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26th European Synchrotron Light Source RF Workshop

Upgrades of RF amplifiers towards Elettra 2.0

C. Pasotti, A. Cuttin, M. Rinaldi, L. Bortolossi

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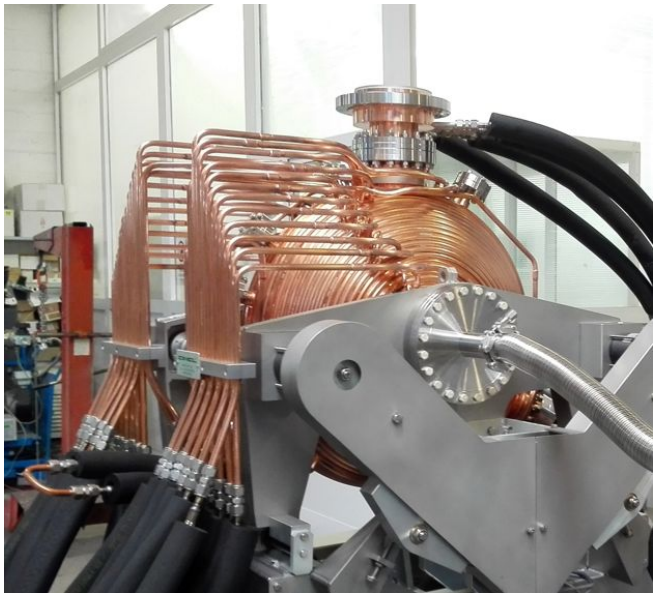
Summary

1. Solid State power Amplifiers for Elettra and Elettra 2.0
2. SSAs performance
3. Control / radioprotection integration
4. RF lines layout
5. Booster PA
6. Challenges and Operations
7. Lessons Learned

Storage Ring RF Systems for Elettra 2.0

Baseline:

- RF frequency: 500 MHz
- Normal Conducting (NC) cavities
- same number of NC cavities (4)
- “Elettra type” cavity



Solid State power Amplifier (SSA) requirements:

- Power to the cavity: increase to > 100 kW
- Efficiency improvements
- Reliability

CONCLUSION: new SSAs can (must??) be procured and installed during the last runs of Elettra.

Solid State at Elettra (SSAtE) project launched
Contract awarded to Cryoelectra

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SSAs key features and specifications

- Dynamic range from 1 W to 130 kW
- RF output power $P_{out} \geqslant 130$ kW with $P_{in} = 0$ dBm
- Gain G > 50 dB at $P_{out} = 130$ kW
- Efficiency: better than 48% (single module 60%)
- Level of harmonics: < -40 dBc
- Spectral purity: < -75 dBc over 20 MHz
- Tolerance to failure of 19 RF transistors ($P_{out} = 100$ kW)
- Tolerance to failure of 6 PS modules ($P_{out} = 100$ kW)

