Observation with Diamond Sensors during LHC Operation

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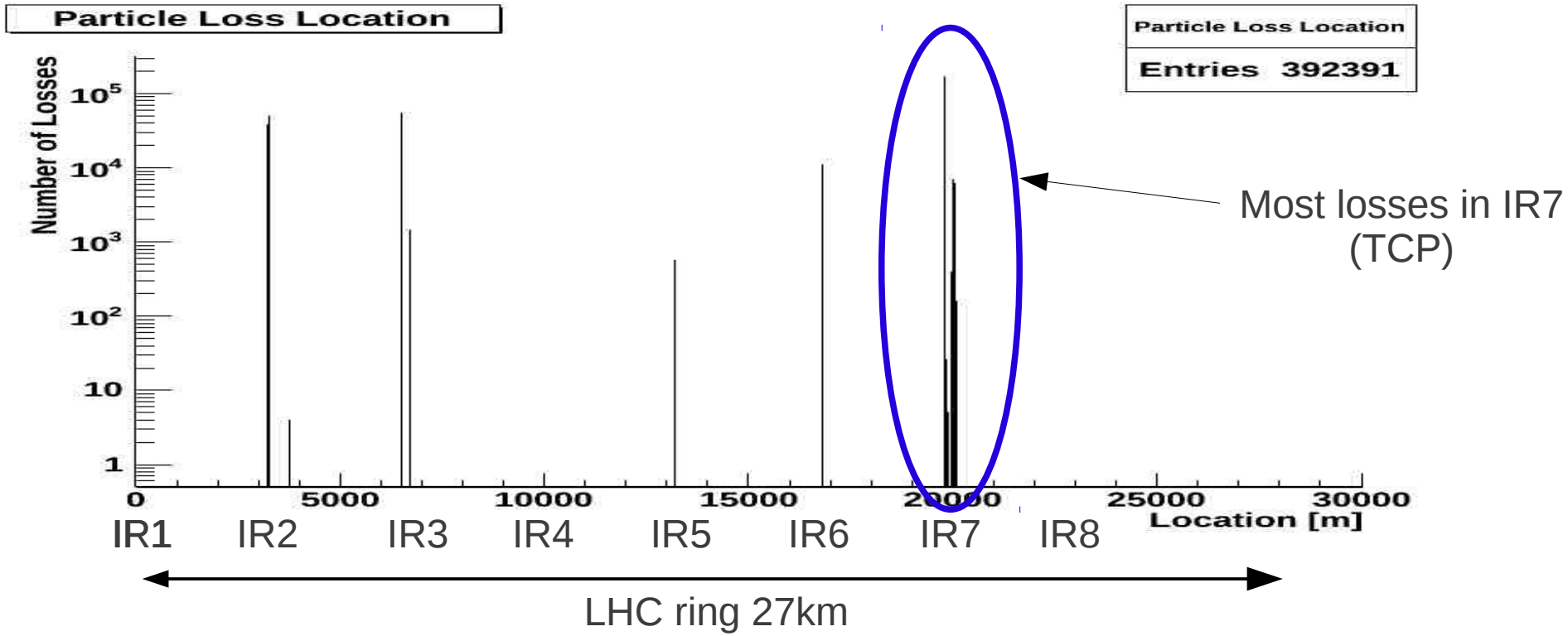
Motivation

- Studies of beam losses due to UFOs in MKI
- Simulations of scattering process between Al + p done by Anton Lechner and the FLUKA team
- Tracking of elastic scattered particle with Mad-X around the LHC ring



Motivation

- Observation of beam losses with diamonds sensors
- Diamond sensors have a temporal resolution of about 2ns
  - Observation of beam losses per bunch
  - Ionization chambers (BLMs) have only a time resolution of 40µs (half LHC turn)
- All big losses are observable in IR7 due to the collimators
  - 5.7σ (injection) and 4.3σ (stable beam)

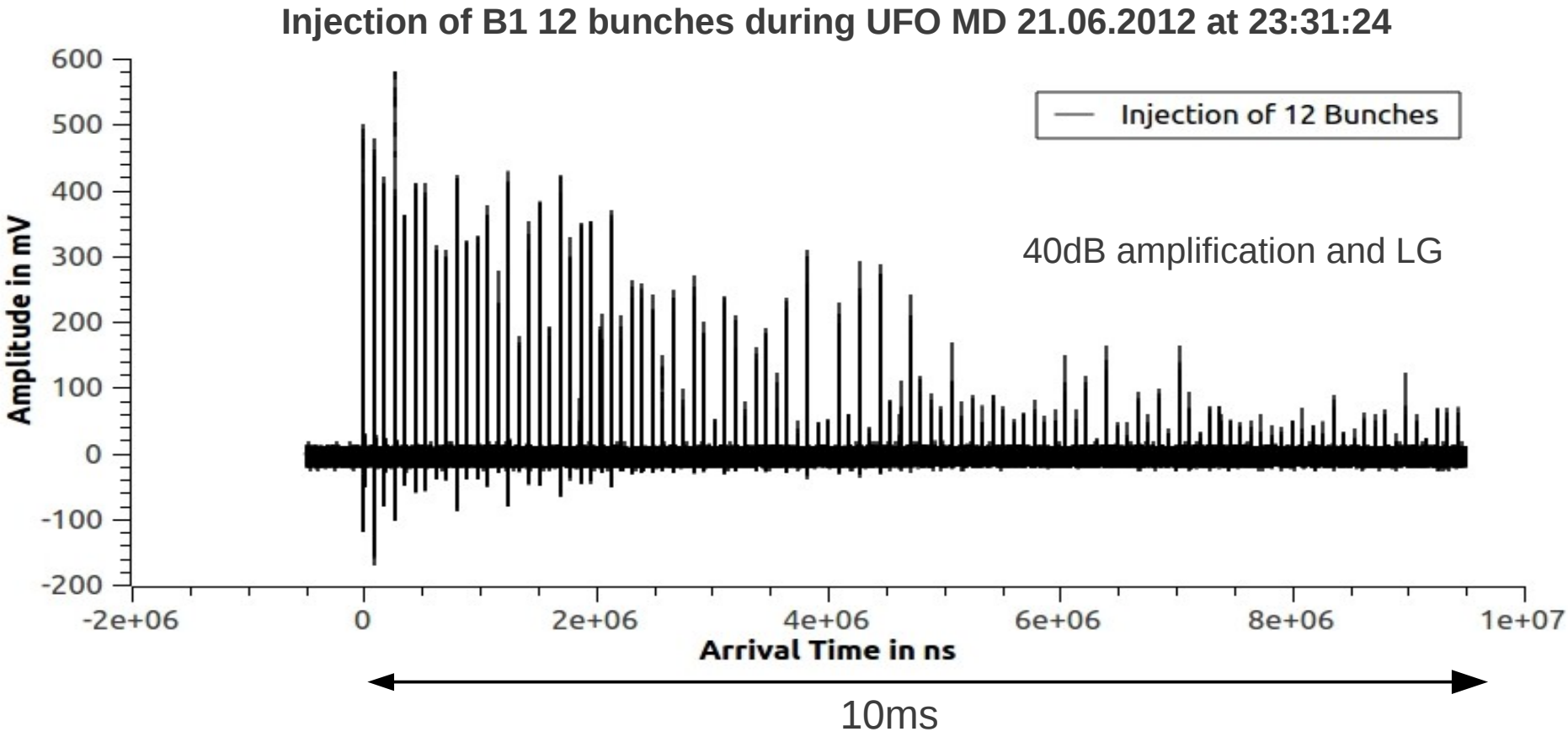
Setup

- 8 diamond sensors around the LHC
- Connected to scopes
- Control & acquisition with FESA class
  - Operational since >1 year
  - No remote connection needed
- Two gains for each diamond: HG & LG
- For P7 we use a remote connection
  - Changing the selftrigger (just above the noise level)
- Diamond sensor in P7 is able to measure main losses due to injections, beam dumps, UFOs and instabilities)
- Problem: no reference signal (turn clock)

