Electrical Properties of ATLAS Modules

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Issues:

r- ϕ modules: hybrid <u>across</u> detector —> lower capacitance, clock pick-up ?
z modules: fan-out <u>across</u> detector—> no clock pick-up(?), higher capacitance (fan-out)

Experience with r-ϕ Modules

Capacitance measurements
Noise measurements
Delay curves
Data acquisition during read-out

Experience with z Modules

Capacitance measurements
Noise measurements of Keystone (in- line) vs z Module (proposed)
Noise measurements as function of channel number for z (proposed)

Recommendations/Conclusions

Properties of r-ϕ Modules

Modules of 12cm length
AC and DC coupled Si detectors , both n- and p-side
hybrid mounted across the center of the module instead of the end:

- 40MHz control and data signals cross detector strips
- signal path minimized from strips into FEE
- effect of strip resistance minimized

Experience (with Binary Read-out only)

"in-line" PCB hybrids for KEK beam tests
Fully loaded modules for H8

- Both 6cm and 12cm detector length
- Both ceramic and Kapton hybrids mounted across detectors
- Both un-compressed and zero-suppressed data transmission
- Support Board for cable termination and filtering.

Studies

Capacitance measurements
Beam test, noise and efficiency on- line
Noise studies
Pick-up studies with calibration: Clock delay, data acquisition during read-out
Source studies with non-uniformly irradiated detectors

Performance of r-ϕ Modules:
Electrical

Electrical behavior excellent.

Gain and noise are uniform across the module.

Noise immunity is very important because the digital readout lines are clocking with 40MHz across the detector.
It can be checked with delay curves, where we change the phase of the calibration signal relative to the clock.
Clock pick-up is less than a few mV compared to the threshold at 1fC: 180mV and to the noise of about 30 to 40mV.

We see the different level of noise for 6cm and 12cm long strips:

At a bias voltage of 200V, the 50µ pitch n-side shows:
- for 6cm long detectors, σ_{noise} = 1180e^-, noise occupancy < 10^{-6} @ 1fC
- for 12cm long detectors, σ_{noise} = 1550e^-, noise occupancy < 10^{-4} @ 1fC

Somewhat lower noise can be expected for new 75µ detectors, CAFE chip.

This data was acquired while data transmission was active.

r-ϕ Interstrip Capacitance

one strip vs 6 neighbors, next 10 grounded
(i.e. >90% of the total interstrip capacitance):

UCSC Module (Kapton) n-side AC coupledat 200V Bias

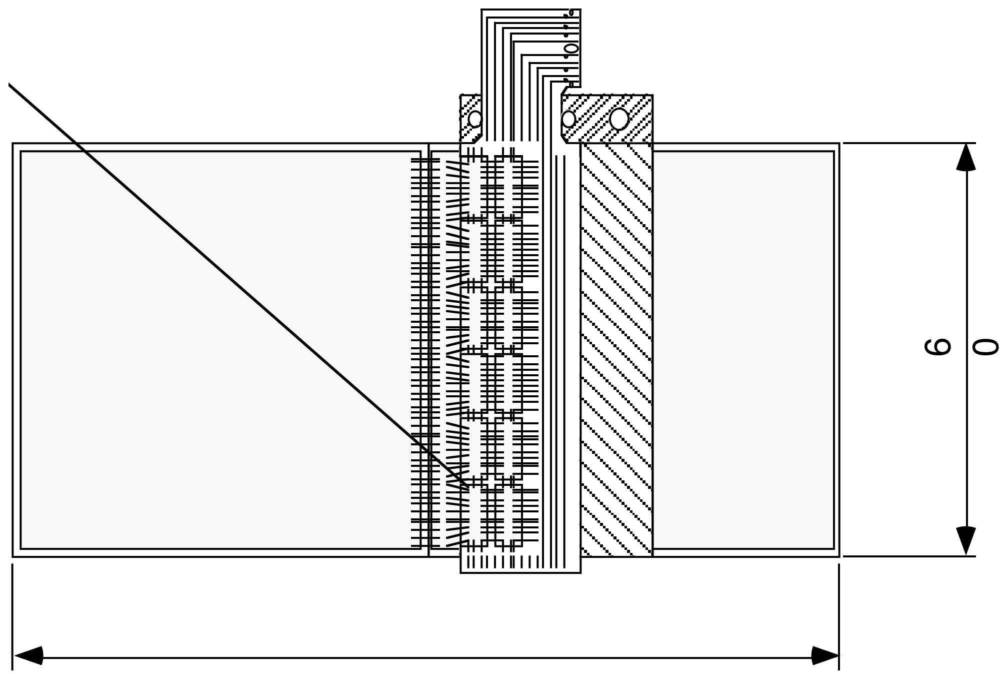
	pF
6cm	6.0
6cm under Kapton	6.7
12cm under Kapton	12.1

