Optimization of the Scheme 2 LPAS and its ramps

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Sources for Plasma Accelerators and Radiation Compton with Lasers And Beams

Plasma stage design & optimization

- Require minimal capillary length for plasma stage @ chosen plasma wave regime, keeping into account RF capabilities in longitudinal compression:

n_0 [cm^{-3}]	10^{17}
L [cm]	50

(expected approx. 10 GV/m)

- Allow for "comfortable" laser propagation (requires $k_p \sigma_l \geq 1$):

$$L_{pd} > L_d \sim 1 \text{ m}$$

Plasma stage design & optimization

Considerations for Input ramp length:

- actual length depends on capillary tip geometry:

$$l_{char.} \approx d_{cap.}$$

unless tips are designed to lengthen/shape them;

- usually, longer ramps require tighter focusing (i.e. larger α_T):

$$f = \beta_T^{(0)}/\Delta\alpha_T \qquad (1)$$

- profile is most important mainly in absence of significant beam loading in ramps [1,2];

[1] K. Floettmann, PRSTAB **17**, 054402 (2014).
I. Dornmair, K. Floettmann and A.R. Maier, PRSTAB **18**, 041302 (2015).

[2] X.L. Xu et al., PRL **116**, 124801 (2016).

Plasma stage design & optimization

Considerations for Output ramp length:

- needs to fulfill the condition at ramp end [1]:

$$\alpha_T^2 > 1 \qquad (2)$$

CONCLUSIONS:

1) Since in our setting beam loading is always dominant in ramps, a plausible exponential ramps profile is used.

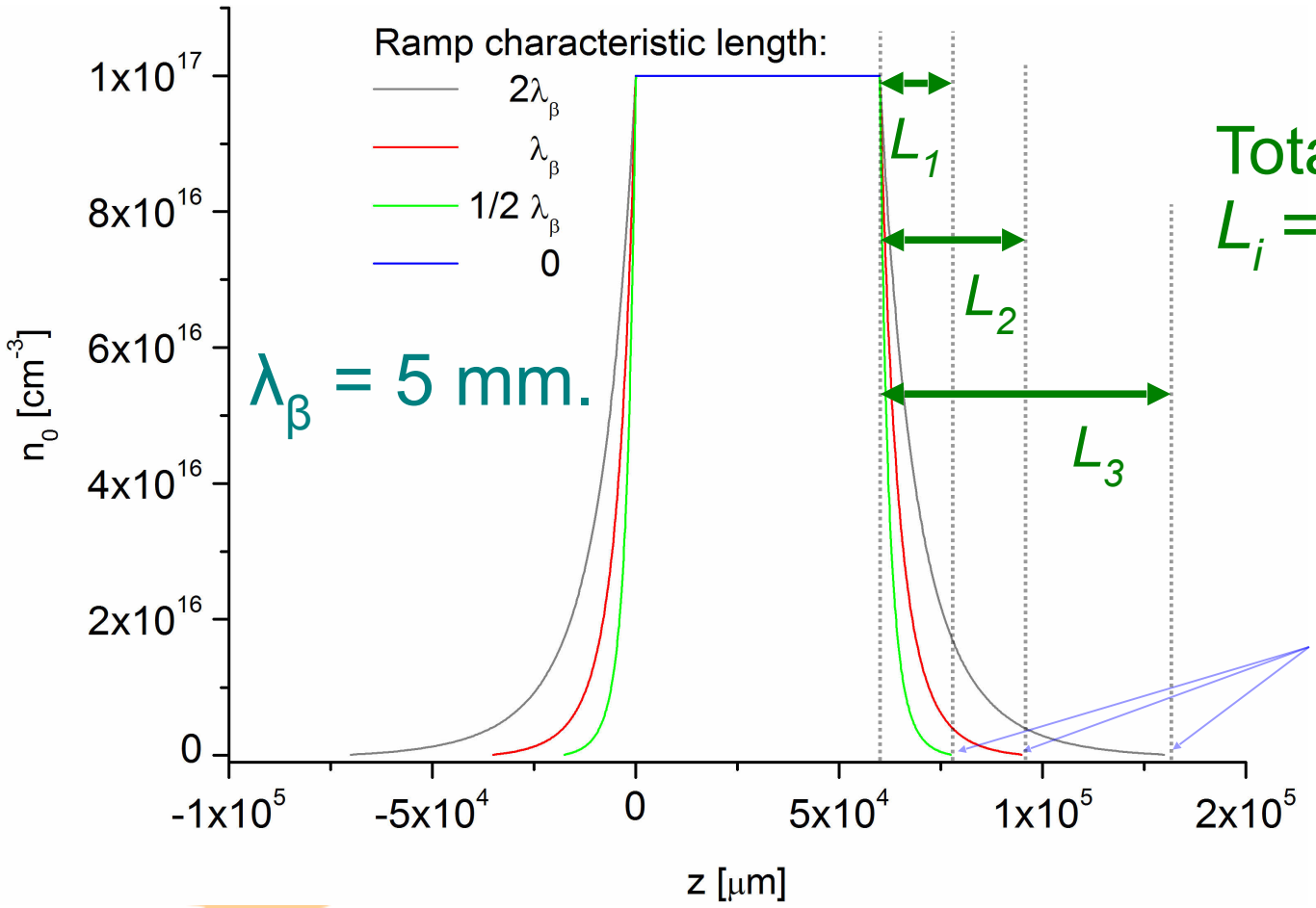
2) Ramp length is set so that $l_{char.} \geq d_{cap.}$ but short enough to require feasible matching optics.

