



KETEK GmbH

High Throughput Large Area Silicon Drift Detectors

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EPS-TIG Workshop
,Advanced Radiation Detectors for Industrial Use‘

Ravenna, Nov 12th 2013



KETEK

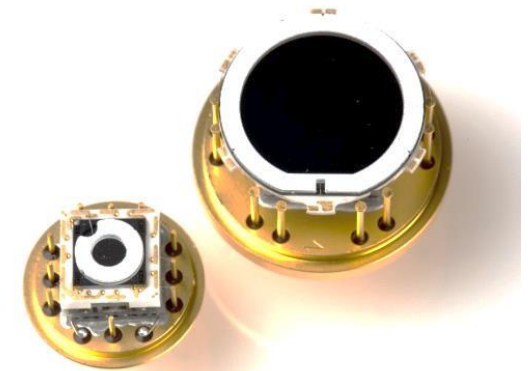
Creative Detector Solutions



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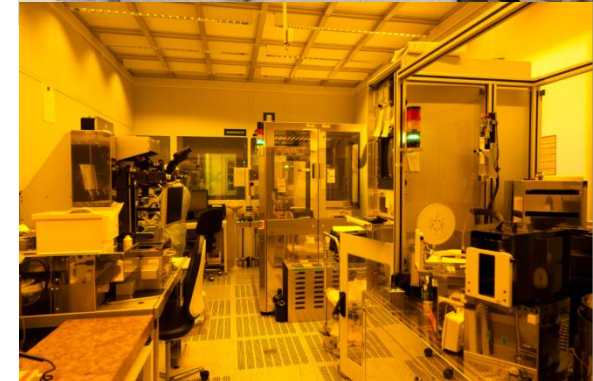
KETEK High Throughput Large Area Silicon Drift Detectors
EPS-TIG Workshop ,Advanced Radiation Detectors for Industrial Use‘
Ravenna, Nov 12th 2013

- KETEK Company Overview
- History and Basics of Silicon Drift Detectors
- Small to large area Silicon Drift Detectors
- New CUBE-ASIC as first pre-amplification stage
- New 7 channel large area SDD array
- SDD read out electronics
- Future requirements for solid state XRF detectors
- How science and industry can better collaborate (KETEKs view)



KETEK at a Glance

- Family owned enterprise, formation 1989 by Dr. Josef Kemmer
- Number of employees: 75
- Company headquarters & facilities: Munich, Germany
- Major product lines: SDD-Modules, Arrays, Detector Electronics and Complete Detector Systems; Silicon Photo Multiplier Modules (SiPM) since 2012
- Sales and distribution: worldwide
- Global market share (SDD) 2013: approx. 45%



KETEK History

- 1970-76 Josef Kemmer develops planar Silicon technology for semiconductor detectors
- 1983 E. Gatti and P. Rehak introduce principle of silicon drift detector
- 1983 Cooperation between J. Kemmer, P. Rehak and MPI, first SDDs produced at TU München
- 1985 Cooperation with MPI to develop new detector concepts: SDD with homogeneous entrance window, DEPMOS, DEPFET
- 1989 KETEK founded by Josef Kemmer
- 1991 Qualification of Kemmer's planar Silicon process completed
- 1998 First commercial SDD systems available
- 2003 2000th KETEK SDD sold
- 2010 80mm² KETEK SDD with 120.6eV FWHM in commercial application, just 1eV above the theoretical limit
- 2012 KETEK SDD on the Mars as part of the NASA rover Curiosity;
Worlds largest (circular) SDD with 150mm² collimated area by KETEK
- 2013 More than 30.000 KETEK SDD systems in the field;
KETEK is the global SDD technology and commercial market leader

Industry Applications and Requirements for Silicon Drift Detectors

Application	Major Requirements to X-ray Detector
XRF – Benchtops	good energy resolution, high throughput , compact housing, low cost
XRF – Handhelds	high thermal budget, low power consumption, compact housing, high throughput , low cost
Micro-XRF	very good energy resolution and P/B, large area and high throughput for shorter imaging times
TXRF	good energy resolution, large detector area (large solid angle)
EDX in SEM & TEM	excellent energy resolution, very good low energy performance, large area, high count rate capability , compact housing, non magnetic materials (TEM)

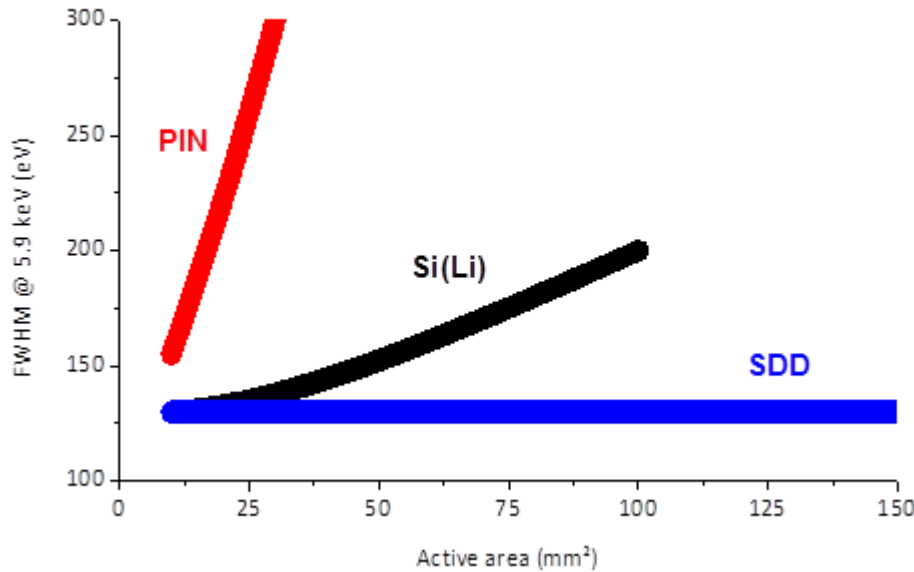
Silicon Drift Detectors fulfill most specific detector requirements

- replace Si(Li) detectors in high end applications
- replace Pin Diodes in low end applications

Silicon Drift Detectors from KETEK

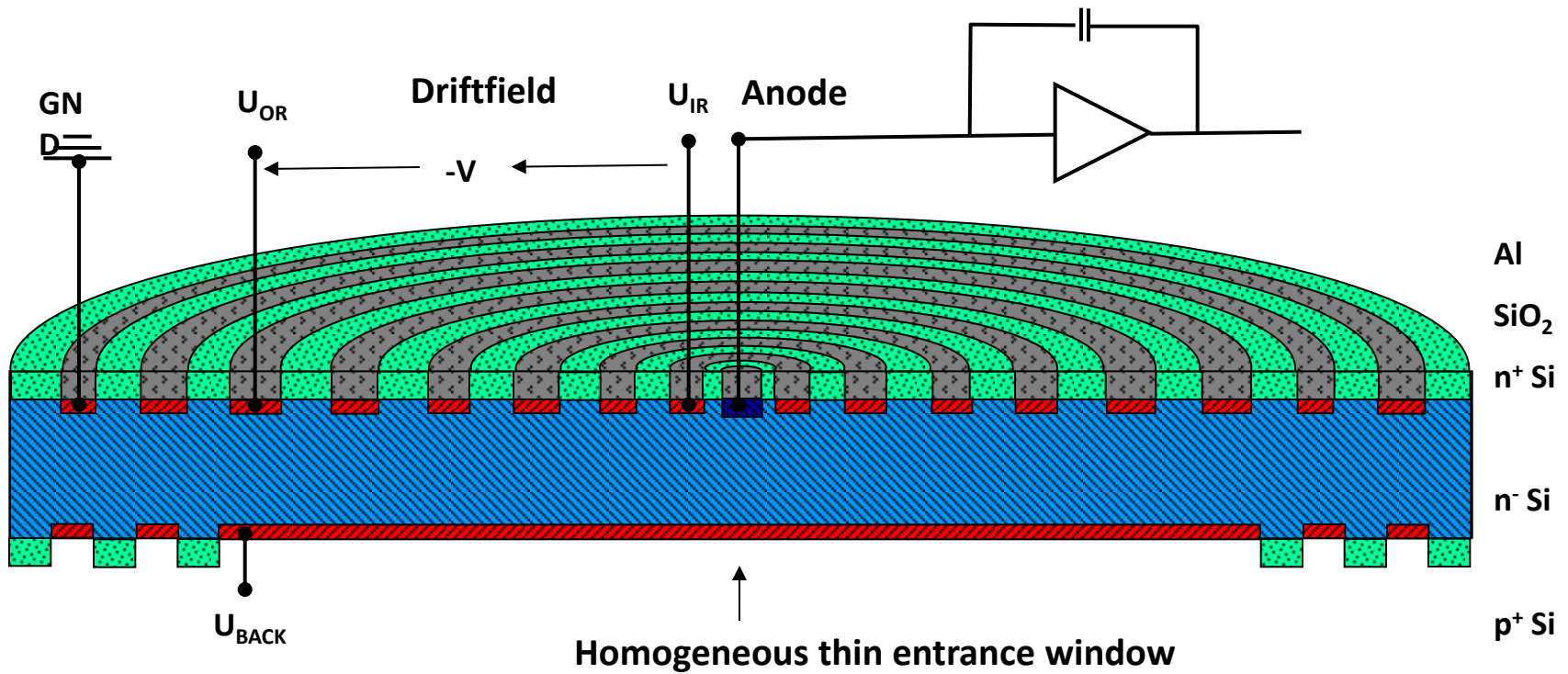


Advantage of SDDs – performance independent from detector size



- Very low overall capacitance of SDD modules independent of detector area
- Spectroscopic performance independent of detector area
- Extremely large solid angles achievable
- High count rate / fast measurement applications

Silicon Drift Detector with Circular Geometry



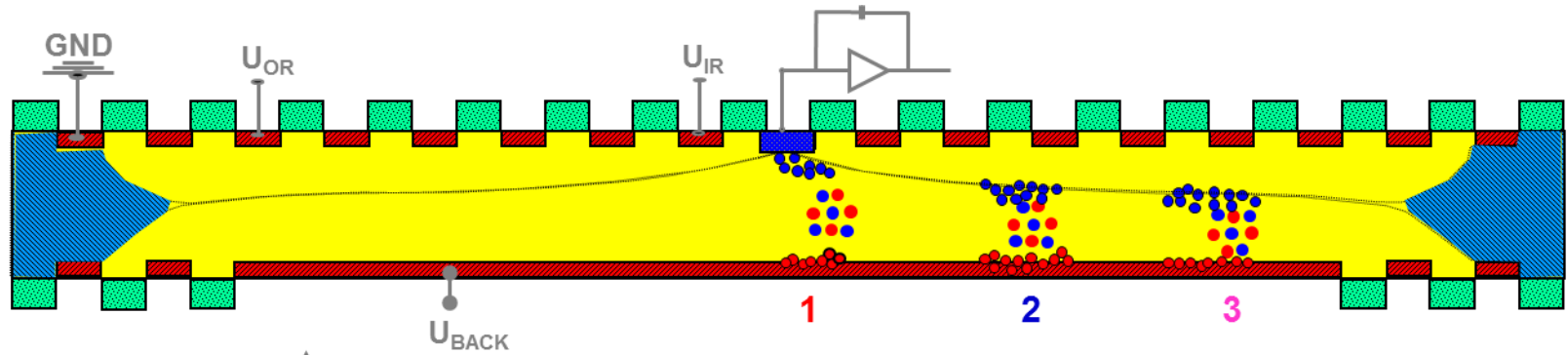
Small size of output capacitance:

