AHCAL
Mechanics

status report

Karsten Gadow

CALICE AHCAL main meeting

DESY, 17.12.2014

HELMHOLTZ ASSOCIATION

DESY

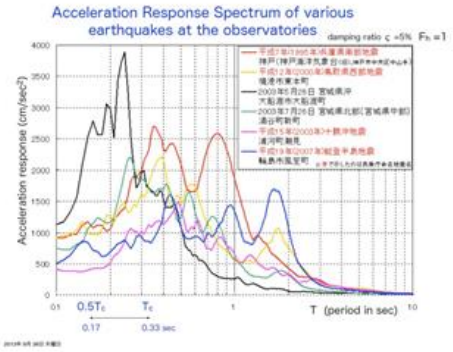
Absorber structure validation (earth quake)

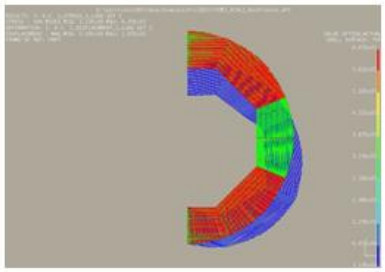
AHCAL Mechanics
Absorber structure validation (earth quake)

ILD workshop, Cracow, 24-26 September 2013

Summary on seismic issues

1. Earthquake protection will follow the ISO3010;
   uses analysis with acceleration response spectrum
2. Earthquake model at Kitakami site :
   150 gal (100 years) as earthquake representative
   , where flat period between 0.17 to 0.34sec (dT_c - T_c)
   the amplification factor(f_A) of less than 2.5
3. We would like to analyze ILD earthquake protection.
   - Rigidness of ILD detector
   - Isolation method with respect to the platform
     and detailed layout needed





Simulation for
AHCAL barrel structure
will be done in summer 2014 by DESY-ZM1

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AHCAL absorber structure validation

Internal order to DESY Group ZM1 (group engineers: M.Lemke, R.Platzer)

Order requirements:

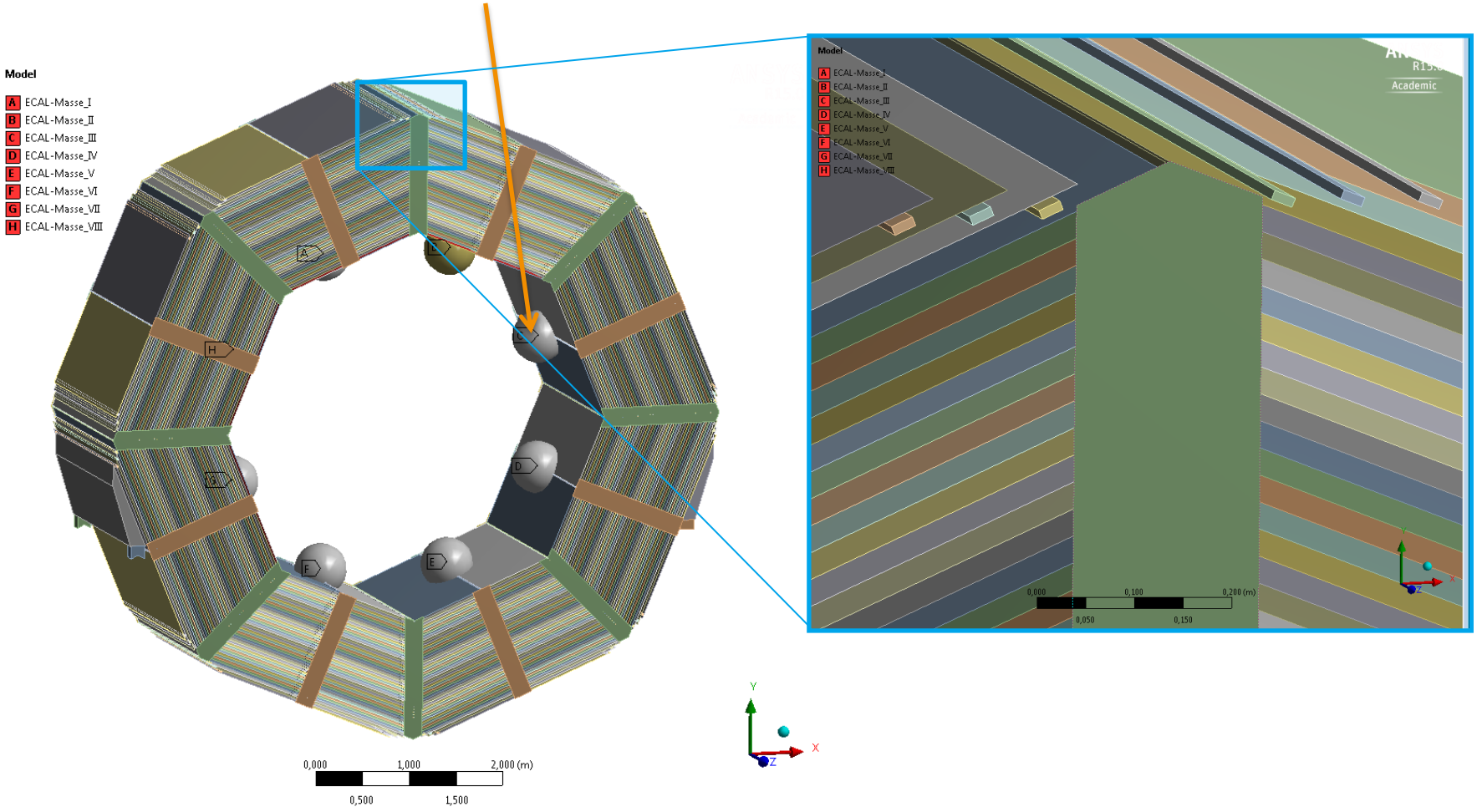
- stress analysis for the design concept of the AHCAL and test the static integrity of the absorber structure including the detailed investigation of all screw joints **(65% done)**
- dynamic stress analysis for the design concept of the AHCAL to proof the static integrity for an possible ILD construction area in Japan **(20% done)**
- the dynamic stress analysis must fulfill the ISO 3010 and Eurocode 8 (earthquake) **(5% done)**
- the dynamic stress analysis must be done with real earthquake data from März 2011 (Ichinoseki / data: NIED K-NET IWT010 2011/03/11) **(5% done)**

AHCAL geometry preparation

- analysis of conceptual setup of the ILD CAD model **(done)**
- check constrains from AHCAL to the other detector parts
  ILD platform<>Iron Yoke<>Coil Cryostat<>AHCAL with rail system<>ECAL **(done)**
- get all relevant data for the finite element analyses FEM masses for
  all detector components (ECAL, Coil, ...) **(done)**
- simplify the connection between AHCAL and cryostat **(done)**
- create full shell model for AHCAL **(done)**
- create 3D detail models incl. all single parts and screw joints
  for detailed investigation **(done)**
- creating of the principle main model of the middle iron yoke, coil cryostat,
  AHCAL and ECAL for the dynamic analyses **(50% done)**

