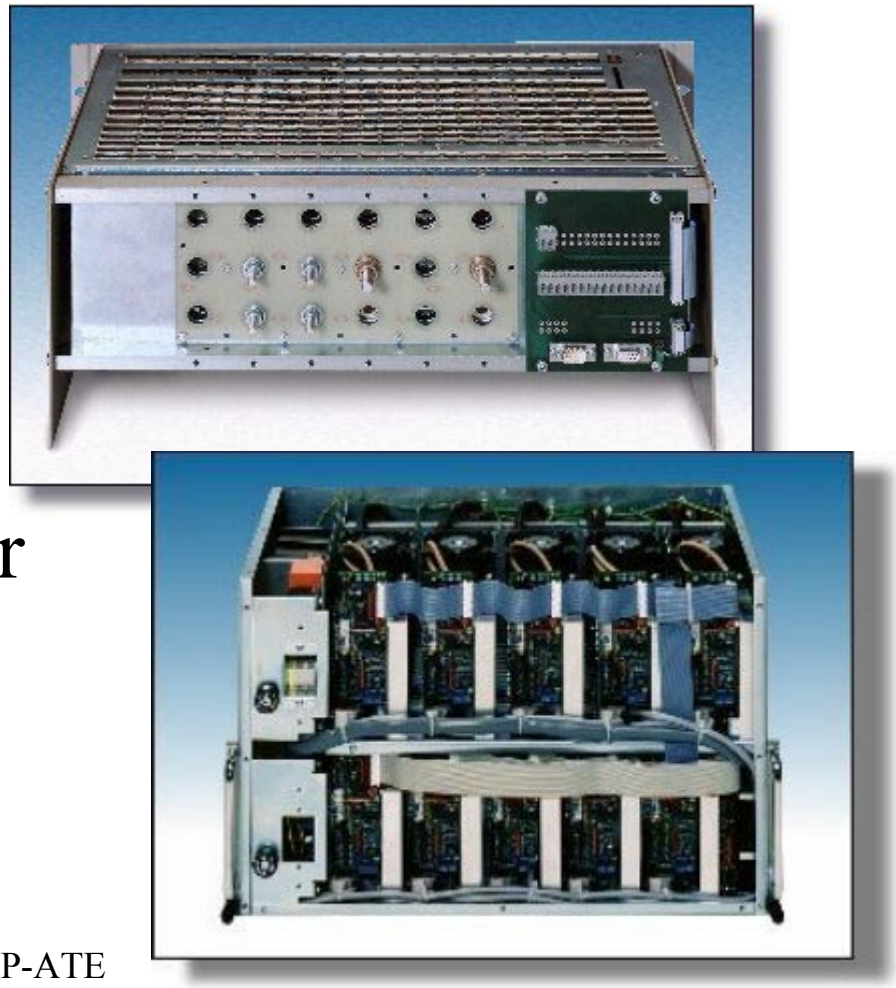
WIENER PL500 technical overview

- PL500 is multichannel low voltage power supply
- Modular design
- Max total output power up to 3kW
- 3U box



WIENER PL500 technical overview

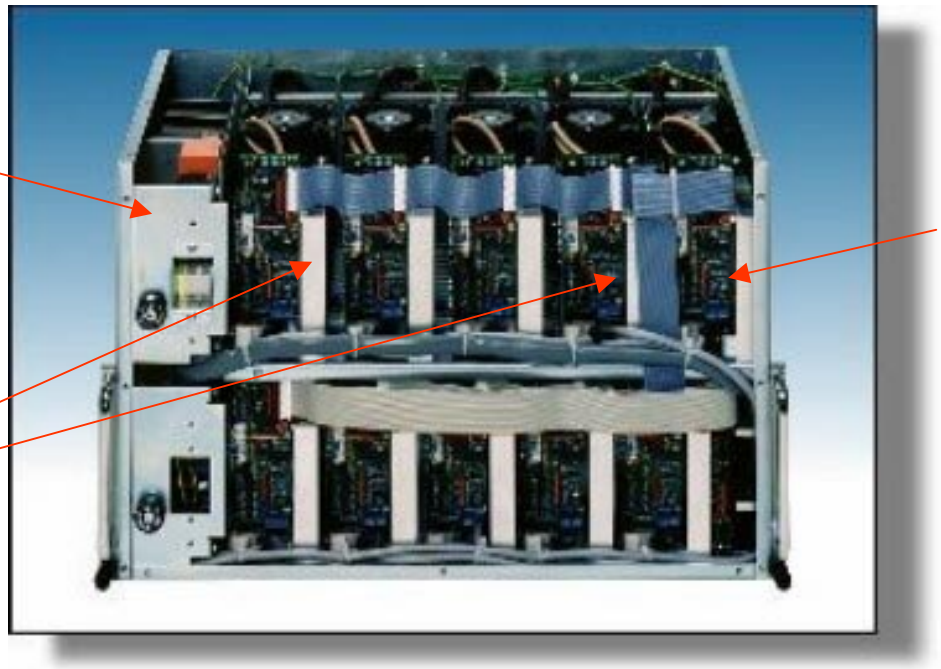
- Input 240V AC
- Selectable output levels

min. to max. range	max. output	(with C, E, H, K mains input)
2... 7V	115A / 550W	type MEH
4... 10V	85A / 650W	type MEH
7... 16V	46A / 550W	type MEH
12... 30V	23A / 550W	type MEH
30... 60V	13.5A / 650W	type MEH
2... 7V	(+/-) 20A / 140W (280W)	type MDH
7... 24V	(+/-) 11.5A / 140W (280W)	type MDL
7... 30V	(+/-) 7.4A / 180W (360W)	type MDL

