SESAME RF SYSTEM

Arash Kaftoosian

SESAME = Synchrotron light for Experimental Science and Applications in the Middle East

is a 2.5 GeV synchrotron radiation facility, under construction near Amman, Jordan.

The members are Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, Palestinian Authority and Turkey

Observers: France, Germany, Greece, Italy, Japan, Kuwait, Morocco, Portugal, Russia, Sweden, UK, USA

SESAME Location and the Member states

Members:

- Bahrain
- Cyprus
- Egypt
- Iran
- Israel
- Jordan
- Pakistan
- Palestine
- Turkey

Main Ring Parameters:

Energy = 2.5 GeV

Circumference = 133.2 m

16 Straights sections

{8 x 4.44 m + 8 x 2.38 m}

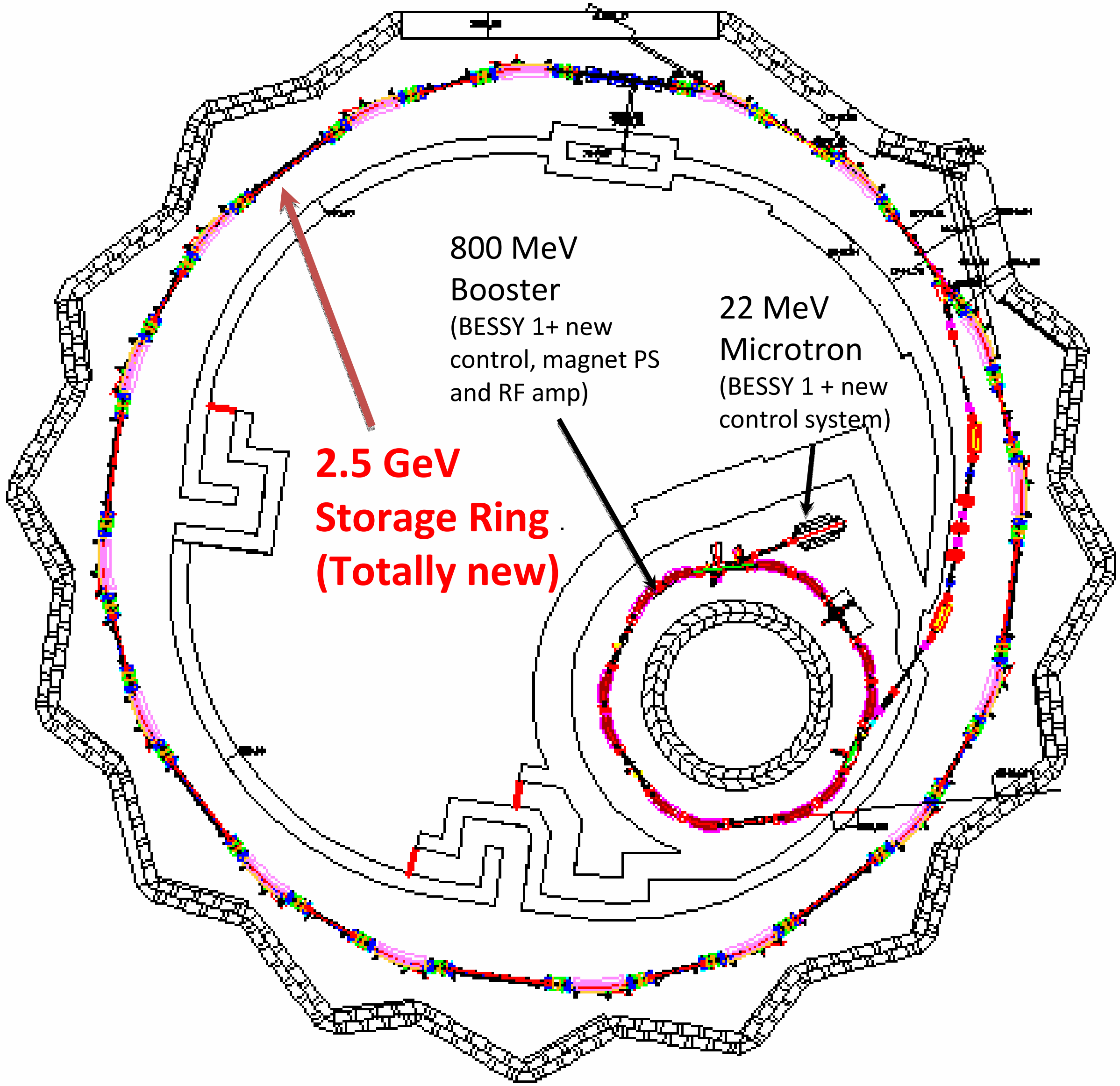
Up to 28 Beamlines:

12 Insertion Devices

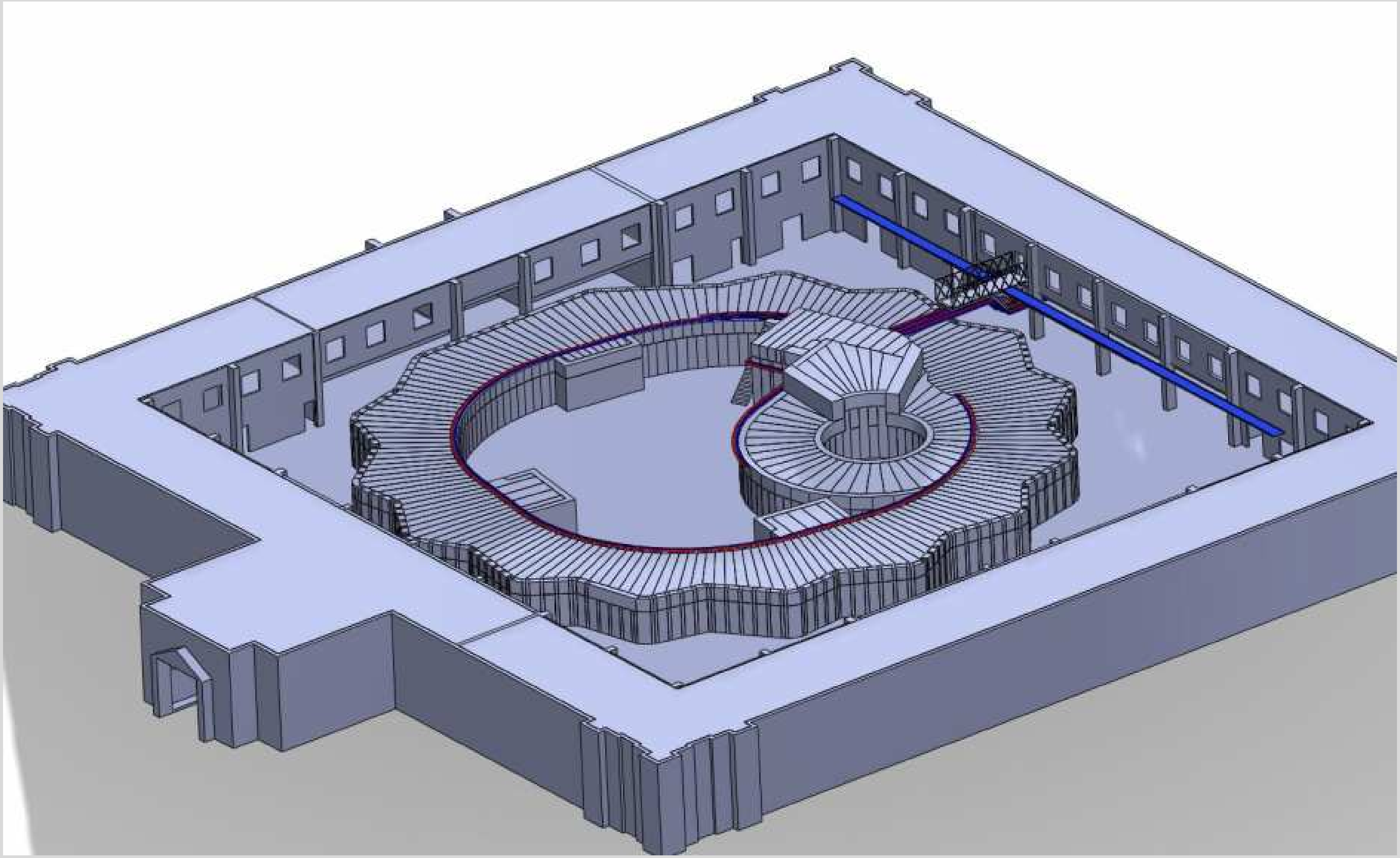
16 Dipole magnets

Beamlines length range from

21 m – 36.7 m



3D View



SESAME milestones:

- Microtron commissioning:
  - ✓ Successfully done in July 2009
- Booster commissioning:
  - To be finished in 2011
- Storage ring commissioning:
  - Planned for 2014

