Injection and Top-Up experience at SOLEIL

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and Source & engineering division

Topical Workshop on Injection
and Injection systems

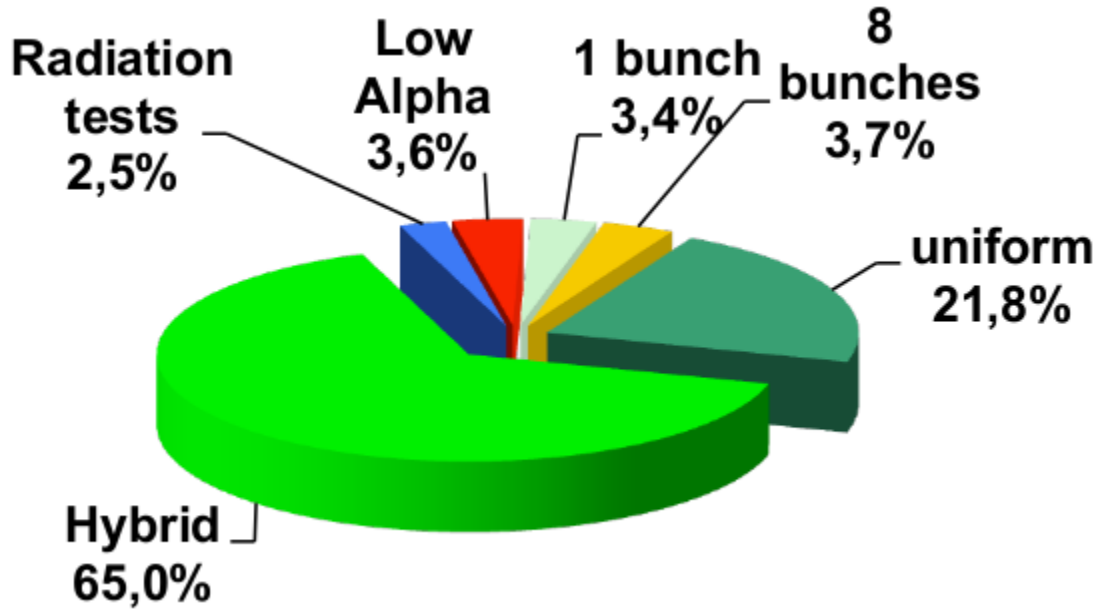
HZB / BESSY II – Berlin
27-30 August 2017

Outline

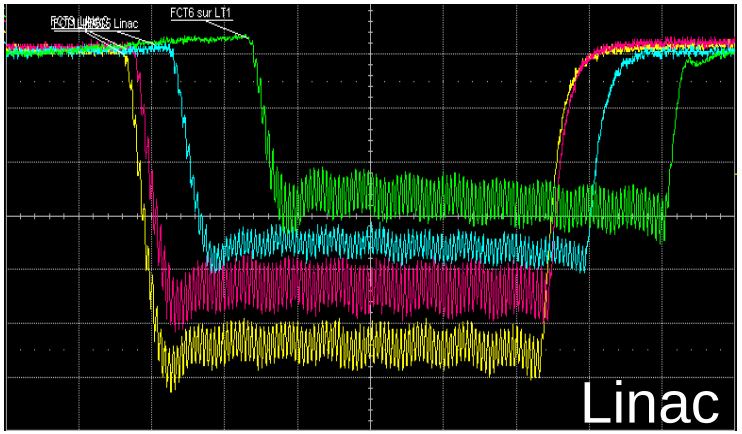
- Top-Up overview at SOLEIL
- Residual bump corrections from pulsed elements
- Conclusion

