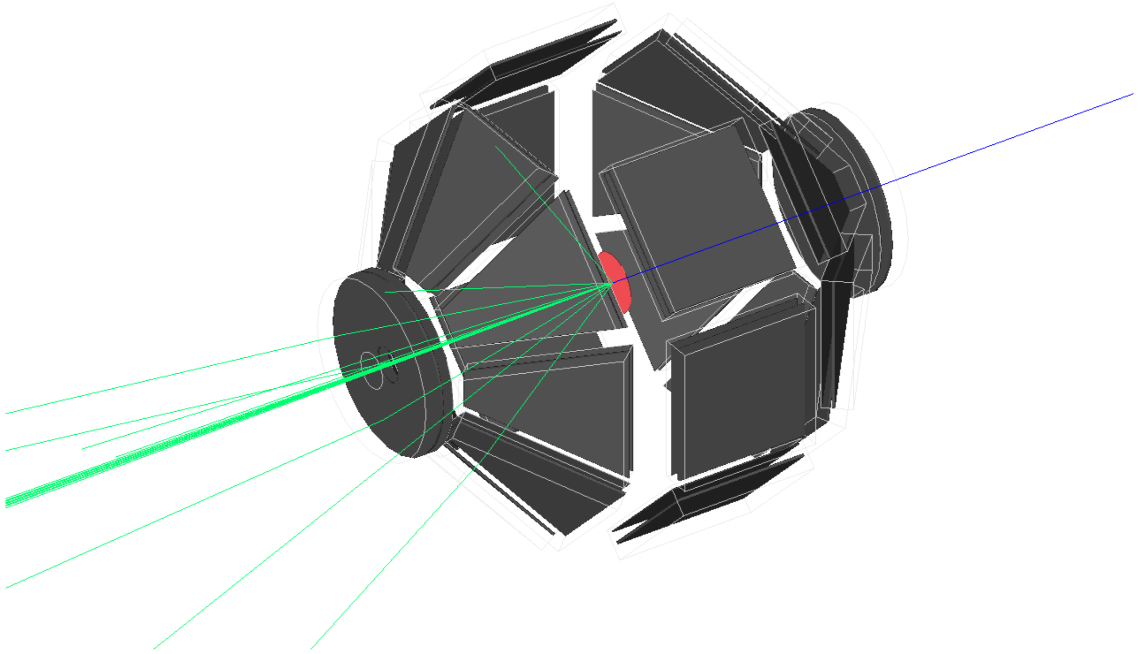
GRIT simulations in nptool v4



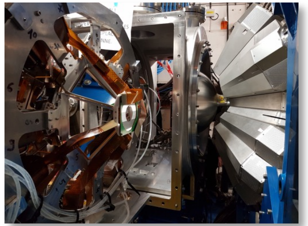
GRIT workshop 2025

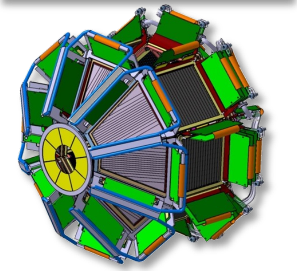
Girard-Alcindor Valérian - IJCLab

Nuclear physics in a nutshell (caricatural…)

Nuclear physics code standard:

- Custom analysis code for each experiment:
  - Not reusable:
    - Not maintained
    - Not modular
    - Not well documented
  - New code from scratch for each experiment
  - Inconsistent from one experiment to the other
- analysis/simulation code are not treated similarly (inconsistency)





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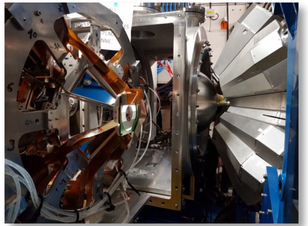
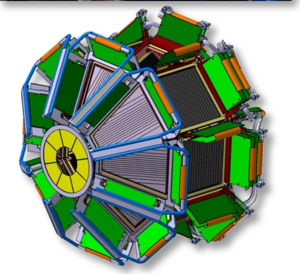
The increasing complexity of detectors requires a change of philosophy!

