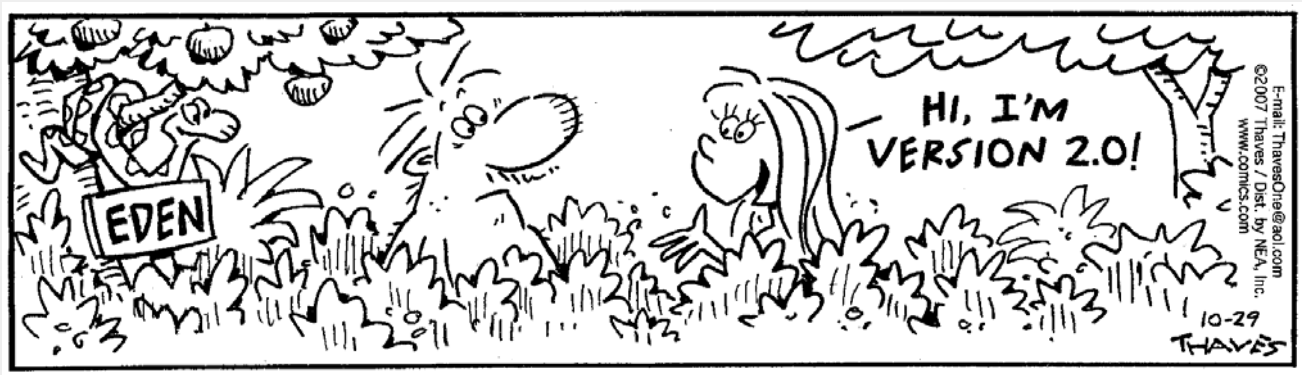
OpenGGCM

Prepared by Jimmy Raeder (who could not attend this time)

Given by Masha Kuznetsova (thanks, Masha!)



CCMC meeting, Puerto Rico, November 2007

Model development and use, so far

- OpenGGCM 3.1 delivered to CCMC in 2007
  - Improved robustness
  - Outputs along satellite tracks
  - Lots of minor bug fixes
  - Everything under subversion now
  - Collection of analysis/plot tools
- 3d visualization with Visit (LLNL) now, file reader plugins available
- A number of different grids is now available at CCMC for different purposes
- ~250 runs at CCMC, more at UNH
- Initial code porting to PS3/CBE (Cell Broadband Engine) architecture (see below)
- OpenGGCM website: http://openggcm.sr.unh.edu/wiki/index.php/Main_Page
- With our own 340 CPU cluster at UNH (Zaphod) runs with 30-100 million cells are now routine.

Model development and uses, underway

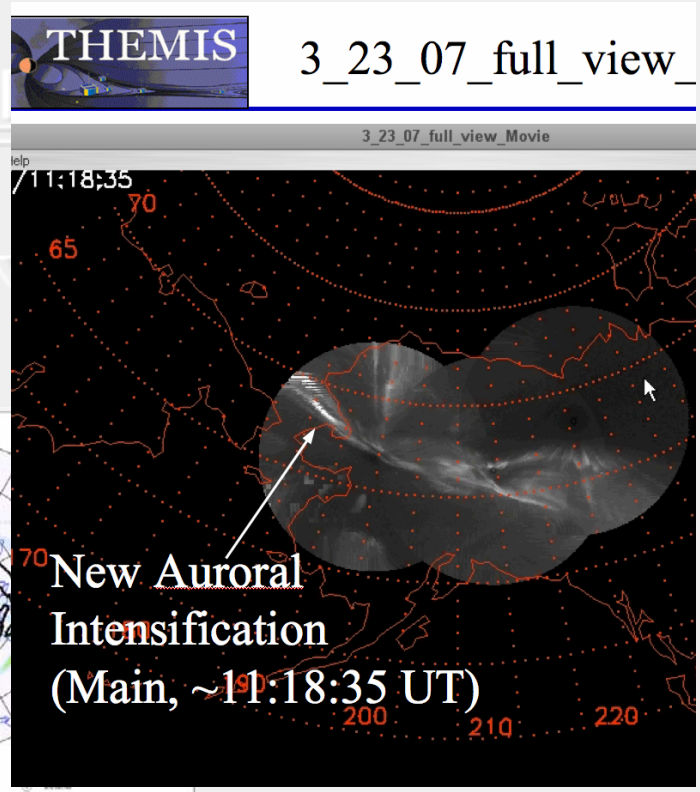
- RCM and CRCM coupling effort ongoing.
- New LWS/NSF "strategic capabilities" funding for:
  - CTIPe integration (w/ Tim Fuller-Rowell, Naomi Maruyama, CU)
  - RCM integration (w/ Frank Toffoletto, Rice)
  - CRCM integration (w/ Mei-Ching Fok, GSFC)
  - New unified potential solver (Art Richmond, NCAR)
  - RB module integration (Mei-Ching Fok, GSFC, Anthony Chan, Rice)
  - Extensive validation and verification.
- UNH group has grown:
  - Wenhui Li (CTIPe, validation, THEMIS support)
  - Eddie Kaghashvili (RCM coupling, THEMIS support)
  - Alex Vapirev (CRCM coupling)
  - Larry Kepko (THEMIS data analysis and model comparisons)
  - Doug Larson, Burlen Loring, N UG students (code maintenance, visualization, etc.)
  - Huyn-Ju Kim (graduate student)

