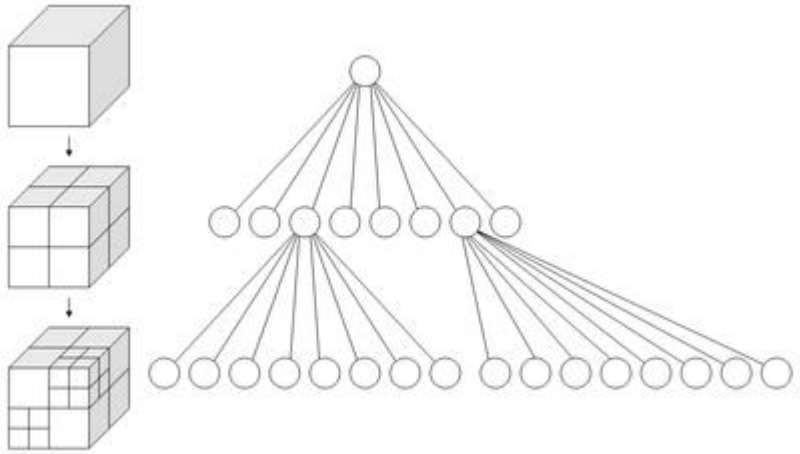
cfMeshによるメッシュ作成入門

秋山善克

cfMesh

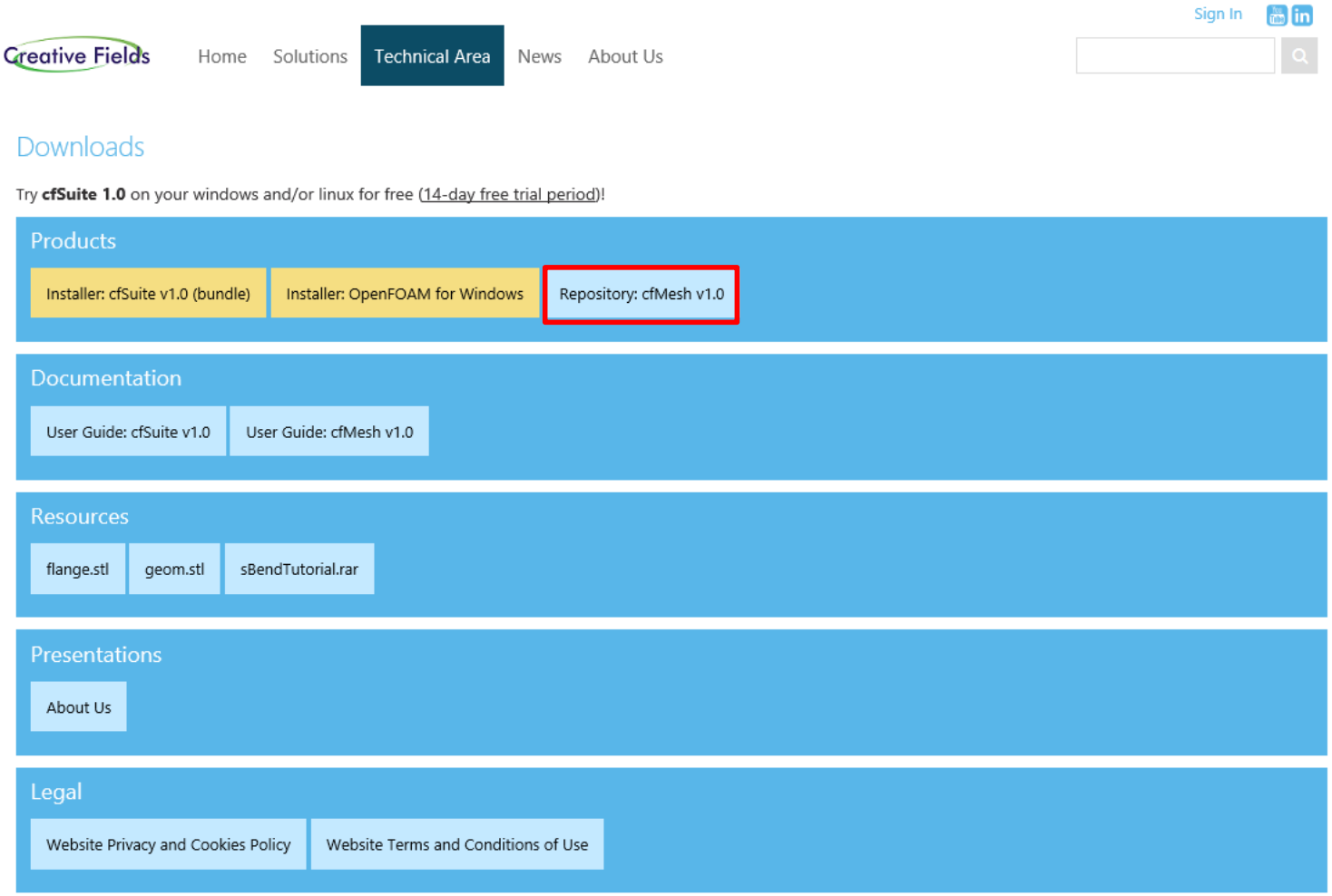
- 八分木法によるメッシュ生成
  - 最大セルサイズを基準とした細分化を実施
- STL表面や基礎形状で細分化領域を指定できる
  - 八分木法により指定領域はセルサイズを下回る大きさまで細分化される
- STL表面に適合するようにメッシュを生成
- STL表面に境界層挿入できる
  - 一括挿入も可能
  - STL領域毎に指定することも可能



http://ja.wikipedia.org/wiki/%E5%85%AB%E5%88%86%E6%9C%A8

cfMeshのダウンロード

http://www.c-fields.com/technical-area/downloads

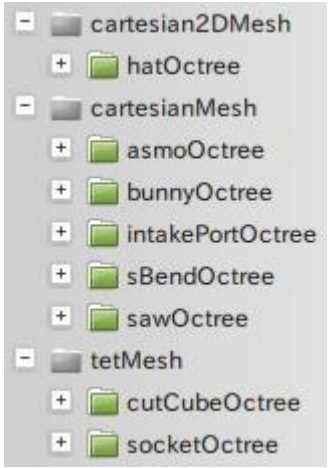


cfMeshのインストール

※OpenFOAM-2.3.0

cfMesh-v1.0を展開
cfMesh-v1.0フォルダー内のAllwmakeを端末内で実行

cfMeshのtutorials

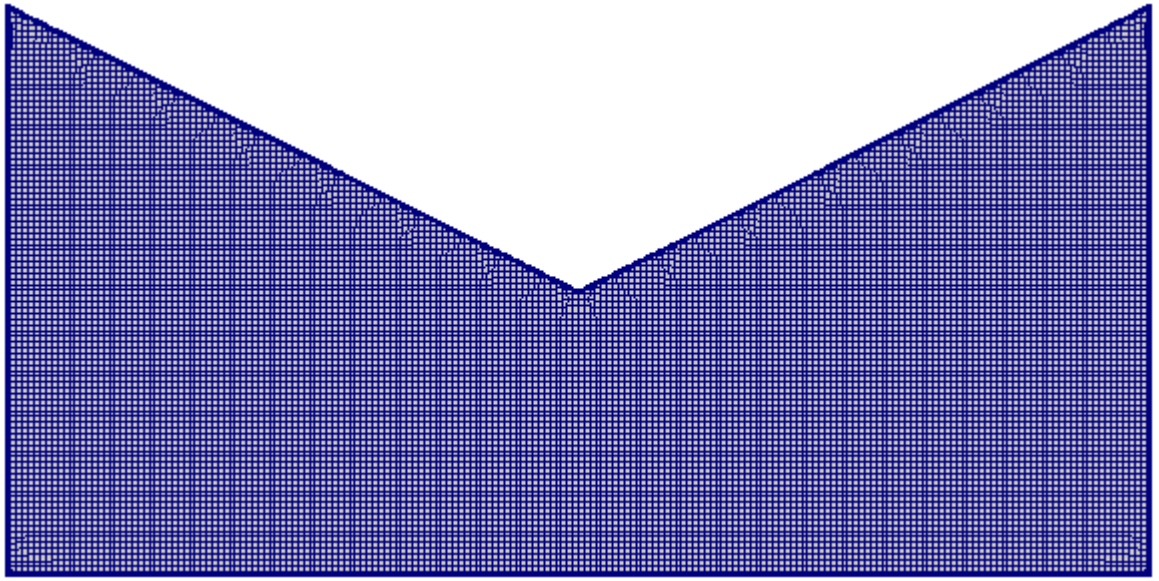


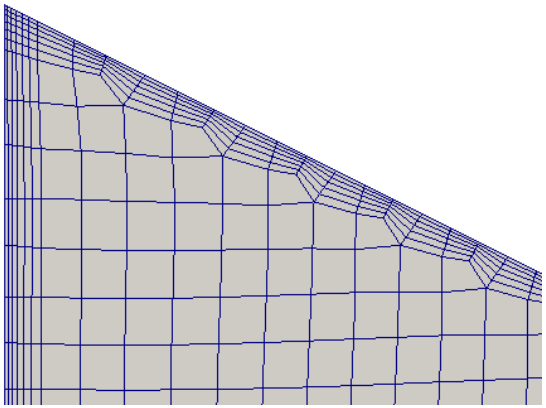
cartesian2DMesh/hatOctree

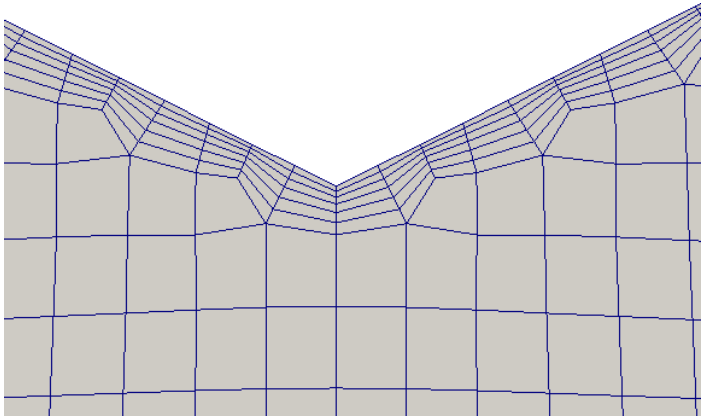
Please run cartesian2DMesh to generate a 2D mesh.

meshDict

```
maxCellSize  0.01;

surfaceFile    "geom.fms";

boundaryLayers
{
    nLayers         6;
    thicknessRatio  1.2;
}
```





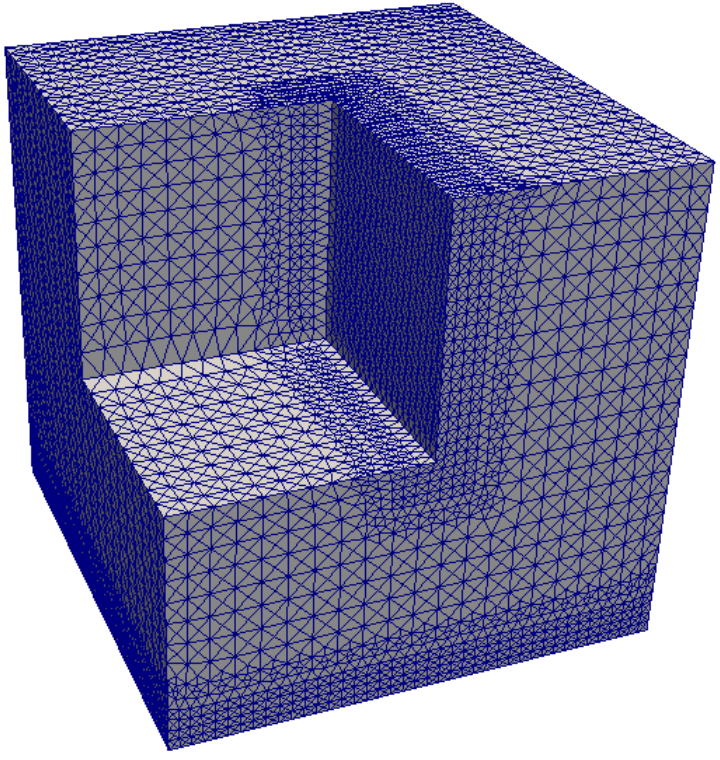


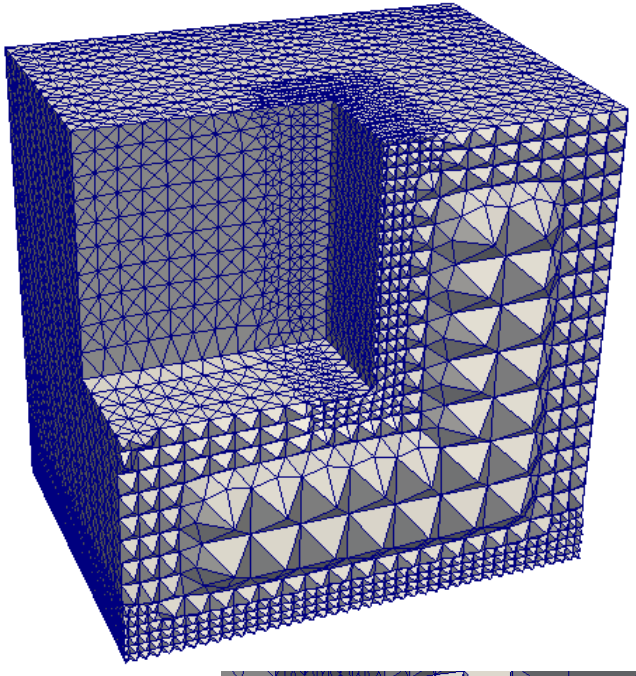
tetMesh/cutCubeOctree

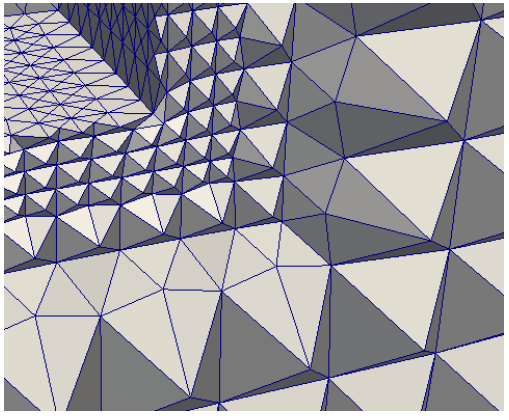
Please run tetMesh to generate a tetrahedral mesh.

meshDict

```
surfaceFile "geom1.stl";

maxCellSize 0.2;

boundaryCellSize 0.1;

minCellSize 0.1;

localRefinement
{
    patch0000
    {
        cellSize  0.05;
    }
    patch0007
    {
        cellSize  0.05;
    }
}
```







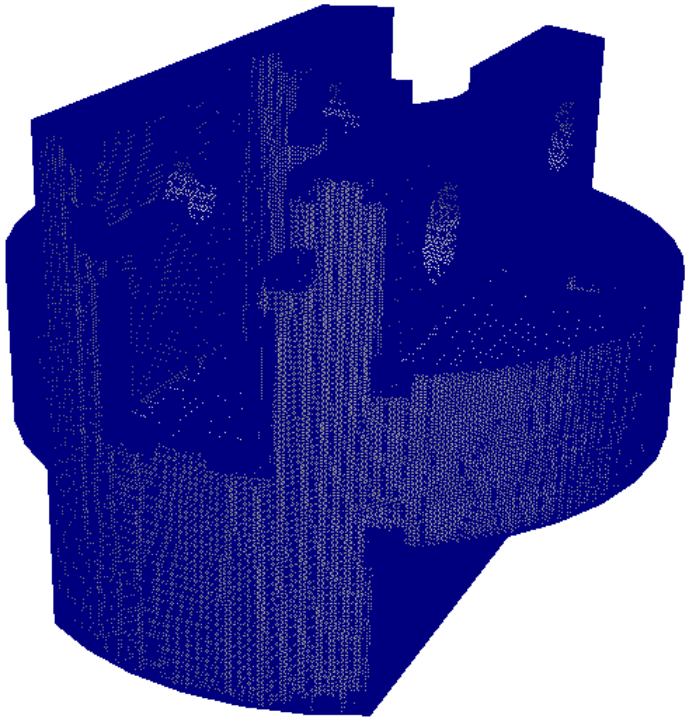
tetMesh/socketOctree

Please run cartesianMesh or tetMesh to generate te volume mesh.

