Lars Sonnenschein
Boston University

- How does the STT work
- What is relevant for the shifter
- Trouble shooting
• How does the STT work
DØ Run 2 detector
Central Fiber Tracker

- Scintillating fibers
- Up to $|\eta| = 1.7$
- $20 \text{ cm} < r < 51 \text{ cm}$
- 8 double layers
- 77,000 channels
Silicon Microstrip Detector

- 4 H–Disks
- 12 F–Disks
- 6 Barrels

- 6 barrels (12 cm long) and 16 disks
- 793,000 channels of electronics
  (112,000 axial channels)
- SMT hit resolution $\approx 10 \mu m$
The idea

- Need to make very fast decisions!

- $b$ quarks are key in many areas:
  - $B$ physics
  - top quark physics ($t \rightarrow Wb$)
  - Higgs Physics ($ZH \rightarrow \nu\bar{\nu}bb$)

- $B$ hadrons have finite lifetime
  - travel mm’s before decay
  - $\Rightarrow$ displaced tracks

- Trigger on displaced tracks
  - using SMT precision
  - IP resolution 55 $\mu$m @ high $p_\perp$
    (Including 35 $\mu$m from beamspot)
STT Conceptual Schematic

- L1CTT \Rightarrow tracks in CFT
  - Define road in SMT
- Select axial SMT hits in roads
- Fit trajectory to L1CTT+SMT hits
  - Measure $p_\perp$, IP and azimuth $\phi$
- Send results to L2
- Pass L1CTT information to L2
- Send L2 output + SMT clusters to L3
6 identical 60° sector crates each containing:

1 Fiber Road Card
- sync with D(0)
- L1CTT inputs

9 Silicon Trigger Cards
- SMT clustering
- Coarse cluster - road match

2 Track Fit Cards
- Final cluster selection
- Track fitting
All six $60^\circ$ sector crates in MCH2
STT mother- and daughterboards

Serial board links for inter-communication

SCL

Fiber Road Card or
Silicon Trigger Card or
Track Fit Card

Link Receiver and/or Transmitter Boards

Buffer Controller

Lars Sonnenschein
Physics Department, Boston University
Fermilab, 16 November 2004/11
9Ux400mm VME64x compatible

3 x 33MHz PCI busses for onboard communications

Data communicated between cards via point-to-point links (LVDS) Link Transmitter and Receiver Cards

Control signals sent over backplane using dedicated lines

VME bus used for Level 3 Readout and initialization/monitoring
Fiber Road Card (FRC) schematic

- Receives tracks from L1 Central Track Trigger
- Communicates with trigger framework (TF) via SCL receiver card
- Transmits tracks and trigger info to other cards
- Manages L3 buffering and readout via Buffer Controller (BC) daughter cards on each motherboard

Silicon Trigger Card (STC) Design
Silicon Trigger Card (STC) schematic

Performs silicon clustering and cluster-road matching

Clusters adjacent SMT hits (axial and stereo)

Axial clusters are matched to ±2 mm-wide roads around each fiber track via precomputed LUT

Masks bad strips and applies pedestal/gain corrections (via LUT)

Track Fit Card (TFC) Design

8 DSP’s Matrix LUT
Perform final SMT cluster filtering and track fitting

Receives 2 CFT hits and axial SMT clusters in CFT road

Selects clusters closest to road center and performs linearized track fit using precomputed matrix elements stored in on-board LUT

\[ \phi(r) = \frac{b}{r} + \kappa r + \phi_0 \]

Requires only 3 out of 4 silicon layers

Output to L2CTT via Hotlink Transmitter cards

- Beamspot determined by vertex examine
- Written to coor name value server
- At beginning of run:
  - coor tells comics to download values to
    - STT
    - L3 farms (for reconstruction)

Allowable beamspot variation for the STT:
- position < 1 mm
- tilt < 5 \times 10^{-4}
STT documents of general interest

DØ STT home page:
http://www-d0.fnal.gov/trigger/stt/

DØ STT Commissioning page:
http://www-d0.fnal.gov/trigger/stt/sttcommiss.html

Compact conference note about STT (Oct. 2000):

Trigger workshop (22 April 2002):
What is relevant for the shifter
STT Basic Operating Instructions

TOC will be automatically generated here and replace this text. Do not remove.

