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	SLS 2.0
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SLS 2.0 Layout Management	**SLS2-AM81-004-1**
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1. Introduction

The new storage ring is currently under design. To build the machine, we need a document that describes the layout and can be shared among expert groups. Traditionally at GFA, such a document was called “Heilige Liste” or Holy list, which includes the names and positions of accelerator components together with other important information.

However, it is not always used properly, and unfortunately there are discrepancies between the actual layout of the SLS storage ring and the layout of application input file: the actual positions of some BPMs are shifted with respect to the layout of OPA file by a few mm. At the time of SLS construction, Holy list was manually edited and other application input files were independently modified. This would be partly the source of inconsistencies.

To avoid such inconsistencies for the SwissFEL construction, the workflow was better organized:

a) The accelerator designer (namely S. Reiche) prepared “Master layout” file
b) Proto-holy list and other application input files are all generated from Master layout file with scripts
c) Missing components in Proto-holy list are added (mainly vacuum components by L. Schulz) to obtain a complete Holy list
d) When the layout of the machine is updated, first Master layout file is updated, and the changes are propagated to other applications.

In this way, accidental inconsistency was minimized or fully eliminated.

We now try to establish similar workflow for the SLS2 design and construction.

2. Master layout file

Master layout file of SwissFEL is a python script. Although it is readable even for non-python user, it may not be the most convenient format.

We employ a simple text file format, which can be rather easily interpreted by human and by script. It is intended to simplify and thus minimize the information included in Master layout file:

a) Types and dimensions of components
b) Common lines (or structure) of the layout
c) Layout of 12 sectors

An example of Master layout file is found in Appendix.

3. Applications

There are several applications, and their (input) files are generated with scripts based on Master layout file. So far, we have written python scripts to generate:

a) Proto-holy list
b) OPA input file
c) MADX input file

It is straightforward to cover/support more applications such as Tracy and Elegant, and high level applications for commissioning and operation in the future, for instance a list of Epics channel names can be generated as well.

Since the information included in Master layout file is minimized, additional information is required. From time to time, the same component is given various names, depending on the application. For example, all sextupoles are ARSnn-MSXT-mmm, where nn is the sector number, and mmm is the position number (see the naming convention [1]) in Holy list while they are called such as SD1, SD2, SF1, SF2, which are the names of sextupole families in the beam dynamics applications. The application-dependent information is stored in separate file.

4. Workflow

The lattice design work is performed within OPA (A. Streun). At this moment, Master layout file is generated based on OPA file when a new lattice is released. Consistency between OPA file and Master layout file is checked by regenerating OPA file inversely from Master layout file. Afterward, Holy list is generated from Master layout file. This workflow is summarized in Figure 1.

5. File location

Master layout files (for different lattice versions) are currently store under AFS project directory

/afs/psi.ch/project/SLS2/BD/OnlineModel/Layout

Proto-holy list of the latest lattice version, B059_004, is also found there.

The location of the files will be reorganized in a convenient manner.

6. How to generate Proto-holy list

A script named HolyList.py is used to generate a Proto-holy list. The usage is

> python3 HolyList.py <MasterLayoutFile> <AdditionalInfoFile>

The first input for the lattice version B059_004 is MasterLayout.B059_004.txt found in the directory above. The second input includes additional information that is not in Master layout file and specific for Holy list. It is HolyListPattern.B059_004.py and also found in the directory above.

There is also a Windows executable. One can use it in Windows (in command prompt) as

> HolyList.exe <MasterLayoutFile> <AdditionalInfoFile>

References

[1] A. Streun, SLS2-SA81-001-9_naming_convention

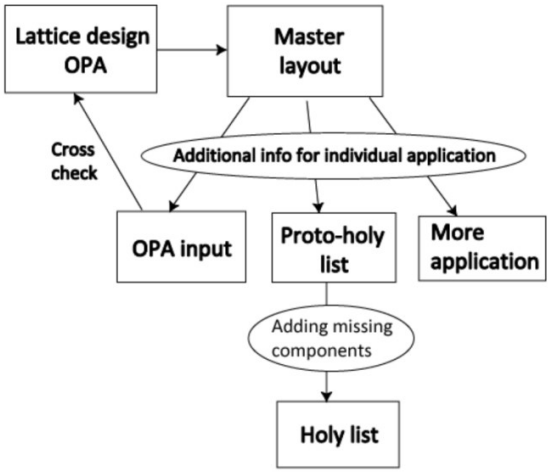

Figure 1. Workflow from the lattice design to Holy list and other applications.

