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ENGINEERING SPECIFICATION

SAFE MACHINE PARAMETERS SYSTEM THRESHOLD & TRIM DEFINITIONS

2009-10 OPERATION

Abstract

This document specifies the thresholds to be used in the generation of mission critical flags in the Safe Machine Parameters System of both the SPS and LHC.

The definition of these values is intended for the operation of LHC and SPS in 2009-10, a subsequent specification is required for operation beyond LHC hardware and beam related commissioning to 3.5 TeV.

This document also includes the description and specification of the trim settings which can be applied to the Safe Machine Parameters Systems.

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History of Changes

Rev. No.	*Date*	*Pages*	*Description of Changes*
2.0	2009-10-05	All	Moved to MPS approval list

Table of Contents

1. INTRODUCTION

The SPS and LHC are each equipped with a Safe Machine Parameter System, charged with the generation of several flags and values which are critical for the operation of each machine. These two systems are distinct and separate, but their functions are similar.

For a full specification of the systems, consider EDMS 810607

This document further refines EDMS 810607, to accommodate operational requirements in 2009-10, for both the SPS and LHC accelerators.

1.1 INSTRUCTIONS TO READERS

This specification forms the basis of thresholds settings and trimming capabilities of each of the systems, not all values are of interest to all readers:

SPS Operations – Please consider SPS Unique Thresholds in section 3 on page 9, and in particular the PROBE_BEAM_ LIMIT trim described in section 5.1, on page 13.

LHC Operations – Please consider LHC Unique Thresholds in section 4 starting on page 9, in addition the SAFE_BEAM_FLAG_FORCE trim described in section 5.2 on page 13, and ENERGY trims, described in section 5.3 on page 14.

Experiments – Please consider the LHC Unique Thresholds in section 4 starting on page 9. In addition, STABLE_BEAMS and MOVEABLE_DEVICES flags require ENERGY trims, described in section 5.3 on page 14.

2. SMP SYSTEMS INTRODUCTION

To facilitate the understanding of this document, the key parameters of the two SMP Systems are introduced in the following sections. Other widely used names are presented as aliases in parentheses.

2.1 SPS SAFE MACHINE PARAMETERS

The basic function of the Safe Machine Parameters in SPS is to take (in the SPS context) MACHINE_ENERGY and MACHINE_INTENSITY. Then using thresholds and trims derive four flags:

1. E400_FLAG (CNGS_CYCLE_FLAG)
2. E450_FLAG (LHC_CYCLE_FLAG)
3. SPS_SBF (SPS_SAFE_BEAM_FLAG or SPS_SET_UP_BEAM_FLAG)
4. SPS_PBF (SPS_PROBE_BEAM_FLAG)

2.1.1 E400_FLAG (CNGS_CYCLE_FLAG)

Requires Data: MACHINE_ENERGY
Requires Threshold(s): E400_LOWER_LIMIT
E400_UPPER_LIMIT
Parameter transmitted to: Beam-2 Extraction Master (1kHz)
Calculation:

E400_FLAG = TRUE when
(MACHINE_ENERGY ≥ E400_LOWER_LIMIT) AND (MACHINE_ENERGY ≤ E400_UPPER_LIMIT)
else E400_FLAG = FALSE

2.1.2 E450_FLAG (LHC_CYCLE_FLAG)

Requires Data: MACHINE_ENERGY,
Requires Threshold(s): E450_LOWER_LIMIT
E450_UPPER_LIMIT
Parameter transmitted to: Beam-2 Extraction Master (1kHz)
Calculation:

E450_FLAG = TRUE when
(MACHINE_ENERGY ≥ E450_LOWER_LIMIT) AND (MACHINE_ENERGY ≤ E450_UPPER_LIMIT)
else E450_FLAG = FALSE

2.1.3 SPS_SBF (SPS_SET_UP_BEAM_FLAG, SPS_SAFE_BEAM_FLAG)

Requires Data: MACHINE_INTENSITY,
Requires Threshold(s): SAFE_BEAM_LIMIT
Parameter transmitted to: Beam-1 Extraction Master (1kHz)
Beam-2 Extraction Master (1kHz)
SPS General Machine Timing (10Hz)
Calculation:

SPS_SBF = TRUE when
(MACHINE_INTENSITY ≤ SAFE_BEAM_LIMIT)
else SPS_SBF = FALSE

2.1.4 SPS_PBF (SPS_PROBE_BEAM_FLAG)

Requires Data: MACHINE_INTENSITY
Requires Threshold(s): PROBE_BEAM_LIMIT
Requires Trim(s): OPERATOR_PROBE_BEAM_LIMIT
Parameter transmitted to: Beam-1 Extraction Master (1kHz)
Beam-2 Extraction Master (1kHz)
Calculation:

SPS_PBF = TRUE when
(MACHINE_INTENSITY ≤ PROBE_BEAM_LIMIT)
else SPS_PBF = FALSE

PROBE_BEAM_LIMIT can be trimmed by OPERATOR_PROBE_BEAM_LIMIT

2.2 LHC SAFE MACHINE PARAMETERS

The basic function of the Safe Machine Parameters in LHC is to take (in the LHC context) MACHINE_ENERGY, MACHINE_INTENSITY_1, MACHINE_INTENSITY_2 and BEAM_MODE. Then using thresholds and trims derive:

1. LHC_SBF1 (LHC_SAFE_BEAM1_FLAG, LHC_SET_UP_BEAM1_FLAG)
2. LHC_SBF2 (LHC_SAFE_BEAM2_FLAG, LHC_SET_UP_BEAM2_FLAG)
3. LHC_BPF1 (LHC_BEAM1_PRESENCE_FLAG)
4. LHC_BPF2 (LHC_BEAM2_PRESENCE_FLAG)
5. STB (STABLE_BEAM_FLAG, SAFE_STABLE_BEAM_FLAG)
6. MDI (MOVEABLE_DEVICES_FLAG, MOVEABLE_DEVICES_ALLOWED_IN_FLAG)

2.2.1 LHC_SBF (LHC_SAFE_BEAM_FLAG, LHC_SET_UP_BEAM_FLAG)

Requires Data: MACHINE_ENERGY
MACHINE_INTENSITY_1
MACHINE_INTENSITY_2

Requires Threshold(s): SAFE_BEAM_FLAG_1 to _64

Parameter transmitted to: Beam-1 Extraction Master (1kHz)
Beam-2 Extraction Master (1kHz)
LHC General Machine Timing (10Hz)

Calculation:

Using MACHINE_ENERGY, select a SAFE_BEAM_FLAG_n bin

LHC_SBF = TRUE when

(MACHINE_INTENSITY ≤ SAFE_BEAM_FLAG_n)

else LHC_SBF = FALSE

Note: Beam-1 and Beam-2 flags are independent, but the same calculation is used for both, in the formula above, replace MACHINE_INTENSITY with MACHINE_INTENSITY_1 to determine LHC_SBF1, replace with MACHINE_INTENSITY_2 to determine LHC_SBF2.

Due to the limitations of the controller, this calculation is approximated; see section 4.1 starting on page 10.

The LHC_SBF1 and LHC_SBF2 are transmitted as a redundant pair, 1A, 1B, 2A, 2B. They can be individually forced to FALSE for testing or sequential purposes.

2.2.2 LHC_BPF (LHC_BEAM_PRESENCE_FLAG)

Requires Data: MACHINE_INTENSITY_1
MACHINE_INTENSITY_2

Requires Threshold(s): BEAM_PRESENCE_LIMIT

Parameter transmitted to: Beam-1 Extraction Master (1kHz)
Beam-2 Extraction Master (1kHz)
LHC General Machine Timing (10Hz)

Calculation:

LHC_BPF = TRUE when

(MACHINE_INTENSITY ≥ BEAM_PRESENCE_LIMIT)

else LHC_BPF = FALSE

Note: Beam-1 and Beam-2 flags are independent, but the same calculation is used for both, in the formula above, replace MACHINE_INTENSITY with MACHINE_INTENSITY_1 to determine LHC_BPF1, replace with MACHINE_INTENSITY_2 to determine LHC_BPF2.

For the 2009-10, this flag will be generated in the Beam Current Transformer electronics, the Safe Machine Parameter System will only retransmit the value received.

