



WP4 Strategy for RF System

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International Review of the Crab Cavity system design and production plan for the HL-LHC

19-21 June 2019

CERN



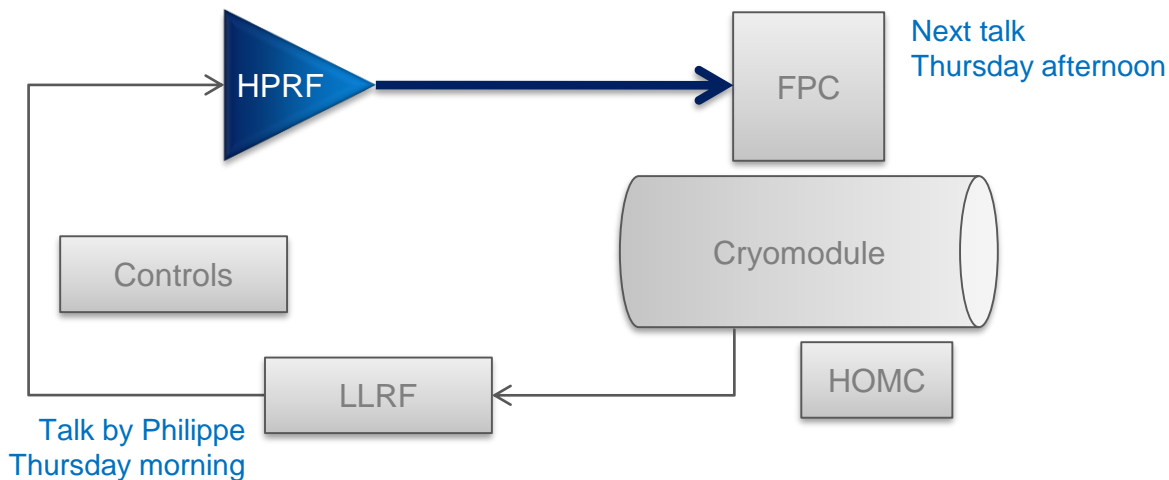
RF system

HPRF *High Power RF station (including power transmission lines)*

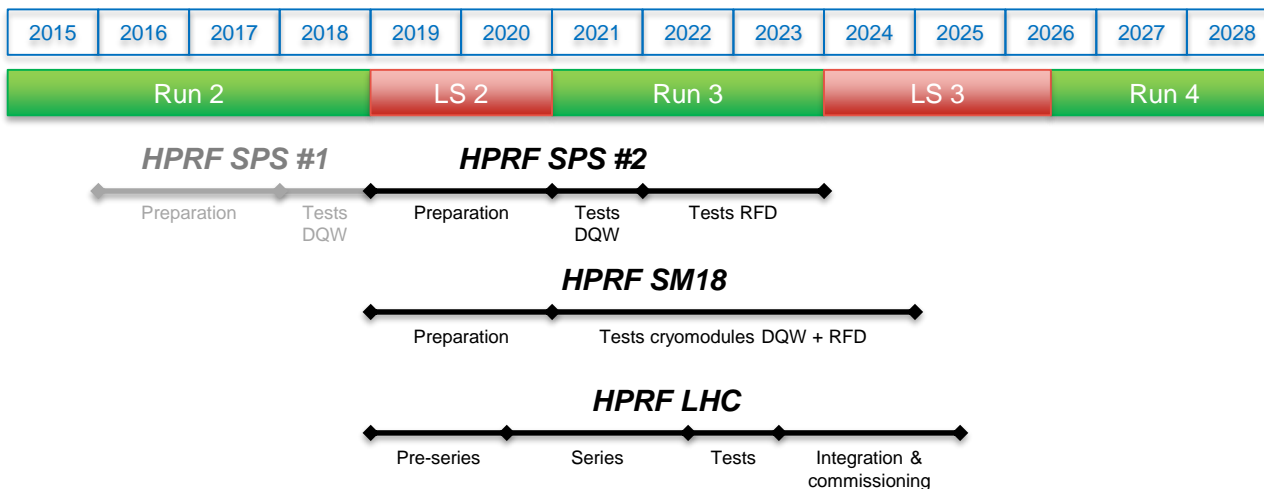
FPC Fundamental Power Coupler

HOMC High Order Mode Coupler

LLRF Low Level RF



Outlook



High Power RF in SPS and lessons learned

High Power RF in SM18 and in SPS

HL-LHC High Power RF systems

High Power RF in SPS

HPRF for SPS has been designed based on a known IOT system already in use for the TWC800MHz in the SPS

