Detector Powering in the 21st Century
Why stay stuck with the Good old 20th Century methods?

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Technology and Instrumentation in Particle Physics 2011
9-14 June 2011, Chicago, Illinois

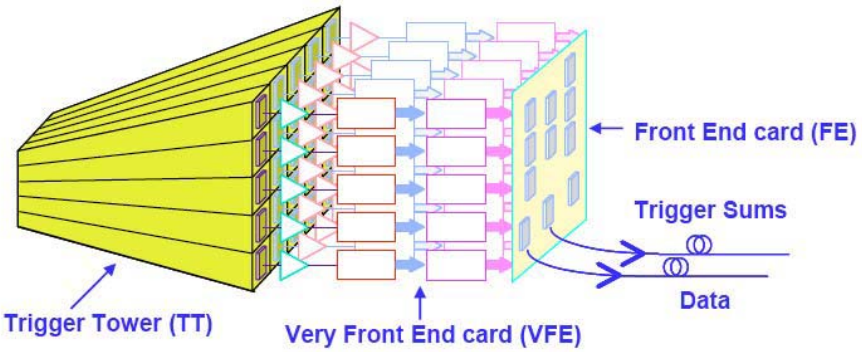
Agenda
CMS ECAL- powering

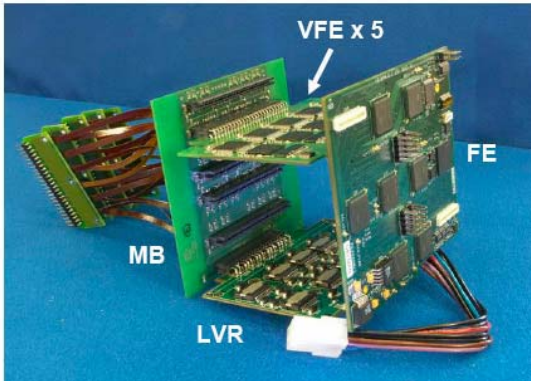
Thomas Edison

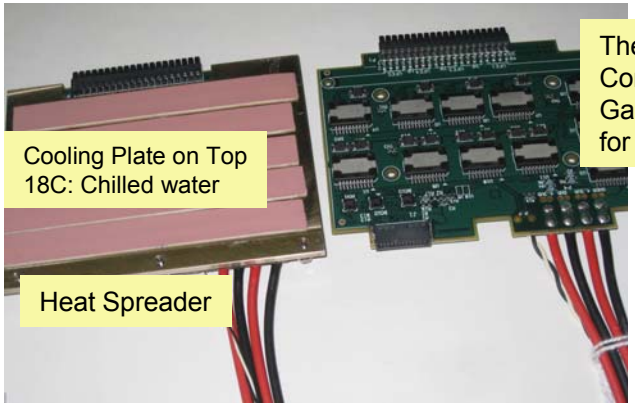
20th Century State of Power Distribution – *LHC Detectors*

ECAL readout system was:

