BeamCal operation parameters

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- ILC accelerator TDR parameters
- Changes since TDR
- ILC beam time structure
- Signals at the BeamCal readout
- MIPs, BeamCal calibration
- BeamCal based on sapphire sensors

ILC baseline parameters

(Technical Design Report)

Centre-of-mass energy	E_{CM}	GeV	200	230	250	350	500
Luminosity pulse repetition rate		Hz	5	5	5	5	5
Positron production mode		Hz	10	10	10	Nom.	Nom.
Estimated AC power	P_{AC}	MW	114	119	122	121	163
Bunch population	N	$x10^{10}$	2	2	2	2	2
Number of bunches	nb		1312	1312	1312	1312	1312
Linac bunch interval	tb	ns	554	554	554	554	554
RMS bunch length	z	nm	300	300	300	300	300
Normalized horizontal emittance at IP	x	µm	10	10	10	10	10
Normalized vertical emittance at IP	y	nm	35	35	35	35	35
Horizontal beta function at IP	x	mm	16	14	13	16	11
Vertical beta function at IP	y	mm	0.34	0.38	0.41	0.34	0.48
RMS horizontal beam size at IP	x	nm	904	789	729	684	474
RMS vertical beam size at IP	y	nm	7.8	7.7	7.7	5.9	5.9
Vertical disruption parameter	Dy		24.3	24.5	24.5	24.3	24.6
Fractional RMS energy loss to beamstrahlung	Bs	%	0.65	0.83	0.97	1.9	4.5
Luminosity	L	$x10^{34}$	0.56	0.67	0.75	1.0	1.8
Fraction of L in top 1% ECM	$L_{0.01}$	%	91	89	87	77	58
Electron polarisation	P-	%	80	80	80	80	80
Positron polarisation	P+	%	30	30	30	30	30
Electron relative energy spread at IP	p/p	%	0.20	0.19	0.19	0.16	0.13
Positron relative energy spread at IP	p/p	%	0.19	0.17	0.15	0.10	0.07

ILC-2017 parameters

		TDR		New
Ecm	GeV	250	500	250
N	e10	2.0	2.0	2.0
Collision frequency	Hz	5.0	5.0	5.0
Electron linac rep rate	Hz	10.0	5.0	5.0
Nb		1312	1312	1312
Bunch separation	ns	554	554	554
Beam current	mA	5.78	5.78	5.78
P_B	MW	5.3	10.5	5.3
σ_z	mm	0.3	0.3	0.3
σ_E/E(e-)	%	0.188	0.124	0.188
σ_E/E(e+)	%	0.15	0.07	0.15
ε_{nx}	μm	10.00	10.00	5.00
ε_{ny}	nm	35.0	35.0	35.0
electron polarization	%	80	80	80
positron polarization	%	30	30	30
β_x	mm	13.0	11.0	13.0
β_y	mm	0.41	0.48	0.41
σ_x	nm	729.0	474.2	515.5
σ_y	nm	7.66	5.86	7.66
θ_x	μr	56.1	43.1	39.7
θ_y	μr	18.7	12.2	18.7
Dx		0.26	0.30	0.51
Dy		24.5	24.6	34.5
Upsilon (average)		0.020	0.062	0.028
Ngamma		1.21	1.82	1.91
δ_{BS}	%	0.97	4.50	2.62
Lgeo	1.0E+34	0.374	0.751	0.529
L (simulation, waist shift)	1.0E+34	0.82	1.79	1.35

(Kaoru Yokoya for the Parameter Group)