- Need of analysis code that is:
    - Standardized
    - Reproducible
    - Reusable
    - Modular
    - Collaborative
- Develop consistent analysis/simulation code





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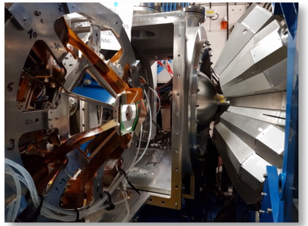
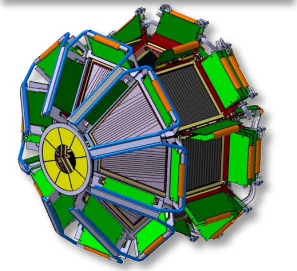
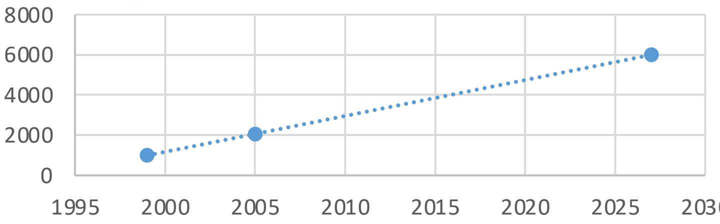
MUST:
- 1000- strips



MUST2/MUGAST:
- 2000+ strips



GRIT:
- 6000+ strips!

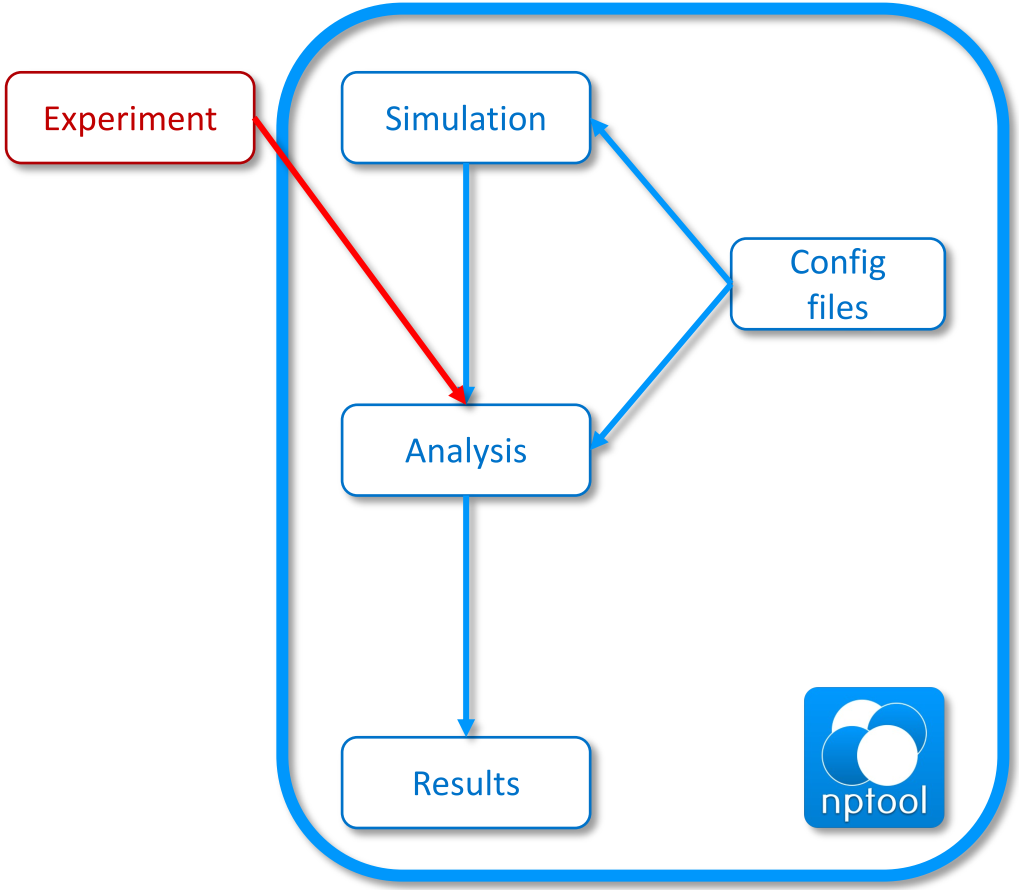


Based on this in 2100 : 20000+ strips!

What is nptool?

nptool is:

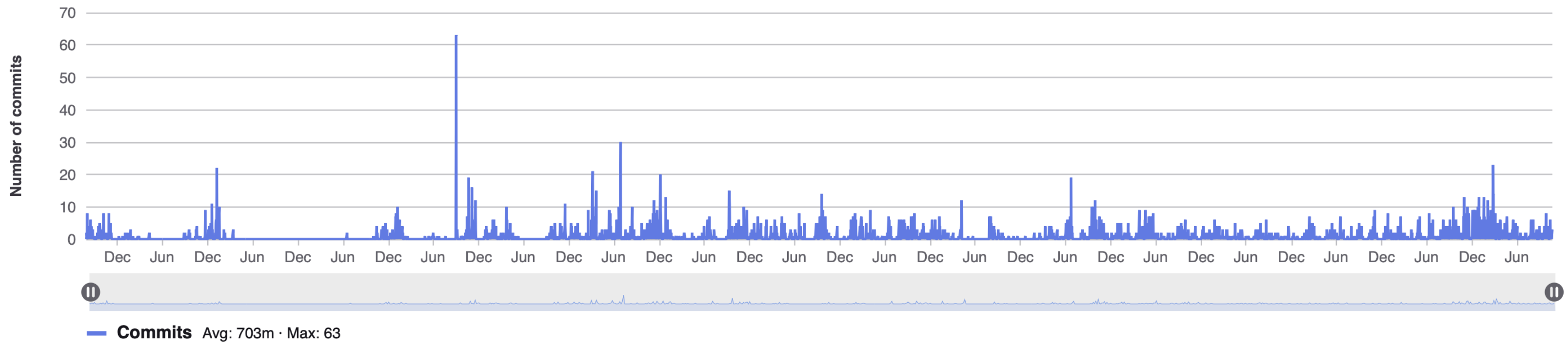
- A common framework for nuclear physics experiment
- Based on standard "toolboxes" developed by CERN:
  - Root: Analysis
  - Geant4: Simulation
- Collaborative and open source
- Modular and flexible:
  - Any detector, any setup, any physics…
- Aim at promoting good practices:
  - Framework philosophy
  - Standard code structure
  - Well commented, documented, readable code
  - Tried and tested
  - Validate simulation and analysis together



nptool v3 successes...

nptoolv3 in numbers:

- Since 2008
- MUST2 / GASPARD -> Now > 90 detectors
- 45 contributors
- ~ 5000 commits
- Widely used in europe and in the US/Japan
- Cited in 54 papers



nptoolv3 limitations…

nptool v3 limitations:

- All detectors/event generators in the same repo
    - Problem with push/pull only dev branch
    - You get nptool with all the detectors, especially the one you do not need…
- Compatibility with previous experiments can be easily broken
- Authorship is unclear

Nptool v3: https://gitlab.in2p3.fr/np/nptool

- NPLib:
    - Core
    - Physics
    - Detectors (80+)
- NPSimulation:
    - Core
    - Process and EventGenerators
    - Detectors (80+)

Everything on a single repo:

- Detectors
- Event generator…
- All author work on the same nptool…

nptool v4: Toward a modern framework

nptoolv4 <=> (nptoolv3 core + plugin manager)

- Same method to install all plugins (detectors, unpacker, event generators…):
  - nptool --install grit
  - nptool --install npmfm
  - nptool --install g4-two-body-reaction…
- Example of pros:
  - Detectors analysis/simulation managed by authors/collaboration
  - Duplicate plugins to modify or save them in projects at a moment in time
- New features:
  - Conversion (mfm, faster, mesytec,…)
  - Online monitoring (web based, monitoring on linux, mac and even windows)

nptool v4: https://gitlab.in2p3.fr/nptool/nptool

- Core
- Plugin Manager

Plugins:

MUST2: https://gitlab.in2p3.fr/mugast/must2

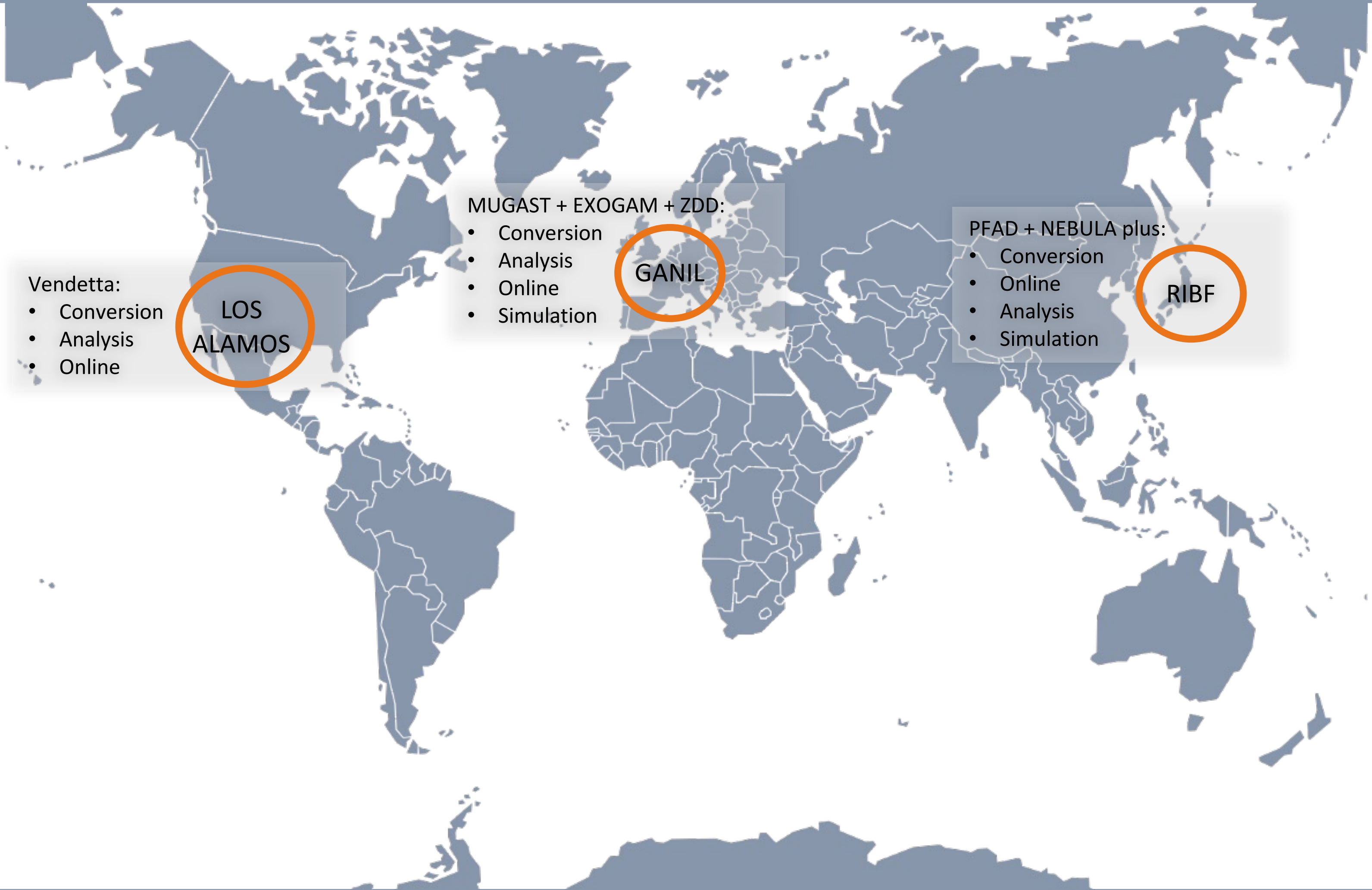
MFM unpacker: https://gitlab.in2p3.fr/valerian.girard-alcindor/npmfm

GRIT: https://gitlab.in2p3.fr/valerian.girard-alcindor/grit

AGATA: https://gitlab.infn.it/Simulation/Agata (for illustration only)

Independent repo

nptoolv4 in the field



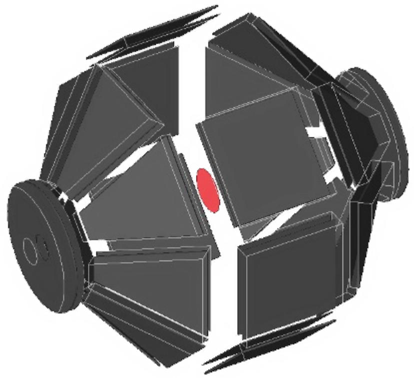
Now let's explain what it actually means to use the v4!

First step, follow the guide:

https://nptool.in2p3.fr/manual-v4/

Then for GRIT specifically I made a git project:

https://gitlab.in2p3.fr/valerian.girard-alcindor/grit_simu



Full GRIT + solid target

The main difference, is that one need to install each plugins, for example after cloning the grit simu project, it is required to do:

```
> nptool --install root,geant4,g4-two-body-reaction,g4-dssd-scorer,grit
```