- designed in ~2000
- produced in 2001-2007
- commissioned in 2006-2007

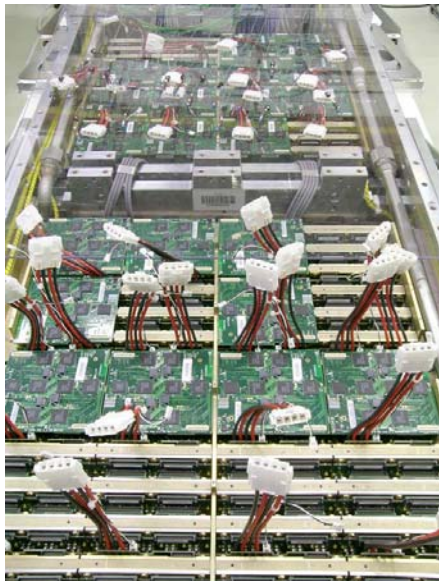


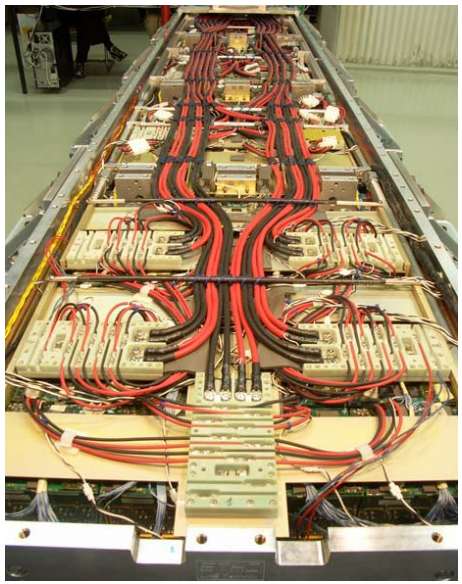


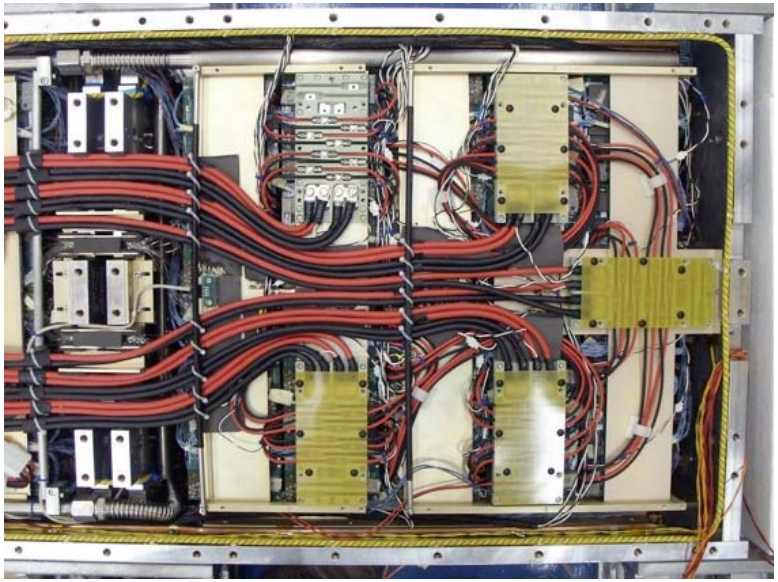


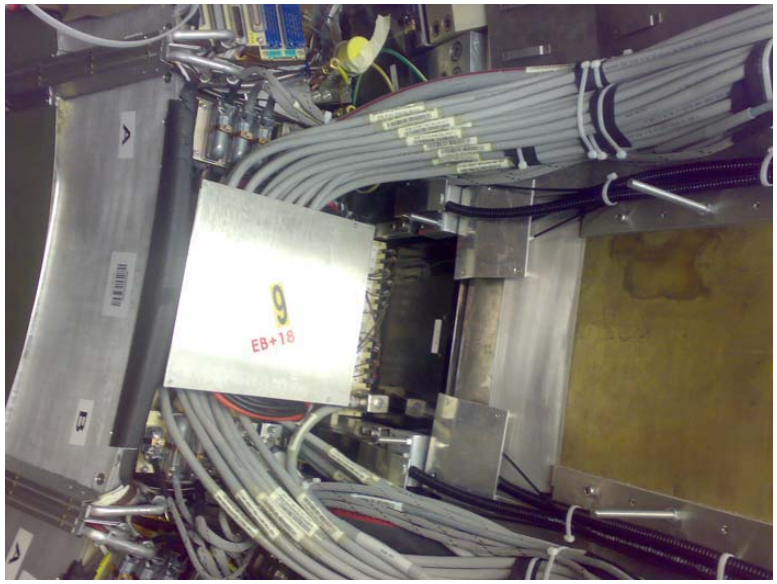
FE produces distributed heat low W/sq cm
Power Boards High W/sq cm. use heat spreaders

