

MicroTCA.4 based Single Cavity Regulation

including Piezo Controls

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on behalf of MSK Group, DESY

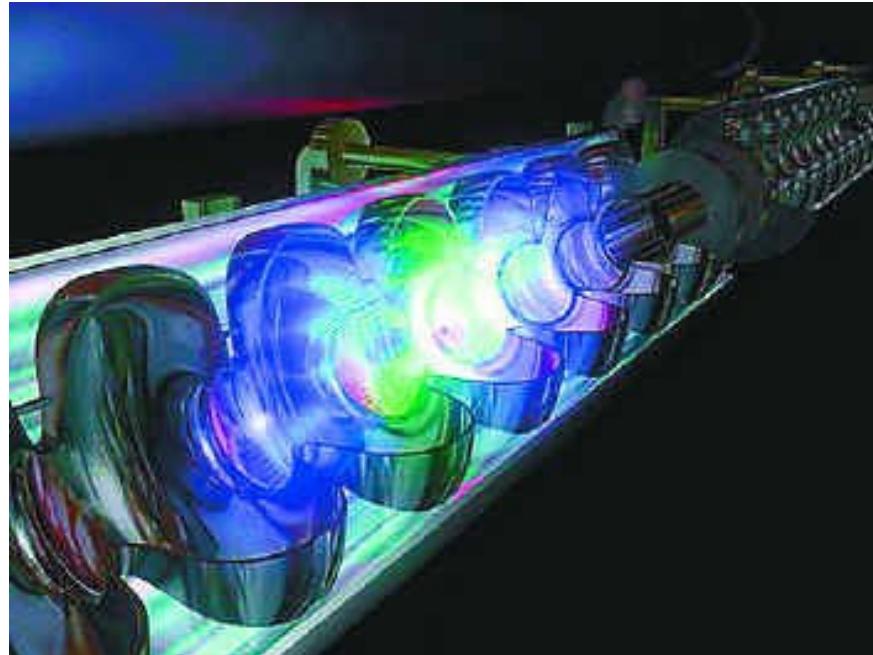
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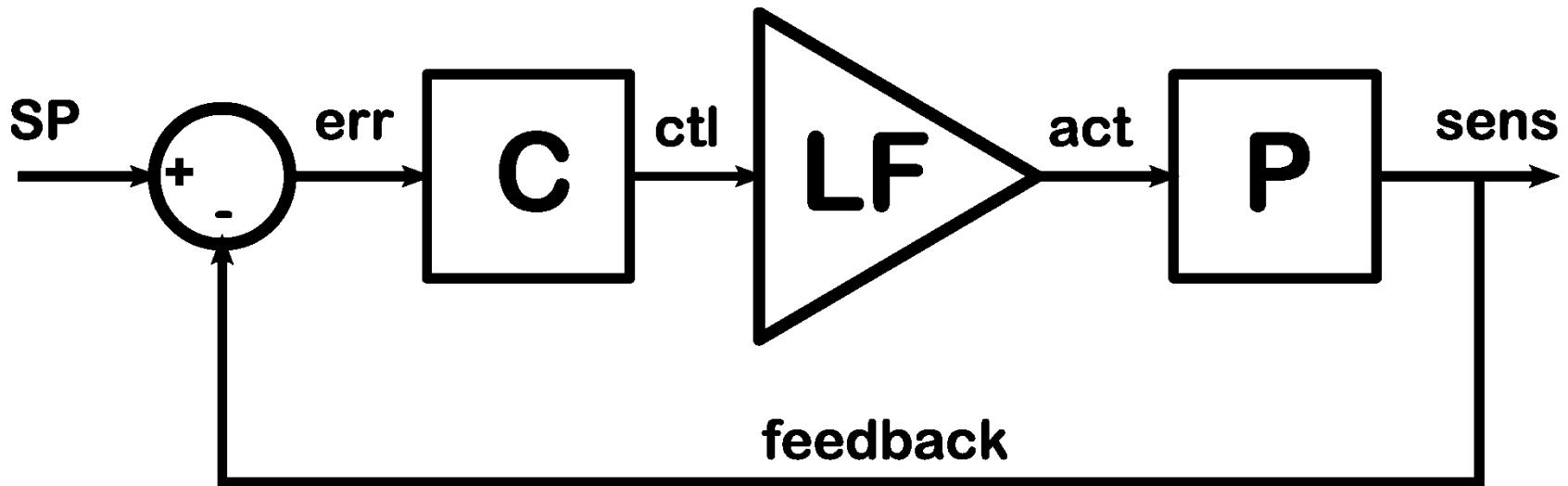
Outline

- Single cavity regulation
- Hardware
- Firmware
- Software
- CW experiment
- Results
- Possible applications



