LLRF at SSRF

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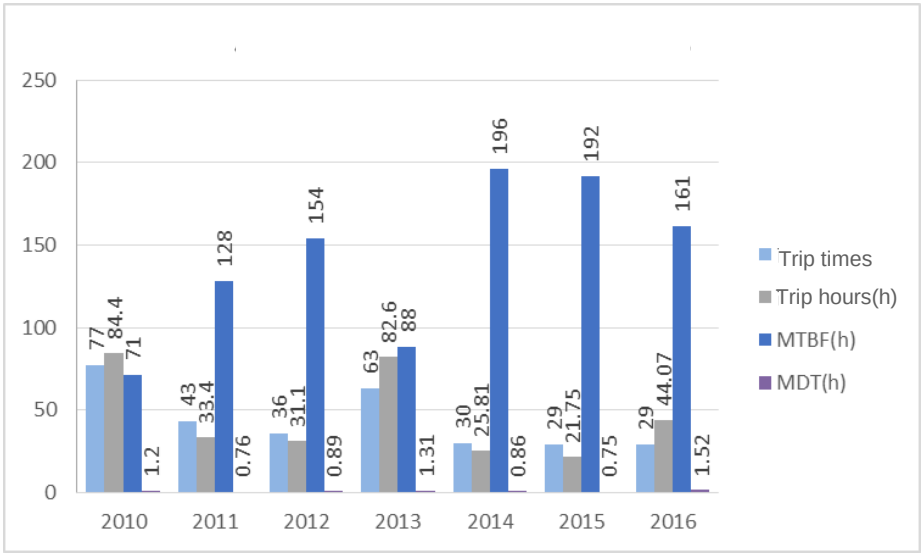
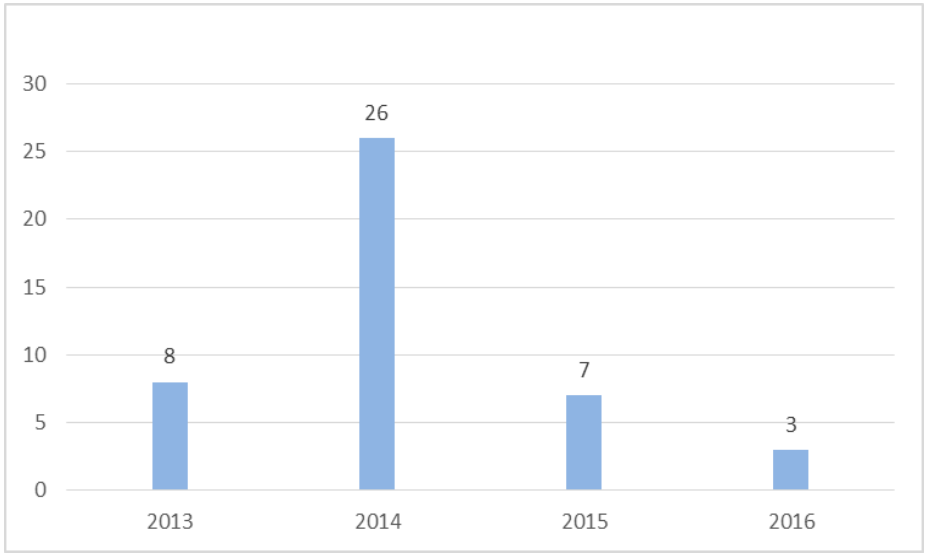
contents

- SSRF RF operation status
- Proton therapy　LLRF
- Third harmonic cavity LLRF
- Three LINAC LLRF
- Hard X FEL LLRF (future project)

Trip statistics of RF system

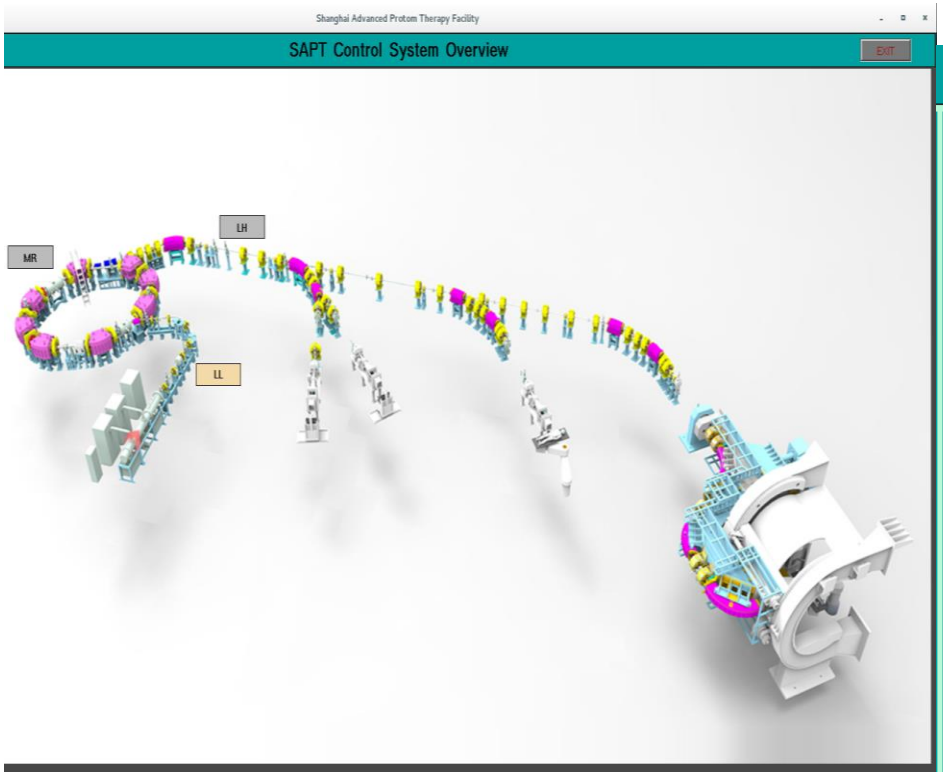


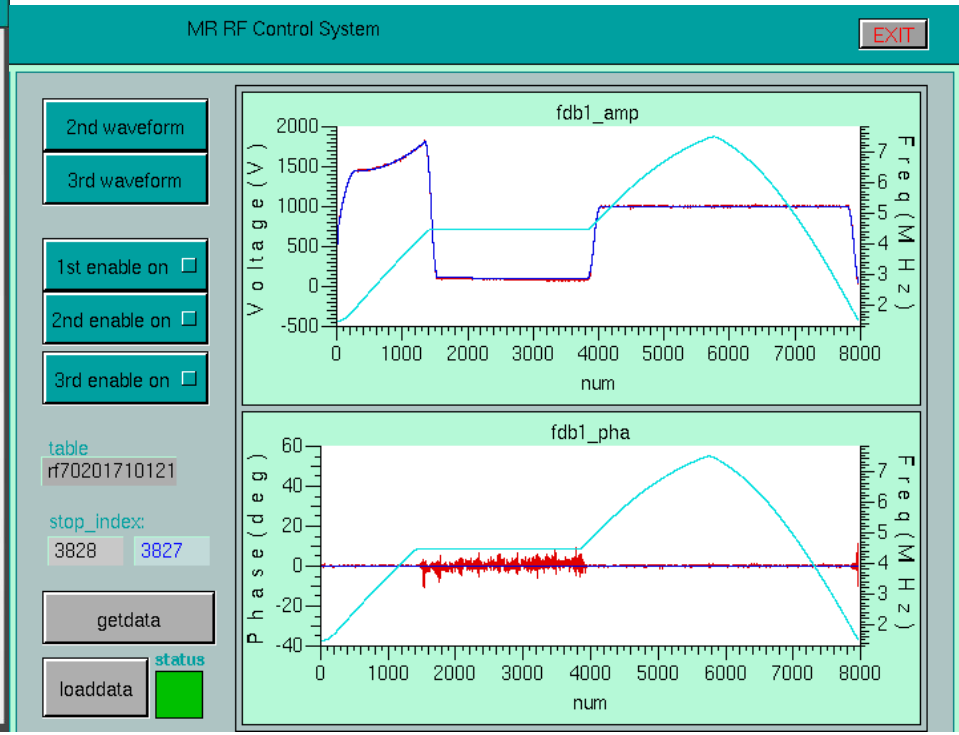
Storage Ring RF
Three CESR type cavities



Booster RF
Two five-cell normal cavities

Proton Therapy LLRF (1)





