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XLS CAD model

Nick Gazis, Eugene Tanke,

Andrea Bignami, Emmanouil Trachanas, Evangelos Gazis

IASA & ESS Team

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Outline

1. Introduction of 3D CAD MODEL
2. CAD/CAM System CATIA V5 & V6
3. 3D CAD: Study Case the XLS-Injector
4. 3D CAD model for XLS based on the baseline layout
5. Girder Analysis
6. Requests from CAD modelers to XLS Collaboration

1. Introduction of 3D CAD MODEL   Why a 3D CAD XLS model?

A 3D model provides benefits such as:

- **It aids in planning and design (e.g.– conceptual design during the conceptual phase)**
- **It aids in integration activities:**
  - The 3D models can be used to support vision sharing, and they help discovering, resolving design issues early (e. g. **clashes, interfaces, assembly clearances** etc.) and the models can be readily available for **FEA simulations**
- **It is the smart modern way of design** – avoiding the need for an army of designers and engineers
- Our 3D model can range from the overall XLS layout down to detailed models of individual accelerator components
- It can serve as a repository of the 3D designs (XLS Engineering Data Management System-EDMS repository)

This presentation explains the modeling technique and shows examples of model usage

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2. CAD/CAM System CATIA V5 & V6

Our CAD team has been using CATIA V5 & V6 and is available to ***support XLS at the appropriate level of detail for design studies.***

- This platform is typically used for medium or large technical designs as it can handle tenths of thousands of unique designs and specs.

- **User Friendly** (light representations) of the models can be imported in freeware software (Navisworks) for simple use (e.g. distance measurements, presentation discussions) in **different OS (Windows, Mac** etc).

- **3D-models** and **2D-drawings** can be produced on the same platform with the capability of using **version control** and design evolution validation

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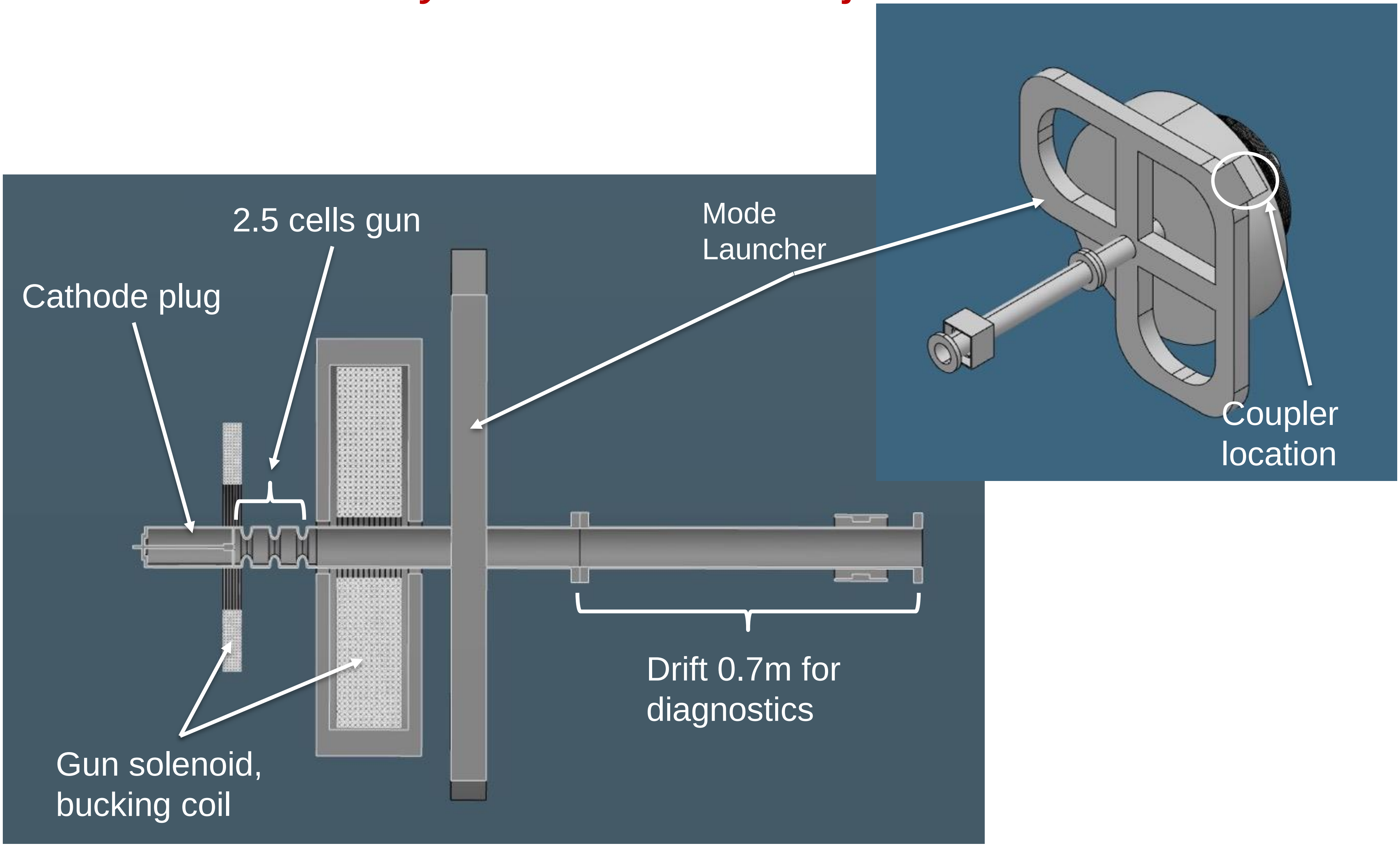
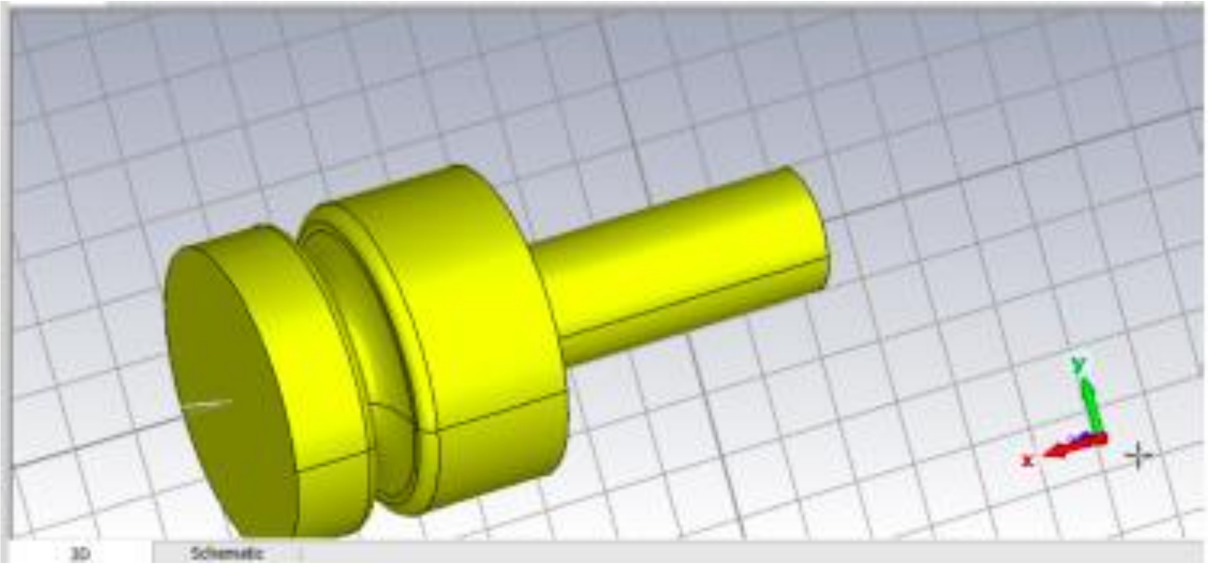
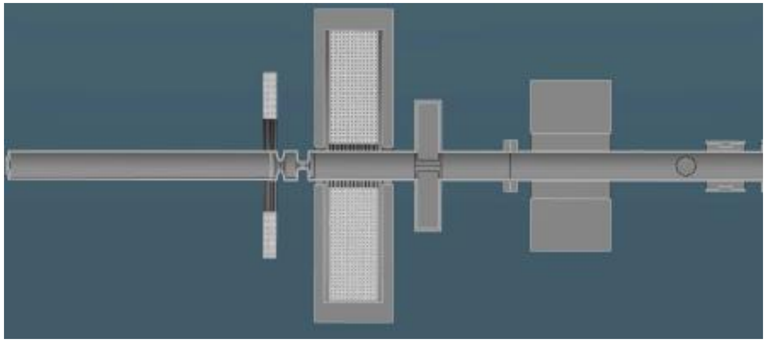
3. 3D CAD: Study Case the XLS-Injector

