UI Interface

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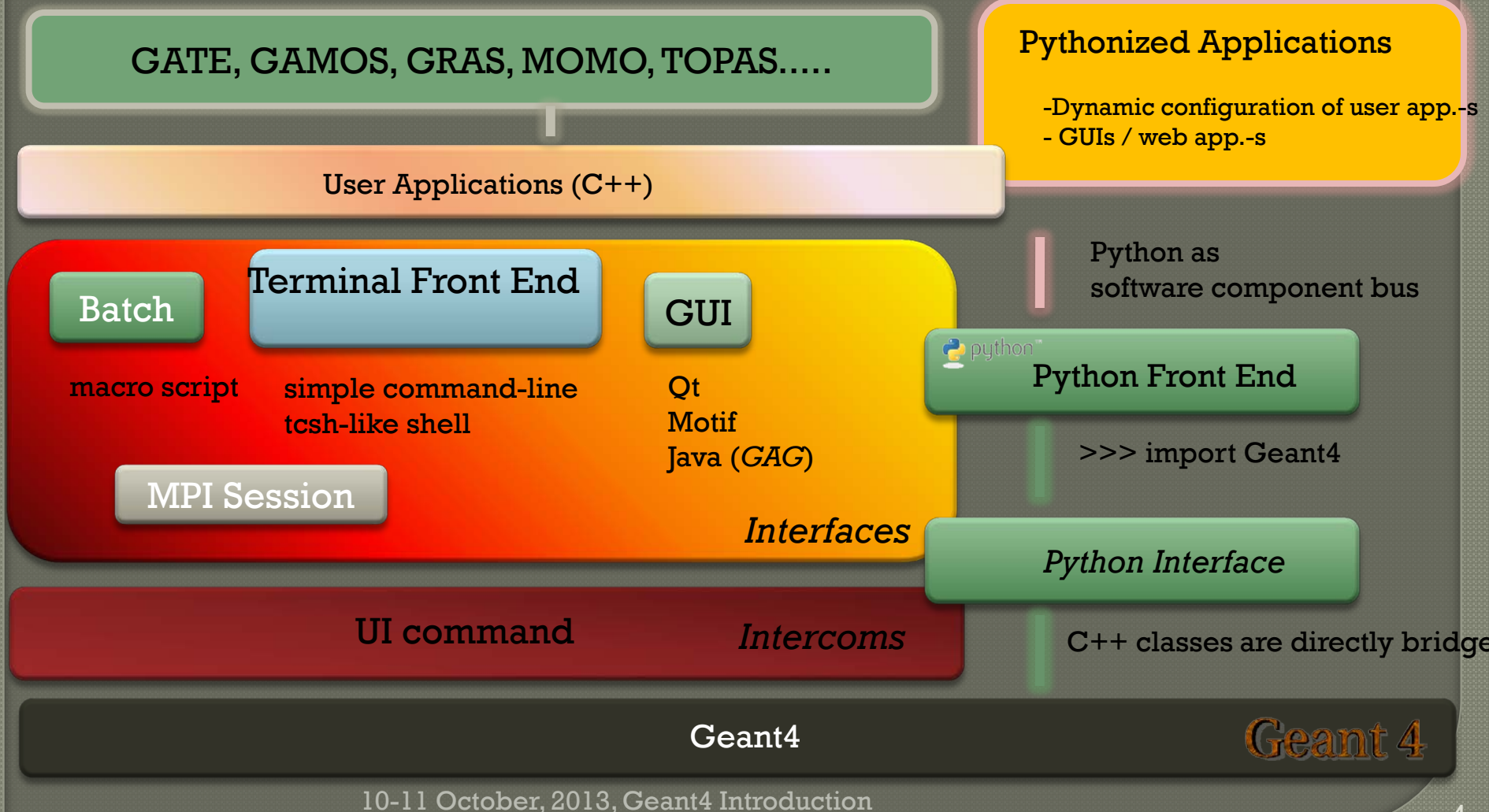
UI session

How to use UI session (CLI, GUI, batch)

