RECENT OBSERVATIONS IN DIAMOND DETECTORS SIGNAL IN THE SPS EXTRACTION AND LHC INJECTION REGIONS

F. Burkart

for TE-ABT

with many inputs from M. Barnes, S. Bart Pedersen, T. Bohl, B. Dehning, L. Drosdal, E. Effinger, V. Kain, S. Sousa, R. Steerenberg, O. Stein

Outline

- Introduction dBLMs around LHC
- Measurement Results
- Loss Mitigation
- Current status of DAQ and Outlook

Acronyms for this presentation

dBLM – diamond based beam loss monitor

MKI – LHC injection kicker magnet

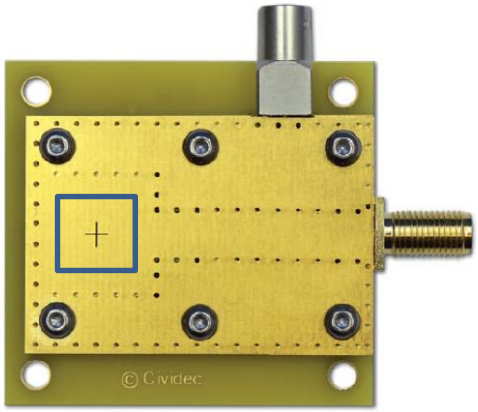
MKE – SPS extraction kicker magnet

MKP – SPS injection kicker magnet

TPSG – SPS septum protection

TDI – LHC injection protection absorber

Diamond detectors



- pCVD diamond based beam loss monitors, CIVIDEC.
- Active area: 1 cm^2.
- Thickness: 500 µm.
- E field strength: 1 V / µm.
- Nanosecond time resolution.
- Radiation hard.
- Rise time of 1 ns.
- Characterized between 1 – 1E8 MIPs.
- Can be installed at cryogenic temperatures.
- Vacuum compatibility.
- RF shielded.
- Can be used for beam based alignment.

Aim:

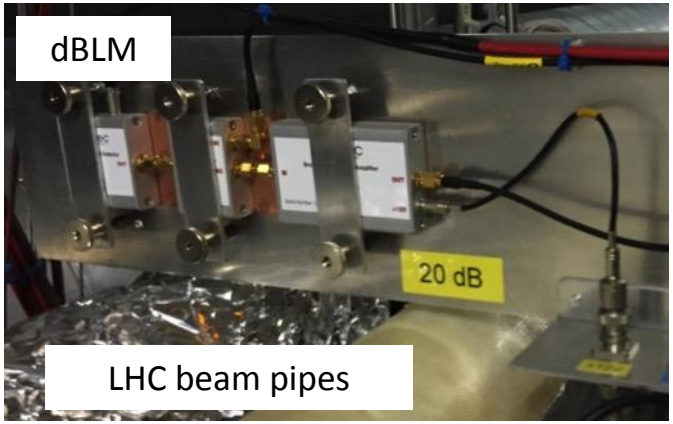
- Bunch-by-bunch loss data.
- Detect ghost bunches and RF – recapture at injection.
- Study UFOs.
- etc.

dBLMs around LHC

In total: 8 dBLMs.

- **Extraction losses at the PS** – position: installed close to **septum MU16**.
- **Extraction losses at the SPS** – position: installed close to **septum protection in LSS4 and LSS6**.
- **Injection losses at LHC** – position: IR2 and IR8, downstream of **TDI**.
- **Global losses** and post-mortem event recordings **in left and right IR7**, downstream TCPs.
- **Extraction losses at LHC** – position: IR6, downstream of **TCDQ**.
- **Transfer line losses** – position close to **TCDI** in TI2 and TI8 – after the next TS.

Close collaboration with BE-BI-BL, (Bernd Dehning et al.)



3 DAQs installed.

OASIS scope (PS)

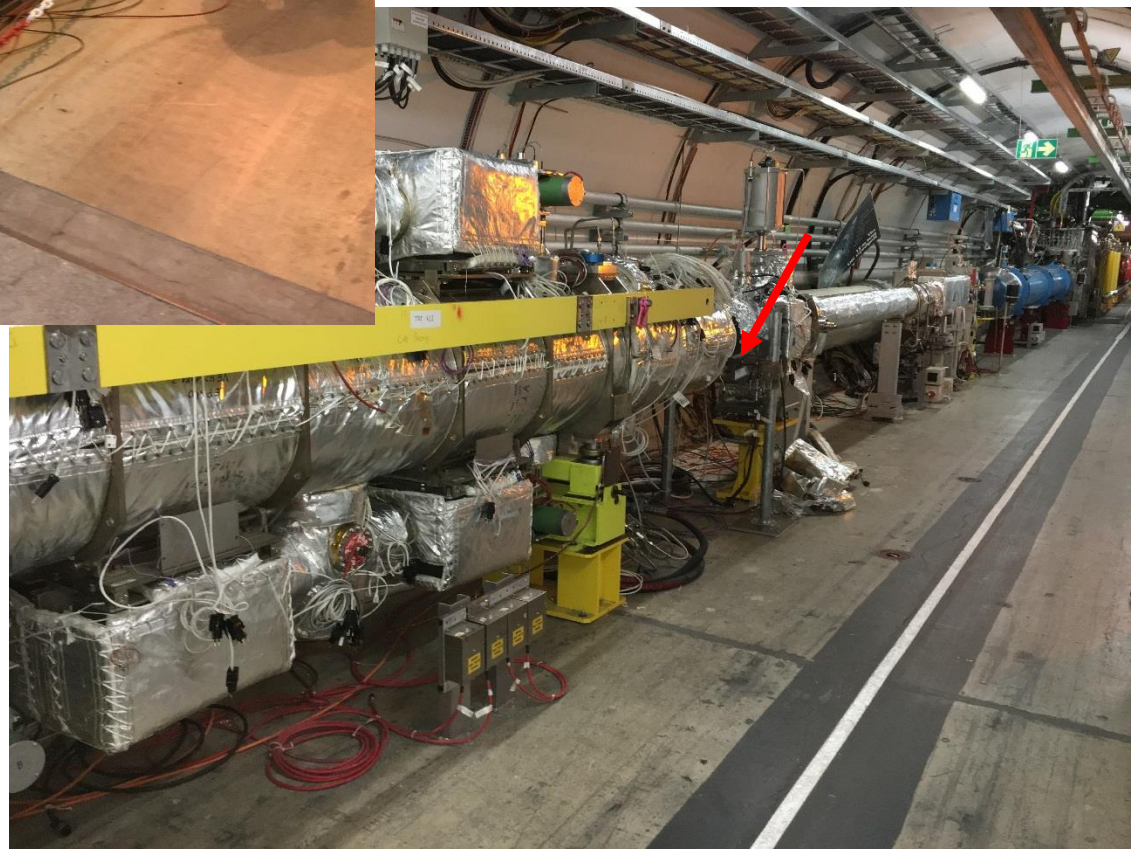
Oscilloscope (IP2, IP6, IP7, IP8, SPS)

ROSY CIVIDEC, Scope and Histogram unit (IP4, IP7)

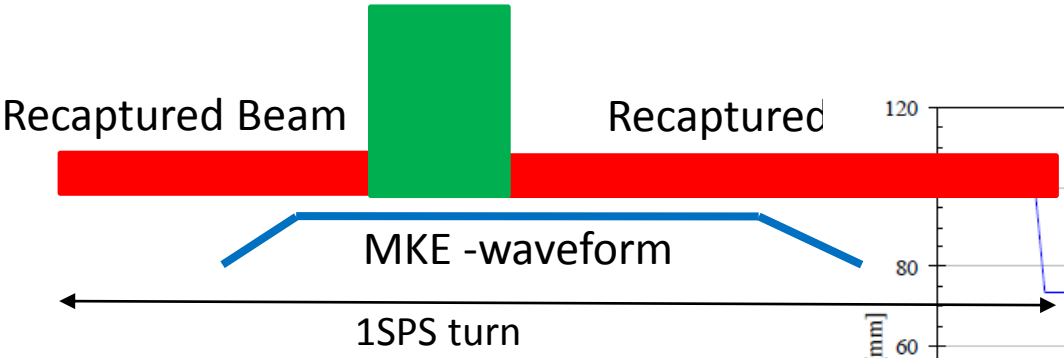
FESA class for oscilloscope systems.

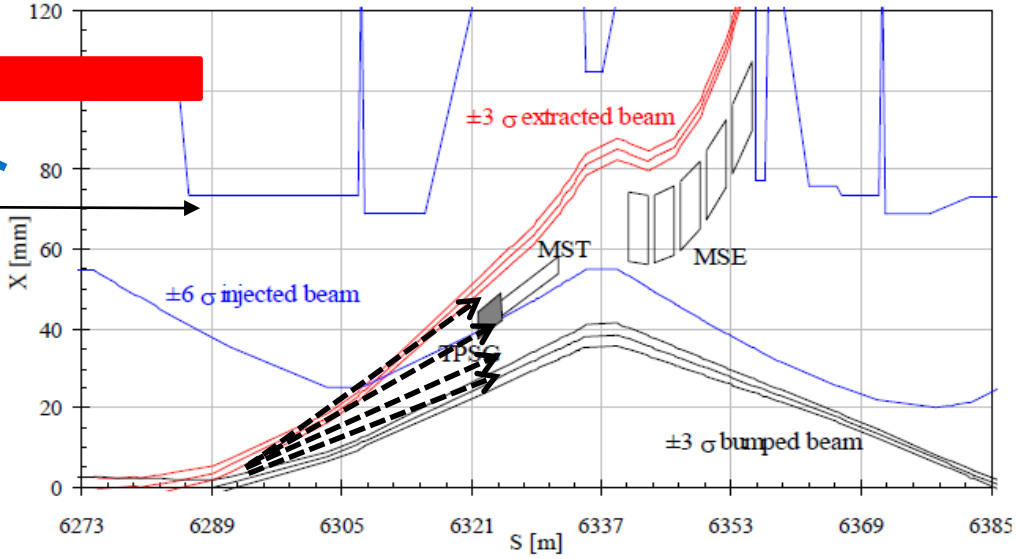
Close collaboration with BE-BI-SW (Stephane Bart Pedersen)

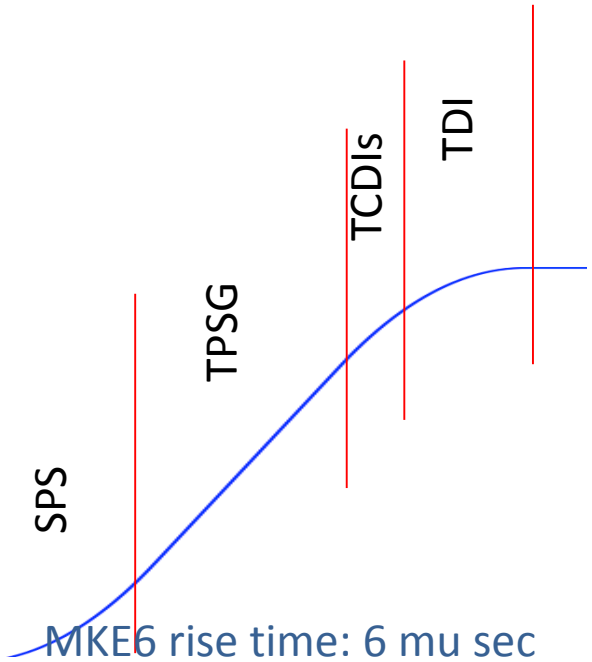
New DAQ card will be developed by BI.