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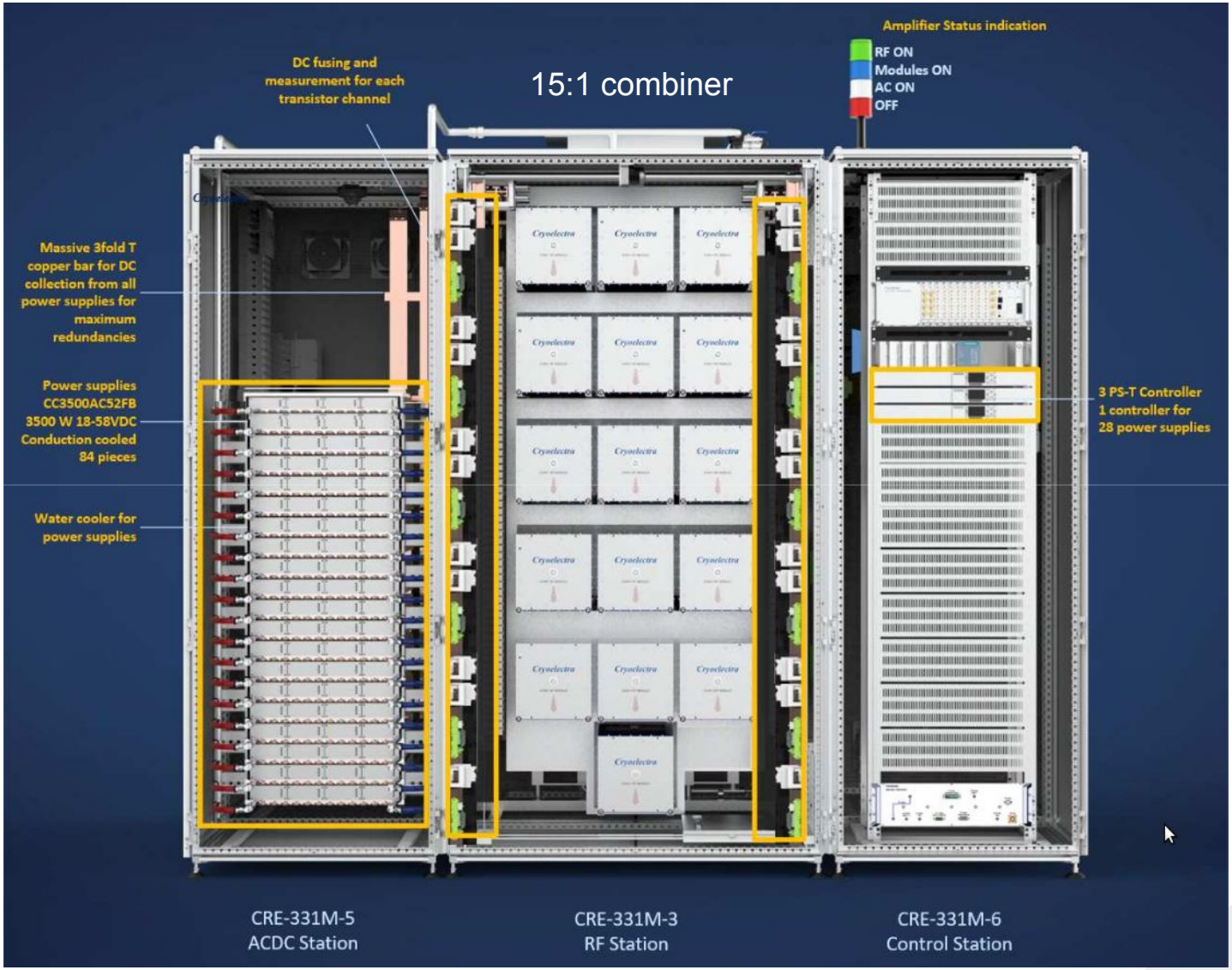
SSA overall layout



