



Low power HV supply

Base for 10 dynodes PMT
In single photon count mode

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Reference: <http://iopscience.iop.org/1748-0221/5/12/C12049/>

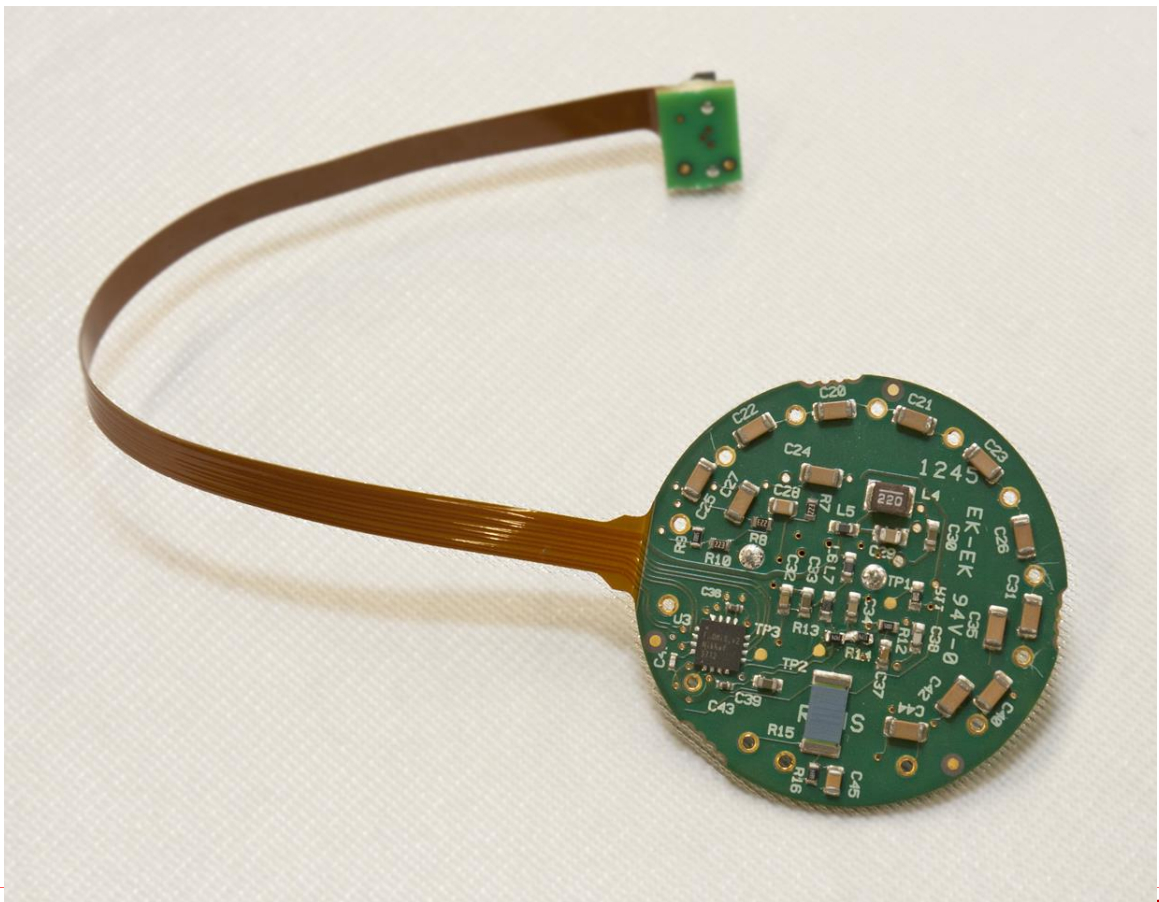
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24-Jun-2013

Collaboration Meeting Catania

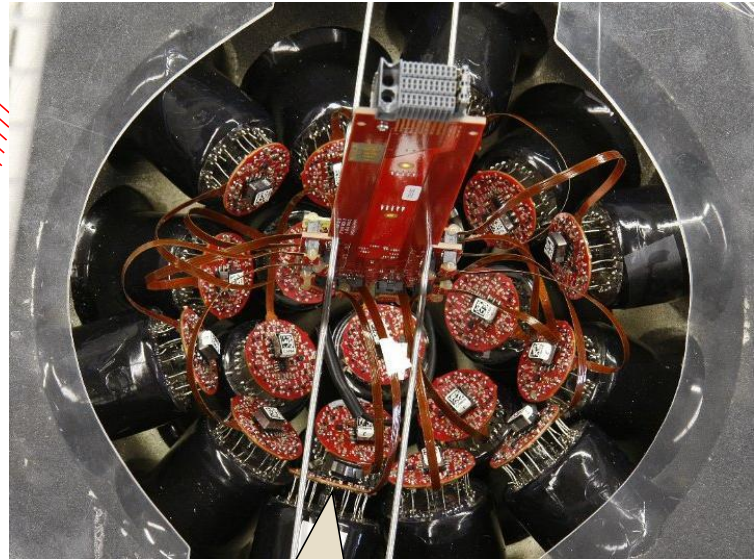
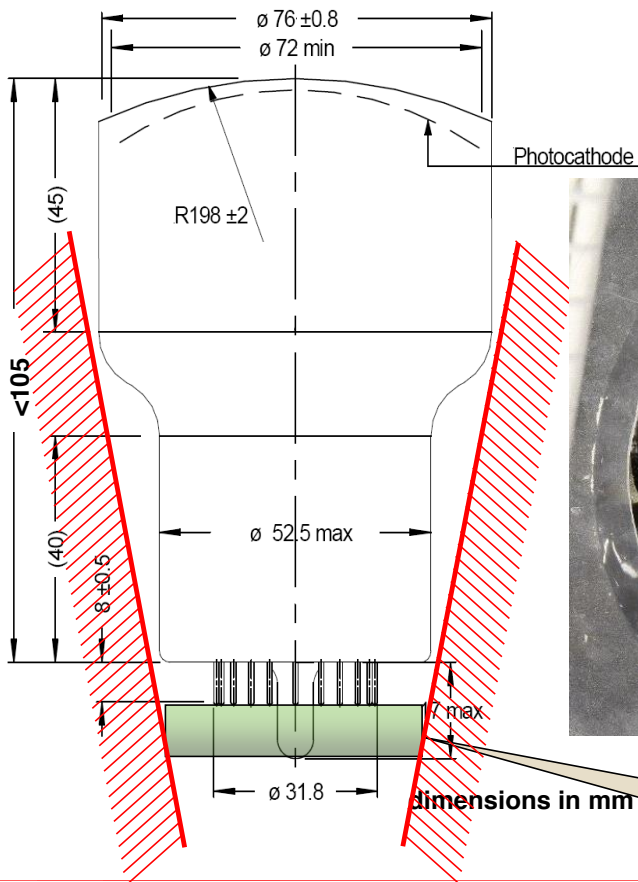
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The product



