UNIVERSITÀ DEGLI STUDI DI TRIESTE
Dipartimento di Fisica
Department of Physics

INFN
Istituto Nazionale di Fisica Nucleare
Sezione di Trieste

Belle II - Trieste
SVD activities 2014

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INFN and Univ. Trieste
(*) now at INFN - TIFPA

Outline

- Micron and HPK microstrip sensors tests
- SVD+PXD interlocks: PLC
- Humidity monitoring/interlock
- Temperature monitoring
  - Optical Fibres Sensors (FOS)
  - NTC thermistors
- Radiation monitor & beam abort
  - scCVD diamond sensors, electronics
  - Background simulations

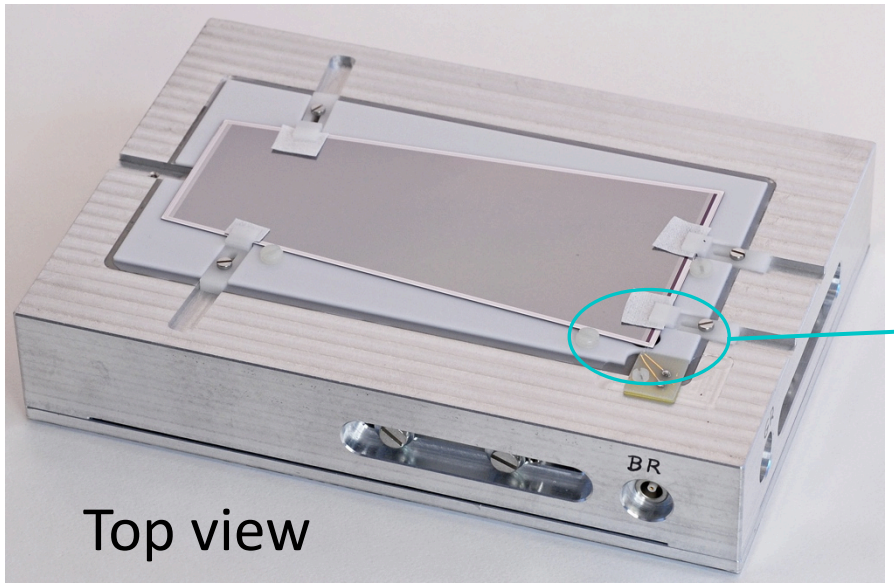
L.Bosisio (Univ. & INFN)
I.Rashevskaia (INFN-TIFPA)
G.Orzan (INFN)

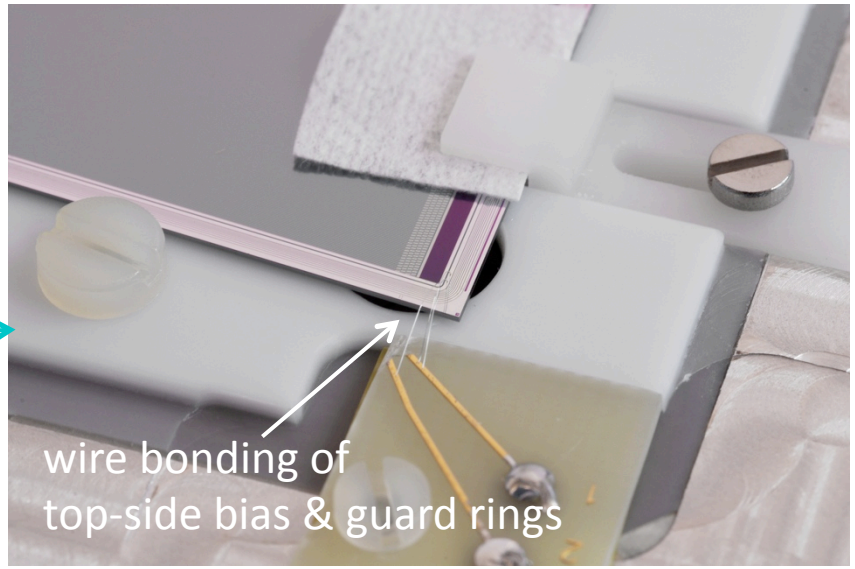
MICROSTRIP SENSORS TESTS

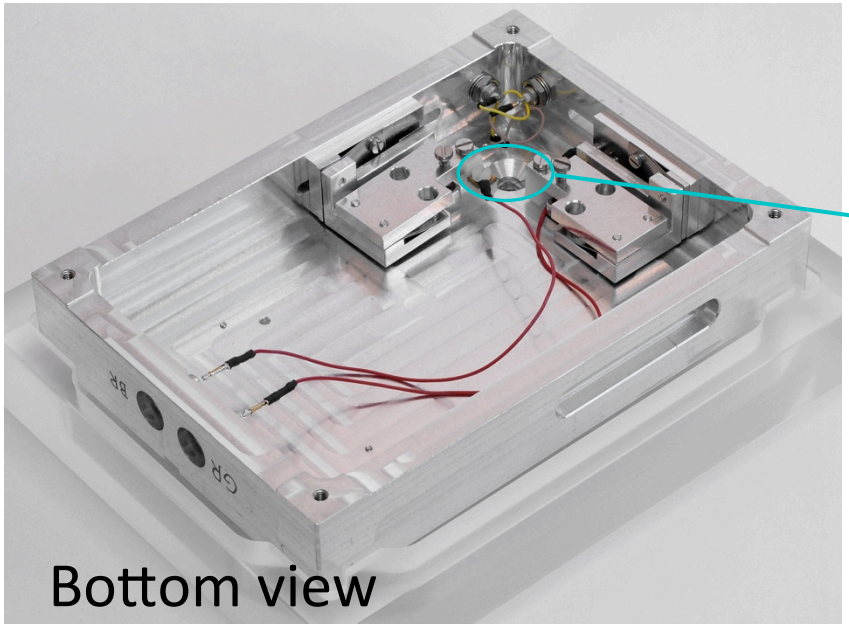
Trapezoidal Sensor Testing

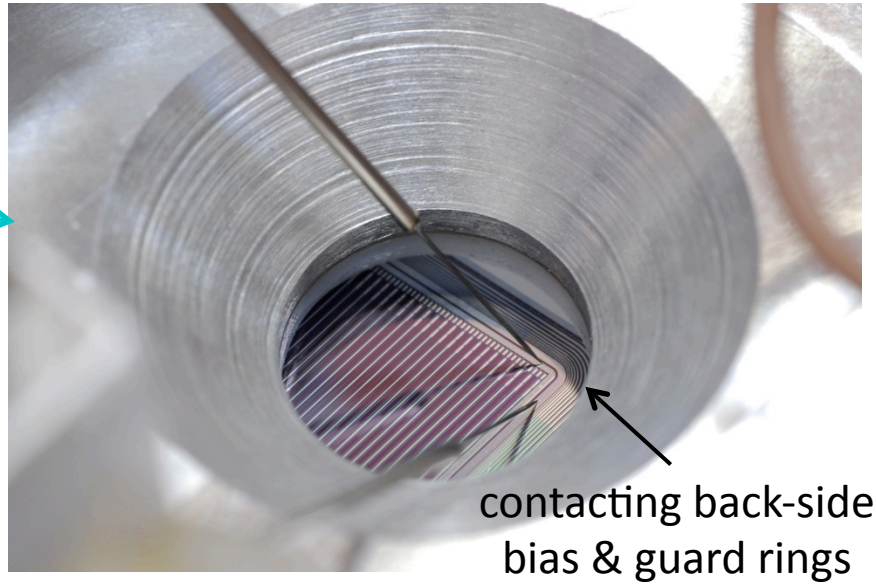
- 41 wedge-shaped sensors to be installed in SVT (forward region of layers 4, 5, 6).
- 60 sensors ordered (by HEPHY) to Micron Semiconductor.
- Trieste is sharing with Vienna the test of these sensors, using a semi-automatic prober and probe cards.
- A dedicated jig for interfacing the double-sided sensors with our prober has been designed and fabricated.
- Two 40-needle probe cards have been procured:
  - 100 µm pitch card for p-side
  - 240 µm pitch card for n-side

Sensor testing Jig

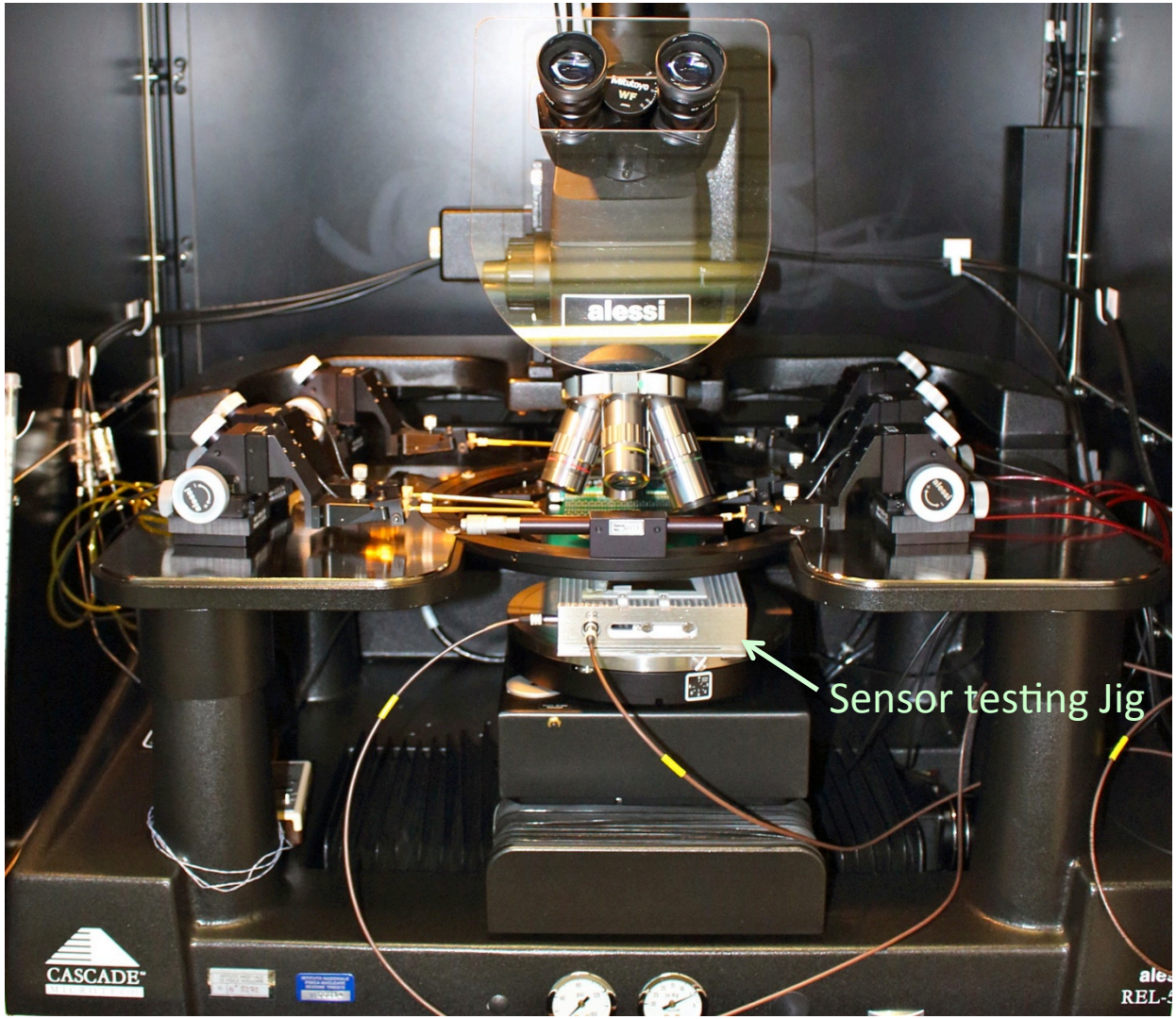








Sensor testing set-up



- Front and Back-side Rings are connected through cables
- Strips are contacted by a 40-needle Probe Card

Sensor Testing Procedure

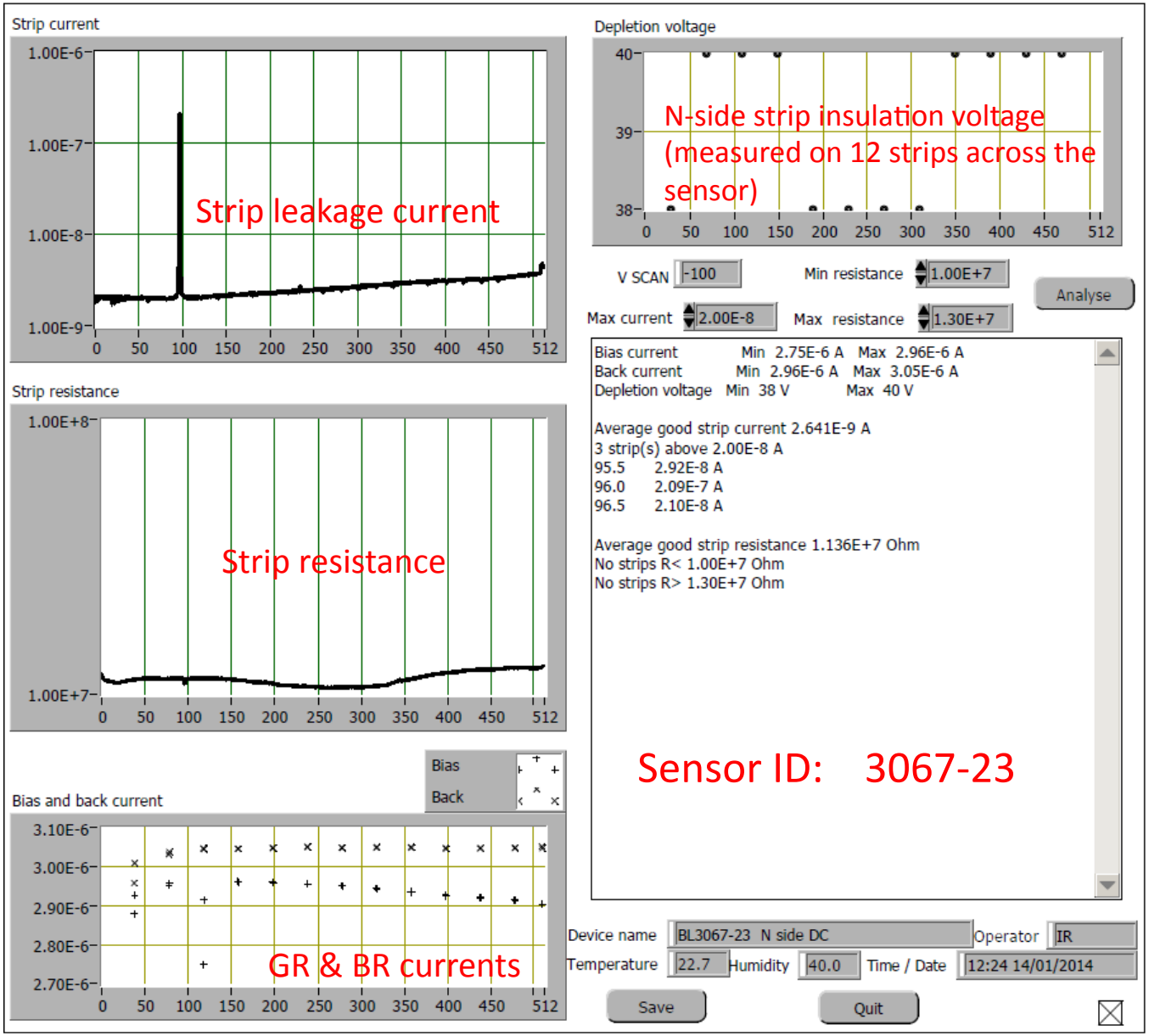
- Mount the sensor *n*-side up on the jig, bond the *n*-side Rings
- *I-V* measure of the whole sensor and of one *n*-side strip
- AC (metal) strip Scan on *n*-side, using the 240 µm probe card
- DC (implanted) STRIP SCAN on *n*-side, using the 240 µm probe card to contact (in two steps) the readout strips and the non-readout ones (120 µm pitch)
- Remove the bonds on *n*-side, turn the sensor and bond the *p*-side Rings
- AC strip Scan on *p*-side (along short edge), using the 100 µm probe card to contact (in two steps) all 50 µm pitch metal strips
- DC STRIP SCAN on *p*-side, using the 100 µm probe card to contact (in four steps) all 25 µm pitch implanted strips

An example: DC Strip Scan on *n*-side

Summary report of the analysis program.

