Recent updates on FLArE simulations

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FLArE Technical Meeting

Infrastructure update and move to LXPLUS

LXPLUS @ CERN

- The LXPLUS service (lxplus.cern.ch) provides a cluster for **interactive computing** and access to a **HTCondor batch system**.
- Anyone with a valid CERN computing account can access it.
- Visit the list of services at the CERN Resources Portal, and search for boxes: “LXPLUS and Linux”, “AFS Workspaces”, “EOS/CERNBox”.
  1. Subscribe to “LXPLUS and Linux”
  2. Subscribe and setup your “AFS Workspaces”:
     - /afs/cern.ch/user/<initial>/<username> (up to 10 GB)
     - /afs/cern.ch/work/<initial>/<username> (up to 100 GB)

     You can set storage limits from the Settings in the "AFS Workspaces".
  3. Subscribe to EOS/CERNBox and login to https://cernbox.cern.ch/
     - /eos/user/<initial>/<username> (up to 1 TB)

Work environment

- Work on code in AFS areas and use EOS/CERNBox for data storage.
- Script for setting up environment on LXPLUS: source lxplus_setup.sh

```
## get software stack from LCG in CVMFS
## this setups both ROOT and Geant4
## docs: https://lcginfo.cern.ch/
echo "Setting up LGC_105 software stack..."
source /cvmfs/sft.cern.ch/lcg/views/LCG_105/x86_64-el9-gcc11-opt/setup.sh

## HEP_HPC: this is not available in LGC: it's a Fermilab/NOvA-specific package
## DUNE cvmfs: compiled with an older HDF5 than LGC...
## Current solution: build HEP_HPC locally on lxplus with HDF5 from LGC.
## Use env variable to point to it later in CMakeLists.txt
export hep_hpc_path="/afs/cern.ch/work/m/mvicenzi/public/HEP_HPC/bin"

## for CERNBOX eos access
export EOS_MGM_URL=root://eosuser.cern.ch

echo "Setup completed!"
```

Dependencies:
Geant4 v4_11_2_0
ROOT v6_30_02
HEP_HPC v0_14_01
HDF5 v1_12_2

- No GENIE dependency: ghep files need to be converted in the gst format (plain ROOT tree) using GENIE native utility gntpc

Building the code

It's a standard cmake + make build. In any AFS area:

1. Download the code (private repo):
   git clone https://github.com/WenjieWu-Sci/FLArE.git
2. Create a build directory:
   mkdir /path/to/build
3. Assume downloaded code is in /path/to/source.
   To prepare for compiling the code:
   source /path/to/source/lxplus_setup.sh
   cmake -S /path/to/source -B /path/to/build
4. And finally compile the package:
   cd /path/to/build
   make

Running the code

- The build directory now contains the FLArE executable.
- Running requires passing a macro with the configuration: ./FLArE /path/to/macro.mac
- If no macro is passed, the default is displaying the geometry.

The full list of available macro commands is in README.md
Example macros for simple tasks are also available.

Macro command

Geometry

Command	Description	Default
/det/saveGdml	option for saving detector geometry in a GDML file, run before `/run/initialize`	`false`
/det/checkOverlap	check overlap of volumns during detector construction, run before `/run/initialize`	`false`
/det/addFLArE	option for adding the FLArE detector, run before `/run/initialize`	`true`
/det/addFLArEPos	position of the FLArE detector, run before `/run/initialize`	`0 0 4300 mm`
/det/material	option for detector material, choose `LAr` or `LKr`, run before `/run/initialize`	`LAr`

Example: macro for ν_μ

Generating 5 ν_μ events starting from entry i=5 in the GENIE file w/ reference hall geometry.

```
# define detector material before run initialization
/control/execute macros/geometry_options/FPF_hall_Reference.mac

/run/initialize
/random/setSeeds 324199 420475

# define genie input options
/genie/useGenie true
/genie/genieInput /eos/user/m/mvicenzi/genie/numu_kling_ar40_e5000.gst.root
/genie/genieIStart 5

# define output options
/histo/save3DEvd false
/histo/save2DEvd false
/histo/saveHit false
/histo/addDiffusion false
/histo/fileName test_genie_numu.root

# shoot 5 particles
/run/beamOn 5
```

gst file in common area!

```
# This file defines the standard configuratio
# The geometry contains:
# - FLArE (TPC + HadCather + MuonFinder)
# - FORMOSA
# - FASERnu2
# - FASER2 (SAMURAI magnet)

# Configuring FLArE
/det/addFLArE true
/det/addFLArEPos 0 0 4300 mm
/det/material LAr
/det/module 3x7
/det/field 1. tesla

# Configuring FORMOSA
# assuming 1.2m gap from FLArE
/det/addFORMOSA true
/det/addFORMOSAPos 0 0 13870 mm

# Configuring FASERnu2
# assuming 1.2m gap from FORMOSA
/det/addFASERnu2 true
/det/addFASERnu2Pos 0 0 22023 mm

# Configuring FASER2
# assuming 1.2m gap from FASERnu2
# (which include veto stations)
# + 10m decay tunnel
/det/addFASER2 true
/det/addFASER2Pos 0 0 42636 mm
```

