Use Intelligent Simultaneous Digitizers to Solve Demanding Data Acquisition Problems

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High Performance Simultaneous Data Acquisition

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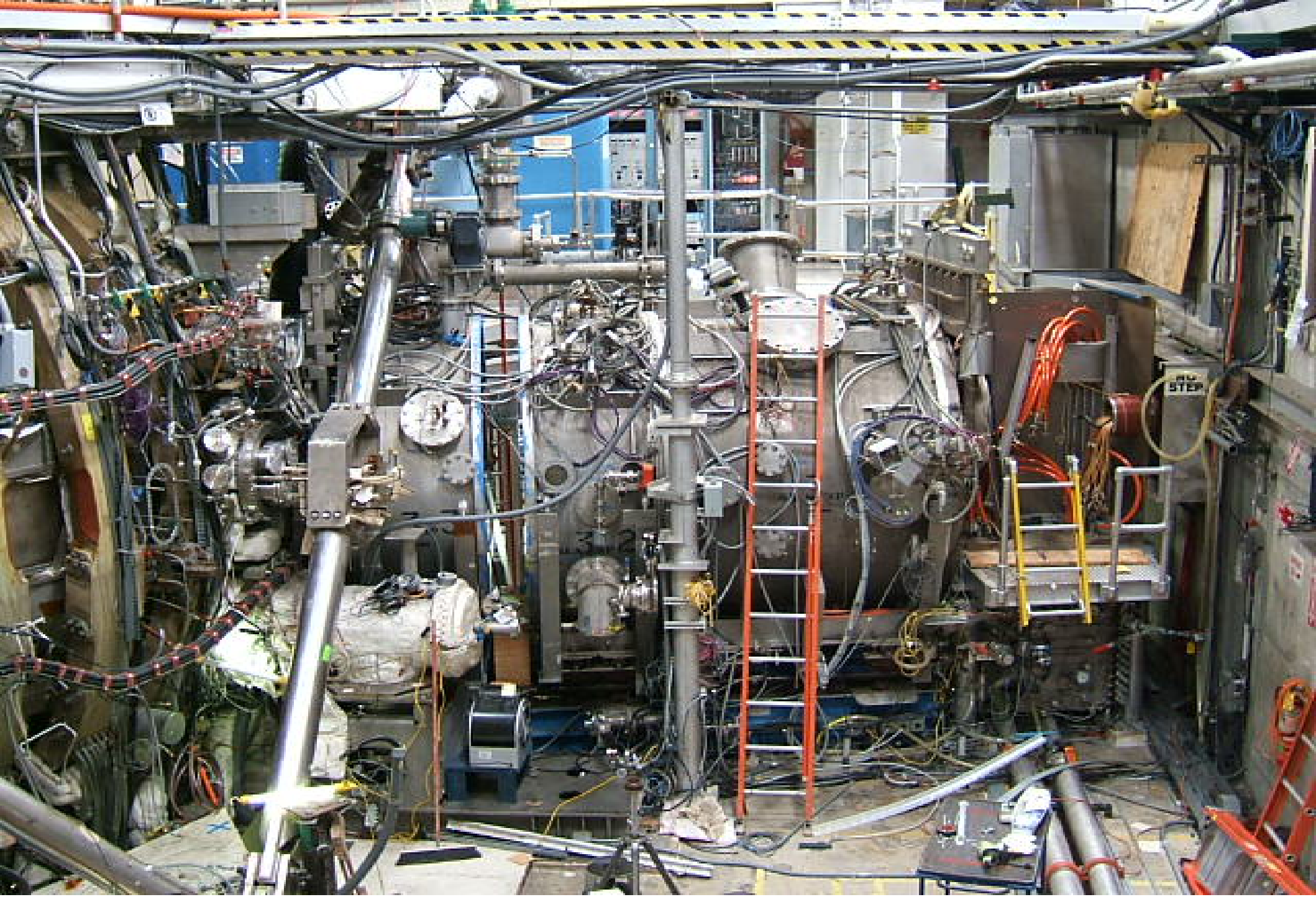
Typical Challenges

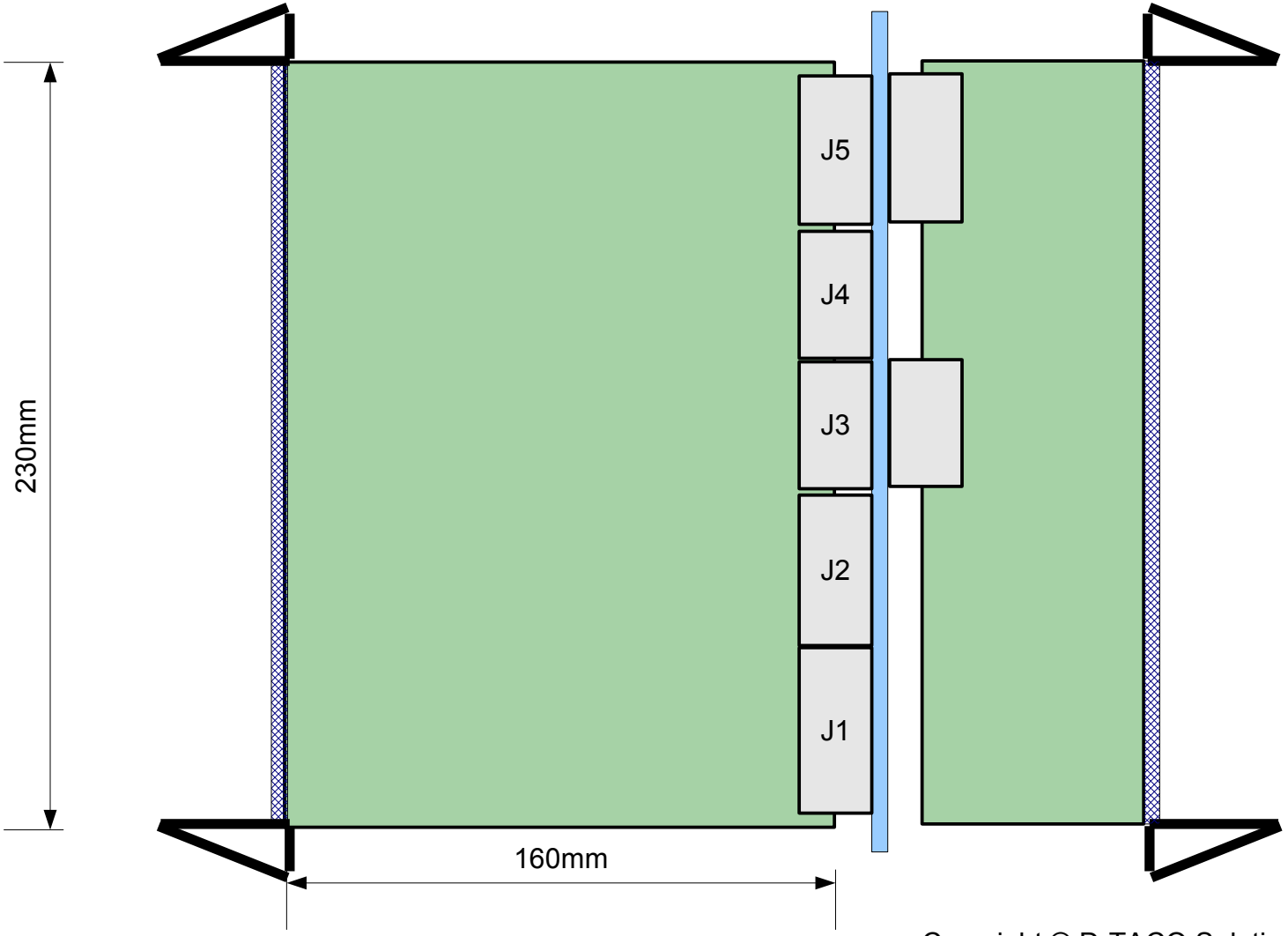
- Tokamak – diagnostics, 100s of simultaneous channels, transient capture with trigger.
- Imaging – continuous streaming data.
- Control – plasma control, 100’s of inputs, very low latency data transfers.