Technical staff

	Name	Field of Activity	Nationality
1	Maher Attal	Acc. Physics.	Palestine
2	Firas Makahleh	Cooling system/Vacuum	Jordan
3	Seadat Varnasseri	Diagnostics &Power Supplies	Iran
4	Adel Amro	Vacuum/Layout	Jordan
5	Maher Shehab	Mech. Engineering	Jordan
6	Arash Kaftoosian	RF	Iran
7	Darweesh Foudeh	RF	Jordan
8	Tasaddaq Ali Khan	RF	Pakistan
9	Moh'd. Alnajdawi	Mechanical Engineering	Jordan
9	Salman Matalgah	Control System	Jordan
10	Ahed Aladwan	Control System	Jordan
11	Adli Hamad	Radiation Safety	Jordan
12	Thaer Abu Haniah	Alignment & Survey	Jordan
13	Hamed Tarawneh	Acc. Physics/ Magnet	Jordan
14	Moayyad Sbahi	Cabling	Jordan
15	Saed Budair	Vacuum	Jordan

The RF Group

Arash Kaftoosian
(RF, Amplifiers, Cavity, Group leader)

Darweesh Foudeh
(Electronics, LLRF)

Tasaddaq Ali Khan
(Control H/S, LLRF)

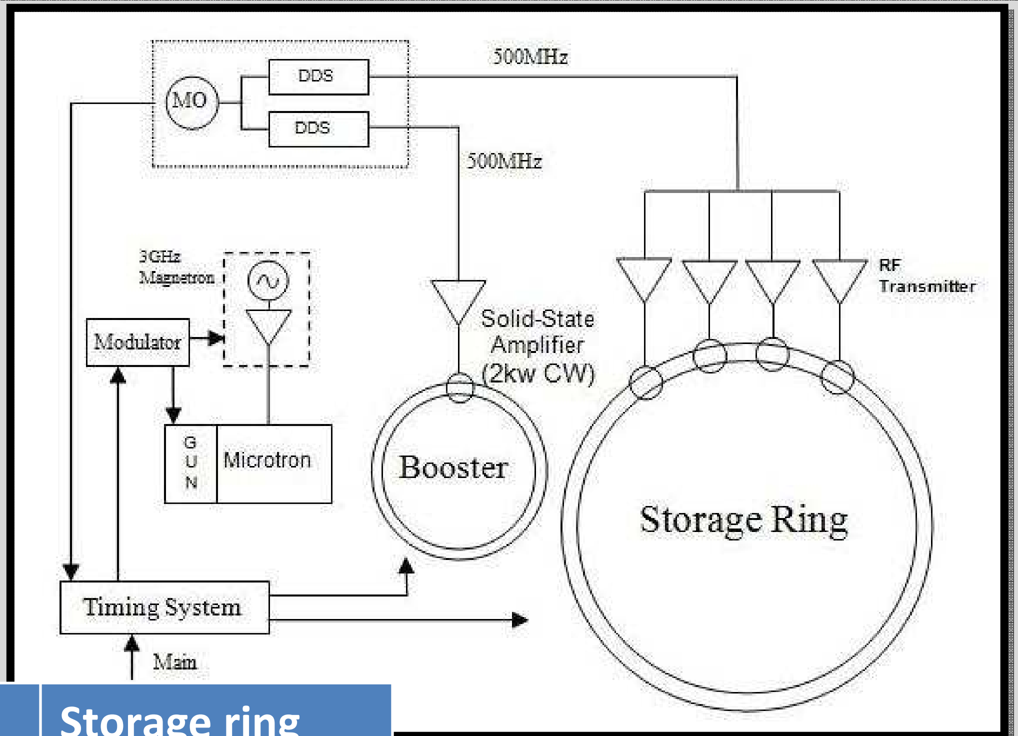
Microtron Commissioning

First beam obtained from Microtron in July 14, 2009

RF group was in charge of:

- ✓ The 3 GHz, 2MW (peak) RF system
- ✓ The RF gun and auxiliary gun
- ✓ The electronics and power supplies

General layout of the SESAME RF system



Parameter	Booster	Storage ring
RF frequency	499.654 MHz	499.654 MHz
Harmonic number	64	222
Circumference	38.4 m	133.20 m
Revolution freq.	7.807 MHz	2.25 MHz
RF wavelength	0.600 m	0.600 m
Coincidence freq.	70.334 KHz	