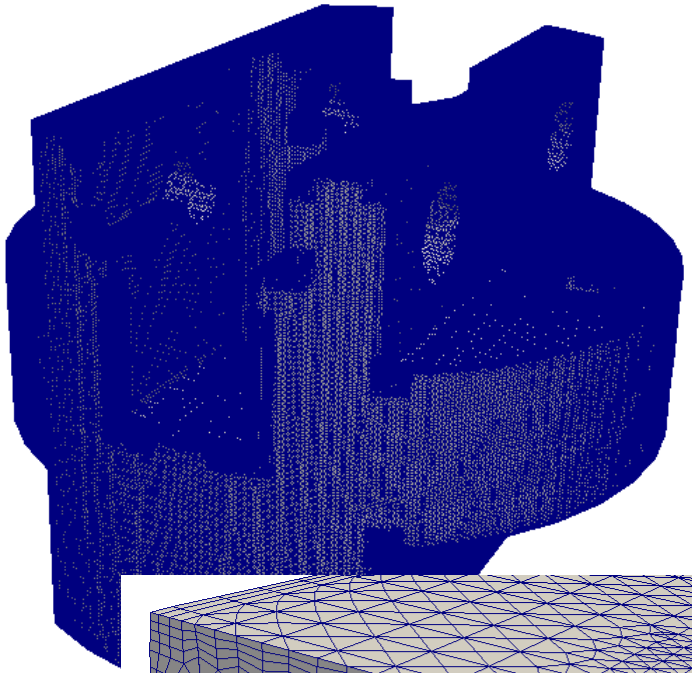
meshDict

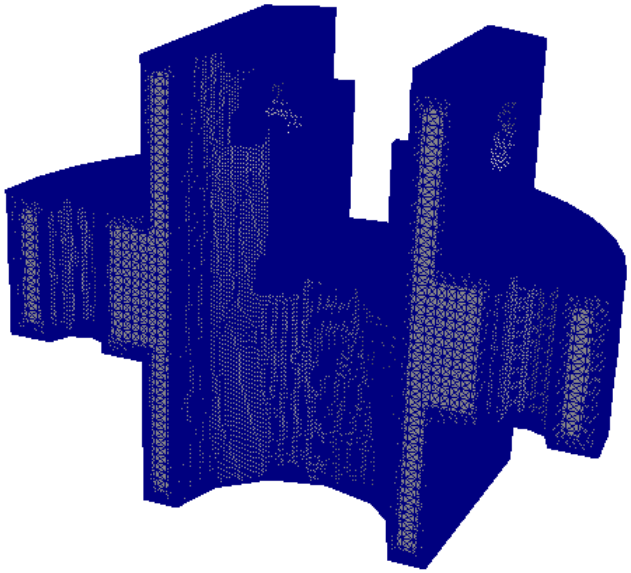
```
boundaryCellSize              1.5;
keepCellsIntersectingBoundary         1;
maxCellSize  3;
minCellSize   0.375;
removeGluedMesh               0;
surfaceFile    "socket.fms";

boundaryLayers
{
    maxFirstLayerThickness0.5;
    nLayers     3;
    thicknessRatio            1.2;

    patchBoundaryLayers
    {

        patch7
        {
            allowDiscontinuity   0;
            maxFirstLayerThickness        0.5;
            nLayers               4;
            thicknessRatio        1.1;
        }
    }
}
```

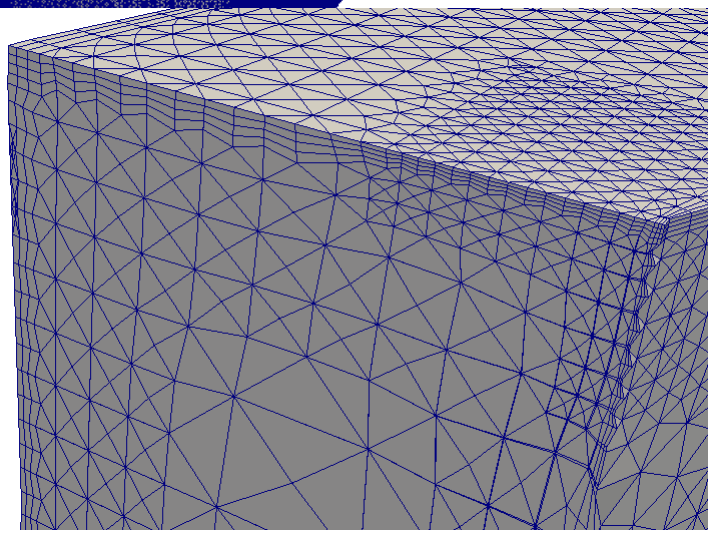
```
localRefinement
{

    patch15
    {
        additionalRefinementLevels        1;
    }

    subset1
    {
        cellSize 1.5;
    }

    subset2
    {
        cellSize 1.5;
    }
}
```

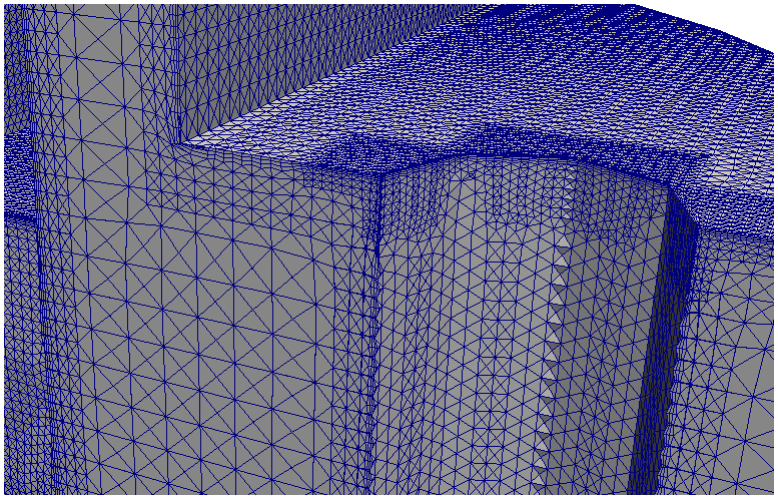


tetMesh/socketOctree







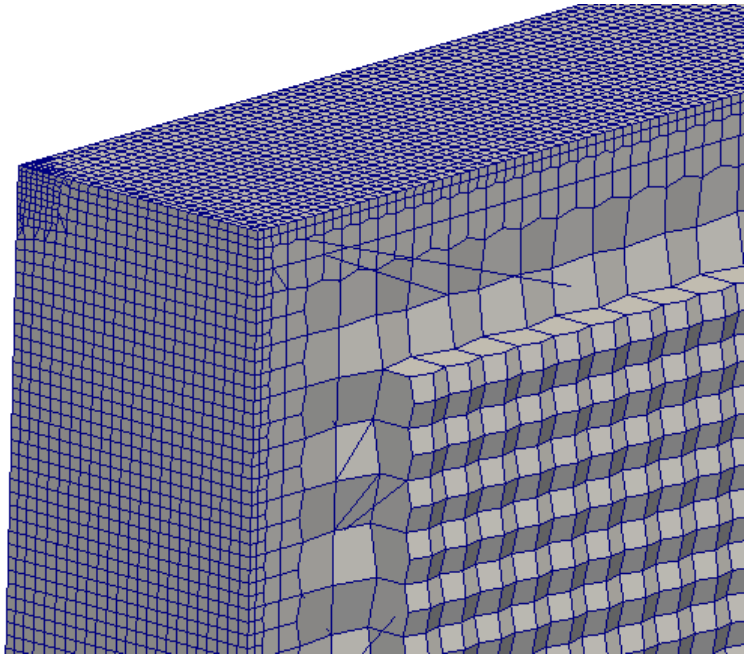


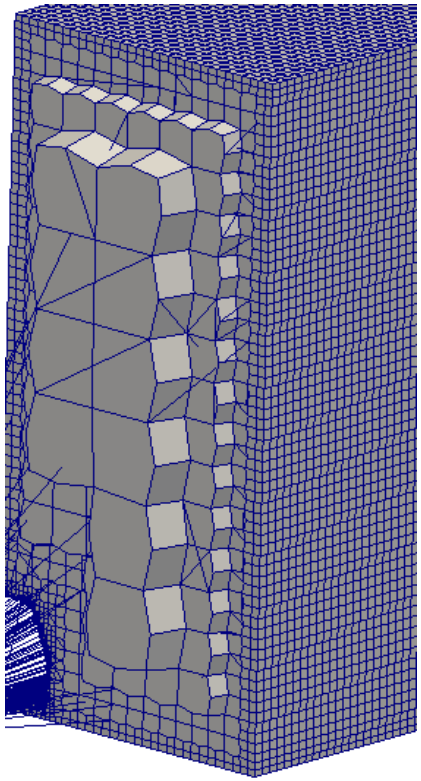
cartesianMesh/asmoOctree

Please run cartesianMesh to generate the mesh

meshDict

```
surfaceFile "geom.stl";

maxCellSize 0.2;

boundaryCellSize 0.025;

minCellSize 0.0125;

localRefinement
{
    defaultFaces0006
    {
        cellSize 0.005;
    }
    defaultFaces0007
    {
        cellSize 0.0025;
    }
    defaultFaces0009
    {
        cellSize 0.0025;
    }
}
```



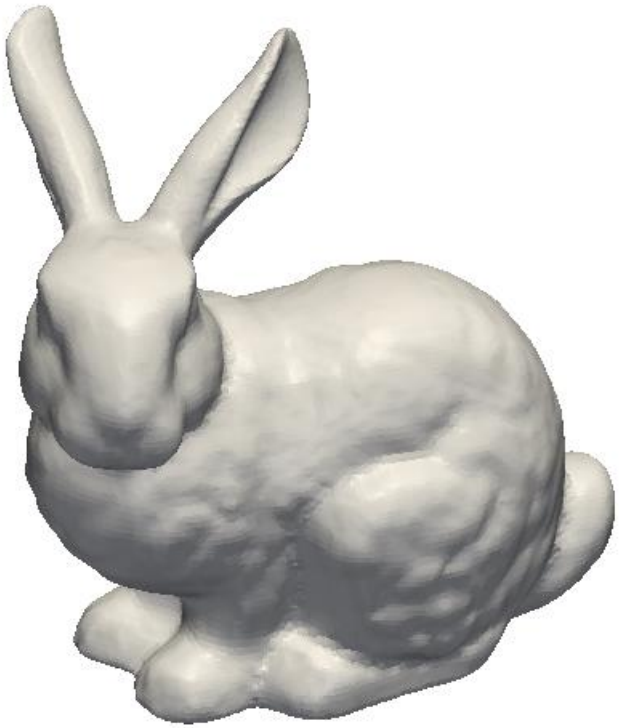


cartesianMesh/bunnyOctree

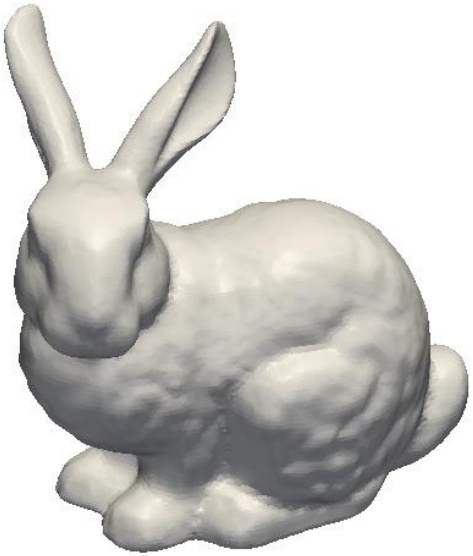
This tutorials demonstrates the usage of primitive refinement sources

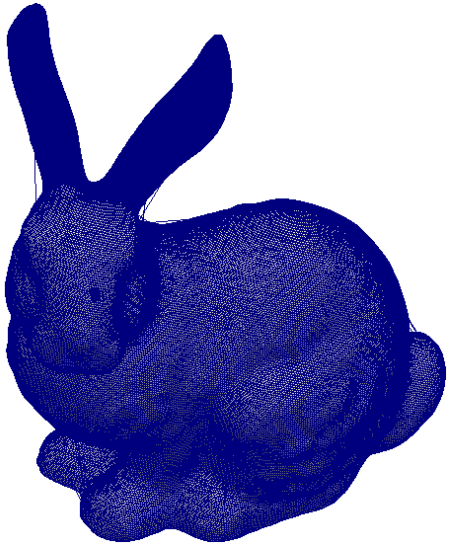
meshDict

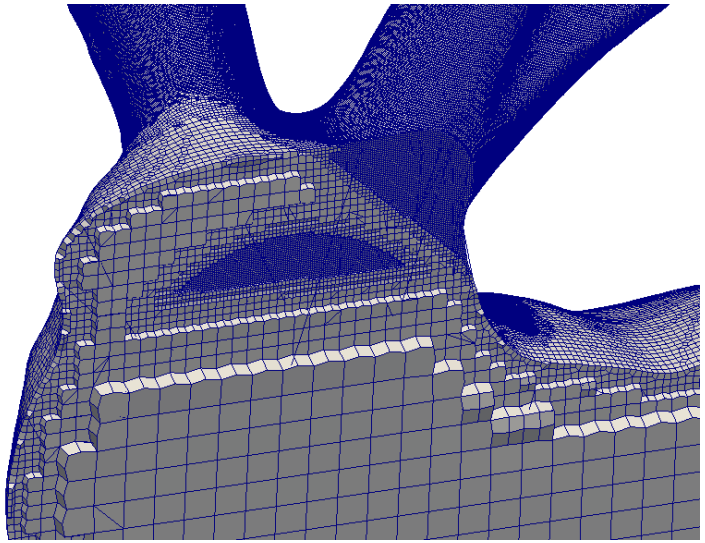
```
surfaceFile "bunnyWrapped.stl";

maxCellSize 30.0;

boundaryCellSize 7.5;

objectRefinements
{
    ear1
    {
        cellSize 3.75;
        type cone;
        p0   (-100 1873 -320);
        radius0  200;
        p1   (-560 1400 0);
        radius1   200;
    }
    ear2
    {
        cellSize 3.75;
        type cone;
        p0   (-650 1873 -620);
        radius0  200;
        p1   (-670 1300 0);
        radius1  200;
    }
    tail
    {
        cellSize 3.75;
        type box;
        centre  (500 500 150);
        lengthX  100;
        lengthY  150;
        lengthZ  200;
    }
    insideTheBody
    {
        cellSize 3.75;
        type sphere;
        centre  (0 700 0);
        radius  50;
    }
    muzzlePiercing
    {
        cellSize 3.75;
        type line;
        p0      (-750 1000 450);
        p1      (-750 1500 450);
    }
}
```

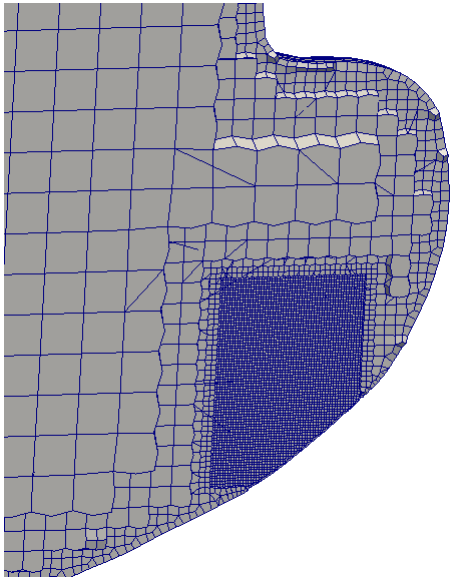


cartesianMesh/bunnyOctree





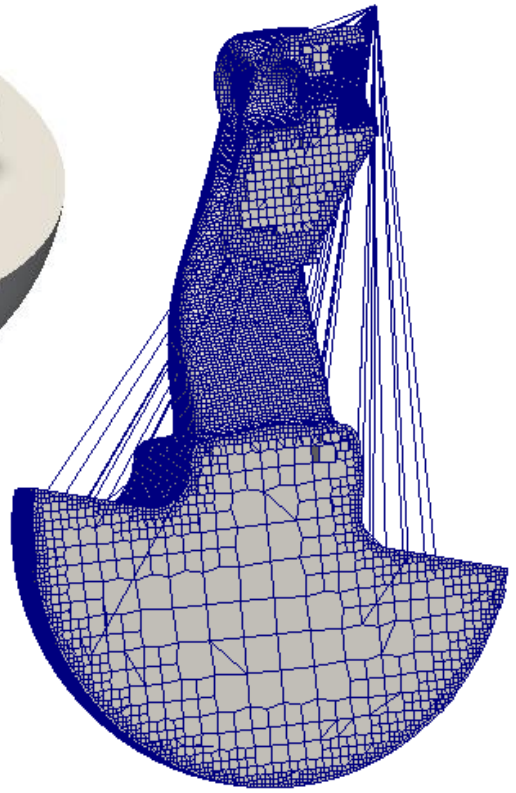




cartesianMesh/intakePortOctree

meshDict

```
surfaceFile "geom2.stl";

maxCellSize 10;

boundaryCellSize 1.25;

minCellSize 2.0;

localRefinement
{
    patch001
    {
        cellSize 0.625;
    }
    patch002
    {
        cellSize 0.625;
    }
    patch003
    {
        cellSize 0.625;
    }
    patch004
    {
        cellSize 0.625;
    }
    patch005
    {
        cellSize 0.625;
    }
    patch006
    {
        cellSize 0.625;
    }
    patch007
    {
        cellSize 0.625;
    }
    patch008
    {
        cellSize 0.625;
    }
}
```



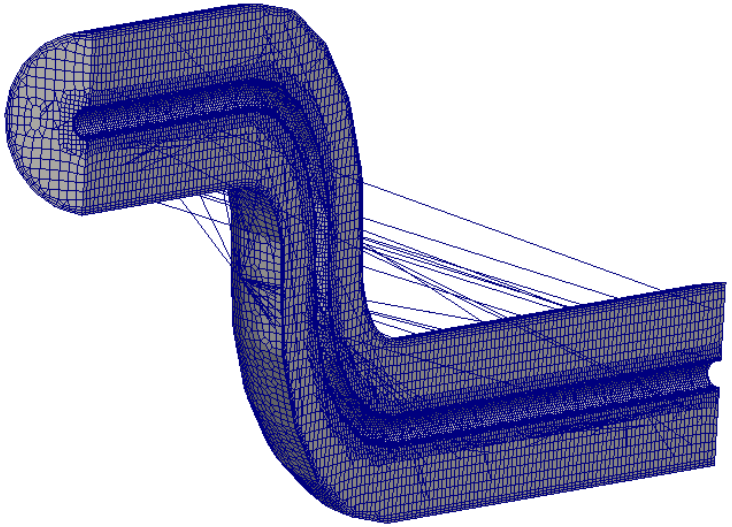
cartesianMesh/sBendOctree

The exmaple demonstrates usage of subsets for refinement, and how to set up boundary layer properties. To generate the mesh please run cartesianMesh or tetMesh.

meshDict

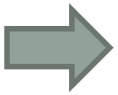
```
maxCellSize  0.1;

surfaceFile    "sBend.fms";

boundaryLayers
{
    nLayers     1;

    patchBoundaryLayers
    {

        walls
        {
            nLayers             3;
            thicknessRatio      1.2;
        }
    }
}
```

```
localRefinement
{

    refFine
    {
        cellSize 0.025;
    }

    walls
    {
        cellSize 0.05;
    }
}
```



sBend.fmsファイルを変更

```
5(
object
wall
inlet
patch
outlet
patch
symm
symmetryPlane
walls
wall)
```



```
5(
object
wall
inlet
patch
outlet
patch
symm
patch
walls
wall)
```

cartesianMesh/sawOctree

Please run cartesianMesh to generate the mesh.

meshDict

```
surfaceFile "sav1.stl";

maxCellSize 0.25;

boundaryCellSize 0.125;
```

