



**WP4**

**RF equipment needs**

**20160603 (updated 20160609)**

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HL-LHC Integration meeting



# Conceptual specification

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| ✓ | Name   | Modified           | Modified By |
|---|--|--------------------|-------------|
|   | Conceptual Specification ADT System - WP4            | 18 August, 2014    | Rama Calaga |
|   | Conceptual Specification Harmonic System - WP4       | 05 September, 2014 | Rama Calaga |
|   | Conceptual Specification LHC Crab cavities - WP4     | 05 September, 2014 | Rama Calaga |
|   | Conceptual Specification LHC Crab RF System - WP4_v5 | 31 March           | Rama Calaga |
|   | Conceptual Specification SPS Crab cavities - WP4     | 19 June, 2014      | Rama Calaga |

WP4 Home

- RF Parameters
- EDMS WP4
- Indico Meetings WP4
- Reference Documentation
- Shared Documents
- Tasks
  - Cavities & Cryomodule
  - High Power RF
  - LLRF & Controls
  - SPS Test Stand
  - Site Contents

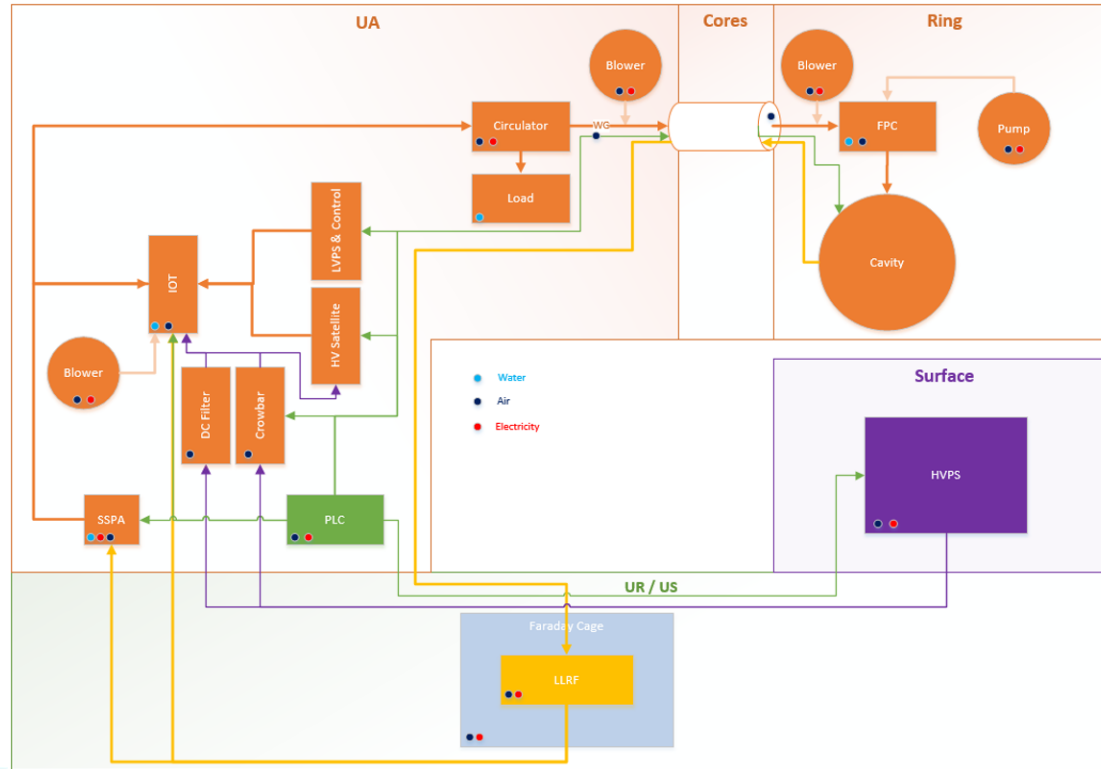
Reference document:  
Conceptual specification  
updated 31<sup>st</sup> March 2016



# RF System Bloc Diagram per IP side

One Power unit per cavity (nor more combination of tubes)

Crowbar + HV filters in UA



HVPS moved to surface building

# Table 4 : Electricity requirement : for one IP side RF system the following services are required

- surface

| Equipment    | Location   | Electricity |   |     |   |     |                 |
|--------------|------------|-------------|---|-----|---|-----|-----------------|
|              |            | Qty         | IOT (100 kW RF)   | Qty | Tetrodes (50 kW RF)   | Qty | SSPA (25 kW RF) |
| HVPS         | Surface    | 8+1         | TE-EPC : 1980 kVA – 40 kV<br>(for 8 x 100 kW RF)<br>100 kW x (8+1) = 900 kW -> 1.8 MVA + η hvps => 1980 kVA | 8+1 | TE-EPC : 1000 kVA – 10 kV<br>(for 8 x 50 kW RF)<br>50 kW x (8+1) = 450 kW -> 0.9 MVA + η hvps => 1000 kVA | -   | -               |
| <b>Total</b> | <b>ALL</b> |             | <b>2.0 MVA</b>  |     | <b>1.0 MVA</b>  |     | -               |

