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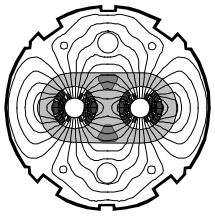

the
Large
Hadron
Collider
project

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Functional Specification

POWERING LAYOUT OF THE SSS CORRECTION SCHEME

(Optics version 6.4)

Abstract

This Functional Specification defines the approach used to power the corrector magnets in the Short Straight Sections of the LHC machine with beam-optics version 6.4.
Some criteria involved in the setting-up of the correction scheme are given and the position of the magnets is shown on the attached drawings.
The powering layout has been designed to minimise the number of superconductor wires installed in the auxiliary bus bar tube (N Line).
In the attached drawings, all the cell numbers contained in the continuous cryostat in each sector of the machine are displayed. Thus, the position and the function of every single corrector or corrector family can be outlined. The powering and the location of the corresponding power converter are shown as well.

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History of Changes

Rev. No.	*Date*	*Pages*	*Description of Changes*
0.1 - draft	30-Aug-1999		1st draft prepared by Paolo Burla.
0.2 - draft	24-Sep-1999		Checked by P. Proudlock and J-P. Koutchouk, P. Lefèvre, R. Ostojic and sent for approval.
0.3 - draft	27-Sep-1999		Sent for approval.
1.0	08-Nov-1999		Modification of the paragraph 2. CORRECTORS FAMILIES + Table 1 in 2.3.
			Approved by the above list and released.
1.1	24-Jan-2000		Annex 7 - Correction of the sequence of chromaticity sextupoles for beam 2 in sector 78
			Document released
1.2	16-May-00	6	Minor modifications on Table 1: IP2 L&R, IP8 L&R: Q12, Q13 = MQ + MQT. Document released
2.0	21-July-00		Abstract: Optics version 6.2. Section 2.4, Skew Quadrupoles Section 3.5, Skew Quadrupoles setting up criteria Annexes 1 to 8: Skew Quadrupoles position and powering.
			Document released
2.1	24-Aug-00	6	Modification (pattern) on Table 1.
			Document released
2.2 – draft	2002-08-13	 4 6	New version 2.2 – draft: Section 2.1 – List – Point 2: Q6 = MQM + MQML Table 1: IP2 and IP8 left and right: Q6 = MQM + MQML Document sent for check and approval to the defined list. **Deadline: 30 August 2002.**
3.0	2002-10-07	All	Modifications of New Optics Version: **6.4** (instead of 6.2) + section 2.1 + Table 1 adapted to Optics version 6.4. Document released.

Table of Contents

1. INTRODUCTION

The SSS correction scheme for the LHC beam-optics version 6.1 was discussed at the 51st meeting of the Parameters & Layout Committee held on May 19th 1999. It was also presented and approved at the July 6th 1999 meeting of the Technical Committee.

The powering philosophy proposals presented at the 52nd meeting of the Parameters & Layout Committee held on June 16th 1999 are taken into account. An optimised version of the powering layout for the correction magnets is included in this document. In particular the left/right feeding of the corrector families has been reviewed to minimise the size and the number of superconducting wires of the cable in line N and hence its size.

This Functional specification was undertaken in view to make the powering layout of the correction scheme easily readable. It should specially serve as a basis to the definition of the auxiliary superconducting cables, and to the mechanical layout of the housing of line N.

2. CORRECTOR FAMILIES

This Functional Specification only applies to the corrector magnets installed in the long continuous cryostat near the main quadrupoles and powered through the auxiliary superconducting bus bar housed in line N of the 8 sectors of the LHC.

The spool piece correctors in the arc Main Dipoles and the arc orbit corrector dipoles are not powered through the auxiliary superconducting bus bar, even if installed in the long continuous cryostat. The powering scheme of these magnets is outside the scope of this document and is, therefore, not considered here.

2.1 MATCHING SECTIONS (Q4 - Q7)

Except left and right of IP3 and IP7, most of the Matching Sections are built with MQM or MQY type individually powered quadrupoles. No additional correctors are required when this type of magnets is used.

The connections between the power converters and the individually powered MQM's or MQY's are made in line with the cabling layout approved at the 42nd P&LC meeting held on September 16th 1998. The magnets on the two beams are connected with the corresponding power converters by means of a three-conductor bus bar. The central conductor of this arrangement carries only the difference of currents flowing in the two magnets, provided that the two magnets are connected with reversed polarities.

The Matching Sections configuration depends on IP's special features. The existing configurations are described in the list below.

1. Except for left and right of IP3 and IP7, the matching sections are composed of the following individually powered quadrupoles with no additional correctors:

• Q4	MQY	in IP1, IP5 and IP6	2xMQY	in IP2 and IP8	
• Q5	MQML	in IP1 and IP5	2xMQY	in IP2L and IP8R	MQY in IP4 and IP6
			2xMQM	in IP2R and IP8L	
• Q6	MQML	in IP1 and IP5	MQH+MQML	in IP2 and IP8	MQY in IP4
• Q7	2xMQM	in IP1, IP2, IP5, IP8			MQM in IP4.

From Q4 to Q6, the above magnets are fitted in individual cryostats whereas Q7 in located at the end of the long continuous arc cryostat beside the electrical feed box DFBA.

2. Left and right of IP3 and IP7 (cleaning insertions), between the IP's and Q6, no individually powered quadrupoles are installed in LSS. The Q6 quadrupoles of these IP's are composed with 6 low current (600 A) MQTL type magnets in series housed in individual cryostats. The Q7 quadrupoles are of the same type and are powered in series with arc quadrupoles. They are fitted at the end of the arc continuous cryostat. For each Q7 quadrupole an MQTL type corrector magnet is required in this case.