LSS6 extraction

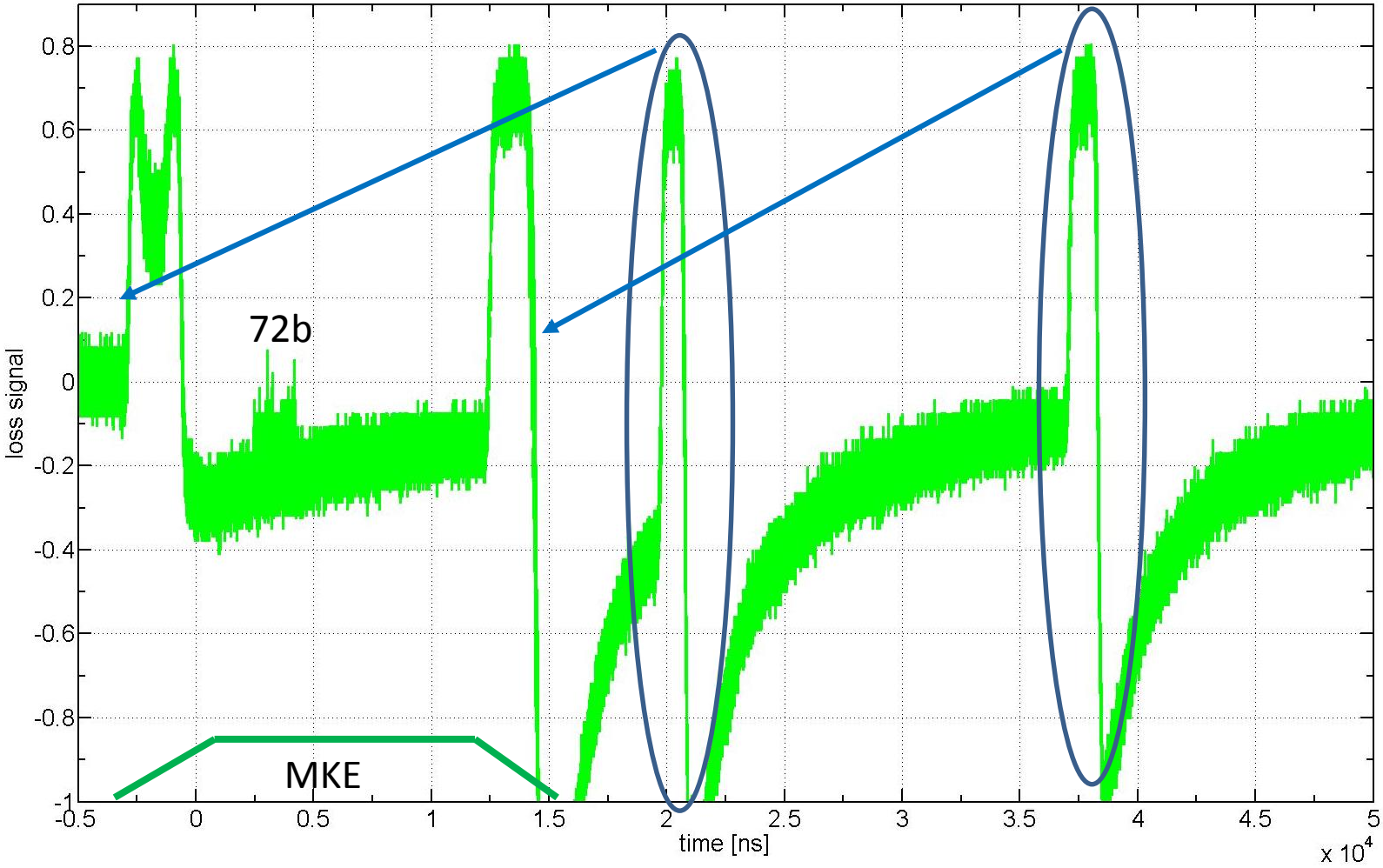




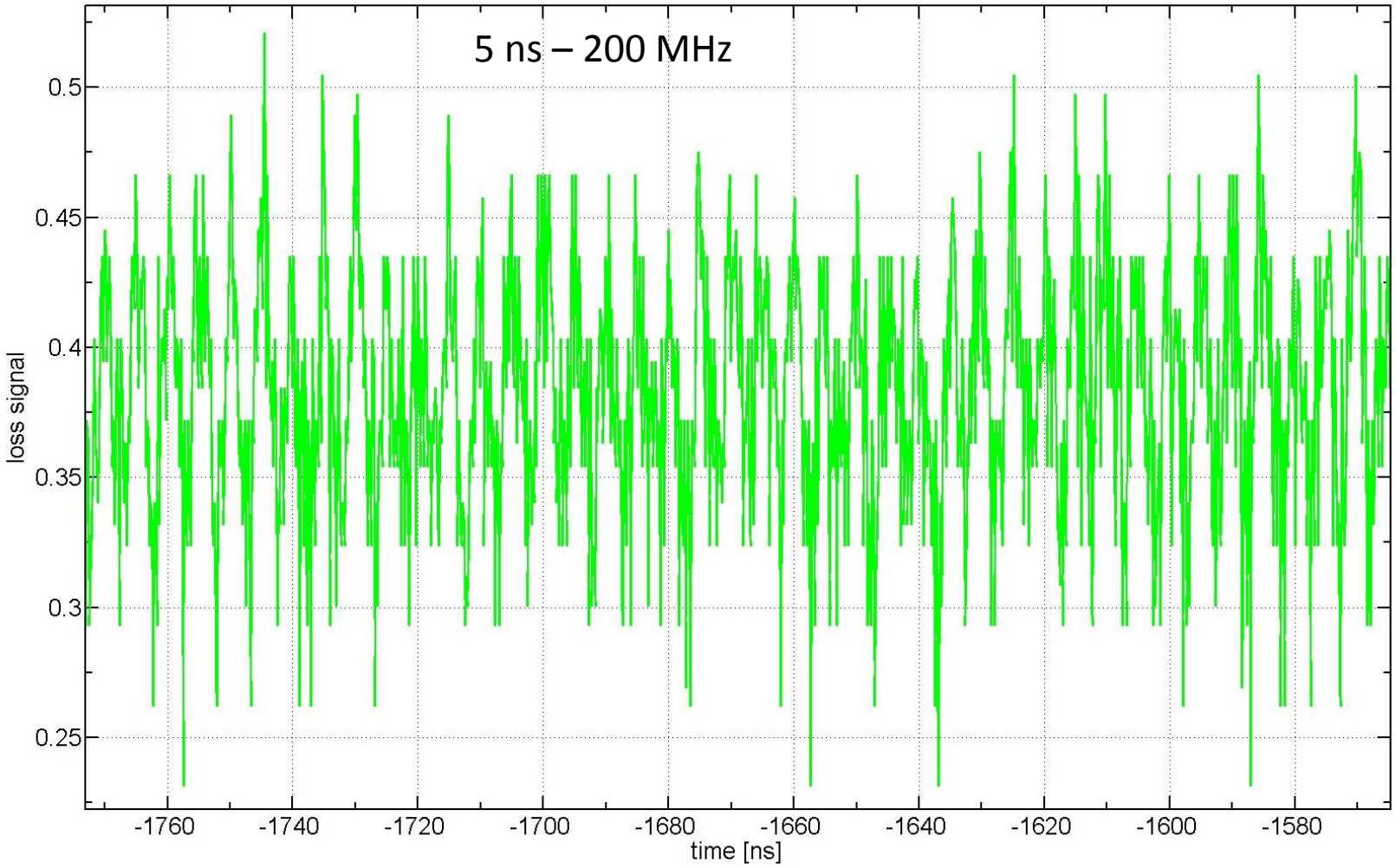


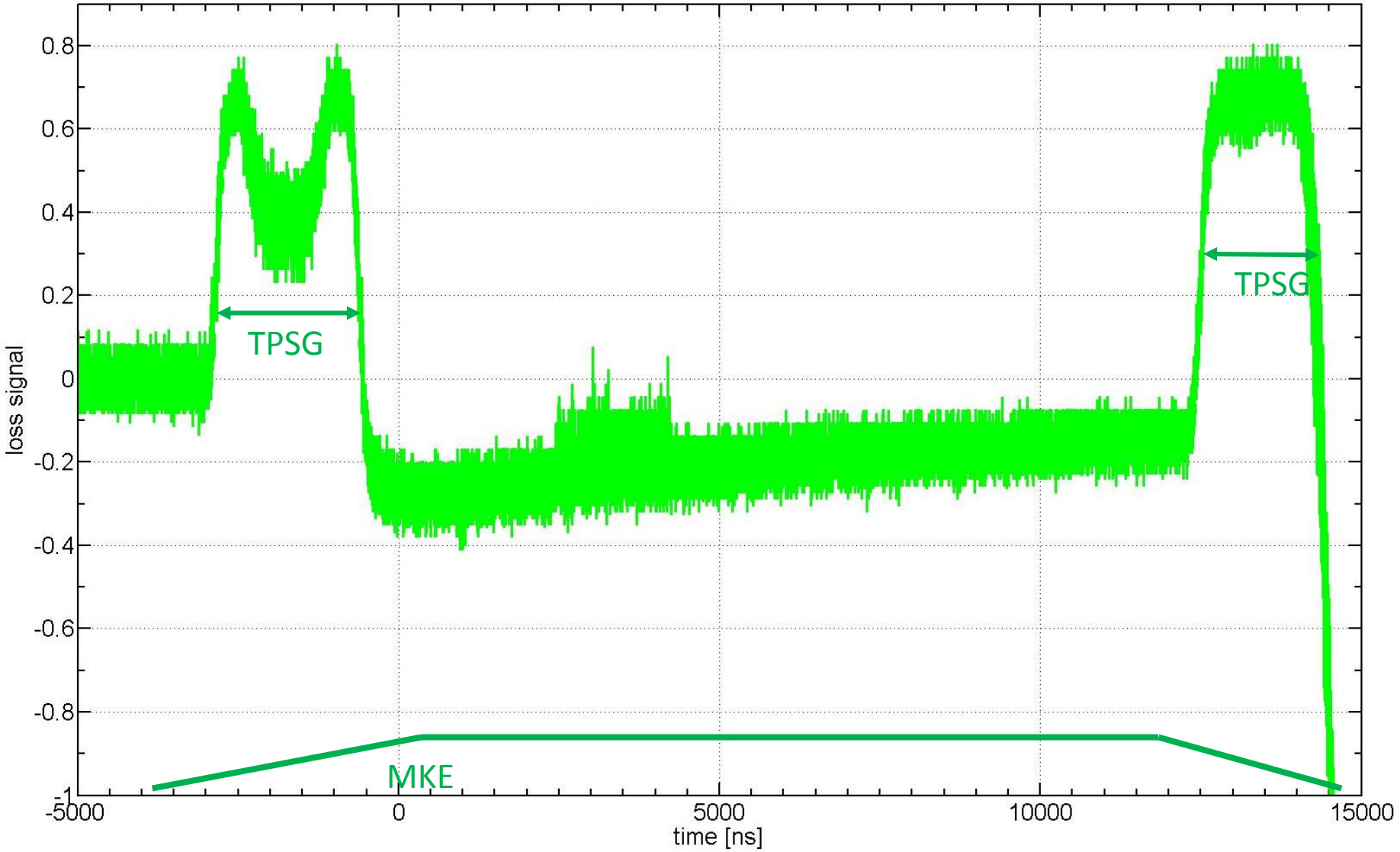
MKE6 rise time: 6 mu sec

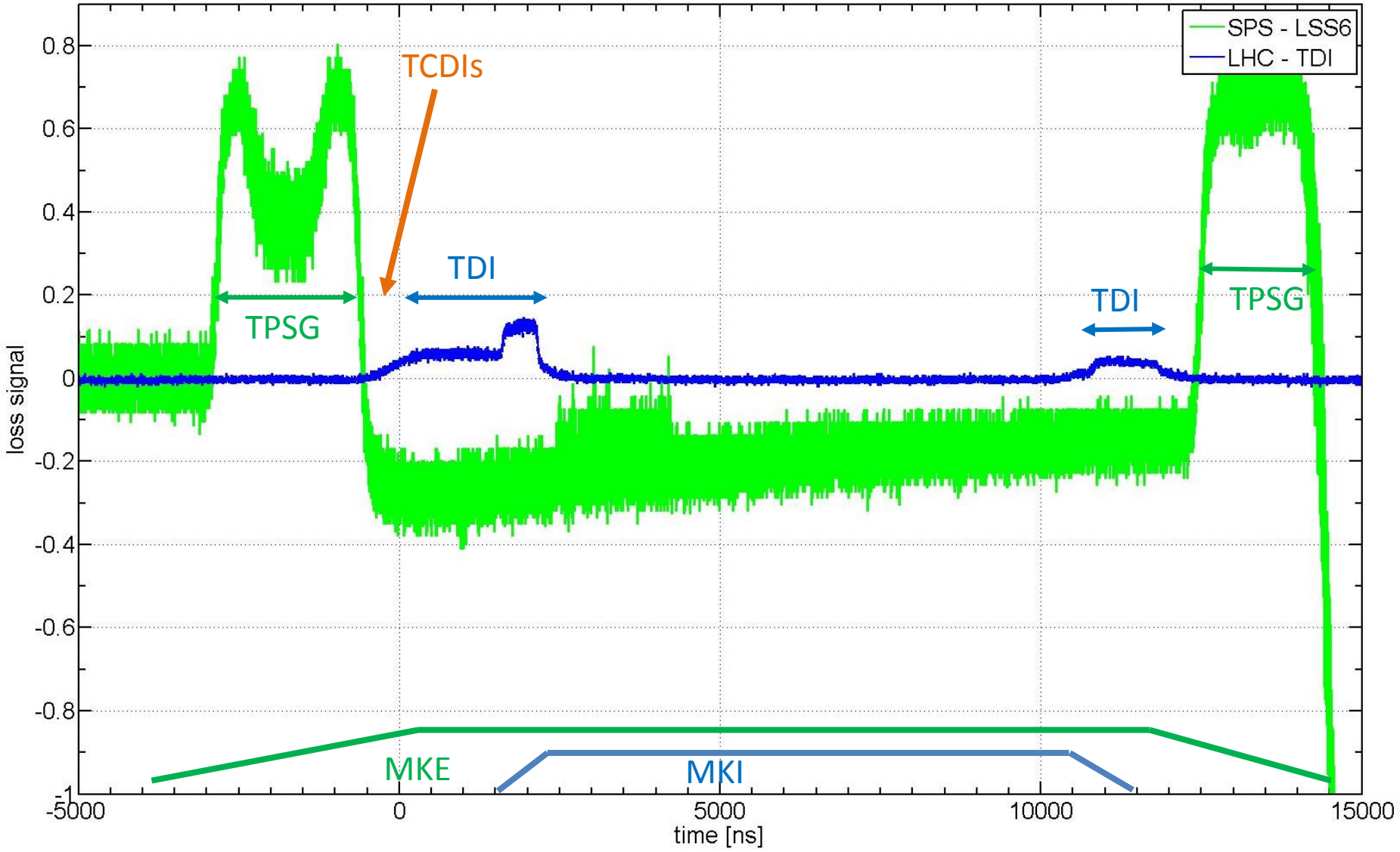
SPS losses – extraction LSS6 (B1)

