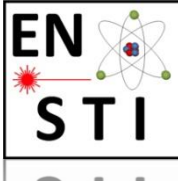


Running FLUKA inputs with Geant4

CERN/EP/SFT Meeting
02 Apr 2019

Vasilis.Vlachoudis@cern.ch



EN-STI-BMI

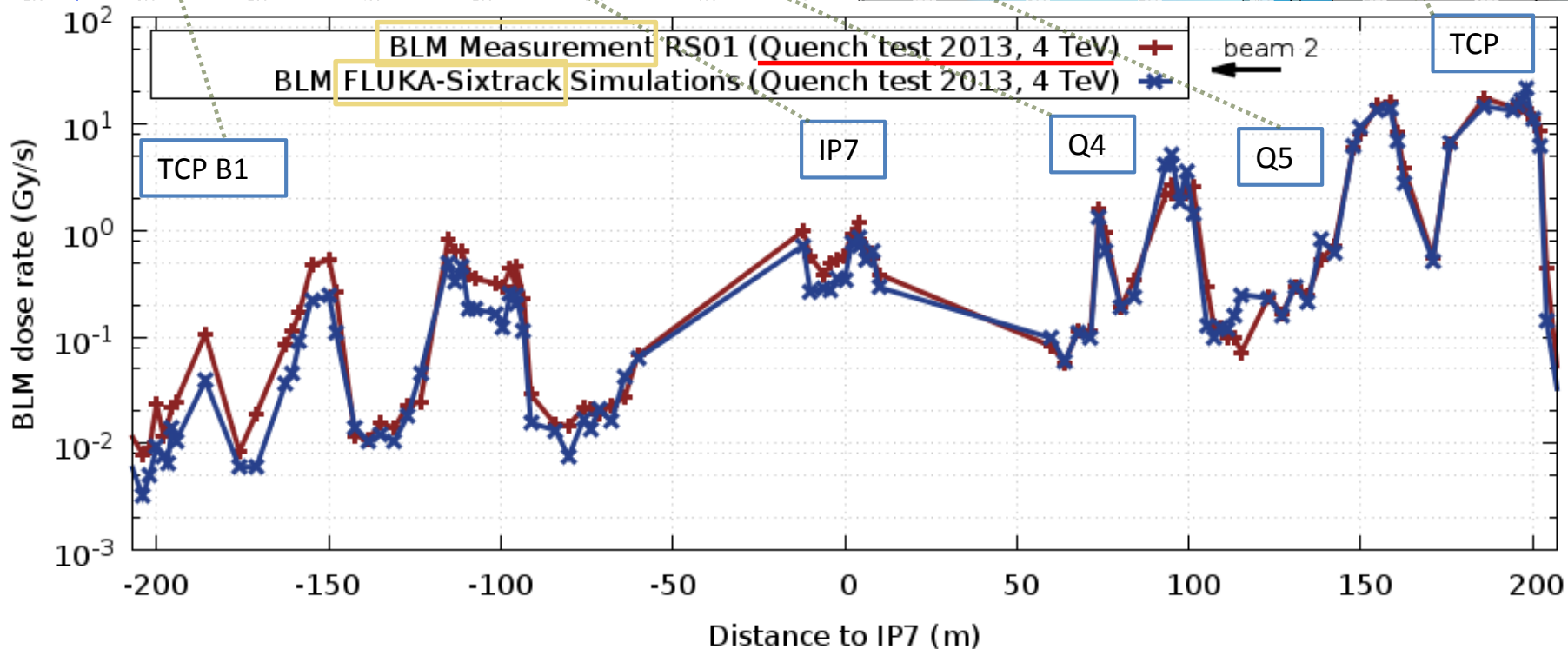
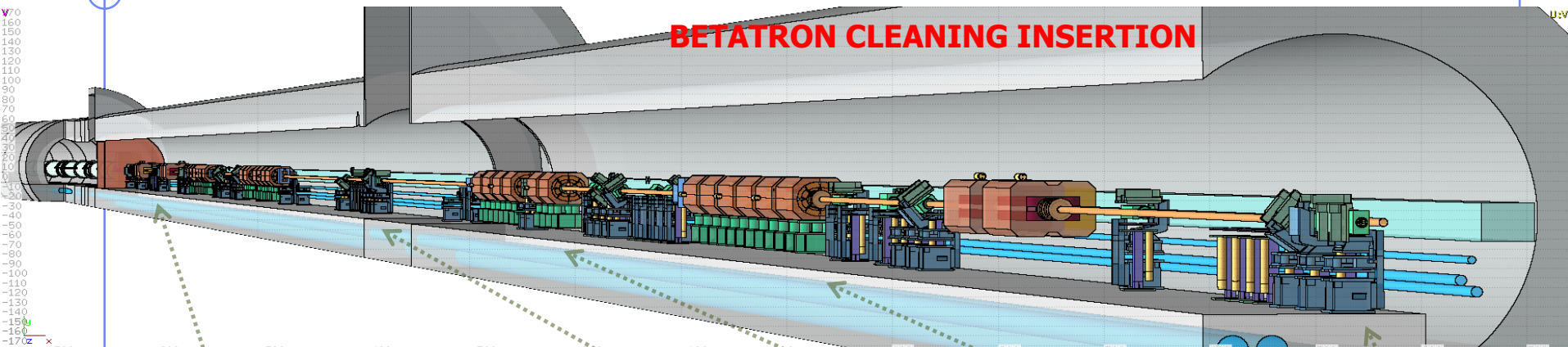
EN-STI- Engineering Department – Source Target Interactions

