Monte Carlo application for the ELIMED beam-line

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Outline

Goals

Model

Results

Future development

Conclusion

Goals

Beam-line design and construction support

- Description of all elements
- Flexibility in parameters/arrangement
- Read-out capabilities

User experiments @ ELI

- User-friendly interface
- Good documentation + extensibility
- Integration with ELI tools

Model

(and the application structure)

Geant4

"Toolkit for the simulation of the passage of particles through matter."

Why?

- history
- licence
- variability
- extensibility

http://www.geant4.org

Application structure

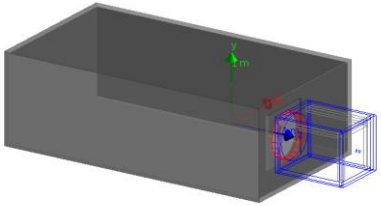
Component design

- geometry *(detector construction + fields)*
- scoring & other *(user actions)*
- source *(primary generator actions)*

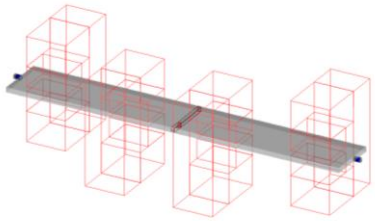
Other general tools

- particle writer *(custom scoring)*

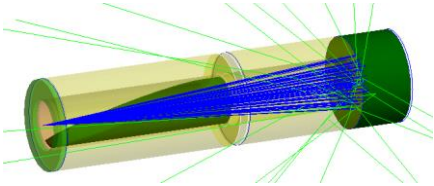
Geometry (components)



