Power Converters with GaN HEMT (High Electron Mobility Transistor) FETs

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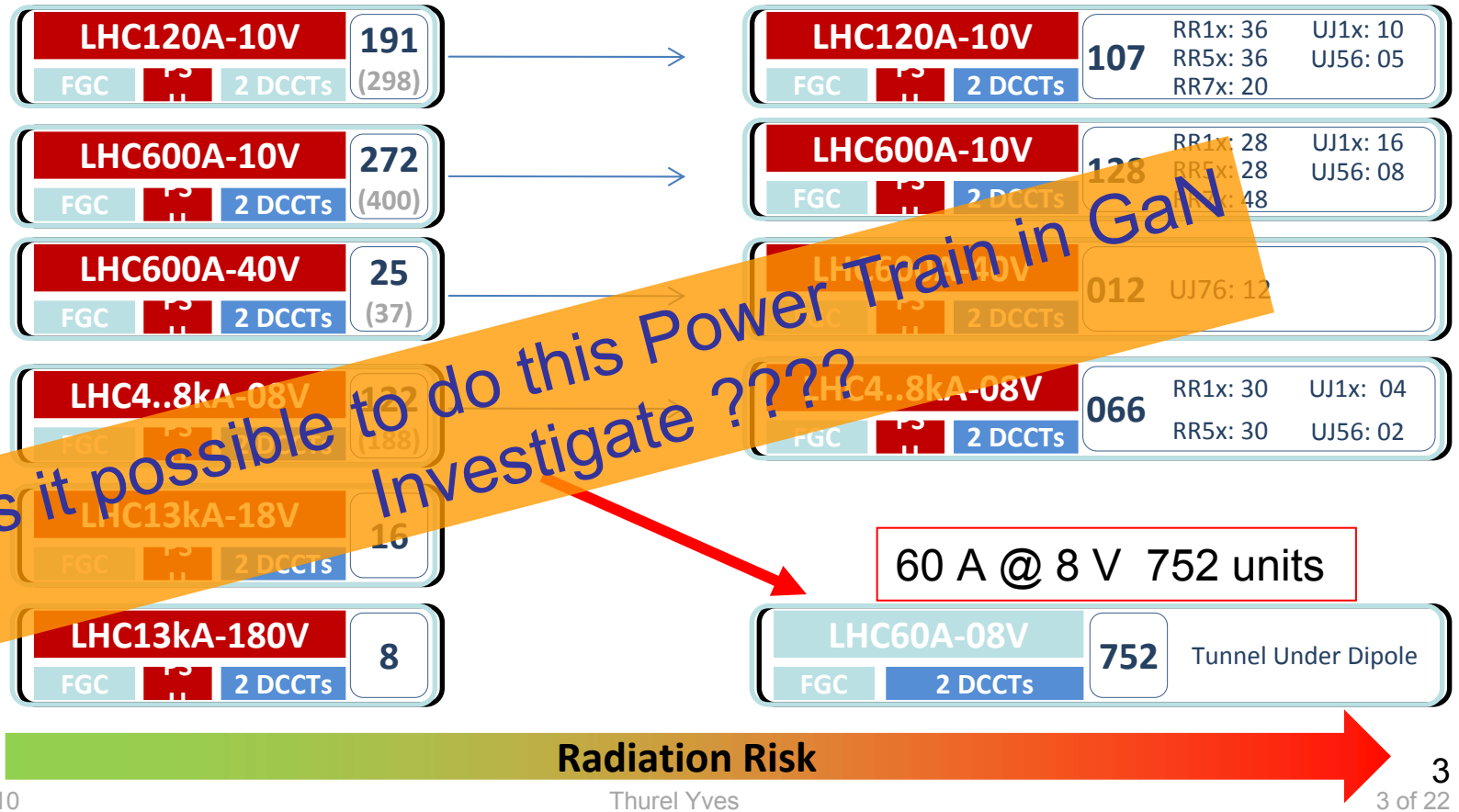
Radiation Resistant Power Supplies with GaN ?

- Materials Journey Se .. Ge…Si…GaN
- Why Gallium Nitride. Better FOM = $R_{DS(ON)}$ X Q_G
- Enable new Capabilities ?
- High Electron Mobility
- High Frequency – 10 GHz
- X10 higher dielectric strength
- Higher Thermal Conductivity
- Majority Carrier Device – No reverse recovery
- Cost ?
- Is it easy to use? Learning curve
- End of the Silicon near?
- DC-DC Converters 48V- 1V, 400V- 48V Radiation ?
- Development 600V,1200,5000V

CERN – Chamonix 2010 Report

- **LHC CONVERTERS VS RADIATION *[2010]***
  - Rad Tolerant Design *or* standard Design with low Rad sensitivity (safe components)
  - Standard Design *and* Rad sensitivity unknown (too many components, sub-assemblies...)



First commercial GaN devices for Power Switching (DC-DC Converters)

Tests done using EPC (Efficient Power Conversion Corp, El Segundo, CA) Demo Boards