WIENER PL500 technical overview

AC/DC conversion
w soft-start

DC/DC
converters



MCU with CAN bus

WIENER PL500 technical overview

- Design
  - Half bridge forward converter
  - UC3825 PWM chip - UNITRODE
  - Crate MCU based on PCF80C529 PHILIPS
- Features
  - soft start
  - sense feedback inputs
  - CAN bus steering or RS232 steering

WIENER PL500 technical overview

- Future features
  - PFC controller
  - water cooling
  - Radtol control board
- Potential future problems
  - non hardwired protection circuits
  - strong dependency of behavior on MCU

WIENER PL500 technical overview

- LHC experiments joint activity group
  - ALICE, ATLAS, CMS, LHCb + EP-ESS group (Bruno Allongue)
- Pre-qualification criteria for LHC experiments
  - Radiation criteria
    1x10^11 p/cm^2 (TID ~14krads,NIEL ~ 1.6 x 10^11 n/cm^2 at 1MeV)

WIENER PL500 technical overview

- Magnetic field criteria
  <50mT ATLAS Muon barrel or <100mT ATLAS Muon end cap, <500mT for ALICE
  - test in preparation at CERN Prevessin - H8 area
- Known results
  - SEE measurements shown that DCDC converter boards survived requested level - special presentation

WIENER PL500 technical overview

- Conclusion
  - SEE test done for DCDC converters - qualified
  - SEE test must be done for input stage or PFC and for MCU units
  - magnetic test in preparation

Radiation test of PL500 in TCC2

- Conclusion from last test in Louvain
  - All DCDC converters ran continually without trip off or other observable problems
  - Rectifier module was probably damaged by radiation after ~8.5 E 10 p /cm^2. Problem found in optocoupler which sends information about finishing of softstart sequence to MCU
  - MCU didn't tested

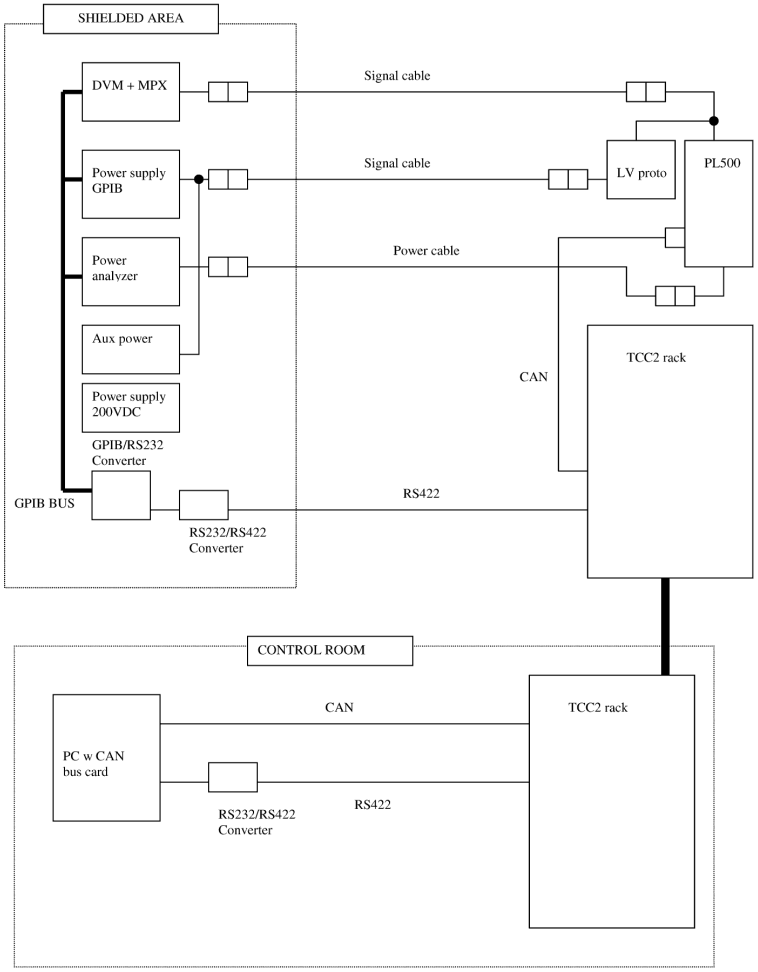
Radiation test of PL500 in TCC2

- Decision taken to make a test in TCC2
  - no available test facility around up to the summer 2002
  - closest date in available facility August 2002 in Louvain
- Test for TCC2 prepared during March and part of April
  - Test of MCU with improved SW & AC/DC converter with rad-tol optocoupler