Lists:

- Defective strips
  - high current
  - low resistance
- Average current of 'good' strips
- Average total resistance of 'good' strips



Wedge Sensor Summary

- 43 production sensors delivered in Trieste (37 to Vienna).
- 31 sensors (plus 3 pre-series units) fully tested in Trieste.
- General quality is quite good. 27 out of 31 accepted.
- Besides standard tests, detailed investigations have been made of a contact resistance problem found on *p*-side.
- 12 more sensors are waiting to be tested.
- Due to competing projects and a failure of air conditioning in the lab (to be replaced in January), testing will resume in the second half of January. To be concluded in February.

Test of Hamamatsu Sensors

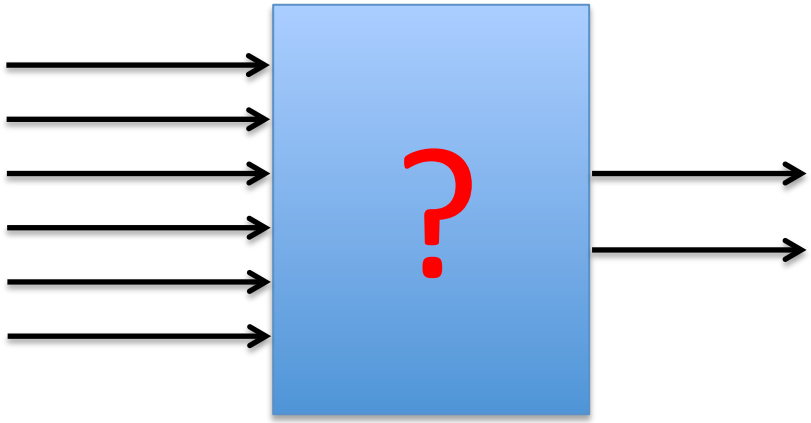
- Two rectangular sensors for Layer 3 of SVD, previously tested by HPK and by Vienna have been thoroughly tested in Trieste for cross-checking the test results.
- This required fabricating a new, dedicated support jig.
- Some inconsistencies in Hamamatsu tests have been found (later acknowledged by HPK).
- A strip insulation problem on *p*-side has been found and extensively investigated.
- (overall sensor quality: acceptable)

INPUTS

INTERLOCK LOGICS

OUTPUTS

?



?

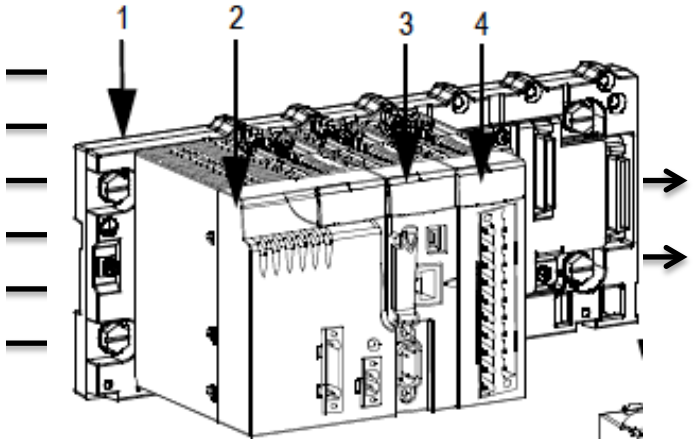
SVD + PXD INTERLOCKS

INPUTS

INTERLOCK LOGICS

OUTPUTS

Temperature (NTCs)
Dew point (Vaisala)
Sniffer Pump(s)
Cooling plant failure
Beam Abort
Fire alarm?
…etc



PXD power supplies
VXD power supplies
(not segmented)
…etc

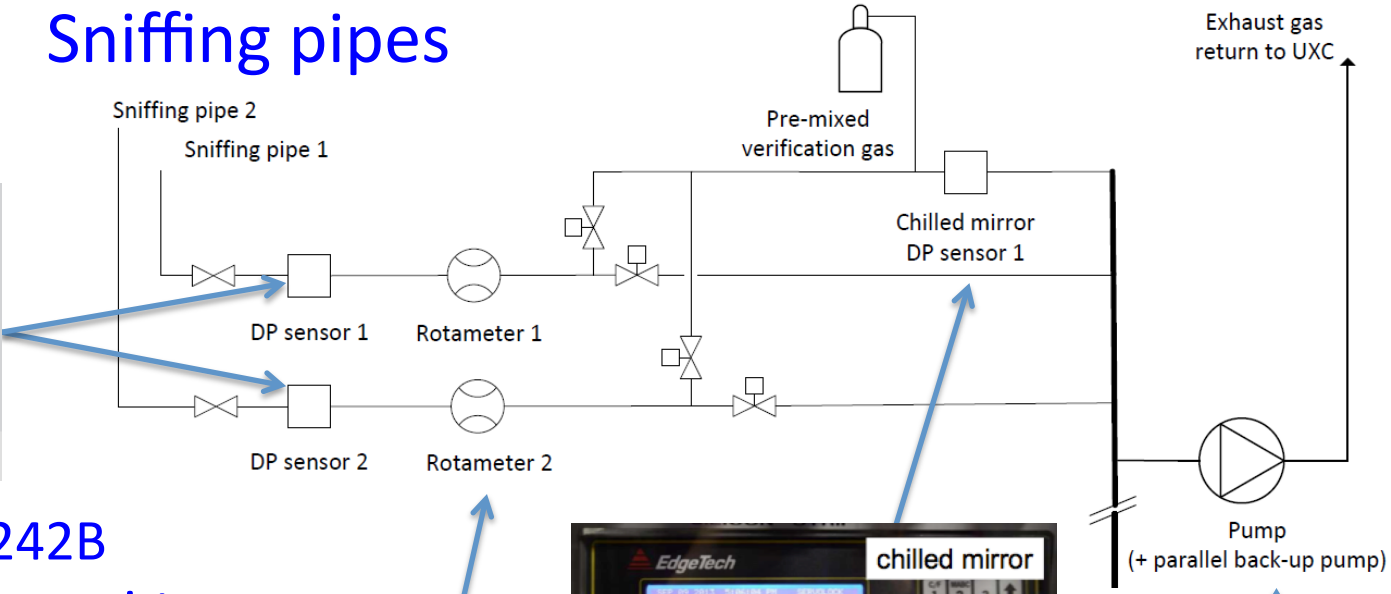
Programmable Logic Controller (PLC)
Schneider M340 – cpu BMX P34 2030
Modbus/EPICS drivers exist! expandable
kit (p.s. + cpu + I/O + software) purchased
Local expertise: INFN technician

SVD + PXD INTERLOCKS

HUMIDITY MONITORING & INTERLOCK

Dew Point Sensors (interlock @ -30°C)

Sniffing pipes



Vaisala DMT242B
Dew Point Transmitters
[-60, +60]°C dew point range

Edgetech Dewmaster
Chilled Mirror Hygrometer
(for calibrations)

Rotameter
flux meters

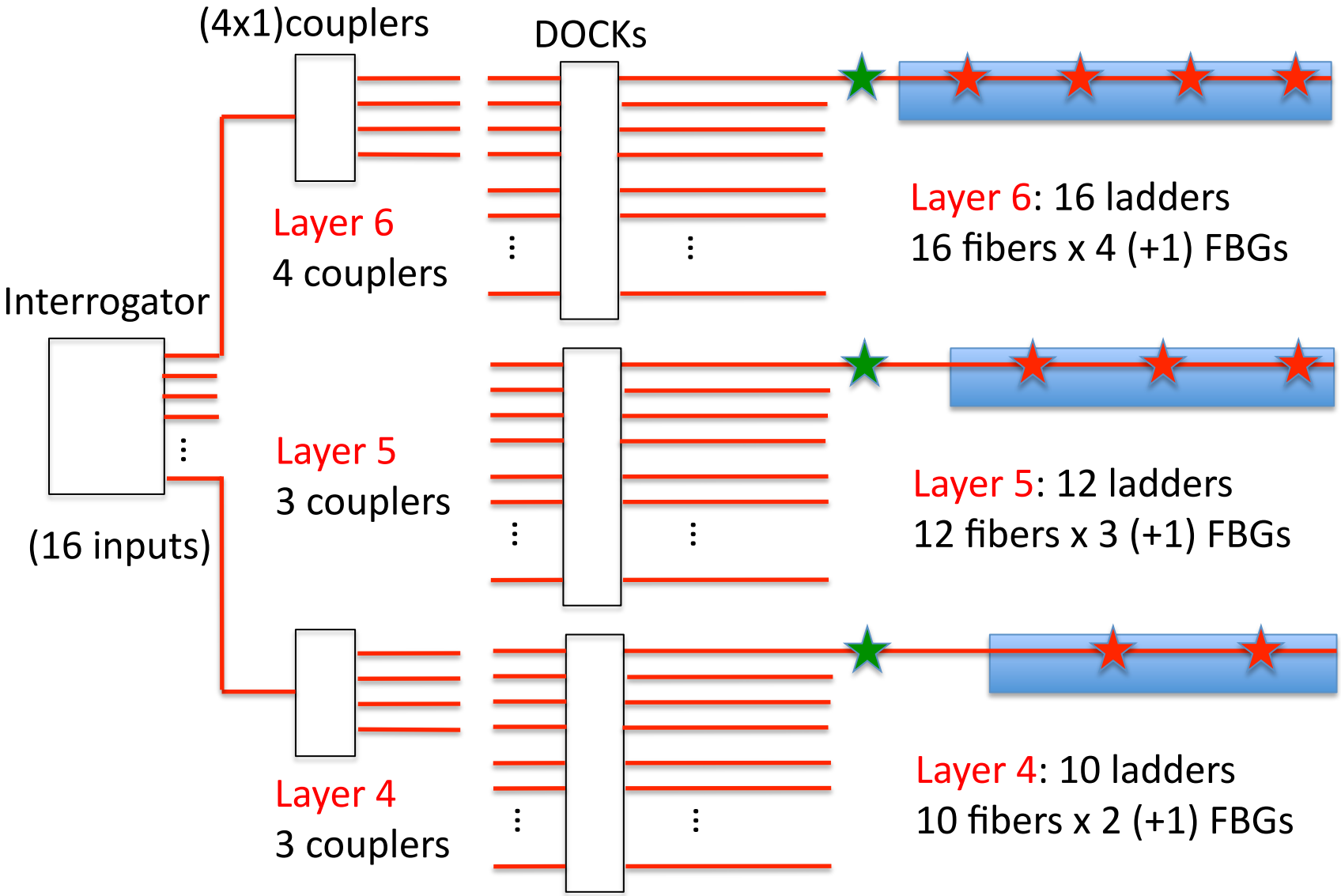
Pump

Main components purchased, Prototype planned (1st quarter 2015)

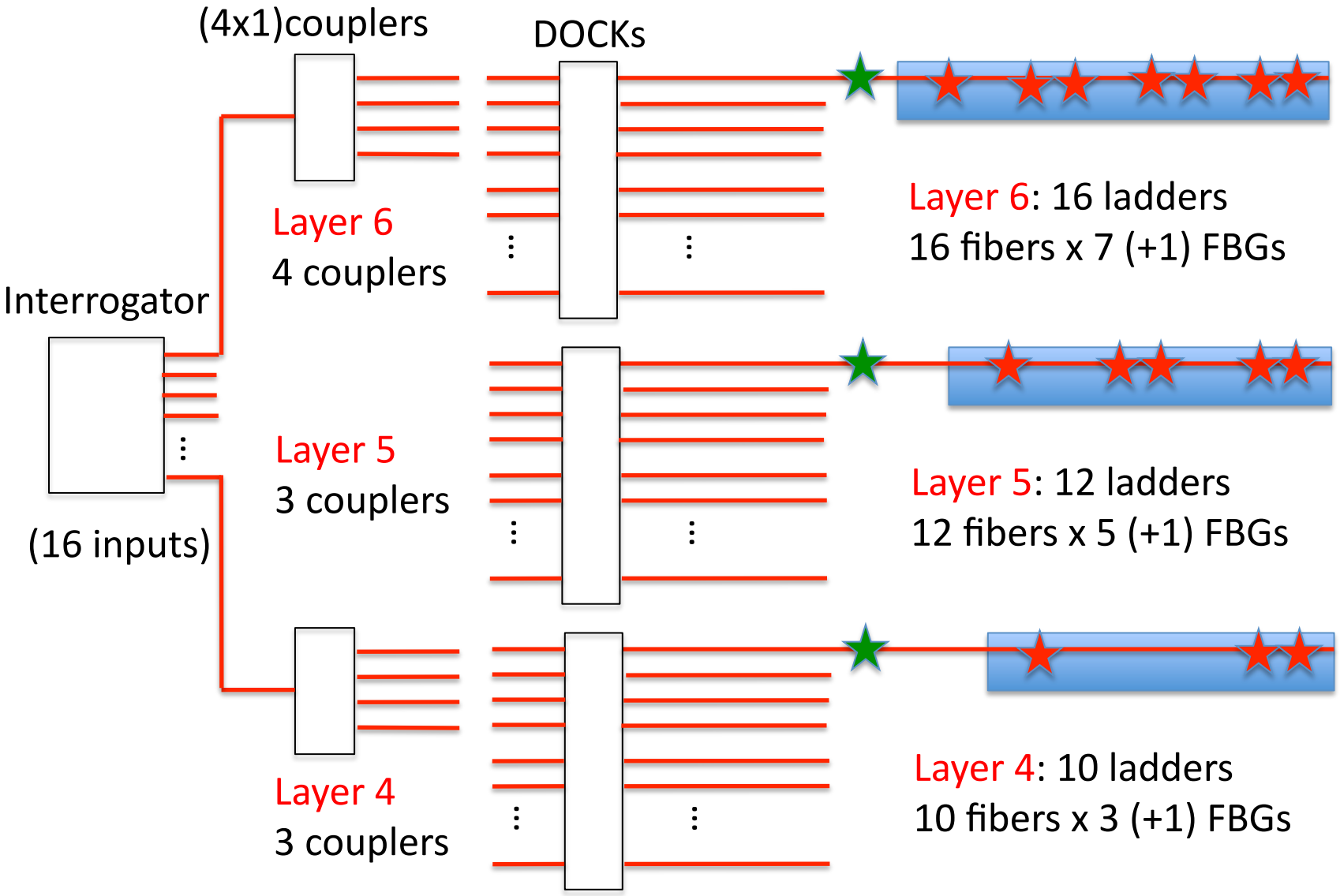
Pietro Cristaudo (INFN): NTC readout!