- Among others: ...the group is responsible for the **design**, construction, operation of all intercepting devices across the CERN complex...

-BMI Beam Machine Interactions

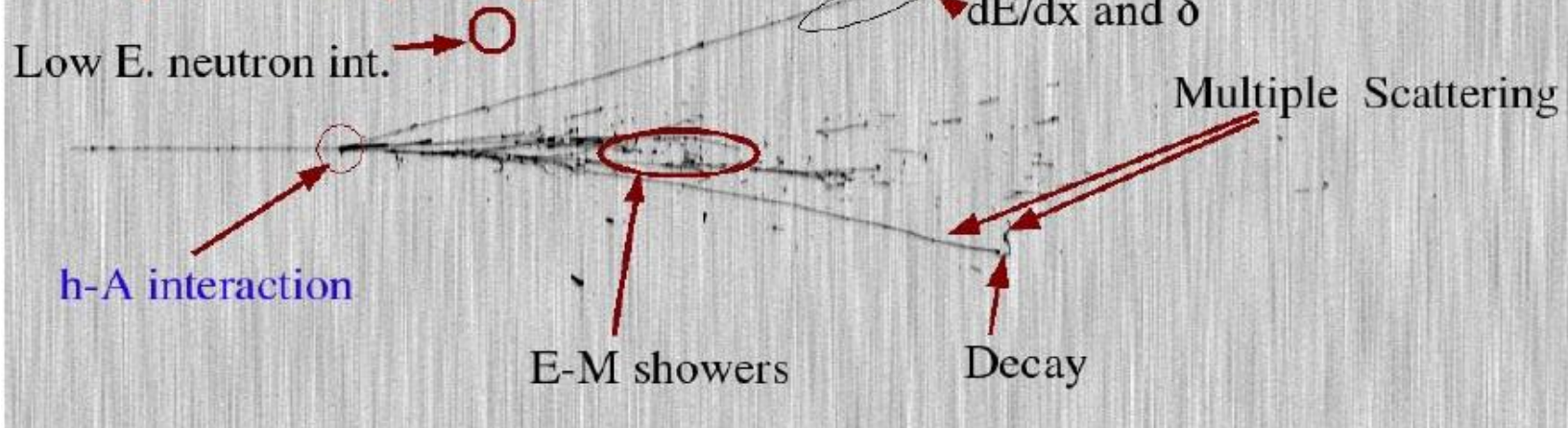
- Our section has strong **computational physics background** mainly in model development (FLUKA), and it is the reference group for beam-matter interactions and beam intercepting devices for all present and future projects at CERN.
(+15years experience)
- Manpower:
 - STAFF: 6
 - Fellows/Students/Associates: ~25

Example: BLM signals in LHC IR7



FLUKA: Interaction and Transport Monte Carlo Code

6 GeV proton in Liquid Argon



- Hadron-nucleus interactions
 - Nucleus-Nucleus interactions
 - Electron interactions
 - Photon interactions
 - Muon interactions (inc. photonuclear)
 - Neutrino interactions
 - Decay
 - Low energy neutrons
 - Ionization
 - Multiple scattering
 - Combinatorial geometry
 - Voxel geometry
 - Magnetic field
 - Analogue or biased
 - On-line buildup and evolution of induced radioactivity and dose
- 14000 registered users
 - User-friendly GUI thanks to *Flair*

