Simulations of Heat Load and Induced Stress in Target of ILC Positron Source

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Outline

- Introduction to Heat Load Problem
- Simulation Results
  - Stress after 1st train (ANSYS, Andriy)
  - Temperature and stress evolution in time (ANSYS, Friedrich)
- Outlook
- Shortly about Other Topics

Introduction to Problem

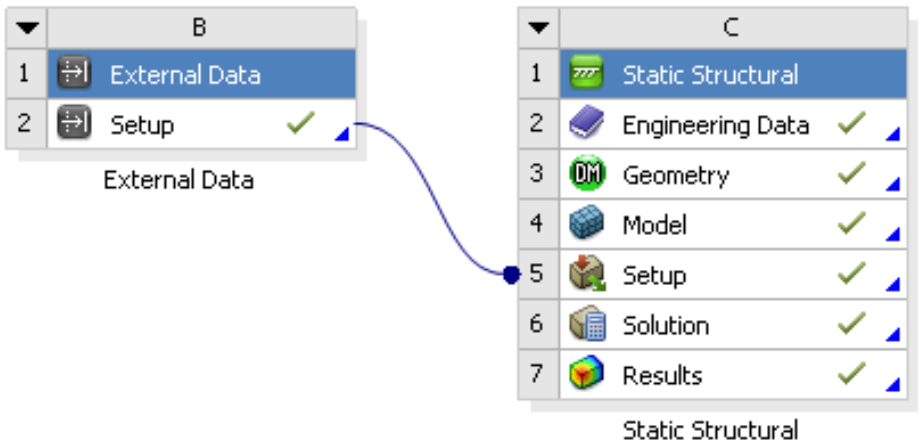
High energy deposited in target and resulting pressure/stress could destroy the target

- Thermal stress has been calculated by Werner Stein (Daresbury talk, 2005). LLNL codes Topaz-3d (thermal conduction code) coupled to Dyna-3d (dynamic structural response code) have been used.
- Tom Piggot has used COMSOL to estimate the stress in target (Argone talk, 2007).
- FlexPDE model has been developed by Alexander Mikhailichenko (Argone talk, 2007). "... negative pressure cracks the target more likely right after the first shot".

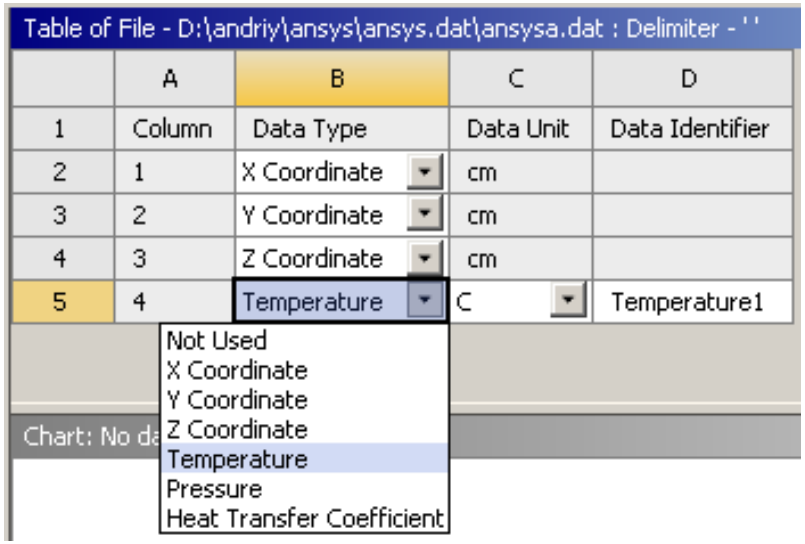
- Olufemi continues Stefan Hesselbach work on FlexPDE model (Olufemi talk, POSIPOL, 30 August)
- ANSYS calculations have been started

