Optimizing Source Parameters

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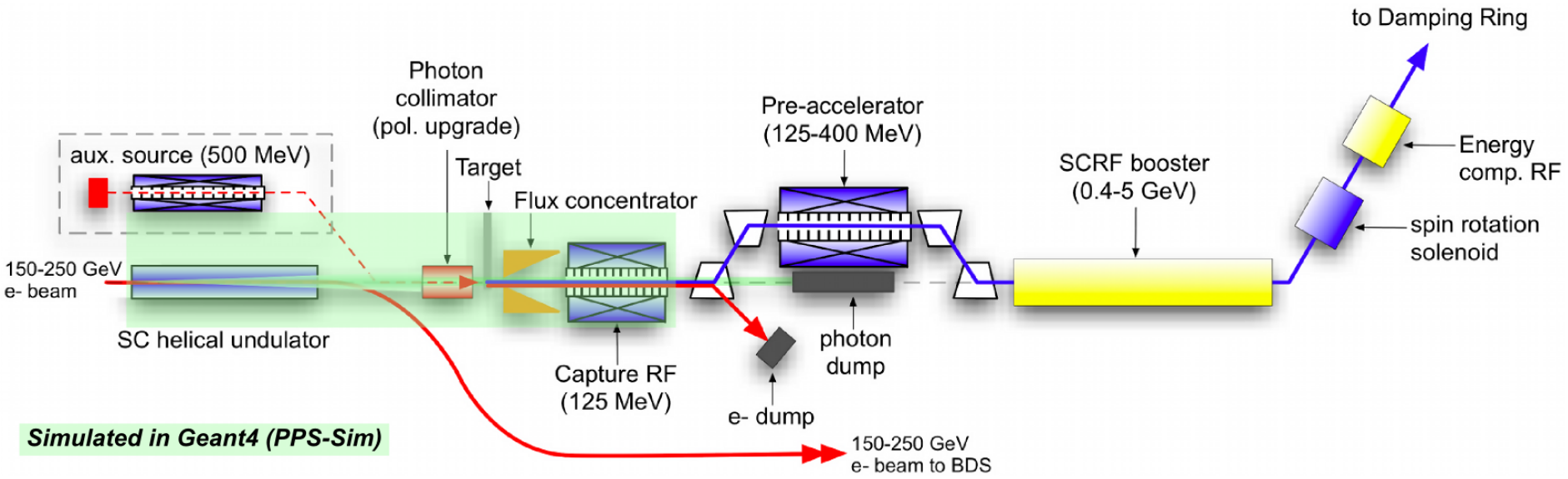
DESY

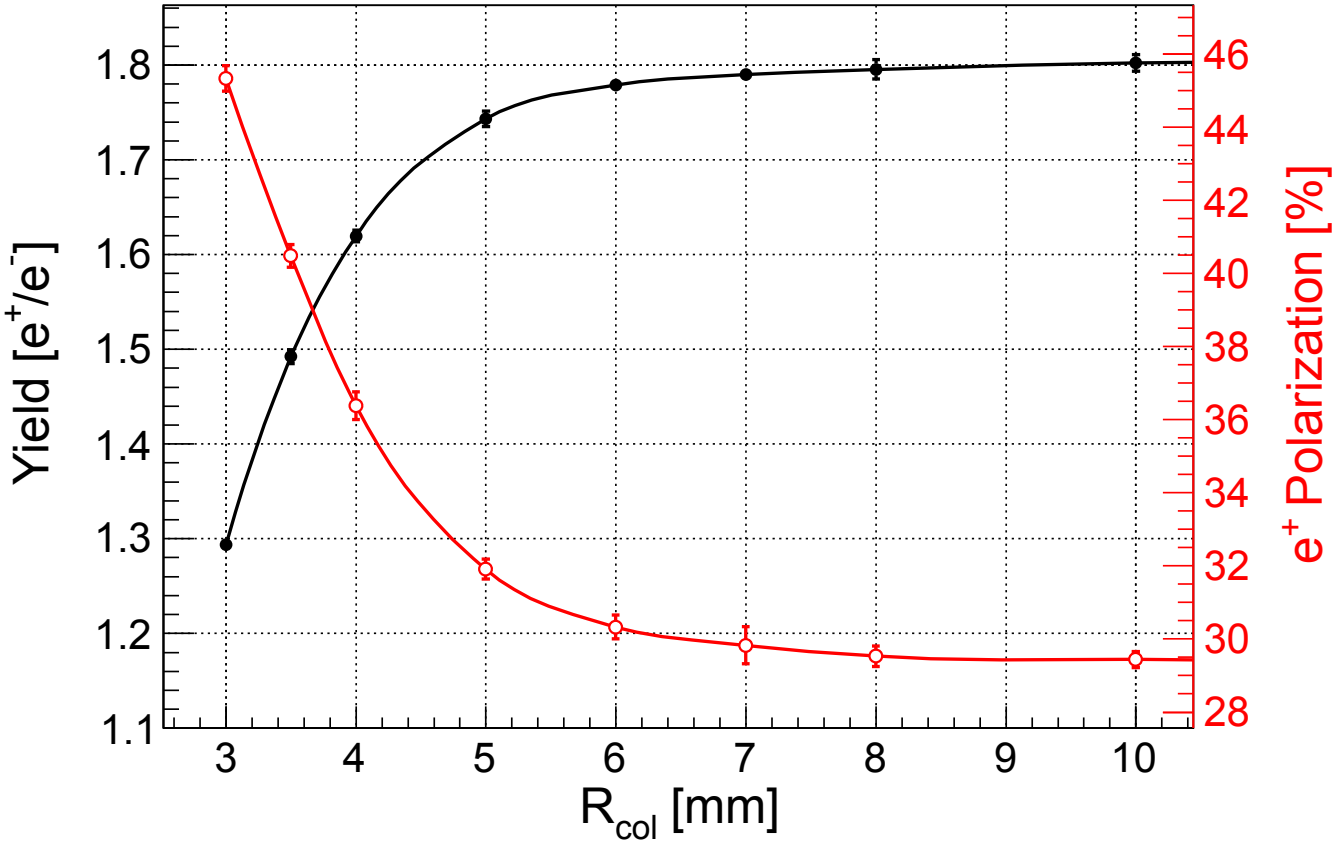
e^+ Source Scheme



Undulator-based source (RDR helical undulator) can be used at 250 GeV center-of-mass energy (more details in my LCWS13 talk)

- 231 m active magnet length of undulator *is required*
- 3.2 T **F**lux **C**oncentrator with 8.5 mm minimal aperture radius *is recommended* (LLNL prototype of FC has 6.5 mm aperture radius)

