ELECTRON CLOUD STUDY AT SX OPERATION MODE AT J-PARC MR

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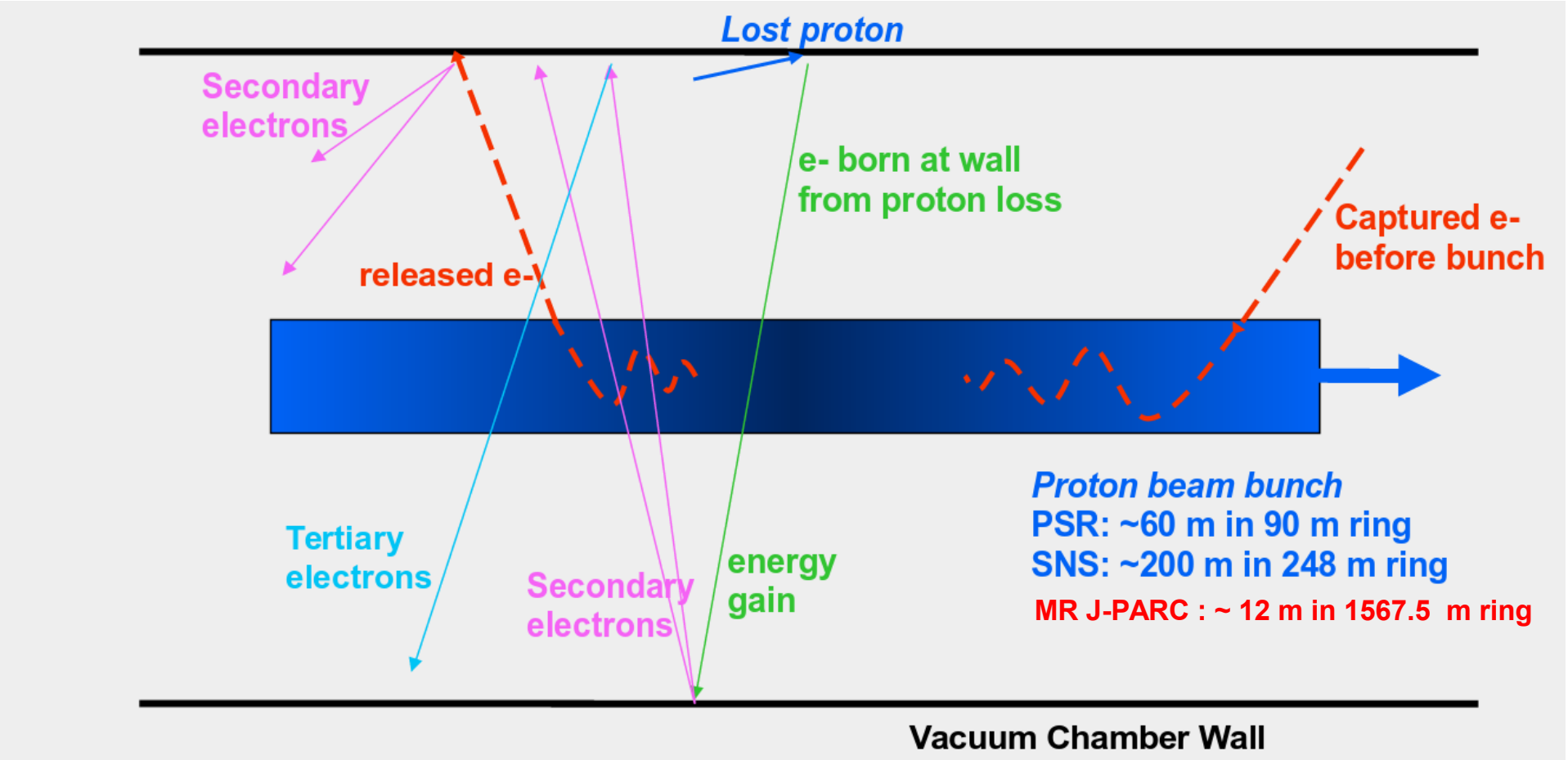
Outline

- Introduction
- Measurements
- Results
- Conclusions & Outlook

Introduction

Electron cloud



Courtesy of Y. Sato et al “Electron Cloud Simulations Using Orbit Code”, Proceedings of the Electron Cloud Conference (2007).

Electron cloud in proton machines

The presence of the electron cloud at the high power proton accelerators represents an important challenge for their satisfactory performance.

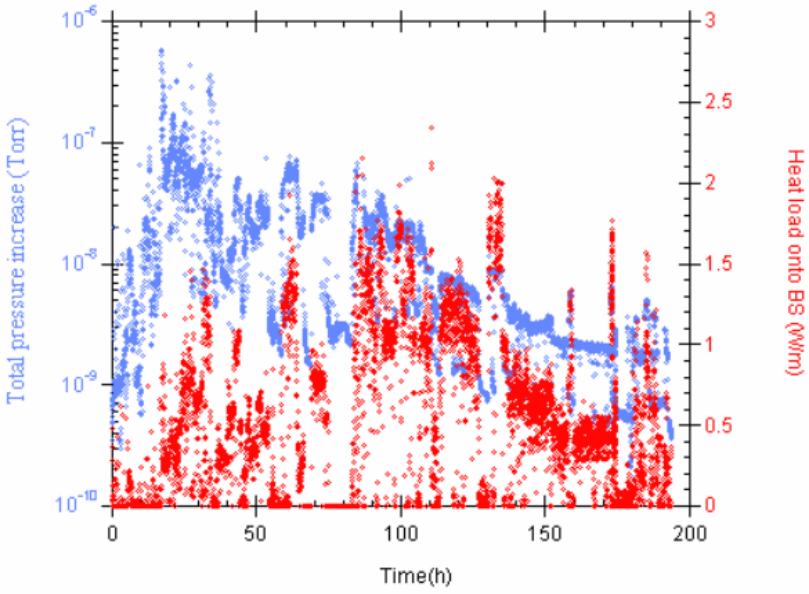
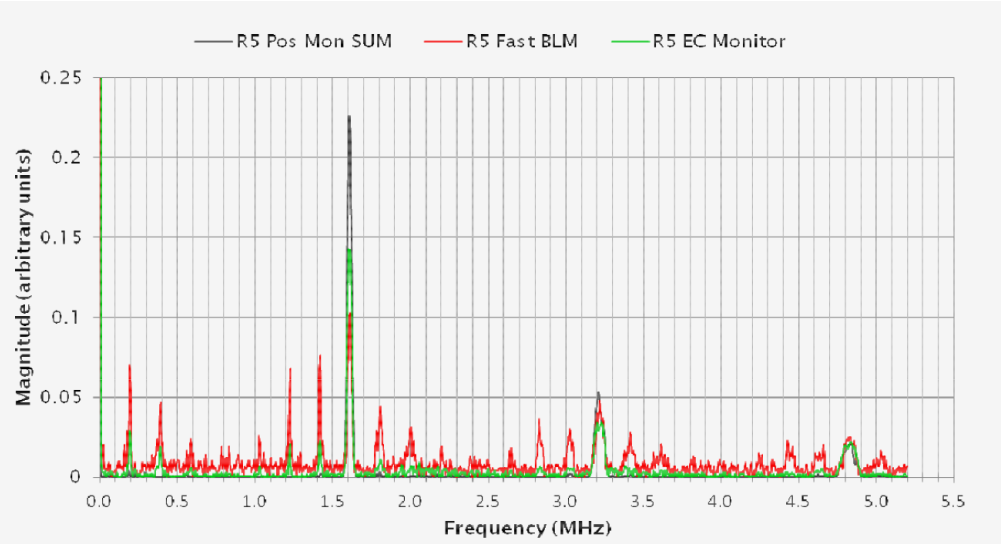