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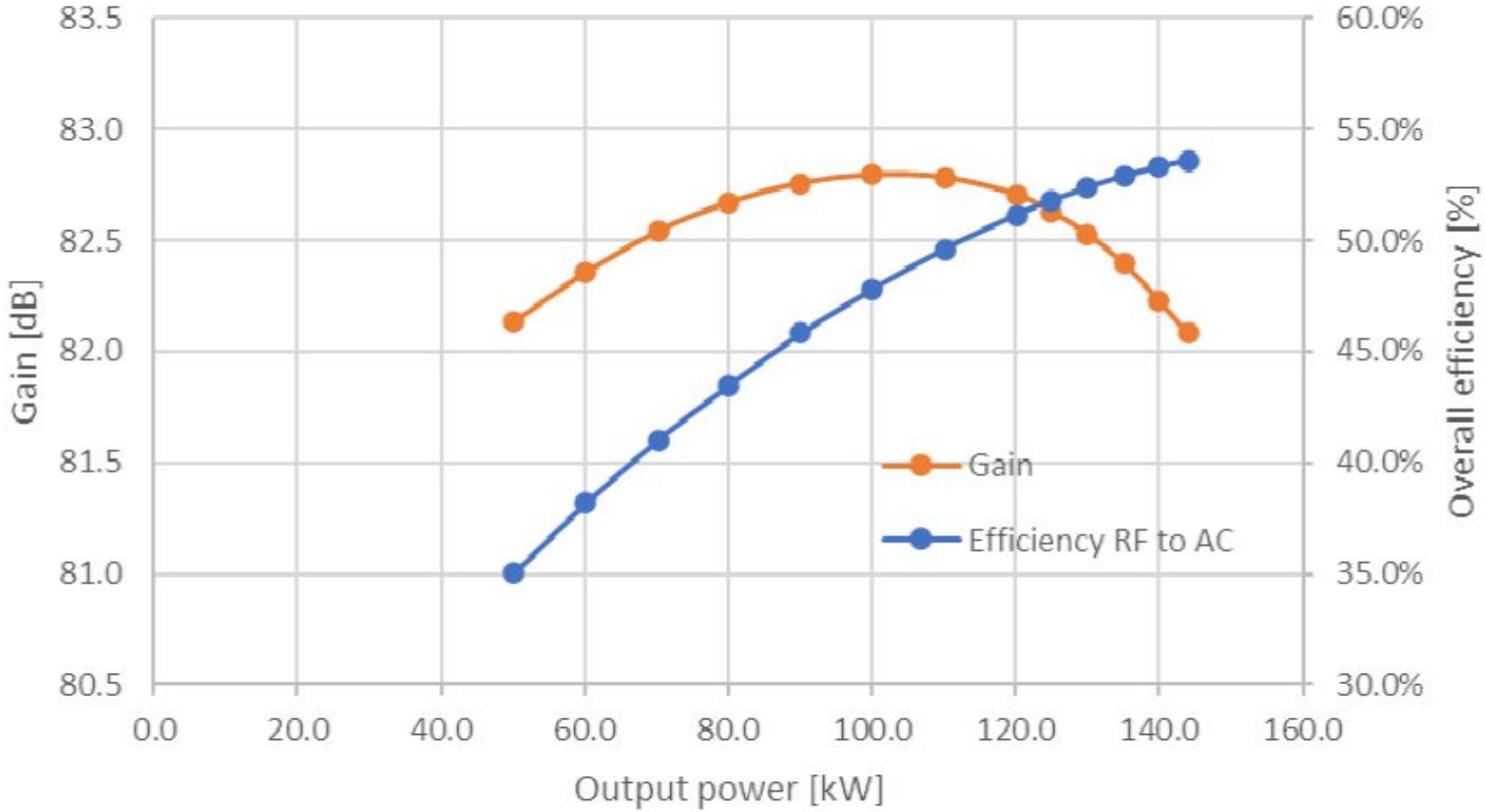
SSA overall layout

Gain and efficiency



CRE-331M-001, Drain Voltage 44 V

Gain stability is within the range of R&S NRP-Z81 power sensor measurement uncertainty

