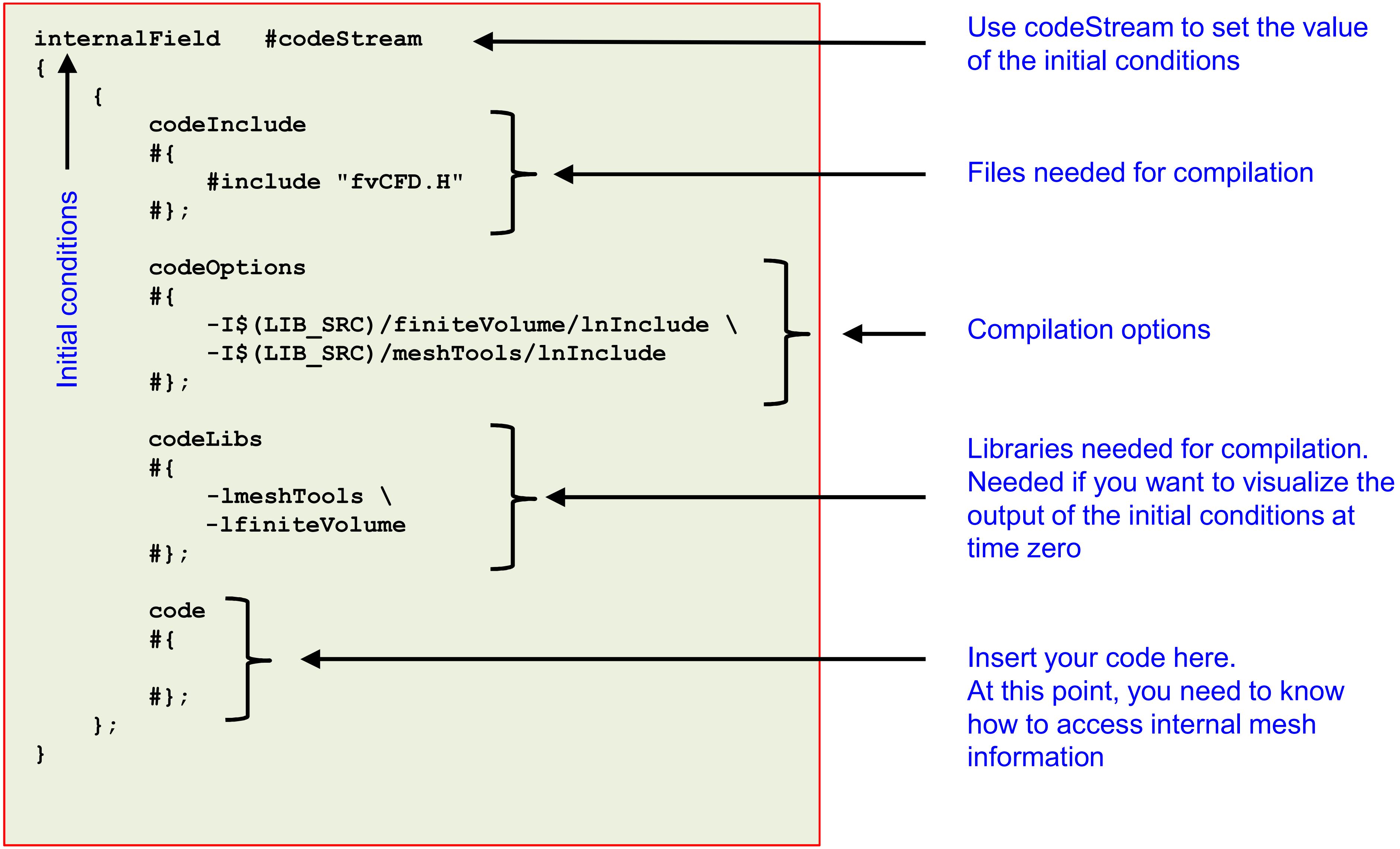
Solution initialization using codeStream

- When it comes to initial conditions, you can use the utility `setFields`.
- This utility is very flexible, you can even read STL files and use them to initialize your fields.
- But in case that you can not get the desired results using `setFields`, you can implement your own initial conditions using **codeStream**.
- To implement initial conditions using **codeStream**, we proceed in a similar way as for boundary conditions.
- The source code and binaries are automatically generated and copied in the directory **`dynamicCode`** of the current case.
- The source code is compiled automatically at run-time.
- The use of **codeStream** is a very good alternative to avoid high level programming of initial conditions or the use of external libraries.
- Hereafter we will use **codeStream** to implement new initial conditions.

Solution initialization using codeStream

Body of the **codeStream** directive for initial conditions



```
internalField   #codeStream
{
    {
        codeInclude
        #{
            #include "fvCFD.H"
        #};

        codeOptions
        #{
            -I$(LIB_SRC)/finiteVolume/lnInclude \
            -I$(LIB_SRC)/meshTools/lnInclude
        #};

        codeLibs
        #{
            -lmeshTools \
            -lfiniteVolume
        #};

        code
        #{

        #};
    };
}
```

Use codeStream to set the value of the initial conditions

Files needed for compilation

Compilation options

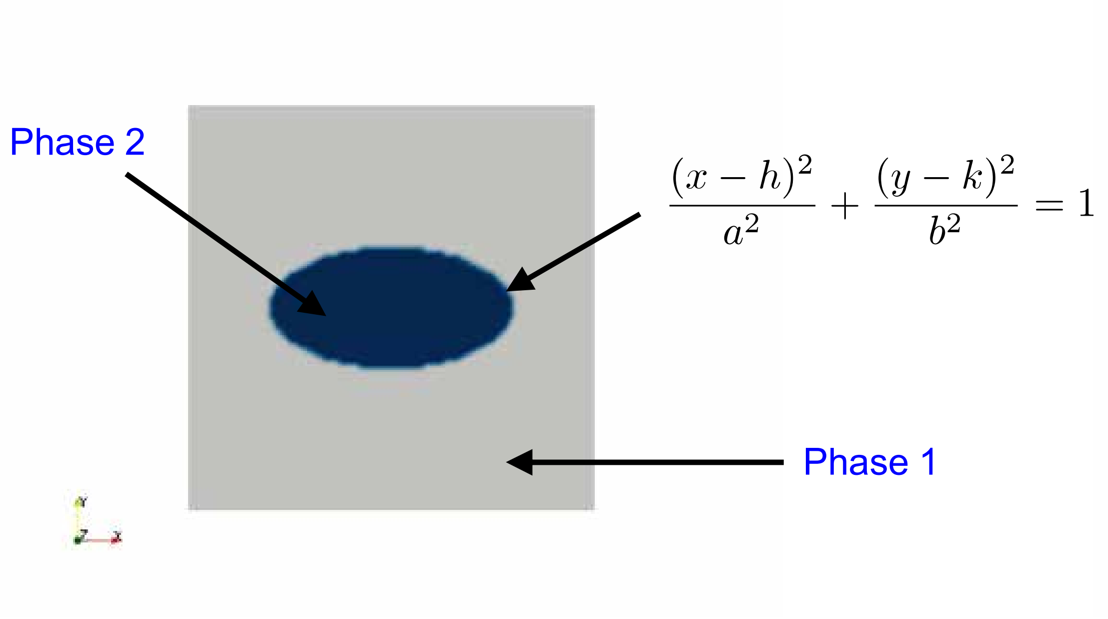
Libraries needed for compilation.
Needed if you want to visualize the output of the initial conditions at time zero

