SVD (VXD) Monitoring

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Belle II Italia, Padova 31/05/2016

1. DESY Beam Test & Mock-up: Temperature, Humidity
2. BEAST 1 Radiation & Background Studies (diamonds)
3. Conclusions & Planning

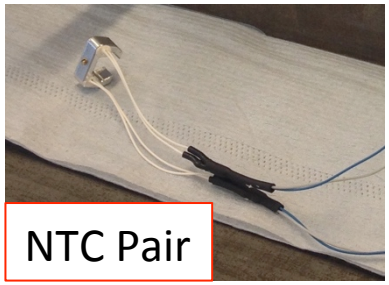
1. DESY: BEAM TEST AND MOCK-UP

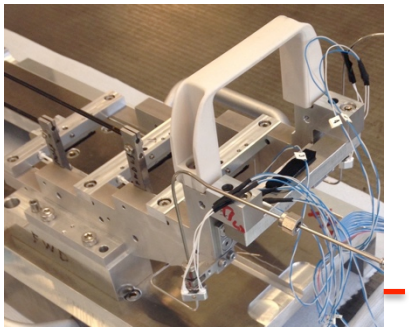
Monitoring System installed @ BT

- NTC temperature monitor:
  - 24+7 NTCs, 4 short cables (3m) - patch panel - 2 long cables (20-40m)
  - Final Readout system with LabView and with EPICS
- FOS temperature monitor:
  - 1 prototype fiber (5 sensors, SVD Layer 6), PXD interrogator (EPICS)
- Humidity, dew point measurement/alarm:
  - Simple prototype “sniffer”; copper pipe (4 mm), 16 m long
  - 1 Vaisala Dew Point Transmitter + display + pump
  - No EPICS control: display monitored by a video camera
- PLC for interlocks:
  - Simple program to detect interlock conditions from NTC thermistors
  - No EPICS control, no power supply interlock, only stand-alone tests
- Alarm display module:
  - Simple NIM module displaying Dew Point and NTC alarms (3 LEDs)

