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Preliminary Study on CLIC Undulator Positron Scheme

Wei Gai, Wanming Liu @ ANL

John C. Sheppard @ SLAC

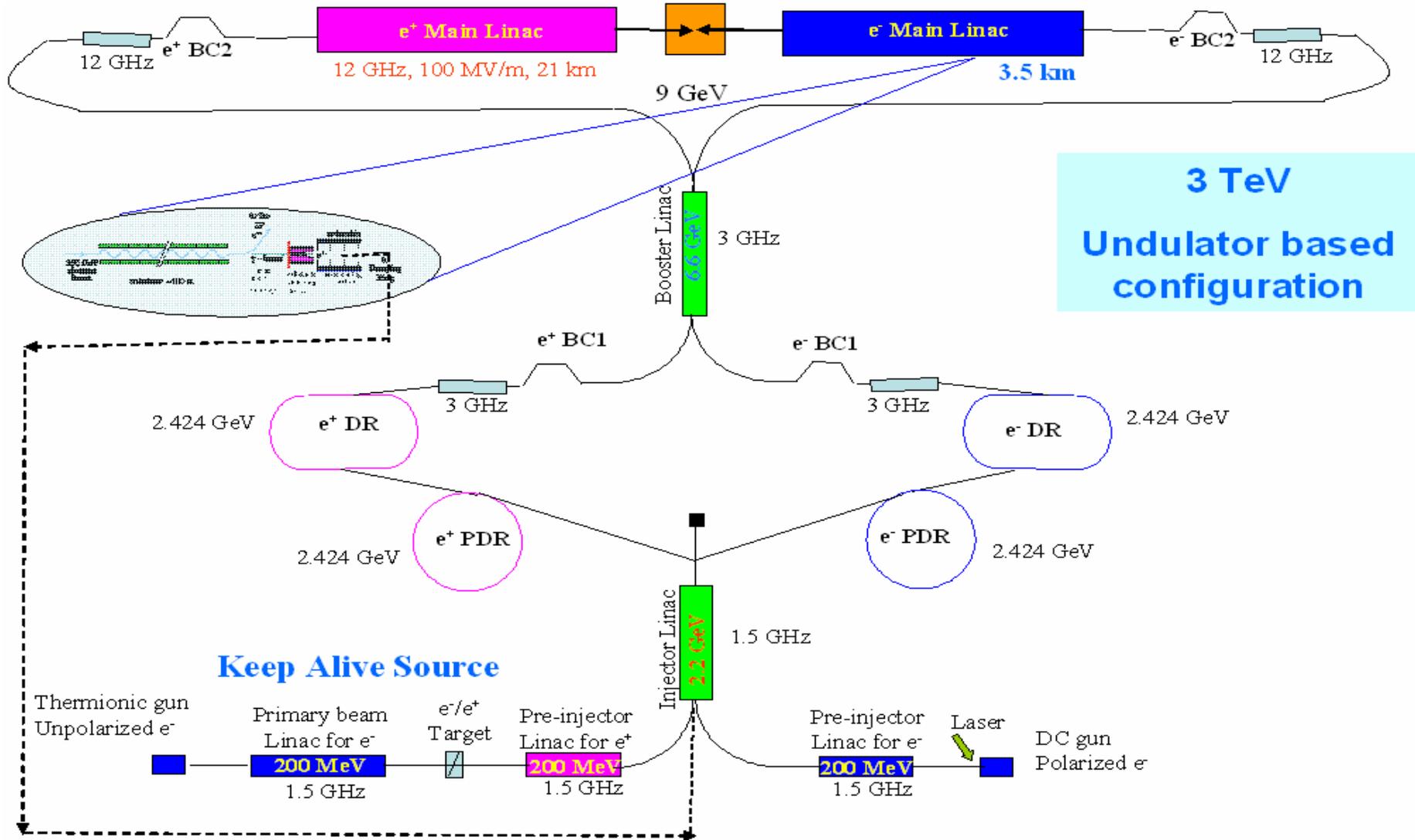
Louis Rinolfi @ CERN

*Positron Collaborating Meeting, ANL
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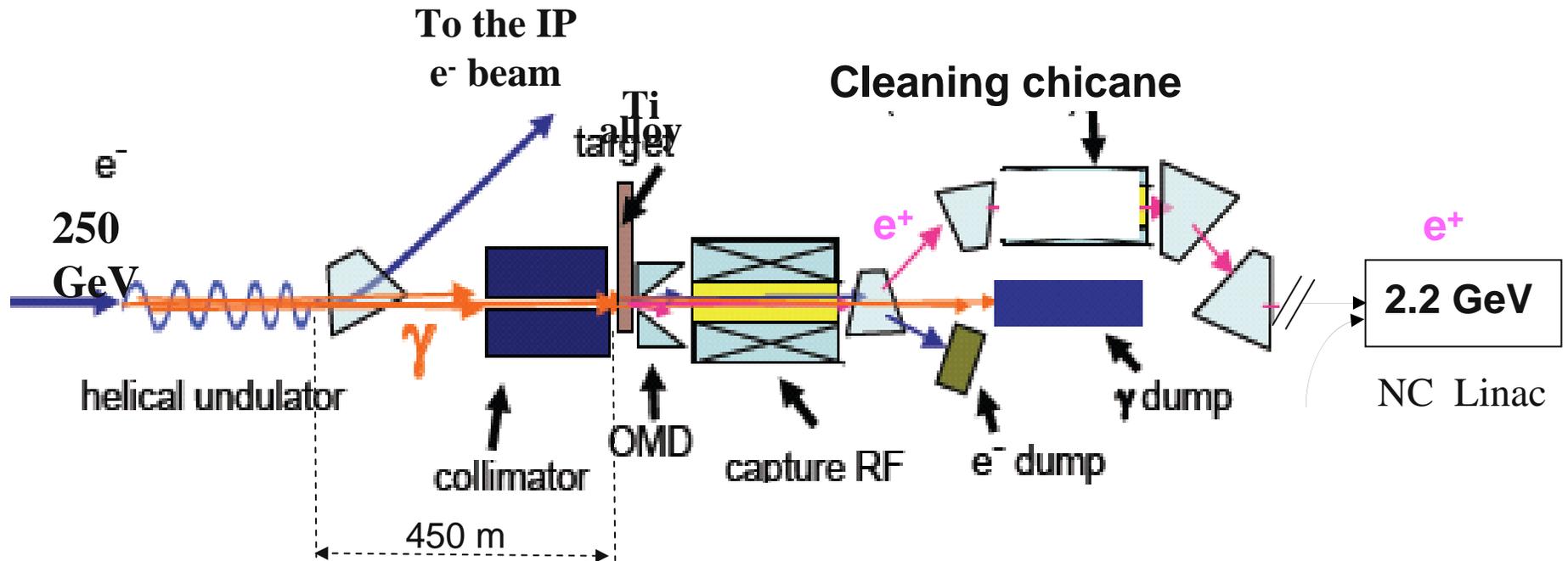
Outline

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⁺



Pre-Injector Linac

Injector Linac

Undulator

$G = 12 \text{ MV/m}$

$G = 17 \text{ MV/m}$

$K = 0.75$

$E = 200 \text{ MeV}$

$E = 2.424 \text{ GeV}$

$\lambda_u = 1.5 \text{ cm}$

$f_{\text{RF}} = 1.5 \text{ GHz}$

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$L = 100 \text{ m}$

$B = 0.5 \text{ T}$

$f_{\text{rep}} = 50 \text{ Hz}$

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
$\epsilon_{x,y}$	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	%