Basic Operating Instructions

These instructions cover basic STT running. The essential items are

1. All STT crates and required input and output crates should be in the run. (See amon or ask DAQ shifter)
2. The standard programs should be running, and if we're in store
   ○ the alarms and monitor displays should show all green conditions,
   ○ the examine plots should match the reference sets.
3. The download much match the magnet polarity and list of enabled FDI's must be correct.

See the section starting from scratch below for start up instructions, the accessing STT crates section for information about specific crates, and the checklist page to make sure the STT is running properly.

If the STT hangs, what does the shifter do? (Basic instructions)

If there are problems with crates 0x70 - 0x75, do the following

1. Request an scl init
2. Check to make sure the PCI bus isn't hung and then, if it's not, Hard Reset (+ SBC reset if need be)
3. Pci reset + reboot with "Set FRC only" in the download GUI followed by a Hard Reset in reset GUI
4. If the problem persists, call the pager expert.
   1. During normal working hours, use the building page to page the STT or call expert
   2. Outside normal working hours, or if the on call expert doesn't respond, call the pager
To start the Reset GUI:
1. log onto d0ol36
2. setup d0online
3. cd /scratch/stt/debug/stttestpython
4. sttResetGui.py &
Check Busy/Errors button

[d0stt@d0ol136 stttestpython]: ******************CRATE X71***************

FRC STATUS INFORMATION:

CRATE: d0olstt01
SLOT : 13
Tue Apr  6 17:59:08 2004

-------------------------------------------------------------------------------

TRDF STATUS REGISTER

<table>
<thead>
<tr>
<th>OPTION</th>
<th>STATUS</th>
<th>OPTION</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOE MISSING ERROR</td>
<td>no (0)</td>
<td>BX MISMATCH ERROR</td>
<td>no (0)</td>
</tr>
<tr>
<td>EOF MISSING ERROR</td>
<td>no (0)</td>
<td>NO CTT DATA</td>
<td>no (0)</td>
</tr>
<tr>
<td>RESERVED</td>
<td>no (0)</td>
<td>RR SM IDLE</td>
<td>yes(1)</td>
</tr>
<tr>
<td>RR_DATA LATCH</td>
<td>no (0)</td>
<td>RR_DATA_WRITE</td>
<td>no (0)</td>
</tr>
<tr>
<td>RR_FIFO_EMPTY</td>
<td>yes(1)</td>
<td>RR_FIFO_FULL</td>
<td>no (0)</td>
</tr>
<tr>
<td>RR_FIFO_FULL LATCHED</td>
<td>no (0)</td>
<td>START TEST</td>
<td>yes(1)</td>
</tr>
<tr>
<td>TEST MODE</td>
<td>no (0)</td>
<td>TEST_REPEAT</td>
<td>no (0)</td>
</tr>
<tr>
<td>TRDF STARTED</td>
<td>yes(1)</td>
<td>TURN MISMATCH ERROR</td>
<td>no (0)</td>
</tr>
</tbody>
</table>