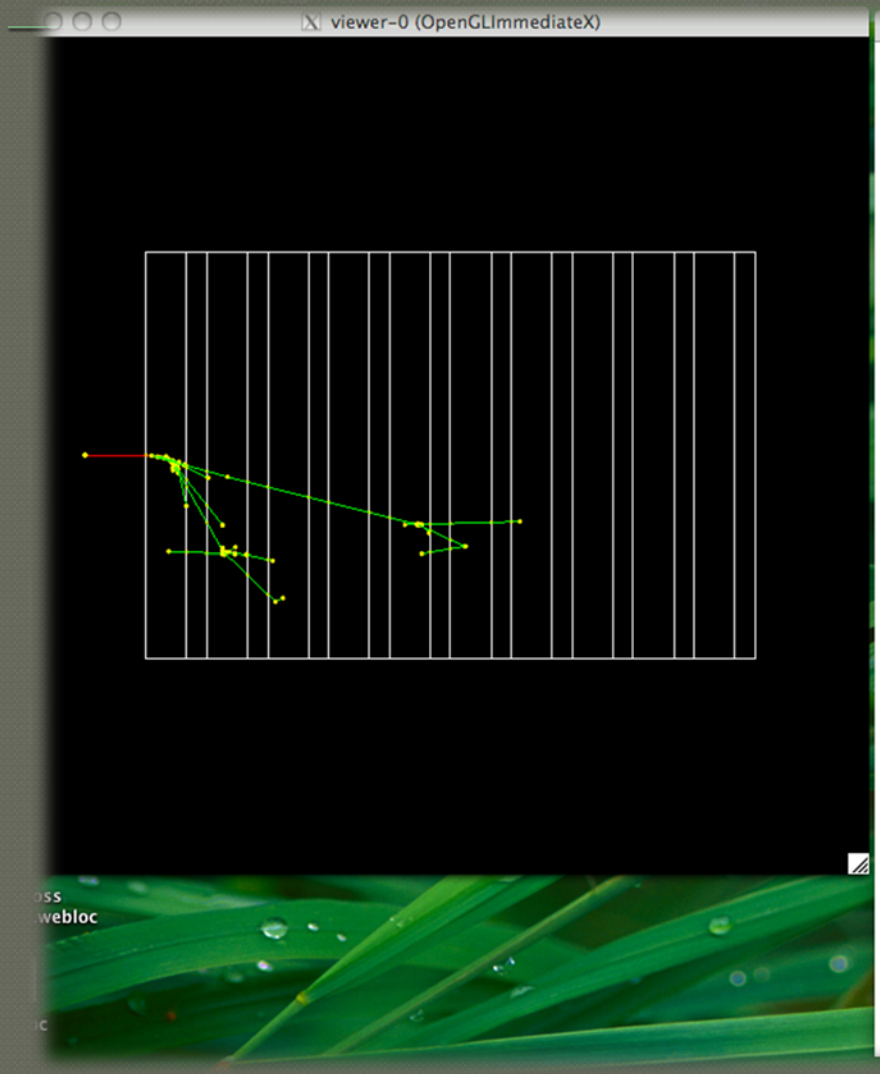
Interactive Front Ends

- G4UIterminal
  - CLI (command-line interface)
  - runs on all Geant4-supported platforms
  - G4UItcsh available
    - alternative shell of G4UIterminal
    - tcsh-like read-line
    - command completion, history (across sessions), etc.
- G4UIQt, G4UIXm, G4UIXaw, G4UIXWin32
  - GUI (graphical user interface)
  - G4UIterminal implemented over Qt, Motif, Athena and WIN32 widgets
- G4UIGAG
  - interface with GAG/MOMO, Java-based GUI interface
  - runs on all Geant4-supported platforms