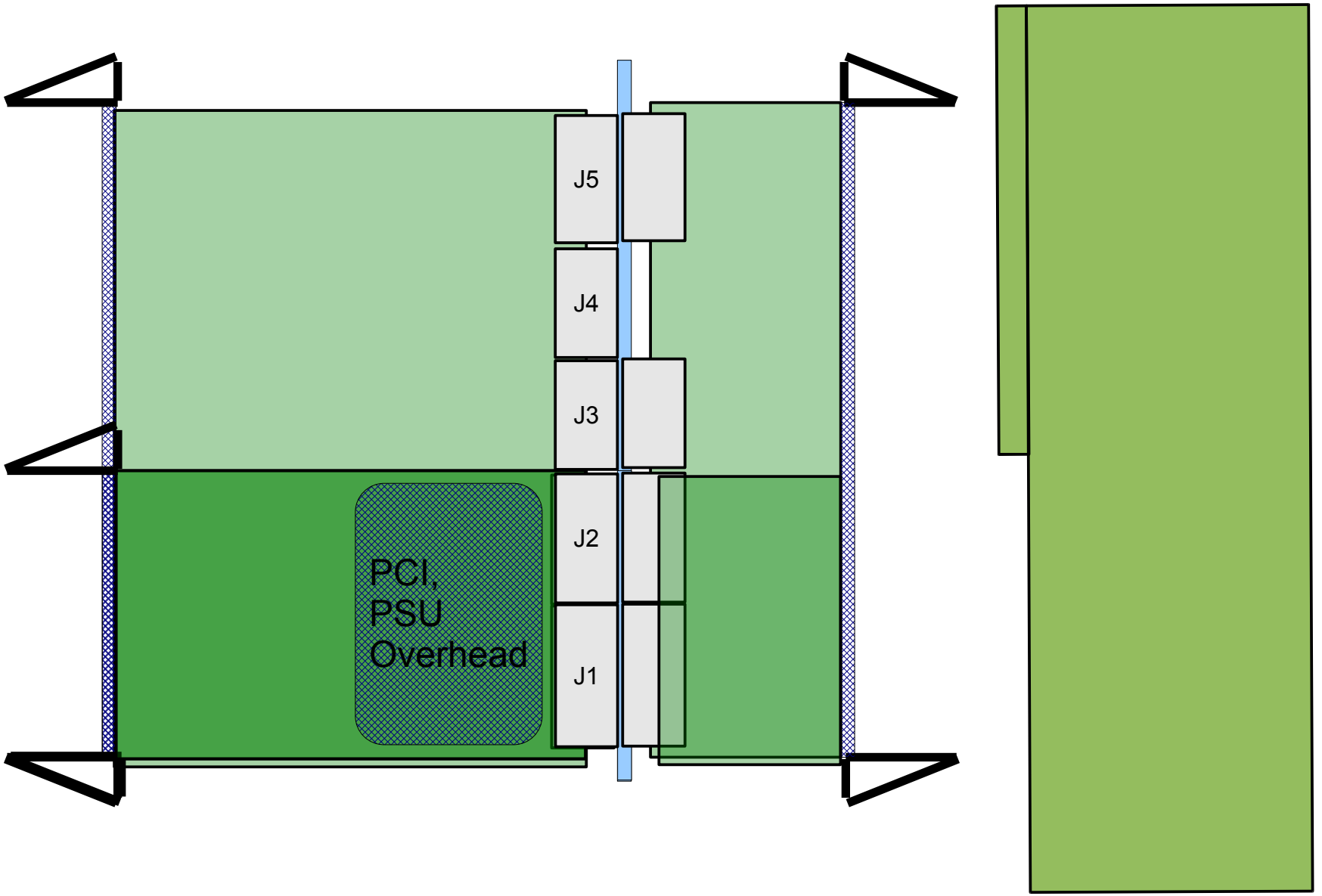
Architecture Choices

- Array of ADC devices. ADC per channel – simultaneous and higher throughput.
- Fast and wide local buses. 64 bit or more
- High Performance FPGA
- Onboard microprocessor with DMA
- Onboard DDRAM to 1 gigabyte
- Off board high performance PCI backplane interface, 64 bit, 66MHz.
- Networking.

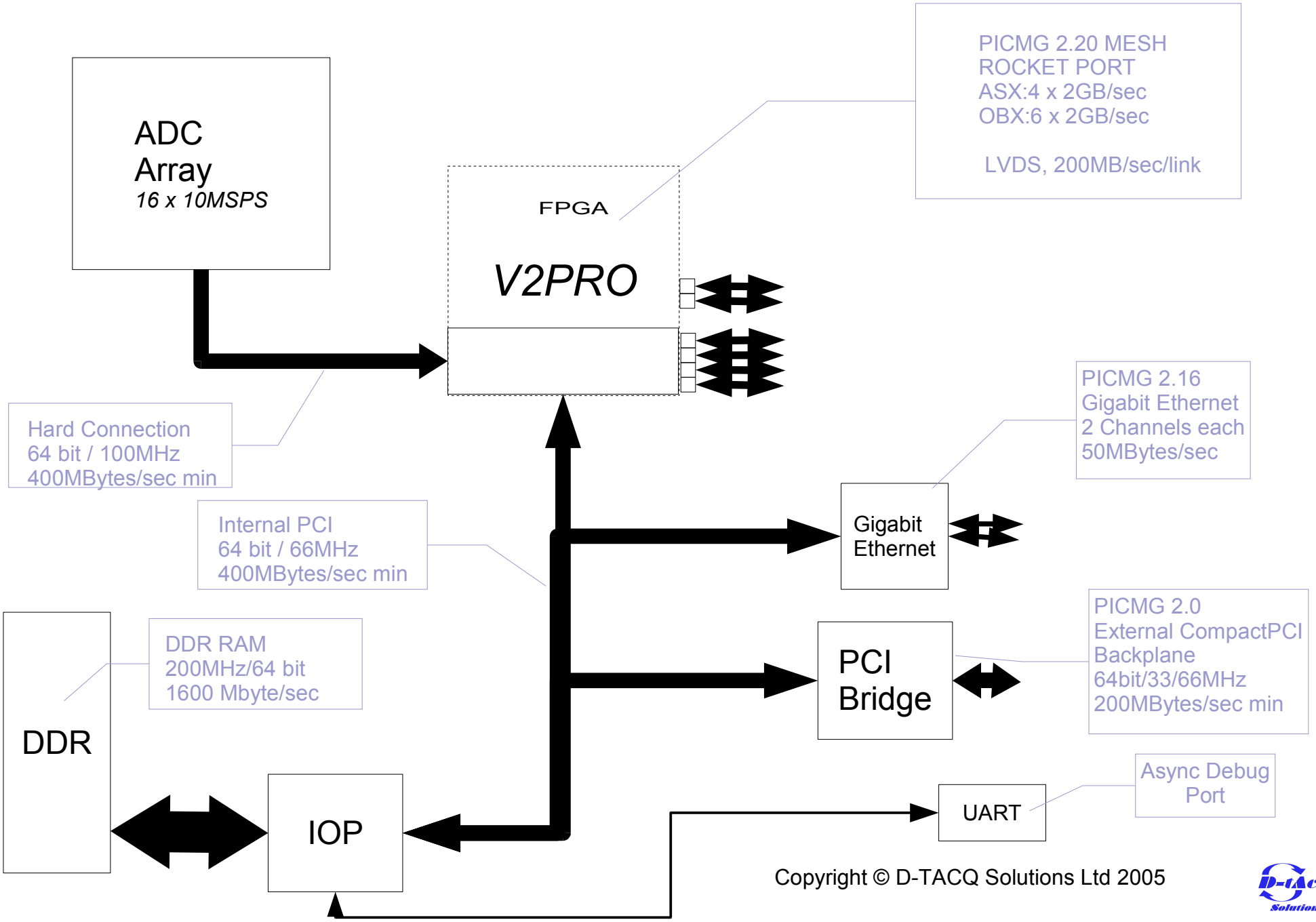
Form Factor: 6U Compact PCI



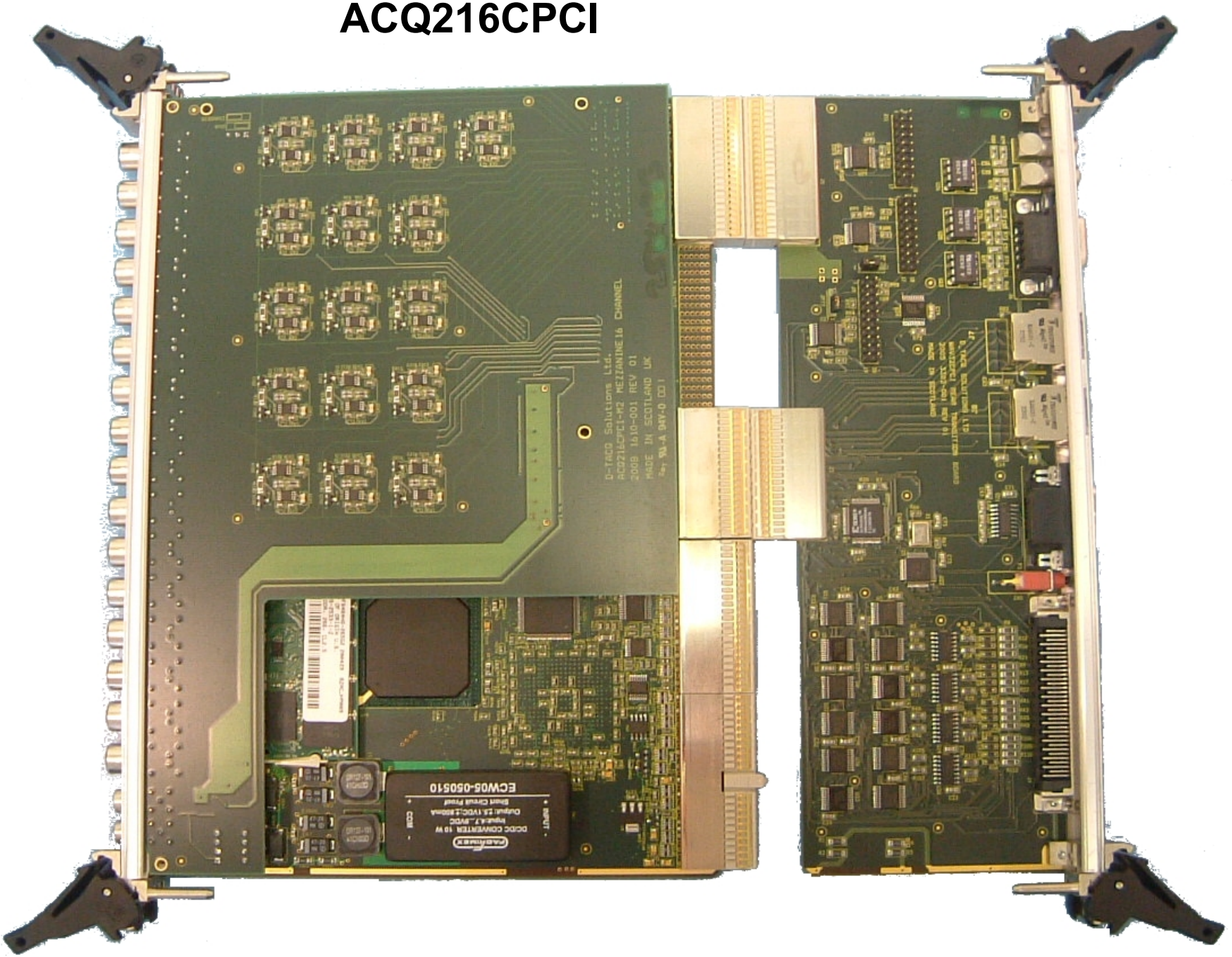
Form Factor: 6U Compact PCI vs 3U vs PCI



