POCPA3 – DESY, May 21-23, 2012

Status of Booster Bending Magnets Power Supply refurbishment

Marco Cautero

2010 Status: Kempower PS Specs

	Dipoles	Quads	Sextupoles	Units
Digital Control and Interface	PSI	PSI	PSI	
# of Power Converters	2	2	2	
Output Voltage	±1000	±400	±35 / ±70	Vpk
Output Current Range	15-800	5-400	±35 / ±70	A
Instantaneous Peak Power	600 / -400	115 / -50	1.2 / 4	kVA
Max. Op. Frequency	3.125	3.125	3.125	Hz
Current Ripple/stability	±15	±15	±15	ppm
Load Nom. Resistance	260	360/310	700	mOhm
Load Nom. Inductance	112	81/54	42	mH

2010 Status: Operation at 2.5GeV

- Output modules IGBTs explode randomly without triggering any hardware protection
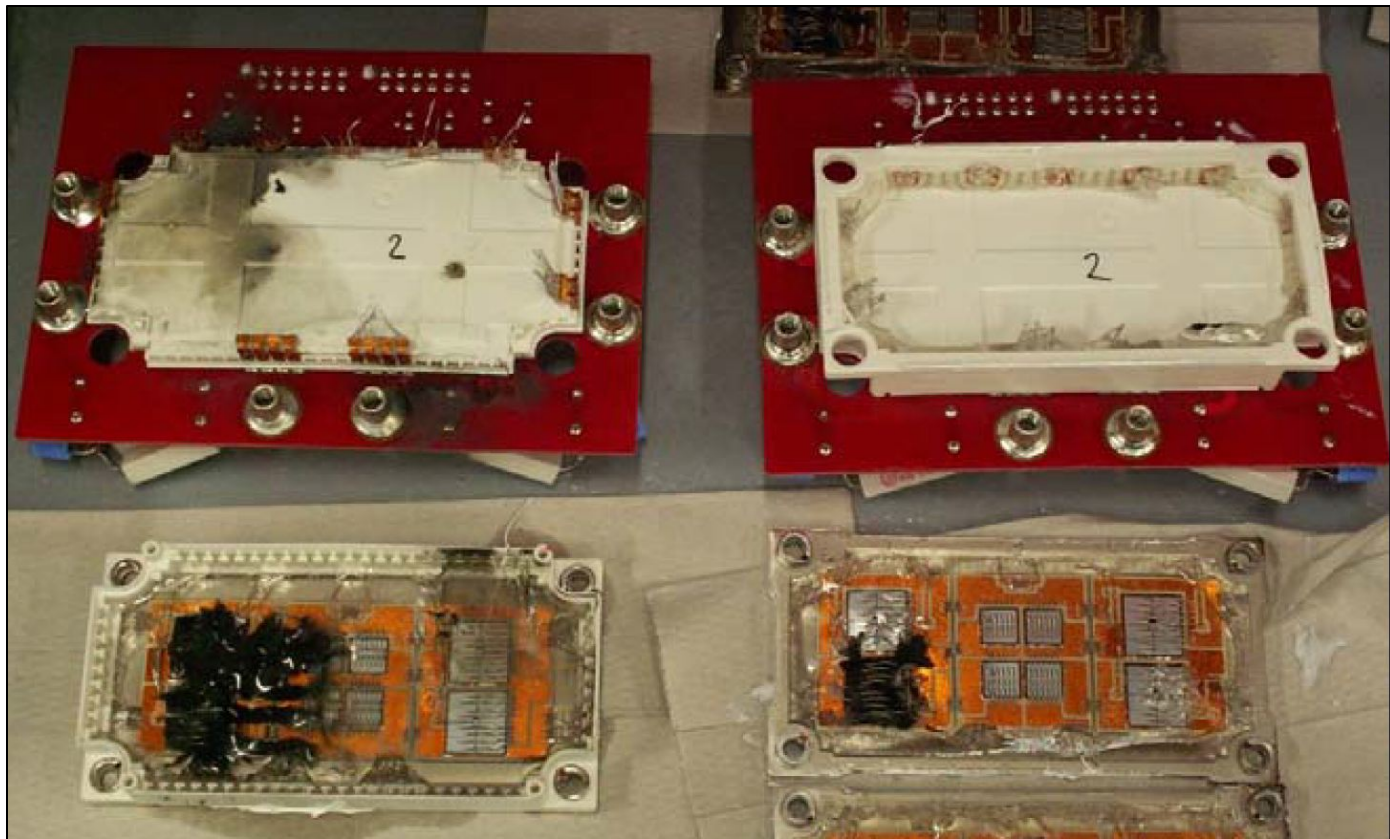
2010 Status: Kempower actions