Geant4 (User) Interface and Applications

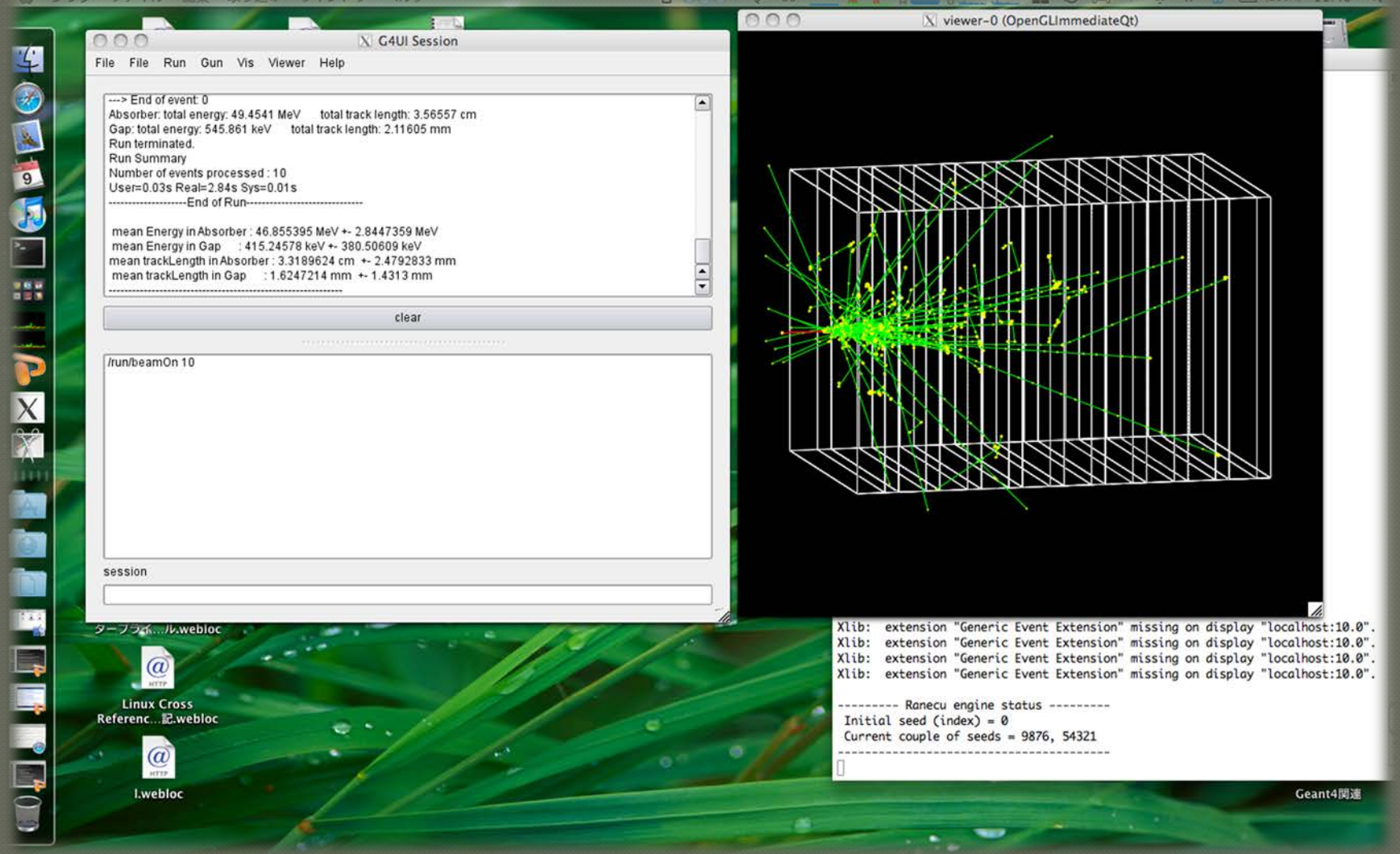


Terminal session




```
LCARS — ⌘1
G4GeometryManager::ReportVoxelStats -- Voxel Statistics

    Total memory consumed for geometry optimisation:   0 kByte
    Total CPU time elapsed for geometry optimisation: 0 seconds

    Voxelisation: top CPU users:
    Percent   Total CPU    System CPU       Memory  Volume
    -------   ----------   ----------     --------  ----------
       0.00         0.00         0.00           1k Calorimeter
       0.00         0.00         0.00           0k Layer

    Voxelisation: top memory users:
    Percent     Memory      Heads    Nodes   Pointers    Total CPU    Volume
    -------   --------     ------   ------   --------   ----------   ----------
      71.82          0k         1       10         10         0.00    Calorimete
r
      28.18          0k         1        3          4         0.00    Layer
### Run 0 start.
Start Run processing.

---> Begin of event: 0

--------- Ranecu engine status ---------
 Initial seed (index) = 0
 Current couple of seeds = 9876, 54321
----------------------------------------
---> End of event: 0
   Absorber: total energy:      50 MeV       total track length:  3.6009 cm
        Gap: total energy:       0 eV       total track length:       0 fm
Run terminated.
Run Summary
  Number of events processed : 1
  User=0.02s Real=3.11s Sys=0.01s

--------------------End of Run------------------------------

 mean Energy in Absorber : 50 MeV +- 0 eV
 mean Energy in Gap      : 0 eV  +- 0 eV

 mean trackLength in Absorber : 3.6009 cm  +- 0 fm
 mean trackLength in Gap      : 0 fm  +- 0 fm
------------------------------------------------------------

1 event has been kept for refreshing and/or reviewing.
Idle>
```

Qt interface



MOMO

MOMO (environments/MOMO/)

