# Polarized Positrons for the ILC - Update on Simulations

A. Ushakov[1], O. S. Adeyemi[1], G. Moortgat-Pick[1], F. Staufenbiel[2], S. Riemann[2]

[1] *University of Hamburg/DESY, Hamburg*
[2] *DESY, Zeuthen*

*POSIPOL 2011*

28 August 2011, IHEP, Beijing, China

# Outline

- Introduction to Heat Load Problem
- Results of Simulations for ILC Target (FLUKA + ANSYS)
  - Deposited Energy
  - Temperature
  - Thermal Stress
- Spin Tracking
- Outlook

# Introduction to Problem

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

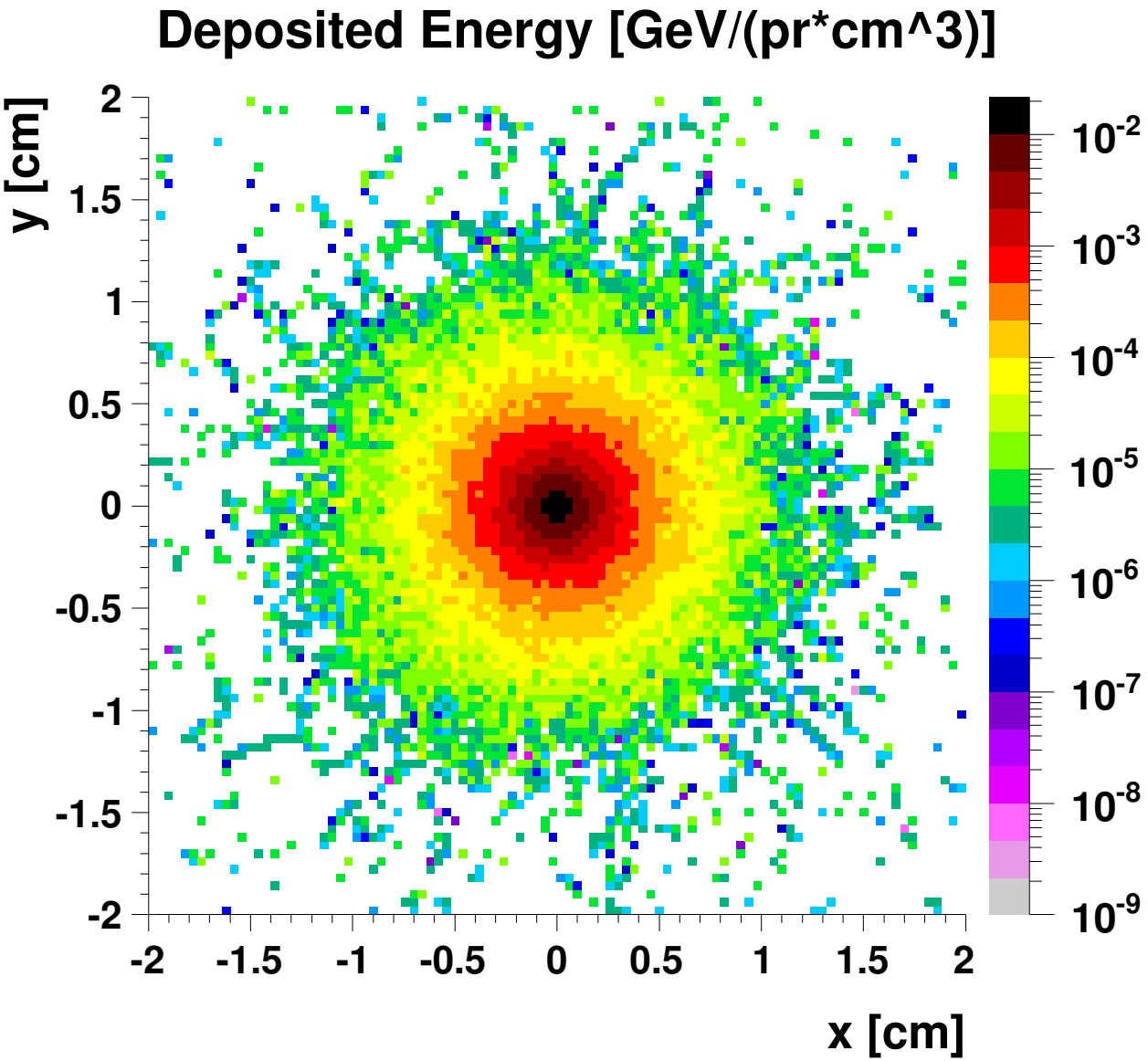
- Thermal stress has been calculated by Werner Stein (Daresbury talk, 2005). LLNL codes Topaz-3d (thermal conduction code) coupled to Dyna-3d (dynamic structural response code) have been used.
- Tom Piggot has used COMSOL to estimate the stress in target (Argone talk, 2007).
- FlexPDE model has been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

