Minutes of LHC-CP Link Meeting 7

Subject	:	LHC Controls Project		
Date	:	16:00 5th December 2000		
Place	:	936 Conference Room		
Participants	:	Billen, R		SL-MR
		Bland, A		SL-CO
		Brahy, J		LHC-IAS
		Carlier, E		SL-BT
		Ciapala, E		SL-HRF
		Daneels, A		IT/CO
		Epting, U		ST-MO
		Gavaggio, R		LHC-VAC
		Gayet, P		LHC-ACR
		Gras, JJ		SL-BI
		King, Q	(Secretary)	SL-PO
		Lamont, M		SL-OP
		Lauckner, R	(Chairman)	SL-DI
		Martel, P		EST-ISS
		Pezzetti, M		LHC-ECR
		Rodriguez Mateos, F		LHC-ICP
		Saban R.		AC-TCP
		Schmidt, R		AC-TCP
		Sollander, P		ST-MO
		Tyrell, M		SL-CO
		Vanden Eynden, M		SL-CO
Excused	:	Walckiers, L		LHC-MTA
Absent	:	Bruning, O		SL-AP
		De Rijk, G		SL-MS
		Di Maio, F		PS-CO
		Wolf, R		LHC-MMS
Distribution	:	Via LHC-CP website: **http://cern.ch/lhc-cp** Notification via: **lhc-cp-info@cern.ch**		
Agenda	:	1. Minutes from previous meeting		
		2. Controls News		R. Lauckner
		3. Function Generation in LEP		M. Lamont
		4. TDS naming convention		P. Sollander
		5. Cryo naming convention		P. Gayet
		6. LHC naming convention		R. Saban
		7. AOB		

1. Minutes from Previous Meeting

The minutes from meeting 6 were approved.

2. Controls News R. Lauckner

The chairman reported the following items of controls news to the meeting:

- Pedro Ribeiro is working on a proposal for the real-time sub-project which is expected within a few days.
- Philippe Gayet has a draft mandate, see project web site, for the Components sub-project, the project team is being built and a first meeting is planned before Christmas.
- The Controls Board again discussed SCADA systems for LHC and again there was no consensus, however guidelines have been requested by the time of the April LHC-CP workshop. R. Lauckner has announced his position to the Controls Board and asks that the project members focus their efforts (see attached slides).
- Axel Daneels has joined the project to lead the planning effort. The initial aim is to identify major priorities for the 2nd project workshop in April 2001.
- Marc Vanden Eynden has been working on the EDMS workspace for the LHC-CP and will present it at a future meeting.
- Alastair Bland has replaced Michel Jonker as the linkman for SL/CO.
- Mark Tyrrell has been invited to join the LHC-CP meetings as leader of the Alarms sub-project.
- Quentin King will be stepping down as secretary of the LHC-CP meetings at the end of the year. A new secretary is needed!

3. Function Generation in LEP M. Lamont

Mike Lamont explained how function generation for LEP started with the computation of a set of optics using MAD (see attached slides). These defined the field strengths in an energy independent way, with the intention of optimising the beta functions according to the phase of operation, e.g. injection, ramp, squeeze, physics.

The sets of optics would then be associated with beam energies and times to define the ramp and squeeze. The physics parameters and magnet strengths were then interpolated between the optics to create functions of time.

Magnet strengths were then converted into currents using calibration curves. These were combined with empirical trim functions to compensate for errors in the MAD model. The resulting functions of current against time were sent to the power converters which used linear interpolation between data points.

4. TCR Data Server (TDS) naming convention P. Sollander

Peter Sollander presented the TDS naming convention (see attached slides). This is based on alphanumeric tag containing 3 fields: Class, Member, Attribute. The naming convention has been in use for more than 3 years and tens of thousands of tags have been defined within a smart sockets application used within the TCR.

A tag identifies a variable which can be a string, a Boolean or a floating point value. The tag name space is flat, however the format of a tag is fundamentally hierarchical, and has been mapped easily to PVSS data point types which are also hierarchical.

