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Debugging with DDT at NERSC

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Contents

- Overview of Allinea and DDT
- Using Allinea DDT to fix bugs at NERSC
- Hands on

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Allinea Software

- **HPC tools company since 2001**

- **Core products**
  - **DDT** - Debugger for MPI, threaded/OpenMP and scalar applications
  - **OPT** - Optimizing and profiling tool for MPI and non-MPI applications
  - **DDTLite** - Plugin for Microsoft Visual Studio 2008
    - Adds parallel and multi-threaded components to user interface
    - Real parallel debugging for Windows!
    - Released September 22nd 2008

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High Profile Clients (extract)

Partners

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- Government
  - CEA, NERSC, IDRIS, BSC, ONERA, AWE, RAL, HLRS, CASPUR, CINECA, ORNL, NERSC, LLNL, Ifremer, Proudman, Plymouth Marine, BGS
- Universities
  - Sharcnet, Jülich, North West Grid, Vanderbilt, Penn State, TACC, IPGP, ETHZ, HLRS, LRZ, Dresden, Karlsruhe, ICHEC, Bristol, Nottingham, Glasgow, Edinburgh, Oxford, Tokyo, USATU, Arizona, UCL
- Aerospace research
  - DLR, EADS CCR, CIRA, MBDA, BAE Systems
- Commercial research
  - Synopsys, Airbus, Fujitsu (Japan & UK), CGGVeritas, Total, IFP, OHM, AVL, MTEM, Konica-Minolta

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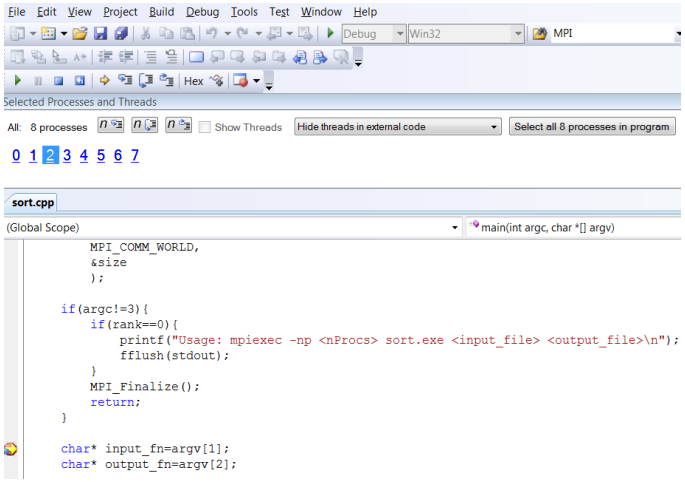
Other Allinea products: DDTLite



- **DDTLite for Visual Studio**
  - Simplifying development on the Microsoft® platform
  - Bringing features from DDT into Visual Studio®
  - Take total control of all processes
  - Makes Visual Studio® a true parallel debugger
  - Released last week!

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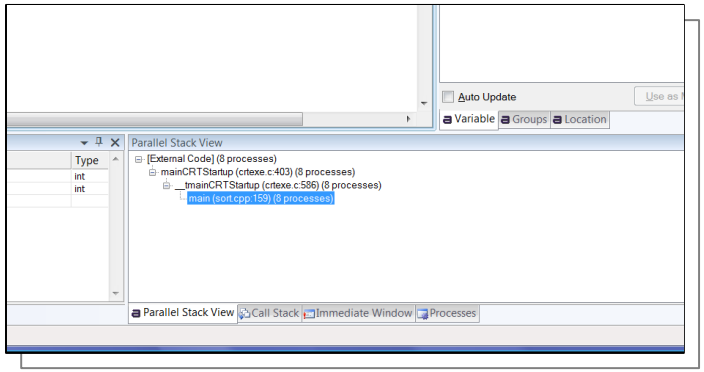
Debugging with DDTLite



- **Group control**
  - Step or play multiple processes
- **Compare data over processes**
- **See all the process stacks**
- **C/C++/C#, Intel or PGI Fortran**

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Using DDT

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Using DDT to fix bugs - fast!

- Overview of the features
- How to get started with DDT
- Memory Debugging with DDT

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Parallel Software is Complicated

- **Multithreaded, multiprocess code**
  - The usual issues: bugs, speed
  - ... now add communication, synchronization, race conditions, deadlock, scalability
- **Hardware / Software capability misaligned**
  - Significant gap between user requirements and application capabilities
  - Emphasis is now moved to software development
  - How do we address this issue?

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Some problems DDT helps with

- **For when you have a bug – if your application**
  - Crashes all the time
    - Click play and run until it crashes – DDT shows the point of segfault, abort or exit – before it has quit
  - Crashed yesterday
    - Load up the core file and look at where it crashed
  - Crashes sometimes
    - Possibly a memory error – turn on memory debugging and force the problem
  - And many other scenarios – not just crashes
- **It helps when maintaining and developing code**
  - When you need to know how it works to add a feature
    - Load DDT and just watch how your program runs

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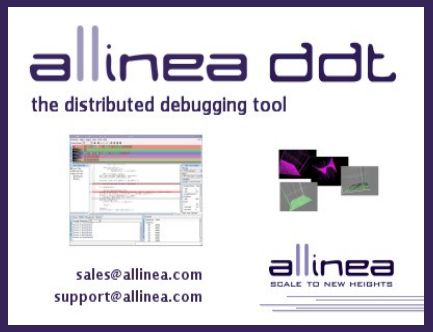
DDT - Distributed Debugging Tool

- **A mature, powerful and highly intuitive tool**
  - Traditional focus has been HPC
  - Developing new capabilities.....multicore, GP-GPU
- **Cross-platform support**
  - Linux, Solaris, AIX, Super-UX
  - GNU, Absoft, IBM, Intel, PGI, PathScale, Sun compilers
  - x86, x86-64, ia64, PowerPC, Cell, UltraSparc, NEC
  - Support for all major scheduling systems
  - Across all MPIs
  - OpenMP and Threads