- ANSYS calculations have been started

# Source Parameters

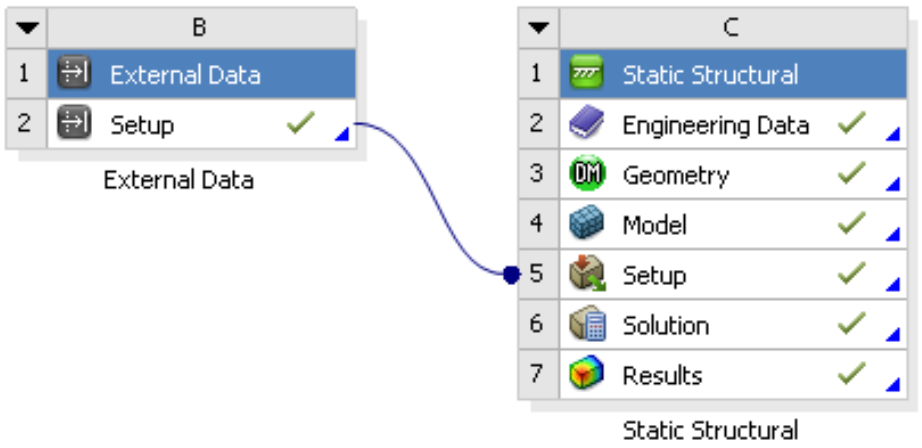
| | |
|---|---|
| $e^-$ Beam Energy | 250 GeV |
| No. of $e^-$ | $2 \cdot 10^{10}$ $e^-$/bunch |
| No. of Bunches | 1312 bunches/train |
| Undulator K-value | 0.92 |
| Undulator Period | 11.5 mm |
| Photon Yield | 1.94 ph/($e^-$ m) |
| Undulator-Target Distance | 500 m |
| Undulator Length (QWT) | 70 m |
| Target Material | Ti6Al4V |
| Target Thickness | 0.4 $X_0$ |
| Rotation Speed | 100 m/s |