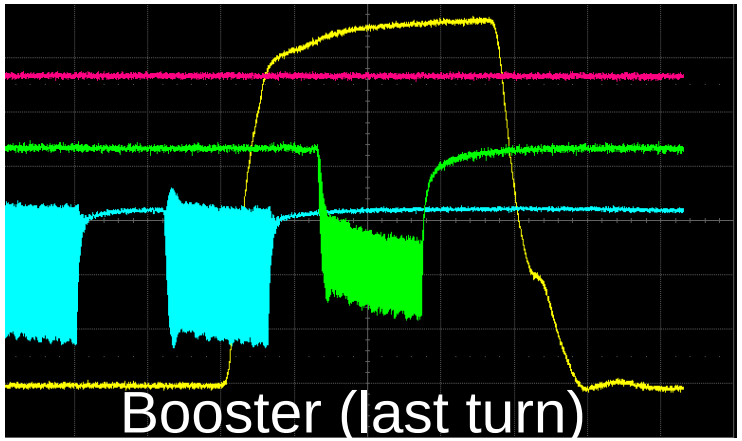
Different filling patterns

Top-Up operated since 2009



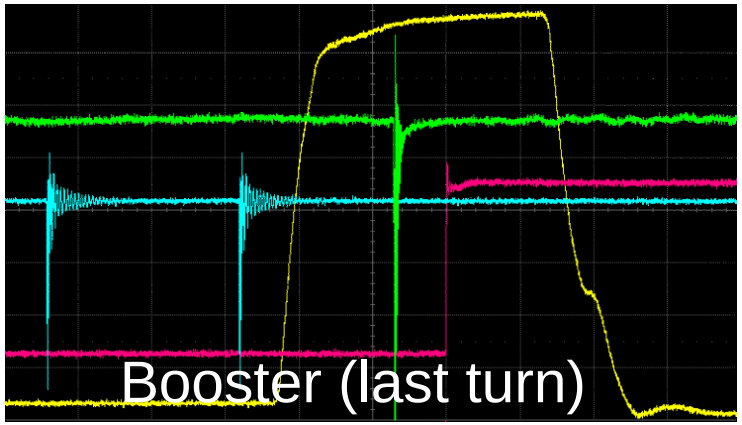
Different filling patterns



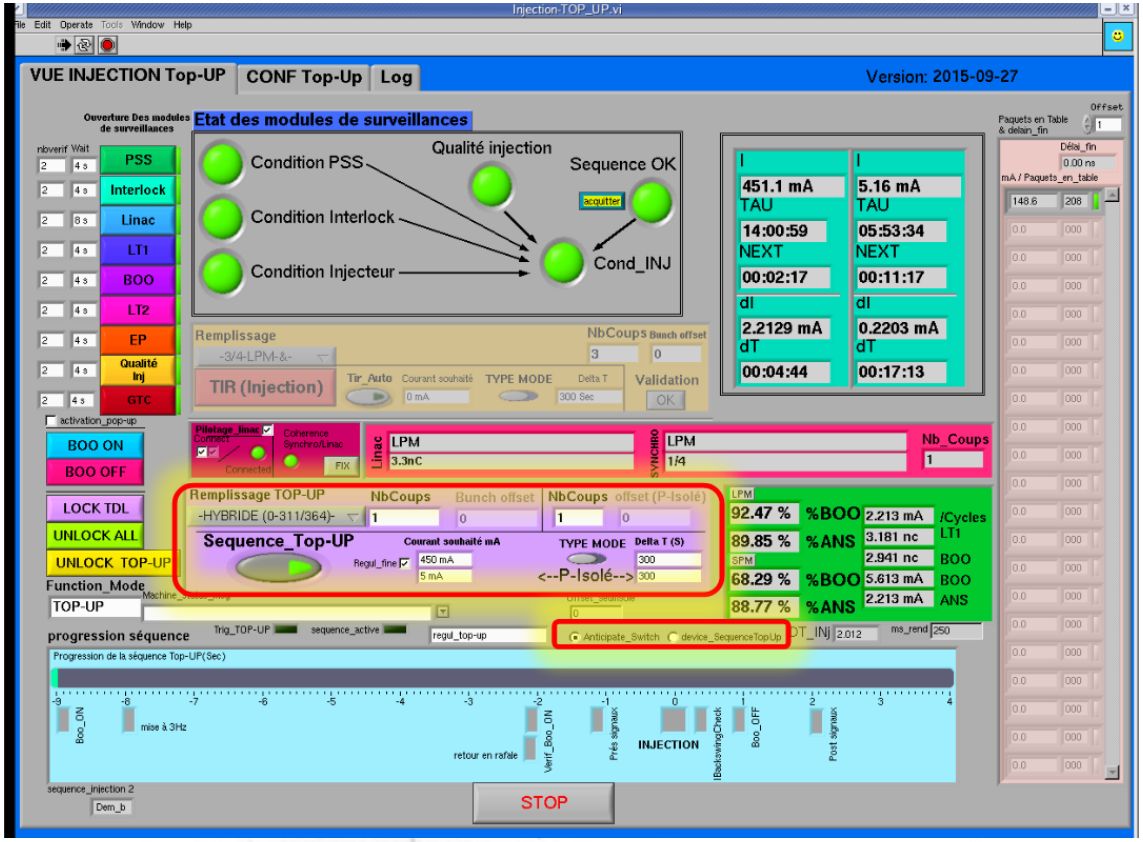


Good flat shape linac pulse
100 bunches / 300 ns

3 Hz booster power supplies
ramped up and down over 10 s



Top-Up operation survey



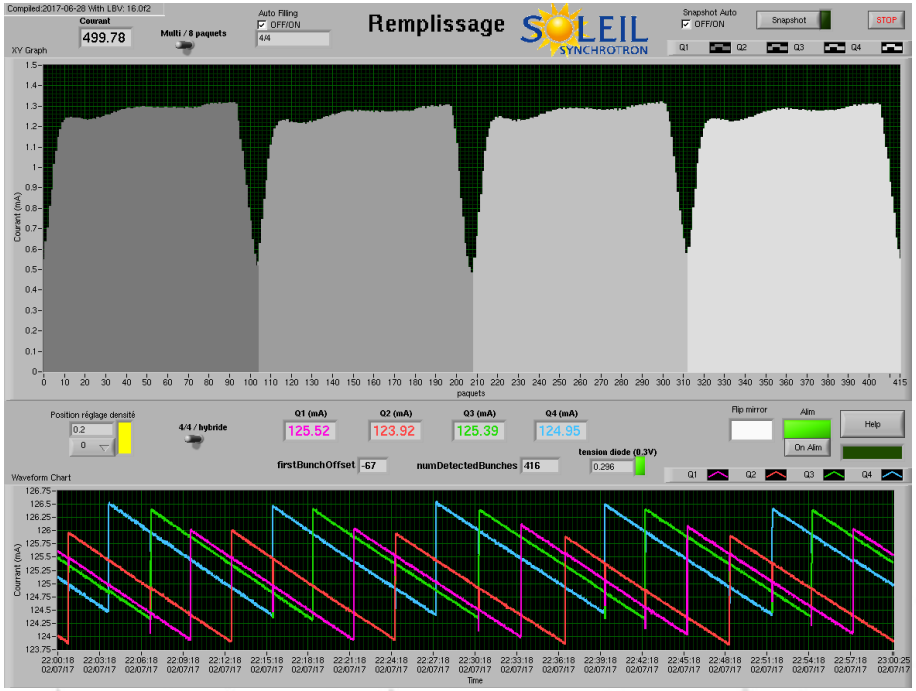
Before injection sequence checks :

- Machine PSS
- Machine interlock
- Injector status
- As well as the last injection Efficiencies

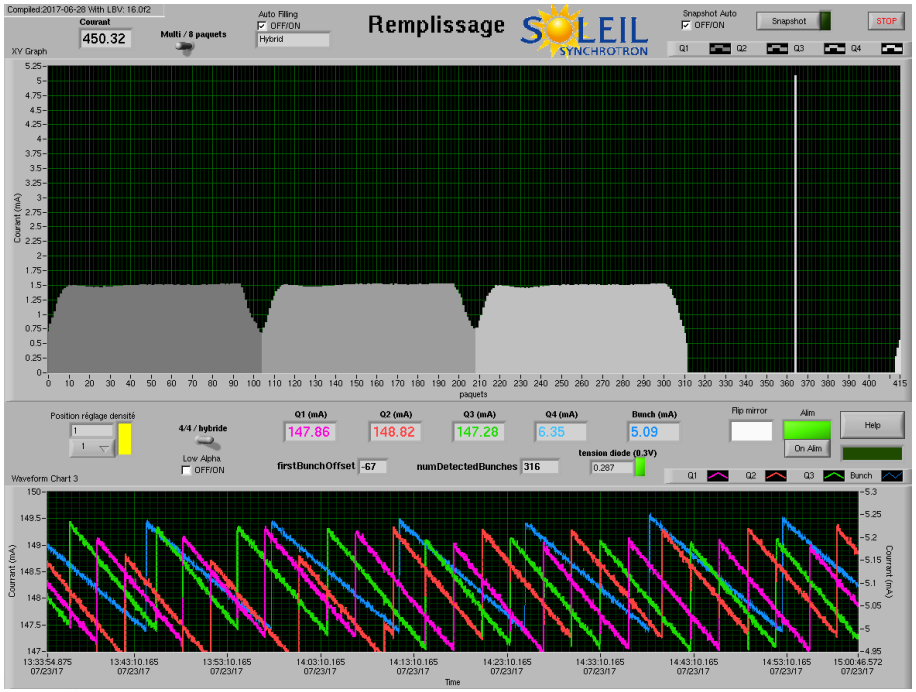
Manage the different ring filling patterns