Env. Panel

Panel for setting environment variables

Momomake.gmk

GGE

Geometry Editor

Geometry.cc
Geometry.o

GPE

Physics List Editor

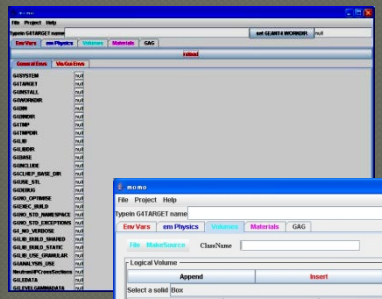
PhysicsList.cc
PhysicsList.o

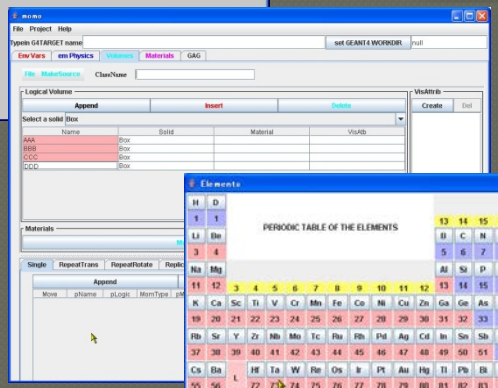
GAG/Gain

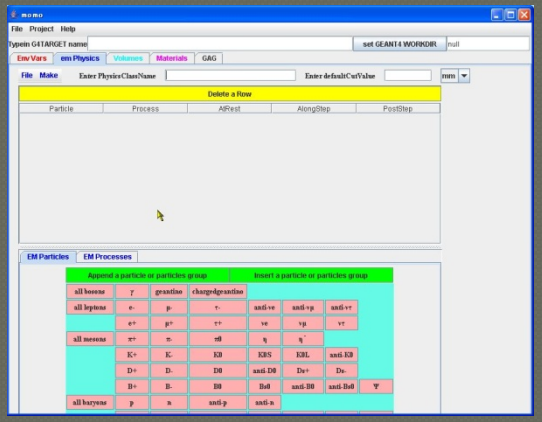
MySimulation.cc, *.cc
MySimulation.o, *.o

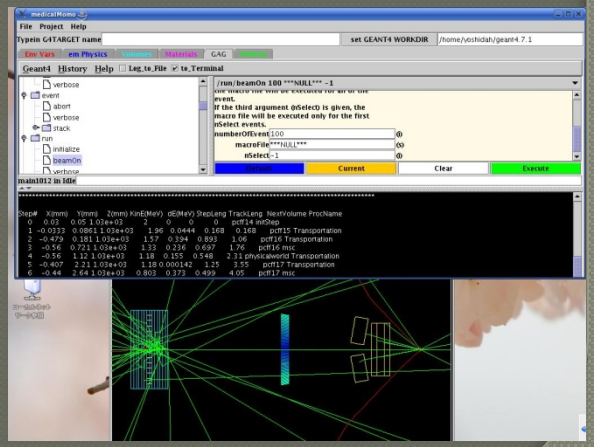
compile them!

User Applications w/ GAG interface









Notes on building/using sessions

- To build/use G4UIQt, G4UIXm, G4UIXaw, or G4UIXWin32, extra environment variables are necessary;

  G4UI_BUILD_QT_SESSION / G4UI_USE_QT
  G4UI_BUILD_XM_SESSION / G4UI_USE_XM
  G4UI_BUILD_XAW_SESSION / G4UI_USE_XAW
  G4UI_BUILD_WIN32_SESSION / G4UI_USE_WIN32

- None required to use G4UIterminal, G4UItcsh, G4UIGAG
  - these sessions do not need external libraries, so they are automatically built and linked.

Practical Usage

- In your main(),

```
#include “G4UIxxx.hh”
// xxx = terminal, Qt, Xm, Xaw, Win32, GAG
#include “G4UItcsh.hh” // if use a ‘tcsh’ module

G4UISession* session = new G4UIxxx;
session-> SessionStart(); // main loop starts…
delete session;
```

- For a tcsh-like session, a session is instantiated by

```
G4UIsession* session =
          new G4UIterminal(new G4UItcsh);
```

Practical Usage (G4UIExecutive)

- G4UIExecutive is available since *9.3 release*.
  - convenient class for selecting a UI session according to environment variables, G4UI_USE_XXX.
    - TCSH, XM, WIN32, QT, UIterminal (default)
    - select a session type by the order above
  - *Pros*: just one line cares the selection of a session type
  - *Cons*: Environment variables might cause unexpected behaviors.
- In your main(),

```
#include “G4UIExecutve.hh”

G4UIExecutive* ui = new G4UIExecutive(argc, argv);
ui->SessionStart();
delete ui;
```

- More practical implementation, see main() in novice examples.