We had to modify the trolley in order to tune it to 400 MHz

Two systems have been built for the SPS tests and have been assembled in BA6 (crab test area)



Eight IOT power stations in operation in the SPS since 2014
System availability for beam 99.5 %

High Power RF in SPS

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Left, Thales IOT Trolley operating at 800 MHz
Right, modified by CERN trolley for an operation at 400 MHz
James proudly showing the very good job done

High Power RF in SPS

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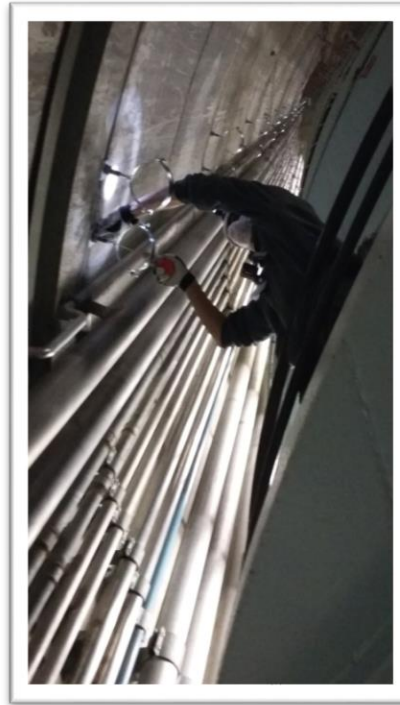
Two systems in the SPS for the DQW tests
Charles and Fred setting-up the systems

High Power RF in SPS

The cubicles were connected to the circulators on the table with 150 m of 6-1/8" coaxial lines

A very special 6-1/8" coaxial rotatable line has been specially designed to allow the table movements

LHC main RF systems circulators (330 kW) and loads have been integrated, and will be re-used later for the LHC main RF system



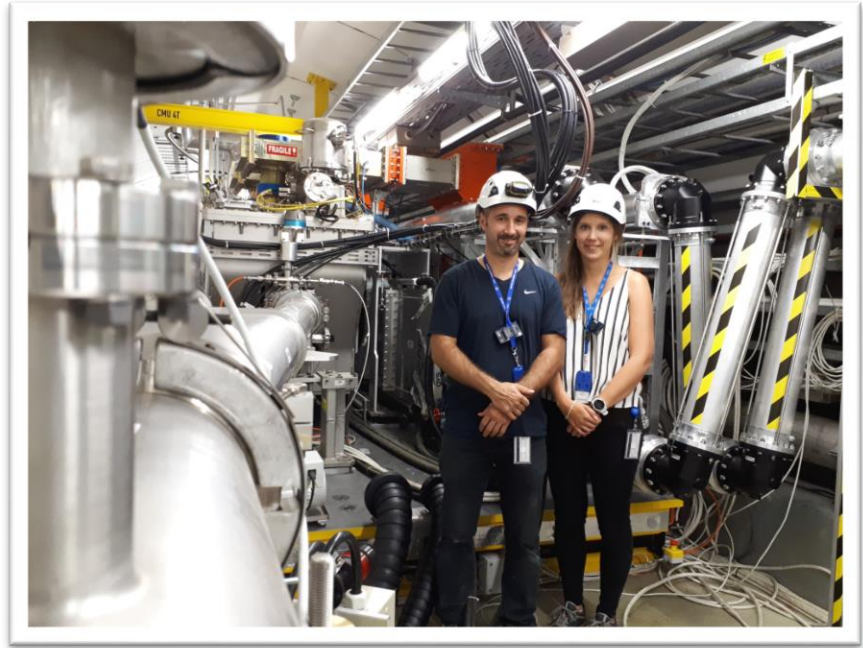
Connection to the table had to be done with 6-1/8" lines
Seb, David, and team did a very good job !