- Q6 6xMQTL
  ↧ In series with arc MQ's
- Q7 MQ + MQTL.

2.2 DISPERSION SUPPRESSOR (Q8 - Q11)

In all sectors, except left and right of IP3 and IP7, most of the Dispersion Suppressor short straight sections are built around MQM type individually powered quadrupoles. No additional quadrupole correctors are required when individually powered quadrupoles are used.

The same cabling layout as described in 2.1 will be applied.

- Q8 MQML
- Q9 MQMC+MQM
- Q10 MQML.

However, in all sectors, Q11 is of the same type and is powered in series in the same way as the arc quadrupoles. In this case, the quadrupoles of the two beams are fitted with individually powered MQTL type corrector magnets.

↧ In series with arc MQ's

- Q11 MQ + **MQTL**.

2.2.1 EXCEPTION OF IP3 AND IP7

Left and right of IP3 and IP7 the quadrupoles in the short straight sections are of the same type and are powered in series in the same way as those in the arc. The quadrupoles of the two beams are fitted with individually powered corrector circuits.

↧ In series with arc MQ's

- Q8 MQ + **MQTL**
- Q9 MQ + **2xMQTL**
- Q10 MQ + **MQTL**.

2.3 DISPERSION SUPPRESSOR EXTENSION (Q12-Q13)

In all sectors, the quadrupoles of the two beams are fitted with individually powered MQT type corrector magnets.

↧ In series with arc MQ's

- Q12 MQ + **MQT**
- Q13 MQ + **MQT**

Table 1: Dispersion suppressor quadrupole magnets in the long continuous cryostat

	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
IP1 left	MQY	MQML	MQML	2xMQM	MQML	MQMC + MQM	MQML	MQ +MQTL	MQ + MQT	MQ + MQT
IP1 right	MQY	MQML	MQML	2xMQM	MQML	MQMC + MQM	MQML	MQ + MQTL	MQ + MQT	MQ + MQT
IP2 left	2xMQY	2xMQY	MQM + MQML	2xMQM	MQML	MQMC + MQM	MQML	MQ + MQTL	MQ + MQT	MQ + MQT
IP2 right	2xMQY	2xMQM	MQM + MQML	2xMQM	MQML	MQMC + MQM	MQML	MQ + MQTL	MQ + MQT	MQ + MQT
IP3 left				MQ + MQTL	MQ + MQTL	MQ + 2xMQTL	MQ + MQTL	MQ + MQTL	MQ + MQT	MQ + MQT
IP3 right				MQ + MQTL	MQ + MQTL	MQ + 2xMQTL	MQ + MQTL	MQ + MQTL	MQ + MQT	MQ + MQT
IP4 left		MQY	MQY	MQM	MQML	MQMC + MQM	MQML	MQ + MQTL	MQ + MQT	MQ + MQT
IP4 right		MQY	MQY	MQM	MQML	MQMC + MQM	MQML	MQ + MQTL	MQ + MQT	MQ + MQT
IP5 left	MQY	MQML	MQML	2xMQM	MQML	MQMC + MQM	MQML	MQ + MQTL	MQ + MQT	MQ + MQT
IP5 right	MQY	MQML	MQML	2xMQM	MQML	MQMC + MQM	MQML	MQ + MQTL	MQ + MQT	MQ + MQT
IP6 left	MQY	MQY			MQML	MQMC + MQM	MQML	MQ + MQTL	MQ + MQT	MQ + MQT
IP6 right	MQY	MQY			MQML	MQMC + MQM	MQML	MQ + MQTL	MQ + MQT	MQ + MQT
IP7 left				MQ + MQTL	MQ + MQTL	MQ + 2xMQTL	MQ + MQTL	MQ + MQTL	MQ + MQT	MQ + MQT
IP7 right				MQ + MQTL	MQ + MQTL	MQ + 2xMQTL	MQ + MQTL	MQ + MQTL	MQ + MQT	MQ + MQT
IP8 left	2xMQY	2xMQM	MQM + MQML	2xMQM	MQML	MQMC + MQM	MQML	MQ + MQTL	MQ + MQT	MQ + MQT
IP8 right	2xMQY	2xMQY	MQM + MQML	2xMQM	MQML	MQMC + MQM	MQML	MQ + MQTL	MQ + MQT	MQ + MQT
	Matching				Dispersion Suppressor (DS)				DS Extension	
Local individual cryostats				Long continuous cryostats						

2.4 ARC SHORT STRAIGHT SECTIONS

1. Tuning Quadrupoles:
2 families/arc **MQT** [1] QTF, QTD

2. Skew Quadrupoles:
In even sectors, beam 1 & in odd sectors beam 2:
2 families/arc **MQS** [1] QS
In odd sectors, beam 1 & in even sectors beam 2:
1 family/arc **MQS** [1] QS

3. Chromaticity Sextupoles:
4 families/arc **MS** [1] SF1, SF2, SD1, SD2 or

4. Skew Sextupoles: (=tilted MS)
1 family/arc **MSS** [1] SS

5. Octupoles:
2 families/arc **MO** [1] OF, OD

3. CORRECTION SCHEME AND POWERING LAYOUT

3.1 TUNING QUADRUPOLES

- The four circuits formed by the two families per beam are independent in terms of powering. The power converters are always installed in the even IP end of the sector.
- In all sectors, the Tuning Quadrupoles are installed in cells 14 to 21, left and right.