- The modules are undergoing continuous modifications, upgrades and substitution of faulty IGBTs and triggering cards after failures, without finding the real cause of malfunctioning.

- Elettra team decided to study the complete converter schematic, finding dramatic design flaws

Early 2011: PS-Group actions

- What was wrong with Kempower power supplies?

- The power supply output stages have been found lacking important features like Over Current alarms, VCE saturation alarm, NTC temperature alarm and anti-cross conduction circuitry.
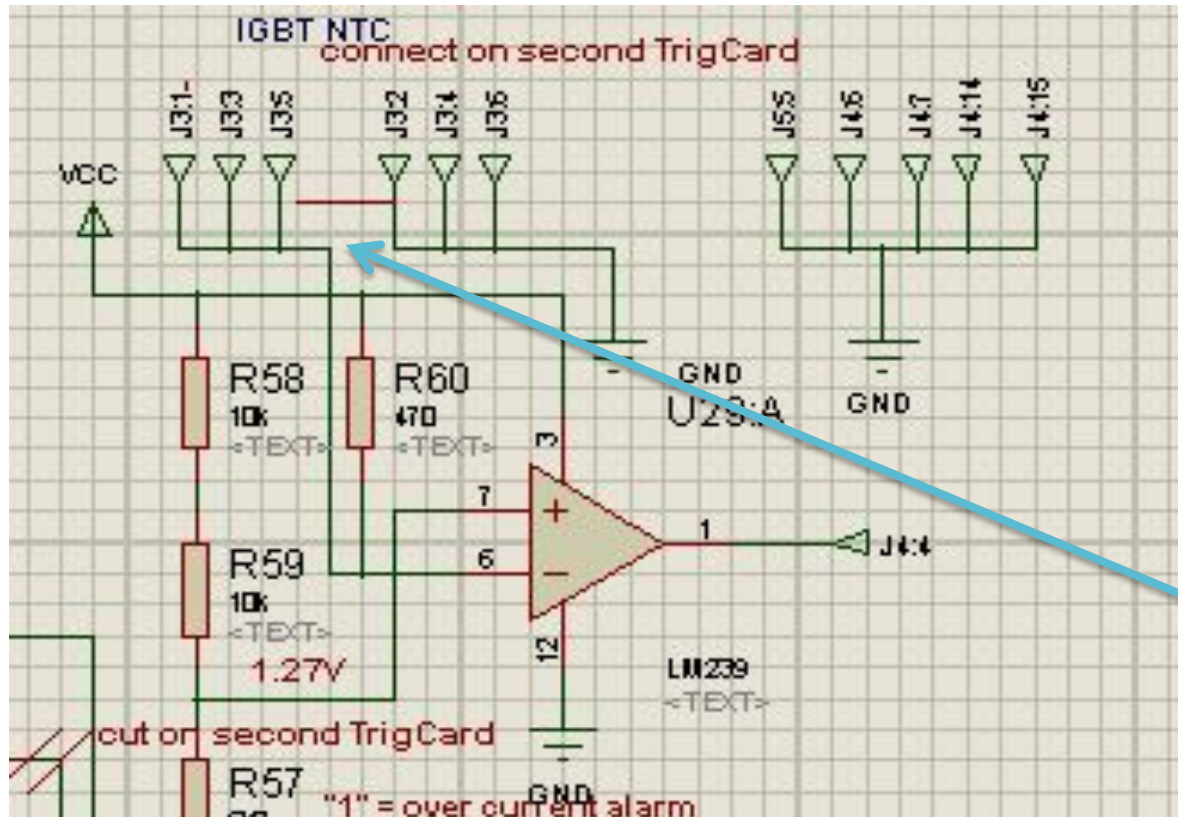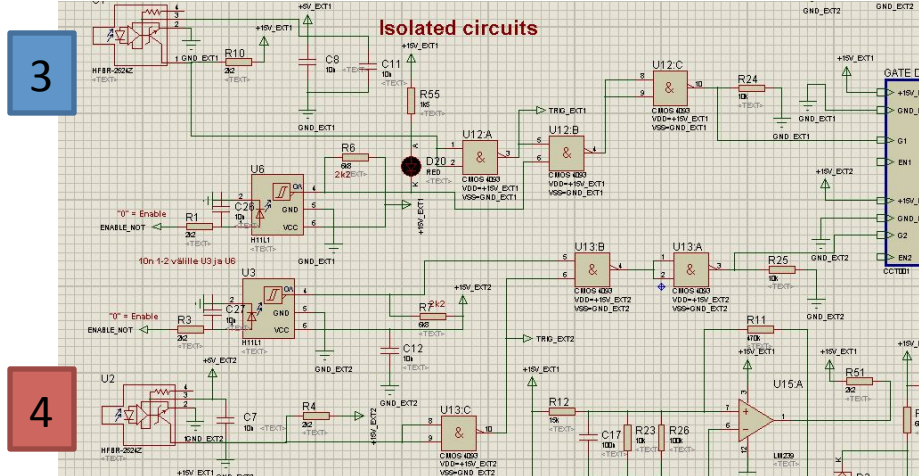
Mid 2011: PS-Group actions
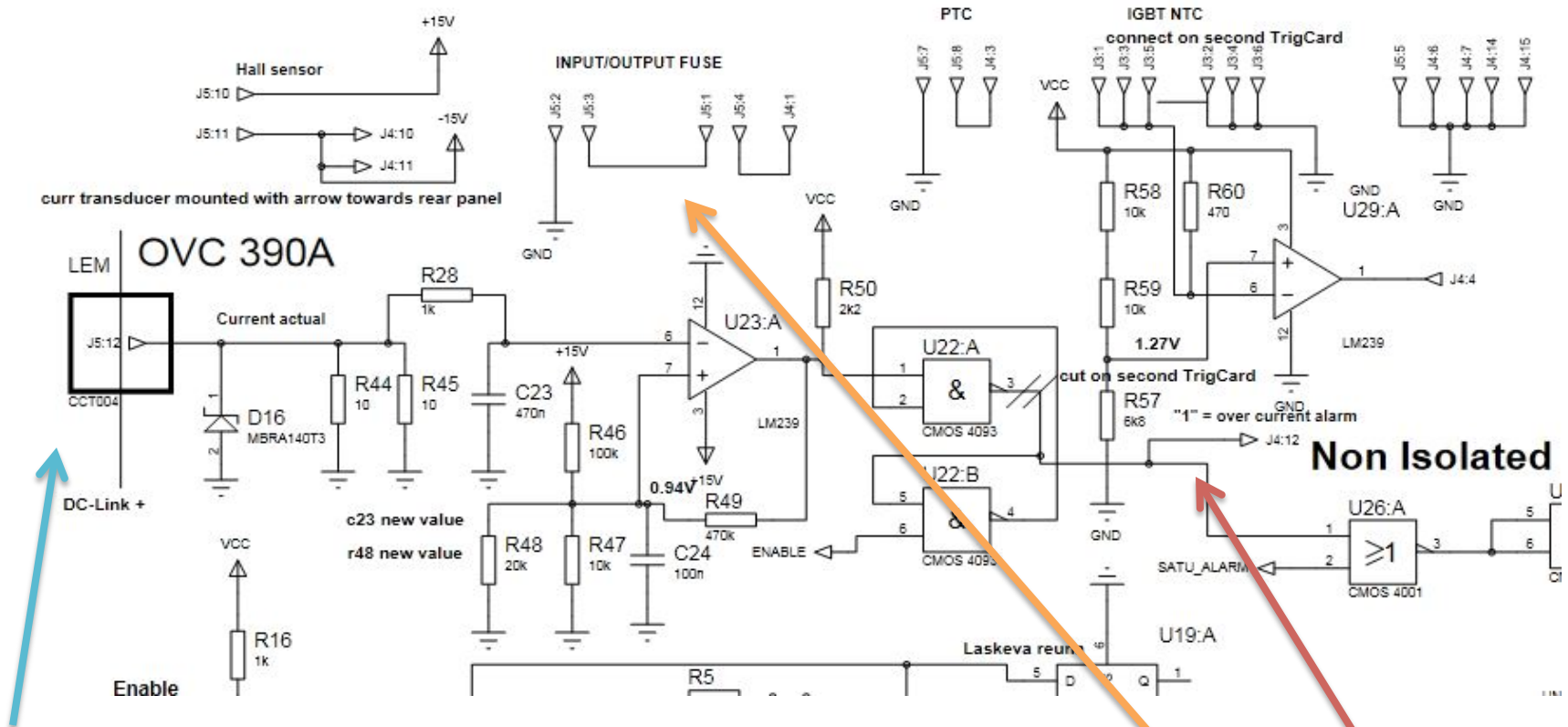
- Current transducer was reversely mounted
- Two boards are wire-ORed, thus output pins are connected together, if one has no error, ties pin low and no further errors are detected
- Output fuses switches not cabled correctly and when tripped, no indication fed to control
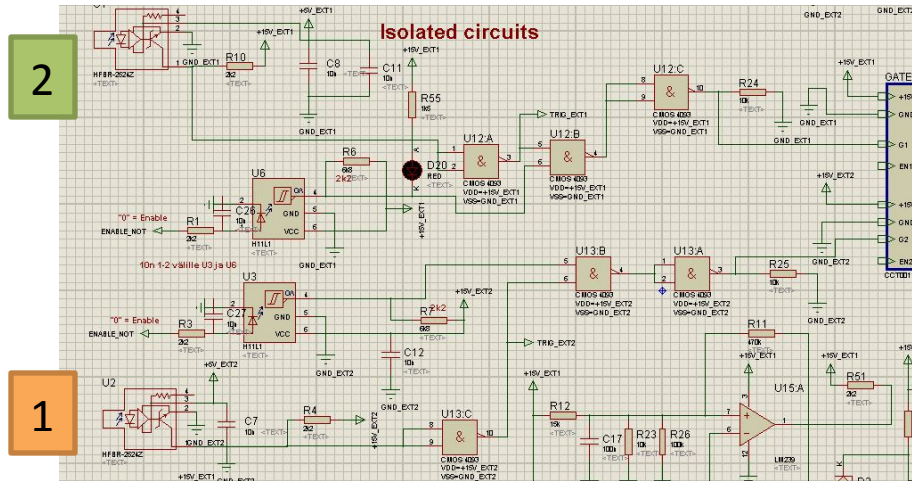
Mid 2011: PS-Group actions