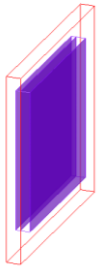
Interaction chamber



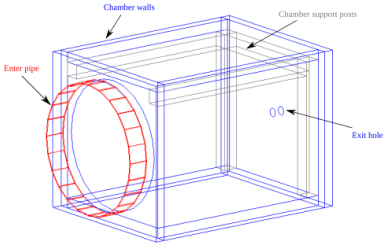
Energy selector



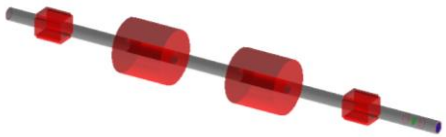
Faraday cup



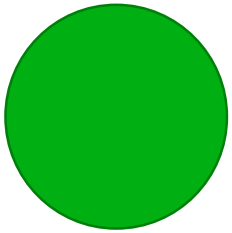
Monitor chamber



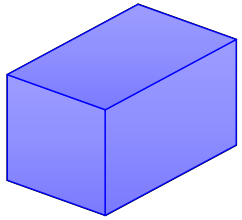
Auxiliary chamber



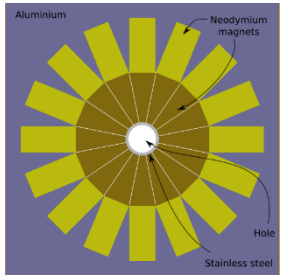
Conventional magnets



Secondary Emission Monitor



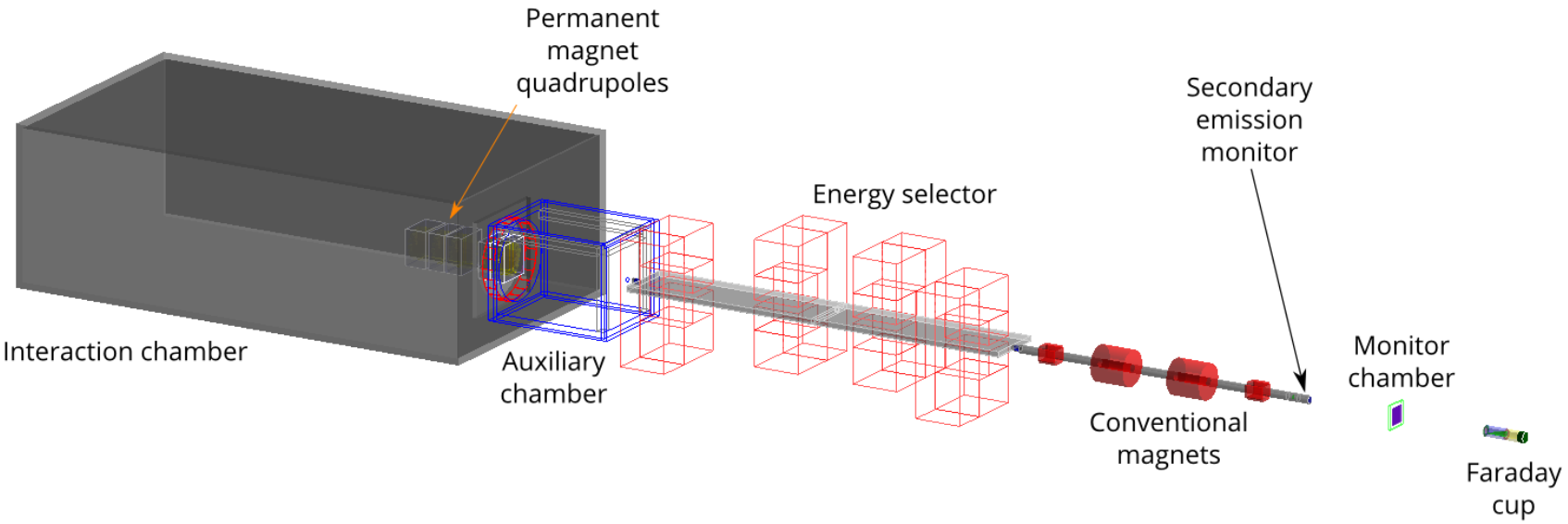
Water phantom



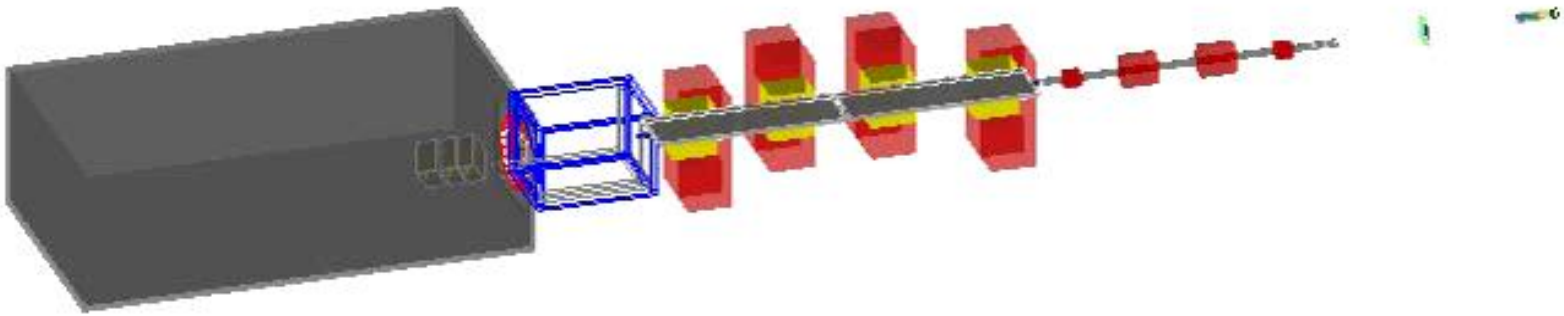
Permanent quadrupole

Add yours...

Geometry (overview)



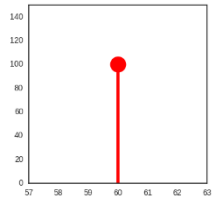
Geometry (overview)



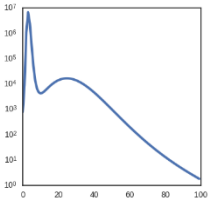
Beam-line configuration for
60-MeV protons

Adaptive source

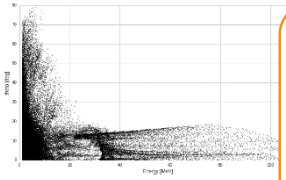
Monoenergetic



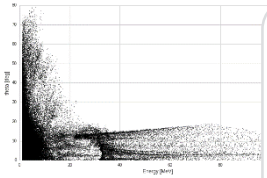
Analytic



PIC 2D



PIC 3D



...

?

Network

Particle writer – universal scoring

What?

- all particle kinematic and track info

Where?

- any volume, virtual planes

When?

- enter, exit, step, create, stop
- physics process
- activation

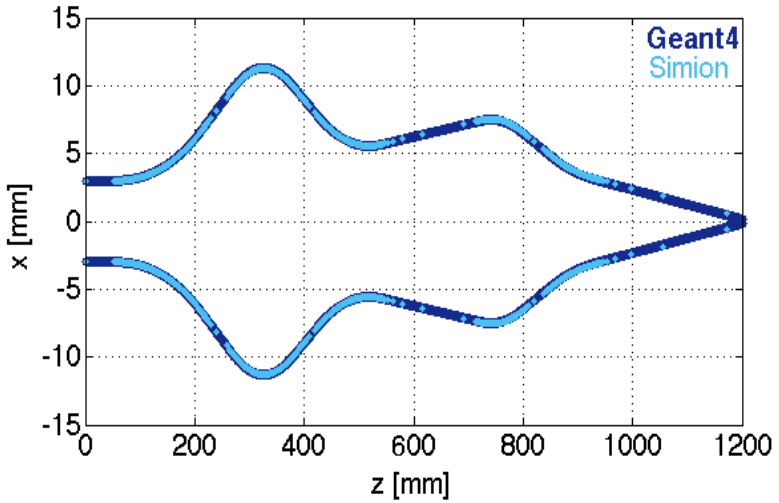
(implemented as combination of sensitive detector, parallel world, step action, stacking action)

(sub-sub-sub-subset of the)

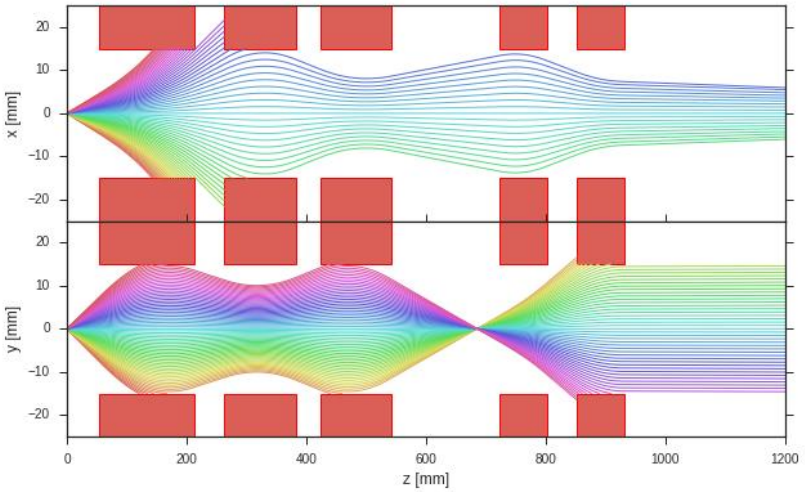
Results

Tracks (benchmark 1)