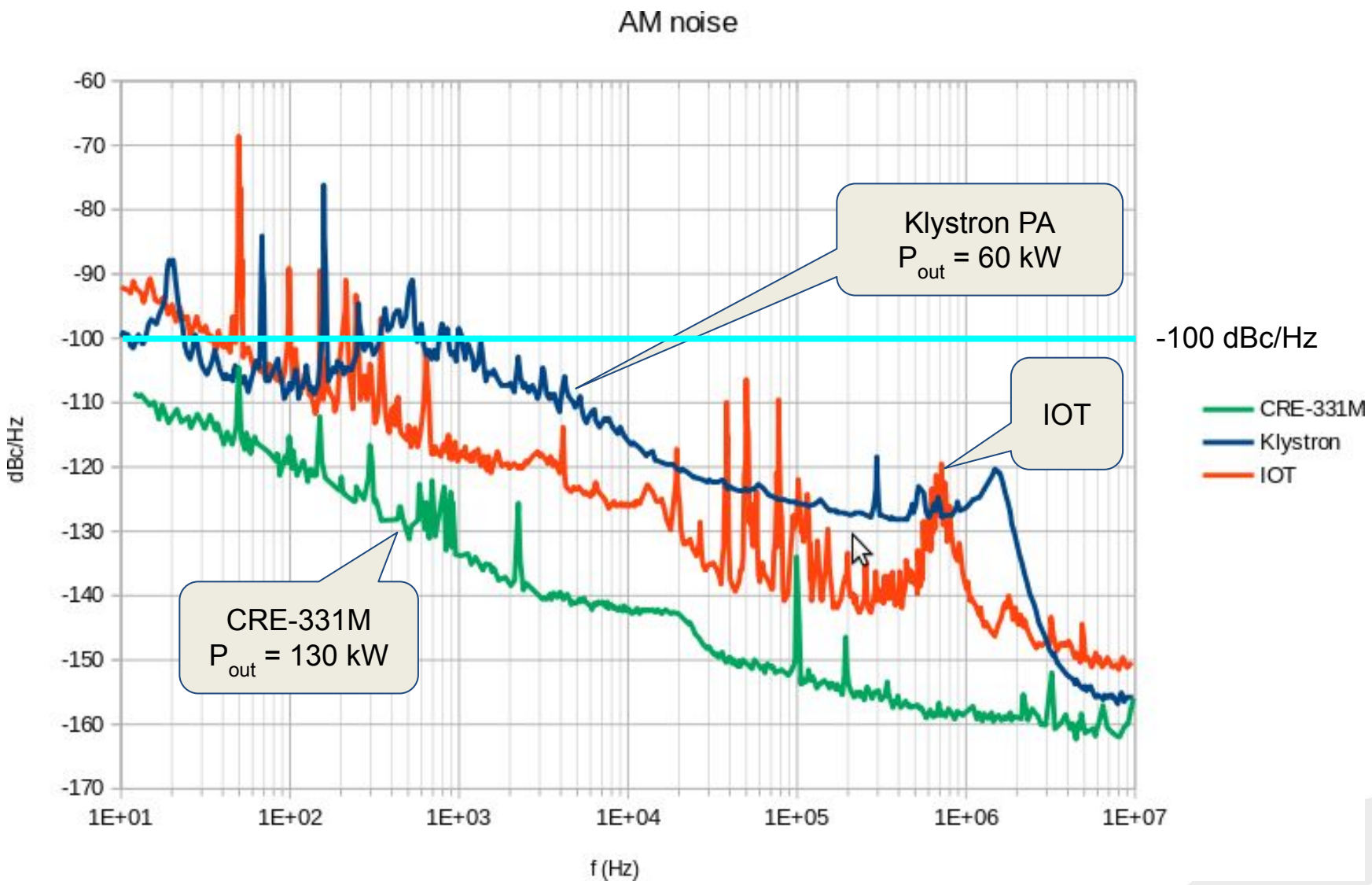
Efficiency

- Wall-plug to RF efficiency: 52% at P_{out} = 130 kW
- Base controller vs PS-T controller
- PS-T controller: better drain voltage regulation and diagnostics

CRE-331M-nnn	P_{out} @ 2 GeV	WP Efficiency	Controller
001	45 kW	33%	Base
003	46 kW	33%	Base
004	47 kW	42%	PS-T
005	52 kW	45%	PS-T

25 + 25 kVA of saved power

Beam quality



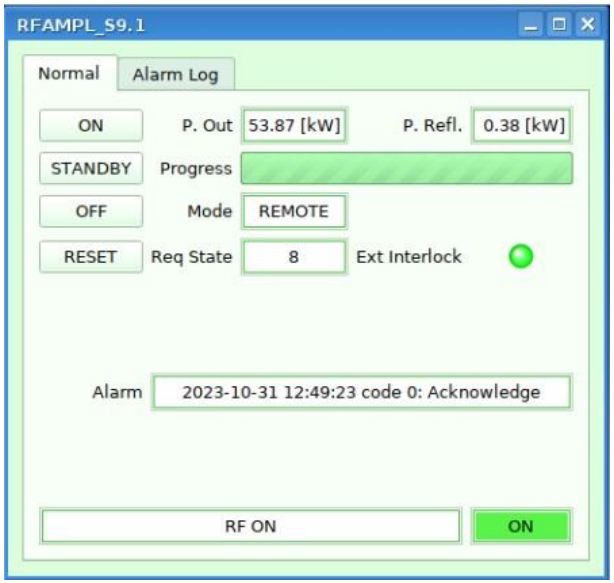
Control room & Radioprotection integration

