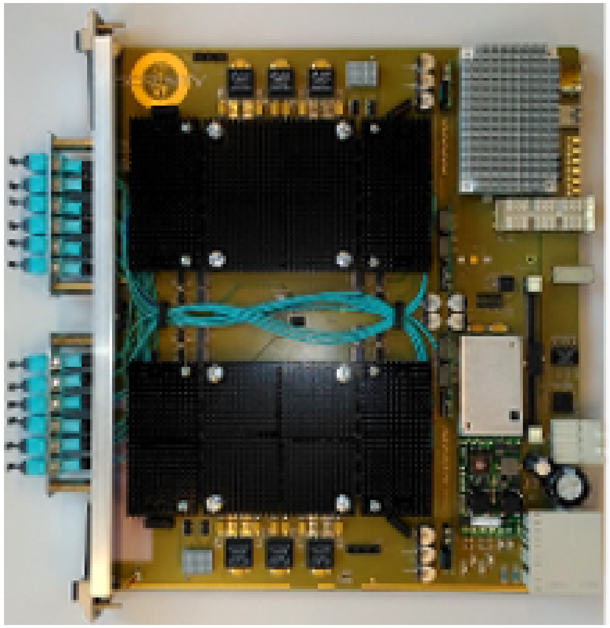
The SERENITY Read-Out Board & Beam Monitors using foils

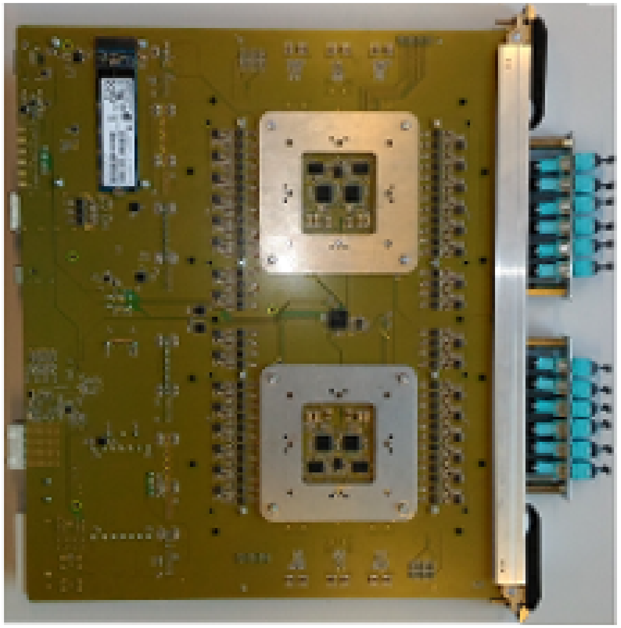
1. SERENITY - overview
2. Key Features
3. Application to Imaging
4. Beam Monitoring Foils

Alex Howard

SERENITY

- 72 x 2 firefly links can run at up to 28Gbps/link
- 2 Daughter Card sites (custom FPGA)
- Carrier card with service FPGA and CPU
- ATCA, but adaptable form factor (e.g. rack/pizza box)