Radiation test of PL500 in TCC2

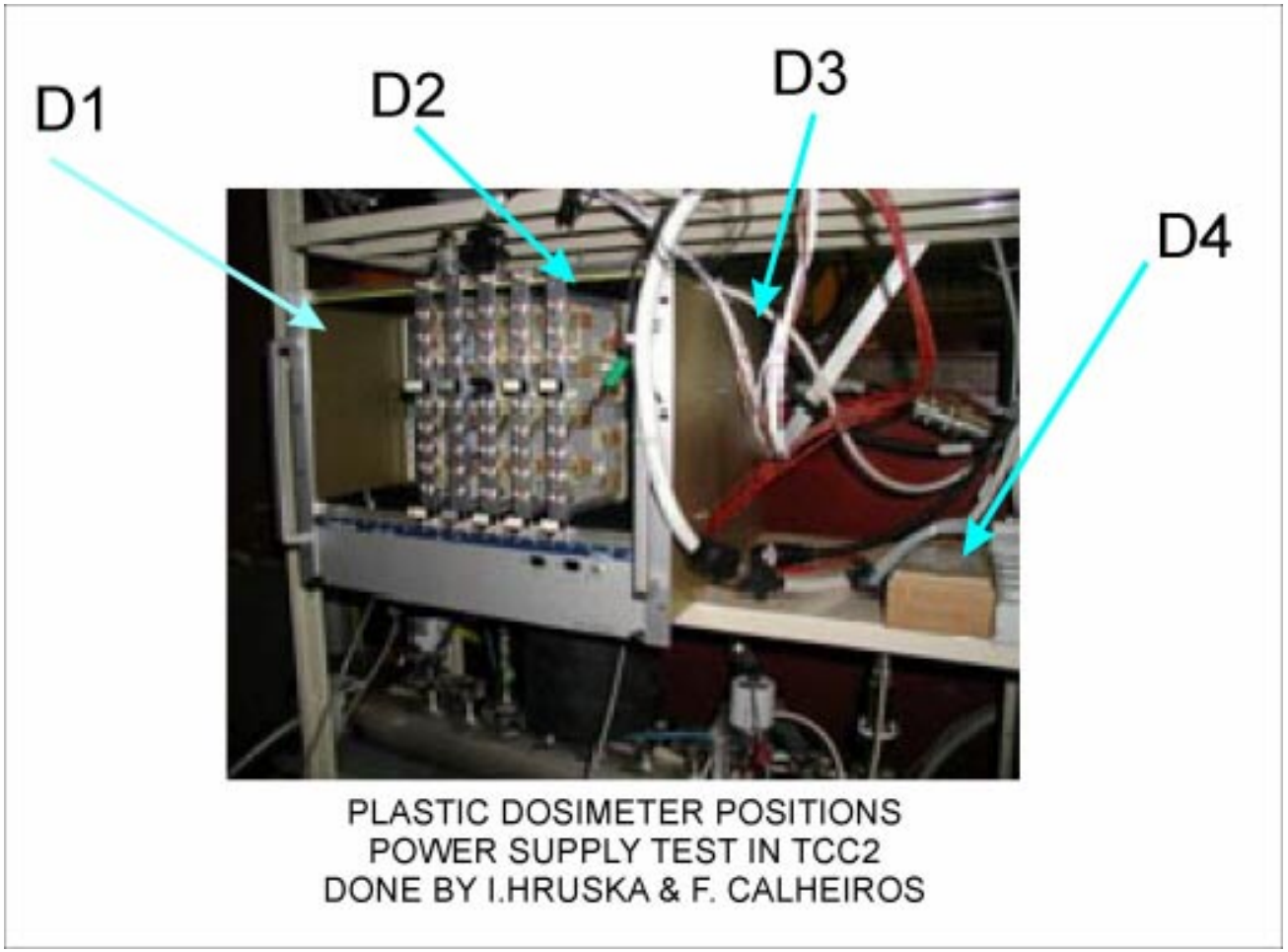
- Test setup
  - common setup for PL500 & TILECAL brick test
  - setup placed in shielded area ~ 25m from the test place - no acces during beam
  - control computer accessible - on-line & off-line data accessible through the web