Proton accelerator layout

LLRF remote GUI

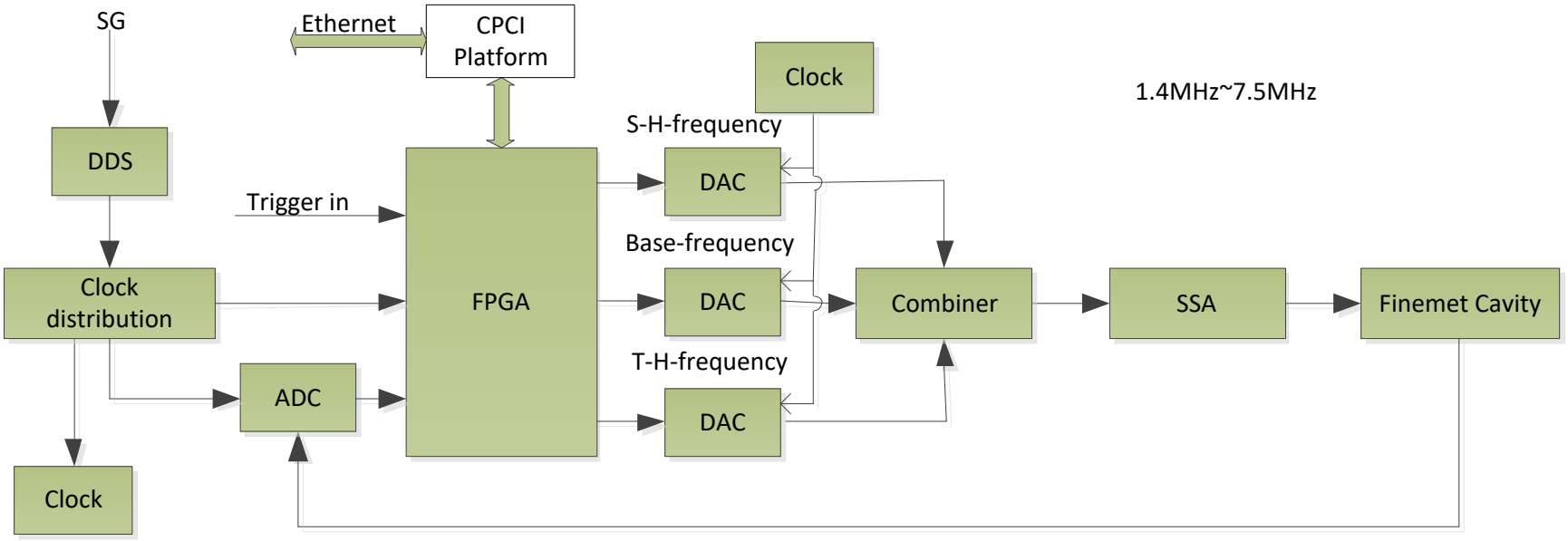
Status:

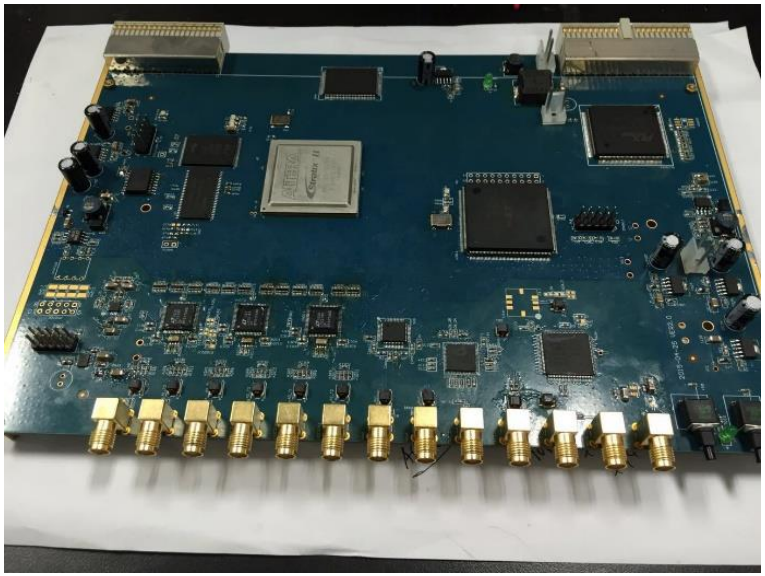
- Energy have been arrived 250MeV
- Optimize the parameters of 70MeV, 250MeV and extraction
- The treatment system isn't installed

8000 point look up table:

- **Frequency ramp**
- **Amplitude ramp**
- **Phase complement**

Proton Therapy LLRF （2）





Parameters:

1. Frequency: 1.4~7.5MHz
2. Finemet Cavity, Q ~ 0.5
3. SSA:10kW 1.4~7.5MHz
4. Include second and third harmonic frequency acceleration
5. Accelerate voltage: 2kV

Proton Therapy LLRF (3)

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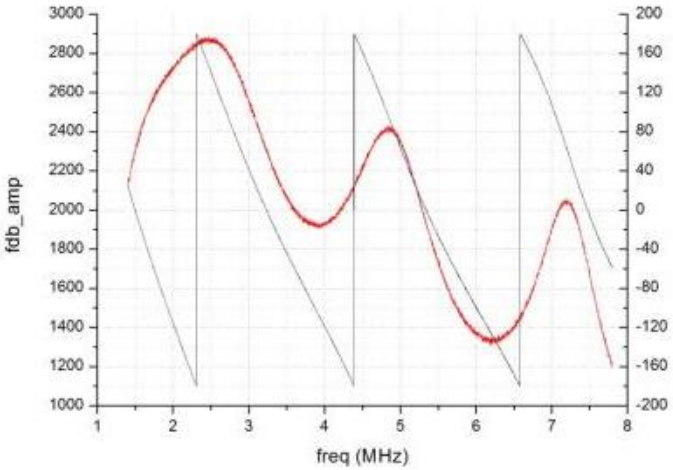
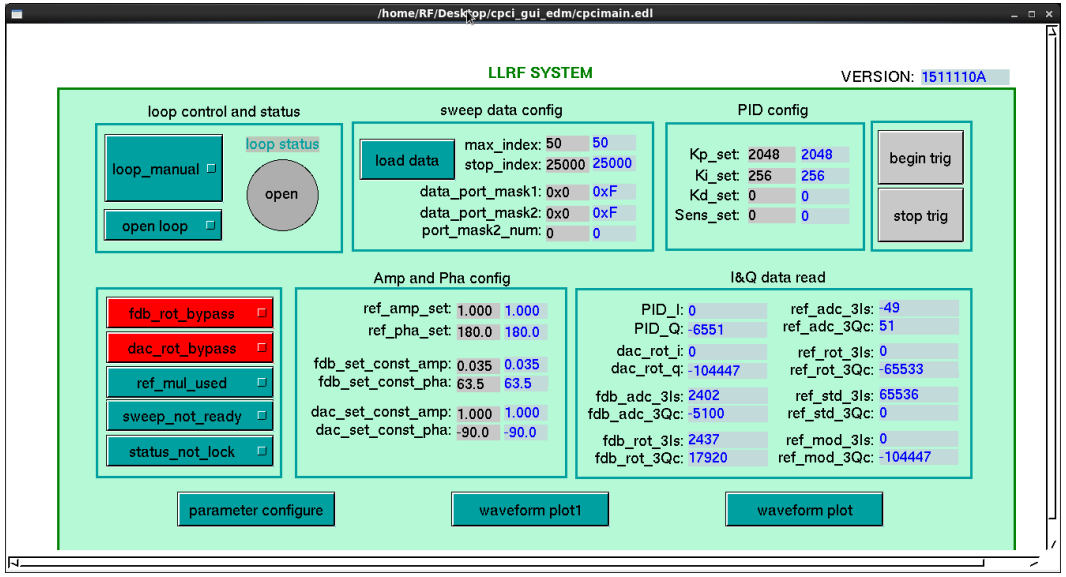
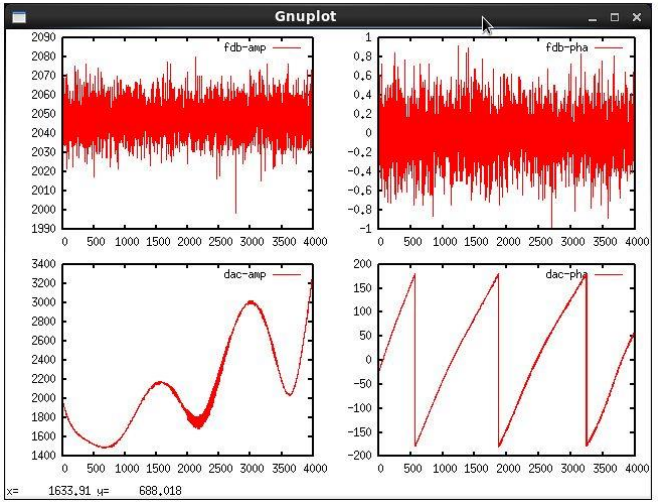
test