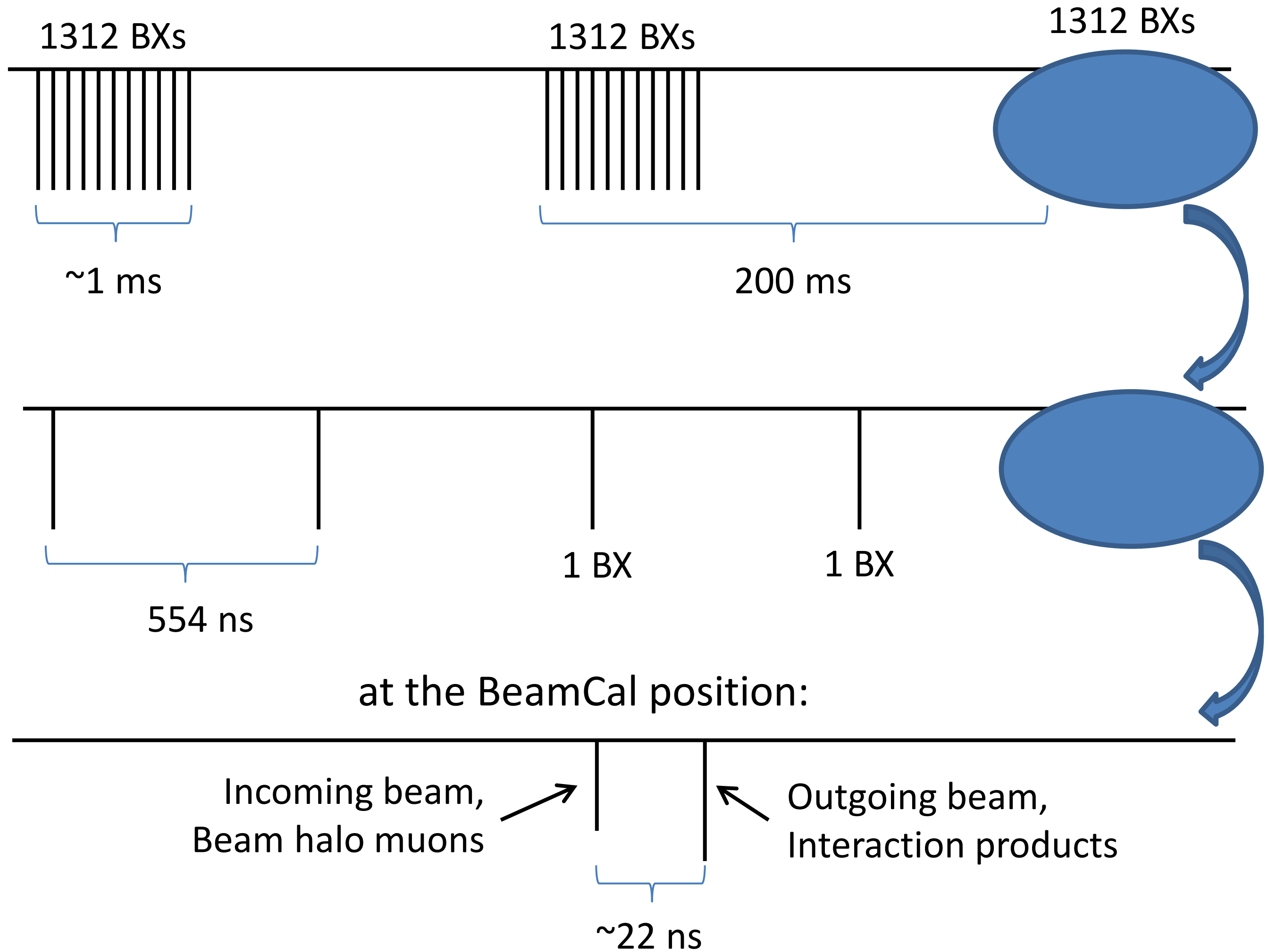
The luminosity at the center-of-mass energy 250GeV can be improved by factor ~1.65 by adopting the horizontal emittance at IP factor 2 smaller than in the TDR. This is achieved by modifying the damping ring design slightly.