In the discussion afterwards, it was asked why tag names are so long. It was explained that the naming convention had to unify signals from very diverse systems. Information about tags is stored in a database, so an application can make the selection of variables easier by grouping tags by location etc…

It was noted that tags identify variables related to an equipment's functional position, and is not a "part number" for a particular piece of equipment.

5. Cryo naming convention — P. Gayet

Philippe Gayet presented the Cryo naming convention (see attached slides). This is also a system of naming functional positions for equipment and is based on an alphanumeric string with four fields: Equipment code, position code, family and instrument.

It was explained that the boundaries between the fields have been diluted to some extent by the inclusion of a "vertical position" identifier in the equipment code field. It was also noted that although the first letter of the equipment code for cryo is Q, cryo instruments embedded in structures belonging to other groups, e.g. magnets, will be identified by the equipment code for the structure. This can make it difficult to recognise the instrument as a cryo device.

The complete name identifies a particular instrument, for example, a valve. A data structure is defined for each instrument type which may contain many different variables. If this were mapped to TDS tags, one cryo instrument would be mapped to a unique Class and Member, and each variable would have a unique attribute string. Thus, a single cryo name maps to multiple TDS tags. It was shown how cryo names could be automatically reformatted to produce TDS tag names.

It was also explained that at present, the naming convention does not work very well when identifying cryo elements which are physically large, in particular, cooling circuits. It was noted that there are parallels between cooling circuits and electrical powering circuits.

6. LHC naming convention — R. Saban

Roberto Saban explained the background to the naming convention used for LHC (see attached slides). It began as a way to identify lattice elements in MAD simulations, and was then extended to other components. Again, the objective is to name functional positions rather than individual pieces of equipment. The complete document defining equipment naming conventions can be found at:

http://edmsoraweb.cern.ch:8001/cedar/doc.page?document_id=103369&version=1.0

7. AOB

None.

Actions	**People**
Establish Real-time and Components sub-projects.	R Lauckner
Set up the LHC Controls Engineering data tree in EDMS	M. Vanden Eynden
Complete planning questionnaire for all LHC controls related sub-projects with a group	All LHC-CP linkmen

SCADA - LHC-CP Position, Control Board 30th November, 2000

R. J. Lauckner

The quality of the JCOP technical survey is noted, particularly those aspects that could be relevant to a large scale usage in the CERN accelerators.

At the April 2000 LHC-CP workshop the deadline of April 2001 was set for SCADA recommendations and guidelines

The existence of the purchasing arrangement for all CERN is noted and is essential to establish a standard at CERN

The chairman’s report from the CERN working group on SCADA recommending PVSS is noted

The common issues between JCOP and the machine both in the respective requirements and the coupling between the operational models is noted

Therefore technical projects at the LHC-CP will now focus on PVSS:

- TCR software infrastructure
- CERN Alarm System
- Middleware integration of industrial systems
- Future evolution of existing SCADA solutions

and a final decision to standardise on PVSS (or not) will be made in February 2001

The technical synergy developed by a single system at CERN is already growing and impressive!

The establishment of strong technical support, central and local, for operational systems in the next 12 months is essential

The recommendation on SCADA is late and careful attention must be given to the retrofitting of the decision to existing systems (Wizcon, PCVue)

Basic concepts -dipole

Balance Lorentz and centrifugal force

$$evB_z = -\frac{mv^2}{\rho}$$

$$\frac{1}{\rho}[m^{-1}] = 0.2998\frac{B_0[T]}{p_0[GeV/c]}$$

Basic concepts - quadrupole

$$B_z = -gx$$ where $$g = \frac{\partial B_z}{\partial x}$$

Introduce momentum independent quadrupole strength

$$k = \frac{eg}{p_0} \quad [f = \frac{1}{kl_q}]$$

$$k[m^{-2}] = 0.2998\frac{g[T/m]}{p_0[GeV/c]}$$

$$k_1 = \frac{1}{B\rho}\frac{\partial B_z}{\partial x}$$

Setting generation

- Work off-line in MAD with normalized, energy independent strengths.
- Complete set of strengths for all magnets usually referred to as “optics”.
- Optics:
  - doesn’t change in arcs
  - is changed in insertions to change beta8 at interaction point: “the squeeze”.