LBIC Module (Ceramic) p-side DC coupled 100V bias

	pF
6cm	4.6
6cm under Ceramic	4.9
12cm under Ceramic	9.6-10.1

needs check!

Hybrid contributes about 5% to interstrip capacitance on r-ϕ module.


6
0

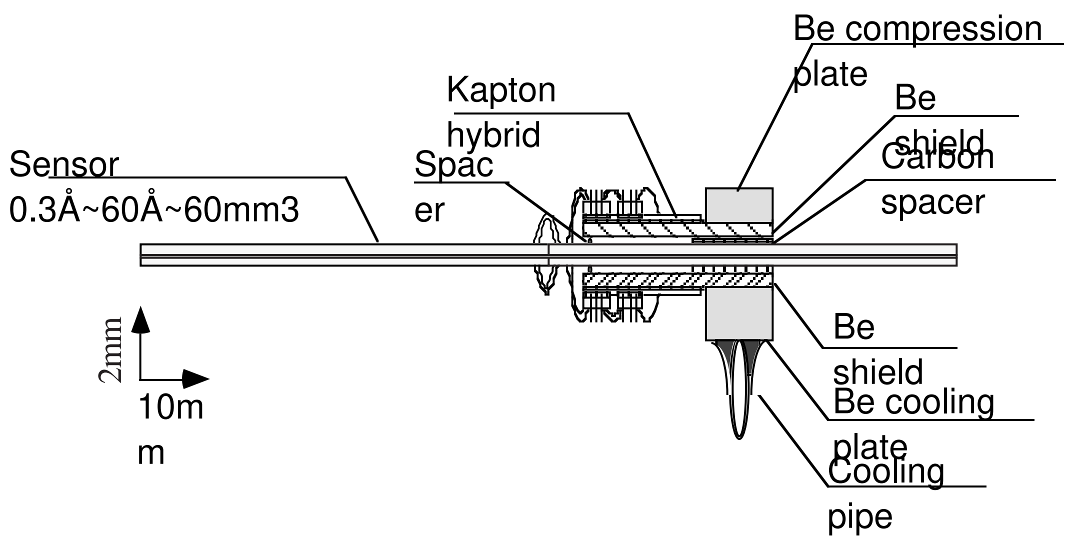

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plate
Kapton
hybrid
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shield
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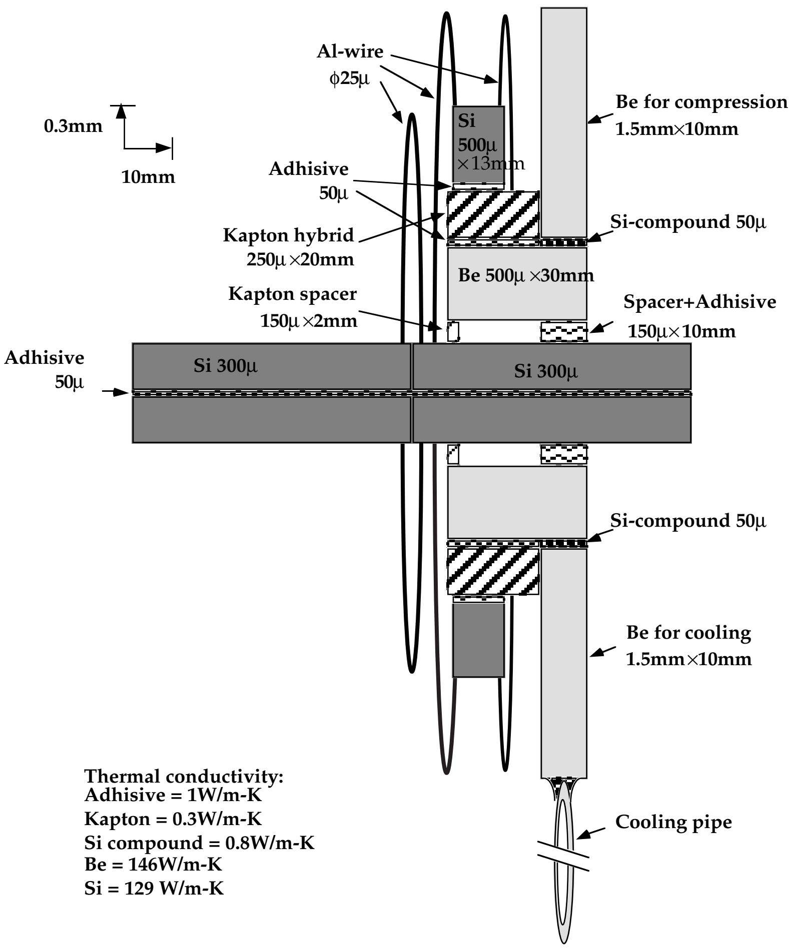
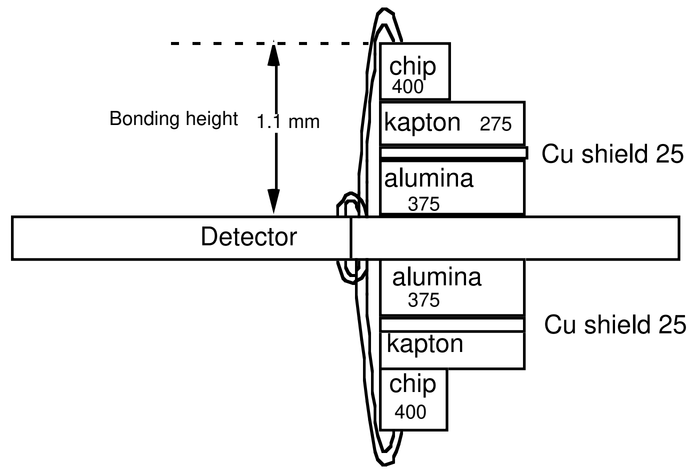


Model for the material-budget calulation



H8 Version

Properties of *z* Modules

Modules of 6 & 12cm length
DC- or AC- coupled Si detectors, both n- and p- side
hybrid along the side of the module instead of the end:
- control and data signals are separated from the detector strips
- fan-out across strips bring signal from strips into FEE
- capacitative load not uniform across the module ?

Experience (with Analog Read-out only)

"in-line" PCB hybrids for Keystone modules for H8 (for comparison)
Fully/partially loaded modules for H8
- Fan-ins mounted across detectors
- Both analog and digital local FEE
- Support Board