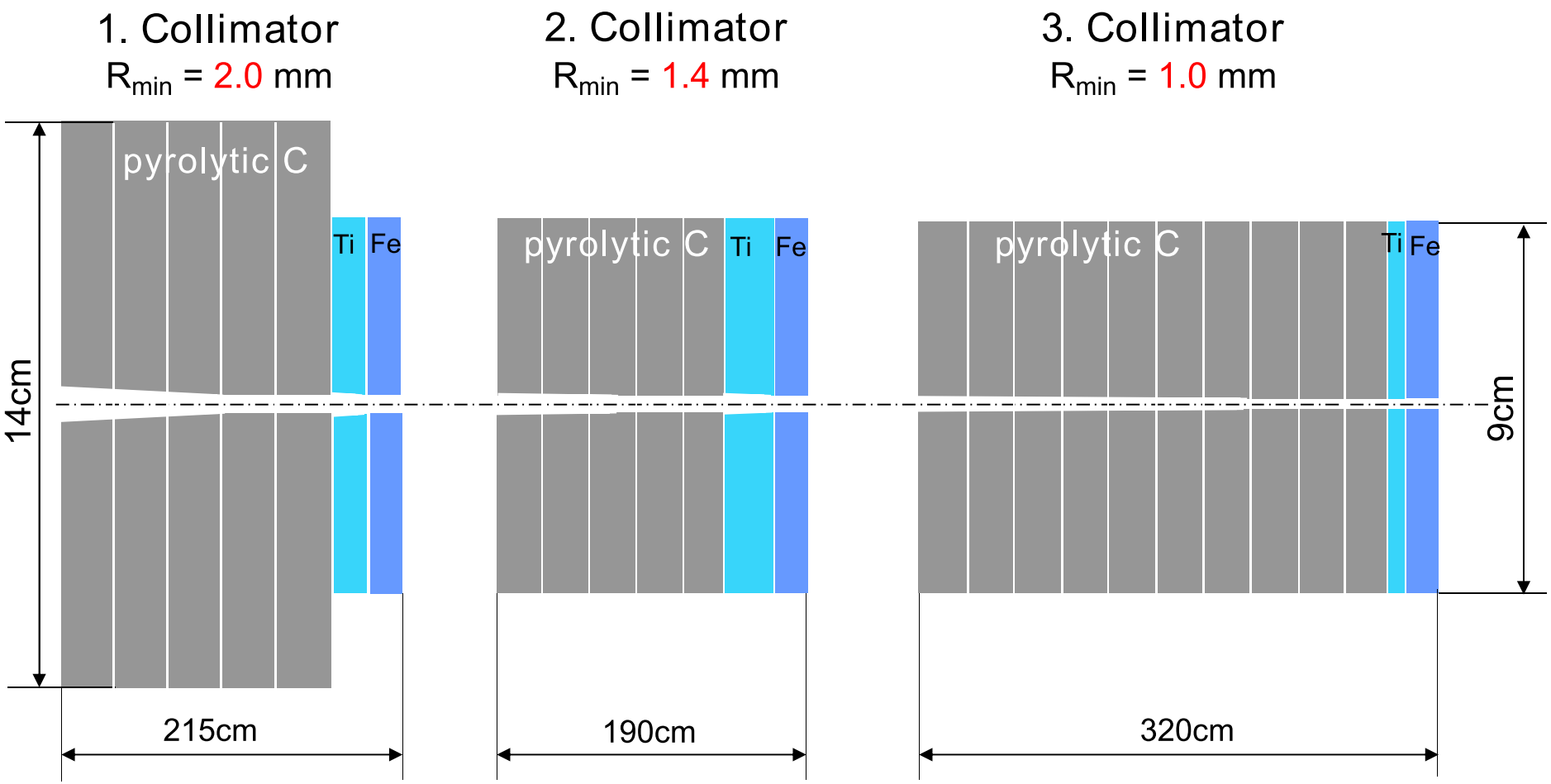
e^+ Polarization at 120 GeV e^-



e^+ polarization of source at 120 GeV e^-:

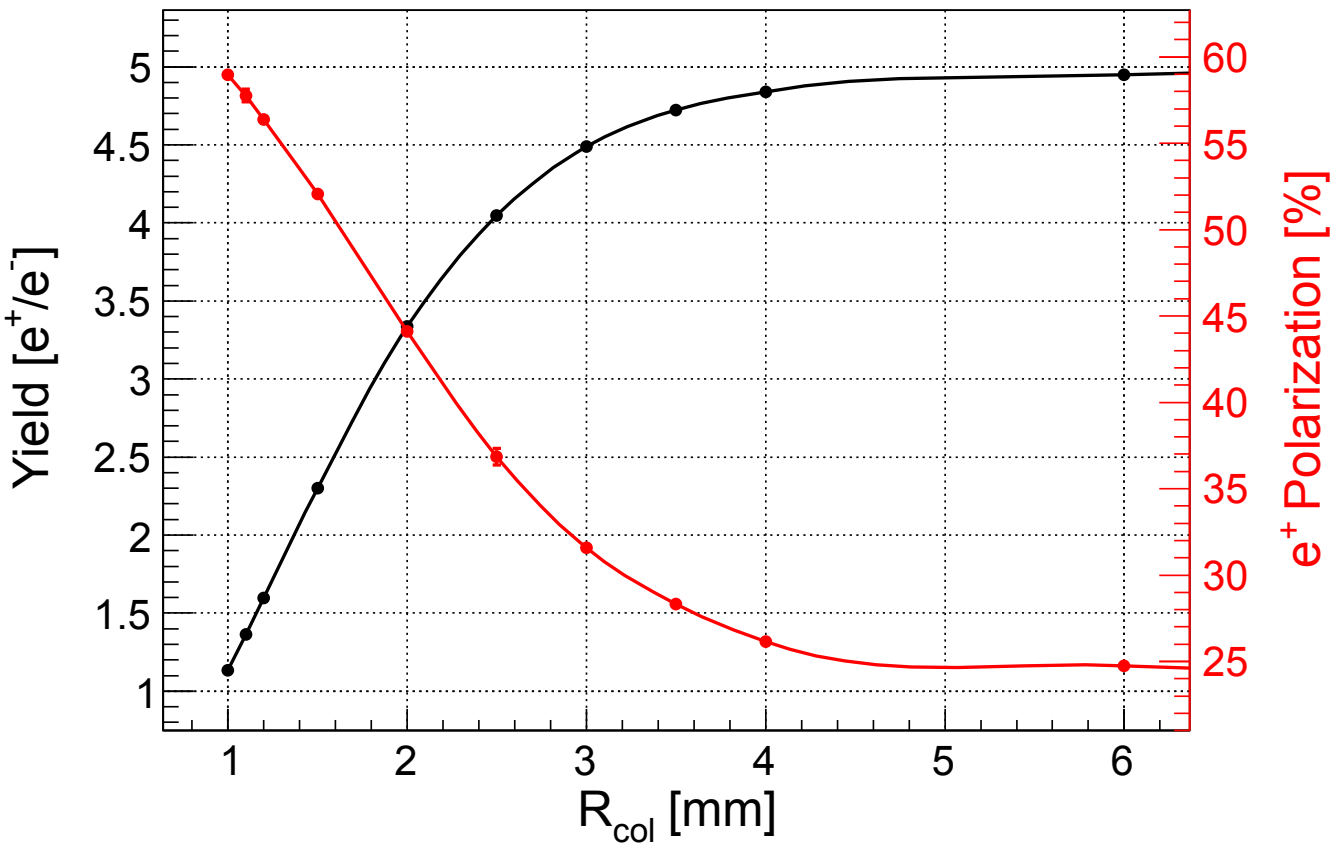
- $P_{e^+} \simeq$ **40%** for $R_{\text{col}} = 3.5$ mm and $L_{\text{u}} = 231$ m, $K = 0.92$
- $P_{e^+} \simeq$ **31%** without collimator and $L_{\text{u}} = 231$ m, $K = 0.84$

