Session 1:
Experience with existing machines

summary

6 talks of 30 minutes each (20+10)

- *Injection R&D at Diamond and Diamond II*
  Riccardo Bartolini
- *Injection and Top-Up experience at SOLEIL*
  Alexandre Loulergue
- *Kickers correction system for transparent Top-Up at SPRing-8*
  Dr. Chikaori Mitsuda
- *Issues with modelling the BESSY-II transfer line optics*
  Peter Kuske
- *Experience at ESRF*
  Simon White
- *Last studies of injection system at PETRA III transport line and PETRA IV upgrade*
  Xavier Nuel Gavaldà

Covered Content:

- injection schemes & injection efficiency maximization
- TopUp transient / residual motion of stored beam
  → kickers: bump closure, parameters, coatings
- TopUp schemes and boundary conditions → table
  (radiation protection, machine protection, accelerator physics)
- transfer line optimization / modeling
- progress on NLK implementation

Table summarizing Injection Conditions

	general machine parameters						Limit			avg. InjEff		vg lifetime / l		TopUp scheme			nce / rad pm (bare l		relative residual		on of InjEff			KickerBum	offAxisInj /	contacts	Remarks	Links
Machine	**Operation Mode**	**TopUp**	**Energy /**	**Current**	**shot InjE**	**vg Inj Ef**	**Lifetime**	**in Curre**	**ax Curre**	**Ids open**	**Ids closed**	**Ids op**	**Ids clo**	**time be**	**# shot**	**# bun**	**horizontal**	**vertical**	**horiz**	**vertic**	**Ra**	**Ma**	**AccPhys**					
BESSY II	Multibunch	x	1.70	300	60%	90%	5.00	200.00	300.00	96%	92%			120	1	5	7000				x							
	single bunch	x	1.70	15	60%	90%	1.00	8.00	30.00	96%	92%				1	1	7000				x							
	low-alpha stable	decay	1.70	16	decay	decay	decay	decay	decay	30%	decay			decay	decay	decay	40000				x							
	low-alpha bursting	decay	1.70	100	decay	decay	decay	decay	decay	30%	decay			decay	decay	decay	40000				x							
DIAMOND	Standard	x	3.00	300	0%	50%	7.00	50.00	500.00	85%	75%	13.0	13.0	600	~50	1	2700	8			x					Ian Martin	Standard=900 bunche	
	Hybrid	x	3.00	300	0%	50%	7.00	50.00	500.00	85%	75%	11.0	11.0	600	~50	1	2700	8			x					Ian Martin	Hybrid=686bunches,g	
	Timing Mode	x	3.00	136	0%	50%	7.00	50.00	500.00	85%	75%	9.0	9.0	600	~20	1	2700	12			x					Ian Martin	every 6th bunch popu	
	low-alpha stable	x	3.00	20	0%	10%	10.00	7.00	35.00	20%	20%	25.0	25.0	3600	~250	1	4500	40			x					Ian Martin	400 bunch	http://acce
	low-alpha bursting	x	3.00	10	0%	5%	5.00	7.00	15.00	15%	15%	25.0	25.0	3600	~250	1	4500	40			x					Ian Martin	200 bunches	
ALBA	Multibunch	x	3.00	150	0%	0%	10.00	20.00	250.00	90%	90%	25.0	20.0	1200	20	64	4000	?			x					Montse Pont		
Spring-8	Multibunch	x	8.00	100	0%	?	?	?	100.00	92%	87%	200.0	?	20	1	1	2300	?			x					Chikaori Mitsuda		
	Hybrid	x	8.00	100	0%	?	?	?	100.00	92%	87%	?	?	20	1	1	2300	?			x					Chikaori Mitsuda		
	single bunch	x	8.00	1	0%	?	?	?	100.00	92%	87%	15.0	?	?	1	1	2300	?			x					Chikaori Mitsuda		
SLS	Multibunch	x	2.40	400	doseL	doseL	doseL	doseL	doseL	98%	95%	10.0	10.0	180	9	1	5000	10			x					Michael Bo	lifetime feedback (ma	
	CamShaft	x	2.40	400	doseL	doseL	doseL	doseL	doseL	98%	95%	10.0	10.0	180	9	1	5000	10			x					Michael Bo	lifetime feedback (ma	
	Femto	x	2.40	400	doseL	doseL	doseL	doseL	doseL	98%	95%	10.0	10.0	180	9	1	5000	10			x					Michael Bo	lifetime feedback (ma	
SOLEIL	Uniform	x	2.75	500	40%	40%	?	450.00	500.00	95%	80%	15.0	12.0	180	1	100	4000	40			x			18	7	MAT		
	Hybrid	x	2.75	450	40%	40%	?	?	?																			
	8 bunch	x	2.75	?	40%	40%	?	?	?																			
	single bunch	x	2.75	?	40%	40%	?	?	?																			
	low-alpha	x	2.75	?	40%	40%	?	?	?																			
ESRF	Multibunch	decay	6.00																									
	16x6	x	6.00											1200														
	4x10	x	6.00											3600														
PETRA III	40 AD bunches	x	6.00	100	doseL	doseL	doseL	doseL	100.00	60%	60%	1.2	1.2	40	20	1	1200	12			x			39		Heiko Ehrlichmann, Xavier Nu		
	960 AD bunches	x	6.00	100	doseL	doseL	doseL	doseL	100.00	60%	60%	8.0	8.0	300	50	1	1200	12			x					Heiko Ehrlichmann, Xavier Nu		
APS	24 bunch	x	7.00	100	0%	0%	?	?	?	80%	?	?	9.0	120	1	1	3000	50			x			?	8			
	Hybrid	x	7.00	100	0%	0%	?	?	?	80%	?		6.0	60	1	1	3000	50			x			?	8			
	324 bunch	decay	7.00	100	0%	0%	?	?	?	80%	?		50.0	43200	1	1	3000	50			x			?	8			
ALS	Multibunch	x	1.90	500	?	?	0.00	?	500.00	100%	?	?	12.0	?	?	?	2000	30			x			?	?	C. Pappas		
	2 Bunch	x	1.90	35	?	?	0.00	?	200.00	100%	?	?	?	?	?	?	2000	30			x			?	?	C. Pappas		
ELETTRA																												
SPEAR3	Hybrid	x	3.00	500	? 40% ?	doseL	doseL	50.00	500.00	95%	80%	7.5	7.5	300	50	1	10000	10			x			22	11	Xiaobiao H.		rms/sqrt(b
MAX IV																												
SIRIUS																												
new machines & upgrades starting here --																												
DIAMOND II																												
ESRF-EBS																												
ESRF																												
SLS II																												
PETRA IV																												
APS-U																												
ALS-U																												

