Brief Summary on ESLS-RF Workshop 2010

Cristina Pasotti

ESLS XVIII European Synchrotron Radiation Light Source Workshop
Trieste, Italy 25-26/11 2010

Main RF components for Storage Ring

- Accelerating structure 100 - 352 - 500 MHz
  - normal conducting single/multi cell cavities
  - superconducting cavities
- Power plant
  - klystron transmitter (high power station)
  - IOT based transmitter (medium power station)
  - solid state amplifier (modular design)
- RF control and diagnostic
  - digital low level RF
- RF tools
  - input power coupler, cavity combiners, …

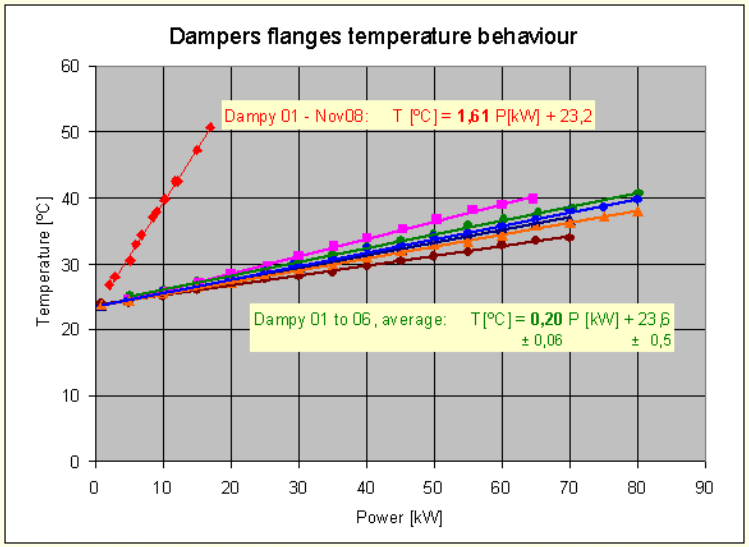
NC accelerating structures

- Normal conducting single/multi cells cavities are well known structure.
- SLS has confirmed this choice

Courtesy F. Perez (ALBA)

ALBA accelerating structures

- To avoid H.O.M. longitudinal instability: DUMPY CAVITY . NC single cell equipped with wave guides to extract HOM's field.
- Installed and full RF power tested.

