Reducing Memory footprint
Strategies for MT

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Parallel session 7B – Hadronics issues related to MT

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Overview

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- Each threads own instances of Hadronic models/processes/ cross-section
- A part of the per-thread memory overhead is due to hadronics
- How much is it?

- Memory Profile FullCMS application: 1 thread, a single 50 GeV pi- event with FTFP_BERT
  - Check memory allocations (e.g. churn)
  - Concentrate on initialization routines
  - Show here only methods that allocate more than 1MB of memory (e.g. concentrate on the "hot-spots")

Overview

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- Measurements done on Mac OS X, numbers not so different from Linux box

- Master thread allocates 113.4 MB
- Worker thread: 24 MB
  - Includes everything
  - Concentrate on Hadronics calls in next slides

Results (all tags updated to Monday 16th Sept)

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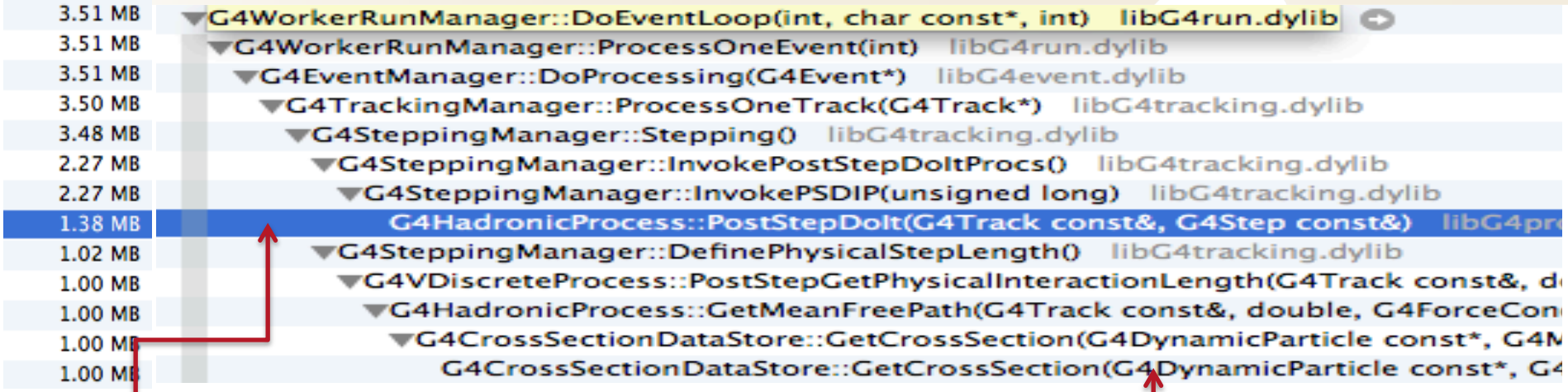

Processes/models during event loop: lost of relatively small (<1MB) objects, to be studied more in detail

Hadronic cross-sections account for about 2MB in total, see previous presentation, possibilities to reduce

Results (all tags updated to Monday 16th Sept)

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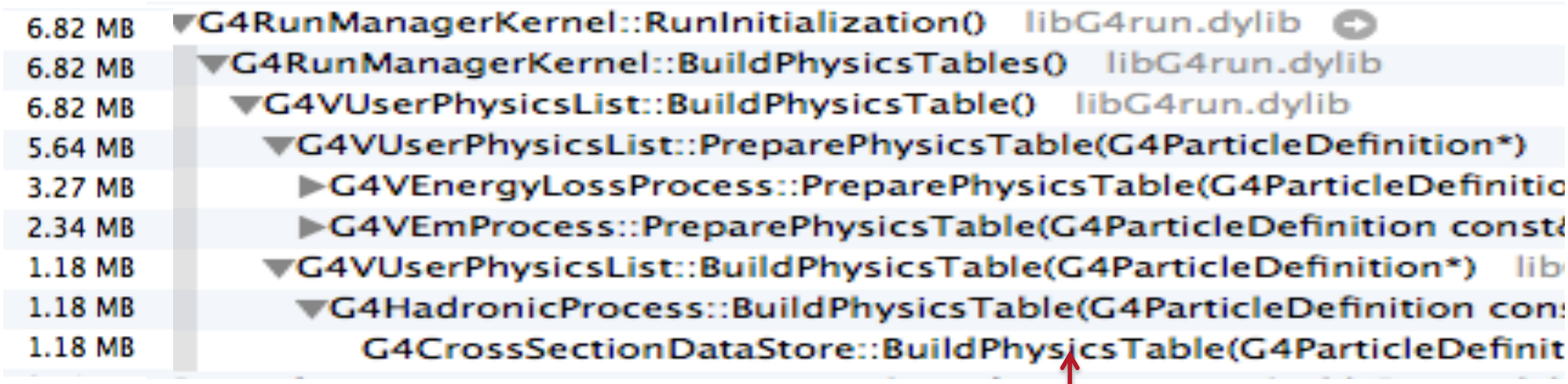