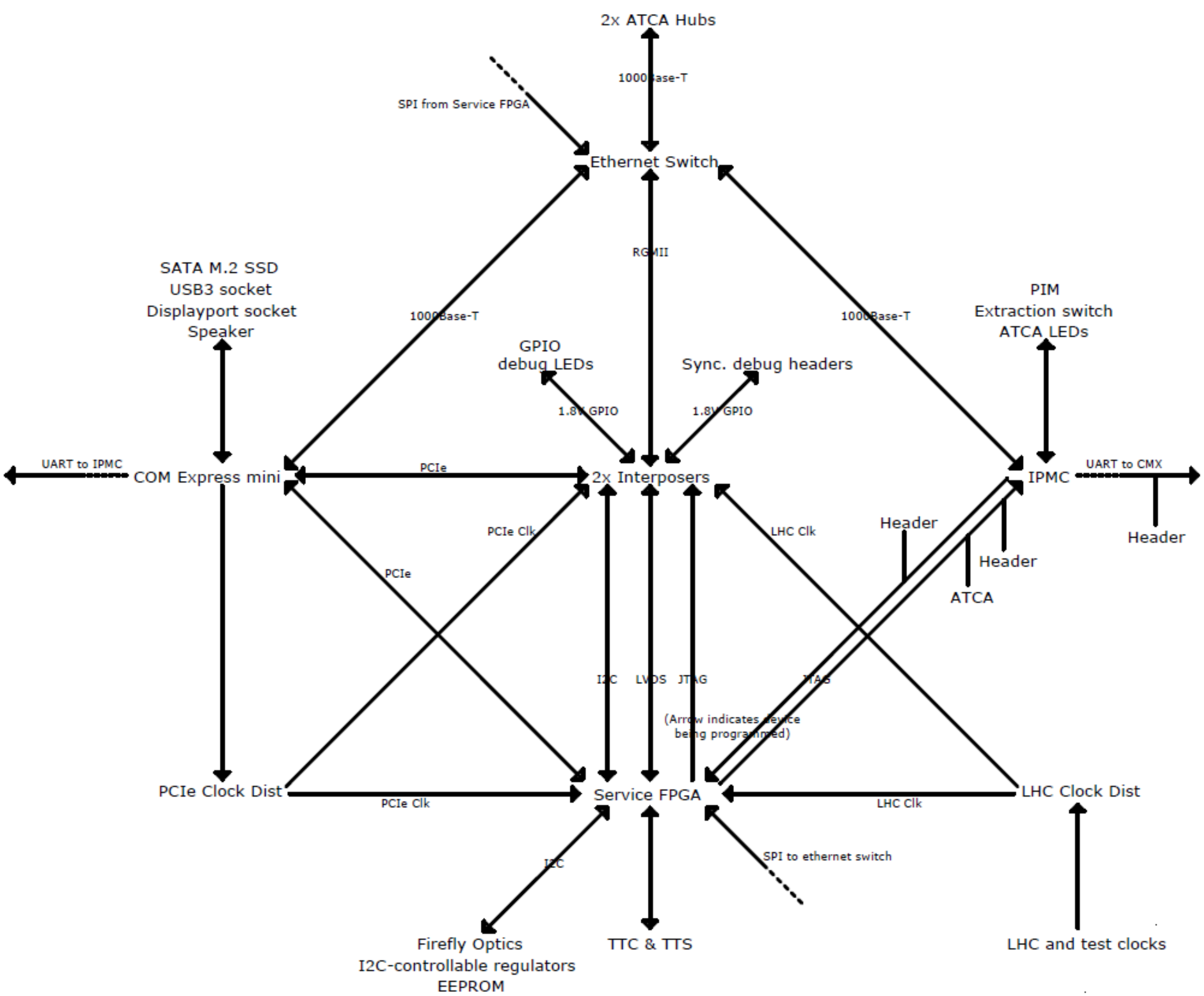


SERENITY Overview

- SERENITY is a read-out board for the CMS Phase-2 upgrade (~2024)
- Essentially a “data engine” capable of processing 5Tb/s
- Main FPGAs mounted on two daughter card sites
  - Reduces complexity of the carrier card
  - Enables customisation and optimisation for a resource efficient FPGA choice
- Firmware and Software stack created in a generic way
- “Payload” concept introduced for algorithm deployment within the FPGA
  - Removes dependency on the infrastructure/fabric
  - Optimises firmware development and I/O functionality
- A service FPGA and CPU are provided on the board
  - Flexible control routing (slow, medium and firmware upload)
  - Fast PCIe protocol used for gathering “slow” control information (up to 800Mb/s)
  - PCIe can also be used for uploading of the firmware (real-time algorithm tuning?)