2.2.3 STB (STABLE_BEAM_FLAG, SAFE_STABLE_BEAM_FLAG)

Requires Data: BEAM_MODE
MACHINE_ENERGY

Requires Threshold(s): ENERGY_PHYSICS_LOWER_LIMIT
ENERGY_PHYSICS_UPPER_LIMIT

Requires Trims(s): OPERATOR_PHYSICS_LOWER_LIMIT
OPERATOR_PHYSICS_UPPER_LIMIT

Parameter transmitted to: LHC General Machine Timing (10Hz)

Calculation:

STB = TRUE when

(BEAM_MODE = "STABLE BEAMS") AND

[(MACHINE_ENERGY ≥ OPERATOR_PHYSICS_LOWER_LIMIT) AND

(MACHINE_ENERGY ≤ OPERATOR_PHYSICS_UPPER_LIMIT)]

else STB = FALSE

OPERATOR_PHYSICS_LOWER_LIMIT and _UPPER_LIMIT must be used, this is a trim which is applied, ENERGY_PHYSICS_LOWER_LIMIT and _UPPER_LIMIT as boundary conditions. See section 5.3 starting on page 14 for detailed requirements.

2.2.4 MDI (MOVEABLE_DEVICES_FLAG, MOVEABLE_DEVICES_ALLOWED_IN_FLAG)

Requires Data: BEAM_MODE
MACHINE_ENERGY

Requires Threshold(s): ENERGY_PHYSICS_LOWER_LIMIT
ENERGY_PHYSICS_UPPER_LIMIT

Requires Trims(s): OPERATOR_PHYSICS_LOWER_LIMIT
OPERATOR_PHYSICS_UPPER_LIMIT

Parameter transmitted to: LHC General Machine Timing (10Hz)

Calculation:

MDI = TRUE when

[(BEAM_MODE = "STABLE BEAMS") OR (BEAM_MODE = "UNSTABLE BEAMS")] AND

[(MACHINE_ENERGY ≥ OPERATOR_PHYSICS_LOWER_LIMIT) AND
(MACHINE_ENERGY ≤ OPERATOR_PHYSICS_UPPER_LIMIT)]
else MDI = FALSE

OPERATOR_PHYSICS_LOWER_LIMIT and _UPPER_LIMIT must be used, this is a trim which is applied, ENERGY_PHYSICS_LOWER_LIMIT and _UPPER_LIMIT as boundary conditions. See section 5.3 starting on page 14 for detailed requirements.

3. SPS UNIQUE THRESHOLDS

Note that Energy values must be a multiple of 120MeV.

Threshold Name	Typical value [units]	Function [Accelerator]
E400_UPPER_LIMIT	402.600 [GeV]	This is the upper limit for the Energy 400 flag to be considered TRUE [SPS]
E400_LOWER_LIMIT	397.440 [GeV]	This is the lower limit for the Energy 400 flag to be considered TRUE [SPS]
E450_UPPER_LIMIT	455.040 [GeV]	This is the upper limit for the Energy 450 flag to be considered TRUE [SPS]
E450_LOWER_LIMIT	444.960 [GeV]	This is the lower limit for the Energy 450 flag to be considered TRUE [SPS]
PROBE_BEAM_LIMIT	1E11 [p]	This is the limit below which the Probe Beam Flag will be TRUE [SPS]
SAFE_BEAM_LIMIT	1E12 [p]	This is the limit below which the Safe Beam Flag will be TRUE [SPS]

4. LHC UNIQUE THRESHOLDS

Note that Energy values must be a multiple of 120MeV.

Threshold Name	Typical value [units]	Function [Accelerator]
SAFE_BEAM_FLAG_1 to SAFE_BEAM_FLAG_64	1 = 1E12 … 64 = 1E10	This is the range of limits below which the Safe Beam Flag will be TRUE [LHC]
BEAM_PRESENCE_LIMIT	3E9 [p]	This is the limit above which the Beam Presence Flag will be TRUE [LHC]
ENERGY_PHYSICS_UPPER_LIMIT	3510.000 [GeV]	This is the absolute upper limit use by Stable Beam Flag and the Moveable Devices In Flag [LHC]
ENERGY_PHYSICS_LOWER_LIMIT	440.040 [GeV]	This is the absolute lower limit use by Stable Beam Flag and the Moveable Devices In Flag [LHC]