Design of Photon Collimator* (DESY Zeuthen)



* ILC Technical Design Report, 2013

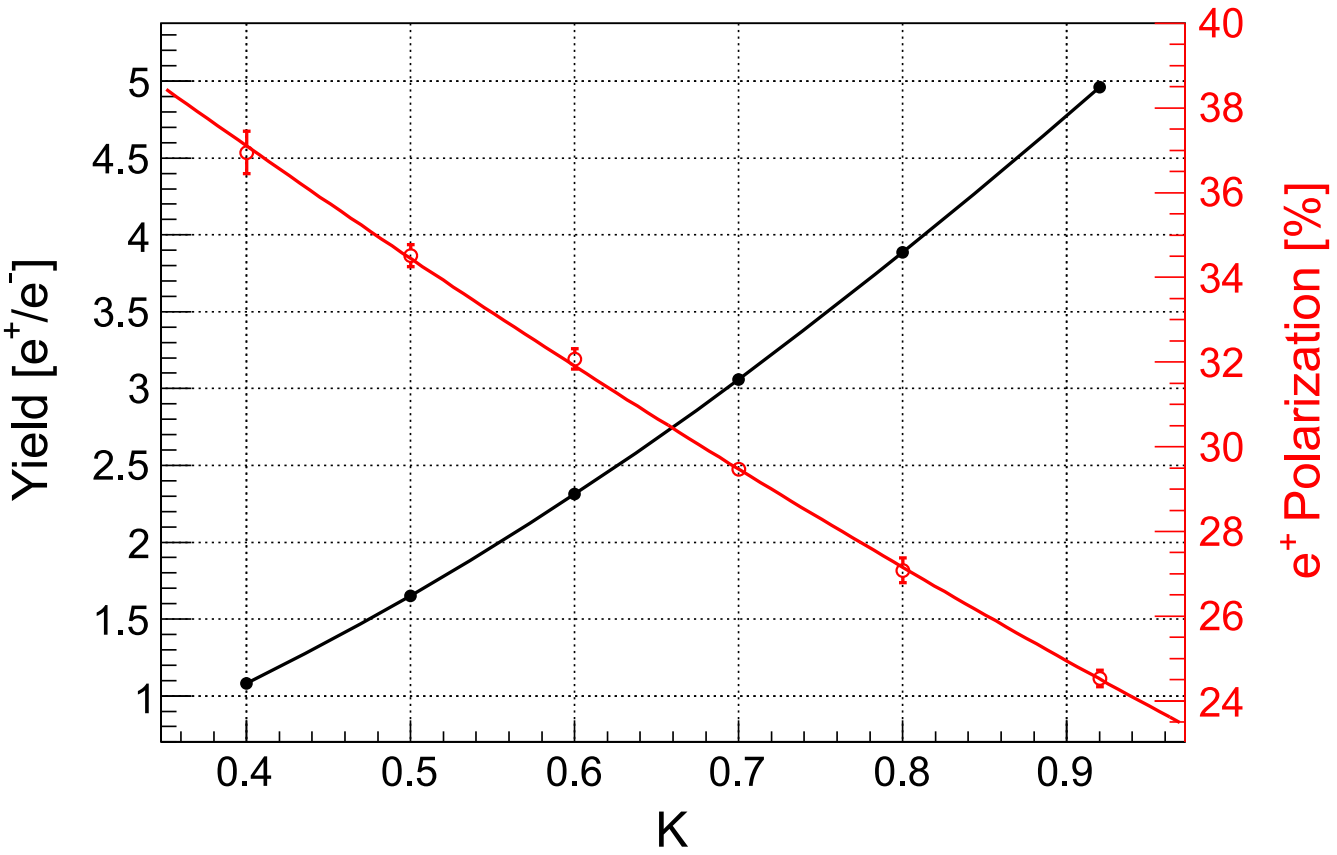
e^+ Polarization with Photon Collimator at 175 GeV e^-



e^+ polarization of source at 175 GeV e^- (with photon collimator):

$P_{e^+} \simeq$ **56%** for $R_{\text{col}} = 1.2$ mm, $L_{\text{u}} = 220$ m, $K = 0.92$

