Programming into Slicer3

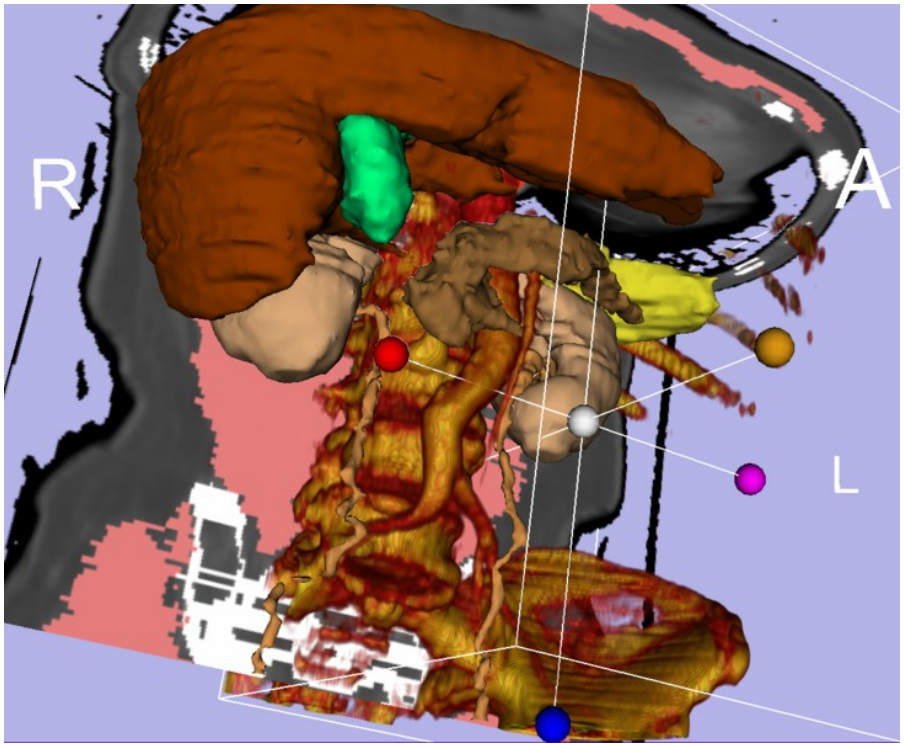
Sonia Pujol, Ph.D.

Surgical Planning Laboratory
Harvard University

Ferdinand Bol (1616-1680), The Officers of the Amsterdam Guild of Wine Merchants Alte Pinakothek, München

The NA-MIC Kit

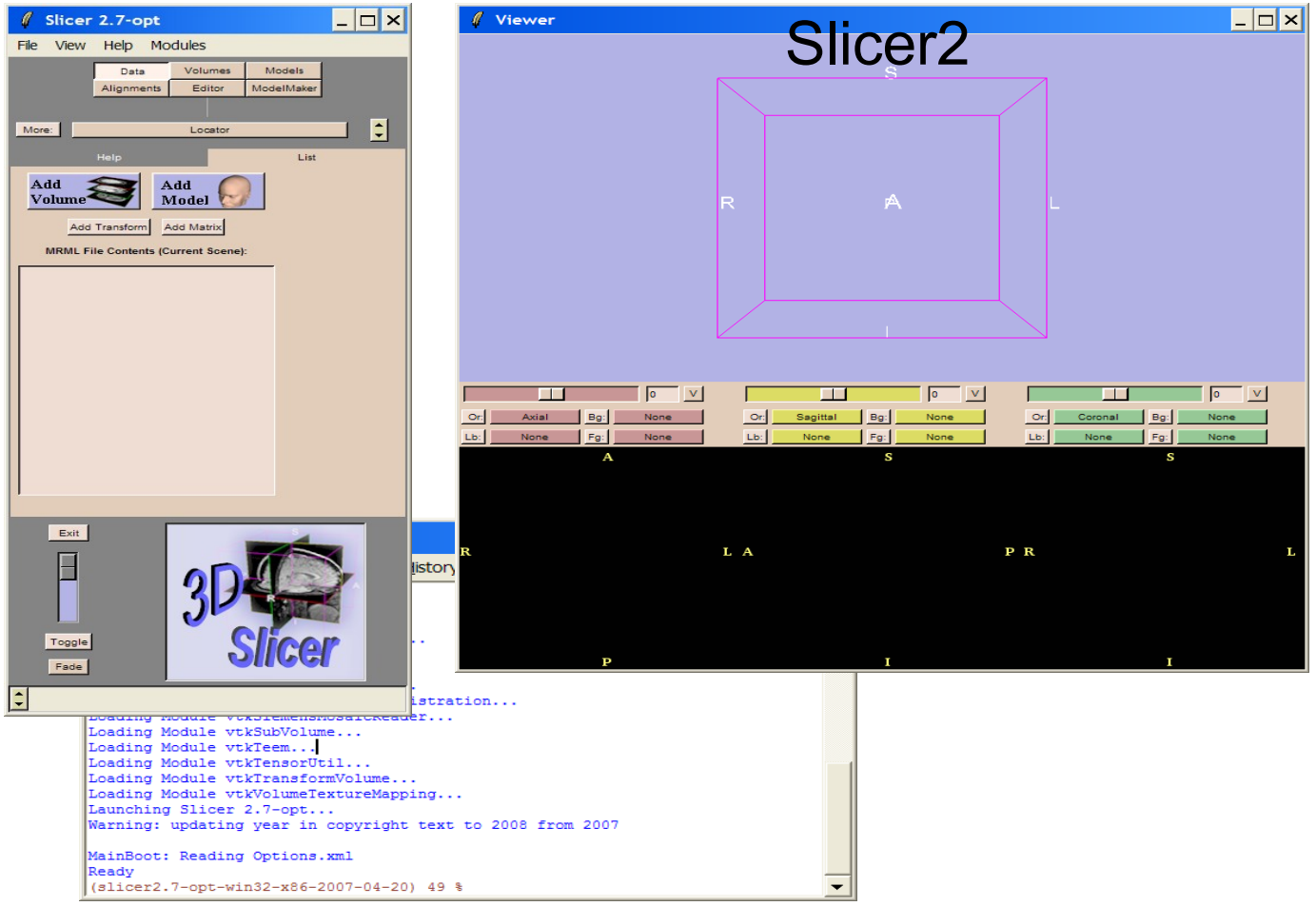
Slicer3



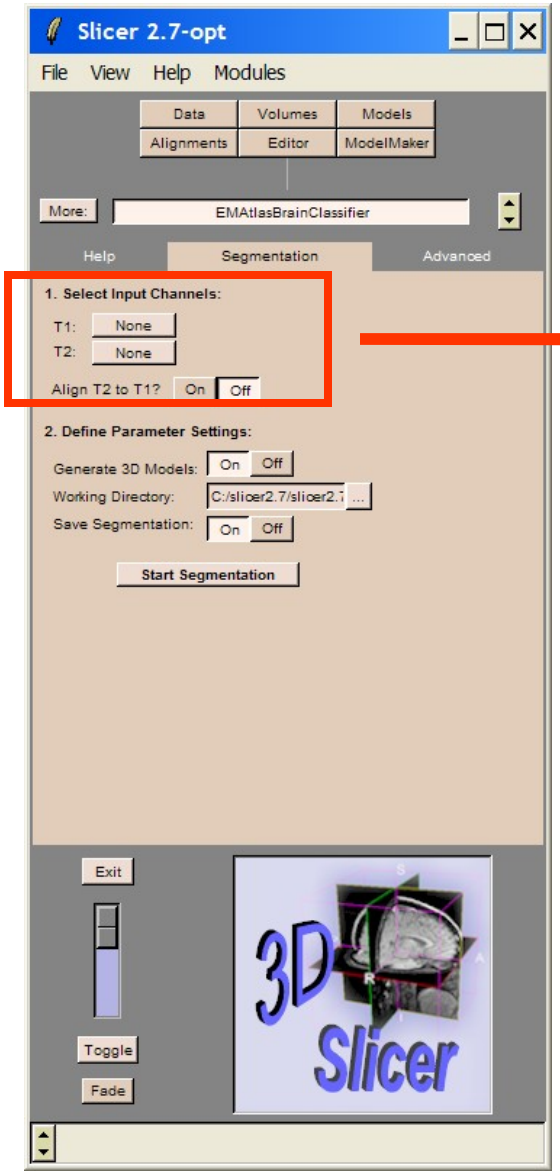
Integrated Volume Rendering.
R.Kikinis

- An end-user application for image analysis
- An open-source environment for software development
- A software platform that is both easy to use for clinical researchers and easy to extend for programmers