- Only one card had NTCs connected (3 IGBTs), so the other card inputs were left open, thus output is wire-ORed and was always tying pin low (no error)
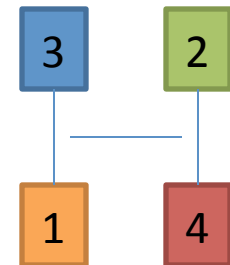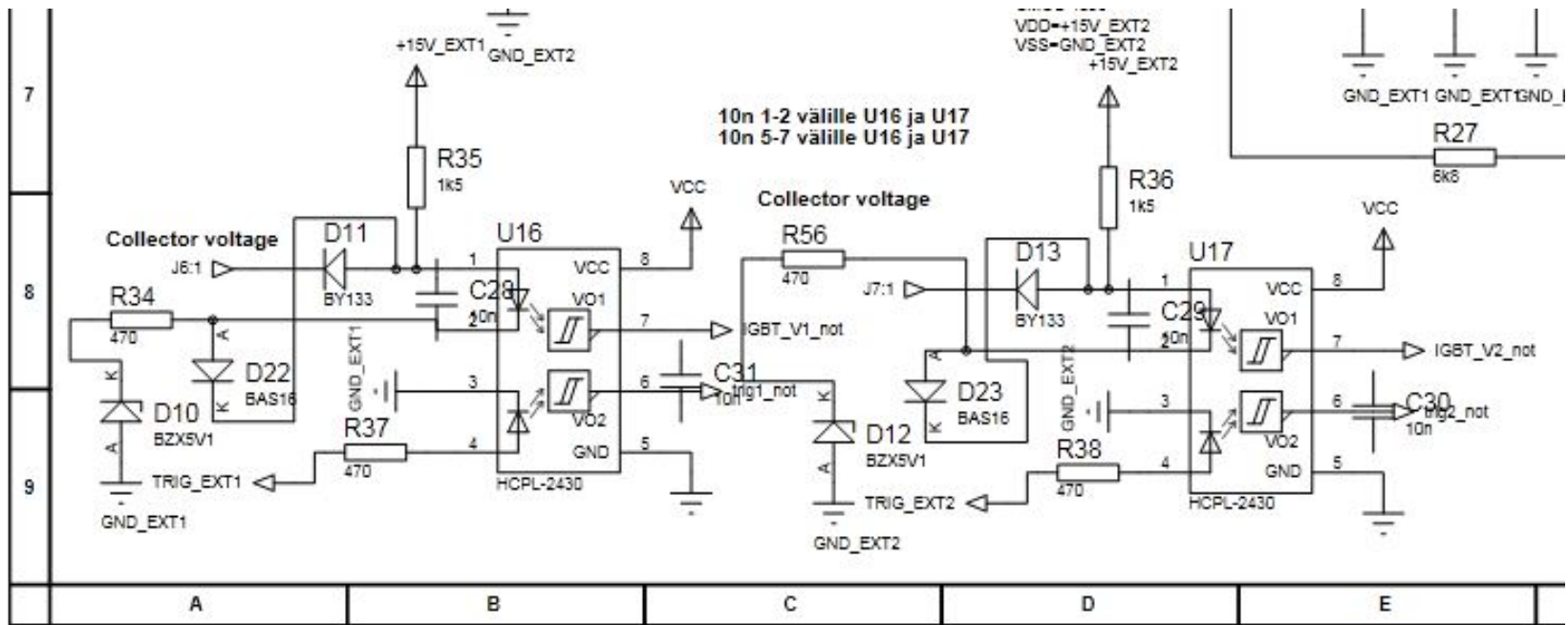
Mid 2011: PS-Group actions

