Analytical models of BDS energy distribution

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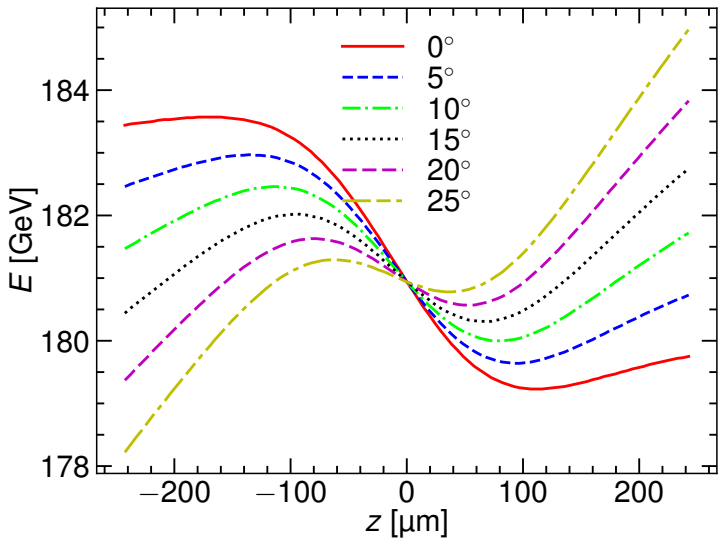
Motivations

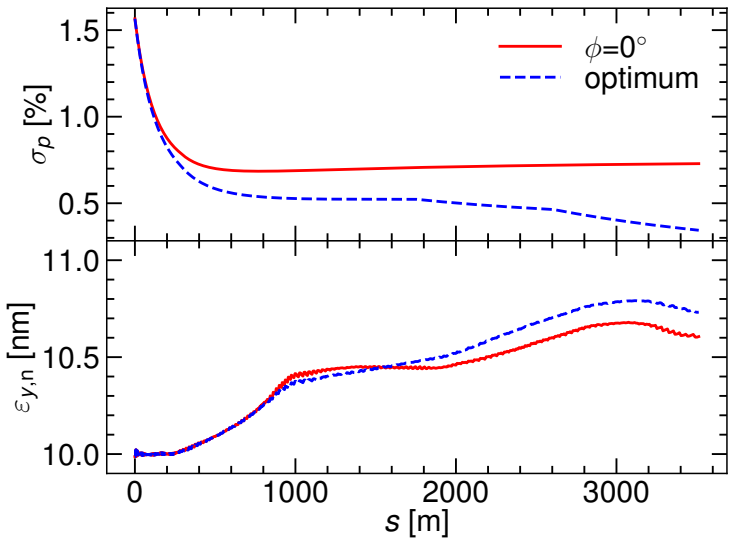
- To model the energy distribution of beam from ML
- A valid and feasible energy distribution model for particle generation in the MAPCLASS

[1] R. Tomás, PRST-AB , 9: 081001, 2006.

Acceleration in the ML

- Introducing BNS damping to compensate ε_y growth due to Wakefield
- Optimise RF phase to control σ_p and ε_y growth



