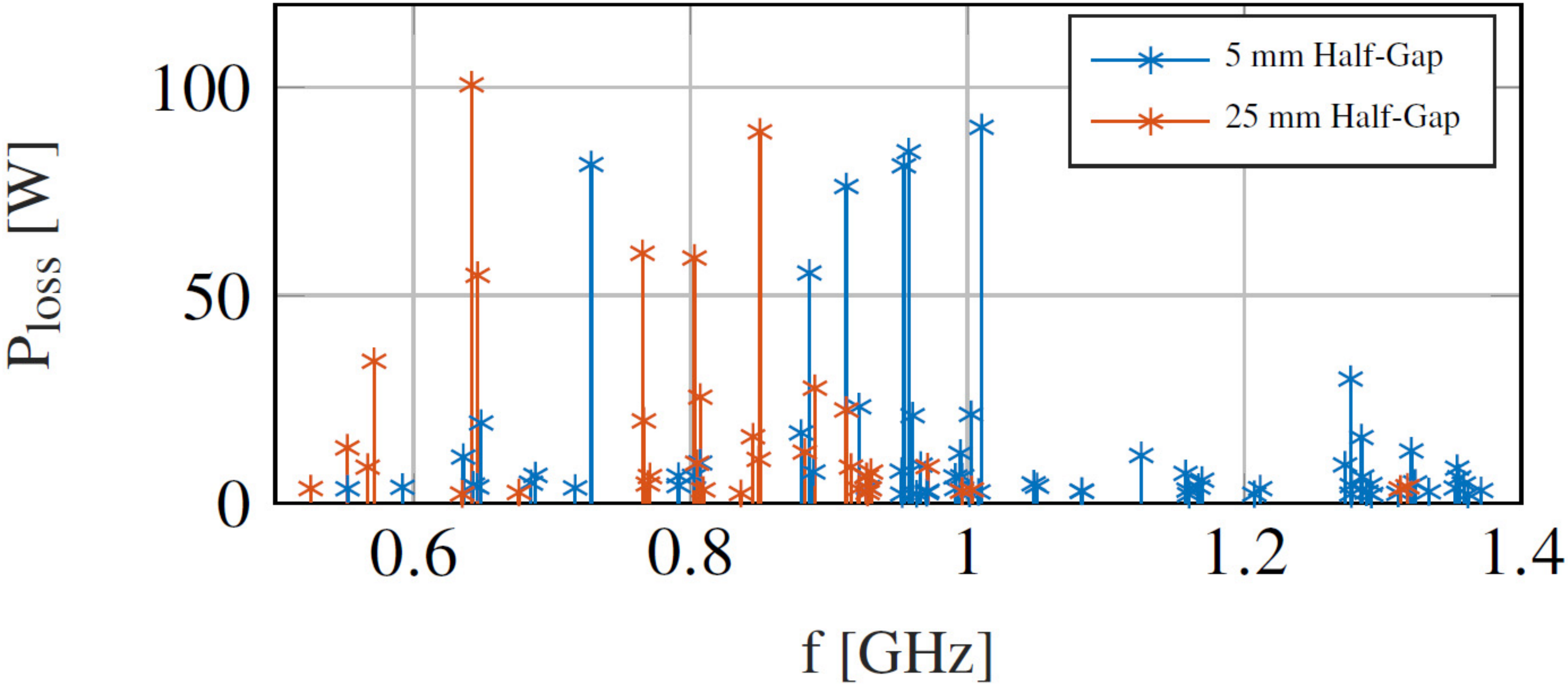
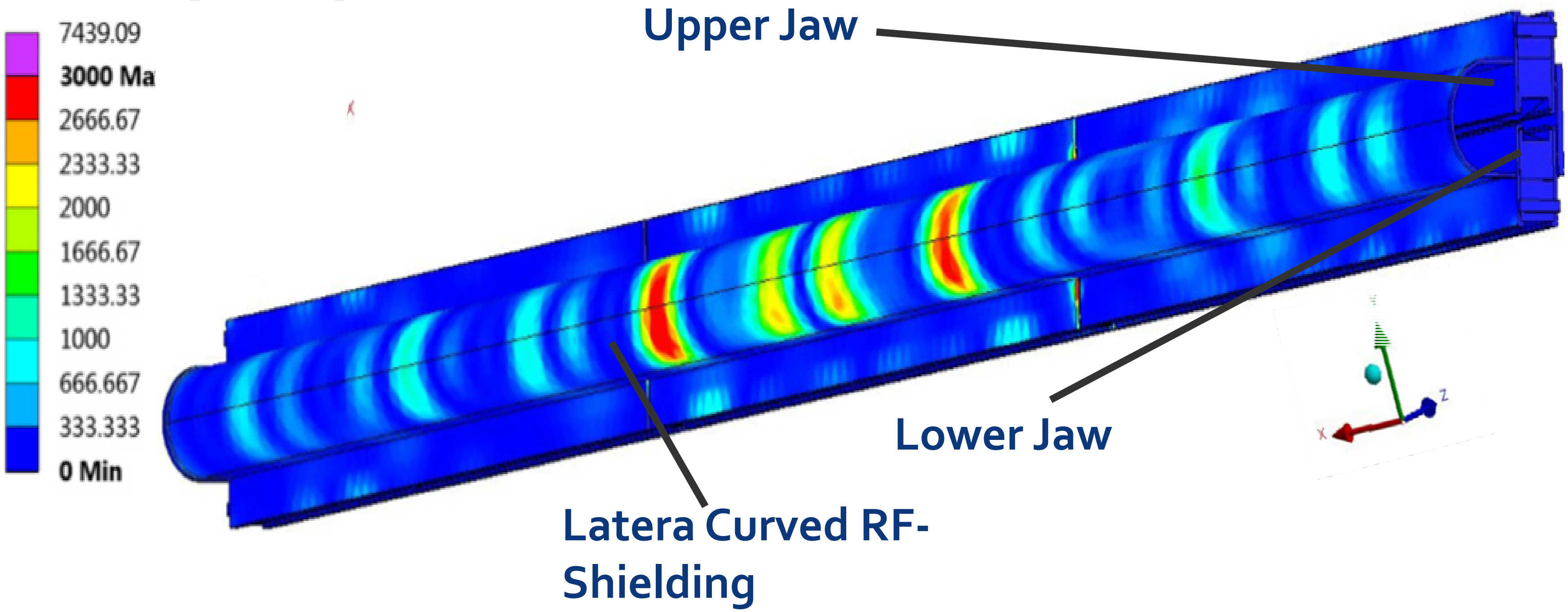


