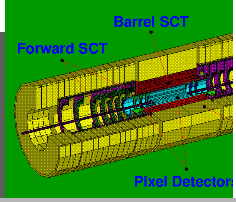
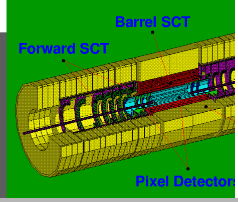


Conclusions

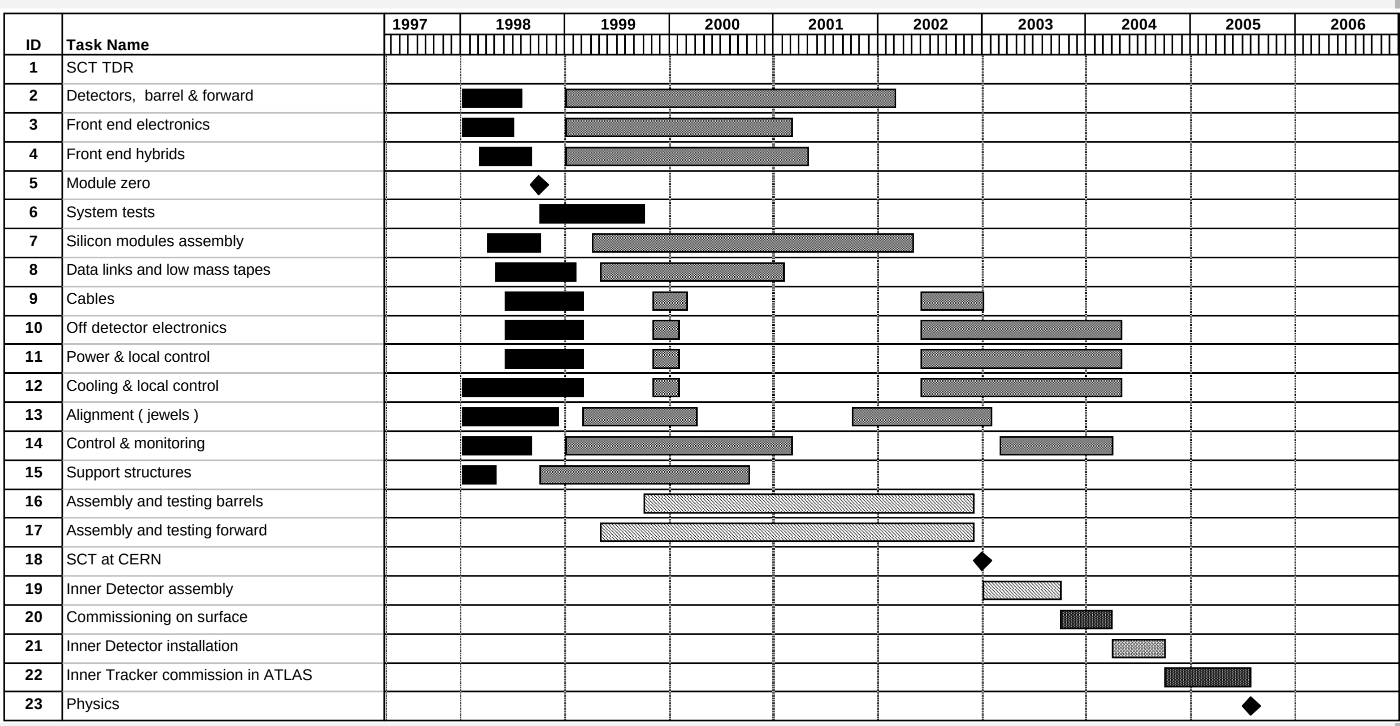
- •Extensive R&D Programme over last 7+ years.
- •Radiation tolerant detectors, electronics, optics and supports have been developed and prototyped.
- •Layout has low mass, whilst remaining a practical and conservative design.
- •Assembly and maintence is planned for
- •SCT collaboration is ready to proceed to the construction phase.

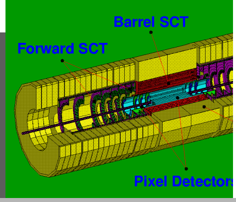


Project Oranisation

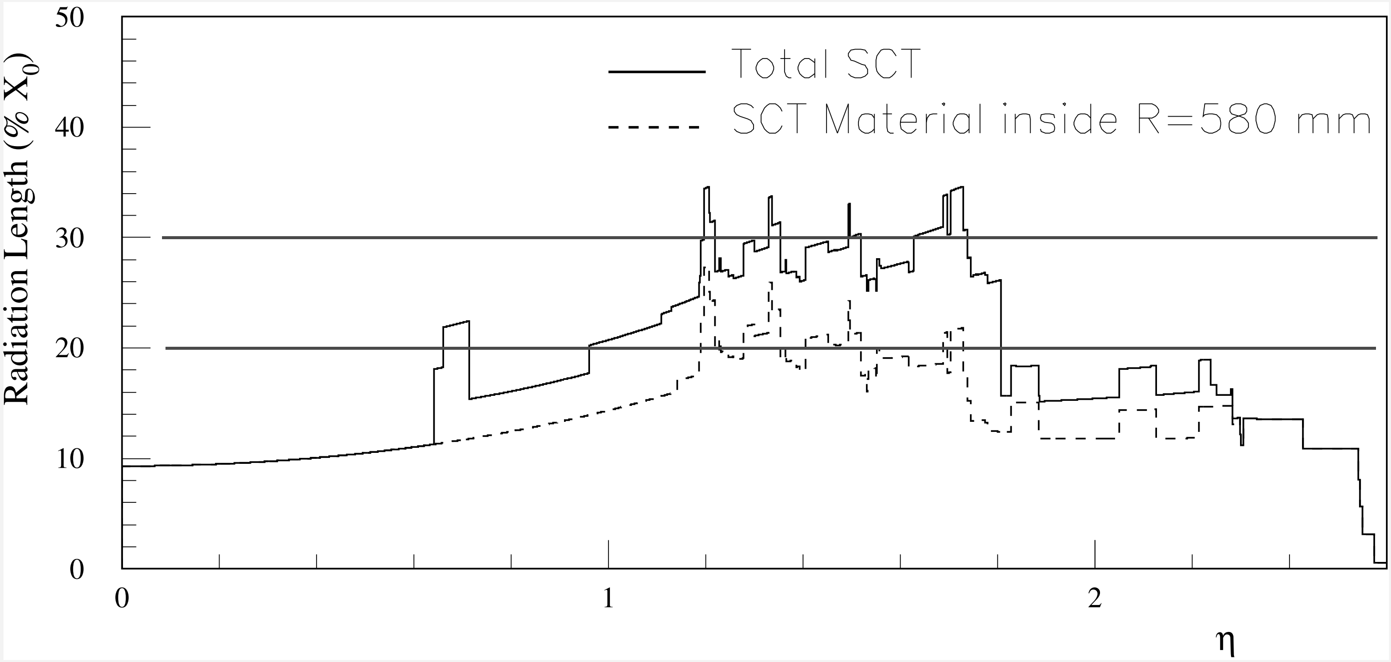
Region of SCT	Number of modules	Cluster	Institutes
Barrel 3	461	Nordic	Bergen, Oslo, Uppsala
Barrel 4	576+50	UK-B	Birmingham, Cambridge, Oxford, QMW, RAL
Barrel 5	691	Japan	Hiroshima, KEK, Kyoto
Barrel 6	756	USA	Irvine, LBL, UCSC
FWD 1,2,3	854	UK-V	Glasgow, Lancaster, Liver-pool, Manchester, RAL, Sheffield, UCL, Valencia
FWD 4,5,6	~758	CS	Australia, CERN, Cracow, Geneva, Ljubljana, MSU, Prague
FWD 7,8,9	~758	CN	Freiburg, MPI[a], Nikhef, Prague, Protvino

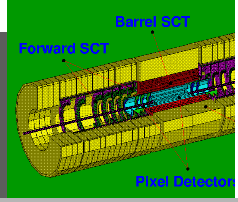
a. under discussion, see statement on MPI participation on page 583.




Barrel SCT
Forward SCT
Pixel Detectors

Material


Radiation Length (% X0)
50
40
30
20
10
0
0
1
2
η
Total SCT
SCT Material inside R=580 mm



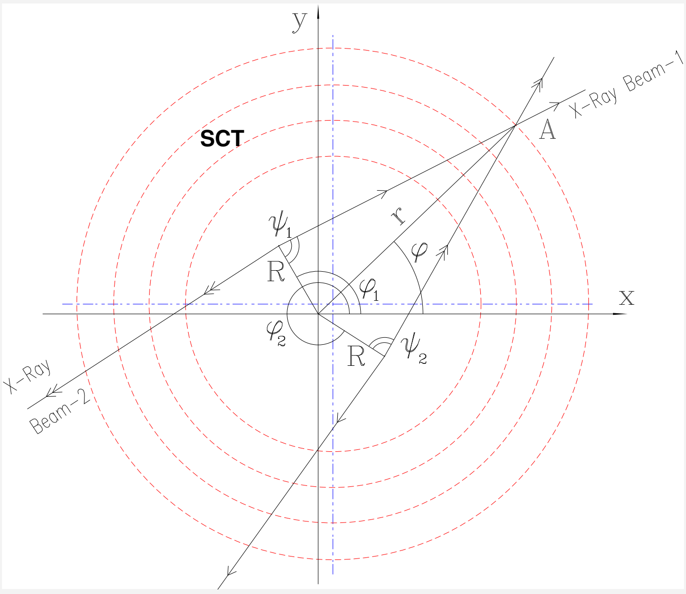
Alignment

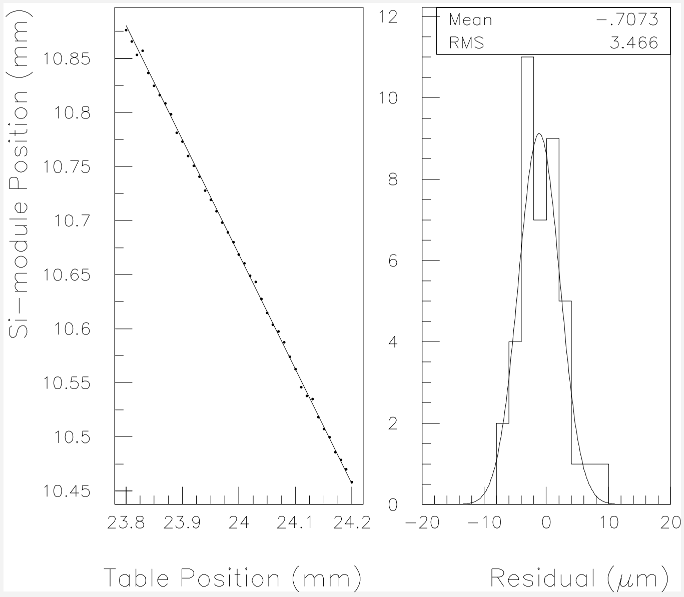
this transparency to be removed

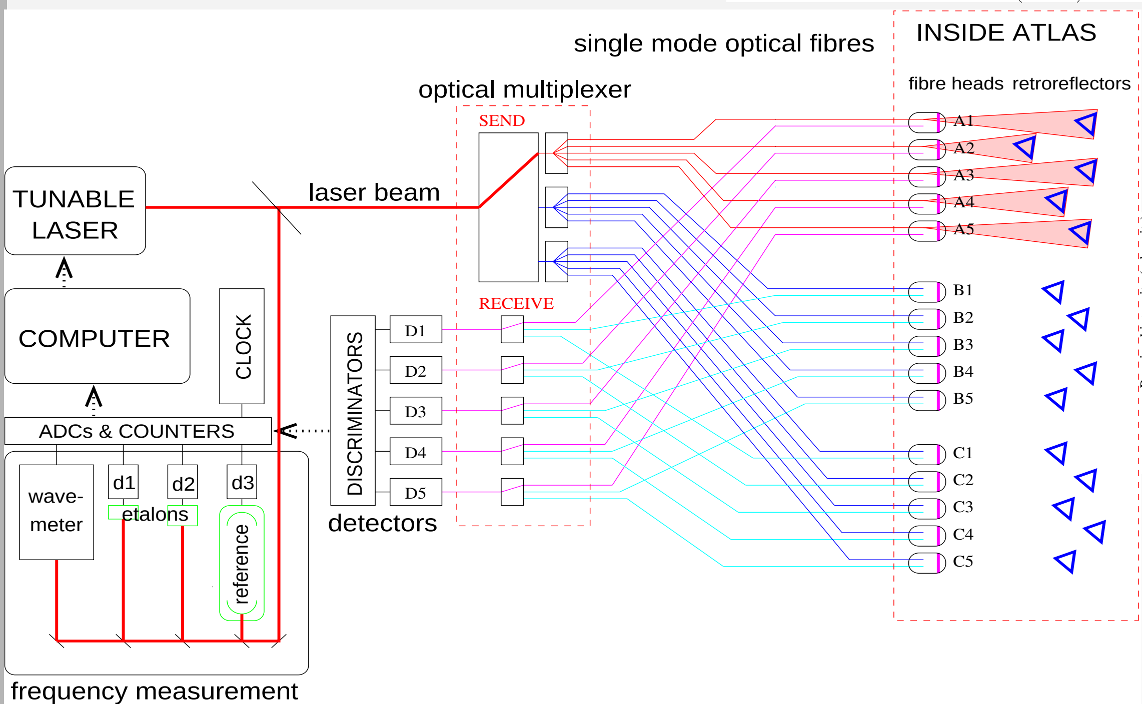
FEA and measurements (eg ESPI) relate motion of modules to motion of structure

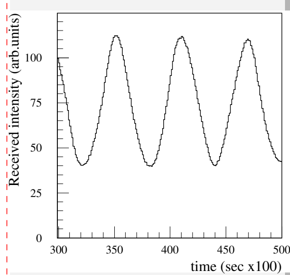
Survey, including x-ray and optical locate modules

