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Preliminary Study on CLIC Undulator Positron Scheme

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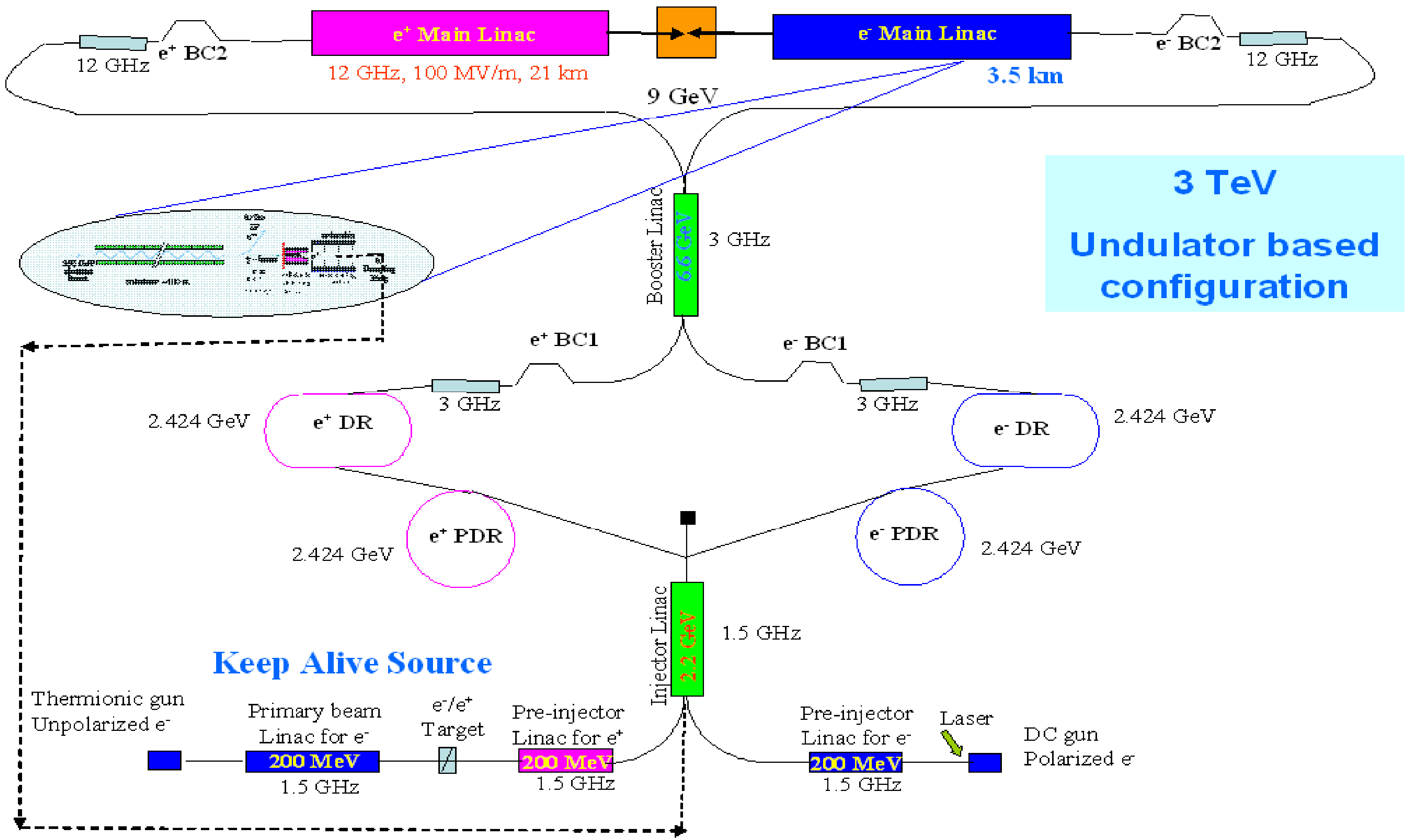
Positron Collaborating Meeting, ANL
Sept. 17-19, 2007