RF-Heating



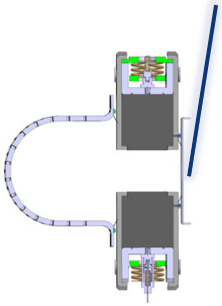
RF-Heating

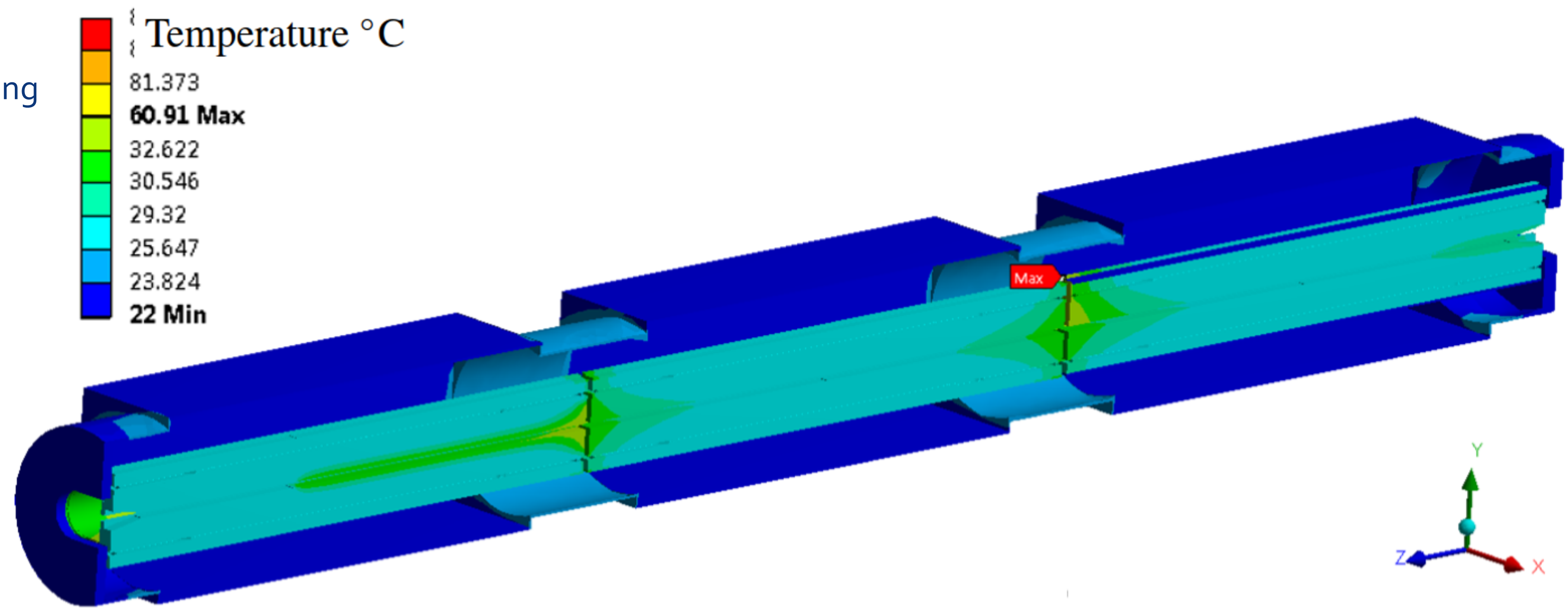
Impedance RF-Heating
Heat Flux [W/m^2]