# Energy Deposition in Target (FLUKA)

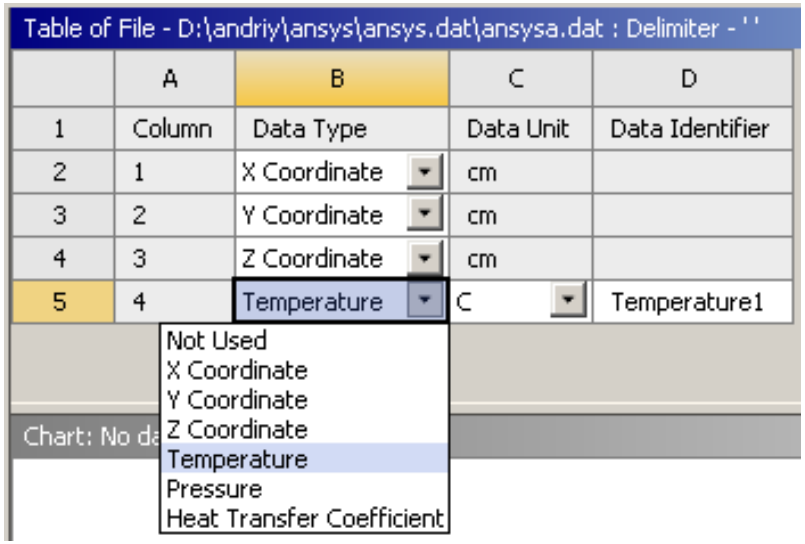


# Import Data into ANSYS

## Structure of Project in ANSYS Workbench

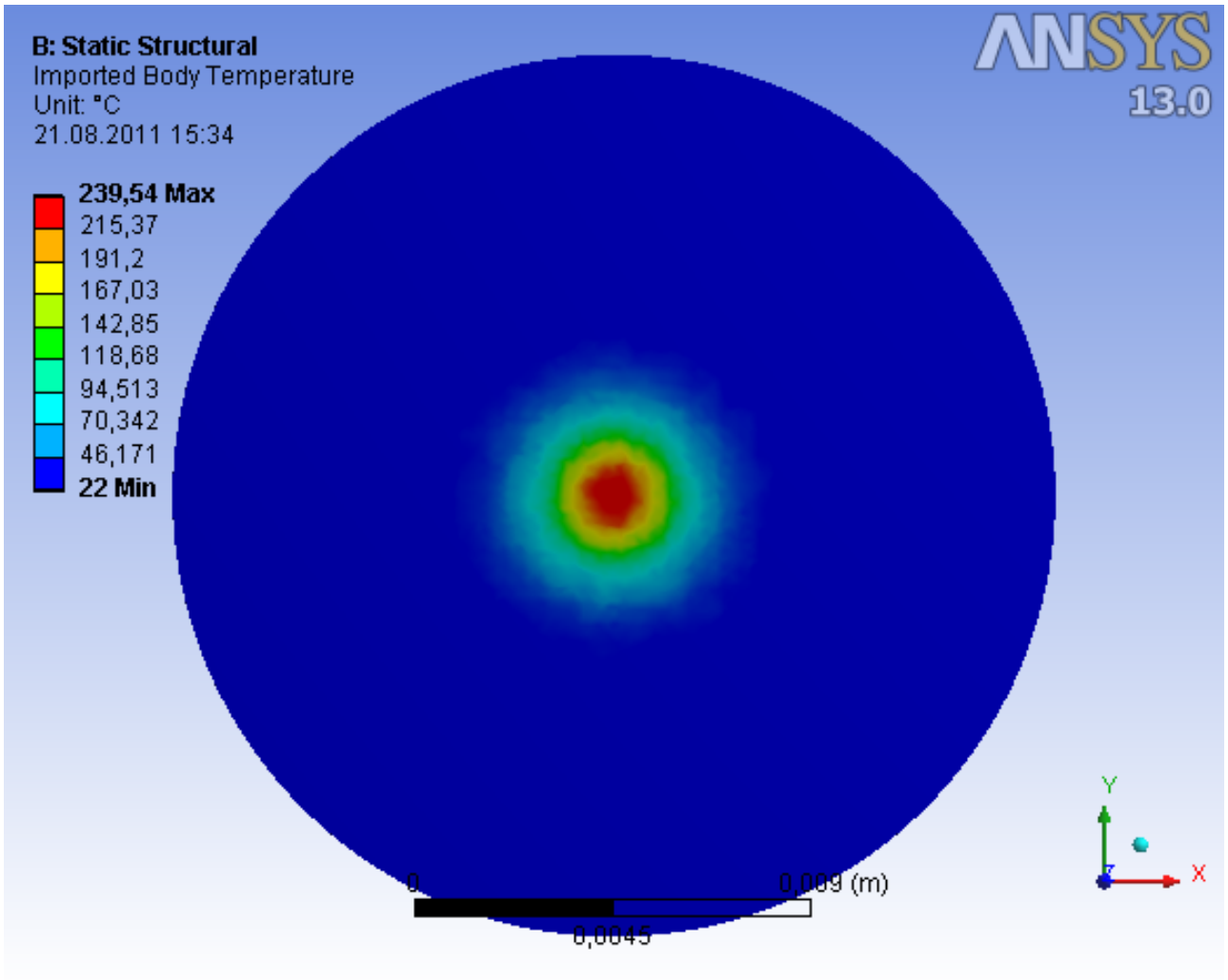



## Description of Data Structure



# Temperature Close to Backside of Target

$$\delta T[\mathrm{K}] = E[\mathrm{GeV/(ph \cdot cm^3)}] \cdot 1.6 \cdot 10^{-10}[\mathrm{J/GeV}] \cdot 2 \cdot 10^{10}[\mathrm{e\text{-}/bunch}] \cdot 1.94[\mathrm{ph/(e\text{-}\ m)}] \cdot 70[\mathrm{m}] / / 4.49[\mathrm{g/cm^3}] / 0.523[\mathrm{J/(g\ K)}] \cdot 100[\mathrm{bunch}]$$