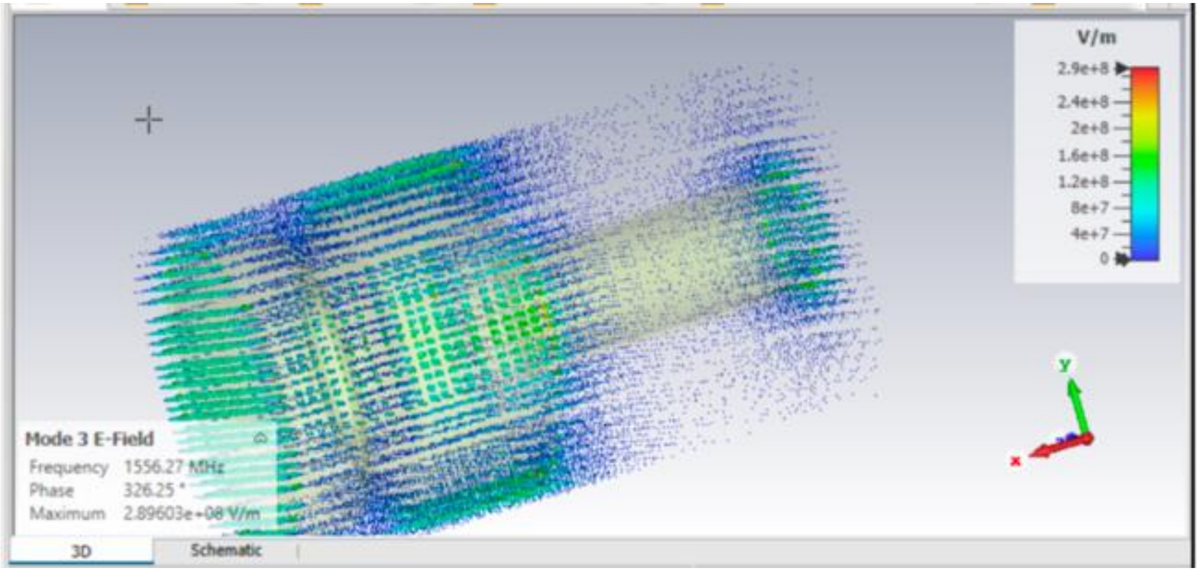
2.5 Cell Gun



3. 3D CAD: Study Case the XLS-Injector 1.6 Cell Gun





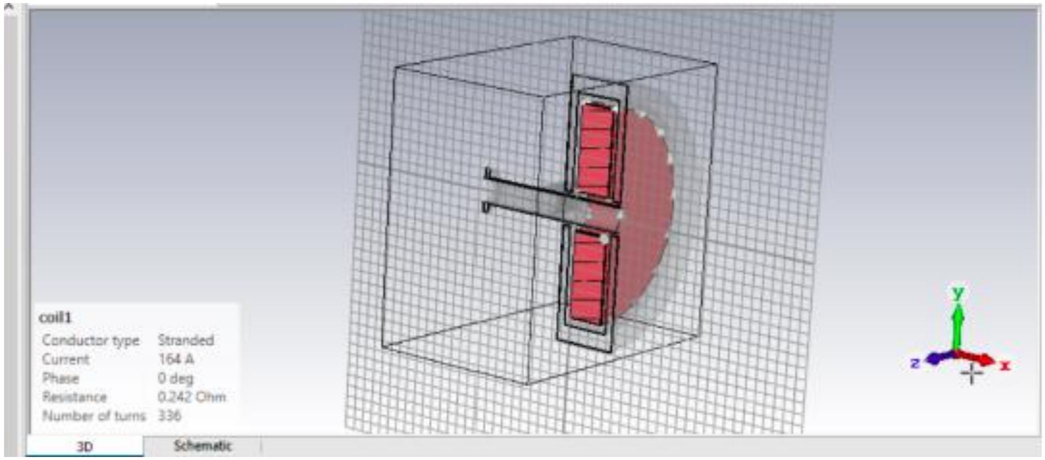


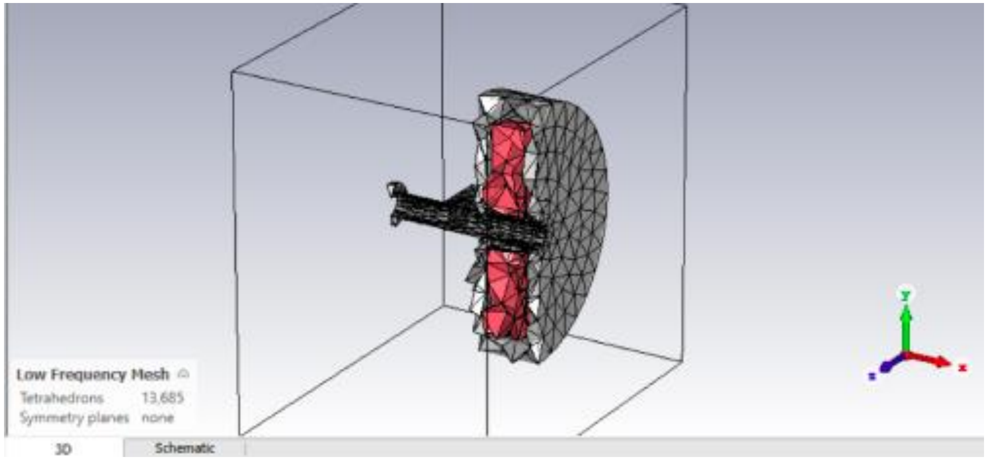
CST Eigenmode analysis

A preliminary 1.6 cell cavity was used to perform first Eigenvalue simulations without excitation.

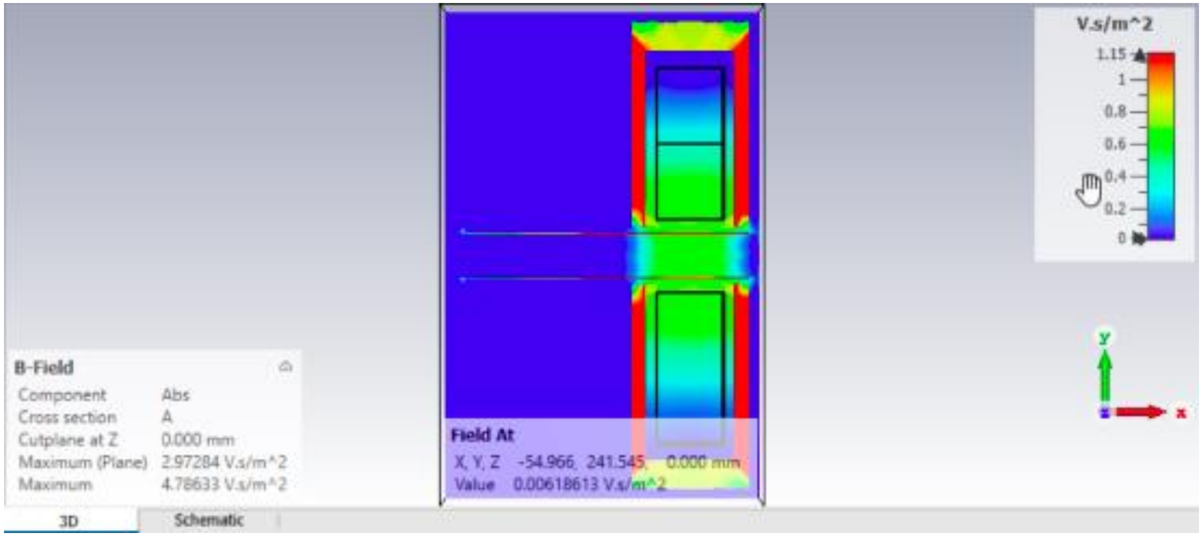
Tetrahedral Mesh was used with the method AKS (Advanced Kyrlov Subspace) for the first 35 EM modes.

3. 3D CAD: Study Case the XLS-Injector Gun Solenoid





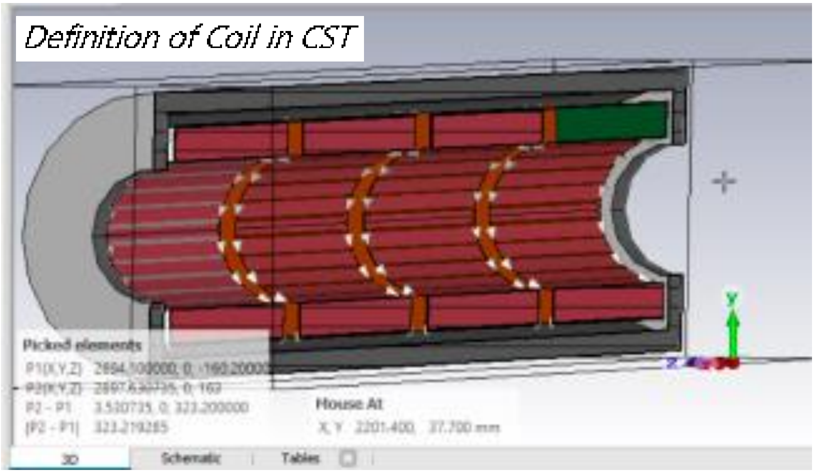
CST Magneto-Static analysis

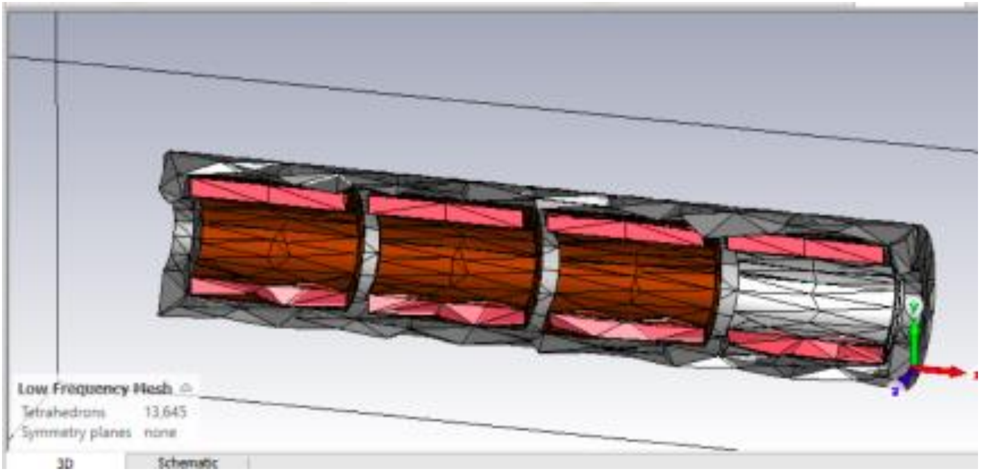


Field distribution

Result is in between Emmanouil's and Alessandro's field values

3. 3D CAD: Study Case the XLS-Injector TW Solenoids



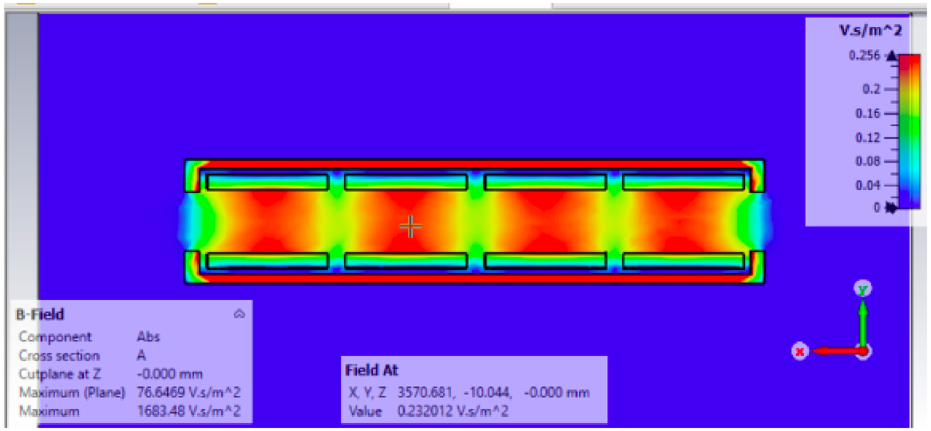


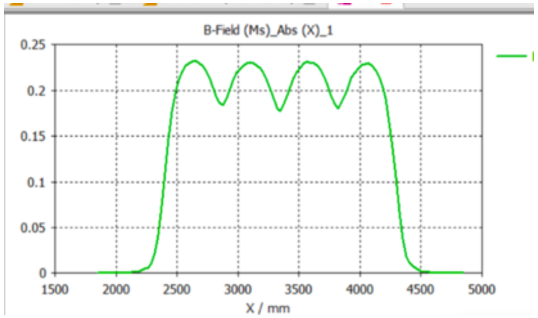
CST Magneto-Static analysis

The 3D file was imported in CST studio to perform a magneto-static simulation.
Steel-1008 was chosen for yoke material, as the lowest carbon-steel percentage available in CST library. Annealed Cu was chosen for the coil material. Coils were defined with the CST coil tool, inserting the same amount of current, ampere turns and resistivity as presented in the solenoid parameters. The result in the center of the solenoid on the beam axis is 0.22 T (magnetic flux density), same value obtained by SUPERFISH also.