Before Slicer3

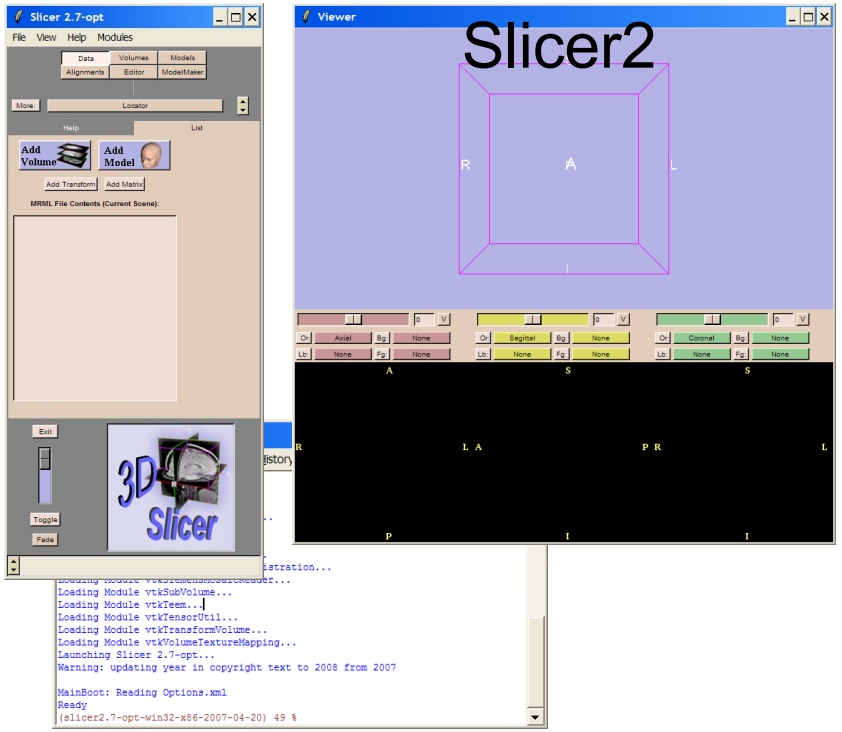


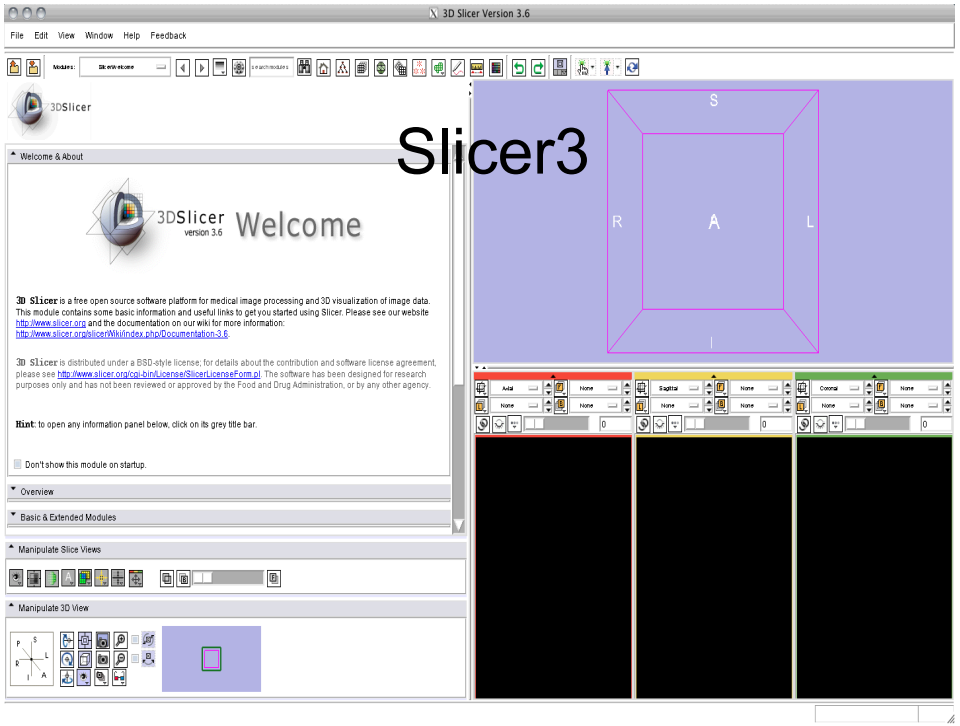
Programming into Slicer2



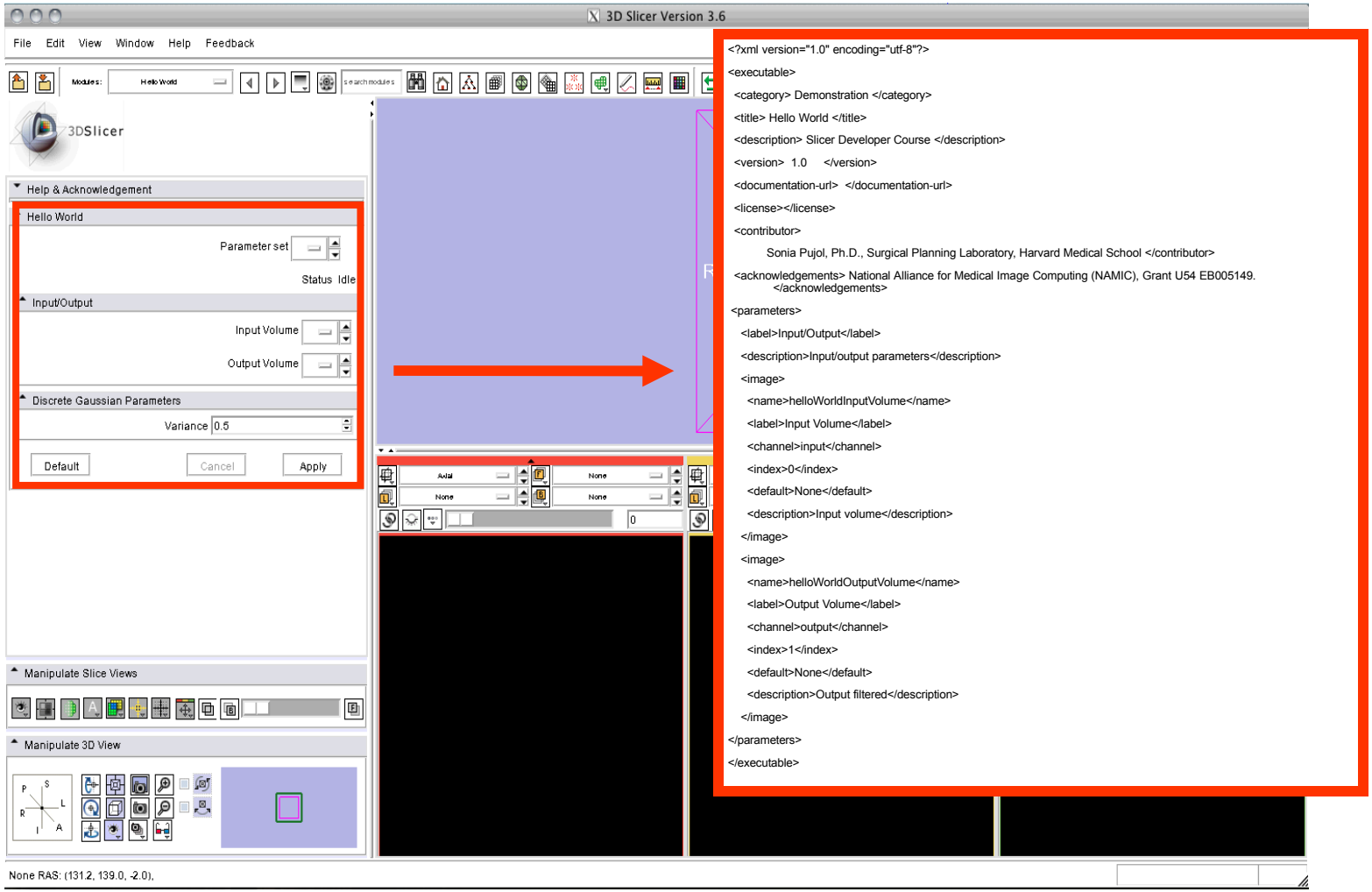

```
#-------------------------------------------
# 1. Step
#-------------------------------------------
set f $fSeg.fStep1
DevAddLabel $f.lTitle "1. Select Input Channels: " WTA
pack $f.lTitle -side top -padx $Gui(pad) -pady 1 -anchor w
frame $f.fInput -bg $Gui(activeWorkspace)
pack $f.fInput -side top -padx 0 -pady 0  -anchor w
foreach frame "Left Right" {
    frame $f.fInput.f$frame -bg $Gui(activeWorkspace)
    pack $f.fInput.f$frame -side left -padx 0 -pady $Gui(pad) }
foreach LABEL "T1 T2" Input "SPGR T2W" {
    DevAddLabel $f.fInput.fLeft.l$Input "  ${LABEL}:"
    pack $f.fInput.fLeft.l$Input -side top -padx $Gui(pad) -pady 1 -anchor w
    set menubutton   $f.fInput.fRight.m${Input}Select
    set menu         $f.fInput.fRight.m${Input}Select.m
eval {menubutton $menubutton -text [Volume($EMAtlasBrainClassifier(Volume,${Input}),node) GetName]
-relief raised -bd 2 -width 9 -menu $menu} $Gui(WMBA)
    eval {menu $menu} $Gui(WMA)
    TooltipAdd $menubutton "Select Volume defining ${Input}"
    set EMAtlasBrainClassifier(mbSeg-${Input}Select) $menubutton
    set EMAtlasBrainClassifier(mSeg-${Input}Select) $menu
    # Have to update at UpdateMRML too
    DevUpdateNodeSelectButton Volume EMAtlasBrainClassifier Seg-${Input}Select Volume,$Input
    pack $menubutton -side top  -padx $Gui(pad) -pady 1 -anchor w }
frame $f.fAlign -bg $Gui(activeWorkspace)
TooltipAdd  $f.fAlign "If the input T1 and T2 are not aligned with each other set flag here"
pack $f.fAlign -side top -padx 0 -pady 2  -padx $Gui(pad) -anchor w
DevAddLabel $f.fAlign.lAlign "Align T2 to T1? "
pack $f.fAlign.lAlign -side left -padx $Gui(pad) -pady 1 -anchor w
foreach value "1 0" text "On Off" width "4 4" {
    eval {radiobutton $f.fAlign.r$value -width $width -indicatoron 0\
            -text "$text" -value "$value" -variable EMAtlasBrainClassifier(AlignInput) } $Gui(WCA)
    pack $f.fAlign.r$value -side left -padx 0 -pady 0  }
```

From Slicer2 to Slicer3





The New Execution Model



Slicer3 Execution Model

- This course is based on the Execution Model which provides a mechanism for incorporating command line programs as Slicer modules.
- Slicer Communication with external executables
- Jim Miller, Dan Blezek, Bill Lorensen (GE)

http://www.slicer.org/slicerWiki/index.php/Slicer3:Execution_Model_Documentation

Learning objective

Following this course, you'll be able

1) to plug-in an external program into Slicer3
2) to implement an image filter and to run the analysis from Slicer3
3) to write and run a test using the CTest tool

Material

This course requires the following material

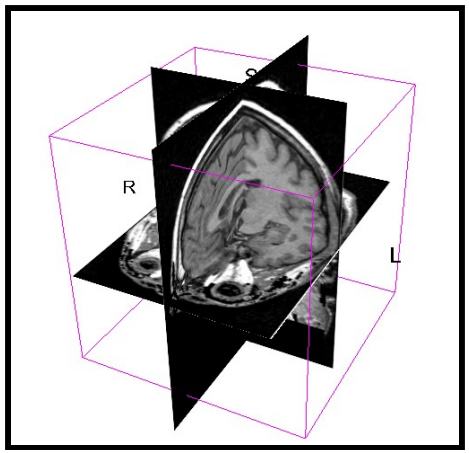
- Slicer 3.6 Software
- HelloWorld_Plugin.zip

Disclaimer

It is the responsibility of the user of 3DSlicer to comply with both the terms of the license and with the applicable laws, regulations and rules.

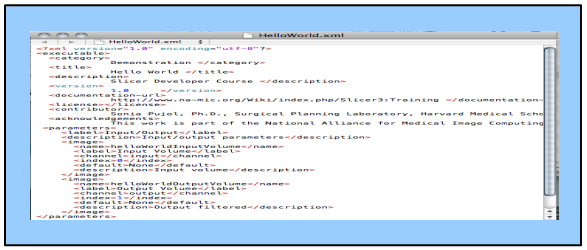
HelloWorld_Plugin.zip archive

Unzip HelloWorld_Plugin.zip

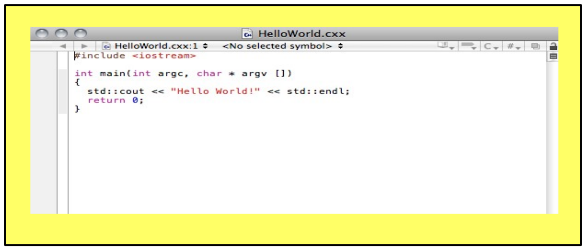


spgr.nhdr spgr.raw.gz

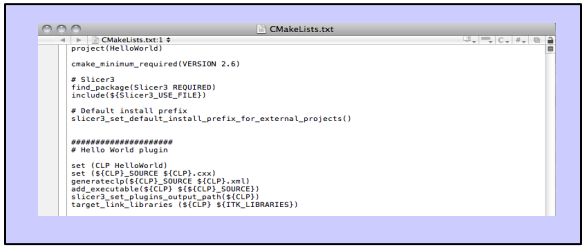
(124 SPGR images)



HelloWorld.xml
(Execution Model)



HelloWorld.cxx
(application)

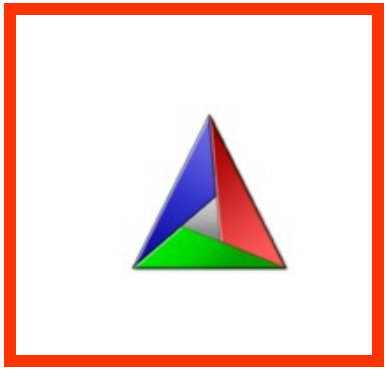


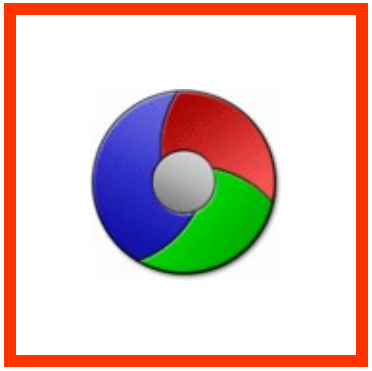
CMakeLists.txt
(CMake)

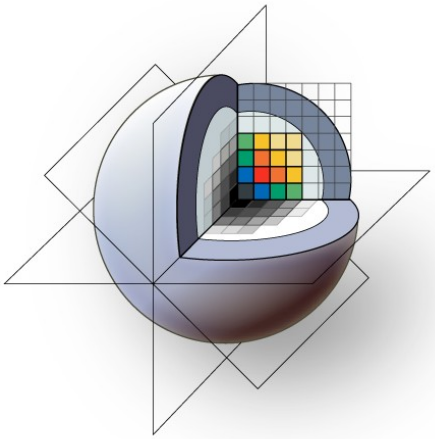
Overview

- Part A: integration of the HelloWorld program into Slicer3
- Part B: implementation of a Discrete Gaussian filter within the HelloWorld module
- Part C: implementation of a test for the HelloWorld module

Slicer Programming Course

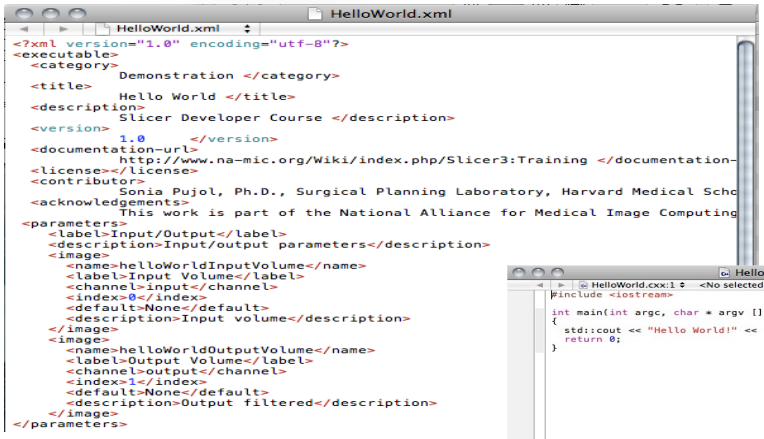


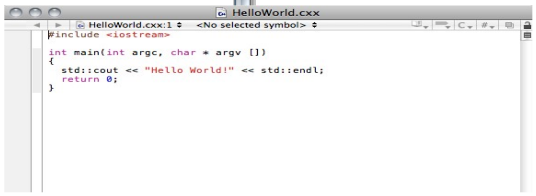




3DSlicer

Part A: Integrating an executable into Slicer3





Slicer3 Execution Model

- The Execution Model which provides a mechanism for incorporating command line programs as Slicer modules.

- The Slicer modules are described using XML files which are used to generate
  - the C++ command line code
  - the Graphical User Interface (GUI).

Modifying CMakeLists.txt

Open the file **CMakeLists.txt** located in the directory **/HelloWorld_Plugin/HelloWorld/**

CMakeLists.txt

```
project(HelloWorld)

cmake_minimum_required(VERSION 2.6)

# Slicer3
find_package(Slicer3 REQUIRED)
include(${Slicer3_USE_FILE})

# Default install prefix
slicer3_set_default_install_prefix_for_external_projects()

######################
# Hello World plugin



######################

######################
# Tests for the plugin

enable_testing()


######################
```

Ln 1, Col 1 | Insert | Sel: Normal | DOS | File size: 399

Editing CMakeLists.txt – part 1

Add the following lines to CMakeLists.txt

set (CLP HelloWorld)

set (${CLP}_SOURCE ${CLP}.cxx)

generateclp(${CLP}_SOURCE ${CLP}.xml)

CMakeLists.txt

```
project(HelloWorld)

cmake_minimum_required(V

# Slicer3
find_package(Slicer3 REQ
include(${Slicer3_USE_FI

# Default install prefix
slicer3_set_default_inst


#####################
# Hello World plugin

set (CLP HelloWorld)
set (${CLP}_SOURCE ${CLP}.cxx)
generateclp(${CLP}_SOURCE ${CLP}.xml)


#####################


#####################
# Tests for the plugin
```

*GENERATECLP generates the file **HelloWorldCLP.h** for parsing the command line arguments.*

'CLP' means Command Line Processing

Editing CMakeLists.txt – part 2

Add the following lines to CMakeLists.txt after the ‘generateclp’ line you just added

add_executable(${CLP} ${${CLP}_SOURCE})

slicer3_set_plugins_output_path(${CLP})

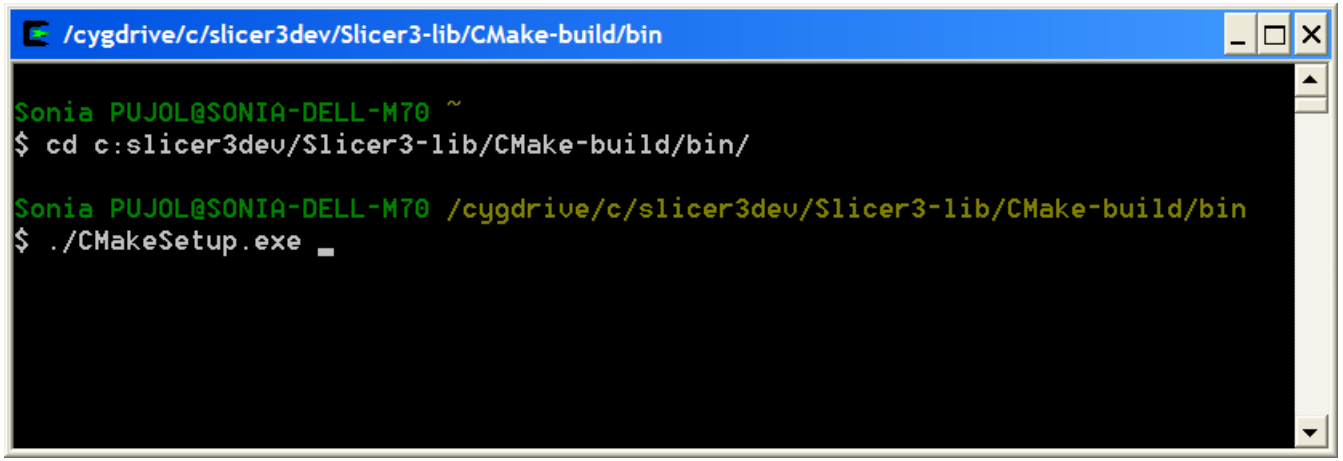
target_link_libraries (${CLP} ${ITK_LIBRARIES})