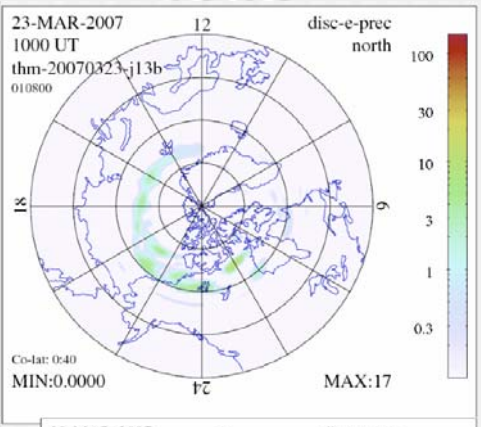
Model development and uses, contd.

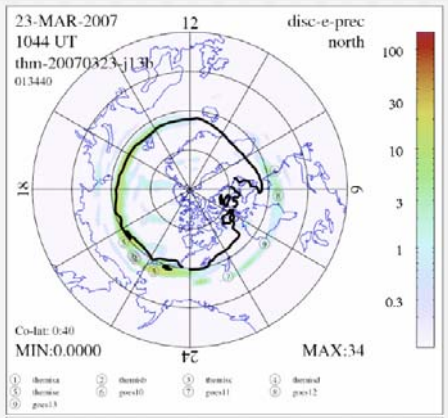
- OpenGGCM developer/user workshop at UNH, October 10-12, 2007.
- Dedicated support for THEMIS events since early 2007.
- THEMIS - OpenGGCM support page: http://themis.sr.unh.edu/index.php?n=Main.HomePage
- THEMIS event runs so far:
  - 2007-03-23: "First Light" substorm (V. Angelopoulos, J. Raeder, and others).
  - 2007-03-24: Storm interval, -80 Dst, with highly interesting oscillations and x-lines near the dusk flank (L. Kepko).
  - 2007-06-21: IP shock impact (E. Kaghashvili)
  - 2007-06-03: Plasma capture and CDPS formation at the subsolar magnetopause (W. Li)
- THEMIS now focuses OpenGGCM science on substorms. Note that THEMIS prime substorm phase begins February 2008, through April 2008.
- THEMIS level 2 data are freely available: http://themis.ssl.berkeley.edu/index.shtml

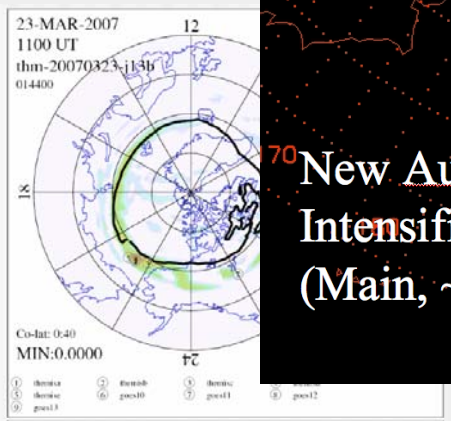
Science highlight Ia: 2007-03-23 substorm