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PMT proposed form factor



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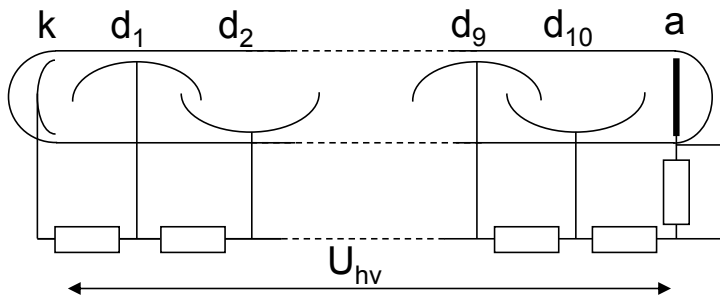
dimensions in mm

PCB space



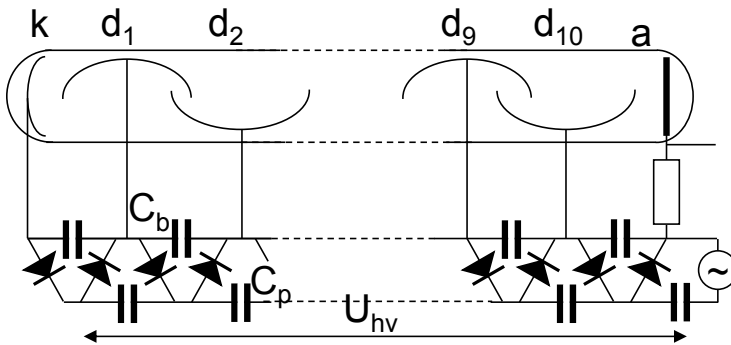
HV generation

Resistor base



- High power
- Temp. Sensitive
- Volume

Cockroft Walton base



- +Low power
- Fixed voltage ratio

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Specifications

HV circuit, for 10 dynodes PMT

Low ripple

706 mV₁₁₇₀ 8.5 < T(°C) < 22.1

0.07% 8.5 < T(°C) < 22.1

Voltage stable at 3 V < V_{input} < 3.6 V

Vripple < 500 mV/dynode

Low power

V_{input} 3.3 V

0.46 – 0.85 mA_{3v3} at 700 - 1500 V < **3 mW**

(commercial available 50 mW)

Low RFI

dV/dt < 75 mV/μs, RFI -20 dB @ 150 kHz-10 MHz

Adjustable HV

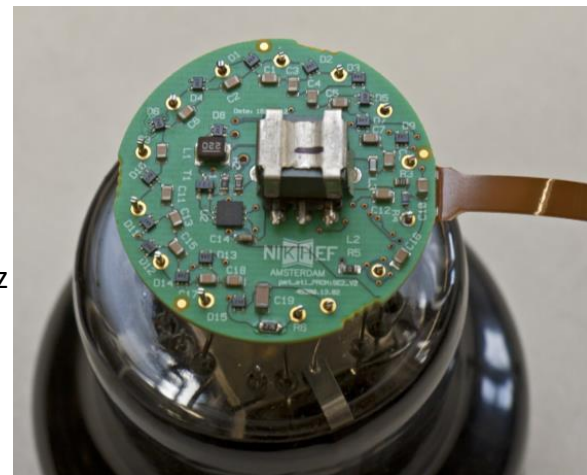
cathode voltage -700 _ -1500 V

Small foot print

PCB = 38_42 mmØ (depends on PMT layout)