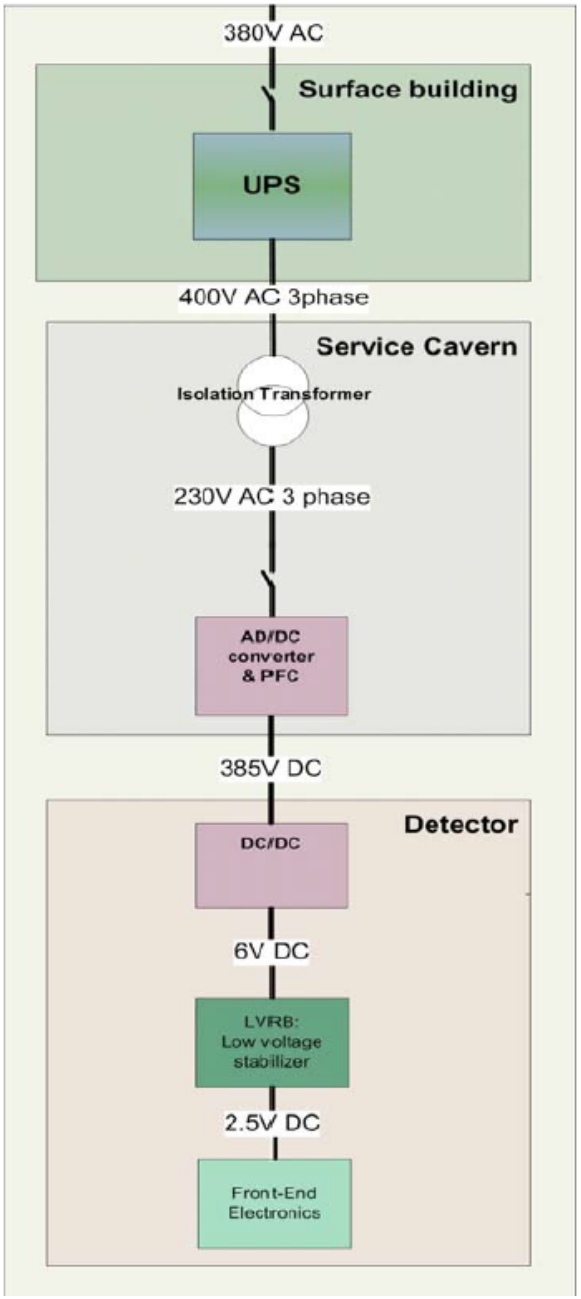
CMS ECAL Super modules











380V AC

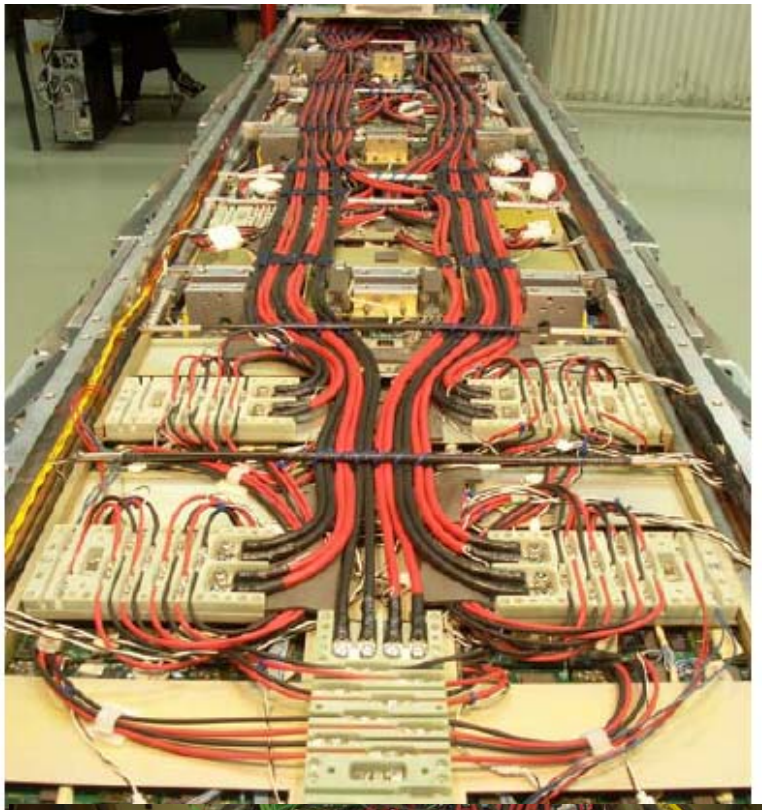
400V AC

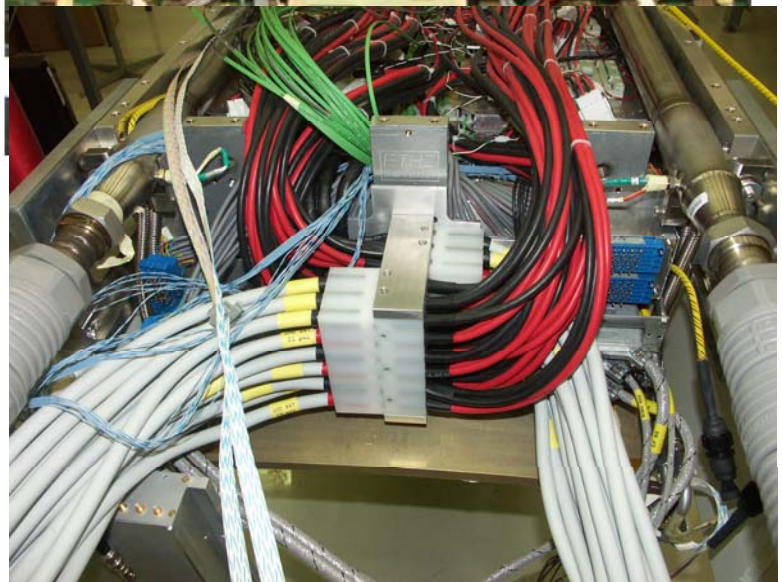
230V AC

385V DC

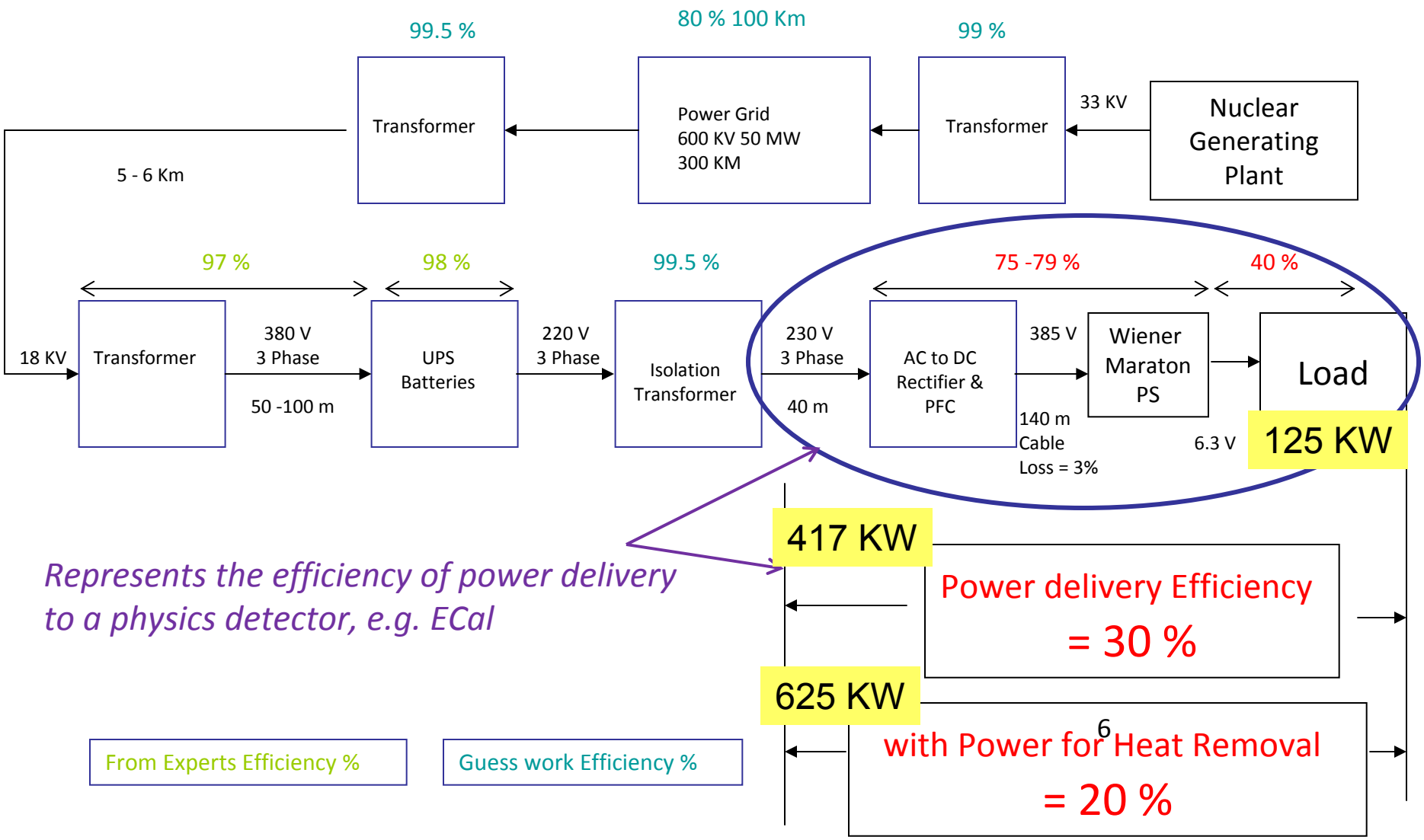
6V DC

2.5V DC





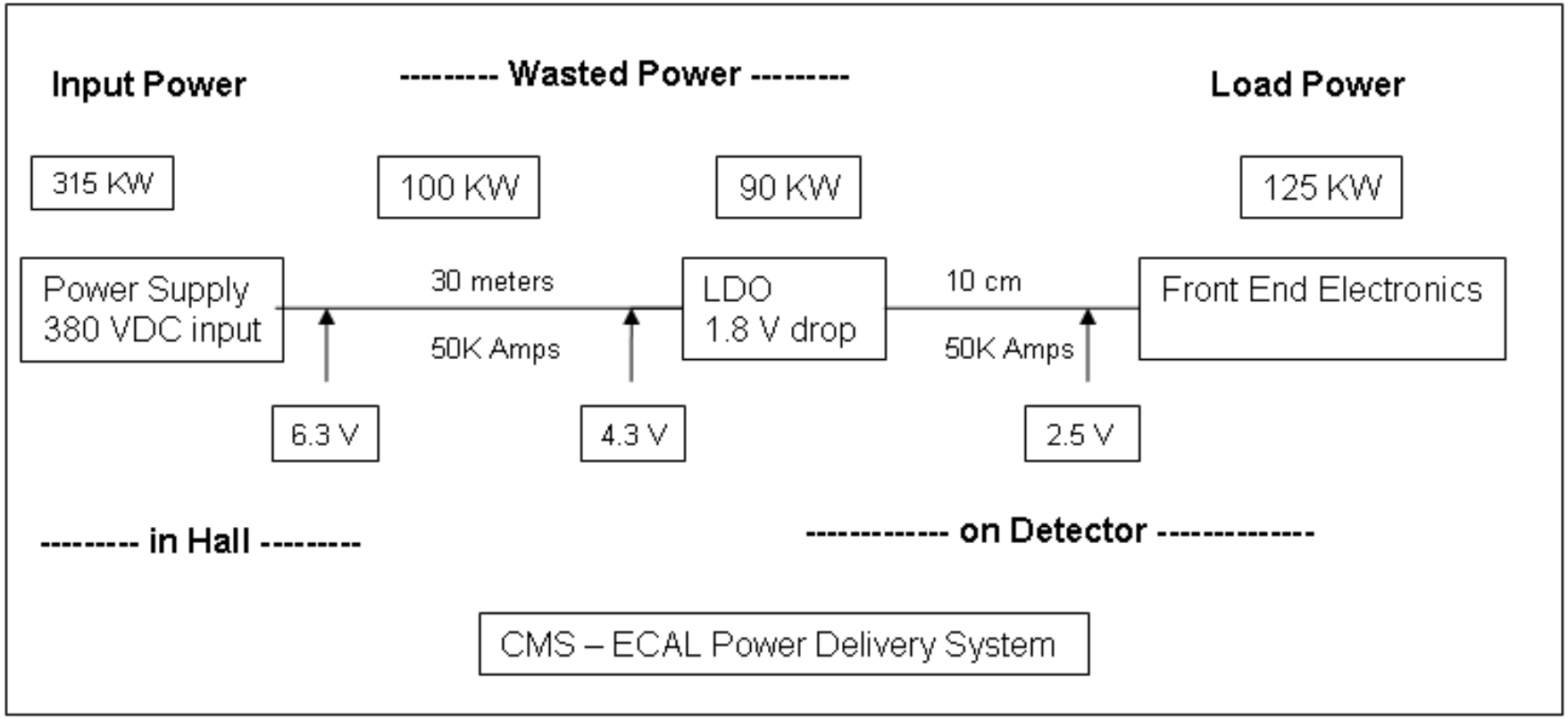
Power Chain Efficiency for CMS ECAL



Represents the efficiency of power delivery to a physics detector, e.g. ECal

It takes 2 watts of power to remove 1 watt of heat load

Power Efficiency _ Inefficiency _ Wasted Power



Collider Detector Magnetic Field & Radiation
Sub-Systems operate:
Main 1.5 to 4 Tesla
Fringe Magnetic field 0.1 to 1 Tesla