3) Ramps effectiveness is evaluated ex post by (1) for Input and by fulfilling (2) for output.

[1] K. Floettmann, PRSTAB **17**, 054402 (2014).

Plasma stage design & optimization

- Different characteristic ramp lengths tested
- Good matching found in any situation, provided α_T and β_T are tunded
- S2E are performed with $l_{char.} = ½ \lambda_\beta$



Total ramp length is
$L_i = 7\ l_r$

$n_f = 10^{14}$ cm^{-3} = n_i

Laser parameters optimization

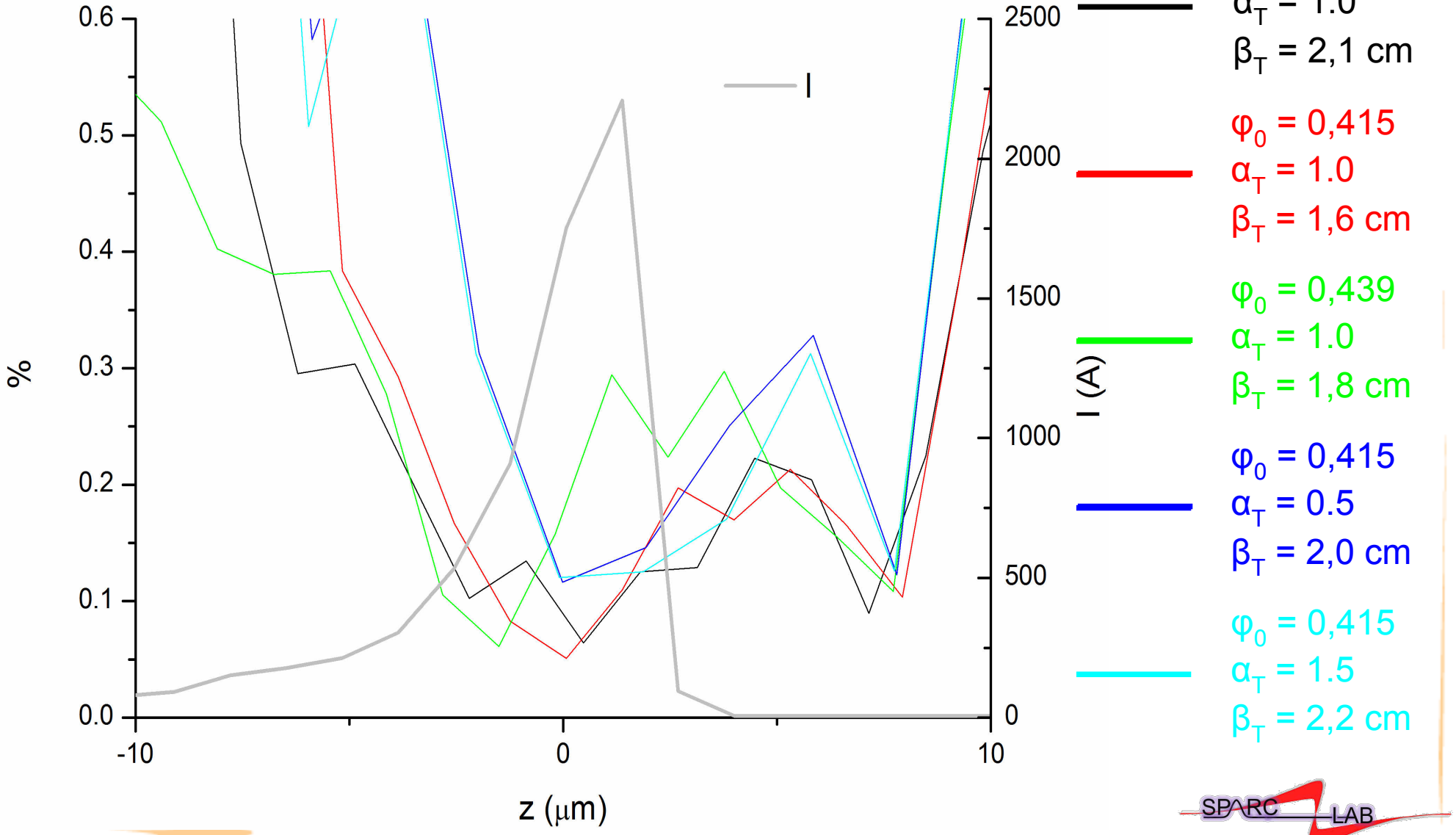
- In general, require minimal parameters for laser;
- Fulfill the condition $k_p \sigma_l \geq 1$;
- Fulfill the condition $a_0 \approx 1$;
- Smooth laser propagation:

$$L_{pd} > L_d \sim 1 \text{ m}$$

σ_l [μm]	70
τ_{FWHM} [fs]	112
E [J]	24.5
a_0	≈1

Optimization of injection parameters

Slice energy spread results (just a few)