Studies

Capacitance measurements
Beam test, signal-to-noise ratio
Noise studies
Source studies

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Noise measurements with Analog/z Modules:

From P. Allport's Hiroshima talk, only for illustrations!

FEE	RD	#Ch	side	cm	pitch	S/N	Hybrid	Analysis	Remarks
ADAM	RD2	32	p?	6	200	11	in-line?	Digital	
APV5	RD20	128?	p	12	~100?	14	in-line	Peak	Keystone
APV5	RD20	128?	n	12	112	??	z	Peak	Not all channels
FELIX128	RD20	128	p	6	50	33	in-line	Peak	350µ thick, FOXFET
				6		15	in-line	Deconv	
				12		11	in-line	Deconv	
FELIX128	RD20	128	n	6	112	17	z?	Peak	
						11	z?	Deconv	

No comparison possible, because different FEE are used

z Module Capacitance

Detector Interstrip Capacitance C_S

Fanout Interstrip Capacitance C_F

Strip-Fanout Capacitance C_{SF}

$C^I_{tot} = C_S + C_F + C_{SF}$ Total Interstrip Capacitance

$C_S \approx 8$pF (measured to nearest neighbors => 13-16pF relative to all neighbors?)

$C_F \approx 1 - 3.5$pF (measured to nearest neighbor? => 2- 5/7pf relative to all neighbors?

$C_{SF} = ?$ (if measured to nearest neighbors => factor 1.5--2 relative to all neighbors?)