Vector	Energy [GeV]	β^*_y [cm]	β^*_x [m]
0	22	20	2.0
64	30	20	2.0
88	33	10	2.0
568	93	10	2.0
576	94	9	2.0
584	95	6	2.0
592	96	5	2.0
600	97	5	1.75
608	98	5	1.5
664	105	5	1.5

TDS Tag Naming

Peter Sollander
CERN, ST/MO/IN

Outline

- TDS tag naming
  - Basic principles
  - Examples
- PVSS naming
  - Basic principles
  - Systems, Data point types
- Conclusions

Basic Principles

- **Tags represent variables** held by the TDS Data acquisition modules
- There is one tag for each variable and all tags have a **unique name**
- It is based on *device-oriented* principles
- The codification of systems follows the rules of the LHC Naming convention (LHC-PM-QA-204)
- A tag name is composed of **three components** Class, Member & Attribute

Basic Principles

Field 1	CLASS	Six characters	Combination of Codes defining the system, subsystem to which the tag is allocated and the class of equipment
Field 2	MEMBER	Up to 15 characters	Combination of Codes defining the functional location, coding form, and identification of the equipment
Field 3	ATTRIBUTE	Four characters	Combination of Codes indicating the nature and function of the tag.

`sfdi03.m30gmcdei09065.zaxx`

Class.Member.attribute

Class

Part 1	**SYSTEM**	char 1	Identifier for the system to which the equipment belongs
Part 2	**SUB-SYSTEM**	char 2	Identifier for the sub-system to which the equipment belongs
Part 3	**CLASSID**	char 3-6	Code identifying a class of equipment chosen on the basis of common surveillance characteristics that are defined as attributes within the TDS. For example all fire detectors of a certain type may send a level 3 alarm, an inhibition signal or a malfunction alarm. (It is however possible for attributes to optional and therefore not to apply to all instances of a class).

Member

Part 1	**FUNCTION**	Char 1-3	Code identifying the site, area, zone or accelerator related to the equipment
Part 2	**FORM**	char 4, 5	Code identifying the way the coding system used to establish the member name.
Part 2	**NAME**	char 6-15	Name identifying the equipement

Attribute

Part 1	**TYPE**	char 1, 2	Code giving an indication the function and nature of the tag. **(According to *ISO 3511/2 CODE LETTERS FOR IDENTIFICATION OF INSTRUMENT FUNCTIONS*)**
Part 2	**NAME**	char 3, 4	Identifier qualifying the type **(Free choice)**

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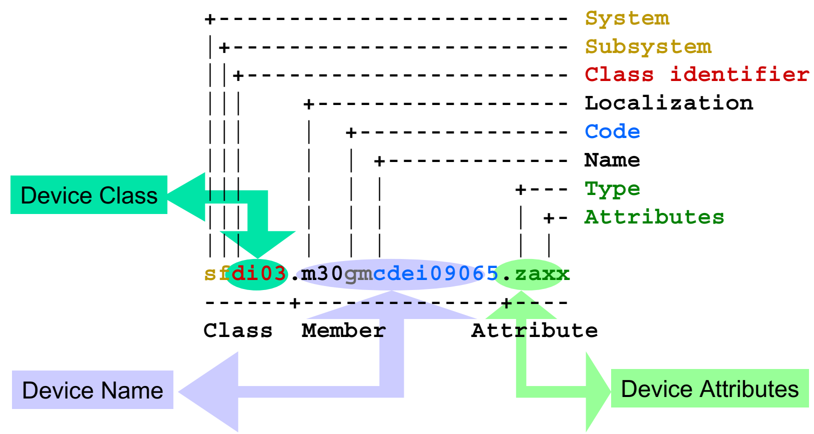
Basic Principles



