Cornell University
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CESR Synchrotron Radiation Tables

- Range of Photon Rates and Beta-averaged Photon Rates -

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Analysis of Lattice Synchrotron Rad Tables

The tables posted on the wiki provide optics and sr radiation information in 1-cm steps: 76.8k entries.
Surface power density, linear power density and photon rates are included.
The photon rate data exhibits unphysically large fluctuations, while the power values are stable and well-correlated.
The ratio of the photon rate to the power density provides information on the average sr photon energy and therefore on the source of the radiation.
Tables are available for six lattices:

1) *1.885 GeV CESR-c: bmad_20050626a (June, 2007 tune shift measurements)*
2) *5.3 GeV CHESS, pretzel off, wigglers closed: chess_20050617 (June/July 2008 measurements)*
3) *2.085 GeV CESR-c, low-emittance: bmad_6wig_8nm_2085 (June 11-26, 2008 measurements)*
4) *2.085 GeV CESR-c, high-emittance: bmad_6wig_100nm_2085 (June 14&23, 2008 measurements)*
5) *2.085 Cesr-TA startup: bmad_12wig_2085_20081103 (November 2008, January 2009)*
6) *2.085 Cesr-TA, L0 wigglers off: bmad_6wig_2085_20081103*

For each lattice, four files are included: electron/positron beams, inside/outside wall.

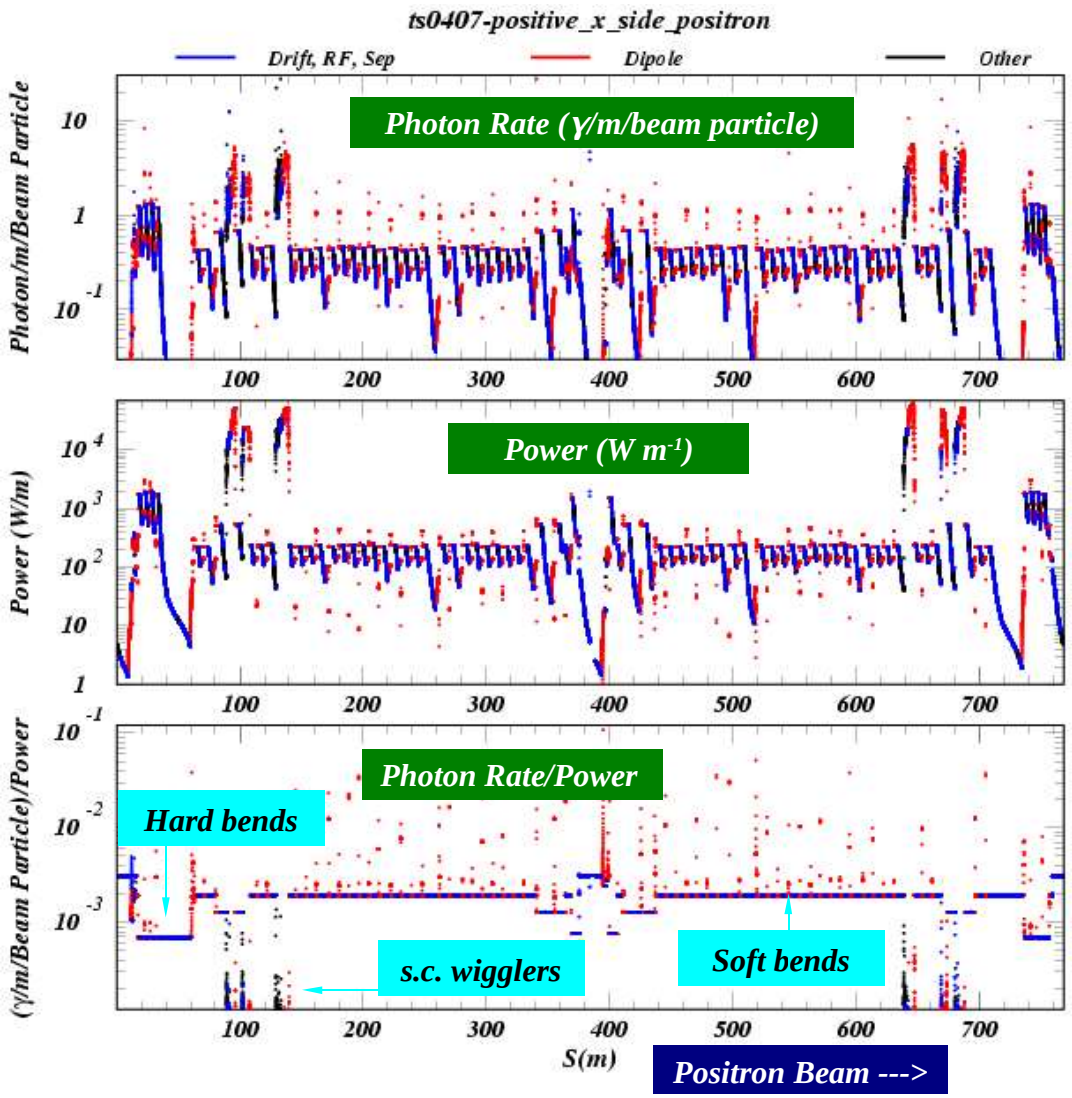
Inspecting the four sets of 77k entries for the 1.885 CESR-c lattice, I use the ratio of photon rate to power to filter out unphysical entries. The requirement that this value vary from cm to cm by less than a factor of 20 eliminates 5-15 entries per file. The effect on the calculated average quantities is dramatic, because the unphysical entries can deviate by ten orders of magnitude.