"Naive model" $C^I_{tot} = C_S + C_F$

Measure C^I_{tot} to all neighbors!

(if measured to nearest neighbors => factor 1.5--2 relative to all neighbors?)

Capacitance Measurements on 12cm z-Module (Martin Gibson RAL)

Full 12cm z-module with AVP5 (H8), biased at 30V
Frequency: 100kHz (?)
Capacitance to nearest neighbors only
Measurement at 3 different strip location:

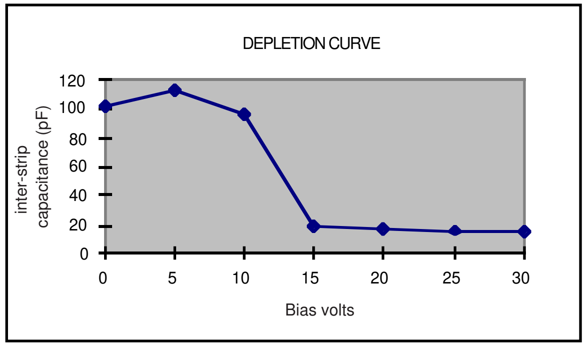
strip#	C_F [pF]	C^I_{tot} (measured) [pF]	Naive model [pF]
15	3.5	13.5	11.5
320	2	15	10
470	1	14	9

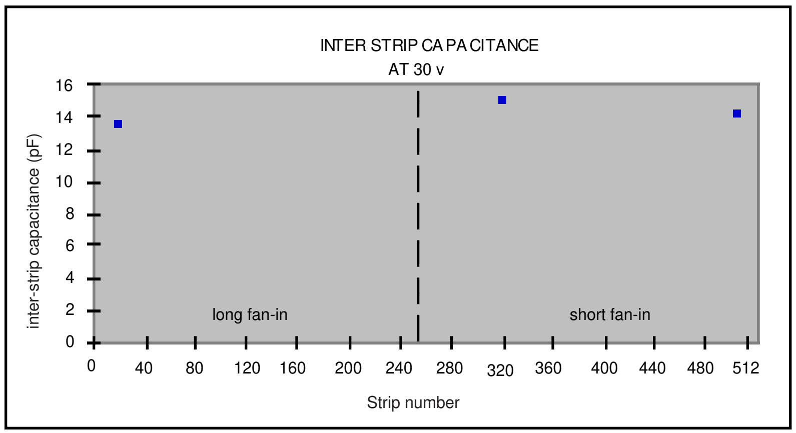
The capacitance is approx. uniform across to Module!

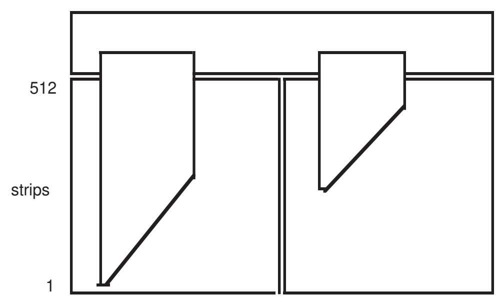
Conclusions: Naive expectations are wrong!

Strip-Fanout capacitance not negligeable ?
Not possible to predict total capacitance:
- certainly wrong to just scale up this measurement up by factor 1.5 - 2!
- extrapolation from nearest neighbors measurement to total capacitance different for different contribution C_S,, C_F, C_{SF}?

Very difficult measurement because it involves the whole detector!
Frequency dependence of measurement.







all measured strips are 120 long and include the fan-in but exclude APV5

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Conclusions / Recommendations

Comparison should be done with fewer variables changing,

=> keep FEE and detector constant.

Measure noise / capacitance on 12cm detectors
and compare performance of "in-line" and z module
with same detector and same fast FEE (20ns shaping).

Suggested Program:

1) Binary : need z-module and r-ϕ module with new Hamamatsu detector:
in progress.

2) Analog signal / noise measurements:
compare "in-line" (or Keystone) with z-module using same detectors
with same FEE (FELIX128 or APV5)
need z module with all pads connected to ground or FEE
analog r-ϕ module ?

3) Capacitance measurements on full z-module
at 1MHz, relative to all other strips!

By next SCT Review?

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