ATLAS SCT Status

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SCT System Overview

ATLAS SemiConductor Tracker

- barrel - 4 barrels
  - 2112 modules
- forward - 2×9 disks
  - 1976 modules

  of 2×2 detectors
  glued back-to-back
  at small stereo angle

...or broken up

- 15392 detectors
  - 63 m^2 active Si
- 49056 ABCD ASIC's
  - 6.3 M channels

... and also

- 500 km of cables
  - 30 kW of power in
- heat exchangers, pipes
  - 30 kW of power out
- 1500 km of optical fibres

  control & read out

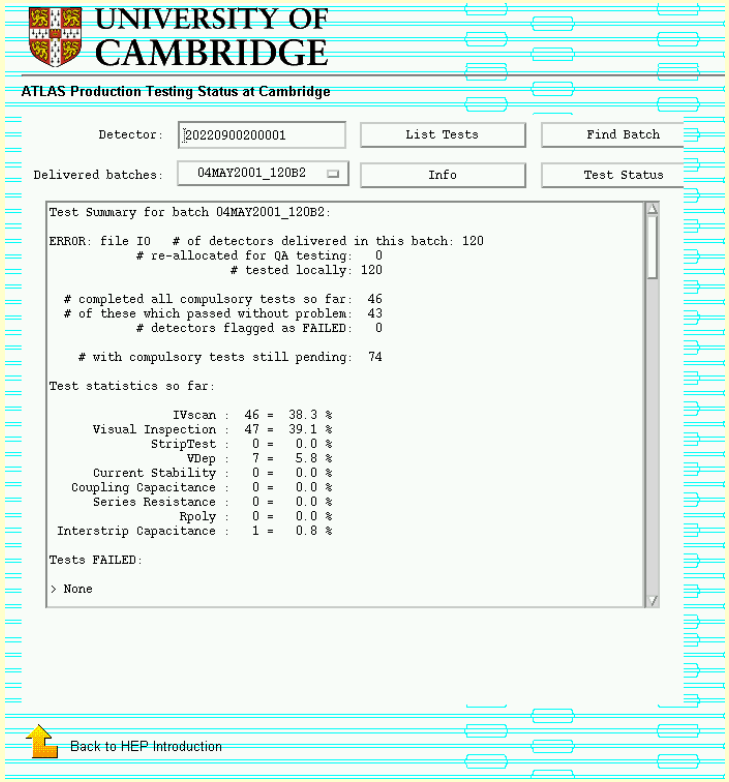
Silicon Strip Sensors

- PRR in August 2000 after 5 % preseries qualification
- series sensor production underway (January 2001 - end 2002) at Hamamatsu ($> 80\ \%$) and CiS

- 1 barrel ($\sim$ square) and 5 forward (wedge) detector types
- insertable pixel layout required change of inner disk (W12) detectors

Silicon Strip Sensors (cont.)

- 16 % of barrel and 16 % of forward detectors delivered

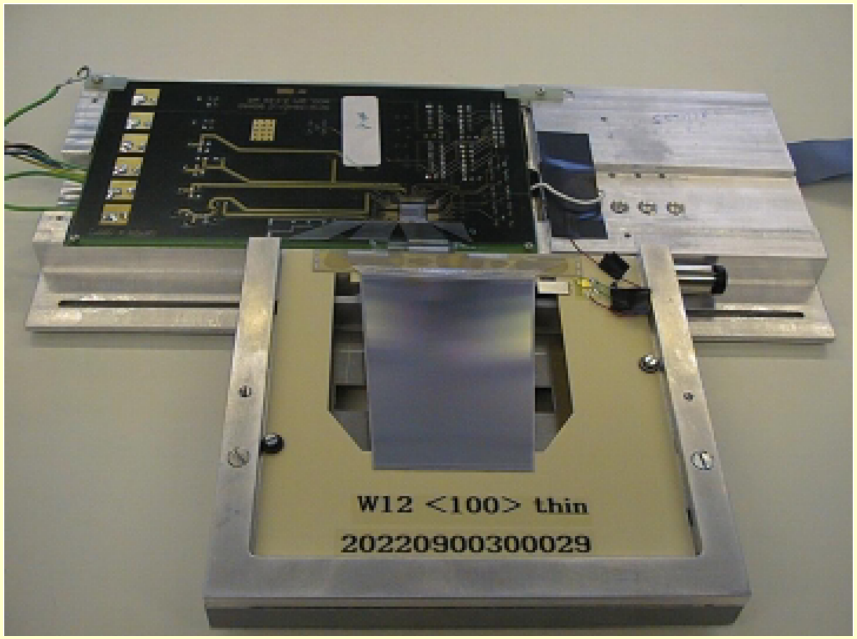


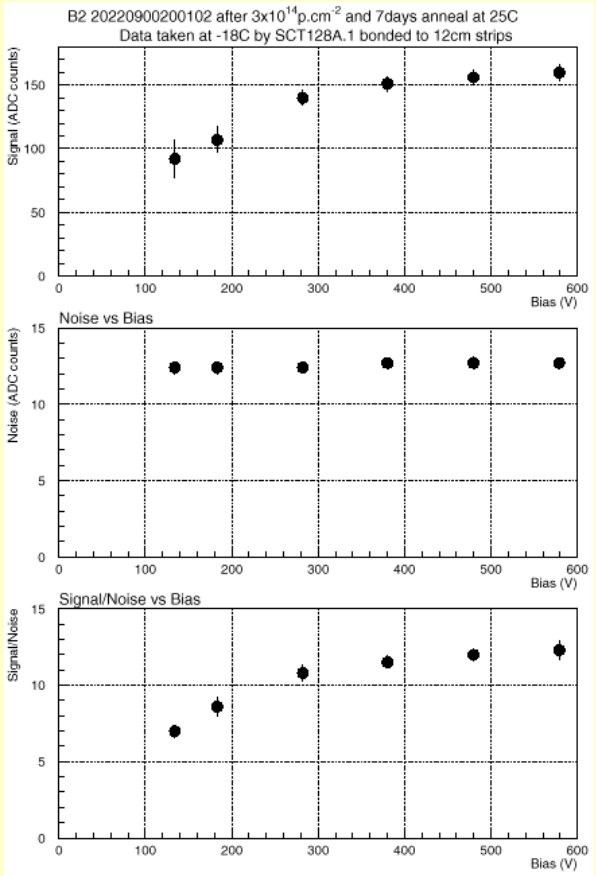
- acceptance QA currently at 8 SCT institutes
  - every detector
    - visual inspection
    - I-V to 500 V
  - 10 % subsample
    - depletion voltage
    - full strip evaluation
    - metal R
    - $C_{interstrip}$

- current average yield of perfect strips - 99.9 % !

