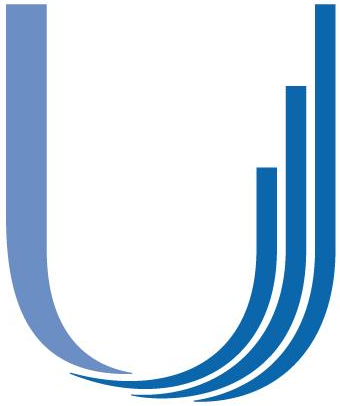


LHC Injectors Upgrade

LHC Injectors Upgrade

LEIR model
A plan for understanding/upgrading the LEIR performance limitations

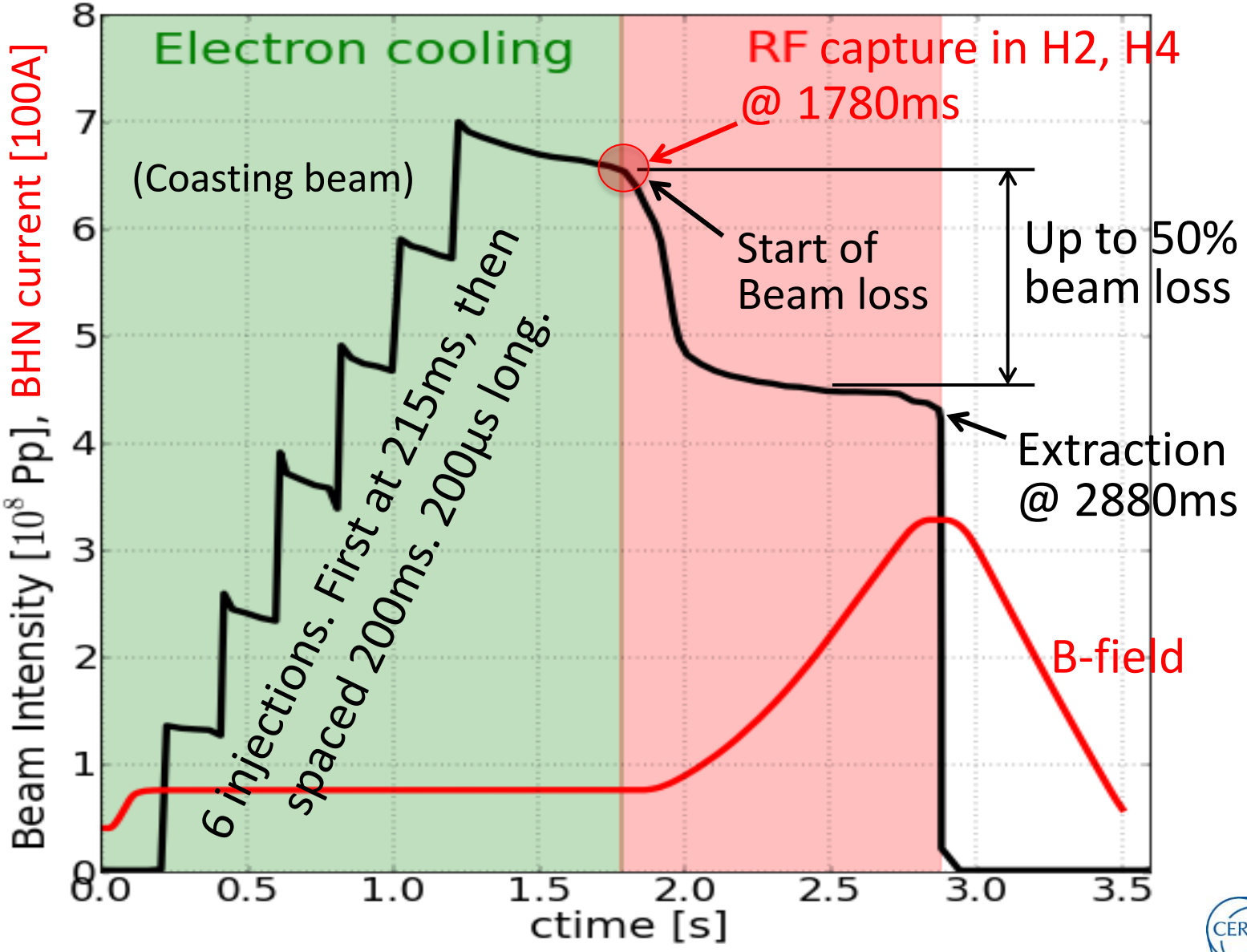
M.Bodendorfer BE/ABP & LEIR team

LEIR performance, 2013 and LIU Ions
Why upgrade?
All HI LHC experiments want by 2035: $10nb^{-1}$

Parameter	Unit	LEIR 2013 run	LEIR Baseline upgrade	LEIR Full upgrade
Pb charge state	[-]	54+		
Output Energy	[GeV/u]	0.0722		
In/Out Bρ	[Tm]	1.138 / 4.8		
Inject. to next machine	[-]	1		
Bunches/ring	[-]	2		
Charge at flat bottom	Charges	~$6.0x10^{10}$	$6.0x10^{10}$	$1.1x10^{11}$
Total extracted charge	Charges	~$5.4x10^{10}$	$5.4x10^{10}$	$8.6x10^{10}$

From: **PERFORMANCE OF THE INJECTORS WITH IONS AFTER LS1**
D. Manglunki for the LIU-Ions team, CERN, Geneva, Switzerland, 2013