- high energy resolution
- high count rate capability

Low leakage current level:

- operation at moderate cooling
- no liquid nitrogen necessary

SDD Function Principle

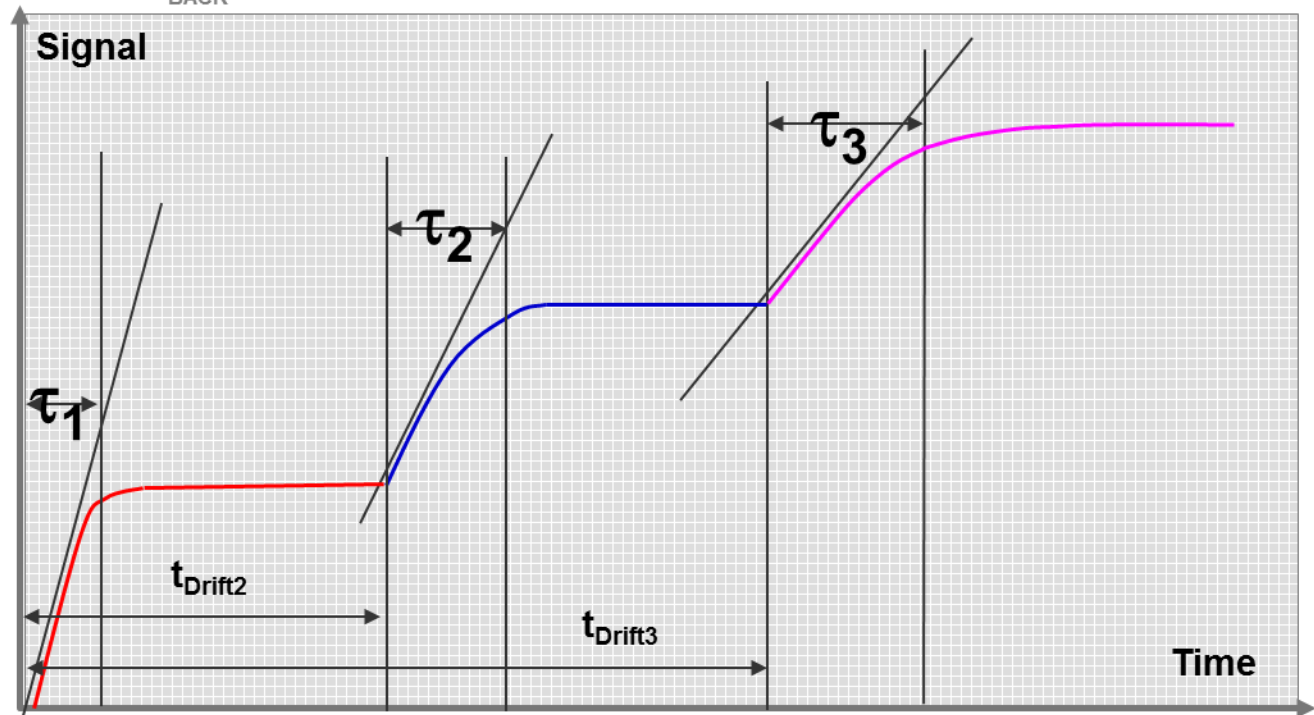


Charge collection:

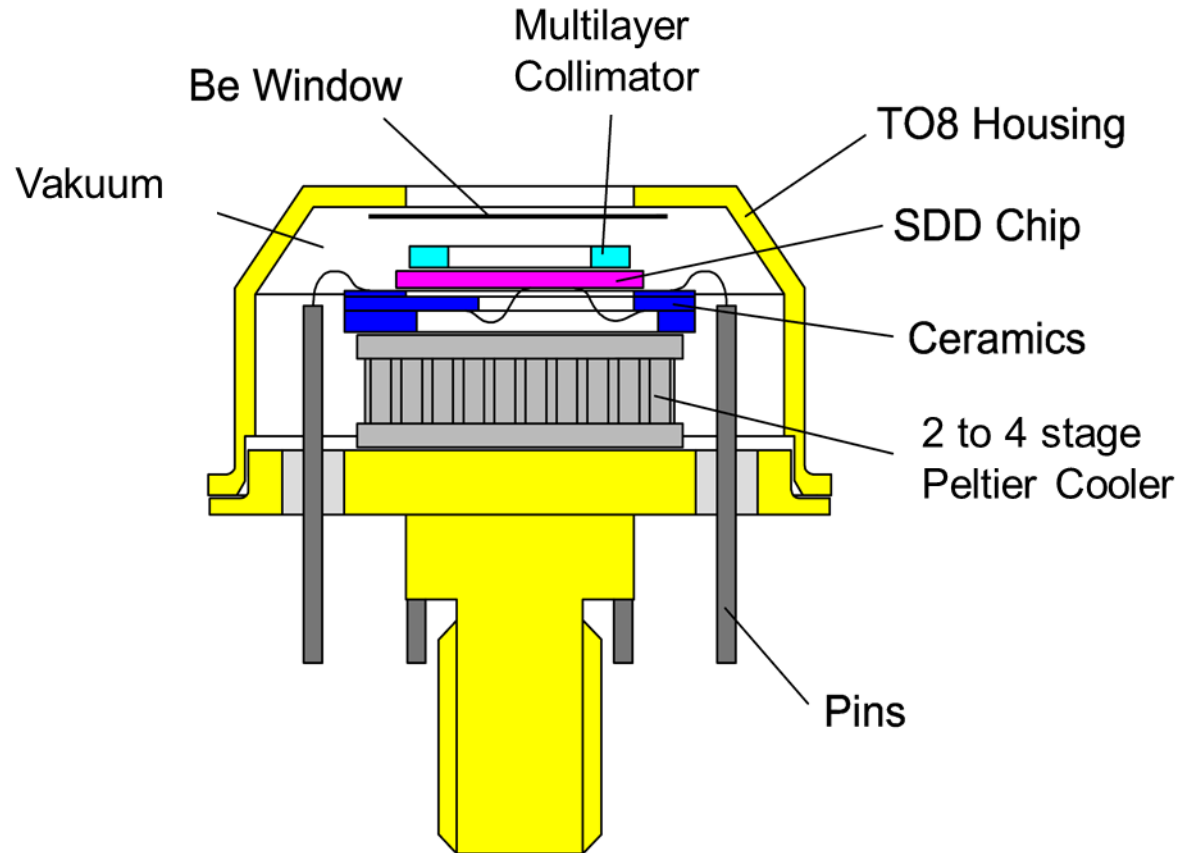
Event 1 **signal 1**

Event 2 **signal 2**

Event 3 **signal 3**



Basic Construction of a Silicon Drift Detector



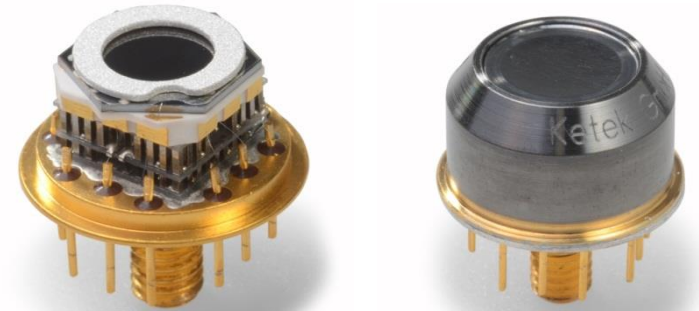
VITUS Silicon Drift Detectors

X-Ray Detectors for XRF & EDX

- Sizes from 7 – 150 mm² active area
- Energy resolutions **down to 121eV** (Mn K α)
- Peak to Background > 20.000
- Sensitive for soft x-rays from 100eV up to 30keV (detection down to **Lithium K α** line possible)
- Vacuum types with high thermal budget: $\Delta T > 100K$
- No detector fluorescence lines
- State of the art product in the analytic market