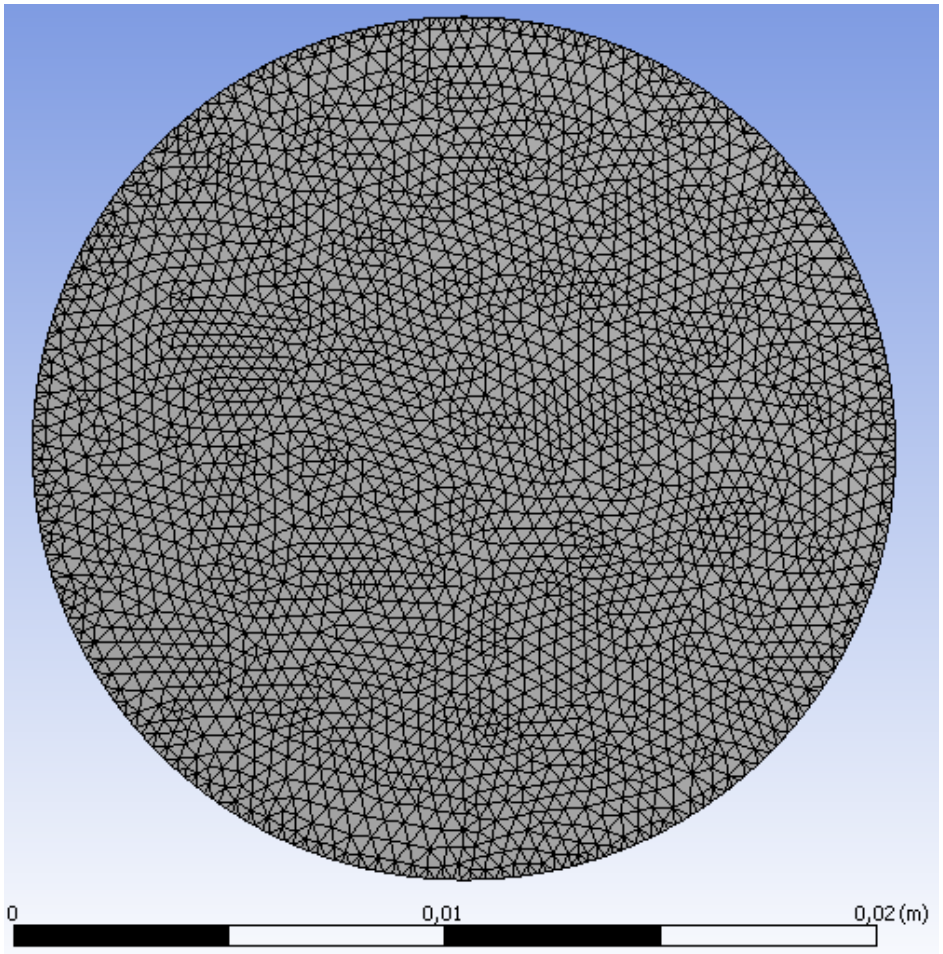


# Material Properties

Properties of Outline Row 12: Titanium Alloy

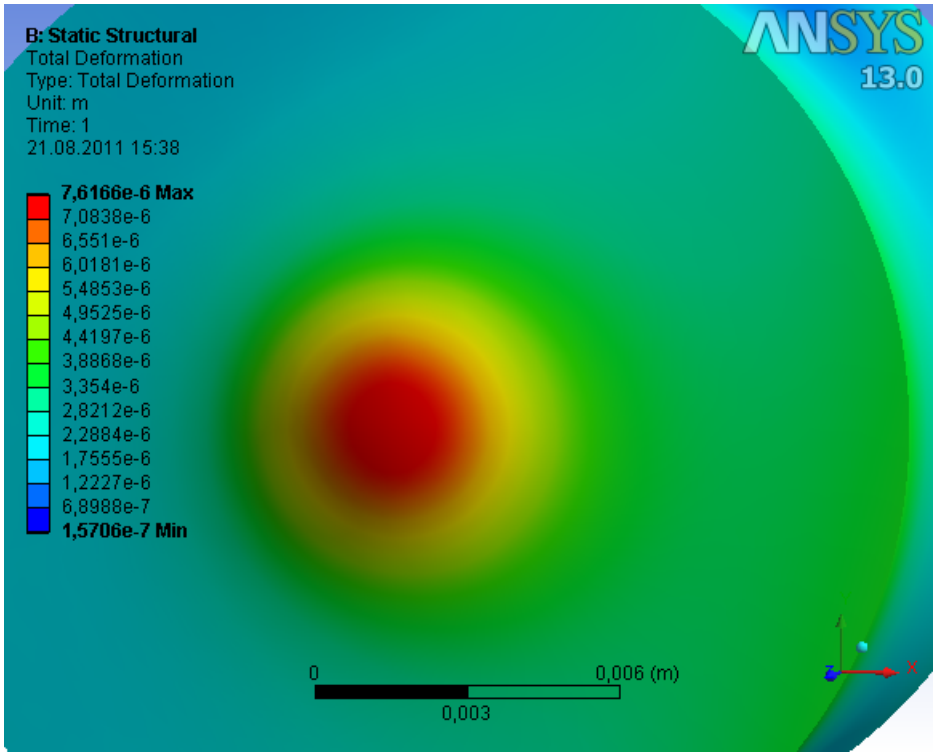
| | A | B | C |
|---|---|---|---|
| 1 | Property | Value | Unit |
| 2 | Density | 4620 | kg m^-3 |
| 3 | Isotropic Secant Coefficient of Thermal Expansion | | |
| 4 | Coefficient of Thermal Expansion | 9,4E-06 | C^-1 |
| 5 | Reference Temperature | 22 | C |
| 6 | Isotropic Elasticity | | |
| 7 | Derive 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 |