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The basic features

- **Automatically locates source files**
- **Step, play, pause**
- **Breakpoints and data watchpoints**
- **Fortran 90, 95 and 2003**
  - Modules, allocatable data, pointers and derived types
- **C, C++ support**
  - Structs, classes, pointers, STL, namespaces, virtual functions and templates
  - Catch exceptions at throw or at catch point

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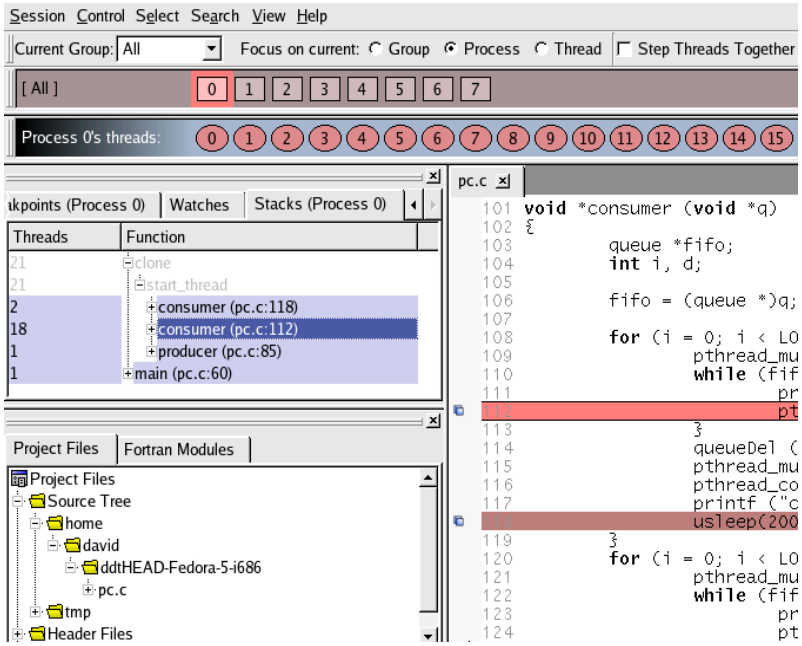
Features for multithreading

- **Perform actions individually or collectively**
- **Breakpoints for all or per thread**
- **See all threads at a glance**
  - Parallel stack view shows threads and groups common stacks



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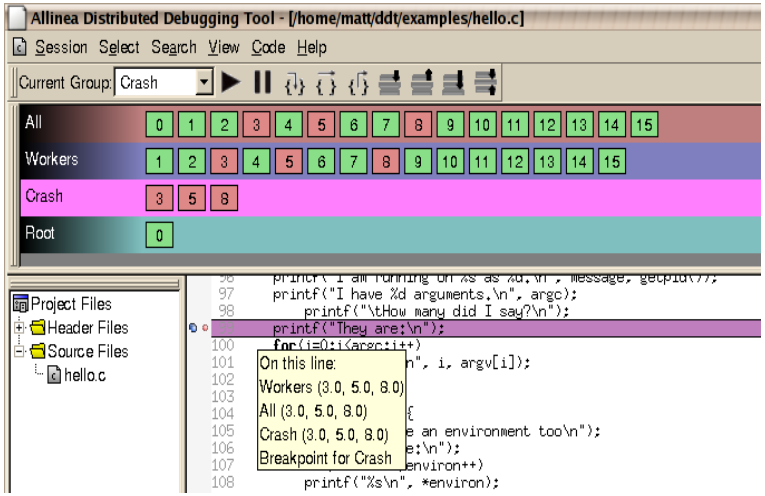
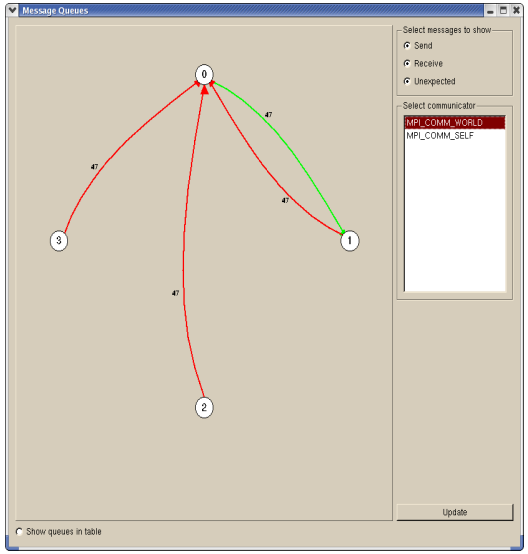
Features for parallel codes

- **Support for every MPI**
- **Control processes individually or by groups**
- **Visualize message queues**