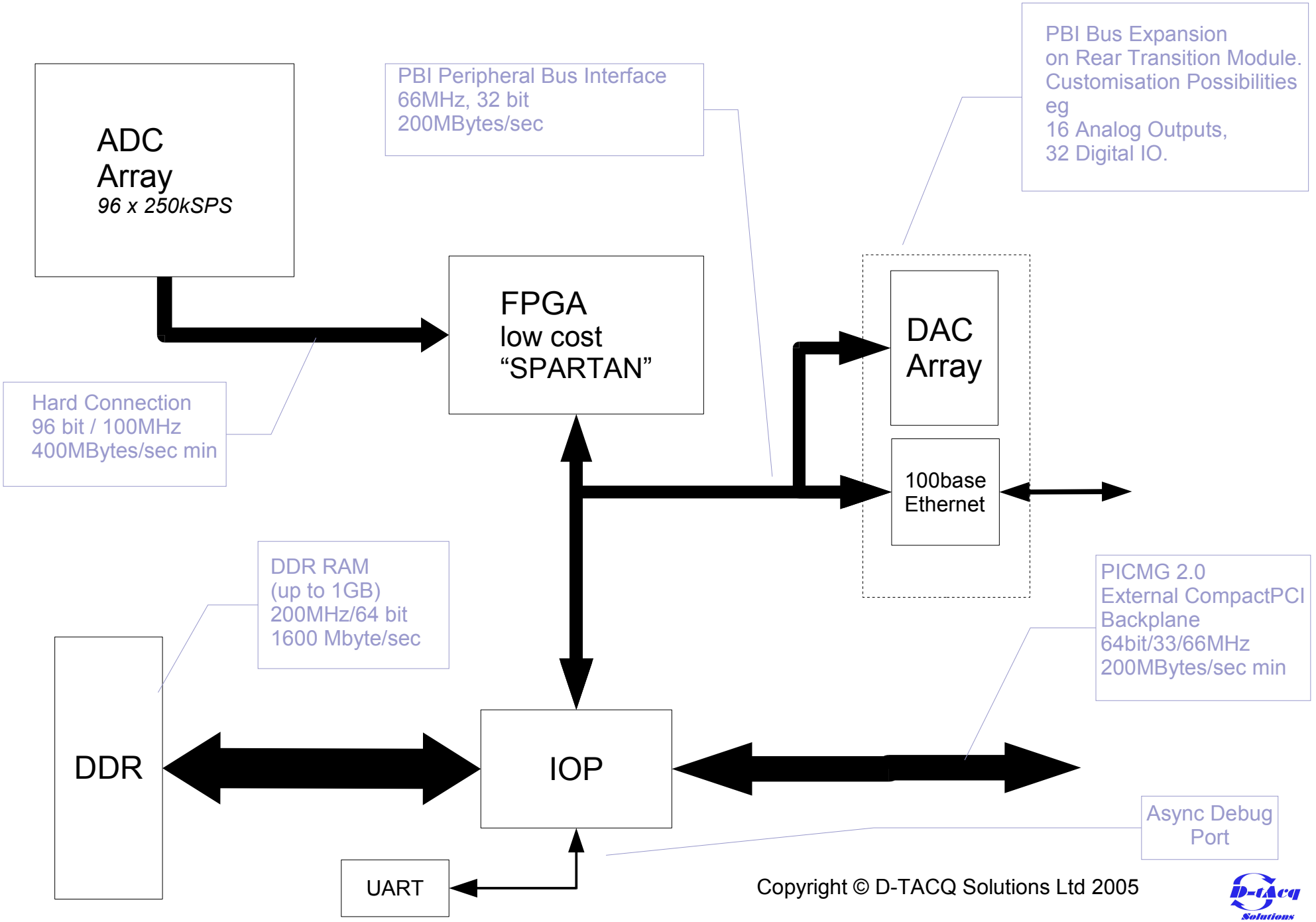
2G Architecture :ACQ216CPCI



ACQ216CPCI



ACQ196CPCI Data Flows



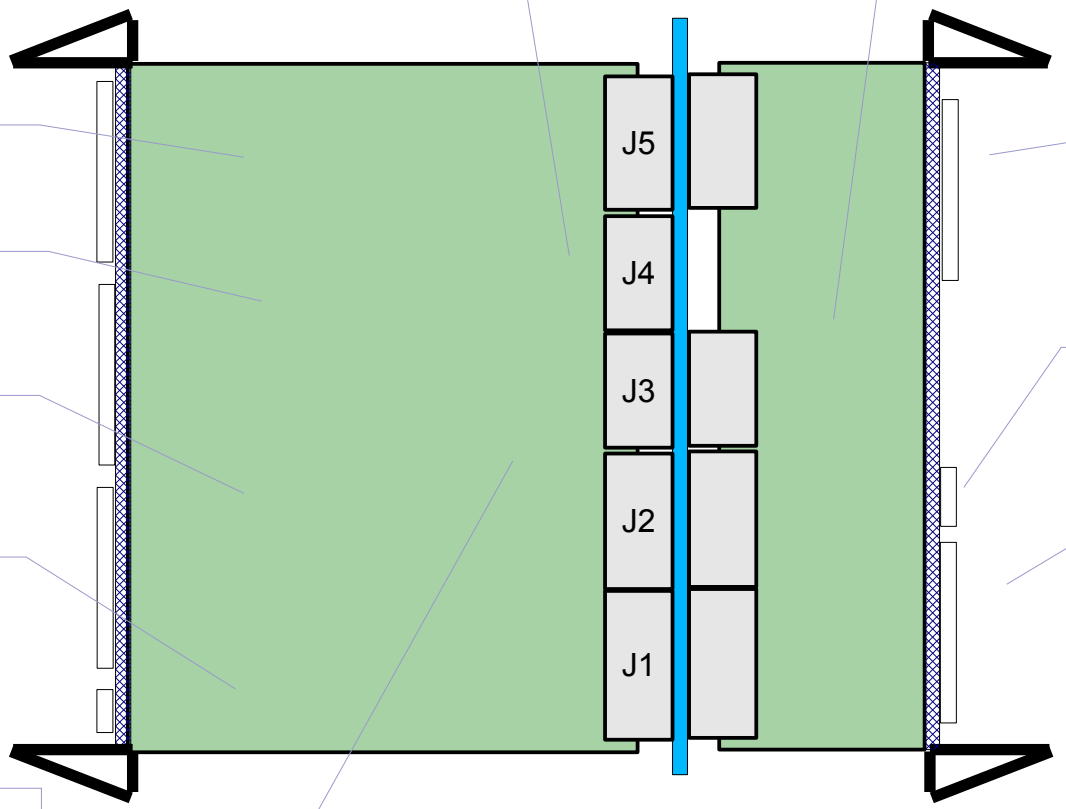
ACQ196CPCI Plan View

AI – analog input
AO – analog output
DIO – digital IO

ACQ196CPCI, 96 Channels, 250kSPS, 16bit
Up to 1024MB memory.

Input range: +/-10V, differential, protected to 100V
Can be configured as standalone networked Linux system.
Optional large size FPGA for real time signal processing.

