



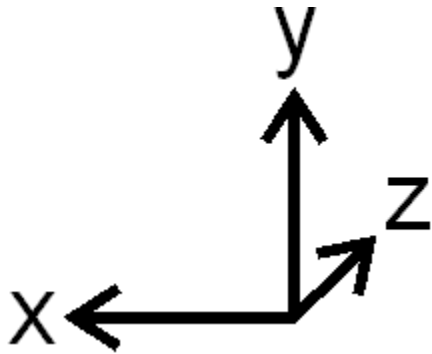
# Magnets

## XFEL Operator Training



# Conventions: Dipoles (Incl. Correctors)

2



The XFEL has a  
right-handed  
coordinate system.  
z points  
downstream.



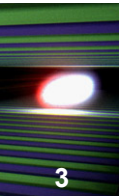
Where does this corrector  
deflect the electron beam?

UP

Which sign does its field/  
strength/kick have?

+

# Conventions: Quadrupoles



3

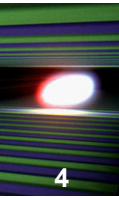


Is this quadrupole  
focusing or  
defocusing in the  
horizontal plane?

**DEFOCUSING**

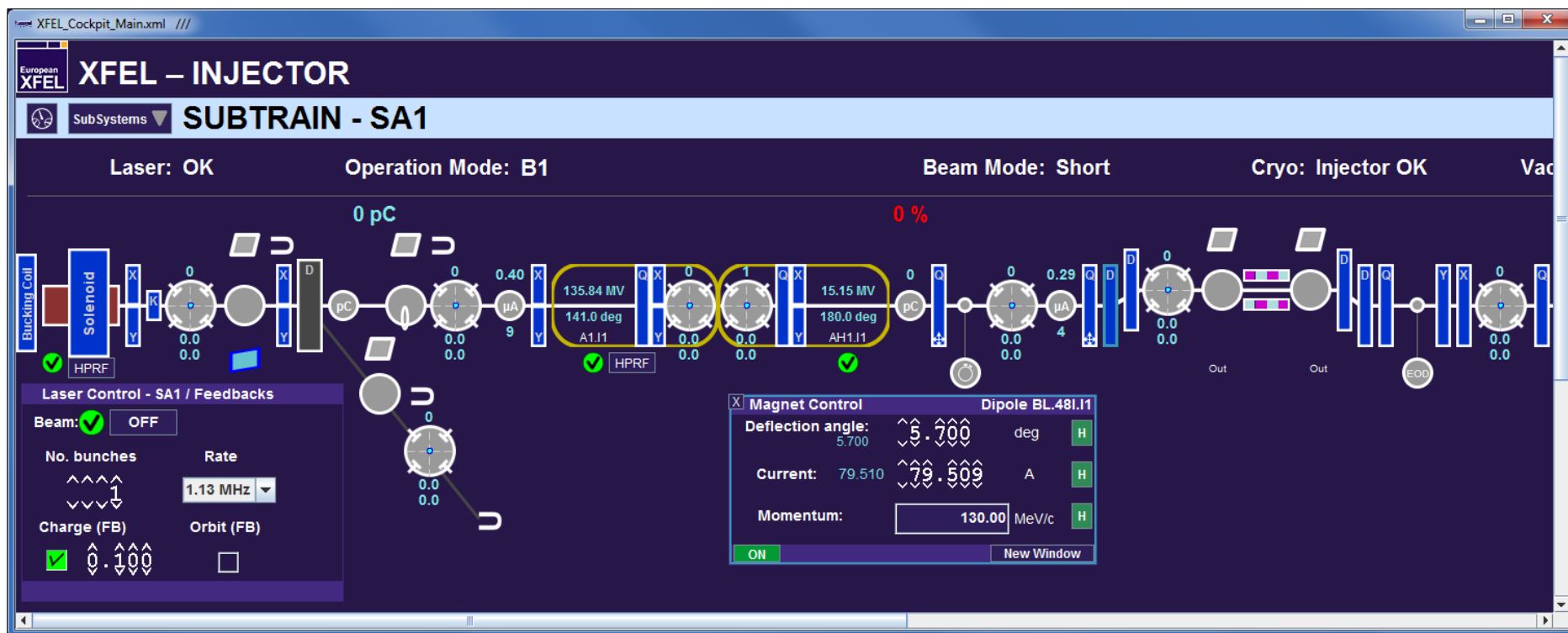
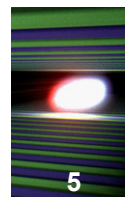
What is the sign  
of its gradient/  
strength/  
integrated  
strength?

—



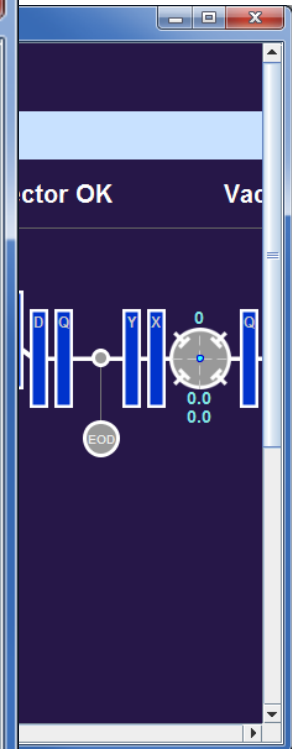
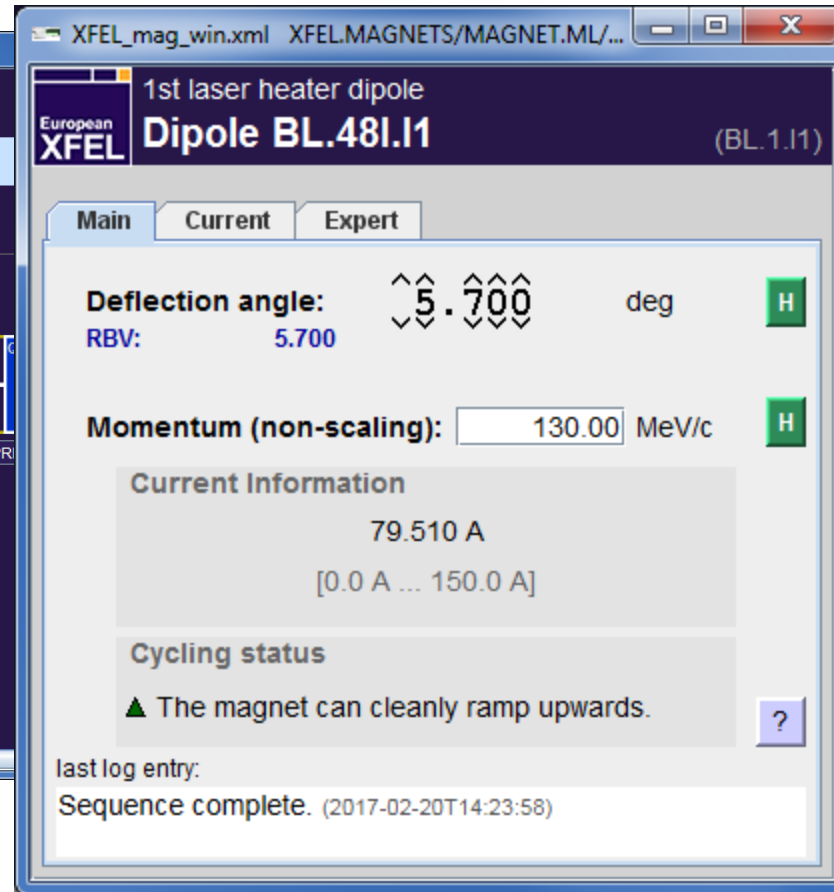
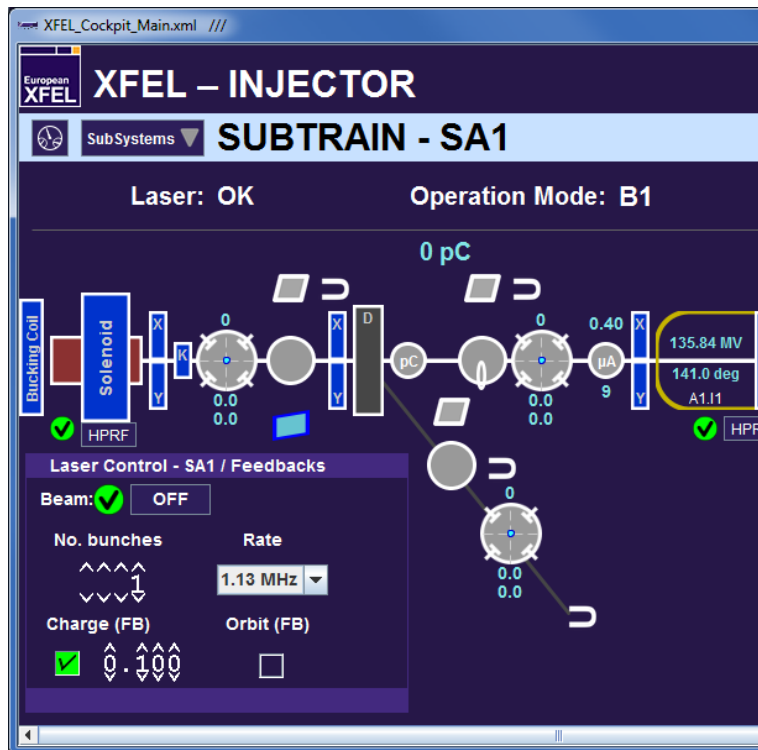
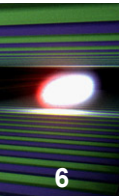
- Dipoles and correctors with a positive field deflect electrons to the left (in positive  $x$  direction) or up (in positive  $y$  direction).
- Quadrupoles with a positive *generalized* field are horizontally focusing for electron beams.
- Usually, positive fields are driven by positive currents, but there are exceptions.

