



SAPIENZA  
UNIVERSITÀ DI ROMA



# Phase Noise Studies (updates)

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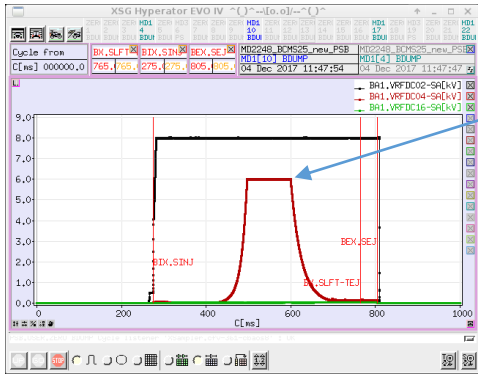


# Motivation

- In the main presentation it was pointed out that RF noise injection in  $h=1$  gives worse results than C16 for BCMS and LHCINDIV beams.
- These two types of beam are currently accelerated in single RF and noise was injected keeping the same configuration.
- The following slides show the obtained new results when the C04 cavity in bunch-lengthening mode (blm) is added during the blow-up.
- This choice was motivated by the fact that noise was successfully applied for LHC25ns, ISOLDE and SFTPRO beams, where C04 is used in operation.

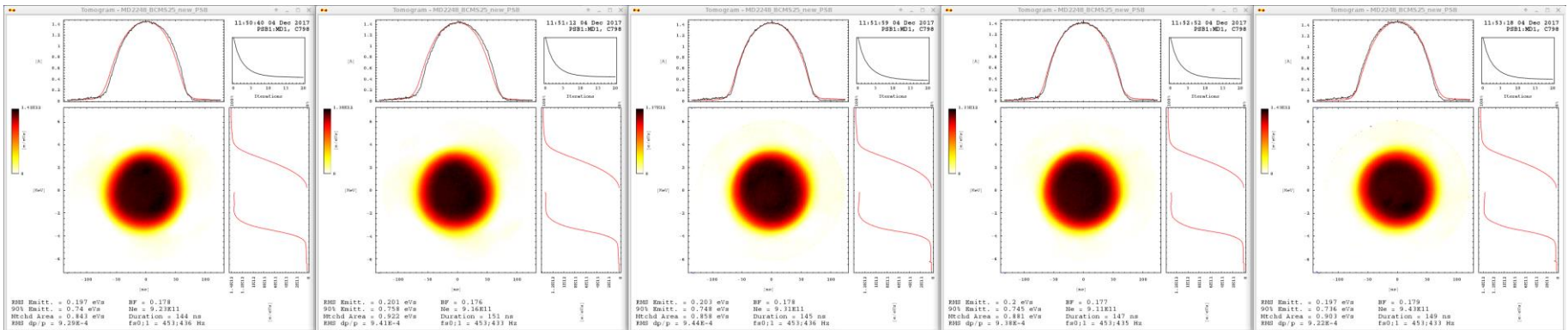
# BCMS

## Voltage programs

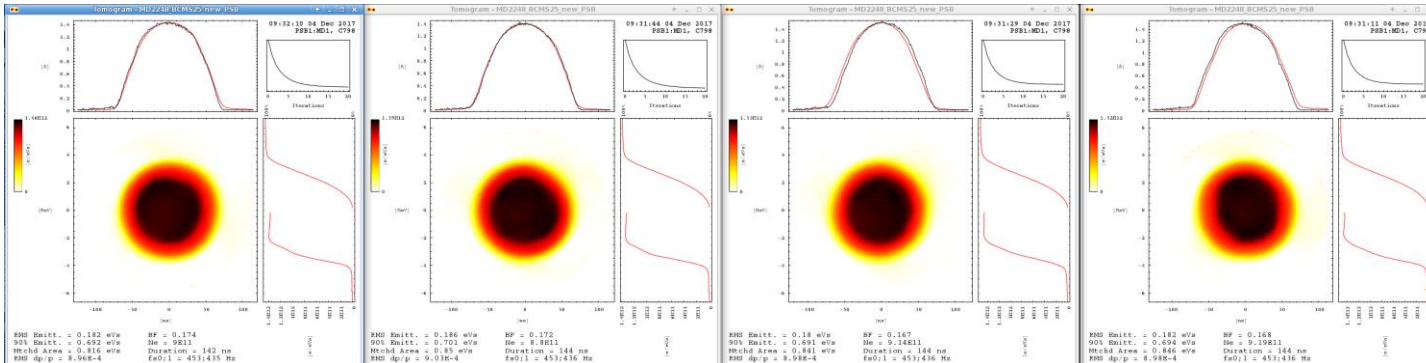