Geant4 vs FLUKA [1/3]

	Geant4	FLUKA
Architecture	Toolkit	"Monolithic" code
Extending	Anybody	Not possible for end users
License	G4 license ~ Open Source	Proprietary – closed source
Language	C++ (v11)	Fortran 77 + some F90
Input	Application in C++ Persistency: GDML, textgeom, ...	Card based text input file
Geometry		
... description	Hierarchical	Boolean flat in space
... repetitions	infinite nesting	only one nesting
... similarities to	ROOT (MARS via ROOT)	MCNP, SHIELD, PHITS,...
... solids	up to high order (twisted) + tessellated	up to quadratics (2 nd degree) + voxels (no torus)
... universes	multiple parallel worlds	only one universe

Geant4 vs FLUKA [2/3]

	Geant4	FLUKA
Physics	users responsibility	No free choice (apart some options to enable/disable processes)
... hadronic	multiple models available	PEANUT GINC
... heavy ions	?	BME, RQMD, DPMJET
... leptonic	multiple models	Originating from EGS
... neutronic	point wise HP + low acc.	Group wise + few point-wise
Primary source	Particle Gun, advanced GPS, User specified	Several predefined distributions, pp collisions, radioactive decay, user routine
Biasing	Importance, interaction, leading particle, WW, ...	same
Field	Magnetic, Electric, Gravitational	Magnetic (Electric as a hack)
Radioactive runs	Yes (user coding is required for scoring)	Yes fully coupled prompt&decay run, with separation on settings and scoring

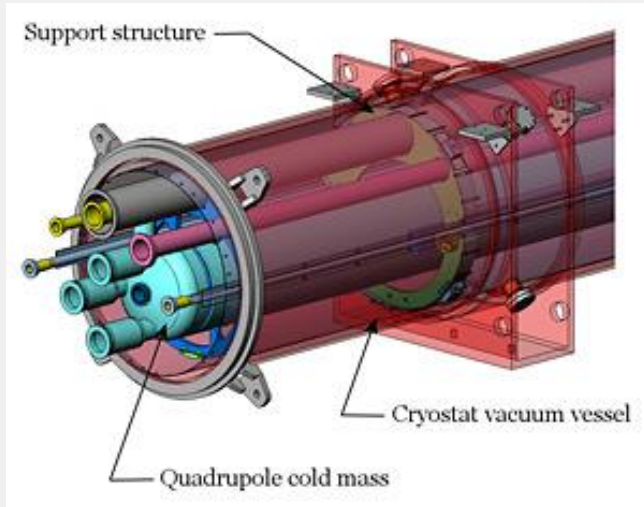
Geant4 vs FLUKA [3/3]

	Geant4	FLUKA
Multi Threading	Yes	No
Scoring	Some built-in + custom SD	Mostly built-in + user coding
... Mesh scoring	built-in + UI	built in on multiple quantities
... Boundary	(built-in) User action	built in
... Track length	(built-in) User action	built in
... Yield	User action	multiple combinations
... Hits	User action (collections)	builtin (detect), mgdraw
... dpa	no	yes (restricted) arcdpa, nres
Post processing	User responsibility	built in (auxiliary tools)
GUI	Various mostly on visualization	flair, simplegeo, ...

... a non exhaustive list

BMI Tools

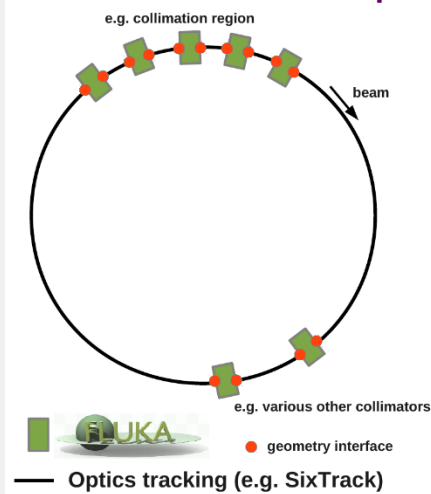
Fluka Element DataBase



Line Builder



Fluka-SixTrack Coupling



FEDB + Line Builder + Coupling helps in creating and simulating assembly of actual beam lines, in an easy, flexible and consistent way...

flair – fluka advanced interface



- Without hiding the inner functionality of FLUKA, flair offers all tools for:

Front-end

- Fully featured Input file Editor;
- Geometry: interactive visualization editing, and debugging;
- Compilation of the FLUKA Executable;
- Running (Spawning on multi-core) and monitoring of the status of one/many run(s)

Back-end

- Post processing of FLUKA output
- Plot generations with gnuplot
- Photorealistic 3D plots with USRBIN data superimposed

Other

- Parametric editing with expressions
- Database of Materials, Isotopes
- FLUKA hypertext manual
- ...

