Multi-Channel Electronics

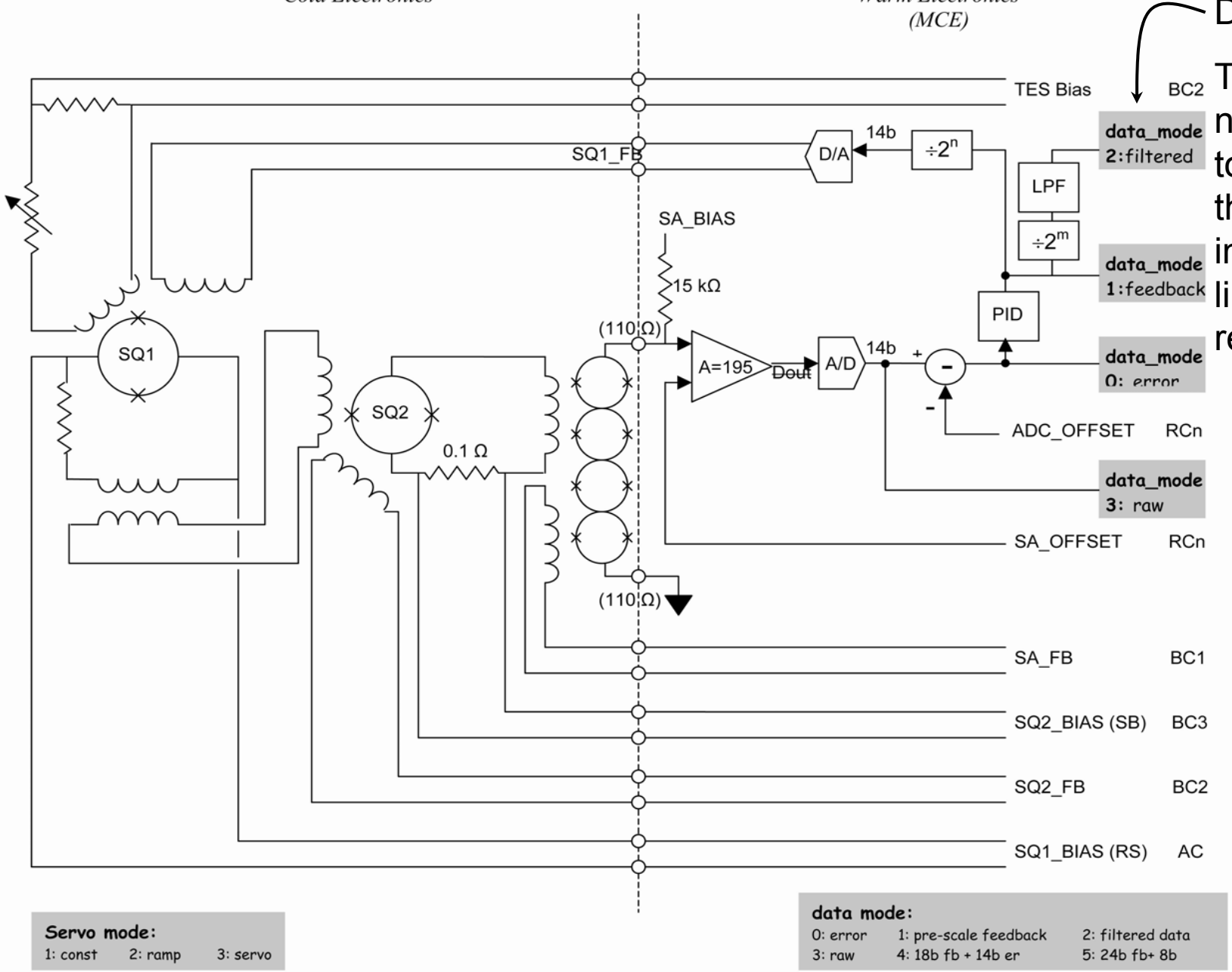
Elia Battistelli
(on behalf of)
Mark Halpern
and a lot of
people @ UBC