Comparison between Geant4 and SIMION

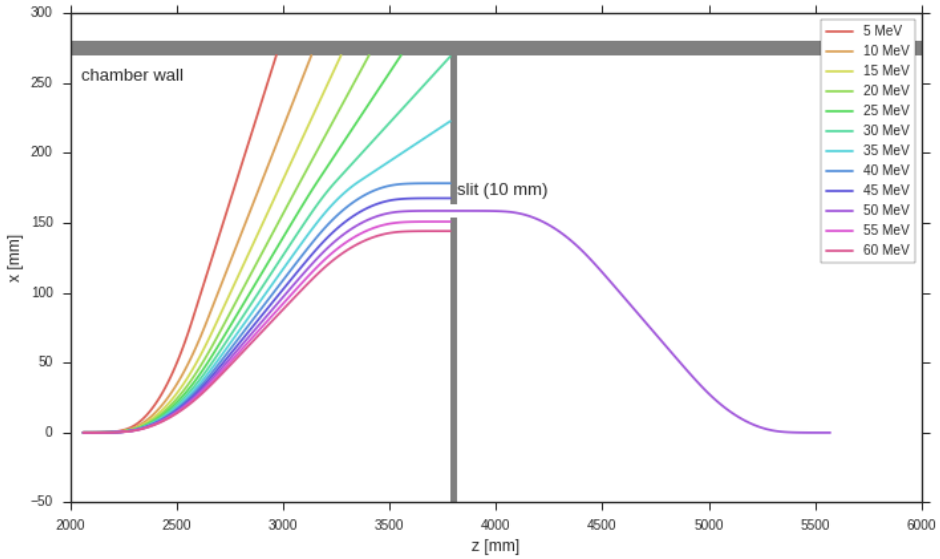


60-MeV protons in PMQ

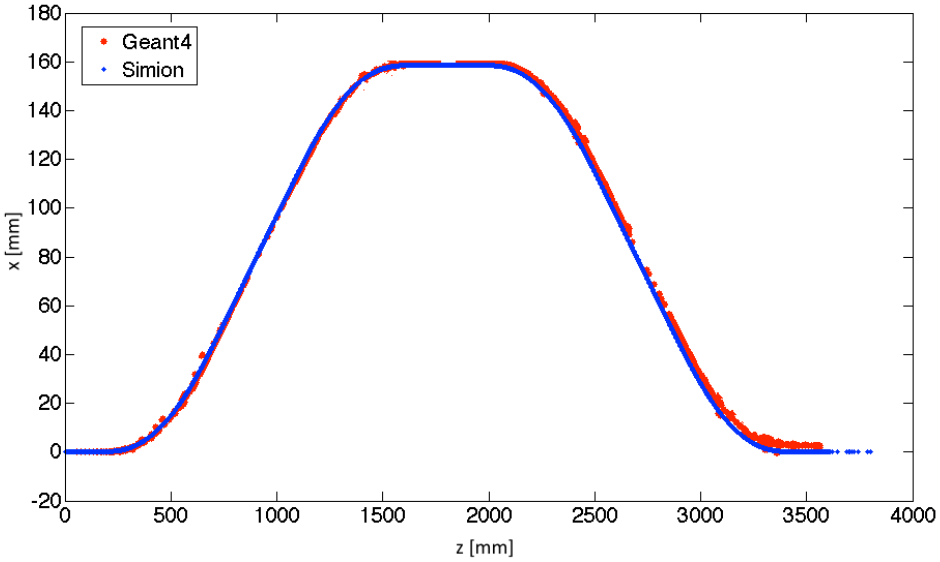


Tracks (benchmark 2)