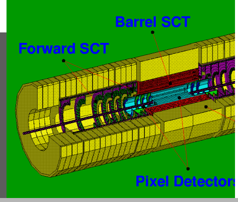
FSI monitors



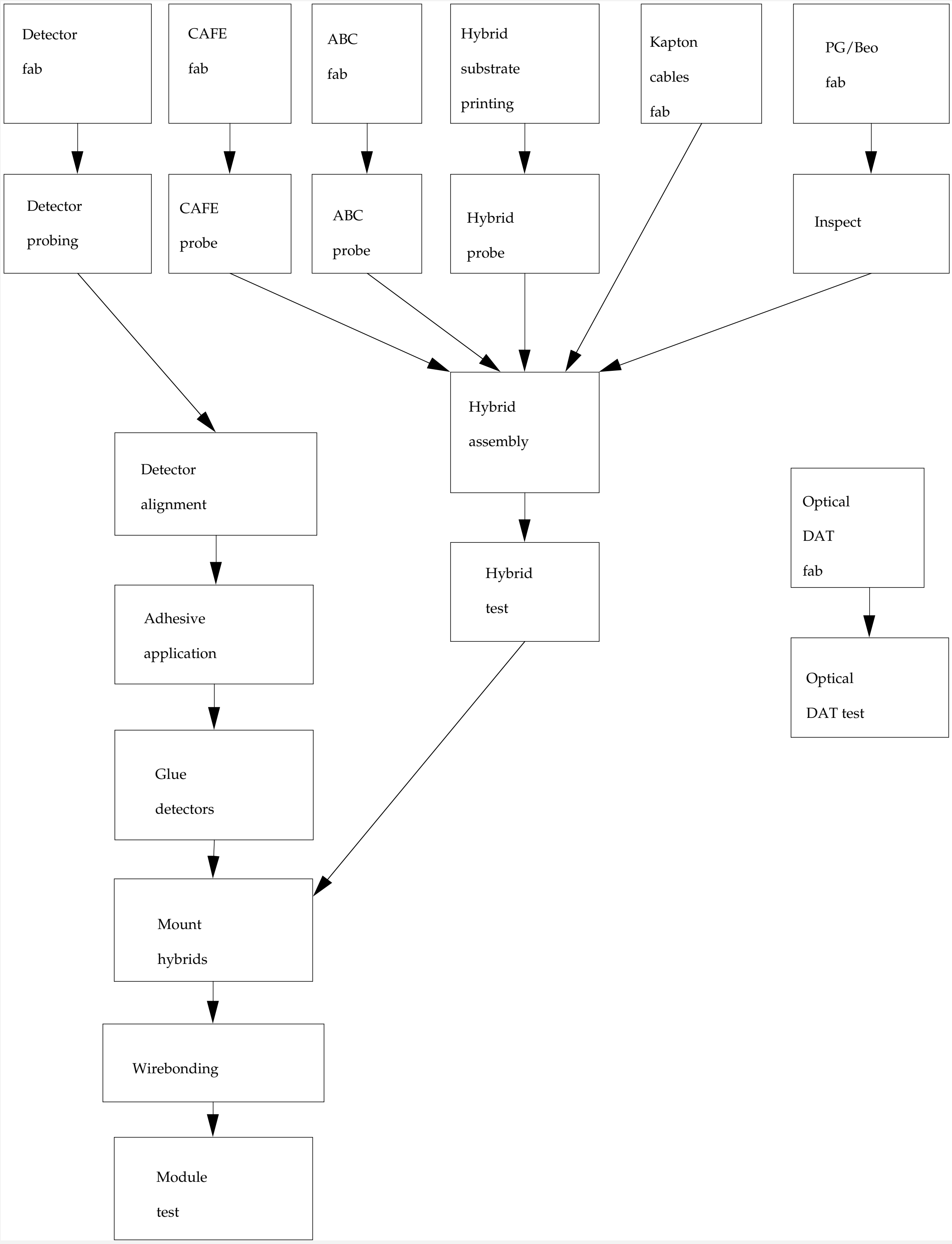


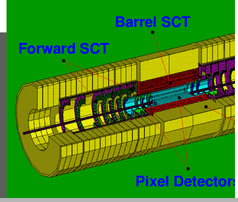




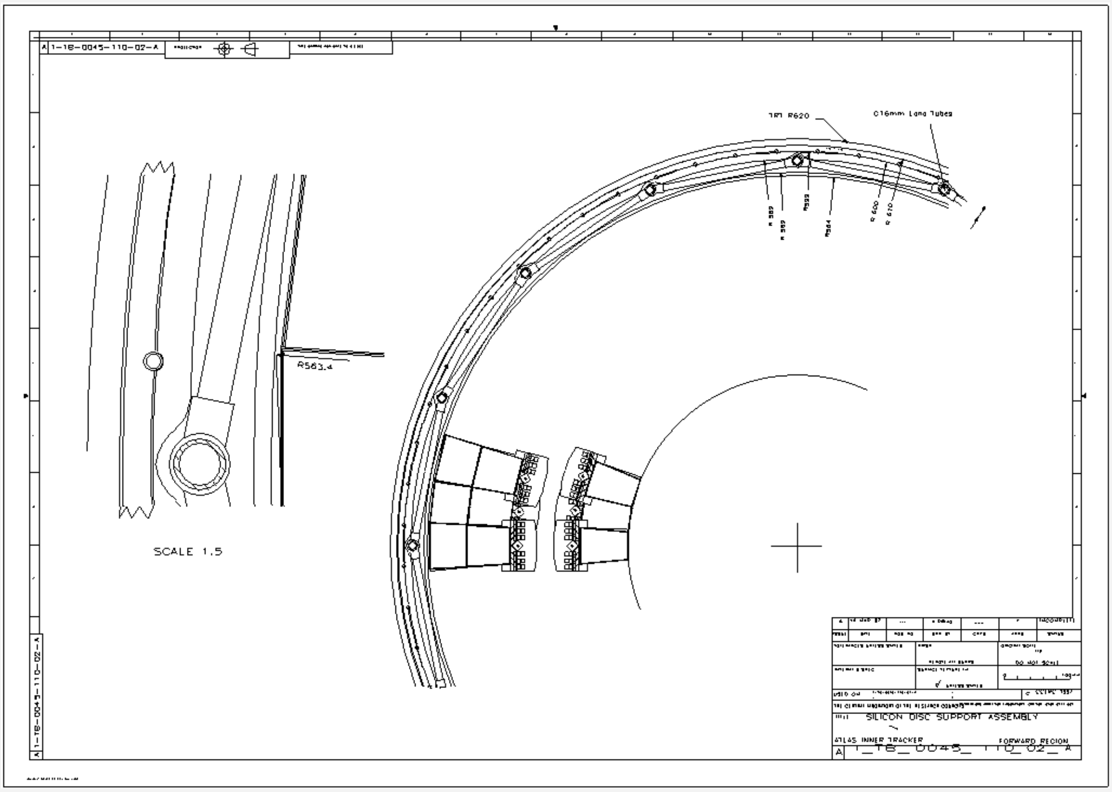

Barrel SCT
Forward SCT
Pixel Detector

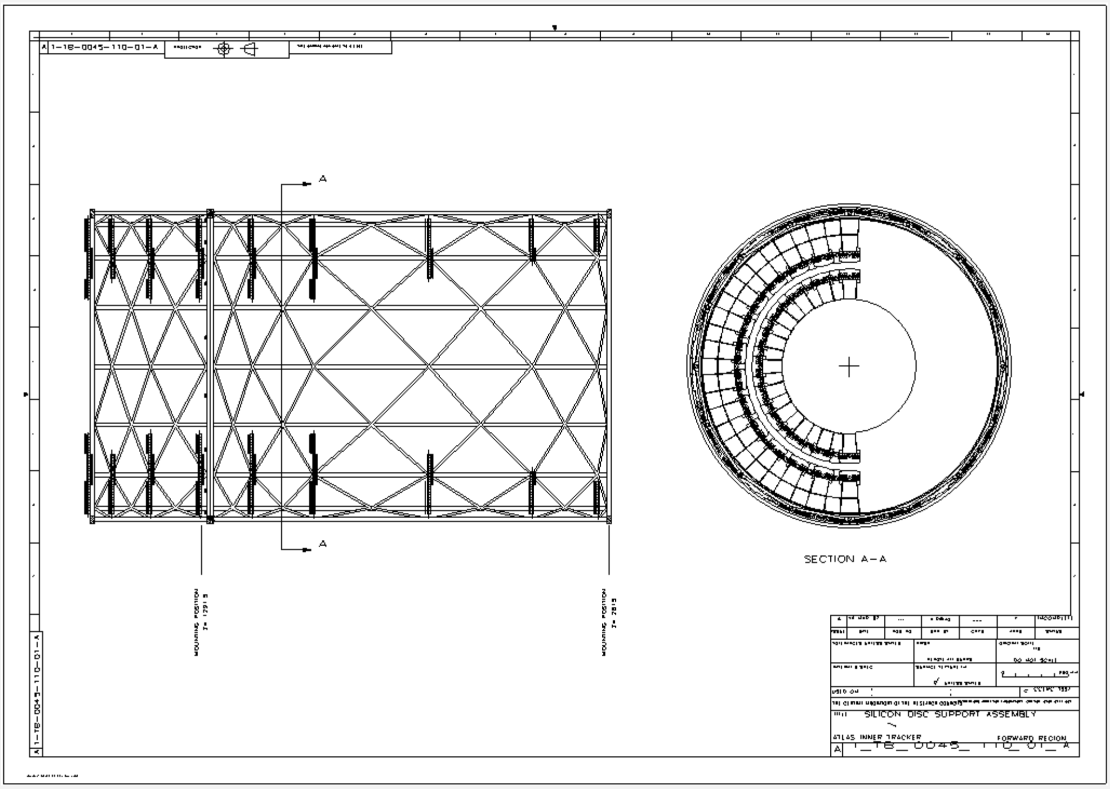
Assembly


Detector fab
CAFE fab
ABC fab
Hybrid substrate printing
Kapton cables fab
PG/Beo fab
Detector probing
CAFE probe
ABC probe
Hybrid probe
Inspect
Hybrid assembly
Detector alignment
Optical DAT fab
Hybrid test
Adhesive application
Optical DAT test
Glue detectors
Mount hybrids
Wirebonding
Module test

