Summary Session: Lattice Solutions towards High Brightness

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3 Talks

Lattice Solutions towards High Brightness

08:30 **Review of Lattice Options for High-Brightness Light Sources** *25′*
Speaker: Laurent Nadolski

08:55 **Comparison of Optimization Methods for APS Upgrade Nonlinear Dynamics** *25′*
Speaker: Yipeng Sun

09:20 **Coupling Control and Optimization at Diffraction-Limited Light Sources** *25′*
Speaker: Christoph Steier

Review of Lattice Options for High-Brightness Light Sources (L. S. Nadolski, SOLEIL)

	Energy	circumference	emittance	emit/gamma^2	Lattice	Qx	Qy	Q'x	Q'y	Optics strain**	Cell length	Cell #
PETRA-IV	6	2304	10	7,3E-08	H7BA							NA
Pep-X	4,5	2200	30	3,9E-07	7BA	113,23	65,4	-162	-130	2,8	30	NA
Spring8-II	6	1436	67	4,9E-07	H5BA	108,1	45,6	-143	-147	4,3	30	40
APS-U	6	1104	41	3,0E-07	H7BA	95,1	36,1	-131	-122	4,7	27,6	40
ESRF-EBS	6	844,4	133	9,6E-07	H7BA	76,21	27,34	-109	-82	4,3	26,4	32
DIAMOND-II	3	561	120	3,5E-06	DTBA	58,18	21,31	-77	-118	7,3	22,6*	24
MAX-IV	3	528	328	9,5E-06	7BA	42,2	16,28	-50	-50	3,6	26	20
SIRIUS	3	518	240	7,0E-06	5BA	49,11	14,17	-119	-81	13,9	25,9	20
CLS-II	3	510	186	5,4E-06	7BA	37,22	10,32	-66,7	-40,4	7,0	24,3	21
SOLEIL-II	2,75	354,1	200	6,9E-06	H6BA-H7BA	39,12	14,24	-75	-85	11,4	22*	16
SLiT-J	3	350	600	1,7E-05	DDBA	29,21	9,28	-69,3	-41	10,5	21,9	16
SLS-II	2,4	290	100	4,5E-06	7BA	37,22	10,32	-66,6	-40,4	7,0	24,1	12
Elettra-II	2	259,2	250	1,6E-05	S6BA	33,2	9,3	-63	-50	10,2	12,6	12
ALS-U	2	196,8	109	7,1E-06	9BA	41,38	20,39	-64	-67	5,1	16,35	12

**$\textbf{Optics strain} = Qx'/Qx*Qy'/Qy$

Compact & **Rigid** lattice **Exotic** magnets

TGB / LGB **Combined function** - magnets

Hybrid MBA more adapted for large storage ring (sextupole strength relaxed)

Relevant cell length is the one limited to magnetic structure

Anti-bend relaxes fairly nicely the constraints on the emittance and increases tunability

High periodicity is privileged for ultra-low emittance lattices **3-4 % LMA** **Low MCF**

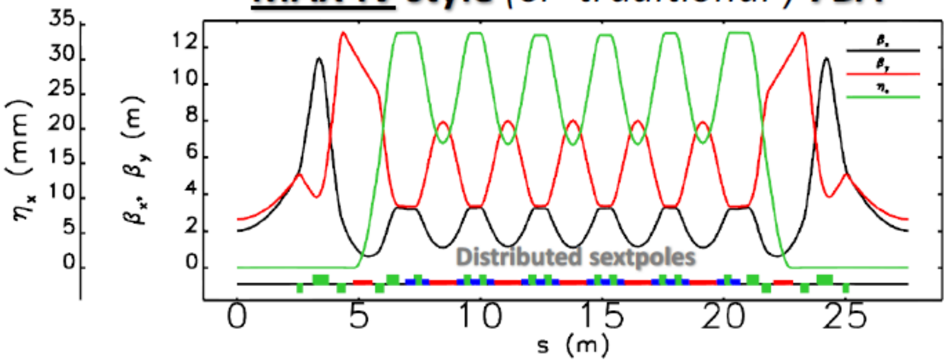
Laurent S. Nadolski HBLS, BNL/NSLS-II, April 25-28, 2017 29

Review of Lattice Options for High-Brightness Light Sources (L. S. Nadolski, SOLEIL)

Deciding on the "M" part of the MBA.