Rear Transition module
TMAO



32 AI
on 68W SCSI2

32 AI
on 68W SCSI2

32 AI
on 68W SCSI2

EXT CLK,
TRIG on LEMO

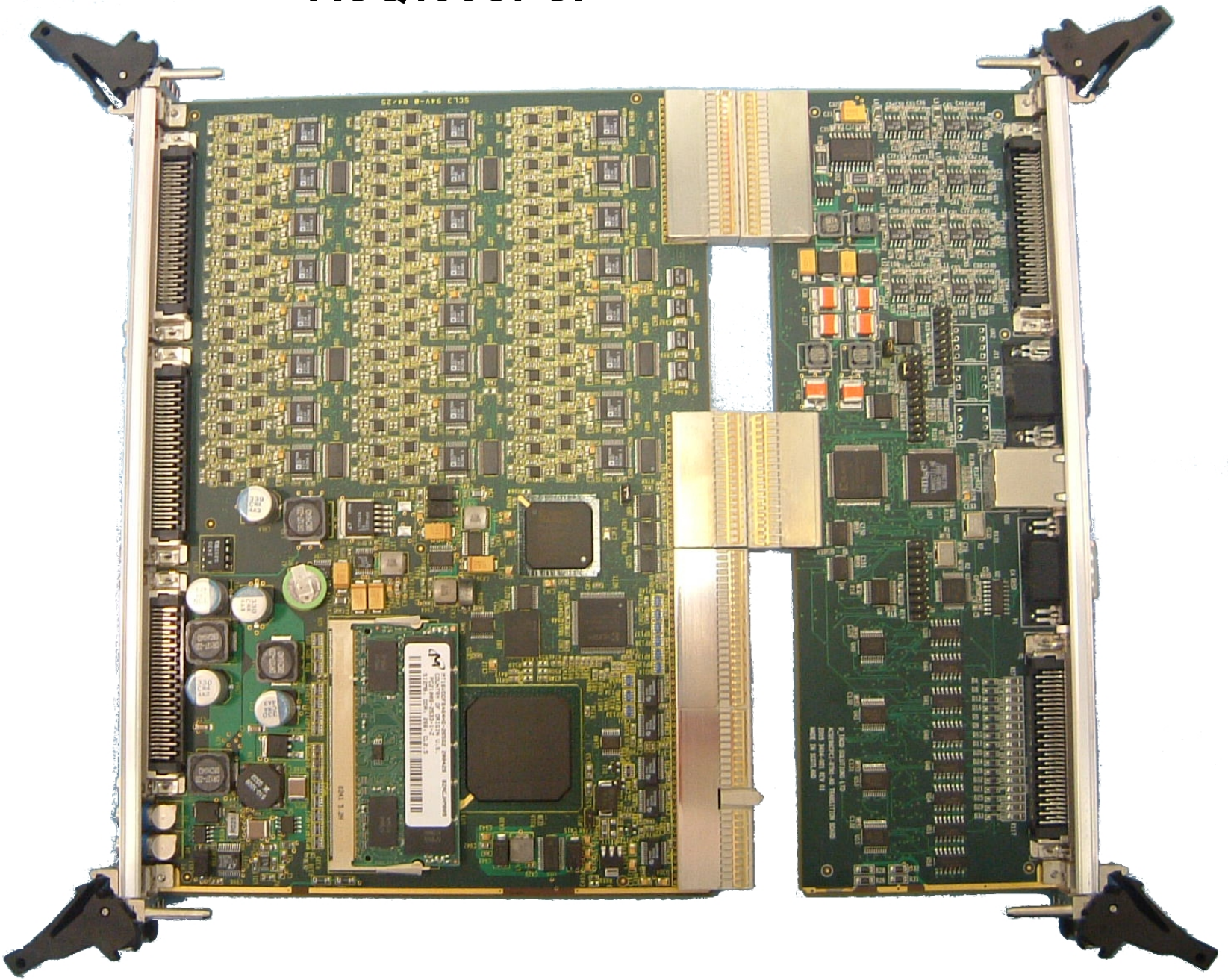
16 AO/
68W SCSI2

100BaseT
Eth RJ45

32 DIO/
68W SCSI2

64 bit, 66MHz PCI bus interface.
Compact PCI Peripheral slot device.
Bus master DMA