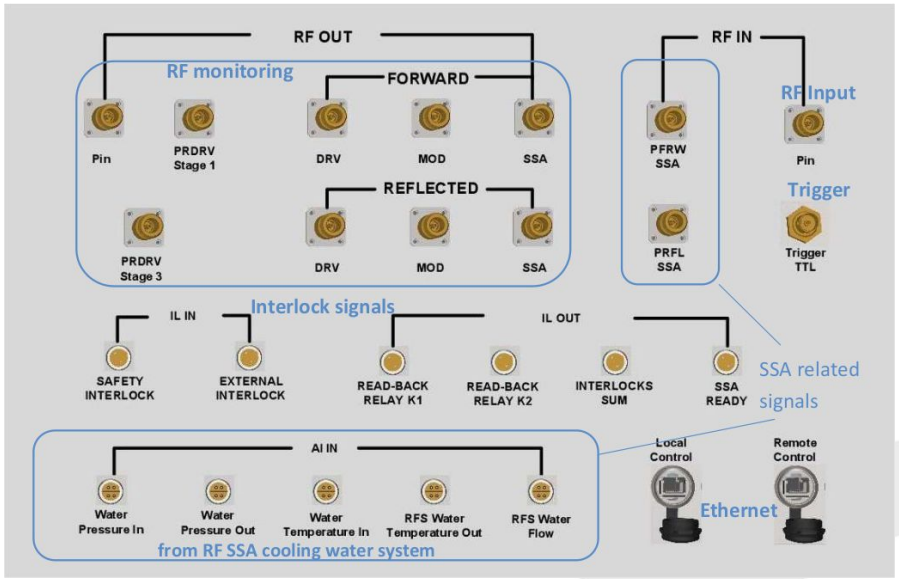
Operator interface

- internally designed in QT
- full panel with all the variables
- atomic panel for basic operations and commands
- remote desktop as last resort before access in Service Area
- training for the operators

Radioprotection integration

- Safety interlock for personnel protection in the SSA





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RF line - SAT provisional setup