## Controlling Magnets... From the Cockpit



# Controlling Magnets... From a Stand-Alone Panel

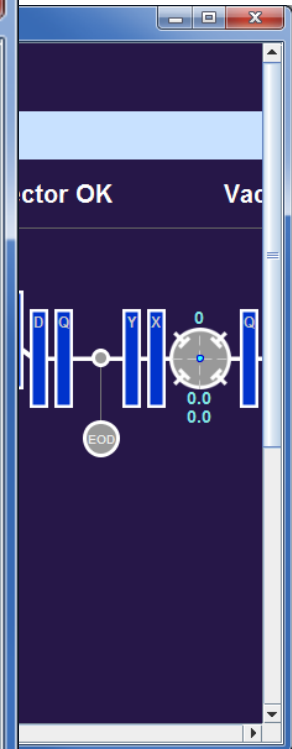
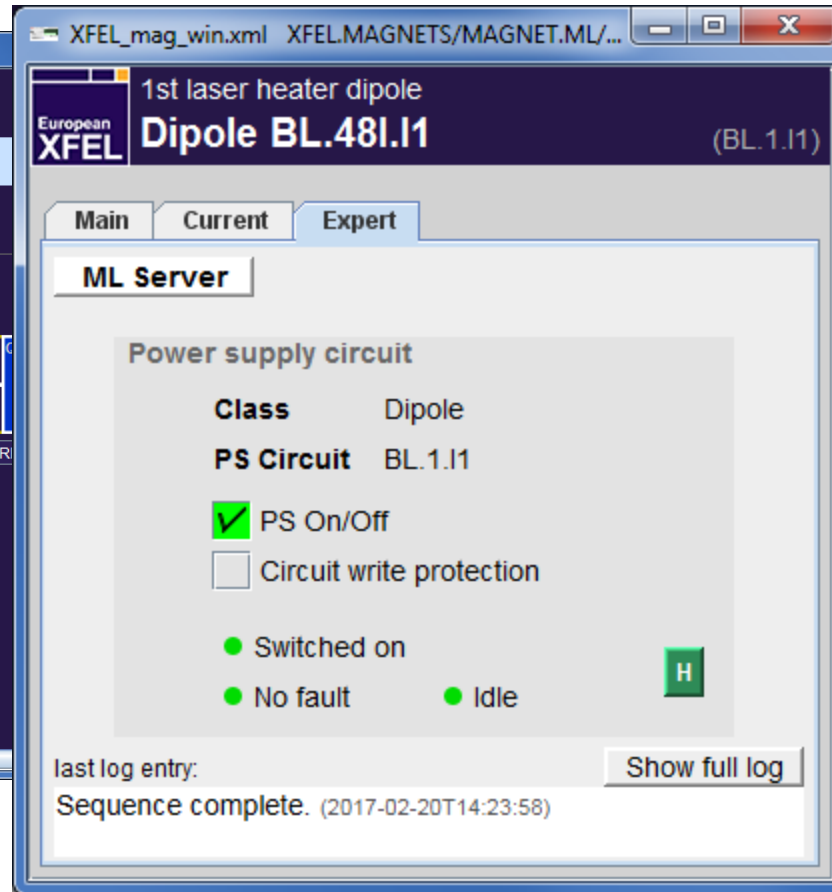
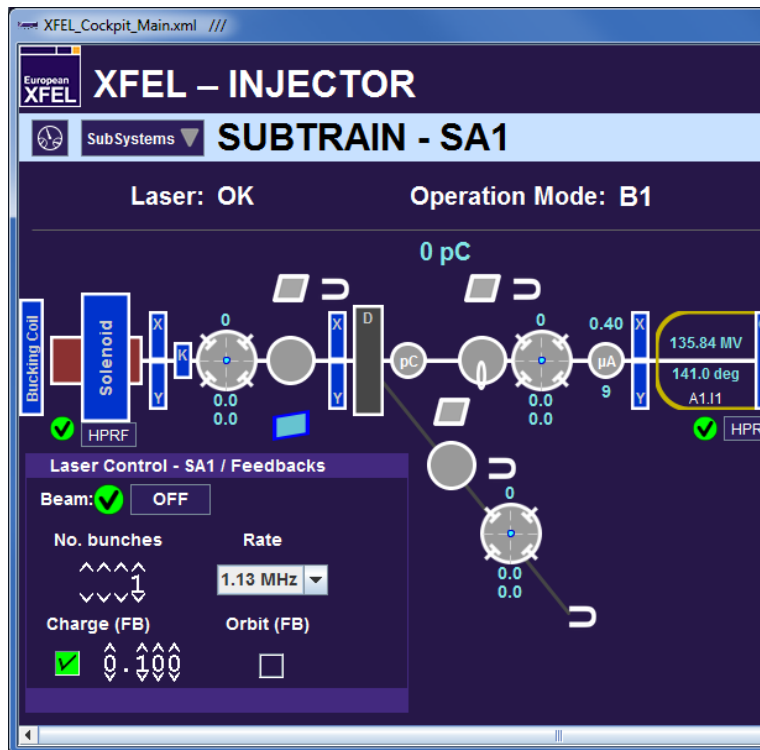
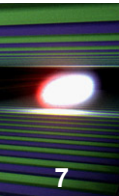
6





## Controlling Magnets... From a Stand-Alone Panel

7



## Controlling Magnets... From the ML Server Panel

8

The screenshot displays the 'MAGNET MIDDLE LAYER SERVER - BL.481.11' interface. The main control panel for 'Dipole BL.481.11' (1st laser heater dipole) shows the following parameters:

- Deflection angle:** 5.700 deg (range: 0.068 < 5.700 < 10.647)
- Nominal momentum:** 130.00 MeV/c
- Current:** 79.509 A (range: 0.0000 < 79.509 < 150.0000)

The **Power supply** section indicates 'Switched on' and 'No fault' status.

