Université Grenoble Alpes

IDEFIX User Days Tutorial: Usage I

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MHDiscs

IPAG

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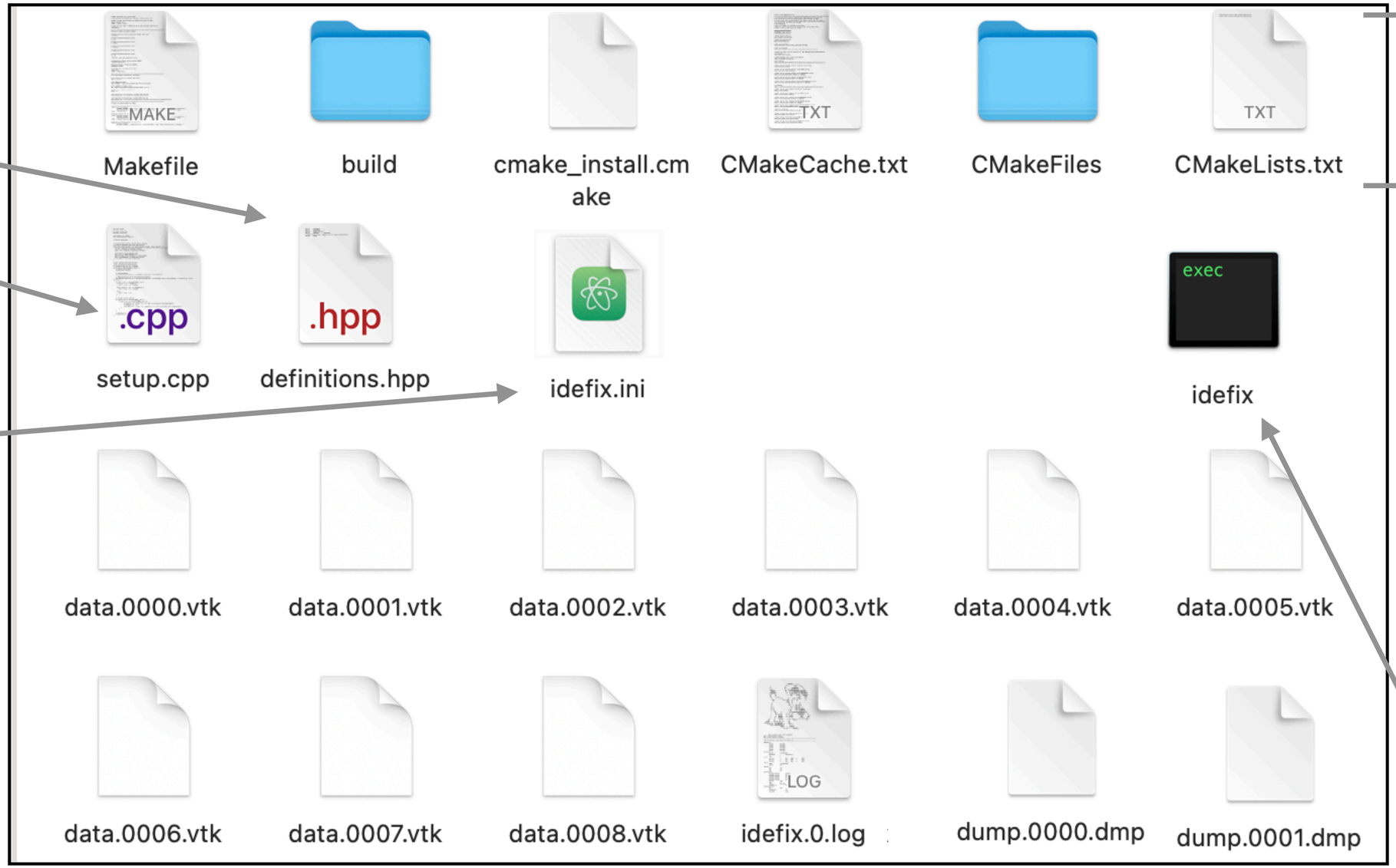
Setup directory



Header file

Setup file (Marc)

Input file

Output files

Config files

Using Cmake

Compile

Executable

Header file

Summary

MANDATORY
OPTIONAL

Contains major global parameter which strongly affect the code structure

Header file from isothermal SOD test

definitions.hpp

```
1  #define   COMPONENTS    2
2  #define   DIMENSIONS    1
3  #define   ISOTHERMAL
4
5  #define   GEOMETRY      CARTESIAN
6
```