ACQ196CPCI



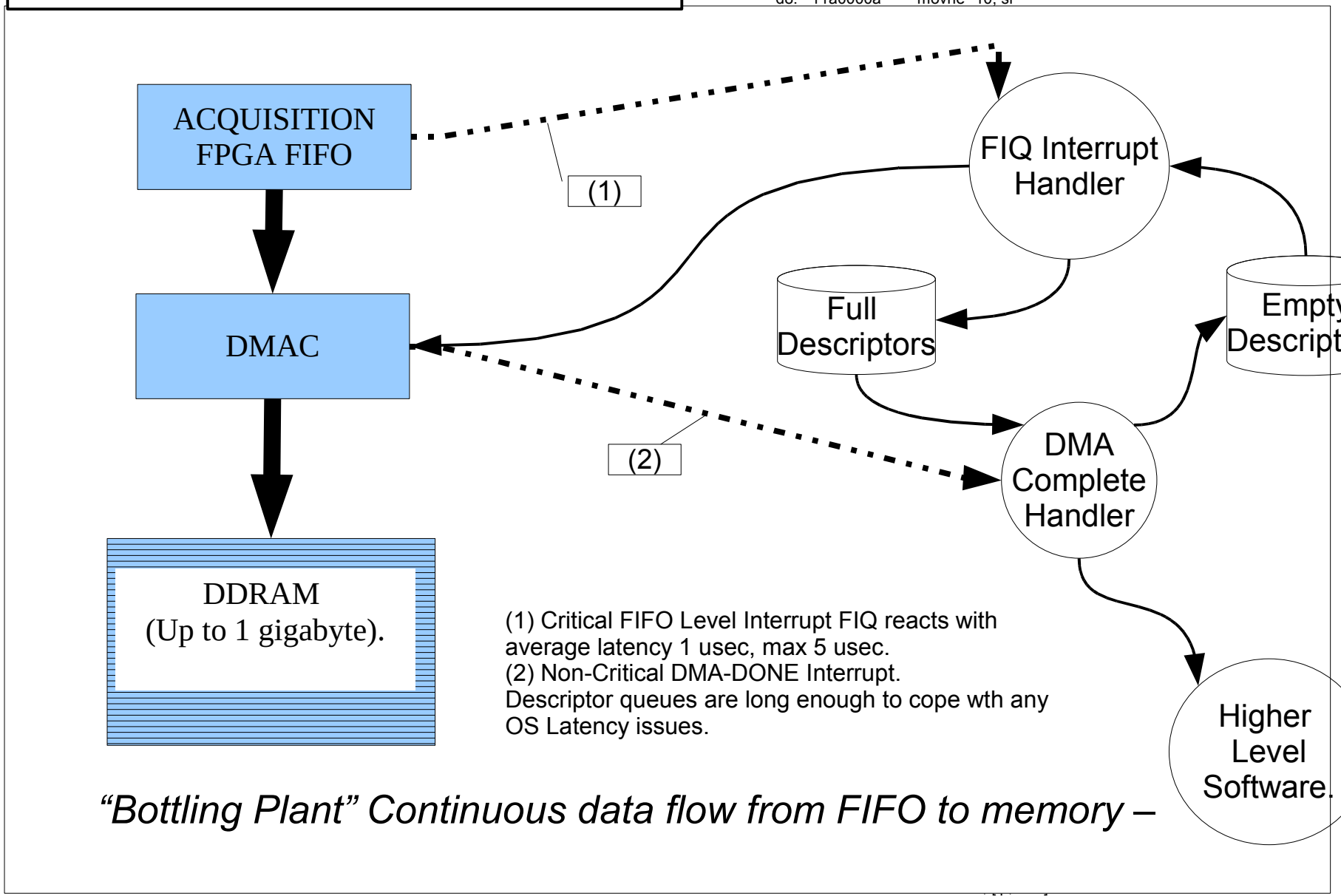
Intelligent Features

- High Performance FPGA, controls data flow, event detect and timestamping, DSP.
- Microprocessor runs Linux, but a single real time interrupt handles critical data. DMA does the work, system is still responsive at 400MB/sec
- 1GigaByte rotating, segmented buffer. Regions of interest may be reserved and returned.
- Roles - Peripheral, Standalone, System Slot
- Linux – Networking is easy.

```
00000000 <acq200_pipe_fiq>:
   0:   e599a008        ldr     sl, [r9, #8]
   4:   e59bd004        ldr     sp, [fp, #4]
   8:   e1a0d40d        mov     sp, sp, lsl #8
   c:   e58bd000        str     sp, [fp]
  10:   e589d080        str     sp, [r9, #128]
  14:   e3180103        tst     r8, #-1073741824        ; 0xc0000000
  18:   158b8010        strne   r8, [fp, #16]
  1c:   138dd001        orrne   sp, sp, #1      ; 0x1
  20:   158bd000        strne   sp, [fp]
  24:   11a0842d        movne   r8, sp, lsr #8
  28:   e28cd048        add     sp, ip, #72     ; 0x48
  2c:   e8ad40ff        stmia   sp!, {r0, r1, r2, r3, r4, r5, r6, r7, lr}
  30:   1a000032        bne     100 <do_stats_wo_next_load+0x4>
  34:   03a000d0        moveq   r0, #208        ; 0xd0
  38:   0a00002b        beq     ec <err_chk+0x1c>

0000003c <rb_put>:
  3c:   e1d410b0        ldrh    r1, [r4]
  40:   e1d400b2        ldrh    r0, [r4, #2]
  44:   e2400001        sub     r0, r0, #1      ; 0x1
  48:   e3c00901        bic     r0, r0, #16384  ; 0x4000
  4c:   e1510000        cmp     r1, r0
  50:   e594000c        ldr     r0, [r4, #12]
  54:   0a00001c        beq     cc <starve+0x18>
  58:   e1811001        orr     r1, r1, r1
  5c:   e7805101        str     r5, [r0, r1, lsl #2]
  60:   e2811001        add     r1, r1, #1      ; 0x1
  64:   e3c11901        bic     r1, r1, #16384  ; 0x4000
  68:   e1c410b0        strh    r1, [r4]
  6c:   e5940004        ldr     r0, [r4, #4]
  70:   e2800001        add     r0, r0, #1      ; 0x1
  74:   e5840004        str     r0, [r4, #4]
  78:   e1a0f00e        mov     pc, lr

0000007c <rb_get>:
  7c:   e1d300b2        ldrh    r0, [r3, #2]
  80:   e1d370b0        ldrh    r7, [r3]
  84:   e1500007        cmp     r0, r7
  88:   0a00002a        beq     138 <do_stats_histo+0x14>
  8c:   e593700c        ldr     r7, [r3, #12]
  90:   e5931008        ldr     r1, [r3, #8]
  94:   e2811001        add     r1, r1, #1      ; 0x1
  98:   e7977100        ldr     r7, [r7, r0, lsl #2]
  9c:   e2800001        add     r0, r0, #1      ; 0x1
  a0:   e3c00901        bic     r0, r0, #16384  ; 0x4000
  a4:   e1c300b2        strh    r0, [r3, #2]
  a8:   e5831008        str     r1, [r3, #8]
  ac:   e3570000        cmp     r7, #0  ; 0x0
  b0:   e1a0f00e        mov     pc, lr

000000b4 <starve>:
  b4:   e5991010        ldr     r1, [r9, #16]
  b8:   e3a08000        mov     r8, #0  ; 0x0
  bc:   e58c803c        str     r8, [ip, #60]
  c0:   e58c0038        str     r0, [ip, #56]

   c4:   e3c11001       bic     r1, r1, #1      ; 0x1
  c8:   e5891010        str     r1, [r9, #16]
  cc:   ea00005c        b       244 <acq200_pipe_fiq_isr_version+0xb4>

000000d0 <err_chk>:
  d0:   e59c0034        ldr     r0, [ip, #52]
  d4:   e01a0000        ands    r0, sl, r0
  d8:   11a0000a        movne   r0, sl
  dc:   1a00002b        bne     190 <acq200_pipe_fiq_isr_version>
  e0:   e59c602c        ldr     r6, [ip, #44]
  e4:   e3a02000        mov     r2, #0  ; 0x0
  e8:   e59c503c        ldr     r5, [ip, #60]
  ec:   e2864014        add     r4, r6, #20     ; 0x14
  f0:   e585a008        str     sl, [r5, #8]

000000f4 <dmac_chain_resume>:
  f4:   eb00000d        bl      130 <do_stats_histo+0xc>
  f8:   e59c3030        ldr     r3, [ip, #48]

000000fc <do_stats_wo_next_load>:
  fc:   e5930020        ldr     r0, [r3, #32]
 100:   e3520000        cmp     r2, #0  ; 0x0
 104:   e28c70b4        add     r7, ip, #180    ; 0xb4
 108:   e2800901        add     r0, r0, #16384  ; 0x4000
 10c:   c2800901        addgt   r0, r0, #16384  ; 0x4000
 110:   e5830020        str     r0, [r3, #32]

00000114 <do_stats_dma_blocks>:
 114:   e2873004        add     r3, r7, #4      ; 0x4
 118:   e7931102        ldr     r1, [r3, r2, lsl #2]
 11c:   e2811001        add     r1, r1, #1      ; 0x1
 120:   e7831102        str     r1, [r3, r2, lsl #2]

00000124 <do_stats_histo>:
 124:   e1a00a2a        mov     r0, sl, lsr #20
 128:   e2873024        add     r3, r7, #36     ; 0x24
 12c:   e200000f        and     r0, r0, #15     ; 0xf
 130:   e7931100        ldr     r1, [r3, r0, lsl #2]
 134:   e2811001        add     r1, r1, #1      ; 0x1
 138:   e7831100        str     r1, [r3, r0, lsl #2]

0000013c <do_stats_nfints>:
 13c:   e5970000        ldr     r0, [r7]
 140:   e2800001        add     r0, r0, #1      ; 0x1
 144:   e5870000        str     r0, [r7]

00000148 <resume_dmac_chain>:
 148:   e3a00000        mov     r0, #0  ; 0x0
 14c:   ee070f9a        mcr     15, 0, r0, cr7, cr10, {4}
 150:   ee100f10        mrc     15, 0, r0, cr0, cr0, {0}
 154:   e1a00000        nop                     (mov r0,r0)
 158:   e3a00003        mov     r0, #3  ; 0x3
 15c:   e58b0000        str     r0, [fp]

00000160 <teeup_next_call>:
 160:   e2863000        add     r3, r6, #0      ; 0x0
 164:   eb00001d        bl      1e0 <acq200_pipe_fiq_isr_version+0x50>
 168:   158c703c        strne   r7, [ip, #60]
 16c:   03a00000        moveq   r0, #0  ; 0x0
 170:   0a00002b        beq     224 <acq200_pipe_fiq_isr_version+0x94>
 174:   e5978018        ldr     r8, [r7, #24]
```

Optimise for Throughput

```
000000d0 <err_chk>:
  d0:   e59c0034        ldr     r0, [ip, #52]
  d4:   e01a0000        ands    r0, sl, r0
  d8:   11a0000a        movne   r0, sl
```



(1) Critical FIFO Level Interrupt FIQ reacts with average latency 1 usec, max 5 usec.
(2) Non-Critical DMA-DONE Interrupt.
Descriptor queues are long enough to cope wth any OS Latency issues.

"Bottling Plant" Continuous data flow from FIFO to memory –

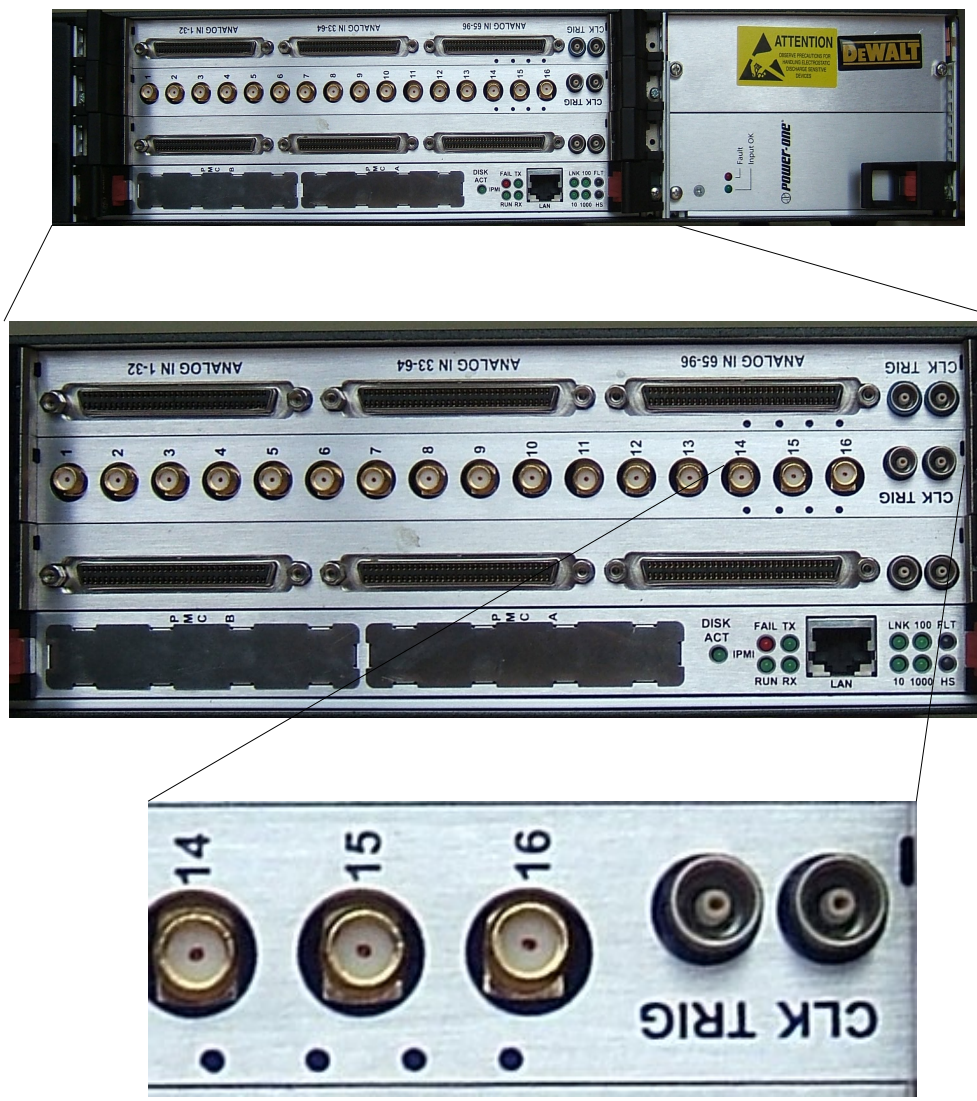
```
b8:   e3a08000        mov     r8, #0  ; 0x0
bc:   e58c803c        str     r8, [ip, #60]
c0:   e58c0038        str     r0, [ip, #56]

  c4:   e3c11001        bic     r1, r1, #1      ; 0x1
c8:   e5891010        str     r1, [r9, #16]
cc:   ea00005c        b       244 <acq200_pipe_fiq_isr_version+0xb4>
```

```
16c:   03a00000       moveq   r0, #0  ; 0x0
170:   0a00002b       beq     224 <acq200_pipe_fiq_isr_version+0x94>
174:   e5978018       ldr     r8, [r7, #24]
```

Transient Capture

- 2x8x25MSPS : 2 gigabytes in 3 sec
- “Traditional Pentium in Slot 1”
- Lots of local disk space
- Compact design, 5 slots spare.