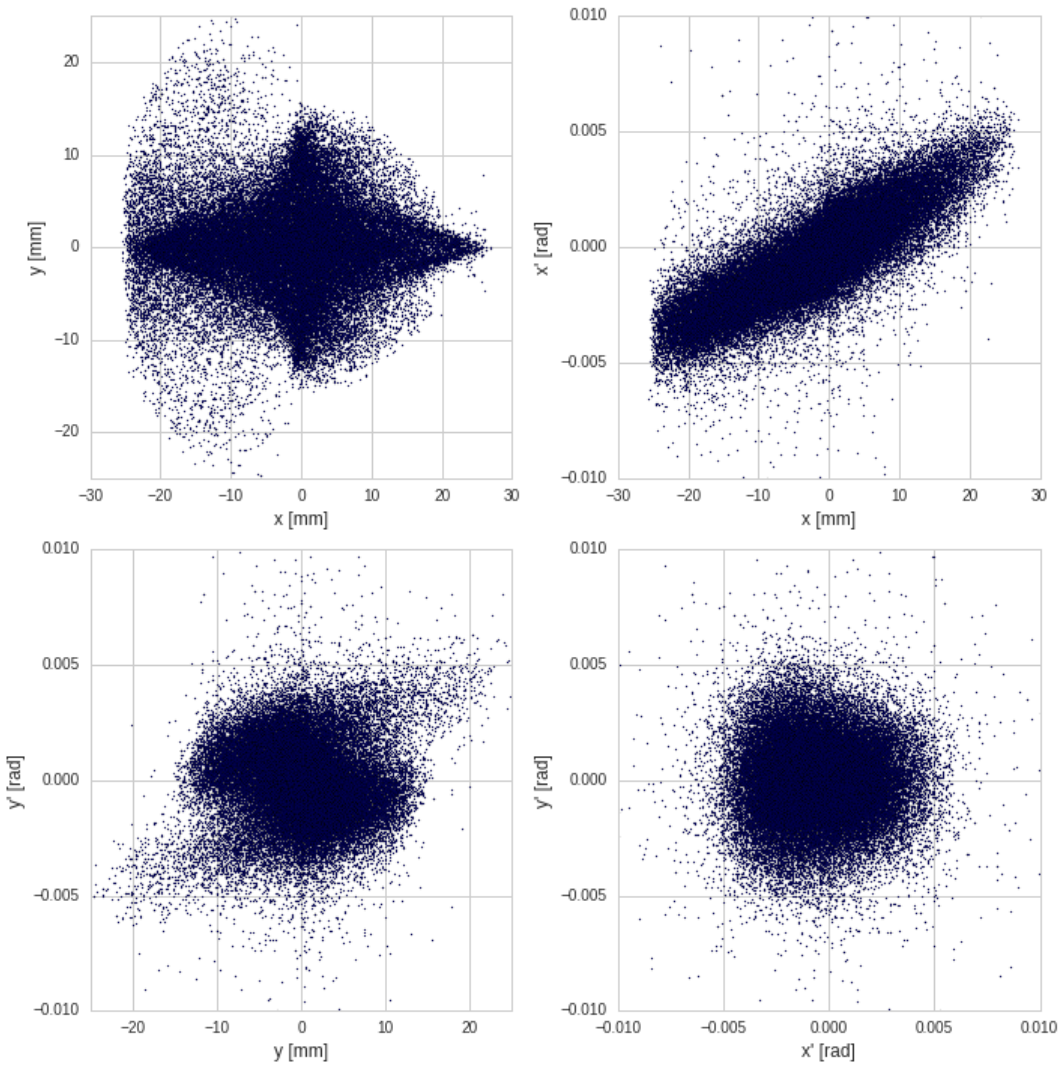
Protons in energy selector



Comparison between Geant4 and SIMION

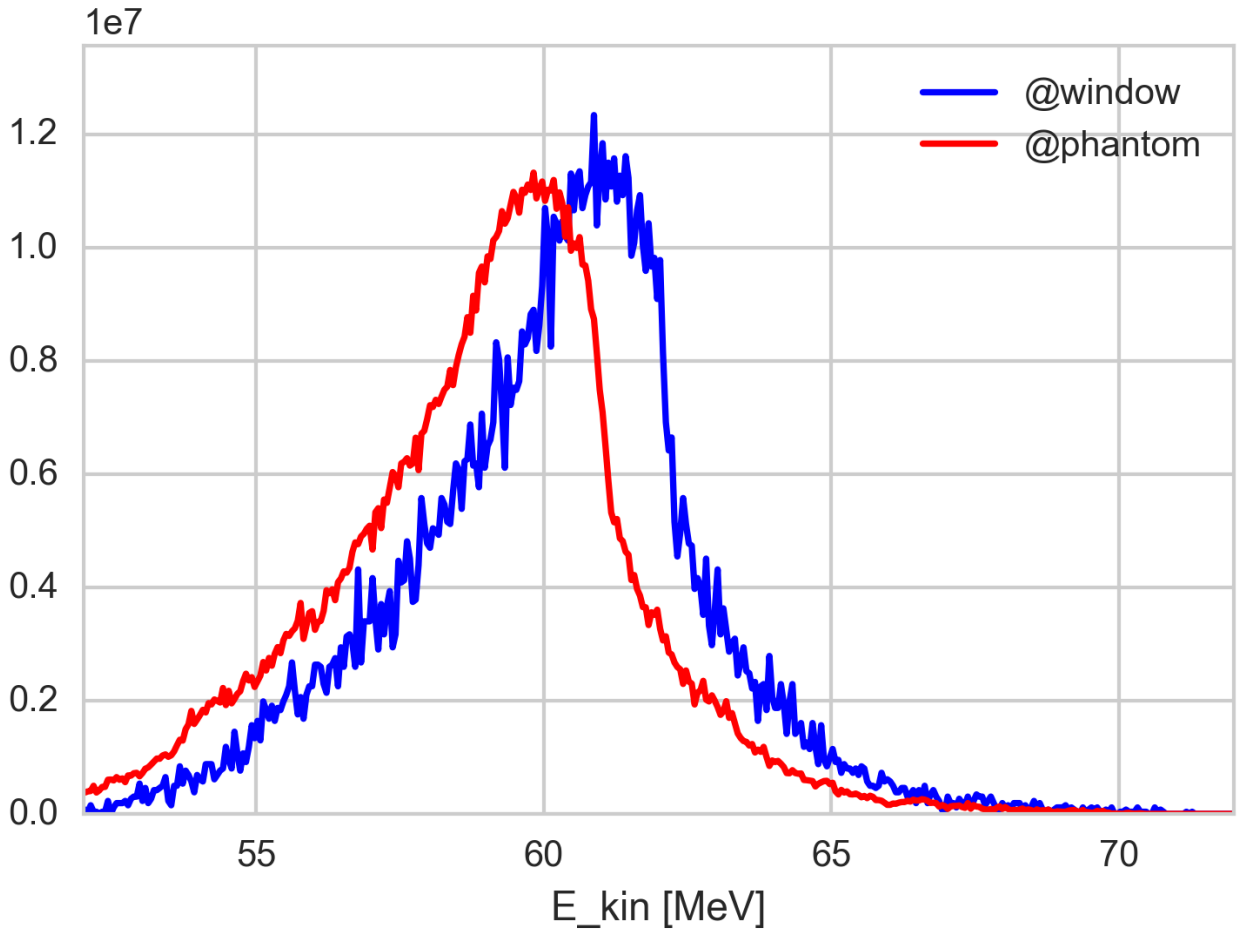


In-air kinematic properties



At the kapton window,
60-MeV configuration
10-mm slit width

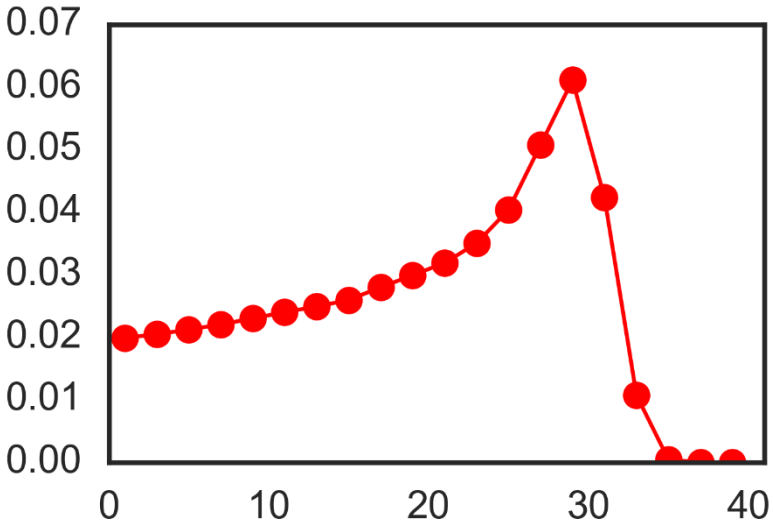
In-air energy spectra