Field distribution

Results H filed, B filed, Magnetic Energy Density and comparison with SUPERFISH results:





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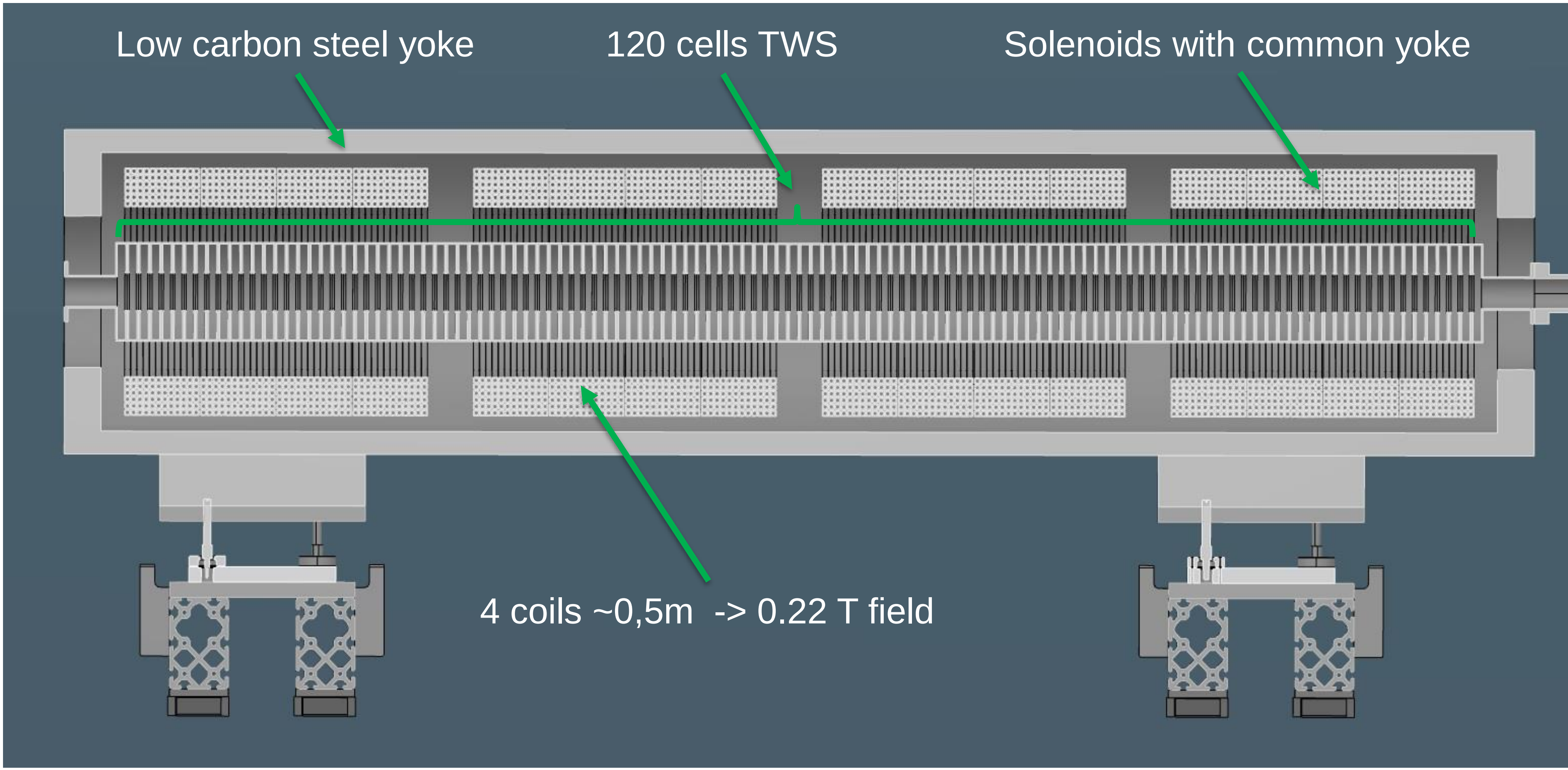
3. 3D CAD: Study Case the XLS-Injector

Injector TWS



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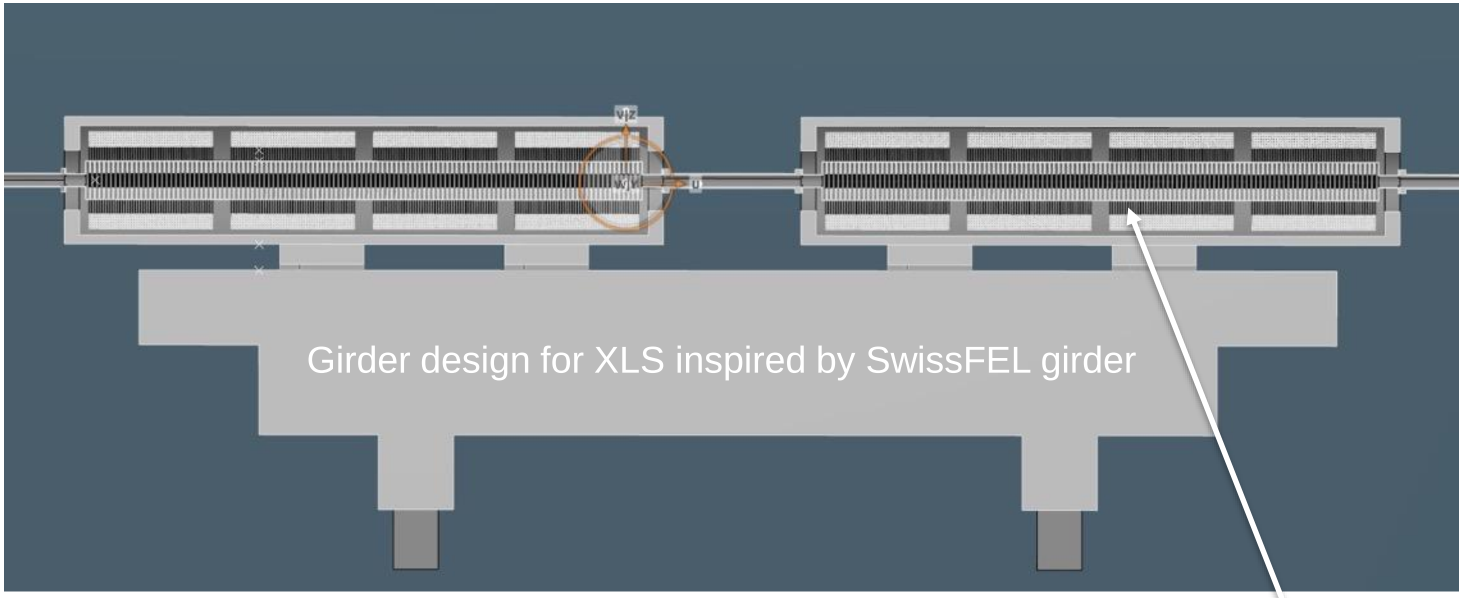
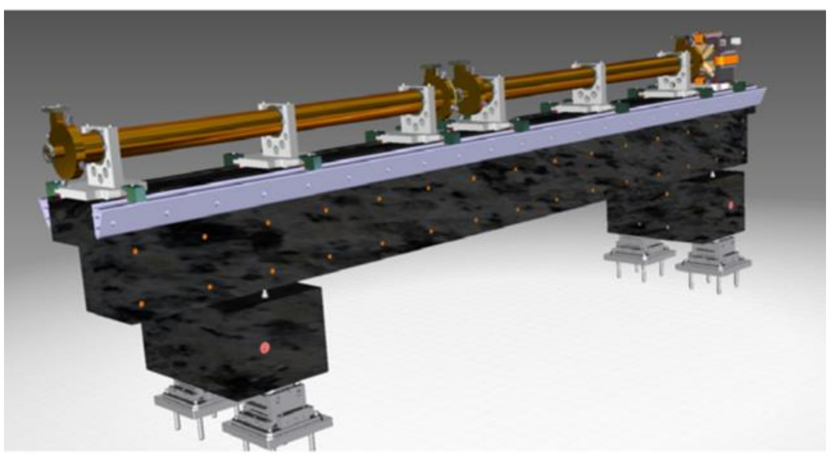
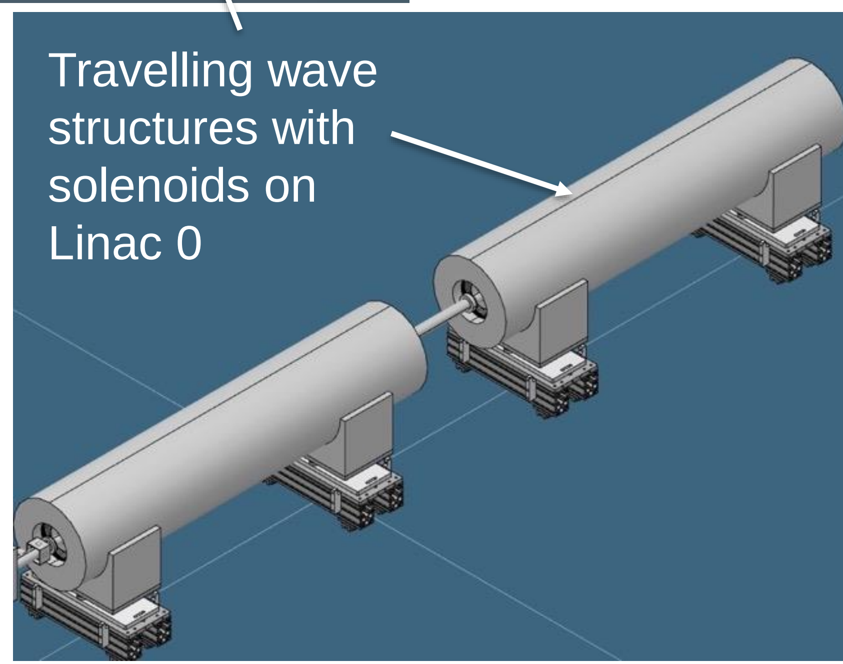
3. 3D CAD: Study Case the XLS-Injector

