DØSMT

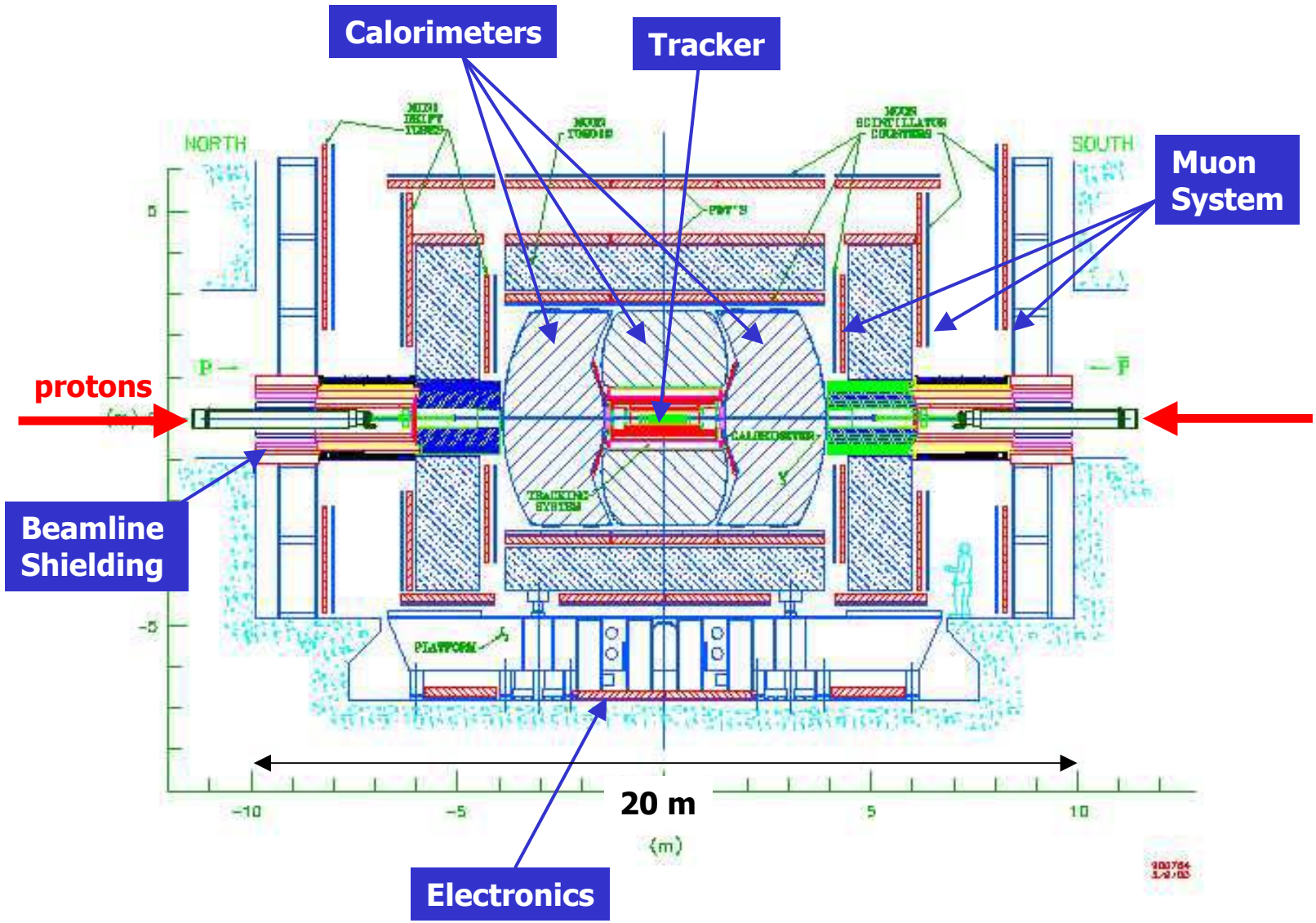
DØ Silicon Microstrip Tracker for runIIa

- Design
- Production
- Assembly
- Readout
- Installation
- Commissioning/Operation

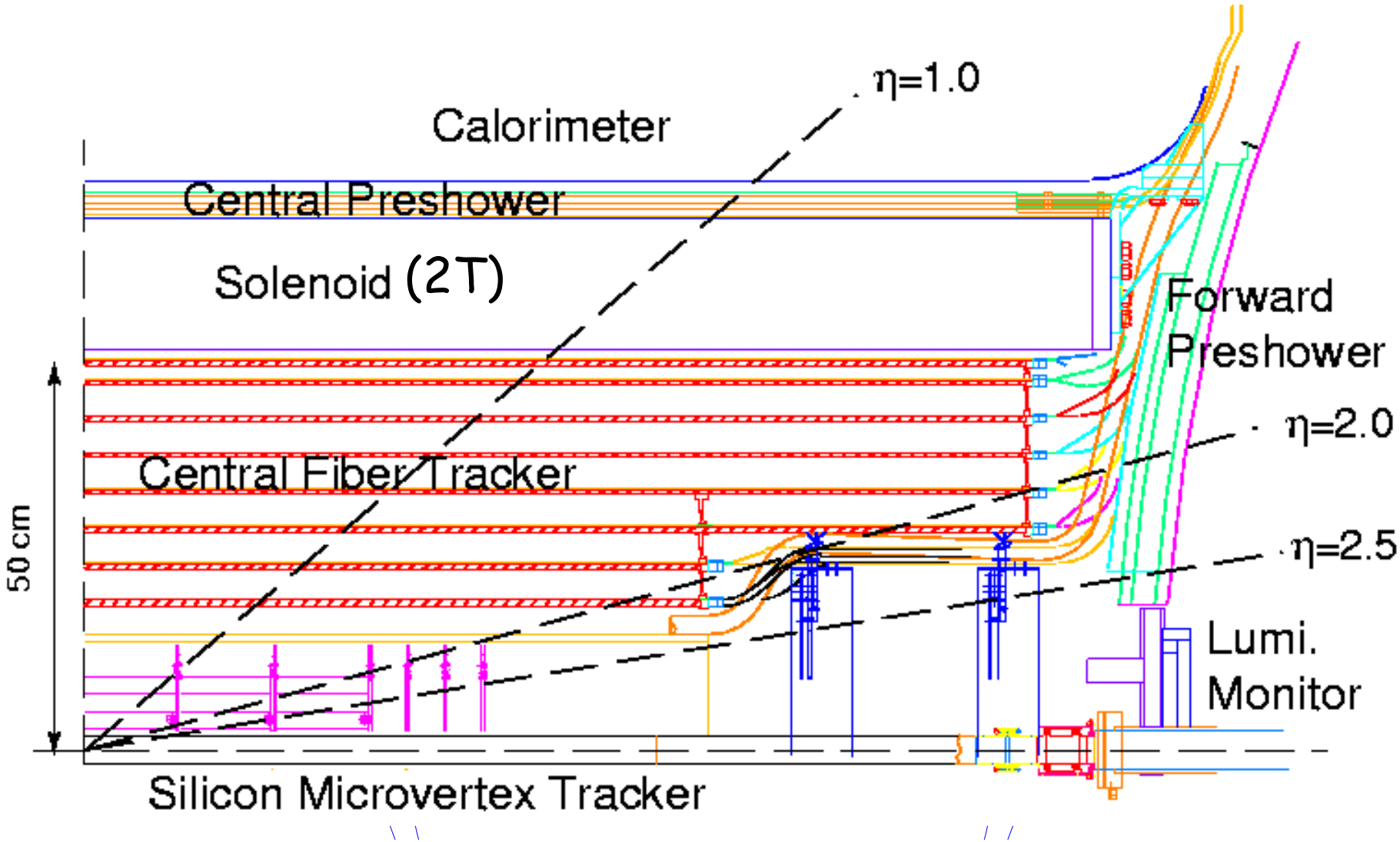
Eric Kajfasz (CPPMarseille)

DAQ shifter training, Feb 18, 2003

The DØ Detector

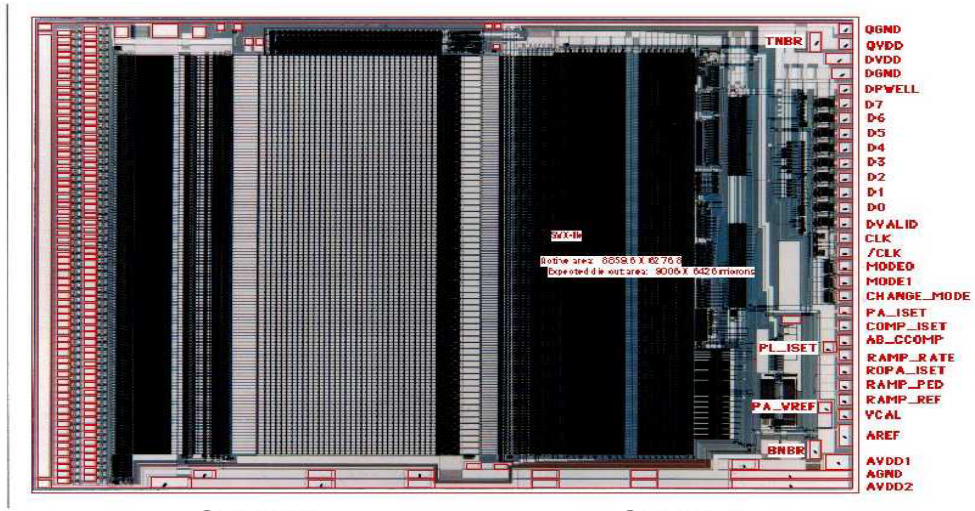


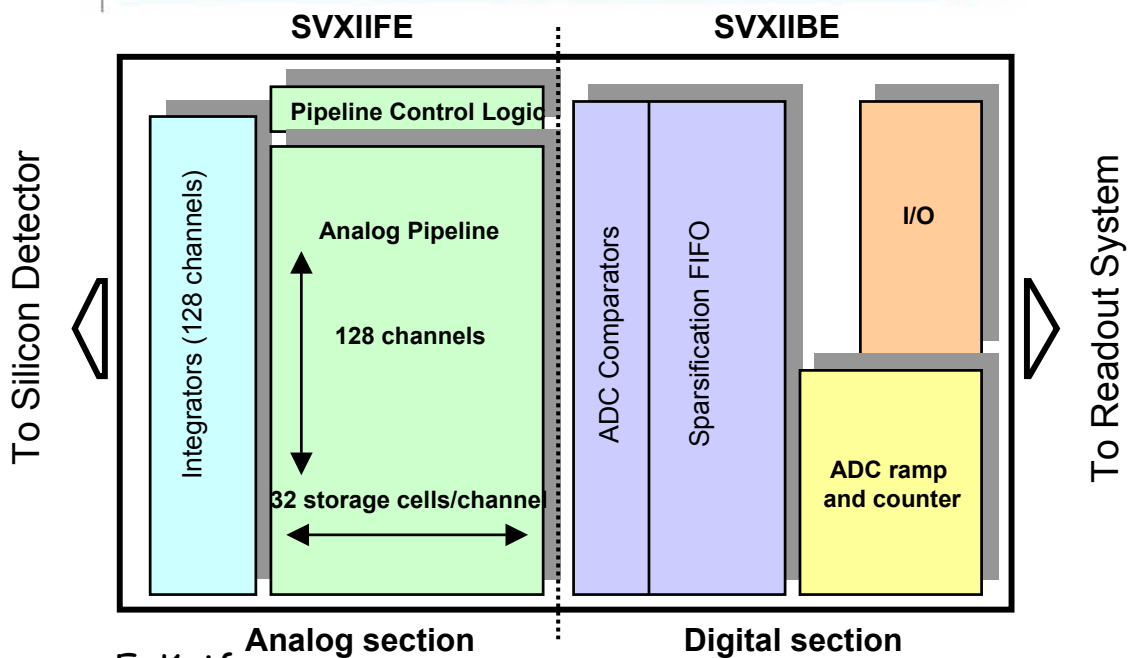
RunIIa SMT Design



SVXIIe chip

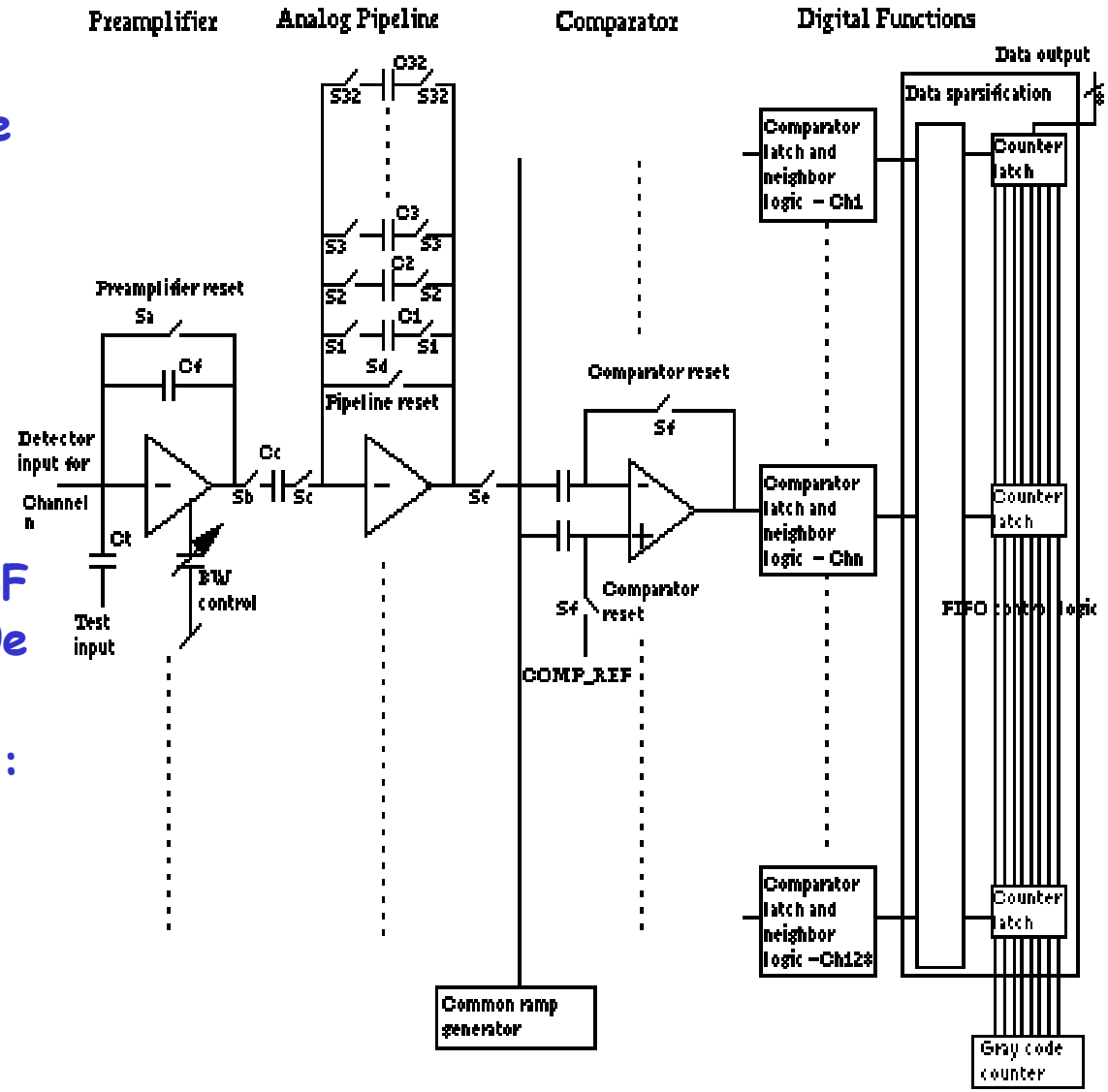
- 1.2 um CMOS amplifier/analog delay/ADC chip fabricated in the UTMC rad hard process
- Designed by LBL/FNAL
- Some features:
  - 128 channels
  - 32 cell pipeline/channel
  - 8-bit Wilkinson ADCs
  - Sparsification
  - 53 MHz readout
  - 106 MHz digitization
  - 6.4 x 9.7 mm2
  - ~ 85,000 transistors
  - noise: 490e + 50e/pF





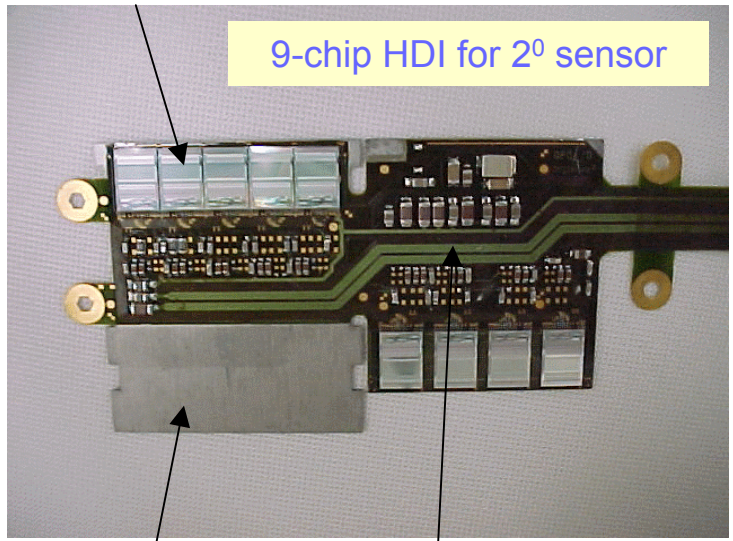
SVXIIe chip

- Externally programmed to achieve optimal performance for 132 or 396ns beam crossings and detector capacitances from 10 to 35pF (preamp bandwidth adjustment)
- Chip noise
  490e + 50e/pF
  i.e. ~1200e ENC for C=15pF
  1 MIP => ~4fC => ~25,000e
  => S/N ~ 20
- Max delay in analog pipeline:
  32 x 132ns = 4.2us