Table summarizing Injection Conditions

TopUp boundary conditions

Machine	Mode	Current	1shotEff	avgEff	Lifetime	Min Cur	Reason		
BESSY II	Multibunch	300 mA	60 %	90 %	5 h	200 mA	RadProt		
DIAMOND	Standard	300 mA	0 %	0 %	7 h	50 mA	RadProt		
ALBA	Multibunch	150 mA	0 %	0 %	10 h	20 mA	RadProt		
Spring-8	Multibunch	100 mA	?	?	?	?	RadProt		
SLS	Multibunch	400 mA	doseL	doseL	doseL	doseL	RadProt		
SOLEIL	Uniform	500 mA							
ESRF									
PETRA III	40 ad bunches	100 mA	doseL	doseL	doseL	doseL	RadProt		
APS	24 bunch	100 mA	0 %	0 %					
ALS	Multibunch	500 mA							
ELETTRA									
SPEAR	Hybrid	500 mA	? 40 % ?	doseL	doseL	50 mA	RadPr		
MAX IV									

To be filled

Table summarizing Injection Conditions

TopUp scheme

Machine	Slot interval	Shots per slot	Bunches per shot	meas InjEff IDs open	meas InjEff IDs closed				
BESSY II	120 s	1	5	96 %	92 %				
DIAMOND	600 s	~ 50	1	85 %	75 %				
ALBA	1200 s	20	64	90 %	90 %				
Spring-8	20 s	1	1	92 %	87 %				
SLS	180 s	9	1	98 %	95 %				
SOLEIL	180 s	1	100	95 %	80 %				
ESRF									
PETRA III	40 s	20	1	60 %	60 %				
APS	120 s	1	1	80%	?				
ALS				100%					
ELETTRA									
SPEAR	300 s	50 s	1	95%	80%				

To be filled

Table summarizing Injection Conditions

Residual Orbit Motion

Machine									
BESSY II									
DIAMOND									
ALBA									
Spring-8									
SLS									
SOLEIL									
ESRF									
PETRA III									
APS									
ALS									
ELETTRA									
SPEAR									