Injector TWS

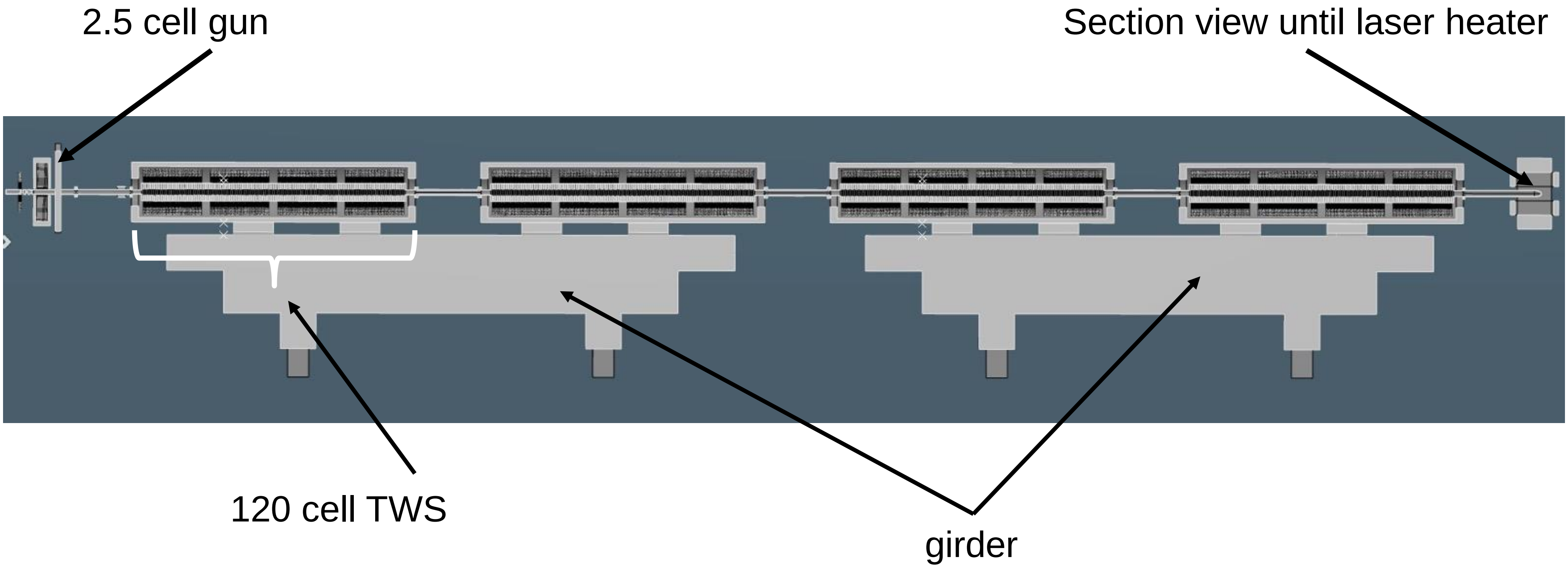




SwissFEL girder
Reference: SwissFEL Conceptual Design Report



3. 3D CAD example XLS-Injector with Girder



3. 3D CAD example with XLS-Injector for our next steps

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Full C-band XLS Injector

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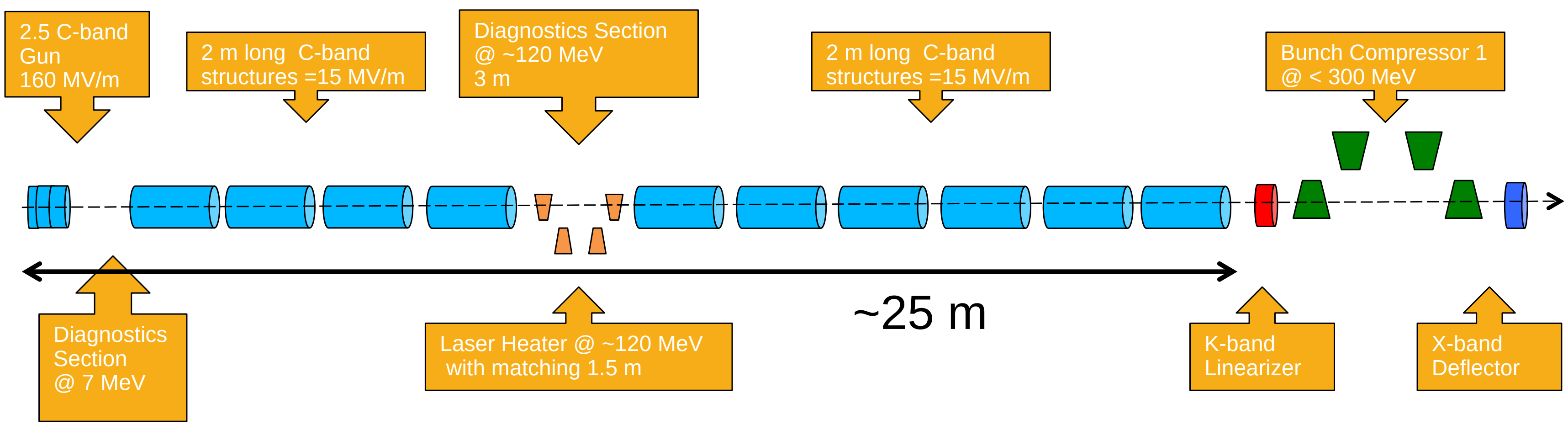
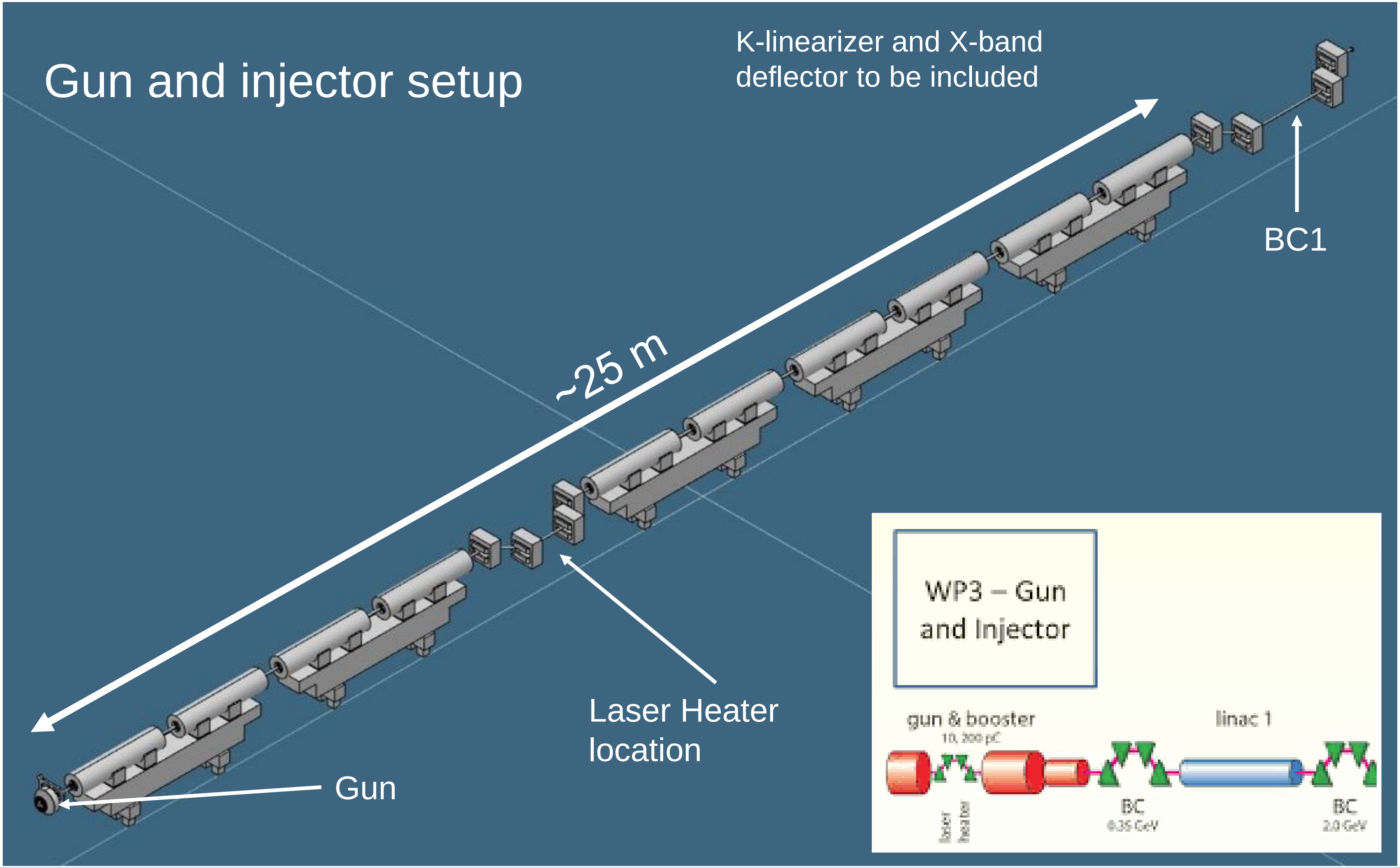
- One injector for all the operational modes (HRR and LRR)
  - 2.5 C-band gun with 160 MV/m cathode peak field ⇒ longer drift for diagnostics
  - Copper cathode and TiSa Laser
  - Same gradients 15 MV/m in the 2 m long C-band structures, max gain 30 MeV/structure
  - Same diagnostics positions (@gun exit 7 MeV and in the drift parallel to the LH @120 MeV)
  - Same beam parameters at the linac exit
  - Matching with LH to be determined