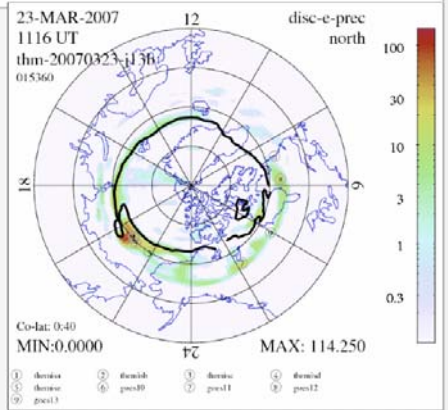
- Northern hemisphere, discrete e- flux (aurora) shown here.
- Clear onset ~2200 MLT, 1044 UT.
- Clear westward traveling surge (WTS) in good agreement with observations, see THEMIS GBO image on right.
- THEMIS footpoints map directly into WTS (T96 gets that wrong).
- THEMIS observes the corresponding flows in the dusk flank, next slide.
- Caveat: real substorm is triggered by NBZ turn, OpenGGCM substorm is ~15 min early and not externally triggered.

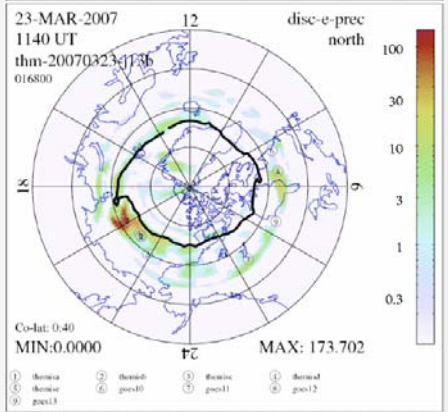