sfdi03.m30gmcdei09065.zaxx

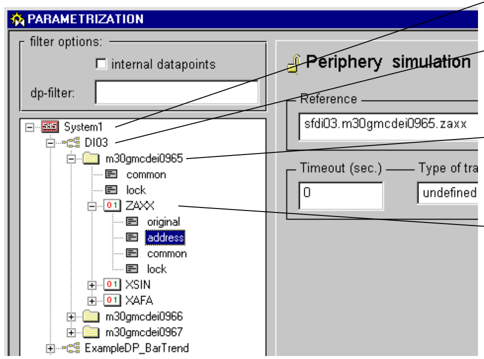
Constraints

- Subsystem codes are unique only within systems
- Classes may be used in several systems
  - fwpp01, fbpp01, fgpp01, ...
- A member belongs to exactly one class
  - **m30gmcdei09065** ∈ **di03**
- **Attributes are unique within classes**
  - di03..**xsin** ≠ ebd1..**xsin**

PVSS

- SCADA system to be used a lot at CERN
  - LHC experiments, ST, SL?, LHC?
- Device oriented
  - Data point types (DPT) define device types and device elements
  - Data points are instantiations of DPT
- ST will prototype PVSS as future user interface tool (mimics, alarms, trends)
- TDS tag names map to PVSS DPT-DP

PVSS naming schemes



System name: **Unique**

Data Point Type: **Unique throughout all communicating systems** (TDS class)

Data Point: **Unique within system** (TDS member)

Data Point Element (TDS attribute)

sfdi03.m30gmcdei09065.zaxx

Advantages & Disadvantages

- The tag naming is not application specific
  - No TDS references
- The tag names are meaningful (if you know how to read them)
- It turns out that TDS naming works fine with PVSS variable structure

- Good knowledge of the technical structure of devices is crucial
- It is difficult and it takes time to name data
- Tag names may change!
  - We use a "tagId" as the primary key of our databases.

Cryogenic Instruments naming convention

Cryogenic Instruments naming convention

- According to the LHC naming convention all machine instruments are identified by an alphanumeric code consisting of equipment code, position code an optional unit code and instrument name.

Equipment code • **Position Code** [• **family Code**] / **Instrument Name**

Equipment code	=	up to 5 characters
Position code	=	up to 5 characters
family code	=	up to x characters optional
Instrument name	=	up to 9 characters (for cryo)

Cryogenic Equipment code

- First letter defines the system (Q for cryo)
- second letter defines the verticale position
  - S : surface / U : underground / R : Tunnel ring/P : Pit
- Third letter defines the nature of equipment
  - C : Compressor set / R : Cold box
  - I : interconnection valve box / L : Transfer line
  - V : Gaseous Storage / D : Liquid storage (Dewar)
- Forth/Fifth letters define the type of the equipment.
  - SA,SB,... Service module of type A,B,...
  - A,B,C type Cryoplant A existing, B new 4.5, C 1.8K

Example of Equipment Code

- for Cryoplants: **QURC**

QURC = 1.8 K cryoplant coldbox located underground

- for the QUI: **QUI**

QUI = interconnection box located underground

– QRL: **QRLSA**

– QRL = Cryogenic Distribution Line located in the ring tunnel; S= Service module; A = Type A

- **BUT** for instruments located on a Magnet or DFB we have to follow the other equipment group coding rule
  - LBA for a cryo-dipole assembly of type A (MBA,MCS,MCDO+.....)
  - DFB electrical feed box
  - DFLA Current lead

Location code

- For ring components located in a half cell or on the QRL
  - One digit to define which part of the half cell (S,A,B,C)
  - Two digit to define the quad/half cell number
  - One digit to define which side of the IP
  - One digit to define the IP
- for cryoplants, QUI, storages, lines
  - One digit to define which side of the IP (optional)
  - One digit for the IP

Example of Location

– for the QRL: **S06L1**

S06L1 = module on Cell number 06; Half-octant L1, at the level of SSS

– for the magnets: **A11L1**

A11L1 = On magnet A module of Half Cell number 11; Half-octant L1

- for the Cryoplant: **R4**

R4 = located at right of IP4

- for the QUI: **4**

4 = located at IP4

Family code

- For certain type of equipment a family name is used
  - DFB components : each valve is related to a current lead