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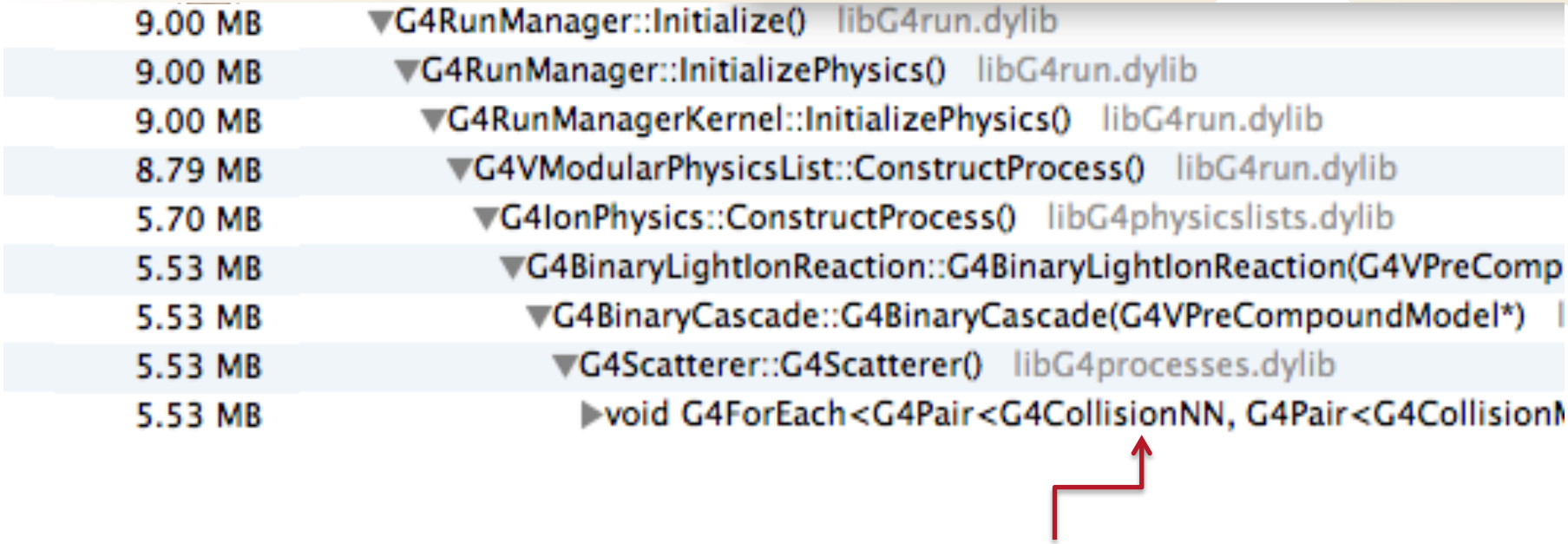

Memory churn from BIC model: note this is done even if the model is not used

Some work needed (not a trivial fix)

Measurements Conclusions

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- The hadronics most memory hungry (5MB) hot-spot is **BIC** model (even when not used). Some rework needed
- The second Hadronics components using more memory are **cross-sections** (2.2MB) stored in G4CrossSectionDataStore
- Models/processes account for about 1MB of memory
- It is realistic to reduce memory footprint for Hadronics of a factor 2

- Note: other models have a completely different profile
  - HP models: currently each thread load all HP tables, test11 for HP uses several GB of memory. No work on this done yet
  - Requires strategy for sharing database files

Reducing memory footprint

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- In the following a procedure to reduce memory footprint is shown
  - The aim is to propose a step-by-step guide that can help also non-MT experts
- Some special cases may require thinking or redesigning few spots here and there

Reducing memory footprint

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- Good candidates for sharing are "static" objects/tables
  - Search in your code large arrays of numbers (cross-sections) these are very good candidate for sharing
  - Also look at large objects created at run time (e.g. a table being calculated)
- In G4 there is a very good chance these objects are already marked as "static"
- To make these thread-safe these have been transformed to TLS:
  - Static G4ThreadLocal double largeData[100] = { …. };
  - Static G4ThreadLocal double largeData[100] = calculateXS();

Const objects

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- The easiest thing to do is to try to use the "const" keyword. If you can add "const" than you can probably transform:
  - Static G4ThreadLocal double largeData[100] = {…}
  - Static const double largeData[100] = {…}
- Nothing else to do
- Good practice: use const as much as you can, including in method signatures:
  - Const G4Something* GetSomething(const G4Data&) const;

Const objects

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- However, consider the following example (they do exist in G4):
- G4Class.cc

```
G4Class::G4Class() { ….}
  Void G4Class :: Method() {
       static G4ThreadLocal double largeData[100] = someFunc();
  }
```

- This should not be transformed simply removing G4ThreadLocal (long discussion, I can provide pointers)
  - Try the following:

```
Namespace {
     static double largeData[100];
          G4Mutex aMutex = G4MUTEX_INITIALIZER;
}
G4Class::G4Class() {
    G4AutoLock l(&aMutex);
     largeData = someFunc(); //initialize static data
}
Void G4Class::Method() {
}
```

Lazy initialized objects

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- None of the above work if: initialization is lazy and depends on quantities calculated during event loop (e.g. a model cross-section for a specific ion created only if ion is found in interaction)
- In such case, **you probably cannot** share the object (unless you use costly locks that should be always avoided!)
  - Safer solution: leave as it is, however try to remove both static and G4ThreadLocal (it has a small but non zero cost every time you use the variable): move to class data member
  - If these data are top list of memory consuming, we can work together on that and find a different solution

Tradeoffs: memory vs speed

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- Remember Mike's receipt, in order of preference when you see a "static G4ThreadLocal":

1. Try to **remove** G4ThreadLocal applying one of the suggested receipt
2. If not possible and memory consumption is not large: **move** to class data member (no memory reduction, but at least no penalty for G4ThreadLocal) – do a profile yourself! (ask Performance Task Force how to)
3. If neither possible/desirable: **leave** as it is now, probably the best solution
4. In very special cases (though I cannot think of good example): **convert** to local variables
5. In any case **avoid** locks and mutex, if you think that you absolutely need them, let's discuss …