Automatized Compilation of Large Packages Example of mpdroot

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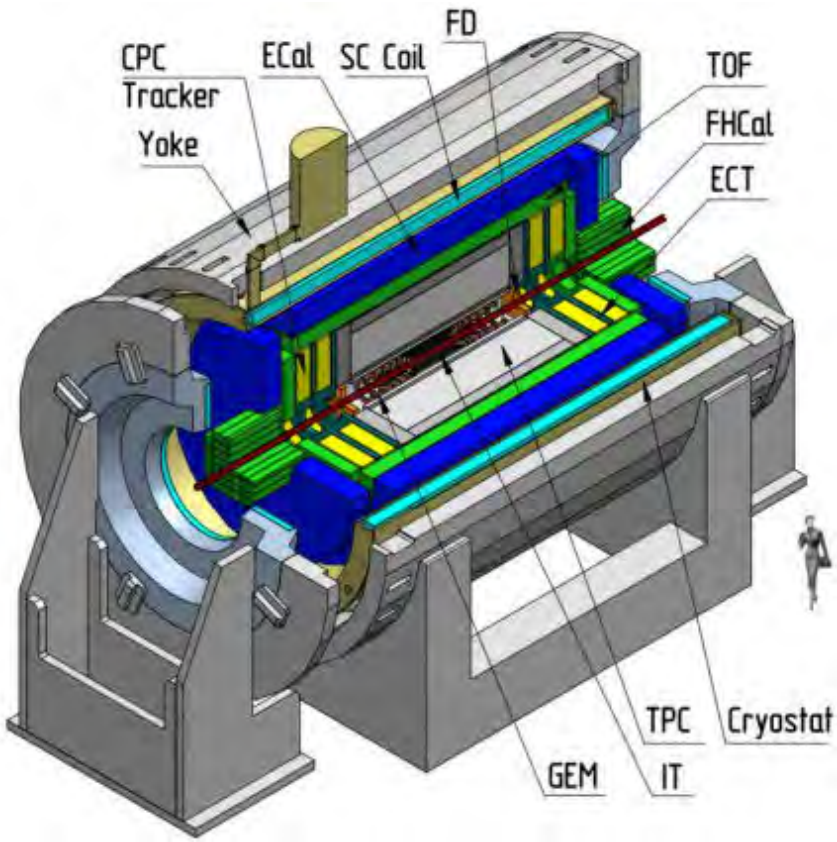
Multi-Purpose Detector

- part of **N**uclotron-based **I**on **C**ollider f**A**cility
- **M**ulti **P**urpose **D**etector – main detector under costruction
- mpdroot – library for reconstruction of tracks and physical analysis (`http://mpdroot.jinr.ru/`)



Just Install FairRoot and Build mpdroot...