Top-Up operation survey

Uniform 500 mA

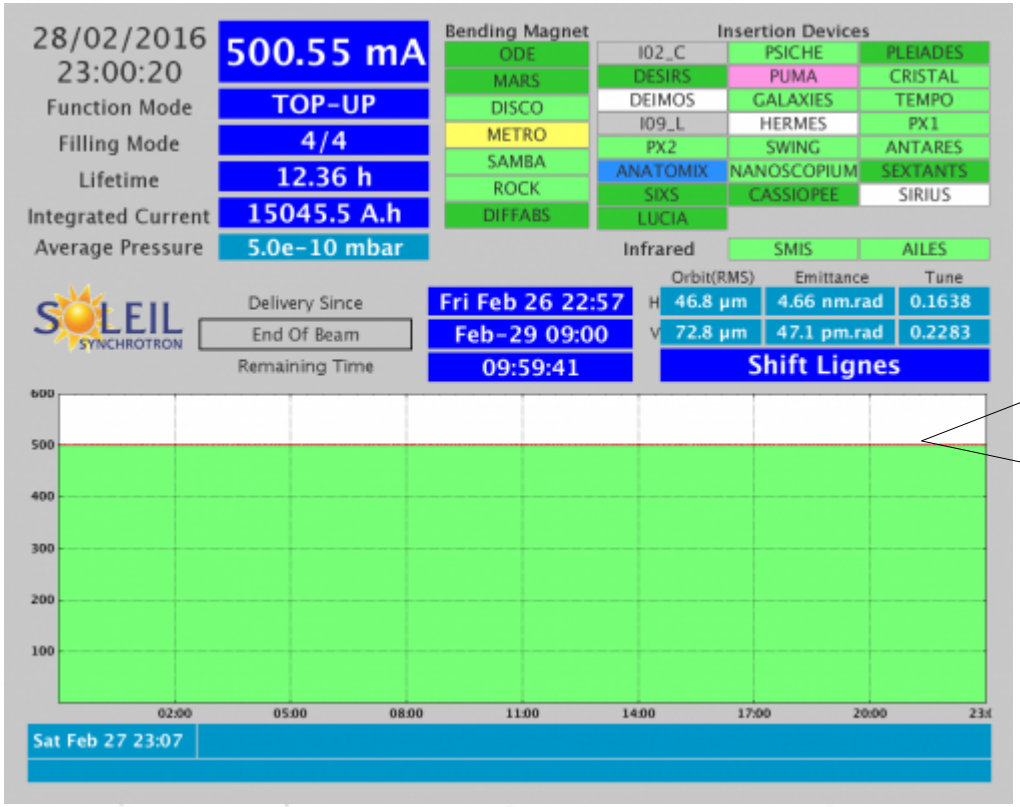


Hybrid 445 + 5 mA



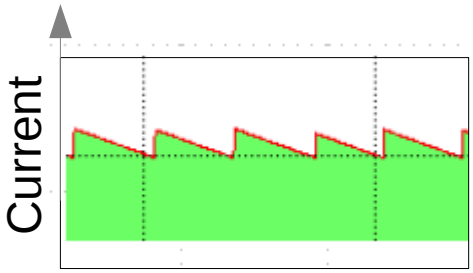
Filling current control quarter to quarter
Refill the lowest one

Top-Up operation



Typically 2 mA every 3 mn
Current stability below ±0.2 %

Top-Up operation



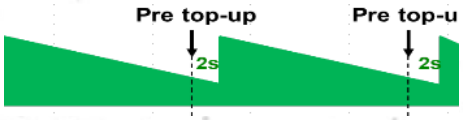
Current stability below ±0.2 %

Constant thermal load on beam-line optics
Mirror alignment, thermal optical bumps, …

Constant thermal load on accelerator equipments.
Reduction of thermal drift on BPM electronics.

Only way to reach sub micron stability level
But Not suitable for all user needs (long integration time, image scanning, …)