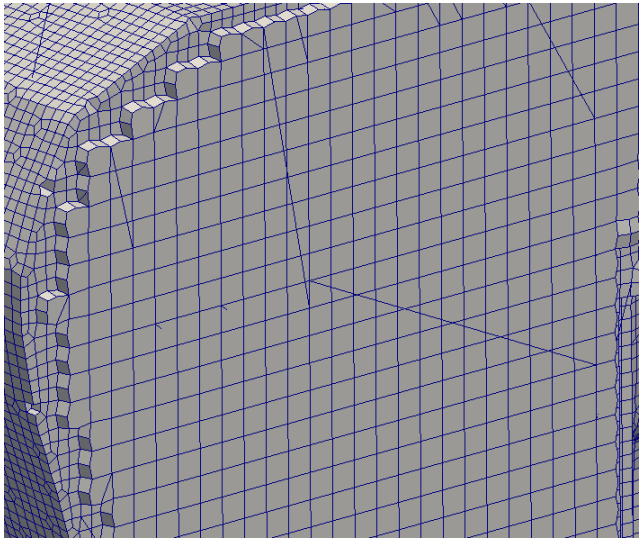
decomposeParDict

```
numberOfSubdomains  4;
```

Allrun

```
#!/bin/sh
# Source tutorial run functions
. $WM_PROJECT_DIR/bin/tools/RunFunctions

runApplication preparePar
runParallel cartesianMesh 4
runParallel checkMesh 4
#runApplication reconstructParMesh -zeroTime
runApplication reconstructParMesh -constant -fullMatch
```

Tutorialsそのままでは動かない



本日の演習内容

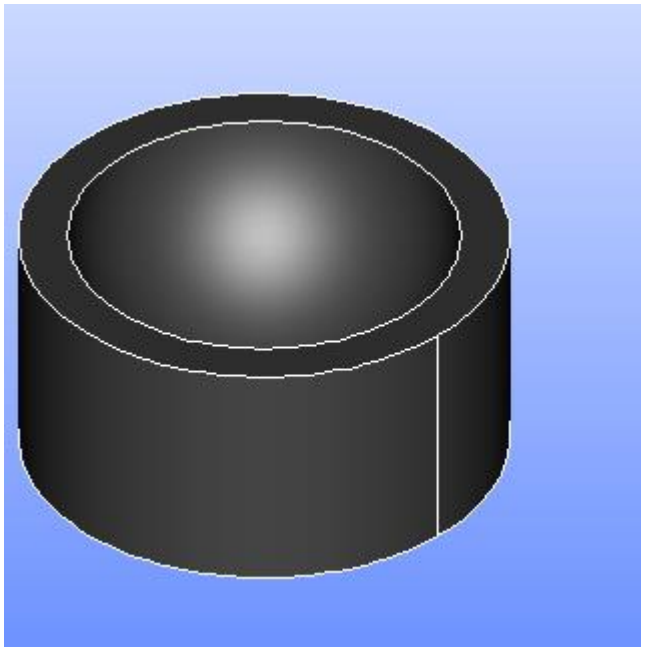
- GeometryからcfMesh作成
- 表面メッシュ作成したのちcfMesh作成
- 境界層の作成
- 部分的なセルサイズの指定
- 欠けた形状のメッシュ作成

演習1　Primitivesによるモデル作成

①XY平面を底面基準とし、Z軸を中心軸とする半径50mm、高さ50mmの円柱を作成する。（ソリッドモデルA）

②座標値(0,0,50)を中心とする半径40mmの球形状を作成する。（ソリッドモデルB）

③円柱（ソリッドモデルA）と球（ソリッドモデルB）を組み合わせる。

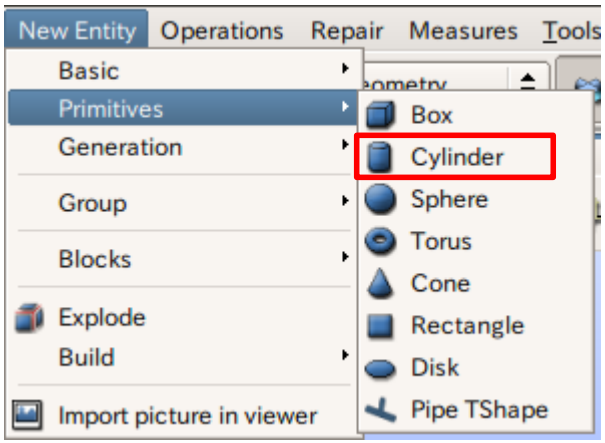


演習1　Primitivesによるモデル作成

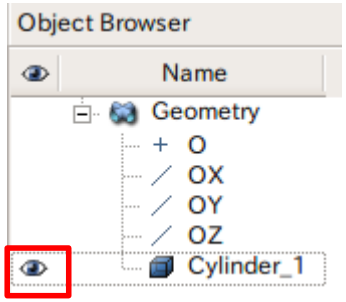
①XY平面を底面基準とし、Z軸を中心軸とする半径50mm、高さ50mmの円柱を作成する。（ソリッドモデルA）

円柱の作成

New Entity>Primitives>Cylinder



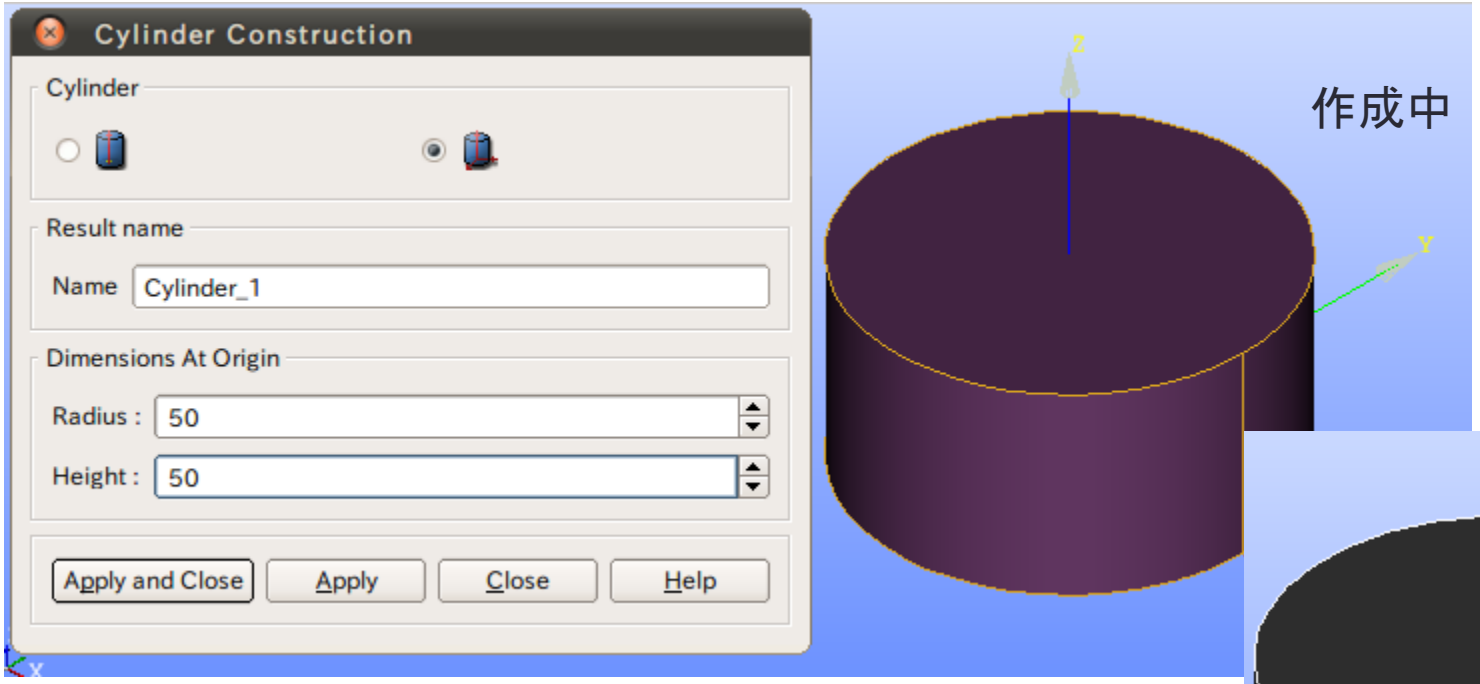
連続して作成する場合はApply

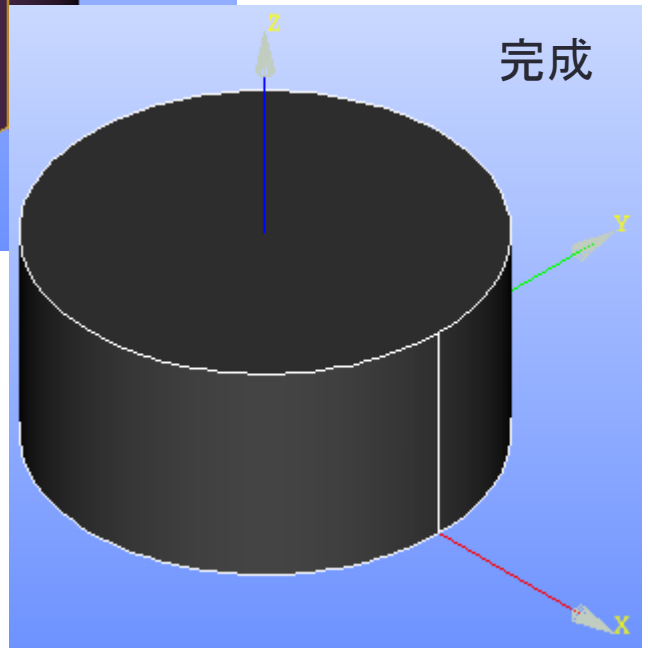


オブジェクトブラウザに追加される

表示/非表示切り替え

演習1　Primitivesによるモデル作成



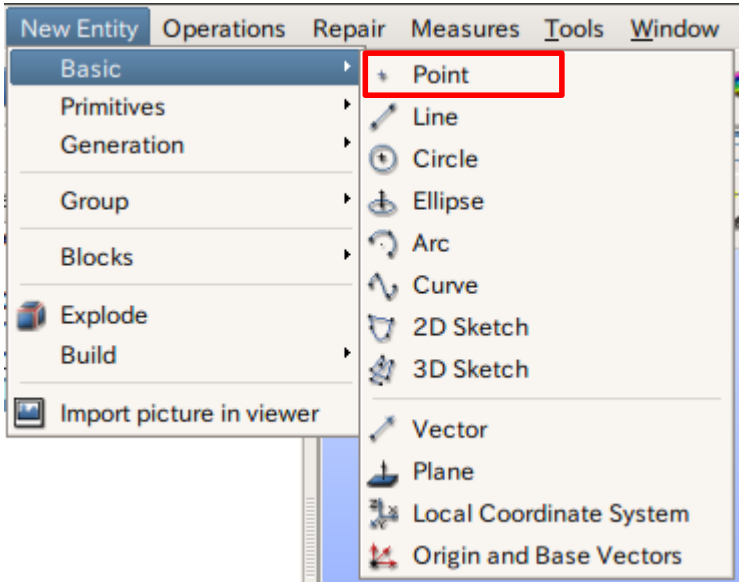


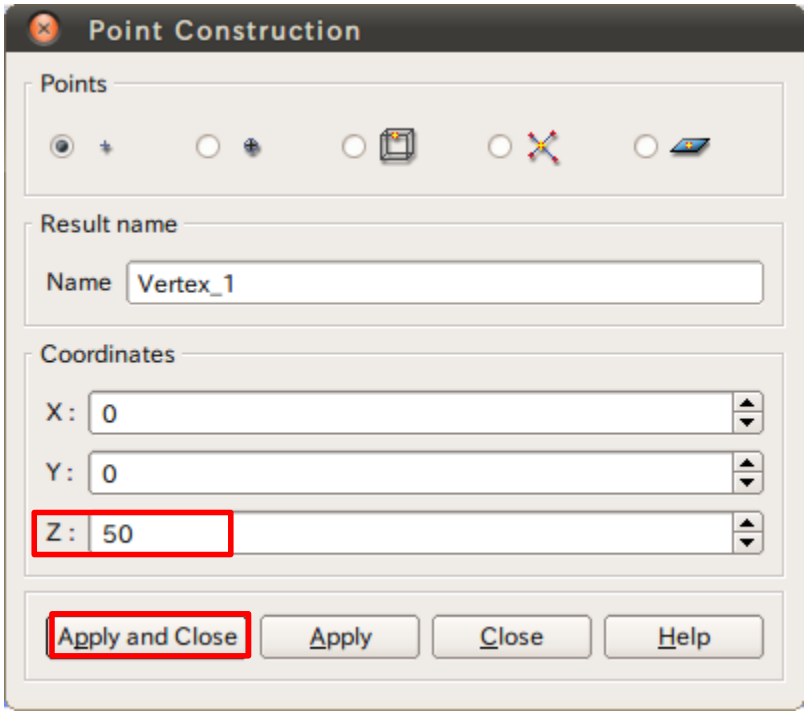
演習1　Primitivesによるモデル作成

②座標値(0,0,50)を中心とする半径40mmの球形状を作成する。(ソリッドモデルB)

点の作成

New Entity>Basic>Point



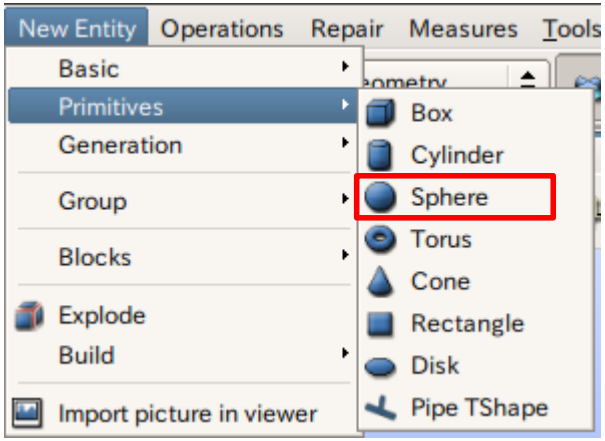


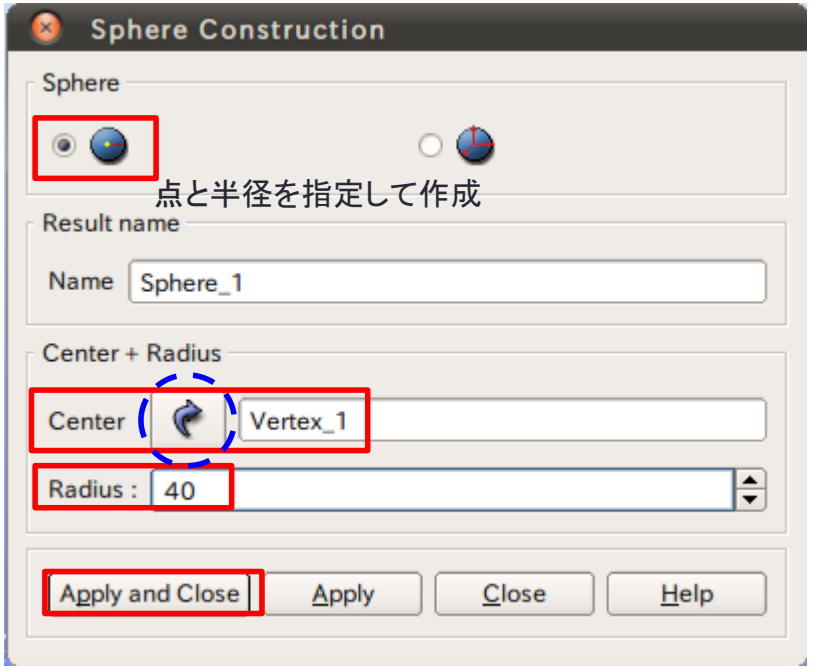
演習1　Primitivesによるモデル作成

②座標値(0,0,50)を中心とする半径40mmの球形状を作成する。(ソリッドモデルB)