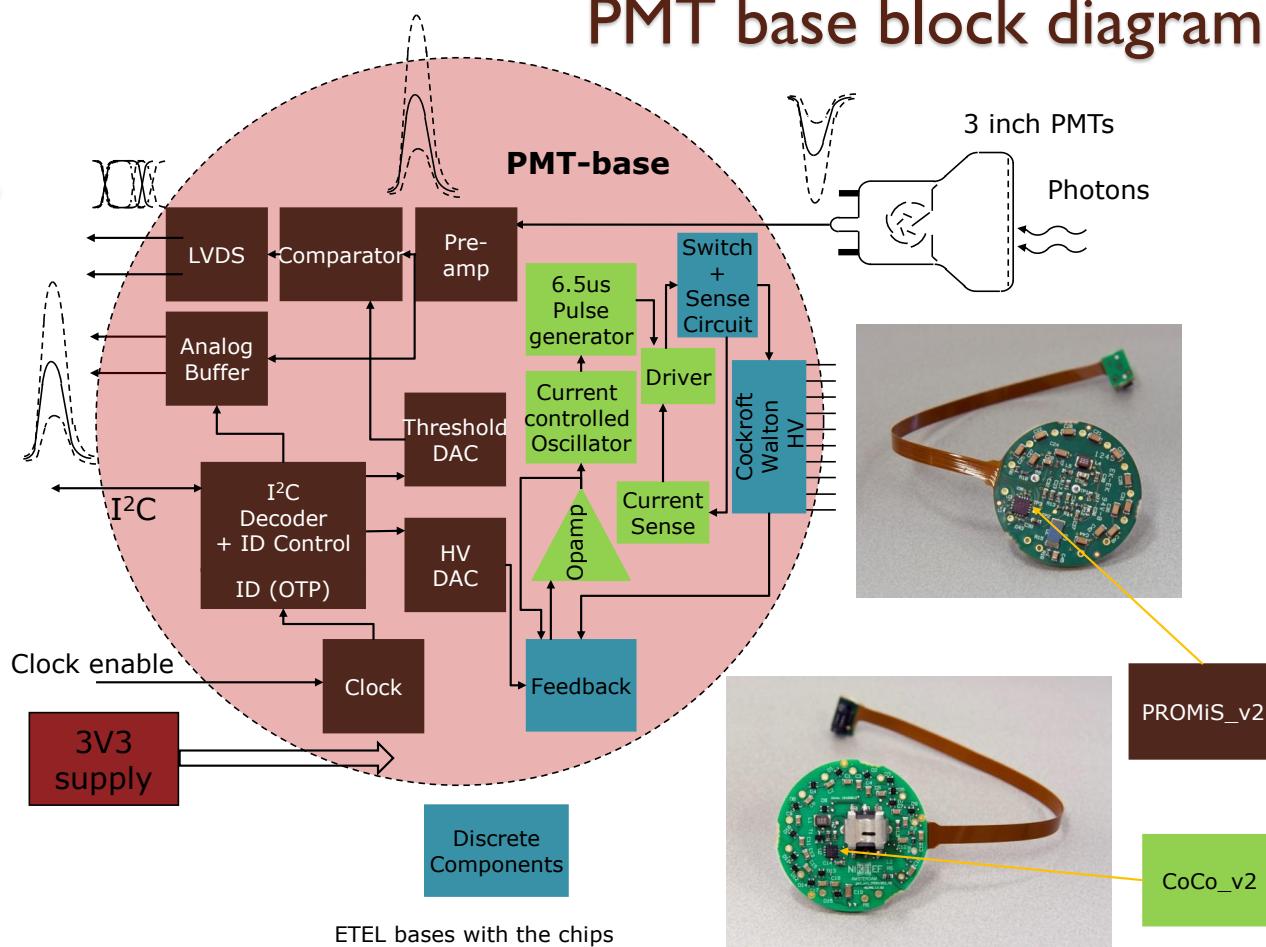
Reliability

250 FIT @ 20 °C, stationary use, after tests





PMT base block diagram

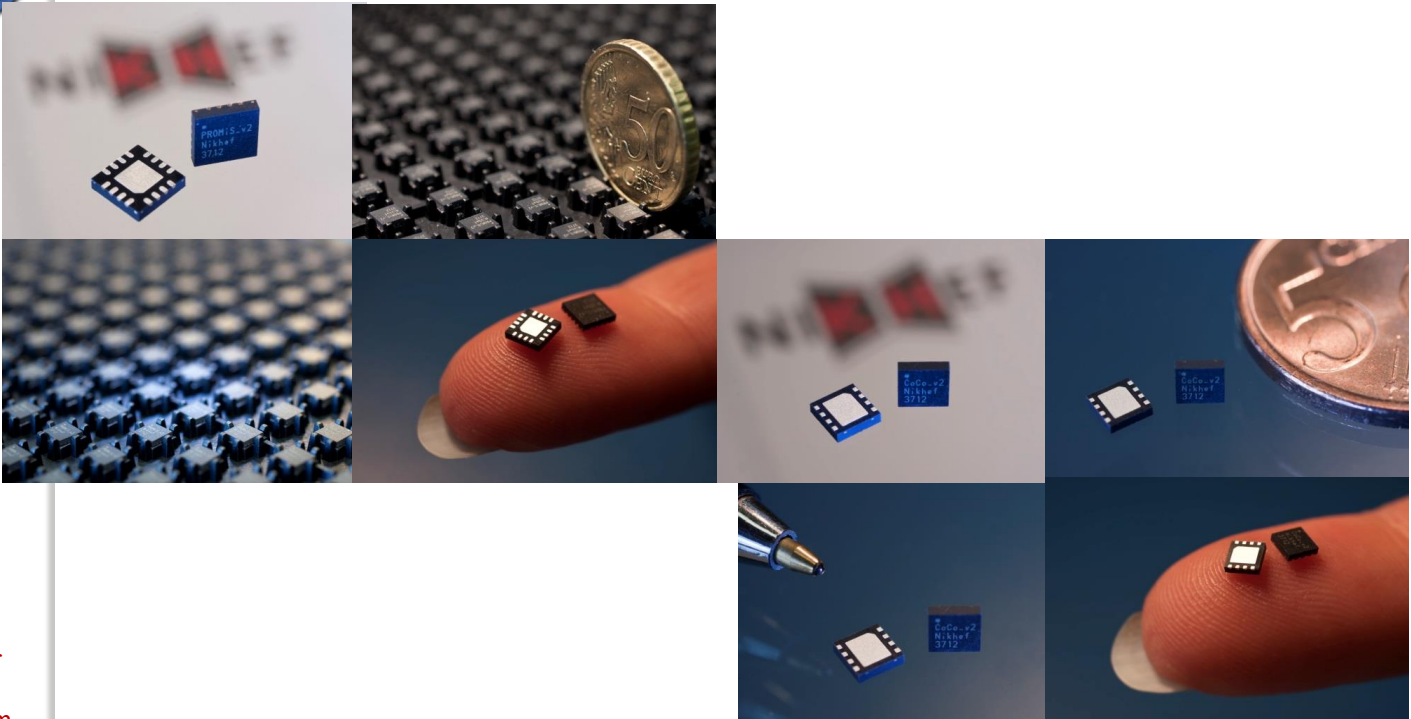


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PROMiS_v2 and CoCo_v2 ASICs



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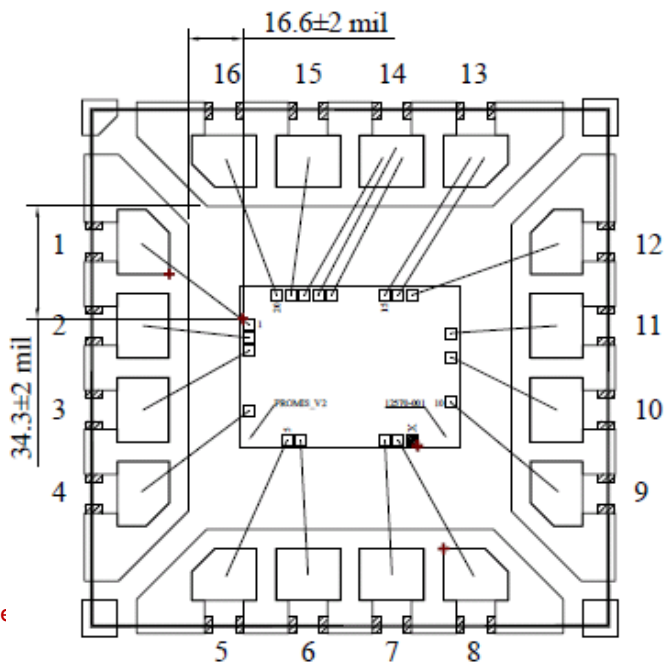