e^+ Polarization without Photon Collimator at 175 GeV

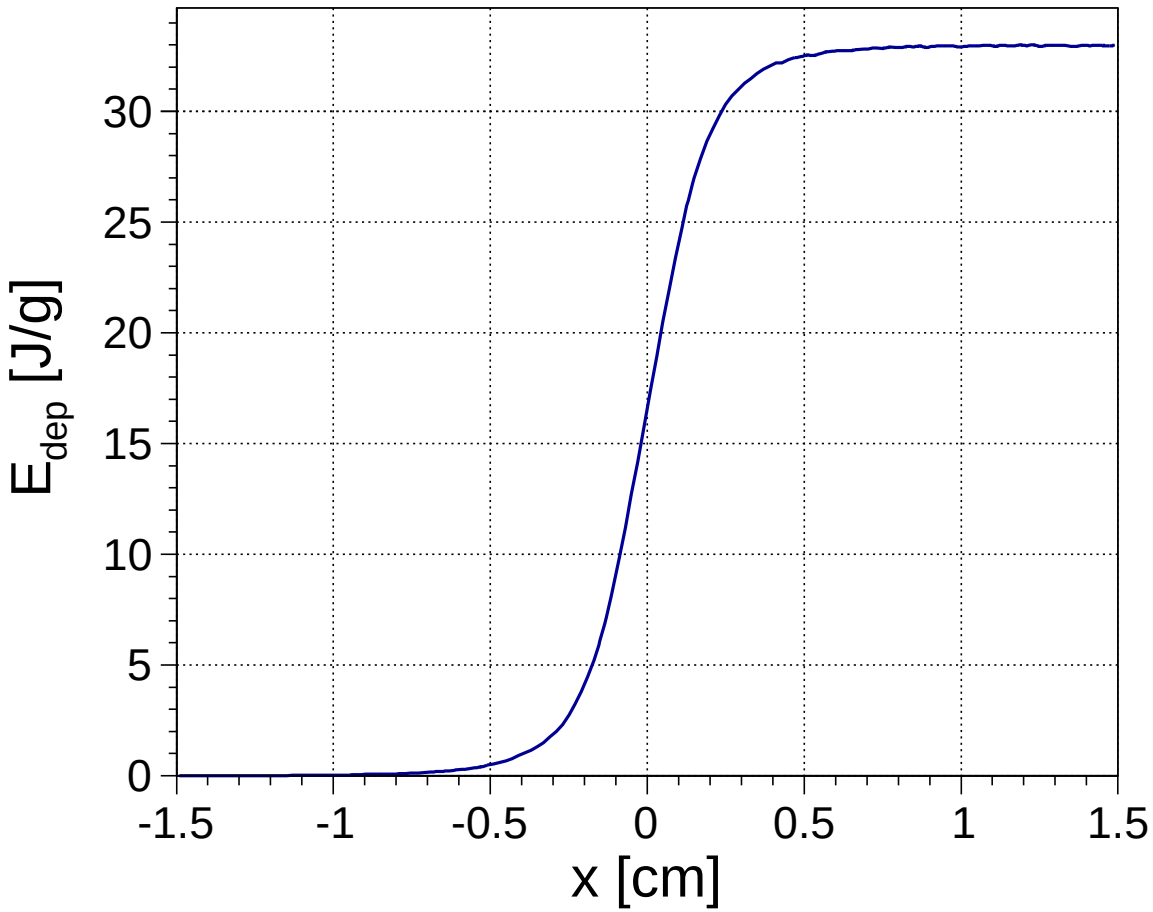


e^+ polarization of source at 175 GeV e^- (without photon collimator):

$P_{e^+} \simeq$ **35%** for $L_u = 231$ m, $K = 0.47$

Energy Deposition in Target at 175 GeV e^-

70 m undulator with $K = 0.92$, 100 m/s rotating speed, 554 ns bunch spacing



$\langle E_{ph} \rangle = 14.5$ MeV

$\langle E_{dep} \rangle = 1$ MeV/ph

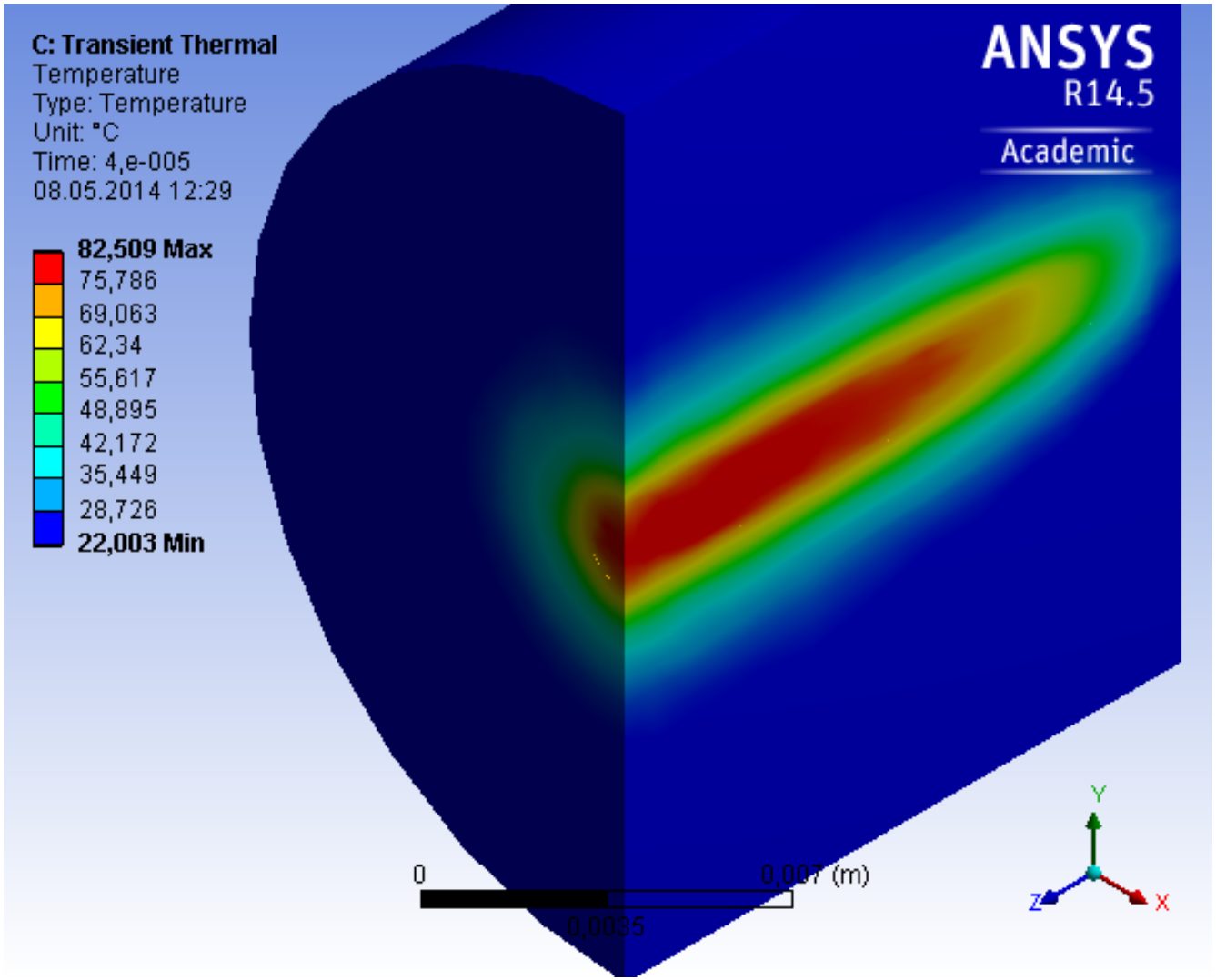
1312 bunches/pulse,
5 Hz repetition rate:

$\langle P \rangle \approx$ 3 kW

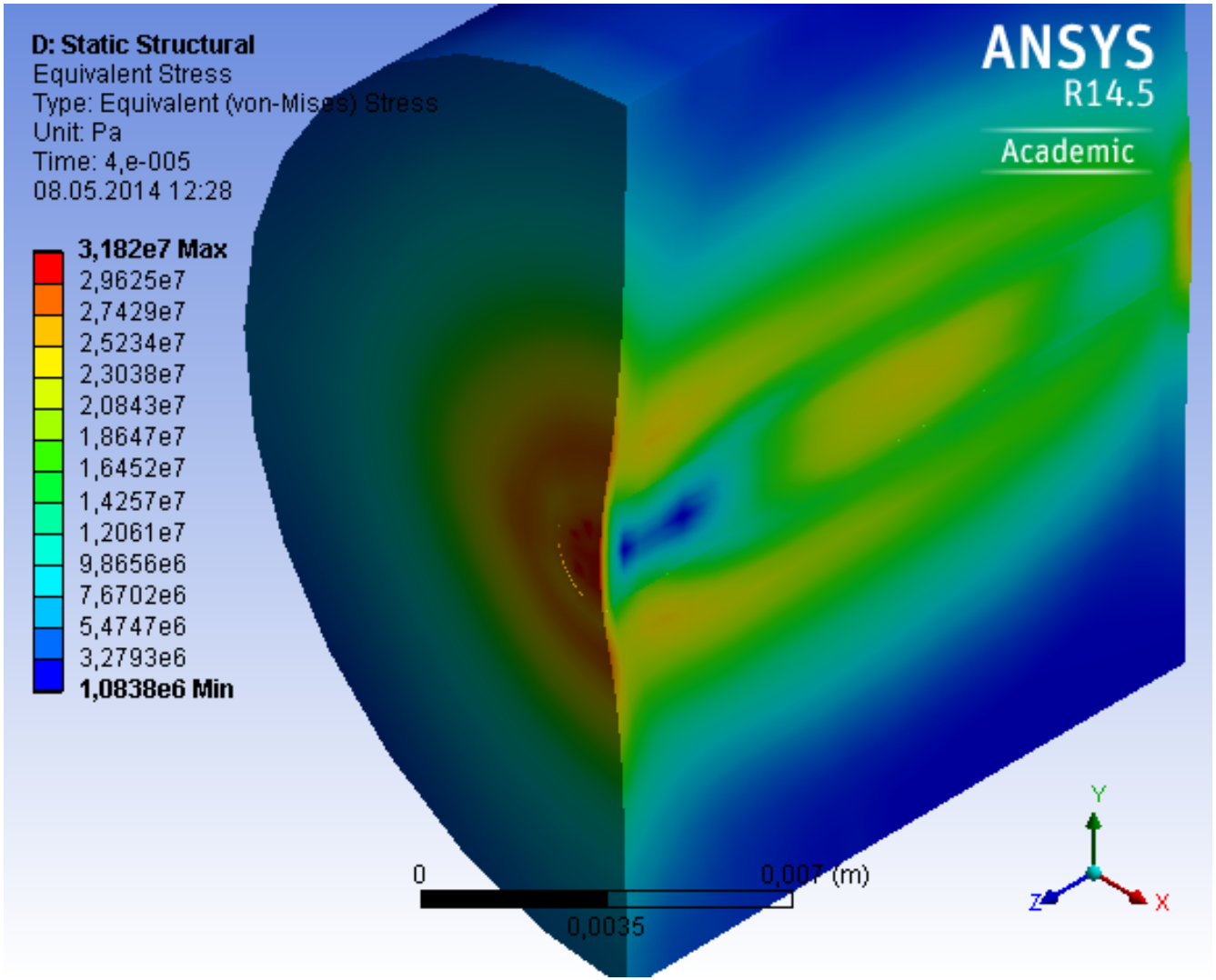
per Bunch: PEDD = 0.5 J/g $\Rightarrow \Delta T \approx 1$ K
per Pulse: PEDD = **33 J/g** $\Rightarrow \Delta T = 63$ K

66 bunches/pulse

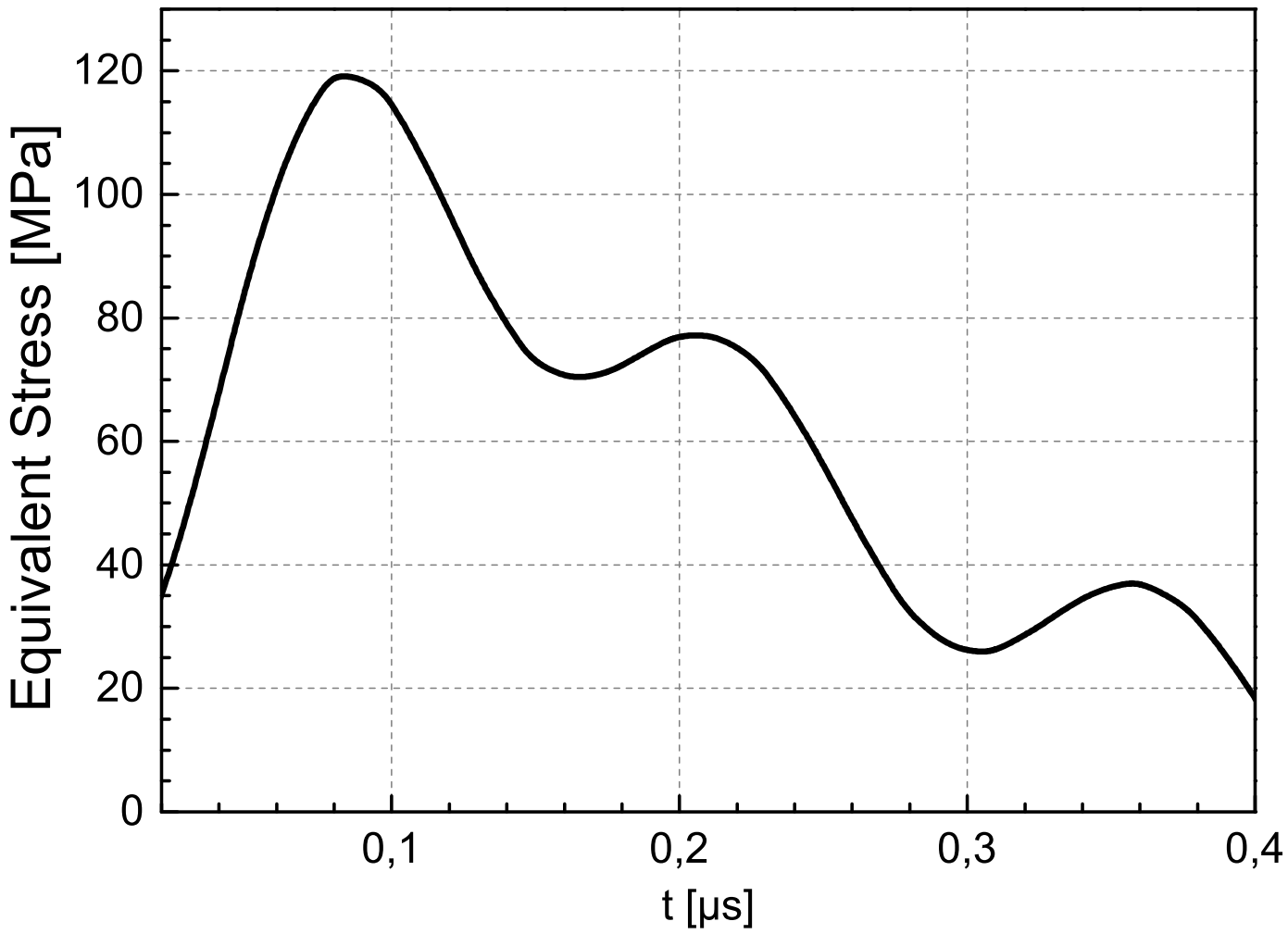
Temperature Distribution after Bunch Train at 175 GeV