LEIR NOMINAL cycle



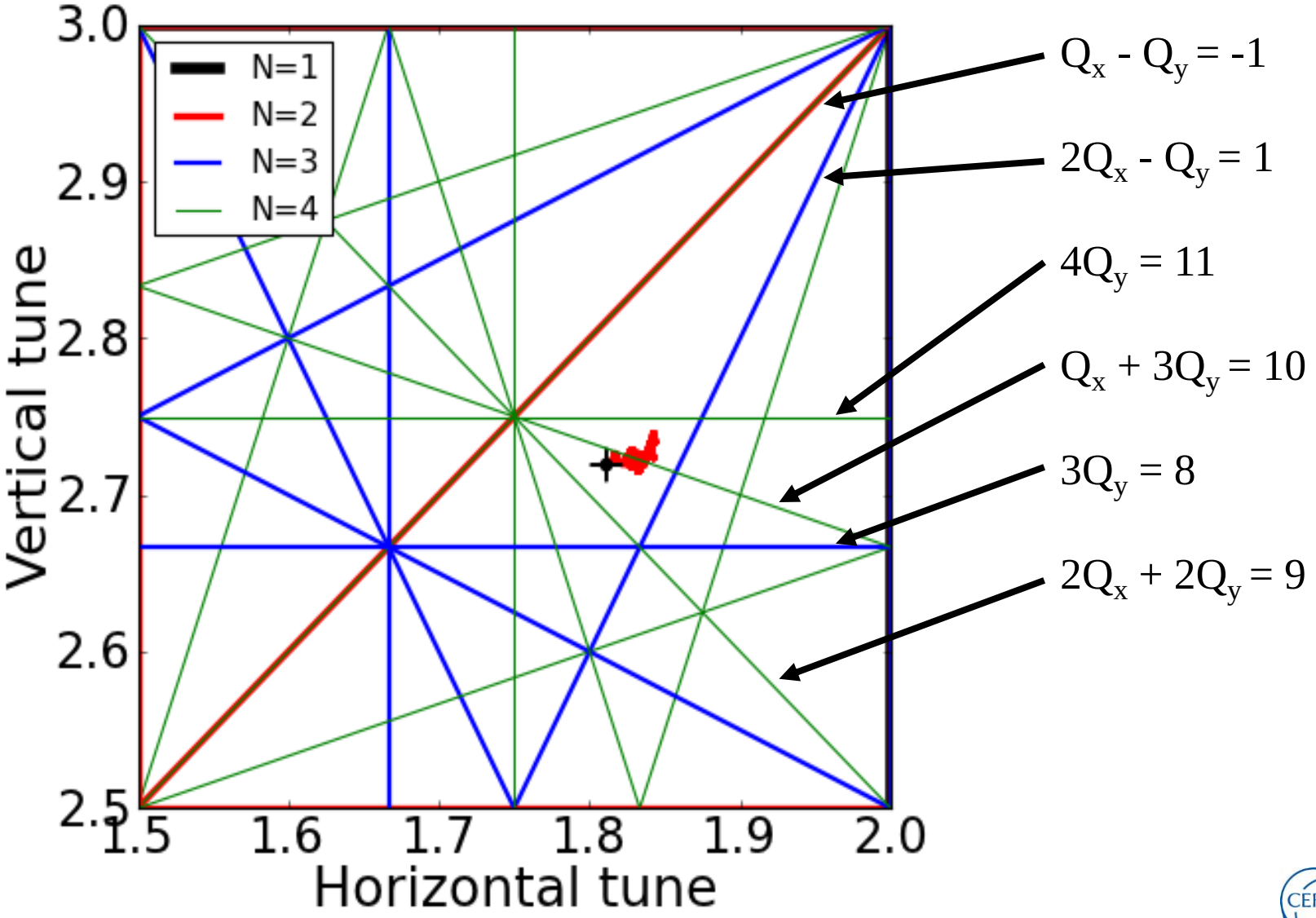
Finding a solution for LEIR

- **What we have found so far:**
  1. Working point on 4th order resonance
  2. Transverse instability at RF capture
  3. Positive chromaticity in the vertical plane
  4. Beam loss associated to RF-capture rather than magnetic Ramp

- **Proposed MDs series dedicated to each of the above findings in 2014, 2015.**

1. LEIR working point

Design tune: Q_H=1.82, Q_V=2.72



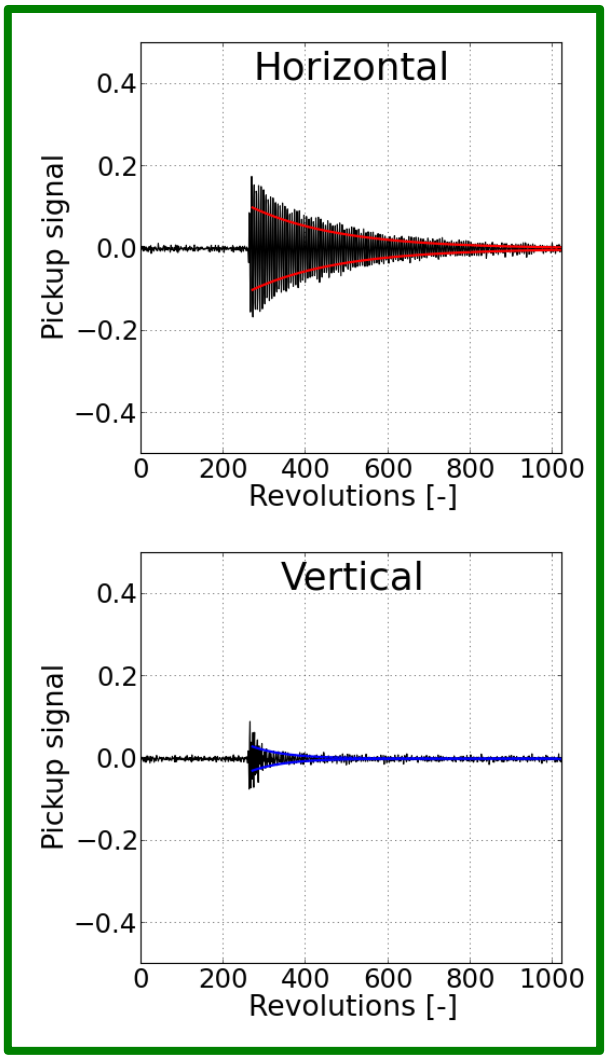
2. LEIR Instability at RF capture and ramp

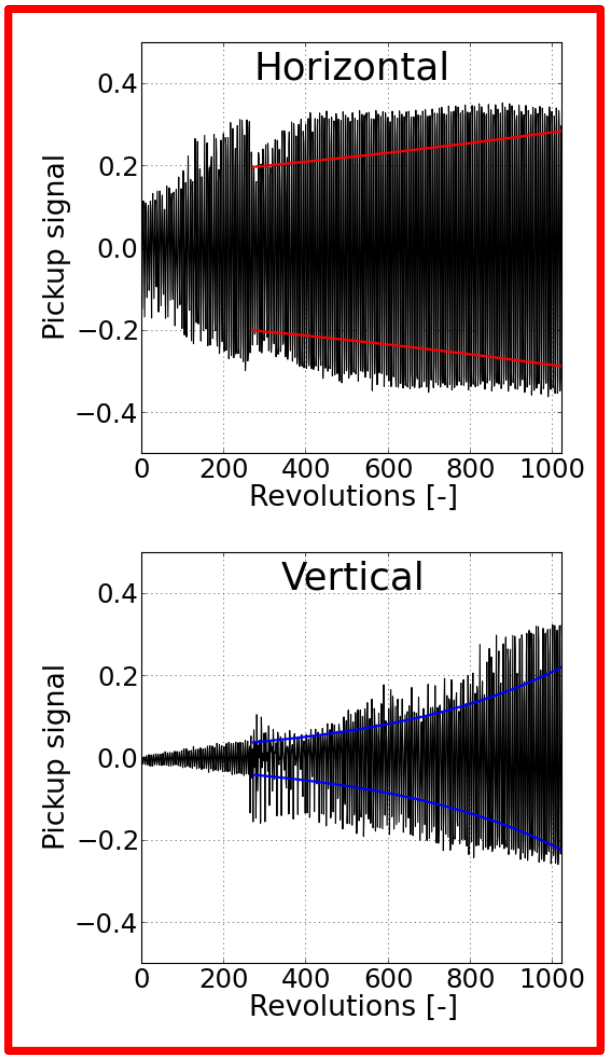
Pickups output:

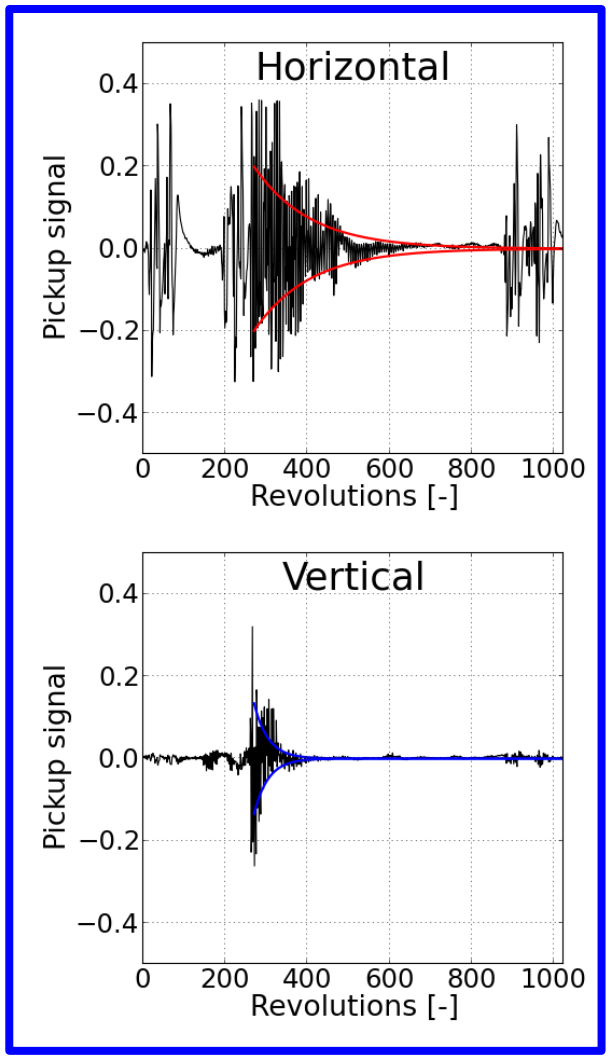
Before: -20ms

1815ms
Beam loss **starts** here

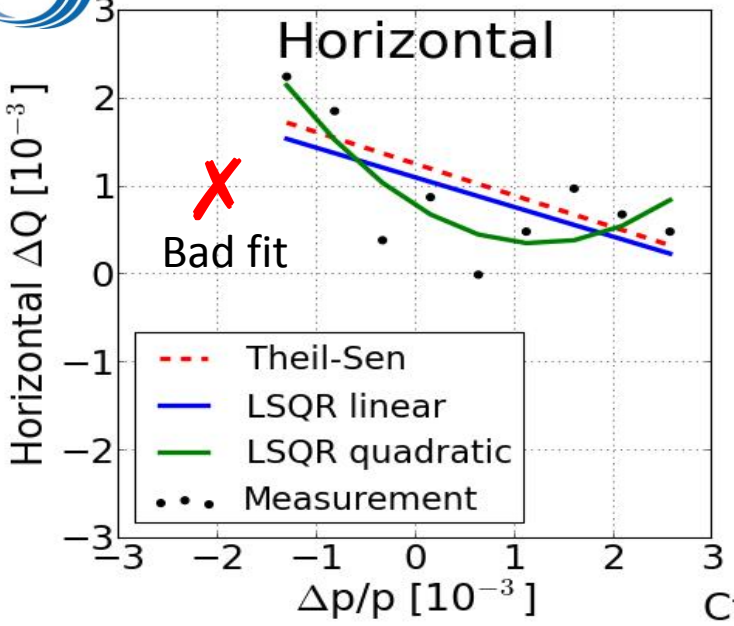
After: +20ms
Beam loss **continues**

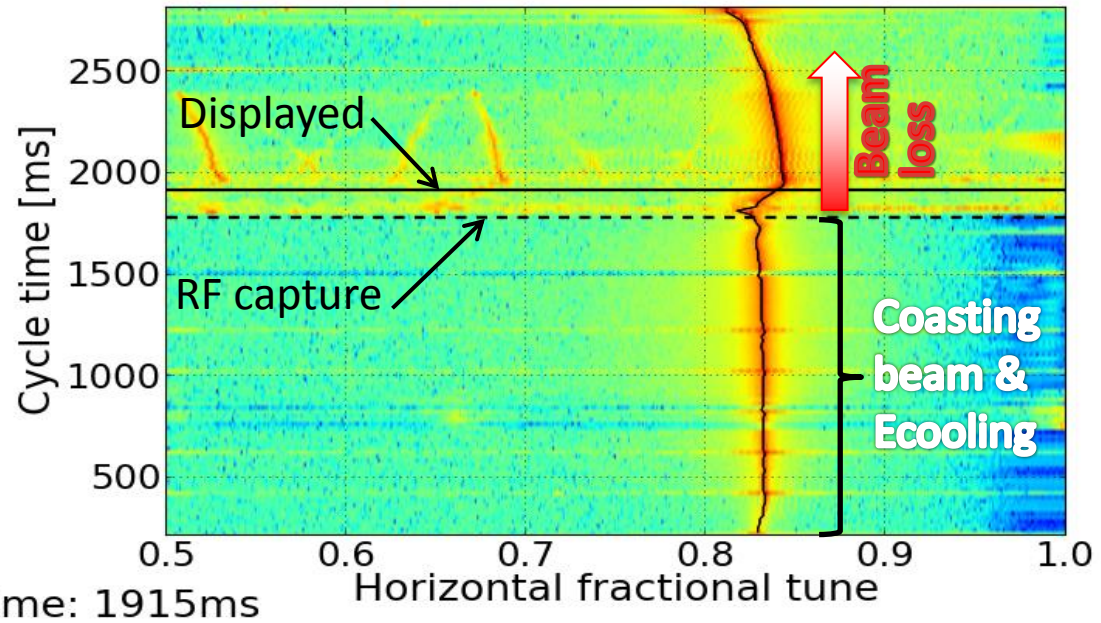




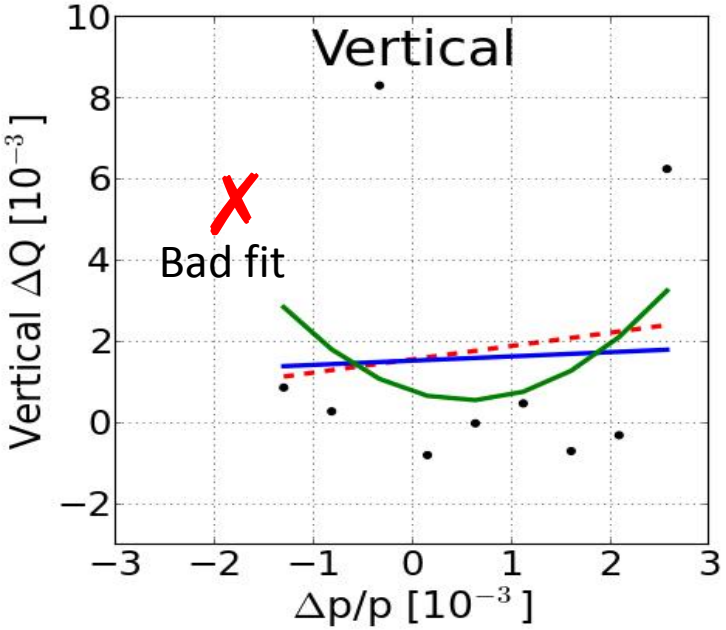


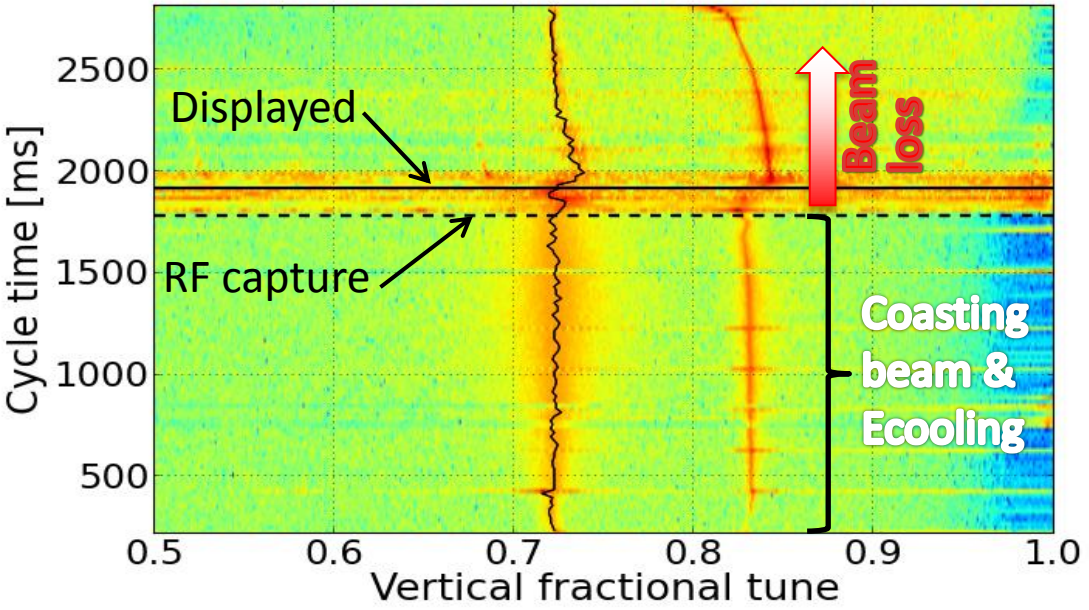
3. Tune and chromaticity measurement after RF-capture