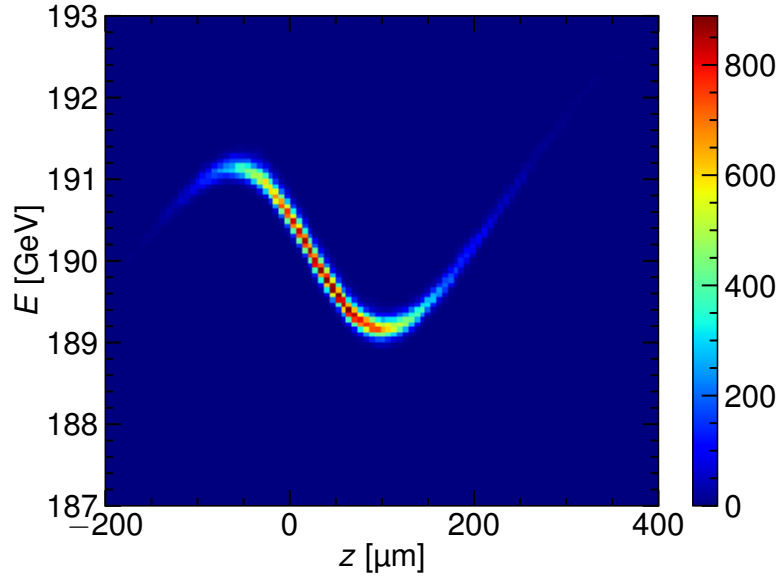


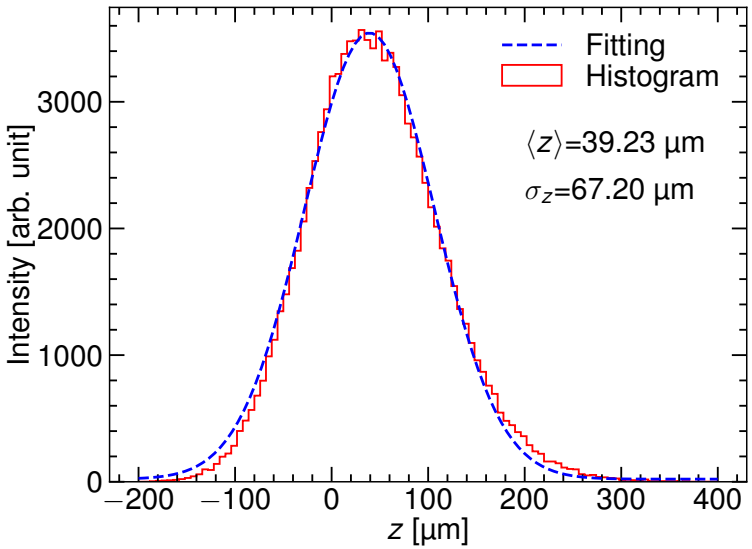
[1] Reproduced from N. Blaskovic's talk in LCWS 2018

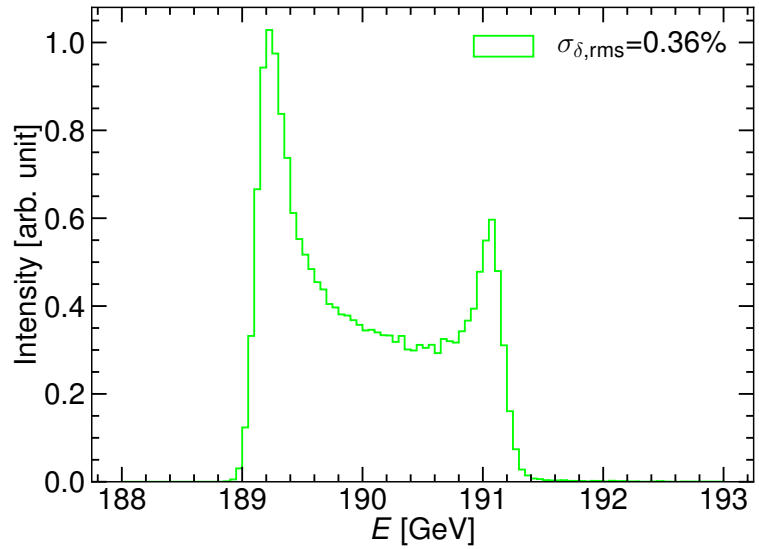
Longitudinal distributions

- With the optimum RF setting
  - $\delta_{\mathrm{rms}} = 0.36\%$, $\sigma_z \approx 67$ µm
- Asymmetric energy distribution

  $\Rightarrow$ characterization and modeling?
  $\Rightarrow$ impact on lumi.?