D. Gajanana et al. ET

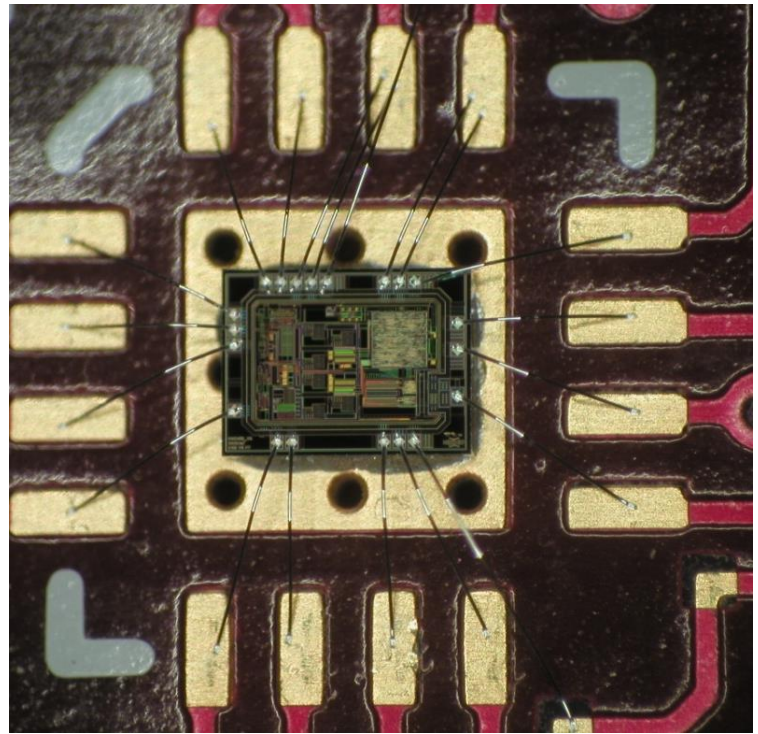
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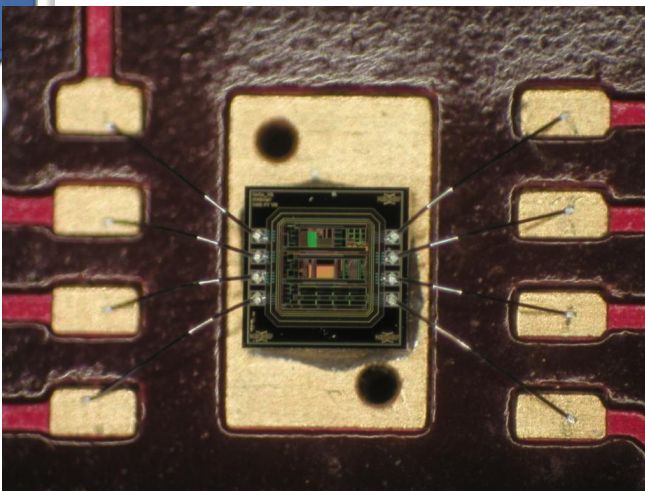


- Silicon Die size : 1.7 mm × 1.25mm
- Packaged in QFN16
- Package body size : 4mm × 4mm.
- Lead pitch : 0.65 mm
- Package height : 0.9 mm

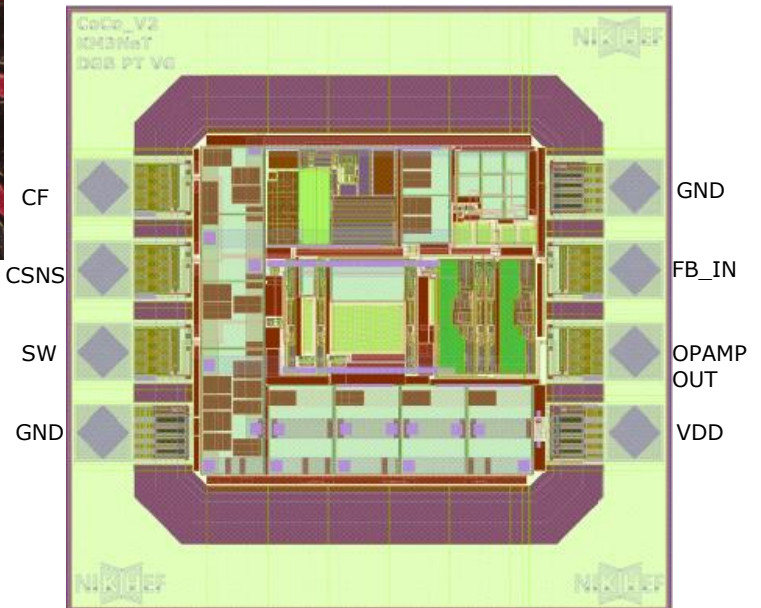
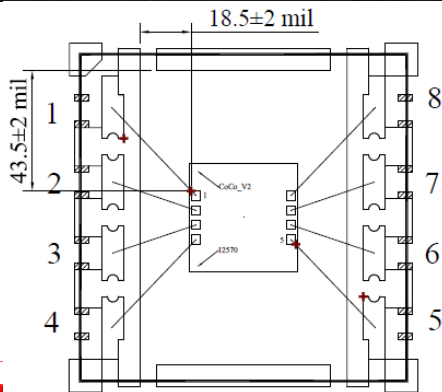


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CoCo Chip



- Silicon die size : 1mm × 1mm
- Packaged in DFN8
- Package body size : 3mm × 3mm.
- Lead pitch : 0.65 mm
- Package height : 0.9 mm

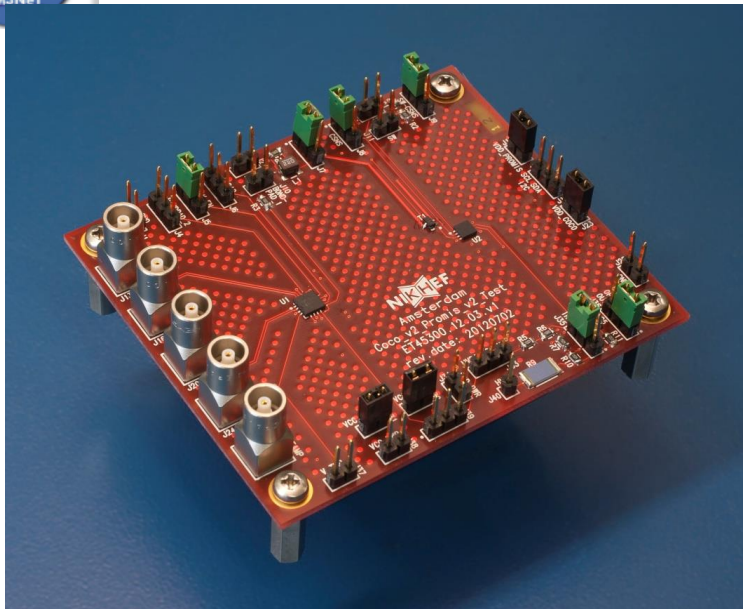


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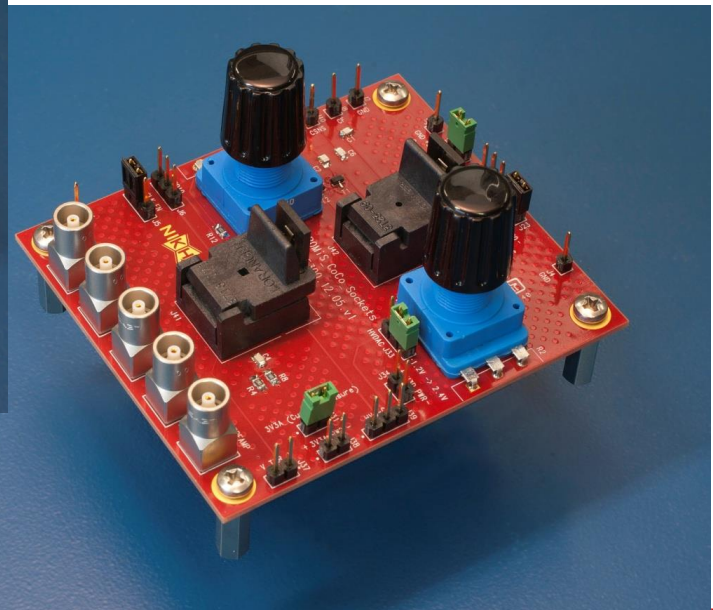




Testing ASICs



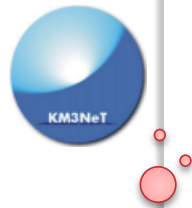
All 170 packaged PROMIS devices were functional. Tested using sockets



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166 out of 168 packaged CoCo devices were functional. Tested using sockets.