Multi-Channel Electronics

- Warm electronics of multi-pixel time-multiplexed CCD-like bolometers array
- Each MCE box controls bias, fb and reads the signals from a (up to) 32X41 pixel sub-array→ 25 boxes for SWcam
- mounted on the cryostat wall and connected to cryogenic cables through 5 MDMs
- connected by a fiber optic cable to a data acquisition PC running RTL

Multi-Channel Electronics

- 4 readout cards (RC)
  - each reads 8 output columns through 14-bit 50MHz ADCs
- 1 address card (AC)= squid-1 Bias
  - addresses the [41] rows at $\nu_{add} \leq 850$kHz, set by L/R
  - $\nu_{frame} \leq \nu_{add}$ /41≈ 20kHz
- 1 clock card (CC)
  - master card: interprets the commands and synchronizes all the cards using a 25MHz clock. Drives fibre to PC.
- 3 bias cards (BC)
  - BC 1: squid series-array feedback (x32) + TES bias(x1)
  - BC 2: squid-2 feedback (x32)
  - BC 3: squid-2 bias(x32) + TES heaters(x1)


Cold Electronics
Warm Electronics (MCE)
DATA!
The fb needed to keep the SQ1 in a linear regime
TES Bias
BC2
data_mode 2:filtered
14b
÷2^n
D/A
SQ1_FB
LPF
÷2^m
data_mode 1:feedback
SA_BIAS
15 kΩ
PID
(110 Ω)
A=195
Dout
A/D
14b
+
-
data_mode 0: error
ADC_OFFSET
RCn
SQ1
SQ2
0.1 Ω
data_mode 3: raw
SA_OFFSET
RCn
(110 Ω)
SA_FB
BC1
SQ2_BIAS (SB)
BC3
SQ2_FB
BC2
SQ1_BIAS (RS)
AC
Servo mode:
1: const 2: ramp 3: servo
data mode:
0: error 1: pre-scale feedback 2: filtered data
3: raw 4: 18b fb + 14b er 5: 24b fb+ 8b

MCE hardware and firmware

- Hardware: UBC electronic lab (Stan Knotek head). PCI card to communicate with MCE over fibre optic cable (San-Diego Univ.). Rethink for CCAT…

- Everything generated in firmware with ALTERA fpga (Mandana Amiri and Bryce Burger firmware developers…and much more!) (10 man-year fw development so far)

- UK ATC DAS; shell scripts that call C functions to issue commands to MCE + some visualization

MCE data modes

- Operating data modes:
  - Engineering modes:
    - No filtering no sychronization needed
    - AD converter signal is sent to the CC at 850kHz; usefull for Fourier analysis
    - error, unfilt. fb, filtered fb, 18b fb+14b er, 24b fb + 8b
  - In normal science mode the SQ1 fb signal read at 20kHz, is low-pass filtered (4-pole BW with ν_{cutoff}~50 Hz); data may be reported sending a command like: supply 1000 frames…however we need a synchronization

MCE synchronization

- We built a sync box that supplies data-valid pulses (DV) to the MCE's (through optic fiber) and to the pointing system together with a Sequence Number
- Upon specific command, at every DV, the CC waits to finish one address cycle and reports $41 \times 8 \times 4$ 32-bit values + header to RTL
- No other commands (but stop) are allowed during acquisition. Remember that in the engineering modes we can always change parameters and request new frames as fast as the RTL allows (~400Hz)