4.1 FULL LISTING OF SAFE_BEAM_FLAG THRESHOLDS

The Safe Beam Flag in LHC is based on a simple calculation involving the machine Energy and Intensity. As of September 2009, the basic definition is as follows:

The Safe Beam Flag is True if:

$$\left(\frac{E\,[GeV]}{450\,[GeV]}\right)^{1.7} \times I\,[p] \leq Threshold$$

Where *Threshold* is a fixed value of $1x10^{12}$ protons, this implies that:

1. At injection energy (450GeV), beam with intensity 1×10^{12} protons will be considered SAFE, anything above this will be considered UNSAFE.
2. At initial collision energy (3500GeV), beam with intensity $\approx 3.1 \times 10^{10}$ protons will be considered SAFE, anything above this will be considered UNSAFE.
3. At later collision energy (5000GeV), beam with intensity $\approx 1.7 \times 10^{10}$ protons will be considered SAFE, anything above this will be considered UNSAFE.

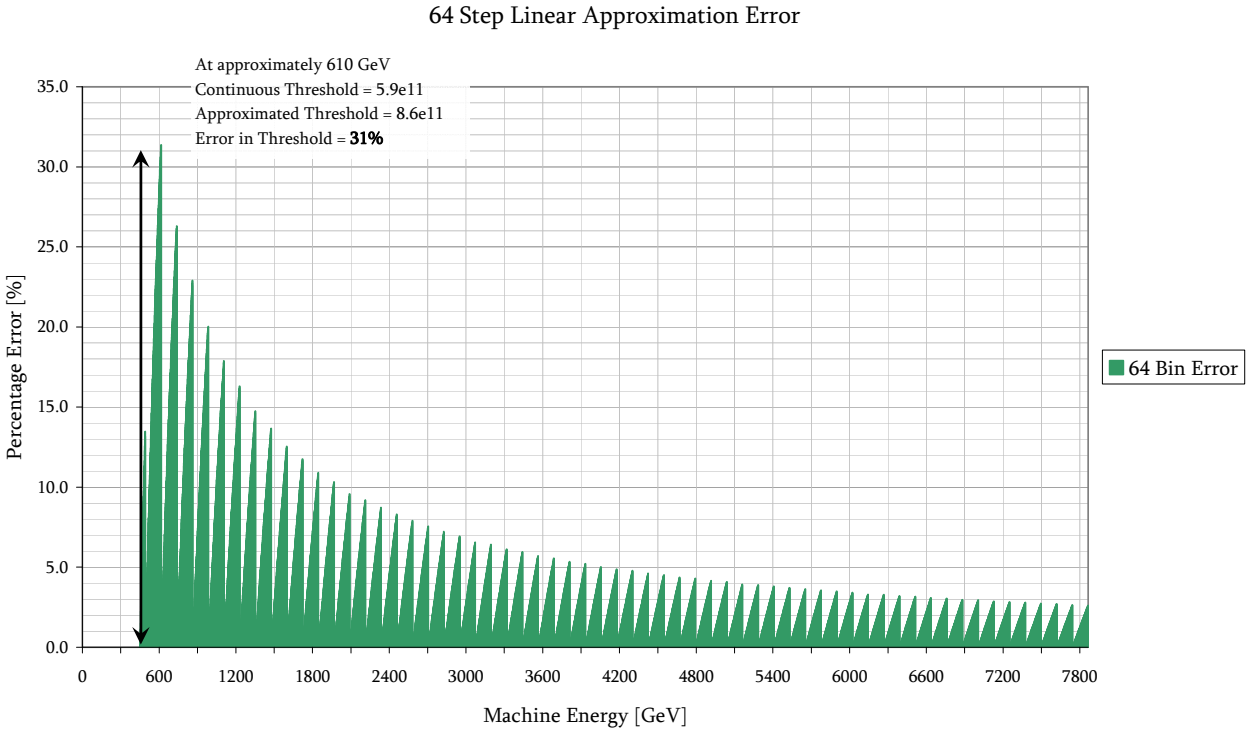
The range of possible energies has been windowed, and the relevant intensities pre-calculated in order to facilitate the calculation of the Safe Beam Flag within FPGA architectures.