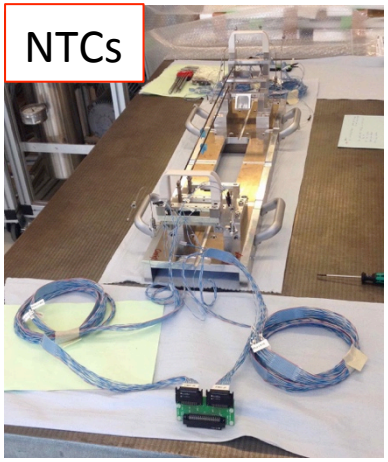
Monitoring Hardware @ BT

NTC Pair

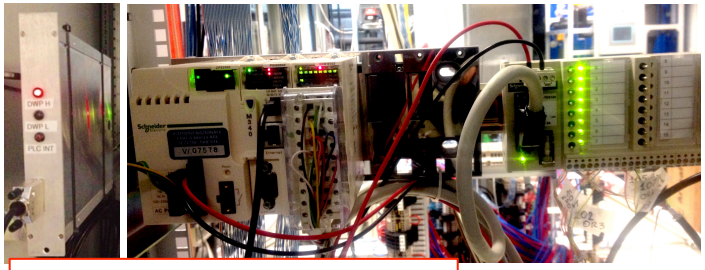




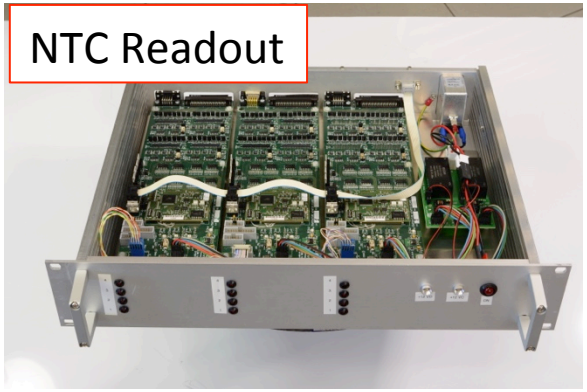
NTCs



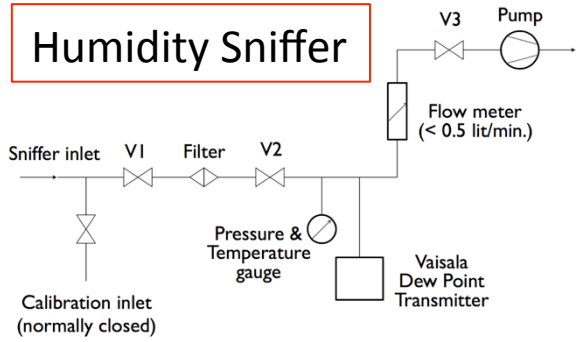
Alarm Module & PLC



NTC Readout

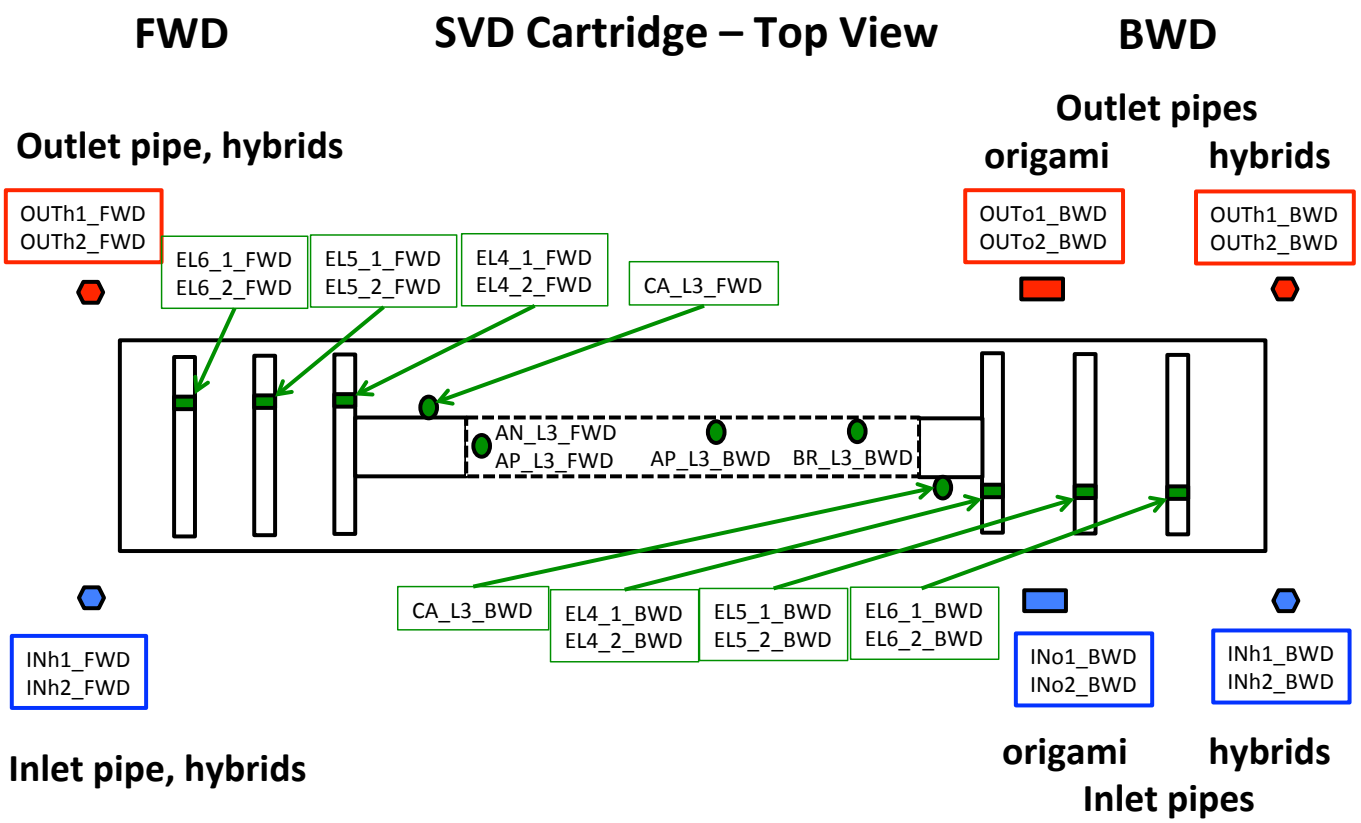


Humidity Sniffer



Monitoring Rack

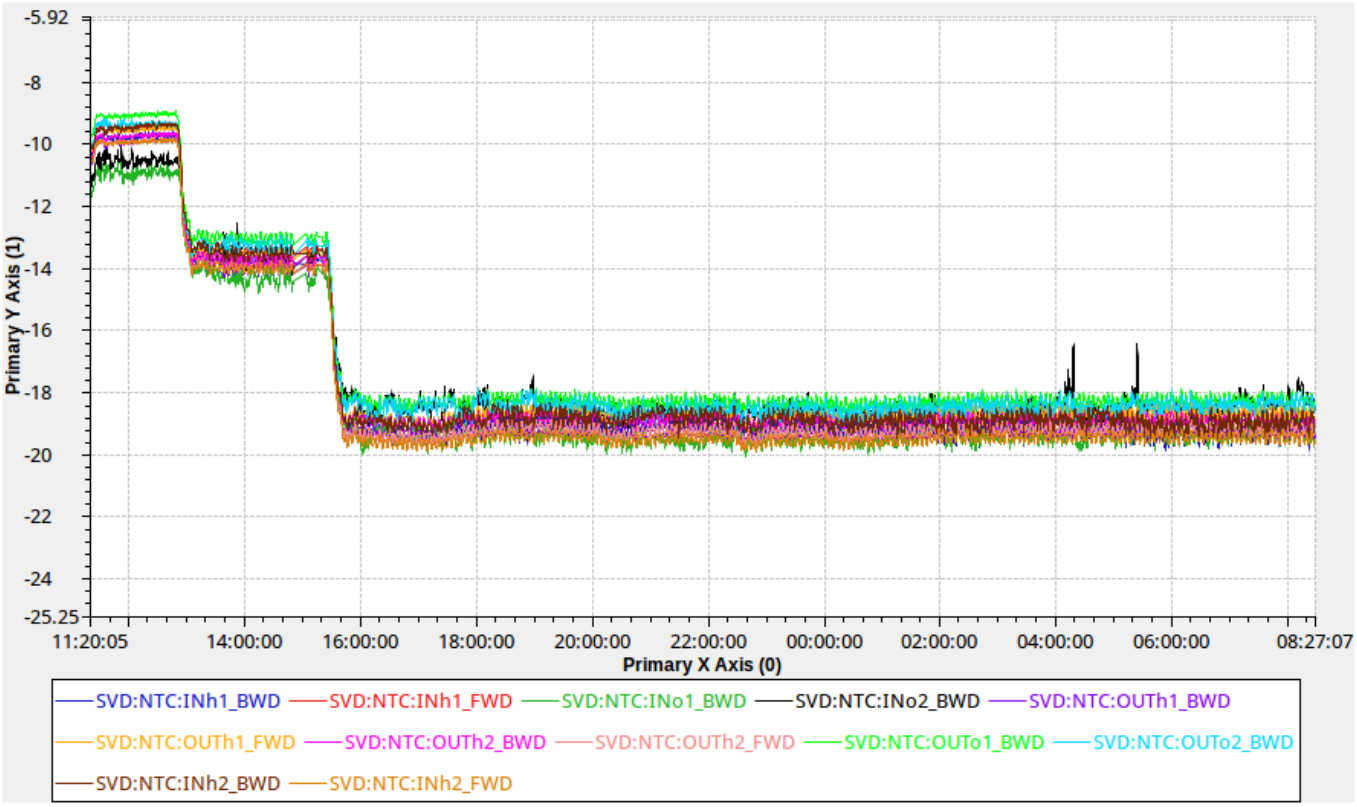
NTC Sensors in SVD Cartridge @BT



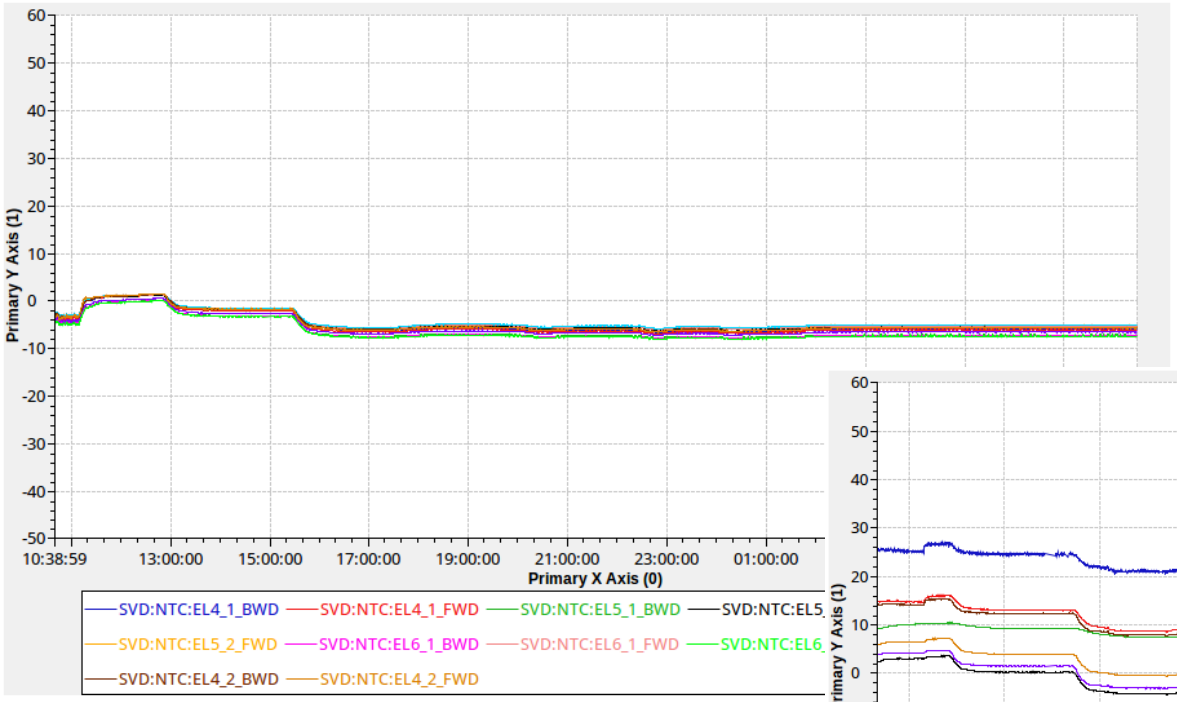
Similar to the final SVD configuration, where pairs of NTCs will monitor inlets and outlets of the CO_2 cooling lines, and each of the supporting "half rings", with their cooling channels

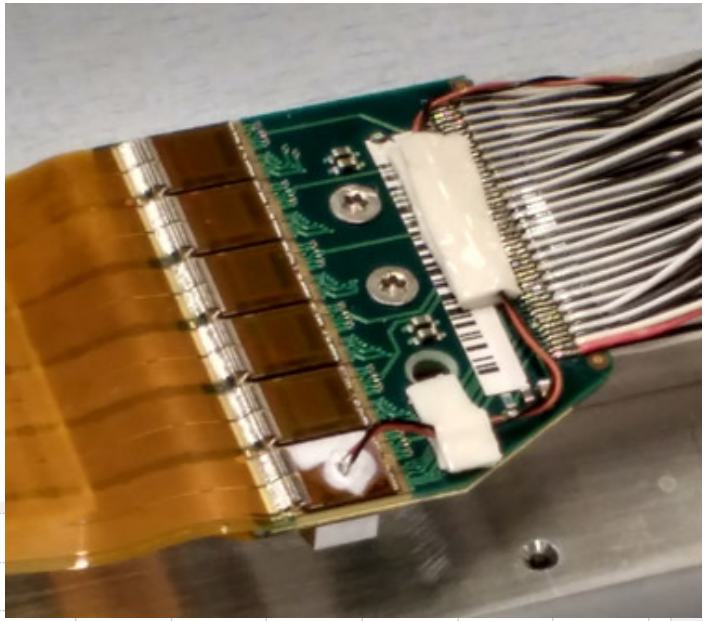
NTC Temperature @BT

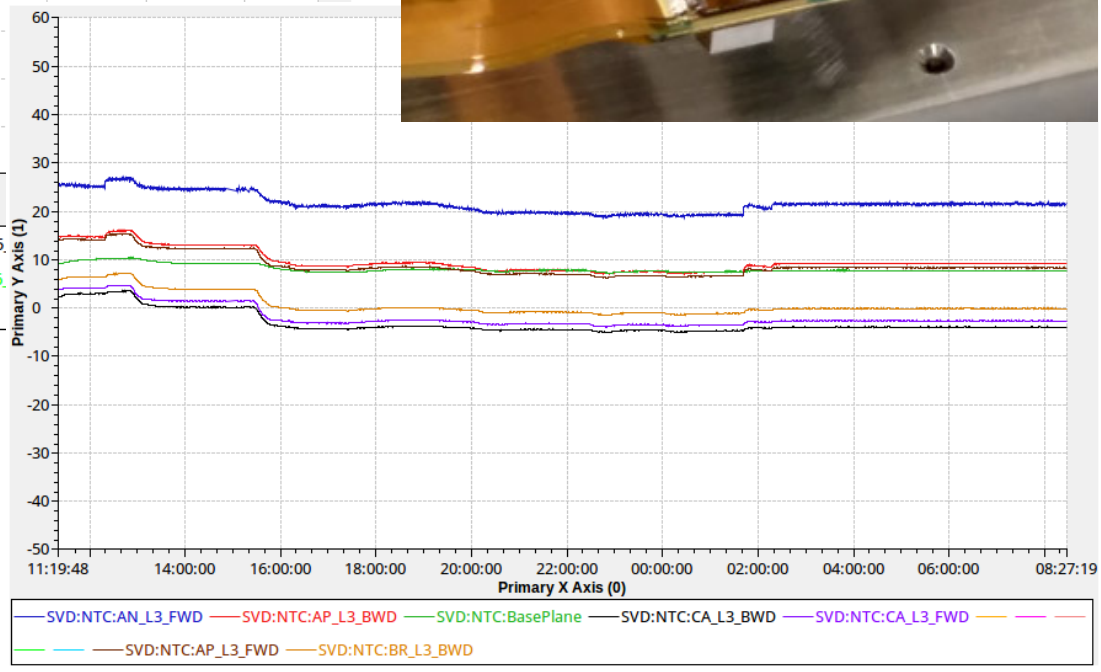
The temperature of the CO_2 cooling system (MARCO) decreased gradually in steps. With MARCO running at -27°C, NTC readings of SVD CO_2 in/out lines were at -20°C



Endmounts and L3 Temperature @BT







Layer 3 hottest spot: 21°C

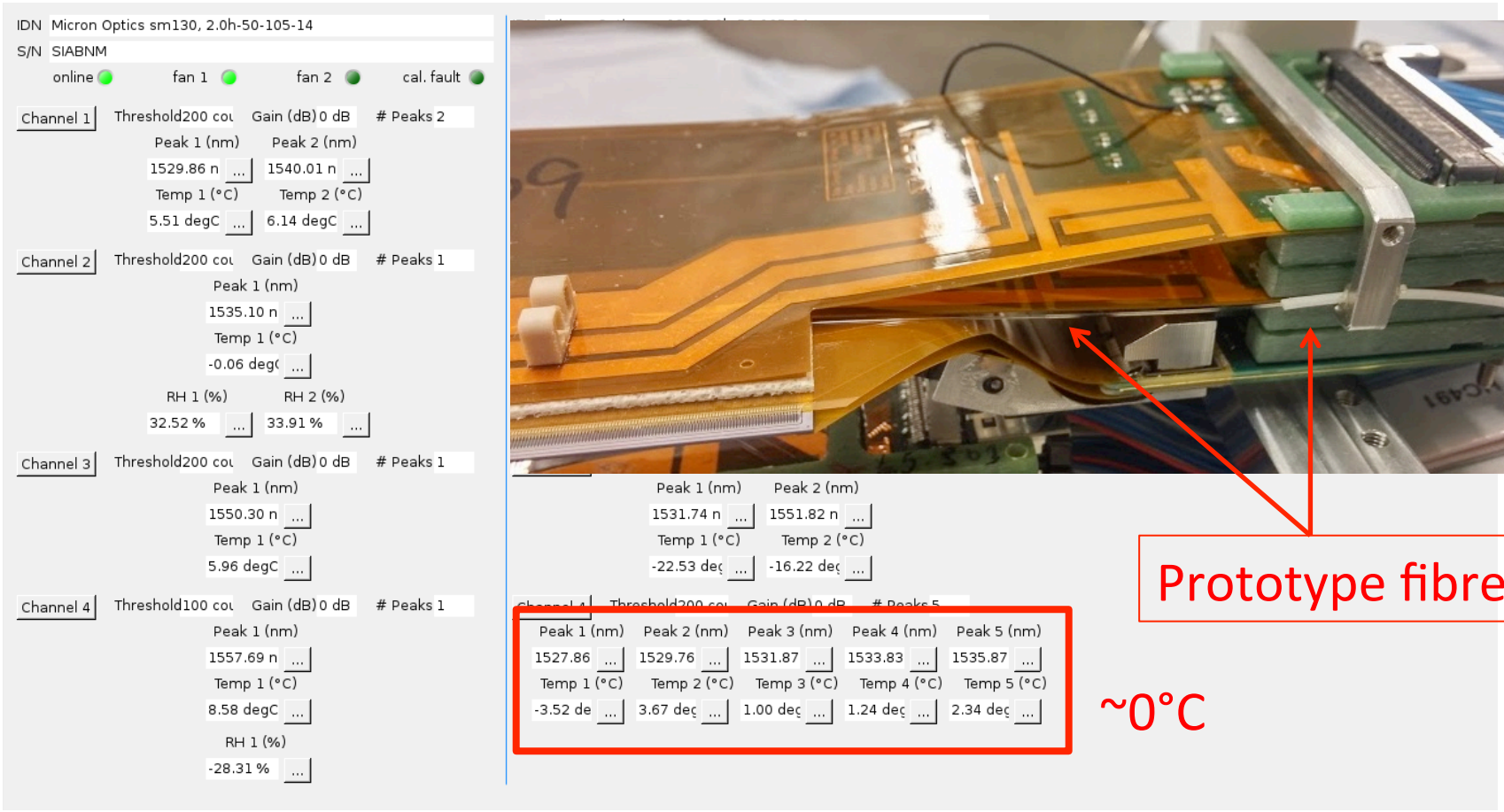
$T(CO_2)$ = -27°C

ΔT = 48°C

(SVD looking for remedy!)

FOS Temperature @TB

A prototype Fibre with 5 Optical Sensors was used to monitor L6 inserted in a special groove, 3 sensors in corrispondence of APV chips



Monitoring Work @ DESY: Summary

- General aims
  - Validate sensors, mechanics, readout electronics **OK**
  - Check reliability and stability in a realistic environment **OK**
  - Progress in EPICS control software **OK for NTC and FOS**
- Subsystem goals
  - NTC thermistors: **final** system **OK**
  - FOS: first measurements in a real working ladder **OK**
  - Humidity sniffer: proof of principle, reliability **OK (prototype only)**
  - Interlocks: alarms only, start with NTC only to PLC **OK (partial prototype)**
- Plans for the future
  - Mock-up: NTCs were installed; future measurements: to be followed up
  - December 2016 Beam Test: provide more advanced humidity and interlocks
  - In Trieste: production tests & calibrations on all items; installations at KEK

2. BEAST-I: RADIATION MONITORING AND BACKGROUNDS

SuperKEKB and BEAST 1

- SuperKEKB

  Machine tuning, many items (see SKB daily meetings)

  Current increase and vacuum scrubbing: according to guidelines!

