Large Synoptic Survey Telescope

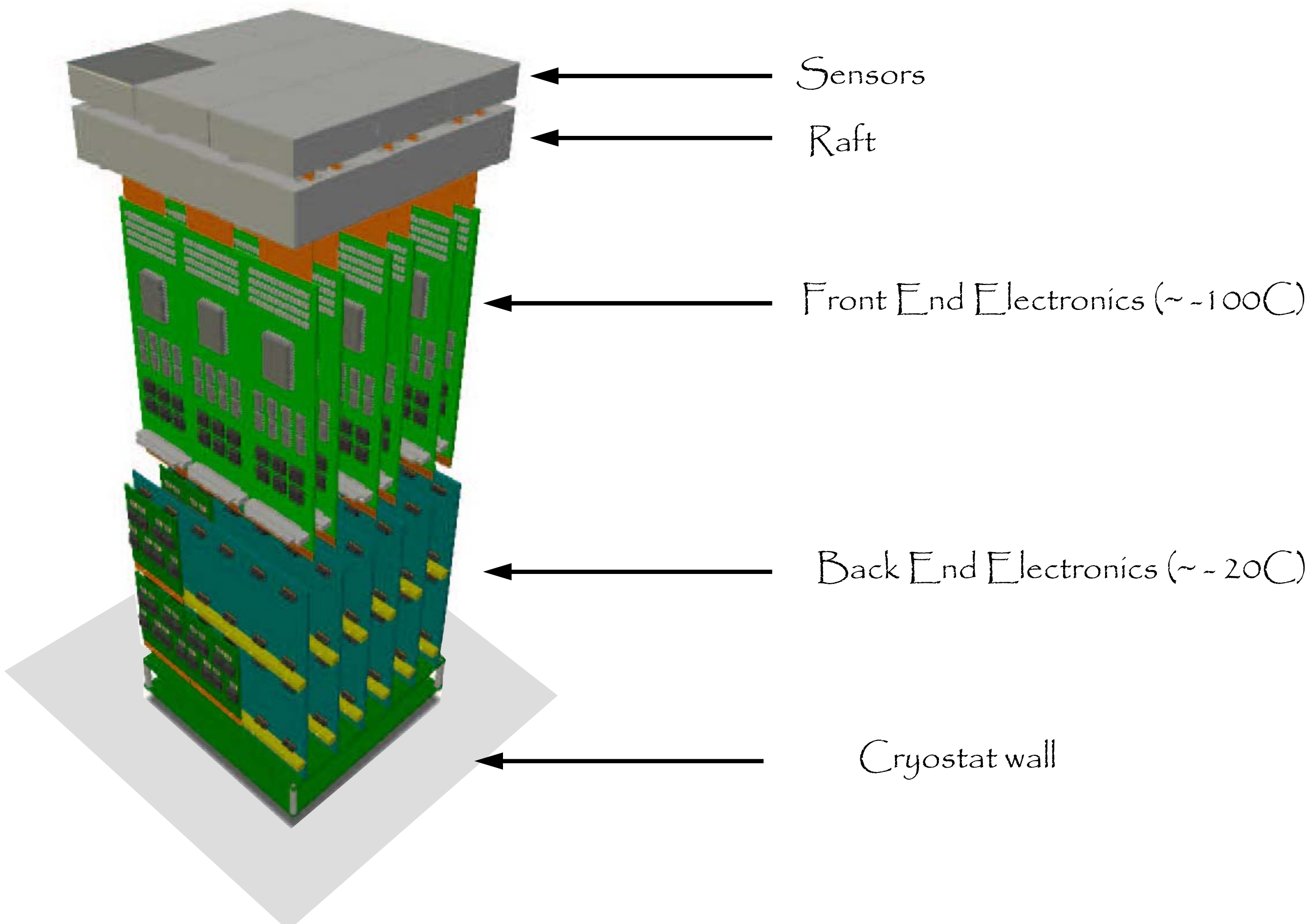
Electronics configuration studies

J. Geary, P. O'Connor, J. Oliver, V. Radeka, R. Schindler

Charge : Evaluate electronics configurations with regard to;