- No cross-conduction circuitry between channels 1 and 3 nor 2 and 4. Each board separately drives slash and back-slash IGBTs
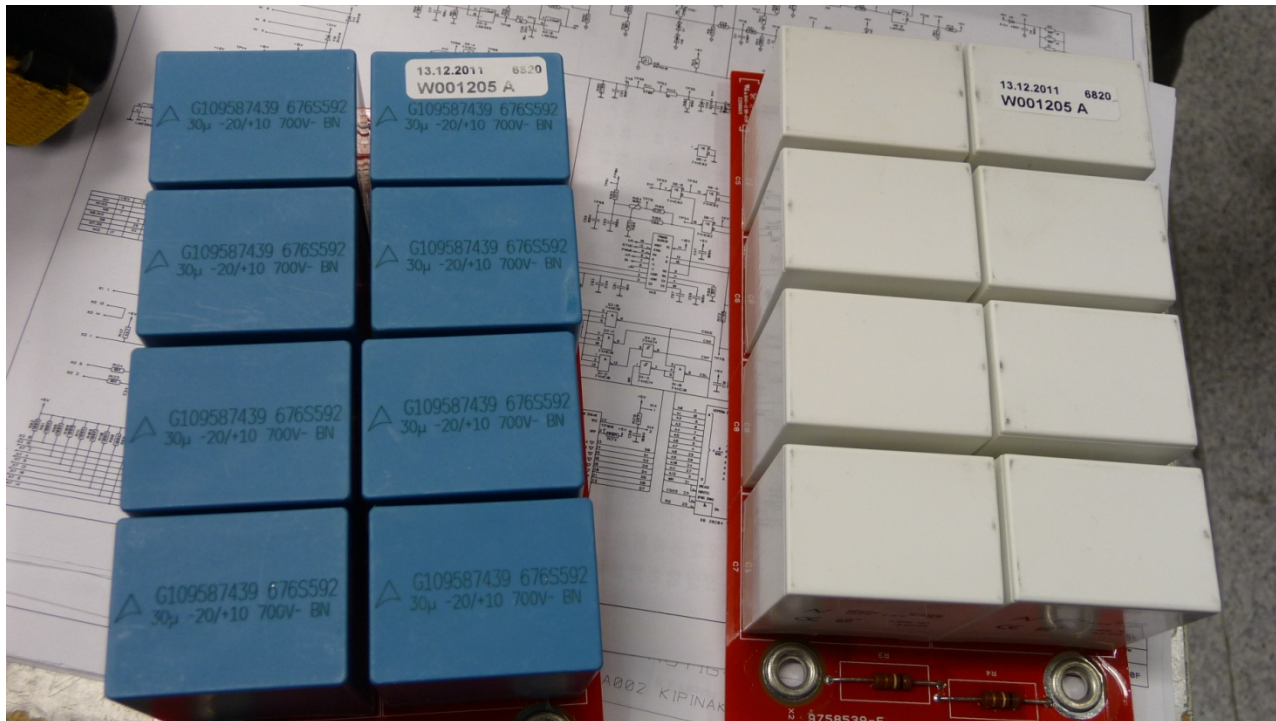
IGBT layout