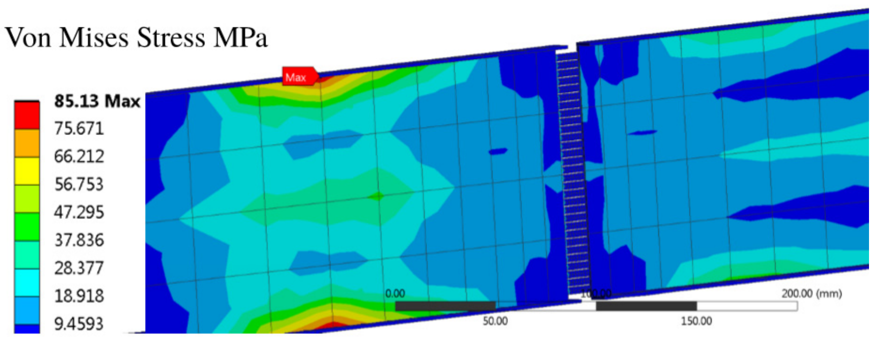


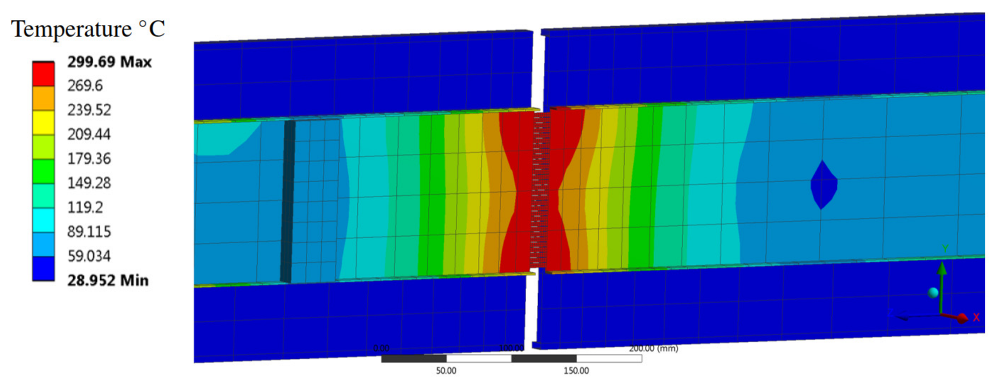
RF-Heating Results

Lateral
Straight
RF-Shielding

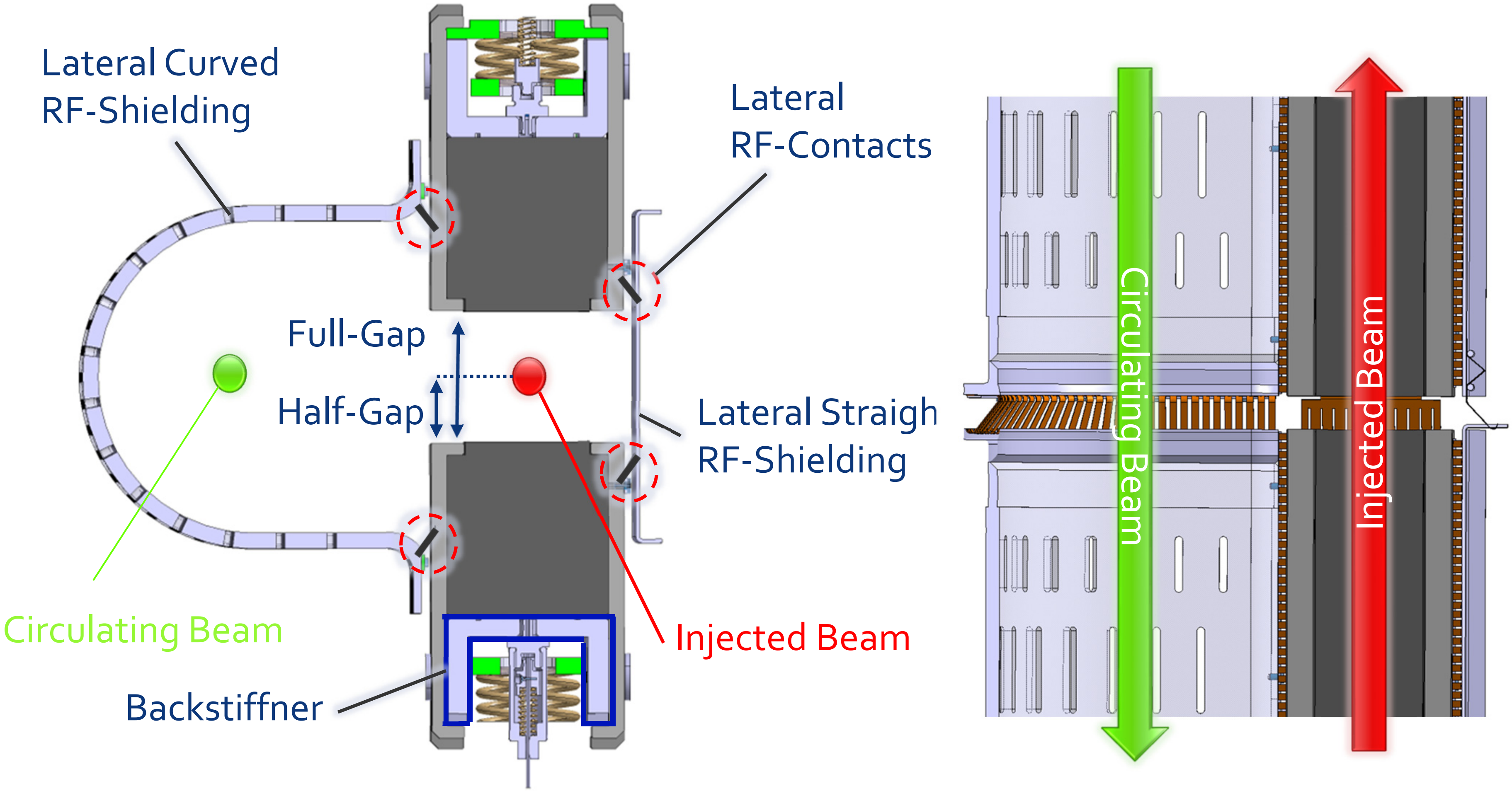




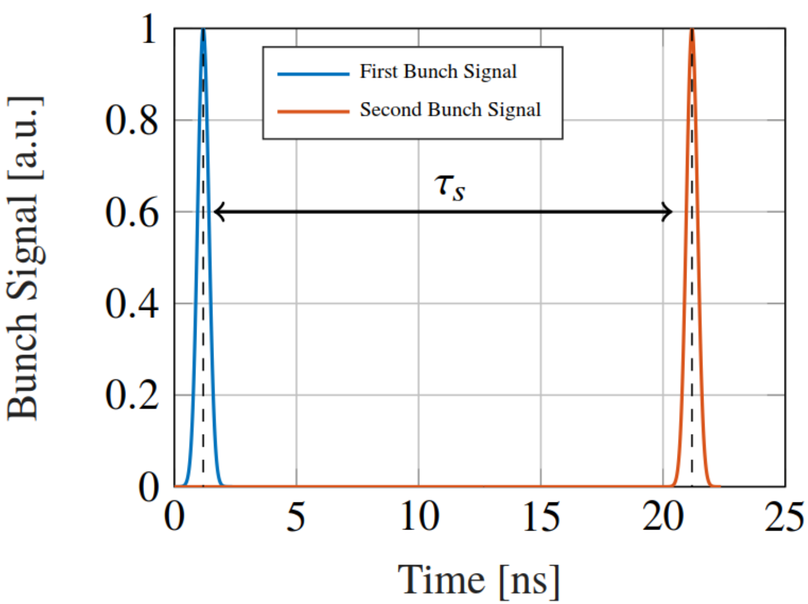


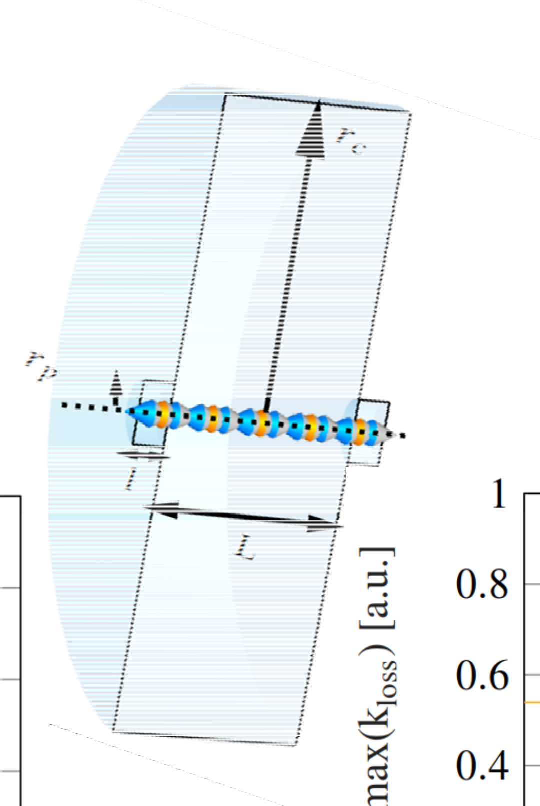


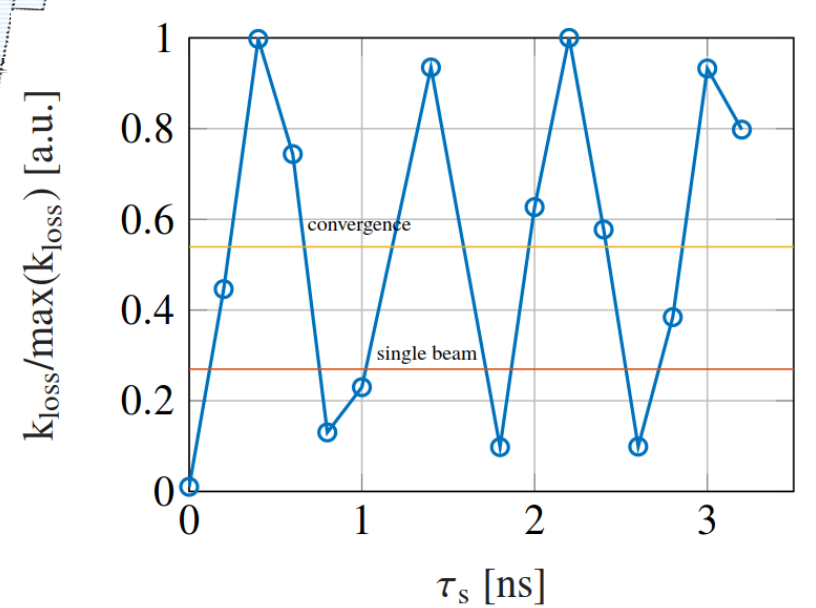
A Third Critical Scenario: The Nominal One