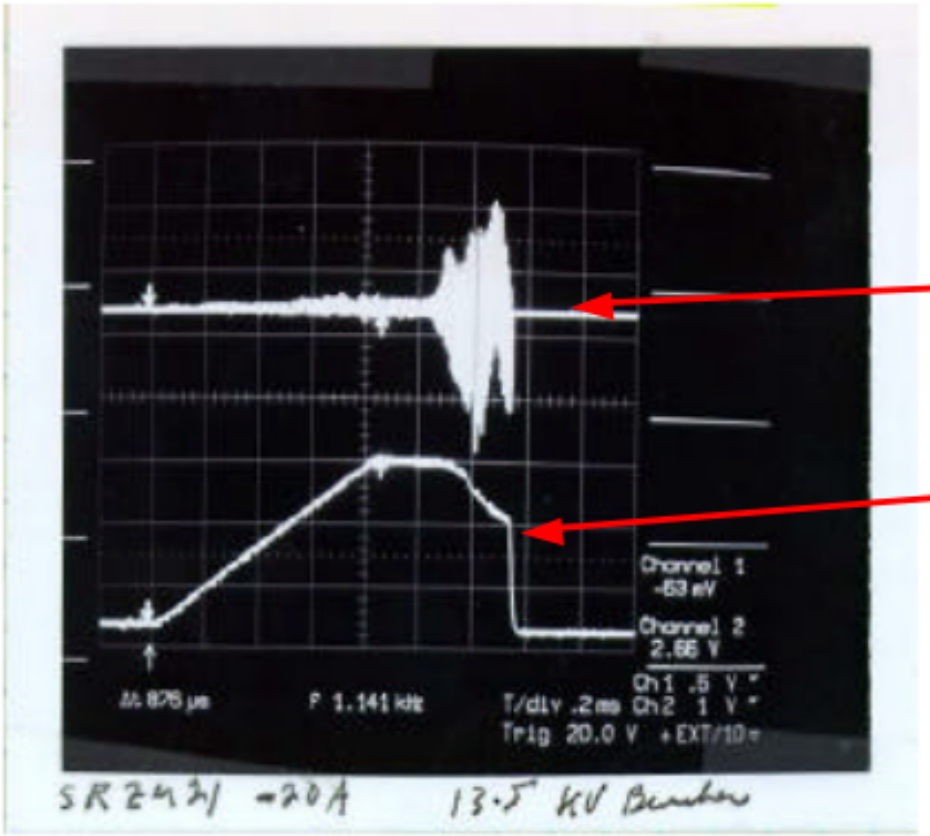
Figure 2 : Raw data of the dynamic pressure in COLDEX and the dissipated heat load onto the beam screen measured during the circulation of the LHC type proton beam in the SPS.

V. Baglin et al, "PRESSURE AND HEAT LOAD IN A LHC TYPE CRYOGENIC VACUUM SYSTEM SUBJECTED TO ELECTRON CLOUD," Proceedings of the Electron Cloud conference (2004)



A. Pertica, "Electron Cloud Observation at the ISIS Proton Synchrotron", Proceedings of the Electron Cloud Conference (2012)

Beam instability



Instability signals

BPM ΔV signal

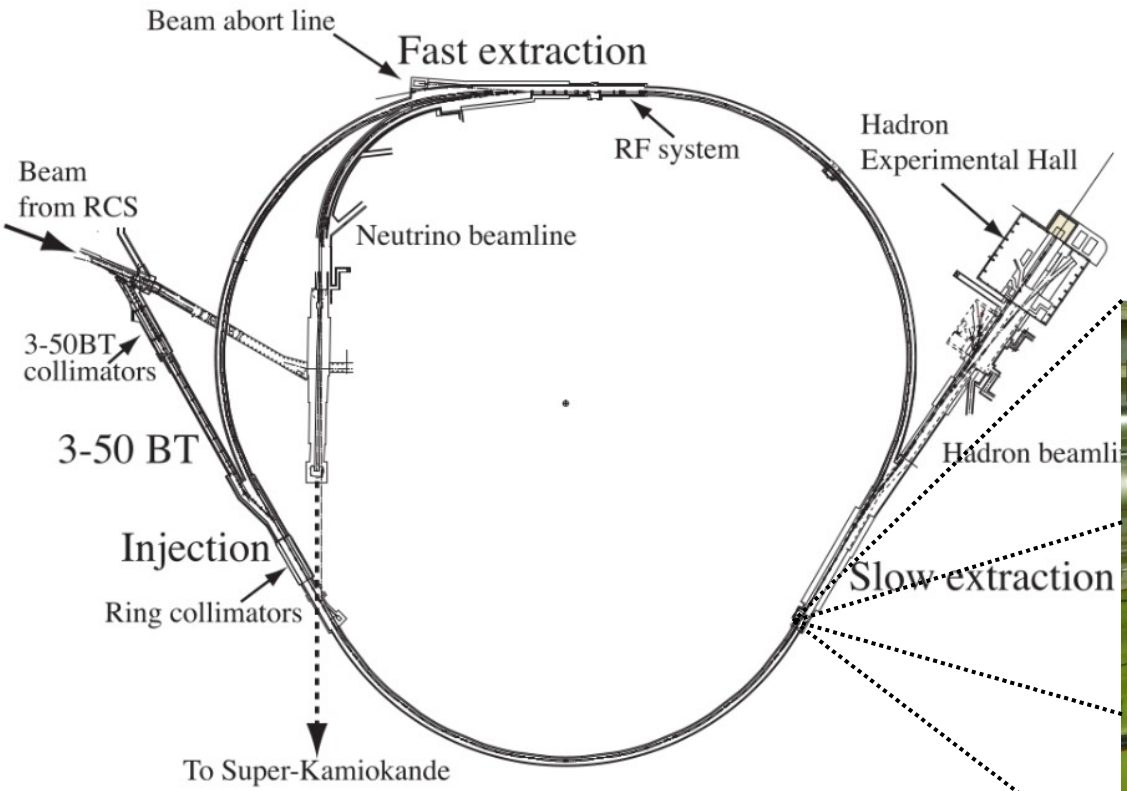
CM42 (4.2 μC) (Circulating Beam Current)