Optimization of injection parameters

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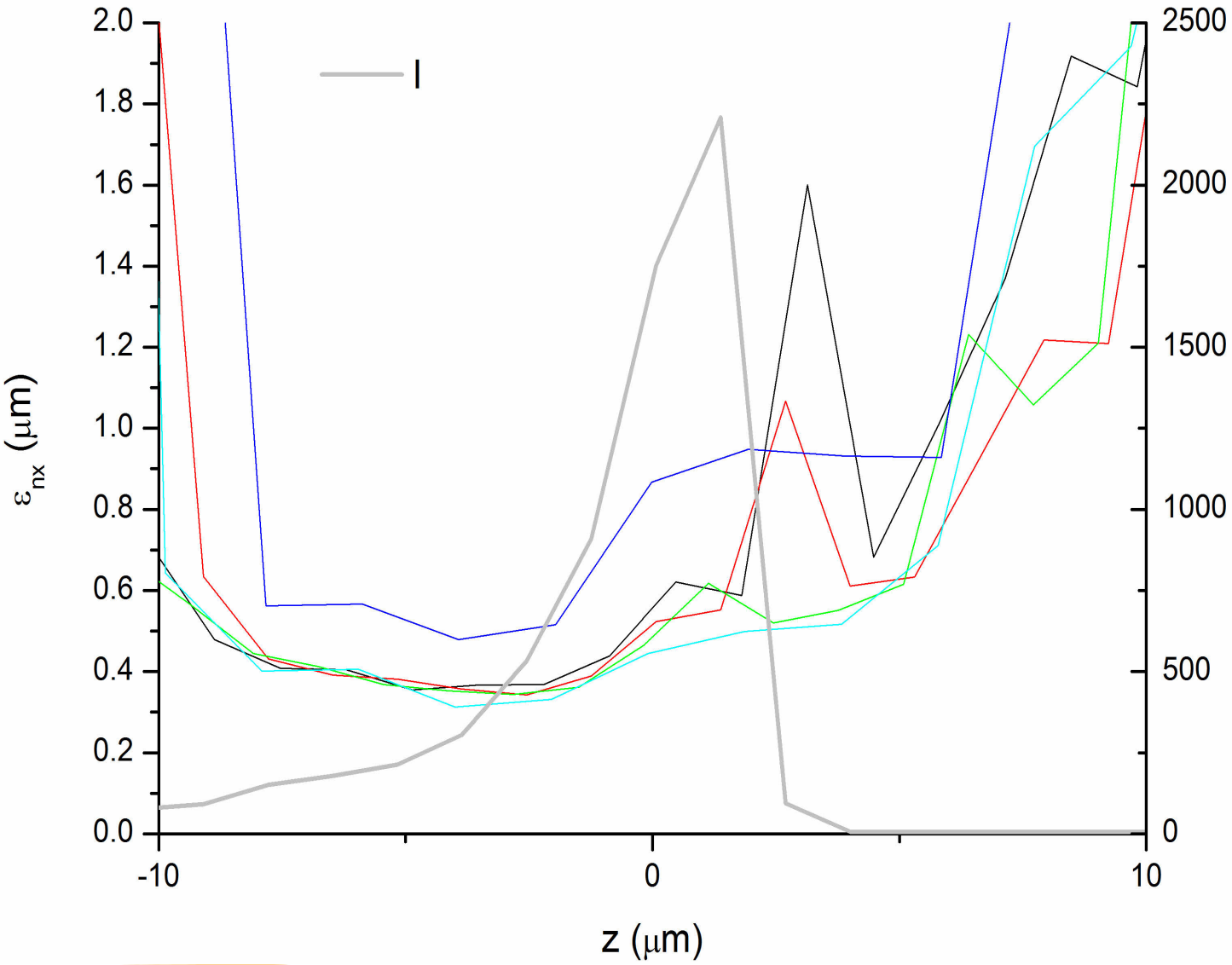

$\varphi_0 = 0{,}415$
$\alpha_T = 1.0$
$\beta_T = 2{,}1$ cm

$\varphi_0 = 0{,}415$
$\alpha_T = 1.0$
$\beta_T = 1{,}6$ cm

$\varphi_0 = 0{,}439$
$\alpha_T = 1.0$
$\beta_T = 1{,}8$ cm

$\varphi_0 = 0{,}415$
$\alpha_T = 0.5$
$\beta_T = 2{,}0$ cm

$\varphi_0 = 0{,}415$
$\alpha_T = 1.5$
$\beta_T = 2{,}2$ cm