Mid 2011: PS-Group actions

- Kempower disabled VCEsat circuitry because it was triggering too many false alarms.

  ...but this schematic is still tripping us...

Mid 2011: PS-Group actions

- Original output filtering circuit has been designed with wrong capacitor types (DC-link caps). Electrical contact is made only through the two feedthrough visible on the photo.

Late 2011: PS-Group actions

- Original output module had three complete H-bridge IGBTs in parallel connection.

- We decided to put two rugged half bridge IGBTs per module. We used a known commercial driver custom built over the IGBT (900 Apk)

Late 2011: PS-Group actions
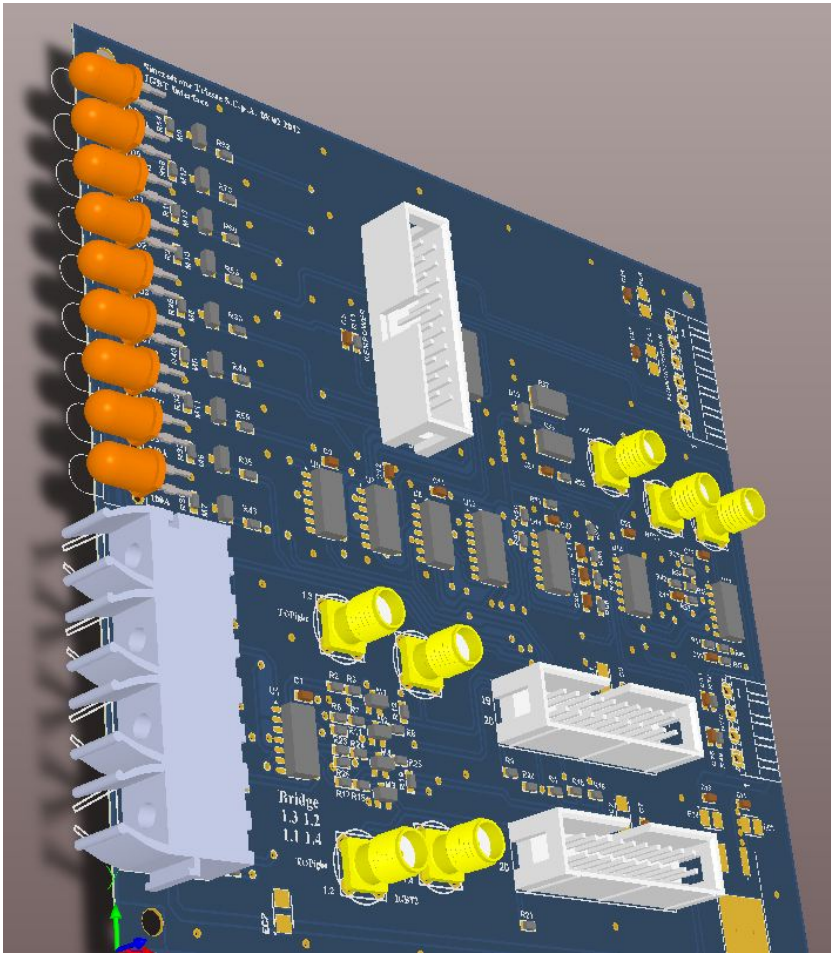
- This driver board has been developed by Elettra and embeds all features that allow a proper and safe operation.