“Manual” switch

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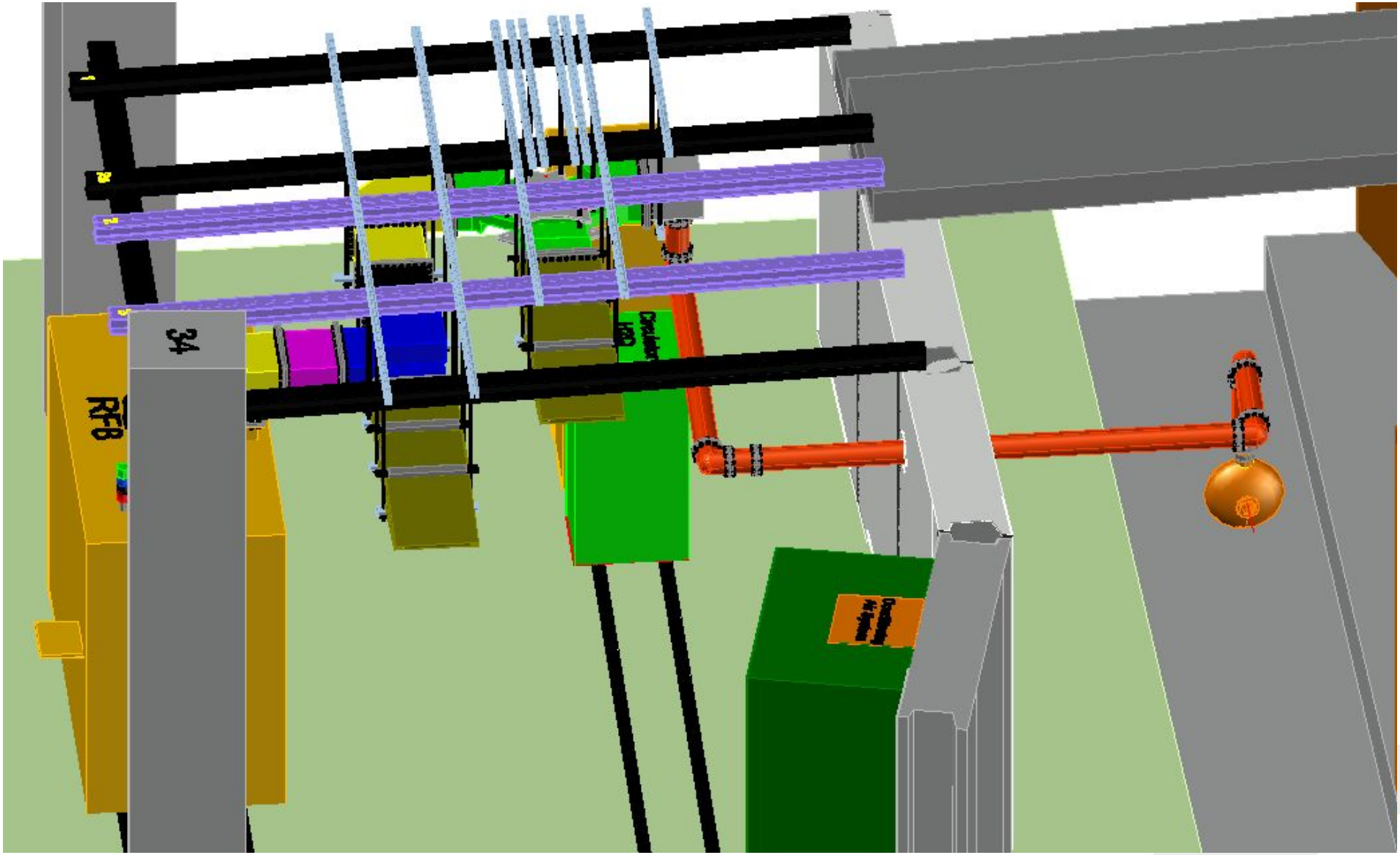
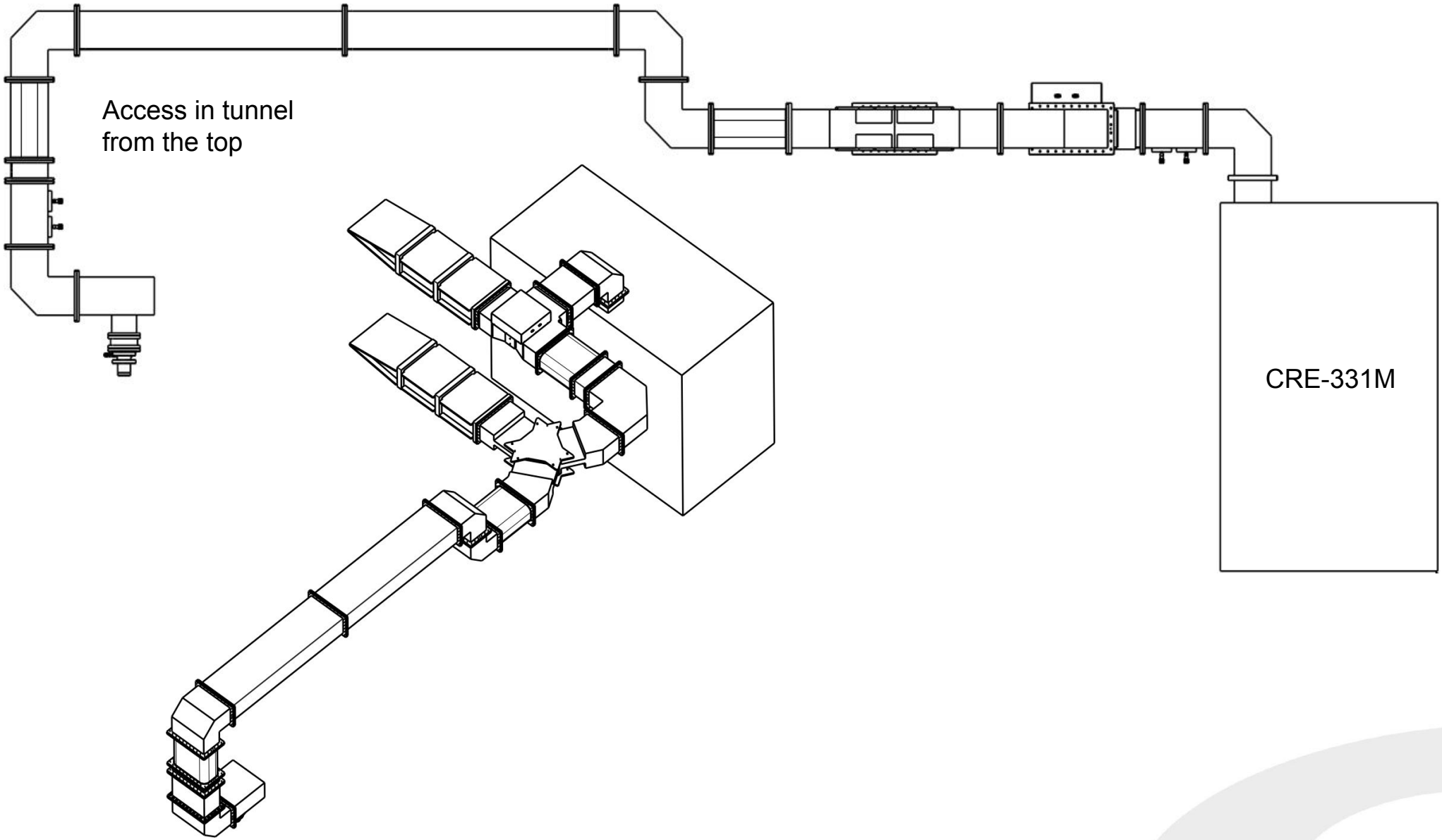
RF line - Elettra “1.5” setup



