Undulator-Based Positron Source with Photon Collimator and QWT

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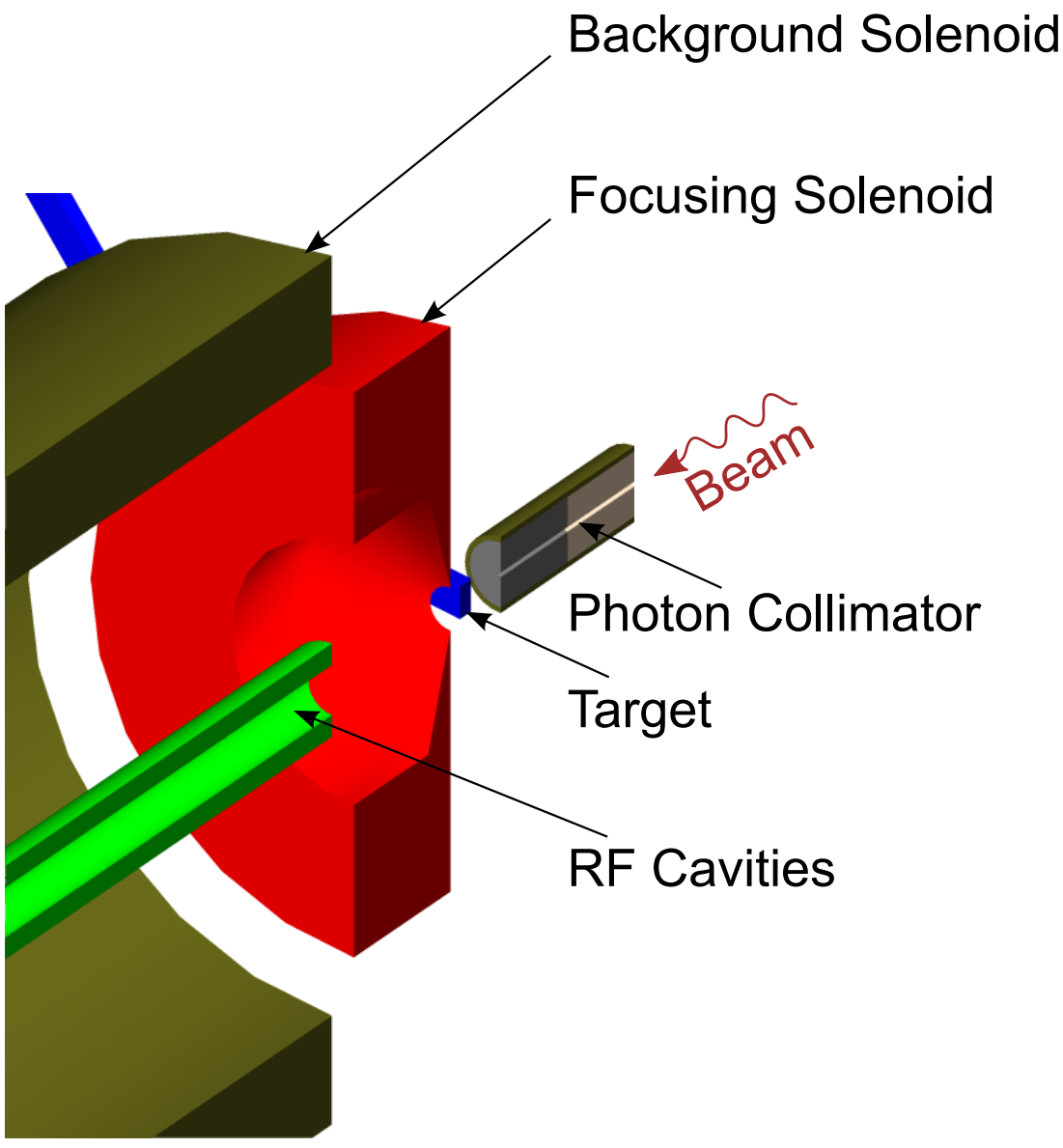
Outline

- PPS-Sim model of positron source
- Field of QWT
  - Simplified field distribution of QWT
  - More realistic QWT field
  - Yield and polarization of source with QWT
- Photon collimator
  - Implementation of collimator in PPS-Sim
  - Heat load in collimator
- Summary
- Status of Activation Studies