Number of vector components
≥
Setup dimensions

Setup is isothermal

Setup geometry

POLAR (3D) ≠ CYLINDRICAL (2D, right-handed)

Any modification requires compilation

Input file

Summary

Input file from isothermal SOD test

idefix.ini

```
[Grid]
X1-grid    1  0.0  500  u  1.0
X2-grid    1  0.0  1    u  1.0
X3-grid    1  0.0  1    u  1.0

[TimeIntegrator]
CFL         0.8
tstop       0.2
first_dt    1.e-4
nstages     2

[Hydro]
solver     roe
csiso      constant  1.0

[Boundary]
X1-beg     outflow
X1-end     outflow
X2-beg     outflow
X2-end     outflow
X3-beg     outflow
X3-end     outflow

[Output]
vtk    0.1
dmp    0.2
```

Defines the setup physical and numerical properties

- Global grid configuration
- Integration method and parameters
- Hydro parameters, additionnal physics
- Boundary conditions for each direction
- Output properties

Bedrock of input file. Additional sections for additional physics/ numerics

No need to recompile when modified

Input file

[Grid] section

MANDATORY
OPTIONAL

Each entry can be a succession of contiguous patches

Number of patches

idefix.ini

```
1  [Grid]
2  X1-grid    #patches   xbeg   #cells   spacing   xend   (#cells   spacing   xend   ...)
3  X2-grid    ...
4  X3-grid    ...
```

One entry per direction

Patch beginning in the coordinate system (once)

Number of cells in the patch

Spacing type (u,l,s±)

Patch end in the coordinate system

Stretch requires uniform patch from left (s-) or right (s+)

Input file

[Grid] section - examples

Isothermal SOD test

idefix.ini

```
1  [Grid]
2  X1-grid    1  0.0  500  u  1.0
3  X2-grid    1  0.0  1    u  1.0
4  X3-grid    1  0.0  1    u  1.0
```

Unused
as the setup is 1D

Core collapse model

idefix.ini

```
1  [Grid]
2
3  X1-grid    2    1.0    512   l    10000.
4  X2-grid    3    0.0    32  s+   1.2707963267948965   64    u   1.8707963267948966  32 s-  3.14159265358979
5  X3-grid    1    0.0    64   u    6.283185307179586
```

Input file

[TimeIntegrator] section

MANDATORY
OPTIONAL

Isothermal SOD test

```
6   [TimeIntegrator]
7   CFL         0.8
8   tstop       0.2
9   first_dt    1.e-4
10  nstages     2
```

Should be <1 to ensure stability

Final integration time in code units

IDEFIX compute dt from previous cycle

Number of sub-cycles

Also: fixed_dt, CFL_max_var, max_runtime…

Input file

[Hydro] section

MANDATORY
OPTIONAL

Isothermal SOD test

```
12  [Hydro]
13  solver     roe
14  csiso      constant  1.0
```

Solver type (HD or MHD)

Prescribed value: constant+value or userdef

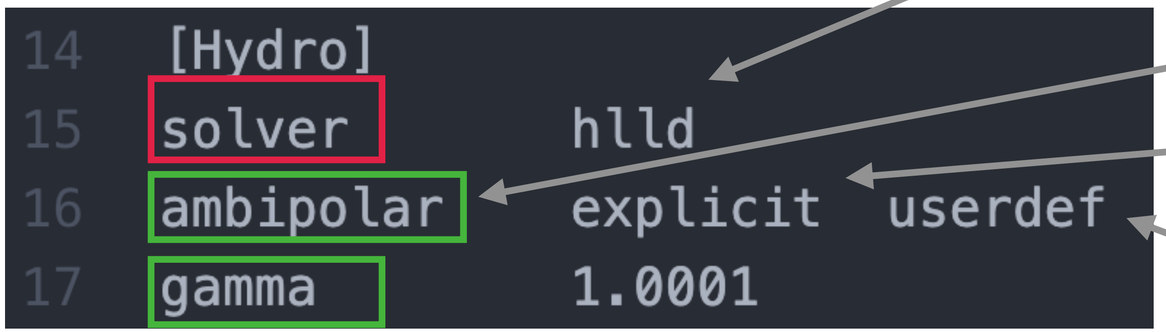
When isothermal

Input file

[Hydro] section

MANDATORY
OPTIONAL

AmbipolarWind test



MHD only

Diffusion term (resistivity, hall, viscosity...)