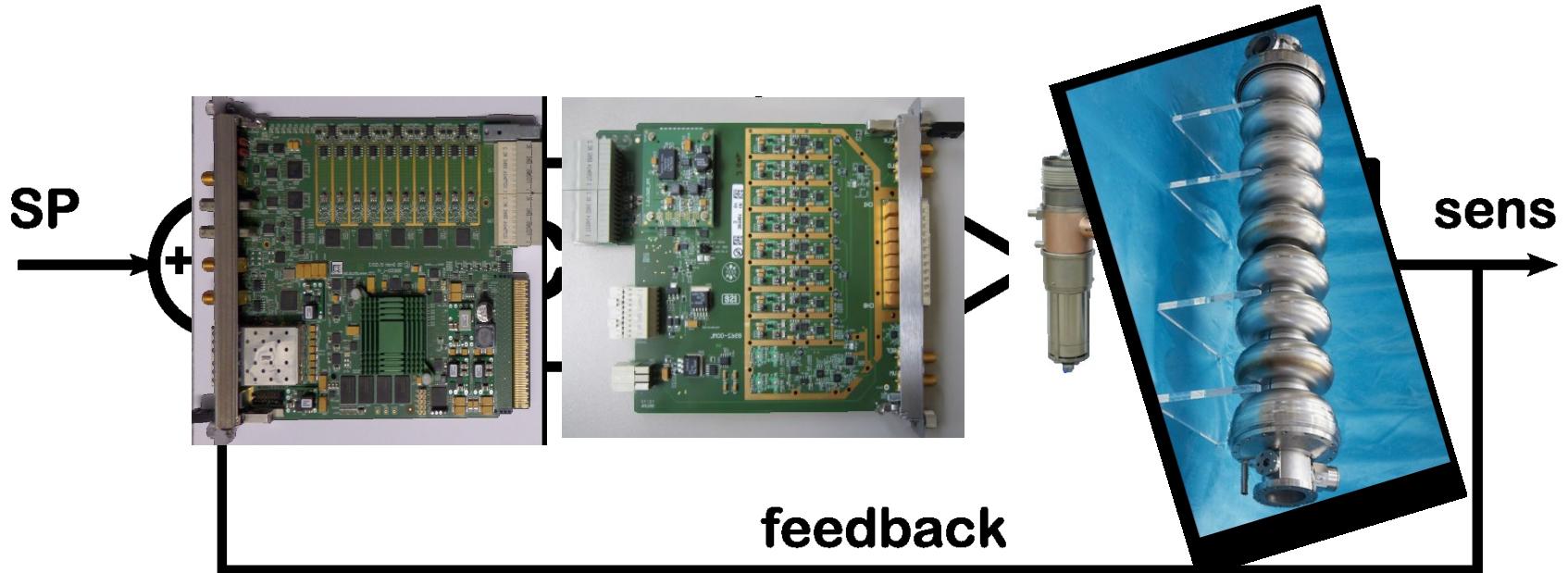
Single Cavity RF and Detuning Controllers