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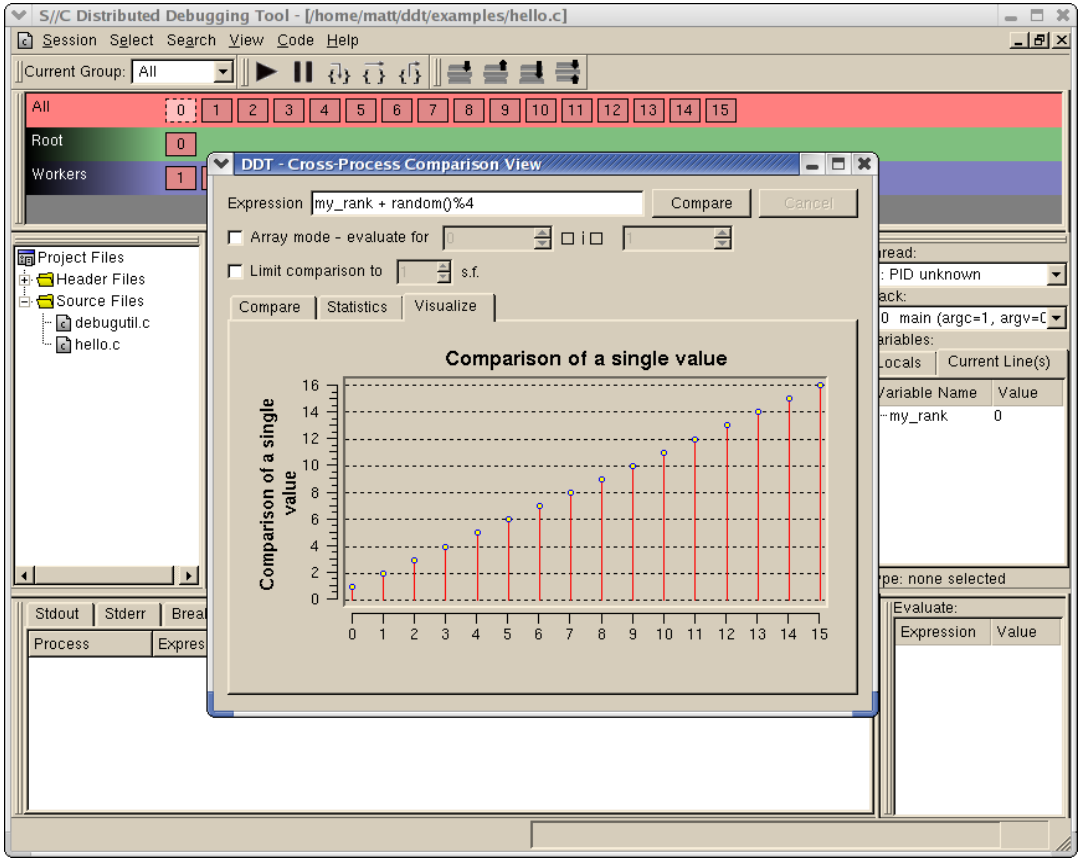
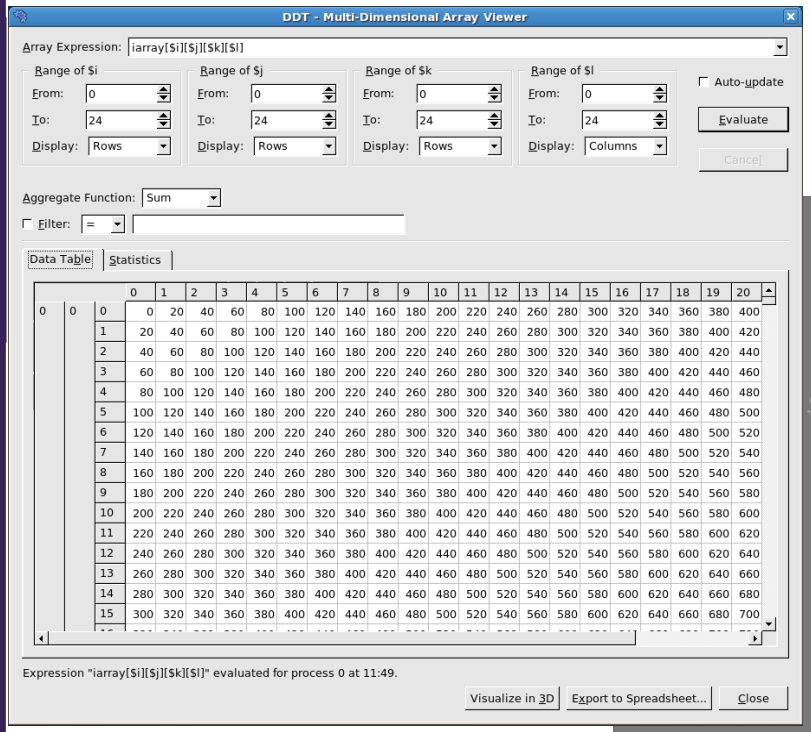
Viewing concurrent data

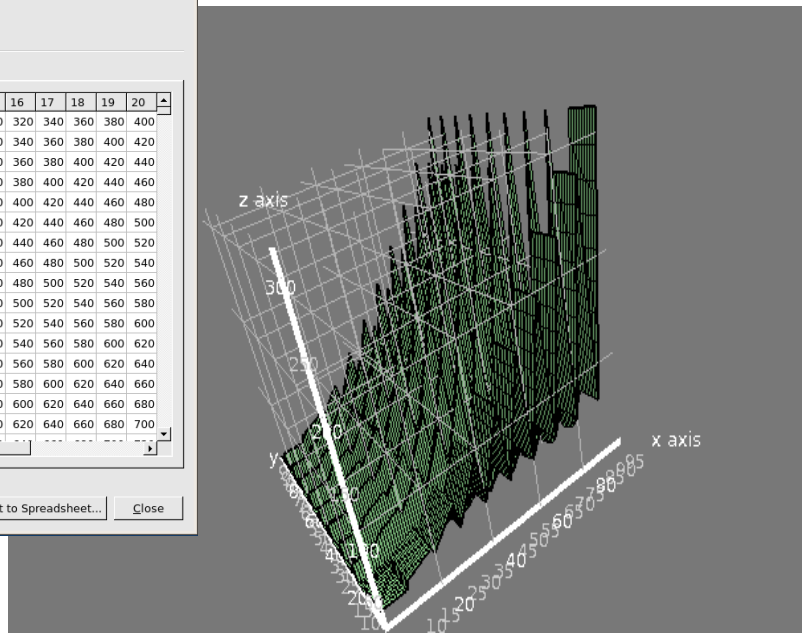
- **Cross process/thread comparison**



Viewing vast data

- **Visualize multidimensional data**
  - From 2D viewer to new multidimensional viewer
  - 3D OpenGL array viewer (stereo !)