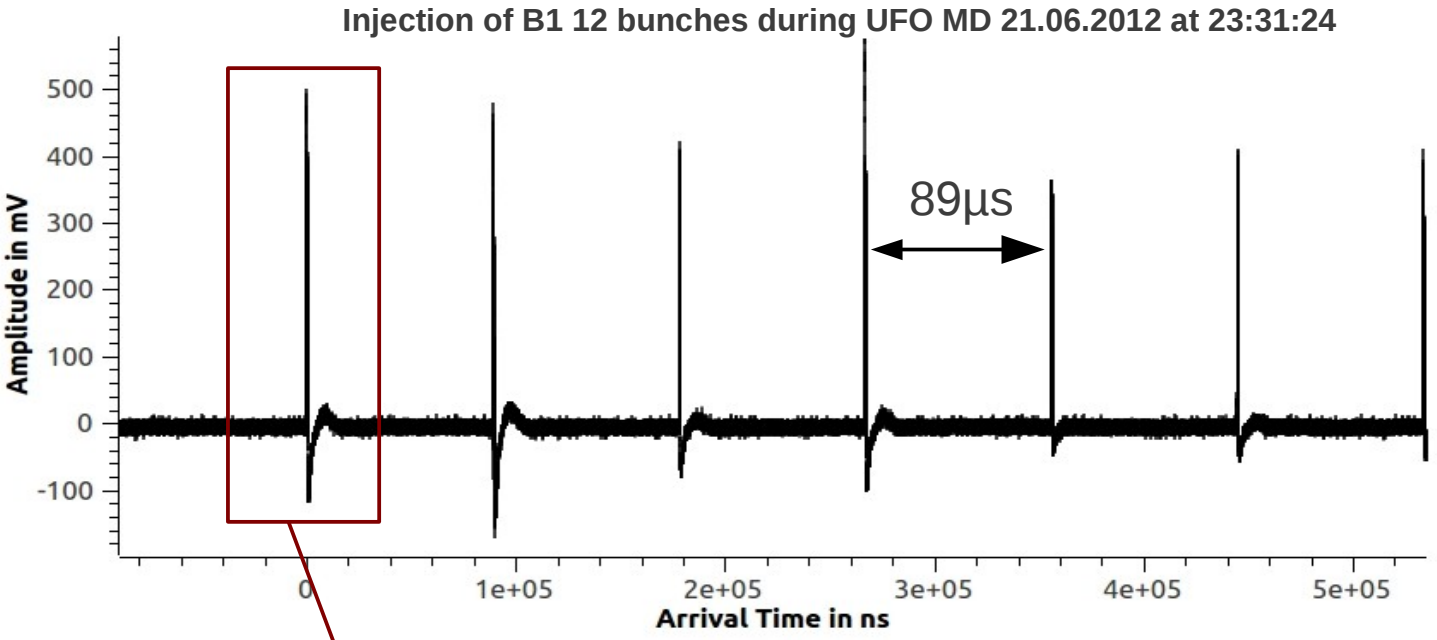
Location	number	trigger
P2	1	injection
P3	2	PM trigger
P6	2	PM trigger
P7	2	Selftrigger on loss amplitude
P8	1	injection

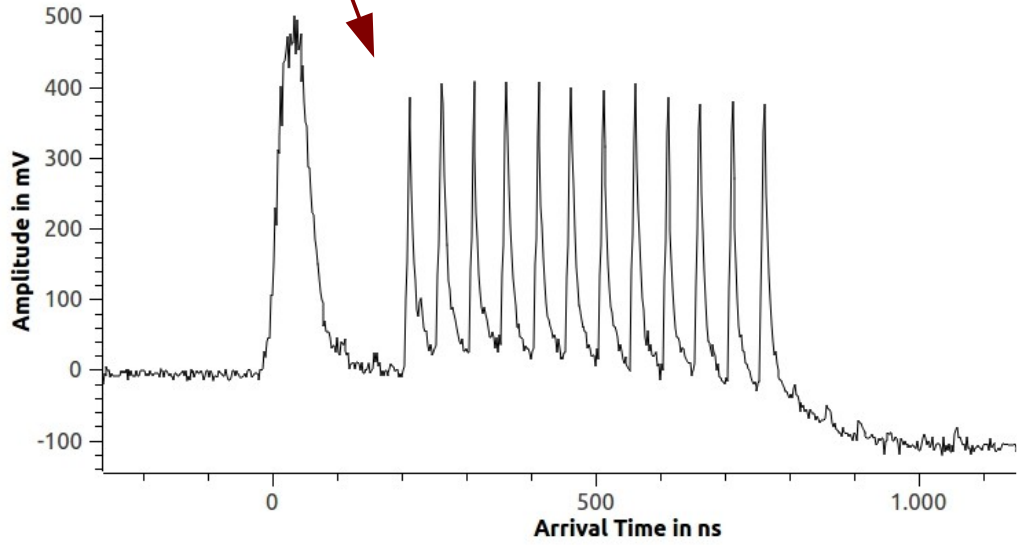
Injection

- Injection of 12 bunches in B1 during the UFO MD
- Observation of losses over 10ms



