Comments on "Comparison of PCA and MBEC for EIC" by Gennady Stupakov

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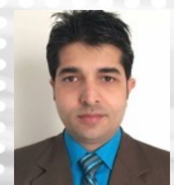
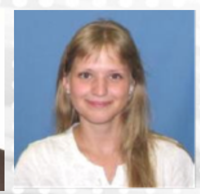

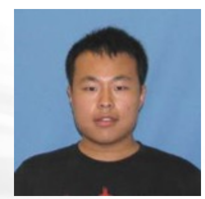
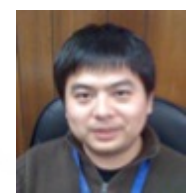
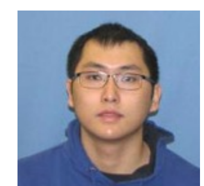

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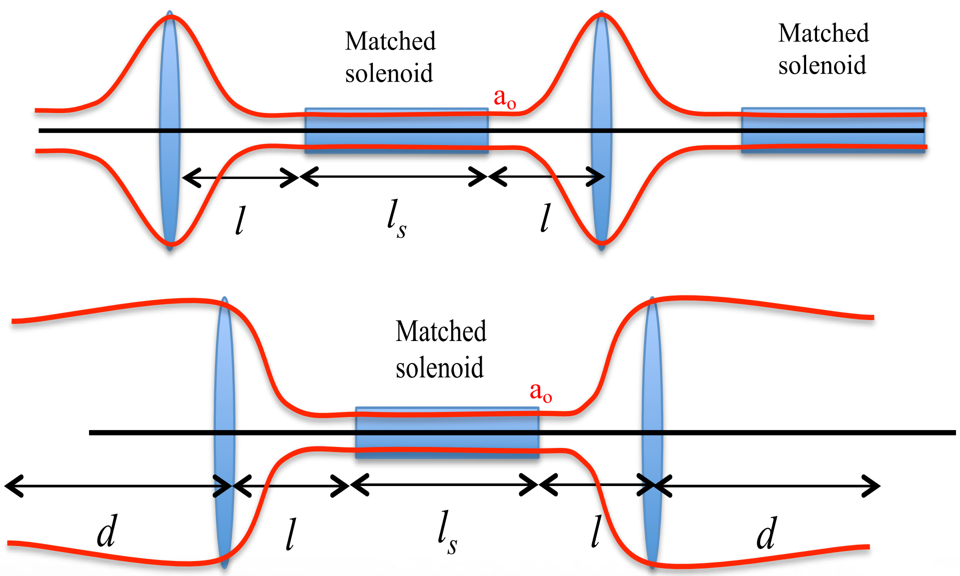
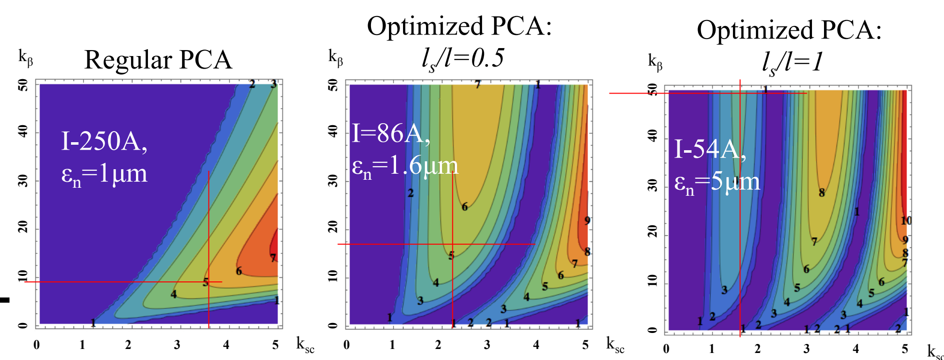
General comment

From the day one we planned to use optimized PCA for EIC CeC cooler (https://arxiv.org/abs/1802.08677) – it provides addition al controls "knobs" which reduce requirements for the electron beam, increase PCA gain and overall making the cooler feasible.

Using a simple PCA (case 1, η=0), as in Gennady's presentation, is the worst-case scenario. The beam parameters, optimized for chicane-based MBA are completely wrong for optimum PCA CeC.



PCA gain per cell



$$k_{sc} = \sqrt{\frac{2}{\beta_o^3\gamma_o^3}\frac{I_o}{I_A}\frac{l^2}{a_o^2}};\quad k_\beta = \frac{\varepsilon l}{a_o^2};\quad \eta = \frac{l_s}{2l}$$

Corrections

- Statement:

> - PCA cell is 2-3 λ_p in length (MBEC amplification section is $\frac{1}{4}\lambda_P +$ chicane). For the EIC CDR parameters with the peak current of 30 A, and $\gamma = 293$ PCA these cells are too long. Large gain also requires a large variation of the beta function in the cell. In the simplest configuration, M-PCA-K, there is a mismatch at M-PCA and PCA-K boundaries that lowers the wake.