The **Cycling status** section shows 'The magnet can cleanly ramp upwards.' and a graph titled 'Generalized Field vs. Current' plotting [T] against [A]. The graph shows a linear relationship with a red line and a blue data point at approximately (80, 0.15).

The left sidebar lists various magnet components, including SOLA.23.11, SOLB.23.11, CKX.23.11, CKY.23.11, CKX.24.11, CKY.24.11, BK.24.11, CKX.25.11, CKY.25.11, Q.37.11, CY.37.11, CX.37.11, Q.38.11, CY.39.11, CX.39.11, QI.46.11, QI.47.11, BL.481.11 (selected), BL.501.11, BL.501.11, QI.50.11, CIY.51.11, CIX.51.11, QI.52.11, QI.53.11, QI.54.11, CIY.55.11, QI.55.11, CIX.57.11, QI.57.11, CIY.58.11, QI.59.11, QI.60.11, QI.61.11, BB.62.11D, CBB.62.11D, CIY.63.11, QI.63.11D, and QI.63.11.

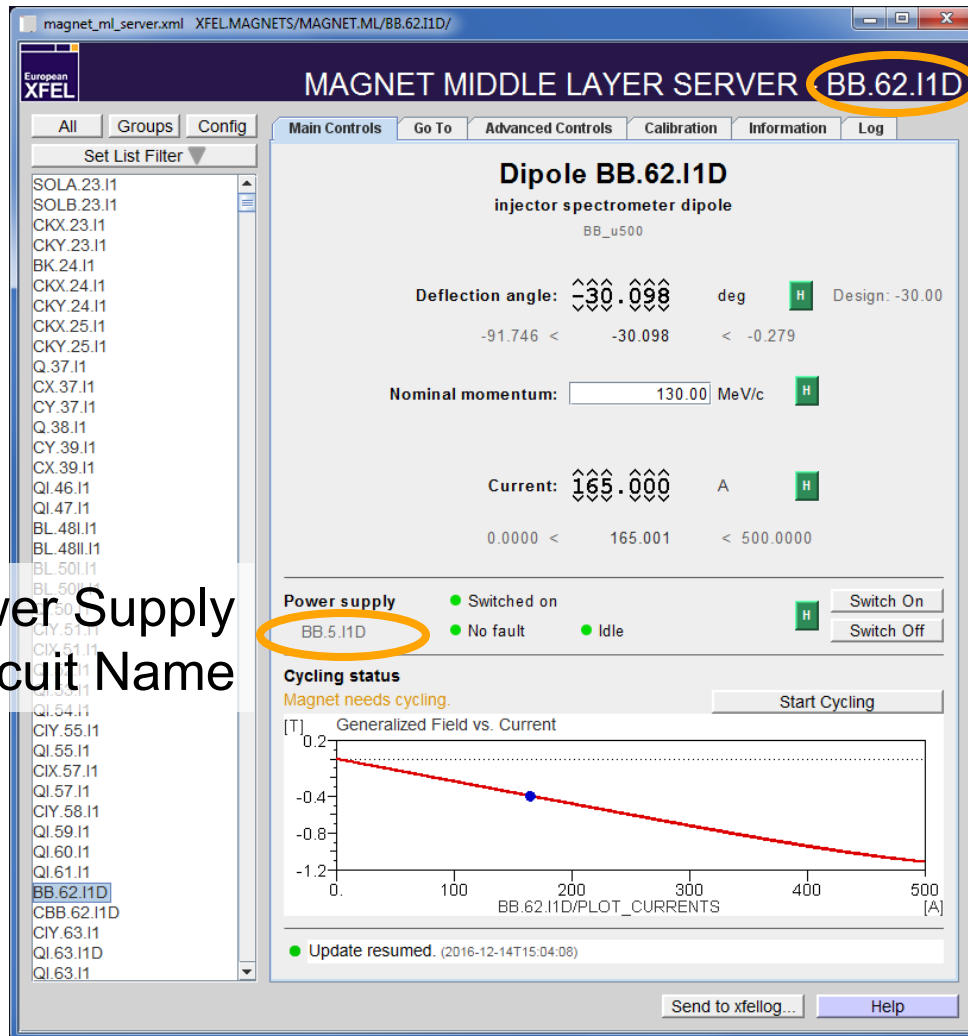
The background shows the 'XFEL - INJECTOR' cockpit with 'SUBTRAIN - SA1' and 'Laser: OK' status.



# Magnet Middle Layer Server

9

Power Supply  
Circuit Name



Magnet Name

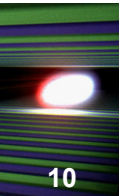
**<type>.<zpos>.<section>**

- SOL\* – Solenoids
- C\* – Correctors
- B\* – Dipoles
- Q\* – Quadrupoles
- S\* – Sextupoles
- O\* – Octupoles
- CB\* – Correction/trim coils on dipoles (additional windings)

*PS circuit names are similar:*

**<type>.<ID>.<section>**

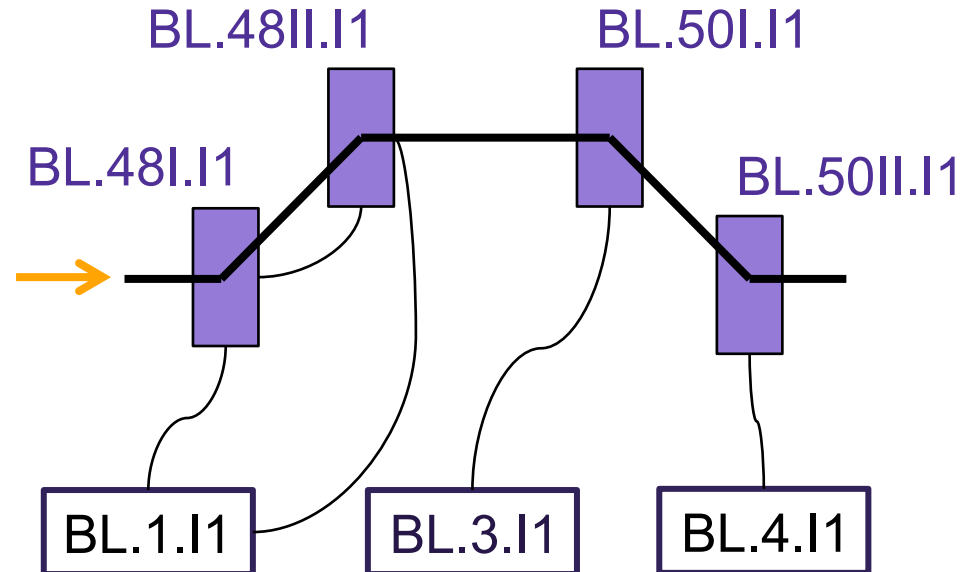
# Many Magnets Can Share The Same Circuit