Insert your code here.
At this point, you need to know how to access internal mesh information

Solution initialization using codeStream

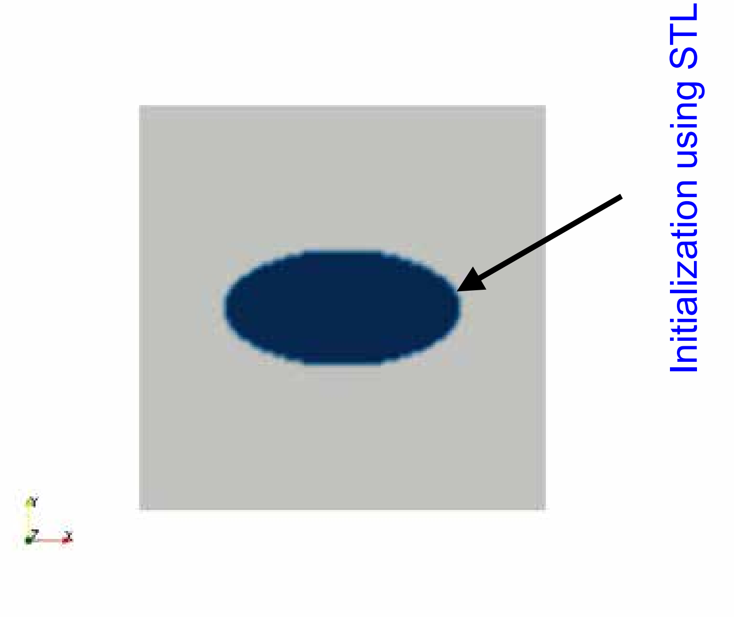
Implementation of an elliptic initialization using **codeStream**

- Let us implement an elliptic initialization using **codeStream**.
- The firs step is to know your domain and identify the region that you want to initialize.
- Then you will need to do a little bit of math to get the expression for the initialization.
- In this example, we are also going to show you how to do the same initialization by reading a STL file with the utility `setFields`.



$$\frac{(x-h)^2}{a^2}+\frac{(y-k)^2}{b^2}=1$$

Initialization using **codeStream**



Initialization using a STL with `setFields`

Solution initialization using codeStream

- The **codeStream** IC in the body of the file *alpha.phase1* is as follows,

```
internalField   #codeStream
{
    {
        codeInclude
        #{
            #include "fvCFD.H"
        #};

        codeOptions
        #{
            -I$(LIB_SRC)/finiteVolume/lnInclude \
            -I$(LIB_SRC)/meshTools/lnInclude
        #};

        codeLibs
        #{
            -lmeshTools \
            -lfiniteVolume
        #};

        code
        #{

        #};
    };
}
```

Use codeStream to set the value of the initial conditions

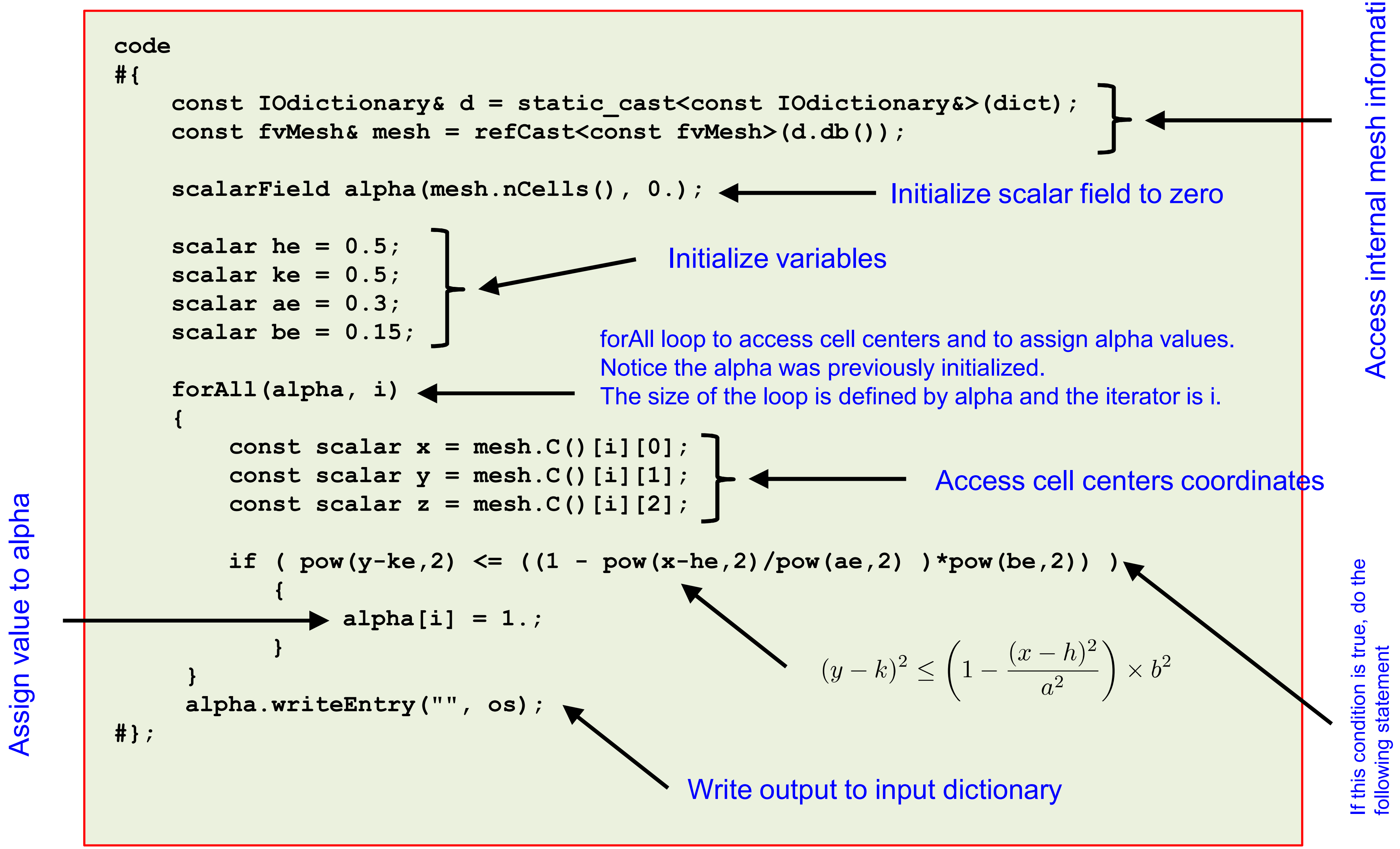
Depending of what are you trying to do, you will need to add new files, options and libraries.