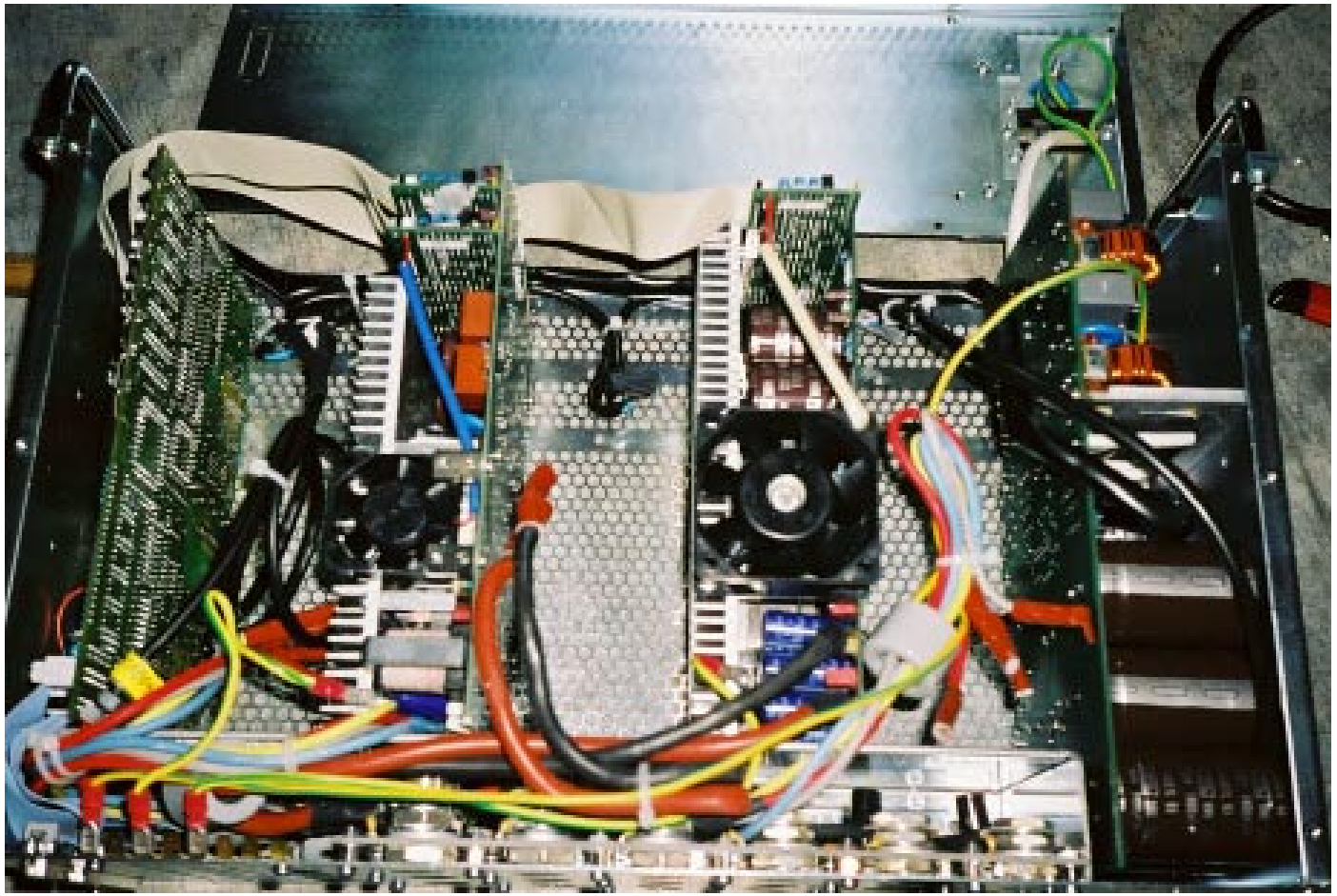
Radiation test of PL500 in TCC2



Radiation test of PL500 in TCC2

- We used plastic dosimeters placed over whole PL500 crate
  - 1) Alanine - spaghetti (flexible) placed at D1,D3
  - 2) Alanine - bar D2
  - 3) RPL D2,D4
  - D1 ~ 300Gy, D2 ~ 275Gy (Both types shown same value), D3 ~ 190Gy, D4 ~ 225Gy
  - Fixed dosimeters shown ~ 60 - 70 Gy


D1
D2
D3
D4
PLASTIC DOSIMETER POSITIONS
POWER SUPPLY TEST IN TCC2
DONE BY I.HRUSKA & F. CALHEIROS



Radiation test of PL500 in TCC2

- Results
  - Installation ready and setup running since 27th April because of limited acces in next weeks
  - Beam started Thursday 23th May afternoon.
  - **24th May. 5:44 morning**
  - CAN BUS started to show wrong voltages but good currents, DVM values are OK.
  - TID ~ 0.6krad

Radiation test of PL500 in TCC2

- **24th May , Friday morning ~ 10:14**
  - Dropdown of +12V channel to 4.3V
  - CAN shows decrease of current due to drop of voltage
  - positions of values from CAN are swapped - 5V current in position of +12V and +12V current in position of 5V current
  - voltages read by CAN are still wrong
- **24th May 15:40**
  - we are loosing power meter data
- **25th May morning ~ 10:26**
  - dropdown of all 3 channels to zero

Radiation test of PL500 in TCC2

- **28th May**
  - revival of +12V and -12V channels back to the proper values by unknown reason
  - CAN reads voltages OK and positions of current are also back
  - 5V is dead.
- **29th May afternoon**
  - we did a power cycling of crate and all voltages are back
  - CAN doesn't read +5V anyway the voltage is there by DVM
  - power meter after its power recycling is back in function
  - TID ~ 3.2krad

Radiation test of PL500 in TCC2

- **30th of May ~ 21:00**
  - all outputs are dead
- **3rd of June afternoon - exceptional access**
  - after power cycling voltages were back
  - but only for 3 minutes
- **12th of June**
  - removal of PL500 from TCC2

Radiation test of PL500 in TCC2

- Conclusion
  - PL500 didn't survived more than 10 hours with radiation ~ 0.6krad
  - behavior has been worse and worse with increasing TID
  - CANbus steering and readout lost
  - Decisions taken to
    - return crate to manufacturer for analysis
    - stop the prepared test in PSI facility
  - Suggestions for next development sent to WIENER

SEE test of WIENER PL500

- SEE test done in PSI Villingen, 1-3 Nov 2001
- Beam of protons 250MeV reduced to 60MeV with flux 2.5E7 p/cm^2/s with diameter ~ 80mm
- Tested fluence 10^11p/cm^2 => 66min / spot

SEE test of WIENER PL500

- Allocated time in the beam since 1st Nov 20:00 up to 2nd Nov 2:00
- 2 MCU boards + 2 AC/DC rectifier module to irradiate
- Beam focused to CPU (80C592) & surrounding circuits

SEE test of WIENER PL500

- Test setup
  - 1 Electronic load
  - Multimeter with multiplexer for output & aux voltages measurement
  - PC with GPIB bus for data storage with VB software + CANBUS
- We had support of Mr. Koester, designer from WIENER company

SEE test of WIENER PL500

- Run
  - 21:11 first run (delay) with first CPU board
  - Then after 2.3E10 p/cm^2 or 3.11krads first SEE
    - typical latch-up revived by power cycling
    - lost of output voltage via CANbus only

SEE test of WIENER PL500

- Test continued until 4.41E10 or 6.8krads
  - then dropout of output voltage
  - restarted via CANbus
- The same effect happened once again at ~5.4E10 or 8krads
- Finaly reached 1E11 and 14krads as specified

SEE test of WIENER PL500

- 0:12 test of first rectifier unit
- reached 1E11 and 14krads as specified without any problems
- 1:52 test of second rectifier unit
  - immediately after start crate trip off
  - impossible to continue the test
- Test stopped at 2:15