Silicon Strip Sensors (cont.)

- irradiation tests (to 3×10^{14} p/cm^2) - full detectors, miniature detectors
  - I-V < 0.25 mA up to 450 V @ -18°C
  - CCE 90 % @ 350 V (40 MHz SCT128A)





ASIC's

- frame contract with ATMEL in place
- minimum guaranteed yield 26 % (upper limit on cost)
- target yield 38 %

- so far all delivered wafers (well) below or at minimum yield !
- (at least) a big load on testing

- ATMEL believe target yield can be met with new epitaxial material and defect screen in place prior to metal deposition

- new test set-up developed at LBNL
  installed and being qualified at CERN, LBNL, RAL and UCSC
  wafers already tested with old CERN tester serve as benchmark
- ✔ testers operational but improved test algorithms need to be completed for full production

ASIC's (cont.)

ABCD3T irradiation with PS protons to 3×10^{14} cm^{-2} in Oct/Nov 00

☞ two problems experienced

- receiver circuit: higher V_{dd} (up to 4.8 V) needed for operation
  - ☞ not understood completely
  - ✎ appears beyond 2×10^{14} p/cm^2 on some chips from one wafer
  - ✔ not seen in recent irradiation on 4×12 ABCD3T chips
- trimming circuit: problem of trim-DAC range setting
  - ☞ understood in simulation
  - ✔ solved by metal mask modification and reprocessing
  - ✔ not appearing in recent irradiation

☞ PRR scheduled July 4$^{\text{th}}$

Modules - Barrel

procurement/production starting

- ☞ FDR passed May 24,25
- ✎ module shown to adhere to ATLAS SCT specs

selected performance figures from FDR:

- ❖ pre-irradiation noise summary (1400-1700 e_0)
- ❖ noise occupancy vs. threshold
  - stable operation to zero threshold
  - occupancy 1.3×10^{-5} @ 1 fC threshold
- ❖ signal/noise of unirradiated (15 > 200 V) & irradiated (10 @ 400 V) modules in KEK beam
- ❖ resolution from CERN H8 Aug'00 - 23 μm

- ☞ 3 modules irradiated in April 2001 - under annelaing & evaluation

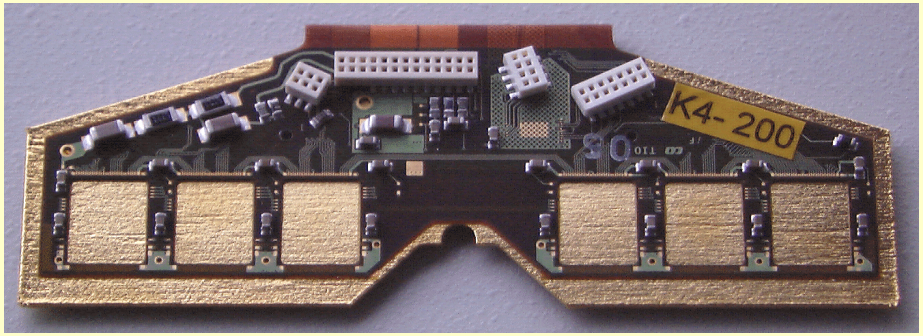
- ✎ pre-series production of 18 module-0 ongoing, stock building up

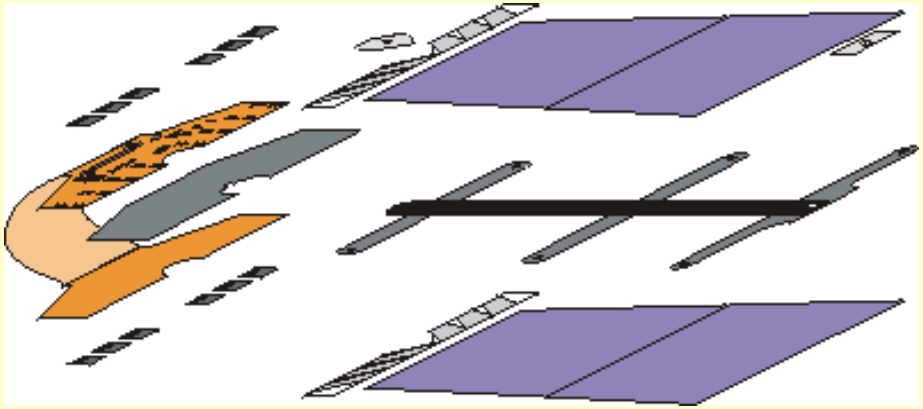
- ☞ production starting November 01, completed June 03
  in 4 clusters: Japan, Nordic, UK, US