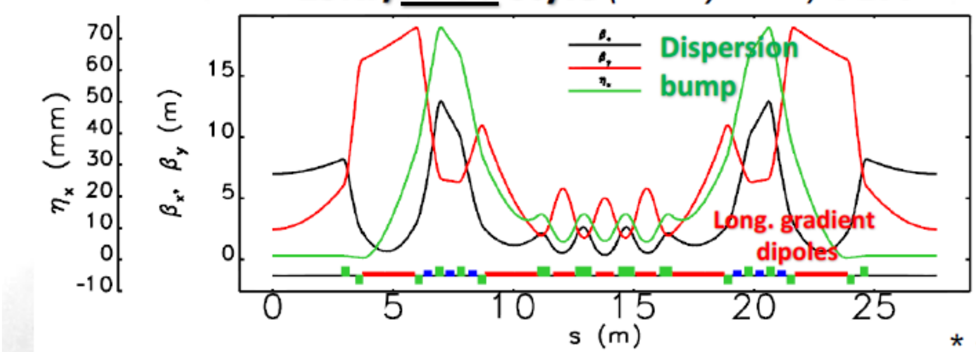
$$\varepsilon_0 \sim \frac{\gamma^2}{N_B^3}$$

MAX-IV style *(or 'traditional')* **7BA***



SIRIUS
MAX-IV
ELETTRA-II*
SLS-II**
ALS-U***
CLS-II
SLiT-J

ESRF/APSu style *(or 'hybrid')* **7BA***



ESRF-EBS
HEPS
PEPX
APS-U*
SPRing8-II
PETRA-IV
DIAMOND-II***
SOLEIL-II***

* variation

Comparison of Optimization Methods for APS Upgrade Nonlinear Dynamics (Y. Sun, ANL)

- Both linear and nonlinear optics optimized for APS-U 41-pm lattice
- Different algorithms and optimization targets implemented for nonlinear optics optimizations
  - Some are much faster than original optimization approach using **LMA**
  - Explored different solutions spaces
  - Comparable performance
- There are some indications that improved orbit and lattice correction will allow increasing the lifetime of APS-U
- APS applications improved machine performance
  - Simulation based optimization
  - Online machine based optimization

Comparison of Optimization Methods for APS Upgrade Nonlinear Dynamics (Y. Sun, ANL)

In general, these methods take less computing time than **LMA** and **DA**

- **ANA**: objective of nonlinear chromaticity and driving/detuning terms[1]
  - Objectives targets selected from optimization results of other methods (LMA, DET...)
- **CSI**: objective of CS invariant distortion and chromatic detuning[2,3,4]
  - Track for one turn, or one super-cell
  - Different initial conditions of x-y space
- **DET:** objective of detuning of x-y grids, w/ or w/o energy offset

1. J. Bengtsson. SLS-TME-TA-1997-0009, SLS (1997).
2. B. Autin. M. Month et al., eds., Physics of Particle Accel-erators, 288. American Institute of Physics (1987).
3. J. Hagel. CERN LEP-TH 86-22, CERN (1986).
4. Y. Li and L. Yu. TUPOB54, NA-PAC 2016.

Coupling Control and Optimization in DLSRs (C. Steier, LBNL)

- Coupling correction is important to optimize the performance
  - Direct benefit: increased brightness
  - Also improves dynamic (momentum) aperture and therefore injection efficiency and lifetime
- There are several correction methods:
  - Combined approach targeting local coupling, global coupling and vertical dispersion simultaneously is usually used.
  - Using orbit response matrix analysis (LOCO), emittance ratios below 0.1% have been achieved (<1 pm at ALS).
- DLSRs can require larger emittance ratios than currently in use
  - Multiple ways to achieve (including operating on coupling resonance)
  - Beam dynamics impact manageable
  - Beamsize stability requires good tune control, reasonable resonance strength
- Insertion devices provide new challenge if they contribute significantly to total energy loss

Coupling Control and Optimization in DLSRs (C. Steier, LBNL)

Emittance Stability and Undulators

	ε_x [nm rad]	
	Without IBS	With IBS
Bare lattice	0.326	0.453
Bare lattice with LC	0.326	0.372
Lattice with four PMDWs and LC	0.263	0.297
Lattice with four PMDWs, ten IVUs, and LC	0.201	0.231

Max-4 example: S. Leemann, et al., PRSTAB 12, 120701 (2009)

- DLSRs / MBAs / Rings with low average bend magnet field have Beamsize stability issue beyond coupling
- Significant variation of energy loss per turn results in variation of damping times, natural emittance, energy spread
- Extend of effect varies, but can be >20% (including machines already in operation)
- This does not just mean emittance goes down as more undulators are installed, also depends on undulator scans (larger field variation for longer period undulators – ALS: undulator energy loss varies 50% typical week)
- (Additional) Damping wigglers can help in correction, but expensive (cost, space, RF) – full range might not be feasible
  - Other means are less efficient (e.g. limited tunability of MBA lattices)
  - Need to better understand user requirements / impact of uncorrected or partially mitigated