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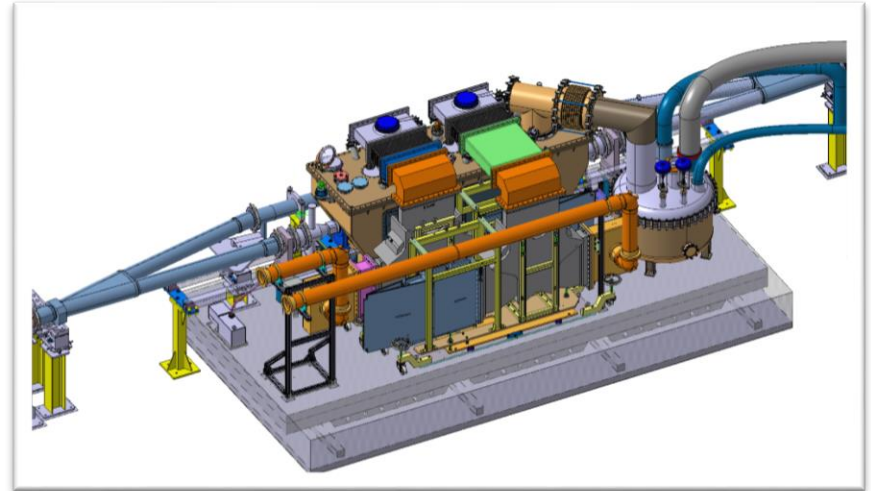
Seb invented a very special rotatable 6-1/8" system
He is proudly pausing with Frida who helped him designing,
constructing and installing it

High Power RF in SPS

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LHC main RF system circulators and loads seats behind the cryomodule, and ferrite loads have been shortened to fit within the table size

High Power RF in SPS

The Fundamental Power Couplers were connected with WR2300 waveguides

Transition and flexible waveguides were inserted not to stress the ceramic window of the FPC

The FPC has been designed based on SPL design, and should be able to sustain more than 1 MWp up to the conical line



Connection of the FPC to the circulators
Antoine, Seb and Frida did very carefully this very sensitive
last HPRF action

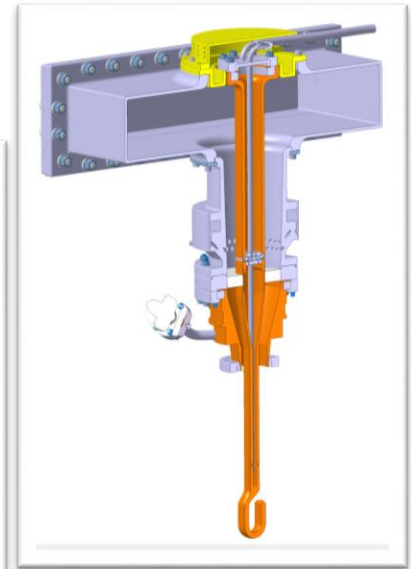
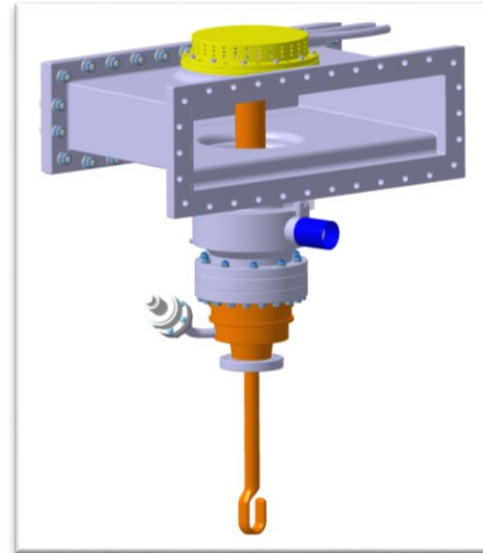
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Talk Thursday
afternoon



Crab FPC design is an evolution of the SPL FPC
Air side and ceramic window has been designed to sustain 200 kW average and 1 MWp, the crab hook will sustain the Crab requirements (100+ kW CW)