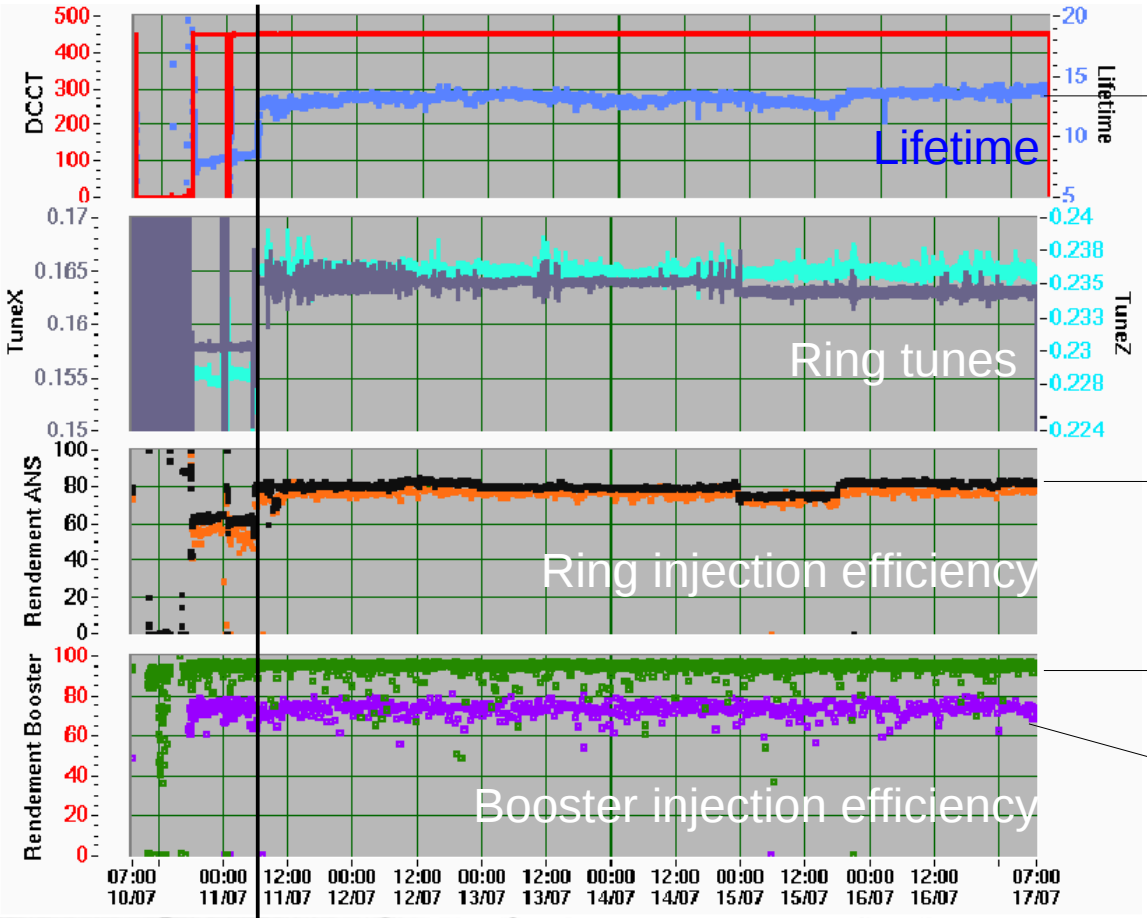
Gating signal :



Very significant improvement for the data quality recorded at the SMIS IR-beamline. This results in an increase of the S/N of the spectra by a factor between 12 and 15!