Preliminary Results







Conclusion

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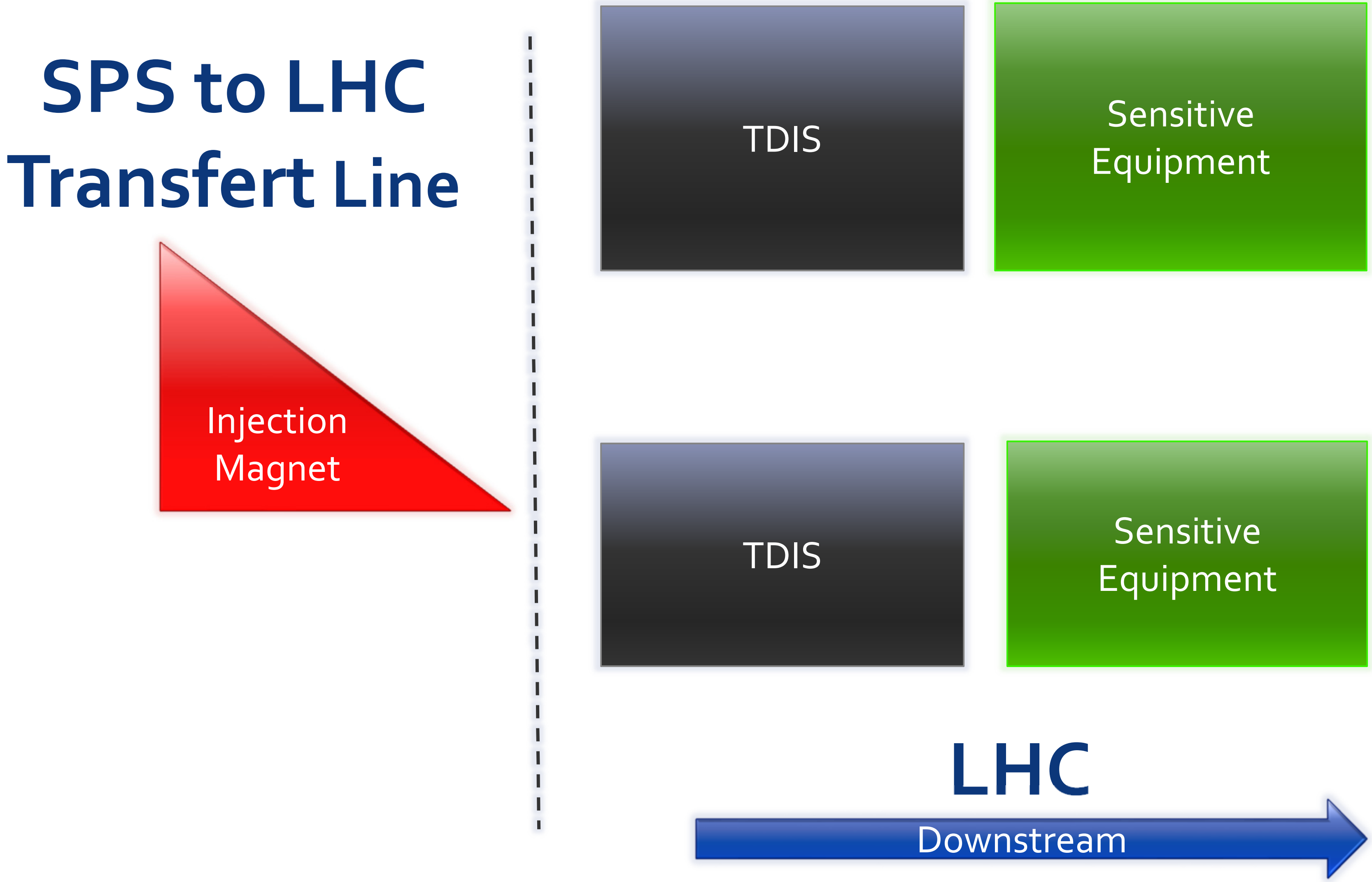
- Further studies are on going on the last case.

Thank You For Your Attention

The TDIS: Scope



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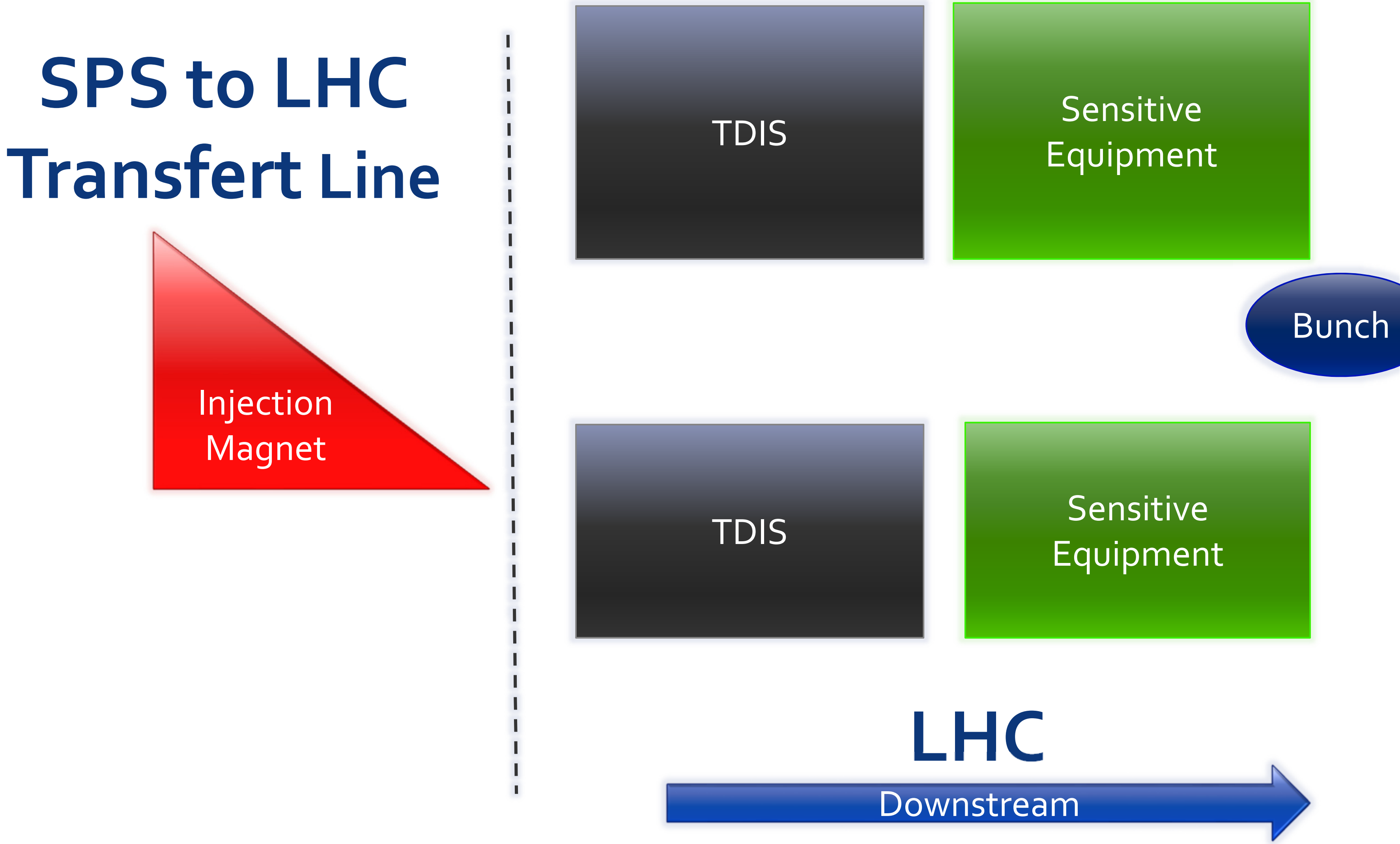