Import Data into ANSYS

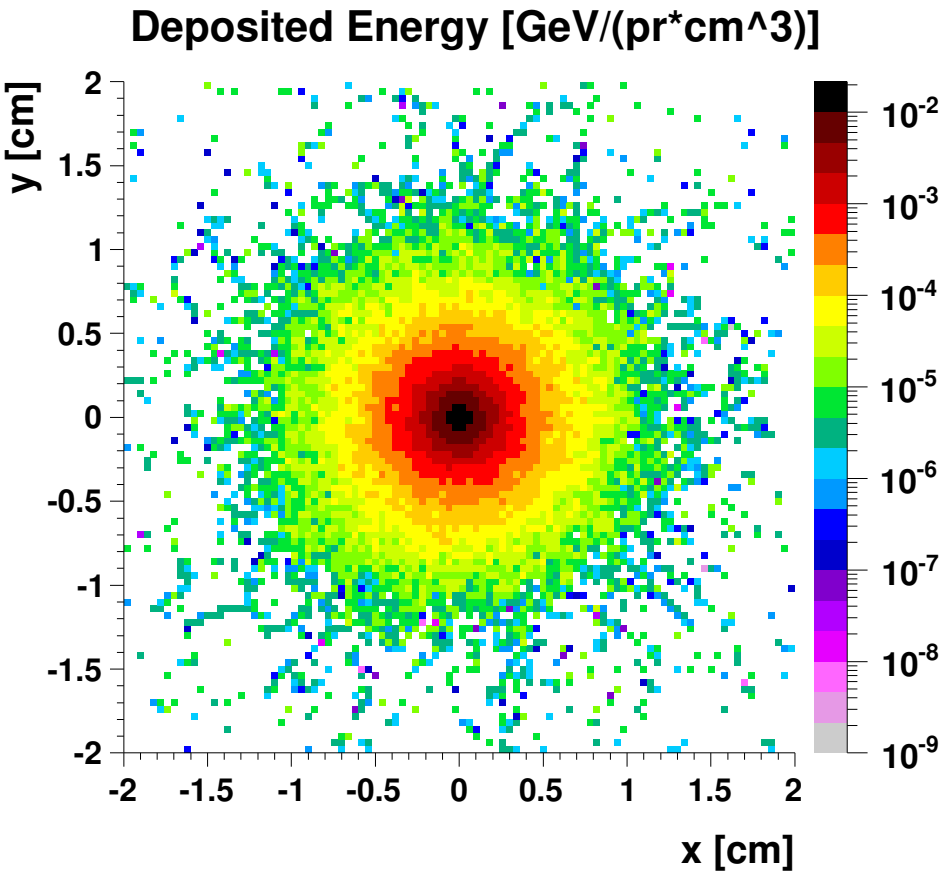
Structure of Project in ANSYS Workbench



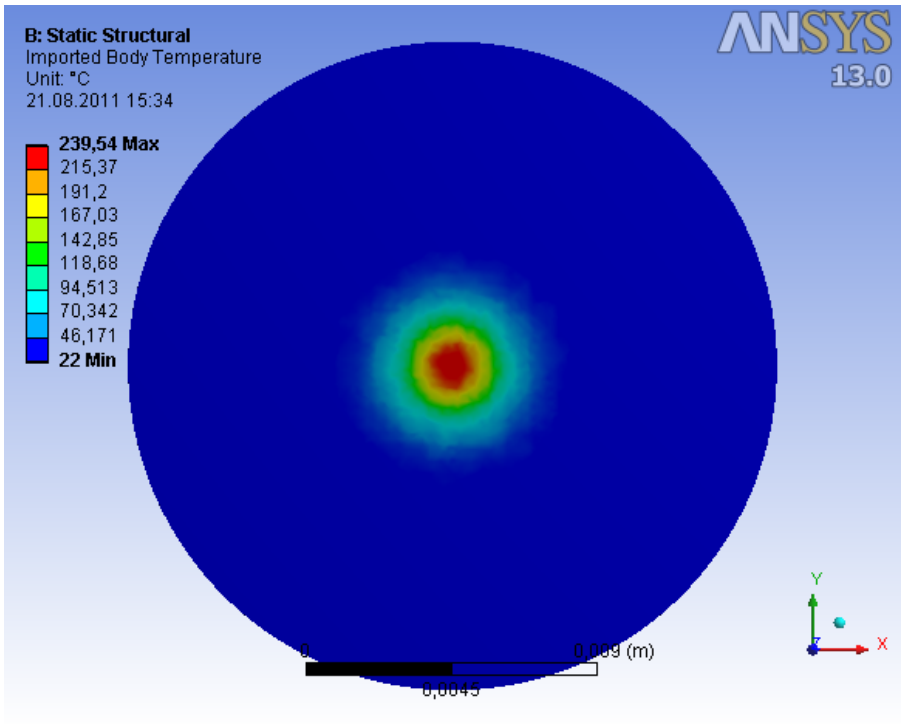
Description of Data Structure



Deposited Energy and Temperature Distributions



Temperature Map of Target Backside



$$\delta T[\mathrm{K}] = E[\mathrm{GeV/(ph \cdot cm^3)}] \cdot 1.6 \cdot 10^{-10}[\mathrm{J/GeV}] \cdot 2 \cdot 10^{10}[\mathrm{e\text{-}/bunch}] \cdot 1.94[\mathrm{ph/(e\text{-}\ m)}] \cdot 70[\mathrm{m}]/$$

