

# Mechanical Engineering of Accelerator Components and Peripherals

Antti Kolehmainen, Tommi Mikkola and Tuukka Lehtinen  
on behalf of CERN EN-MME

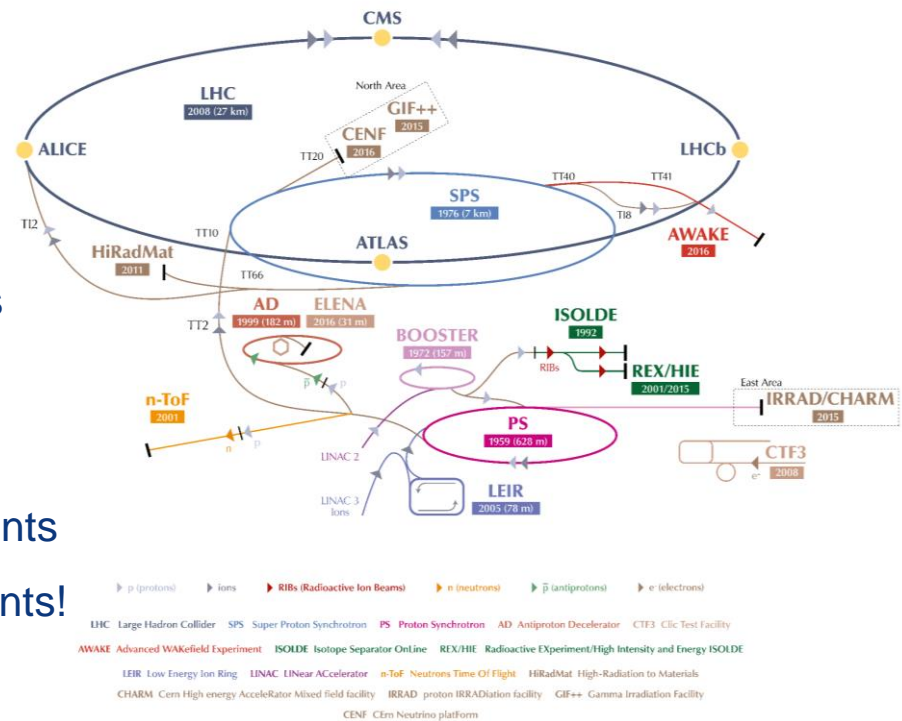


ENGINEERING  
DEPARTMENT

# CERN EN-MME Group

*“The mandate of the MME group is to provide to the CERN community specific engineering solutions combining mechanical design, fabrication and material sciences.”*

- EN-MME group size roughly 180 people
- Our main activities are:
  - Mechanical design
  - Engineering calculations and simulations
  - Production and sourcing
  - Material development
  - Mechanical and geometrical measurements
- We work on all the machines and experiments!



EN-MME = Engineering Department – Mechanical and Materials Engineering

# Mechanical Design – Design Inputs

## Client specification

## Space limitations and interfaces

Page 4 of 11

**1. INTRODUCTION**  
This document represents the basic requirements for the 3D model of the ELENA MBR design, done in CATIA. It further represents the interface document between the magnet work package and the design office.

**2. NOMENCLATURE**  
All the parts and assemblies established for this magnet shall follow the same nomenclature as the prototype (e.g. AD\_MBHEKXXXX, where XXXX is a consecutive number).