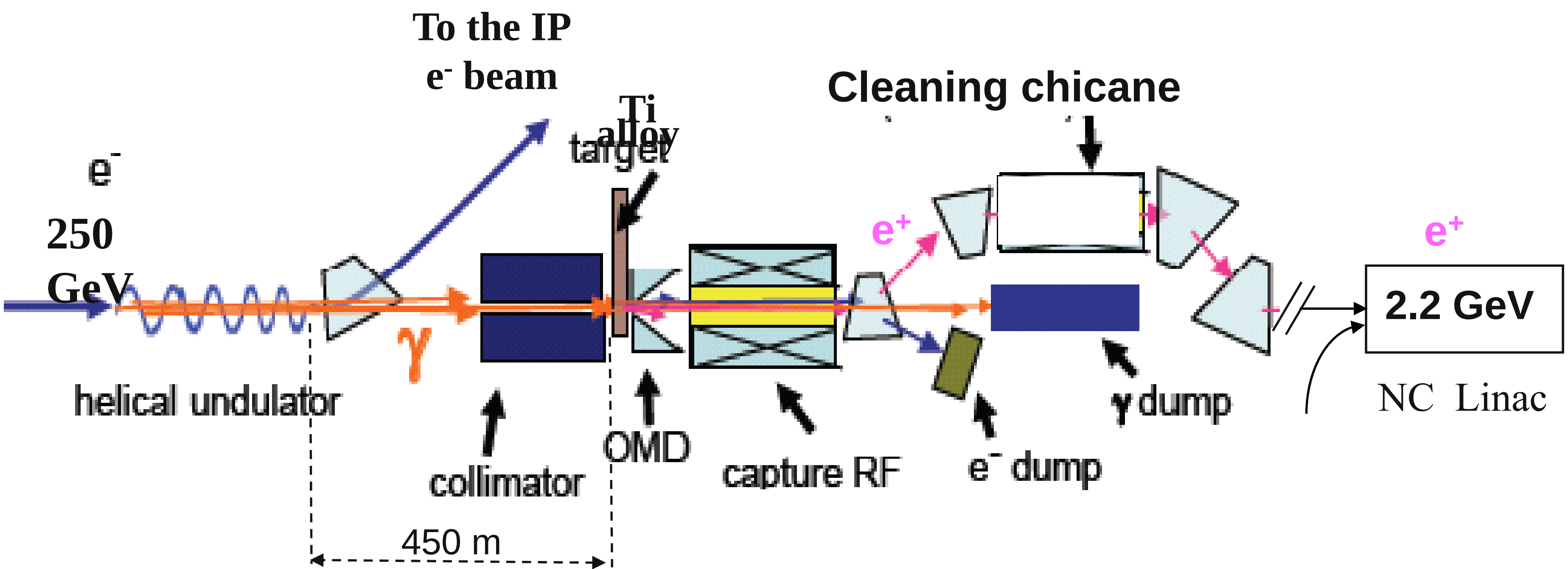
Outline

1. A possible CLIC undulator scheme e+ source
2. Numerical Simulation on the effect of undulator parameter and accelerating gradient
3. Optimizing OMD for yield
4. Summary

CLIC Injector complex



A possible CLIC scheme for polarized e^+



Undulator	Pre-Injector Linac	Injector Linac
$K = 0.75$	$G = 12$ MV/m	$G = 17$ MV/m
$\lambda u = 1.5$ cm	$E = 200$ MeV	$E = 2.424$ GeV
$L = 100$ m	$f_{RF} = 1.5$ GHz	$f_{RF} = 1.5$ GHz
	$B = 0.5$ T	$f_{rep} = 50$ Hz

Main beam parameters comparison

At the entrance of the Main Linac for e$^-$ and e$^+$

		NLC (1 TeV)	CLIC 2007 (3 TeV)	ILC (Nominal)
E	GeV	8	9	**15**
N	10^9	7.5	4 - 4.1	**20**
n_b	-	190	311	**2625**
Δt_b	ns	1.4	0.667 (8 RF periods)	**369**
t_{pulse}	ns	266	207	**968625**
$\varepsilon_{x,y}$	nm, nm	3300, 30	600, 10	**9 000, 24**
σ_z	µm	90-140	43 - 45	**300**
σ_E	%	0.68 (3.2 % FW)	1.5 - 2	**1.5**
f_{rep}	Hz	120	50	**5**
P	kW	219	91	**630**

"Nominal" CLIC positron source parameters

	Symbol	**Value**	Units
Positron per bunch at IP	n_b	4×10^9	number
Bunches per pulse	N_b	311	number
Pulse repetition rate	f_{rep}	50	Hz
Positron energy (PDR injection)	E_0	2.424	GeV
Pre-Damping transverse acceptance	$\gamma (A_x + A_y)$	0.09	m - rad
Pre-Damping energy acceptance	δ	± 1	%
Pre-Damping longitudinal acceptance	A_l	4980	eV . m
Electron drive beam energy	E_e	250	GeV
Electron beam energy loss in undulator	ΔE_e	2.27	GeV
Positron polarization	P	~ 60	%

