MOPV012

ESRF | The European Synchrotron

The ESRF-EBS Simulator: a Commissioning Booster

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ICALEPCS workshop 14th-22nd October 2021, Shanghai

HOW TO TEST CONTROL SOFTWARE?

Test in progress….

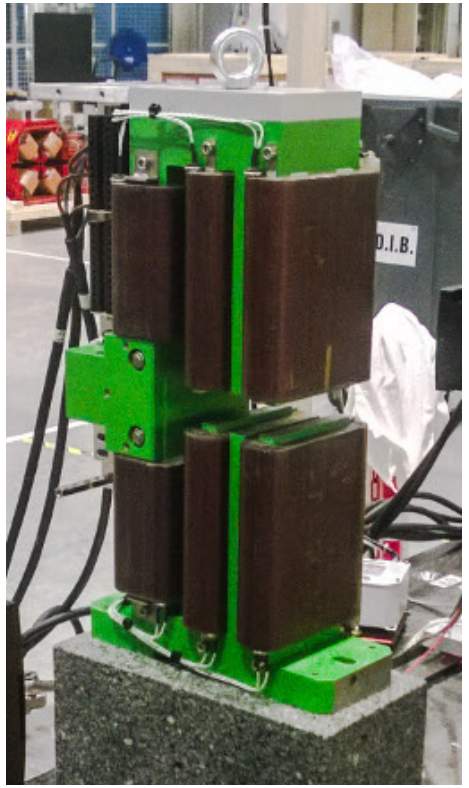
Tested ✓

Tested ✓

User ▷ Control software ▷ Power Supply ▷ electromagnet

Go to 50A!

TANGO controls



If the equipment we want to test can be **separated** from the rest it may be close to trivial.

THERE MAY BE MORE LAYERS OF SOFTWARE

Test in progress….

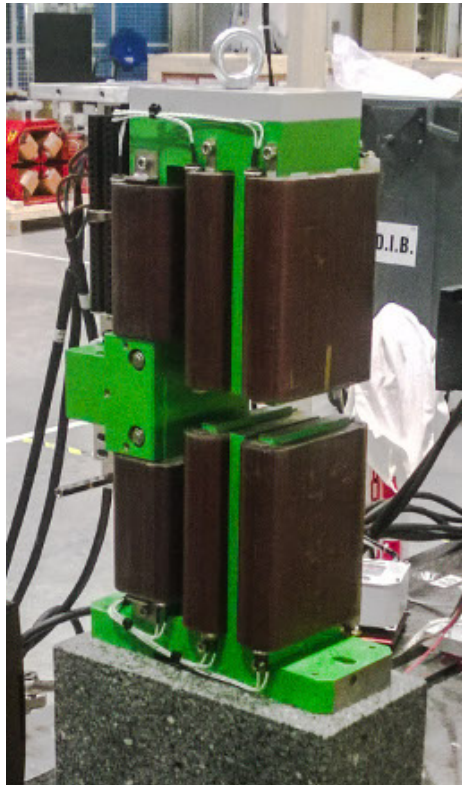
Test in progress….

Tested ✓

Tested ✓

User → Strength-2-Current → PS Control → Power Supply → electromagnet

Go to 100 T/m!



There may be **several layers** of software

THERE MAY BE MORE LAYERS OF HARDWARE AND SOFTWARE

User

Go to 100 T/m!

Test in progress….

Strength-2-Current

TANGO

Test in progress….

PS Control

TANGO

Test in progress….

TANGO

Test in progress….

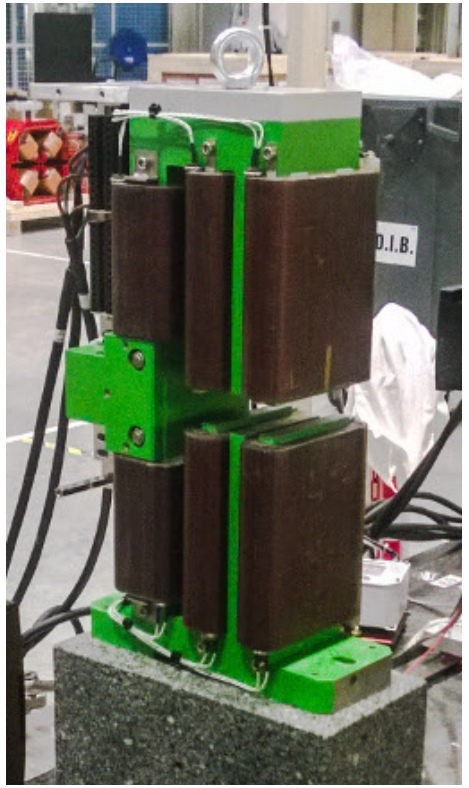
TANGO

Tested ✓

Power Supply

Tested ✓

electromagnet



There may be **several layers** of hardware and software

THERE MAY BE MORE LAYERS OF LAYERS OF HARDWARE AND SOFTWARE

User

Go to :

