GAMBIT-light

1. What is GAMBIT-light?
2. Why do we need it?
3. *For users:* how does it work?
4. *For GAMBIT developers:* how do we maintain it?
5. Future plans

1. What is GAMBIT-light?

- GAMBIT-light: **GAMBIT without all the physics**
- A lightweight yet powerful tool for statistical fits and optimisation tasks
- *What GAMBIT-light is not:* A full-blown tool for global fits in <your discipline> — for that you'd want more of the full GAMBIT functionality
- Key design principles:
  - Users should never need to modify and rebuild any GAMBIT code
  - Minimise the extra maintenance work for GAMBIT developers

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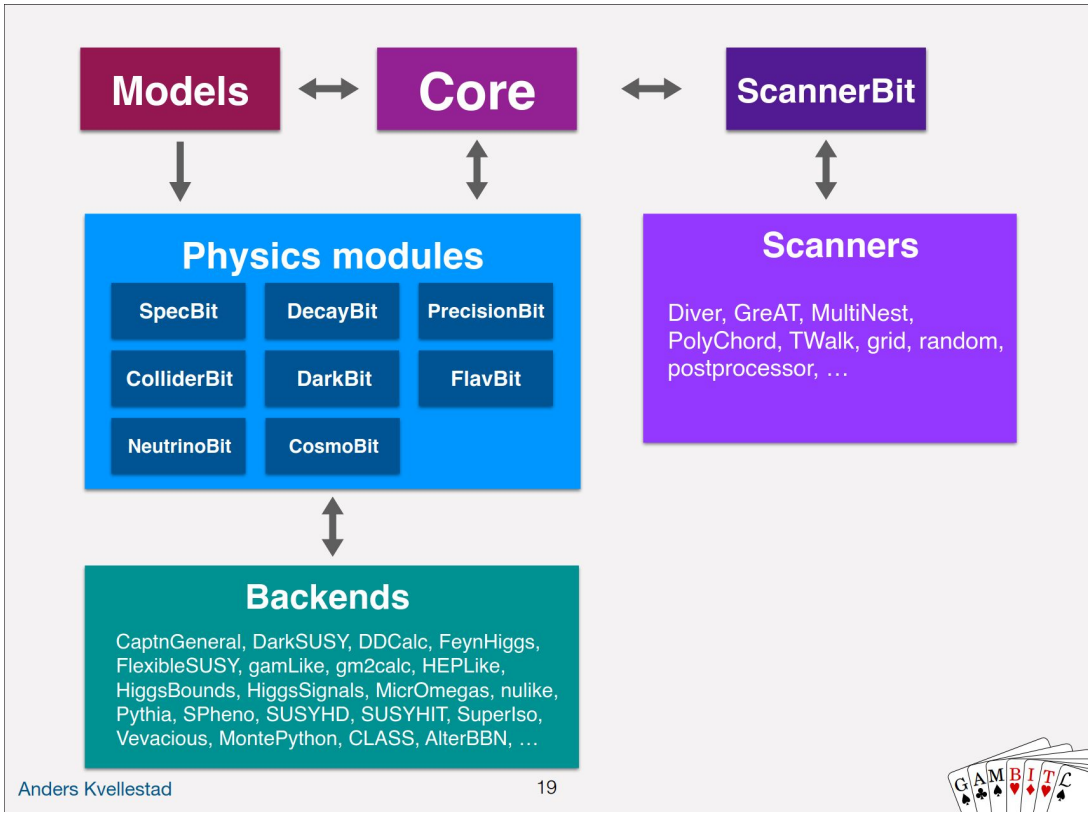
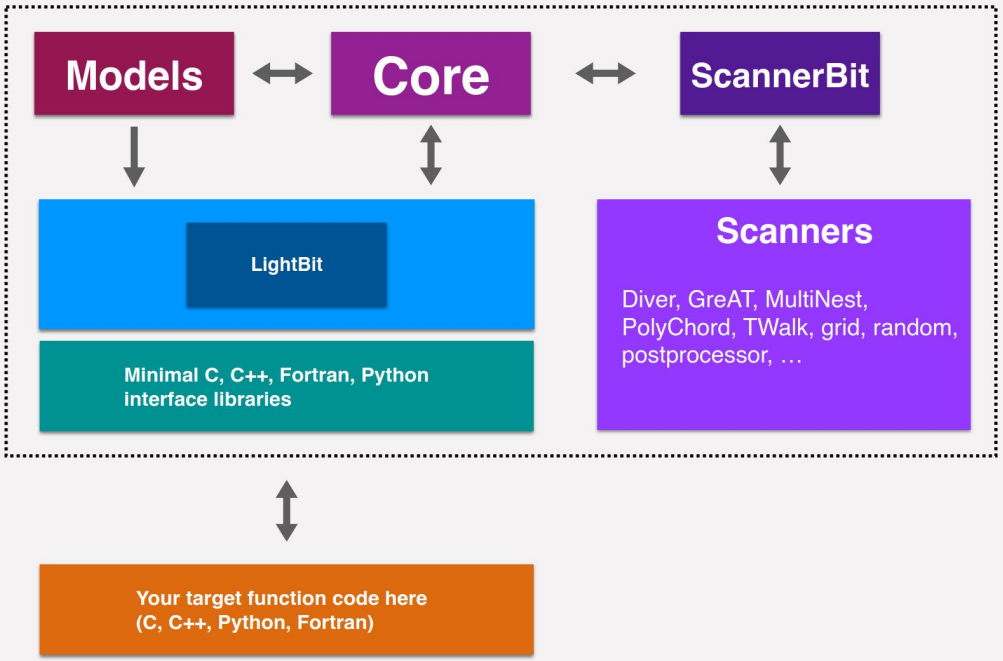
Brainstorming, early code drafts, testing:

Janina Renk, **Fabio Zeiser**, **Andreas Mjøs**, ++


Models
Core
ScannerBit
Physics modules
SpecBit
DecayBit
PrecisionBit
ColliderBit
DarkBit
FlavBit
NeutrinoBit
CosmoBit
Scanners
Diver, GreAT, MultiNest, PolyChord, TWalk, grid, random, postprocessor, …
Backends
CaptnGeneral, DarkSUSY, DDCalc, FeynHiggs, FlexibleSUSY, gamLike, gm2calc, HEPLike, HiggsBounds, HiggsSignals, MicrOmegas, nulike, Pythia, SPheno, SUSYHD, SUSYHIT, SuperIso, Vevacious, MontePython, CLASS, AlterBBN, …


Models
Core
ScannerBit
LightBit
Minimal C, C++, Fortran, Python interface libraries
Scanners
Diver, GreAT, MultiNest, PolyChord, TWalk, grid, random, postprocessor, …
Your target function code here (C, C++, Python, Fortran)

2. Why do we need it?

- Background:
  - We designed GAMBIT to be very general and physics-agnostic
  - We put a lot of effort into the main code framework
    (Core, ScannerBit, Printers, CMake system, …)
  - → GAMBIT *can* be used for optimisation/fits outside particle/astro/cosmo

- Practical experience:
  - GAMBIT is a particle physics power tool → fairly heavyweight
  - Considerable threshold for non-experts to pick up and use/modify
  - In particular: frequent and slow recompilation kills the flow of the early development/experimentation stage of projects

- External motivation for GAMBIT-light:
  - Help projects outside particle/astro/cosmo use GAMBIT
  - In particle/astro/cosmo:
    suitable for quick experimentation, MSc projects, etc.

- Internal motivation for GAMBIT-light
  - Increase visibility and impact of Core & ScannerBit work
  - Increase visibility for Core & ScannerBit papers
    (GAMBIT-light should *not* have a separate code paper – users should cite the main GAMBIT & ScannerBit papers)
  - Sandbox for quick experimentation

3. For users: how does it work?

1. Build GAMBIT once

```
mkdir build
cd build
cmake -DCMAKE_BUILD_TYPE=Release -DWITH_MPI=On -DCMAKE_CXX_COMPILER=g++-11 -DCMAKE_C_COMPILER=gcc-11
make -jN scanners   # where N is the number of cores to use for the build, e.g. 4
cmake ..            # this step is needed for GAMBIT to detect the built scanners
make -jN gambit
```