Adaptable Platform

- The carrier card has a very flexible and open connectivity:



Adaptable Platform

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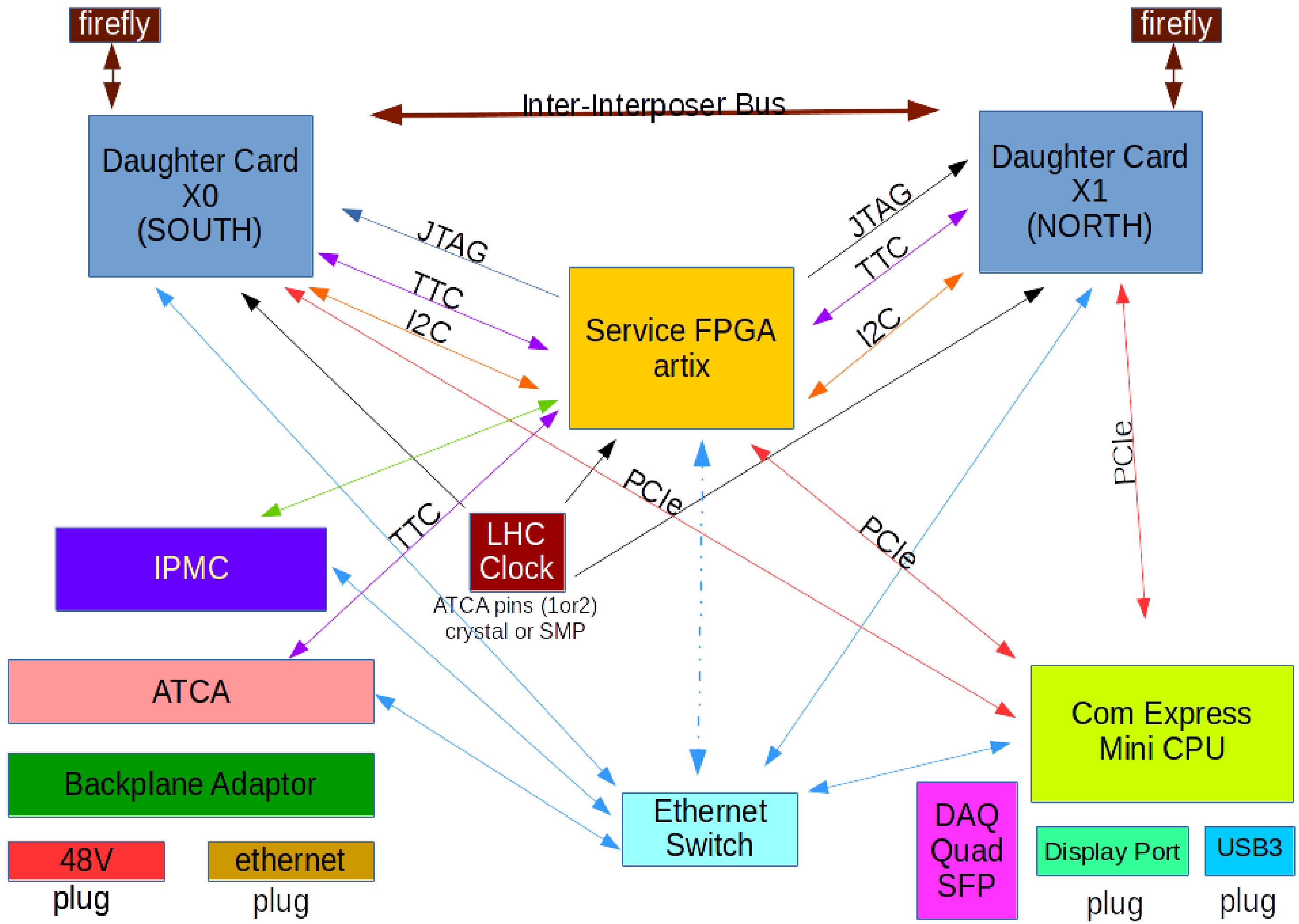
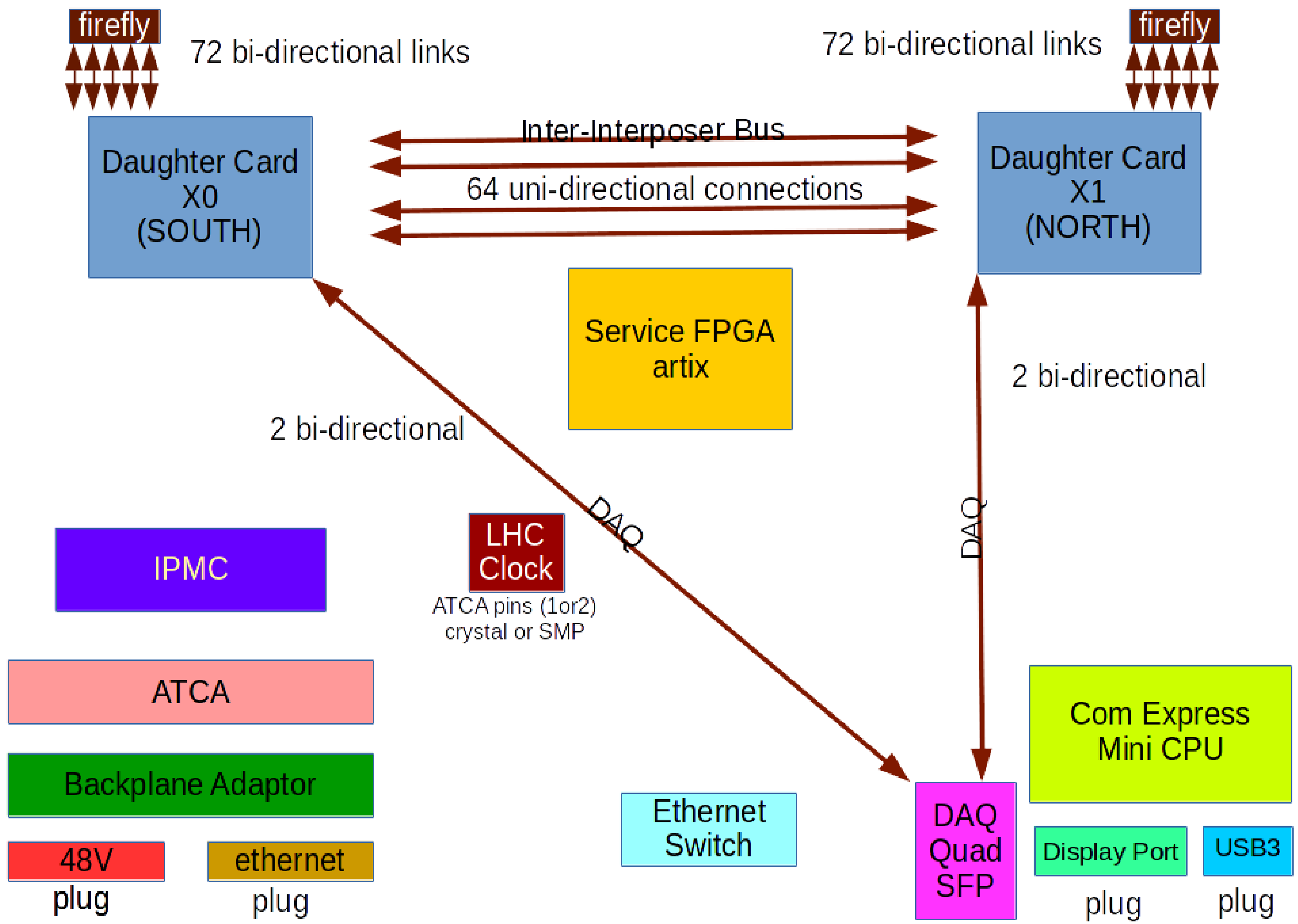