> Control Theory Point of View



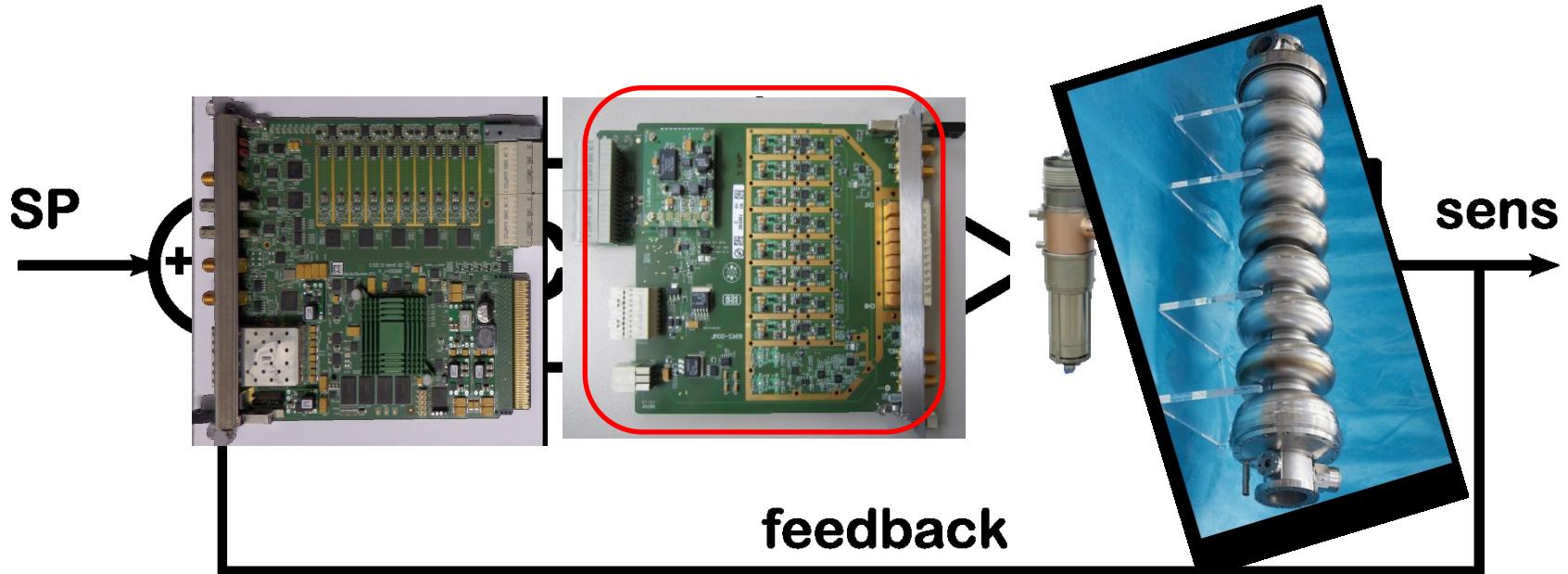
Single Cavity RF Controller

> MTCA.4 Point of View



Single Cavity RF Controller

> MTCA.4 Point of View



MTCA.4 Electronics: RTM 8 Channel Down-Converter 1 channel Vector-Modulator

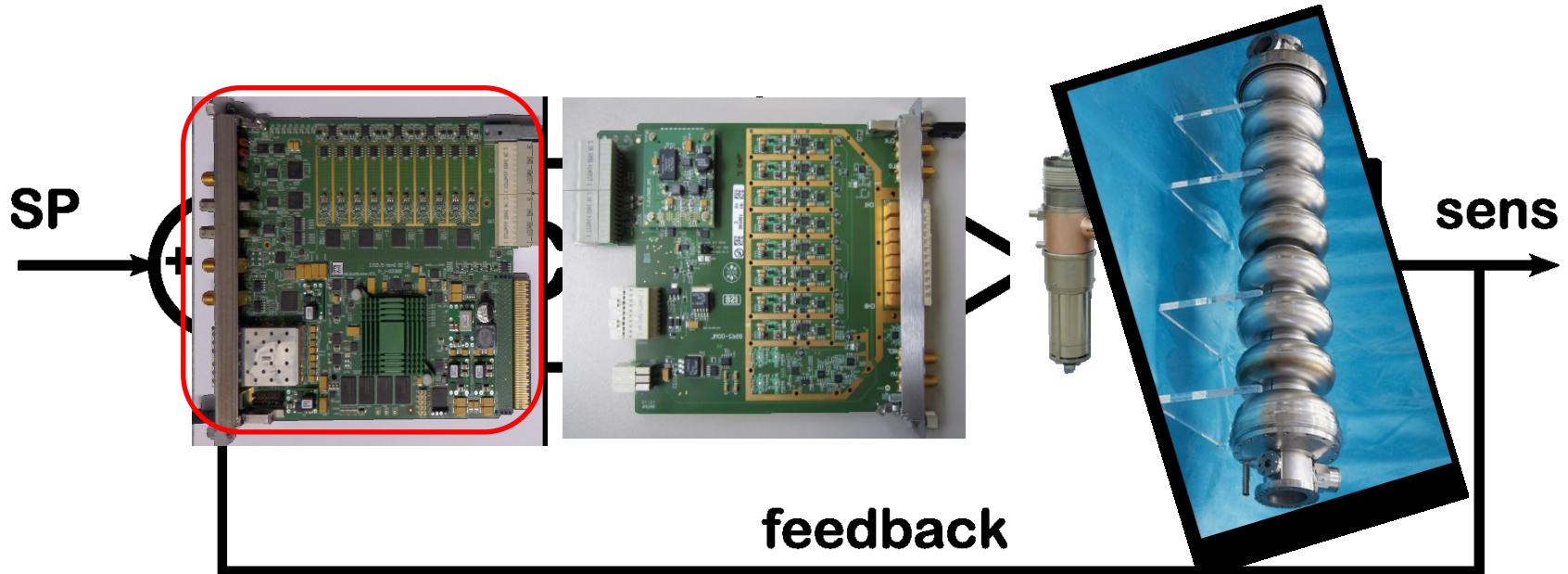
- Double width MTCA.4, Mid-Size Rear-Transition Module (RTM), Class A1.0, A1.1, A1.2 compatible
 - Features:
 - 8 down-conversion input channels (AC) with programmable attn.
 - LO input for analog down-conversion 1.3 GHz
 - 2 analog general purpose inputs (DC)
 - 1 up-conversion output channel (AC) with programmable attn.
 - REF input for analog up-conversion 1.3 GHz
 - ADC clock input (AC) up to 125 MHz
 - Interlock signal support



DRTM-DWC8VM1
licensed by Struck Innovative Systems

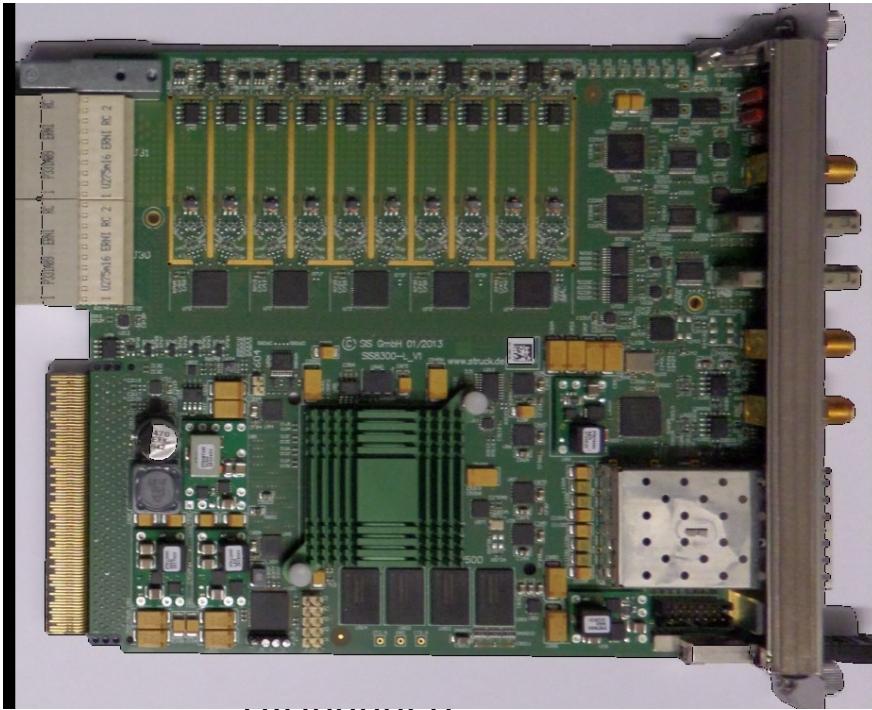
Single Cavity RF Controller

> MTCA.4 Point of View



MTCA.4 Electronics: AMC Fast Digitizer

- Double width MTCA.4, Mid-Size Advanced Mezzanine Card (AMC), Class A1.0, A1.1 compatible
- Features:
 - 10x Analog Inputs: ADC 125 MSPS
 - 2x Analog Outputs: DAC 125 MSPS
 - RTM linked to Virtex 6 FPGA
 - RTM hotplug support
 - PCIe 4x served by Virtex 6 FPGA
 - 6 MGTs (4xLLL + 2x SFP) => up to 10 Gbps