Users Top-Up operation over 6 days

450 mA hybrid mode



12-14 hrs

80 %

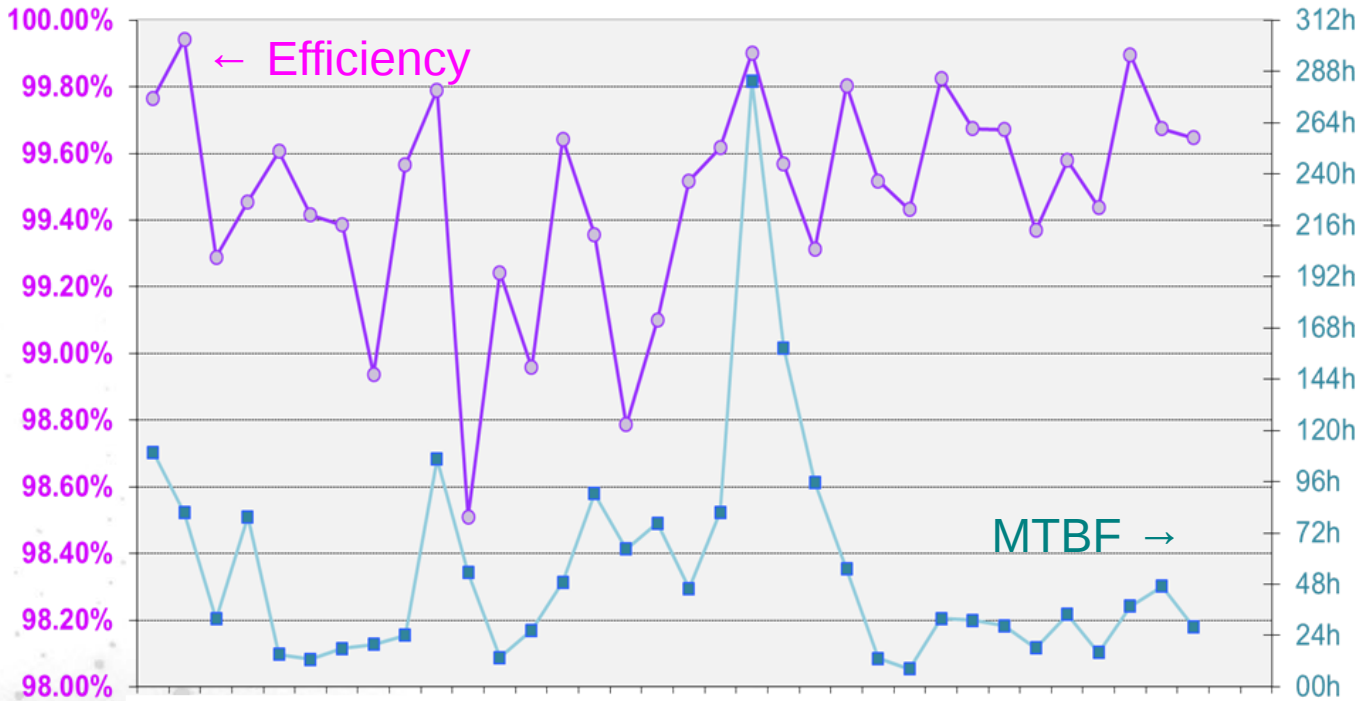
90-95 % LPM

70-80% SPM

User times

Top-up efficiency and MTBF

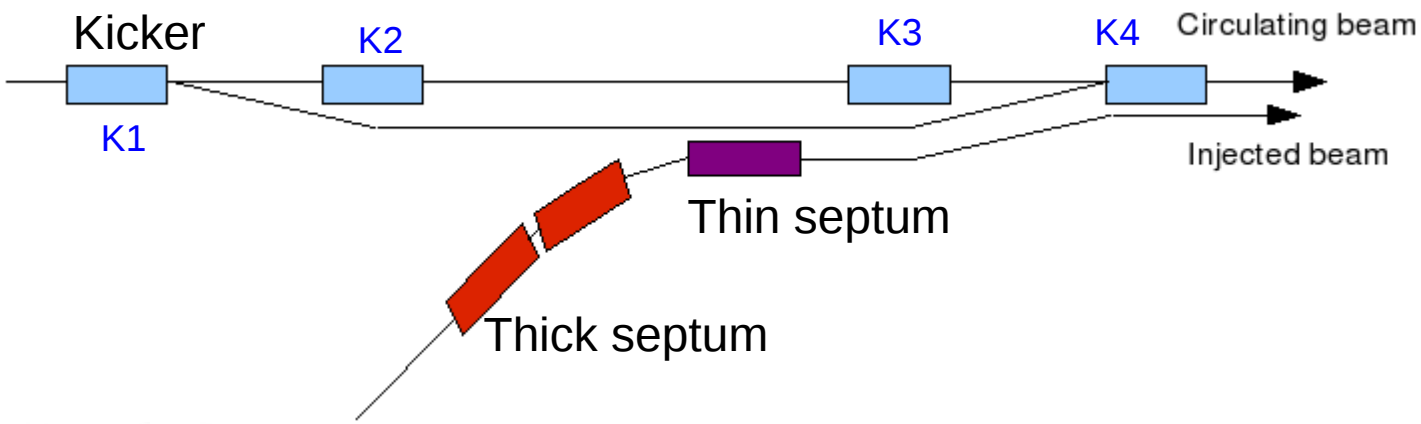
When the stored current drops below 0.5 mA from the nominal value



← 6 years →

Ring injection layout

Inserted in free 12m long section

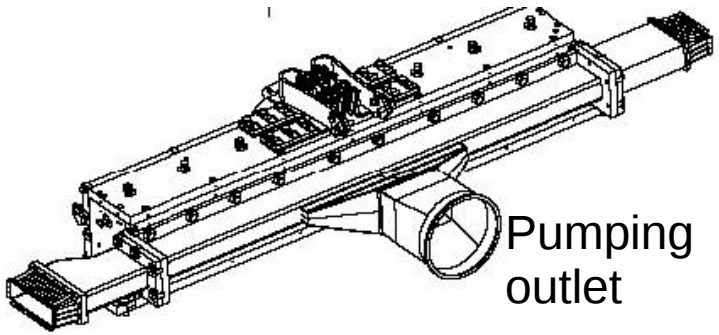


Thin Septum :
Full sine wave
120 µs
400 mT
In vacuum Eddy current septum
3 mm thick
20 mm from axe

Thick Septum :
Half sine wave
3.3 ms
1 T

Kickers :
Half sine wave
7 µs (6 turns)
120 mT

Thin Septum H & V residual bump



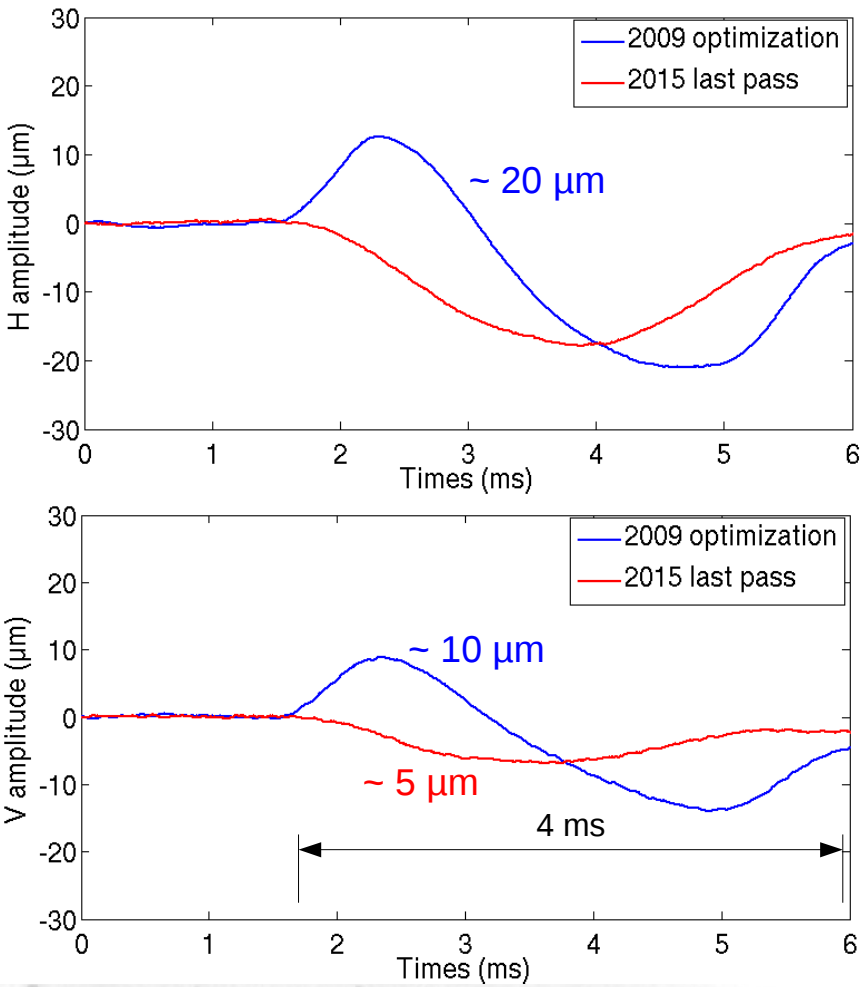
Initial : Half sine wave, no shielding

Step 1 : Change the pulse profil from an half sine to a full sine wave
Gain = a factor of 2

Step 2 : Adapt a shield screen over the complet SR inner chamber including the pumping outlet
Magnetic alloy : SuperImphy of 0.5 mm thickness
Gain=a factor of 100

=> Residual stray field reduced from 400 µTm to ~2 µTm (Mag. Meas.)
=> Residual orbits ~ cancelled

Thick Septum H & V residual bump



2009 Bump reduced by means od µ-metal and grounded upstream Eddy current.

A last pass in 2015 grounding downstream the Eddy current.

