10^{34} Luminosity ideas

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- Two betas
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Two betas

In EIC's there appears to be a significant first order electron perturbation of the electrons by the hadrons approaching the IP. As a result, the IP beam size is defined by a local β_1^* that is distict from a β_2^* that defined by the IR lattice designers. It is important to distinguish two βs.

1. The local β_1^*s at the IP, including perturbationing by the oncoming beam.

$$\sigma(IP) = \sqrt{\beta_1^* \ \epsilon}$$

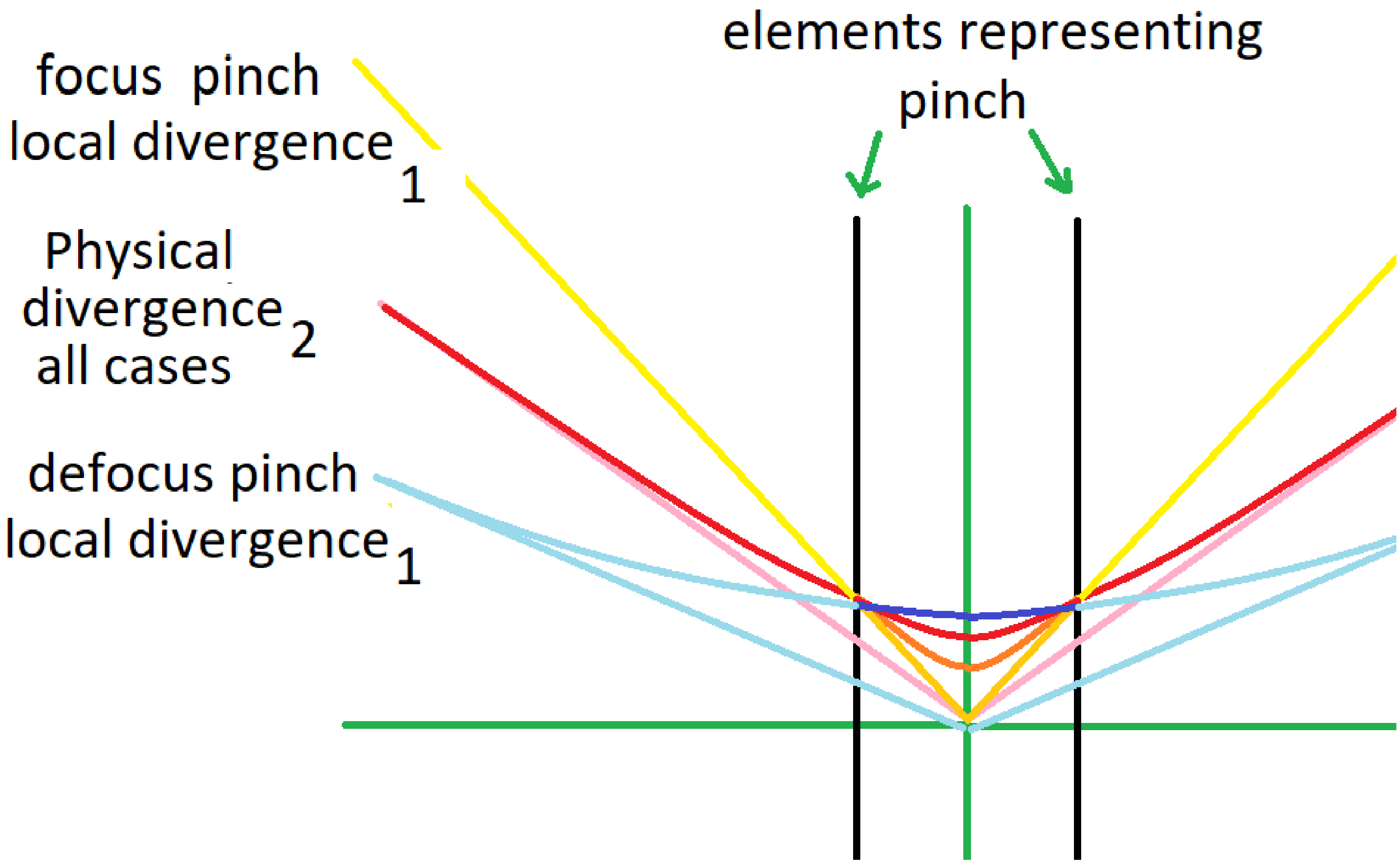
$$\sigma'(IP) = \sqrt{\frac{\epsilon}{\beta_1^*}}$$

2. The β_2^*s are what will appear in an IR latice, and which are the value at the IP without any perturbation effect. i.e. with no significant focusing or defocusing by interactions with the oncoming beam.

$$\sigma_2'(\text{lattice}) \approx \sqrt{\frac{\epsilon}{\beta_2^*}} \qquad \text{for L}^* \gg \beta^*$$

$$\text{Aperture} \approx L^* \ \sigma_2'(\text{lattice}) \qquad \text{for L}^* \gg \beta^*$$

The two σ'



Local focusing (or defocusing) will change the local $\sigma(IP)$ and also the divergence $\sigma'(\mathrm{Lattice})$, increasing it with focus and decreasing it with defocus.