VITUS H30

40mm² SDD chip; 30mm² active area;
multi-layer collimator; 8 μ m Be window

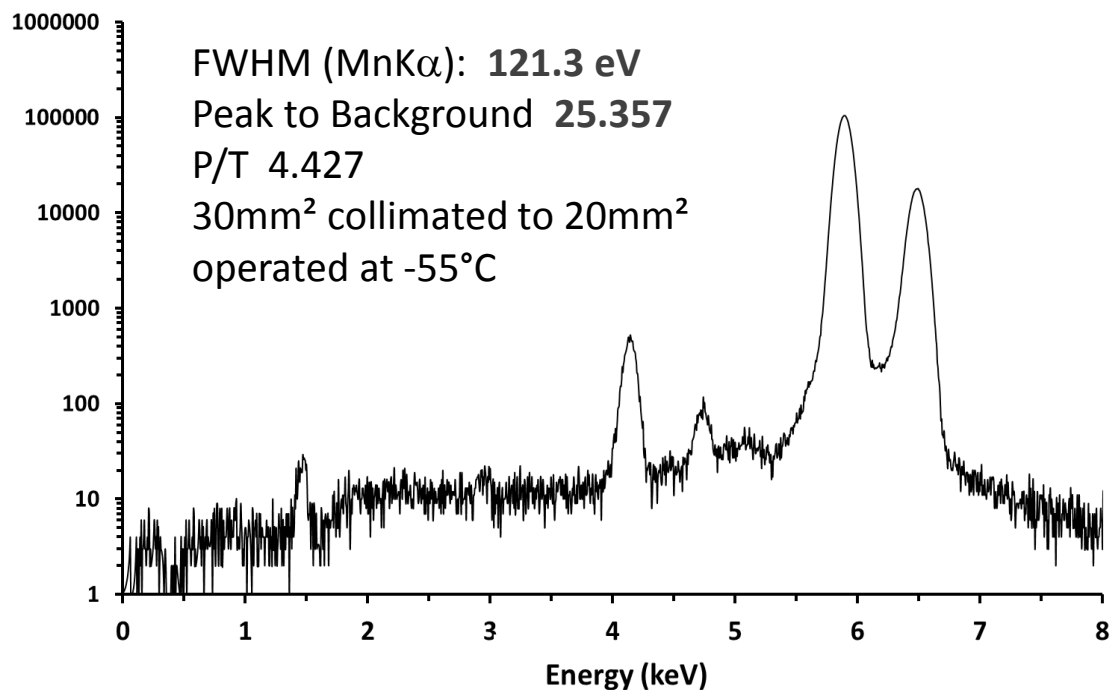


VITUS H50

65mm² SDD chip; 50mm² active area;
multi-layer collimator; 12.5 μ m Be window



Continuous improvement of typical energy resolution and peak to background ratio



2004 : < 139 eV* P/B > 5,000

2006: < 136 eV P/B > 8,000

2008: < 133 eV P/B > 10,000


2010: < 129 eV P/B > 15,000

*FWHM MnK α

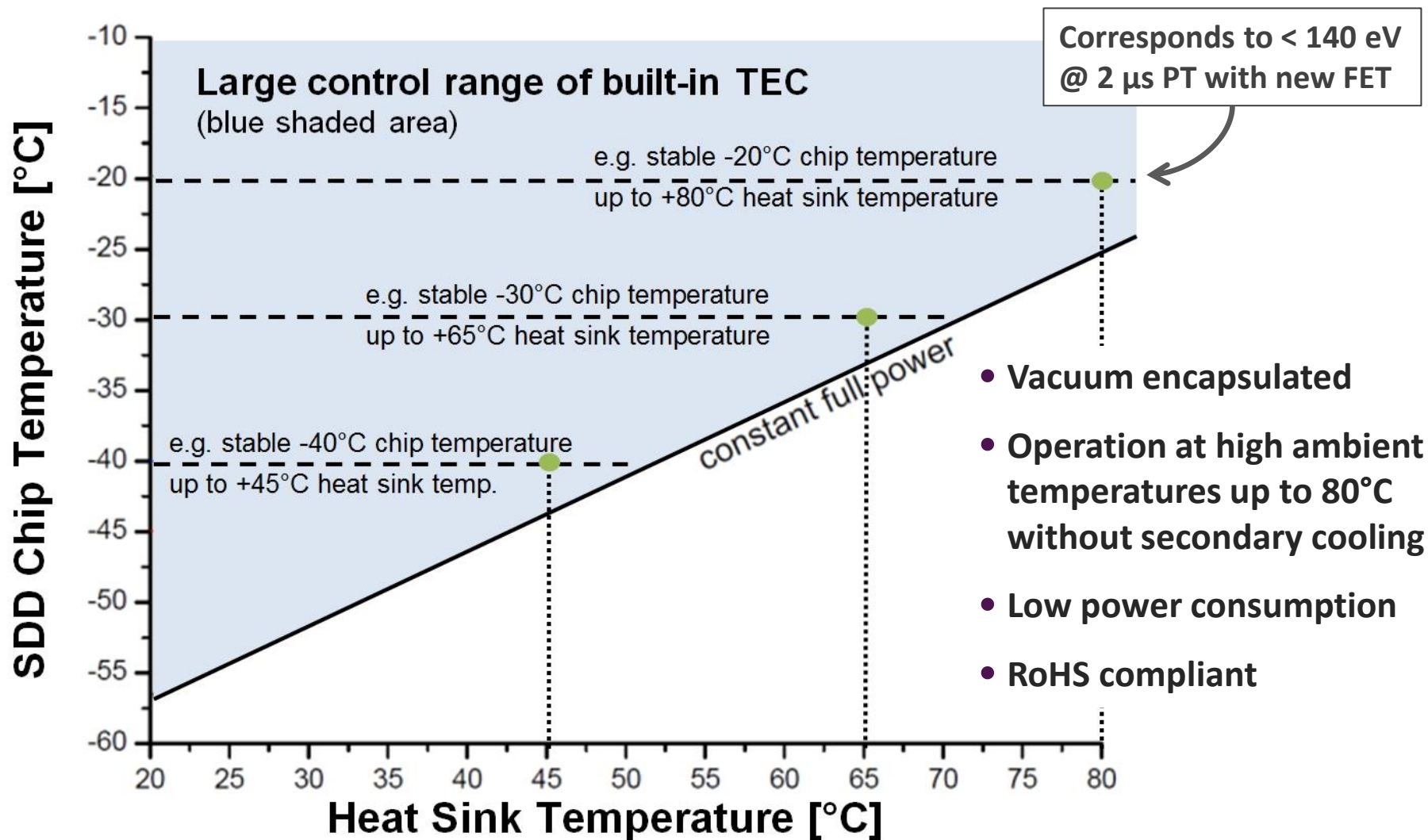
Performance 2013

- FWHM down to **121 eV**
- Typical FWHM < **126 eV**
- Typical P/B > **20,000**
- Perfect gaussian shape of peaks

KETEK VITUS SDD Portfolio 2013

VITUS Silicon Drift Detectors 			Premium Class (guaranteed values)		Standard Class (guaranteed values)	
VITUS Type	Active Area	Window	FWHM @ 5.9 keV	P/B	FWHM @ 5.9 keV	P/B
H7	7mm ²	Be 8 μm	≤ 129 eV	> 15000	≤ 139 eV	> 6000
H7LE	7mm ²	AP3.3 low-energy	≤ 133 eV	> 10000	≤ 139 eV	> 6000
H15LE	15mm ²	AP3.3 low-energy	≤ 136 eV	> 10000	≤ 144 eV	> 6000
H20	20mm ²	Be 8 μm	≤ 129 eV	> 15000	≤ 139 eV	> 6000
H30	30mm ²	Be 8 μm	≤ 129 eV	> 15000	≤ 139 eV	> 6000
H50	50mm ²	Be 12.5 μm	≤ 129 eV	> 15000	≤ 139 eV	> 6000
H80	80mm ²	Be 25 μm	≤ 136 eV	> 15000	≤ 160 eV	> 6000
H150	150mm ²	Be 25 μm	≤ 139 eV	> 15000	≤ 160 eV	> 6000

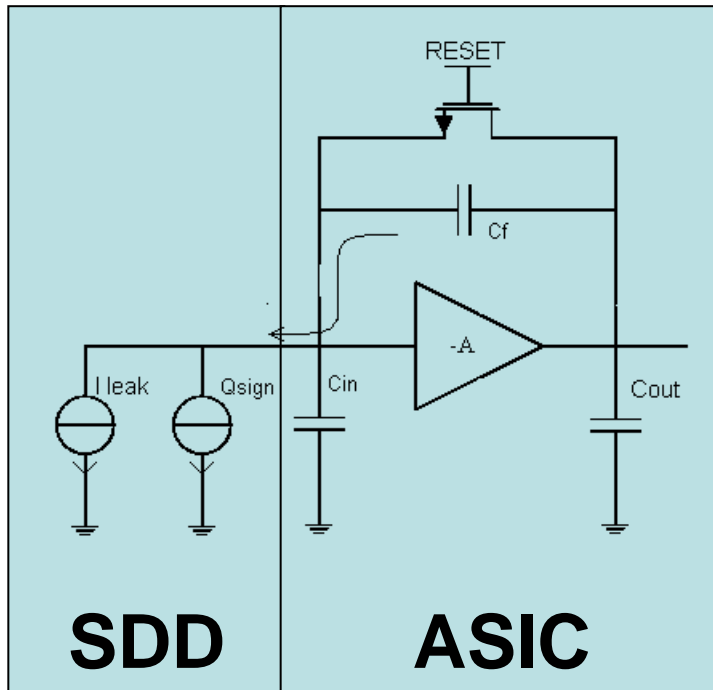
Further improved thermal budget of VITUS SDDs



NEW

VITUS CUBE series

ASIC replaces FET in SDD module: charge sensitive pre-amplification done inside the SDD module directly at the SDDs anode



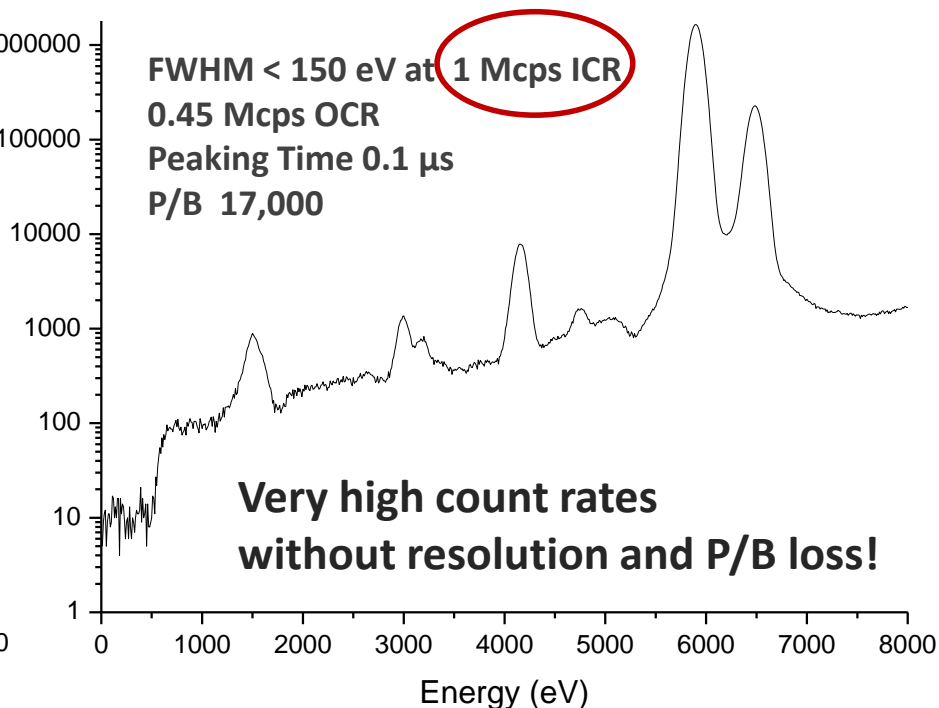
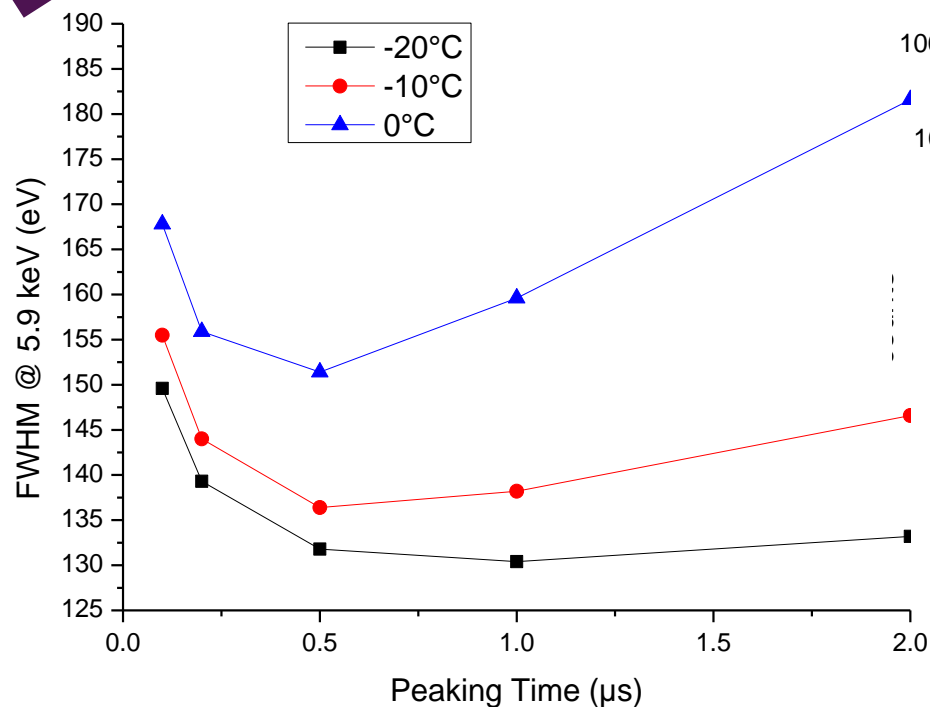
Advantages

