EXTRACTION BEAM LOSS AT 1 TEV CM WITH TDR PARAMETERS

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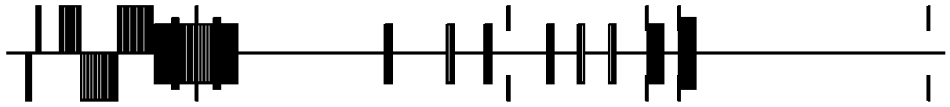
Lattice and beam parameter options

- Extraction line with $L_{ext}^* = 6.3$ m
- SiD solenoid field with anti-DID and orbit correction downstream of IP
- 1 TeV CM energy
- 14 mrad crossing angle
- Disrupted electron and photon beam distribution at IP generated using Guinea-Pig
- Beam parameter options:
  - A1 – low beamstrahlung
  - B1b – high beamstrahlung (~2 times more energy loss compared to A1)
  - ideal head-on collisions
  - with vertical offset (±) between the beams at IP adjusted for maximum disruption
- Electron and photon power losses for the disrupted beams are obtained using DIMAD tracking simulations

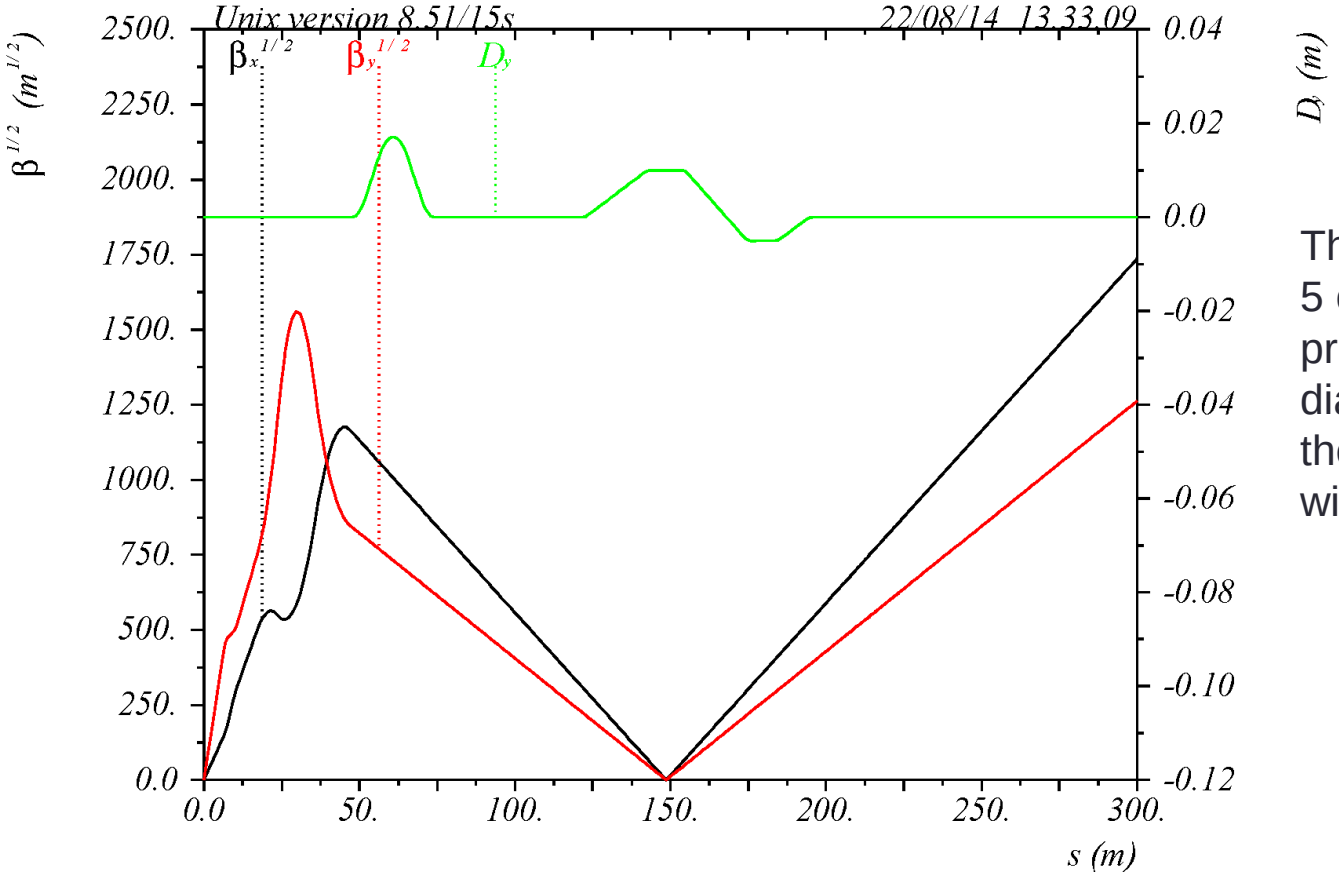
TDR beam parameters

Parameter		Center-of-mass energy, E_{cm} (GeV) Baseline 200	250	350	500	Upgrades 500	1000 (A1)	1000 (B1b)	Unit
Nominal bunch population	N	2.0	2.0	2.0	2.0	2.0	1.74	1.74	$\times 10^{10}$
Pulse frequency	f_{rep}	5	5	5	5	5	4	4	Hz
Bunches per pulse	N_{bunch}	1312	1312	1312	1312	2625	2450	2450	
Nominal horizontal beam size at IP	σ_x^*	904	729	684	474	474	481	335	nm
Nominal vertical beam size at IP	σ_y^*	7.8	7.7	5.9	5.9	5.9	2.8	2.7	nm
Nominal bunch length at IP	σ_z^*	0.3	0.3	0.3	0.3	0.3	0.250	0.225	mm
Energy spread at IP, e^-	$\delta E/E$	0.206	0.190	0.158	0.124	0.124	0.083	0.085	%
Energy spread at IP, e^+	$\delta E/E$	0.190	0.152	0.100	0.070	0.070	0.043	0.047	%
Horizontal beam divergence at IP	θ_x^*	57	56	43	43	43	21	30	μrad
Vertical beam divergence at IP	θ_y^*	23	19	17	12	12	11	12	μrad
Horizontal beta-function at IP	β_x^*	16	13	16	11	11	22.6	11	mm
Vertical beta-function at IP	β_y^*	0.34	0.41	0.34	0.48	0.48	0.25	0.23	mm
Horizontal disruption parameter	D_x	0.2	0.3	0.2	0.3	0.3	0.1	0.2	
Vertical disruption parameter	D_y	24.3	24.5	24.3	24.6	24.6	18.7	25.1	
Energy of single pulse	E_{pulse}	420	526	736	1051	2103	3409	3409	kJ
Average beam power per beam	P_{ave}	2.1	2.6	3.7	5.3	10.5	13.6	13.6	MW
Geometric luminosity	L_{geom}	0.30	0.37	0.52	0.75	1.50	1.77	2.64	$\times 10^{34}$ cm^{-2} s^{-1}
– with enhancement factor		0.50	0.68	0.88	1.47	2.94	2.71	4.32	$\times 10^{34}$ cm^{-2} s^{-1}
Beamstrahlung parameter (av.)	Υ_{ave}	0.013	0.020	0.030	0.062	0.062	0.127	0.203	
Beamstrahlung parameter (max.)	Υ_{max}	0.031	0.048	0.072	0.146	0.146	0.305	0.483	
Simulated luminosity (incl. waist shift)	L	0.56	0.75	1.0	1.8	3.6	3.6	4.9	$\times 10^{34}$ cm^{-2} s^{-1}
Luminosity fraction within 1 %	$L_{1\%}/L$	91	87	77	58	58	59	45	%
Energy loss from BS	δE_{BS}	0.65	0.97	1.9	4.5	4.5	5.6	10.5	%
e^+e^- pairs per bunch crossing	n_{pairs}	45	62	94	139	139	201	383	$\times 10^3$
Pair energy per B.C.	E_{pairs}	25	47	115	344	344	1338	3441	TeV