Radiation Tolerance: Highest for trackers ~ 100 Mrads
~ 1 Mrads for outer sub systems

Collider Detector Power Essential
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Main 1.5 to 4 Tesla
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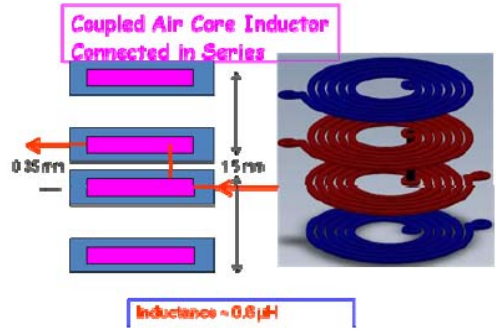
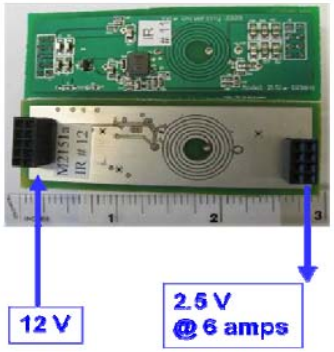
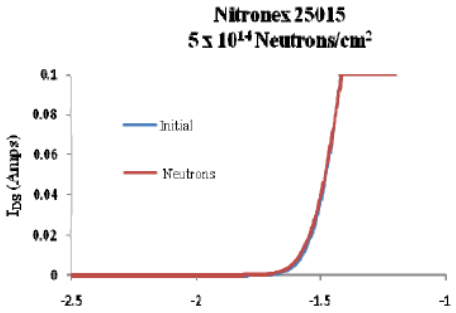
TABLE III Radiation Testing Matrix for GaN Devices

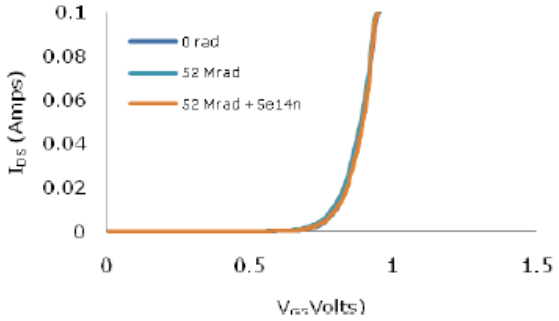
Company	Device	60Co	Neutron Fluence (cm^{-2})	Proton Fluence (cm^{-2})
Nitronex	25015	17.4Mrad	5×10^{14}	1×10^{15}
Cree	40010		5×10^{14}	1×10^{15}
Eudyna	EGNB010	43 Mrad	5×10^{14}	1×10^{15}
EPC	EPC1015	64 Mrad		1×10^{15}