- Furthermore it is compatible with all the Kempower circuitry behind
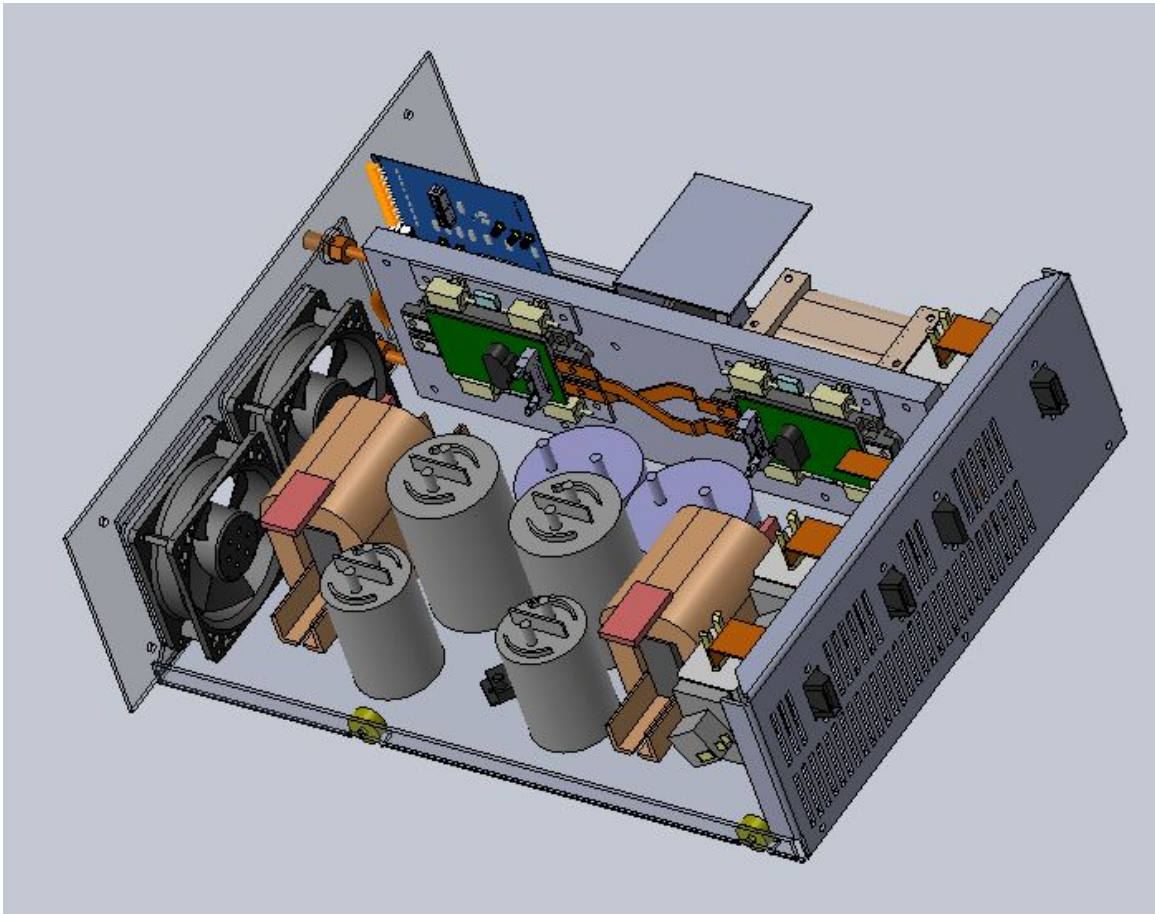
Early 2012: constraints

- Any intervention must be completed during shutdown periods.

- All systems must be working at least one day before restart.