Amplitude and phase response from 1.4MHz to 7.8MHz



Local GUI



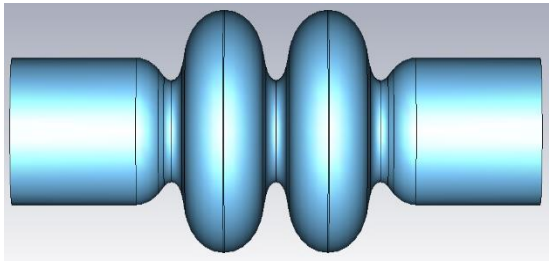
Amplitude and phase stability：
+/-1%，+/-1 Degree

LLRF for Harmonic cavity (1)

Harmonic cavity in SSRF

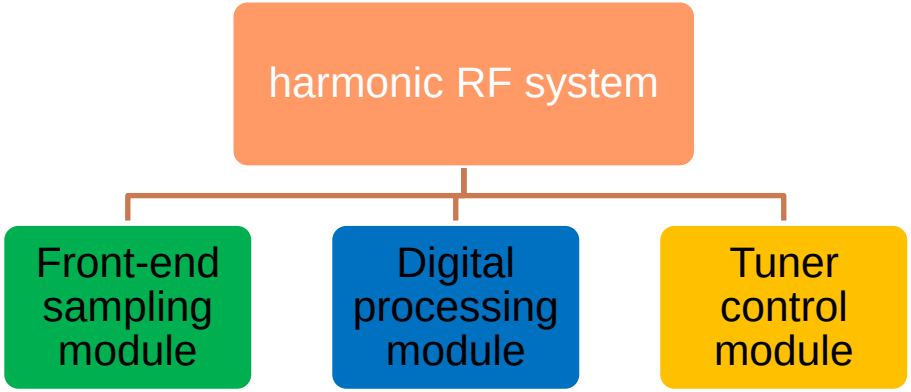
In Shanghai Synchrotron Radiation facility (SSRF), A passive third harmonic cavity will be used to increase Touschek lifetime.

SSRF



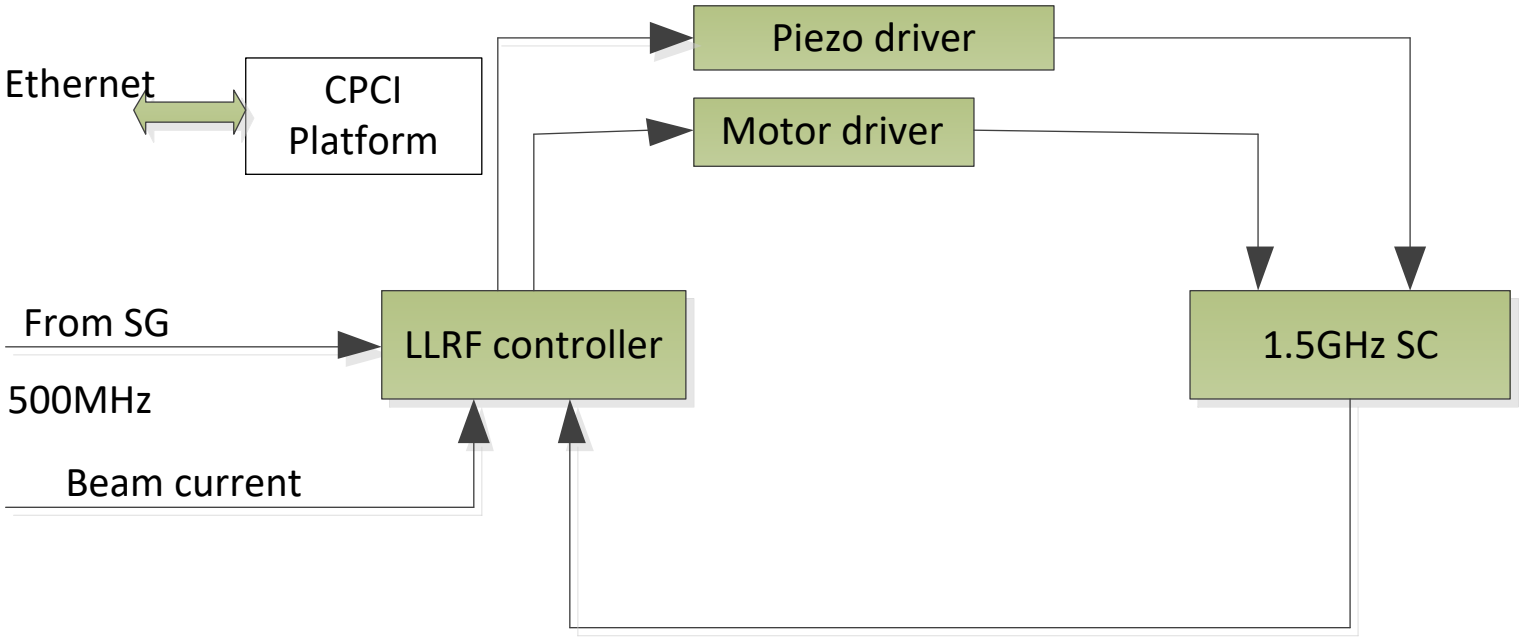
Preliminary design

To control the voltage of harmonic cavity, a tuned loop control system will be designed for it.



LLRF for Harmonic cavity (2)

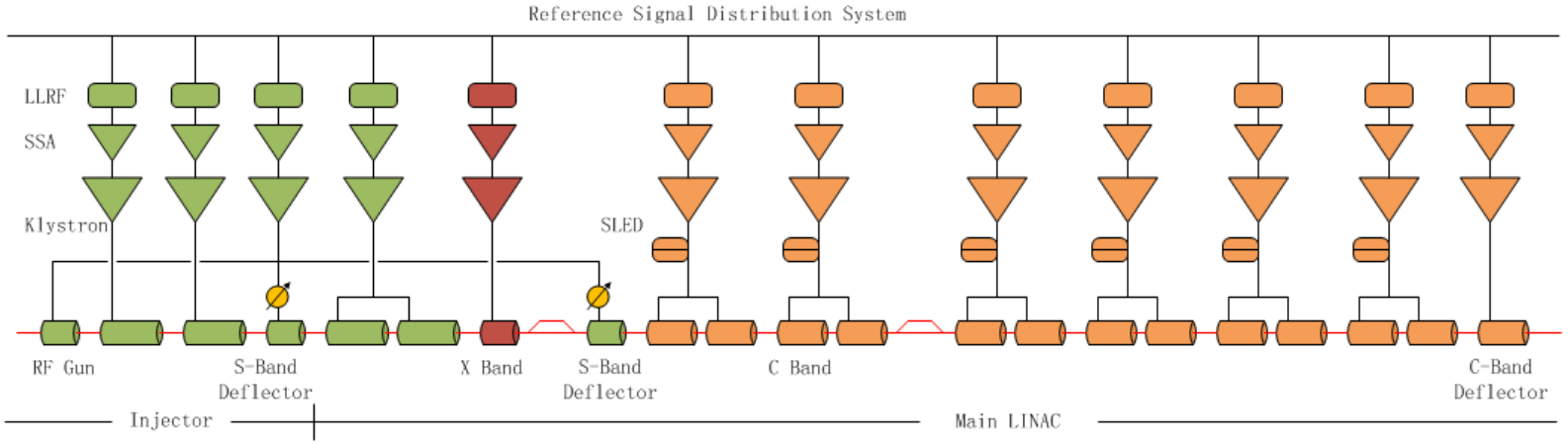
Third Harmonic SC control block



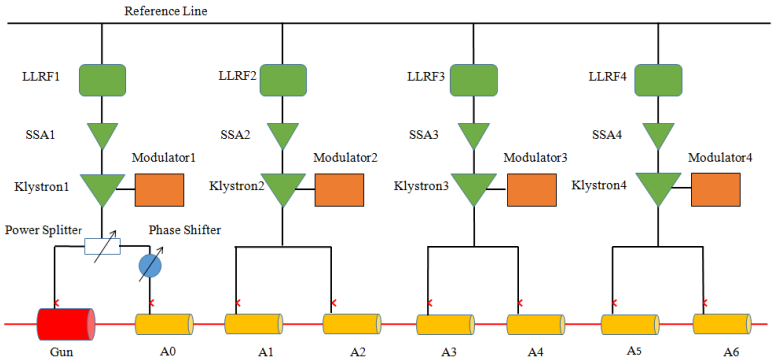
A. The hardware will same as our third generation LLRF
B. Detect the amplitude of cavity and beam current

LINAC LLRF(1)