I have posted plots and tables for the 1.885 GeV CESR-c lattice. The others are available and will be posted, perhaps modified according to suggestions from today's discussion.

Sync Rad Photon Rates and Energy for the e+ Beam
April, 2007 Measurements

Lattice: bmad_12wig_20050626a

ts0407-positive_x_side_positron_0_768.pdf

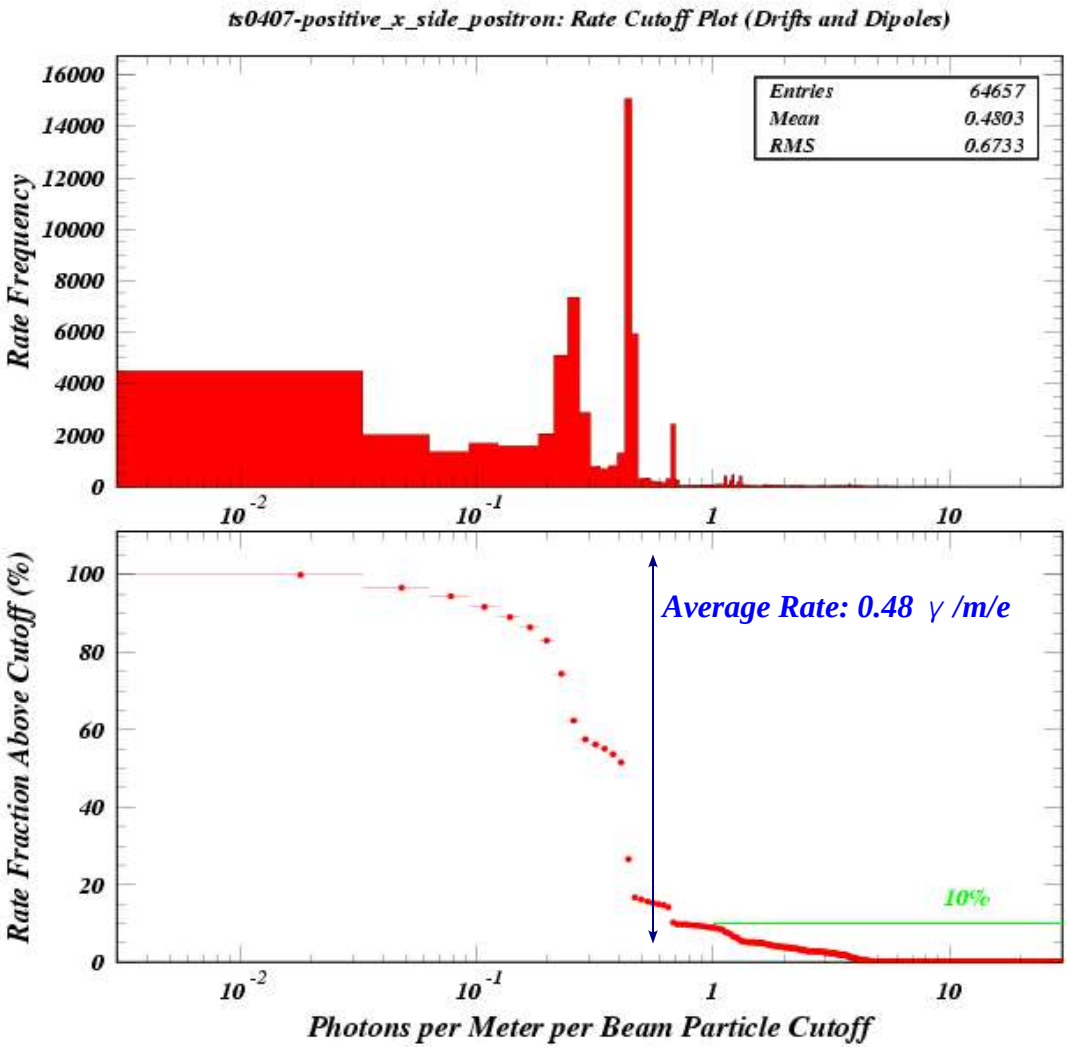


The range of photon rates is large, the maximum rates in the wiggler regions exceeding the rates in the bend regions by more than a factor of 50.

Our tune shift analyses assume a linear relationship between the photon rate and the space charge field strength at the beam. Is this approximation good enough?

Relative Contribution of High-Rate Regions

Lattice: bmad_12wig_20050626a



High rate regions contribute relatively little to the total cloud, even though the rate averaged over one cm can exceed the average rate by a factor of 50.

For example, the s.c. wigglers at 2 GeV contribute much less than 10% to the total cloud.

At our present level of accuracy, the assumption of linearity is working well for the April, 2007 measurements. We may need to reassess this approximation for other ring configurations and beam currents.

Synchrotron Radiation Summary Tables

Lattice: bmad_12wig_20050626a

ts0407-positive_x_side_positron_0_768.table

Used to weight tune shift calculations

Used as input to cloud modelling

Element	Nr Seg	<Length>	Tot Length	Fraction	<Beta X>	<Beta Y>	<Phot/m/e>
Dipole	47390	0.010	473.9	61.7%	15.4	18.8	0.563
Drift	17488	0.010	174.9	22.8%	19.6	18.8	0.248
Wiggler	2452	0.010	24.5	3.2%	20.4	16.3	0.572
Quadrupole	6545	0.010	65.4	8.5%	18.3	19.8	0.369
Sextupole	2229	0.010	22.3	2.9%	18.8	19.8	0.377
Solenoid	518	0.010	5.2	0.7%	13.7	24.1	0.019