Appendix: Format of Master layout file

1) Case insensitive through the file
2) Comment can be inserted with '!' character. If '!' is at the beginning of line, the entire line is regarded as comment. If it is somewhere in a line, only after '!' is taken as a comment
3) A long line can be split by '\\'
4) Spaces and tabs can be put at any location
5) Lattice version should be given in a line, for example 'Version B059_004'
6) Layout information are divided into several "class"es
7) 'class Constant' is the place, where constants are defined, for example, 'gdbs5 = 0.0720255'
8) 'class Type' is the place, where the type of component is defined. For example, QP quadrupole magnet is defined as 'QP: MQUA, L=0.1, RL=0.035'. Here, L is the length of the magnet and RL is the reserve length before and after the magnet, i.e. space for coils.
9) 'class CommonLine' is the place, where a segment including several components can be defined. For example, the longitudinal gradient bend is defined as 'BNV: MBLG, [VBI,BN|SRC_DIP,VBO]'. The components used here should be defined in 'class Type'. In this example, a marker which represents dipole source point is inserted in the middle of BN magnet by using '|' character. One can also use numbers (integer or float) in the rectangular bracket to specify a drift space. The length of the drift is the number itself (unit=m).
10) Finally, the entire ring layout is defined in 'class Sequence' sector by sector. Sector 1, for example, is defined as 'ARS01:[GINI_SEC,SS01,G0A,GINI_ARC,MATI,ECELLI,CellL2,CellL1,CellC40,CellR1,CellR2,ECELLO,MATO,G0A]'. In the rectangular bracket, one can use both the component defined in 'class Type' and segment defined in 'class CommonLine'.

The actual Master layout file is attached below:

```
! Master layout file draft
! Comment with '! at the beginning of the line
! Line continuation with '\\'
! Spaces and tabs can be put anywhere

! Short names
!
! MBEN: Bending magnet
! MBCF: Combined function
! MBSC: Superconducting bending magnet
! MQUA: Quadrupole
! MSXT: Sextupole
```

! MOCT: Octupole (to be confirmed)
! MCOX: Horizontal corrector
! MCOY: Vertical corrector
! GSRC: Source point marker (to be confirmed)
! MKIK: Injection kicker
! MSEP: Injection septum
! DBPM: BPM
! None: Others (do not appear in Holy list)
!
! and various names for unit as MSOQ,MBLG, etc.

Version b059_004

class Constant
! Define constants for covenience
! We can use these constants in other classes

gdbs5 = 0.0720255
gdbs27 = -0.02548275
gdbs4 = 0.0750426

lshft9 = 0.0
lshft5 = -0.785

ddm = 0.03
abam = 0.26
abev = 1.0
abeh = 2.4+abam-abev
ddem4 = 0.61
ddem5 = 0.17
dsstr = 2.03+ddm
dmstr = (6.0+2*ddm-ddem4-ddem5)/2
lundu = 2