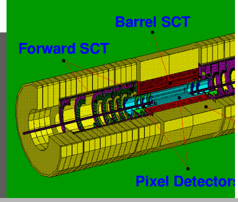

Barrel SCT
Forward SCT
Pixel Detectors

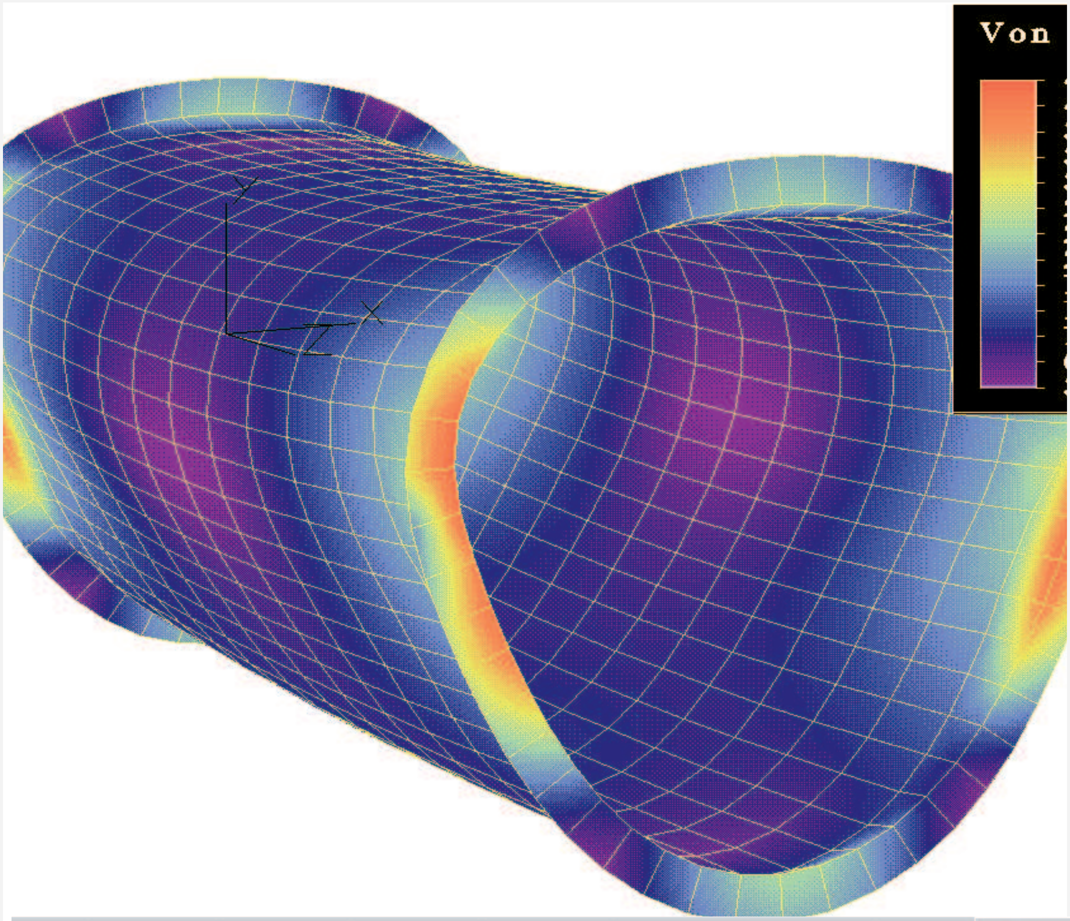
Forward

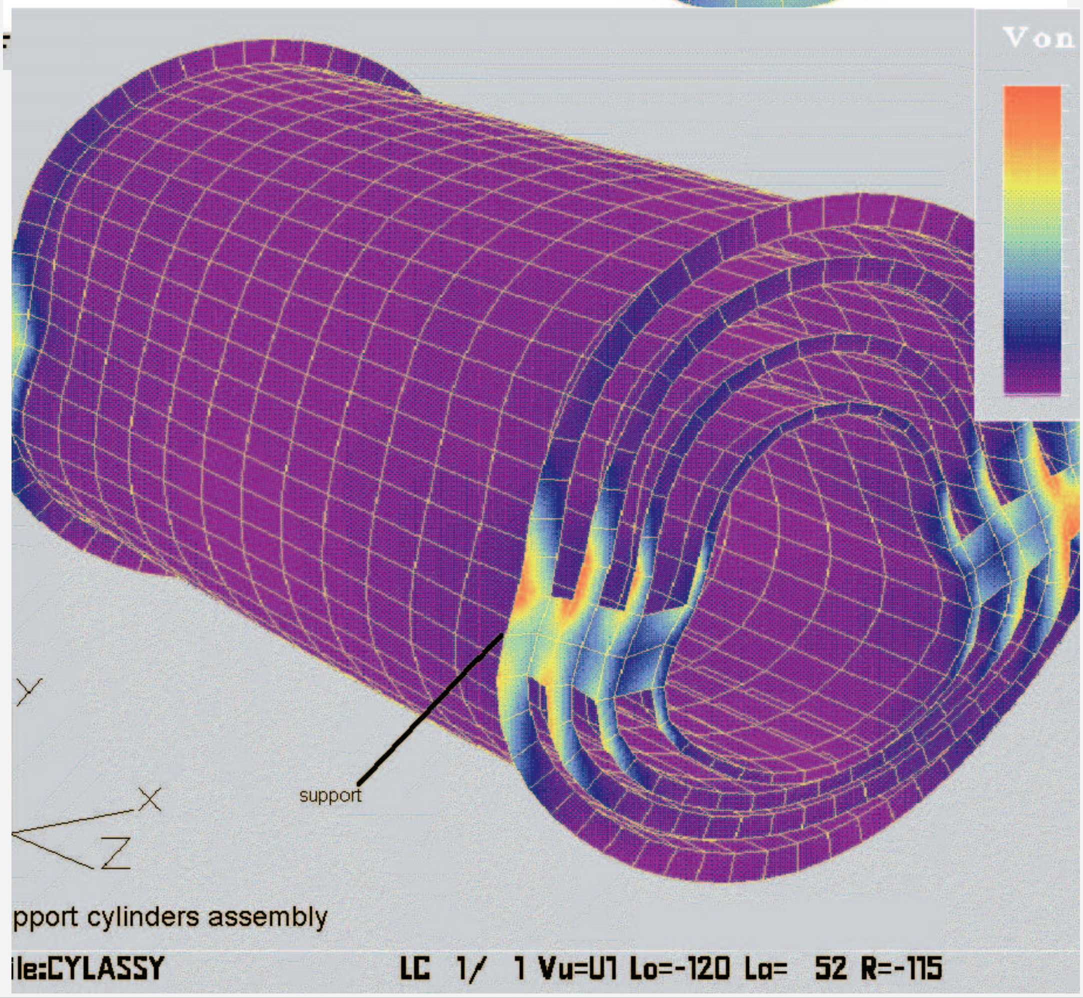

R563.4
SCALE 1.5
SILICON DISC SUPPORT ASSEMBLY
ATLAS INNER TRACKER
FORWARD REGION

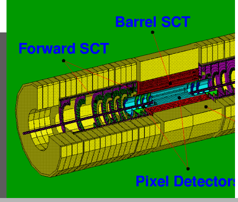

A
A
SECTION A-A
SILICON DISC SUPPORT ASSEMBLY
ATLAS INNER TRACKER
FORWARD REGION

ATLAS INNER DETECTOR



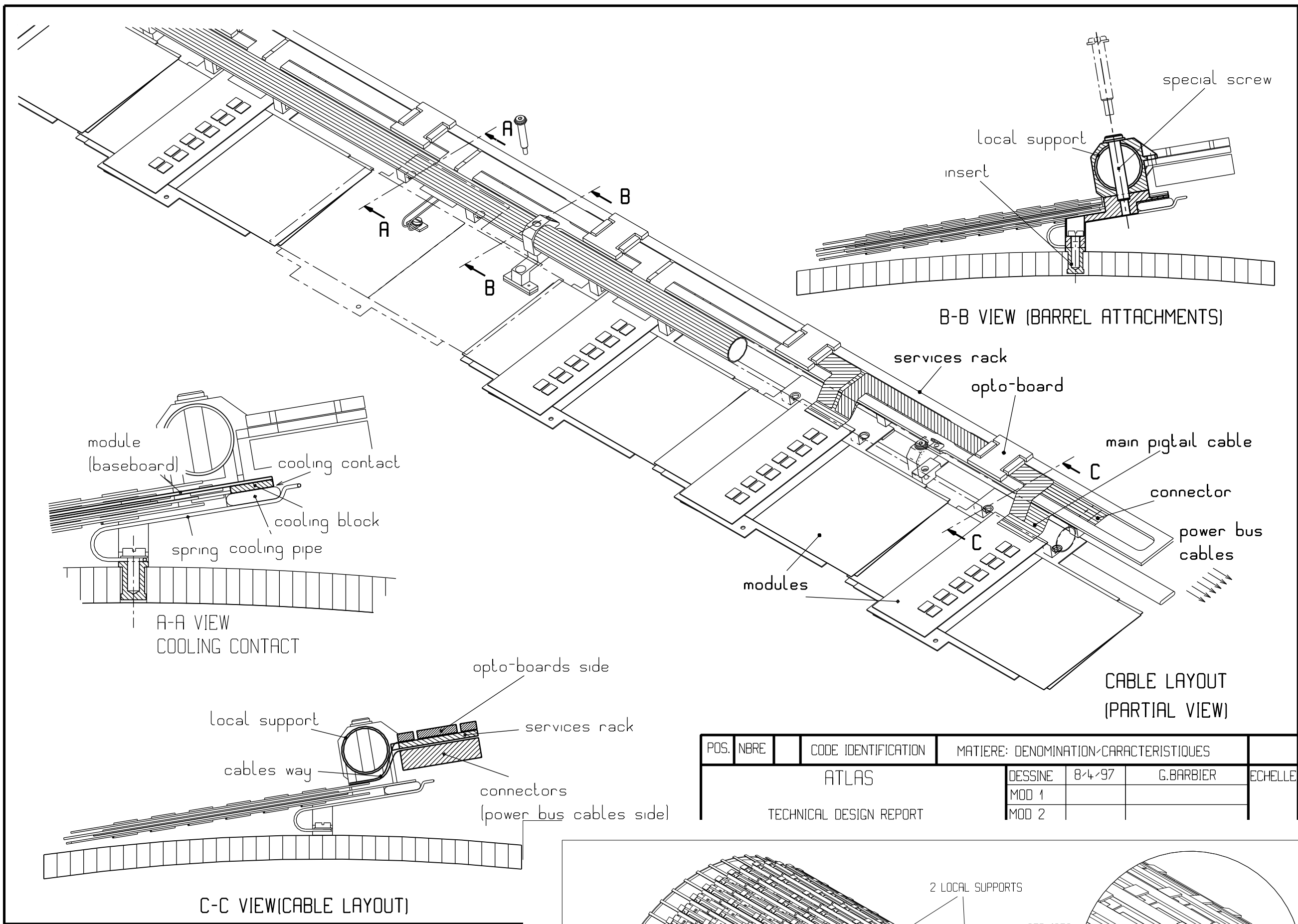


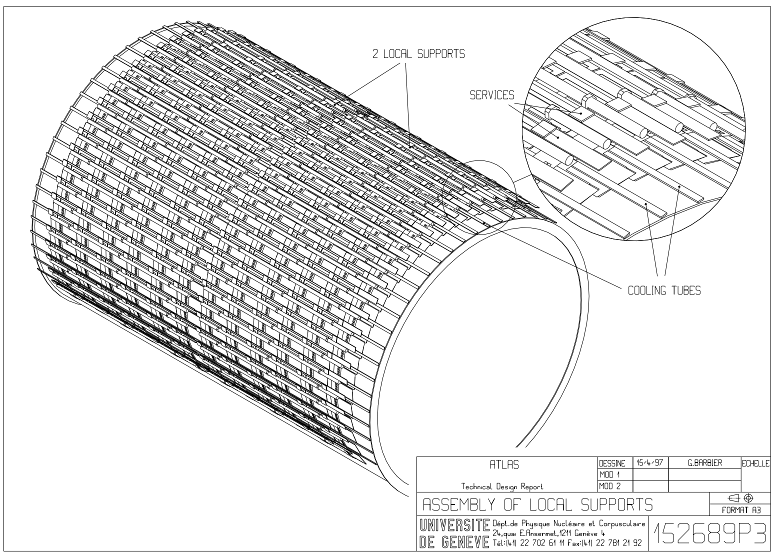


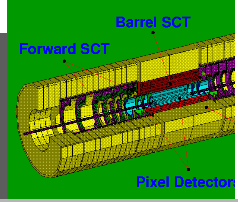


Support Structures

Barrel





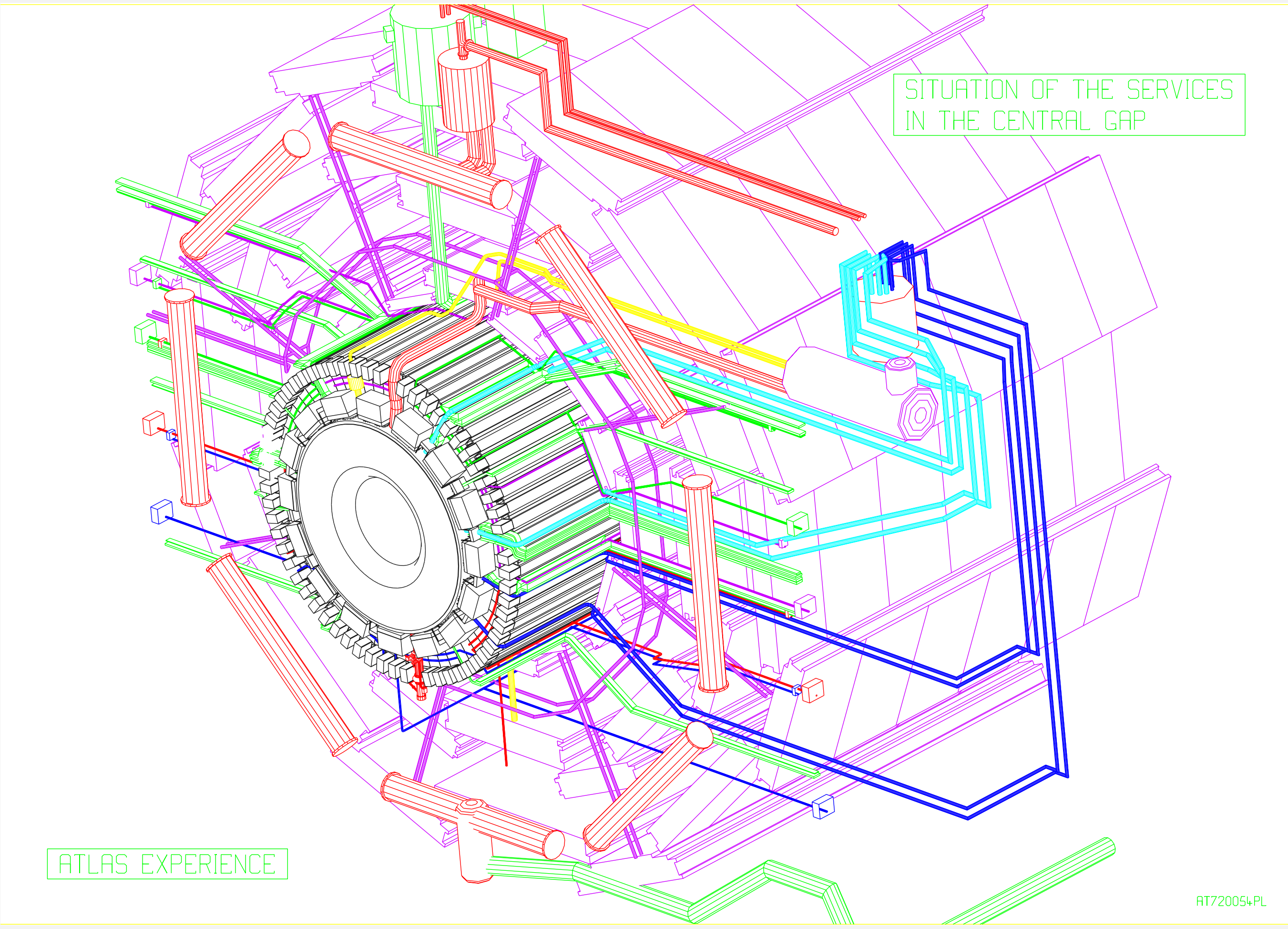


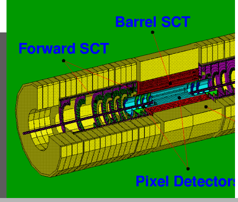
Cooling System

100kW of cooling (including pixels and both and outside detector)

Binary Ice

- almost isothermal
- high heat capacity
- method used in industry



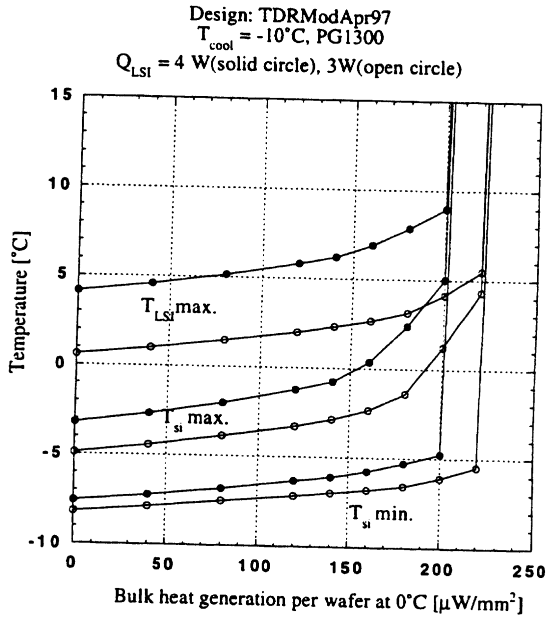


Module Thermal Performance

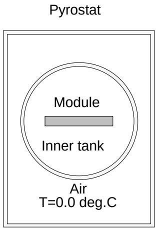
Essential to

Avoid ‘Thermal runaway’

Operate silicon at low temperature

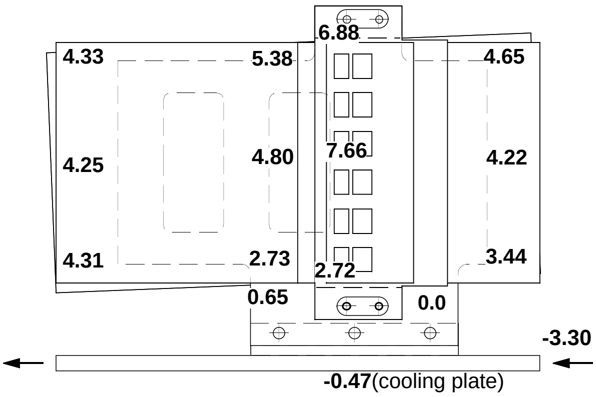


Temprature profile of thermal modules
in 1atm. and a vacuum



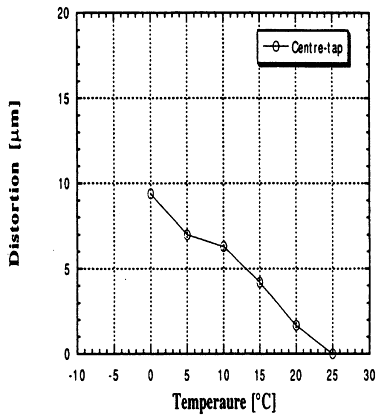
The test setup

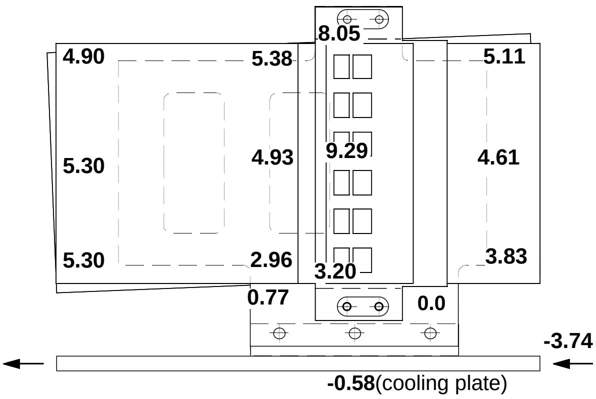
PG700 baseboard	Water flow=300 cc/min.
1 pipe cooling	Coolant temp.=0 deg.C
Ambient temp.=0 deg.C	Si=1 W
Ambient =Air	IC=3 W



Centre-tap module
Pressure=1 atm.

