

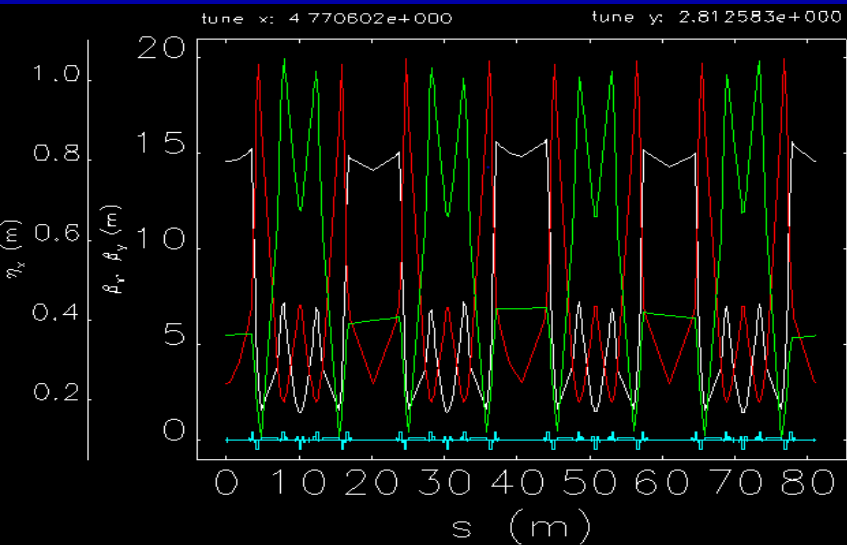
Beam injection for light sources

T.P.
SLRI A.D. seminar
25/11/15

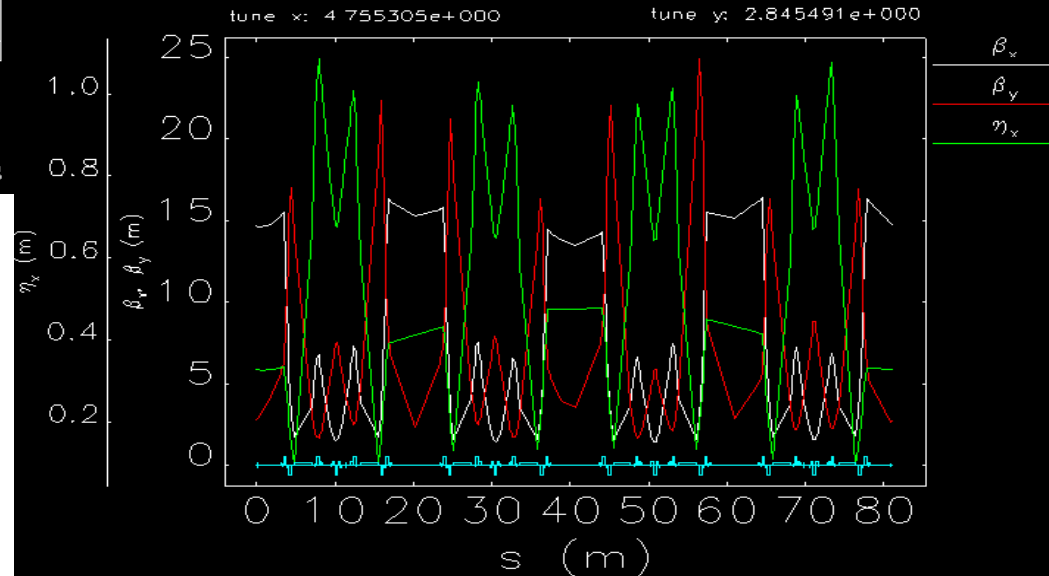
Layout

- SLRI Injection (with the existence of MPW)
- Multipole kicker injection (study for DLS)
 - Pulsed quadrupole magnet (PQM)
 - Pulsed sexupole magnet (PSM)
 - Pulsed multipole (PM) <- Bessy-II design
- Longitudinal injection (SLS)
- Swap out injection (APS)

