Cleaning of Parasitic Bunches in Booster Rings

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Why?

- Arbitrary patterns with high purity
- Compatibility with top-off

  (Compatibility top-off "2 bunches")
- Cleaning at lower energies

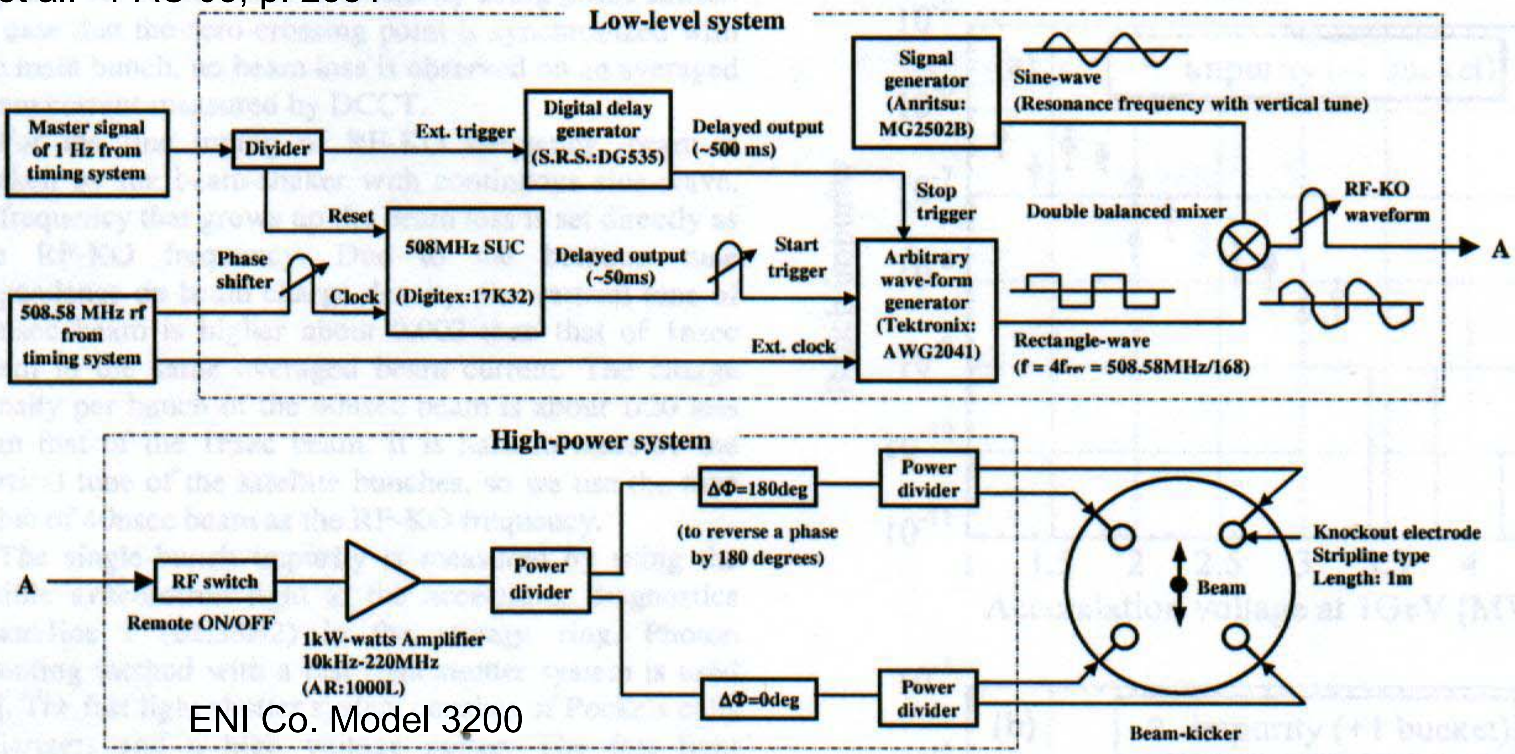
Necessary Conditions

Parasitic bunches have to be generated only during the injection of the booster or in the first phase of the energy ramping (before cleaning)

No leakage during the final part of the energy ramping (after cleaning) and during the storage ring injection