Extraction line optics with $L_{ext}^* = 6.3$ m



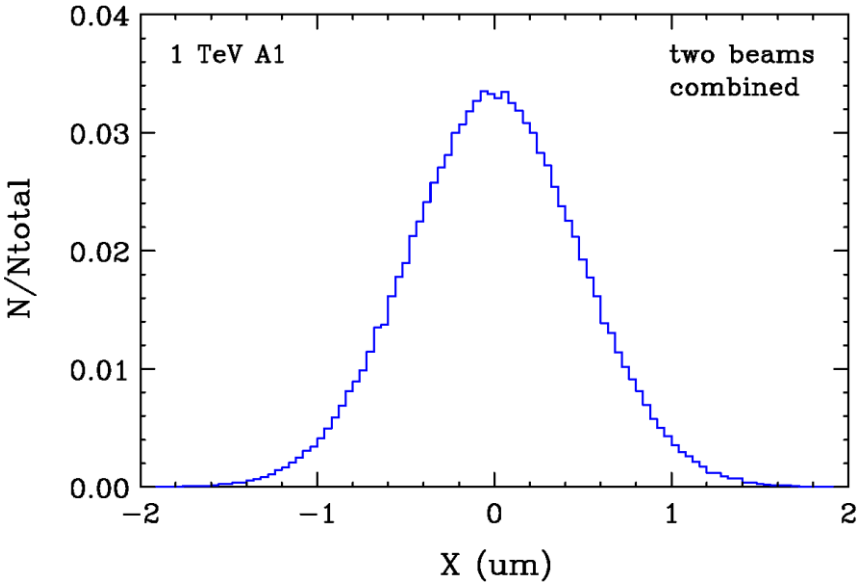
ILC extraction line with Lext = 6.3 m.*

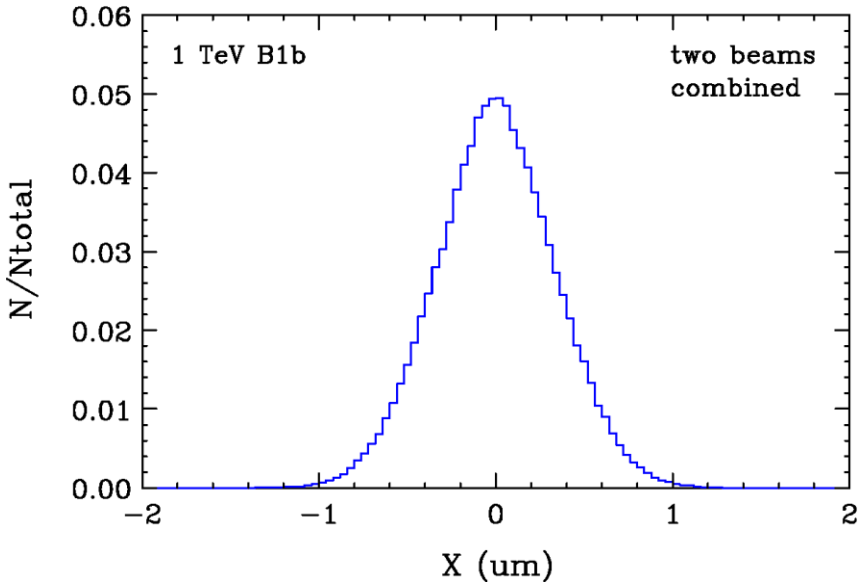


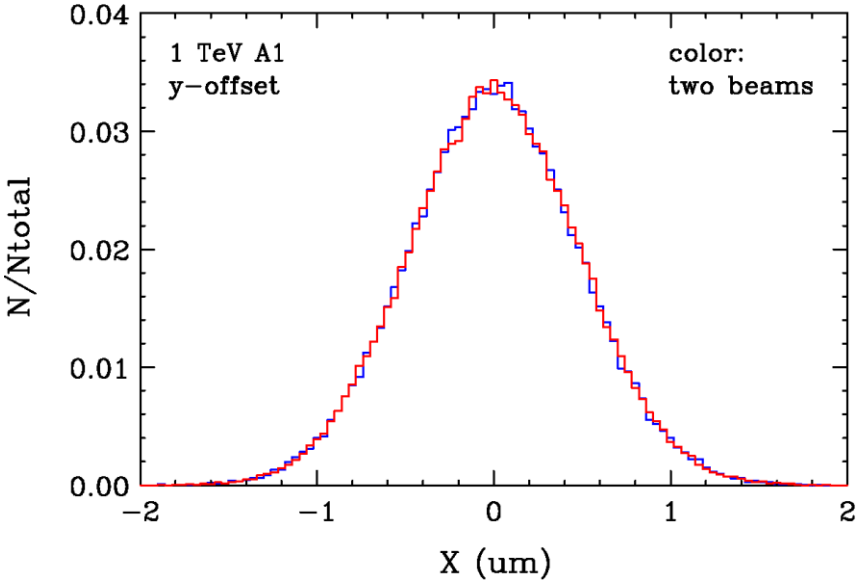
The beamline includes 5 collimators for protecting the diagnostics and limiting the beam size at dump window

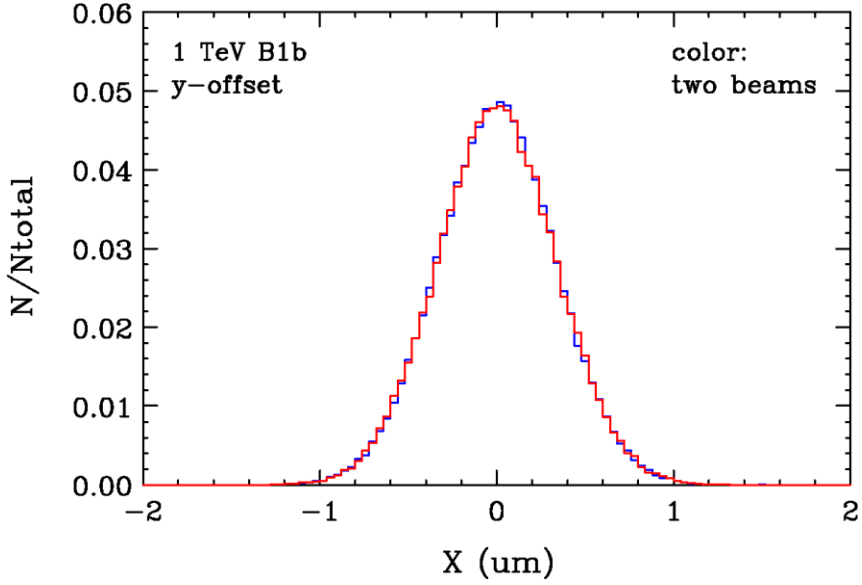
Shown β-functions correspond to A1 disrupted beam