Si Tmax=5.38 deg.C
Si DeltaT=2.65
Hybrid Tmax=7.66
Hybrid DeltaT=4.94
Coolant T=-3.3

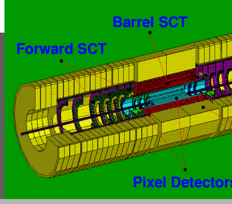




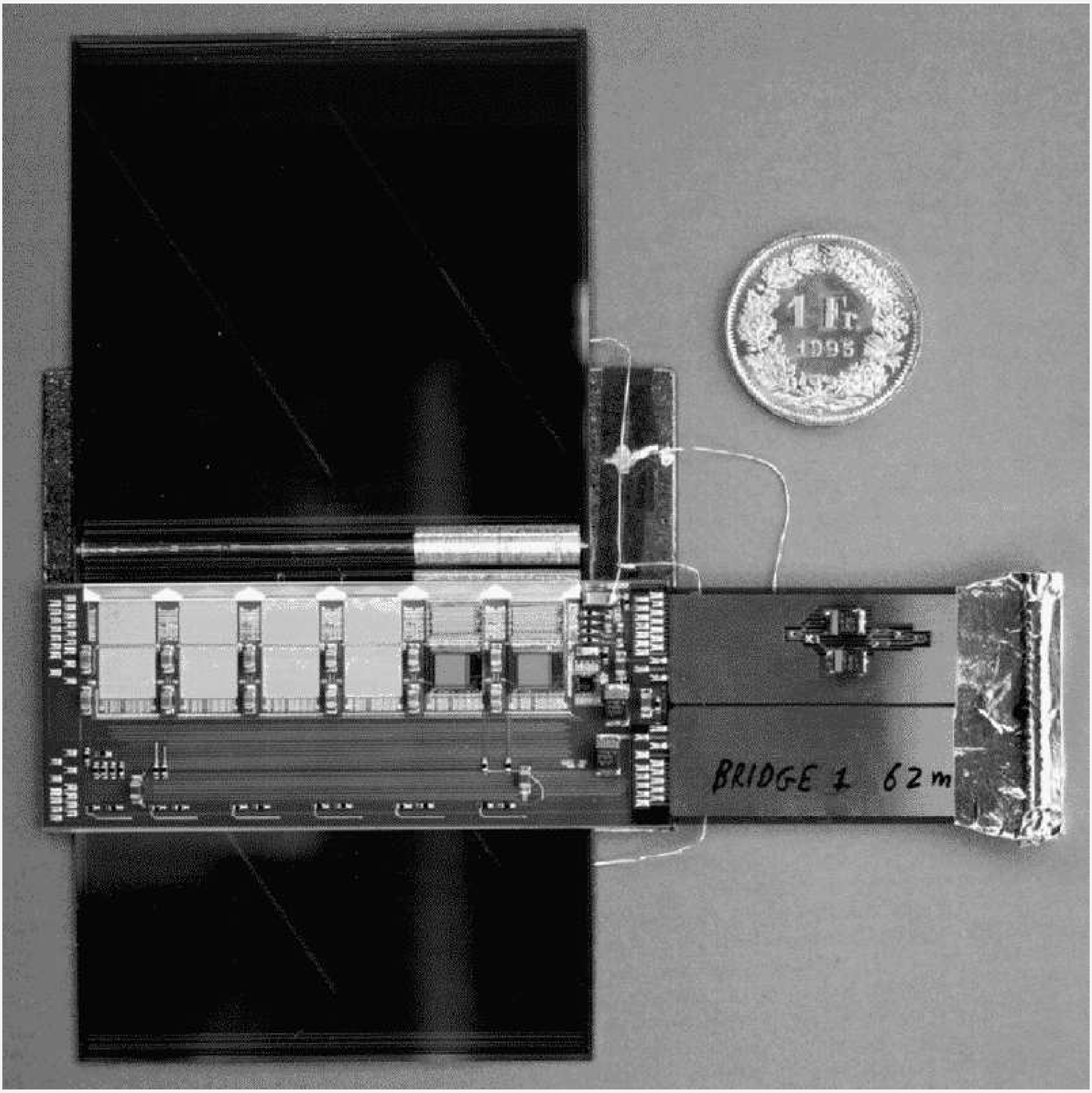
Centre-tap module
Pressure=Vacuum(8 Pa.)

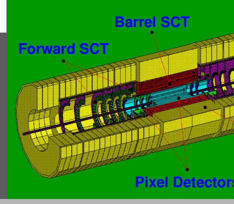
Si Tmax=5.88 deg.C
Si DeltaT=2.92
Hybrid Tmax=9.29
Hybrid DeltaT=6.07
Coolant T=-3.69