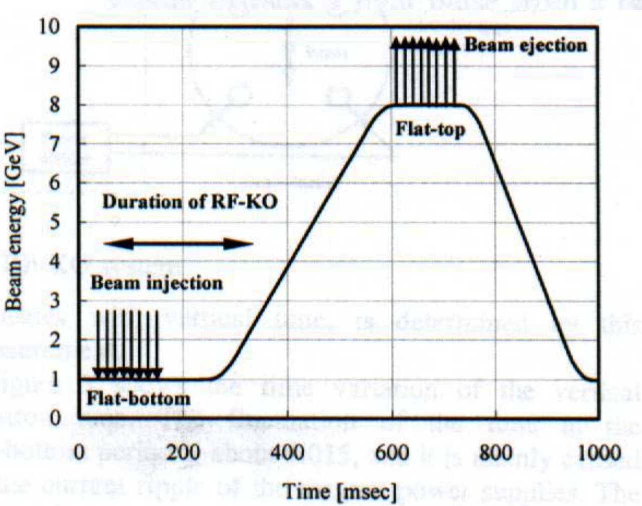
SPRING 8 Case

T. Aoki et al. - PAC 03, p. 2551

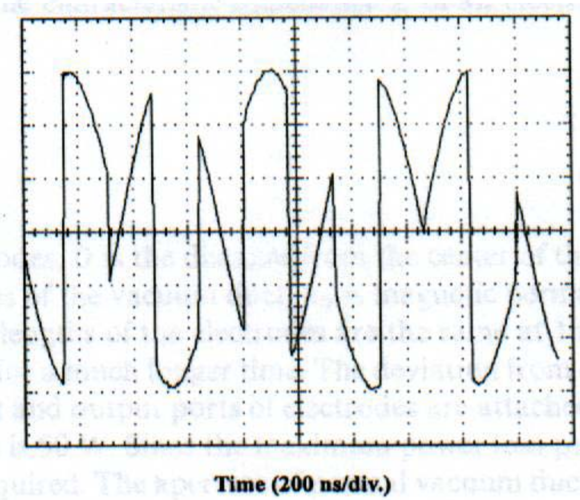


ENI Co. Model 3200

re 2: Block diagram of RF-KO system



Purity < 10^{-6}

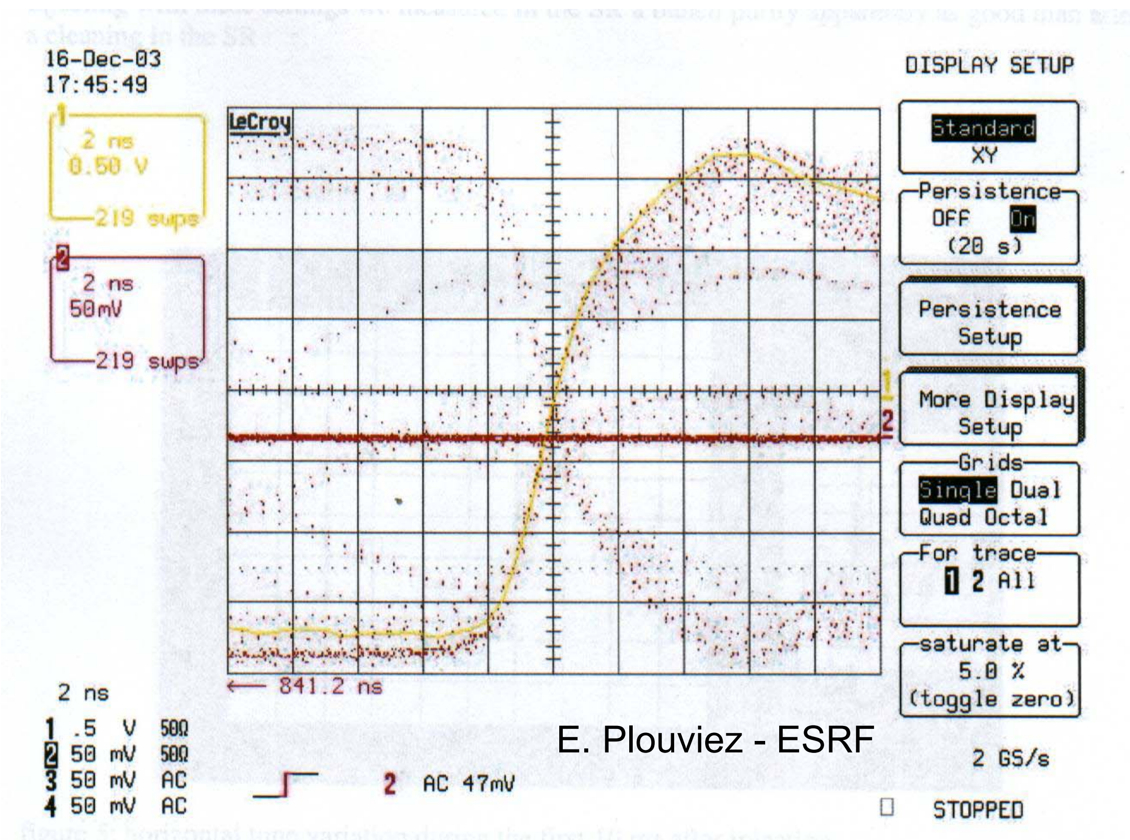


ESRF Case: Cleaning During Ramping

ESRF:
f_{RF} = 352.2 MHz
f_{Cl} =180.0 kHz
10 Hz Injec. Rate
Injec. Energy = 200 MeV
Extrac. Energy = 6 GeV

Ec = 300 MeV ~ 5ms after injection
Chromaticity & Tune optimized at 300 MeV
Continuous excitation

Purity < 10^{-6}



E. Plouviez - ESRF

2 Amplifiers:
RFPA
100 W
0.1 - 200 MHz

and BESSY II ...

Power Requirement

H. Suzuki et al, NIM A 444 (2000) 515-533:

$$\Delta z \cong \frac{1}{2} \frac{\Delta\theta \frac{\tau_d}{T_0} (\beta_K \beta_{MAX})^{1/2}}{\left[1 + \left(2\pi \frac{\tau_d}{T_0} \Delta\nu_z \right)^2 \right]^{1/2}} \qquad z = x, y$$

$\tau_d >> T_0$:

$$\Delta z \sim \frac{\Delta\theta (\beta_K \beta_{MAX})^{1/2}}{4\pi \Delta\nu_z} \qquad z = x, y$$

$$\Delta\theta_y = \frac{2e}{\gamma mc} B_x L$$

Stripline Kicker:

$$B_x = \frac{\mu_0}{\sqrt{2}\pi} \frac{1}{D} \left(1 - \frac{D^2}{R^2} \right) I$$

