DOE ADC Designs Program Review

August 2014

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Contractor Name: Ridgetop Group, Inc.
Contractor Address: 3580 West Ina Road, Tucson, AZ 85741
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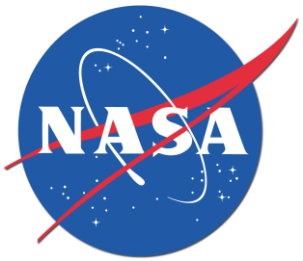
PROPRIETARY | SBIR DATA RIGHTS

Ridgetop Group, Inc.

- **Arizona-based firm, founded in 2000, with focus on electronics for critical applications**
  - **Two divisions: Semiconductor & Precision Instruments (SPI) and Advanced Diagnostics & Prognostics (ADP)**
- **Technology leader in precision mixed signal IC design for harsh environments**
- **Expertise in mitigation of radiation effects**
- **Complete Cadence-based IC design tool set**

- **Extensive instrumentation design experience**
- **Foundation in physics-of-failure for reliable electronic systems**

Partners and Customers



Award-Winning Design Recognition

Raytheon Small Business Partner Award

Japanese IP Innovation Award

Ridgetop Accreditations

CERTIFICATE OF REGISTRATION

Management Certification
MCNA
of North America

This is to certify that the
Quality Management system of:
Ridgetop Group, Inc.
3580 West Ina Road
Tucson, AZ 85741
US
has been assessed and found complying with the requirements of

ISO 9001:2008 & AS9100C

Approval is hereby granted by Management Certification of North America under its ANAB accreditation and in accordance with the AAQG Program and AS9104 Rev A, provided the certification rules and conditions are observed at all times.

Certification Scope:

Provision of engineering, research & development, electronic prognostics, integrated circuit design.

Certificate Number: 1107004 **Audit Date:** 22-Dec-2011

Issue Date: 27-Jan-2012 **Expiration Date:** 26-Jan-2015

On Behalf of:
Management Certification NA

ANAB ACCREDITED

This certificate is non-transferable and remains the property of Management Certification of North America, The Woodlands, Texas, to whom it must be returned upon request.

ISO9001:2008 Quality Management System

AS9100C Quality Management System

ACCREDITATION OF TRUST

Microelectronics Trusted Source
CATEGORY 1A

By these presents the undersigned expresses the confidence of the Department of Defense, Defense Microelectronics Activity (DMEA) in the ability of the organization known as

Ridgetop Group, Inc.

to deliver trusted foundry microelectronic goods and services to end users within the United States Government that correspond to Trusted Category 1A which meets Mission Assurance Category 1 as defined by Instruction 8500.2 of the Department of Defense Directives, effective this date.

078	1QDG8	12 OCT 2010	12 OCT 2012
Site Accreditation Number	CAGE Code	Effective Date	Renewal Date

Ted Glum
Director, Defense Microelectronics Activity

SCOPE OF ACCREDITATION

Ridgetop Group, Inc.

IS ACCREDITED FOR TRUST IN THE FOLLOWING FIELD(S):

CATEGORY	FIELD
1A	Design Services

078	1QDG8	12 OCT 2010	12 OCT 2012
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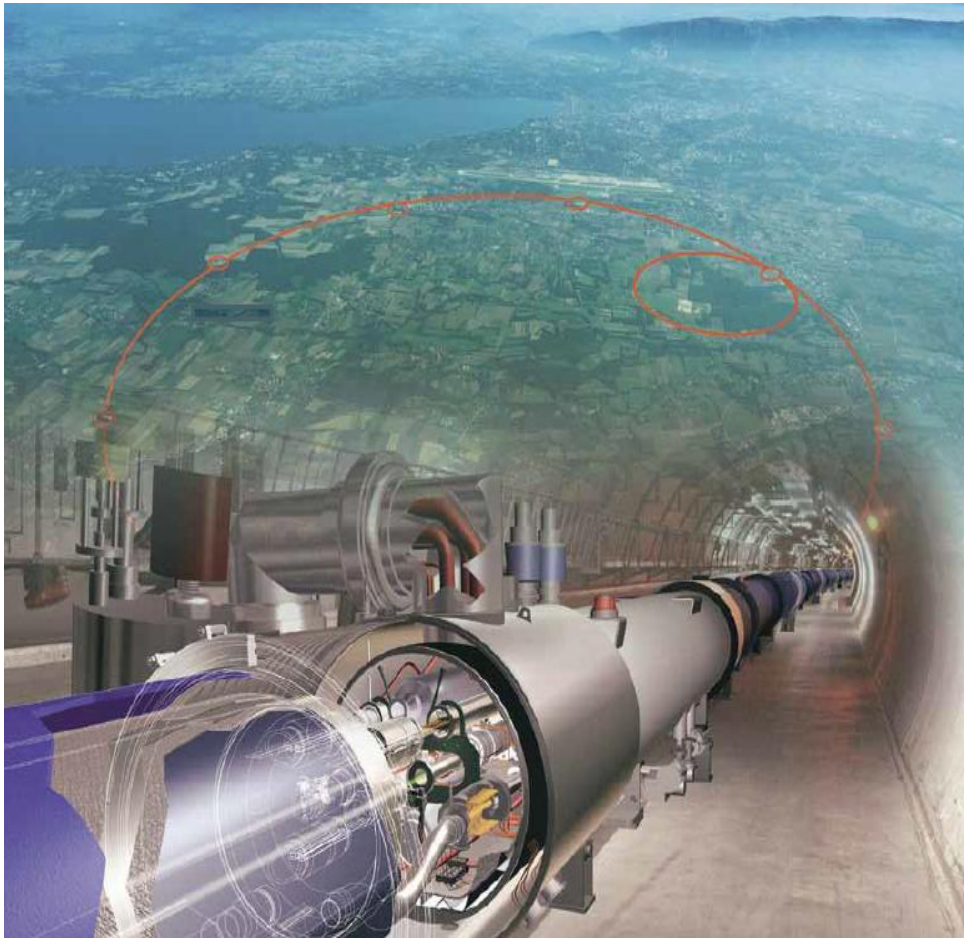
Microelectronics Trusted Supplier (Defense Microelectronics Agency)