Save the file after editing

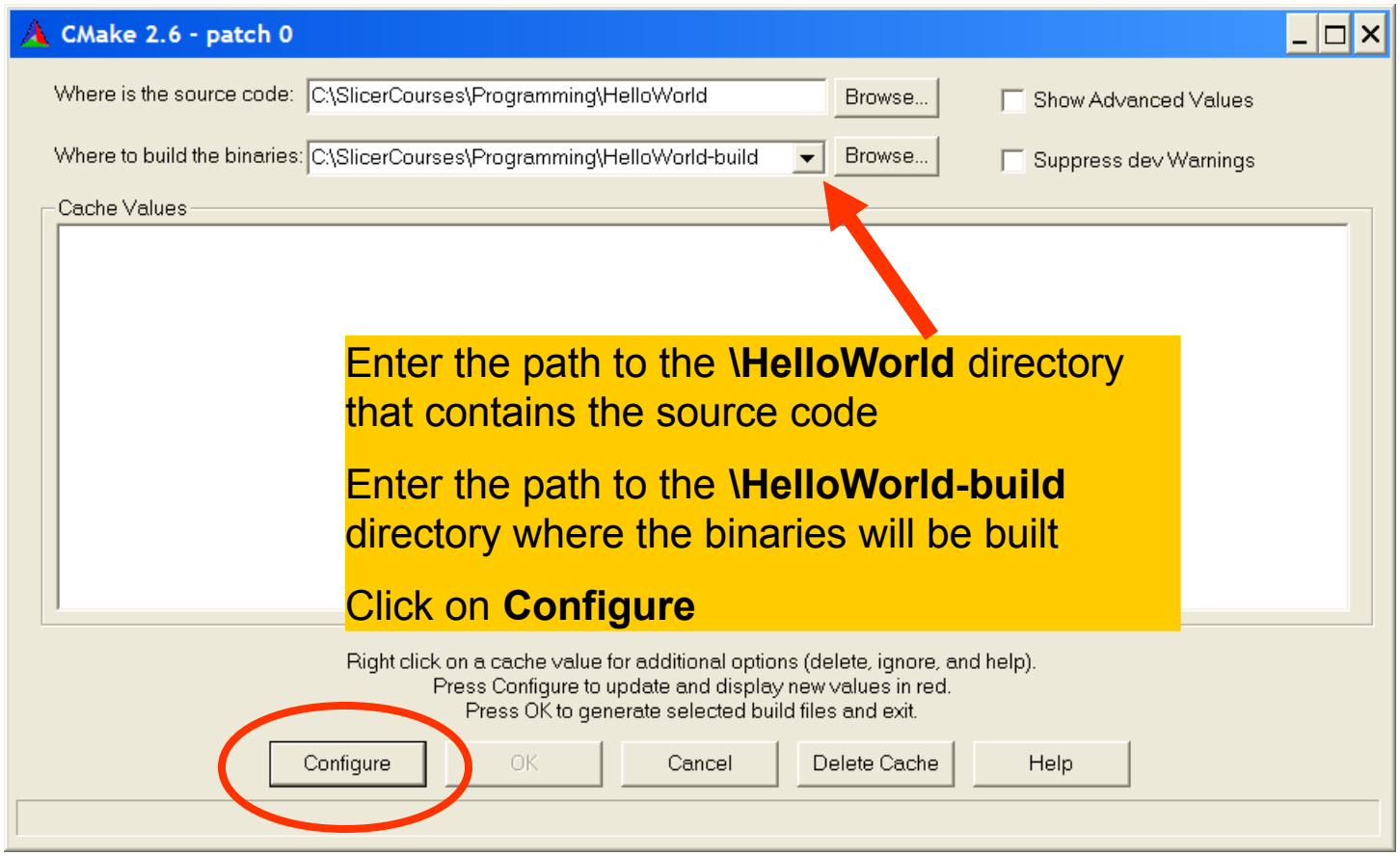
ADD_EXECUTABLE creates the stand-alone executable ***HelloWorld.exe*** *that can be run from a command line.*

Configuring HelloWorld - WINDOWS (1/5)

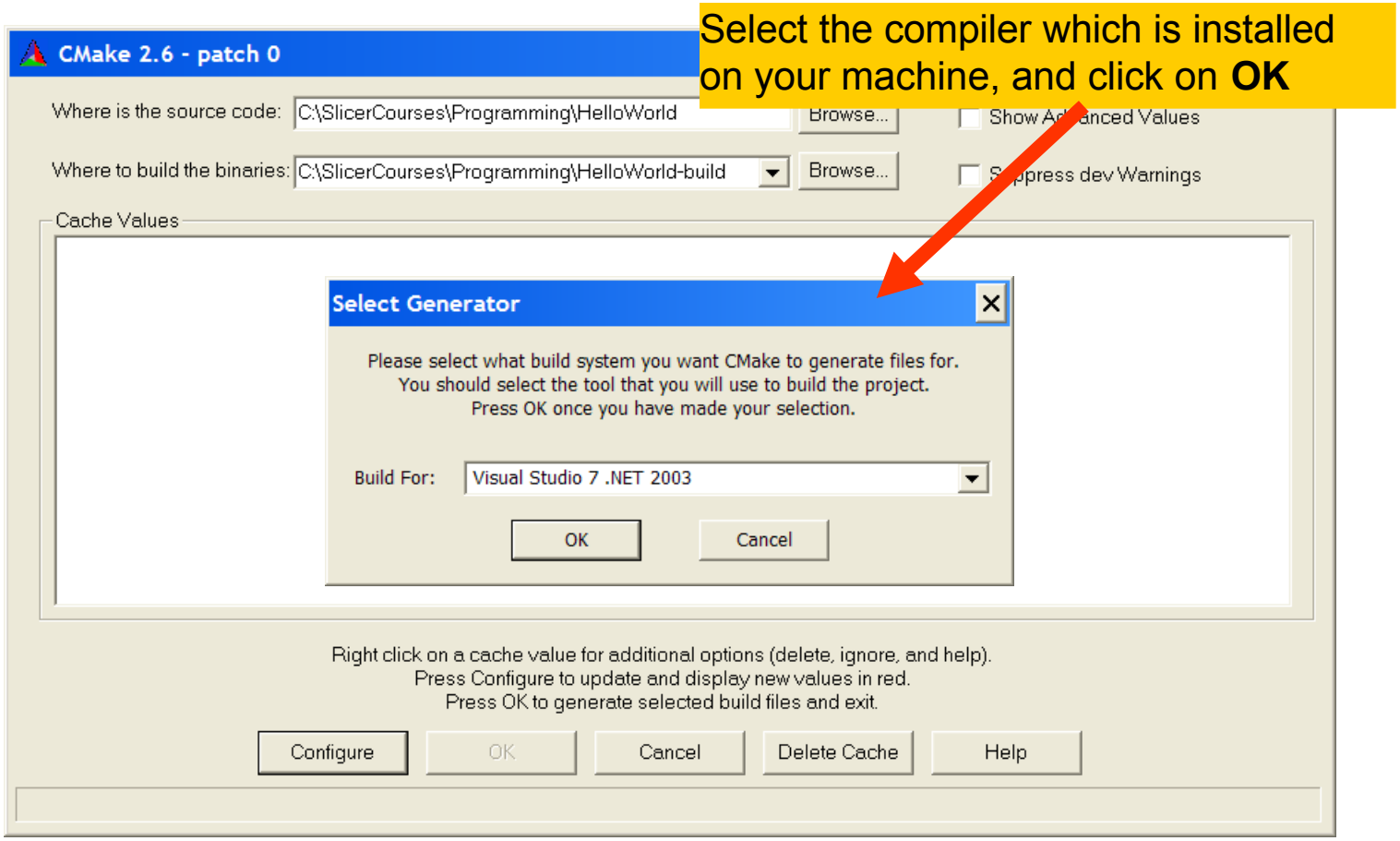
- Launch the CMake executable located in the directory Slicer3-lib/CMake-build/bin



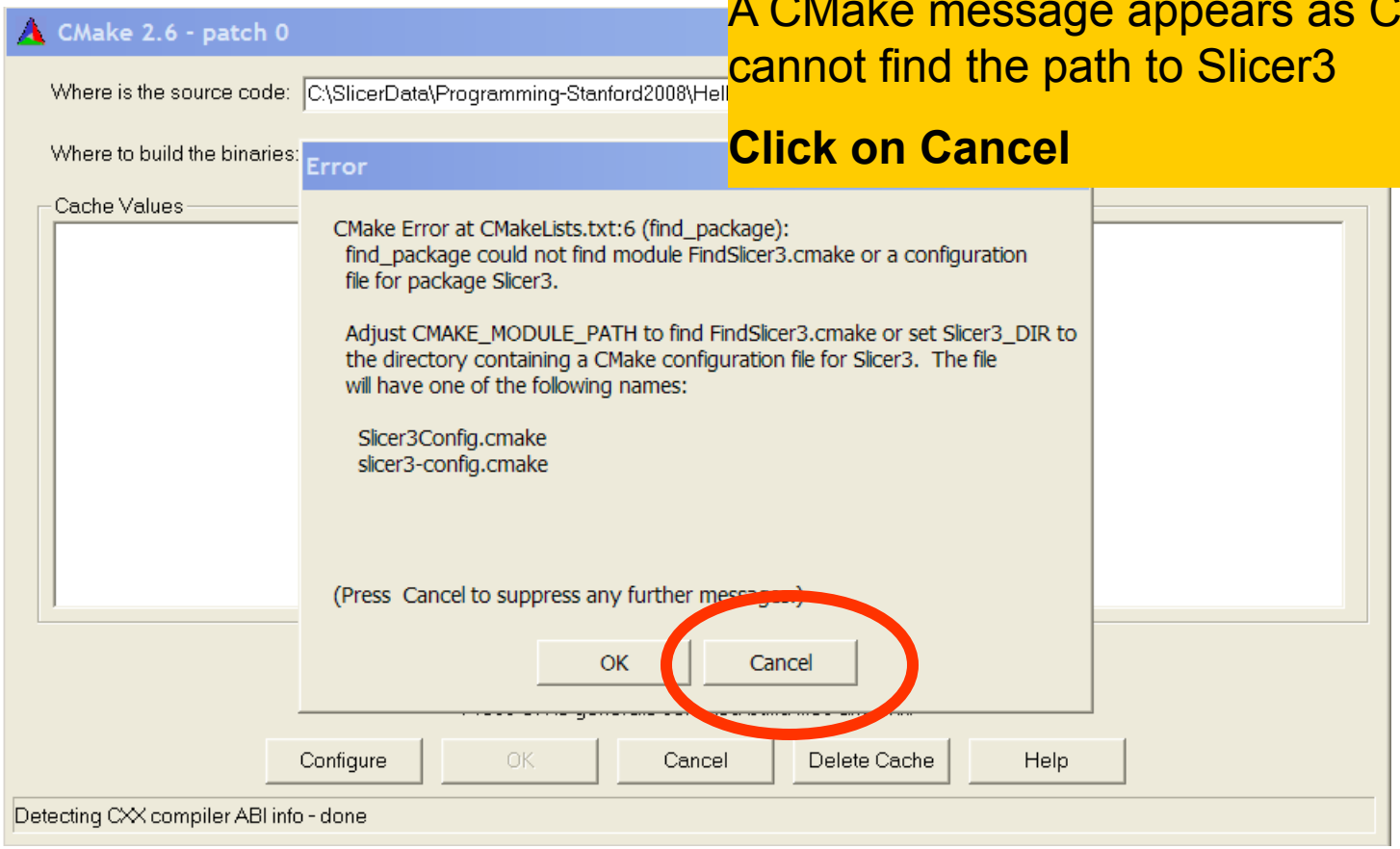
Configuring HelloWorld - WINDOWS (2/5)



Configuring HelloWorld - WINDOWS (3/5)



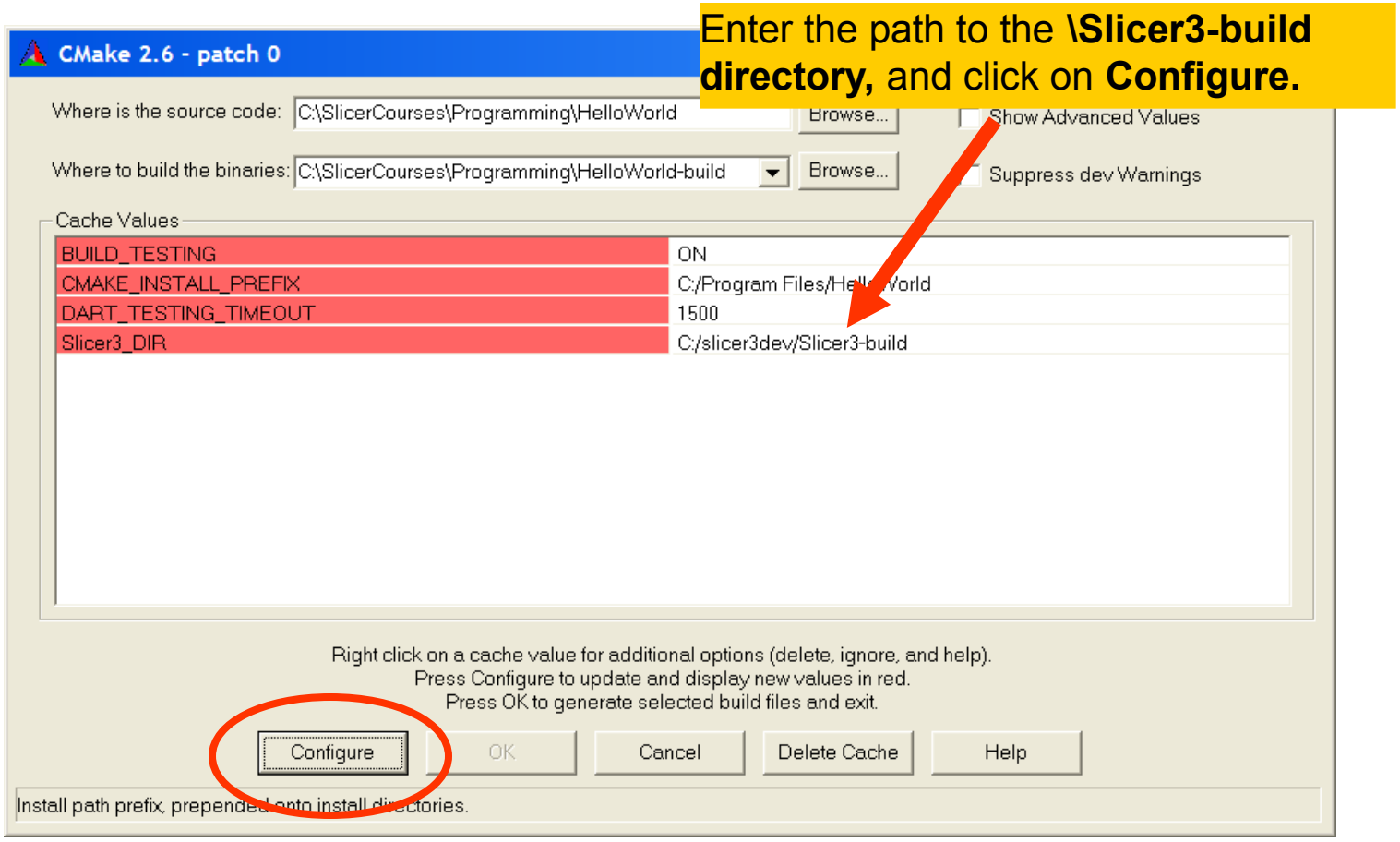
Configuring HelloWorld - WINDOWS (3/5)