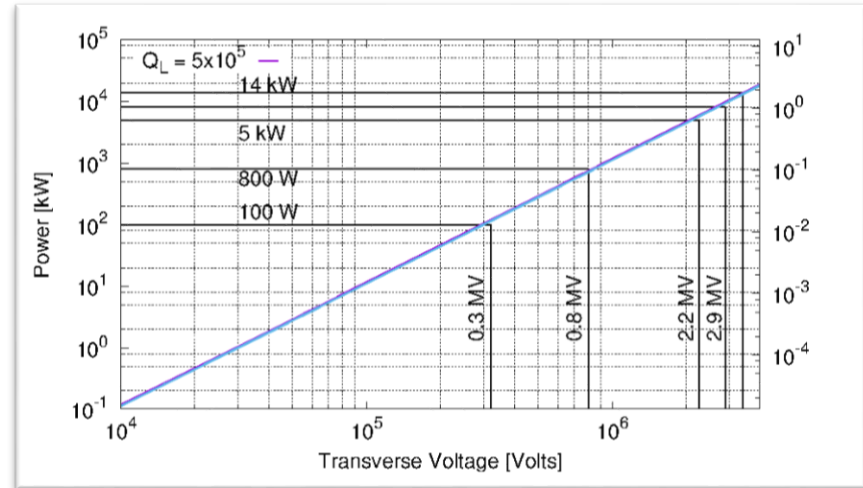
High Power RF in SPS – lessons learned

Linearity has been found to be a key parameter, especially at very low power

This is unusual request for such high power system

It will have to be added in specification of future HPRF system

Courtesy Rama Calaga



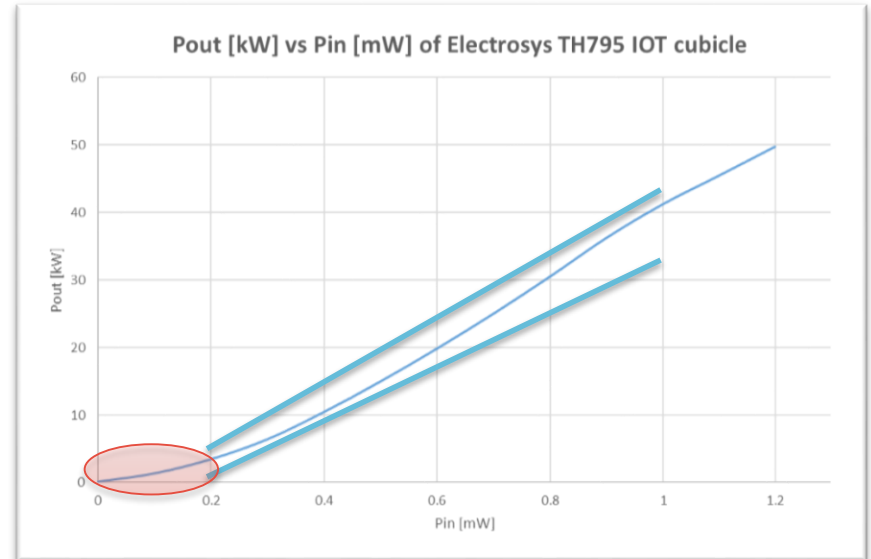
With a no offset beam, the request of power is very little
LLRF systems requires linearity that was
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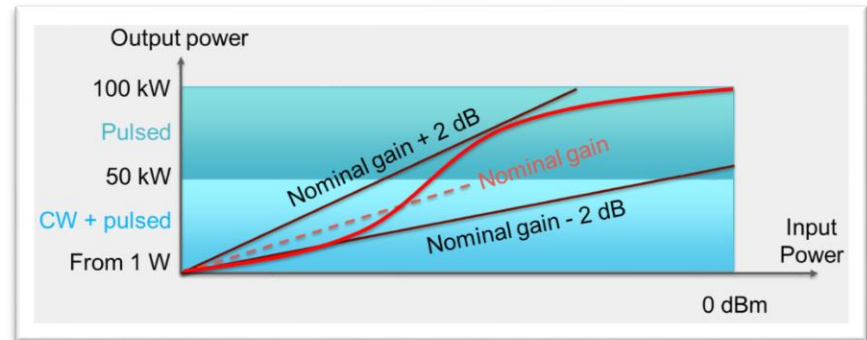
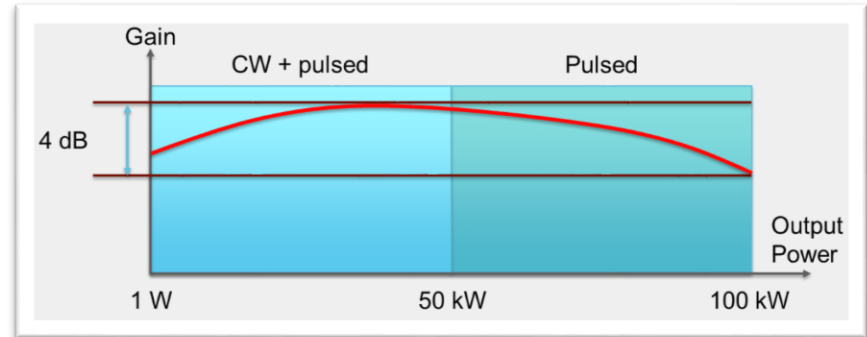
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New specifications already discussed with supplier of amplifiers

High Power RF in SPS – lessons learned

Talk Thursday afternoon

FPC have been pre-conditioned individually prior to be assembled in clean room

Cavities have been pre-conditioned up to 1 kW in SM18 bunker prior to be installed in the SPS

RF processing was (on purpose to take no risk) very slow in the SPS

Conditioning 'on tune' was more complex than expected



After pre-processing of the two FPC, they have been carefully assembled in clean room onto the crab cavity. Here Seb and Max removing the second FPC from its test box before assembling it on the cavity in less than half a day.