There are several side effects:

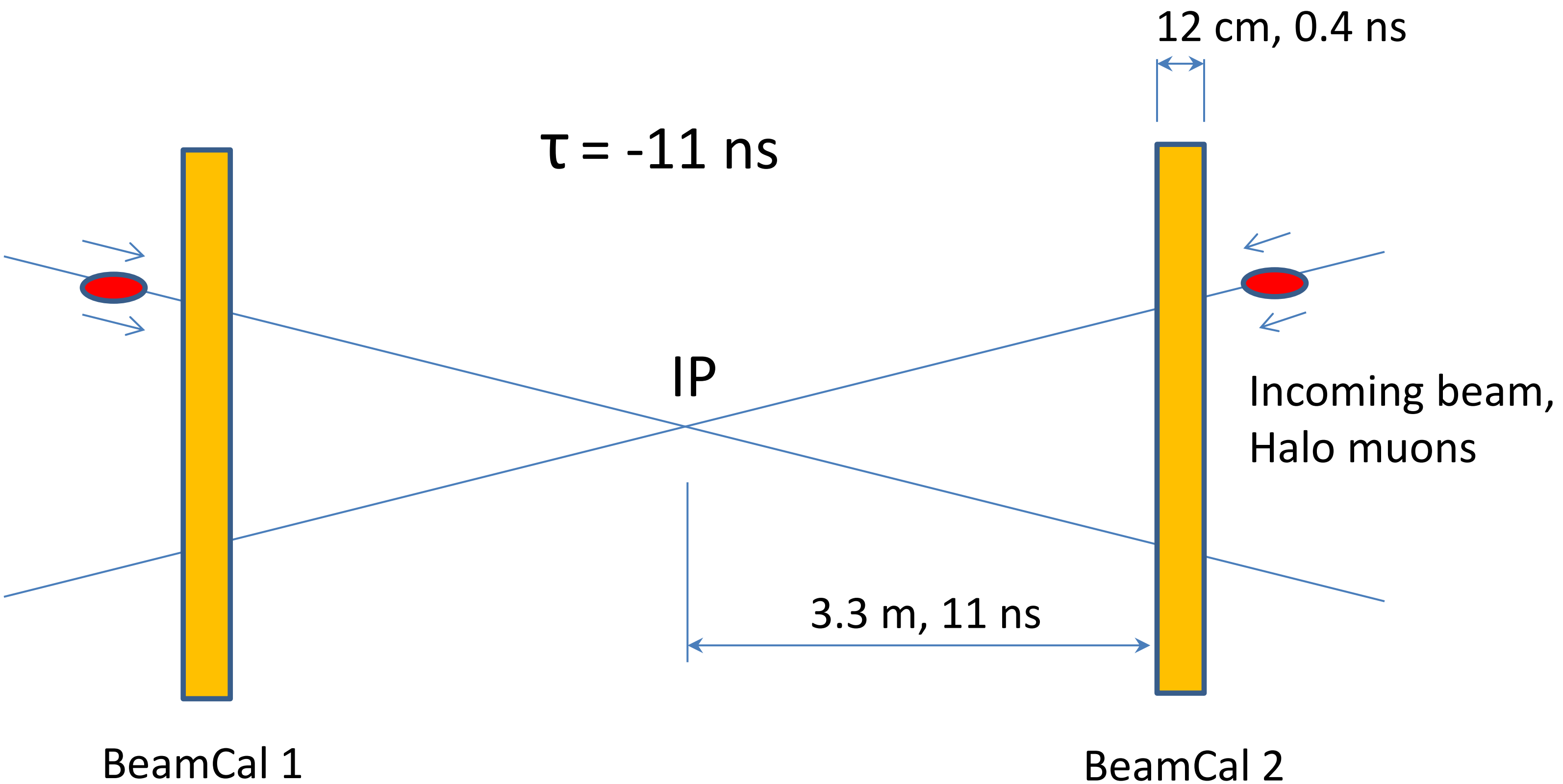
-The energy loss by the beamstrahlung will increase about a factor ~2.6. Also, the background from the incoherent pair creation increases by factor ~3.

-The vertical disruption parameter increases from ~25 to ~35. This might require more accurate IP position control but within the manageable range.