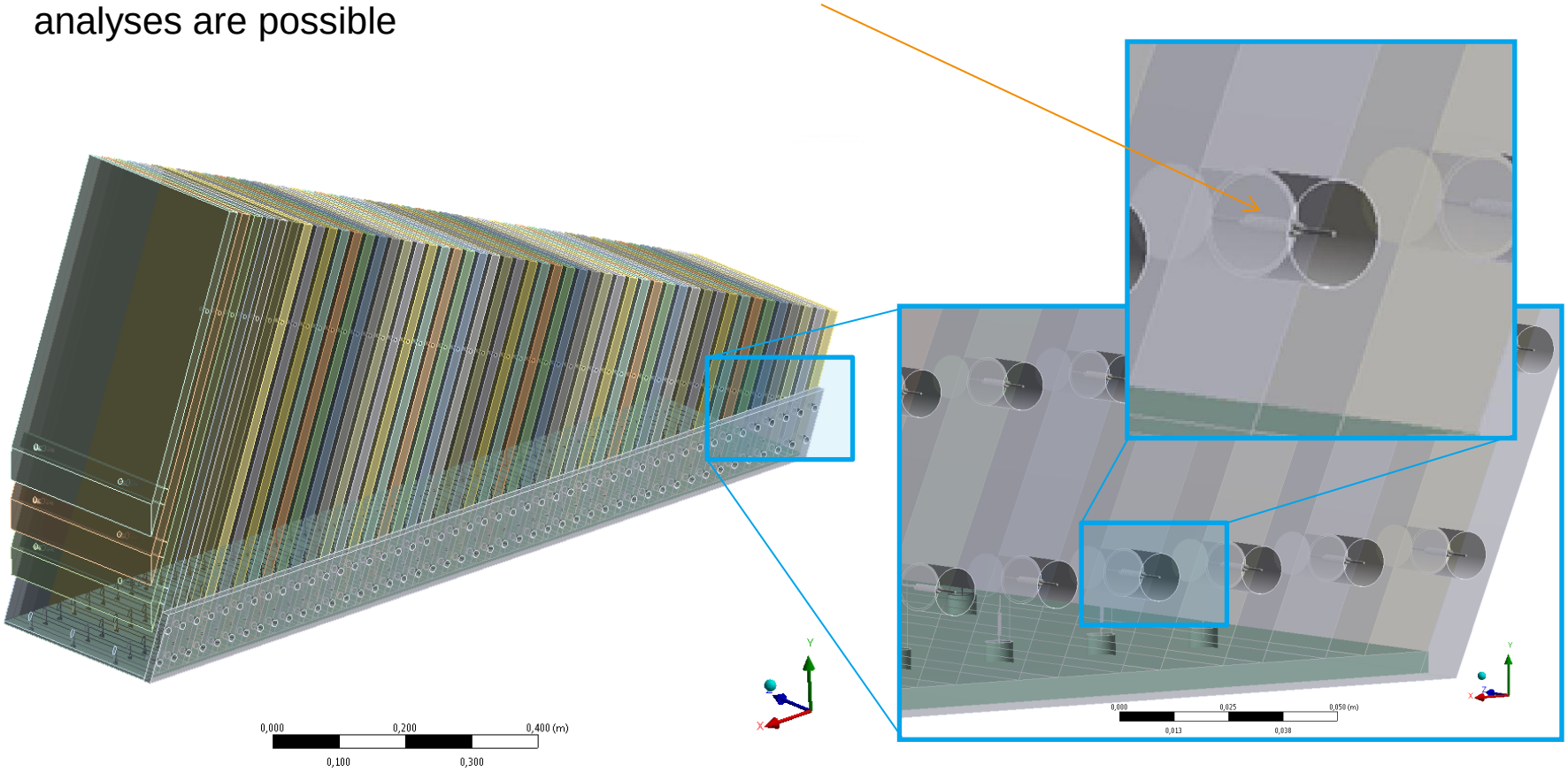
AHCAL shell model

AHCAL shell model with ECAL point masses



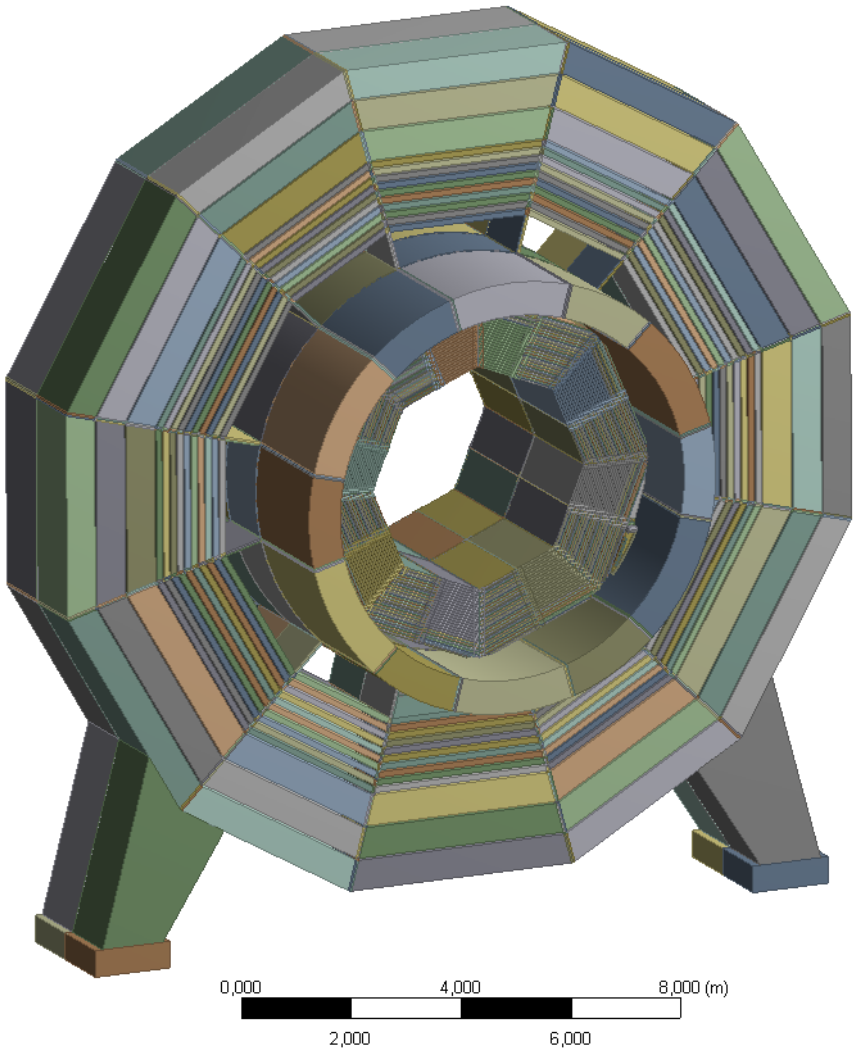
AHCAL screw joints

- detailed modeling with 3D structures
- screw joints are modeled as preloaded elastic spring parts therefore single screw joints analyses are possible



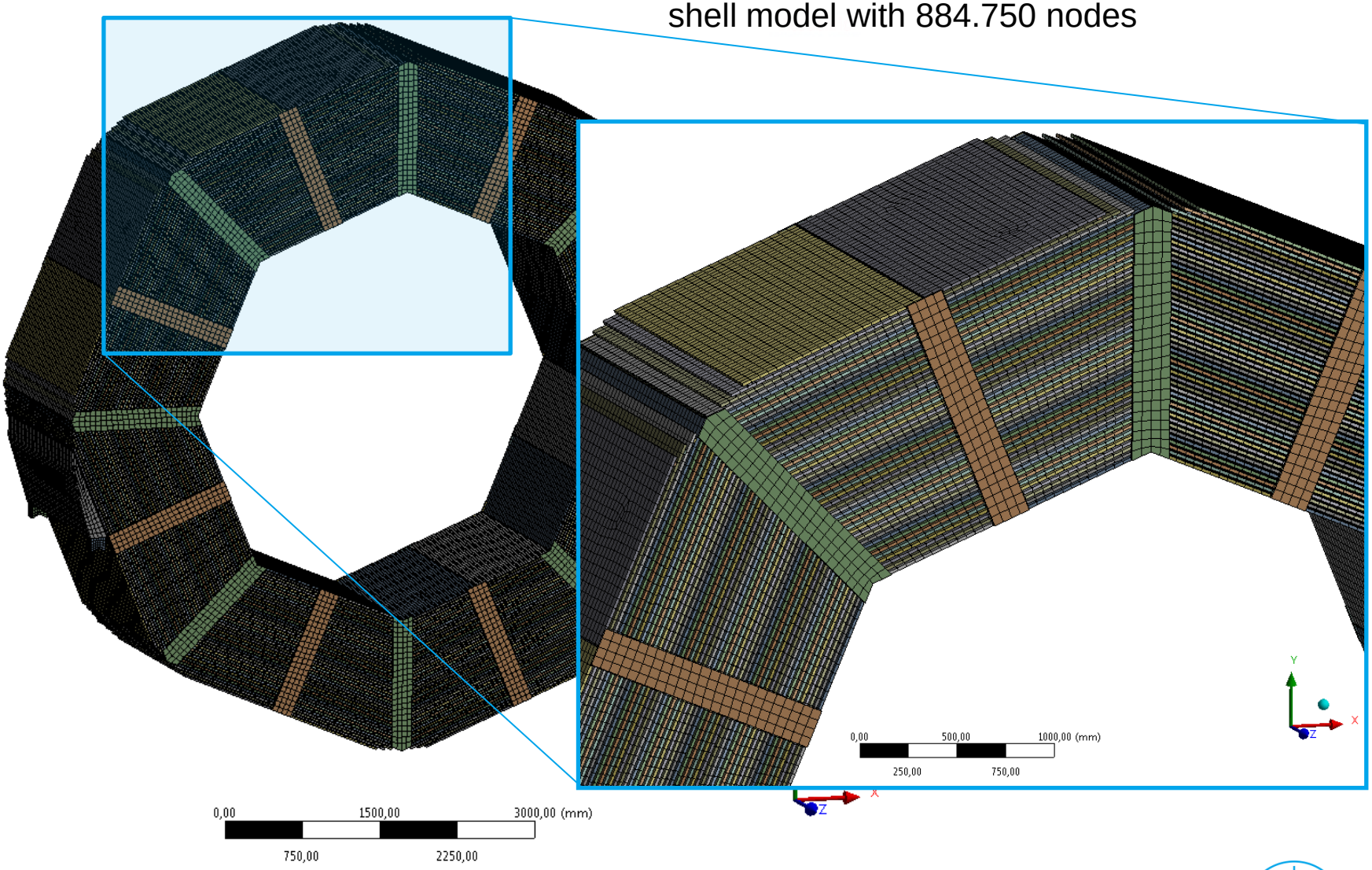
Main ILD shell model

shell model for dynamic analyses consisting from middle iron yoke, coil cryostat, AHCAL and ECAL