- C04 is added in blm,  $V_{C04} = 6$  kV during C500-C600
- Noise is applied during just 20 ms (50 ms required for C16)
- Quadrupole oscillations excited, constant rms, flat spectrum
- Same results obtained for all four rings.

## Results with noise



## Results with C16



Fixed the matched area, RMS emittance higher with noise!

Noise at least as good as C16

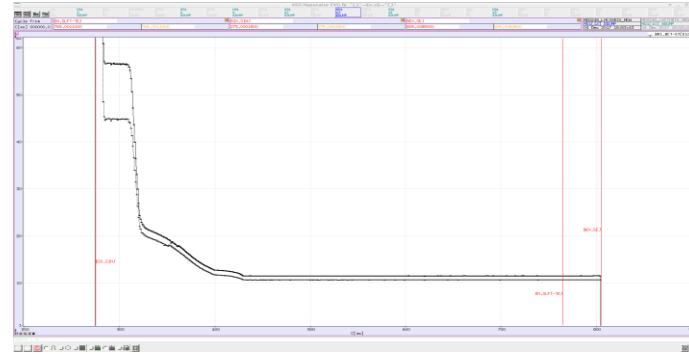
# LHCINDIV (1/6)

- In operation: shaving during C300-C400 with C16 and reduction of longitudinal emittance dropping C02 voltage during next 20 ms

Voltage programs

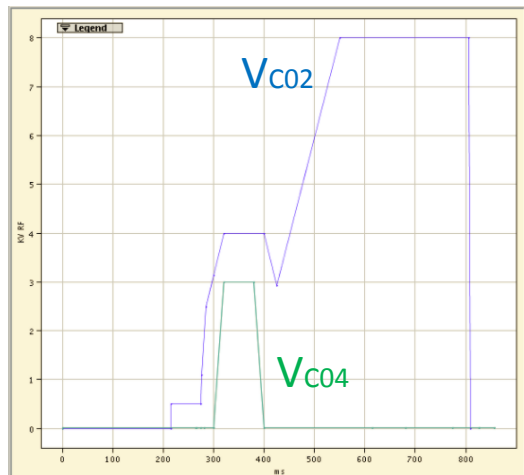


Particles alive

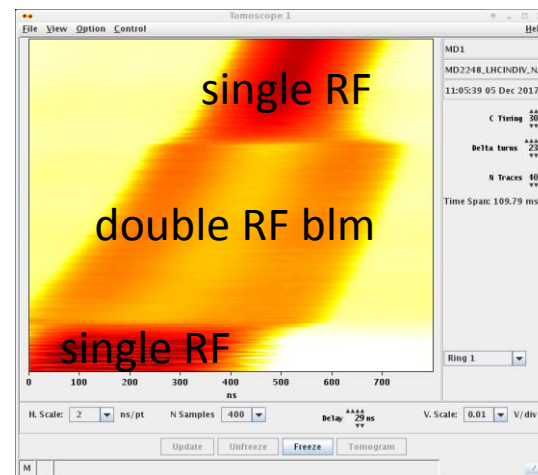


- Double RF in blm with noise: voltages set to 4+3 to have the same ratio as 8+6 (which works very well for all the other beams)