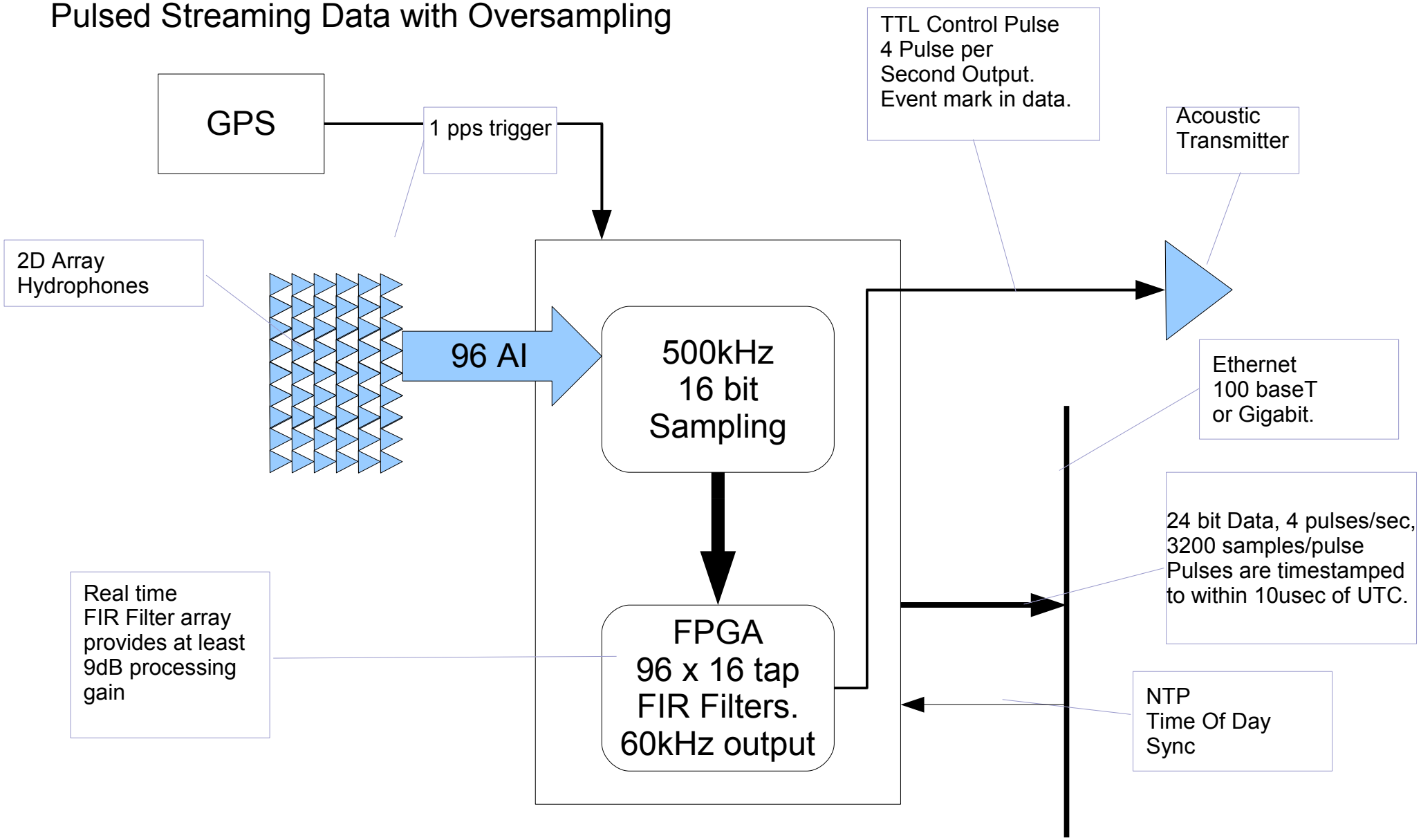
Transient Recorder Networked Satellite



- 2U box, no Pentium
- Application is soft Xray imaging.
- 300 channels, 250kSPS/channel, 3seconds.
- High magnetics environment – network to remote disks

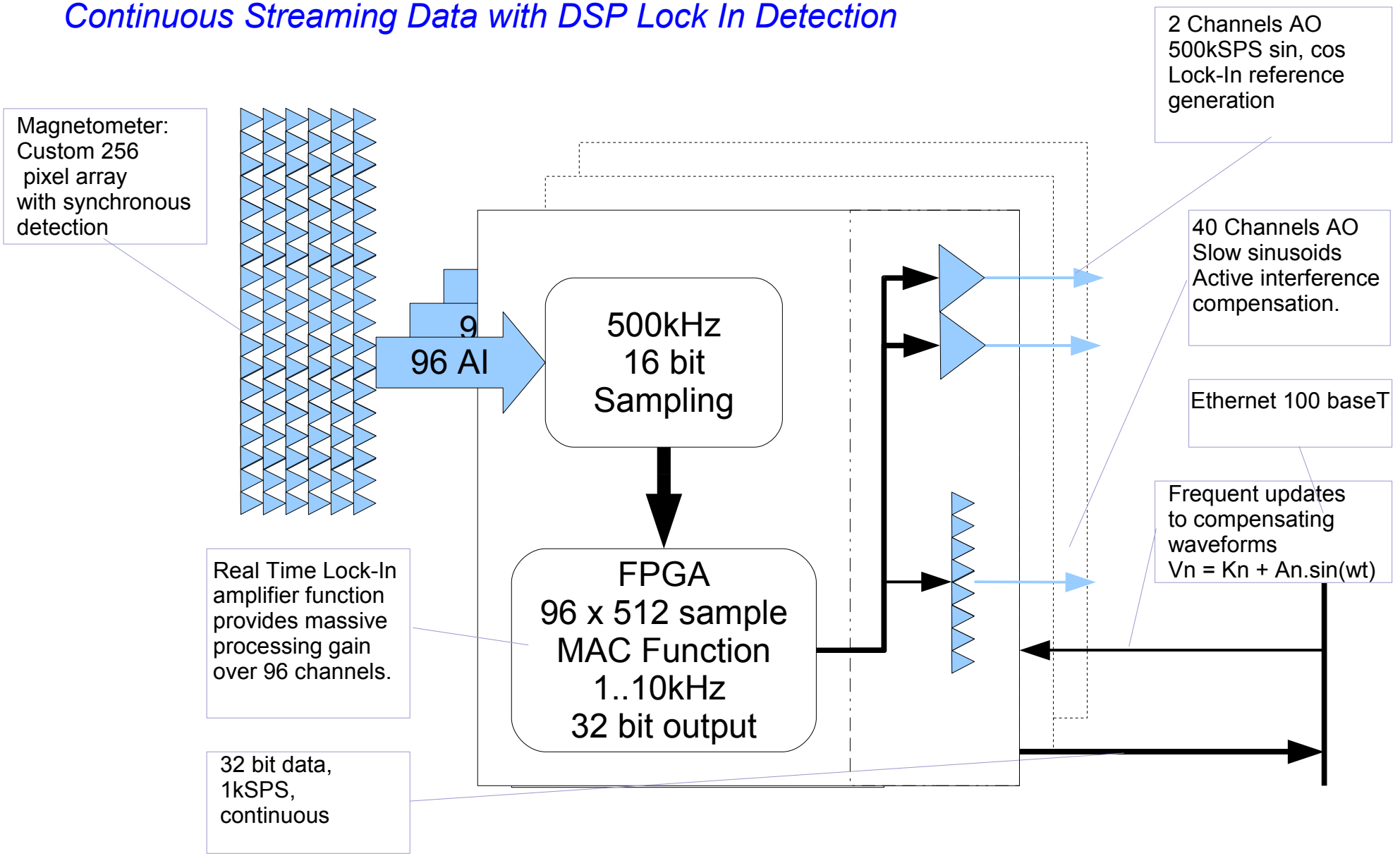
ACQ196CPCI Seismic Survey Application

Pulsed Streaming Data with Oversampling



ACQ196CPCI Medical Imaging Application

Continuous Streaming Data with DSP Lock In Detection



Gyrotron Test Stand
Hybrid Streaming, Transient

- 3600s
- 300ch x 1kHz stream
- 100ch x 250kHz, PreP/Fault triggers
- 16ch x 12MHz, PreP/Fault trigger
- Ethernet System
- MDSplus Thin Client – data push model

Plasma Control

- 300 AI Channels
- Multiple Pentium computers, gigabit low latency links
- Latency: all data in host memory in 20usecs
- 20kHz rep rate

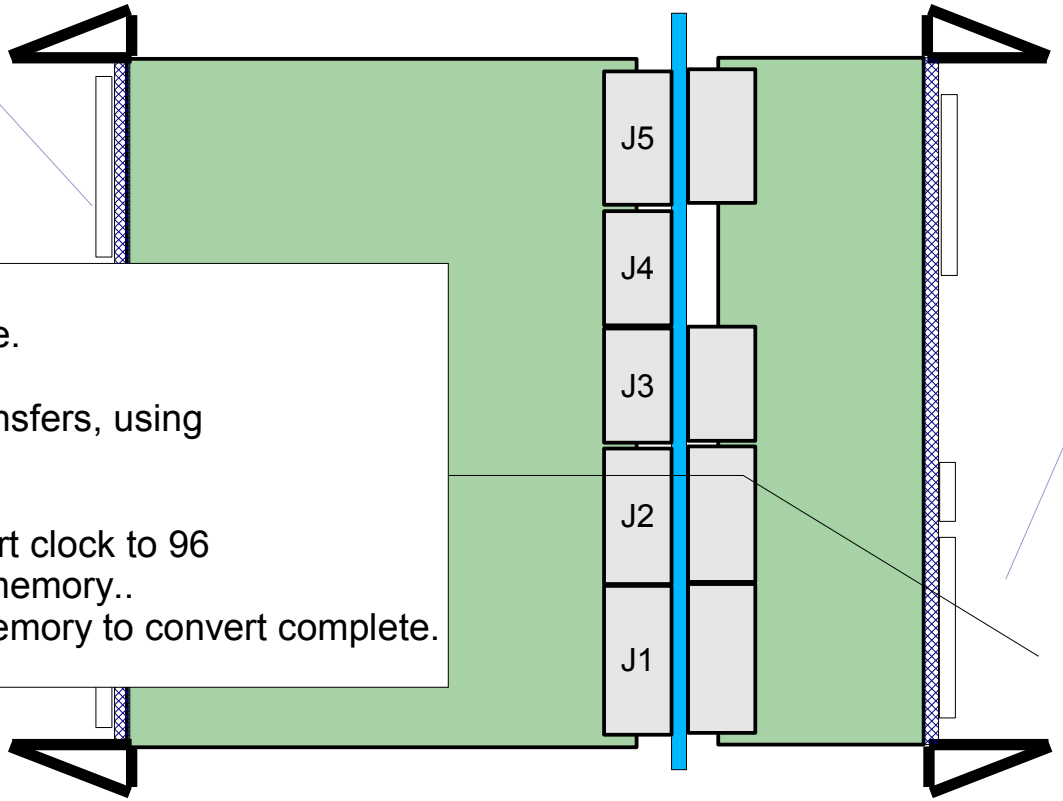
ACQ196CPCI Single Slot Solution for Control

AI – analog input
AO – analog output
DIO – digital IO

ACQ196CPCI, 96 Channels, 250kSPS, 16bit
128MB memory.