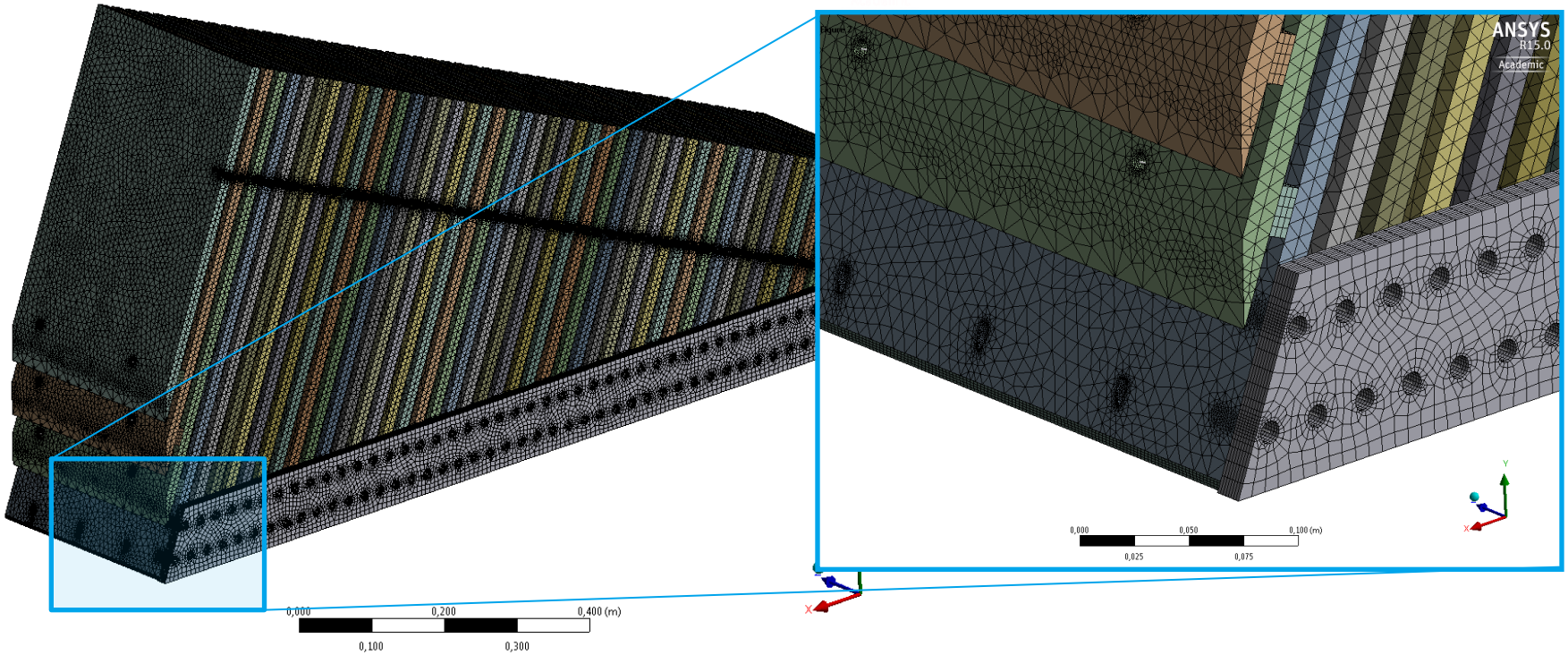
AHCAL shell model grid

shell model with 884.750 nodes



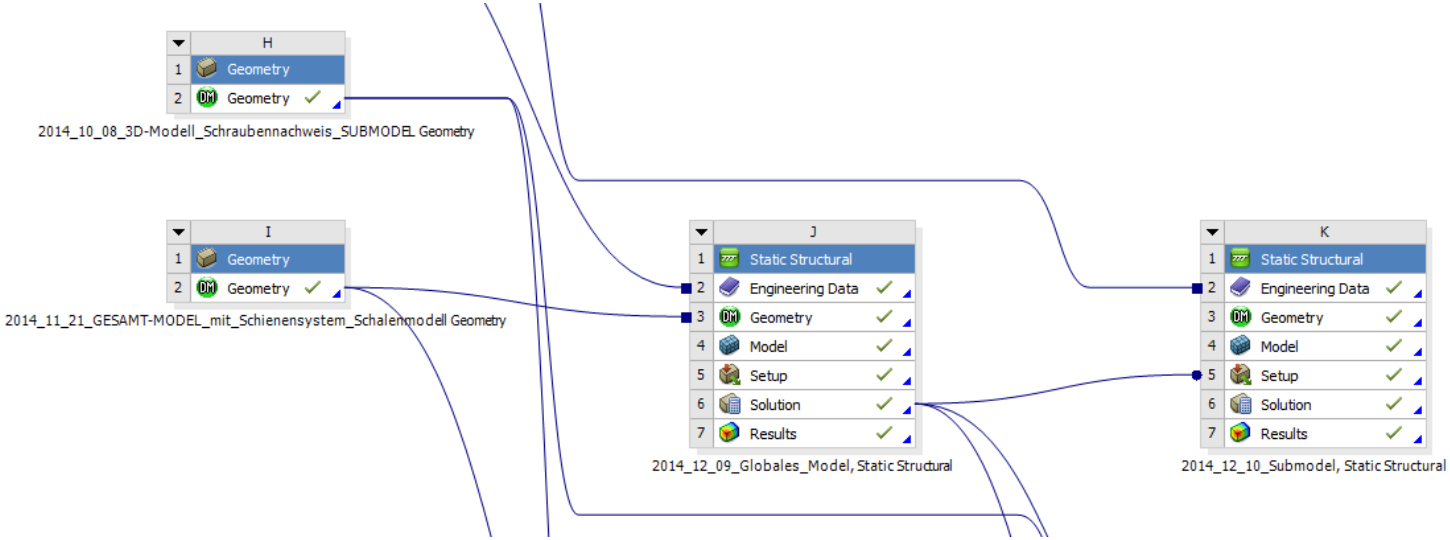
AHCAL detail shell model grid

tetrahedron and hexahedron elements with quadratic element functions are the basis of the 3D grid geometry (here 6,45 mi. nodes)