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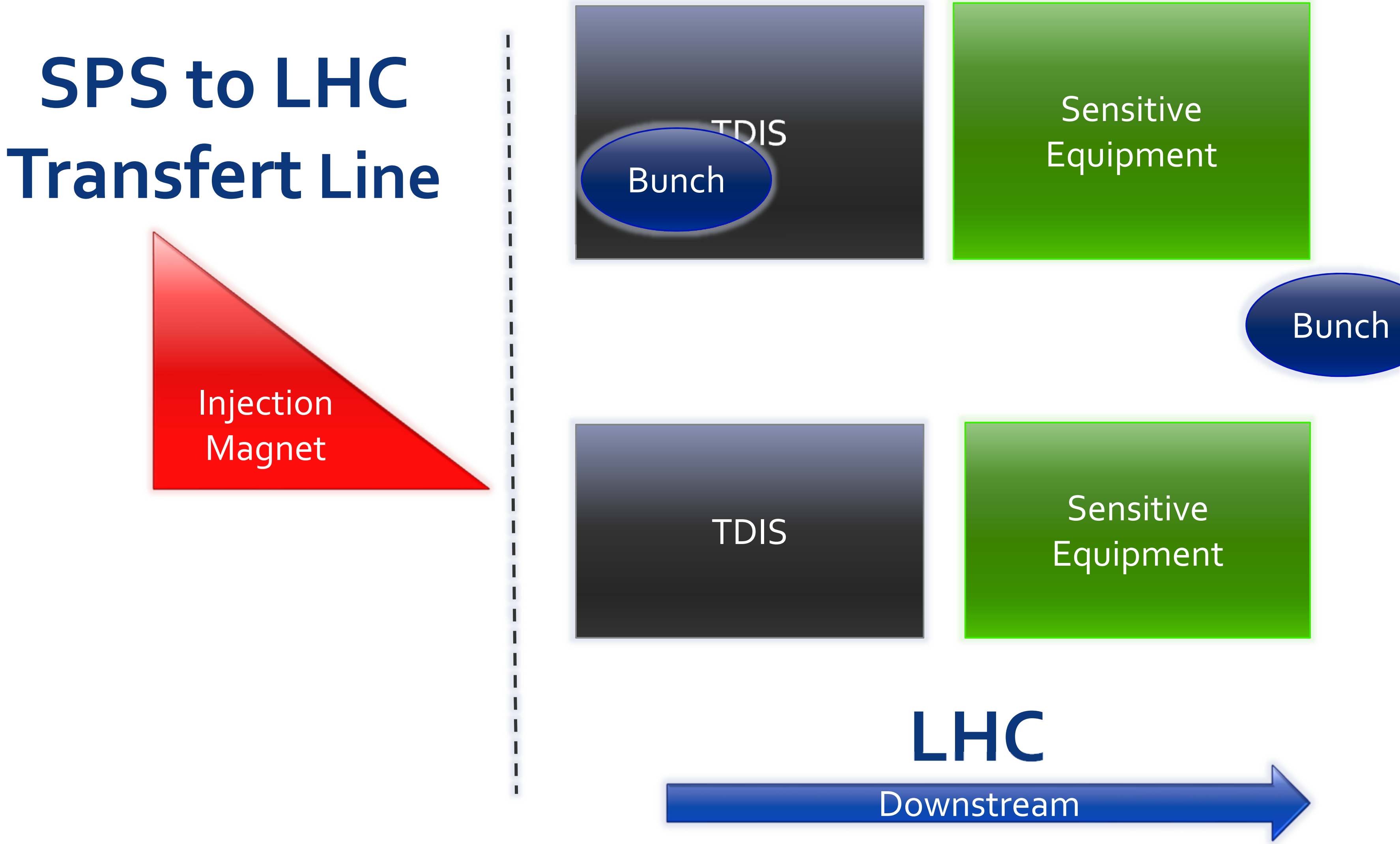

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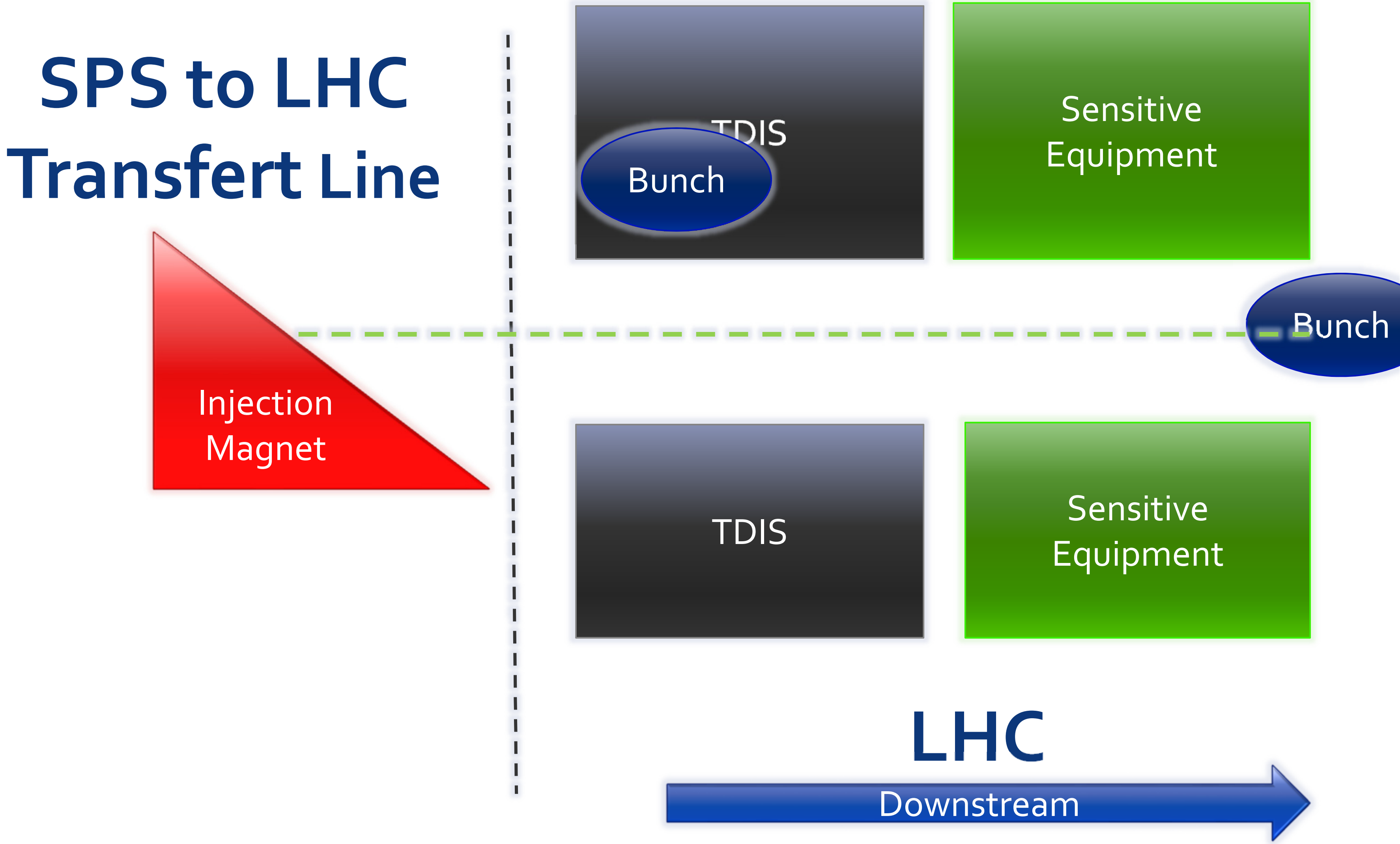