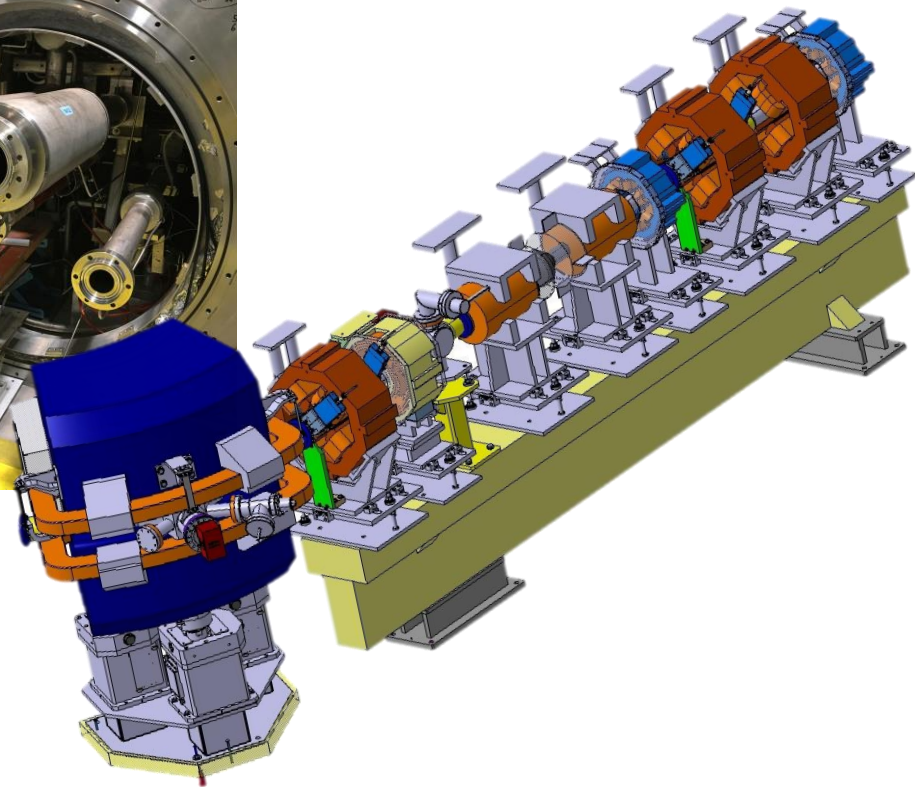
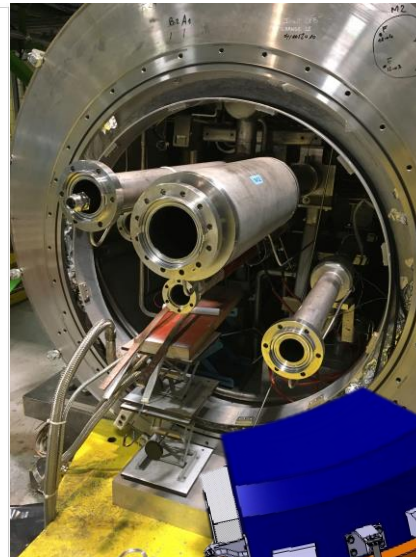
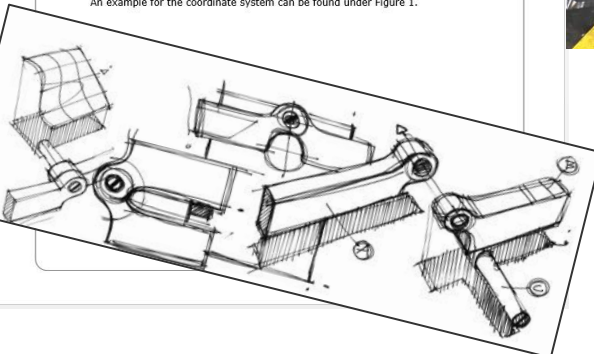
**3. SOFTWARE**  
For this design it has been agreed that the software used will be CATIA V5. The release version may change according to CERN procedures.

**4. COORDINATE SYSTEM**  
The coordinate system to be observed shall be the following:

Right handed, orthogonal coordinate system to be used

- z-axis: tangential to the beam in the direction of the beam in the center of the magnet
- y-axis: vertical in the opposite direction to gravity, 0 at the magnet center
- x-axis: According to a right-handed coordinate system perpendicular to x and z (0 at mechanical pole center)

An example for the coordinate system can be found under Figure 1.

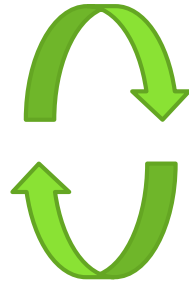


All project parties participate in defining design inputs!

