

## Abstract

Recent developments at the UK National Data Centre, hosted by UK Radionuclide Laboratory GBL15 have significantly improved the data processing capabilities for IMS radionuclide data.

The GBL15 analysis sequence for gamma and beta-gamma spectral data employs software written using Python, SQL, Bash and ROOT languages to provide a comprehensive, automatically generated interpretation of each sample. The software is able to identify samples of interest, probe the IMS network for preliminary data captured during the sample acquisition, independently verify the identification of nuclides of interest, and flag this to GBL15 Radionuclide Specialists.

This poster summarises the work that has gone in to developing a custom automatic analysis pipeline for radionuclide data; through the design and incorporation of separate analysis sequences. It also presents opportunities for further enhancing the capability of automated radionuclide analysis and data fusion in the UK.

## System Overview

The aim of this work is to provide a single terminal that is capable of running a full analysis of the radionuclide data from the CTBT IMS.

The system is built on a high performance machine running CentOS 7 and can be easily cloned. A series of computer codes, utilising various languages are employed sequentially.

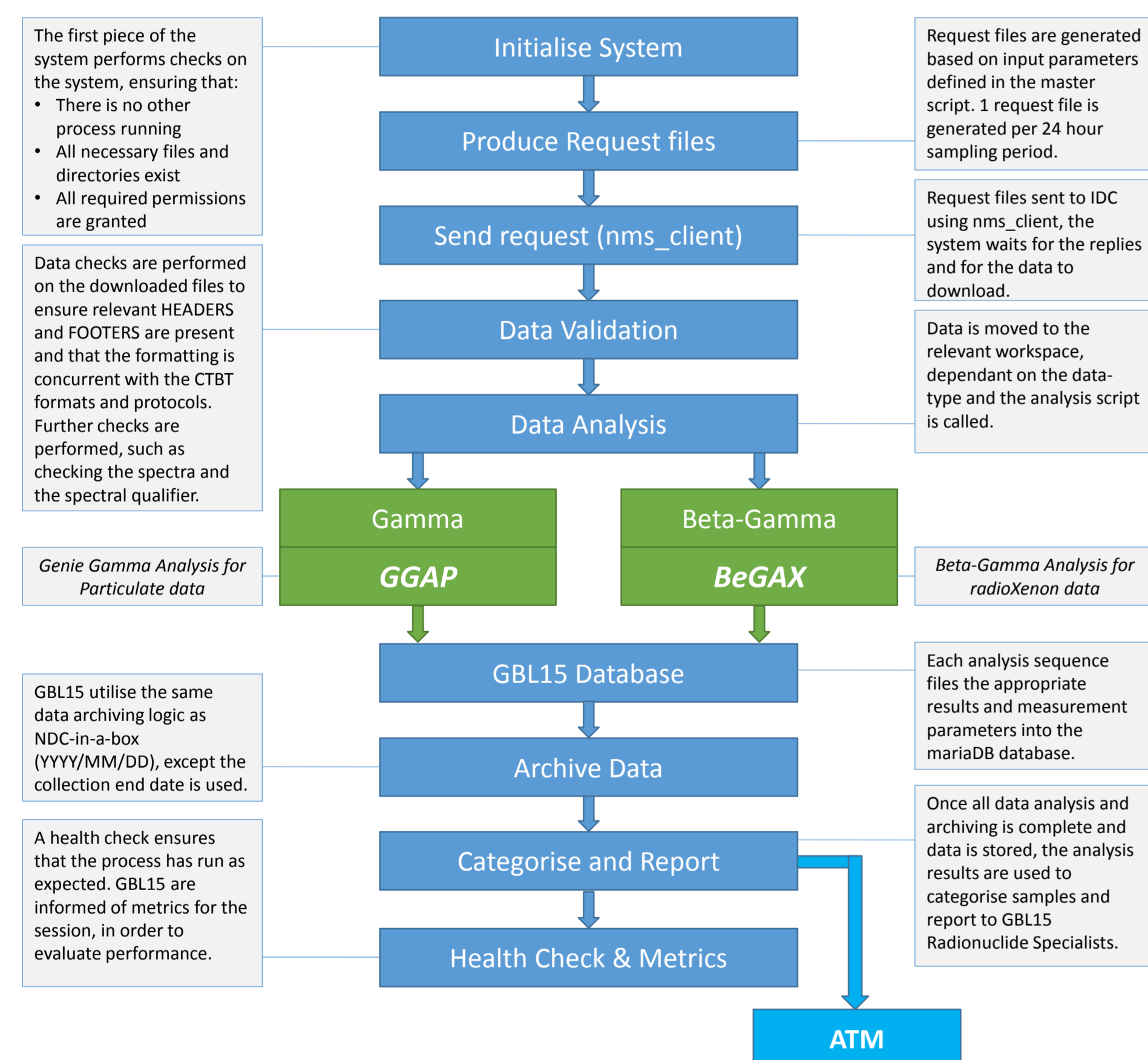
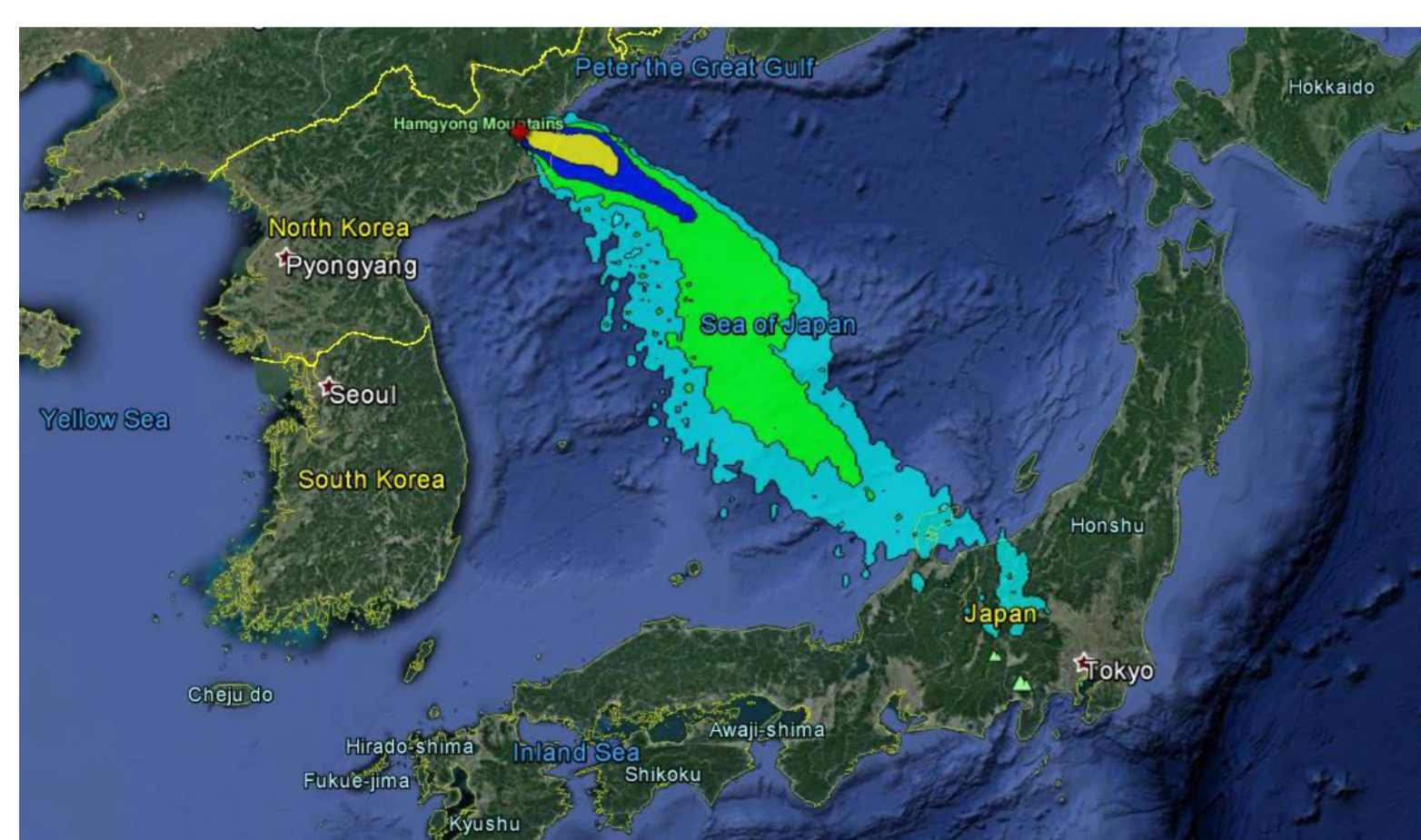