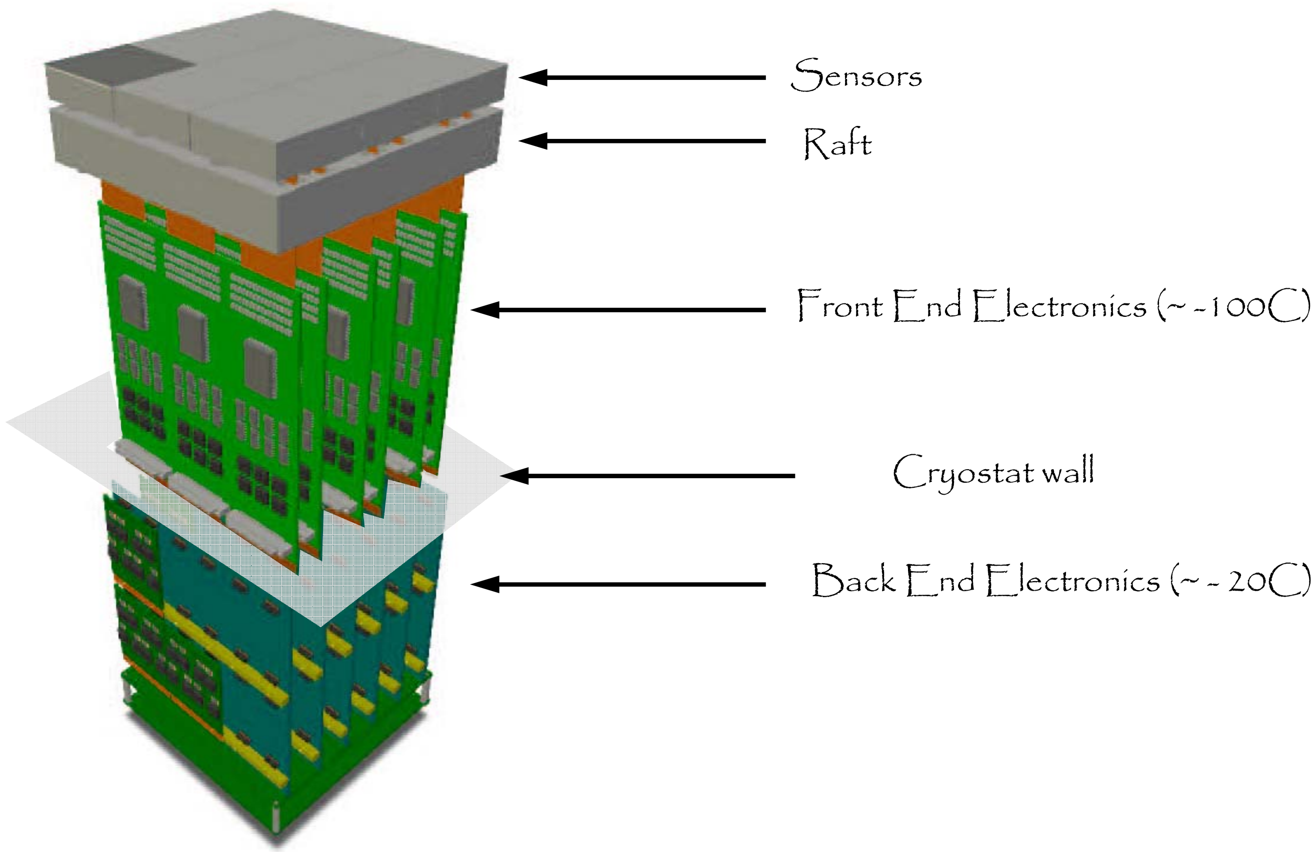
- Reliability of in-cryostat electronics → How often will cryostat need to be opened due to internal electronics failures?
- Vacuum contamination
  - Optimization with respect to electronics configuration
  - Testing, mitigation, certification
- Evaluate "Internal" vs "External" Back End Electronics