/fleə(r)/ n [U,C] natural or instinctive ability (to do something well, to select or recognize what is best, more useful, etc. [*Oxford Advanced Dictionary of Current English*])

FLUKA Advanced Interface

is more than a graphical Interface

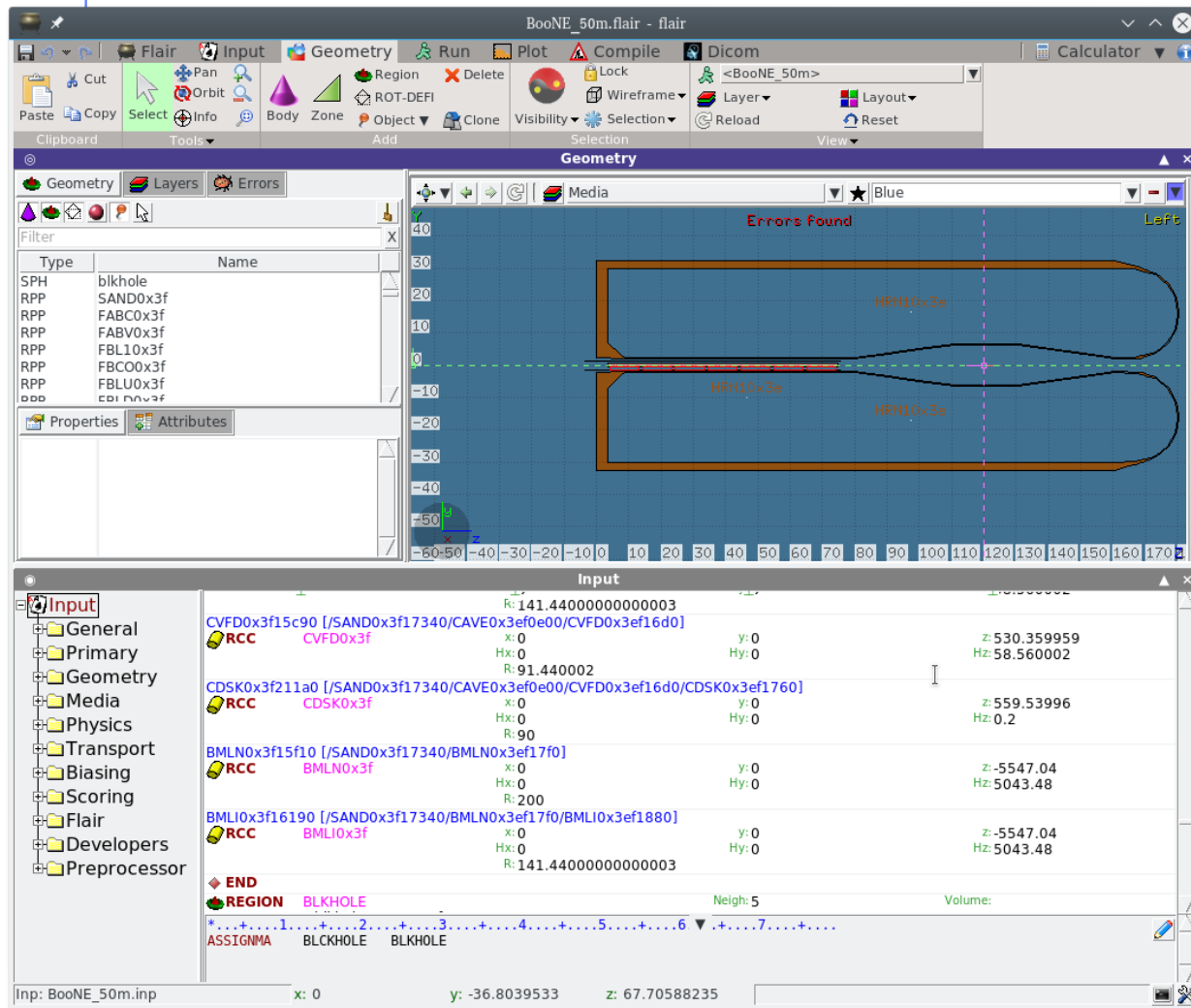
→ is a complete integrated working environment for FLUKA