SEE test of WIENER PL500

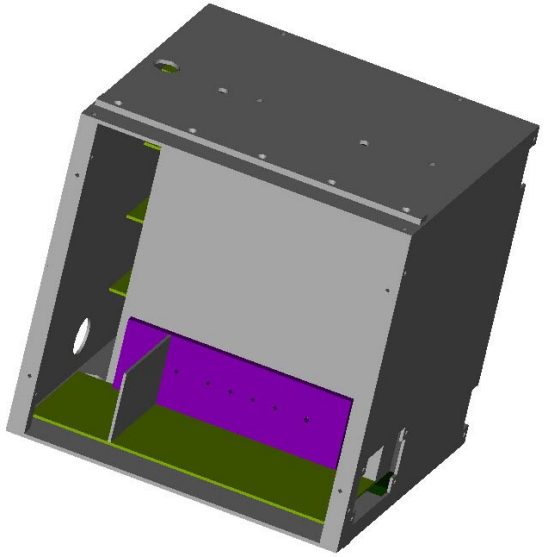
- Conclusion
  - Confirmed results from TCC2 that MCU unit is not robust anyway WIENER did some changes to improve the tolerance
  - One rectifier module completely OK, second impossible to test with immediate SEU, reasons unknown
  - Next negotiations with company on the schedule

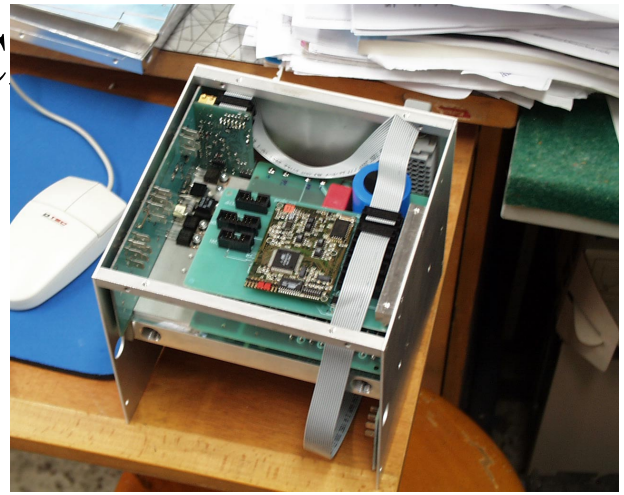
LV brick for TILECAL

- Overview
  - New design description & progress
  - Results form TCC2
  - Results from radiation tests in PSI Villingen
  - Plans for future
  - Some corrections of power computings

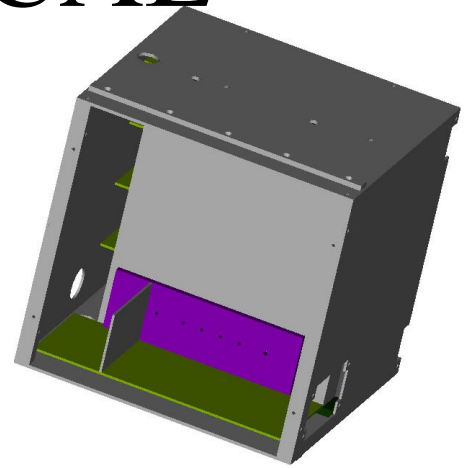
LV brick for TILECAL

- Summer 2001 LV Box prototype
  - Converts 300V DC to levels +5V,+15V,-





LV brick for TILECAL



- LV Box prototype 2001
  - has common ground for all outputs
  - uses unified brick
    - plug-in module common for all output levels (+ & -)
    - output voltage possible to set from 2.5 to 16V
    - integrated steering & measurement of in/out parameters
    - 150W maximum output power
  - steered by ELMB
    - special motherboard for ELMB
  - all components selected from rad databases
    - old components
    - low conversion frequency
    - big size of some components (inductors & capacitors)

LV brick for TILECAL

- New brick
  - After testbeam 2001 new requirements arrived
    - split off the grounds
    - minimize the number of electrolytic capacitors
  - Completely new design of brick necessary
    - isolated DC/DC converter
    - using modern components to have
      - high conversion frequency (small inductive parts)
      - high efficiency
    - but
      - unknown behavior in radiation
  - Possible use the work done on steering, cooling & mechanics for LV box prototype

LV brick for TILECAL

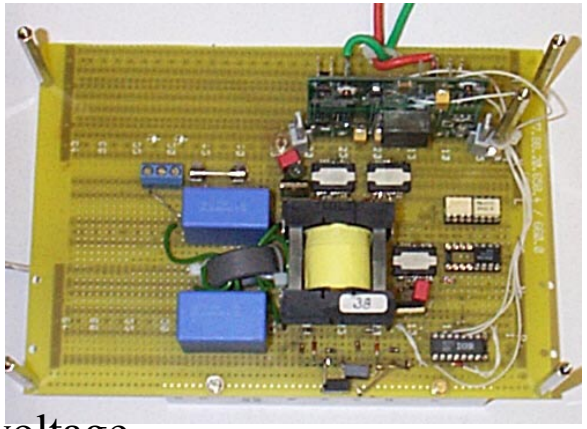
- New brick requirements
  - 150W of maximum output power
  - 200- 300V input / isolated output
  - 3 standard levels with trim +/- 20% - 5V, 3.3V, 15V
  - Radiation tolerance requirement

TILECAL LV supply radition test requirements

	Worst numbers for PS region from simulation	SF	Test doses required	Doses obtained by SEE	factor - number of pieces to reach the TID		
TID	5.31E+00	70.00	371.70	2447.20	6.58	Gy per 10 years	
TID	5.31E-01	70.00	37.17	244.72	6.58	krad per 10 years	
NIEL	3.18E+11	20.00	6.36E+12	3.98E+12	0.63	n/cm^2 per 10 years	
SEE	8.74E+10	20.00	1.75E+12	-		p/cm^2 per 10 years	
Time of the SEE test in case of		5.00E+08	p/cm^2/s a	8	pieces is	7	min
1.00E+11 p/cm^2 with energy 60MeV means ~14krad							
1.00E+11 p/cm^2 is equivalent to 1.6n/cm^2 for NIEL							