WITH MPW gab23.5 mm

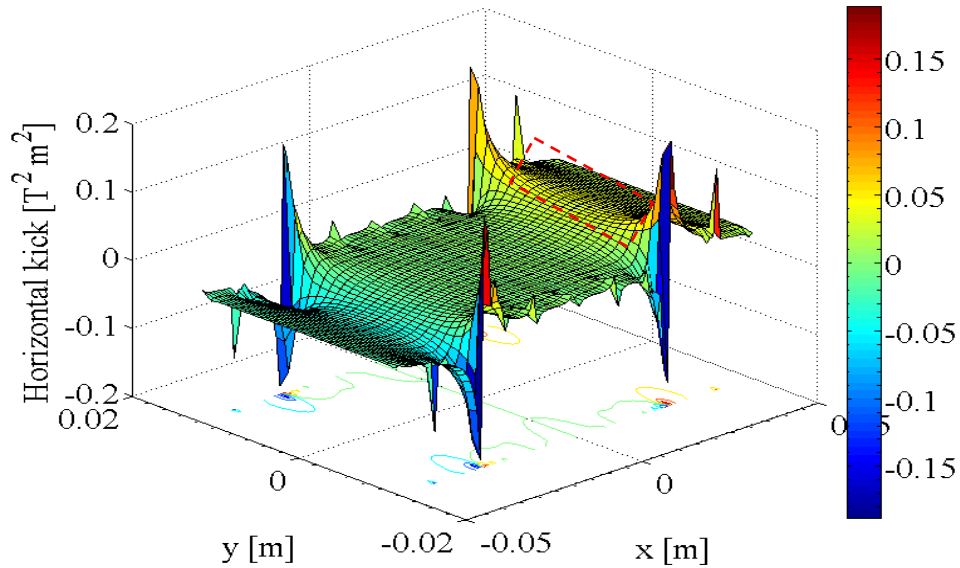


NaturalEmittance: 6.190908915118131e-008

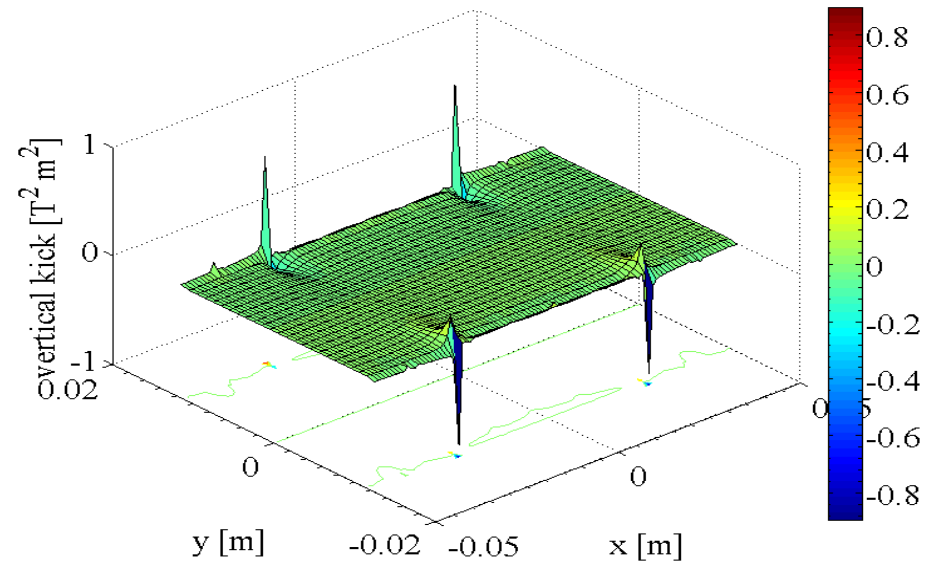


NaturalEmittance: 6.084779024437096e-008
November 25th 2015

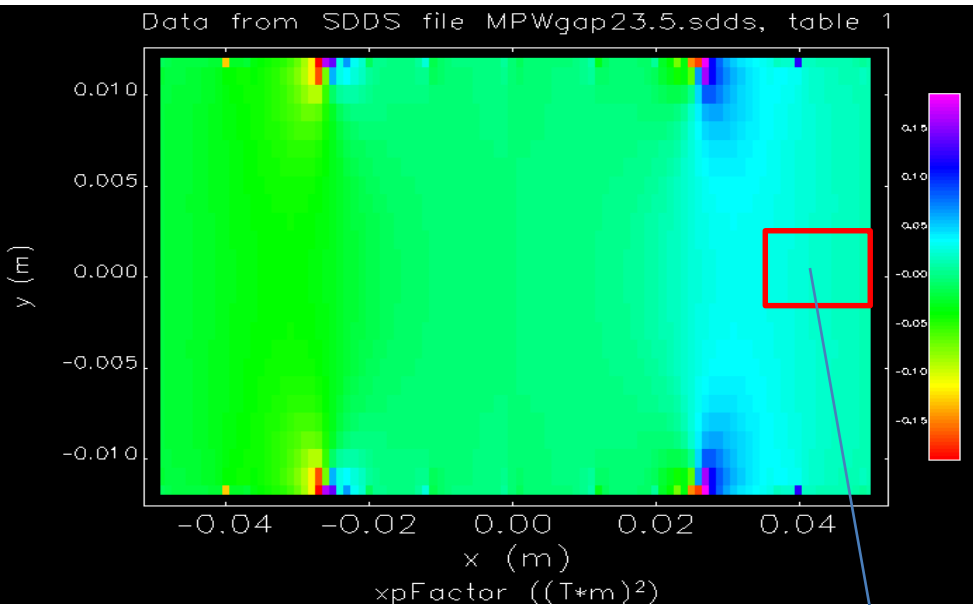
MPW kickmap (from Prapaiwan)



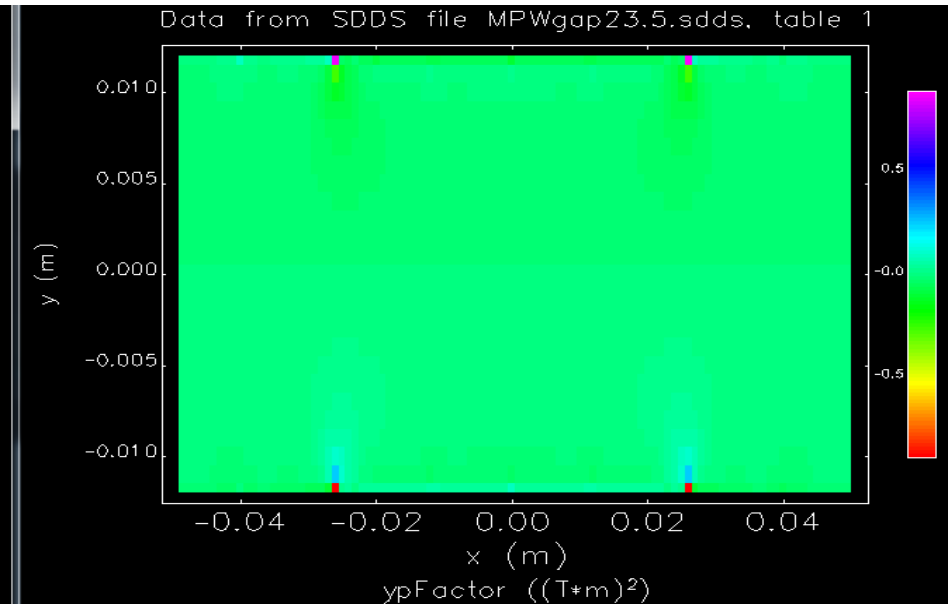
Kick map is exacted from Radia model.



MPW kickmap (from Prapaiwan)



Hor. kick

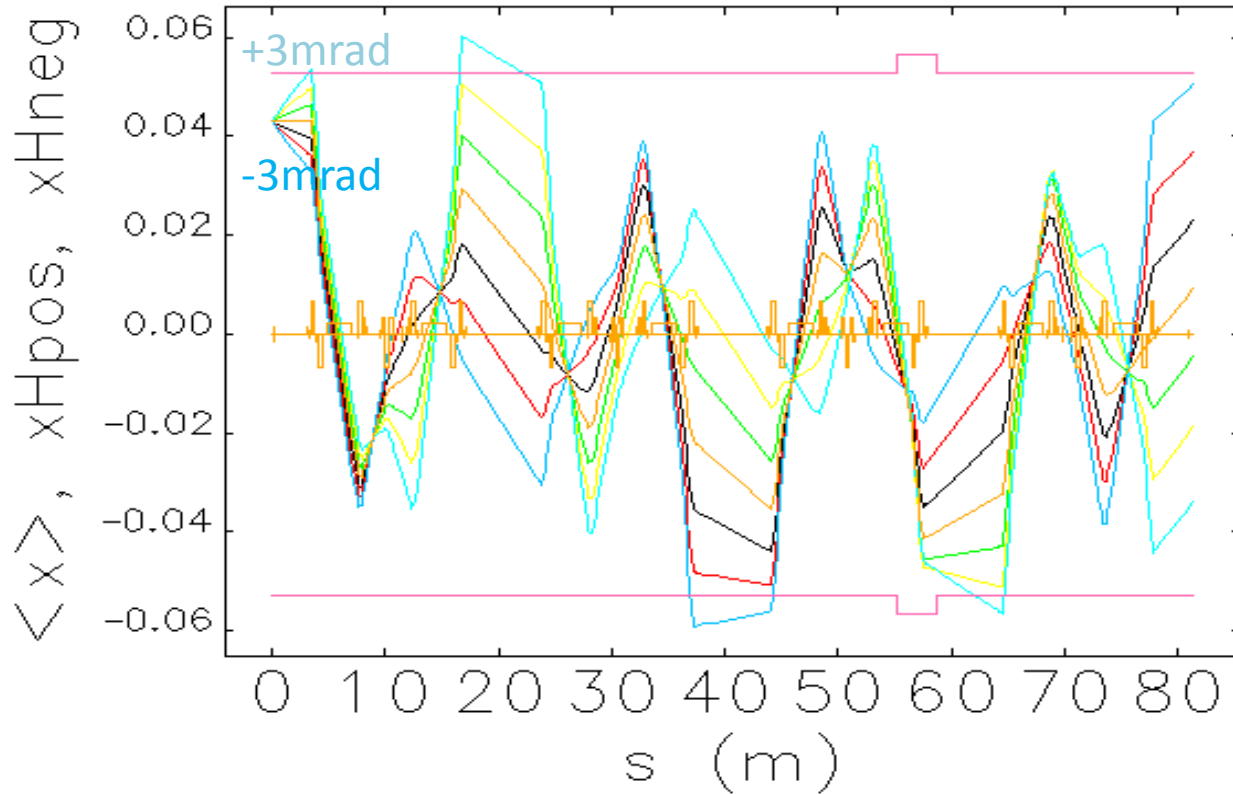


Ver. kick

Positive kick (go out)