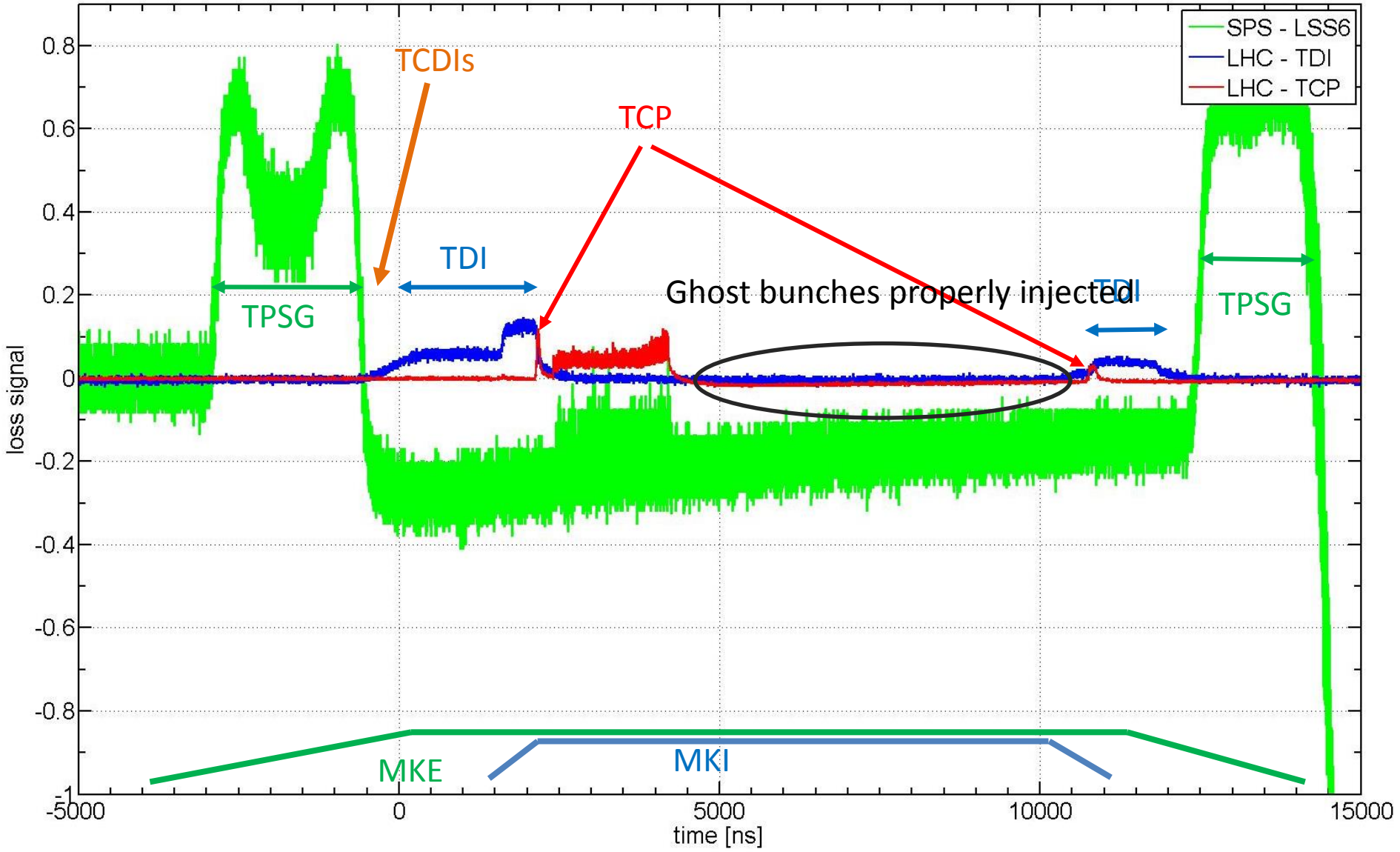


SPS losses - zoom

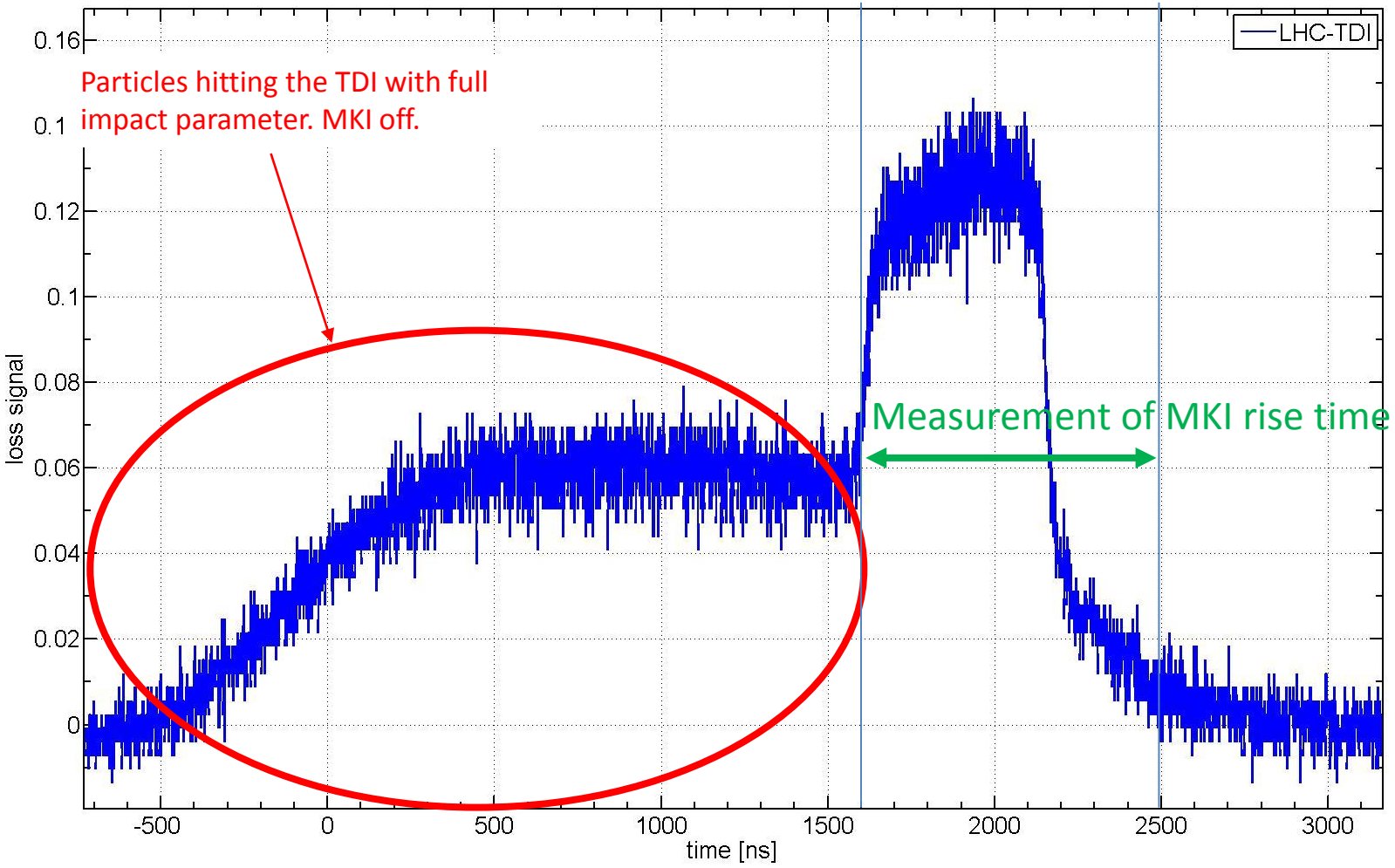



0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
loss signal
-5000
0
5000
10000
15000
time [ns]
TPSG
TPSG
MKE


SPS - LSS6
LHC - TDI
TCDIs
TDI
TPSG
TDI
TPSG
MKE
MKI
loss signal
time [ns]
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-5000
0
5000
10000
15000

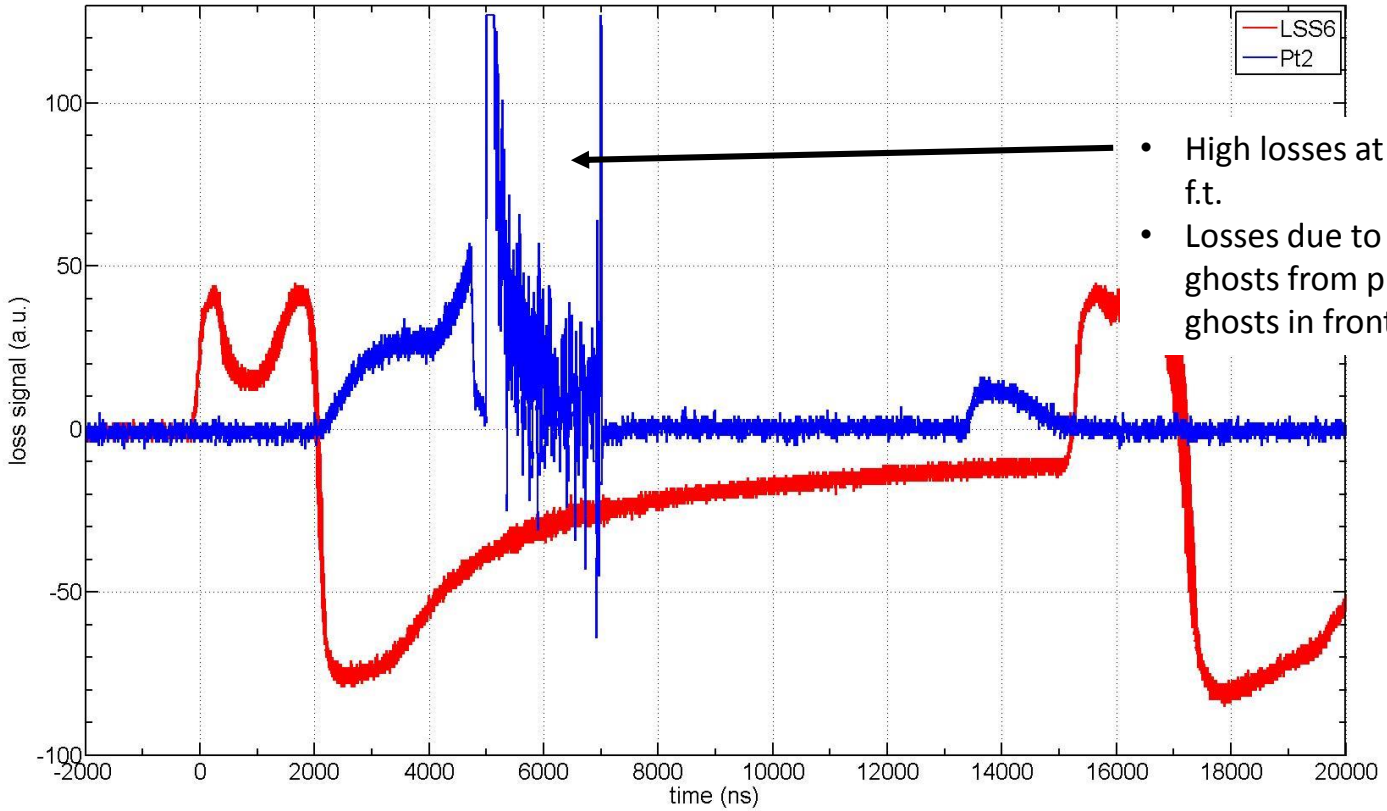

SPS - LSS6
LHC - TDI
LHC - TCP
TCDIs
TCP
TDI
TPSG
Ghost bunches properly injected
TDI
TPSG
MKE
MKI
loss signal
time [ns]
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-5000
0
5000
10000
15000

TDI losses


LHC-TDI
Particles hitting the TDI with full impact parameter. MKI off.
Measurement of MKI rise time
loss signal
time [ns]
0.16
0.1
0.12
0.1
0.08
0.06
0.04
0.02
0
-500
0
500
1000
1500
2000
2500
3000