# Mechanical Design – Process

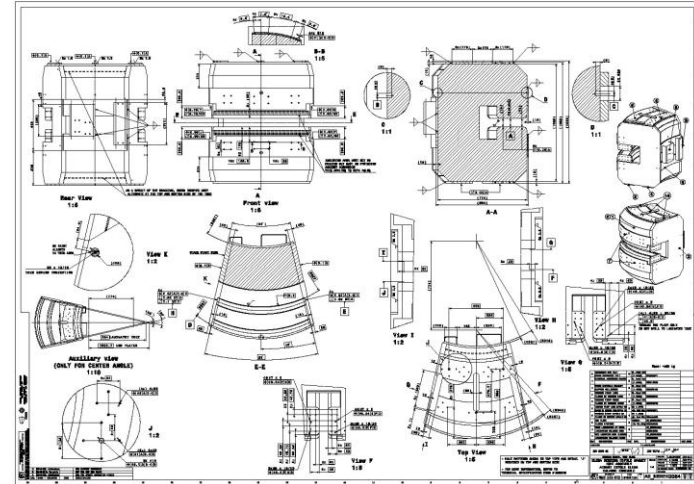
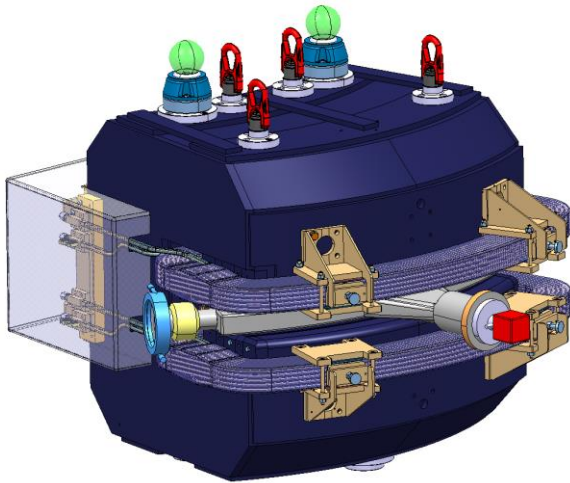
## Iteration:

- Designer – Client
- Analysis, simulation
- Integration
- Manufacturing



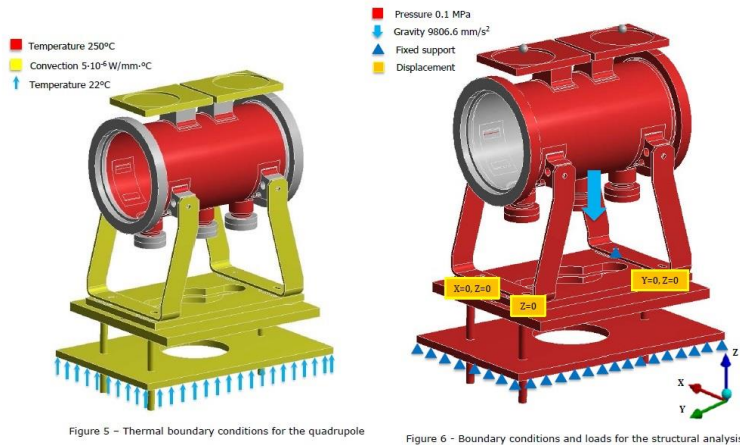
## Deliverables:

- 2D drawings
- 3D models
- Supporting documents, such as analysis or measurement reports



# Engineering Calculations and Simulations

**Why:** To guide design work, to meet requirements, and to assess safety



Boundary conditions

Functional device

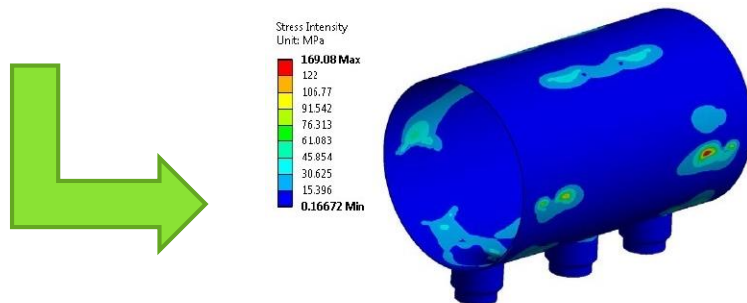


Figure 10 - Stress intensity for the vacuum vessel.