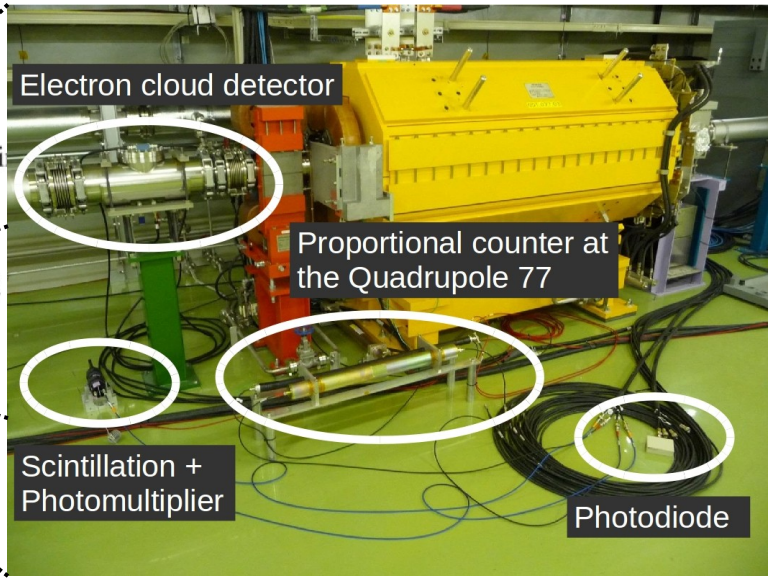
8

pulse)

J. Wei et al .,"Electron-cloud Effects in High-intesity Proton Accelerators" Proceding of the Electron Cloud conferences (2002).

J-PARC MR





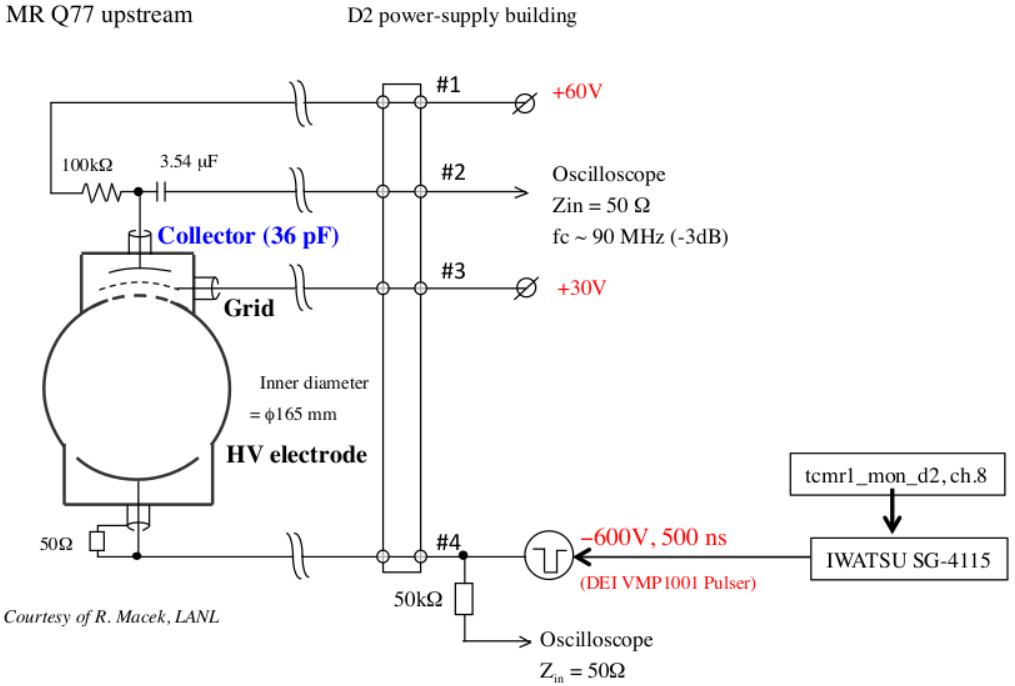
T. Koseki et al., Progress of Theoretical and Experimental Physics 2012, 02B004 (2012)

Detector System

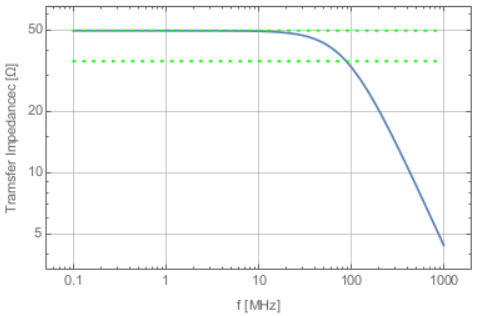
Severals systems are used to measure direct and indirect the presence of the electron cloud:

- Beam position monitors
- Scintillators plus photomultiplier detectors
- Ion and Cold cathode gauges
- Fast current transform and wall current monitors.
- Sweeping electron detector

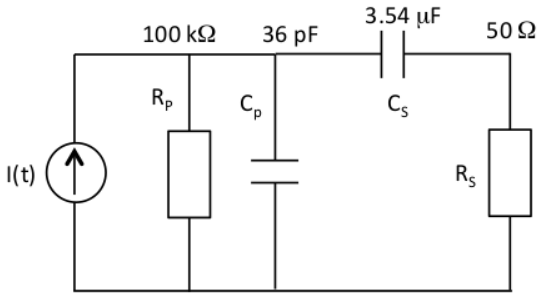
Sweeping Electron Detector



Higher frequencies

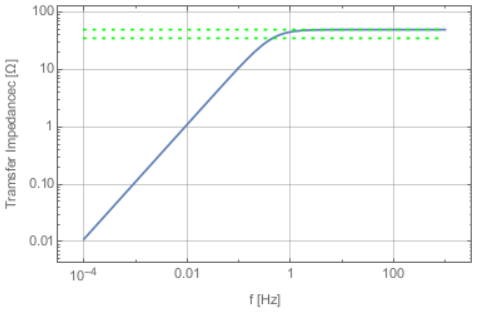


Equivalent circuit



$$V_R(t) = \frac{R_S}{1 + j\omega C_P R_S + \frac{C_P}{C_S} + \frac{R_S}{R_P} + \frac{1}{j\omega C_S R_P}}$$

Lower frequencies



Previous studies

Simulations studies:

- K. Ohmi et al., Phys. Rev. ST Accel. Beams 5, 114402 (2002).
- K. Ohmi et al., “Study of ep instability for a Coasting Proton Beam in Circular Accelerators”, Proceedings of the Particle Accelerator Conference (2010).
- T. Toyama et al., “Electron Cloud Effects in the J-PARC Rings and Related Topics”, Proceedings of ECLOUD Vol. 4 (2004).