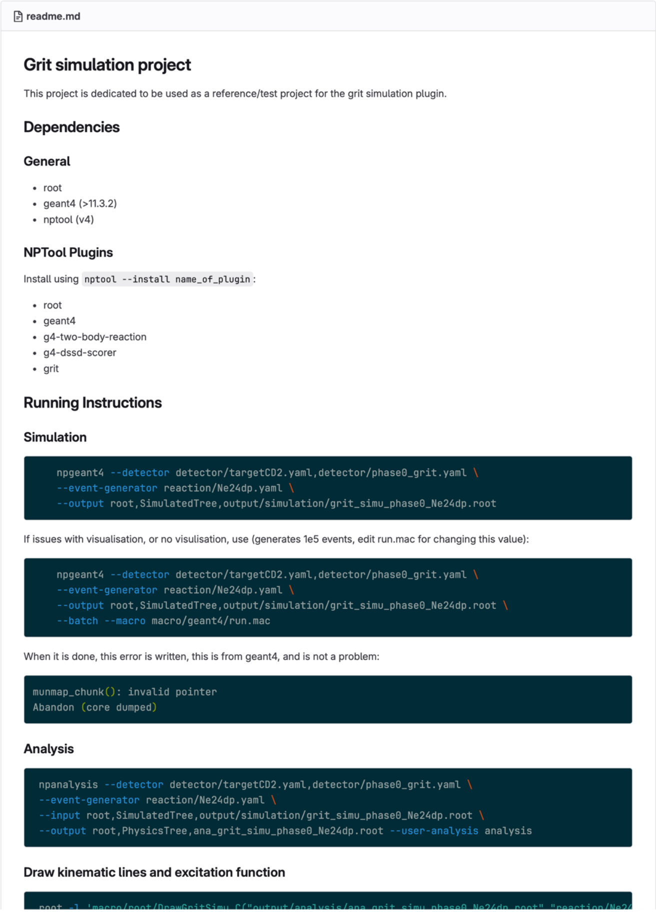
Please note that the root and geant4 are the plugins of nptool, one still need an install of root (>6.37 tested) and geant4 (>11.3.2 tested)
Also note that the current grit simulation is still in development.*

The grit project for simulation provides:

GRIT simulation and analysis in v4

The grit project for simulation provides:

- A README with detailed instructions



readme.md

Grit simulation project

This project is dedicated to be used as a reference/test project for the grit simulation plugin.

Dependencies

General

- root
- geant4 (>11.3.2)
- nptool (v4)

NPTool Plugins

Install using `nptool --install name_of_plugin`:

- root
- geant4
- g4-two-body-reaction
- g4-dssd-scorer
- grit

Running Instructions

Simulation

```
npgeant4 --detector detector/targetCD2.yaml,detector/phase0_grit.yaml \
--event-generator reaction/Ne24dp.yaml \
--output root,SimulatedTree,output/simulation/grit_simu_phase0_Ne24dp.root
```

If issues with visualisation, or no visulisation, use (generates 1e5 events, edit run.mac for changing this value):

```
npgeant4 --detector detector/targetCD2.yaml,detector/phase0_grit.yaml \
--event-generator reaction/Ne24dp.yaml \
--output root,SimulatedTree,output/simulation/grit_simu_phase0_Ne24dp.root \
--batch --macro macro/geant4/run.mac
```

When it is done, this error is written, this is from geant4, and is not a problem:

```
munmap_chunk(): invalid pointer
Abandon (core dumped)
```

Analysis

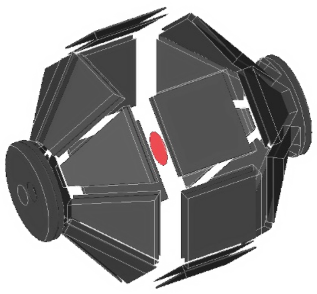
```
npanalysis --detector detector/targetCD2.yaml,detector/phase0_grit.yaml \
--event-generator reaction/Ne24dp.yaml \
--input root,SimulatedTree,output/simulation/grit_simu_phase0_Ne24dp.root \
--output root,PhysicsTree,ana_grit_simu_phase0_Ne24dp.root --user-analysis analysis
```

Draw kinematic lines and excitation function

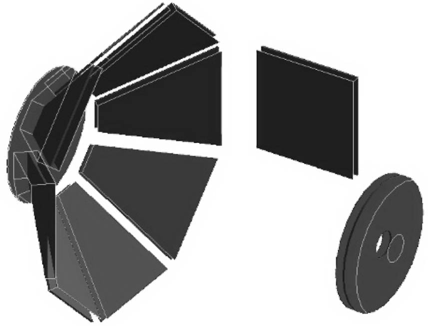
GRIT simulation and analysis in v4

The grit project for simulation provides:

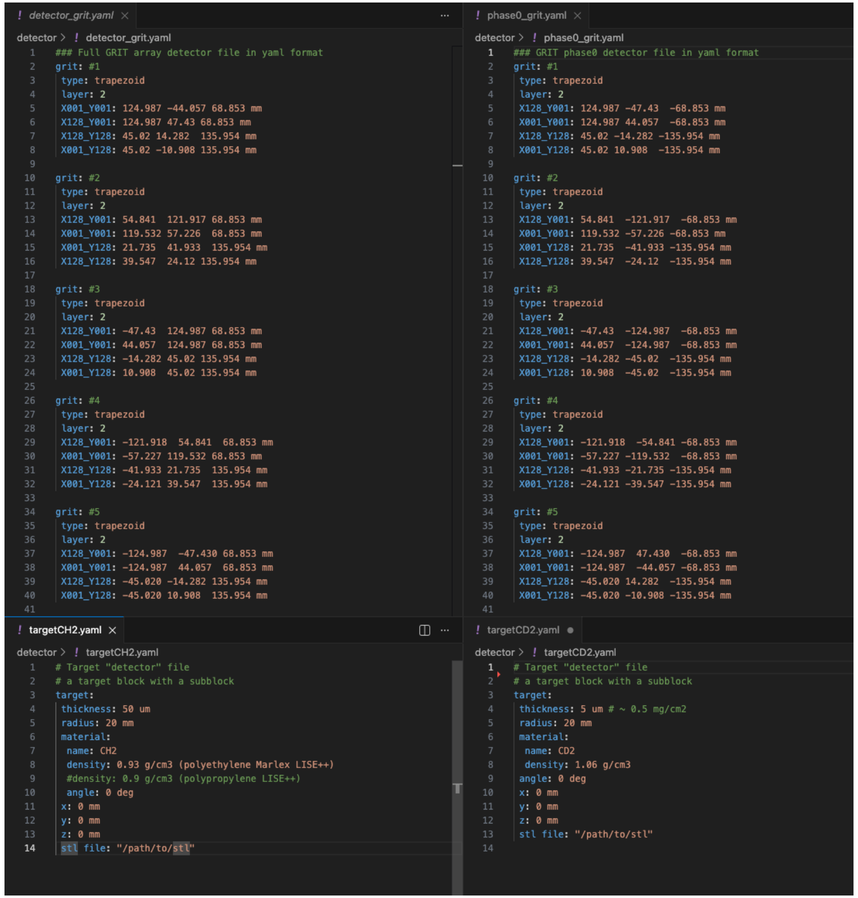
- A README with detailed instructions
- Up to date geometry:
  - Full setup
  - Phase 0
  - CH2 target
  - CD2 target



Full GRIT + solid target



GRIT phase 0



detector > detector_grit.yaml

```yaml
### Full GRIT array detector file in yaml format
grit: #1
 type: trapezoid
 layer: 2
 X001_Y001: 124.987 -44.057 68.853 mm
 X128_Y001: 124.987 47.43 68.853 mm
 X128_Y128: 45.02 14.282  135.954 mm
 X001_Y128: 45.02 -10.908 135.954 mm

grit: #2
 type: trapezoid
 layer: 2
 X128_Y001: 54.841  121.917 68.853 mm
 X001_Y001: 119.532 57.226  68.853 mm
 X001_Y128: 21.735  41.933  135.954 mm
 X128_Y128: 39.547  24.12 135.954 mm

grit: #3
 type: trapezoid
 layer: 2
 X128_Y001: -47.43  124.987 68.853 mm
 X001_Y001: 44.057  124.987 68.853 mm
 X128_Y128: -14.282 45.02 135.954 mm
 X001_Y128: 10.908  45.02 135.954 mm

grit: #4
 type: trapezoid
 layer: 2
 X128_Y001: -121.918  54.841  68.853 mm
 X001_Y001: -57.227 119.532 68.853 mm
 X128_Y128: -41.933 21.735  135.954 mm
 X001_Y128: -24.121 39.547  135.954 mm

grit: #5
 type: trapezoid
 layer: 2
 X128_Y001: -124.987  -47.430 68.853 mm
 X001_Y001: -124.987  44.057  68.853 mm
 X128_Y128: -45.020 -14.282 135.954 mm
 X001_Y128: -45.020 10.908  135.954 mm
```

detector > phase0_grit.yaml

```yaml
### GRIT phase0 detector file in yaml format
grit: #1
 type: trapezoid
 layer: 2
 X128_Y001: 124.987 -47.43  -68.853 mm
 X001_Y001: 124.987 44.057  -68.853 mm
 X128_Y128: 45.02 -14.282 -135.954 mm
 X001_Y128: 45.02 10.908  -135.954 mm

grit: #2
 type: trapezoid
 layer: 2
 X128_Y001: 54.841  -121.917  -68.853 mm
 X001_Y001: 119.532 -57.226 -68.853 mm
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grit: #4
 type: trapezoid
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 X128_Y128: -45.020 14.282  -135.954 mm
 X001_Y128: -45.020 -10.908 -135.954 mm
```