  LER blow-up effect: equivalent to KEKB in 2001, after years of run

  Specific background tests for Belle II/BEAST ← Preliminary Analysis, Diamond Sensors

- BEAST 1

  Beam size scan: Touschek background ← Preliminary Analysis, Diamond Sensors

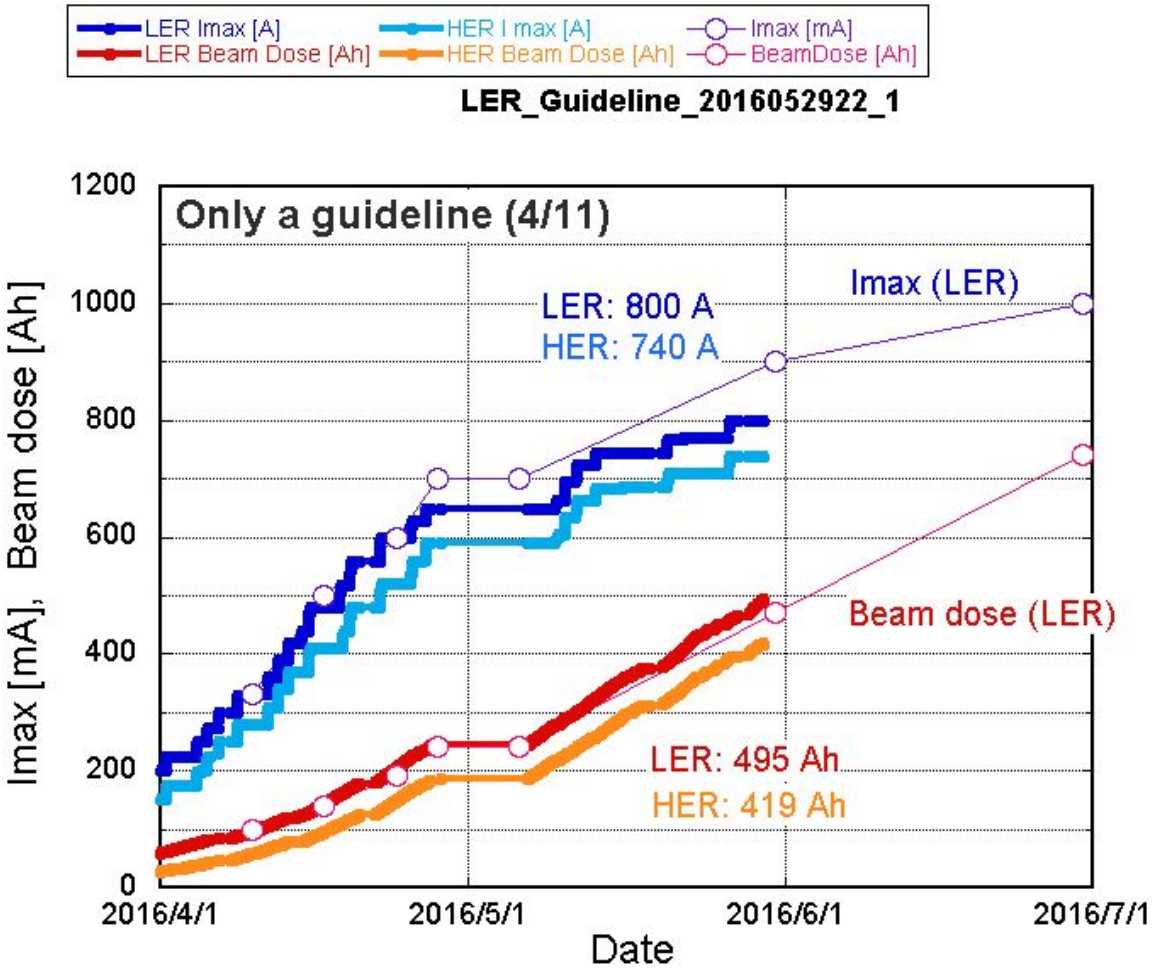
  Vacuum bumps study: beam-gas background ← Preliminary Analysis, Diamond Sensors

  Collimator studies

  Injection backgrounds ← See talk by Riccardo

SuperKEKB Progress

From Y.Funakoshi (weekly report at the SKEKB meeting 30/05/2016)
Present maximum currents: I(LER) = 800 mA, I(HER) = 740 mA



Diamond Sensors in BEAST 1

4 sensors
4.5 x 4.5 x 0.5 mm^3

EPICS label: Dia0

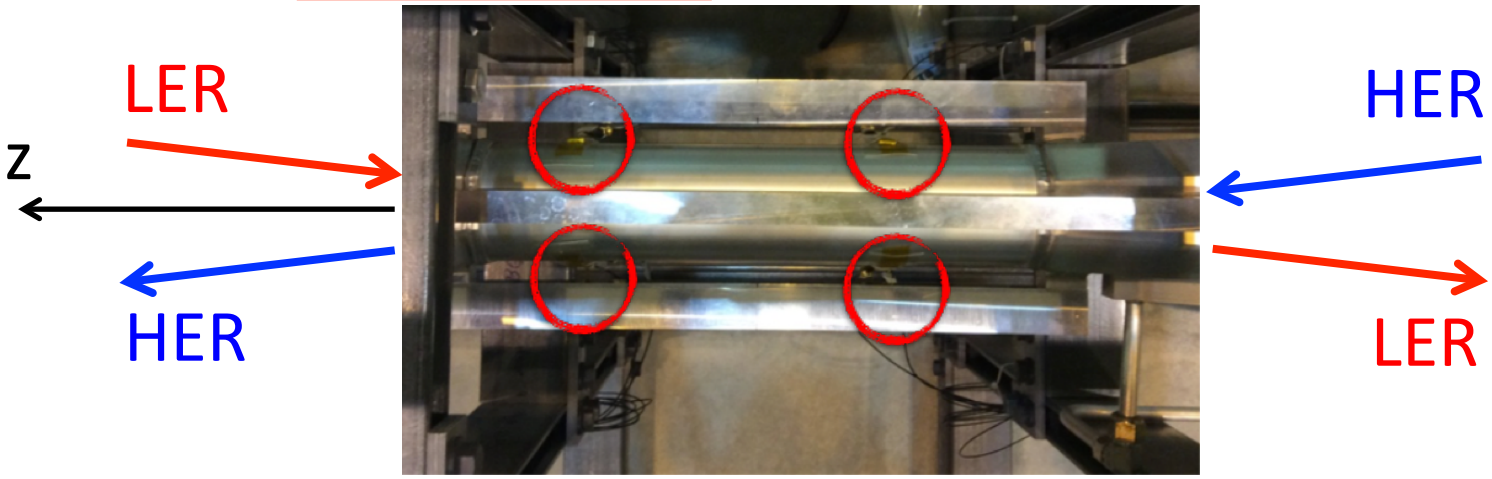
pCVD, Micron
Al metallization

FW_180
DM7 Z = +95 mm

BW_180
DM5 Z = -132 mm

EPICS label: Dia2

sCVD, Micron
Al metallization



sCVD, CIVIDEC
Ti+Pt+Au metall.

FW_0
DC3 Z = +95 mm

BW_0
DM4 Z = -132 mm

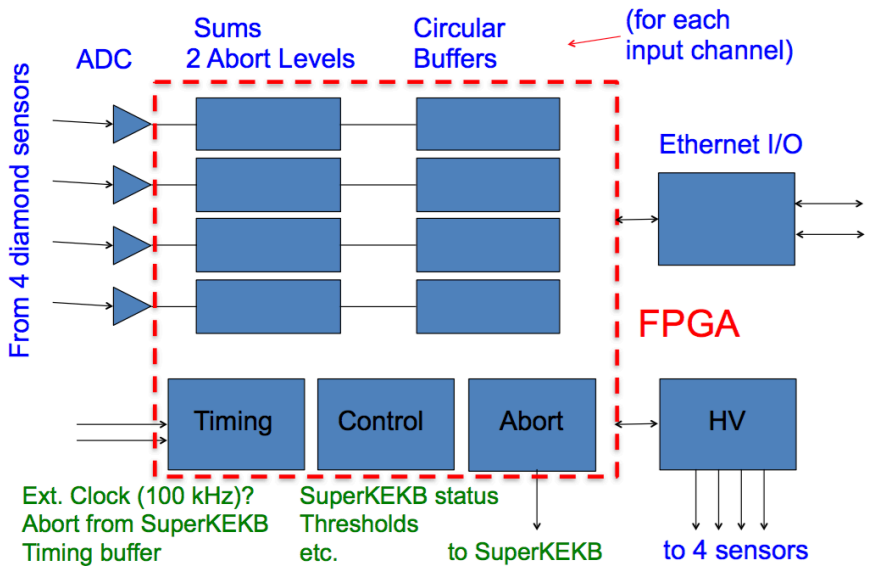
sCVD, Micron
Al metallization

EPICS label: Dia1

EPICS label: Dia3

Diamond Electronics in BEAST 1

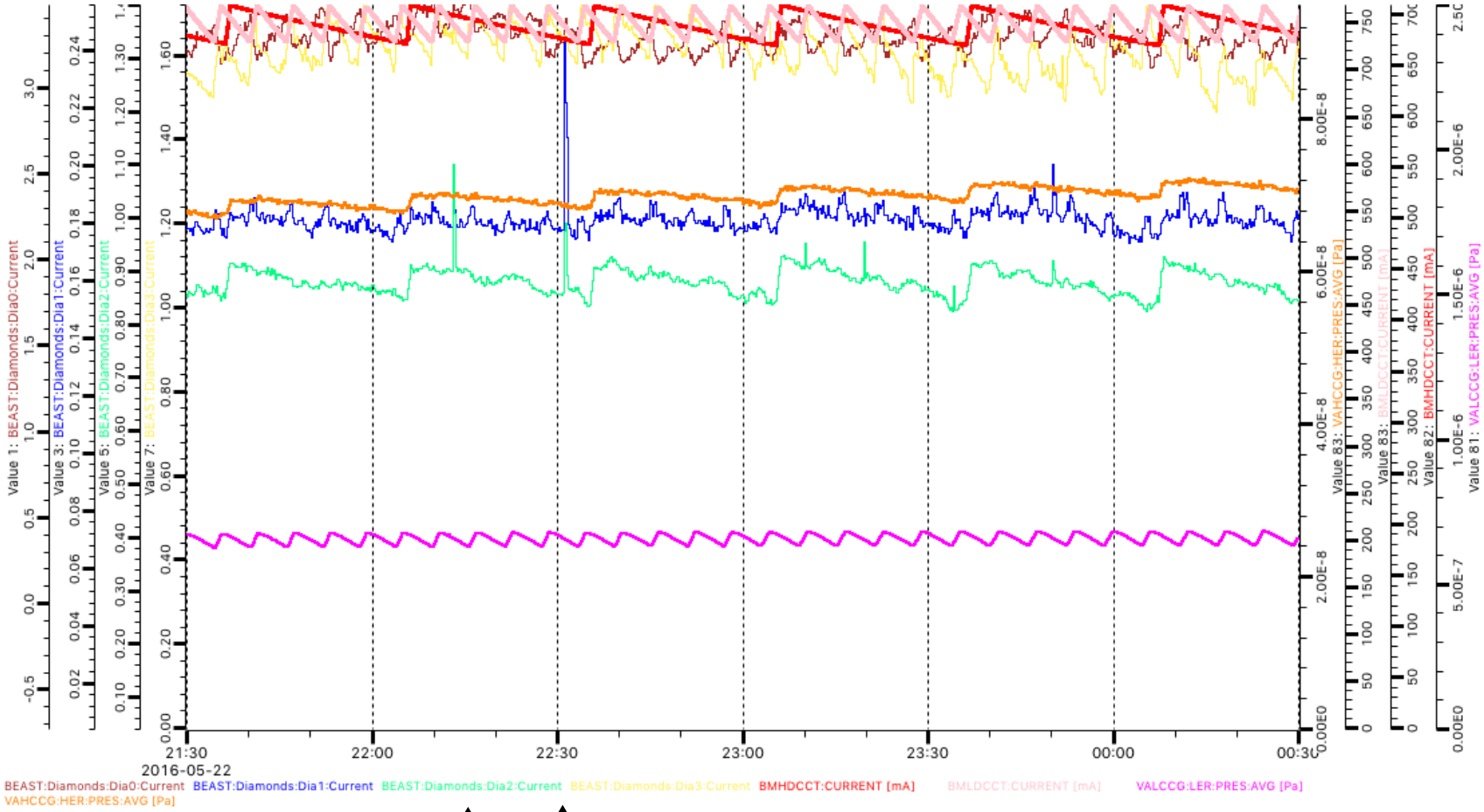
- Analog front-end picoammeters
  - transimpedance amplifiers
  - 16-bit ADCs, 130 MHz oversampling
  - 2 selectable current ranges
- Digital section: Stratix III FPGA
  - Running averages (4 levels)
  - Programmable abort thresholds, depending on machine status
  - Timing & Control
- External RAM, Ethernet
- DAC for HV module control