$$P = Z I^2$$

Stripline Kicker

$$B_x = \frac{\mu_0}{\sqrt{2}\pi}\frac{1}{D}\left(1 - \frac{D^2}{R^2}\right) I$$

$D = 46.1$ mm
$R = 60.0$ mm
$Z = 50\ \Omega$

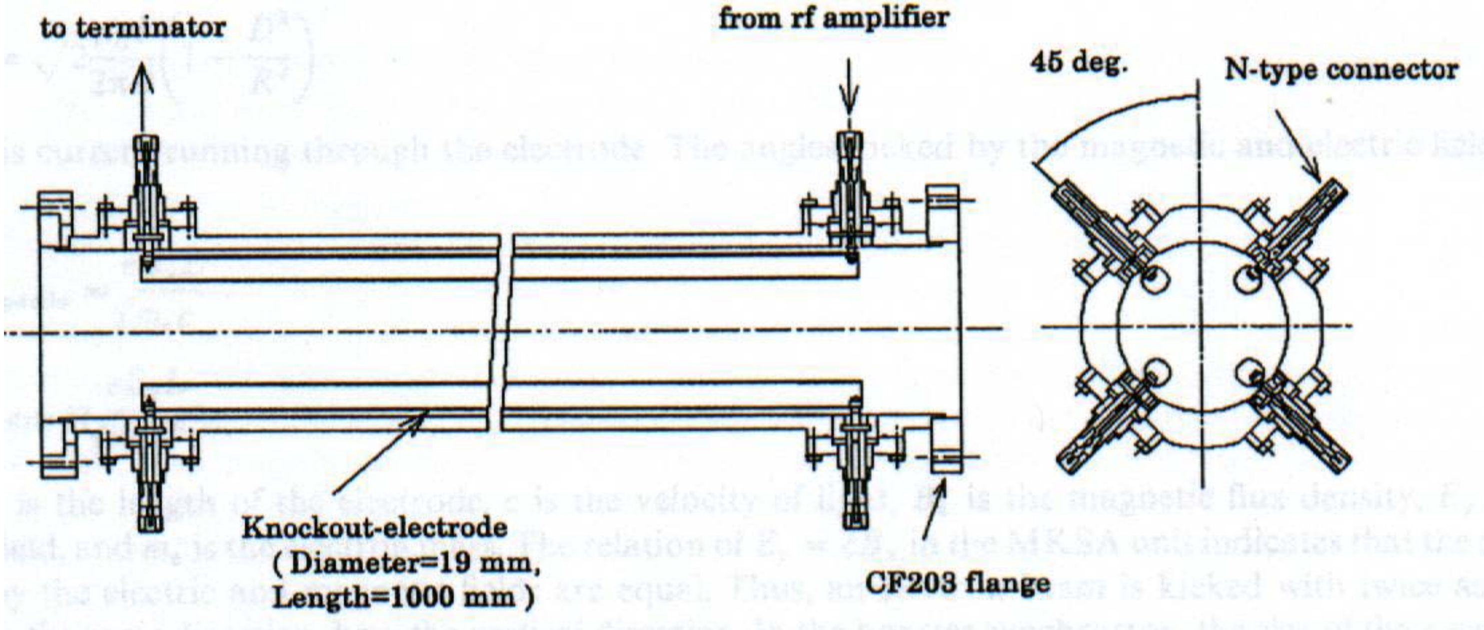


Fig. 6. Cross-sectional view of RFKO electrodes.

H. Suzuki - Spring 8

ALS Booster Case: Amplifier Power

$T_0 = 250.2$ ns

$\tau_T \sim 800$ ms @ 300 MeV

$\beta_{MAX} = 11.6\ /\ 11.6$ m $\left(x/y\right)$

$\Delta z_{VC} = 30.0\ /\ 22.0$ mm (x/y)