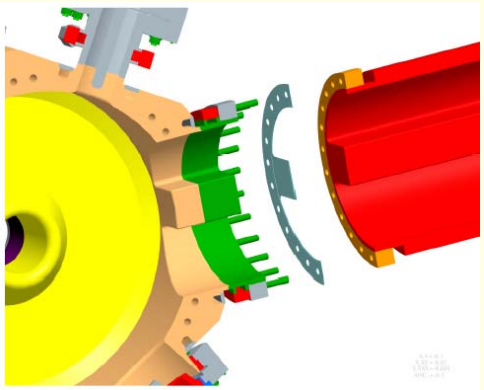


RF power level vs temperature. Courtesy F. Perez

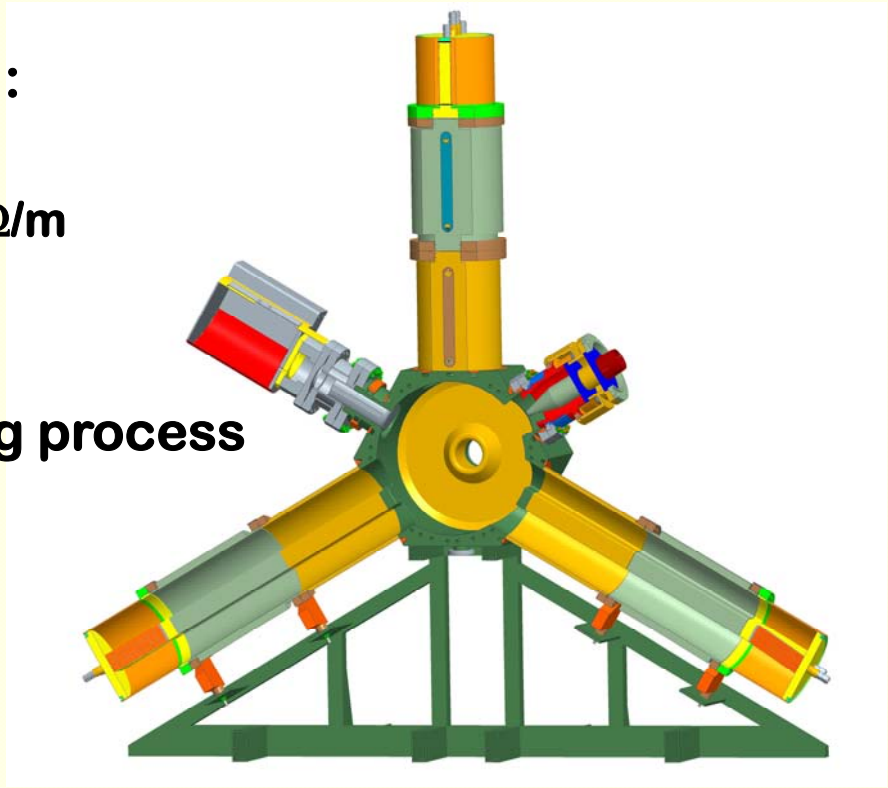
ALBA cavities. Courtesy F. Perez

BESSY II Accelerating structures

- **BESSY HOM damped cavity :**
  - **Long. Impdance < 11 KΩ**
  - **Trans. impedance and 60 kΩ/m**
  - **Rshunt ~ 3.4 MΩ**
  - **100 kW expected operation**
- **Bessy II new cavity: ordering process**



"no gap" modification for the ridged WG (ALBA, ESRF, HZB) Courtesy E. Weihreter

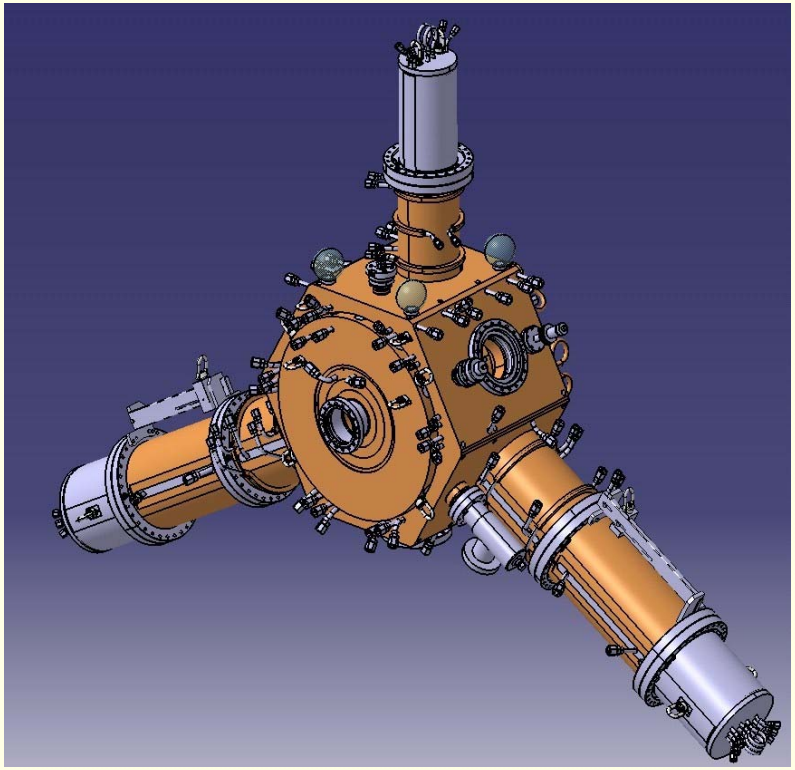


HZB BESSY II new cavity. Courtesy E .Weihreter

ESRF of accelerating structures

- ESRF RF upgrade: 6 cavities (5 cell each) replaced by 18 NC cavities single cell HOM dumped

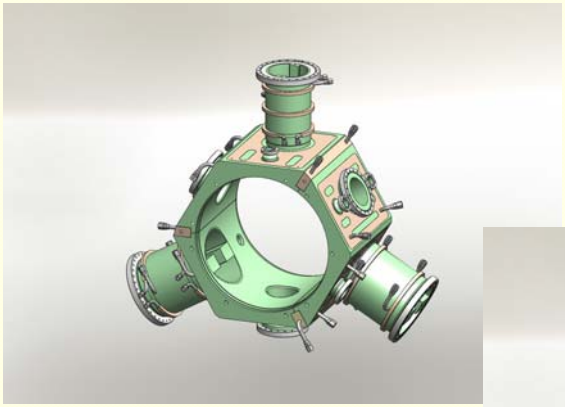
- 9 MV with at least 12 cavity
- operate at 0.3 A
- power capability for 0.5 A
- HOM longitudinal impedance below threshold for 1 A.