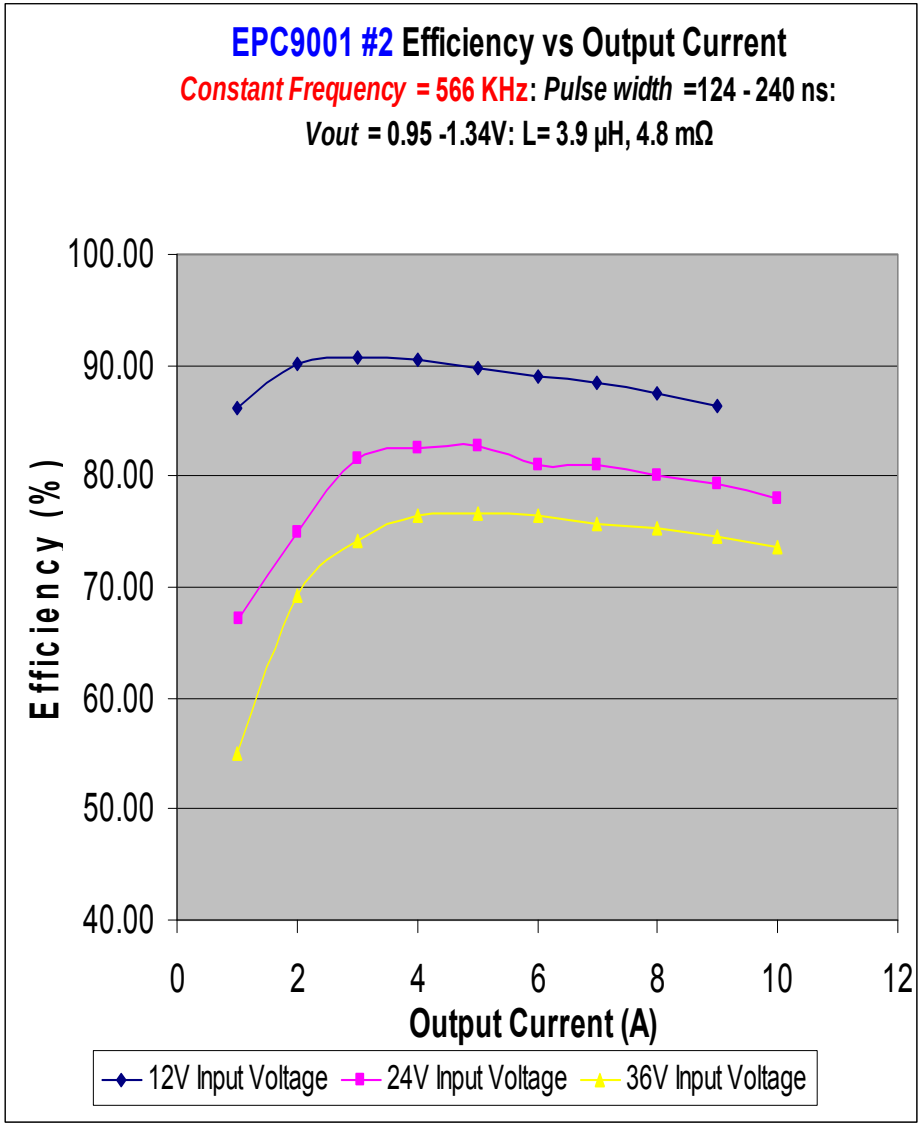
Plot conversion efficiency vs output current
40V Devices: Input 12 / 24 /36 Volts Output ~ 1.2V
100V Devices: Input 24 /36 /48 Volts Output ~ 1.2 -1.8V

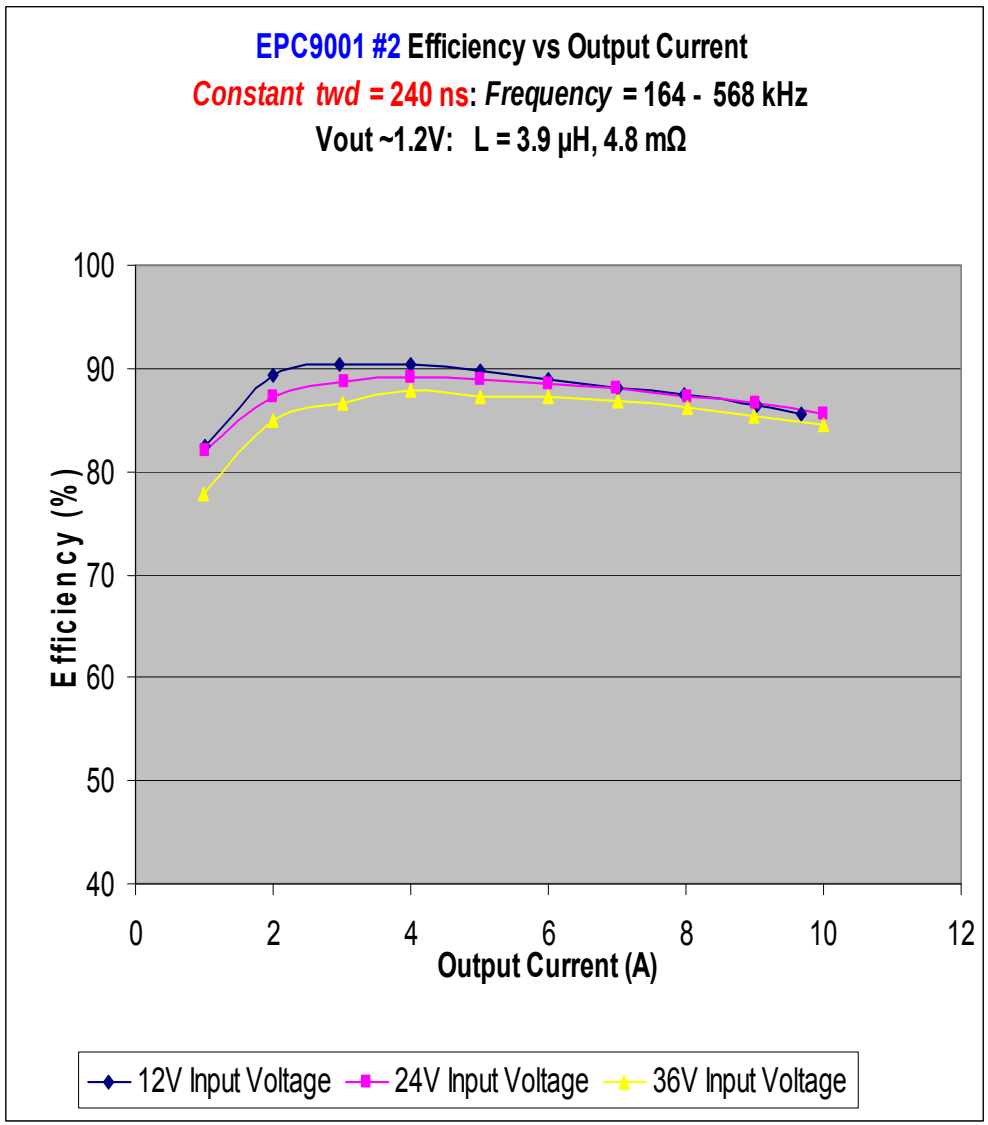
Radiations Tests Schedule

- BNL: Gammas July 28, 2010
- TRIUMF (Organized by Sandia National Laboratories): Protons September 13-17, 2010