Primary application

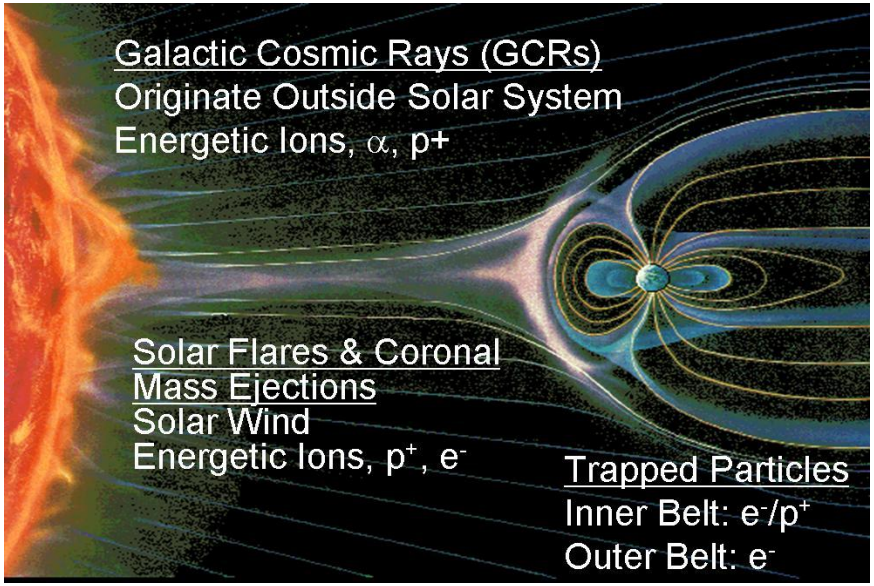


Radiation-Hardened ADC for Particle Accelerator Instrumentation clusters

Strong interest from CAEN

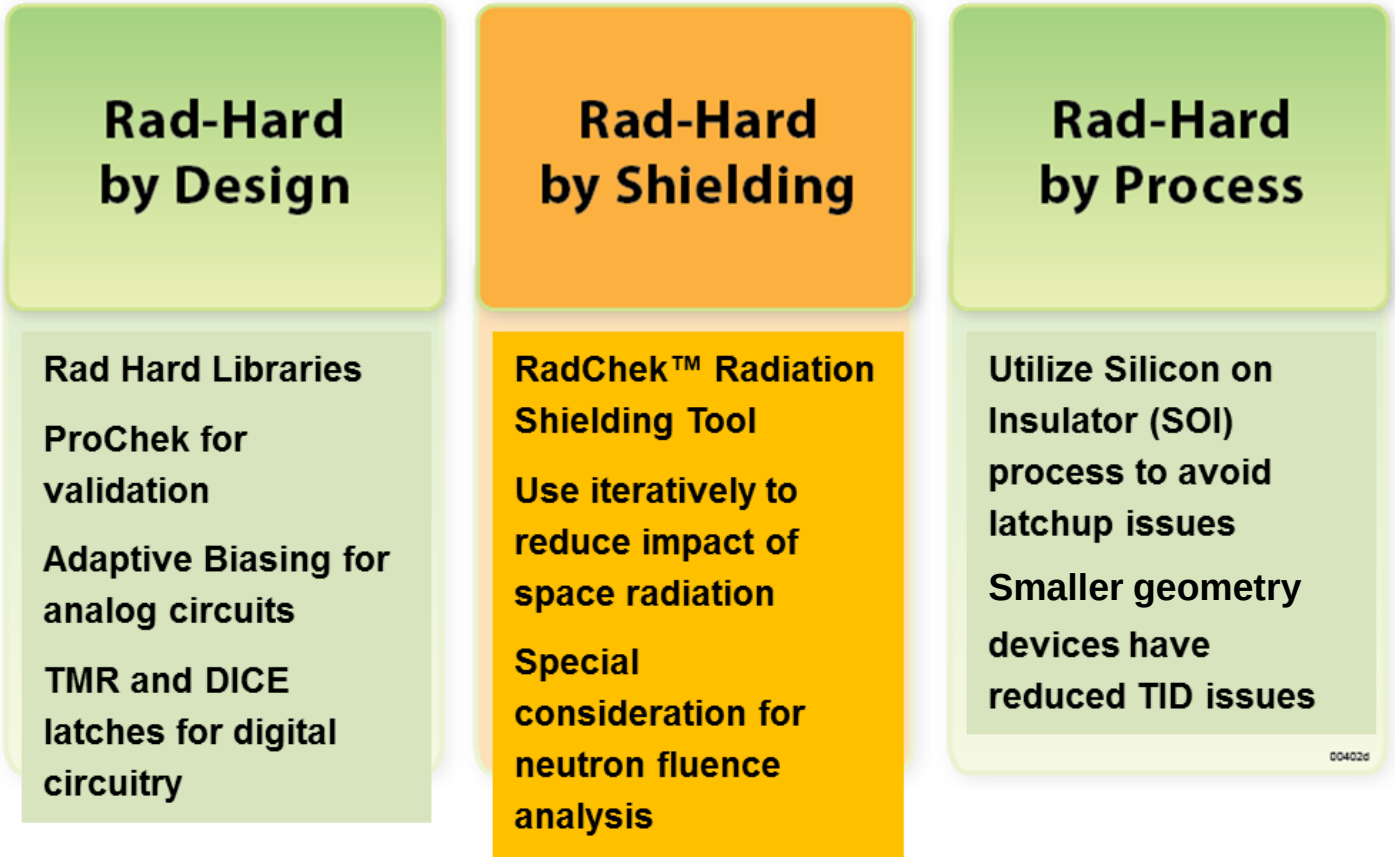
Two ADC orders from ON Semiconductor for ADC design