Greatly enhanced productivity

→ users focus on their problem rather on technicalities

Vasilis.Vlachoudis@cern.ch **...and many more...**

Modern interface



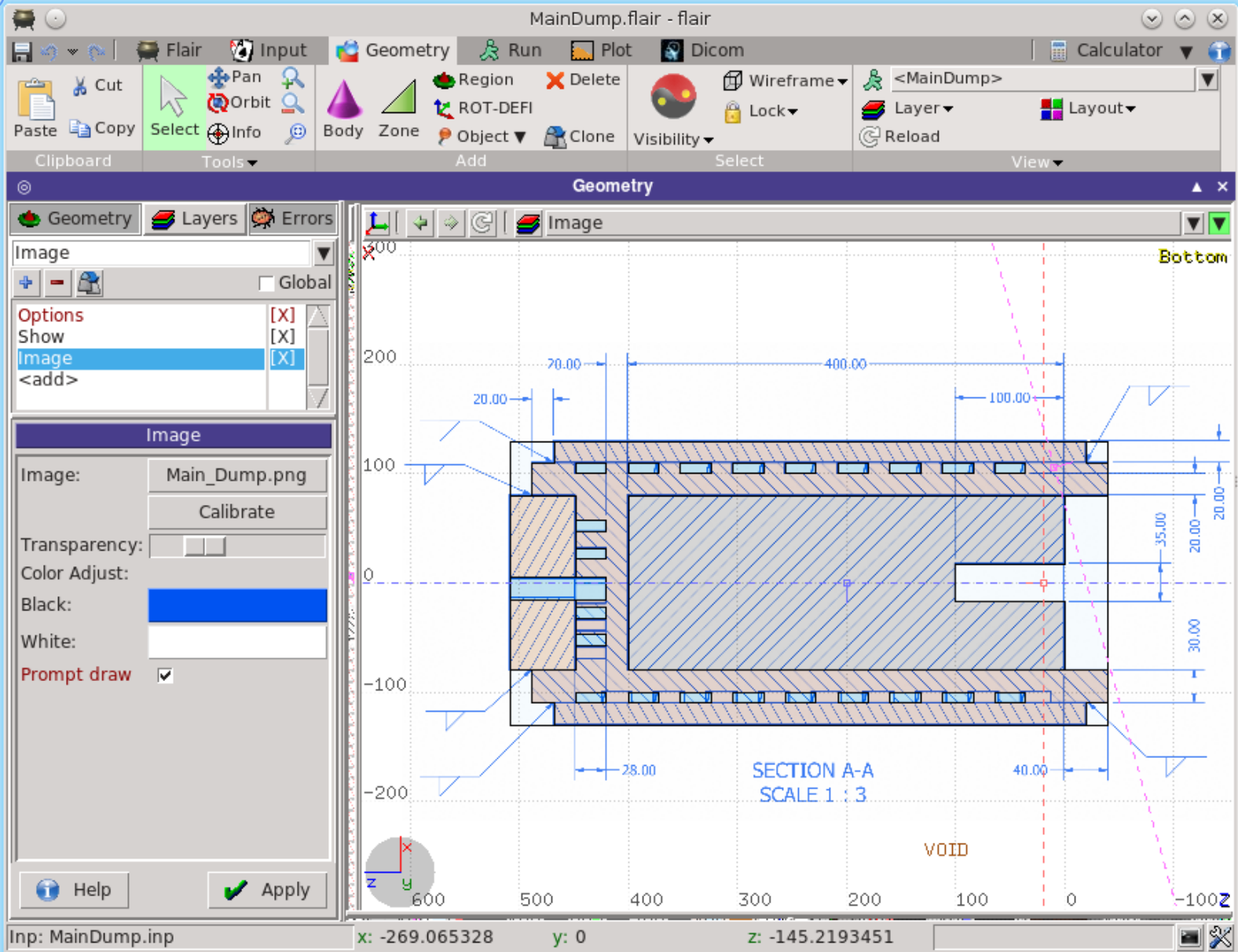
Interface

- Fully customizable interface
- Visual organization of ribbons, tabs, pages etc..
- Online error checking, syntactical and geometrical
- Multi threaded
- Highly optimized