Submitting jobs

- Quick Start Guide: https://batchdocs.web.cern.ch/local/quick.html
- Jobs requires an executable (which sets up the environment, copies required files, etc) and a submission file that configures the job.
  condor_submit example.sub (submit command)
  condor_q (checking status)
- Examples are available…

File: `example.sub`

```
executable              = example.sh
arguments               = $(ClusterId) $(ProcId)
output                  = /afs/cern.ch/work/m/mvicenzi/public/LOGS/$(ClusterId)/out/welcome.$(ProcId).out
error                   = /afs/cern.ch/work/m/mvicenzi/public/LOGS/$(ClusterId)/err/welcome.$(ProcId).err
log                     = /afs/cern.ch/work/m/mvicenzi/public/LOGS/$(ClusterId)/log/welcome.$(ProcId).log
transfer_input_files    = /afs/cern.ch/work/m/mvicenzi/public/FLArE/lxplus_setup.sh,/afs/cern.ch/work/m/mvicenzi/pub
output_destination      = root://eosuser.cern.ch//eos/user/m/mvicenzi/HTCONDOR_OUTPUT/$(ClusterId)/
MY.XRDCP_CREATE_DIR     = True
queue 1
```

File: `example.sh`

```
#!/bin/bash

cluster=$1
process=$2

# source the environment
source lxplus_setup.sh

# create log directories
mkdir -p /afs/cern.ch/work/m/mvicenzi/public/LOGS/${cluster}/out
mkdir -p /afs/cern.ch/work/m/mvicenzi/public/LOGS/${cluster}/err
mkdir -p /afs/cern.ch/work/m/mvicenzi/public/LOGS/${cluster}/log

# import gst file if needed by mac file
eos cp /eos/user/m/mvicenzi/genie/numu_kling_ar40_e5000.gst.root .

echo "Running ./FLArE macro.mac"
./FLArE macro.mac
```

Example: ν jobs submission

- Submission of jobs of ν events from GENIE made easy with a ready-to-use script that automatically generate submission files.
- Logs must go to /afs, output can be sent directly to /eos.
- Run with:
  ./nu_job.sh

```
###-----------------------------------------
### DEFINITION OF PRODUCTION PARAMETERS
###-----------------------------------------

# Production name for output directories
# This is used to place output logs and files
export prodname="test_numu"

# Define how many jobs, how many files
# Jobs will be placed in the same cluster
export n_jobs=2
export n_evt_per_job=10

# Set the max wall time duration allowed
# See https://batchdocs.web.cern.ch/tutorial/exercise6b.html
# eg: espresso = 20 min, microcentury = 1 hour, longlunch = 2 hours
export max_duration="microcentury"

# Path to FLArE build directory in /afs/cern.ch
export builddir="/afs/cern.ch/work/${USER:0:1}/${USER}/public/FLArE/build"
export flare="${builddir}/FLArE"
export setup="${builddir}/lxplus_setup.sh"
export libdict="${builddir}/libFLArE_rdict.pcm"

# Path to geometry macro in /afs/cern.ch
export geometry="${builddir}/macros/geometry_options/FPF_hall_Reference.mac"

# Path to genie gst file in /eos/
export geniegst="/eos/user/m/mvicenzi/genie/numu_kling_ar40_e5000.gst.root"

# Path to log directory
export logdir="/afs/cern.ch/work/${USER:0:1}/${USER}/public/LOGS"
# Path to /eos/user output directory
export outdir="/eos/user/${USER:0:1}/${USER}/HTCONDOR_OUTPUT"
```