MCE SQUIDS characterization

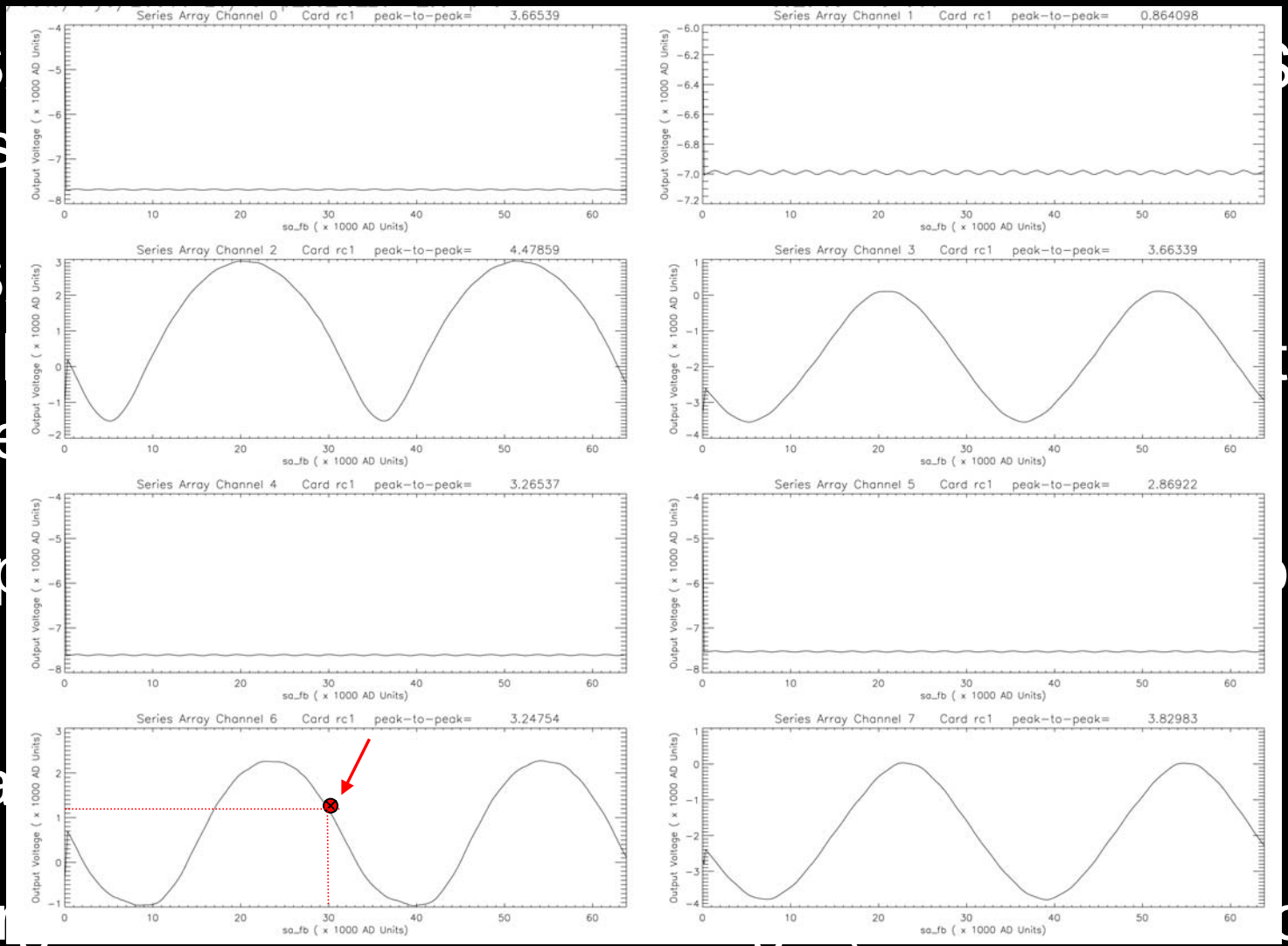
- We run commands to change parameters and acquire frames
- Start from the SSA, then the SQ2 and then SQ1
- We want to find the best bias' and fb for a correct functionality of the SQUIDS by measuring their V-phi
- Individual choices for the SSA bias, SSA fb, SQ2 bias. Compromise for the SQ1 bias over the 32 SQ1 of a given row and single choice for the SQ2 fb which however is also a compromise over the 41 rows of a given column → space for further work

MCE SSA characterization

- SSA: 2D grid ramping of the SSA fb and the SSA bias
- SSA gets to the I_{c_max} and the V-phi curve is exploited by reading the output as a function of the fb for every bias
- In principle we want the highest slope but this occurs and $I<I_{c\_max}$.
- Bias chosen by the maximum peak-to-peak
- Target chosen in the mid range (not the max slope)

MCE SSA characterization

- SS… …SA bias…
- SS… exp… …the fb for e…
- In p… …ccurs and…
- Bia…
- Tar… …ope)