Analytic models

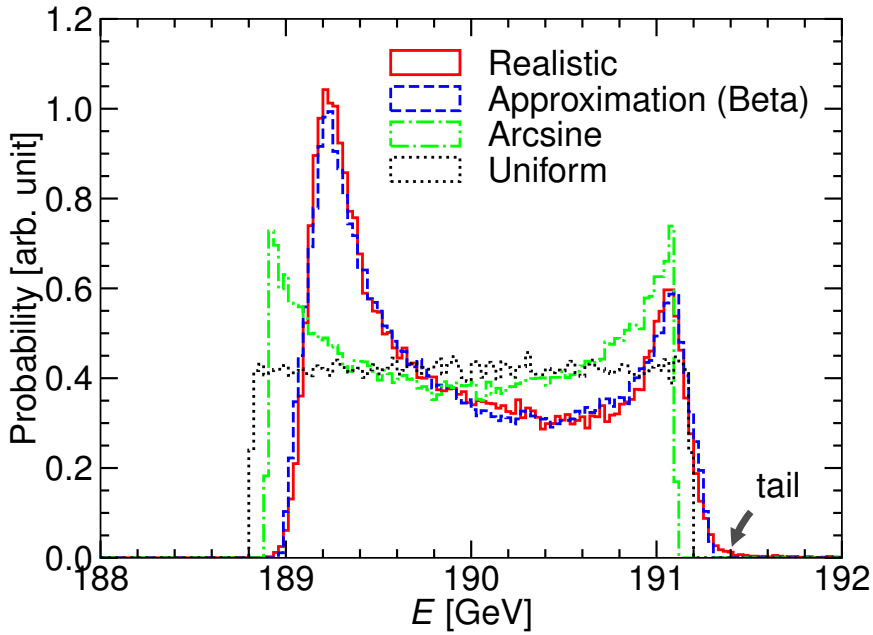
- Approximation w/ beta distribution

$$f(E) = \begin{cases} k_1 E + c_1 & E_{\min} < E \leqslant E_1 \\ \frac{1}{B}(E-a)^{\alpha-1}(b-E)^{\beta-1} & E_1 < E < E_2 \\ k_2 E + c_2 & E_2 \leqslant E < E_{\max} \end{cases}$$

- Arcsine distribution (cuts at $3f_{\min}$)

$$f(E) = \frac{1}{\pi\sqrt{(E-a)(E-b)}}$$

- Uniform distribution



Tracking results

- For the BDS w/ $L^* = 6$ m (PLACET+GUINEA-PIG)
- Lower $\mathcal{L}/\mathcal{L}_{1\%}$ for realistic E-profile b' of energy tail (<1%)
- Analytical models give smaller σ_y^* (<3%) and higher lumi. (<5%)

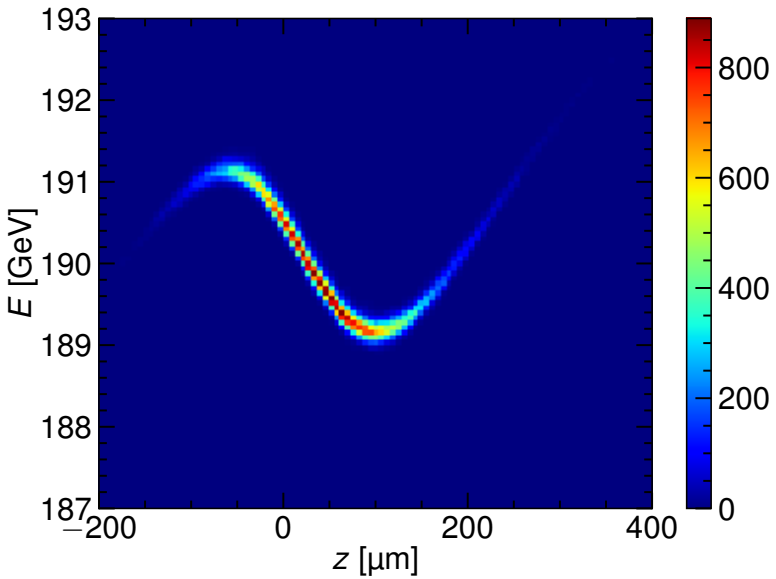
	Real.	Real.+tail cut	Beta	Arcsine	Uniform
σ_x^* [nm]	137.43	137.36	138.32	138.87	136.95
σ_y^* [nm]	2.30	2.31	2.28	2.23	2.25
$\mathcal{L}$ [10^{34} cm^{-2}s^{-1}]	2.12	2.14	2.14	2.19	2.17
$\mathcal{L}_{1\%}$ [10^{34} cm^{-2}s^{-1}]	1.16	1.17	1.19	1.22	1.20