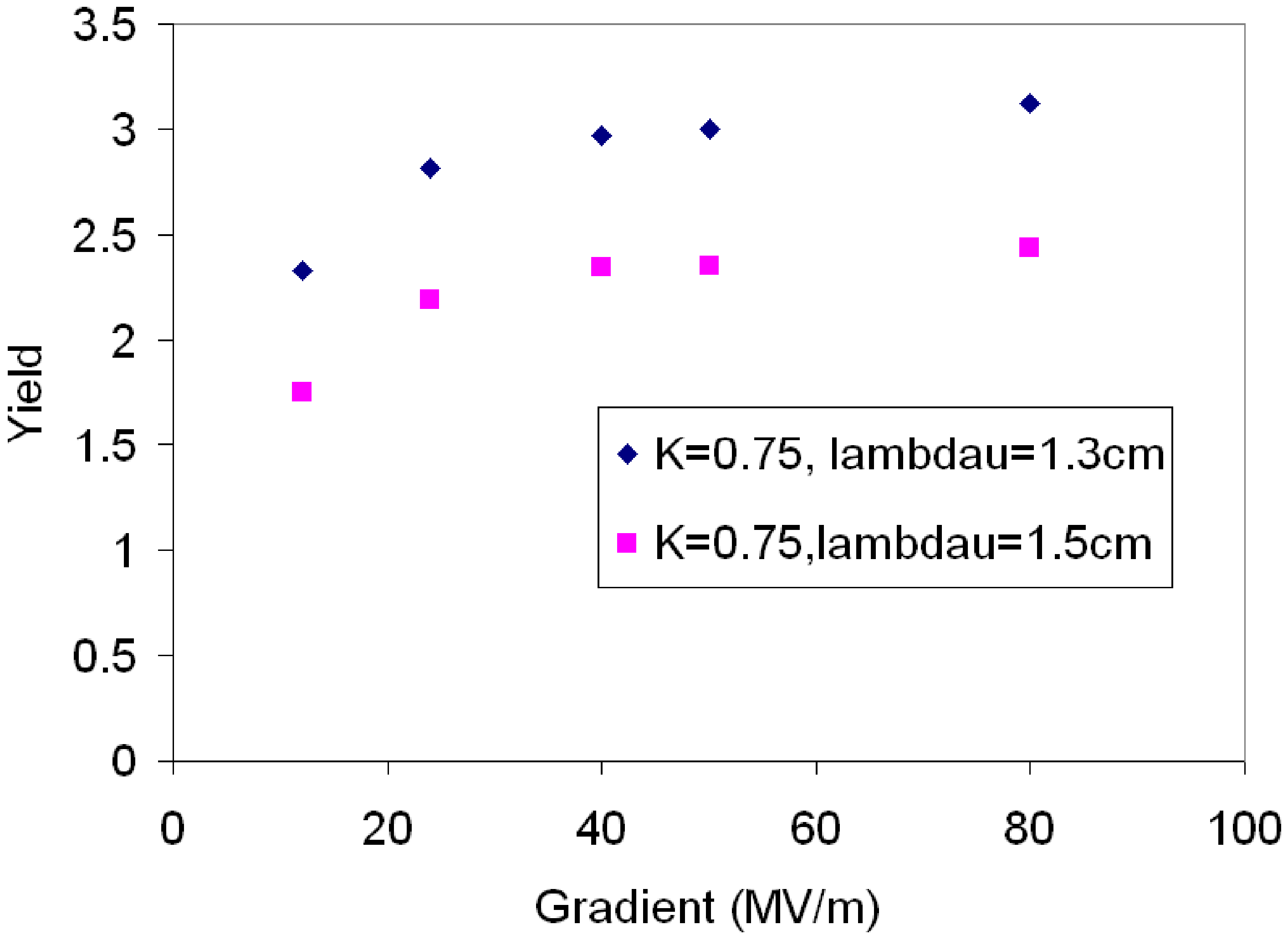
Numerical Simulation on the effect of undulator parameter and accelerating gradient

- Drive e- beam energy: 250GeV
- Undulator K: 0.75 and 0.5
- Undulator period: 1.5cm and 1.3cm
- Length of undulator: 100m
- Drift to target: 450m
- Accelerator gradient and focusing: 12MV/m to 80MV/m for beam energy <250MeV, 0.5T background solenoid field focusing; for 250MeV to 2.4GeV, 25MV/m with discrete FODO set.
- OMD: 7T-0.5T in 20cm; 10T-0.5T in 20cm
- Photon collimator: None
- Target material: 0.4 rl Titanium, immersed and non-immersed
- Yield is calculated as Ne+ captured/Ne- in drive beam.
- Positron capture is calculated by numerical cut using damping ring acceptance window: +/-7.5 degrees of RF(1.3GHz), $\varepsilon x+\varepsilon y<0.09\pi$.m.rad,1% energy spread with beam energy ~2.4GeV