detector > targetCH2.yaml

```yaml
# Target "detector" file
# a target block with a subblock
target:
 thickness: 50 um
 radius: 20 mm
 material:
  name: CH2
  density: 0.93 g/cm3 (polyethylene Marlex LISE++)
  #density: 0.9 g/cm3 (polypropylene LISE++)
  angle: 0 deg
 x: 0 mm
 y: 0 mm
 z: 0 mm
 stl file: "/path/to/stl"
```

detector > targetCD2.yaml

```yaml
# Target "detector" file
# a target block with a subblock
target:
 thickness: 5 um # ~ 0.5 mg/cm2
 radius: 20 mm
 material:
  name: CD2
  density: 1.06 g/cm3
 angle: 0 deg
 x: 0 mm
 y: 0 mm
 z: 0 mm
 stl file: "/path/to/stl"
```

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- A README with detailed instructions
- Up to date geometry:
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  - Phase 0
  - CH2 target
  - CD2 target
- Example event generators:
  - Two body reaction (132Sn(d,p) and 24Ne(d,p))
  - source (mono energetic alpha).

Sn132dp.yaml

reaction > Sn132dp.yaml

```yaml
beam:
  Particle: 132Sn
  Energy: 1320 MeV
  SigmaEnergy: 0 MeV
  ZEmission: -1000 mm
  ZProfile: 0 mm
  SigmaThetaX: 0.42 deg
  SigmaPhiY: 0.42 deg
  SigmaX: 1.7 mm
  SigmaY: 1.7 mm
  MeanThetaX: 0.3 deg
  MeanPhiY: 0 deg
  MeanX: 1.0 mm
  MeanY: 2.0 mm

two-body-reaction:
  Beam: 132Sn
  Target: 2H
  Light: 1H
  Heavy: 133Sn
  ExcitationEnergyLight: 0.0 MeV
  ExcitationEnergyHeavy: 0.0 MeV
  CrossSectionPath: reaction/Sn132dp_10AMeV_CS.txt CS
```

Ne24dp.yaml

reaction > Ne24dp.yaml

```yaml
beam:
  Particle: 24Ne
  Energy: 192 MeV
  SigmaEnergy: 0 MeV
  ZEmission: -1000 mm
  ZProfile: 0 mm
  SigmaThetaX: 0 deg
  SigmaPhiY: 0 deg
  SigmaX: 0 mm
  SigmaY: 0 mm
  MeanThetaX: 0 mm
  MeanPhiY: 0 mm
  MeanX: 0 mm
  MeanY: 0 mm

two-body-reaction:
  Beam: 24Ne
  Target: 2H
  Light: 1H
  Heavy: 25Ne
  ExcitationEnergyLight: 0 MeV
  ExcitationEnergyHeavy: 0.0 MeV
  CrossSectionPath: reaction/Ne24dp_CS.txt CS
  # CrossSectionPath: reaction/flat.txt CS
```