ASICs: Conclusions and Future

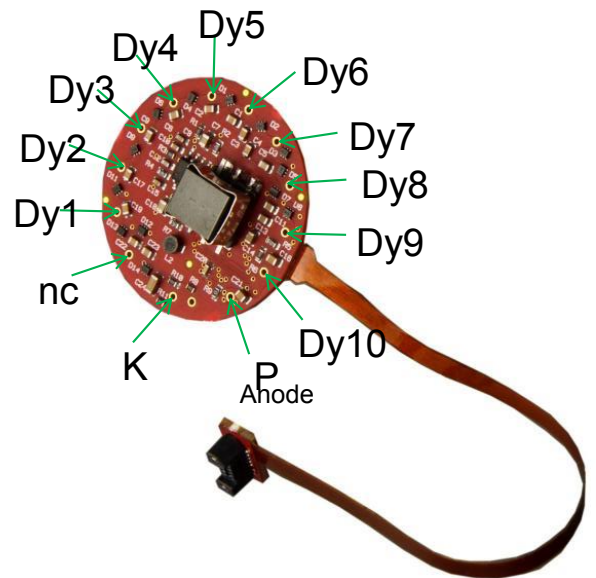
- **MPW** were successful proof of concepts, performance and the technology.
- **Packaging of chips was successful with satisfactory yield both in silicon and packaging.**
- **Proven to comply with full specifications (Electrical, performance, operational & environmental conditions and mechanical specifications)**
- **All functional and characterization tests will be performed at the test house with automatic test-setups**
- **Lifetime and long-term reliability tests are foreseen at the test-house.**
- **6 months after the start-date of the production process, the packaged and fully tested parts are expected.**

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PMT-base next steps

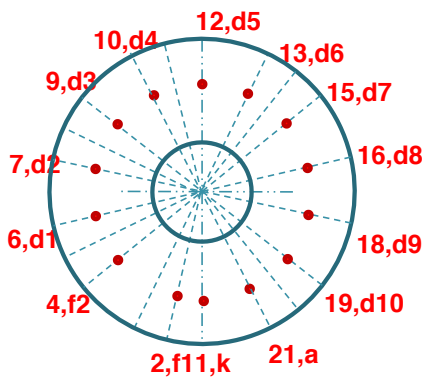
- PCB layout / PMT – type
- Test devices
 - Acceptance test
 - Cleaning, coating device
- Production
 - External?
 - Internal?
 - Institute
- Assembling with PMT
 - Soldering
 - Testing



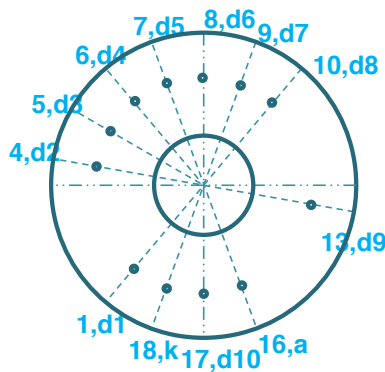
Base for ETEL model used in Antares DOM and PPM-DU

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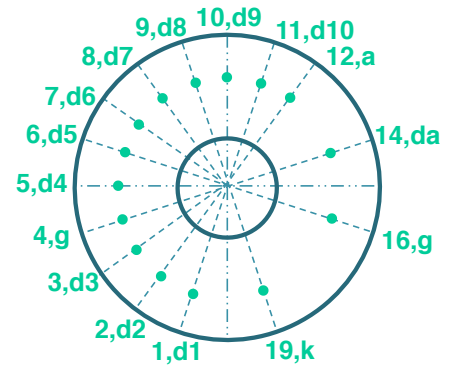
Layout differences



ETEL
D783L
D782L



Hamamatsu
R6233
R12199



HZC

K	da	g(f1)	d1	d2	d3	d4	d5	d6	d7	d8	d9	d10	A
0.15	1	1.5	2	1	1	1	1	1	1	1	1	1	1
0		3	1	1	1	1	1	1	1	1	1	1	1
0.1		2.5	1	1	1	1	1	1	1	1	1	1	1

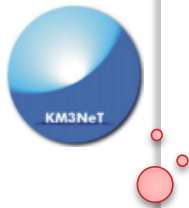
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Status PMT Bases

- **The last base design for the ETL PMT-tube has been successfully tested. From this design 10 pcb's were made. Some of these new bases will already be used in the PPM-DU.**
- **For the Hamamatsu PMT-tube a new design is ready. For this design 10 bases are now being manufactured. We expect that they can be tested in a few weeks.**
- **For the HZC PMT-tube a study for the base has started. As the layout of the pins is not fixed the design cannot be finished yet. The design for the HZC tube is the most complex. The connections of the dynodes are not subsequent and the diameter is smaller because the HZC tube is longer.**

