MSREM

MSREM= Miniaturised Standard Radiation Environmental Monitor

Review of MSREM activity.

Contract No. 14060/99/NL/SB

Starting: February 2000

Closed : April 2002

Presented by J. Schneider (jack.schneider@unaxis.com)

and H.U. Mathys (hansulrich.mathys@unaxis.com)

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MSREM Outline

Presentation outline:

1. Contract outline
2. Review of SREM Design
3. Proposed activities
4. Details of the activities
5. Conclusion
6. Next Steps

Contract Outline

Contract Goals:

The overall objectives in this project shall be, **starting from the existing design,** to review all relevant developments, tools and components including their capabilities and limitations as applied to the SREM. **The "enhanced attributes" we are seeking are:**

- Reduction in total dimensions and mass
- Reduction in power consumption
- Improved radiation tolerance
- Reduced recurrent cost

However, none of these improvements shall be achieved by compromising the scientific capabilities of the existing SREM instrument in any way.

This was to be changed and higher performance was required.

Review of SREM Design

SREM Monitors:

- Development 1996-1998 (2PFM's)
- Batch manuf. 1999-2001 (8PFM's)
- 3 of 10 units in Space
  (STR1C/Integral/Proba)

SREM selected for:

Rosetta

GOCE

Planck

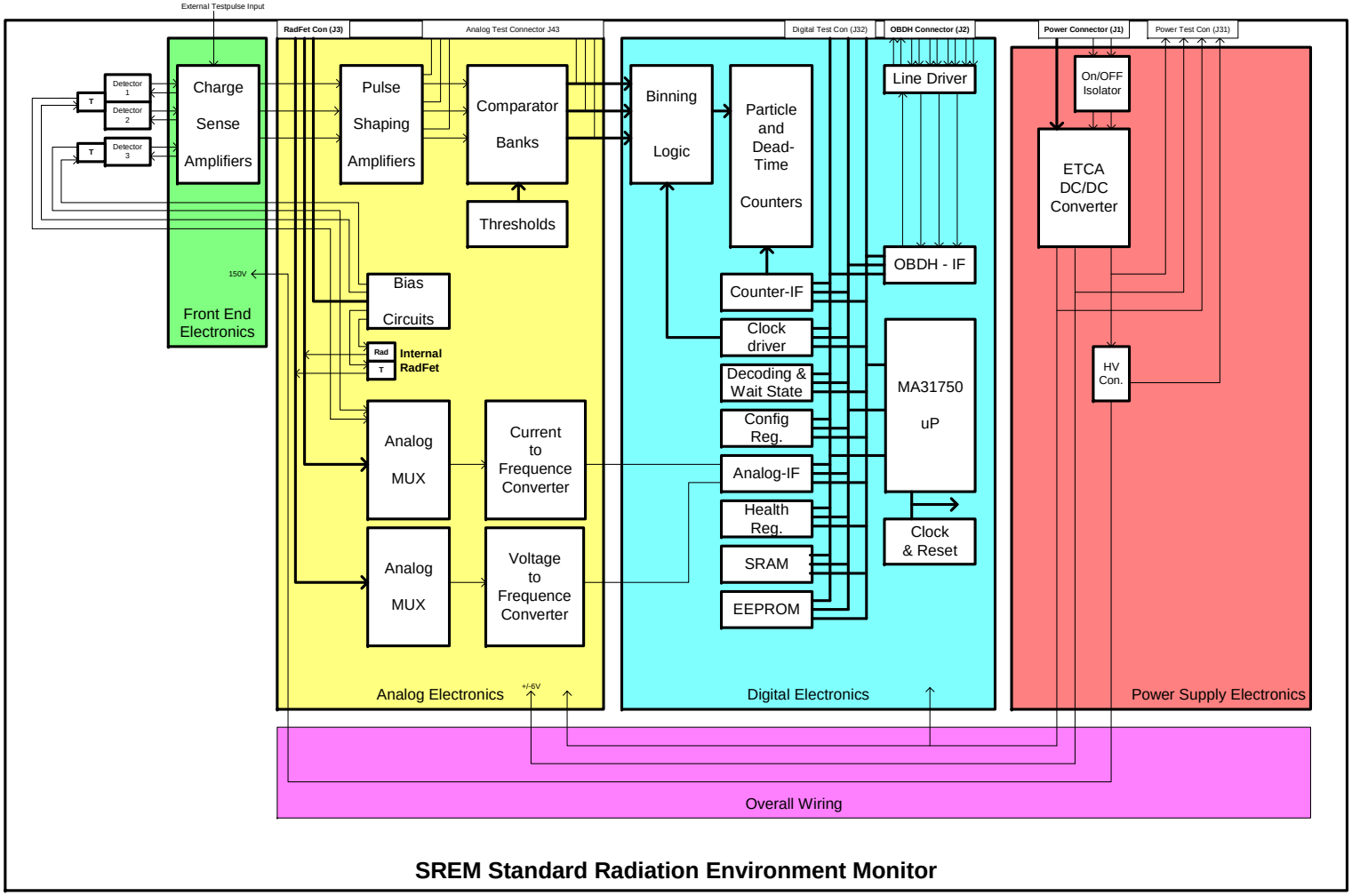
GSTB

.

Review of SREM Design

SREM

Block diagram:



SREM Standard Radiation Environment Monitor

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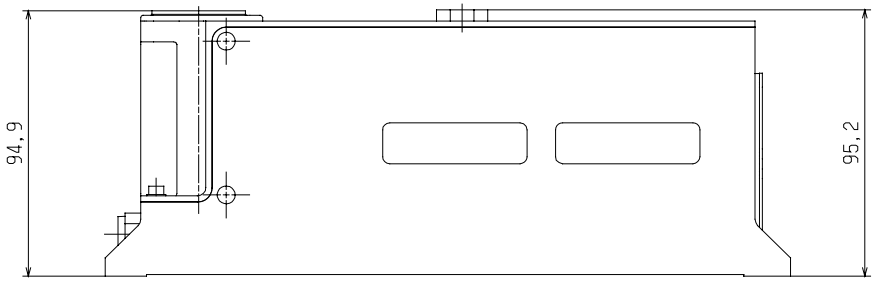
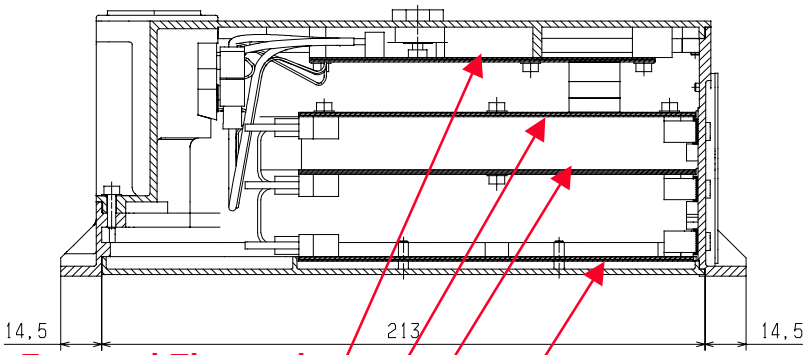
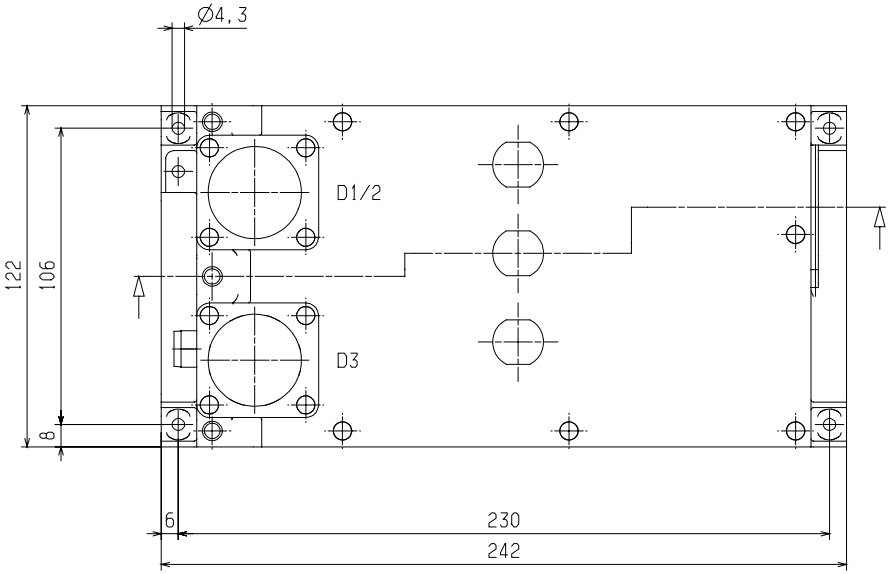
Review of SREM Design

SREM Mechanical dimension:







Key figures:

Mass: 2.4 kg

Dim.: 95 x 213 x 122 mm (without food prints)

Power: < 2.5 Watts (-20 to 60 ºC & 20 - 55 Vdc)