Measurements surveys:

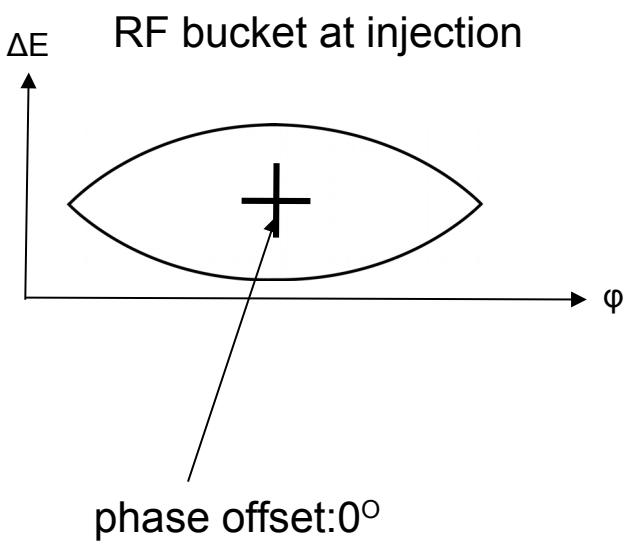
- T. Toyama et al., “Electron Cloud Observed During Debunching for Slow Beam Extraction at J-PARC Main Ring”, Proceedings of the Particle Accelerator Society of Japan (2015).
- B.Yee-Rendon et al., “Electron Cloud Measurements at J-PARC Main Ring”, Proceedings of the International Particle Accelerator Conference (2016).

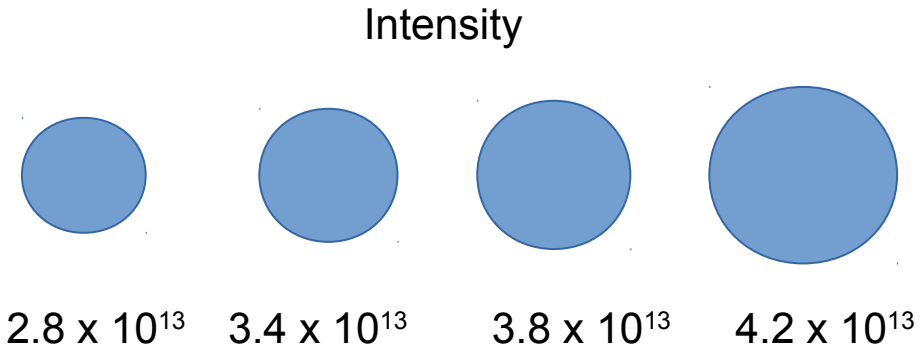
Measurements

Study I

The study was divided in two parts:

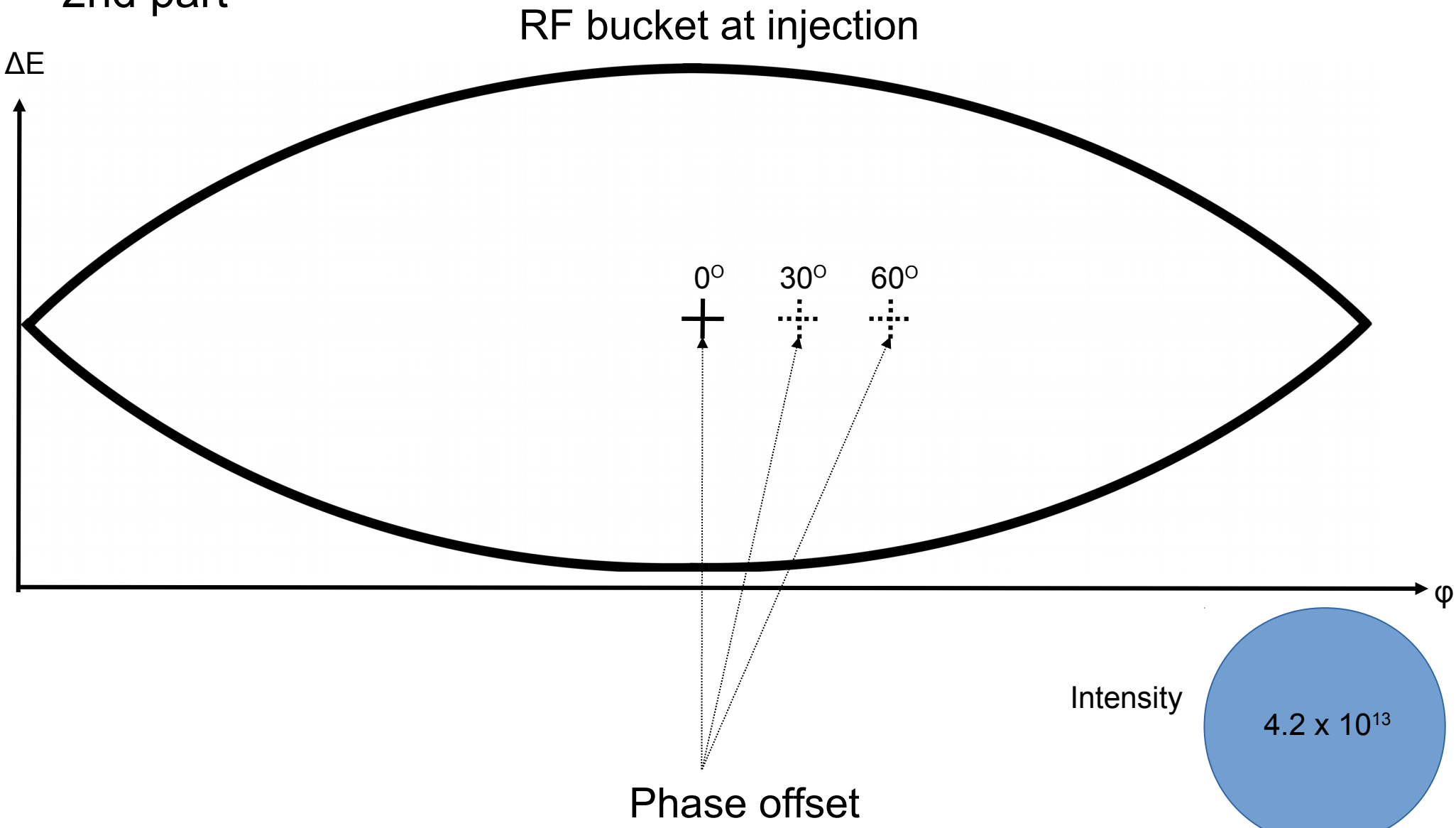
- 1st part



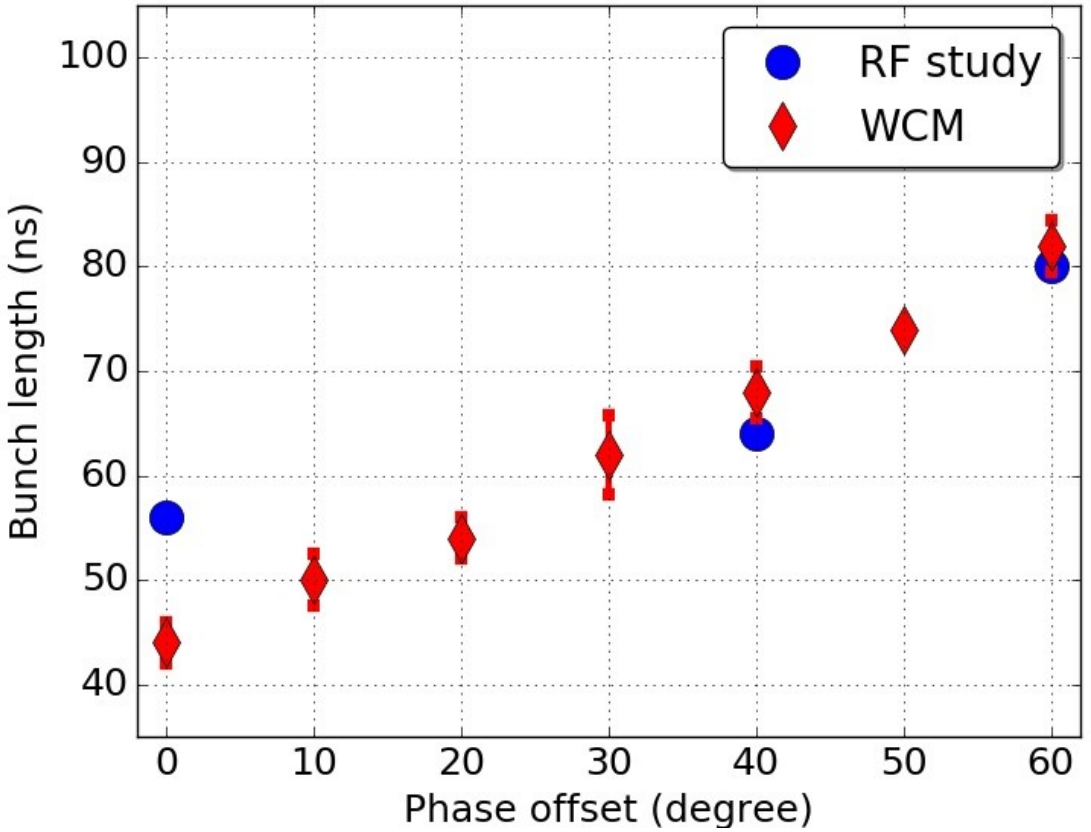


Study II

- 2nd part



Bunch length as a function of the phase offset



The bunch length using the wcm (red diamond) compare with RF study (blue circles). The measurements and simulations present a good agreement for large phase Offsets.

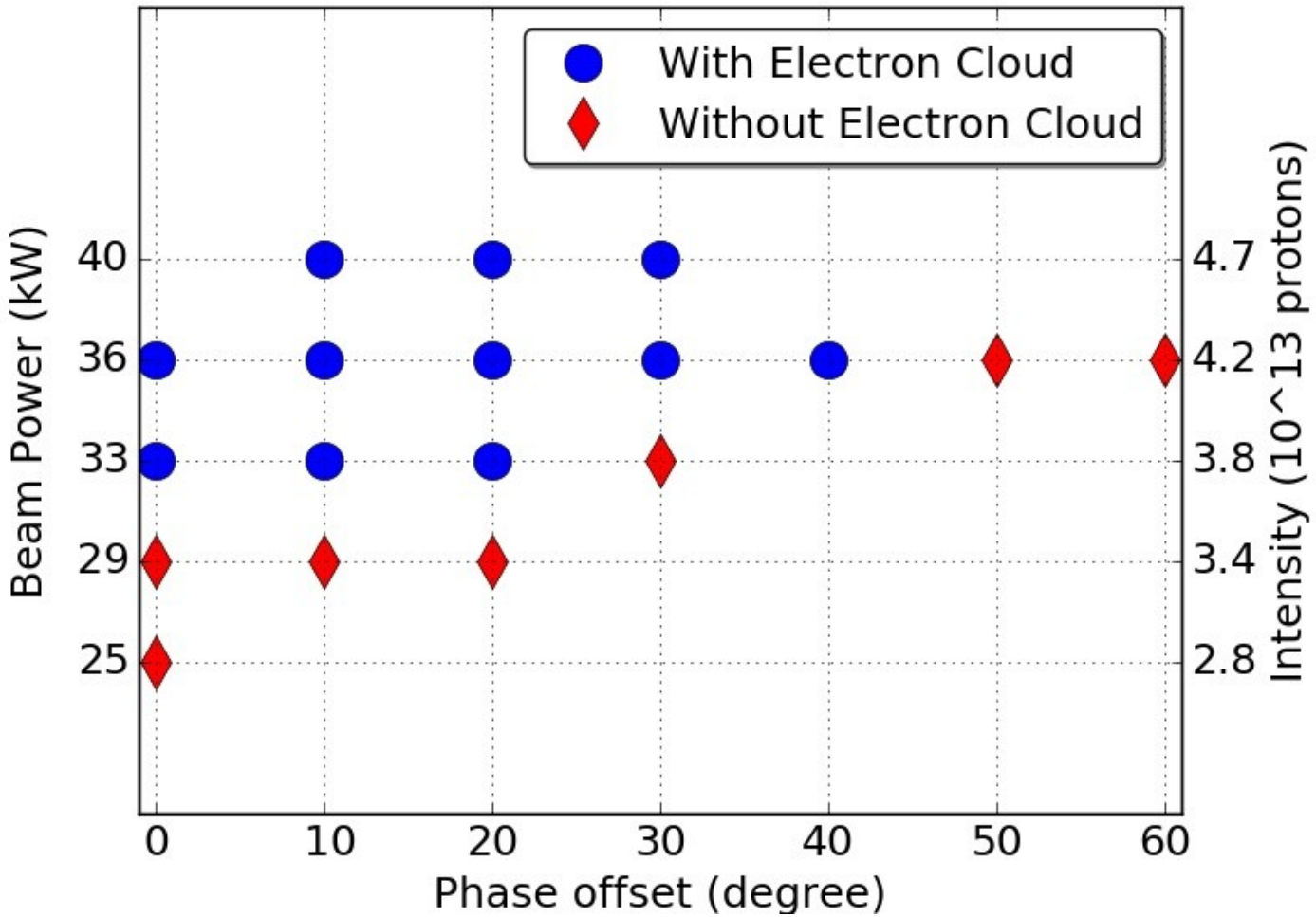
Relevant parameters

The Table presents the main beam parameters during the study.

Parameters	Units	Values
Energy	GeV	30
Beam Power	kW	25-40
Intensity	10^{13} ppp	2.8-4.7
Phase offset	degree	0-60
Q_x, Q_y		22.3,20.8
Q_s		0.000119