TEMPERATURE MONITORING

SVD FOS fibers system (baseline)



SVD FOS fibers system -2 FBGs/origami

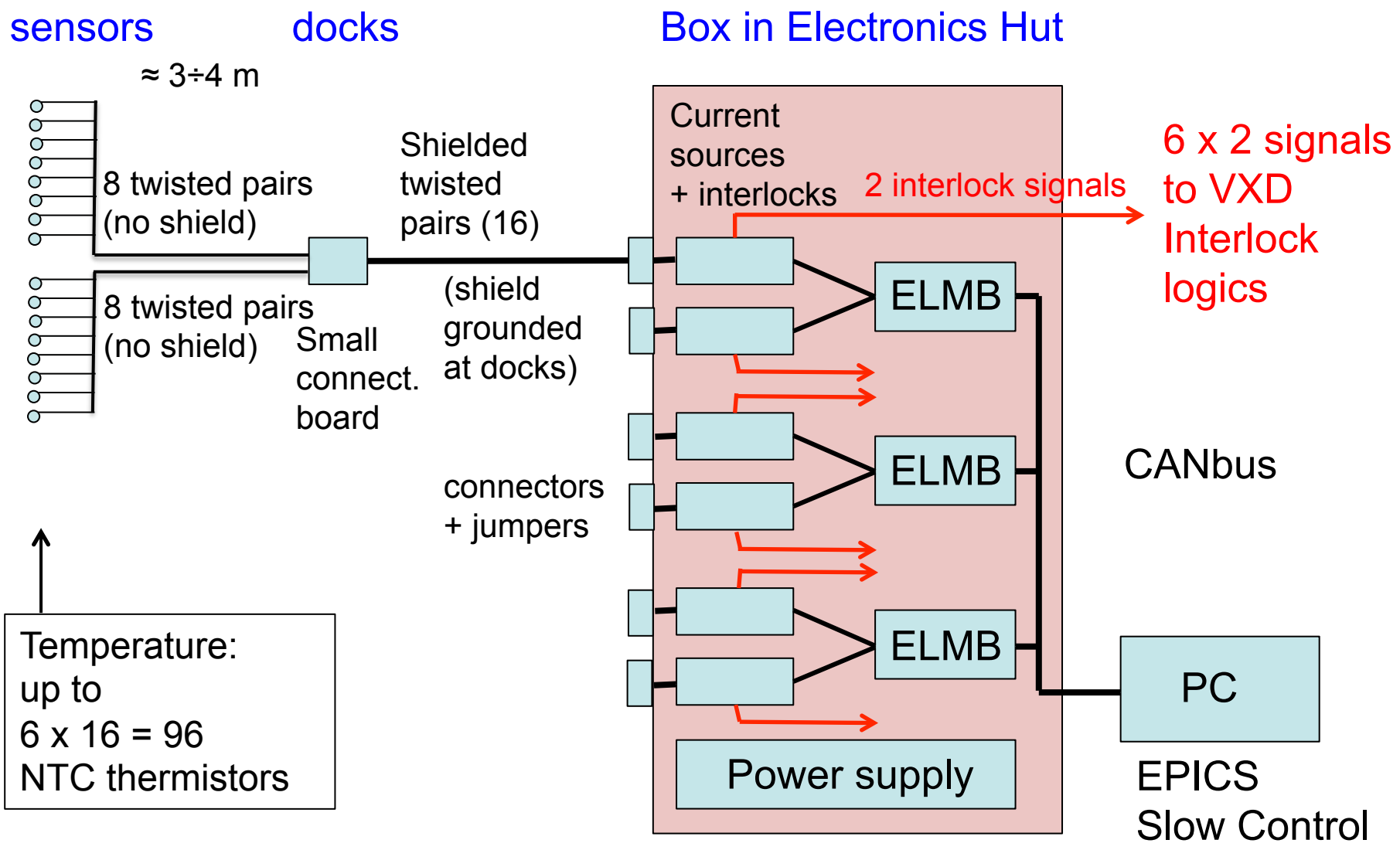


FOS temperature sensors: status

- Recent purchases (delivery foreseen: early 2015):
  - 16-channel interrogator, Micron Optics (Pisa)
  - Procurement of prototypes with different numbers of sensors per fibre, from 2 providers:
    - Micron Optics
    - Smart Fibres
  - Final purchases
    - Early 2015

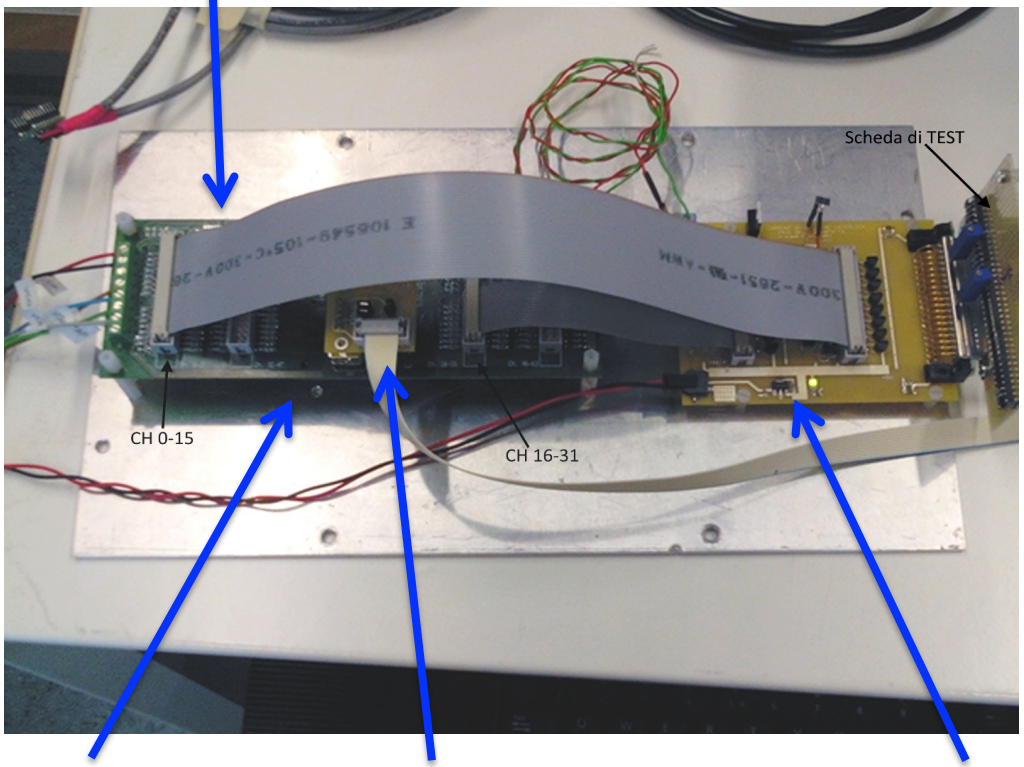
- Environmental chamber for calibrations
  - [−30°C ÷ +70°C], available in Trieste

NTC ELMB readout, preliminary design

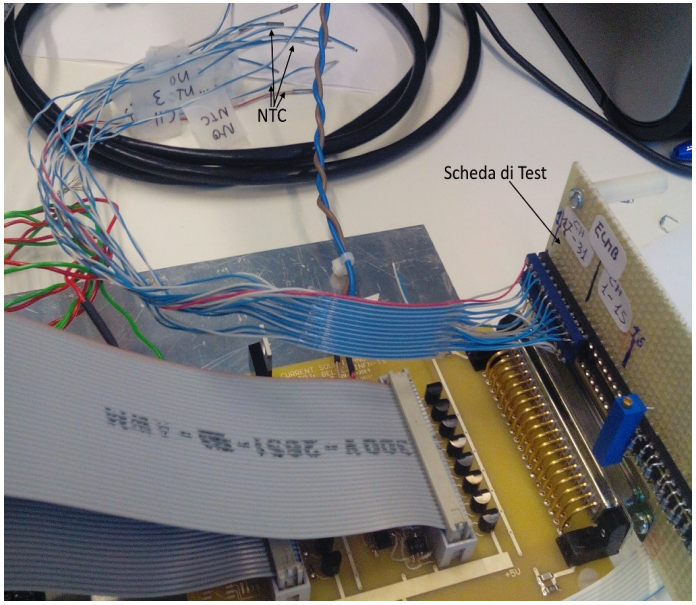


NTC: full prototype chain tested

Motherboard



100k NTC thermistors
- Betatherm (TS)
- Murata (Vienna)



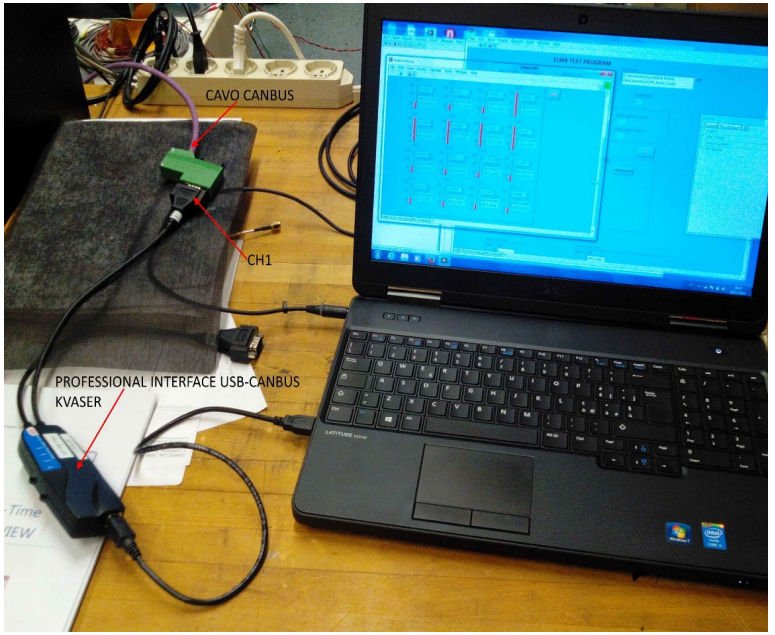
ELMB board

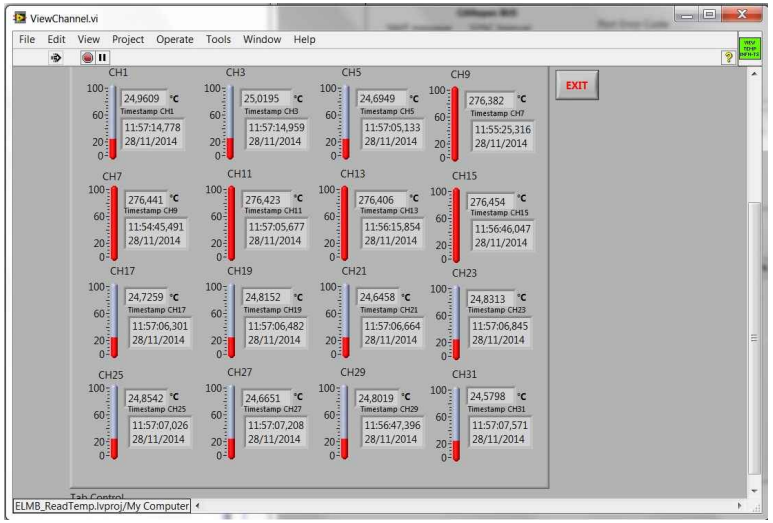
CANbus adapter

Current sources
Interlock comparators

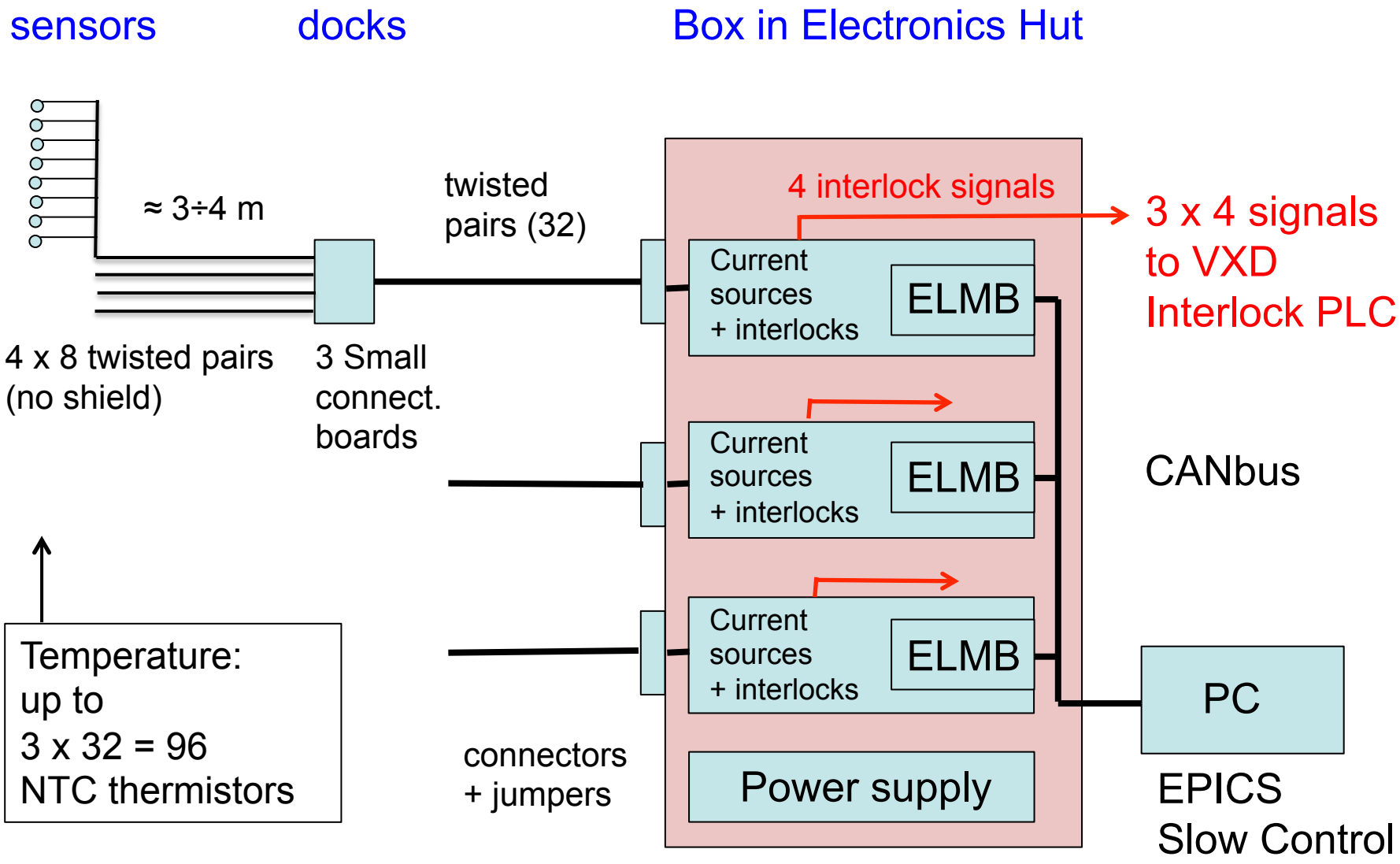
Interface, software and stability

- New Kvaser CANbus-USB interface installed
- Software
  - Stand-alone debugging program
  - LabView + CANopenOPCServer 2.9.7.4
  - (EPICS: expert visit expected)
- Uniformity and stability tests on 11 thermistors
  - OK !