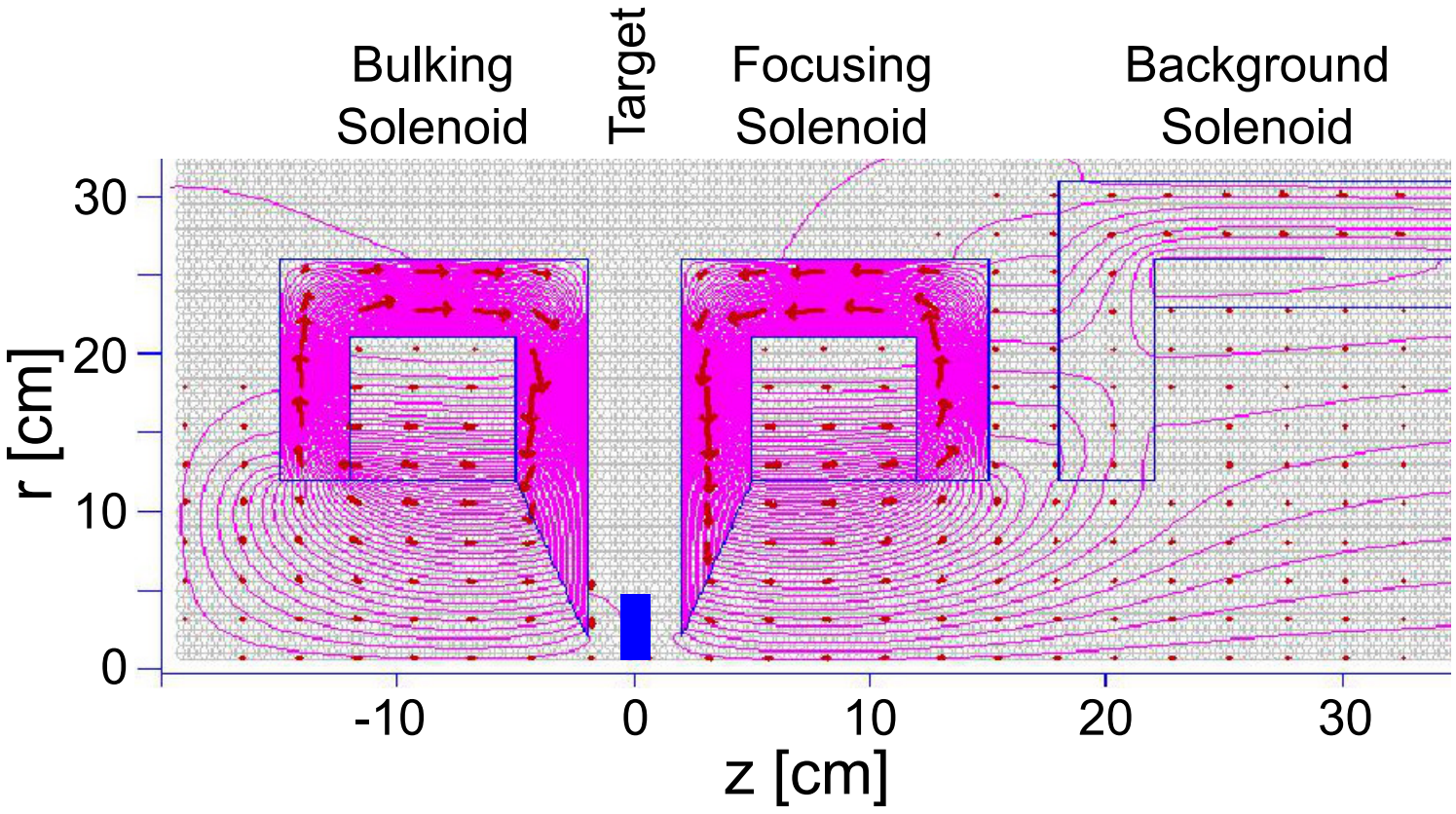
PPS-Sim Model of Positron Source



QWT Field

B-field distribution

calculated in Poisson Superfish

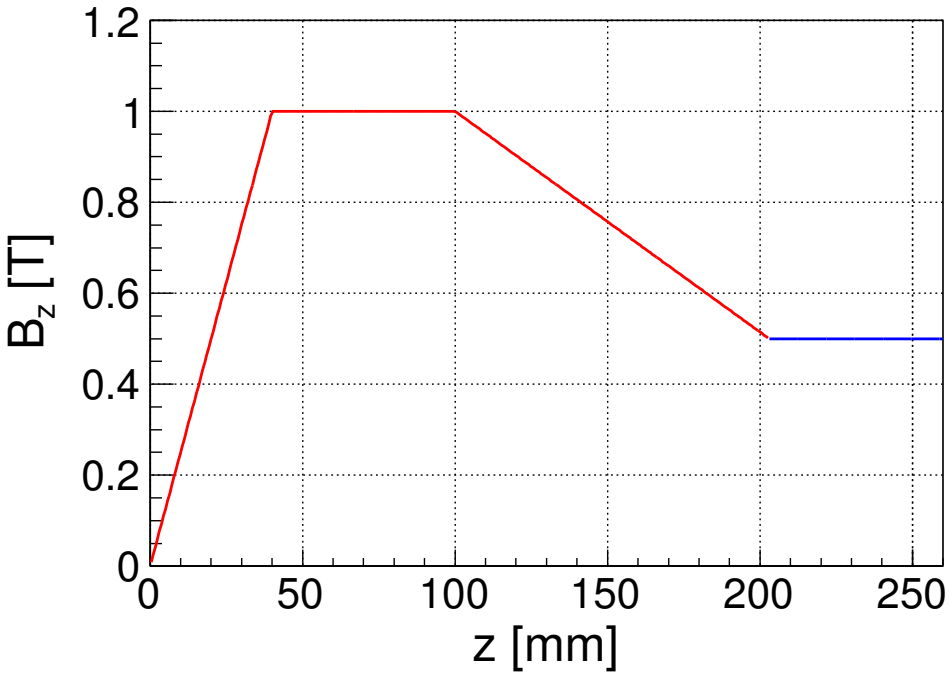


Geometry of QWT has been provided by Wanming Liu and Wei Gai

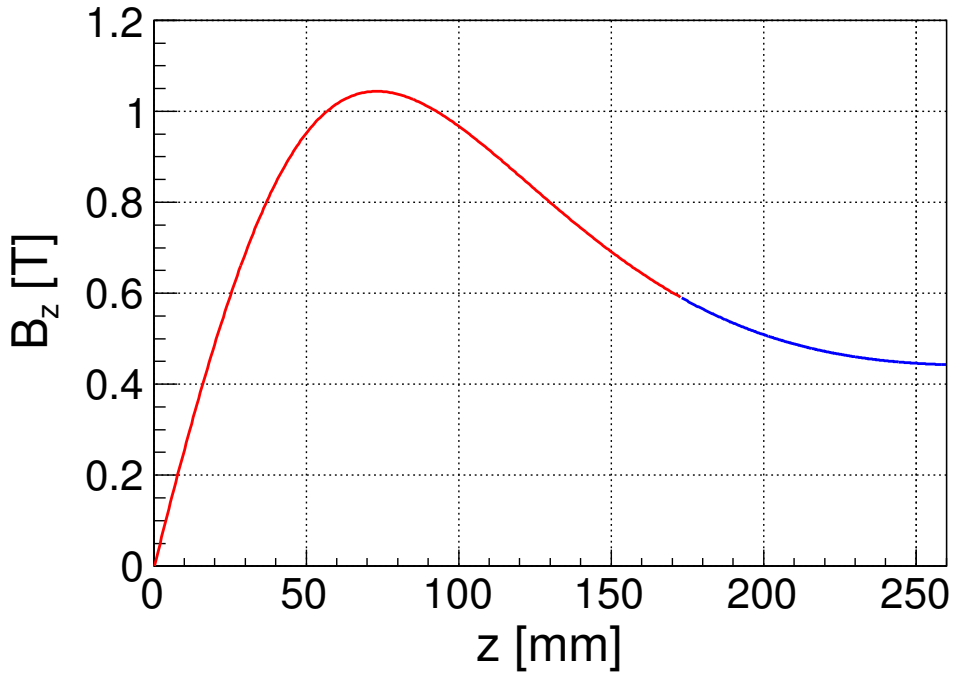
Implemented QWT Field in PPS-Sim

B_z-field profile along beam axis downstream the target

QWT Model 1



QWT Model 2

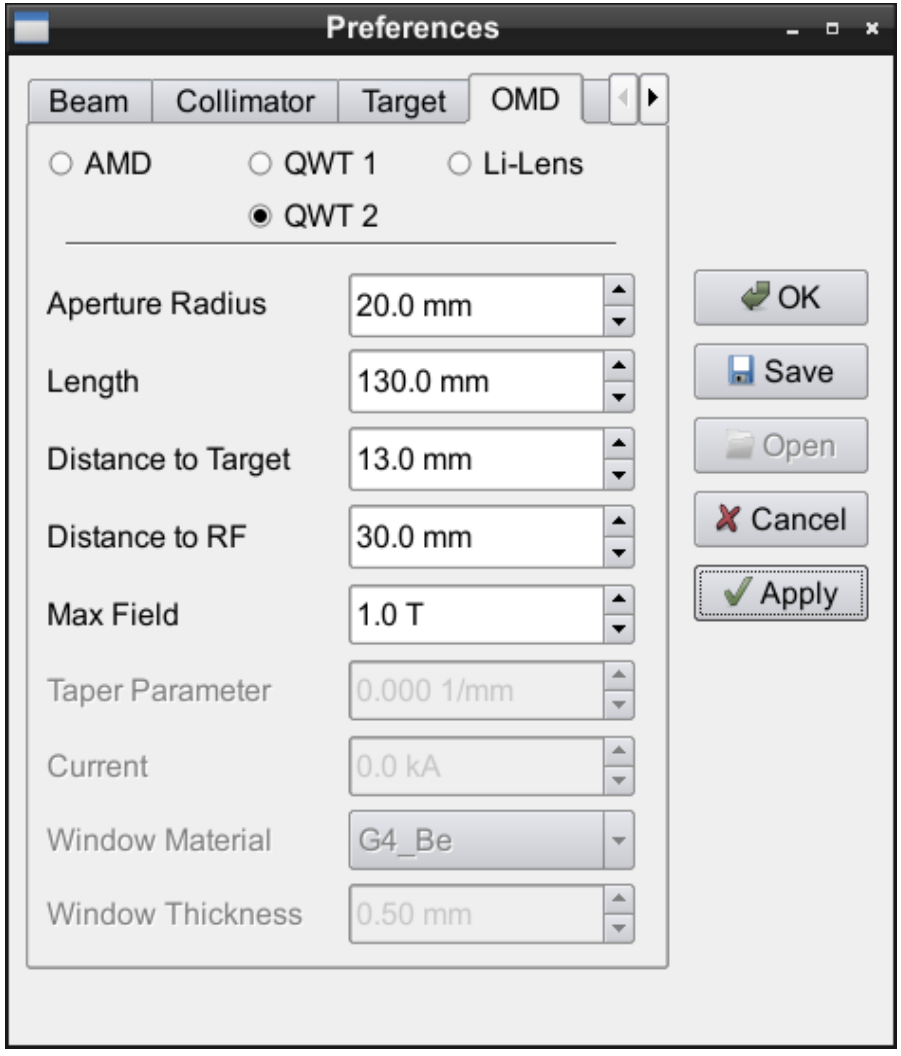