December 14,1996
KEK T Kohriki

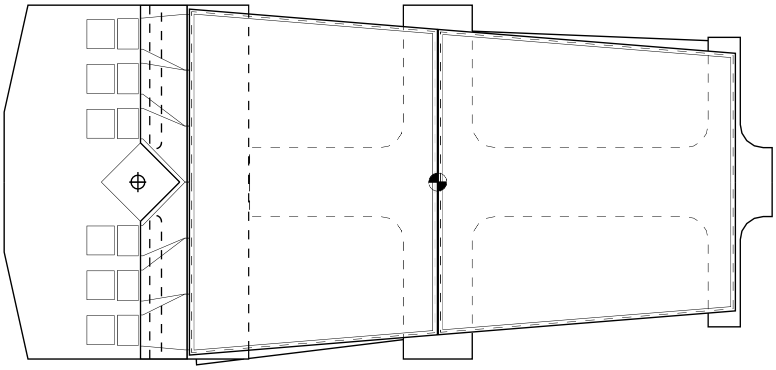


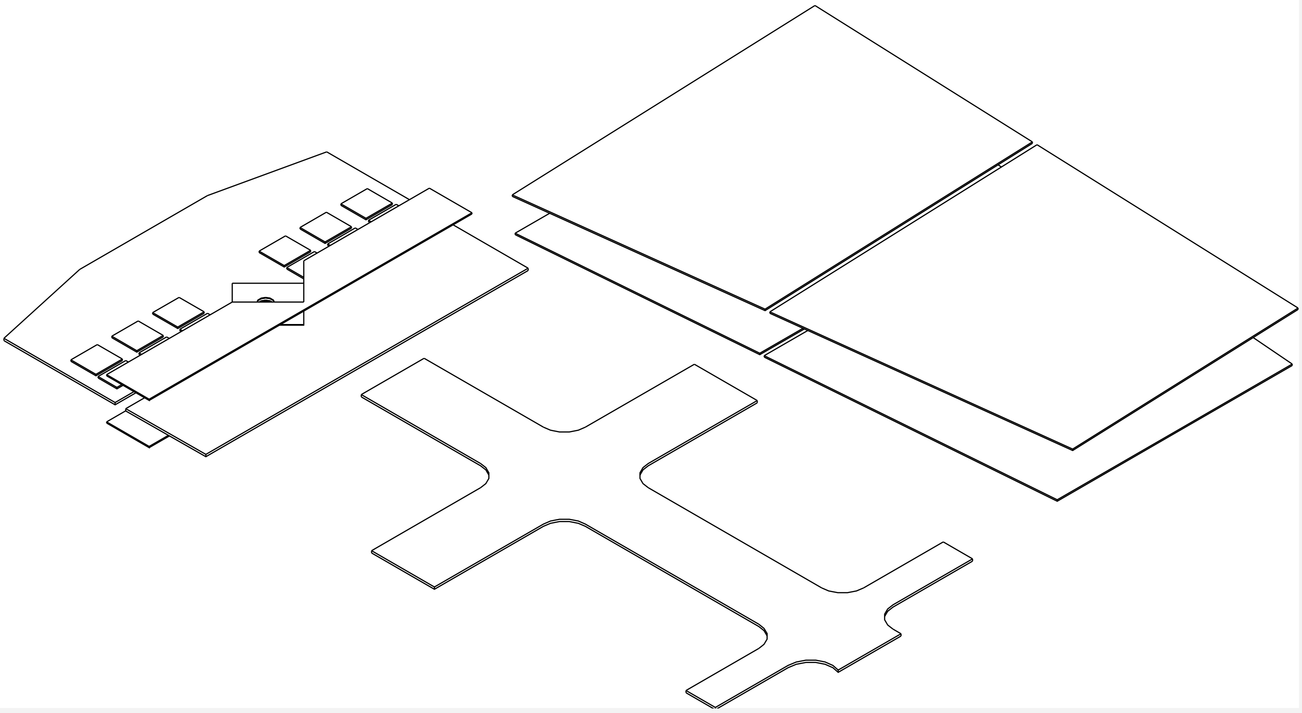
Barrel Beam Test Prototype

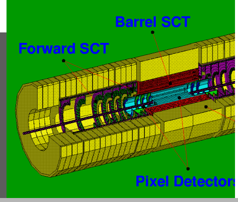




Forward Modules

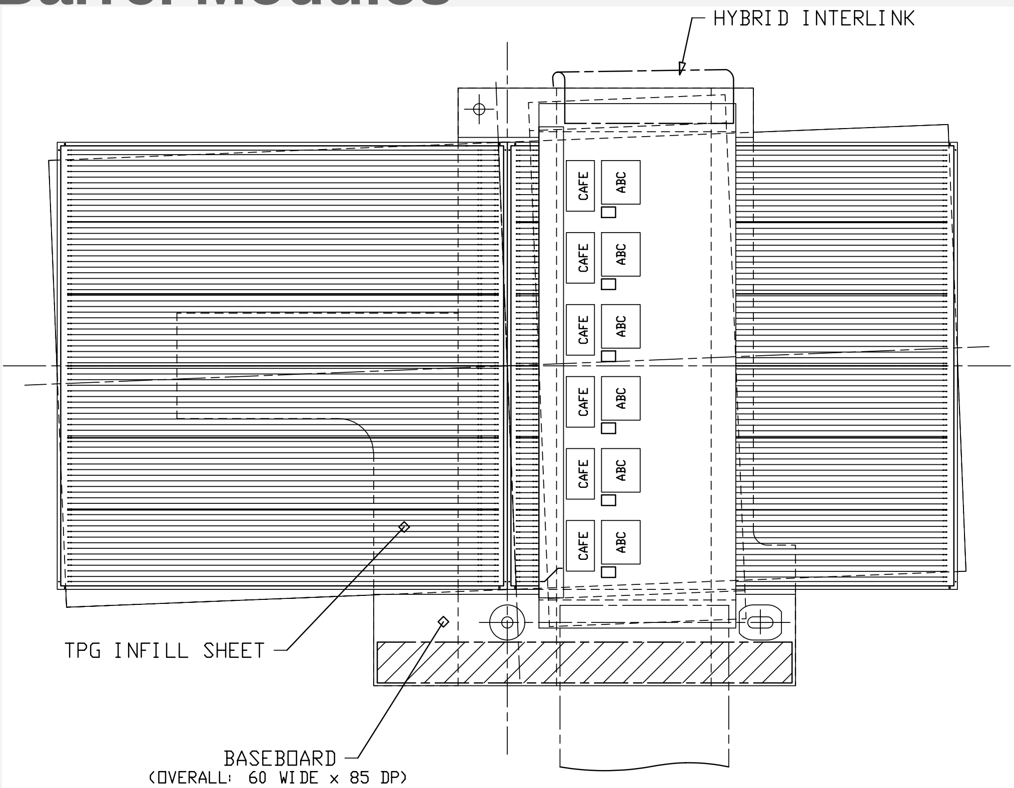


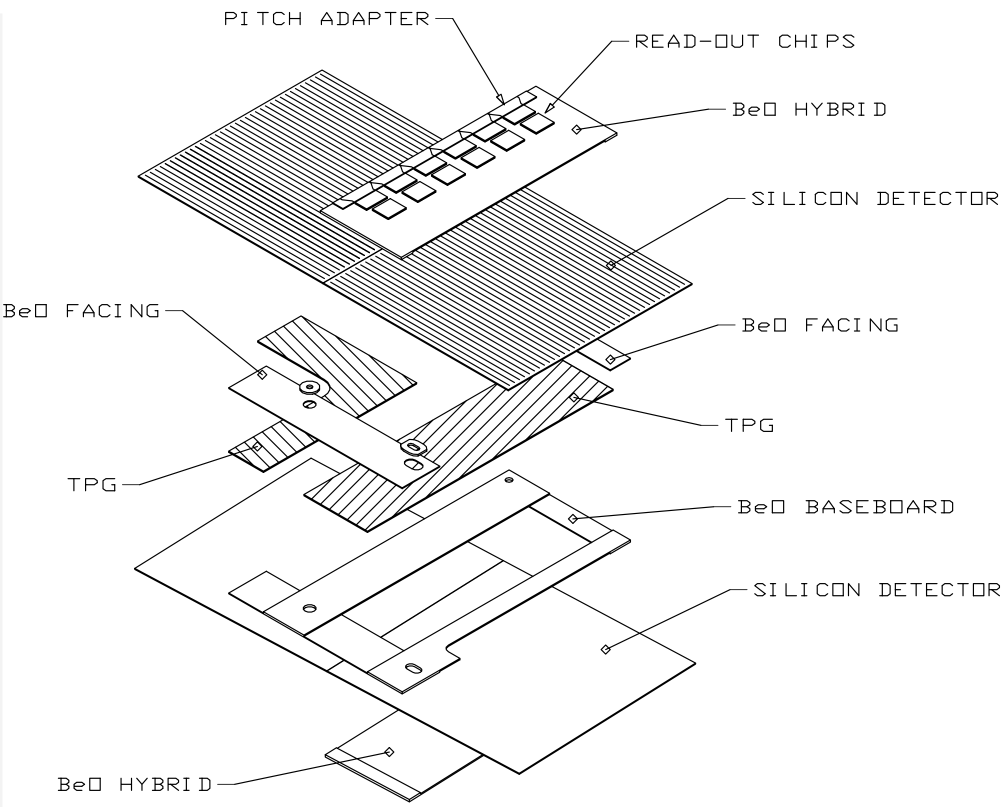




Modules

Barrel Modules





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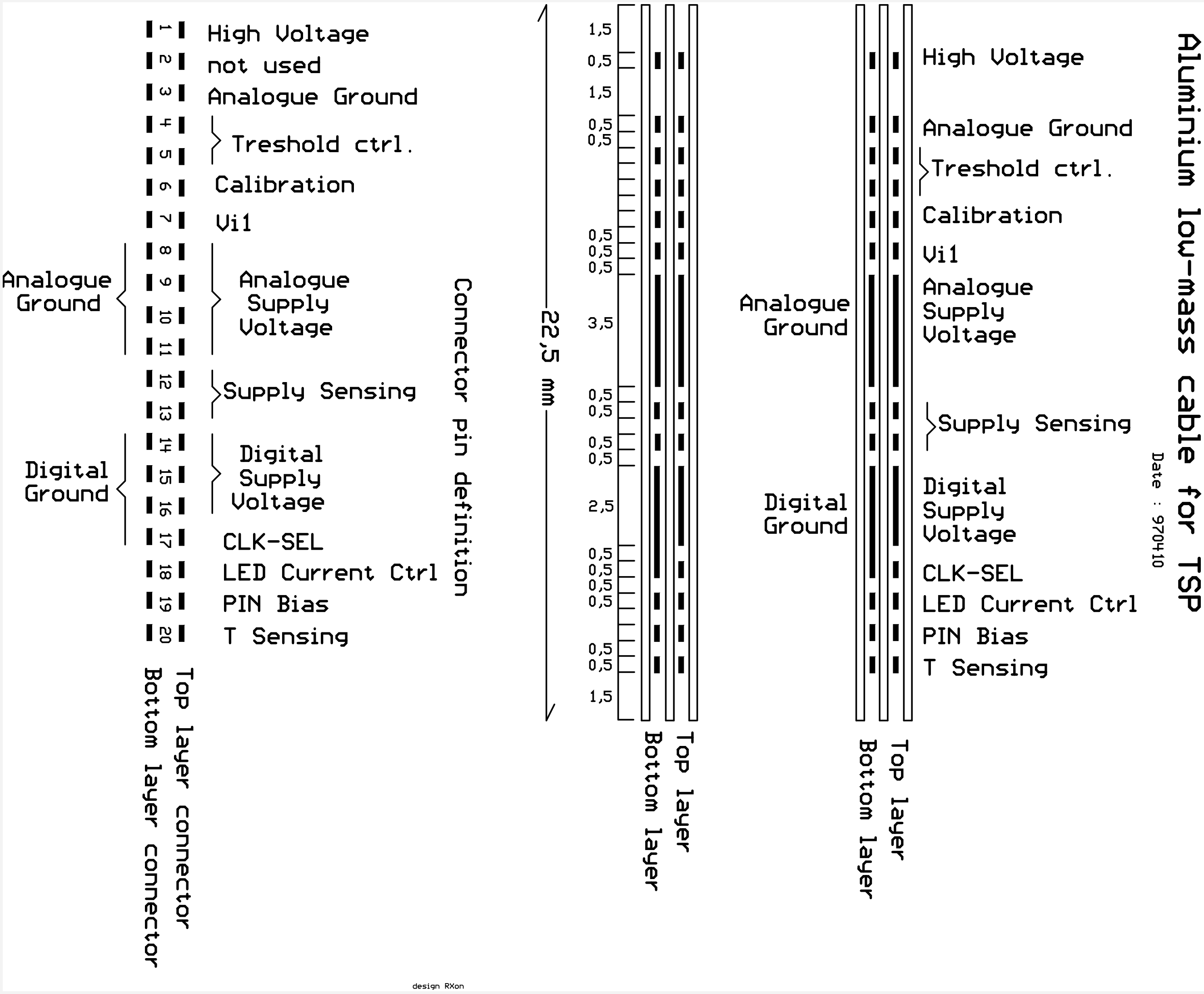
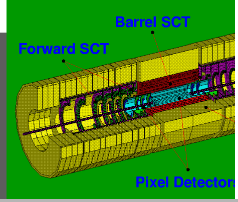
Aluminium Power Tapes

One flat cable includes

- All power, including detector bias
- DC electrical control signals
- DC lines for monitoring temperature

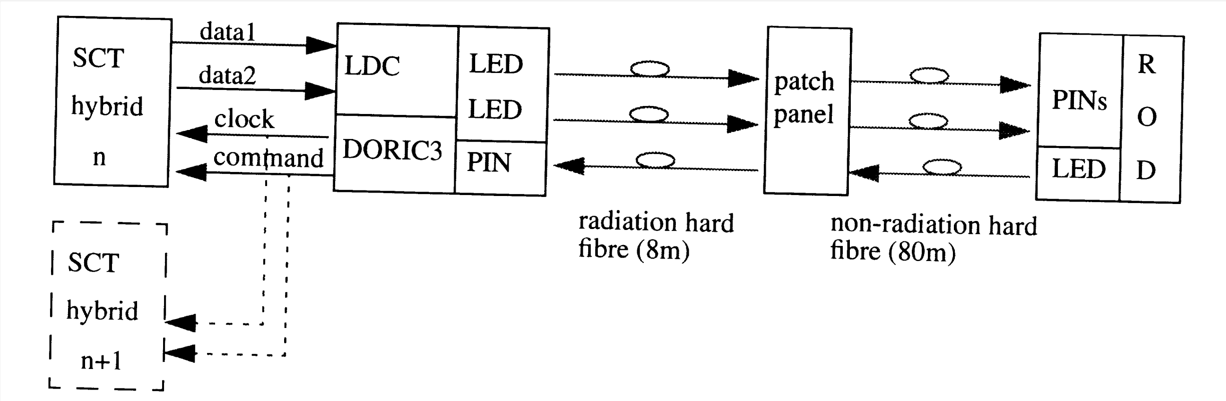
They do not include cooling safety system or environmental temperature, pressure, humidity monitors

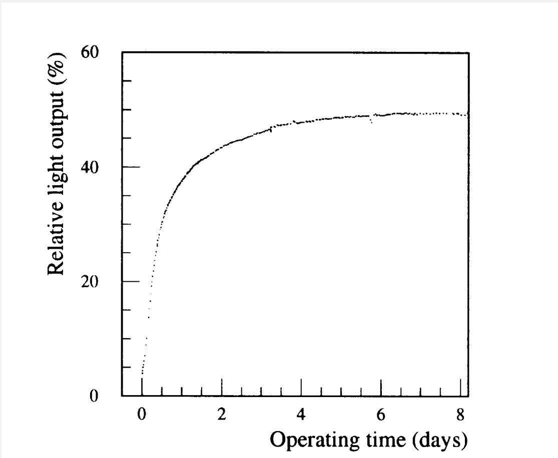




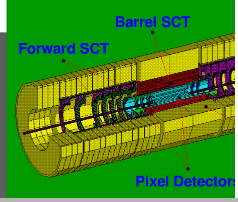
Optical Data Transmission

LED/PINs at 820nm with multi-mode fibre

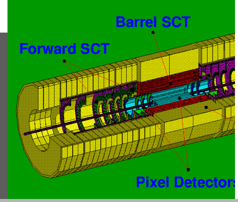




LED Type	Part.	Fluences (10^{14}/cm^2)	Irrad. LEDs	DC operating time at ±10˚C / 50˚C (days)	Corresponding time in the SCT (years)
ABB pigtailed	n	1.4 ± 20%	5	162 / 158	57
ABB pigtailed	n	1.4 ± 20%	5	272 / 0	9
ABB unpackaged	n	3.2 / 5.3	39	1..35 / 123..126	~41
ABB unpackaged	p	0.6 .. 2.2	52	6 .. 44 / 59 .. 126	20 .. 43
GEC unpackaged	n	4.4	12	15 .. 18 / 39	~13
GEC unpackaged	p	1.2 .. 2.5	31	18 .. 40 / 39 .. 106	13 .. 36



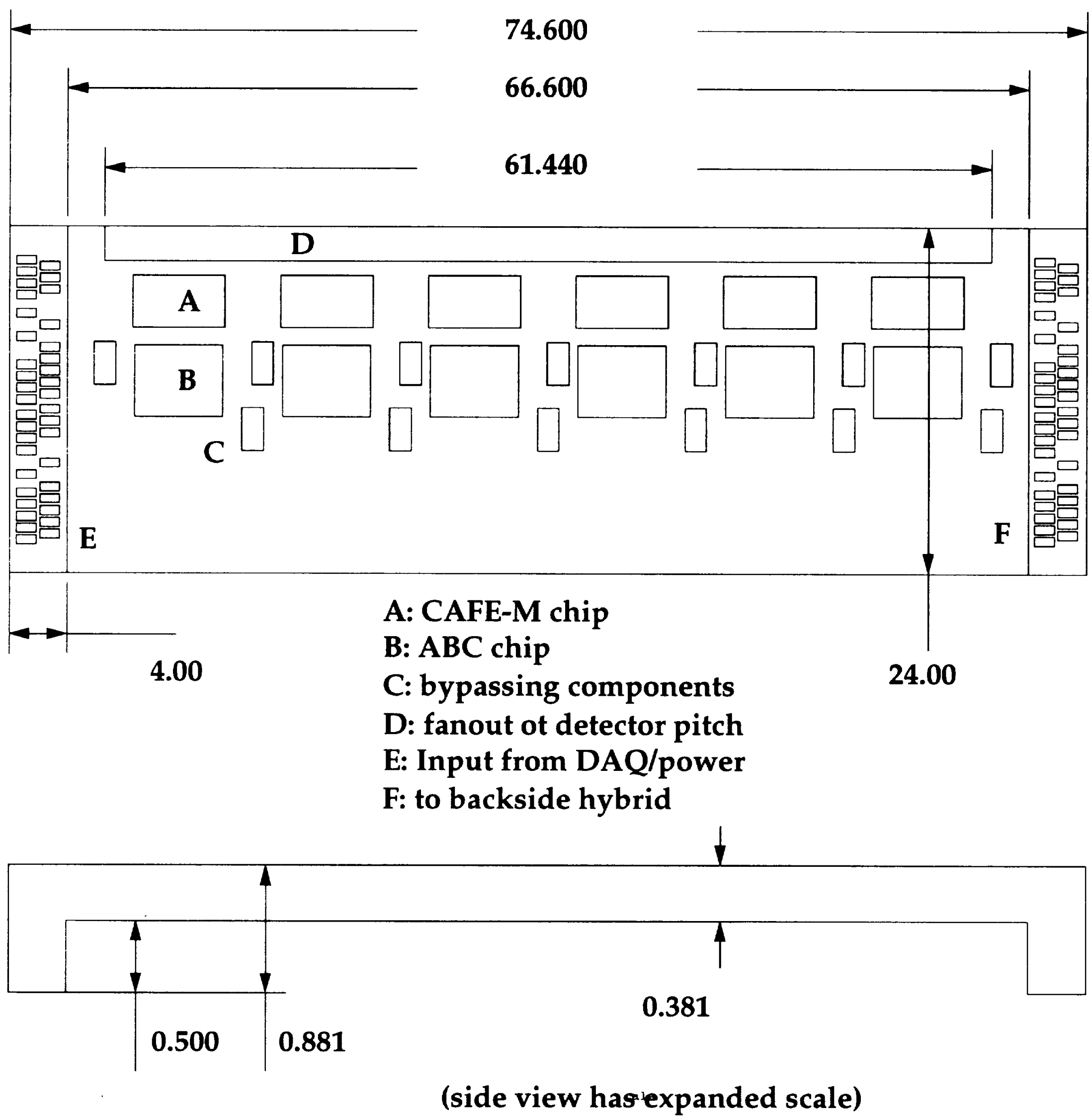
Transparnecy to be added with radiation damamge to chips studies