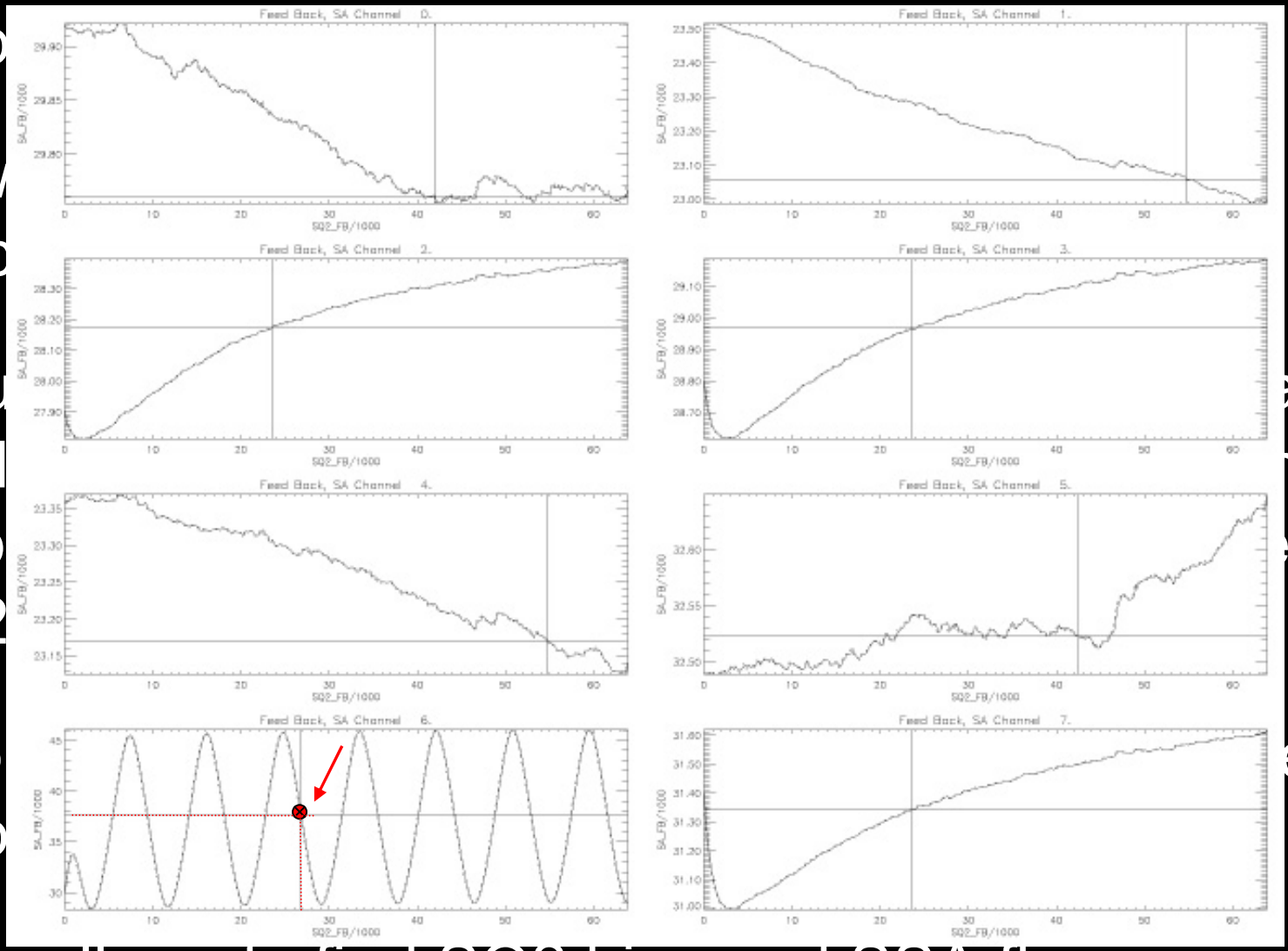


MCE SQ2 characterization

- In principle one could do the same for the SQ2
- However this would give a strange convolution difficult to interpret
- Thus we run a closed loop ramping the SQ2 fb and reading the SSA fb adjusted in such a way that the output stay at a fixed value. This gives you the real SQ2 V-phi curve
- C program performs the calculation with a simple proportional feedback term and repeats it twice
- This allows to find SQ2 bias and SSA fb