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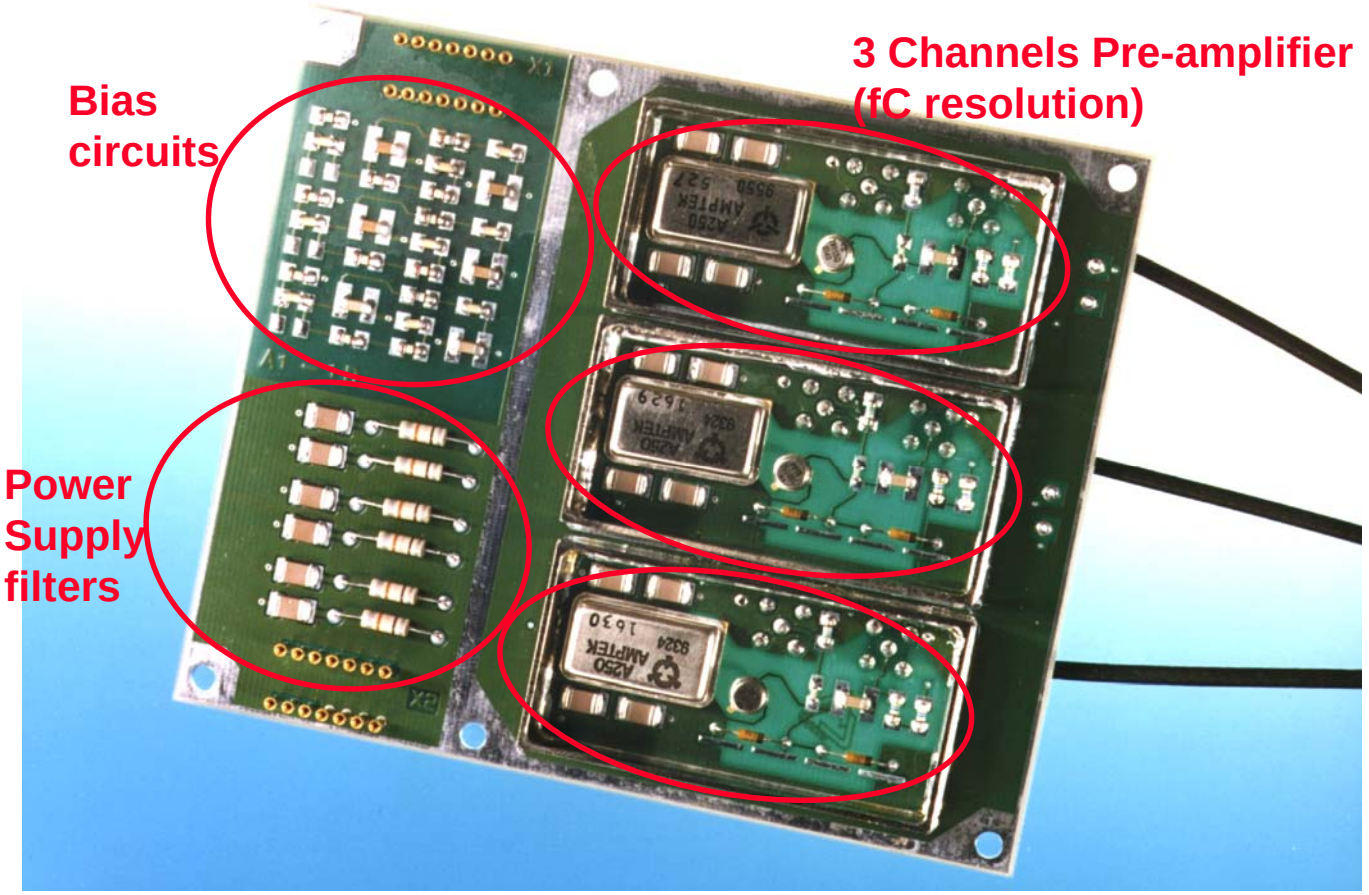
Review of SREM Design

SREM Frontend electronics:



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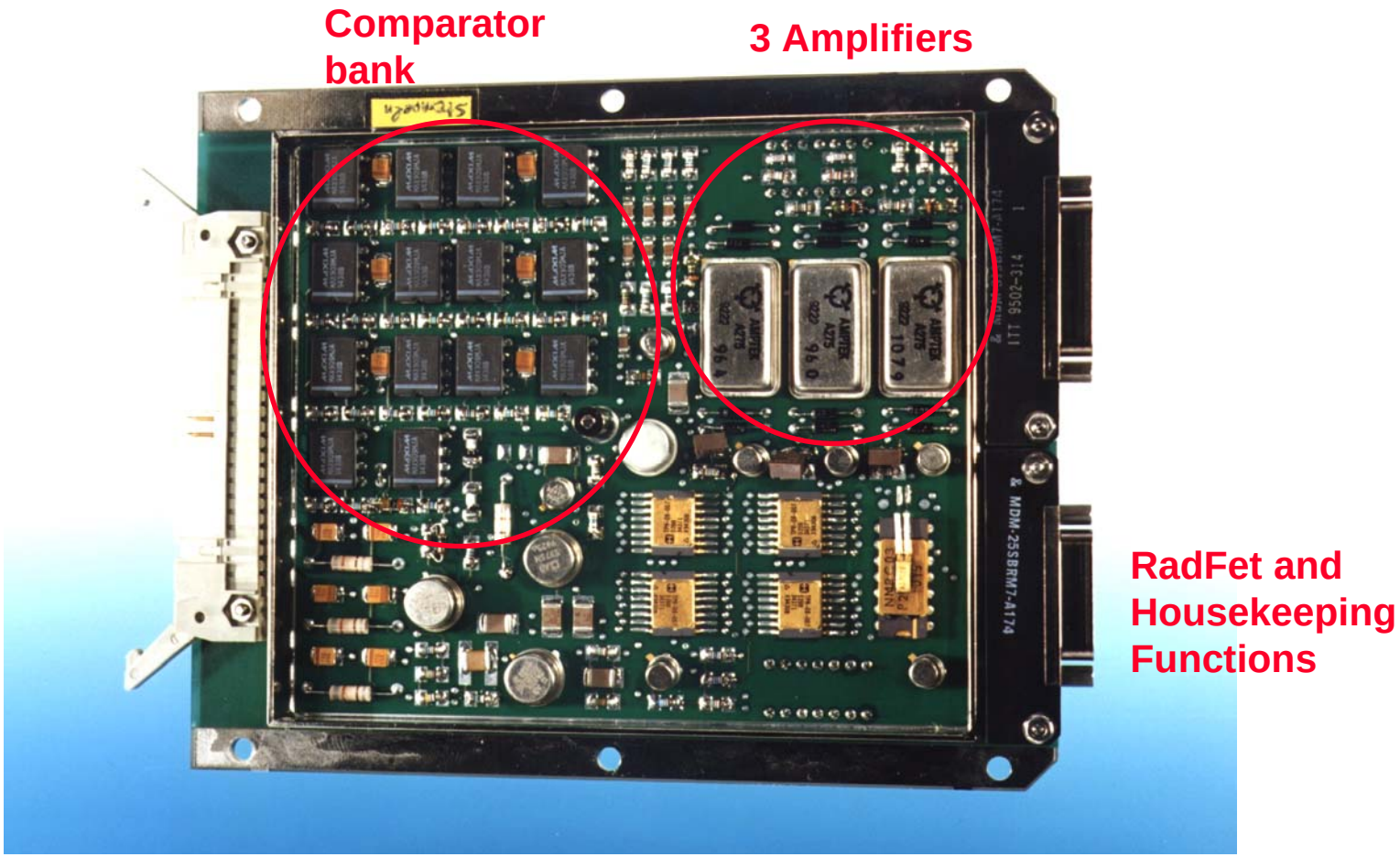
ESTEC Final Presentation Days

Review of SREM Design

SREM Analogue Electronics:



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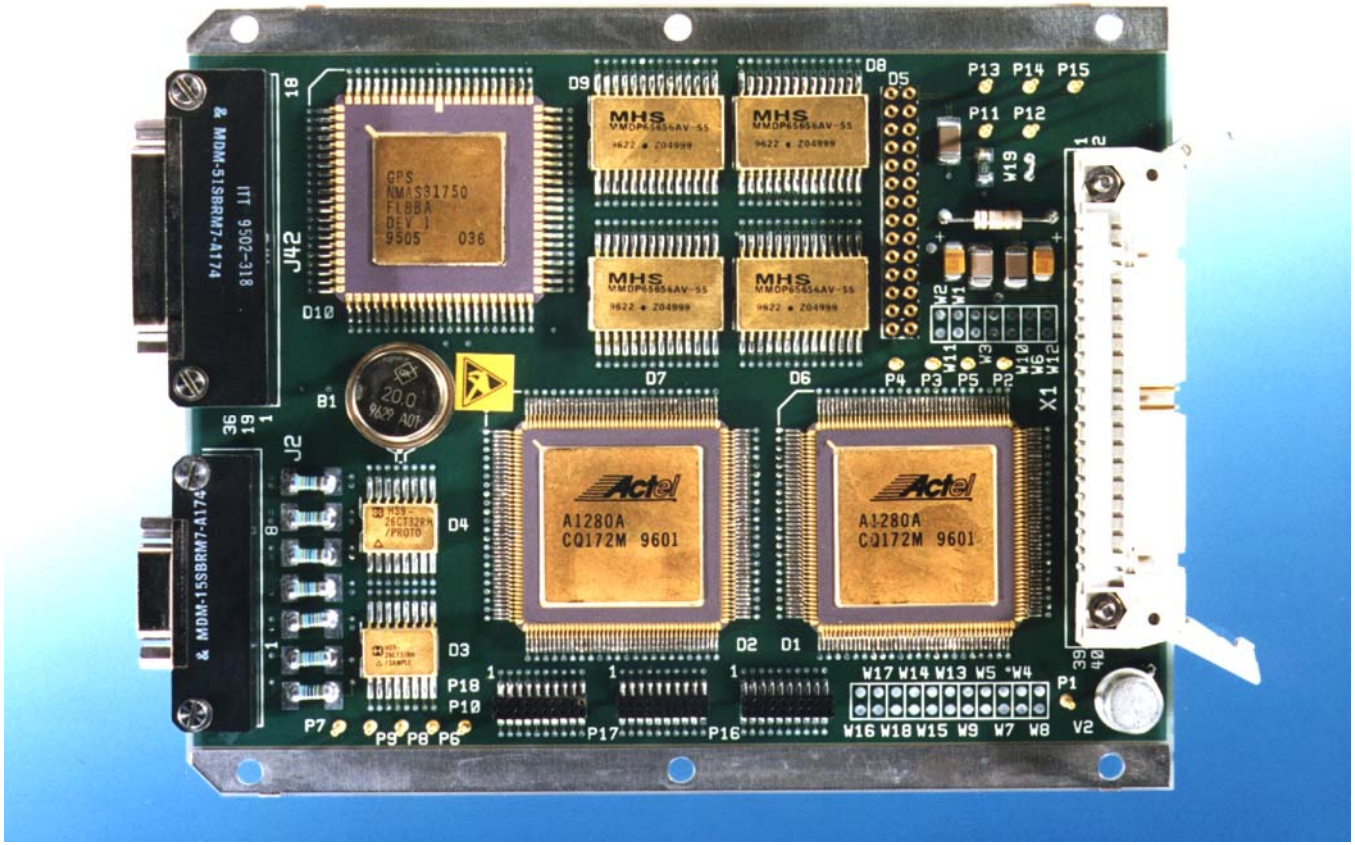
Review of SREM Design

SREM Digital Electronics:



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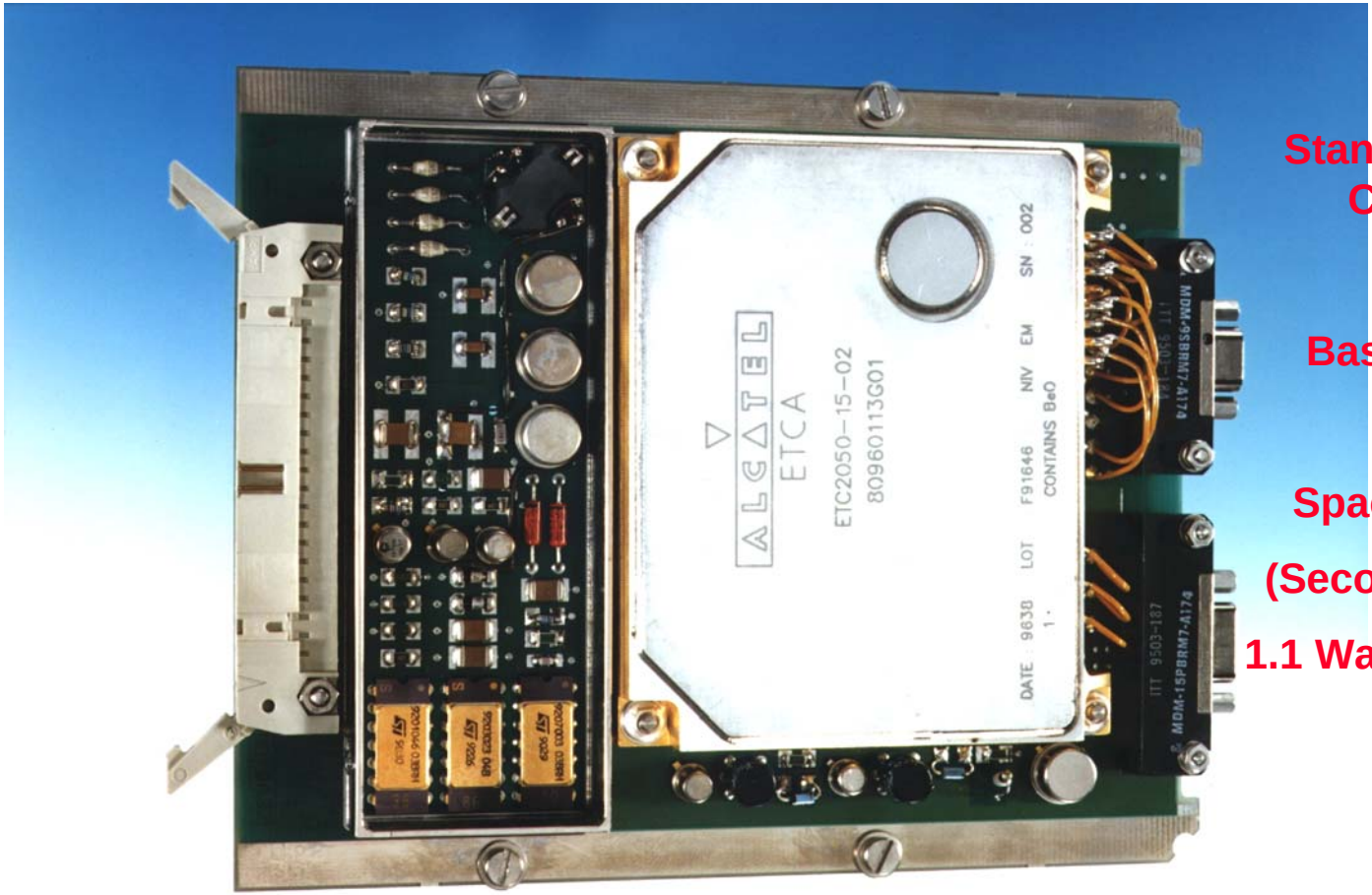
Review of SREM Design

SREM DC/DC Converter Electronics:



Standard DC/DC Converter

Base-Version:

15 Watt

Space qualified

(Secondary power

1.1 Watt worst case)

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Proposed activities

Improvement activities for the new Miniaturised SREM

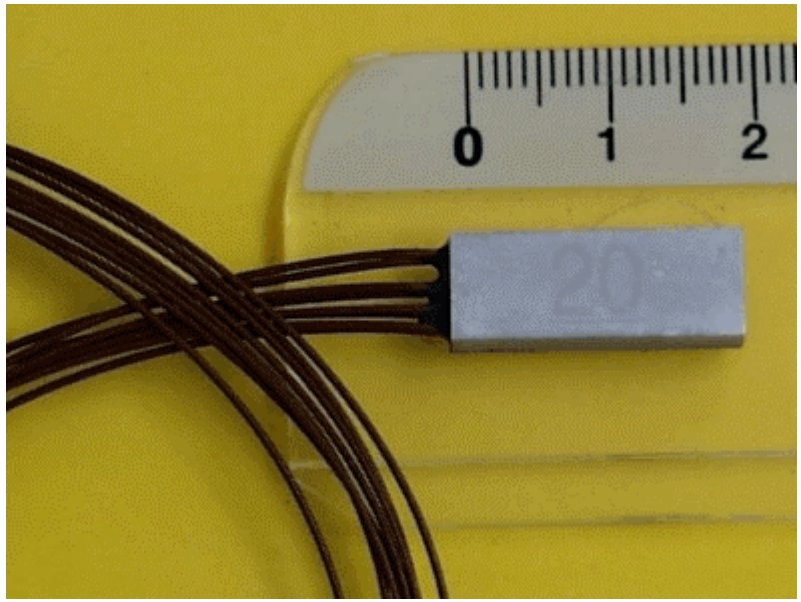
Performed Breadboards:

- SIP controller Bread Board
- A/D controller Bread Board
- PDFE controller Bread Board (Only Study, No realisation)
- Detector module design

SIP Controller Bread-Board

Based on the SIP (Smart Instrumentation Point) from Xensor System (www.xensor.nl)

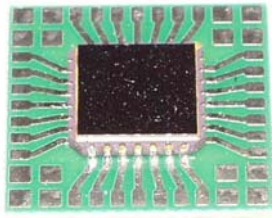
First units flying on Proba.