- There is one device for each magnet
- ... even if multiple magnets share the same power supply

## Laser Heater Chicane

### Magnet Names



### Power Supply Names

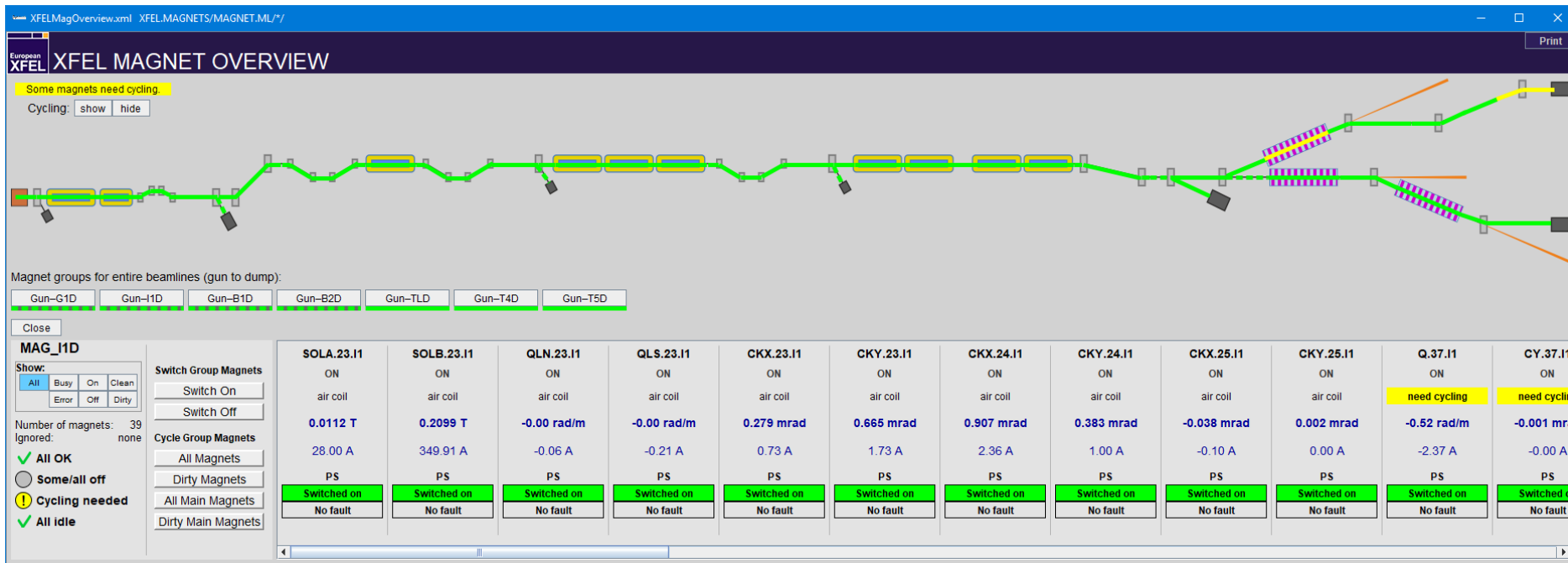
# Main Taskbar > Magnets

The screenshot displays the XFEL Main Taskbar (XFELMainTaskbar.xml) interface. The top menu bar includes 'Datei', 'Optionen', and 'Hilfe'. The main workspace is divided into several functional areas:

- Top Navigation Bar:** Contains icons for Status, Operations, Feedbacks, Diagnostics, and Tools. Below these are icons for MPS, Injector, RF, Orbit, Photons, Beam Dynamics, Magnets, Vacuum, Cryo, and Controls.
- Magnets Section:** A large panel on the left with a 'Magnets' icon and a red arrow pointing to the 'Overview' button. It lists several sub-functions: Overview, Magnet Server, Magnet Energizer, Magnet Coupling Server, State Monitoring, Cold Quad Monitoring, Dipole Setup, and Chicane Control.
- Power Supplies Section:** Lists PS Monitoring & Control, PS Control (deprecated), and T1/T2 Special Grounding.
- Kickers Section:** Lists TLD Operation and Expert.
- Quad Mover Section:** Lists Overview.
- Tools Section:** Lists Kicks from Sequencer.

At the bottom, the 'Magnet Overview' section shows a diagram of the accelerator beamline with various magnets and components highlighted in green and yellow. The status bar at the bottom indicates 'MCS10LFROEHLI 03.12.18 18:08:48 Operations Mode [Betrachten] Serveranwahl [Default] (1)KeinInDatei'.

# The Magnet Overview Panel

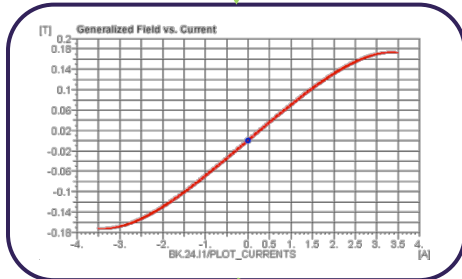
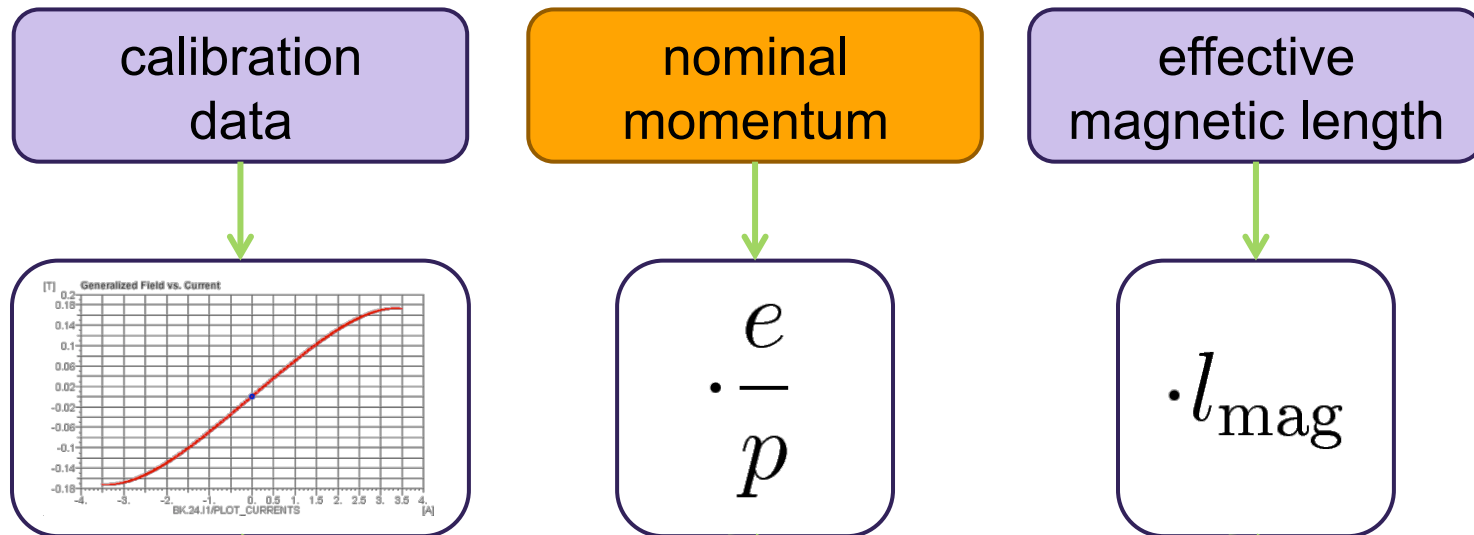


**Current, Field, Strength, Gradient, Kick, Momentum, ...**

---

... and other sophisticated words like “hysteresis” and “remanence”!

