OPERATION AND RELIABILITY OF THE ALBA KICKER MAGNETS

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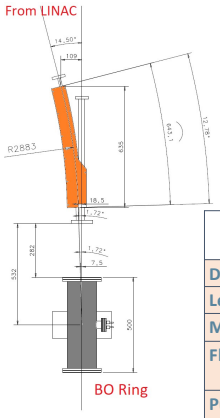
The pulsed magnets of the ALBA Synchrotron consist of 3 Septa, 2 thyratron-driven Kickers and 4 thyristor-driven Kickers. Along the years, efforts to enhance the ALBA pulsed magnets performance and reliability have been devoted, resulting in an improvement of the LINAC-to-Booster and Booster-to-Storage beam transmission efficiency and its Mean Time Between Failures (MTBF). The performance enhancement has been achieved thanks to online feedback and control routines of the pulse signals correlated with the beam position and energy, but also by the incorporation of regular preventive hardware maintenance procedures, most of them created after our own experience with degradation of the components, few of them implemented after replacing obsolete parts requiring different maintenance routines.

Booster and Storage Ring injection schemes

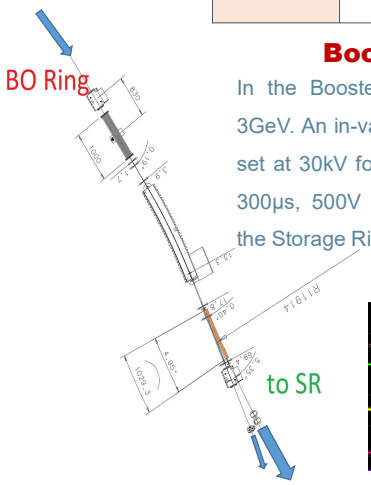
Booster Injection



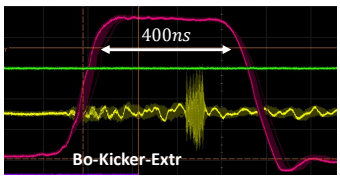
The 110MeV electron beam from the Linac is injected into the Booster Ring by means of a 210μs, 84V Septum followed by an in-vacuum thyratron-driven Kicker set at 15kV.

	Booster Injection Kicker	Booster Extraction Kicker
Deflection	$33mrad$	$3.35mrad$
Length	$400mm$	$900mm$
Magnet layout	In-vacuum C-shape with ferrite plates	
Flat Top Pulse	$\tau = 0.4\mu s\ V = 12.9kV$ $B = 0.003T$	$\tau = 0.4\mu s$ V $= 26.3kV$ $B = 0.037T$
Pulse Forming Network	7 (KiInj) or 9 (KiExt) cells of capacitors of $C = 1.7nF\ V = 50kV$ and inductances $L_{KiInj} = 0.4\mu H, L_{KiExt} = 0.5\mu H$ Installed under the magnet.	
Thyratron	Teledyne E2V CX2610 $V_{peak} = 55kV$ $I_{peak} = 10kA$	

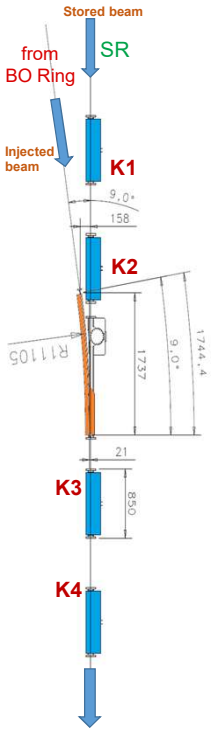
Booster Extraction



In the Booster the beam is accelerated up to 3GeV. An in-vacuum 0.4μs thyratron-driven Kicker set at 30kV followed by a bending magnet and a 300μs, 500V Septum extract the beam towards the Storage Ring.



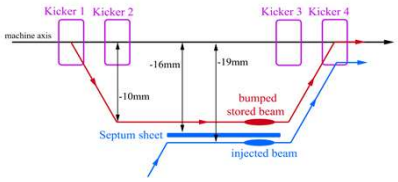
Storage Ring Injection

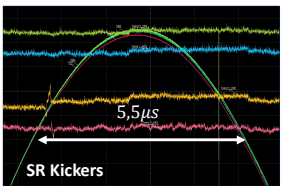


The injection to the Storage Ring is done by a chicane composed by four thyristor-driven identical Kickers and one Septum. The kickers consist of a ceramic vacuum chamber with a 400 nm Ti coating layer.

i. The stored beam is displaced 22mm from the nominal orbit by the first two kickers.
ii. Injected beam merge with the stored beam with the help of a 360μs 600V Septum.
iii. The last two kickers return the stored and the injected beam into the nominal orbit.

	Storage Ring Injection Kickers
Deflection	$\pm 7mrad$
Length	$680mm$
Magnet layout	Outside vacuum C-shape with ferrite plates.
Ti coating	$b = 400nm\ P_{loss} = 65W$ $\frac{B_{max}}{B_0} = 97\%\ \tau_{delay} = 200ns$
Half Sine Pulse	$\tau = 5.5\mu s, V = 10kV, B = 0.129T$
Thyristors 4 in series	ABB SPY 15F4502 $V_{peak} = 4.5kV, I_{peak} = 24kA$
Ti coating	$b = 400nm\ P_{loss} = 65W$ $\frac{B_{max}}{B_0} = 97\%\ \tau_{delay} = 200ns$





Pulsed Magnets impact on Storage Ring performance

Since 2019: **12 hours** with no beam stored at Storage Ring due to a pulse magnet incident and **4 incidences** that did not allow reinjecting for long time (>40 min).

Main hardware failures:

– At magnet cabinets (inside the tunnel):
  • Driver board inside the SR-Kickers failures due to degraded integrated circuits or burned low voltage power supplies. Radiation shielding has been improved.
  • Thyratron degradation of the thyratron-diven Booster Kickers resulting in a degradation of the flat top of the pulse which shows thermal drifts and jitter.
– At the magnets (inside the tunnel):
  • RF-fingers deformation of the SR-Kickers, causing beam block. They have been all removed and no heating problems have been observed.
– At control system (outside the tunnel): degraded contactors, PLC and safety relais inside the Control Units.

Hardware maintenance and upgrades:

– Preventive hardware electronics renovation: contactors, integrated circuits and small power supplies are replaced every 4 years at the magnet cabinets driver boards and at the Control Units. We observed their live cycle is between 5 and 6 years.
– Thyratron replacement when jitter is too high (> 100ns): performance shows a degradation after 5 years in use.
– Cooling and radiation shielding improvements.
– Implementation of data acquisition and online feedback control routines that help optimizing in real time pulse variations to recover beam injection efficiency.

M. Pont et al., "Septum and Kicker magnets for the ALBA booster and Storage Ring", in Proc. IPAC'11, San Sebastián, Spain, 2011, pp. 2421-2422.

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