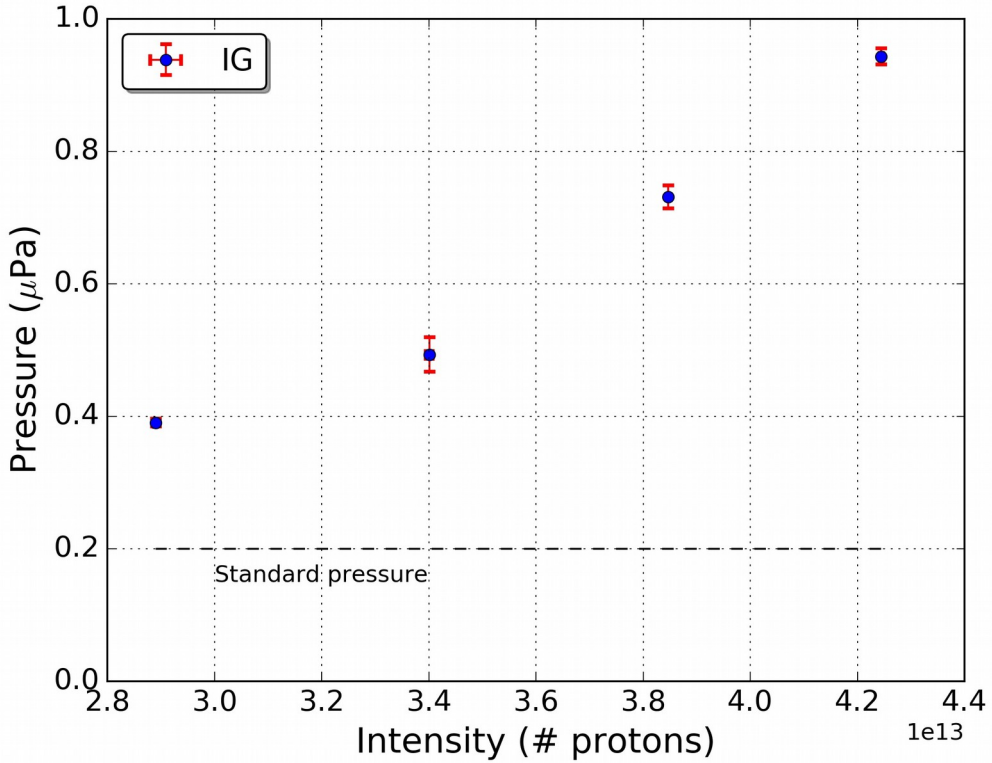
Results

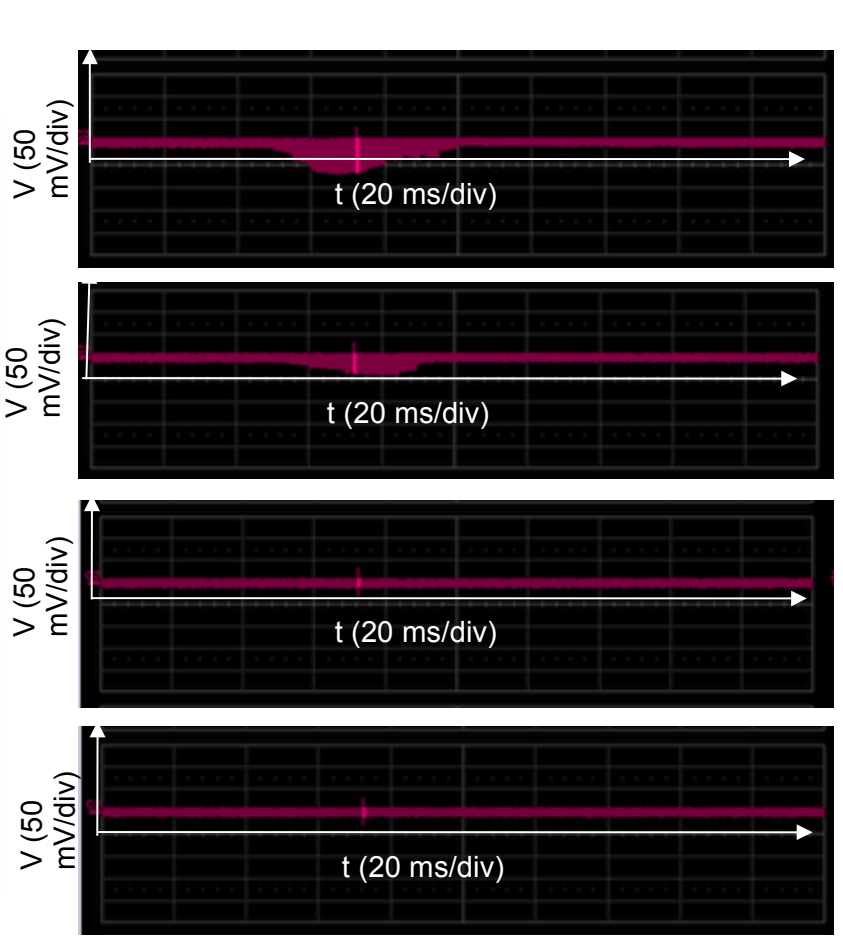
Electron cloud results



The presence (blue circles) or absence (red diamond) of the electron cloud as a function of the intensity and phase offset.

