Quench Test strategy WG

Introduction

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Motivation

In past 3 teams actively interested in quench tests:

- BLM for thresholds
- Collimation for performance
- MPP

Different opinions concerning the methods to perform tests and interpretation of results.

Just before Chamonix:

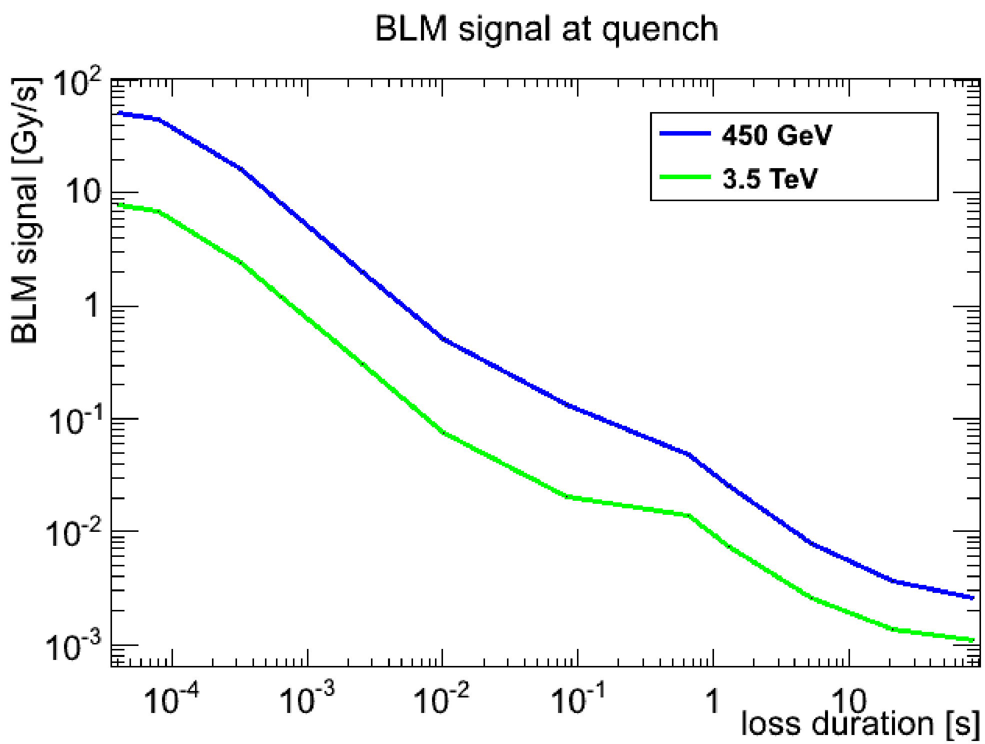
- Rudiger: proposal for quench limit workshop after summer
- Bernd: after summer is too late, we should meet and prepare tests before

Working Group objective

- **Discuss the importance and plan in quite detail quench tests (to be performed in 2012) which are needed to operate LHC after LS1.**
- **Give coherent output to management.**

- Meetings: about once per month
- Close relation to Machine Protection Panel and BLM threshold WG.

3 main types



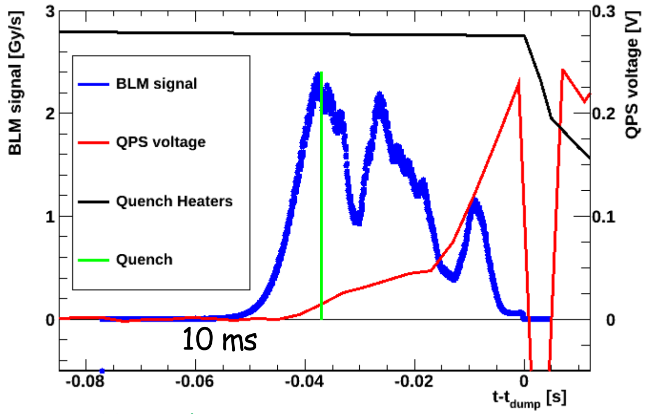
fast UFO-like ? steady state

Injection and dump (*on magnet!*)