β_x = 14 m @ BPM (long straight)

σ_x = 320 µm @ 4 nm.rad

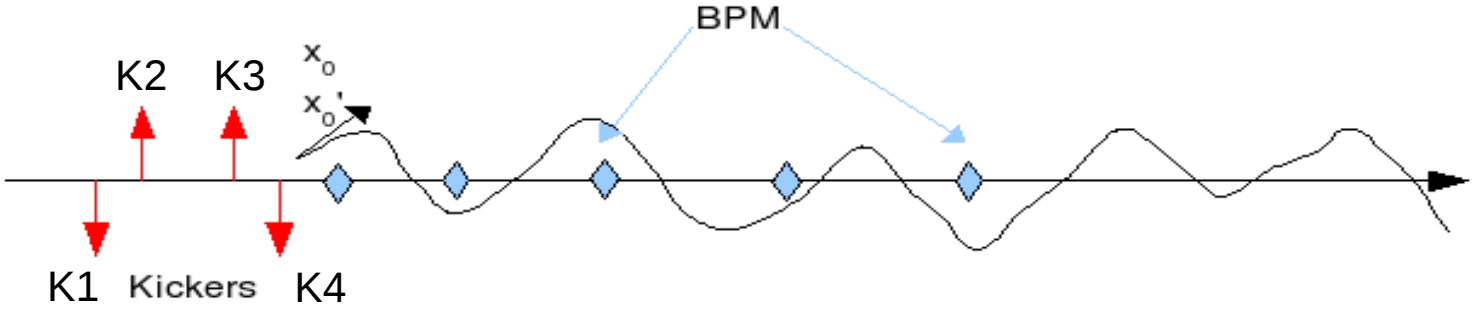
20 µm => ~6% of σ_x=> Below 10 %

β_z = 12 m @ BPM (long straigth)

σ_z = 20 µm @ K=1%

5 µm => ~25% of σ_z=> Still larger than 10%

Kicker pulse profile investigation



<u>Beam Based turn by turn data analysis</u> :

Get the differential (x,x', z,z') induced by the 4 kickers at each turn on a set of BPMs

Fit the differential kickers profiles in both planes

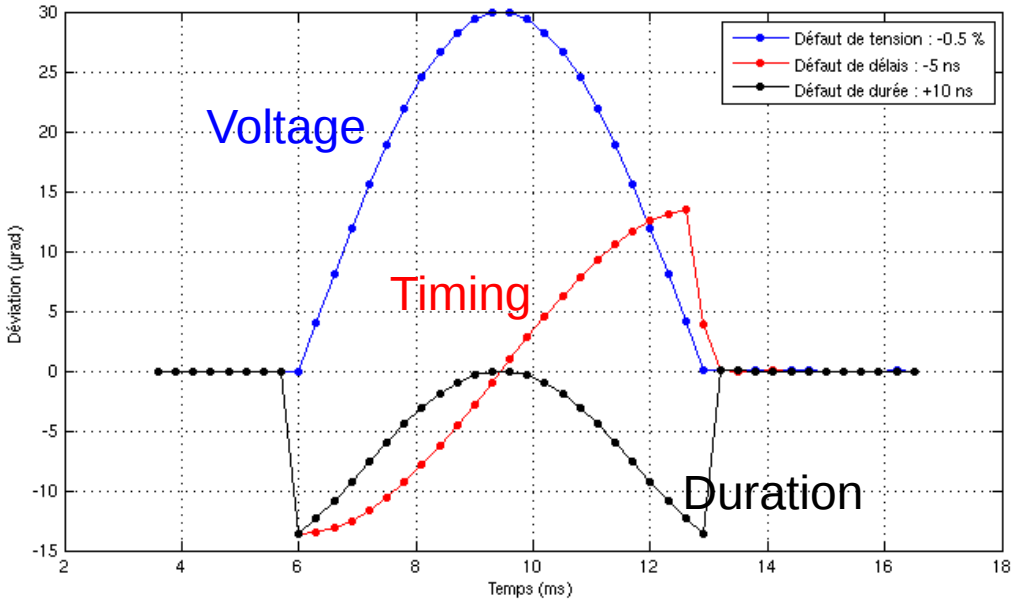
Repeat with different timing (circulating beam vs kicker) to sample the pulse profile measurements

Kicker pulse profile investigation

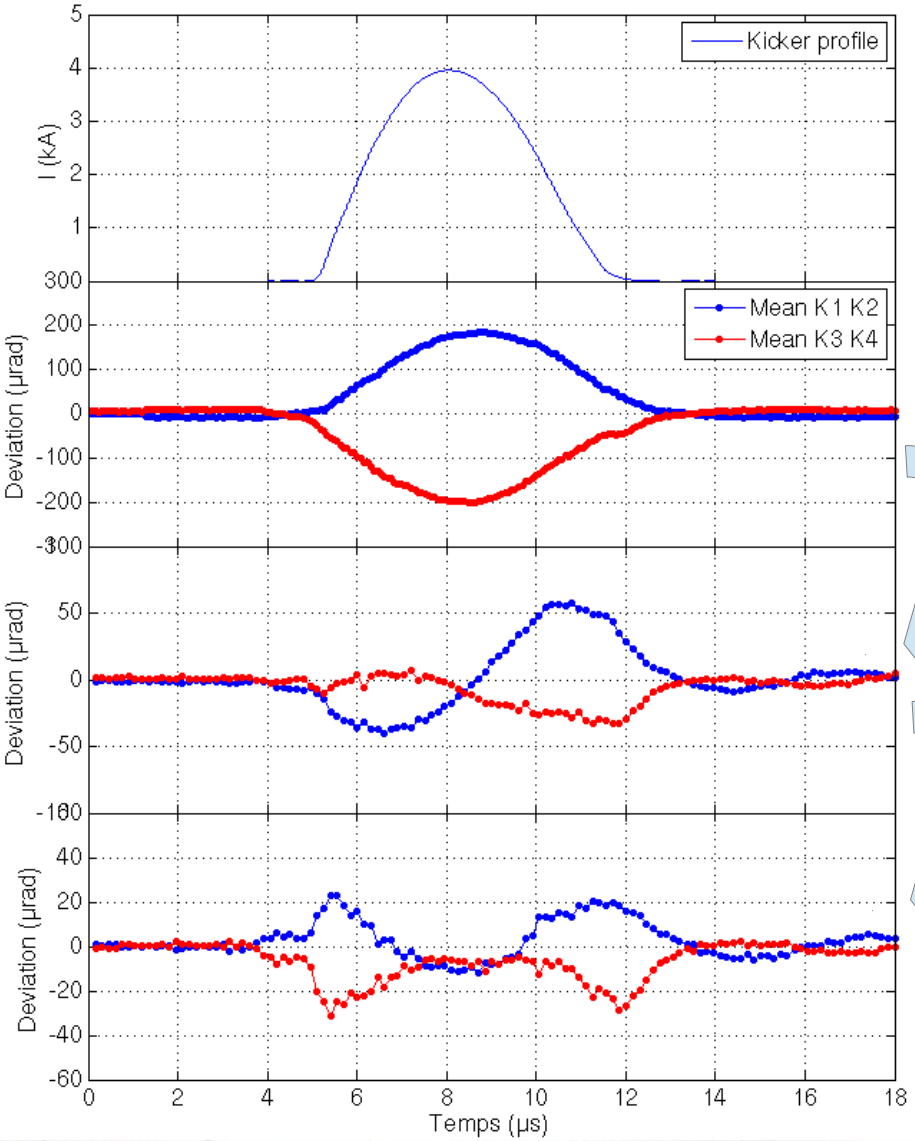
Without any BPMs in between the kickers, it is not possible to distinguish the 4 kickers, there is only 2 unknowns per plane :