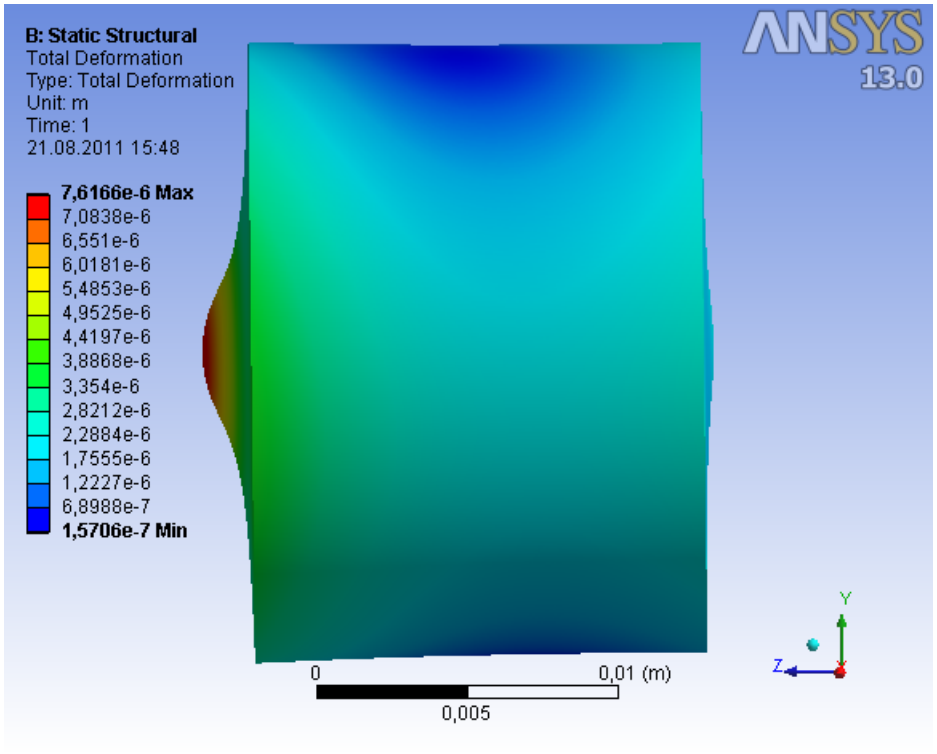
# “Meshing” of Target




| 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

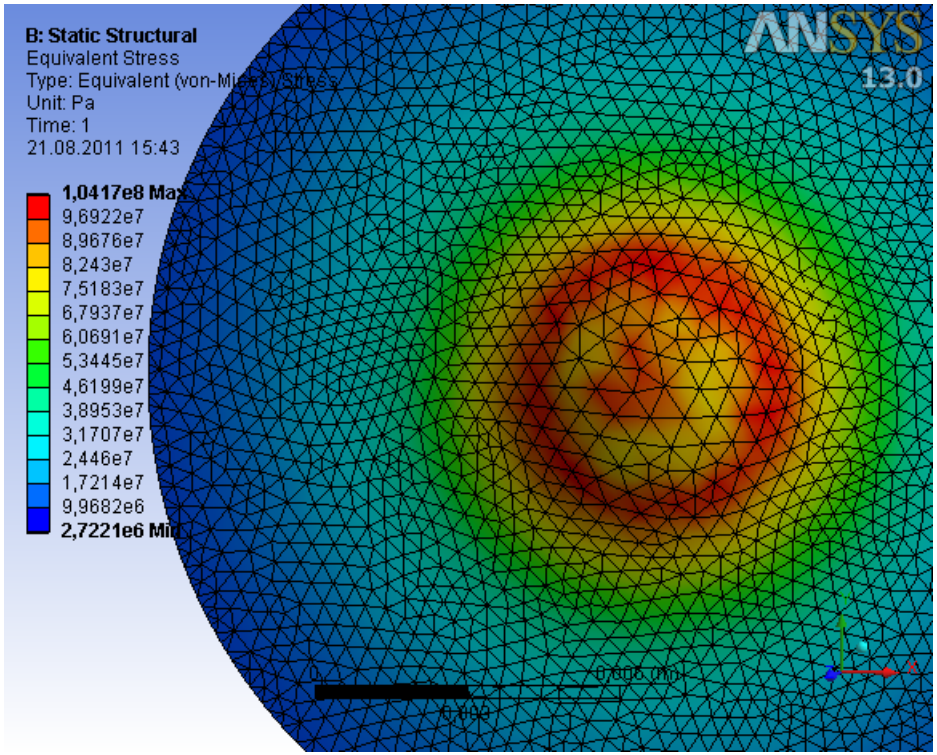


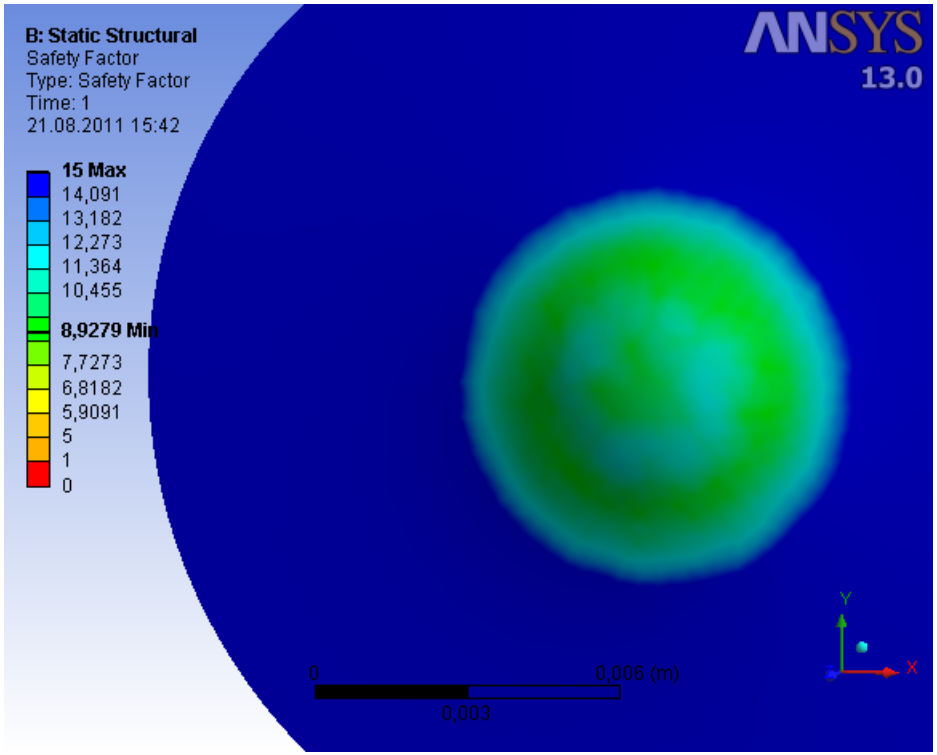

Maximal Deformation $\approx 8\ \mu$m

# Equivalent Stress

## Equivalent Stress



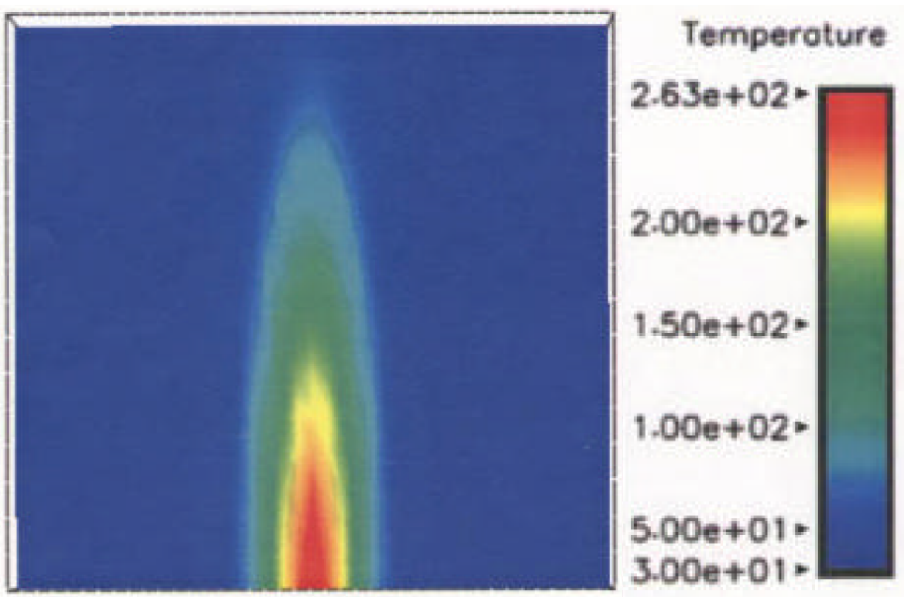