Secondary Application



Trapped protons cause most of the degradation effects TID/oxide damage, displacement damage and resulting SEEs from heavy ion strikes)

Radiation Mitigation Methods



SBIR Program Objectives

ADC 3 GSPS 12 bit (Topic 44g)

R&D Program started 8/8/12 and Ends 8/8/14

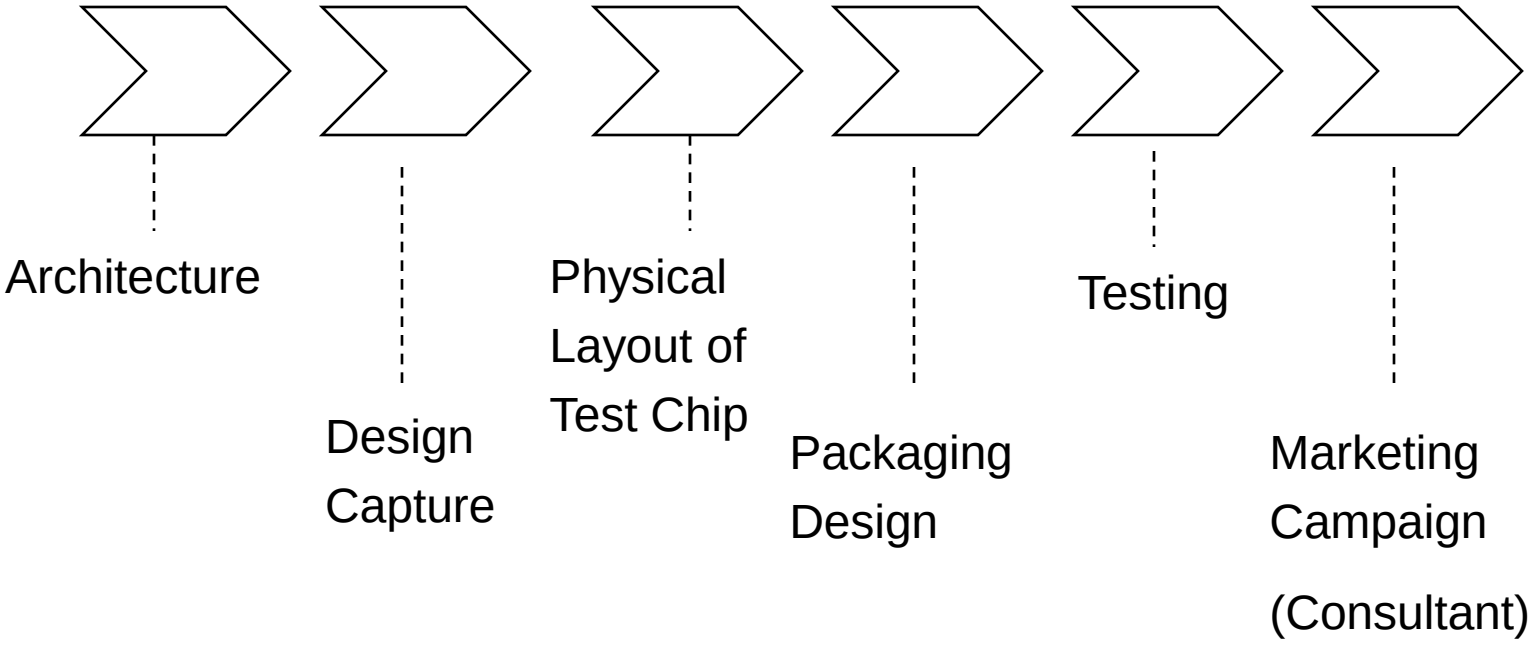
Programmable, Time-Interleaved double sampled pipeline, high speed (500 MS/s – 3 GS/s), high resolution (12-14 bits) analog-to-digital data converter (ADC), highly linear with an INL and DNL of no more than ±0.5 LSB, an operating temperature range of at least -10 to 80 °C, a very high effective number of bits (ENOB) of 11.0, and a total ionization dose (TID) rating of 1 Mrad.

ADC 40 MSPS 12 bit (Topic 61a)

R&D Program started 8/8/12 and Ends 8/8/14

Programmable, low-power pipeline (<100 mW), high performance (40 MS/s), high resolution (12 bits) analog-to-digital converter (ADC), highly linear with an INL and DNL of no more than ±0.5 LSB, an operating temperature range of at least -10 to 80 °C, a very high effective number of bits (ENOB) of 10.0, and a total ionization dose (TID) rating of 1 Mrad.