ILC beam time structure

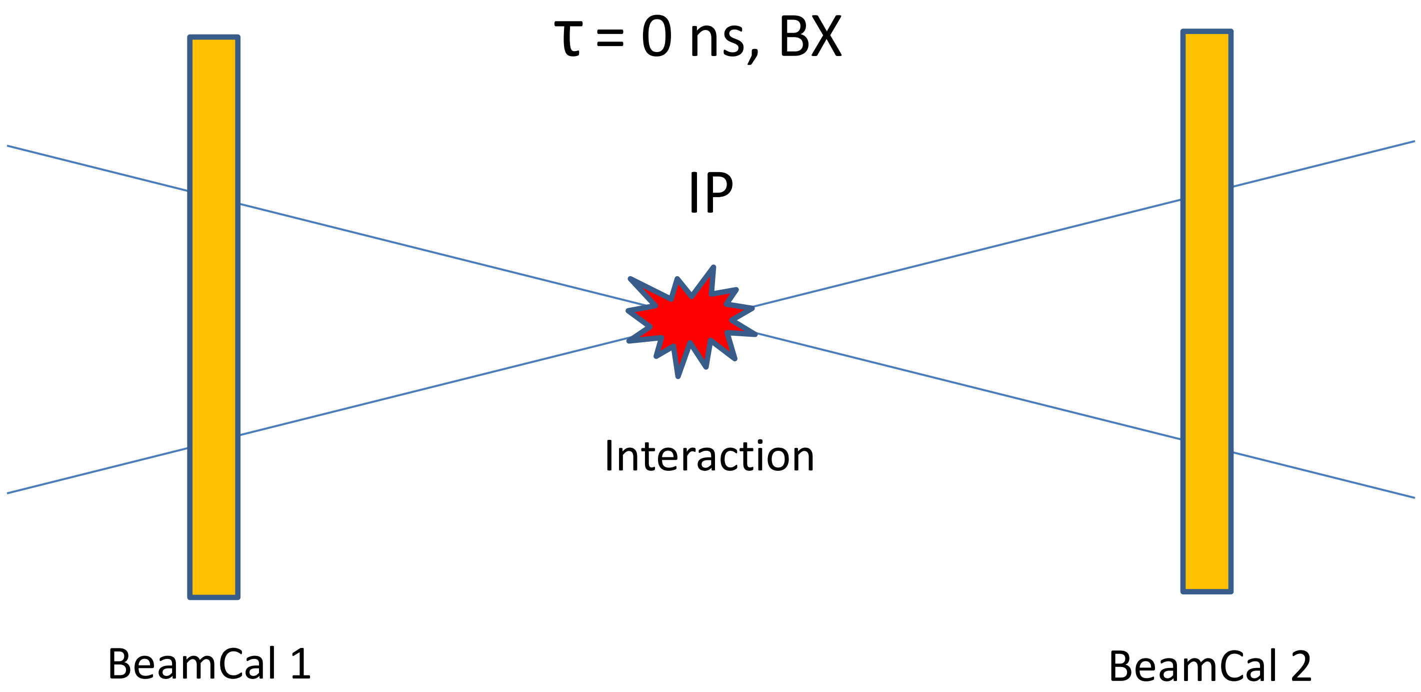


Signals at the BeamCal Readout



Signal arrival time incertainty due to geometrical factors:
Longitudinal ~ 0.4 ns
Radial ~ 0.4 ns