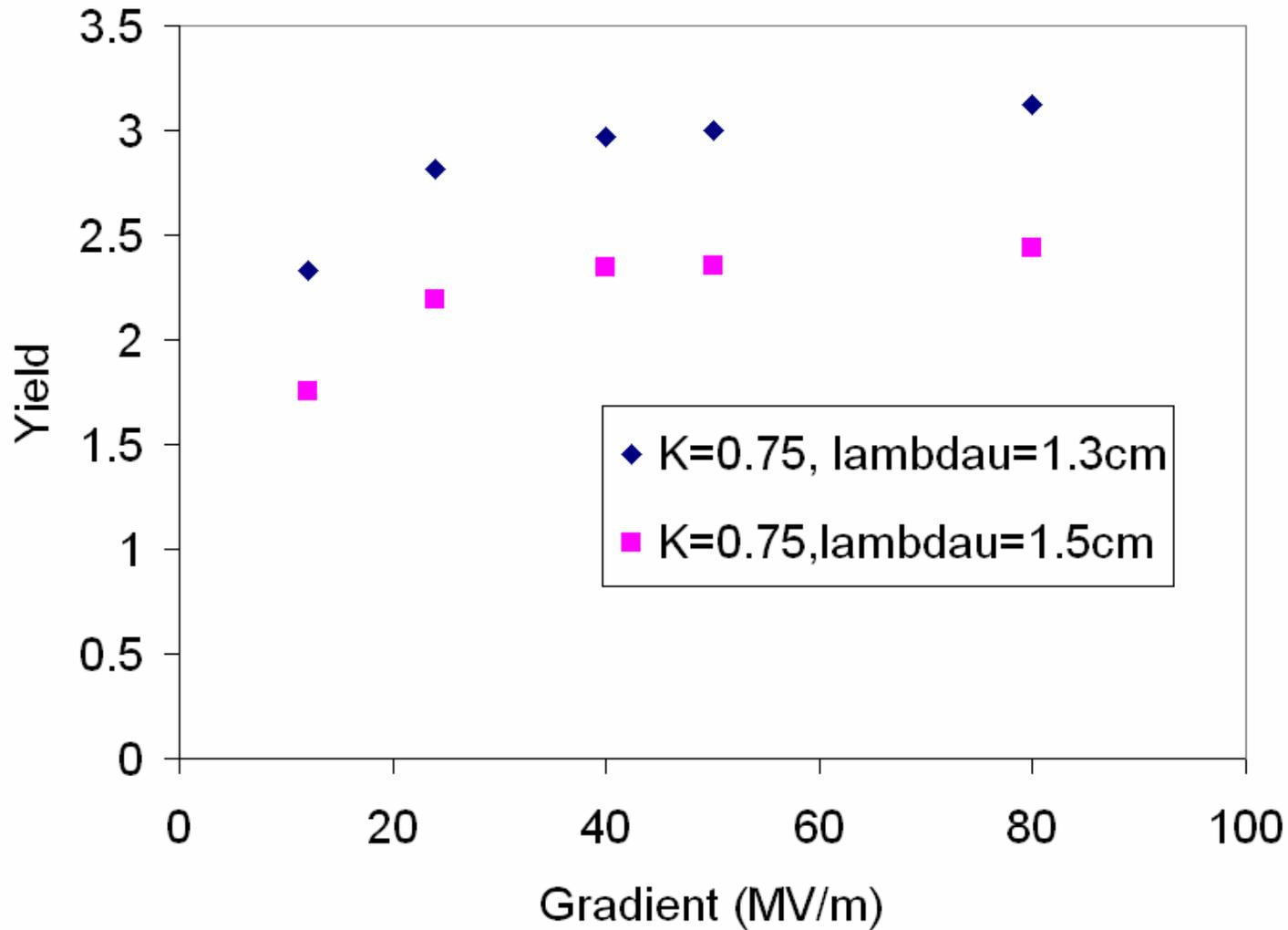
Numerical Simulation on the effect of undulator parameter and accelerating gradient

- 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), $\epsilon_x + \epsilon_y < 0.09\pi$.m.rad, 1% energy spread with beam energy ~2.4GeV