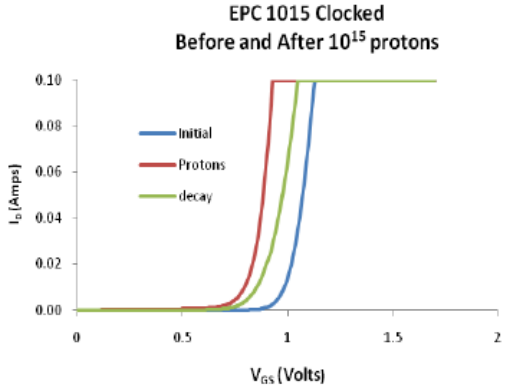


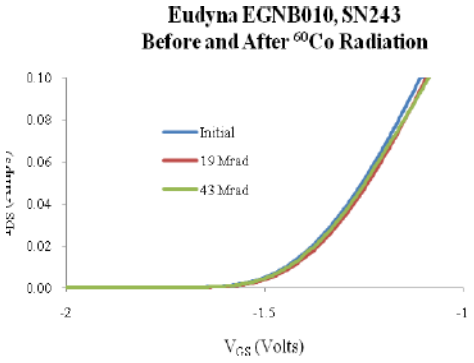


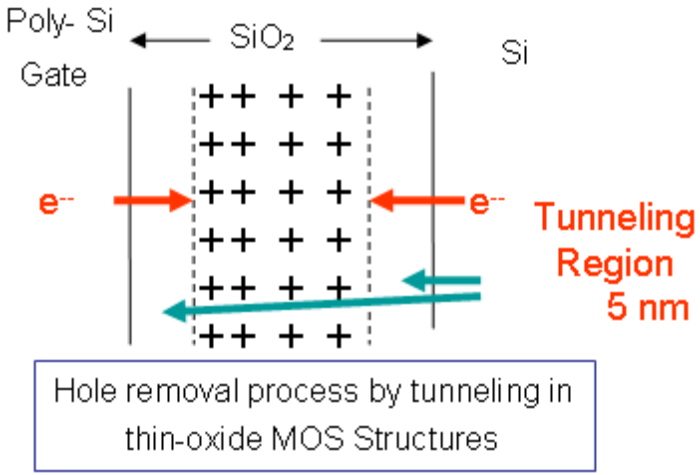
XySemi MOSFET Radiation Effects



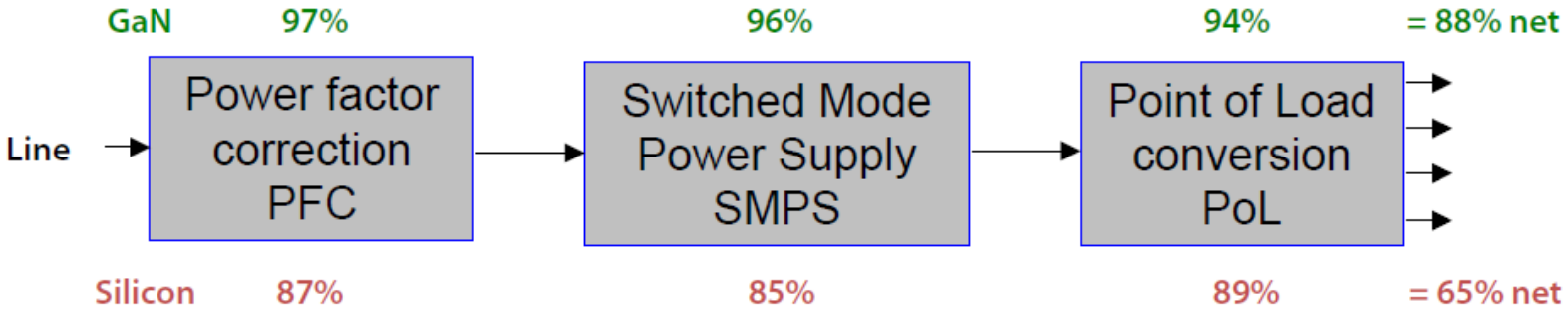








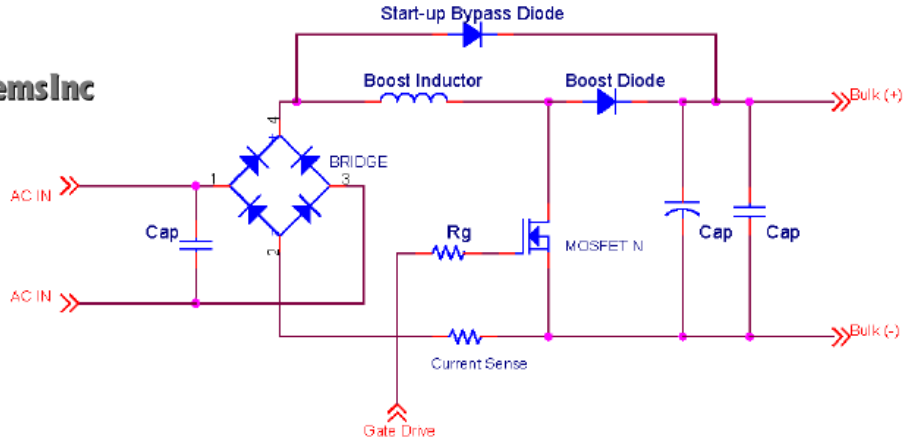
Hole removal process by tunneling in thin-oxide MOS Structures