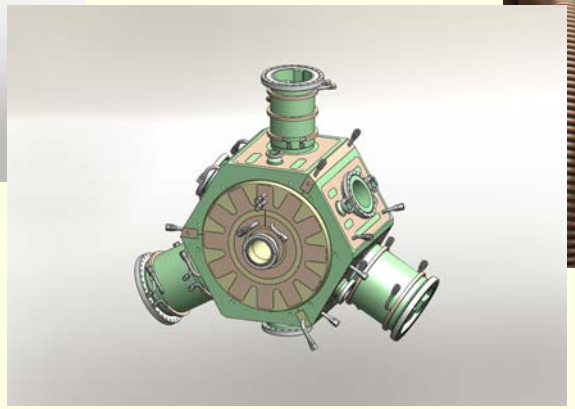


ESRF 352 MHZ Cavity. Courtesy J. Jacob

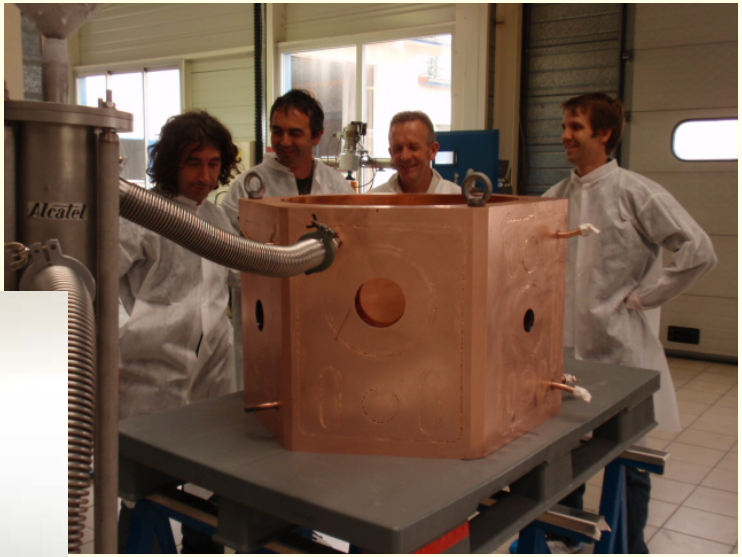
ESRF accelerating structure

- ESRF has performed cavity design and validation of prototype, mechanical and thermal design “ in house”.
- three prototypes under fabrication: on November first delivery
- create a market for fabrication of this device