For most of the cases, this part is always the same.

Insert your code here.
At this point, you need to know how to access internal mesh information

Solution initialization using codeStream

- The **code** section of the **codeStream** IC in the body of the file *alpha.phase1* is as follows,



```
code
#{
    const IOdictionary& d = static_cast<const IOdictionary&>(dict);
    const fvMesh& mesh = refCast<const fvMesh>(d.db());

    scalarField alpha(mesh.nCells(), 0.);

    scalar he = 0.5;
    scalar ke = 0.5;
    scalar ae = 0.3;
    scalar be = 0.15;

    forAll(alpha, i)
    {
        const scalar x = mesh.C()[i][0];
        const scalar y = mesh.C()[i][1];
        const scalar z = mesh.C()[i][2];

        if ( pow(y-ke,2) <= ((1 - pow(x-he,2)/pow(ae,2) )*pow(be,2)) )
           {
               alpha[i] = 1.;
           }
     }
     alpha.writeEntry("", os);
#};
```

Access internal mesh information

Initialize scalar field to zero

Initialize variables

forAll loop to access cell centers and to assign alpha values.
Notice the alpha was previously initialized.
The size of the loop is defined by alpha and the iterator is i.

Access cell centers coordinates

Assign value to alpha

$$(y-k)^2 \leq \left(1 - \frac{(x-h)^2}{a^2}\right) \times b^2$$

If this condition is true, do the following statement

Write output to input dictionary

Solution initialization using codeStream

Implementation of an elliptic initialization using **codeStream**

- This case is ready to run, the input files are located in the directory **`$PTOFC/101programming/codeStream_INIT/elliptical_IC`**
- To run the case, type in the terminal,

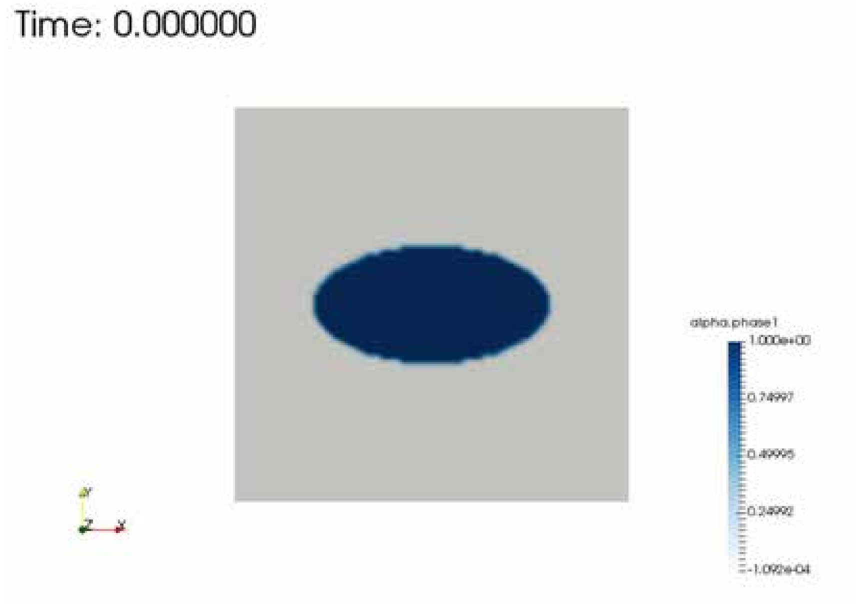
```
1.  $> cd $PTOFC/101programming/codeStream_INIT/elliptical_IC
2.  $> foamCleanTutorials
3.  $> blockMesh
4.  $> rm -rf 0
5.  $> cp -r 0_org 0
6.  $> paraFoam
7.  $> interFoam | tee log
8.  $> paraFoam
```

- In step 6, we launch `paraFoam` to visualize the initialization.
- FYI, you can run in parallel with no problem.

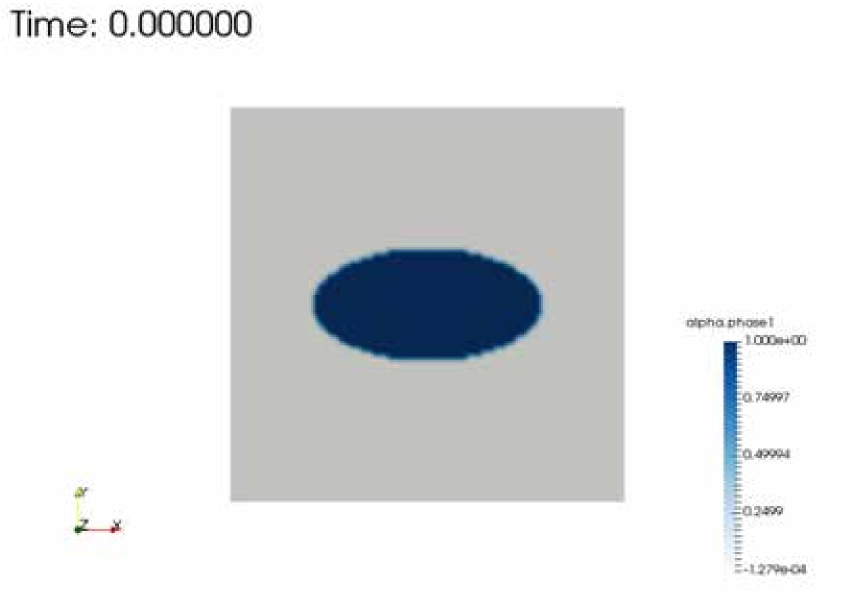
Solution initialization using codeStream