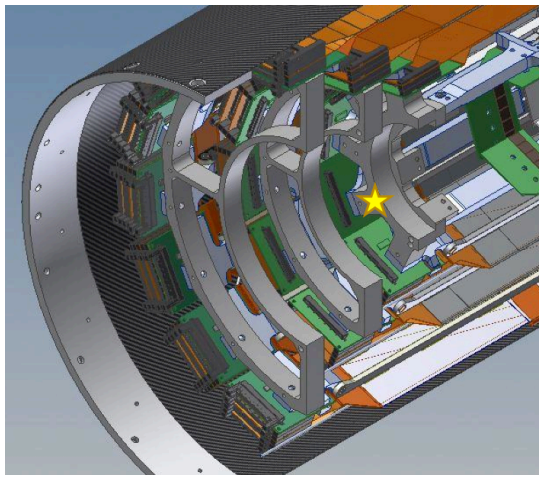


Final motherboards design, underway



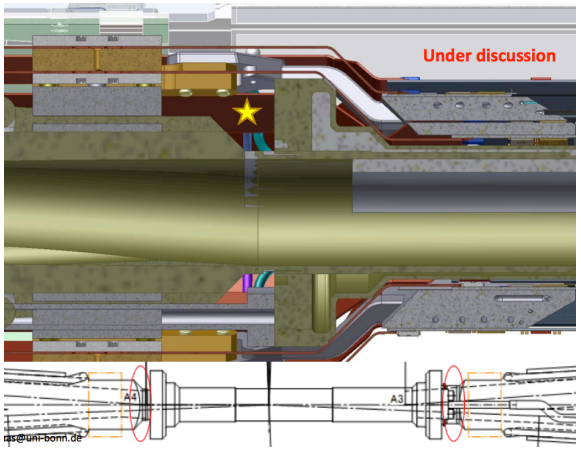
RADIATION MONITORING & BEAM ABORT

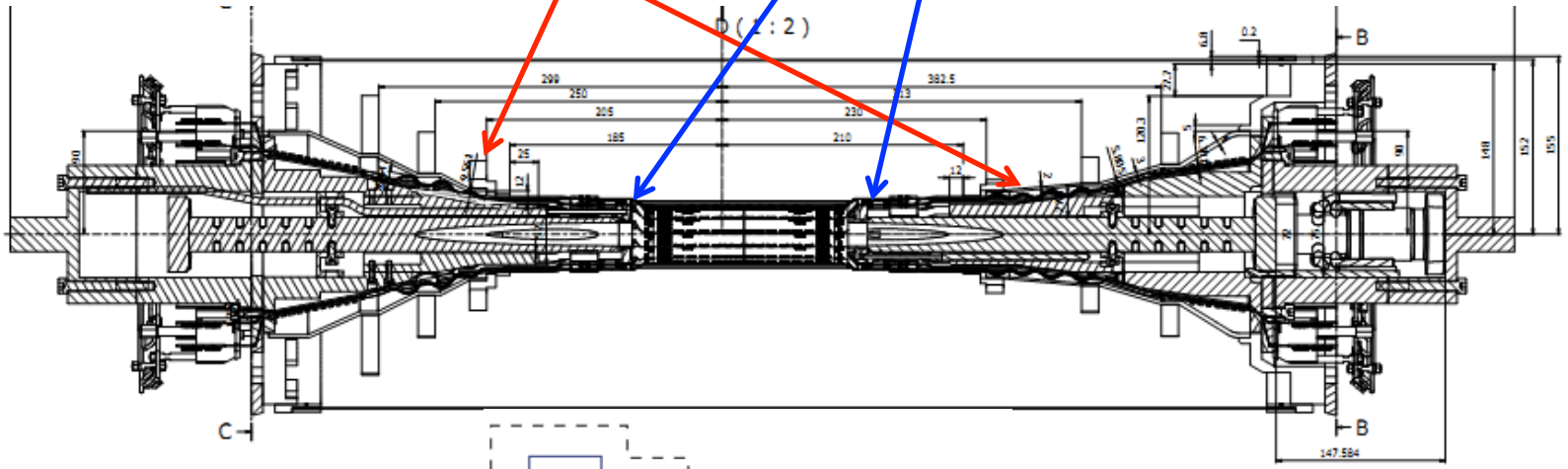
scCVD radiation sensors



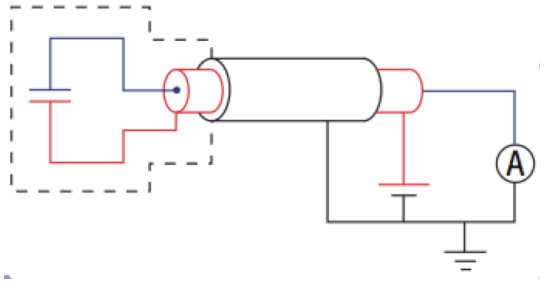
4 + 4 sensors
PXD-beam pipe

6 + 6 sensors
close to SVD L3
support rings





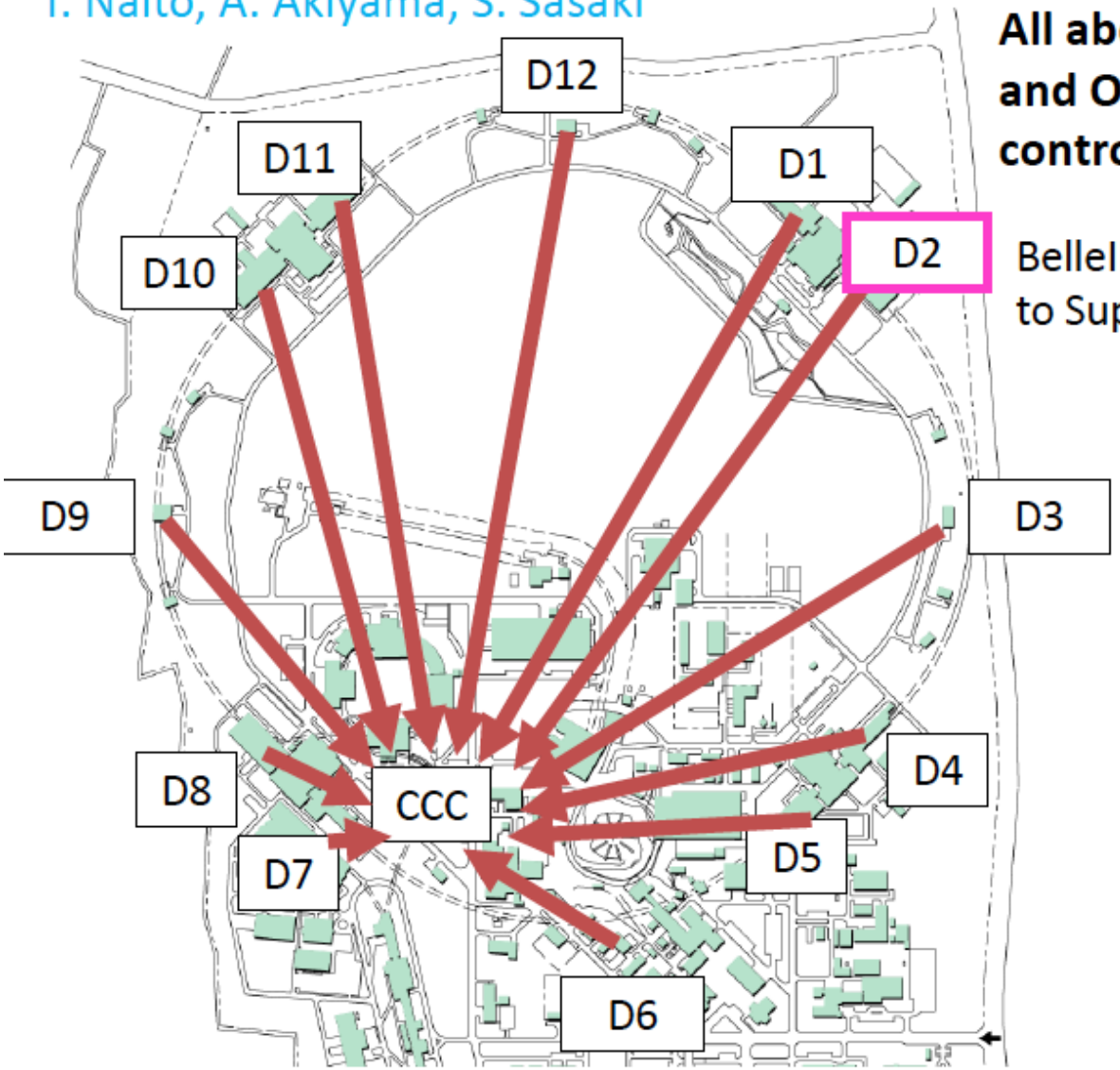
Shielded
diamond
sensors



3+15 m (3+40 m) cables
Voltage sources (150÷500 V)
picoAmmeters

Abort trigger system for SuperKEKB

T. Naito, A. Akiyama, S. Sasaki

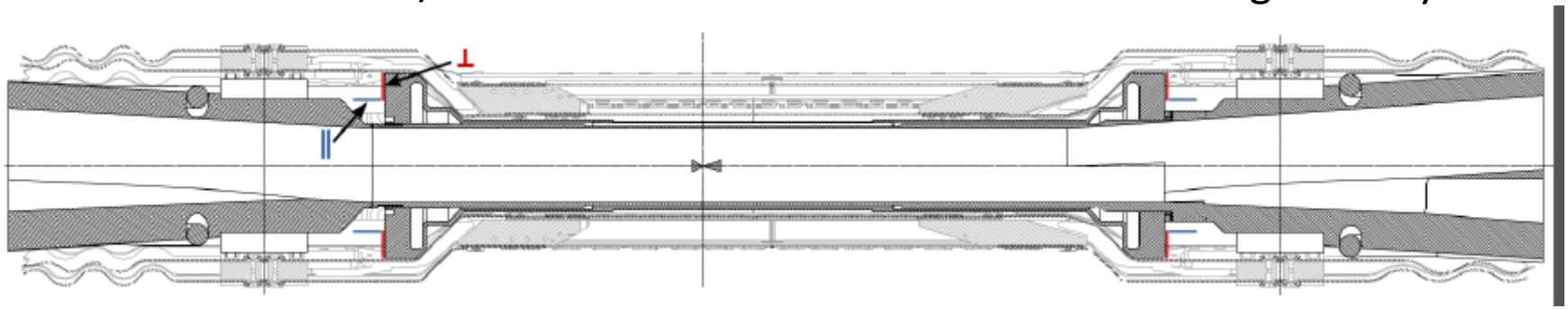


All abort trigger signal is gathered and ORed together, at the SuperKEKB control building.

BelleII Abort signal is sent to SuperKEKB via D2.

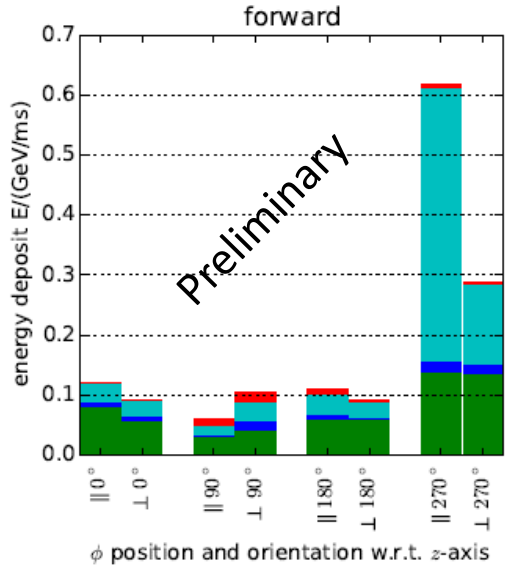
Expected radiation from simulations

VXD radiation/abort sensors now included in simulation geometry

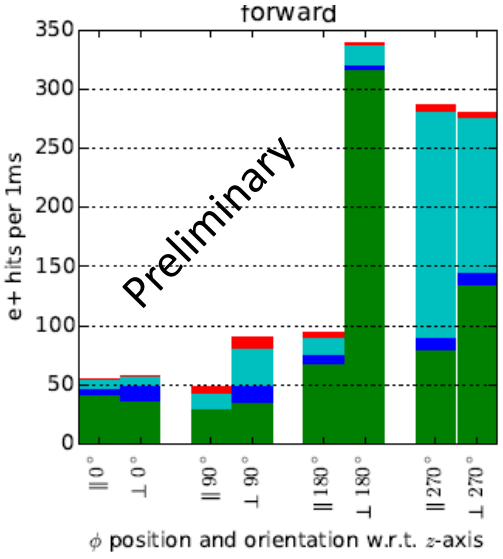


TwoPhoton Touschek RBB Coulomb

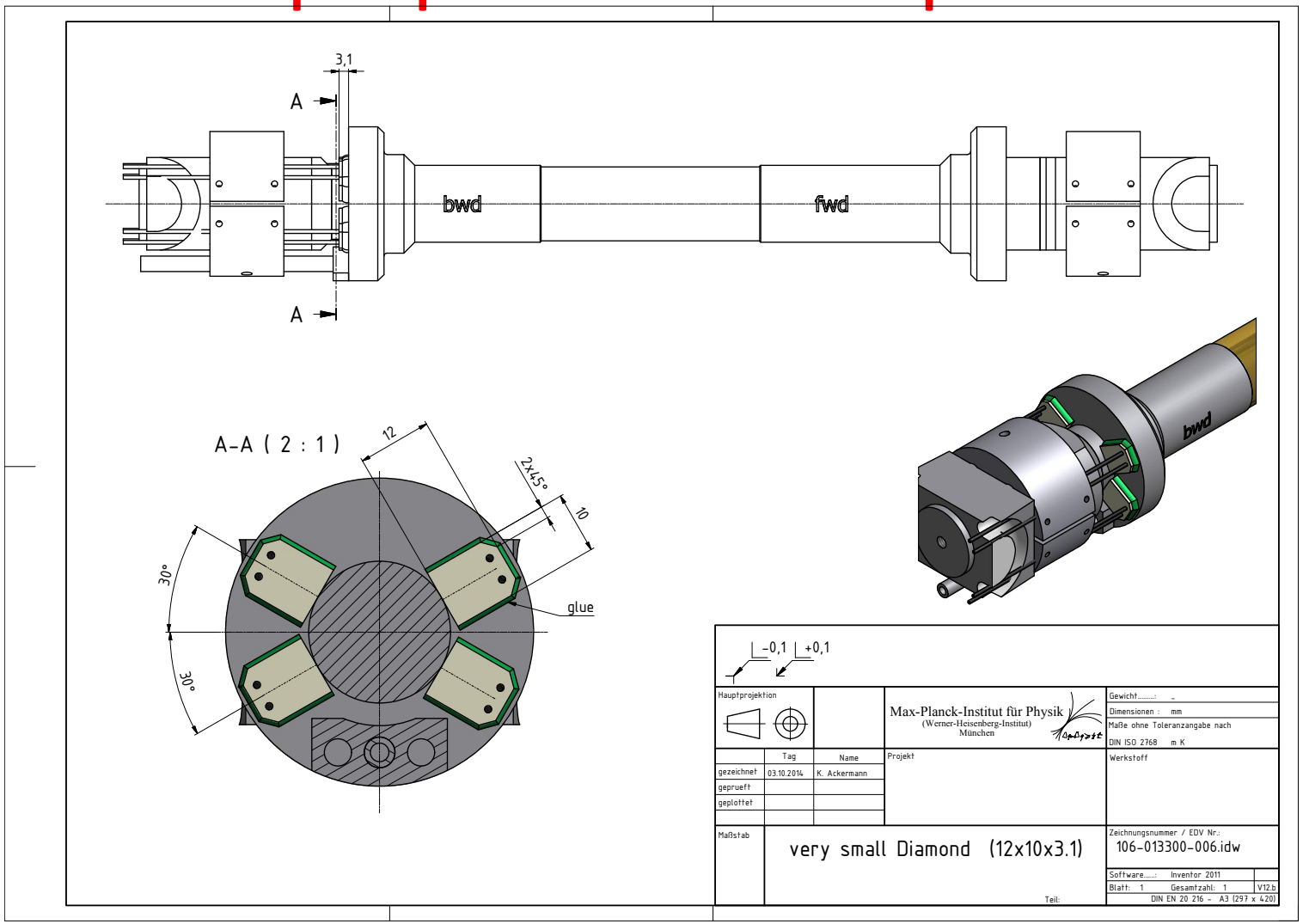
Energy deposit



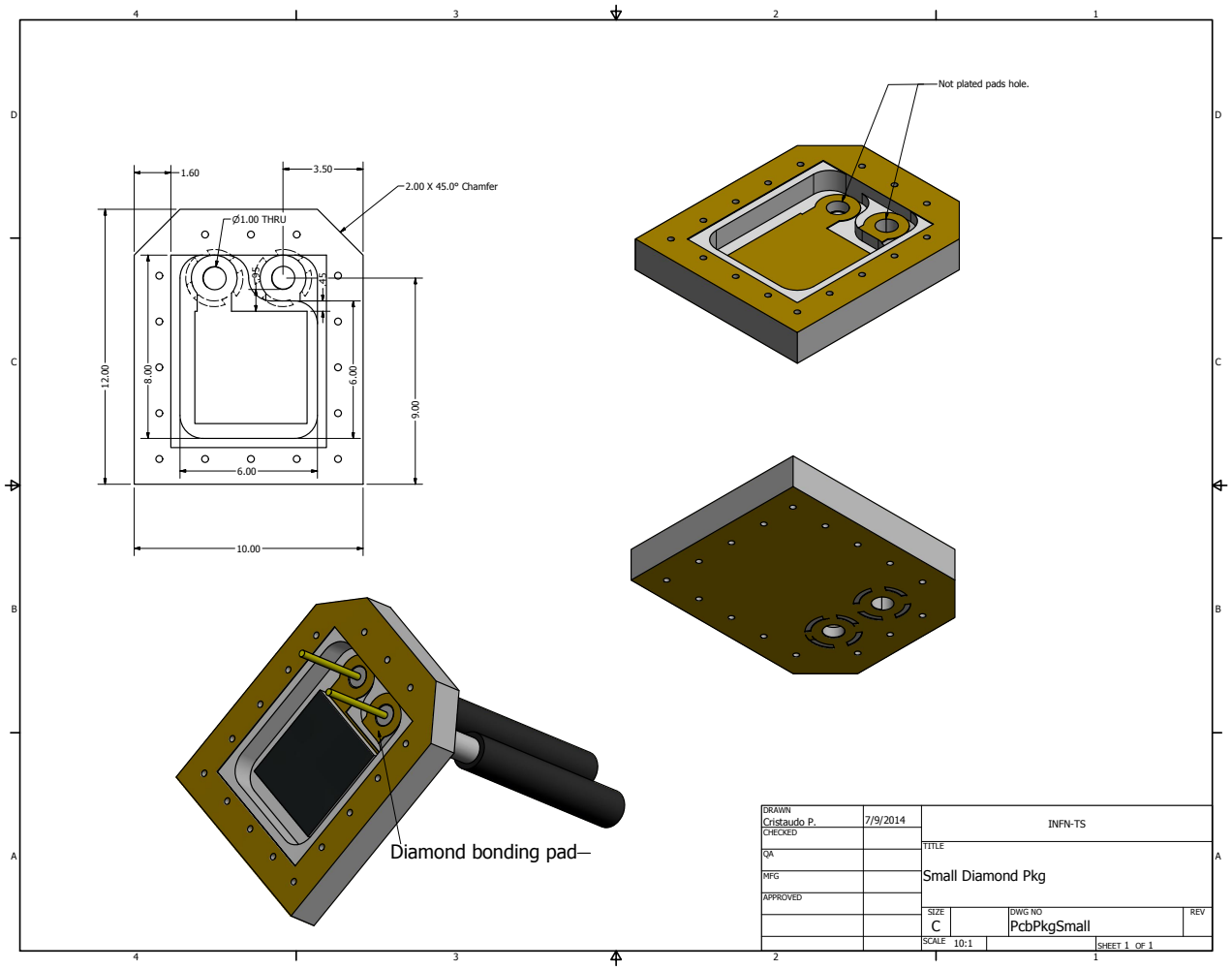
Particle fluence (e-)