LabVIEW program
Monitoring readout at 10 Hz
Connected to EPICS, archived at 1 Hz

Abort buffer memories read out on request on a separate channel

Diamonds in EPICS - scrubbing



Dia0 Dia2

Dia1 Dia3

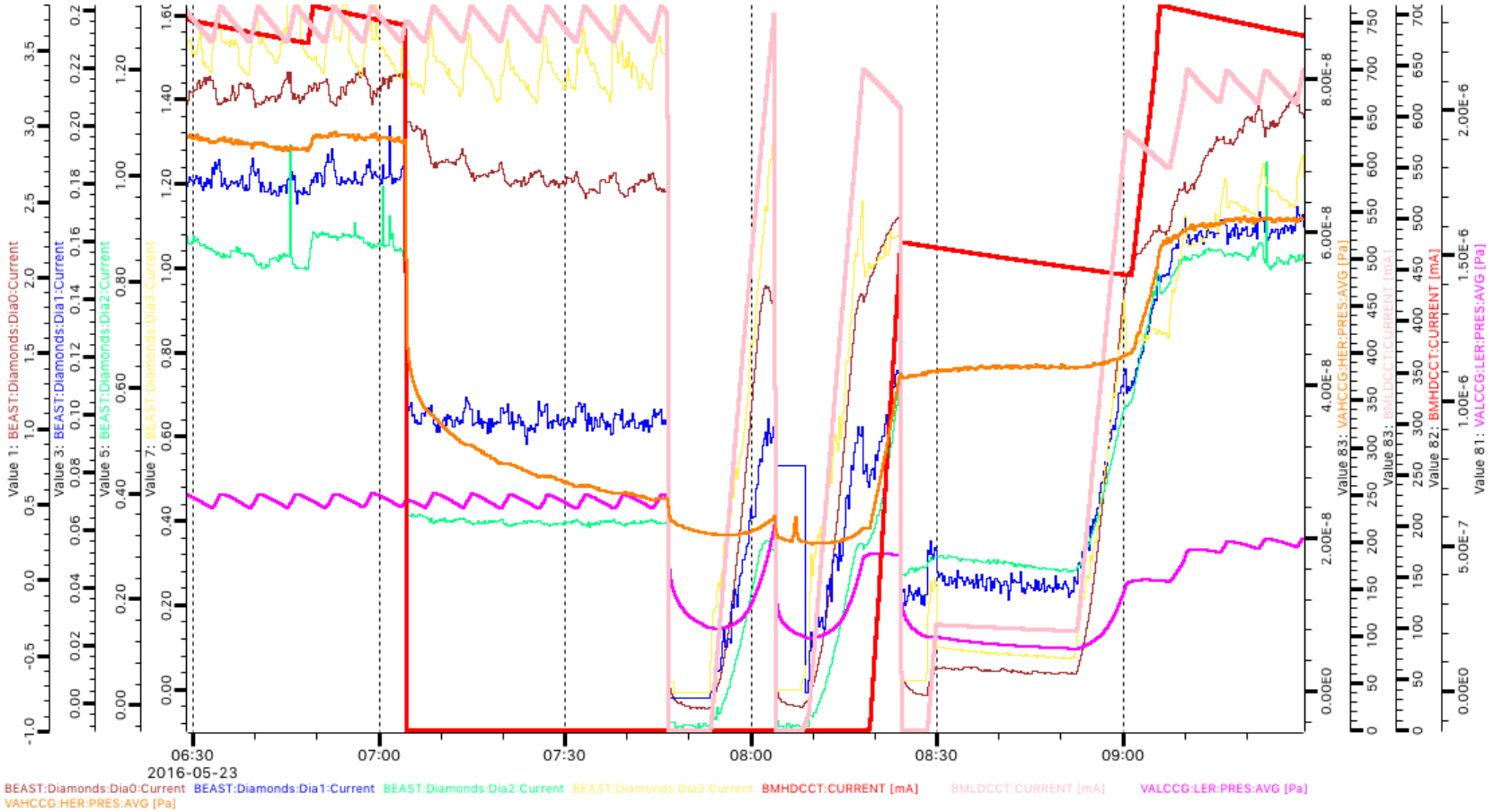
Occasional spikes

In coincidence with BGO, etc.