Modules - Endcap

☞ a few months behind barrel

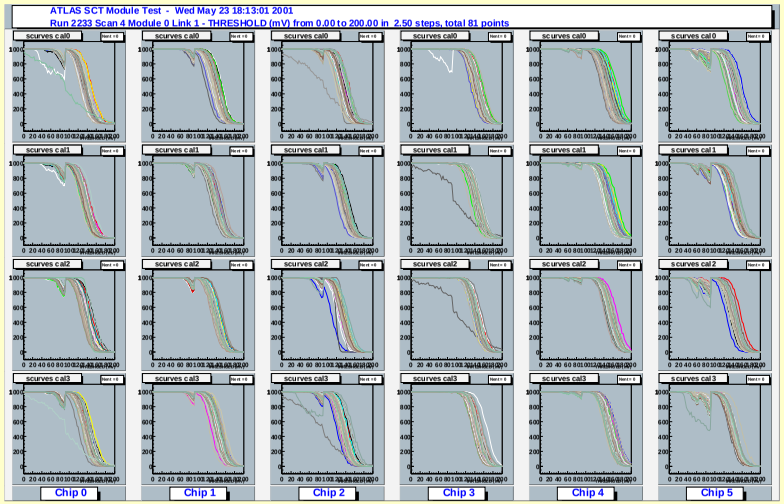
✔ new hybrid K4 - carbon-carbon substrate - improved thermal performance

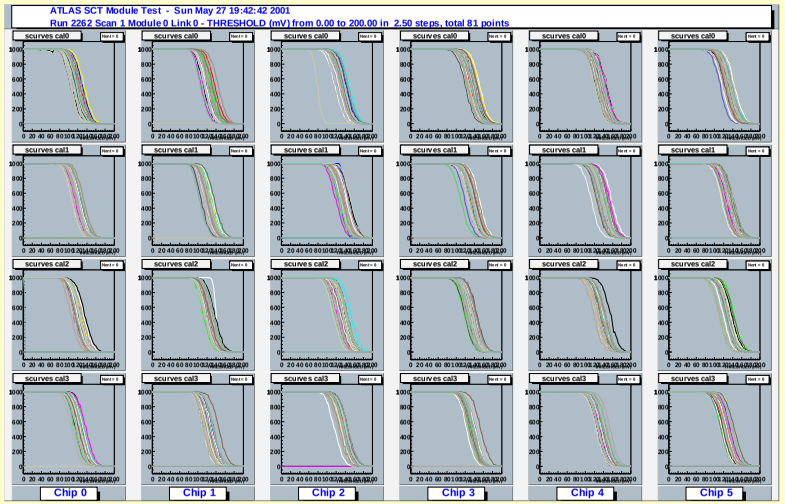




Modules - Endcap (cont.)

- first pre-series modules under test, stability problems
- ✔ to great extent solved ⇒ irradiation of one module at CERN PS now



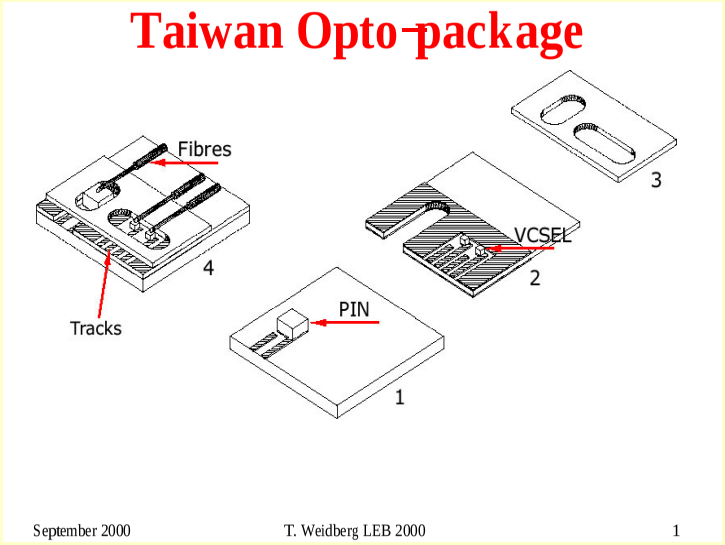


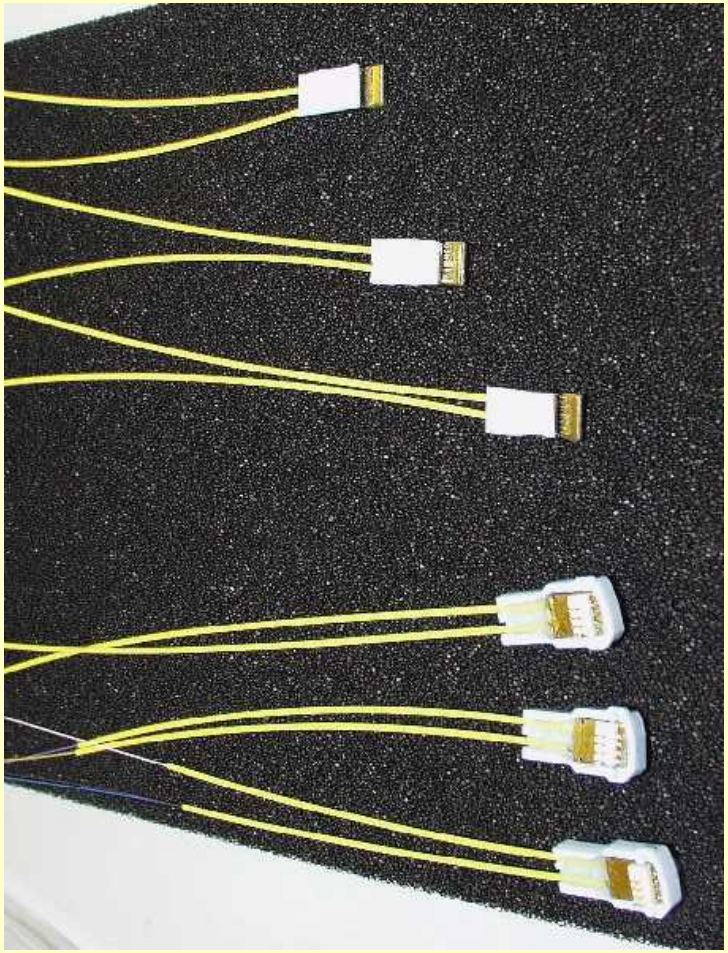
- to start production in February 02 requires FDR in July
- ! difficult to meet, decision at SCT week end June