Smart Instrumentation Point

Features

- Temperature sensor
- Radfet radiation dose monitor
- Programmable voltage interface
- Programmable bias current source
- Programmable sensor multiplex
- 14 bits accurate A-to-D converter
- Two wire serial bus output
- Bipolar radiation resistant technology (>100 kRAD)
- Designed in collaboration with ESTEC/ESA



SIP Controller Bread-Board

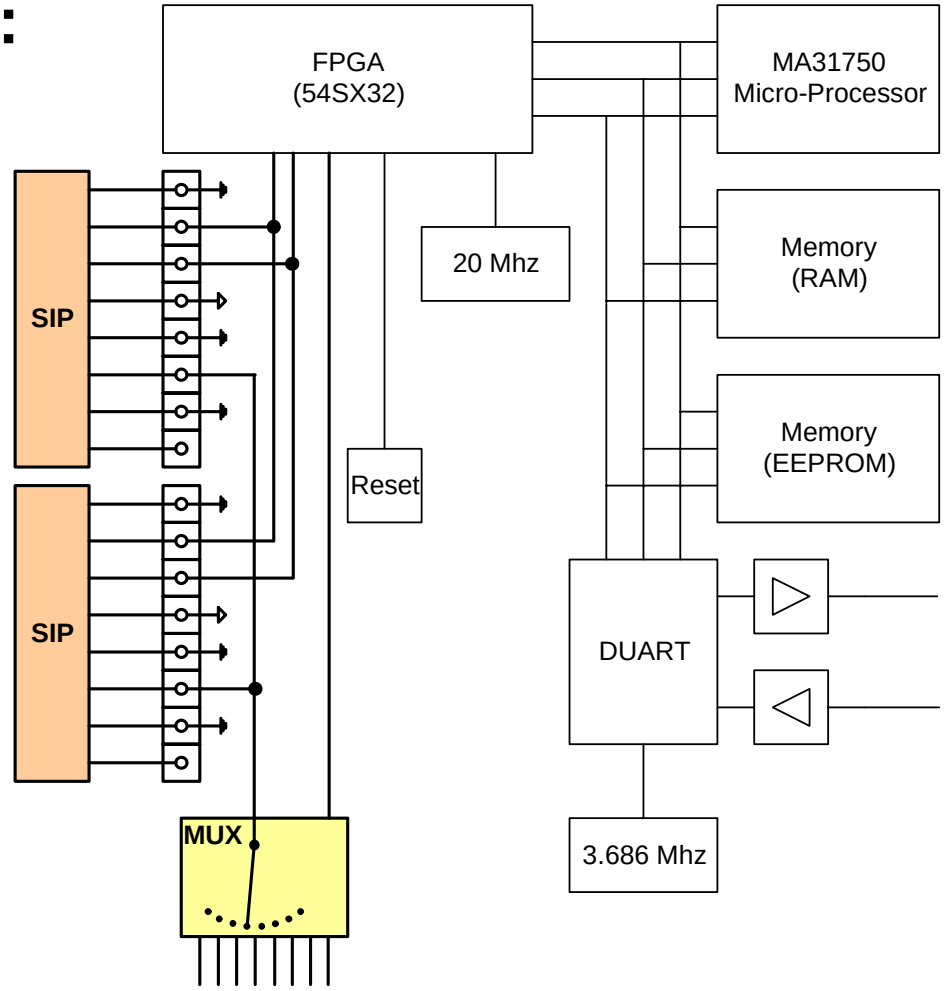
Applications

- Application in satellites
- Radiation sensitive applications
- Thermocouple measurement
- **Internal temperature measurement**
- **Internal radiation total dose measurement**
- Potentiometer measurement
- Resistive bridge measurement
- Resistive measurement
- Voltage measurement
- Current (consumption) measurement or relais
- Measurement ranges 42 mV / 640 mV and 2.6 V.

- **Serial bus allows to connect more than 30 external modules for monitoring of external total dose & temperature at critical spacecraft positions. (Maximal length shall be improved).**

SIP Controller Bread-Board

Block diagram:



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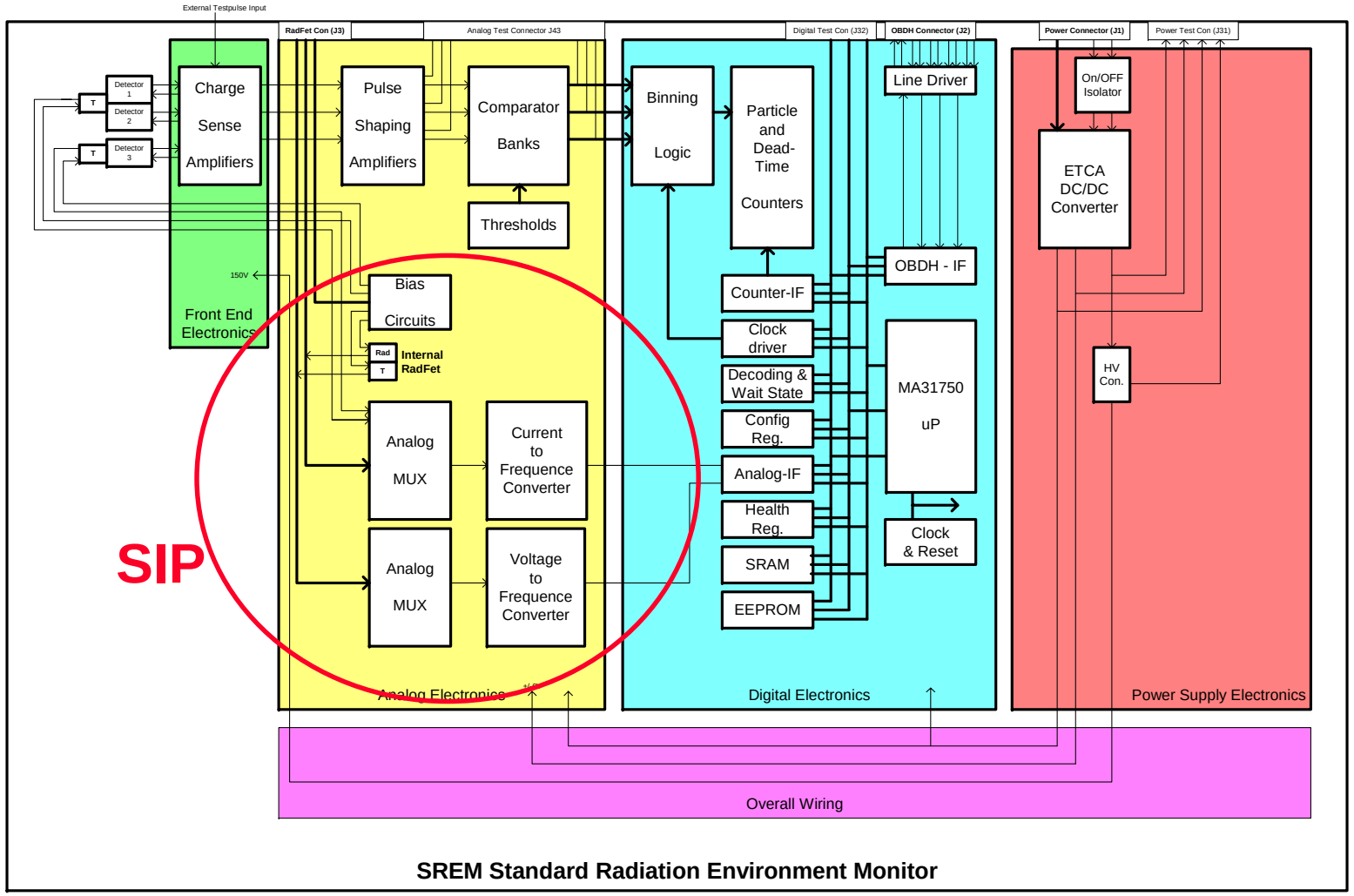
SIP Controller Bread-Board



SREM Standard Radiation Environment Monitor

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SIP Controller Bread-Board

Measurement Results:

42 mV Range

		+/- 42 mV								
Input Voltage [mV]		0	10	-10	20	-20	30	-30	38	-38
Zeros	8 bit	119	89	150	59	179	28	210	3	235
Ones		136	166	105	196	76	227	45	252	20
Total		255	255	255	255	255	255	255	255	255
	9 bit	238	177	300	118	360	56	420	7	470
		273	334	211	393	151	456	91	504	41
		511	511	511	511	511	512	511	511	511
	10 bit	357	267	449	176	540	84	691	12	705
		410	500	318	591	227	683	136	755	62
		767	767	767	767	767	767	827	767	767
	11 bit	595	444	749	295	900	141	1053	20	1173
		684	835	530	984	379	1138	226	1259	106
		1279	1279	1279	1279	1279	1279	1279	1279	1279
	12 bit	1072	800	1349	528	1621	254	1895	36	2114
		1231	1503	954	1775	682	2049	408	2267	189
		2303	2303	2303	2303	2303	2303	2303	2303	2303
	13 bit	2025	1512	2549	998	3063	479	3579	69	3994
		2326	2839	1802	3353	1288	3872	772	4282	357
		4351	4351	4351	4351	4351	4351	4351	4351	4351
	14 bit	3932	2935	4938	1939	5949	929	6947	134	7750
		4515	5512	3499	6508	2498	7518	1500	8313	697
		8447	8447	8437	8447	8447	8447	8447	8447	8447
	15 bit	7743	5780	9745	3818	11716	1832	13684	263	15266
		8896	10859	6894	12821	4923	14807	2955	16376	1373
		16639	16639	16639	16639	16639	16639	16639	16639	16639
	16 bit	15367	11472	19341	7574	23256	3636	27163	520	30299
		17656	21551	13682	25449	9767	29387	5860	32503	2724
		33023	33023	33023	33023	33023	33023	33023	33023	33023
	17 bit	30497	22768	38393	15015	46142	7208	53912	1054	60125
		35038	42767	27142	50520	19393	58327	11623	64481	5410
		65535	65535	65535	65535	65535	65535	65535	65535	65535