Injection



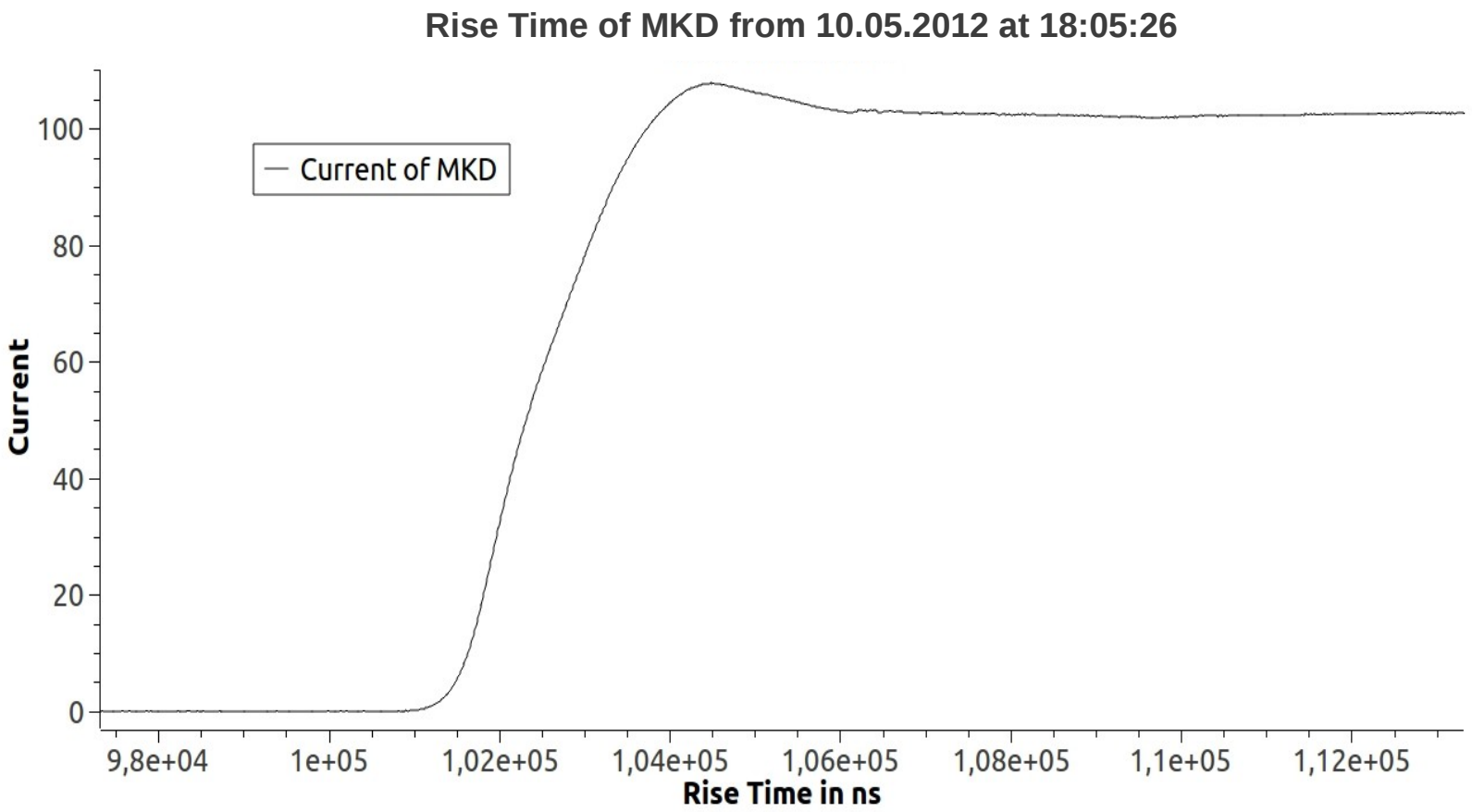


Time between two peaks: 89µs

- First peak unbunched beam from pilot or SPS?
- 12 bunches with 50ns spacing

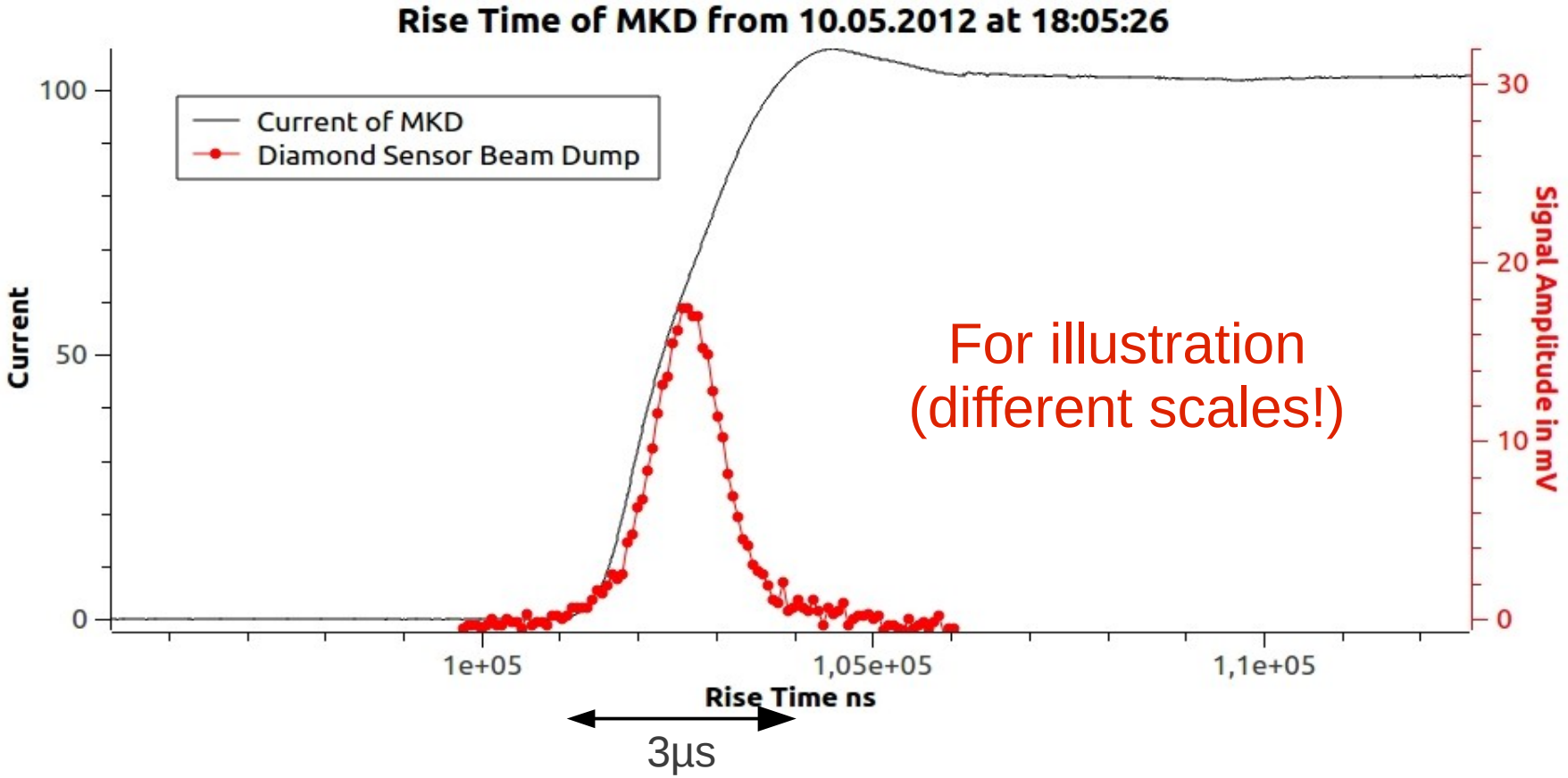
Beam Dump – Kicker Rise Time

- Beam losses during the beam dump due to the rise time of the MKD



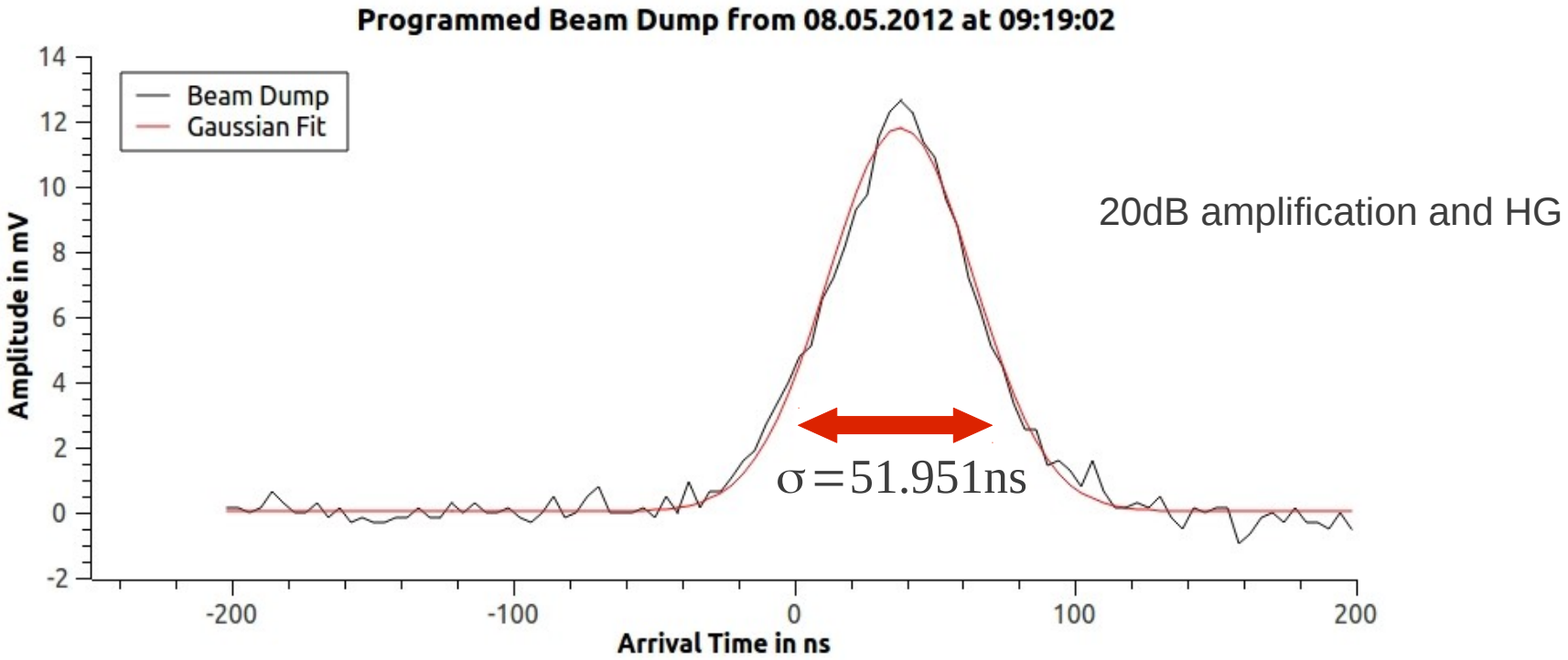
Beam Dump – Kicker Rise Time

- The idea is that the beam losses measured by diamond sensors in IR7 are due to unbunched beam in the abort gap which is not intercept by the IR6 collimators during the rise time of the MKD