A CMake message appears as CMake cannot find the path to Slicer3

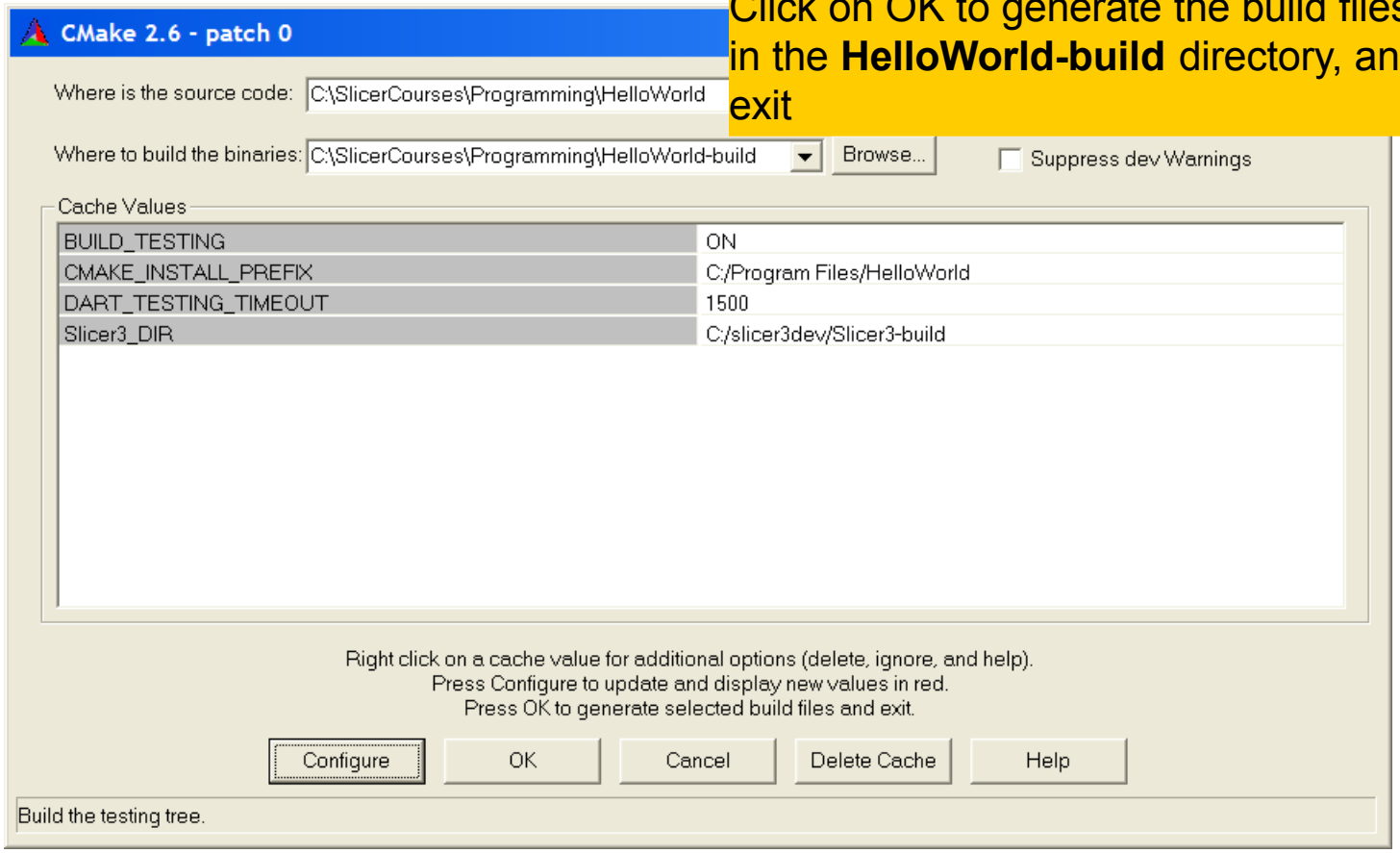
Click on Cancel

Configuring HelloWorld - WINDOWS (4/5)



Configuring HelloWorld - WINDOWS (5/5)

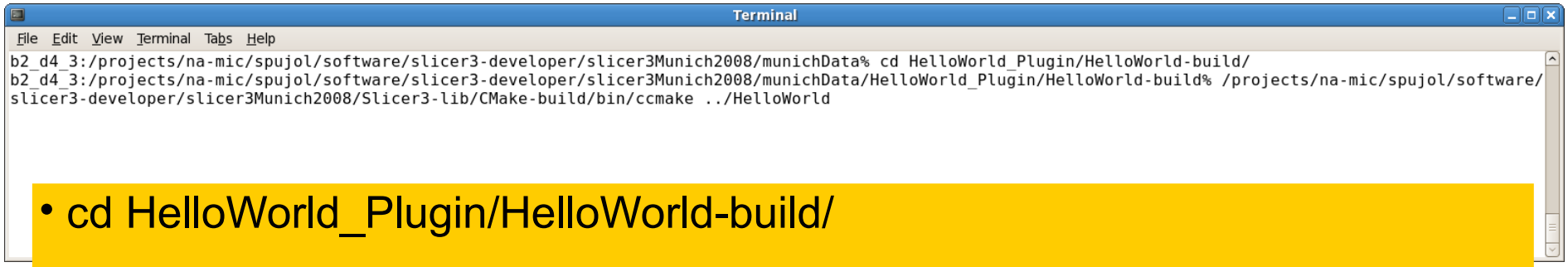
Click on OK to generate the build files in the **HelloWorld-build** directory, and exit



Configuring HelloWorld (Linux & Mac) 1/4

- From the **HelloWorld-build/** directory,

launch the ccmake executable located in the **Slicer3-lib/CMake-build/bin/** directory

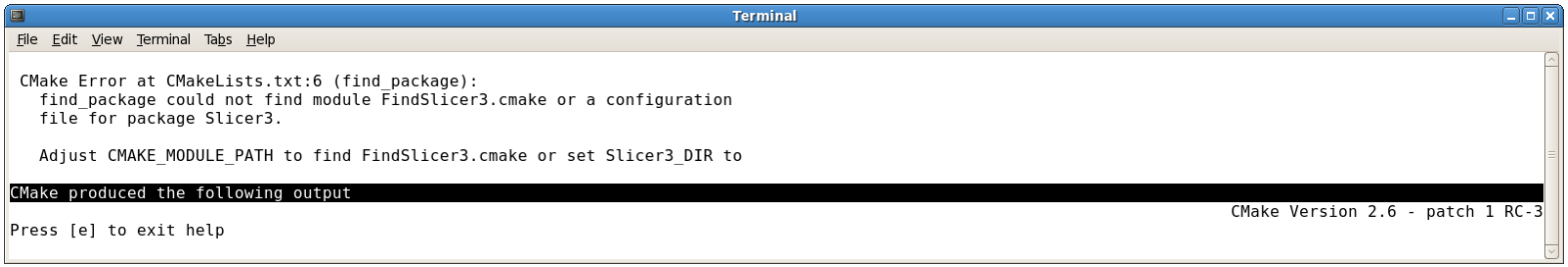


- cd HelloWorld_Plugin/HelloWorld-build/
- /path/to/Slicer/build**/Slicer3-lib/CMake-build/bin/ccmake ../HelloWorld**

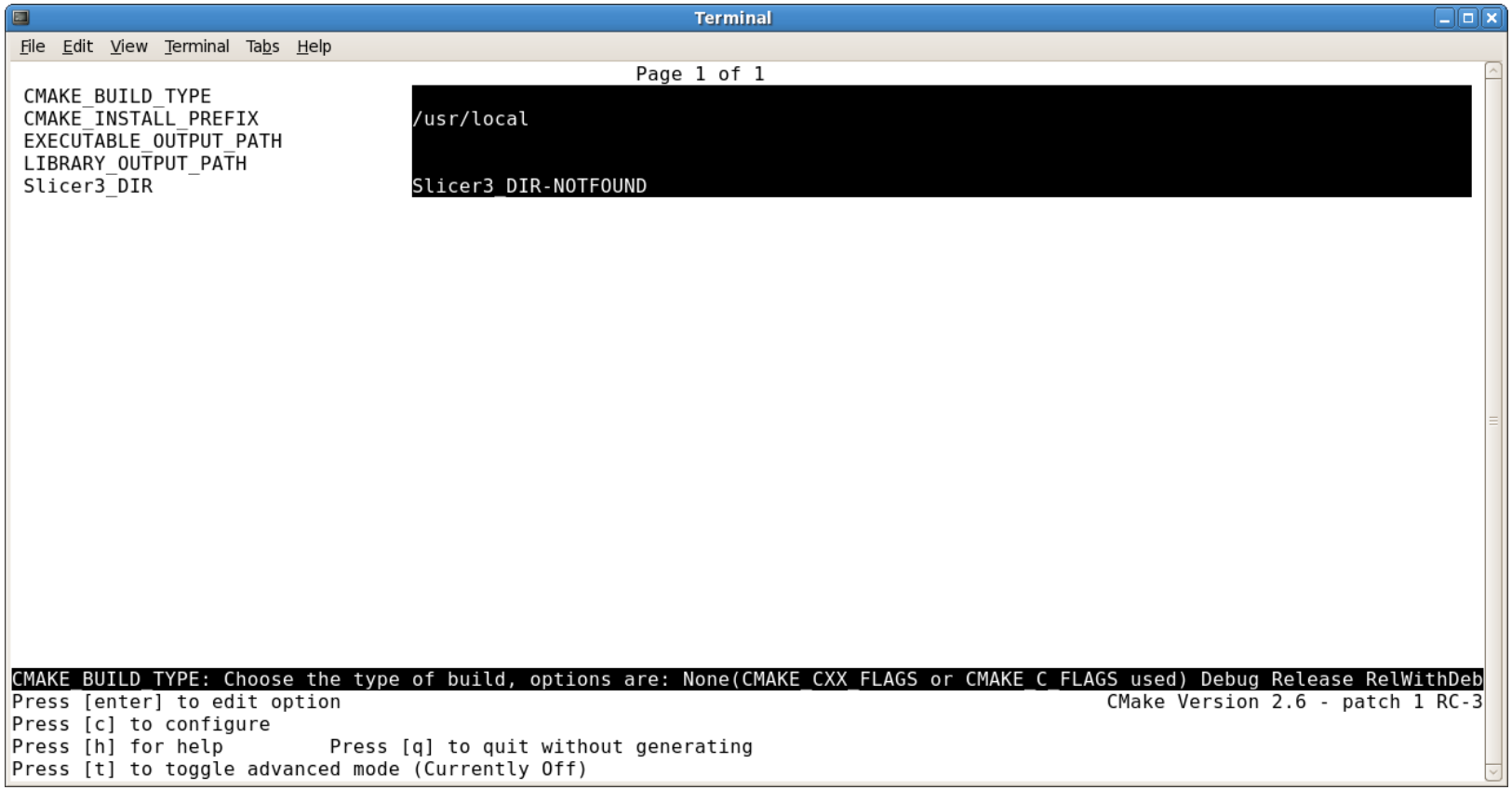
Configuring HelloWorld (Linux & Mac) 2/4

You need to enter the path to Slicer3 manually:

Press **e** to get to the configuration options



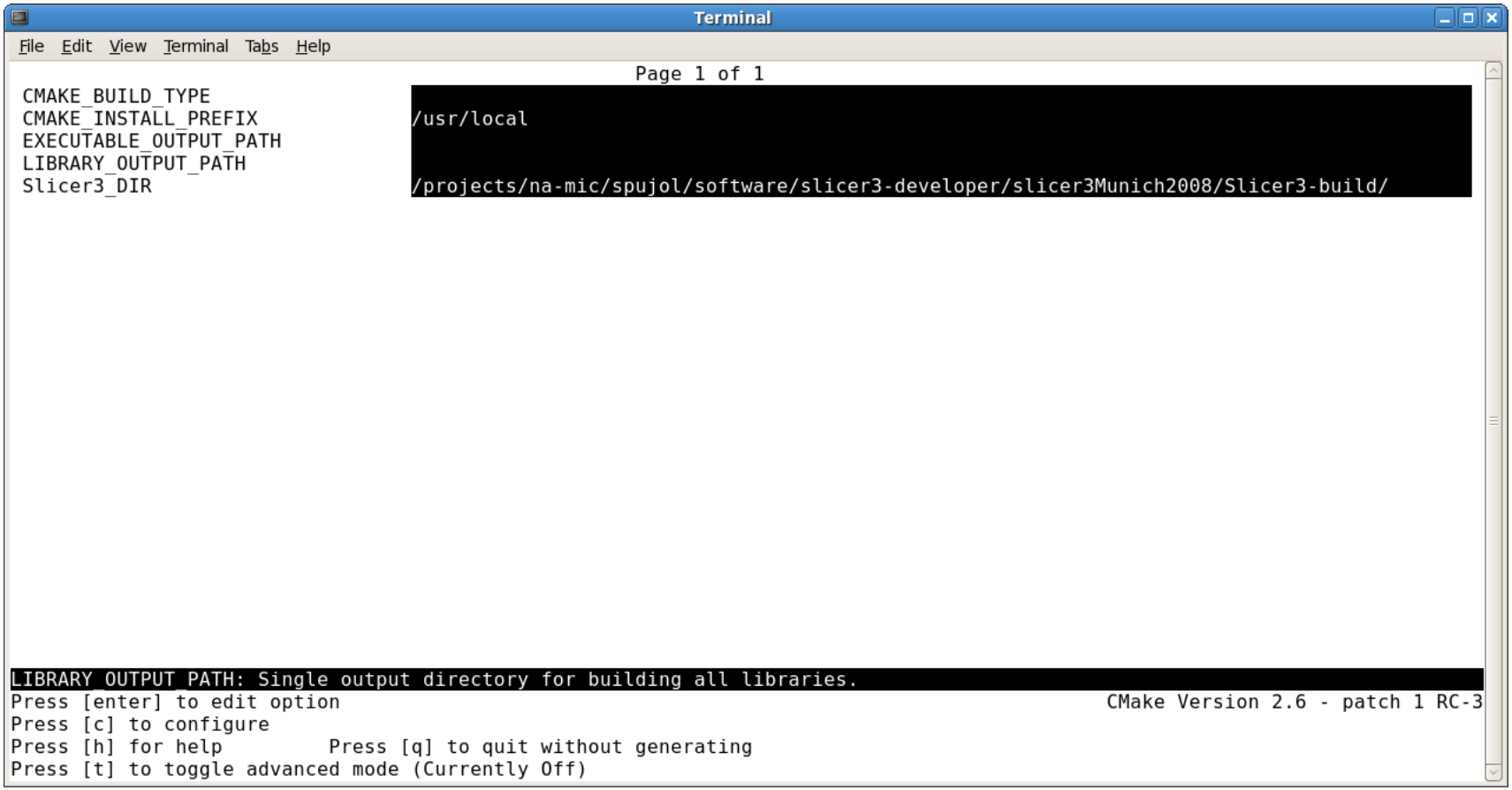
Configuring HelloWorld (Linux & Mac) 3/4



Enter the path to the directory Slicer3-build/:

- Arrow down to the Slicer3_DIR and Hit Enter to edit the path
- Arrow up once you have finished editing the path

Configuring HelloWorld (Linux & Mac) 4/4



Press C to configure

Press C to configure again

Press G to generate the **Makefile**

HelloWorld.xml

Module Description

Module Parameters

Open the file **HelloWorld.xml** located in the directory **HelloWorld_Plugin/HelloWorld**

```
<?xml version="1.0" encoding="utf-8"?>
<executable>
 <category>
        Demonstration </category>
 <title>
        Hello World </title>
 <description>
        Slicer Developer Course </description>
 <version>
        1.0     </version>
 <documentation-url>
        http://www.na-mic.org/Wiki/index.php/Slicer
 <license></license>
 <contributor>
        Sonia Pujol, Ph.D., Surgical Planning Laboratory, Harvard Medical School </contributor>
 <acknowledgements>
        This work is part of the National Alliance for Medical Image Computing (NAMIC),
        funded by the National Institutes of Health through the NIH Roadmap for Medical Research,
        Grant U54 EB005149. </acknowledgements>

 <parameters>
   <label>Input/Output</label>
   <description>Input/output parameters</description>
   <image>
     <name>helloWorldInputVolume</name>
     <label>Input Volume</label>
     <channel>input</channel>
     <index>0</index>
     <default>None</default>
     <description>Input volume</description>
   </image>
   <image>
     <name>helloWorldOutputVolume</name>
     <label>Output Volume</label>
     <channel>output</channel>
     <index>1</index>
     <default>None</default>
     <description>Output filtered</description>
   </image>
 </parameters>
</executable>
```