class Aperture
!to be defined

class Type
! Type name corresponds to the one that appears in Holy list 'Type' column.
! Parameters (case insensitive)
! L: the physical length

```
! RL: Reserved length before and after the element,
!     for example coil space for magnets (Zero if not present)
!     For now, only the same length at the entrance and exit.
! ANG (or ANGLE): Bending angle (only valid for bend) in units of degree
! AP: Aperture type. No aperture if not present. Aperture definition is not yet fixed.

! Bending. If Short name is not given, it should start with 'B'
! E1 and E2 is interpreted assuming that it is SBEND
! If E1 and E2 are both omitted, they will be a half of ANG
! If only E1 or E2 is defined, the other one is computed from ANG

AN: MBCF, L= 0.14, ANG= -0.24
VBO: MBCF, L= 0.185, ANG= 1.0, E1= -1.74, E2=  2.74
VBI: MBCF, L= 0.185, ANG= 1.0, E1=  2.74, E2= -1.74
VBXO: MBCF, L= 0.185, ANG= 1.0, E1= -1.74, E2=  2.74
VBXI: MBCF, L= 0.185, ANG= 1.0, E1=  2.74, E2= -1.74

BN: MBEN, L =0.2025*2, ANG = 1.74*2

! BESI, BEHI, BEVI have to be explicitly defined
! to appear in Type column of Holy list
BESO: MBEN, L = 0.03, ANG = 0.1, E1 = -abeh, E2 = abeh+0.1
BESI: MBEN, L = 0.03, ANG = 0.1, E1 = abeh+0.1, E2 = -abeh

BEHO: MBEN, L = 0.2125, ANG = abeh, E1 = 0.0, E2 = abeh
BEHI: MBEN, L = 0.2125, ANG = abeh, E1 = abeh, E2 = 0.0

BEVO: MBCF, l = 0.24, ANG = abev, E1 = abev, E2 = 0.0
BEVI: MBCF, L = 0.24, ANG = abev, E1 = 0.0, E2 = abev

ANM: MBCF, L = 0.14, ANG = -abam
!     E1 = -abam/2, E2 = -abam/2  ! Not needed since E1=E2

! LGB has to be split already here to compute the geometry of the ring...
BS27: MBSC, \\
L=0.065280+gdbs27 | 0.079470 | 0.045410 | 0.037840 | 0.037840 | 0.045410 | 0.079470 |
0.065280+gdbs27], \\
ANG=[0.02890 | 0.57770 | 0.56470 | 0.56870 | 0.56870 | 0.56470 | 0.57770 | 0.02890], \\
E1=[1.74000 | 1.71110 | 1.13340 | 0.56870 | 0.0 | -0.56870 | -1.13340 | -1.71110], \\
E2=[-1.71110 | -1.13340 | -0.56870 | 0.0 | 0.56870 | 1.13340 | 1.71110 | 1.74000]
```

BS40: MBSC, \\
L=[0.027660 | 0.025630 | 0.017540 | 0.016190 | 0.014840 | 0.013490 | 0.012140 | 0.012140 | 0.013490 | 0.014840 | 0.016190 | 0.017540 | 0.025630 | 0.027660], \\
ANG=[0.08100 | 0.28380 | 0.27840 | 0.27880 | 0.27060 | 0.27170 | 0.27570 | 0.27570 | 0.27170 | 0.27060 | 0.27880 | 0.27840 | 0.28380 | 0.08100], \\
E1=[1.74000 | 1.65900 | 1.37520 | 1.09680 | 0.81800 | 0.54740 | 0.27570 | 0.0 | -0.27570 | -0.54740 | -0.81800 | -1.09680 | -1.37520 | -1.65900], \\
E2=[-1.65900 | -1.37520 | -1.09680 | -0.81800 | -0.54740 | -0.27570 | 0.0 | 0.27570 | 0.54740 | 0.81800 | 1.09680 | 1.37520 | 1.65900 | 1.74000]

BS50: MBSC, \\
L=[0.029690 | 0.031760 | 0.022100 | 0.016570 | 0.012430 | 0.009670 | 0.008290 | 0.008290 | 0.009670 | 0.012430 | 0.016570 | 0.022100 | 0.031760 | 0.029690], \\
ANG=[0.06570 | 0.28350 | 0.28770 | 0.28140 | 0.28560 | 0.27520 | 0.26090 | 0.26090 | 0.27520 | 0.28560 | 0.28140 | 0.28770 | 0.28350 | 0.06570], \\
E1=[1.74000 | 1.67430 | 1.39080 | 1.10320 | 0.82180 | 0.53620 | 0.26100 | 0.0 | -0.26100 | -0.53620 | -0.82180 | -1.10320 | -1.39080 | -1.67430], \\
E2=[-1.67430 | -1.39080 | -1.10320 | -0.82180 | -0.53620 | -0.26100 | 0.0 | 0.26100 | 0.53620 | 0.82180 | 1.10320 | 1.39080 | 1.67430 | 1.74000]