Think of the phase space: if the spot gets smaller, the angular spread must rise. If the spot gets larger, the spread will be less.

Examples

Normal perturbation: reducing σ(IP) and increasing divergence $\sigma'(\mathrm{lattice})$

From DXU may 26 page 4/5 Vadim's case:
$\beta_y = 10.9$ cm and $\epsilon_y = 1.7$ nm
giving calculated $\sigma_{2y} = 13.6$ μm.

$\sigma_{1y} = 12.5\mu$m, from simulation at IP

i.e. the perturbation is reducing the σ_y by 8%,

and expected to increase $\sigma'_y(lattice)$ by the same 8%

Inverted perturbation: increasing σ(IP) and decreasing divergence $\sigma'(\mathrm{lattice})$

From Derong May 23, page 1/13 note:

β_{2x} cm	ϵ_x nm	σ_y μm	calcσ_y μm
49	20	11.5	9.9
59	20	13	10.8

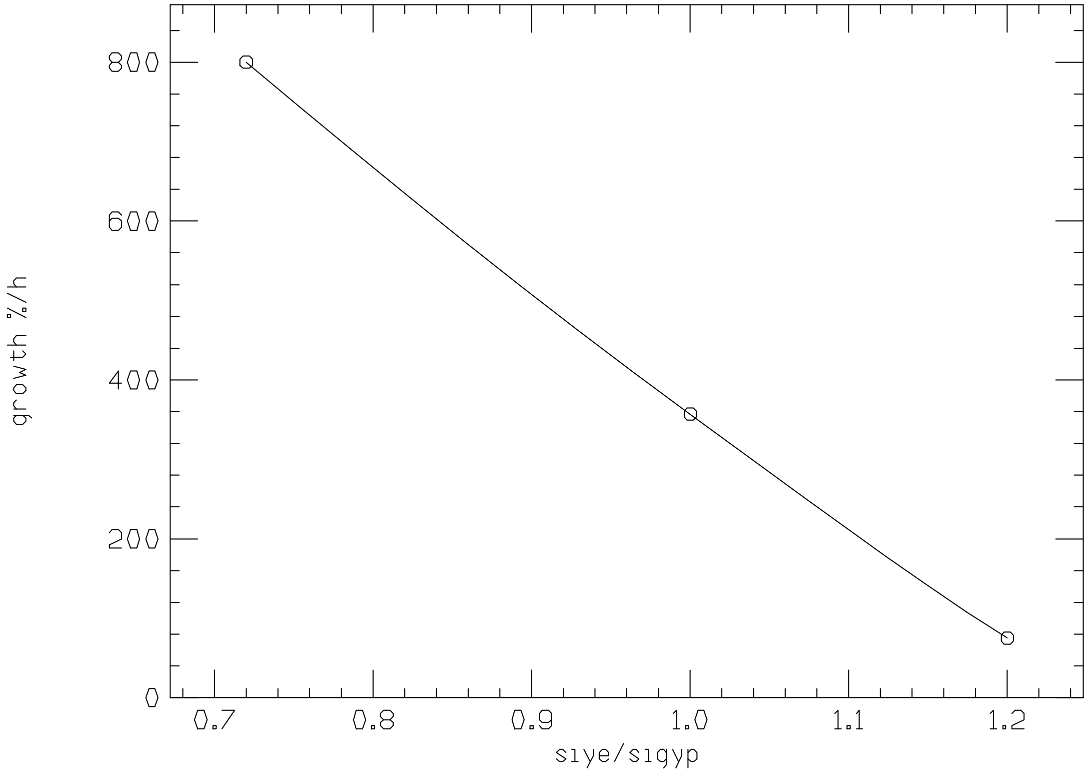
In all cases σ(IP) is LARGER than a non-perturbationed calculation.

If the beams are very asymmetric, as they are, the "perturbation" can be asymmetric too, like a quadrupole electron lens.