red line — field between target and background solenoid

blue line — field inside of background solenoid and RF cavity

QWT Settings in PPS-Sim

GUI: QWT Settings



- All parameters of QWT Model 1 (geometry and field) can be adjusted
- Only maximal field of QWT Model 2 can be changed

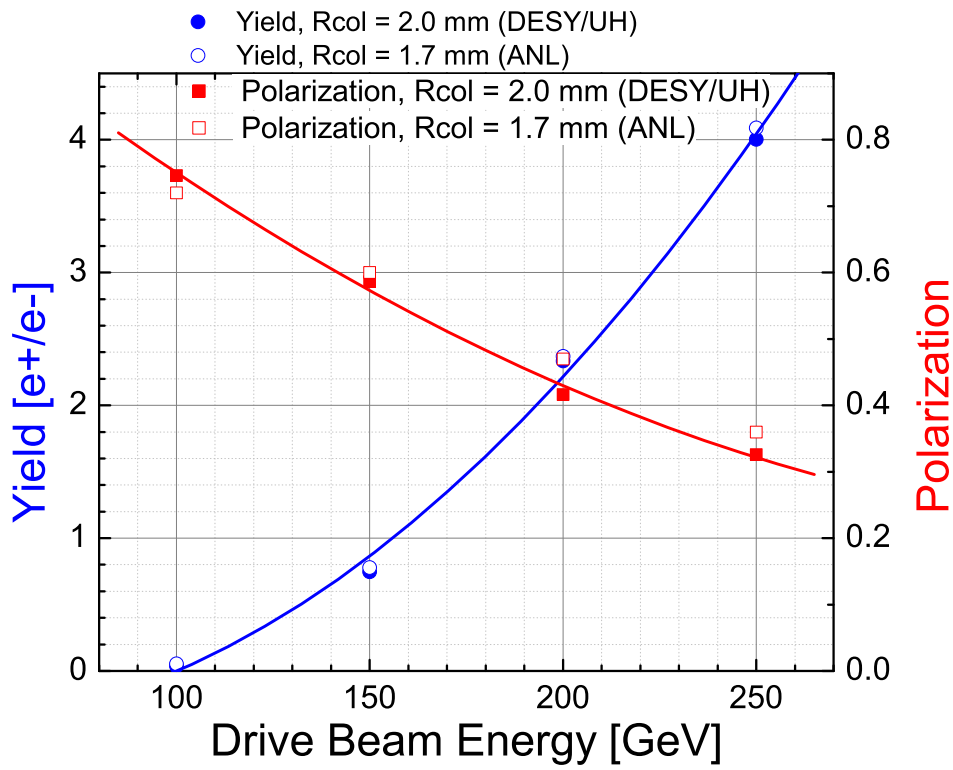
Not all geometry and field parameters of positron source are available in EDMS. This work is ongoing.