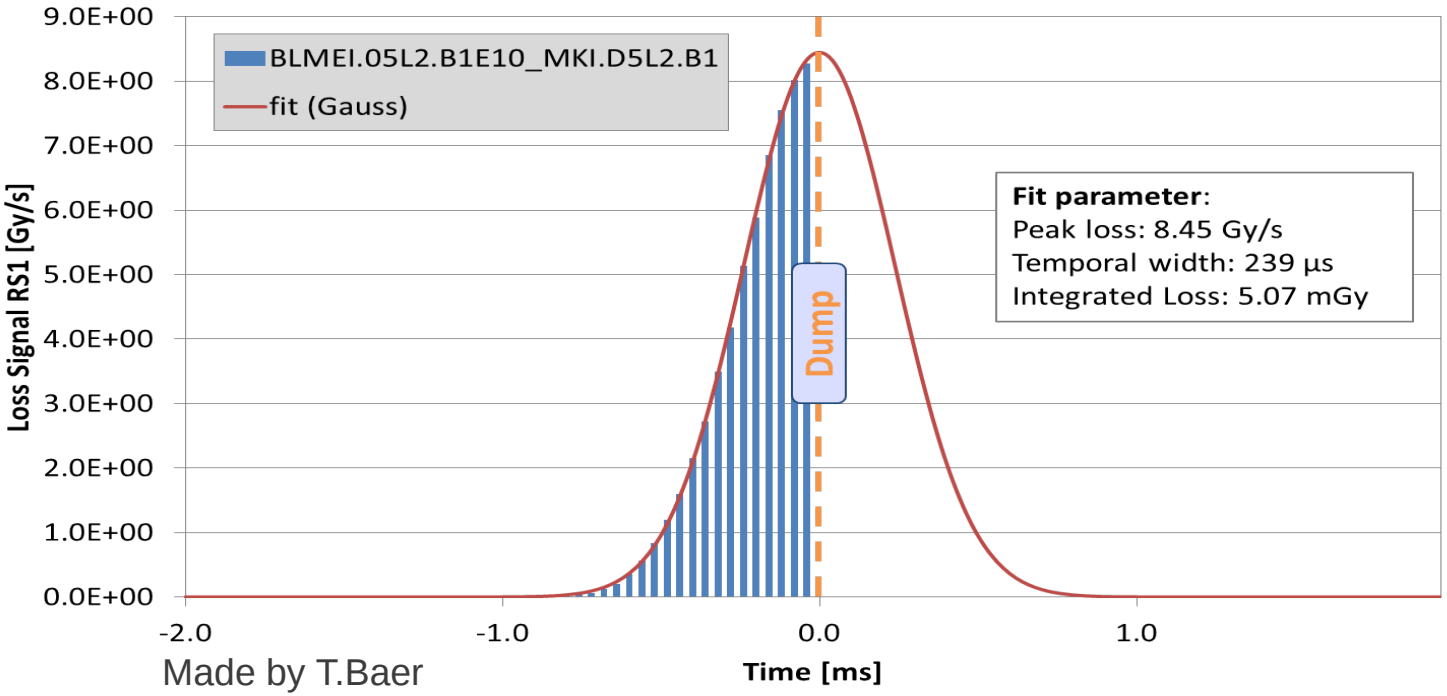
Beam Dump - Gaussian

- Beam losses during dump due to unbunched beam in the abort gab
- Diamond sensors measured several beam dumps
- Temporal beam loss pattern has always a Gaussian shape



UFO

- A dust particle falls into the beam and leads to beam losses
- Beam loss duration is around 10 LHC turns
  - Temporal beam loss pattern over several turns has Gaussian shape
  - Really big UFOs are dumbed on the rising edge