Optical links

- new collaborator: Academia Sinica, Taiwan:

- Truelight PIN/VECSEL packages replacing GEC
- electro-optical harness assembly

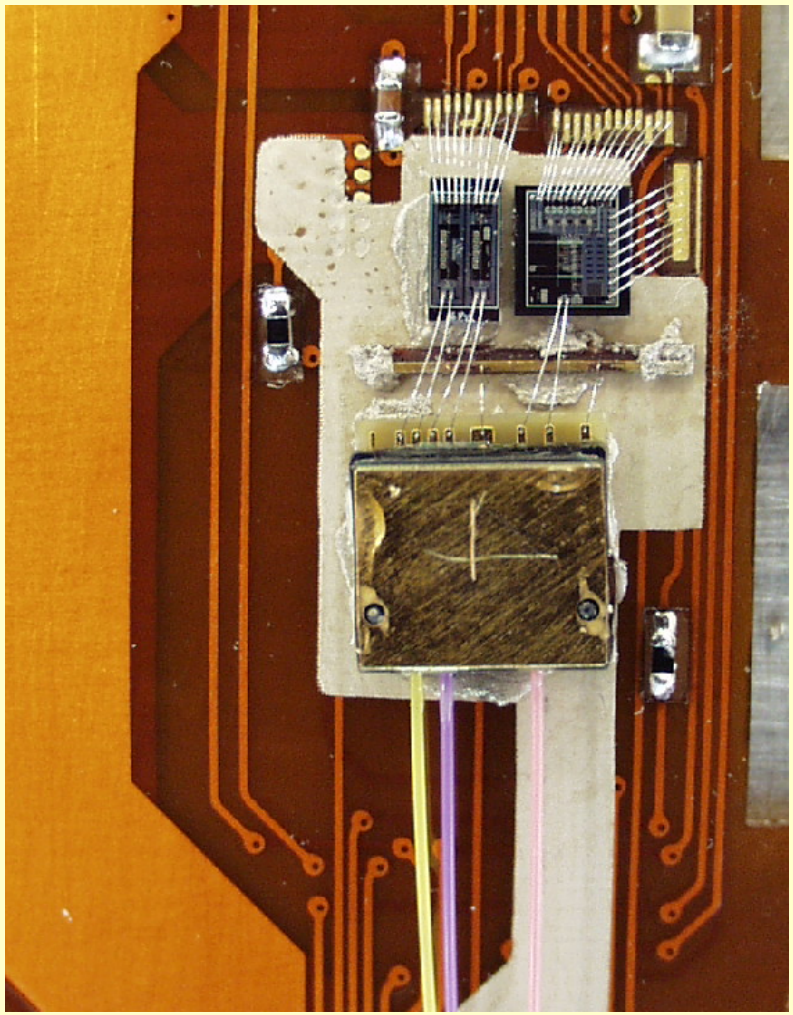




Optical links (cont.)

harness assembly tests at RAL:

✔ first harnesses produced and tested



Optical links (cont.)

DORICs and VDCs production wafers back

- first wafer tested, yield 95 %

Schedule:

- opto-ASIC (DORIC, VDC) FDR in July 01
- opto-electrical harness FDR September 01

$\Rightarrow$ harness production: September 01 $\rightarrow$ January 03

Power Supplies and Cables

☞ doubled power requirements ⇒ increased cost & volume required for services ⁉

☞ PS critical design review, EB gap task force
⇒ two important and helpful concessions by ATLAS

- PP2 in muons at $z \sim \pm 3.5$ m
- 40 mm gap enlargement in z

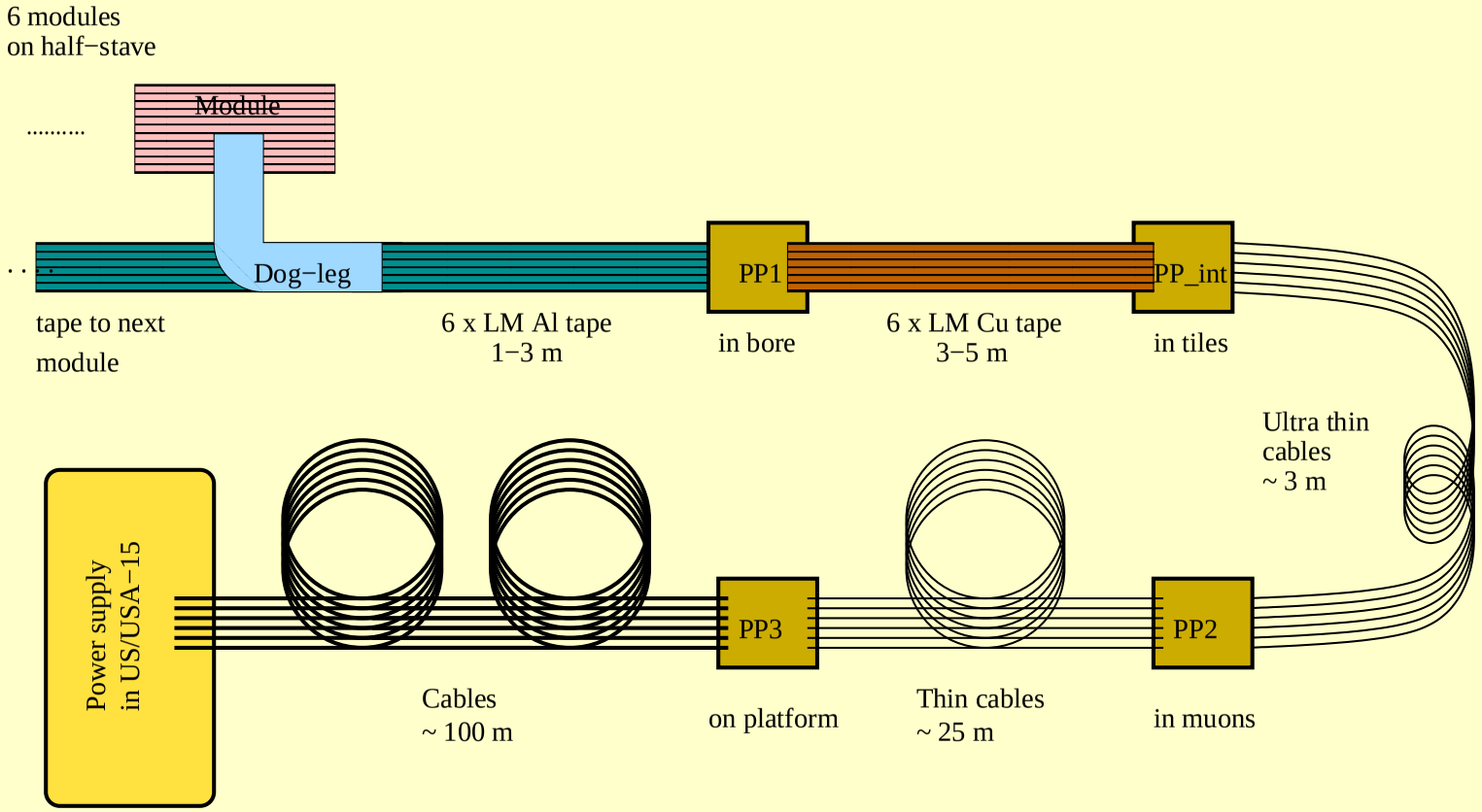
... working hard to fit services in allocated space considering all possibilities