! 'Q'uadrupoles
QA-SLS: MQUA, L=0.2, RL=0.07
QP: MQUA, L=0.1, RL=0.035
QPH: MQUA, L=0.14, RL=0.035

QAO: MQCO, L=0.05, RL=0.015
QAI: MQCO, L=0.05, RL=0.015

QAWO: MQCO, L=0.05, RL=0.015
QAWI: MQCO, L=0.05, RL=0.015

! Skew quad, to be fixed, Need different short name, otherwise QA and QS get the same name
! because they are both integrated into Octupole
QSO: MQSK, SKEW=1
QSI: MQSK, SKEW=1

QSWO: MQSK, SKEW=1
QSWI: MQSK, SKEW=1

!'S'extupole

SXO: MSXT, L=0.09, RL=0.025
SXI: MSXT, L=0.09, RL=0.025

SXQ: MSXT, L=0.09, RL=0.025 ! Wide elliptical aperture

SXWO: MSXT, L=0.09, RL=0.025 ! Yoke with ears
SXWI: MSXT, L=0.09, RL=0.025 !

!'O'ctupole
OCO: MOCT
OCI: MOCT

OCWO: MOCT
OCWI: MOCT

! Diagnostics
BPM: DBPM, L=0.0,RL=0.0125

! What are the physical length of CH and CV? Does not matter for HL
CH: MCOX, L=0.0
CV: MCOY, L=0.0

! 'SRC' point markers, type name to be defined...

SRC_STR_S: GSRC
SRC_STR_M: GSRC
SRC_STR_L: GSRC
SRC_SUPERB: GSRC
SRC_DIP: GSRC
SRC_ENDB: GSRC

! 'G'eometrical markers. If Short name is None, the first character SHOULD be 'G'
GINI_SEC: GMRK, L=0 ! Beginning of Sector
GINI_ARC: GMRK, L=0 ! Beginning of Sector

GINJ: GMRK, L=0 ! Beam injection point (At the exit of TYIN)
G0A: None ! Arc girder open-end
G1A: None ! Arc girder joint
G0S: None ! Straight section girder

! Drift space, which is explicitly reserved, i.e., Absorber. Short name to be defined?
! If Short name is None, the first character SHOULD be 'D'
DABS: None, L=0.17

! Undulators are drift for now.
DUND4H: None, L=lundu/2
DUND8: None, L=lundu

D5LA: None, L=(5.755+ddm+lshft5)/2*2
D5LB: None, L=(5.755+ddm-lshft5)/2*2
D9LA: None, L=(5.755+ddm+lshft9)/2*2
D9LB: None, L=(5.755+ddm-lshft9)/2*2
DLMAT: None, L=0.18-ddm
DUND2S: None, L=dsstr-1.1
DSCUT4: None, L=dsstr-lundu/2
DMCUT8: None, L=(dmstr-lundu)/2

DEM4: None, L=ddem4
DEM5: None, L=ddem5

KIN: MKIK, L=0.6, RL=0.125
KINJ: MKIK, L=0.8
YIN: MSEP, L=0.8, RL=0.0955
TYIN: MSEP, L=0.4, RL=0.05

class CommonLine
! The name of CommonLine is either the one that appears in HL Type column or a one created.