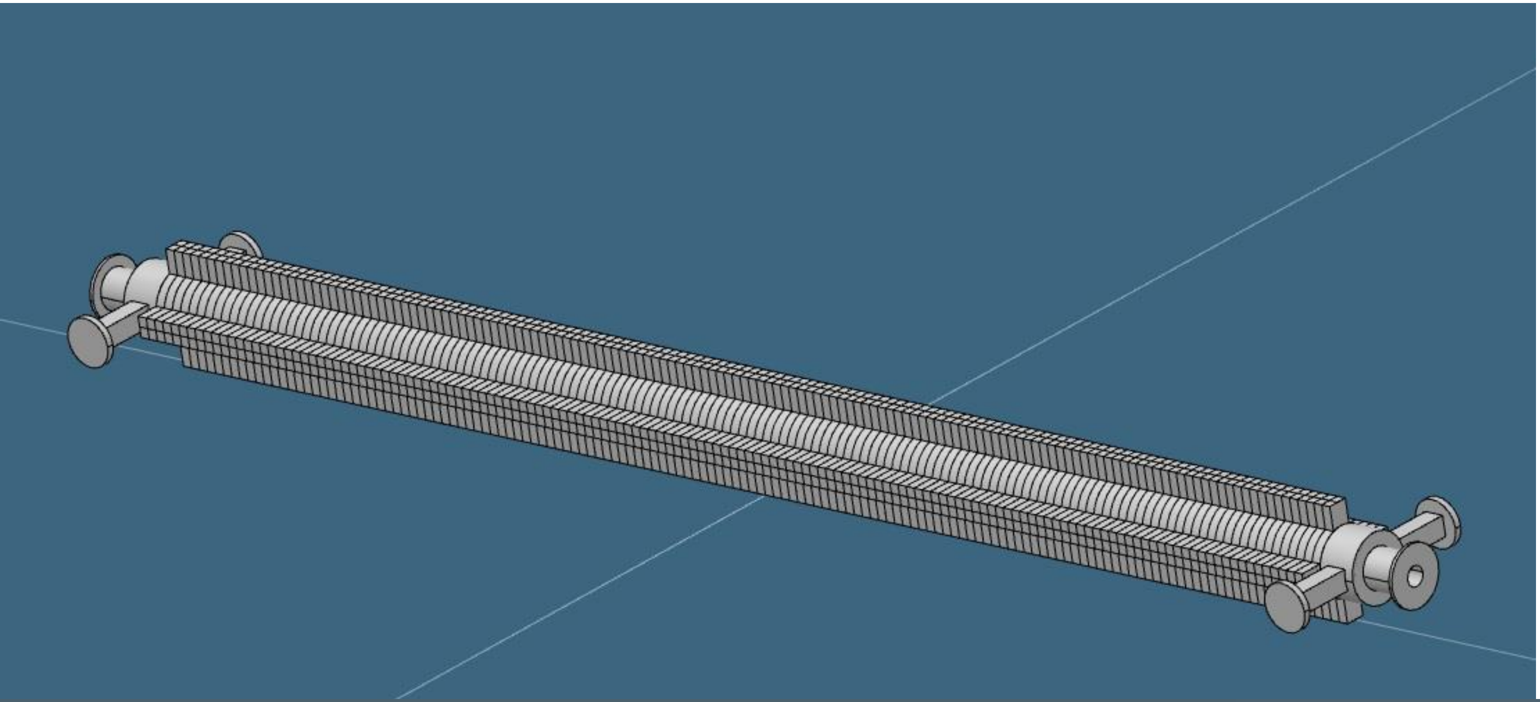


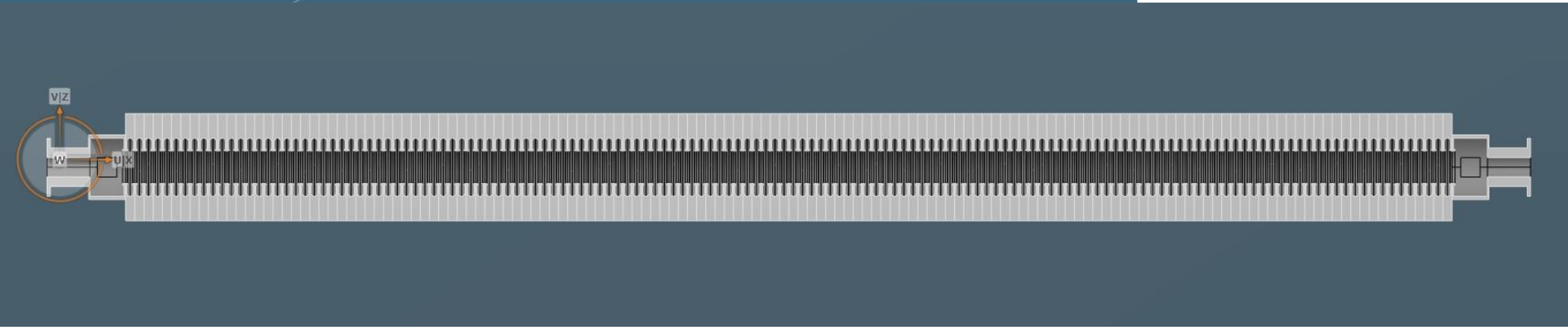
- Optimal BC1 input energy (⇒ and position) to be determined
  - Without Velocity Bunching
  - With Laser Heater less than 2 m long
  - K-band Linearizer just before the BC1, X-band RFD downstream BC1
  - Same beam parameters at the BC1 exit
  - Matching with BC1 to be determined

3. 3D CAD: XLS-Injector case study



3. 3D CAD example with XLS-Injector X-band structure





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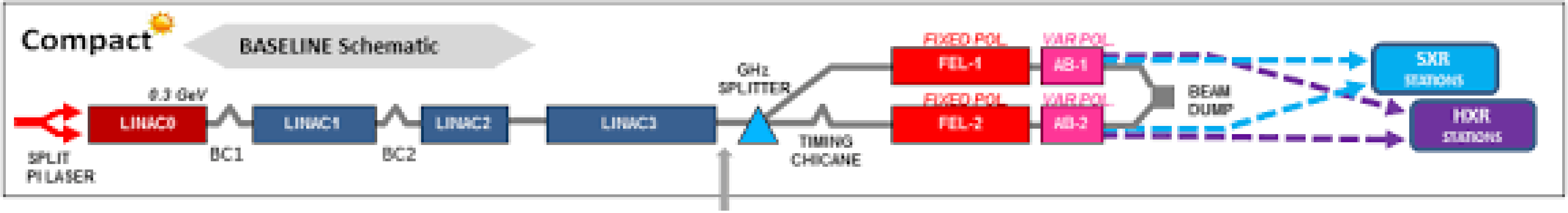
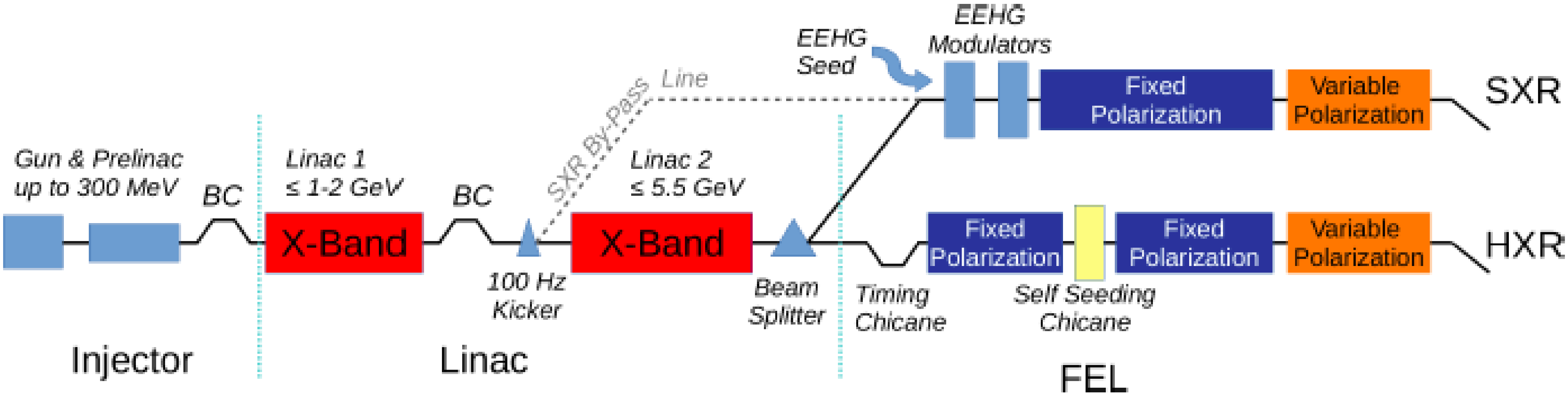
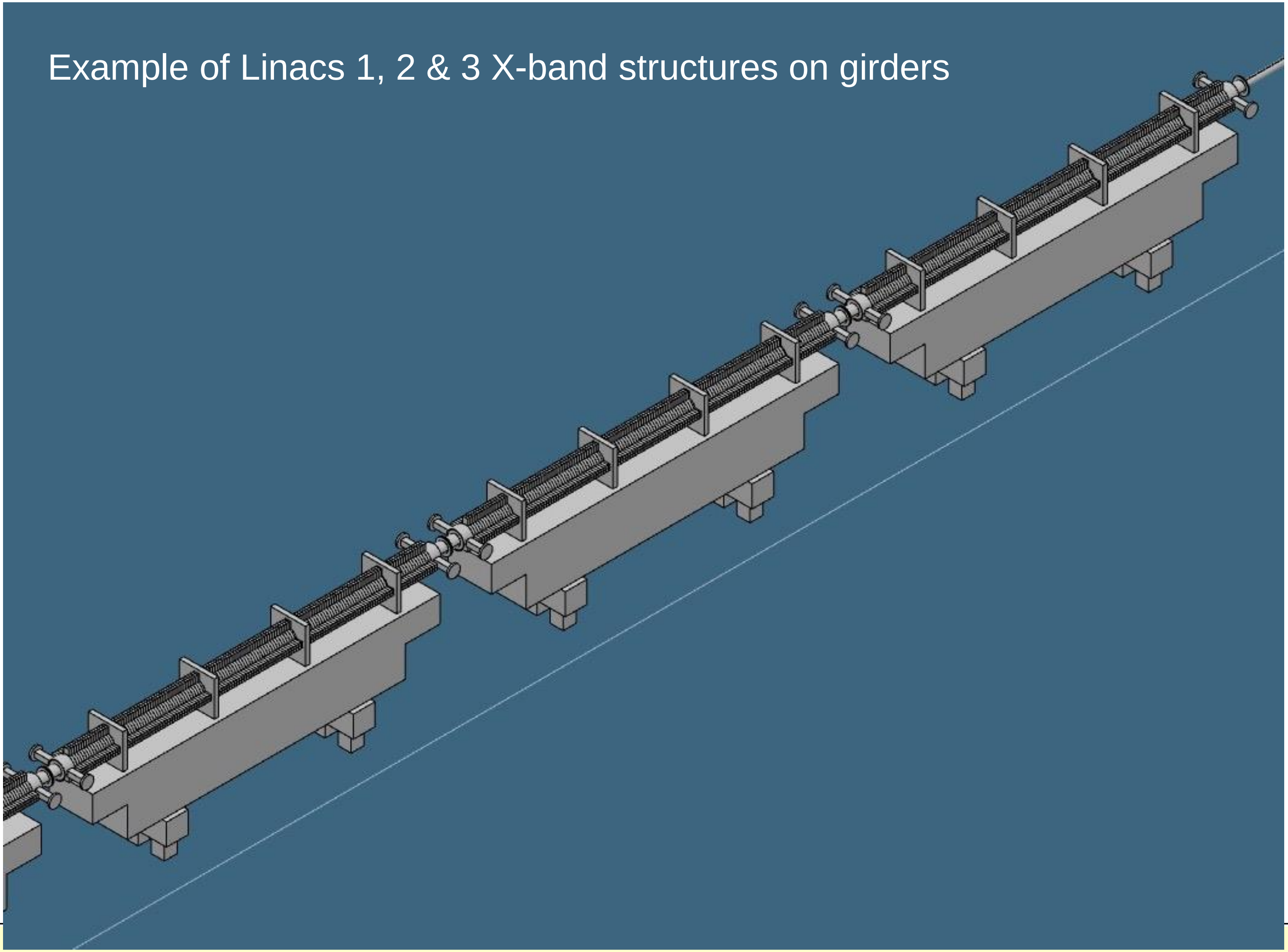
4. 3D CAD model for XLS based on full baseline layout

This baseline layout will be followed; taking into account any further improvement.