Implementation of an elliptic initialization using **codeStream**

- If everything went fine, you should get something like this



codeStream initialization
Visualization of volume fraction (alpha.phase1)
www.wolfdynamics.com/wiki/BCIC/bubble_zeroG.gif



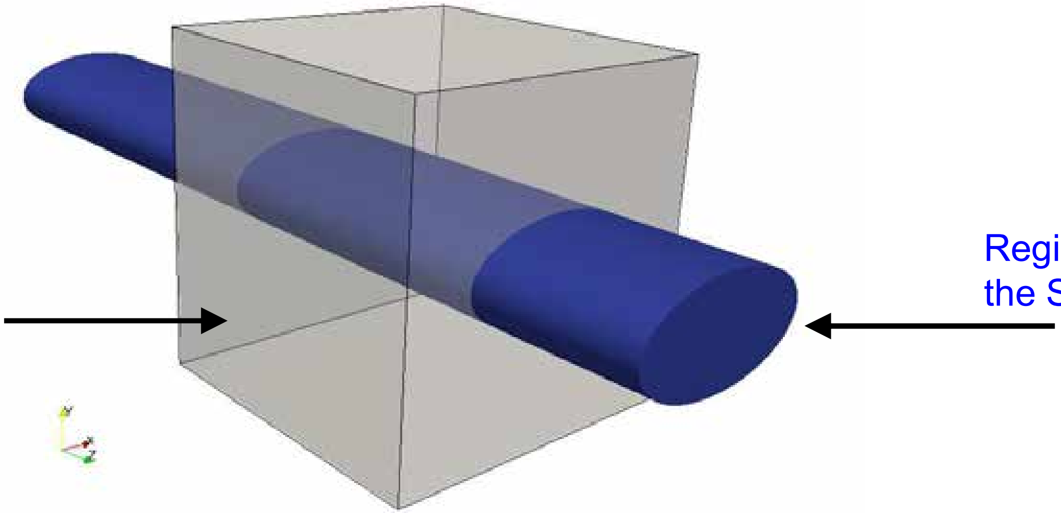
setFields initialization
Visualization of volume fraction (alpha.phase1)
www.wolfdynamics.com/wiki/BCIC/bubble_zeroG_SF.gif

Surface tension driven flow - Bubble in a zero gravity flow using interFoam

Solution initialization using codeStream

Elliptic initialization using **setFields**

- Let us do the same initialization using a STL file with `setFields`.
- First, you will need to create the solid model that encloses the region you want to initialize. For this, you can use your favorite CAD/solid modeling software. Remember to save the geometry is STL format.
- Then you will need to read in the STL file using `setFields`. You will need to modify the `setFieldsDict` dictionary.

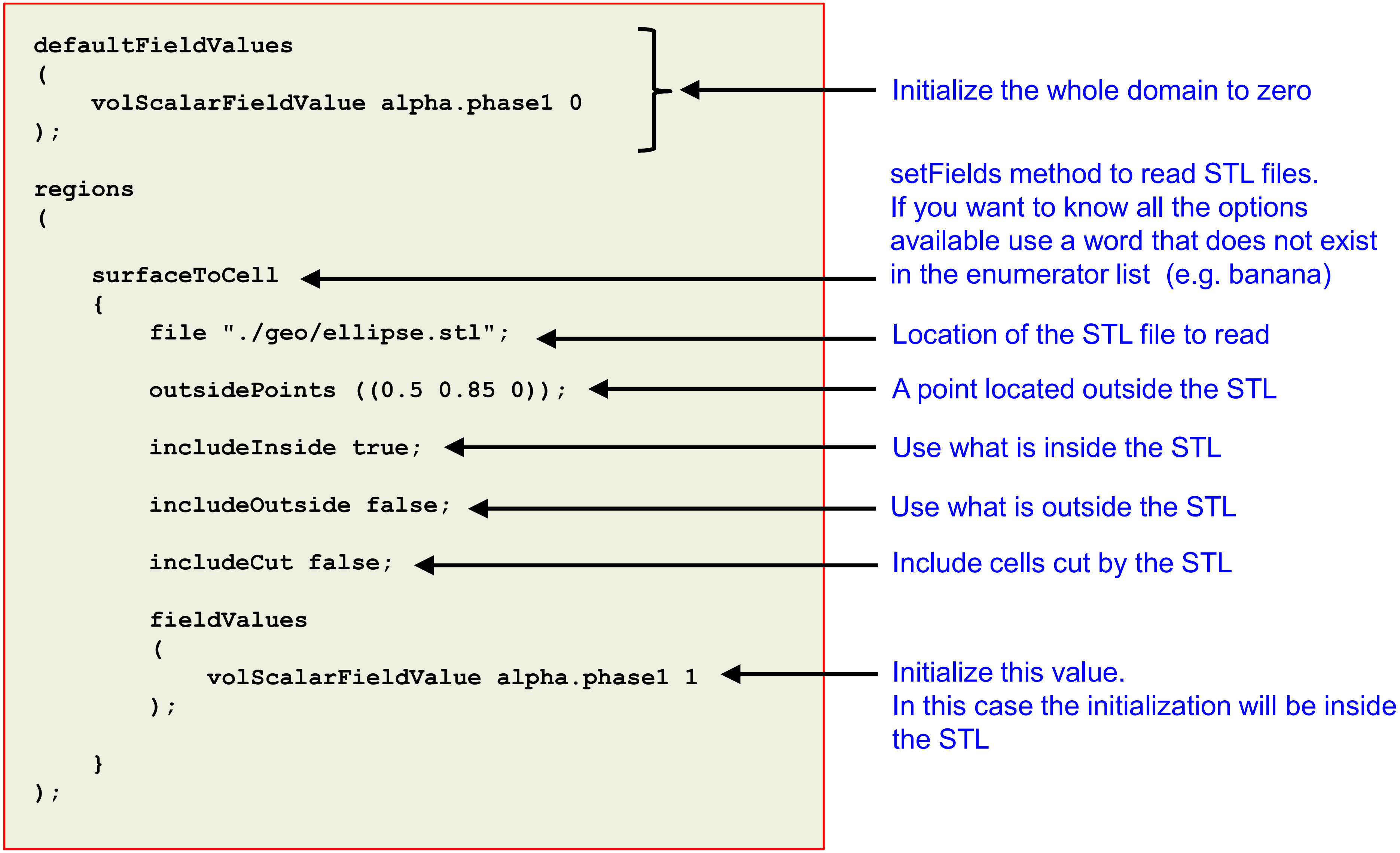


Computational domain

Region defined by the STL file

Solution initialization using codeStream

The **setFieldsDict** dictionary



```
defaultFieldValues
(
    volScalarFieldValue alpha.phase1 0
);

regions
(

    surfaceToCell
    {
        file "./geo/ellipse.stl";

        outsidePoints ((0.5 0.85 0));

        includeInside true;

        includeOutside false;

        includeCut false;

        fieldValues
        (
            volScalarFieldValue alpha.phase1 1
        );

    }
);
```