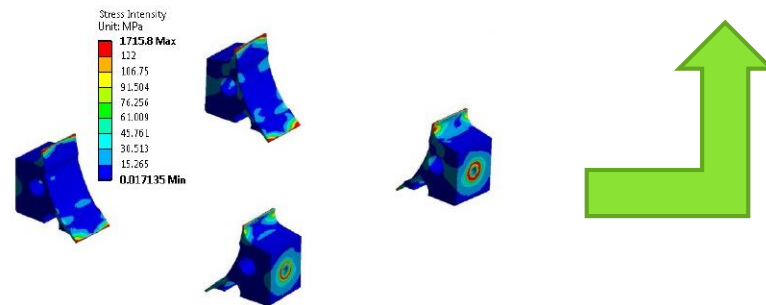
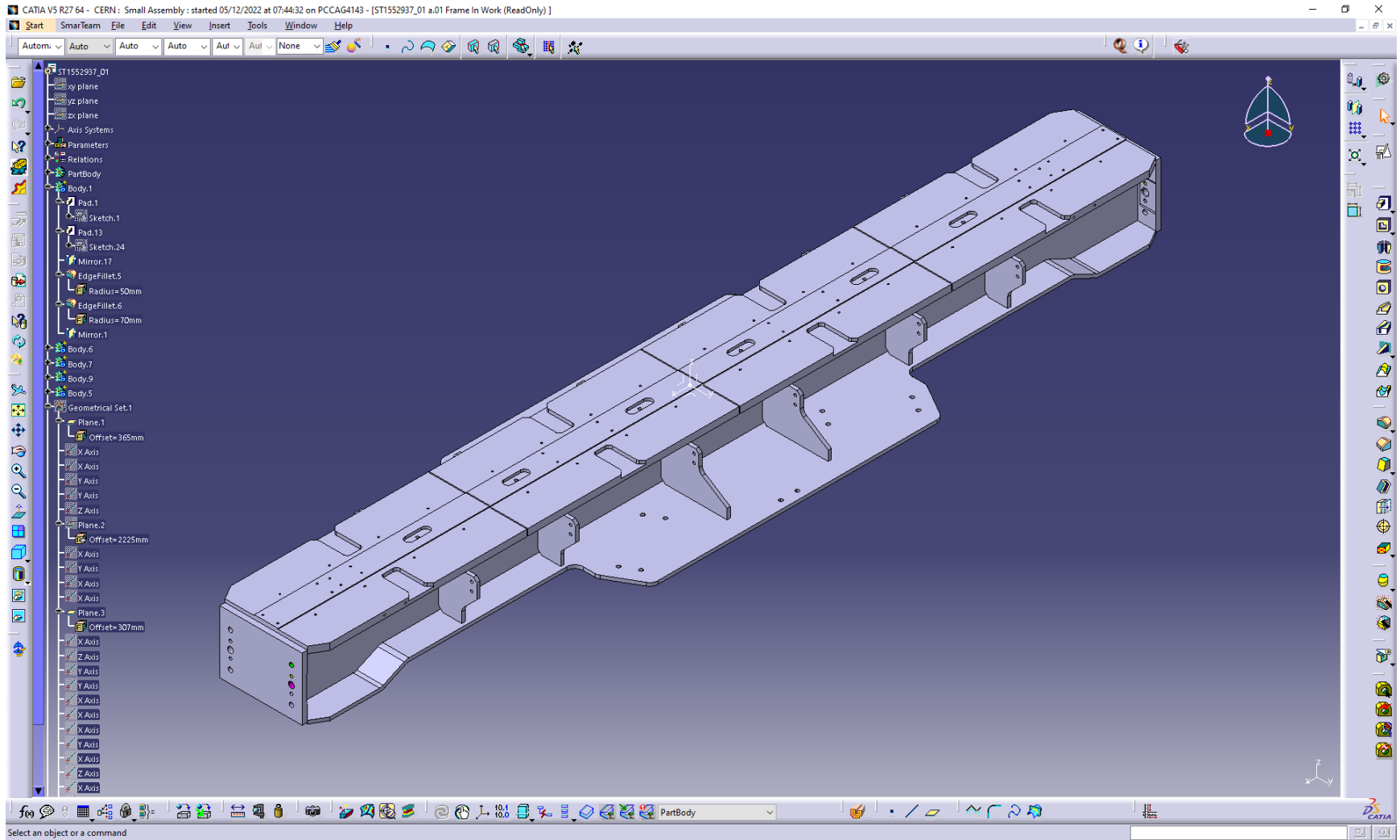


Figure 11 - Stress intensity for the welded connectors.