Example of UNIT

– DFLA.7L2.52
- DFLA = current leads of type A (13kA)
- 7L2 = located beside quadrupole 7 ; Half-octant L2
- 52 = Unit 52

Instrument Name

(ACR note modified for compatibility to ECR needs)

- Corresponds to the P&ID name
- It consists of:

Unit code	Instrument type	Instrument number

Instrument name up to 9 characters

Unit	=	up to 2 characters
Instrument type	=	up to 3 characters
Instrument number	=	up to 4 digits

Instrument Name (2)

- Unit (0 to 2 digits)
  - Define the number of component duplicated (ie-turbines, compressor, ...)
- Type (2 to 3 digits)
  - Defines the type of instrument
    - 3 digits are only used for PTD, and the switches (PSH, TSL, LSH,...)
- Number (3 to 4 digits)
  - for ACR we have to follow an earlier ACR note

Example of Instrument Name

- for the Cryoplant: **1CV210**

1CV210 = Control Valve at the inlet of turbine 1

- for the QUI: **7CV710**

7CV710 = Control Valve toward IP7

– for the QRL: **TT960**

TT960 = Temperature Transmitter at inlet of header C

– for the magnet: **TT821**

TT821 = Temperature Transmitter on cold mass

– for the ECR: **1TT2960**

1TT2960 = Temperature Transmitter in a experiment magnet

Example of Cryogenic Instrument Names

- for the Cryoplant: **QURC.R4/1CV210**

QURC = 1.8 K cryoplant
R4 = located at right of IP4
1CV210 = Control Valve at the inlet of turbine 1

- for the QUI: **QUI.6/7CV710**

QUI = interconnection box
6 = located at right of IP6
7CV710 = Control Valve for header toward IP5

– for the QRL: **QRLSA.S11L1/TT960**

QRL = Cryogenic Distribution Line; S= Service module; A = Type A
S11L1 = Cell number 11; Half-octant L1
TT960 = Temperature Transmitter at inlet of header C

Example of instruments connected to Cryo control system with names related to another system

– for the Magnet: **LBA.A12L1/TT821**

LBA = Cryo-Dipole assembly
A06L1 = A dipole A; Half Cell number 06; Half-octant L1
TT821a = cold mass temperature , sensor

– for the current leads: **DFLA.7L2.52/CV8xx**

DFLA = current leads of type A (13kA)
7L2 = located beside quadrupole 7 ; Half-octant L2
52 = bus bar family 52
CV8xx = control valve

Drawbacks/Limitations (1)

- Integration In control system

- Not compatible with IEC1131 naming convention
  - this naming convention used within PLC does not accept the special character as . Or /
  - we have then to replace them by _
- No indication on the nature of the tag
  - Add an attribute in the control system Tag name, this as to be defined by cryo-control people.

Drawbacks/Limitations (2)

- Name not identifying always the connection to Cryogenic control system.
  - For the project the letter Q is associated to cryogenic.But we will have name starting by L or D in our naming scheme.
  - This may lead in trouble during operation when people will have to cross check information in temporal databases for post mortem or Alarm analysis
  - ***Imply the creation of a special database for cross reference and to determine who is responsible***

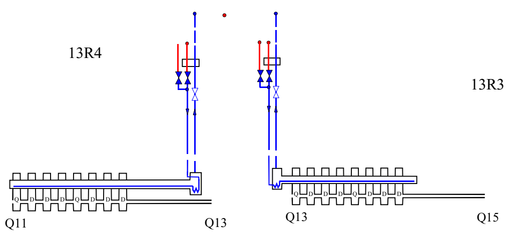
Drawbacks/Limitations (3)

- Not adapted for maintenance
- Maintenance Naming convention shall oriented toward the type of equipment and not its location
  - presently in Rapier /MP5
    - Q1CCV010001: Screw compressor of type 01 number 0001
    - Q1ICP01002541 : Pressure sensor of type 01 number 2541
  - ***establish a database for cross correlation***

Drawbacks/Limitations (4)

- Problem of control loop identification
  - In the tunnel the 1.8K control loops are not following a simple scheme according to the local configuration