100T/m

30T/m

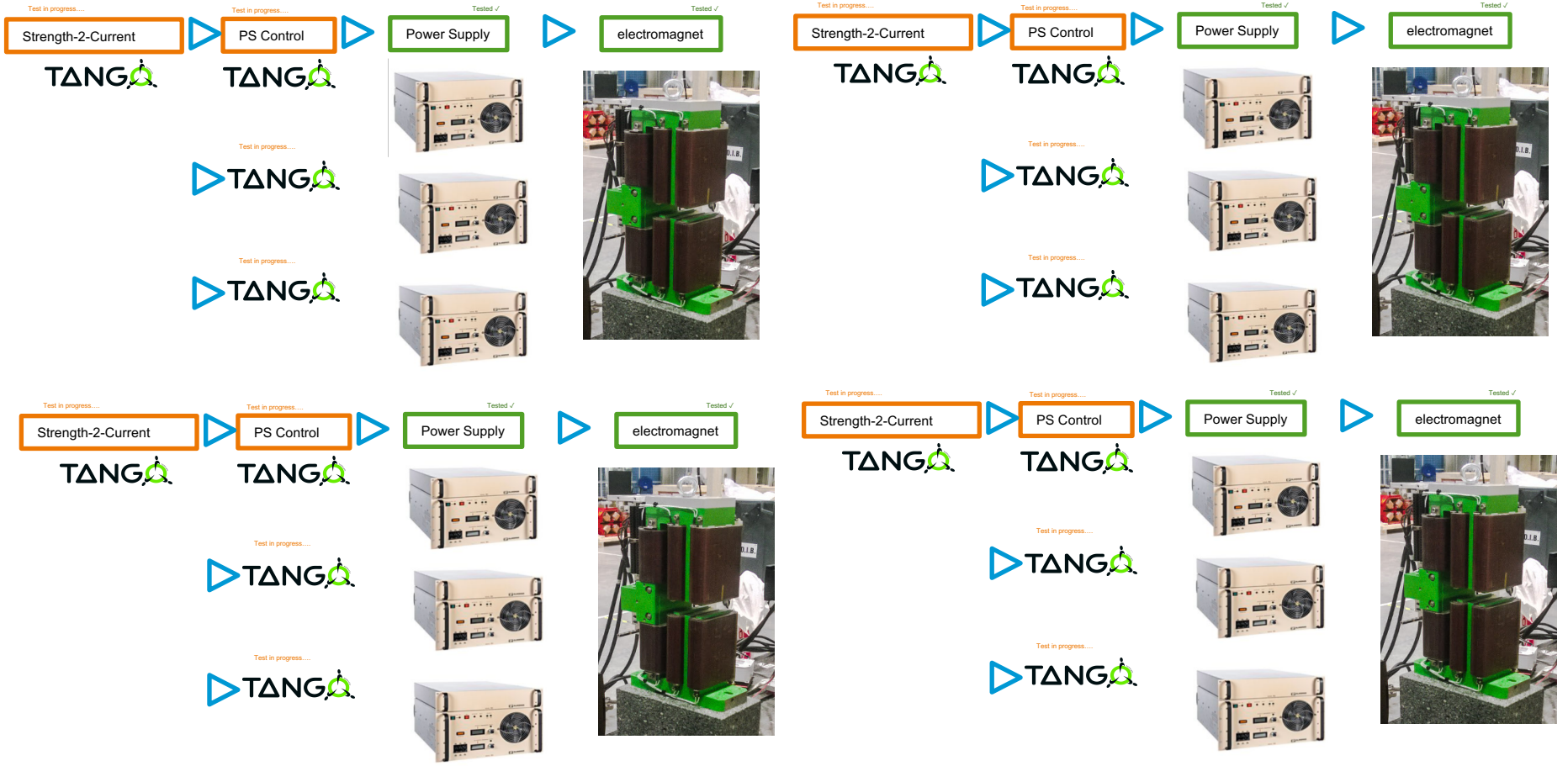
21T/m

-10T/m

61T/m

-120T/m

…



There may be **several layers of layers** of hardware and software

IN SOME CASES IT IS NOT POSSIBLE TO SEPARATE FROM THE WHOLE

Test in progress….

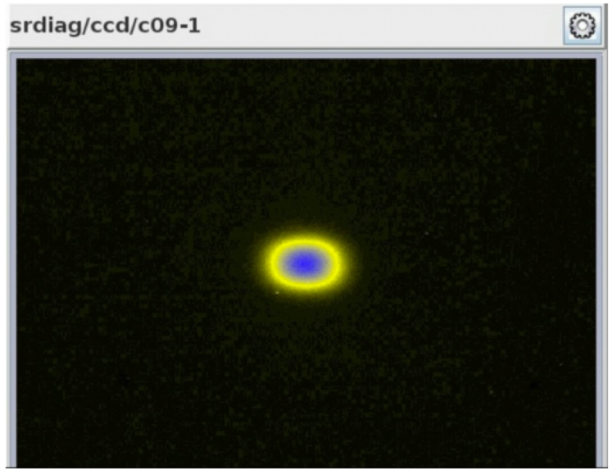
Tested ✓

Tested ✓

User ▷ Control software ▷ hardware ▷ Electron beam

Go to
133 pm!

TANGO controls



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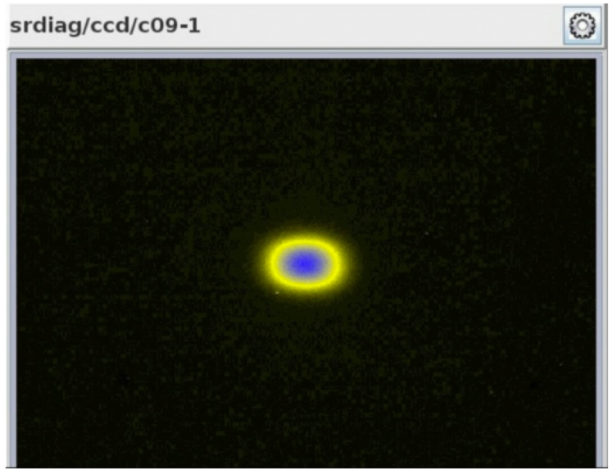
TANGO controls



What to do?

In some cases it is **not** possible to separate from the whole

THE EBS SIMULATOR

Test in progress….

Tested ✓

Tested ✓

User → Control software → hardware → Electron beam

Go to
133 pm!

Replace the electron beam by software!