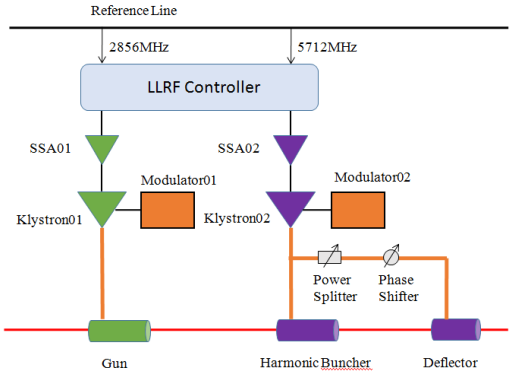
Three project: SXFEL DCLS UEDM



SXFEL(Soft-X Free Electron Laser) Installed at 11/2016, Under RF conditioning
Including 4 Sets of S-Band (2856MHz), 7 Sets of C-Band (5712MHz), 1 Set of X-Band(11424MHz)



DCLS(Dalian Coherent Light Source), Installed at 07/2016
Including 4 Sets of S-Band



Ultrafast Electron Diffraction and Microscopy at Shanghai Jiaotong University, Installed at 05/2017
Including 1 Set of S-Band 1 Set of C-Band

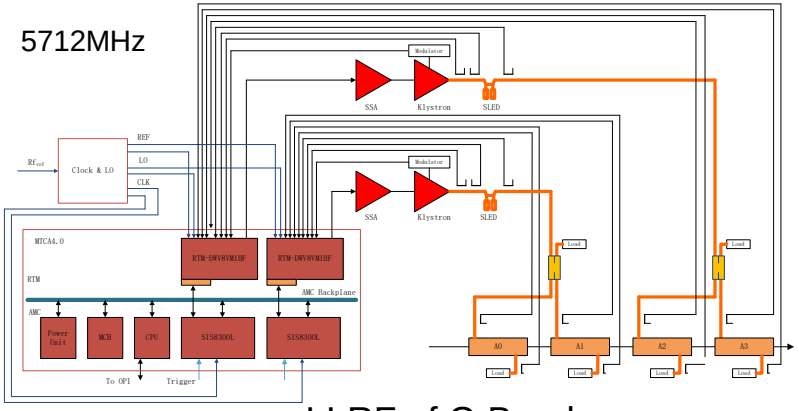
-By microwave group

LINAC LLRF(2)

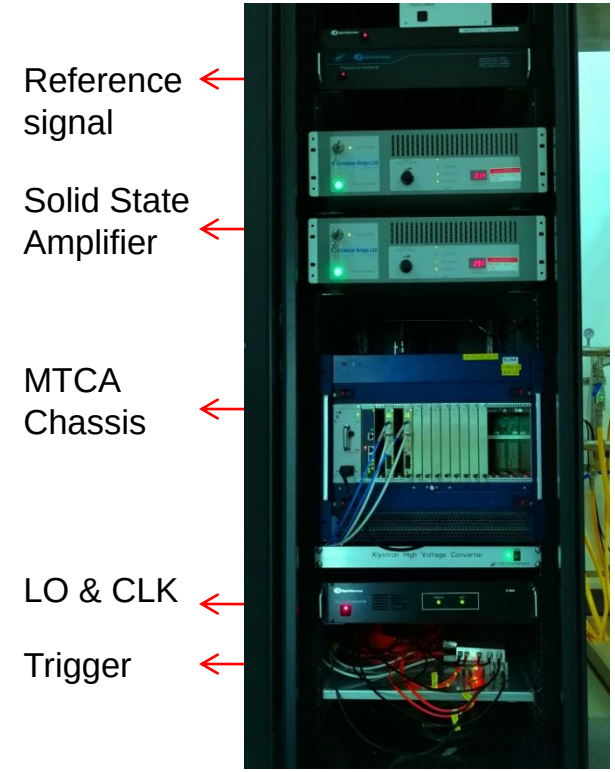
LLRF architecture

Two sets of LLRF cards are installed in one MTCA chassis to drive two amplifiers.
The LLRF cabinet is one water-cooled, temperature-controlled rack, whose temperature stability is ±0.1º.

SIS8300L2+
DWC8VM1(HF)



LLRF of C-Band

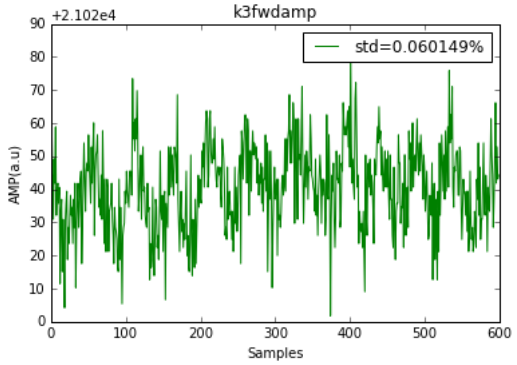


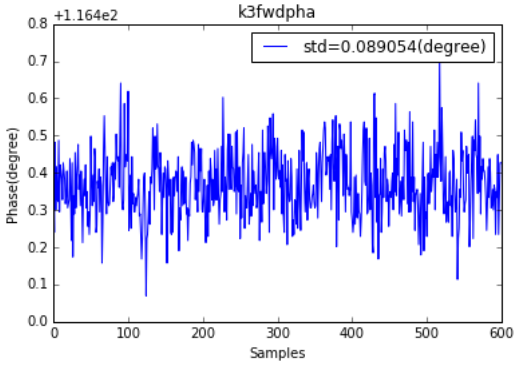
LLRF Cabinet

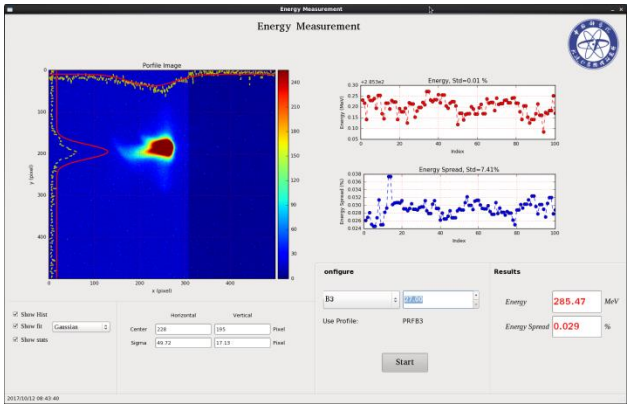
-By microwave group

LINAC LLRF(3)

The results

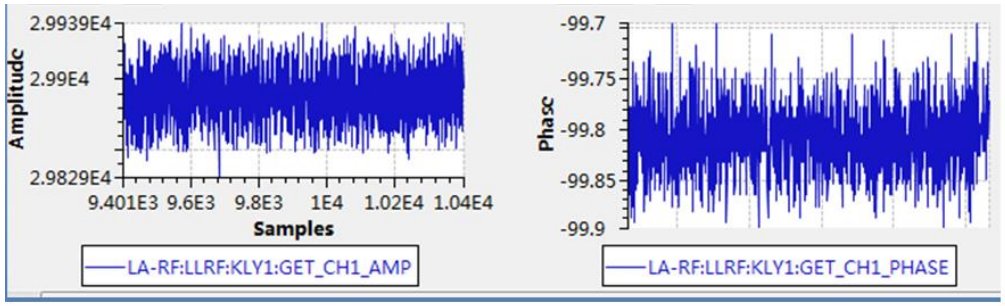


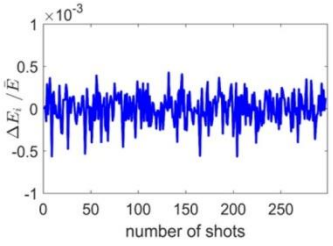


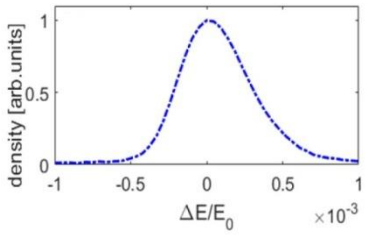


DCLS
Amplitude and phase stability: 0.06%(rms), 0.09º(rms)

Energy: 285.47MeV,
Energy Spread: 0.029%







Ultrafast Electron Diffraction and Microscopy
Amplitude and phase stability: 0.06%(rms), 0.03º(rms)

Energy: 3.06MeV,
Energy stability: 0.05%
Energy spread: 0.06%

Soft-X FEL is under testing

-By microwave group

Hard X FEL project introduction and LLRF

Hard X FEL parameters

- Beam current: 0.2mA
- Beam energy: 8GeV
- CW mode operation, bunches up to 1MHz
- TTF type cavity