HER current, pressure

LER current, pressure

Diamonds in EPICS – aborts, refilling



Dia0 Dia2

Dia1 Dia3

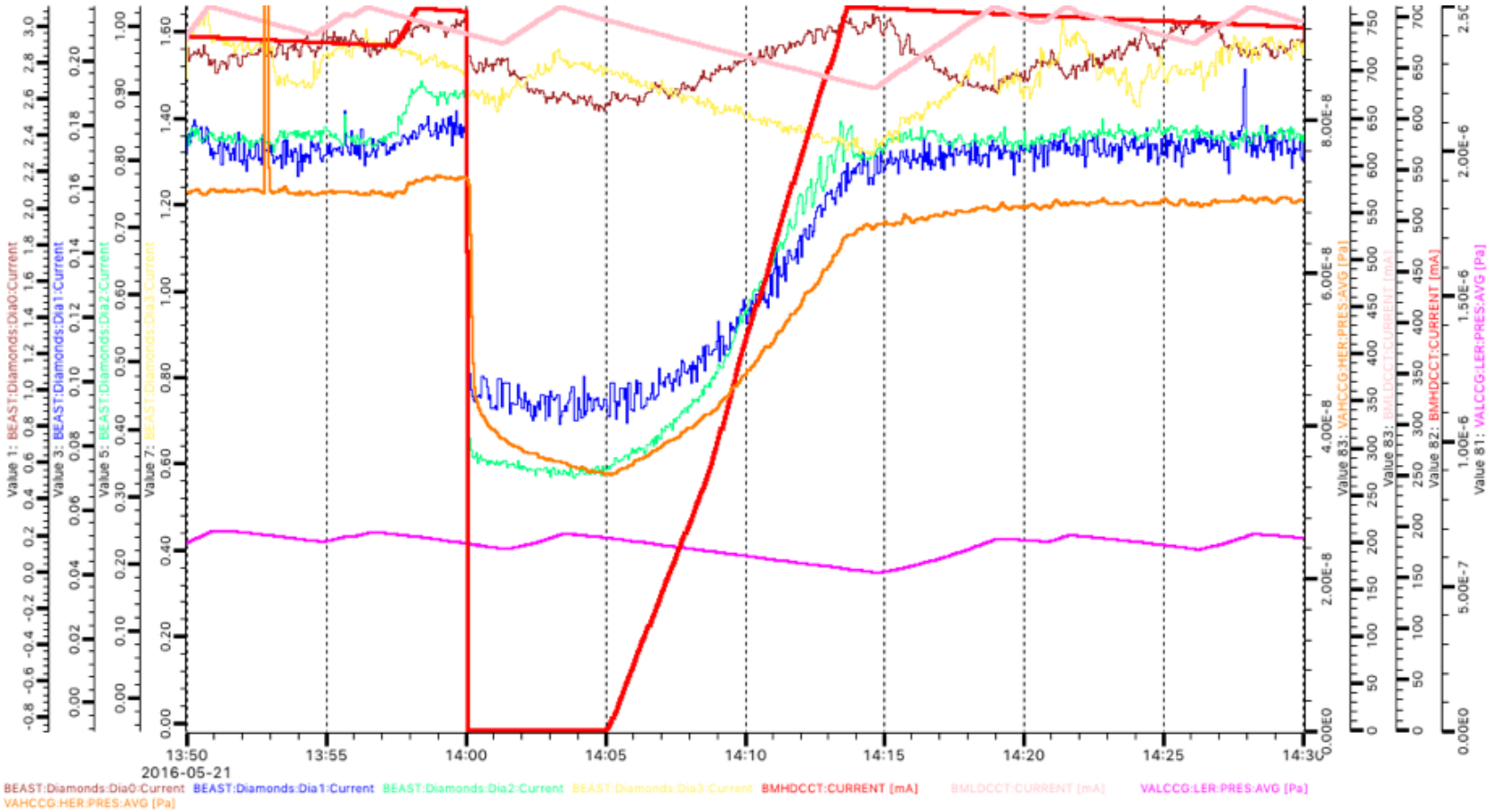
HER Abort

3 LER Aborts

HER current, pressure

LER current, pressure

Correlations with LER, HER



Dia0 Dia2
Dia1 Dia3

FW_180, BW_0: very sensitive to LER, not to HER

FW_0, BW_180: same sensitivity for both

HER current, pressure

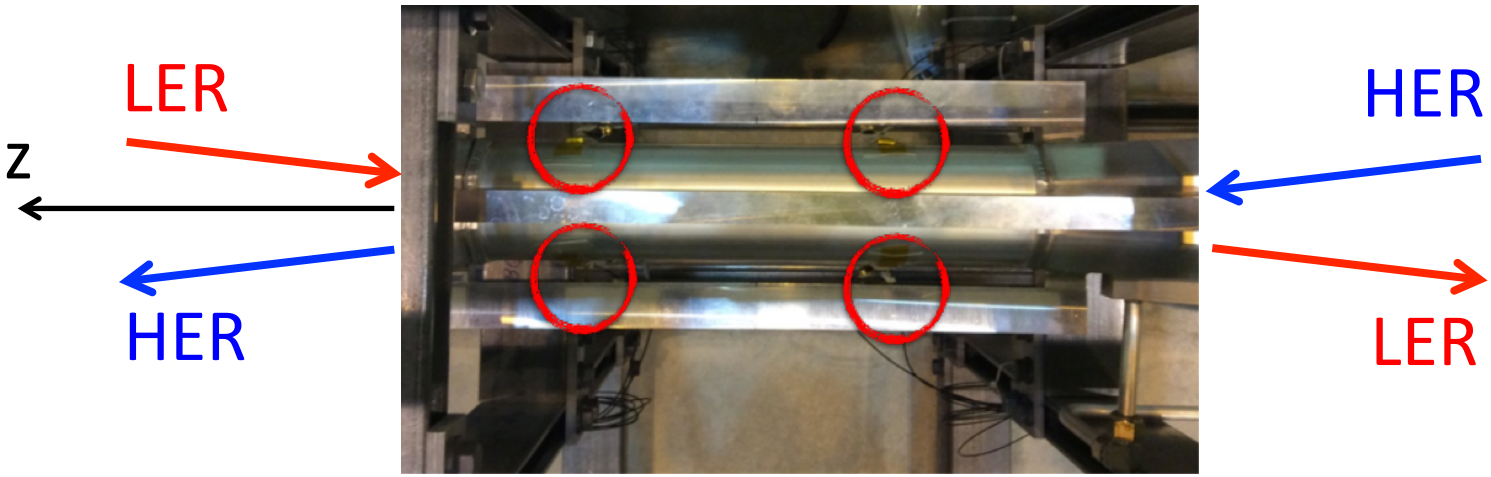
LER current, pressure

Diamonds: correlation with LER, HER

LER only: 2.5 nA
HER only: 0.1 nA
LER+HER: 2.6 nA

LER only: 0.3 nA
HER only: 0.4 nA
LER+HER: 0.7 nA

FW_180 BW_180

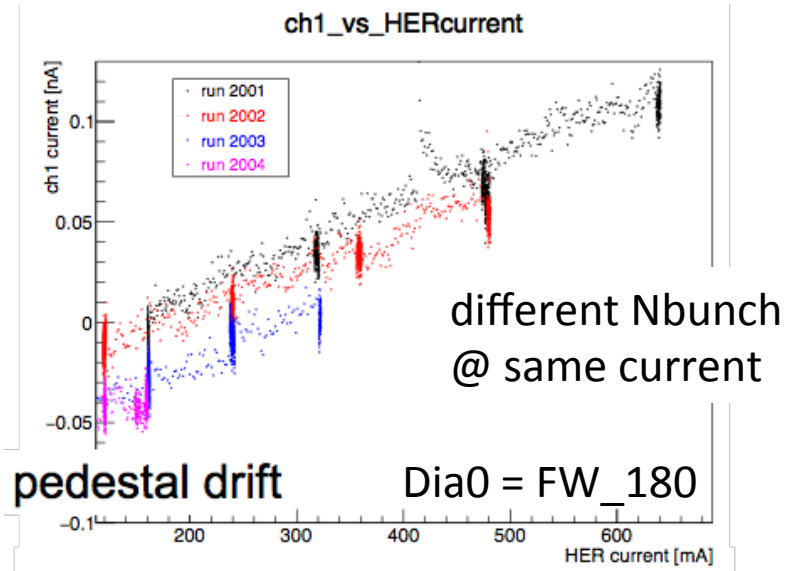


FW_0 BW_0

LER only: 0.08 nA
HER only: 0.08 nA
LER+HER: 0.16 nA

LER only: 1.2 nA
HER only: 0.1 nA
LER+HER: 1.3 nA

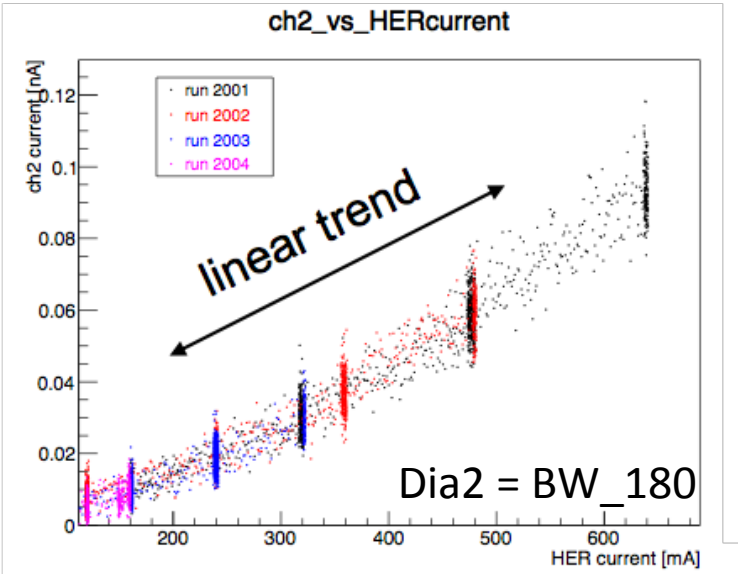
HER Current & Nbunch Scan



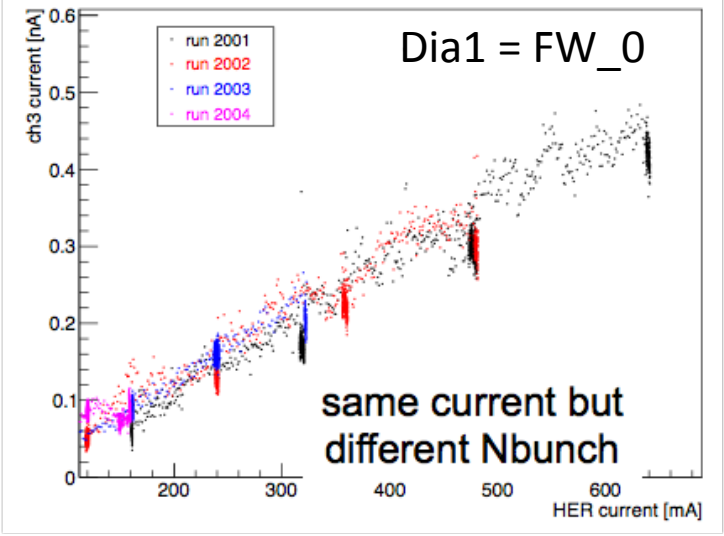
different Nbunch
@ same current

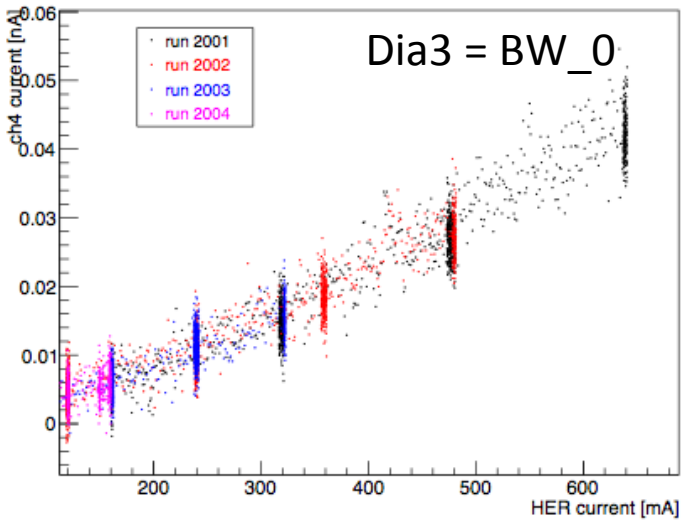
pedestal drift

Dia0 = FW_180

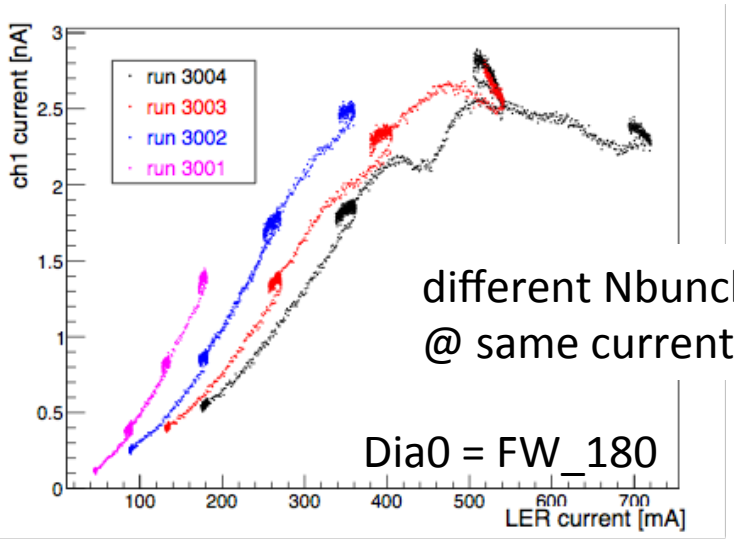


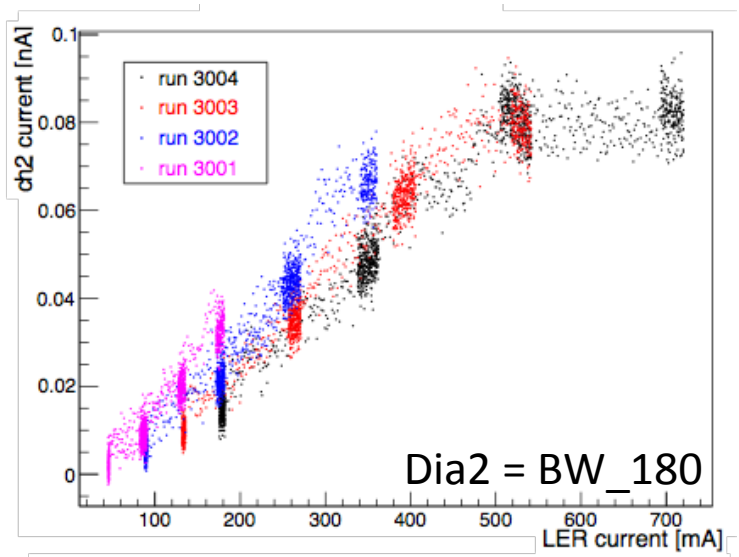