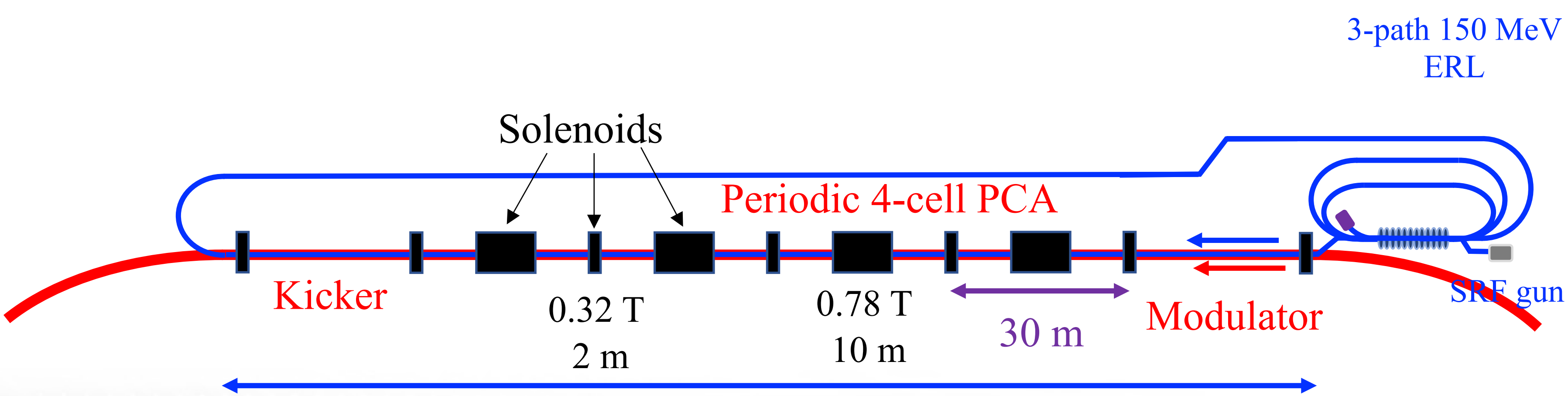
- Corrections: Beam parameters selected for CeC using chicane-based MBA (presented by Erdong) were selected for optima performance for this specific design and should not be used for PCA-based CeC. "Apple-to-Apple" comparison means using optimized designs for both options

Corrections

- Statement:

> PCA may work for smaller energies, but for $\gamma = 293$ the system looks prohibitively long.

- This is clearly personal opinion: PCA CeC design has the same length as chicane-based CeC.



Corrections

- Statement:

- Going to high electron peak current ($I_e \sim 150$ A) would result in large electron noise affecting the cooling (even assuming the nominal Poisson-like shot noise in the e-beam).

- Corrections: Poisson-short noise of each electron does not increase as function of the peak current. Density modulation at specific scale is proportional to square root of the number of electrons in the sample and, therefore, diffusion of the ion beam is proportional to the total change in the electron beam, not to peak current

Corrections

- Statement:

- The modulator and kicker response is peaked in the range ~ 50 THz; if the PCA amplifier bandwidth extends to ~ 1 PHz, there will be a mismatch between the amplifier and M/K.

Corrections: Having large bandwidth if the PCA amplifier (500 THz with PCA vs 30 THz with chicane-based MBA) is actually an advantage. There is no implied ”mismatch”, especially when we compare “apples with apples” and use the same assumption that R_{56} for hadrons can be controlled.

Parameter	Unit	CeC 1	CeC 2
Beam energy	MeV	149.8	149.8
Injector			
Electron gun		DC, inverted	SRF, QW
Gun voltage	MV	0.4	1.5*
Charge per bunch	nC	1	1.5*
Bunch frequency, max	MHz	98.5	49.25**
Beam current	mA	98.5	73.9
Injection beam energy	MeV	5.6	3.5
ERL			
Number of passes		1	3
ERL linac, fundamental	MV	163	51
Harmonic section		3^{rd}	5^{th}
ERL linac, harmonic	MV	18	2
Beam parameters in CeC			
Peak current	A	17-30	150
Norm. emittance, rms	mm-mrad	3	1.25*
Bunch length, rms	mm	3.5-7	1.2
Energy Spread, rms	σ_γ/γ	$<1\text{x}10^{-4}$	$<2\text{x}10^{-4}$*

* *Demonstrated parameters in the current CeC accelerator and SRF gun* [18]

** *For the same cooling time: with 98.5 MHz rep-rate cooling time will be ½ of the CeC 1.*