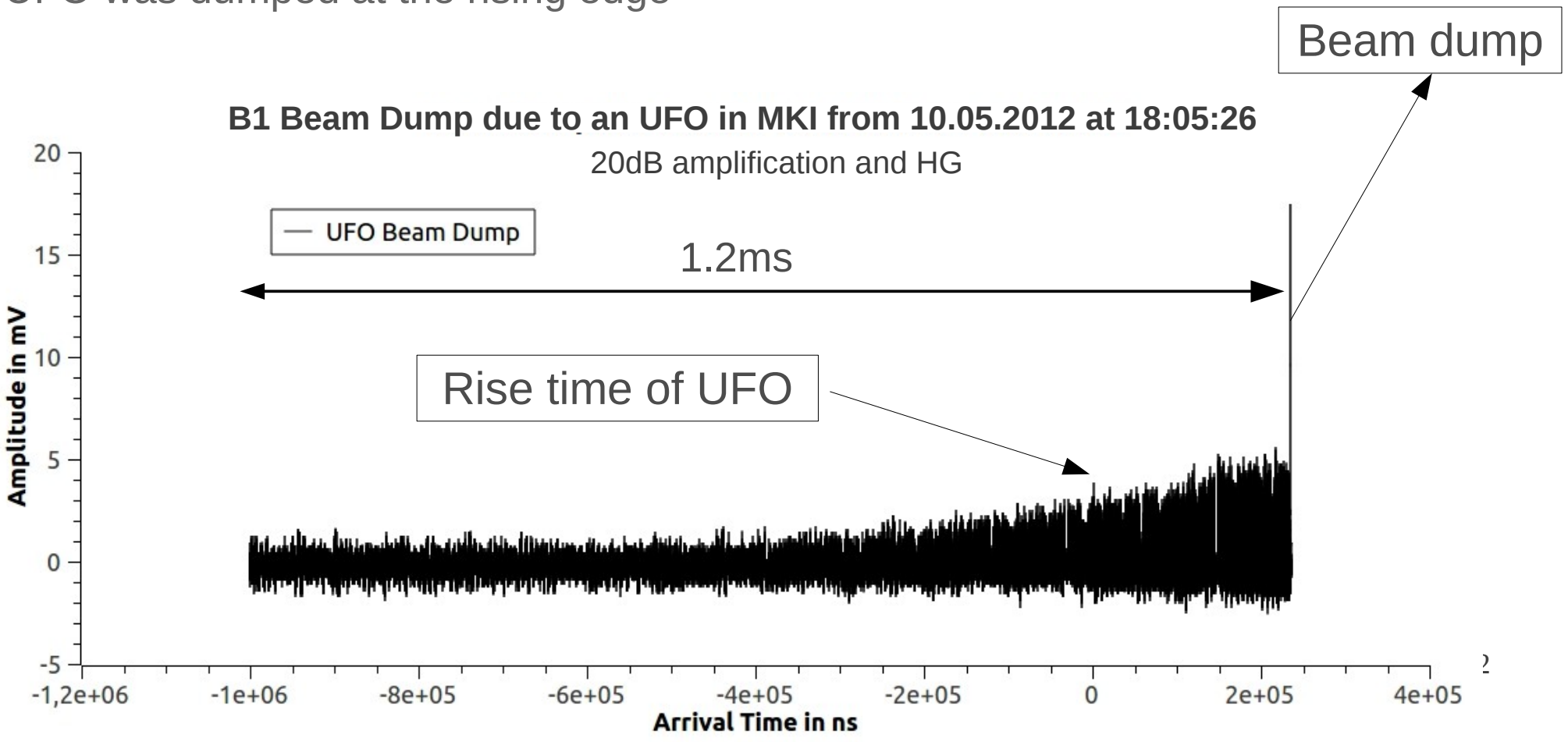


Made by T.Baer

Example of temporal loss pattern of an UFO from 16.07.2011 at 14:09:18

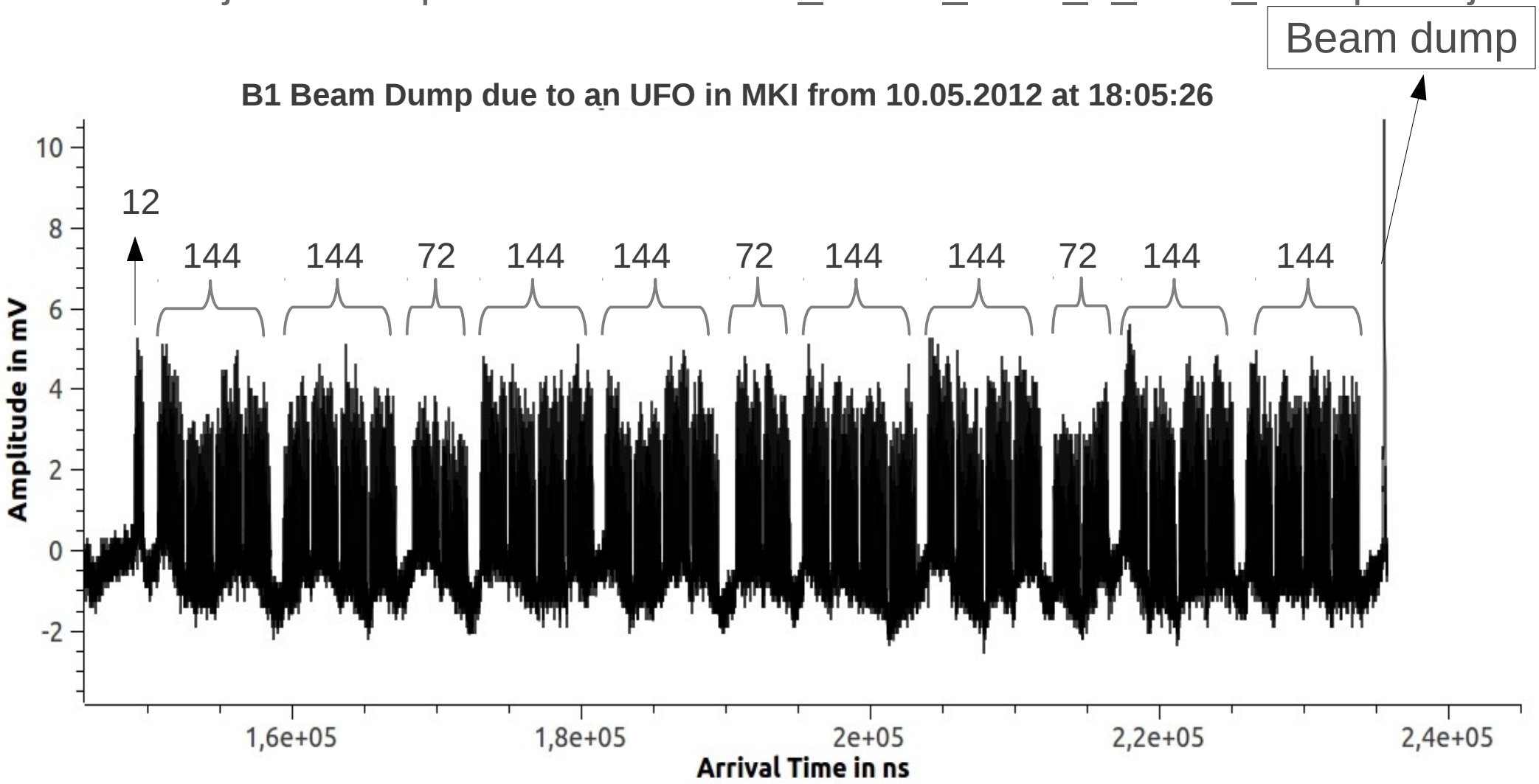
UFO

- Small UFOs have a beam loss in the range of the noise level
  - At the moment not possible to observe
- Diamond sensors saw/measured an UFO that happened in the MKI (large losses)
- UFO was dumped at the rising edge