Voltage programs



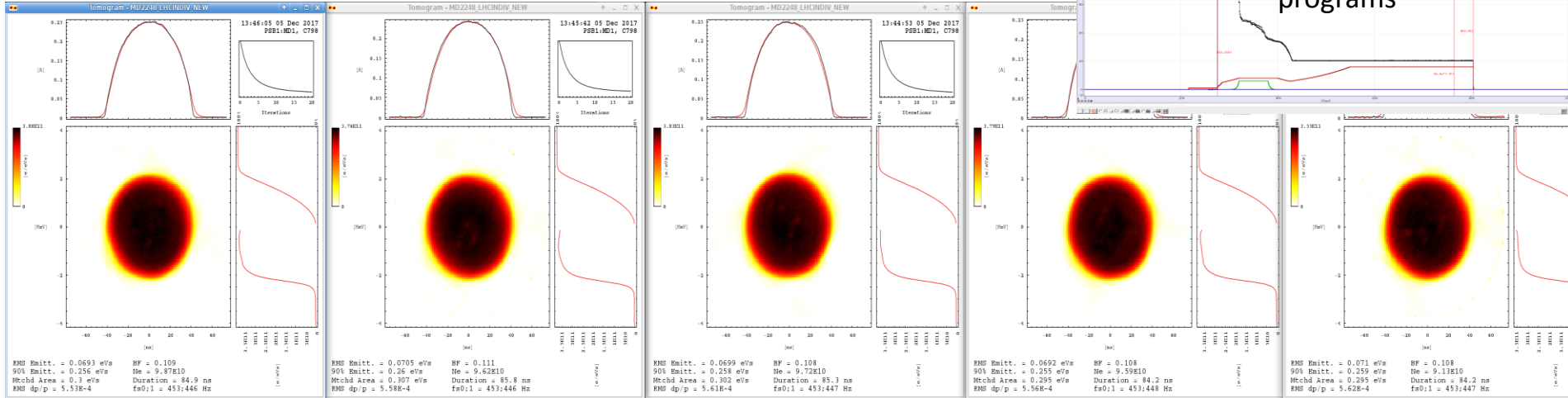
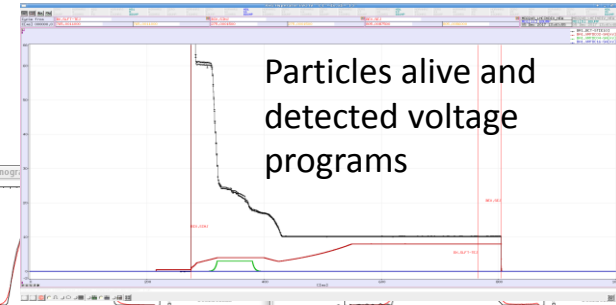
Profile waterfall



# LHCINDIV (2/6)

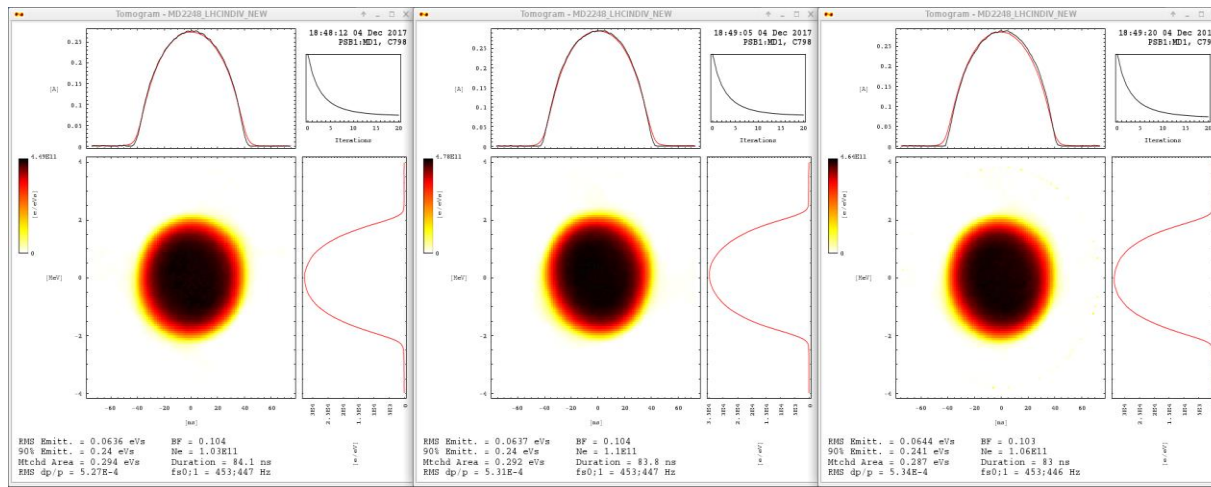
## Results with noise (constant RMS amplitude in C320-C380)