LV brick for TILECAL

- New brick - Design approaches
  - First approach - Extension of Linear Technology sample
    - Origin parameters
      - Size 50 x 50 mm
      - Output 5V/10A
      - Input 40 - 70V
      - uses LT1681 & LTC1698
      - efficiency 90% typically
    - Dual transistor forward converter
    - Extension to run on 200 - 300V input voltage
    - Extension to have measurement of in/out parameters
    - Improvement radiation critical circuits
    - Minimization of number of magnetic components



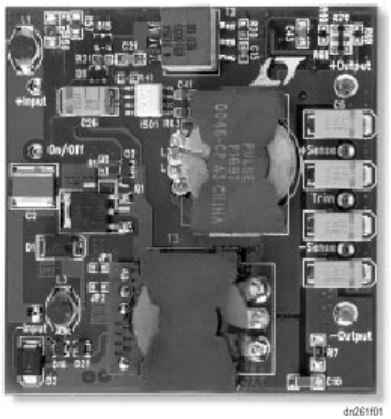
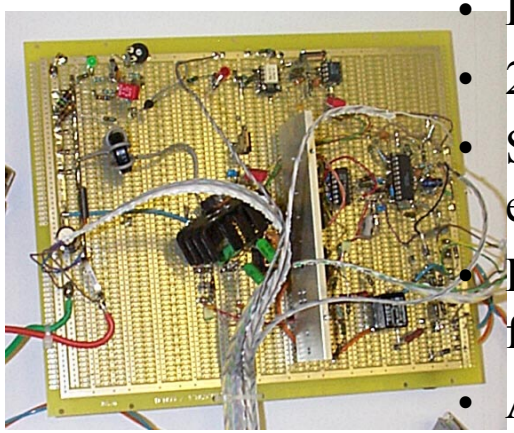


Figure 1. 3.3V/20A Supply in Half-Brick Footprint

LV brick for TILECAL

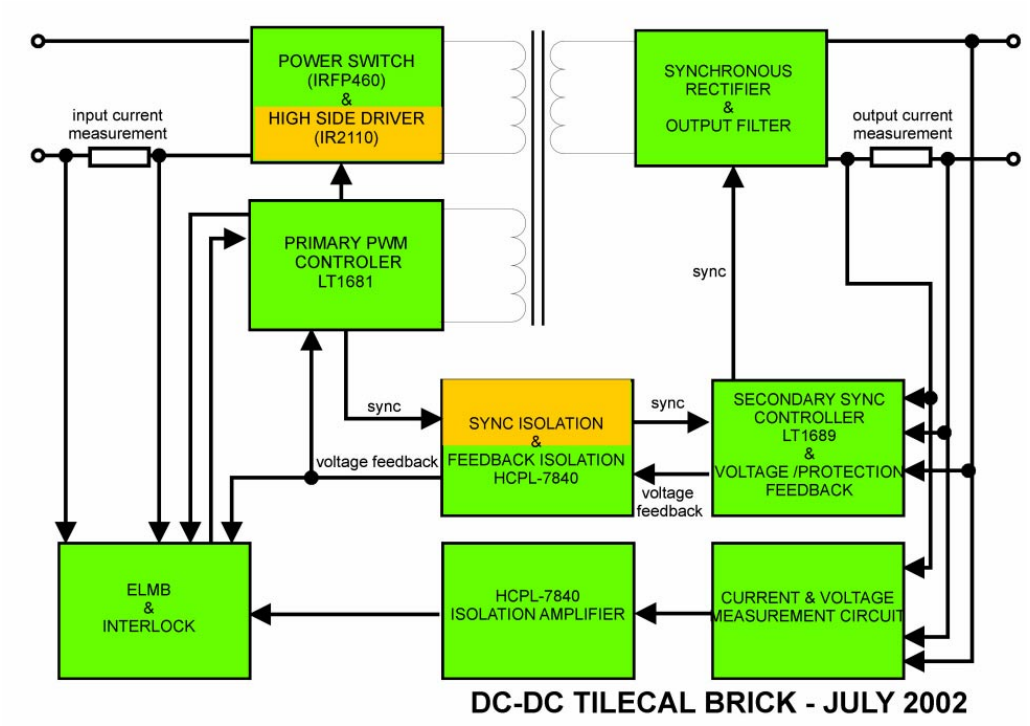
- New brick - Design approaches
  - Second approach - Half bridge converter



    - Based on old chip UC3526
    - 200 - 300V input voltage
    - Secondary side & auxiliary circuits designed same as for extended LT brick - not realized yet
    - Primary side with diode rectifier on secondary side prepared for radiation test
    - Advantage in comparison with first approach is that
      - can use smaller transformer core
    - but
      - needs additional 2 big sized capacitors