Baseline configuration →
Minimization of Cryostat Penetrations



Alternate configuration →
Minimization of Cryostat electronics for

- Reliability
- Outgassing, vacuum compatibility



Back End Electronics - Reliability

High part count components will dominate failure rate

Function	Technology	Qty/sensor	No Sensors	Qty
16 bit ADC	0.6u CMOS	32	201	6432
Differential amplifier	2.5u^2 bipolar	32	201	6432
Opamp	2.5u^2 bipolar	32	201	6432
Reference	2.5u^2 bipolar	2	201	402
Frame buffer	0.18u CMOS	2	201	402

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Back End Electronics – Reliability (con't)

- Semiconductor failure rates are reported by vendors (Analog Devices data on all AD parts)
- Failure rates follow exponential dependence on junction temperature
- Failure rates double for each ~8C junction temperature increase
- Junction temperature is dependent on ambient & thermal resistance of package

Back End Electronics - Reliability

MTBF at junction temp
- +55C (air cooling from room temp)
- +20C (heatsink to liquid cold plate @ ~ 0 C

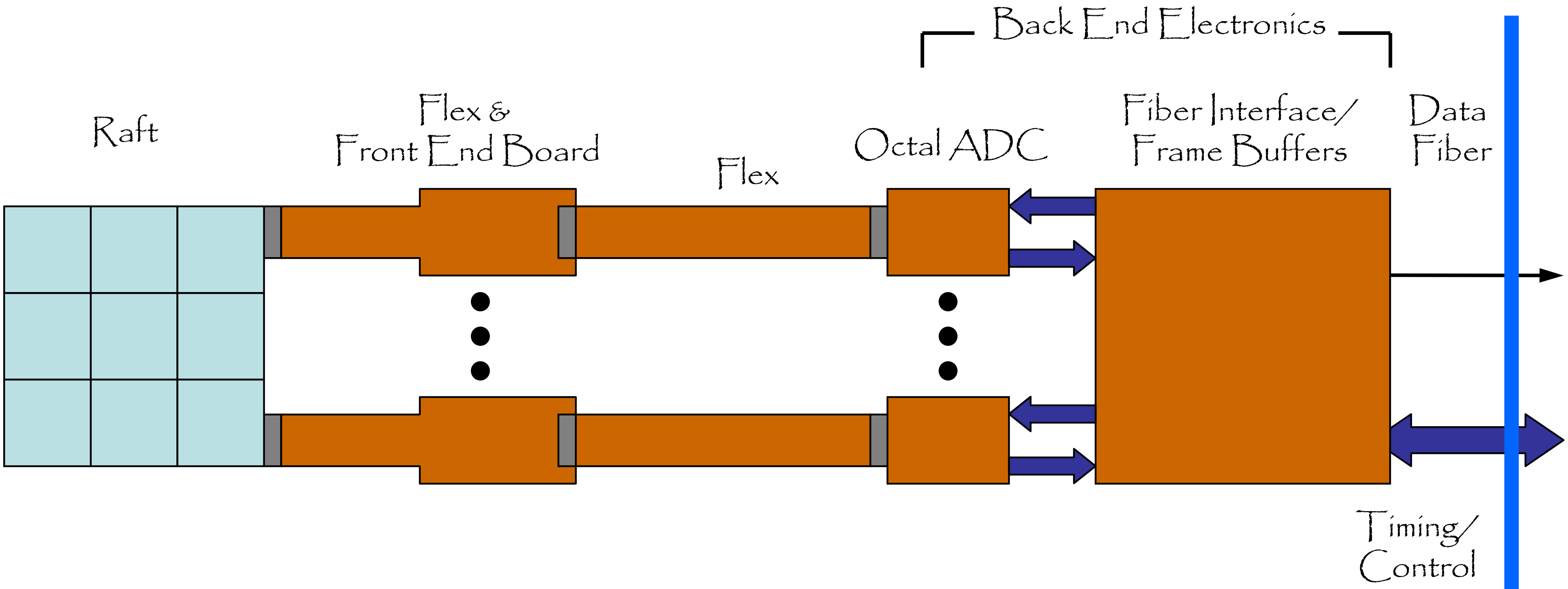
(typical, estimate only)