$\nu'_{z0} = -10.51\ /\ -4.810$ (x/y)

$\beta_{MAX} = \beta_K = 11.6$ m

$\Delta y_{VC} = 22.0$ mm

$\frac{\Delta E}{E} \sim 1\times10^{-4}$ @ 300 MeV

$\tau_L \sim 400$ ms @ 300 MeV

$\nu'_y = \pm 0.1 \Rightarrow \Delta\nu_y\left(\Delta p/p = 0.005\right) \sim 5\times10^{-4}$

$$\Delta\theta_y\left(\Delta\nu_y = 0.0005\right) \sim 12\ \mu\text{rad}$$

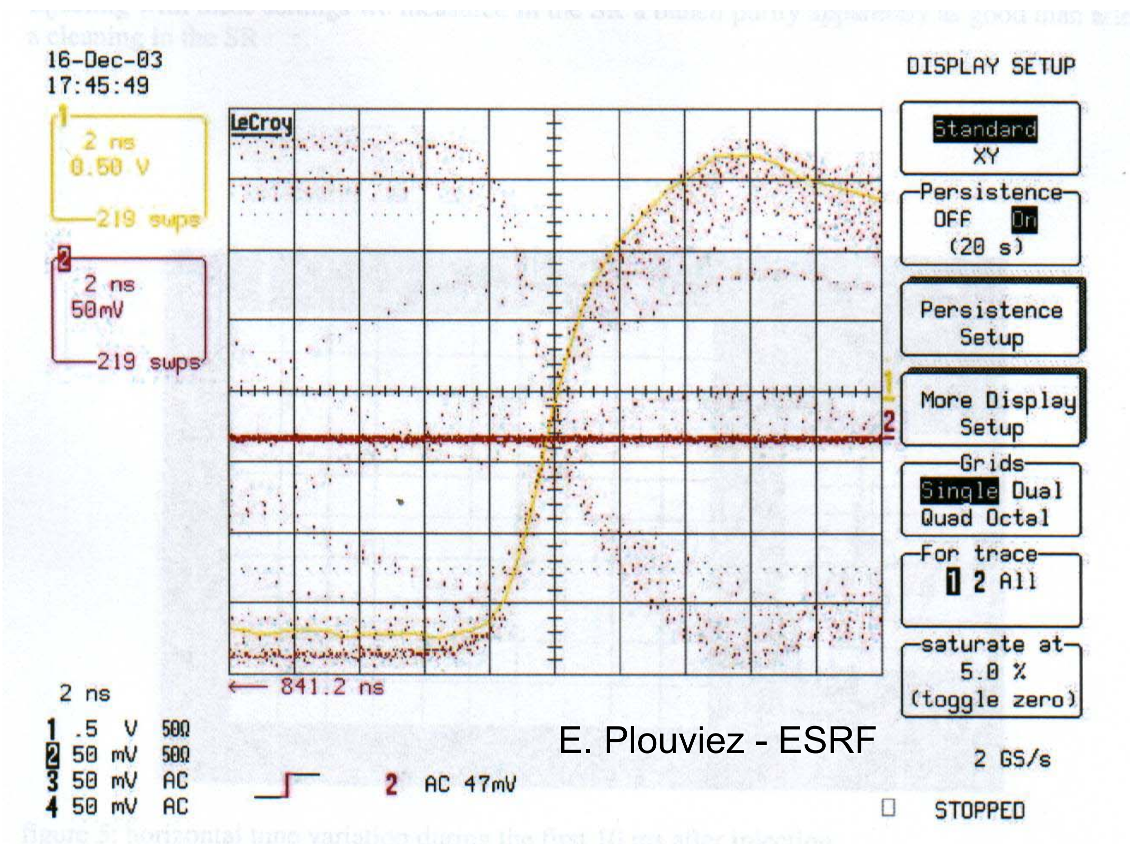
$$B_x L \sim 6\times10^{-6}\ \text{Tm @ 300 MeV}$$