G4UIterminal (command line interface)

- Geant4 can be driven by a series of commands, which are tidied up in categorized directory structure.
- G4UItermial supports some Unix-like commands for directory.
  - cd, pwd : change and display current command directory
  - ls / lc : list available UI commands and sub-directories in the current directory
- also supports some built-in commands.
  - history : show previous commands
  - !historyID : re-issue previous command
  - arrow keys : scroll command history (TC-shell only)
  - ?command : show current parameter values of the command
  - help [UIcommand] : show command help
  - exit : terminate the session
- *Notes:* These commands are not passed to the Geant4 kernel, so that you cannot use them in a macro file!

Batch Mode

- A Geant4 simulation can be executed in a batch mode.
  - A macro file consists of a series of UI commands
  - A macro file can be specified as an argument.

```
$ task2a myrun.mac >& myrun.log  (csh)
# task2a myrun.mac > myrun.log 2>&1 (bash)
```

- To enable batch mode,
  - In your main(),

```
G4UImanager* UI = G4UImanager::GetUIpointer();
G4String command = "/control/execute ";
G4String fileName = argv[1];
UI-> applyCommand(command+fileName);
```

UI command

What is UI commands

Geant4 UI command

- A G4UIcommand consists of
  - Command directory
  - Command
  - Parameter(s)

```
/run/verbose 1
/vis/viewer/flush
```

- A parameter can be a type of
  - *string, bool, integer or double*
  - Space is a delimiter
  - Use double-quotes (“”) for string with space(s).
- A parameter may be omittable.
  - A default value will be taken if you omit the parameter.
  - Default value is either *‘predefined default value’* or *‘current value’* according to its definition.
  - A default value can be specified by *“!”*;

```
/dir/command ! 123
```

Command Execution

- Geant4 UI commands can be executed
  - in a UI session / terminal
  - in a macro file
  - by hard-coded implementation
    - a way to bypass a class pointer (C++ access)
    - Using inside an event loop is NOT recommended!!

```
G4UImanager* UI = G4UImanager::GetUIpointer();
UI-> ApplyCommand("/run/verbose 1");
                  // runManager-> SetVerbose(1);
```

- Some commands are available only for limited Geant4 application states
  - Geant4 is a state machine.
  - E.g. `/run/beamOn` is *available only for Idle states*.

Built-in Commands

- There are built-in commands roughly organized according to Geant4 categories.

```
Idle> ls
Command directory path : /
 Sub-directories :
   /control/   UI control commands.
   /units/     Available units.
   /geometry/  Geometry control commands.
   /tracking/  TrackingManager and SteppingManager control commands.
   /event/     EventManager control commands.
   /run/       Run control commands.
   /random/    Random number status control commands.
   /particle/  Particle control commands.
   /process/   Process Table control commands.
   /material/  Commands for Materials
   /vis/       Visualization commands.
   /gun/       Particle Gun control commands.
 Commands :
```

UI Macro

- Code reviewed in 9.1 release.
- A macro file contains a series of UI commands
  - one command in each line
  - All commands must be given in *their full-paths*.
  - White spaces at the head of a line are allowed.
  - continued line by '\' or '_'
- "#" is used for a comment line.
  - First "#" to the end of the line will be ignored.
  - Comment lines will be echoed if /control/verbose is set to 2.
- A macro file can be executed
  - *interactively* or *in another macro file*

```
/control/execute file_name
```

  - From c++ code (NOT recommended – use in exceptional case)

```
G4UImanager* UI = G4UImanager::GetUIpointer();
UI->ApplyCommand("/control/execute file_name");
```

Alias: *Scripting with UI commands*

- Alias can be defined by
  - `/control/alias [name] [value]`
  - Aliased value is always treated as a string.
  - Use with curly brackets, { and }.
- Example:

```
/control/alias tv /tracking/verbose
{tv} 1
# Aliases can be used recursively.
/control/alias file1 /diskA/dirX/fileXX.dat
/control/alias file2 /diskB/dirY/fileYY.dat
/control/alias run 1
/myCmd/getFile {file{run}}
```

Loop: *Scripting with UI commands*

- /control/loop and /control/foreach commands repeatedly execute a macro file.
  - Aliased variable name can be used inside the macro file.
- `/control/loop [macroFile] [counterName] [initialValue] [finalValue] [stepSize]`
  - counterName is aliased to the number as a loop counter
- `/control/foreach [macroFile] [counterName] [valueList]`
  - counterName is aliased to a value in valueList.
  - valueList must be enclosed by double quotes (" ").
- An example:

```
/control/loop myRun.mac Ekin 10. 20. 2.
```