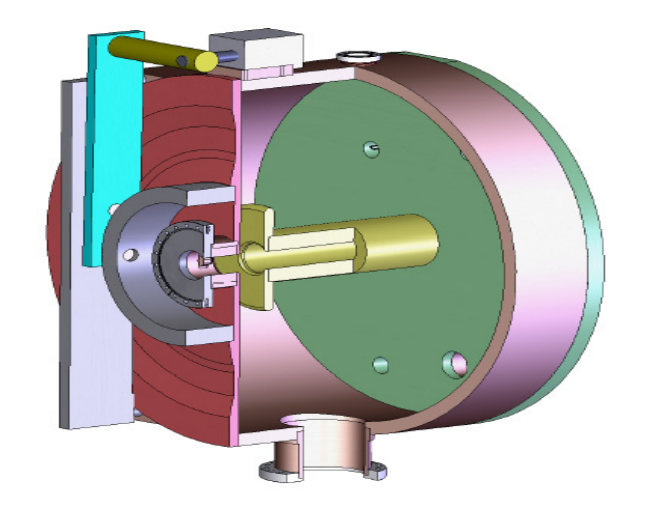


Courtesy V. Serrière

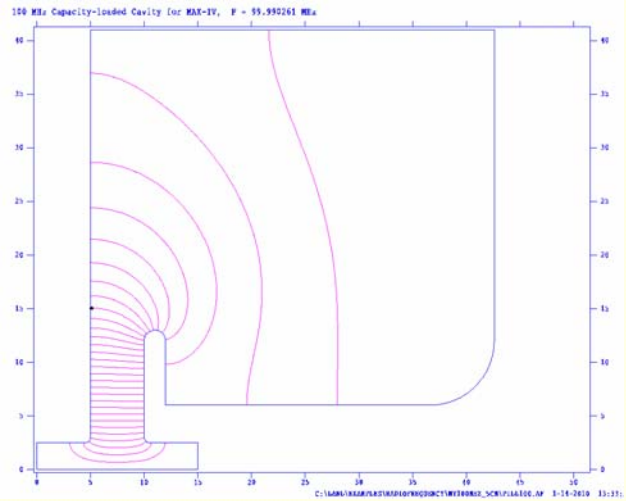


MAX IV accelerating structure

- For MAX IV rings the optimized design of the existing Max II and Max III 100 MHz cavities (higher voltage and improved heat exchange capability)
- 2 RF station (60 kW each) required for 1.5 GeV ring
- 6 RF station (120 kW each) required for 3.0 GeV ring
- Call for tender for cavity fabrication



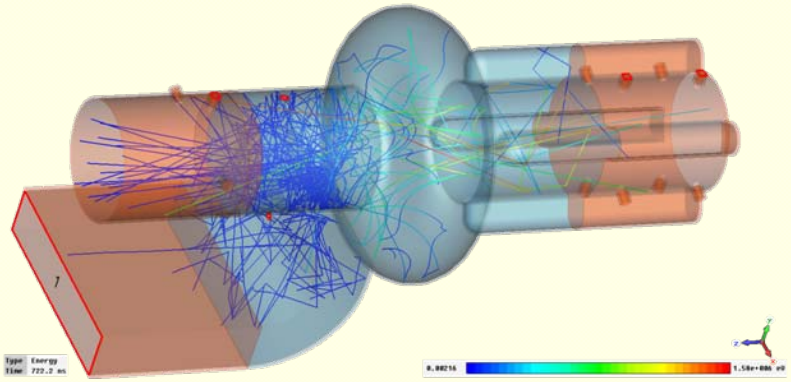
Max II and Max III cavity
Courtesy Å. Andersson



Max IV Inner cavity shape
Courtesy Å. Andersson

SC Accelerating structures

- superconducting cavity operational at Diamond and Soleil, 3rd harmonic (Elettra, SLS)
- experience good reliability, but when they fail… their recover takes relatively long time