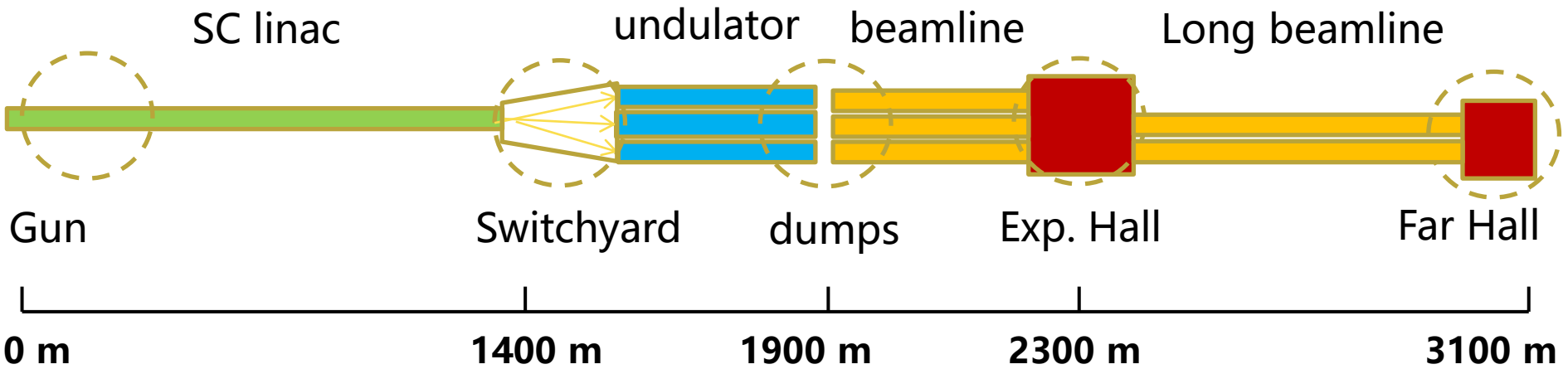
Hard X FEL Schedule

- Begin at end of 2017, finished 2024

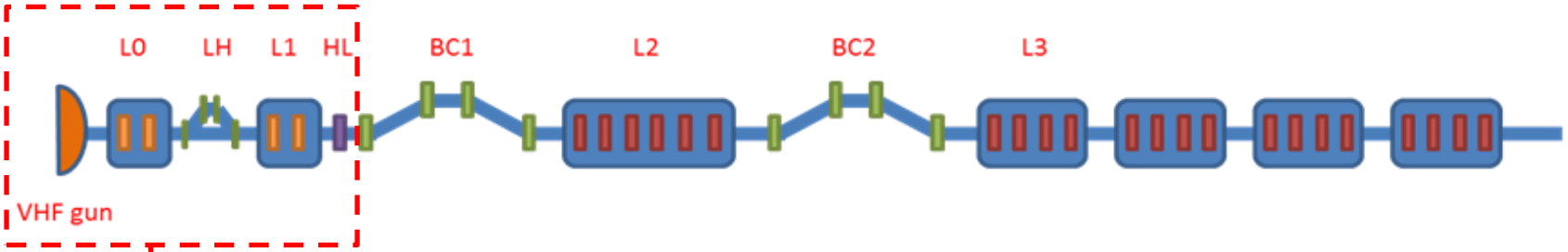
- Tunnel construction： 2017-2020
- Utility： 2019-2021
- Key technique and prototype manufactured：2017-2021
- Main device manufactured： 2018-2023
- Device installed and integrated： 2021-2023
- commissioning： 2022-2024

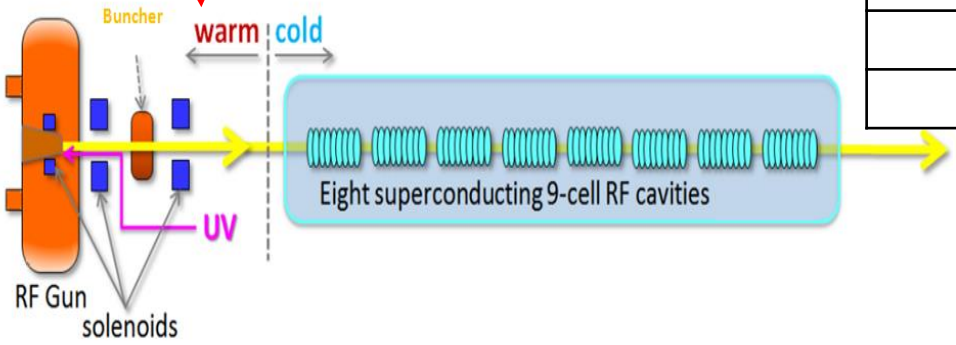
Approved in 2017.4

Hard X FEL

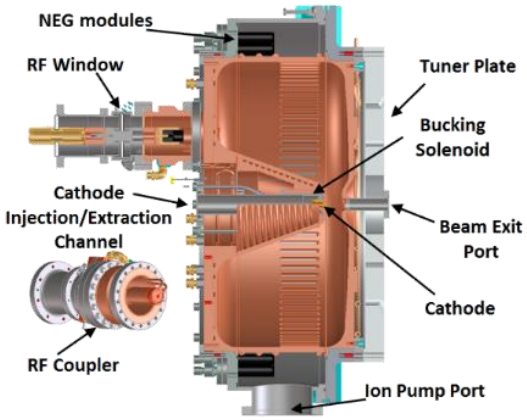

SC linac
undulator
beamline
Long beamline
Gun
Switchyard
dumps
Exp. Hall
Far Hall
0 m
1400 m
1900 m
2300 m
3100 m

Injector



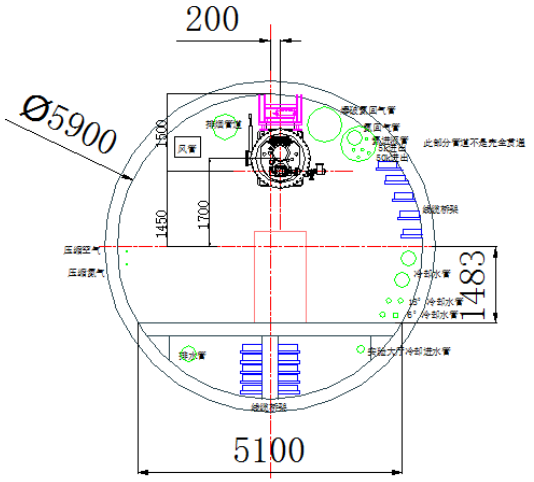


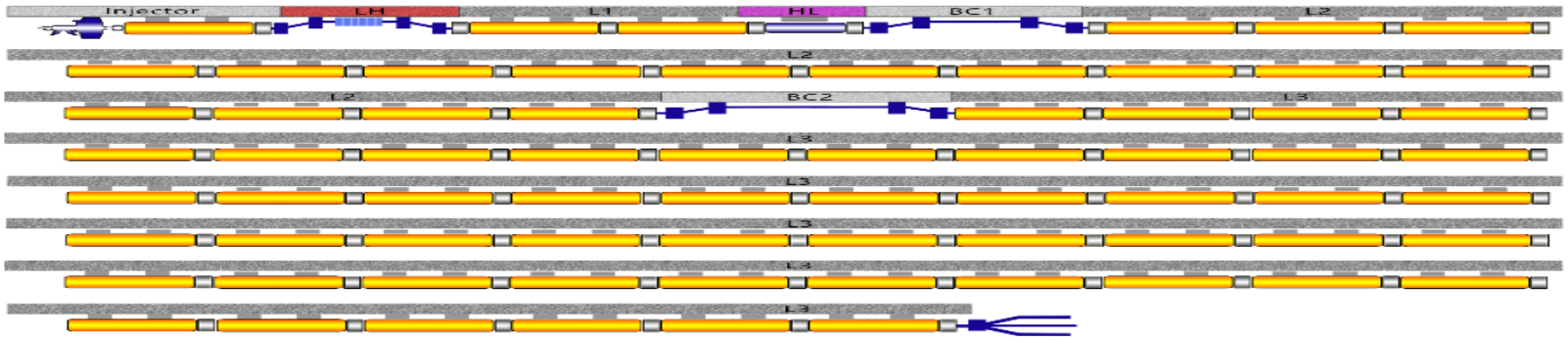
Charge quantity（pC）	100
energy（MeV）	100
bunch length（FWHM，ps）	8
Emittance RMS（mm-mrad）	0.39
Delta Energy RMS	0.14%