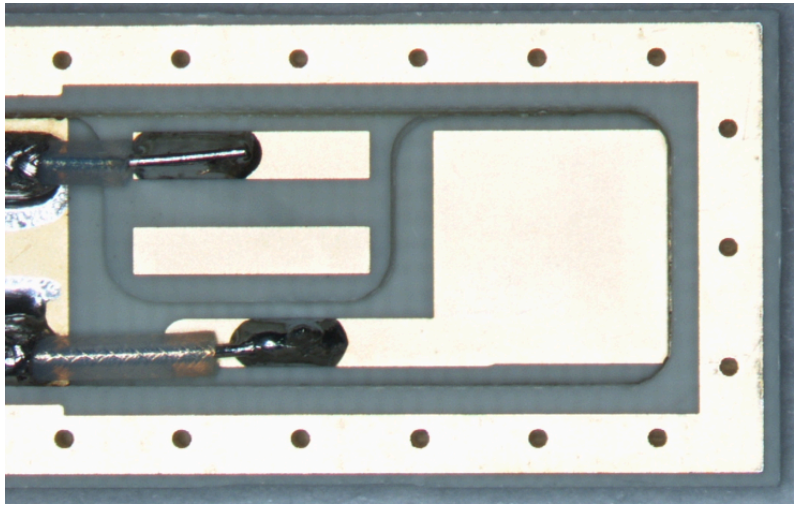
Location for “beam pipe” sensors: “perpendicular” option

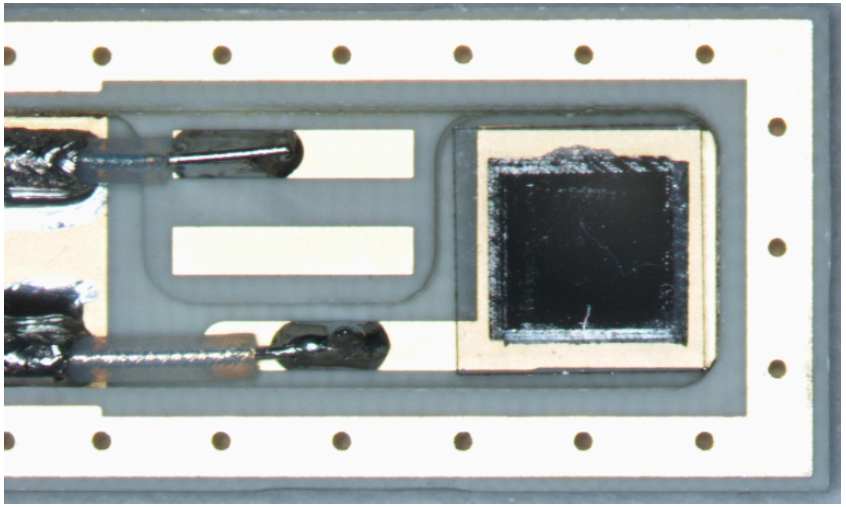


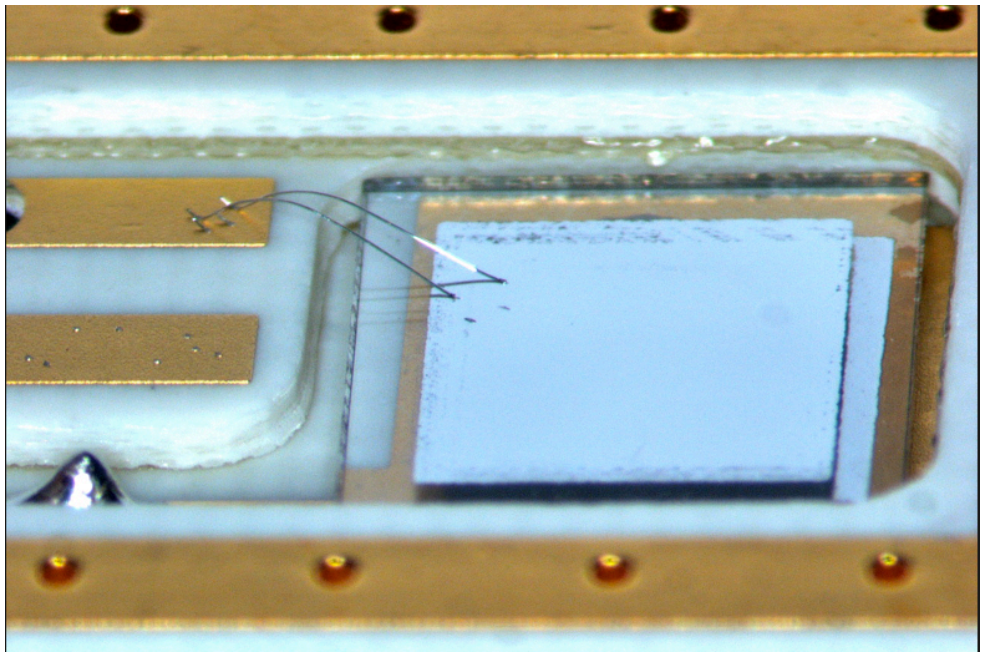
Modified package for “perpendicular”



First tests of “final” package

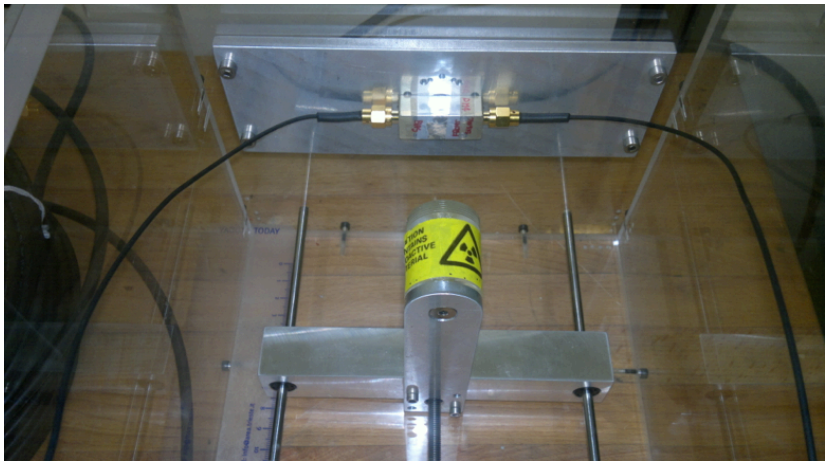


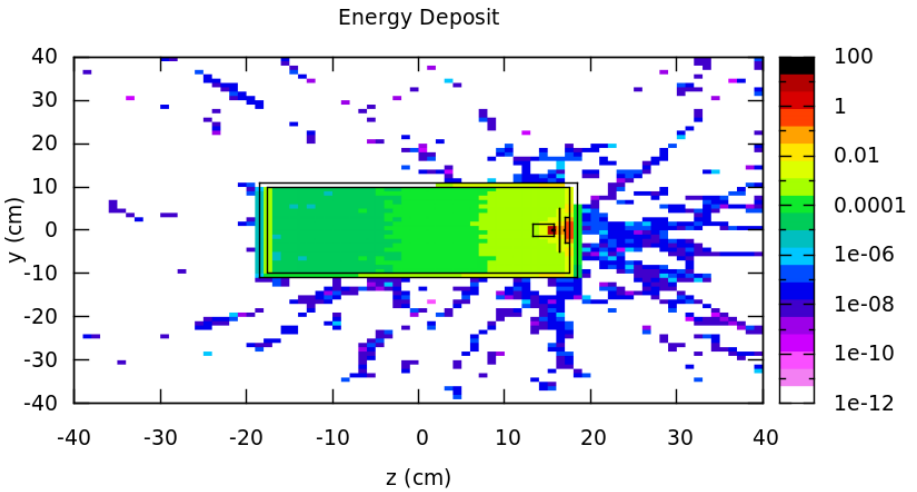


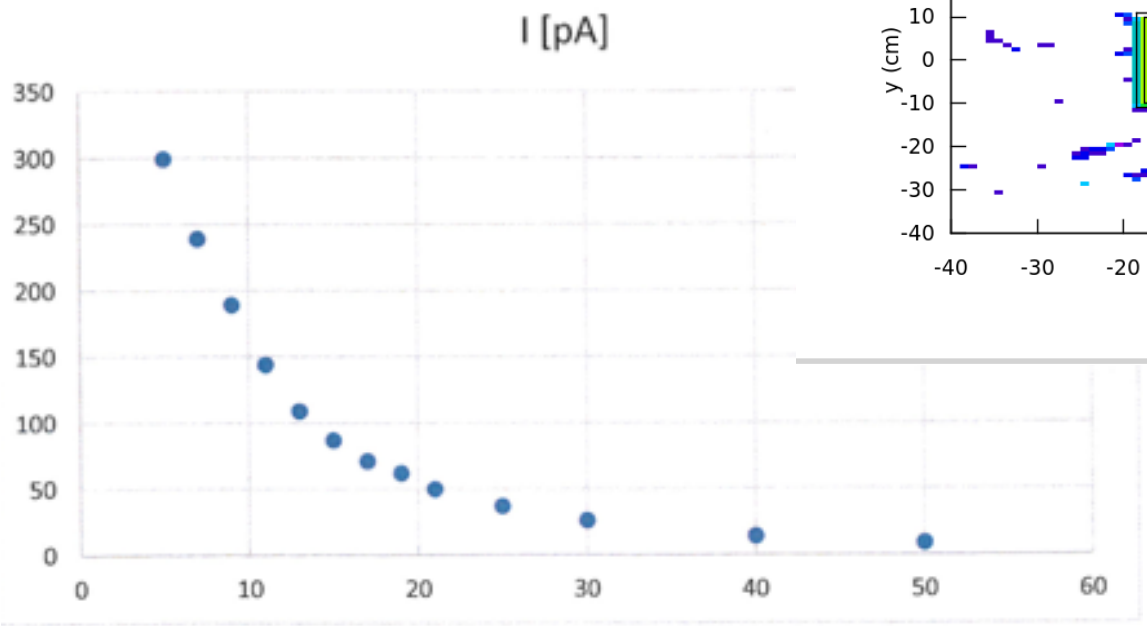


After MIPs tests: dosimetry

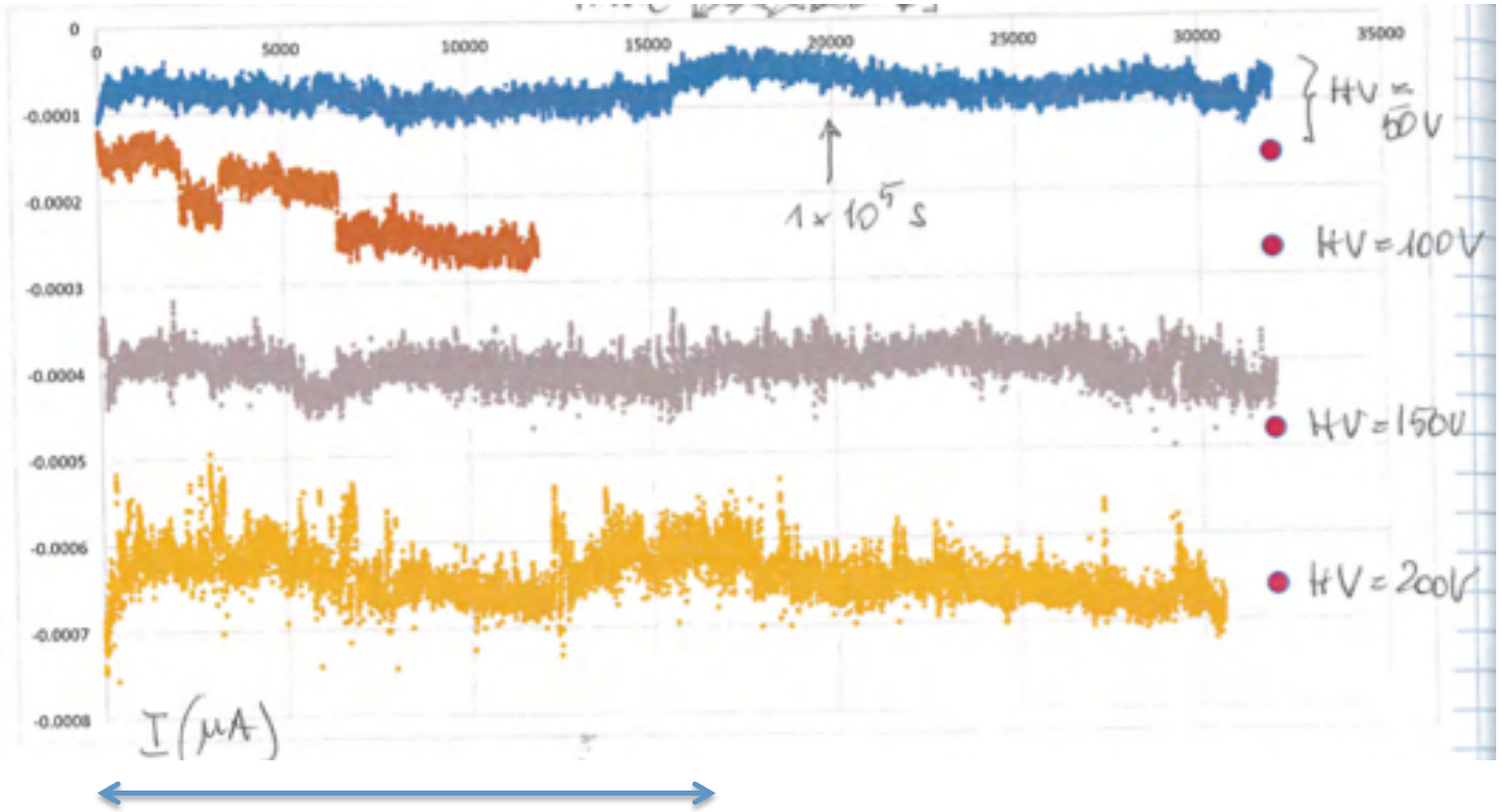
Sr90 point-like source, 2 MBq, at different distances, compared to FLUKA simulations