Figure 1. Overview of the Radionuclide Analysis Pipeline

Figure 2. Hysplit ATM output of an emission originating from the DPRK



## Gamma Analysis – GGAP

### Genie Gamma Analysis for Particulate data

GBL15 have utilised Canberra's long established Genie2000 analysis algorithms for peak-fitting and gamma spectrum analysis. In order to be able to perform the Genie analysis, it is currently required that a corresponding windows PC is used in conjunction with the NDC computer.

Figure 3 explains how the data is manipulated in order to incorporate Genie into the process.

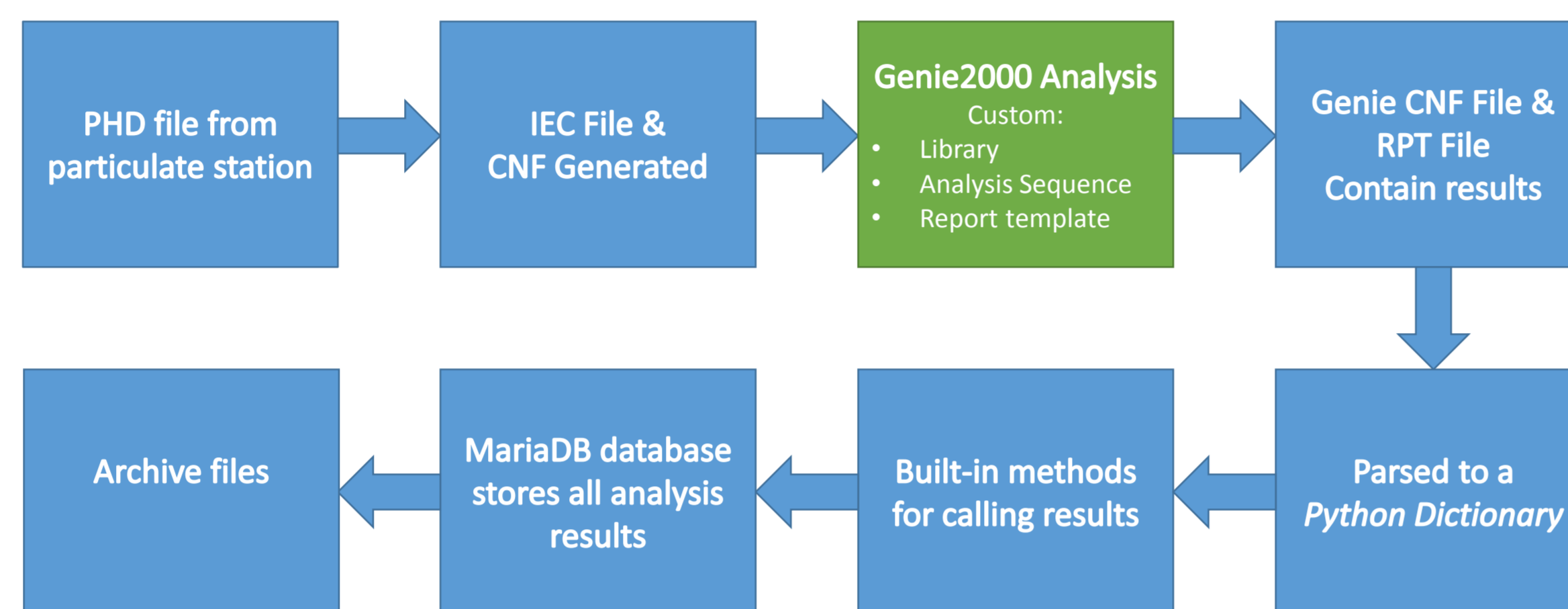


Figure 3. GGAP process diagram

Part of the process is repeated in order to calculate both activity and activity concentration, as well as MDA and MDC for each radionuclide. GGAP is able to interface with the GBL15 database to store the results.