球の作成

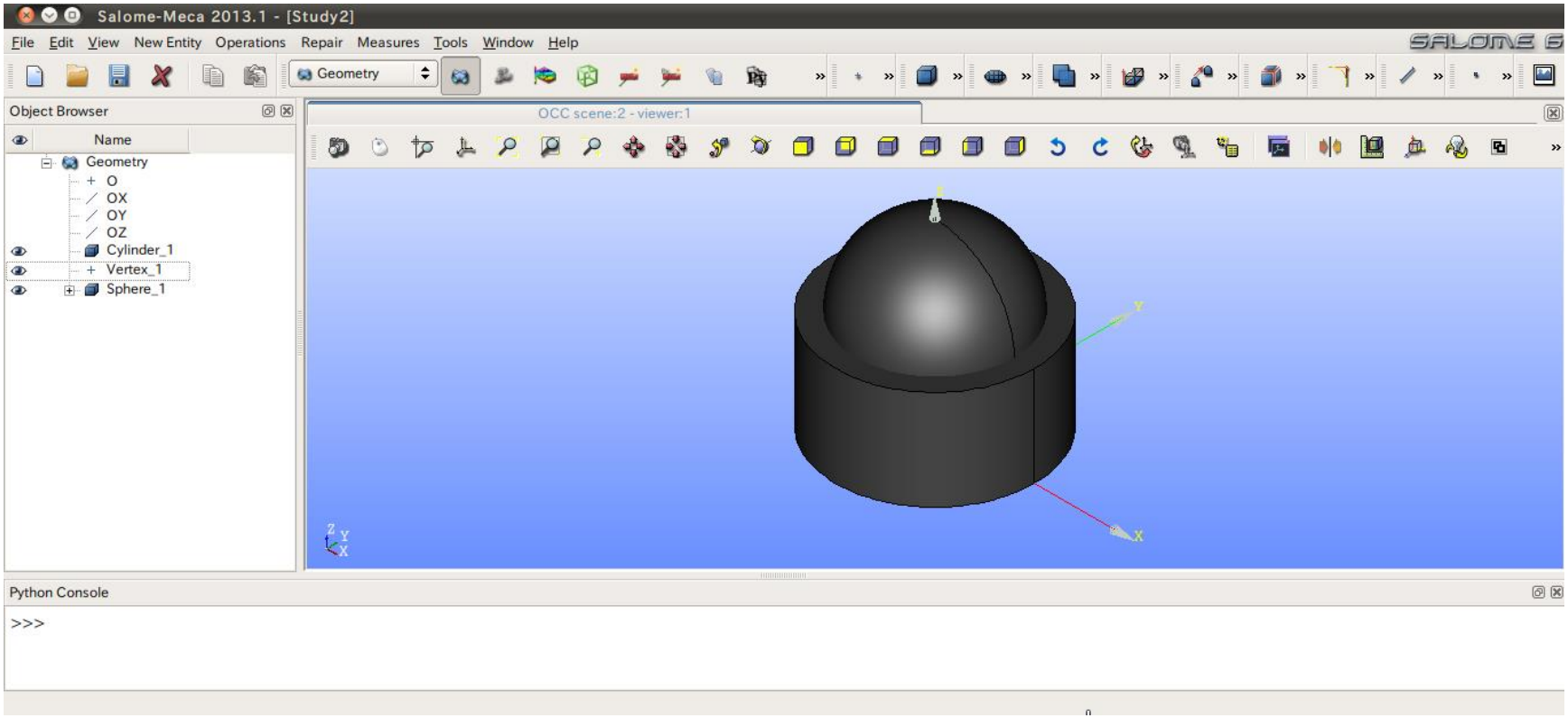
New Entity>Primitives>Sphere





矢印を選択するとグラフィックウインドウまたはオブジェクトブラウザから選択可能

演習1　Primitivesによるモデル作成

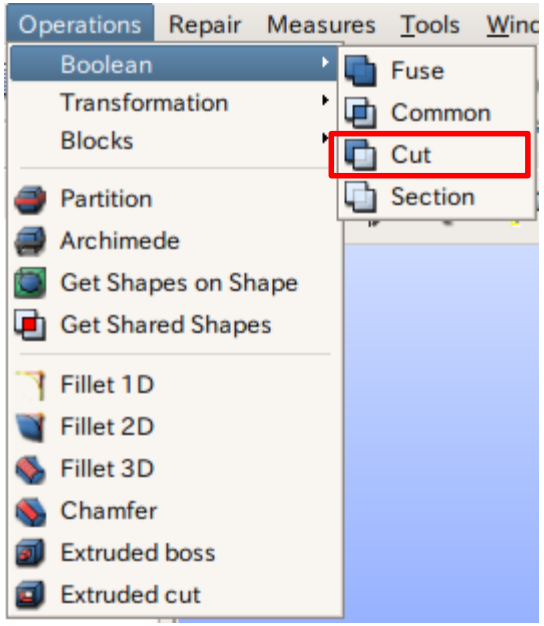


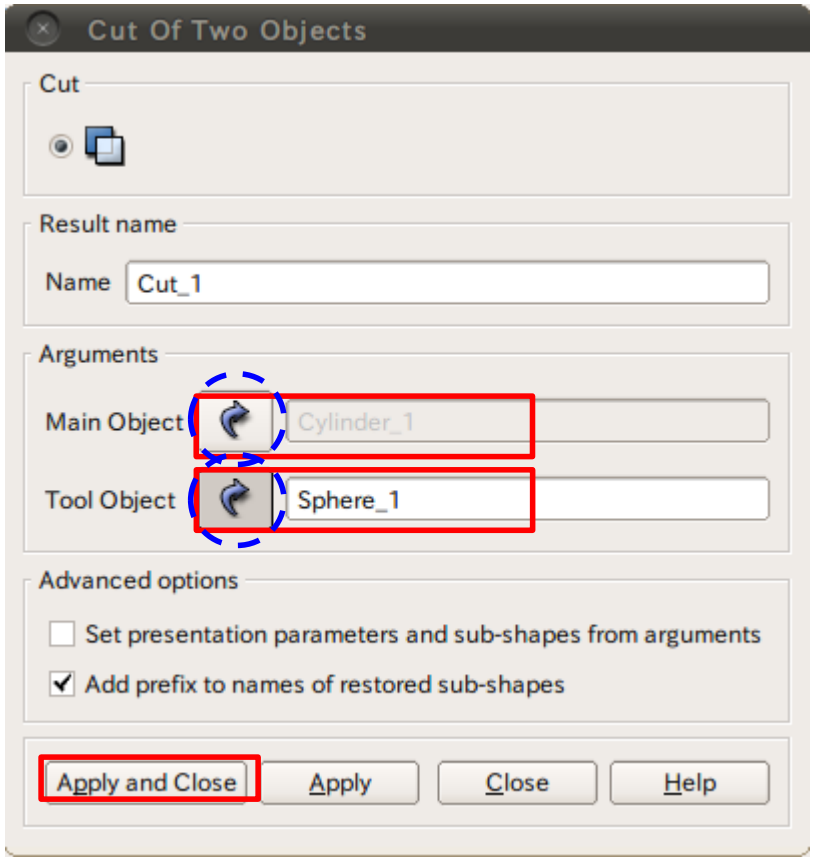
演習1　Primitivesによるモデル作成

② ソリッドモデルAに対し、点B（0，0，50）を中心点とする半径40mmの球形状を除去しなさい。これをソリッドモデルCとする。

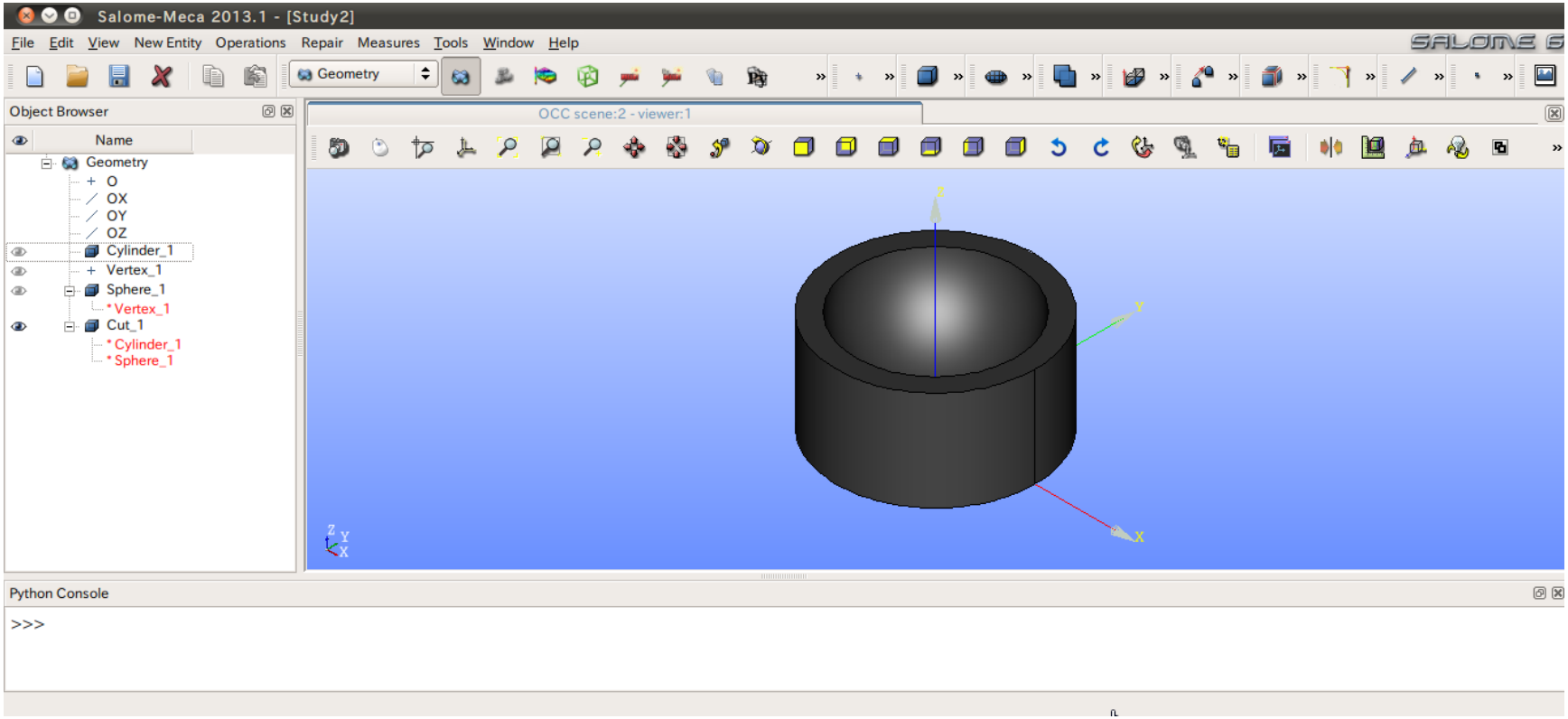
球の作成

Operations>Boolean>Cut





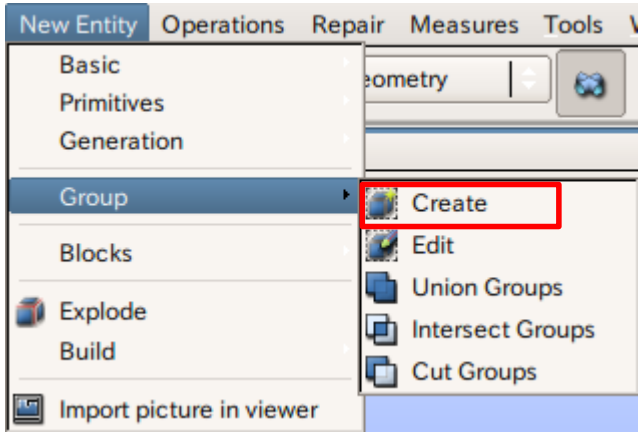
演習1　Primitivesによるモデル作成

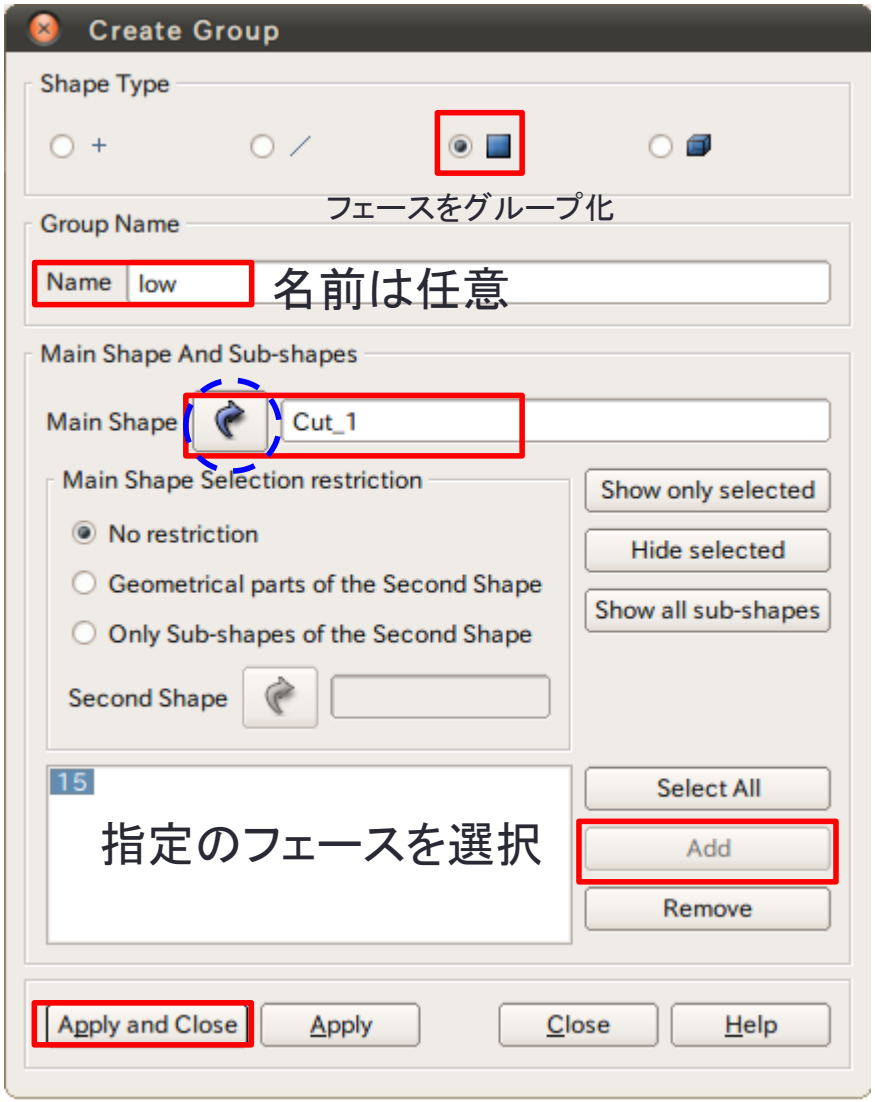


演習1　グループの作成

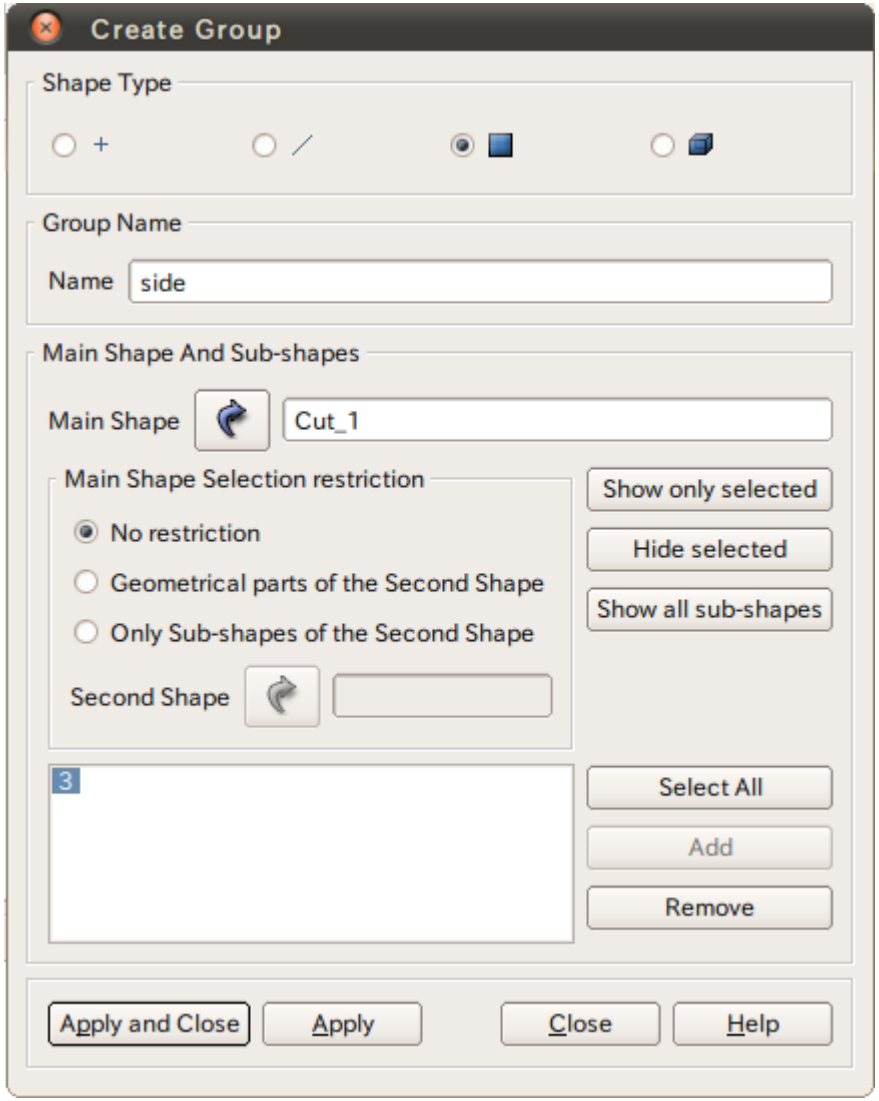
グループの作成

New Entity>Group>Create

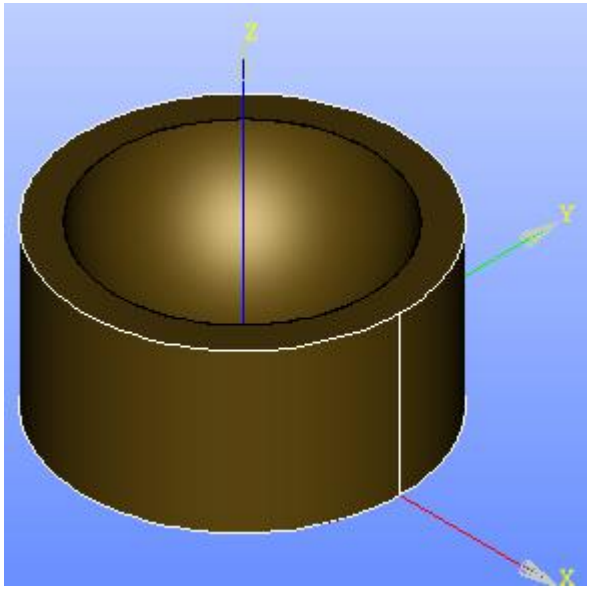




演習1　グループの作成



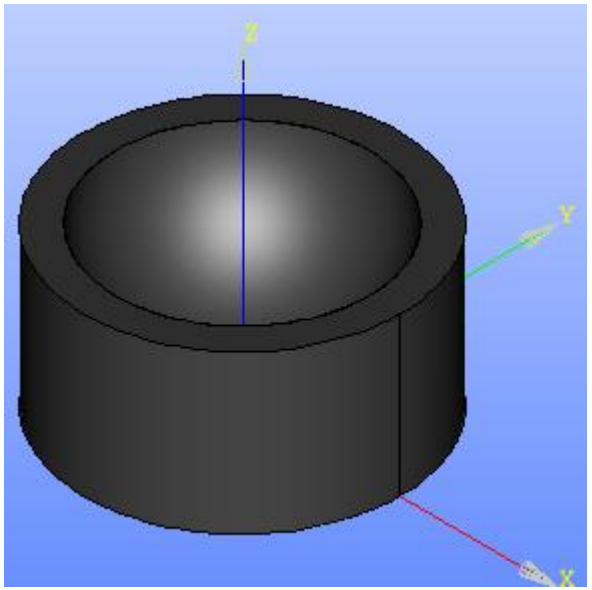
作成中

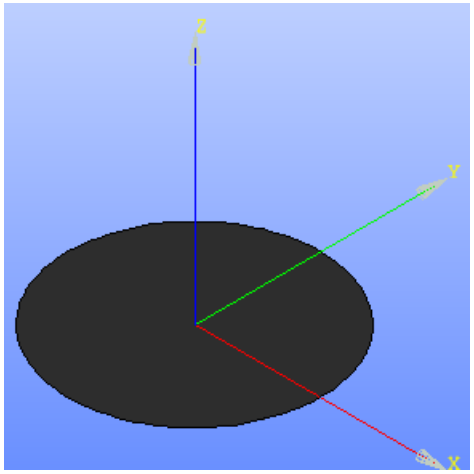


選択するとハイライトされる

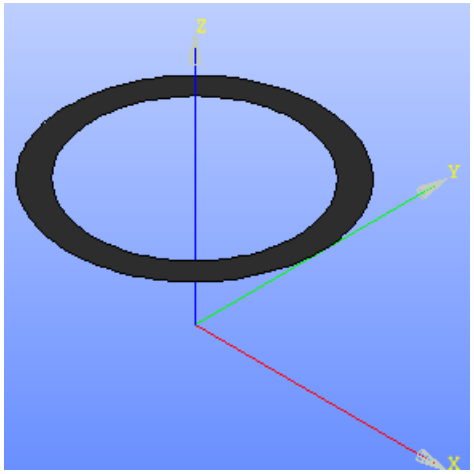
演習1　グループの作成

グループの作成

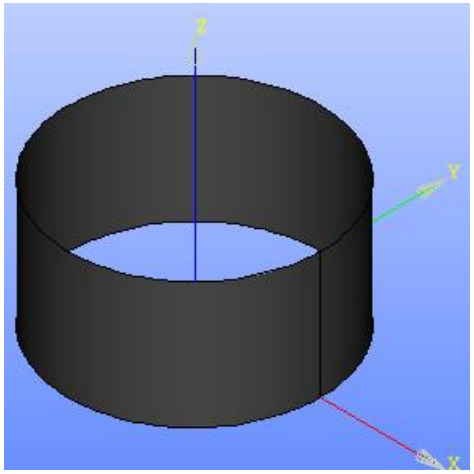




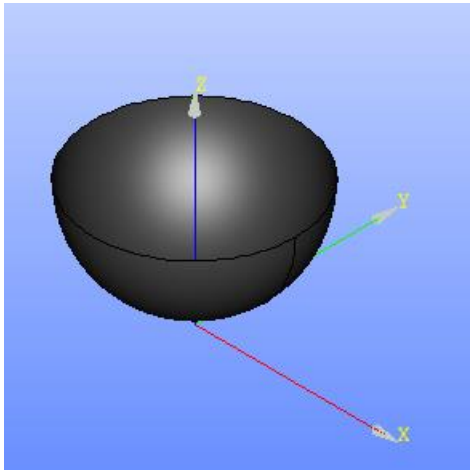
low



up



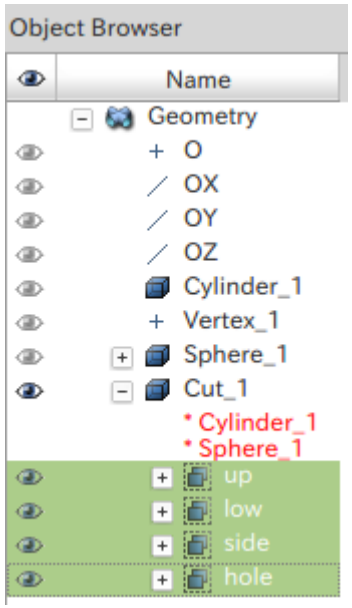
side



hole

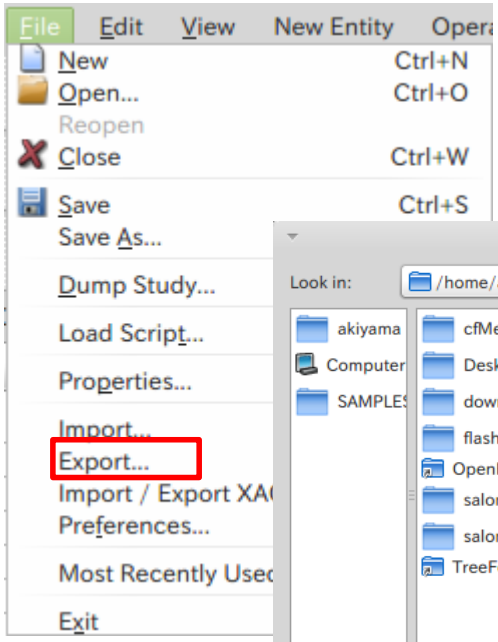
演習1　geometryの出力

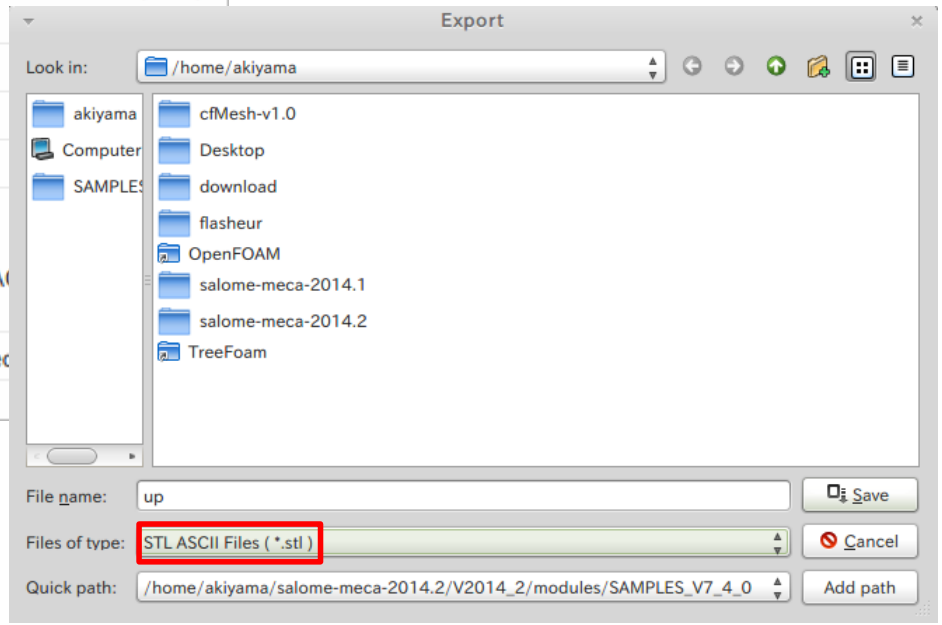
グループを選択した状態にする



geometryの出力

File>Export





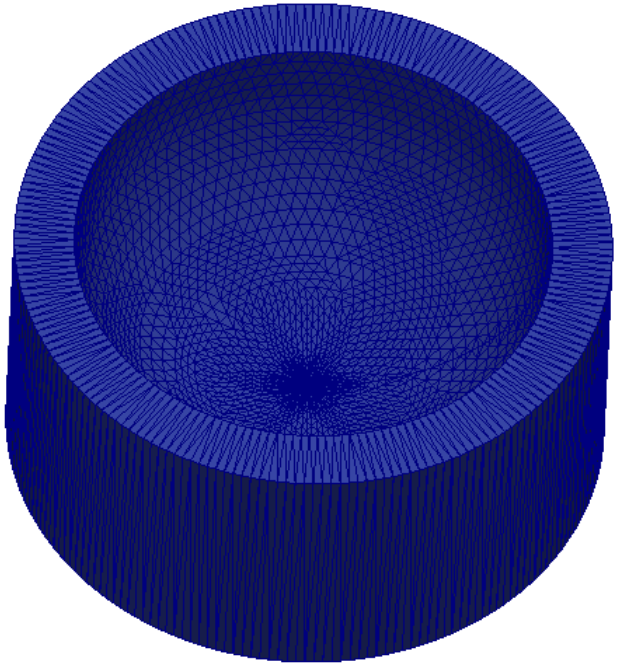
Cut_1と各サーフェスグループを出力

STL ASCII Filesを選択

演習1-1　Cut_1のcfMesh作成

system/mesh.Dict

```
/*--------------------------------*- C++ -*----------------------------------*¥
| =========                 |                                                 |
| ¥¥      /  F ield         | cfMesh: A library for mesh generation           |
|  ¥¥    /   O peration     |                                                 |
|   ¥¥  /    A nd           | Author: Franjo Juretic                          |
|    ¥¥/     M anipulation  | E-mail: franjo.juretic@c-fields.com             |
¥*---------------------------------------------------------------------------*/

FoamFile
{
    version   2.0;
    format    ascii;
    class     dictionary;
    location  "system";
    object    meshDict;
}

// * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * //

maxCellSize        2;

surfaceFile        "Cut_1.stl";

// ************************************************************************* //
```



Cut_1.stl

StlファイルとmaxCellSizeを指定するのみでメッシュ作成可能

$cartesianMesh

演習1-1　Cut_1のcfMesh作成

$checkMesh

Create time

Create polyMesh for time = 0

Time = 0

Mesh stats
　points:　　42707
　internal points:　31825
　faces:　　116932
　internal faces:　106052
　cells:　　37164