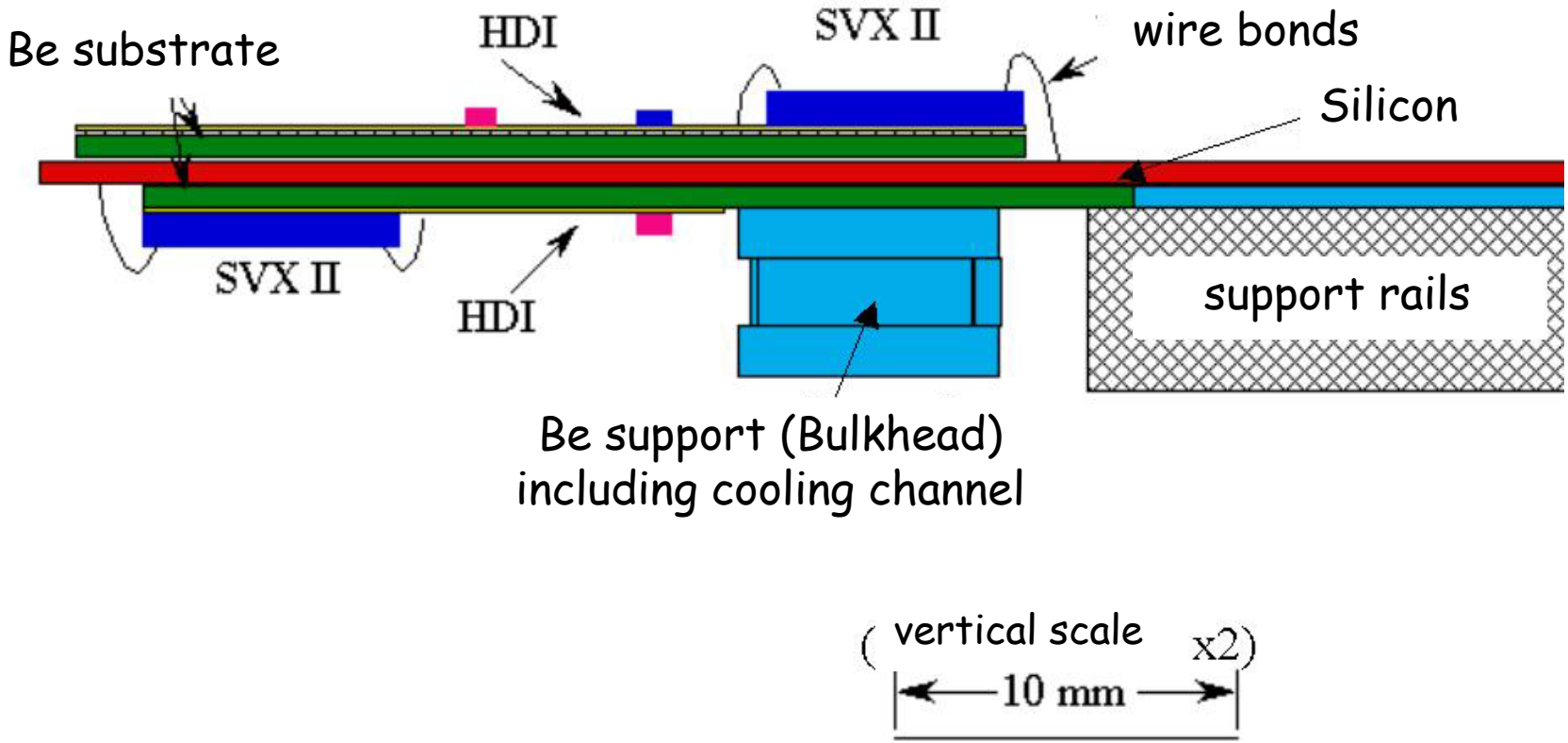


High Density Interconnect

- Kapton based flex circuits with 0.2 mm pitch for chip mounting
- Laminated to Beryllium substrate and glued to Silicon sensor
- Connects Sensor to SVXII chips and SVXII chips to flex circuit via wire bonds (Al wedge bonding)
- Connects to a Low Mass Cable which carries the signals out of the interaction region



Production: ladder design



Micron-UK L3

72 Single Sided
50 um pitch

Micron-UK L6 n-side

144 DSDM

p-side L6

50 (p)/153(n) um

Family of DOSMT Detector types (all AC coupled)

n-side L9

216 DS 2° stereo

Micron-UK L9 p-side

50 (p)/60(n) um

92x2 SS +/- 7.5°

H6

Elma-Russia

F6 n-side

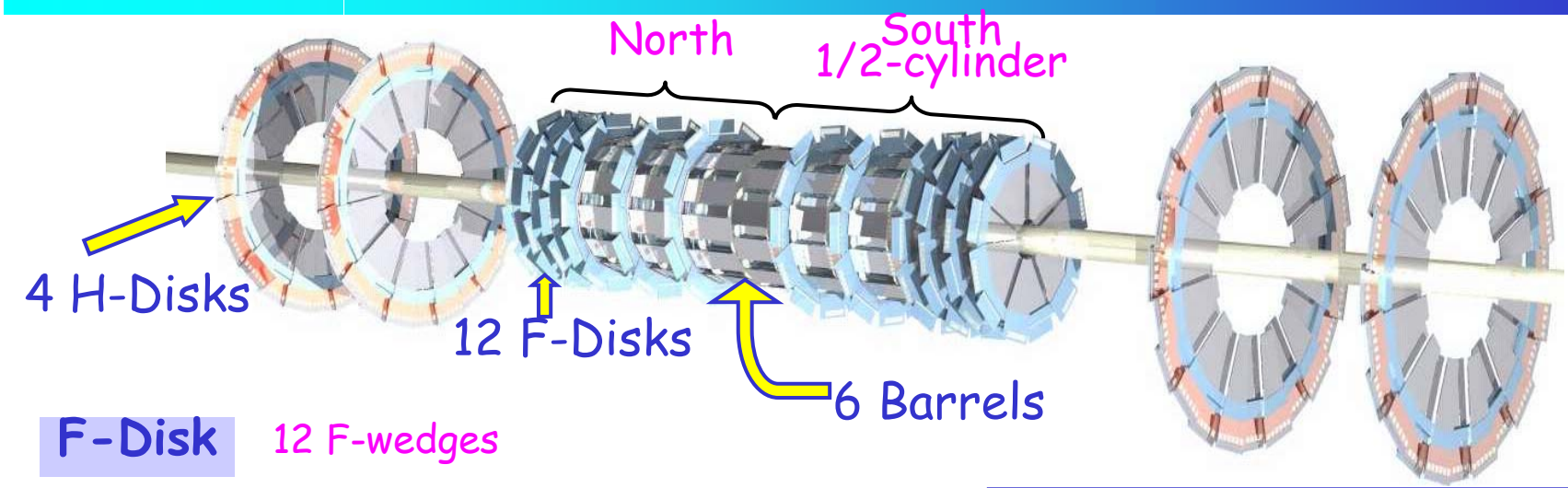
70% Micron-UK, 30% Eurysis-France

144 DS +/- 15° stereo

p-side F8

50 (p)/62.5(n) um

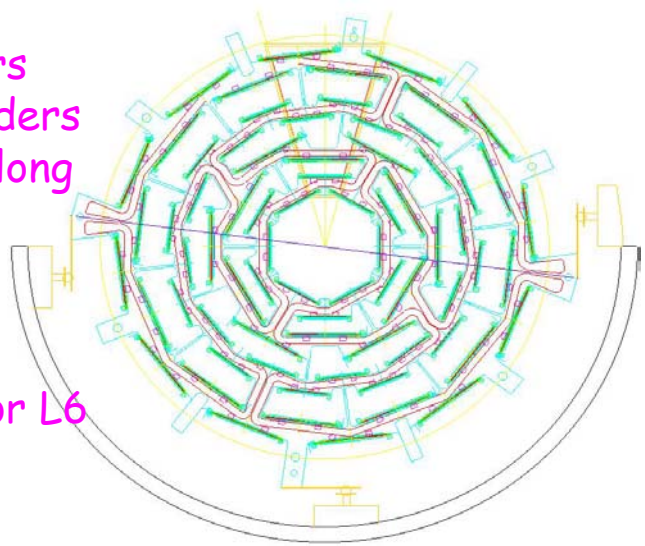
RunIIa SMT Design



F-Disk 12 F-wedges

H-Disk 24 H-wedges

Barrel 8 layers
72 ladders
12 cm long

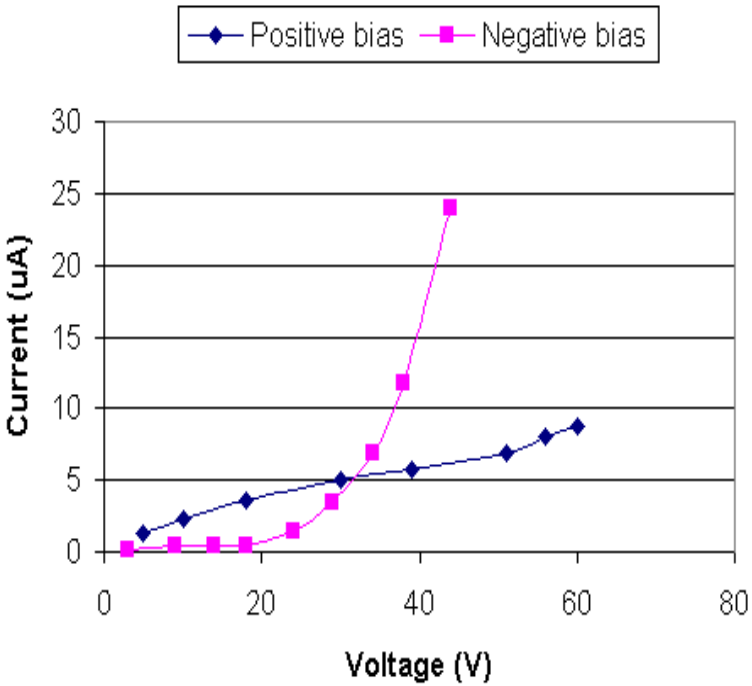


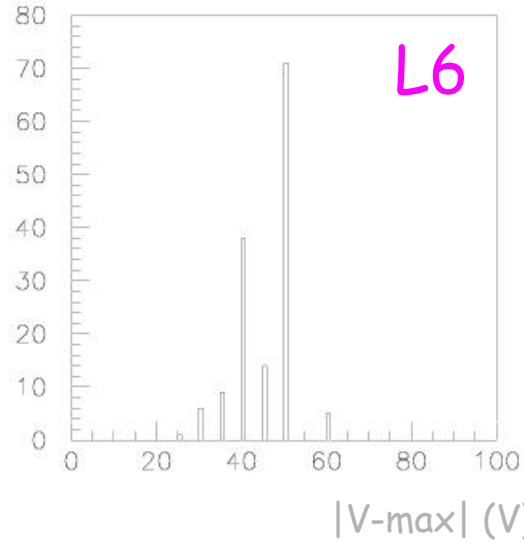
Layers 1,2,5,6: L3 or L6
Layers 3,4,7,8: L9

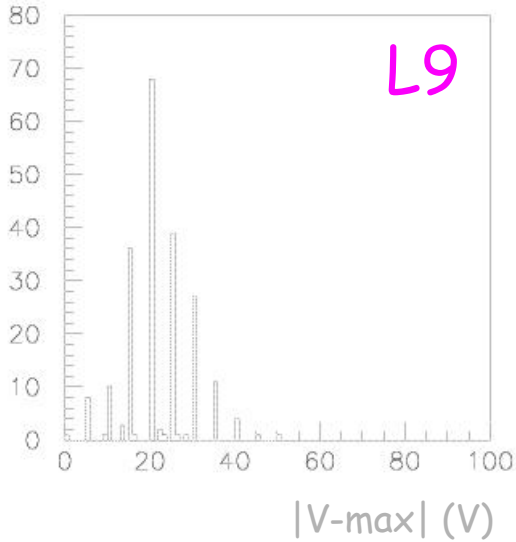
	Barrels	F-Disks	H-Disks
Channels	387072	258048	147456
Modules	432	144	96
Si Area	1.3 m^2	0.4 m^2	1.3 m^2
Inner R	2.7 cm	2.6 cm	9.5 cm
Outer R	9.4 cm	10.5 cm	26 cm

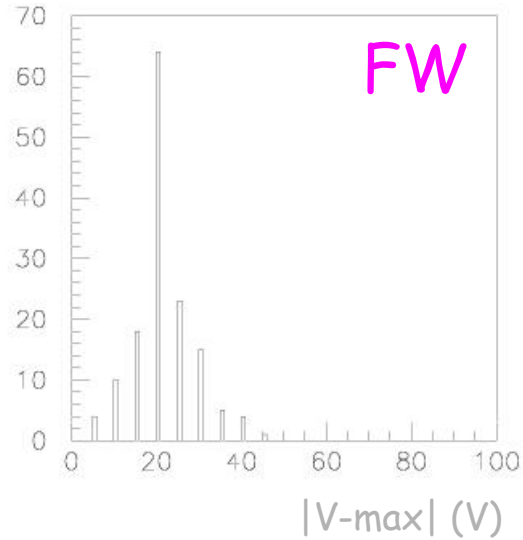
6192 R/O chips = 792,576 channels
> 1.5 million wire bonds