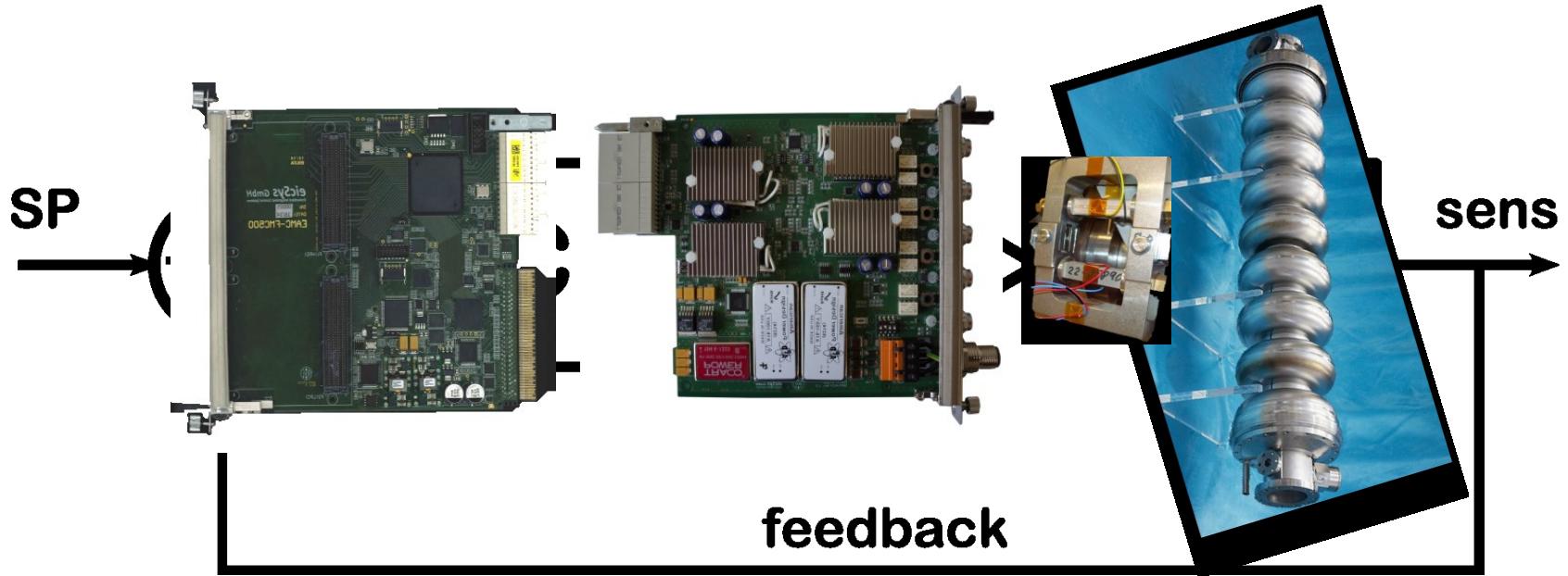


SIS8300LZ

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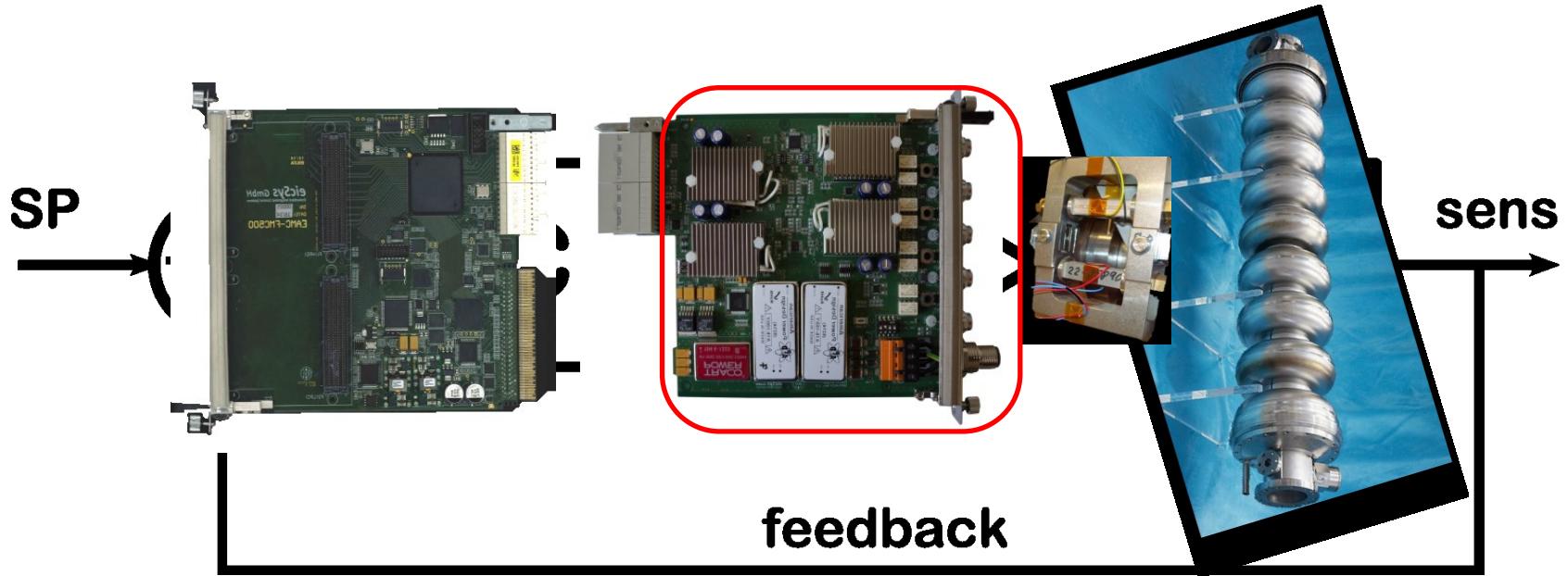
Single Cavity Detuning Controller