1. extremely low capacitance of total sensor system
2. amplified signal at detector output
3. no ESD sensitive terminals at SDD
4. supports long signal paths

-> high count rates in combination with very good energy resolution

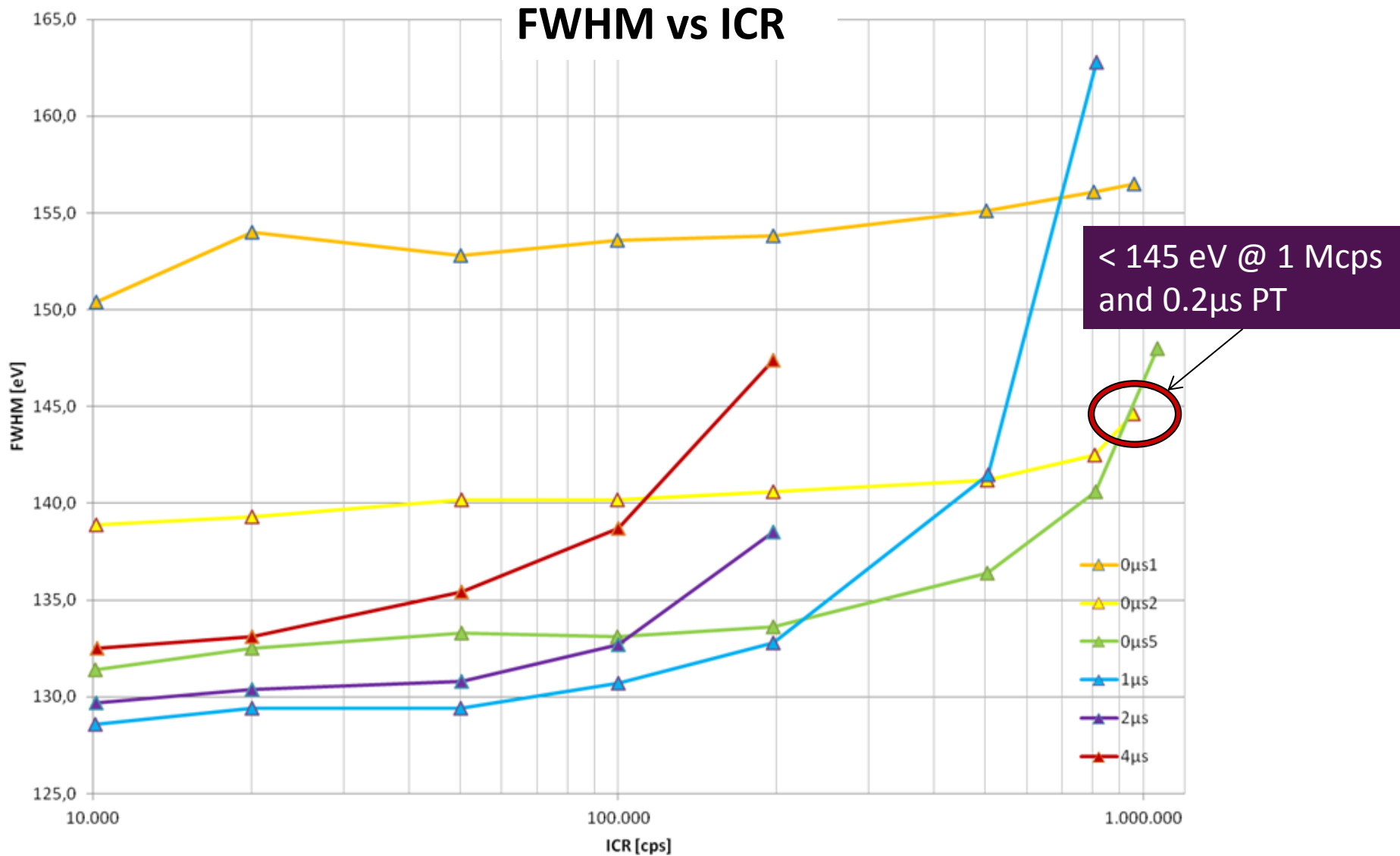
NEW

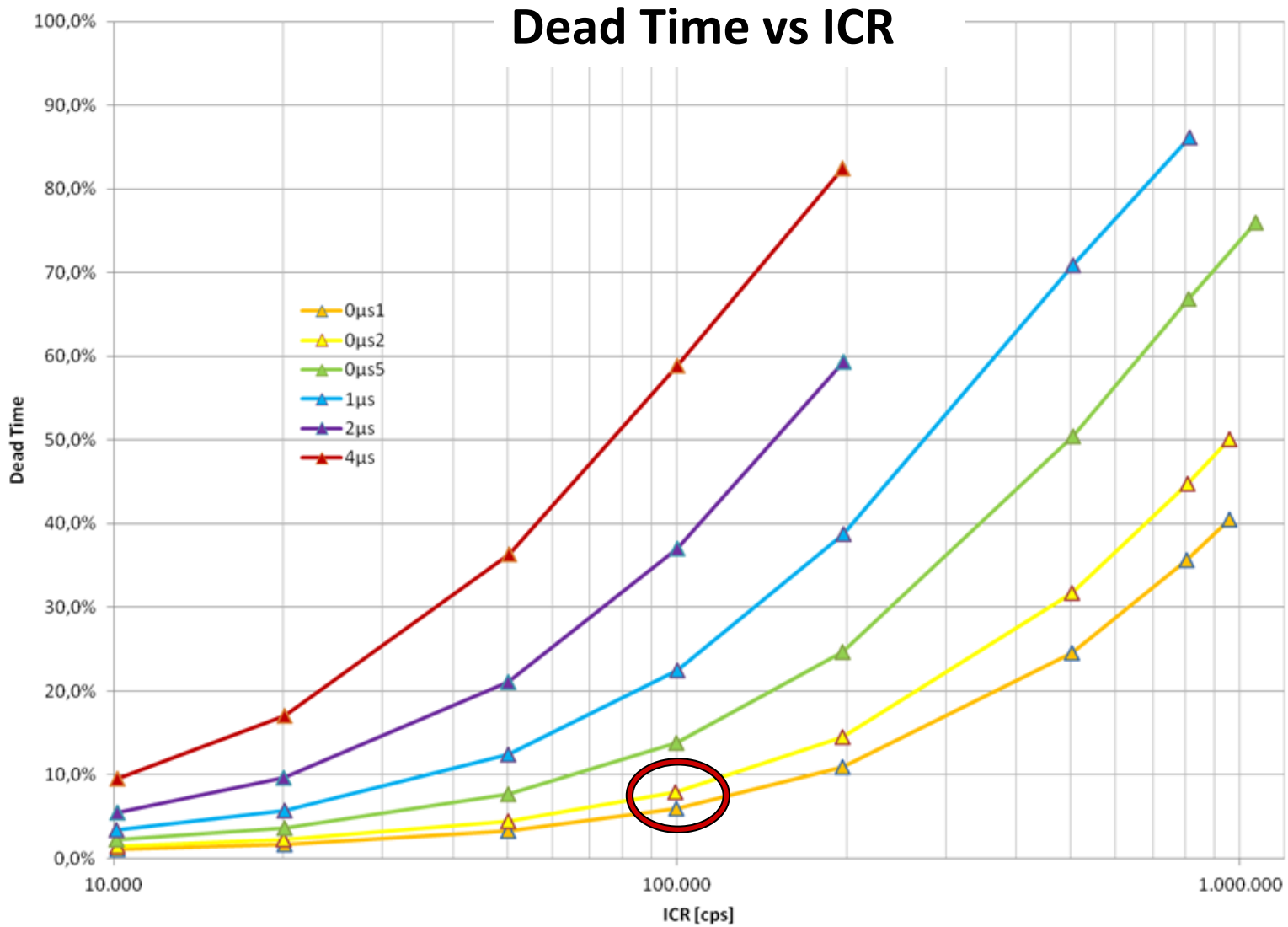
VITUS SDD with very low capacitance ASIC as primary amplification stage



- Excellent performance at very short peaking times and high chip temperatures
- Optimum Peaking Time at 0.5 to 1.0 μs
- High count rate capability with very good FWHM: < 150 eV with 1 Mcps ICR

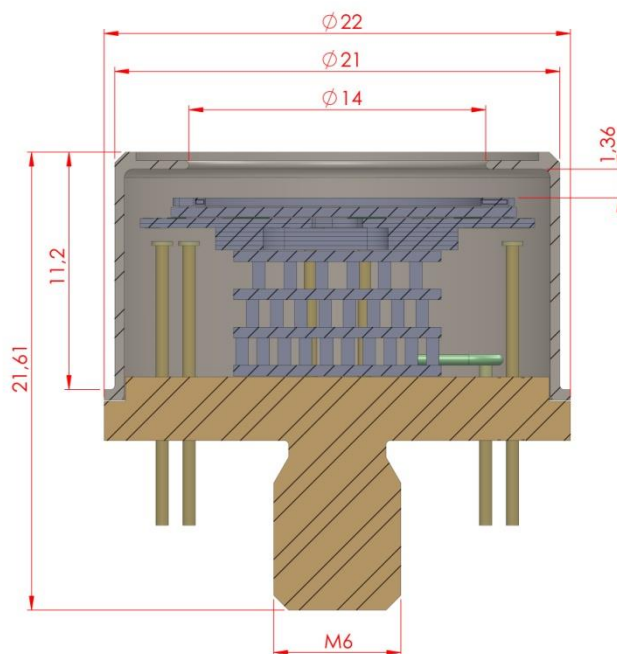
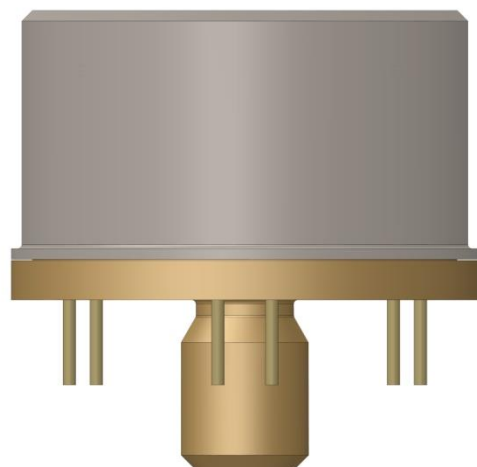
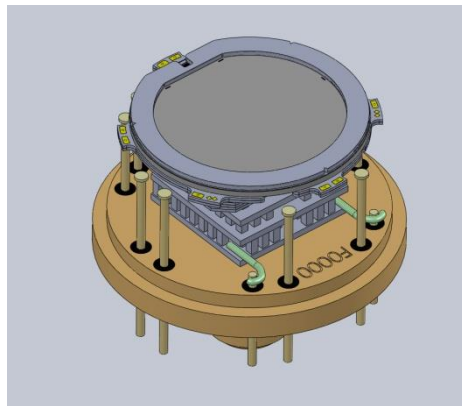
VITUS-CUBE SDD Performance