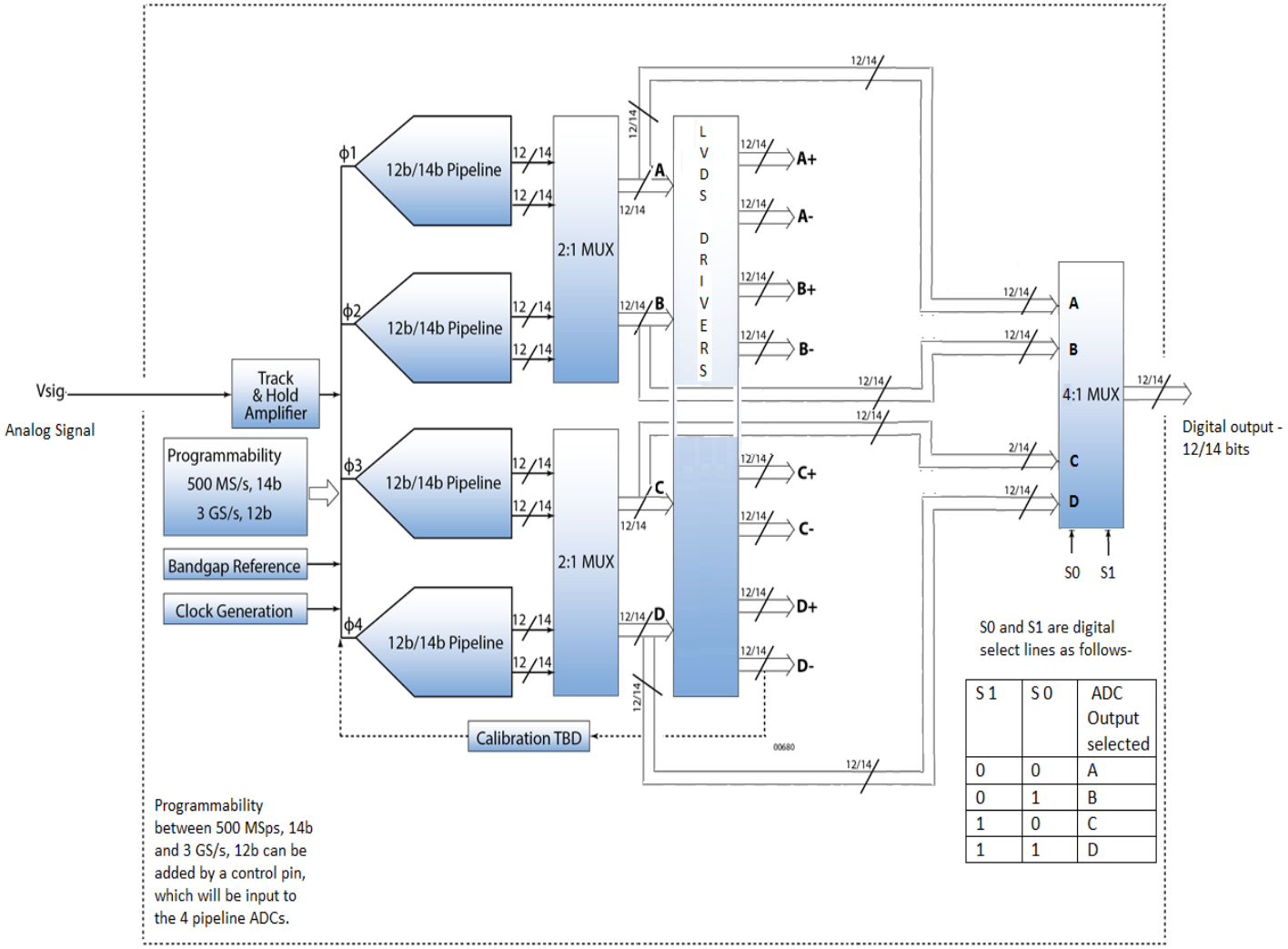
IC Design Flow



ADC Pipeline 3 GSPS

- **Programmable ADC**
- **Time-Interleaved double sampled pipeline, high speed (500 MS/s – 3 GS/s)**
- **High resolution (12-14 bits)**
- **Highly linear with an INL and DNL of no more than ±0.5 LSB,**
- **Operating temperature range of at least -10 to 80 °C,**
- **Total ionization dose (TID) rating of 1 Mrad.**

ADC Architecture 3 GSPS



S 1	S 0	ADC Output selected
0	0	A
0	1	B
1	0	C
1	1	D

3 GSPS ADC Targeted Specifications

Specification	Original Goal	Current Estimate
Resolution [bits]	12	12
Sampling speed [GS/s]	0.5 - 3.0	0.5 - 3.0
Input analog bandwidth [GHz]	2.0	12
Power [W]	1.0	2.5
SFDR [dB]	74	72.7
ENOB at 250MHz input [bits]	11.0	11.0
ENOB at 1.5GHz input [bits]	11.0	8.5
TID hardness [krad]	1000	>1000
SEL hardness [Mev-cm^2/mg]	120	120
Process	IBM 130 nm SiGe	IBM 130 nm SiGe
Operating Temperature	-40 to +85 ^{o}C	-40 to +85 ^{o}C

Centering the ADC Design

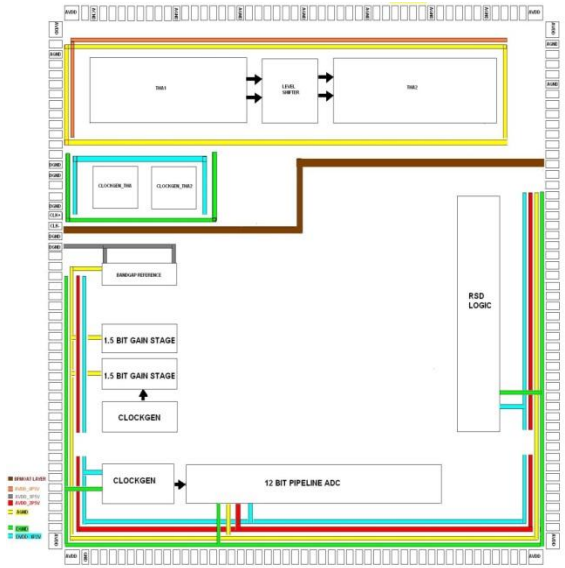
- **Small-geometry fabrication processes are very complex and have many reliability concerns for demanding applications:**
  - **Bias Temperature Instabilities (NBTI and PBTI)**
    - **Including hard-to-detect annealing effects**
  - **Dielectric Breakdown**
  - **Hot Carrier Effects**
  - **Radiation**
  - **Combined effects (e.g., radiation and NBTI)**
  - **Electromigration**
  - **Stress Migration**
  - **Process Mismatch Effects**
  - **Lot-to-lot Variation**
  - **Etc.**