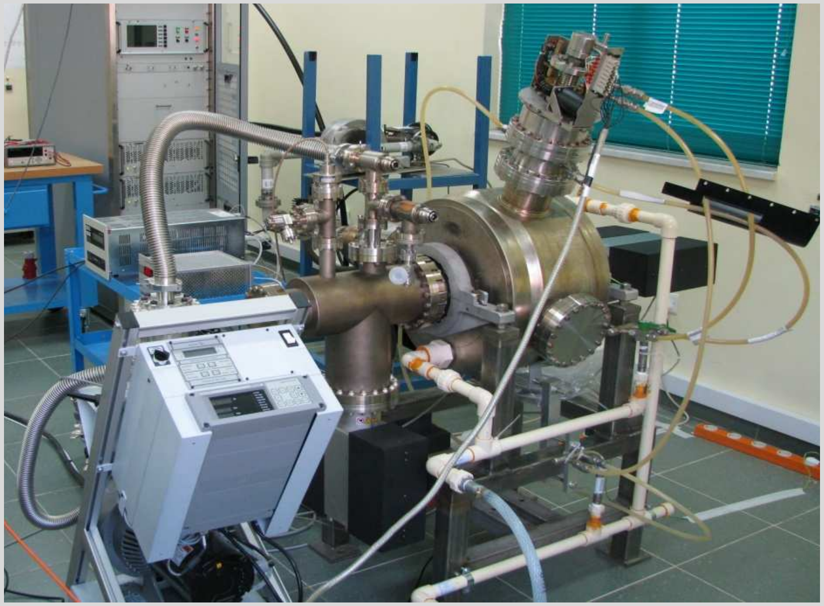
Storage Ring main RF parameters

Parameter	Value
Energy	2.5 GeV
Circumference	133.20 m
RF frequency	499.654 MHz
Radiation loss/turn	590 KeV
Beam current (maximum)	400 mA
Beam power loss (bare machine)	236 kW
Harmonic number	222
Momentum compaction factor	0.00833
Total RF voltage (maximum)	2.4 MV
Over voltage factor	4
Number of cavities	4
Energy acceptance	1.45 %
Synchrotron frequency	37 KHz
Synchronous phase	165.5 º

Booster RF system

Booster Cavity and its tuning system shipped from BESSY to the SESAME site in June 2009

(Many thanks to Dr. Ernst Weihreter and Thomas Westphal from BESSY)



Then Cavity prepared for conditioning in the RF lab (July 2009)

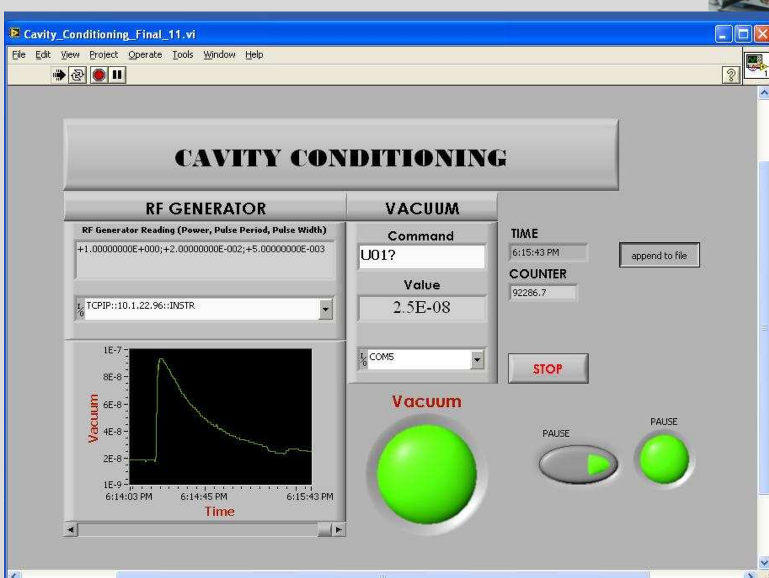
Booster RF system

Booster LLRF (from BESSY I) tested in the RF lab

The new 2kW Solid-State amplifier as replacement for the old klystron used in BESSY I