## Safety Factor



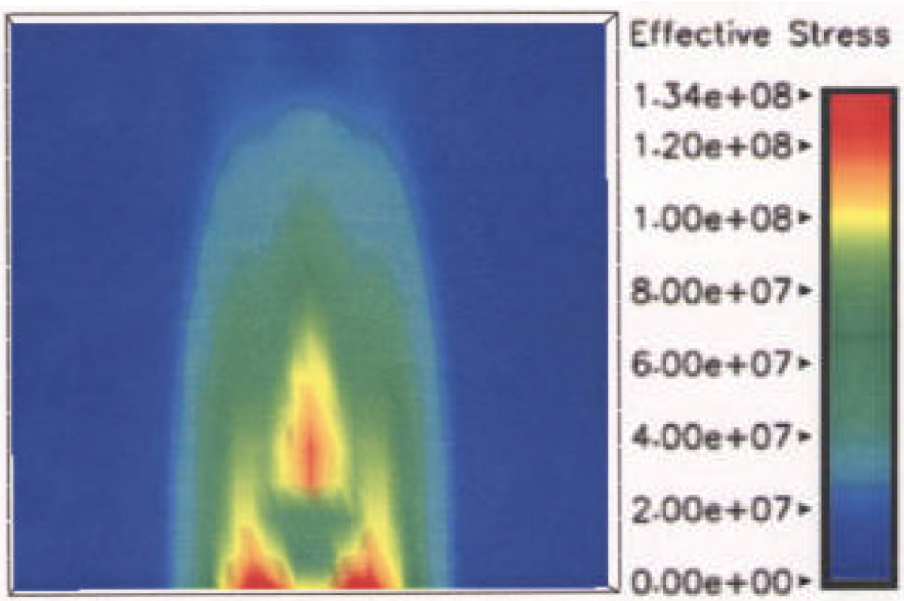

Maximal Stress $\approx$ 100 MPa

# Equivalent Stress in NLC Target*

Temperature after One Pulse




Thermal Stress




Maximal Stress $\approx$ 130 MPa

* Werner Stein and John Sheppard “NLC Polarized Positron Photon Beam Target Thermal Structural Modeling”, SLAC-TN-03-045 (2002)