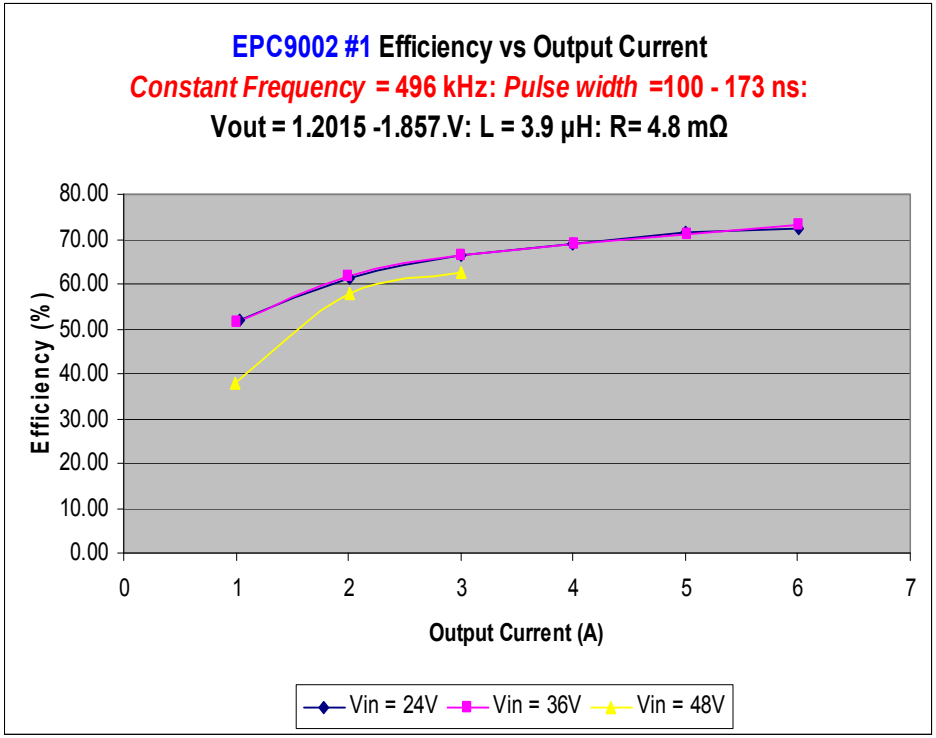
New GaN Devices for Power Switching

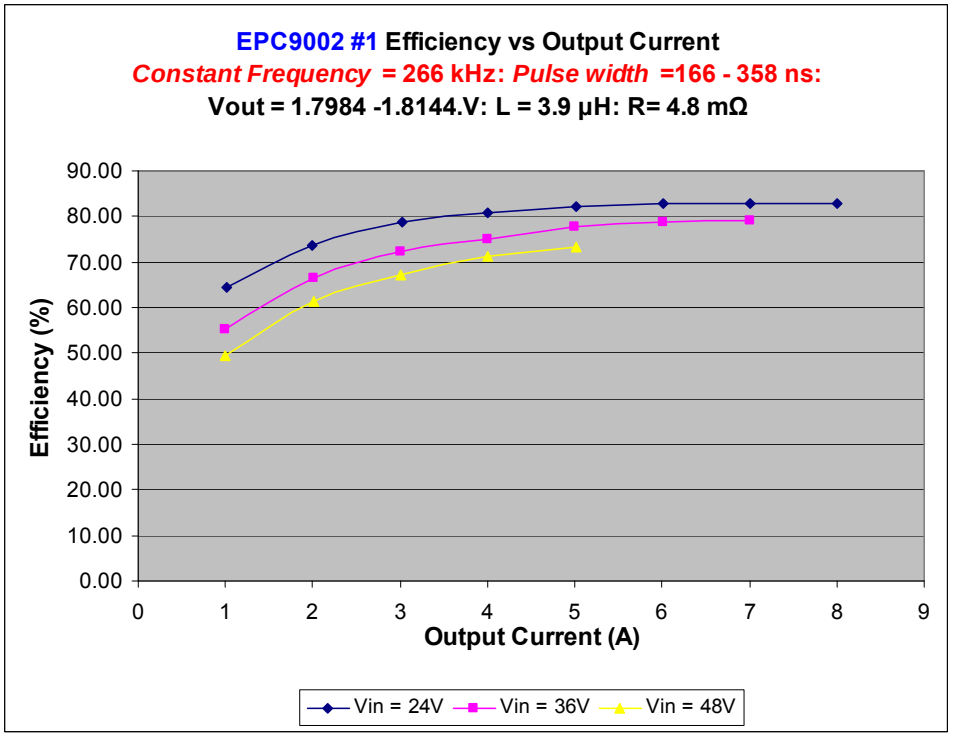
: Converter Efficiency Inputs = 12, 24 & 36 volts
output ~ 1.2 v