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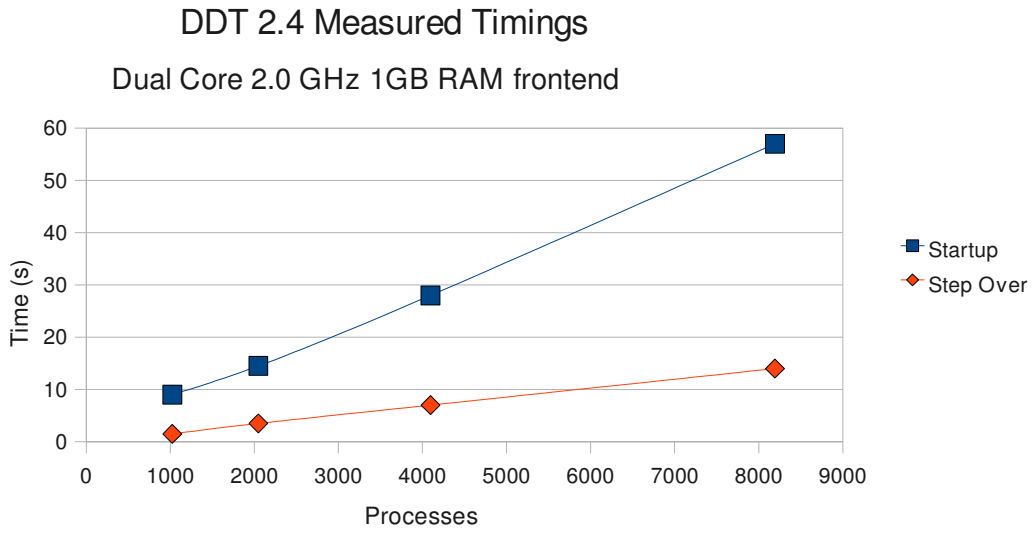
Scaling up

- **Increased thread and processor counts are coming**
  - Desktop multicore and GPUs - multithreading by default
  - 1,000+ core clusters everywhere
- **DDT allows control of 1,000s of processes**
  - An MPI application or a custom network of processes
  - Highly threaded codes GPUs, and (very-) multi-core ready
  - Or many single core Monte Carlo applications



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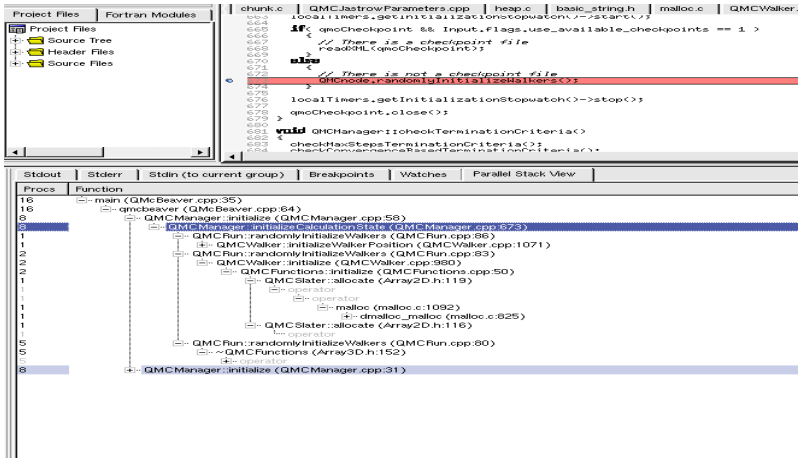
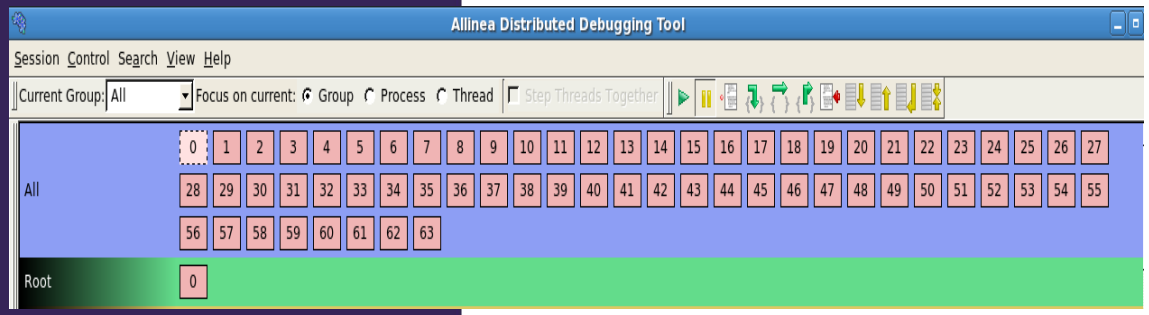
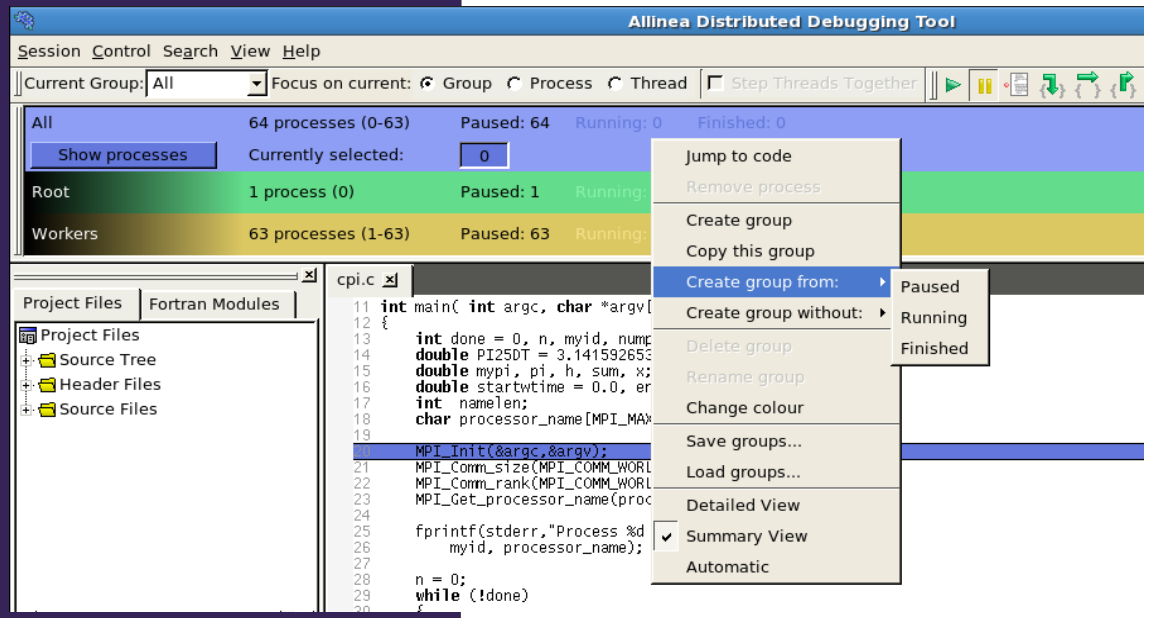
Finding rogues quickly