Workflow for all finite element analyses

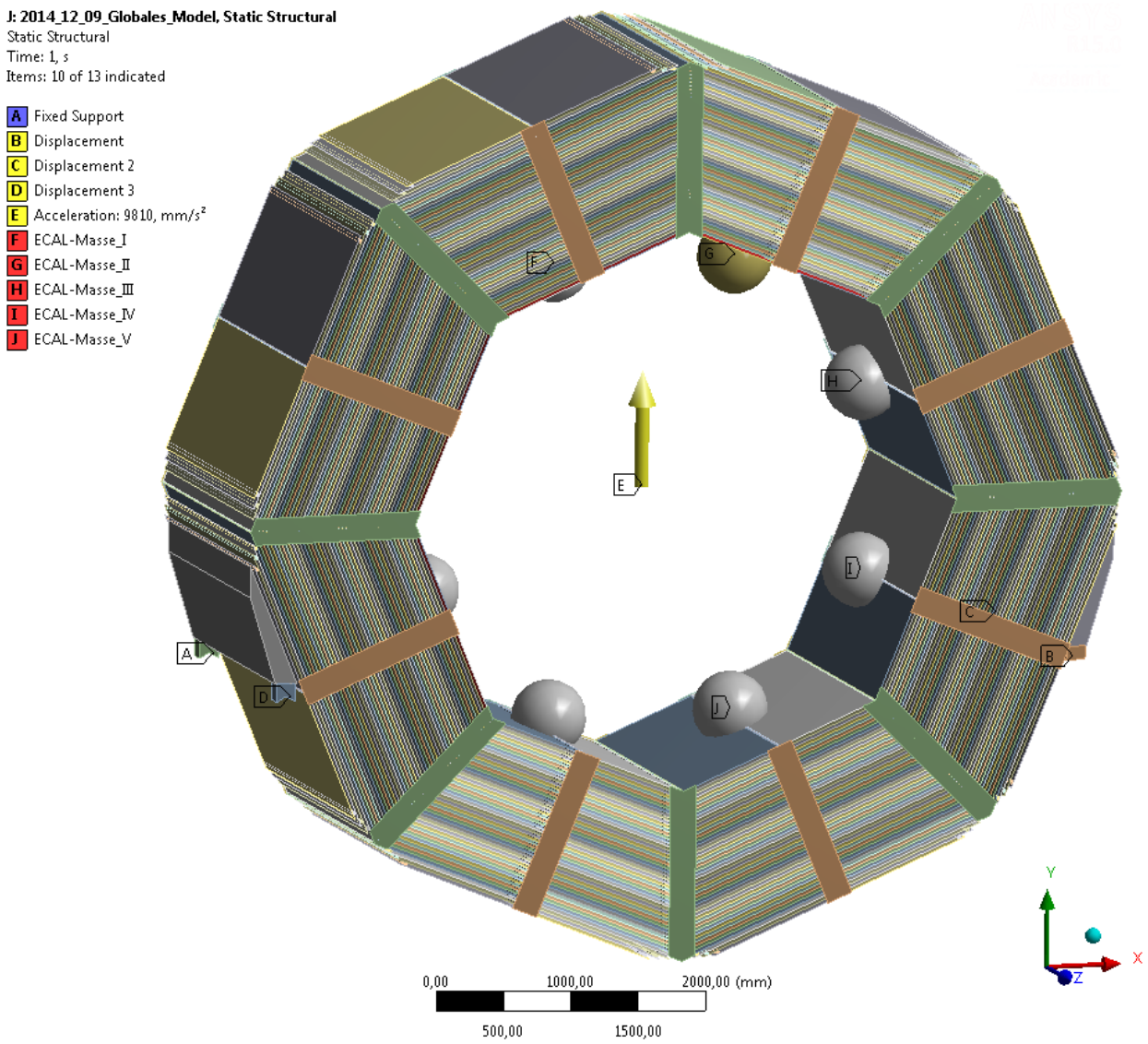
- determining of the calculation diagram (very big model size) **(done)**
- calculation of the entire AHCAL model (shell model) **(done)**
- detailed calculation with complete 3D geometry's at relevant segments of the entire AHCAL model **(done)**
- calculation of the mechanical load to the structural components (displacement, tension) **(done)**
- working load of the screw joints and detailed verification **(started)**



Static finite element analyses

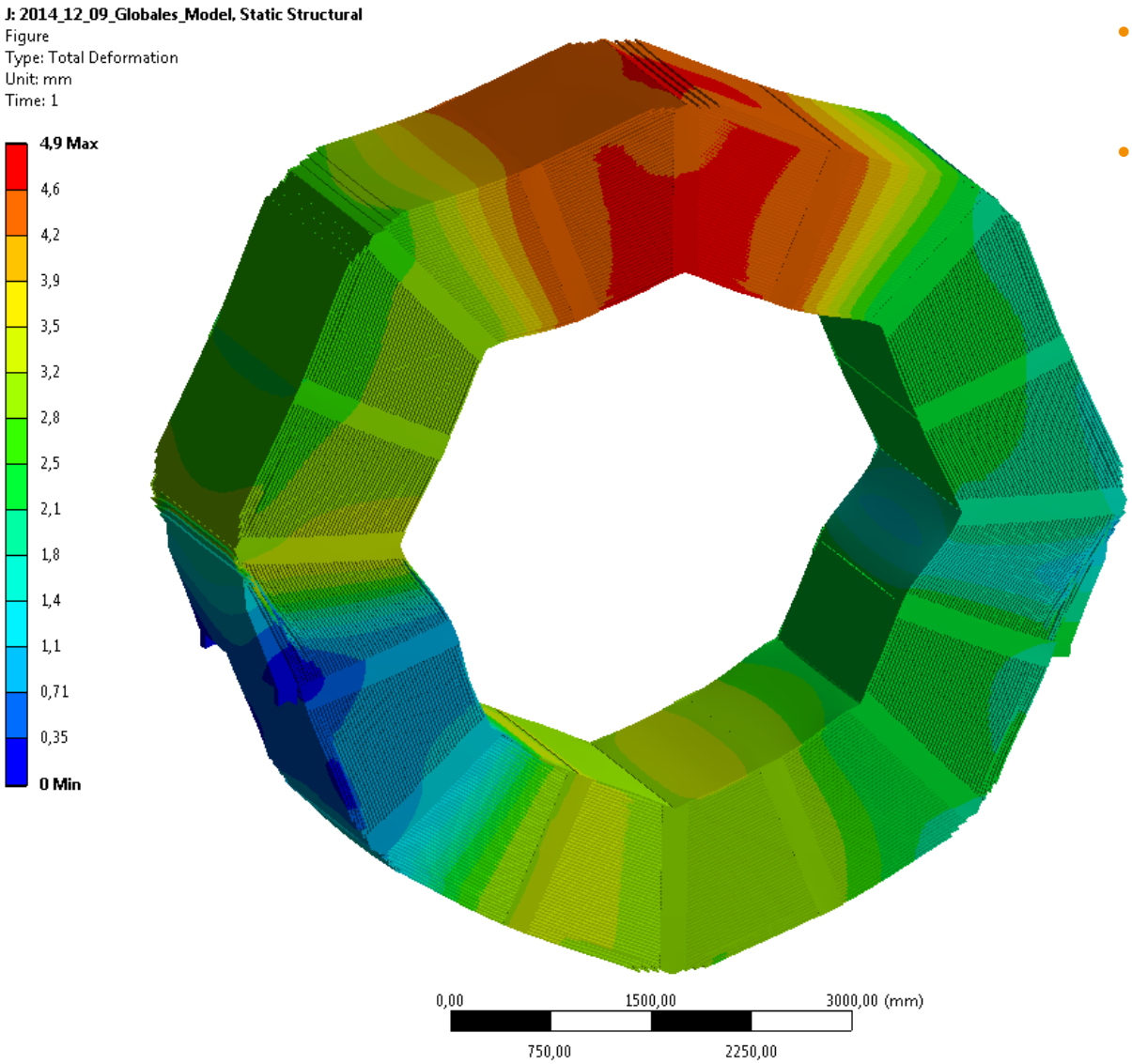
- static finite element analyses to investigate the entire AHCAL detector structure to characterize the stiffness and deformation behavior as a baseline for the dynamic analyses of earth quake incidents.
- static calculation of the AHCAL incl. sensor mass of 16,82 kg/m² and ECAL segments
  - AHCAL on rail system with dead load **(done)**
  - AHCAL on rail system with dead load and 9,81 m/sec² *vertical* acceleration **(done)**
  - AHCAL on rail system with dead load and 9,81 m/sec² *horizontal* acceleration **(done)**
  - AHCAL on rail system with dead load and 9,81 m/sec² *diagonal* acceleration **(done)**
- 3D detail model calculation with the four loads at all critical zones **(50 % done)**