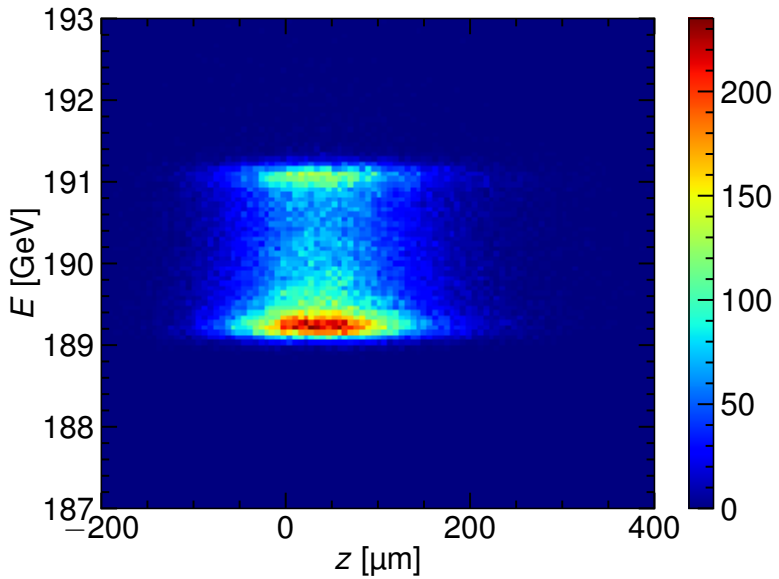
[1] δ_{rms}=0.36% for all energy distributions
[2] w/ SR at bends and quads

Tracking results

- Influence from correlation between z and trans. plane is small (<1%)

	Real.	Real.+cut	Real.+cut+decorr.
σ_x^* [nm]	137.43	137.36	137.36
σ_y^* [nm]	2.30	2.31	2.31
$\mathcal{L}$ [10^{34}cm^{-2}s^{-1}]	2.12	2.14	2.14
$\mathcal{L}_{1\%}$ [10^{34}cm^{-2}s^{-1}]	1.16	1.17	1.18



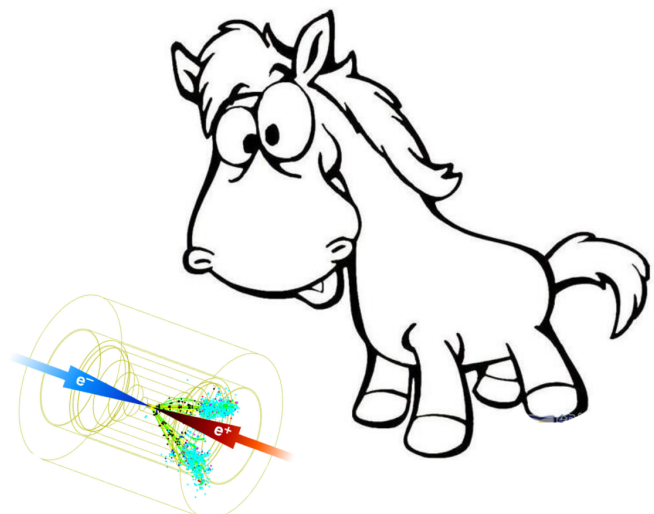


[1] w/ SR at bends and quads

Conclusion

- Simulations with approached energy distributions can represent expected luminosity.
- Piecewise function with beta distribution gives a best fitting. The correlation between z and E is negligible.
- Analytical energy distribution models, e.g., the uniform distribution applied in MAPCLASS, are reasonable.

Thank you for your attention!



Advanced profile fitting

$$f(x) = A \exp[-(x-a)^{40}] \exp[(x-b)^2]$$