		+/- 42 mV								
Input Voltage [mV]		0	10	-10	20	-20	30	-30	38	-38
Measuremnt Range [mV]		42	42	42	42	42	42	42	42	42
Calculated	8 bit	2.8	9.9	-10.2	19.8	-19.8	30.0	-30.0	38.2	-38.2
Value [mV]	9 bit	2.9	10.0	-10.2	19.7	-20.1	29.9	-29.9	38.0	-38.1
	10 bit	2.9	9.9	-10.1	19.8	-20.0	29.9	-31.1	37.8	-38.1
	11 bit	2.9	9.9	-10.1	19.7	-20.0	29.8	-30.1	37.8	-38.0
	12 bit	2.9	9.9	-10.1	19.8	-20.0	29.8	-30.0	37.8	-38.0
	13 bit	2.9	9.9	-10.1	19.8	-20.0	29.8	-30.0	37.8	-38.0
	14 bit	2.9	9.9	-10.1	19.8	-20.1	29.9	-30.0	37.8	-38.0
	15 bit	2.9	9.9	-10.1	19.8	-20.1	29.8	-30.0	37.8	-38.0
	16 bit	2.9	9.9	-10.1	19.8	-20.1	29.8	-30.0	37.8	-38.0
	17 bit	2.9	9.9	-10.1	19.8	-20.1	29.9	-30.0	37.7	-38.0
Input Voltage [mV]		0	10	-10	20	-20	30	-30	38	-38
Deviation [%]	8 bit		-1.2	2.1	-1.2	-1.2	-0.1	-0.1	0.6	0.6
	9 bit		0.3	1.9	-1.4	0.3	-0.2	-0.3	-0.1	0.4
	10 bit		-1.4	0.8	-0.9	0.2	-0.3	3.6	-0.6	0.3
	11 bit		-0.8	1.1	-1.5	0.2	-0.6	0.3	-0.6	-0.1
	12 bit		-0.8	1.0	-0.8	0.1	-0.5	0.1	-0.6	0.0
	13 bit		-1.0	1.2	-0.9	0.2	-0.5	0.0	-0.6	0.0
	14 bit		-0.9	0.6	-0.9	0.3	-0.5	-0.1	-0.6	-0.1
	15 bit		-0.9	1.1	-0.9	0.3	-0.5	0.0	-0.6	-0.1
	16 bit		-0.9	1.1	-0.9	0.3	-0.5	0.0	-0.6	0.0
	17 bit		-0.9	1.2	-0.8	0.3	-0.5	0.0	-0.7	-0.1
Average deviation [%]			-0.9	1.2	-1.0	0.1	-0.4	0.4	-0.4	0.1
Max deviation [%]			0.3	2.1	-0.8	0.3	-0.1	3.6	0.6	0.6
Min deviation [%]			-1.4	0.6	-1.5	-1.2	-0.6	-0.3	-0.7	-0.1

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SIP Controller Bread-Board

Conclusion of SIP Controller Beard-Board:

- The SIP measurements shows an accuracy of about 1 %.
- For precision measurements the offset between the measurement ranges must be measured (initial or online by ground measurements).
- Multiple SIP use on the bus wasn’t analyse related to an change request for an MSREM application by extension of cable length.

A/D Controller Bread-Board

The performance requirements should be not reduce. For the counting the performance was increased by

	SREM	MSREM	Value
counting rate	100’000	500’000	events/seconds
Energy levels	3 * 5	4 * ? (1024)	Detectors * Thresholds (Energy levels)

The present design with comparator and fixed thresholds must be changed.

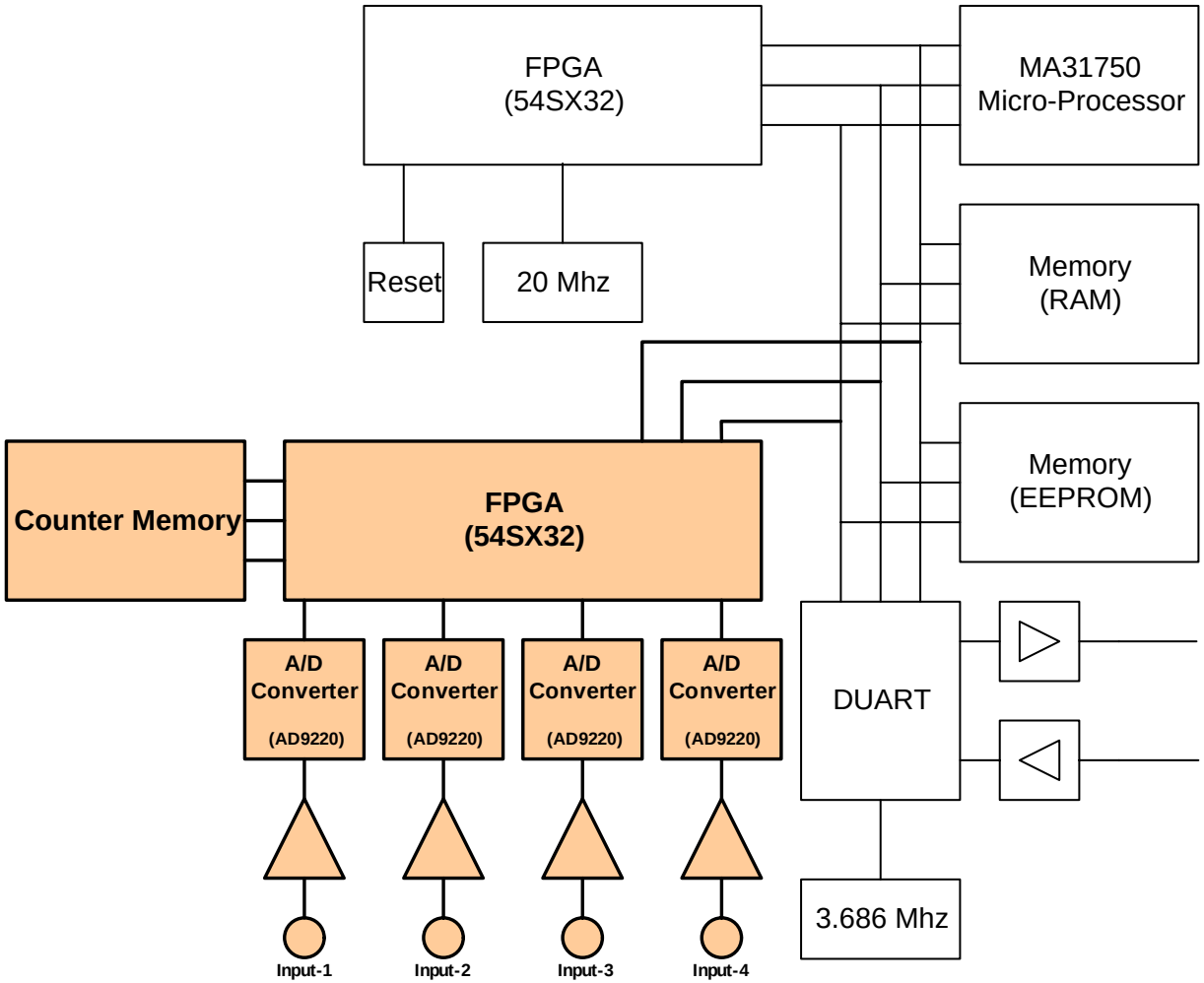
New Concept:

A/D converter (or PDFE) and with respect to the amount of event counters counting in a memory by the sequence of read / count(increment) / write of the corresponding counter (memory address).

The event counter was direct used as address of the memory address of the corresponding detector.