Booster Cavity Conditioning

Booster cavity has been conditioned in the RF lab at SESAME site in July 2009

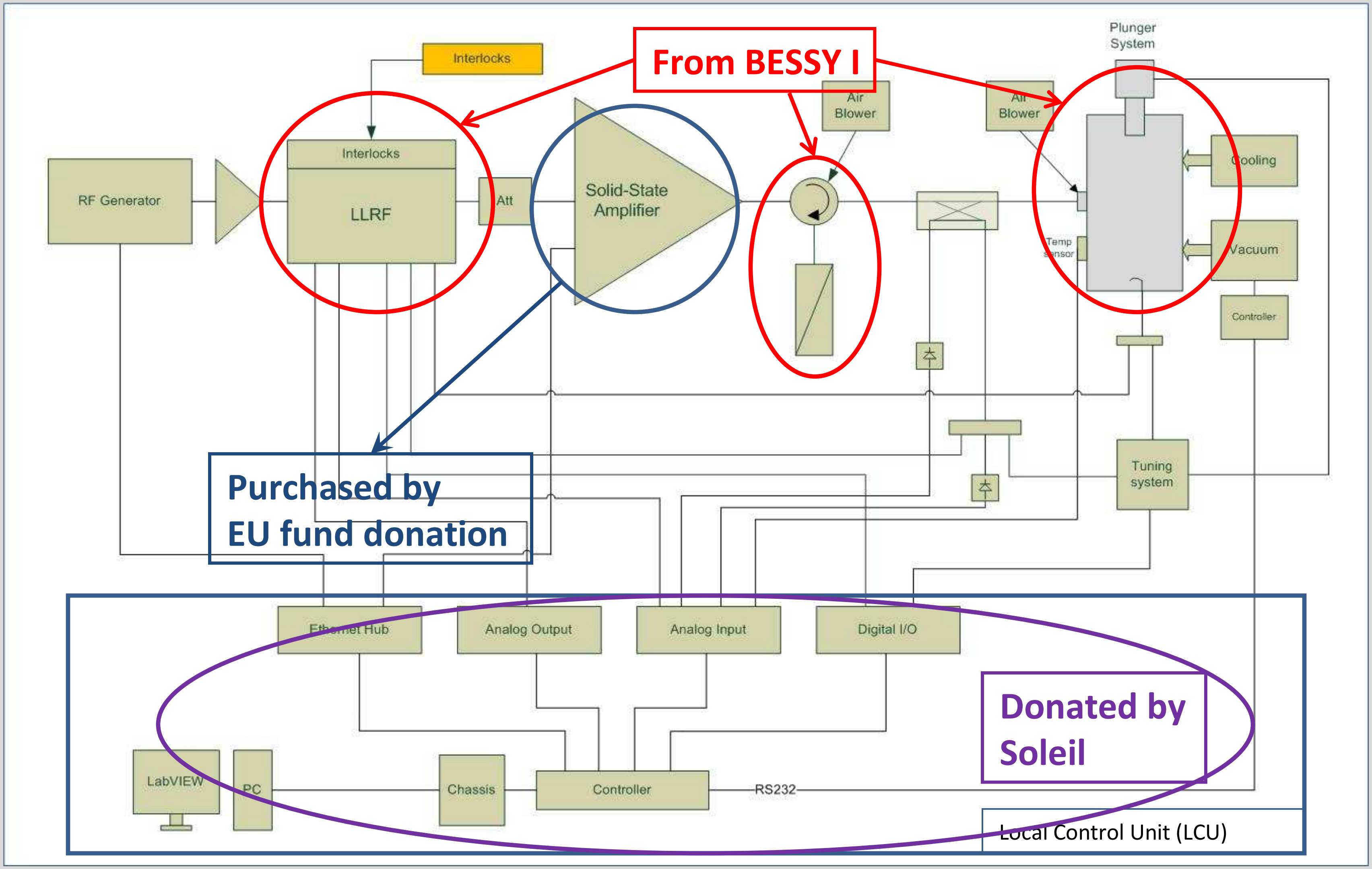


Cavity conditioned in about 9 hours because it had already conditioned at BESSY with 1 kW RF power

Booster Cavity Conditioning

- Cavity conditioning is done with 1.7kW RF power
- RF starts from narrow pulse (20us/20ms) increasing pulse width up to CW in 10 steps.
- For each pulse width, RF level changes from 500W to 1.7kW in 5 steps
- Each step, of totally 50 steps, lasts for 10 minutes
- At the starting point, pressure inside the cavity was 2×10^{-9} mbar
- If pressure exceeds 1×10^{-7} mbar, RF is turned off for one minute
- After finishing the cavity conditioning, plunger was also conditioned for 1 MHz bandwidth around the fundamental frequency, divided into 10 steps, with 5 minutes pause on each frequency.