# Summary on Heat Load in Target

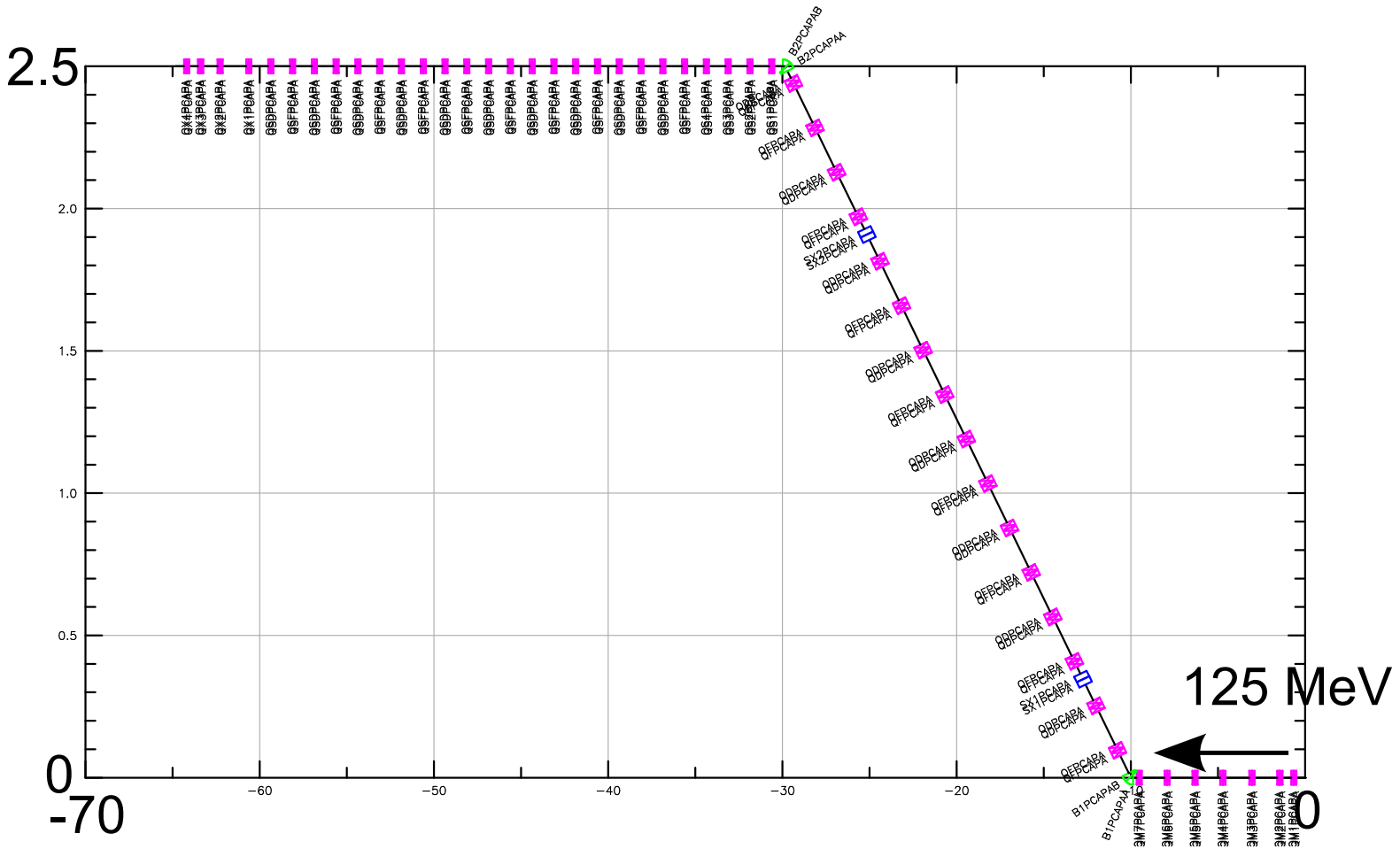
- First ANSYS simulations of stress induced in target have been performed
- Peak stress for SB2009 parameter set is not too high (about 100 MPa)
- Next steps:
  - Import deposited energy
  - Add cooling
  - Simulate rim target (including rotation)