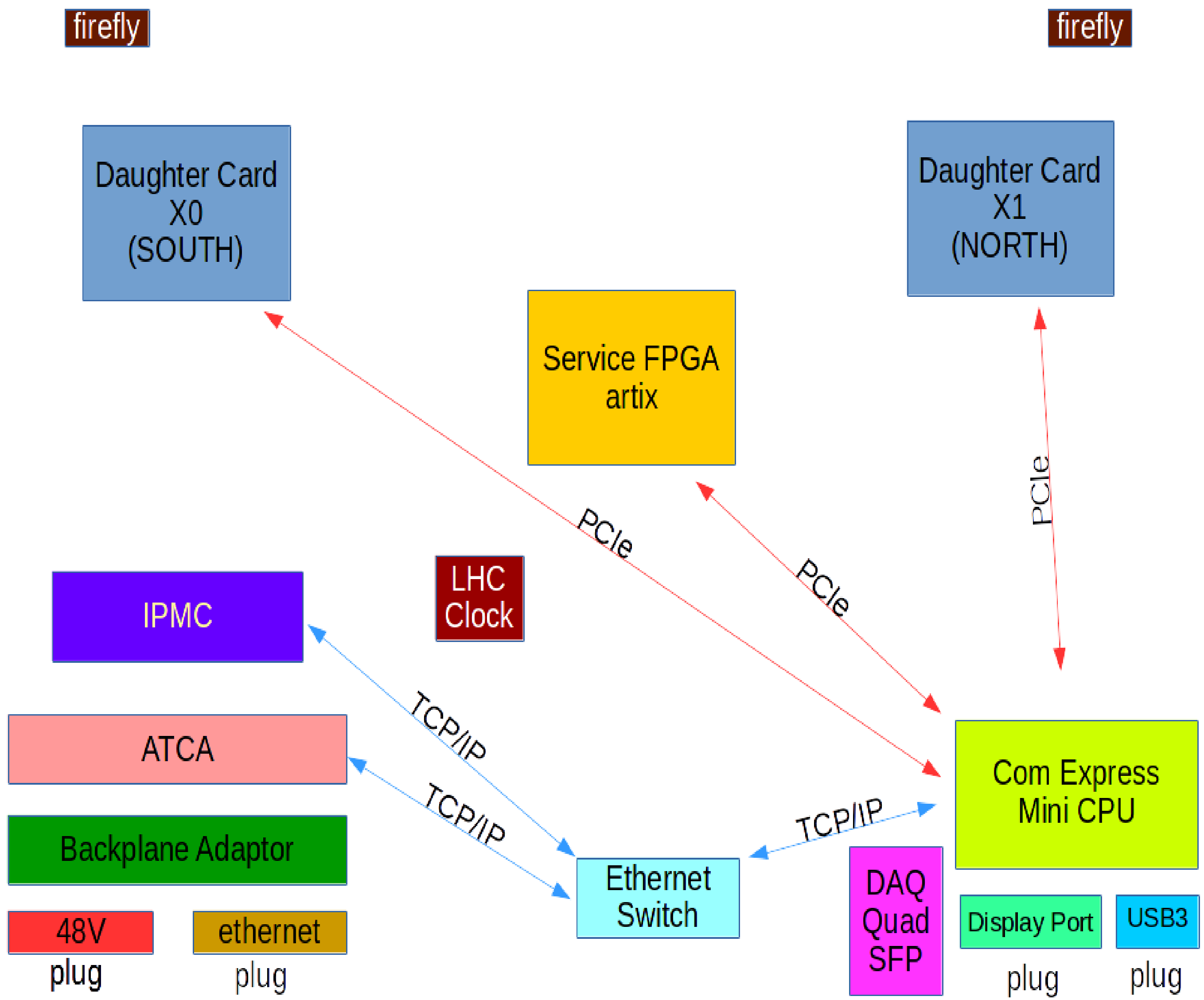
Adaptable Platform - Data

- Designed for data throughput (data engine):