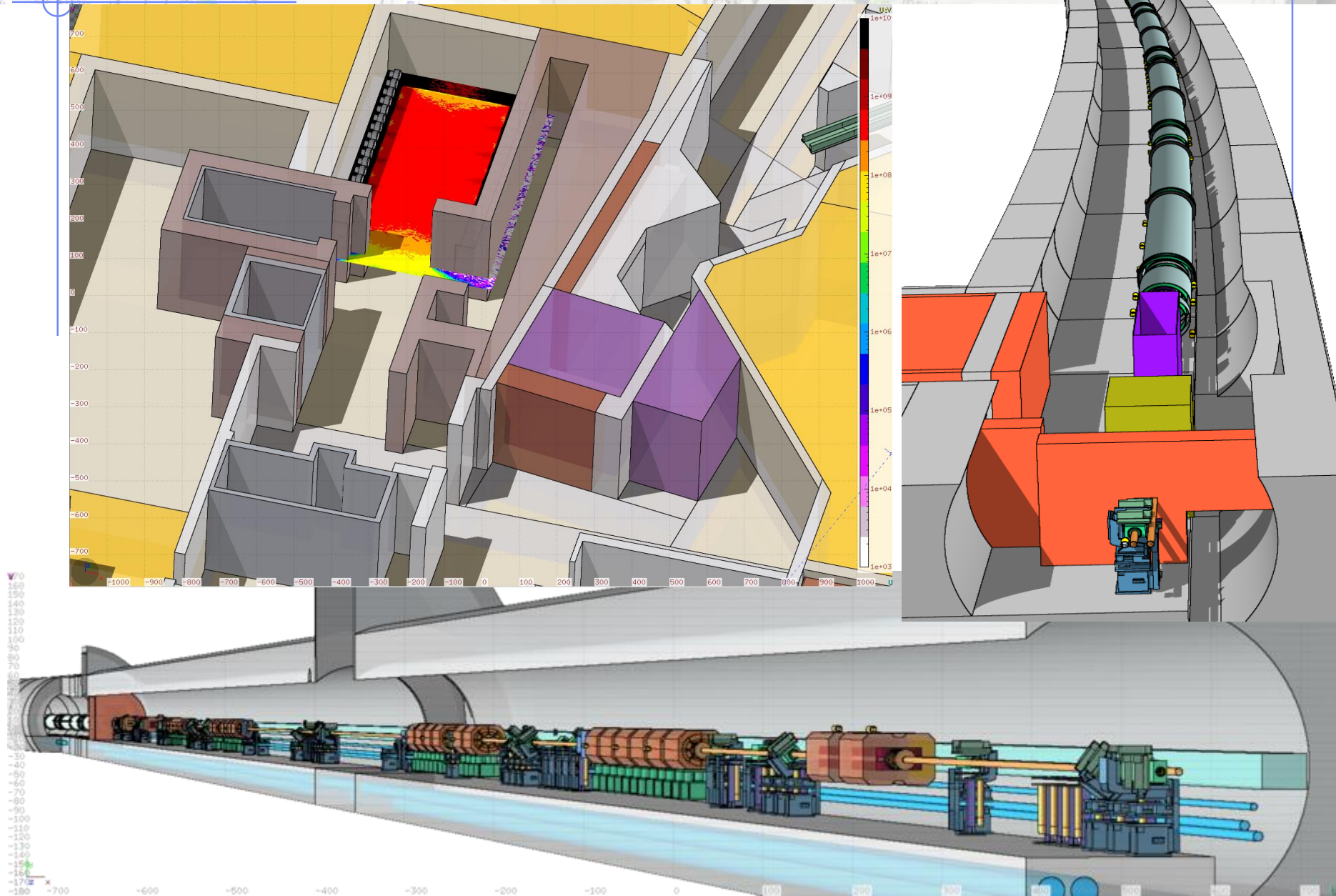
Import / Export

- MCNP [I/O]
- GDML [I]
- DXF [O]
- POVRay [O]
- STL [I experimental]

