



Centro Nazionale di Ricerca in HPC,
Big Data and Quantum Computing

BoGEMMS-HPC The Bologna Geant4 Multi Mission Simulator (BoGEMMS) updated to HPC architectures and new I/O interfaces

Status update

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Outline

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- 3. New features in the ICSC activity**
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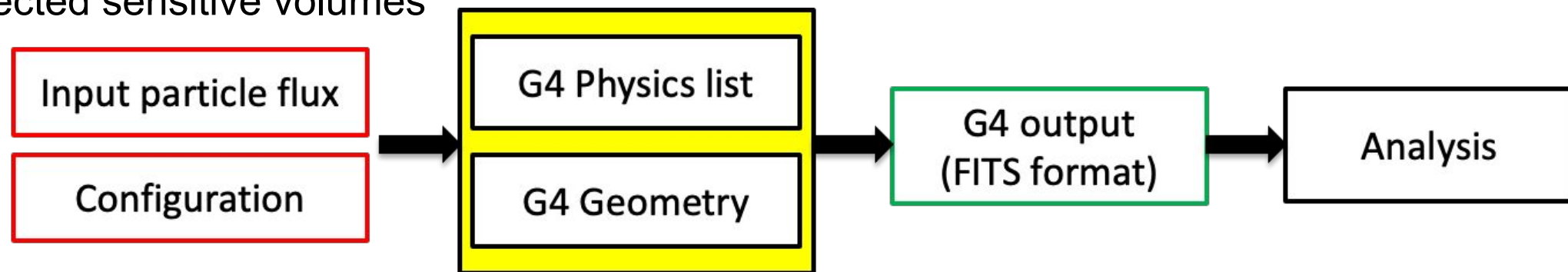


UC overview

- **Pipeline for GEANT4 simulations in HPC environments, with the simulation of the NASA COSI Anti-Coincidence System (ACS) as a test case**
 - The goal of the project is applying new methodologies for multi-threading and multi-node computation in a pipeline for Geant4 multi-purpose simulations in HPC architectures while exploring new I/O interfaces (e.g. CAD geometries, databases). The pipeline will use the Bologna Geant4 Multi-Mission Simulator (BoGEMMS) as baseline simulation framework to validate the results and as starting point for the implementation of new HPC-oriented features.
- **WPs: WP3, WP6**
- **Flagship UC: WP3.4 PIPELINE**
- **Members:**
 - **V. Fioretti (INAF, 3m/yr) - coordinator**
 - **A. Ciabattini (ICSC PhD, UniBo & INAF)**
 - **S. Lotti (INAF, 1m/yr)**

BoGEMMS - Bologna Geant4 Multi-Mission Simulator

- Geant4 (Allison+ 2016) is an open-source C++ toolkit library for particle transport, developed by the CERN and currently maintained by a large scientific collaboration (with members from INFN and ESA)
- **BoGEMMS** is a Geant4-based simulation project started at INAF OAS in 2010 (Bulgarelli+2012, Fioretti+2012, Fioretti+2014), with the aim of building an **Astronomy-oriented** multi-application simulation framework that handles the configuration of the input particles, geometry, output data format (formatted in FITS files) with configuration files at runtime
- The output data model is an “event list”, with each row describing the particle interaction with selected sensitive volumes





BoGEMMS - Bologna Geant4 Multi-Mission Simulator

- BoGEMMS was used for the simulation of operating and proposed space missions such as XMM-Newton, AGILE, Simbol-X, NHXM, Athena, e-ASTROGAM, COSI
- The code was never released to the community because of lack of manpower to implement mandatory features, documentation, manuals, etc
- The ICSC funding represented the perfect opportunity to port BoGEMMS to HPC architectures with multi-threading and multi-node computation and adding new features (CAD and GDML geometry support, new output data format)
- The simulation of the COSI (Compton Spectrometer and Imager) mission (NASA Small Mission program) was selected as testcase for the new BoGEMMS, and the Flagship PIPELINE UC hosts the BoGEMMS pipeline