# Magnet ML: Physical Parameters



current

Dipole  
Quadrupole  
Sextupole  
Octupole

(gen.) field

[B] = T  
[g] = T/m  
T/m<sup>2</sup>  
T/m<sup>3</sup>

(gen.) strength

[1/ρ] = 1/m  
[k] = 1/m<sup>2</sup>  
[m] = 1/m<sup>3</sup>  
[r] = 1/m<sup>4</sup>

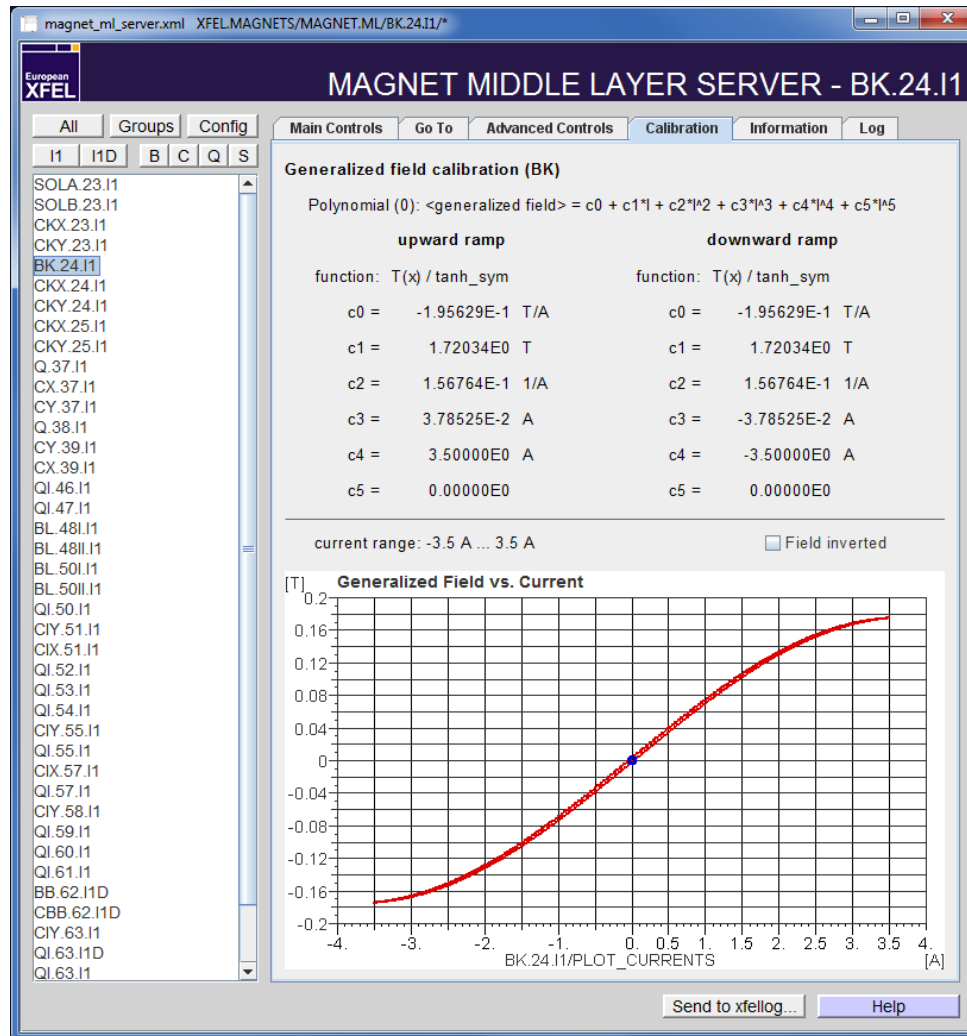
(gen.) kick

rad  
rad/m  
rad/m<sup>2</sup>  
rad/m<sup>3</sup>

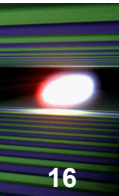


# Magnet ML: Calibration & Hysteresis

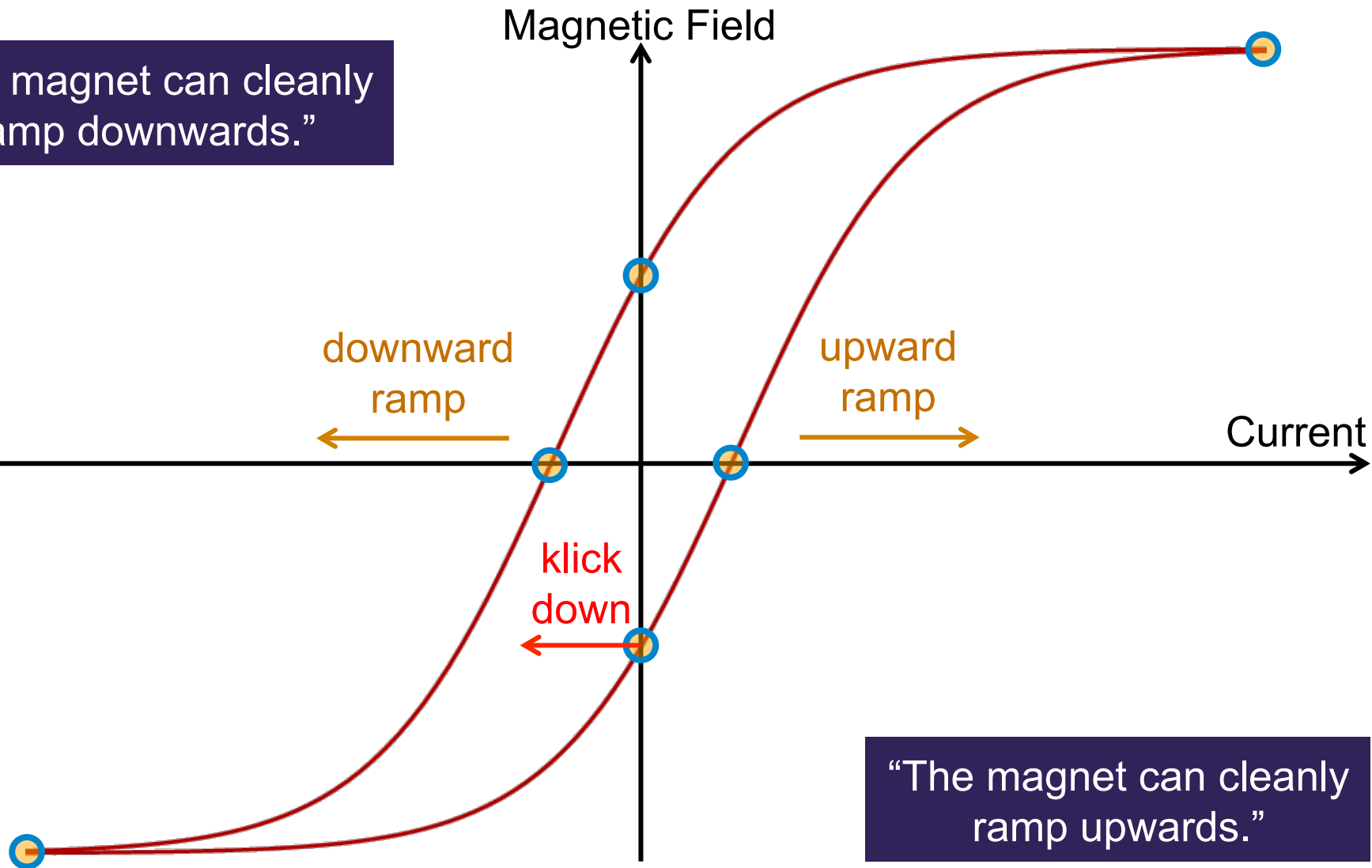
15



# Dealing with Hysteresis

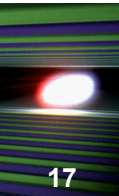


“The magnet can cleanly ramp downwards.”