Comparison of QWT (Model 2) with ANL Results

Some PPS-Sim settings:

- Length of RDR undulator is 231 m
- Distance between middle of undulator to target is 500 m
- Aperture radius of photon collimator is 2 mm
- Distance between target and QWT focusing solenoid is 13 mm
- QWT focusing solenoid length is 130 mm
- Distance between QWT focusing solenoid and background solenoid is 30 mm
- Maximal field of QWT focusing solenoid is 1.5 Tesla
- Field of background solenoid is 0.5 Tesla

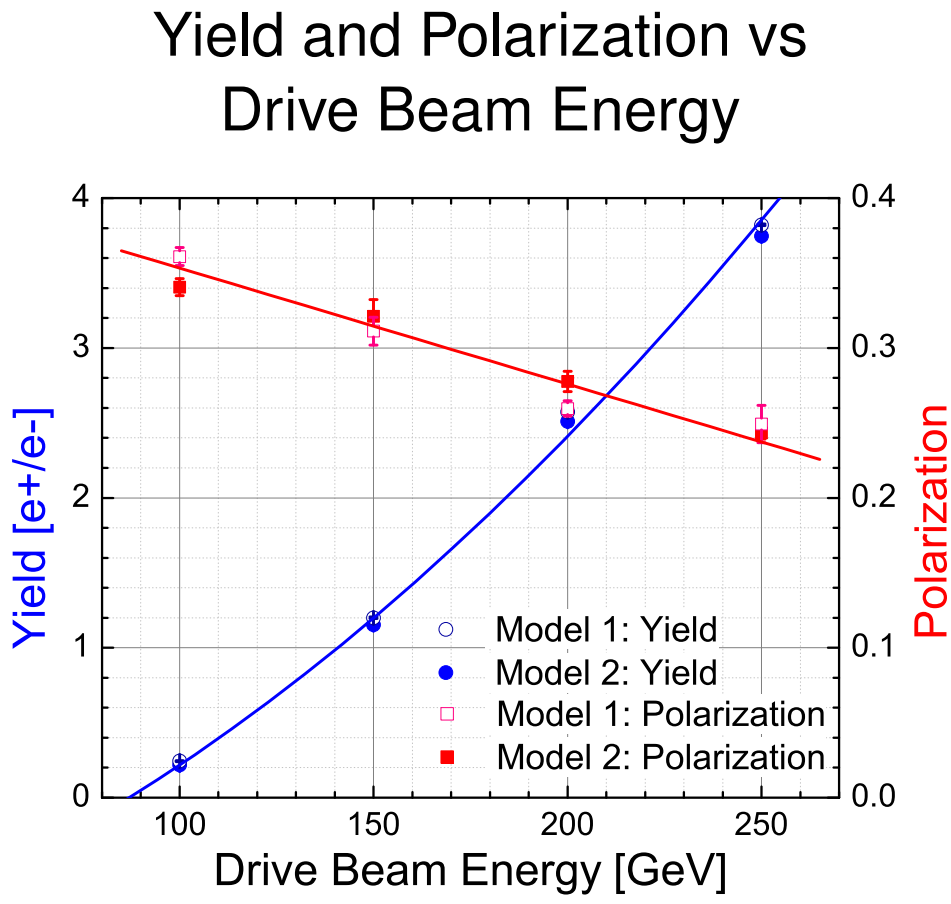
Yield and Polarization vs Drive Beam Energy



Note: ANL data was taken from Wei Gai BAW-2 talk

PPS-Sim: Comparison of Two QWT Models

- **Without** photon collimator
- Both models have similar geometry (**same position and length** of coils)
- Maximal field of focusing solenoid is **1 T**