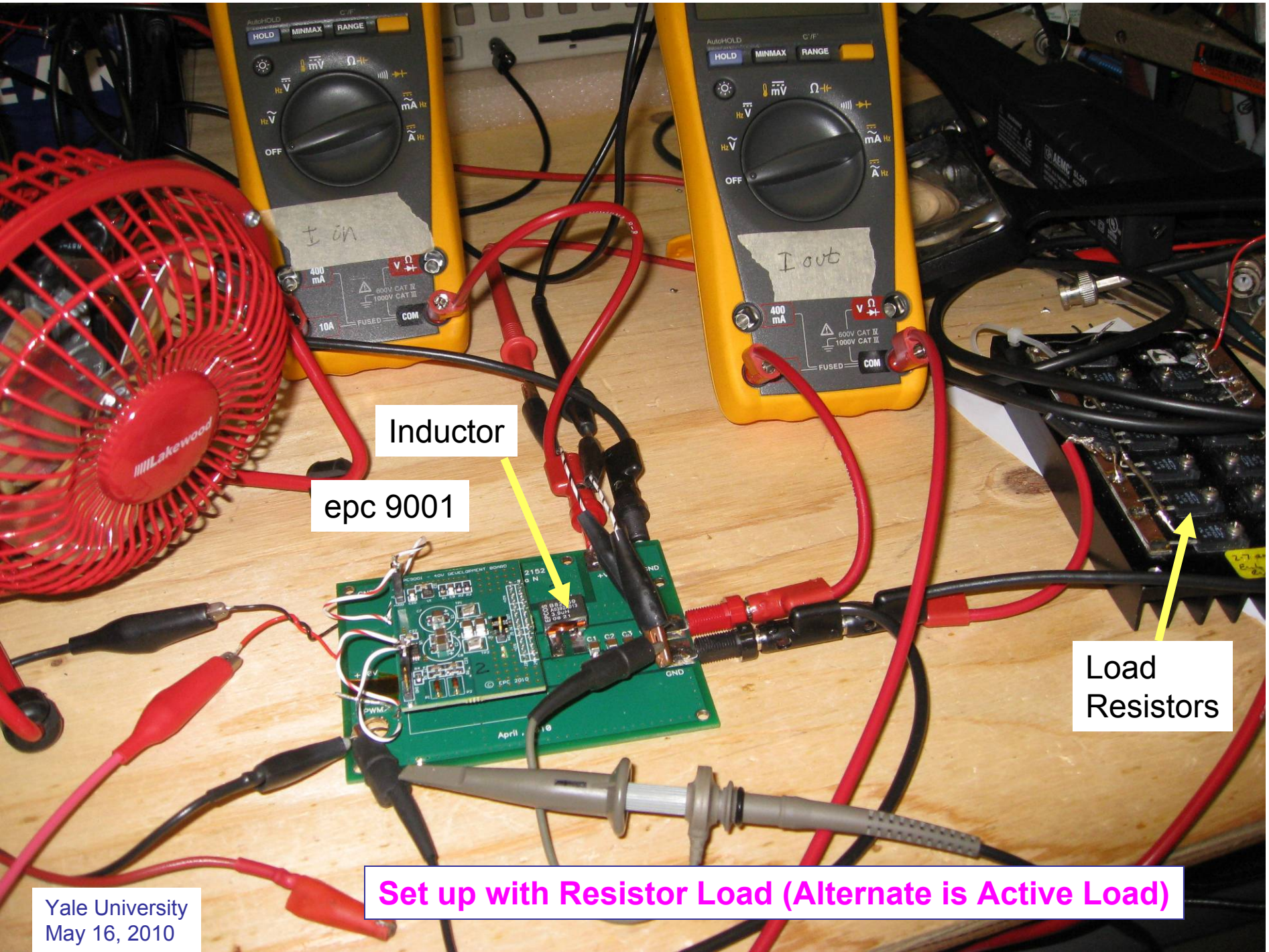


Converter Efficiency Inputs = 24, 36 & 48 volts output ~ 1.8 v





Longer On Time improves efficiency (Lower Frequency)


Inductor
epc 9001
Load
Resistors
Set up with Resistor Load (Alternate is Active Load)
Yale University
May 16, 2010

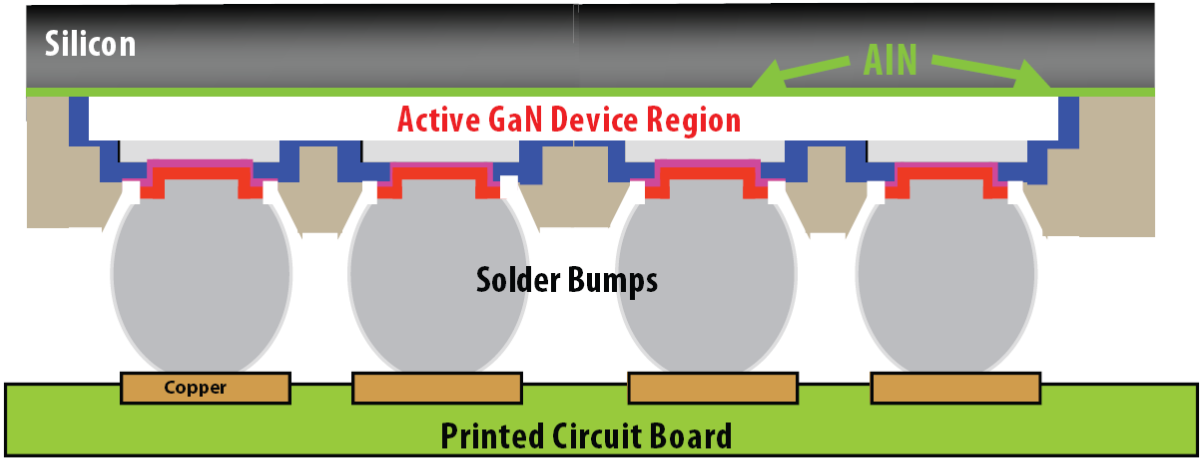


Figure 8: GaN on silicon can be used as a "flip chip". The active device is isolated from the silicon substrate and can be completely encapsulated prior to singulation.