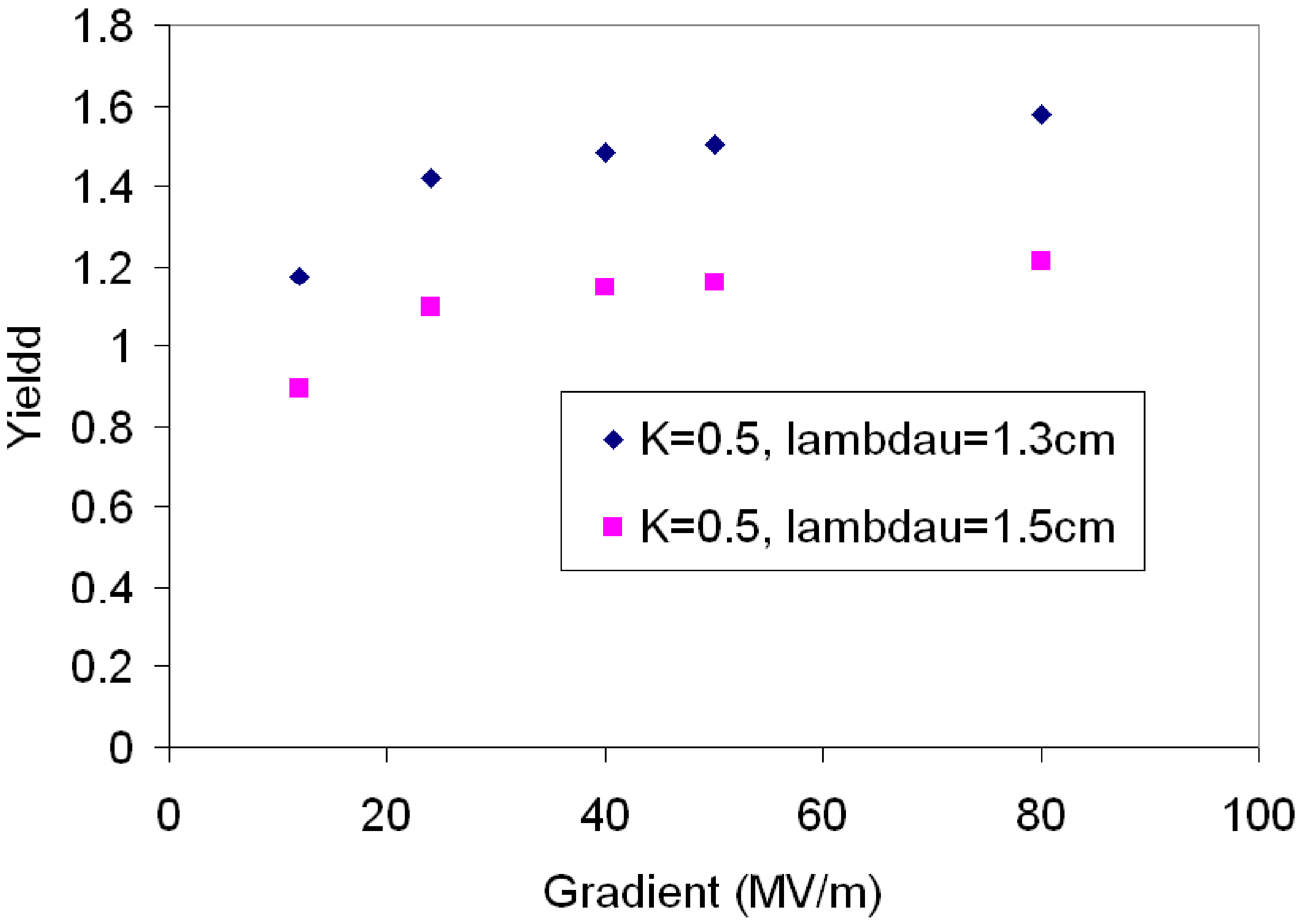
Yield of cases with immersed target

- For immersed case, the OMD field is 7T on the surface of target and decrease adiabatically down to 0.5T in 20cm.
- We considered helical undulators with K=0.75 and 0.5, λu = 1.5cm and 1.3cm.