- underground

| Equipment             | Location       | Electricity |  |     |  |     |   |
|-----------------------|----------------|-------------|--|-----|--|-----|---|
|                       |                | Qty         | IOT (100 kW RF)  | Qty | Tetrodes (50 kW RF)  | Qty | SSPA (25 kW RF)   |
| Faraday Cage services | UR / US        | 1           | 230 V – 2 kVA  | 1   | 230 V – 2 kVA  | 1   | 230 V – 2 kVA   |
| LLRF                  | UR / US        | 8           | 230 V – 12 KVA (UPS)<br><i>Philippe</i>  | 8   | 230 V – 12 KVA (UPS)<br><i>Philippe</i>  | 8   | 230 V – 12 KVA (UPS)<br><i>Philippe</i>   |
| Driver SSPA           | UA             | 8           | 400 V - 12 KVA<br>700 W x 8 = 6 KW -> 12 KVA   | 8   | 400 V – 56 KVA<br>3.5 KW x 8 = 28 KW -> 56 KVA   | -   | -   |
| PLC                   | UA             | 4           | 230 V – 6 KVA (UPS)<br><i>Luca</i>   | 4   | 230 V – 6 KVA (UPS)<br><i>Luca</i>   | 4   | 230 V – 6 KVA (UPS)<br><i>Luca</i>  |
| LVPS                  | UA             | 32          | 230 V – 8 KVA<br>35 VA (Ion PS) + 375 VA (Fil PS) + 80 VA (Grid PS) + 375 VA (Foc PS)<br>= 865 W x 8 -> +15% = 8 KVA | 24  | 400 V – 7 KVA<br>385 VA (Fil PS) + 105 VA (G1 PS) + 240 VA (G2 PS) = 730 W x 8 -> +15% = 7 KVA | 8   | 400 V - 440 KVA<br>(for 8 x 25 kW RF)<br>25 kW x 8 = 200 kW -> 400 KVA + 10% => 440 KVA |
| Amplifiers            | UA             | 8           | -  | 8   | -  | 8   | -   |
| Circulators           | UA             | 8           | 400 V - 8 KVA<br>1 KVA x 8 -> 8 KVA (ref TCU Electrosys)   | 8   | 400 V - 8 KVA<br>1 KVA x 8 -> 8 KVA (ref TCU Electrosys)                                       | 8   | 400 V - 4 KVA<br>0.5 KVA x 8 -> 4 KVA (ref TCU Electrosys)                              |
| Loads                 | UA             | 8           | -  | 8   | -  | 8   | -   |
| Blower Amplifier      | UA             | 8           | 400 V - 16 KVA<br>8 x 2 KVA per blower = 16 KVA  | 8   | 400 V – 16 KVA<br>8 x 2 KVA per blower = 16 KVA  | -   | -   |
| Blowers WG            | UA             | 8           | 400 V - 4 KVA<br>0.5 KVA x 8 -> 4 KVA  | 8   | 400 V – 4 KVA<br>0.5 KVA x 8 -> 4 KVA  | 8   | 400 V – 4 KVA<br>0.5 KVA x 8 -> 4 KVA   |
| Blowers WG + FPC      | Ring           | 8           | 400 V - 4 KVA<br>0.5 KVA x 8 -> 4 KVA  | 8   | 400 V – 4 KVA<br>0.5 KVA x 8 -> 4 KVA  | 8   | 400 V – 4 KVA<br>0.5 KVA x 8 -> 4 KVA   |
| FPC                   | Ring           | 8           | -  | 8   | -  | 8   | -   |
| <b>Total</b>          | <b>UR / US</b> |             | <b>14 KVA</b>  |     | <b>14 KVA</b>  |     | <b>14 KVA</b>   |
| <b>Total</b>          | <b>UA</b>      |             | <b>54 KVA</b>  |     | <b>97 KVA</b>  |     | <b>454 KVA</b>  |
| <b>Total</b>          | <b>Ring</b>    |             | <b>4 KVA</b>   |     | <b>4 KVA</b>   |     | <b>4 KVA</b>  |
| <b>Total</b>          | <b>ALL</b>     |             | <b>72 KVA</b>  |     | <b>115 KVA</b>   |     | <b>472 KVA</b>  |