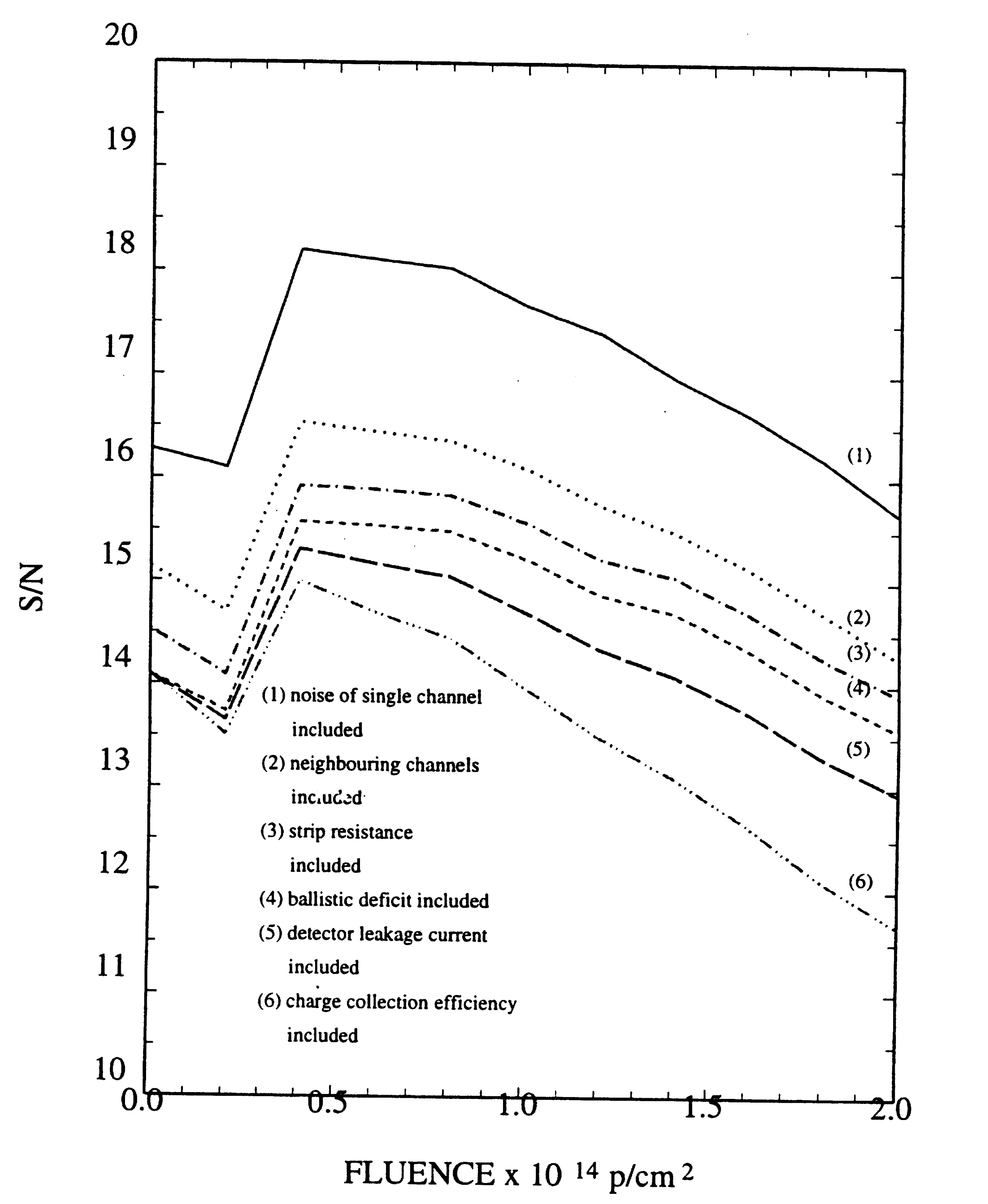
Hybrids

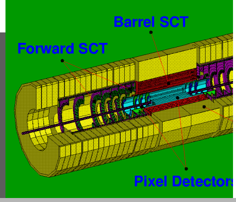
BeO thick-film Hybrids

- 380µm thick BeO
- 8µm gold traces (200µm wide on 400µm pitch min)
- five layers, two interconnect and three power/ground
- token passing architecture, with bypass routes



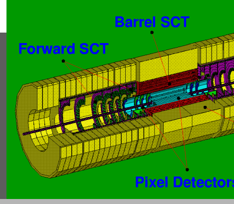
Contributions to S/N ratio





Electronics Specifications

Parameter	Specification
Noise	< 1500 e^-
Efficiency	99%
Occupancy due to noise	$<5\text{x}10^{-4}$
B.C. tag resolution	1 bunch crossing
Occupancy due to real hits captured in extra bunch crossing slots	1% of real hit occupancy
Double pulse resolution	50 ns for 3.5 fC signal following 3.5 fC signal
Large charge recovery time	1 µs for 3.5 fC signal following 80 fC signal
Minimum L1 trigger spacing	2 bunch crossing
Pipeline length	128 location
Functionality temperature range	-15 °C to 30 °C
Power dissipation	< 3.8 mW/channel
Radiation total dose	2x1014 n/cm2 10 Mrad



SCT Electronics Architecture

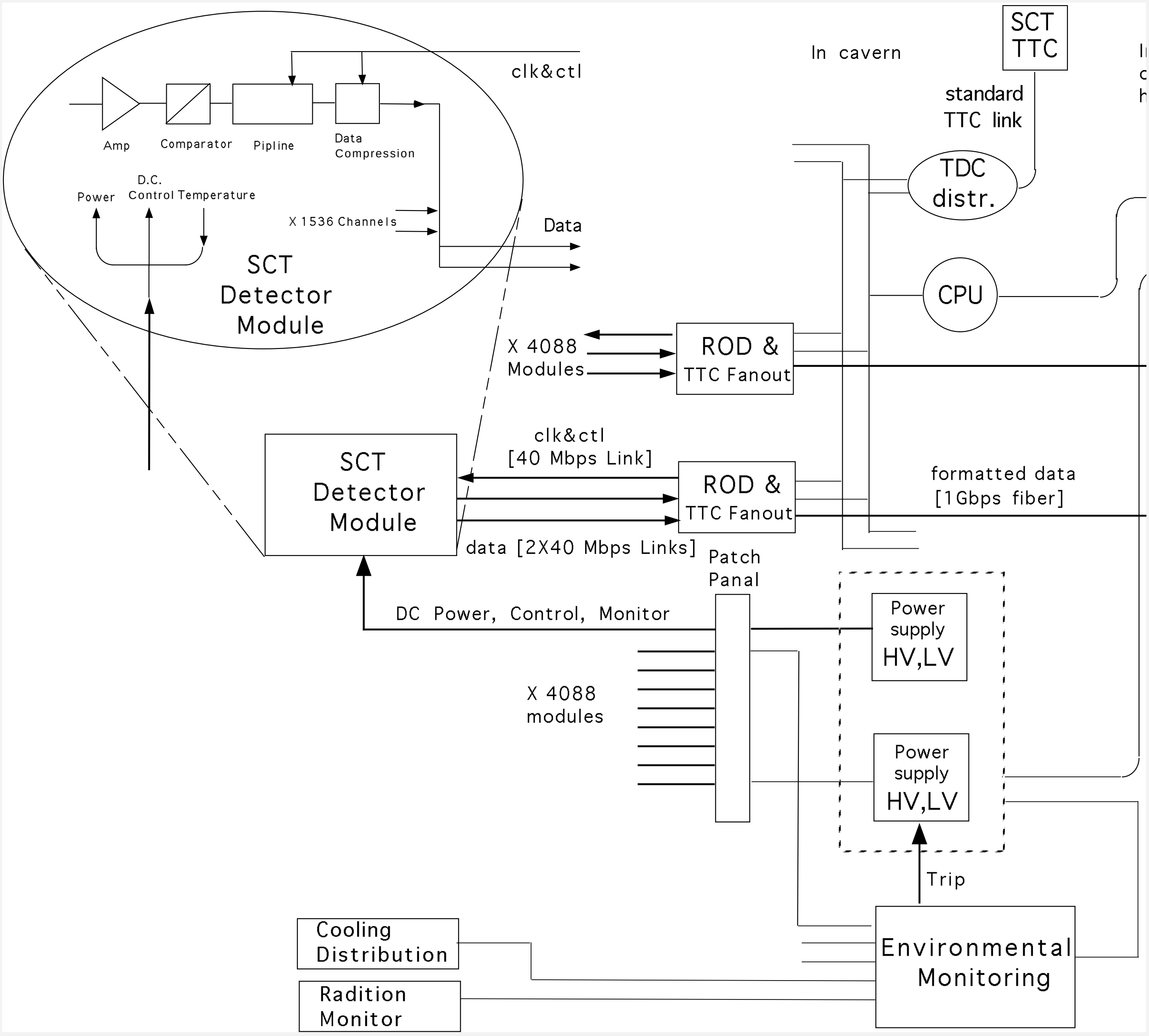
binary front-end

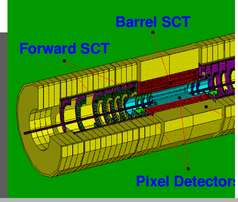
optical data transmission and clock/control

off-detector ROD and ROB

redundant data paths and f/e chip bypassing

deadtimeless and pipelined

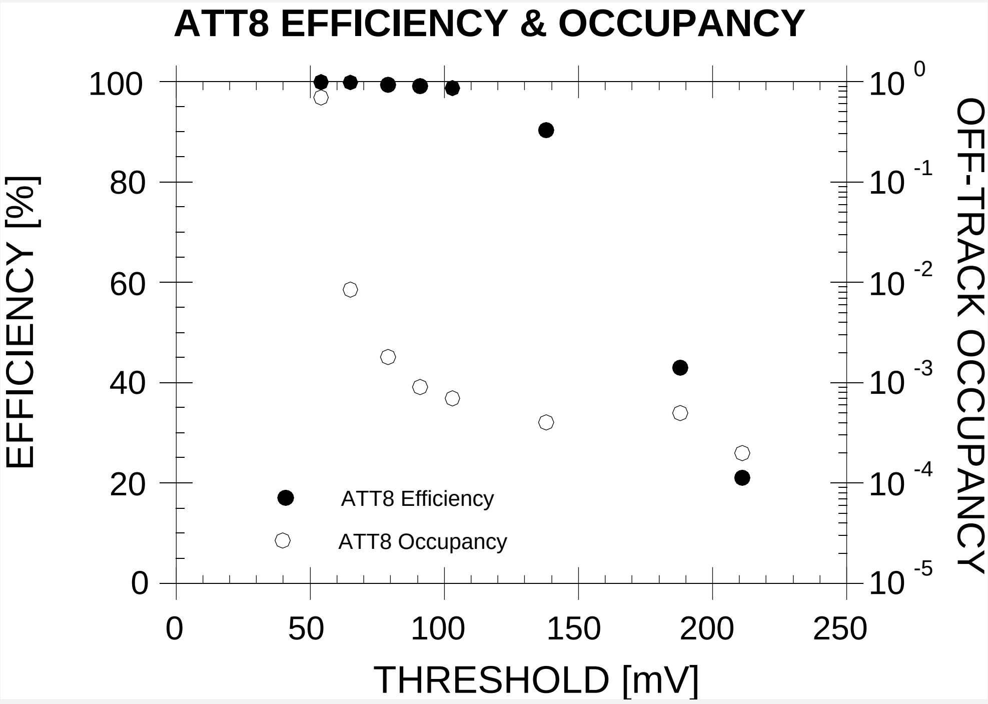


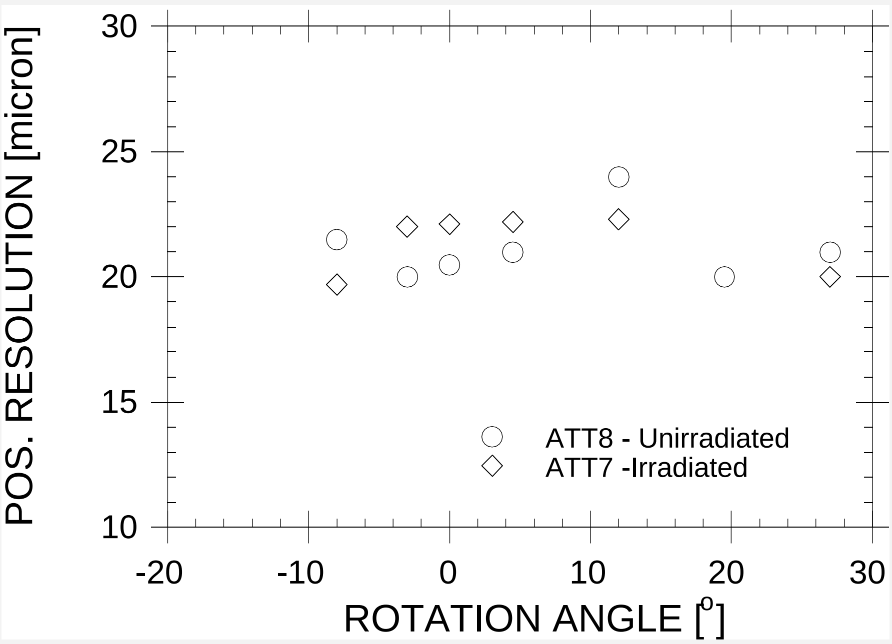


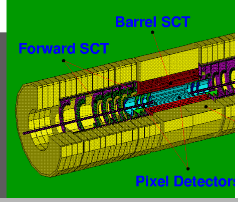
Irradiated Detector Prototypes

Irradiated to 1 x 10^{14} p/cm^2

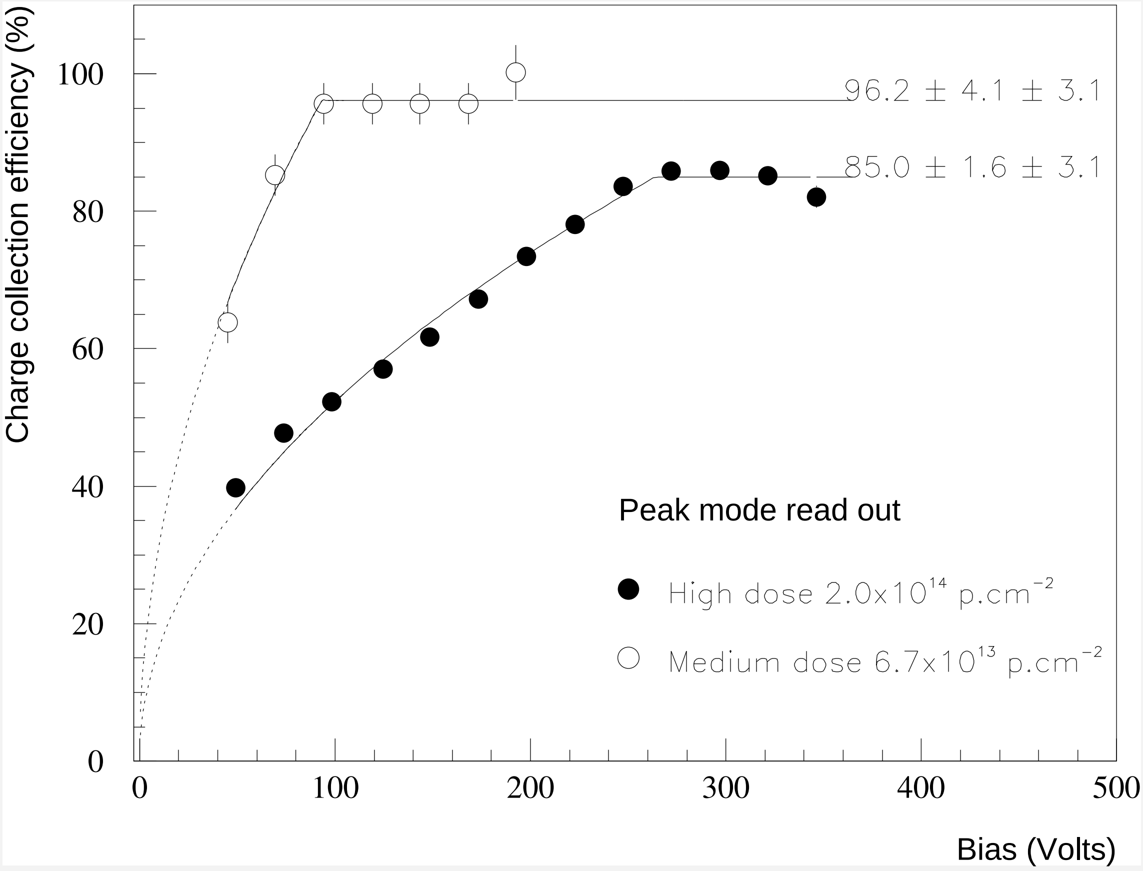
Position resolution 22 µm, not strongly angle dependant