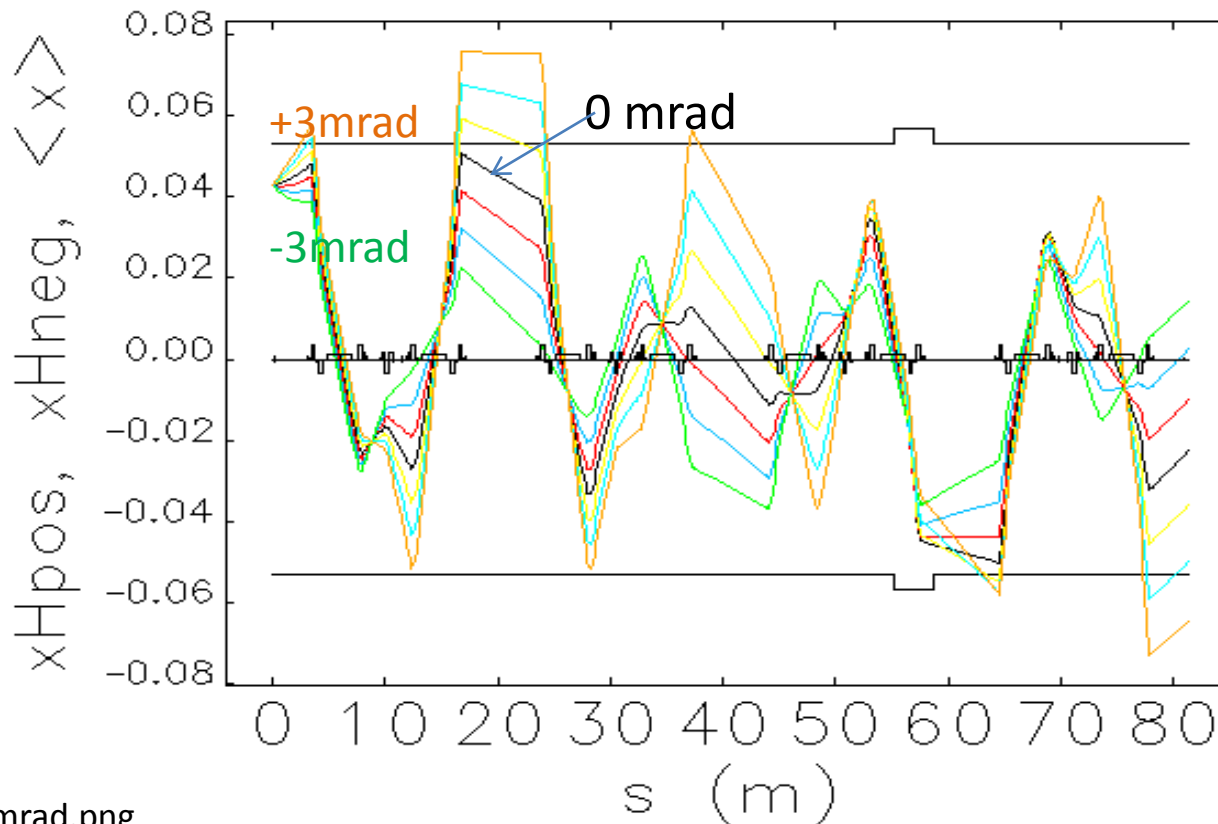
MPW:UKICKMAP,L=1.4,INPUT_FILE="MPWgap23.5.sdds",N_KICKS=24

Injected beam trajectory



Bare ring

Injected beam trajectory (with MPW)



trackInj.ele

MPW kicks the injected beam outwards closer to the physical limit.

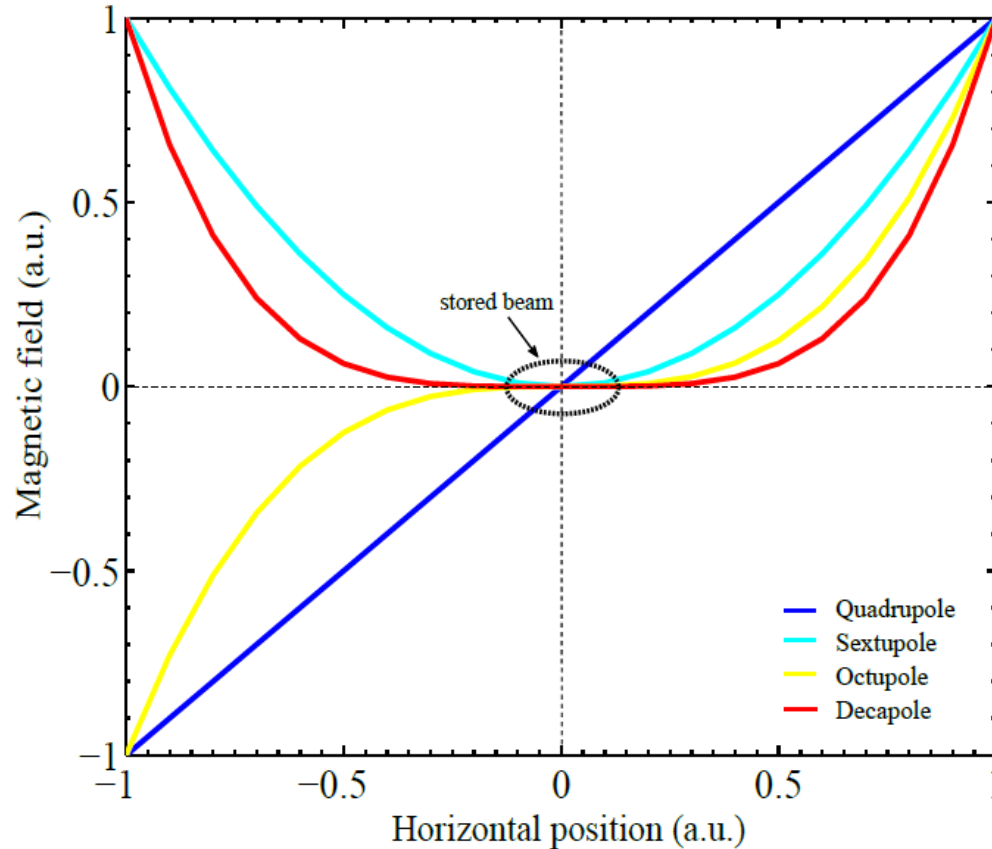
injMPW_upto3mrad.png

sddsplot -col=s,xHpos chamber_slri.sdds-2 -col=s,xHneg chamber_slri.sdds-2 -col=s,Cx injMPW_*.cen -graph=line,vary