3.2 SKEW QUADRUPOLES

- In all sectors, skew quadrupoles are installed in cells 23 and 27 (left and right).
- In the even sectors (12, 34, 56, 78).
  - On beam 2;
    One single family/beam of 4 magnets, forming a single circuit powered as a whole. The power converter feeding this circuit is installed in the odd IP at one end of the sector.
  - On beam 1;
    2 families/beam of 2 magnets (right of the odd IP & left of the even IP), forming 2 individually powered circuits. The power converters feeding these circuits are installed in the corresponding IP at both ends of the sector.
- In the odd sectors (23, 45, 67, 81).
  - On beam 1;
    One single family/beam of 4 magnets, forming a single circuit powered as a whole. The power converter feeding this circuit is installed in the odd IP at one end of the sector.
  - On beam 2;
    2 families/beam of 2 magnets (right of the even IP & left of the odd IP), forming 2 individually powered circuits. The power converters feeding these circuits are installed in the corresponding IP at both ends of the sector.

3.3 CHROMATICITY SEXTUPOLE

- The eight circuits formed by the four families per beam are independent in terms of powering. The power converters are always installed in the even IP at one end of the sector.
- Beam 1 enters on the right of an IP at Q11 fitted with SF1 or SD1 depending on sector, and exits on the left of the next IP at Q11 equipped with SF2 or SD2 respectively.
- Beam 1 starts with a focusing Sextupole (SF1) in arc 12.
- The sequence is always:

  SF1, SD1, SF2, SD2 or

  SD1, SF1, SD2, SF2
- If one sextupole is "Focusing" on one beam, it is "Defocusing" on the other.

3.4 SKEW SEXTUPOLES

- The two circuits formed by the Skew Sextupoles single family/beam are independent in terms of powering. The power converters feeding these circuits are always installed in the odd IP at one end of the sector.
- In the cells containing a Skew Sextupole, the latter will take the place of a normal Sextupole.
- A Skew Sextupole always replaces a focusing Sextupole.
- Whenever possible the Skew Sextupoles are centred around Q34; otherwise they are shifted one half-cell clockwise.

3.5 OCTUPOLES

- The four circuits formed by the two families per beam are independent in terms of powering. The power converter feeding each family is always installed in the odd IP at one end of the sector.
- In all sectors, the Octupoles are installed in cells 22 to 34, left and right, with the exception of 23 and 27 (Skew Quadrupoles rules above § 3.2).

4. SSS CORRECTION SCHEME DRAWINGS

Each of the attached drawings, in Annexes 1 to 8, is dedicated to one particular sector of the LHC machine.

Colour was employed to build the original version of these drawings so that more information can be displayed on the document, and in addition, the reading is made easier.

The following information can be found in these drawings:

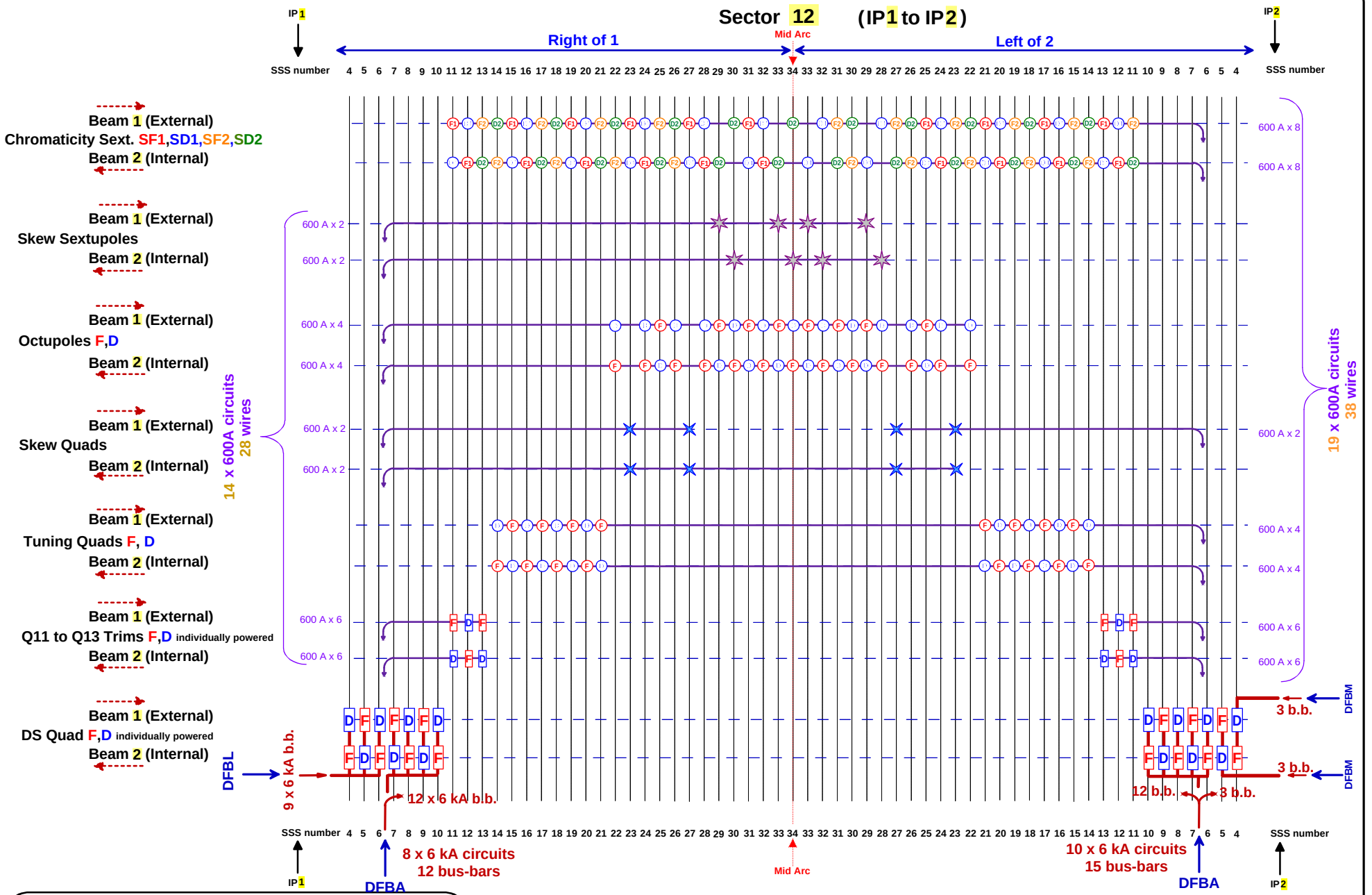
- Number, position (internal, external) and direction of beams.
- Position of the arc DFBA for the sector.
- Position and function of corrector magnets in the sector.
- IP number in which the power converter feeding a magnet or magnet family is installed.
- Number of wires or bus bars entering a sector and connected to a DFBA.