Initialize the whole domain to zero

setFields method to read STL files.
If you want to know all the options available use a word that does not exist in the enumerator list (e.g. banana)

Location of the STL file to read

A point located outside the STL

Use what is inside the STL

Use what is outside the STL

Include cells cut by the STL

Initialize this value.
In this case the initialization will be inside the STL

Solution initialization using codeStream

Elliptic initialization using **setFields**

- This case is ready to run, the input files are located in the directory **`$PTOFC/101programming/codeStream_INIT/elliptical_IC`**
- To run the case, type in the terminal,

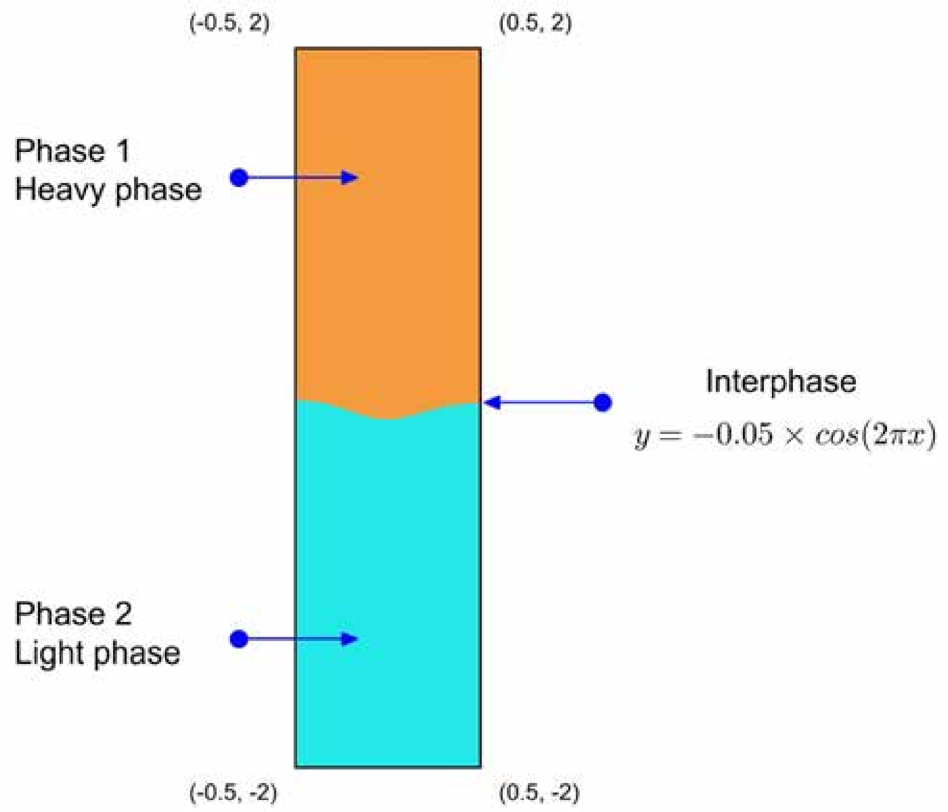
```
1.  $> cd $PTOFC/101programming/codeStream_INIT/elliptical_IC
2.  $> foamCleanTutorials
3.  $> blockMesh
4.  $> rm -rf 0
5.  $> cp -r 0_org 0
6.  $> setFields
7.  $> paraFoam
```

- At this point, compare this initialization with the previous one.
- Also, feel free to launch the simulation using `interFoam`.

Solution initialization using codeStream

Rayleigh-Taylor instability initialization

- Let us study the Rayleigh-Taylor instability.
- In this case, we have two phases with different physical properties (one phase is heavier).
- To onset this instability, we need to perturbate somehow the interface between the two phases.
- We will use **codeStream** to initialize the two phases.
- For simplicity, we will only show the **code** section of the input files.
- The entries **codeInclude, codeOptions,** and **codeLibs**, are the same most of the times.



Solution initialization using codeStream

- The **code** section of the **codeStream** IC in the body of the file *alpha.phase1* is as follows,

```
code
#{
    const IOdictionary& d = static_cast<const IOdictionary&>(dict);
    const fvMesh& mesh = refCast<const fvMesh>(d.db());

    scalarField alpha(mesh.nCells(), 0.);

    forAll(alpha, i)
    {
        const scalar x = mesh.C()[i][0];
        const scalar y = mesh.C()[i][1];

        if (y >= -0.05*cos(2*constant::mathematical::pi*x))
        {
            alpha[i] = 1.;
        }
    }

    alpha.writeEntry("", os);
#};
```

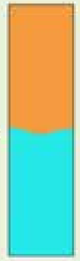
Access internal mesh information

Initialize scalar field to zero

Access cell centers coordinates

Assign value to alpha

$$y = -0.05 \times cos(2\pi x)$$



Write output to input dictionary

- For simplicity, we only show the **code** section.
- The rest of the body of the **codeStream** IC is a template.

Solution initialization using codeStream

Rayleigh-Taylor instability initialization

- This case is ready to run, the input files are located in the directory **`$PTOFC/101programming/codeStream_INIT/rayleigh_taylor`**
- To run the case, type in the terminal,

```
$> cd $PTOFC/101programming/codeStream_INIT/rayleigh_taylor
$> foamCleanTutorials
$> blockMesh
$> interFoam | tee log
$> paraFoam
```

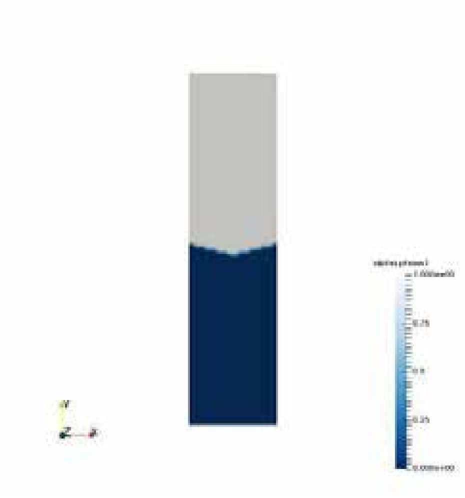
- FYI, you can run in parallel with no problem.