➤  $N=10e10$  ppb and  $\epsilon_L = 0.3$  eVs



## Results with C16

➤  $N=10e10$  ppb and  $\epsilon_L = 0.3$  eVs



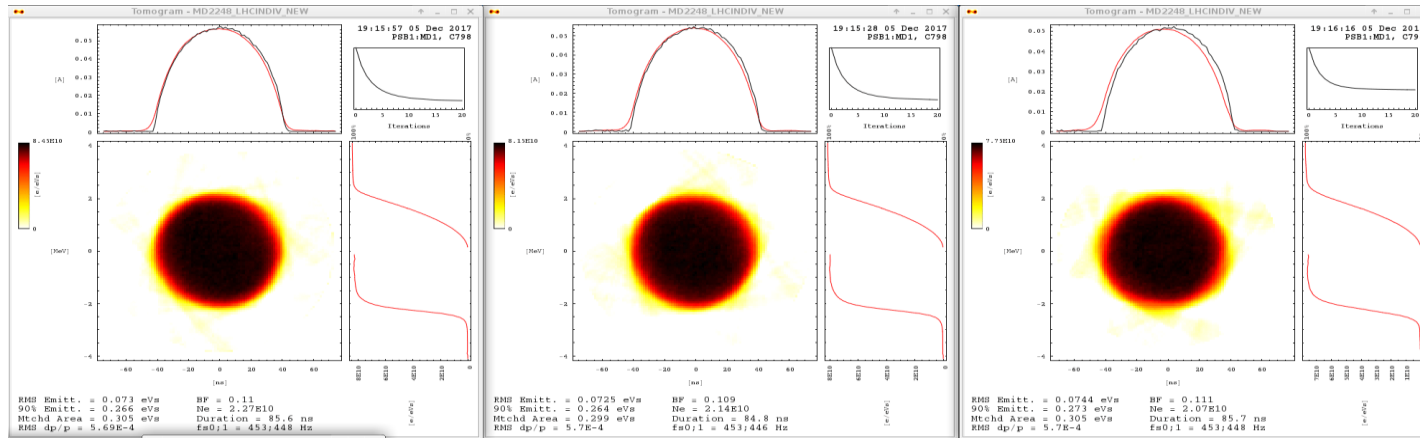
Fixed the matched area, RMS emittance higher with noise!

Noise at least as good as C16

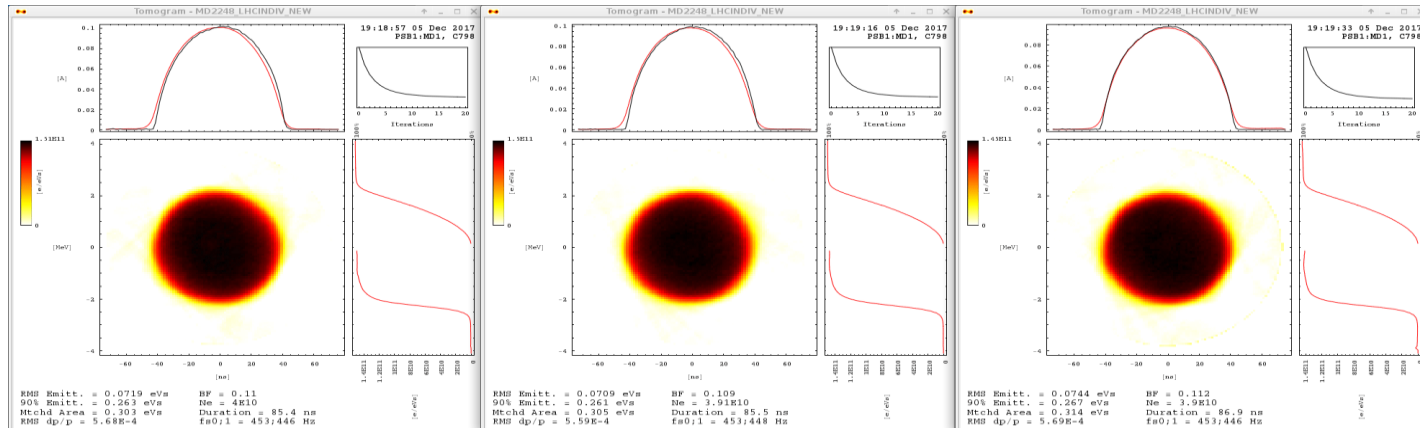
# LHCINDIV (3/6)