Injection methods comparison

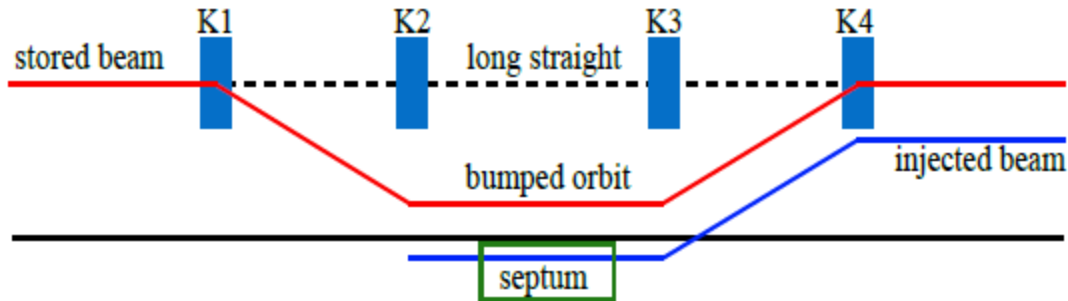
Injection scheme	On-axis	Off-energy	Off-phase	Orbit bump
Conventional	No	No	No	Yes
Multipole kicker	No	No	No	No
Off-momentum multipole kicker	Yes	Yes	No	No
Swap-out	Yes	No	No	No
Longitudinal	Yes	Yes	Yes	No

Multipole kicker injection

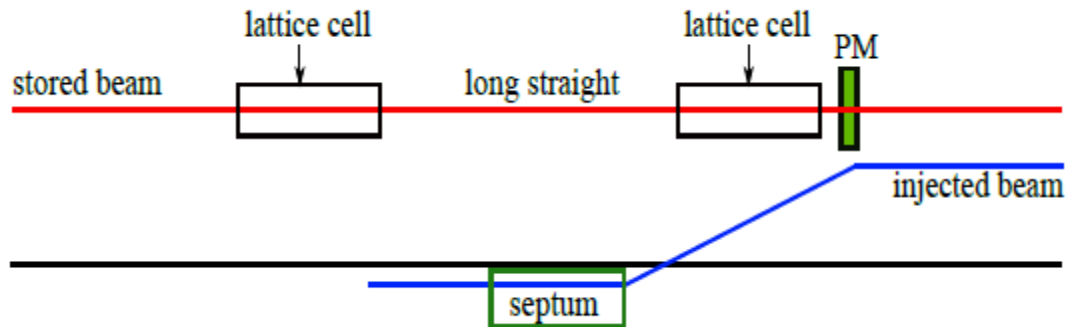


- Off-axis injection
- Low field at the center

Pulsed magnet injection

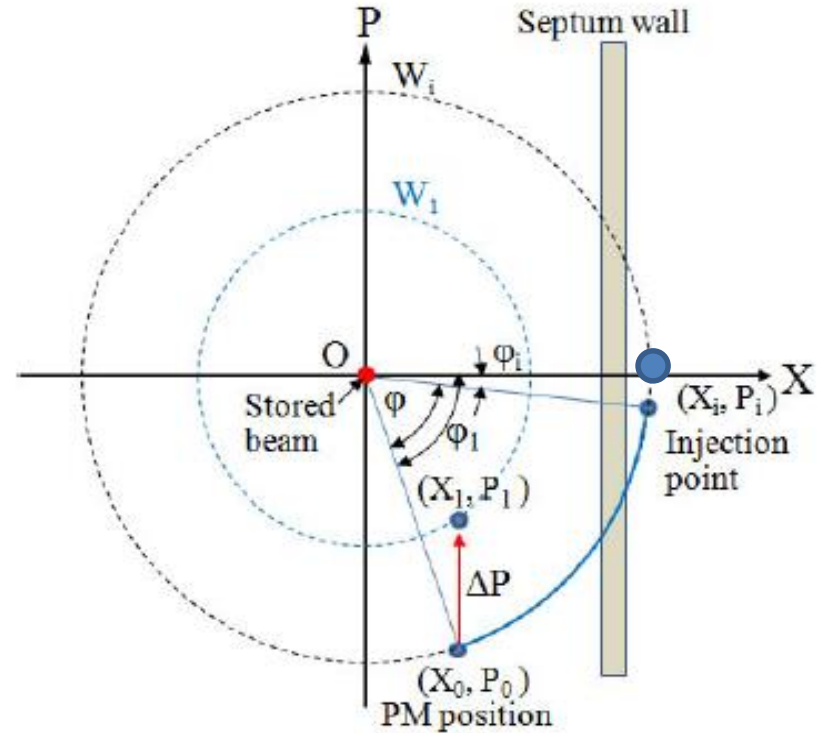
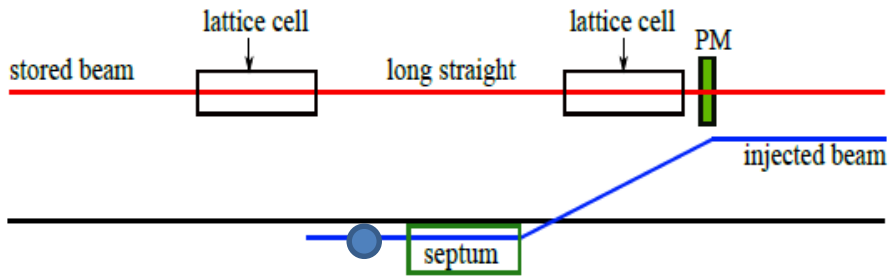


Conventional Injection (dipole)



Multipole kicker injection

Injection process



- Invariant can be reduce with a single kick $W_i \rightarrow W_1$
- Leaving the stored beam at the center unperturbed.

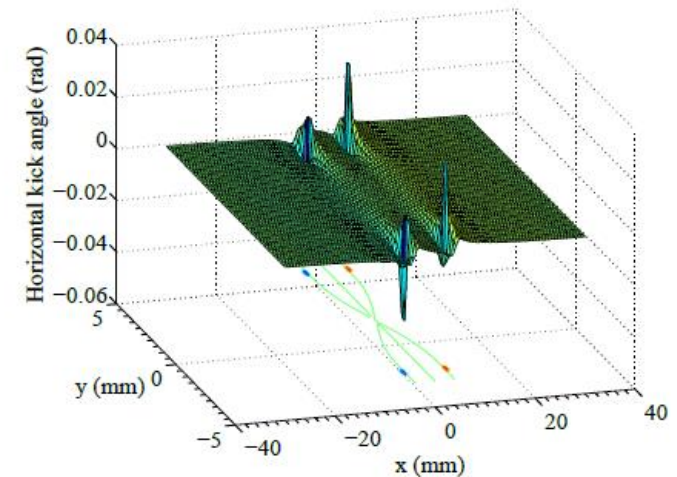
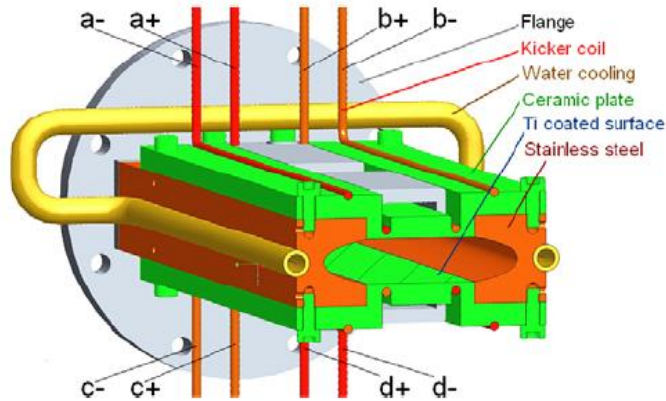
Advantages

- Much simpler to operate with only one kicker
- Less required space
- Small perturbation to the stored beam

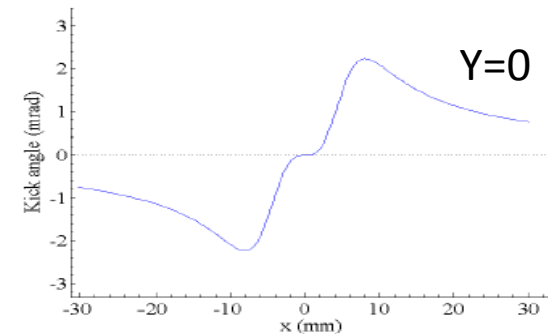
Require small injected beam for good inj.Eff.