Dia2 = BW_180

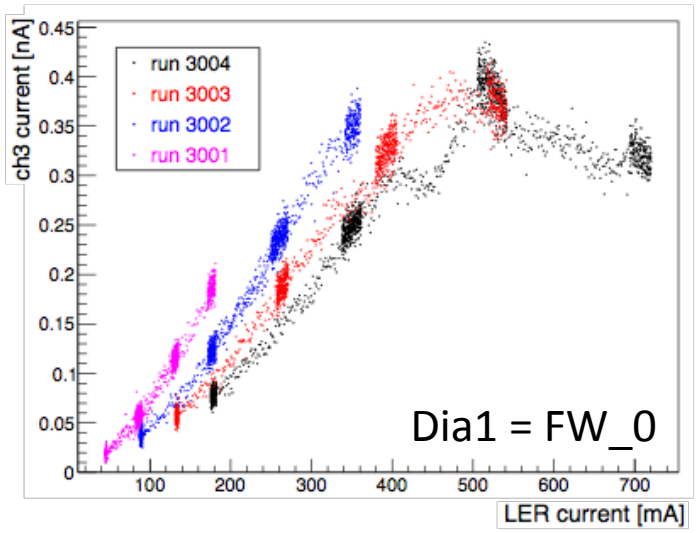


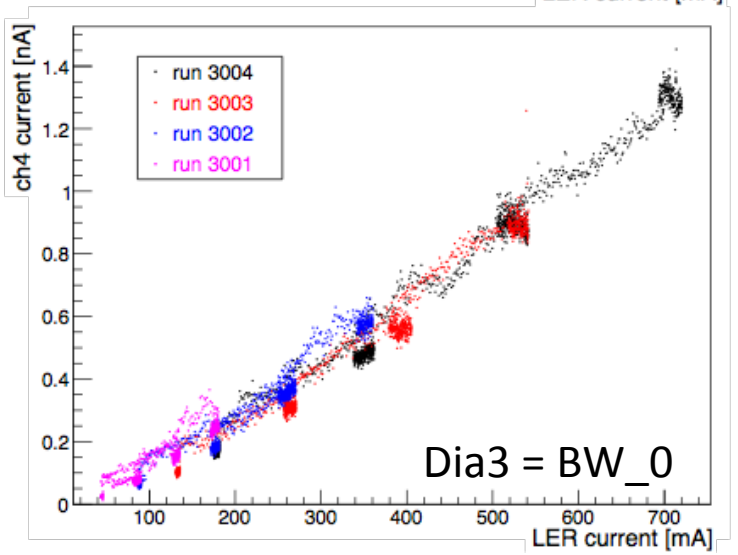


LER Current & Nbunch Scan

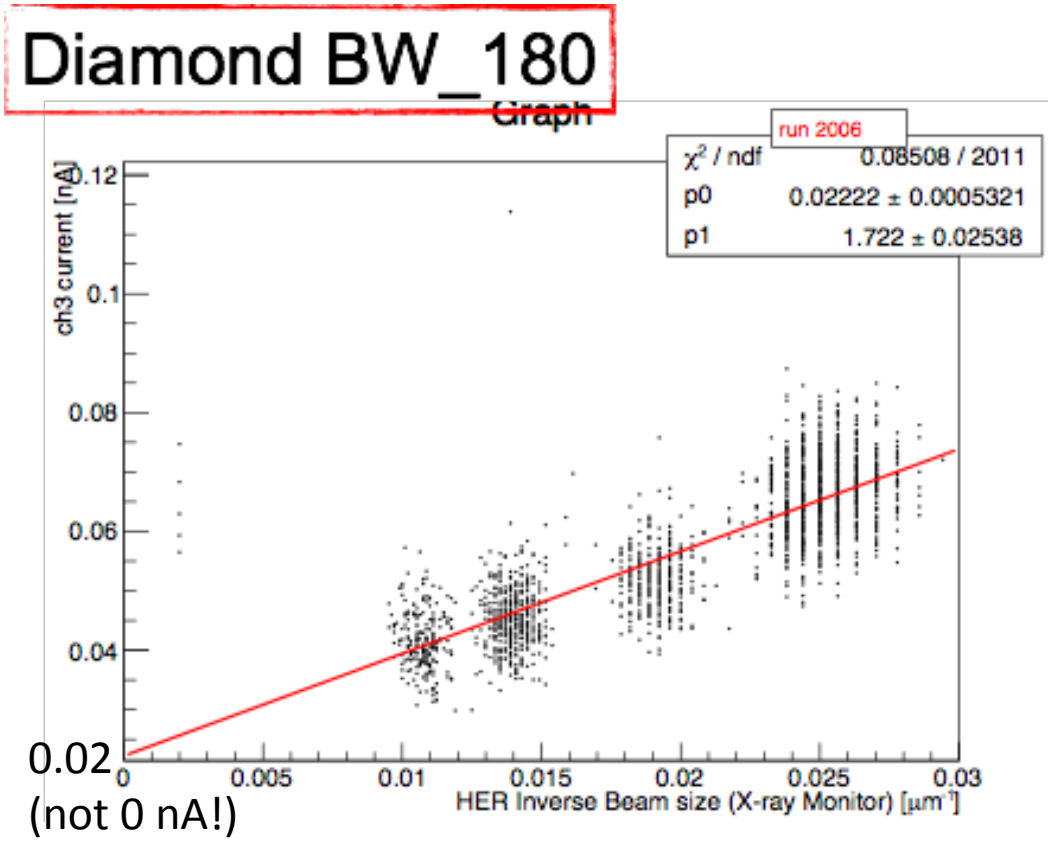






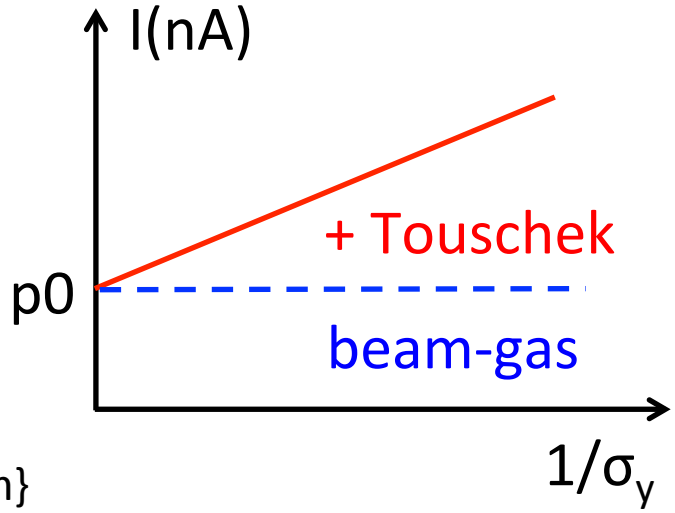


HER Beam Size Scan: Touschek



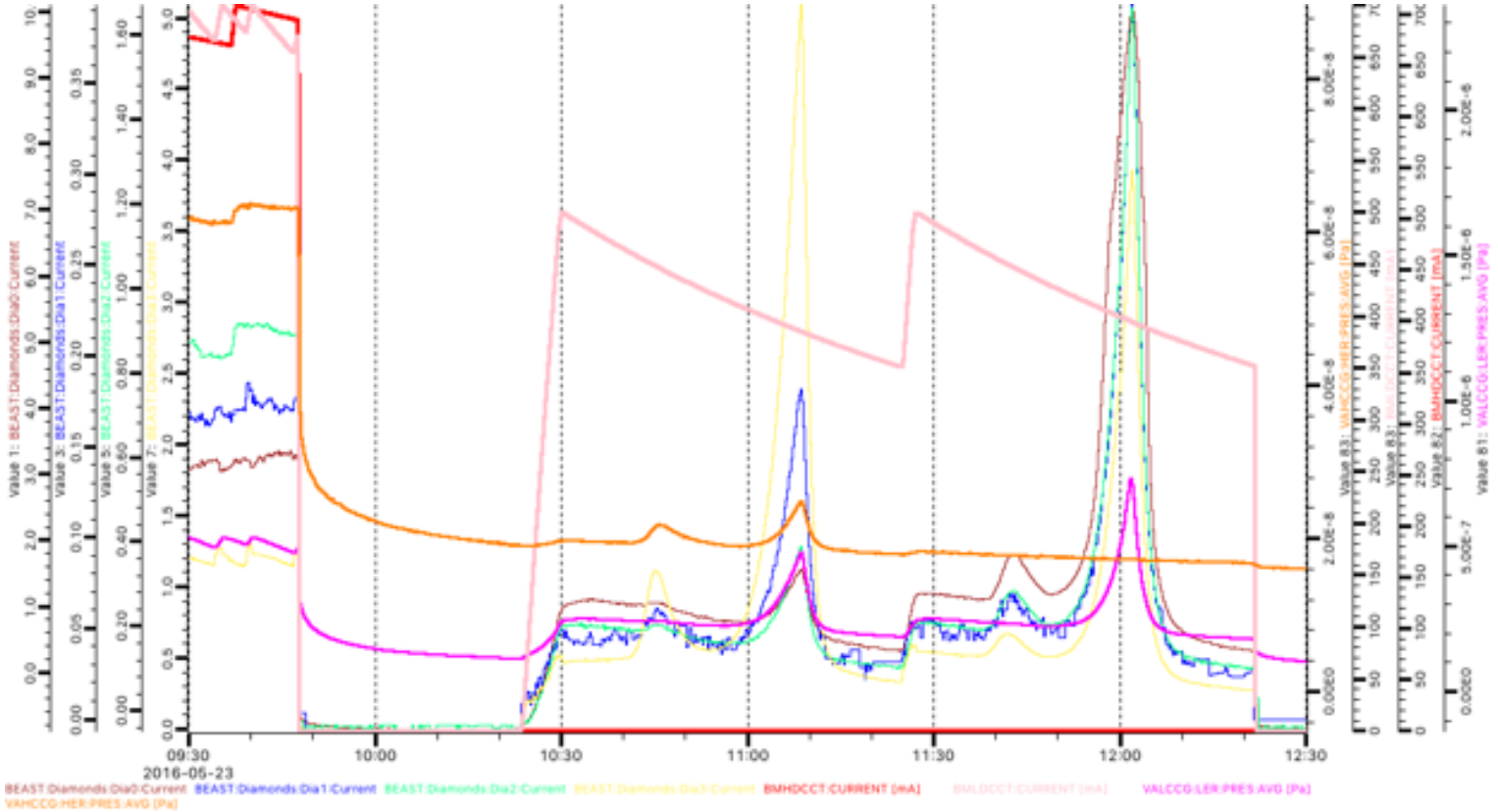
(not 0 nA!)

Diamond current vs inverse beam size:
Linear fit, intercept
p0 = (0.0222 ± 0.0005) nA
extrapolation to pure beam-gas contribution



Just one example for HER and diamond BW_180:
beam vertical size = {90 um, 75um, 51um, 46um, 42 um}
I HER = 160 mA

Vacuum bumps: Beam-Gas (LER)



Very large effects, in agreement with the neighboring PIN diodes.

Similar for HER

Detailed analysis in progress

Dia0 Dia2

Dia1 Dia3

HER current, pressure

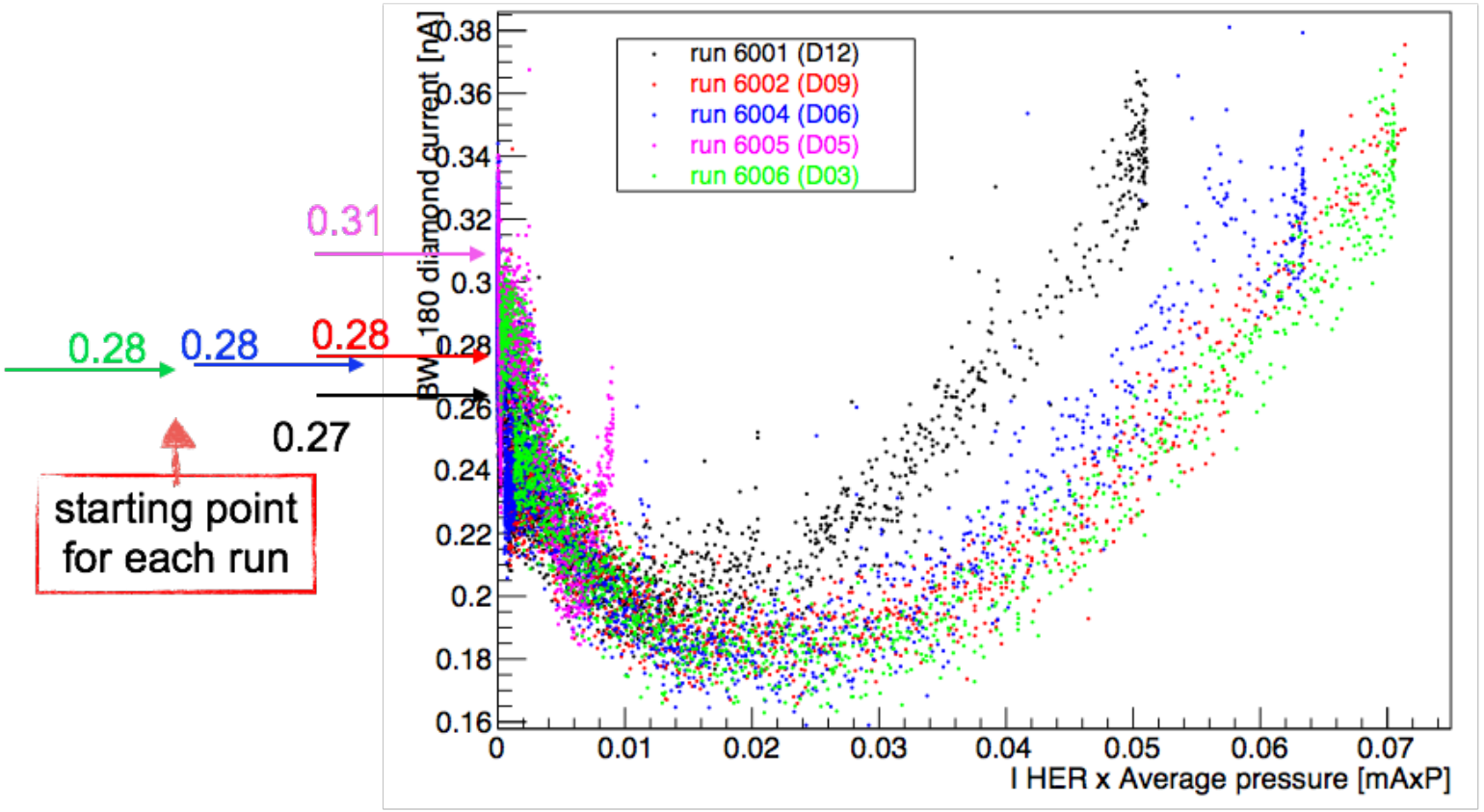
LER current, pressure

Vacuum bumps: Beam-Gas (HER)

Diamond BW_180

Diamond current vs I HER x Pressure

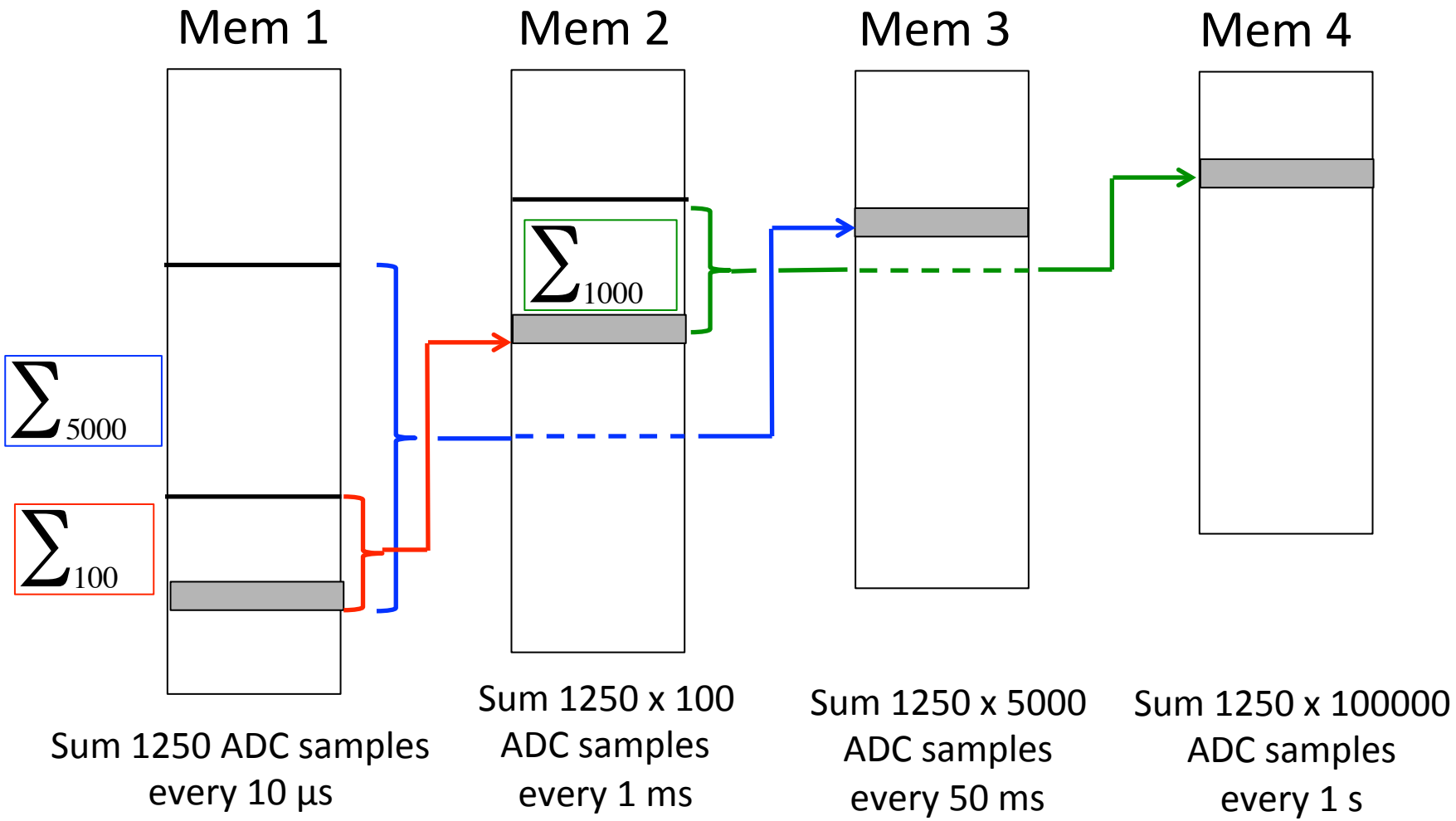
HER on LER off



in this case the effects are smaller then LER vacuum study but still observable especially for BW_180.