The number of wires for each location can be easily deducted.

5. REFERENCES

[1] Hallgeir KLETTE “Equipment codes”, EDMS No. 107834: Magnet System.

Auxiliary bus-bars and connections for Short straight section correction scheme



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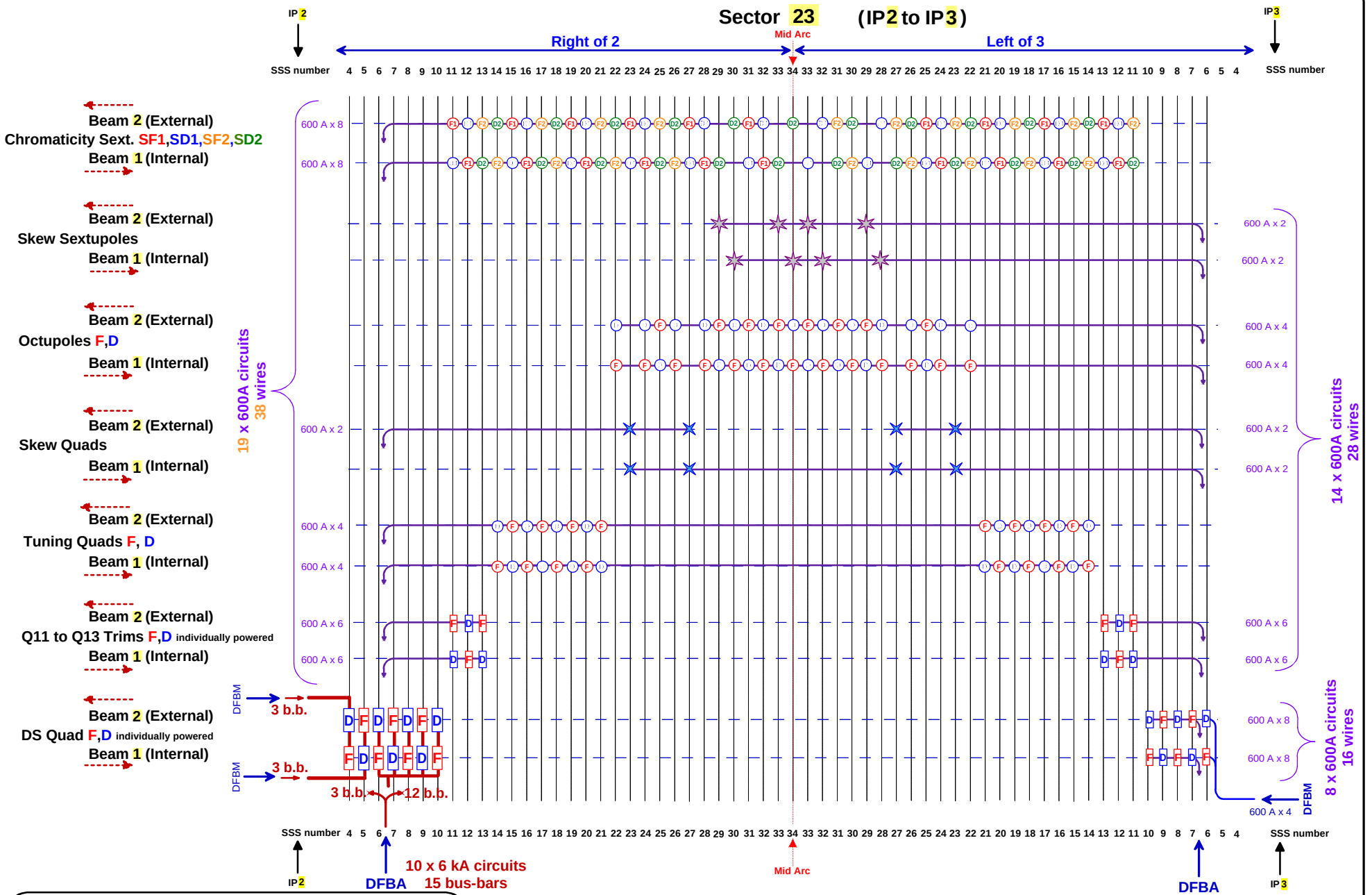