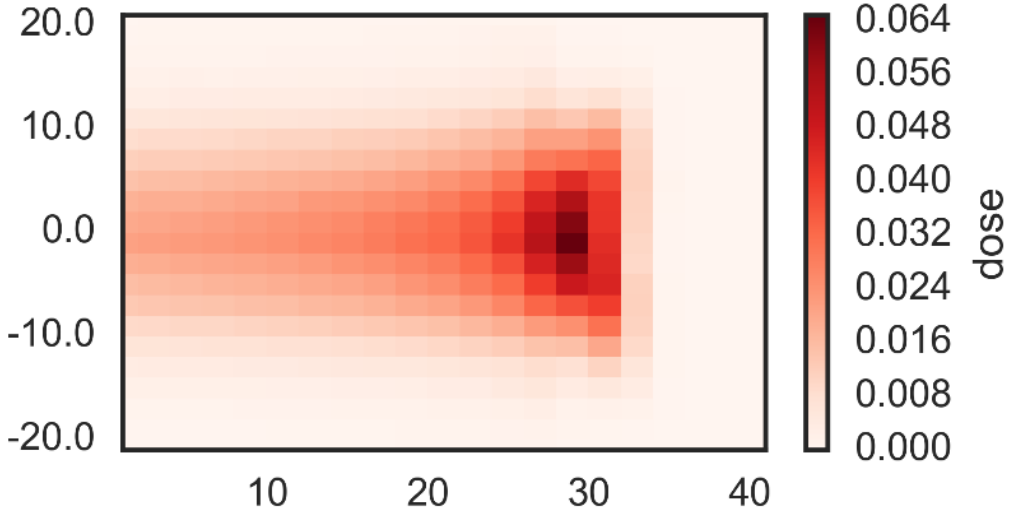
60-MeV configuration,10-mm slit

In-air dose profiles

Bragg peak, dose in Gy per shot



depth [mm]

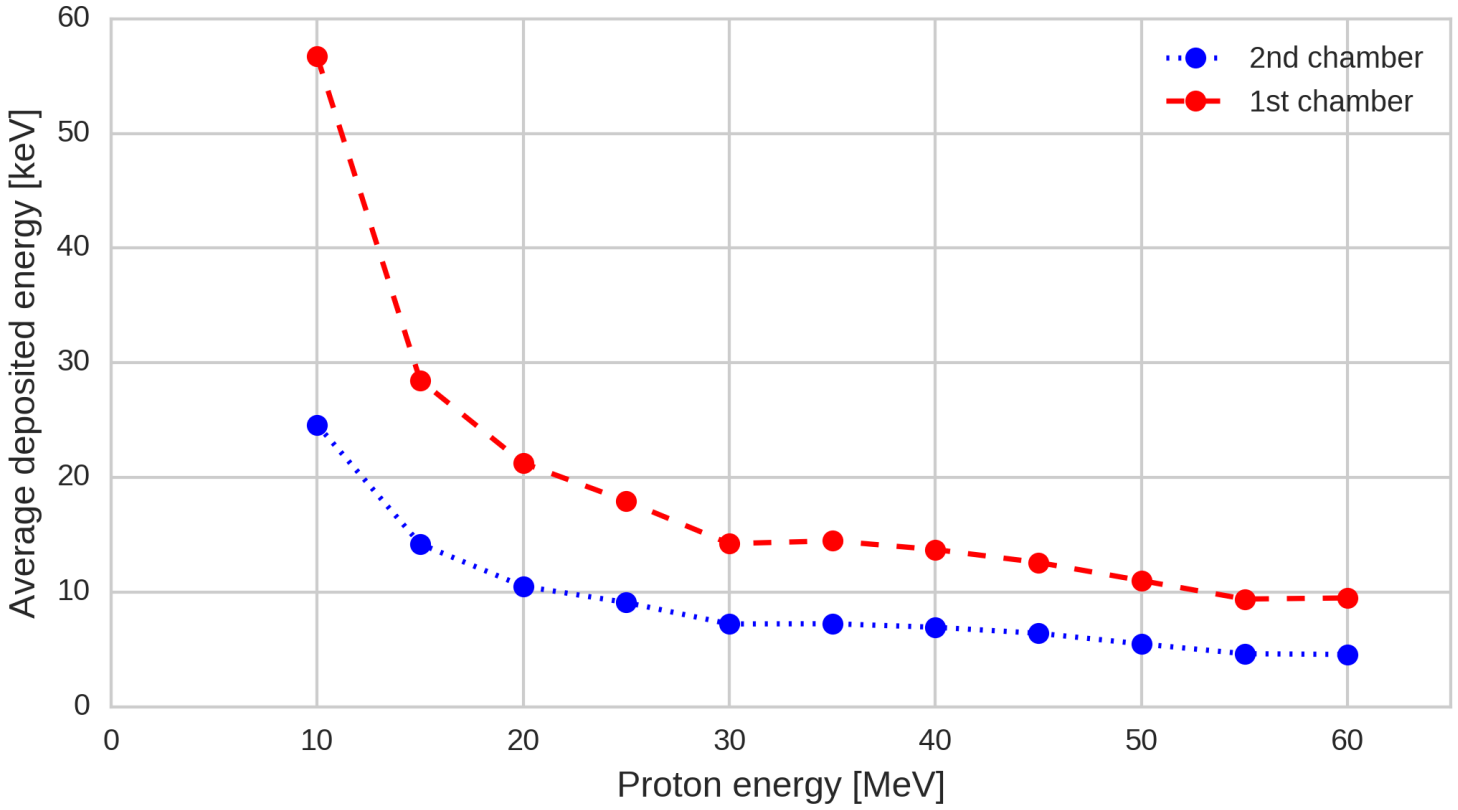


vertical plane [mm]

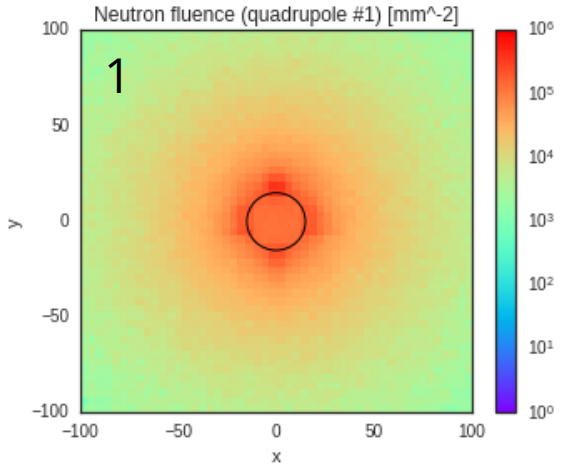
60-MeV proton configuration, slit width=10 mm
(in water phantom, 1 m after kapton window)