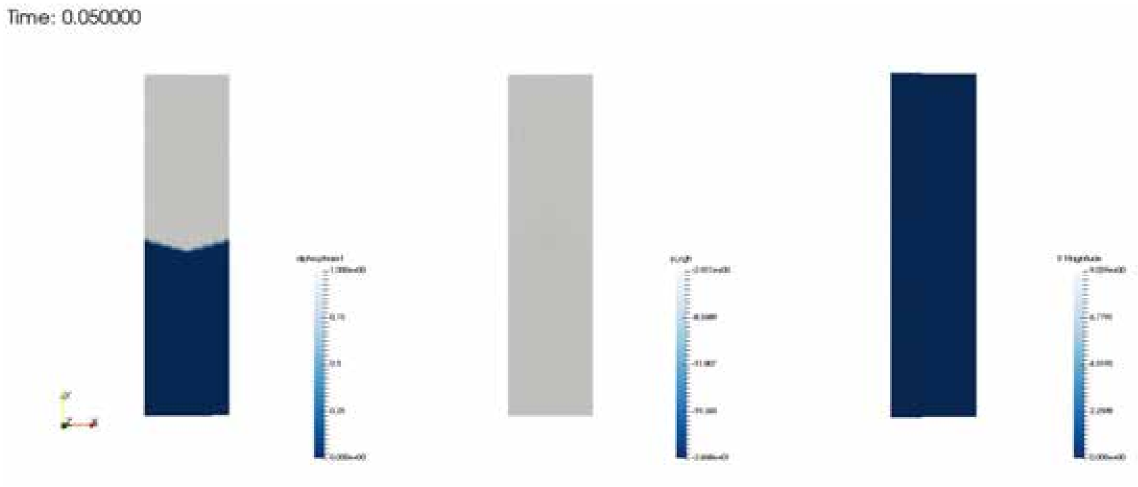
Solution initialization using codeStream

Rayleigh-Taylor instability initialization

- If everything went fine, you should get something like this

🎞





Initial conditions

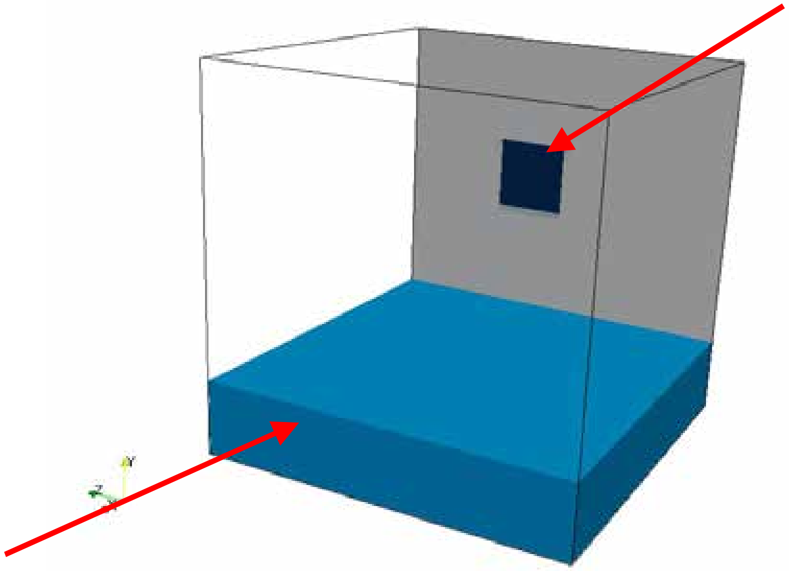
Visualization of volume fraction, static pressure and velocity magnitude

www.wolfdynamics.com/wiki/BCIC/rayleigh_taylor_ins1.gif

Solution initialization using codeStream

Filling a tank using **codeStream** and **codedFixedValue**

- Let us do a final example.
- We will implement BCs and ICs at the same.
- For simplicity, we will only show the **code** section of the input files.
- This setup is similar to the last example of the previous section (filling a tank using **codedFixedValue**).