Power Supplies and Cables (cont.)

✔ baseline just fits, but not fully modeled

✎ technology to be finalized on basis of reliability, cost & space

SCT Power distribution baseline scheme



Power Supplies and Cables (cont.)

options considered (under severe schedule pressure)

- (ultra-)thin TP cables to PP1 (fit in ID space ?)
- modularity & packing of services (module noise ? space gain ?)
- modularity of power supplies (module noise ? cost gain ?)
- move power supplies to UX-15 (radiation tolerance ? SEU ?)

☞ deadline imposed by assembly schedule: Power Supply FDR/PRR March 02
☞ low-mass cables included in opto-electrical harness FDR September 01

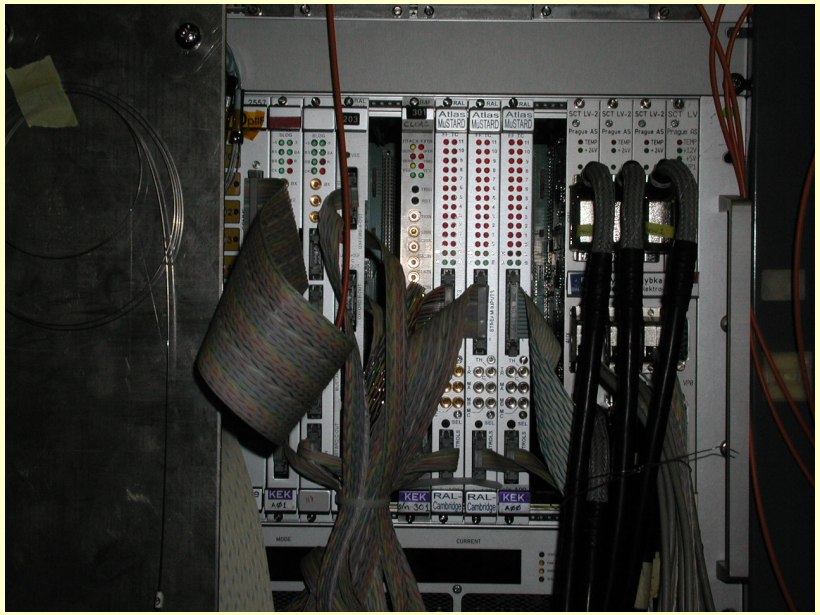
currently

- ~ 100 LV power supplies in production for system-test / assembly site needs
- production of low-mass tapes for system test and harness prototype assembly

System Test

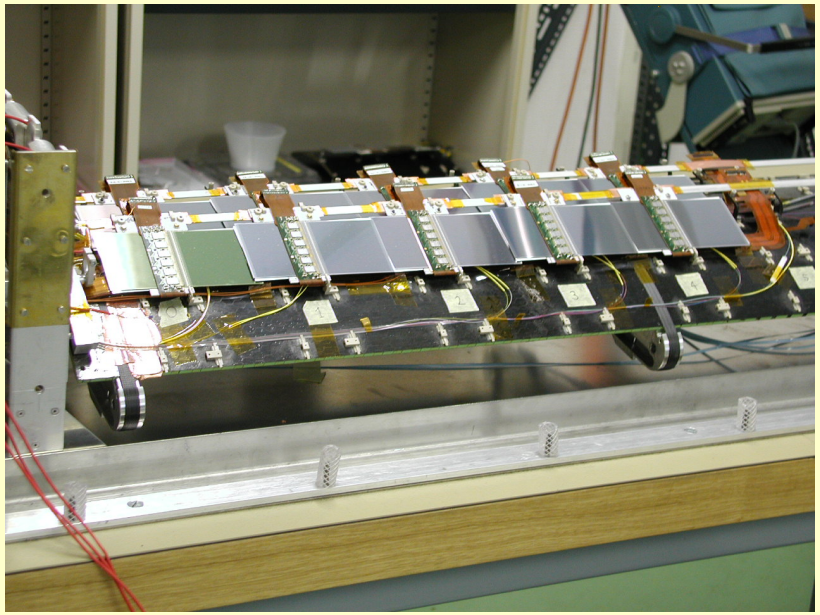
purpose:

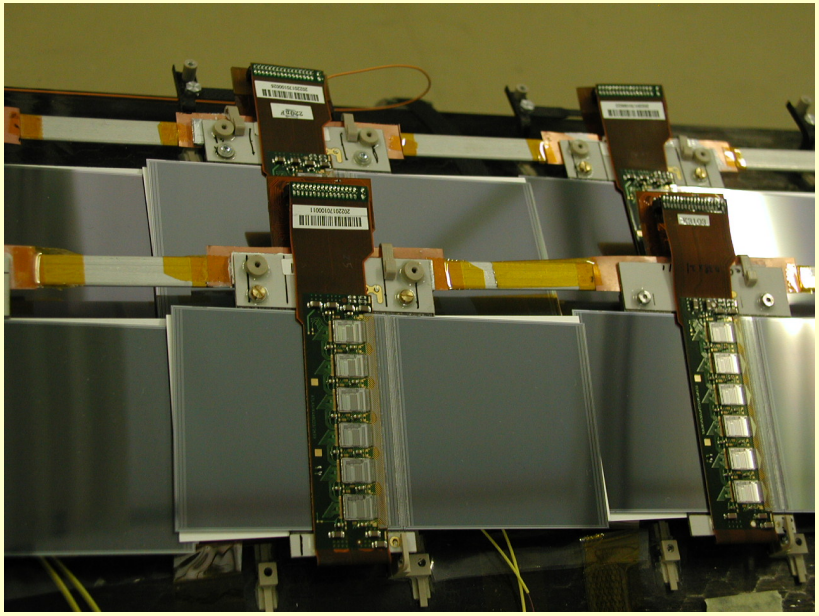
- test multiple modules in a realistic SCT environment, including SCT PS & cables/harnesses and opto readout
- find optimal grounding & shielding scheme



System Test - Barrel

barrel - 10 modules on sector (3+1 half-staves)
equipped with cooling pipe & opto-electrical harnesses (3 LH + 1 RH)

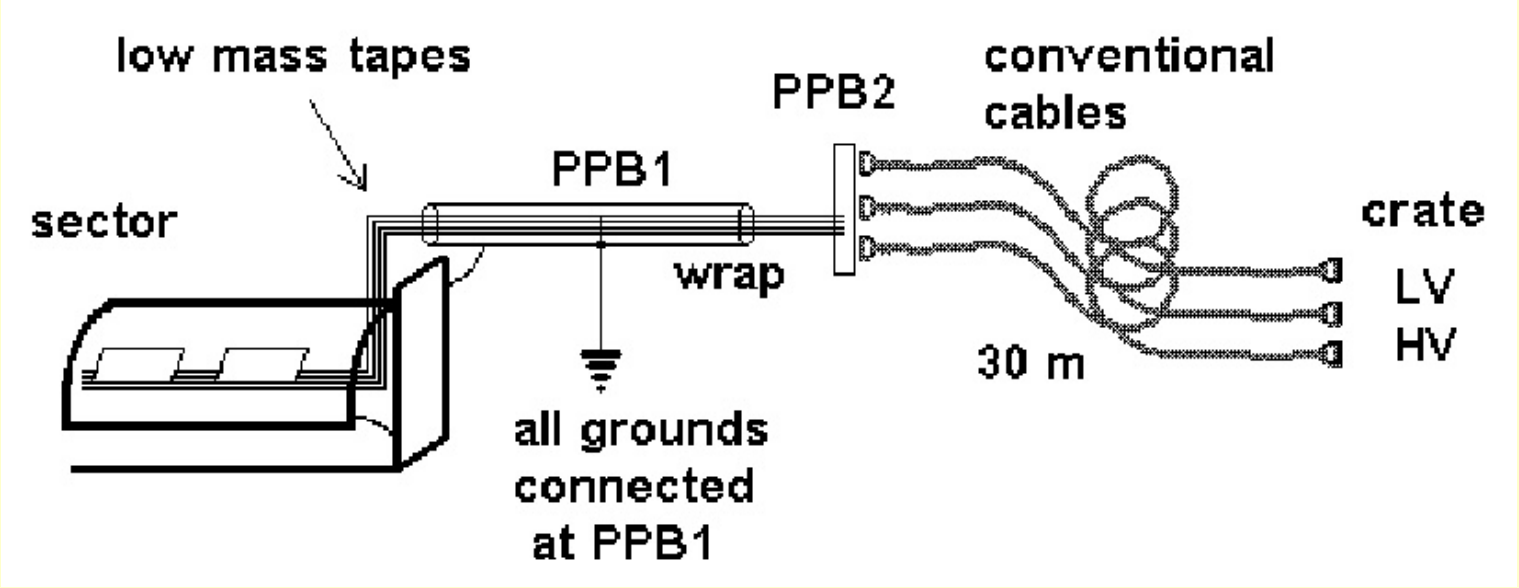




System Test - Barrel (cont.)

grounding & shielding scheme for barrel

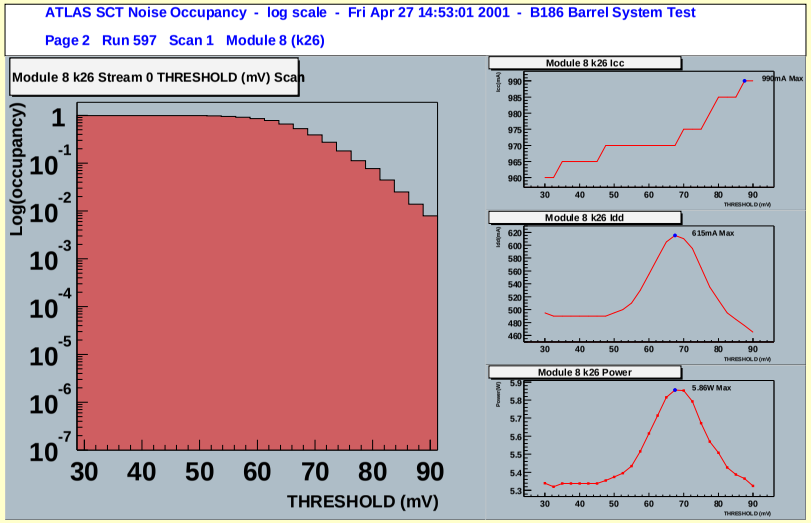
- jumpers on patch panels allow easy configuration changes
- a lot of “Scotch physics” still going on