Function	MTBF (55C) per part (x 10^6Hrs)	Camera MTBF (Yrs)	MTBF (20C) per part (x 10^6Hrs)	Camera MTBF (Yrs)
16 bit ADC	259	4.6	4,976	88.3
Differential amplifier	273	4.9	5,254	93.2
Opamp	273	4.9	5,254	93.2
Reference	273	77.7	5,254	1,492.0
Frame buffer	259	73.5	4,976	1,413.1
		1.5		29.3

BEE will operate at
- ~ -20C ambient cold liquid
- << 40 C ΔT rise to junction (low power)
- << 20 C junction temp (likely closer to 0 C)

Semiconductor junction failures are predicted to be negligible

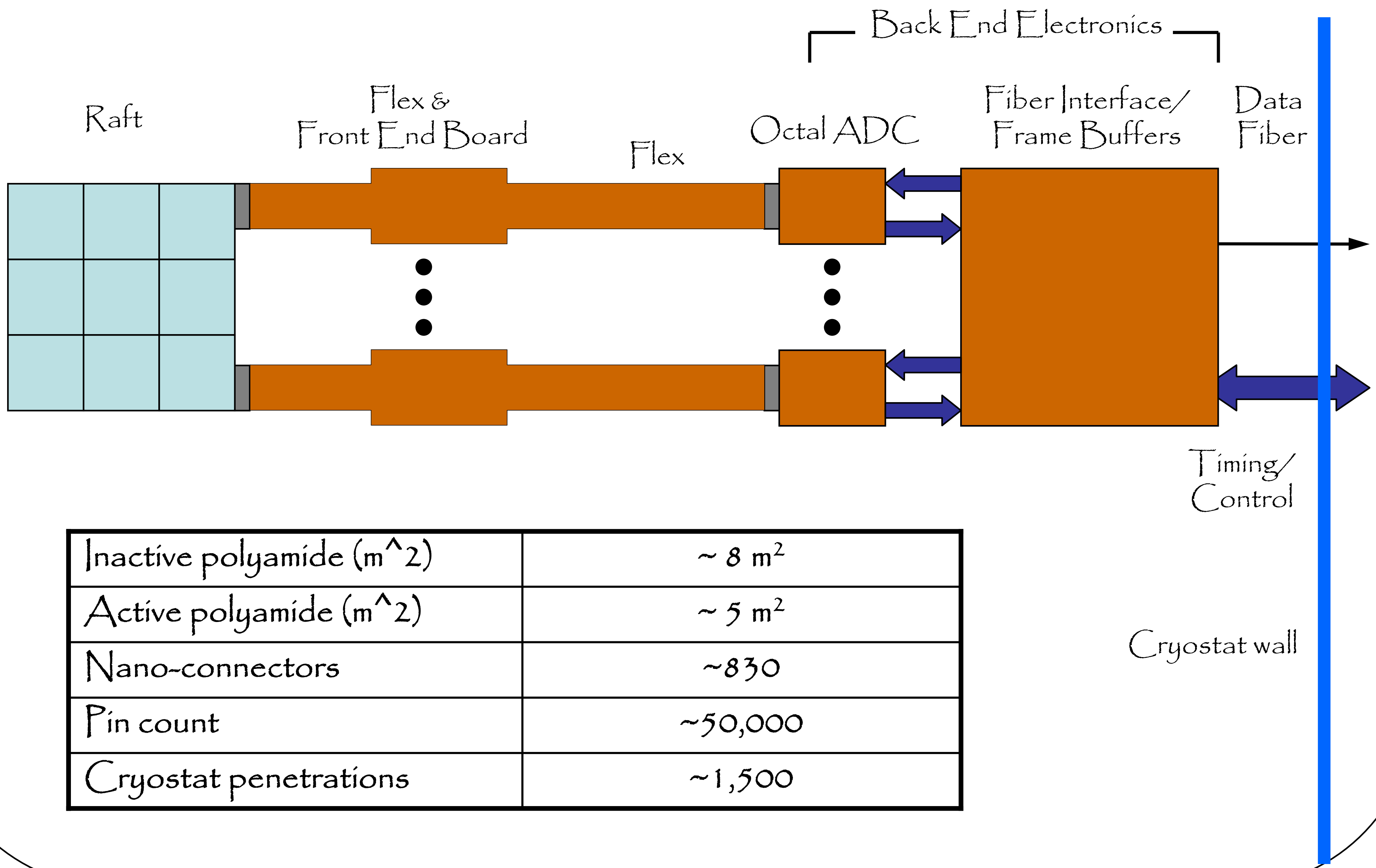
"Internal" configuration



Inactive polyamide (m^2)	~ 8 m^2
Active polyamide (m^2)	~ 5 m^2
Nano-connectors[1]	~1,230
Pin count[2]	~73,800
Cryostat penetrations	~1,500

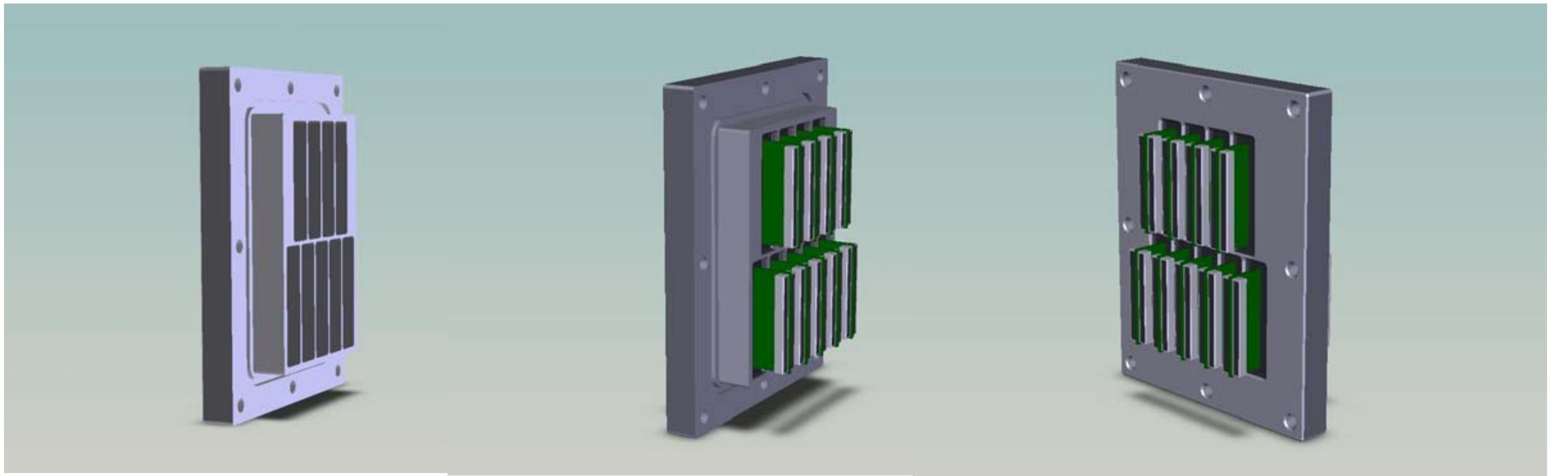
[1]connectors requiring breaking vacuum to replace
[2]based on 60 pins per connector

"Internal" configuration
(connector minimization)