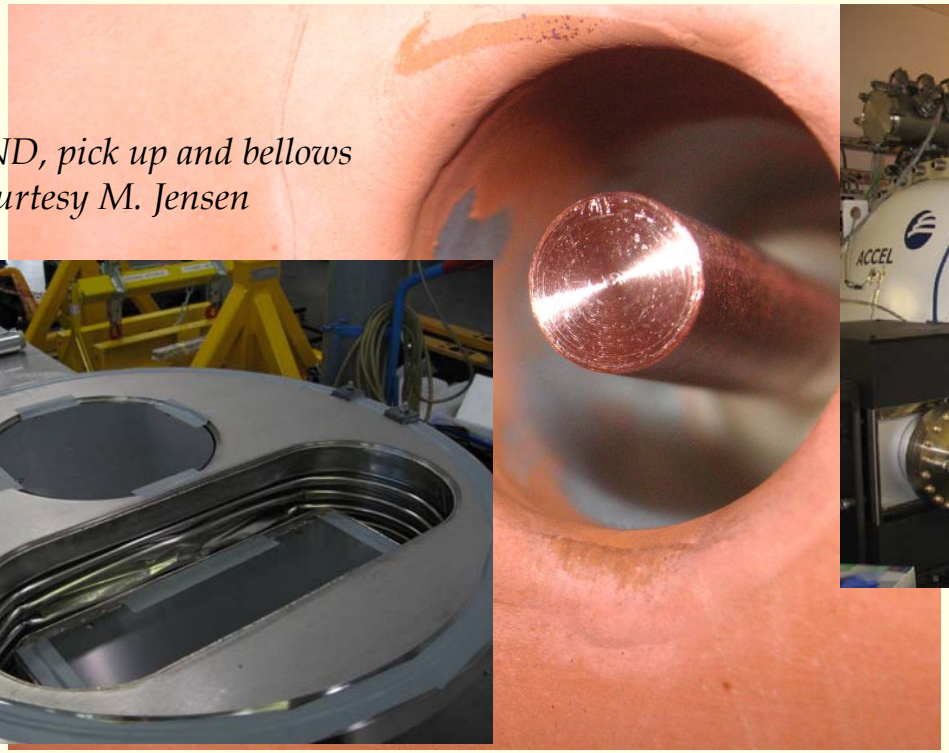


DIAMOND multipacting studies
Courtesy M. Jensen

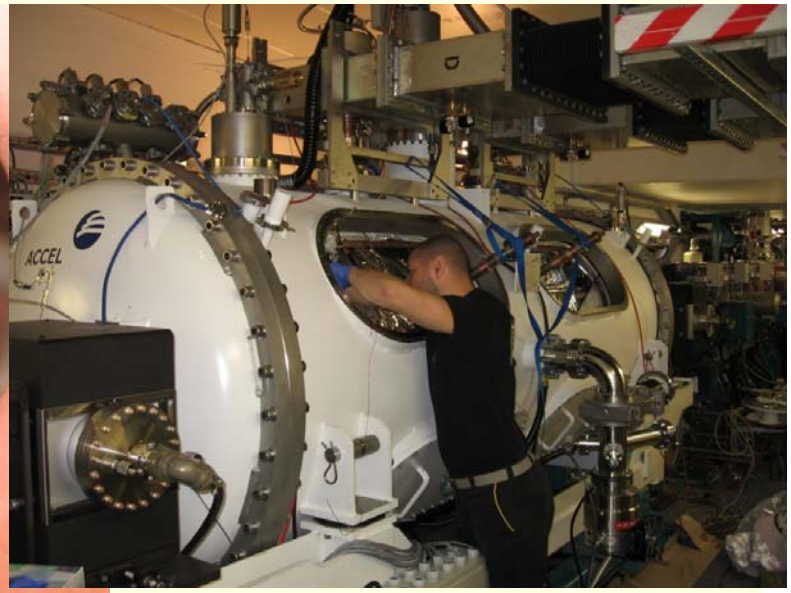
SOLEIL cryo-module
Courtesy M. Elajjouri

SC accelerating structures

- need redundancy in the system (compressor, spare cryo-module), carefully maintenance procedure
- further optimizations required: mechanical design (plunger, pick up), and simulation (multipacting studies)



DIAMOND, pick up and bellows
Courtesy M. Jensen



SOLEIL planetary gearbox replacement
Courtesy M. Elajjouri

Klystron-based Power Plant

SLS klystron (EEV K3418P)
Courtesy L. Stingelin

- **Klystron-based transmitter: several "sizes" from 800 kW (Petra III) to 180 kW (SLS) to 60 kW (Elettra). Typical gain ≈ 40 dB**
- **the market: who's going to build them, cost, delivery time, know how.**
- **Storage (HZB) and refurbishing (SLS) problems**

HZB-Bessy transmitter plant. Courtesy W. Anders

I.O.T. based power plant

- IOT typical “size” at 500Mhz is 80 kW cw, gain ≈ 23 dB. The required power level is reached combining two/four tubes together
- IOT plants at Diamond and Elettra (E2V D2130,TH 793 and TH 793-1 LS) at MLS (CPI CHK5900W1), Alba (TH 793-1 LS)

TED TH 793-1 LS installation at Diamond before December 2009 Courtesy M. Jensen

TED E2V D2130 installation at Diamond after December 2009 Courtesy M. Jensen

I.O.T. based power plant

- Elettra has two sockets system: one E2V (June 2010) and one TED tube (TH 793 last installation aug-2009)

TED TH 793-1 installation at Elettra before June 2010

E2V D2130 installation at Elettra after June 2010

I.O.T. based power plant

IOT performances :