Module Description

```
<?xml version="1.0" encoding="utf-8"?>
<executable>
  <category>
        Demonstration</category>
  <title>
      Hello World</title>
  <description>
          Slicer Developer Course</description>
  <version>
        1.0</version>
  <documentation-url></documentation-url>
  <license></license>
  <contributor> Sonia Pujol, Ph.D., Surgical Planning Laboratory, Harvard Medical School </contributor>
  <acknowledgements>
            This work is part of the National Alliance for Medical Image Computing (NAMIC), funded by the
    National Institutes of Health through the NIH Roadmap for Medical Research, Grant U54 EB005149.
</acknowledgements>
```

Module Parameters

```
<parameters>
  <label>Input/Output</label>
  <description>Input/output parameters</description>
  <image>
    <name>helloWorldInputVolume</name>
    <label>Input Volume</label>
    <channel>input</channel>
    <index>0</index>
    <default>None</default>
    <description>Input volume</description>
  </image>
<image>
    <name>helloWorldOutputVolume</name>
    <label>Output Volume</label>
    <channel>output</channel>
    <index>1</index>
    <default>None</default>
    <description>Output filtered</description>
  </image>
</parameters>
</executable>
```

Input Volume

Output Volume

A file that specifies the image

Modifying the source code

Open the file HelloWorld.cxx

```
# include <iostream>

int main(int argc, char * argv [])
{

   std::cout<< “Hello World !”<<std::endl;

   return 0 ;
}
```

Modifying the source code

Add the following lines to the file HelloWorld.cxx

```
# include <iostream>
#include "HelloWorldCLP.h"
int main(int argc, char * argv [])
{
  PARSE_ARGS;
  std::cout<< “Hello World !”<<std::endl;
  return EXIT_SUCCESS ;
}
```

Building HelloWorld.exe

Mac/Linux

Run '**make**' in the directory **HelloWorld-build/**

Windows

In Visual Studio, select **Build→Build Solution** to build the solution **HelloWorld.sln** located in **HelloWorld-build/**