Overall efficiency - Silicon = 65% Total losses = 157 Watts

- GaN = 88% Total losses = 54 Watts

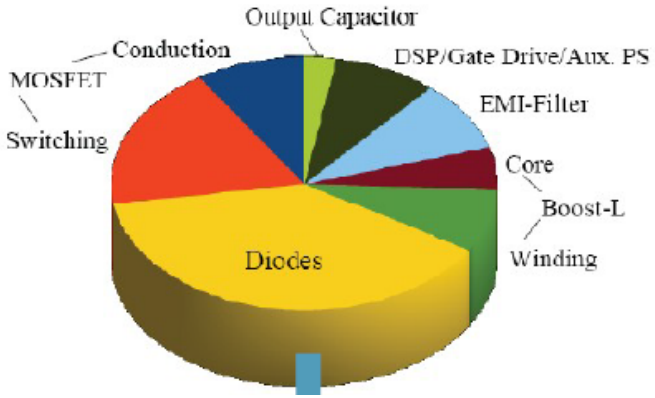
GaNSystemsInc

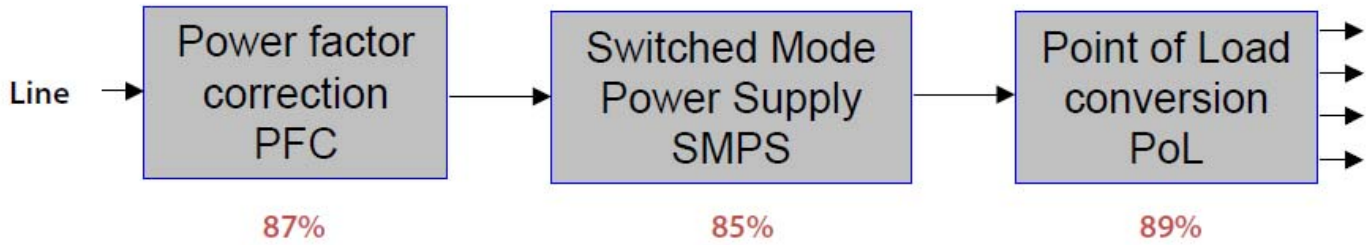


Ultra High Efficiency PFC

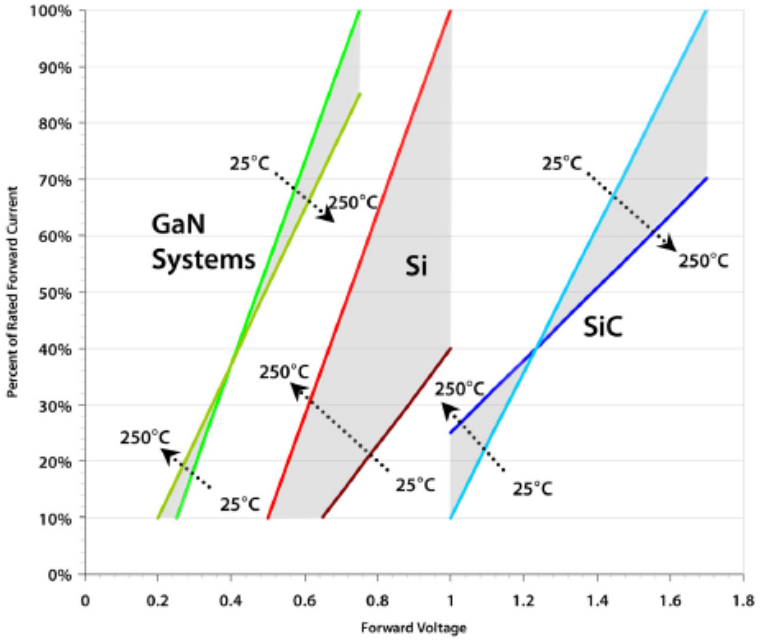
- Integrated Magnetics
  Volume / Loss Reduction
- New MOSFETs / Diodes
- Ceramic Capacitors
- Low Power DSP