==> Fit the mean profile of K1 K2 and K3 K4

Exemple of differents mis-matching kicker pulse :
Voltage
Timing
duration



Kicker pulse profile investigation



Exemple of kickers matching process by step

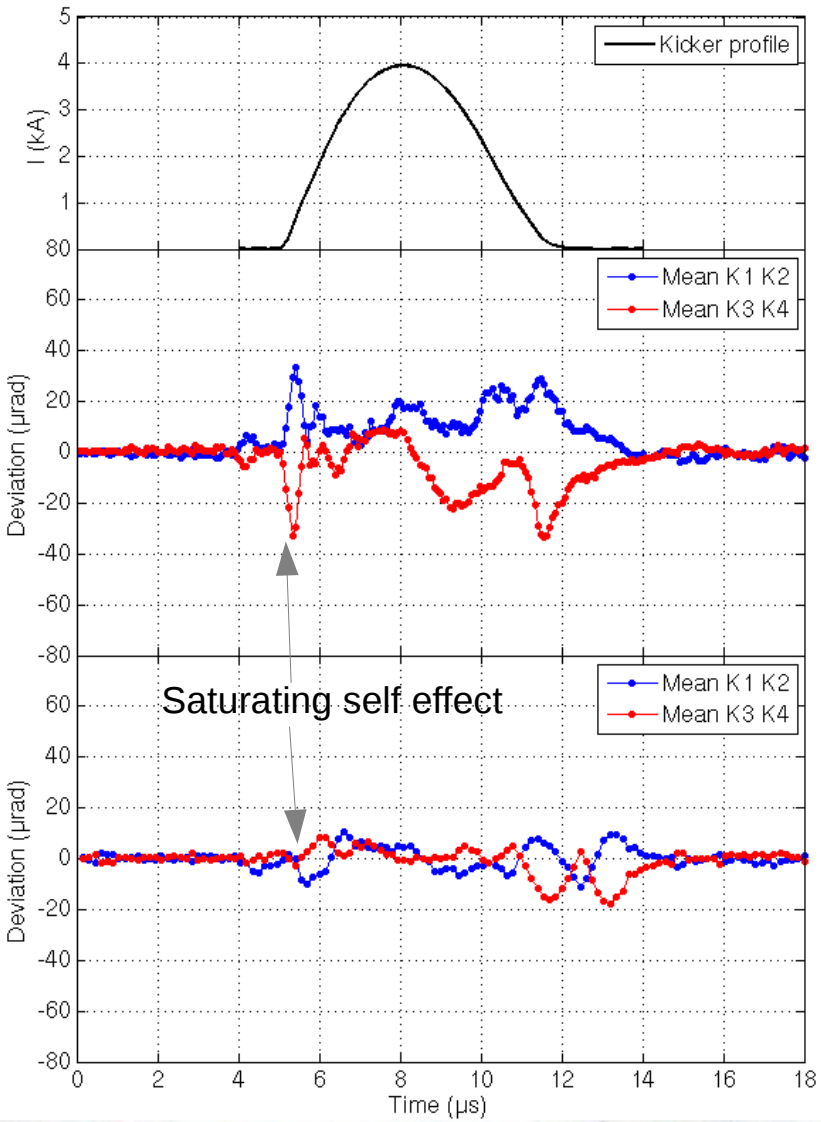
Ring filled with 1 quarter
Kicker pulse duration over 6 turns

Voltage correction

Timing correction

Need duration correction
==> Pulser modification

Kicker pulse profile investigation



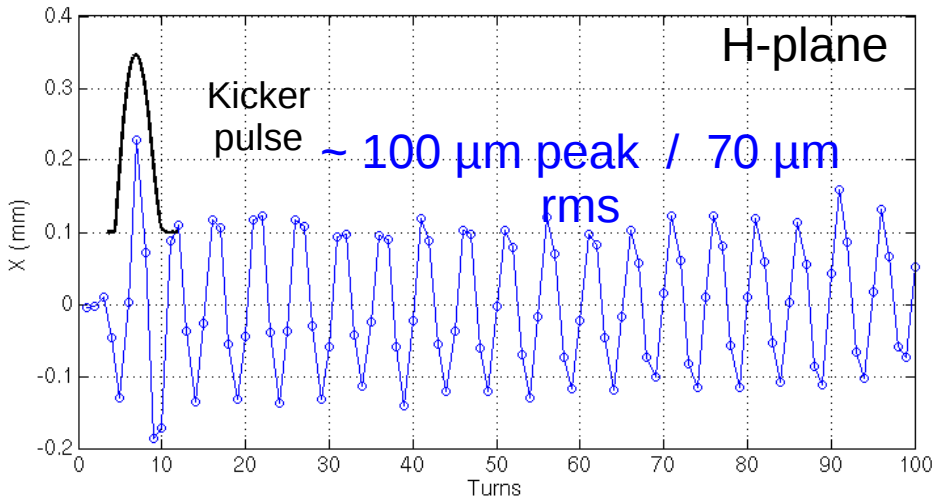
Optimization based on :
Saturating self
Parallel capacitor