Integration scheme

Prescribed value: constant+value or userdef

Prescribed value. Default is 5/3

When adiabatic.

userdef ⇒ function in setup file (Marc)

Input file

[Boundary] section

MANDATORY
OPTIONAL

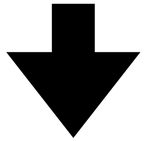
Core collapse model

```
50  [Boundary]
51
52  X1-beg                  userdef
53  X1-end                  userdef
54  X2-beg                  axis
55  X2-end                  axis
56  X3-beg                  periodic
57  X3-end                  periodic
```

Two entries per dimension : left and right

Same as for [Hydro]

To include the axis



X2 from 0 to π

X3 from 0 to $2\pi/n$, n integer

If n=1, MPI decomposition is one or even

Last cells are copied in ghost cells

Also: outflow, reflective, shearing box

Input file

[Output] section

MANDATORY
OPTIONAL

Core collapse model

```
[Output]

analysis                50.
vtk                     50.
dmp                     100.
uservar                 phiP Cs etaA
```

Analysis frequency (user-defined)

Output frequency, -1 to disable

List of additional user-defined variables (stored in the vtk files)

Also: log entry with associated writing frequency in number of integration cycles (default is 100)

Cmake tool

Summary

- Configuration can be done via three ways :
  - With Cmake through command line using : cmake $IDEFIX_DIR -D options (it's okay).
  - With Cmake through a graphic interface : ccmake $IDEFIX_DIR, where the options are to be set manually (the best !!!)
  - Using idefix_cli, a command line framework to configure, compile and run idefix : https://idefix-cli.readthedocs.io/en/latest/
- Main options are :
  - To enable MHD : -D IDEFIX_MHD=ON
  - To enable MPI decomposition : -D IDEFIX_MPI=ON
  - To trigger basic debug routine : -D IDEFIX_DEBUG=ON
  - To enable CUDA for GPU computation : -D Kokkos_ENABLE_CUDA=ON
  - With associated architecture : -D Kokkos_ARCH_{…}=ON
  - To list available options: -LH
- A *CMakeList.txt* can be added to the setup directory:
  - Used to replace source files by user-defined files, enable parameters…
  - Changes are taken into account by Cmake when configuring.