3. 3D CAD example with XLS-Injector linac with Girder



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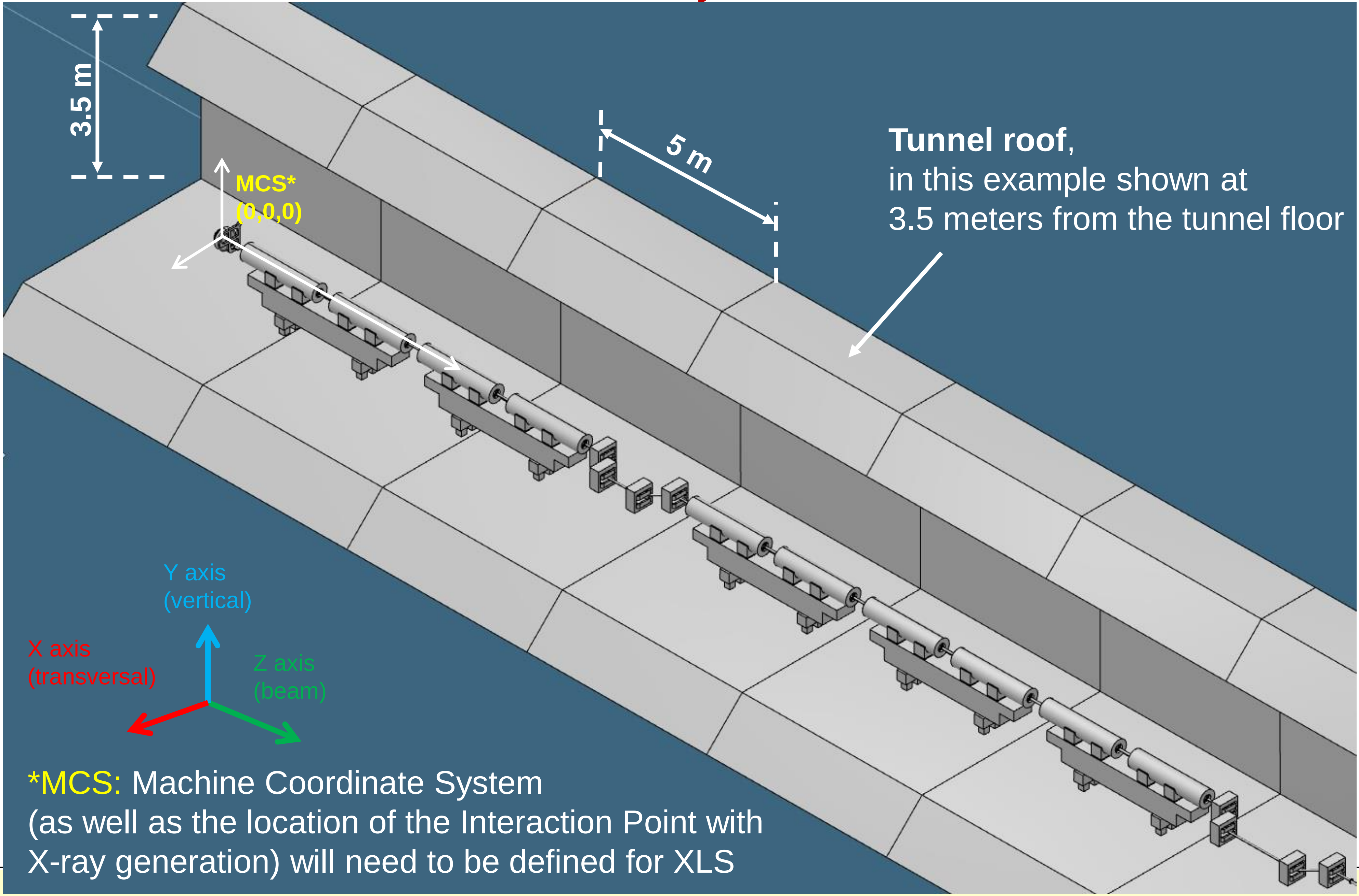
4. 3D CAD MODEL for XLS injector in the tunnel



5. Girder Choice: Points to keep in mind

- **Modular** design of component "clusters" is imperative for a **compact** machine
- Common girders allow for compact **pre-assembly**, extensive part **testing** and **reduce** drastically the **installation time**
- **Tolerances**, machine **precision** and alignment **degrees of freedom** will seriously impact the **cost** profile of the accelerator
- Active **repositioning** or passive **alignment** is a choice dictated by beam tolerance and machine alignment budget
- Investing in **CAD design & integration** combined with **supporting system** study in this stage will reduce errors of manufacturing, assembly and future needs for spares

This implies that analysis of the girders will be required

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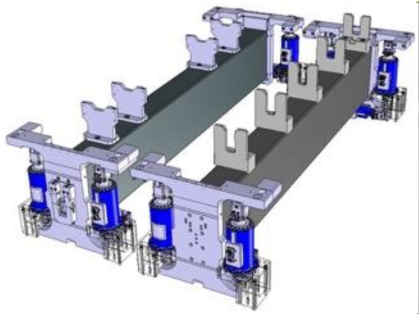
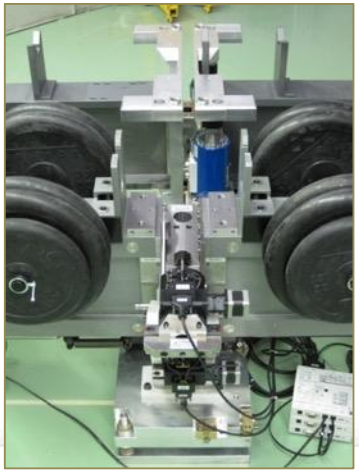
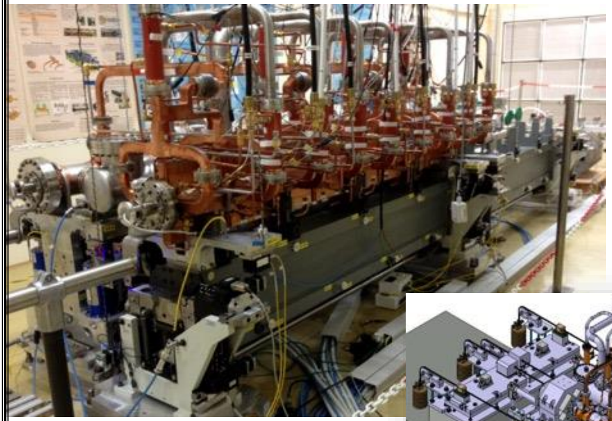
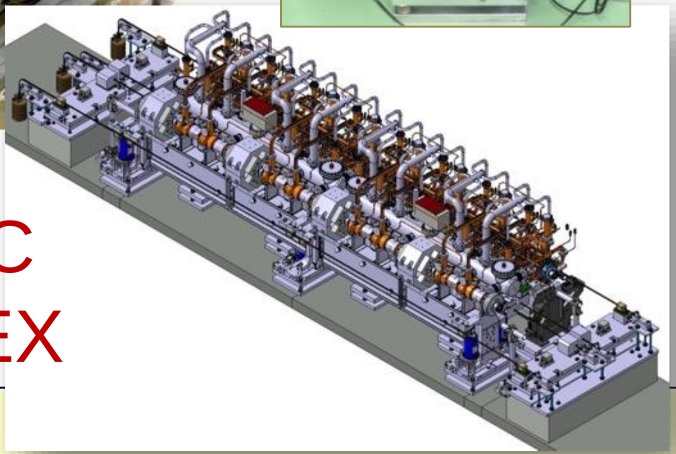
5. Girder Analysis: Few options for supports and alignment




Prestressed isolating girders with active alignment

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CTF & CLEX

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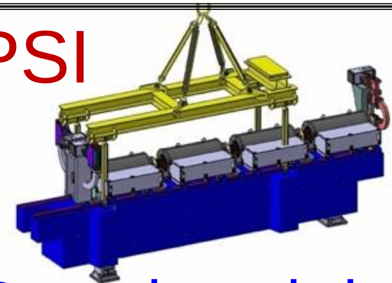
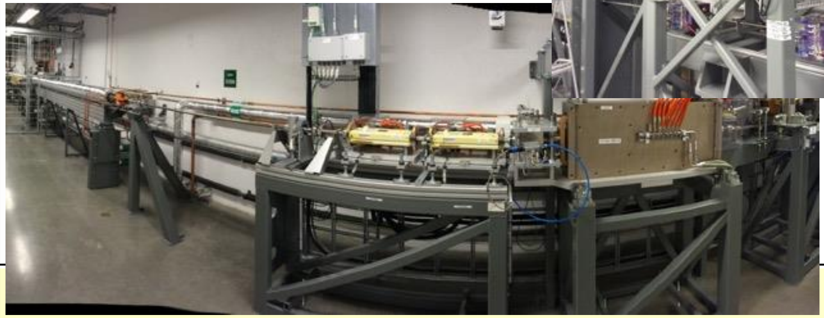