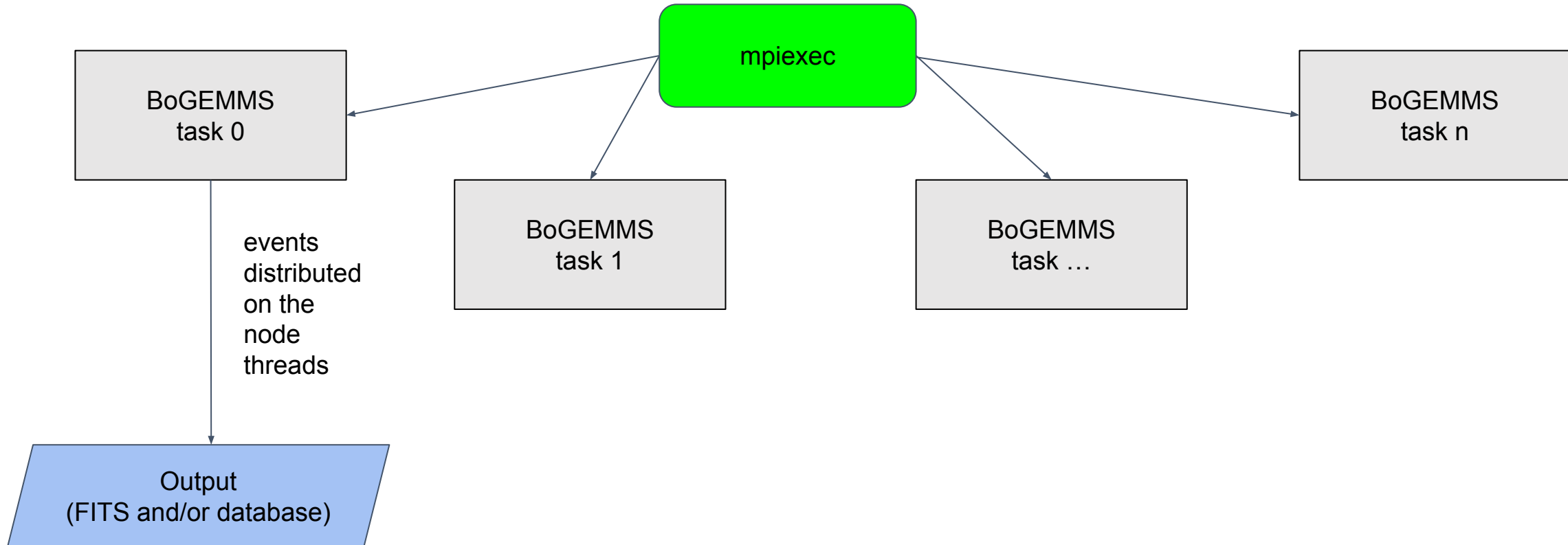


BoGEMMS-HPC (2.0? new BoGEMMS? ...work in progress!)

- BoGEMMS geometries:
 - the user can add new geometry classes and assign a unique ID
 - within the geometry classes the user can read CAD geometry files using the open-source library CADmesh
 - TBD: reading and configuring CAD geometries with a configuration file at runtime
 - the user can read GDML (Geometry Description Markup Language) geometries and assign the sensitive volumes using a configuration file at runtime
- BoGEMMS output: FITS files, SQLite database
- BoGEMMS now supports the Geant4 multi-threading (MT) built-in feature that distributes each event on different threads
 - when a thread writes on FITS files, the other threads are placed on hold
- BoGEMMS now supports the G4-mpi library (K. Murakami (KEK)) for parallel computation, distributed by Geant4 but not included in the Geant4 installation
 - tested with open MPI
 - BoGEMMS runs independent applications (with separated output) on different nodes.