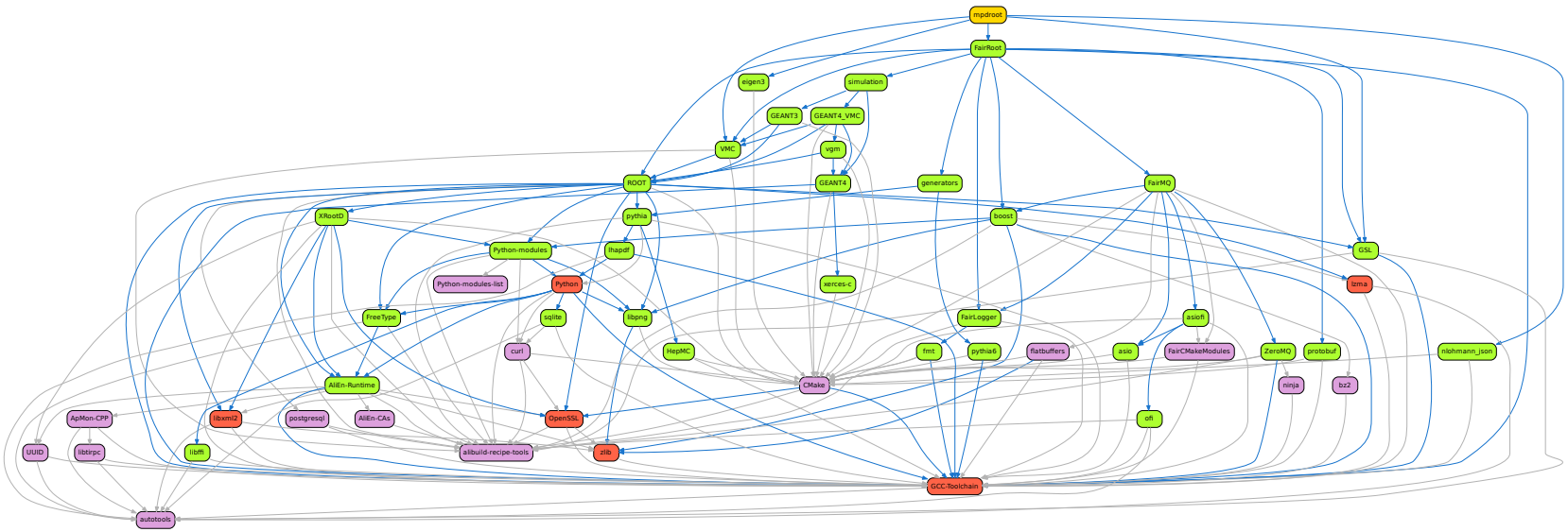
How to install MPDroot (each user had to build own version):

- install all basic packages (about 70);
- download, patch, and build FairRoot;
- download and build mpdroot from sources. In-source build highly recomended.

It's really "easy":

- basic packages are often not available in compatible versions
- patching FairRoot can be tedious (during last major version change more than 100 lines of code)
- building FairRoot takes about 2−4 hours on a regular computer
- in-source build guides users to use improper paths when linking own code
- users tend to use same version of mpdroot for long time

The mpdroot Dependencies



Centralized Build of MPDroot

Requirements:

- we want to deliver latest version of MPDroot to the users
- all dependencies have to be statisfied and no version clashes are allowed
- results need to be repeatable

Solution:

- CVMFS – robust distribution of software not only between clusters/supercomuters
- aliBuild – set of tools for building software together with its dependencies
- toolbox – rootless wrapper for podman (docker). Supported on most linux-based systems. On MacOS and Windows one can use docker
- EnvironmentModules – environment enabling loading multiple versions of the same software with its dependencies

CernVM-FS
https://cernvm.cern.ch/fs/

- CMVMFS is a **read-only** file system
- anyone can mount the shared directories to its computer
- extensively uses caching of the files on local computer
- only used (accessed) files are downloaded. That makes first load slow but following are as fast as local usage
- since it is centralized, changes on server are directly available to all users

Toolbox
https://github.com/containers/toolbox

- wrapper for podman (rootless docker alternative) – ordinary user can use it
- allows user to "work" inside virtual machine – no connection to the users system
- we support CentOS7, but to test our software we build also CentOS Stream 8 and 9 versions
- basic system image is fixed without any updates and therefore all results are reproducible

Environment Modules
https://modules.readthedocs.io/

- started as a project to separate various versions of same software
- simple "module files" contain paths to the software together with list of dependencies
- to use some software one has to load it first via command `module add mpdroot/latest`. Paths to executables as well as libraries is than added in the commandline. All necessary dependencies are loaded as well.

Example of module file (excerpt):

```
module load BASE/1.0 GEANT4/$GEANT4_VERSION-$GEANT4_REVISION
module load ROOT/$ROOT_VERSION-$ROOT_REVISION
setenv MPDROOT \$PKG_ROOT
prepend-path ROOT_INCLUDE_PATH \$PKG_ROOT/include
prepend-path LD_LIBRARY_PATH \$PKG_ROOT/include
```

aliBuild
https://alisw.github.io/alibuild/

- created as a solution to the ALICE experiment software distribution problem
- automatic build of software and all its dependencies
- reusing already built packages
- if some package was changed, all dependants are rebuild
- apropriate modules are created and numbered automatically
- can get messy if packages change frequently and are not cleared
- based on recipes – guides how to build some package