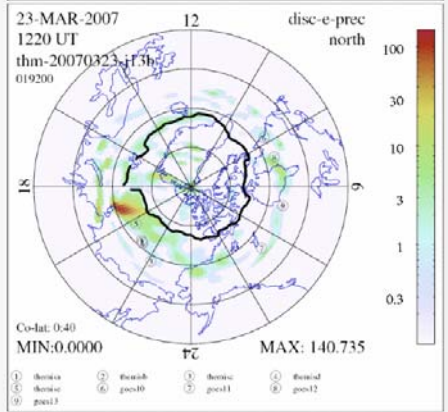






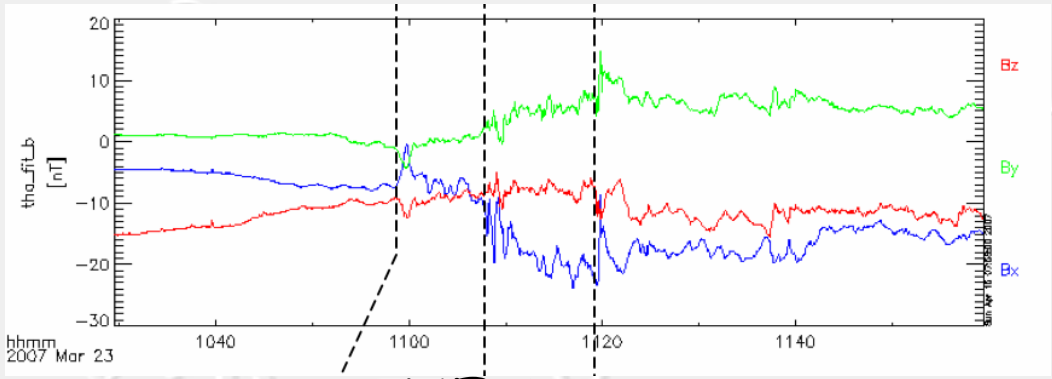




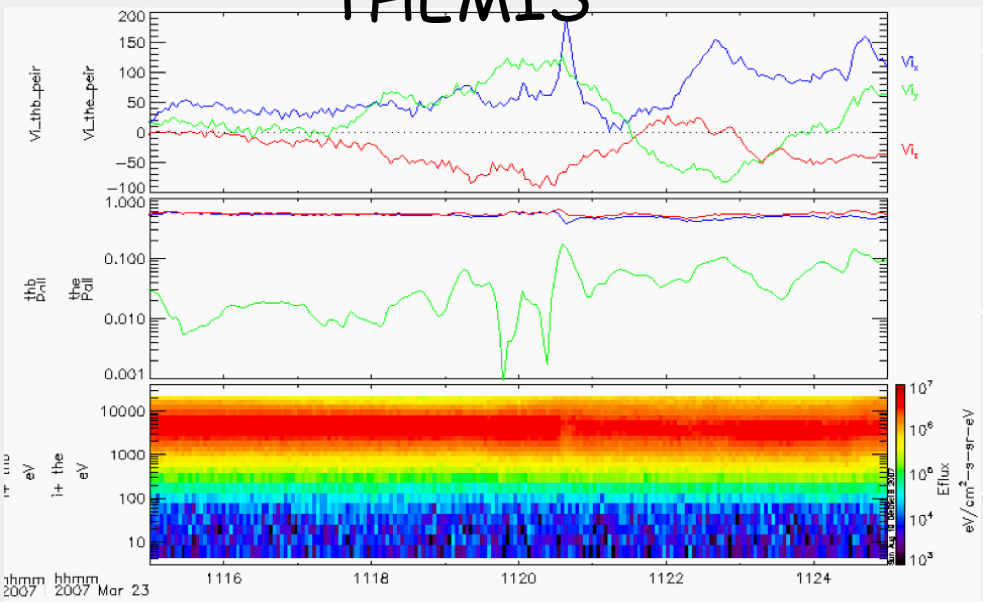


Science highlight Ib: 2007-03-23 substorm

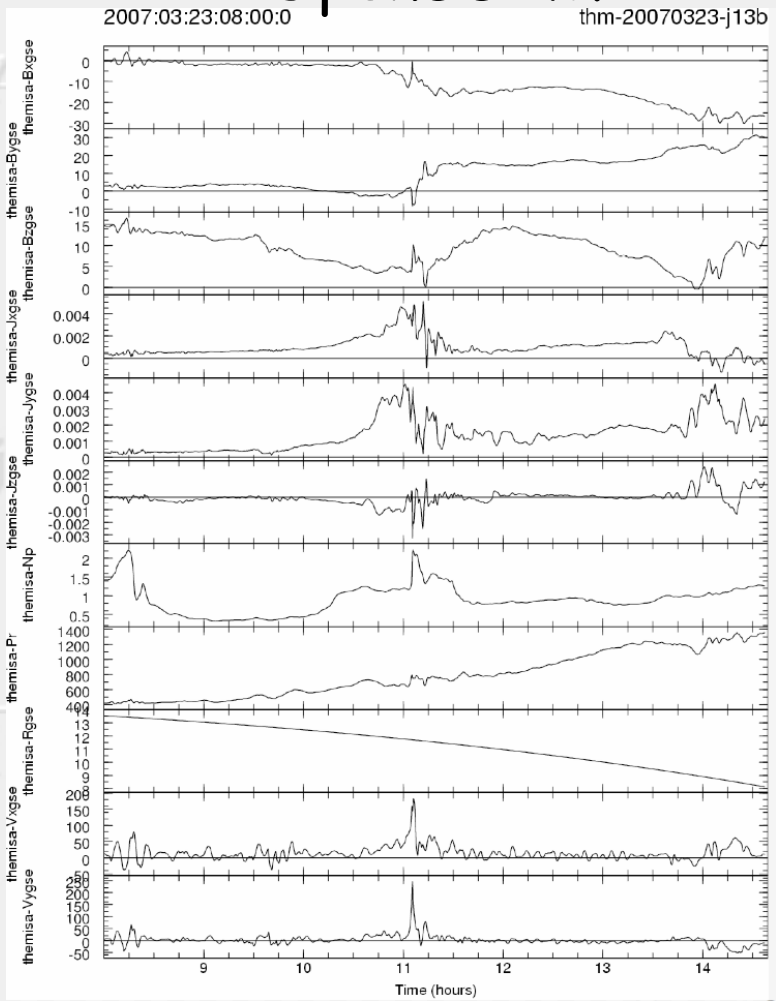
- Model-data comparisons:
  - Dipolarization (Bx, By, Bz model: top 3 panels right, THEMIS: top panel below).
  - Flow surge: (OpenGGCM Vx, Vy, 2 lower panels on the right, THEMIS: bottom plot below, blue: Vx, sunward surge).
  - Watch out for different time scales on these plots.