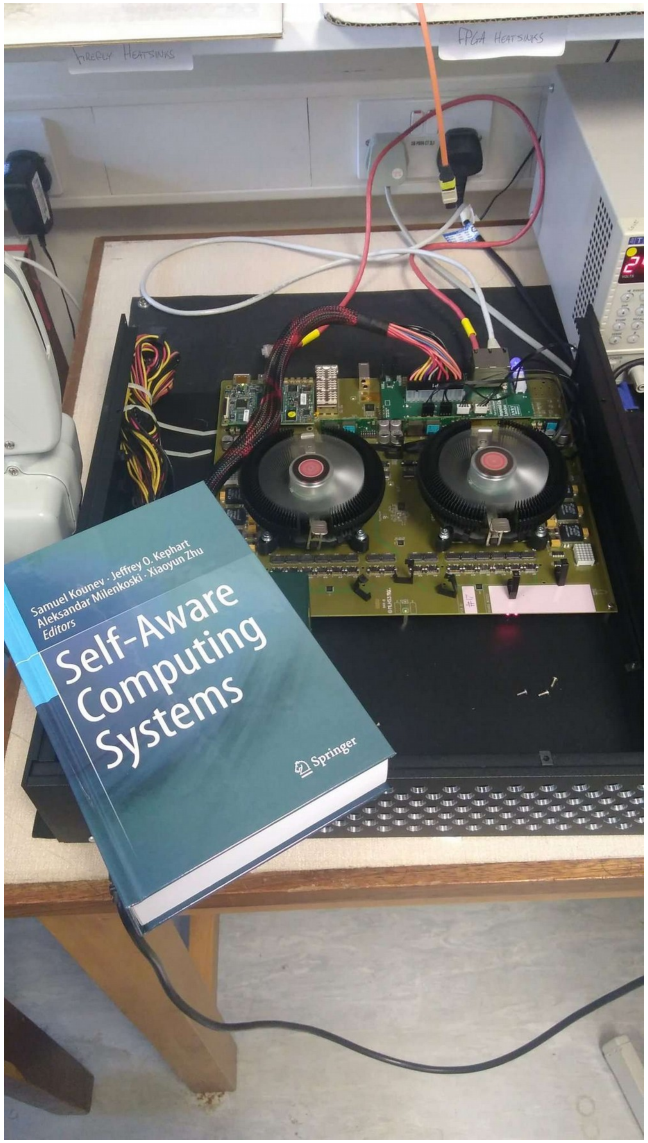


Adaptable Platform - reprogramming

- But also FPGAs are very re-programmable:



Smart Control Architecture



- Software and Hardware:
  - Firmware framework (EMP)
    - “slow” control (IPBUS) up to 0.5Gbps (GbE), 0.8Gbps(PCIe)
  - hardware control (SMASH)
    - register access software (µHAL)
- Written in a modular and component manner
  - User can be decoupled from the actual hardware
  - Algorithms can be developed, deployed and tested independently of the underlying architecture
  - Firmware is more robust and faster to turn around

SERENITY - imaging

- Very high data rates (~5Tbps/board) are probably not applicable to medical imaging
- A benefit could be the FPGA approach (pipeline processing, adaptable algorithms, local memory)
- The SERENITY system includes a separation between the infrastructure (fabric) and the algorithm (payload)
- In addition the control architecture is also “smart”
- Algorithm development for real-time imaging?
- Real-time response – reactive system?
- Adaptable and open architecture
  - tailored for what’s required
- System is ready to be exploited!

Beam Monitoring - history

- Some years ago I was shown a tiny beam monitor for an ion tandem accelerator (AMS – atomic mass spectrometry)
- The sensor was AlN or SiN with etched electrodes front and back to measure the **current** of the beam with spatial information
- Thickness of material only **50 – 150 nm**
  - **Choice of material means it can be quite flexible and even withstand 1 bar**
  - **Chemical etching facilitates achieving such thin wafers**
  - **However, still fragile if touched (like bursting a bubble)**
- A Geant4 collaborator was discussing beam monitoring using conventional (strip) detectors and the excessive multiple scattering/beam interaction from them
- I suggested he look at ultra-thin foils
- I believe these devices have been manufactured with diameters of 10s centimetres – most likely free standing or with support bars/frame
- However, they have gone silent for the last 2 – 3 years – exploitation?