Name	Lower Energy Value		Upper Energy Value		Intensity Value	
	[GeV]	[16-bit] [1 = 1.2x10⁸]	[GeV]	[16-bit] [1 = 1.2x10⁸]	[protons]	[24-bit] [1 = 1x10⁸]
SAFE_BEAM_FLAG_1	0.000	0000	122.760	3FF	1.000E+12	002710
SAFE_BEAM_FLAG_2	122.880	0400	245.640	7FF	1.000E+12	002710
SAFE_BEAM_FLAG_3	245.760	0800	368.520	BFF	1.000E+12	002710
SAFE_BEAM_FLAG_4	368.640	0C00	491.400	FFF	1.000E+12	002710
SAFE_BEAM_FLAG_5	491.520	1000	614.280	13FF	8.607E+11	00219E
SAFE_BEAM_FLAG_6	614.400	1400	737.160	17FF	5.890E+11	001701
SAFE_BEAM_FLAG_7	737.280	1800	860.040	1BFF	4.320E+11	0010E0
SAFE_BEAM_FLAG_8	860.160	1C00	982.920	1FFF	3.324E+11	000CFC
SAFE_BEAM_FLAG_9	983.040	2000	1105.800	23FF	2.649E+11	000A59
SAFE_BEAM_FLAG_10	1105.920	2400	1228.680	27FF	2.168E+11	000878
SAFE_BEAM_FLAG_11	1228.800	2800	1351.560	2BFF	1.813E+11	000714
SAFE_BEAM_FLAG_12	1351.680	2C00	1474.440	2FFF	1.542E+11	000605
SAFE_BEAM_FLAG_13	1474.560	3000	1597.320	33FF	1.330E+11	000531
SAFE_BEAM_FLAG_14	1597.440	3400	1720.200	37FF	1.160E+11	000488
SAFE_BEAM_FLAG_15	1720.320	3800	1843.080	3BFF	1.023E+11	0003FF
SAFE_BEAM_FLAG_16	1843.200	3C00	1965.960	3FFF	9.099E+10	00038D
SAFE_BEAM_FLAG_17	1966.080	4000	2088.840	43FF	8.153E+10	00032F
SAFE_BEAM_FLAG_18	2088.960	4400	2211.720	47FF	7.355E+10	0002DF
SAFE_BEAM_FLAG_19	2211.840	4800	2334.600	4BFF	6.674E+10	00029B
SAFE_BEAM_FLAG_20	2334.720	4C00	2457.480	4FFF	6.088E+10	000260
SAFE_BEAM_FLAG_21	2457.600	5000	2580.360	53FF	5.579E+10	00022D
SAFE_BEAM_FLAG_22	2580.480	5400	2703.240	57FF	5.135E+10	000201