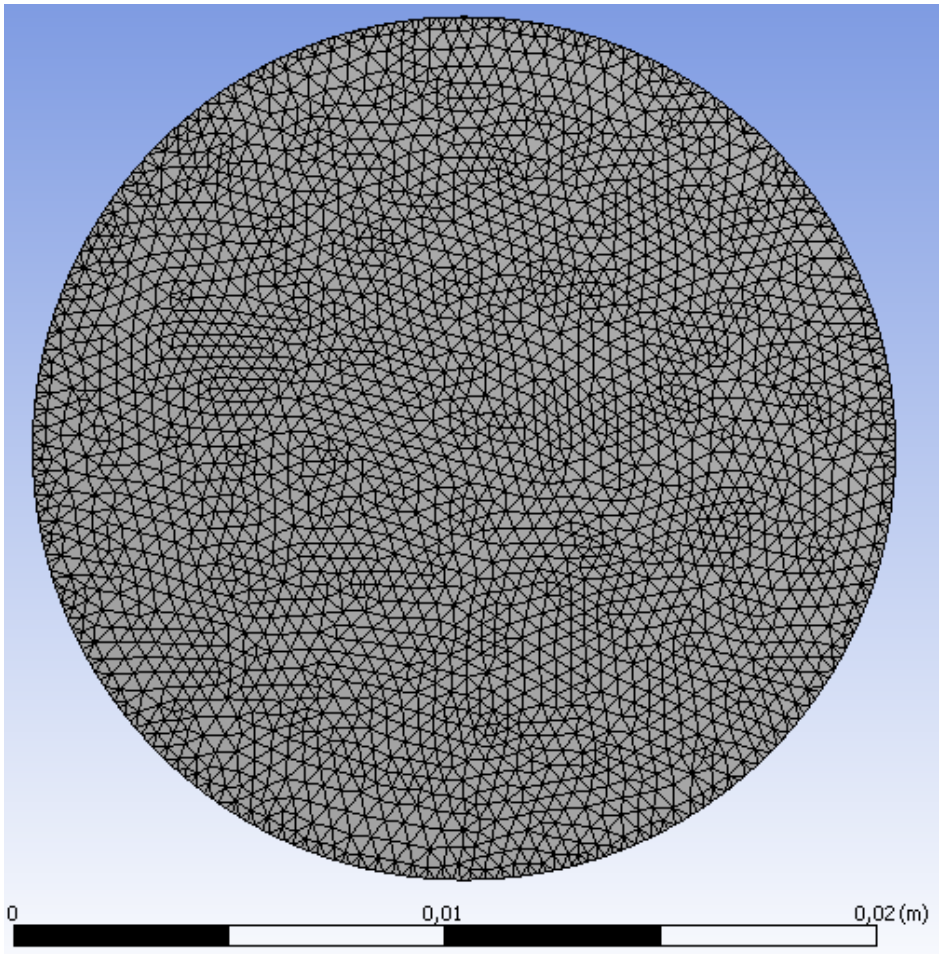
$$/4.49[\mathrm{g/cm^3}]/0.523[\mathrm{J/(g\ K)}] \cdot 100[\mathrm{bunch}]$$

Material Properties

Properties of Outline Row 12: Titanium Alloy

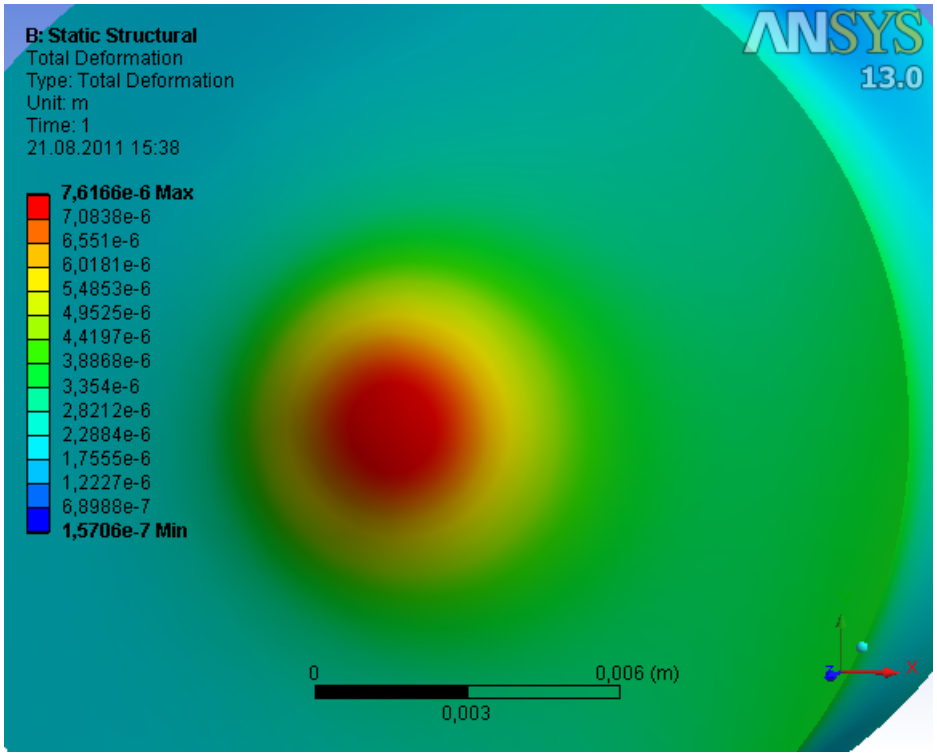
	A	B	C
1	Property	Value	Unit
2	Density	4620	kg m^-3
3	Isotropic Secant Coefficient of Thermal Expansion		
4	Coefficient of Thermal Expansion	9,4E-06	C^-1
5	Reference Temperature	22	C
6	Isotropic Elasticity		
7	Derive from	Young's Modulu...	
8	Young's Modulus	9,6E+10	Pa
9	Poisson's Ratio	0,36	
10	Bulk Modulus	1,1429E+11	Pa
11	Shear Modulus	3,5294E+10	Pa
12	Tensile Yield Strength	9,3E+08	Pa
13	Compressive Yield Strength	9,3E+08	Pa
14	Tensile Ultimate Strength	1,07E+09	Pa
15	Compressive Ultimate Strength	0	Pa