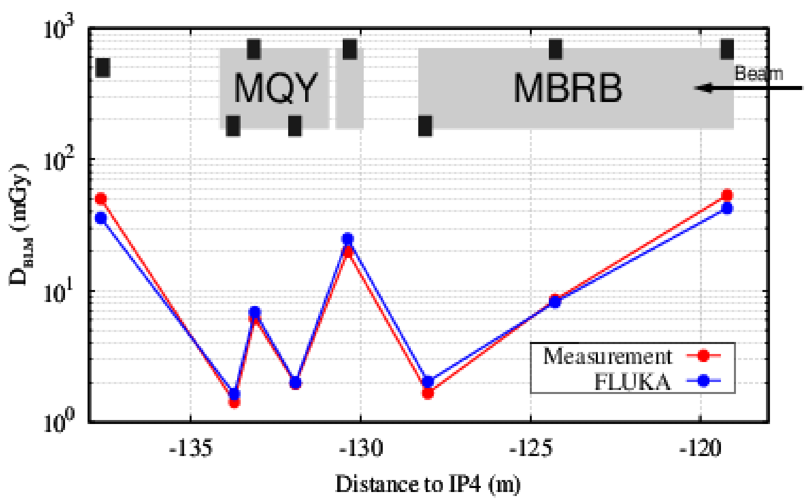
- Single turn losses at injection energy.
- 7 quenches of this kind:
  - On the ring: two in 2008, two in 2009, one in 2011 *(LHC Proj Note 422)*
  - Injection (many magnets involved): 2010 and 2011
- In addition a quench test when injected beam was dumped on collimator (TCLIB) – magnet current were ramped (increasing magnet sensitivity to quench) – no quench occurred. *(ATS-Note-2011-067 MD)*
  - FLUKA simulations – soon; they will allow to understand the results (lack of quench).
  - In 2012 this test could allow to determine easily the QL(E_{beam}) for short losses (UFO quenches as a function of beam energy?).

UFO losses (I)

- Highly recommended to be studied (Chamonix 2012 workshop) as UFOs can be limitation to lumi production after LS1.
- Wire scanner quench test done in 2010
- Lack of UFO-generated quenches



(ATS-Note -2011-062)



	energy density [mJ/cm³]		
	FLUKA and experiment	QP3, dry coil, FLUKA radial shape	Current method
cable average	11.6	15.6	70

UFO losses (II)

Strategy A

1. Repeat wire scanner test with shorter duration
2. Perform orbital bump test on the same magnet with the same timescale (using ADT)
3. Results extrapolated to other magnets using FLUKA/G4+QP3 code

Advantages:

1. Detailed FLUKA simulation exists
2. Only way to asses directly difference between UFO and bump loss

Disadvantages:

1. MBRB magnet (4.5 K) – is special -> QP3
2. MBRB - only one spare -> end of run
3. Different geometry than for the arc ->FLUKA/G4

UFO losses (III)

Strategy B:

1. UFO *fishing*

i.e. increase BLM thresholds in cells with healthy splices and extra BLMs
and wait for UFO to quench

2. Set BLM thresholds according to registered signal, get Quench Limit from FLUKA/G4

Advantages:

1. Real UFO quench

We should not relay on this option only

Disadvantages:

1. Quench may not happen
2. UFO location and size not well controlled
3. the FLUKA/G4 accuracy in terms of Quench Limit reduced

UFO losses (III)

Strategy C:

1. Orbital bump test in millisecond scale with ADT on arc
2. Use FLUKA/G4 to extrapolate results to UFO-like loss

Advantages:

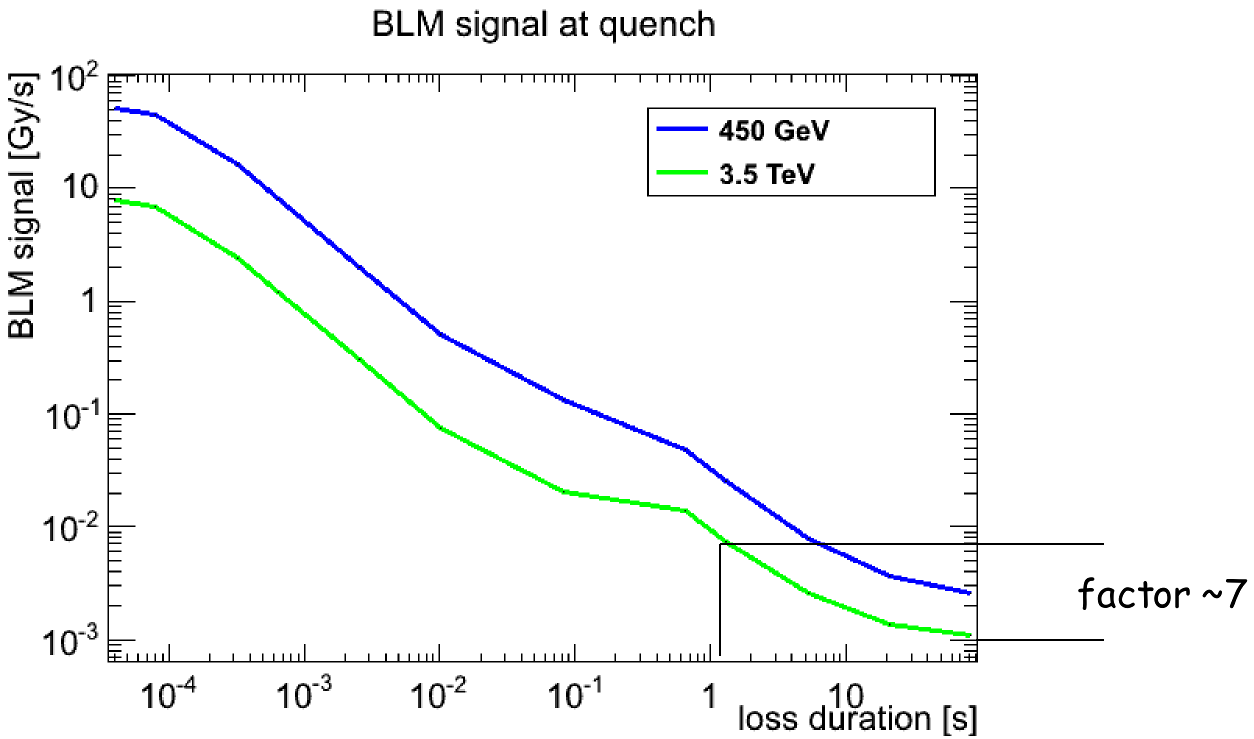
1. Arc magnet used (most abundant)

Disadvantages:

1. No direct testing of the difference between UFO and bump loss.

steady state losses

- LHC performance depends on steady state quench limit which remains not well known.
- During MD in 2011 we have reached nominal power on collimators without quenching for 1 s losses



- Two complementary approaches are possible: orbital bump or dispersion suppressor.
- For me this is very important as we plan very-high lumi runs.

Conclusions

- Chamonix priority are UFO losses.

  There are a few ways to investigate them.

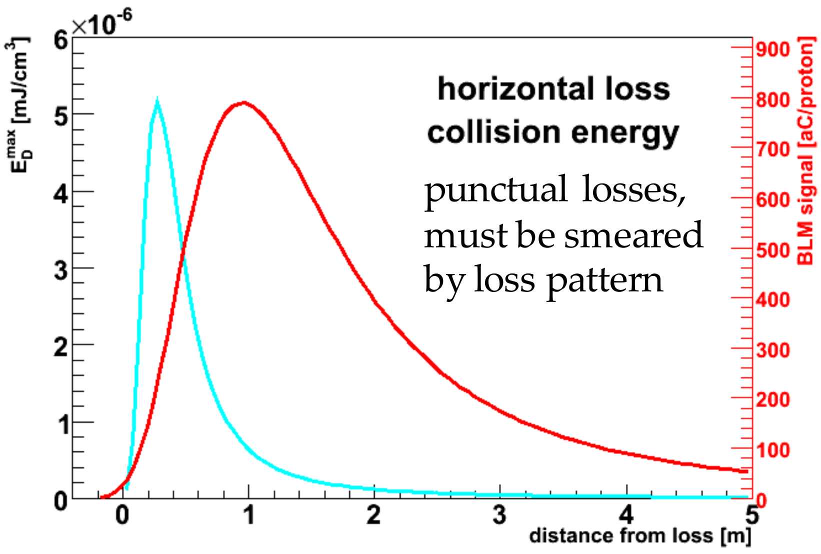
- Steady state would be good to test.
- We have tools which may still turn to be very useful:
  - ADT
  - QPS scope
  - cryo measurements (K. Brodzinski, next MPP)
- Do we miss something?
  - 0.1 s losses: Ralph claimed they often appear in operation

THANK YOU FOR YOUR ATTENTION!