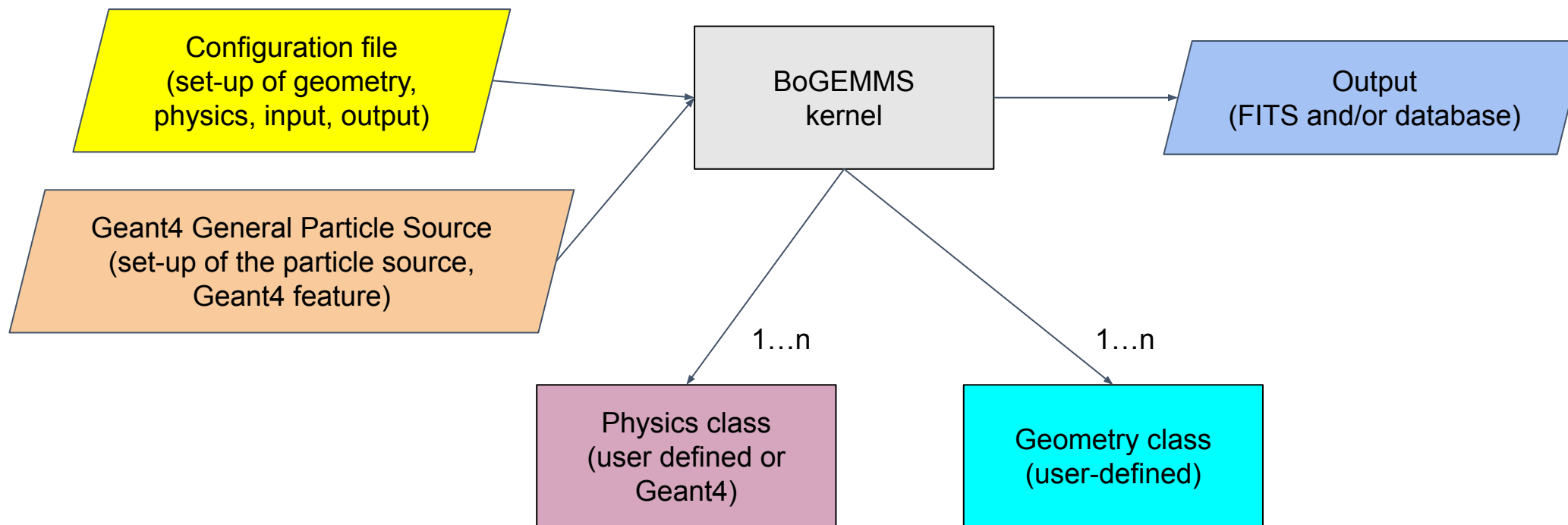


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Next steps in the near future

- Testing BoGEMMS on the OAS local cluster and HPC architecture
 - a singularity container with cfitsio, openmpi, SQLite, Geant4 v11.1, G4-mpi has been prepared
 - we could ask for a Class Test in the INAF-CINECA MoU (1 month trial)
- Developing a python analysis script for reading the database
- Cleaning the code, writing the manual, preparing the gitlab repository
- Performance analysis using the testbed

Further possible actions:

- extending the G4MPI library to secondaries?
- adding modularity for using CAD files as input to the simulation, selecting geometries and physics lists



Schools, Courses, Publications

Reports:

- A. Ciabattoni et al., “Verification of optical processes in Geant4 for the simulation of the COSI mission: using simple slabs as test case”, OAS Bologna Technical Report, 2023
- A. Ciabattoni et al., “Validation of optical processes in Geant4 for the simulation of the COSI mission: the CLAIRE simulation”, OAS Bologna Technical Report, 2023

Schools:

- A. Ciabattoni, Summer School on Parallel Computing, Cineca - Casalecchio di Reno, Italy, 3-14 July 2023

Courses:

- “Introduction to Leonardo HPC cluster, for users and developers”, Cineca- BOLOGNA on October 27th 2023.