2. Develop your target/likelihood function code

```python
# To import gambit_light_interface, first append the directory containing
# gambit_light_interface.so to sys.path. (Alternatively, add this directory
# to the PYTHONPATH environment variable.)
import sys
import os
current_dir = os.path.dirname(os.path.abspath(__file__))
sys.path.append(os.path.join(current_dir, "../lib"))
import gambit_light_interface as gambit_light


# User-side log-likelihood function, which can be called by GAMBIT-light
def user_loglike(input_names, input_vals, output):

    # Make a dictionary of the inputs?
    input = {input_names[i]: input_vals[i] for i in range(len(input_names))}

    # Error handling: Report an invalid point using gambit_light.invalid_point.
    # gambit_light.invalid_point("This input point is no good.")

    # Error handling: Report a warning using gambit_light.warning.
    gambit_light.warning("Some warning.")

    # Error handling: Report an error using gambit_light.error.
    # gambit_light.error("Some error.")

    # Error handling: Error handling, alternative to using gambit_light.error: Throw an exception.
    # raise Exception("Some exception.")

    # Compute loglike
    loglike = input["param_name_1"] + input["param_name_2"] + input["param_name_4"]

    # Save some extra outputs
    output["py_user_loglike_output_1"] = 1
    output["py_user_loglike_output_2"] = 2
    output["py_user_loglike_output_3"] = 3

    return loglike

```

2. Develop your target/likelihood function code
(C++/C/Fortran: build as shared library)

```cpp
#include "gambit_light_interface.h"

// User-side log-likelihood function, which can be called by GAMBIT-light.
double user_loglike(const std::vector<std::string>& input_names,
                    const std::vector<double>& input_vals,
                    std::map<std::string,double>& output)
{

    // Make a map of the inputs?
    std::map<std::string,double> input;
    for (size_t i = 0; i < input_names.size(); i++)
    {
        input[input_names[i]] = input_vals[i];
    }

    // Error handling: Report an invalid point using gambit_light_invalid_point.
    // gambit_light_invalid_point("This input point is no good.");

    // Error handling: Report a string warning using gambit_light_warning.
    gambit_light_warning("Some warning.");

    // Error handling: Report an error using gambit_light_error.
    // gambit_light_error("Some error.");

    // Error handling, alternative to using gambit_light_error: Throw a runtime_error.
    // throw std::runtime_error("Some runtime_error.");

    // Compute loglike
    double loglike = input.at("param_name_2") + input.at("param_name_3");

    // Save some extra outputs
    output["cpp_user_loglike_output_1"] = 1;
    output["cpp_user_loglike_output_2"] = 2;
    output["cpp_user_loglike_output_3"] = 3;

    return loglike;
}

GAMBIT_LIGHT_REGISTER_LOGLIKE(user_loglike)