Applications

High level Device Servers

To be tested in the EBS-Simulator
CTRM PRODUCTION SOFTWARE

THE EBS SIMULATOR

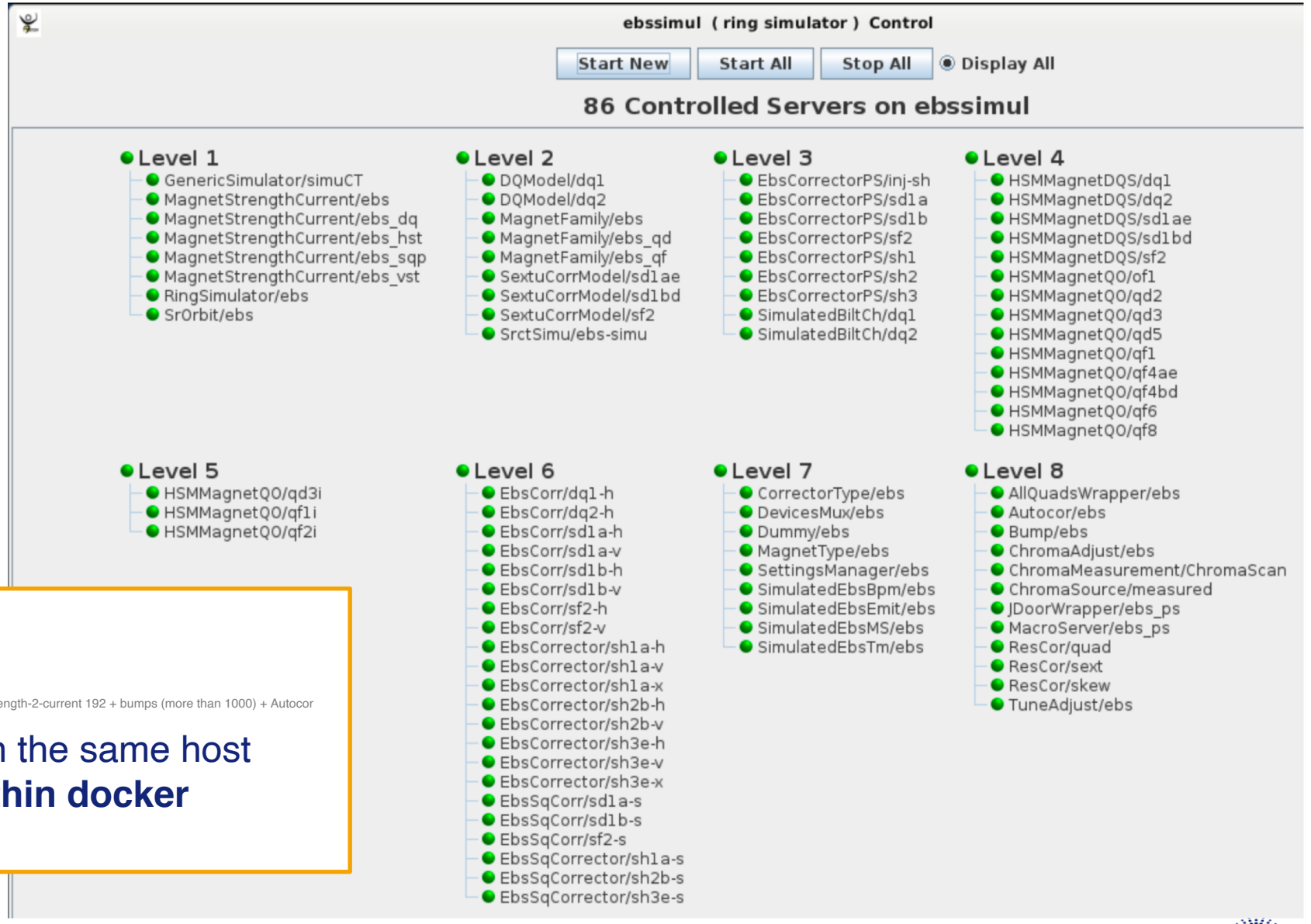
Simulated Hardware DS

Simulated electron Beam response

Simulated beam diagnostics DS

Same DeviceNames/Attributes/Commands as CTRM

JIVE + DOCKER



servers **(86)** .
devices (**~4000**)

514+96+288+64+384+288+288 + 4*288 +96 + 50(vectorized) + diagnostics 320 + 2 + strength-2-current 192 + bumps (more than 1000) + Autocor

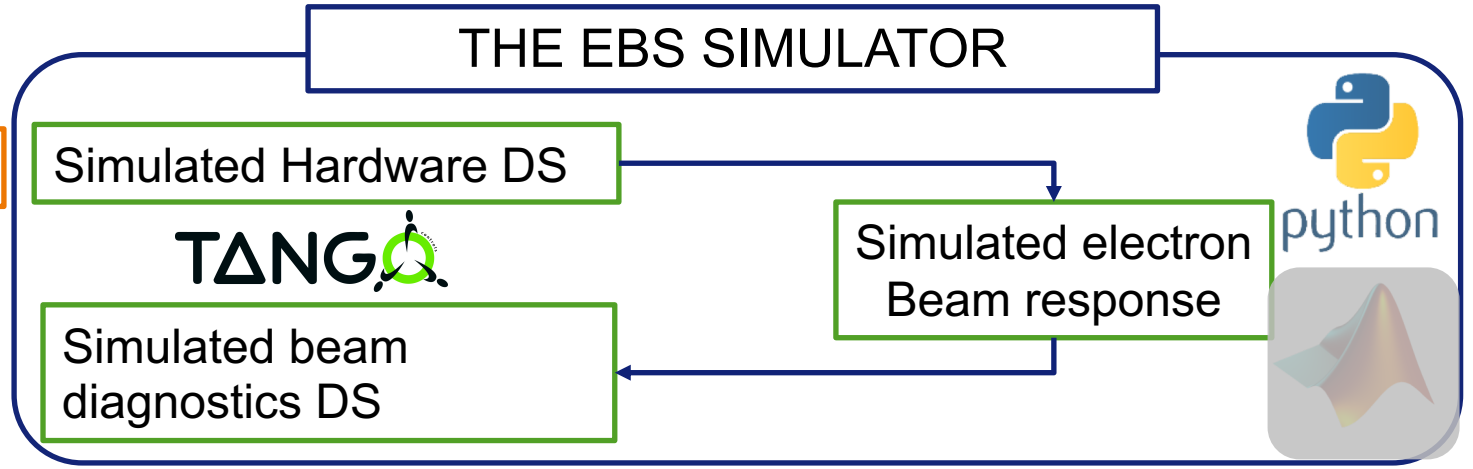
To have multiple simulators on the same host computer, **simulators run within docker images**: 4 simulators running.

WITH THE EBS SIMULATOR WE CAN TEST APPLICATIONS ON BEAM NOW.