Production: V-max



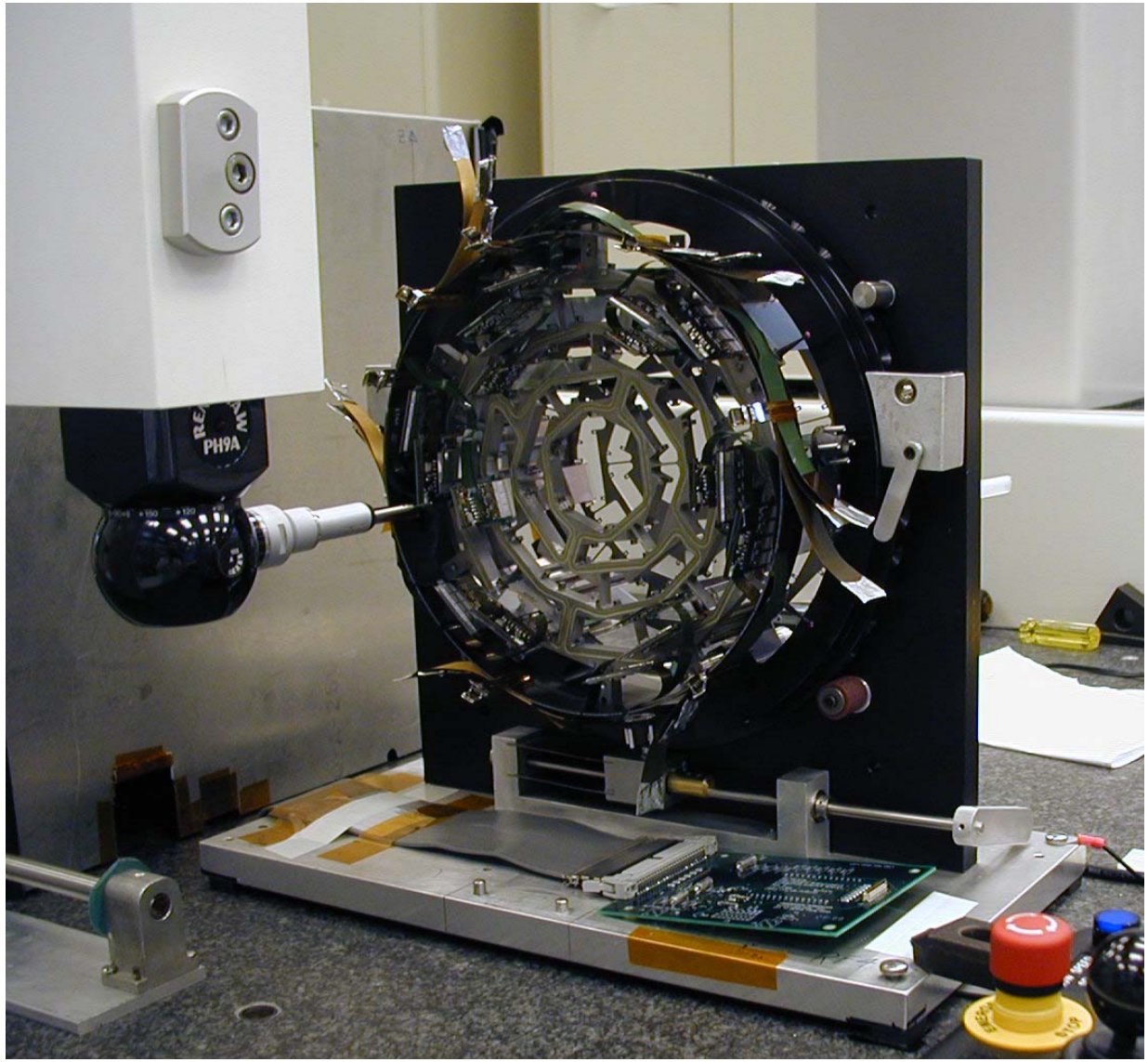




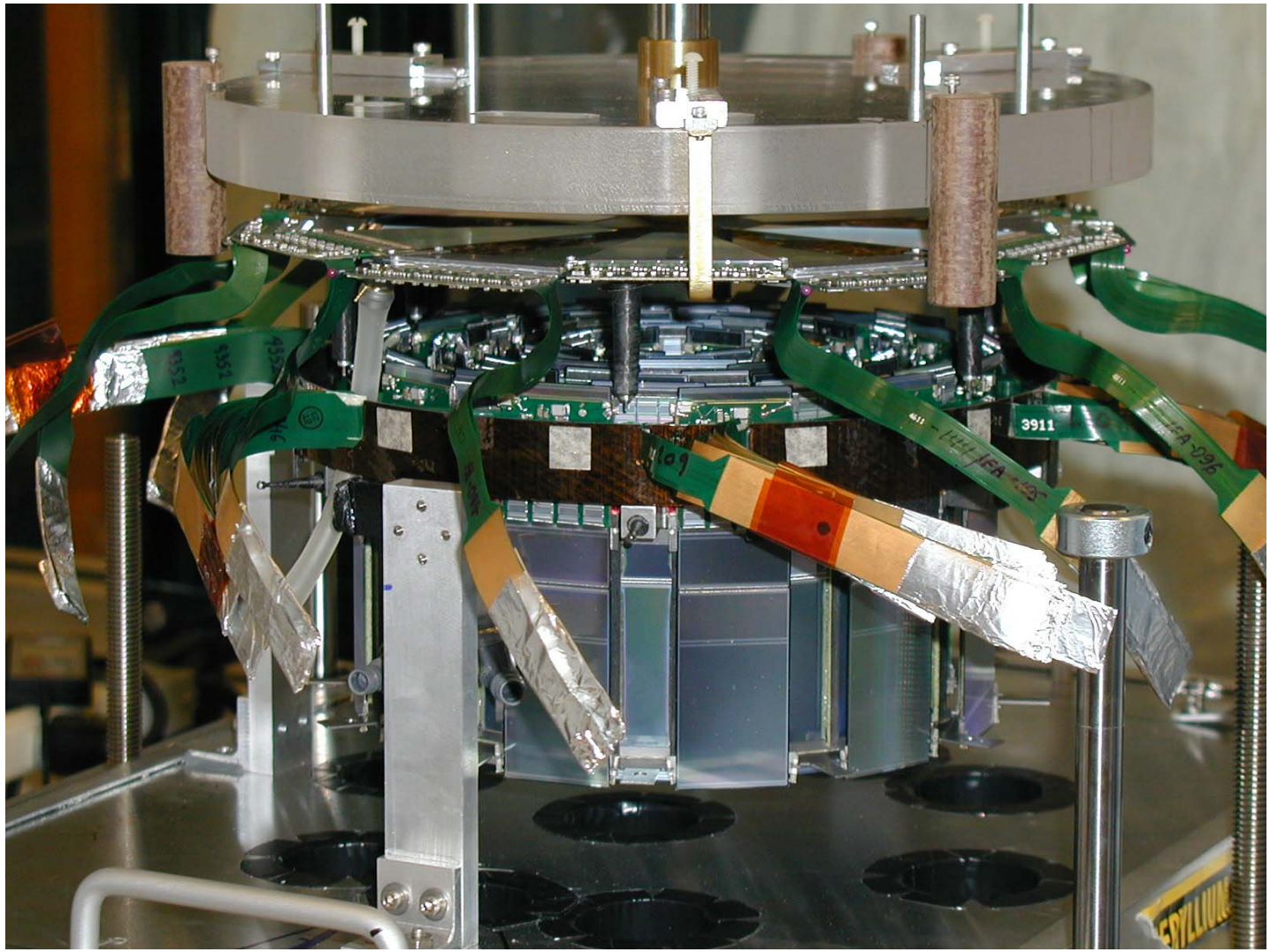


Assembly: Barrel assembly

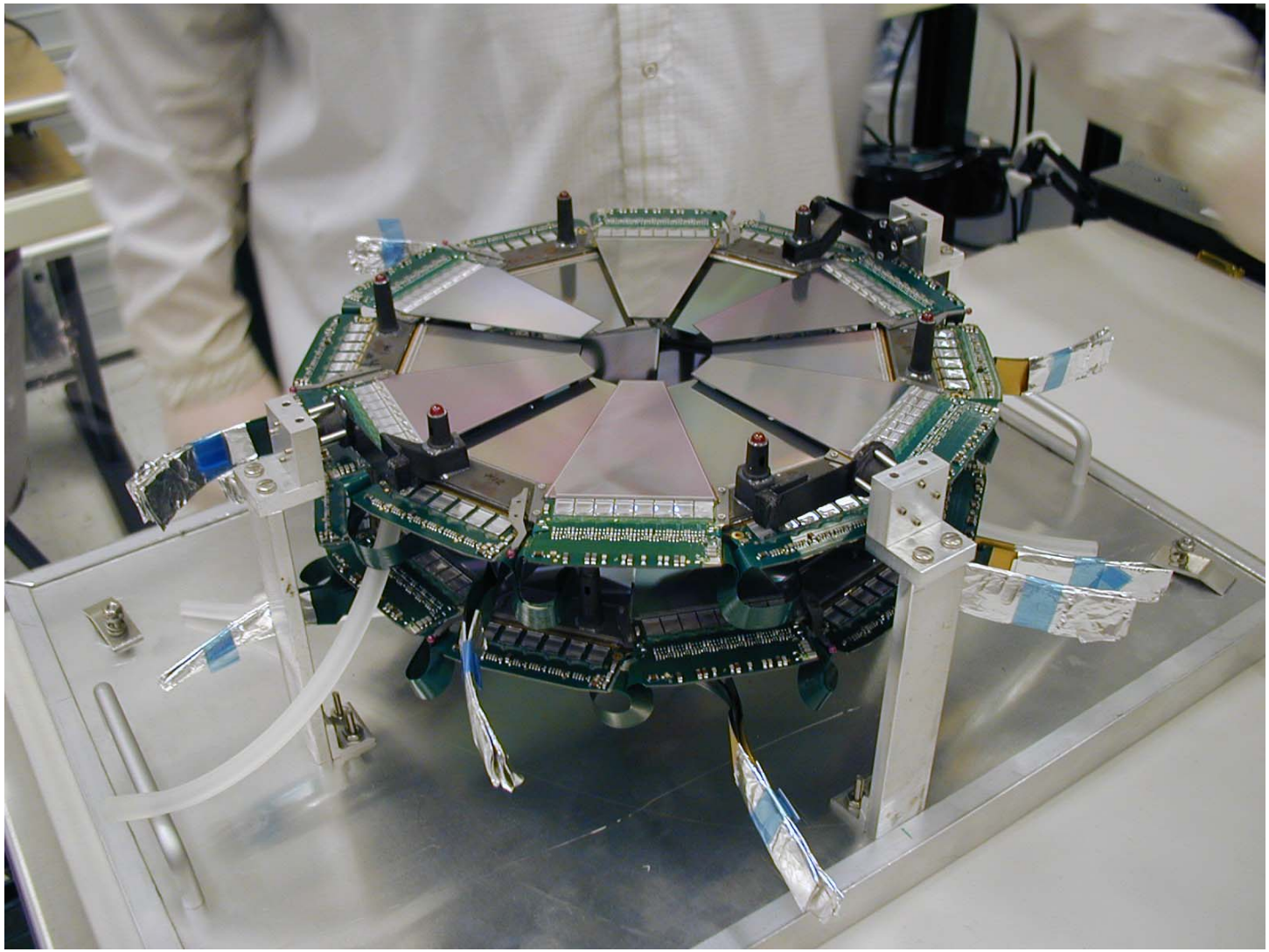
- Ladders placed on barrels using an insertion fixture
- Internal alignment done using a CMM (touch probe)