RF line - Elettra 2.0 setup



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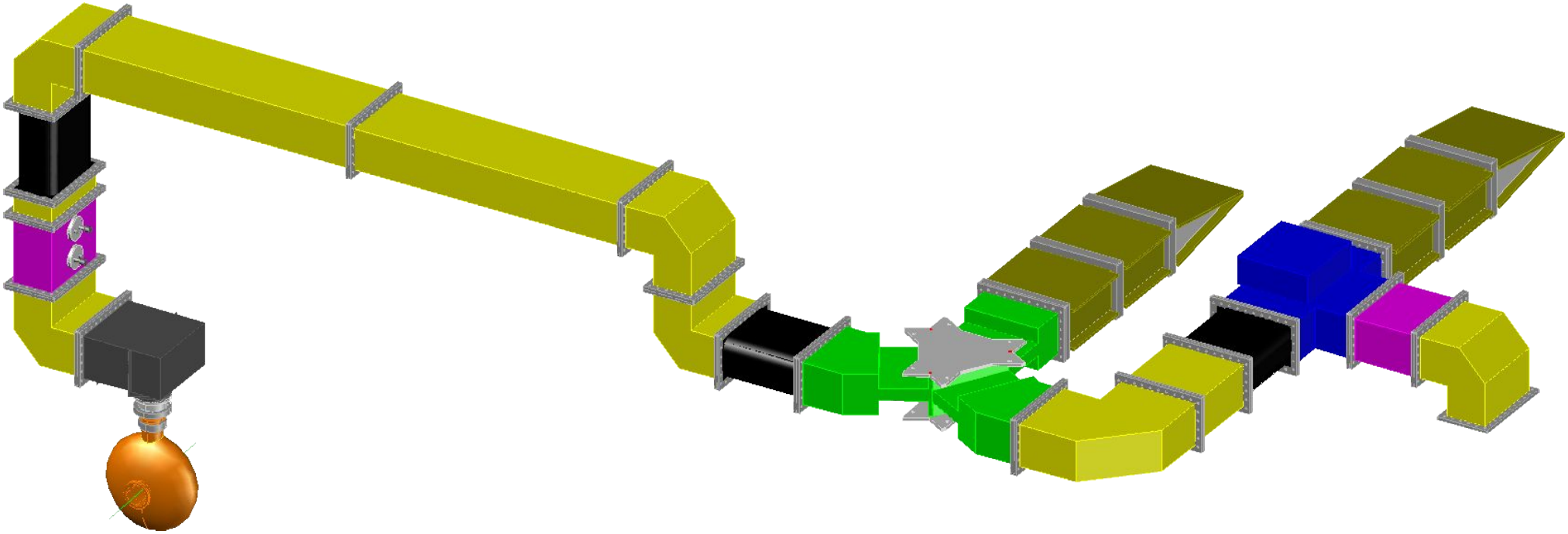
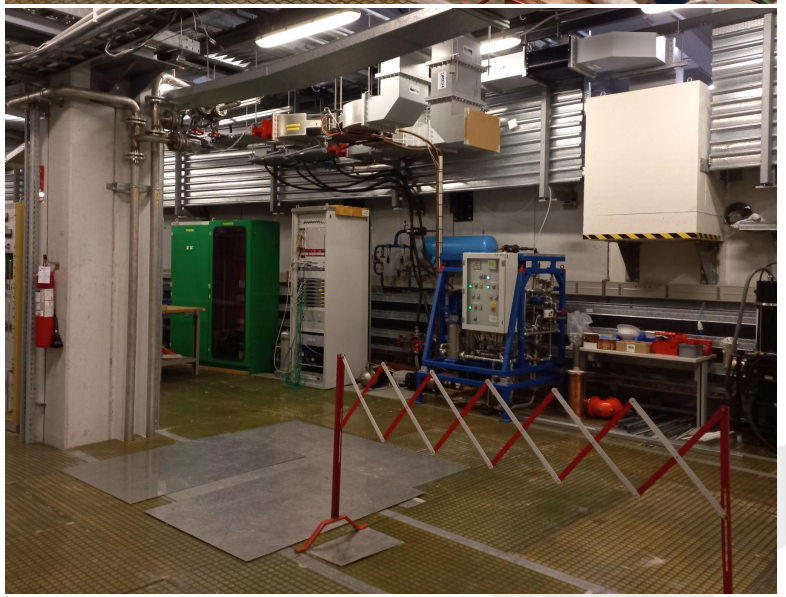
RF line - Elettra 2.0 setup