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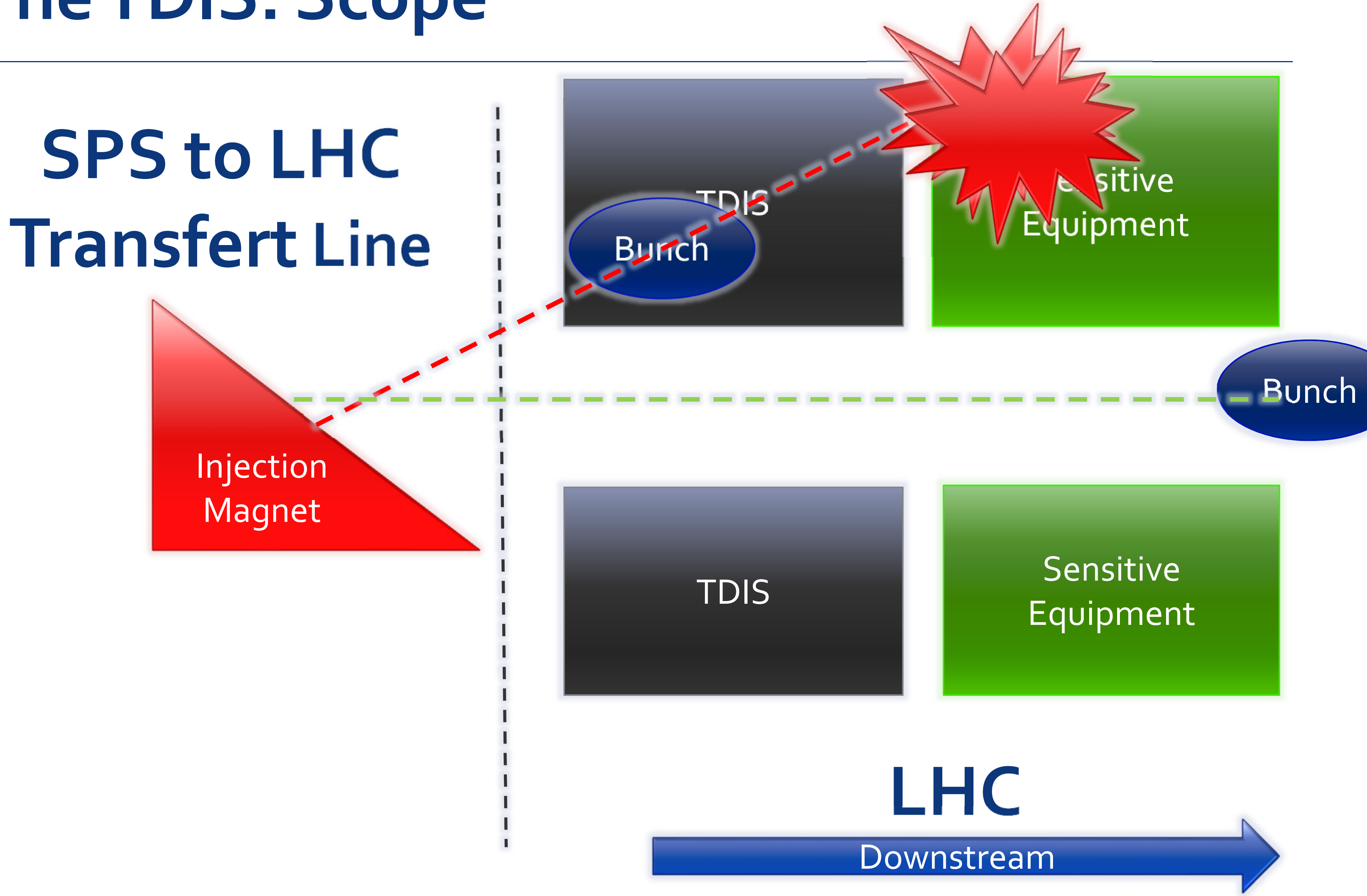
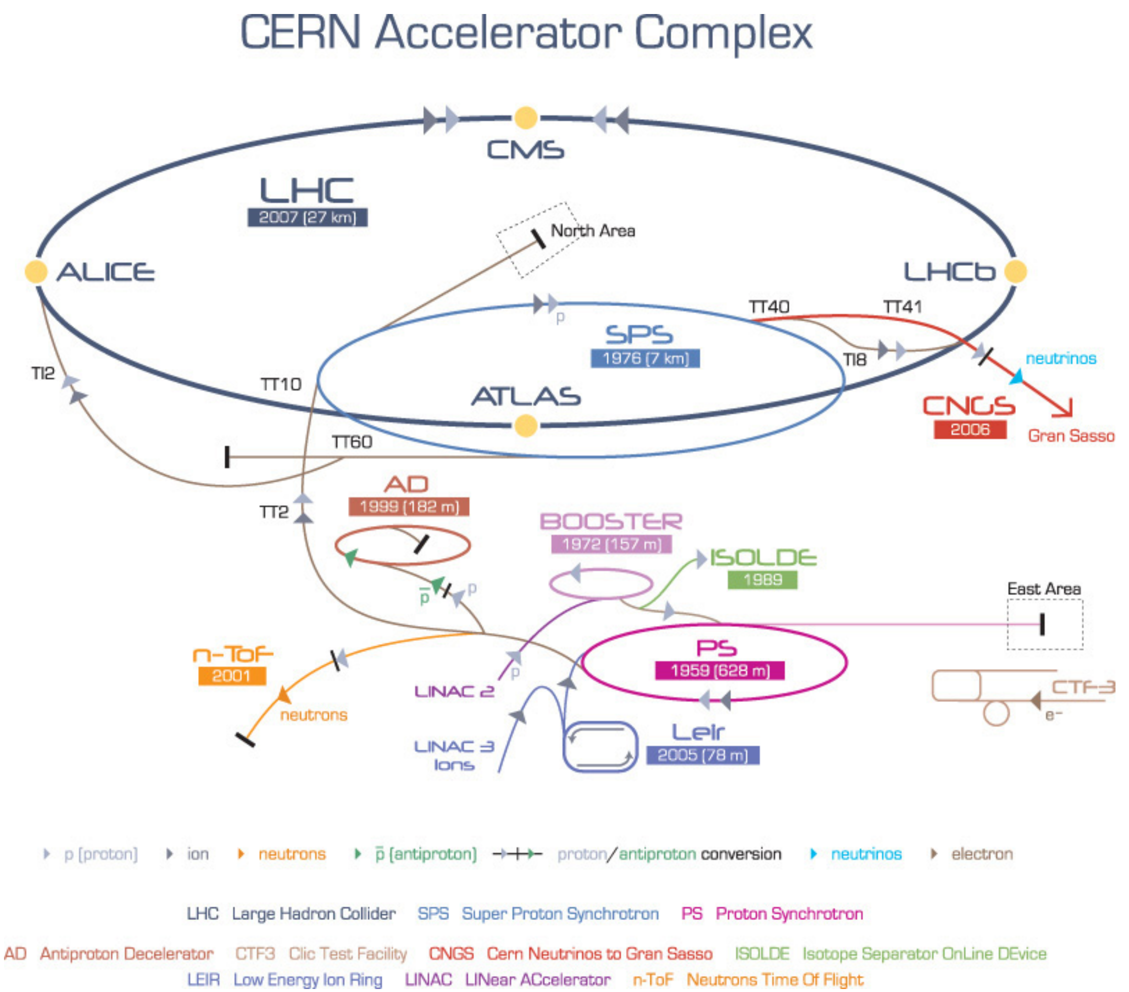