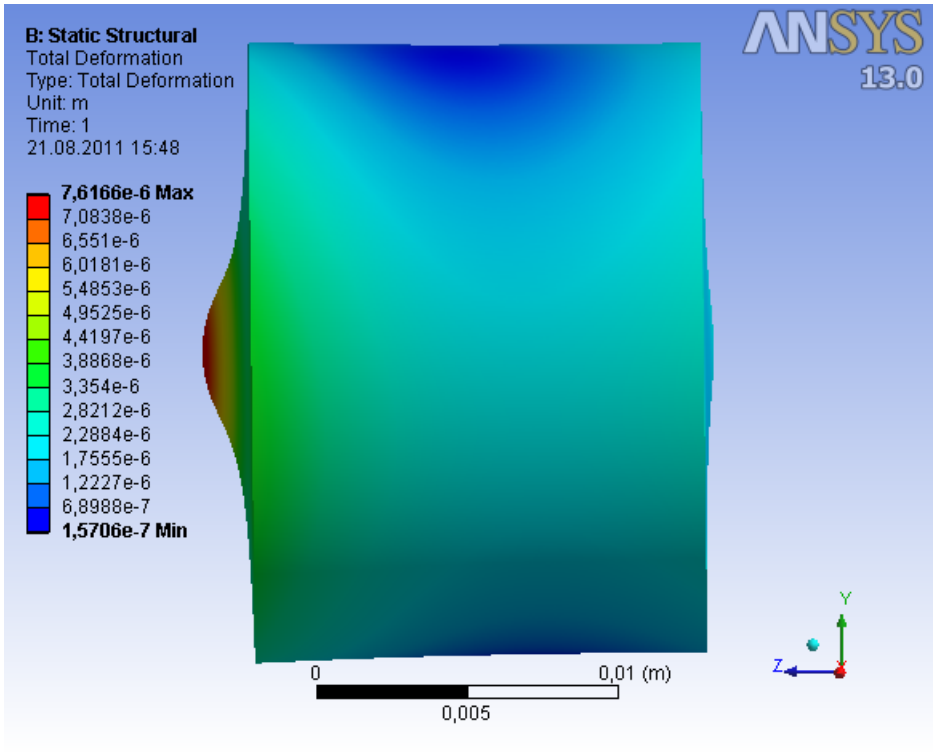
“Meshing” of Target



Details of "Mesh"	
Defaults	
Physics Preference	Mechanical
Relevance	0
Sizing	
Use Advanced Si...	Off
Relevance Center	Fine
Element Size	2,e-004 m
Initial Size Seed	Active Assembly
Smoothing	High
Transition	Fast
Span Angle Center	Fine
Minimum Edge Le...	6,2832e-002 m
Inflation	
Advanced	
Defeaturing	
Statistics	
Nodes	476511
Elements	312449
Mesh Metric	None