Booster Power Amplifier

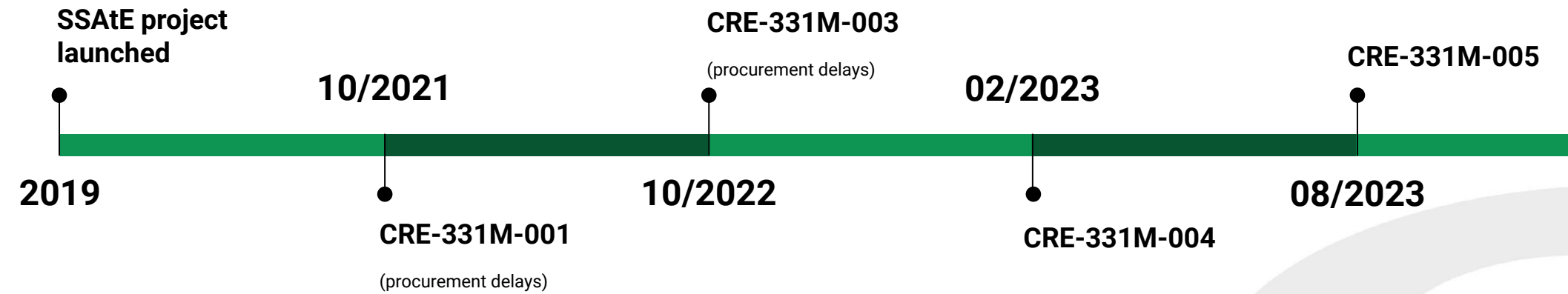
One IOT PA repurposed for redundancy / power margin

- Shutdown #1:
  - from twin PA setup to single PA setup
  - RF combiner removal
  - 1 PA cleanup
- Shutdown #2:
  - complete removal and cleanup
  - move 1 IOT PA to Booster
  - install SSA
- Shutdown #3: IOT power-up



Challenges and Operations

- Installations schedule constrained to Elettra calendar
  - week 1: preparations, positioning, assembly
  - week 2: Site Acceptance Test (including 24 h non stop operation)
  - week 3: integration with cavity, radioprotection, controls
- 1 SSA in - 1 old PA out (burn your bridges carefully!)
- 4/4 RF plants operational at every startup
- > 14000 h logged so far (P_{out}< 60 kW)
- ~0 infant mortality (1/1024 transistor, 1/336 PS)



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Lessons learned

- on site power measurement will not be the manufacturer power reading
- account for *a lot* of advance preparation (especially with other teams)
- problems like to hide in the interfaces (of any kind)
- be(a)ware of software interlocks
- stock up on spare parts (*all parts*, they are not easy to get as you might think)
- detectors may fail you surprisingly (and cause false positive interlocks)
  - prefer functionality over high-end tech
  - verify calibration
- verify that good version control practices are in place

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Conclusions

- CRE-331M SSAs configuration to be finalized:
  - ✔ PS-T controller installation
  - ✔ final software validation
- Experience curve for the machine *and* the company (2 SSAs in 1 year)
- Good responsiveness from the company
- Continuous support and communication

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