- **Parallel Variable View**
  - Find processes or threads with different data
- **Parallel Stack View**
  - Identifies classes of process and thread behaviour easily
  - Allows rapid grouping of processes
- **Integrated with process groups**



Using groups for process control





- **At lower parallelism**
  - See state of each process
  - Drag and drop to manage groups
- **At 100s or 1000s of processes**
  - Summary view gives rapid overview and same level of control

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How to get started at NERSC

- **Compile your code – with "-g" option**
- **Bring up the DDT GUI - "ddt"**
- **Select your program**
- **Click submit! DDT submits the job for you.**

- **Is it that easy?**

- **Not quite:**
  - Temporarily complicated until MPT update to 3.1
    - `module unload xt-mpt/3.0.2`
    - `module load xt-mpt/2.0.53b`
    - Recompile your code

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Considerations for NERSC

- **Interactive sessions?**
  - Change “Session/Options/Job Submission” so that DDT does not submit for you.
    - “qsub -I ....” and wait, then launch DDT in the shell
  - Why would I do that?
    - Quickly and repeatedly try something: run 10 times in a 10 minute session instead of waiting in the queue 10 times
  - Why wouldn't I do that?
    - Easier not to – is a trade off – it's convenient if your program runs for a while
- **Using the queue differently with DDT**
  - Can change the default queue at click of button
    - Click “change” on launch page default is “debug”
  - Can use DDT up to 1024 processes
    - “regular” queue, not “debug” queue
    - But remember your budgeted hours....!!
  - Change the walltime in the same manner

Interlude!

DDT demo

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A Tour of Memory Debugging

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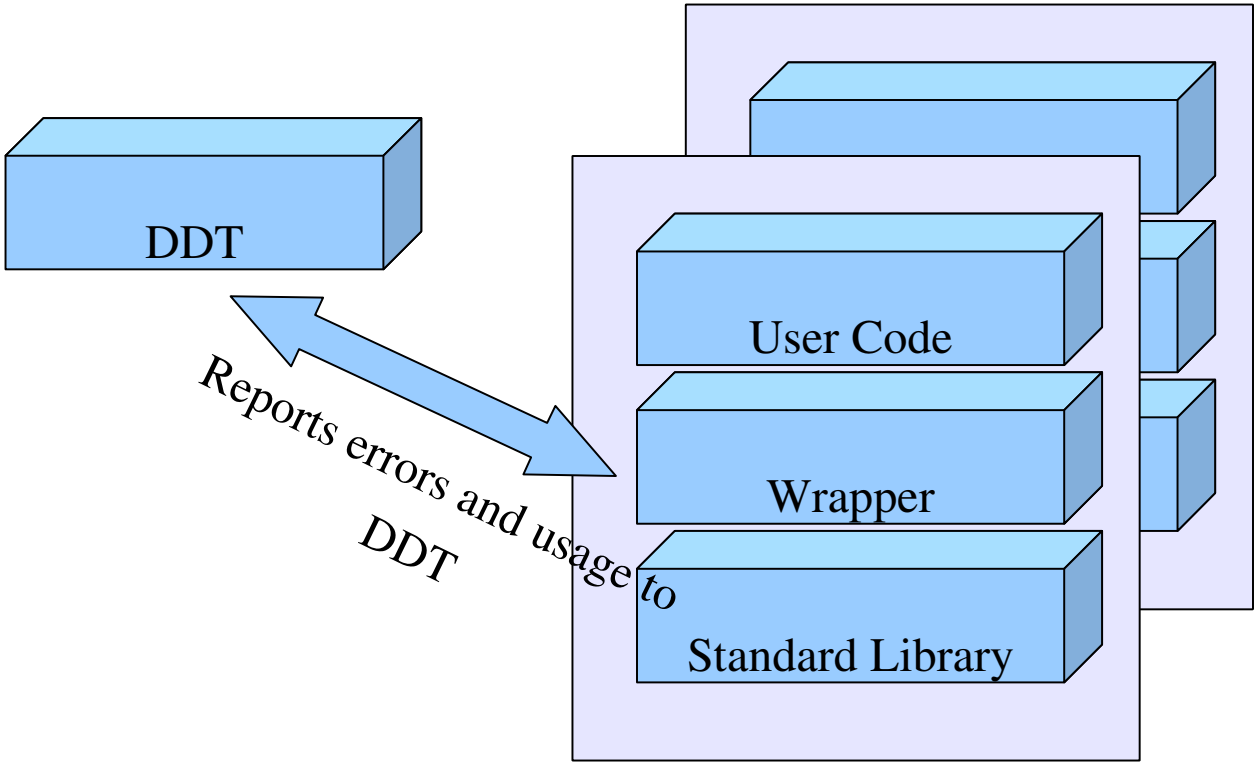
Focus on Memory Debugging