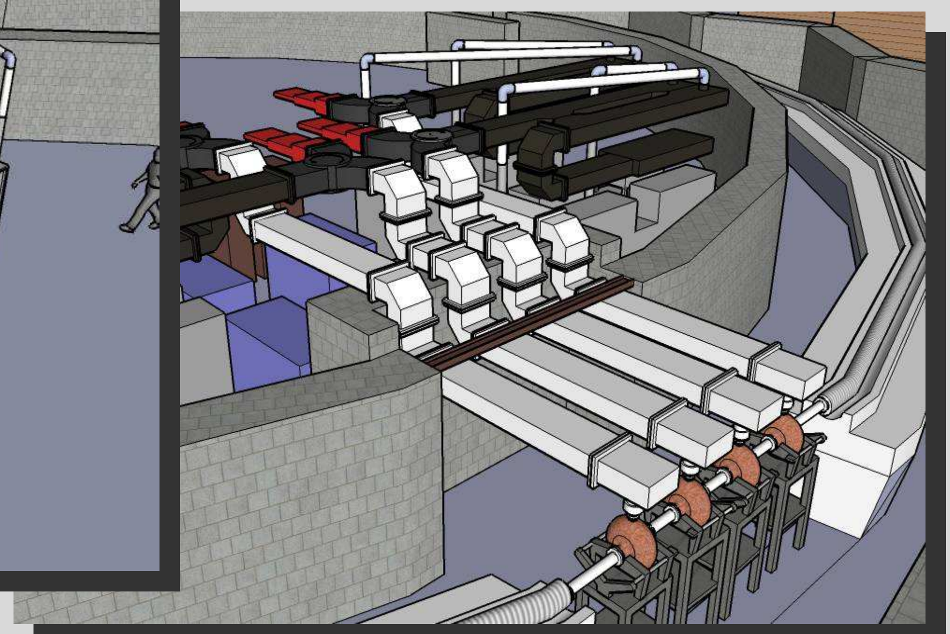
Booster RF system test assembly



Storage Ring RF system

SESAME RF SYSTEM

- It was initially decided to use 2 x 80 kW IOT for feeding each cavity in the Storage Ring
- Now the plan is to develop 140 kW Solid-State amplifiers to be used for each cavity (in collaboration with Soleil)
- In phase 1, two ELETTRA cavities (Donation from ELETTRA) will be used in the SR



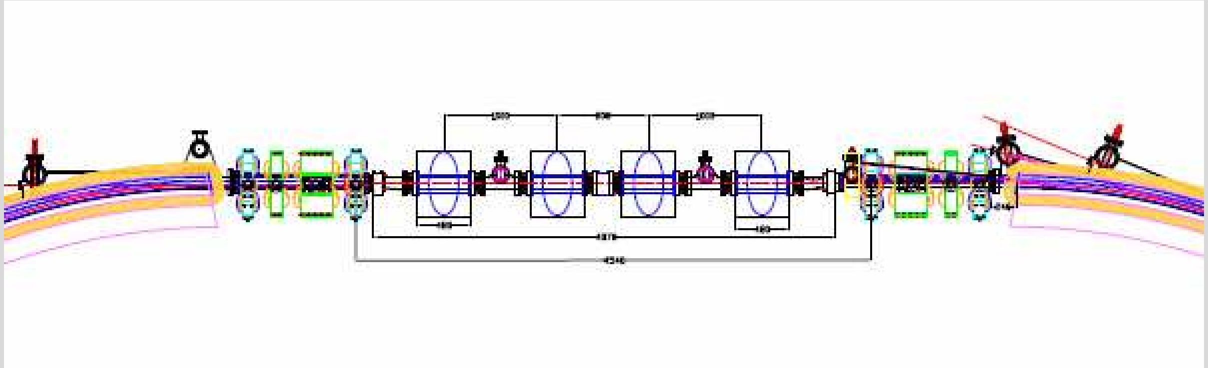
- In the second phase, two more RF plants will be added in order to achieve the maximum current as well as compensation of the power losses due to the Insertion Devices

RF values in phase 1 and 2

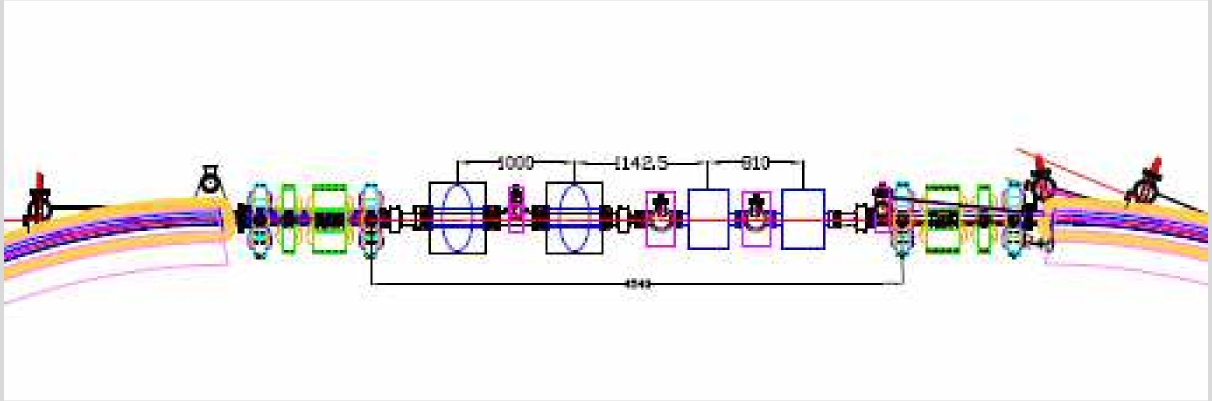
Nb of Cav.	I_b mA	V_{RF} MV	P_{cav} total kW	Over Volt. factor	RF accep %	P_b kW	P_{tot} needed kW	$P_{RF/cav}$ needed kW	Available Power for IDs kW
2	300	1.2	106	2	0.75	177	283	141	0
4	400	2.4	212	4	1.45	236	448	112	112*