$$L = .55\ \text{m} \Rightarrow B_x \sim 1.1\times10^{-5}\ \text{T}$$

$$I \sim 4.3\ \text{A} \Rightarrow P = ZI^2 \sim 93\ \text{W}$$

ALS Booster Case: Amplifier Bandwidth

$$\tau_{Rise} \leq 1.6 \text{ ns} \quad \Rightarrow \quad BW \sim 200 \text{ MHz}$$



E. Plouviez - ESRF

ALS Booster Case: Synchrotron Frequency Excitation

$$f_0 = 3.997 \text{ MHz}$$

$$\nu_x = 6.264$$

$$\nu_y = 2.789$$

$$f_{\beta x} = \begin{cases} (n + 0.264) f_0 \\ ((n+1) - 0.264) f_0 \end{cases} \quad (n = 0, 1, 2, \ldots.) \quad \Rightarrow \quad f_{\beta x} = 1.055 \text{ MHz}$$

$$f_{\beta y} = \begin{cases} (n + 0.789) f_0 \\ ((n+1) - 0.789) f_0 \end{cases} \quad (n = 0, 1, 2, \ldots.) \quad \Rightarrow \quad \boxed{f_{\beta y} = 0.843 \text{ MHz}}$$

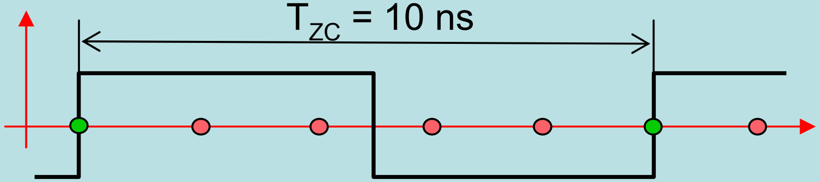
ALS Booster Case: Zero crossing signal

Square Wave (equispaced bunches):

$1\ bunch\quad f_{ZC} = f_0 \sim 4\ \text{MHz}$

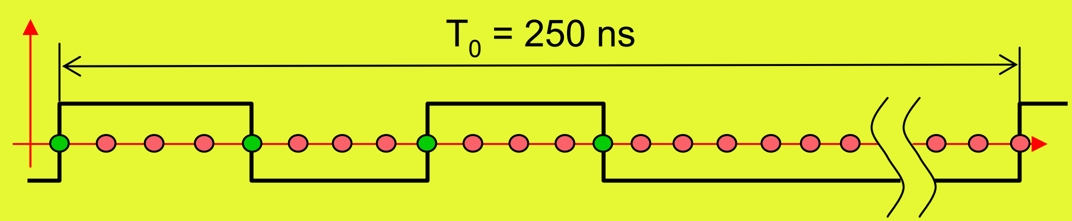
$5\ bunches\quad f_{ZC} = 5f_0 \sim 20\ \text{MHz}$

$25\ bunches\quad f_{ZC} = 25f_0 \sim 100\ \text{MHz}$



Arbitrary Function Generator with BW > 500 MHz

Example: Booster multibunch injection:
4 bunches from the linac



Main Components & Requirements

- 200 W, 200 MHz BW class A Amplifier (TFB spare?)
- Stripline Kicker (TWE ?)
- Tune pickup (TWE ?)
- Photon Counting System for the storage ring
- Arbitrary Function Generator with BW > 500 MHz
- Vertical Scraper ?

- Tune measurement system
- Chromaticity correction (~ +/- 0.1)
- Possibility of storing beam in the booster. Characterization and tune of the system.
- Possibility of testing the system in the Storage Ring