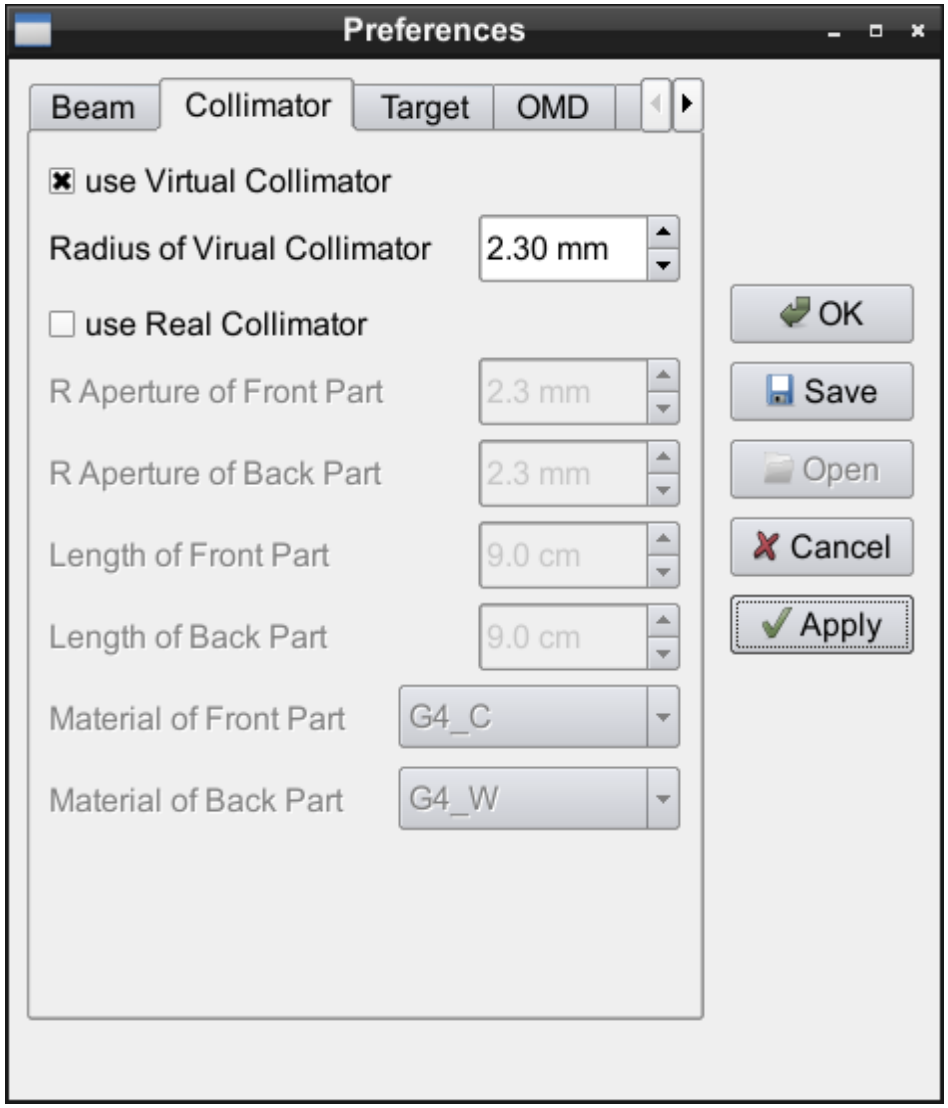


Simplified Model No. 1 can be used for “optimization” studies

PPS-Sim: Choice of Photon Collimator

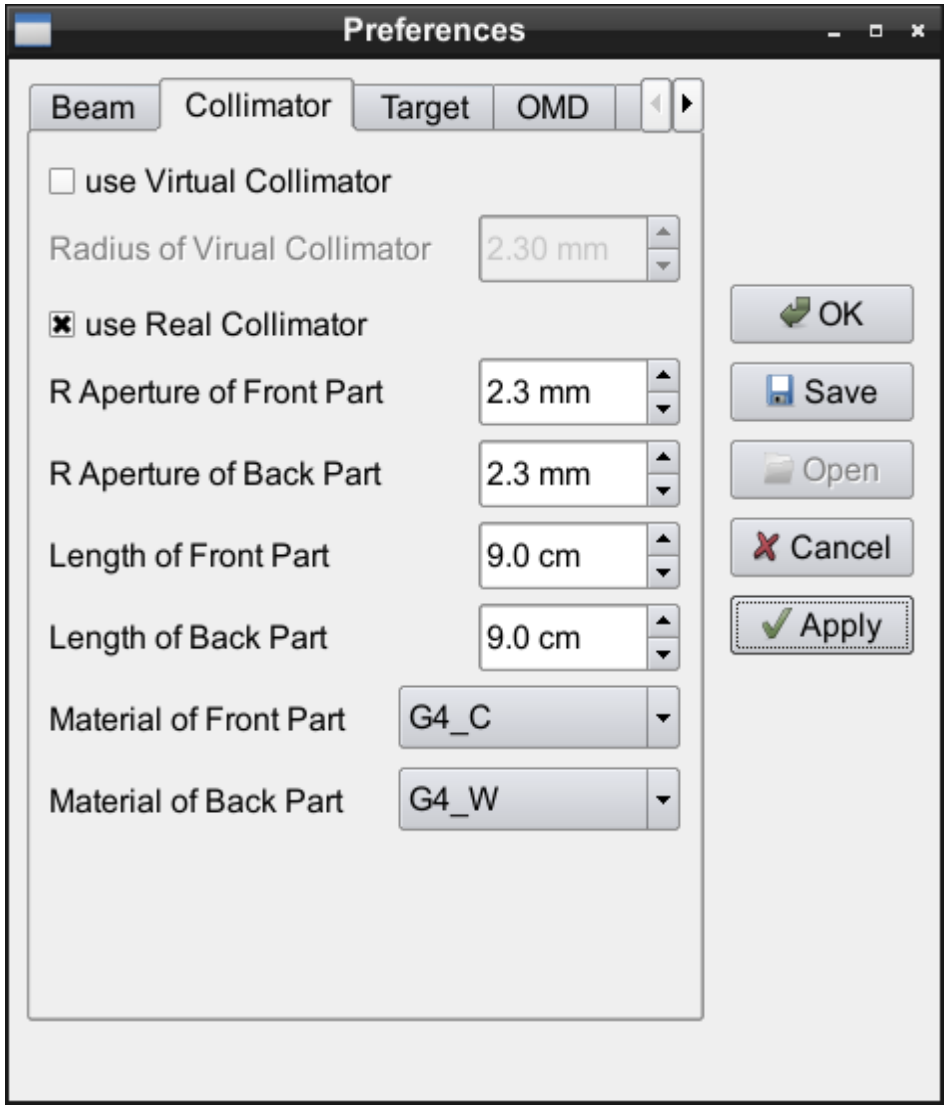
Virtual Collimator

(no Physical Object)