```

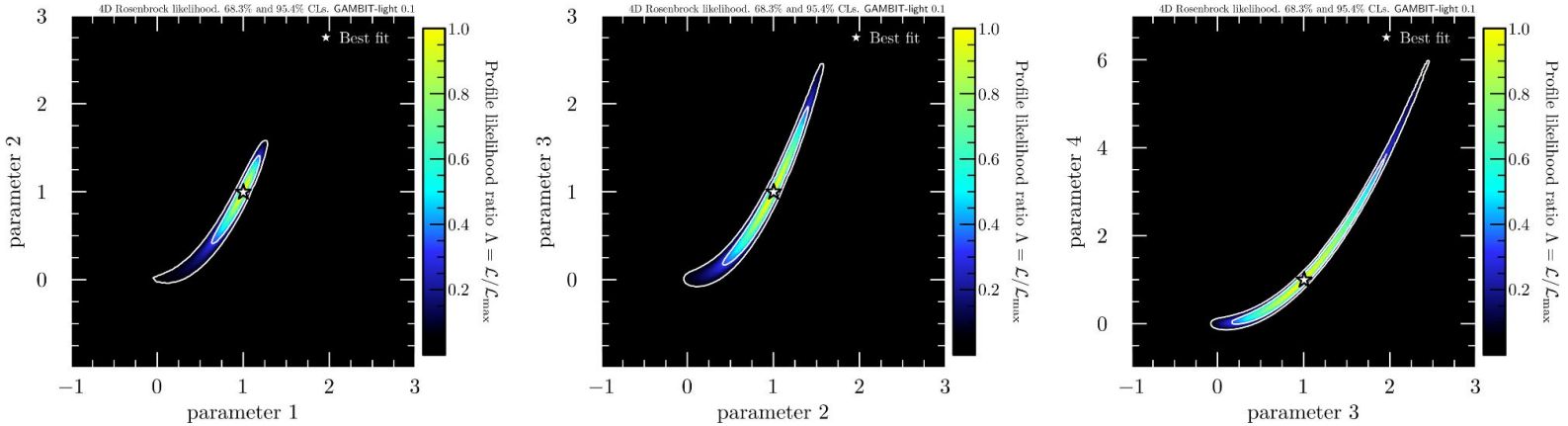
3. Configure GAMBIT run with a YAML file

```yaml
UserModel:

  p1:
    name: param_name_1
    prior_type: flat
    range: [0.0, 5.0]
  p2:
    name: param_name_2
    prior_type: flat
    range: [0.0, 5.0]
  p3:
    name: param_name_3
    fixed_value: 3.0
  p4:
    name: param_name_4
    same_as: UserModel::p1
  p5-p7:
    name: param_name_
    prior_type: flat
    range: [-1.0, 1.0]

UserLogLikes:

  py_user_loglike:
    lang: python
    user_lib: gambit_light_interface/example_python/example.py
    func_name: user_loglike
    output:
      - py_user_loglike_output_1
      - py_user_loglike_output_2
      - py_user_loglike_output_3

  cpp_user_loglike:
    lang: c++
    user_lib: gambit_light_interface/example_cpp/example.so
    func_name: user_loglike
    input:
      - param_name_2
      - param_name_3
    output:
      - cpp_user_loglike_output_1
      - cpp_user_loglike_output_2
      - cpp_user_loglike_output_3

```

4. Run GAMBIT

```
mpiexec -np 4 ./gambit -f yaml_files/your_configuration_file.yaml
```

5. Modify your own code, rerun GAMBIT, modify your own code, rerun GAMBIT, …



6. Analyse output samples (saved in HDF5 or ascii format)

Also: user-supplied prior transformation

Python

```python
# User-side prior transform function, which can be called by GAMBIT-light.
def user_prior(input_names, input_vals, output):

    for i,v in enumerate(input_vals):
        output[i] = v * 10.

```

C++

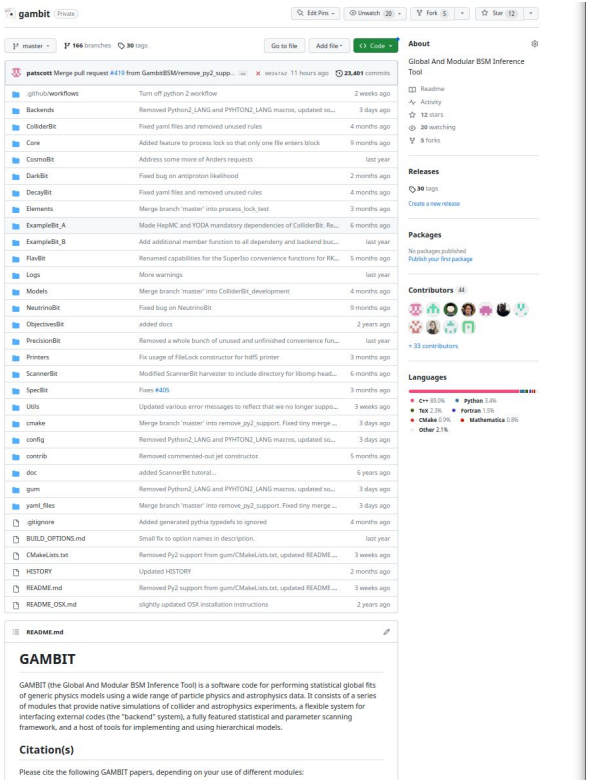
```cpp
// User-side prior transform function, which can be called by GAMBIT-light.
void user_prior(const std::vector<std::string>& input_names,
                const std::vector<double>& input_vals,
                std::vector<double>& output)
{
    for (size_t i = 0; i < input_vals.size(); i++)
    {
        output[i] = input_vals[i] * 10.;
    }
}

GAMBIT_LIGHT_REGISTER_PRIOR(user_prior)
```