## Results with noise (scanning different N)

- First 10 ms with high amplitude noise to lose particles and then lower amplitude to smoothly blow-up
- $N=2e10$  ppb and  $\epsilon_L = 0.3$  eVs

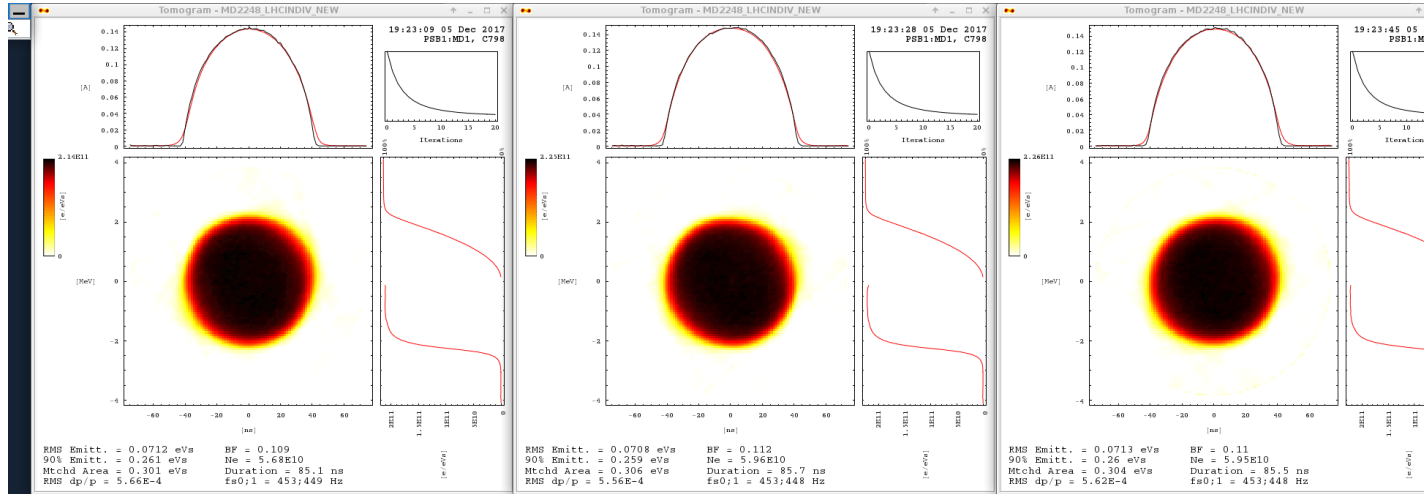


- $N=4e10$  ppb and  $\epsilon_L = 0.3$  eVs ( $\sigma_{noise}^{RMS} = 0.49$  rad in C320-C330)