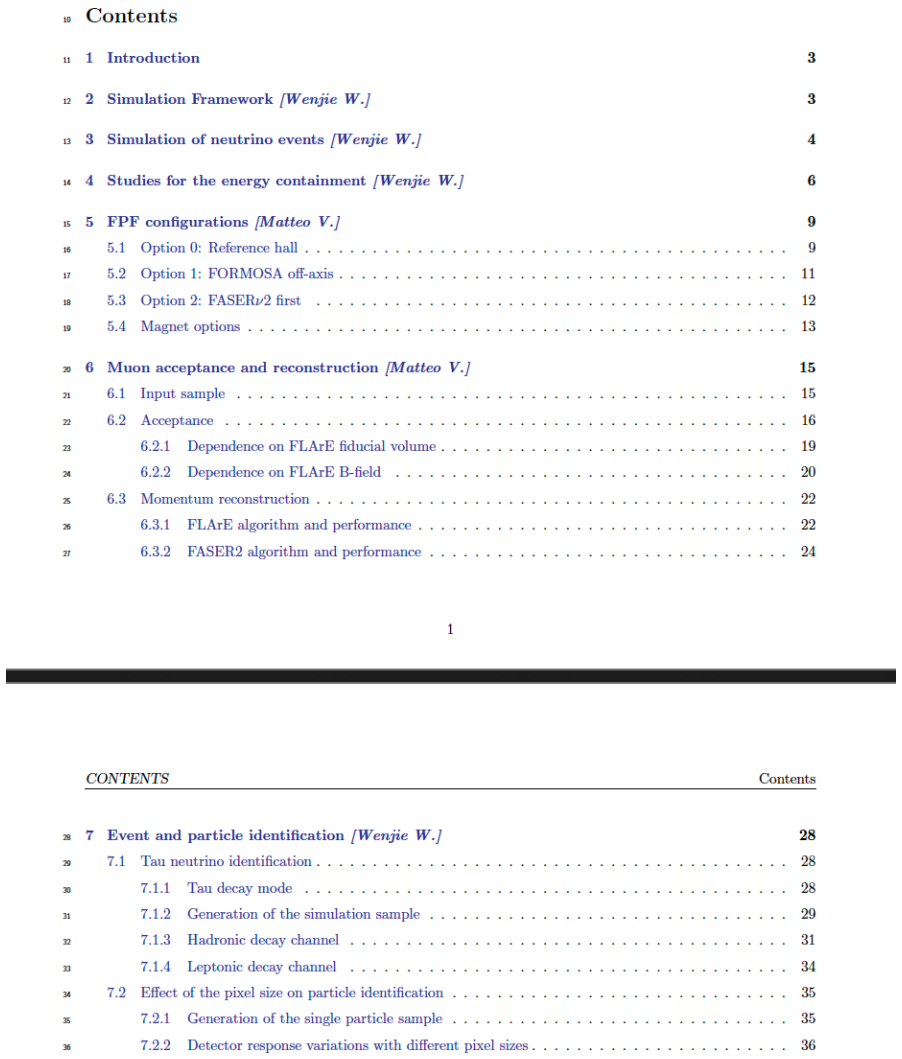
Status

- CERN is the host lab: everyone is supposed to have a CERN computing account.
- LXPLUS is the long-term solution in terms of dedicated resources for the simulation effort, offering both interactive machines and a batch system.
- As of June, the package has been fully ported to lxplus.cern.ch with all its functionalities!

Technical Note Overview

Technical note in progress

- We have a draft of the technical note on the simulation studies: https://www.overleaf.com/16255216 14bgrvrfzsgqhx#2c82dd
- Currently a collection of semi-independent studies, lacks a common theme.
- Some sections need to be finalized, conclusions for the studies need to be drawn.
- Unfortunately, no significant updates since April…



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Tech note review (1)

Contents

To be revisited at the end…

Description of the simulation framework,
Should be mostly okay, some details to be updated (eg: GENIE)

Determination of optimal transverse size for FLArE, length of HadCatcher
→ To be updated?

Geometry of the cavern has changed a lot; reference is now Option 1a?
Too qualitative? lack of metrics to compare them (except acceptance..)

Mostly okay, conclusion is simple: the closer the better.
SAMURAI vs CrystalvPullers more interesting… but Kin is working on understanding biases on that…

Tech note review (2)

Very bad performance in current geometry (optimized only for E containment)… need better design → BabyMIND?

SAMURAI okay, but Crystal Pullers very bad (issue w/ algorithm)… can't compare properly… → to be fixed!

Should be okay.
Possibly affected by new TPC layout (gaps)?