Foil Manufacturers (1)

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- Etched Si3N4 with outside support frame
- Very thin free standing (I believe), can withstand 1 bar
- Formerly hsfoils in Finland, now amptek foil specs

Specifications

	C1	C2
Thickness (Si3N4)	150 nm	40 nm
Aluminum Coating (Grounded)	250 nm	30 nm
Window Diameter	6.3 mm	5 mm
Window Area	30 mm^2	20 mm^2
Grid Type	Hexagonal Si, 15 µm thick	
Open Area Grid	80%	80%
Helium Leak Rate	<1 x 10^{-10} mbar l/s	Do not put the C2 window into He purge !
Operating Temperature	-55°C to +150°C (0 bar pressure differential)	
	-40°C to +85°C (1 bar front pressure differential)	
Pressure Testing for C1 and C2 Windows:	1.6 bar front pressure differential for 10 seconds	
	10 cycles of 1 second duration with 1.6 bar front differential pressure	

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Foil Manufacturers (2)

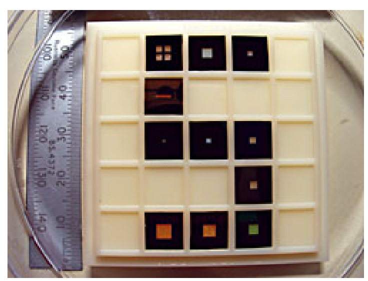
- Same Si_3N_4 material, probably etched
- Silson is a small UK company
- Rely more on a support frame (200µm), smaller area than hsfoils?
- http://www.silson.com/

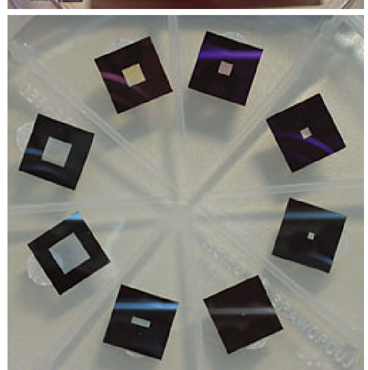
Silson

CONTACT US HOME

- > Standard windows
- > Multi-frame arrays
- > Large area windows
- > Multi-element windows
- > Windows for TEM
- > Bespoke service
- > MEMS Prototyping
- > Lithography wafers
- > Zone Plates & Lithographic Products
- > Microfluidic Cells

Since 1994, Silson Ltd has been supplying ultra-thin membranes and related lithographic products to Corporations, Universities and Government Research Laboratories throughout the world. Products are extensively used within the x-ray and e-beam communities but additionally Silson is now able to offer a MEMS prototyping service.





Standard silicon nitride membrane windows

The standard range of Silson silicon nitride membrane windows consist of square silicon nitride membranes in square silicon supporting frames. The standard frame sizes are: 5.0, 7.5 and 10.0 mm.

The default frame thickness is 200 µm but we are also able to offer the full range of membrane thicknesses on 381, 525 and now 100 µm thick substrate stock. The standard membrane sizes are: 0.25, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0 and 5.0 mm

The maximum membrane size within a 5.0 mm frame is 1.5 mm and the maximum for a 7.5 mm frame is 3.0 mm. Otherwise, the full range of membrane sizes is available within each of the standard frame sizes. The following range of standard membrane thicknesses is available: 30, 50, 75, 100, 150, 200, 500 and 1000 nm.

If your preferred design is not covered by the above permutations then we may able to help you with one of our other products.

Use the standard product finder to see if your preferred permutation is available. go

Beam Monitoring – way forward?

- Ecole Polytechnique (Paris) exploiting this technology
- Since the initial introduction/idea they have been quiet
- We could go ahead and recreate the detector?
- Relies on beam current
  - SiN is used an insulator, probably also creates signal (ionisation chamber approach)
  - Electrodes back and front could give 2-D beam profiles
  - Average response (i.e. non-event based)
- What’s required?