Building HelloWorld.exe

Mac/Linux

HelloWorld.exe is located in
/HelloWorld-build/lib/slicer3/plugins

Windows

HelloWorld.exe is located in
/HelloWorld-build/lib/slicer3/plugins/debug

Running Slicer3

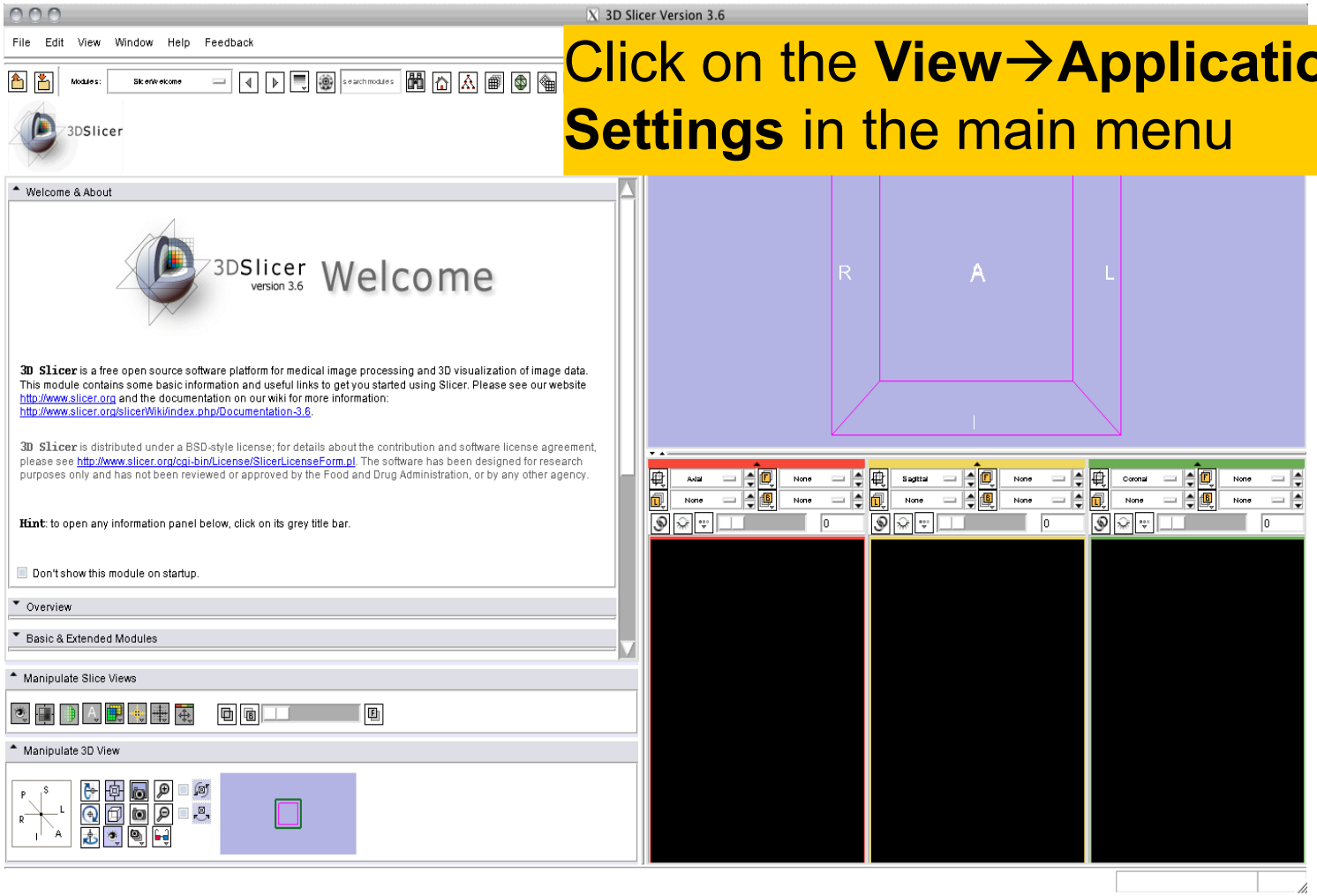
Mac/Linux

Run **'./Slicer3'** in Slicer3-build/

Windows

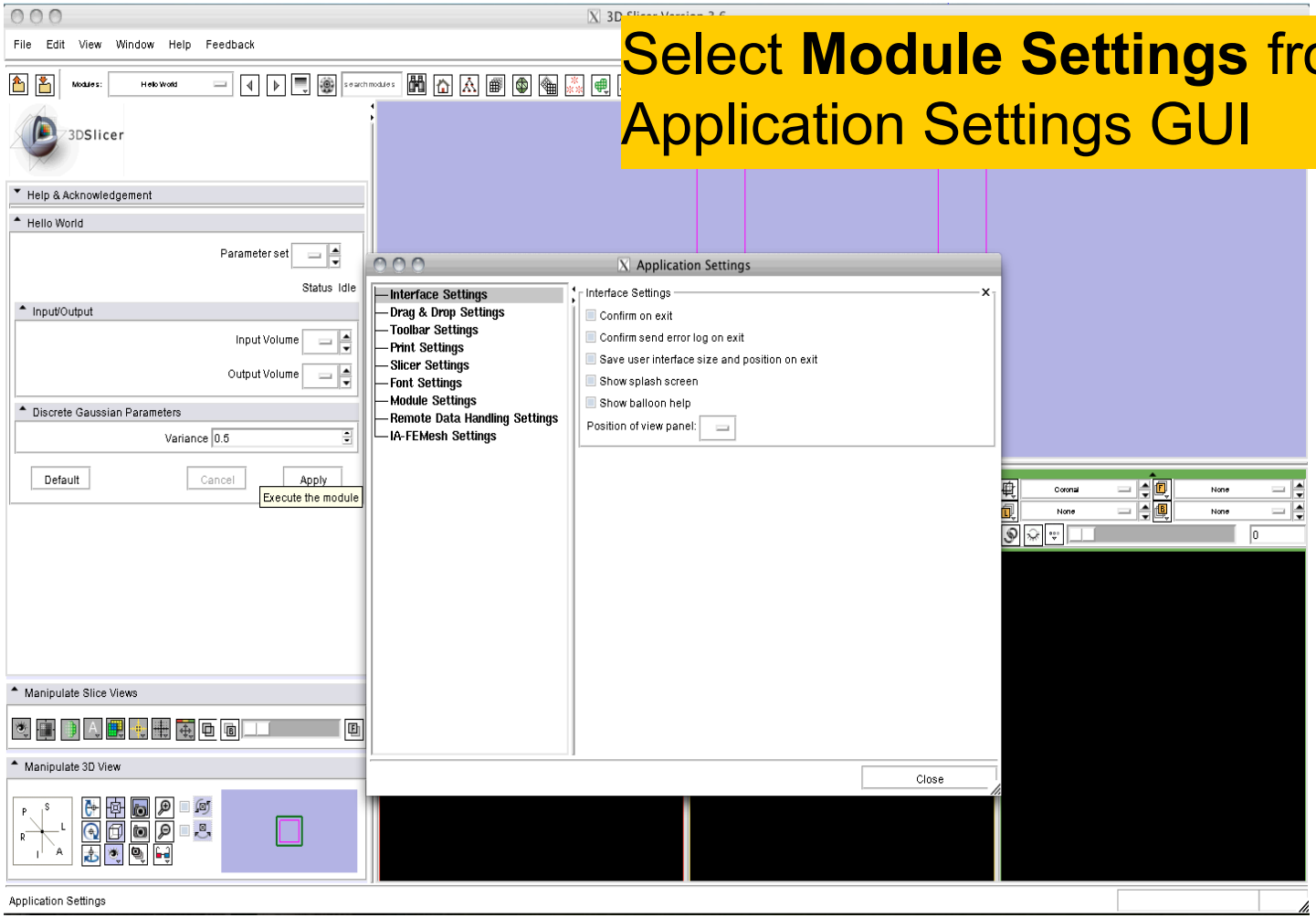
Run **'./Slicer3'** in Slicer3-build/

Running Slicer3

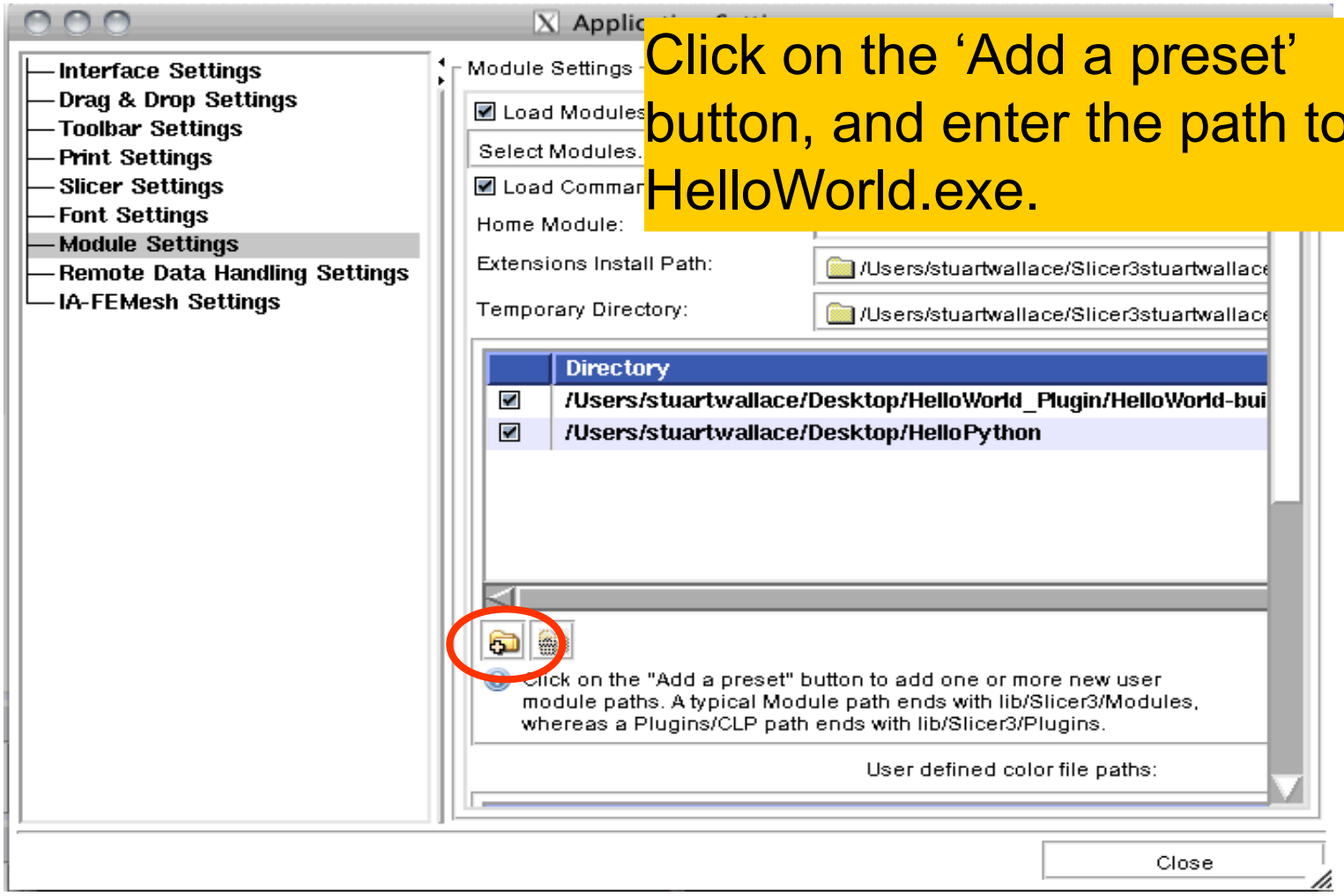


Click on the **View→Application Settings** in the main menu

Setting the HelloWorld plugin path

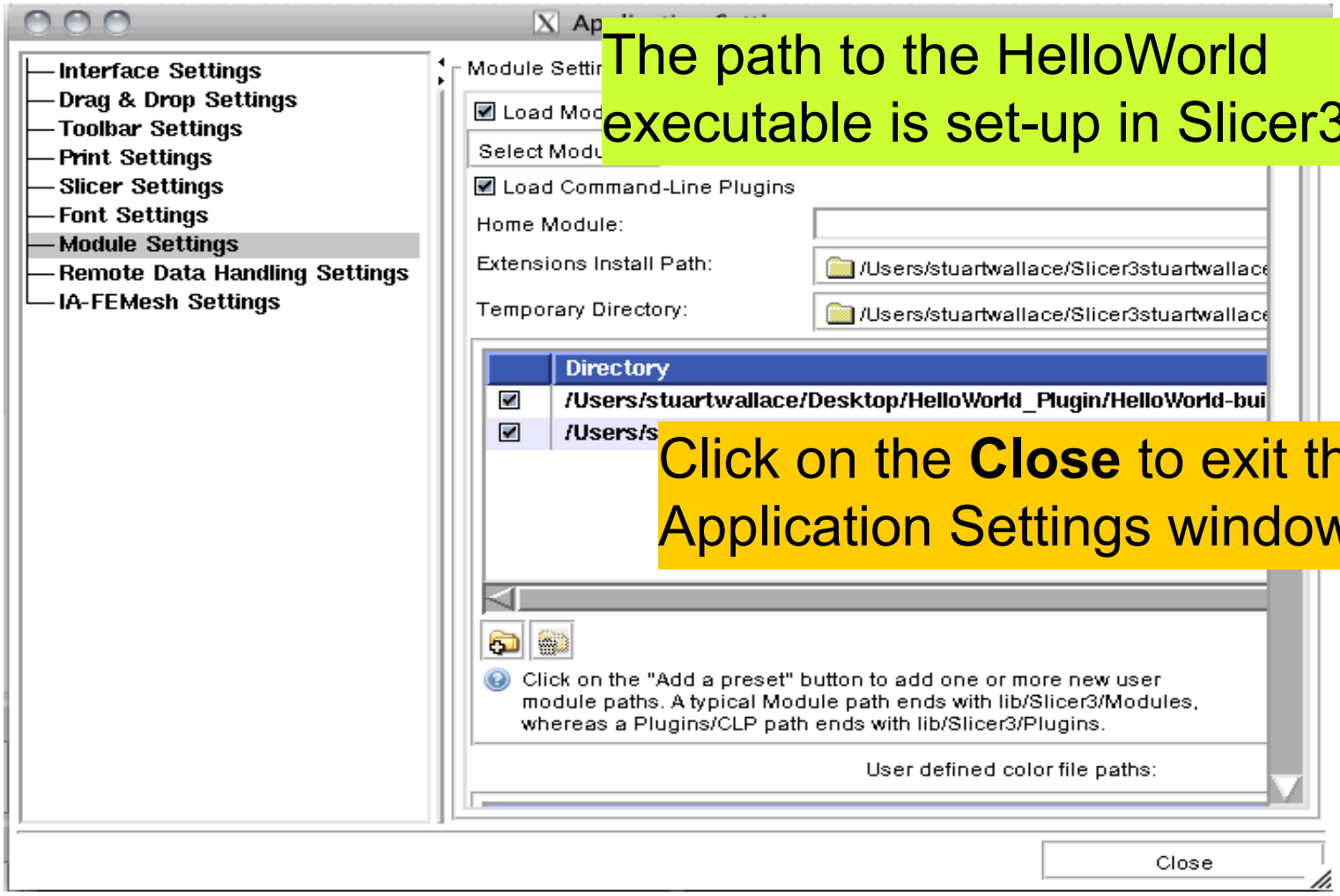


Setting the HelloWorld plugin path



Click on the 'Add a preset' button, and enter the path to HelloWorld.exe.

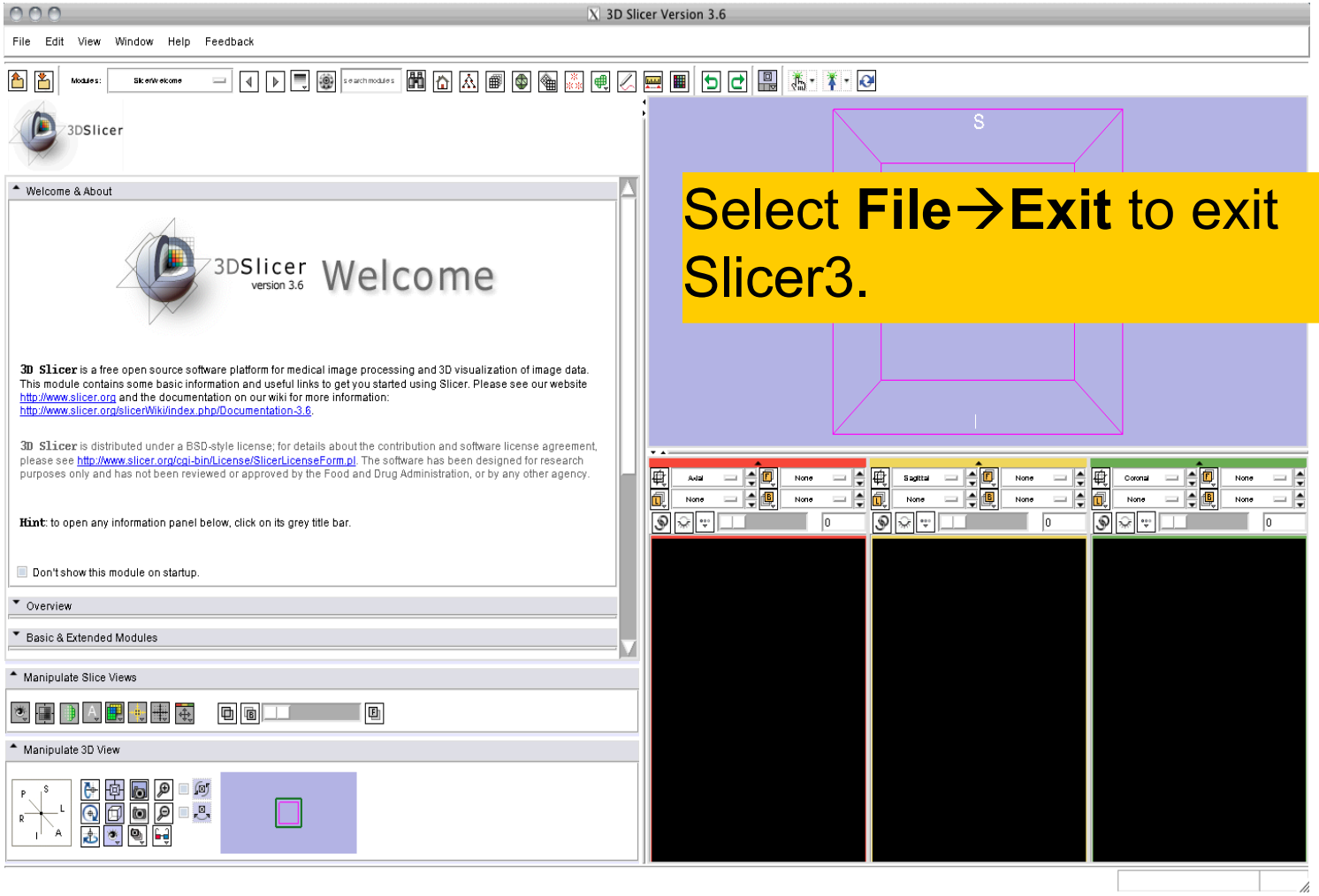
Setting the HelloWorld plugin path



The path to the HelloWorld executable is set-up in Slicer3.

Click on the **Close** to exit the Application Settings window.

Setting the HelloWorld plugin path



Select **File→Exit** to exit Slicer3.

Running Slicer3

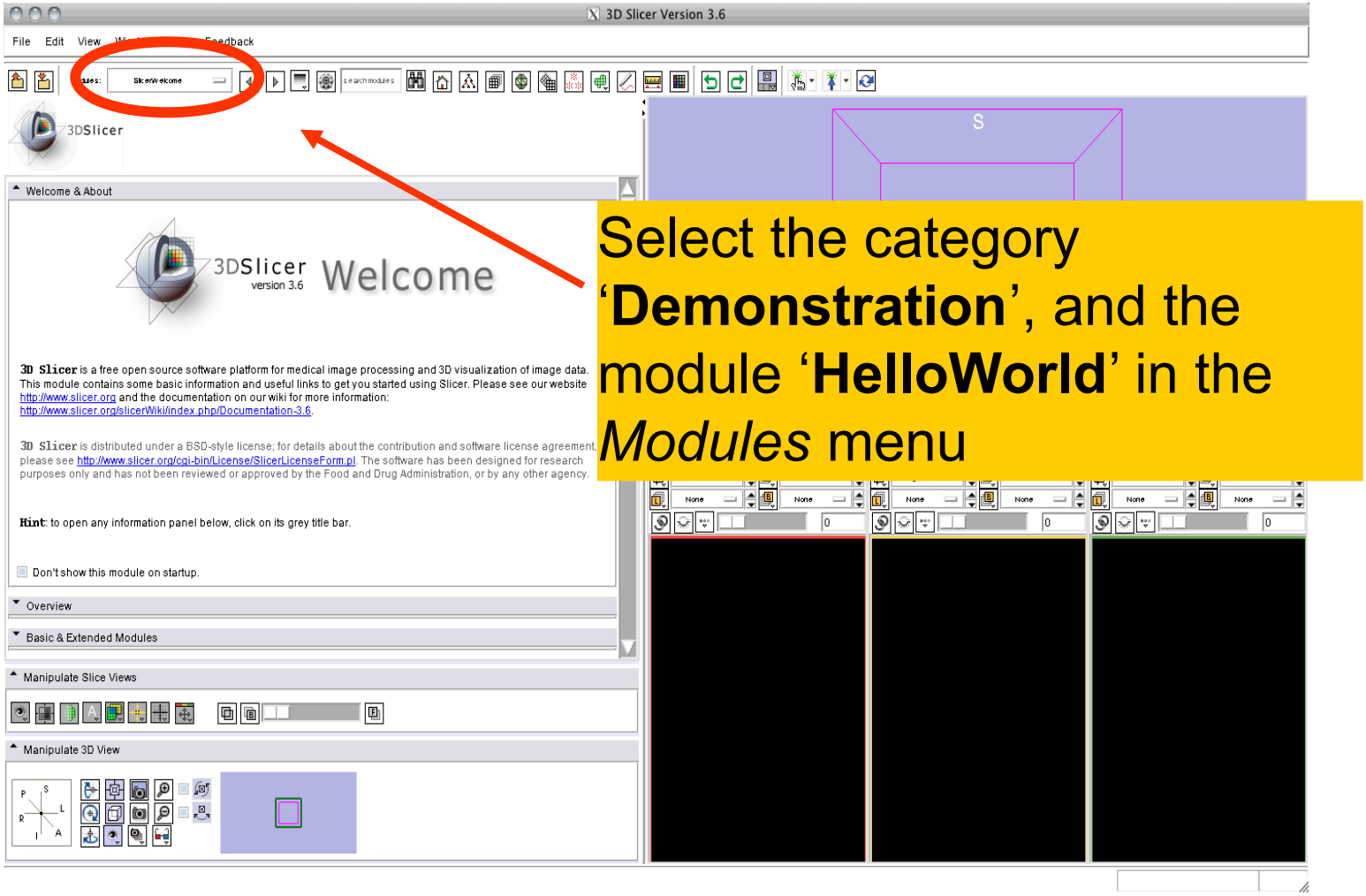
Mac/Linux

Run **'./Slicer3'** in Slicer3-build/

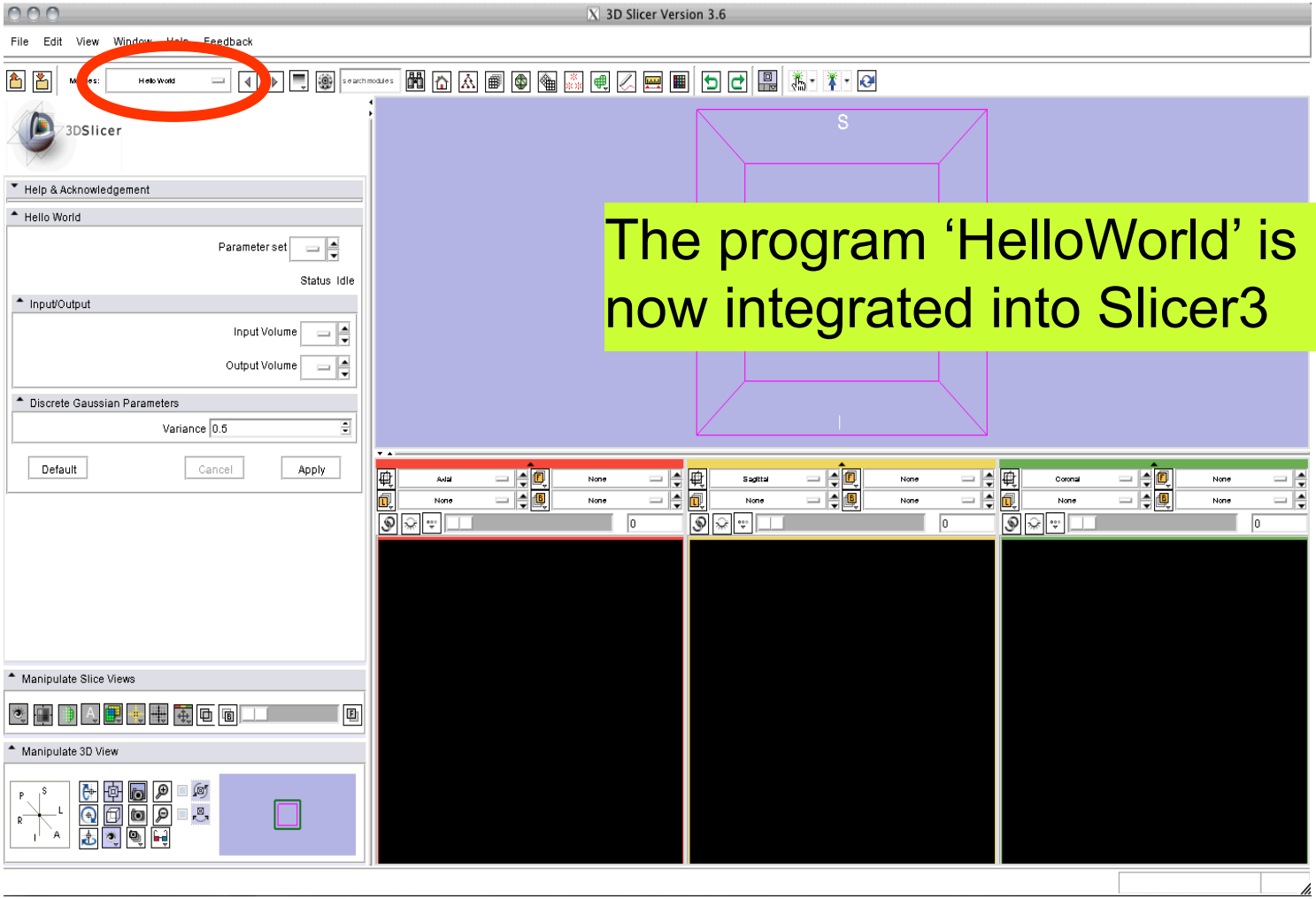
Windows

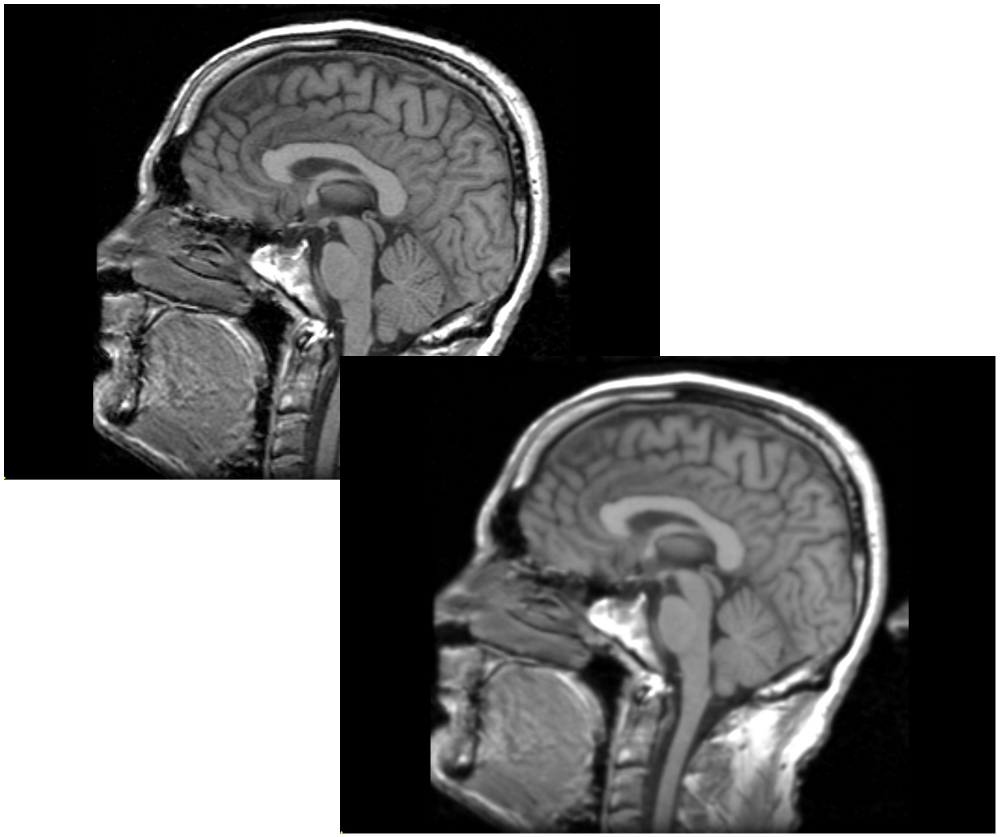
Run **'./Slicer3.exe'** in Slicer3-build/