Analysis results

# CAE Tools - CATIA



# CAE Tools - CATIA

CATIA V5 R27 64 - CERN : Small Assembly : started 05/12/2022 at 07:44:32 on PCCAG4143 - [ST1552937\_02 a.00 Frame In Work (ReadOnly)]

Start SmartTeam File Edit View Insert Tools Window Help

Default

Sheet.1

Front view  
Top view  
A-A  
C-C  
B-B  
D  
View F  
Isometric view  
G  
View J  
E-E

View F 1:10  
View J 1:5 2x  
A-A 1:5 2x  
B-B 1:5 6x  
C-C 1:5 4x  
D 1:5 6x  
E-E 1:5  
G 1:5 2x

1:15

Notes:  
• Large sheet metal plates may be manufactured out of multiple sheets by means of their welding given that full material strength is maintained.  
• 2011 or equivalent.

Title Block	
Part Name	Frame
Part Number	ST1552937_02
Revision	02/21
Author	
Checked	
Released	
Drawn	
Scale	1:10
Date	
Sheet	1 of 1

Select an object or a command

# CAE Tools - ANSYS

**J: Static Structural - Mechanical [ANSYS Mechanical Enterprise]**

**ANSYS 2020 R2**

**J: Static Structural**  
 Equivalent Stress  
 Type: Equivalent (von-Mises) Stress - Top/Bottom  
 Unit: MPa  
 Time: 1 (Unconverged)  
 06/12/2022 10:04

**2624.9 Max**  
 2333.8  
 2042.7  
 1751.6  
 1460.6  
 1169.5  
 878.41  
 587.32  
 296.24  
**5.1635 Min**

**Details of "Equivalent Stress"**

**Scope**

Scoping Method	Geometry Selection
Geometry	All Bodies
Layer	Entire Section
Position	Top/Bottom

**Definition**

Type	Equivalent (von-Mises) Stress
By	Time
Display Time	1.e-002 s
Calculate Time History	Yes
Identifier	
Suppressed	No

**Integration Point Results**

Display Option	Averaged
Average Across Bodies	No

**Results**

Minimum	5.1635 MPa
Maximum	2624.9 MPa
Average	1132.2 MPa
Minimum Occurs On	SYS-@Surface(Eigenvalue Buckling)
Maximum Occurs On	SYS-@Surface(Eigenvalue Buckling)

**Graph**

Animation | 100 Frames | 4 Sec | 3 Cycles

Y-axis: [MPa] (Scale: 1.e-2)  
 X-axis: [s]