Disrupted electron horizontal size at IP

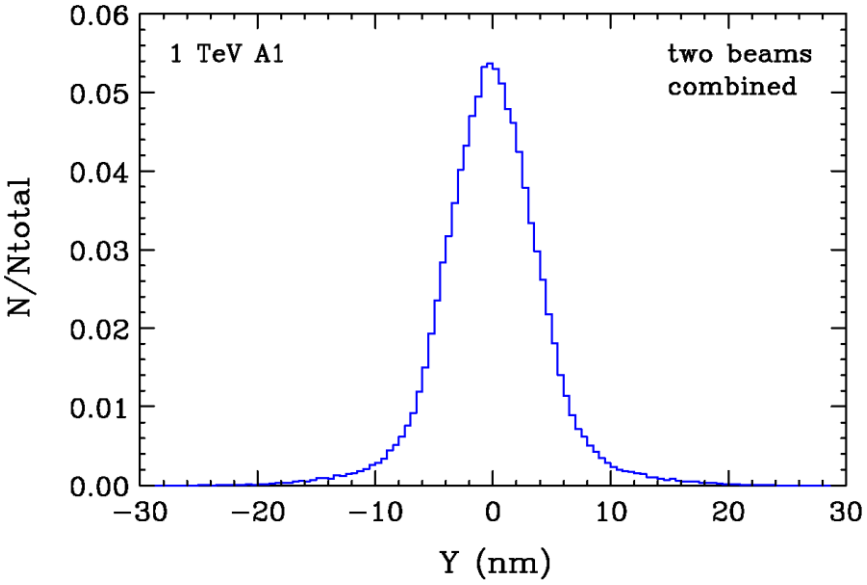


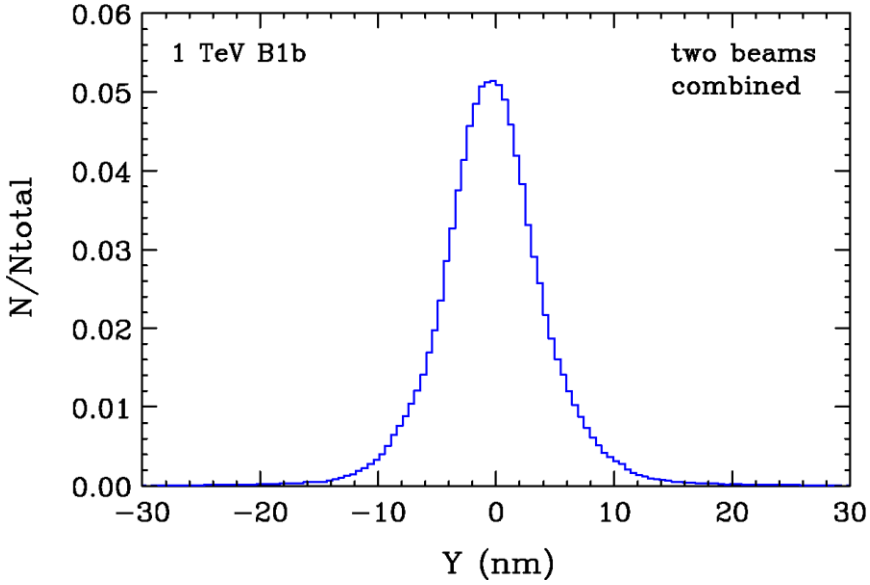


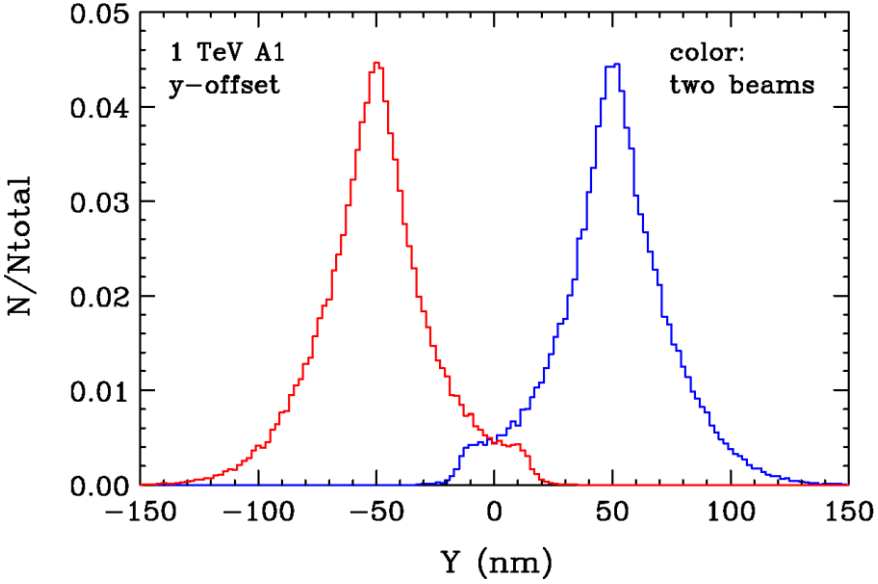


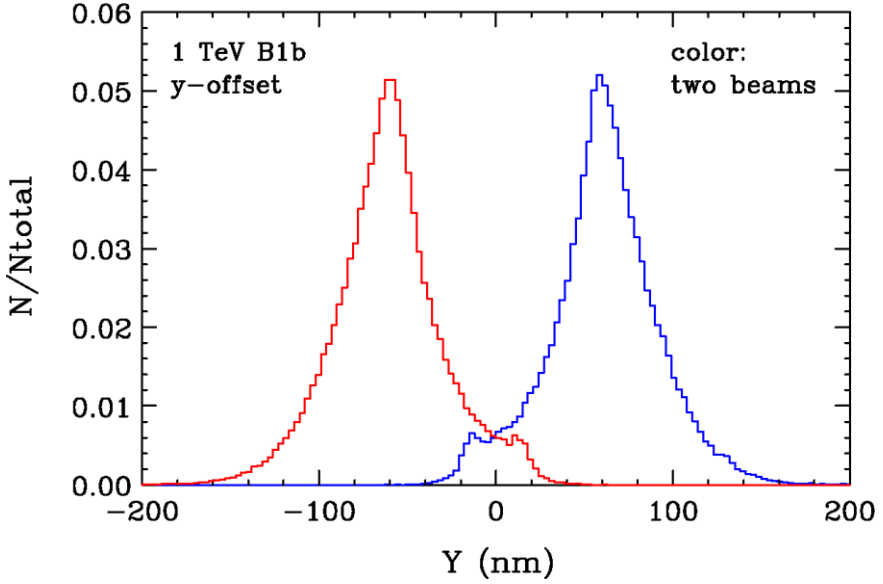


Disrupted electron vertical size at IP

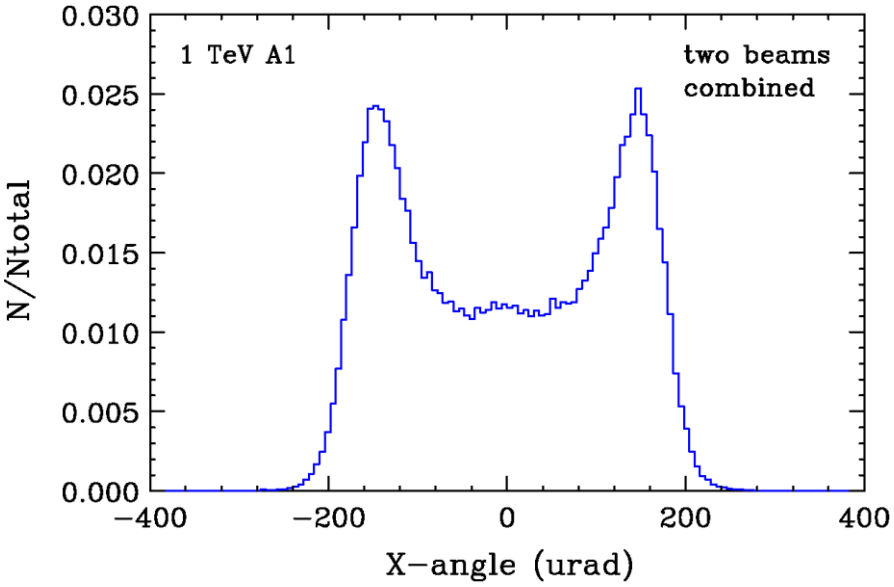


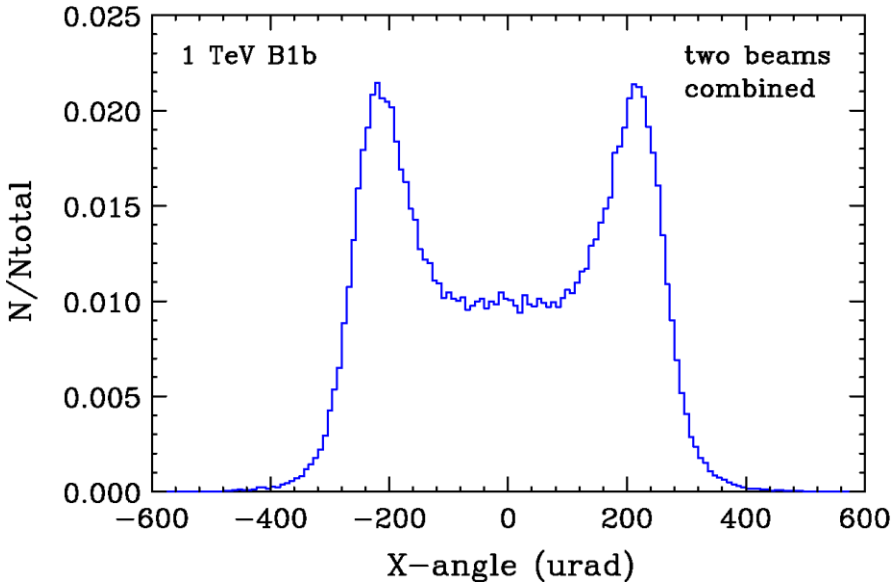