Multipole kicker consideration

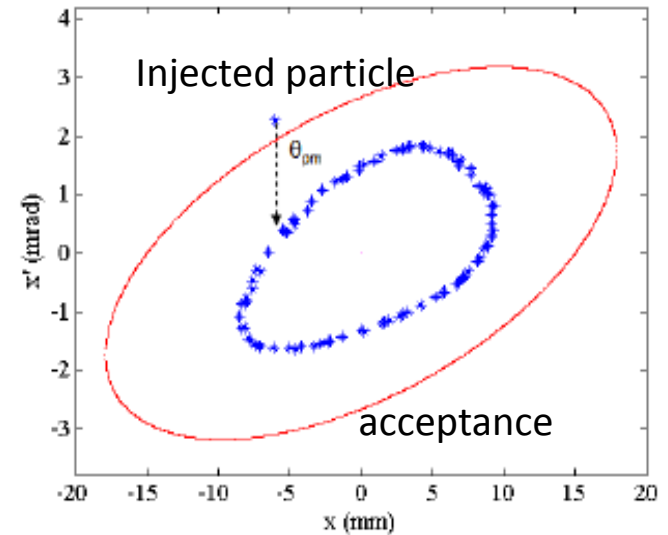
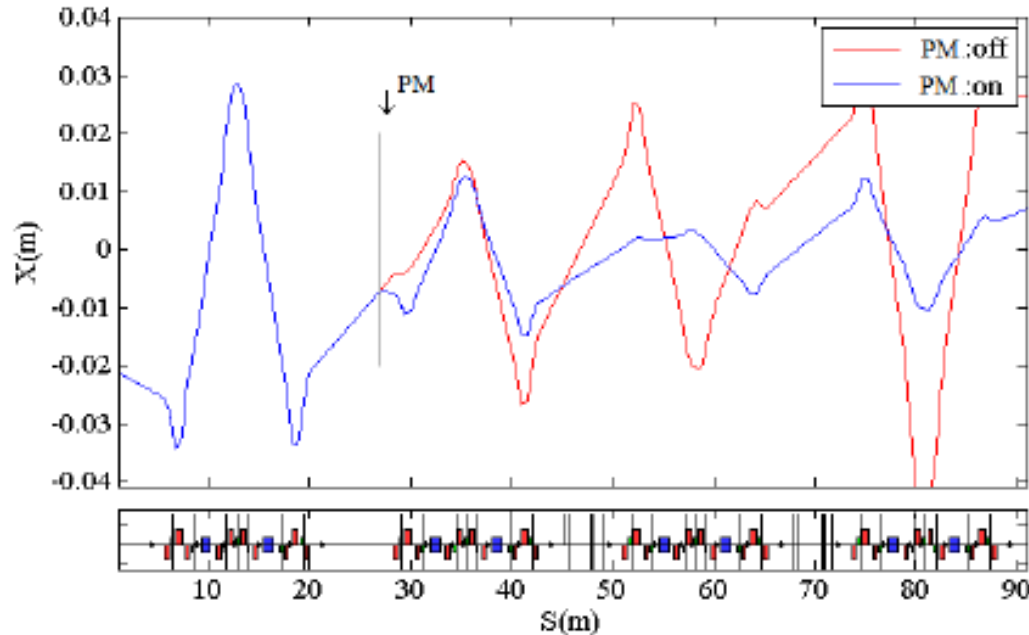
Pulsed multipole kicker (Bessy-II design)



(a) Horizontal kick map.



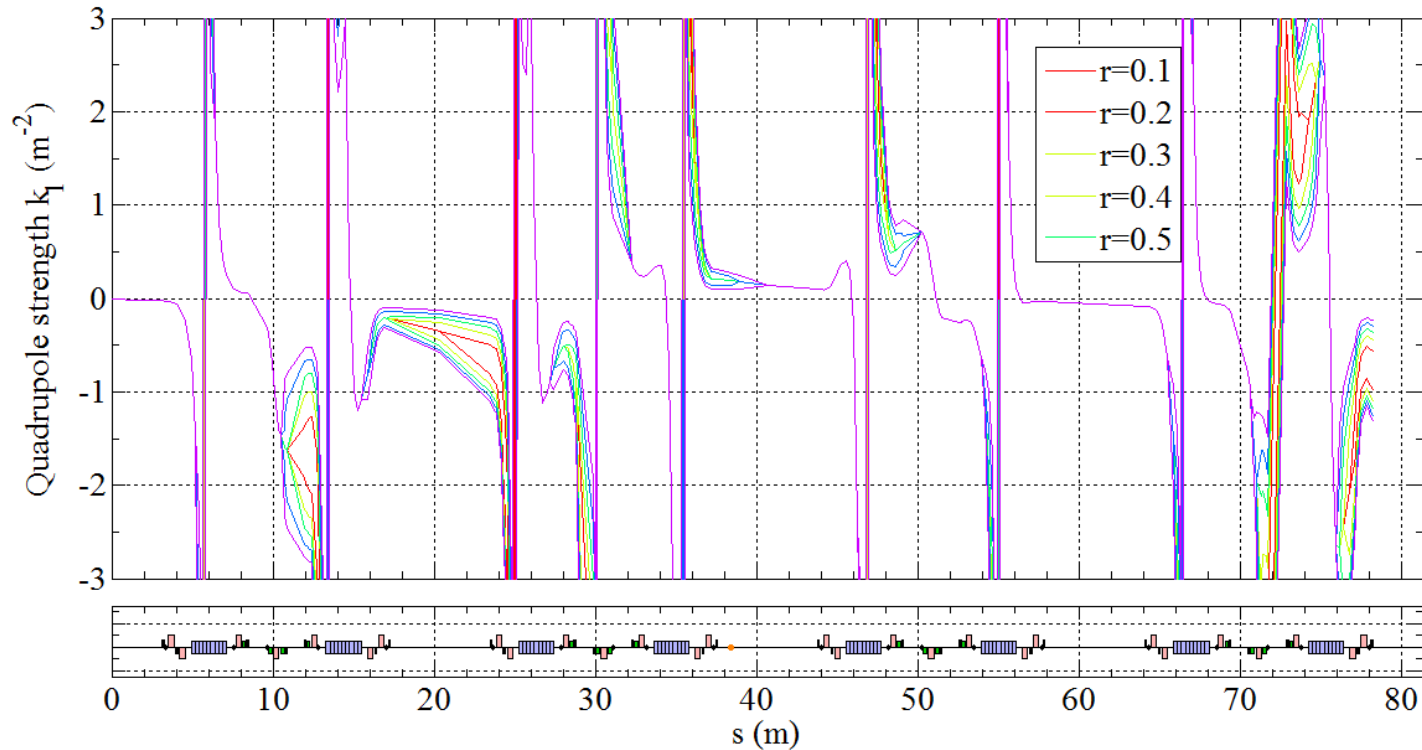
Pulsed multipole kicker



Single turn kick

The amplitude of the injected beam trajectory can be reduced to be accepted in the machine.