Distribution of Quasi-Static Stress at 175 GeV



Time Evolution of Dynamic Stress at 175 GeV



$\sigma_{max} \approx$ **120 MPa** on back side of target at beam center

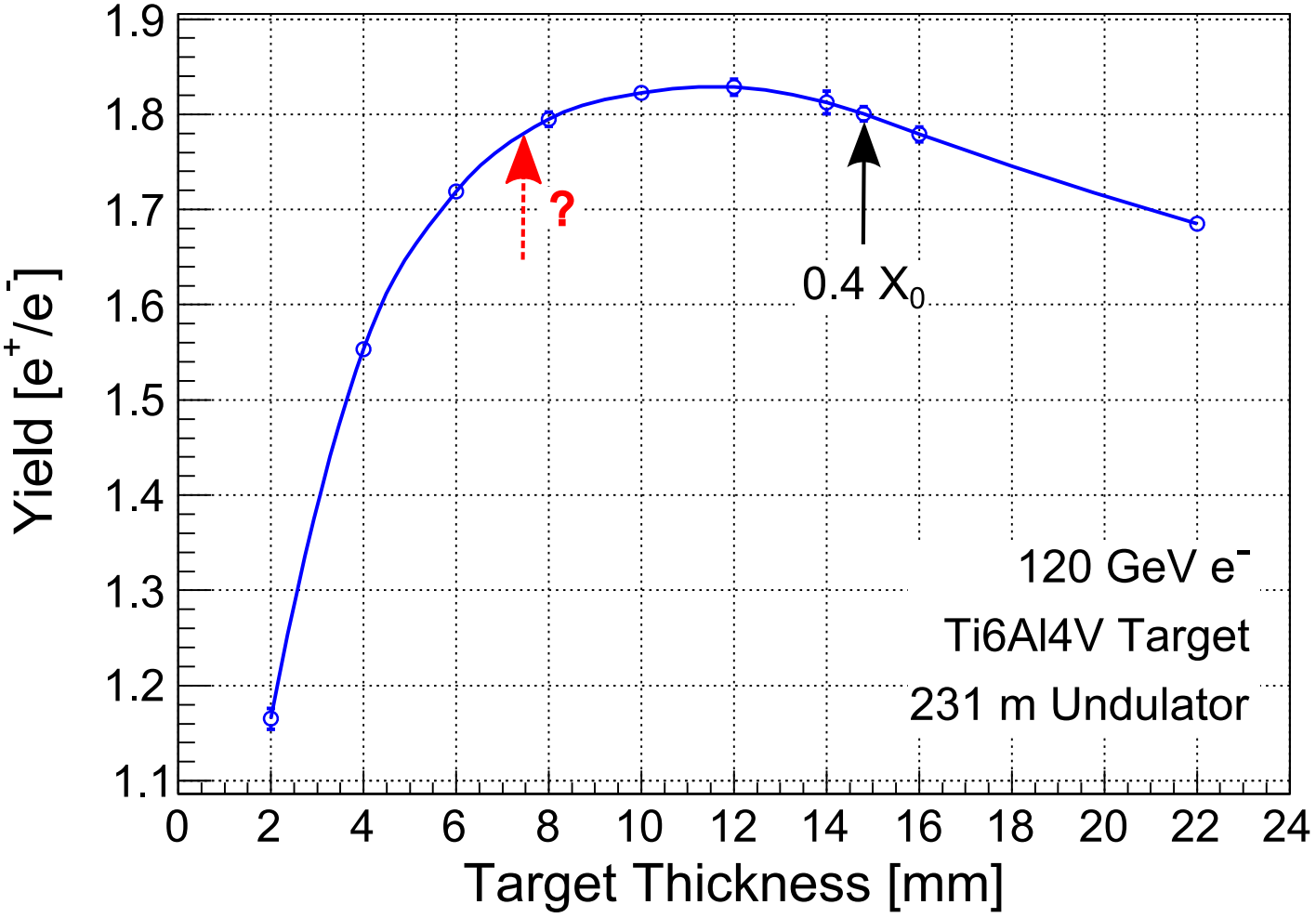
(at 120 GeV e^- $\sigma_{max} \approx$ 140 MPa; fatigue strength for Ti6Al4V is 510 MPa)

Summary

- e^+ source at 175 GeV e^- and 231 m active undulator length has much more "freedom" for *polarization upgrade* in comparison to 120 GeV
- e^+ polarization without using photon collimator is **35%** at $K = 0.47$
- Photon collimator with 1.2 mm aperture radius will allow to increase P_{e^+} up to **56%**
- At 175 GeV the maximal dynamic thermal stress in target induced by bunch train is $\approx$**120 MPa**. It is approx. 4 times less then the fatigue strength.
  Can rotation speed at 175 GeV be reduced 4 times?
  The eddy currents, mechanical stress due to rotation and material properties degradation due to radiation damage have to be studied.