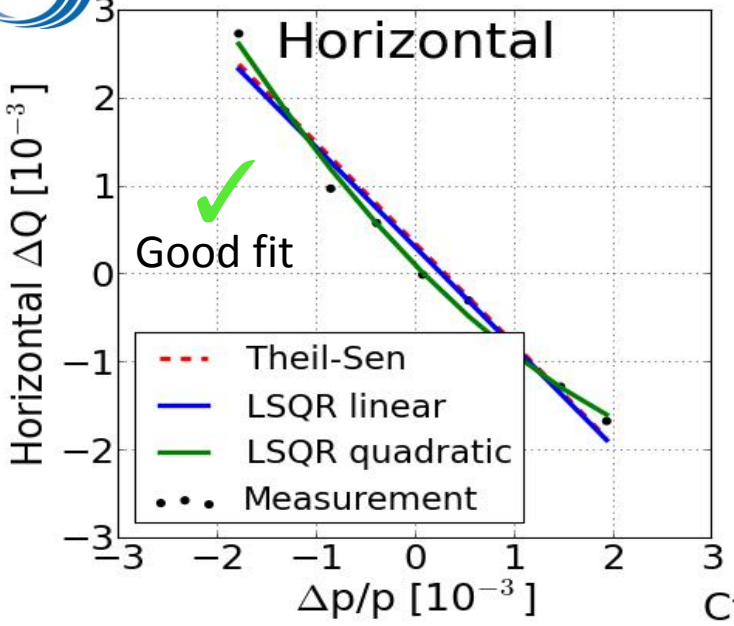


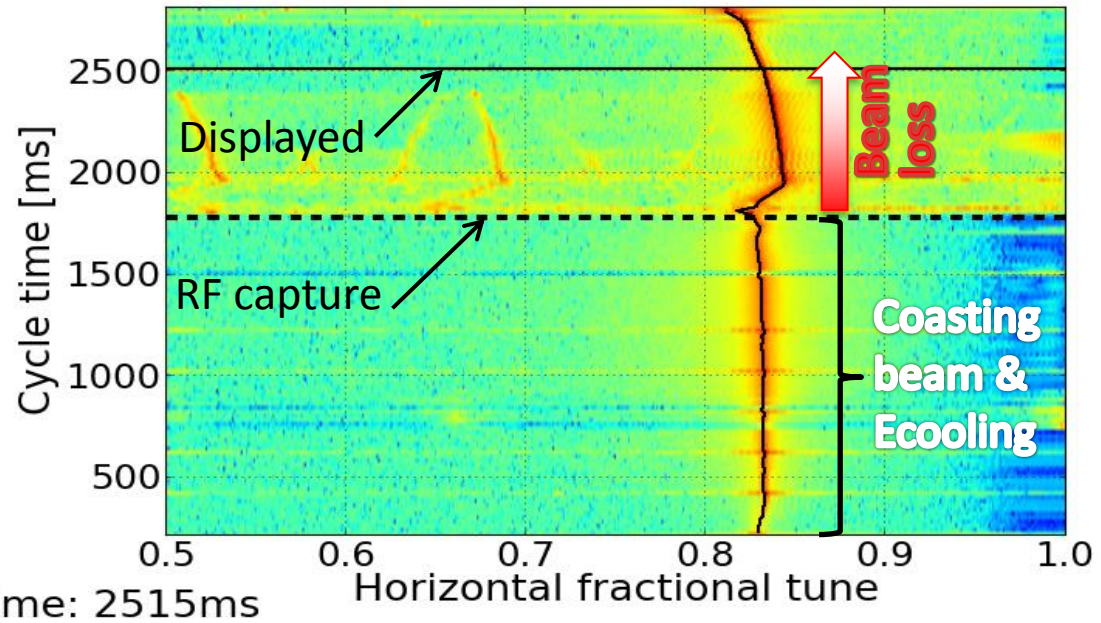
Ctime: 1915ms



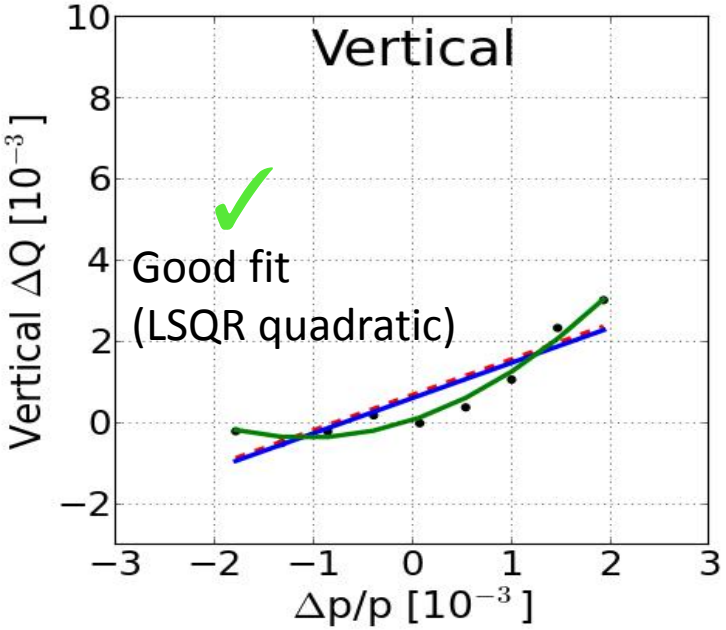


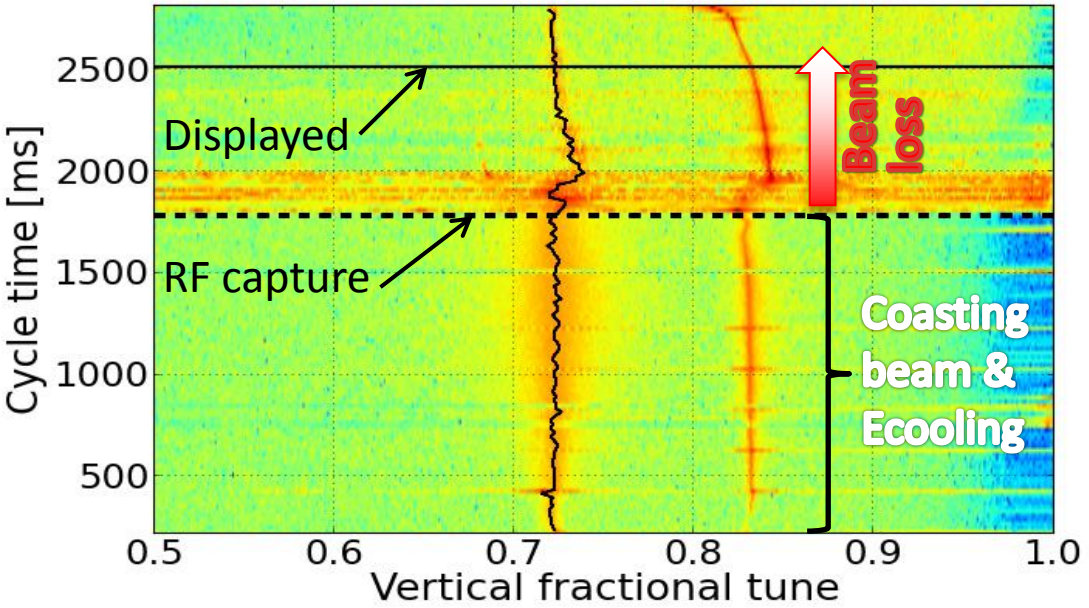
3. Tune and chromaticity measurement after RF-capture