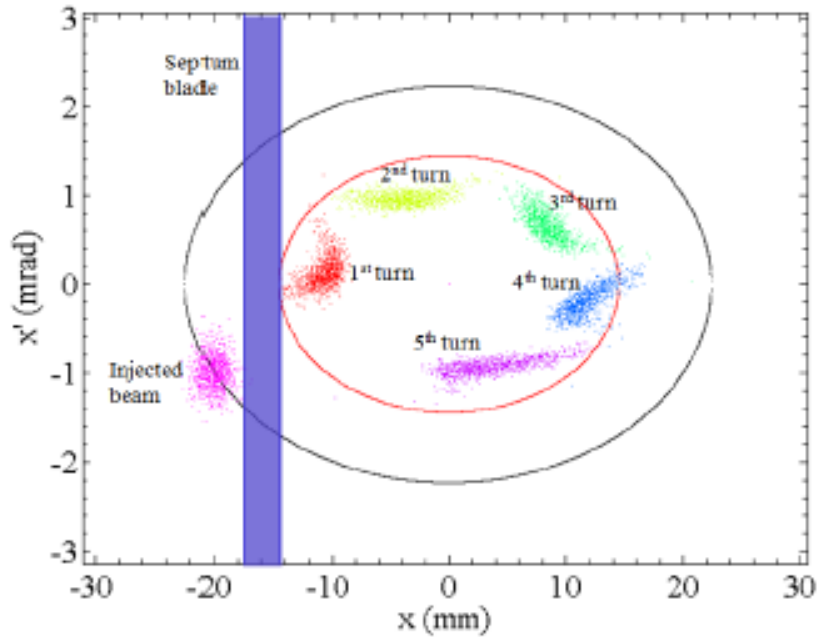
PM injection suitable places



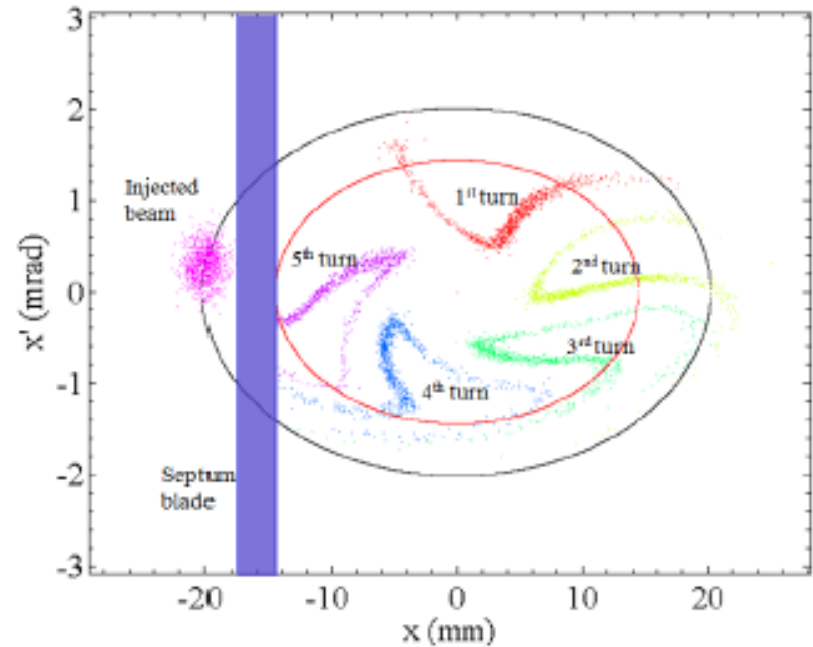
SPS lattice

$$k_1 l = -\tan \varphi \pm \sqrt{\frac{r}{\cos^2 \varphi} - 1}, \quad \rightarrow r = \frac{W_1}{W_i}$$

Pulsed multipole kicker



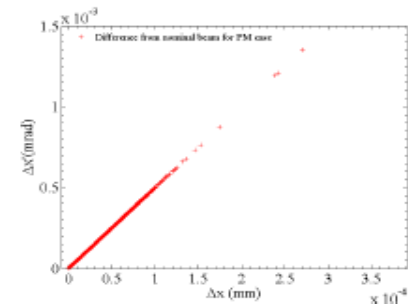
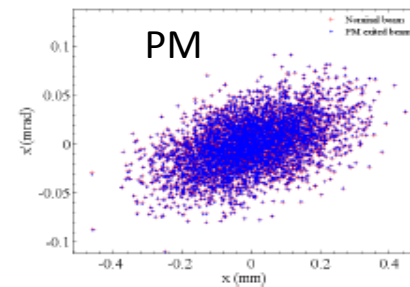
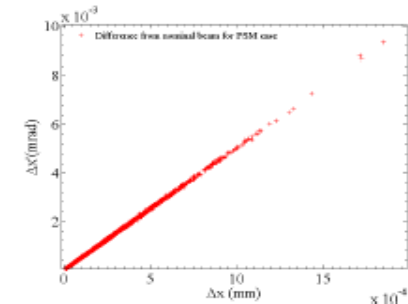
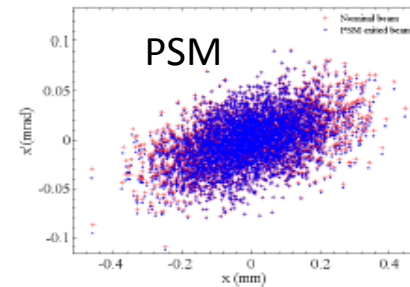
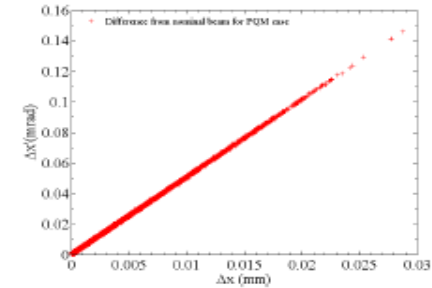
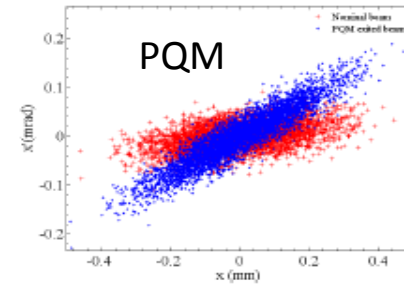
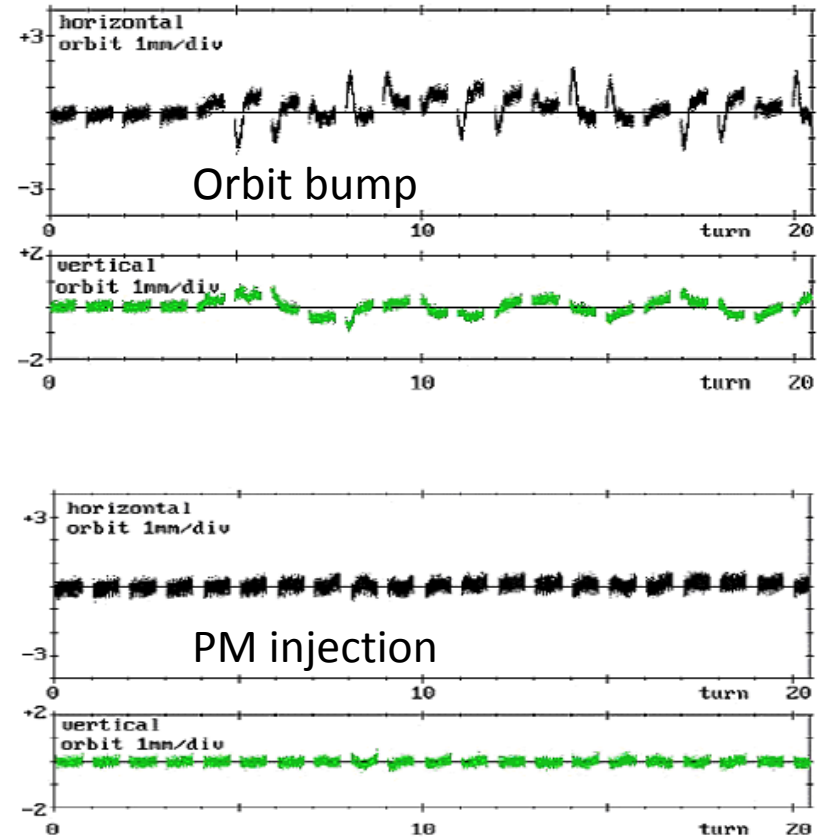
PM at straight 2