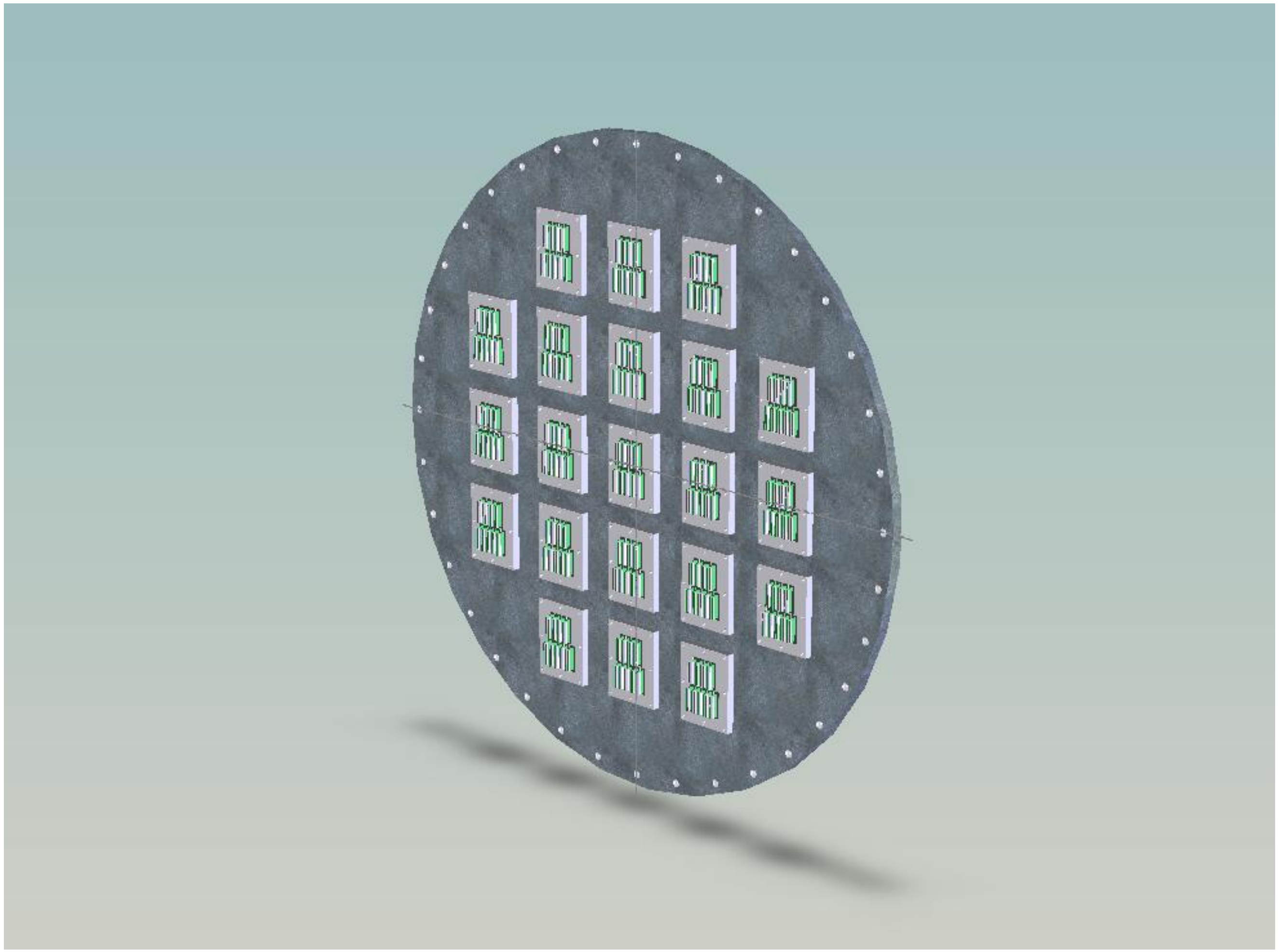


Inactive polyamide (m^2)	~ 8 m^2
Active polyamide (m^2)	~ 5 m^2
Nano-connectors	~830
Pin count	~50,000
Cryostat penetrations	~1,500