# Table 5 : **Water requirement** : for one IP side RF system the following services are required

- surface

| Equipment    | Location   | Water |                 |  |     |                     |  |     |                 |  |
|--------------|------------|-------|-----------------|--|-----|---------------------|--|-----|-----------------|--|
|              |            | Qty   | IOT (100 kW RF) |  | Qty | Tetrodes (50 kW RF) |  | Qty | SSPA (25 kW RF) |  |
| HVPS         | Surface    | 8+1   | TE-EPC          |  | 8+1 | TE-EPC              |  | -   | -               |  |
| <b>Total</b> | <b>ALL</b> |       | <b>180 KW</b>   |  |     | <b>90 KW</b>        |  |     | <b>-</b>        |  |

- underground

| Equipment        | Location   | Water |  |  |     |   |  |     |   |  |
|------------------|------------|-------|--|--|-----|---|--|-----|---|--|
|                  |            | Qty   | IOT (100 kW RF)  |  | Qty | Tetrodes (50 kW RF)   |  | Qty | SSPA (25 kW RF)   |  |
| Faraday Cage     | UR / US    | 1     | -  |  | 1   | -   |  | 1   | -   |  |
| LLRF             | UR / US    | 8     | -  |  | 8   | -   |  | 8   | -   |  |
| Driver SSPA      | UA         | 8     | 5.5 KW<br><i>12 kVA x 50% RF efficiency x 90% in water = 5.5 KW</i>            |  | 8   | 25 KW<br><i>56 kVA x 50% RF efficiency x 90% in water = 25.2 KW</i>           |  | -   | -   |  |
| PLC              | UA         | 4     | -  |  | 4   | -   |  | 4   | -   |  |
| LVPS             | UA         | 32    | -  |  | 24  | -   |  | 8   | -   |  |
| Amplifiers       | UA         | 8     | 760 KW (for 800 kW RF)<br><i>100 KW x 8 = (800 KW + 5%) x 90% eau = 756 KW</i> |  | 8   | 375 KW (for 400 kW RF)<br><i>50 KW x 8 = (400 KW + 5%) x 90% eau = 375 KW</i> |  | 8   | 190 KW (for 200 kW RF)<br><i>25 KW x 8 = (200 KW + 5%) x 90% eau =&gt; 189 KW</i> |  |
| Circulators      | UA         | 8     | 4 KW<br><i>0.5 kVA x 8 -&gt; 4 KW</i>  |  | 8   | 4 KW<br><i>0.5 kVA x 8 -&gt; 4 KW</i>   |  | 8   | 4 KW<br><i>0.5 kVA x 8 -&gt; 4 KW</i>   |  |
| Loads            | UA         | 8     | 800 KW<br><i>100 KW x 8 = 800 KW</i>   |  | 8   | 400 KW<br><i>50 KW x 8 = 400 KW</i>   |  | 8   | 200 KW<br><i>25 KW x 8 = 200 KW</i>   |  |
| Blower Amplifier | UA         | 8     | -  |  | 8   | -   |  | -   | -   |  |
| Blowers WG       | UA         | 8     | -  |  | 8   | -   |  | 8   | -   |  |
| Blowers WG + FPC | Ring       | 8     | -  |  | 8   | -   |  | 8   | -   |  |
| FPC              | Ring       | 8     | 16 KW<br><i>(100 kW RF with 2% losses in each FPC x 8)</i>                     |  | 8   | 8 KW<br><i>(50 kW RF with 2% losses in the FPC x 8)</i>                       |  | 8   | 4 KW<br><i>(25 kW RF with 2% losses in the FPC x 8)</i>                           |  |
| Total            | UR / US    |       |  |  |     |   |  |     |   |  |
| Total            | UA         |       | 1570 KW  |  |     | 804 KW  |  |     | 394 KW  |  |
| Total            | Ring       |       | 16 KW  |  |     | 8 KW  |  |     | 4 KW  |  |
| <b>Total</b>     | <b>ALL</b> |       | <b>1585.5 KW</b>   |  |     | <b>812 KW</b>   |  |     | <b>398 KW</b>   |  |

# Table 6 : Air requirement : for one IP side RF system the following services are required

- surface

| Equipment    | Location   | Qty | Air              |     |                     |     |                 |
|--------------|------------|-----|------------------|-----|---------------------|-----|-----------------|
|              |            |     | IOT (100 kW RF)  | Qty | Tetrodes (50 kW RF) | Qty | SSPA (25 kW RF) |
| HVPS         | Surface    | 8+1 | TE-EPC<br>180 KW | 8+1 | TE-EPC              | -   | -               |
| <b>Total</b> | <b>ALL</b> |     | <b>180 KW</b>    |     | -                   |     | -               |