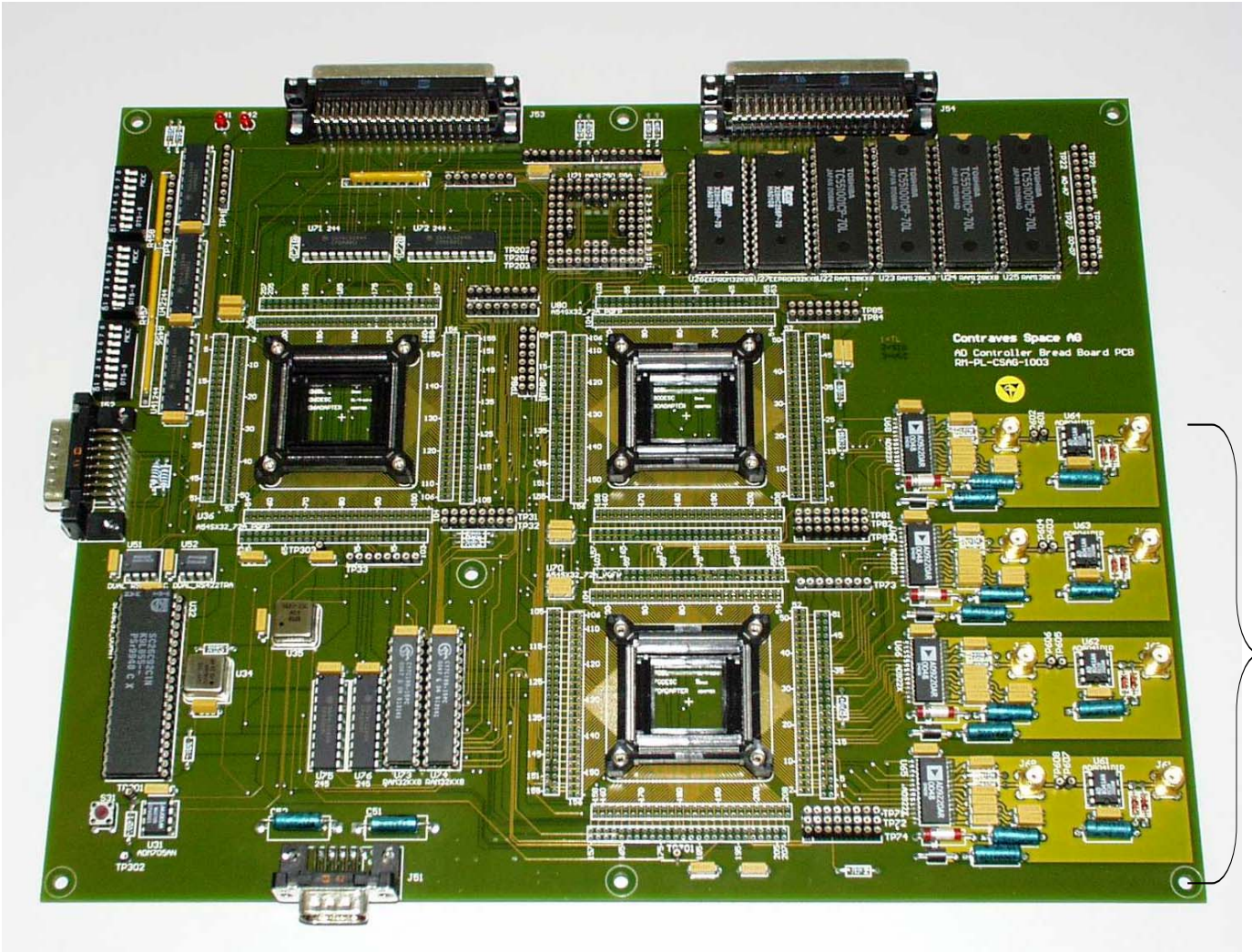
A/D Controller Bread-Board

Block diagram:



A/D Controller Bread-Board

Bread-Board:



Analogue Inputs with amplifier and A/D converter.

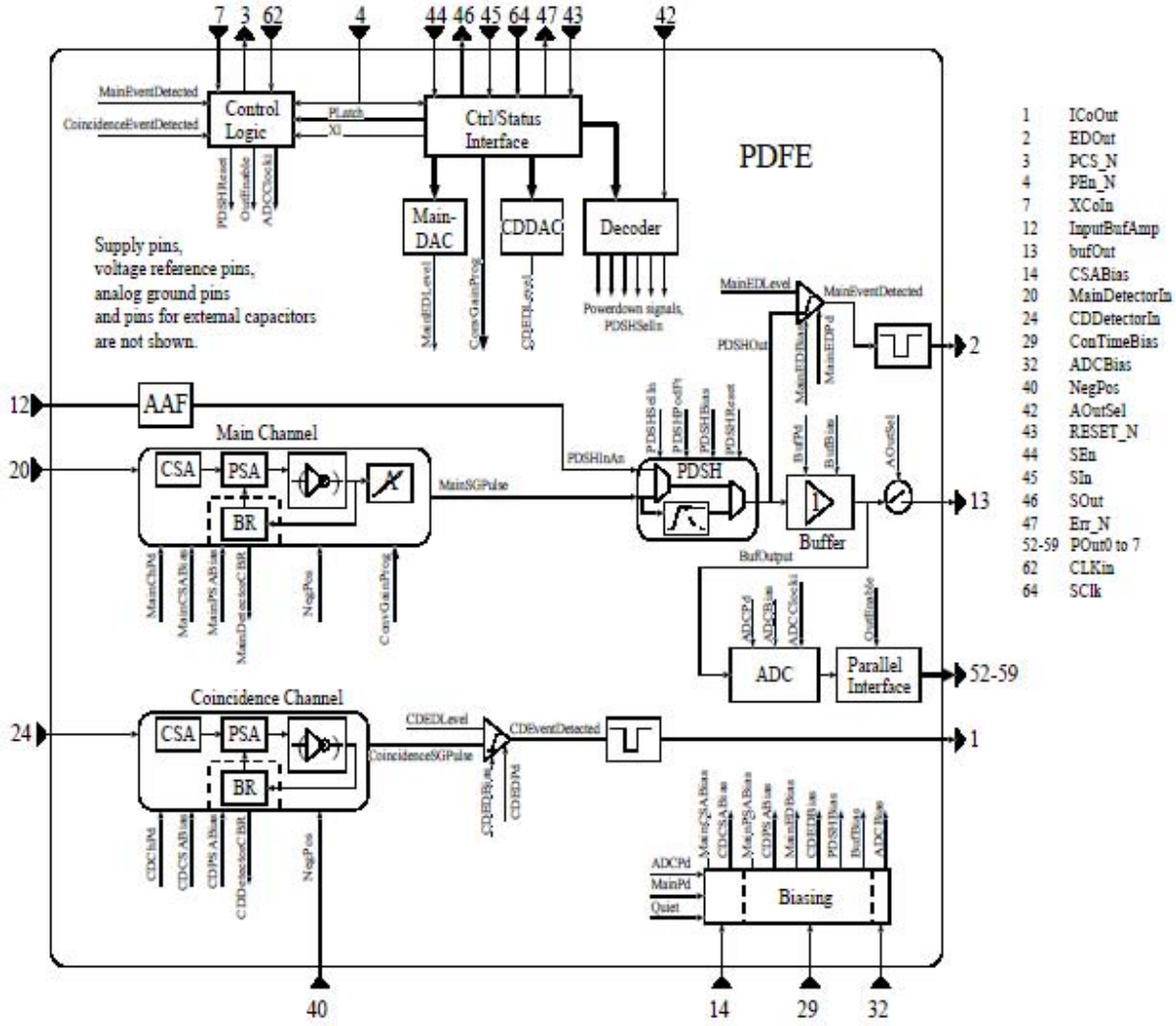
A/D Controller Bread-Board

Conclusion:

- **An extension of energy levels could be done using a A/D converter (extreme fine resolution).**
- **With respect to the power / volume a limitation of the the amount of energy ranges (between 32 to 128) should be required.**
- **Power consumption of a commercial high speed A/D converter (radiation tolerance verification needed) is much higher than a simple comparator solution.**

PDFE Solution Analysis

Particle Detector Front End



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PDFE Analysis Conclusion

PDFE solution

Advantages:

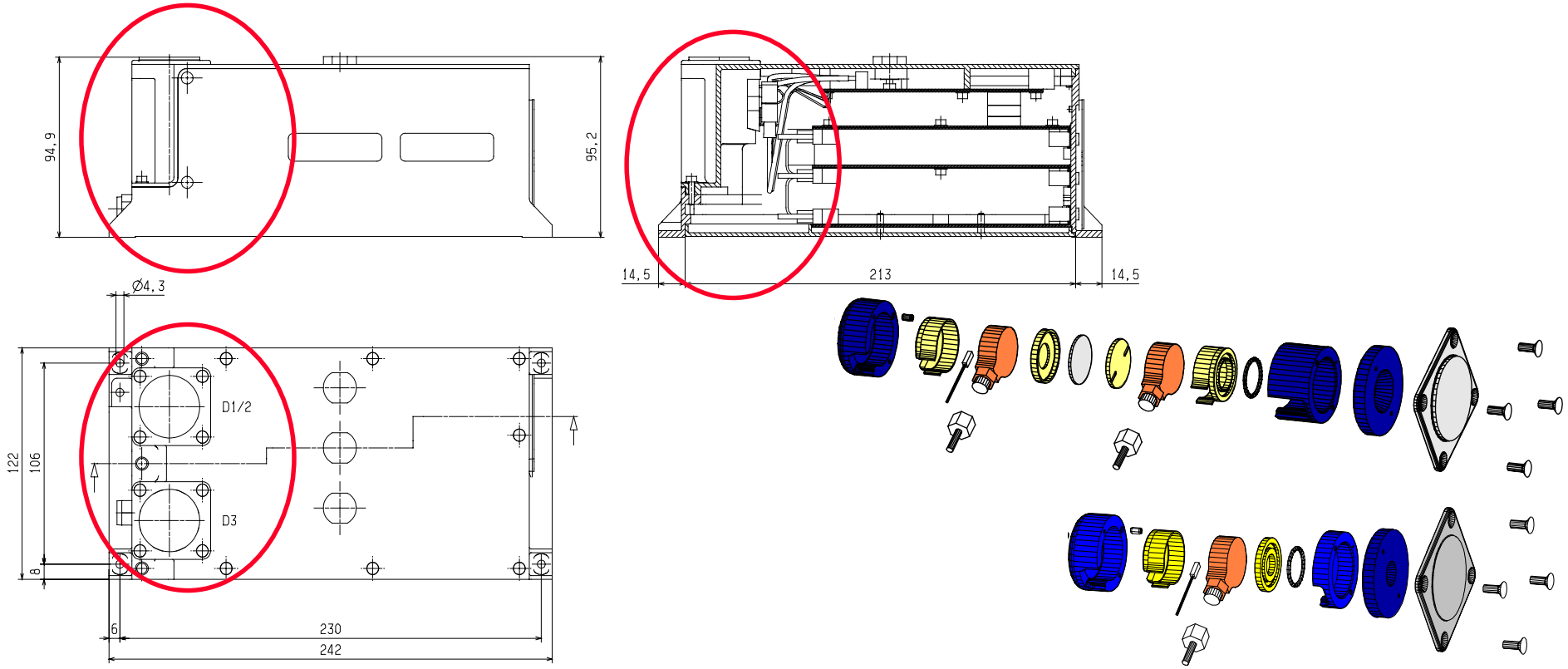
- low power consumption
- single device for preamplifier and A/D converter (8 bit)

Disadvantages:

- detection speed from 100 kevents / sec down to 20 kevents / sec
- different decoupled power supplies
- first chips problems:
    - noise problems
    - radiation hardness

Detector module design

To reduce the overall dimension and mass an update of the the detector was required.