## Canberra Genie Python packages – Development

Canberra have recently developed Python-based tool (SDK package), allowing access to the Genie analysis algorithms. It is possible to run these scripts from a Linux machine, thus eliminating the remote connection to a Windows terminal. This upgrade will provide a significant increase in processing speed for the GGAP system.

Finally, the RIMMER (Randomised Iterative Monte Carlo Model for ENSDF Records) code will be plugged in to the pipeline, providing branching ratios and CCF (Coincidence Correction Factors) calculated from nuclear data and modelled efficiencies. [1-4]

## Atmospheric Transport Modelling

GBL15 exploit the Hysplit ATM modelling tool, developed by NOAA (National Oceanic and Atmospheric Administration). GDAS wind vector data is used and two types of models are run:

- 1) *Backward Simulations*
  - i. Upon the reporting of a high-category sample from the IMS, an automated backward simulation is triggered. This aims to identify a possible source location for the radionuclides.
- 2) *Forward Simulations*
  - i. In order to proactively predict 'hits' on the IMS system, GBL15 have developed a code which models the effect of a constant radioxenon output from a series of known medical isotope production facilities and locations of special interest.
  - ii. This results in the ability to model the contribution to IMS radioxenon measurements that are not weapons test related. This divides the samples of concern from those that are expected.

## Beta-Gamma Analysis – BeGAX

### Beta-Gamma Analysis for Radioxenon data

BeGAX has been designed as dual purpose, for use in either:

- 1) *Manual Mode*
- 2) *Pipeline Mode*

The standard BeGAX analysis provides an iterative breakdown of the various calculations and corrections used in the NCC (Net Count Calculation) method for beta-gamma analysis. These are outlined in Figure 4.

Pipeline Mode is instigated as part of the NDC analysis sequence. Whilst the analysis logic is the same for both, *Pipeline Mode* offers the following additional features:

- Find the relevant GASBKPHD and QCPHD files for the SPHD
- Iteratively work through all samples in a workspace
- Connect to the mariaDB hosted GBL15 database and insert results