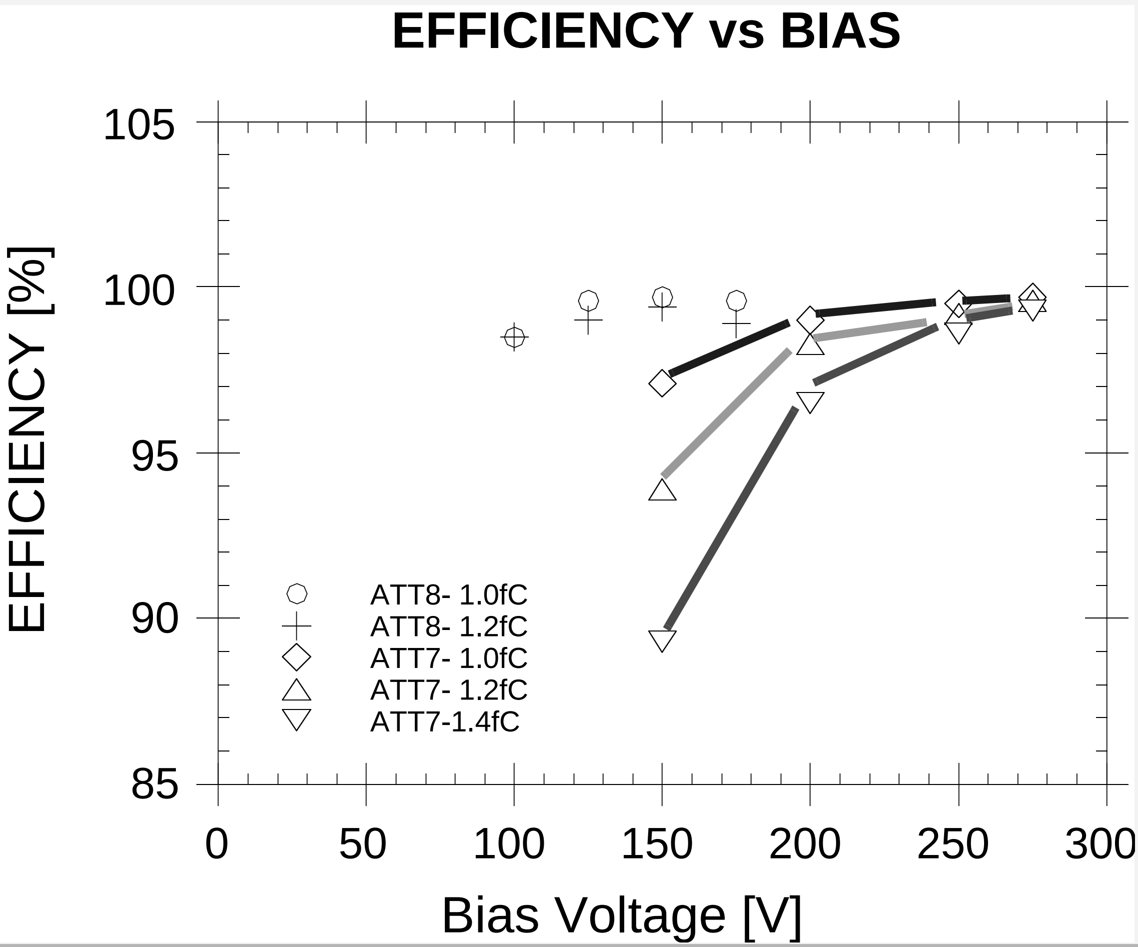




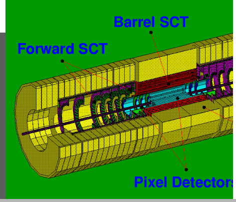
Barrel SCT
Forward SCT
Pixel Detector



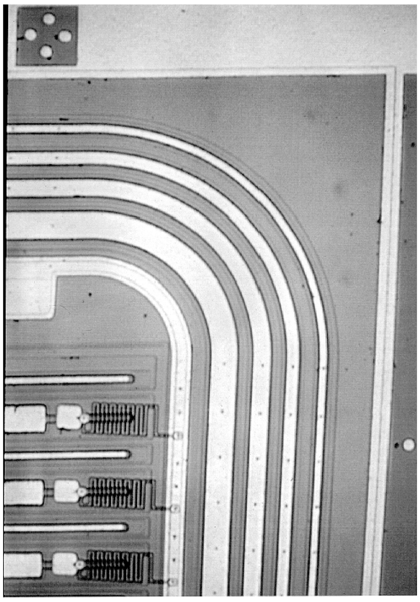
Charge collection efficiency (%)
96.2 ± 4.1 ± 3.1
85.0 ± 1.6 ± 3.1
Peak mode read out
High dose 2.0x10^14 p.cm^-2
Medium dose 6.7x10^13 p.cm^-2
Bias (Volts)



EFFICIENCY vs BIAS
EFFICIENCY [%]
ATT8- 1.0fC
ATT8- 1.2fC
ATT7- 1.0fC
ATT7- 1.2fC
ATT7-1.4fC
Bias Voltage [V]