High Power RF in SPS – lessons learned

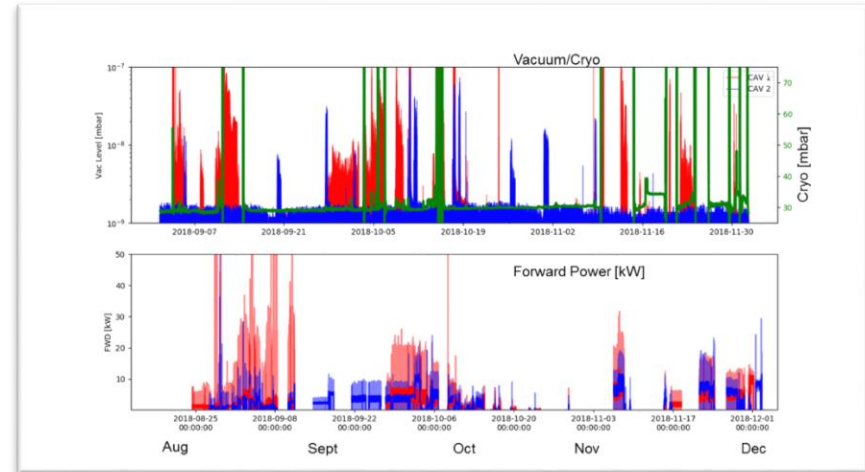
Talk Friday morning

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The process was on purpose very slow, with a very well know system that we successfully apply with all our FPC since the 90's

<https://indico.esss.lu.se/event/528/session/2/contribution/15>

Future HPRF systems

Collaboration with BINP (Novosibirsk, Russia) is being setup

Once fully agreed, Solid State Power Amplifiers will be the new baseline

LIU project was very difficult, but very instructive with respect to SSPA amplifier design

Triada TV showed an impressive capability of constructing very well designed SSPA units



Институт ядерной физики
имени Г. И. Будкера СО РАН



Having Alexey Tribendis (BINP RF responsible) there as link person is a very high added value !

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We spent more than four years solving all troubles with SSPA for LIU, we now have a high level of expertise
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Triada TV transformed an old cement factory into high technology RF factory

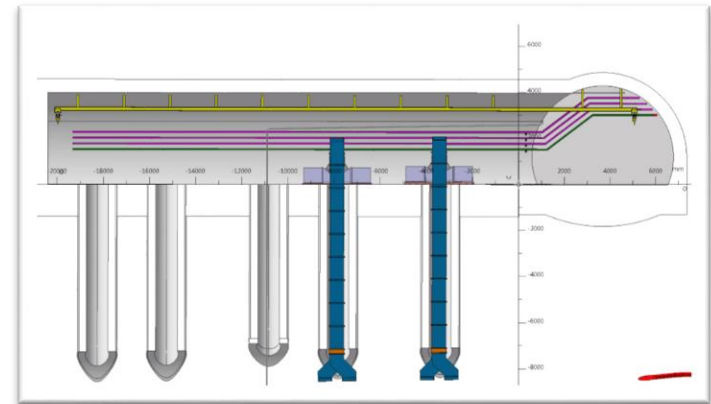
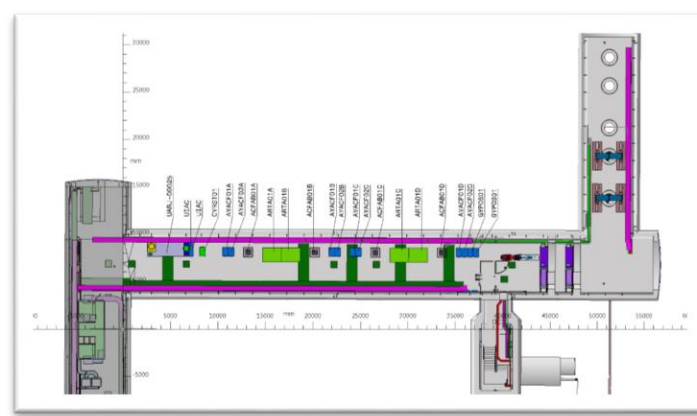
They have an all in one factory, from design, pcb, machining, assembly, tests, and packing... really impressive !