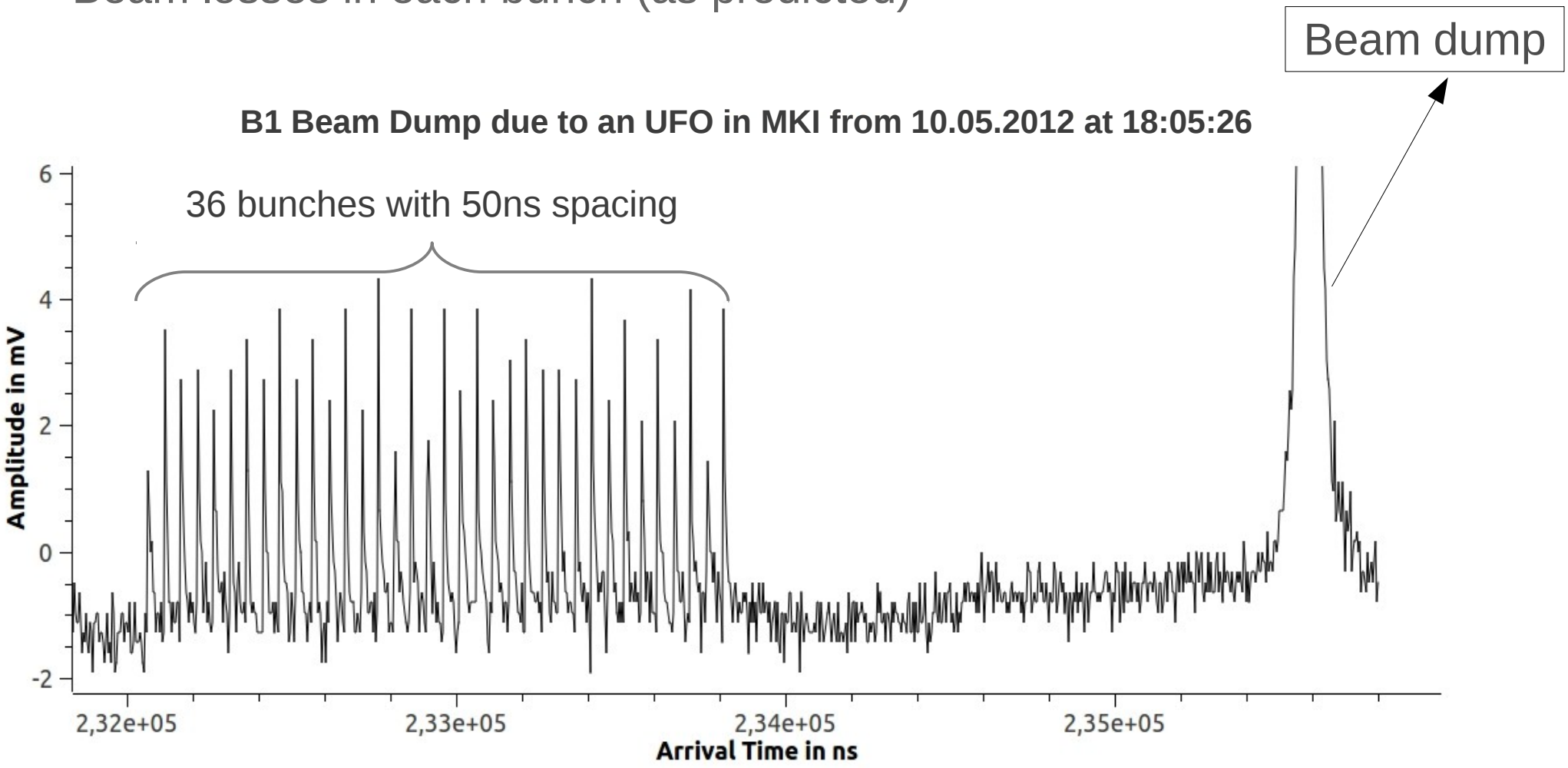
UFO – First Zoom

- Clear injection sequence visible: 50ns_1380b_1331_0_1320_144bpi12inj



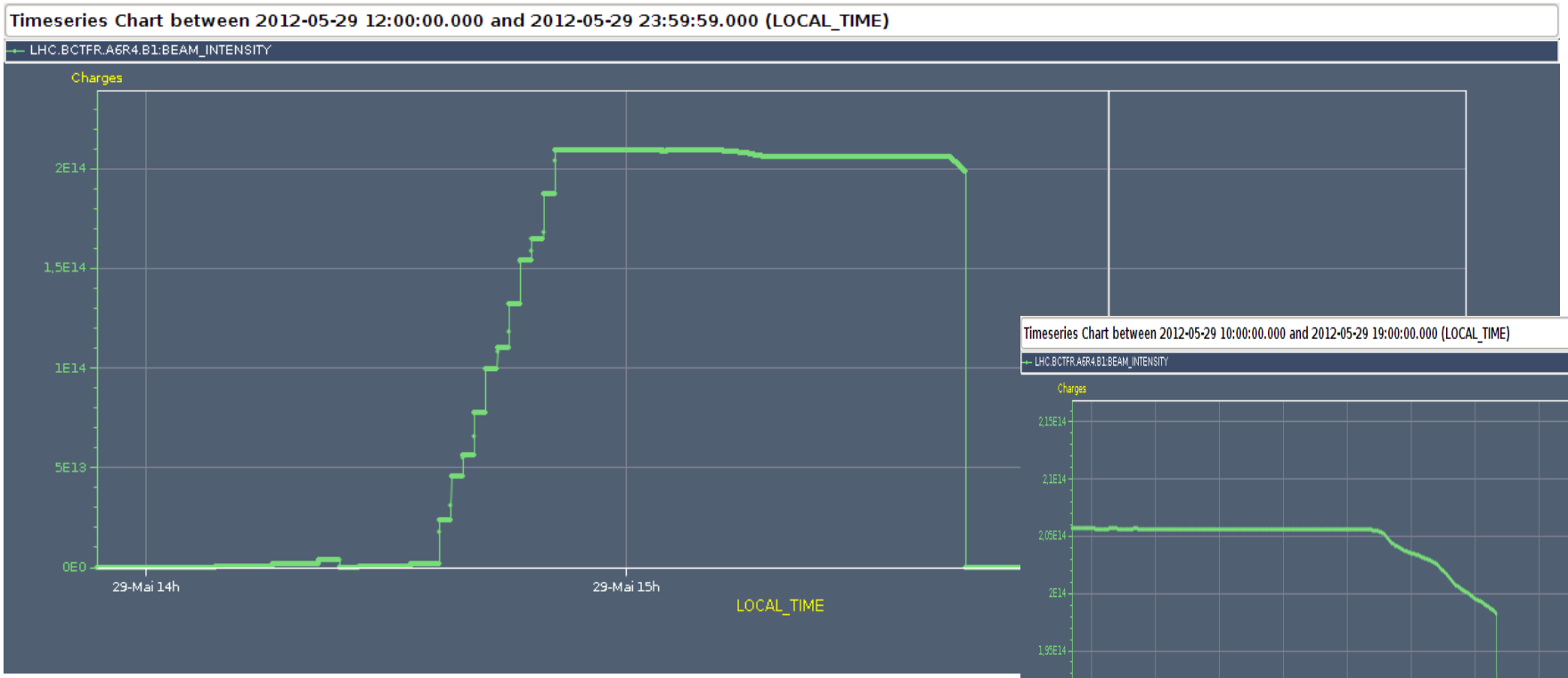
UFO – Second Zoom

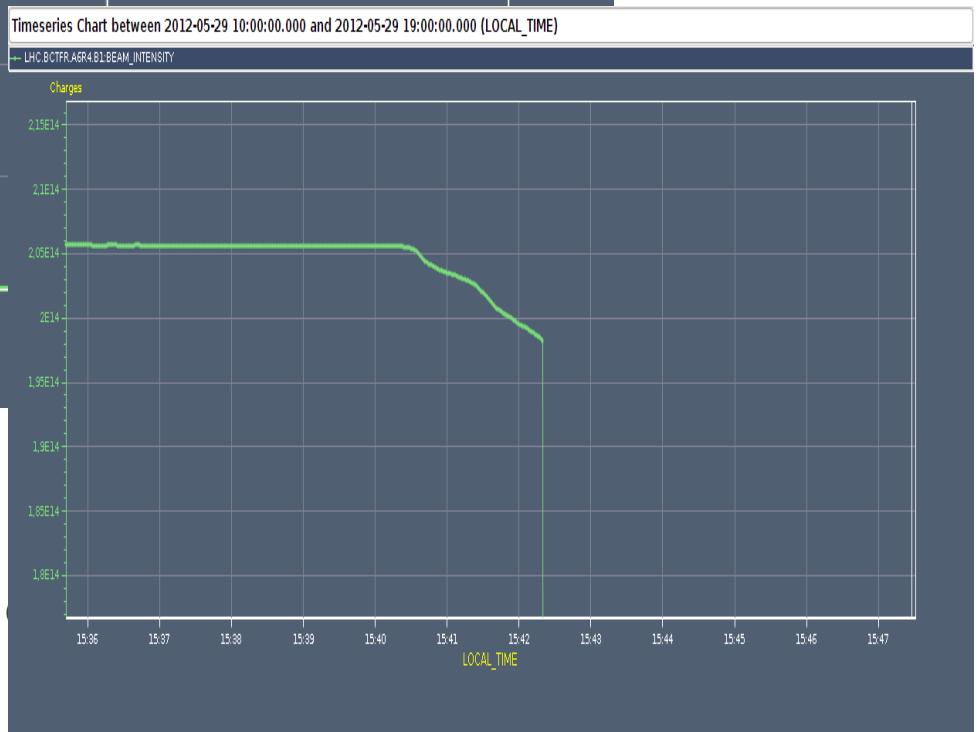
- Beam losses in each bunch (as predicted)



Instability – BCT Plot

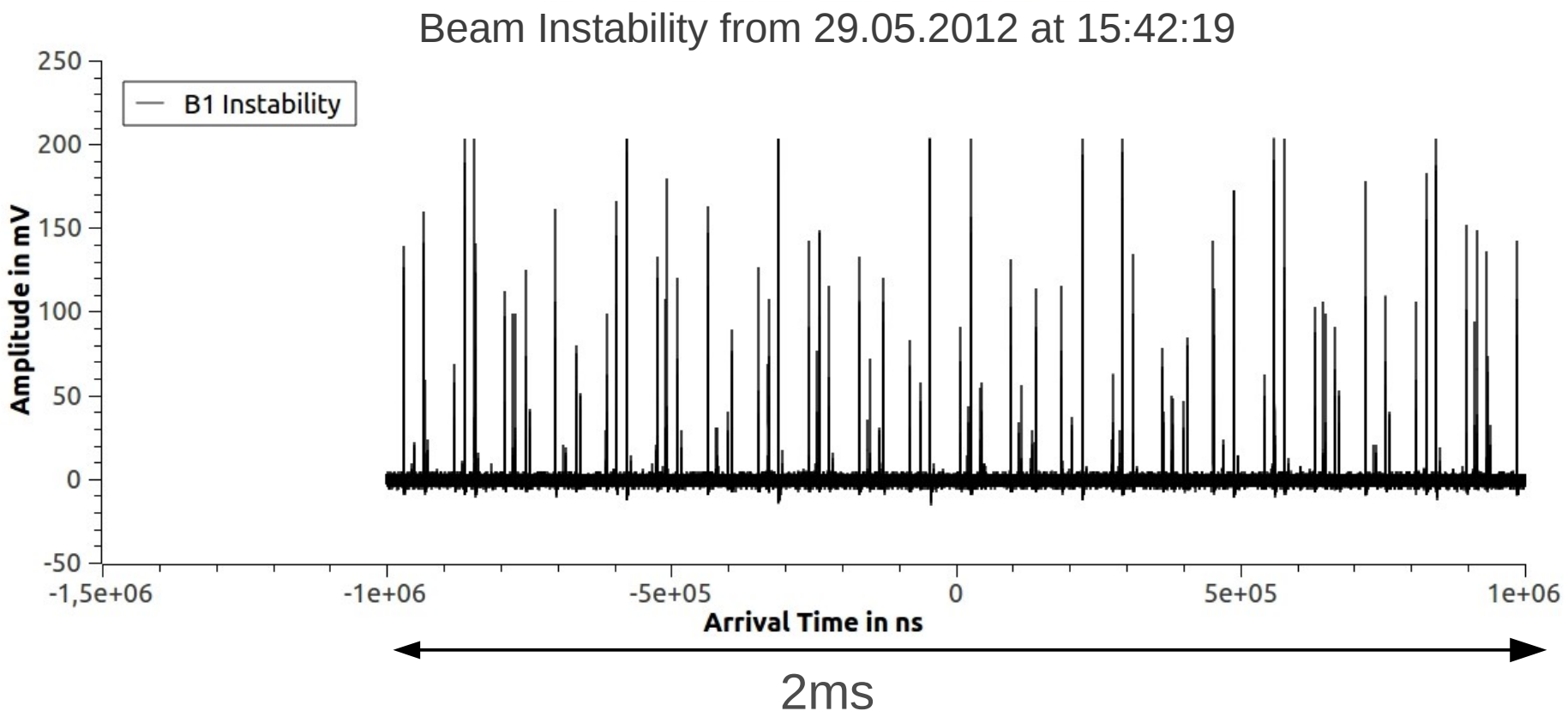
- Instability during Adjust from the 29.05.2012 at 15:42:19
- Losses over 2min