AHCAL boundary conditions for static FEA



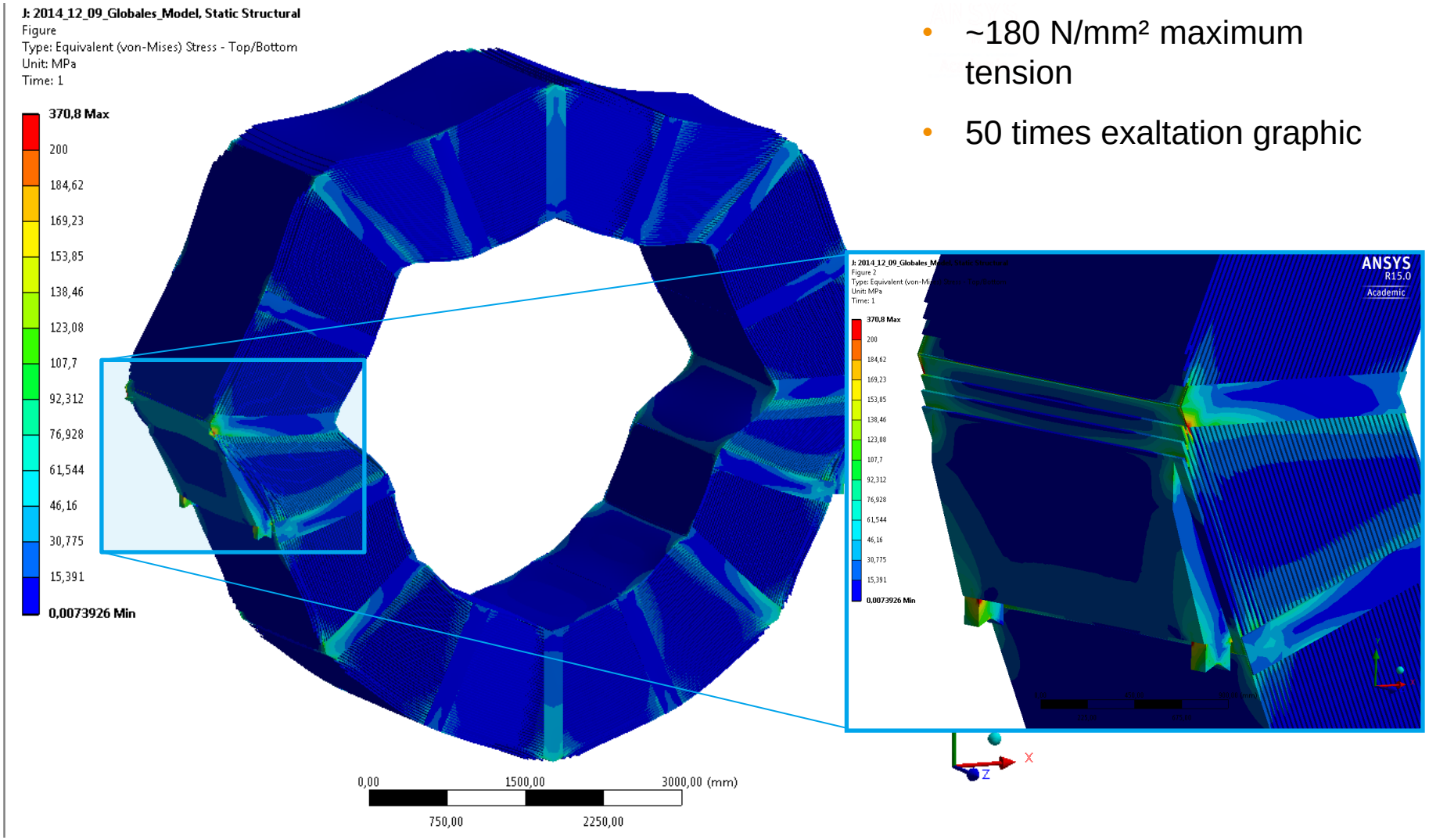
- gravity
- realistic support and displacements
- installed ECAL masses

AHCAL deformation results for static FEA



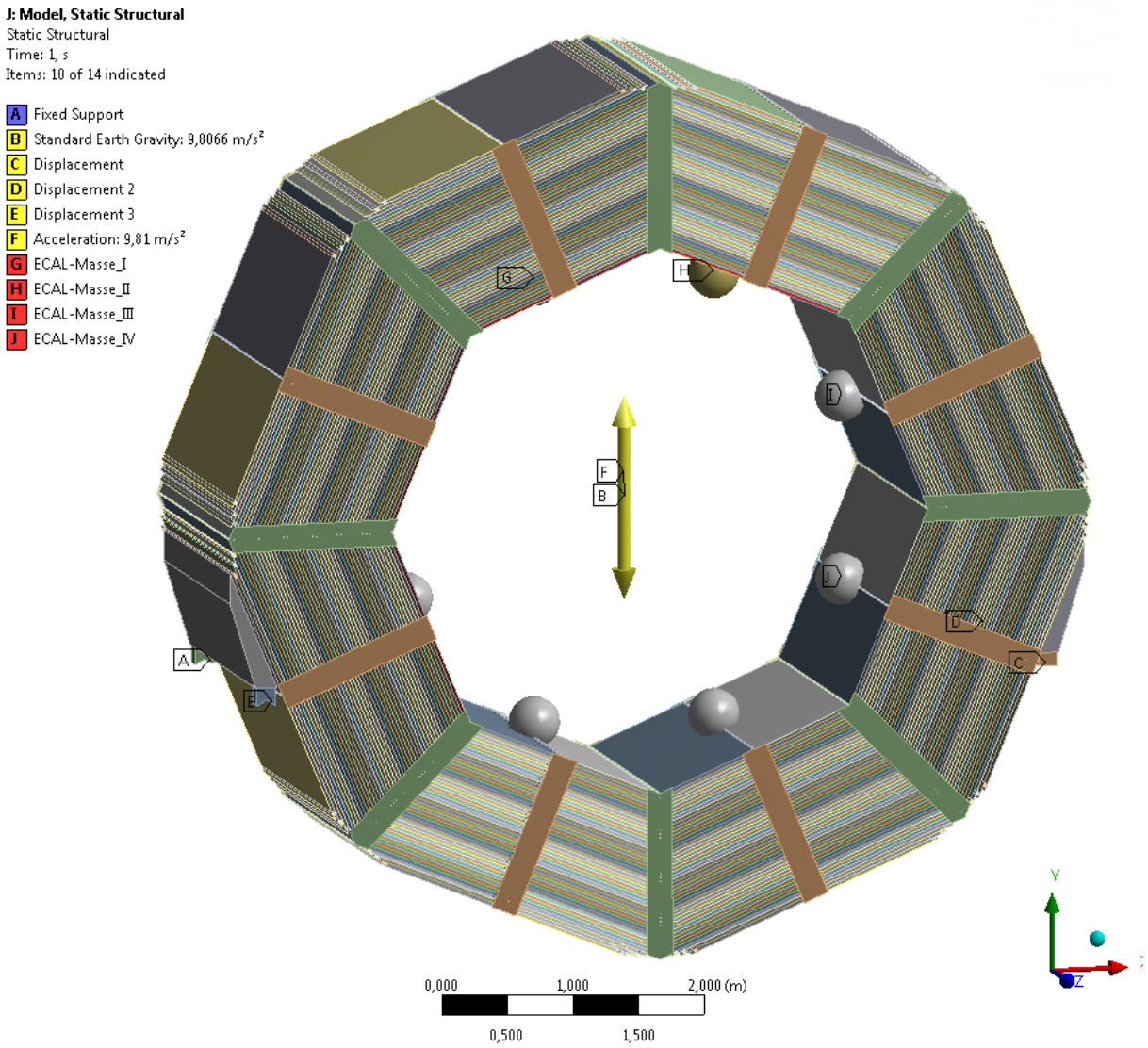
- 5,0 mm maximum deformation
- 50 times exaltation graphic