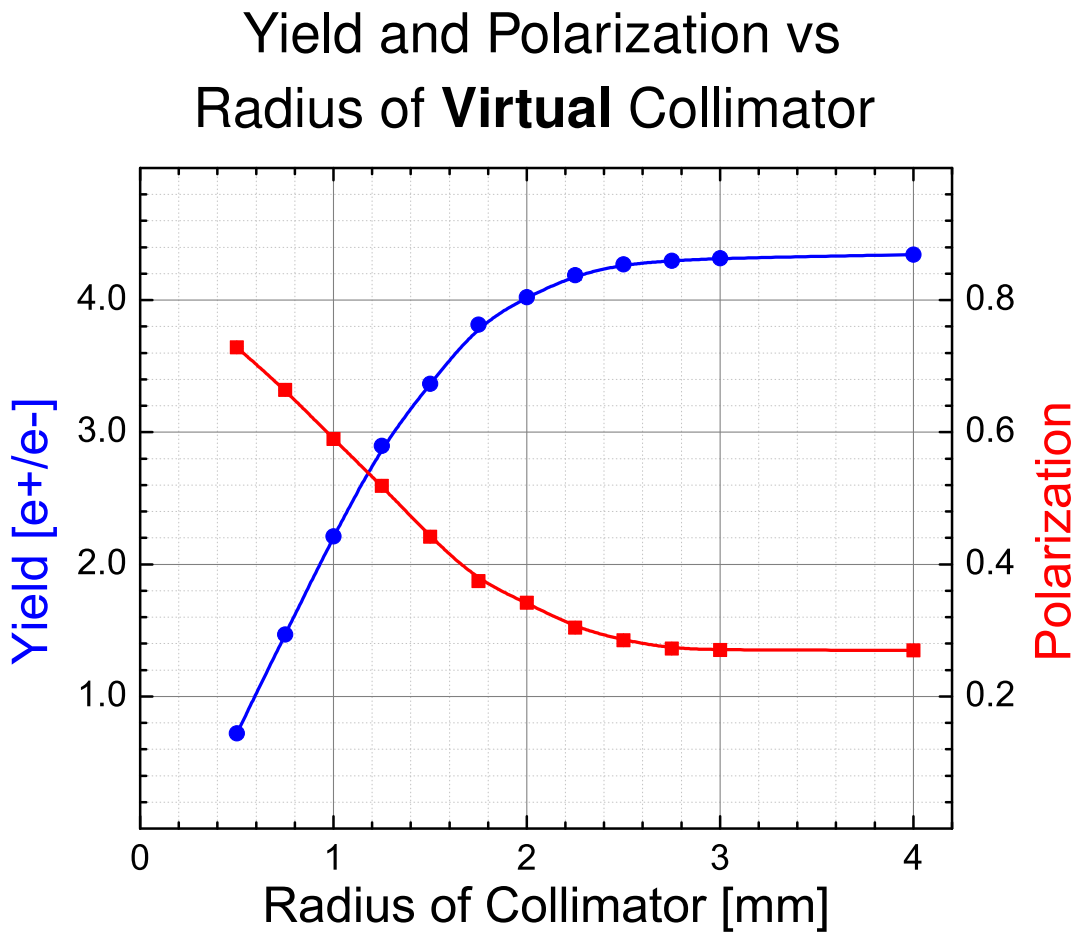
"Real" Collimator

Model of Lei Zang (U Liverpool)



Yield and Polarization vs Radius of Collimator

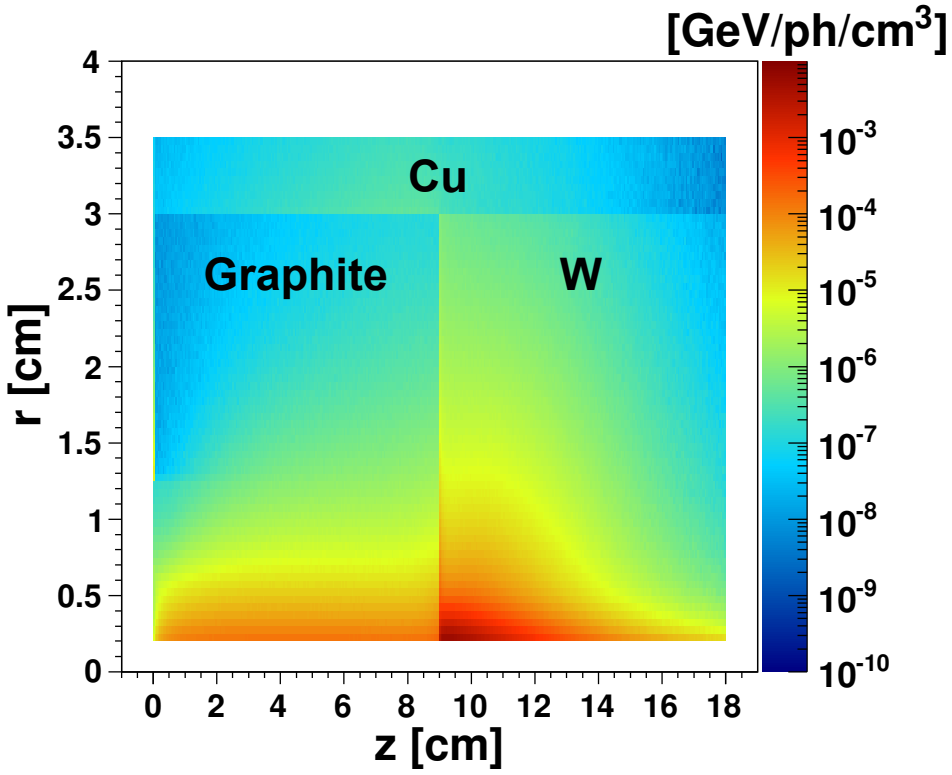
- 250 GeV drive beam
- 231 m RDR undulator
- QWT Model 2
- 1.5 T max. field of focusing solenoid