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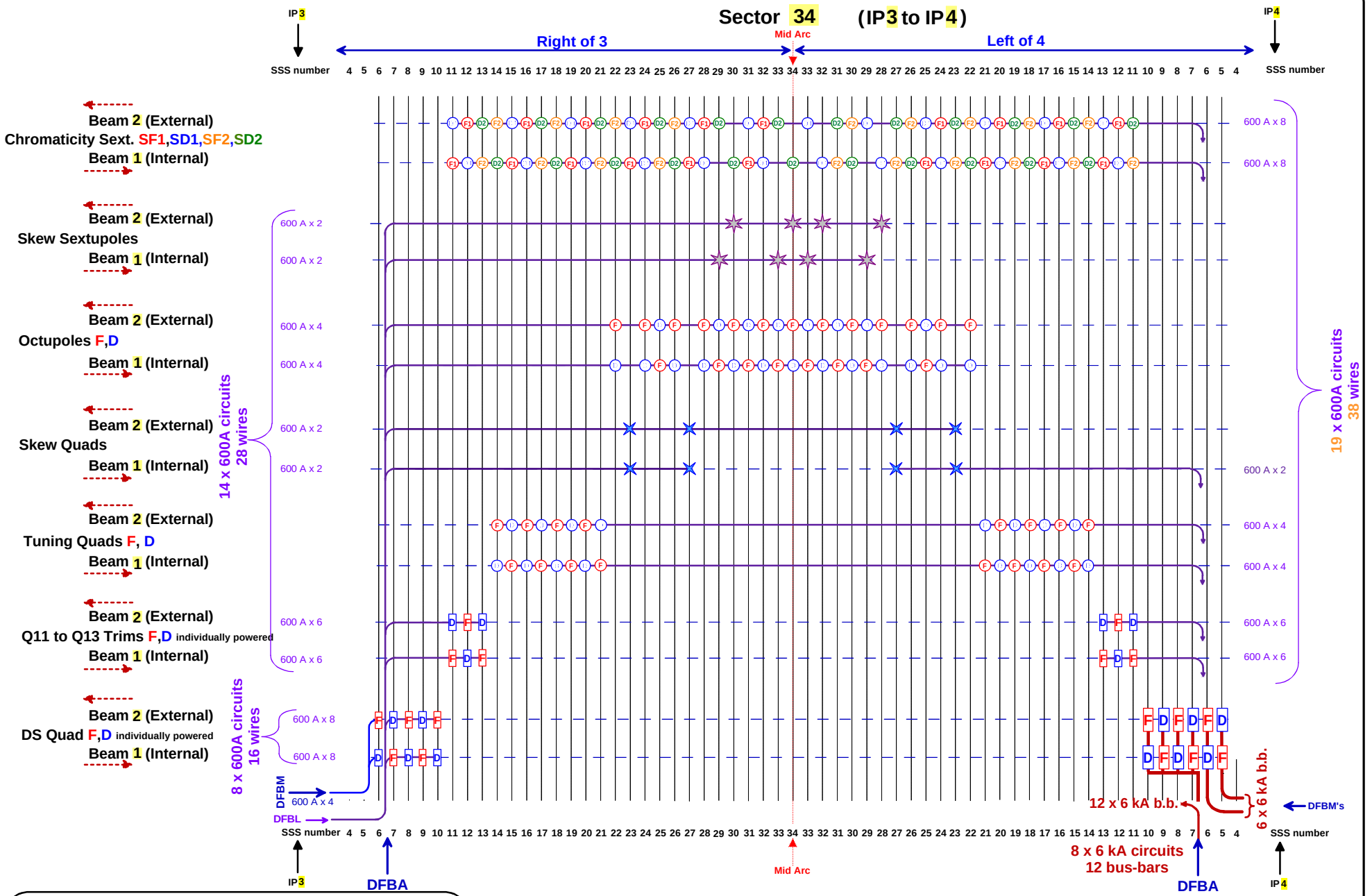

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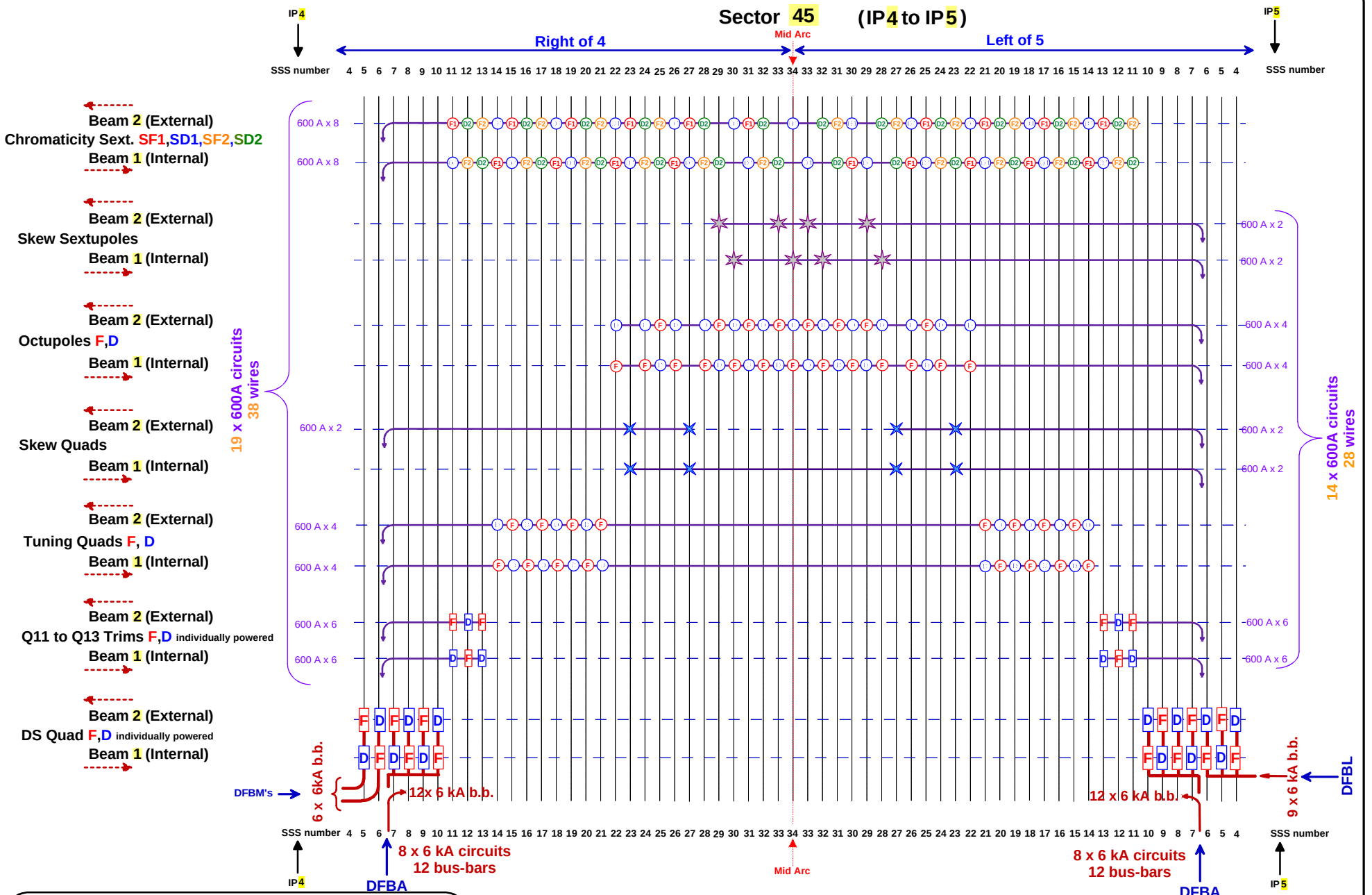