Applications

High level Device Servers

To be tested in the EBS-Simulator
CTRM PRODUCTION SOFTWARE

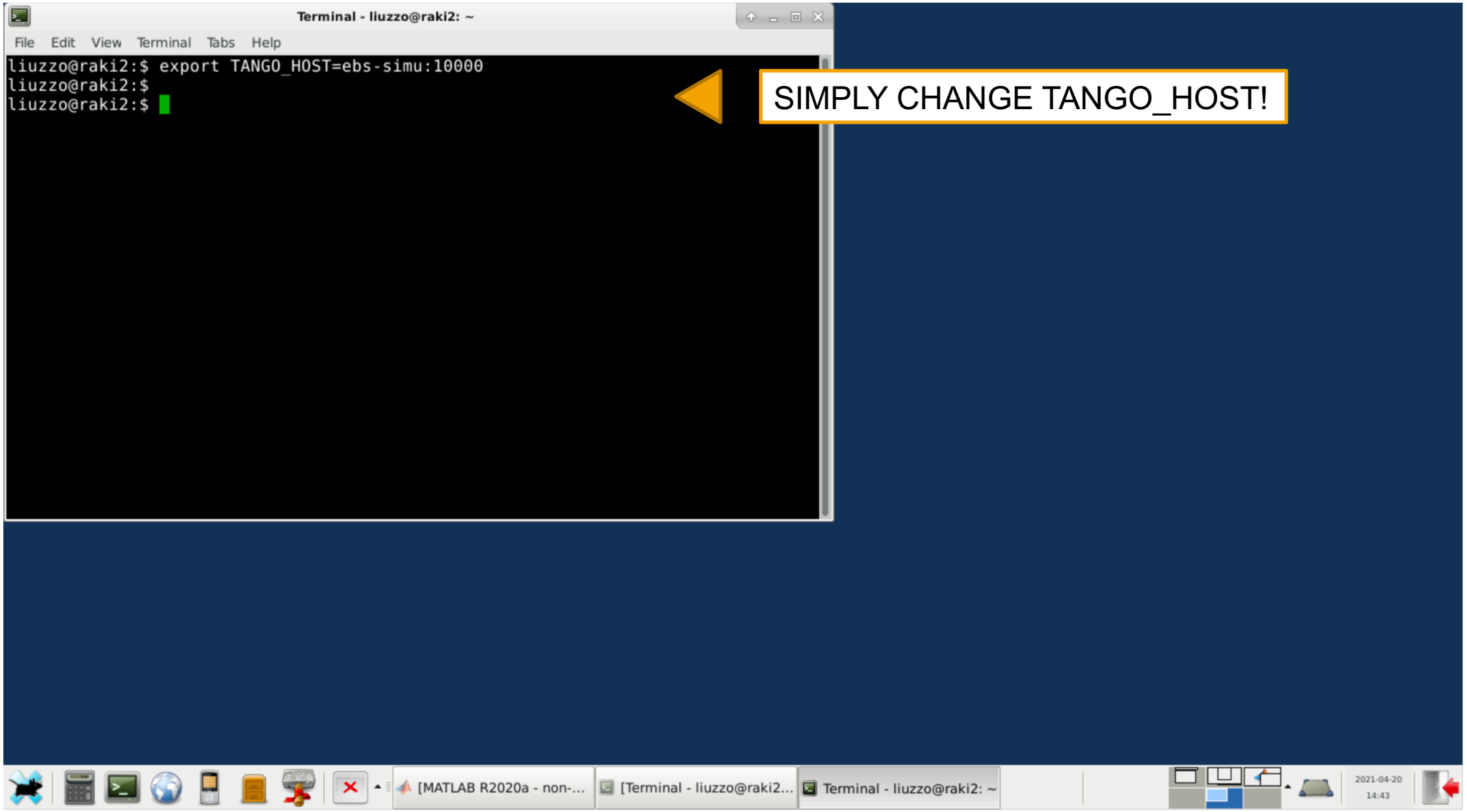


Instead of explaining, I will show, what happens in the simulator.
All that you will see is real, a real EBS Control system simulator.

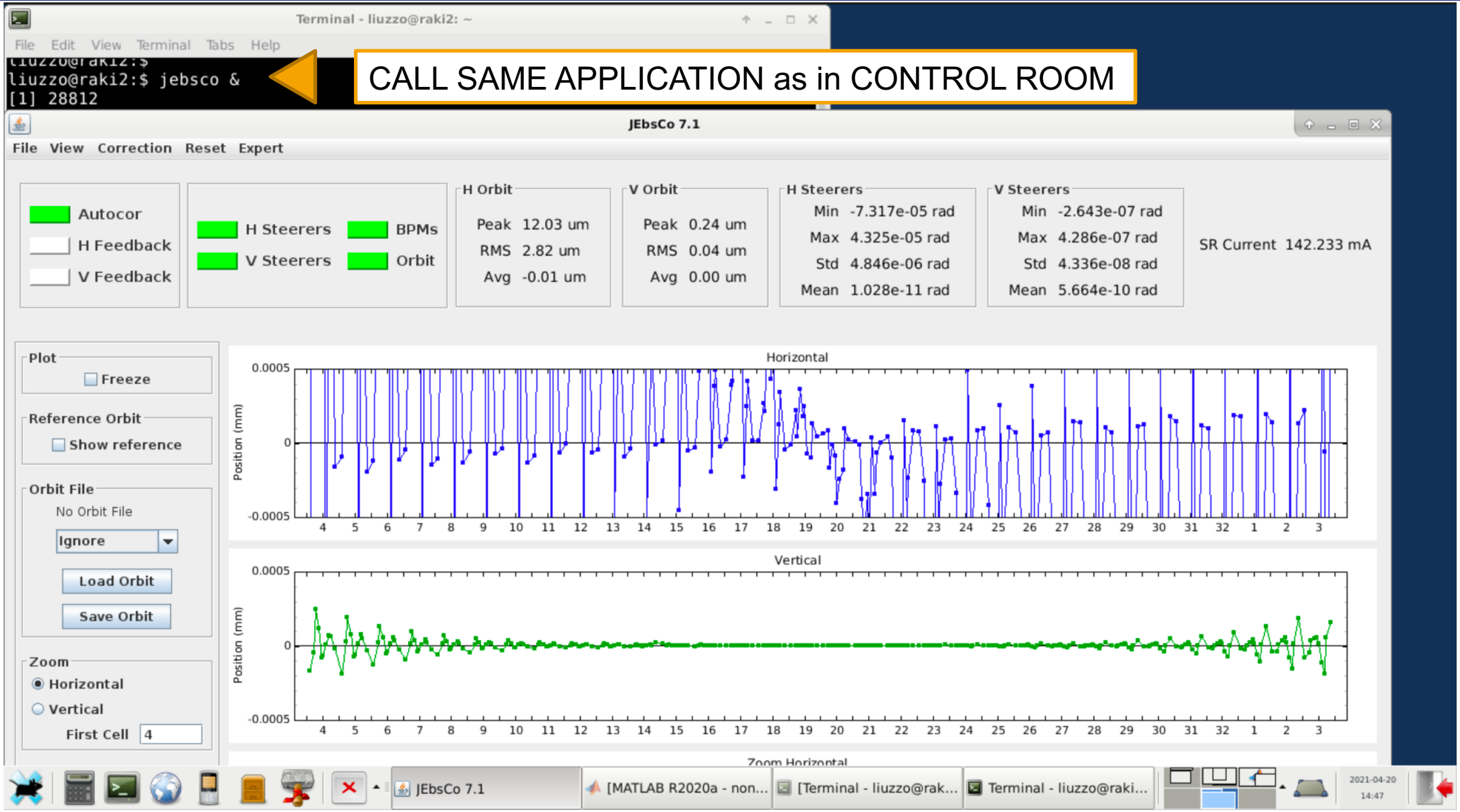
The simulator served already for:
EBS **commissioning** applications and control system **specification**, **design**, **test**
EBS commissioning **debugging** and trouble shooting, etc…
EBS **operation** applications and control system specification, design, test
EBS operation debugging and trouble shooting
Development of new EBS applications

It is so useful that we actually have 4!