Damping girders with high-frequency absorption capacity


MAX IV

Individual girders

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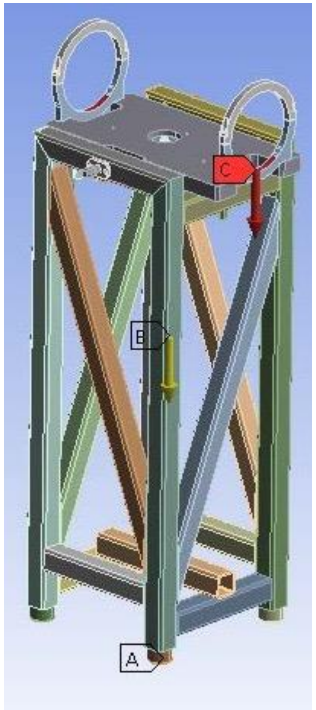
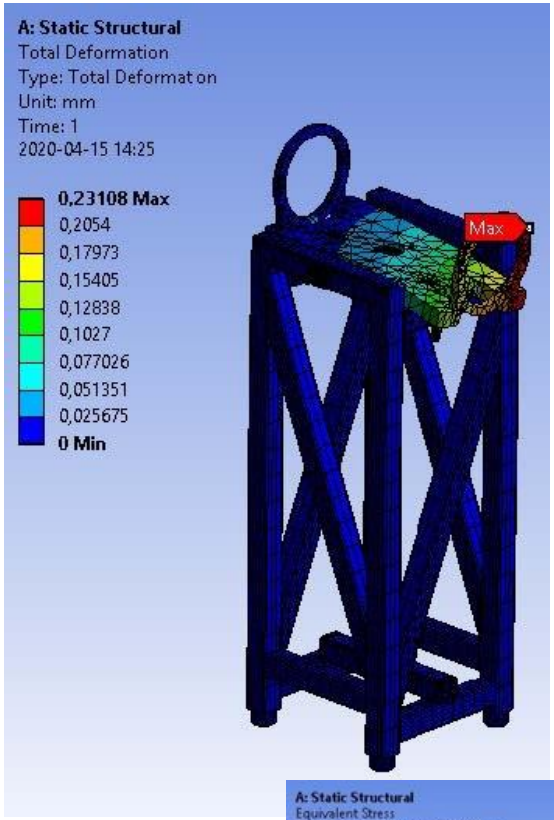
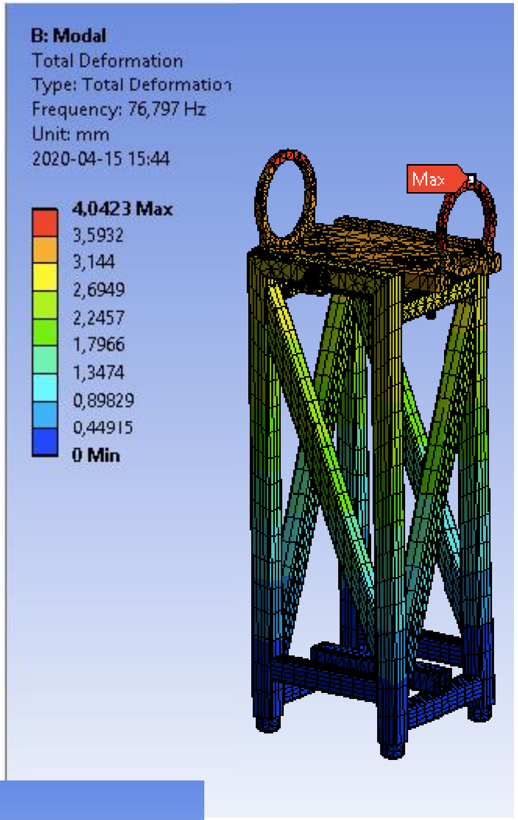
5. Girder ANSYS simulation

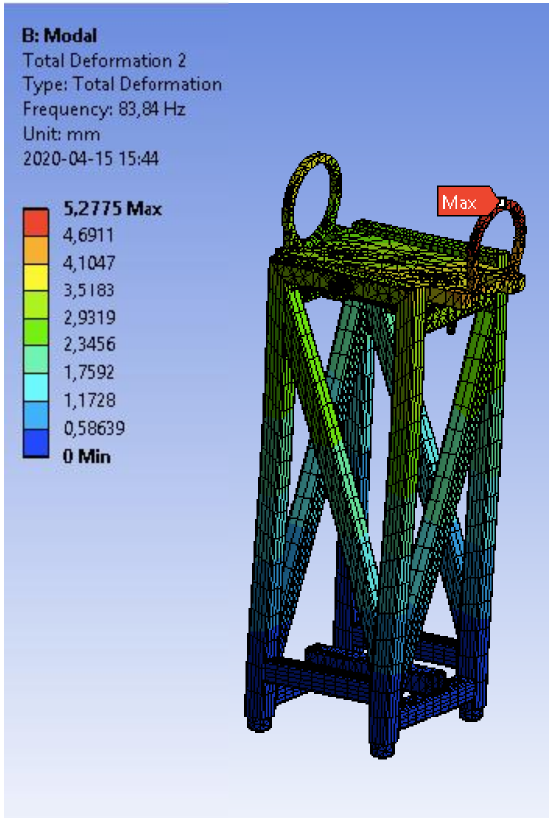
Material: ANSYS Structural Steel for girder material

Geometry: This version of XLS girder is the exact transposition from the **MAX IV**'s girder model



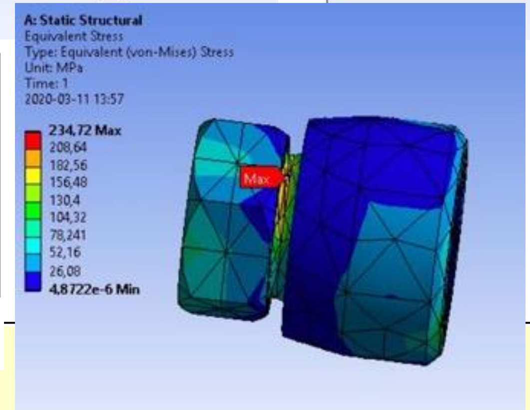






Density	7,85 10^{-6} kg/mm^3
Young's Modulus	200 GPa
Poisson's Ratio	0,3
Compressive Yield Strength	250 MPa
Tensile Yield Strength	250 MPa
Tensile Ultimate Strength	460 MPa

Table.1 – Structural Steel parameters



Max **stress** concentration on the spherical **joint**, between the horizontal support and the legs that allows to orient the horizontal plane on which the round supports are mounted

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6. Requests from CAD modelers to XLS Collaboration

In order to efficiently integrate the XLS accelerator beam line elements in the 3D model, the following information would be needed:

1. Quantity and types of beam line elements
2. Size and Position (e.g. relative to e-gun cathode) of each beam line element and of their internal structure, where possible
3. Space needed for the beam instrumentation parts, deflectors, etc.
4. In order to have a 3D model of the entire facility, the scale of the model should be given by the collaboration

All colleagues are welcome to contact us and request CAD modelling of their parts, integration of designs, etc.!

References

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2. L. Hagge, J. A. Dammann, T. Hongisto, D. Käfer, J. Kreutzkamp, B. List, S. Rohwedder, S. Sühl, N. Welle, ENGINEERING DOCUMENTATION AND ASSET MANAGEMENT FOR THE EUROPEAN XFEL ACCELERATOR, Proc. IPAC2017, 3960-3962

3. N. Bergel, L. Hagge*, T. Hott, J. Kreutzkamp, S. Sühl, N. Welle, INTER-DISCIPLINARY MECHANICAL AND ARCHITECTURAL 3D CAD DESIGN PROCESS AT THE EUROPEAN XFEL, Proc. EPAC08 1467-1469

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Thank you!

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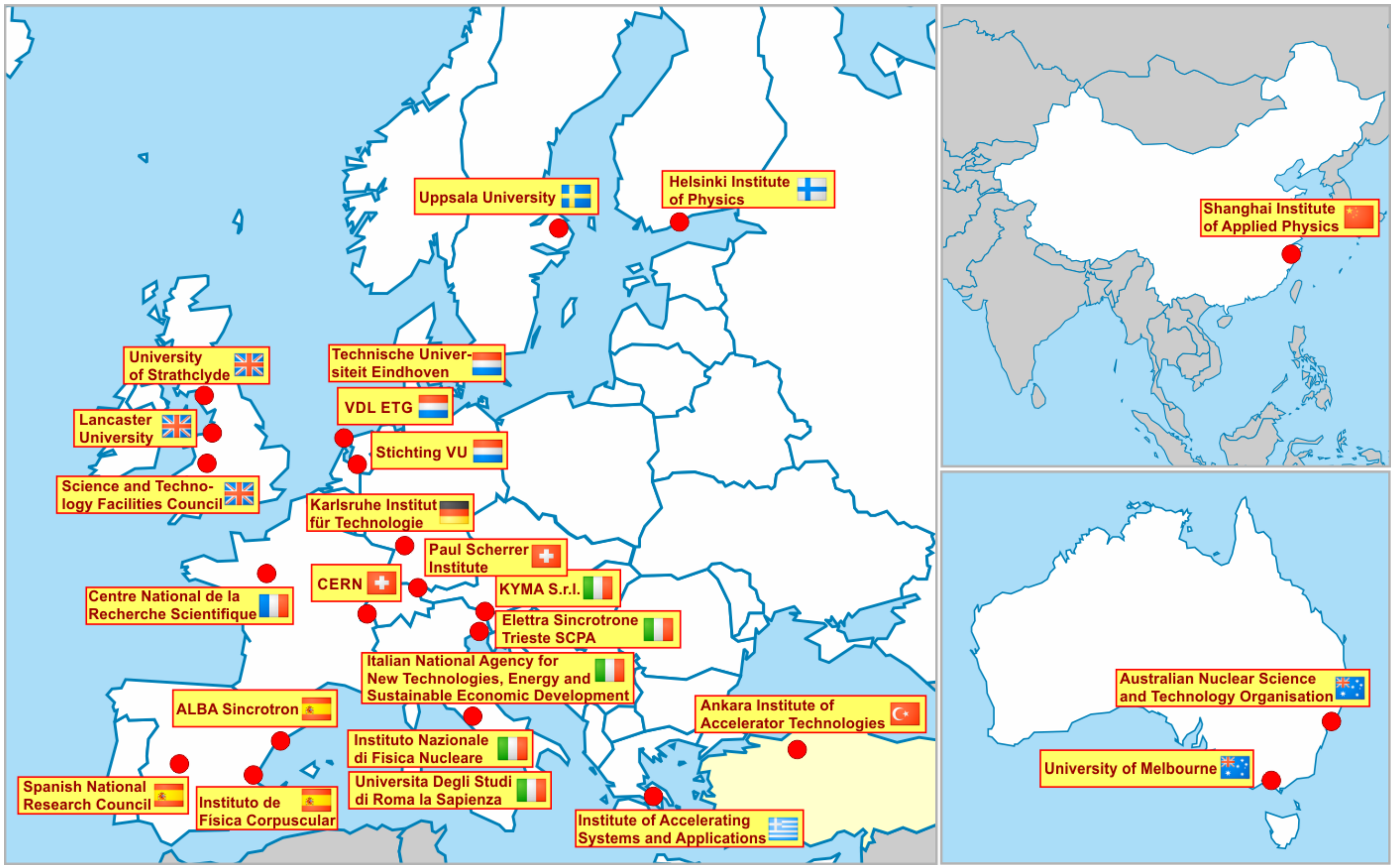