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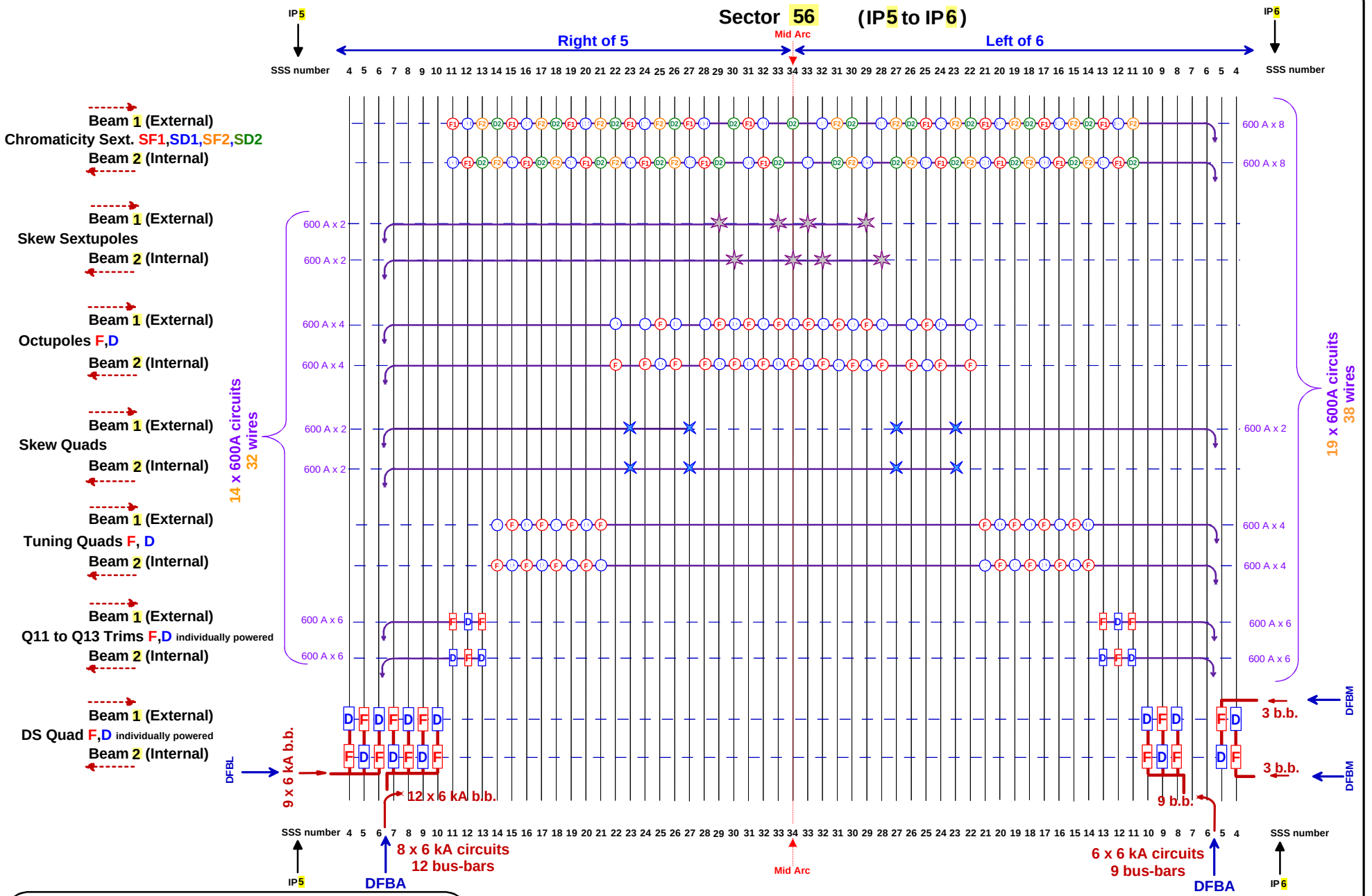