Immersed target, K=0.75



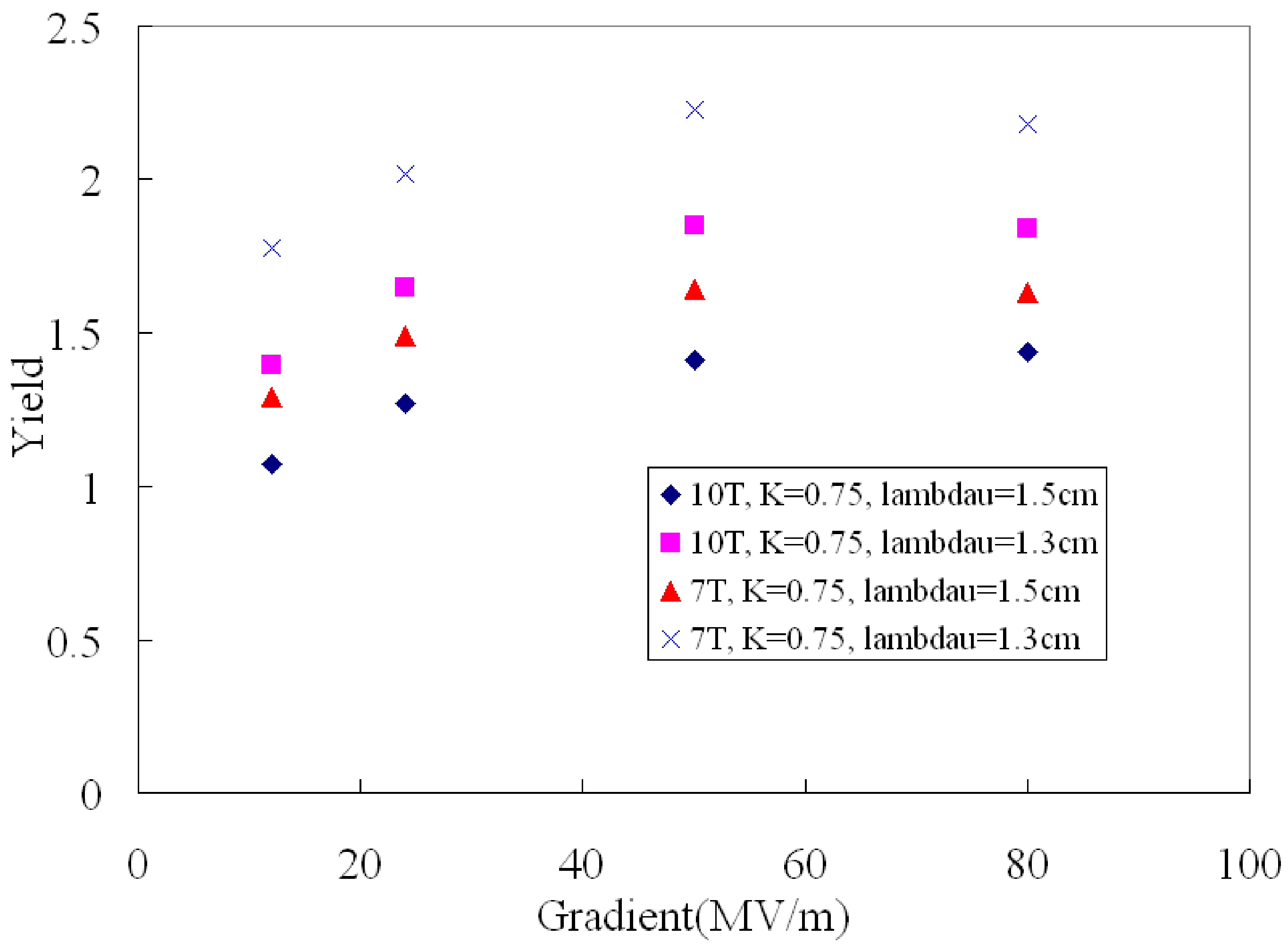
Immersed target, K=0.5



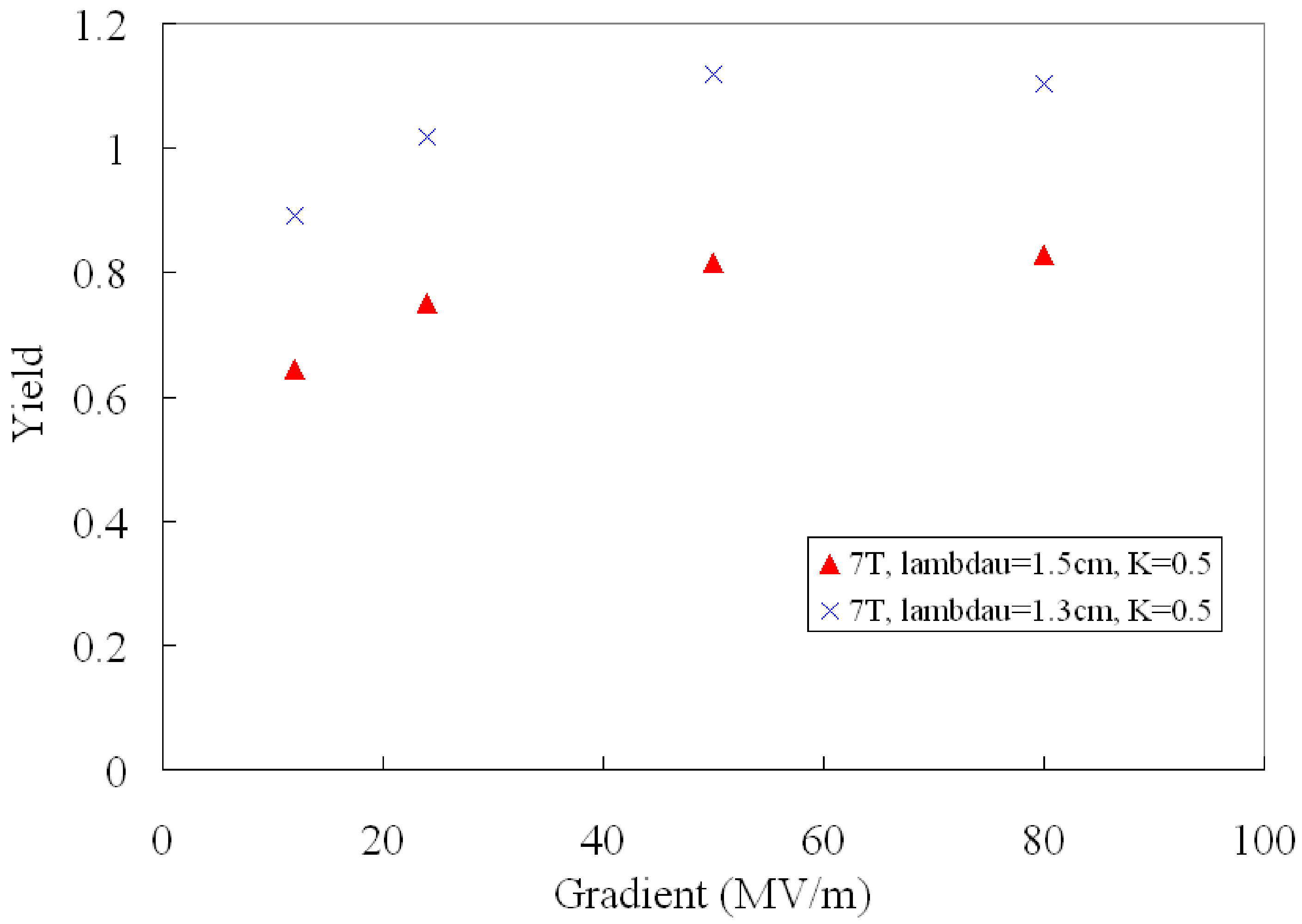
Yield of cases with Non-immersed target

- For non-immersed target, the OMD field is about 0 on the surface of target and ramp up to over 7T or 10T in 2cm and then adiabatically decrease down to 0.5T in 20cm.
- We considered helical undulators with K=0.75 and 0.5, period λu = 1.5cm and 1.3cm.