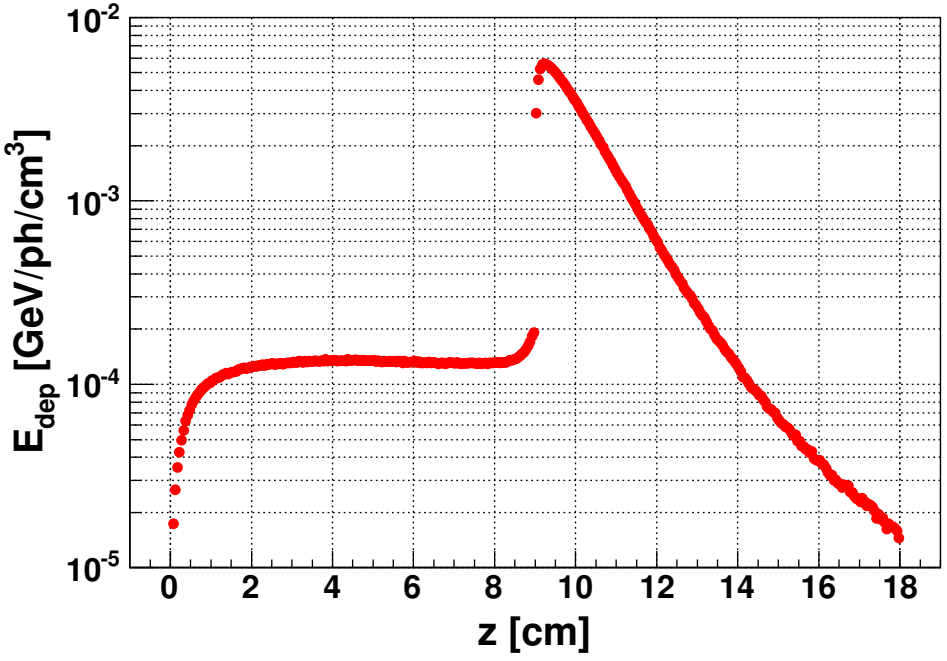
Energy Deposition in Collimator

250 GeV e-, RDR undulator,
collimator with 2 mm aperture radius
placed ≈500 m downstream the undulator

Deposited Energy Map



Deposited Energy along $r \simeq 0.2$ cm



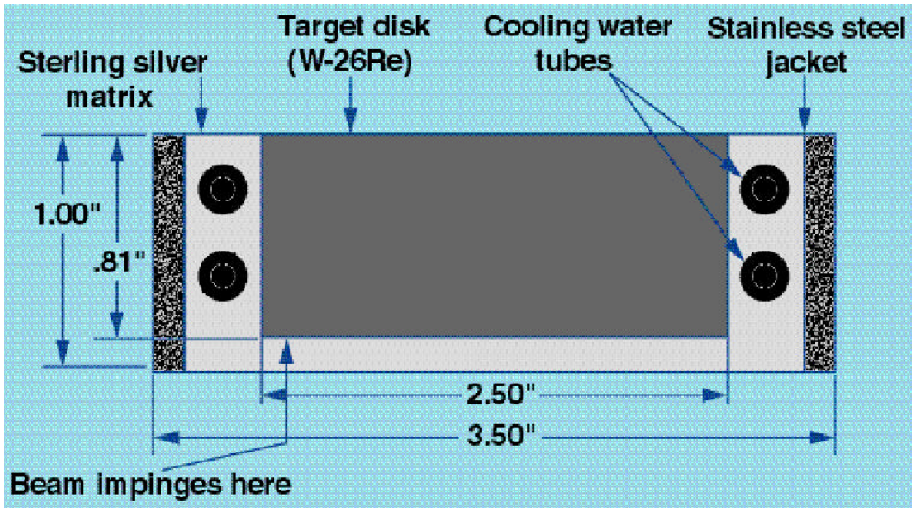
Tungsten: PEDD = 5.6 MeV/photon/cm^3 = ??? J/g

PEDD in Collimator with Aperture Radius of 2 mm

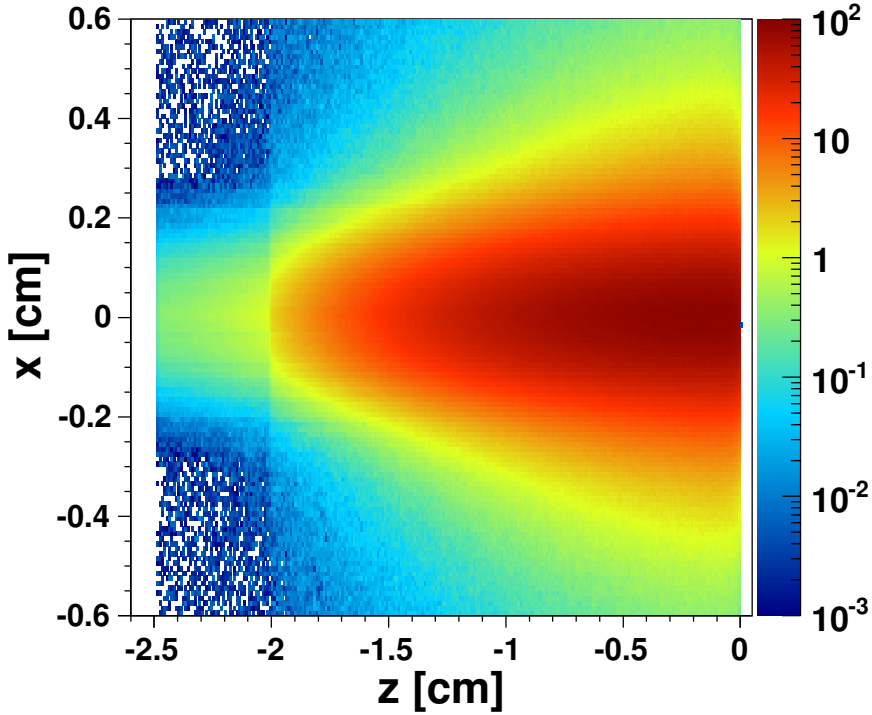
e^- Beam Energy	250 GeV
No. of e^-	$2 \cdot 10^{10}$ e^-/bunch
No. of Bunches	1312 bunches/train
Undulator Type	RDR
Undulator-Collimator Distance	$\approx$500 m
No. of Photons	1.94 ph/(e^- m)
Required Undulator Length (QWT)	**70 m***
No. of Photons	$3.6 \cdot 10^{15}$ ph/train
PEDD in Tungsten Part	5.6 MeV/ph/cm^3
Density of W	19.3 g/cm^3
PEDD in Tungsten Part	**165.5** J/g/train
Heat Capacity of W at 25°C	0.134 J/g/K
Max. Temperature Increase	1235 K/train

* Required undulator length has been calculated by Wei Gai and Wanming Liu for source with QWT to achive 1.5 e^+/e^-

PEDD: SLC Target

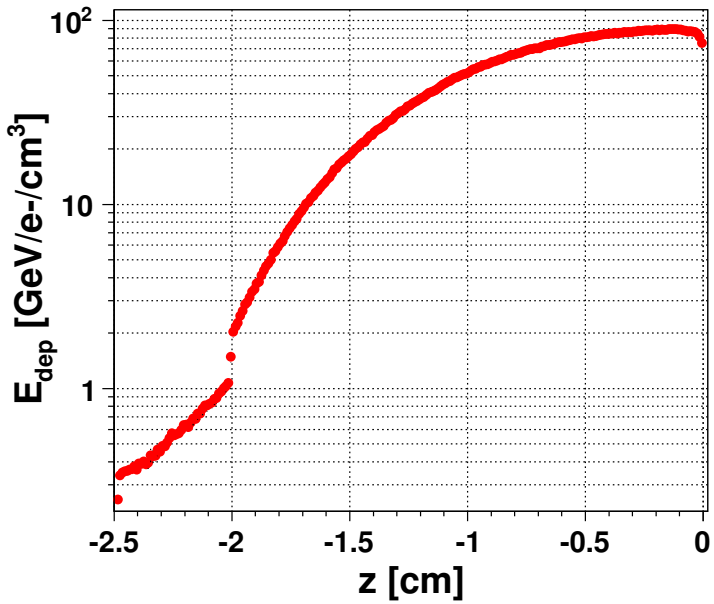


Werner Stein, SLC Positron Target Workshop, April 24, 2001



e^- Beam Energy	33 GeV
e^- Beam Size σ	0.8 mm
No. of e^-	$4 \cdot 10^{10}$ e^-/bunch
No. of Bunches	1 bunch/train
PEDD in 6 X_0 W25Re	89 GeV/e^-/cm^3
Density of W25Re	19.77 g/cm^3
PEDD	**29** J/g/train