SAFE_BEAM_FLAG_23	2703.360	5800	2826.120	5BFF	4.745E+10	0001DA
SAFE_BEAM_FLAG_24	2826.240	5C00	2949.000	5FFF	4.400E+10	0001B7
SAFE_BEAM_FLAG_25	2949.120	6000	3071.880	63FF	4.092E+10	000199
SAFE_BEAM_FLAG_26	3072.000	6400	3194.760	67FF	3.818E+10	00017D
SAFE_BEAM_FLAG_27	3194.880	6800	3317.640	6BFF	3.572E+10	000165
SAFE_BEAM_FLAG_28	3317.760	6C00	3440.520	6FFF	3.350E+10	00014E
SAFE_BEAM_FLAG_29	3440.640	7000	3563.400	73FF	3.149E+10	00013A
SAFE_BEAM_FLAG_30	3563.520	7400	3686.280	77FF	2.967E+10	000128
SAFE_BEAM_FLAG_31	3686.400	7800	3809.160	7BFF	2.801E+10	000118
SAFE_BEAM_FLAG_32	3809.280	7C00	3932.040	7FFF	2.649E+10	000108
SAFE_BEAM_FLAG_33	3932.160	8000	4054.920	83FF	2.510E+10	0000FA
SAFE_BEAM_FLAG_34	4055.040	8400	4177.800	87FF	2.382E+10	0000EE
SAFE_BEAM_FLAG_35	4177.920	8800	4300.680	8BFF	2.264E+10	0000E2
SAFE_BEAM_FLAG_36	4300.800	8C00	4423.560	8FFF	2.155E+10	0000D7
SAFE_BEAM_FLAG_37	4423.680	9000	4546.440	93FF	2.054E+10	0000CD
SAFE_BEAM_FLAG_38	4546.560	9400	4669.320	97FF	1.961E+10	0000C4
SAFE_BEAM_FLAG_39	4669.440	9800	4792.200	9BFF	1.874E+10	0000BB
SAFE_BEAM_FLAG_40	4792.320	9C00	4915.080	9FFF	1.793E+10	0000B3
SAFE_BEAM_FLAG_41	4915.200	A000	5037.960	A3FF	1.717E+10	0000AB
SAFE_BEAM_FLAG_42	5038.080	A400	5160.840	A7FF	1.647E+10	0000A4
SAFE_BEAM_FLAG_43	5160.960	A800	5283.720	ABFF	1.581E+10	00009E
SAFE_BEAM_FLAG_44	5283.840	AC00	5406.600	AFFF	1.519E+10	000097
SAFE_BEAM_FLAG_45	5406.720	B000	5529.480	B3FF	1.460E+10	000092
SAFE_BEAM_FLAG_46	5529.600	B400	5652.360	B7FF	1.406E+10	00008C
SAFE_BEAM_FLAG_47	5652.480	B800	5775.240	BBFF	1.354E+10	000087
SAFE_BEAM_FLAG_48	5775.360	BC00	5898.120	BFFF	1.305E+10	000082
SAFE_BEAM_FLAG_49	5898.240	C000	6021.000	C3FF	1.260E+10	00007D
SAFE_BEAM_FLAG_50	6021.120	C400	6143.880	C7FF	1.216E+10	000079
SAFE_BEAM_FLAG_51	6144.000	C800	6266.760	CBFF	1.175E+10	000075
SAFE_BEAM_FLAG_52	6266.880	CC00	6389.640	CFFF	1.136E+10	000071
SAFE_BEAM_FLAG_53	6389.760	D000	6512.520	D3FF	1.099E+10	00006D
SAFE_BEAM_FLAG_54	6512.640	D400	6635.400	D7FF	1.064E+10	00006A
SAFE_BEAM_FLAG_55	6635.520	D800	6758.280	DBFF	1.031E+10	000067
SAFE_BEAM_FLAG_56	6758.400	DC00	6881.160	DFFF	9.994E+09	000063
SAFE_BEAM_FLAG_57	6881.280	E000	7004.040	E3FF	9.692E+09	000060
SAFE_BEAM_FLAG_58	7004.160	E400	7126.920	E7FF	9.405E+09	00005E
SAFE_BEAM_FLAG_59	7127.040	E800	7249.800	EBFF	9.131E+09	00005B
SAFE_BEAM_FLAG_60	7249.920	EC00	7372.680	EFFF	8.869E+09	000058
SAFE_BEAM_FLAG_61	7372.800	F000	7495.560	F3FF	8.620E+09	000056
SAFE_BEAM_FLAG_62	7495.680	F400	7618.440	F7FF	8.381E+09	000053
SAFE_BEAM_FLAG_63	7618.560	F800	7741.320	FBFF	8.152E+09	000051
SAFE_BEAM_FLAG_64	7741.440	FC00	7864.200	FFFF	7.933E+09	00004F

These 64 windows give the following characteristics for the LHC Safe Beam Flag Threshold as a function of Energy:

The error in the applied threshold versus the continuous function is at worst 31%, as shown in the following diagram:



5. FORCING / TRIMMING FOR 2009-10

To facilitate operations, three mechanisms are in place:

1. Trimming PROBE_BEAM_LIMIT for the PROBE_BEAM_FLAG in SPS
2. Forcing the SAFE_BEAM_FLAGs to FALSE in LHC
3. Trimming ENERGY_PHYSICS_UPPER_LIMIT and _LOWER_LIMIT in LHC

Note that this FORCING and TRIMMING must take into account that there will be two generators in the SPS SMP and two more in the LHC SMP. Multiple values must be written.