Non-immersed target, K=0.75



Non-immersed target, K=0.5

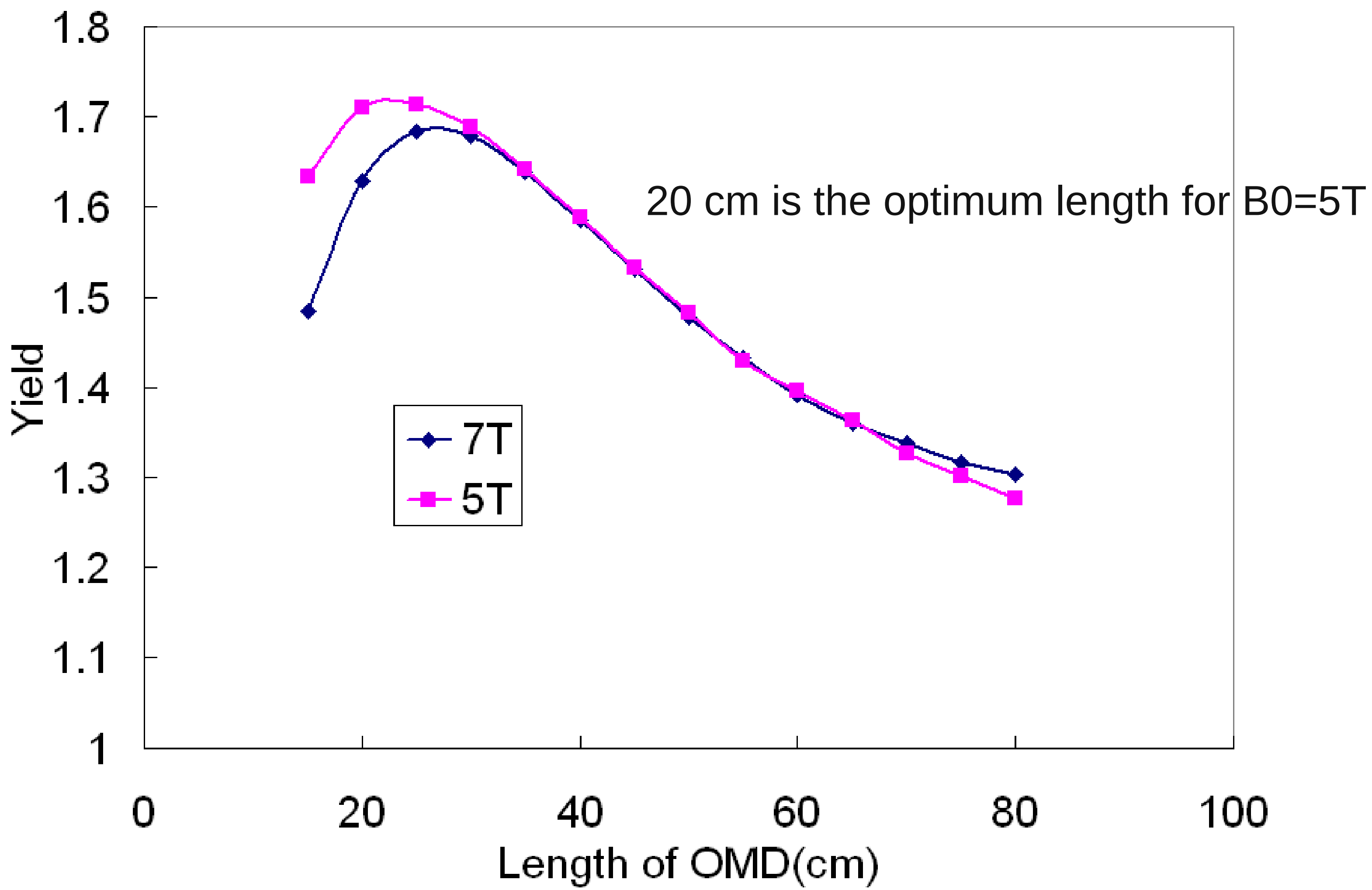


- Using gradient higher than 50MV/m doesn't help much on the yield for either immersed and non-immersed cases.
- For non-immersed target, increasing the OMD field doesn't necessarily increase the yield because of the associated higher transverse B field.
- For low polarization e+ source, yield of 1.5 can be achieved by choosing undulator with K=0.75, λu=1.5cm; using non-immersed target and using accelerator gradient >24MV/m.