The TDIS: Location



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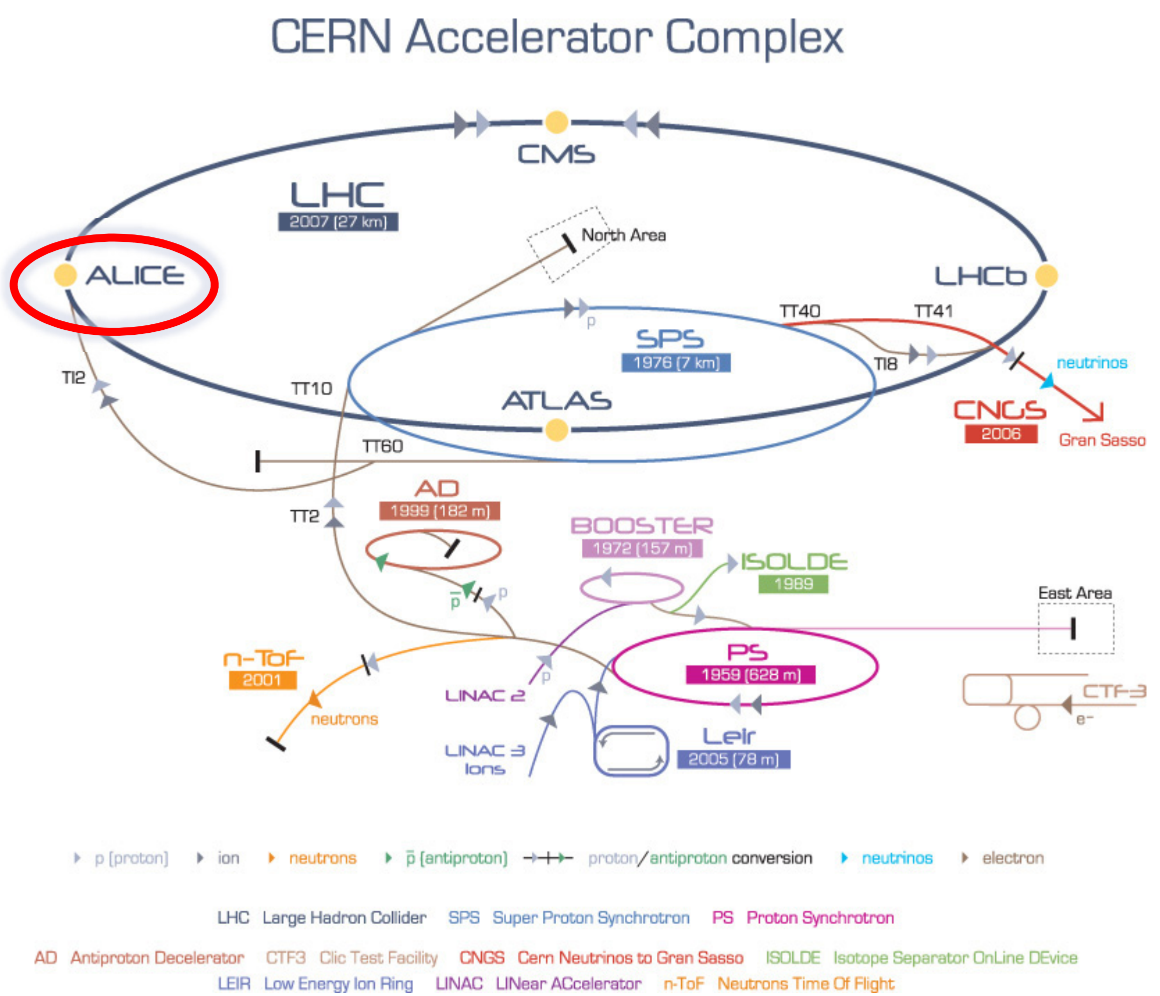