Input range: +/-10V, differential, protected to 100V
Can be configured as standalone networked Linux system.
Optional large size FPGA for real time signal processing.

96 AI



16 AO/
68W SCSI2

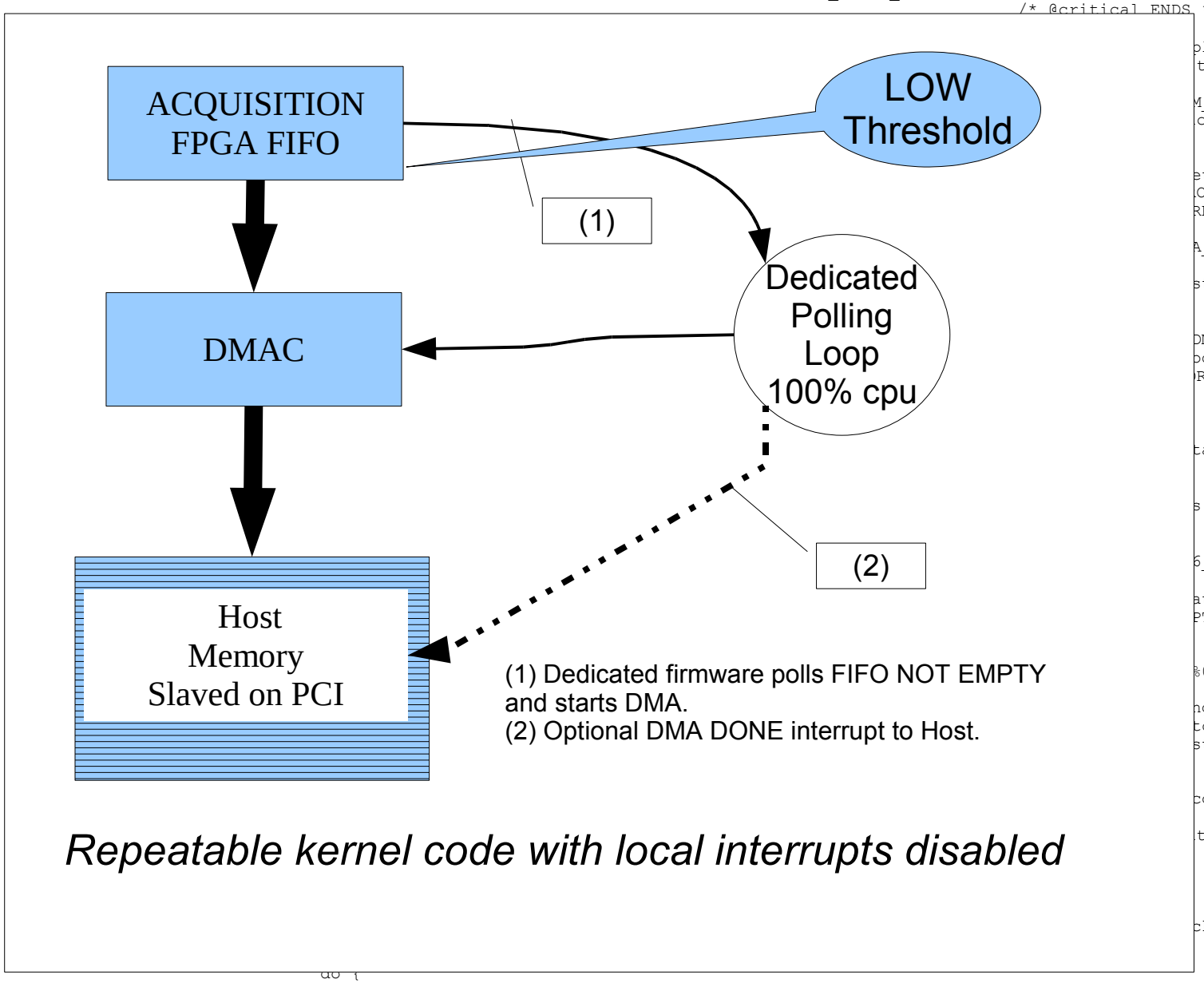
32 DIO/
68W SCSI2

64 bit, 66MHz PCI bus interface.
Compact PCI Peripheral slot device.

Capable of efficient low latency transfers, using
bus master DMA,

Incoming:: sub 10uSec from convert clock to 96
channels data transferred to host memory..
Outgoing: sub 5 uSec from host memory to convert complete.