Cmake tool

CMakeLists.txt - Example

Core collapse model

CMakeLists.txt

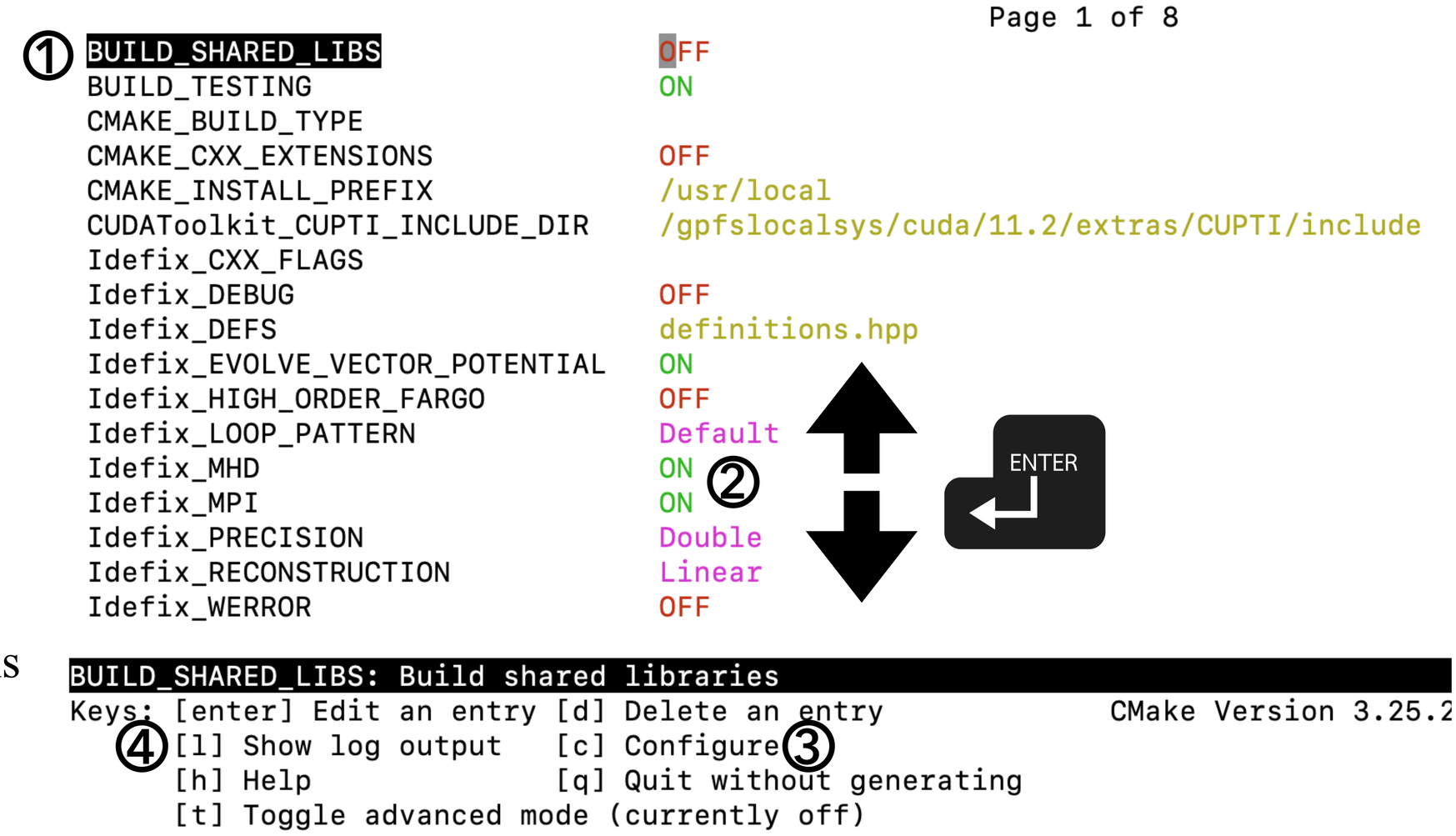
```
1  # add specific source file to idefix build tree
2  replace_idefix_source(evolveStage.cpp evolveStage.cpp)
3  replace_idefix_source(dump.cpp dump.cpp)
4  replace_idefix_source(dumpImage.cpp dumpImage.cpp)
5  replace_idefix_source(dumpImage.hpp dumpImage.hpp)
6  replace_idefix_source(output.hpp output.hpp)
7  replace_idefix_source(output.cpp output.cpp)
8  replace_idefix_source(main.cpp main.cpp)
9  add_idefix_source("analysis.cpp")
10 add_idefix_source("analysis.hpp")
11
```

Cmake tool

Code generation with graphic interface

1. Open graphic interface
2. Enable desired options (MHD ? MPI ? GPU ?)
3. Configure
4. Check log (cheap)
5. Generate

- Compile and run the code :
  - make -j #cpu
  - <path>/setup/idefix -options (see Marc's tutorial)



Cmake tool

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④

```
/linkhome/rech/genipa01/uzs72zf/src/idefix/src/dataBlock/evolveStage.cpp by
evolveStage.cpp
    Replacing: /linkhome/rech/genipa01/uzs72zf/src/idefix/src/output/dump.cpp by
dump.cpp
    Replacing: /linkhome/rech/genipa01/uzs72zf/src/idefix/src/utils/dumpImage.cpp by
dumpImage.cpp
    Replacing: /linkhome/rech/genipa01/uzs72zf/src/idefix/src/utils/dumpImage.hpp by
dumpImage.hpp
    Replacing: /linkhome/rech/genipa01/uzs72zf/src/idefix/src/output/output.hpp by
output.hpp
    Replacing: /linkhome/rech/genipa01/uzs72zf/src/idefix/src/output/output.cpp by
output.cpp
    Replacing: /linkhome/rech/genipa01/uzs72zf/src/idefix/src/main.cpp by main.cpp
    Adding problem-specific source file analysis.cpp
    Adding problem-specific source file analysis.hpp
Idefix final configuration
    MHD: ON (Vector potential)
    MPI: ON
    Reconstruction: Linear
    Precision: Double
    Version: v1.1.0-145-gcc4eb355
    Problem definitions: 'definitions.hpp'
Configuring done

CMake produced the following output
                                                        CMake Version 3.25.2

Press [e] to exit screen
```