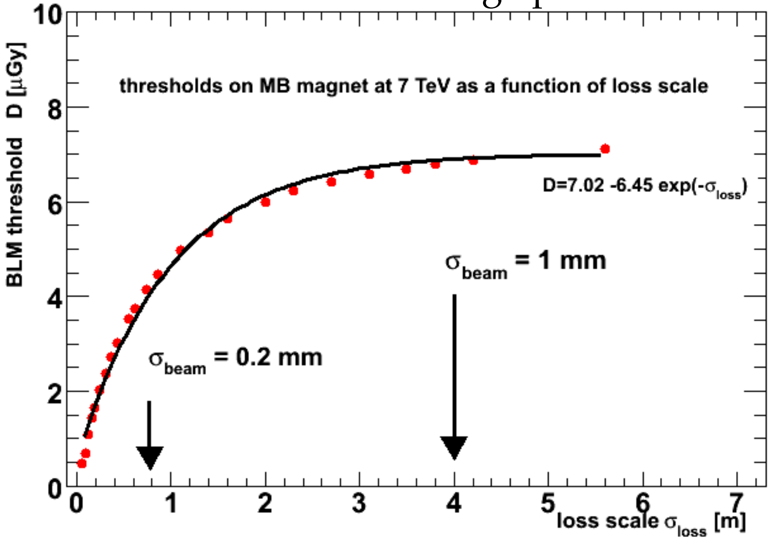
REST OF THE SLIDES ARE SPARE (CHAMONIX 2011)

BLM Quench Limit

- Quench Limit can be expressed in BLM signal [Gy/s] at which the magnet quenches.
- BLM signal (S_{BLM}) at Quench is: $S_{BLM} = R \cdot \mathbf{QL(E,t)}$; $R = E_{BLM}/E_{coil}$



assumed: beam hitting aperture



- In most cases: mJ/cm³ ≠ Gy/s ≠ protons/s ≠ W/m
- Considering all parameters QL determination accuracy is factor 2-3…

Quench list

- List of beam-induced quenches on sharepoint page http://cern.ch/biq
- Up to now 13 quenches, 10-test, 3-injection events

https://espace.cern.ch/BIQ/List of quenches/Forms/Default.aspx

Beam Induced Quenches in the LHC

Welcome Mariusz Gracjan Sapinski

Beam Induced Quenches in the LHC

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Beam Induced Quenches in the LHC > List of quenches