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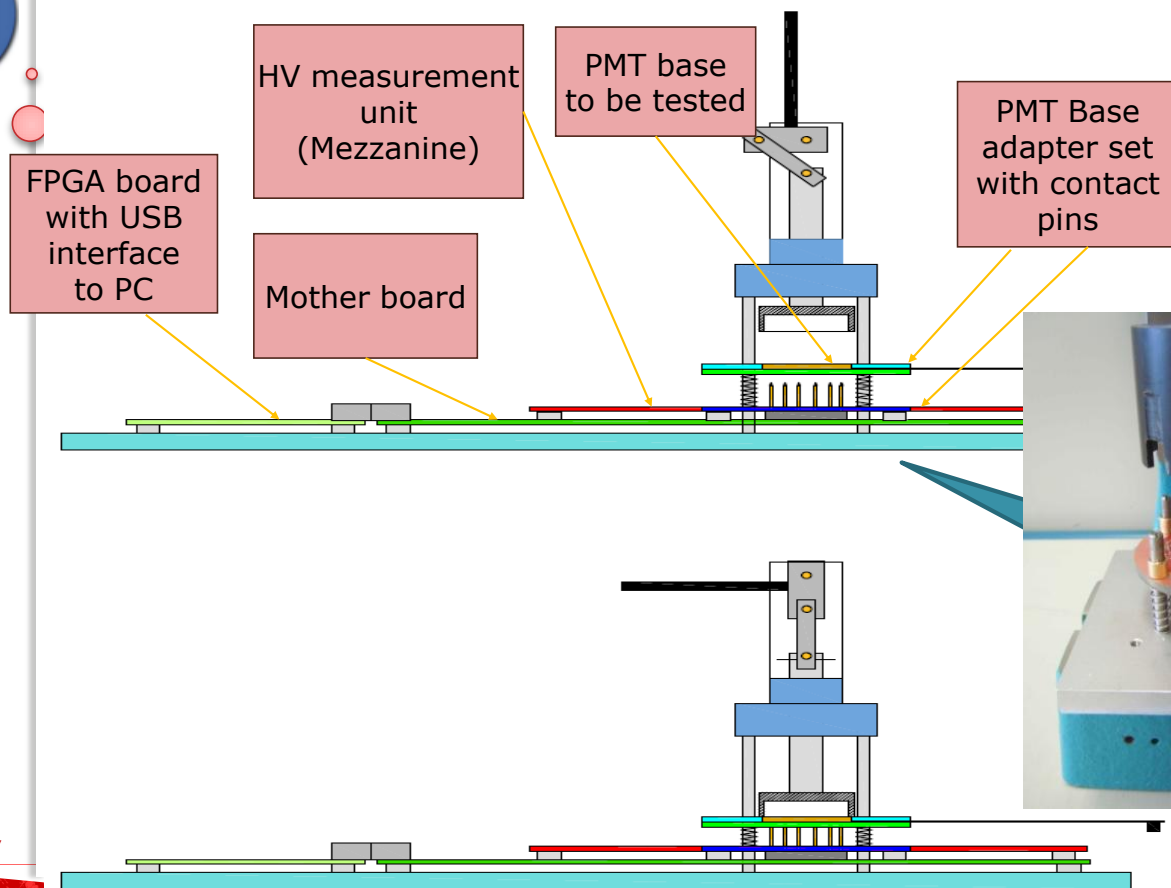


Test procedures

- Validation tests
 - Storage;
Tamb->30min-10 °C ->1h->60 °C ->1h->60 °C ->-10 °C ->30min->Tamb ✓
 - Temp. Shock;
Tamb->Tamb+50 °C ->1h->Tamb+50 °C ->0sec->Tamb ✓✓
 - Influence oscillator frequency on PMT output ✓
- Acceptance tests (meet specifications)
 - Voltage adjustment
 - Current measurements
 - COCO frequency and pulse width
 - PROMIS output
 - HV control and I2C
- Cleaning + Drying
 - Ultrasonics
- Coating
 - Polyurethane