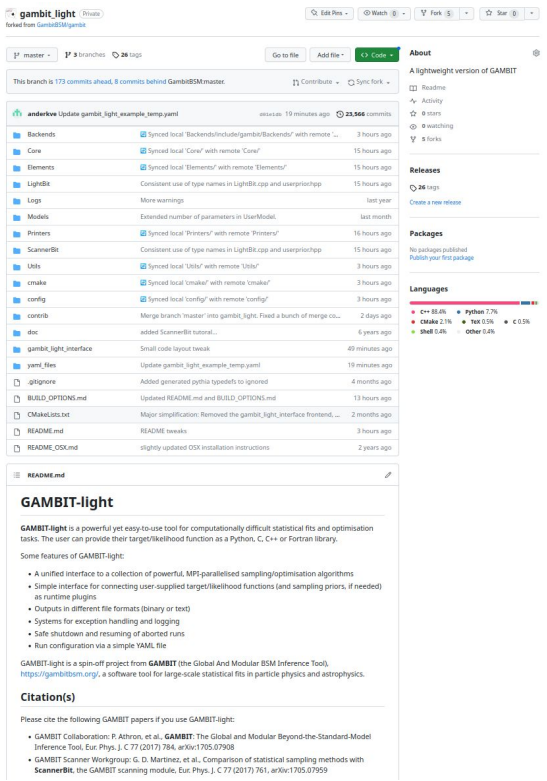
Also: user-supplied prior transformation

```yaml
UserModel:

  p1:
    name: param_name_1
  p2:
    name: param_name_2
  p3:
    name: param_name_3
  p4:
    name: param_name_4
  p5-p7:
    name: param_name_

UserPrior:

  lang: python
  user_lib: gambit_light_interface/example_python/example_prior_transform.py
  func_name: user_prior

UserLogLikes:

  py_user_loglike:
    lang: python
    user_lib: gambit_light_interface/example_python/example.py
    func_name: user_loglike
    output:
      - py_user_loglike_output_1
      - py_user_loglike_output_2
      - py_user_loglike_output_3

  cpp_user_loglike:
    lang: c++
    user_lib: gambit_light_interface/example_cpp/example.so
    func_name: user_loglike
    input:
      - param_name_2
      - param_name_3
    output:
      - cpp_user_loglike_output_1
      - cpp_user_loglike_output_2
      - cpp_user_loglike_output_3

```

4. For GAMBIT developers: how do we maintain it?

- Will describe the current setup – we can change this as needed
- **github.com/GambitBSM/gambit_light** is a fork from our main repo **github.com/GambitBSM/gambit**:





- Will describe the current setup – we can change this as needed
- **github.com/GambitBSM/gambit_light** is a fork from our main repo **github.com/GambitBSM/gambit**
- Only some updates on **gambit** are relevant for **gambit_light** (Core, ScannerBit, Printers, …)
- The branch **gambit:gambit_light_sync** contains
    - a list of the **gambit** files that should be identical on **gambit_light**
    - a GitHub Actions workflow that autogenerates pull requests on **gambit_light** whenever some of these files are updated on **gambit**
- Workflow is currently set to sync **gambit:gambit_light_sync → gambit_light:gambit_light_sync**
- *Example:*
    - On **gambit**: a merge **master → gambit_light_sync** will generate a pull request on **gambit_light** with relevant updates for **gambit_light:gambit_light_sync**
    - On **gambit_light**: when PR is checked and merged, we can merge **gambit_light_sync → master**
- Using the branches **gambit_light_sync** is just to make syncing a bit more manual for now – in the future we can directly sync **gambit:master → gambit_light:master**