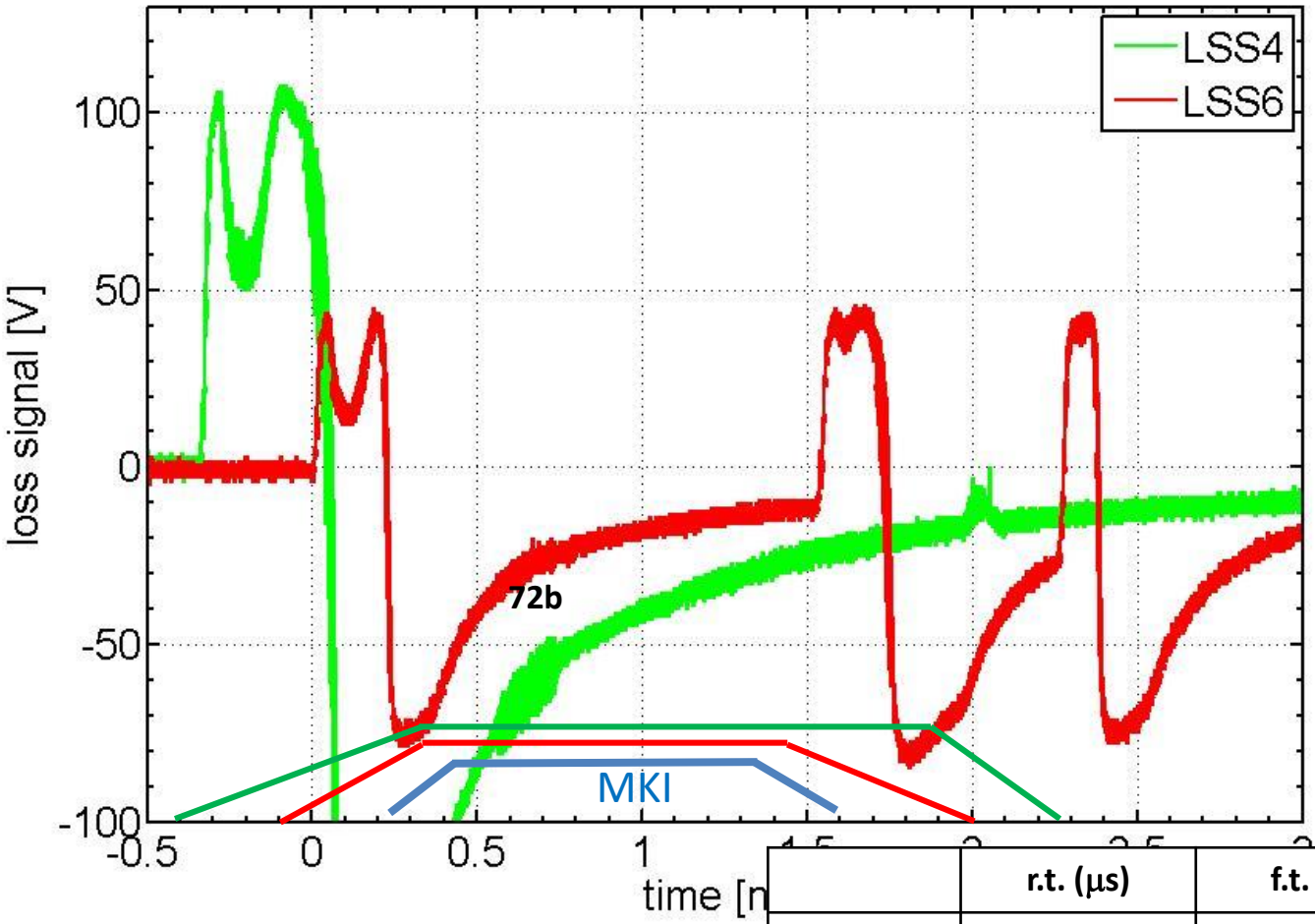
Last week…

NOW: 20.05.2016 – 3.10 am **Beam 1**



- High losses at the beginning of kicker f.t.
- Losses due to kicking circulating ghosts from previous injection or ghosts in front of the injected beam.

Losses at SPS extraction



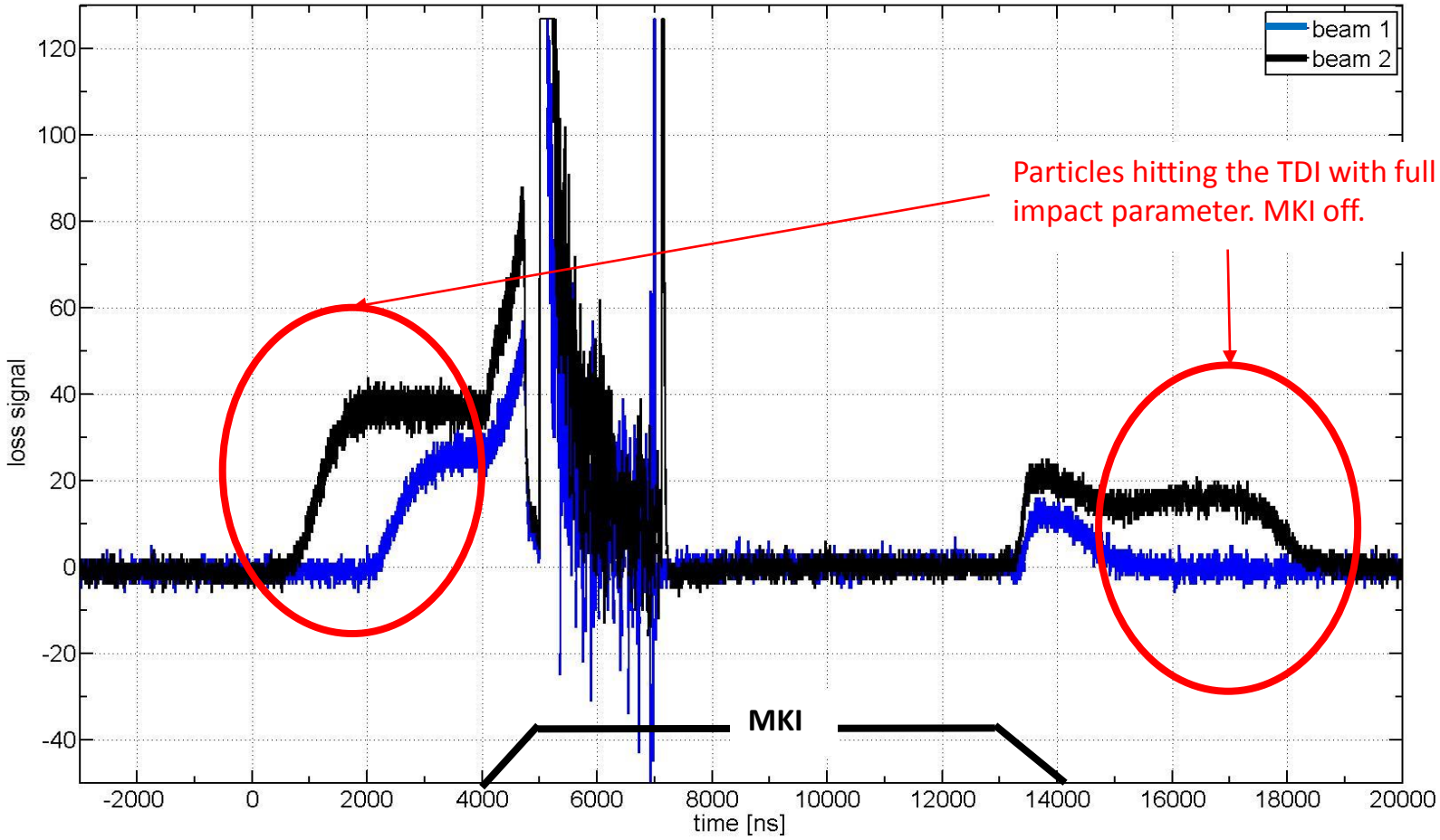
MKE6 shorter rise time, shorter f.t., pulse length below 1 SPS turn, therefore also losses one SPS turn later.
Higher losses on SPS side.

MKE4 pulse length longer then SPS turn. Ghost bunches properly extracted.
Higher losses on LHC side.

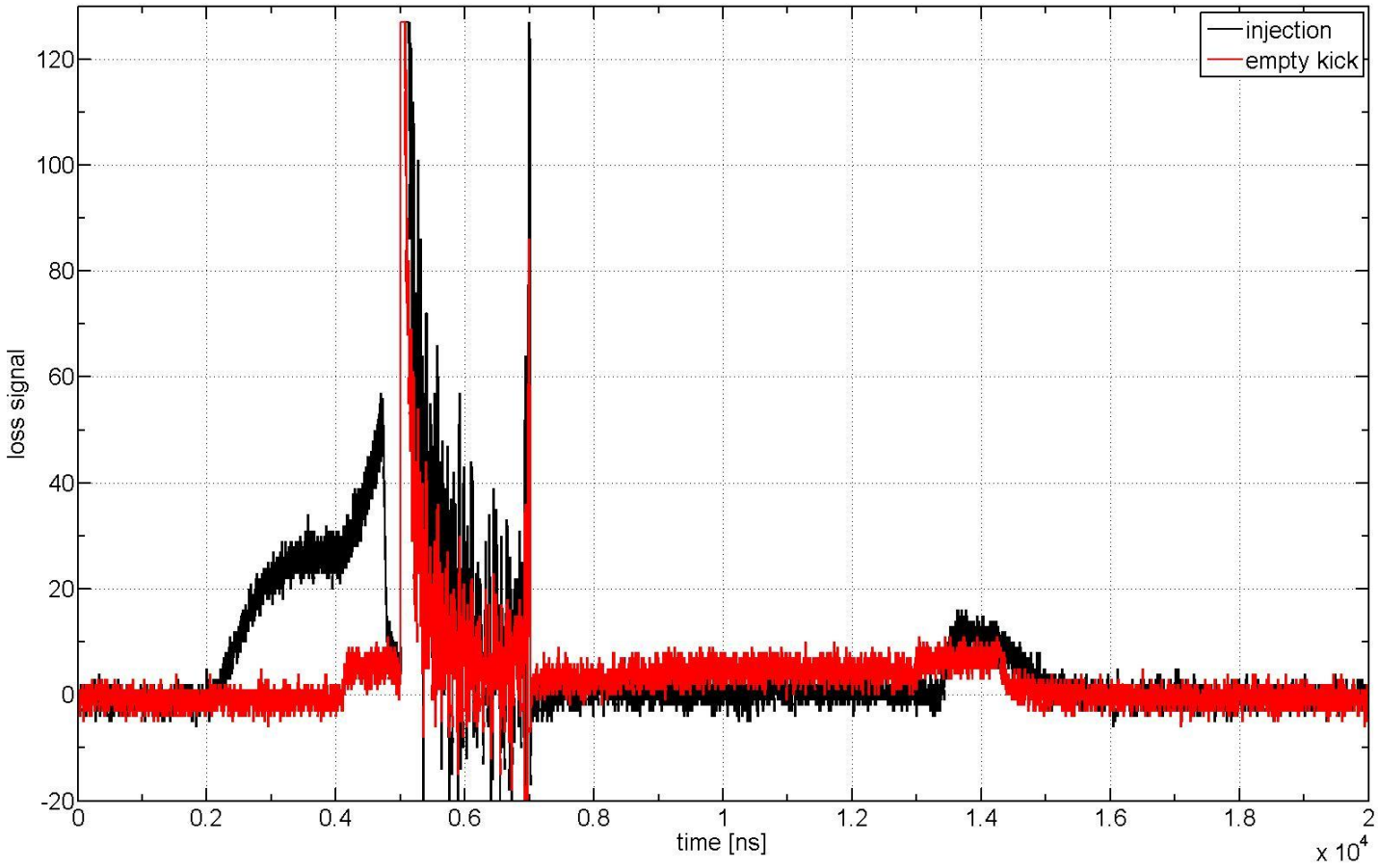
MKE Pulse measurements.

	r.t. (μs)	f.t. (μs)	Pulse length (μs)
MKE4	~ 7	~ 15	~ 24.5
MKE6	~ 6	~ 10	~ 19.5
MKI	0.9	~ 8.3	~ 10.5

Losses at LHC injection (TDI)



Comparison empty kick and injection



Fresh data

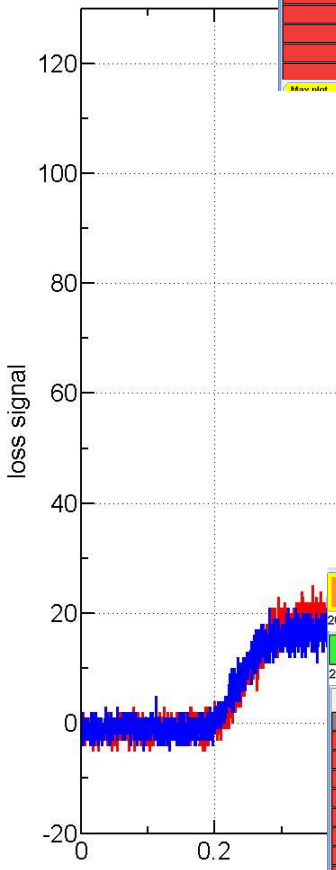
Injection Beam 1 | Injection Beam 2

2016-05-27 3:01:34.285: Beam injected! BQMs: Injected 72 bunches(97 bunches circulating). BLM analysis was bad.

BEAM EXTRACTION | INJECTION KICKER | BEAM LOSS | RF BUCKETS | INJ.OSCILLATIONS | TRANSFER LINE | RF PHASE | SCRAPING

2016-05-27 3:01:34.301: Beam losses above thresholds.

Monitor name	Max loss	IQC applied	IQC ref	Dump threshold	Ratio to dump
BLMTI.04L2.B1E10_TCDI.4L2	5.8102	0.0	0.0	2.3168	250.79%
BLMTI.04L2.B1E10_TDI.4L2.B1	5.6509	1.1500	4.6	23.1680	24.39%
BLMQI.08L2.B1E30_MQML	2.0515	0.5750	2.3	11.5840	17.71%
BLMQI.05L2.B1E20_MQY	0.3160	0.1150	0.46	2.3168	13.64%
BLMTI.04R2.B2E10_TCTPV.4R2.B2	0.5602	0.2325	0.93	4.6336	12.09%
BLMTI.04L2.B1E20_TDI.4L2.B1	2.7104	1.1575	4.63	23.1680	11.70%
BLMQI.08L2.B1E10_MQML	1.3021	0.5750	2.3	11.5840	11.24%
BLMAI.08L2.B2I23_MBA	0.7453	0.1150	0.46	7.7149	9.66%
BLMEI.06L2.B1E10_MSIB	0.7659	0.0	0.0	8.3405	9.18%
BLMAI.08L2.B2I22_MBA	0.6918	0.1150	0.46	7.7149	8.97%
BLMQI.06L2.B1E10_MQML	0.3817	0.2300	0.92	4.6336	8.24%
BLMEI.06L2.B1E20_MSIB	0.1832	0.1150	0.46	2.3168	7.91%
BLMQI.03L2.B1E10_MQXA	0.2981	0.1150	0.46	3.8459	7.75%
BLMEI.06L2.B1E30_MSIB	0.1748	0.1150	0.46	2.3168	7.55%
BLMAI.08L2.B2I21_MBA	0.5558	0.1150	0.46	7.7149	7.20%



Injection Beam 1 | Injection Beam 2

2016-05-27 3:04:17.485: Beam injected! BQMs: Injected 72 bunches(241 bunches circulating). BLM analysis was bad.