GRIT simulation and analysis in v4

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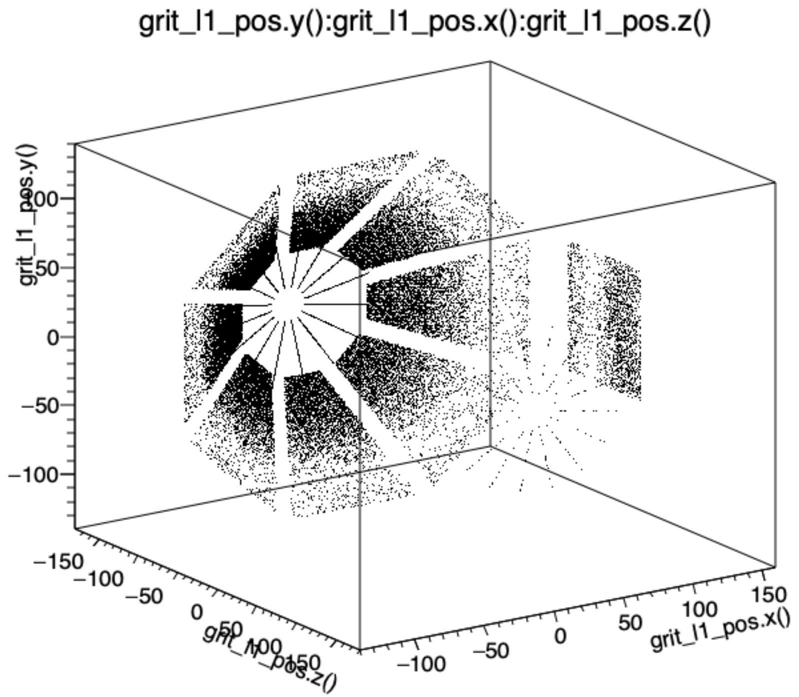
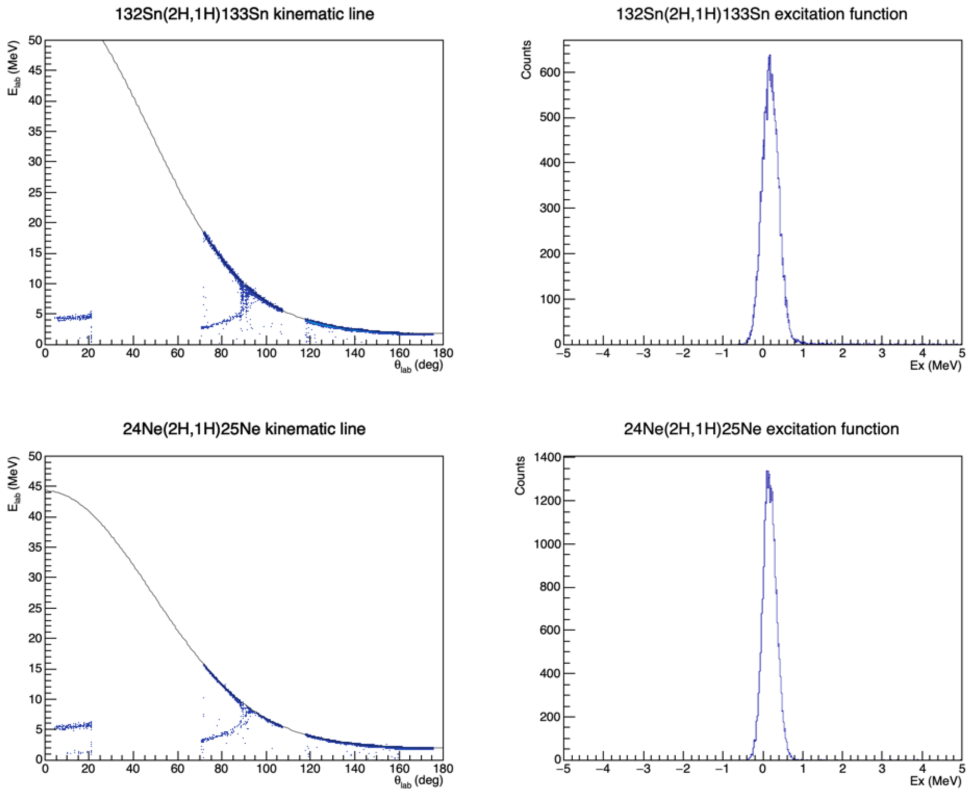
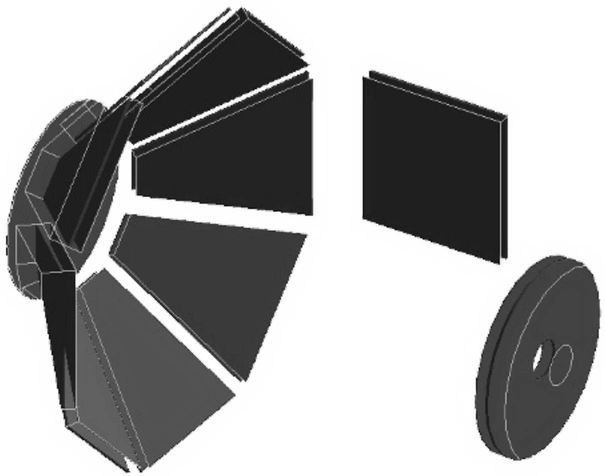
- Example event generators:
  - Two body reaction (132Sn(d,p) and 24Ne(d,p))
  - source (mono energetic alpha).
- Simple analysis:
  - Strip matching
  - Position/Angle reconstruction
  - Missing mass
- Simple draw macro:
  - Kinematic lines
  - Excitation function



nptool

Some first results/simulations:





GRIT phase 0

To do:

- Al dead layers
- Interstrips
- CAD
- Energy loss corrections
- Fix slight mismatch in square detectors

nptool:

- Originally developed to answer the difficulties arising from the analysis and simulation of complex modern nuclear physics
- **The v3 reached its limits**: the number of users, new challenges in term of open-science and long-term code sustainability
- **Simulation now fully working in nptoolv4**
- **GRIT simulation** is mostly working and **can be used for preliminary simulations** for future experiments at GANIL...
- The grit simulation code/project are aimed to be distributed to any users who would like to perform simulation for future proposals
- **Please do not hesitate to clone the test project and let me know if you have any issues:** Grit simu gitlab

Conclusion

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THANK YOU FOR YOUR ATTENTION