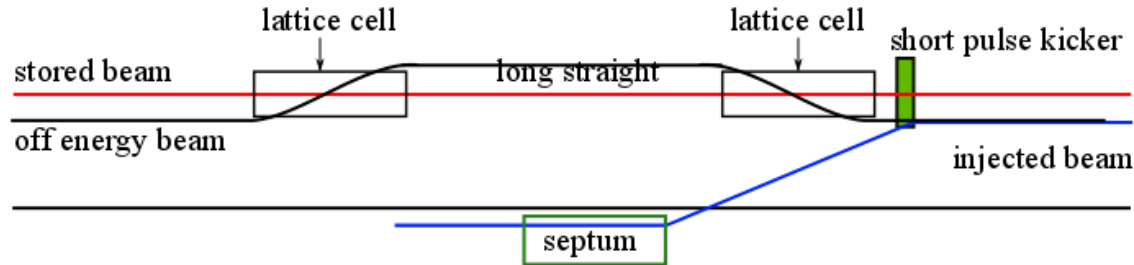
PM at straight 14

Effect of PM on stored beam

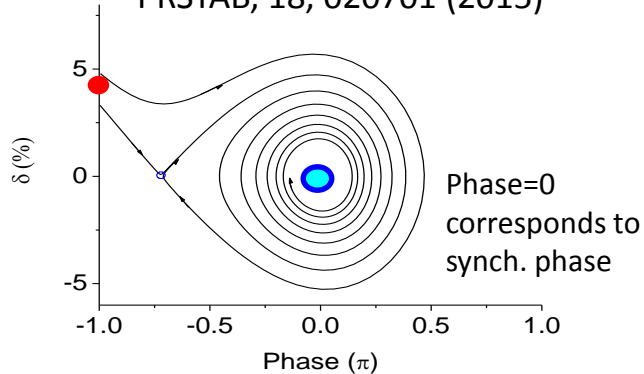
Bessy-II perturbation on the stored beam



Longitudinal injection



*M. Aiba et al.,
PRSTAB, 18, 020701 (2015)

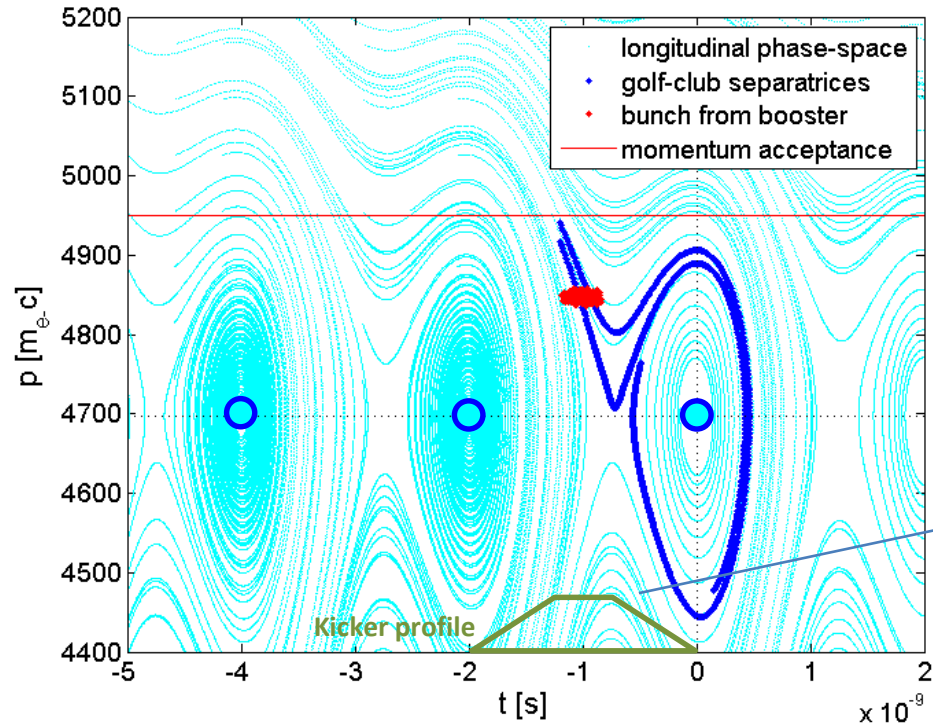


Inject a bunch with off-energy and phase into the off-energy orbit

Needs a static septum and a short-pulse dipole kicker.

Longitudinal injection

500 MHz

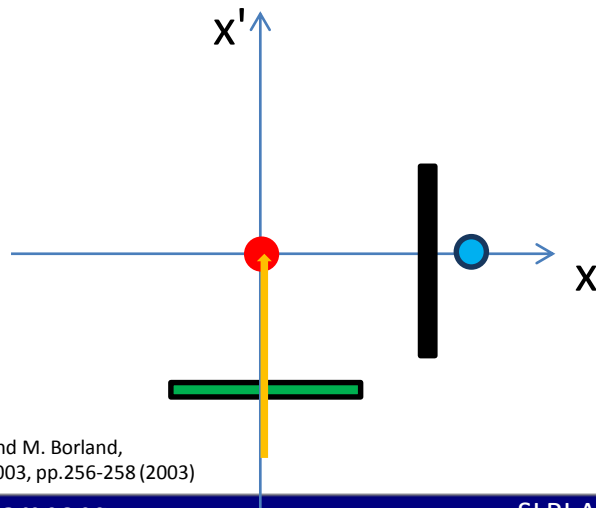
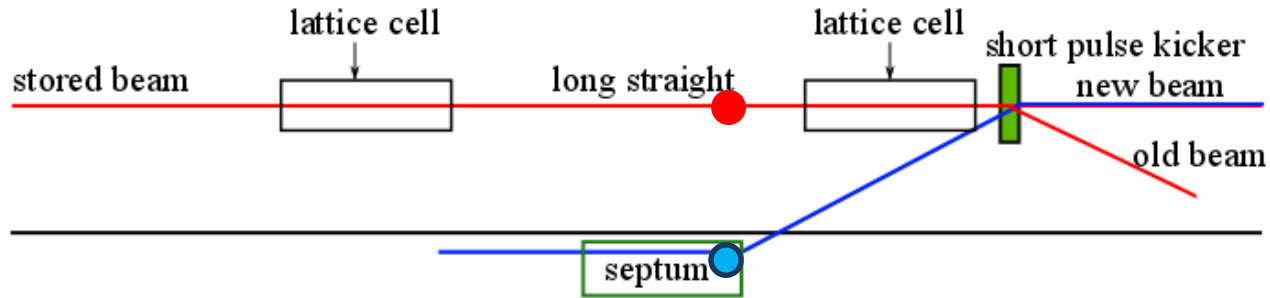