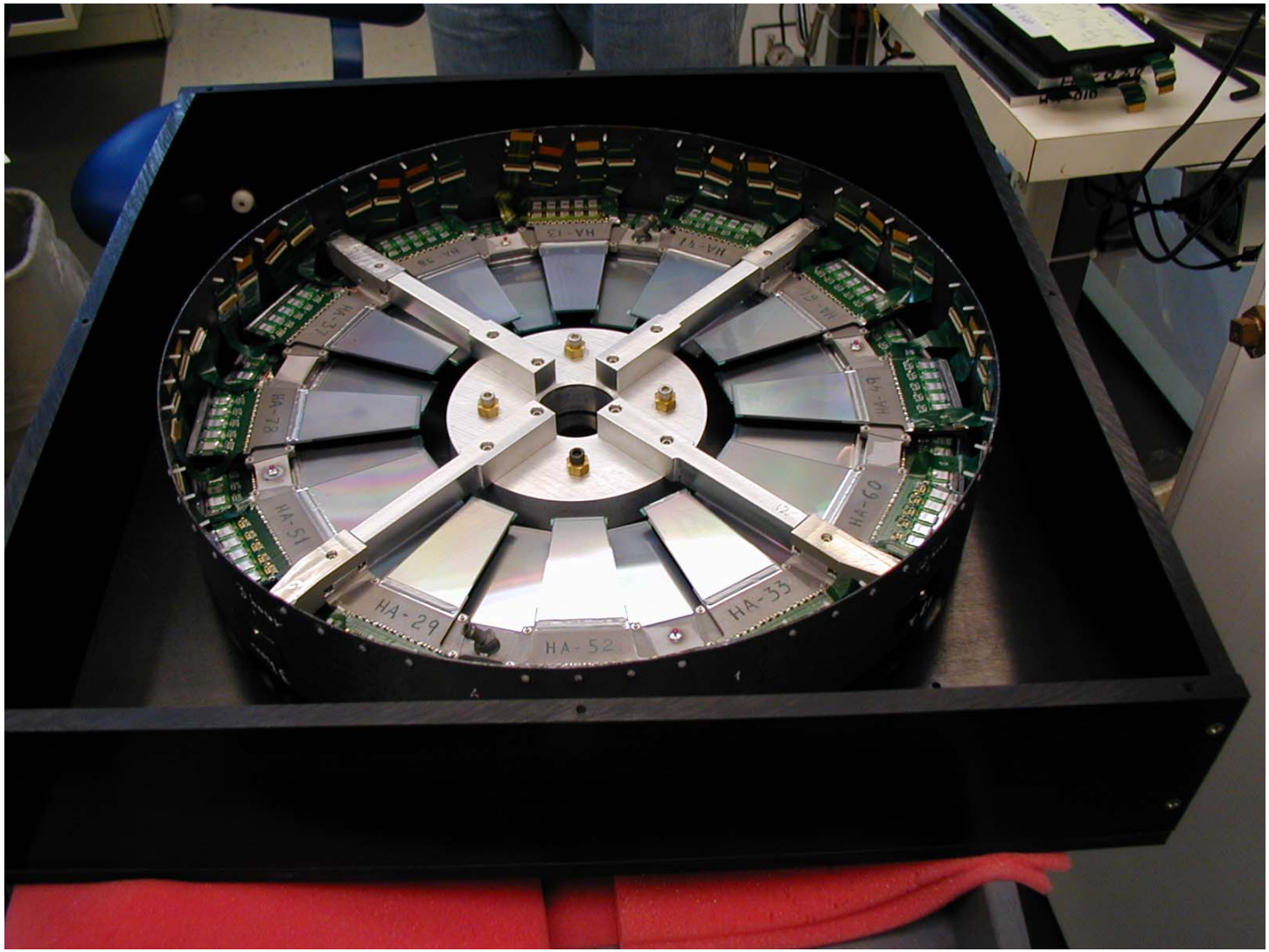
Assembly: Barrel-Fdisk mating



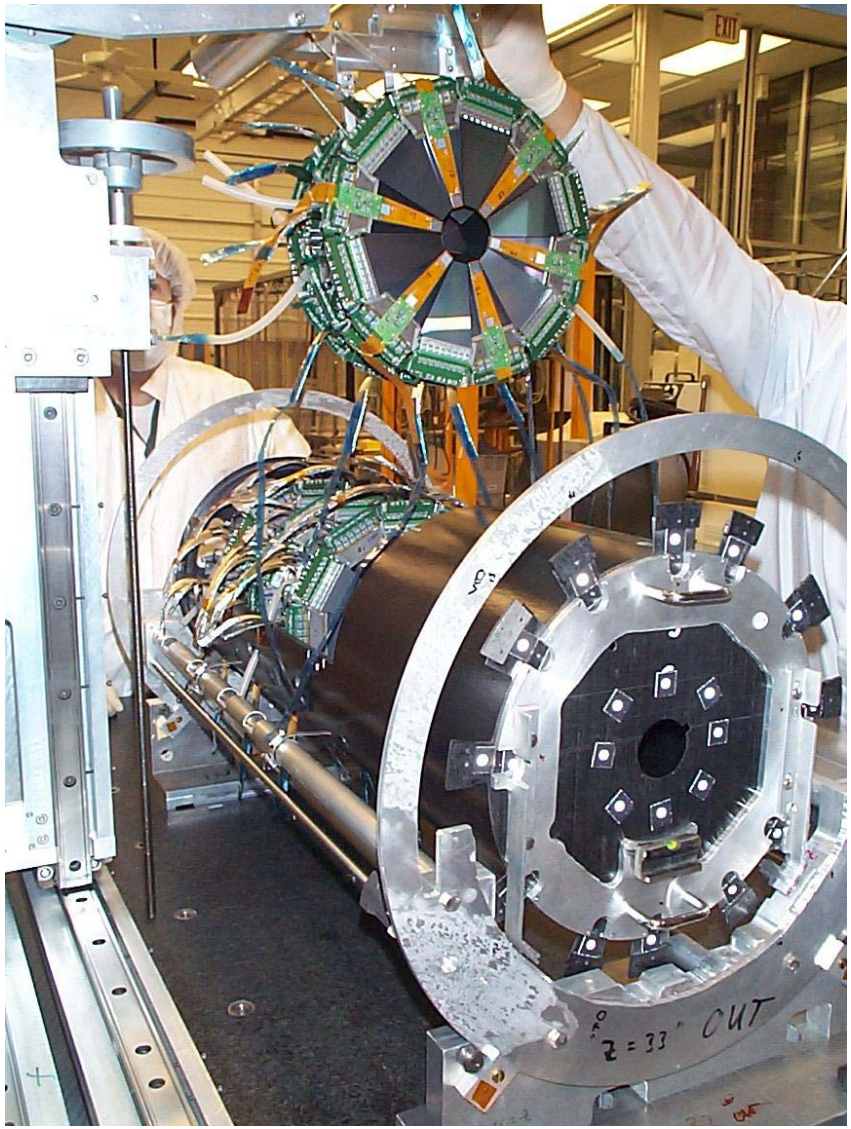
Assembly: End Fdisks mating



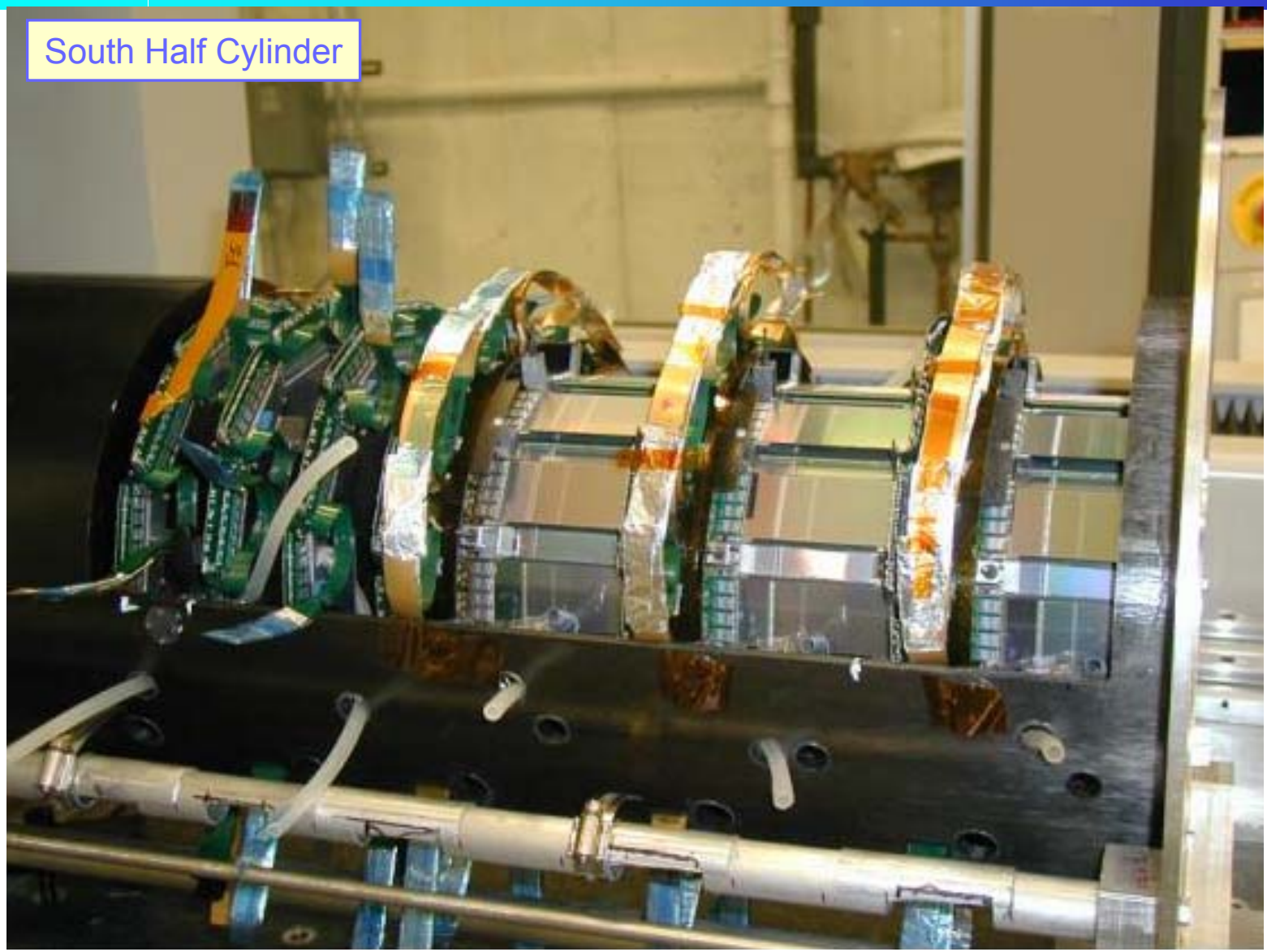
Assembly: Hdisk



Assembly: Radiation monitors



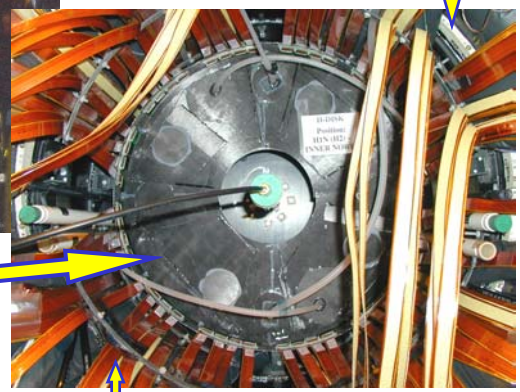
Assembly: 1/2-cylinder

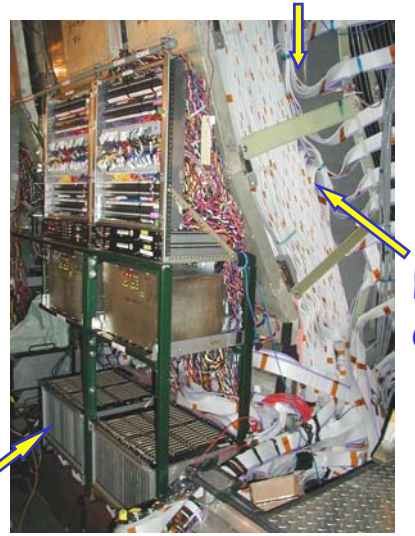


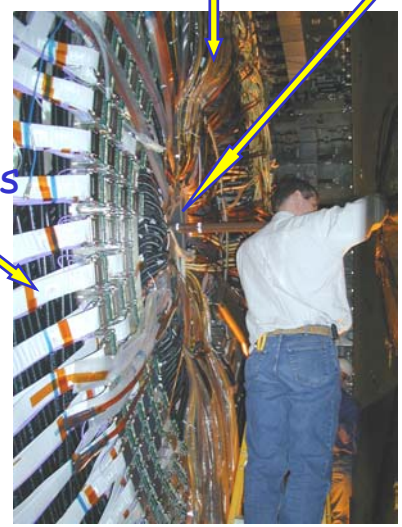
Assembly: 1/2-cylinder

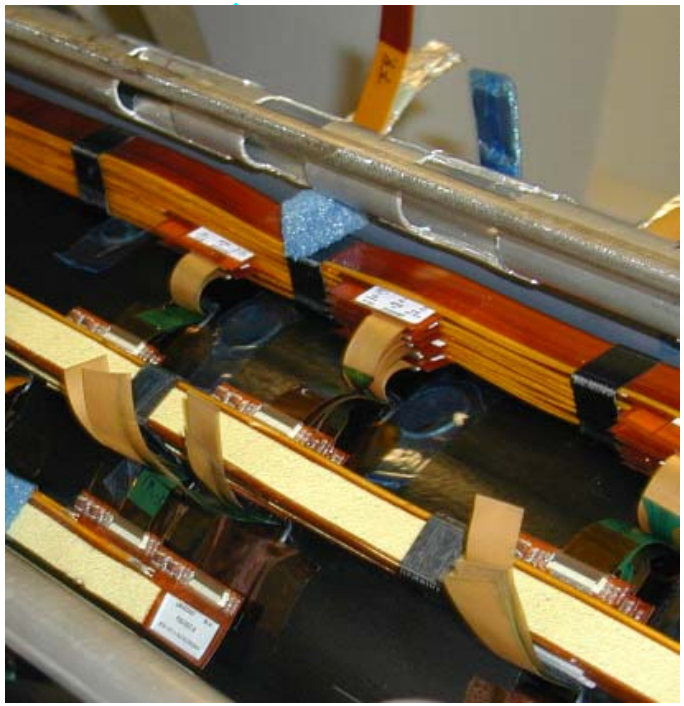
Installation

- Cylinder installation was completed on 12/20/00
  - A 1/2-cylinder of 3 barrels and 6 F disks was inserted into each end of the CFT bore
- H Disk installation was completed on 2/6/01
- The cabling (~15,000 connections) and electronics installation was completed in May 2001

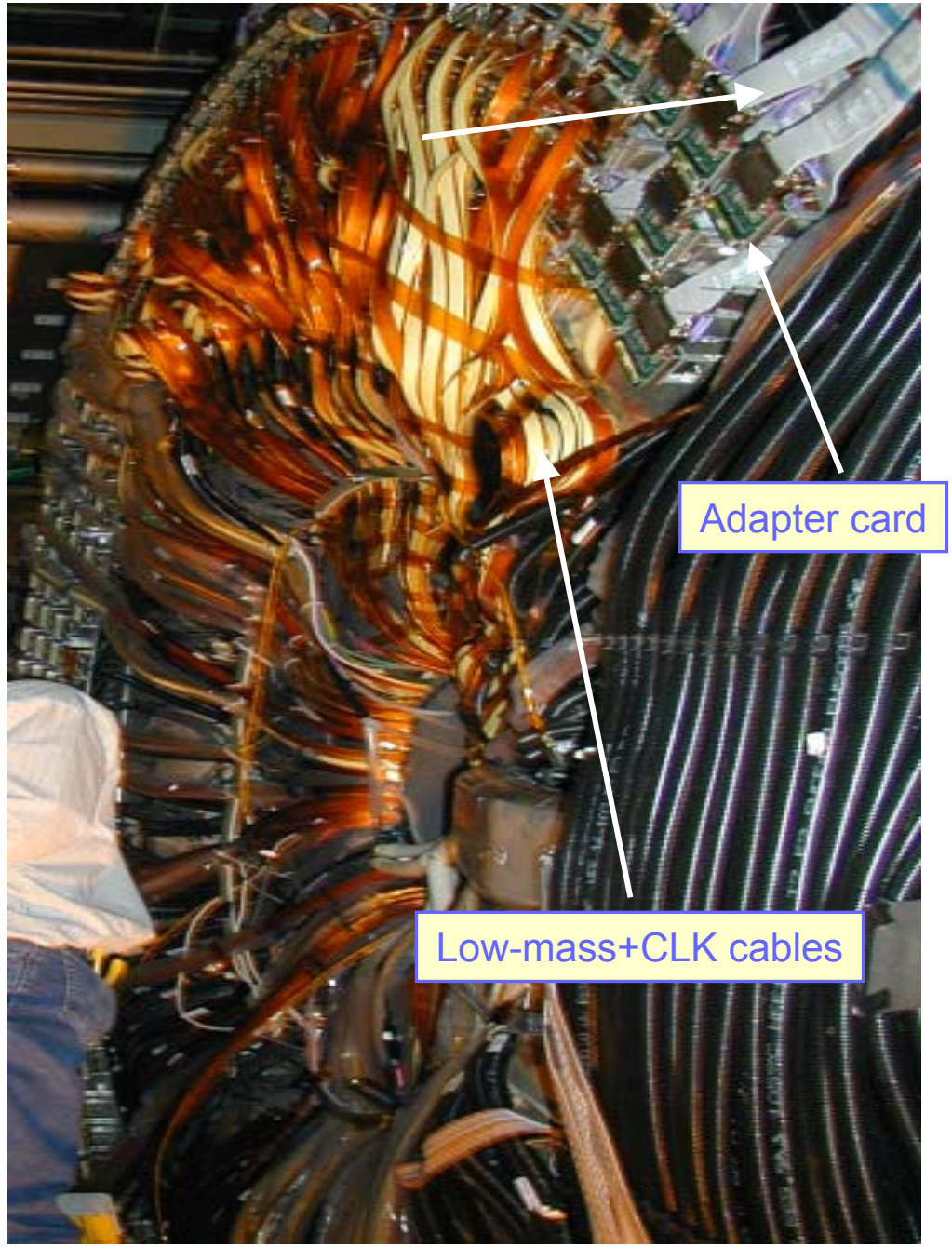


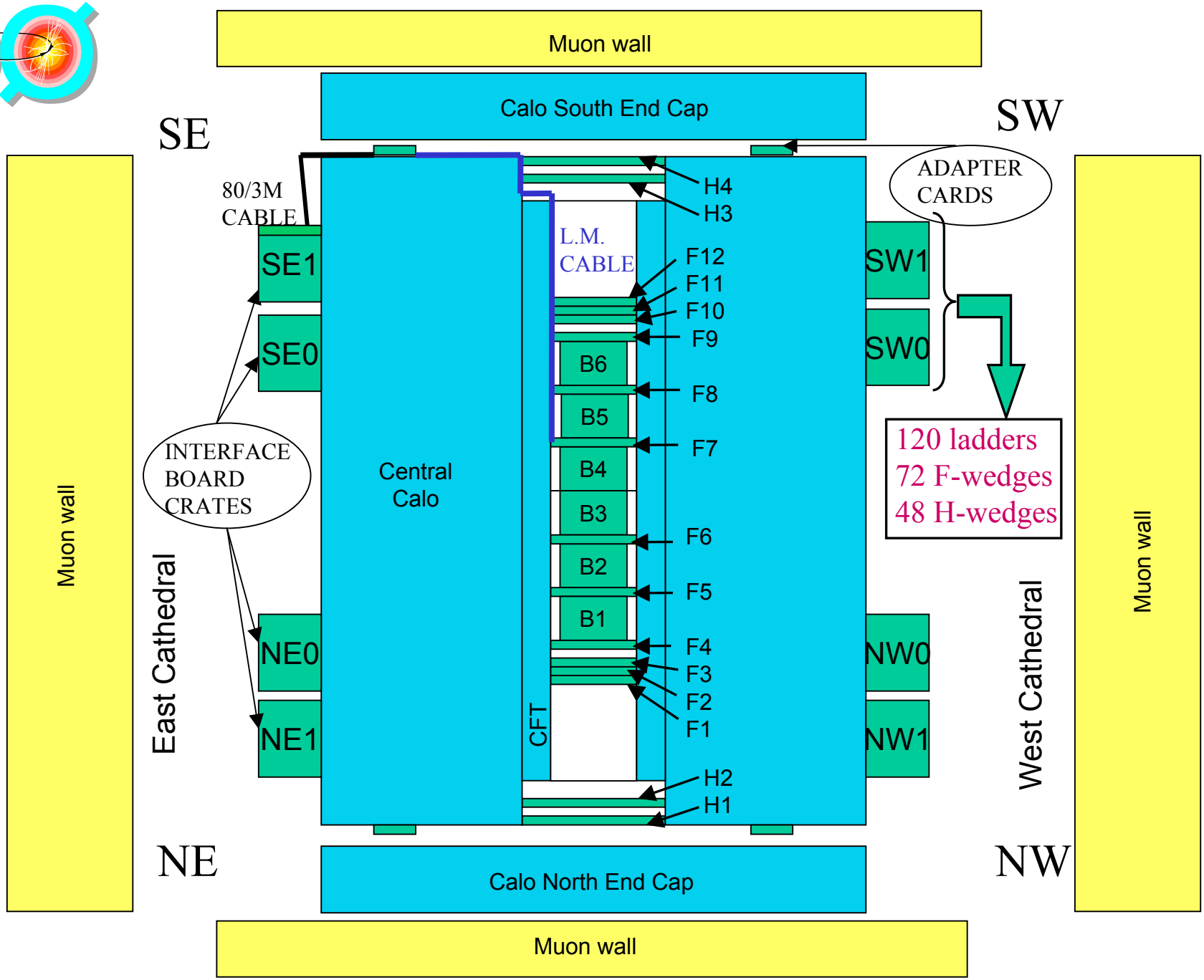






2003/02/


Adapter card
Low-mass+CLK cables

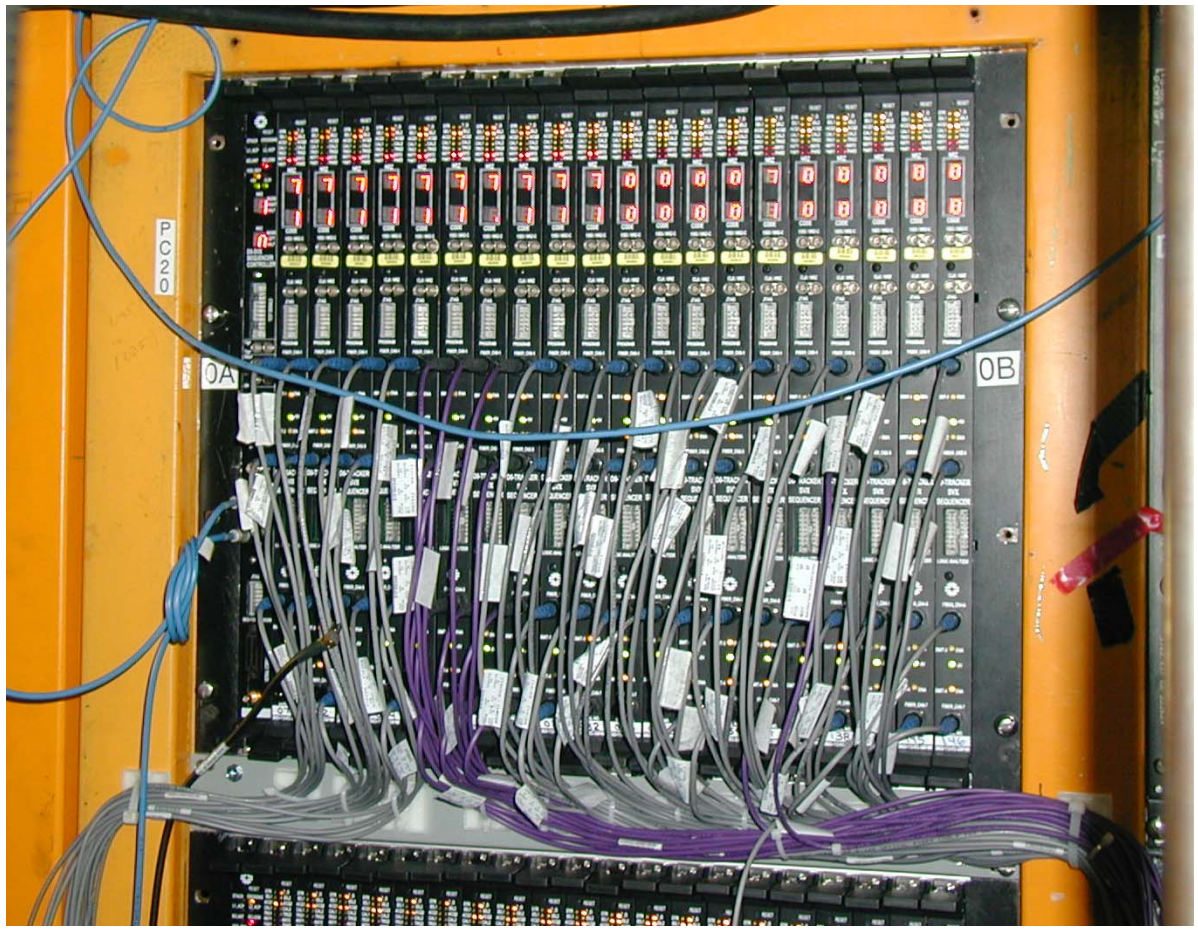

Muon wall
Calo South End Cap
SE
SW
80/3M
CABLE
ADAPTER
CARDS
H4
H3
L.M.
CABLE
F12
F11
F10
F9
SE1
SE0
SW1
SW0
B6
F8
B5
F7
B4
B3
F6
B2
F5
B1
F4
F3
F2
F1
H2
H1
INTERFACE
BOARD
CRATES
Central
Calo
CFT
120 ladders
72 F-wedges
48 H-wedges
Muon wall
East Cathedral
West Cathedral
Muon wall
NE0
NE1
NW0
NW1
NE
NW
Calo North End Cap
Muon wall