THEMIS



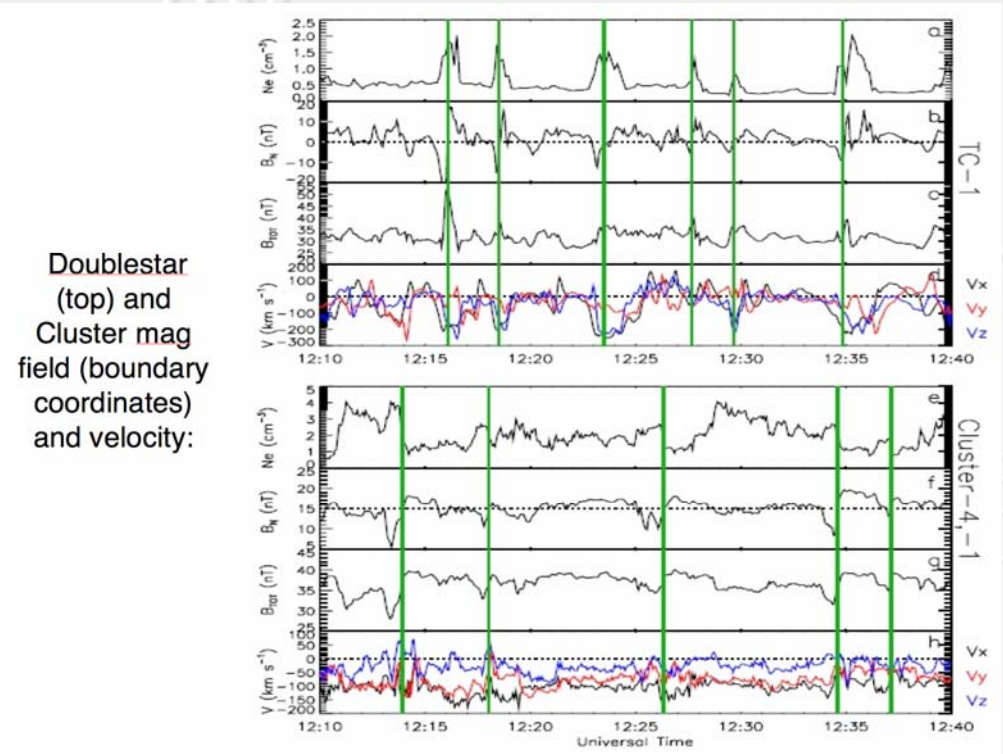
OpenGGCM

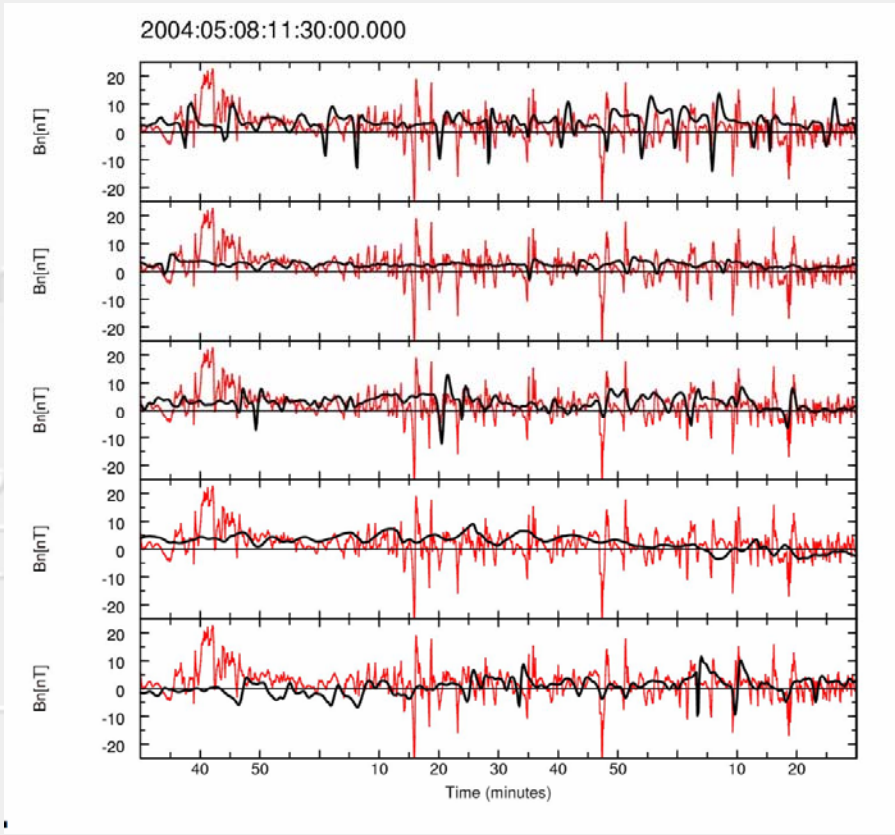


Science highlight IIa: 2005-05-08 Cluster-DS1 FTEs

- Cluster and DoubleStar DS1 observe a series (>10) FTEs near dawn magnetopause (Marchaudon et al., Annales Geophysicae, 2005).
- OpenGGGM (right panel, top, B-normal to MP, red: data, black: OpenGGCM) reproduces FTEs very well: cadence, polarity, amplitude, duration, ...
- Lower panels show same quantities, but lower resolution and/or larger diffusivity: FTEs are less realistic or disappear. Lesson: need sufficient resolution, but results are not very sensitive to microphysics.