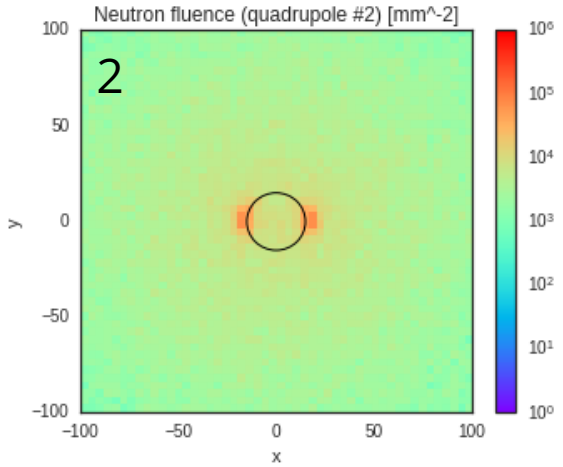
Detector response (example)

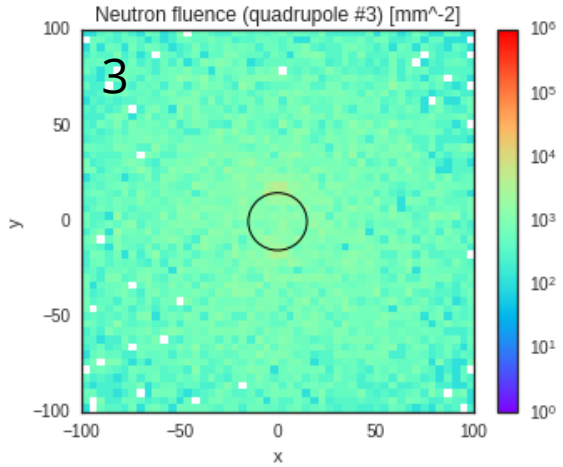
Energy deposited inside the **multi-gap ionization chamber**

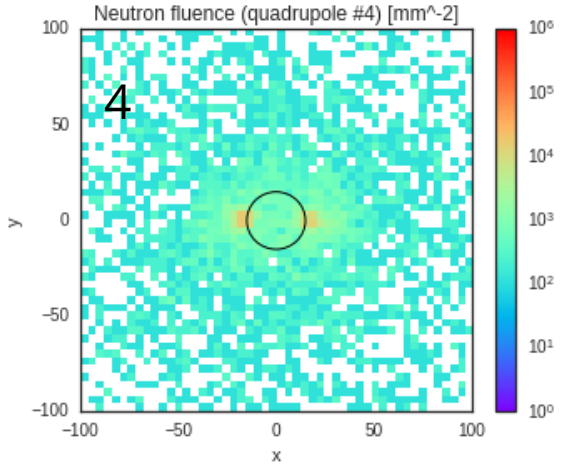


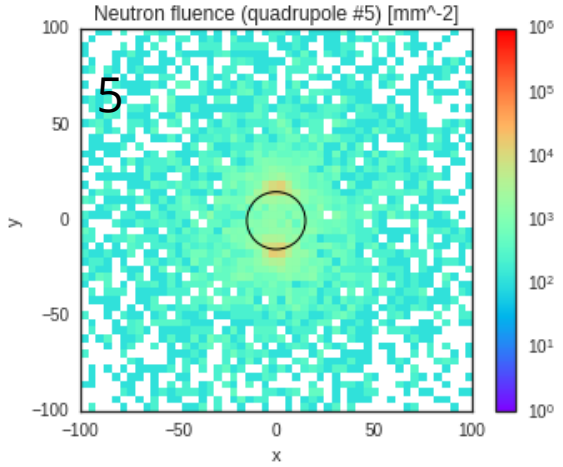
Secondary radiation (1)