Growth vs. e-p σ_y match

Approximate numbers from Derong:

Case	σ_{ye} μm	σ_{ye}/σ_{yp}	Growth %/hour
A	9	0.7	800
B	12.5	1.0	357
C	15	1.2	75



As expected: protons see a more uniform part of the e lens

Design steps

1. Start from Vadim's $L = 6.8\ 10^{33}$ K=.12 equal divergencies (see example 5)
2. Scale all betas down by factor 0.6, to get $L > 10^{34}$ (see example 6)
   - Electron x divergence now $> 220\mu$rad
   - But perturbation modified (in parentheses) divergence $\sigma' \leq 220\mu$rad
   - perturbation modified (in parentheses) electron bunch sigmas larger x, smaller y
   - So perturbation modified (in parentheses) sigmas no longer match hadron's
3. Modify hadron betas to match electrons: larger x, smaller y (see example 10). 9
   - $L = 10.2\ 10^{33}$ and $K = \sigma_y/\sigma_x = .09$, but the flattening came from asymmetric perturbation
4. This study has not studied Vadim's ideas including reductions of electron x emittance that could allow re-adjusting the flatness without generating electron divergencies $\sigma' > 220\ \mu$m.

Parameters

Parentheses give parameters modified by perturbation effects.
In red based, to some extent on b-b simulations
In blue guesses of effects not yet simulated

5) Vadim's current reference

6) My scale down all betas by factor 0.6

10)modifying hadron betas to match electrons with perturbation

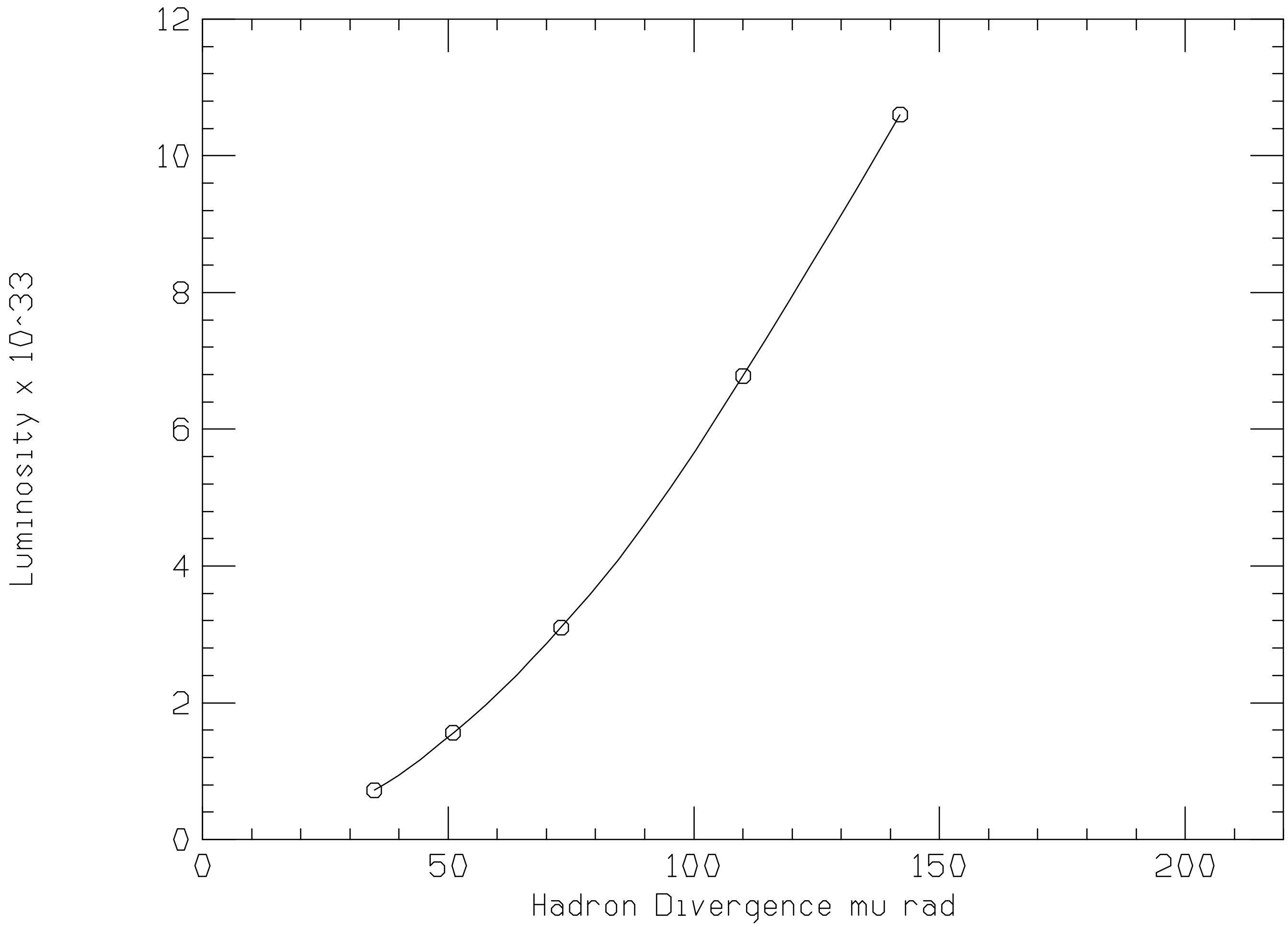
11)Reduced both hadron betas to improve growth