AHCAL tension results for static FEA



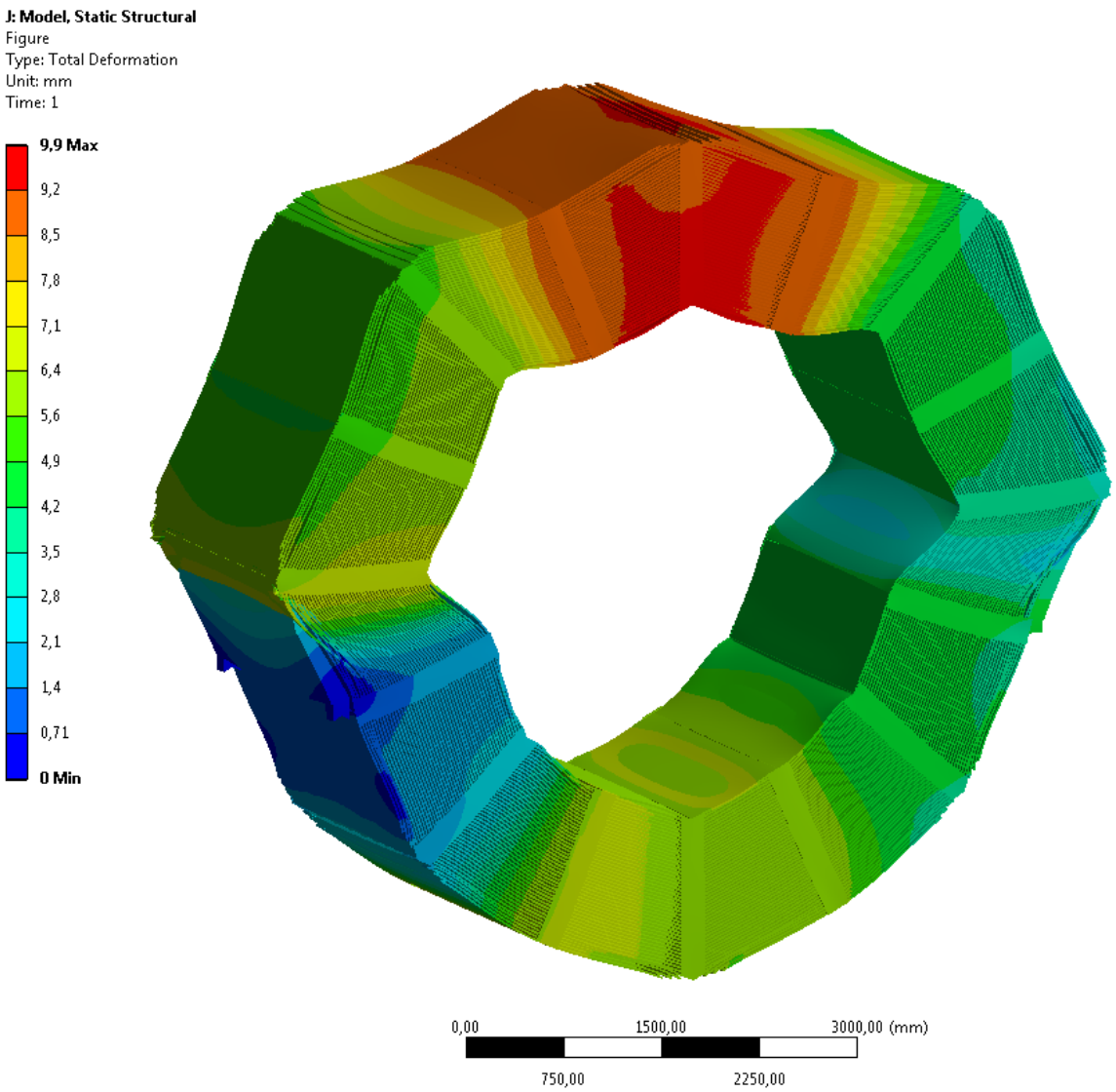
- ~180 N/mm² maximum tension
- 50 times exaltation graphic

AHCAL boundary conditions for static FEA + 1g



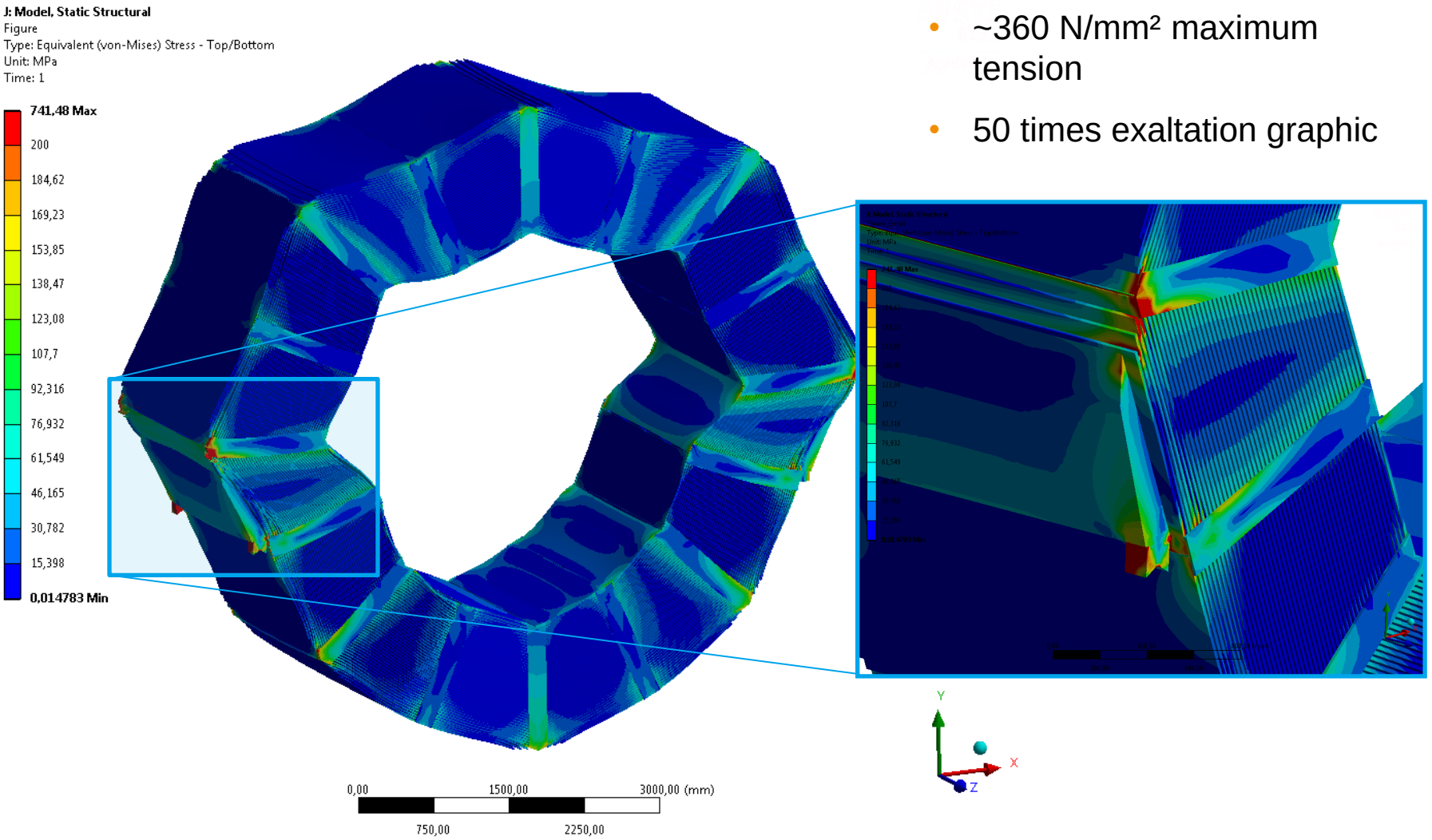
- gravity + 1g
- realistic support and displacements
- installed ECAL masses

AHCAL deformation results for static FEA +1g



- 10,0 mm maximum deformation
- 50 times exaltation graphic

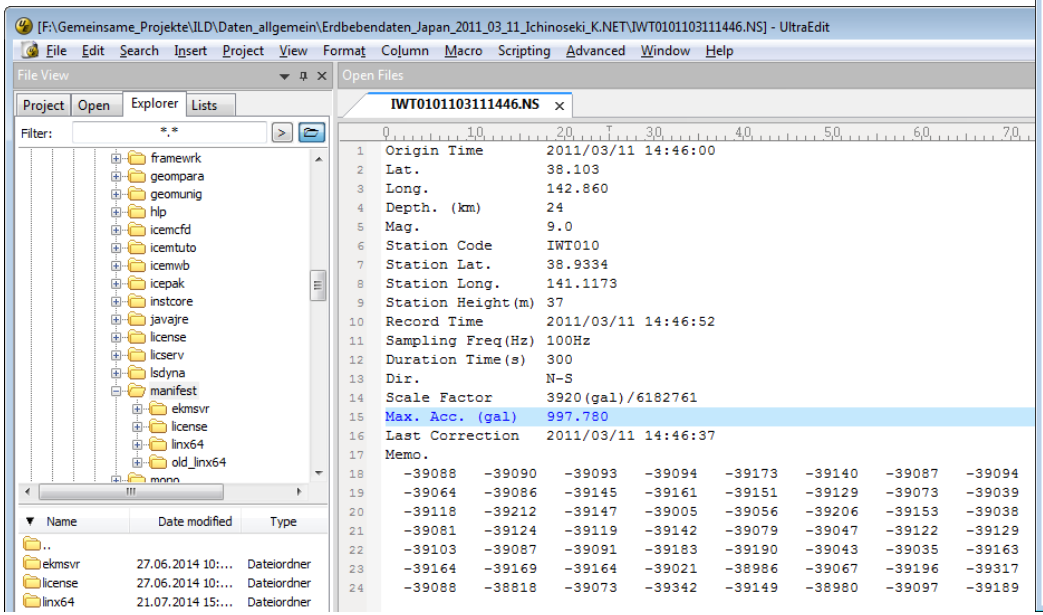
AHCAL tension results for static FEA + 1g