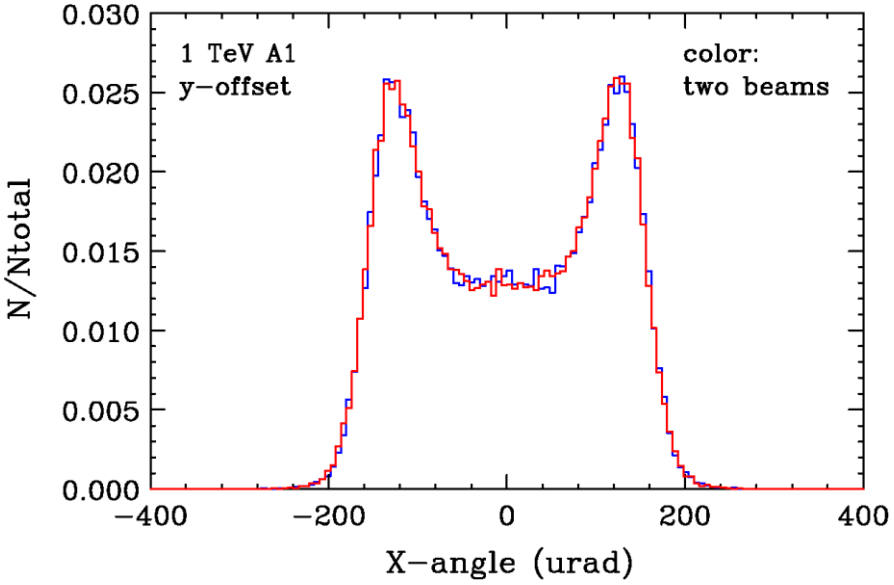


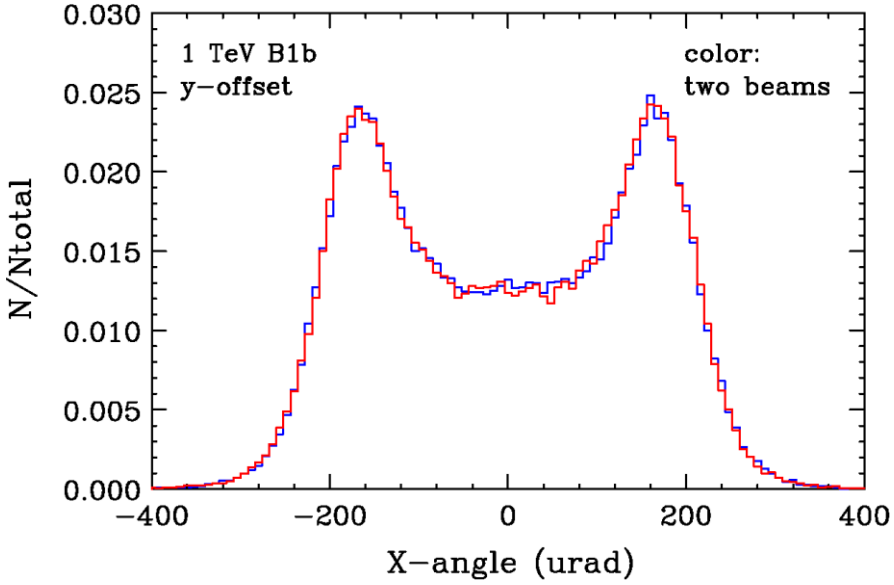


Disrupted electron horizontal angular spread at IP

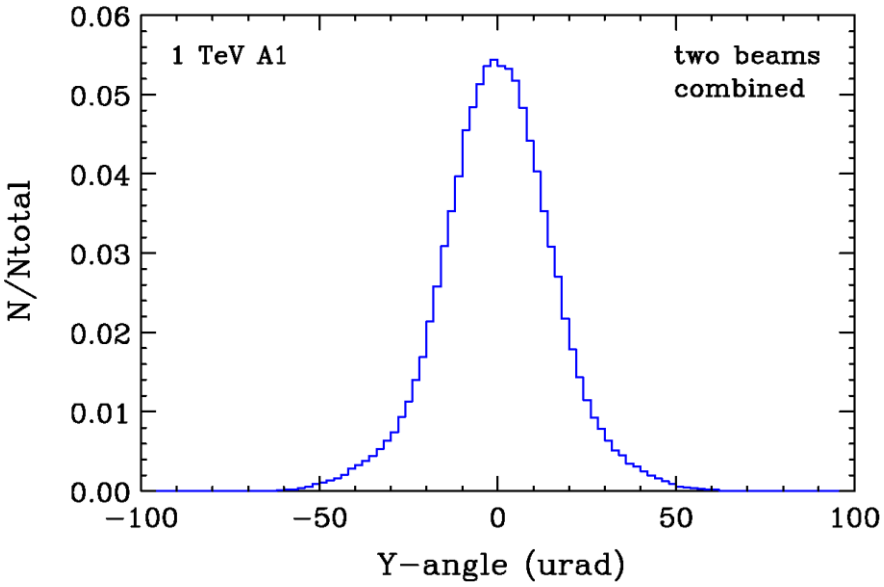


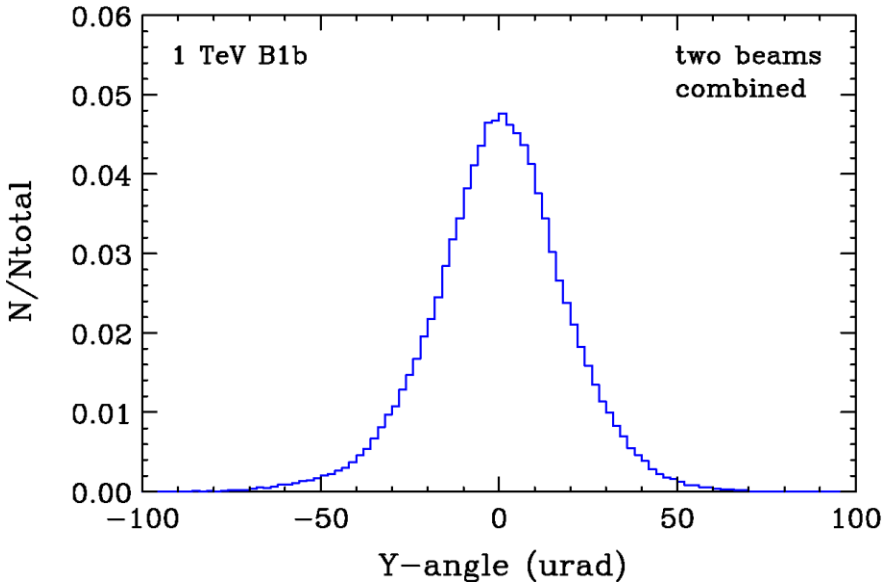


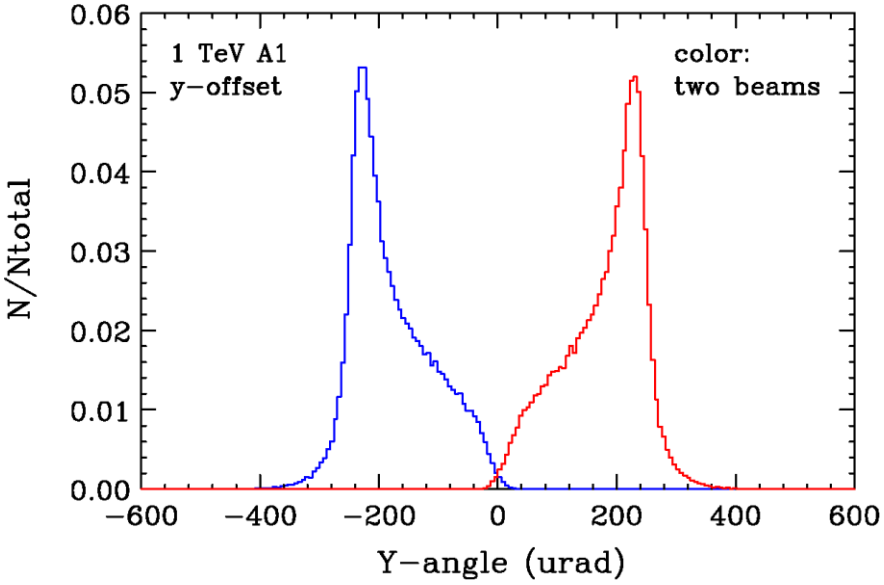


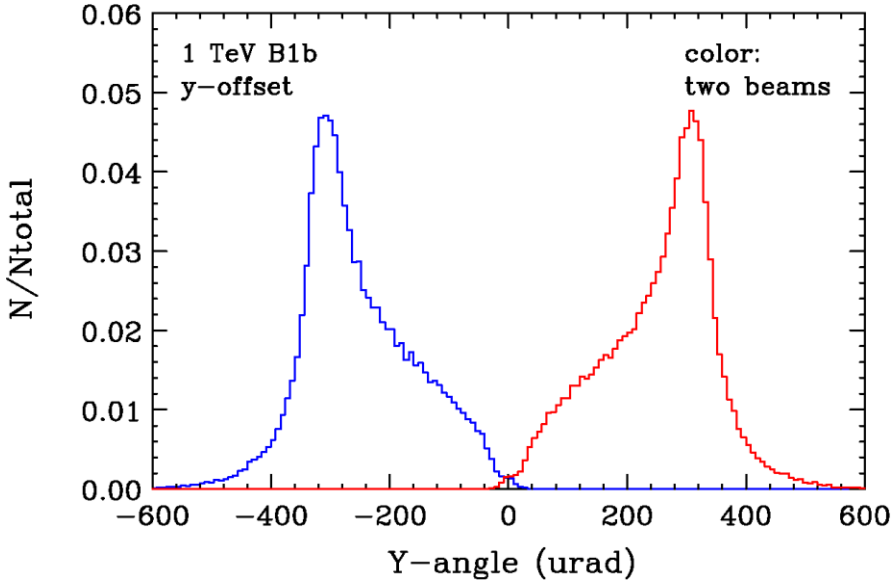


Disrupted electron vertical angular spread at IP