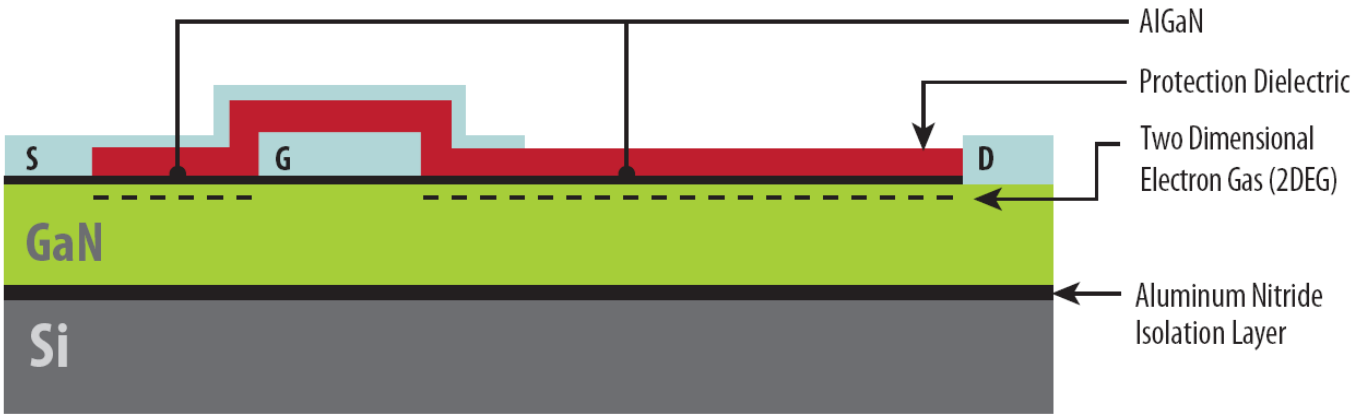
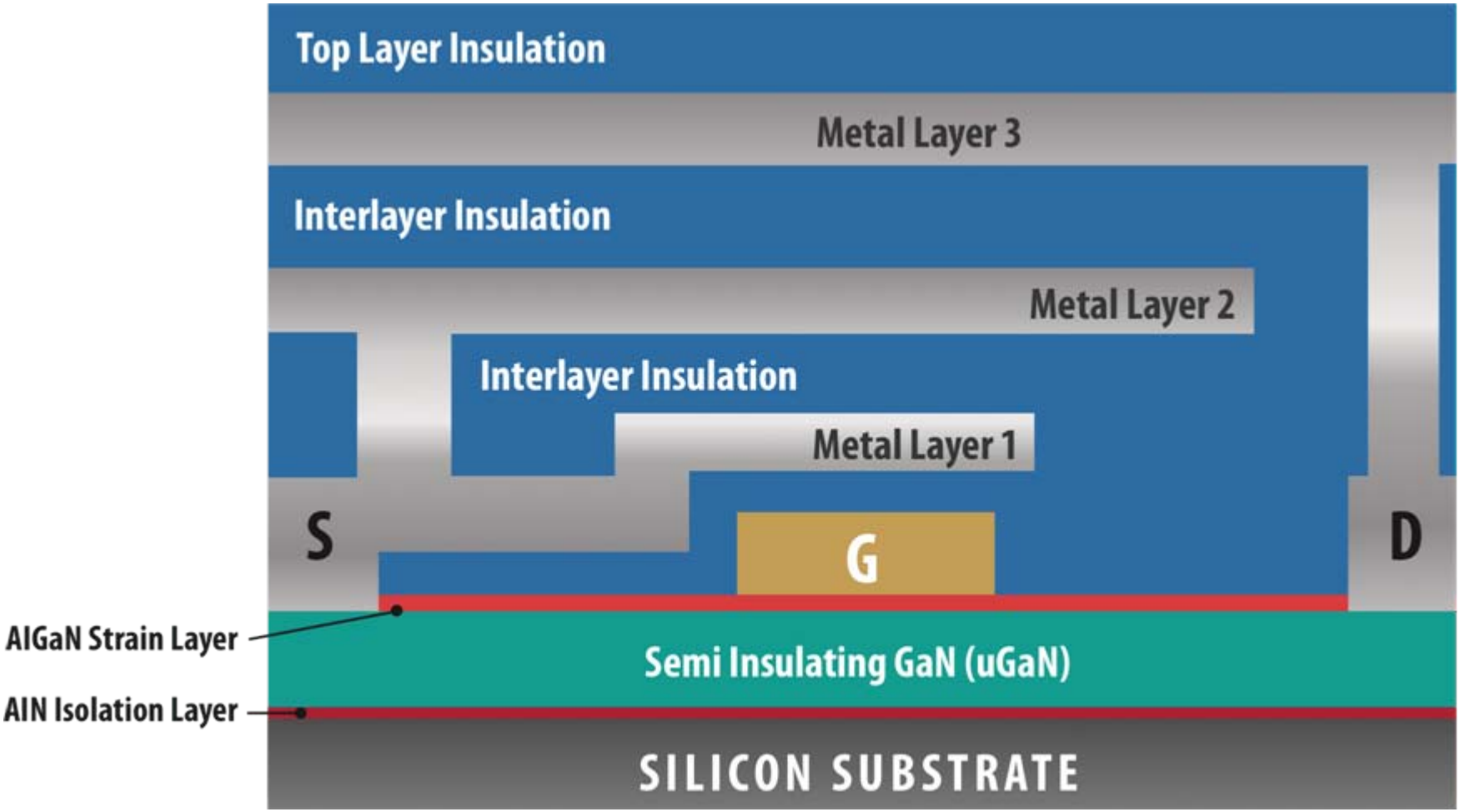
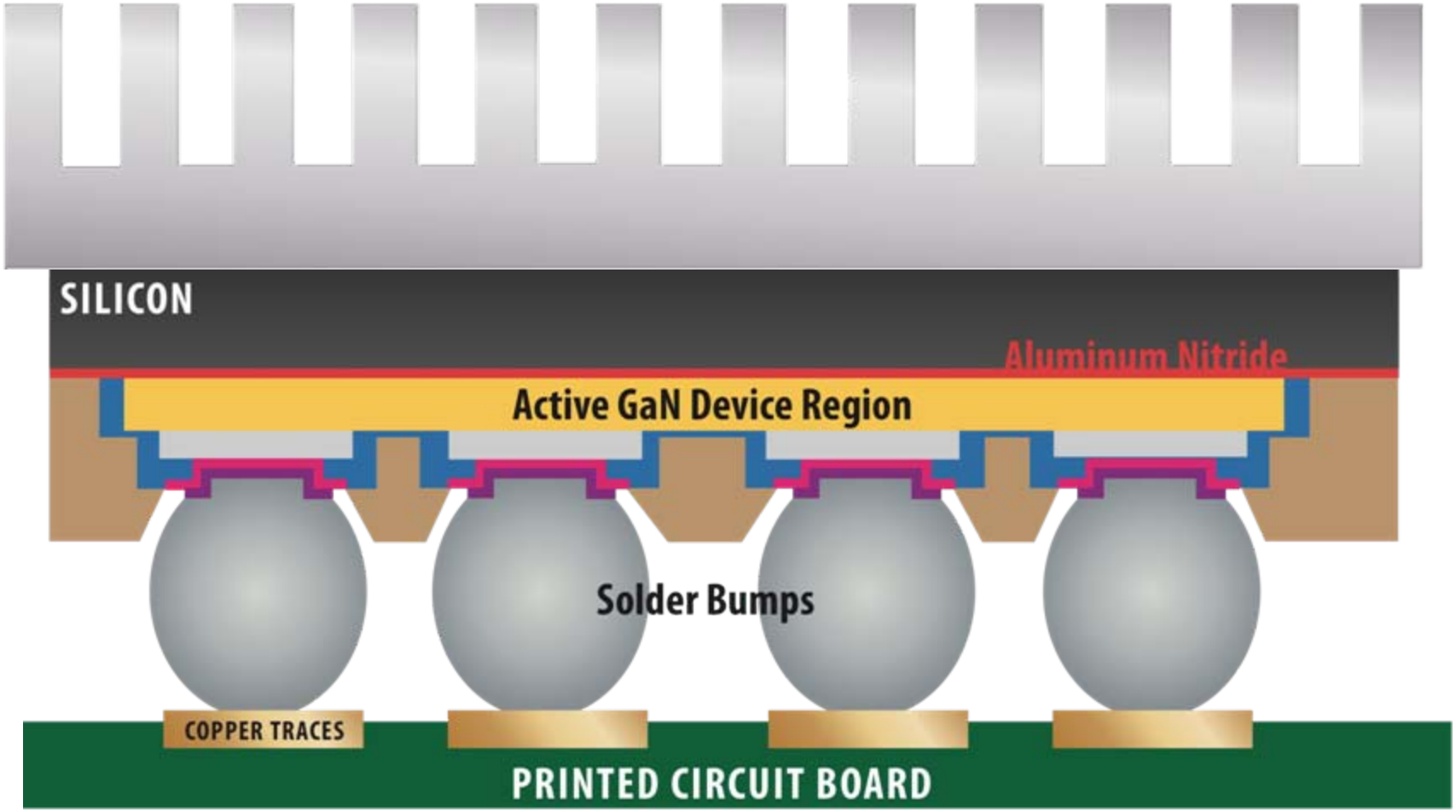


Figure 1: GaN on silicon devices have a very simple structure similar to a lateral DMOS device and can be built in a standard CMOS foundry