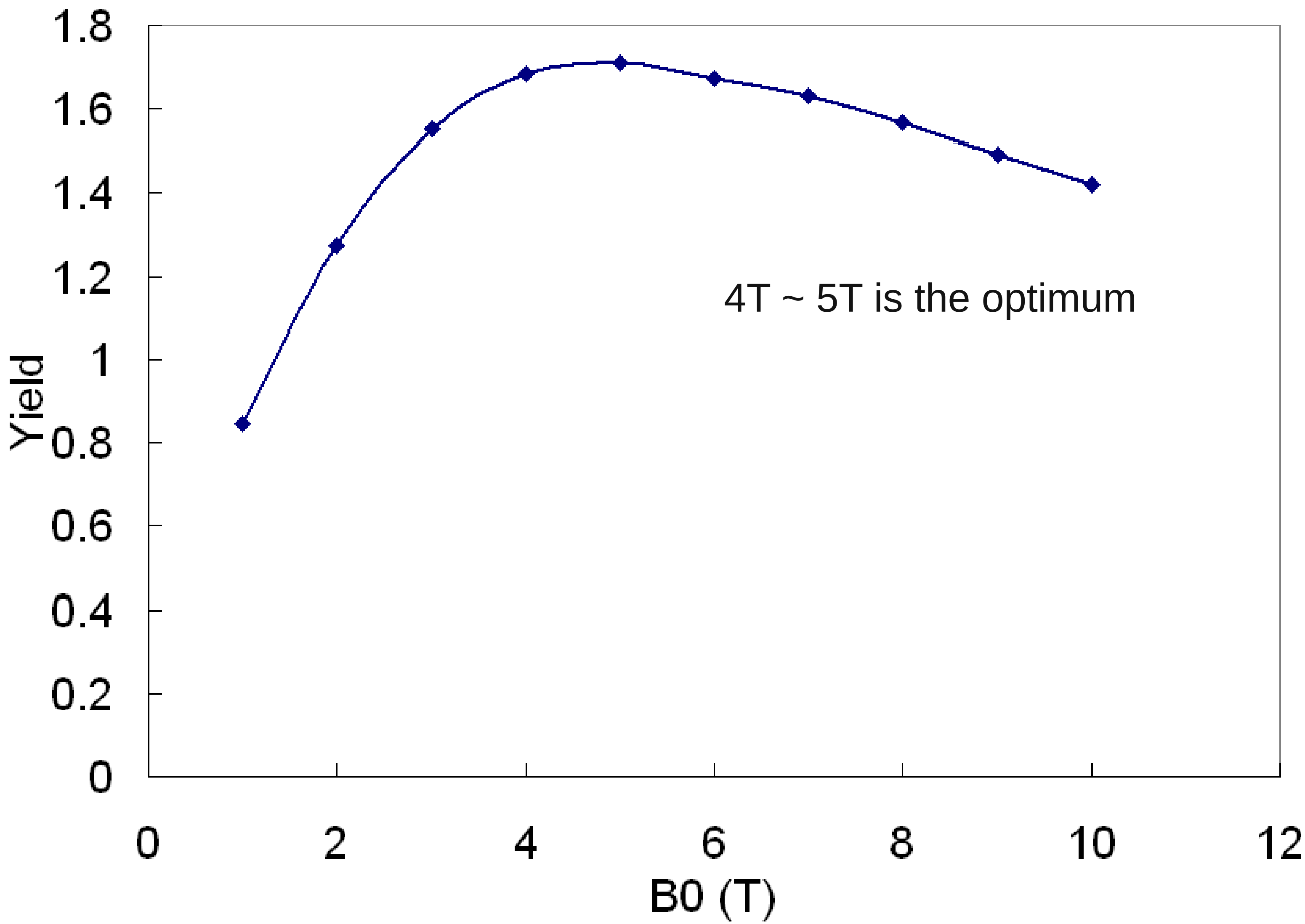
Optimizing OMD for yield

- Drive e- beam energy: 250GeV
- Undulator K: 0.75
- Undulator period: 1.5cm
- Length of undulator: 100m
- Drift to target: 450m
- Accelerator gradient and focusing: 50MV/m for beam energy <250MeV, 0.5T background solenoid field focusing; for 250MeV to 2.4GeV, 25MV/m with discrete FODO set.
- OMD: Non immersed, ramping distance 2cm
  - 1)7T-0.5T and 5T-0.5T, the thickness varies from 15cm to 80cm in 5cm steps;
  - 2) the thickness fixed at 20cm, B0-0.5T, B0 varies from 1 T to 10T
- Photon collimator: None
- Target material: 0.4 rl Titanium, non-immersed
- Yield is calculated as Ne+ captured/Ne- in drive beam.
- Positron capture is calculated by numerical cut using damping ring acceptance window: +/-7.5 degrees of RF(1.3GHz), $\varepsilon x+\varepsilon y<0.09\pi$.m.rad,1% energy spread with beam energy ~2.4GeV