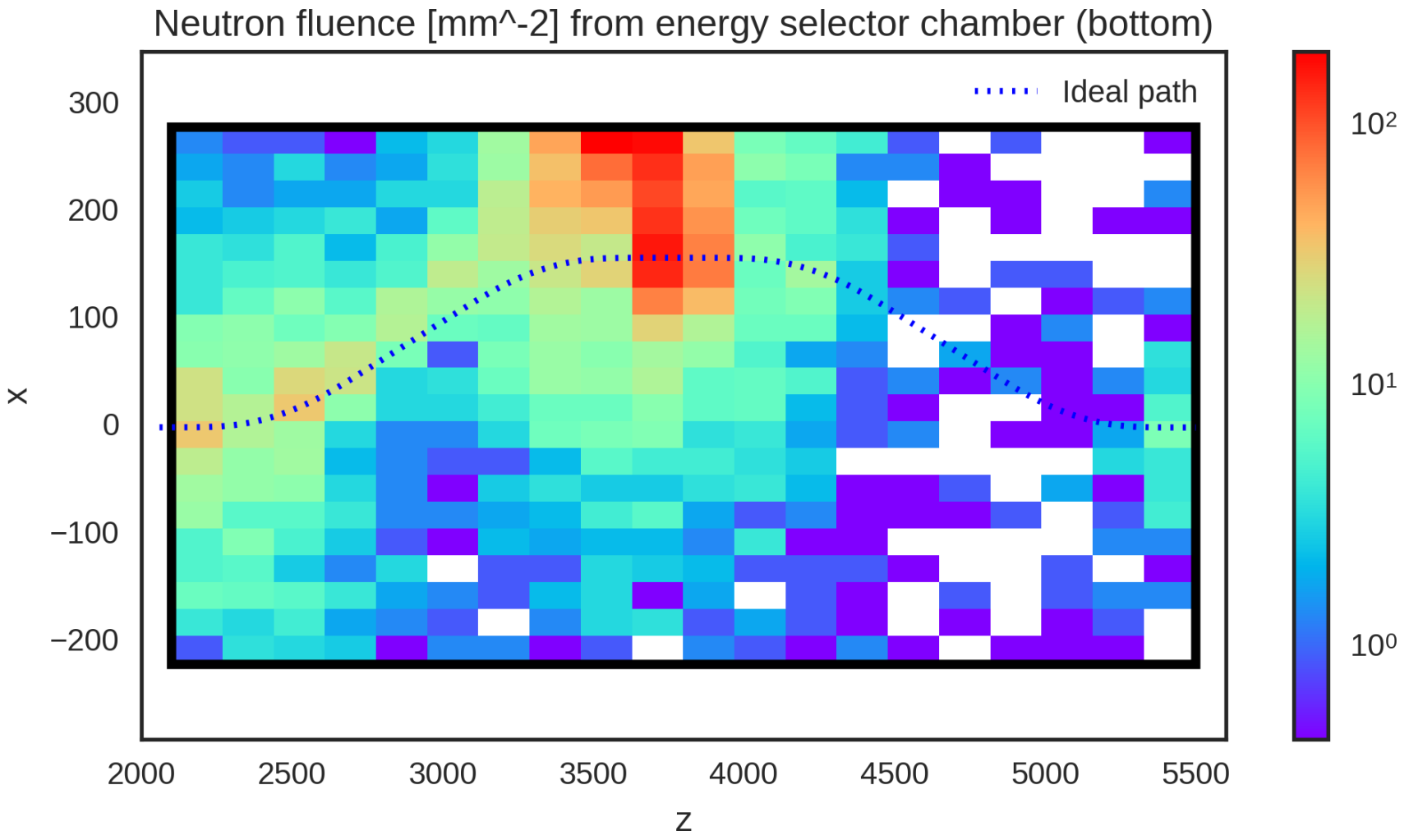






Fluence of neutrons escaping from PMQ front side

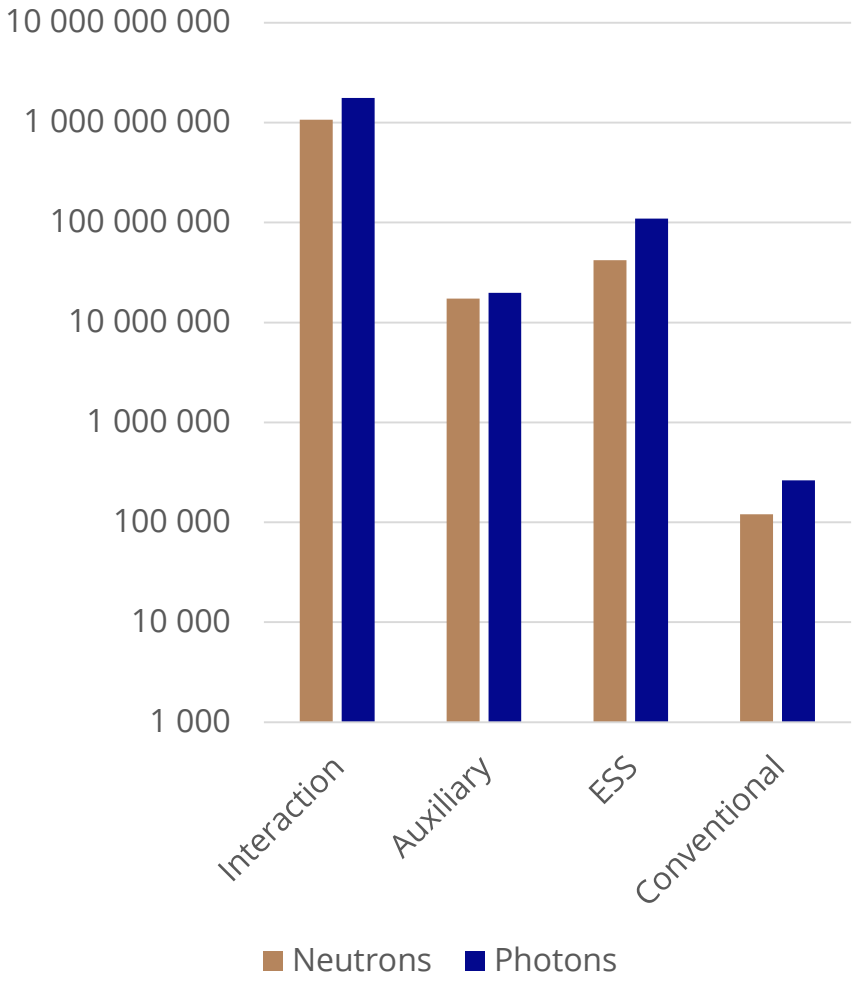
Secondary radiation (2)



Secondary radiation (3)

	Neutrons	Photons
Interaction chamber	1.1×10^9	1.8×10^9
Auxiliary chamber	1.7×10^7	2.0×10^7
Energy sel. chamber	4.2×10^7	1.1×10^8
Conventional pipe	1.2×10^5	2.6×10^5