Diamonds: Abort Buffer Memories

Present configuration of revolving Abort Buffer Memories
to be improved with really “running sums”



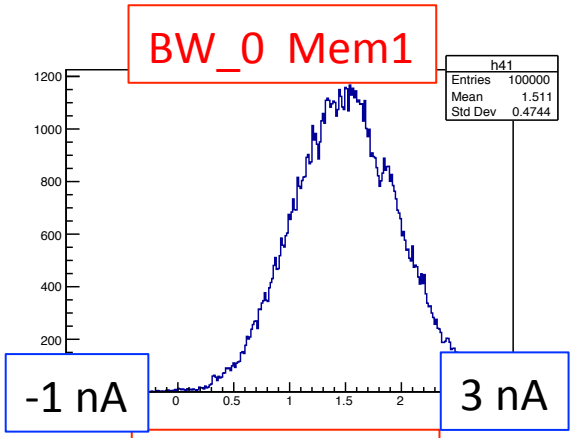
Buffer Memories: Snapshot Example

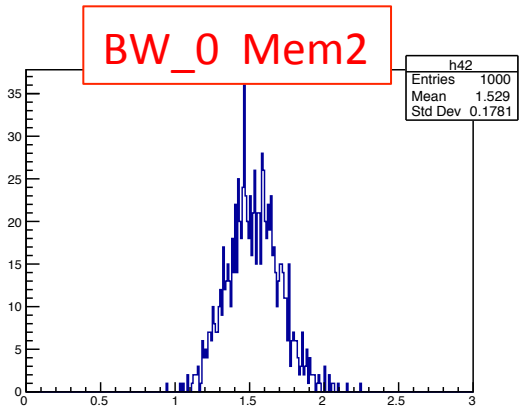
Example of snapshot of Buffer Memories (Mem1 to Mem4) for Dia3 = BW_0 in stable beam conditions, with average I(BW_0) = 1.5 nA

Noise decreases with increased averaging, from about 0.47 nA to < 0.04 nA

OK both for fast (10 µs) and slow (> 1 s) beam aborts with appropriate thresholds

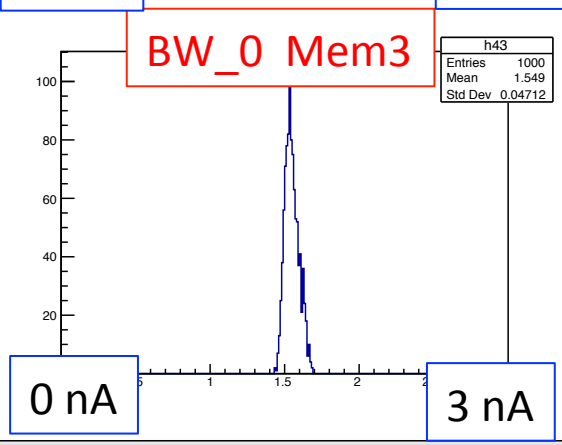
100000 entries
1 s history
σ = 0.47 nA

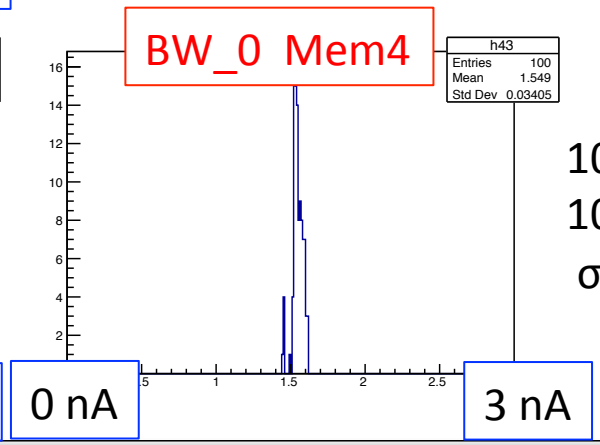




1000 entries
1 s history
σ = 0.18 nA

1000 entries
50 s history
σ = 0.047 nA





100 entries
100 s history
σ = 0.034 nA

Diamonds in BEAST 1: Summary

- Main goals for BEAST 1 and results
  - Validation of sCVD sensor choice, mechanics, cables **OK**
  - Characterization of prototype electronics **OK**
  - Stability and reliability of operation over several months **OK**
  - Correlations with accelerator conditions and backgrounds, contributions to BEAST studies **OK**
  - Initial studies of beam abort features **just started**
  - Integration in EPICS **marginal trick now: to be done!**
- Plans for the future
  - Check absolute calibrations of the 4 BEAST-1 sensors
  - Mounting, test, calibrations of final diamond sensors in Trieste
  - Final electronics production (at least 2 boxes ready for BEAST – 2)
  - Prepare for BEAST – 2 and SVD installation

3. CONCLUSIONS & PLANNING

Conclusions & Planning

That is: why the money we will ask for (2017) will be well spent:

- From our results at DESY and KEK, we are on track…

  Diamonds, radiation: prototype chain validated, final sensors available

  NTC temperature: validated, all hardware available, EPICS OK

  FOS temperature: validated, hardware available, EPICS OK

  Humidity: prototype Sniffer validated

  Interlocks: initial prototype PLC tested as an alarm (NTC & humidity)

- … and a lot of work is still ahead

  2016: Tests and calibrations of all final components in our lab

  Diamond sensors, NTCs, FOS, humidity (+ interlock detailed specifications)

  Dec.2016: again beam test @DESY (Humidity, interlocks)

  2017 in parallel:

  BEAST 2: 8 diamond sensors (PXD) with active beam abort system

  SVD ladder assembly & commissioning:

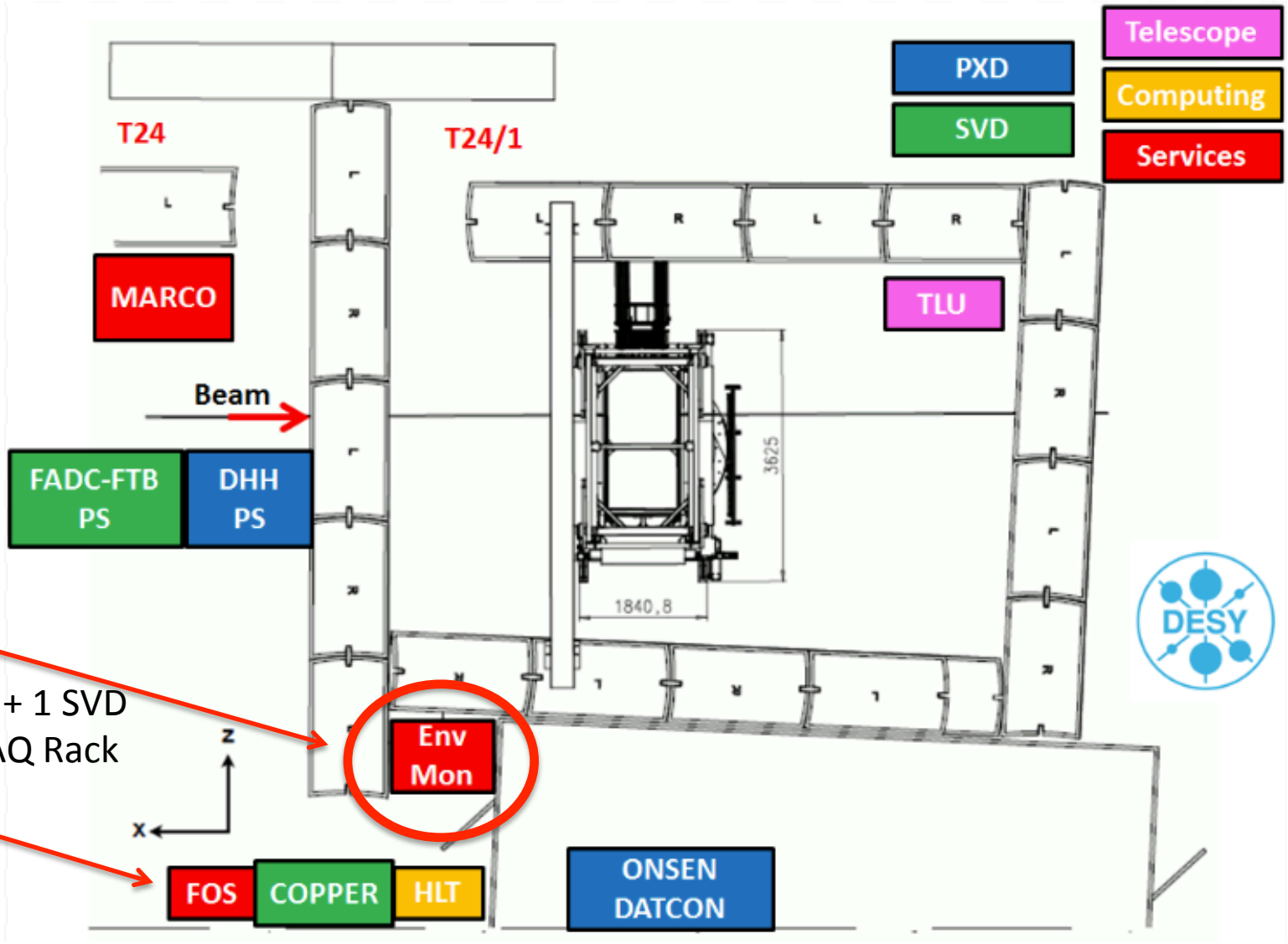
  installation of 12 diamonds, of all NTCs and FOS + humidity interlock

BACK-UP SLIDES

Installations Plans

- Radiation & Beam Abort
  - Sub 1
  - Sub 2
- NTC Temperature
- FOS Temperature
- Humidity, Dew Point
- Interlocks