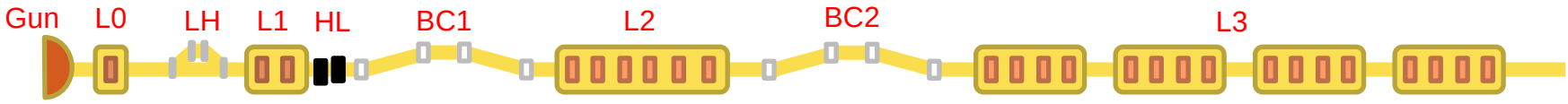


SC LINAC

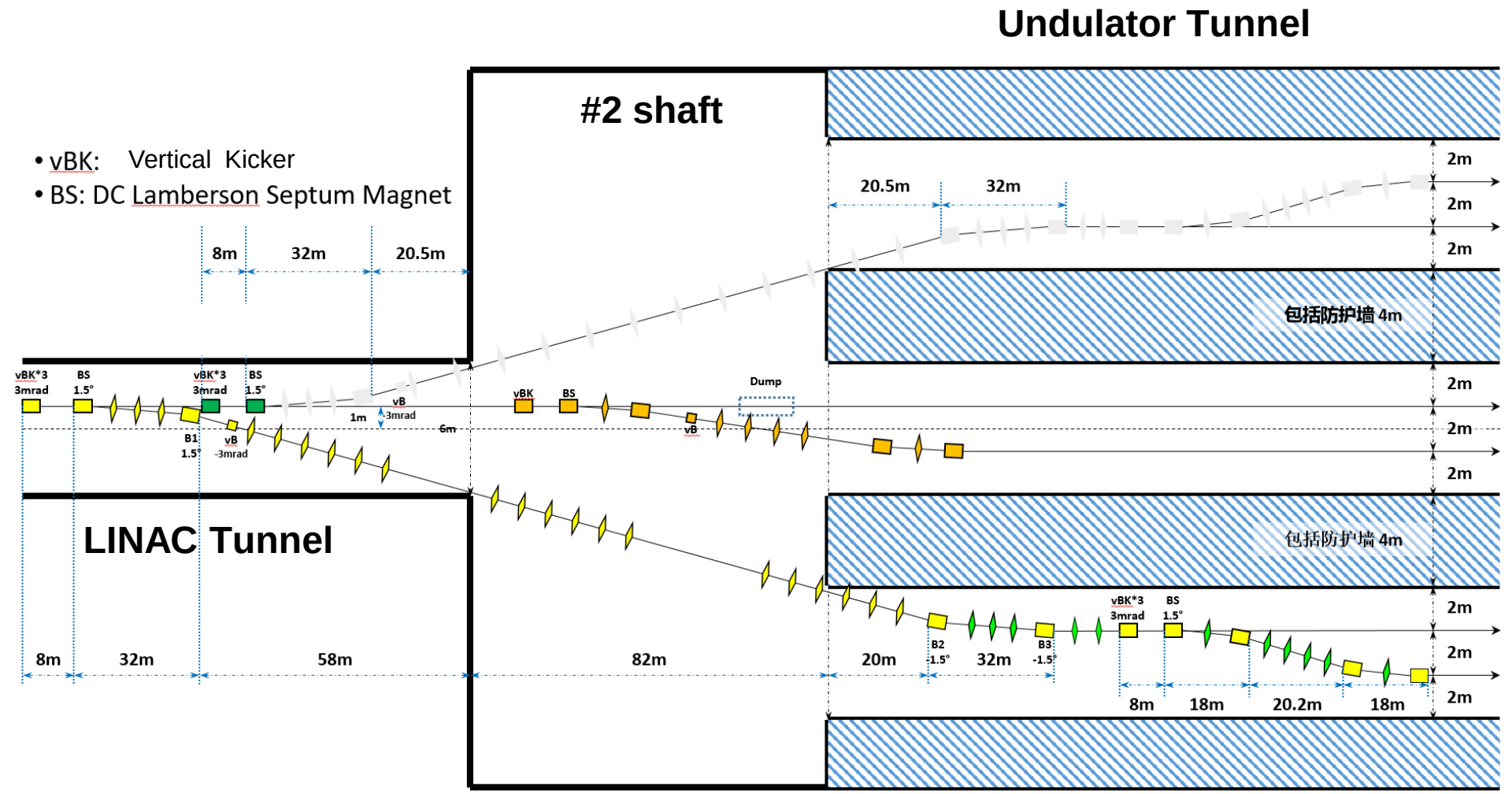
	cryomodule	S-cavities	Beam energy(MeV)
L0	1	8	100
L1	2	16	306
HL	2	16	250
BC1	-	-	250
L2	12	96	1600
BC2	-	-	1600
L3	60	480	8800
total	75+2	600+16	







Beam distribution



Undulator

FEL-I 4keV SS 12keV SS

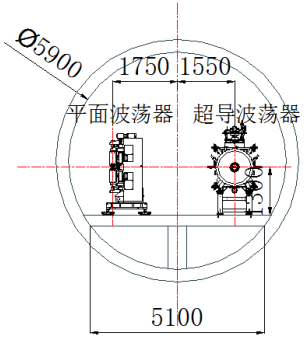
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34

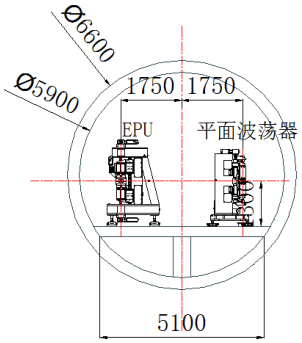
FEL-II

FEL-III

8keV SS 20keV SS

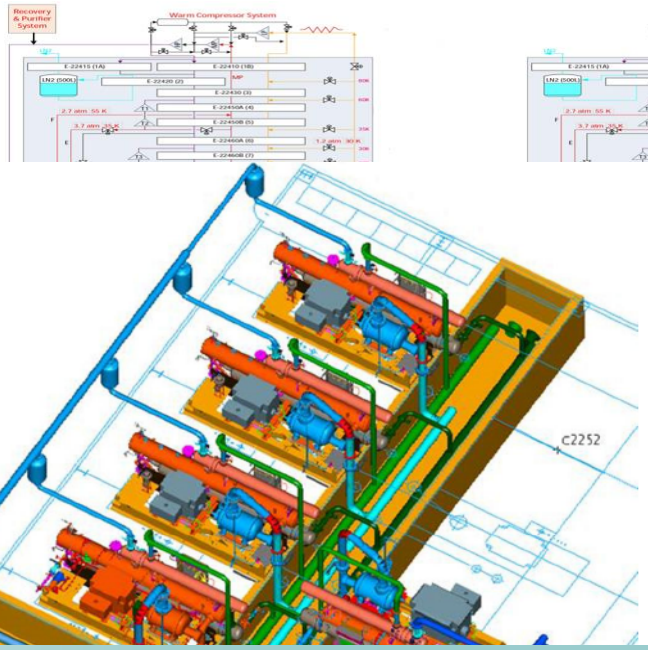
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34