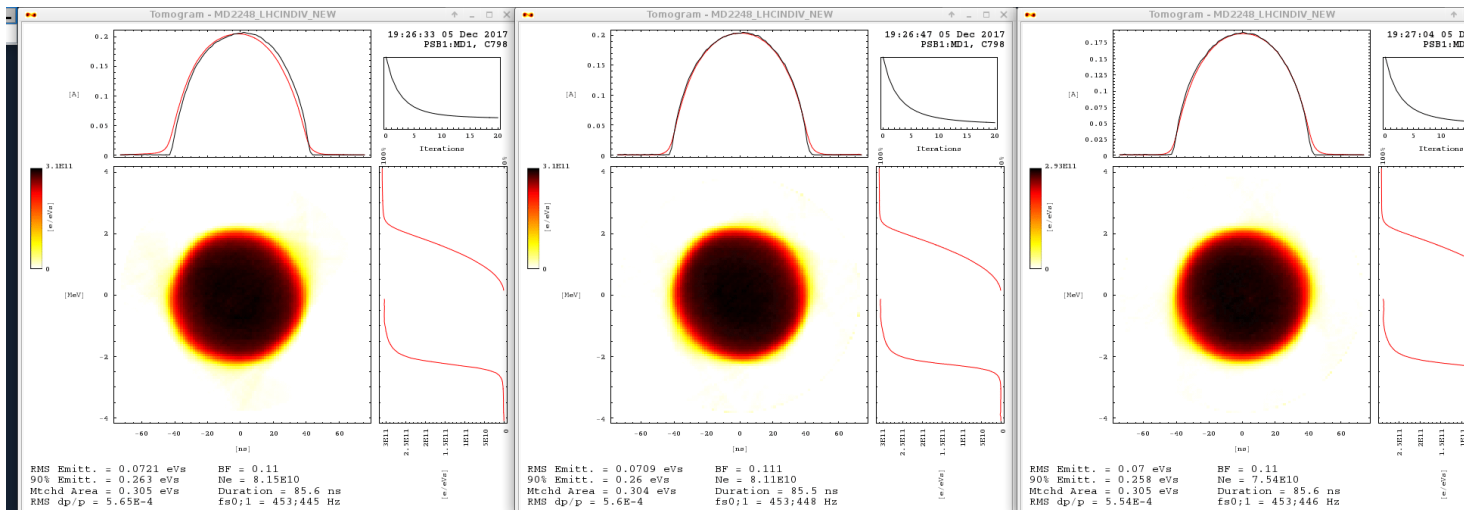


# LHCINDIV (4/6)

➤  $N=6e10$  ppb and  $\epsilon_L = 0.3$  eVs

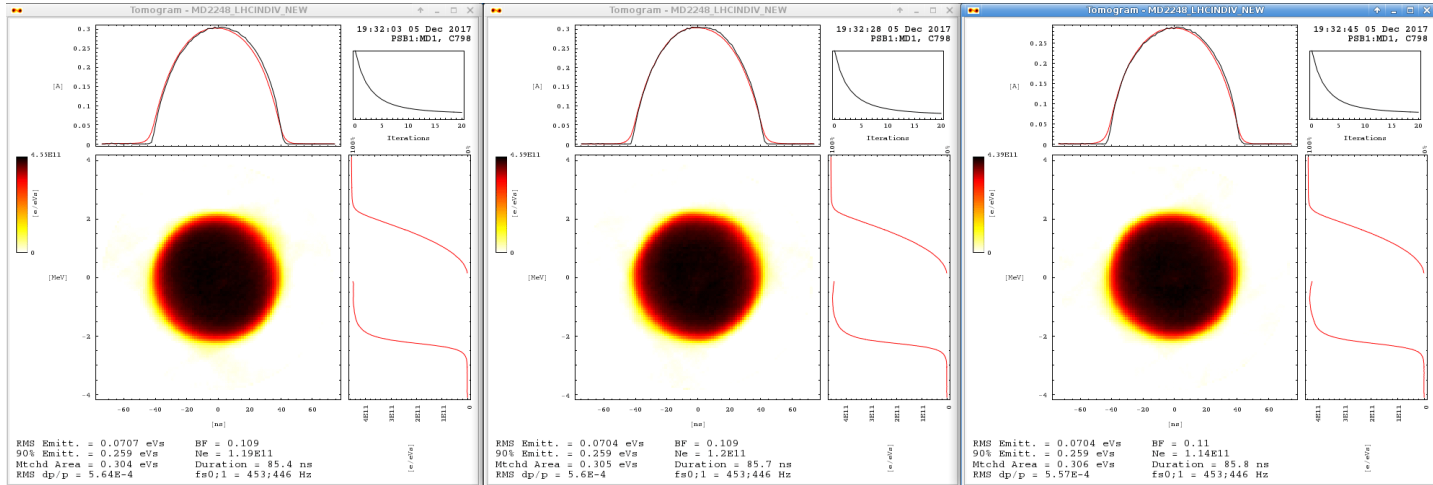


➤  $N=8e10$  ppb and  $\epsilon_L = 0.3$  eVs ( $\sigma_{noise}^{RMS} = 0.39$  rad in C320-C330)