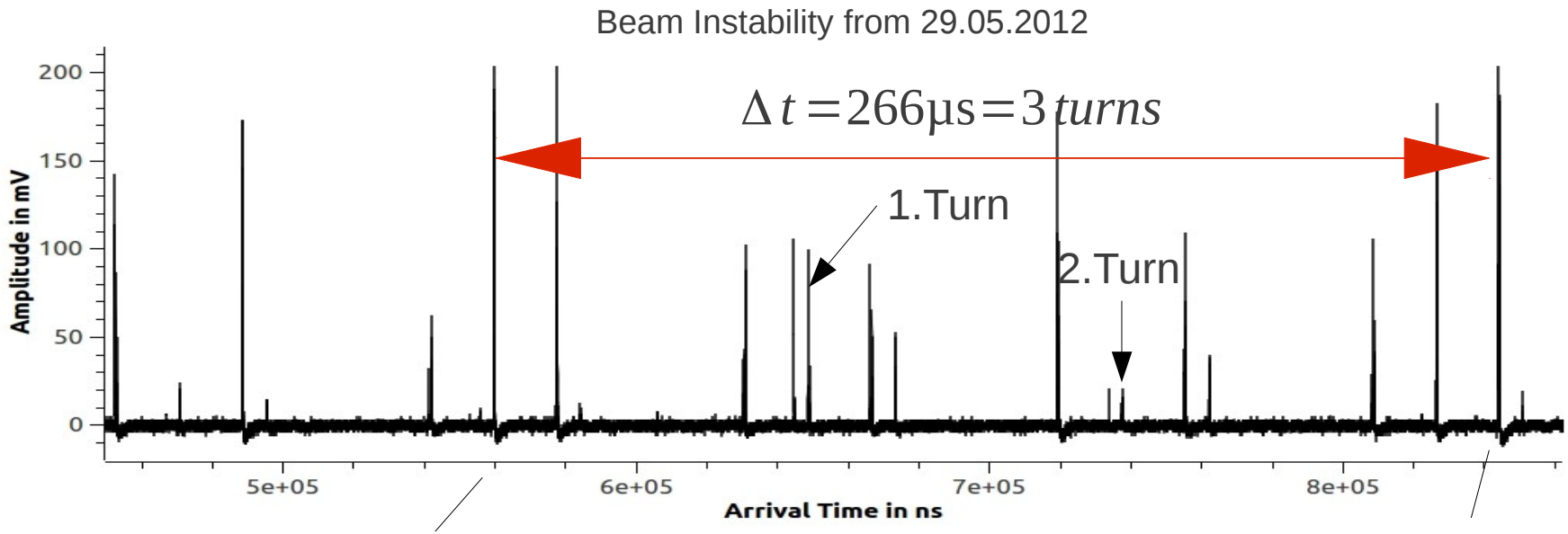


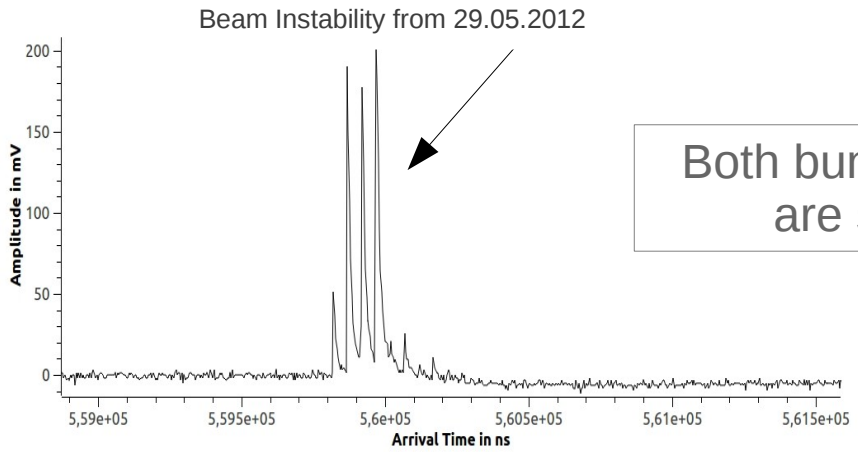
Instability – Diamond Sensor

- Instability caused beam losses only in some bunches
- Losses over several turns (all in all 2min)