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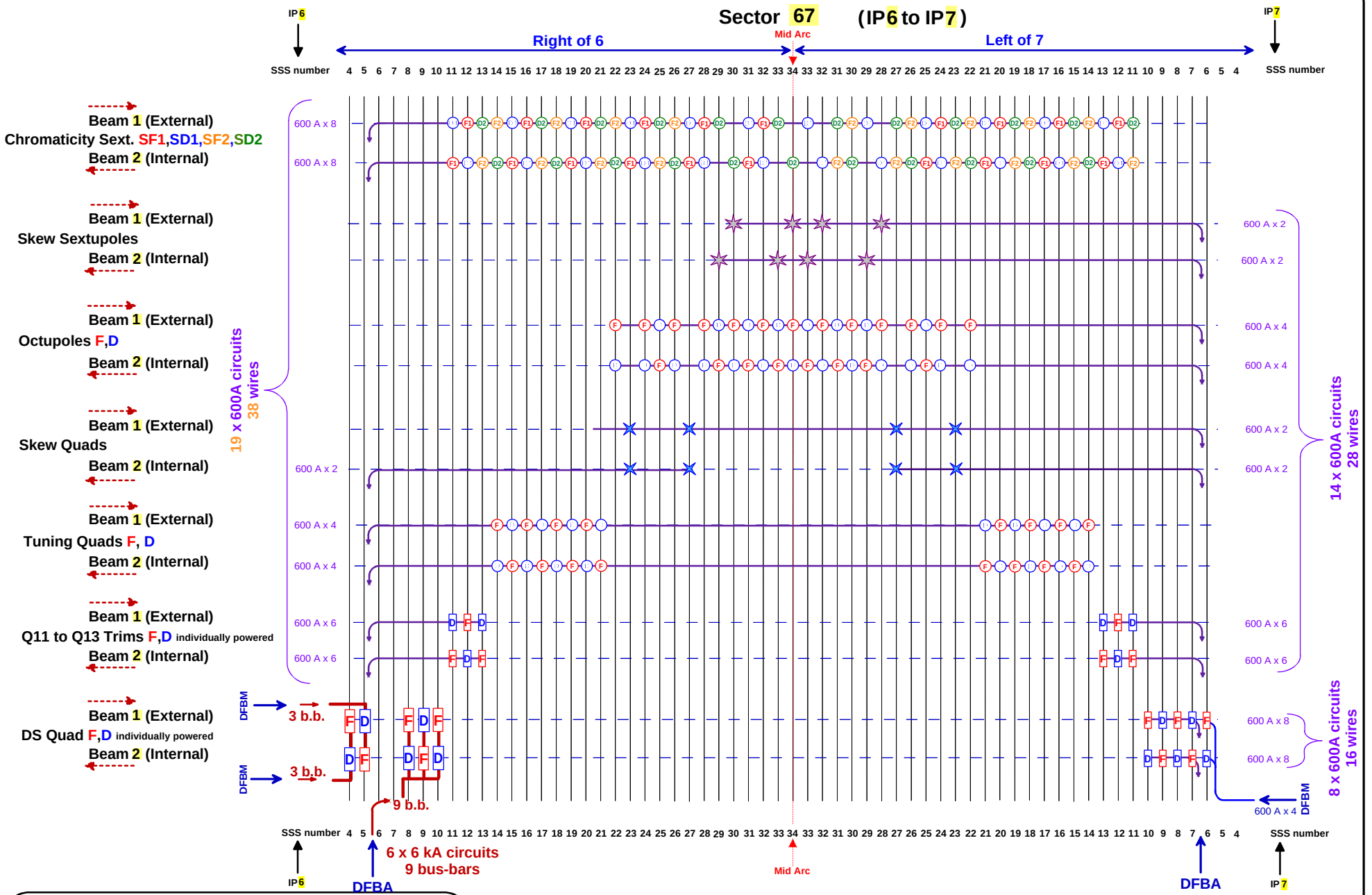
Auxiliary bus-bars and connections for Short straight section correction scheme



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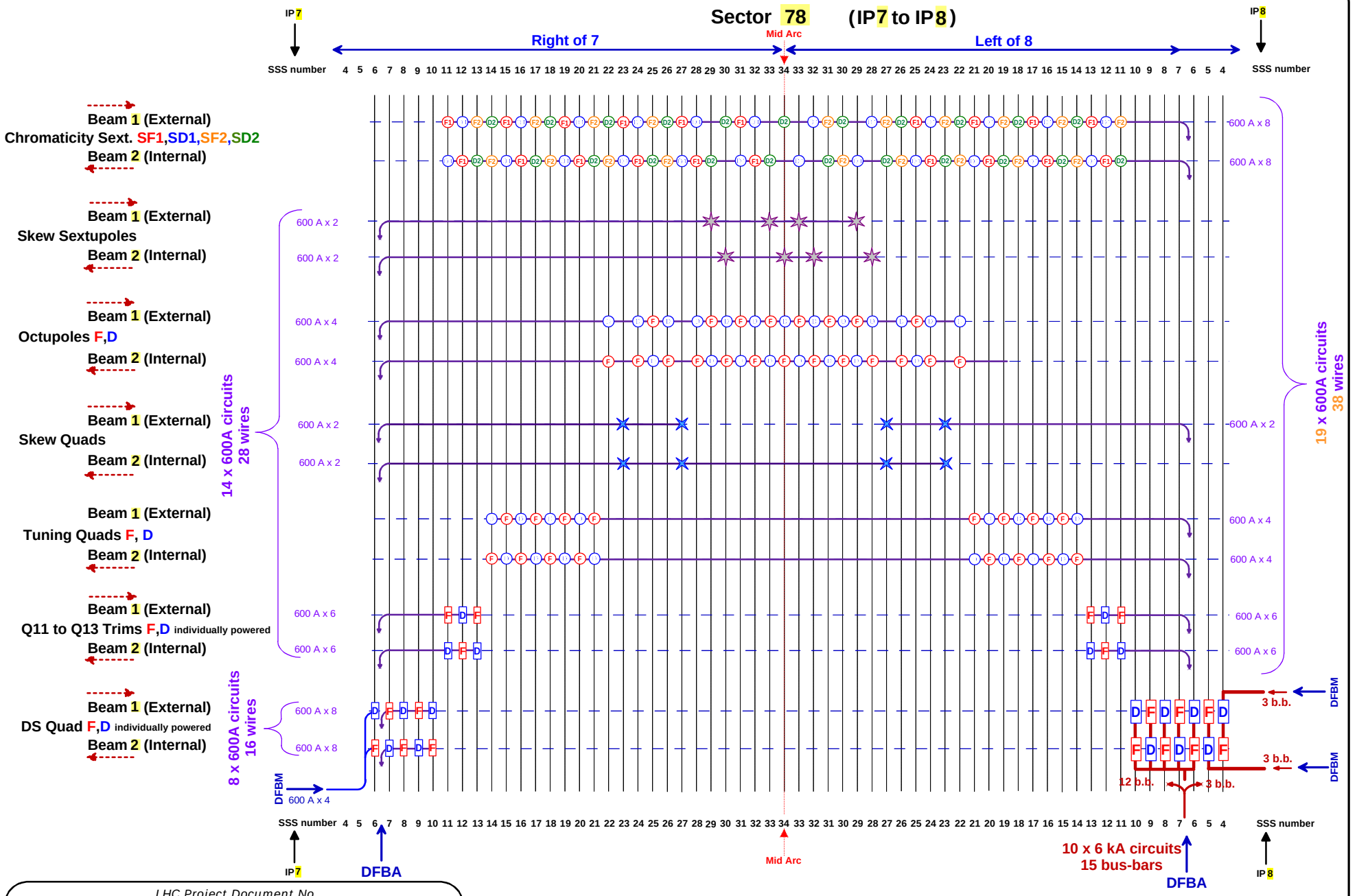
Auxiliary bus-bars and connections for Short straight section correction scheme