Doublestar (top) and Cluster mag field (boundary coordinates) and velocity:





Science highlight IIb: prediction for FTE occurrence

- The 2005-05-08 FTE *OpenGGCM* simulations showed an unexpected result: all FTEs formed near sub-solar MP, AND all FTEs move dawnward.
- 6 runs: (+By,-By) and (summer,zero,winter) tilt.
- Color coded: normal magnetic field on the magnetopause (approximately).
- FTE hemisphere depends on tilt and sign of By:
  - dawn FTEs only for summer/-By and winter/+By.
  - dusk FTEs only for summer/+By and winter/-By.
  - FTEs in both hemispheres if tilt ~=0.
- Contrary to all existing models!

QuickTime™ and a YUV420 codec decompressor are needed to see this picture.

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The future

The crystal ball keeps growing!

Thanks!

If time permits, look at OpenGGCM on PS3, next slides.

"No, no. That's my old crystal ball. We're going to use my new high-definition model."

OpenGGCM on a Playstation 3

Computing: The Old Days…

15 years ago one would have needed something like a Cray Y/MP:

- 8 processors
- ~ 1 GB memory
- ~ 8 x 0.2 Gflops
- ~ $10M
- ~ 200 kW power/cooling
- ~ $1M/y operations.

First global models ran on such machines.

Photograph courtesy of Charles Babbage Institute, University of Minnesota, Minneapolis

Computing:

1992 Y/MP block diagram:

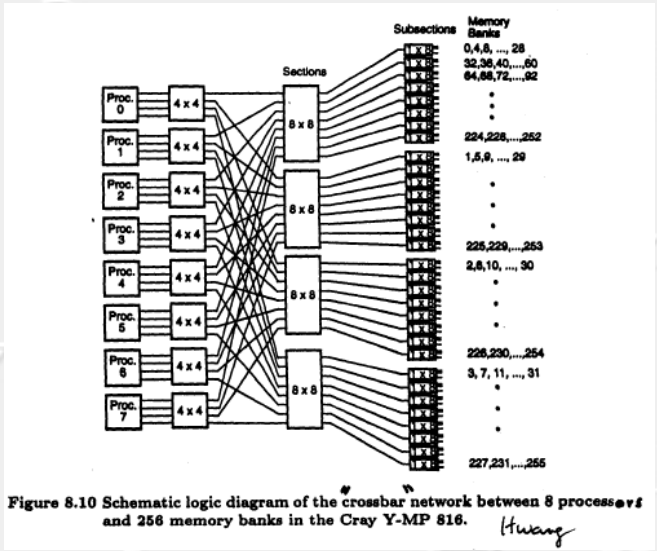
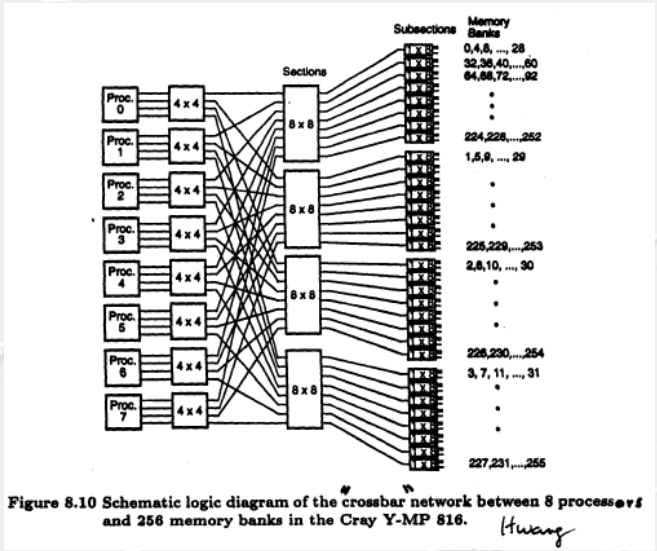


Figure 8.10 Schematic logic diagram of the crossbar network between 8 processors and 256 memory banks in the Cray Y-MP 816. Huang