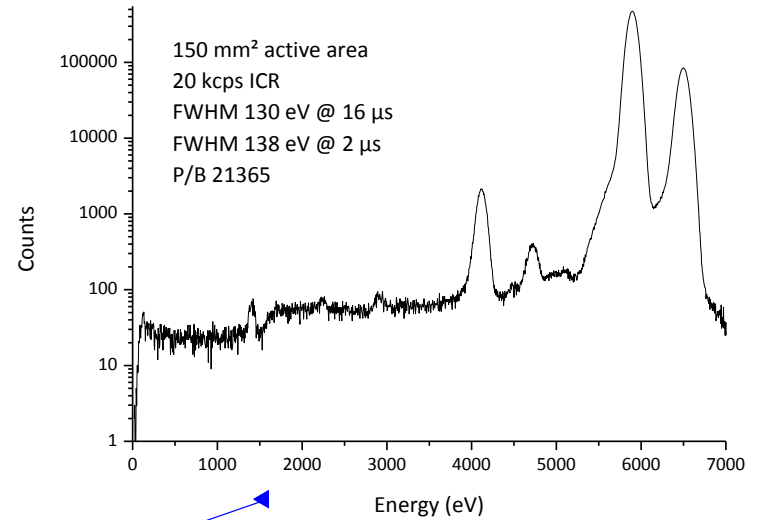
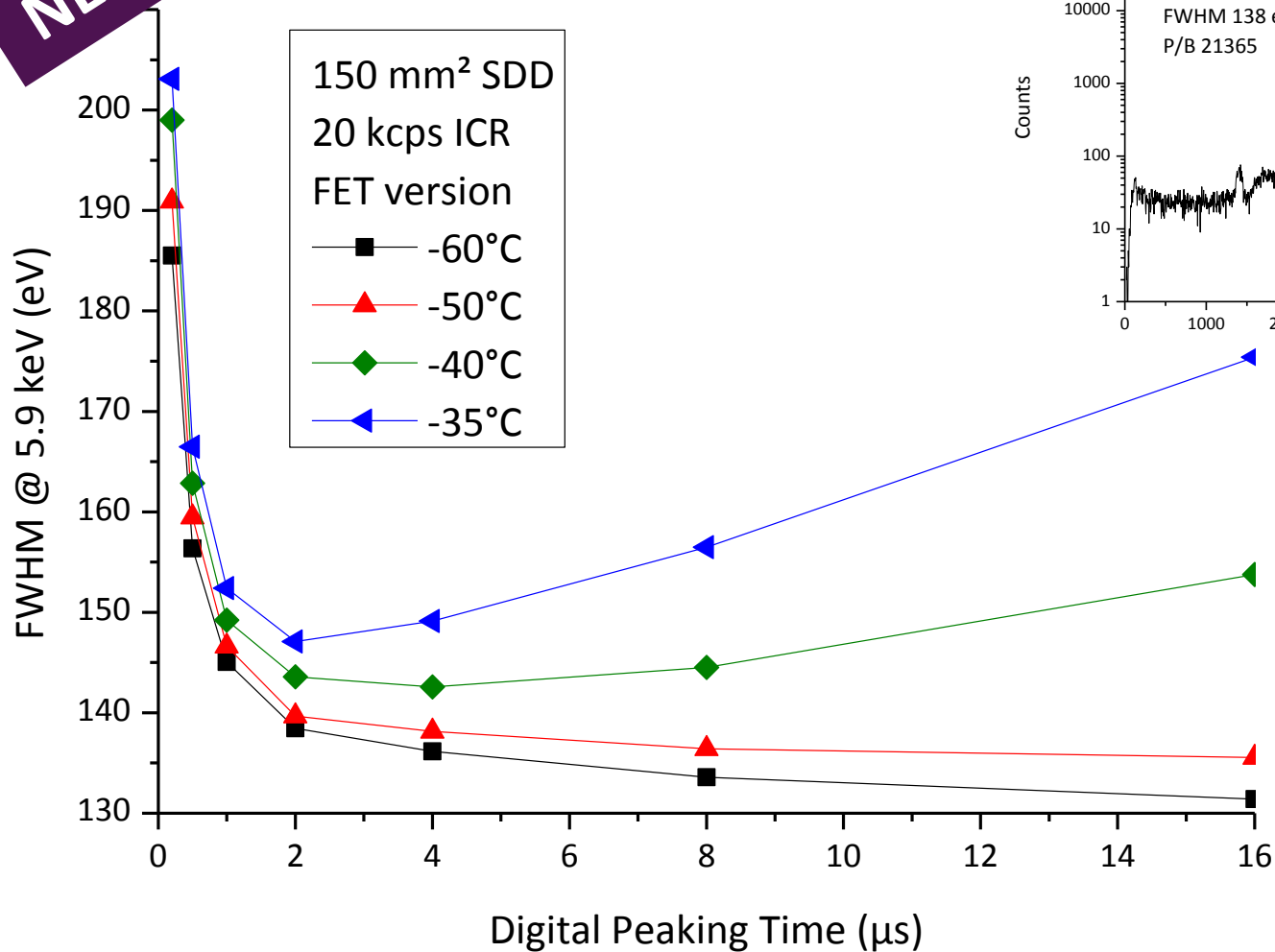
VITUS 150mm² SDD – World's Largest Circular Silicon Drift Detector

NEW

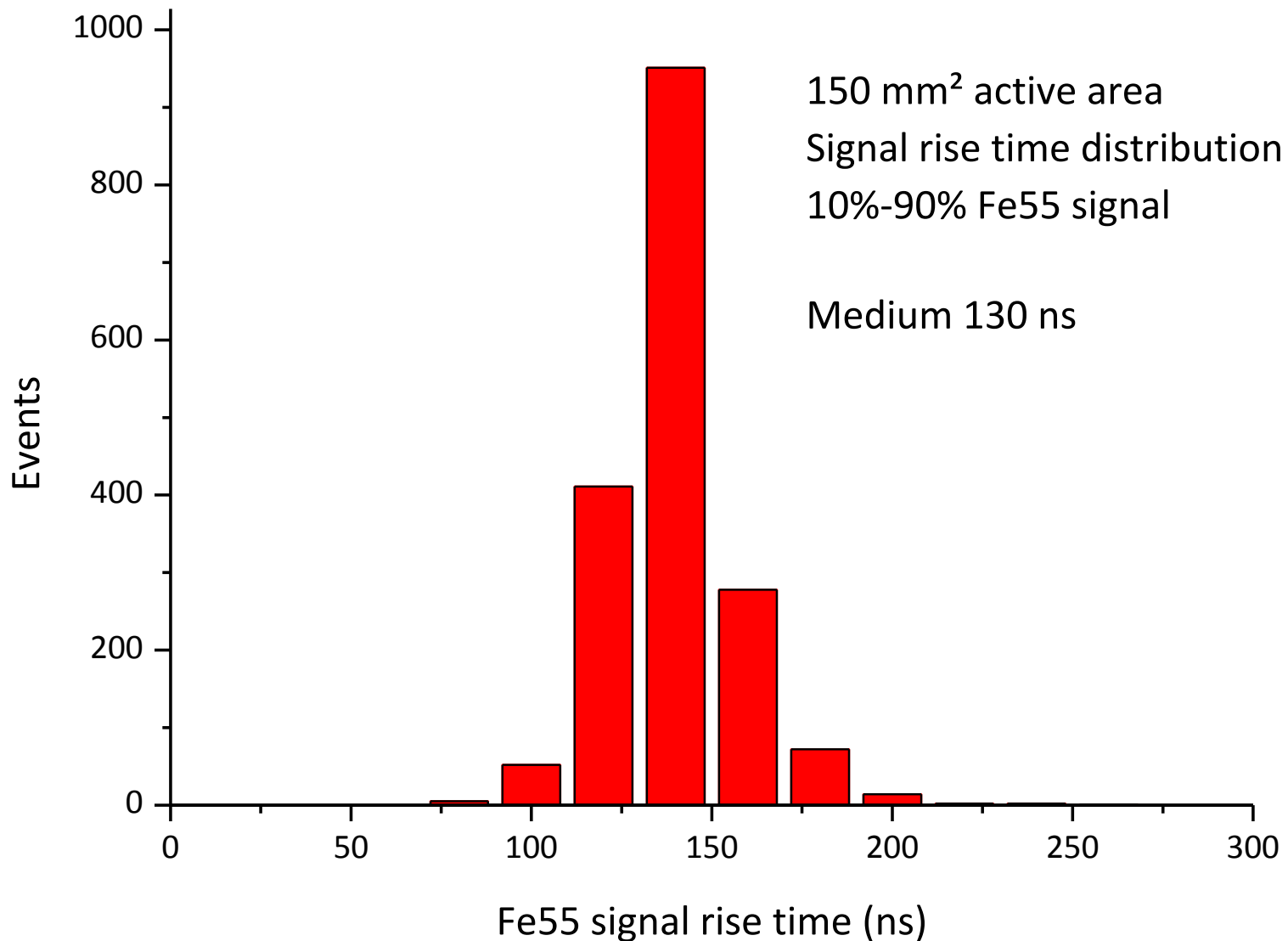


- 150 mm² active, collimated chip area
- 25 µm Dura Coat Beryllium Window
- Multilayer collimator
- Housing diameter 22 mm
- Fill factor ~40%
- Very efficient built-in peltier element: delta T > 110K at +60°C heat sink temperature
- Pin layout identical to 80 mm² VITUS SDD