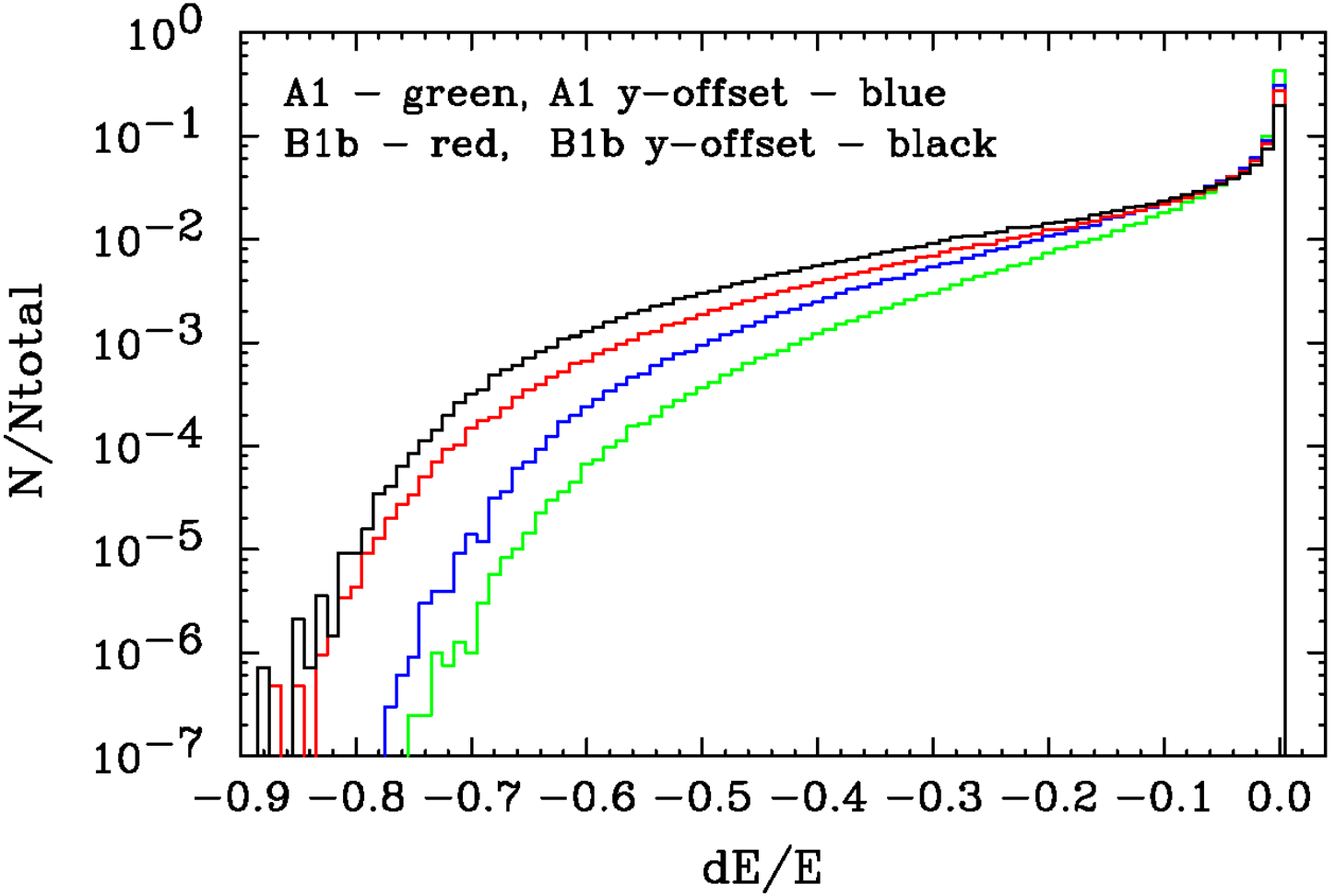




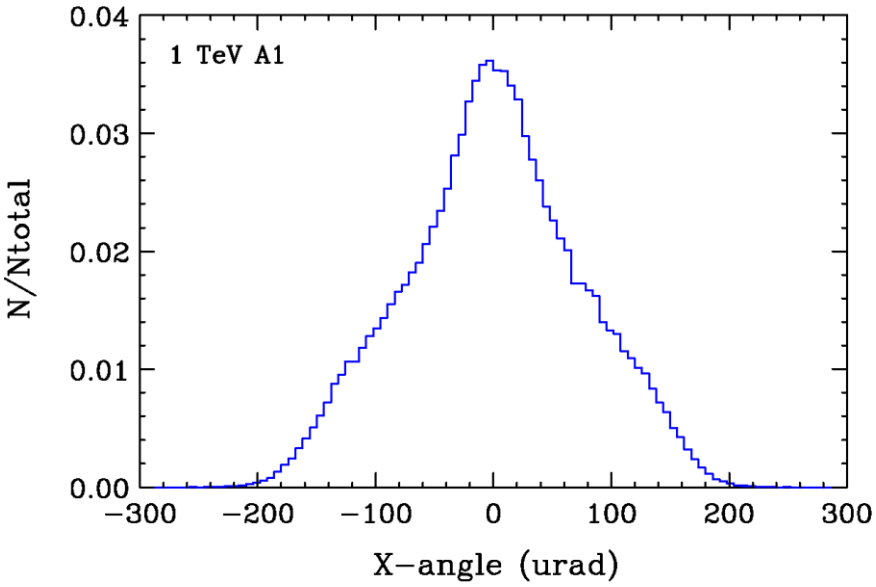


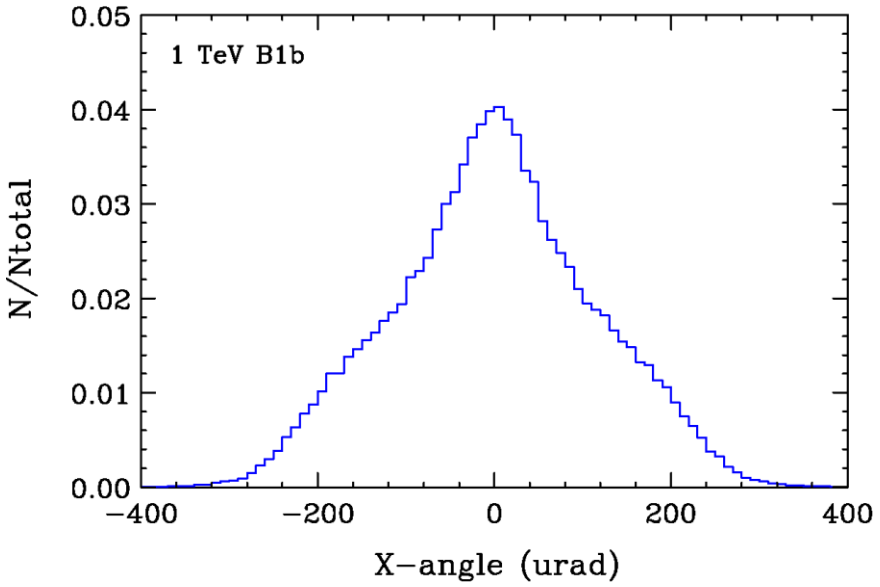
Disrupted electron energy spread at IP

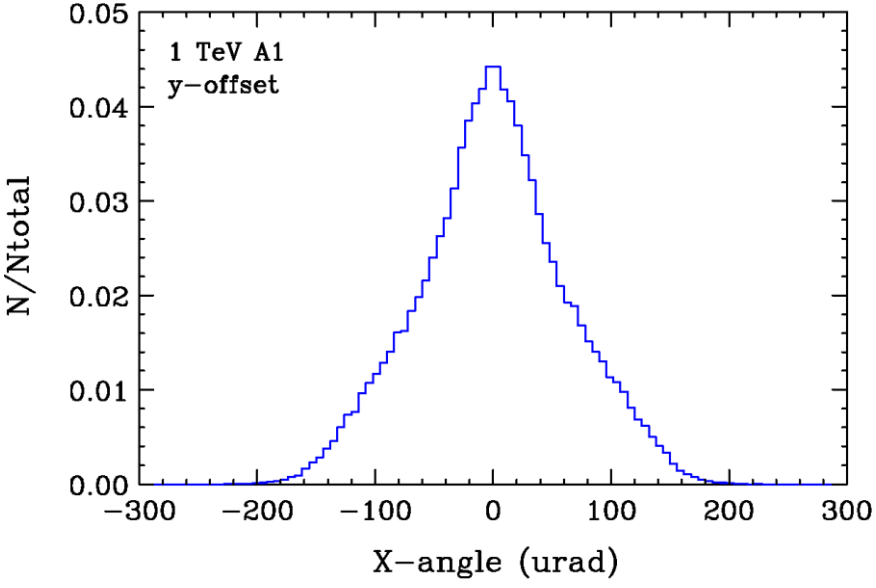
- Option B1b creates much longer energy tail
- IP y-offset increases the energy tail in both (A1 and B1b) options