- myRun.mac

```
/control/foreach mySingleRun.mac pname “p pi- mu-”
```

- mySingleRun.mac

```
/gun/particle {pname}
/gun/energy {Ekin} GeV
/run/beamOn 100
```

Extra Functionality of UI Command

- G4UIcommands abort execution or issue warning in following cases:
  - Wrong application state
  - Wrong type of parameter
  - Insufficient number of parameters
  - Parameter out of its range
    - *for integer or double type parameters*
  - Parameter out of its candidate list
    - *for string type parameters*
  - Command not found

User-defined command

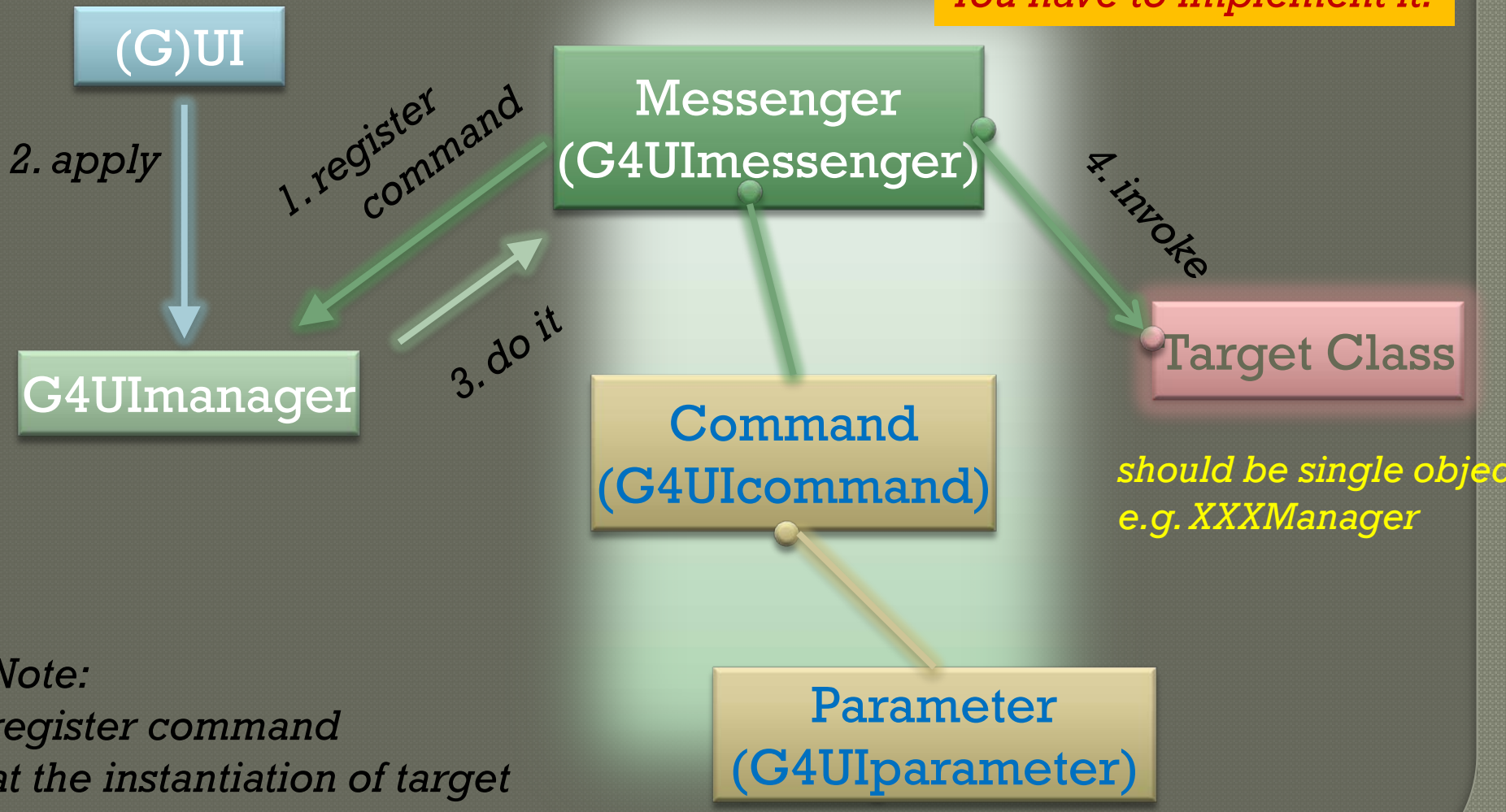
How to define your own UI commands

User-defined Commands

- If built-in commands are not enough, you define your own command.
- Geant4 provides several command classes, derived from *G4UIcommand*:
  - G4UIcmdWith3Vector
  - G4UIcmdWithADoubleAndUnit
  - G4UIcmdWith3VectorAndUnit
  - G4UIcmdWithAString
  - G4UIcmdWithABool
  - G4UIcmdWithAnInteger
  - G4UIcmdWithADouble
  - G4UIcmdWithoutParameter

Mechanism of UI command

You have to implement it.