- **DDT's memory debugging works with the Heap**
  - Memory allocated via allocate (F90), malloc (C), or new (C++)



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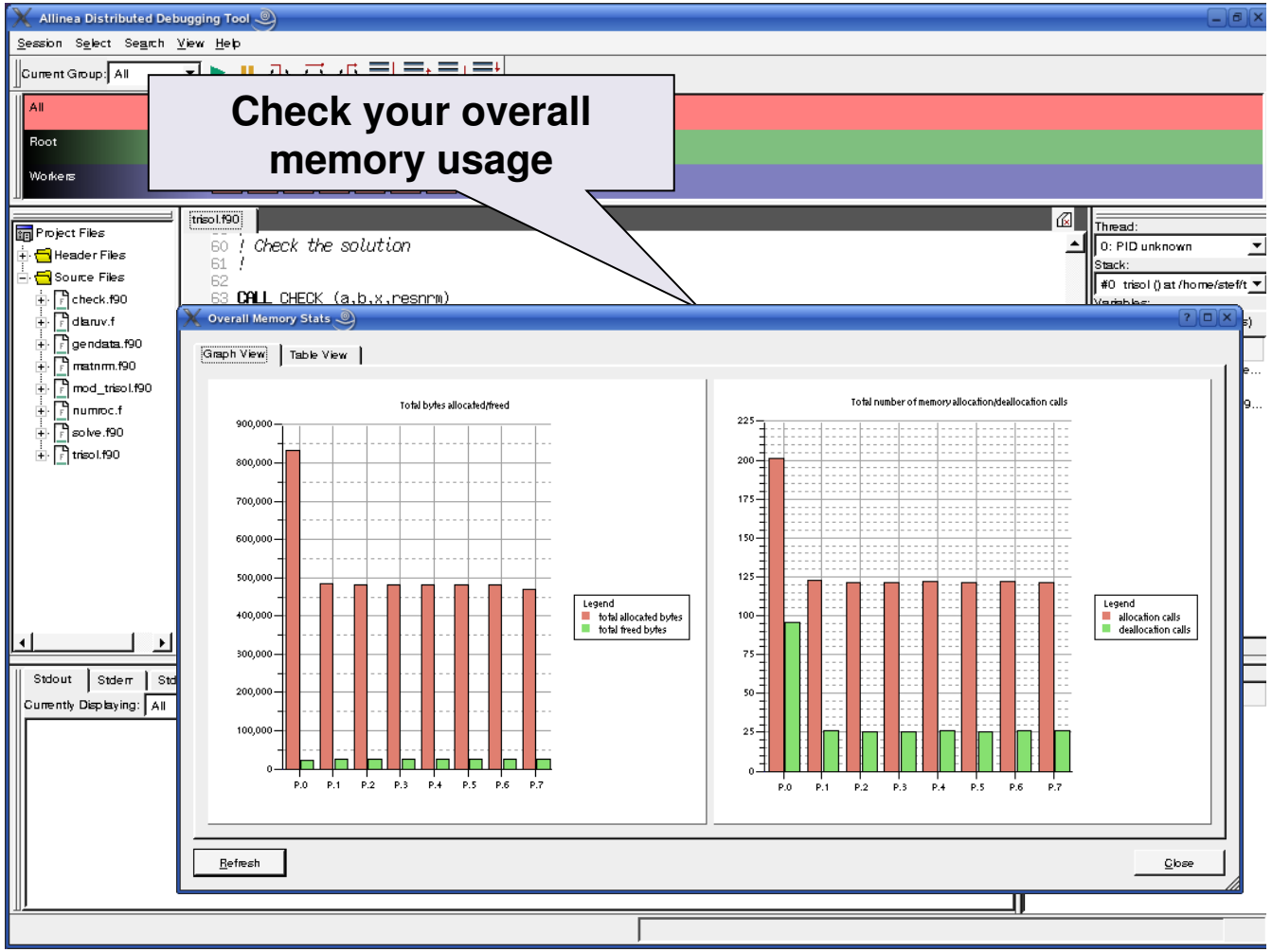
Memory Debugging



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Leaks

- **Common C coding error, increasingly in F90**
  - When memory is not released after use
    - Kills job if repeated too often, eg. calls to leaky function
  - First identify if there is a problem
  - Then find it..

```
void fun()
{
  Car *p;
  p = new Car();
/*
... do something
*/
  return;
}
```