Remaining 3 GSPS ADC Challenges

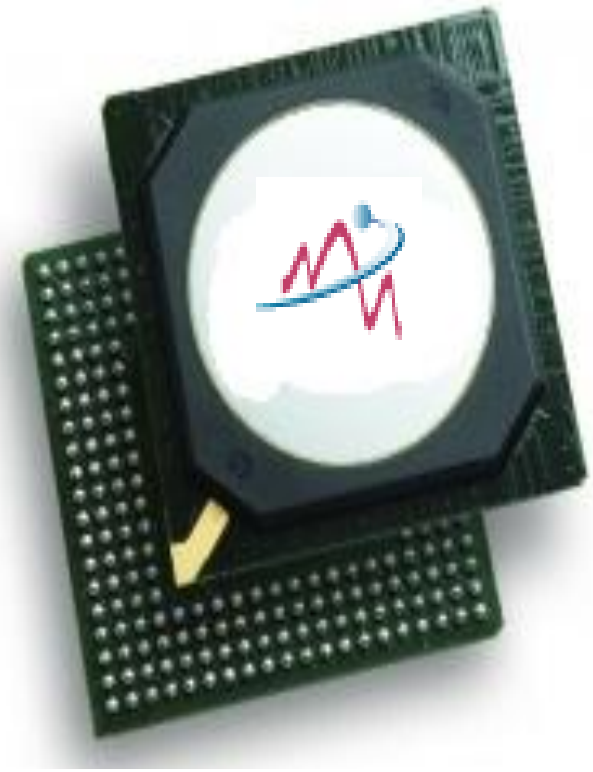
- **Design is largely complete and verified using IBM Process Design Kit (PDK) and recommended Cadence simulator**
- **Ridgetop requests bridge funding for high density packaging that is required at RF frequencies (flip chip) and radiation testing. There is a tradeoff of dynamic range and radiation hardness involved.**
- **There is confirmation of demand from key players such as CAEN, Boeing and ON Semiconductor**

3 GSPS ADC - Packaging

Test chips



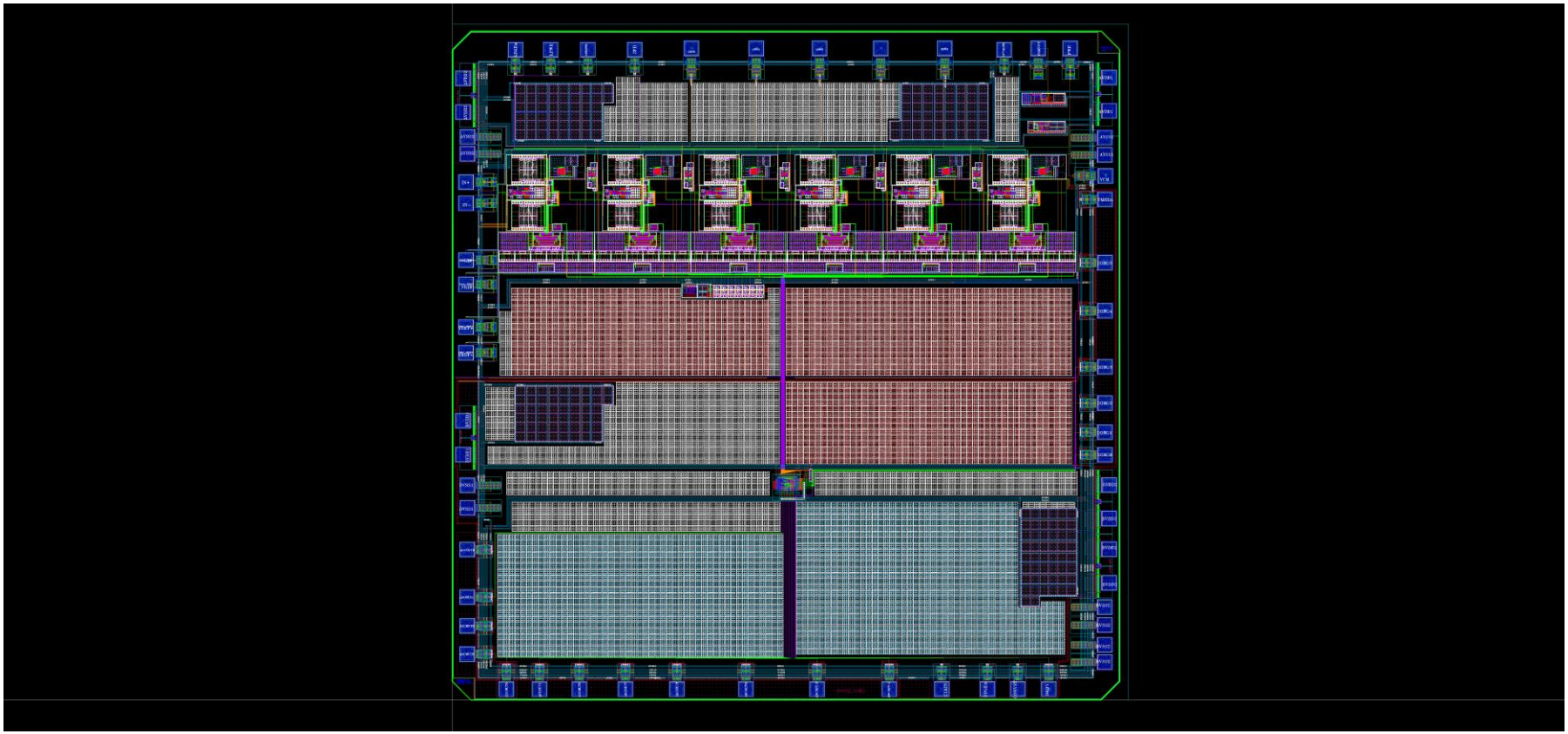
Final chip with High Density Interconnect (HDI)



