<table>
<thead>
<tr>
<th>Time</th>
<th>Section</th>
<th>Presenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00AM</td>
<td>30 min Intro</td>
<td>Mark</td>
</tr>
<tr>
<td>9:30AM</td>
<td>60 min PSM/LCB/MEZ</td>
<td>Peter</td>
</tr>
<tr>
<td>10:30AM</td>
<td>30min Break N/Lunch South</td>
<td>All</td>
</tr>
<tr>
<td>11:00AM</td>
<td>30 min AFE/Flex/Connectors</td>
<td>Mark</td>
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<tr>
<td>11:30AM</td>
<td>30 min TSM</td>
<td>Mark</td>
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<tr>
<td>12:00PM</td>
<td>30 min Lunch North/Break S</td>
<td>All</td>
</tr>
<tr>
<td>12:30PM</td>
<td>45 min Mechanical</td>
<td>Joe</td>
</tr>
<tr>
<td>1:15PM</td>
<td>45 min Software</td>
<td>Nick</td>
</tr>
<tr>
<td>2:00PM</td>
<td>30 min Mfg &amp; Test</td>
<td>Ron</td>
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<tr>
<td>2:30PM</td>
<td>30 min Overall Q &amp; A</td>
<td>All</td>
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<tr>
<td>3:00PM</td>
<td>60 min Panel Session</td>
<td>Panel</td>
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<tr>
<td>4:00PM</td>
<td>15 min Panel report</td>
<td>Torrent team &amp; Panel</td>
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Section 3

- AFE
- Flex cables
- Connectors
CCD AFE
CCD AFE Details

- 4 channels of DC restored, dual slope Correlated Double Sampling (CDS) Video
- 8 channels of Low Voltage Biases: ±17V
- 8 channels of High Voltage Biases: 0 to 28V or -28V to 0
- 16 channels of clocks: ±17V
- On board regulators and references
  - Provides stability over temperature and supply fluctuation
CCD AFE Details

- Optimized for 100 kpix/sec – 350 kpix/sec
  - Maximum design is 500 kpix/sec
- Programmable test points for system debug
  - Allows viewing of clocks and biases on board edge connectors during code development
- EEPROM to hold calibration data
- Temperature sensors at two locations
- Two boards fit in one chassis for the total channel count
Block Diagram of AFE

- Shows the sections of the AFE, showing the relative location of sections also
- Important for noise control
  - Clocks as far away from Video as possible
- Allows ground current control
- Lower chance for ground loops with single board for all connections to CCD
CCD AFE Design

- Designs for Torrent very similar to Orange
  - Clocks, Video processing & Biases identical
- Changes:
  - Higher density/Finer resolution DACS
    - 12 bit vs. 8 bit
    - 16 DACs in a single package for higher density
    - All DAC channels are buffered on chip
  - Different switches for clocks and video
    - Clock switches are smaller and lower $R_{on}$
    - Video switch no longer needs logic supply
  - First video amplifier placed closer to dewar connectors in TSM
    - Gain and rolloff in this stage
    - Allows interchangeability of controllers
CCD AFE Testing

✓ All clocks tested over full range and loads
  – Unloaded rise time of <150 ns
✓ All LV Biases tested for drive, range and noise
✓ All HV Biases tested for drive, range, noise for both polarities
✓ Video channels have several tests for noise to check each section
✓ Programmable test points for system debug
  – Allows viewing of clocks or biases on board edge connectors
AFE Video performance

✓ Shorted input test of 4 channels on one AFE
✓ Shows 2 – 3 ADU of noise on 18 bits
  – Equal to 4μV
  – Dwell time of 1μs
CCD AFE misc

- CCD type done first as opposed to IR
  - More requirements for CCD vs. IR
- We have a reference design for the IR version with 16 channels for each board for a 32 input IR Torrent
- We also have an oversampler design for extremely low noise (<1e-) using statistical oversampling
  - Developed through the Clinic Program with Harvey Mudd Engineering students (www.hmc.edu)
Flex circuits

• We are using flex cables to connect the AFE sections to the TSM
  – One cable carries the Clocks and Biases
  – One cable carries the video inputs
  – Each cable supports two AFE cards
• Selected to help control crosstalk and impedance
  – Controlled by layout of flex cable
Flex cables installed

Shows the Clocks & Biases flex and Video flex
Connecting Controller to TSM

• Selected D series connectors from Positronics
  – Two High density connectors for AFE signals
  – Standard D25 for Utility Board
  – Connectors have guide pins for alignment
    • One side floats
    • Other side is fixed
• TSM Present switch in controller to detect:
  – If there is a TSM
  – Removal of controller with power on
• Shorting switch in TSM to short Preamp A_{GND} to shield when controller removed
  – Time between removal of controller & insertion of shorting plug
TSM and Controller Connectors

Video – Top
Clock & Bias - Bottom

Utility Connector
Section 4

• TSM
  – Preamp, Clock and Bias interface
  – Utility

Dewar Connectors for NOAO
North Dewars
Transition Module

- Customizable part of Torrent
- Resides on the Dewar
- Interface to the Dewar
- Preamp with gain and filtering to buffer the CCD
  - Allows controller to be independent of CCD/Dewar
- Shutter output
- Dewar CCD temperature control
- EEPROM to hold system configuration
- Two Internal Temperature sensors, as usual
Interlocks

• The Torrent design has two hardware interlocks between the controller and the Transition Module
  – TSM Present switch on the LCB
    • Senses the presence of the TSM before turning on the outputs
    • Disables the outputs in case of accidental removal with power applied
  – The TSM Grounding switch on the Preamp
    • shorts the $A_{\text{GND}}$ to shield when the controller is removed, to protect the CCD
TSM Preamp

• Same as first stage of Orange design
  – Load resistor for CCD
  – Capacitor for DC removal
  – Initial filtering of CCD signal using low pass in feedback of opamp
• Set the initial gain here for varying CCD sensitivity
  – Makes controller independent of TSM
• Is the connection area for the Video, Biases and Clocks to dewar interface
• Allows filtering for Clocks and Biases
  – Simple RC network for customization
• The TSM is the only customizable part of Torrent!
  – This version will be versatile enough for most applications
TSM UTILITY

- Added to handle functions missing on Orange as well as new functions
- EEPROM and two Temperature sensors
  - EEPROM holds configuration data for system
  - standard on all Torrent boards
- Opto Isolated Shutter and Preflash outputs
- Two Opto Isolated status inputs
- CCD Thermal control
  - Calibrate for Diode or RTD sensors
  - Heater output up to 8W, jumper selectable
- Connectors for (NOAO-N) standard monitoring TCs
- Again - Remember that this is customized for the project
TSM Utility Board

- Shows the Utility board Input and Outputs
- Does not show
  - calibration pots for RTD & Diode calibration
  - Jumper for heater power setting
Connector I/O on the TSM

External:
- Shutter out*
- Aux out (preflash)*
- Status 1 in (shutter open)*
- Status 2 in (shutter closed)*
  - All on a bulkhead mount
    Lemo 8 pin circular connector
- TC1 (monitor on CCD) and TC2 (monitor on tank)
  - Bulkhead TC Connectors

*Note: These are optically isolated:
  - Resistor to power & common needed for OC output
  - Series resistor & common to drive the LED for input

Internal:
- Heater out**
- Temp 1 in
- Temp 2 in

**Power level programmed by the heater power selection jumper on Utility board
- Connected back to the LCB through PSM
  - EEPROM
  - Temp1
  - Temp2
Next is:
30 min Lunch North/Break S All
45 min Mechanical Joe