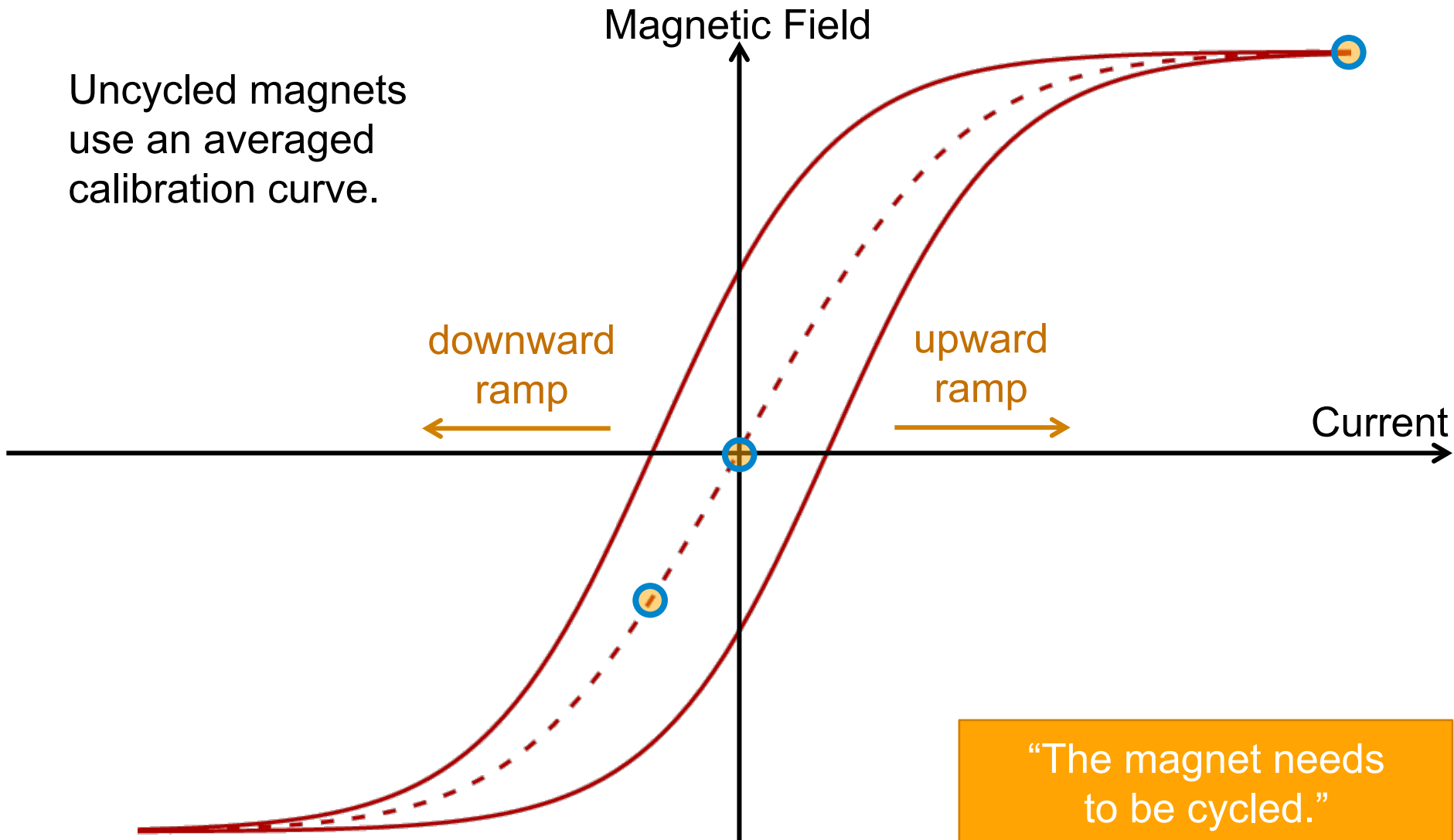


“The magnet can cleanly ramp upwards.”

# Dealing with Hysteresis



Uncycled magnets use an averaged calibration curve.



“The magnet needs to be cycled.”

# Cycling & Degaussing

18

## Cycling

Force the magnet (back) onto its hysteresis curve.  
Ramp to maximum and minimum current a few times.

Magnetic Field

Current

## Degaussing (Demagnetization)

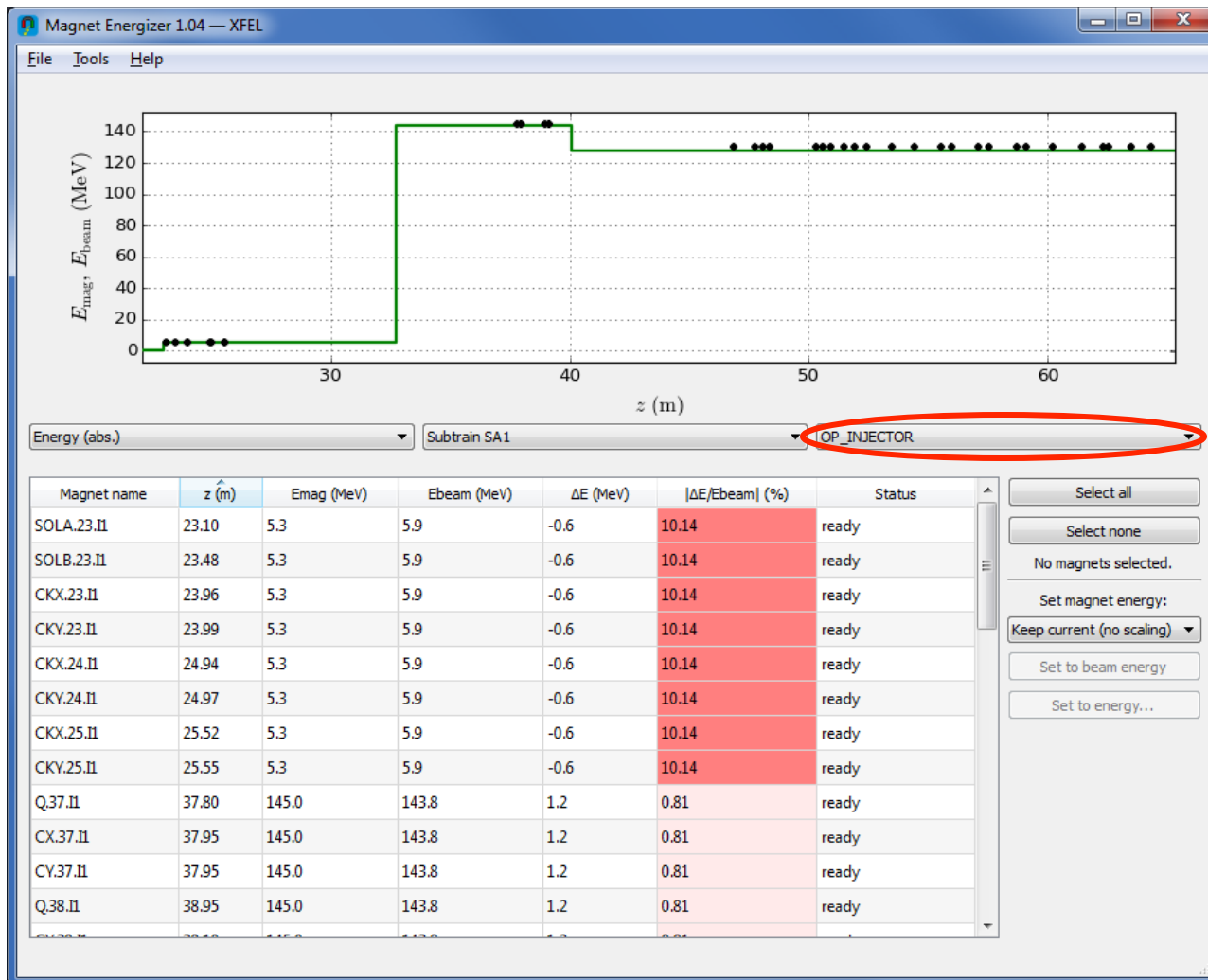
Force the magnet out of its hysteresis curve so it has zero field at zero current.  
Ramp up and down with slowly decreasing currents.