- MLS: 2.5 years of operation for CPI without complains
- Recently Diamond (Dec. 2009) and Elettra (Jun. 2010) have chosen E2V ones.
  - Diamond: no troubles for booster (TH 793), but lots of failures in the storage ring for TED ones. Good behavior of E2V tubes, few trips just at start up.
  - Elettra: lack of reliability for TH 793 (too many trips), severe failure for TH 793-1 LS. Now D2130 tube's total hours are 2860, total trips 9. 89% of the trips in the first 1200 hours. Too early to definitively assess its performance.
- Alba: some troubles during IOT commissioning phase
- Up to now, TED tube does not match the reliability demand for LS. The experience of next machines (ALBA and CERN PS) will tell us more.

Solid State power plant

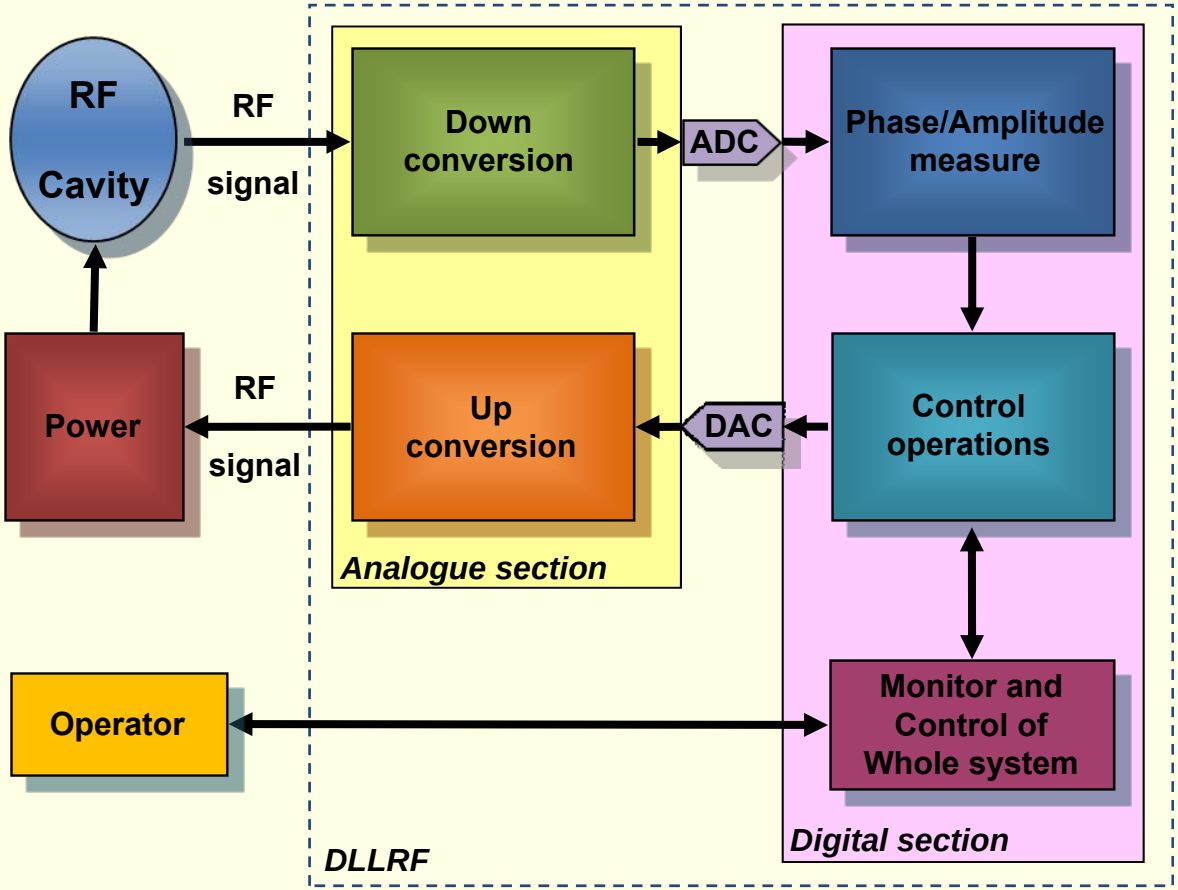
- SOLEIL 352 MHz Solid state amplifier: 20000 hours of operation ≈ 100% operational availability. **Brilliant!**