> MTCA.4 Point of View



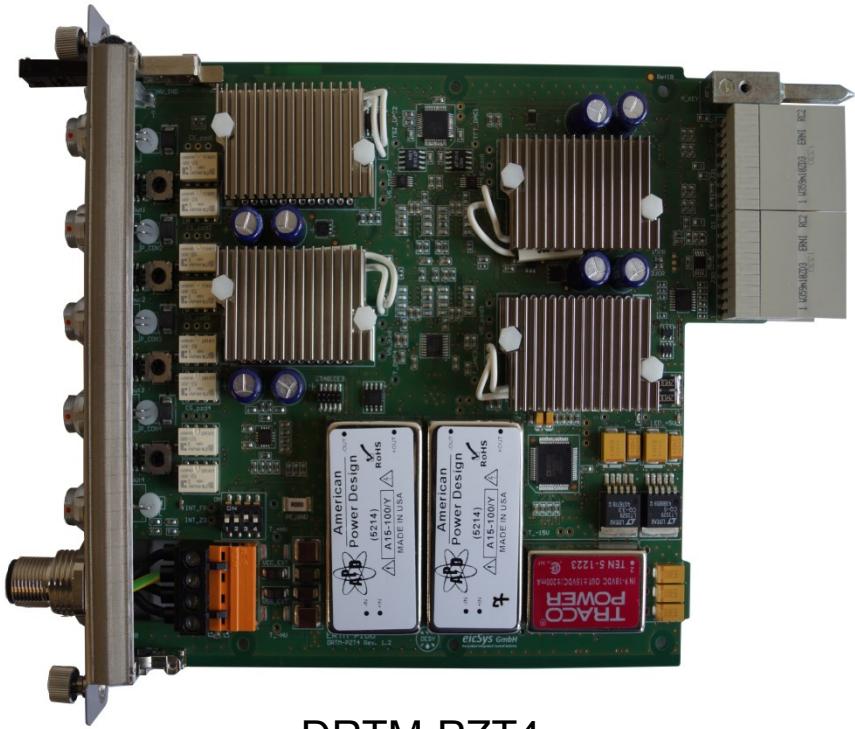
Single Cavity Detuning Controller

> MTCA.4 Point of View



MTCA.4 Electronics: RTM 4 Channel Piezo Driver

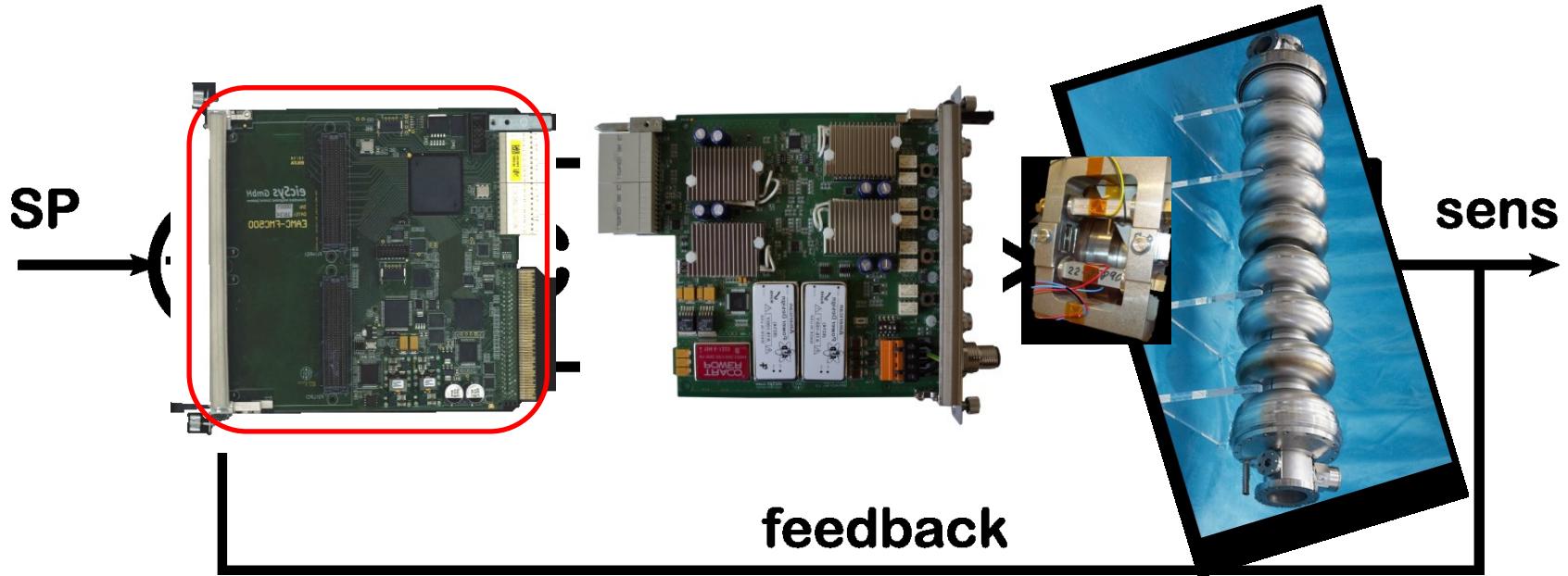
- Double width MTCA.4, Mid-Size Rear-Transition Module (RTM), Class D1.0, D1.1, D1.2 compatible
- Features:
 - Supports 4-channel Piezo Drivers and Piezo Sensors
 - Remotely switchable actuator and sensor functionality
 - Remotely switchable driving input source (ext./int.)
 - 4x DAC 18-bit up to 0.5 MSPS
 - 16x ADC 18-bit up to 100 kSPS
 - Unipolar: 0..+100 V and bipolar: ± 100 V piezo power supplies (ext./int.)
 - Interlock signal support



DRTM-PZT4

Single Cavity Detuning Controller

> MTCA.4 Point of View

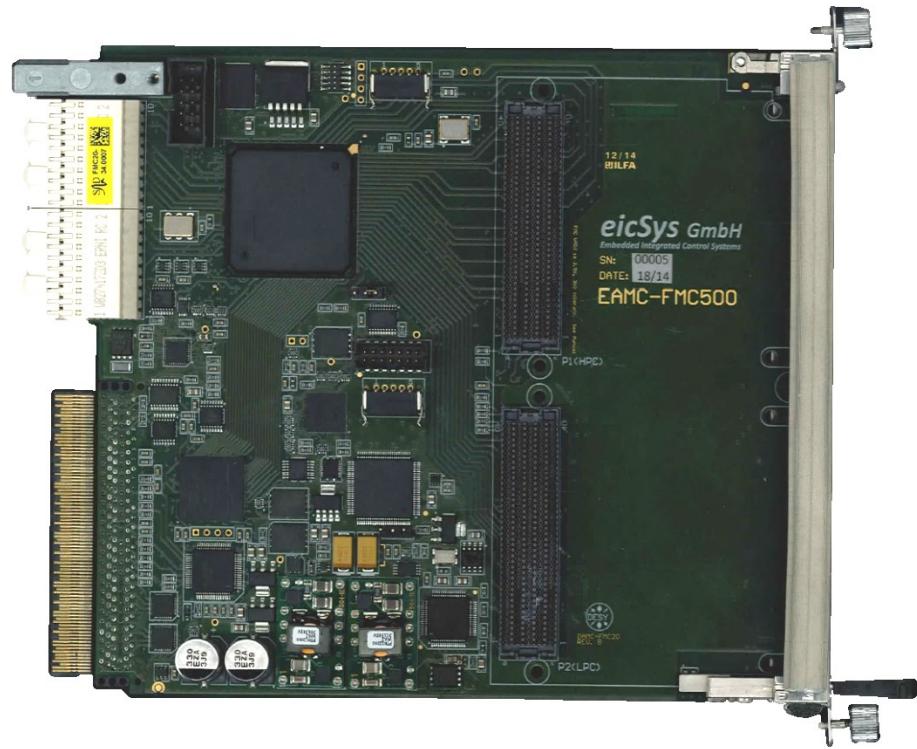


MTCA.4 Electronics: AMC Dual FMC Carrier Board

➤ Double width MTCA.4, Mid-Size Advanced Mezzanine Card (AMC), Class D1.0 compatible