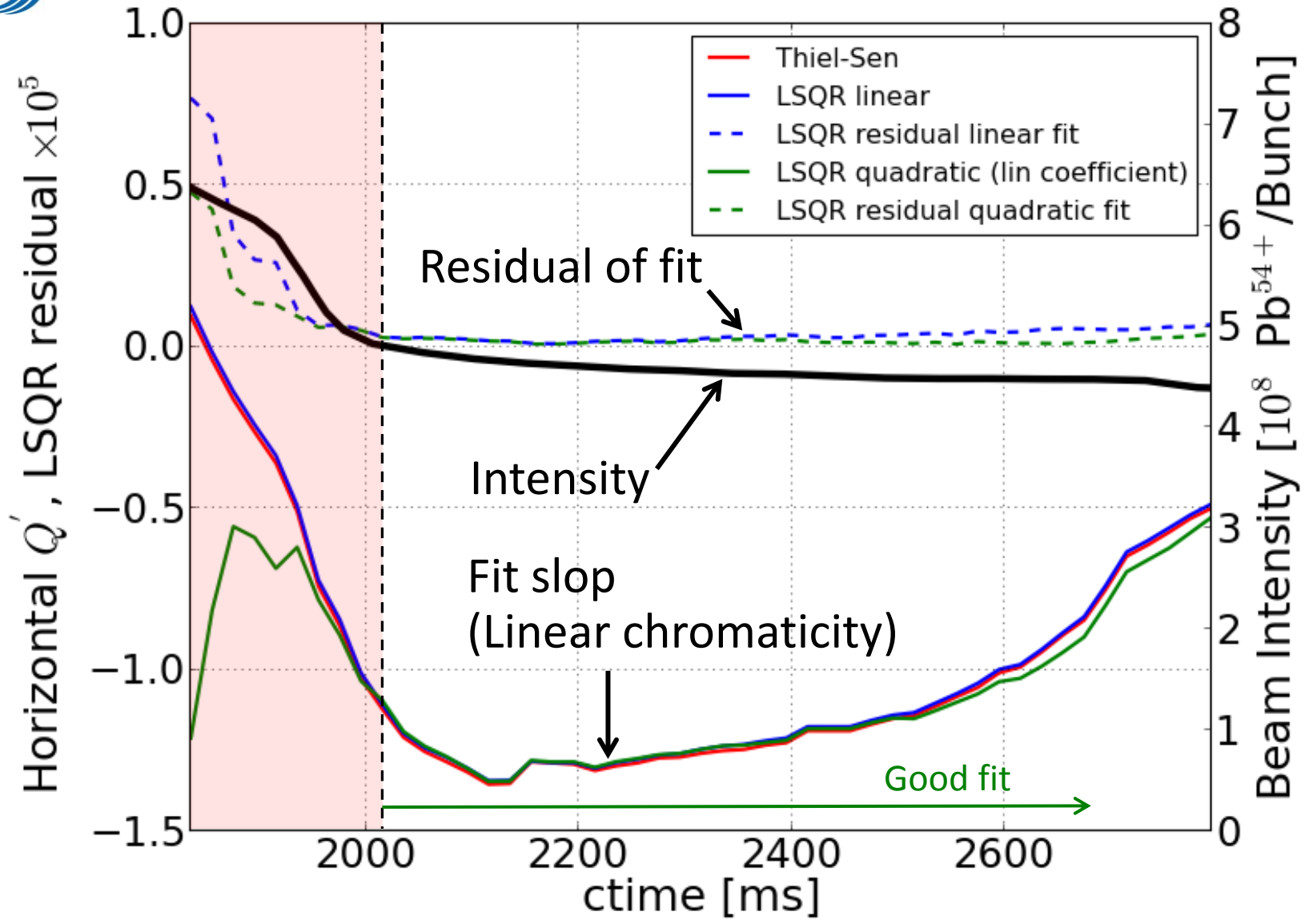


Ctime: 2515ms

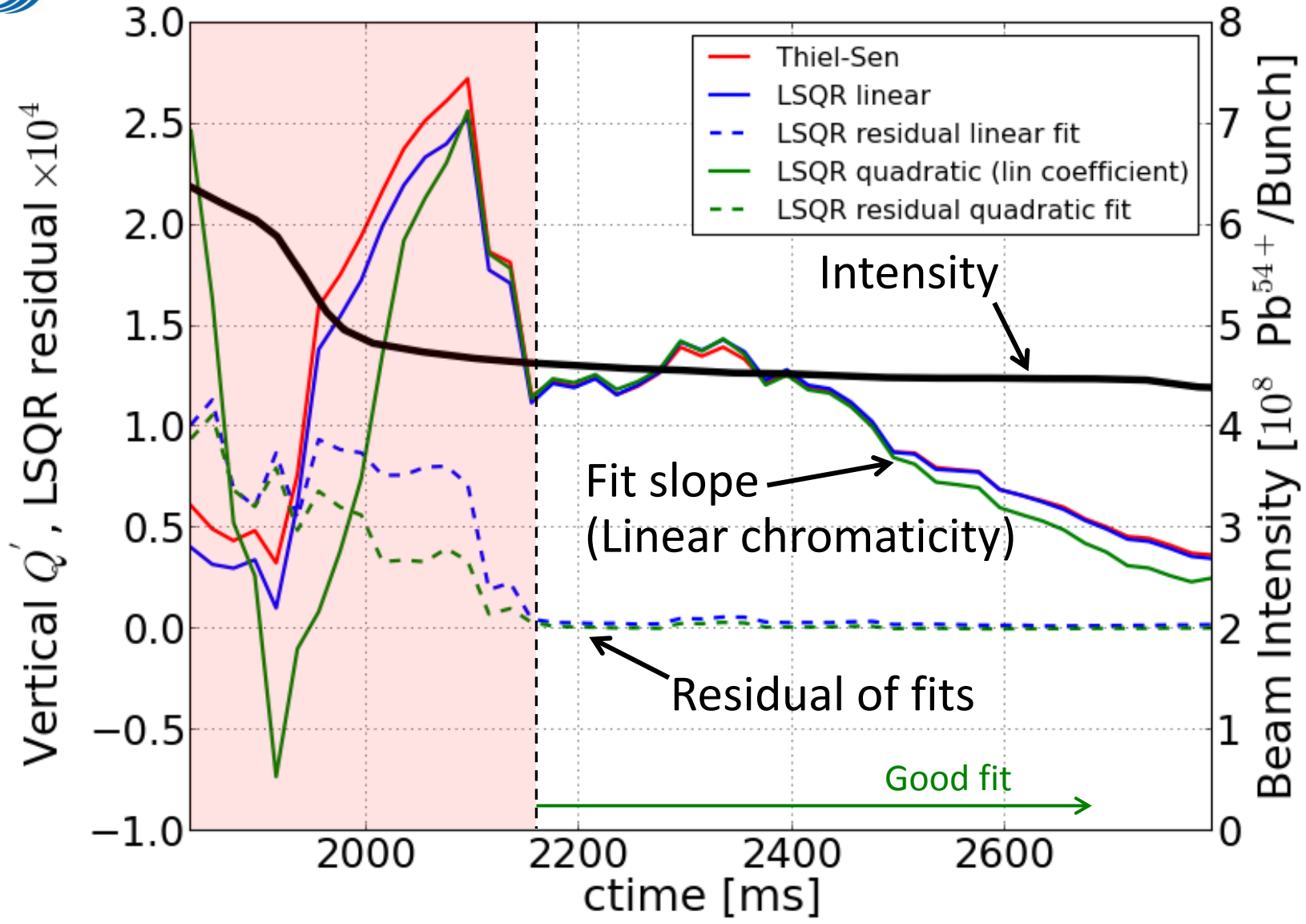




3. Horizontal chromaticity < 0 (after RF capt.) (Horizontal design chromaticy = -1)

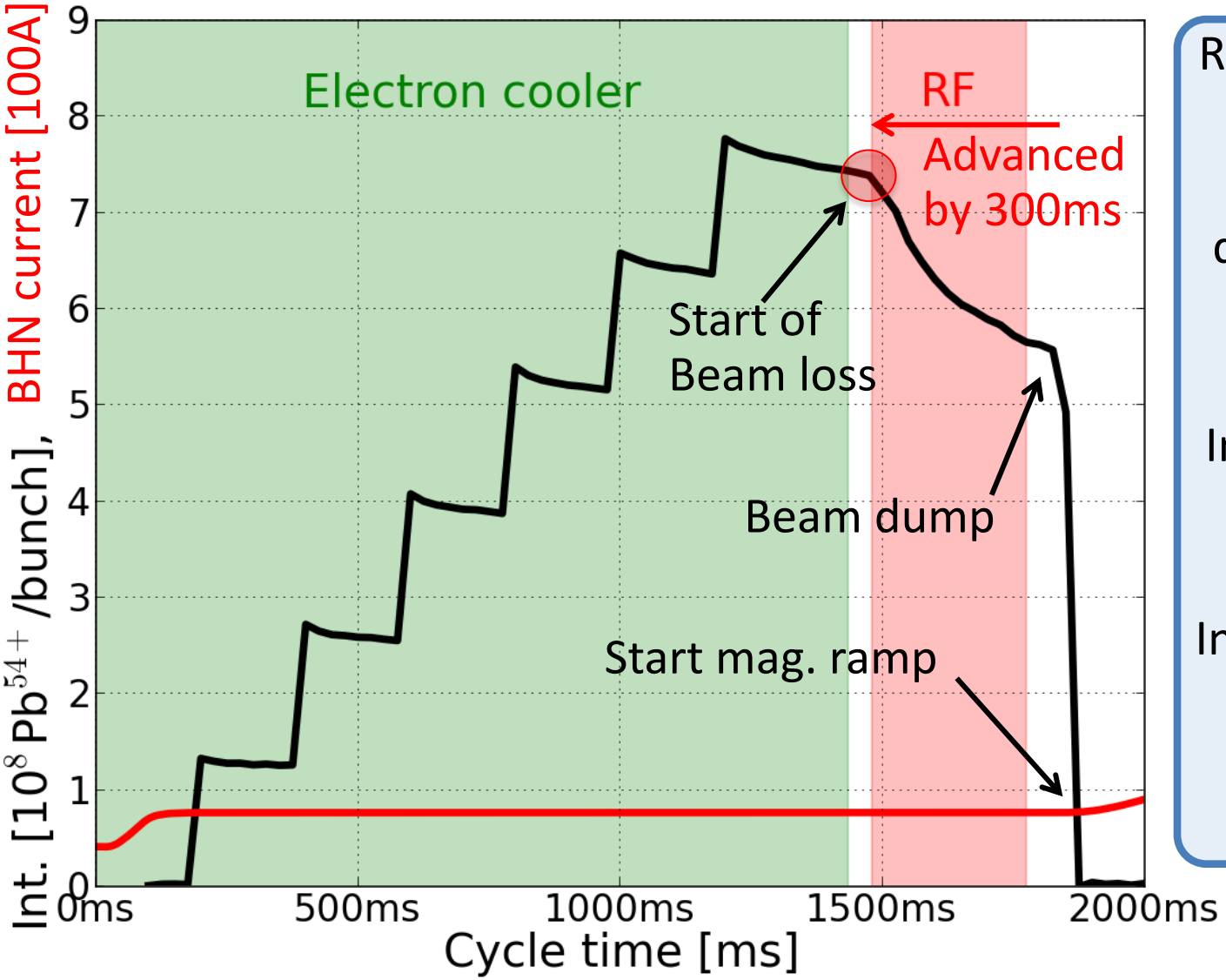


3. Vertical chromaticity > 0 (after RF capt.) (Vertical design chromaticy = -1)