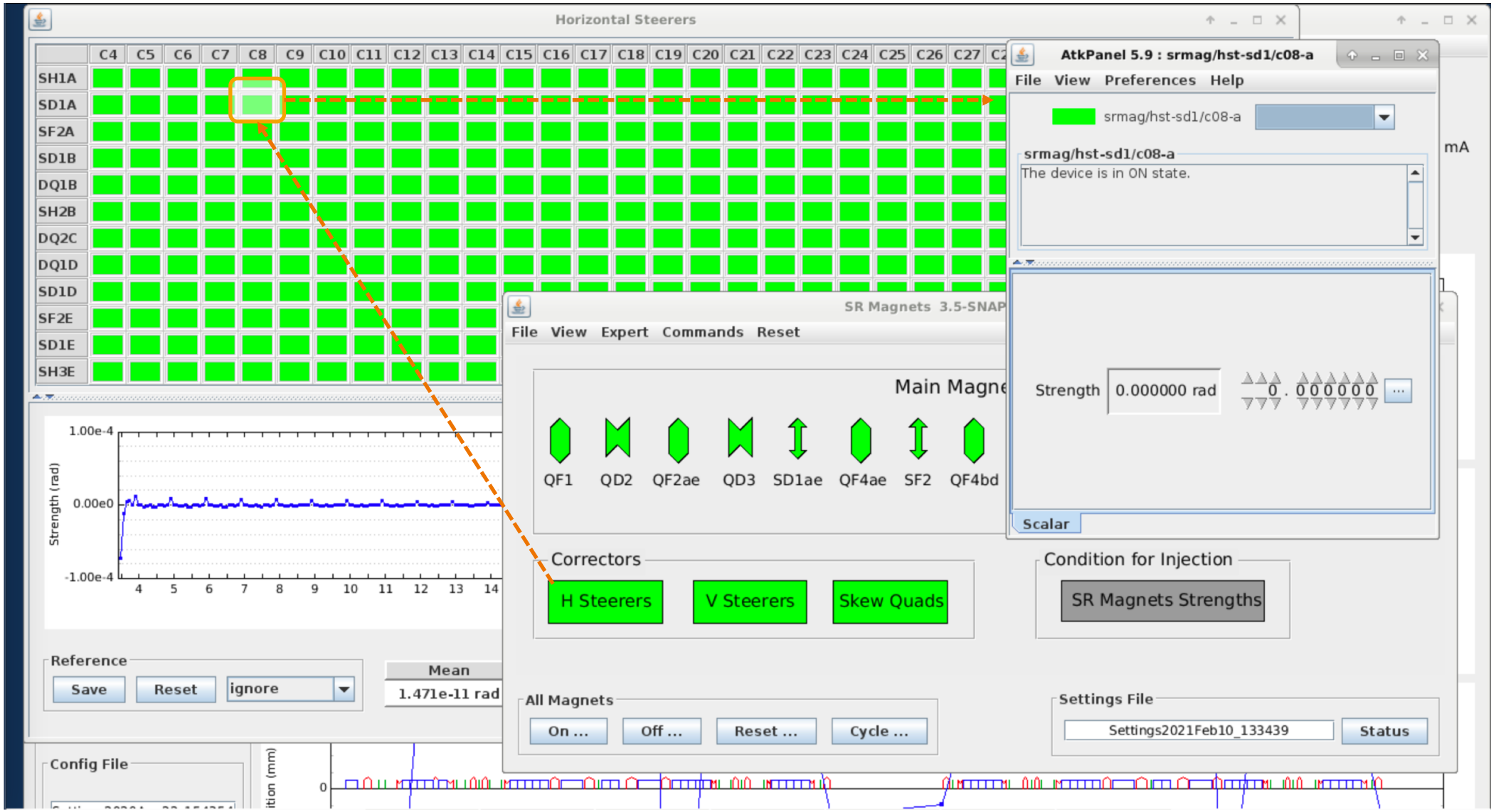
SWITCH TO THE CONTROL-SYSTEM SIMULATOR



SAME APPLICATIONS AS IN CONTROL ROOM

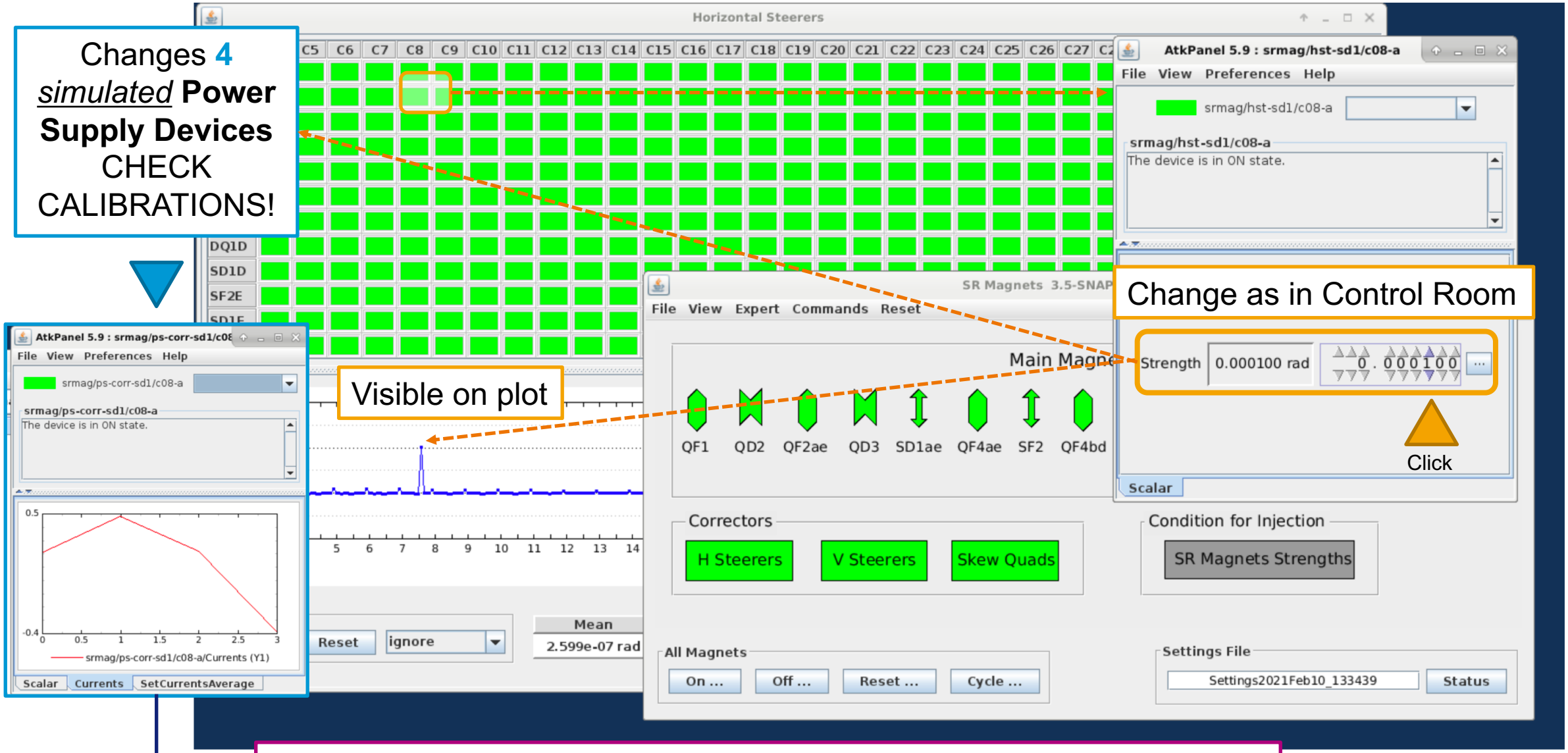


CHANGE A MAGNET STRENGTH



CHANGE A MAGNET STRENGTH

Changes 4 *simulated* **Power Supply Devices** CHECK CALIBRATIONS!