List of quenches

View All Site Content

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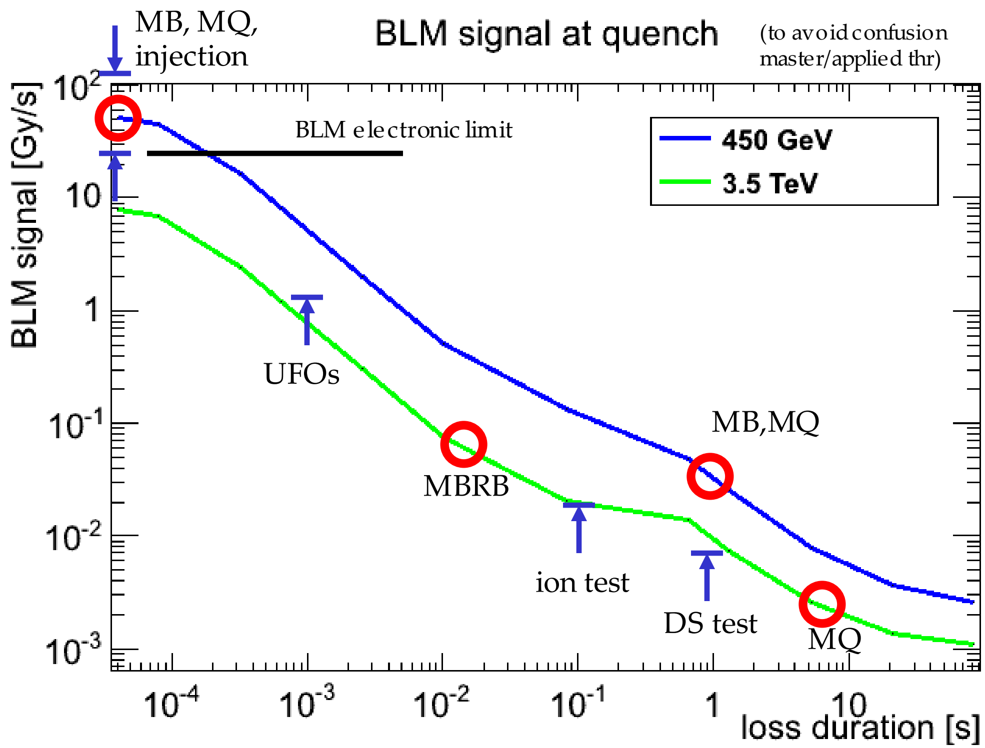
Type	Name	Modified	Modified By	Magnet	Location	E_beam	Duration	Beam	Plane
	2008-08-09 (00h19m51s)	03/08/2011 03:06 PM	Arjan Verweij	MB	8L3	0.45	ns	B1	V
	2008-09-07 (15h34m05s)	03/08/2011 03:22 PM	Arjan Verweij	MB	10R2	0.45	ns	B1	V
	2009-11-20 (18h21m27s)	03/08/2011 03:24 PM	Arjan Verweij	MB	12L6	0.45	ns	B1	H
	2009-12-04 (10h19m49s)	03/08/2011 03:36 PM	Arjan Verweij	MB	15R2	0.45	ns	B1	V
	2010-04-18 (10h33m41s)	03/08/2011 03:36 PM	Arjan Verweij	MB+	20R1	0.45	ns	B1	V?
	2010-10-06 (08h13m58s)	03/08/2011 03:36 PM	Arjan Verweij	MQ	14R2	0.45	1 s	B2	V
	2010-10-06 (10h35m01s)	03/08/2011 03:36 PM	Arjan Verweij	MQ	14R2	0.45	1 s	B2	V
	2010-10-06 (11h37m00s)	03/08/2011 03:36 PM	Arjan Verweij	MB	14R2	0.45	1 s	B1	H
	2010-10-17 (18h23m14s)	03/08/2011 03:36 PM	Arjan Verweij	MQ	14R2	3.5	6 s	B2	V
	2010-11-01 (14h40m04s)	11/09/2011 12:26 PM	Mariusz Gracjan Sapinski	MBRB	5L4	3.5	20 ms	B2	-

What have we learned from Quench Tests?

- 14R2 quench test (2010)
- Wire scanner quench test
- Dispersion suppressor quench tests (protons and ions)
- Injection quench events



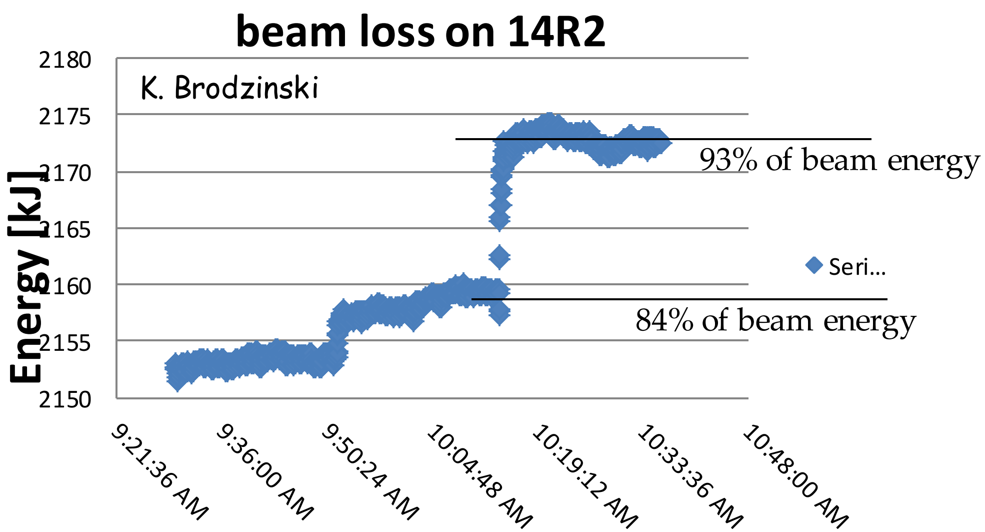
We measure BLM signals and lost beam intensity.