Note:
register command
at the instantiation of target class

Messenger class

- You have to implement a messenger associating with a target class.
  - Each messenger class is derived from *G4UImessenger* base class.
  - A messenger class should be instantiated in the constructor of the target class.
  - Target class should be *a single-object class (for example, singleton)*
    - *e.g. XXXManager or DetectorConstruction*
    - If not (object has multiple copies in memory), there is a mess!
- Implementation of your messenger classes
  - Define command location: *directory* / *command*
  - `void SetNewValue(G4UIcommand* command, G4String newValue)`
    - Convert "*newValue*" parameter string to appropriate value(s) and invoke a method of the target class
  - `G4String GetCurrentValue(G4UIcommand* command)`
    - Access to a get-method of the target class and convert the current values to a string

An example of command definition

```
A01DetectorConstMessenger::A01DetectorConstMessenger
                          (A01DetectorConstruction* a01)
: target_class(a01)
{
  mydetDir = new G4UIdirectory("/mydet/");
  mydetDir-> SetGuidance("A01 detector setup commands.");

  armCmd = new G4UIcmdWithADoubleAndUnit
               ("/mydet/armAngle", this);
  armCmd-> SetGuidance("Rotation angle of the second
  arm.");
  armCmd-> SetParameterName("angle", true);
  armCmd-> SetRange("angle>=0. && angle<180.");
  armCmd-> SetDefaultValue(30.);
  armCmd-> SetDefaultUnit("deg");
}
```

Parameters

```
void SetParameterName(const char* parName,
                      G4bool omittable,
                      G4bool currentAsDefault=false);
```

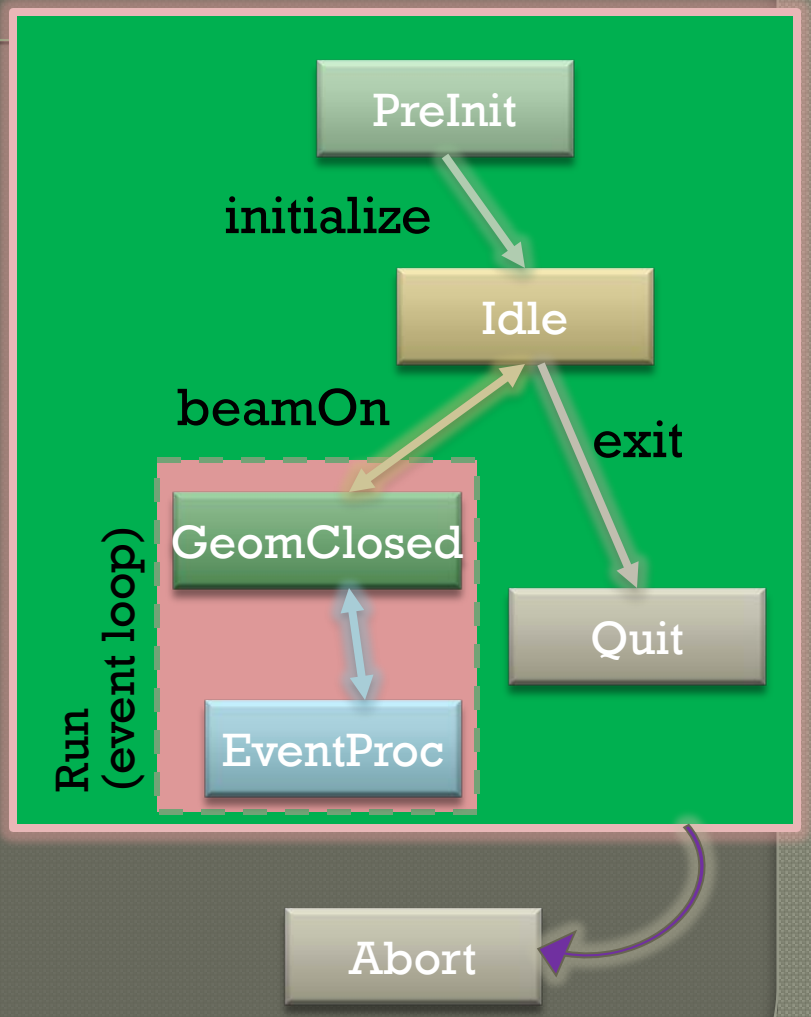
- If "*omittable*" is true, the command can be issued without specifying a parameter value.
- If "*currentAsDefalult*" is true, the current value of the parameter is used as a default value.
  - The default value must be defined with *SetDefaultValue()* method.