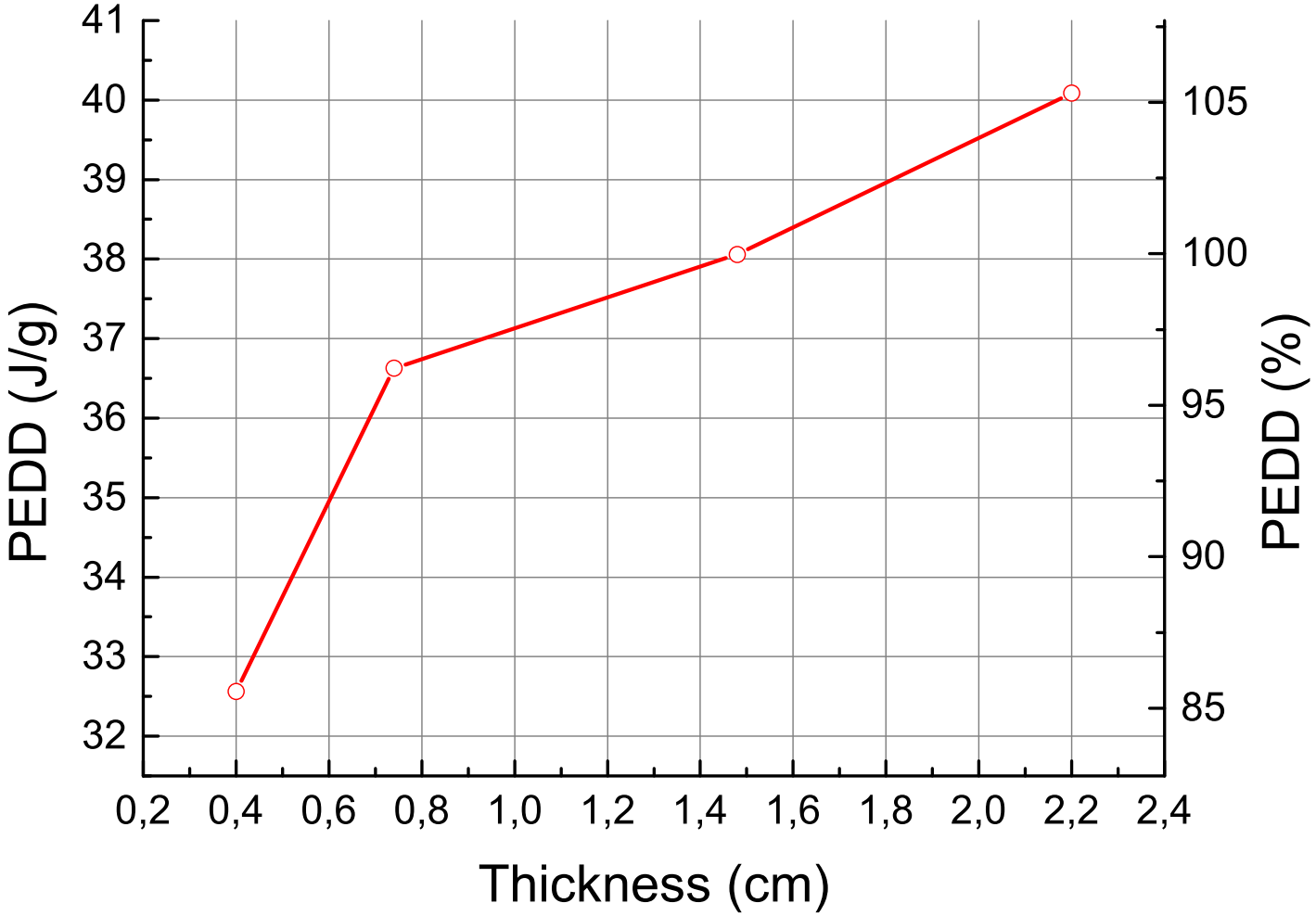
  At nominal ILC operation mode (1312 bunches/train, 554 ns bunch spacing): 66 bunches per pulse are crossing the same target area.
  Total average deposited by beam power in target is 3 kW

Yield vs Target Thickness



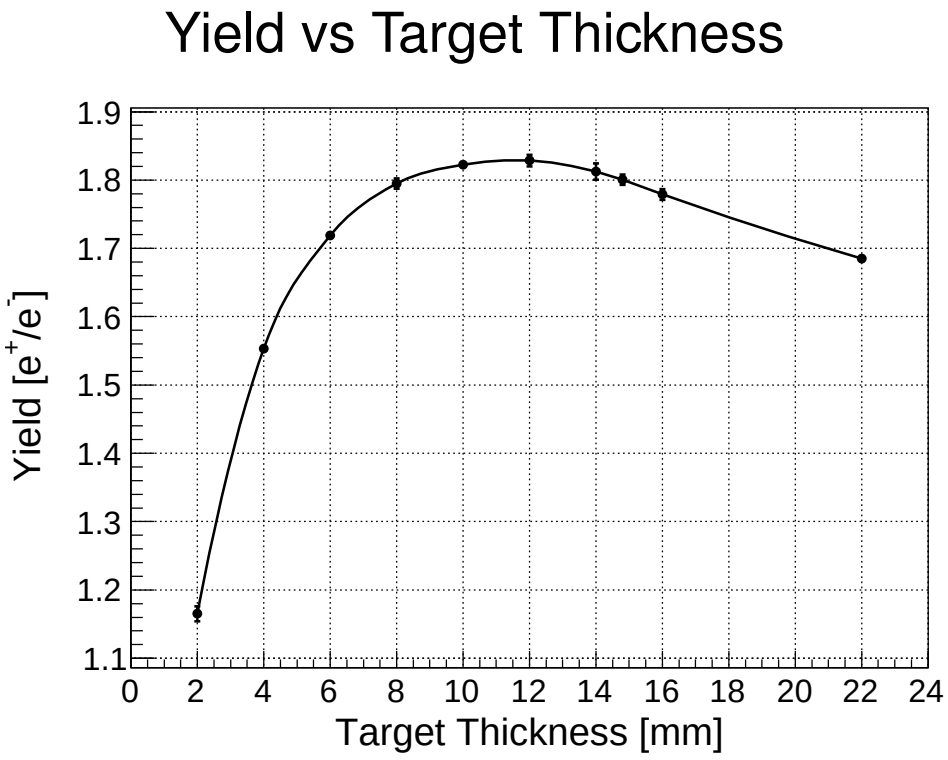
Can target be made 2 times thinner? (P. Sievers)

