LabVIEW Real Time for High Performance Control Applications

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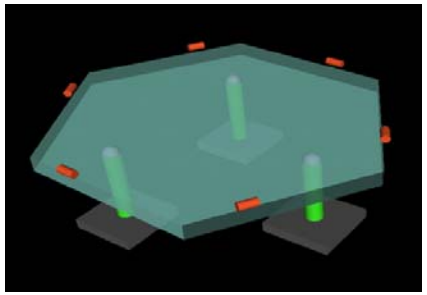
Why talk to me?

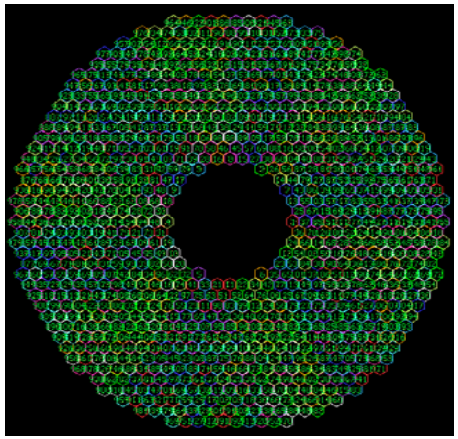
Learn about a GREAT platform for fast development of complex real-time applications

- Faster matrix-vector multiplication algorithm (3k x 3k matrix, <1 ms, 1 week development)
- FPGA based deterministic communication protocol for distributed 15k x 9k matrix-vector multiplication (2 weeks)
- Faster, problem geometry-aware, algorithm for solving set of (non)linear equations applied to PDEs (4 weeks)
- GP-GPU and more…

Matrix Vector Multiply



- At the heart of many control algorithms

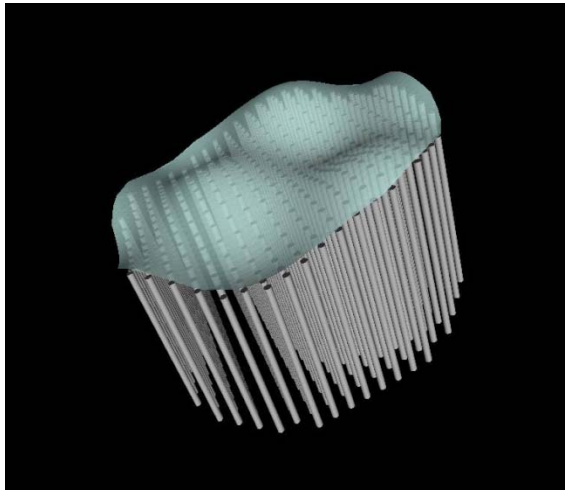


- Use Case: E-ELT M1 Mirror
  - 1 millisecond
  - 3k x 3k matrix by 3k vector
  - Off-the-shelf HW
- Solution: new multiplication algorithm
  - 750 µs (worst case)
  - Dell 7400T (2x2.6 GHz Quad-Core Xeon)
- GPU (dual Tesla): 850 µs

M1 – mirror
984 hexagonal mirrors
6 sensors/3 actuators each

Matrix Vector Multiply (cont.)

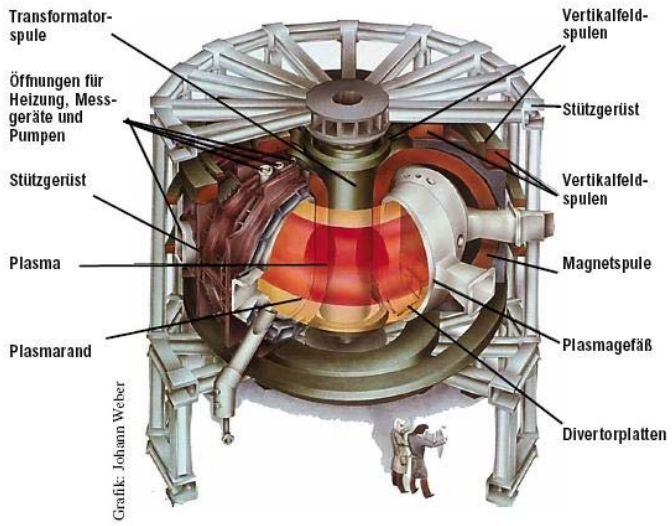
- Use Case: E-ELT M4 Mirror
  - 9k x 15k matrix by 15k vector
  - millisecond range
  - Distributed computation
    - Deterministic communication
    - On-the-fly data recombination
- Solution: custom LabVIEW FPGA protocol
  - Up to 107 MB/s
  - f32 math, retries, configurable, …
  - 2 weeks



M4 – mirror
6000-8000 actuators

(Non)Linear Elliptic Partial Differential Equations

- Used in many control algorithms
  - PDE to model the system
- Use Case: Tokamak
  - 1 millisecond
  - 39x69 grid
- Solution: new geometry-aware algorithm
  - 111x63 grid (6993x6993)
  - 7th order RHS polynomial
  - < 1ms (4 iterations, error 10^{-5})



Grad-Shafranov PDE

$$R\frac{\partial}{\partial R}\left(\frac{1}{R}\frac{\partial \psi}{\partial R}\right)+\left(\frac{\partial^2 \psi}{\partial Z^2}\right)=-\mu_o R J(\psi)$$