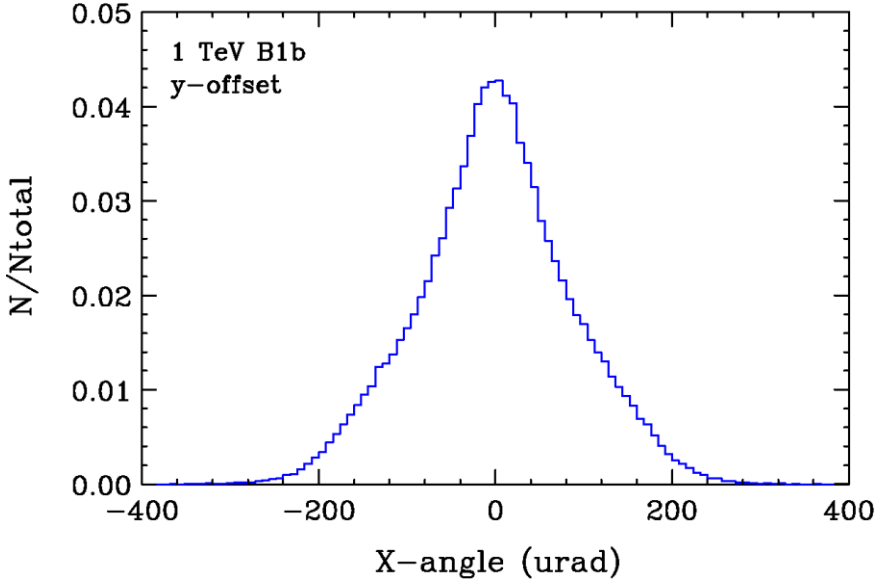


Photon horizontal angular spread at IP

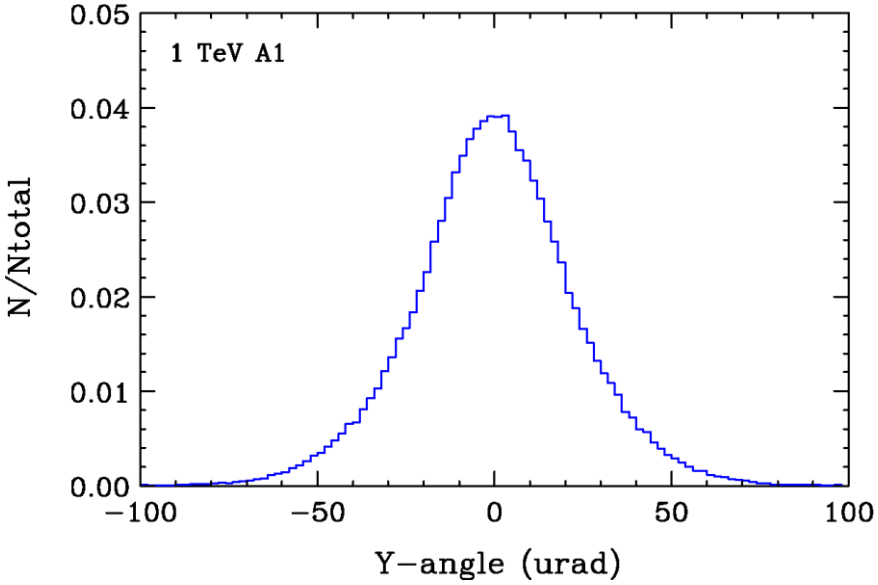


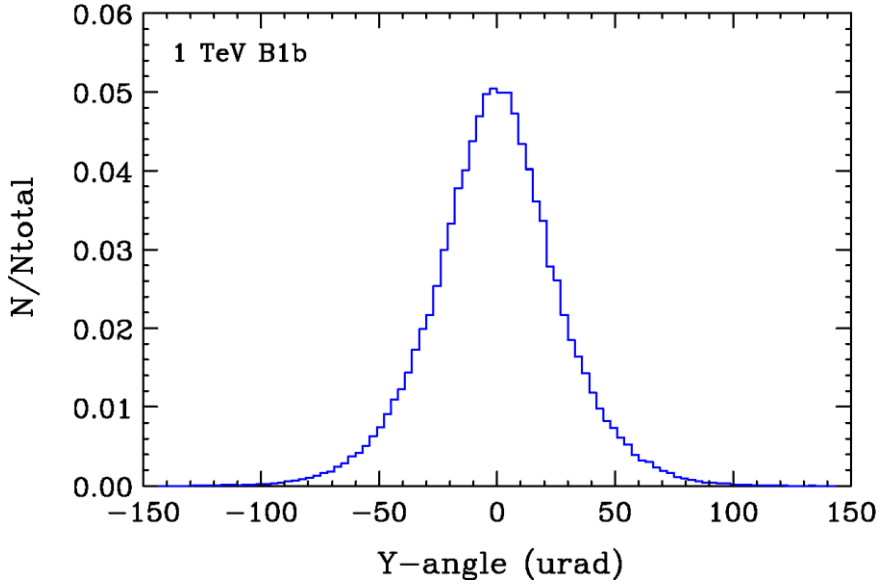


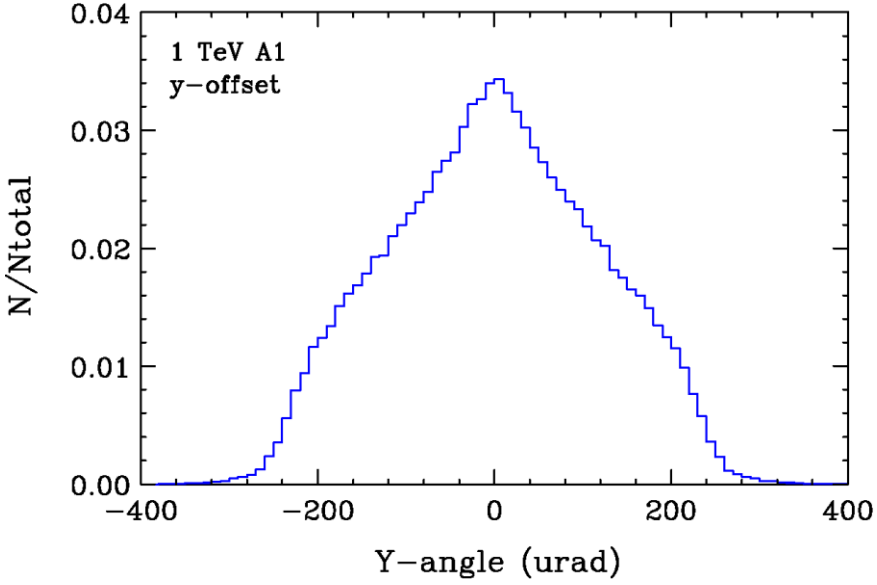


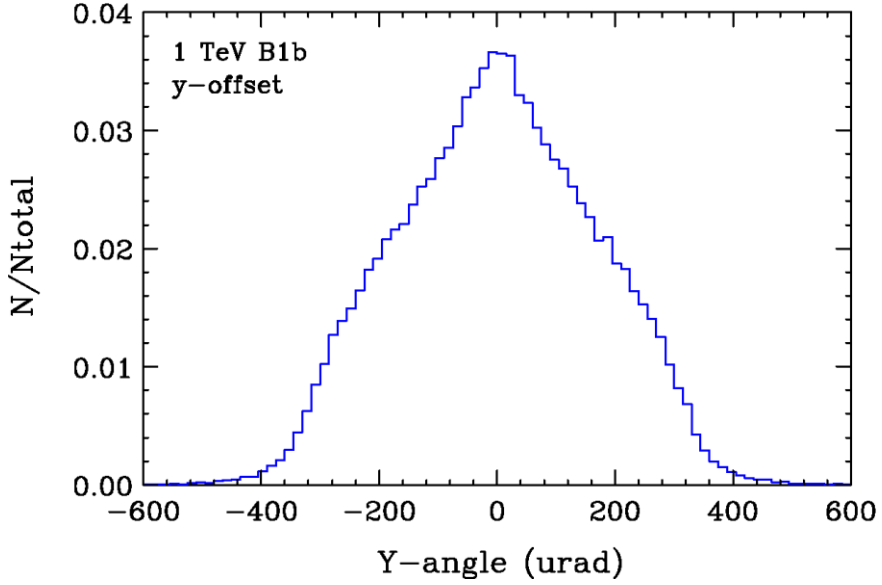


Photon vertical angular spread at IP

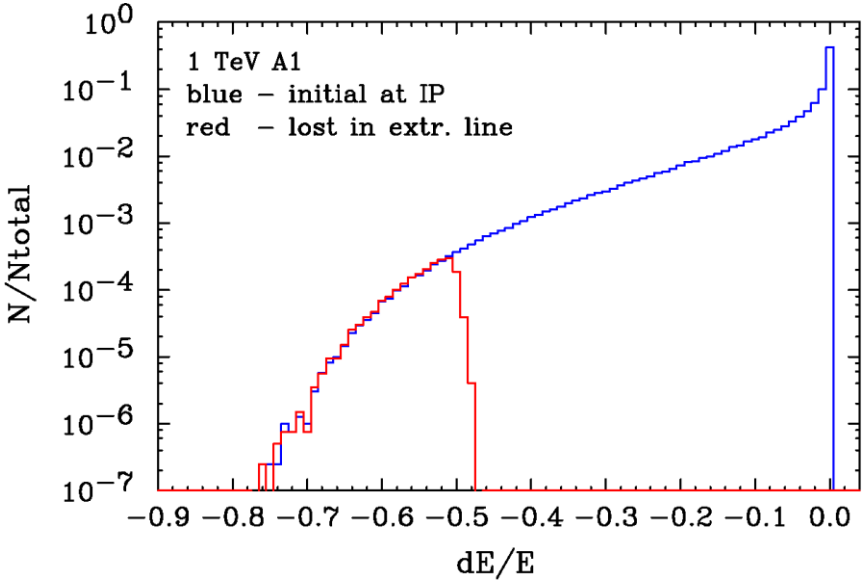