Deformation

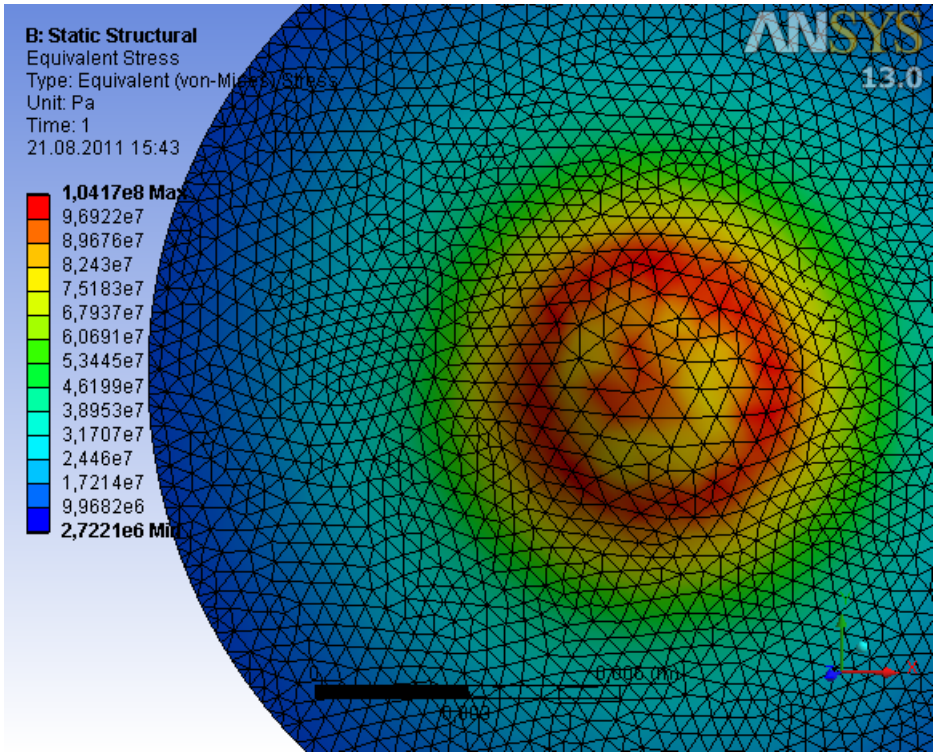




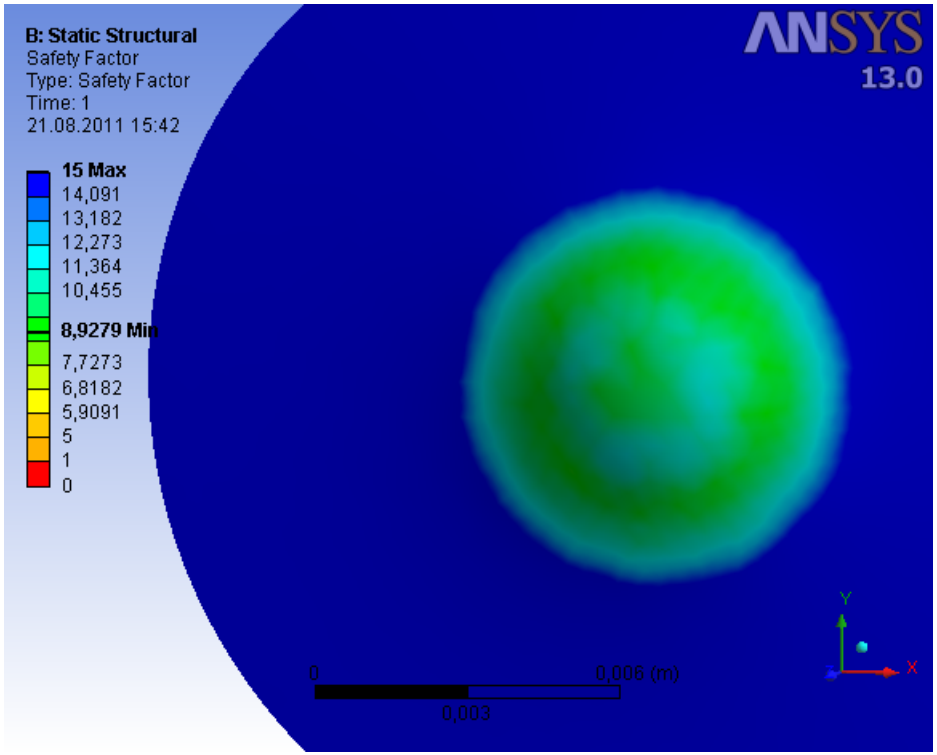
Maximal Deformation $\approx 8\mu$m

Equivalent Stress

Equivalent Stress

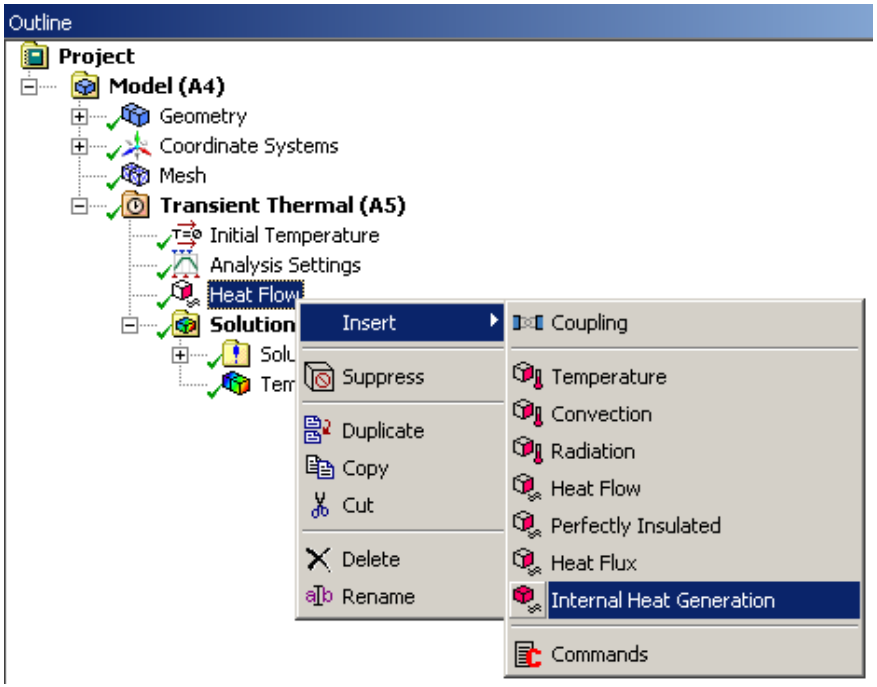


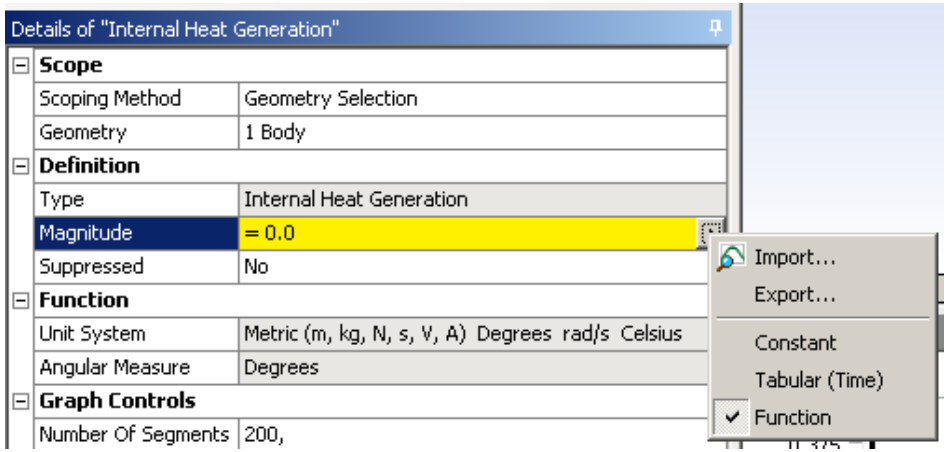
Safety Factor



Maximal Stress $\approx$ 100 MPa