The criteria to decide if the electron cloud appears

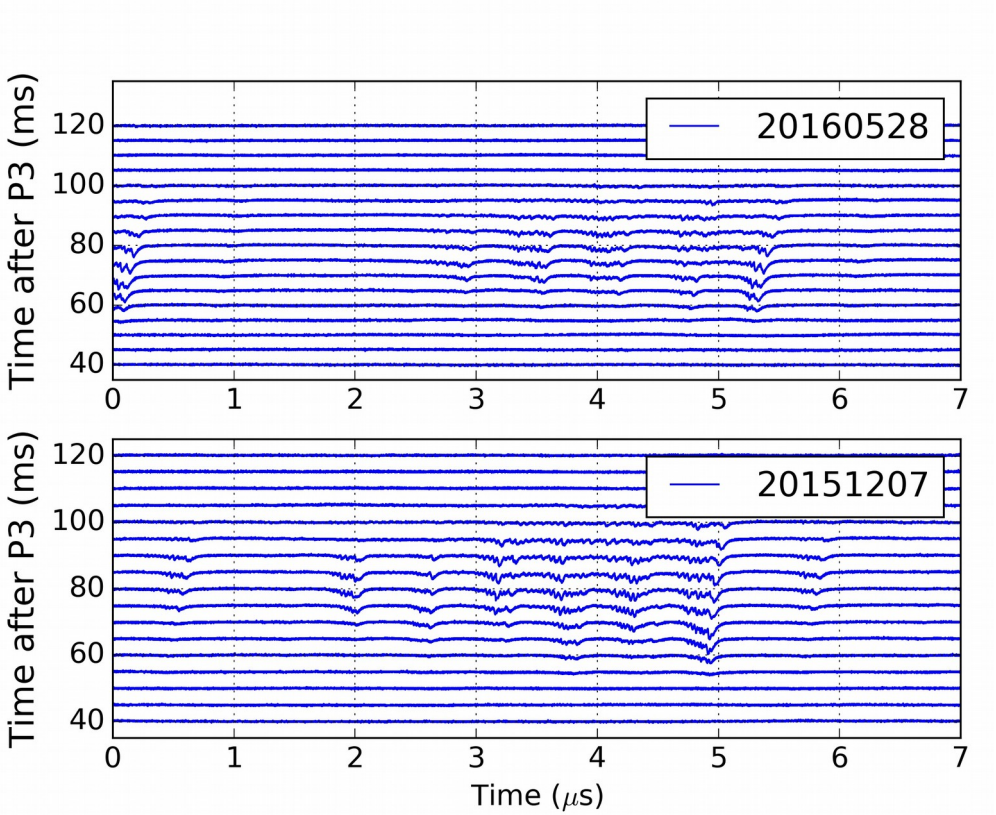


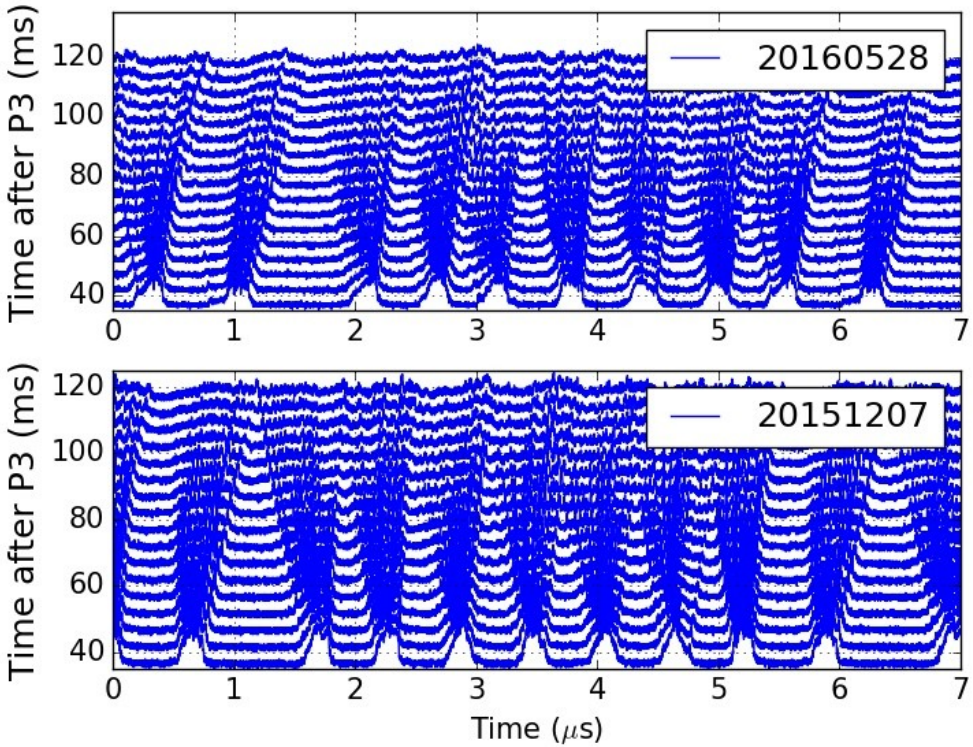


The pressure rise by a factor of three or more with respect to standard value.

The appearance of a “signal bump” in the electron cloud detector.