5.1 PROBE_BEAM_LIMIT

It is possible to adjust the value PROBE_BEAM_LIMIT which is used for the calculation of the PROBE BEAM FLAG in the SPS Flag Generator. The value used for the calculation is called OPERATOR_PROBE_BEAM_LIMIT and writing it is **optional**.

Rules for the trim:

Rule 1. OPERATOR_PROBE_BEAM_LIMIT must be beam intensity in 24-bits (1-bit = $1x10^8$ charges).

Notification of failure: FESA Exception

Rule 2. OPERATOR_PROBE_BEAM_LIMIT must be less or equal to the value for PROBE_BEAM_LIMIT.

Notification of failure: FESA Property -> Value -> Status Flag

Rule 3. If the value is not written OPERATOR_PROBE_BEAM_LIMIT will be set to PROBE_BEAM_LIMIT.

Notification of failure: FESA Property -> Value -> Status Flag

Rule 4. If the written value does not obey the rules 1-2, then OPERATOR_PROBE_BEAM_LIMIT will be set to PROBE_BEAM_LIMIT.

Notification of failure: FESA Property -> Value -> Status Bit

5.2 FORCING LHC SAFE BEAM FLAG TO FALSE

The LHC Safe Beam Flags can be forced FALSE, by setting bits in the SMP Generators. It will be possible to force any of the four Safe Beam Flags to FALSE independently of the other safe beam flags.

1. SAFE BEAM FLAG 1 A
2. SAFE BEAM FLAG 1 B
3. SAFE BEAM FLAG 2 A
4. SAFE BEAM FLAG 2 B

5.3 ENERGY_PHYSICS_UPPER_LIMIT AND LOWER_LIMIT

The window defined by ENERGY_PHYSICS_UPPER_LIMIT and ENERGY_PHYSICS_LOWER_LIMIT must be trimmed.

The trimmed values are called OPERATOR_PHYSICS_UPPER_LIMIT and OPERATOR_PHYSICS_LOWER_LIMIT.

This trimming allows operation at several different "physics energies" without requiring any intervention in the LHC Safe Machine Parameter System.

Rules for the trim:

Rule 1. OPERATOR_PHYSICS_UPPER_LIMIT must be written as beam energy in 16-bits (1-bit = 120 MeV).

Notification of failure: FESA Exception

Rule 2. OPERATOR_PHYSICS_LOWER_LIMIT must be written as beam energy in 16-bits (1-bit = 120 MeV).

Notification of failure: FESA Exception

Rule 3. A value must be written value for OPERATOR_PHYSICS_UPPER_LIMIT

Notification of failure: FESA Property -> Value -> Status Flag

Rule 4. OPERATOR_PHYSICS_UPPER_LIMIT must be less than or equal to ENERGY_PHYSICS_UPPER_LIMIT

Notification of failure: FESA Property -> Value -> Status Flag

Rule 5. A value must be written value for OPERATOR_PHYSICS_LOWER_LIMIT

Notification of failure: FESA Property -> Value -> Status Flag

Rule 6. OPERATOR_PHYSICS_LOWER_LIMIT must be greater than or equal to ENERGY_PHYSICS_LOWER_LIMIT

Notification of failure: FESA Property -> Value -> Status Flag

Rule 7. OPERATOR_PHYSICS_UPPER_LIMIT must be greater than OPERATOR_PHYSICS_LOWER_LIMIT

Notification of failure: FESA Property -> Value -> Status Flag

Rule 8. OPERATOR_PHYSICS_UPPER_LIMIT - OPERATOR_PHYSICS_LOWER_LIMIT must be less than 20.040 GeV[i].

Notification of failure: FESA Property -> Value -> Status Flag

Rule 9. If any of the Rules 1 – 8 are not adhered to then

STB (STABLE_BEAMS_FLAG) and

MDI (MOVEABLE_DEVICES_ALLOWED_IN_FLAG)

will be blocked **FALSE**

Notification of failure: FESA Property -> Value -> Status Flag

[i] This figure is chosen as 20.040GeV as it must be a multiple of 120MeV.