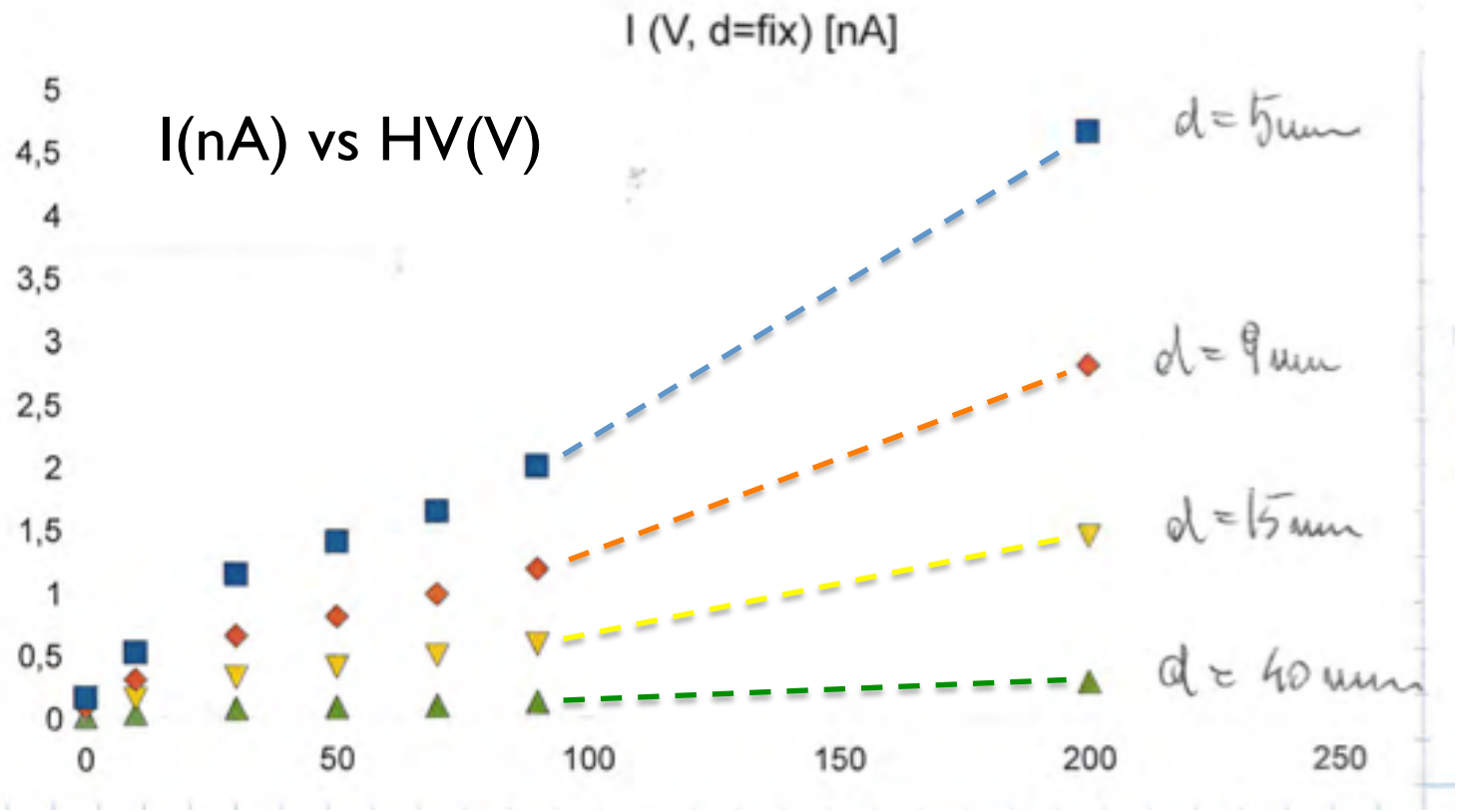
Long term stability studies



1 day

HV = 50-200 V

Current (dose rate) vs HV



unexpected voltage dependence (no saturation?)

- on both tested sensors (Micron)
- at all distances
- cross checked with different picoammeters

Diamond sensors are not that simple

- Simplest model: just “ionization chambers”, but…
- pCVD, known solid-state effects:
  - “pumping” or “priming” (filling of long-lived “deep” traps)
  - on/off transients (“shallow” traps, space charge and polarization)
  - electrodes: complicated metal-diamond interfaces
    - blocking vs ohmic contacts, depending on materials & preparation
    - charge injection and “photoconductive gain >1” are possible
- scCVD: less defects, more stable behaviour
  - However similar (smaller) effects are possible
  - Seen in our lab, to some extent (transients, gain?)

Sensors: plans

- One “final” Cividec prototype ordered recently
- Final acceptance tests will include:
  - I-V without irradiation, both polarities
  - Charge collection efficiency, MIPs (^{90}Sr β-source)
  - Currents/dose rates measurements (^{90}Sr β-source)
  - Possibly: additional tests (^{241}Am α-source, TCT technique)
- At the moment Cividec
  - seems to be the most expert commercial provider of complete, metallized (and preliminarly tested) sensors

Progress in electronics design

- Collaboration with electronics&detectors group at Elettra, Trieste
  - G. Cautero, D.Giuressi, R.H.Menk + F.Vulpone (student)

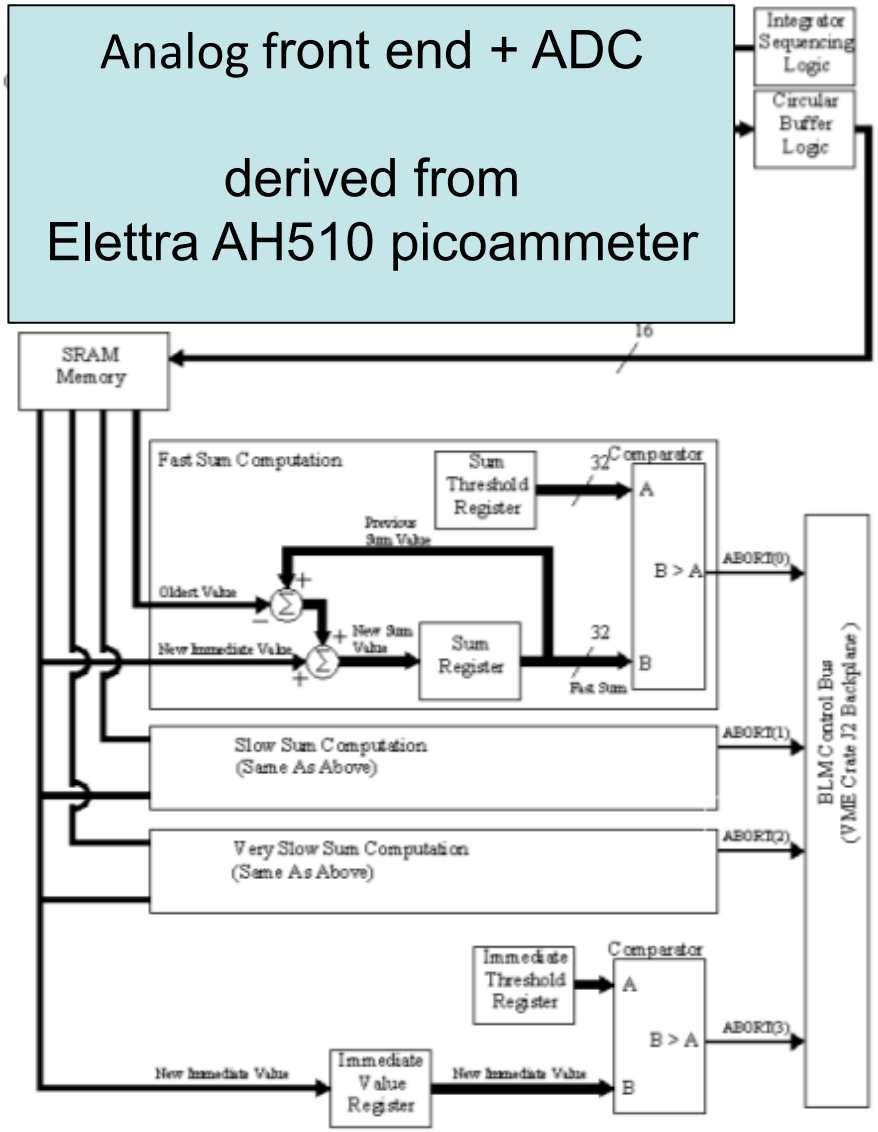
- Modular design, FPGA + Memory + ADCs + HV + Ethernet
  - project's kernel: ALTERA DE3 evaluation board, with a STRATIX III FPGA
  - External memory: Transcendt 1GB DDR2 RAM
  - 3 peripheral boards will be connected with DE3
    - board with 4 ADCs, HSMC connector
    - board with 2 Ether-W-ease (ethernet), 2 GPIO connectors
    - board with 4 DACs and 4 HV diamond bias outputs

- Schedule plans:
  - "Final" prototype available for test with 4 sensors at BEAST phase 1
  - "Production" modules ready for BEAST phase 2

BLM Digitizer Card ("logger"):
ADCs, circular buffers, running sums

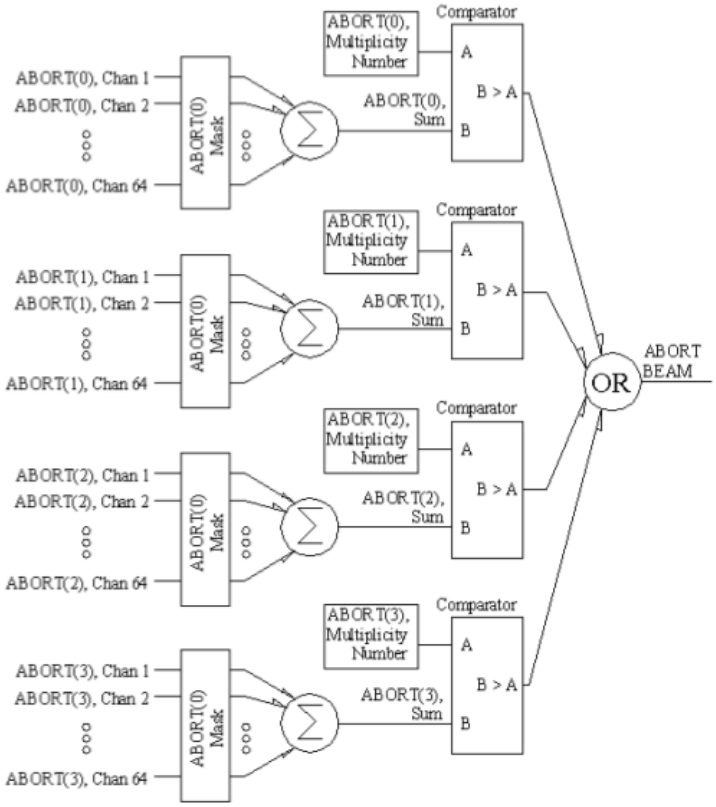
Analog front end + ADC

derived from
Elettra AH510 picoammeter



Desired functionality:
similar to Fermilab BLM

BLM Abort Card:
masks, majority logic,
thresholds (4 levels)



Similar approach: BLM at LHC

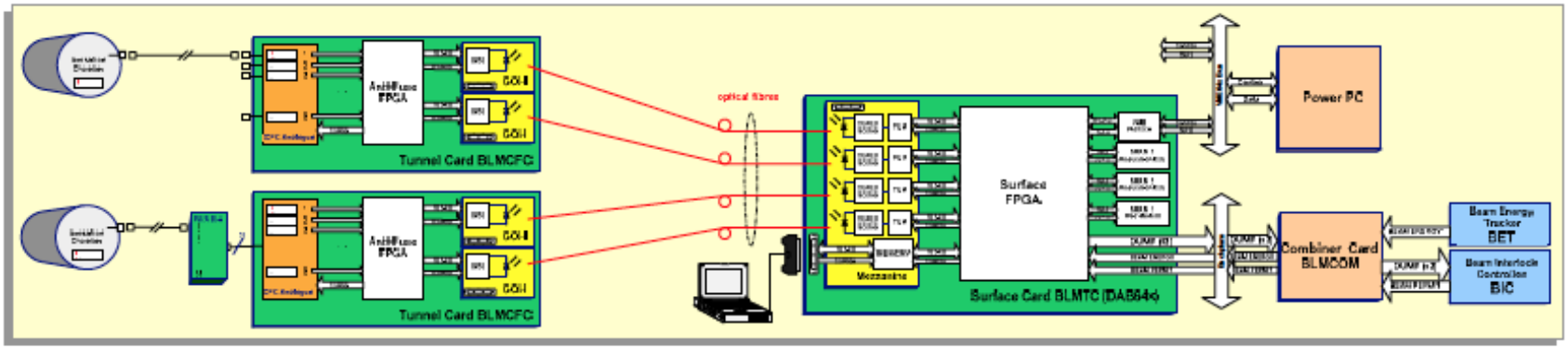


Figure 1: Overview of the complete BLM System for the LHC.

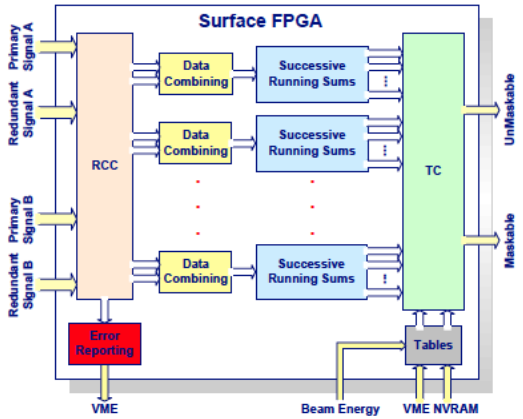


Figure 2: Block diagram of processes related to data analysis running in the surface FPGA.

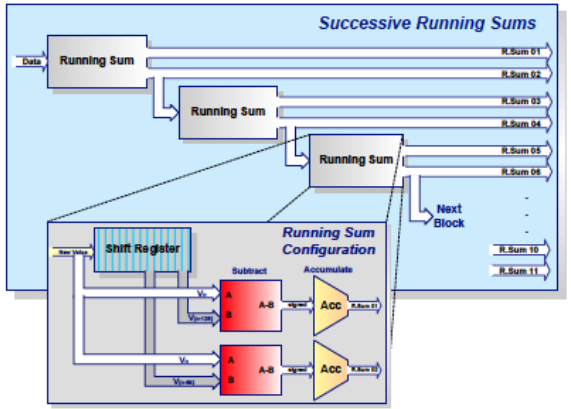


Figure 5: Production of Successive Running Sums.