Monte Carlo simulations allows to conclude about Quench Limits [mJ/cm3].

Quench tests with orbital bump 2012

- It is proposed to repeat this test in 2012:
- Quench with raising orbital bump (better horizontal this time).
- 2nd ramp with orbital bump amplitude steered by BLM orbit feedback

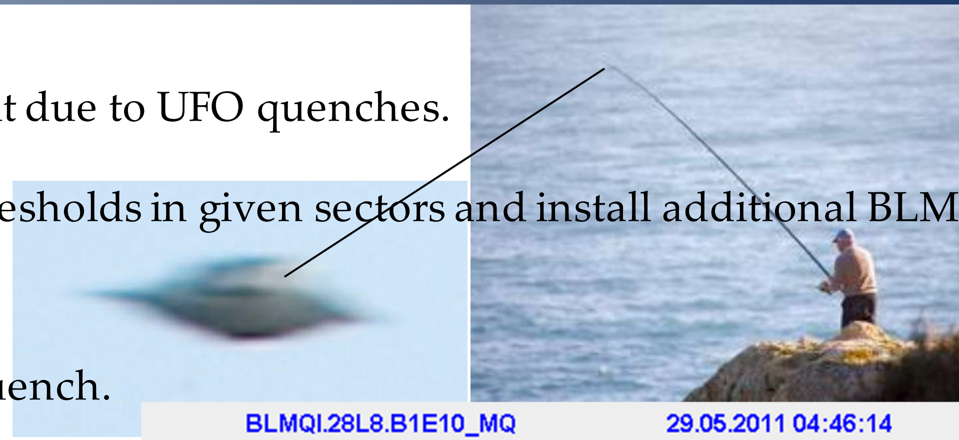
  at 50-80% of BLM signal of previous quench. Alternatively: bump + ADT blowup.
- Expected: steady-state loss lasting ~1 minute, without quench.
- Real steady-state quench limit determination in well-controlled , clean conditions.
- Cryogenic calorimetry and QPS scope measurements