MCE SQ2 characterization

- In p
- Hov
diffic
- Thu
read
outp
SQ2
- C p
prop
- This allows to find SQ2 bias and SSA fb

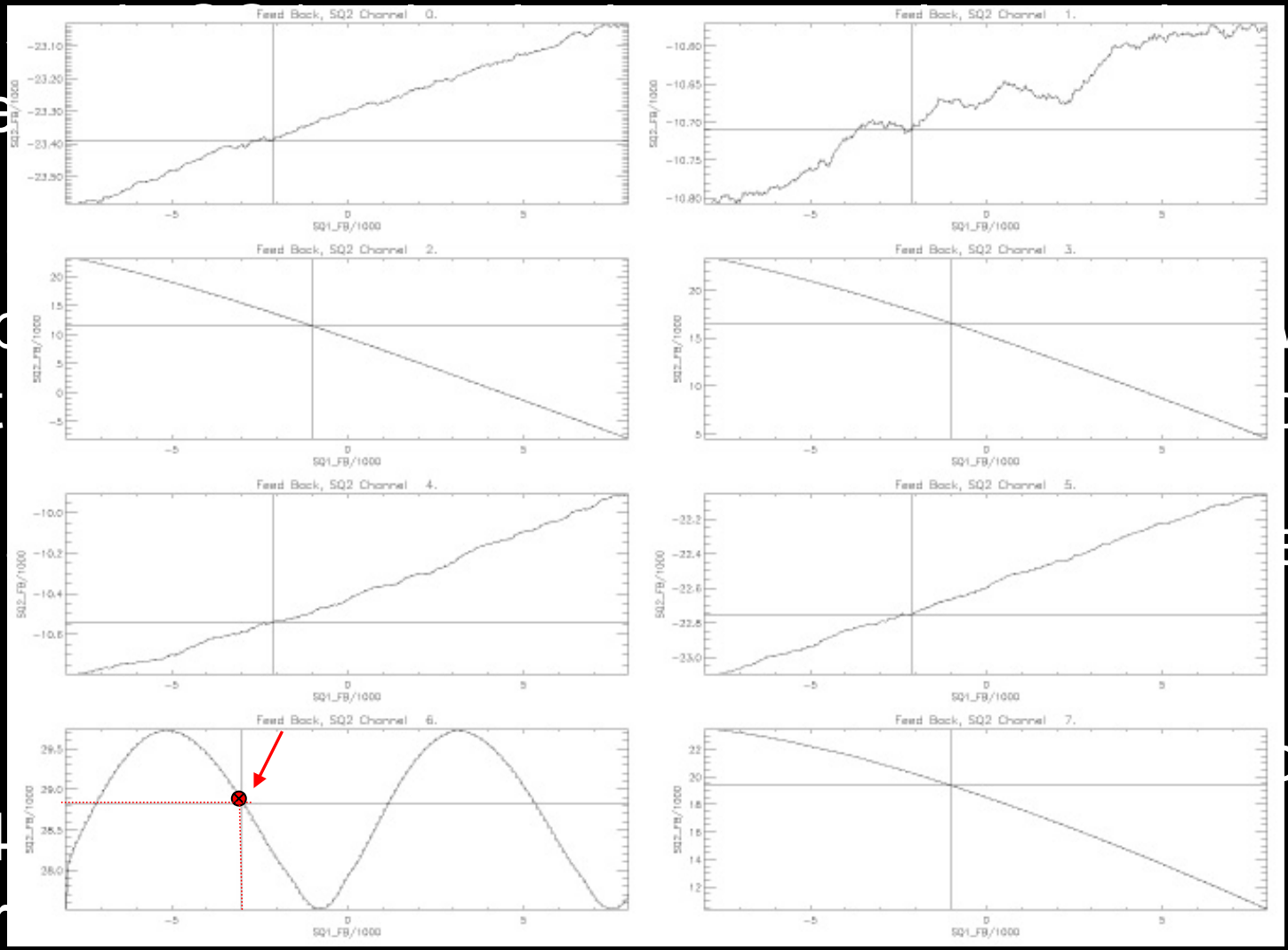


MCE SQ1 characterization

- We study SQ1 using both an open loop and a closed loop using different commands
- We choose the SQ1 bias (RS) which is a compromise over the 32 columns of each row. We want all of them to be on but also the best solution
- We are able to choose 41 different SQ1 bias' but they are already a compromise…however there could be a gradient
- We choose the SQ2 fb which is a compromise over the 41 rows of each column and again can set different values for the 32 SQ2 fb