Different Approach to Define Heat Load

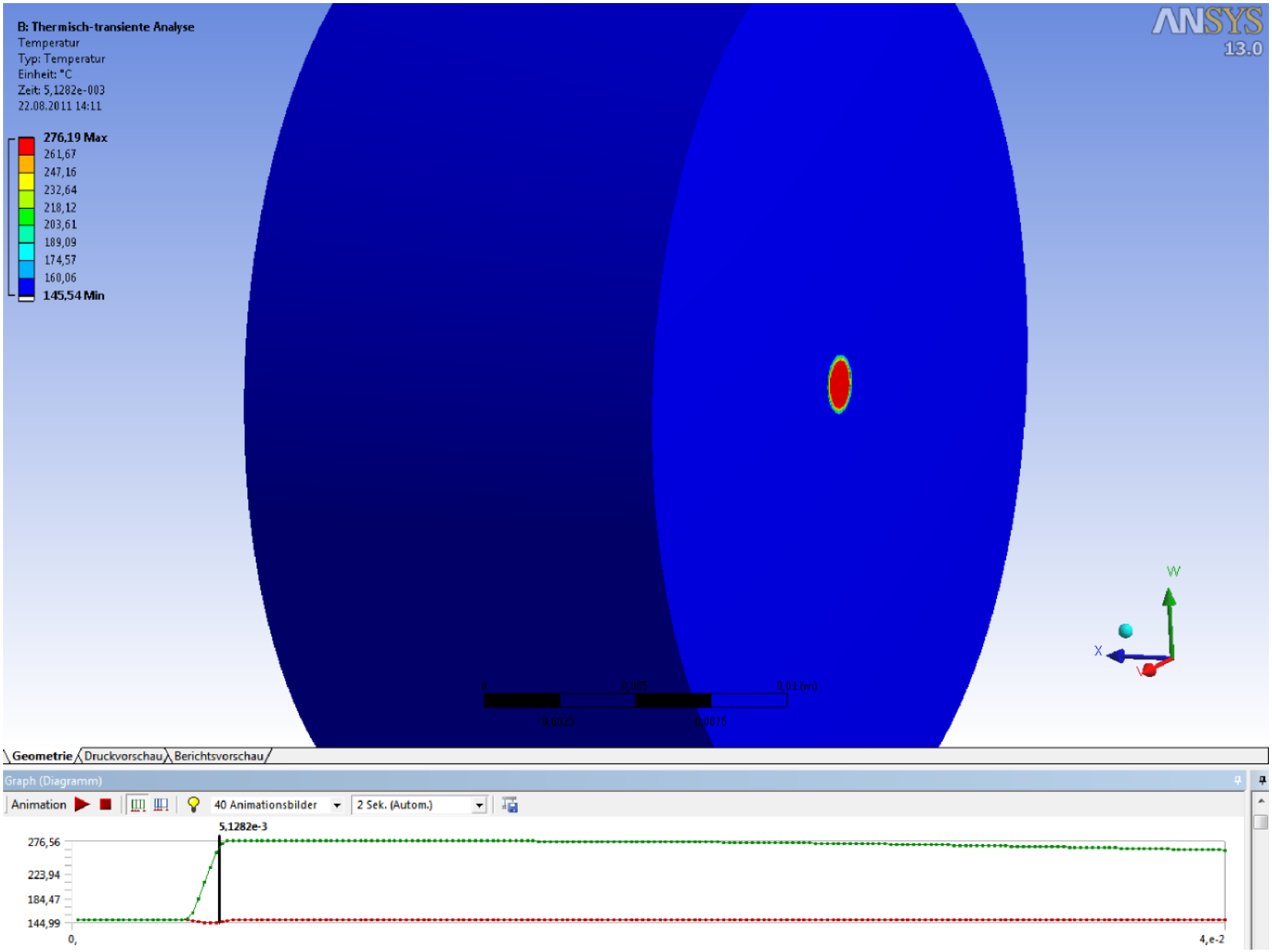




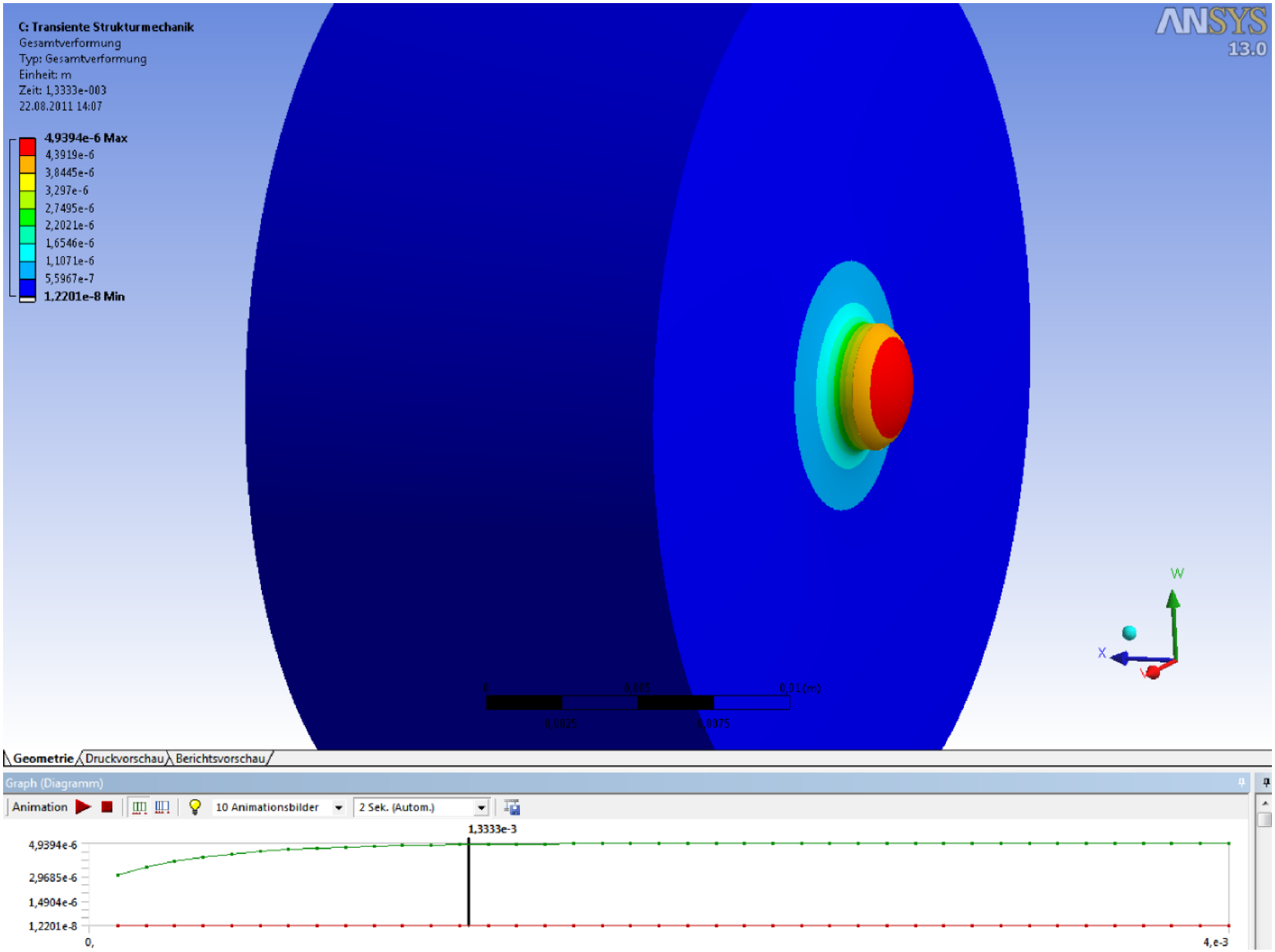
\+ Time evolution can be evaluated

— Homogenious distribution in volume

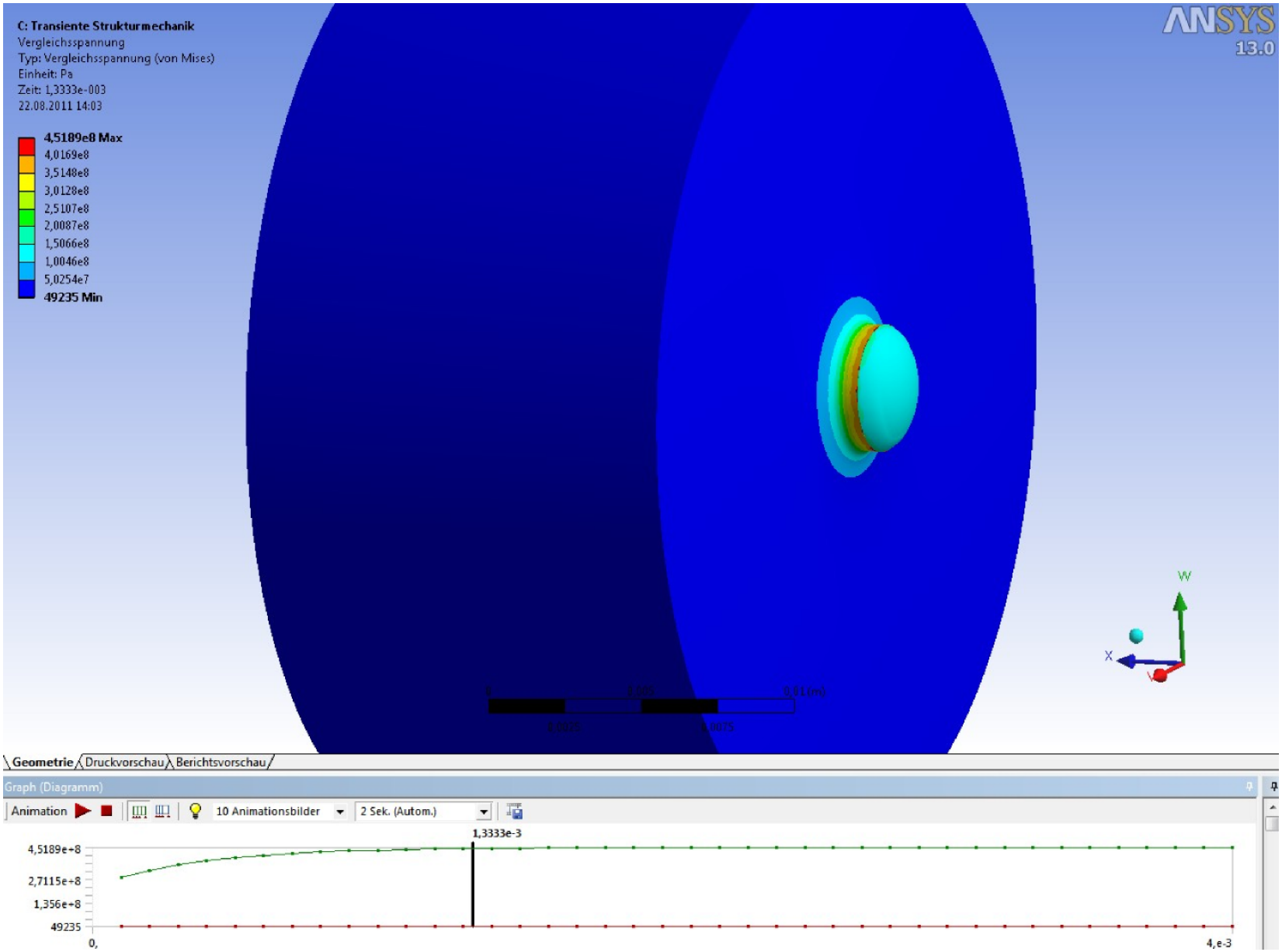
Temperature



Deformation



Thermal Stress



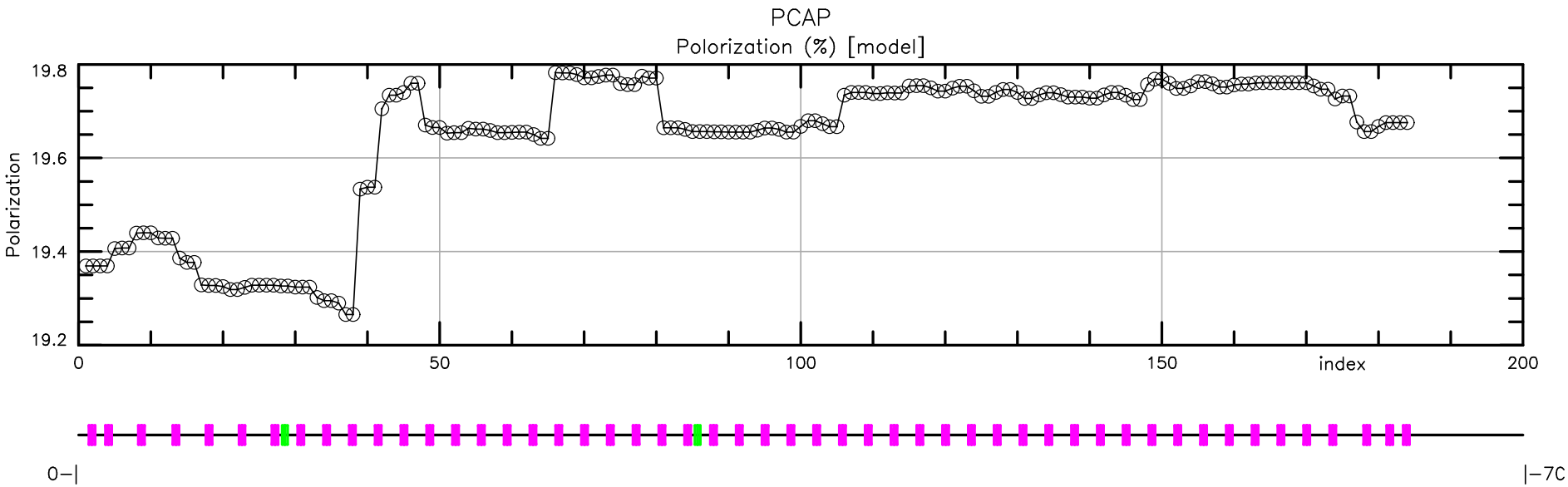
Summary and Outlook

- First ANSYS simulations of stress induced in target have been performed
- Peak stress for SB2009 parameter set is not too high (about 100 MPa)
- Next steps:
  - Learn how to import heat load data from FLUKA/Geant4
  - Add cooling
  - Simulate rim target (icluding rotation)

Other Topics

- PPS-Sim:
  - Added more realistic field of QWT (some results will be in Valentyn talk)
  - Added one model of photon collimator
  - Improved/extended storing of data and user interface
- BMAD:
  - Transfer data from PPS-Sim to BMAD
  - First look at spin tracking up to DR (RDR lattice)

Spin Transport in PCAP



Emittance Change in PCAP