-------------------------------------------------------------------------------

BM STATUS REGISTER 0

<table>
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<th>OPTION</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
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<td>GET_ALL_WAIT</td>
<td>no (0)</td>
<td>GET_DONE TIMEOUT</td>
<td>no (0)</td>
</tr>
<tr>
<td>GET_DONE_WAIT</td>
<td>no (0)</td>
<td>L1 FIFO FULL</td>
<td>no (0)</td>
</tr>
<tr>
<td>L2 FIFO FULL</td>
<td>no (0)</td>
<td>L3XFER NUMBER FIFO FULL</td>
<td>no (0)</td>
</tr>
<tr>
<td>MON DONE</td>
<td>no (0)</td>
<td>MON IN PROGRESS</td>
<td>no (0)</td>
</tr>
<tr>
<td>MON INTERRUPT</td>
<td>no (0)</td>
<td>PCI3 L3 FIFO FULL</td>
<td>no (0)</td>
</tr>
<tr>
<td>PUT_ALL_WAIT</td>
<td>no (0)</td>
<td>PUT_DONE TIMEOUT</td>
<td>no (0)</td>
</tr>
<tr>
<td>PUT_DONE_WAIT</td>
<td>no (0)</td>
<td>SCL DONE</td>
<td>no (0)</td>
</tr>
<tr>
<td>SCL INIT ACK</td>
<td>no (0)</td>
<td>SCL INTERRUPT</td>
<td>no (0)</td>
</tr>
<tr>
<td>SCL REQ</td>
<td>no (0)</td>
<td>SLAVE READY</td>
<td>no (0)</td>
</tr>
</tbody>
</table>

if yes ⇒ CTT input problem

if yes ⇒ reboot (FRC only download)

Lars Sonnenschein
Physics Department, Boston University
Fermilab, 16 November 2004/23
Check Busy/Errors output (continued)

SLV_DONE_CHK no (0) || SLV_DONE_END no (0)
SOFTWARE_TRIGGERED_DMA (no SBC) no (0) || START BM yes (1)
=====================================================================================================  
BM STATUS REGISTER 1
=====================================================================================================  
<table>
<thead>
<tr>
<th>OPTION</th>
<th>STATUS</th>
<th>OPTION</th>
<th>STATUS</th>
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</thead>
<tbody>
<tr>
<td>BM_L1_BUSY</td>
<td>0</td>
<td>BM_L2_BUSY</td>
<td>0</td>
</tr>
<tr>
<td>GET DONE</td>
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<td>GET DONE</td>
<td>1</td>
</tr>
<tr>
<td>L1_BUSY</td>
<td>0</td>
<td>L1_ERROR</td>
<td>0</td>
</tr>
<tr>
<td>L2_BUSY</td>
<td>0</td>
<td>L2_ERROR</td>
<td>0</td>
</tr>
<tr>
<td>OVERFLOW_ERROR (L1)</td>
<td>0</td>
<td>OVERFLOW_ERROR (L2)</td>
<td>0</td>
</tr>
<tr>
<td>PUT DONE</td>
<td>0</td>
<td>PUT DONE</td>
<td>1</td>
</tr>
<tr>
<td>STT_L1BUSY#</td>
<td>1</td>
<td>STT_L1ERROR#</td>
<td>1</td>
</tr>
<tr>
<td>STT_L2BUSY#</td>
<td>1</td>
<td>STT_L2ERROR#</td>
<td>1</td>
</tr>
<tr>
<td>STT_OUTPUT_FIFO FULL (Latched)</td>
<td>0</td>
<td>XFER_ERR_SBC</td>
<td>0</td>
</tr>
<tr>
<td>XFER_IN_ERR</td>
<td>0</td>
<td>XFER_OUT_ERR</td>
<td>0</td>
</tr>
</tbody>
</table>

LRB status (mip6)
CSR: 003f1260
Status register: 00200007
Receiver counters

<table>
<thead>
<tr>
<th>Channel</th>
<th>Words</th>
<th>Blocks</th>
<th>Fixed</th>
<th>Error</th>
<th>ID Err</th>
<th>Fifo</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Fiber Road Card (FRC)
Link Receiver Board (LRB)
Push this button to make a debug dump by hand. If one or several STT crates go L1 or L2 Front End Busy (verify in Daq_Dialog monitoring GUI) an SCLinit issues automatically a debug dump onto d0ol66:/scratchb/vxworks/debug/
This binary debug dump can be converted to human readable text via the debug_dump-binary.csh script in ~d0stt/stttestpython/ and
d0ol36:/scratch/stt/debug/stttestpython/
Switching a crate into run mode, Resets, etc.