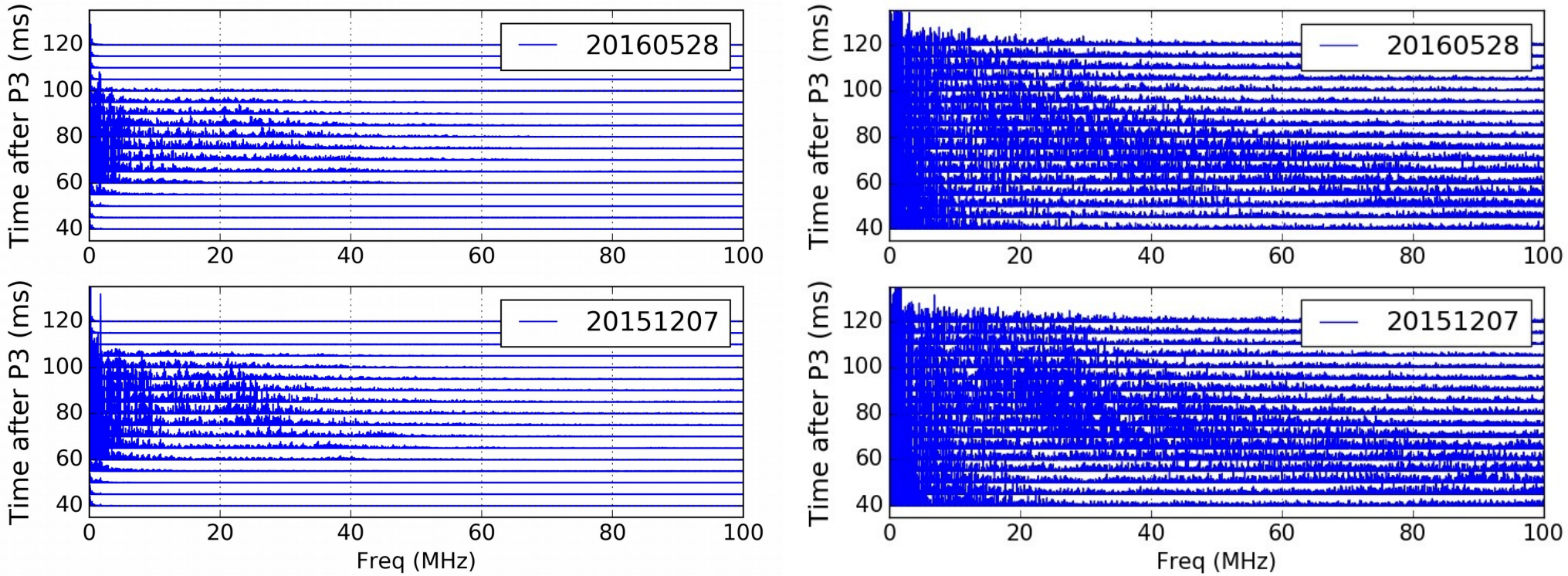
Electron cloud signal reproducibility





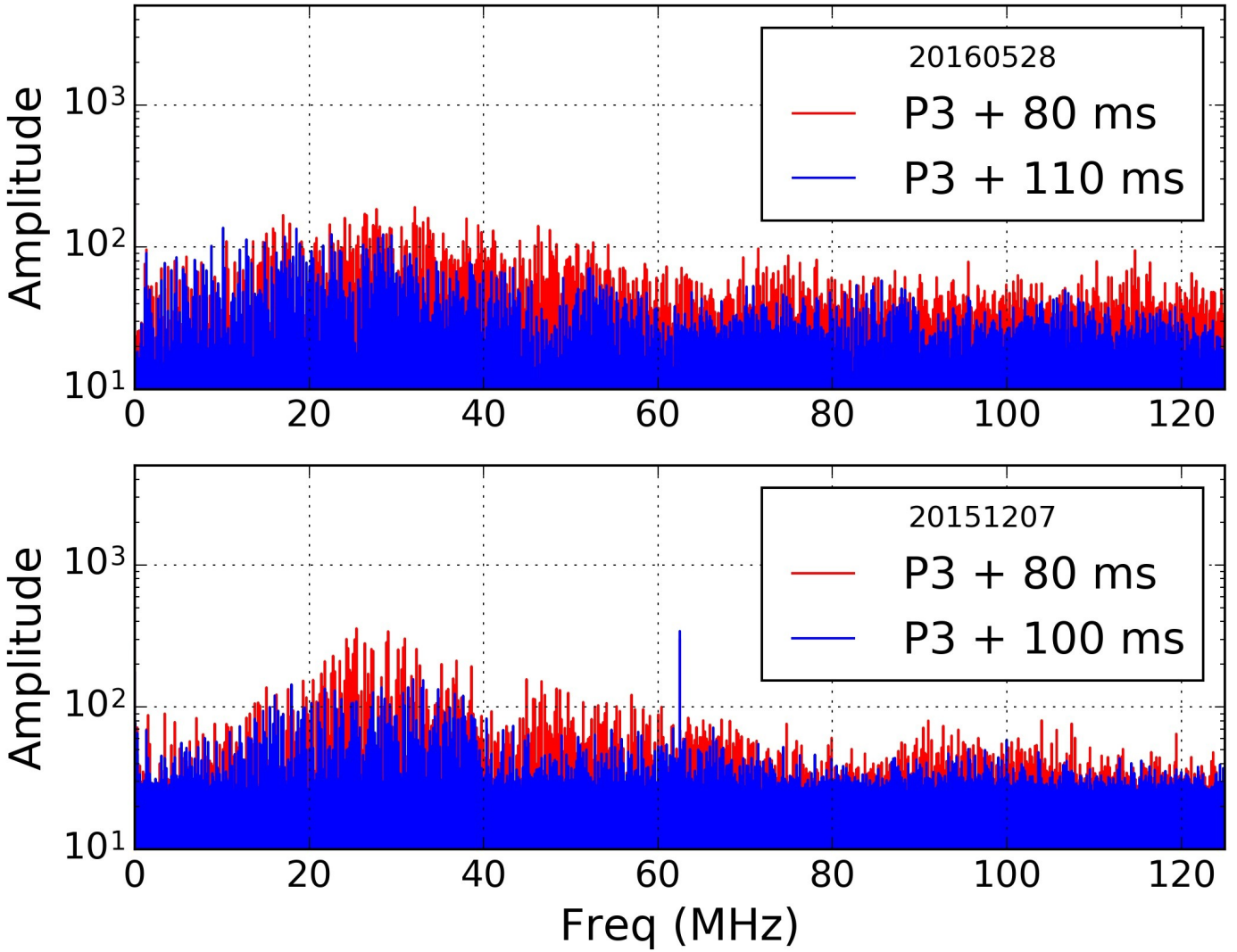
The electron cloud detector signals (left) and beam current (right) for the present study and the previous one in the time domain, top and bottom, respectively.

Electron cloud signal reproducibility



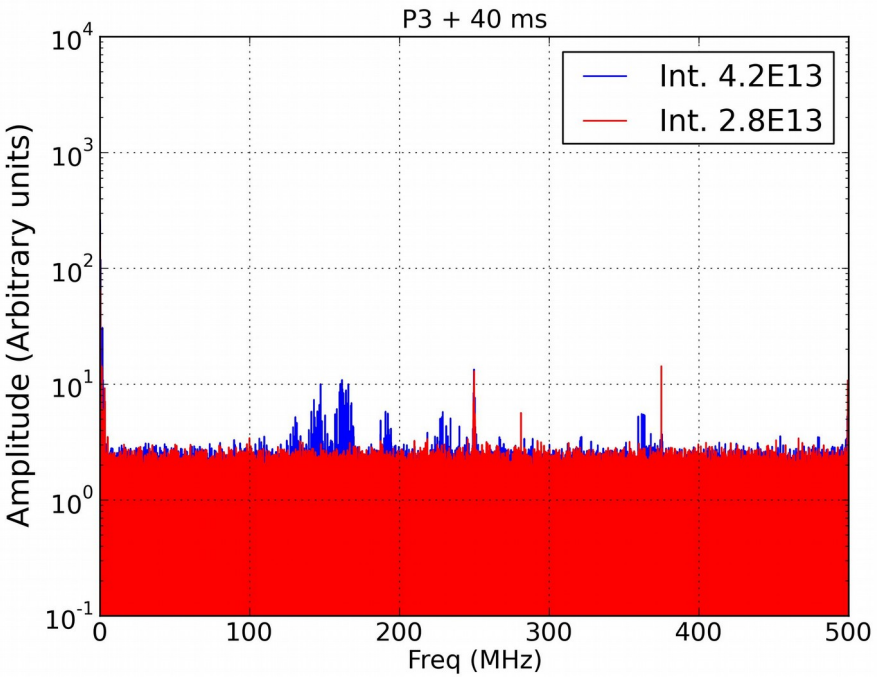
The electron cloud detector signals (left) and beam current (right) for the present study and the previous one in the frequency domain, top and bottom, respectively.

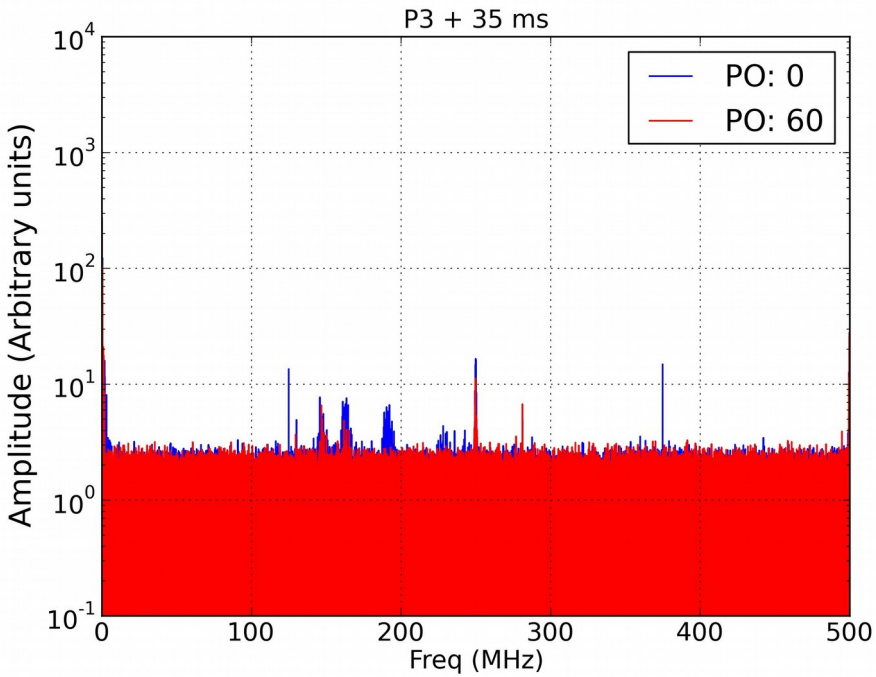
BPM signal Fourier analysis



The comparison of the ΔX signal for the beam position monitors for the actual study and the last one, top and bottom, respectively.

Fourier analysis of the electron cloud signal





The Fourier analysis of the electron cloud signal at different intensities (left) and phase offsets (right). The contrast in the components between 150-200 MHz for the electron cloud cases is evident.

Conclusion & Outlook

Summary

- Dependence of the beam intensity as well as the bunch length in the formation of the electron cloud at the J-PARC MR.
- Presence of the harmonics between the 150-200 MHz in the early stage of the electron cloud cases.
- Longer bunches (large phase offset) take less time to become coasting than short bunches (small phase offset).
- The measurements by beam loss detector were significantly enhanced, however, their frequency domain did not present a clear difference between the cases with and without electron cloud.

Future work

- Using the accumulated knowledge, an electron cloud model is under develop. This code uses an update version of the early studies. For these simulations a scheme for bunched to unbunched beam is being implemented.

ありがとうございました