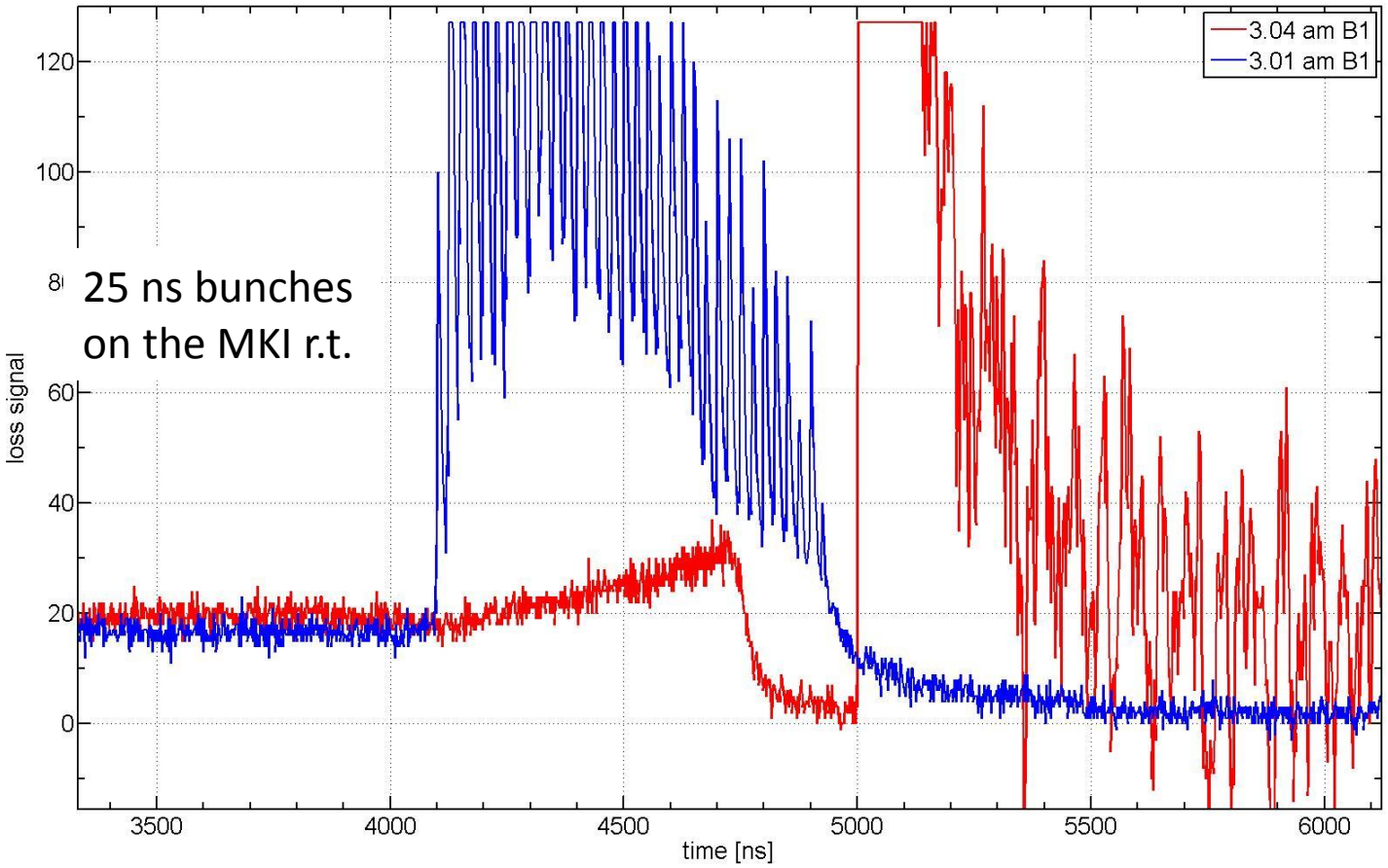
BEAM EXTRACTION | INJECTION KICKER | BEAM LOSS | RF BUCKETS | INJ.OSCILLATIONS | TRANSFER LINE | RF PHASE | SCRAPING

2016-05-27 3:04:17.501: Beam losses above thresholds.

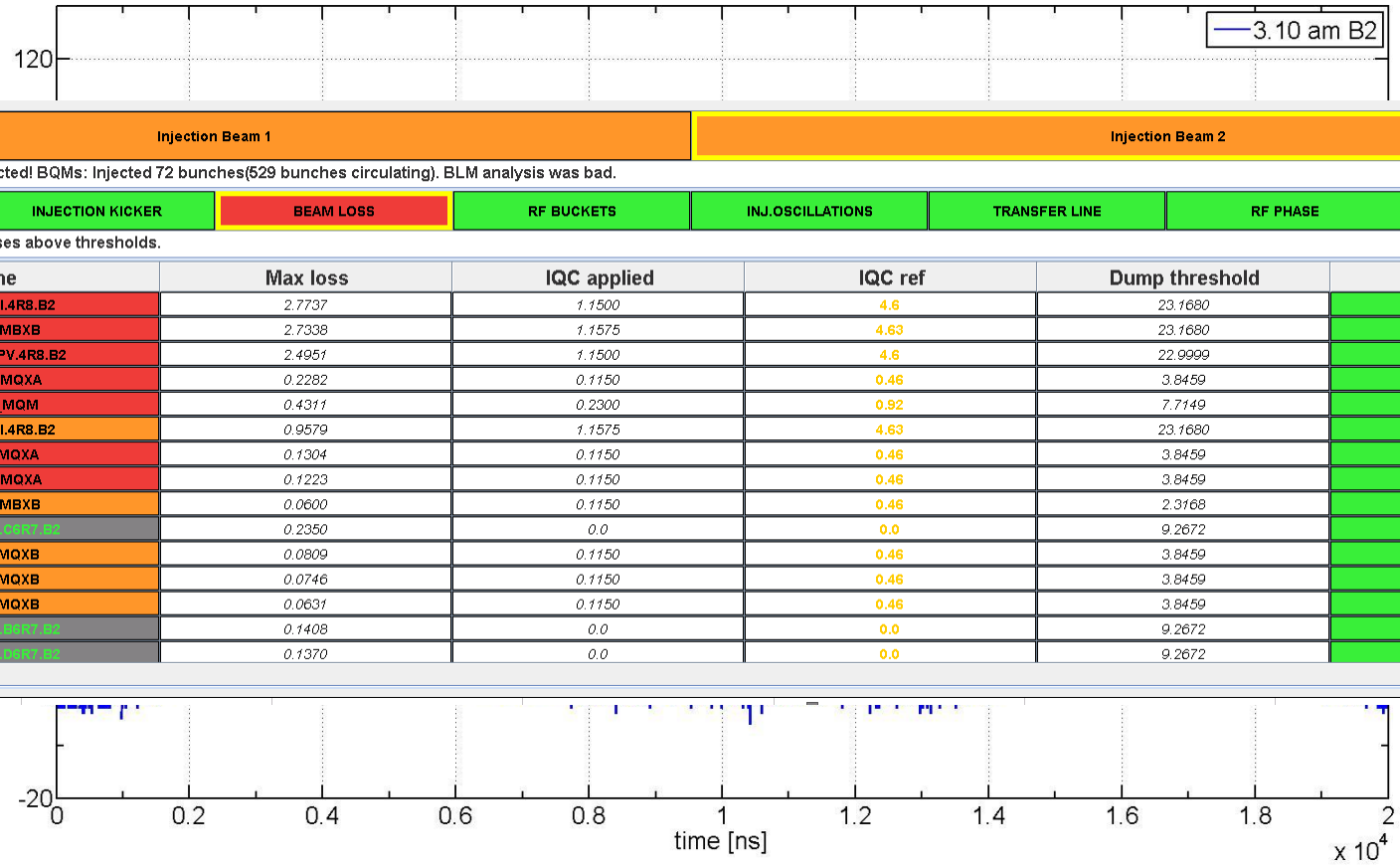
Monitor name	Max loss	IQC applied	IQC ref	Dump threshold	Ratio to dump
BLMTI.04L2.B1E10_TCDI.4L2	6.9021	0.0	0.0	2.3168	297.91%
BLMTI.04L2.B1E10_TDI.4L2.B1	11.5499	1.1500	4.6	23.1680	49.85%
BLMTI.04L2.B1E20_TDI.4L2.B1	4.3426	1.1575	4.63	23.1680	18.74%
BLMQI.08L2.B1E30_MQML	1.4527	0.5750	2.3	11.5840	12.54%
BLMQI.03L2.B1E10_MQXA	0.4790	0.1150	0.46	3.8459	12.46%
BLMQI.03L2.B2I20_MQXA	0.3836	0.1150	0.46	3.8459	9.98%
BLMQI.05L2.B1E20_MQY	0.1939	0.1150	0.46	2.3168	8.37%
BLMQI.08L2.B1E10_MQML	0.9141	0.5750	2.3	11.5840	7.89%
BLMQI.02L2.B2I30_MQXB	0.2807	0.1150	0.46	3.8459	7.30%
BLMAI.04L2.B1E10_MBXA	0.1588	1.1575	4.63	2.3168	6.86%
BLMEI.06L2.B1E10_MSIB	0.5629	0.0	0.0	8.3405	6.75%
BLMAI.08L2.B2I23_MBA	0.4828	0.1150	0.46	7.7149	6.26%
BLMQI.06L2.B1E10_MQML	0.2759	0.2300	0.92	4.6336	5.96%
BLMQI.03L2.B1E20_MQXA	0.2260	0.1150	0.46	3.8459	5.88%
BLMAI.08L2.B2I22_MBA	0.4515	0.1150	0.46	7.7149	5.85%

Max plot | Per slot | Per BLM

3.01 am injection – there was a 12b injection before …



B2 injection clean



Monitor name	Max loss	IQC applied	IQC ref	Dump threshold	Ratio to dump
BLMTI.04R8.B2E10_TDI.4R8.B2	2.7737	1.1500	4.6	23.1680	11.97%
BLMAI.04R8.B2E20_MBXB	2.7338	1.1575	4.63	23.1680	11.80%
BLMTI.04R8.B2E10_TCTPV.4R8.B2	2.4951	1.1500	4.6	22.9999	10.85%
BLMQI.03R8.B2E10_MQXA	0.2282	0.1150	0.46	3.8459	5.93%
BLMQI.07R8.B2E10_MQM	0.4311	0.2300	0.92	7.7149	5.59%
BLMTI.04R8.B2E20_TDI.4R8.B2	0.9579	1.1575	4.63	23.1680	4.13%
BLMQI.03R8.B1I20_MQXA	0.1304	0.1150	0.46	3.8459	3.39%
BLMQI.03R8.B2E20_MQXA	0.1223	0.1150	0.46	3.8459	3.18%
BLMAI.04R8.B2E10_MBXB	0.0600	0.1150	0.46	2.3168	2.59%
BLMTI.06R7.B2I10_TCP.C6R7.B2	0.2350	0.0	0.0	9.2672	2.54%
BLMQI.02R8.B1I30_MQXB	0.0809	0.1150	0.46	3.8459	2.10%
BLMQI.02R8.B1I23_MQXB	0.0746	0.1150	0.46	3.8459	1.94%
BLMQI.02R8.B1I22_MQXB	0.0631	0.1150	0.46	3.8459	1.64%
BLMTI.06R7.B2I10_TCP.B6R7.B2	0.1408	0.0	0.0	9.2672	1.52%
BLMTI.06R7.B2I10_TCP.D6R7.B2	0.1370	0.0	0.0	9.2672	1.48%

Possible loss mitigation

- Situation should be better for 288b train injections.