Readout Electronics (Cathedrals)

- Interface Boards
  - 8 crates (144 boards) located inside the cathedrals
  - Regenerates signals
  - SVX monitoring and power management
  - Bias voltage distribution

Readout Electronics (Platform)

- SEQuencers
  - 6 crates (120 boards) located on the detector platform
  - Use SVX control lines to actuate acquisition, digitization and readout
  - Convert SVX data to optical signals

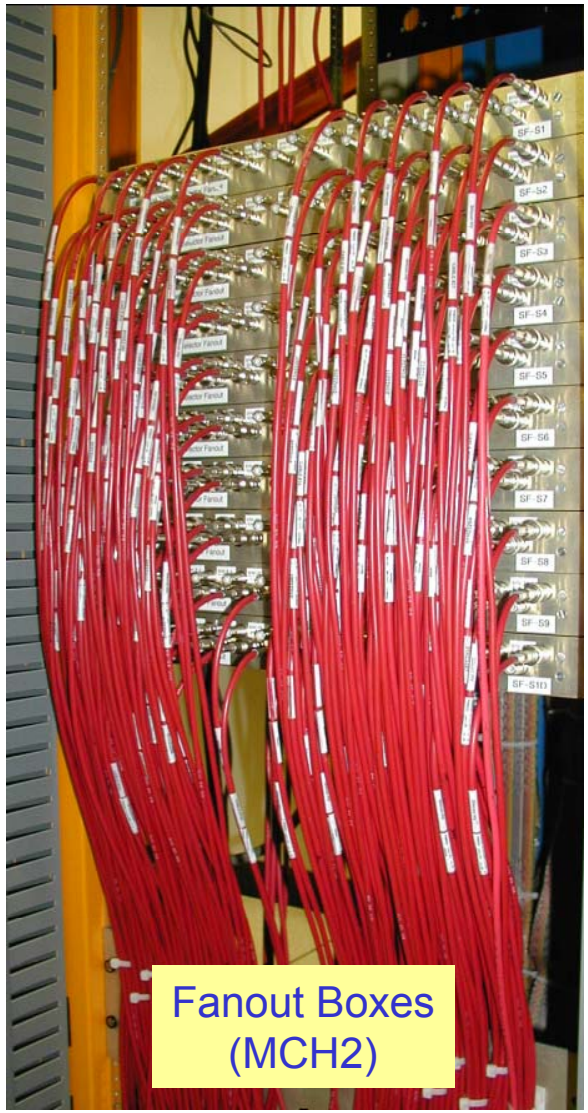


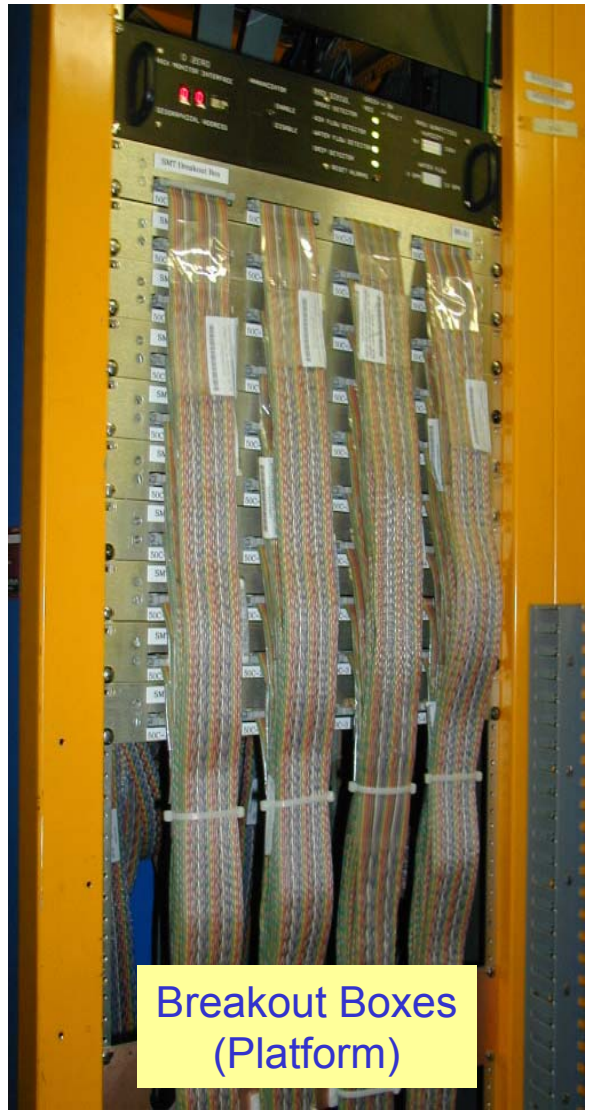
Readout Electronics (MCH2)

- VRBs (Readout Buffers)
  - 12 crates (120 boards) located in MCH2
  - Data buffer pending L2 trigger decision

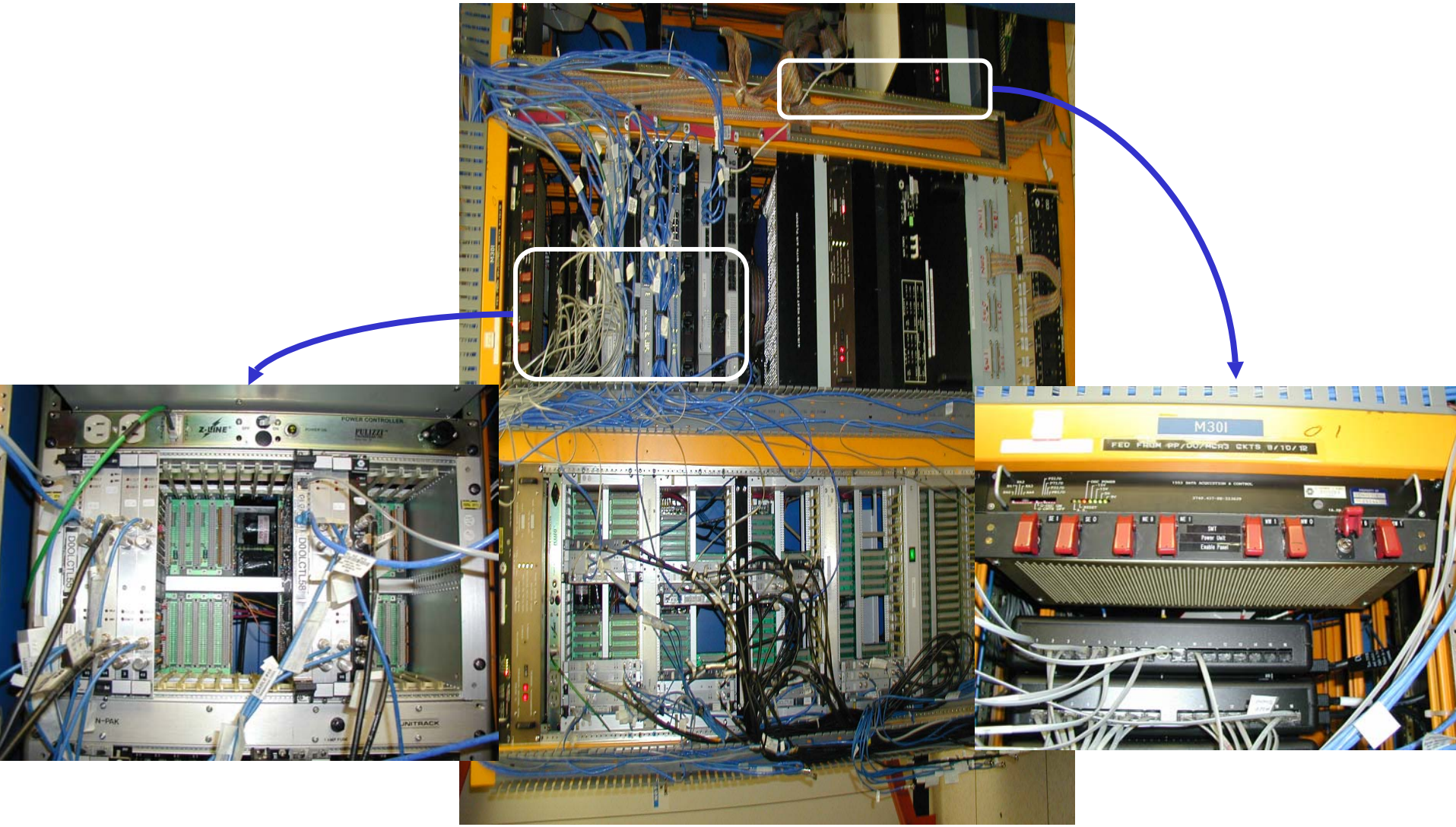
- Input @ 5-10 kHz L1 accept rate ~ 50 Mb/s/channel
- Output @ 1 kHz L2 accept rate ~ 50 Mb/s