4. Disentangling beam loss from magnetic ramp

Beam loss with advanced RF-capture



RF beam bunching

↓

Higher peak density increases **space-charge**

↓

Individual particle tune shift

↓

Individual particles cross resonance

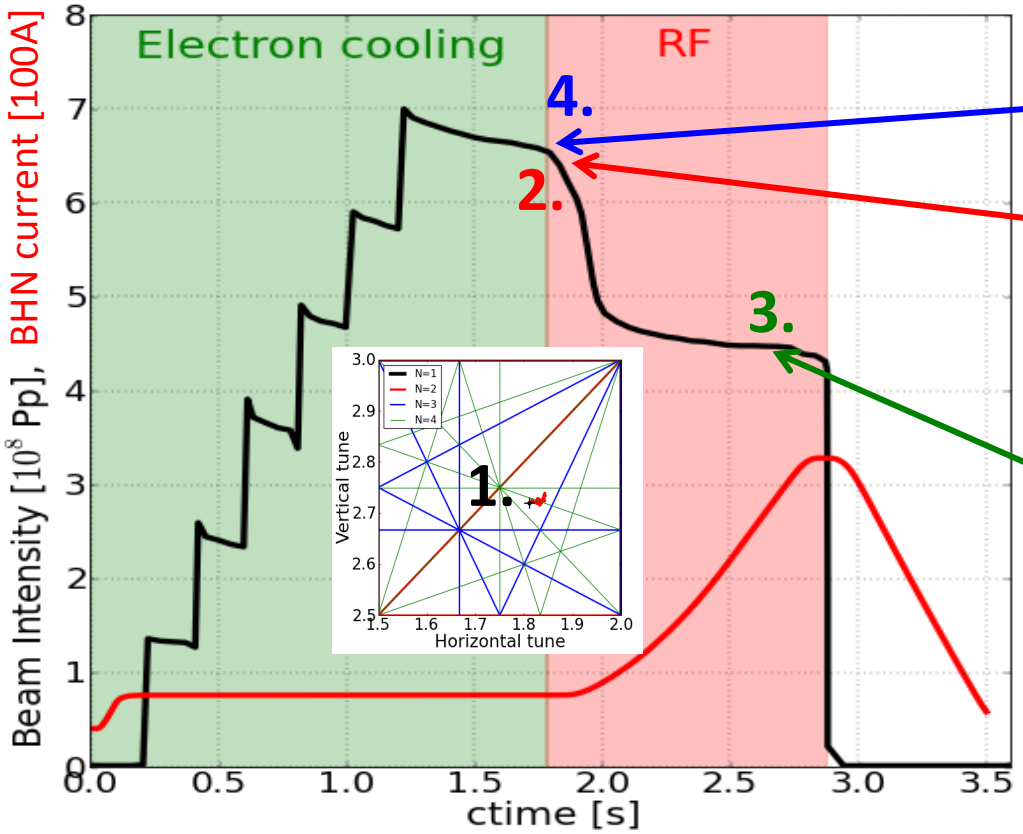
↓

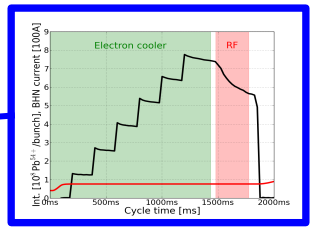
Loss