2007 optimization
30 µrad residual kicker deviation
0.5% from max deviation

factor 2 to 3 gain

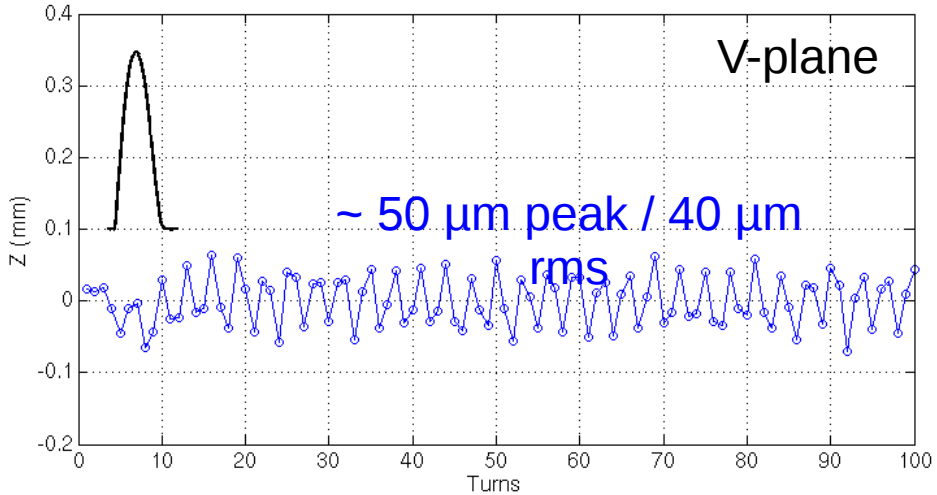
2009 optimization
10 µrad residual kicker deviation
0.2% from max deviation

Kicker pulse profile investigation



β_x = 14 m @ BPM (long straight)
σ_x = 320 µm @ 3.7 nm

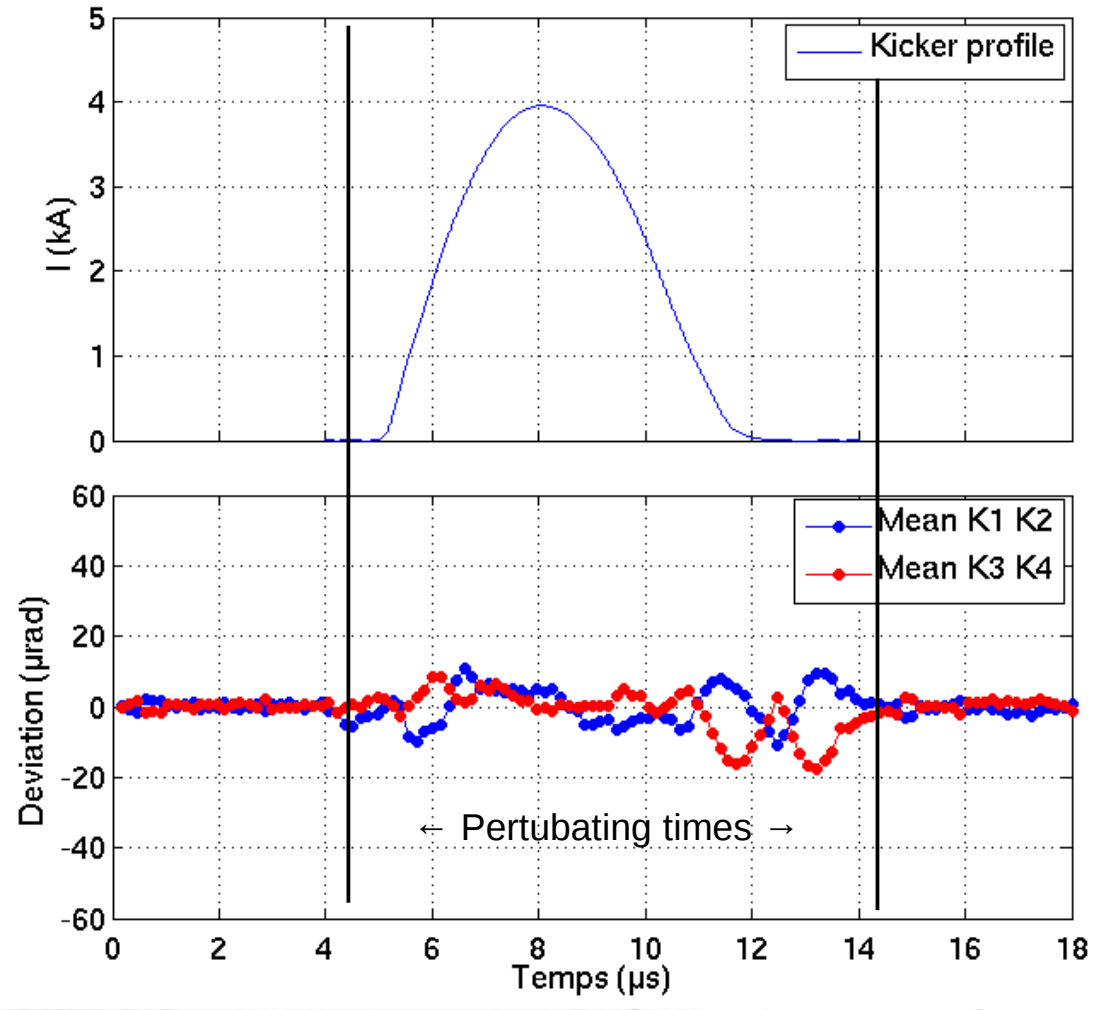
70 µm rms => ~20% of σ_x =>Still larger than 10%



β_z = 12 m @ BPM (long straight)
σ_z = 20 µm @ K=1%

40 µm rms => ~200% of σ_z
==> Very large !

Kicker pulse profile investigation



The perturbation times appears to be much larger than the kicker pulse….

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 ?

Conclusion

Top-Up operation :

- Fully operated since 2009 in all filling pattern modes
- Since 2011, the Top-Up efficiency is about 99.5 %
- Provides a good beam stability (constant thermal load)
- Pre-injection signal gating provided to the beamlines (long integration times)

Residuals Orbits / Oscillations

- We have still about 20% in Hor. and 200% in Vert. plane beam size perturbations
- Beamlines presently don't complain from these perturbations
- A NLK (à la BESSY) is under construction in the frame of SOLEIL / MAXIV collaboration. Installation is planned in 2018.
- A feedforward (feedback?) will be necessary, at least in the vertical plane, to reduce these oscillations toward 10% beam size : under investigation

Thank you for your attention