mpdroot Recipe

```
package: mpdroot
version: "%(commit_hash)s"
tag: "dev"
source: https://git.jinr.ru/nica/mpdroot.git
requires:
  - FairRoot
  - eigen3
  - nlohmann_json
  - VMC
  - GSL
---
unset SIMPATH
export MPDROOT=$INSTALLROOT

cmake $SOURCEDIR                                                              \
      ${BOOST_ROOT:+-DBOOST_ROOT=$BOOST_ROOT}                                 \
      ${EIGEN3_ROOT:+-DEIGEN3_ROOT=$EIGEN3_ROOT}                              \
      ...
      ${LIBXML2_ROOT:+-DPC_LIBXML_LIBDIR=$LIBXML2_ROOT/lib}                   \
      ${NLOHMANN_JSON_ROOT:+-DNLOHMANN_JSON_ROOT=$NLOHMANN_JSON_ROOT}         \
      -DCMAKE_INSTALL_PREFIX=$MPDROOT
cmake --build .  -j$JOBS install

# Modulefile
MODULEDIR="$INSTALLROOT/etc/modulefiles"
MODULEFILE="$MODULEDIR/$PKGNAME"
mkdir -p "$MODULEDIR"
alibuild-generate-module --bin --lib > $MODULEFILE
cat >> "$MODULEFILE" <<EoF
setenv MPDROOT \$PKG_ROOT
setenv MPDROOT_MACROS \$PKG_ROOT/macros
prepend-path ROOT_INCLUDE_PATH $::env(BASEDIR)/GSL/$GSL_VERSION-$GSL_REVISION/include
EoF
```

Changing Defaults

```
default:
  - &MPDROOT_TAG v22.09.22
  - &GCC_TOOLCHAIN_TAG v10.2.0-alice2
package: defaults-release
version: v1
disable:
  - arrow
env:
  CMAKE_BUILD_TYPE: RELWITHDEBINFO
  CXXFLAGS: -fPIC -O2 --std=c++17
  ENABLE_VMC: 'ON'
overrides:
  mpdroot:
    tag: *MPDROOT_TAG
    version: *MPDROOT_TAG
  ROOT:
    tag: "v6-26-08"
    requires:
      - GSL
      - libxml2
  GCC-Toolchain:
    tag: *GCC_TOOLCHAIN_TAG
    version: *GCC_TOOLCHAIN_TAG
---
```

Wrapping Up

Our view:

- software is stored in git
- on each push to master or creation of tag, command `aliBuild --build --no-deps --defaults releaseName` is called and built package is placed into CVMFS. Software is available no later than 1h after being sucessfully built.

Developer's view:

- `toolbox enter c7-nica`
- `source /cvmfs/nica.jinr.ru/sw/login/login.sh`
- `module add mpddev/latest`
- `export MPDROOT=/path/to/install`
- `git clone path_to_mpdroot && mkdir build && cd build && cmake .. && make install`

Wrapping-Up (Continued)

User's view:

- `toolbox enter c7-nica`
- `source /cvmfs/nica.jinr.ru/sw/login/login.sh`
- `module add mpdroot/latest`