$$N_b = 1160,\ E = 275,\ E_e = 10\ GeV,\ n_p = 6.9,\ n_e = 17.2\ 10^{10}$$

		ϵ_x nm	ϵ_y nm	$\beta_{1x}(\beta_{2x})$ cm	$\beta_{1y}(\beta_{2y})$ cm	$\sigma_{1x}(\sigma_{2x})$ μm	$\sigma_{1y}(\sigma_{2y})$ μm	$K_{y/x}$	$\sigma'_{1x}(\sigma'_{2x})$ μrad	$\sigma'_{1y}(\sigma'_{2y})$ μrad	ξ_x	ξ_y	ΔQ	σ_s cm	I A	HG %	lum 10^{33}
5																	
	p	10.9	1.3	90.0	10.9	99	11.9	.12	110	109	.012	.012	.007	6.0	1.00	94	6.78
	e	20.0	1.70	49.0 (60)	8.4(7)	99(109)	11.9(10.9)	0.12(0.1)	202(184)	142(155)	.070	.100	.000	2.0	2.50		
6																	
	p	10.9	1.3	54.0	6.5	77	9.2	0.12	142	141	.012	.012	.007	6.0	1.00	88	10.60
	e	20.0	1.7	29.4(40)	5.0(4)	89(77)	8.4(9.2)	0.12(.09)	261(220)	184(215)	.070	.100	.000	2.0	2.50		
10																	
	p	10.9	1.3	72	5.2	89	8.2	0.09	123	159	.012	.009	.007	6.0	1.00	87	10.10
	e	20.0	1.7	29.4(40)	5.0(4)	89(77)	8.4(9.2)	0.12(.09)	261(220)	184(215)	.072	.079	.000	2.0	2.50		
11																	
	p	10.9	1.3	57.6	4.2	80.1	8.0	0.09	135	175	.012	.009	.007	6.0	1.00	87	11.1
	e	20.0	1.7	29.4(40)	5.0(4)	89(77)	8.4(9.2)	0.12(.09)	261(220)	184(215)	.072	.079	.000	2.0	2.50		

Remember the βs to be used in a lattice and for input to a simulation code are those β_2s that are in parentheses. The ones before are those $\beta 1$s inside the intersctions.

Appendix on Luminosity vs. Divergences



For the Physicists it may be nice to see what luminosity woykd be possible with hadron parameters giveng very low divergencies and that able to seperate outgoing hadrons with lower transverse momenta (down to 100 MeV/c).

Parameters of lower divergence solutions

		E	N	$\epsilon_x(\epsilon_{Nx})$	$\epsilon_y(\epsilon_{Ny})$	β_x	β_y	σ_x	σ_y	σ'_x	σ'_y	ξ_x	ξ_y	ΔQ	σ_s	I	HG	lum
		GeV		nm(μm)	nm(μm)	cm	cm	μm	μm	μrad	μrad				cm	A	%	10^{33}
6	com	104.9																
	p	275	6.9	10.9(3.2)	1.3(0.4)	54.0	6.5	77	9.2	142	141	.012	.012	.007	6.0	1.00	88	10.60
	e	10.0	17.2	20.0(391)	1.70(33)	29.4(40)	5.0(4)	77	9.3	261(223)	184(215)	.070	.100	.000	2.0	2.50		
7	com	104.9																
	p	275	6.9	10.9(3.2)	1.3(0.4)	207.0	25.1	150	18.1	73	72	.012	.012	.007	6.0	1.00	98	3.08
	e	10.0	17.2	20.0(391)	1.70(33)	112.7 (124)	19.3	150	18.1	133	94	.070	.100	.000	2.0	2.50		
8	com	104.9																
	p	275	6.9	10.9(3.2)	1.3(0.4)	414.0	50.1	212	25.5	51	51	.012	.012	.007	6.0	1.00	99	1.56
	e	10.0	17.2	20.0(391)	1.70(33)	225.4	38.6	212	25.6	94	66	.070	.100	.000	2.0	2.50		
9	com	104.9																
	p	275	6.9	10.9(3.2)	1.3(0.4)	900.0	109.0	313	37.6	35	35	.012	.012	.007	6.0	1.00	100	0.72
	e	10.0	17.2	20.0(391)	1.70(33)	490.0	84.0	313	37.8	64	45	.070	.100	.000	2.0	2.50		