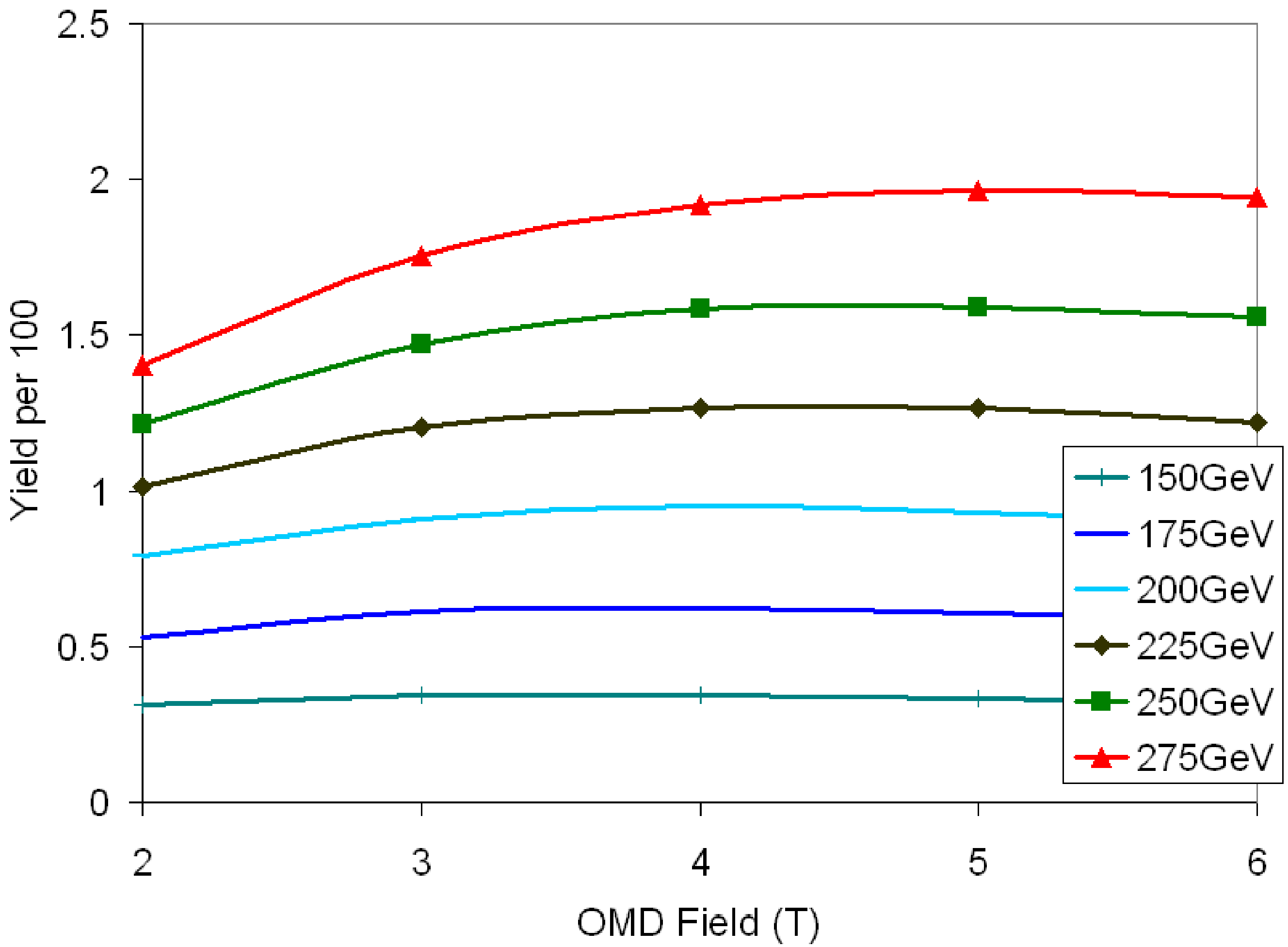
Optimum length of OMD

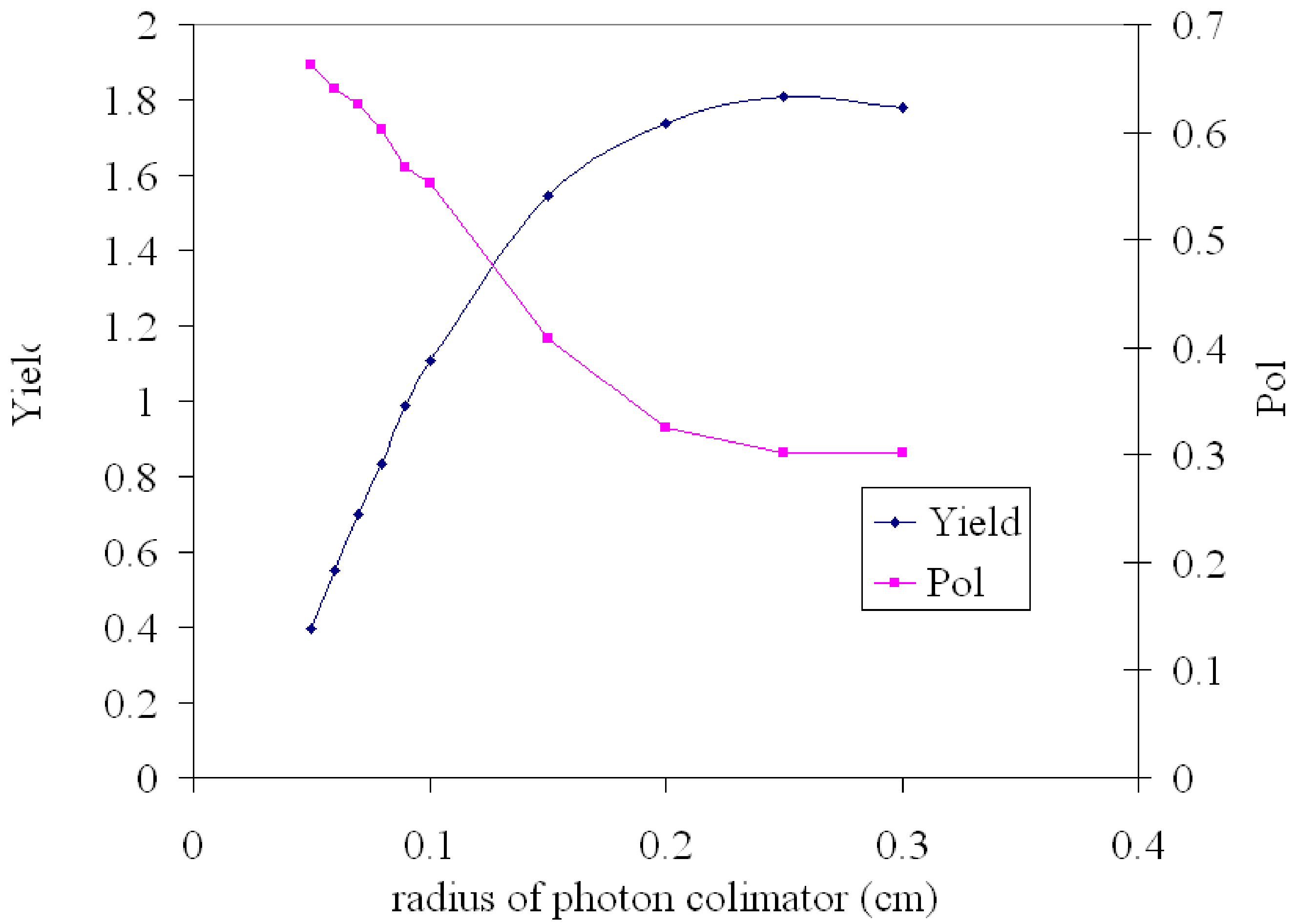


Optimum B0 of OMD (non-immersed case)



Yield as function of drive beam energy and OMD




2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
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Yiel(
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0.1
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radius of photon colimator (cm)
Yield
Pol