HelloWorld module in Slicer3



HelloWorld Module in Slicer3





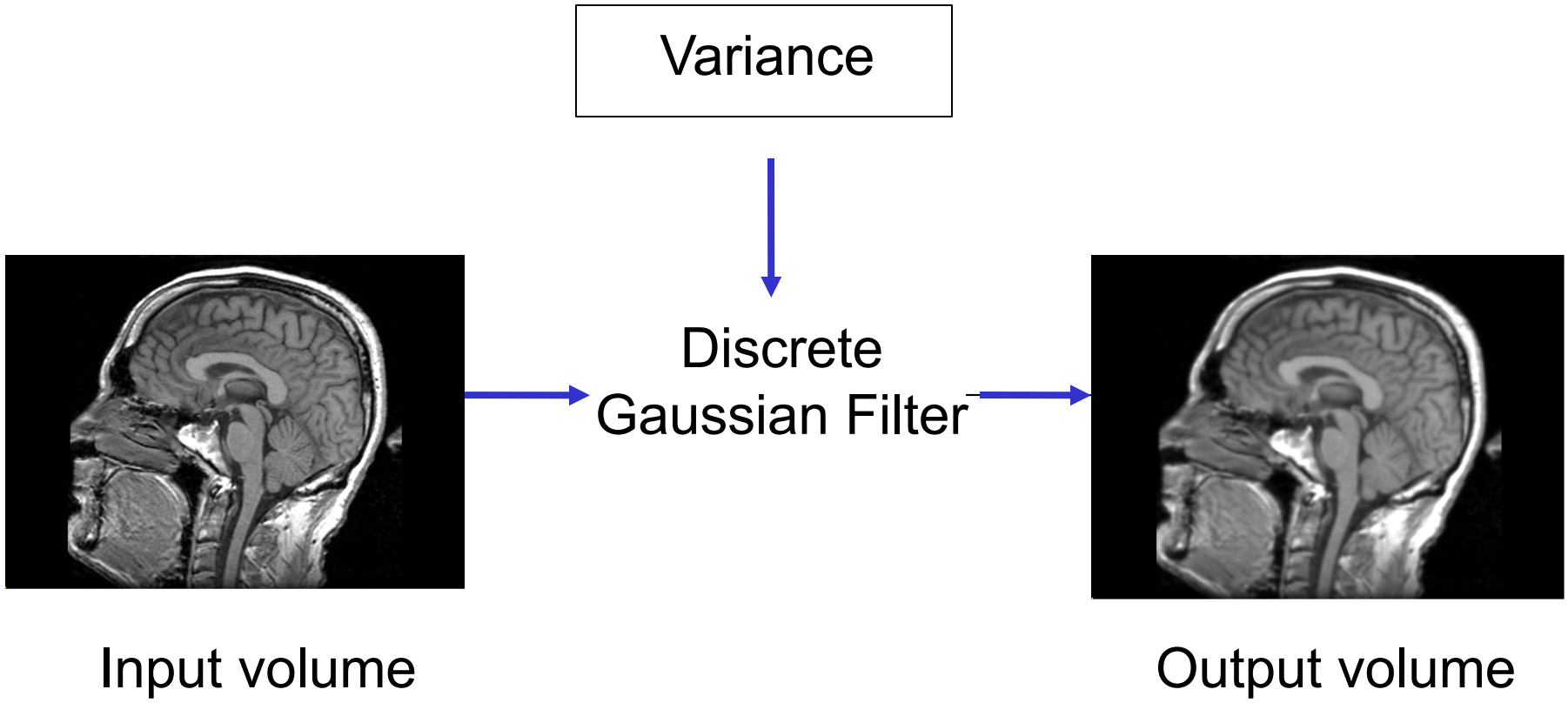
Part B: Implementing an image filter

Goal

- In this section, we'll implement a Gaussian smoothing operator to 'blur' the images and remove detail and noise.

- This implementation will allow us to run the filter on volumes loaded in Slicer, and to integrate the resulting filtered volumes as MRML nodes.

Discrete Gaussian Filter



Editing the file HelloWorld.xml

```
<?xml version="1.0" encoding="utf-8"?>
<executable>
  <category>
          Demonstration</category>
  <title>
        Hello World</title>
  <description>
            Slicer Developer Example</description>
  <version>
          1.0</version>
  <documentation-url></documentation-url>
  <license></license>
  <contributor>
            Sonia Pujol, Ph.D, Surgical Planning Laboratory, Harvard Medical School </contributor>
  <acknowledgements>
                This work is part of the National Alliance for Medical Image Computing (NAMIC), funded by the National Institutes of Health through the NIH Roadmap for
        Medical Research, Grant U54 EB005149. </acknowledgements>

<parameters>
    <label>Input/Output</label>
    <description>Input/output parameters</description>
     ....
</parameters>

<parameters>
          <label>Discrete Gaussian Parameters</label>
          <description>Parameters of the Discrete Gaussian Filter </description>

</parameters>

</executable>
```

Add a new parameter group to HelloWorld.xml

Editing the file HelloWorld.xml

```
<parameters>
    <label>Discrete Gaussian Parameters</label>
    <description>Parameters of the Discrete Gaussian Filter </description>

    <double>
    <name>variance</name>
    <longflag>--variance</longflag>
    <description>Variance ( width of the filter kernel) </description>
    <label>Variance</label>
    <default>0.5</default>
    </double>

</parameters>
```

Add the parameter ‘variance’ which corresponds to the variance of the Discrete Gaussian Filter to HelloWorld.xml

Implementing I/O functionalities

Add the following lines to HelloWorld.cxx

```
#include <iostream>
#include "HelloWorldCLP.h"
#include "itkImage.h"
#include "itkImageFileReader.h"
#include "itkImageFileWriter.h"
int main(int argc, char * argv [])
{
        PARSE_ARGS;
        std::cout << "Hello World!" << std::endl;
        return EXIT_SUCCESS ;
}
```

Implementing I/O functionalities

Add the following command lines to set-up the reading and writing functionalities in the 'main' procedure in HelloWorld.cxx

```
int main ( int argc, char * argv[])
{
    PARSE_ARGS;
    std::cout << "Hello World!" << std::endl;

    typedef itk::Image<short,3>   ImageType;
    typedef itk::ImageFileReader<ImageType>  ReaderType;
    typedef itk::ImageFileWriter<ImageType>  WriterType;
    ReaderType::Pointer reader = ReaderType::New();
    WriterType::Pointer writer = WriterType::New();

    return EXIT_SUCCESS;
}
```

Implementing I/O functionalities

Set the input and output volumes parameters defined in HelloWorld.xml

```
int main ( int argc, char * argv[])
{
    PARSE_ARGS;
    std::cout << "Hello World!" << std::endl;
    typedef itk::Image< short, 3 >   ImageType;
    typedef itk::ImageFileReader< ImageType  >  ReaderType;
    typedef itk::ImageFileWriter< ImageType >  WriterType;
    ReaderType::Pointer reader = ReaderType::New();
    WriterType::Pointer writer = WriterType::New();

    reader->SetFileName(helloWorldInputVolume.c_str() );
    writer->SetFileName (helloWorldOutputVolume.c_str());

    return EXIT_SUCCESS;
}
```

Implementing the filter in HelloWorld.cxx

Implement the filter itk::DiscreteGaussianImageFilter

```
#include "itkDiscreteGaussianImageFilter.h"
int main ( int argc, char * argv[])
{
    PARSE_ARGS;
    std::cout << "Hello World!" << std::endl;
    typedef itk::Image< short,  3 >   ImageType;
    typedef itk::ImageFileReader< ImageType  >  ReaderType;
    typedef itk::ImageFileWriter< ImageType >  WriterType;
    ReaderType::Pointer reader = ReaderType::New();
    WriterType::Pointer writer = WriterType::New();
    reader->SetFileName( helloWorldInputVolume.c_str() );
    writer->SetFileName(helloWorldOutputVolume.c_str());

    typedef itk::DiscreteGaussianImageFilter <ImageType, ImageType> FilterType;
    FilterType::Pointer filter = FilterType::New();

return EXIT_SUCCESS;
}
```

Implementing the filter in HelloWorld.cxx

Add the following lines for the filter execution:

```
int main ( int argc, char * argv[])
{
      PARSE_ARGS;
      std::cout << "Hello World!" << std::endl;
      typedef itk::Image< short,  3 >   ImageType;
      typedef itk::ImageFileReader< ImageType  >  ReaderType;
      typedef itk::ImageFileWriter< ImageType >  WriterType;
      ReaderType::Pointer reader = ReaderType::New();
      WriterType::Pointer writer = WriterType::New();
      reader->SetFileName( helloWorldInputVolume.c_str() );
      writer->SetFileName (helloWorldOutputVolume.c_str());
      typedef itk::DiscreteGaussianImageFilter <ImageType, ImageType> FilterType;
      FilterType::Pointer filter = FilterType::New();
      try {
      filter->SetInput(reader->GetOutput());
      filter->SetVariance(variance);
      writer->SetInput(filter->GetOutput());
      writer->Update();
      }
      catch (itk::ExceptionObject &excep){
            std::cerr << argv[0] << ": exception caught !" << std::endl;
      return EXIT_FAILURE;}
return EXIT_SUCCESS;}
```

Building HelloWorld

Mac/Linux

Run '**make**' in the directory **HelloWorld-build/**

Windows

Select **Build→Build Solution** to build the solution **HelloWorld.sln** located in **HelloWorld-build/**