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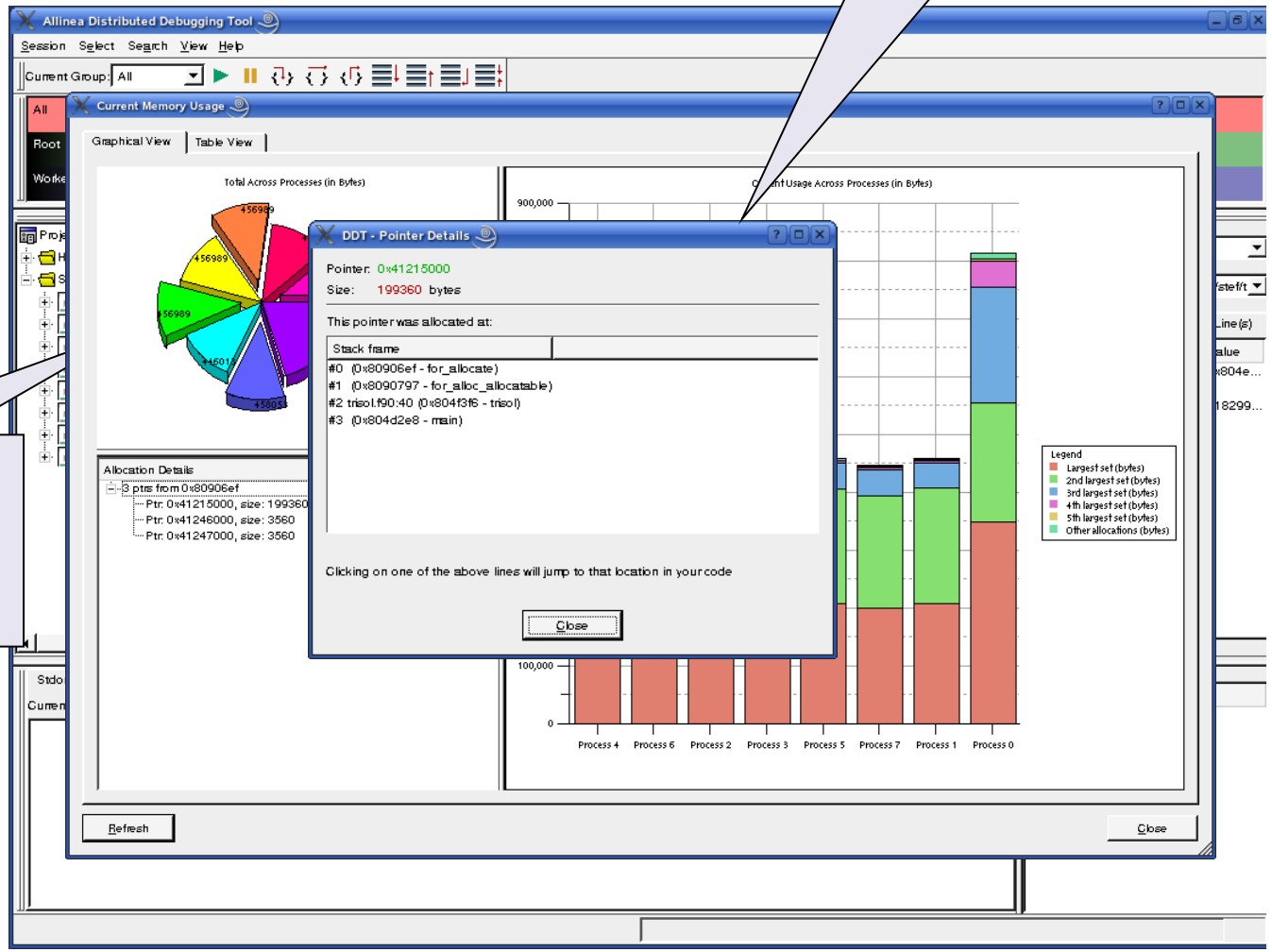
Checking for leaks

Locate where memory was allocated in depth



Check your current memory usage and where memory was allocated

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Memory Errors

- **Dangling Pointers**
  - Pointer variables pointing to memory after it has been discarded
  - Pointing to discarded memory now reissued to another role
- **We can prevent both**

```
Car *p, *q;
p = new Car();
q = p;
/*
... do something
*/
delete p;

/*
... something else
*/
q->drive();
```

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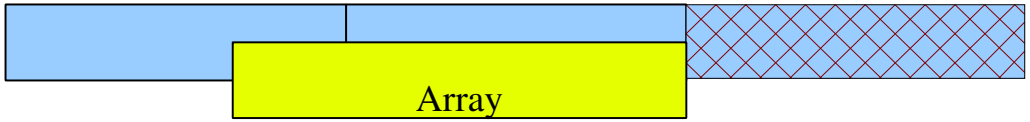
Beyond Bounds Reading

- **"Guard Pages"**
  - Instant protection against read/write outside an array



- **DDT uses OS to lock the page**
  - Above or below for protection (but not both)
  - Or lock more pages.. for multi-dimensional arrays
- **.. and can still allow you to continue!**
- **"Fence post" checking**
  - Periodic protection against write outside an array – at both ends