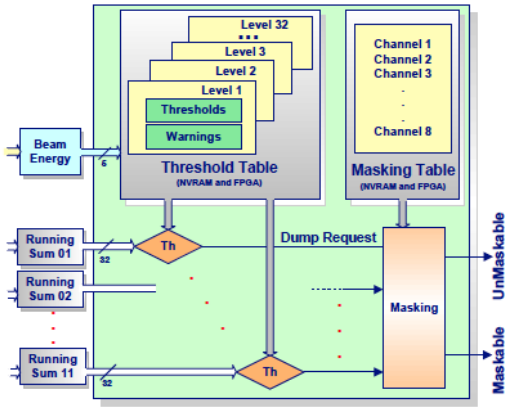
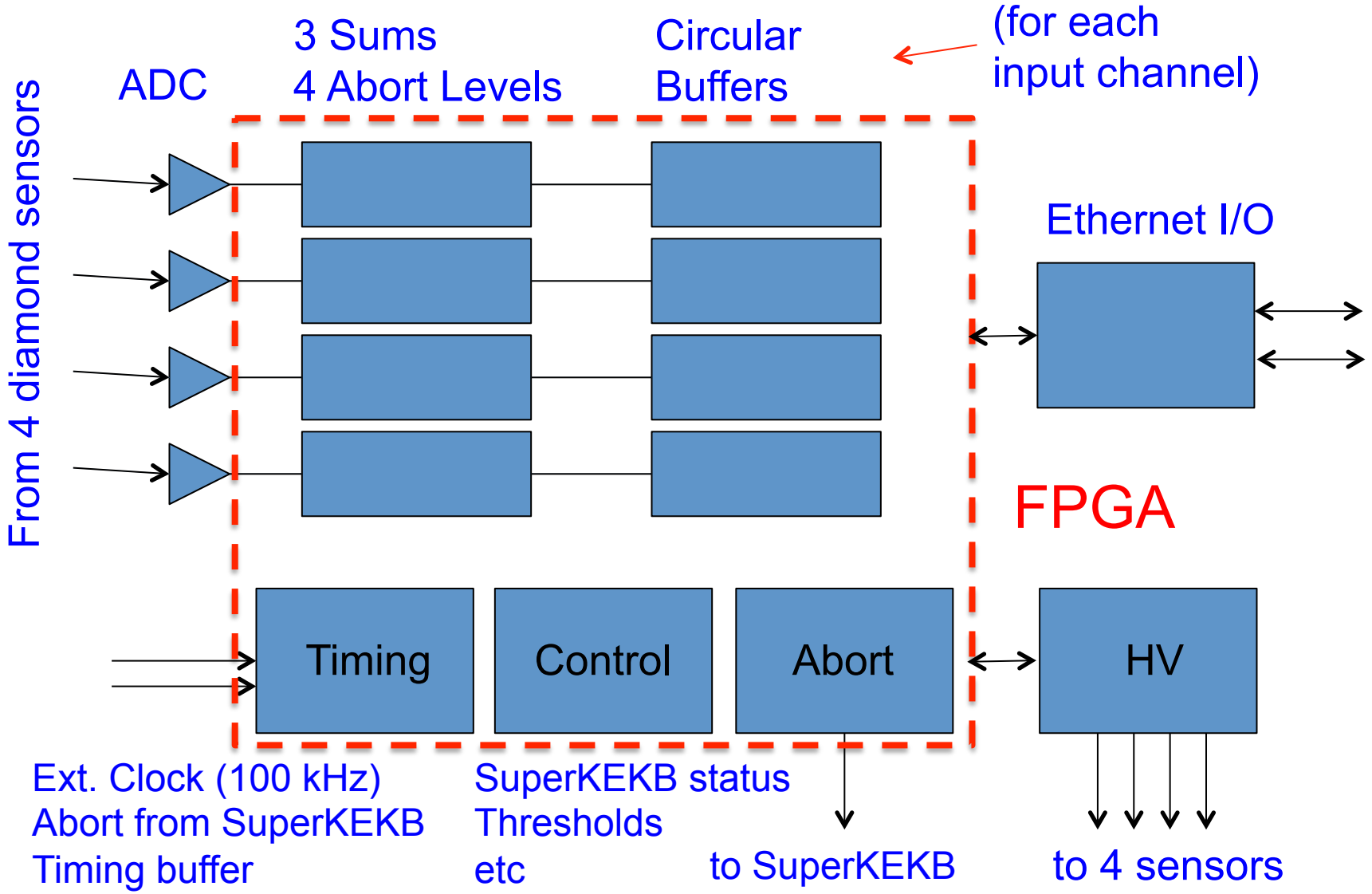


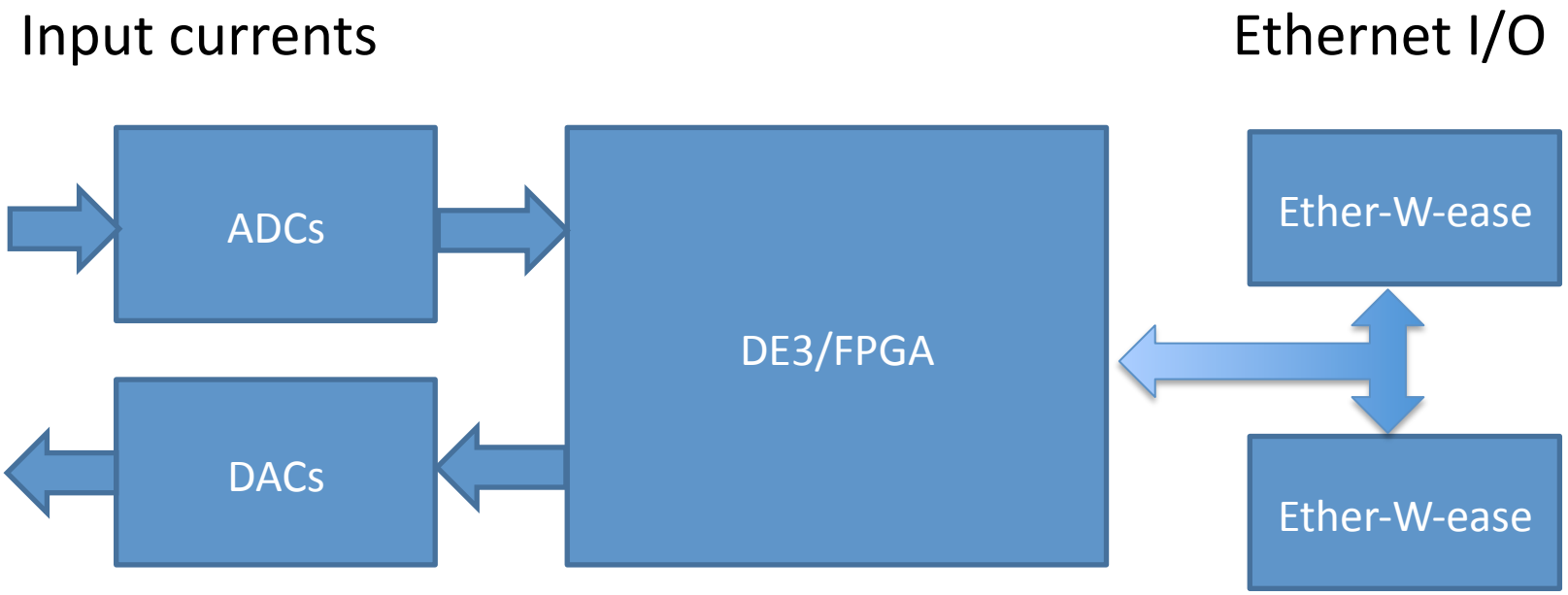
Figure 6: Threshold Comparator (TC) Block Diagram.

FPGAs Running Sums Thresholds

Rad.Mon+Abort, 4-channel Box



Design and implementation plans



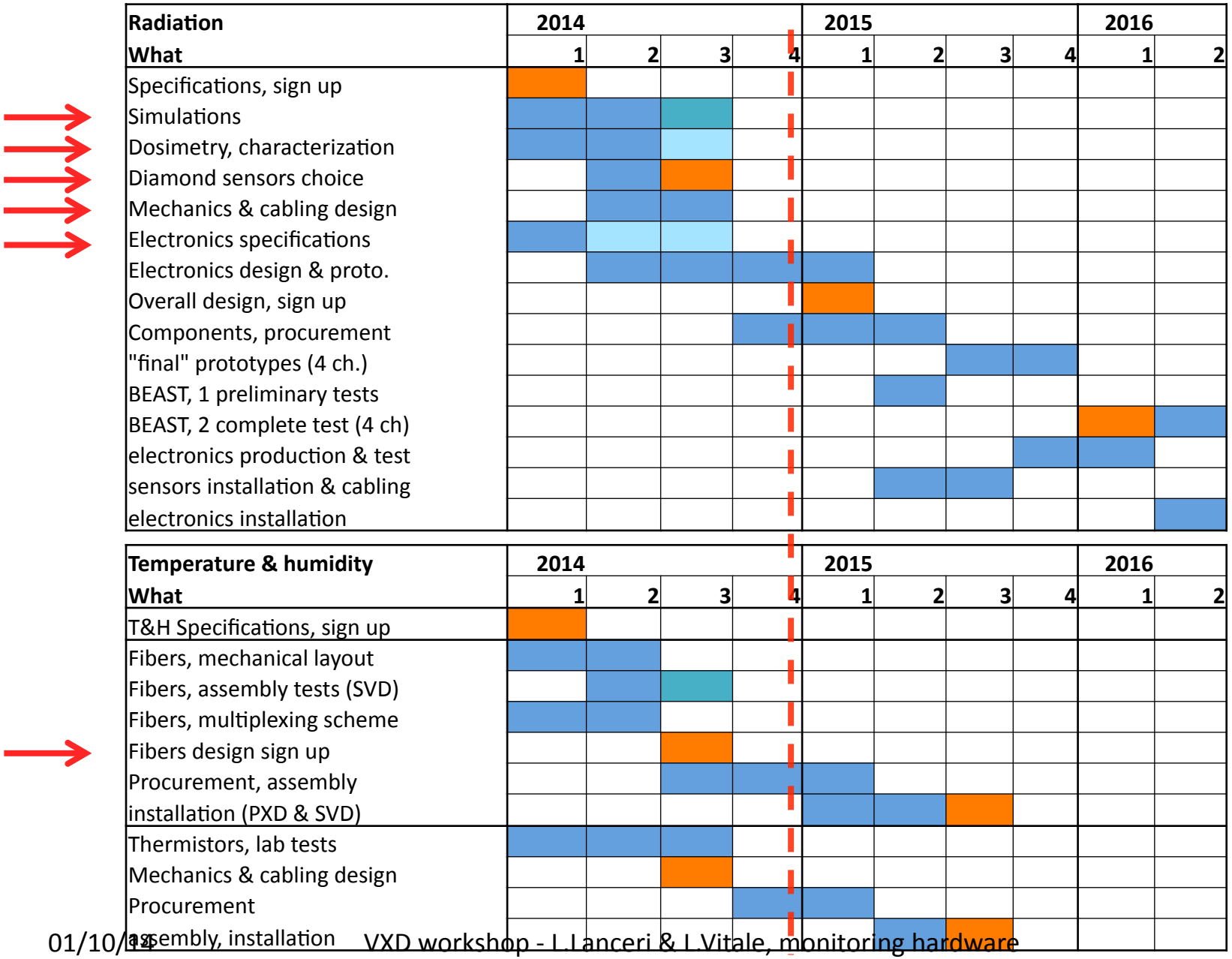
- read and write the external RAM memory using the FPGA
- Design and prototypes of the ADC's and DAC's boards
- Design and prototype board with two Ether-W-ease
- VerilogHDL program for the FPGA
  Synchronization, buffers, running sums, thresholds, abort logics

Summary

- Good progress on:
  - Micron and HPK microstrip sensors tests
  - SVD+PXD interlocks: PLC
  - Humidity monitoring/interlock
  - Temperature monitoring
  - Radiation monitor & beam abort

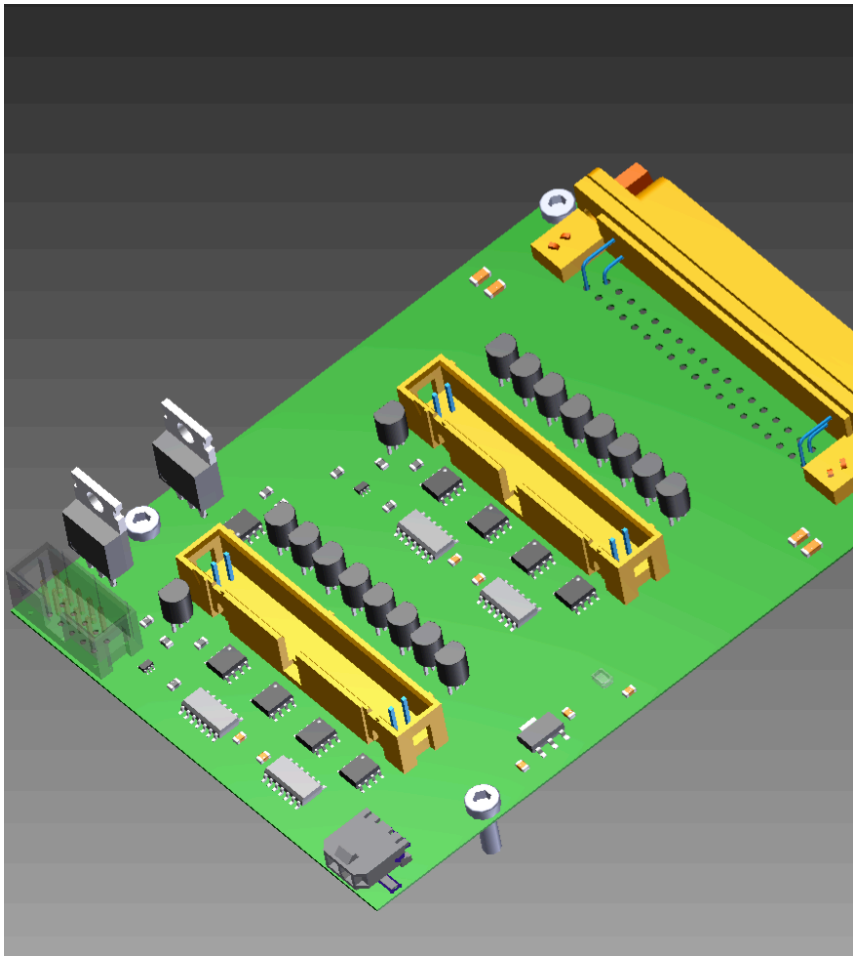
- A very busy 2015 ahead!

Approximate schedule



Back-up slides

NTC current sources and interlock signals

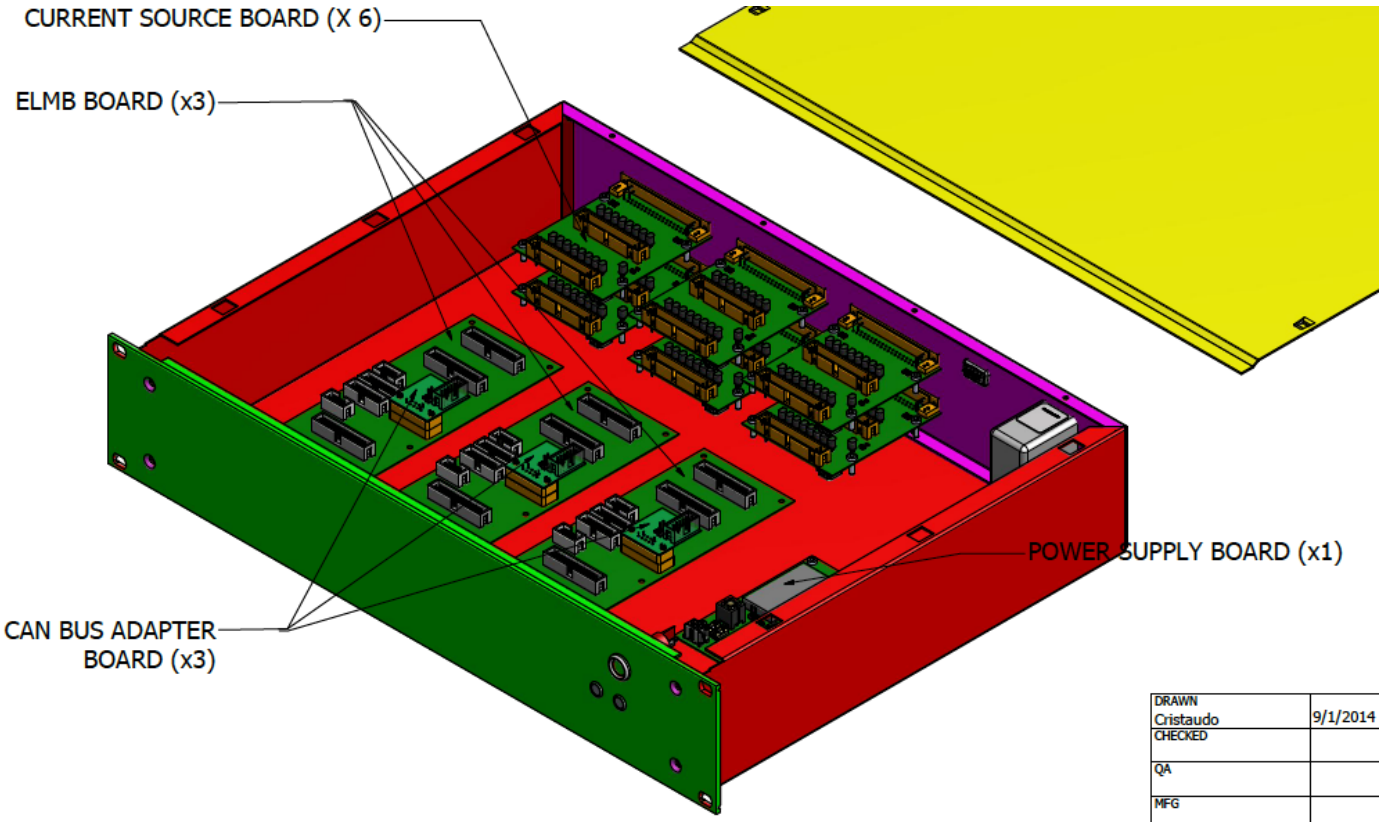


- 6 small boards, each:
  - Current sources for 16 NTCs
  - 16 comparators with hardwired thresholds
  - 2 interlock signal outputs (each: OR of 8 channels)
- Built-in redundancy
  - 2 NTCs per measurement point
  - Each contributes to a separate interlock OR
- Design completed, prototype channel tested