* In case of running the transmitters with 140 kW

RF cavities in the SR (phase 2)

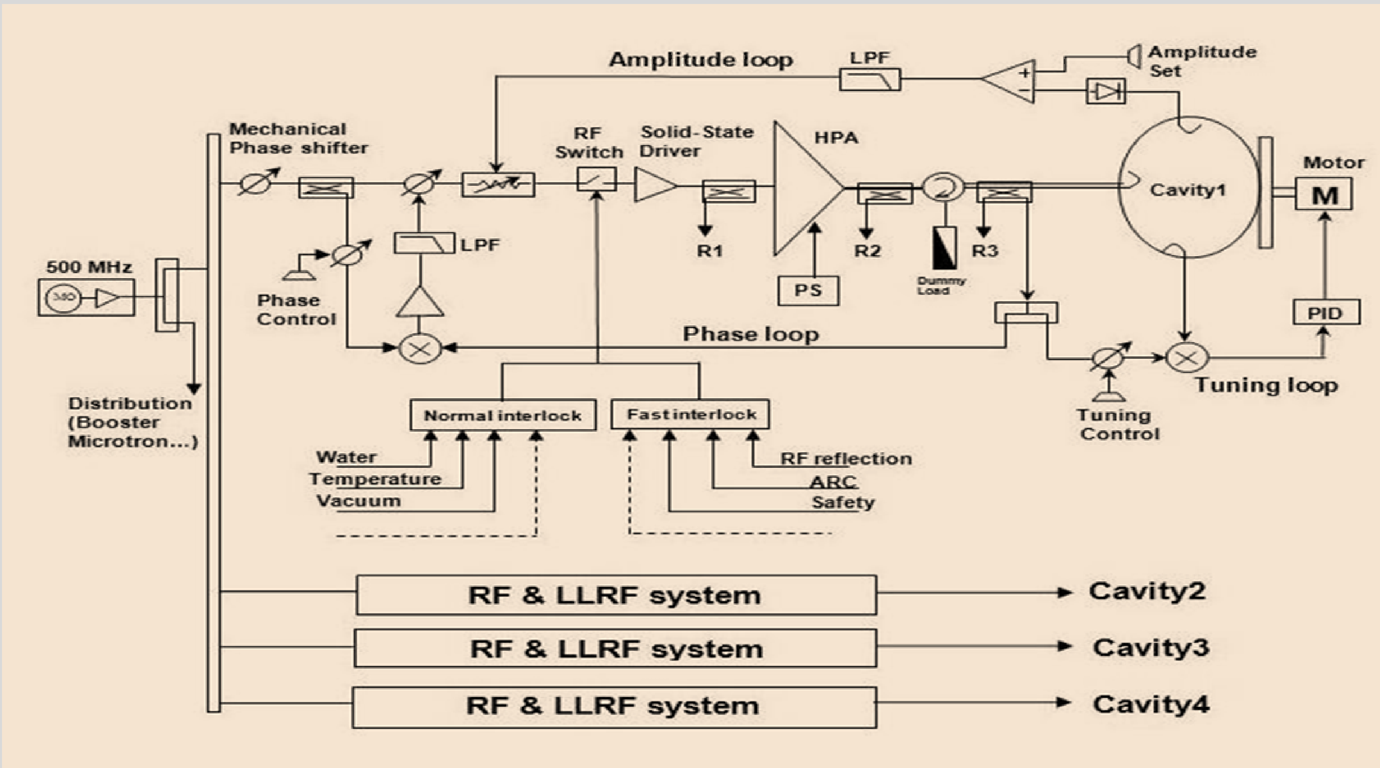


Fist option: Having 4 ELETTRA cavities



Second option: Having 2 ELETTRA cavities and 2 BESSY cavities

Low Level Electronics (LLRF)

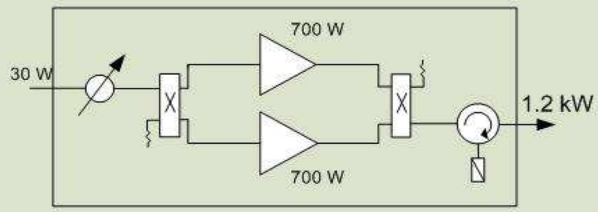


- So far, the above analog LLRF has been suggested for the Storage Ring
- As a strong alternative, adopting a digital LLRF for the Storage Ring RF system is being studied.