- **Booster Service Area cannot be accessed during uptime.**
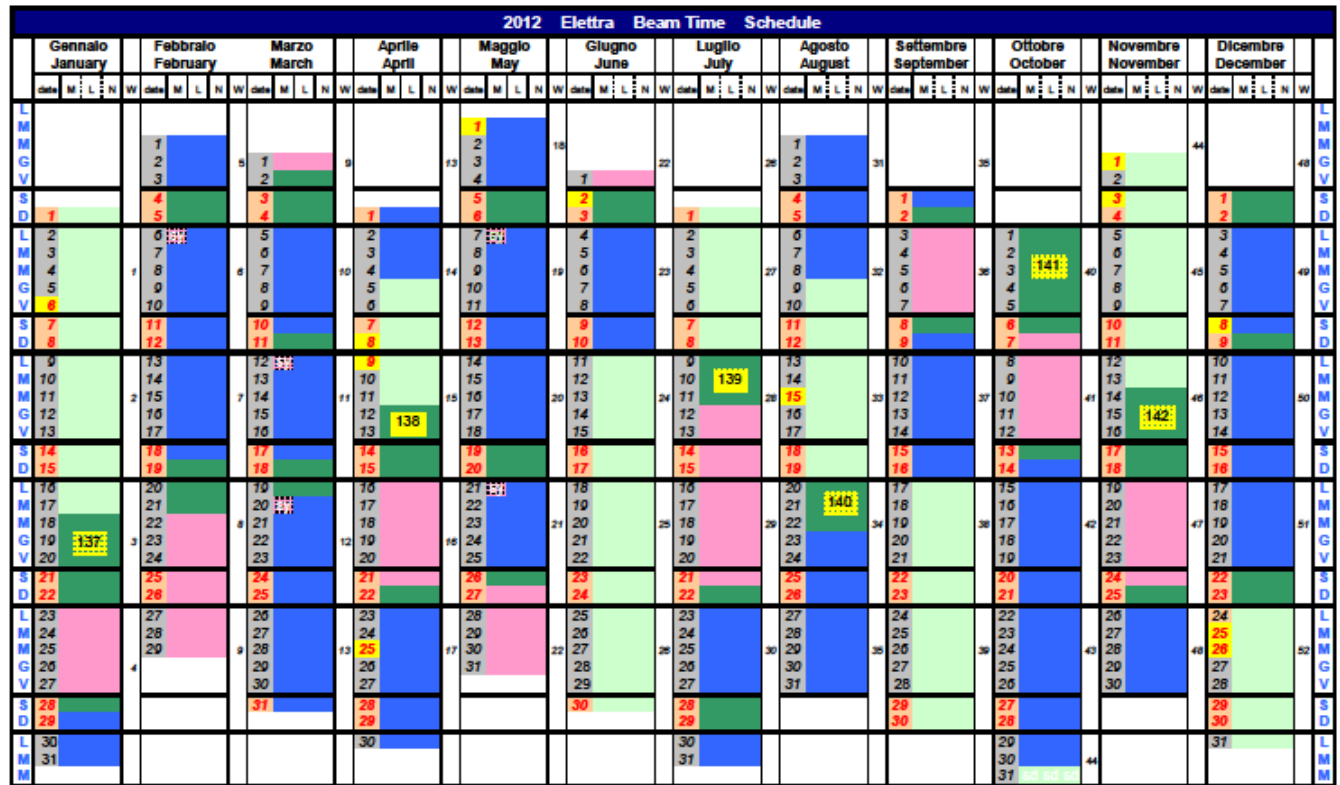
Shutdown periods: light green

Mid 2012: New Output Module

Using the same case and heat sink, we have rearranged all new components.

the new output stage passive filter with high current snubber capacitors is displayed in the central part

Perspectives

- Situation now:

  The original modules had some of the flaws fixed. The output filters are still using the wrong capacitor types and will need replacing soon.

  Two prototypes of the new kind are up and running since January on the quadrupoles power supply

- By 2013 our goal is to substitute all original output modules with Elettra ones.

- In the next years we intend to modify the AC/DC modules and work at full power@3.125 Hz

Acknowledgements

- Works are on the good way, thanks to the following people:

  - Denis Molaro
  - Piergiorgio Tosolini
  - Walter Cortivo
  - Alessandro Gubertini
  - Alessandro Carniel
  - Christian Amasoli

  And last but not least: Roberto Visintini

  Thank you for you attention