　faces per cell:　6
　boundary patches: 1
　point zones:　　0
　face zones:　　0
　cell zones:　　0

Overall number of cells of each type:
　hexahedra:　　37164
　prisms:　　0
　wedges:　　0
　pyramids:　　0
　tet wedges:　　0
　tetrahedra:　　0
　polyhedra:　　0

Checking topology...
　Boundary definition OK.
　Cell to face addressing OK.
　Point usage OK.
　Upper triangular ordering OK.
　Face vertices OK.
　Number of regions: 1 (OK).

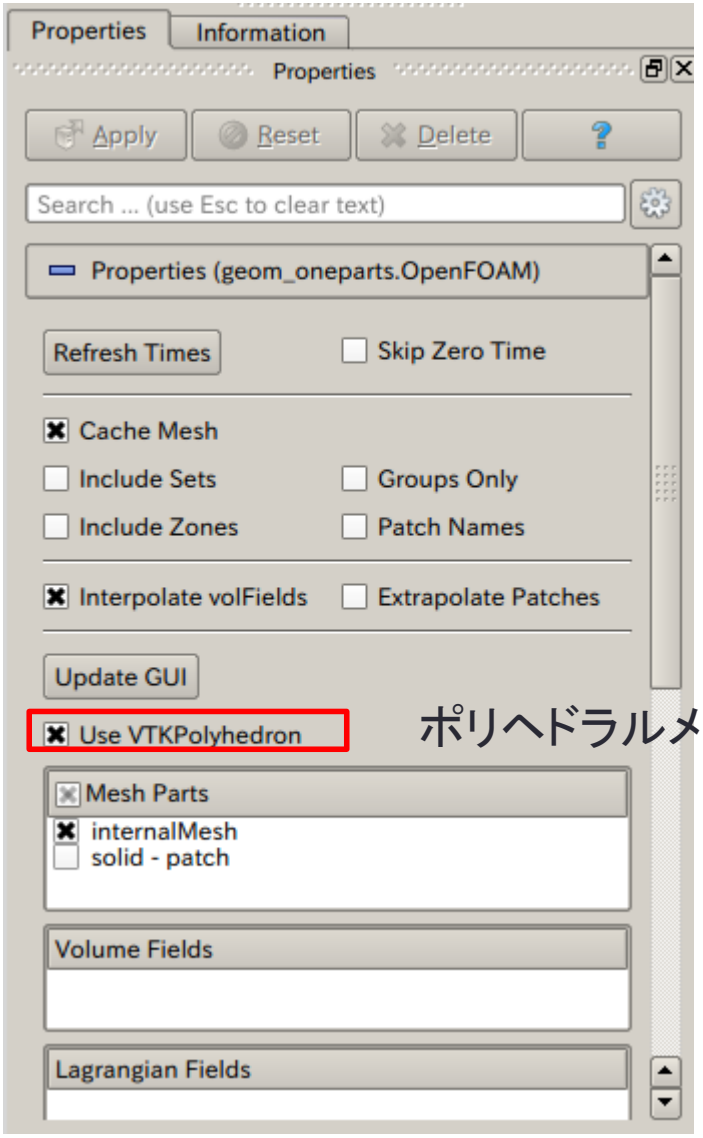
Checking patch topology for multiply connected surfaces...
　Patch　　Faces　Points　Surface topology
　solid　　10880　10882　ok (closed singly connected)

Checking geometry...
　Overall domain bounding box (-49.9999 -49.9999 -3.76233e-28) (49.9998 49.9999 50)
　Mesh (non-empty, non-wedge) directions (1 1 1)
　Mesh (non-empty) directions (1 1 1)
　Boundary openness (-5.16849e-17 3.7172e-17 -4.65867e-17) OK.
　Max cell openness = 3.31525e-16 OK.
　Max aspect ratio = 2.38403 OK.
　Minimum face area = 1.03424. Maximum face area = 5.4622.　Face area magnitudes OK.
　Min volume = 1.9871. Max volume = 10.035.　Total volume = 256821.　Cell volumes OK.
　Mesh non-orthogonality Max: 20.1503 average: 3.31061
　Non-orthogonality check OK.
　Face pyramids OK.
　Max skewness = 0.493938 OK.
　Coupled point location match (average 0) OK.

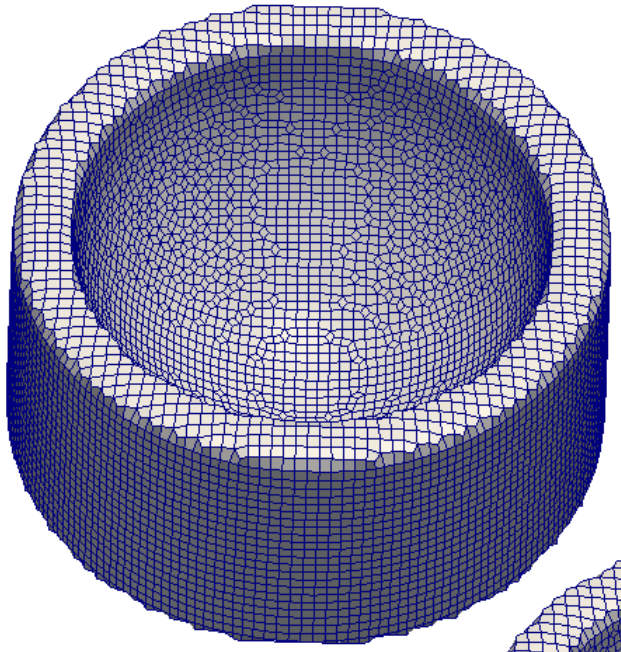
Mesh OK.

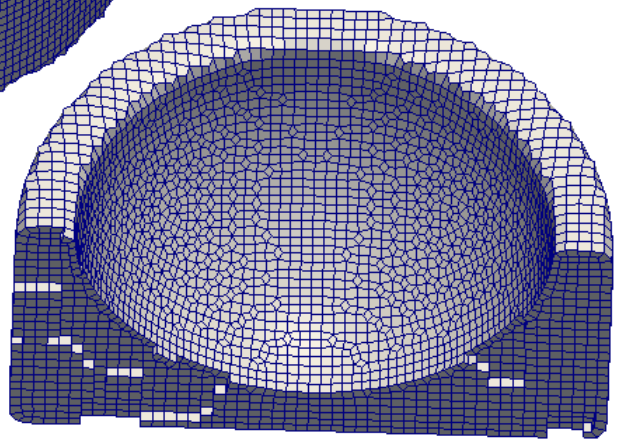
End

演習1-1　Cut_1のcfMesh作成



ポリヘドラルメッシュの表示





特徴線が抽出されない

演習1-2　特徴線ありのcfMesh作成

Stlファイルから特徴線を抽出し*.fmsファイルへ変換する

$surfaceFeatureEdges -help

Usage: surfaceFeatureEdges [OPTIONS] <input surface file> <output surface file>
options:
  -angle <scalar> 特徴線の抽出角度
  -case <dir> specify alternate case directory, default is the cwd
  -noFunctionObjects
  do not execute functionObjects
  -srcDoc display source code in browser
  -doc display application documentation in browser
  -help print the usage

surfaceFeatureEdges -angle 10 Cut_1.stl Cut_1.fms

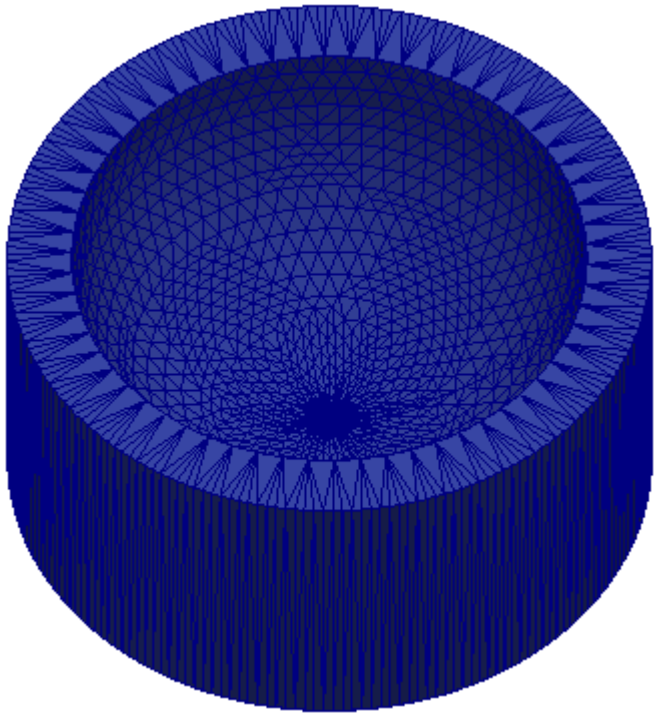
Stlファイル名　fmsファイル名

演習1-2　特徴線ありのcfMesh作成

meshDict内のCut_1.stlをCut_1.fmsに変更

--> FOAM FATAL ERROR:
Cannot construct the quadric surface for point (2.44921e-15 -5.99864e-31 10) because the normal does not exist!
This indicates that the input surface mesh is of poor quality

From function template<class ListType>
inline quadricFitting::quadricFitting(const point& origin, const vector normal, const ListType& otherPoints)
in file lnInclude/quadricFittingI.H at line 227.