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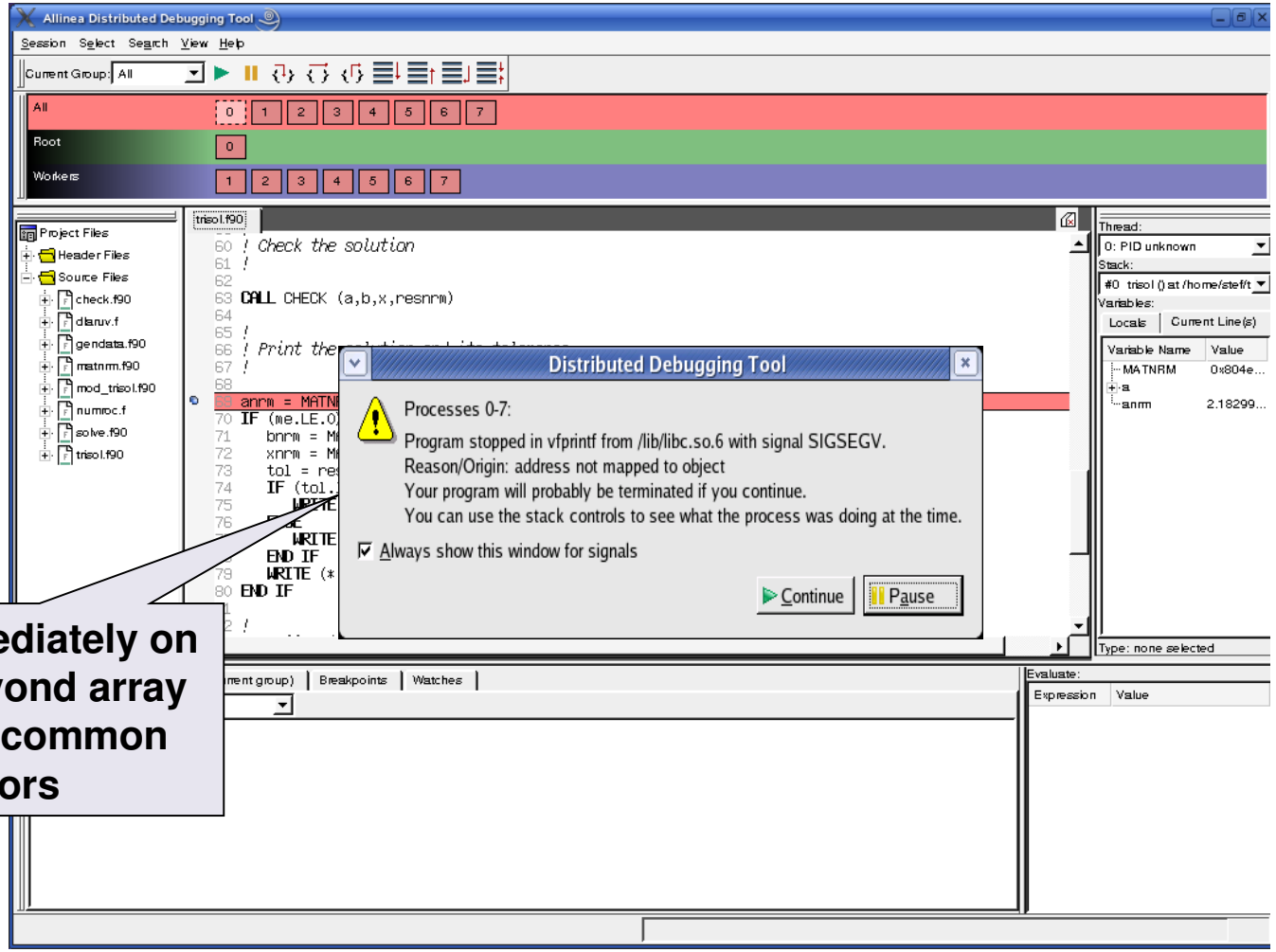
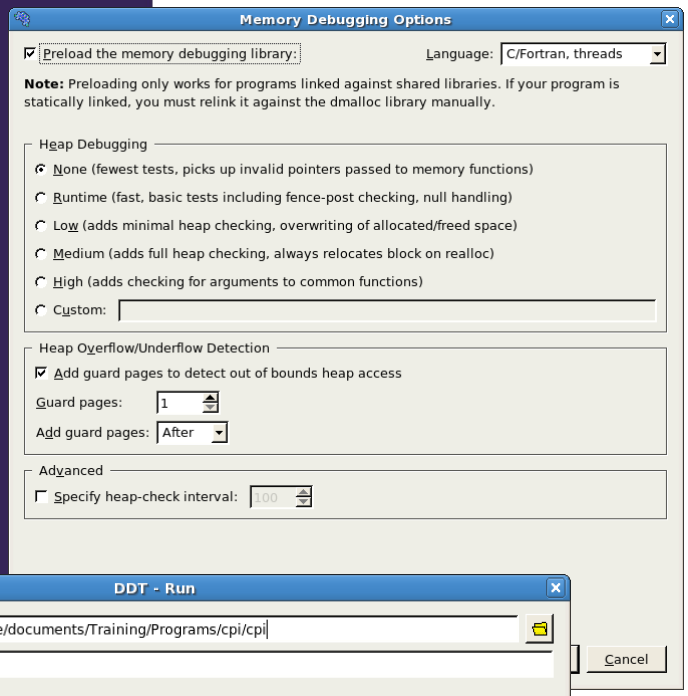
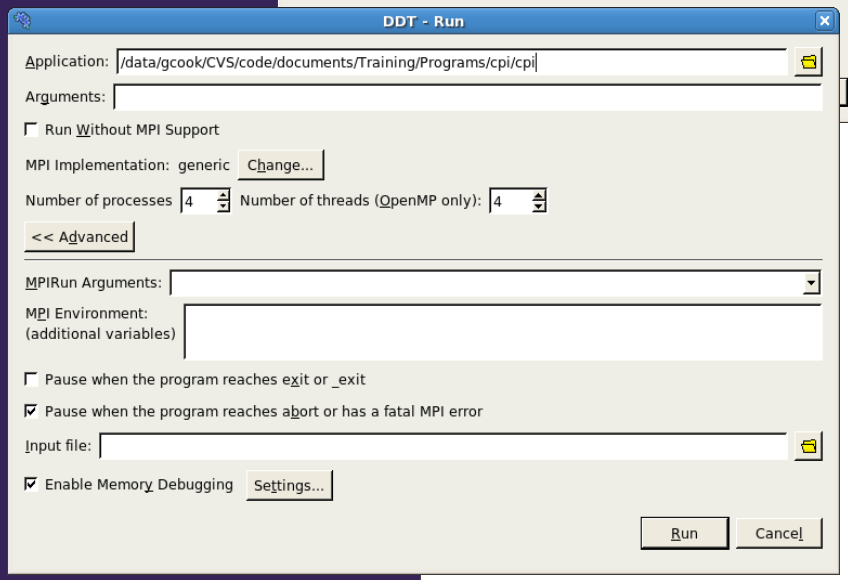
Memory Debugging



Stop immediately on reads beyond array end and common errors

Using memory debugging





- **Easy to use**
  - Tick check box to enable and use the default, or choose your own settings
  - Do not tick “Preload” - we use link explicitly on Cray
- **Relink**
  - Use “-Bstaticddt” compile option at NERSC

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Q & A: Open Floor

- **Any questions?**