QRLSA.S13R4/CV910
controled by
LQ.S11R4/TT821
LBA.A11R4/TT821
LBA.B11R4/TT821
LBA.B11R4/TT821
LQ.S12R4/TT821
LBA.A12R4/TT821
LBA.B12R4/TT821
LBA.B12R4/TT821



QRLSA.S13R3/CV910
controled by
LQ.S13R3/TT821
LBA.A13R3/TT821
LBA.B13R3/TT821
LBA.B13R3/TT821
LQ.S14R3/TT821
LBA.A14R3/TT821
LBA.B14R3/TT821
LBA.B14R3/TT821

  - we may add circuit naming to identify the loops.
    - QRLSA.S13R4/CV910#QC18K.S13R4
    - LBA.A11R4/TT821#QC18K.S13R4
  - ***We have to define if we use circuit and if yes the naming***

Drawbacks/Limitations (5)

- Not compatible with the TCR Naming convention TDS
  - this naming convention is use by the technical control room to monitor all services and safety equipment
    - **[Class] _[Member]_[Attribute]**
  - Class (6 Char) : to identify the type of equipment belonging to a system,
    - Format : (1) system, (1) subsytem, (4) type
    - FWFIL1 : specific type of filter on a demineralised water circuit
  - Member (15 Char) : localization and equipment identification
    - Format : (3) site, area, (2) coding rule, (10) name
    - M27 GM CBDI00682: safety zone 27, GM coding, loop detector CDBI000682
  - Attribute (4) : indicate the nature and function on the tag
    - Format (2) type of tag, name of tag

Drawbacks/Limitations (5)

- TDS convention could be amended to allows an easiest translation from LHC.
  - **[Class] _[Member]_[Attribute]**
  - Class & attribute remains as they does not exist in LHC naming
  - Member which localization and equipment identification could be modified
    - TDS [location*3][coding rule*2][name]
    - LHC [equipment*6].[location][family]/[sensor name]
    - alternate TDS members [location as in LCH]_[coding rule]_[equipment]_[family][sensor name]
  - this modification imply the introduction of separators even in the existing database but other ideas are welcome
  - this solves the problem related to origin of the signal
  - this is on the good way for maintenance as TDS is designed to cope with MP5

Example of cryo Names translated in TDS

- for the Cryoplant: **QURC.R4/1CV210**

QL CV01 _ LR4QCC1CV210 _ AO 01

QL CV01 _ LR4_QC_ QURC_1CV210 _ AO 01

– for the QRL: **QRLSA.S11L1/TT960**

QL TT05 _ LL1QCS11TT960 _ AI 01

QL TT05 _ LS11L1_QC_QRLSA_TT960 _ AI 01

– for the Magnet: **LLB.A12L1/TT821**

- **QL TT04 _ LL1QCA12TT821 _ AI 01**
- **QL TT04 _ LA12L1_QC_LLB_TT821 _ AI 01**

for the DBF: **DFLA.7L2.52/CV700**

QL CV02 _ LL2 QC752CV700 _ AO 01

QL CV02 _ L7L2_QC_DFLA_52CV700 _ AO 01

Absolute necessity of a link database to establish translation rules (*TBD)

Conclusion

- We have a tag naming convention easy to understand for cryo people and compatible with LHC naming and the cryogenic documentation (P&I D,...) but we need to :
  - ***Define if we use circuit and if yes the naming convention and how to present them***
  - ***To establish for maintenance an adapted type of coding rule and establish a database for cross correlation***
  - ***Create a database and a coding rule to translate our naming convention in to TDS format***
  - ***check with TDS people if they can adapt the TDS rules***

General

< equipment code > are defined in LHC Project Web Pages

Location in the Tunnel

< half-cell number > :: = { **1** to **34** }

< ip number > :: = { **1** , **2** , **3** , **4** , **5** , **6** , **7** , **8** }

< arc> :: = { **A12** ¦ **A23** ¦ **A34** ¦ **A45** ¦ **A56** ¦ **A67** ¦ **A78** }

< beam > :: = { **B1** ¦ **B2** }

< half-cell > :: = < half-cell number > { **R** ¦ **L** } <ip number >

< position in the insertion >:: = { **R** ¦ **L** } < ip number > }

<position in the half-cell > :: = { **S** ¦ **A** ¦ **B** ¦ **C** }

Four segments are identified. The one containing the short straight section and the three (or two in the case of the dispersion suppressor half-cells) others containing a dipole. The letter **S** is only used for components other than the short straight section (e.g. racks or vacuum equipment).