Stlの品質が悪くcfMeshではメッシュ作成ができない

演習1-2　特徴線ありのcfMesh作成

各サーフェスグループの*.stlファイルを修正する

```
solid
 facet normal -0.000000e+00 -0.000000e+00 -1.000000e+00
   outer loop
     vertex  4.823178e+01  1.317936e+01  0.000000e+00
     vertex  4.860115e+01  1.174430e+01  0.000000e+00
     vertex  4.736632e+01  1.601349e+01  0.000000e+00
   endloop
 endfacet
 facet normal -0.000000e+00 -0.000000e+00 -1.000000e+00
   outer loop
     vertex  4.782005e+01  1.460284e+01  0.000000e+00
     vertex  4.823178e+01  1.317936e+01  0.000000e+00
     vertex  4.736632e+01  1.601349e+01  0.000000e+00
   endloop
 endfacet
.
.
.
 facet normal  0.000000e+00  0.000000e+00 -1.000000e+00
   outer loop
     vertex  5.913659e+00  4.964905e+01  0.000000e+00
     vertex  1.174430e+01  4.860115e+01  0.000000e+00
     vertex  1.317936e+01  4.823178e+01  0.000000e+00
   endloop
 endfacet
endsolid
```

ファイル名を追加（patch名になる）

```
solid low
 facet normal -0.000000e+00 -0.000000e+00 -1.000000e+00
   outer loop
     vertex  4.823178e+01  1.317936e+01  0.000000e+00
     vertex  4.860115e+01  1.174430e+01  0.000000e+00
     vertex  4.736632e+01  1.601349e+01  0.000000e+00
   endloop
 endfacet
 facet normal -0.000000e+00 -0.000000e+00 -1.000000e+00
   outer loop
     vertex  4.782005e+01  1.460284e+01  0.000000e+00
     vertex  4.823178e+01  1.317936e+01  0.000000e+00
     vertex  4.736632e+01  1.601349e+01  0.000000e+00
   endloop
 endfacet
.
.
.
 facet normal  0.000000e+00  0.000000e+00 -1.000000e+00
   outer loop
     vertex  5.913659e+00  4.964905e+01  0.000000e+00
     vertex  1.174430e+01  4.860115e+01  0.000000e+00
     vertex  1.317936e+01  4.823178e+01  0.000000e+00
   endloop
 endfacet
endsolid
```

修正した*.stlファイルをマージする

STLファイルをマージするスクリプト

stl_merge

```
#!/bin/sh

files="*.stl"
for filepath in ${files}
do
  filename=`basename $filepath .stl`
sed -i -e "1s/solid/solid $filename/" $filename.stl

  echo $filename
done

cat *.stl > mesh.stl
```

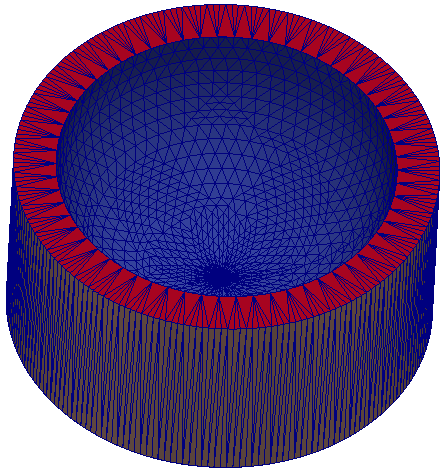
ディレクトリ内にあるstlファイルを検出
検出したstlファイルの数分ループを回す
Stlファイル名を取得
文字列”solid”を検索し”solid ファイル名”に置き換える

Stlファイルをマージし一つのmesh.stlファイルにする

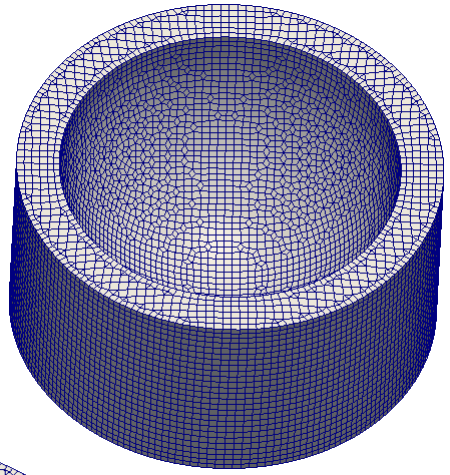
演習1-2　特徴線ありのcfMesh作成

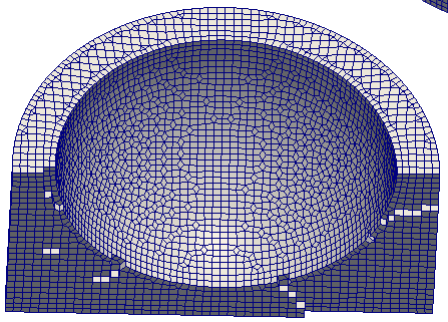
system/mesh.Dict

```
/*--------------------------------*- C++ -*----------------------------------*¥
| =========                 |                                                 |
| ¥¥      /  F ield         | cfMesh: A library for mesh generation
|  ¥¥    /   O peration     |                                                 |
|   ¥¥  /    A nd           | Author: Franjo Juretic                          |
|    ¥¥/     M anipulation  | E-mail: franjo.juretic@c-fields.com
¥*---------------------------------------------------------------------------*/

FoamFile
{
    version   2.0;
    format    ascii;
    class     dictionary;
    location  "system";
    object    meshDict;
}

// * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * //

maxCellSize        2;

surfaceFile        "Cut_1.stl";

// ************************************************************************* //
```

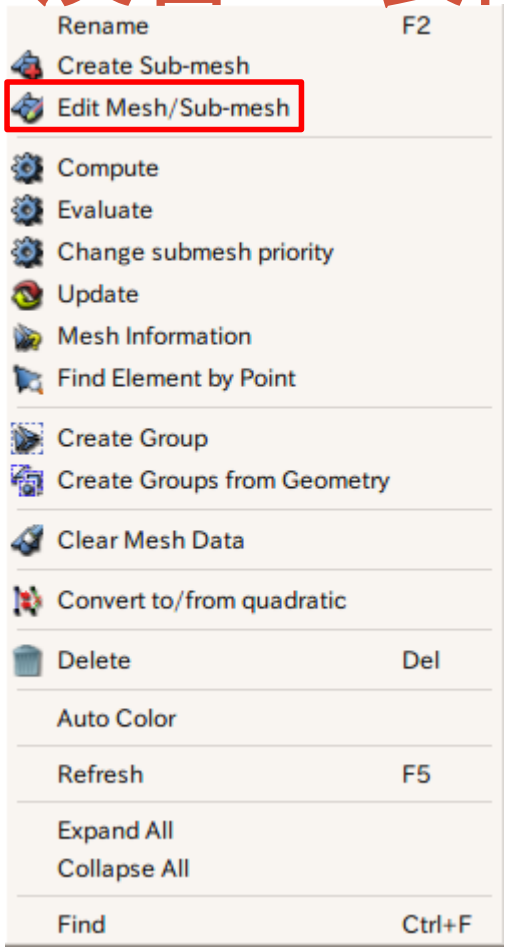


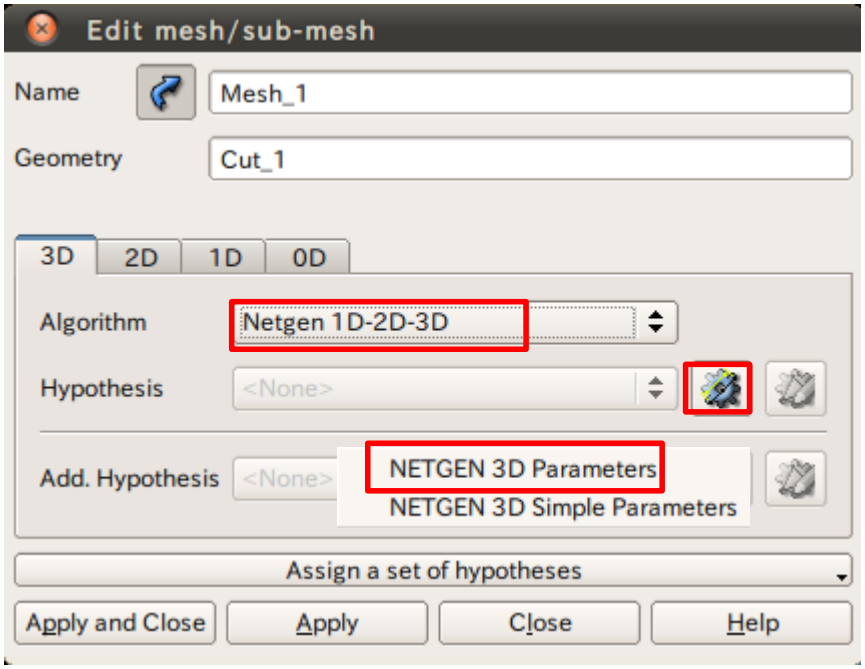
Cut_1.stl





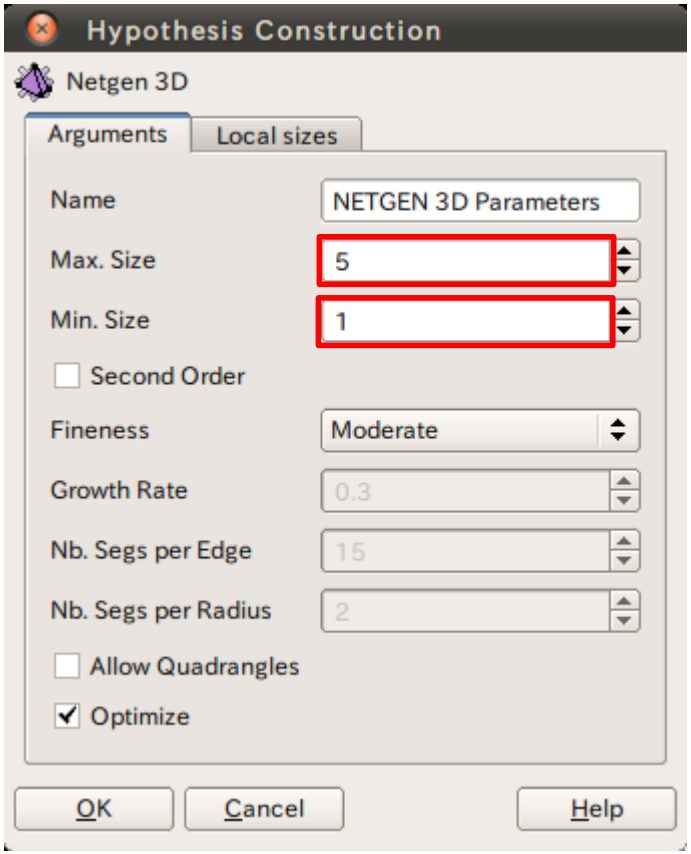
演習2　表面メッシュの作成

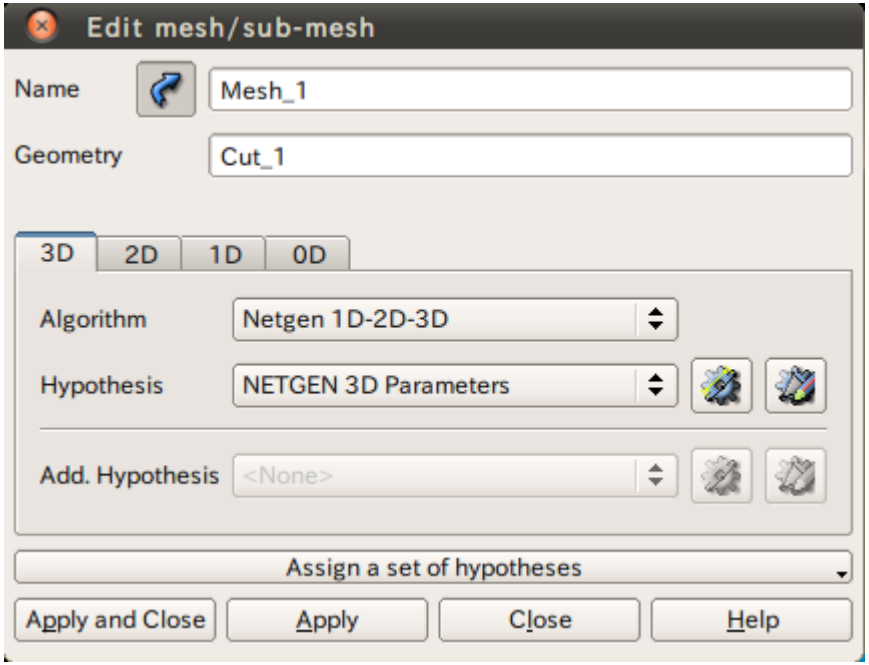




メッシュを選択した状態で右クリック

演習2　表面メッシュの作成





演習2　表面メッシュの作成

Mesh computation succeed

Compute mesh

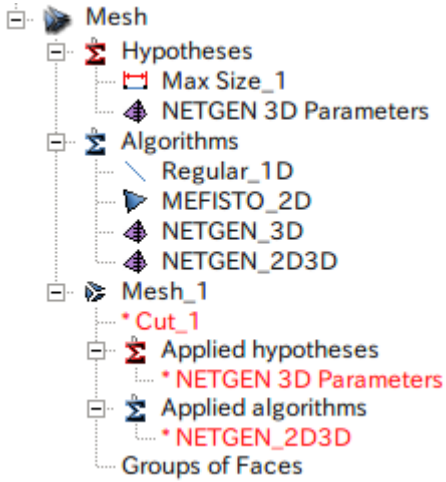
Name

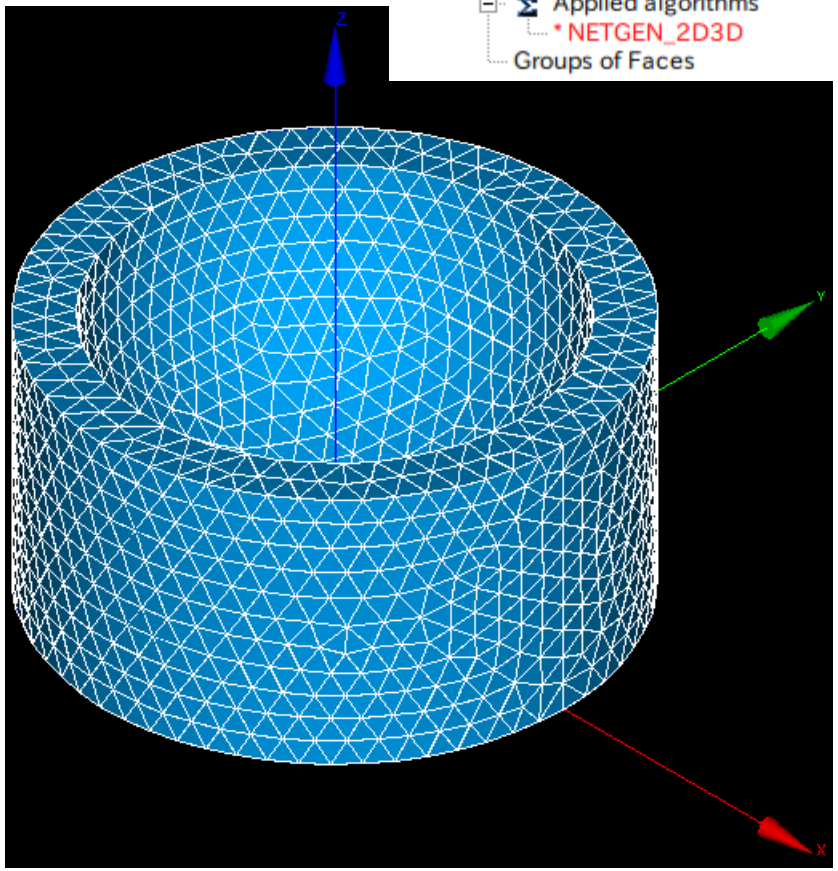
Mesh_1

Mesh Infos

	Total	*Linear*	*Quadratic*
Nodes :	2118		
0D Elements :	0		
Balls :	0		
Edges :	199	199	0
Faces :	3290	3290	0
Triangles :	3290	3290	0
Quadrangles :	0	0	0
Polygons :	0		
Volumes :	7441	7441	0
Tetrahedrons :	7441	7441	0
Hexahedrons :	0	0	0
Pyramids :	0	0	0
Prisms :	0	0	0
Hexagonal prisms :	0		
Polyhedrons :	0		