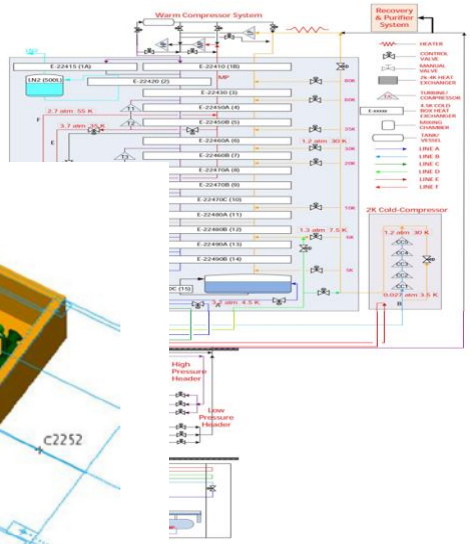


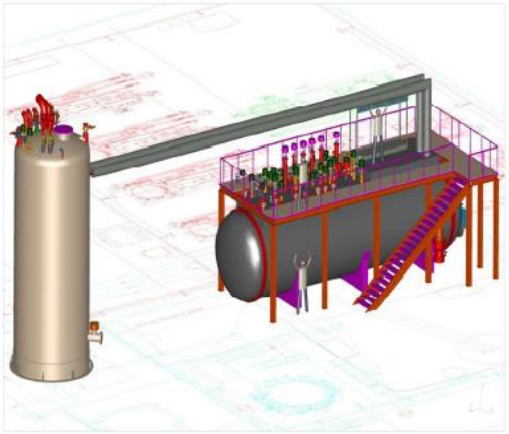


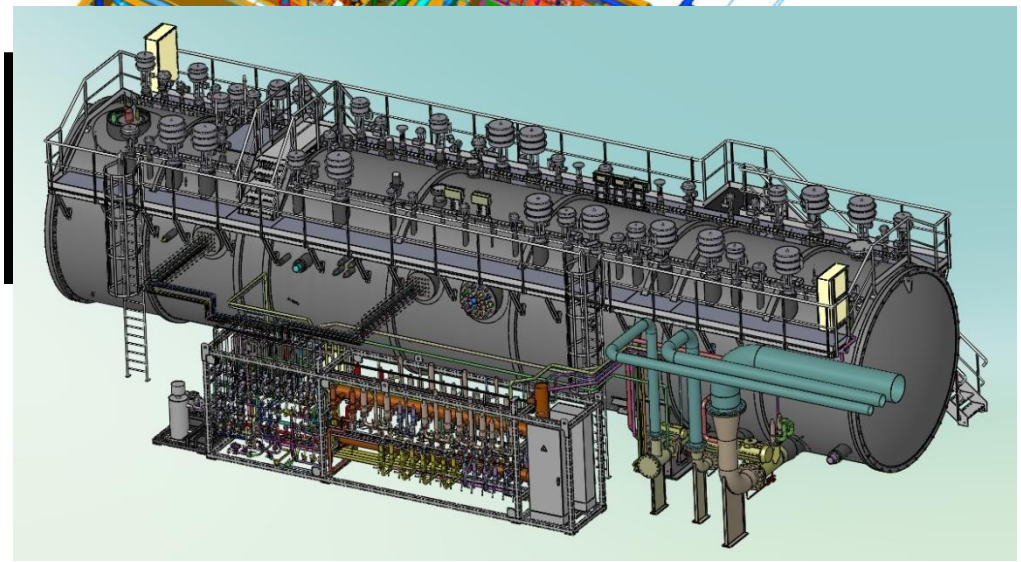
2K cryogenic

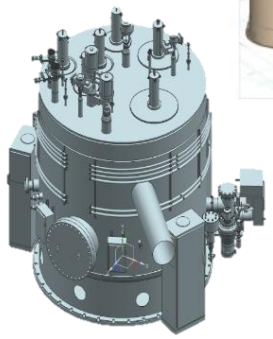
12kW@2.0K cryogenic



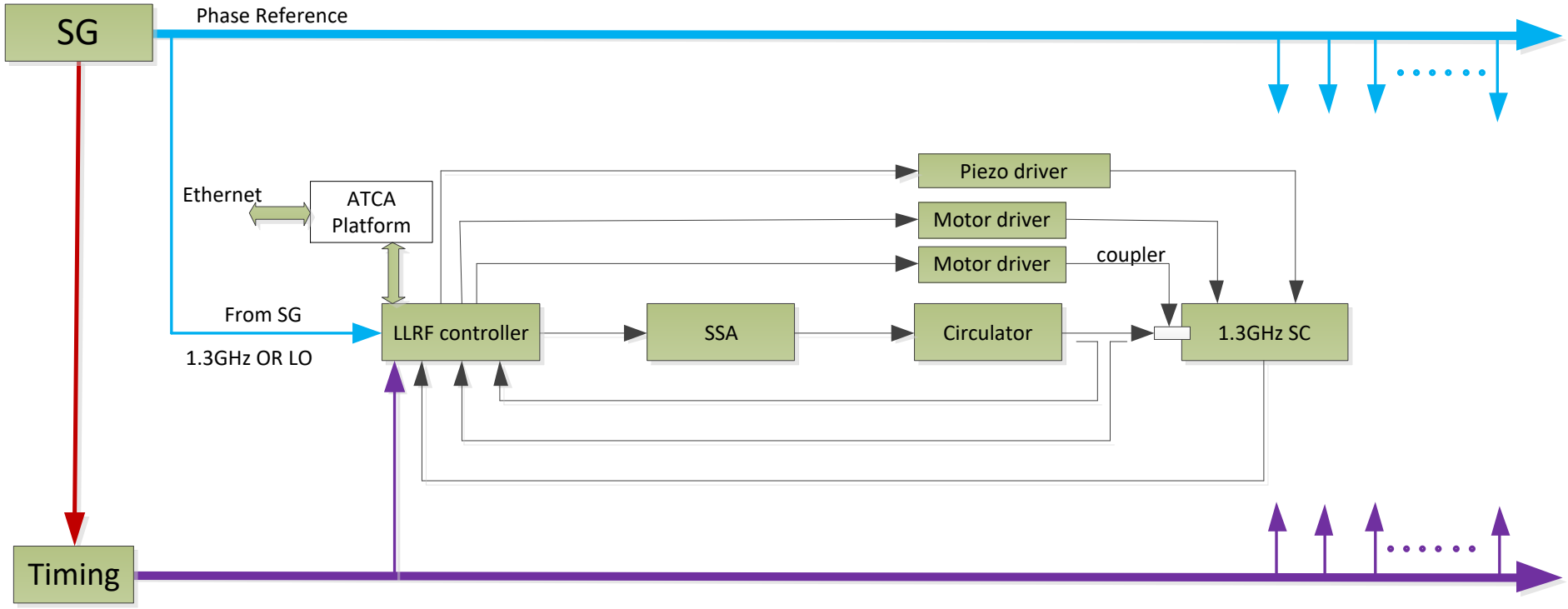






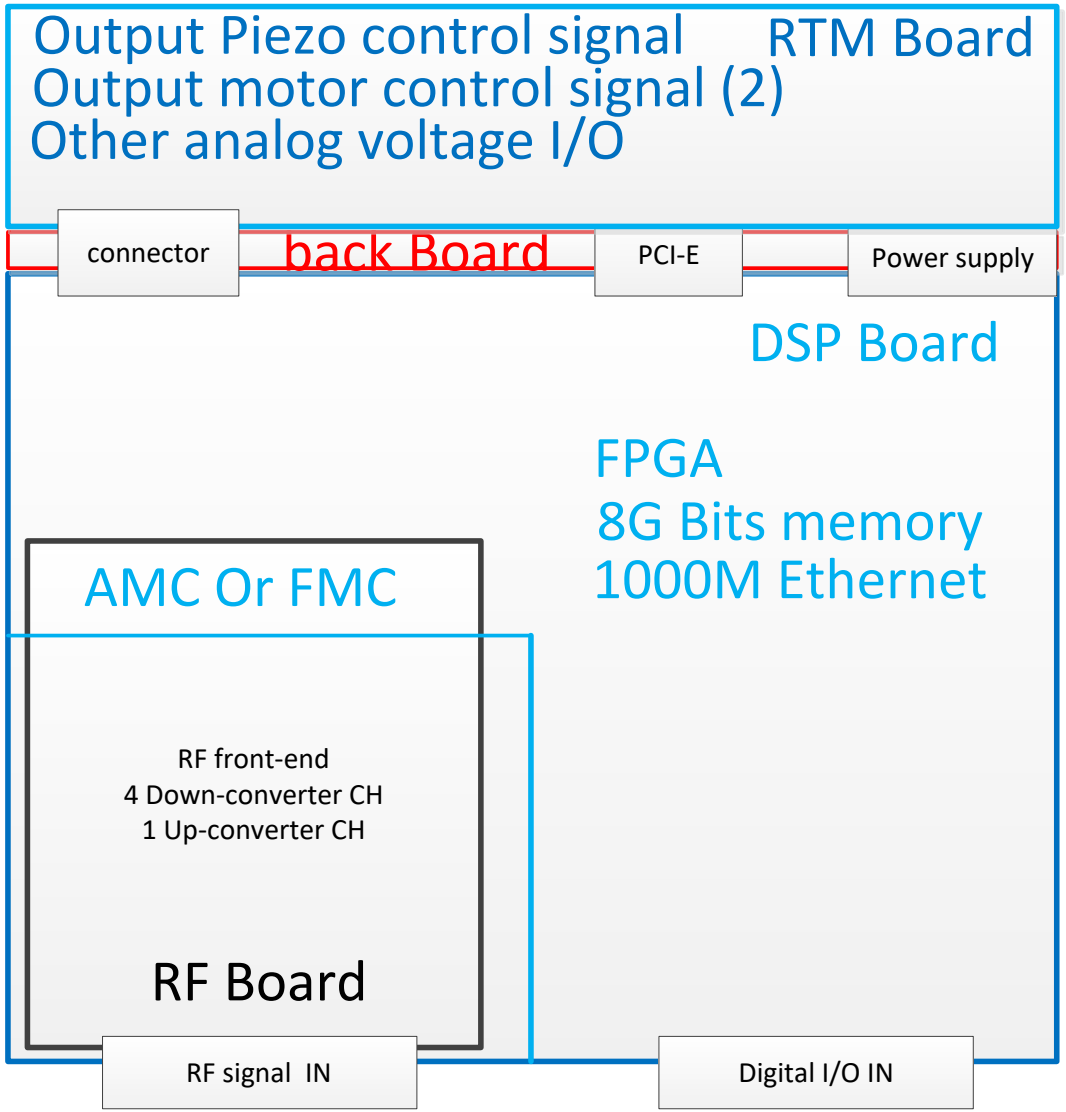


SC LINAC RF Architecture



Single SSA, Single Cavity
SSA:5.2kW@1.3GHz, 2kW@3.9GHz