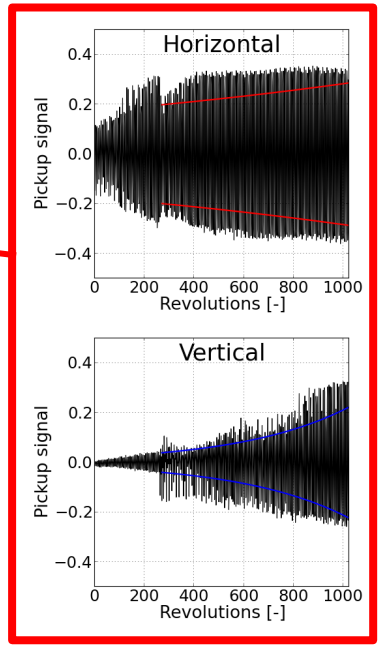
Summary of observations

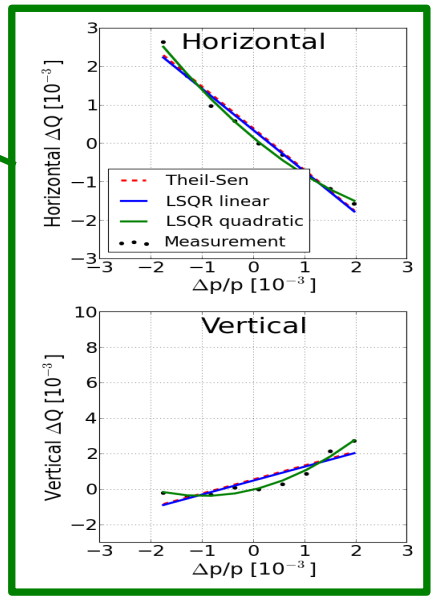
Clues from measurements:

1. Working point on 4th order resonance
2. Transverse instability at RF capture
3. Positive chromaticity in the vertical plane
4. Beam loss associated to RF-capture rather than mag. ramp