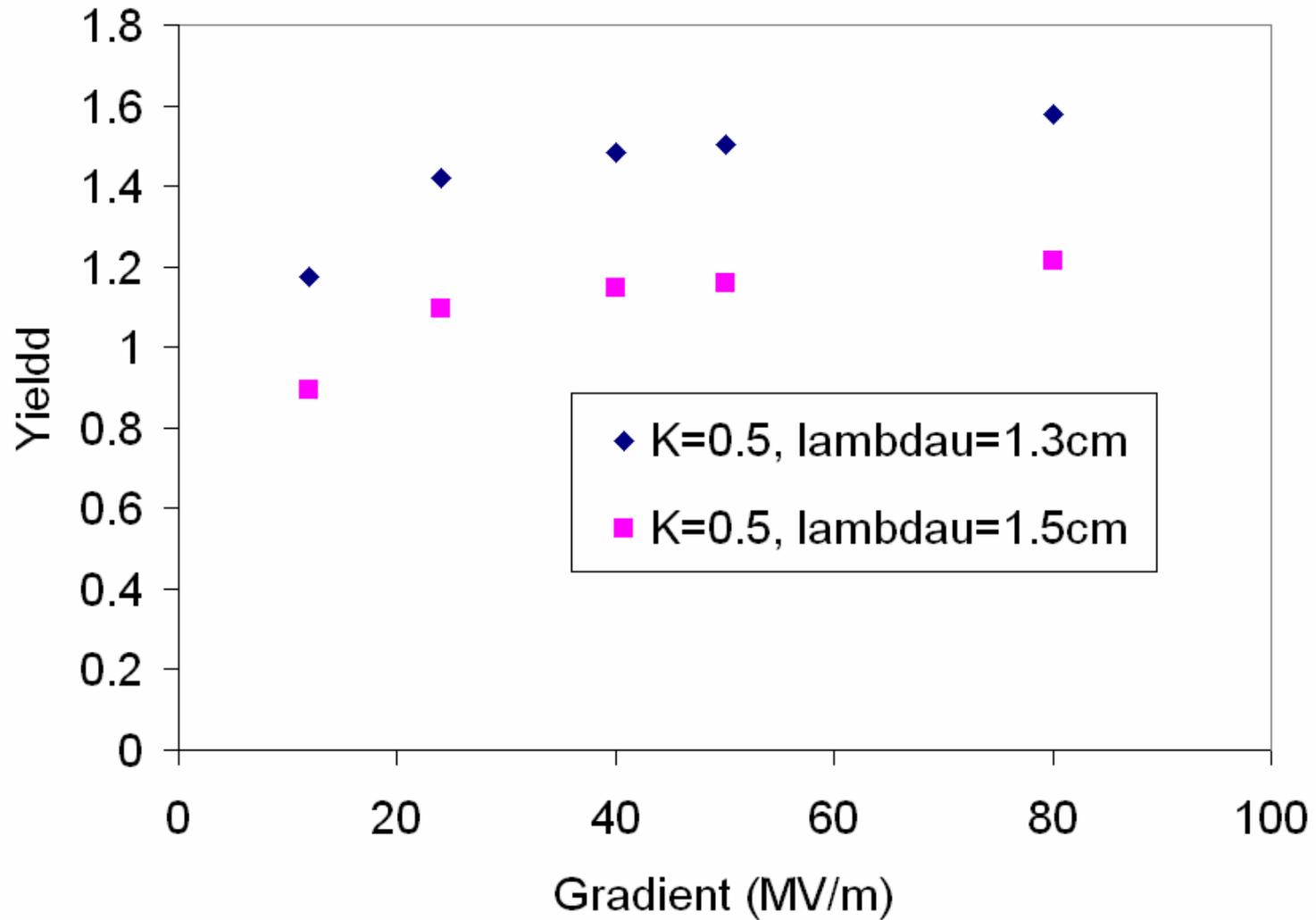
Yield of cases with immersed target

- 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 , $\lambda_u = 1.5\text{cm}$ and 1.3cm .