Signals at the BeamCal Readout



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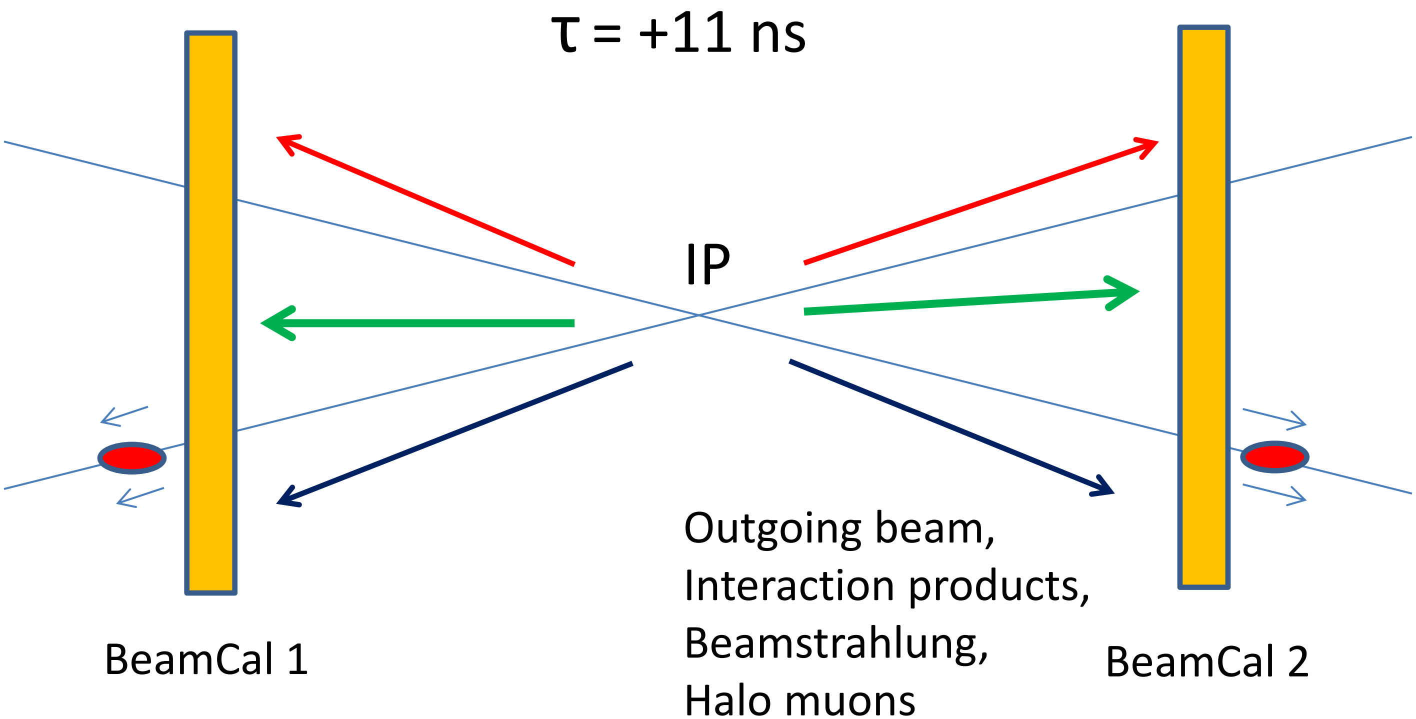
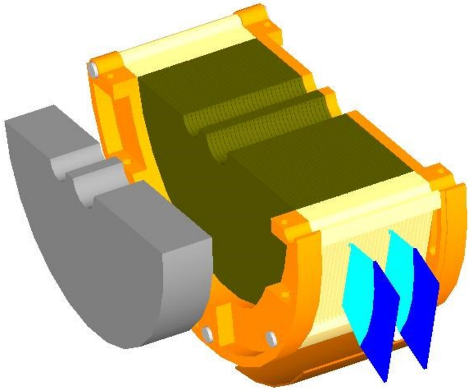
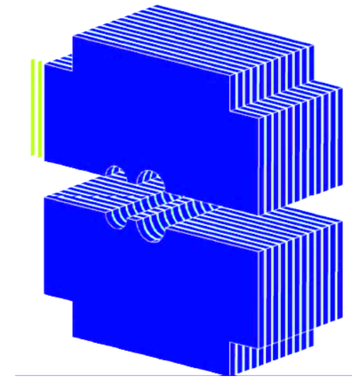