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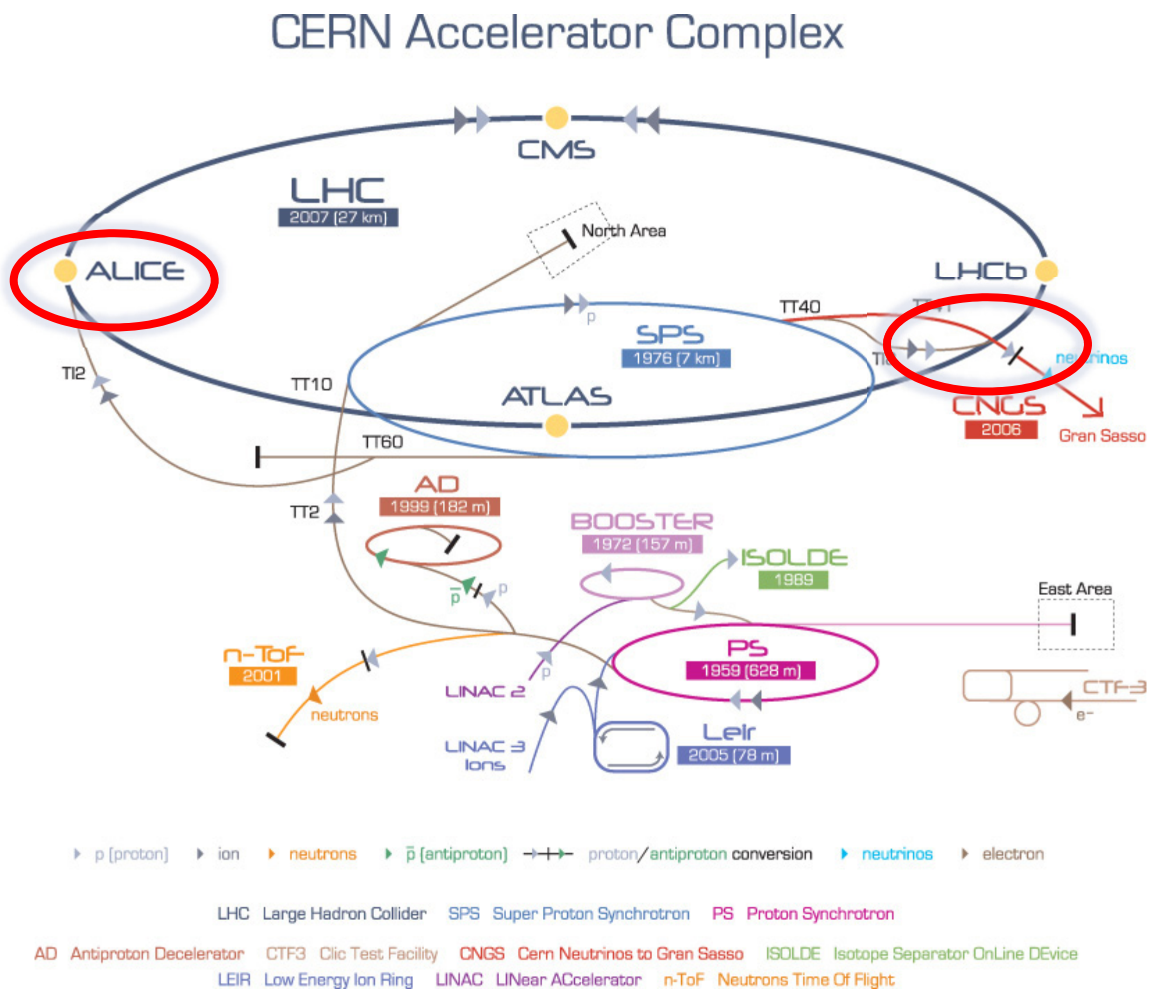
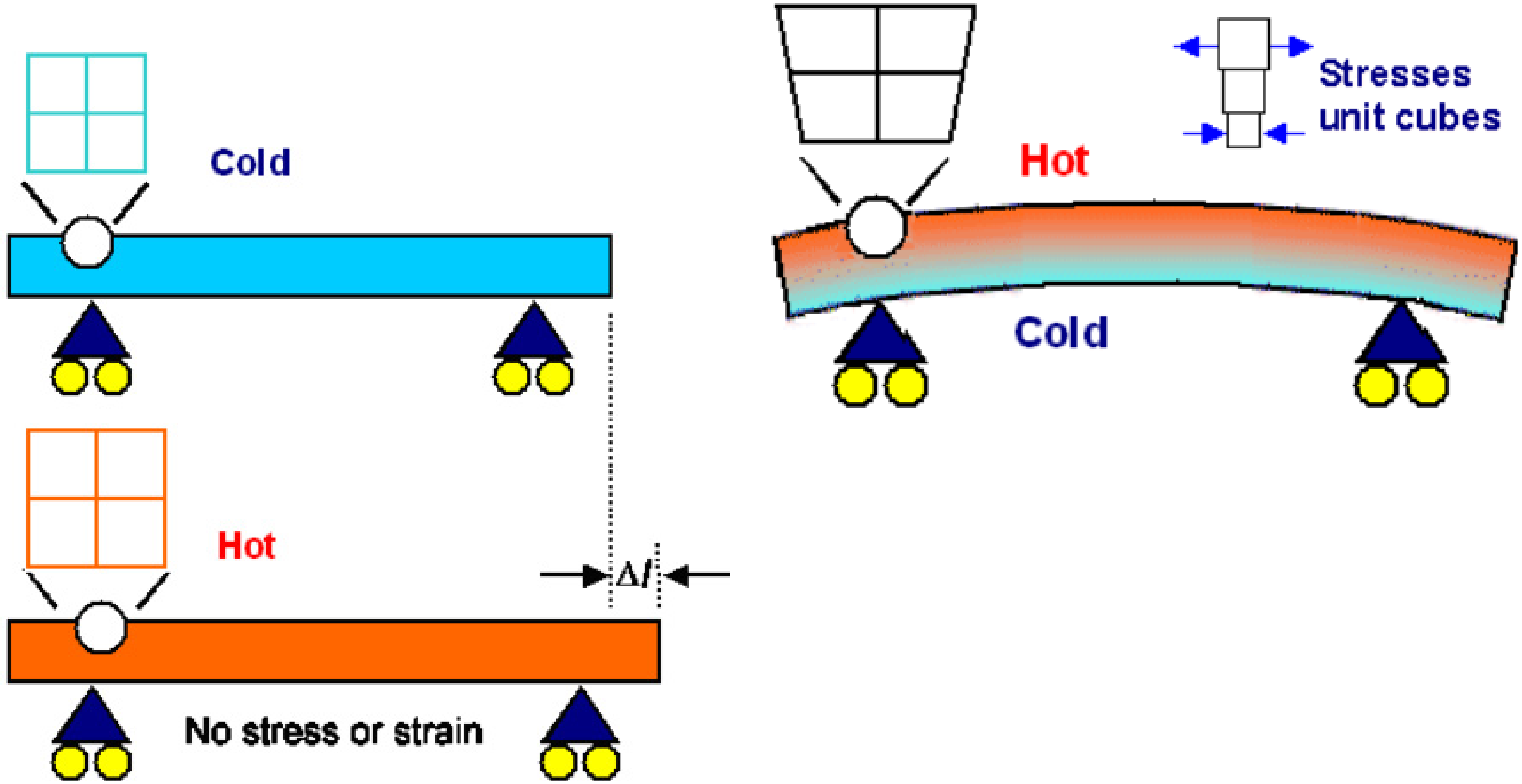
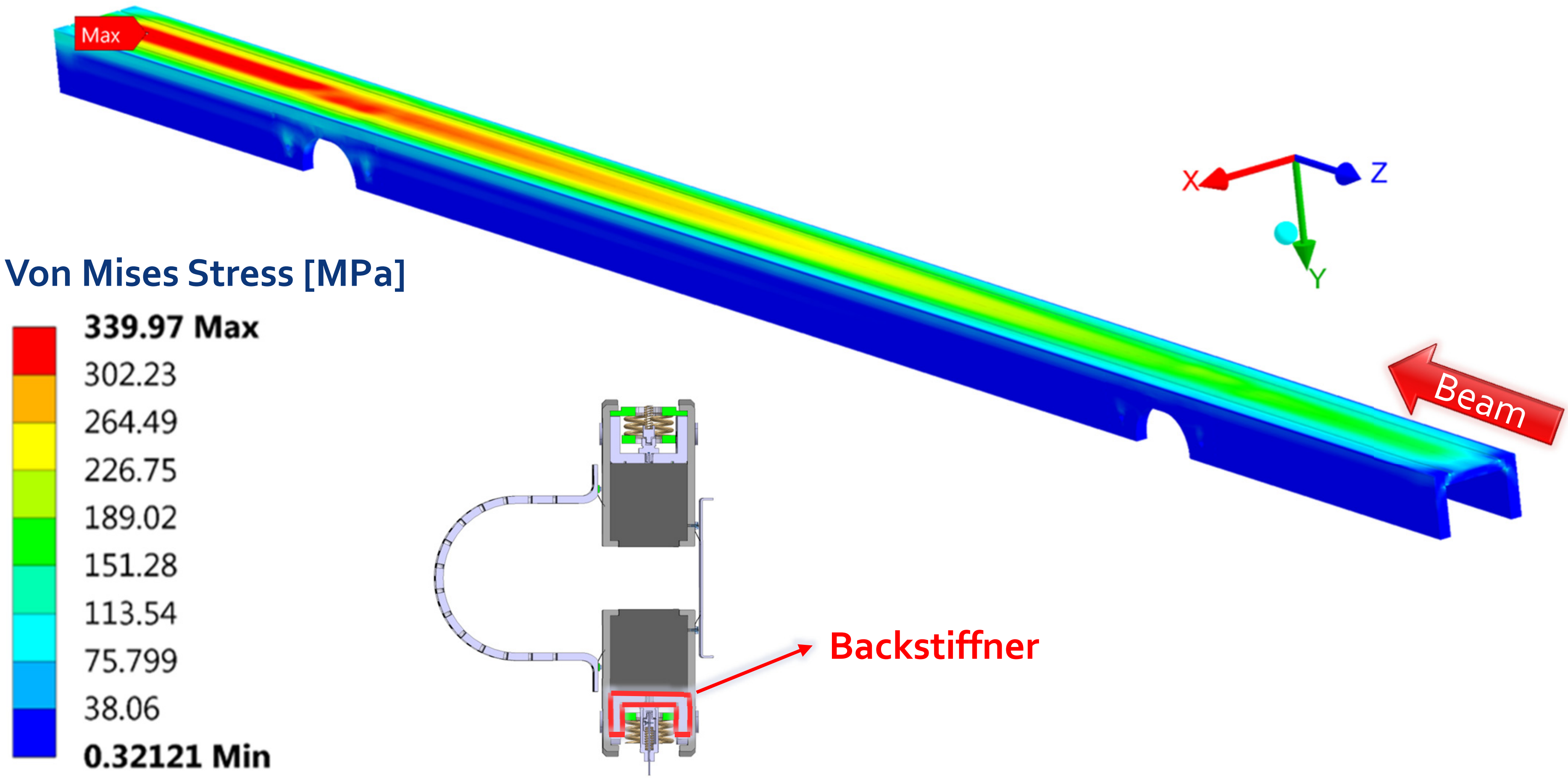


Thermo-Mechanical Stresses



Thermomechanical Simulations: Large Impact



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