Immersed target, $K=0.75$



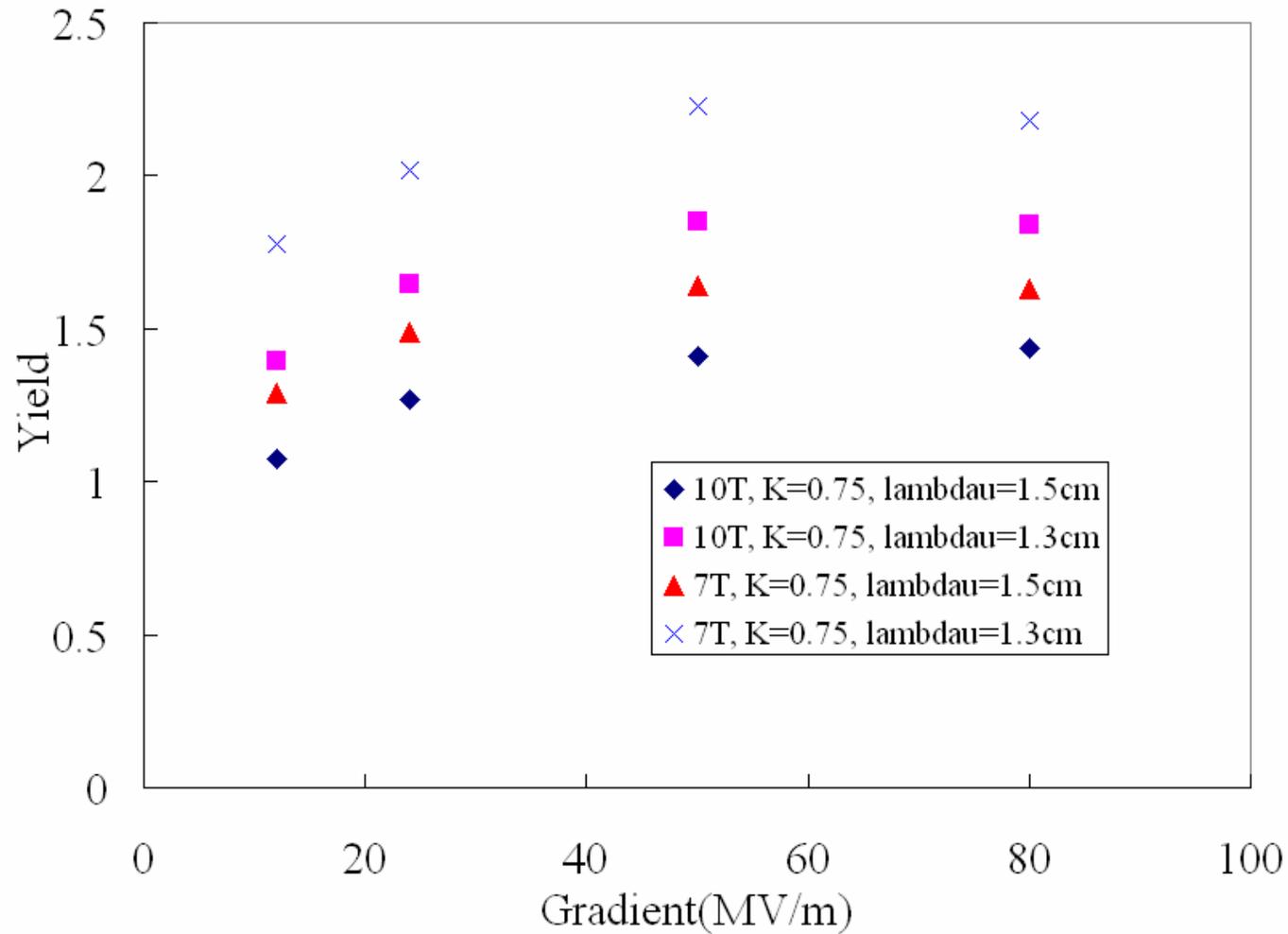
Immersed target, $K=0.5$



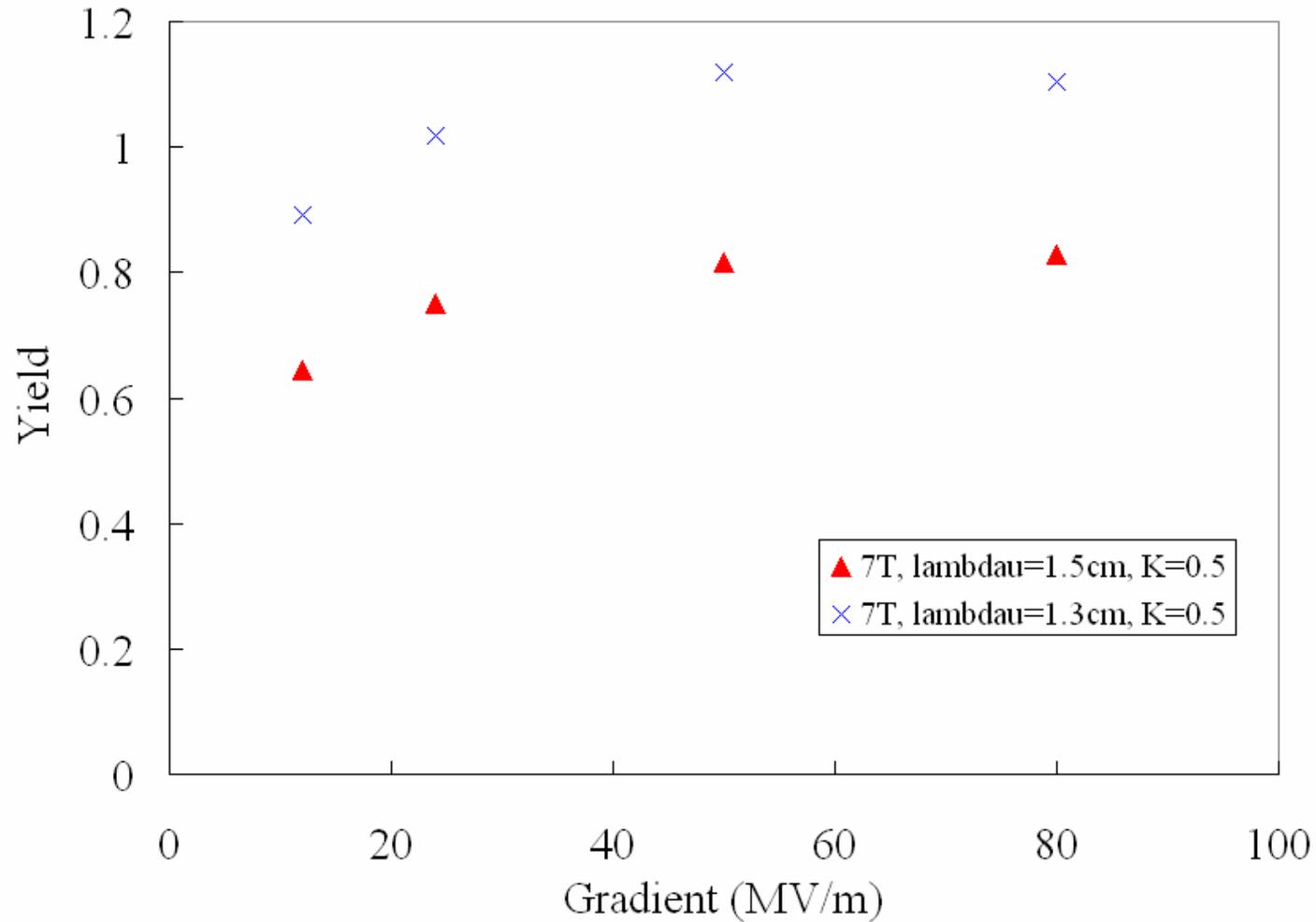
Yield of cases with Non-immersed target

- 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 $\lambda_u = 1.5\text{cm}$ and 1.3cm .