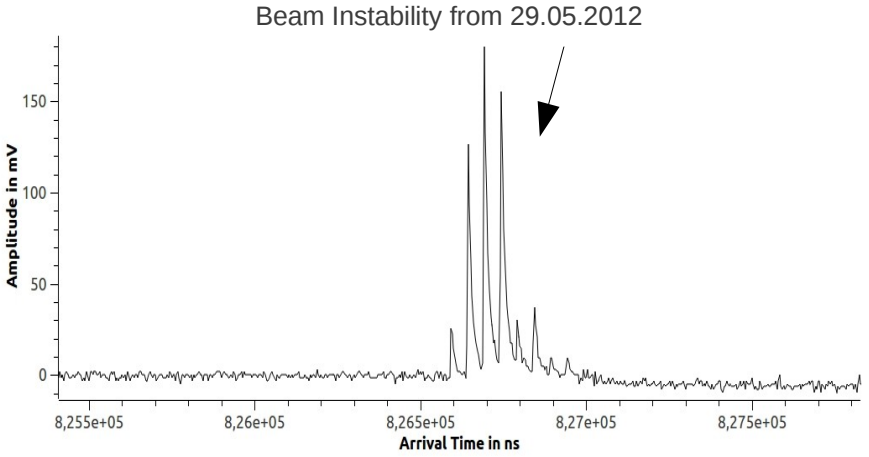


Instability- Closer Look





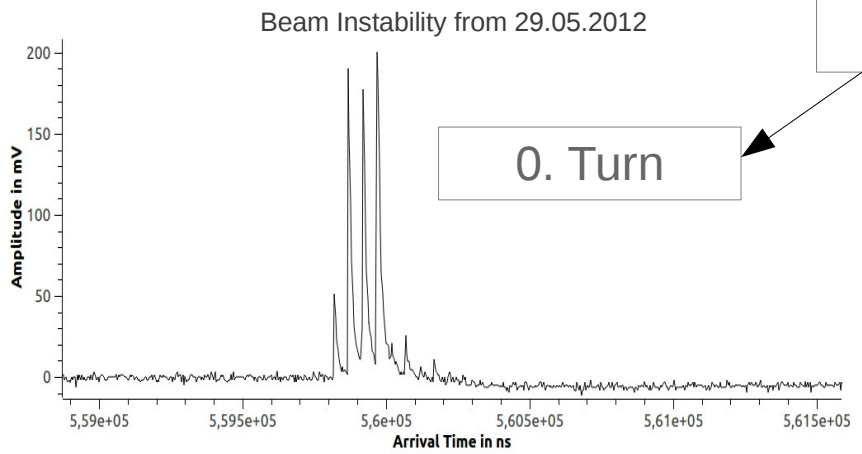
Both bunch pattern are similar

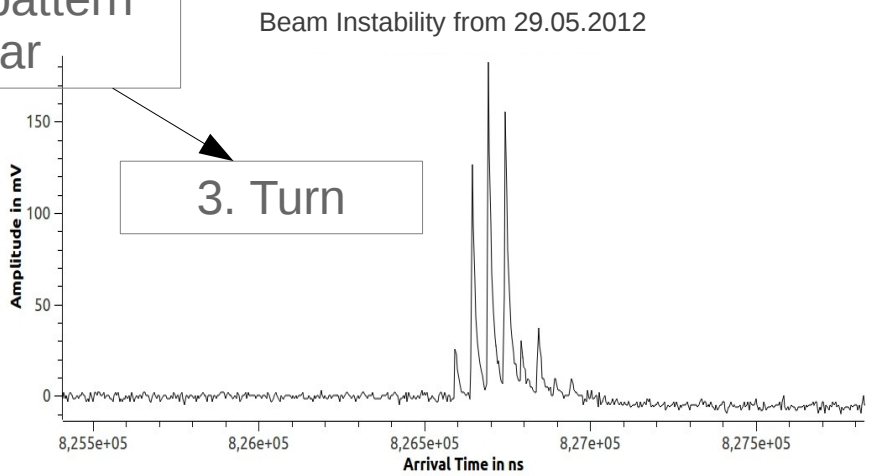


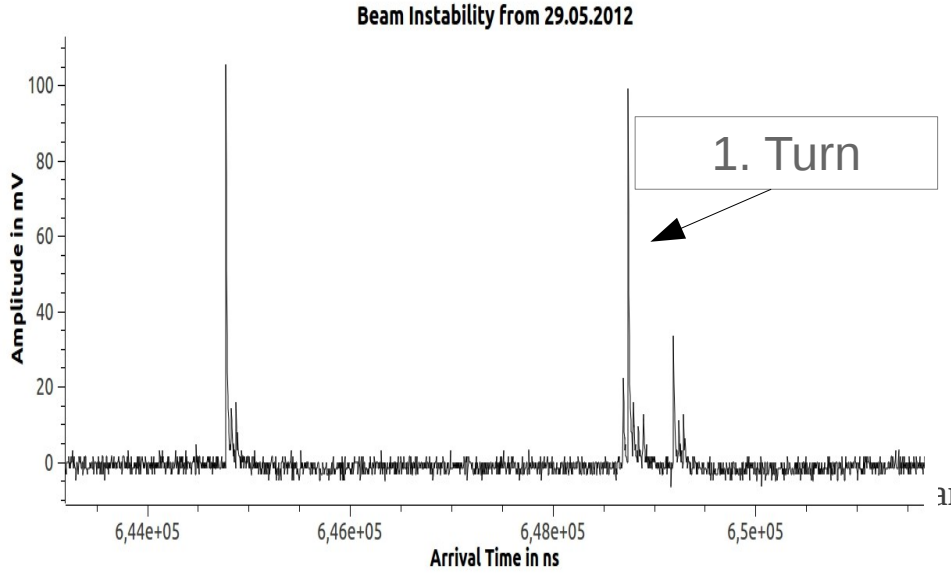
Instabilities

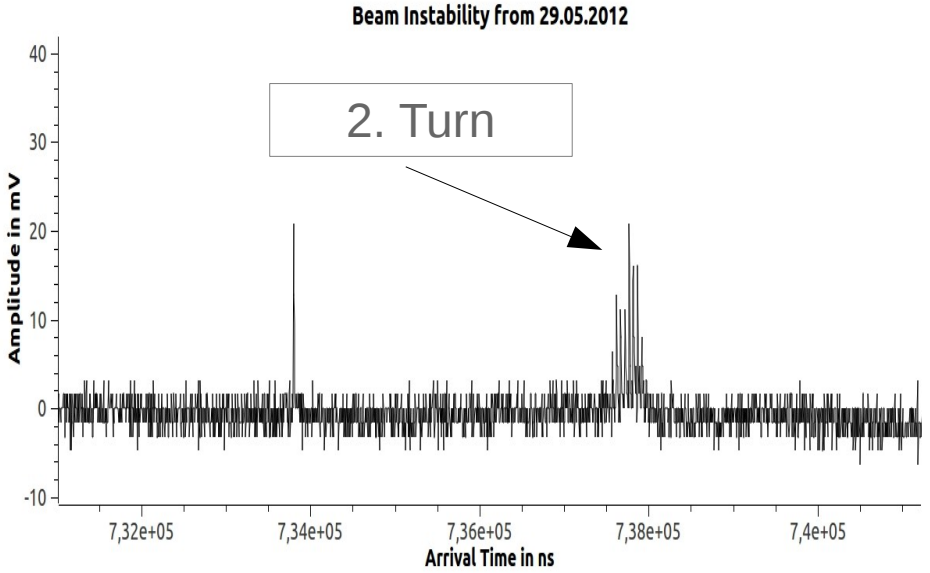
- Time between similar bunch pattern is 3*89µs (3 turns)
  - Due to the Tune of ~0.3

Both bunch pattern are similar









Further Ideas

- Use the FESA class to control also the diamond sensor in IR7 with the selftrigger
- Observation of beam dumps (PM check)
  - Diagnostic for TCDQ
  - Cross check of TCDQ alignments or damage after asynchronous beam dump?
- Diagnostic for instabilities
  - Information of bunch that becomes unstable?
- Diagnostic and observation of small UFO (no beam dump)
- Diagnostic for injection (what is the reason for the unbunched beam before injection?)
- Increased dynamic range of IR7 diamond sensor by different amplifiers (20dB and 40dB)?

Summary

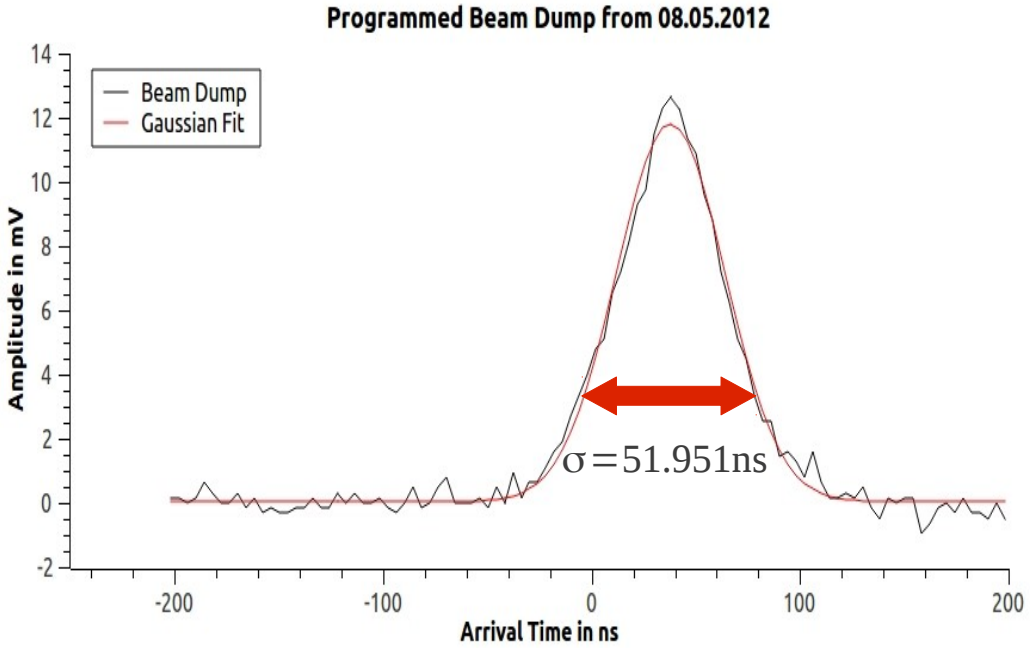
- 8 diamonds in the LHC tunnel
- Two important diamonds are located in IR7
- The diamonds in IR7 are able to see different beam losses
  - **Injection**: losses of injected beam over several turns
  - **Beam dump**: Gaussian loss profile
  - **UFO**: beam loss in each bunch → Gaussian loss profile
  - **Instabilities**: losses over several turns only in some bunches
- Different gains for different purpose/beam losses
- Problems:
  - No reference signal → cannot identify which bunch caused the instability
  - We don't see small UFOs → signal is in the range of the noise level

Backup Slides

Beam Dump – Two different Dumps

- Two different beam dump: after a long and short fill
- Losses in both cases are similar
  - Amplitude: 12mV & 17mV
  - Width: 52ns & 56ns

Beam dump after 10.5h



Beam dump after 0.51h