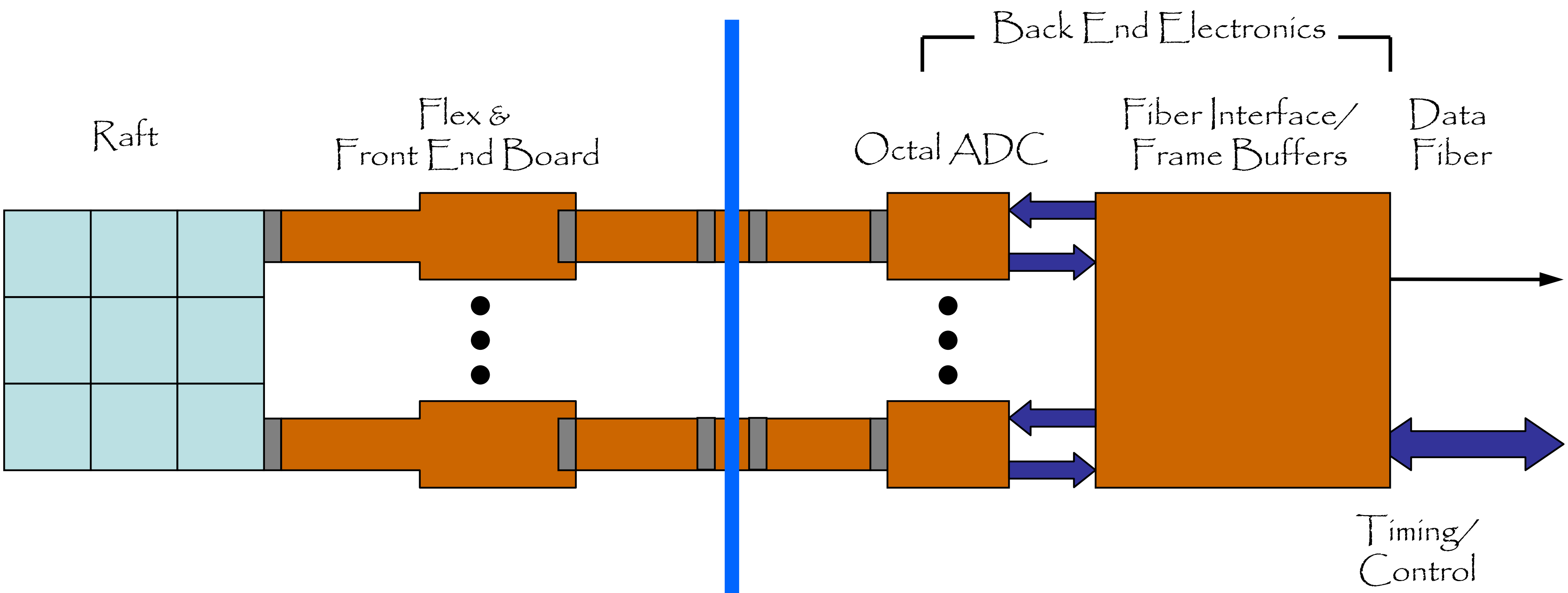
High Density Feed-through Development (J. Geary)
Based on
- PCBs with 2x Nano-connectors on each side
- Epoxy potted on flange with O-ring
- 9x feedthroughs per flange (one raft)