Close

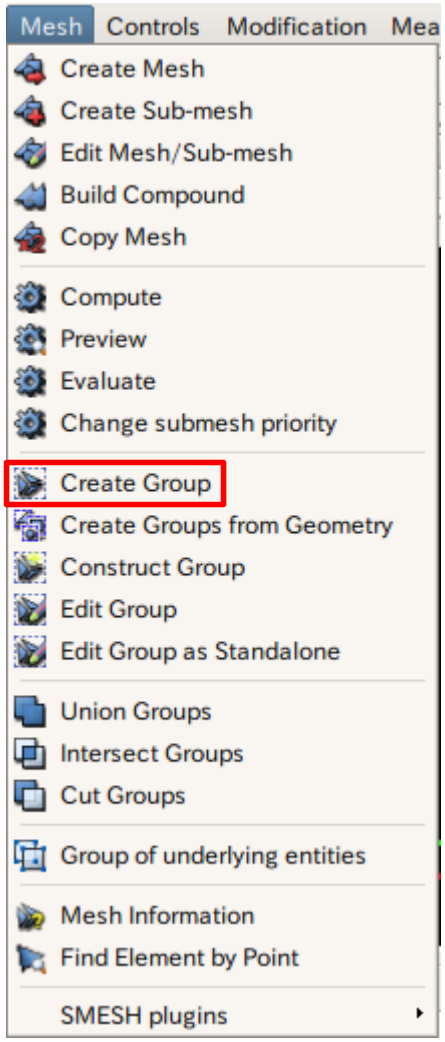




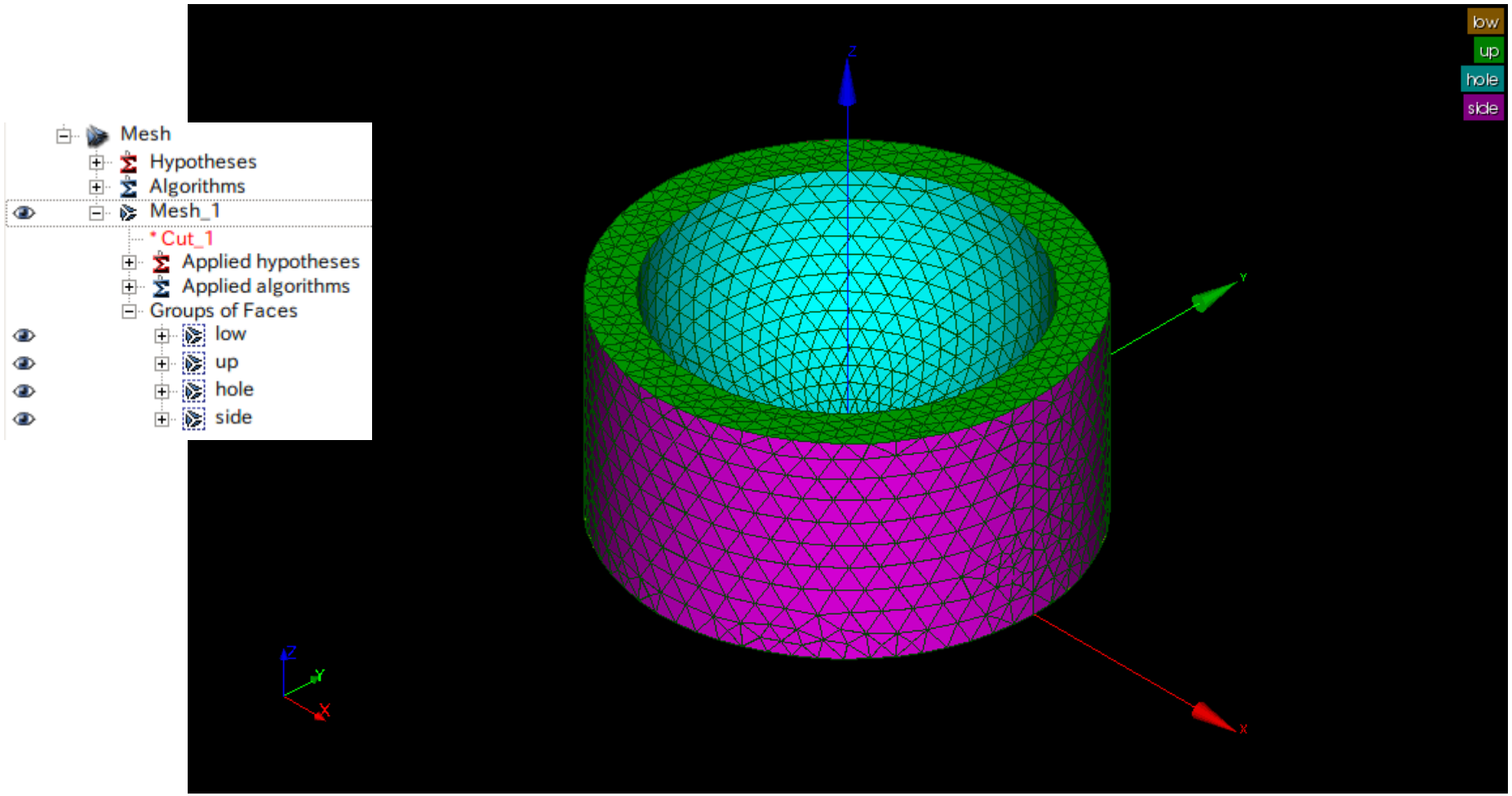
演習2　メッシュのグループ化

グループの作成

Mesh>Create Group

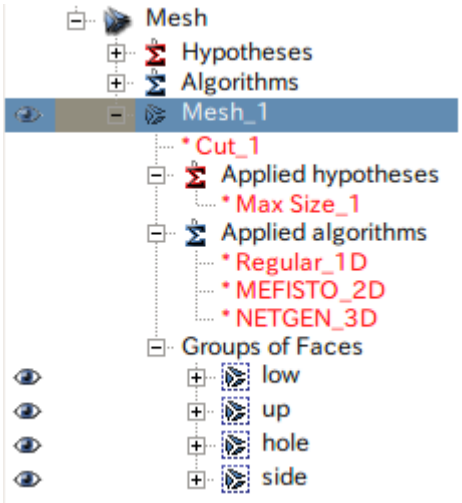


演習2　メッシュのグループ化



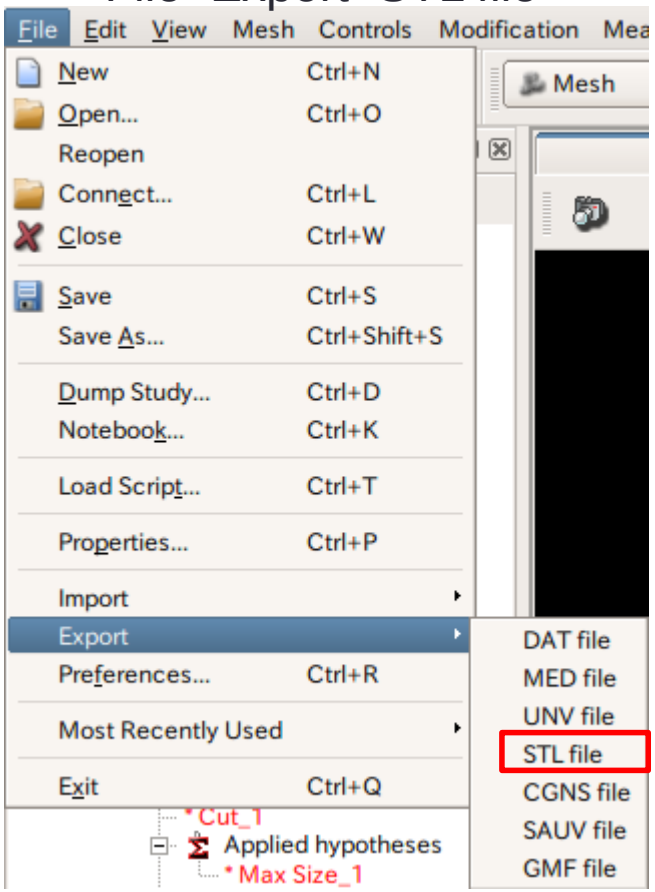
演習2　メッシュの出力

メッシュを選択した状態にする



メッシュの出力

File>Export>STL file

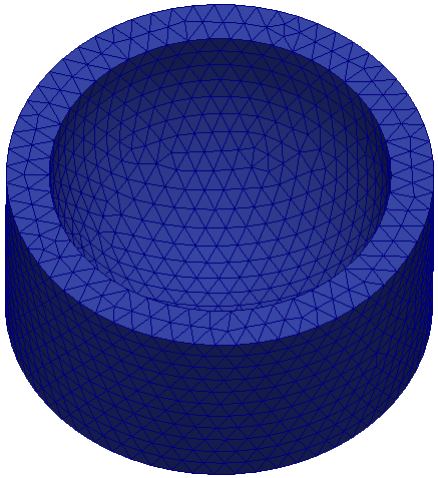


Mesh_1と各サーフェスグループを出力

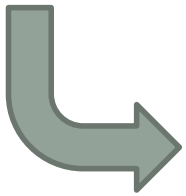
演習2　Mesh_1のcfMesh作成

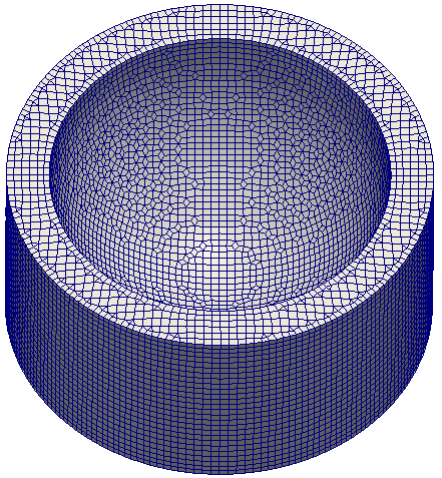
$surfaceFeatureEdges -angle 10 Mesh_1.stl Mesh_1.fms
$cartesianMesh

```
FoamFile
{
    version   2.0;
    format    ascii;
    class     dictionary;
    location  "system";
    object    meshDict;
}

// * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * //

maxCellSize        2;

surfaceFile        "Mesh_1.fms";
```



Mesh_1.stl



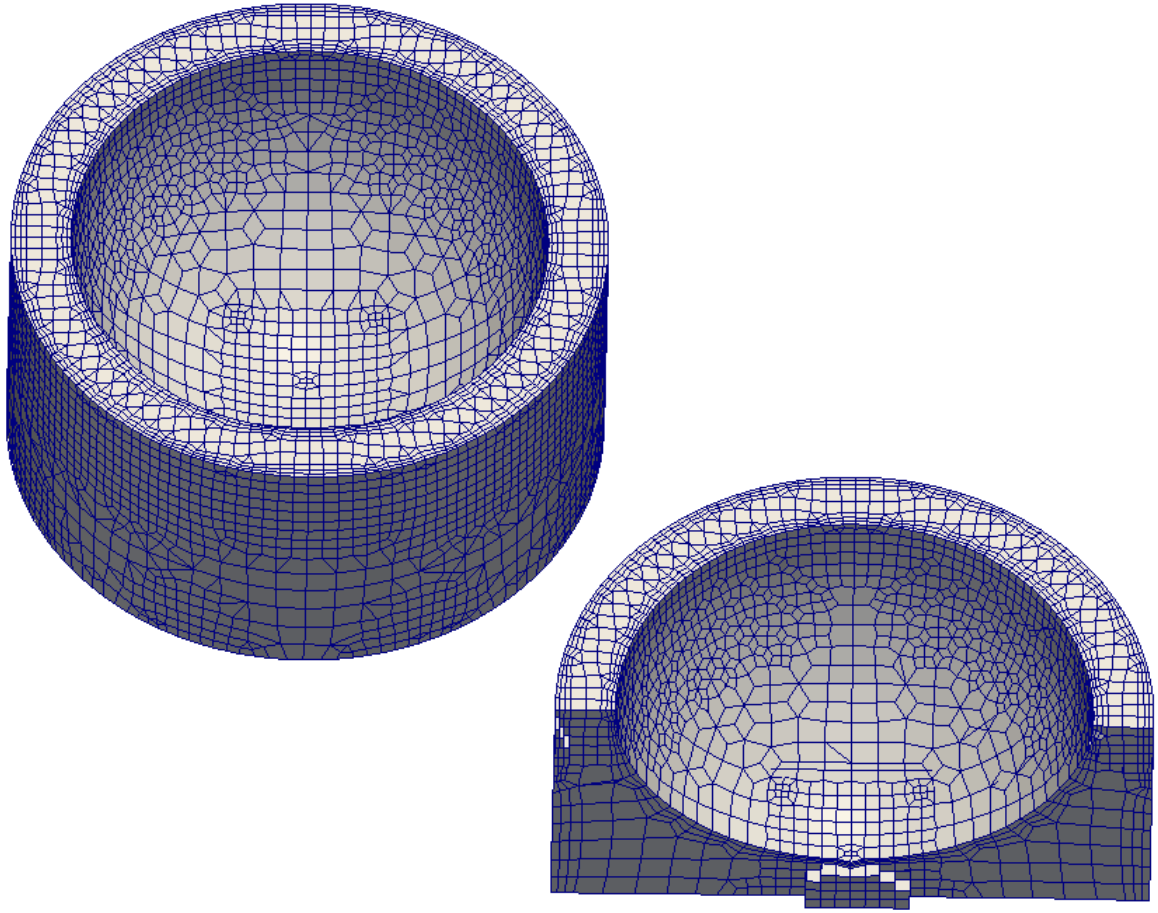


演習3　境界層の作成

```
maxCellSize        10;

minCellSize 2.5;

surfaceFile        "mesh.fms";

boundaryLayers
{

    patchBoundaryLayers
    {

        side
        {
            maxFirstLayerThickness        10;
            nLayers        3;
            thicknessRatio        1.2;
        }

        hole
        {
            maxFirstLayerThickness        10;
            nLayers        3;
            thicknessRatio        1.2;
        }
    }
}
```

表面メッシュを作成した各フェイスのstlファイルをマージ

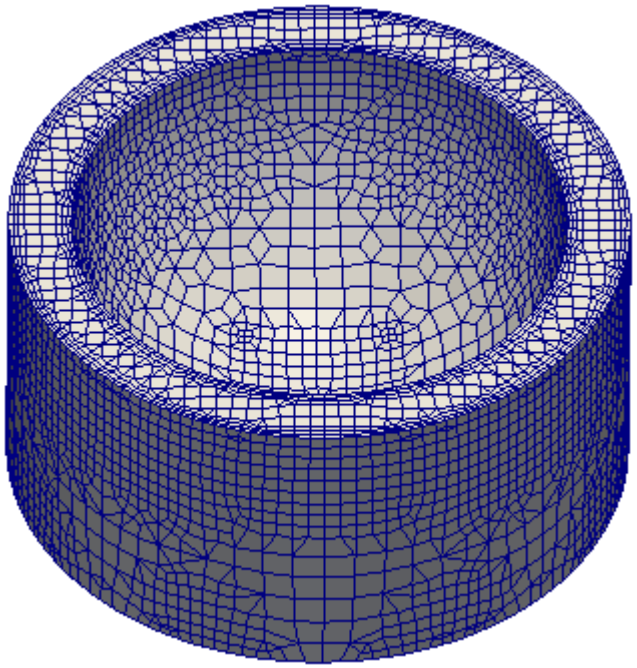
$surfaceFeatureEdges -angle 10 mesh_1.stl mesh_1.fms
$cartesianMesh



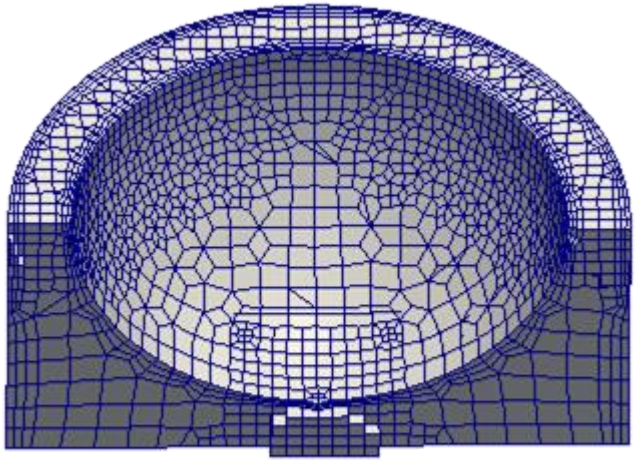
meshDict

```
maxCellSize        10;

minCellSize 2.5;

surfaceFile        "mesh.fms";

boundaryLayers
{

    patchBoundaryLayers
    {

        side
        {
            maxFirstLayerThickness        10;
            nLayers        3;
            thicknessRatio        1.2;
        }

        hole
        {
            maxFirstLayerThickness        10;
            nLayers        3;
            thicknessRatio        1.2;
        }
    }
}
```

最大セルサイズ
最小セルサイズ
fmsファイル名

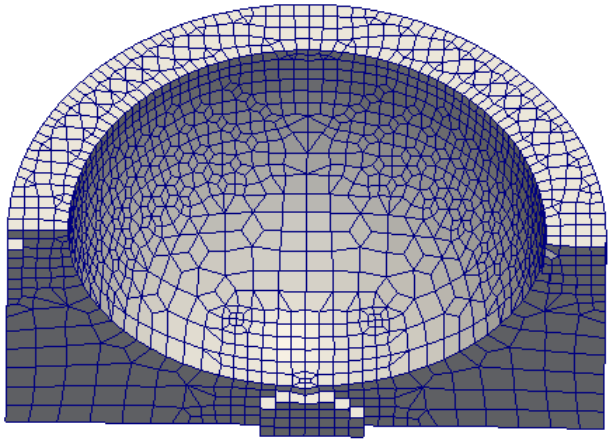


境界層第1層の最大サイズ
層数
成長率

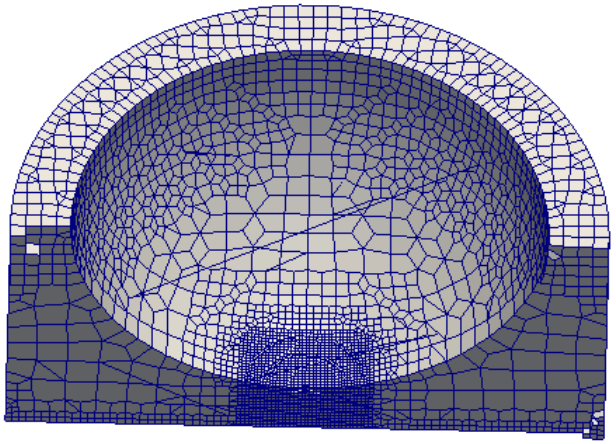


演習4　部分的なセルサイズ指定

```
maxCellSize 10;

minCellSize 2.5;

surfaceFile        "mesh.fms";

localRefinement
{

    low
    {
        cellSize 2;
//       additionalRefinementLevels 1;
    }
}

objectRefinements
{
    area1
    {
        cellSize 1.25;
        type box;
        centre  (0 0 0);
        lengthX  20;
        lengthY  20;
        lengthZ  20;
    }
}
```