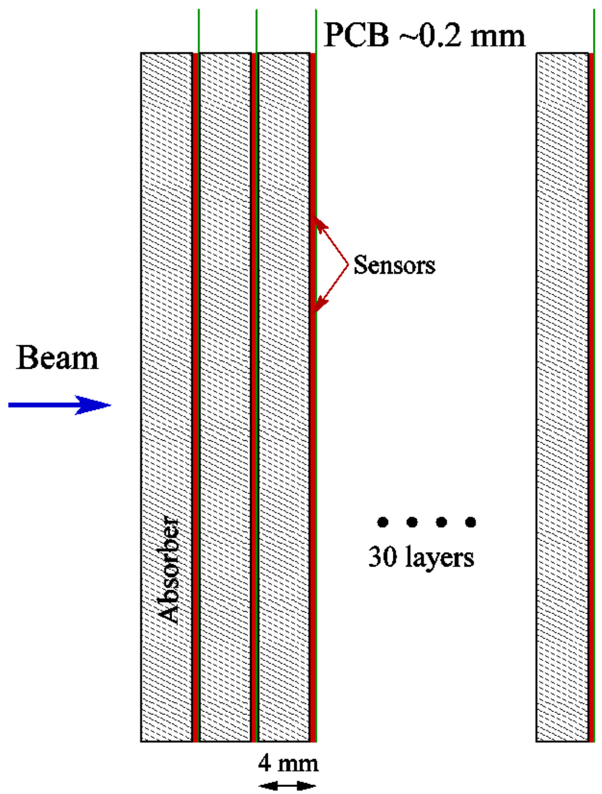


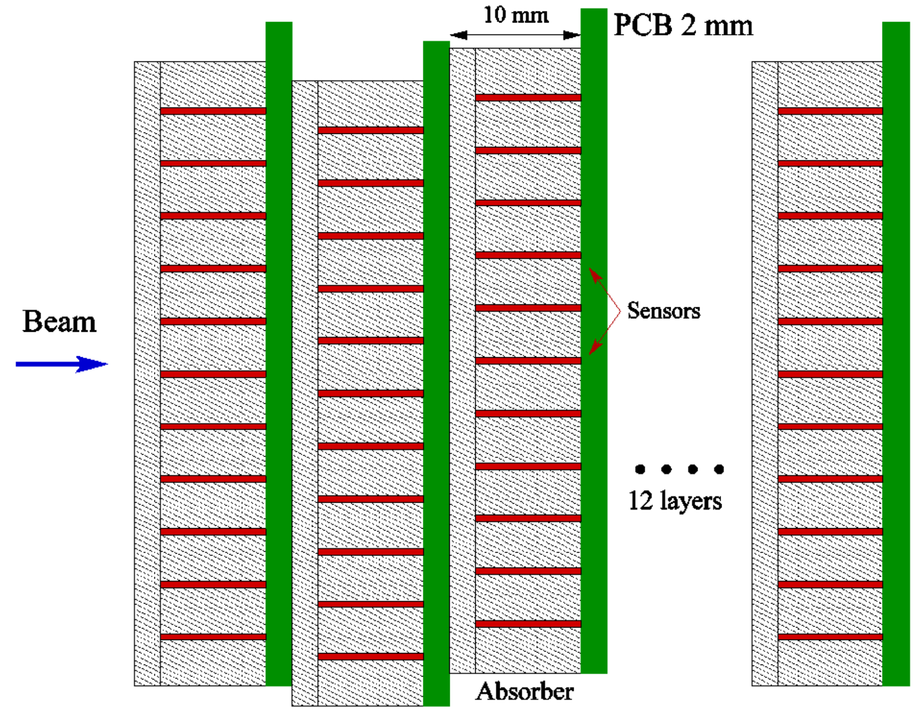
Modification of BeamCal design for sapphire sensors application



Old

New





New vs Old BeamCal design

Pro:

- Better radiation hardness (new sensors) x10
- Easier physical calibration and radiation damage monitoring (to be demonstrated in details)
- Reduced required R/O dynamic range x10