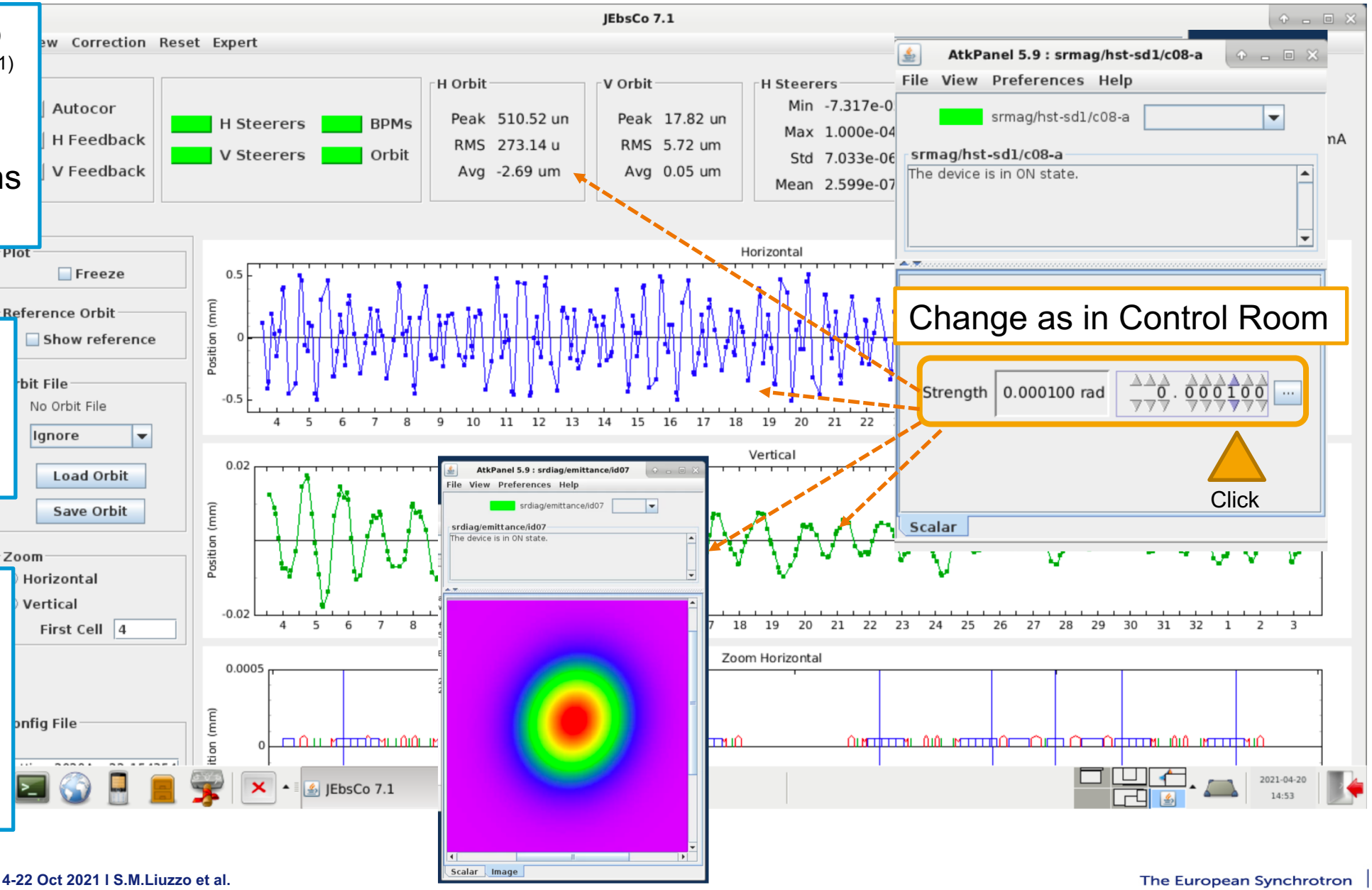
Values sent to Current Power Supply in real life. Stop here in Simulator

CHANGE A MAGNET STRENGTH

Simulator Loop
(matlab <2021 or python > 2021)
continuously monitors all magnets strengths **(0.2-2.0Hz)**.