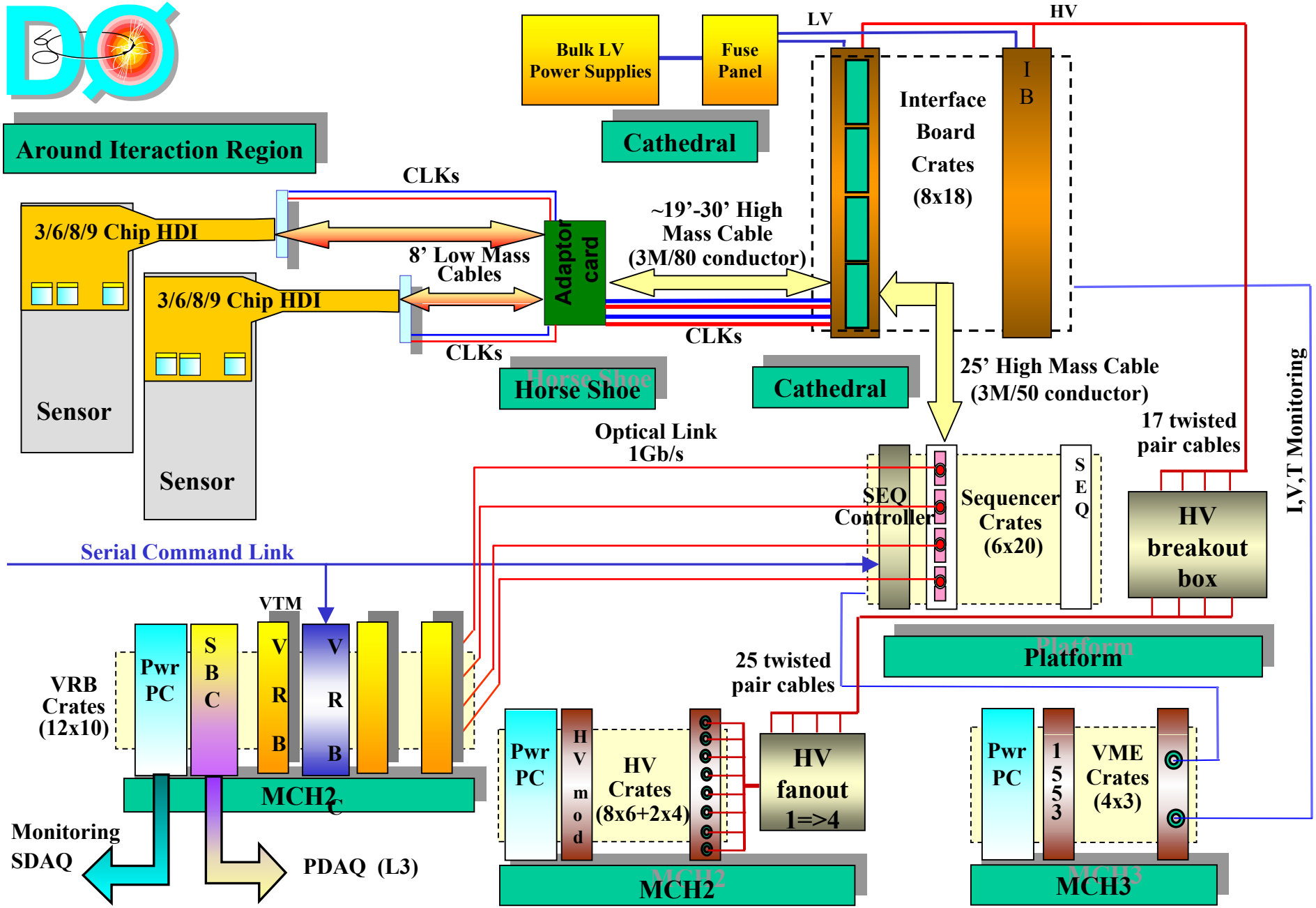
HV distribution





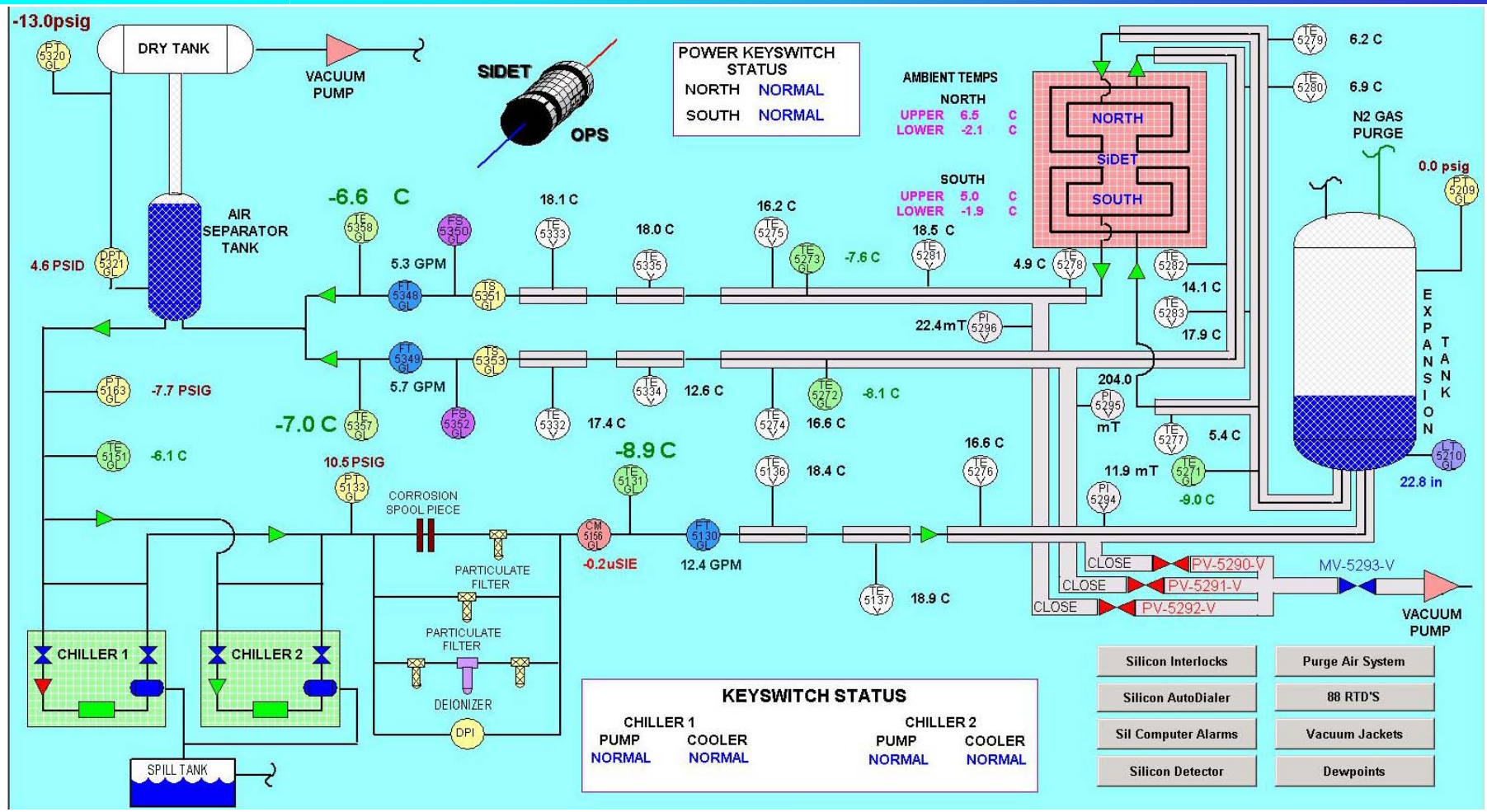
MCH3: 1553 Controllers





PowerPCs and Single Board Computers are accessed thru Ethernet

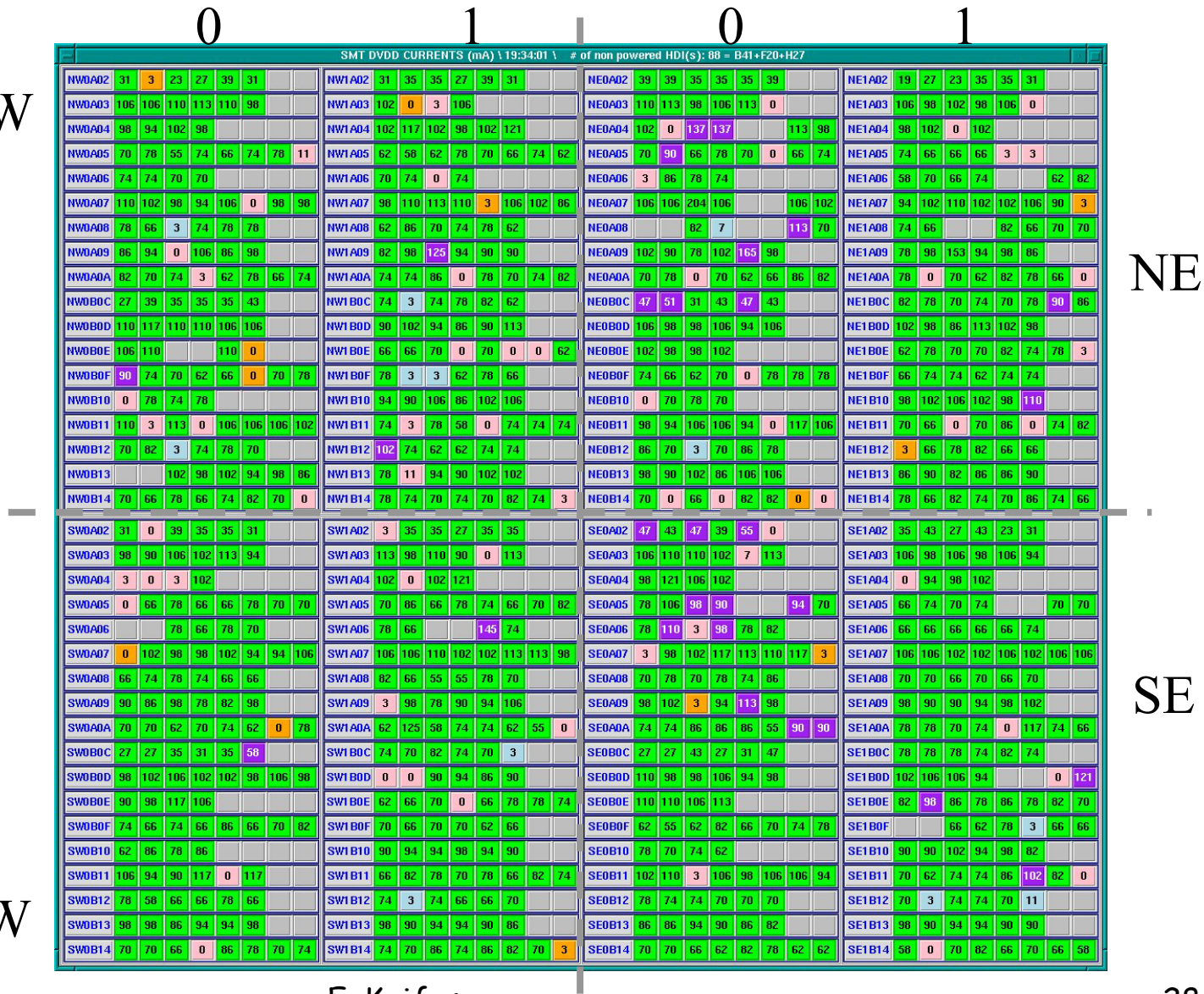
Cooling system



- 30% glycol + water at –10 °C (=> detectors between –5 and 0 °C)
- The tracking volume is purged with dry air to prevent condensation

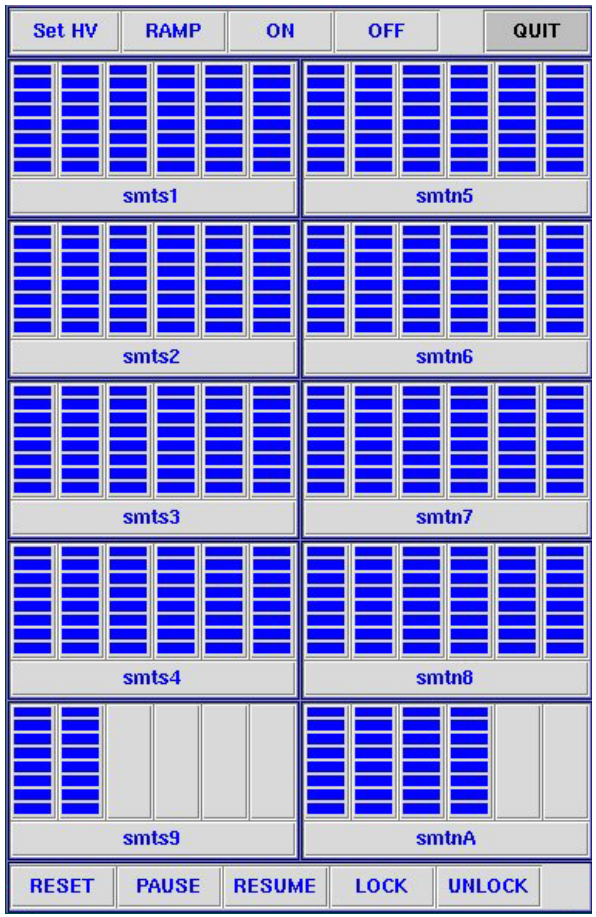
Operations: LV

- Color coding
  - orange: OFF
  - green: OK
  - purple: idvdd a bit too high
  - red: idvdd too high
  - pink: dead
  - light blue: for HV only
  - red/black: tripped
  - gray: not used

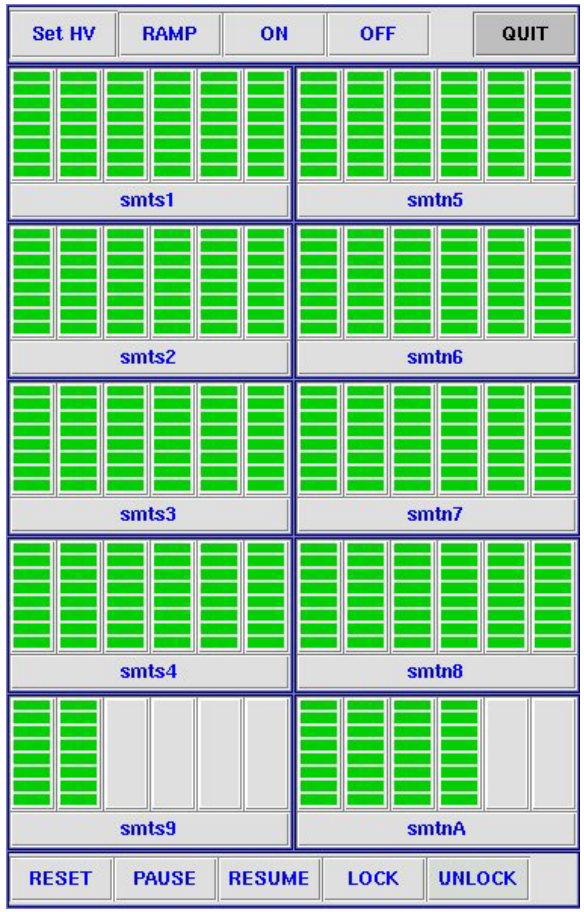


HV Global GUI

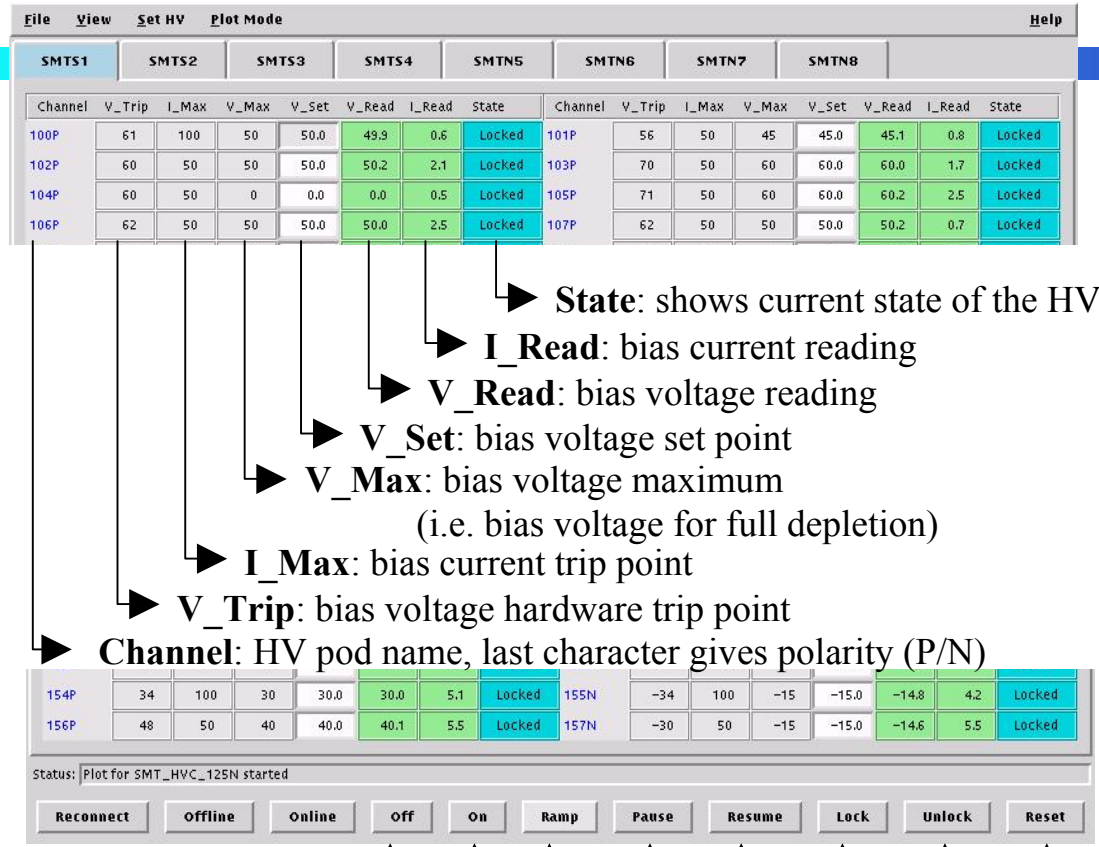
OFF



ON



HV channel GUI



State: shows current state of the HV pod

I_Read: bias current reading

V_Read: bias voltage reading

V_Set: bias voltage set point

V_Max: bias voltage maximum
(i.e. bias voltage for full depletion)

I_Max: bias current trip point

V_Trip: bias voltage hardware trip point

Channel: HV pod name, last character gives polarity (P/N)

Off: turn off pods

On: turn on pods

Ramp: start ramping

Pause: pause ramping

Resume: resume paused ramping

Lock: lock pods at current setting

Unlock: unlock locked pods

Reset: reset tripped pods

HV Alarms

File View Settings Help

Group Name	MAJOR	MINOR	INVALID	DISABLED	GOOD
HV	397	899	0	0	0
LV	0	2	2	0	596
IB	0	0	0	0	0
Occupancy	0	0	0	0	0
Dead	0	0	0	0	0
all	397	901	41	0	817

Status: Connection to server opened

SMT_HVC_100P/VOLT
SMT_HVC_101P/VOLT
SMT_HVC_102P/VOLT
SMT_HVC_103P/VOLT
SMT_HVC_105P/VOLT
SMT_HVC_106P/VOLT
SMT_HVC_107P/VOLT
SMT_HVC_110P/VOLT
SMT_HVC_111P/VOLT
SMT_HVC_112P/VOLT
SMT_HVC_113N/VOLT
SMT_HVC_114P/VOLT
SMT_HVC_115N/VOLT
SMT_HVC_116P/VOLT
SMT_HVC_117N/VOLT

SHOW
DISABLE
DISABLE ALL
CLOSE

********** SMT_HVC_100P/VOLT **********
Alarm cause: LoLo alarm
Alarm value: −0.305175
HiHi limit: 55.000000
High limit: 53.000000
Low limit : 47.000000
LoLo limit: 45.000000

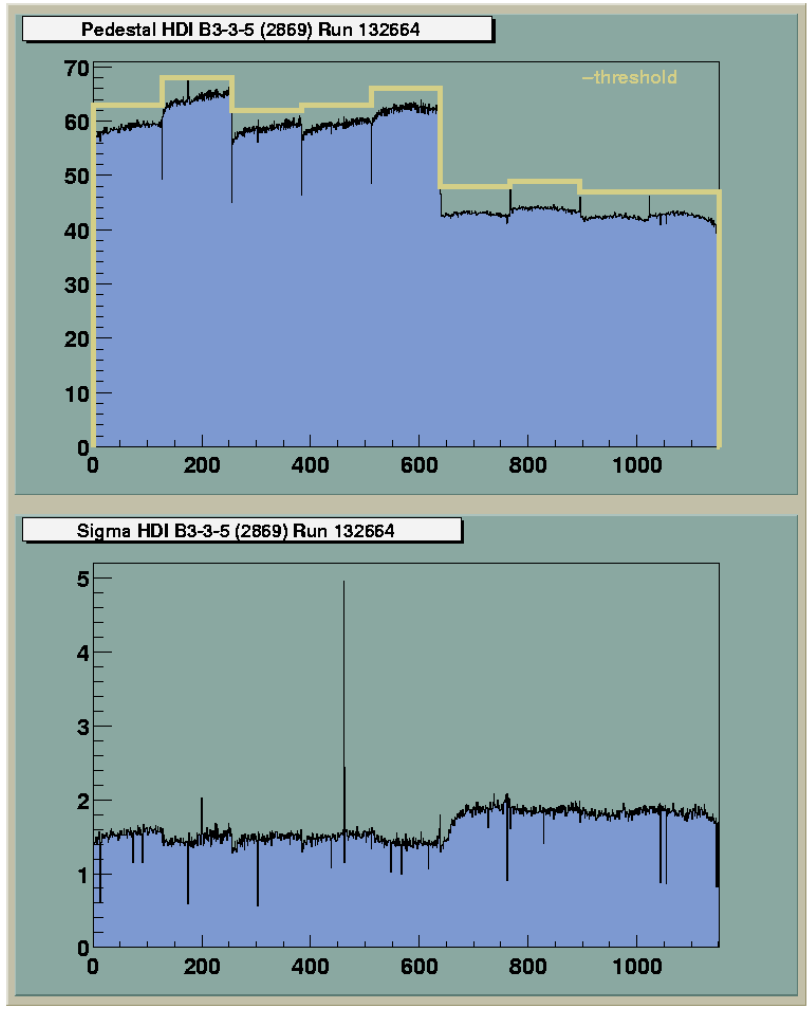
Message contents:

version:	v4
utility:	ef(5,0)
timestamp:	Thu Oct 3 11:14:48 2002
message type:	alarm
name:	SMT_HVC_100P/VOLT
priority:	0
host:	d0olctl08
db entry:	0
parent:	none
children:	none
transition:	bad
severity:	major
alarm type:	analog
parameters:	ai 5 −0.305175 55.000000 53.000000 47.000000 45.000000

CLOSE DISABLE CONTROL GUIDANCE COMMAND

Calibrations

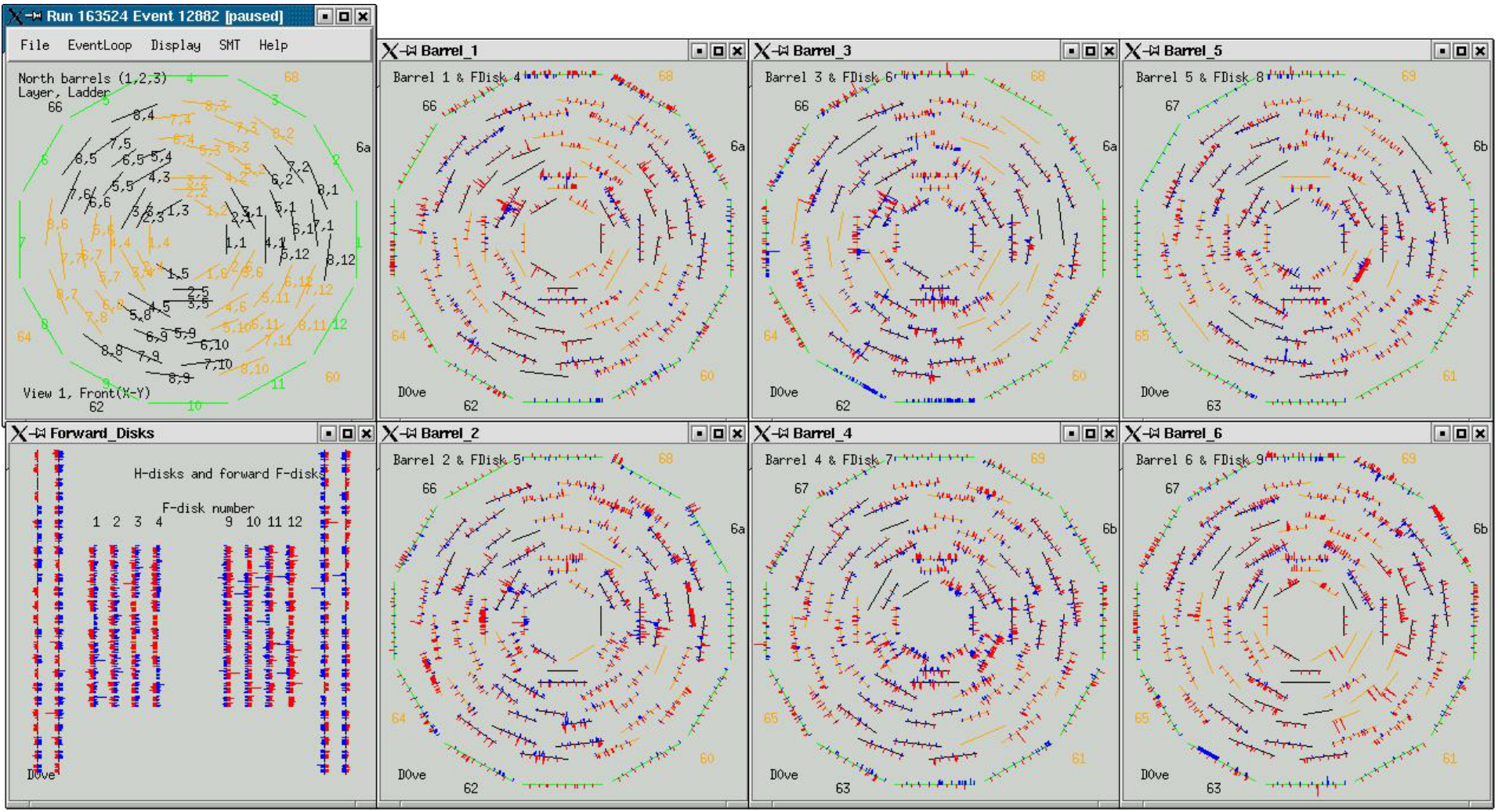
- SMT pedestal, noise and gain measurements are taken using SDAQ.
- Pedestal and noise measurements are used to calculate the threshold per chip to be used in sparse read out