! BN|SRC_DIP means the geometrical marker SRC_DIP will be inserted in the middle of BN. They will have THE SAME position index
BNV: MBLG, [VBI,BN|SRC_DIP,VBO]
BNVXO: MBLG, [VBI,BN|SRC_DIP,VBxO]
BNVXI: MBLG, [VBxI,BN|SRC_DIP,VBO]

! The numbers that appear in a common line is drift space (not reserved) in units of m.
! Although QA and QS coils are integrated into OQ magnet core,
! it is expressed here that the main body is QA and OQ and QS are integrated
! This is for the sake of on-line model (it can be avoided but the script becomes unrobust.)
SOQO:MSOQ, [SXO,0.01,QAO|OCO|QSO]
SOQI:MSOQ, [QAI|OCI|QSI,0.01,SXI]
SOQWO:MSOQ, [SXWO,0.01,QAWO|OCWO|QSWO]

```
SOQWI:MSOQ, [QAWI|OCWI|QSWI,0.01,SXWI]

CHV:MCOR,[0.03,CV,0.045,CH,0.03]
BPMCHV: None, [0.0225,BPM,CHV,0.0175]

! If the short name is None, it is defined to simplify this layout file and decomposed in HL
CellL2: None, [SOQO,0.01,AN,BPMCHV,SOQI,G1A,0.03,BNVXI,0.03,SOQO,DABS,AN,0.01]
CellL1: None, [SOQWO,0.01,AN,BPMCHV,SOQI,0.03,BNV,0.03,SOQO,DABS,AN,0.01]
CellC: None,
[SOQWO,0.01,AN,BPMCHV,SOQI,G1A,0.03,BNV,0.03,G1A,SOQO,DABS,AN,0.01,SOQWI]
CellR1: None, [0.01,AN,BPMCHV,SOQI,0.03,BNV,0.03,SOQO,DABS,AN,0.01,SOQWI]
CellR2: None, [0.01,AN,BPMCHV,SOQI,0.03,BNVXO,0.03,G1A,SOQO,DABS,AN,0.01,SOQI]

CellC27: None,
[SOQWO,0.01,AN,BPMCHV,SOQI,G1A,0.03,VBI,BS27|SRC_SUPERB,VBO,0.03,G1A,SOQO,DABS,A
N,0.01,SOQWI]
CellC40: None,
[SOQWO,0.01,AN,BPMCHV,SOQI,G1A,0.03,VBI,gdbs4,BS40|SRC_SUPERB,gdbs4,VBO,0.03,G1A,
SOQO,DABS,AN,0.01,SOQWI]
CellC50: None,
[SOQWO,0.01,AN,BPMCHV,SOQI,G1A,0.03,VBI,gdbs5,BS50|SRC_SUPERB,gdbs5,VBO,0.03,G1A,
SOQO,DABS,AN,0.01,SOQWI]

! Matching sections
MATI: None, [0.1,QPH,BPMCHV,QPH,0.01,SOQO,0.01, \\
        QP,0.01,SOQO,0.01,QP,0.01,SOQO,BPMCHV]

MATO: None, [0.17,SOQI,0.01,QP,0.01,SOQI,0.01,QP, \\
        0.01,SOQI,0.01,QPH,BPMCHV,QPH,0.1]

! modified outgoing matching for M straight: QP instead of QPH:
MATMO: None, [0.17,SOQI,0.01,QP,0.01,SOQI,0.01,QP, \\
        0.01,SOQI,0.01,QP,BPMCHV,QP,0.1]

! I think the short name of BEI/BEO is not MBEN because they are a combined unit as BNV and
mirror symmetry like SOQO and SOQI.

BEI: MBEB, [BESI,SRC_ENDB,BEHI]
BEO: MBEB, [BEHO,SRC_ENDB,BESO]

ECELLI: None, [0.03,BEI,0.01,SXQ,0.01,BEVI,DLMAT,DABS,ANM,0.01]
```

ECELLO: None, [0.01,ANM,BPMCHV,DLMAT,BEVO,0.01,SXQ,0.01,BEO,0.03]

!generic layout for S and M straights
SU4: None, [DSCUT4, DUND4H, SRC_STR_S, DUND4H, DSCUT4]
MU8: NOne, [DEM4, QPH, DEM5, QP, DMCUT8, DUND8, DMCUT8, SRC_STR_M, DMCUT8, DUND8, DMCUT8]