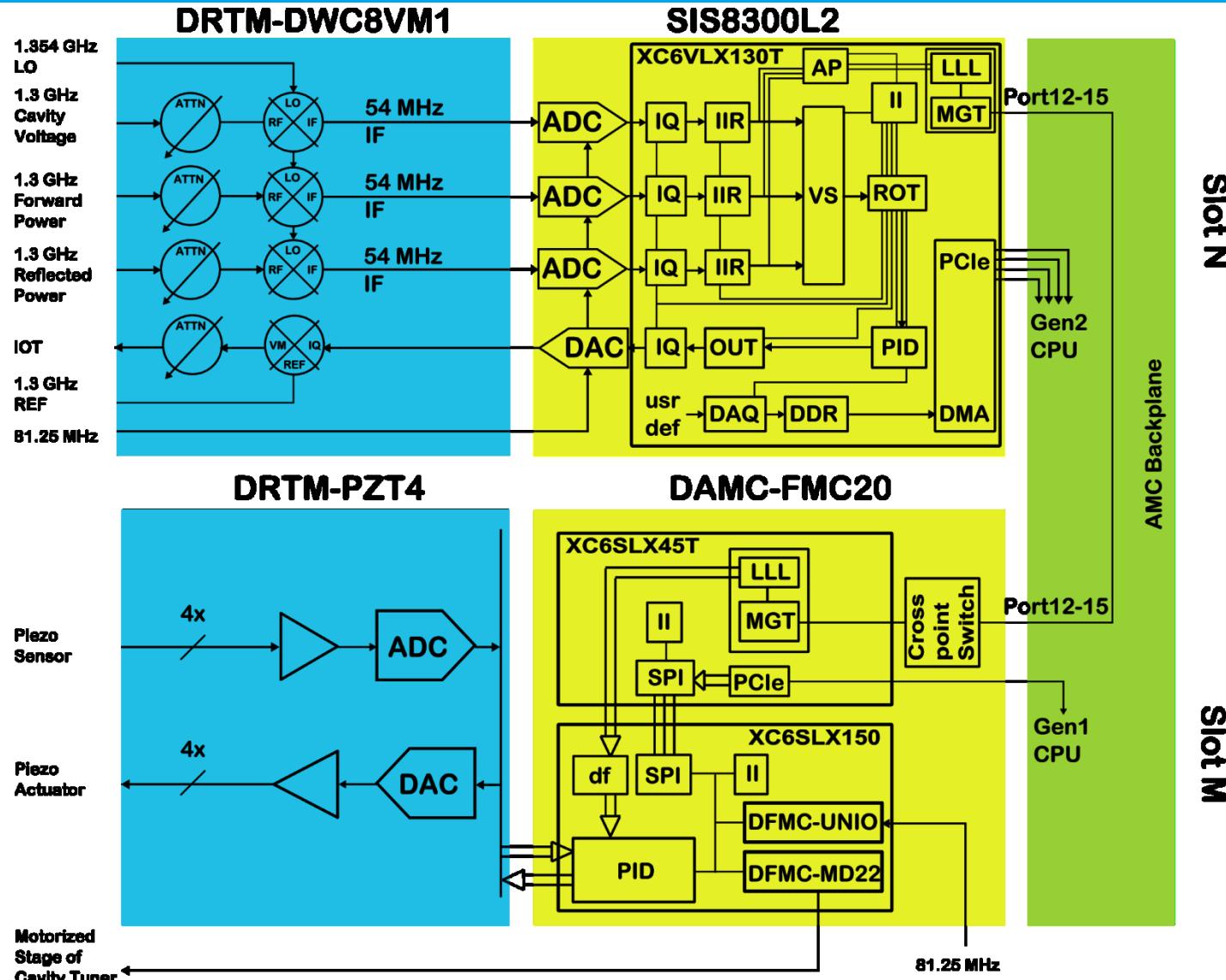
➤ Features:

- 1x HPC and LPC FMC linked to Spartan 6 150 FPGA
- RTM linked to Spartan 6 150 FPGA
- RTM hotplug support
- PCIe 1x => Spartan 6 45 FPGA
- 1x MGT => up to 3 Gbps AMC backplane connection on ports 12-15
- Interlock signal support



DAMC-FMC20

Single Cavity RF and Detuning Controller (Firmware)



Single Cavity RF and Detuning Controller (Software)

```
rf_c=mtca4u('SISL_6')
pzt_c = mtca4u('FMC20_5')
```

rf_ctl_init(rf_c)

rf_ctl_ff(rf_c,val)

rf_ctl_sp(rf_c,val)