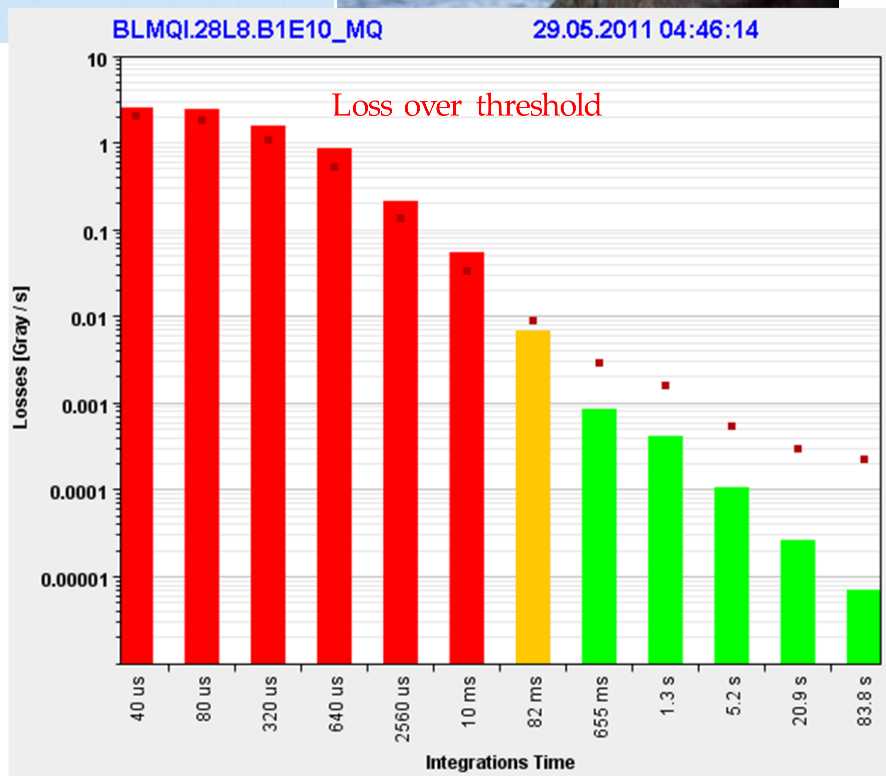


	QPS	scope
sampling	500 S/s	20 kS/s
resolution	5 mV	0.3 mV

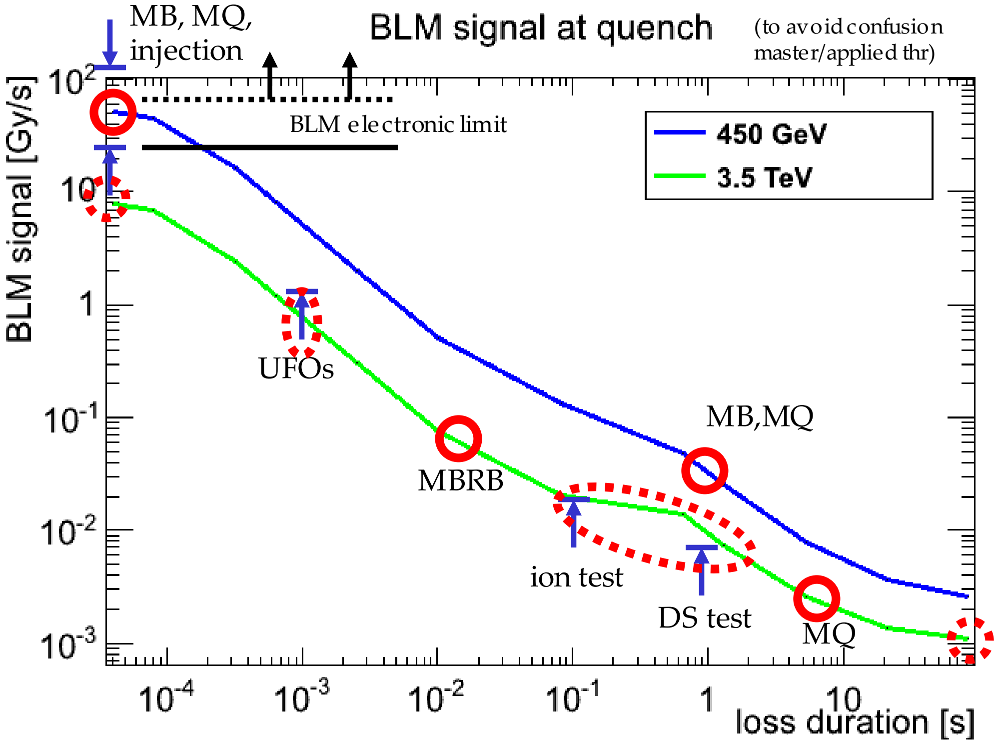
UFO quench fishing

- Need to know operational limit due to UFO quenches.
- It is proposed to raise BLM thresholds in given sectors and install additional BLMs in chosen locations (Q18,19 R3).
- Wait for the UFO-generated quench.
- Simulations are being prepared.
- More in Tobias' presentation.





Example of UFO in cold sector which dumped the beam.



MB, MQ,
injection
BLM signal at quench
(to avoid confusion master/applied thr)
BLM electronic limit
450 GeV
3.5 TeV
BLM signal [Gy/s]
UFOs
MBRB
MB,MQ
ion test
DS test
MQ
loss duration [s]

UFO – BLM thresholds

BLM thresholds on cold elements:

quench limit / BLM signal / energy deposited in coil

$$T\,(E_b,L_s(x,y,z),L_t(t)) = \Delta Q\,(E_b,L_t(t)) * S_{BLM}\,(E_b,L_s(x,y,z))/E_d(E_b,L_s(x,y,z))$$

$L_s(x,y,z)$ – spatial distribution of loss
$L_t(t)$ – loss duration (or evolution timescale)
E_b – beam energy

o) S_{BLM} is measured and simulated, E_d is only simulated, but accuracy of this simulation is controlled by S_{BLM}.

o) quench limits ΔQ are best known for fast transient losses (cable enthalpy) and steady state losses (heat evacuation to cryogenic system) –

ΔQ in milisecond scale?

o) $L_s(x,y,z)$ corresponds beam impacting on the beam screen over many meters (240 μrad) – UFO is similar to loss generated by Wire Scanner