If change **COMPUTE** New beam paramenters

Modified *simulated* **diagnostics** reading, control room operational observable.



AUTOMATIC ORBIT CORRECTION TEST IN THE SIMULATOR

Applications are the same as the real ones.

For example we can run automatic orbit correction (Autocor)

EFFECT OF AUTOMATIC CORRECTION

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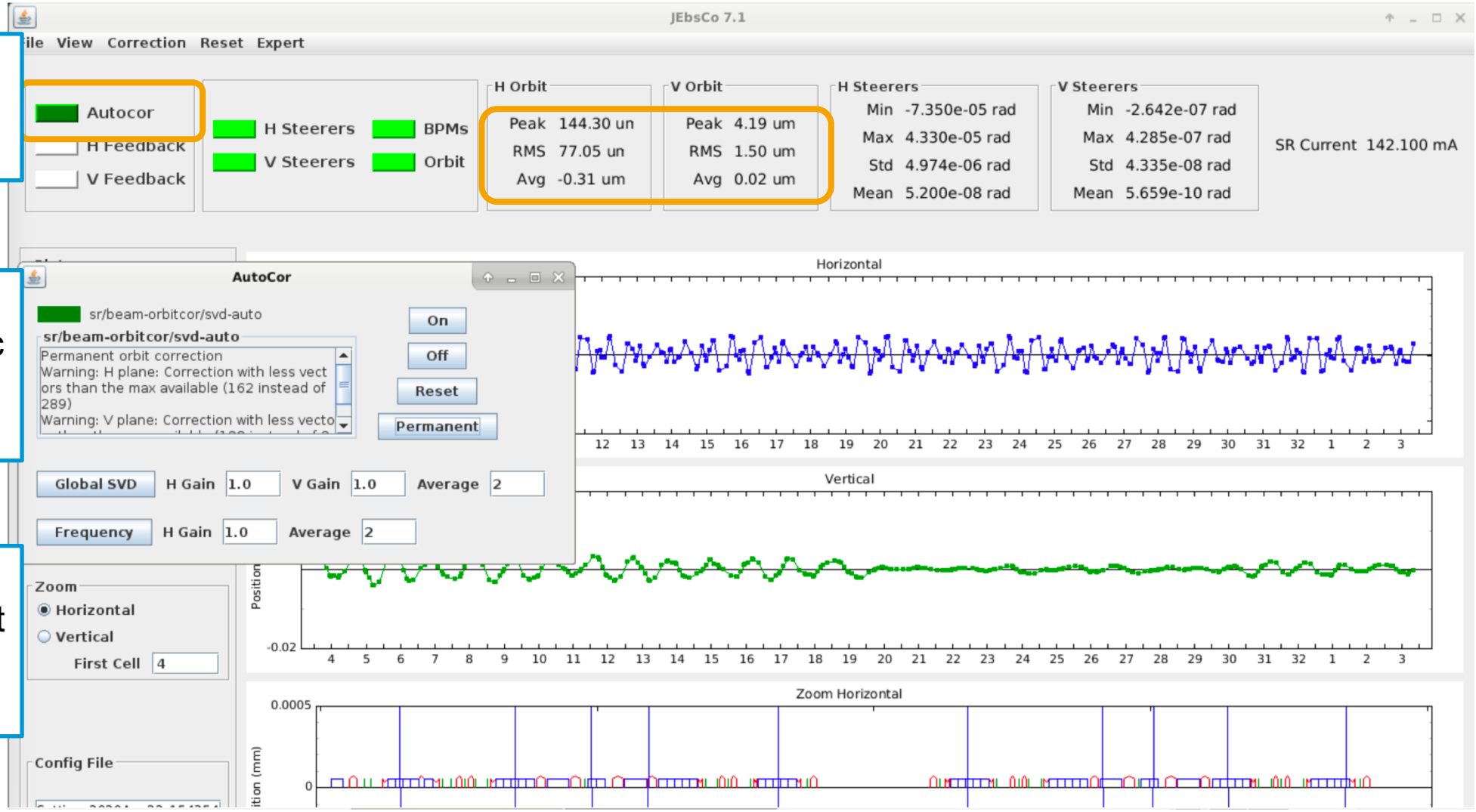
Strengths are changed and orbit follows as expected.