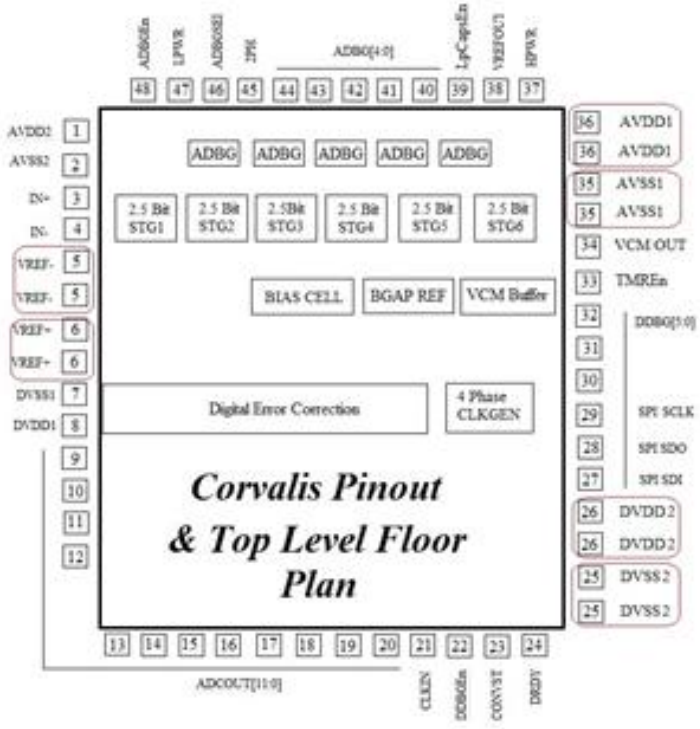
40 MSPS - ADC Specifications

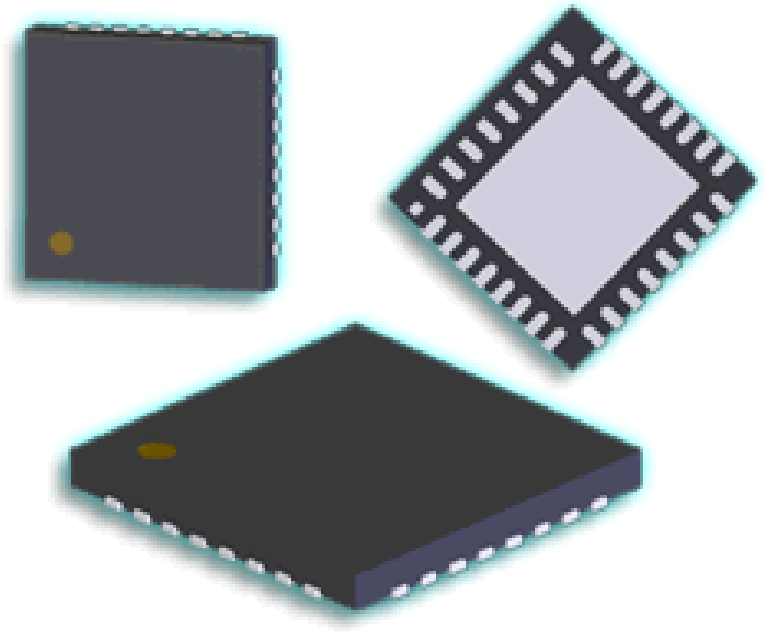
Spec	Original Goal	Simulated
Resolution [bits]	12	12
Sampling speed [MS/s]	40	40
Power [mW]	<100.0	22.5
SFDR [dB]	74	72
ENOB input [bits]	11	10
TID hardness [krad]	1000	>1000
SEL hardness [Mev-cm^2/mg]	120	120
Process	IBM 130 nm SiGe	IBM 130 nm SiGe
Operating Temperature	-40 to +85 ^{o}C	-40 to +85 ^{o}C