Overlapping of technical drawings

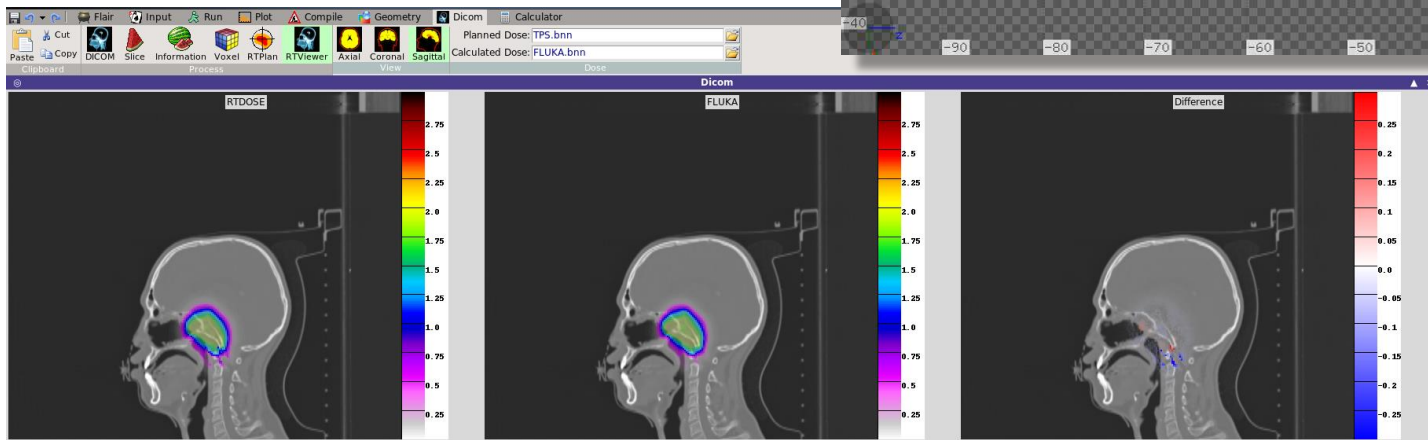
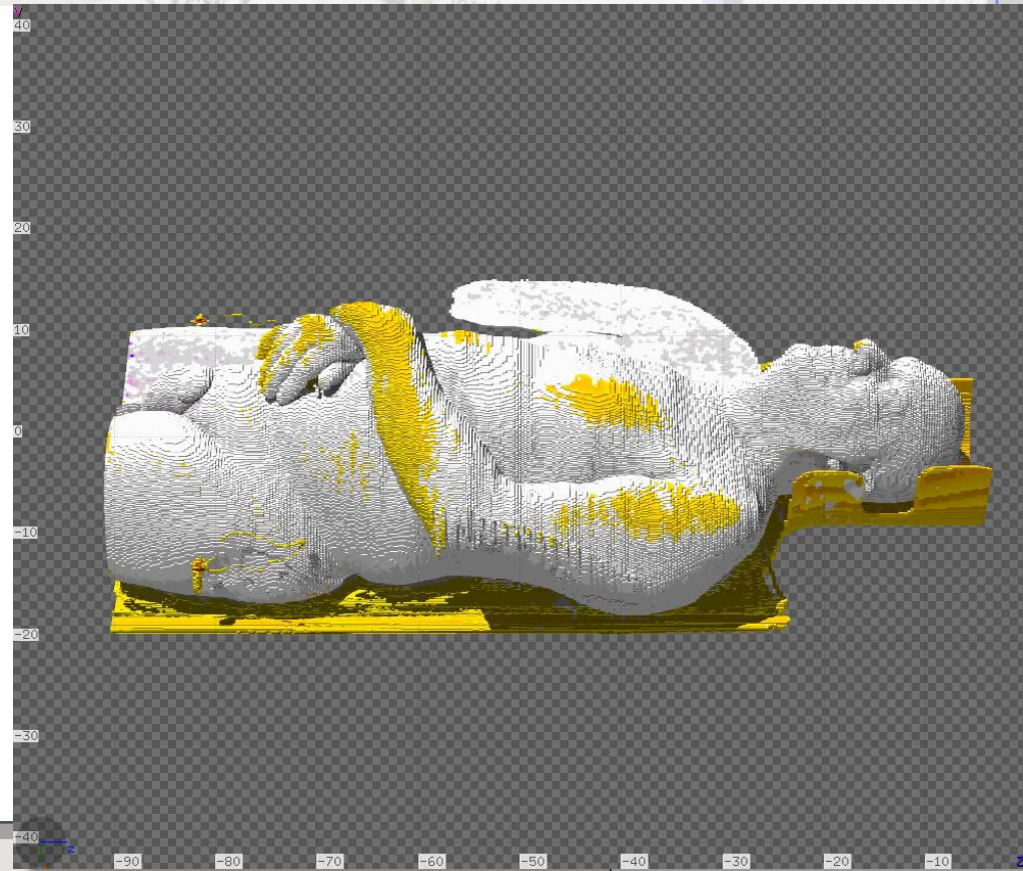