- All files are either **fully synced** or **not synced at all** – no partial syncing
- Most files on **gambit** don't exist on **gambit_light**
- Many files on **gambit_light** (e.g. CMakeLists.txt) are completely detached from the corresponding file on **gambit**
- All such *non-synced* **gambit_light** files can be modified directly on the **gambit_light** repo
- For *synced* files where we need small modifications between **gambit** and **gambit_light**, we can implement the changes on **gambit** with

```
#ifdef GAMBIT_LIGHT
  …
#endif
```

- From the GitHub perspective, the file is fully synced between **gambit** and **gambit_light**. (But it will generate different behaviour when compiled on **gambit_light**.)

```
83          template<typename TYPE, typename... args> TYPE getValue(args... keys) const
84          {
85            const YAML::Node node = getVariadicNode(keyValuePairNode, keys...);
86            if (not node) inifile_error().raise(LOCAL_INFO,"No inifile entry for [" + stringifyVariadic(keys...) + "]");
87            return NodeUtility::getNode<TYPE>(node);
88          }
89
90          template<typename TYPE, typename... args> TYPE getValueOrDef(TYPE def, const args&... keys) const
91          {
92            const YAML::Node node = getVariadicNode(keyValuePairNode, keys...);
93            if (not node)
94            {
95                return def;
96            }
97            return NodeUtility::getNode<TYPE>(node);
98          }
99          /// @}
100
101         /// Getters for model/parameter section
102         /// @{
103         template<typename TYPE> TYPE getModelParameterEntry(str model, str param, str key) const
104         {
105           if (not parametersNode[model][param][key]) inifile_error().raise(LOCAL_INFO,model + "." + param + "." + key + "not found in inifile.");
106           return parametersNode[model][param][key].as<TYPE>();
107         }
108         bool hasModelParameterEntry(str model, str param, str key) const;
109         /// Return list of model names (without "adhoc" model!)
110         const std::set<str> getModelNames() const;
111         const std::vector<str> getModelParameters(str model) const;
112         /// @}
113
114         /// Getter for options
115         const Options getOptions(str key) const;
116
117       protected:
118
119         /// Read in the actual YAML file
120         YAML::Node filename_to_node(str);
121
122         /// Do the basic parsing of the YAML file
123         void basicParse(YAML::Node,str);
124
125         /// Print a node to file
126         void printNode(YAML::Node,str,bool);
127
128        private:
129
130         YAML::Node YAMLNode;
131         YAML::Node keyValuePairNode;
132         YAML::Node parametersNode;
133         YAML::Node priorsNode;
134         YAML::Node printerNode;
135         YAML::Node scannerNode;
136         YAML::Node logNode;
137         #ifdef GAMBIT_LIGHT
138           YAML::Node userModelNode;
139           YAML::Node userPriorNode;
140           YAML::Node userLogLikesNode;
141         #endif
142     };
143
144
145   }
146
147 }
148
149 #endif /* defined(__yaml_parser_base_hpp__) */
```

- This is an experiment – we'll have to tweak things to find the best system for easy development + minimal duplicated maintenance
- Revisit and evaluate at the next face-to-face GAMBIT meetings

5. Future plans

- Code development
  - Keep testing the **gambit** → **gambit_light** syncing
    - First big test: the PR for Python scanners
  - Polish the **gambit_light** examples and documentation
  - PR for initial code updates on **gambit**
  - Document **gambit_light** in the “GAMBIT 2” paper
  - Make **first public release**
  - Next: absorb GAMBIT bugfixes and improvements as they arrive
    (fast-slow, continual learning, …)

- Some ongoing projects that will use GAMBIT-light:
  - With the nuclear physics group in Oslo: **unfolding of gamma spectra**
    (Andreas Mjøs, Erlend Lima, Lasse Braseth, Ann-Cecilie Larsen, Morten Hjorth-Jensen + me)
  - With the Norwegian Institute of Public Health: **optimisation of Monte Carlo simulations of disease spread**
    (Ida-Marie Johanson, Jørgen Midtbø, Francesco Di Ruscio, Yat Hin Chan, Birgitte Freiesleben de Blasio + Are and me)


Computador
Inteligente
Letras
Palavras
Aritmética
Música
Jogos
GAMBIT
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FUNÇÕES INTERESSANTES