40 MSPS ADC Layout

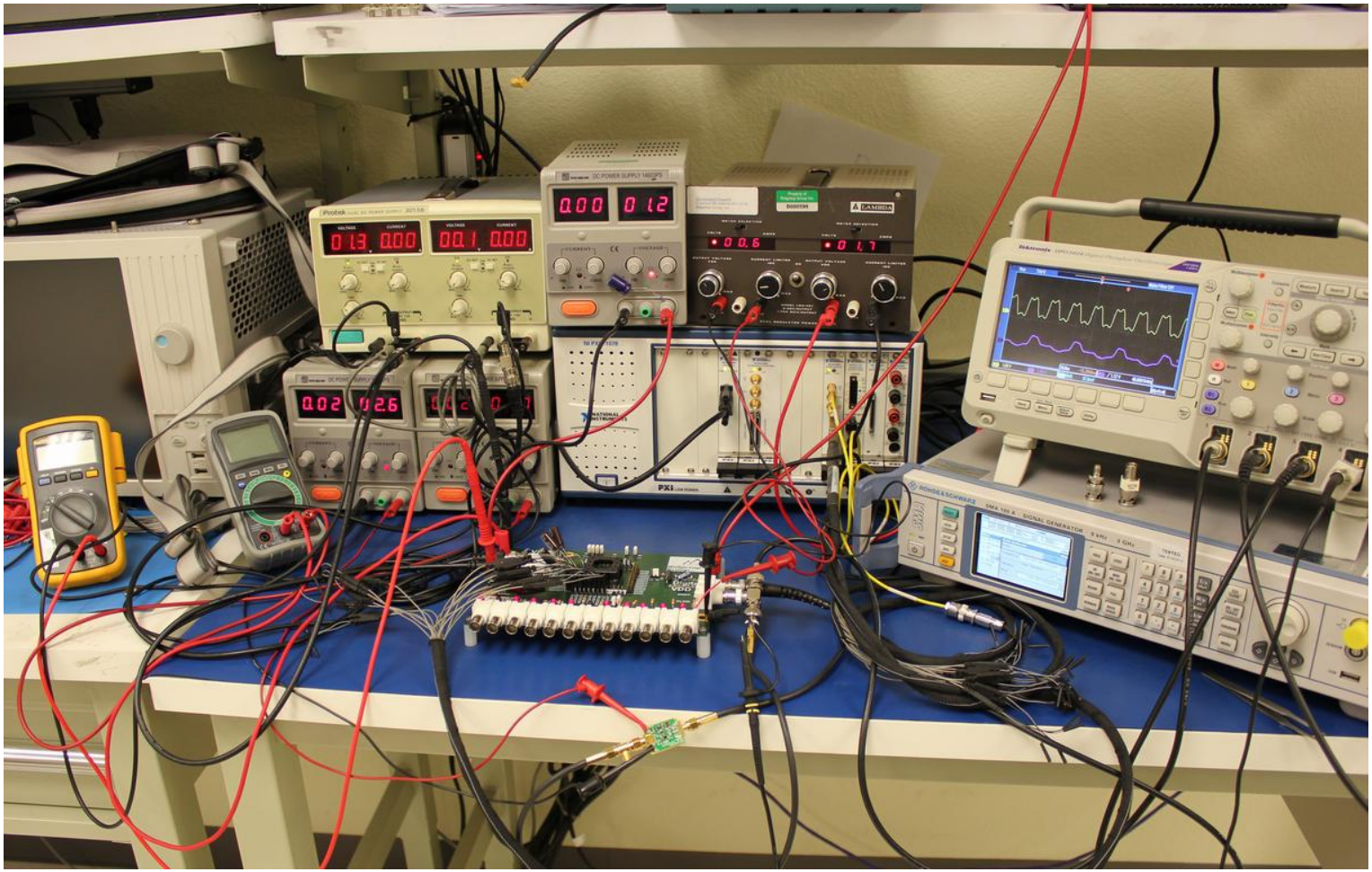


40 MSPS - Packaging

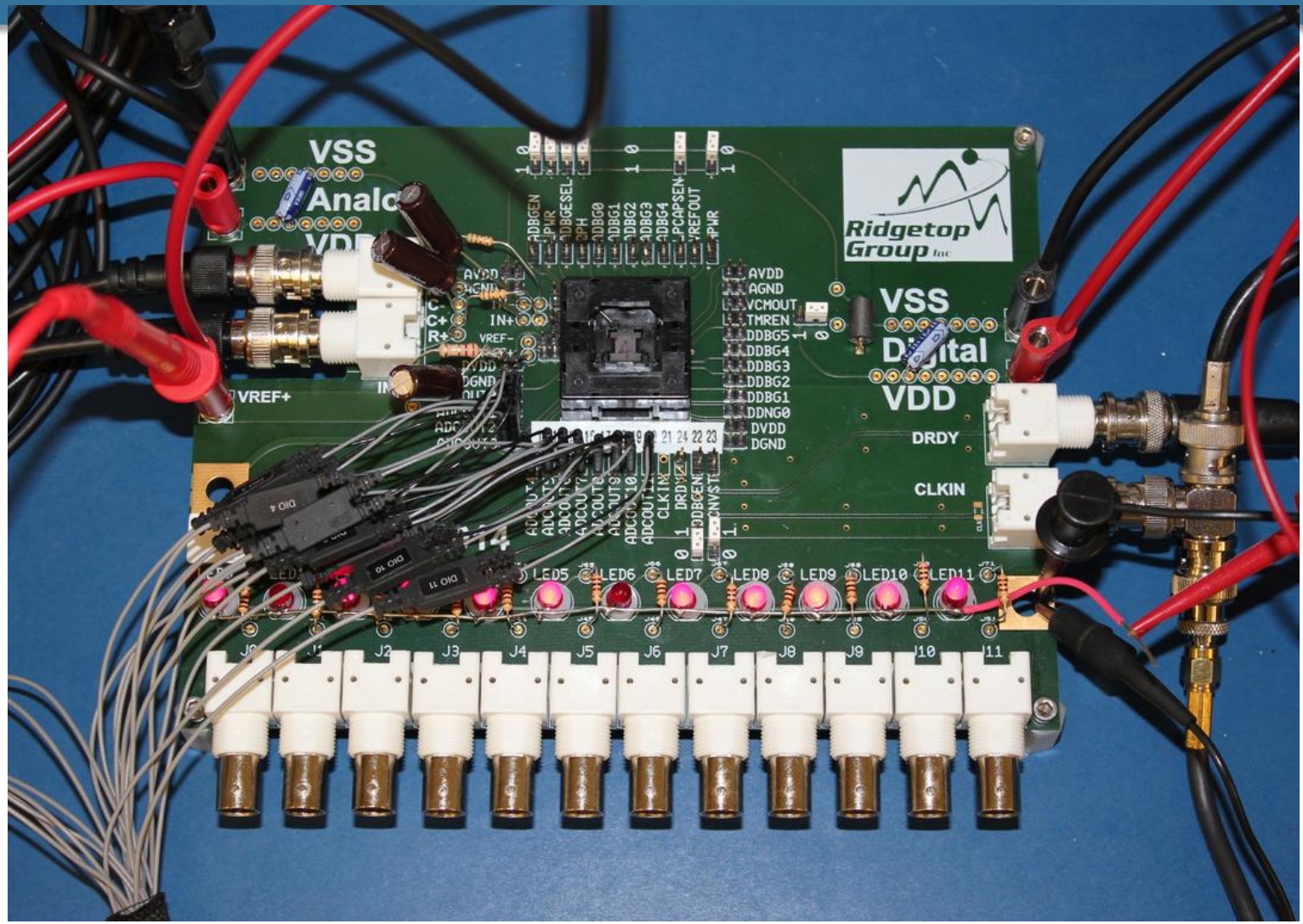




Evaluation Test Bed – 40 MSPS ADC



Test Board – 40 MSPS ADC



Commercialization with CAEN

- CAEN is a leading supplier of precision instruments for particle accelerators.
- Strong interest from CAEN in using Rad Hard ADC from this SBIR program
- Possible collaboration on other products as well.

Dear Doug,

thank you once more for your visit in CAEN !

As promised, I'm sending you in attachment the data sheet of the commercial ADC that we have installed in our fastest digitizers, respectively:

V1751 "4/8 Channel 10 bit 2/1 GS/s Digitizer"

and

V1761 "2 Channel 10 bit 4GS/s Digitizer"

As you remember, these digitizers are available also in the desktop and NIM form factors.

Coming to the radiation levels present in LHC and SuperLHC experiments at CERN, just to have an idea about the environment which your ADC can find, I can confirm you the values expected for LHC in the so called balconies, i.e. at some meters of distance from the beam.

They are:

1*10E11 proton/cm2
2*10E12 neutron/cm2
15 kRad TID

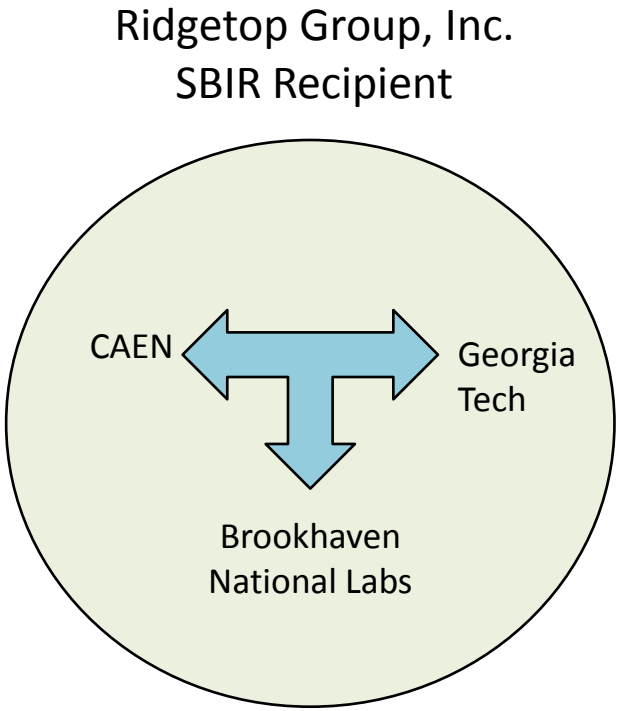
But this is already history, in fact the SuperLHC experiments will face higher values, both for the increased luminosity, and for the fact that digitizing electronics will be probably located closer to the beam, with respect to the balconies.

If you have more questions or comments, please feel free to ask !

Best Regards