Custom Kernel Module Optimised for Latency

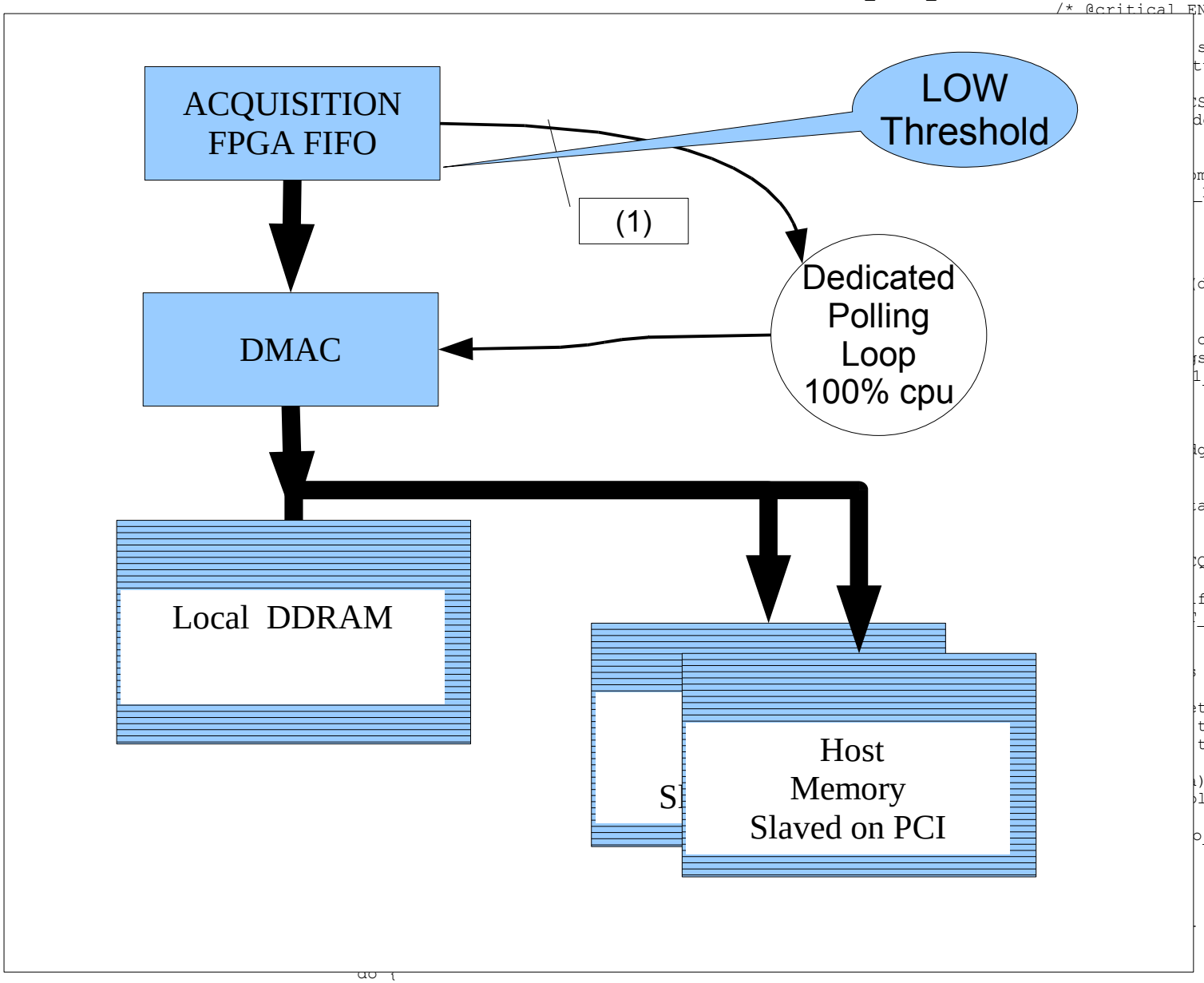


Repeatable kernel code with local interrupts disabled

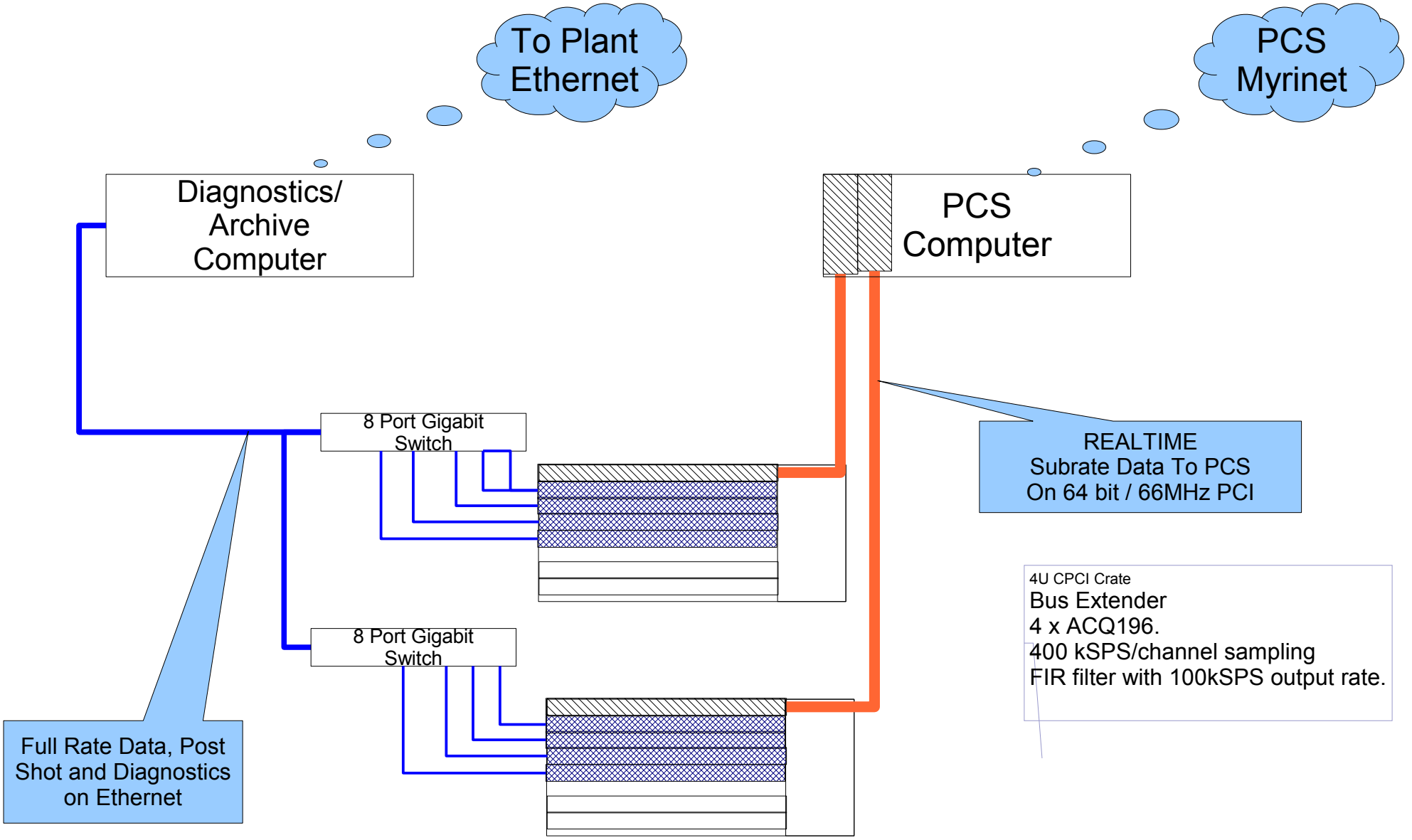
```
DMAC_GO(ai_dma, fifstat);
                                        /* @critical_ENDS */
ble_count == 0){
t0 = dg.status.tlatch;

M_SOFTCLOCK ){
cq32_softClock( 0 );


etion(&ai_dma, 1) != 0){
OR_AND_QUIT(
RROR:DMAC status bad

A_STA(ai_dma));

status.tlatch);


DMA DONE */
odd){
R |=


tatus.tinst);


s.tinst -


6_FIFSTAT;

at)) goto onOverrun;
PTY(fifstat2)) goto


%08x, sent data to 0x%08x

ngs.AI_target,
tch,
st, tcycle);


count++;

ta)){



ck off DMAC with AO data
```

```
do {
        fifstat2 = *ACQ196_FIFSTAT;
        ++dg.status.fifo_poll_count;
    } while(!KICKOFF(fifstat2) && !ESTOP);
}
#endif
```

Scatter DMA: Low Latency, Multiple Target



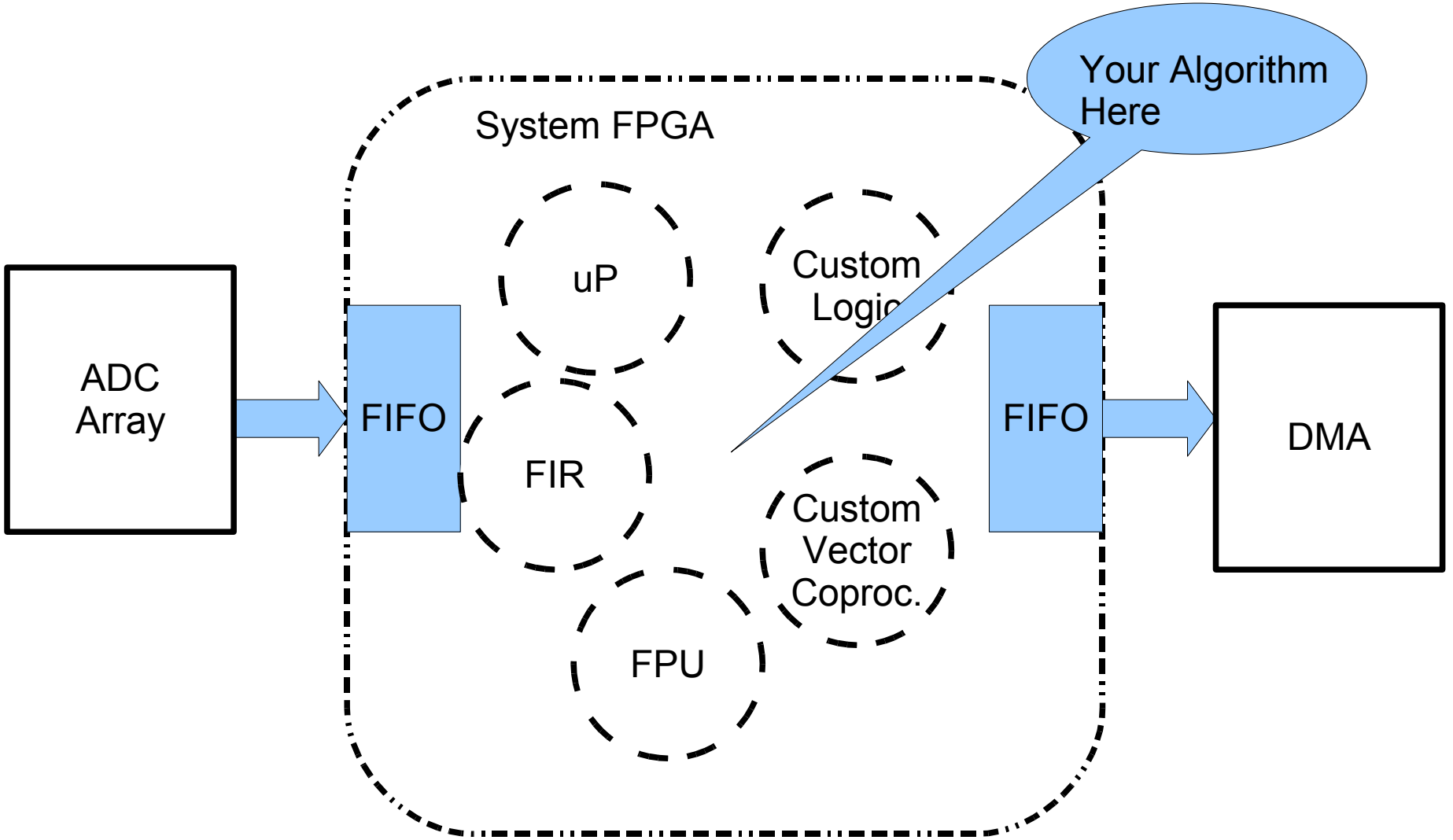
Combined Diagnostics and Control



“You Spec [open standard protocol], We Connect”

- Setup: scripts using ascii commands
- Efficient Data flow using raw binary data
- Backplane, network, same interface.
- Started with Host Pull, but Target Push scales
- “FTP on network replaces DMA on backplane”
- Control script via telnet, ssh, web
- MDSplus server on the box, full ftp client
- Future: web service, DDS, EPICS IOC, LXI?

Inline DSP



Conclusion

- D-TACQ cards give you More:
  - Simultaneous channels, best possible Analog
  - High Bandwidth
  - Deep Memory
  - Firmware operating flexibility
  - Firmware connection flexibility
  - FPGA based general signal conditioning
  - FPGA based custom DSP.