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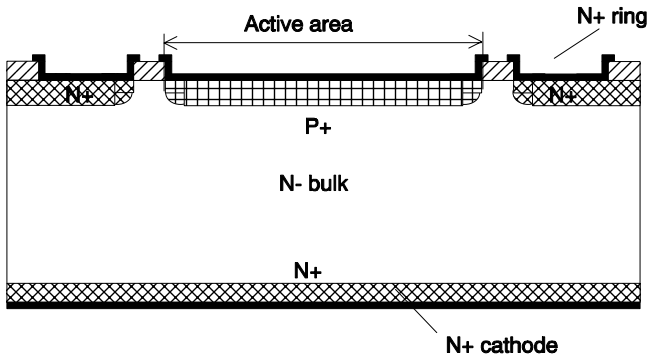
Detector module design

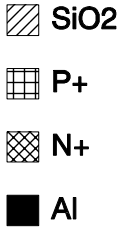
Detector module design starting by detectors:

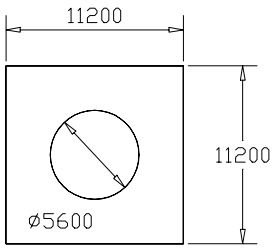
Detectors delivered by DT

Chip Layout:

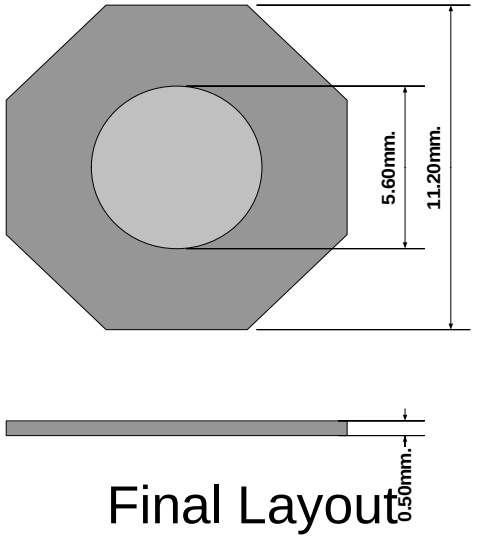


Detail





Manufacturing Layout



Final Layout

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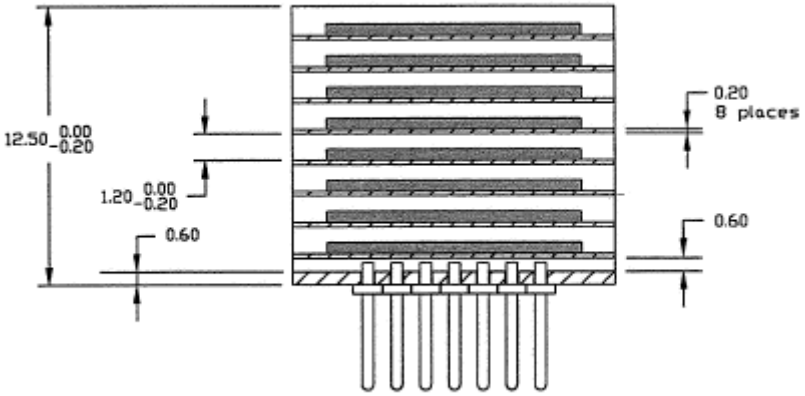
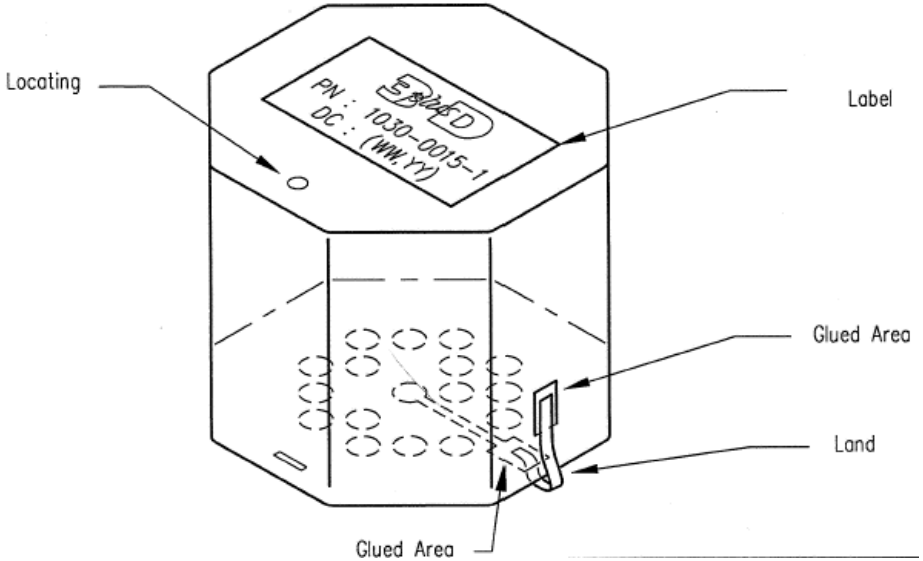
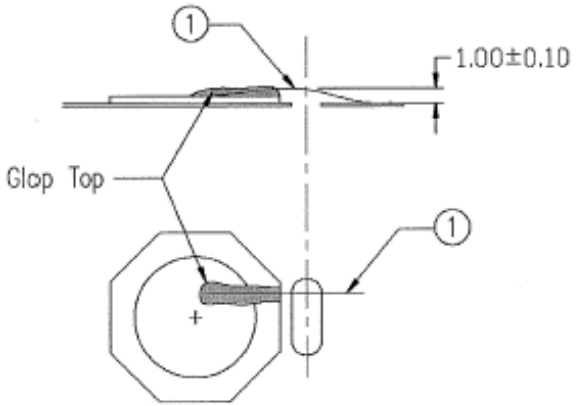
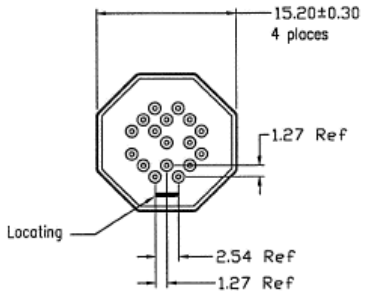
Detector module design

Designing together with 3D-Plus

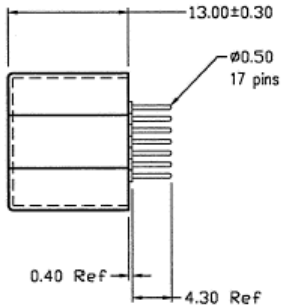


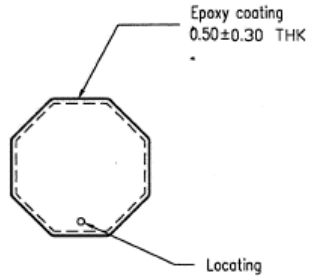






Bottom View





Top View

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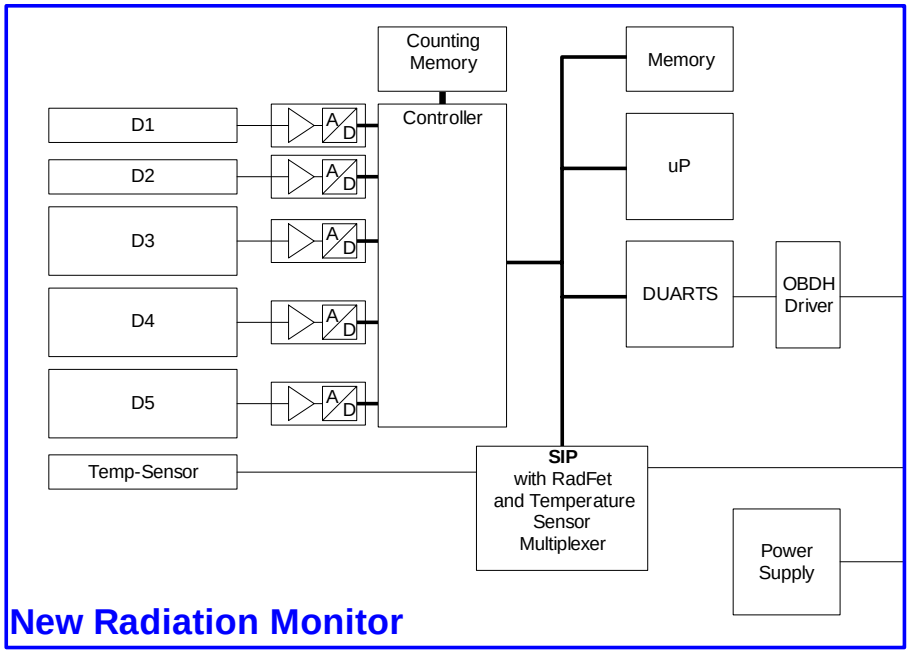
Conclusion

The performed developments SIP, PDFE and Detectors (all supported by ESTEC) show a benefit in reduction of mass and volume.