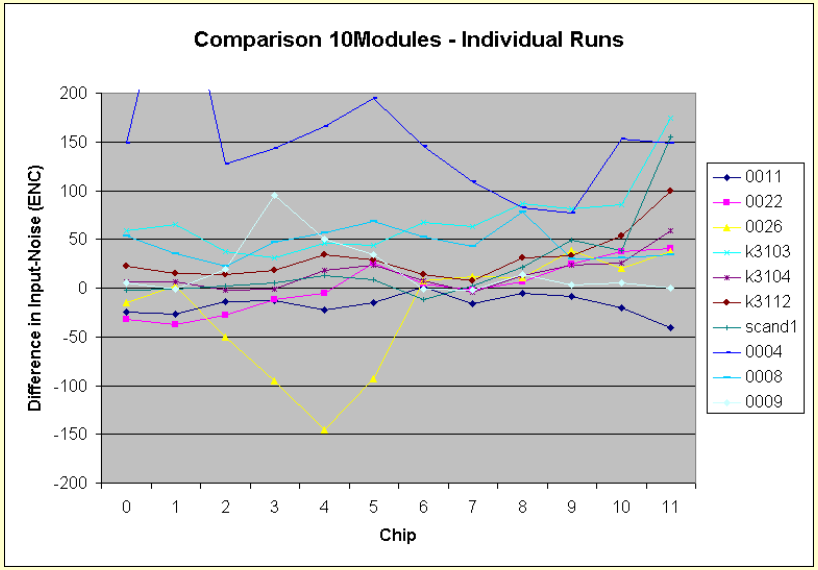


System Test - Barrel (cont.)

selected results

✔ modules behave almost as well on the sector as on electrical stand



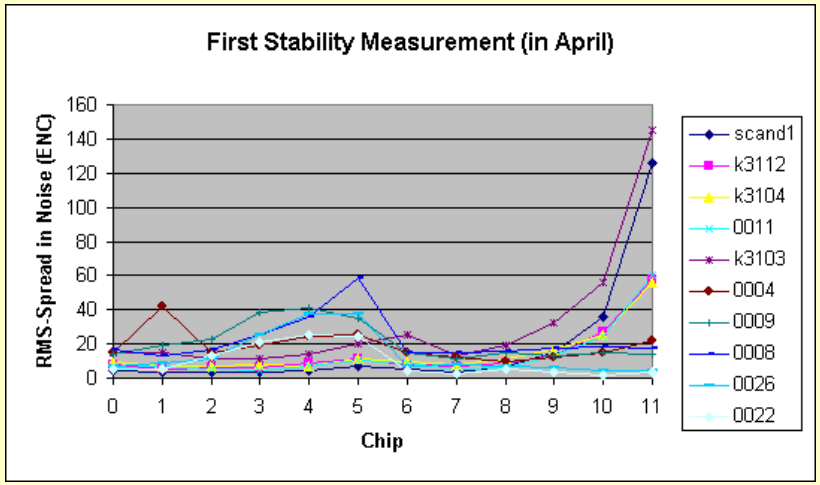


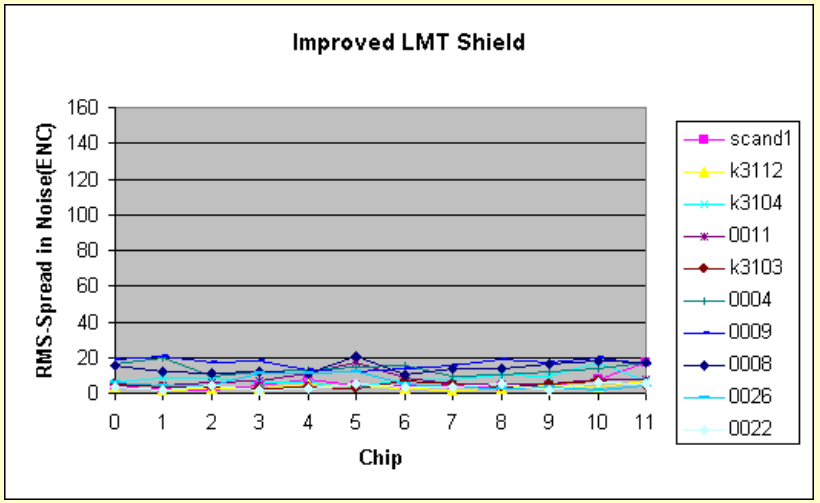
0.00E+000

0mA Typical

System Test - Barrel (cont.)

☞ some fluctuations in noise seen on chips close to neighboring module
✔ fluctuations significantly decreased when grounding and shielding improved