After any Input Output Controller (IOC) reboot or power cycle switch a crate on (into run mode) before putting it into a run

Soft reset a crate (configuring Fiber Road Card (FRC)), includes an FRC ON

Hard reset a crate (resetting all daughter-bords), includes an FRC ON

PCI bus status, need to open a telnet session to the IOC to verify the status printout

PCI bus reset, needed before reboot in case of bus hang
Updating enabled/disabled HDI’s

Push this button to update the Silicon Trigger Card (STC) registers with the present status (enabled/disabled) of the relevant HDI’s.

Just for SMT crates 0x64 and 0x65

All crates in one go!
STT Alarm GUI

To start the alarm GUI:
1. setup d0online
2. start_alarm_matrix -c /online/config/stt/mtx &

Clicking on the alarms reveals more information and suggests (partly) actions.

Click on GS 0x73

Guidance from /online/config/sas/guidance/stt/STT_FRC_TRDCTT.txt:
* CTT data is missing.
* Error type: Event has no CTT data.
* Description: The data does not have CTT tracks. This is most likely due to corrupted data coming from the CTT.
* Action in case of:
  - If in store, this is fine, and is probably due to a CTT calibration.
  - If in store:

   *ONLY IF THE ERROR HAS STOPPED DATA FLOW* ...

   (1). SCL init.
   (2). Hit the 'Hard Reset' button for the crate in the sttResetGui.
   (3). If (1) and (2) don't work then ask the CFT/CTT shifter to issue a resetSTT and/or a fixCTT.

   * Expert pager: 218-3481 Secondary pager: 218-4482

Guidance from /online/config/sas/guidance/stt/STT_FRC.txt: http://www.fnal.gov

Lars Sonnenschein  Physics Department, Boston University  Fermilab, 16 November 2004/28
To start the Download Selection GUI:
1. setup d0online
2. /online/config/stt/utils/py/dwnlGui &

Downloading all cards (after power cycle, to (re-)download LUT’s)

Expert use only

If PCI bus hang, reboot in this configuration (faster)

Shows current settings
Rebooting an IOC

To start the IOC GUI:
1. setup d0online
2. start_daq ioc

Select STT page

Push button to reboot crate

- When pushing the “Reboot” button a window pops up asking for the password (DAQ shifter or SMT/STT expert should know it). If the correct password is entered the crate will be rebooted.
- Watch the “CPU %”, “Mem %” and “FD %” fields. They have to reach stable green i.e. reboot is finished.
- Typically FRC only reboot takes 1min.30s while reboot with download “All” takes 3min.45s.
- If the fields stay green all the time you may have misspelled the password ⇒ no reboot
- After reboot, a crate has to be put into run mode via “Hard Reset”
Solenoid Magnet Polarity

Update Link + reboot with Download “All” whenever polarity changes. Remember to switch crates into run mode after reboot (Hard Reset).

- Shows current solenoid magnet polarity
- Brings LUT’s in accordance with magnet polarity
- Shows which set of LUT’s will be used if downloaded (green=OK, red=wrong polarity)

To start the Magnet Polarity Selection GUI:
1. setup d0online
2. /online/config/stt/utils/py/sttPolarityGui.py &
At beginning of Shift:
Ask the shift Captain if the magnet polarity is expected to change during the shift (typically between stores). If so, notify the captain that you will require ten minutes before the beginning of the store to download the STT crates after the magnet has been energized with the new polarity.