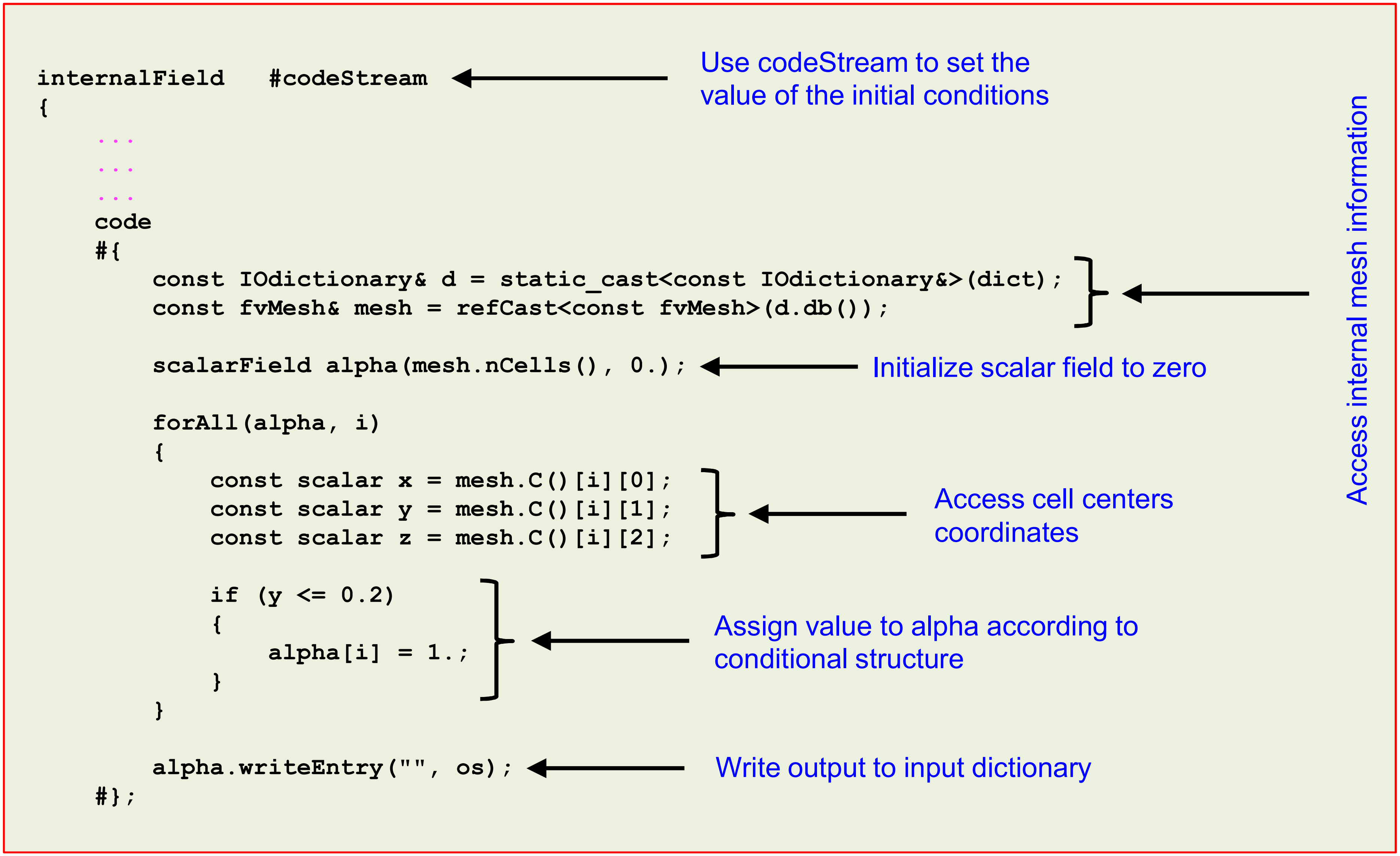


Water enters here
This is a single boundary patch

Initial water level

Solution initialization using codeStream

- The **code** section of the **codeStream** IC in the body of the file *alpha.water* is as follows,



```
internalField   #codeStream
{
    ...
    ...
    ...
    code
    #{
        const IOdictionary& d = static_cast<const IOdictionary&>(dict);
        const fvMesh& mesh = refCast<const fvMesh>(d.db());

        scalarField alpha(mesh.nCells(), 0.);

        forAll(alpha, i)
        {
            const scalar x = mesh.C()[i][0];
            const scalar y = mesh.C()[i][1];
            const scalar z = mesh.C()[i][2];

            if (y <= 0.2)
            {
                alpha[i] = 1.;
            }
        }

        alpha.writeEntry("", os);
    #};
```

Use codeStream to set the value of the initial conditions

Access internal mesh information

Initialize scalar field to zero

Access cell centers coordinates

Assign value to alpha according to conditional structure

Write output to input dictionary

Solution initialization using codeStream

- The **code** section of the **codeFixedValue** BC in the body of the file *U* is as follows,

Name of the patch where we want to implement the boundary condition

```
leftWall
{
    type            codedFixedValue;
    value           uniform (0 0 0);

    redirectType    inletProfile1;

    code
    #{
        const fvPatch& boundaryPatch = patch();
        const vectorField& Cf = boundaryPatch.Cf();
        vectorField& field = *this;

        scalar min = 0.5;
        scalar max = 0.7;

        scalar t = this->db().time().value();
        ...
        ...
        ...
    #};
}
```

Use codedFixedValue BC and initialize value.
The initialization is only needed for paraview
in order to visualize something at time zero.

Unique name of the BC
Do not use the same name in other patches ⚠

Code section. The actual implementation of the BC is done here

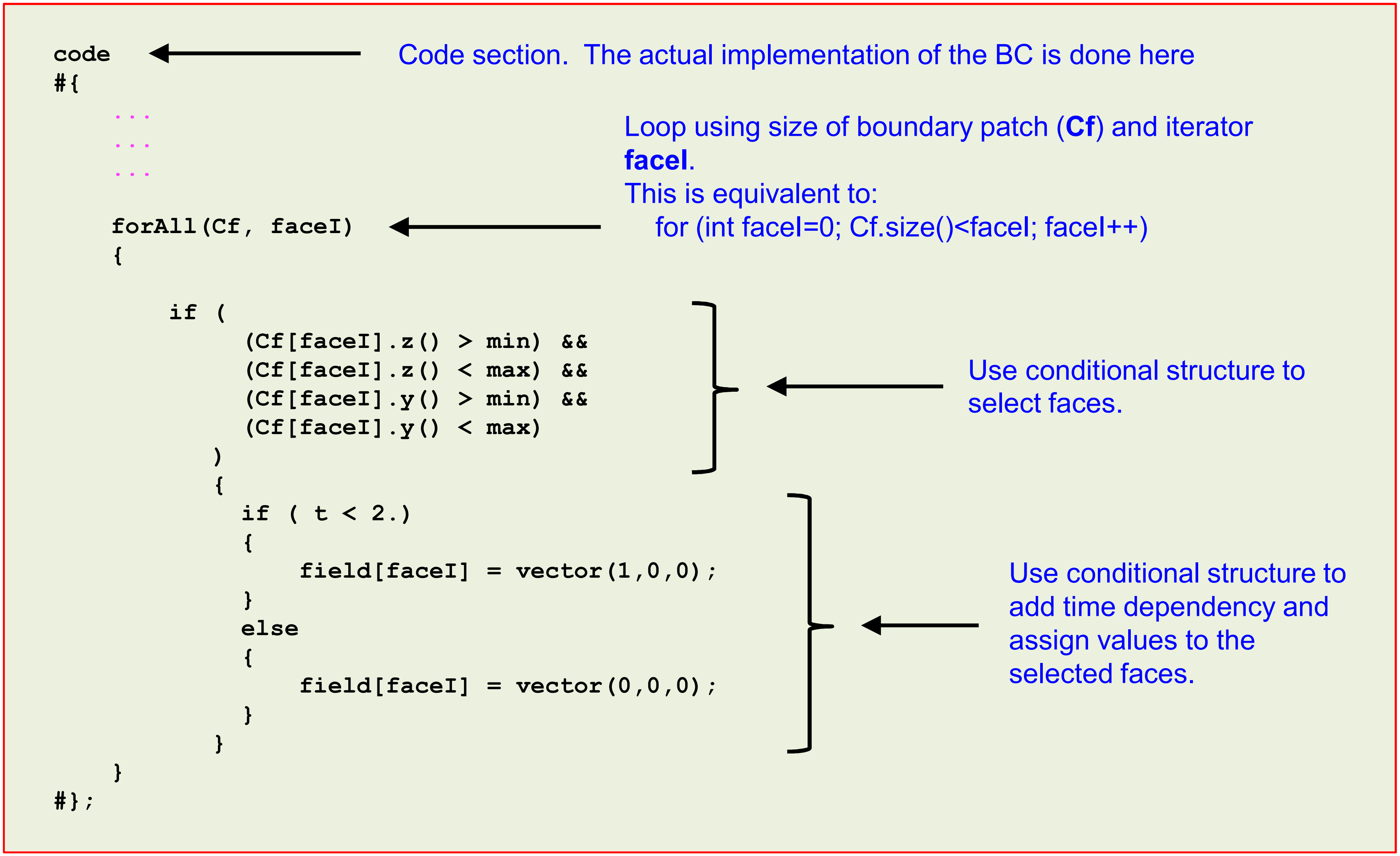
Access boundary mesh
information and initialize
vector field **field**