Device Construction



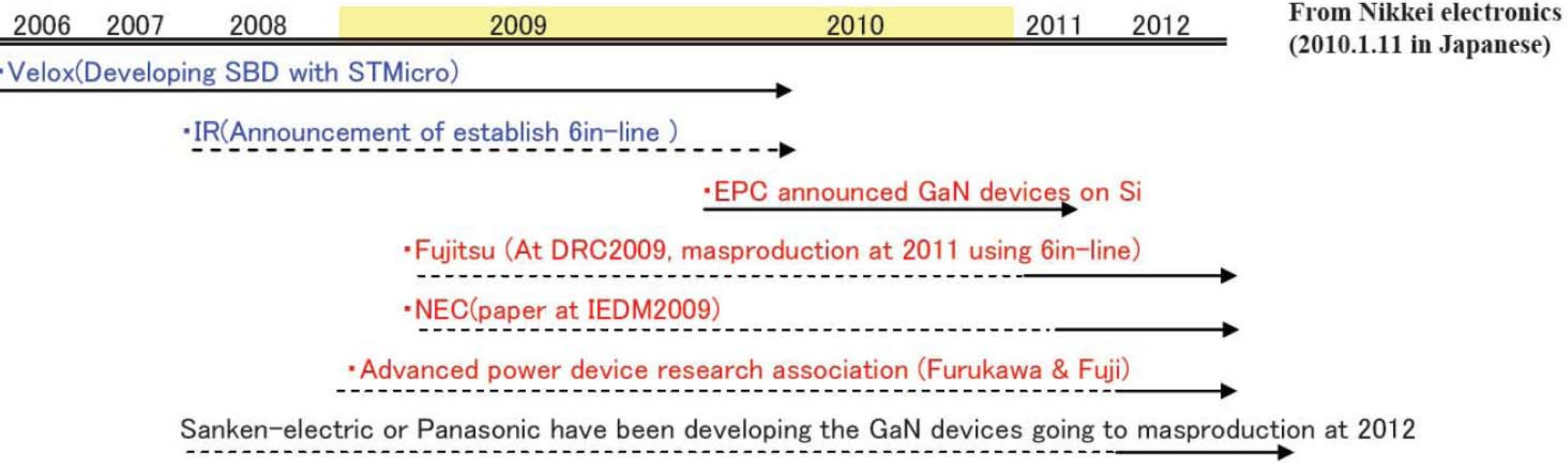
Flip Chip Assembly



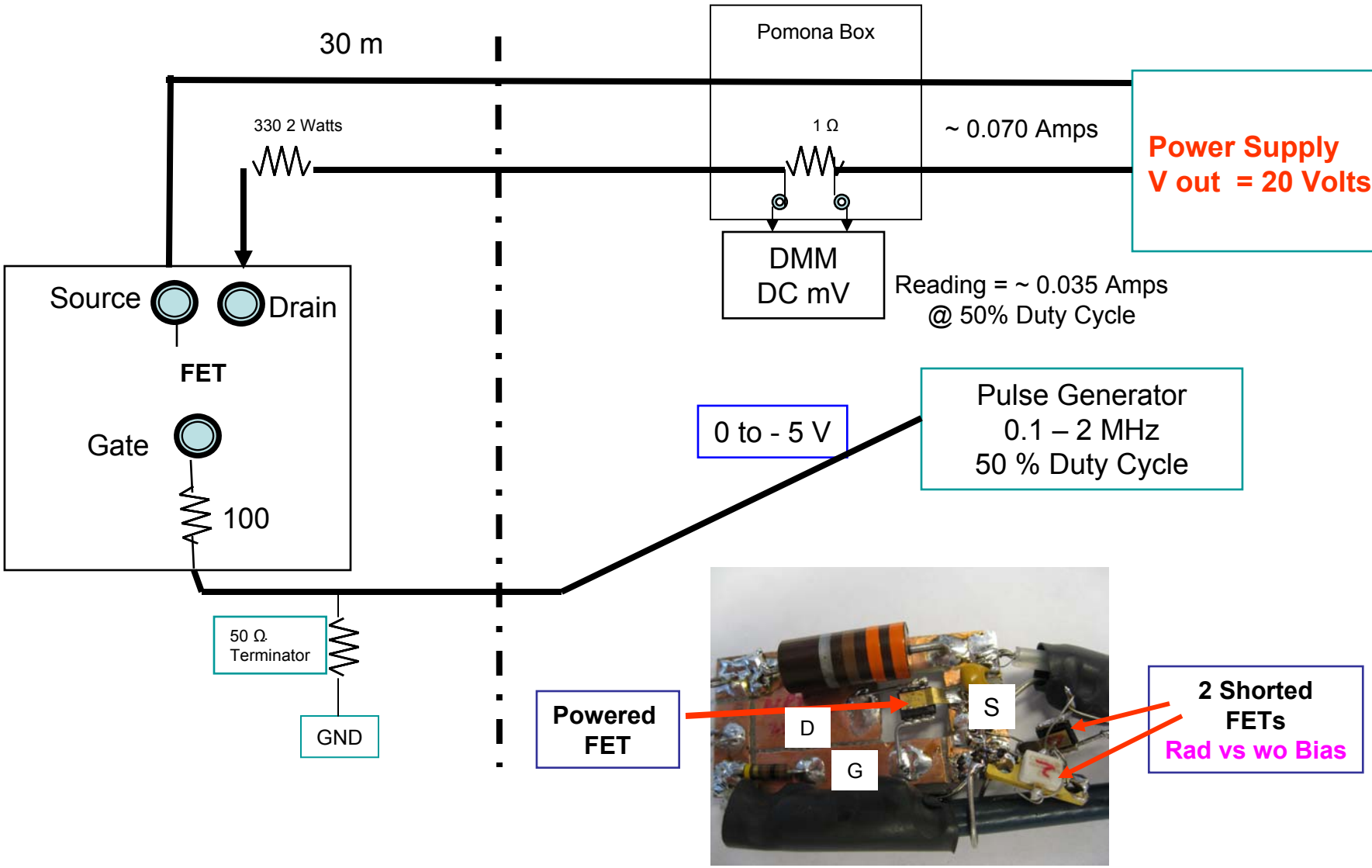
Status of GaN player

Prepared by Dr. Nariaki Ikeda
of Advanced Power Device Research Association
for Yale University