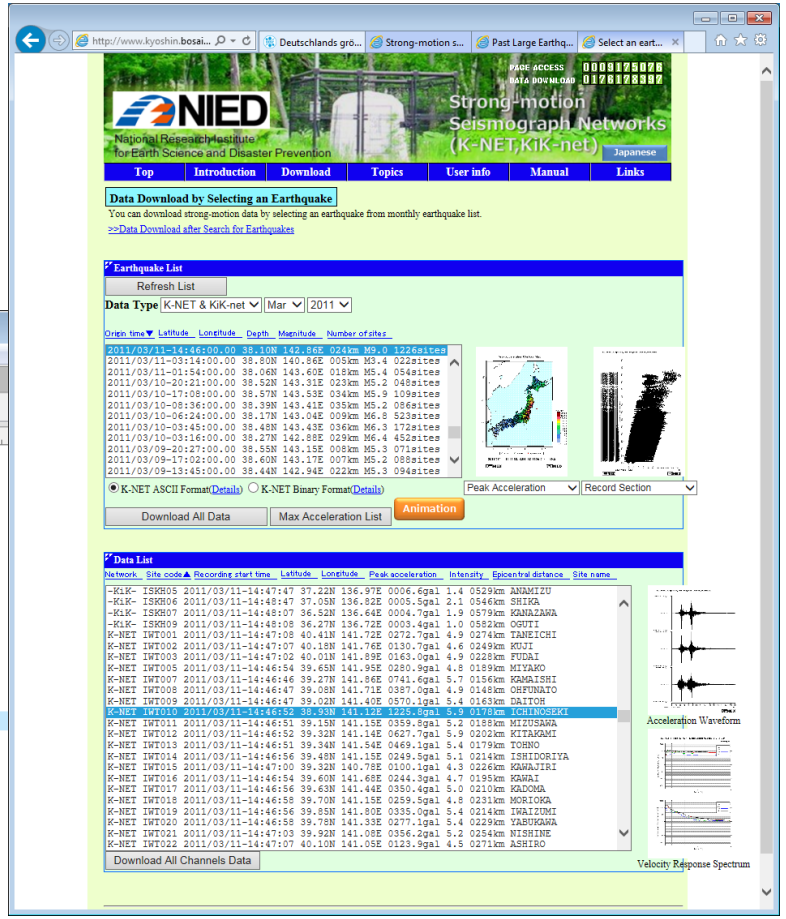


- ~360 N/mm² maximum tension
- 50 times exaltation graphic

earthquake data from Japan (NIED-Network)

- earthquake data Ichinoseki (NIED K-NET IWT010 2011/03/11)
- maximum amplitudes
  - east-west 852,134 gal (8,52 m/sec²=>0,86 g)
  - north-south: 997,780 gal (9,98 m/sec²=>1,02 g)
  - vertical: 352,666 gal (3,53 m/sec²=>0,36 g)





roadmap for dynamic AHCAL finite element analyses

- earthquake data
  - investigate ISO 3010 und Eurocode 8 **(75 % done)**
  - proof of practicability for the finite element model and test **(open)**
  - get, view and prepare data of NIED network at Japan for Ichinoseki (K-NET IWT010 2011/03/11) **(done)**
  - prepare all data for dynamic finite element analyses **(open)**
- dynamic calculation for complete AHCAL with ECAL mass segments
  - prepare dynamic test model **(open)**
  - earthquake calculation according ISO 3010/Eurocode 8 **(open)**
  - earthquake calculation with real data from Japan **(open)**

AHCAL finite element analyses
manpower and cost overview

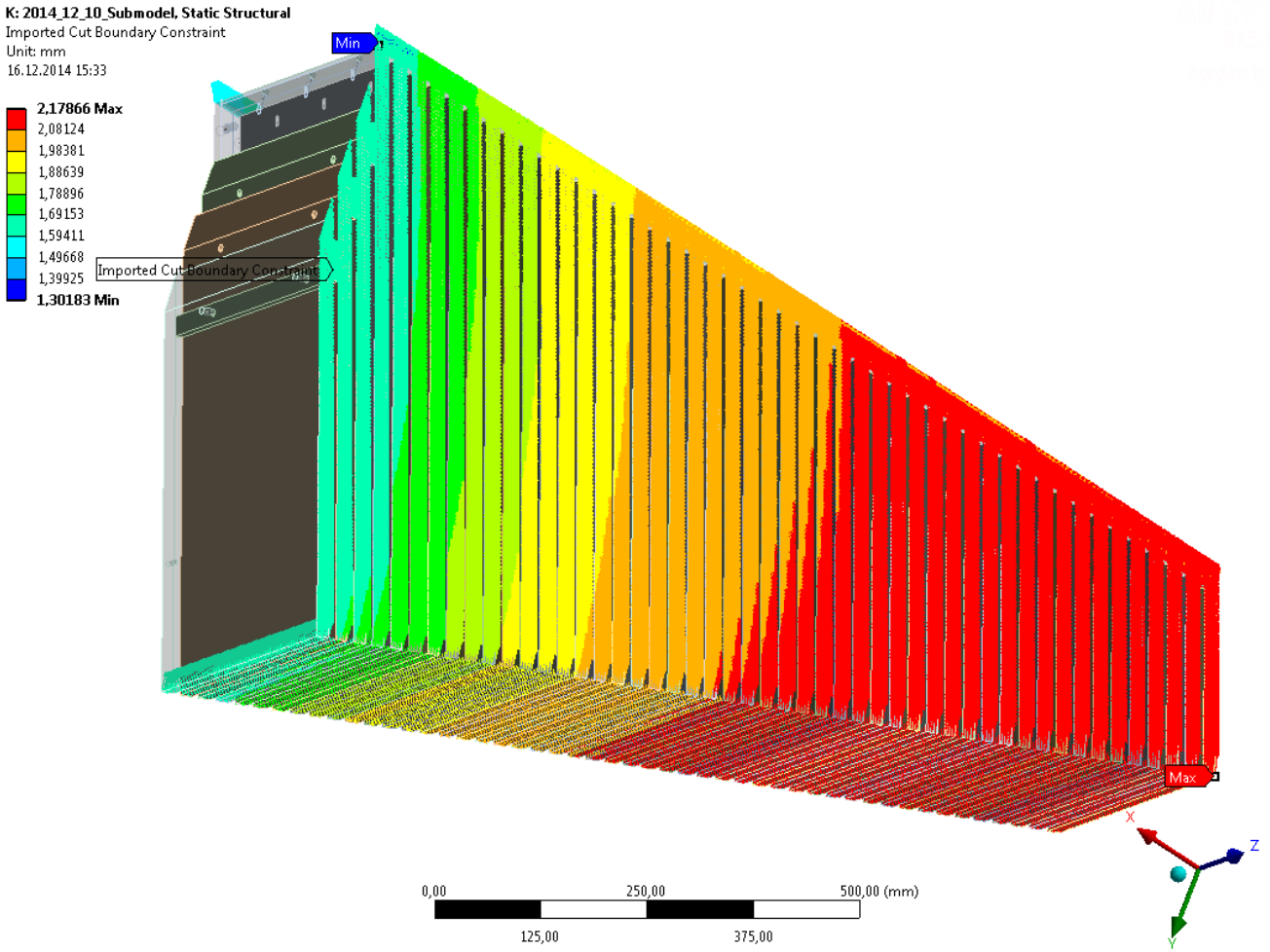
- Manpower and costs 2014
  - DESY ZM1 engineer cost per hour: 56 €/h
  - already accumulated costs 2014: 132 h => 7.400 €
  - July: 22,0 h / August: 18,5 h / September: 28,0 h / October: 18,0 h / November: 20,0 h / December: 25,0 h
  - 14 % average work load per month with 1 engineer (165h/month)
  - low priority due do many running DESY projects (XFEL, Petra III,….)
- Manpower and costs 2015
  - ZM1 engineer team will consist out of 2 engineers
  - hope for 30% average work load per engineer => 100h/month
  - work packages:
    - completion static finite element analyses 80 h => 4.500 €
    - preparation dynamic finite element analyses 40 h => 2.200 €
    - dynamic finite element analyses according ISO 3010 / Eurocode 8 80 h => 4.500 €
    - dynamic finite element analyses according real earth quake data 60 h => 3.350 €
  - assumed costs 14.550 € for 260 hours in 3 month