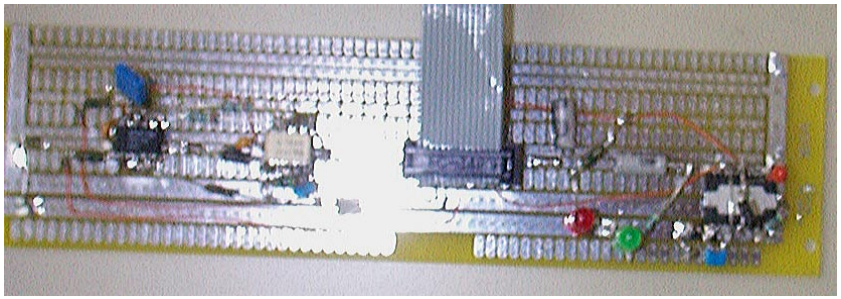
LV brick for TILECAL

- New brick design - LT sample extension

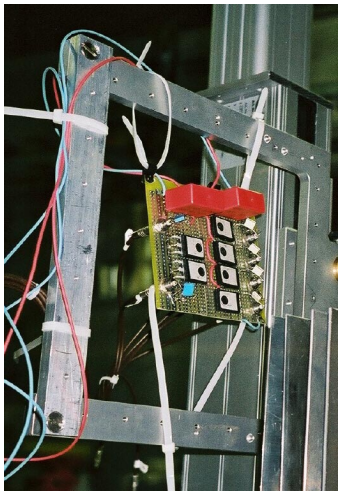


LV brick for TILECAL

- Results form TCC2
  - Test of OIA (Optically isolated amplifier)
    - used for feedback & measurements on secondary side of DC/DC converter
    - Survived 22.5krad without any change of transfer function (measured by plastic dosimeter)
    - Test stopped because of preparation for PSI



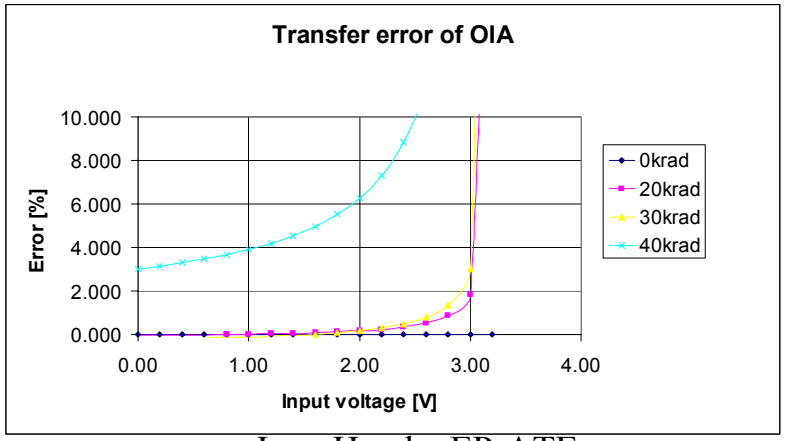
LV brick for TILECAL



- New design radiation test - PSI Villingen
  - Test of components
    - Primary side
      - 6 x IRF460 NO SEE >40krads & 2E12 p/cm^2
      - 8 x IRFP9N60 (SMD) NO SEE >40krads & 2E12 p/cm^2
    - Secondary side
      - 8 x IRF260N NO SEE >40krads & 2E12 p/cm^2
      - 8 x IRF3710 (SMD) NO SEE >40krads & 2E12 p/cm^2
  - Test of modules
    - Original LT brick
      - Survived ~ 40krad - still running
      - Visible SEEs & voltage drift but LT chipset is bipolar
      - Chipset is possible to use

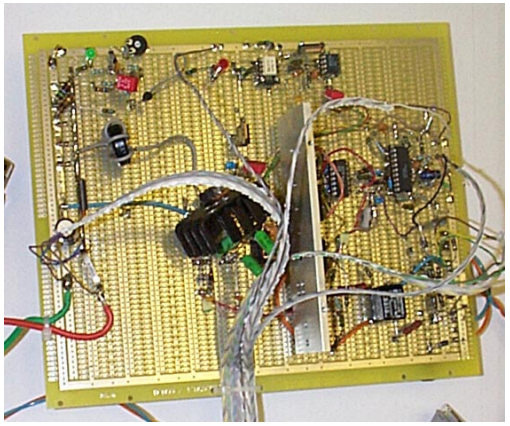
LV brick for TILECAL

- New design radiation test - PSI Villingen
  - Test of modules (continues)
    - Optically isolated amplifier - OIA
      - Uses HCPL 7840 & LM6142
      - Up to 30krad without change of transfer linearity
      - Tested up to 40krad - then few percent change of gain
      - Tested also in TCC2 area up to 20krad - OK



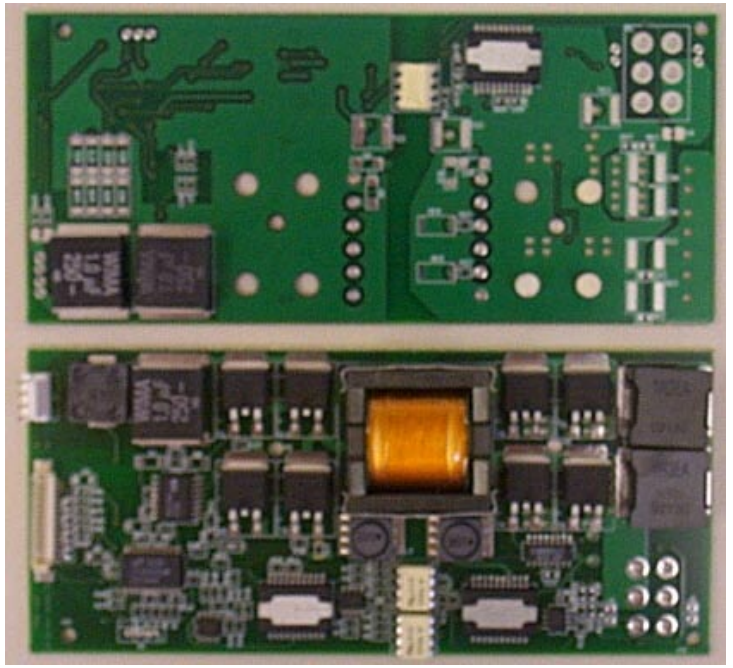
LV brick for TILECAL

- New design radiation test - PSI Villingen
  - Test of modules (continues)
    - Half-bridge converter primary side
      - Uses UC3526 , IR2110 & 2x IRF460
      - Dead after 30krad - fuse OK, unknown reasons yet