In case of solenoid magnet polarity change check the “Solenoid Magnet Polarity GUI”:
- When the downloaded magnet polarity and the current solenoid polarity disagree, click the “Update Polarity” button.
- In the “Download GUI” select the “Set to All” button for all six crates.
- Ask the DAQ shifter to pause the run.
- In the “IOC GUI” push the reboot button for the appropriate crate.
- Wait until the reboot is completed (~ 3min.45s)
- In the “Reset GUI” select the “Hard Reset” button for each crate, one after another.
- When the crates are reset, the run may be resumed.
Each Friday on day Shift:
- log onto d0o137 as user d0stt
- go into the archiver directory: cd ~d0stt/run_archive/
- start the shell script maintain_archive.sh
- log onto d0o1b as user d0stt
- go into the archiver directory: cd ~d0stt/run_archive/
- start the shell script archive_to_SAM.sh
- if failing try the script archive_to_SAM_resubmit.sh

Restarting archiver after power outage or reboot of d0o137:
- log onto d0o137 as user d0stt
- go into the archiver directory: cd ~d0stt/run_archive/
- check if archiver is running: check_archive.py
- if it returns “no archiver running ...” issue: maintain_archive.sh

How to log onto another online node (e.g. d0olxy):
- setup d0online
- d0ssh d0stt@d0olxy
STT Examine instructions

On d0o166 in the directory:
/mnt/examine/p16.00.00/stt-examine

- before starting a new examine:
  kill all (three) automatically popped-up windows
  (.q to quit root session and Ctrl-C to quit x-terms)

start the examine with the shell script:
- RunSTT-Examine.sh (for global physics runs)
- RunSTT-Examine_ZB.sh (for zero bias runs)
- RunSTT-Examine_special.sh (for special runs)

- At the beginning of every physics run
  restart STT examine

- Towards the end of physics run save examine plots:
  On the GMbrowser menue bar
  click in the “FILE” menue on “SAVE ALL”

• How to log onto another online node
  (e.g. d0o166):
  - setup d0online
  - d0ssh d0sst@d0o166
STT Examine instructions (continued)

- Check if the impact parameter distributions for each sextant resemble approximately the reference histogram.
  - If not, is there a double peak structure in one of the sextants?
  - If so, call the STT on-call expert. In the mean time, if possible, ask the DAQ shifter to pause the run.
- In the “Download GUI” select Download “ALL” for the appropriate STT crate.
- In the “IOC GUI” push the reboot button for the appropriate crate.
- Wait until the reboot is completed ($\sim$ 3min.45s)
- In the “Reset GUI” select the “Hard Reset” button for that crate.
- When the crate is reset, ask the DAQ shifter to resume the run.
- Restart the examine and check if the secondary peak has disappeared.
- Check if SMT $R - \phi$ hit distribution is missing whole sextants
  - If yes try a “Hard Reset”, then call expert
- Check FRC error histograms for L1/L3 BX errors
  - If there are any, try a “Hard Reset”, then call the expert
STT Examine: Global distributions

<table>
<thead>
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<th>impact parameter (Prob: 0.204)</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entries</td>
<td>61660</td>
</tr>
<tr>
<td>Mean</td>
<td>11.7</td>
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<tr>
<td>RMS</td>
<td>582.5</td>
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</table>

<table>
<thead>
<tr>
<th>IP significance, all tracks (Prob: 0.468)</th>
<th>bpsig</th>
</tr>
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<tbody>
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<td>Entries</td>
<td>61660</td>
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<tr>
<td>Mean</td>
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<tr>
<td>RMS</td>
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<table>
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<th>bg</th>
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<td>Entries</td>
<td>38746</td>
</tr>
<tr>
<td>Mean</td>
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<tr>
<td>RMS</td>
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<table>
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<tr>
<td>Mean</td>
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<tr>
<td>RMS</td>
<td>3012</td>
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More CTT input tracks due to high luminosity
More CTT input tracks due to high luminosity.
STT Examine: Track transverse momentum

Verify examine plots, watch out for "abnormal" deviations

\[ p_\perp \text{ of fitted tracks} \]
STT Examine: Impact Parameter
STT Examine: Impact Parameter

0x70
Shifted IP distribution
Crate 0x73 needs LUT’s to be redowned
load to “All” and reboot IOC
(Don’t forget HardReset after reboot)

0x71

0x72

0x73

0x74

0x75
Examine Impact Parameter

Beamspot shift due to Tevatron adjustment between stores

Globalexamin needs 15 min. to determine new beamspot

Beginning of next run STT will use updated new beamspot position

Lars Sonnenschein

Physics Department, Boston University

Fermilab, 16 November 2004
STT Examine: Global distributions

Beam spot shift due to Tevatron adjustment between stores

STT will use updated new beam spot for Tevatron next run.