ELMB-based NTC readout

In one box, with 3 x 32 NTC channels modularity:

1 power supply board, 3 motherboards with ELMB and CANbus adapter, 3 x 2 current source (16-channel) boards, 3 x 2 x 16-channel connectors



Mechanics, cabling

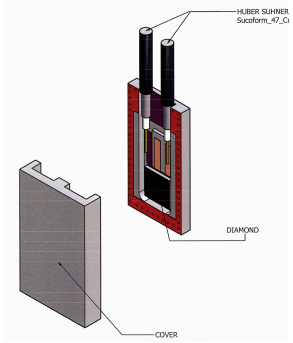
Compact packages:

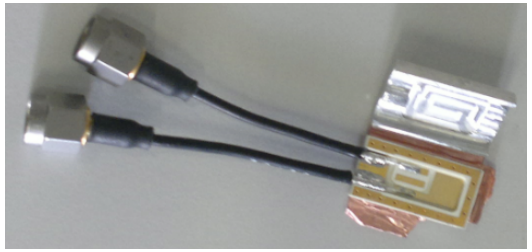
1) SVD 12 x 20 x 3.1 mm^3

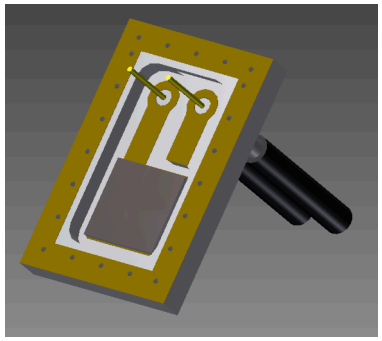
multi-layer package, Rogers laminate ok for SVD (we already have 28 pc)

2) PXD 12 x 10 x 3.3 mm^3

Same material, with perpendicular or parallel mounting (simulation)



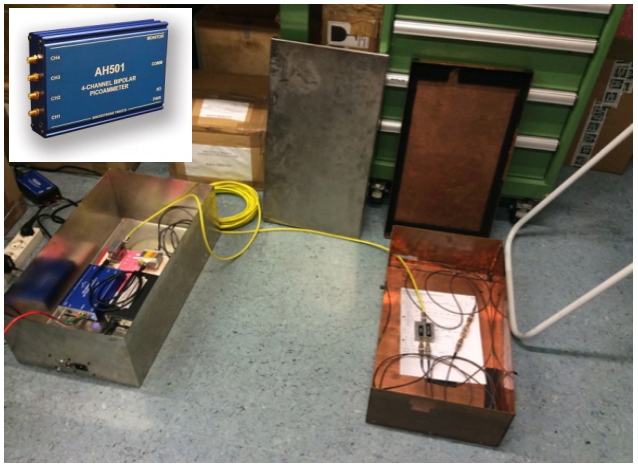




Cabling (~20 m)

3 m coaxial thin (HS SM47LSFH) from sensors to DOCKs

+ 15 m (or more) HS S_04162-B60, double shield

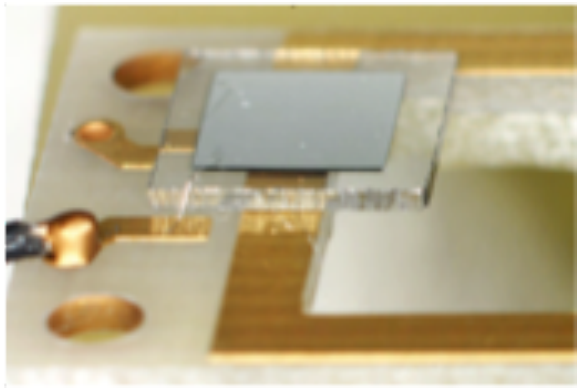


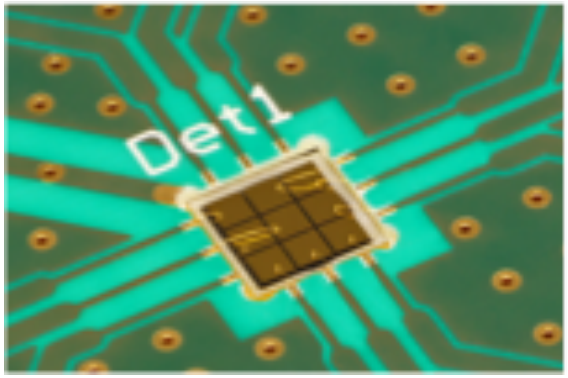
Diamond sensor characterization

Label	Provider	sc/p CVD	Geometry mm^3	pads	Validation ^{90}Sr beta
PD	DDL	sc	4.7x4.7x0.15	2x2	OK
DC1	Cividec	sc	4.7x4.7x0.50	3x3	OK
DC2	Cividec	p	5.0x5.0x0.50	3x3	TBD
DM1*	Micron	p	5.0x5.0x0.50	1	OK
DM2*	Micron	sc	4.7x4.7x0.50	1 round	OK
DM3	Micron	p	5.0x5.0x0.50	1	Rejected
DM4	Micron	sc	4.7x4.7x0.50	1	OK
DM5	Micron	sc	4.7x4.7x0.50	1	OK
DM6	Micron	p	5.0x5.0x0.50	1	TBD

Diamond sensors

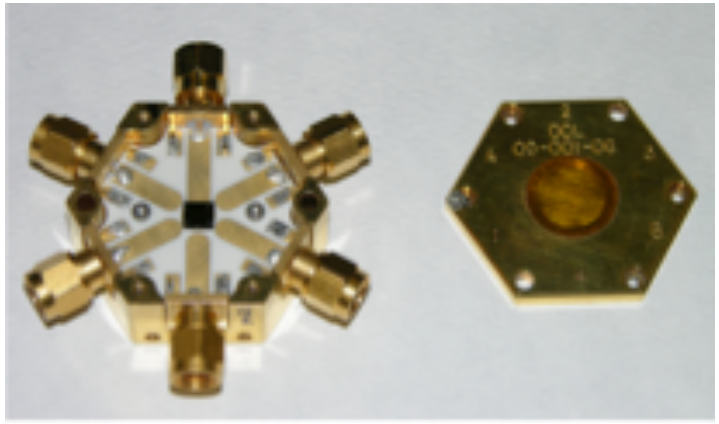
DM1





DC1

PD

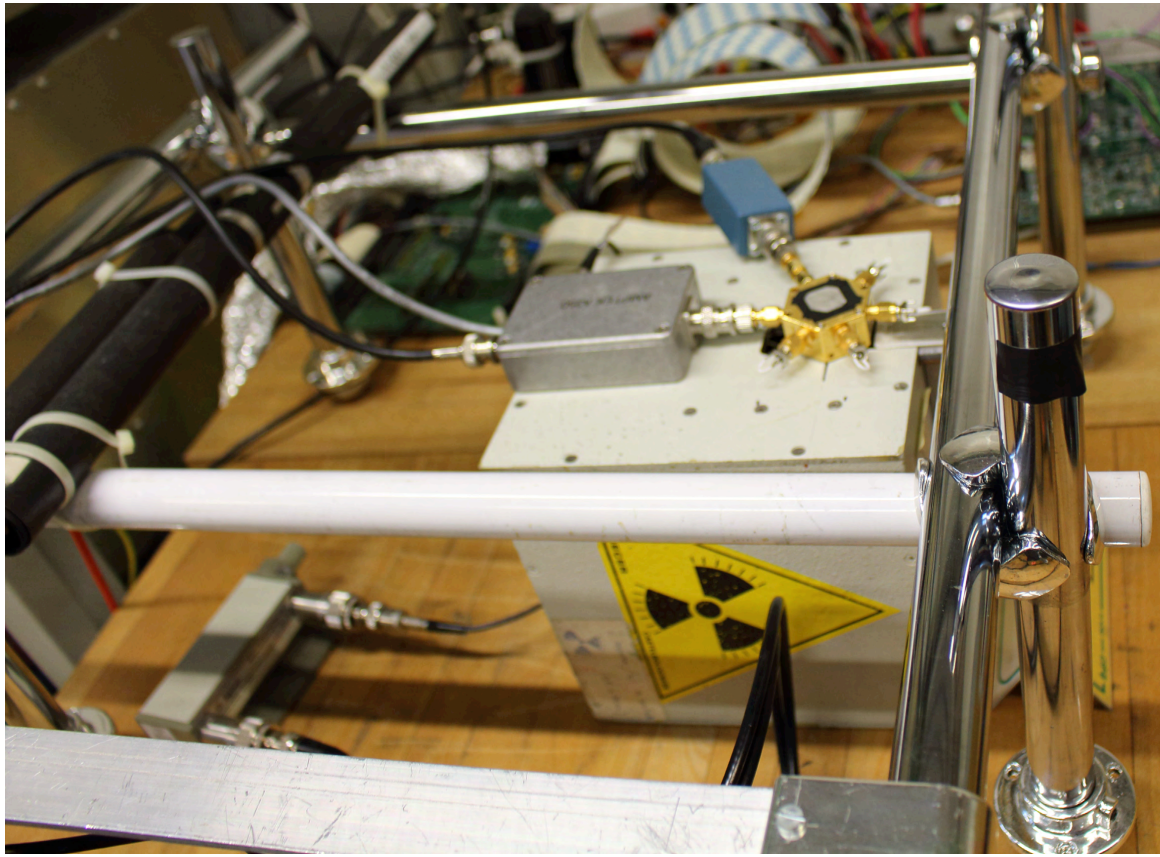


DM4

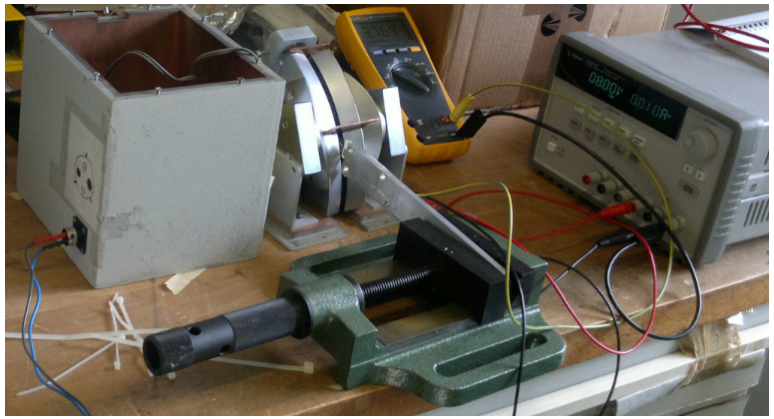
Test tools

- Static characterization of the samples (I-V and C-V)

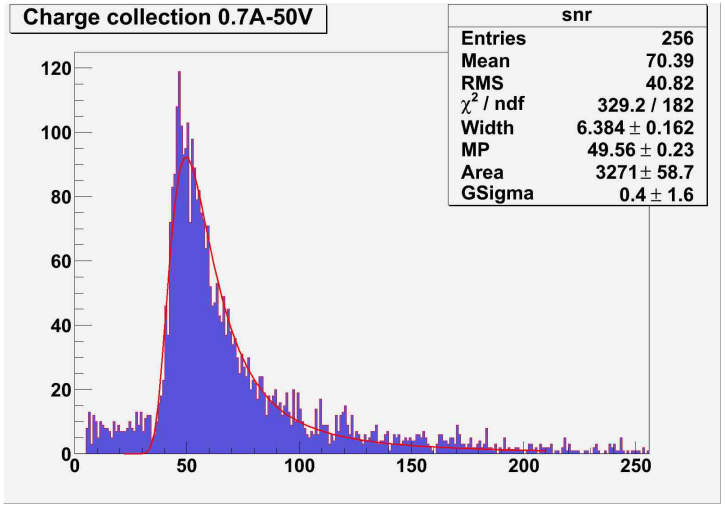
- Single channel Amptek chain: A250 preamp. (2.5 ns risetime) + PX5 digital shaper (semi-gaussian equivalent time 40 ns – 40 µs).
- A pointlike ^{90}Sr source (~2 MBq), beta spectrum hardened by magnetic field and collimators
- Tests repeated at DESY 2-6 GeV electron beam

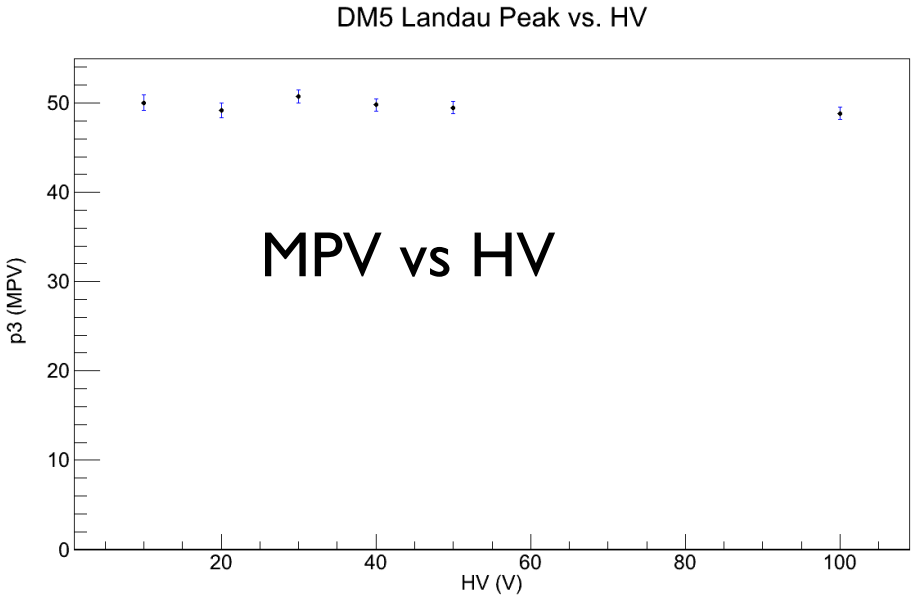


MIP Characterization of scCVD sensors



Single electrons, 1-2 MeV (MIP): Landau peak vs HV





Belle II-VXD Radiation Monitoring and Beam Abort

- Main requirements
  - Measurement of instantaneous dose rates & integrated doses
    - Sensitivity ≈ 1 mrad/s = 10 µGy/s, sampling rate ≈ 100 KHz
  - Beam Abort for excessive beam losses affecting PXD, SVD
    - Programmable thresholds, depending on accelerator conditions (filling injection, stable beams, machine development, …)
    - "Fast" (10 µs = 1 accelerator revolution) Beam Abort trigger
    - "slower" Beam Abort triggers, based on digitally filtered signals (averages over programmable numbers of samplings)
- Conceptual design
  - Based on experience from Belle, BaBar, CDF, LHC
  - scCVD diamond sensors, measurement of currents:
    - Reference: typical pCVD sensor (10 × 10 × 0.5) mm^3 @ 500V: 1 nA = 7 mrad/s = 70 µGy/s
    - Noise should be limited to a few pA, in current measurements
  - 4 + 4 sensors located near PXD (very limited space)
  - 6 + 6 sensors located near SVD
  - Background dominated by electrons

VXD Monitoring & Beam Abort electronics

5 modular Boxes, dealing with 4 scCVD sensors each:

- 4 individual HV bias supplies
- Currents digitization with 4 (16-bit) ADCs at 160 MHz, with oversampling
- Data averaging and buffering for
  - Continuous Monitoring (averaged data, 1-10 Hz read-out)
  - Post-mortem (abort) analysis (full data, frozen circular buffers)
- Running Sums, Programmable Thresholds, Majority logics for Abort signals
- Ethernet interfaces (2) for programming and data read-out

Compatibility with the SuperKEKB Abort System requires:

- Sampling synchronized to SuperKEKB revolution period (10 μs)
- "SuperKEKB status" register, set via EPICS (for the selection of thresholds)
- 2 final output "fast abort" signals, correlated with LER and HER
- 600 ms deep data buffers, read out upon an abort, internal or external
- Synchronization with SuperKEKB aborts: digitization of 2 beam currents, and "abort confirmation" digital signal from SuperKEKB