Problems of last week:

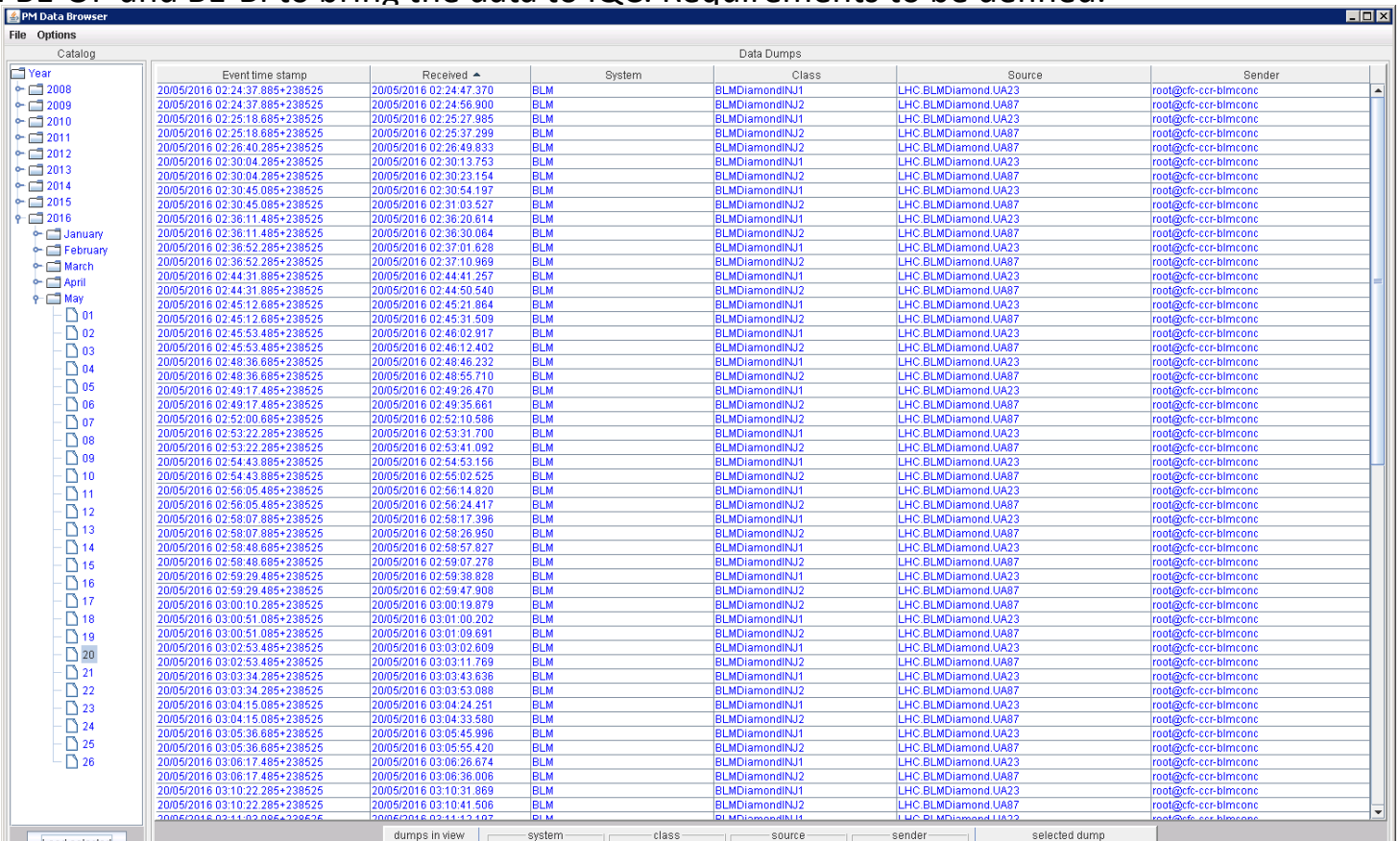
- Improve beam quality from the injectors.

General options:

- Timing of injection gap cleaning?
- Clean around the batches with SPS MKQ tune kicker or transverse damper.
  - Successfully tested during a MD
  - Difficult to set-up.
  - Cleaner extractions – higher losses in the SPS.

Current status of DAQ

- DBLMs at LHC injection operational.
  - Optimization of FESA ongoing (triggering, resolution, file size, etc.)
  - Data in the PM…
  - Meeting with BE-OP and BE-BI to bring the data to IQC. Requirements to be defined.

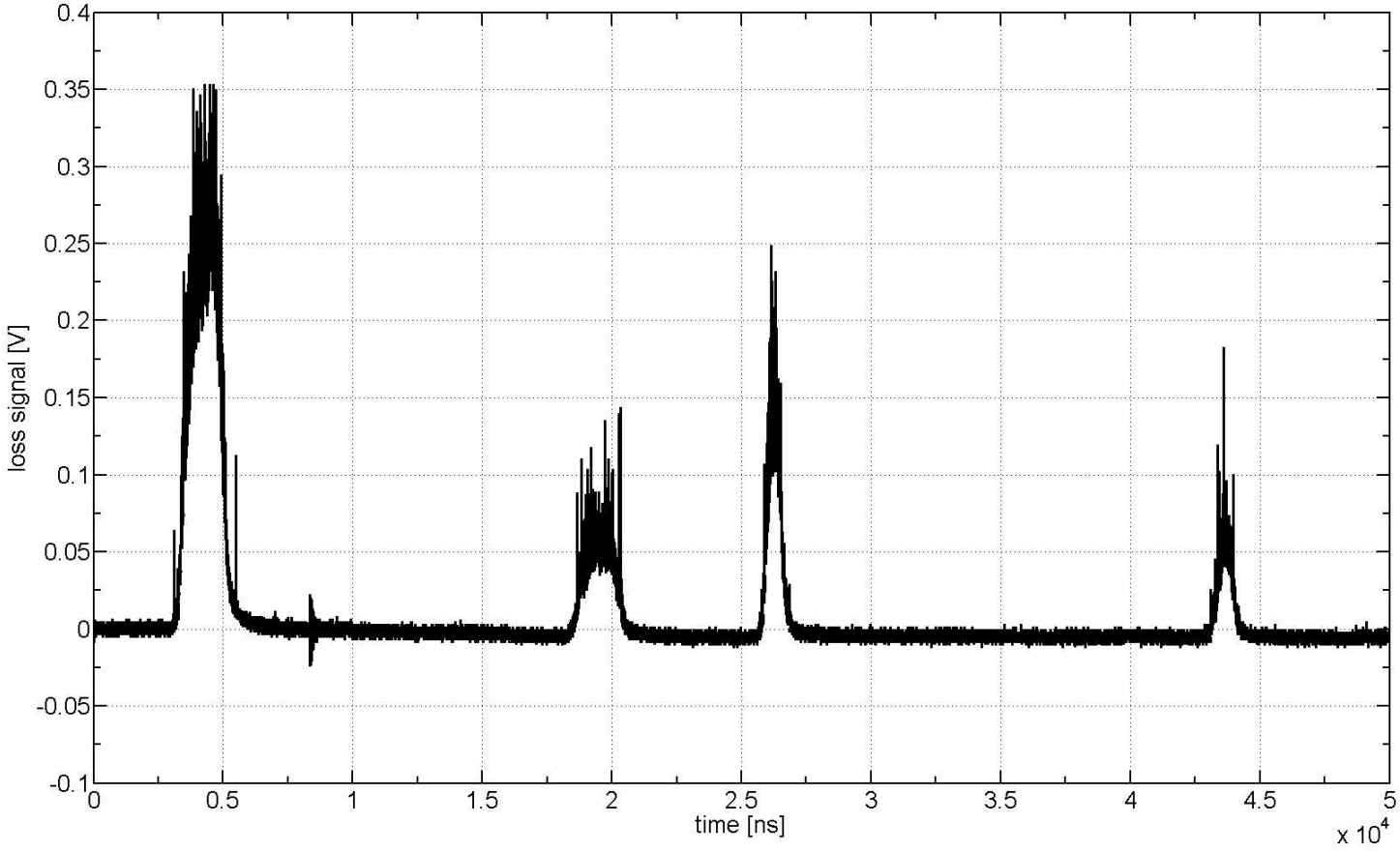


Conclusion

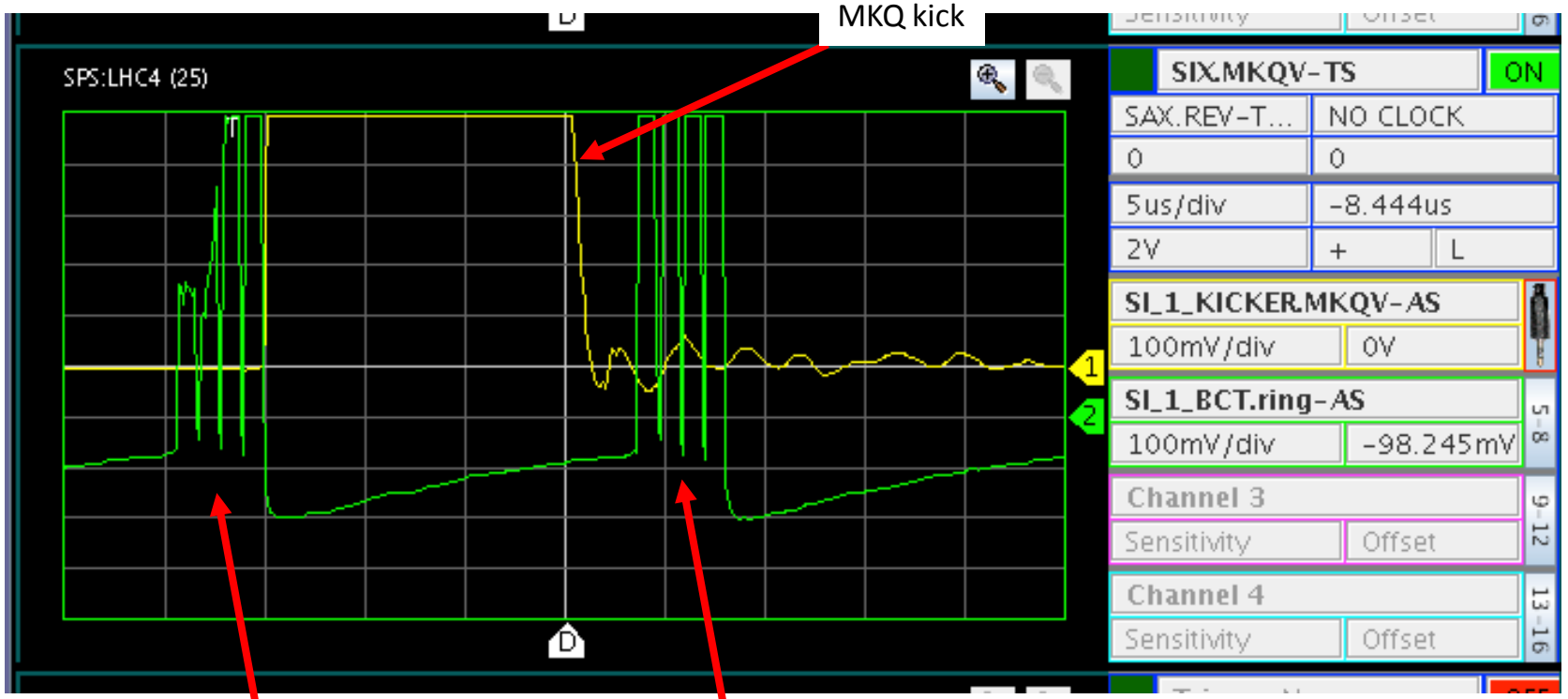
- High longitudinal losses due to **re-captured beam** / ghost bunches coming from SPS.
- Measured with **dBLMs** installed close to the TDIs in IP2 and IP8 and at SPS extraction.
- **Origin of losses to be studied. PS? SPS?**
- Possible loss mitigations proposed.
  - LHC Injection gap cleaning
  - SPS MKQ/ADT cleaning
- **dBLMs operational**, DAQ and FESA to be finally optimized.
- Implementation to IQC – first meeting next week.
- **Loss behavior to be followed-up during intensity ramp-up.**

Thank you for your attention!