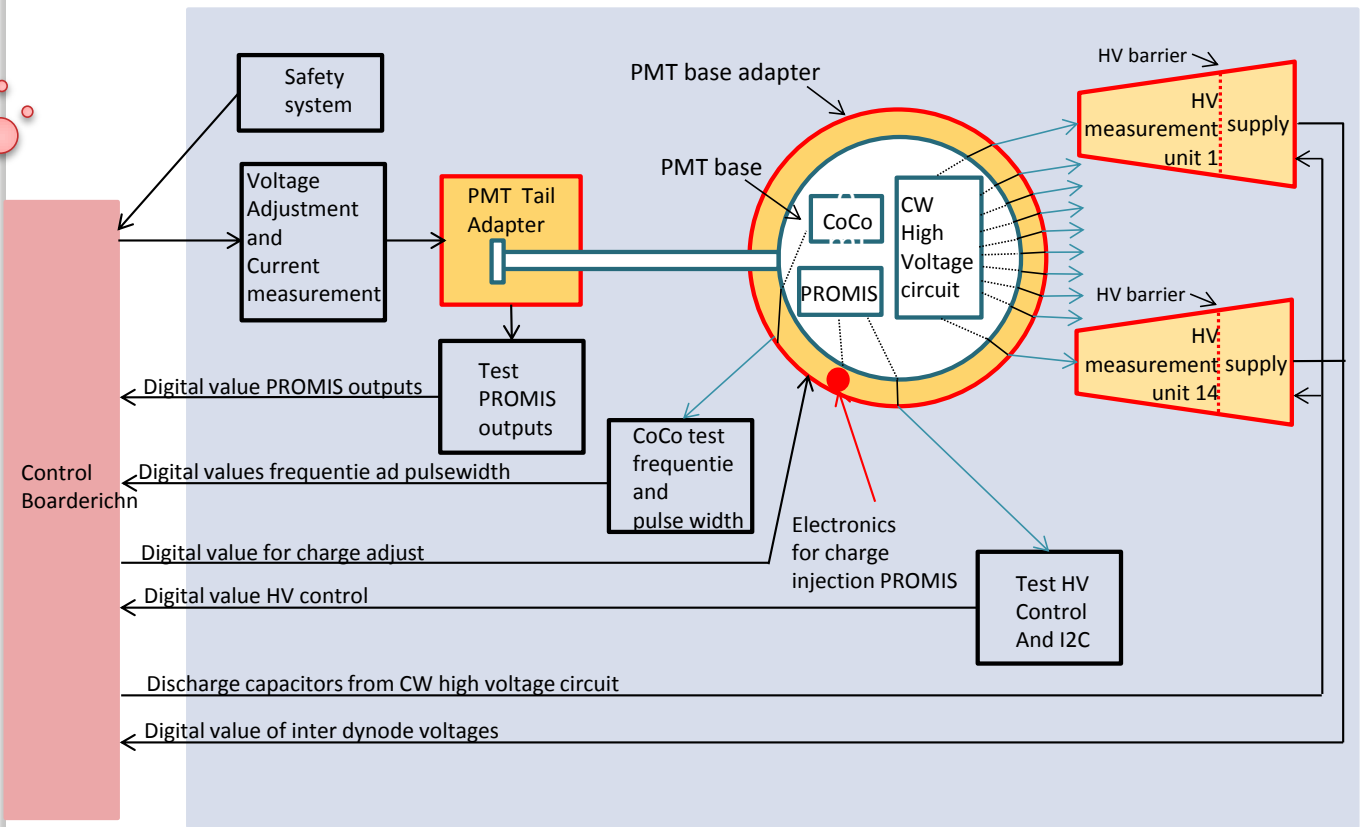


Mechanical overview of tester



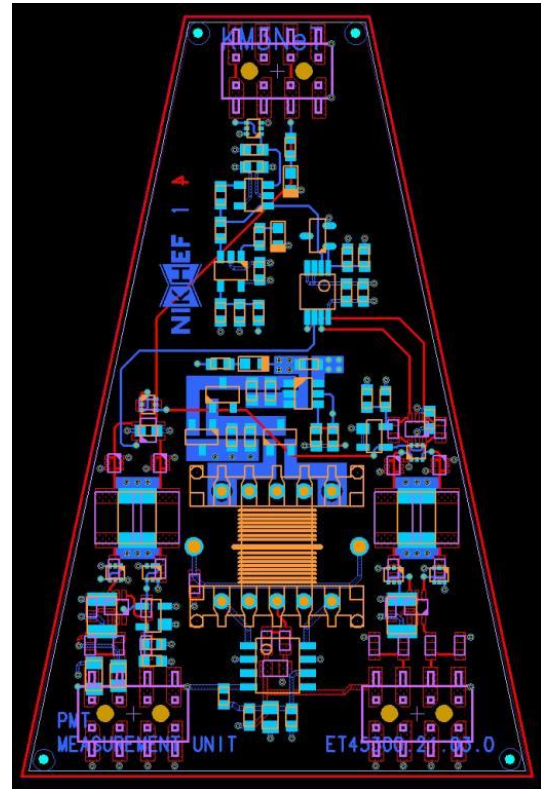
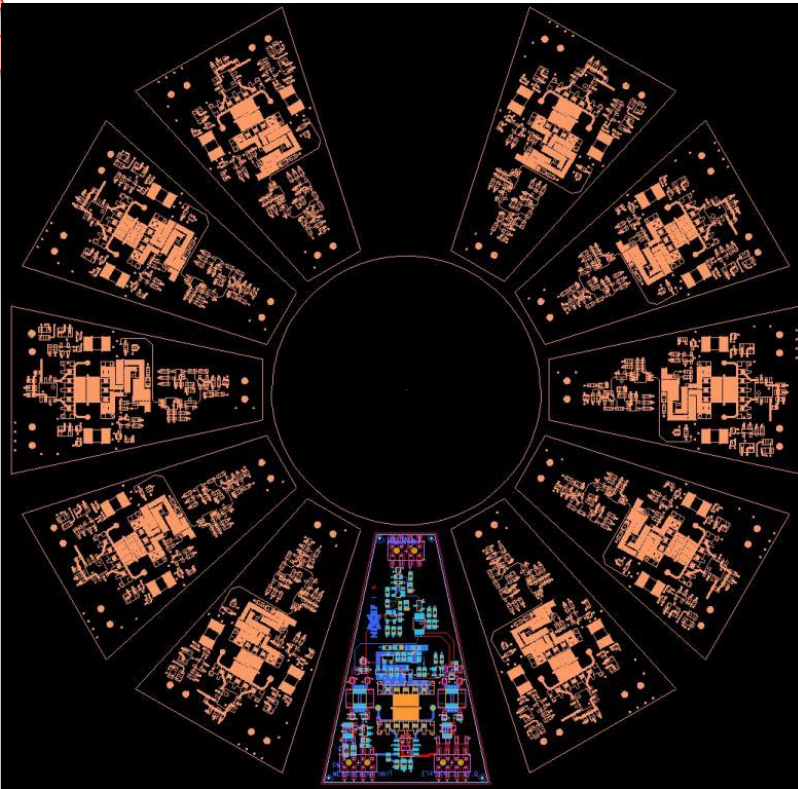
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Test setup



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PCB layout of HV measurement units

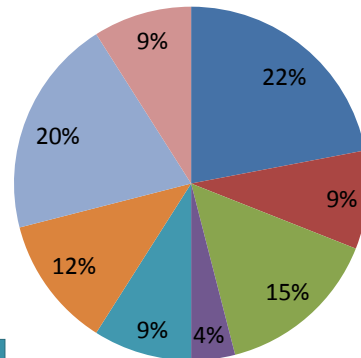


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Reliability

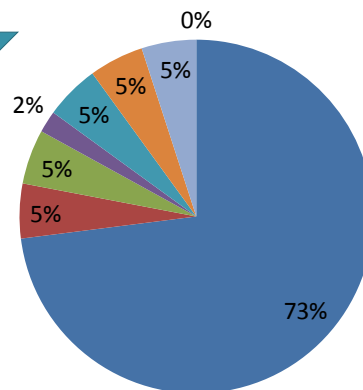
Components @ 45 °C : 1140 FIT
 Stress factors;
 Stationairy use: 0.5
 Temperature @ 20 °C: 0.18



- components
- design
- manufacturing
- system management
- ware out
- induced
- no defects
- software



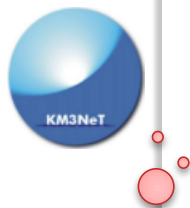
Tests evaluation



Evaluated value: 250 FIT

For 400000 entities with mission time of 15 year,
 3 % failures by Poisson.

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Reliability: some experiences of bases in PPM DOMs

- On these bases the PROMiS-V1 was directly bonded on the PCB. Several bases had problems with the PROMiS-V1. After testing these PMT modules were cleaned and coated. Cleaning was done in an ultrasonic bath. Unfortunately some modules failed when tested again after cleaning. The ultrasonic cleaning caused failure in the bond wires from several PROMiS-V1 chips.
- The PROMiS-V2 will be packaged and assembled together with the other components.
- Because of ultrasonic cleaning also on a few bases the clip of the transformer was unlocked.
- For the transformer another type of clip will be used. This clip has ground pins and will be soldered on the base. For the new transformer errors because of cleaning will not occur.
- There were two bases which had a bad assembled transformer.



Cost estimates

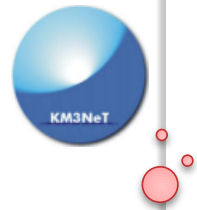
HV-base, PMT-HV-v8				total	31 /OM				
base	Euro	No. / p	Euro tot.	Source	15-05-2013/PT				
Coco_v2	1	1	1.00	Nikhef					
Promis_v2	1	1	1.00	Nikhef					
Nfet PMF370XN	0.077	1	0.08	Farnell					
150V CMLD4448 TR diode	0.048	14	0.67	Alcom					
22nF 0805 200V X7R	0.041	13	0.53	Texim					
47nF 0805 200V X7R	0.039	5	0.19	Texim					
100nF 0805 200V X7R	0.054	13	0.70	Texim					
10pF 0402 5% 16V NPO	0.02	1	0.02	Farnell					
220pF 0402 1% 16V NPO	0.02	1	0.02	Farnell					
100pF 0402 16V X5R	0.01	2	0.02	KEMET					
100pF 0603 50V X7R	0.04	3	0.12	Farnell					
1uF 0603 10V X5R	0.04	1	0.04	Farnell					
10uF 0603 6.3V X5R	0.2	4	0.80	Farnell					
Core EP-CORE-SET EP7-3E27	1.23	1	1.23	Farnell					
Bobbin CSHS-EP7-1S-6P-Z	0.25	1	0.25	Farnell					
Clip CLI/P-EP7	0.45	1	0.45	Farnell					
transformer assembly costs	3.78	1	3.78	assembly firm					
inductor 22uH ELJPA220KF 1210	0.17	2	0.34	Farnell					
BEAD Ferrite, SMD 600 Ohm, 0603	0.033	1	0.03	Farnell					
Resistor 0 0603	0.043	1	0.04	Farnell					
Resistor 1.5 0603	0.016	1	0.02	Farnell					
Resistor 56 0603	0.01	2	0.02	Farnell					
Resistor 1k 0603	0.01	2	0.02	Farnell					
Resistor 22k 0603	0.01	1	0.01	Farnell					
Resistor 1M4 0603 1% 100 PPM	0.005	2	0.01	Farnell					
HV resistor 3G	6	1	6.00	Rhpoint					
Samtec SEM connector	2	1	2.00	calculation 350nm, AMS					
PCB costs	8	1	8.00	1200 mm ² , 6 layer, incl. kapton tail, proto's ca. 20Euro /pc					
Assembly			0.00	guess					
		total	27.40						