SMT Online Monitoring

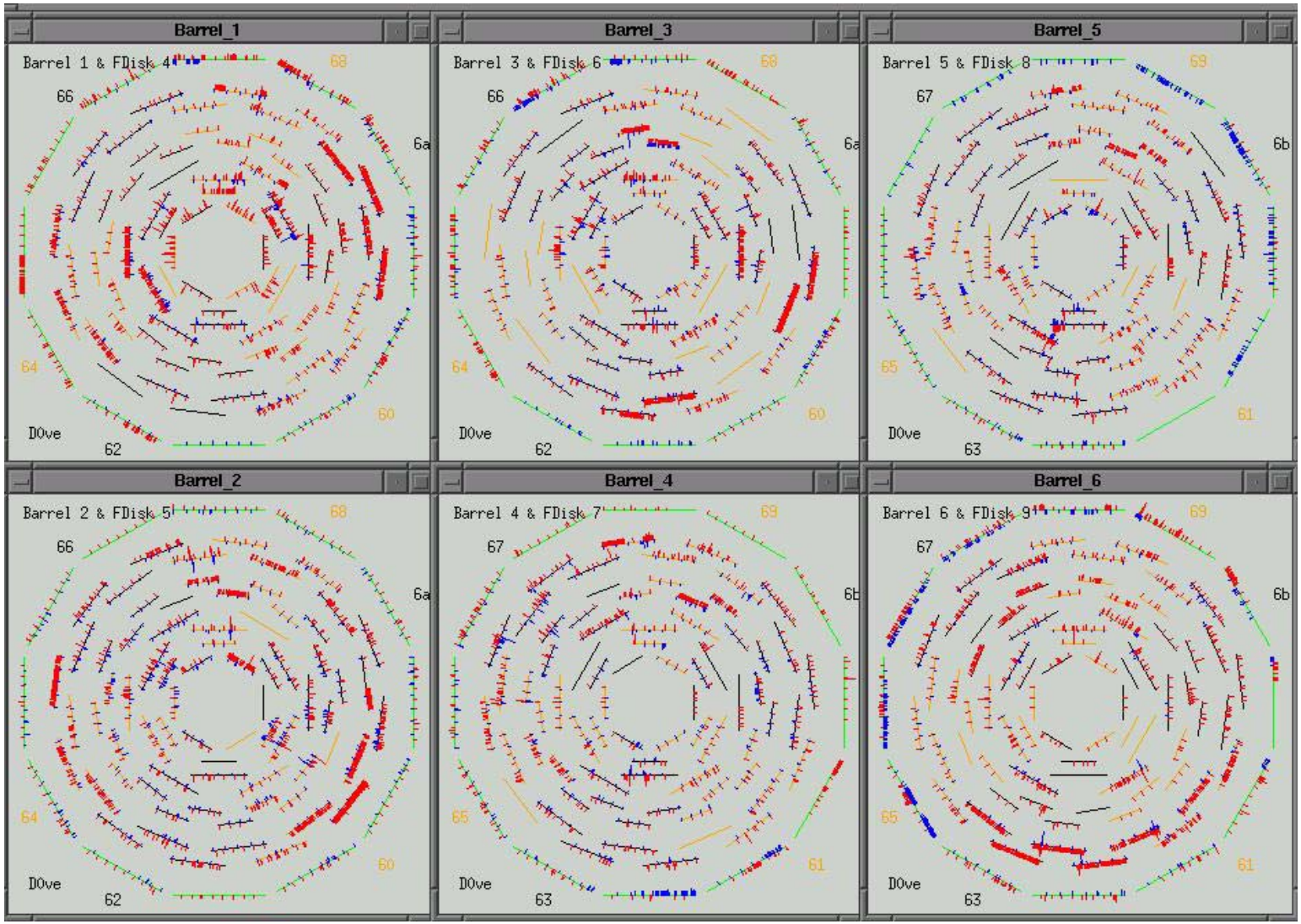
- within the SMT shifter's realm:
  - smt_event_display
    - displays strip level information
  - smt_examine
    - displays strip and cluster level information
  - online_monitoring
    - monitors and displays strip level information
- not directly under SMT shifter's control:
  - vertex_examine
  - cft_examine
  - physics_examine ...

smt_event_display

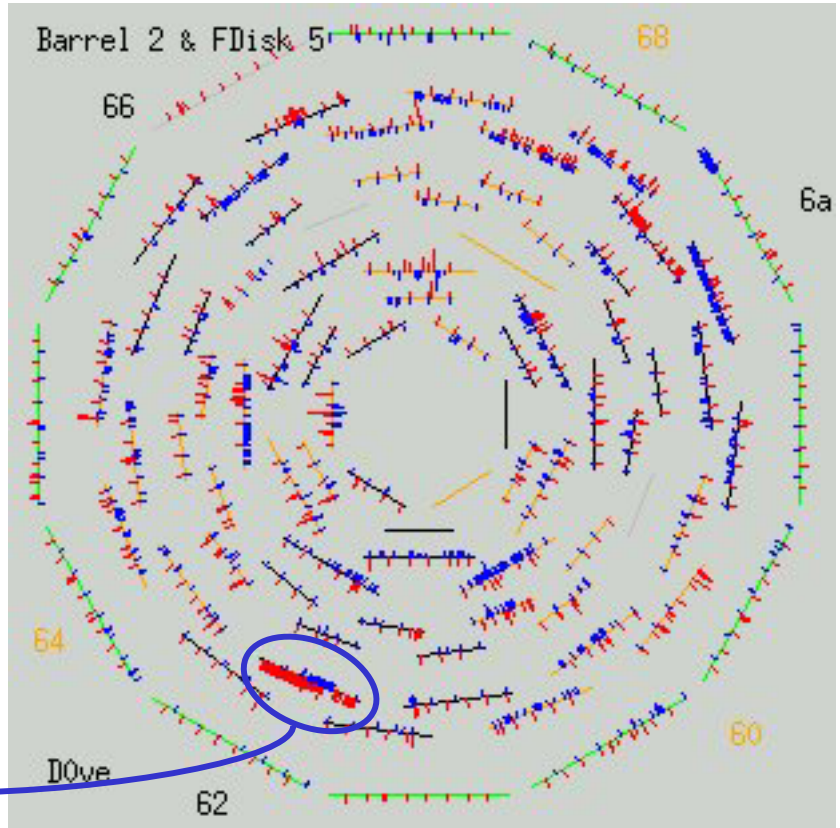


smt_event_display

a busier event



smt_event_display

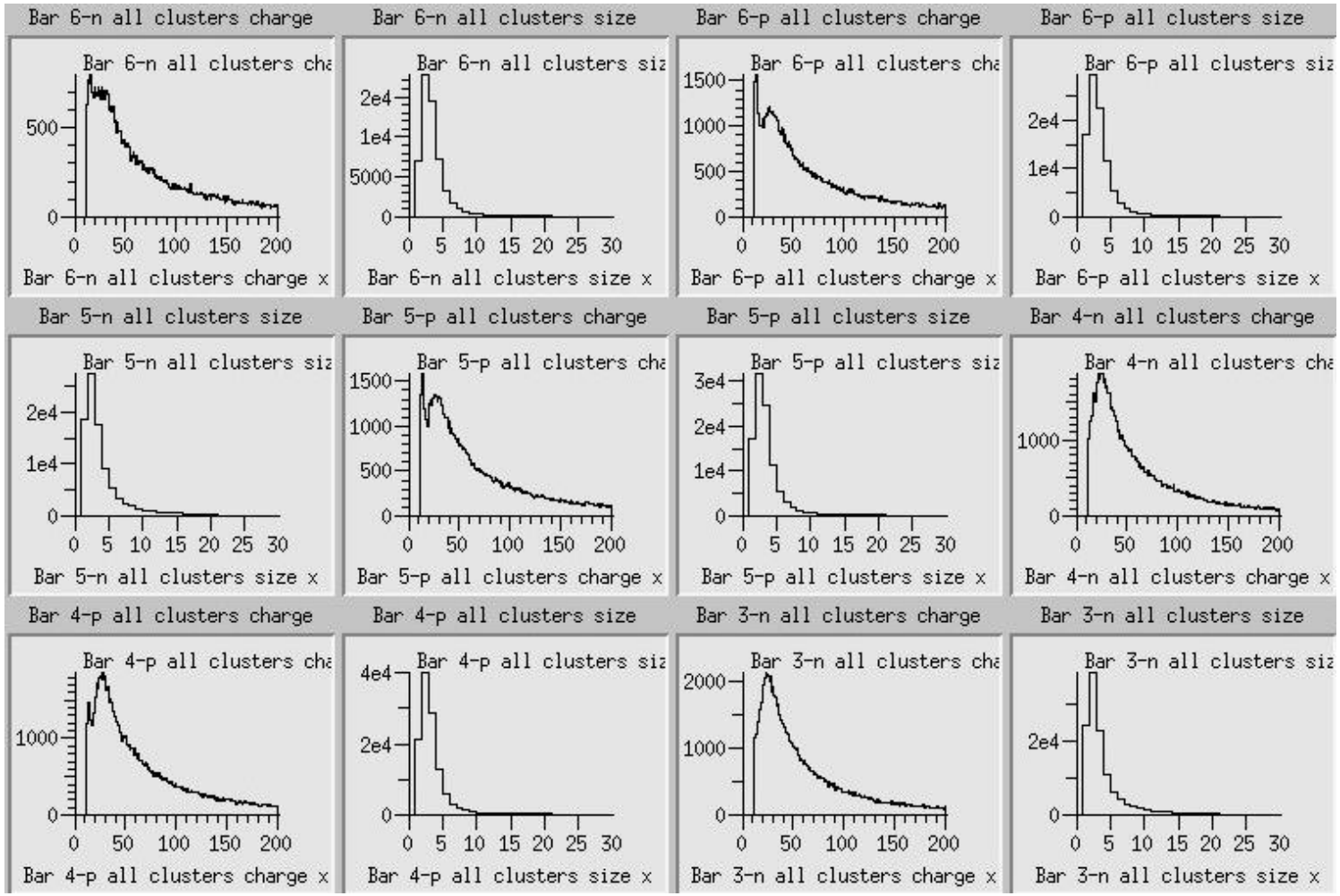


problematic ladder

smt_examine

- strip level information
  - per ladder/wedge:
    - average pulse height
    - sigma of pulse height
    - occupancy vs event
    - number of fired strips
    - fired strips
  - per chip:
    - pulse height vs event number
- cluster level information
  - cluster charge
  - first strip in cluster
  - cluster width
  - cluster charge vs tick number

smt_examine


Bar 6-n all clusters charge
Bar 6-n all clusters size
Bar 6-p all clusters charge
Bar 6-p all clusters size
Bar 5-n all clusters size
Bar 5-p all clusters charge
Bar 5-p all clusters size
Bar 4-n all clusters charge
Bar 4-p all clusters charge
Bar 4-p all clusters size
Bar 3-n all clusters charge
Bar 3-n all clusters size

smt_examine

occupancy_gui

SMT Online Monitoring

- monitoring processes:
  - run in PPC in VRB crates
  - send data to server on d0ol28 which makes histograms available through web pages
  - can send significant events to the SES
- what is monitored:
  - strip/chips signals
  - strip/chips hit counts
  - occupancies
  - raw data structure errors
- what can trigger Alarms:
  - HDIs/chips never reading out
  - HDI occupancies

SMT Online Monitoring

File View Settings Help

Group Name	MAJOR	MINOR	INVALID	DISABLED	GOOD
HV	398	896	0	2	0
LV	0	0	0	0	58
IB	0	0	0	0	0
Occupancy	2	0	0	0	0
Dead	5	0	0	0	0
all	405	896	136	2	75

Status: Connection to server started

SMT_BDISK_B2-8-11/DEAD
SMT_BDISK_B5-8-5/DEAD
SMT_FDISK_F5-2-9/DEAD
SMT_FDISK_F6-1-3/DEAD
SMT_HDISK_H2-2-22/DEAD

SHOW
DISABLE
DISABLE ALL
CLOSE

********** SMT_BDISK_B2-8-11/DEAD **********

Message contents:

version:	v4
utility:	Ef(4,5)
timestamp:	Wed Oct 16 02:32:02 2002
message type:	alarm
name:	SMT_BDISK_B2-8-11/DEAD
priority:	0
host:	d0ol28.fnal.gov
db entry:	0
parent:	none
children:	none
transition:	bad
severity:	major
alarm type:	analog
parameters:	(VRB_6013) Dead chips:B2-8-11-5 B2-8-11-6 B2-8-11-7 B2-8-11-8

CLOSE DISABLE CONTROL GUIDANCE COMMAND

SMT Online Monitoring

File Edit View Go Communicator Help

Bookmarks Location: http://www-d0ol/smtMonitoring/ What's Related

DZero - At Work | D0 CRL Search | Beams Division Notification | WebCal - SMT | Google | SMT Monitoring Page

SMT MONITORING MENU

- SMT_VRBCR_60
- SMT_VRBCR_61
- SMT_VRBCR_62
  - VRB_6209
  - VRB_6210
  - VRB_6211(ok)
    - B2-3-5(9)
    - B3-3-5(9)
    - B2-4-5(9)
    - B3-4-5(9)
    - B2-1-5(6)
    - B3-1-5(6)
    - B2-2-5(6)(disabled)
    - B3-2-5(6)
  - VRB_6212
  - VRB_6213
  - VRB_6215
  - VRB_6216
  - VRB_6217
  - VRB_6218
  - VRB_6219
- SMT_VRBCR_63
- SMT_VRBCR_64
- SMT_VRBCR_65
- SMT_VRBCR_66
- SMT_VRBCR_67
- SMT_VRBCR_68
- SMT_VRBCR_69
- SMT_VRBCR_6A
- SMT_VRBCR_6B
- SMT_VRBCR_79

IOC DATA
UPDATE TIME

SMT_VRBCR_60	(_12-24-2002_16:21:21)
SMT_VRBCR_61	(_12-24-2002_16:22:40)
SMT_VRBCR_62	(_12-24-2002_16:22:19)
SMT_VRBCR_63	(_12-24-2002_16:22:48)
SMT_VRBCR_64	(_12-24-2002_16:22:7)
SMT_VRBCR_65	(_12-24-2002_16:22:32)
SMT_VRBCR_66	(_12-24-2002_16:22:17)
SMT_VRBCR_67	(_12-24-2002_16:22:1)
SMT_VRBCR_68	(_12-24-2002_16:23:2)
SMT_VRBCR_69	(_12-24-2002_16:22:55)
SMT_VRBCR_6A	(_12-24-2002_16:21:49)
SMT_VRBCR_6B	(_12-24-2002_16:21:32)
SMT_VRBCR_79	(NONE)

SES UPDATE

SMT MONITORING

Read before you start playing:

Level	What Information	Data Set	
		FULL_SET	
CrateName	**VRBName**	**HDIName**	**SVXNumber**
SMT_VRBCR_62	VRB_6211	B2-4-5	
LowerTreshold	**UpperTreshold**		
0	999999		