To be filled

thank to the speakers for their contribution

thank to the audience for lively discussion

Injection R&D at Diamond and Diamond II
Riccardo Bartolini

- septum moved closer to reference orbit (2015)
- transparent injection is considered to be a “10-years-vision”
- issues with Ti coating in kicker vessels
- R&D:
  - compensation kickers
  - nonlinear kicker
- DIAMOND II
  - new design candidates with lower emittance and on-axis injection explored

Injection and Top-Up experience at SOLEIL Alexandre Loulergue

- TopUp since 2009
- Kicker pulse investigation by turn by turn BPM data analysis
  → successive optimization
- Residual orbit motion
  - Horizontal: 6 % beam size
  - vertical: 25 % beam size
  - no user complaints so far
- NLK installation 2018
- FeedForward correction scheme

Ring injection layout

Inserted in free 12m long section

Kicker pulse profile investigation

Kicker pulse profile investigation

H & V residual bump
Summarized

Bumps measured at BPM with β_x = 14 m and β_x = 12 m
Target = 10 % beam size (with 1% coupling) !

Plane	H	V
Target	**~30 µm**	**~2 µm**
Thin septum	~0	~0
Thick septum	20 µm	5 µm
Kickers	100 µm	50 µm
To reduce it further :	Need a NLK	NLK ? Need feedforward /feedback ?

Kickers correction system for transparent Top-Up at SPRing-8 -- Chikaori Mitsuda

- Stored beam oscillation dominated by kicker bump
- Optimization
  - DC septum
  - sextupoles within bump
- FeedForward scheme using fast correction kickers in user operation
  - 80% peak suppression
  - Consecutively upgraded

Top-view of beam injection system in SPring-8

Overview of 4 bump magnets arrangement

Failure reasons and improvements for long life operation

Dependency	Failure source	Improvement	Operation life time
Operation pulse width	Miss-driving by self switching noise and device uniformity	Driver circuit improving Noise filter Severe SS-device selection	2d~1week
Beam filling mode	Beam radiation noise	System floating Noise shield enhancing	1 month
Saturation of operation life time	Synchrotron radiation damage	Radiation shield enhancing	more than 3 years

Combining

- We learned from above correlations that the care is necessary to operate the DPS continuously.
- After all of cares by step by step, the operation life time of DPS became more than 3 years and failure got not to occur by beam filling with high current single bunch of 8 mA.

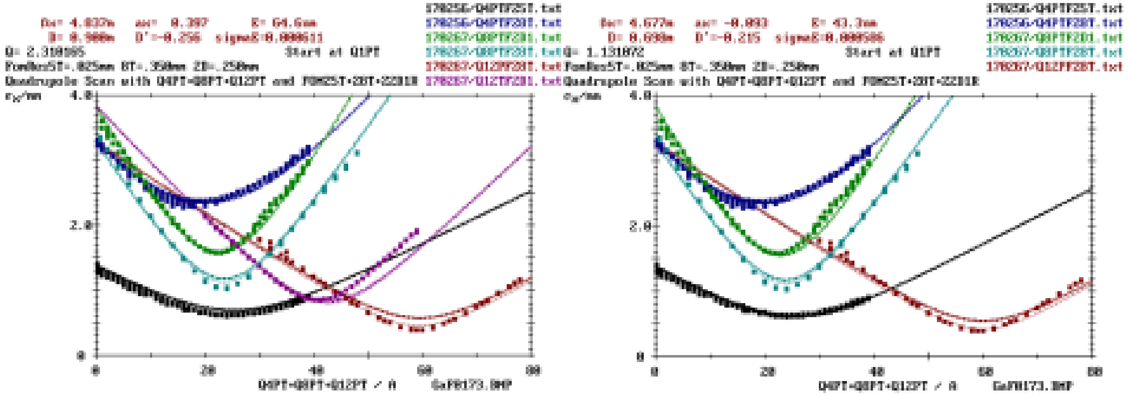
Issues with modelling the BESSY-II transfer line optics
Peter Kuske

- Discrepancies between model and measurement
- Quadrupole scans applied
- Model refined by
  - Defocussing element at TL start
  - QF
- Proposed transverse emittance exchange in TL eventually yielding 20% emittance in SR

II. Comparison of Measured and Simulated Dispersive Orbits

III. 2 Analysis of Quadrupole Scans in the Horizontal Plane

determination of β_x, α_x, ε_x, D_x, D_x' und σ_ε requires more than one quadrupole scan and dipole in between to change dispersion