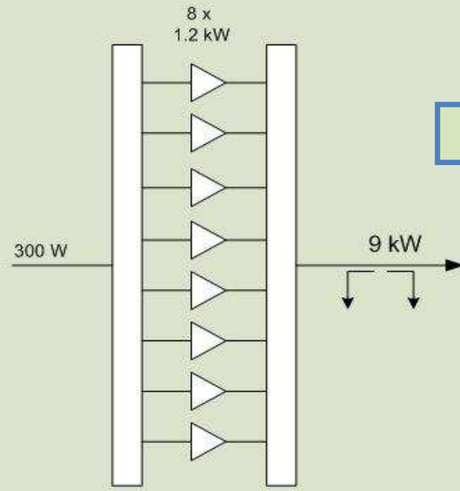
Solid-State Amplifiers

- Two 140 kW 500 MHz solid state transmitters will be developed for feeding two ELETTRA cavities in phase 1
- Collaboration with SOLEIL is to be signed
- State-of-the-art design for power amplifier modules to have better efficiency and stability
- Candidates for transistors: BLF578 (NXP)
  PRF6VP41 (Freescale)

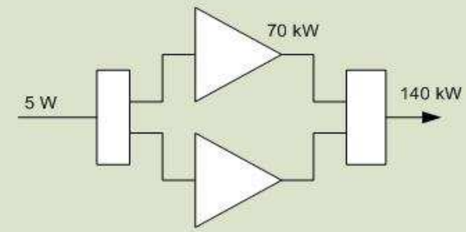
Amplifier Architecture



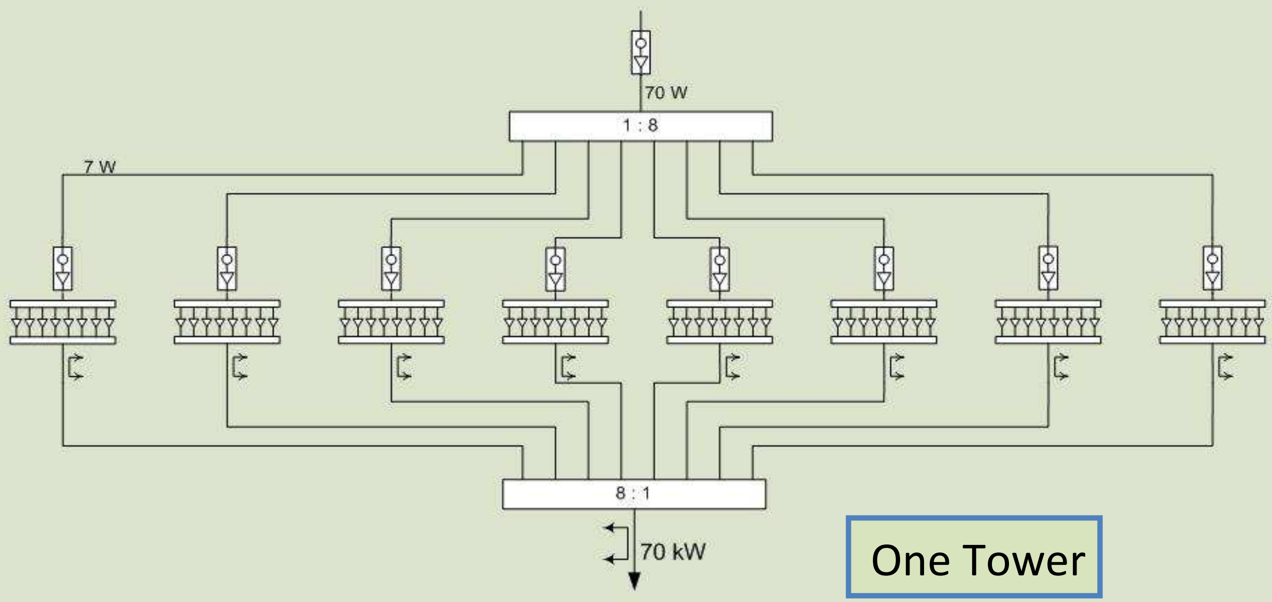
HPA Module



9kW Assembly



Transmitter



One Tower

Advantages of using balanced amplifier (HPA module)

- Good isolation between two transistors which improves amplifier stability
- Good in-out external match → better stability
- Less connectors, cable, circulator, mechanical works, etc.
- Cancelation or attenuation of different products and harmonics
- Easy to design and integrate since good couplers are available
- Using phase shifter to minimize the phase tolerances and increase the power combining efficiency
- Easy to change the type of transistor if it is obsolete

→ Disadvantage: needs two 50 Ω terminations (low and high power)

I would like to thank the European synchrotron light sources for their valuable help and support to SESAME.

My special thanks on behalf of SESAME RF group to BESSY, SOLEIL, ELETTRA and ALBA RF experts who have been always very kind, helpful and supportive to us.

Thank you