NEW

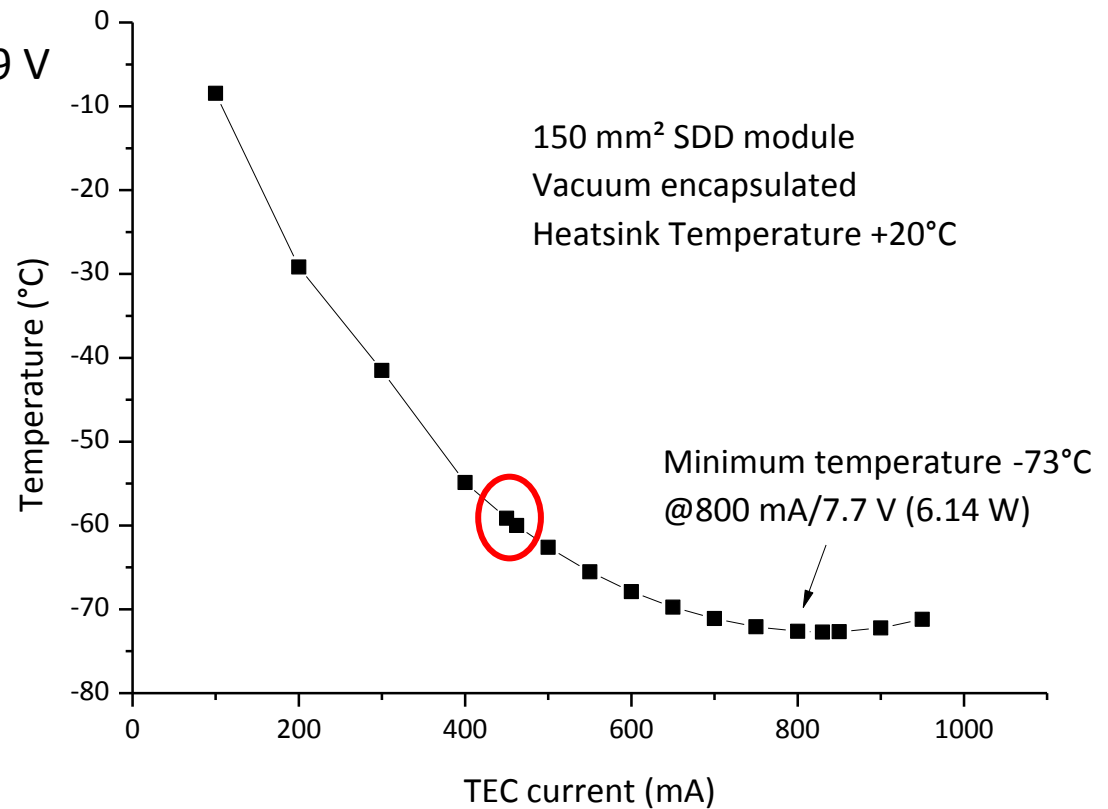


H150 Short Signal Rise Times

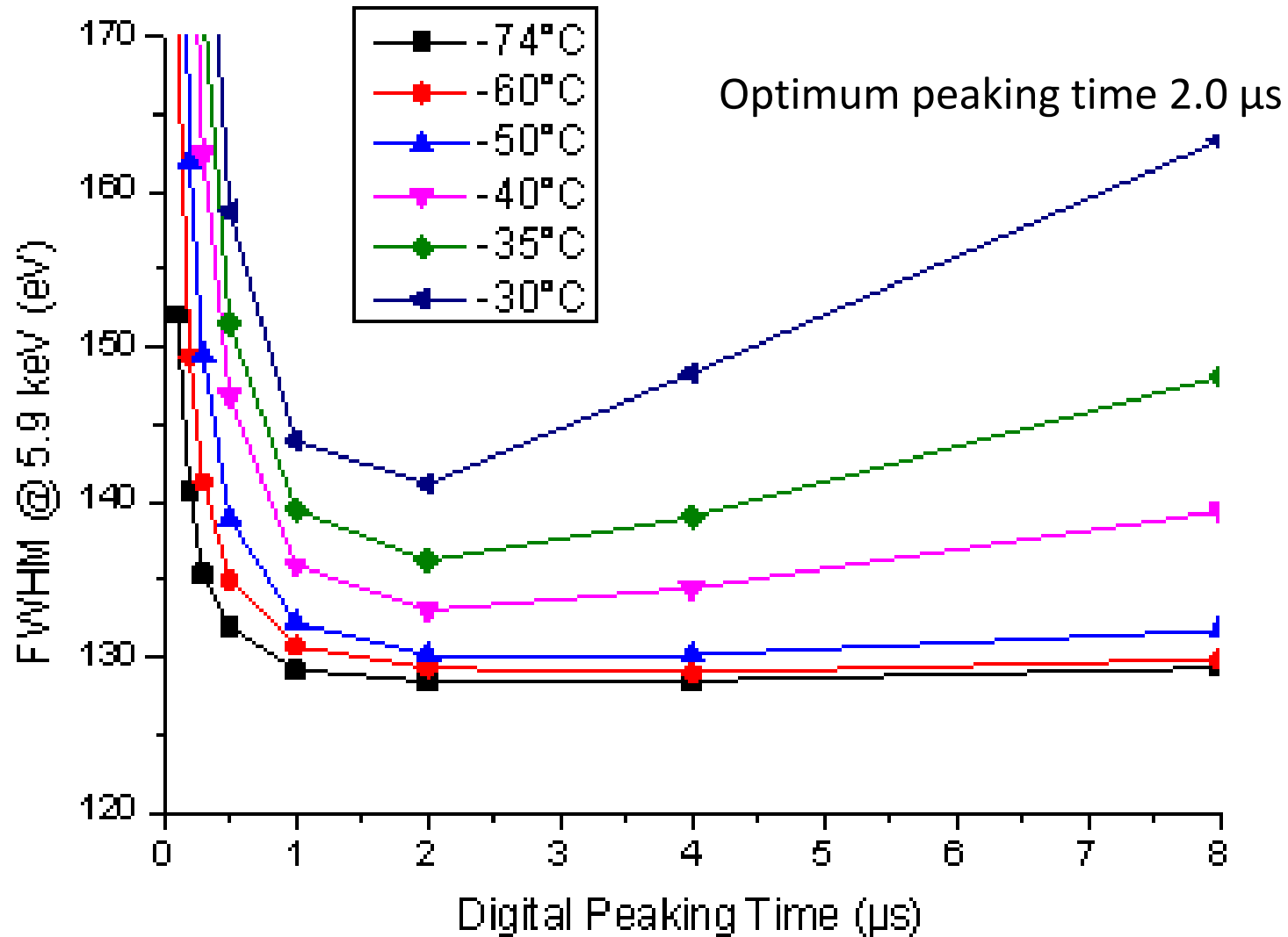


H150 Cooling Performance

- KETEKs 150 mm² SDD is vacuum encapsulated allowing for chip temperatures below -60°C at heat sink temperatures of +20°C
- Maximum Peltier current 1 A
- Maximum Peltier voltage 9 V
- -60°C achievable with 460 mA / 4.7 V
=> TEC power 2.16 W

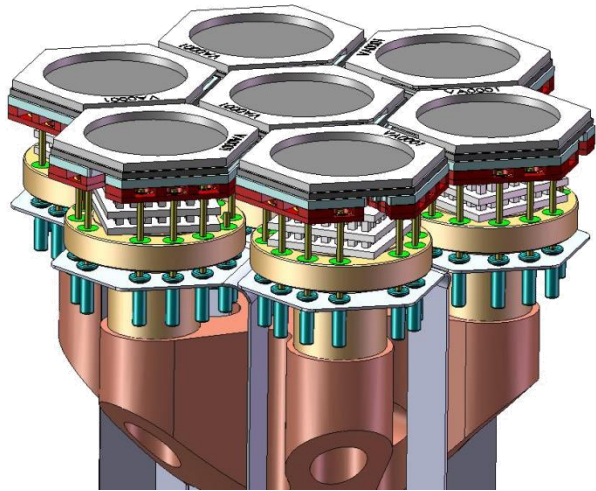


H150-CUBE Version: very good FWHM at short digital peaking times

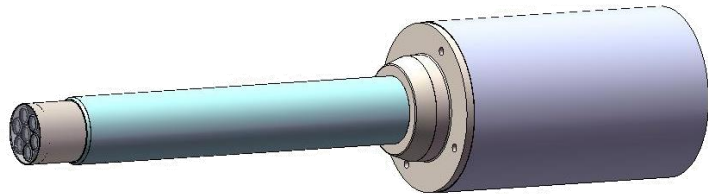


Summary: High Throughput Large Area 150mm² SDD

- Worlds largest circular SDD now available from KETEK
- No ballistic deficit, even at very short peaking times of 0.2 μ s
- Excellent energy resolution up to 1Mcps ICR
- Typical FWHM for FET version 130 eV @ 16 μ s, < 140 eV @ 2 μ s
- Vacuum encapsulation allows for operation temperatures below -70°C or operation at high ambient temperatures up to +80°C without secondary cooling stage
- Typical P/B > 20,000
- Multilayer collimator
- 25 μ m Beryllium window
- All electronics available from KETEK for operation and read out of H150 module



KETEK 7 element array (560mm²)