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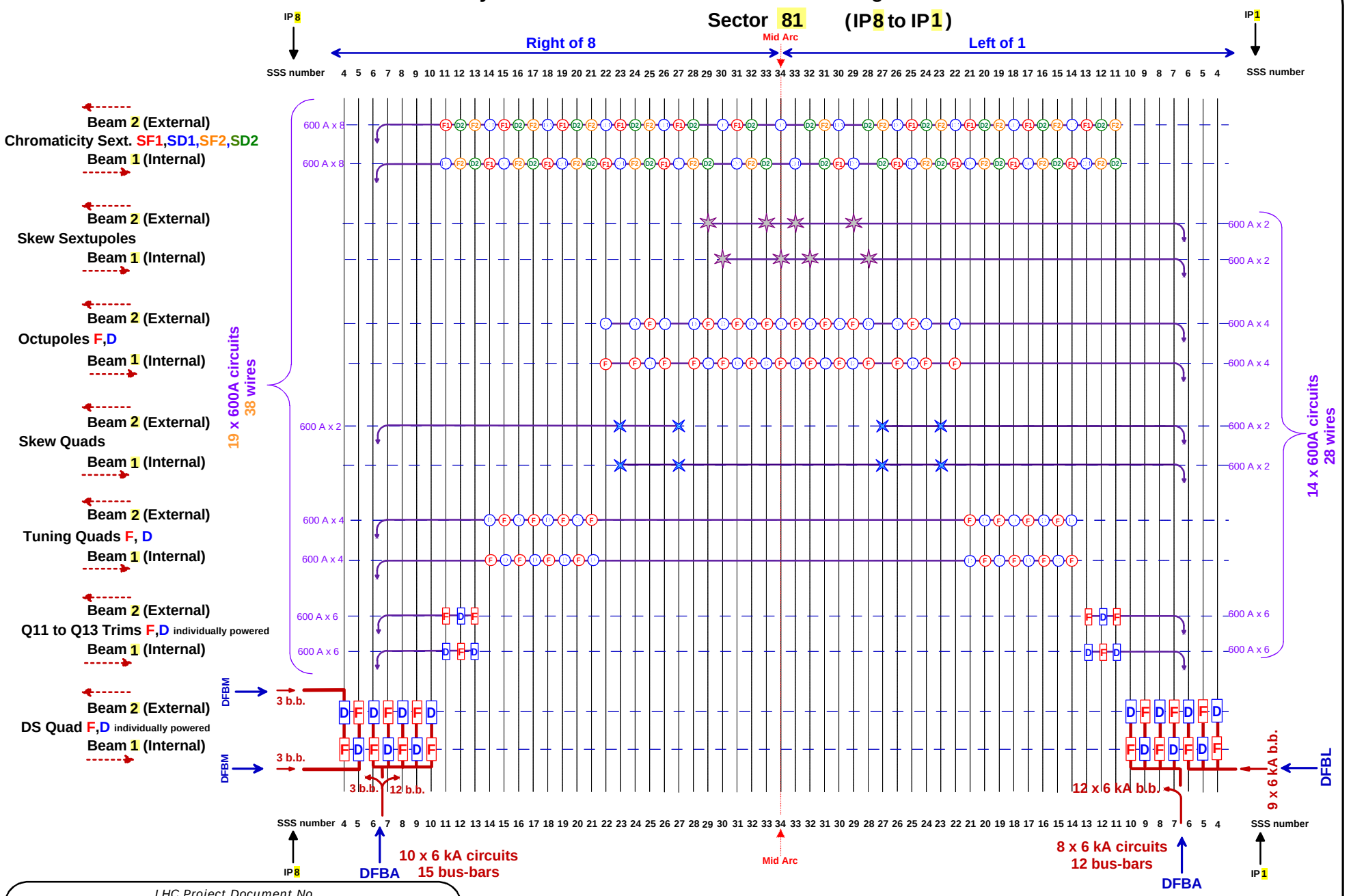

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