AHCAL Mechanics
Status Report

- Backup

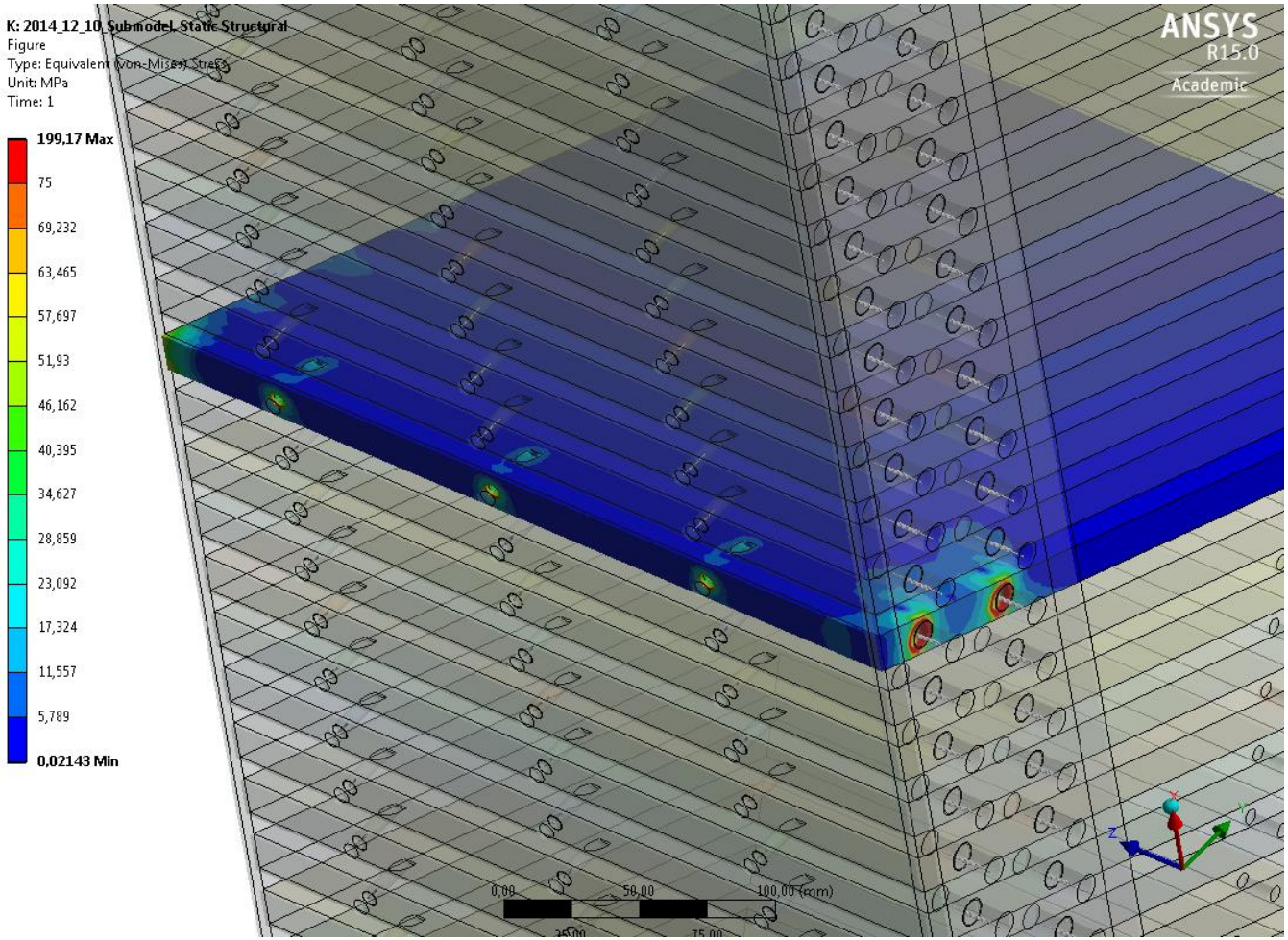
AHCAL static finite element analysis I
3D detail model

- displacements at boundary surfaces by interpolation of complete 3D detailed shell model



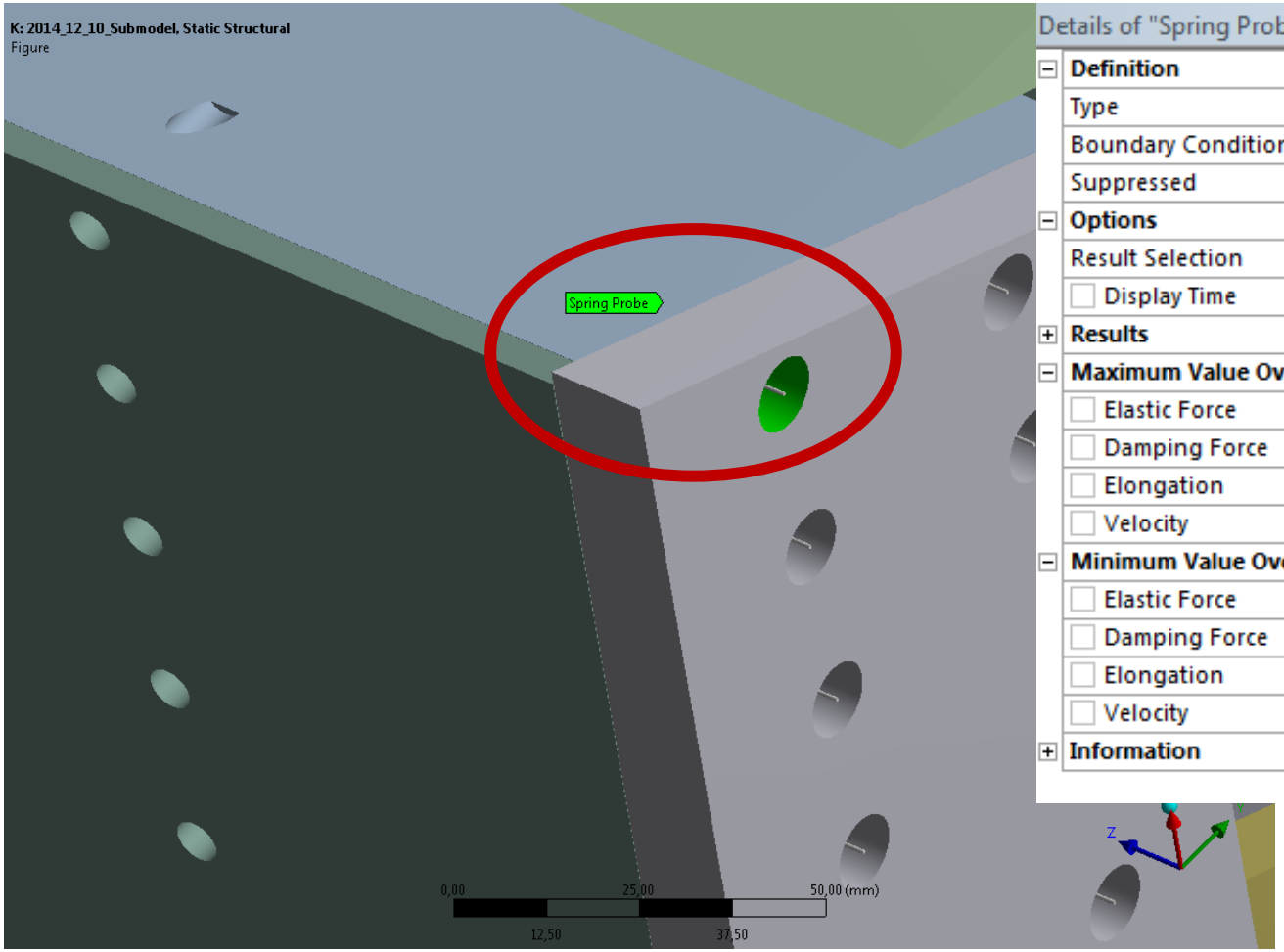
AHCAL static finite element analysis I
3D detail model

- evaluation of single structure parts possible



AHCAL static finite element analysis I
3D detail model

- evaluation of screw joints at arbitrary places possible



Details of "Spring Probe"

Definition	
Type	Spring Probe
Boundary Condition	Longitudinal - Submodel_I.49 To Submod..
Suppressed	No
Options	
Result Selection	All
Display Time	End Time
Results	
Maximum Value Over Time	
Elastic Force	17261 N
Damping Force	0, N
Elongation	-3,5414e-003 mm
Velocity	-3,5414e-003 mm/s
Minimum Value Over Time	
Elastic Force	17261 N
Damping Force	0, N
Elongation	-3,5414e-003 mm
Velocity	-3,5414e-003 mm/s
Information	