< distance in the half-cell> :: = { **1** to **99** }

This distance is measured from the mid-plane of the interconnect between dipole A and the neighbouring quadrupole. It is measured clockwise for half-cells to the right of an IP and anti-clockwise for those left from an IP. In both cases the number, composed of two digits, is positive. The unit is not metric: one unit corresponds to xx m.

< position in the arc > :: = [<position in the half-cell >] < half-cell > ¦
< half-cell > < distance in the half-cell >

Location outside the Tunnel

< underground areas > :: = { **RR**xx, **RE**xx, **UA**xx, **UJ**xx, **US**xx, **Ux**xx, }

< surface buildings > :: = { **SA**xx, **SD**xx, **SE**xx, **SU**xx, **SX**xx, }

Key to formalism
¦ or
[ ] optional
{ } any element of the set
bold literal value

1 Collider Component

< collider component > :: = < equipment code > **.**
< position in the arc >
[**.** < family >]

2 Circuits

< powering area > :: = { **RR17**, **UA23**, **UJ33**, … }

< circuit type > :: = { **RB**, **RQF**, **RQD**, **RQ8**, **RQS1**, **RQS6**, …}

< circuit > :: = < circuit type > [< ordinal >] **.**
{ < arc > [< beam >] ¦
< position in the insertion >[< beam >] } **.**
< powering area >

3 Instrumentation

< sensor > :: = < collider component > **/** < sensor name >

< connector name >:: = < flange code > < connector type > < ordinal >

< connector > :: = < collider component > **/** < connector name >

< wire name > :: = < connector > **/** < sensor name > **:** <wire ordinal>

Key to formalism
¦ or
[ ] optional
{ } any element of the set
bold literal value

4 Components in the Tunnel

< system component >:: = < equipment code >
{ [< ordinal >] ¦ **-** <sub-component> [< ordinal >] }
. < position in the arc > [**#** < circuit >]

5 Racks in the Tunnel

< rack > :: = < system code > **Y** < main usage > < ordinal >
{ **.** < position in the arc > ¦ **/** < underground area > }

6 Racks outside the Tunnel

< rack > :: = < system code > **Y** < main usage > < ordinal >
/ { < surface buildings > ¦ < underground areas >}

7 Cabinets outside the Tunnel

< system component >:: = < equipment code >
{ [< ordinal >] ¦ **-** <sub-component> [< ordinal >] }
= { < surface buildings > ¦ < underground areas >}

Key to formalism

¦	or
[ ]	optional
{ }	any element of the set
bold	literal value

1 Collider Component

LQAOT.12R1	Short straight section of type OT in half cell 12 right of IP 1
LBB.C12R1	Cryodipole assembly of type B in half cell 12 right of IP 1 and in third position (C) from the short straight section.
MCD.C12R1.B1	Decapole spool-piece in the above cryo assembly acting on beam 1

2 Circuits

RB.A12.UA23	Dipole circuit in Arc 1 to 2 powered from UA23
RSF1.A12B2.UA23	Family 1 of the sextupole lattice correctors in Arc 1 to 2 on beam 2 and powered from UA23

3 Instrumentation

LBB.C12R1/TT813	Temperature transducer TT813 (§ IWG) in the above cryo assembly
Qloop.S12R1/CV943	

4 Systems

DQHDS1.C12R1 # RB.A12.UA23	First (of four) quench heater power supplies situated under the above mentioned cryo assembly connected to the dipole circuit

5 Racks

QYCO1.C12R1	First cryogenic rack situated under the above mentioned cryo assembly

Key to formalism

¦	or
[ ]	optional
{ }	any element of the set
bold	literal value