Initialize variables

Access time

Solution initialization using codeStream

- The **code** section of the **codeFixedValue** BC in the body of the file *U* is as follows,



```
code
#{
    ...
    ...
    ...

    forAll(Cf, faceI)
    {

        if (
             (Cf[faceI].z() > min) &&
             (Cf[faceI].z() < max) &&
             (Cf[faceI].y() > min) &&
             (Cf[faceI].y() < max)
           )
           {
             if ( t < 2.)
             {
                 field[faceI] = vector(1,0,0);
             }
             else
             {
                 field[faceI] = vector(0,0,0);
             }
           }
    }
#};
```

Code section. The actual implementation of the BC is done here

Loop using size of boundary patch (**Cf**) and iterator **faceI**.
This is equivalent to:
for (int faceI=0; Cf.size()<faceI; faceI++)

Use conditional structure to select faces.

Use conditional structure to add time dependency and assign values to the selected faces.

Solution initialization using codeStream

- The **code** section of the **codeFixedValue** BC in the body of the file *alpha.water* is as follows,

```
leftWall
{
    type            codedFixedValue;
    value           uniform 0;

    redirectType    inletProfile2;


    code
    #{
        const fvPatch& boundaryPatch = patch();
        const vectorField& Cf = boundaryPatch.Cf();
        scalarField& field = *this;


        field = patchInternalField();

        scalar min = 0.5;
        scalar max = 0.7;

        scalar t = this->db().time().value();
        ...
        ...
        ...
    #};
}
```

Name of the patch where we want to implement the boundary condition

Use codedFixedValue BC and initialize value. The initialization is only needed for paraview in order to visualize something at time zero.

Unique name of the BC
Do not use the same name in other patches

Code section. The actual implementation of the BC is done here

Access boundary mesh information and initialize scalar field **field**

Assign value from the internal field to the patch

Initialize variables

Access time

Solution initialization using codeStream

- The **code** section of the **codeFixedValue** BC in the body of the file *alpha.water* is as follows,

```
code
#{
        ...
        ...
        ...

      forAll(Cf, faceI)
      {
            if (
                    (Cf[faceI].z() > min) &&
                    (Cf[faceI].z() < max) &&
                    (Cf[faceI].y() > min) &&
                    (Cf[faceI].y() < max)
                  )
                  {
                     if ( t < 2.)
                     {
                           field[faceI] = 1.;
                     }
                     else
                     {
                           field[faceI] = 0.;
                     }
                  }
      }
#};
```

Code section. The actual implementation of the BC is done here

Loop using size of boundary patch (**Cf**) and iterator **faceI**.
This is equivalent to:
for (int faceI=0; Cf.size()<faceI; faceI++)

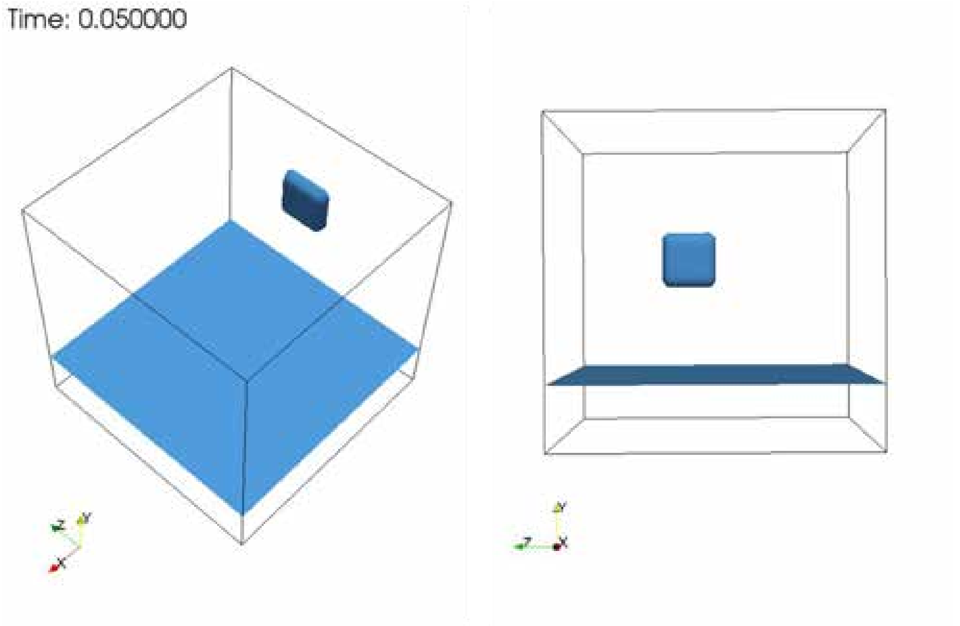
Use conditional structure to select faces

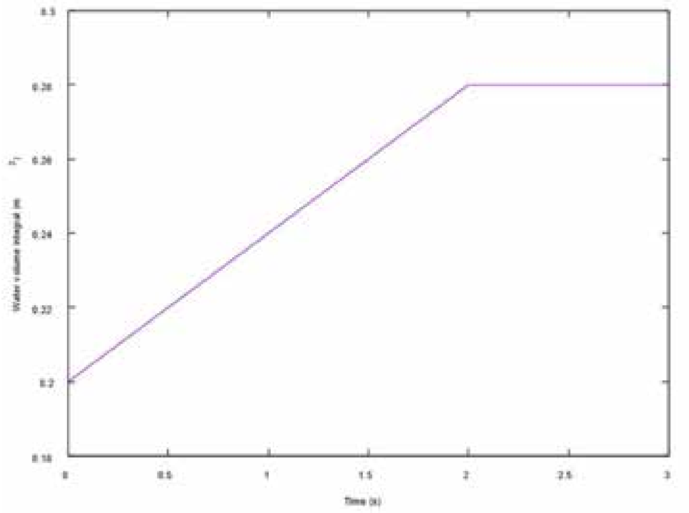
Use conditional structure to add time dependency and assign values to the selected faces.

Solution initialization using codeStream

Filling a tank using **codeStream** and **codedFixedValue**

- If everything went fine, you should get something like this





Visualization of water phase (alpha.water)

www.wolfdynamics.com/wiki/BCIC/filltank2.gif

Volume integral of water entering the domain