SLS case

2 ns full rise-fall time
Can be relaxed with
lower RF frequency

Require very short pulse within the bunch spacing to avoid perturbation

Swap out injection



The old bunch with lower current will be replaced with the new high current bunch.

Requirements

- fast kicker (bunch-by-bunch basis)
- **full current injector is need**

*L. Emery and M. Borland,
Proc. PAC 2003, pp.256-258 (2003)

summary

- Conventional injection is still in use in most light sources. Require a careful tuning of 3-4 bumps to close the stored beam orbit for top-up.
- Stricter requirement for less perturbation during top-up drives PM injection (single element) to gain more attention.
- The next generation storage ring (ultra-low emittance ring), whose DA is small, require on-axis injection.
- Fast kicker technology makes life easier.

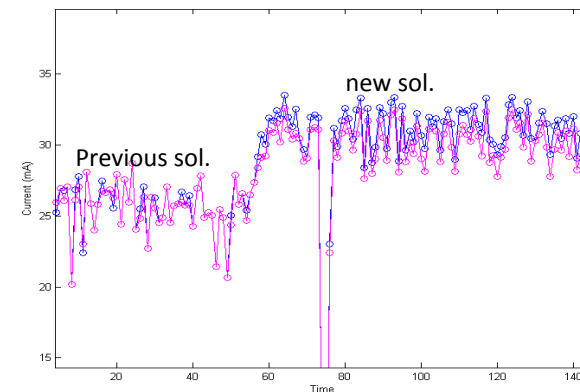
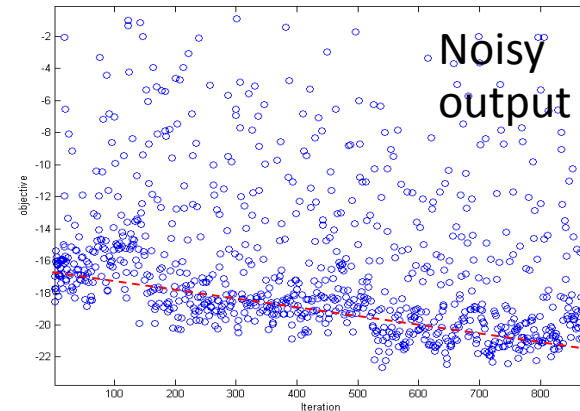
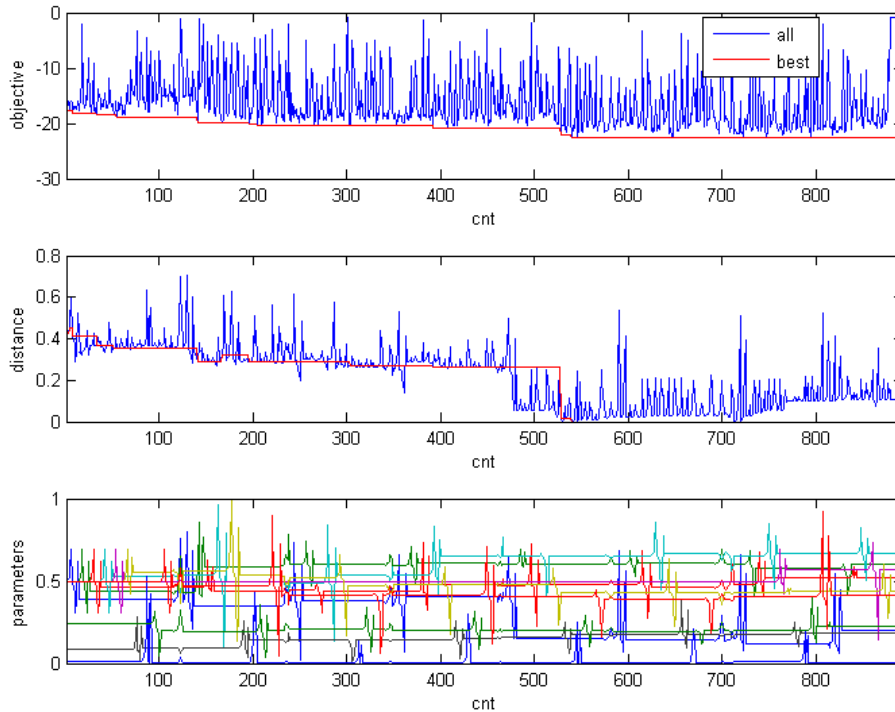
More info.

T.P. Thesis

Angela Saa Hernandez presentation in 1st Low emittance lattice design workshop

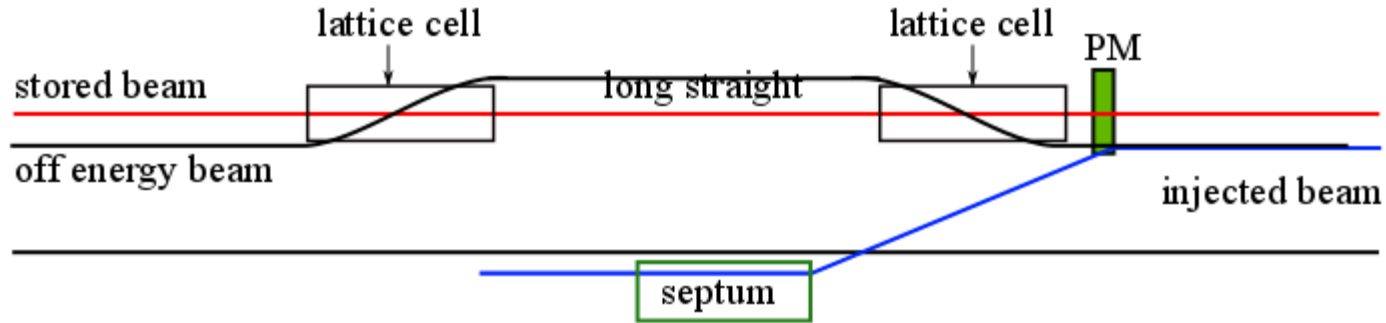
Extra: LBT to booster injection optimisation

RCDS: Robust Conjugate Direction Search (X. Huang)



Questions?

PM injection off-momentum



The beam is injected with a energy offset onto the off energy closed orbit.