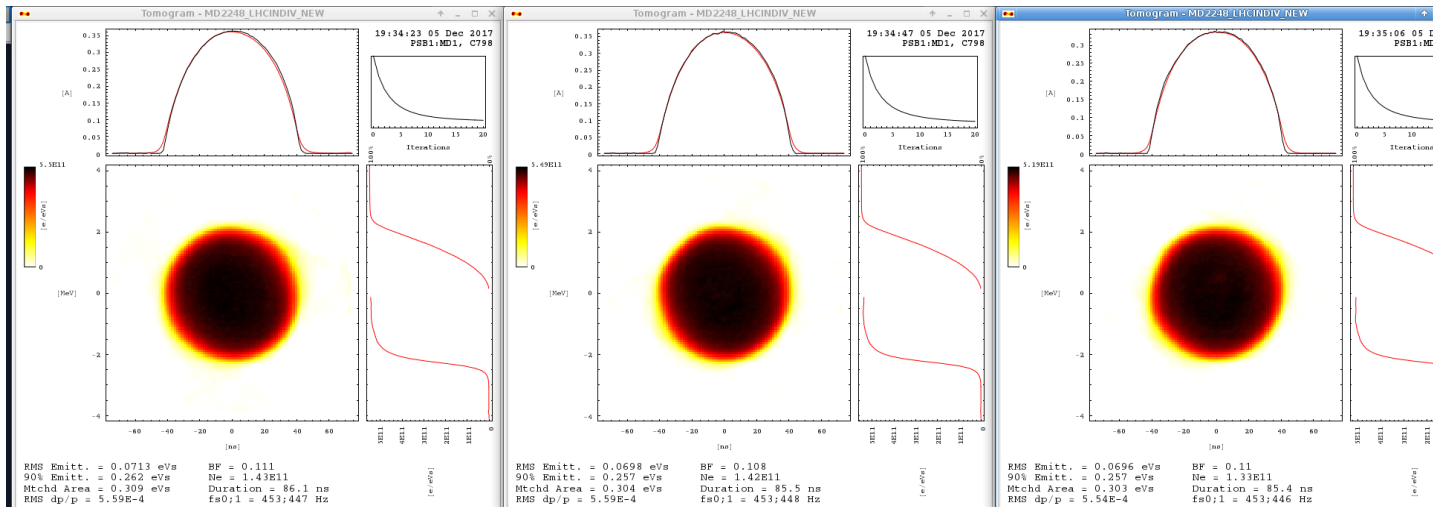


# LHCINDIV (5/6)

➤  $N=12e10$  ppb and  $\epsilon_L = 0.3$  eVs



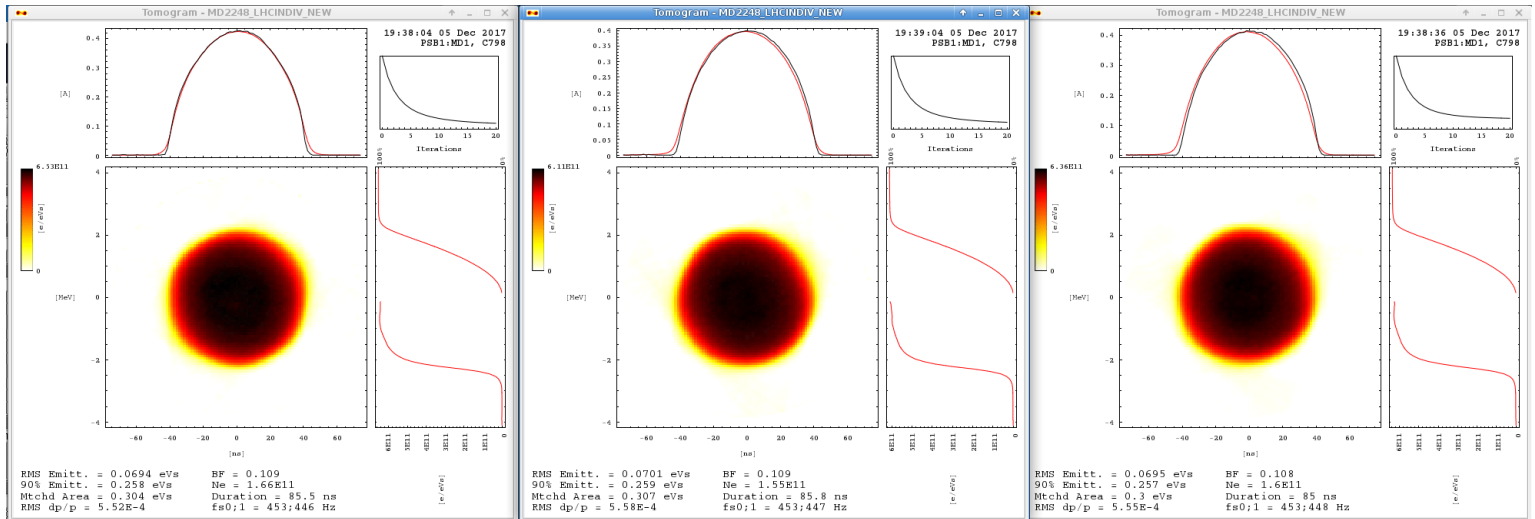
➤  $N=14e10$  ppb and  $\epsilon_L = 0.3$  eVs