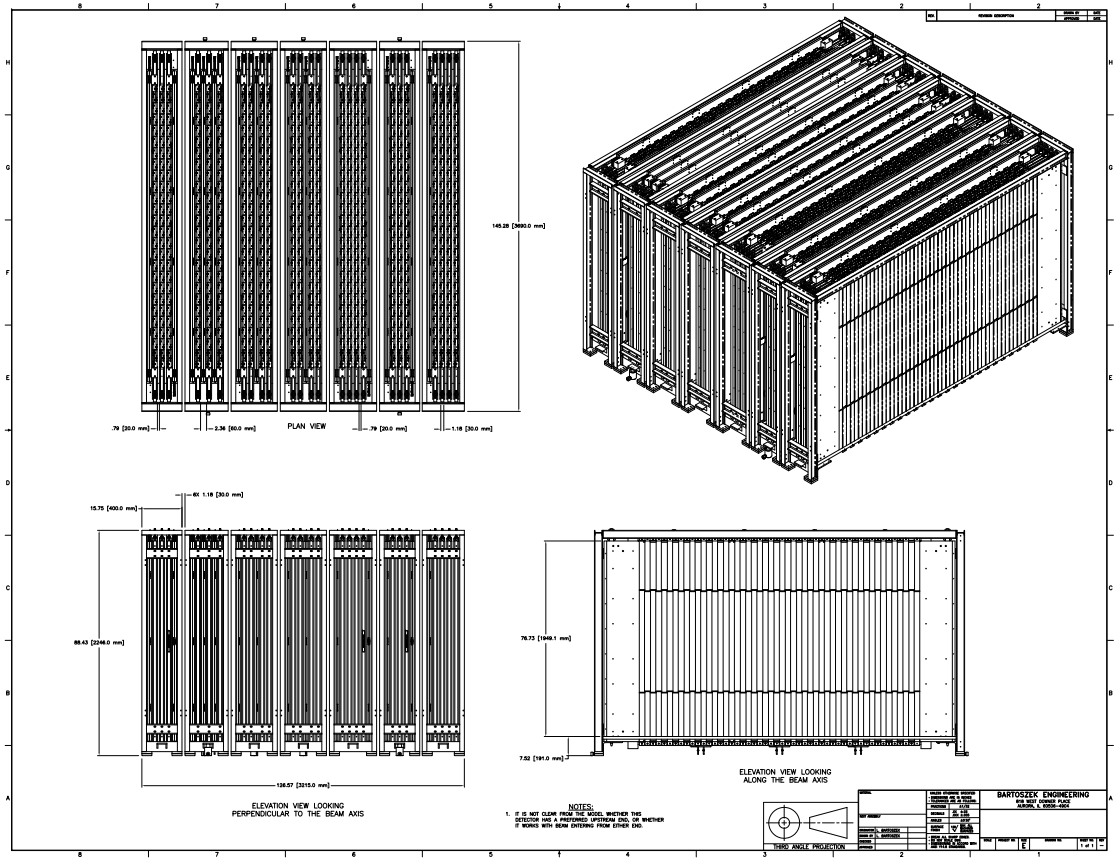
Should be okay?

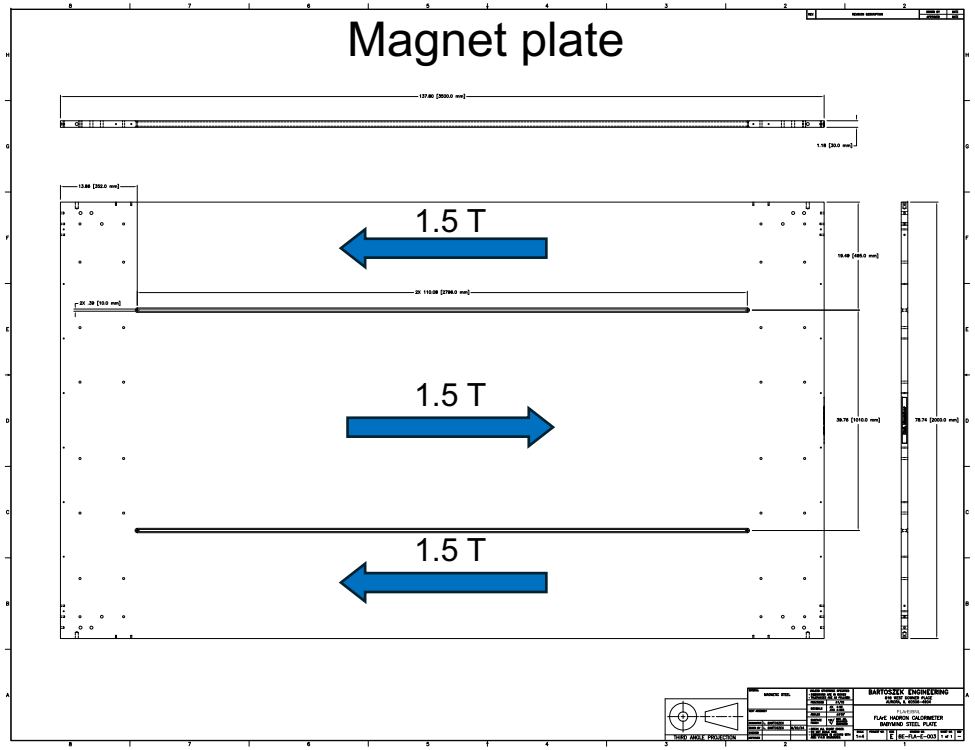
+ needs conclusions to be drawn in a "technical requirements" section at the end

Ongoing work

Current activities

1. Work on implementing NuTeV-like detector in the simulation (Wenjie).
2. Work on implementing BabyMIND in the simulation (Matteo).





Drawings from Larry.

Current activities

3. Work on addressing the acceptance bias between the SAMURAI and Crystal-pulling magnets (Kin).