# Main Taskbar > Magnets

The screenshot displays the XFEL Main Taskbar (XFELMainTaskbar.xml) interface. The top menu bar includes 'Datei', 'Optionen', and 'Hilfe'. The main workspace is divided into several functional areas:

- Top Navigation Bar:** Contains icons for Status, Operations, Feedbacks, Diagnostics, and Tools. Below these are icons for MPS, Injector, RF, Orbit, Photons, Beam Dynamics, Magnets, Vacuum, Cryo, and Controls.
- Magnets Section:**
  - A large 'Magnets' icon with a red arrow pointing to the 'Magnet Energizer' button.
  - Buttons: Overview, Magnet Server, Magnet Energizer, Magnet Coupling Server, State Monitoring, Cold Quad Monitoring, Dipole Setup, Chicane Control.
- Power Supplies Section:**
  - Buttons: PS Monitoring & Control, PS Control (deprecated), T1/T2 Special Grounding.
- Kickers Section:**
  - Buttons: TLD Operation, Expert.
- Quad Mover Section:**
  - Button: Overview.
- Tools Section:**
  - Button: Kicks from Sequencer.
- Magnet Overview:**
  - Label: Kickers:
  - A diagram showing the beam path with various magnet locations marked by colored rectangles (yellow, green, red) and lines.

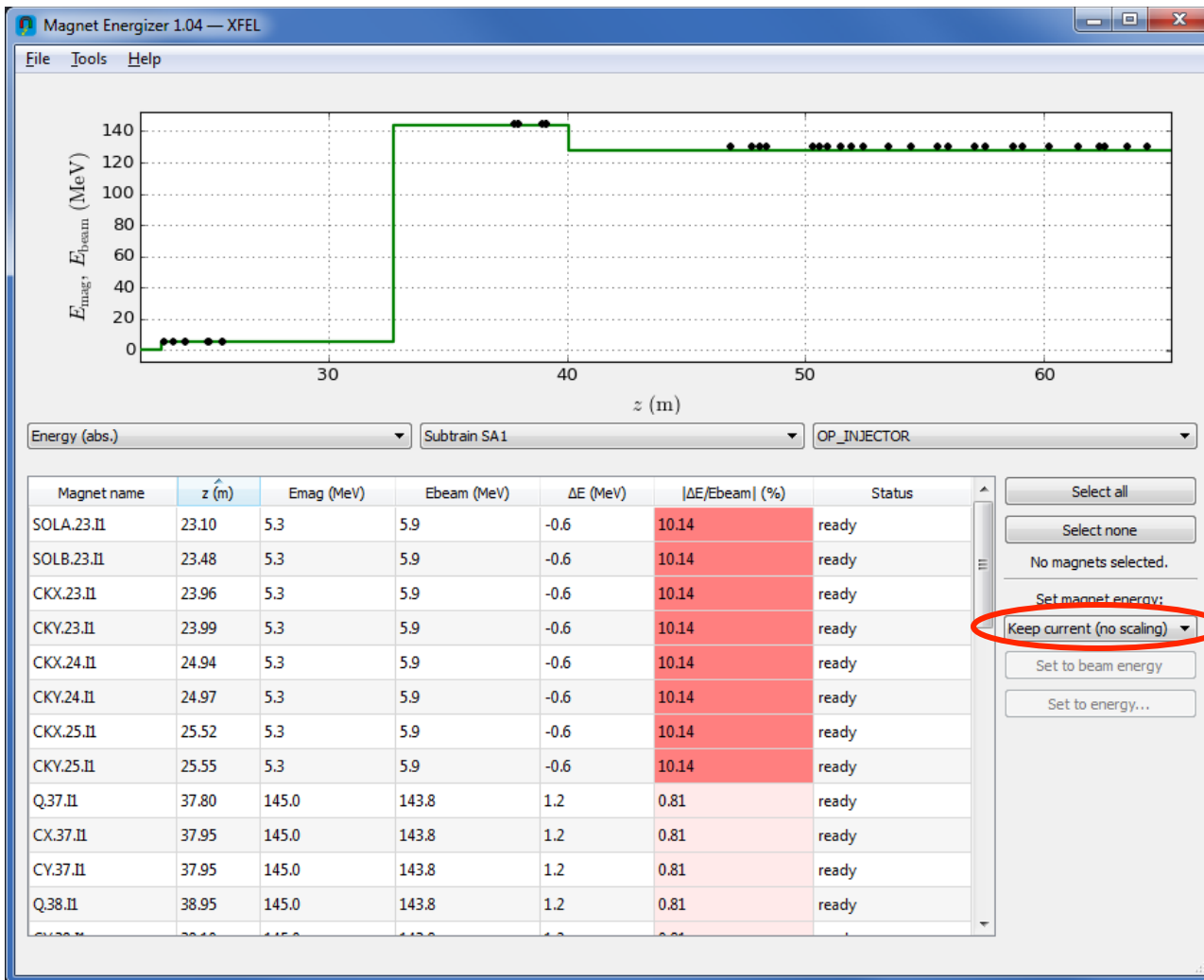
The status bar at the bottom indicates: MCS10LFROEHLI | 03.12.18 18:08:48 | Operations Mode [Betrachten] | Serveranwahl [Default] | (1)KeinInDatei



The combobox on the right selects a group of magnets:

- Sections or subsections:  
I1M, B1, T2, ...
- All magnets that need to be **ON** to transport the beam to a certain dump:  
MAG\_I1D, MAG\_T4D, ...
- All magnets through which the beam **passes** on the way to a certain dump:  
OP\_I1D, OP\_T4D, ...





This combobox selects what happens when „Set to beam energy“ or „Set to energy...“ is used:

- **Keep current (no scaling):**

Only the energy setting is changed, the magnet current stays the same. No impact on the beam, but the calculated kick is different.

- **Keep strenght (scaling):**

The magnet current is changed so that it has the same effect on a different beam. Use this when changing the beam energy.