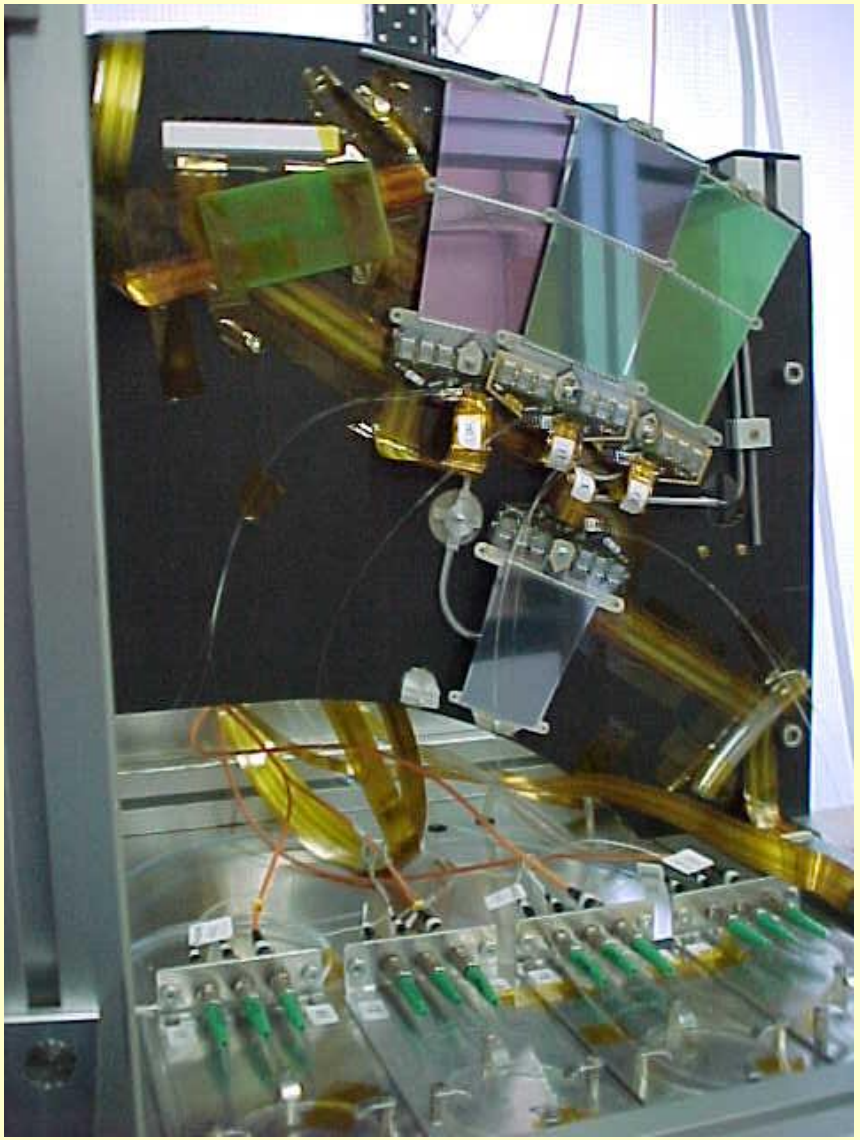


looks promising
☞ but 10 is still a very small number of modules
... we're still in the early days !

System Test - Endcap

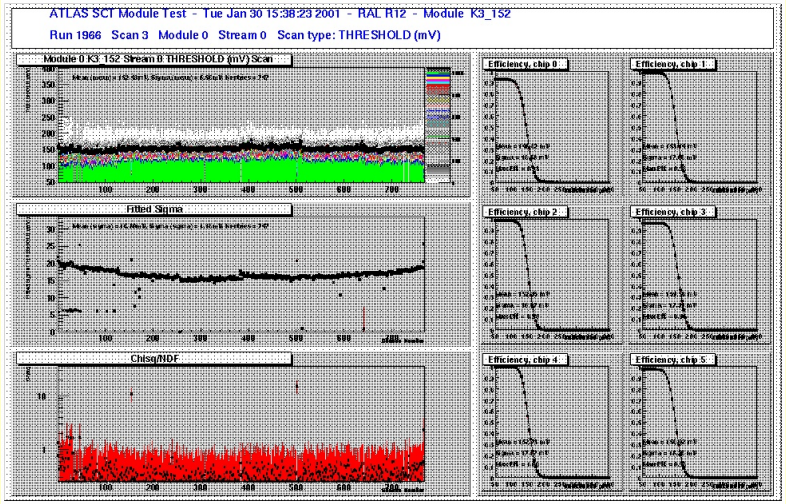
endcap test stand

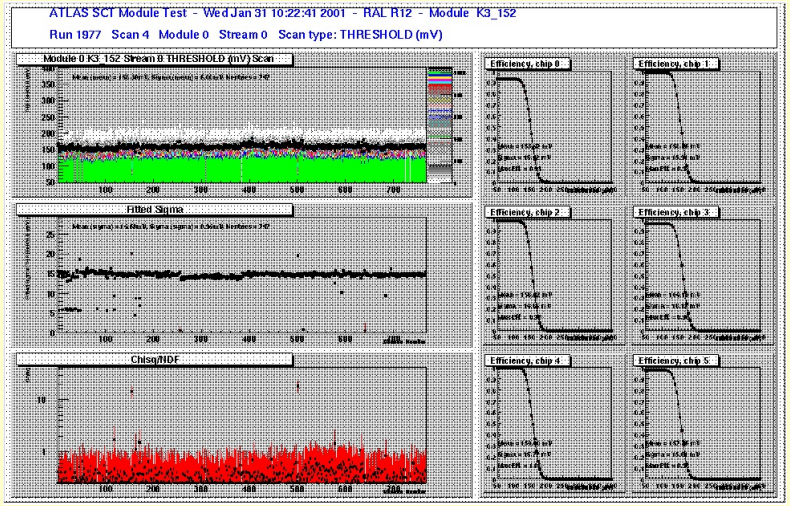
☞ new modules arriving



System Test - Endcap (cont.)

- previous results - endcap modules noisier (higher T) & more sensitive to common mode noise
- hope to have improved by new hybrid (lower T) and better grounding & shielding





System Test - Future Plans

- barrel plans:
  - add more modules
  - test configurations
    - module completely surrounded by other modules
    - row of 12 modules supplied from both sides coupled to same cooling pipe
  - continue studying & improving grounding & shielding
  - incorporate a ROD
  - incorporate power-supply-0
- endcap plans:
  - continue work on quantifying & fighting common-mode noise
  - quarter-disk to arrive end of June
    - 33 module positions
    - enough supplies and readout to operate 18 modules simultaneously
    - with sufficient modules, same type program as on barrel now
- for both barrel and endcap
  - test redundancy scheme for opto readout
  - run at ATLAS temperatures: hardware ready now
  - try interchanging barrel $\leftrightarrow$ endcap grounding & shielding schemes

Conclusions

- SCT on good track to move into bulk production !
  - some parts (detectors) already at full steam
  - some (barrel modules) just starting
  - the rest to follow soon

with a bit of luck and a lot of hard work ...

... at next overview week SCT will be just giving production status reports !