Claudio

Development Ecosystem

- Ridgetop Group, Inc. Sampath Venkatesan, Principal Investigator
- Domain Expertise: Dr. Chen, Brookhaven National Labs
- System Integration Expertise : CAEN –Claudio Raffo
- SiGe Semiconductor Expertise – Dr John Cressler at Georgia Tech



ADC– Additional Applications

Terrestrial Communication Systems

Provides the high-speed ADC required within high performance transceiver hardware.

Software Defined Radio Applications

ADCs – Path forward

- Exceptionally challenging design that can revolutionize measurements in presence of radiation.
- Continue to use SiGe technology with assistance from Georgia Tech
- Develop commercialization paths with CAEN and Boeing, and ON Semiconductor.
- Have received strong interest in extending our work.
- Bridge funding for packaging and refinement are needed

Summary

- Significant progress in providing rad hard ADCs to support DOE and CERN Programs
- Additional funding sought for finalization, packaging and radiation testing.
- Strong commercial market “pull” for performance point of both ADCs

Contact Information

Ridgetop Group Inc

ENGINEERING INNOVATION

Ridgetop Group, Inc.

3580 West Ina Road

Tucson, Arizona 85741

(520) 742-3300

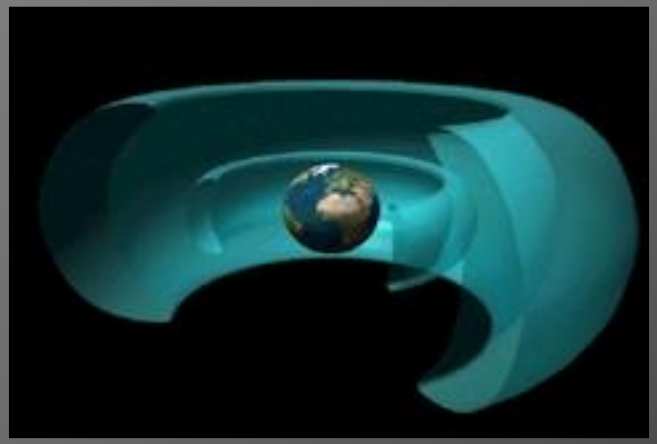
Additional Rad Hard Tools

ProChek Semiconductor Characterization Platform

RadChek™ Radiation Shielding Tool

- Estimate and Analyze the dose reaching the sensitive components…

Environment Modeling



Transport through
satellite structure & shielding