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30 € parts

Questions



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HV-protection



Protect neighbour tails
from HV

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RoHS directive

Restriction of the use of certain Hazardous Substances in electronic equipment.

Consequences;

- Higher solder temperatures (up to 260°C)
- Favorite solder: SnAgCu alloy (217°C)
- Chance for more excessive tin whisker growth

Tin whiskers, length up to 10mm, diameter up to 10µm.

Optimal growth at 50°C

Ref: <http://nepp.nasa.gov/whisker/background/index.htm>

**electrical short circuits
debris, contamination,
metal vapor arc, due to HV.**

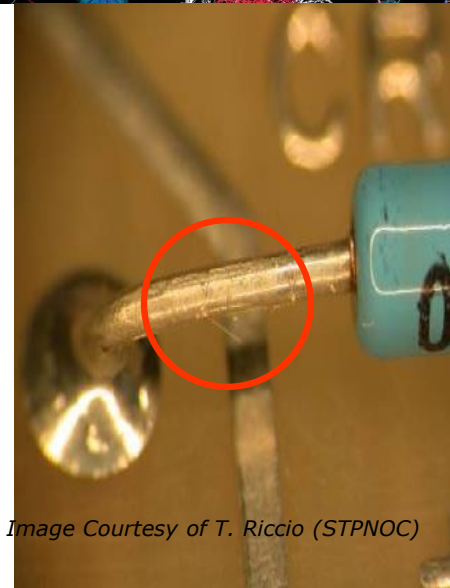
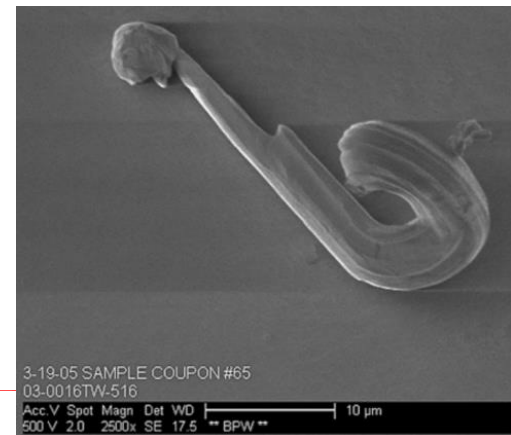


Image Courtesy of T. Riccio (STPNOC)

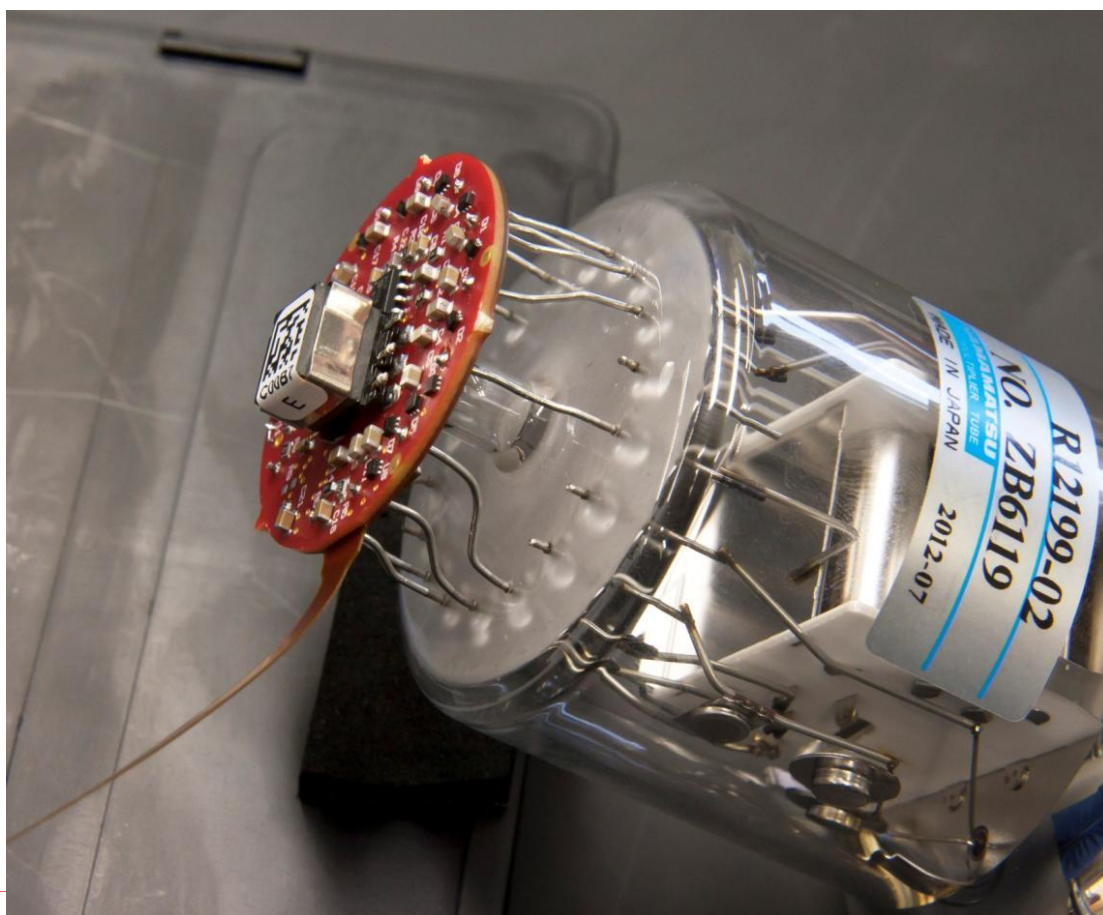
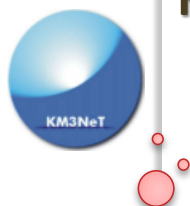


Conformal coating like Parylene C tends to buckle the whisker.



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Hamamatsu PMT with ETL_HV base



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