LV brick for TILECAL

- New design - based on PSI results
  - PCB design ready - 8 pieces produced
  - Now in debugging procedure
  - Transformer tested ~ 1kV isolation



LV brick for TILECAL

- Plans for near future
  - Debugging of prototype
    - Verification of basic functions (5V version)
    - Feedback tuning
    - Ripple
      - Tests of different transformer & filter setups & shunt circuits
    - Tests of 15V & 3.3V versions (different transformer)
    - Flat PCB transformer design
      - simplest manufacturing

LV brick for TILECAL

- Plans for near future (cont.)
  - Additional radiation test
    - PSI 1-3 November 2002
      - SEE Test of MOSFETs (comments to my TMB presentation)
      - SEE Test of high side driver chip IR 2213
      - SEE test of whole brick in few orientations
    - TID 2nd December - Saclay ???
      - Optocoupler for synchronous rectifying
        - » (? Not necessary if we find some already tested)
      - New linear regulators (LM117 - reduction of costs ~ 40CHF/brick)
      - Crowbar (transil)
      - Bipolar latches for remote control

LV brick for TILECAL

- Plans for near future (cont.)
  - Design changes according to results from SEE,TID & electrical tests - new series of bricks
  - Design of remote control PCB based on 2001 design and new ideas how to use ELMB for power supply
    - ELMB is not reliable component in radiation - SEEs
    - Idea of "electronic shielding" by using bipolar latch
    - Result should be
      - possibility of reliable steering in radiation
      - "unreliable" readout of status (in/out current, voltages etc.)

LV brick for TILECAL

- Estimation of costs for LV system

DCDC BRICK		
		%
DIODES	3.77	1.72
OPTOCOUPLERS	22.34	10.16
IC's	92.51	42.06
RESISTORS	2.85	1.30
CAPACITORS	29.31	13.33
TRANSFORMER & INDUCTORS	24.76	11.26
CONNECTORS	9.40	4.27
PCB	25.00	11.37
	209.94	95.45
COMPONENT MOUNTING	10.00	4.55
	219.94	100.00

POWER SUPPLY BOX	
HEATSINK	100.00
ELMB	100.00
ELMB MOTHERBOARD	100.00
BOX	100.00
CABLES	20.00
8 x DCDC CONVERTER	1759.51
	2179.51

270 BOXES	588469

Num of pieces	Component	Price / piece	Price/brick	Pieces/ tileca	Price/Tilecal
1	1N4004	0.119	0.119	2160	257.04
2	8ETH06S	1	2	4320	4320
3	BAS21	0.113	0.339	6480	732.24
6	BAV99	0.219	1.314	12960	2838.24
			3.772		
1	6N139	1.335	1.335	2160	2883.6
3	HPCL7840	7	21	6480	45360
			22.335		
1	IR2110	8.25	8.25	2160	17820
3	L4913_1	15	45	6480	97200
3	LM6142	3.3	9.9	6480	21384
1	LT1681	8	8	2160	17280
1	LTC1698S	8.4	8.4	2160	18144
2	MFET_NPN	1.8	3.6	4320	7776
4	MFET_NPN	2.34	9.36	8640	20217.6
			92.51		
1	RESISTOR	0.35	0.35	2160	756
1	RESISTOR	0.35	0.35	2160	756
1	RESISTOR	0.03	0.03	2160	64.8
1	RESISTOR	0.03	0.03	2160	64.8
1	RESISTOR	0.03	0.03	2160	64.8
1	RESISTOR	0.03	0.03	2160	64.8
1	RESISTOR	0.03	0.03	2160	64.8
1	RESISTOR	0.03	0.03	2160	64.8

LV brick for TILECAL

- Power & cable computing correction

	Voltage	Current	Power	Efficiency	Input power
Hvside	5.00	1.00	5.00	85.00	5.88
	15.00	1.00	15.00	85.00	17.65
	-15.00	4.00	60.00	85.00	70.59
3in1	5.00	20.00	100.00	85.00	117.65
	-5.00	10.00	50.00	85.00	58.82
	15.00	1.00	15.00	85.00	17.65
Digitizer	5.00	10.00	50.00	85.00	58.82
	3.30	10.00	33.00	85.00	38.82
Output power / box			328.00		385.88
Input voltage	200.00				
Input current	1.93				
Fingers connected to one bulk supply-daisy chained fingers	4.00				
Non used power of bulk supply [%]	22.82				
Cable resistance					
Wire crossection [mm^2]	2.50				
Resistivity of cooper	0.0220				
Length [m]	300.00				
Resistance [Ohm]	2.64				
Power loses in cable	157.24	with connected	4.00	fingers	
USA15 output power / finger	1700.77				
Total number of cables needed (no spares)	64.00				
TILECAL Power supply system efficiency profile	Power [w]	% of total input power	% loses		
USA15 input power / TILECAL	120944	100.00			
Bulk supply loses	12094		-10.00		
USA15 output power -> TILECAL in UX15	108849	90.00			
Cable loses	10064		-8.32		
Power loses in converter box	14818		-12.25		
Output power	83968	69.43			83968.00

LV brick for TILECAL

- Conclusion
  - There is technically possible to build DC/DC converter brick which survive radiation > 30krads - more than 10 years of operation - in TILECAL finger with required parameters
  - Estimated cost of one brick should be below $150 (220CHF)
  - Prototype ready in debugging & tuning process
  - Next radiation tests necessary
    - TID test of chipset - better statistics
    - SEE/TID test of prototype & some components
  - Cable estimation did in March 2002 were corrected but conclusion is still OK