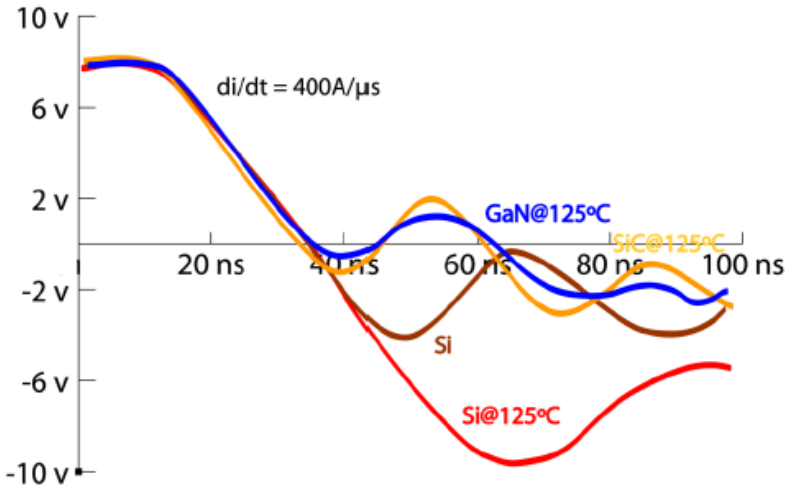
Loss Distribution





Typical conversion efficiency today

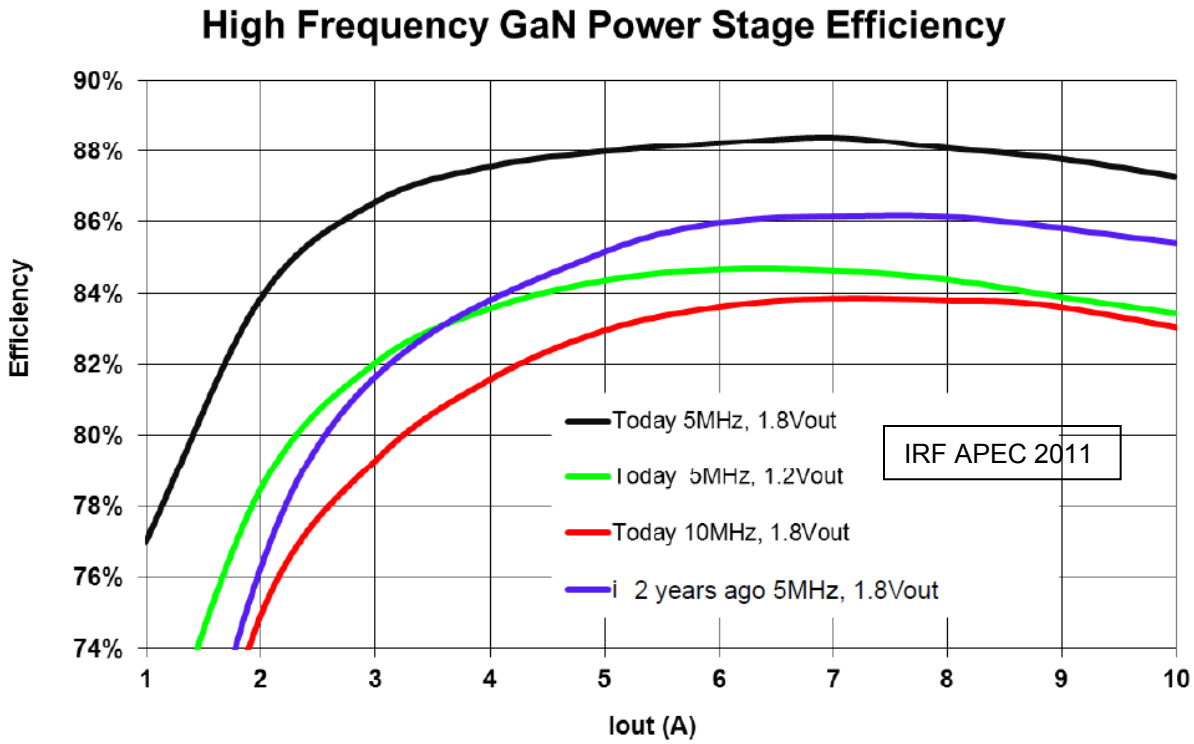




- Ultra Low Voltage Drop
- Temperature Stable

- Zero charge storage
- Temperature Stable

GaNSystemsInc



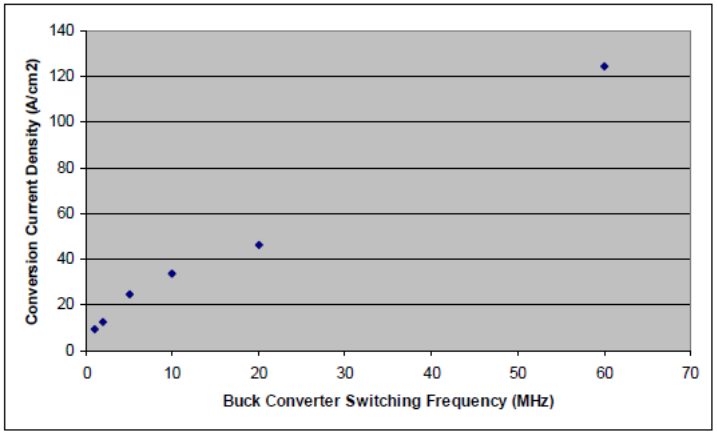
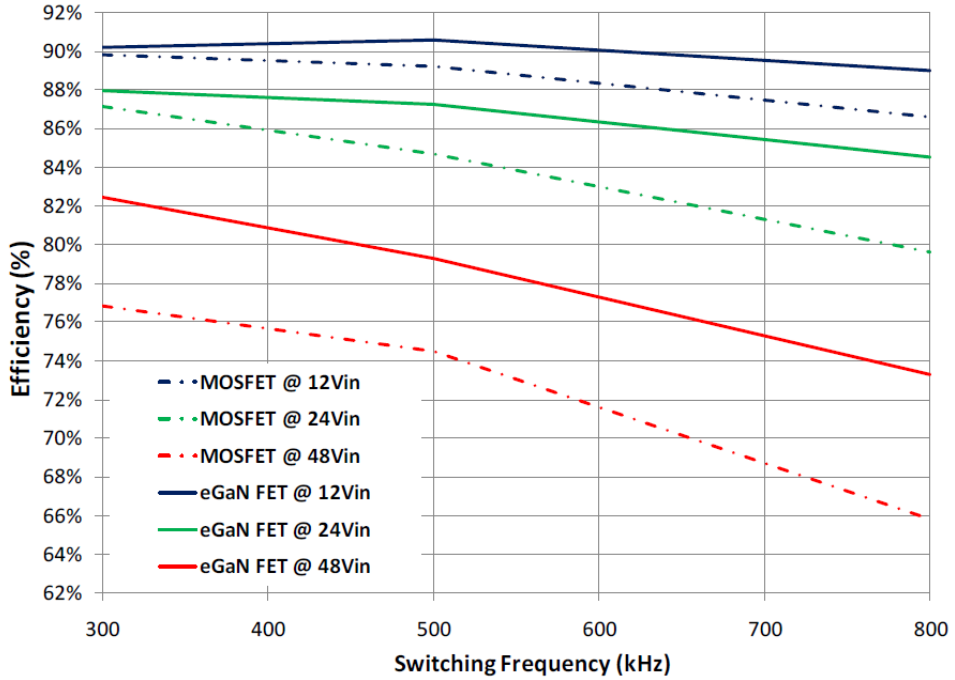
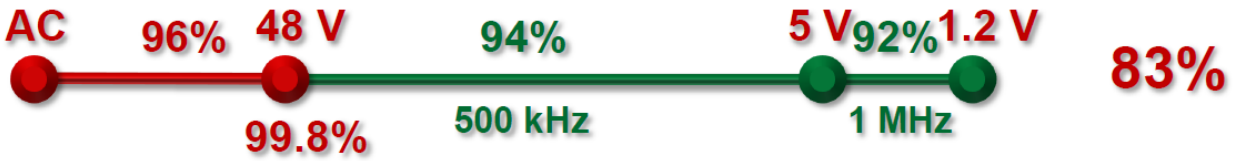


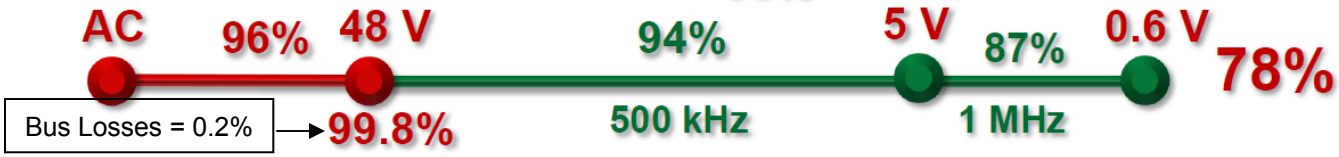
Figure 1: Conversion Current Density for a four phase 120 A, 12 Vin to 1.2 Vout buck converter vs switching frequency.

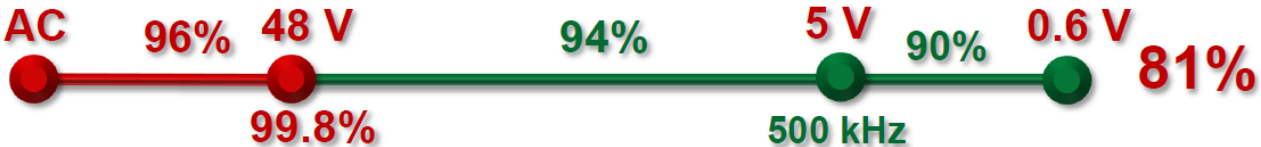
M.A. Briere IEDM 2010


92%
90%
88%
86%
84%
82%
80%
78%
76%
74%
72%
70%
68%
66%
64%
62%
Efficiency (%)
MOSFET @ 12Vin
MOSFET @ 24Vin
MOSFET @ 48Vin
eGaN FET @ 12Vin
eGaN FET @ 24Vin
eGaN FET @ 48Vin
300
400
500
600
700
800
Switching Frequency (kHz)


AC
96%
48 V
96%
12 V
89%
1.2 V
82%
99.8%
500 kHz
800 kHz


AC
96%
48 V
94%
5 V
92%
1.2 V
83%
99.8%
500 kHz
1 MHz


AC
96%
48 V
94%
5 V
87%
0.6 V
78%
Bus Losses = 0.2%
99.8%
500 kHz
1 MHz


AC
96%
48 V
94%
5 V
90%
0.6 V
81%
99.8%
500 kHz

EPC

Improve Efficiency
1 Billion Dollar Data centers
DC Distribution

ETSI standard entering EN public enquiry by July 11.
Safety and EMC, that are out of the scope of the standard should be covered by IEC.
ITU-T should also relay efficiently this work at international level.