# Main Taskbar > Magnets

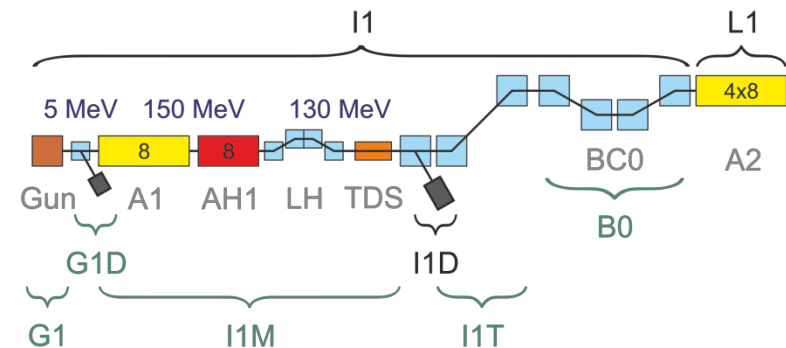
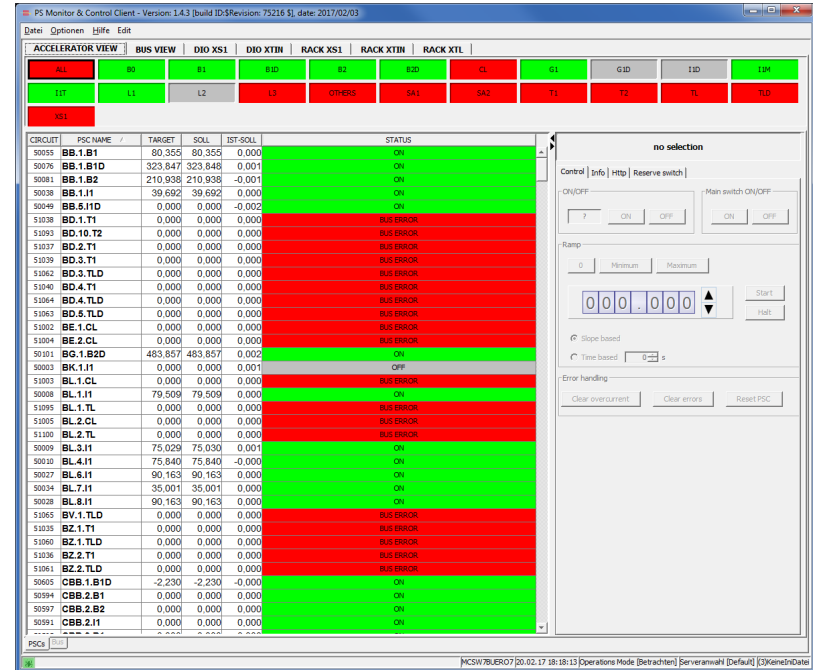
The screenshot displays the 'Main Taskbar (XFELMainTaskbar.xml)' window. The interface is organized into several sections:

- Top Bar:** Contains icons for Status, Operations, Procedures, Feedbacks, Automation, Diagnostics, and Tools.
- Left Panel:** Features the European XFEL logo and a 'Magnets' section with a headset icon.
- Central Grid:**
  - Magnets:** Includes buttons for Overview, Magnet Server, and Magnet Energizer.
  - Power Supplies:** Includes buttons for PS Monitoring & Control and PS Control (deprecated). A red arrow points to this section.
  - Kickers:** Includes buttons for Inj1 Kickers (Exp) and Dark Current Kicker (Exp).
- Magnet Overview:** A large section at the bottom showing a detailed diagram of the magnet layout, with various components highlighted in yellow and green.
- Status Bar:** At the bottom, it shows the current mode as 'Operations Mode [Betrachten]' and other system information.

# PS Monitor And Control (“PS MoCo”)

23

- Low-level view on power supplies
- Uses power supply circuit names
- Has a search function for magnet names, circuit names, and MKK circuit numbers (menu Edit/Search...)
- Use only for troubleshooting or if you're part of MKK!



# Main Taskbar > Magnets

24

The screenshot displays the 'Main Taskbar (XFELMainTaskbar.xml)' window, version 2.3.1. The interface is organized into several sections:

- Top Bar:** Contains icons for Status, Operations, Procedures, Feedbacks, Automation, Diagnostics, and Tools.
- Left Panel:** Features the European XFEL logo and a 'Magnets' section with a headset icon and the text 'Magnets'.
- Central Grid:**
  - Magnets:** Includes 'Overview', 'Magnet Server', and 'Magnet Energizer' buttons.
  - Power Supplies:** Includes 'PS Monitoring & Control' and 'PS Control (deprecated)' buttons. A red arrow points to the 'PS Control (deprecated)' button.
  - Kickers:** Includes 'Inj1 Kickers (Exp)' and 'Dark Current Kicker (Exp)' buttons.
- Magnet Overview:** A large section at the bottom showing a detailed schematic of the magnet layout, with various components highlighted in yellow and green.

The status bar at the bottom indicates the system is in 'Operations Mode [Betrachten]' and shows the server selection as 'Default'.

# The “Good Old” PS Control

25

- It handles only “DESY-type” magnets.
- This means: It does not show all magnets.
- **IT DOES NOT SHOW ALL MAGNETS!**
- Please don't use it – or only as a last resort for troubleshooting, if you know what you're doing.

Kreis	PS	Status	Soll	Ist-Soll
50001	SOLA.1.I1	Ein	23,9998	-0,0042
50002	SOLB.1.I1	Ein	338,2994	0,0034
50008	BL.1.I1	Ein	79,7914	0,0000
50009	BL.3.I1	Ein: Warnung	79,3684	0,0004
50010	BL.4.I1	Ein	81,6248	0,0004
50027	BL.6.I1	DIO Aus: Störung	0,0000	0,0000
50034	BL.7.I1	DIO Aus: Störung	0,0000	0,0011
50028	BL.8.I1	DIO Aus: Störung	0,0000	0,0000
50049	BB.5.I1D	Ein	166,3848	-0,0011
50075	QD.26.B1D	DIO Aus: Störung	0,0000	0,0011
50071	QD.20.B1	DIO Aus: Störung	0,0000	0,0008
50072	QD.21.B1	DIO Aus: Störung	0,0000	-0,0004
50073	QD.22.B1	DIO Aus: Störung	0,0000	200,0000
50074	QD.25.B1D	DIO Aus: Störung	0,0000	-0,0008
50060	QD.9.B1	DIO Aus: Störung	0,0000	0,0023
50065	QD.14.B1	DIO Aus: Störung	0,0000	200,0000
50066	QD.15.B1	DIO Aus: Störung	0,0000	0,0004
50067	QD.16.B1	DIO Aus: Störung	0,0000	0,0015
50038	BB.1.I1	DIO Aus: Störung	0,0000	0,0004
50053	QD.3.B1	DIO Aus: Störung	0,0000	-0,0011
50054	QD.4.B1	DIO Aus: Störung	0,0000	0,0008
50055	BB.1.B1	DIO Aus: Störung	0,0000	-0,0004
50082	QD.6.B2	DIO Aus: Störung	0,0000	-0,0019
50083	QD.7.B2	DIO Aus: Störung	0,0000	-0,0011
50077	QD.1.B2	DIO Aus: Störung	0,0000	0,0000
50078	QD.2.B2	DIO Aus: Störung	0,0000	-0,6416
50079	QD.3.B2	DIO Aus: Störung	0,0000	200,0000
50080	QD.4.B2	DIO Aus: Störung	0,0000	-1,5194
50076	BB.1.B1D	DIO Aus: Störung	0,0000	0,0011