- underground

| Equipment        | Location   | Qty | Air  |     |   |     |  |
|------------------|------------|-----|--|-----|---|-----|--|
|                  |            |     | IOT (100 kW RF)  | Qty | Tetrodes (50 kW RF)   | Qty | SSPA (25 kW RF)  |
| Faraday Cage     | UR / US    | 1   | T* and humidity<br>5 KW  | 1   | T* and humidity<br>5 KW                                       | 1   | T* and humidity<br>5 KW  |
| LLRF             | UR / US    | 8   | 12 KW<br>12 KVA (Elec)   | 8   | 12 KW<br>12 KVA (Elec)  | 8   | 12 KW<br>12 KVA (Elec)   |
| Driver SSPA      | UA         | 8   | 1 KW<br>12 KVA x 50% (RF efficiency) x 10% air = 1 KW          | 8   | 3 KW<br>56 KVA x 50% RF efficiency x 10% air = 3 KW           | -   | -  |
| PLC              | UA         | 4   | 6 KW<br>6 KVA (Elec)   | 4   | 6 KW<br>6 KVA (Elec)  | 4   | 6 KW<br>6 KVA (Elec)   |
| LVPS             | UA         | 32  | 8 KW<br>8 KVA (Elec)   | 24  | 7 KW<br>7 KVA (Elec)  | -   | -  |
| Amplifiers       | UA         | 8   | 80 KW (for 800 KW RF)<br>100 KW x 8 = 800 KW x 10% air = 80 KW | 8   | 40 KW (for 400 KW RF)<br>50 KW x 8 = 400 KW x 10% air = 40 KW | 8   | 20 KW (for 200 KW RF)<br>25 KW x 8 = 200 KW x 10% air => 20 KW |
| Circulators      | UA         | 8   | 8 KW<br>8 KVA (Elec)   | 8   | 8 KW<br>8 KVA (Elec)  | 8   | 4 KW<br>4 KVA (Elec)   |
| Loads            | UA         | 8   | -  | 8   | -   | 8   | -  |
| Blower Amplifier | UA         | 8   | 16 KW<br>16 KVA (Elec)   | 8   | 16 KW<br>16 KVA (Elec)  | -   | -  |
| Blowers WG       | UA         | 8   | 4 KW<br>4 KVA (Elec)   | 8   | 4 KW<br>4 KVA (Elec)  | 8   | 4 KW<br>4 KVA (Elec)   |
| Blowers WG + FPC | Ring       | 8   | 4 KW<br>4 KVA (Elec)   | 8   | 4 KW<br>4 KVA (Elec)  | 8   | 4 KW<br>4 KVA (Elec)   |
| FPC              | Ring       | 8   | 4 KW<br>4 KVA (Elec)   | 8   | 4 KW<br>4 KVA (Elec)  | 8   | 4 KW<br>4 KVA (Elec)   |
| Total            | UR / US    |     | 17 KW  |     | 17 KW   |     | 17 KW  |
| Total            | UA         |     | 123 KW   |     | 84 KW   |     | 34 KW  |
| Total            | Ring       |     | 8 KW   |     | 8 KW  |     | 8 KW   |
| <b>Total</b>     | <b>ALL</b> |     | <b>148 KW</b>  |     | <b>109 KW</b>   |     | <b>59 KW</b>   |

# Losses summary

| <b>UR/US + UA</b>                          | <b>IOT 8 x 100 kW</b> | <b>Tetrode 8 x 50 kW</b> | <b>SSPA 8 x 25 kW</b> |
|--|-----------------------|--------------------------|-----------------------|
| Water [kW]                                 | 1570                  | 804                      | 394                   |
| Air [kW]                                   | 140                   | 96                       | 46                    |
| <b>Total losses in<br/>UR/US + UA [kW]</b> | <b>1710</b>           | <b>900</b>               | <b>440</b>            |

HVPS numbers NOT included, Surface building

# IOT : baseline option



Modification of the IOT station to be operated at 400 MHz, new output cavities & new coupling elements redesigned at CERN

58 kW CW tested  
IOT as new baseline confirmed



# Losses summary

|  | Baseline              | Optional              |
|--|-----------------------|-----------------------|
| <b>UR/US + UA</b>                          | <b>IOT 8 x 100 kW</b> | <b>SSPA 8 x 25 kW</b> |
| Water [kW]                                 | 1570                  | 394                   |
| Air [kW]                                   | 140                   | 46                    |
| <b>Total losses in<br/>UR/US + UA [kW]</b> | <b>1710</b>           | <b>440</b>            |



***Thanks***