Future HPRF systems

Plans are to have one pre-series unit delivered mid-2020 for tests and validation during one year

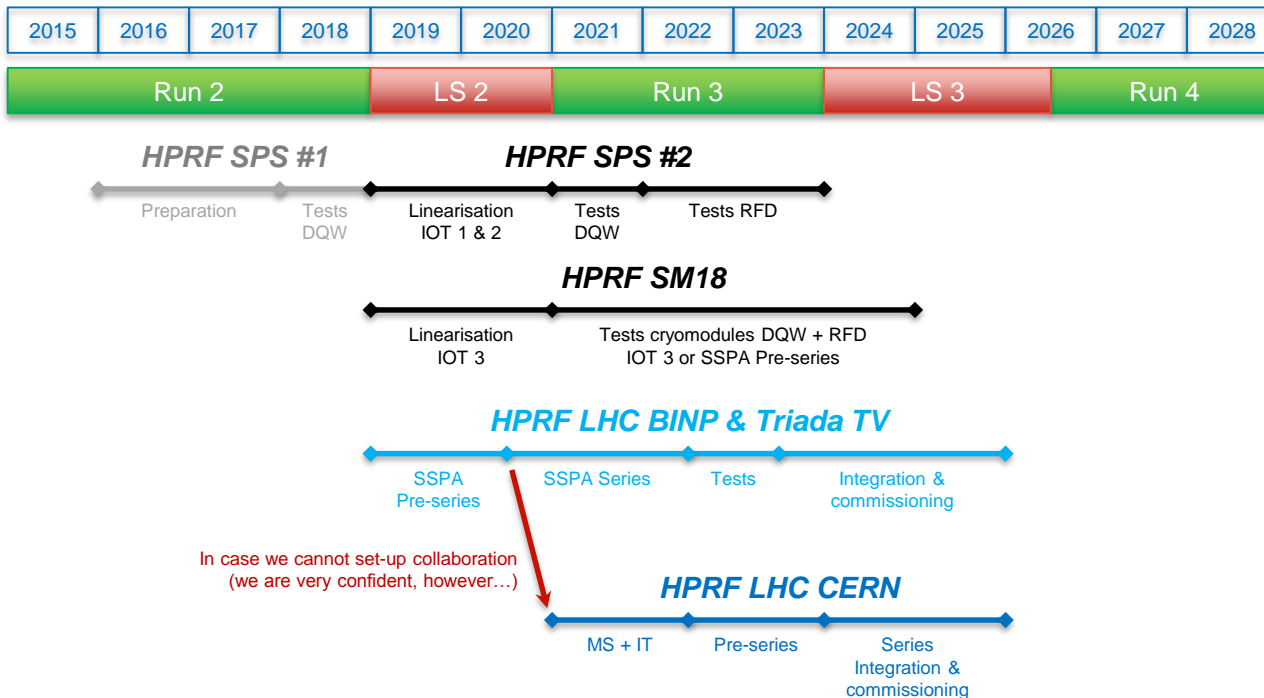
We will then receive 19 additional SSPA systems

Integration has already been found fully compatible to our current baseline (IOT), of course deeper studies will be made in due time



Thanks to Paolo and his team, thanks to EL and CV, integration has been made compatible for IOT and SSPA Circulators and their core will remain whatever the option

HPRF systems



Conclusion

HPRF operated very well during first SPS tests

SPS tests confirmed to be mandatory as we learned that linearity must be improved as being a key parameter for LLRF systems

LIU project made us very confident with respect to SSPA solution

BINP and Triada TV look very solid partners for a SSPA collaboration

Integration into the UA caverns looks very possible, including coaxial lines and circulators

Backup solution based on IOT will quickly be ready to be ordered if needed, including improved linearity requirements

Despite a quite long purchasing process, backup solution, even if tight, would be fully compatible with timeline milestones



Thanks to all colleagues involved with the SPS HPRF systems (special thanks to Fred, Charles, Seb, Antoine, and BE-RF-PM team)

Thanks to Beniamino for his help with BINP collaboration (still a lot to do)

Thanks to Rama and Ofelia (WP4 leaders), to RF management, to BE management and to HL-LHC management, for supporting us with this very exciting (and very challenging) project

We (BE-RF-PM team and all associated colleagues from many groups) are eager to provide HL-LHC with a fantastic (cheap) HPRF system