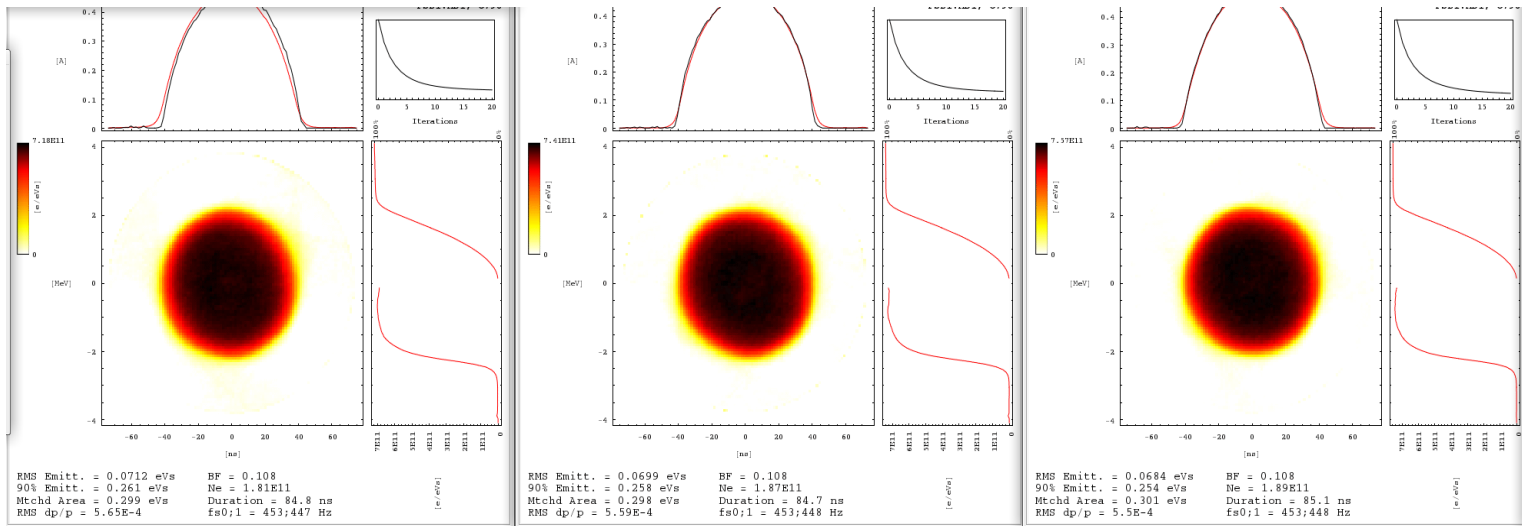


# LHCINDIV (6/6)

➤  $N=16e10$  ppb and  $\epsilon_L = 0.3$  eVs



➤  $N=18e10$  ppb and  $\epsilon_L = 0.3$  eVs



# Conclusion

- RF noise injection in  $h=1$  using C04 in bunch lengthening mode gives results equivalent (or even better) than the one obtained with C16.
- The following beams are concerned: LHC INDIV, BCMS, LHC25ns, ISOLDE and SFTPRO.
- Successes with different intensities, emittances and C-time frames give the noise method enough reliability and flexibility to be a valid alternative to the high frequency modulation given currently by C16.
- Reliability run in 2018 should confirm and establish these positive obtained results.