Cryostat flange with 21 raft feedthrough assemblies

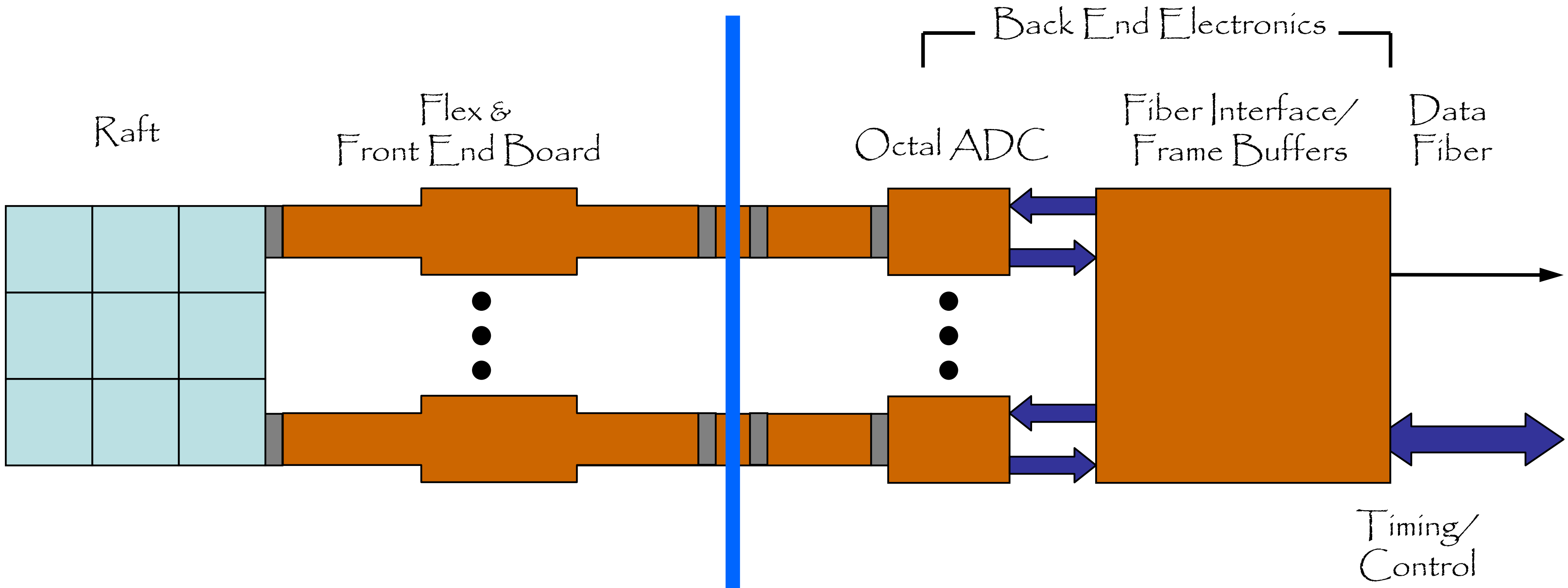


"External" configuration



Inactive polyamide (m^2)	~ 5 m^2
Active polyamide (m^2)	~ 1.6 m^2
Nano-connectors	~1,608
Pin count	~96,480
Cryostat penetrations	~24,120

"External" configuration
(connector minimization)



Inactive polyamide (m^2)	~ 5 m^2
Active polyamide (m^2)	~ 1.6 m^2
Nano-connectors	~1,230
Pin count	~73,800
Cryostat penetrations	~24,120

Comparison : Internal vs External

Configuration	Inactive PA (m^2)	Active PA (m^2)	Nano-connectors	Cryostat penetrations
Internal	~8	~5	800 - 1,200	~1,500
External	~5	~1.6	1,200 - 1,600	~24,00

- Cryostat electronics will have to be clean regardless of configuration
- Standard practices exist
  - All cryostat electronics on polyamide (Kapton) pcbs
  - All active electronics have conformal coating (eg Conothane, ...)
  - Some outgassing data exists (eg NASA, ...)

Conclusions & recommendations (by consensus .... sort of)

- Baseline configuration should be vigorously pursued.
- High Density vacuum feedthrough should be developed as backup "Plan B"
- All in-cryostat materials must be tested and certified
- All materials handling procedures must be specified (eg baking, cleaning, etc)
- Remediation techniques (eg gettering, baffling, ...) must be investigated and documented
- Telescope (site) handling facilities must be specified
- Cryostat Materials Certification should rise to an LSST "Task" with it's own facility and manager.