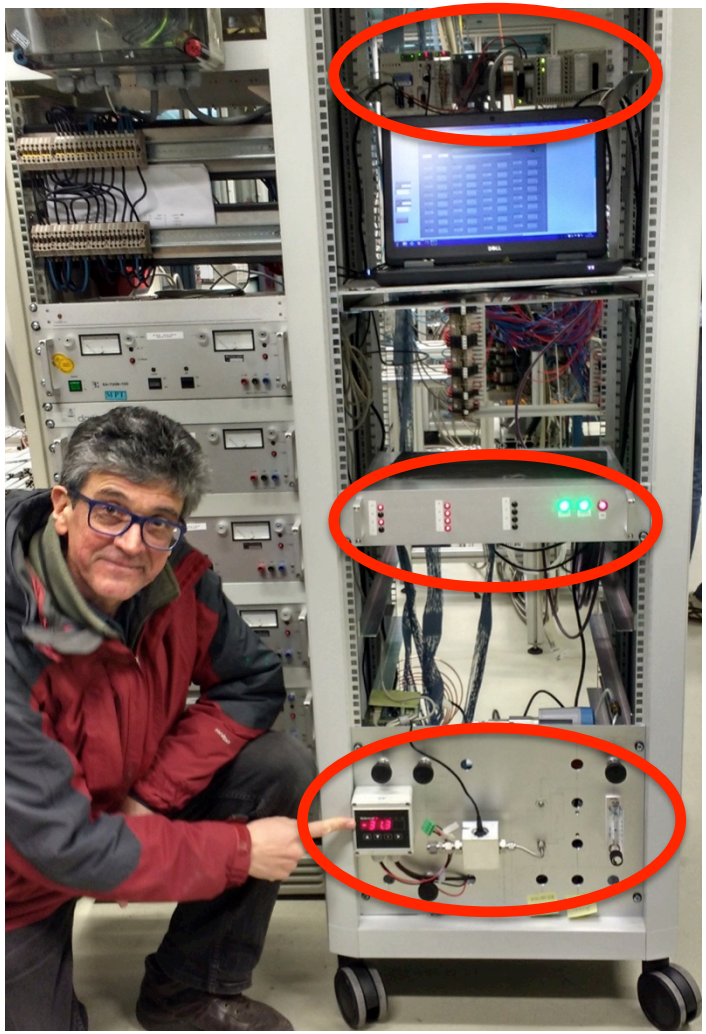
Environmental Monitoring Rack



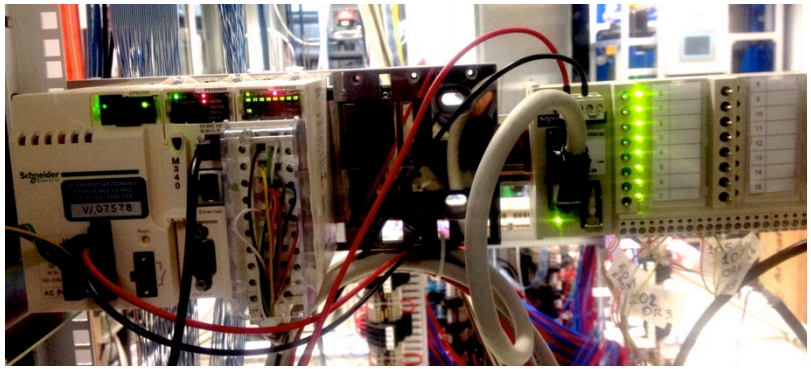
"Corner"
Env. Mon.
Rack

PXD FOS system + 1 SVD
On the top of DAQ Rack

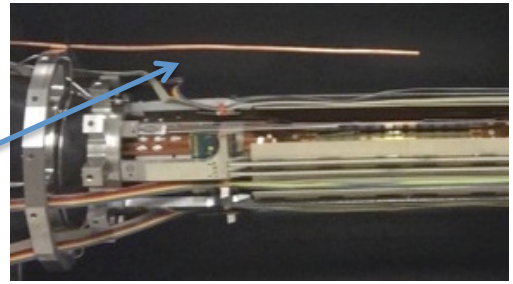
Monitoring setup @ mock-up



PLC connected to NTC HW interlock

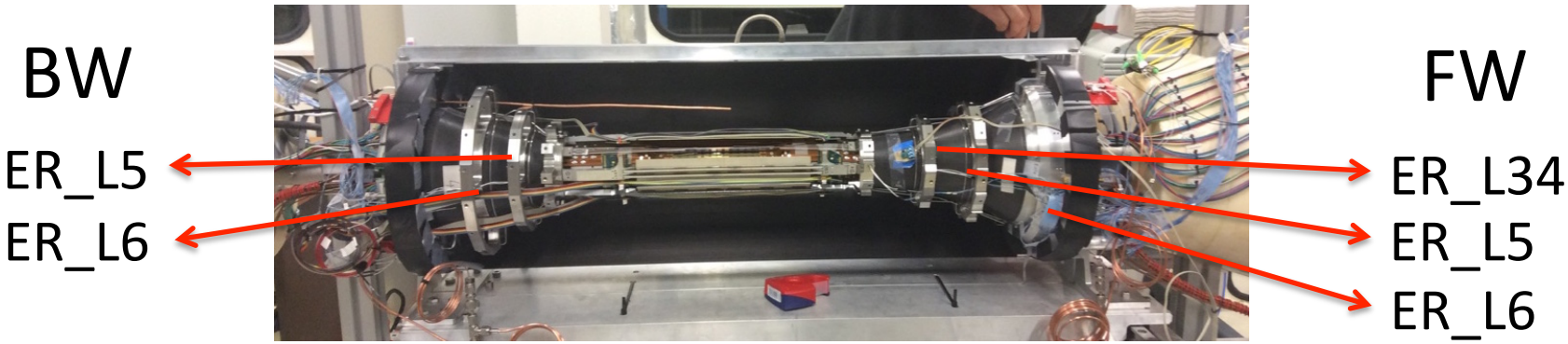


NTC readout & interlock system

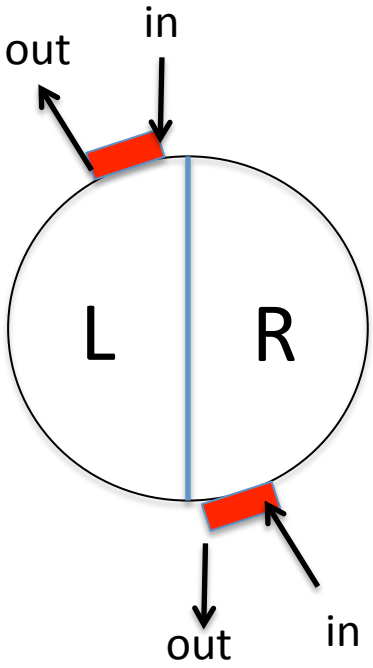


Humidity system:
sniffing pipe
Dew Point transmitter typically @-33°C
Pressure gauge
Flow meter (0.3 l/min)
Pump

NTC thermistors in the mock-up



BW = BackWard, FW = Forward, R = Right, L = Left, ER = EndRing, Lx = Layer x

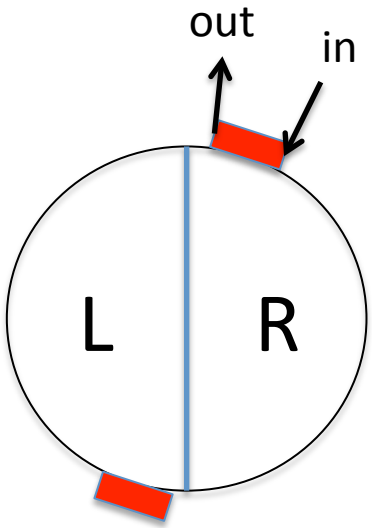


ELMB 0A

channel	sensor		channel	sensor	
NTC_1	in_1_BW_R		NTC_9	in_2_BW_R	
NTC_2	out_1_BW_R		NTC_10	out_2_BW_R	
NTC_3	ER_L5_1_BW_R		NTC_11	ER_L5_2_BW_R	
NTC_4	ER_L6_1_BW_R		NTC_12	ER_L6_2_BW_R	
NTC_17	in_1_BW_L		NTC_25	in_2_BW_L	
NTC_18	out_1_BW_L		NTC_26	out_2_BW_L	
NTC_19	ER_L6_1_BW_L		NTC_27	ER_L6_2_BW_L	

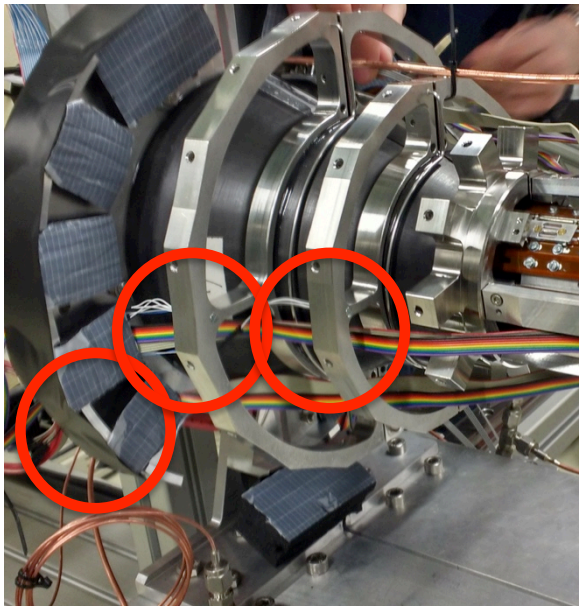
ELMB 0C

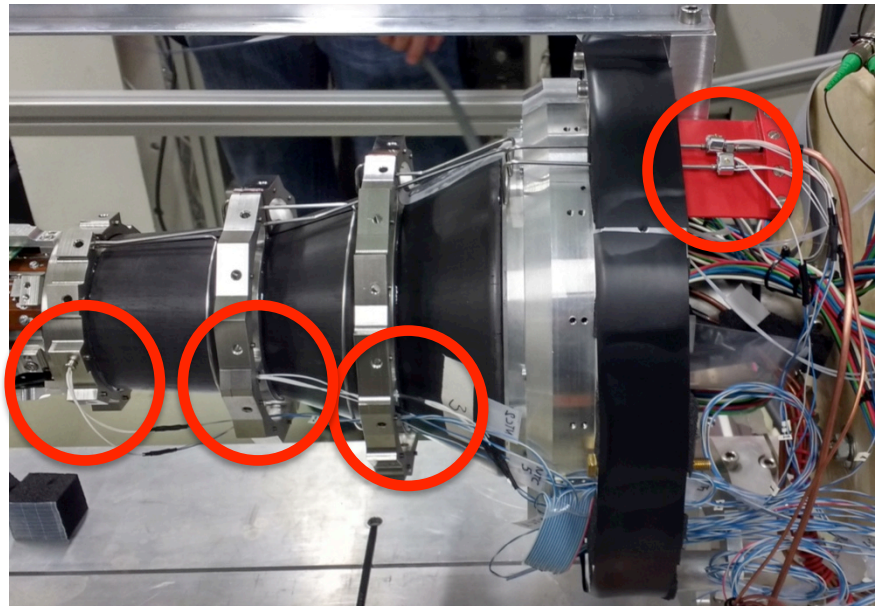
channel	sensor		channel	sensor	
NTC_2	in_1_FW_R		NTC_10	in_2_FW_R	
NTC_3	ER_L34_1_FW_R		NTC_11	ER_L34_2_FW_R	
NTC_4	ER_L5_1_FW_R		NTC_12	ER_L5_2_FW_R	
NTC_18	out_1_FW_R		NTC_26	out_2_FW_R	
NTC_19	ER_L6_1_FW_R		NTC_27	ER_L6_2_FW_R	



NTC locations @ mock-up

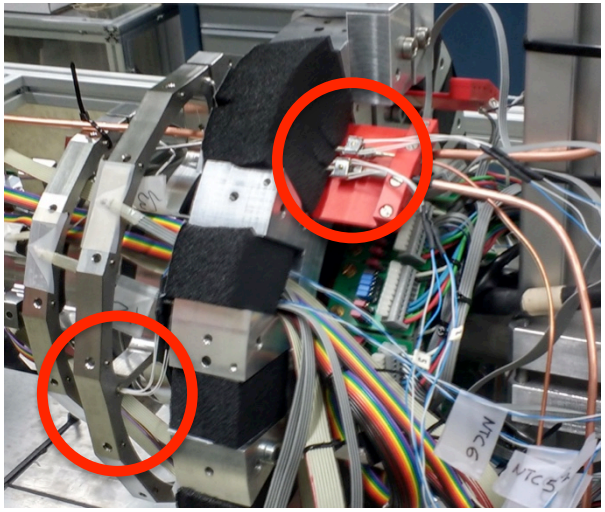
BW_R:
Inlet
Outlet
L6
L5





FW_R:
Inlet
Outlet
L6
L5
L3-4

BW_R:
Inlet
Outlet
L6



Note that since the pipe connectors are different to those of the Beam Test (Streuli vs. Swagelok) the sensors were not glued on the supports. Also for the Endrings the NTC pairs were not glued yet.

NTC: typical temperatures

BW = BackWard, FW = Forward, R = Right, L = Left, ER = EndRing, Lx = Layer x

ELMB 0A

CO_2 set temperature = - 30°C

channel	sensor	T[°C]	channel	sensor	T[°C]
NTC_1	in_1_BW_R	**- 17.1**	NTC_9	in_2_BW_R	**- 16.0**
NTC_2	out_1_BW_R	**- 20.0**	NTC_10	out_2_BW_R	**- 19.8**
NTC_3	ER_L5_1_BW_R	**- 17.8**	NTC_11	ER_L5_2_BW_R	**- 15.1**
NTC_4	ER_L6_1_BW_R	**- 16.5**	NTC_12	ER_L6_2_BW_R	**- 13.6**
NTC_17	in_1_BW_L	**- 17.2**	NTC_25	in_2_BW_L	**- 15.5**
NTC_18	out_1_BW_L	**- 19.9**	NTC_26	out_2_BW_L	**- 18.2**
NTC_19	ER_L6_1_BW_L	**- 15.0**	NTC_27	ER_L6_2_BW_L	**- 19.3**

ELMB 0C

channel	sensor	T[°C]	channel	sensor	T[°C]
NTC_2	in_1_FW_R	**- 15.3**	NTC_10	in_2_FW_R	**- 15.4**
NTC_3	ER_L34_1_FW_R	**- 15.4**	NTC_11	ER_L34_2_FW_R	**- 18.3**
NTC_4	ER_L5_1_FW_R	**- 15.6**	NTC_12	ER_L5_2_FW_R	**- 17.3**
NTC_18	out_1_FW_R	**- 18.8**	NTC_26	out_2_FW_R	**- 21.5**
NTC_19	ER_L6_1_FW_R	**- 18.7**	NTC_27	ER_L6_2_FW_R	**- 18.1**