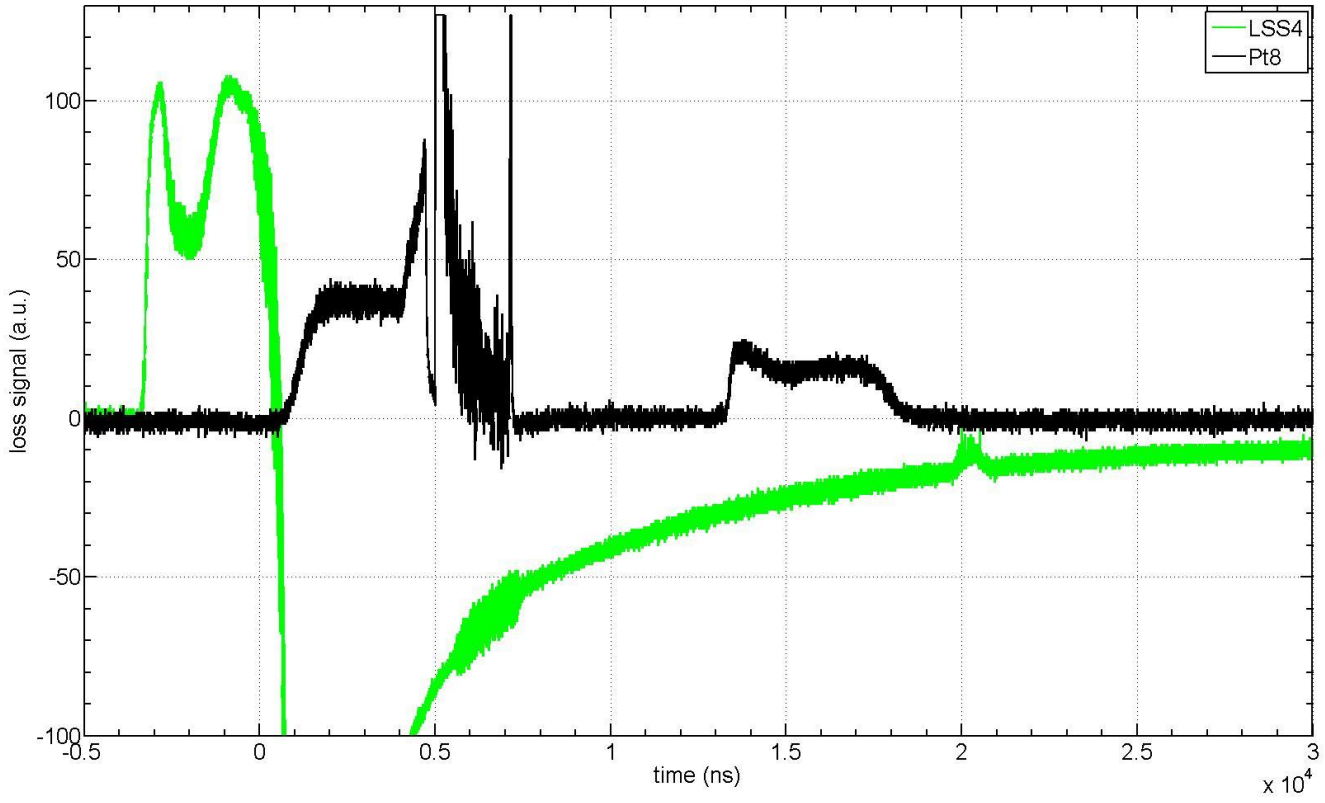
SPS - 1 indiv

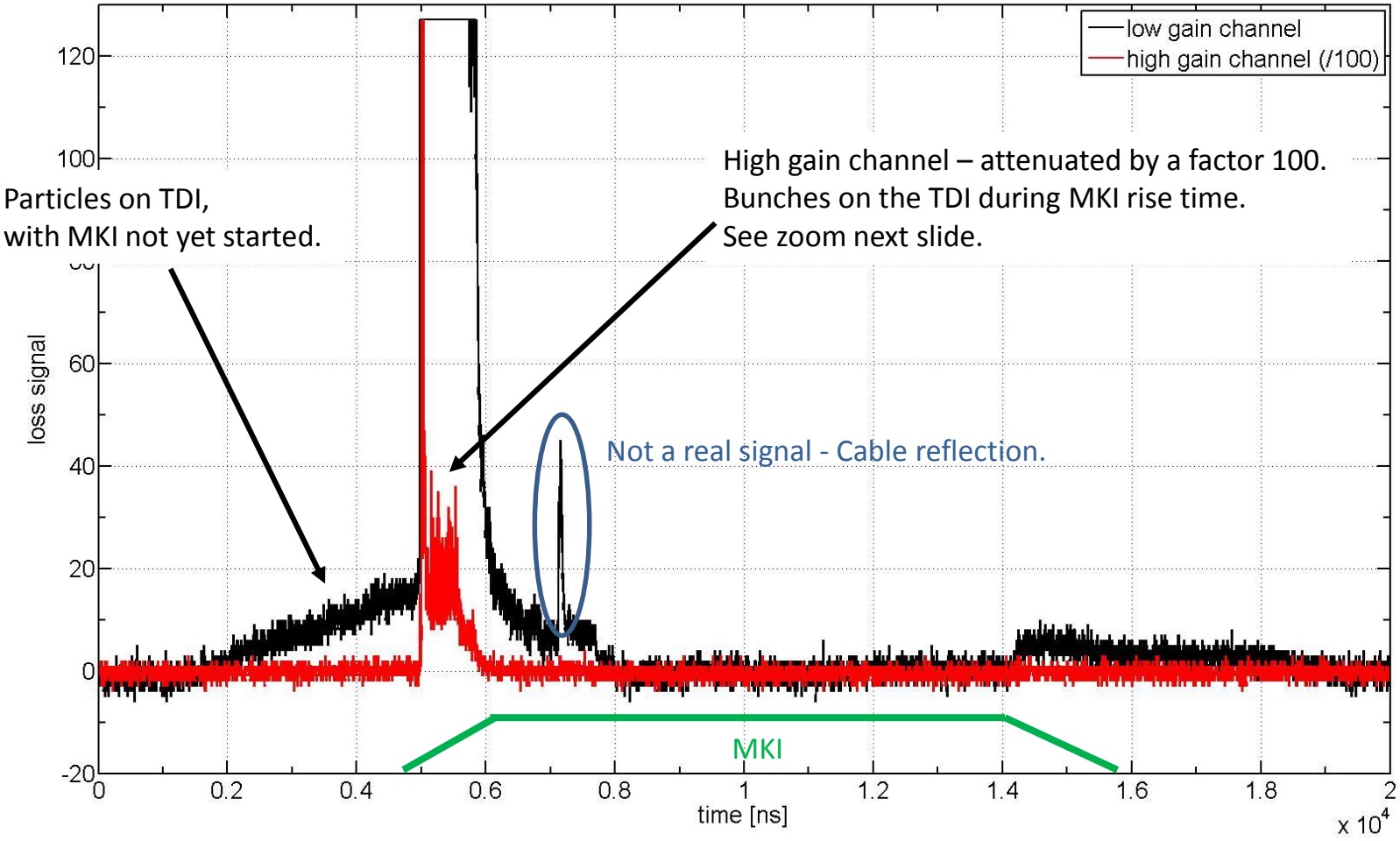

loss signal [V]
time [ns]
x 10^4
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