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Back-up slides

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Engineering considerations

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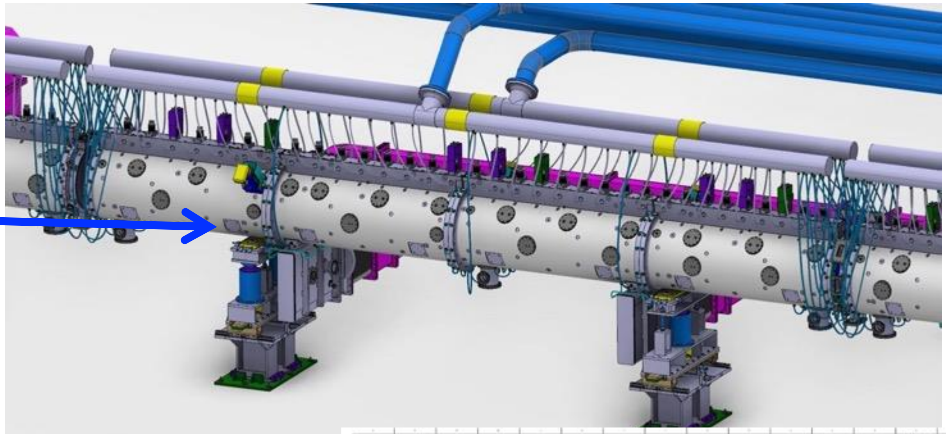
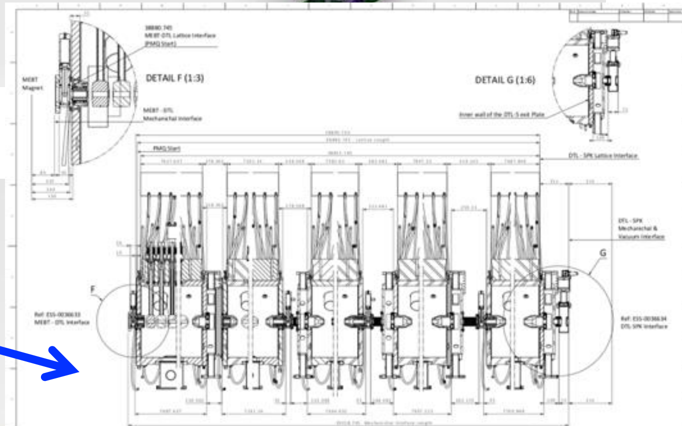
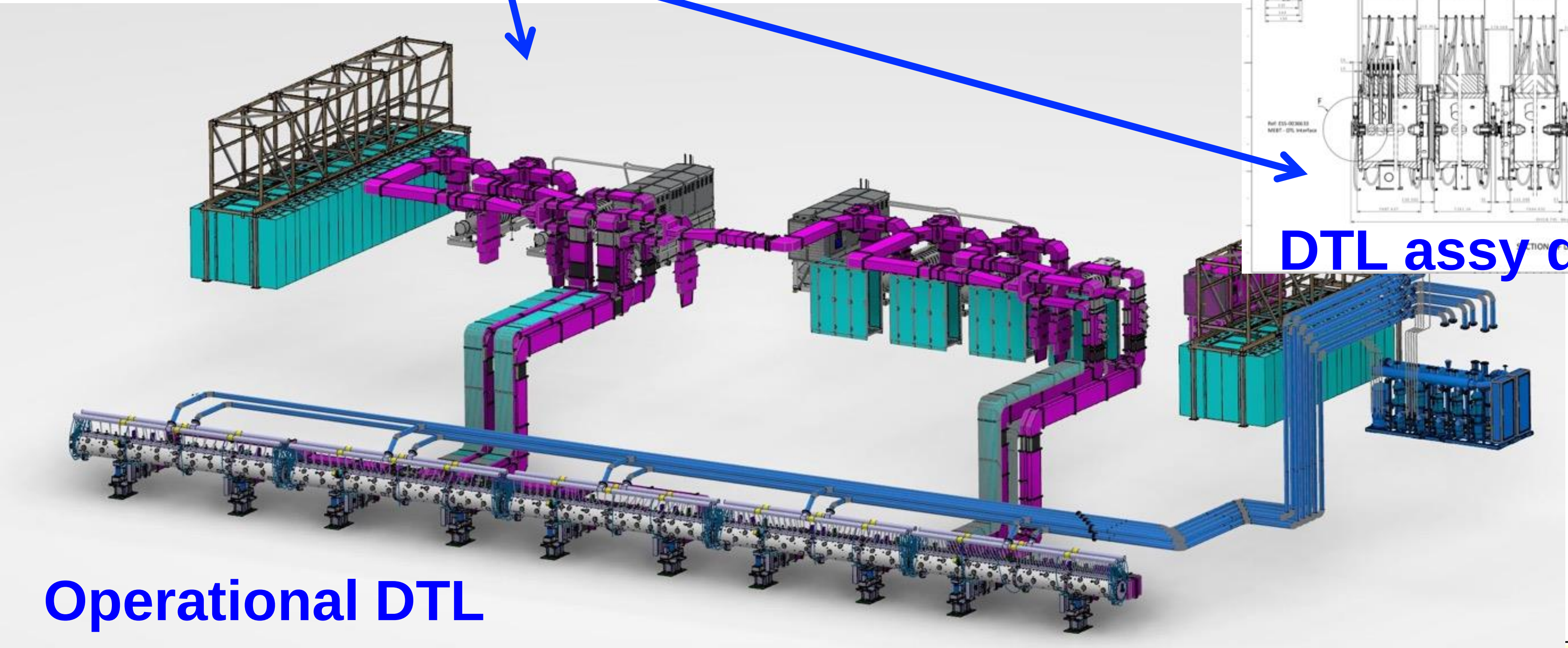
A compact linac does not only contain the **accelerating parts** but also the power sources, electronics, controls, waveguides, cooling sources etc. and assembly that need design and space to fit in



DTL



DTL assy dwg



Operational DTL

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Machine design maturing cycle

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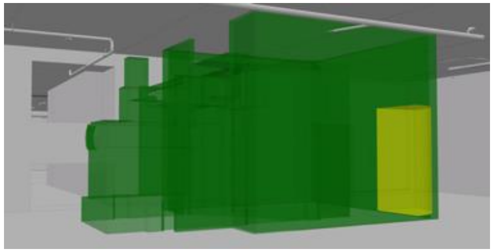
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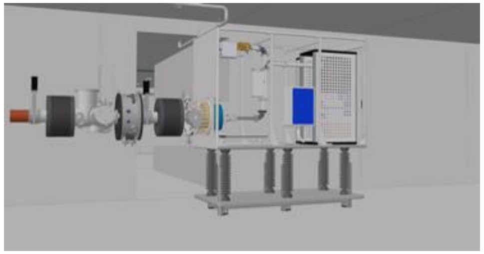
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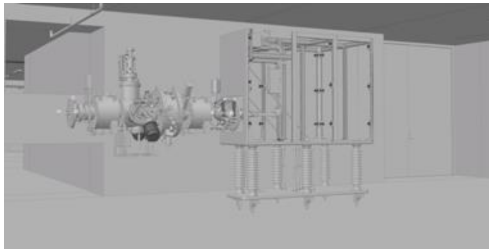
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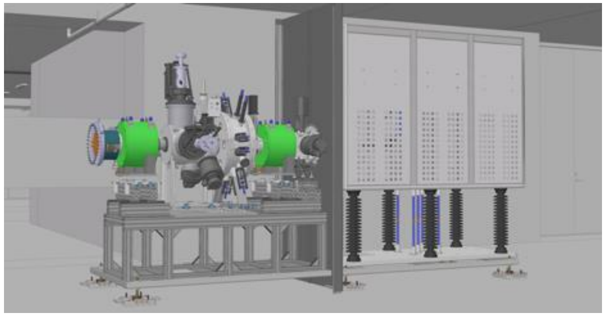
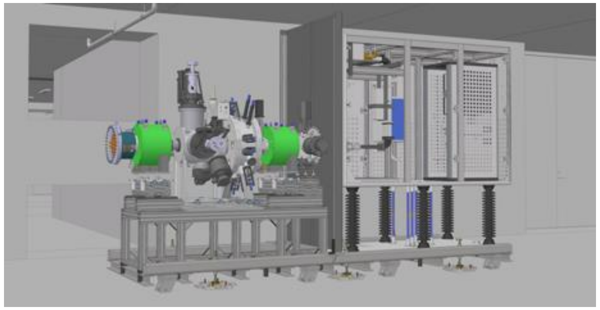
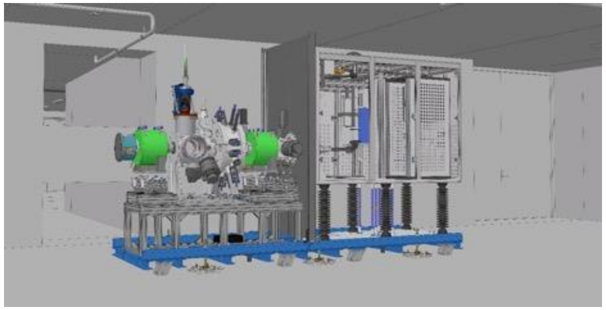

4. Manufacturing launch


5. Installation Review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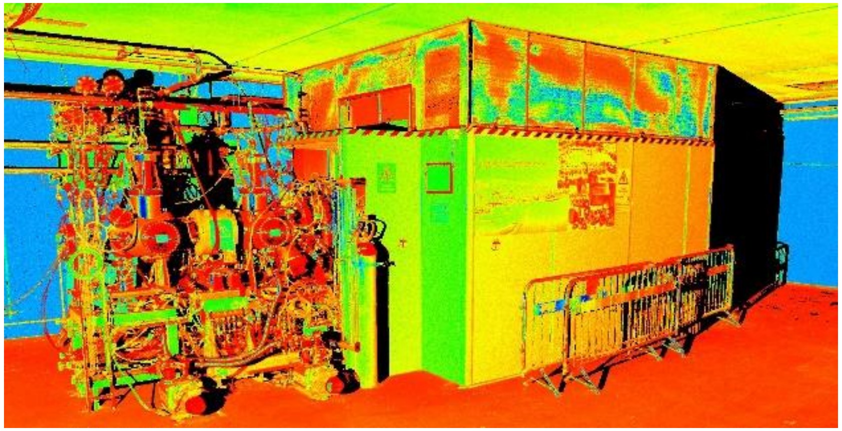
7. As-Scanned


8. As-Built & Commissioned