Mandate 462 - ICT to enable efficient energy use in information and communication networks
A Standardisation mandate addressed to CEN, CENELEC and ETSI in the field of ICT to enable efficient energy use in fixed and mobile information and communication networks has been published. CEN, CENELEC and ETSI, as well as other standardisation organisations, have identified energy efficiency as a key area for standardisation. For the execution of this mandate, particular attention will be given to the involvement of all relevant parties

ETSI World Class Standards

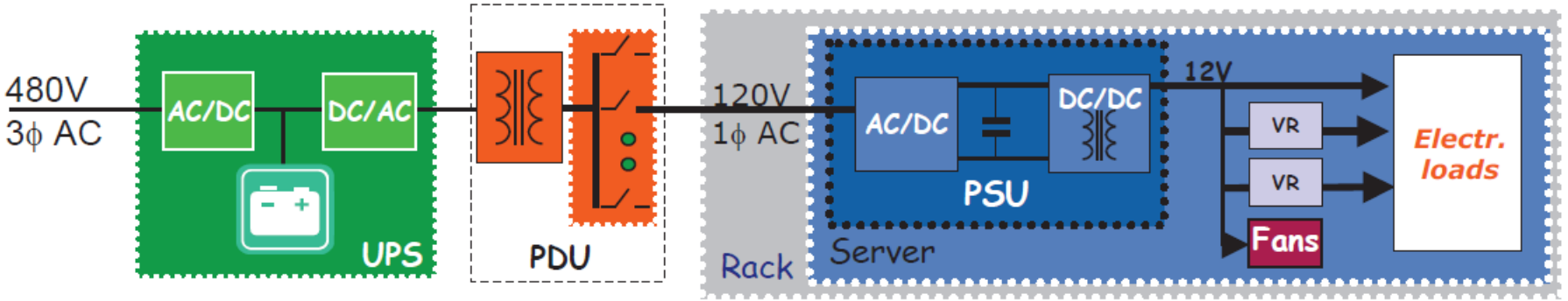
Energy Efficiency

European Commission Mandates

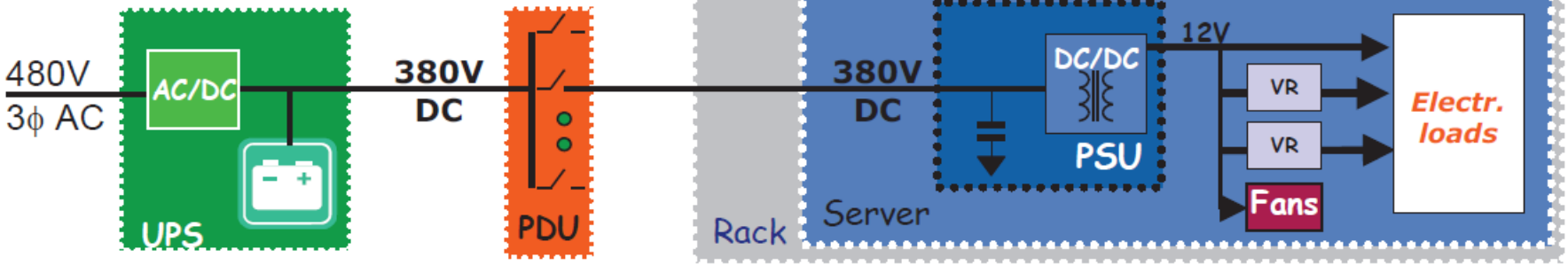
ETSI performs energy efficiency related work in support of European Commission Mandates.
The current Mandates in this domain are:

- Mandate 439: Standardization in the field of standby and off modes power consumption measurement for energy using products
- Mandate 450: Standardisation in the field of measurements of no-load condition electric power consumption and average active efficiency of external power supplies
- Mandate 451: Standardization in the field of power consumption measurement of simple set-top boxes in active and standby modes
- Mandate 462: ICT to enable efficient energy use in fixed and mobile information and communication networks

Efficiency Improvement with DC 380 Volts



90% x 97% x 90% x 86% = 67%



97% x 99% x 94% x 86% = 76%

END

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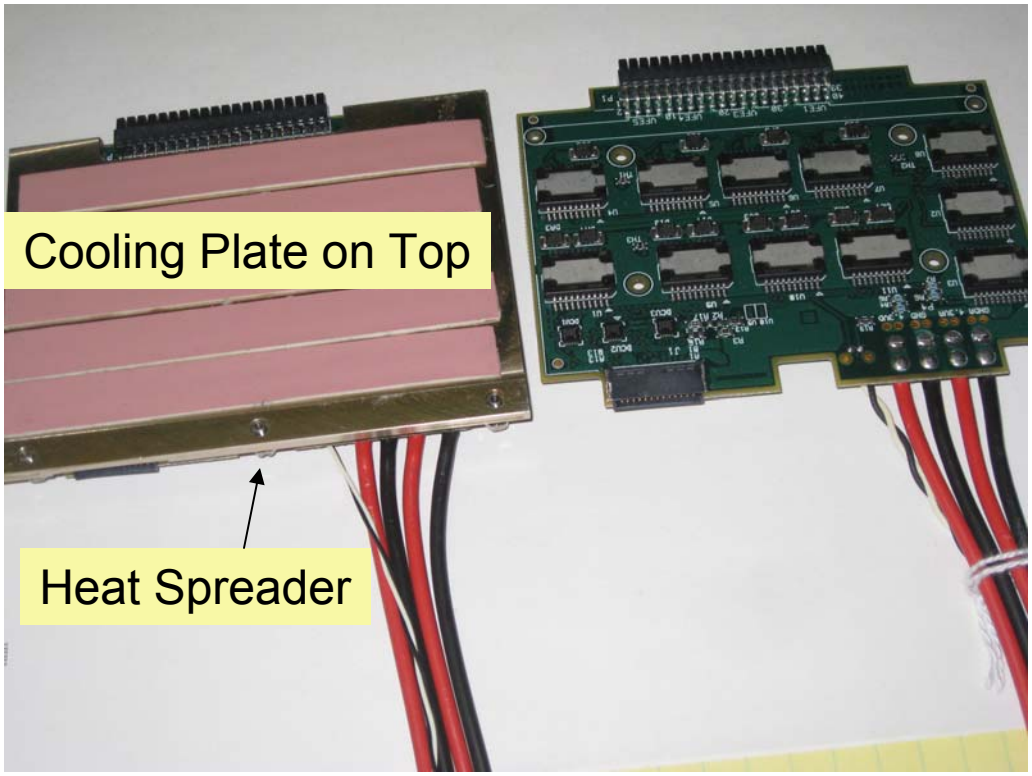

Thermally Conducting Gap Filler for LDO'S

Plenty of material to remove heat