Octupole	152	0.010	1.5	0.2%	14.7	8.8	0.058
Non-dipole	29384	0.010	293.8	38.3%	19.2	18.9	0.307
Non-drift	59286	0.010	592.9	77.2%	16.0	18.8	0.529
Total	76774	0.010	767.7	100.0%	16.8	18.8	0.465

Positron Beam / Outside Beampipe Wall

We calculate the horizontal tune shift via: $\Delta Q_x = e/(4\pi E) \oint \beta_x \langle dE_x/dx \rangle ds$

We implicitly assume a linear dependence of the electric field magnitude on the sr photon rate.

We also use the ring averages of the beta functions.

How accurate is the approximation that the photon rates and beta functions are uncorrelated?

Additional Summary Table of MAX, RMS including Beta-Weighted Rates

Lattice: bmad_12wig_20050626a

ts0407-positive_x_side_positron_0_768.table

Element	<F>=<Phot/m/e>	Max(F)	RMS(F)	<Bx*F>/<Bx>	Max(Bx*F/<Bx>)	RMS(Bx*F/<Bx>)	<By*F>/<By>	Max(By*F/<By>)	RMS(By*F/<By>)
Dipole	0.563	27.189	0.740	0.583	29.541	0.935	0.483	27.269	0.493
Drift	0.248	12.396	0.349	0.227	17.837	0.401	0.244	7.443	0.352
Wiggler	0.572	22.108	0.875	0.620	26.407	1.019	0.494	15.775	0.795
Quadrupole	0.369	27.343	0.559	0.372	27.382	0.685	0.361	26.712	0.553
Sextupole	0.377	3.512	0.446	0.384	6.504	0.586	0.334	2.853	0.389
Solenoid	0.019	0.051	0.012	0.024	0.120	0.038	0.018	0.038	0.012
Octupole	0.058	0.125	0.041	0.057	0.122	0.039	0.078	0.193	0.072
Non-dipole	0.307	27.343	0.482	0.301	28.040	0.578	0.291	27.924	0.453
Non-drift	0.529	27.343	0.721	0.544	33.646	0.898	0.458	28.097	0.509
Total	0.465	27.343	0.665	0.460	31.997	0.790	0.409	28.100	0.487

$$\Delta Q_x = e/(4\pi E) \oint \beta_x \langle dE_x/dx \rangle \, ds$$

The vertical beta-weighted rate average differs from the overall average by 15% for the dipole regions.
The differences for the other three cases are less than 10%.