# Tracking of Polarized e+ Beam

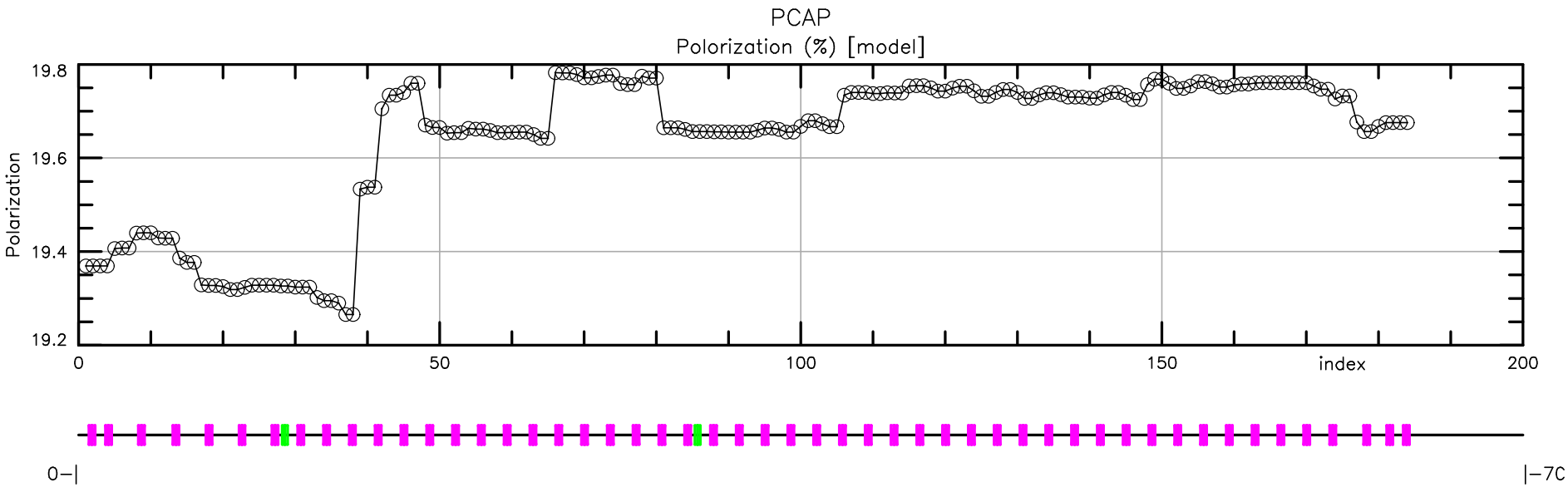
- Simulations of beam line downstream positron capture section (125 MeV) have been started
- Data transfer from PPS-Sim to BMAD has been developed (for instance, the classical spin vector $\vec{S}$ $(S_x, S_y, S_z)$ has to be converted into spinors)
- First look at spin tracking up to DR (RDR lattice) has been performed

# RDR Design: PCAP Lattice (Floor Plan)

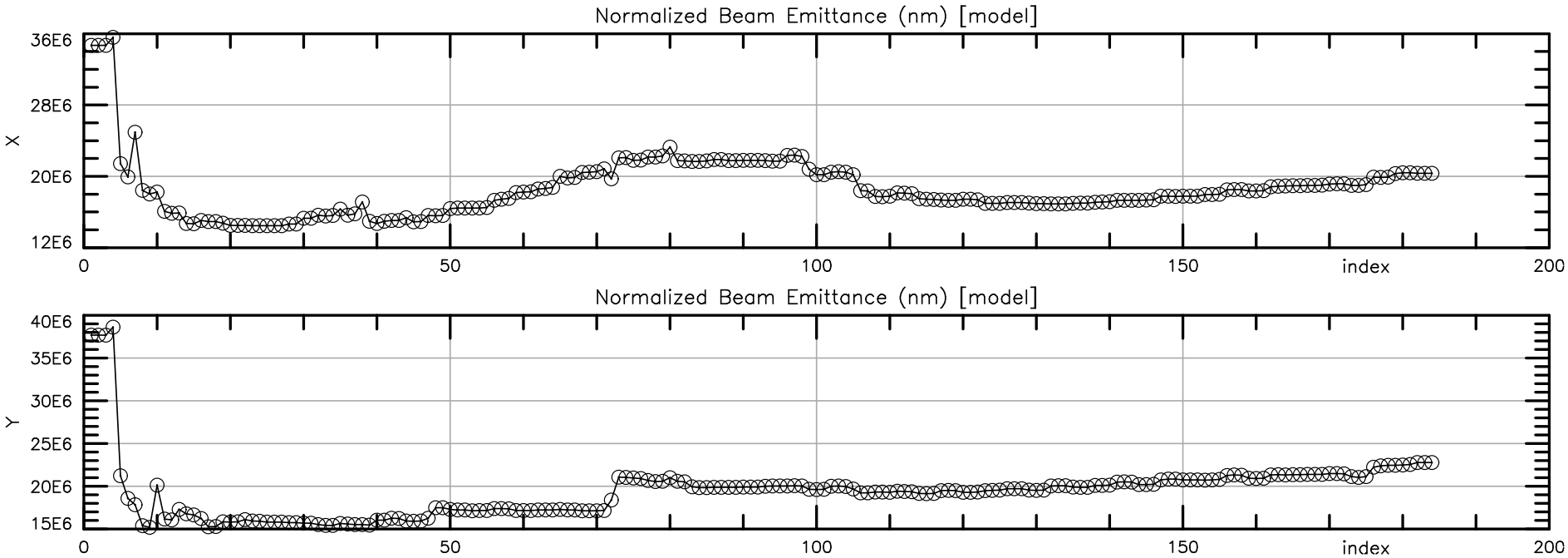
PCAP: beamline that separates the positrons from the electrons and photons



# Spin Transport in PCAP



# Emittance Change in PCAP




$\approx$ 40% of positrons have been lost?!

# Summary on Spin Tracking

- BMAD can be used for tracking of polarized positrons*
- Data transfer from PPS-Sim to BMAD has been tested
- Simulations starting from undulator up to DR (and DR) have to be done for SB2009 lattice

* There is one problem of spin tracking in linac cavities, but David Sagan is continuously improving code and hopefully this problem will be solved soon.