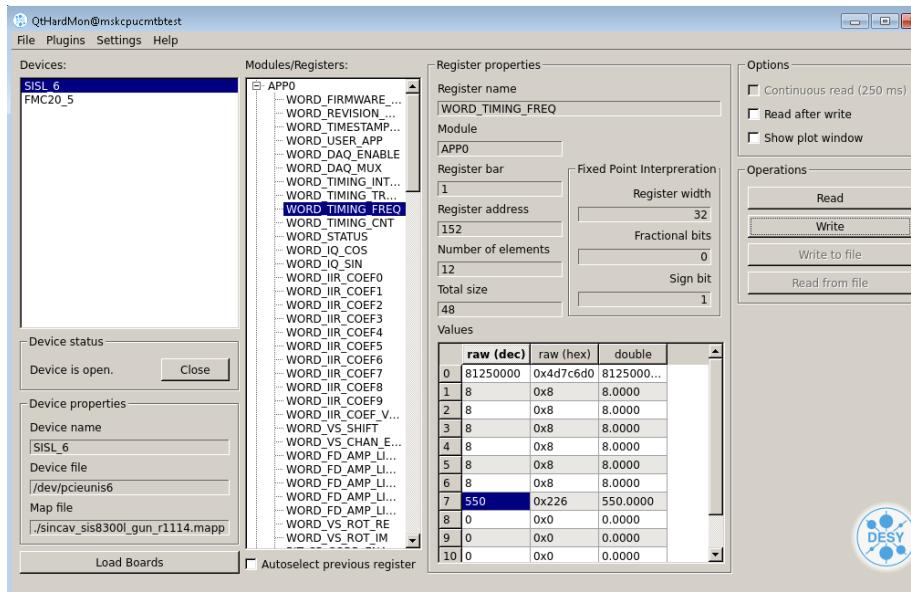
rf_ctl_fb(rc_c,val)

piezo_ctl_init(pzt_c)

piezo_ctl_ff(pzt_c,val)

piezo_ctl_sp(pzt_c,val)

piezo_ctl_fb(pzt_c,val)



```
[a b] = read_dma_daq({rf_c;pzt_c},no_chan, no_samp, addr)
```

Cryo Module Test Bench Facility and CW experiment



Environment:

- 1.3 GHz 9-cell SRF cavities
- $Q_L \sim 1.5 \text{ e}7$
- Bdw. $\sim 86 \text{ Hz}$
- CW operation up to several MV
- High voltage power source: 120 kW IOT tube
- Cavity mechanical tuner (Saclay II model)
 - Sanyo motorized stage for cavity coarse tuning
 - Physik Instrument piezo elements ($\sim 4 \mu\text{F}$) for cavity fine tuning

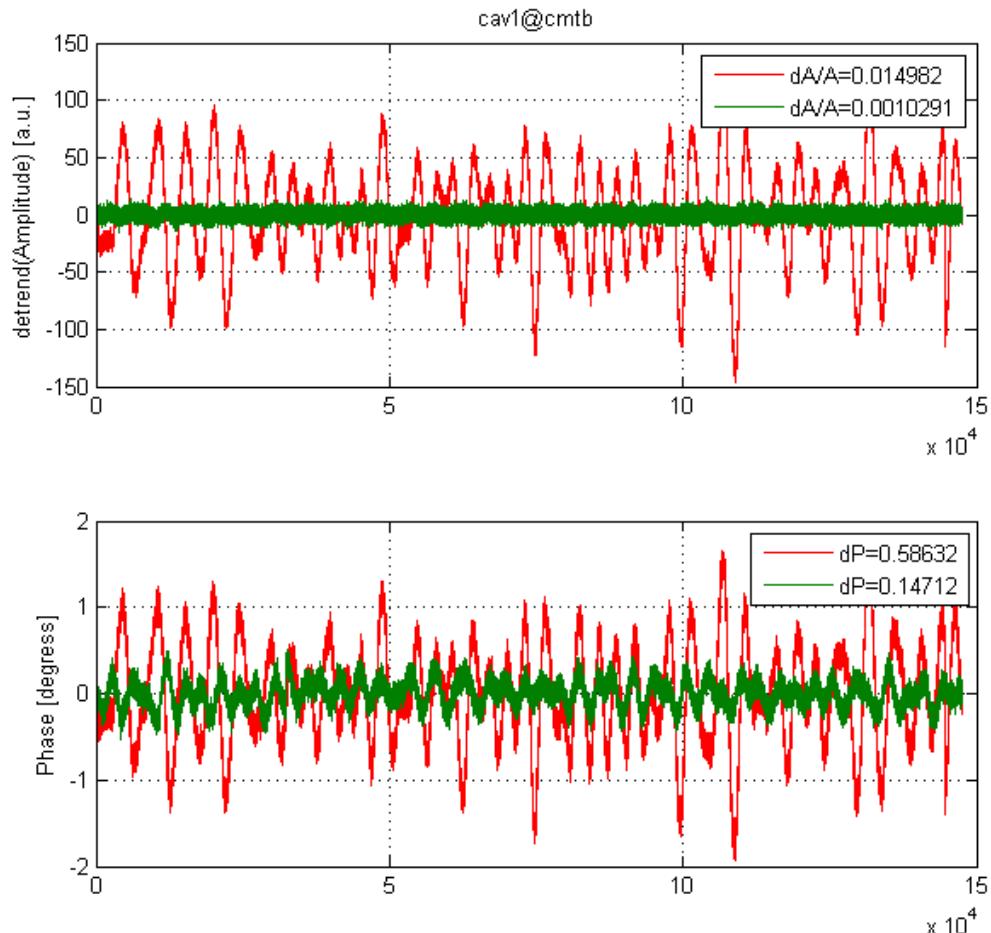


Goal:

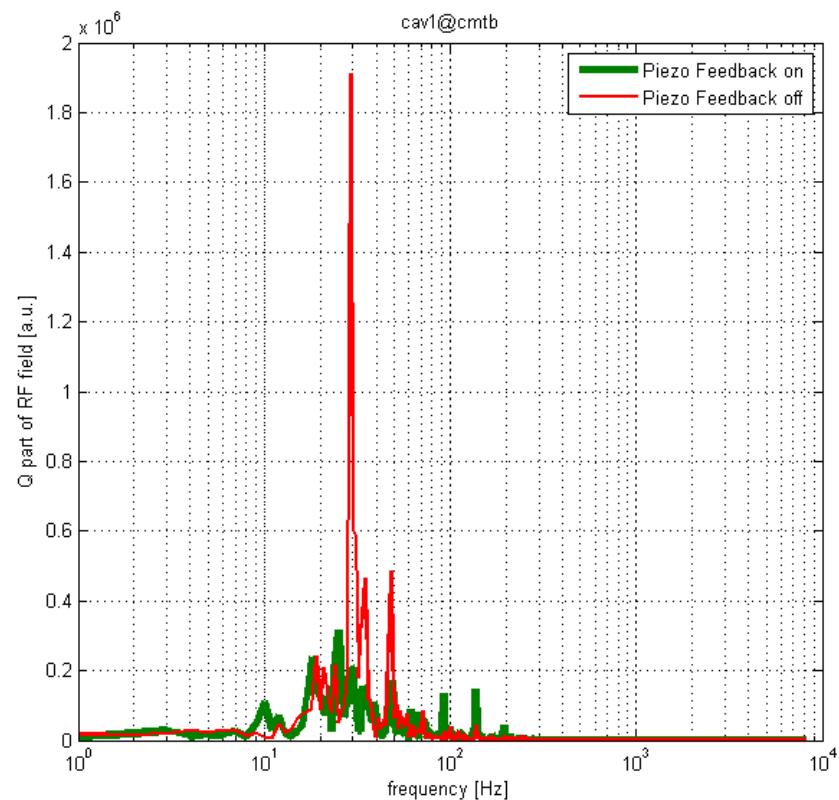
- Stabilize RF field amplitude and phase
- Minimize microphonics effect

Results

> RF feedback

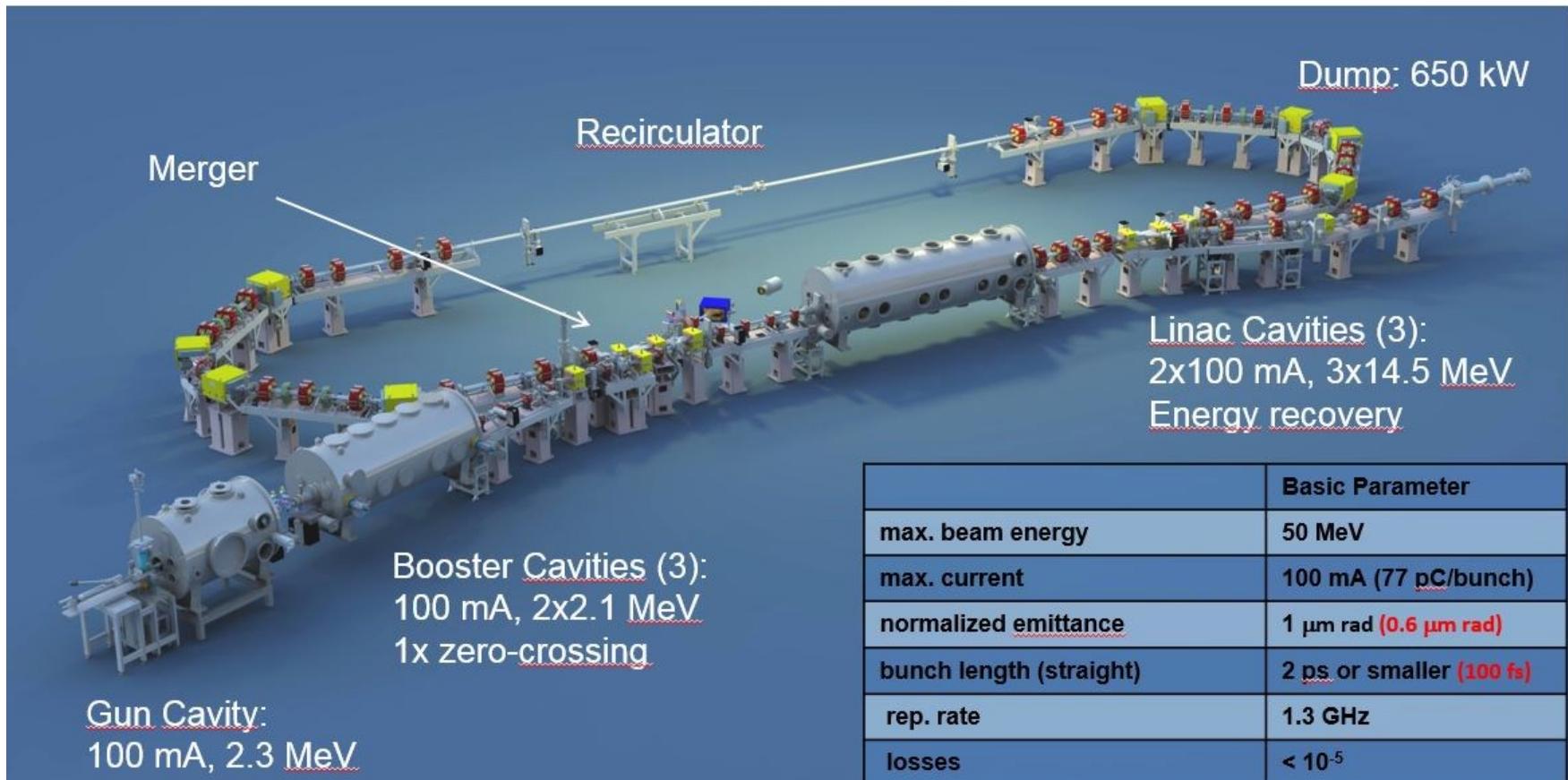


Piezo feedback



Possible Applications

- > Berlin Energy Recovery Linac Project **bERLinPro** at the Helmholtz Zentrum in Berlin:



Courtesy by P. Echevarria

Possible Applications

➤ Berlin Energy Recovery Linac Project **bERLinPro** at the Helmholtz Zentrum in Berlin:

- project goal is the generation of a high current (100 mA), low emittance (below 1 mm mrad) CW electron beam at 2 ps rms bunch duration
- The LLRF control system will be implemented using the MTCA.4 technology and due to the fact each cavity of the accelerator will be fed by its own RF power source (klystrons for the gun and booster and SSA for the linac), the single cavity approach will be used.
- The precise RF amplitude and phase control needed due to the high beam current
- The microphonics compensation needed due to narrow bandwidth of the cavities (especially at the linac module)
- All of the cavities will be equipped with a blade tuner which will be driven by a stepper motor for slow coarse tuning and four piezo actuators for a fine fast compensation



Courtesy by P. Echevarria

Thank You for Attention