! Straight sections
! CYCLE is a marker that you can put anywhere and multiple times.
! It will be used to define the starting point of a list to be created from this Master layout file.
SS01: None, [G0S,KIN,0.025,0.17,0.025,KIN,0.025, 0.17, BPMCHV,\\
G0S, 2.700, YIN, 0.025, QA-SLS,BPMCHV,0.8,QA-SLS,0.025,TYIN, GINJ, CYCLE, 0.025, G0S,\\
0.16,G0S,QA-SLS,1.154,QA-SLS,0.04,BPMCHV,0.025,0.17, \\
KIN,0.025,0.17,0.025,KIN,G0S,G0S]
SS02: None, [0.2,KINJ,0.2,KINJ, 0.2, DUND2S, SRC_STR_S, DUND2S, G0S]
SS03: None, [MU8]
SS04: None, [SU4]
SS05: None,
[D5LA|SRC_STR_L,G0S,QP,BPMCHV,0.03,QPH,0.03,BPMCHV,QP,G0S,D5LB|SRC_STR_L]
SS06: None, [SU4]
SS07: None, [MU8]
SS08: None, [SU4]
SS09: None,
[D9LA|SRC_STR_L,G0S,QP,BPMCHV,0.03,QPH,0.03,BPMCHV,QP,G0S,D9LB|SRC_STR_L]
SS10: None, [SU4]
SS11: None, [MU8]
SS12: None, [SU4]

class Sequence

! Sectors. The names should be ARSnn.
ARS01:[GINI_SEC,SS01,G0A,GINI_ARC,MATI,ECELLI,CellL2,CellL1,CellC40,CellR1,CellR2,ECELLO,MATO,G0A]
ARS02:[GINI_SEC,SS02,G0A,GINI_ARC,MATI,ECELLI,CellL2,CellL1,CellC50,CellR1,CellR2,ECELLO,MATMO,G0A]
ARS03:[GINI_SEC,SS03,G0A,GINI_ARC,MATI,ECELLI,CellL2,CellL1,CellC,CellR1,CellR2,ECELLO,MATO,G0A]
ARS04:[GINI_SEC,SS04,G0A,GINI_ARC,MATI,ECELLI,CellL2,CellL1,CellC,CellR1,CellR2,ECELLO,MATO,G0A]
ARS05:[GINI_SEC,SS05,G0A,GINI_ARC,MATI,ECELLI,CellL2,CellL1,CellC,CellR1,CellR2,ECELLO,MATO,G0A]

ARS06:[GINI_SEC,SS06,G0A,GINI_ARC,MATI,ECELLI,CellL2,CellL1,CellC27,CellR1,CellR2,ECELLO,MATMO,G0A]
ARS07:[GINI_SEC,SS07,G0A,GINI_ARC,MATI,ECELLI,CellL2,CellL1,CellC,CellR1,CellR2,ECELLO,MATO,G0A]
ARS08:[GINI_SEC,SS08,G0A,GINI_ARC,MATI,ECELLI,CellL2,CellL1,CellC,CellR1,CellR2,ECELLO,MATO,G0A]
ARS09:[GINI_SEC,SS09,G0A,GINI_ARC,MATI,ECELLI,CellL2,CellL1,CellC,CellR1,CellR2,ECELLO,MATO,G0A]
ARS10:[GINI_SEC,SS10,G0A,GINI_ARC,MATI,ECELLI,CellL2,CellL1,CellC40,CellR1,CellR2,ECELLO,MATMO,G0A]
ARS11:[GINI_SEC,SS11,G0A,GINI_ARC,MATI,ECELLI,CellL2,CellL1,CellC,CellR1,CellR2,ECELLO,MATO,G0A]
ARS12:[GINI_SEC,SS12,G0A,GINI_ARC,MATI,ECELLI,CellL2,CellL1,CellC,CellR1,CellR2,ECELLO,MATO,G0A]