David C. Schultz et al. LCC-0082, June 2002:
PEDD = 28 J/g

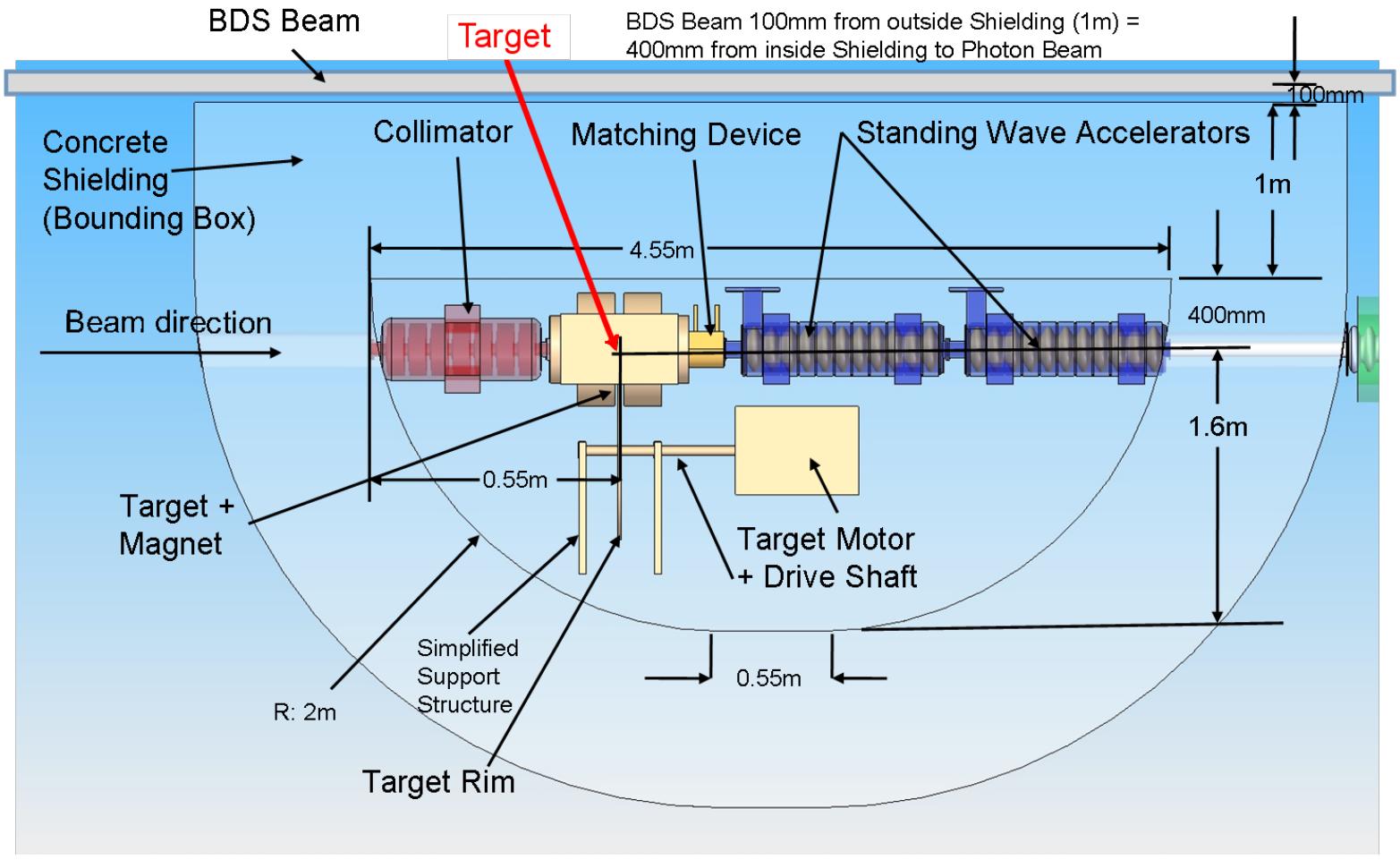


Summary

- More realistics field of QWT has been implemented in PPS-Sim
- PPS-Sim results for source with QWT are in agreement with ANL group simulation results
- More simple QWT model could be also used for “optimization” studies
- One model of photon collimator (graphite + tungsten) has been added to PPS-Sim
- PEDD in collimator even with moderate aperture size ($r = 2$ mm) is very high. Additional (ANSYS) studies are needed

Activation of Target Area. Sketch Concrete Shielding

provided by Norbert Collomb, Neil Bliss (STFC, 2009)



Status of Activation Studies in DESY/Uni Hamburg

Last results: *A. Ushakov et al. LCWA, October 2009*

What has been done?

- Dose equivalent in soft tissue has been estimated in target area for "SB2009 parameter set" during source operation and residual dose rates after source switched off
- Thickness of concrete shielding (required to protect working staff) has been calculated
- FLUKA model includes the following *simplified* source parts:
  - shielding box
  - target rim
  - flux concentrator (state on middle of 2009)
  - 1st RF structure embedded into background solenoid

What is necessary to continue?

- Add to model the missing parts inside concrete shielding box:
  - QWT, background solenoid
  - collimator
  - vacuum chamber ...
- Define dose limits for staff (10 μSv/h behind shielding wall and just after source switched off?) and limits for equipment (target motor, seals etc.)
- Man-power