It was identified that a new (updated) miniaturised monitor could be realised:



New Radiation Monitor

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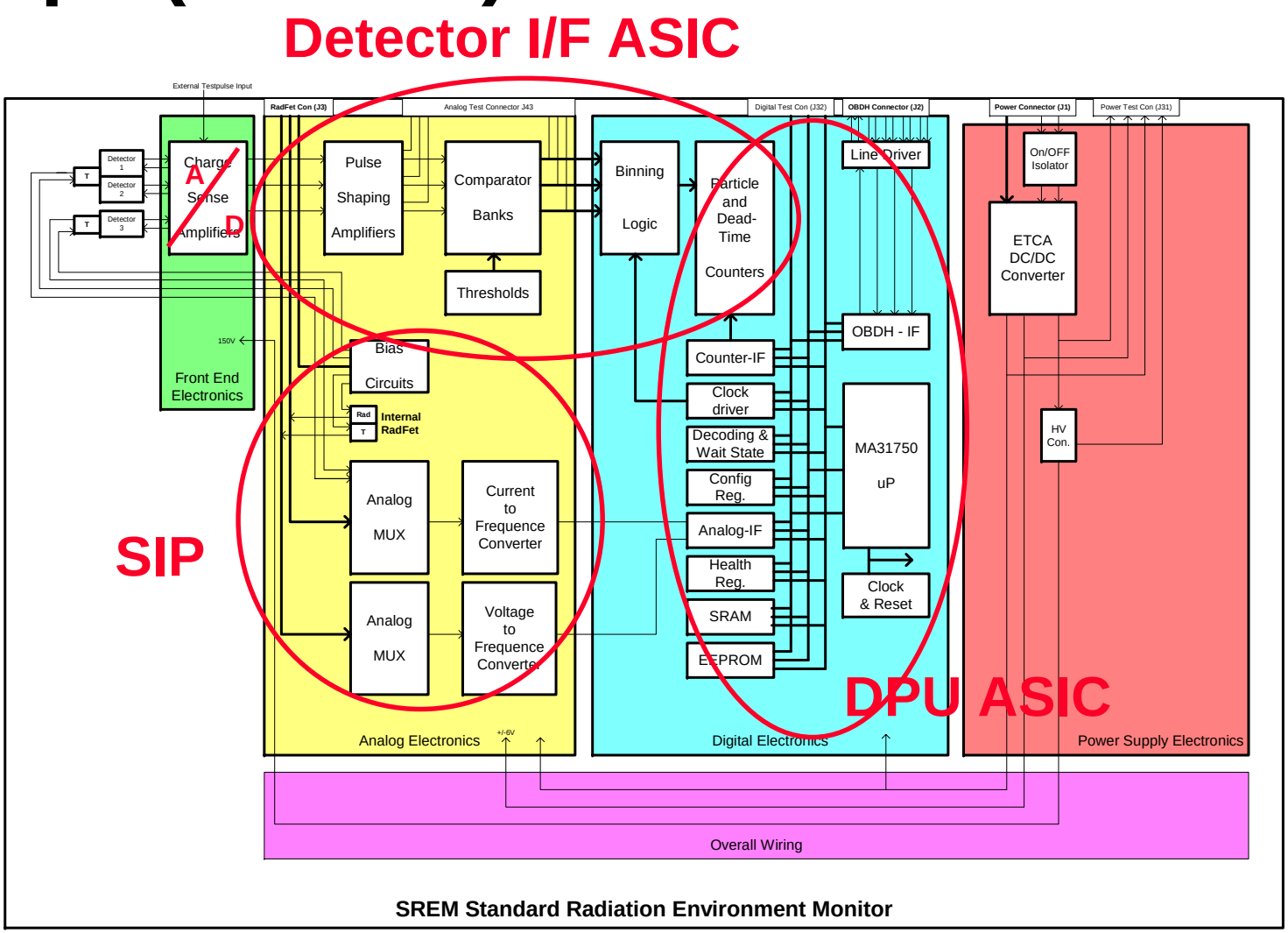
Next Steps

From 2002 to 2003 Contraves Space AG has founded an extended internal project for a new monitor called ASREM (Advanced Standard Radiation Environment Monitor).

Output of this project has given the following results:

Next Steps (ASREM)

Functional Block diagram:



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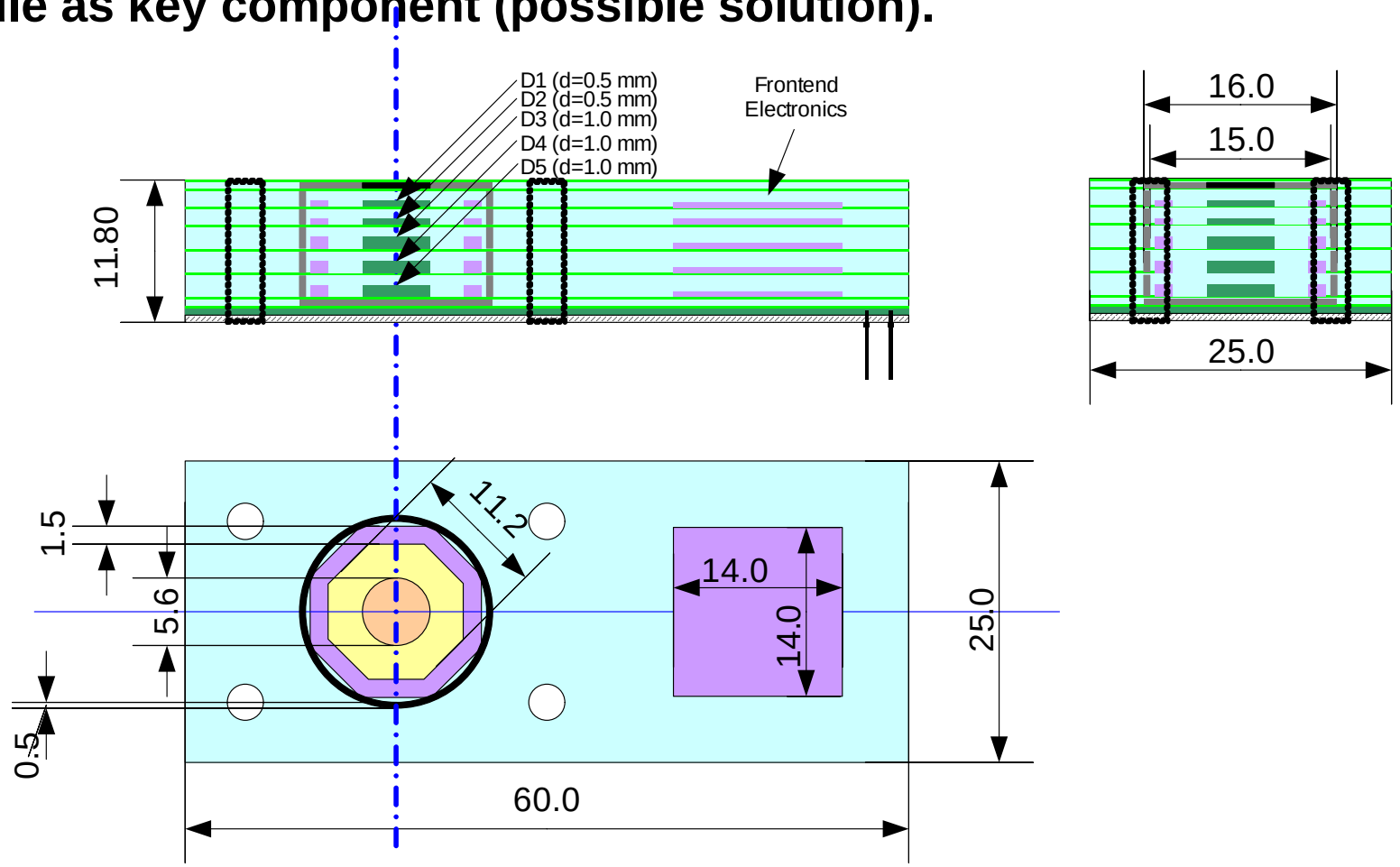
Next Steps (ASREM)

Detector Module as key component (possible solution).



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Next Steps (ASREM)

Presently financial sources are in evaluation to build a this new radiation monitor.

With respect to the present high integration density developments, the concept will be updated again.

<u>Goal of a new monitor shall be:</u>

No degradation of SREM functionality.

Power consumption less than 1 Watt.

Mass less than 1.2 kg.

Close Out

We have to thanks for the support of this contract to:

ESTEC-members:

Colum Smith (Project Manager until his retirement)

Agustin Fernandez-Leon (Project Manager)

Eamon Daly; Petteri Nieminen; Ali Mohammazadeh, S. Habinc, B. Johlander

Xensor System:

Frank Riedijk

3D-Plus:

JF GOUPY

Rémy Frank

Detection Technology Inc. Finnland:

Jussi Koskinen

Mikko Juntunen

IMEC:

Jan Wouters

Carl Das