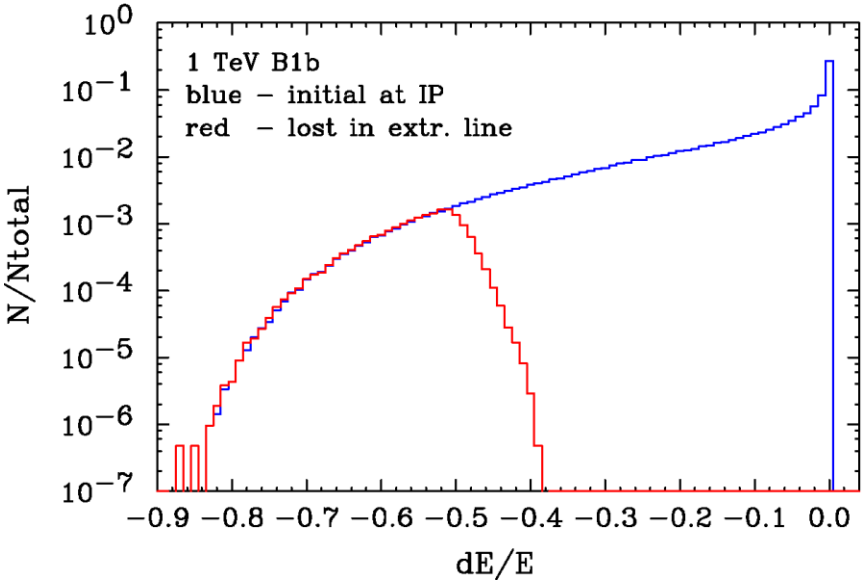


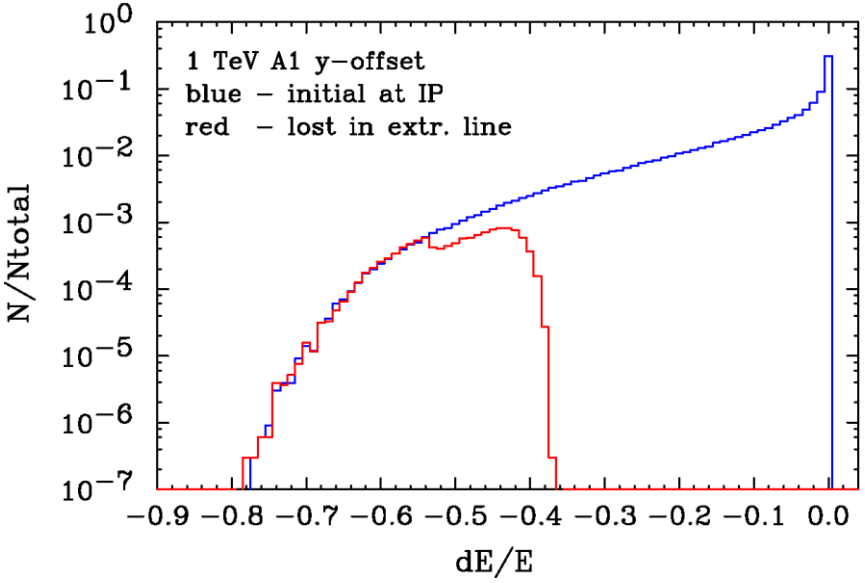


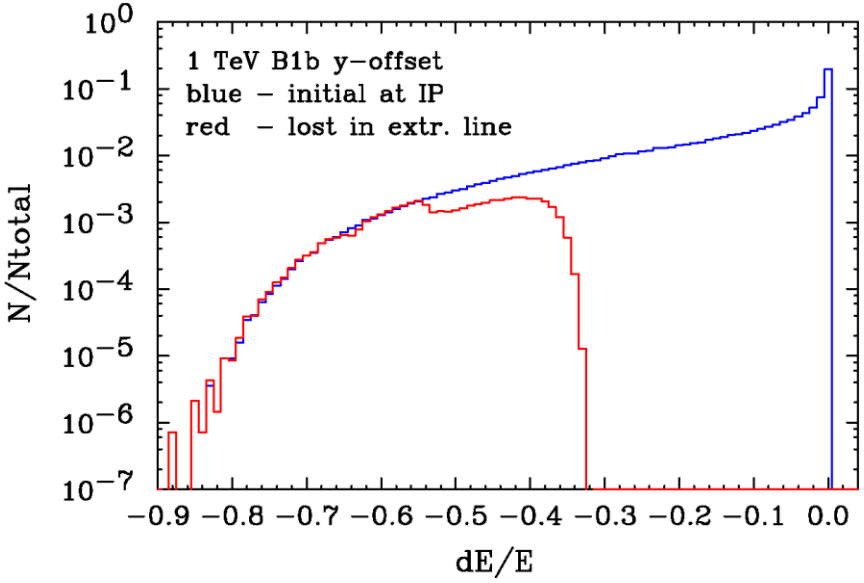


Energy spread of electrons lost in the extraction line

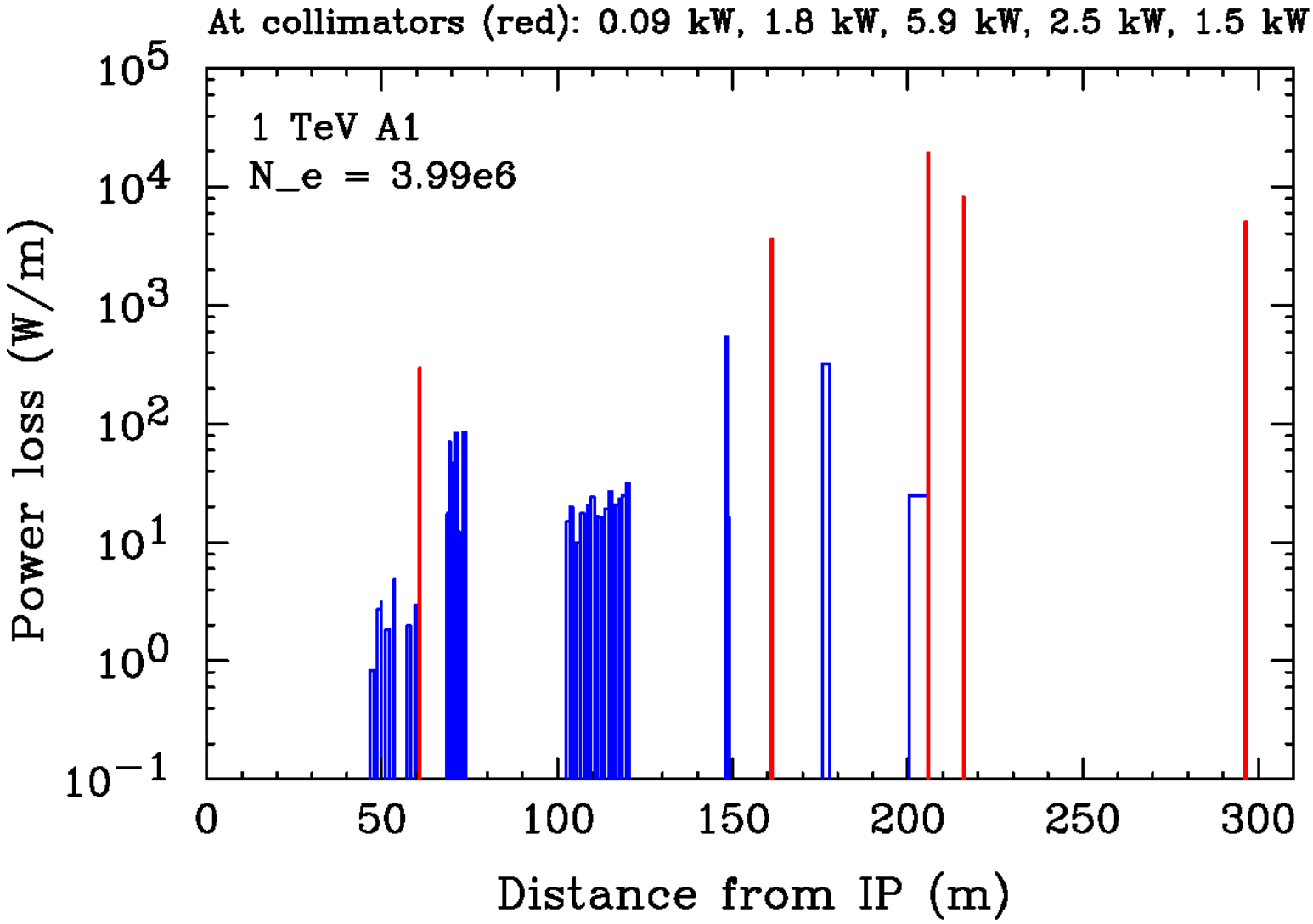




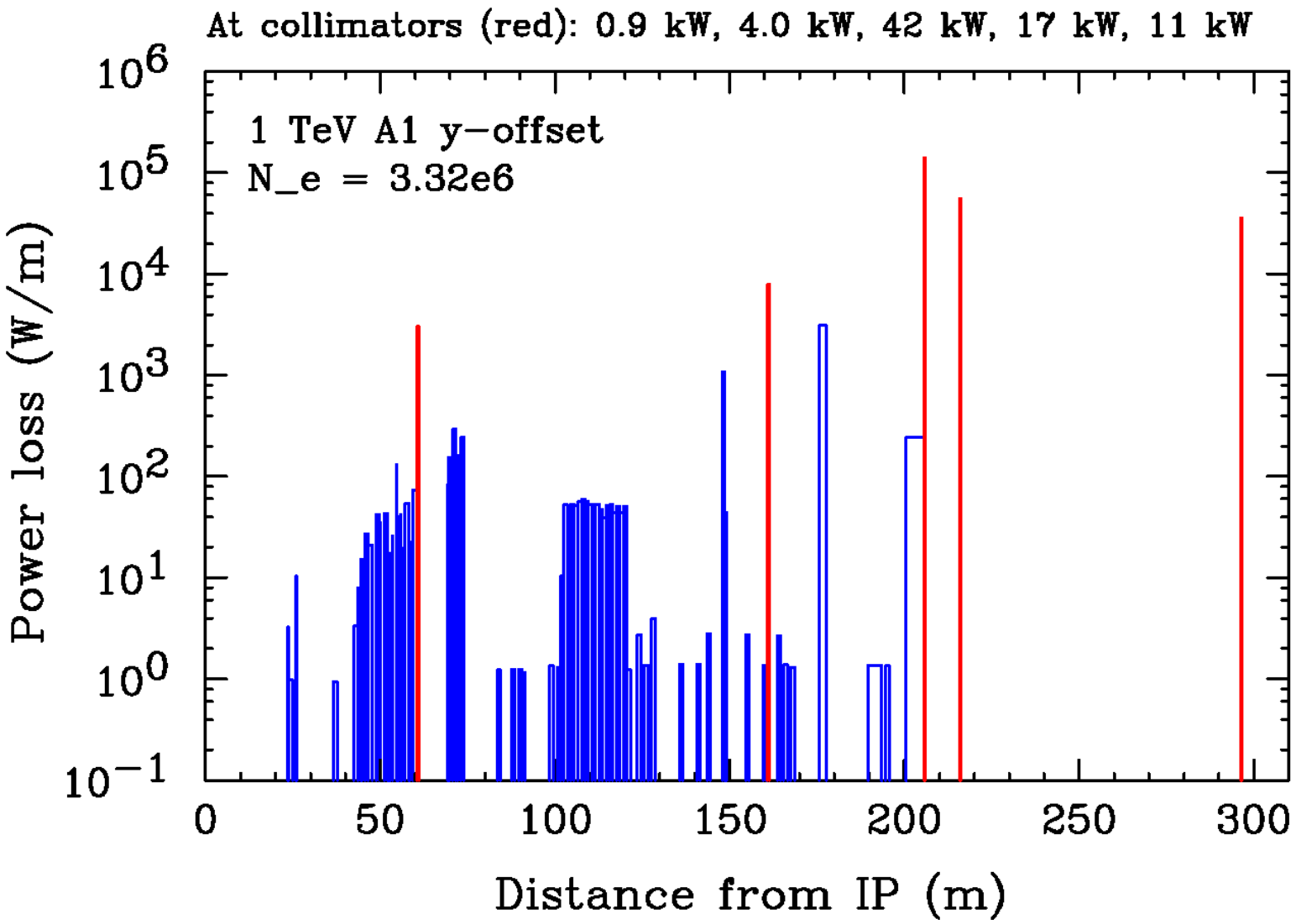




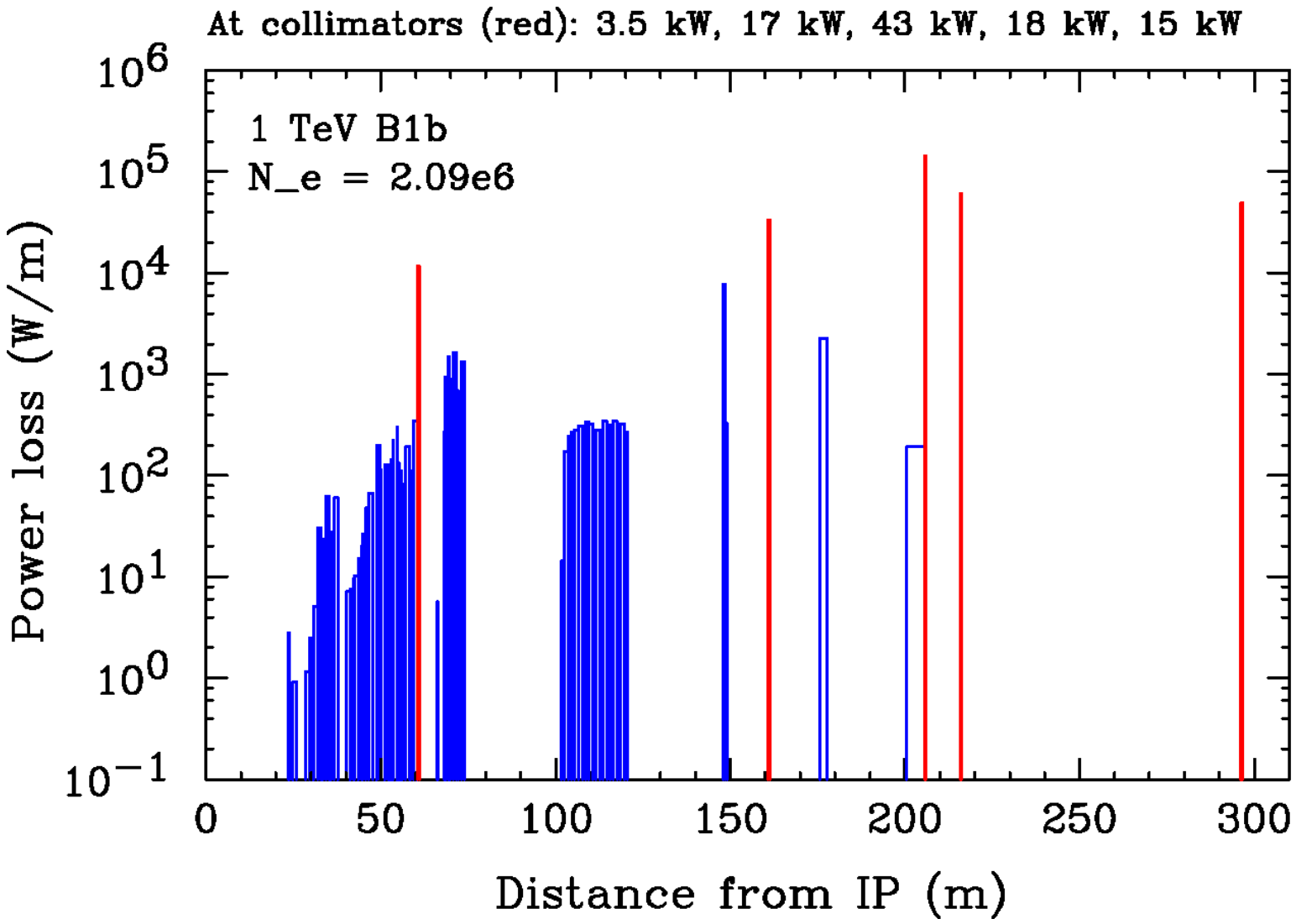
Electron power loss in option A1 with head-on