Running Slicer3

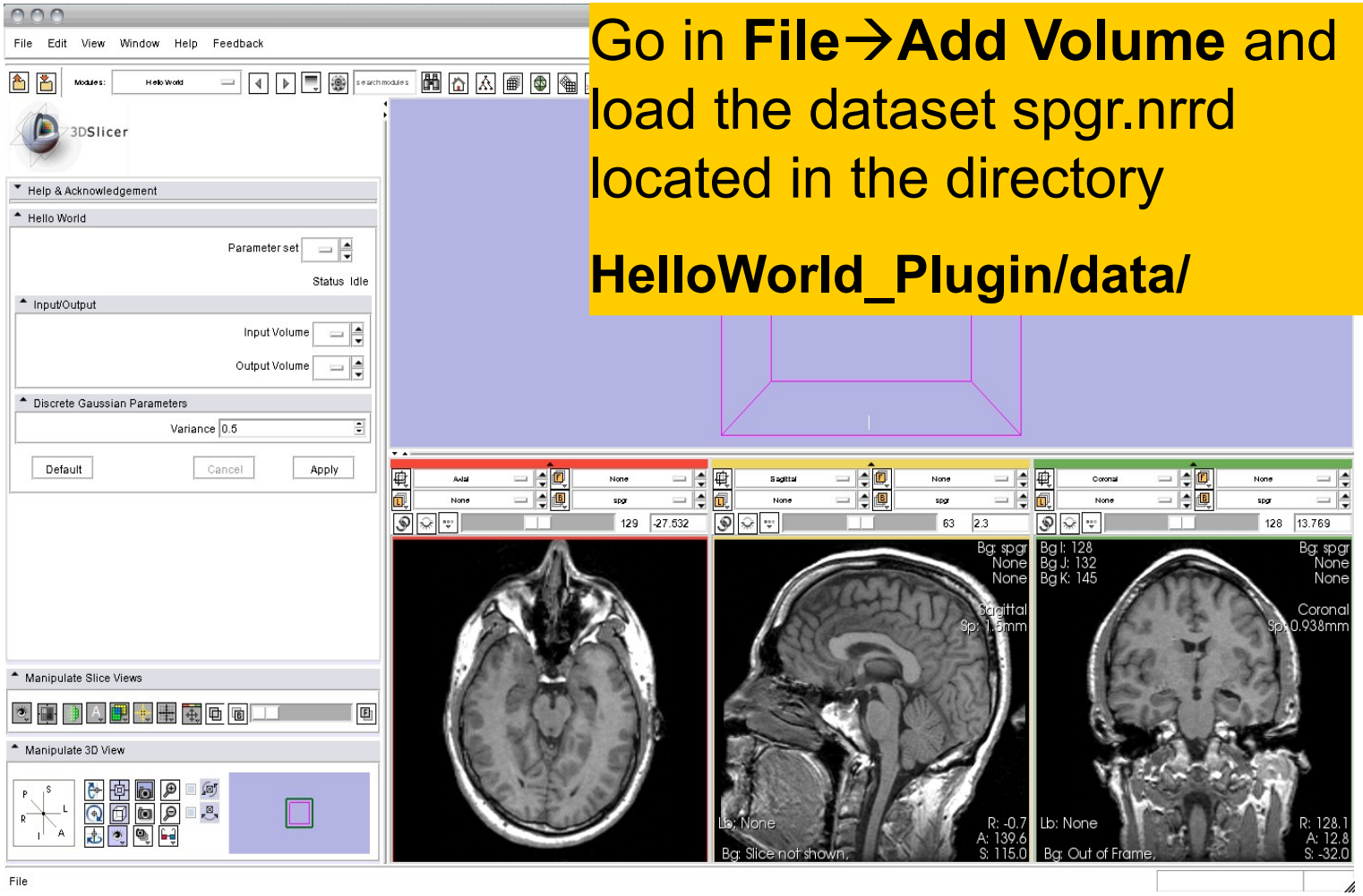
Mac/Linux

Run **'./Slicer3'** in Slicer3-build/

Windows

Run **'./Slicer3.exe'** in Slicer3-build/

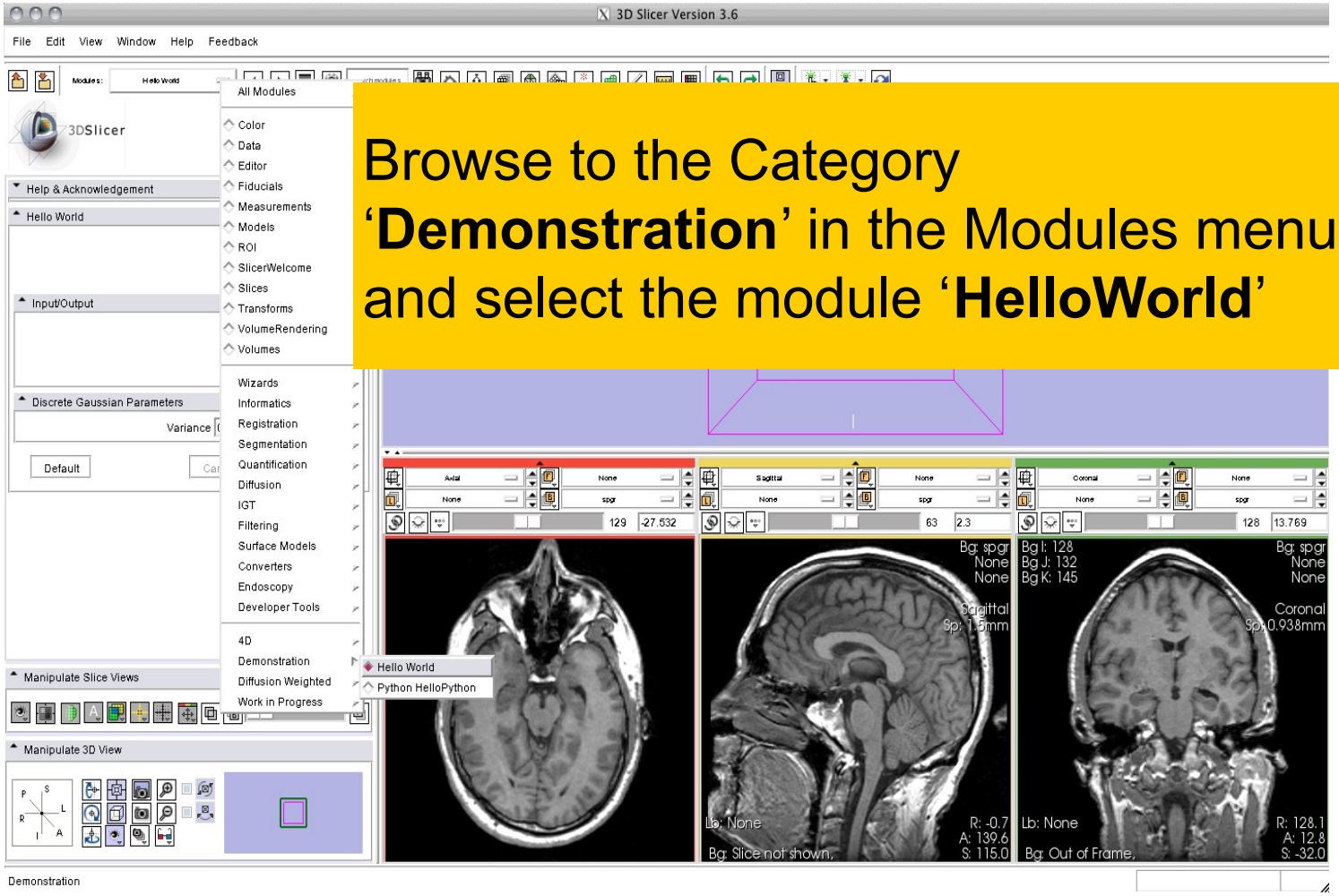
Running the Filter



Go in **File→Add Volume** and load the dataset spgr.nrrd located in the directory

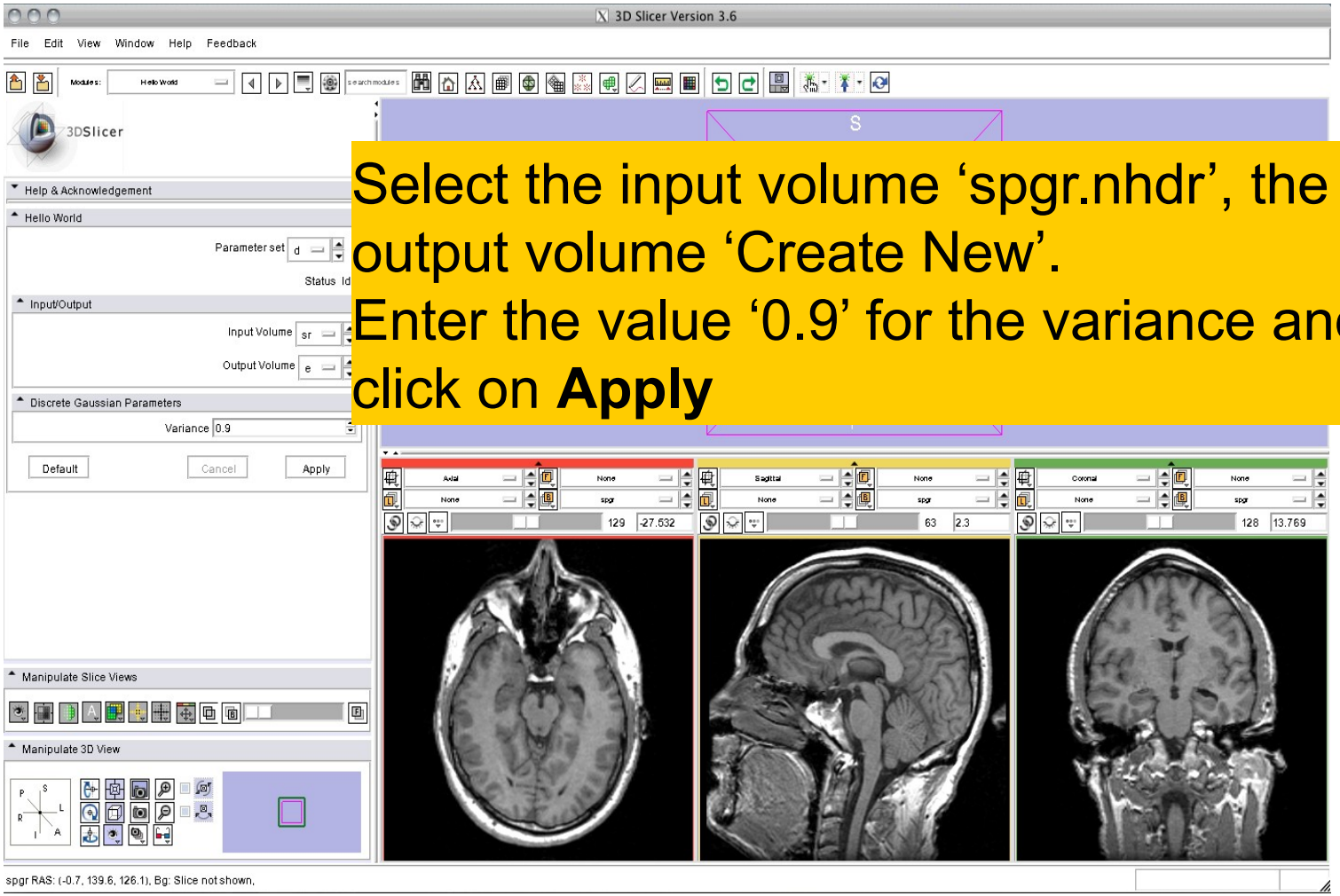
HelloWorld_Plugin/data/

Running the Filter



Browse to the Category '**Demonstration**' in the Modules menu, and select the module '**HelloWorld**'

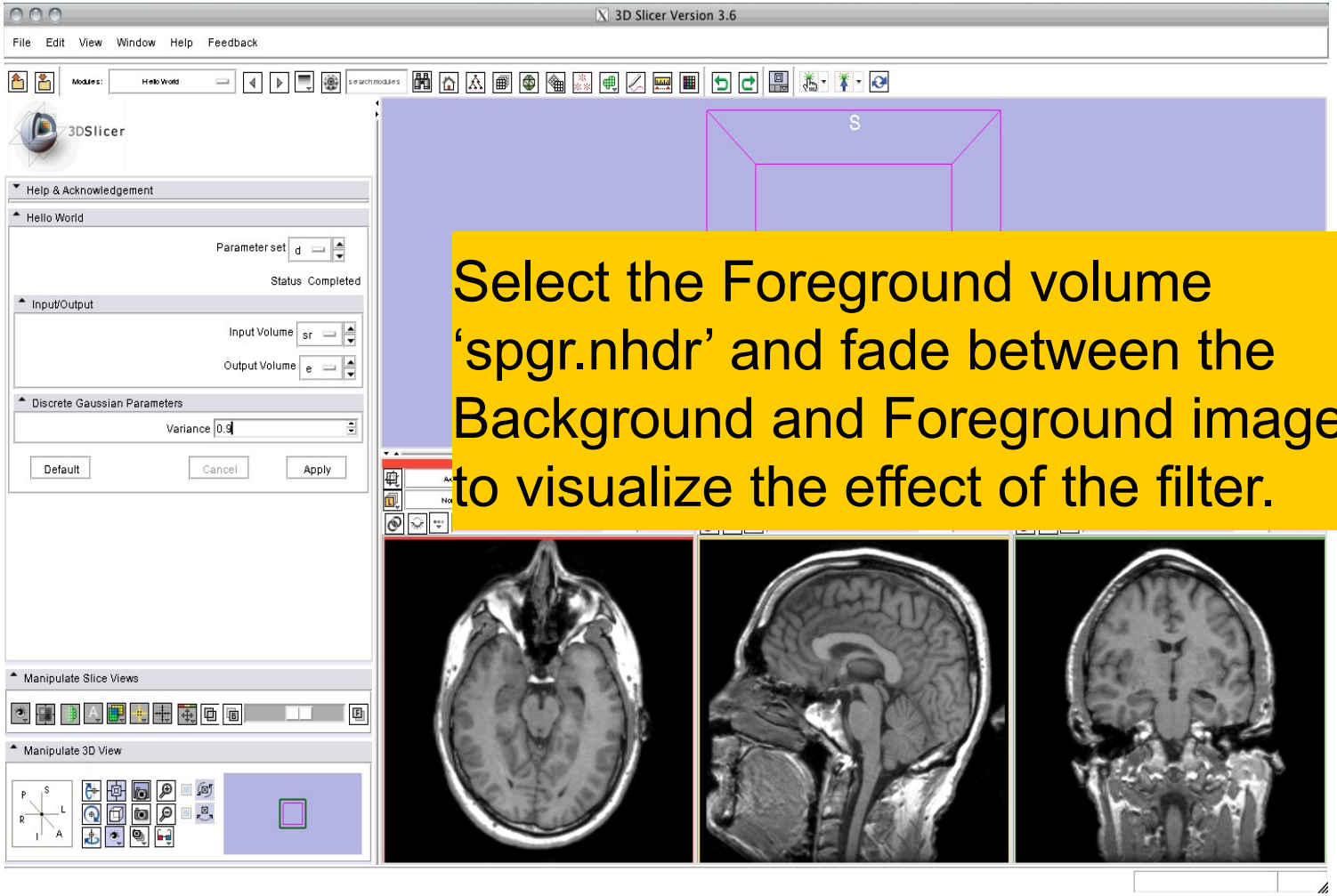
Running the Filter



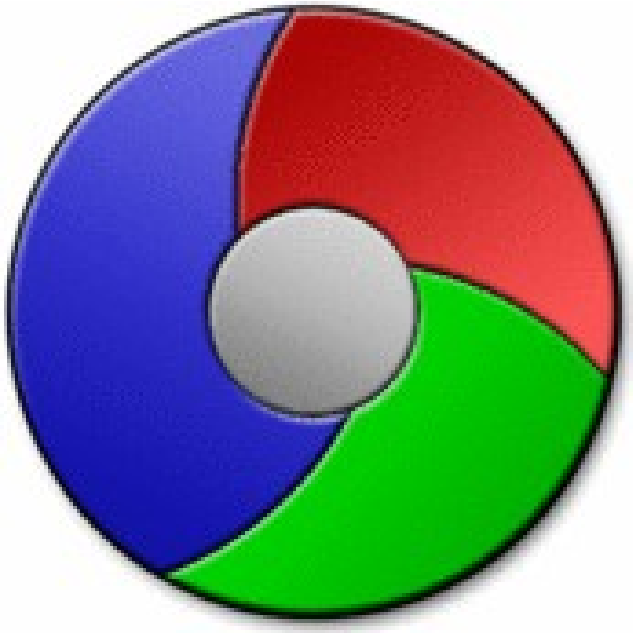
Select the input volume ‘spgr.nhdr’, the output volume ‘Create New’.
Enter the value ‘0.9’ for the variance and click on **Apply**

Running the Filter

Running the Filter



Select the Foreground volume ‘spgr.nhdr’ and fade between the Background and Foreground images to visualize the effect of the filter.



Part C: Testing

Goal

- This section describes a simple example for testing that the 'help' functionality of our newly implemented module 'HelloWorld' works correctly.

- CTest is a core element of Slicer3's quality control system for software development.

  http://www.cmake.org/Wiki/CMake_Testing_With_CTest

- The goal of 'HelloWorldTest1' is to test the following command:

```
./HelloWorld --help
```

HelloWorld Test 1

To implement the test **HelloWorldTest1**, add the following lines to the **CMakeLists.txt** file located in the **HelloWorld** directory:

```
set (SLICER_EXE ${Slicer3_HOME}/Slicer3)
set(BUILD_SUBDIR "")
if(WIN32)
  set(BUILD_SUBDIR Debug)
endif(WIN32)
add_test(HelloWorldTest1 ${SLICER_EXE} --launch ${Slicer3_INSTALL_PLUGINS_BIN_DIR}/${BUILD_SUBDIR}/${CLP} --help)
```

Building HelloWorld

Mac/Linux

Run '**make**' in the directory **HelloWorld-build/**

Windows

Select **Build→Build Solution** to build the solution **HelloWorld.sln** located in **HelloWorld-build/**

Testing HelloWorld

Mac/Linux

- In the directory **/HelloWorld-build/** run the following command:

/path/to/Slicer/build/Slicer3-lib/CMake-build/bin/ctest –R HelloWorldTest1

Windows

- In the directory **/HelloWorld-build/** run the following command:

/path/to/Slicer/build/Slicer3-lib/CMake-build/bin/ctest.exe –R HelloWorldTest1

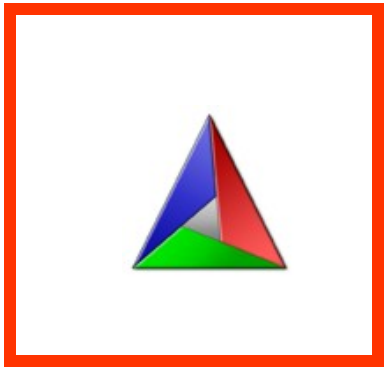
Running HelloWorldTest1

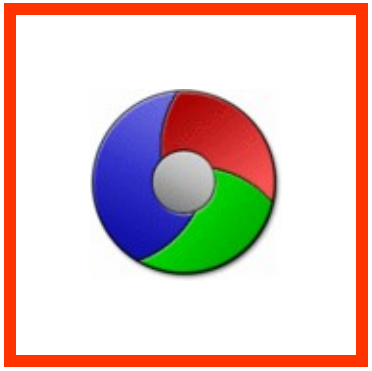
When the module successfully passes the test, the output below is generated:

Conclusion

- This course described functionalities for integrating, developing and testing an external program within Slicer3.
- The Execution Model of Slicer3 provides a simple mechanism for incorporating command line programs as Slicer modules.
- The pipeline guided you through 6 components of the NA-MIC kit.

Slicer Programming Course





Acknowledgments

National Alliance for Medical Image Computing

NIH U54EB005149

Neuroimage Analysis Center

NIH P41RR013218