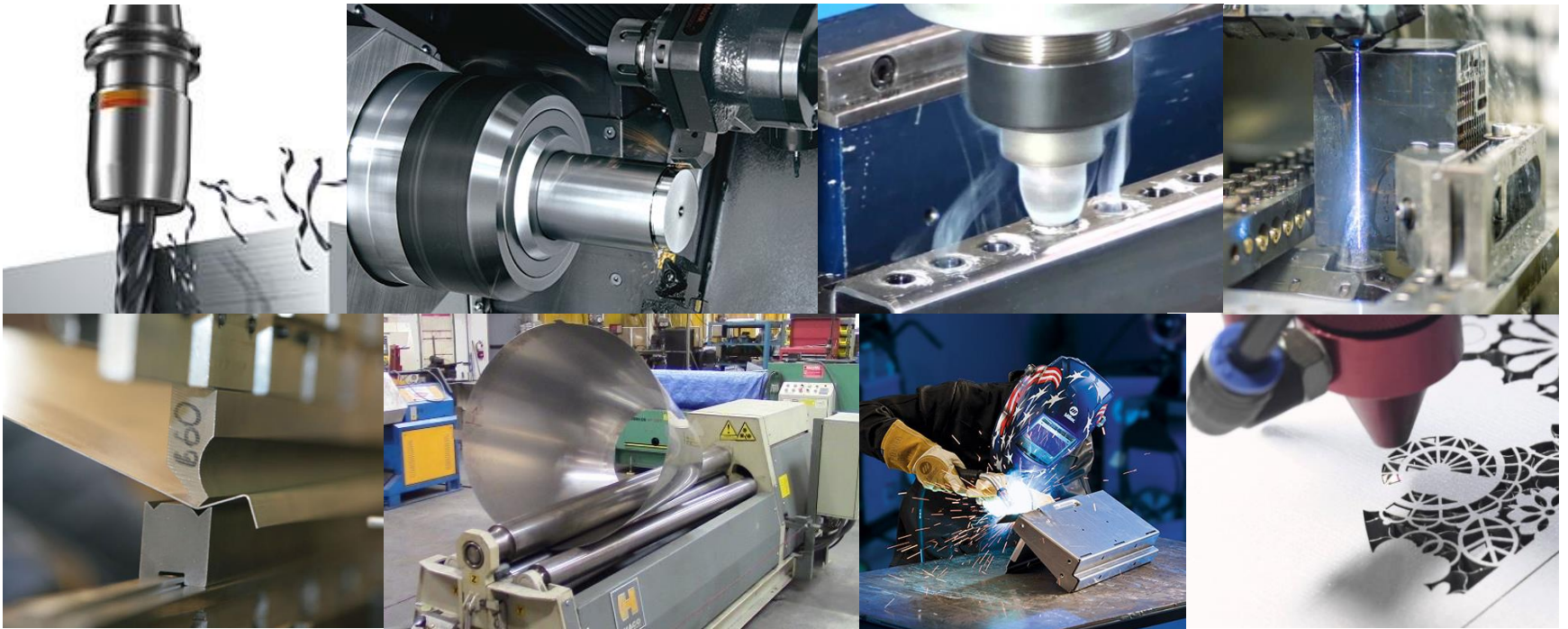
**Tabular Data**

Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1	1.e-002	2.6963	5.9644
2	2.e-002	5.3925	11.928
3	3.e-002	8.089	17.902
4	4.e-002	10.785	23.872
5	5.e-002	13.48	29.851
6	6.e-002	16.175	35.818
7	7.e-002	18.871	41.802
8	8.e-002	21.565	47.78
9	9.e-002	24.259	53.768
10	1.e-001	26.953	59.751
11	0.11	29.647	65.746
12	0.12	32.34	71.733
13	0.13	35.033	77.736



# Manufacturing and Production

- EN-MME operates three machine shops mostly for prototype and small series production
- Capabilities:
  - Machining: Milling, turning, drilling, cutting, grinding, electrical discharge machining, etc.
  - Forming: Sheet metal bending, rolling, punching, pressing, extrusion, etc.
  - Joining: Welding, brazing, soldering, etc.



# Material Development and Measurements

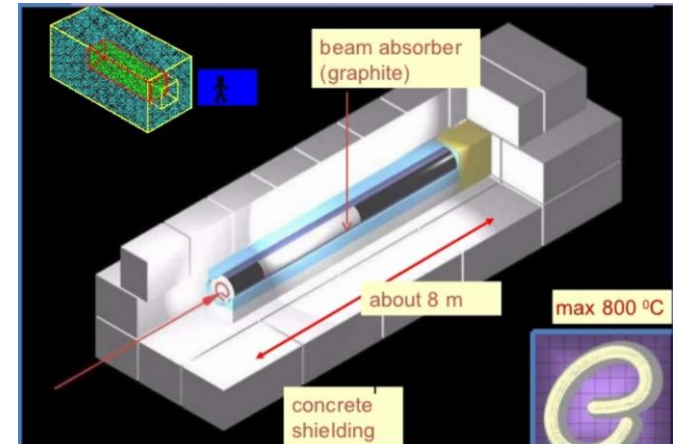
Material development examples:

- Graphites for beam impacts
- Stainless steel alloys for permeability

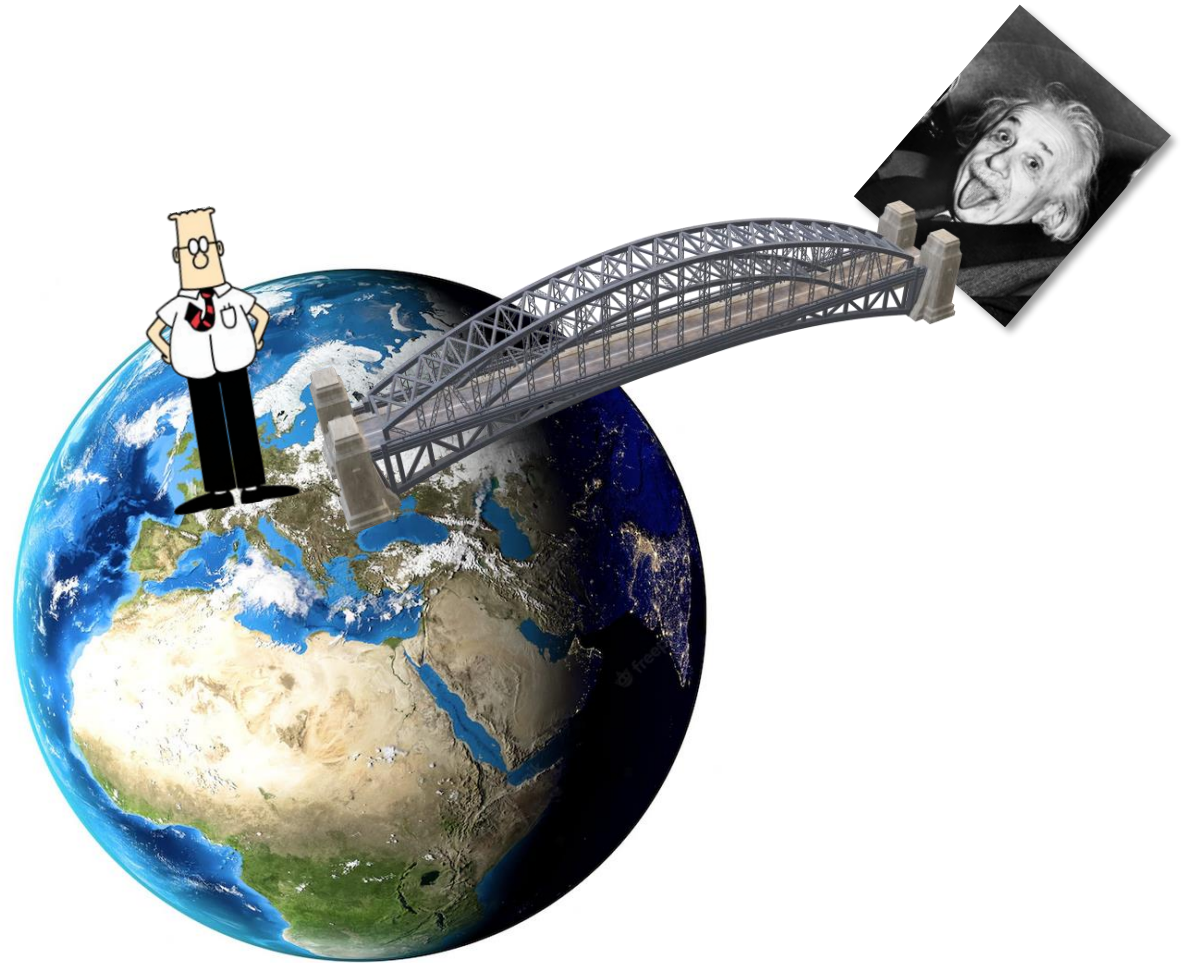
Mechanical measurement examples:

- Non-destructive testing: X-ray for LHC dipole magnets
- Destructive testing: Material tensile strength testing

Geometrical measurements: Verification of component compliance to specification (drawings and/or model)



# Challenges



Note! Bridge length varies between some micrometers to some parsecs...



ENGINEERING  
DEPARTMENT

Questions!