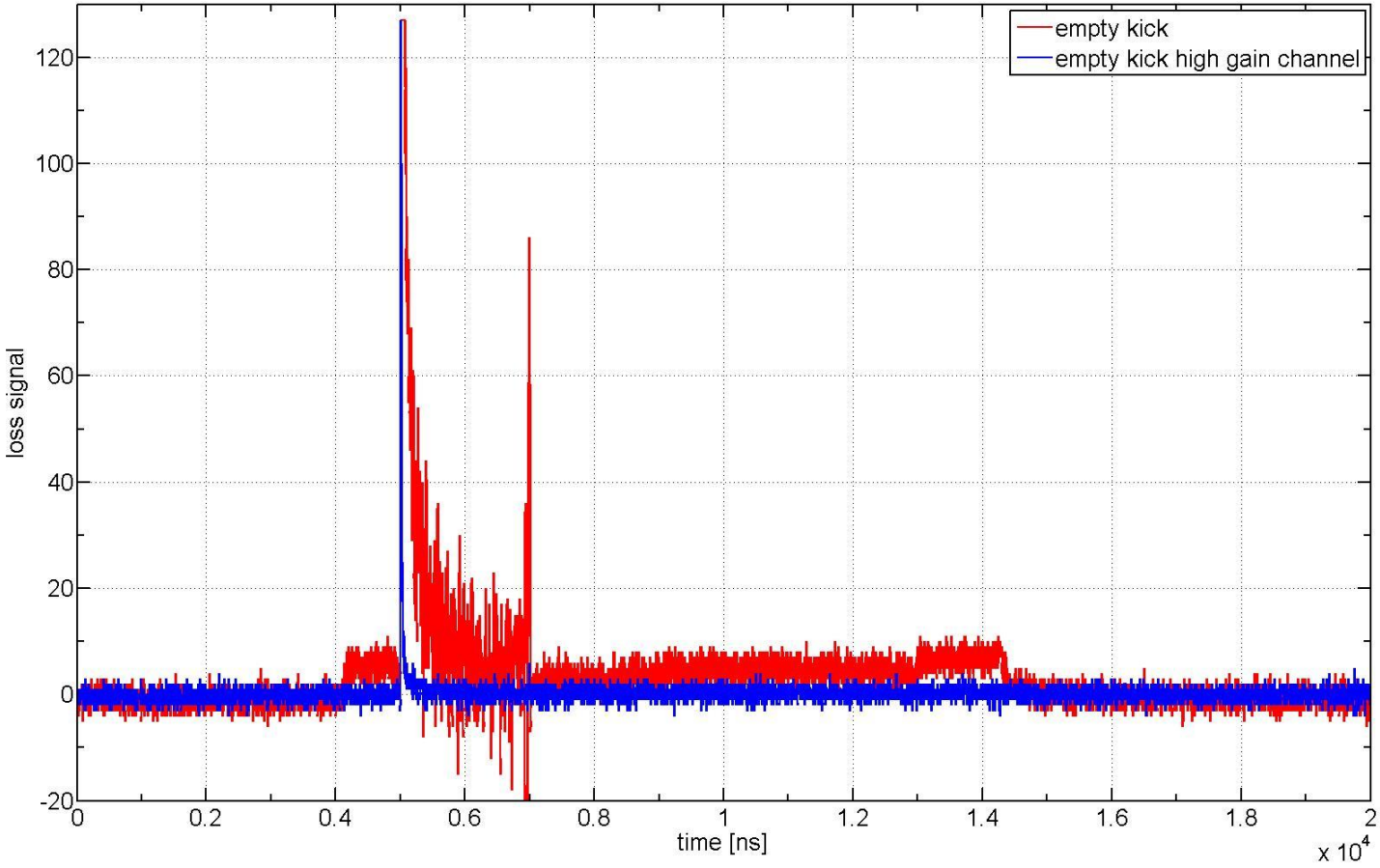
MKQ kick in the SPS – tested during MD



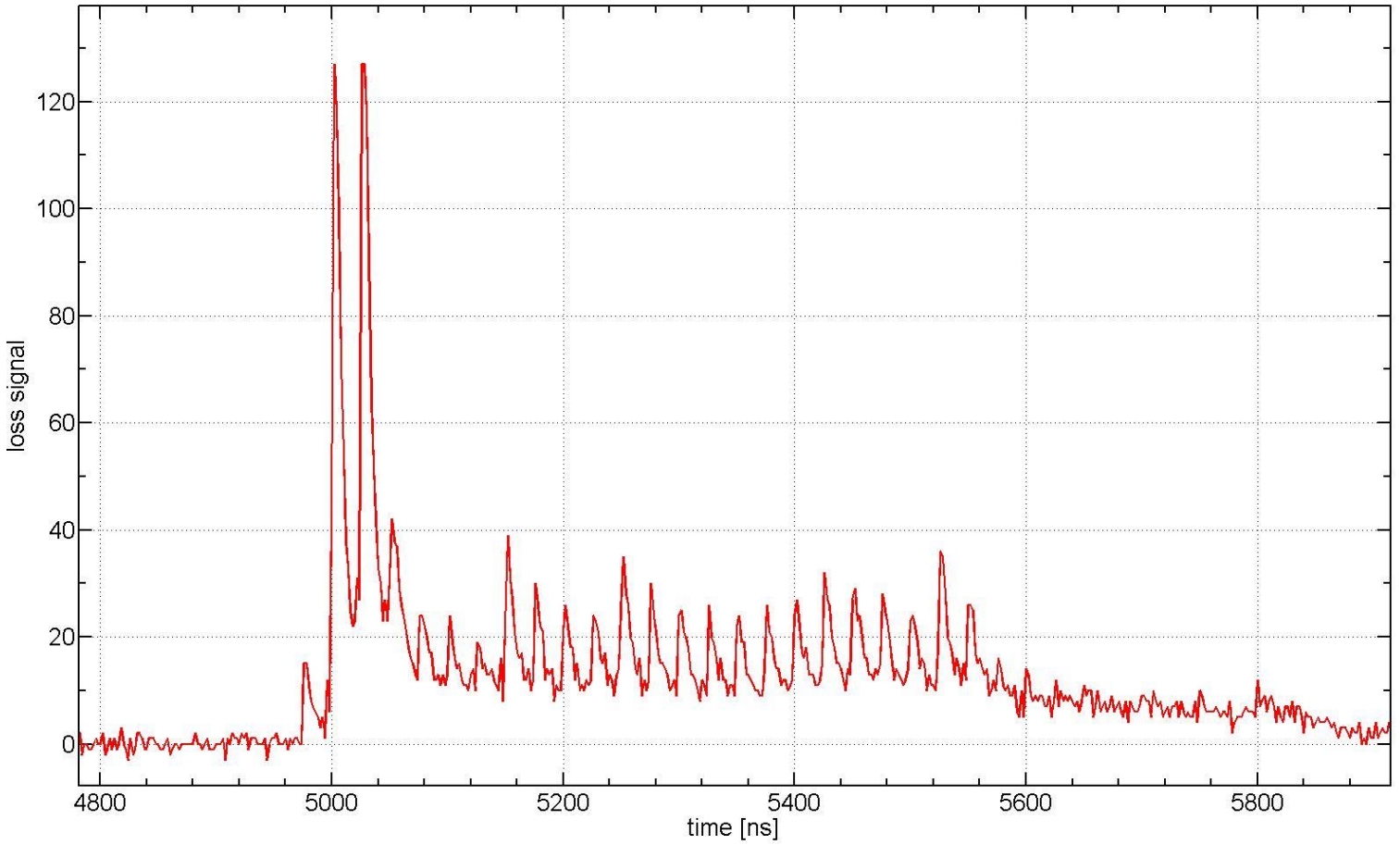
20.05.2016 – 3.11 am **Beam 2**



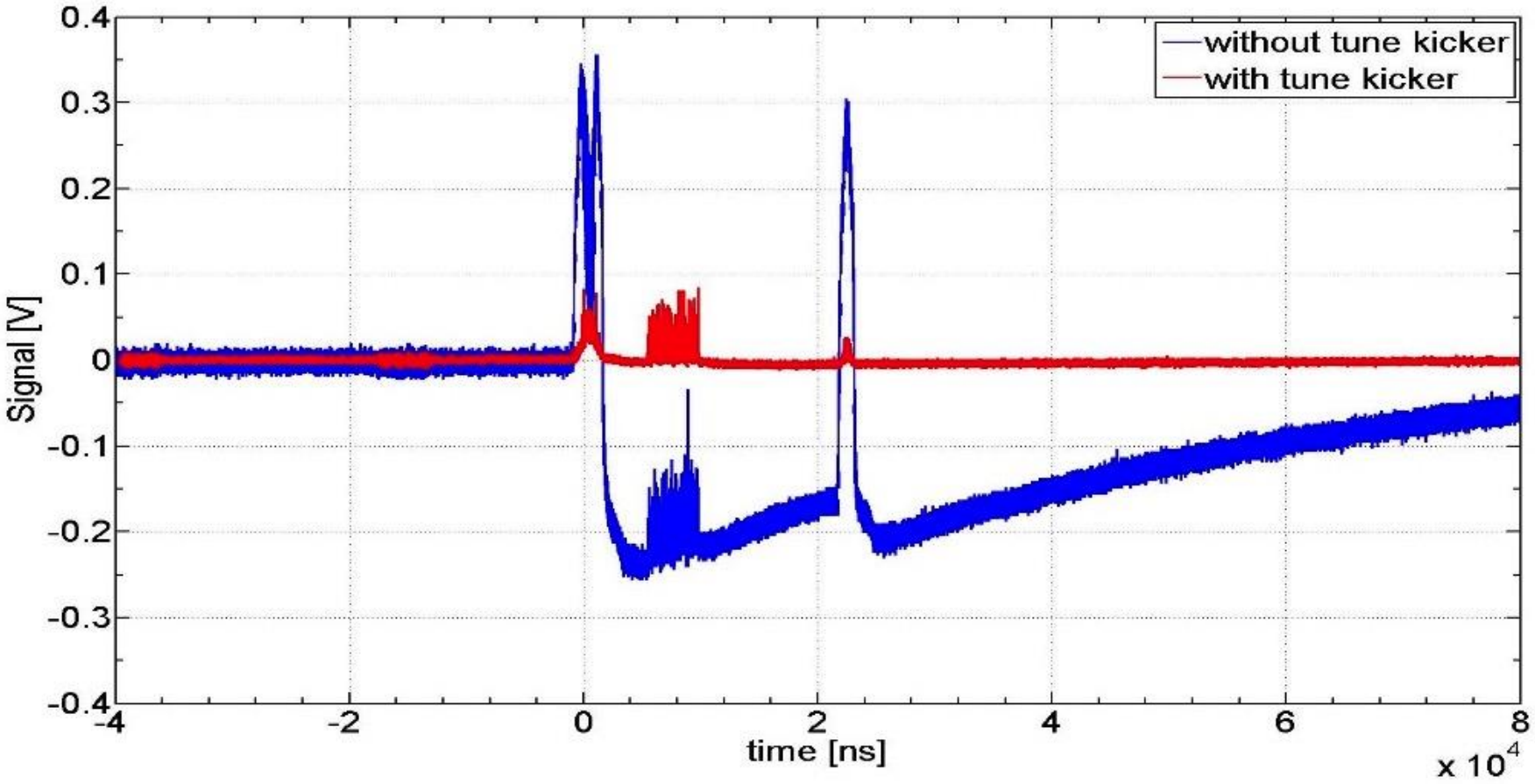

low gain channel
high gain channel (/100)
Particles on TDI,
with MKI not yet started.
High gain channel – attenuated by a factor 100.
Bunches on the TDI during MKI rise time.
See zoom next slide.
Not a real signal - Cable reflection.
MKI
loss signal
time [ns]
x 10^4
120
100
60
40
20
0
-20
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2


empty kick
empty kick high gain channel
loss signal
time [ns]
x 10^4
120
100
80
60
40
20
0
-20
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

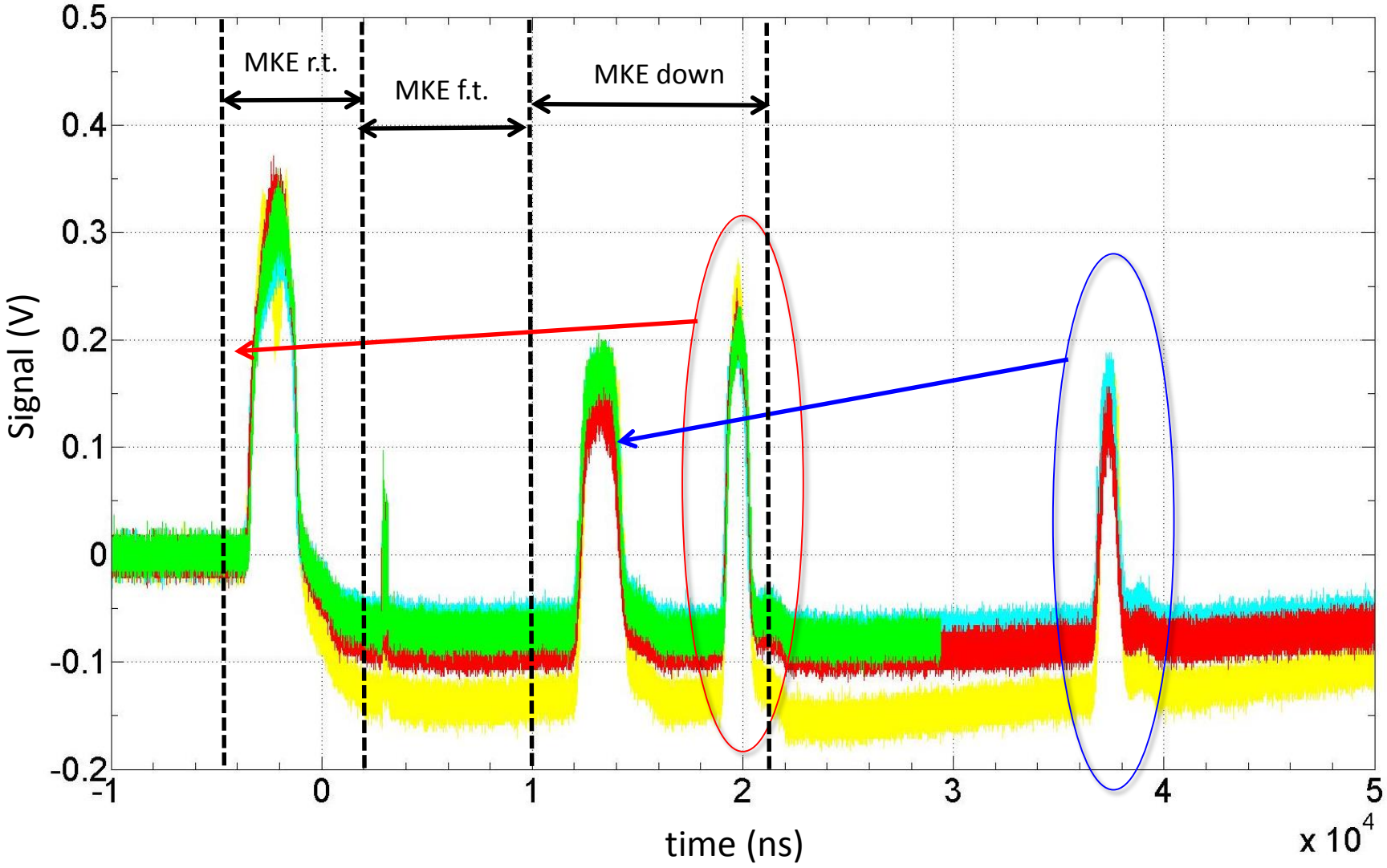
Ghost bunches from PS?
Ghost bunches from previous injection?
Synchronization problem?



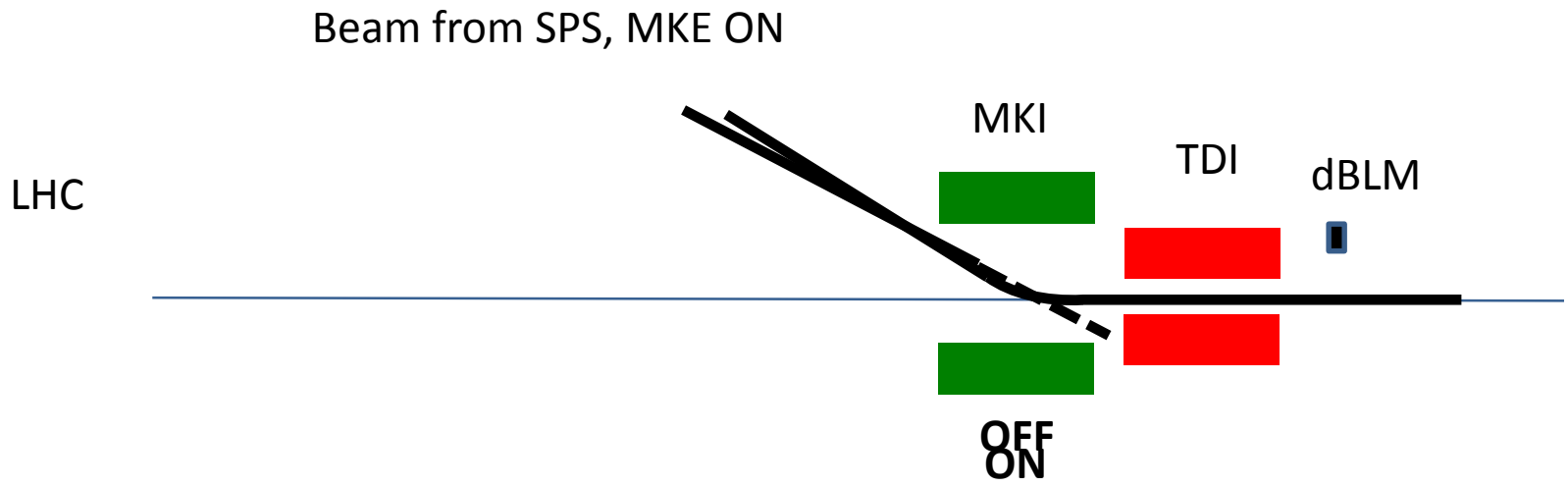
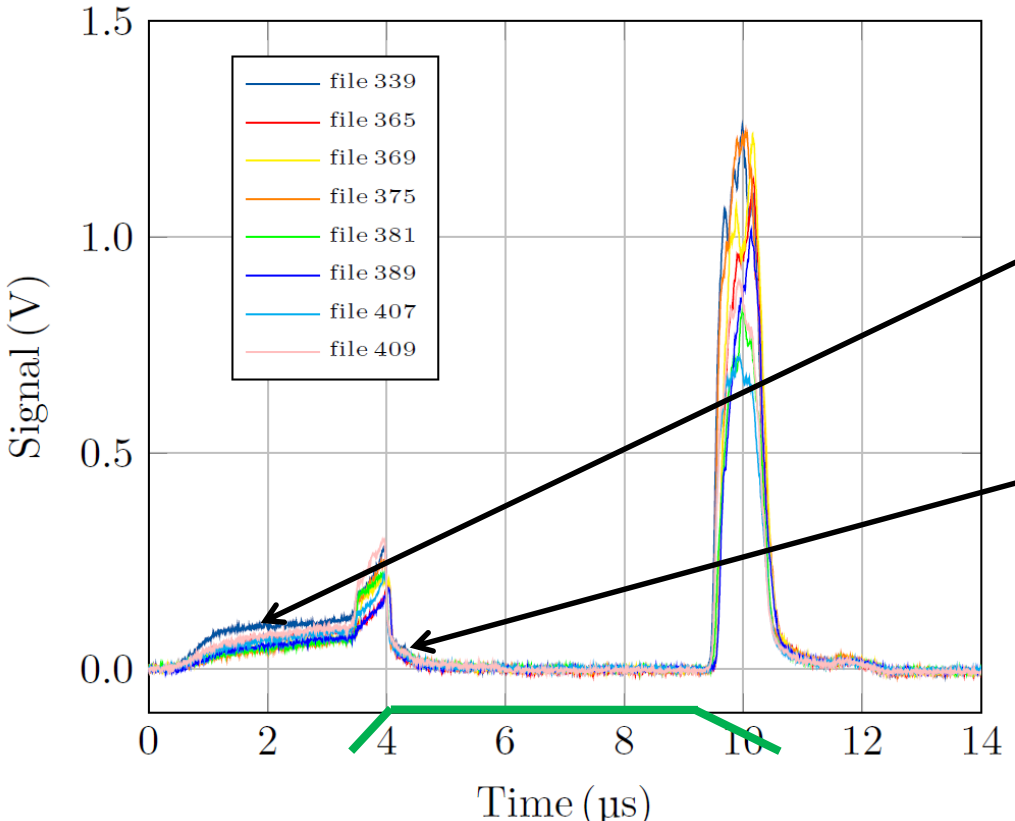
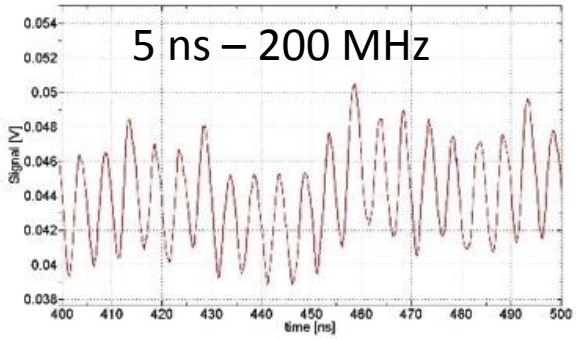
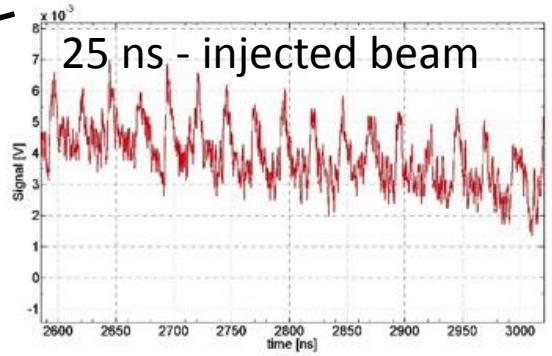
Losses at the TPSG in LSS6



Extraction of 12 bunches



MKI losses



Diamond beam loss monitors (dBLMs) around LHC/SPS/PS