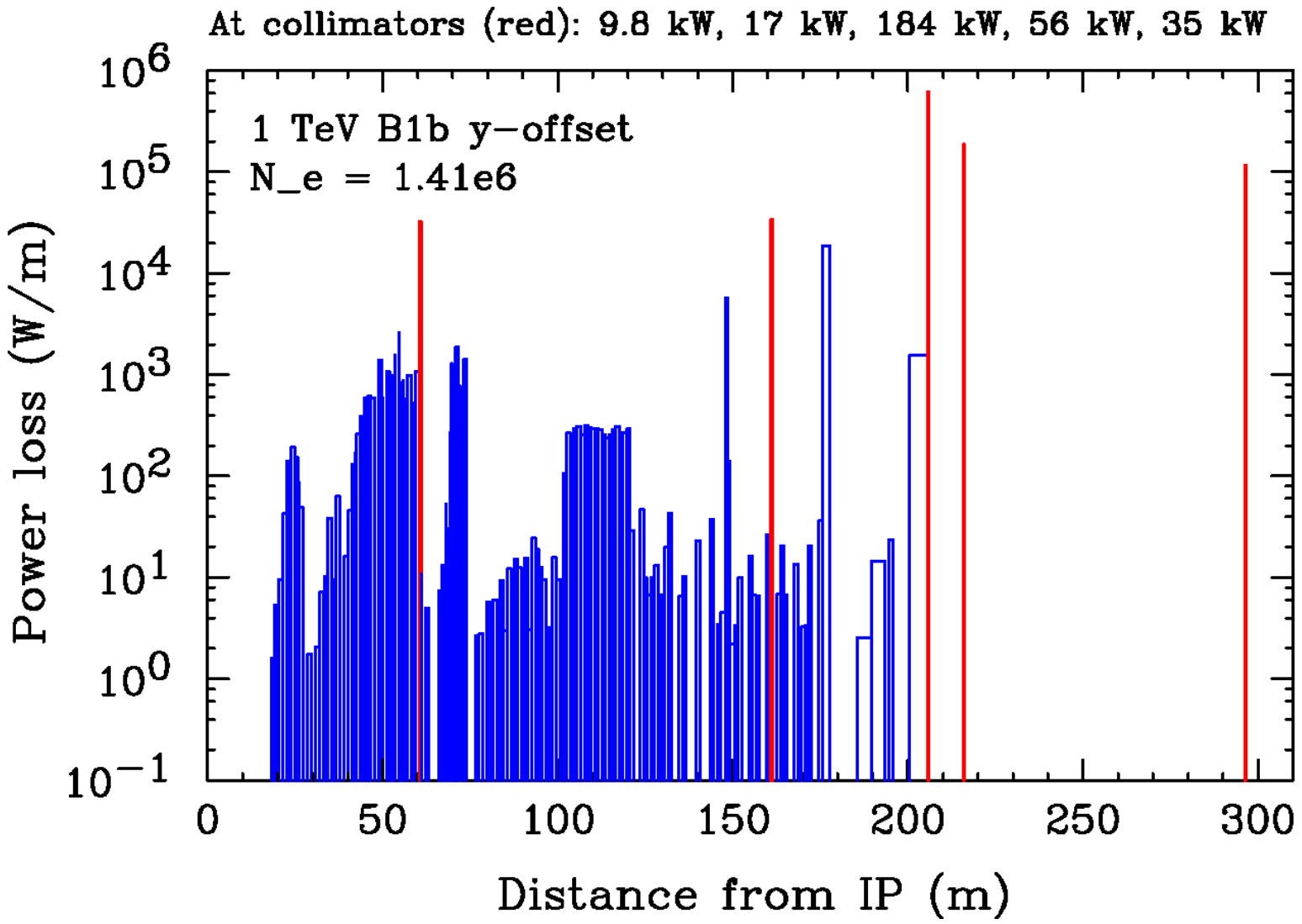
Electron power loss in option A1 with y-offset



Electron power loss in option B1b with head-on

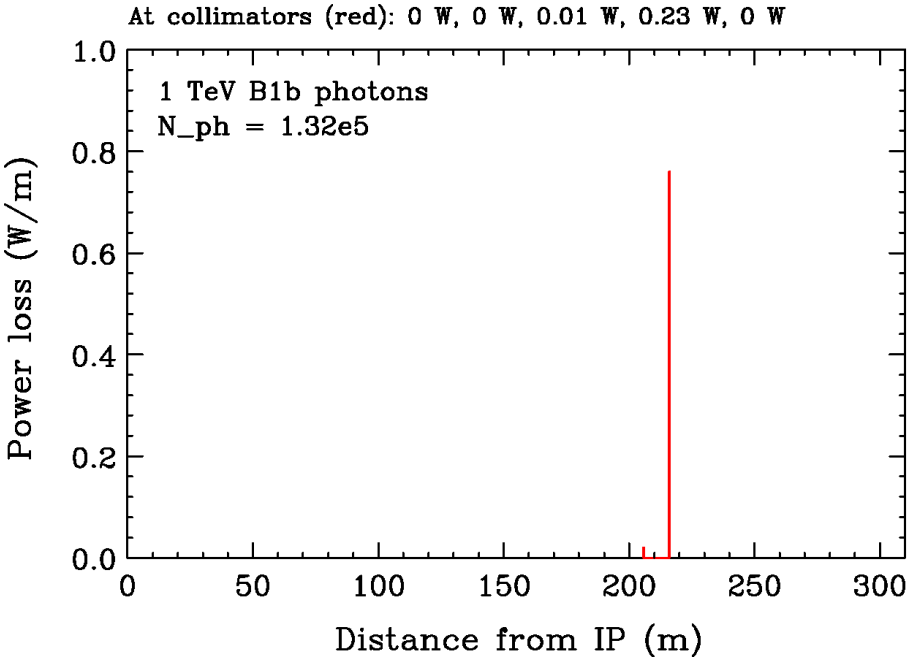


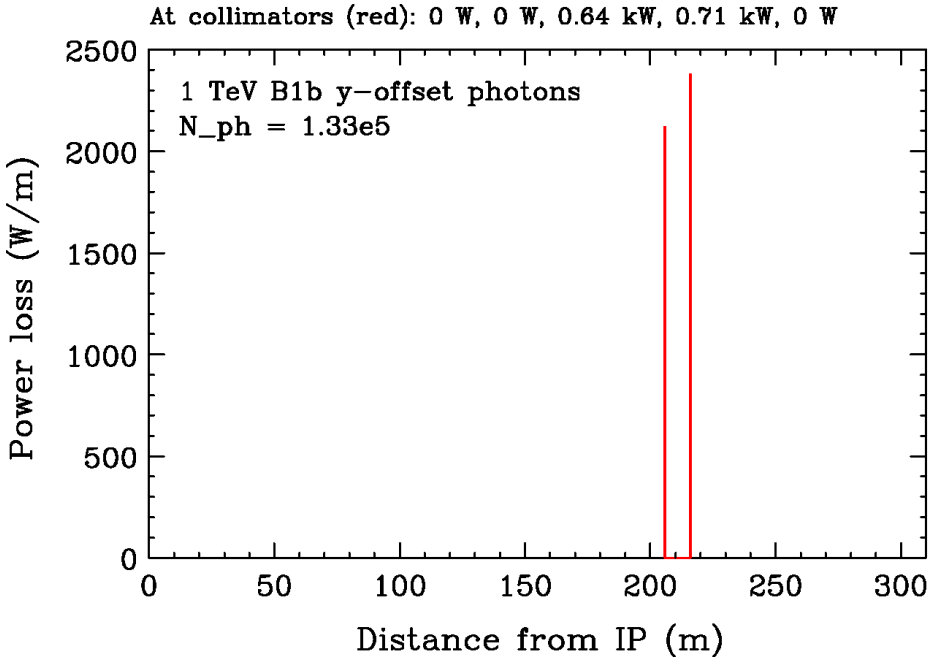
Electron power loss in option B1b with y-offset



Photon power loss in the extraction line

- No photon losses in option A1 (with and without y-offset for 1.3e5 photons)
- Very small losses (only at two collimators) in option B1b





Summary of beam loss

Parameter option	Magnets		Detectors		Collimators				
	SC	Warm (max per magnet)	Synch-rotron	Cheren-kov	Energy	Cheren-kov	Dump-1	Dump-2	Dump-3
A1	0	85 W	0.28 kW	0.64 kW	88 W	1.8 kW	5.9 kW	2.5 kW	1.5 kW
A1 y-offset	0	294 W	0.56 kW	6.3 kW	0.9 kW	4.0 kW	42 kW	17 kW	11 kW
B1b	0	1.6 kW	4.0 kW	4.6 kW	3.5 kW	17 kW	43 kW	18 kW	15 kW
B1b y-offset	0	1.9 kW	3.0 kW	37 kW	9.8 kW	17 kW	184 kW	56 kW	35 kW

- Beam loss in option A1 may be manageable (expert opinion is needed). The much higher losses with the y-offset are expected to be only for short periods of time. The IP offsets are expected to be continuously corrected in operation.
- Beam losses in option B1b are rather high due to the longer beam energy tail and larger angular spread at IP. Of particular concern are the losses on magnets and diagnostic.
- A better collimation may reduce the losses on magnets and diagnostic.
- Losses of photons generated in the collision are negligible (compared to electron losses) and limited to two dump collimators.