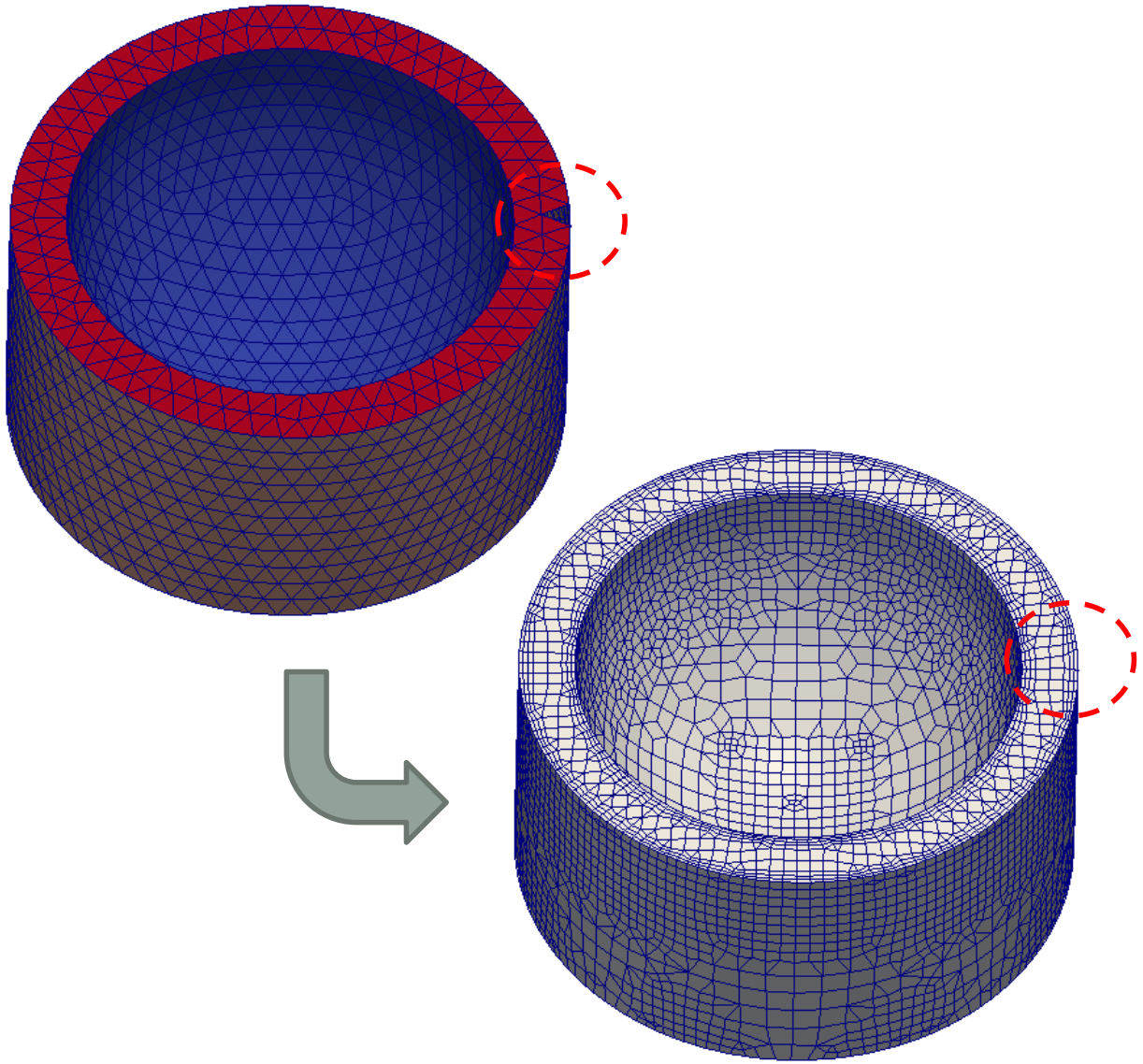


localRefinement, objectRefinements無し



演習5　欠けた形状のメッシュ作成

```
maxCellSize        10;

minCellSize 2.5;

surfaceFile        "mesh.fms";

boundaryLayers
{

    patchBoundaryLayers
    {

        side
        {
            maxFirstLayerThickness        10;
            nLayers        3;
            thicknessRatio        1.2;
        }

        hole
        {
            maxFirstLayerThickness        10;
            nLayers        3;
            thicknessRatio        1.2;
        }
    }
}
```



演習6　snappyHexMeshとの比較

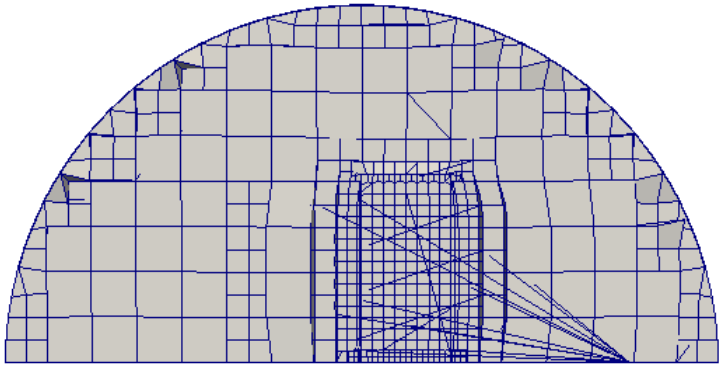
iglooWithFridgesをsnappyHexMeshとcfMeshで比較する

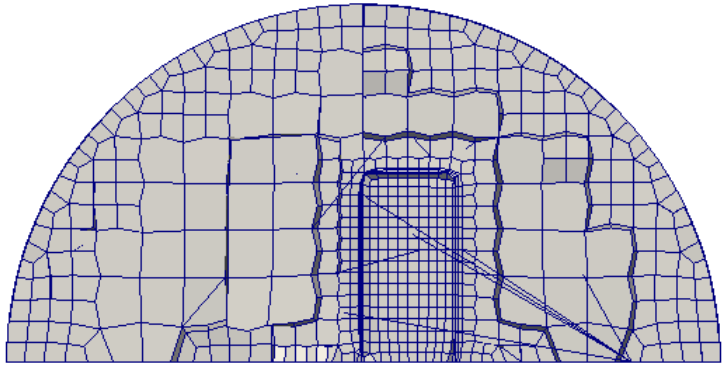
チュートリアル内のiglooWithFridgesを./Allrunで実行
表面メッシュを抽出
$foamToSurface -latestTime mesh.stl

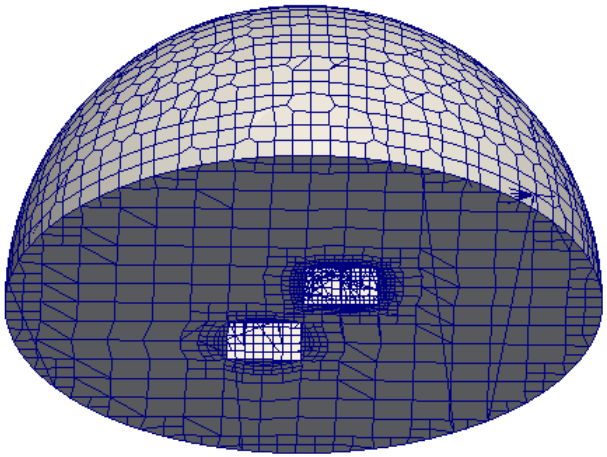
```
maxCellSize        0.5;
surfaceFile        "mesh.stl";
boundaryLayers
{
    patchBoundaryLayers
    {
        twoFridgeFreezers_seal_0
        {
            maxFirstLayerThickness        0.1;
            nLayers        3;
            thicknessRatio        1.2;
        }
        twoFridgeFreezers_herring_1
        {
            maxFirstLayerThickness        0.1;
            nLayers        3;
            thicknessRatio        1.2;
        }
    }
}
```

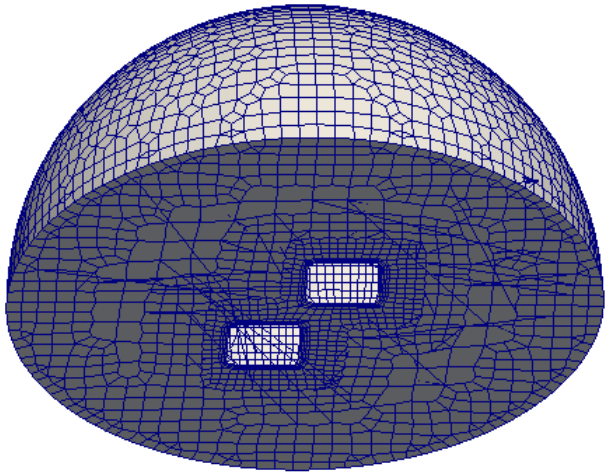
```
localRefinement
{
    igloo
    {
        cellSize        0.25;
//        additionalRefinementLevels        1;
    }
        twoFridgeFreezers_seal_0
    {
        cellSize        0.125;
//        additionalRefinementLevels        2;
    }
        twoFridgeFreezers_herring_1
    {
        cellSize        0.125;
//        additionalRefinementLevels        2;
    }
}
```

演習6　snappyHexMeshとの比較









snappyHexMesh

cfMesh

演習6　snappyHexMeshとの比較

Mesh stats
- points: 14257
- faces: 33693
- internal faces: 30195
- cells: 9998
- faces per cell: 6.39008
- boundary patches: 9
- point zones: 0
- face zones: 0
- cell zones: 0

Overall number of cells of each type:
- hexahedra: 6911
- prisms: 208
- wedges: 0
- pyramids: 0
- tet wedges: 12
- tetrahedra: 0
- polyhedra: 2867

Breakdown of polyhedra by number of faces:

faces	number of cells
4	397
5	168
6	702
7	362
8	40
9	962
11	15
12	99
14	1

snappyHexMesh

Mesh stats
- points: 17644
- faces: 45510
- internal faces: 40456
- cells: 13942
- faces per cell: 6.16597
- boundary patches: 4
- point zones: 0
- face zones: 0
- cell zones: 0

Overall number of cells of each type:
- hexahedra: 12503
- prisms: 128
- wedges: 0
- pyramids: 280
- tet wedges: 0
- tetrahedra: 112
- polyhedra: 919

Breakdown of polyhedra by number of faces:

faces	number of cells
6	176
7	71
8	20
9	458
12	114
15	61
18	19

cfMesh

演習6　snappyHexMeshとの比較

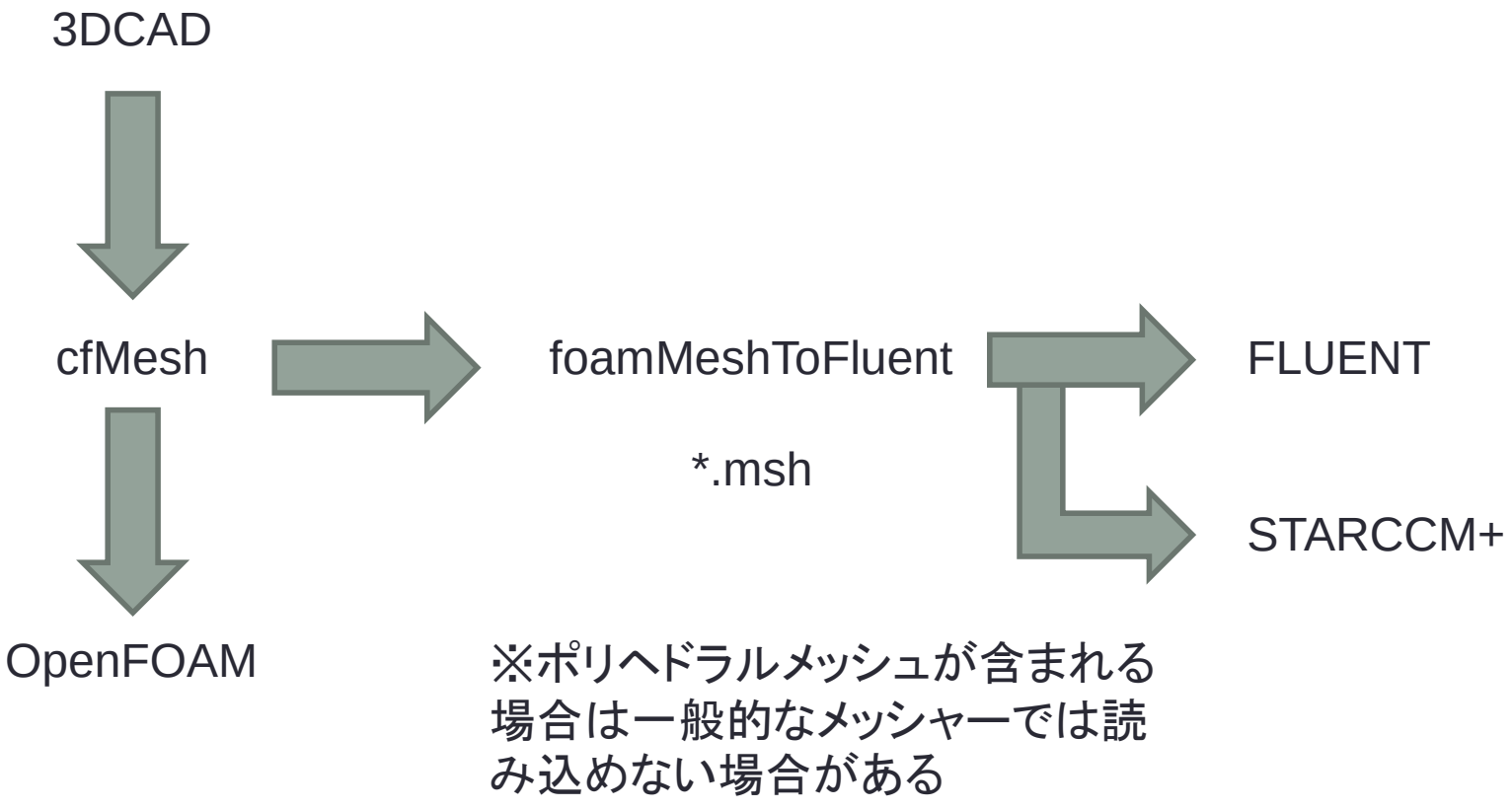
```
Checking patch topology for multiply connected surfaces...
                Patch    Faces   Points               Surface topology
                 maxY        0        0                  ok (empty)
                 minX        0        0                  ok (empty)
                 maxX        0        0                  ok (empty)
                 minY        0        0                  ok (empty)
               ground      830      993  ok (non-closed singly connected)
                 maxZ        0        0                  ok (empty)
               igloo     1276     1649  ok (non-closed singly connected)
   twoFridgeFreezers_seal_0      800      941  ok (non-closed singly
connected)
   twoFridgeFreezers_herring_1      592      625  ok (non-closed singly
connected)

Checking geometry...
    Overall domain bounding box (-1.00389 -1.00395 0) (7.00389 7.00395 4)
    Mesh (non-empty, non-wedge) directions (1 1 1)
    Mesh (non-empty) directions (1 1 1)
    Boundary openness (3.52436e-17 5.92793e-17 -5.43521e-16) OK.
    Max cell openness = 3.20833e-16 OK.
    Max aspect ratio = 11.3868 OK.
    Minimum face area = 0.000490601. Maximum face area = 0.280257.
Face area magnitudes OK.
    Min volume = 2.1449e-05. Max volume = 0.143679.  Total volume =
129.524.  Cell volumes OK.
    Mesh non-orthogonality Max: 51.809 average: 14.8515
    Non-orthogonality check OK.
    Face pyramids OK.
    Max skewness = 3.42668 OK.
    Coupled point location match (average 0) OK.

Mesh OK.
```

snappyHexMesh

```
Checking patch topology for multiply connected surfaces...
                Patch    Faces   Points               Surface topology
               ground     1326     1452  ok (non-closed singly connected)
               igloo     2228     2273  ok (non-closed singly connected)
   twoFridgeFreezers_seal_0      750      769  ok (non-closed singly connected)
   twoFridgeFreezers_herring_1      750      769  ok (non-closed singly
connected)

Checking geometry...
    Overall domain bounding box (-1.00386 -1.00391 0) (7.00386 7.00391
3.99987)
    Mesh (non-empty, non-wedge) directions (1 1 1)
    Mesh (non-empty) directions (1 1 1)
    Boundary openness (-5.93818e-17 -1.84773e-16 3.63569e-16) OK.
    Max cell openness = 2.50477e-16 OK.
    Max aspect ratio = 11.0631 OK.
    Minimum face area = 0.000290858. Maximum face area = 0.307806.  Face
area magnitudes OK.
    Min volume = 2.93306e-05. Max volume = 0.175793.  Total volume =
129.341.  Cell volumes OK.
    Mesh non-orthogonality Max: 44.2681 average: 8.02187
    Non-orthogonality check OK.
    Face pyramids OK.
    Max skewness = 2.1956 OK.
    Coupled point location match (average 0) OK.

Mesh OK.
```

cfMesh

商用ソルバーへの変換


3DCAD
cfMesh
OpenFOAM
foamMeshToFluent
*.msh
FLUENT
STARCCM+
※ポリヘドラルメッシュが含まれる場合は一般的なメッシャーでは読み込めない場合がある

Patch名を修正する

sedコマンドを利用

sed -i -e "s/empty/patch/g" mesh.fms

mesh.fms内の文字列“empty”を検索し”patch”に置き換える
-iをつけることでmesh.fmsを上書きする

emptyをpatchに変更するスクリプト例

emptyTopatch

```
#!/bin/sh

sed -i -e "s/empty/patch/g" $1
```

$1とすることで引数を受け取る

$./emptyTopatch mesh.fms

meshDictで設定できる項目

```
FoamFile
{
    version    2.0;
    format     ascii;
    class      dictionary;
    location   "system";
    object     meshDict;
}
```

固定記述

```
maxCellSize 20.0;

boundaryCellSize 1.0;

minCellSize 10.0;

surfaceFile        "mesh.fms";

boundaryLayers
{
}

localRefinement
{
}

objectRefinements
{
}
```

最大セルサイズ（絶対値でサイズを指定する）
境界層セルサイズ
最小セルサイズ

形状ファイル　stlまたはfms

境界層の設定

Patch名によるサイズ設定

オブジェクトによるサイズ設定

※最大セルサイズが基準となり、それ以降は指定した値より小さいサイズになる

boundaryLayersで設定できる項目

境界層の設定

```
boundaryLayers
{

maxFirstLayerThickness        0.5;
nLayers        3;
thicknessRatio        1.2;

    patchBoundaryLayers
    {

        patch1
        {
            maxFirstLayerThickness        0.1;
            nLayers        3;
            thicknessRatio        1.2;
        }

        patch2
        {
            maxFirstLayerThickness        0.1;
            nLayers        3;
            thicknessRatio        1.2;
        }
    }
}
```

すべての表面から境界層を作成する場合
第1層の最大厚さ
層数
成長率

各patchに境界層を作成する場合
第1層の最大厚さ
層数
成長率

localRefinement で設定できる項目

```
localRefinement
{

    patch1
    {
        cellSize        0.25;
       additionalRefinementLevels        1;
    }
 patch2
    {
        cellSize        0.125;
        additionalRefinementLevels        2;
    }
}
```

各patchによるセルサイズの指定
セルサイズ
or
リファイメントレベル

objectRefinementsで設定できる項目

```
objectRefinements
{
    ear1
    {
        cellSize 3.75;
        type cone;
        p0   (-100 1873 -320);
        radius0  200;
        p1   (-560 1400 0);
        radius1   200;
    }
    tail
    {
        cellSize 3.75;
        type box;
        centre  (500 500 150);
        lengthX  100;
        lengthY  150;
        lengthZ  200;
    }
    insideTheBody
    {
        cellSize 3.75;
        type sphere;
        centre  (0 700 0);
        radius  50;
    }
```

オブジェクトによるサイズ指定

セルサイズ
円錐形状
中心点
半径の長さ

セルサイズ
矩形形状
中心点
各辺の長さ

セルサイズ
球形状
中心点
半径の長さ

```
    muzzlePiercing
    {
        cellSize 3.75;
        type line;
        p0      (-750 1000 450);
        p1      (-750 1500 450);
    }
}
```

セルサイズ
ライン
始点
終点