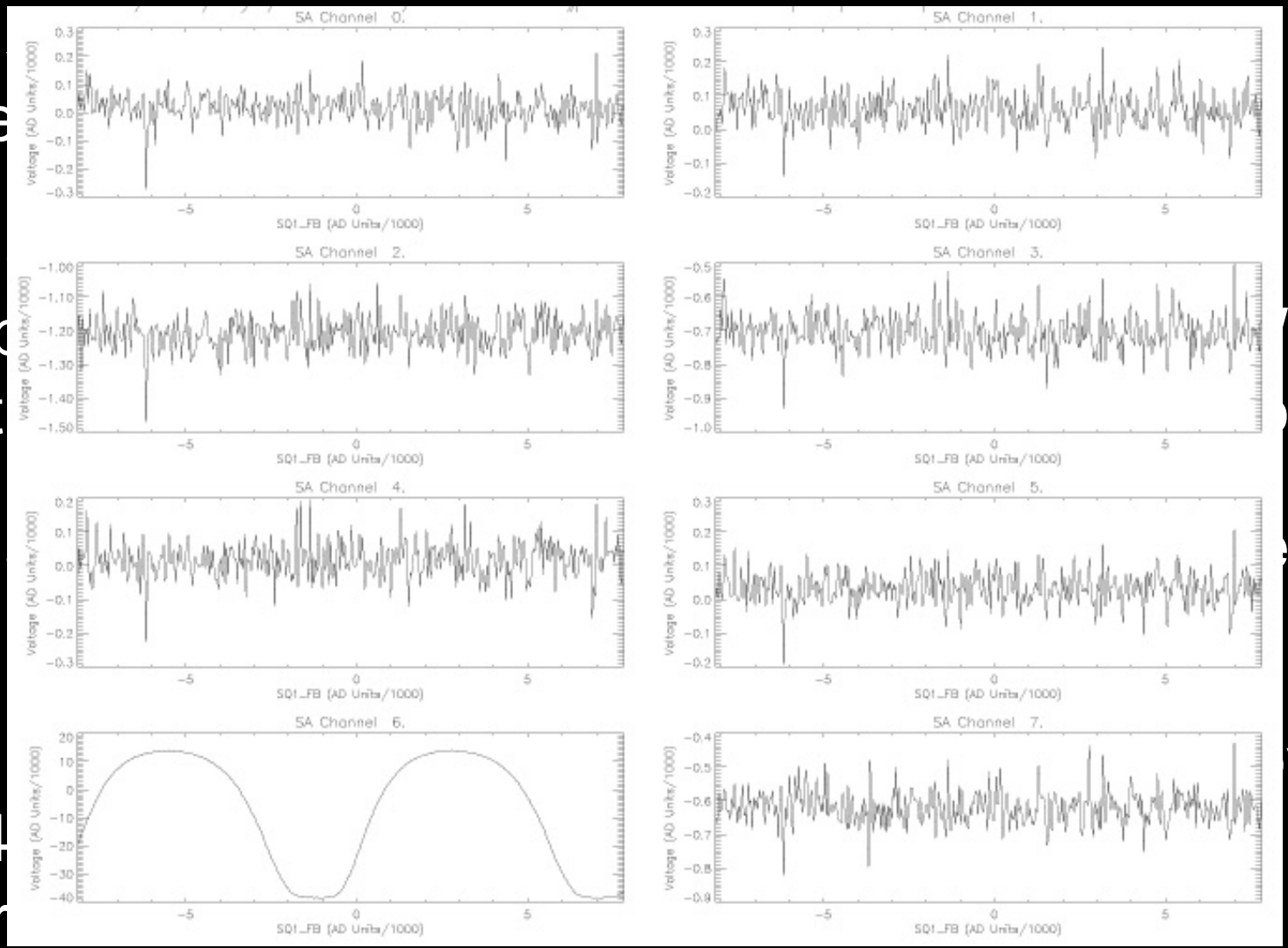
MCE SQ1 characterization

- We
close
- We
comp
want
- We
SQ1
- We
the 4
differ



MCE SQ1 characterization

- We
close
- We
comp
want
- We
SQ1
- We
the 4
differ



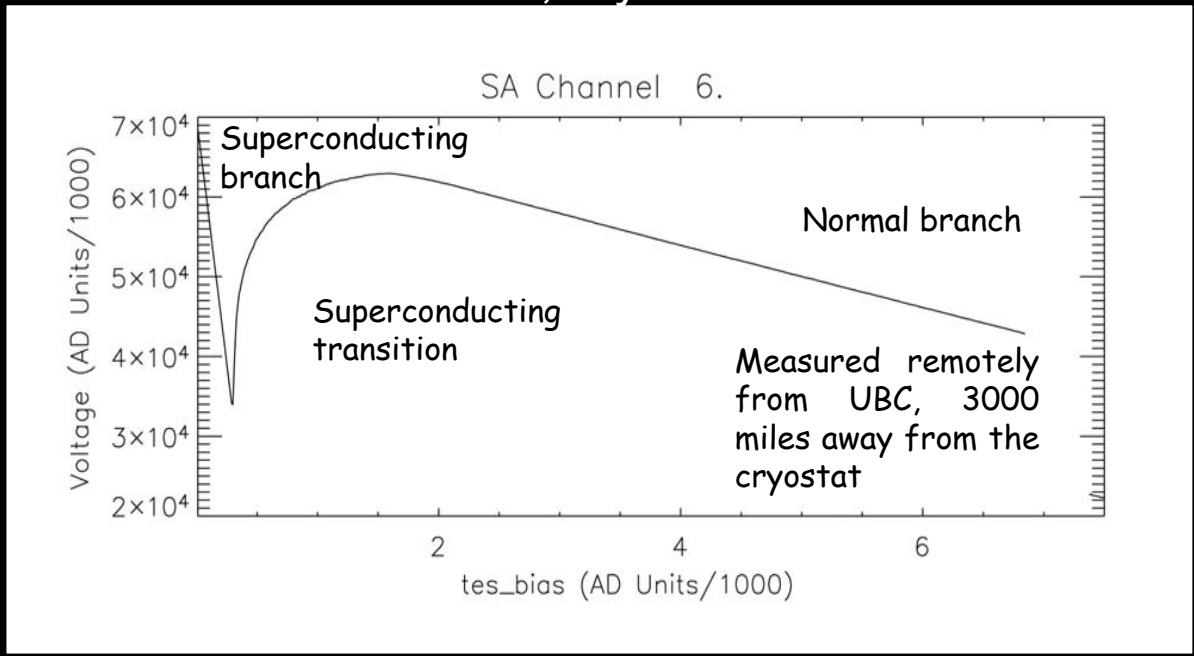
MCE SQUIDS locking

- Then we turn on the servo loop and we choose the correct PID values to keep the system locked
- Once locked the error goes to zero and the fb to a constant value
- We can now take data or calculate TES I-V curves by sweeping the TES bias
- An autosetup program has been developed

MCE remote operation

- On ACT and CIOVER system we already perform remote operation with no need to touch the electronics
- Even the characterization and the visualization of the plotted data
- Last bit was the possibility to download firmware through an ethernet connection

ACT I-V curve; cryostat in Princeton



That's it…


Multichannel Electronics
University of British Columbia
Department of Physics & Astronomy
Wrist Strap
SCUBA-2 Address Card
SCUBA-2 Bias Card
SCUBA-2 Bias Card
SCUBA-2 Bias Card
SCUBA-2 Readout Card
SCUBA-2 Readout Card
SCUBA-2 Readout Card
SCUBA-2 Readout Card
SCUBA-2 Clock Card