Cmake tool

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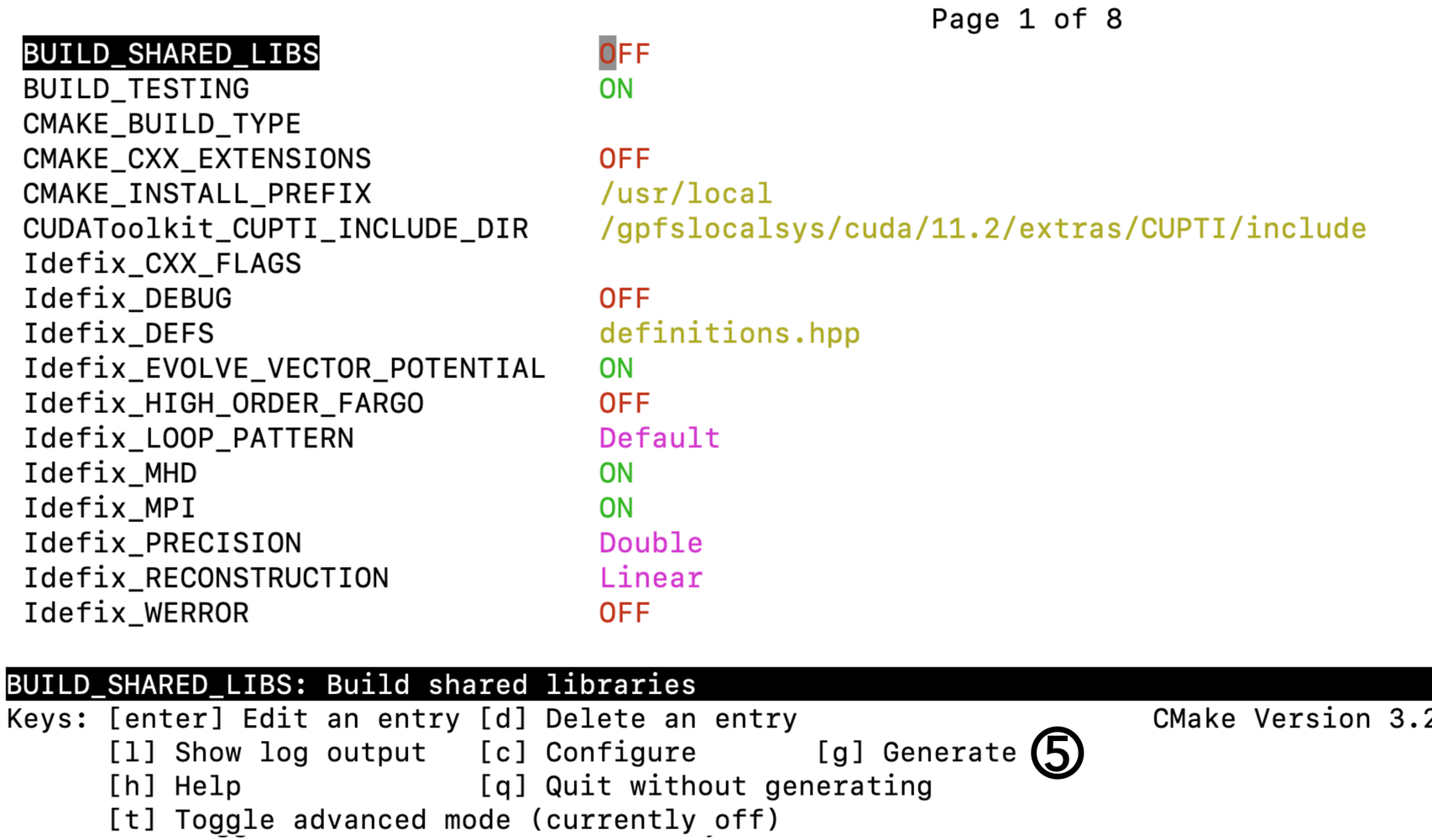

Practice

Kelvin-Helmholtz Instability (KHI)

- Isothermal 2D setup in cartesian geometry
- Uniform grid, X ranging from 0 to 4 with 256 cells, Y from 0 to 1 with 64 cells
- Setup is HD : available solvers in the code documentation
- Constant isothermal sound speed of 10 in code units
- Setup is periodic in X, outflow in Y

Complete the setup KHI in:
…/idefix-days/tutorials/usage/KHI

Roadmap

1. Open graphic interface
2. Enable desired options
3. Configure
4. Check log
5. Generate

- Compile and run the code :
  - make -j #cpu
  - <path>/setup/idefix -options