LLRF boards



ATCA Board

LLRF signal flow

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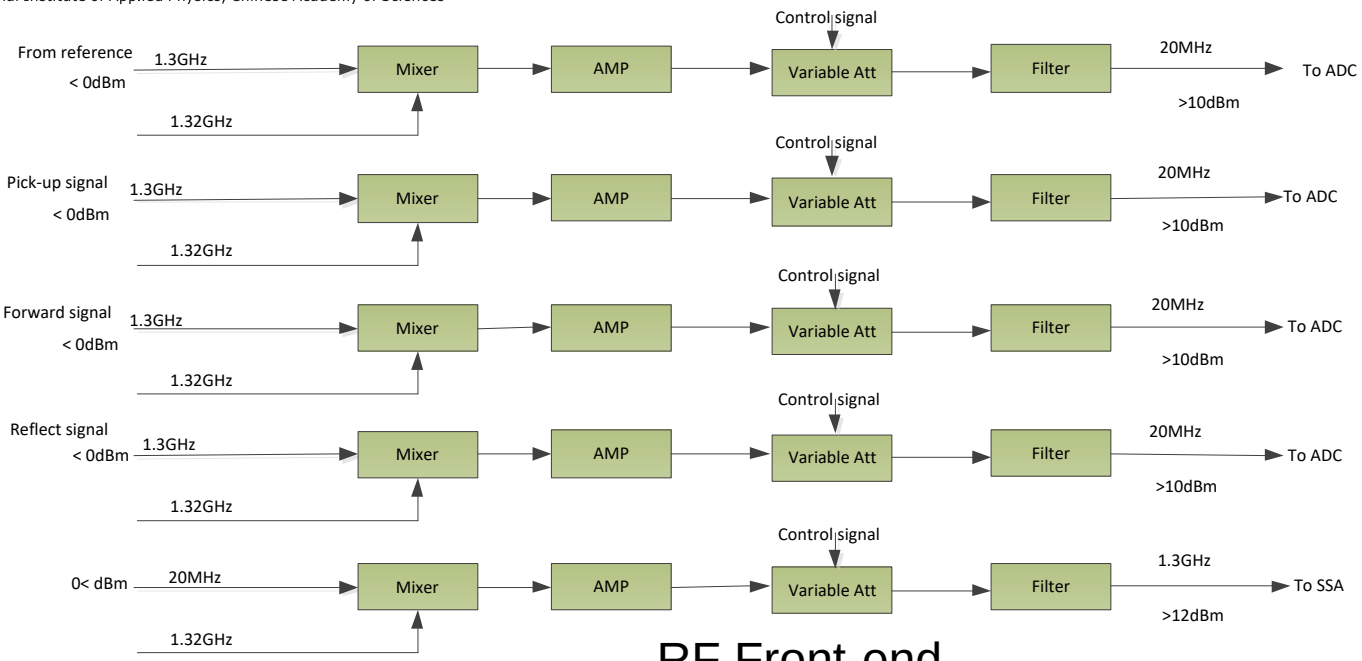
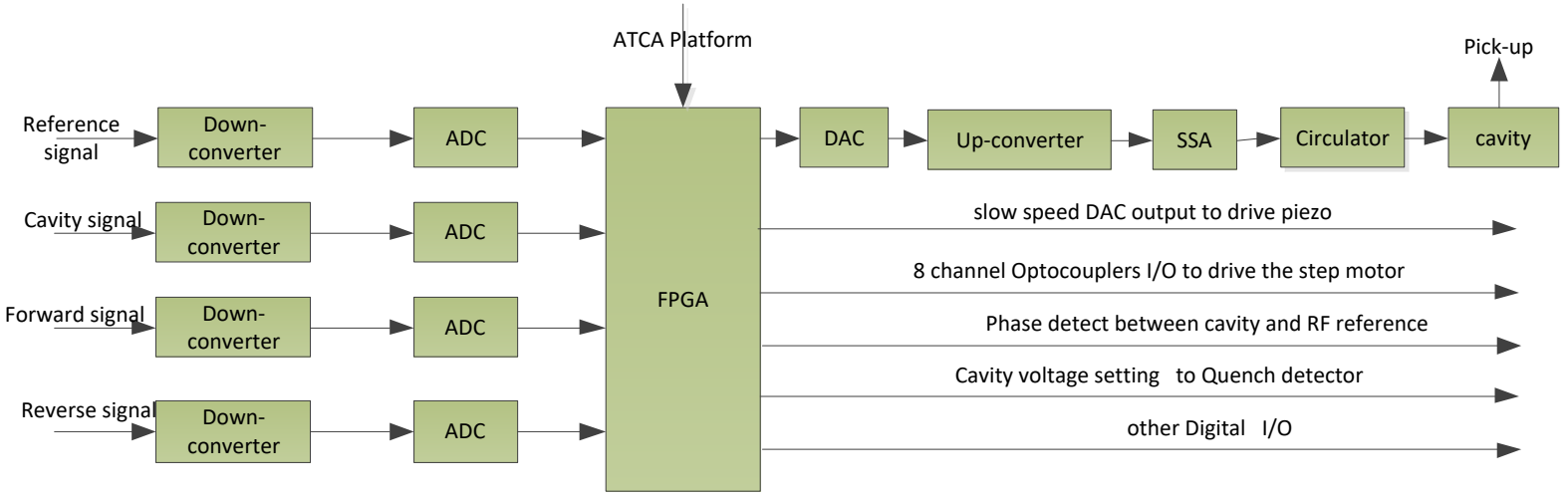
SINAP

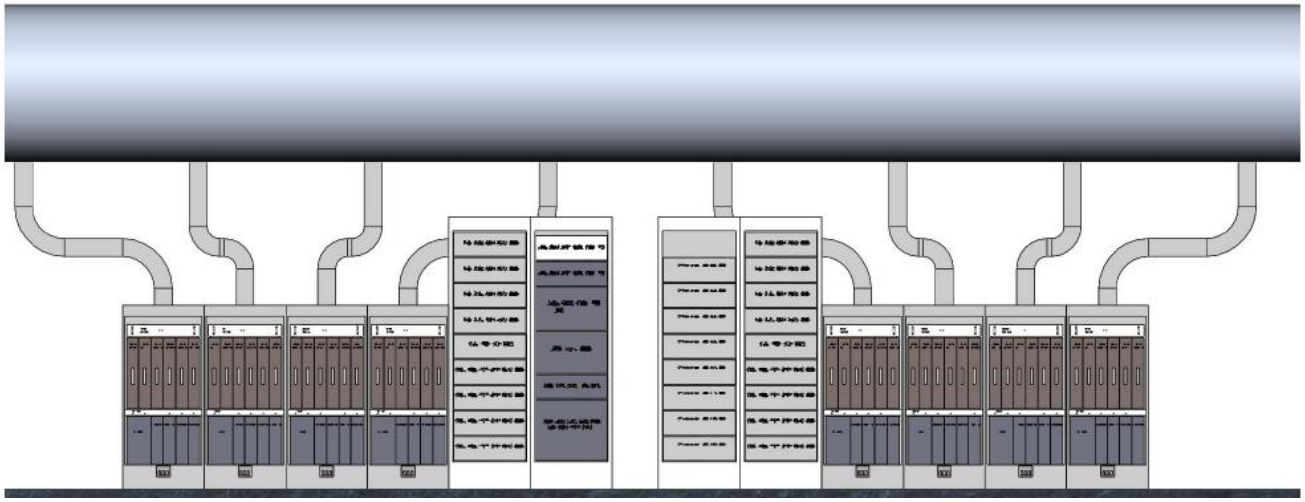


RF Front-end

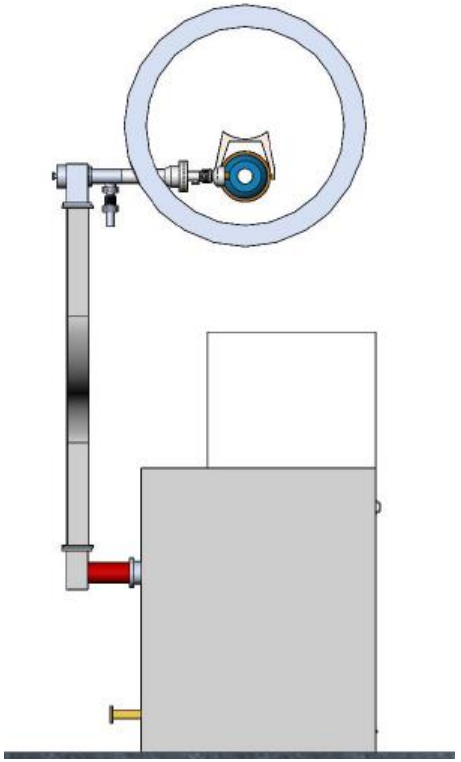


LLRF signal flow and interface

One cryomodule and RF layout



front view



lateral view

Thanks !