Range, unit and candidates

- `void SetRange(const char* rangeString)`
  - Available for a command with numeric-type parameters.
  - Range of parameter(s) must be given in C++ syntax.
    - `aCmd-> SetRange("x>0. && y>z && z>(x+y)");`
  - Names of variables must be defined by *SetParameterName()* method.
- `void SetDefaultUnit(const char* defUnit)`
  - Available for a command which takes unit.
  - Once the default unit is defined, no other unit of different dimension will be accepted.
  - You can also define a dimension (*unit category*).
    - `void SetUnitCategory(const char* unitCategory)`
- `void SetCandidates(const char* candidateList)`
  - Available for a command with string type parameter
  - Candidates must be *delimited by a space*.

Available states

- `void AvailableForStates (G4ApplicationState s1,…)`
- Geant4 has *6 application states*.
  - G4State_PreInit
    - Material, Geometry, Particle and/or Physics Process need to be initialized/defined
  - G4State_Idle
    - Ready to start a run
  - G4State_GeomClosed
    - Geometry is optimized and ready to process an event
  - G4State_EventProc
    - An event is processing
  - G4State_Quit
    - (Normal) termination
  - G4State_Abort
    - A fatal exception occurred and program is aborting



Converting between string and values

- Derivatives of *G4UIcommand* with numeric and boolean parameters have corresponding conversion methods.
- From a string to value
  - used in *SetNewValue()* method in a messenger
  - Unit is taken into account automatically

```
G4bool GetNewBoolValue(const char*)
G4int GetNewIntValue(const char*)
G4double GetNewDoubleValue(const char*)
G4ThreeVector GetNew3VectorValue(const char*)
```

- From a value to string
  - used in *GetCurrentValue()* method in a messenger

```
G4String ConvertToString(...)
G4String ConvertToString(...,const char* unit)
```

SetNewValue() and GetCurrentValue()

```
void A01DetectorConstMessenger
     ::SetNewValue(G4UIcommand* command, G4String newValue)
{
  if( command==armCmd ) {
    target-> SetArmAngle(armCmd-> GetNewDoubleValue(newValue));
  }
}


G4String A01DetectorConstMessenger
         ::GetCurrentValue(G4UIcommand* command)
{
  G4String cv;
  if( command==armCmd ){
    cv = armCmd-> ConvertToString(target->GetArmAngle(),"deg");
  }
  return cv;
}
```

Complicated UI command

- UI command with any number of parameters with different types.
  - A UI command with other types of parameters can be directly defined by *G4UIcommand* and *G4UIparameter*.

```
G4UIparameter(const char * parName,
              char theType,
              G4bool theOmittable);
```

  - "*theType*" is the type of the parameter.
    - 'b' (boolean), 'i' (integer), 'd' (double), and 's' (string)
  - Each *parameter* can take *guidance*, default value (in case "*theOmittable*" is true), parameter range , and candidate list.

- Parameters can be added to a command by

  G4UIcommand::SetParameter(G4UIparameter* const)

Converting string to values

For complicated command, convenient conversion method is not available.
G4Tokenizer tokenizes a string and converts each token to a numerical value.

```
SetNewValue(G4UIcommand* command, G4String newValues) {
  G4Tokenizer next(newValues);
  fAtomicNumber = StoI(next());
  fAtomicMass = StoI(next());
  G4String sQ = next();
  if (sQ.isNull()) {
    fIonCharge = fAtomicNumber;
  } else {
    fIonCharge = StoI(sQ);
    sQ = next();
    if (sQ.isNull()) {
      fIonExciteEnergy = 0.0;
    } else {
      fIonExciteEnergy = StoD(sQ) * keV;
    }
  }
```

G4UIcommand class has some basic conversion methods.

- StoI() : convert string to int
- StoD() : convert string to double
- ItoS() : convert int to string
- DtoS() : convert double to string

Be careful of "omittable" parameters.

Personal comment

- Many applications are built on top of the Geant4 toolkit by creating original user interface
- Majority of these applications use and extend existing UI
  - HEP: ATLAS, CMS, LHCb …
  - Space science: GRAS, …
  - Medicine: GATE, GAMOS, TOPAS…
- Development of private UI command make your work more easy and more effective