Computing: Enter the Cell Chip

1992 Y/MP block diagram:



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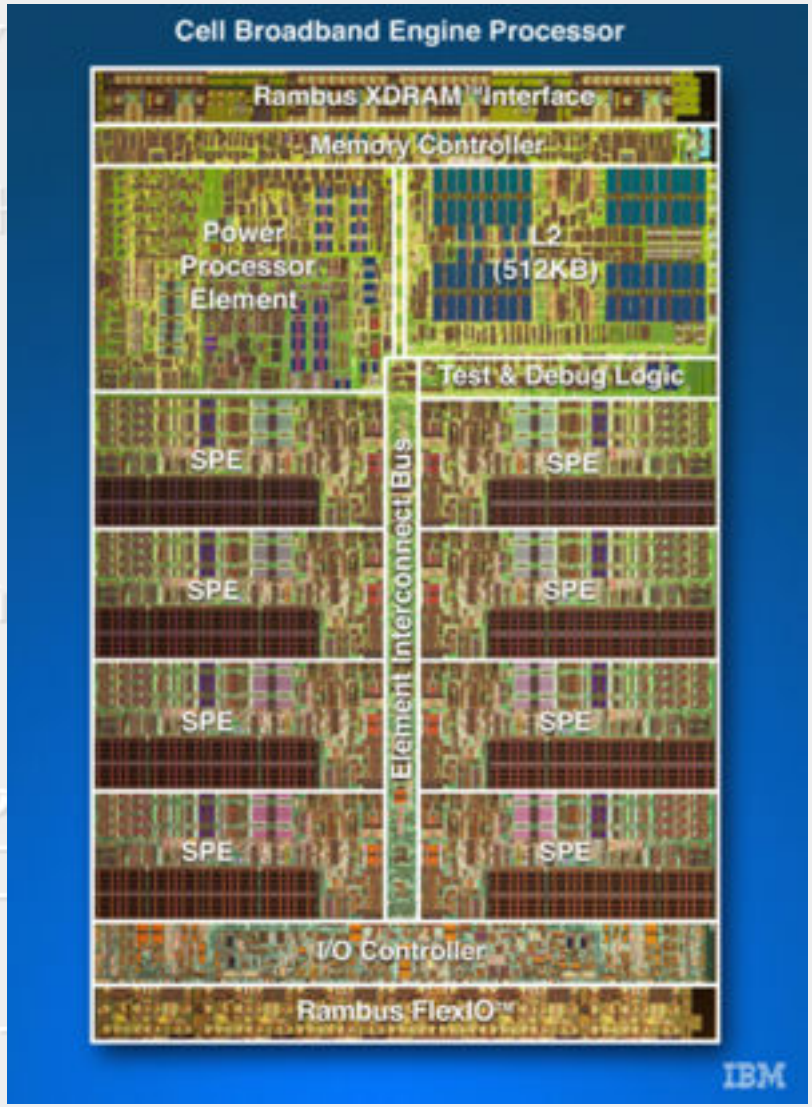
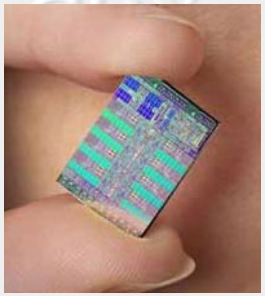
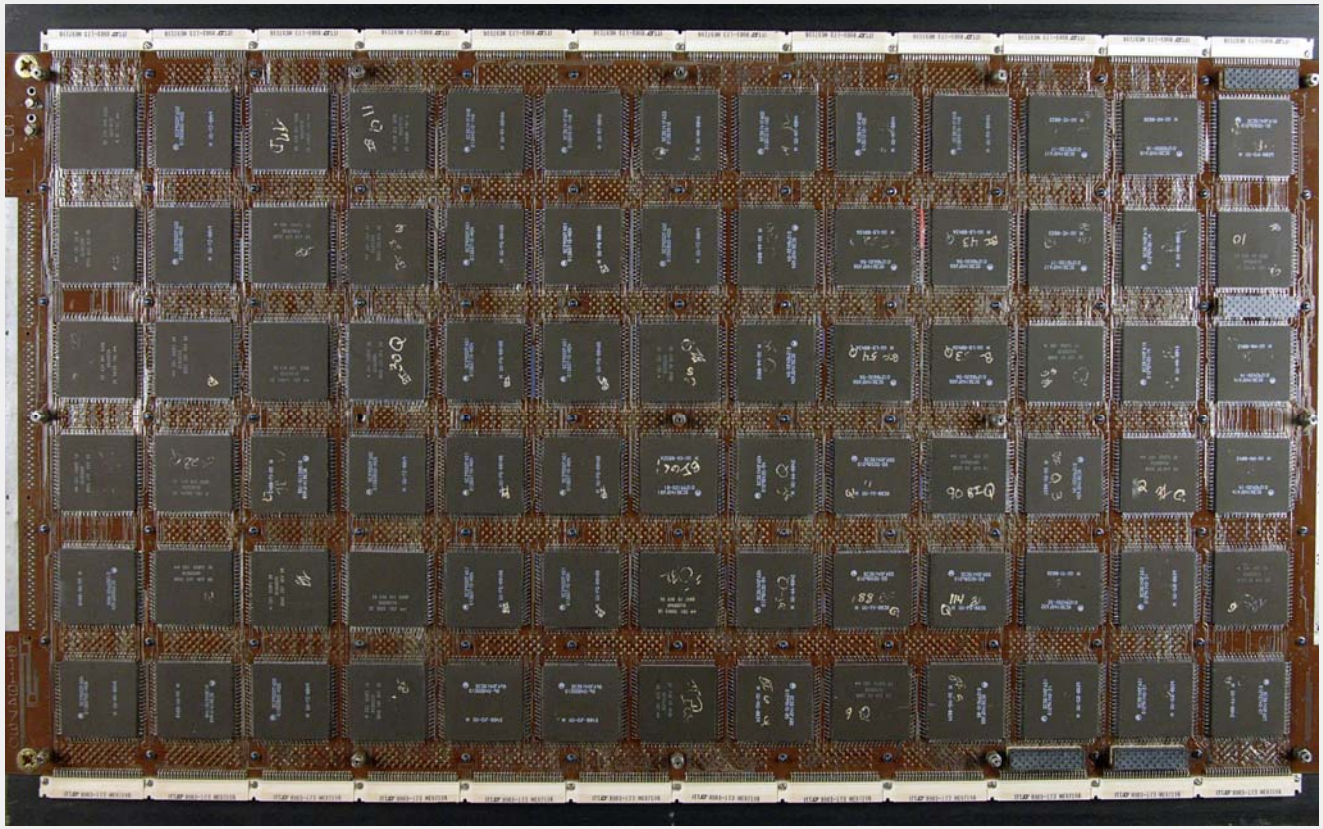
2006 Cell Broadband Engine (CBE) chip (IBM/Sony/Toshiba):