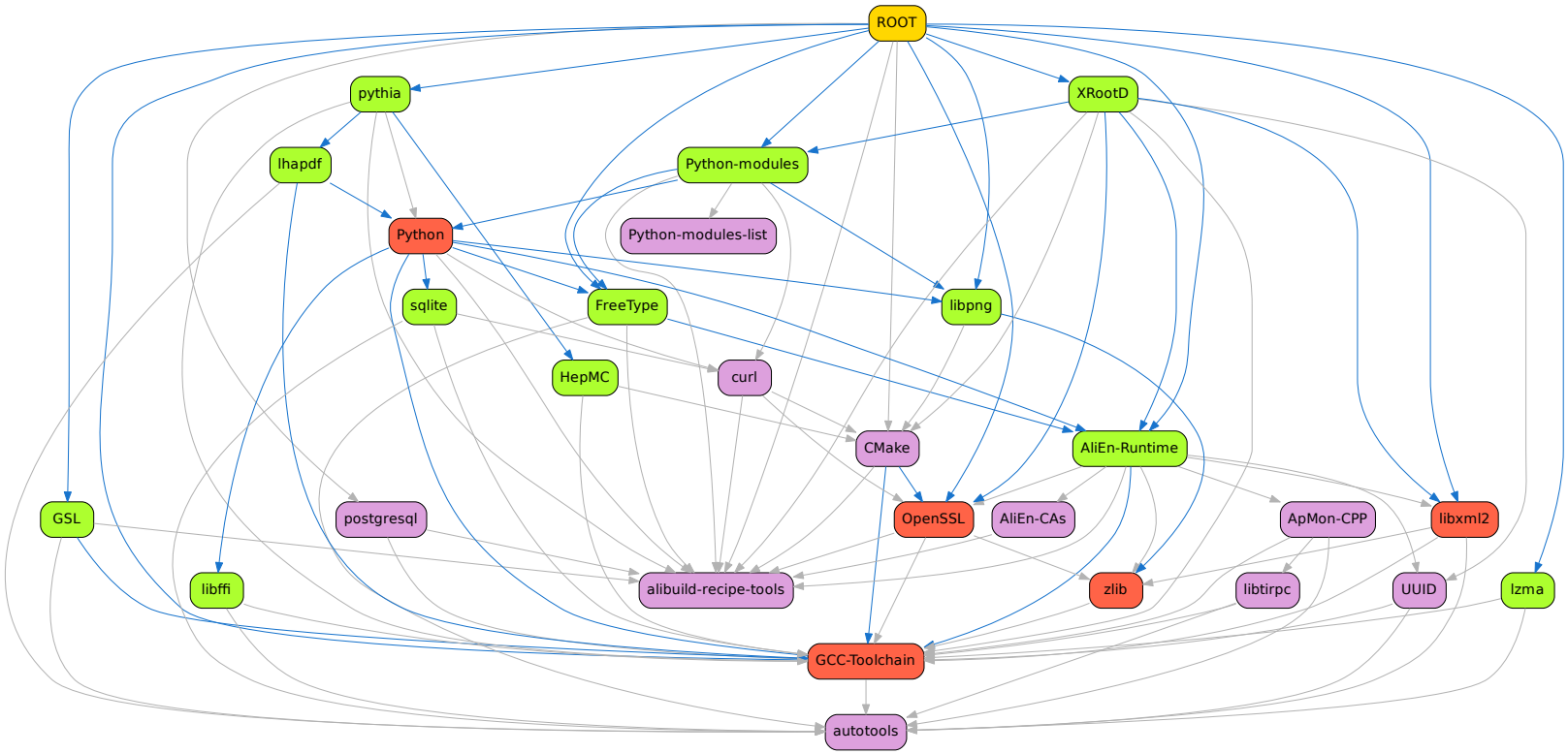
or concrete version

- `module add mpdroot/v22.09.22-1`

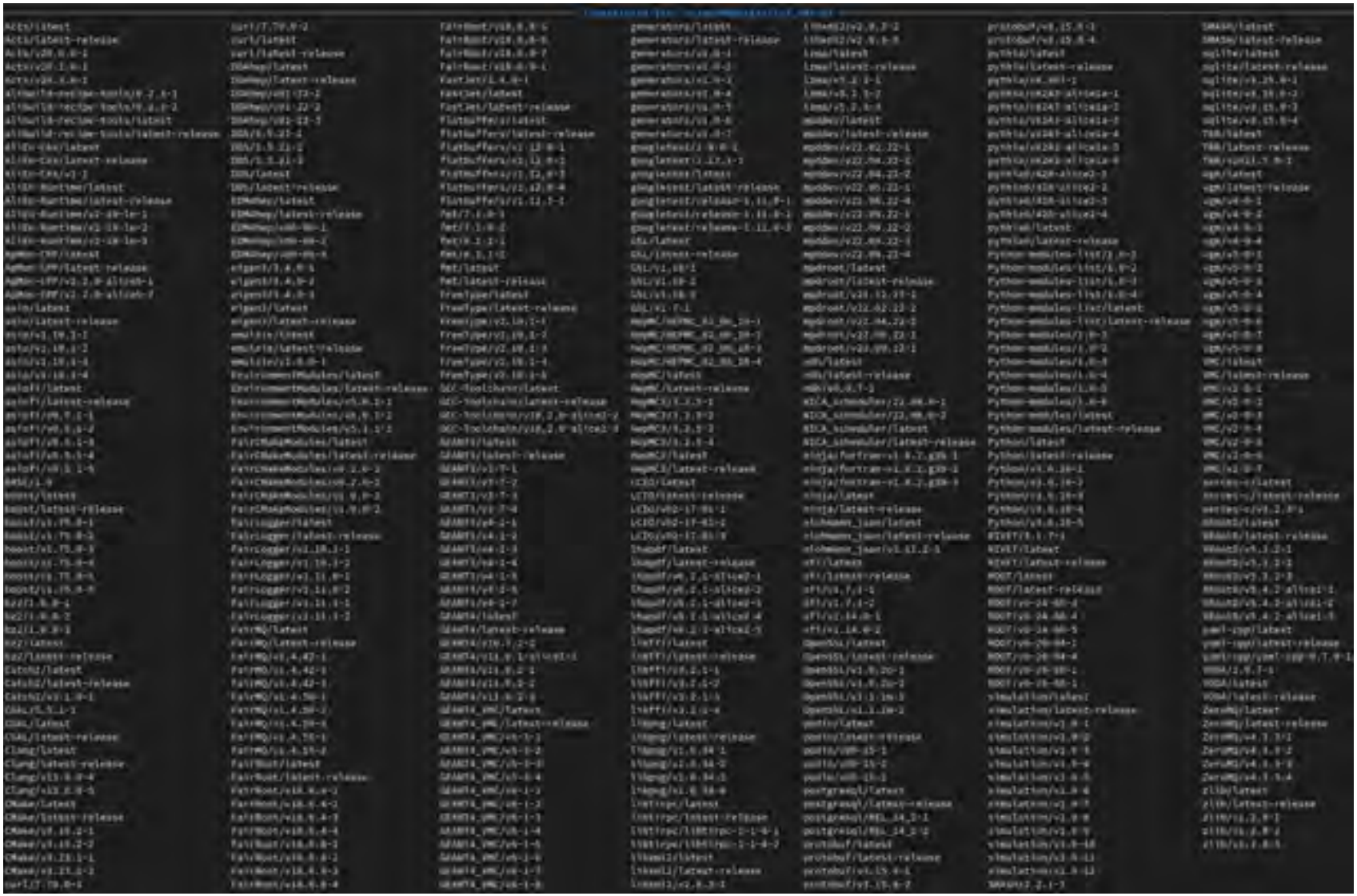
Conclusions

- for ordinary users build of mpdroot takes no time
- latest version of software is instantly available to everyone
- it is easy to return to previous versions (including dependencies)
- all results are repeatable since we store basic system image as well as all recipes
- most of the packages we build from scratch (including low level, s.a., CMake, GCC, OpenSSL)
- with recipes new dependencies are distributed among developers without necessity for them to install anything (it is done automatically)

All Great Except. . .



It can't be that bad, can it?



Help Needed

- (semi)automatic cleaning of obsolete packages needs to be added
- GUI for cleaning of packages would be nice to have
- accounting – which packages were used and what is the distribution of their usage in time
- distribution of mpdroot (and dependencies) via rpms
- protection of closed-source software
- sometimes even new recipes are not easy to add

Bachelor/Master/...

What I need to know:

- nothing – kind of

What will I get:

- diploma

What will I learn (part of/maybe all):

- git (not only for storing files)
- bash, CMake, aliBuild/aliDist
- Docker/Toolboxes, RHEL based packaging
- creating web-based application
- LaTeX