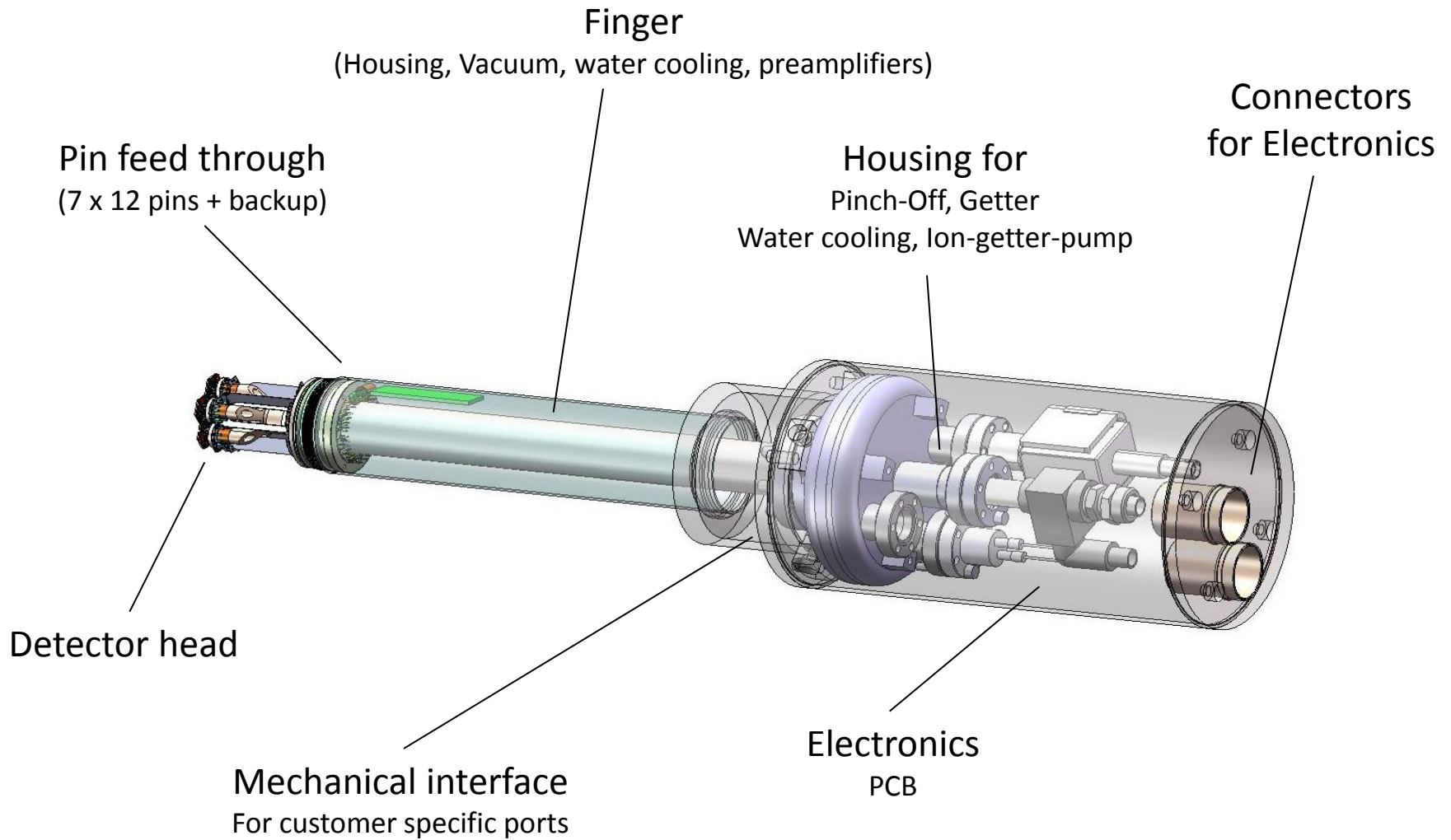


Compact Design with 50mm head diameter

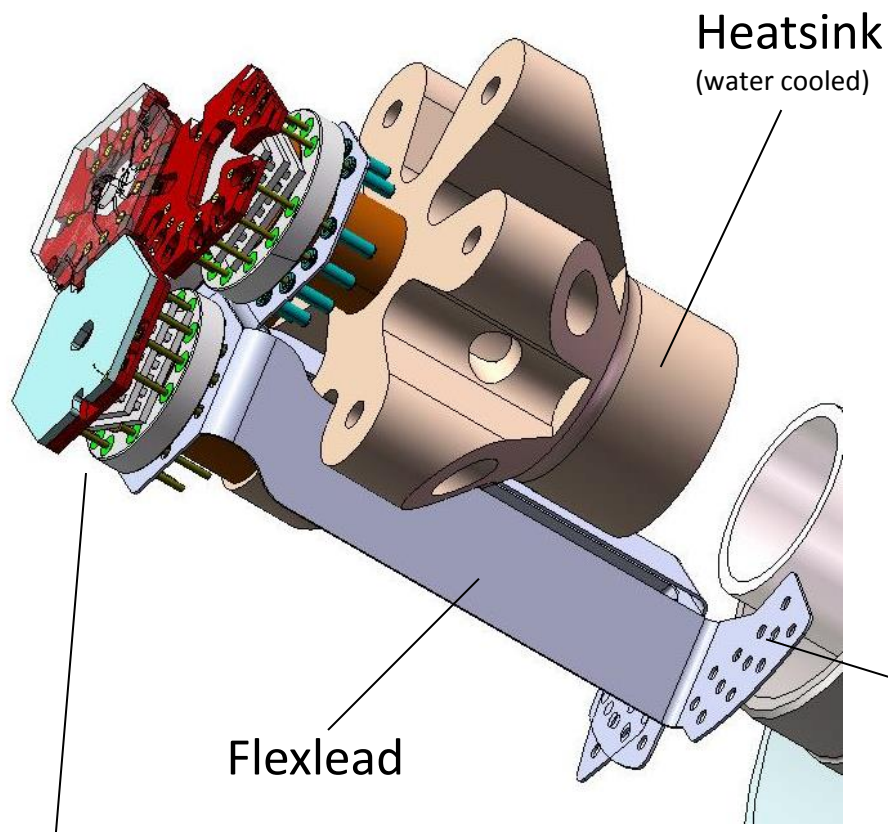
KETEK 7-Channel SDD Array

- Active area: 7 x 80 mm²
- Hexagonal chip design for optimal space filling
- Very compact design with only 50mm head diameter
- Independent individual channels
- Possibility to exchange single channels
- Including preamp, power supplies, water cooling, optional DPP
- 25 μm Be window

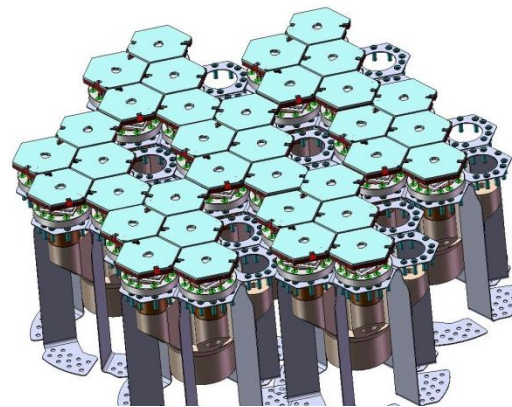
KETEK Array Components



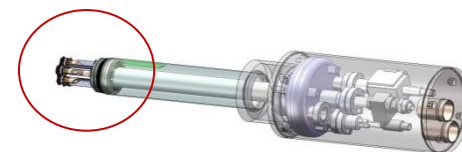
KETEK Large Area SDD Array Concept



Detector VFC100

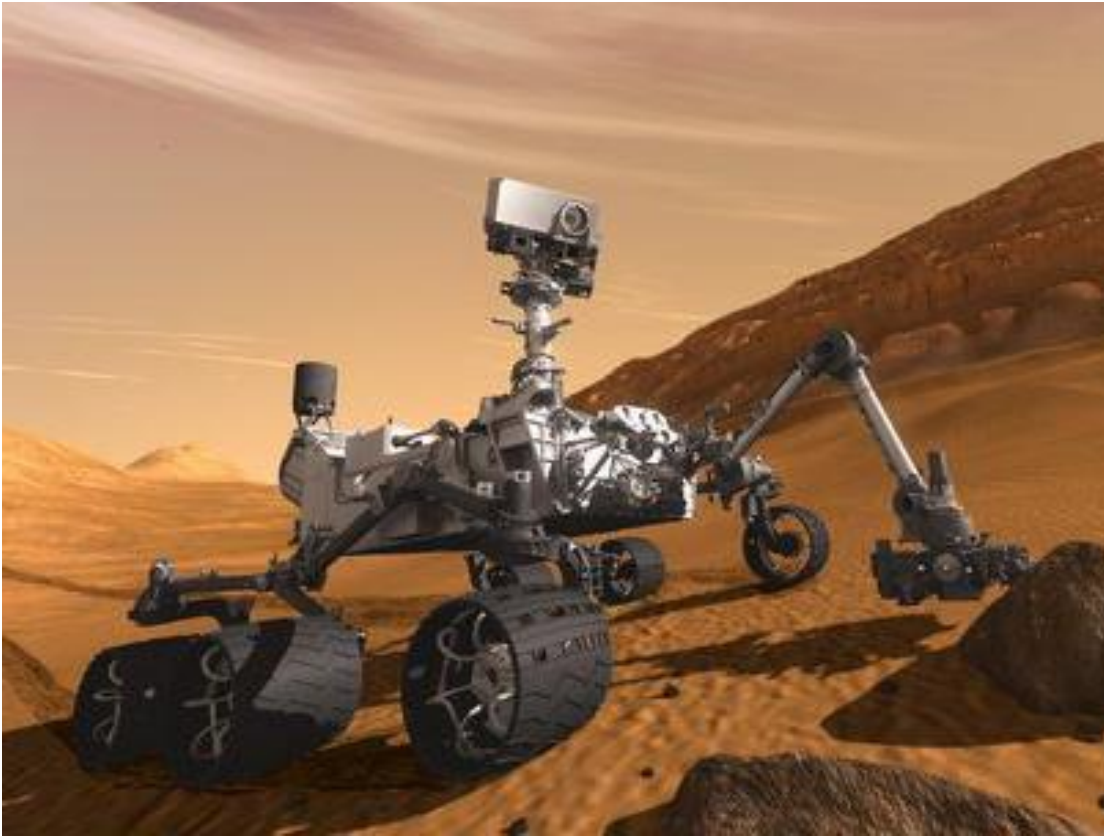


Flexible Detector concept
for large area arrays



Future Requirements for Energy Dispersive Solid State XRF Detectors

- ,Room temperature' detectors
- Lower cost detector systems with simple chip-size package
- New high transmission x-ray windows as alternative to Be and polymers
- High direct conversion quantum efficiency up to several 100keV
- Count rate capability of several Mcps
- Further improved radiation hardness (today: $10E13$ photons)
- Low energy detection down to 100eV without expensive low energy windows
- Very large area detector arrays with simple modular readout logic
- Very low cost, low power, high throughput DPPs for mobile spectrometers
- Highly integrated combinations of excitation source, detector and readout electronics

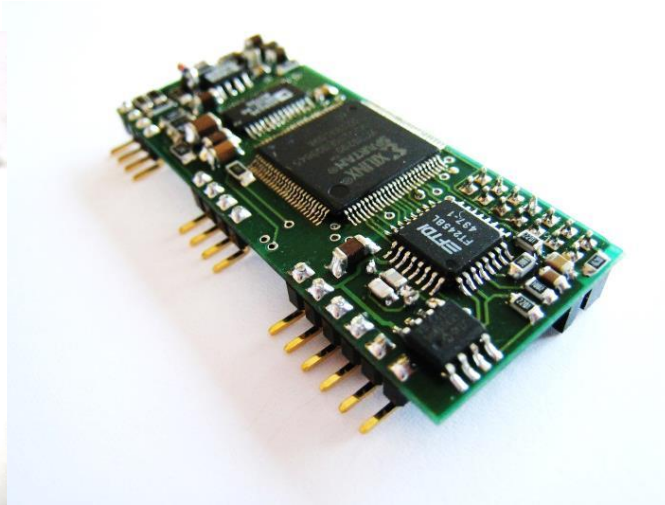


Source: Nasa/JPL-Caltech

KETEK lands on Mars

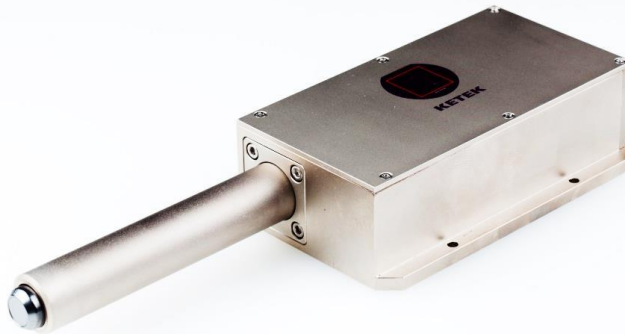
In August 2012, on board of Mars rover Curiosity and as part of a X-ray spectrometer, KETEK's Silicon Drift Detectors have arrived on the Red Planet. This is already the third mission a VITUS SDD has been chosen by the NASA as XRF detector.