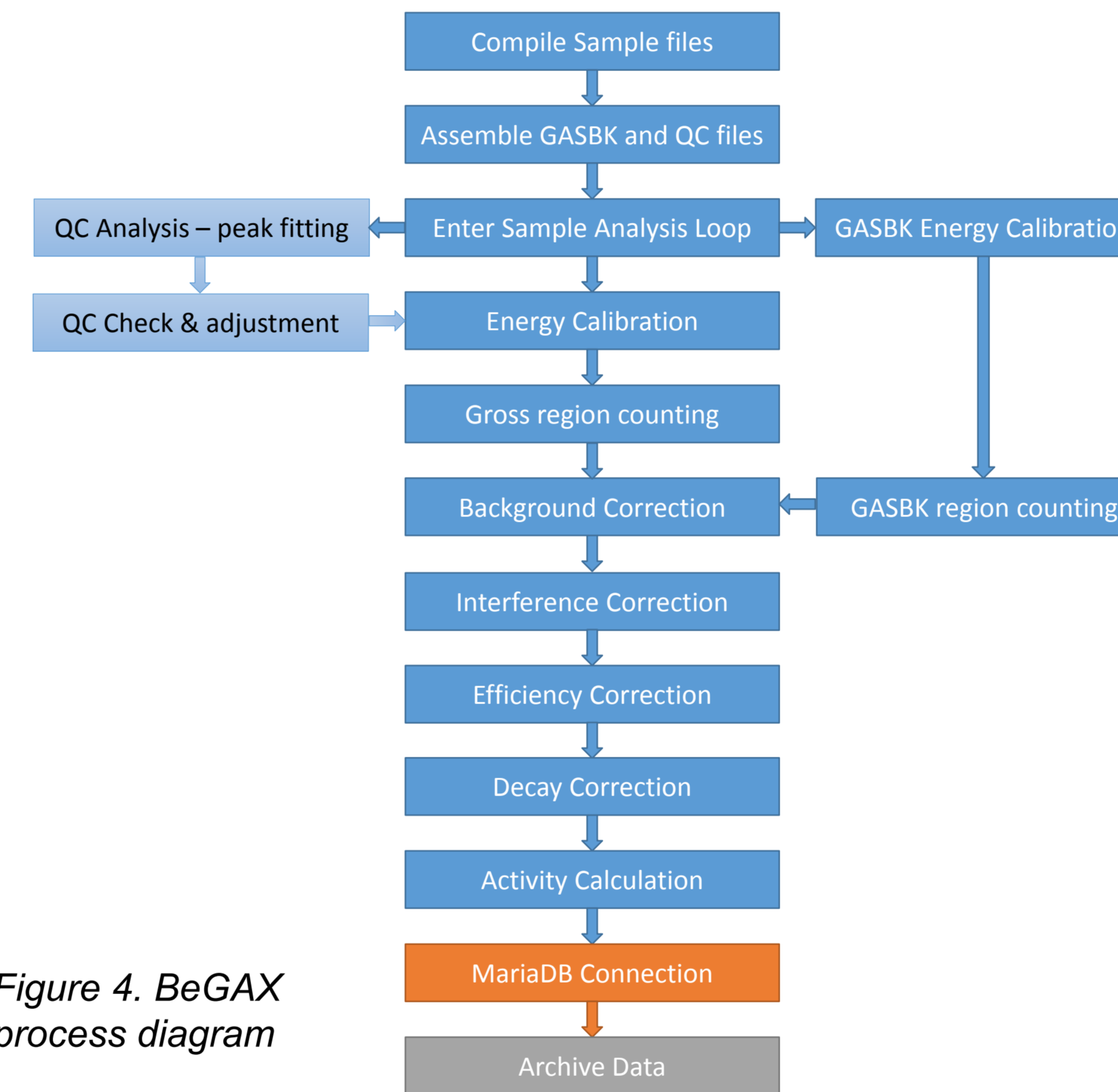


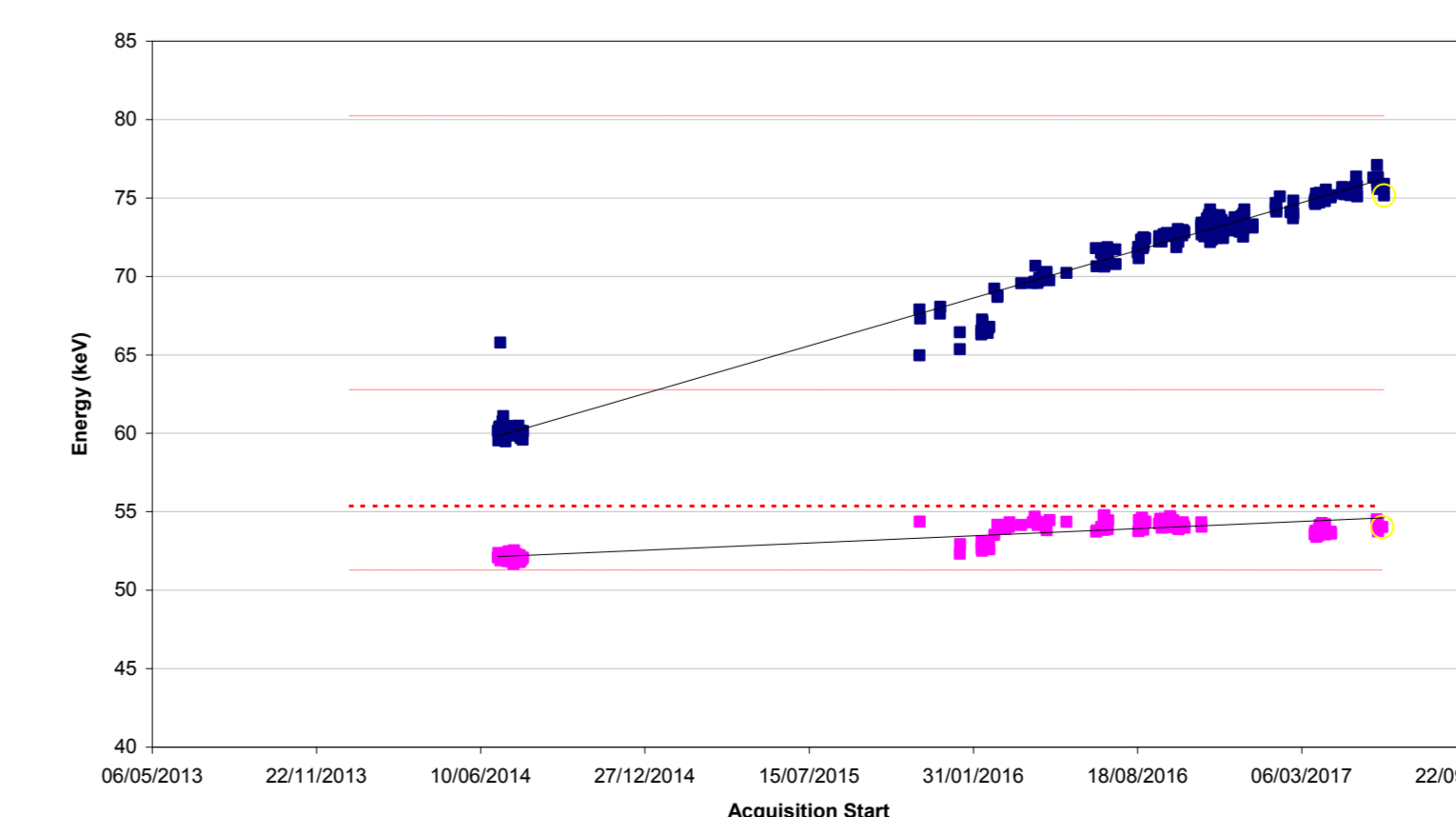
Figure 4. BeGAX process diagram

## BeGAX Development – Peak Fitting & Quality Control

Peak fitting is being developed as an upgrade in a new version of BeGAX. The code will utilise the PyROOT packages in order to perform a series of peak fits within the beta-gamma coincidence spectrum.

Following this, the GBL15 quality control analysis code for beta-gamma systems will be incorporated. This provides information on the  $\beta$  and  $\gamma$  energy calibrations, resolution and count rate for monitoring detector performance.

Figure 5. Chart showing the increase of the Cs-137 662 keV FWHM in a NaI detector between 2014 and 2017



## Initial Testing

Initial tests of the systems showed how both reliability and accuracy exceeded the already mature NDC-in-a-box pipeline. A big advantage to the new system is that it is built on a high-performance Linux terminal rather than a virtual operating system. This has provided a vast increase in processing speed.



Figure 6. Linux Terminals at the UK NDC

## The GBL15 NDC Database

The GBL15 NDC Database is written in mariaDB (uses SQL syntax) and has taken inspiration from the IDC-developed 'NDC-in-a-box'. Currently, the database houses 15 tables:

Table Name	Description
sample_info	Contains information on the sample file
collection_data	Contains information on the sample collection
acquisition_data	Contains information on the measurement acquisition
station_info	Contains information on the IMS stations
rn_library	Radionuclide library of 160 nuclides, from ENSDF
gamma_library	Radionuclide library 1377 gamma lines, from ENSDF
categorisation_data	Results data for categorising samples
xenon_data	Results data for Noble Gas stations
particulate_data	Results data for Particulate stations
bg_energy	Beta & gamma energy calibration coefficients
g_energy	Gamma energy calibration coefficients
bg_efficiency	Beta-gamma efficiency calibration coefficients
g_efficiency	Gamma efficiency calibration coefficients
library_log	Updated when a new library is added
background_library	Contains information on the relevant DETBK files

The tables contain all of the necessary data, without duplicating data from the PHD files. New software will be developed in order to make use of the mass of information recorded in these tables.

There are many opportunities for new software packages to interface with this comprehensive and concise database. Reports can be automatically generated from the database and trends can be observed graphically. A widget-based program is being written to display live data as a layer in Google Earth.

## Conclusion

GBL15 has developed a fully independent radionuclide analysis system that is capable of quickly and accurately analysing IMS data, providing GBL15 Radionuclide Specialists with a solid foundation for further, expert investigation. This provides the UK National Authority with the scientific information that they require, ensuring confidence in the Comprehensive Test Ban Treaty.