Computing: Cray on a Chip



Cell chip versus Y/MP processor board (2 ft wide)



Computing: Comparing the Vitals

	Y/MP	Cell chip
Processors:	8	1+8(6)
Memory:	0.25-1.0 GB	0.25 GB
Peak speed:	~ 2 Gflops	~ 256 Gflops
Memory bw:	2 GB/s	25.6 GB/s
Clock:	0.333 GHz	3.2 GHz
Power:	100 kW	200 W
OS:	UNICOS	Linux
Price:	$10M	599.00 @Walmart
Compilers:	Crap back then	Crap now

Computing: The WalMart Supercomputer

Why NOT run the OpenGGCM on a PS3?

Computing: The WalMart Supercomputer

Why NOT run the OpenGGCM on a PS3?

Because it is a pain to program!

Why run the OpenGGCM on a PS3?

- Extremely low cost.
- Portable.
- Virtually no maintenance.
- Little expertise required: A 5th grader can do it!
- Virtually no infrastructure needed.
- Large ensemble predictions possible.
- Low “entry barrier.”
- Basically a “Space Weather Appliance.”

Computing: OpenGGCM on PS3

- Faster than real time with 128x64x64 (~0.5M cells) grid.
- Main part is still F77 (unchanged), ~ 500 lines of F77 code are recoded in C to use SPEs.
- Code is still MPI based: Multiple PS3 can be tied together via Ethernet for better resolved model.
- Current performance ~ 5-10 Gflops, still far from peak. New code is also 2 times faster on Opterons (better use of SSE instr.).
- Small memory (~200MB shared, ~150kB in SPEs) is main bottleneck.
- It took ~ 3 months.
- All credit to Kai Germaschewski & Doug Larson.

Let's see it running!

(well, we did that at the 2007 Space Weather Week and at the 2007 GEM summer workshop.)