Detectors



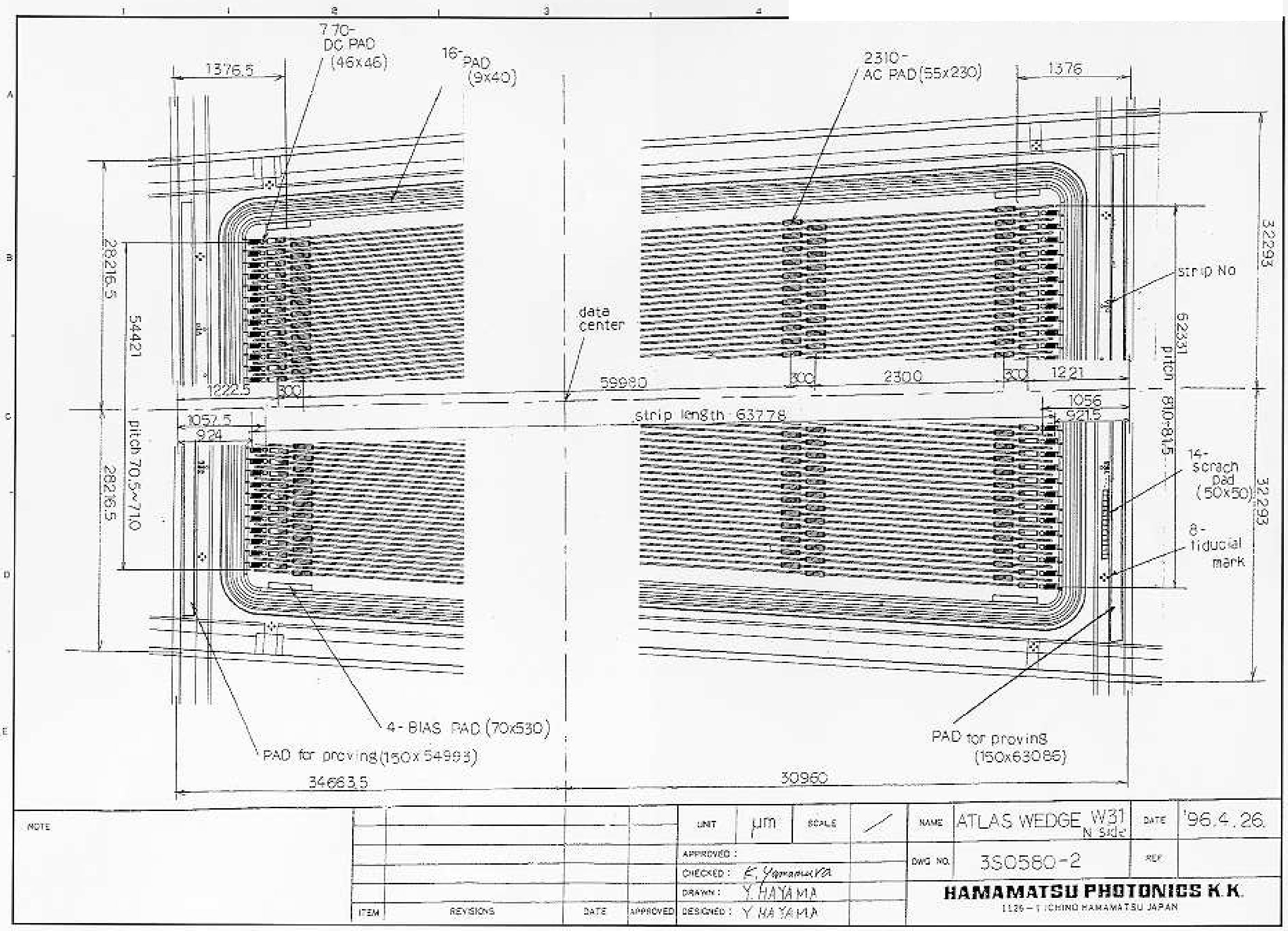
n+ implant on n substrate detectors

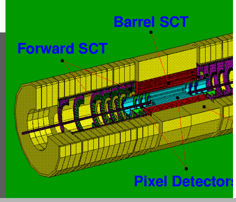
individual p-stop

ac coupling

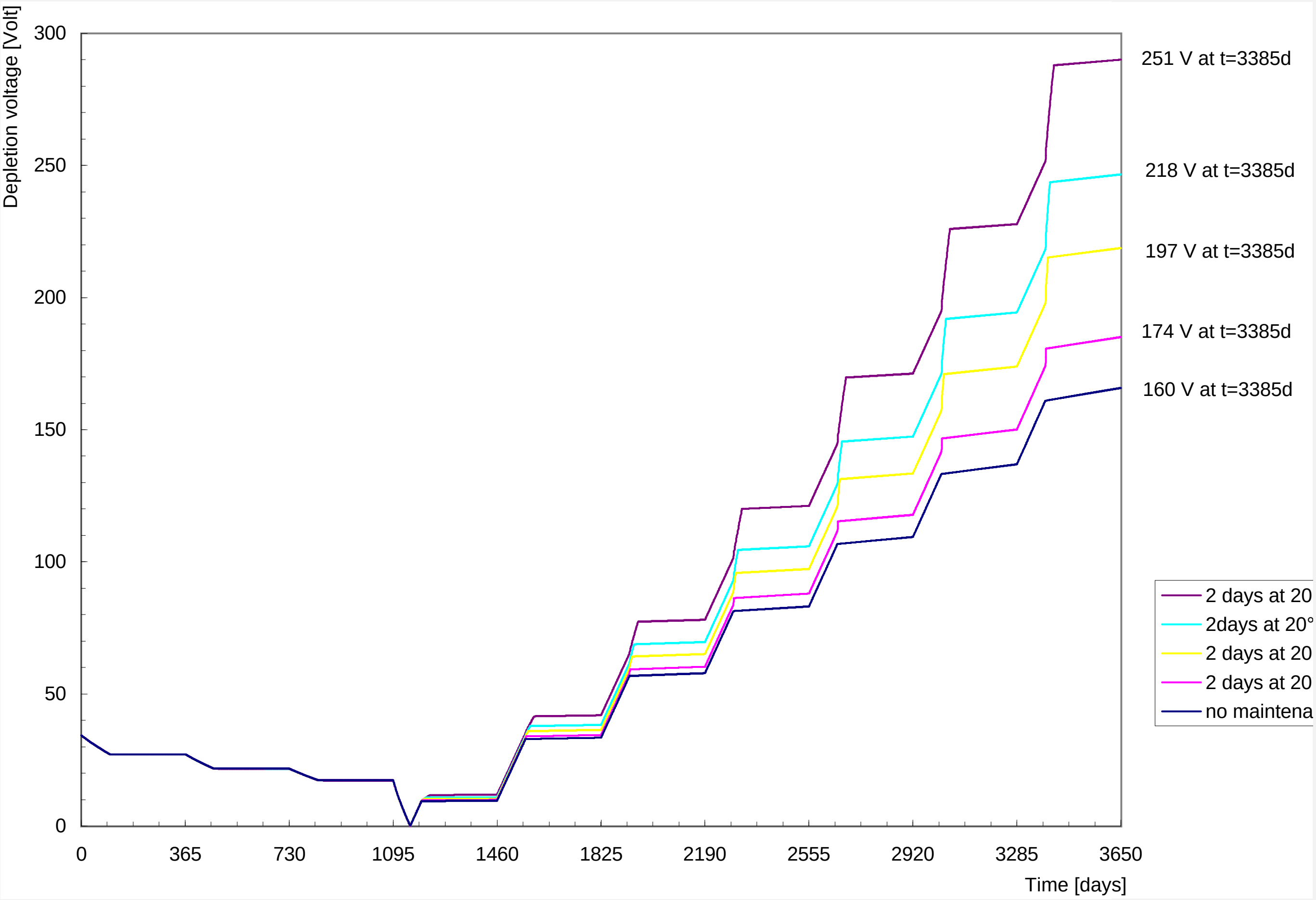
multiple guard rings or field plate

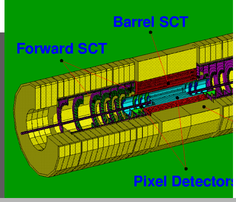
-ve, backside biased





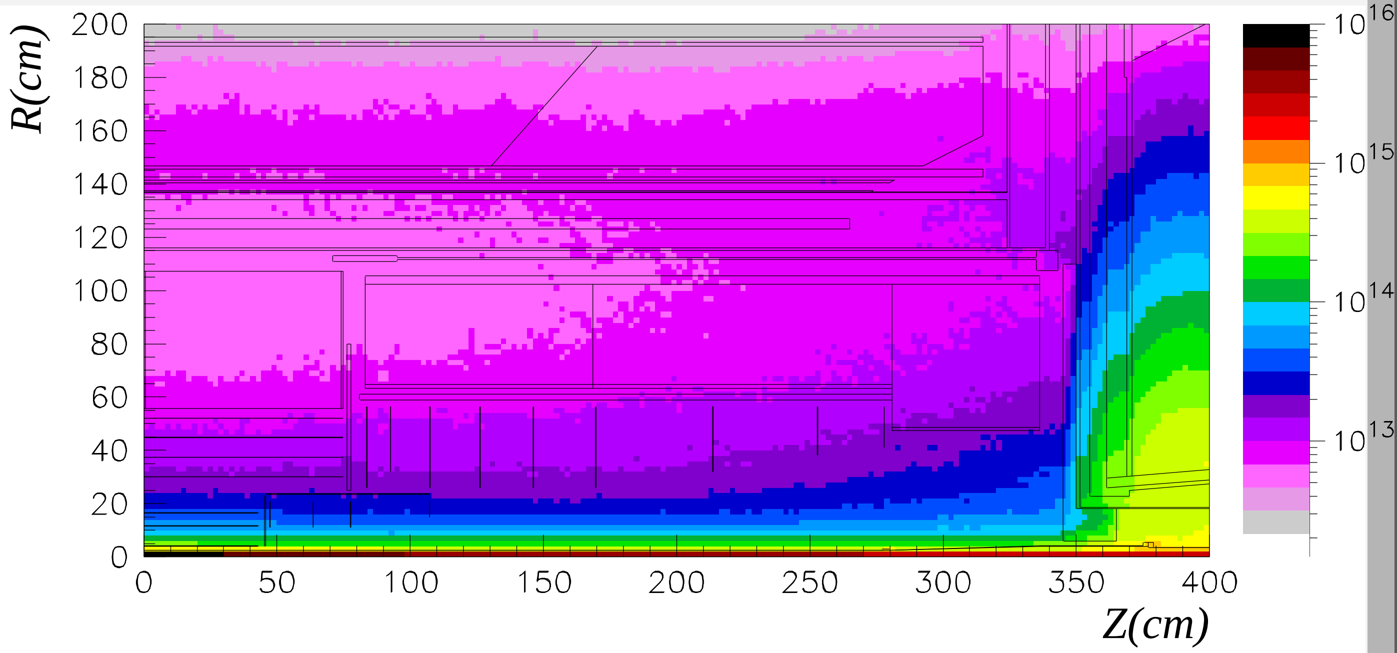
Voltage vs Time

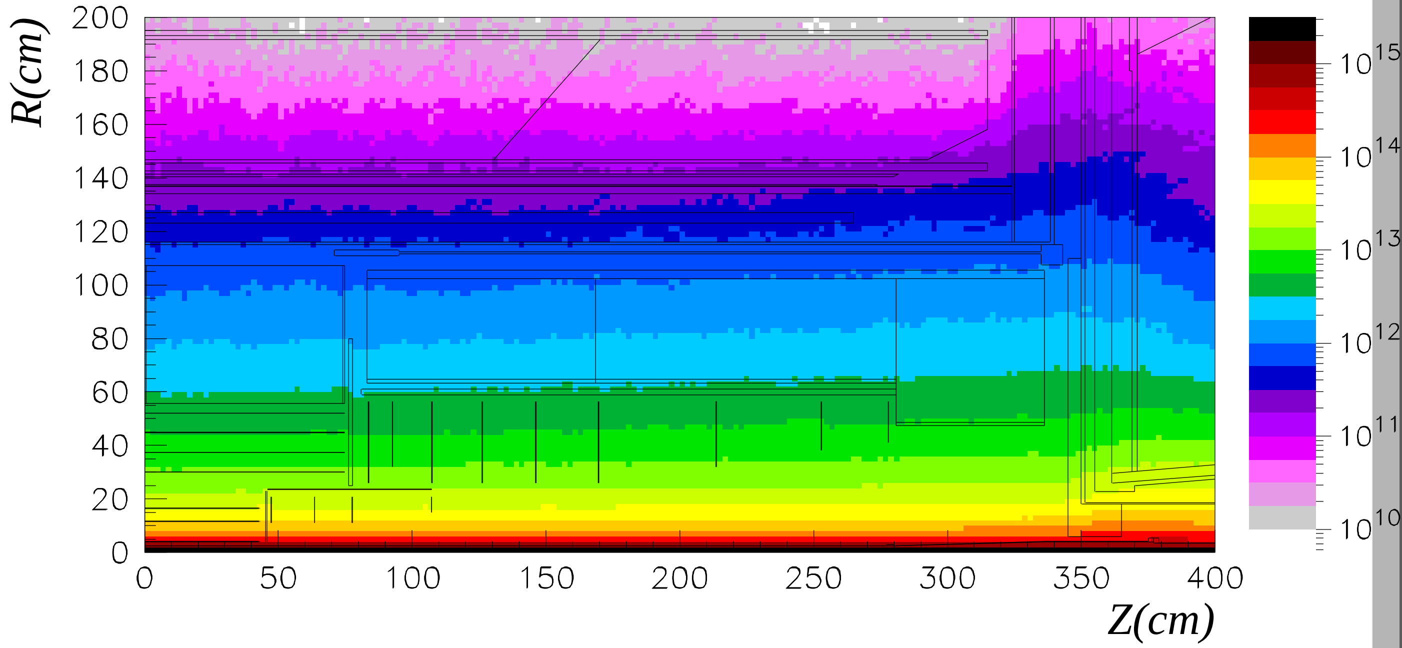


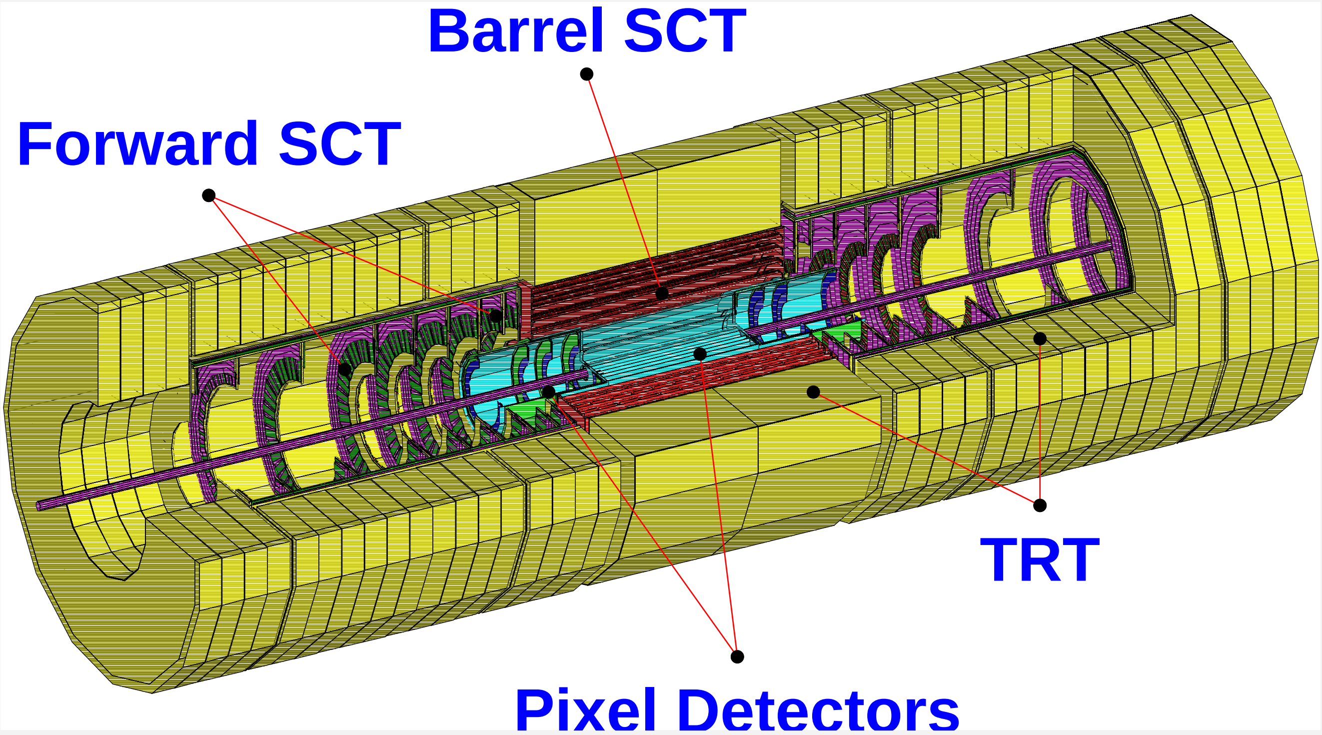


Radiation Environment

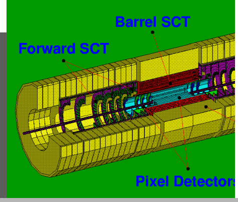
Total Fluence, normalised to 1MeV neutrons



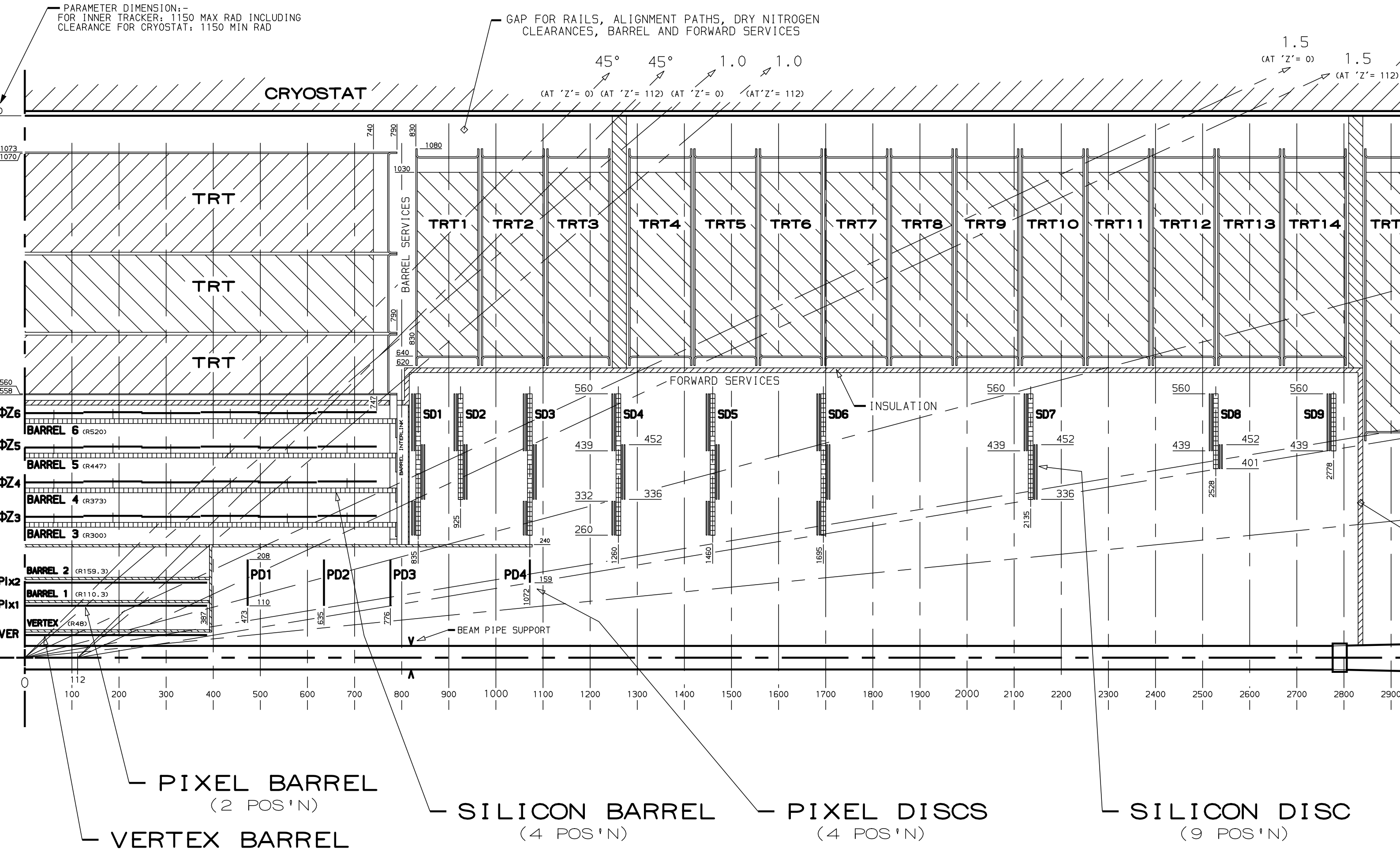


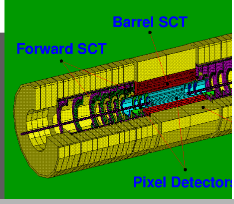

Barrel SCT
Forward SCT
TRT
Pixel Detectors

ATLAS INNER DETECTOR



Layout





Overview

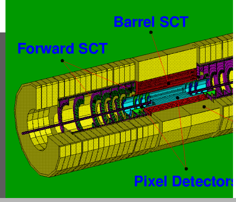
Total substrate area	61 sq. m (34.4 and 26.7)
Total estimated power consumption	~ 25 kW (13 and 12)
Total number of r/o channels	6.2 x 106 (3.2M and 3.0M)
Operating Temperature	-7 C
Total number of modules	4088 (2112 and 1976)

Barrel Region

Module Size, two layers, 40 mr stereo	123.2 mm x 61.4 mm
# of strips / module side [occupancy]	768 [0.6% - 0.3%]
Barrel Length	1493.4 mm
Strip Pitch	80.0 µm
Barrel Radius	300, 373, 447, 520 mm
Radiation dose (equiv. to 10yrs LHC)	1.3 - 0.8 x 10^{14} n/cm^2

Forward Region

Number of wheels	18 (9 + 9)
Module size, two layers, 40mr stereo	768 strips, 12cm long
Strip pitch	54-69, 70-95, 71-90 µm
Radial range	260 mm - 560 mm
Radiation dose	1.4 - 0.9 x 10^{14}



SCT

(TDR Ch 11)

Overview
- Layout
- Environment
- Design Choices

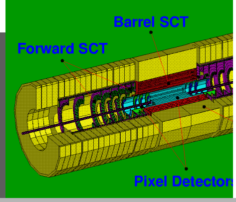
Components
- Detectors
- Electronics
  - F/E chips, optics, power, cables
  - Off-detector electronics (Ch 13 of TDR)

Sub-Assembly Description
- Modules
- Cooling
- Support Structure
- Alignment system (Ch 9 of TDR)

Construction/Assembly Methods
- Modules
- Barrels and Disks

Prototyping

Organisation, Schedule & Cost



SemiConductor Tracker

This transparency to be modified to be the same as TRT/PX

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Collaborating Institutes: 38

Countries 12

Signatories to the TDR 320