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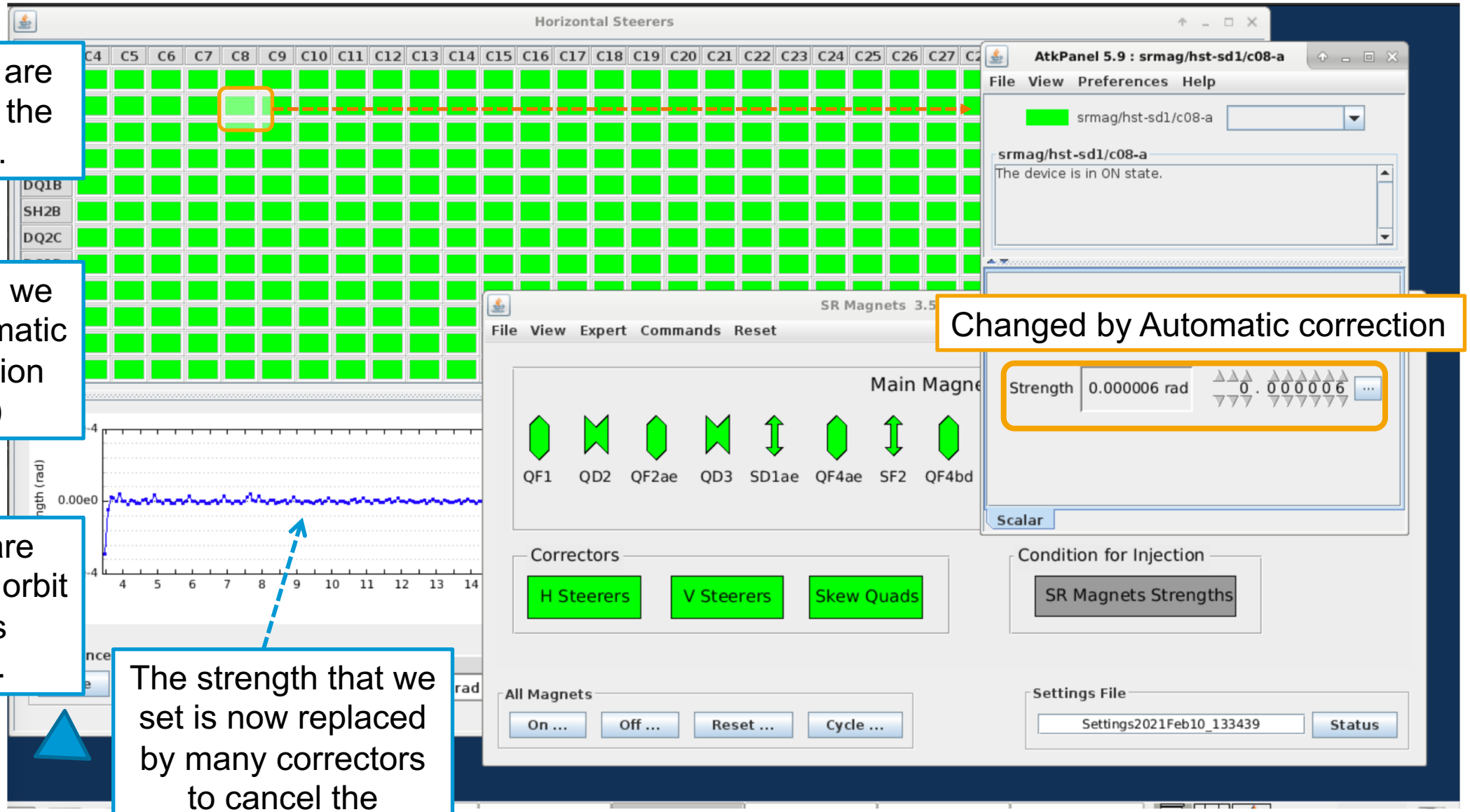
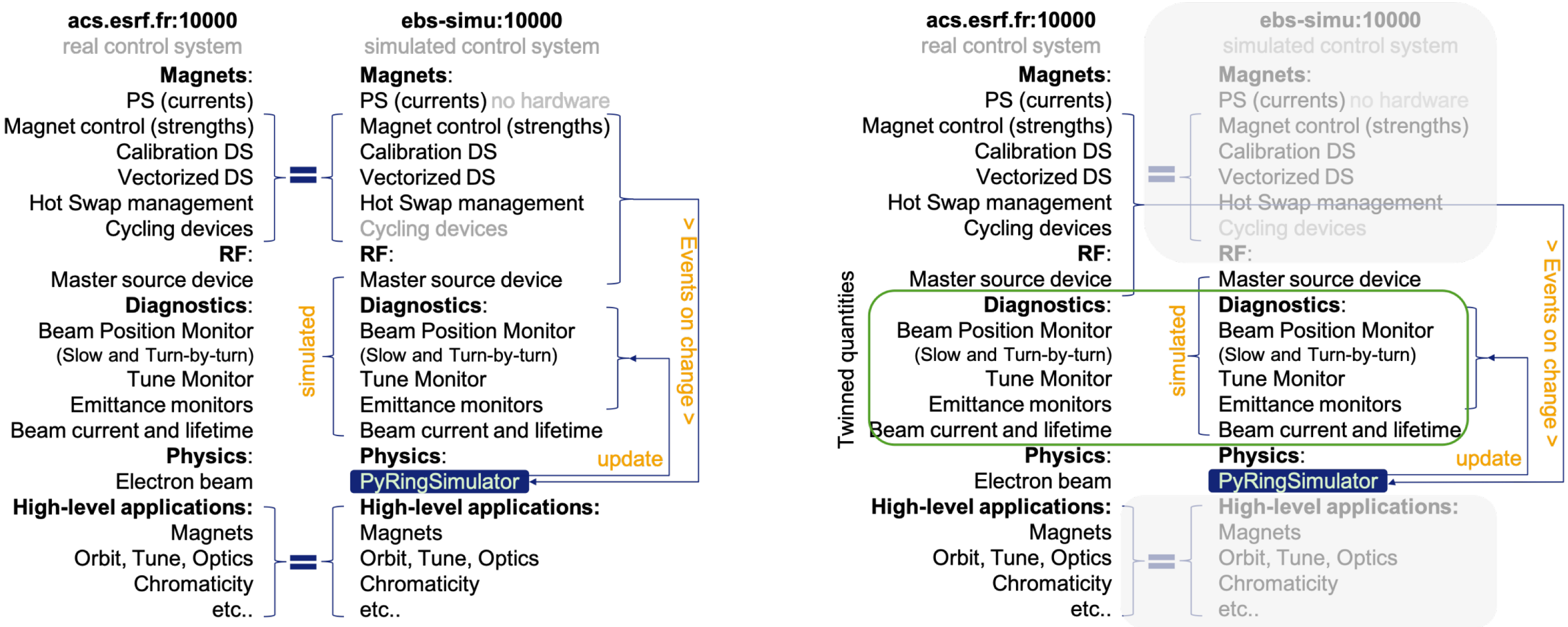


The strength that we set is now replaced by many correctors to cancel the “measured” orbit.

FROM SIMULATOR TO DIGITAL-TWIN

Simulator configuration

Future development: Digital twin configuration



FEATURES OF THE SIMULATOR

- **Able to show all single particle electron beam dynamic effects: orbit, tunes, emittances, beam size, chromaticity, Turn by Turn beam trajectory etc. in presence of realistic errors** (not visible to the user)
- **Follows the variation of any magnet and of the RF parameters.**
- **Pilots simulated PS devices → used in real life to detect calibration issues!**
- **Control room applications work also in the simulator: test applications without real beam, spare precious machine dedicated time, help debugging, finding issues before production.**
  Examples of applications/scripts prepared in the simulator: magnets control, cycling, correction of optics and orbit, beam based alignment, chromaticity, bumps, first turns trajectory steering, etc. (many more)
- **Python (pyAT https://github.com/atcollab/at) replaced Matlab for the simulator loop**
- **Simulator model updated on demand. Reinitialization of the simulator takes <1min.**
- **1 core/simulator dedicated to simulation loop, at the speed of CPU available** (3GHz)**.**
- **All other cores are used by the 86 Device Servers : 1 simulator 25-30% of a 16-core CPU-host**

We are few steps from digital-twinning:
Linking the CTRM PS/RF setting to a simulator running the measured optics model. (much less trivial than it sounds)