Non-immersed target, $K=0.75$



Non-immersed target, $K=0.5$

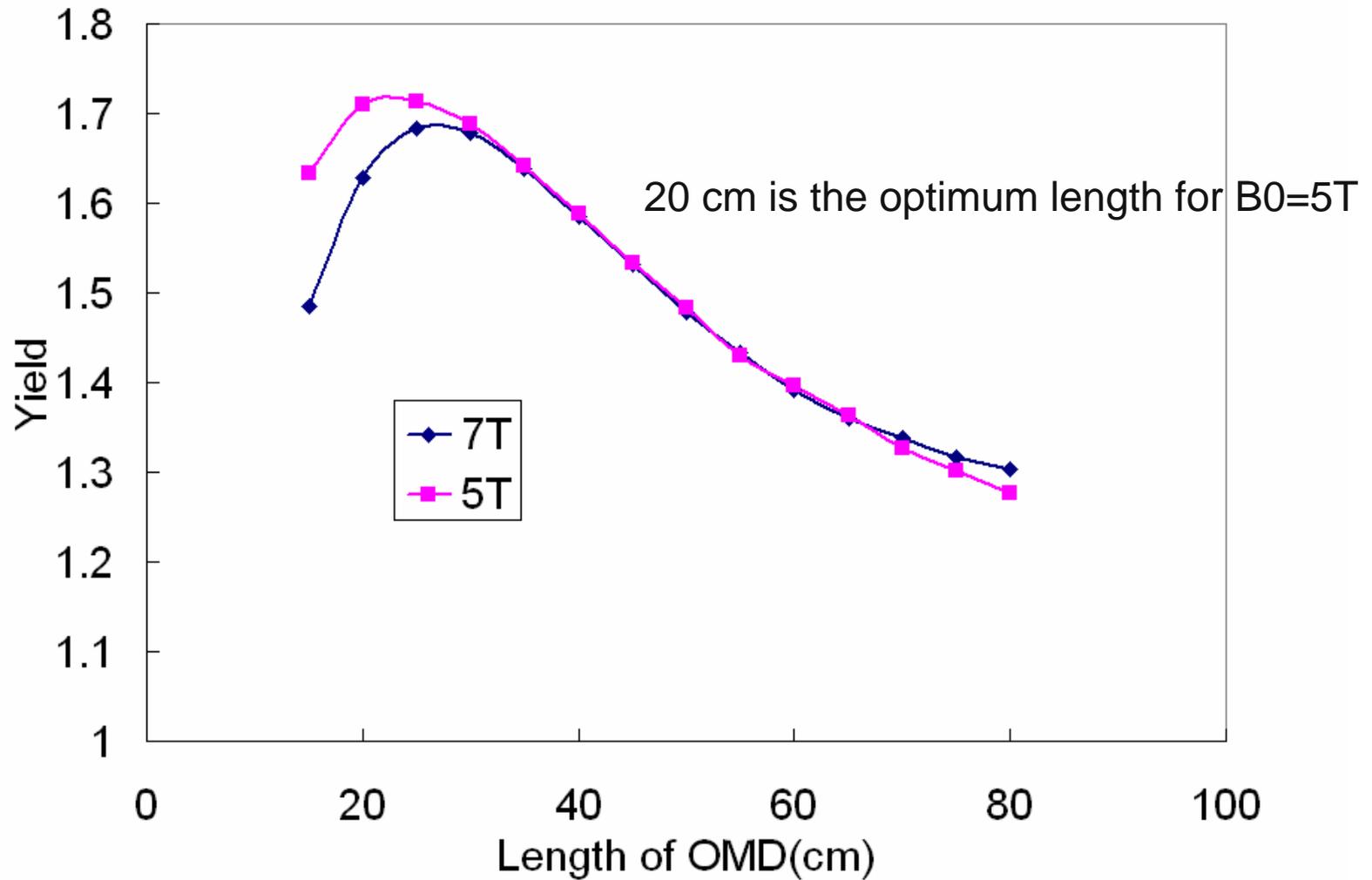


- Using gradient higher than 50MV/m doesn't help much on the yield for either immersed and non-immersed cases.
- For non-immersed target, increasing the OMD field doesn't necessarily increase the yield because of the associated higher transverse B field.
- For low polarization e+ source, yield of 1.5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