Advanced 3D Display



DICOM importing, CT & PET RT

- Converting DICOM to FLUKA voxel geometry
- Assigning materials via the Schneider parametrization
- Automatic PET scanner generator for most commercial models
- Importing RT-Plan, RT-Dose, RT-Struct information for plan verification and re-optimization



Moira - Motivation

Moira (mi.ra): tentative name from Greek (fate) mythology referring to the 3 goddesses who determined human destinies

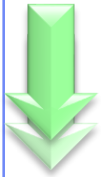
- Our section has invested more than 15 years in developing all the necessary infrastructure for our CERN studies. Always based on FLUKA.
- We need an transparent way to be able to run also other simulation code(s):
 - Important for cross checking and validation
 - Use the best, of what each code can offer
 - Remove "dependency" on a single code
 - ...

Idea:

- Create a hybrid G4 "*application*" that provides a FLUKA experience using the Geant4 toolkit
- Make it as transparent as possible for our users
- Fully integrated with flair
- Expand in the future with all the goodies from each code

Roadmap

current status



- Technical challenges:
Implement an application equivalent to FLUKA inside Geant4
 1. Geometry
 2. Scoring
 3. Biasing
 4. DPMJET
 5. Decay calculations
 6. Custom routines for Magnetic field, specialized sources
 7. Benchmarking and validation
 8. Work on auxiliary modules DICOM, optimizer, etc...
- In parallel “flair” has to be updated to reflect the evolution of the project



Synergies

- Almost all users of FLUKA work through flair
 - ➔ Offering a transparent way to use G4 through flair, it will attract a vast majority of the FLUKA users
- G4 community will benefit from the developments

Current Status: Geometry

- G4Zone: a G4Solid described as the intersection of a number of (in)finite bodies/quadratic surfaces.
 - Re-using as much as possible from the “geoviewer” geometry library (C++) of flair
 - Keep a list of Bodies (surfaces) delimiting the 3D space
 - FLUKA region (union of zones) described as a linked list of G4Zones
- All zones are daughters to a unique mother volume and must “fill” the entire space of the mother volume. No empty gap.
- Logical/Physical volumes are automatically defined for each zone. The transformation/placing is already applied at the body level.
- For the moment no mixing of daughters is permitted: mother with G4Zone and other G4 solids. However it is something possible.
- LATTICE’s appear as zones with “sub-volumes” when a transformation is provided
- Introduction of an external navigator activated when G4Zone exists as daughters
- Using textgeom as input persistency
- + creation of a 2D geometry plotting class in G4

Current Status: Scoring

- Mesh scoring.
 - Reusing as much as possible the existing G4 UI mesh scoring.
 - UserScoreWriter modified to write the output in the same format as FLUKA is using. (To be revised)
- Track length & Boundary crossing, creation of new types using SD detectors
- Total scoring per volume, using the stepping action
- Output: text histogram files.
- Creation of external merging program to combine the statistics from various runs

Various:

- Creation of submission scripts to split into cycles and run in dedicated directory space

Current Status: flair

- Created an abstraction layer of the input file types:
 - Input class
 - ◆ Fluka
 - ◆ Moira (Geant4)
 - ◆ Mcnp
 - ◆ ...
 - Each input class contains all methods for I/O exporting to other formats, plotting, validation,...
- Persistency
 - Input file is written inside the flair project file, with a user-editable format via a text editor. For each card it contains:
 - ◆ comment
 - ◆ list of parameters/values
 - ◆ dictionary of values
 - Each value can be a string, integer, double or expression

Current Status: flair

- Cards:
 - New cards for G4 are automatically created from all the messenger commands
 - Multiple G4 commands are grouped into a macro card for easier editing
- “*Operational*” until now (under testing):
 - Input Editor
 - Running on multi-core
 - Inspecting the files and progress of a run
 - Merging all output data files to combine the statistics
 - Some basic plotting (geometry, mesh, 1D and 2D distributions)
 - Partial conversion of a FLUKA input file to Moira



Summary

- Building a bridge:
 - initially on input level of FLUKA – Geant4
 - ➔ both communities will benefit
- Project already started
 - ... Still in early stage of development
- We need your help/input/guidance for which is the best approach to follow in Geant4
- It is open to anyone who wishes to contribute
- It will be licensed as an open source