Company	Detail of Target or status
Fujitsu Laboratory	Mass-production level in 2011(fiscal)~2012 in the medium Vb over 600V using Si or SiC substrate (representative by Fujitsu Micro-elect.)
Furukawa and Fuji Electric	Commercial use at 2011(fiscal)
International Rectifiers	Commercial use from 2010 Beginning of product is lower Vb such several tens of voltage
NEC (Renesus)	Deliver Sample at 2011(fiscal)
Panasonic	Commercial use at 2011(fiscal)
Rohm	Deliver Sample at 2011(fiscal), also developing GaN native substrate
Sanken Electric	Trial manufacture of Vb over 800 V

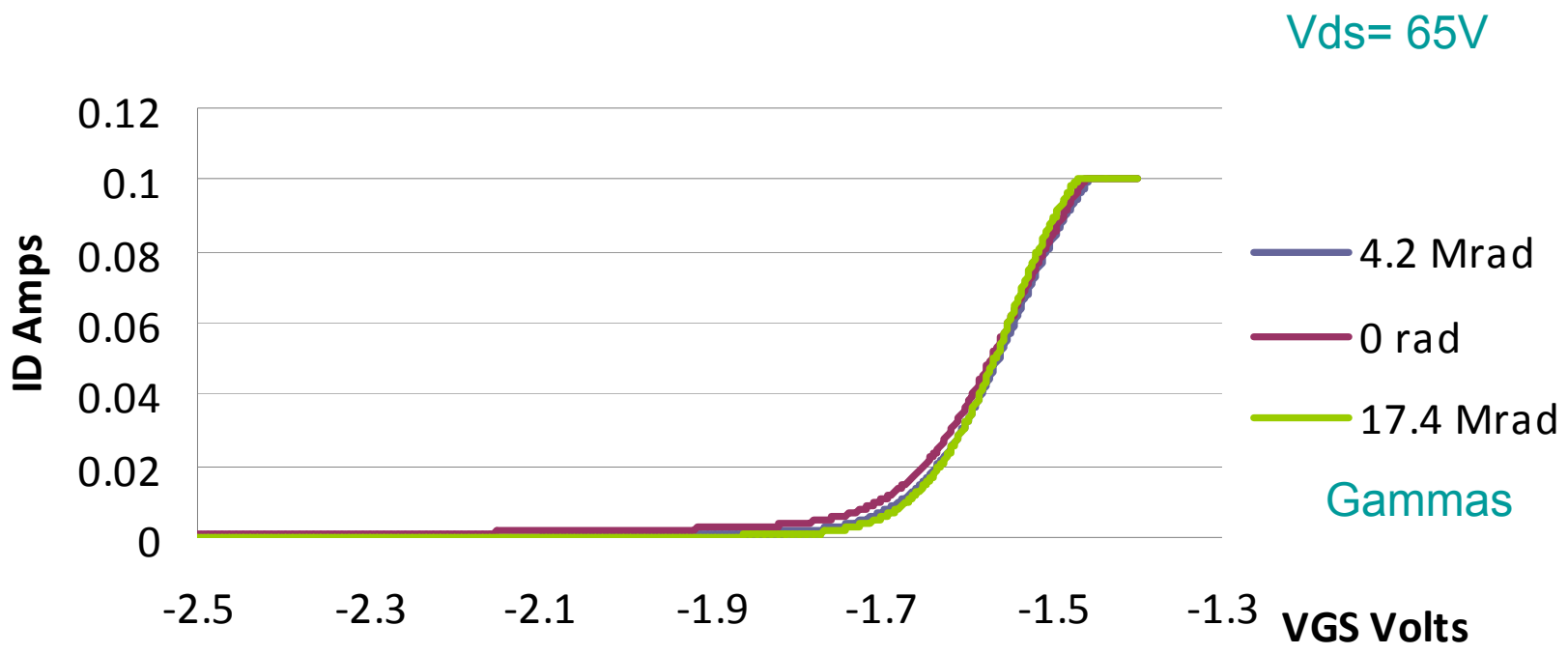


Bias during Radiation
Max operating V & I Limit Power by duty cycle