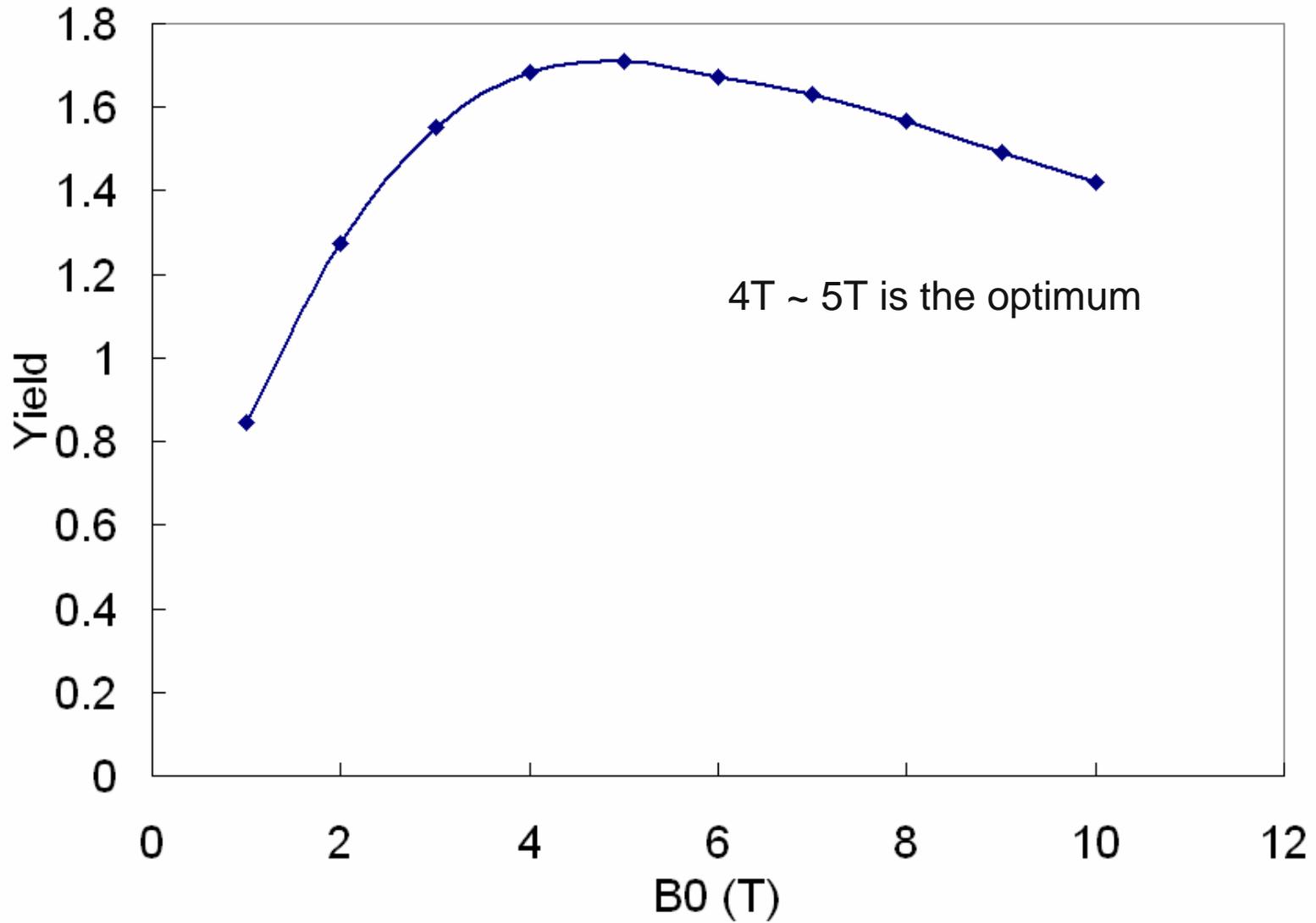
Optimizing OMD for yield

- 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), $\epsilon_x + \epsilon_y < 0.09\pi$.m.rad, 1% energy spread with beam energy ~2.4GeV

Optimum length of OMD



Optimum B_0 of OMD (non-immersed case)



Yield as function of drive beam energy and OMD