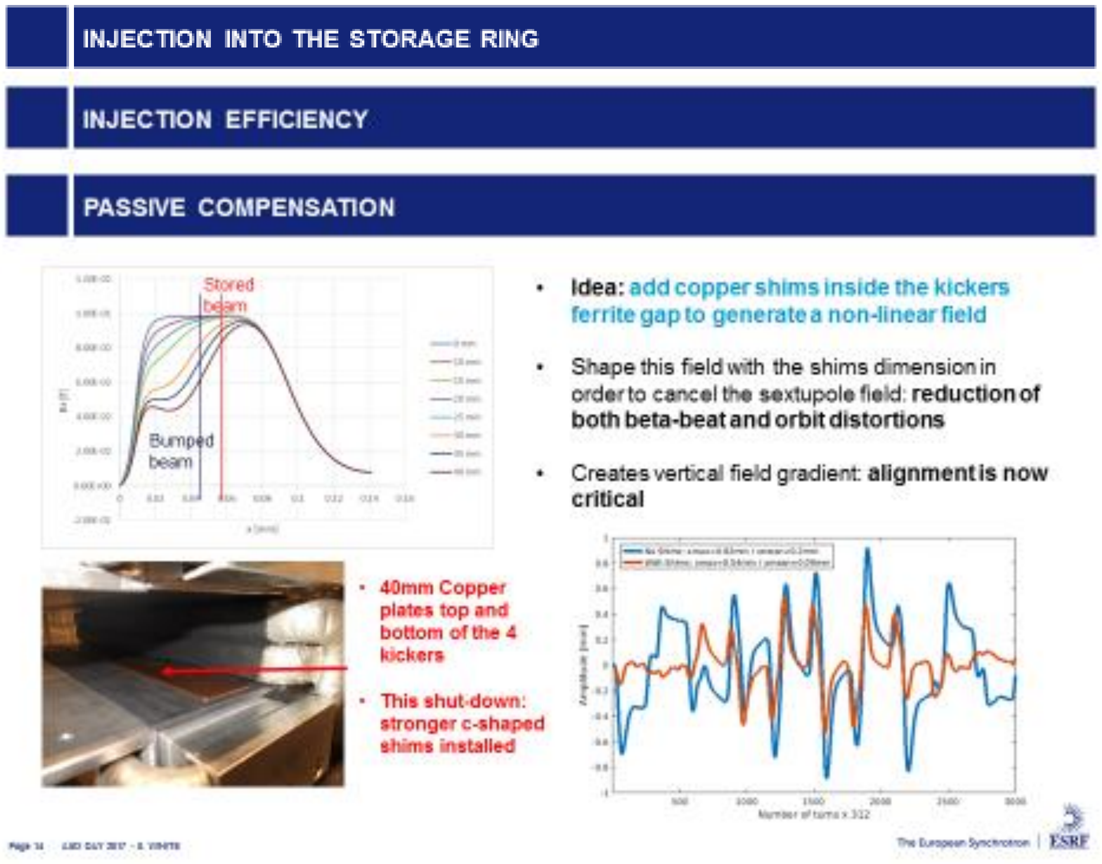
energy spread: $\sigma_\varepsilon \sim 6 \cdot 10^{-4}$, independent on extraction time
emittance - $\varepsilon_x \sim 70 \pm 20$ nm-rad or $\varepsilon_x \sim 50 \pm 10$ nm-rad, for late and early extraction

Position	β_x/m	α_x	Dx/m	Dx'
at Q3PT	7.6	-0.6	0.2	-.06
at Q4PT	8.2	-0.85	0.2	0.18

Peter Kuske, Issues with Modelling the BESSY II Transfer Line, TWIIS, HZB, Berlin, Germany, August 29, 2017 5

Experience at ESRF Simon White

- TopUp since 2016
- Injection efficiency tuned by hand at the beginning of each run: Booster & SR
- Sextupoles inside kicker bump
- Automated tuning of transferline
- No TopUp in Multibunch mode → perturbations too strong
- Added copper shims in kickers to generate a nonlinear field
-



Last studies of injection system at PETRA III transport line and PETRA IV upgrade -- Xavier Nuel Gavaldà

- PETRA IV design will also affect pre-accelerator
  - Reduction of DESY II emittance
  - New booster lattice based on ALBA booster