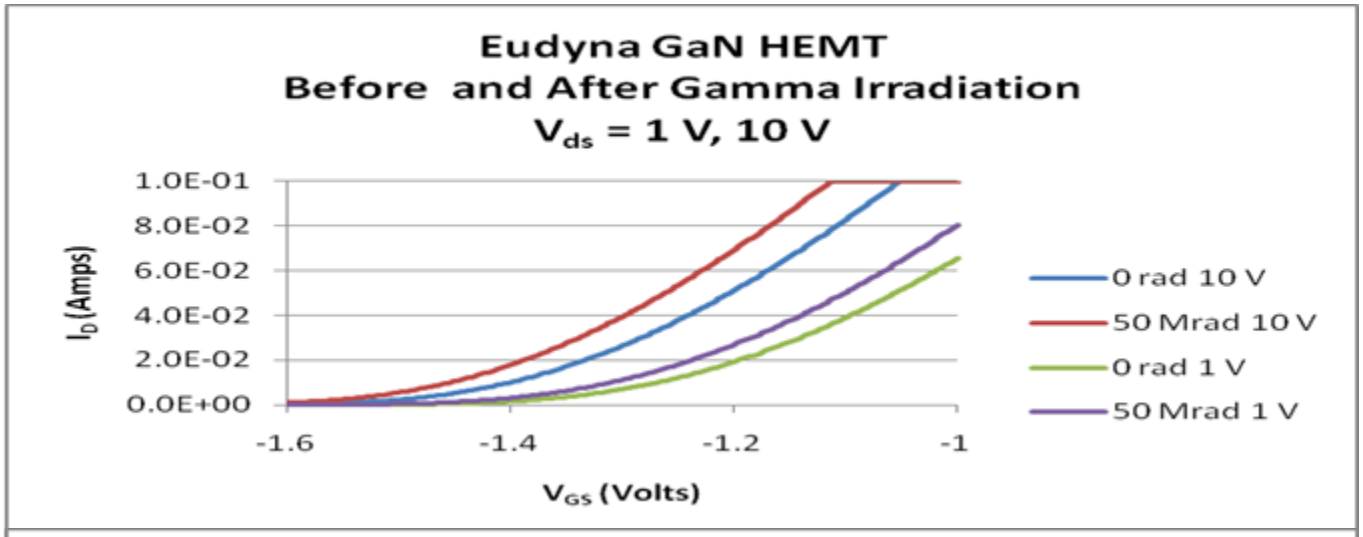


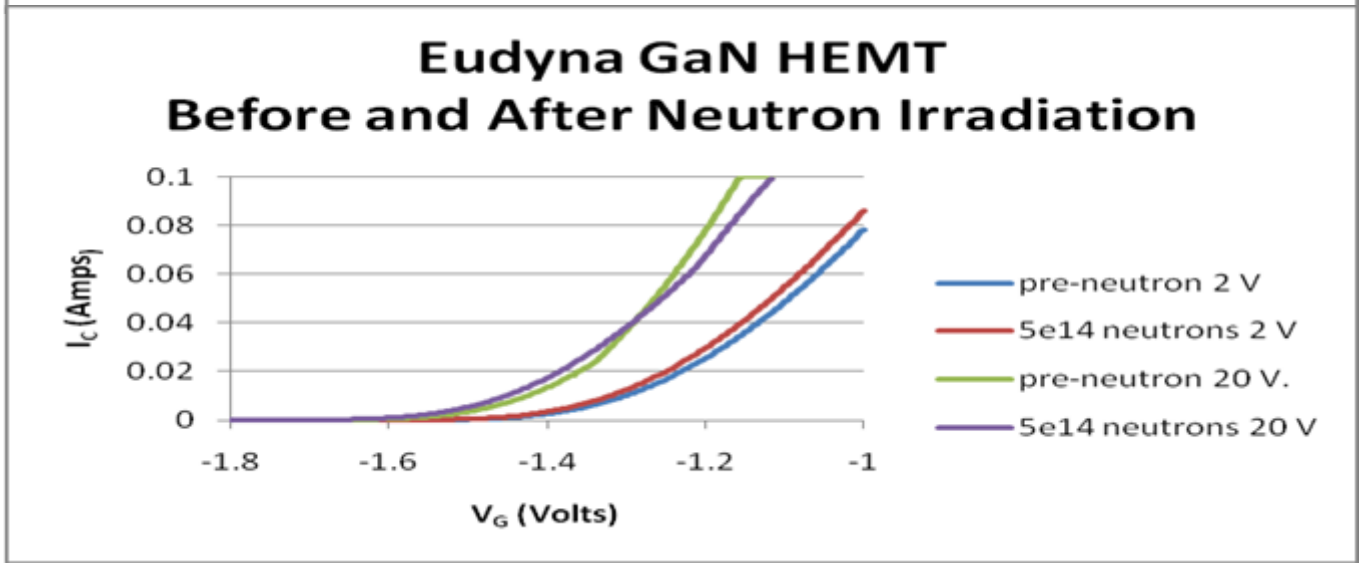
Nitronex 25015

Serial # 1



200 Mrads of Protons had no effect – switching 20 V 0.1 Amp
Parts still activated after 7 months





Our next IEEE TNS Paper shall summarize work to date

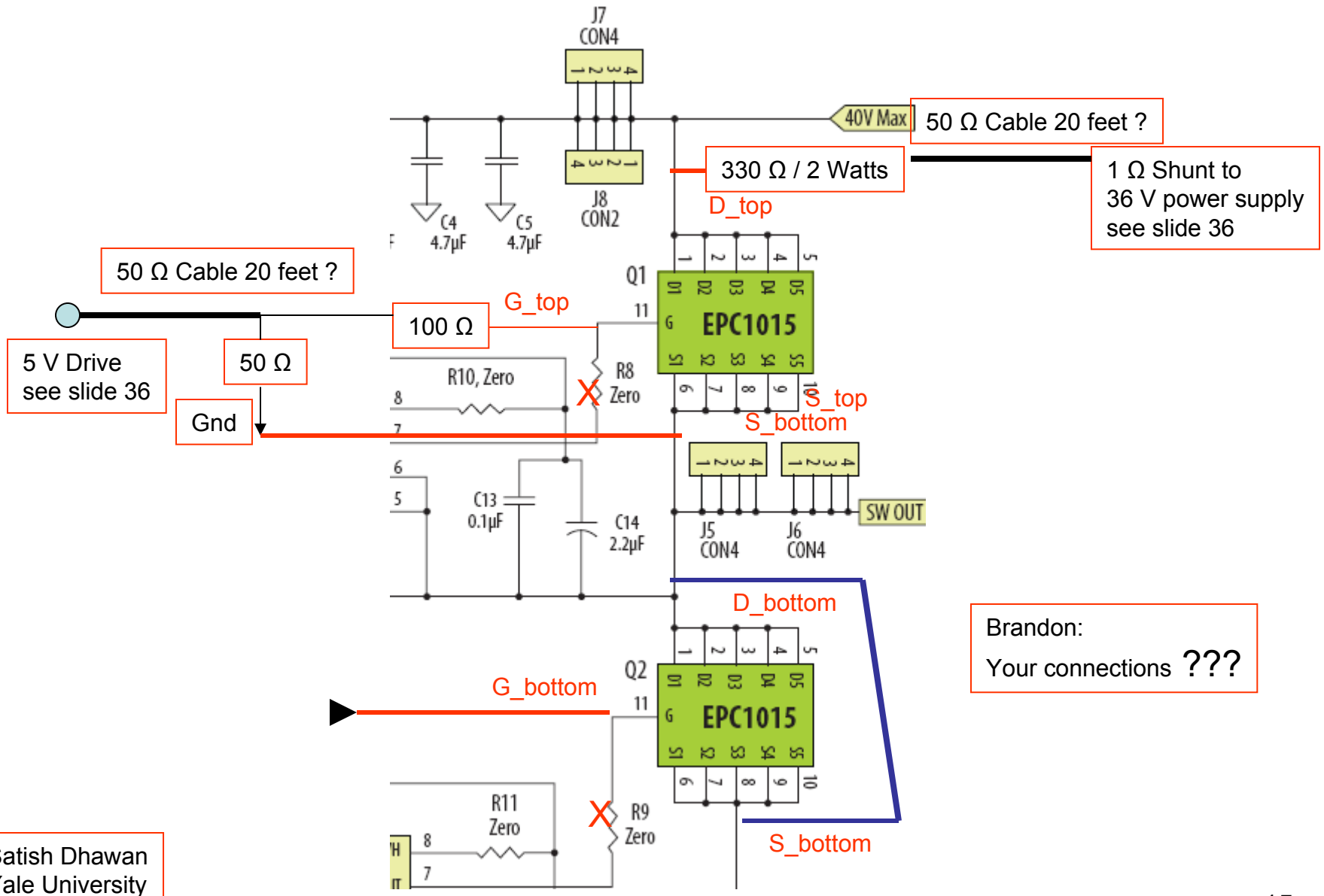
Proton Test

Proton Fluence =1 x 1015p/cm2 over a period of about 24 hours.

Biased = 65 volts switching @ 1MHz

Average current = 65 mA limited by Load resistor . No change in current.

EPC 9001 Demo Board Connections for Rad Testing



Brandon:

Your connections ???

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May 26, 2010