Lars Sonnenschein
Physics Department, Boston University
Fermilab, 16 November 2004/44
FRC parameter and status GUI

The primary purpose of this GUI is to check if parameter settings are consistent with the nominal values.

To start the STC GUI:
1. setup d0online
2. /online/config/stt/frc &

The multi parameter fields can show the value “Normal” (green), “Warning” (yellow) or “Alarm” (red). Clicking on these fields reveals more detailed parameter settings and in the case of disagreement which parameter(s) differ from the nominal value(s).
STC parameter and status GUI

To start the STC GUI:
1. setup d0online
2. /online/config/stt/stc &

The primary purpose of this GUI is to check if parameter settings are consistent with the nominal values.

The multi parameter fields can show the value “Normal” (green), “Warning” (yellow) or “Alarm” (red). Clicking on these fields reveals more detailed parameter settings and in the case of disagreement which parameter(s) differ from the nominal value(s).
### TFC parameter and status GUI

To start the STC GUI:
1. setup d0online
2. /online/config/stt/tfc &

The multi parameter fields can show the value "Normal" (green), "Warning" (yellow) or "Alarm" (red). Clicking on these fields reveals more detailed parameter settings and in the case of disagreement which parameter(s) differ from the nominal value(s).

---

The primary purpose of this GUI is to check if parameter settings are consistent with the nominal values.

---

Lars Sonnenschein  
Physics Department, Boston University  
Fermilab, 16 November 2004/47
• Troubleshooting
What to do if STT crate goes 100% Front End Busy?!

- STT crate(s) 100% L1 and/or L2 FEB
  - SCLinit
    - Dataflow? yes → OK!
    - no → Check Status
      - PCI bus hang? yes → 1. PCI Reset
        2. Set download to FRC only
        3. Reboot IOC
        4. FRC On
      - no → Check Busy/Errors
        - SCL interrupt? yes → 1. Set download to FRC only
          2. Reboot IOC
          3. FRC On
        - no → Hard Reset, try to resume run
          - Several crates? yes → Ask CFT shifter to reset STT senders:
            dfe_ware macro=restore_stt.macro
          - no → Ask CFT shifter for an “Fix CTT”
        - Dataflow? yes → OK!
        - no → 1. PCI Reset
          2. Reboot IOC
          3. Hard Reset
What to do if STT crate is missing events and dataflow stops?!

STT crate(’s) Missing events in üMon and no dataflow

- SCLinit
  - Dataflow? yes → OK!
    no → Hard Reset
  - Hard Reset
    - Dataflow? yes → OK!
      no → Reset SBC
    - Reset SBC
      - Dataflow? yes → OK!
        no → Check SCL mezzanine board
  - Check SCL mezzanine board
    - SCL cable correct seated? yes → Orange LED on? yes → Call expert
      no → Reseat cable properly
    - Orange LED on? no → Hard Reset
      no → Call expert
null
What to do if L2 crate 0x25 claims STT missing events or sync error?!

If at the same time STT crate is missing events in üMon look at flow chart: What to do if STT crate is missing events and data flow stops

```
L2 CTT/STT crate 0x25 stuck in L2 Dataflow GUI

  SCLinit
    Dataflow? yes -> OK!
       no

  Hard Reset
    Dataflow? yes -> OK!
       no

“Check Busy/Errors” of STT crate showing missing inputs into L2 crate 0x25

   no

  L1CTT input problem? yes

    Ask CFT shifter for an “Fix CTT”

      Dataflow? yes -> OK!
         no

  Ask DAQ shifter to reset L2 crate 0x25

    Dataflow? no -> Verify Hotlink Transmitter output cables
       yes -> OK!
```