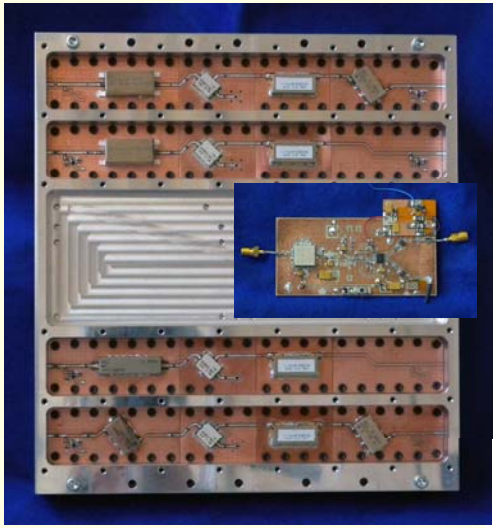
- In house development & design
- R & D of new RF modules
  - Frequencies from 88 to 500 MHz
  - Output power from 1.0 to 0.7 kW
  - Gain > 18 dB
  - Efficiency > 67%
- 2 systems of 50 kW @ 476 MHz (LNLS) successfully tested
- Technology Transfer agreement with private company to build 14 towers of 75 kW for ESRF

SOLEIL: solid state power tower
Courtesy M. Elajjouri

Digital LLRF

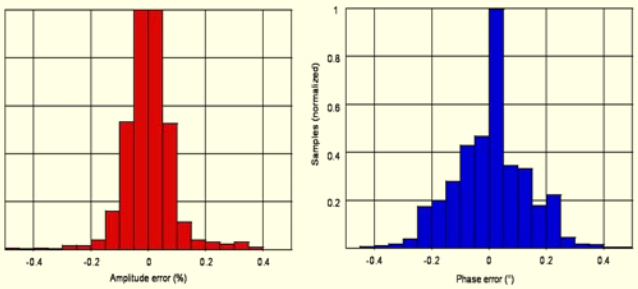
Elettra digital LLRF layout and down conversion board prototype





Digital LLRF

- LLRF Alba Booster is fully commissioned. Automatic start up procedure
- Prototype and first results for Soleil booster and storage ring.
- Prototype and first results for ASTRID

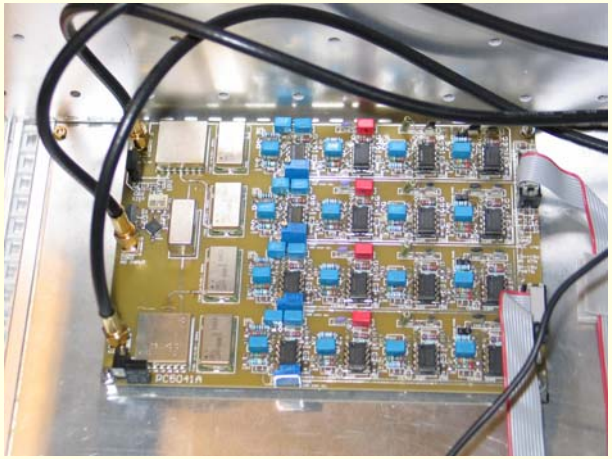


Amplitude (left) and phase (right) error distributions

Measured errors

Amplitude error: 0.3% rms
Phase error: 0.2° rms

SOLEIL: Direct RF and Digital I/Q feedback loop performances. Result at 300 mA. Courtesy R. Sreedharan



ASTRID: I/Q demodulator and 100 kHz low pass filter. Courtesy J.S.Nielsen

RF “strategies”

- collaboration to control cost and push benefit
  - Common spare parts for save operation & storage (HZB proposal for klystron)
  - Common call for tender for cavities and associated equipment (Max IV and Astrid2)
- in house development, design, and, when feasible, fabrication
  - IPC and cavity development (CERN ESRF SOLEIL)
  - IPC (SLS)
- keep high the interest of private companies in making RF devices
  - “know how” shall not be lost
  - avoiding “mono” supplier

http://www.elettra.trieste.it/Conferences/2010/ESLS_RF/

Thank You