notes on:
transient beam loading & comparison with WWs parameters

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SPL steering group meeting, 6 June 2008

tr. beam loading: μ-factory timing

3 scenarios:

6 bunches in accumulator:
42 linac bunches + 20 gaps

I_{peak} = 60 mA, I_{av} = 40 mA

3 bunches in accumulator:
42 linac bunches + 32 gaps

I_{peak} = 70 mA, I_{av} = 40 mA

1 bunch in accumulator:
e.g. 25 bunches + 214 gaps

I_{peak} = 112 mA, I_{av} = 13 mA

"Potential SPL architectures", SPL review, 30 April 2008, F. Gerigk, M. Eshraqi

tr. beam loading: SC cavities

voltage drop during the pulse:

$$\frac{\Delta V}{V} = \sqrt{1 - \frac{2\pi(R/Q)(I_b - i_{av})n_b}{V_{acc}}}$$

	freq. [MHz]	(R/Q)	E [MV/m]	ΔV/V [%]
6 bunches	704.4	570	25	0.006
6 bunches	1408.8	1036	25	0.012
3 bunches	704.4	570	25	0.009
3 bunches	1408.8	1036	25	0.018
1 bunch	704.4	570	25	0.018
1 bunch	1408.8	1036	25	0.036

"Potential SPL architectures", SPL review, 30 April 2008, F. Gerigk, M. Eshraqi

tr. beam loading: NC cavities

voltage drop during the pulse:

$$\frac{\Delta V}{V} = \sqrt{1 - \frac{2\pi V_{acc}(I_b - I_{av})n_b}{P_d Q_0}}$$

	freq. [MHz]	Q_0	E [MV/m]	ΔV/V [%]
6 bunches	352.2	18200	4	0.096
3 bunches	352.2	18200	4	0.144
1 bunches	352.2	18200	4	0.28
PSB inj.	352.2	18200	4	0.48

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power consumption

comparison with WWs results:

the idea is not to calculate absolute numbers for the facility but to crosscheck simulation results:

- remove all efficiencies,
- use a defined linac section,
- RF power quoted as power into the cavity,
- cryo power quoted as cooling power in the cryo-modules normalised to 4.5K, w/o coupler losses and shielding losses,
- these numbers are sufficient to optimise on electricity and cryo-power separately,

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power consumption 704/1408 MHz

assumed is a reference SC linac with:

- acceleration from 880 - 5000 MeV,
- 25/27.5 MV/m (@β=1, then scaled for red. β),
- 5/9 cells, 176/184 cavities, β=0.92/0.94, $Q_0=10^{10}$, 2K

HPSPL, 50 Hz	RF power [MW]			cryo power [kW]		
freq. [MHz]	704	1408	704/1408	704	1408	704/1408
40 mA, 0.4 ms, 4 MW	6.2	4.3	1.4	4.3	2.5	1.72
40 mA, 0.6 ms, 6 MW	7.9	6.0	1.3	5.1	2.9	1.76
20 mA, 0.8 ms, 4 MW	6.2	4.3	1.4	7.4	3.7	2.0
20 mA, 1.2 ms, 6 MW	7.9	6.0	1.3	8.9	4.6	1.93

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power consumption 704/1408 MHz

static klystron power becomes important: 7.05 kW p. klystr.

- efficiencies of 0.5*0.95*0.85 need to be applied to RF power,
- efficiency of 0.85 needs to be applied to static klystron power,
- otherwise same parameters, 5 GeV (!)

LPSPL, 2 Hz	RF power [kW]			klystrs [MW]		cryo power [kW]		
freq. [MHz]	704	1408	704/1408	704	1408	704	1408	704/1408
40 mA, 0.4 ms, 160 kW	249	171	1.5	145	147	1.4	1.3	1.08
40 mA, 0.6 ms, 240 kW	315	239	1.3	145	148	1.4	1.3	1.08
20 mA, 0.8 ms, 160 kW	249	171	1.5	145	148	1.5	1.4	1.07
20 mA, 1.2 ms, 240 kW	315	239	1.3	145	148	1.6	1.4	1.14

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comparison results

- underlying calculations are very close (only one difference for cryo-power for LPSPL),
- to do an optimisation on the sum we need to apply the same efficiencies and have the same static contributions,
- for total numbers the whole linac needs to be calculated,
- 704 MHz needs ~50% more RF power than 1408 MHz,