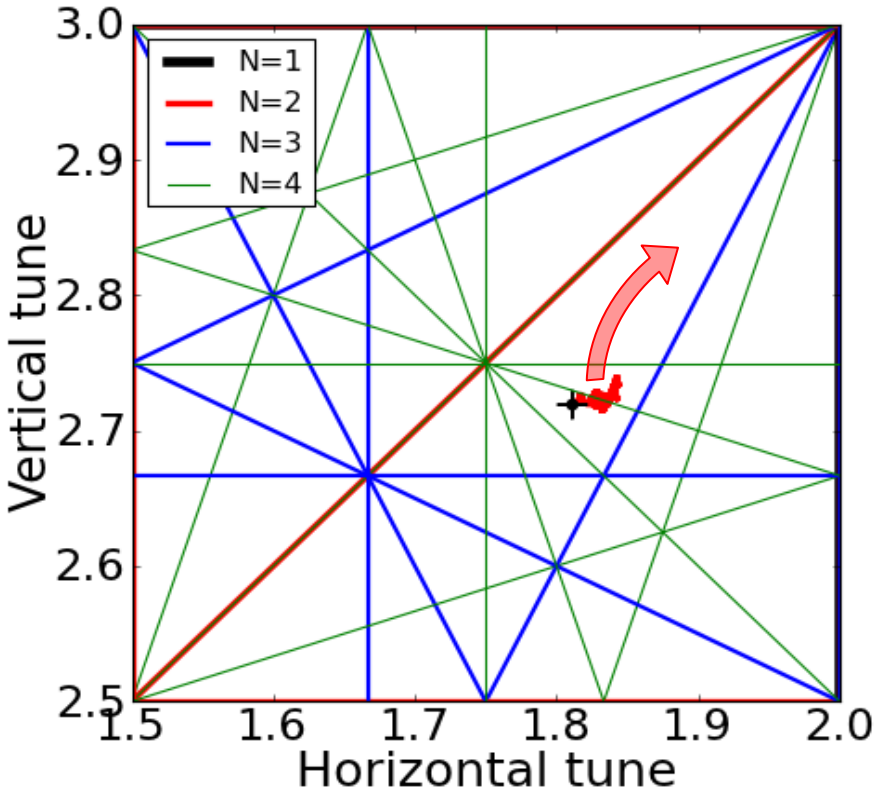




MD suggestions

Measurement clue and suggested MD:

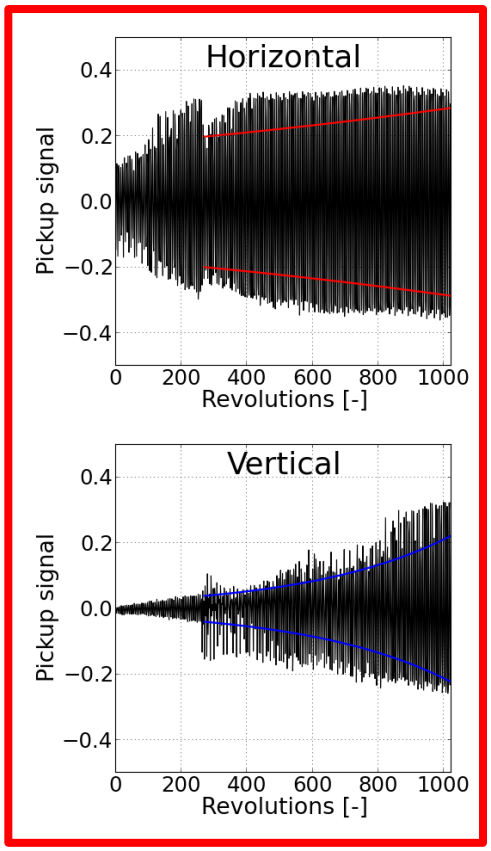
1. Working point on 4th order resonance
    1. Explore other regions of the tune space ($Q_y > 2.75$)
    2. Investigate chromaticity for new tune regions



MD suggestions

Measuremene clue and suggested MD:

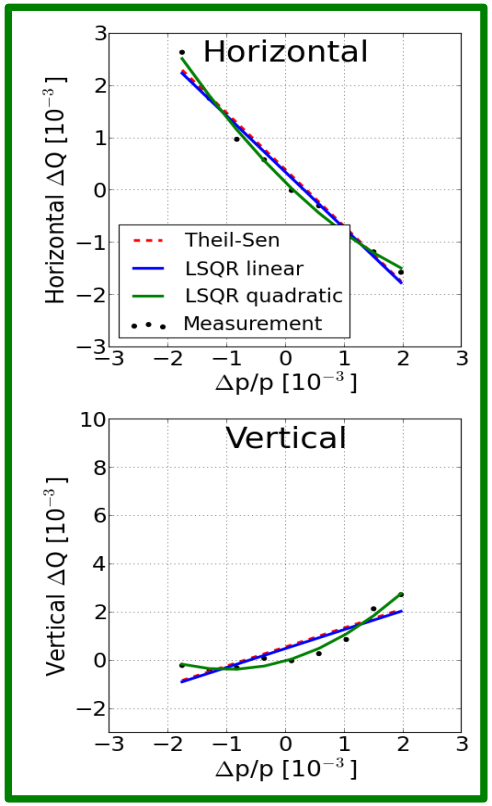
1. Working point on 4th order resonance
2. Transverse instability at RF capture
    1. Study effect of the transverse damper
    2. Investigate origin of instability with transv. damper off



MD suggestions

Measuremene clue and suggested MD:

1. Working point on 4th order resonance
2. Transverse instability at RF capture
3. Positive chromaticity in the vertical plane
    1. Chrom. < 0 for both planes
    2. Qmeter software from PS



MD suggestions

Measuremene clue and suggested MD:

1. Working point on 4th order resonance
2. Transverse instability at RF capture
3. Positive chromaticity in the vertical plane
4. Beam loss associated to RF-capture rather than magnetic ramp
    1. Try RF-capture with different beam parameters (bunch length and transverse emittances) to check the impact of **space-charge**.
    2. Study the effect of electron cooling and acceleration.

Conclusion & Summary

So far we have:

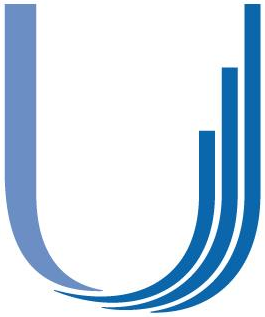
- found working point on/close to resonance
- found transverse instability
- found wrong chromaticity
- Pb^{54+} beam loss associated to RF-capture rather than the magnetic ramp

The Plan:

- Dedicated MD series for each finding.
- Further disentangling of space-charge, transverse instability and resonant beam loss.
- Refine the optics model of LEIR.

Further reading:

- **Plans for the upgrade of CERN's Heavy Ion Complex**, D. Manglunki et al., CERN-ACC-Note-2013-034
- **LINAC3 tank2 phase change and LEIR performance,** M. Bodendorfer, R. Scrivens, CERN-ATS-Note-2013-035
- **Chromaticity in LEIR performance,** M. Bodendorfer & LEIR team, CERN-ACC-Note-2013-0032
- **Longitudinal emittance reduction in LEIR of ion beams for LHC,** M. E. Angoletta, M. Bodendorfer, A. Findlay. S. Hancock, D. Manglunki, **upcoming**



LHC Injectors Upgrade

THANK YOU FOR YOUR ATTENTION!