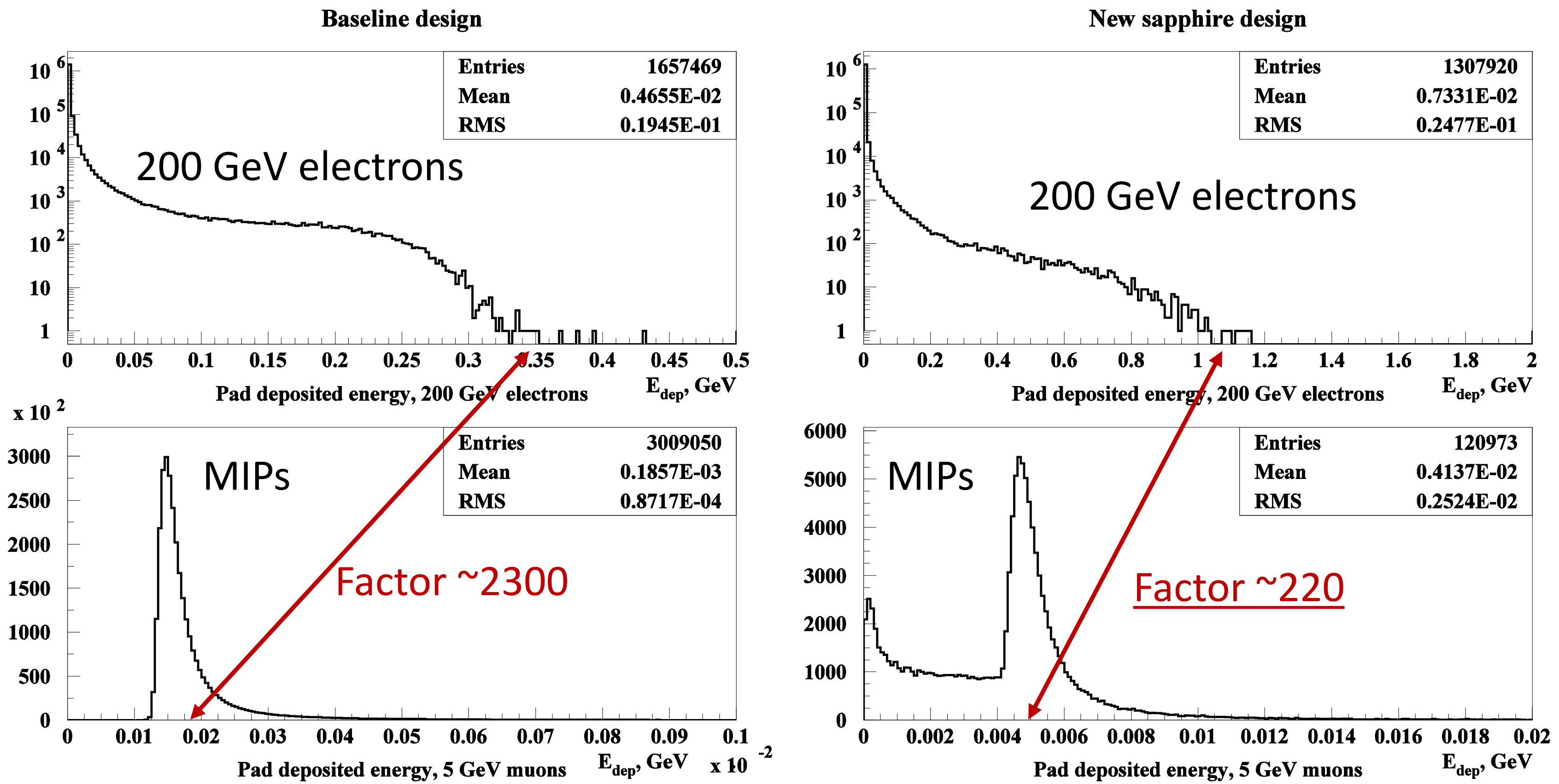
Contra:

- Worse spatial uniformity
- Worse energy resolution

Impact on physics
to be understood

Dynamic range needed for BeamCal readout (high energy electrons/MIPs)

To be updated for new ILC parameters



BeamCal readout dynamic range in the presence of background

- It is very hard to follow up the rapidly changing BeamCal background conditions when ILC parameters are often modified
- Meanwhile we can rely on simple observation: if background level reaches the level of the most energetic (beam energy) electron showers, shower reconstruction efficiency becomes unacceptably low.
- Thus, for estimates, use BeamCal simulation results without background overlapping and at the end increase by a factor of 2 the upper limit of the expected signals.

To be done both for GaAs (baseline) and sapphire designs