KETEK Signal Processing Systems & Electronics

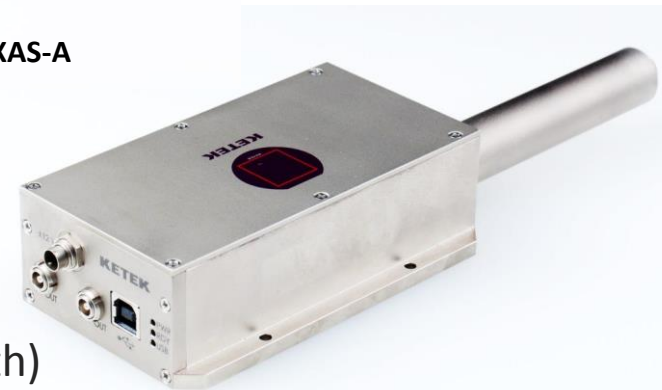


KETEK AXAS-A

- Analog SDD system
 - VITUS SDD
 - Power Supply for Peltier (TEC)
 - Power Supply High Voltage for Ring Biasing
 - Exponential Preamplifier
- For 7 to 50mm² VITUS SDD
- Standard Finger Lengths available (50 to 300mm Length)



AXAS-A



KETEK AXAS-D

incl. Digital Signal Processor

- Complete SDD system
 - VITUS SDD
 - Power Supply for Peltier (TEC)
 - Power Supply High Voltage for Ring Biasing
 - Exponential Preamplifier
 - Digital Pulse Processor (DPP)
- For 7 to 50mm² VITUS SDD
- Standard Finger Lengths available (50 to 300mm Length)
- USB 2.0 (Full Speed) Interface to Host PC
- Software for Windows XP
- DLL for data read out of DPP from customer software available



AXAS-D



KETEK AXAS-M[®]



KETEK AXAS-M2[®]

KETEK AXAS-M1[®]

KETEK AXAS-M

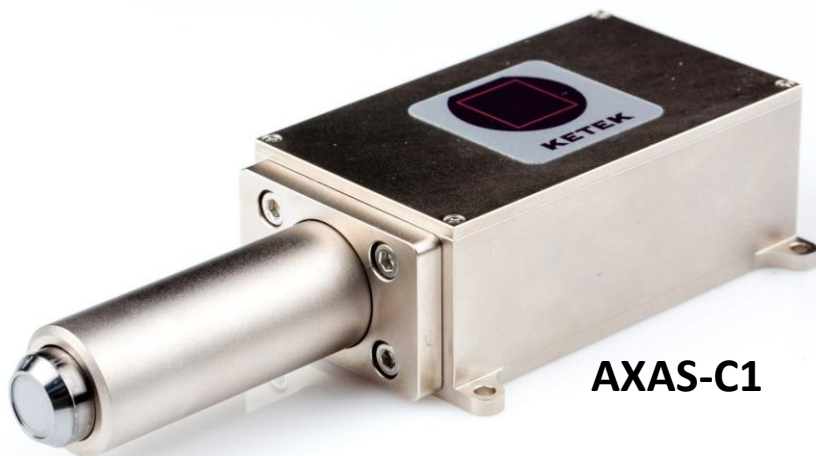
- For 7 – 150mm² VITUS SDD's
- Peltier Element Cooling
- Low Noise Pre-Amplifier
- All power supplies for SDD and TEC
- Extremely Low Noise Electronics
- Standard Finger Lengths available (50 to 300mm)
- Optimized thermal budget
- Optional KETEK Digital Pulse Processor (DPP)



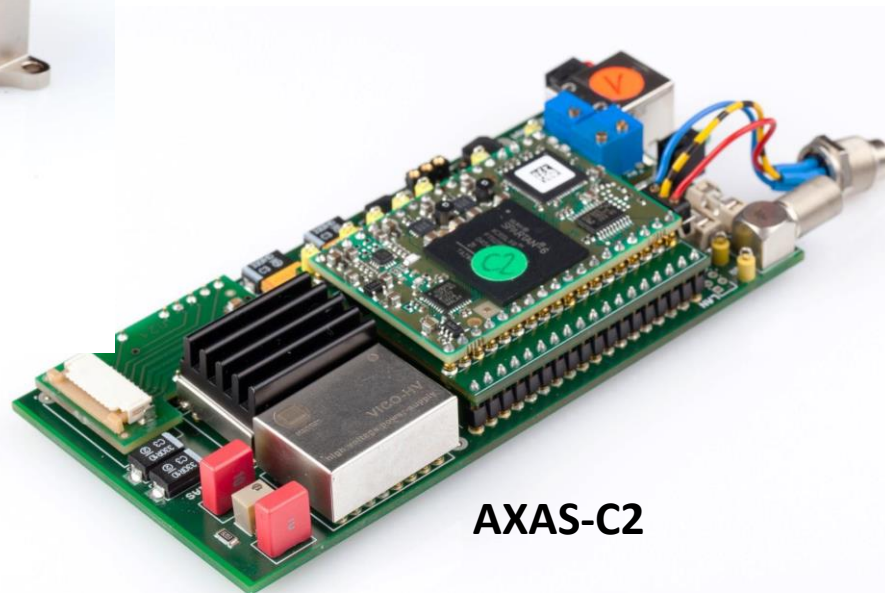
New Compact AXAS-C for Compact XRF Devices

NEW

AXAS-C



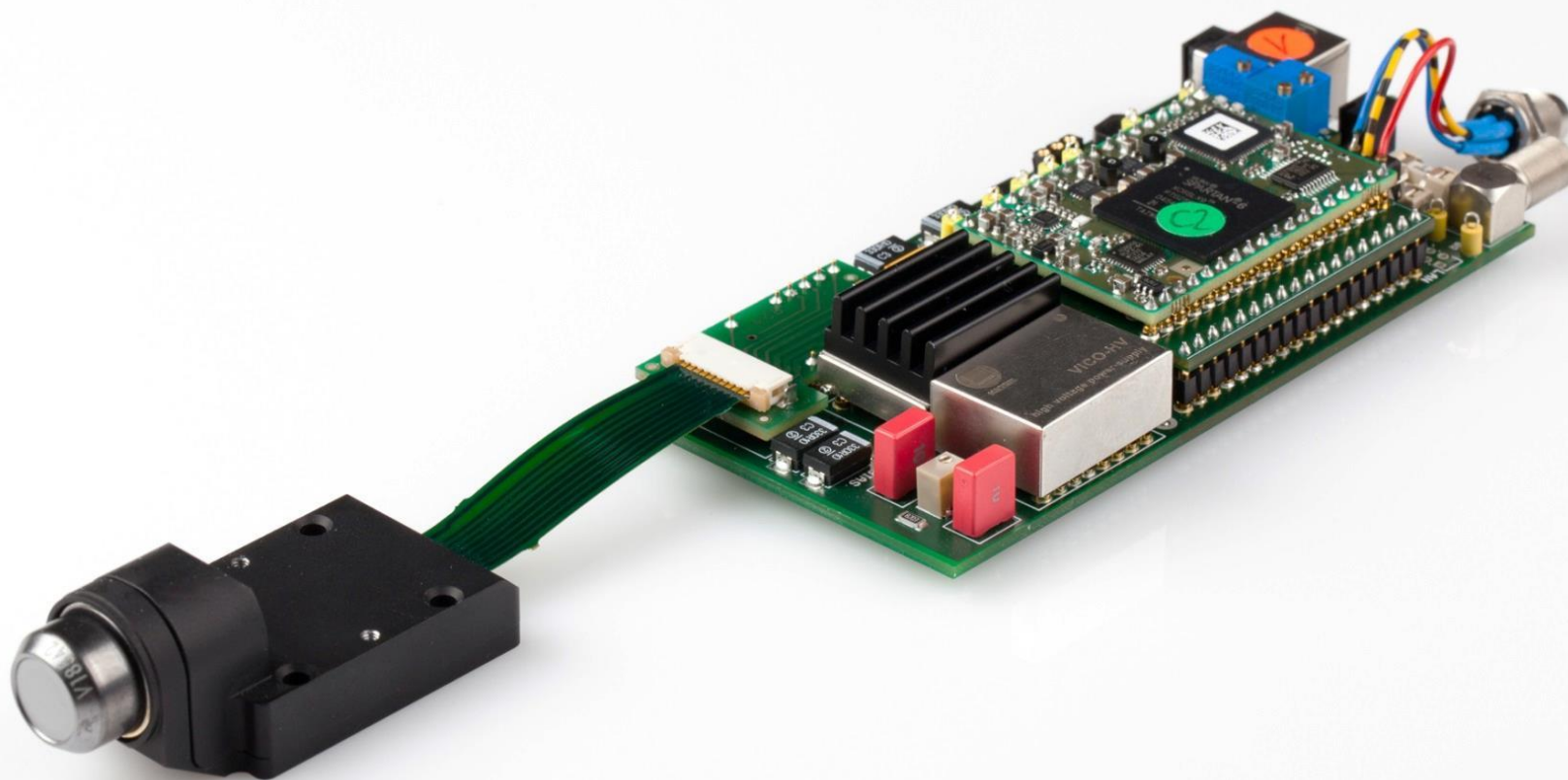
AXAS-C1



AXAS-C2

NEW

VIAMP & VICO OEM Kit



Today many technology companies like KETEK are mainly industry driven

How science and industry can better collaborate (KETEKs view)

- Workshops like this
- Scientists to proactively meet technology companies to phrase practical needs / future requirements
- Industry to proactively seek unsolved technical problems in the academic world
- IP issues can be resolved by involving technology transfer offices
- Industry to accept also longer return-in-invest times; e.g. it took more than a decade in industry to migrate from PIN diodes to SDDs
- Generally enforce synergies between basic, funded research and industries R&D

WELCOME TO **KETEK** SILICON DETECTORS FOR X-RAY AND OPTICAL SPECTROSCOPY



HOME PRODUCTS COMPANY DOWNLOADS NEWS CONTACT



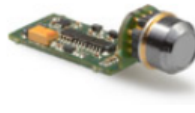
VITUS SDD

Silicon Drift Detectors with 7 mm² to 100 mm² active area for X-ray spectroscopy
[read more](#)



AXAS

Analytical X-ray Acquisition Systems complete with SDD, preamplifier and pulse processor
[read more](#)



VIAMP

OEM solution combines Silicon Drift Detector with preamplifier in optional housing
[read more](#)



VICO

Electronic components for optimised use of VITUS SDDs in OEM devices
[read more](#)



Accessories

Additional equipment for Silicon Drift Detectors, e. g. preamps, DPP etc.
[read more](#)



SiPM

Silicon Photo-multipliers with 1.4 mm² to 36 mm² active area for low-level light detection
[read more](#)

NEWS

FOUNDATION OF...

Fraunhofer-Einrichtung für Modulare Festkörper-Technologien (EMFT), Siemens AG, LFoundry GmbH, KETEK...
[...read more](#)

NEW 50MM² HIGH-END...

KETEK is introducing its new 50mm² silicon drift detector with unprecedented guaranteed energy...
[...read more](#)

PRODUCTS

VITUS SDD
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VIAMP
VICO
Accessories
SDD Technology

SiPM
SiPM Technology

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Managing Directors
Managing Team
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24
YEARS
1989 - 2013
THANK
Y O U