DataAction

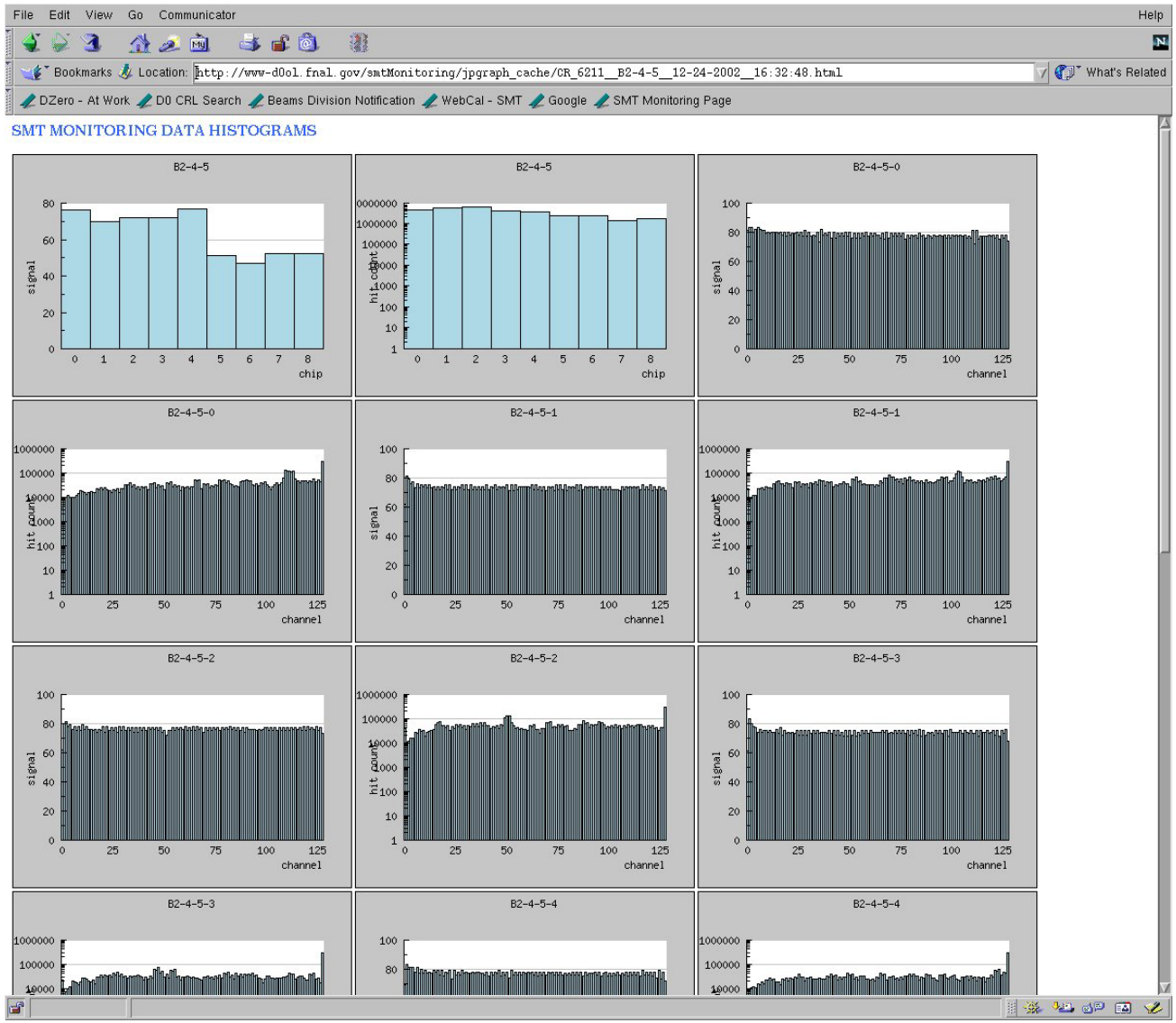
SMT MONITORING GRAPHICS

Level	Type	What Information	Data Set
	HDI_TYPE	SIG_HIT_GRAPH	FULL_SET
CrateName	**VRBName**		
SMT_VRBCR_62	VRB_6211		
LowerTreshold	**UpperTreshold**		
0	999999		

Da

- SIG_HIT_GRAPH
- SIGNAL_GRAPH
- HITCOUNT_GRAPH
- OCCUPANCY_GRAPH
- ERROR_GRAPH
- BITPATTERN_GRAPH
- MISS_BITS_GRAPH
- EVENT_SIZE_GRAPH
- EVENT_BUFF_GRAPH
- BUNCH_SIG_HIT_GRAPH
- BUNCH_SIG_HIT_127_GRAPH
- BUNCH_SIG_GRAPH
- BUNCH_SIG_127_GRAPH
- BUNCH_HIT_GRAPH
- BUNCH_HIT_127_GRAPH

SMT Online Monitoring



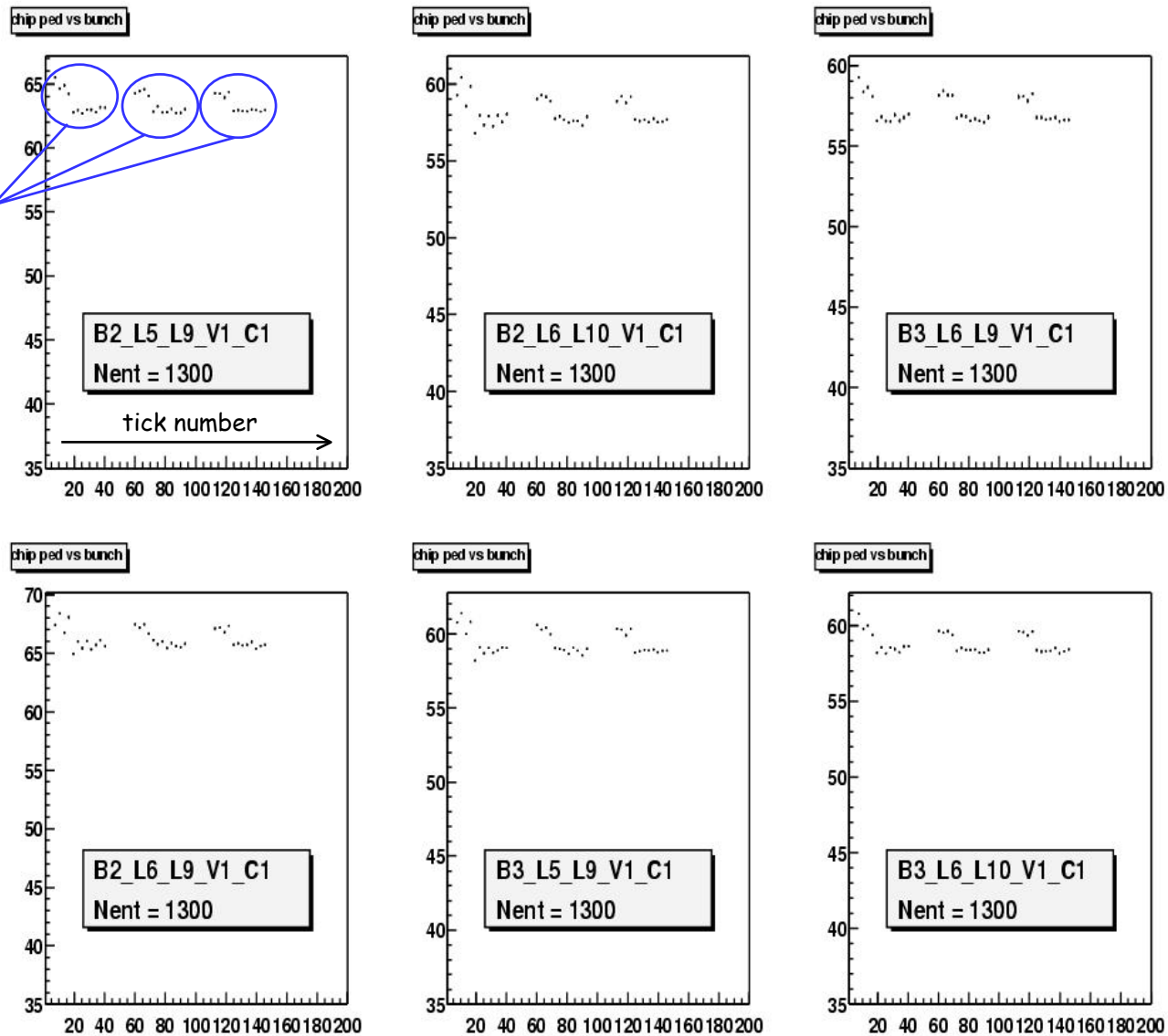
SMT Online Monitoring: what we need ...

- smt_examine:
  - include tick and turn checks
  - include histograms to better study L1busy
  - include global tracking and AA SMT stand alone tracking (including disks)
    - phi and z track distributions
    - clusters associated to tracks (charge, position, width)
    - detector efficiencies
  - automatize distribution checks
  - migrate from histoscope to root
- online_monitoring
  - get a Visa for Maciej
  - improve the categorization of R/O errors
- other tools:
  - raw data dump and check examine based tool
- at L3:
  - include tick and turn checks

Operations issues: Pedestal shifts

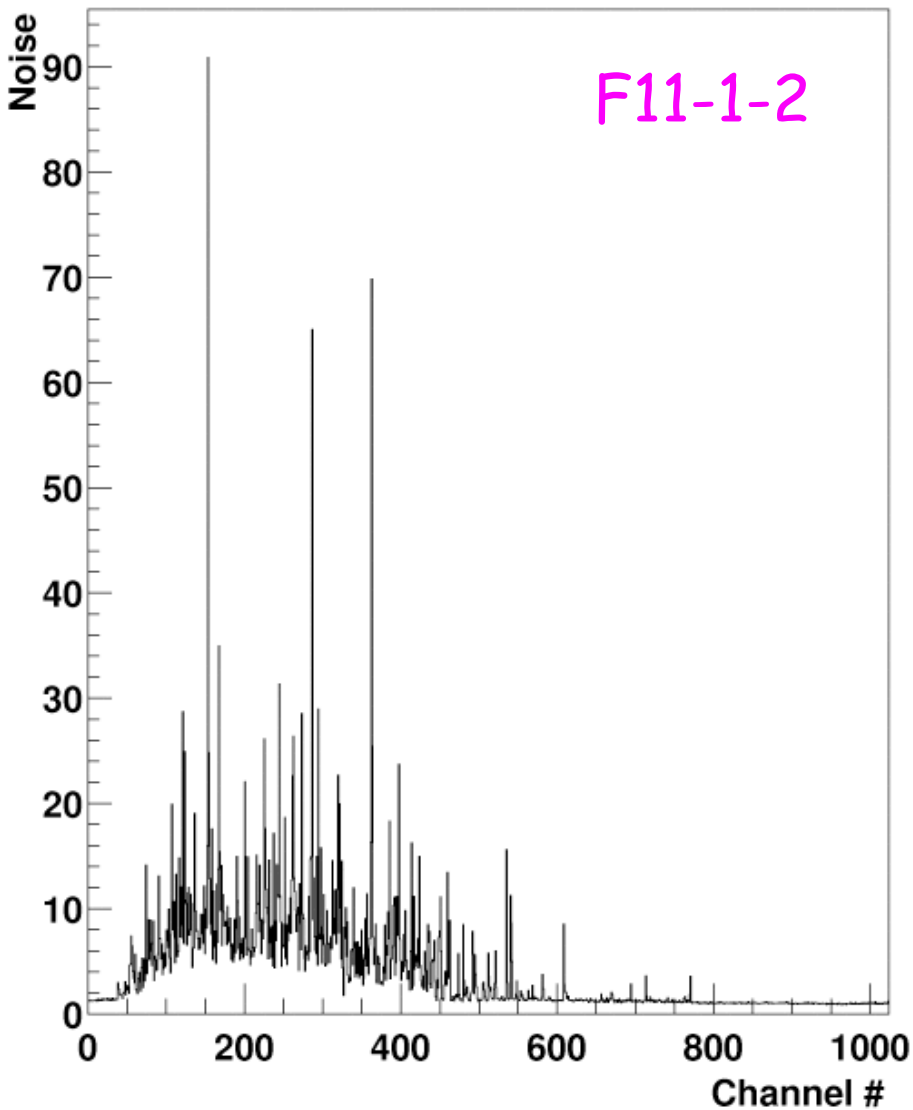
3 superbunches of 12 bunches

- pedestals seem to be different at the beginning of each superbunch
- Investigating ...



Operations issues: F-Wedges noise (1)

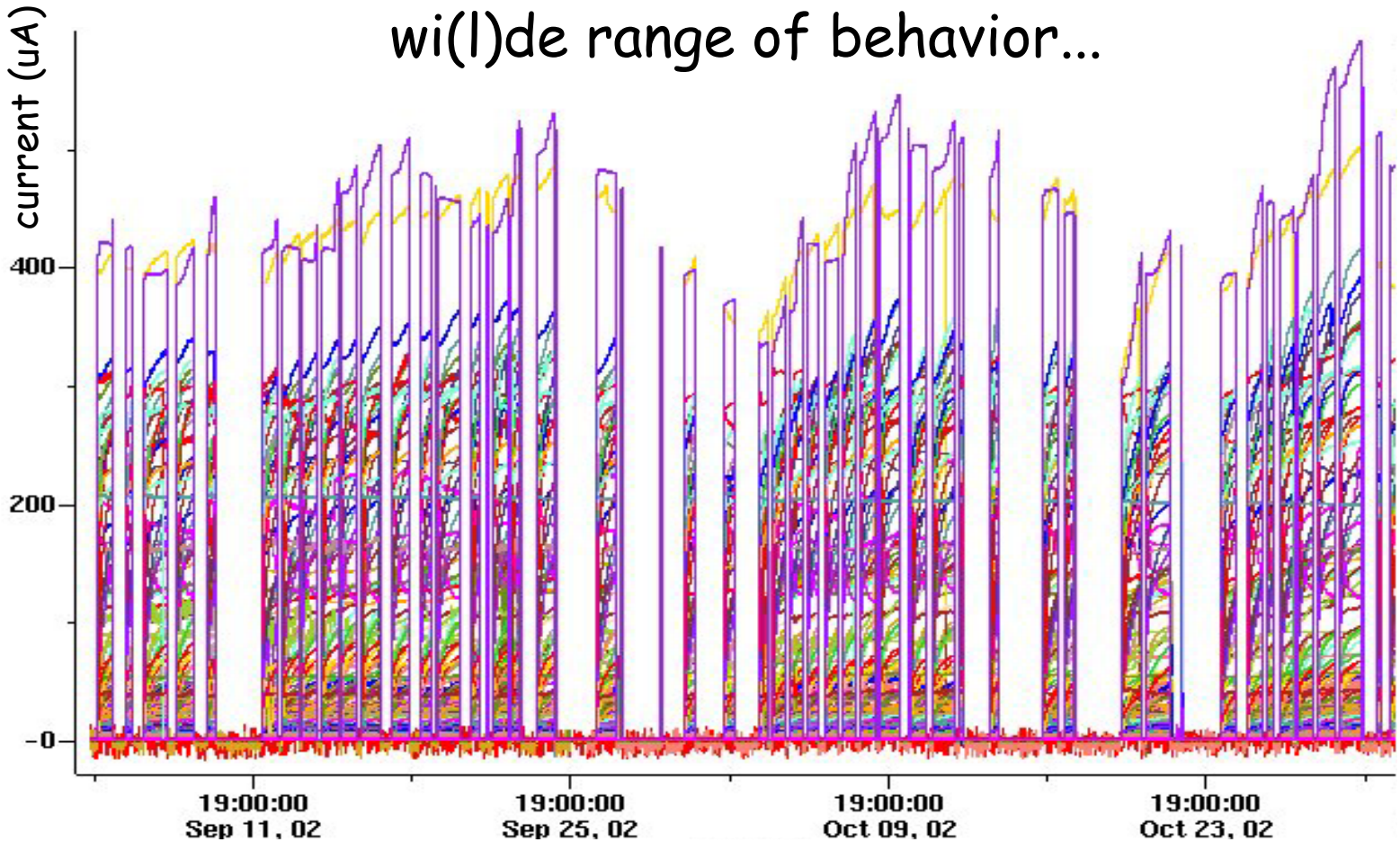
- seems to affect only the p-side of a fraction of the Micron sensors
- does not seem to depend on the biasing scheme
- does not seem to depend on temperature
- still investigating ...



Operation issues: F-Wedges noise (2)

# of wedges in disk	w/ > 10% noisy strips				w/ > 20% noisy strips				w/ > 30% noisy strips			
	P-side			N-side	P-side			N-side	P-side			N-side
threshold (ADC)	4	6	10	4	4	6	10	4	4	6	10	4
01 (Micron)	6	4	1	3	2	2	1	1	1	1	0	0
02 (Micron)	4	1	0	1	2	0	0	1	1	0	0	1
03 (Eurysis)	0	0	0	0	0	0	0	0	0	0	0	0
04 (Micron)	5	4	2	2	4	3	1	1	3	2	1	1
05 (Eurysis)	0	0	0	1	0	0	0	1	0	0	0	0
06 (Micron)	7	5	5	7	6	5	3	4	4	3	2	4
07 (Micron)	3	2	2	1	2	2	1	0	1	1	0	0
08 (Eurysis)	0	0	0	0	0	0	0	0	0	0	0	0
09 (Micron)	4	4	3	2	4	3	1	1	2	2	0	1
10 (Eurysis)	0	0	0	0	0	0	0	0	0	0	0	0
11 (Micron)	5	3	3	4	3	2	0	1	2	1	0	0
12 (Micron)	6	3	2	2	2	2	2	0	2	2	0	0
TOTAL (144)	40	26	18	23	25	19	9	10	16	12	3	7

Bias currents



most of this is not bulk current.