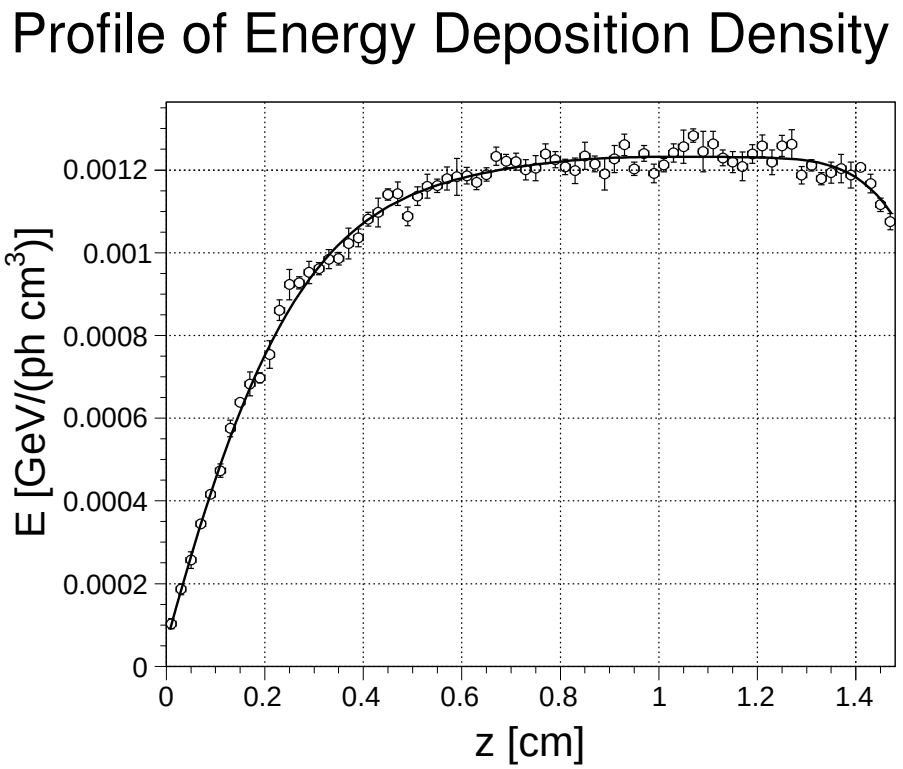
PEDD vs Target Thickness (120 GeV e^-)



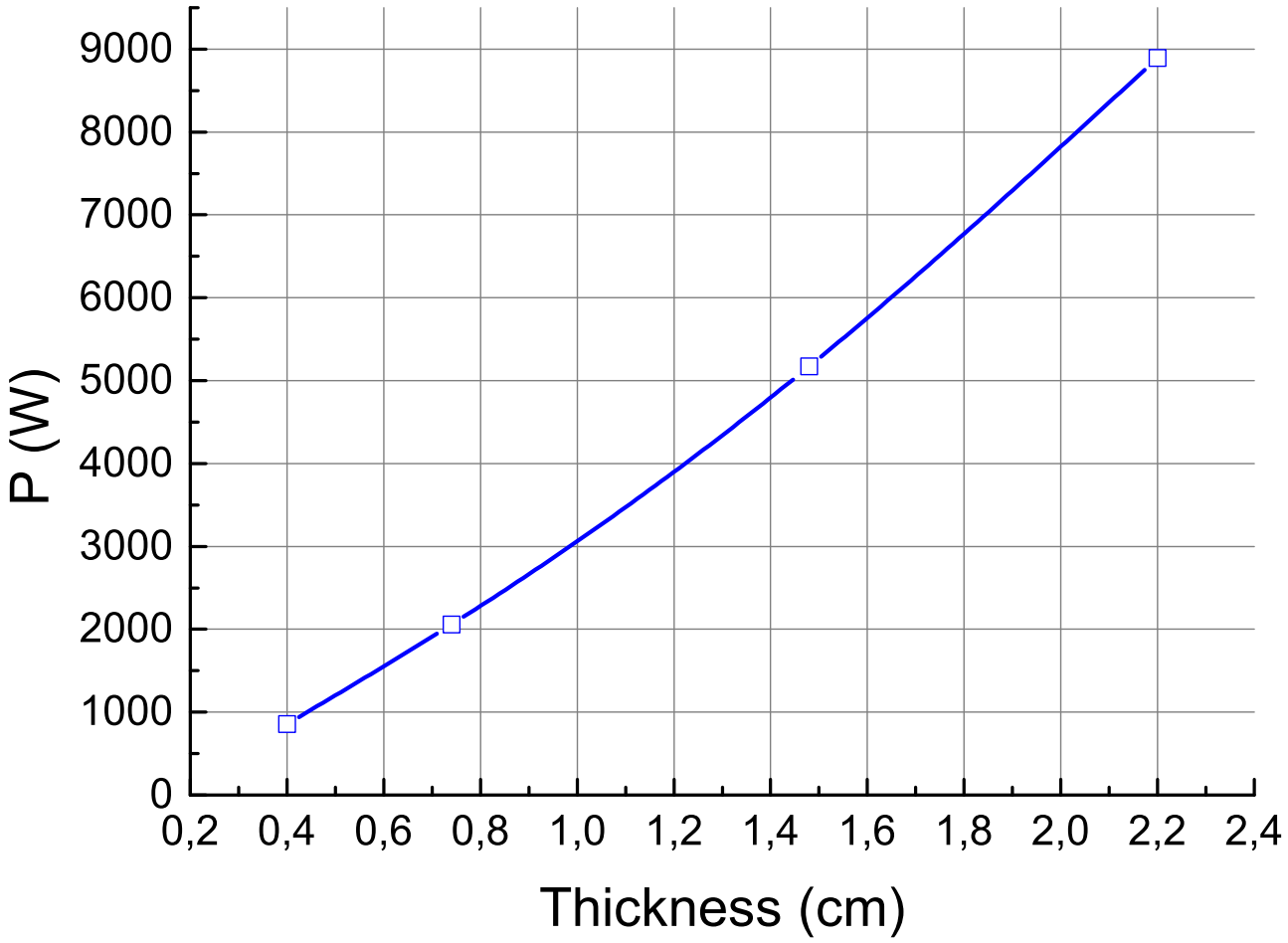
$0.4X_0 \rightarrow 0.2X_0 \quad \Rightarrow \quad$ **−4% PEDD**

Energy Deposition Density on Beam Axis (120 GeV e^-)





Total Average Deposited Power (120 GeV e^-)



$0.4X_0 \rightarrow 0.2X_0 \quad \Rightarrow \quad$ **−60%** Total Deposited in Target Energy

Topic of future study: Can, for example, $0.2X_0$ W25Re target be used without active (water) cooling, just using **radiative cooling** only?