Source: 1.15×10^{12} protons



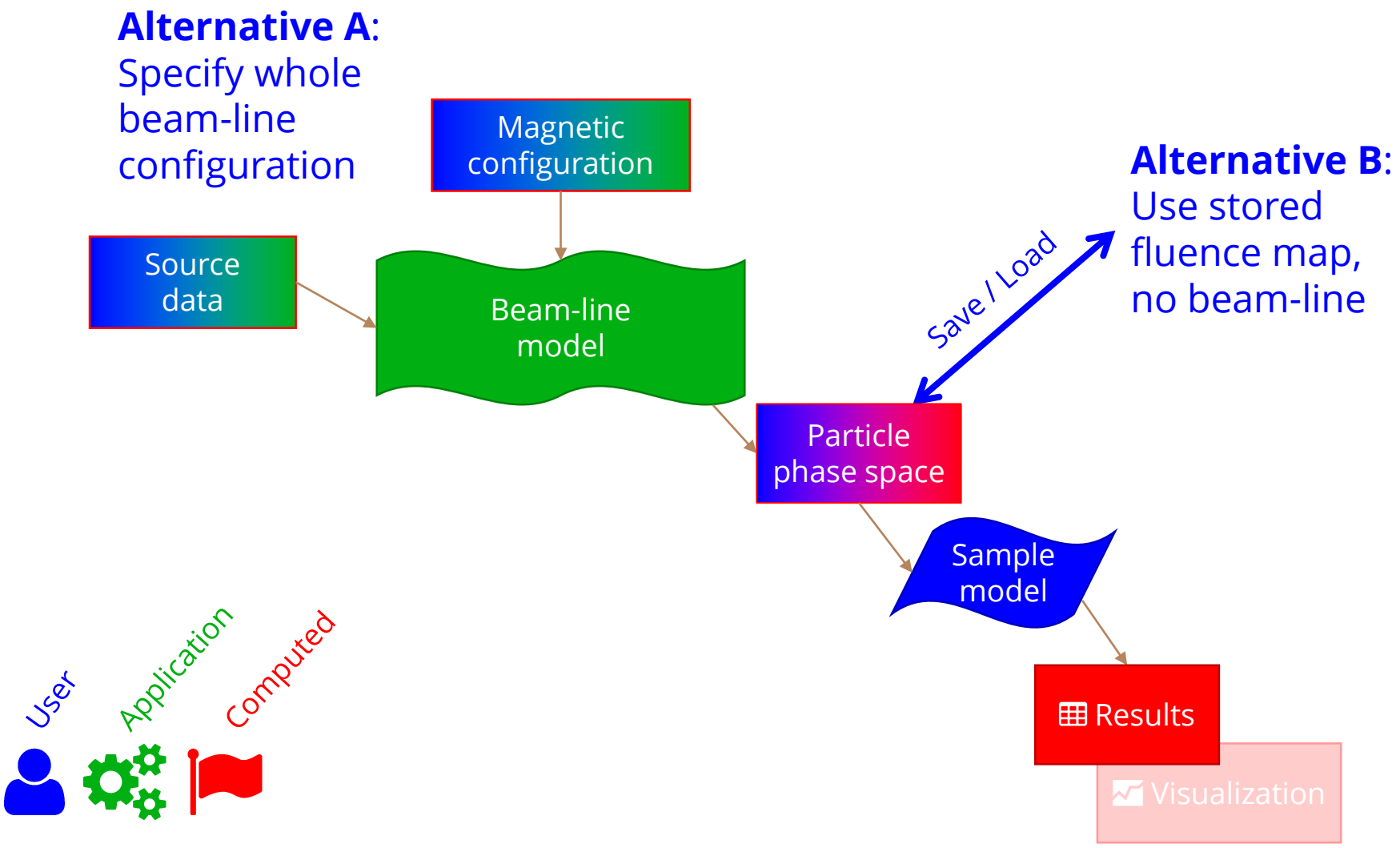
Towards user application

(and future development)

Further enhancements

- Comparison of physics models with FLUKA
- Calculation of RBE & LET
- Integration of Geant4-DNA
- Voxel phantom import (from DICOM)
- …

User workflow



Remote control

Current status

- classical Geant4 UI + macro commands
- experiments with ❶ web services / ❷ ZMQ protocol
- programmable via Python / Matlab using ❶

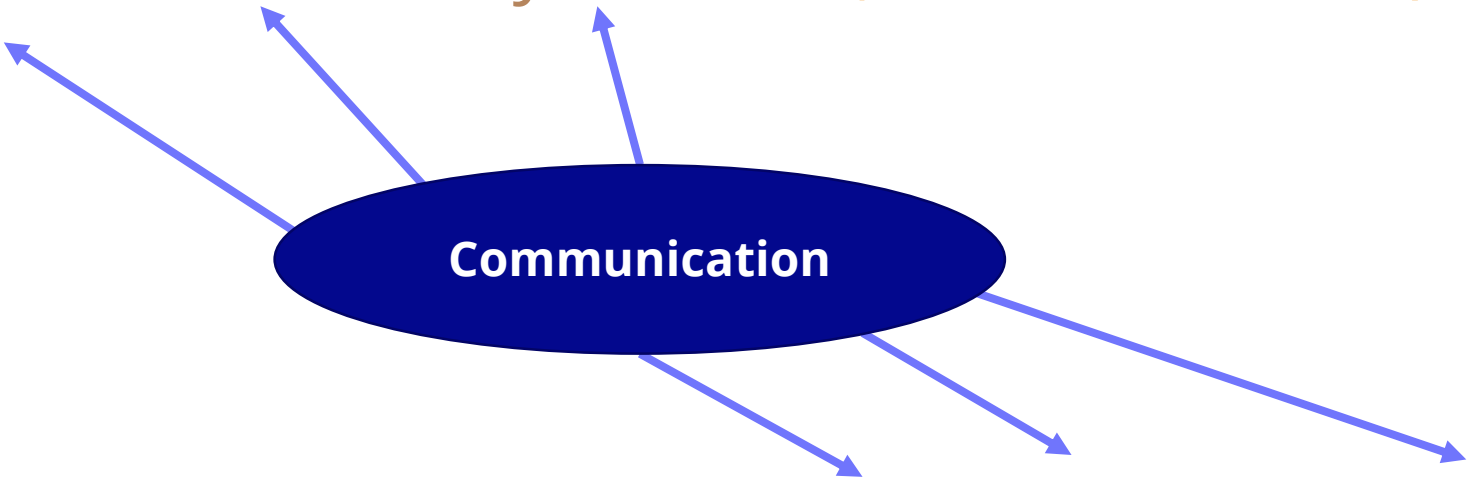
Goal

- universal remote protocol
- web interface based on this protocol
- virtual experiment (ELI) interface

What do *you* want?

You are the users

You know best what you want *(or at least better)*



We may implement

We may help

Conclusion

Complete model of the beam-line

Current results

- Beam characteristics
- Detector response
- Secondary radiation

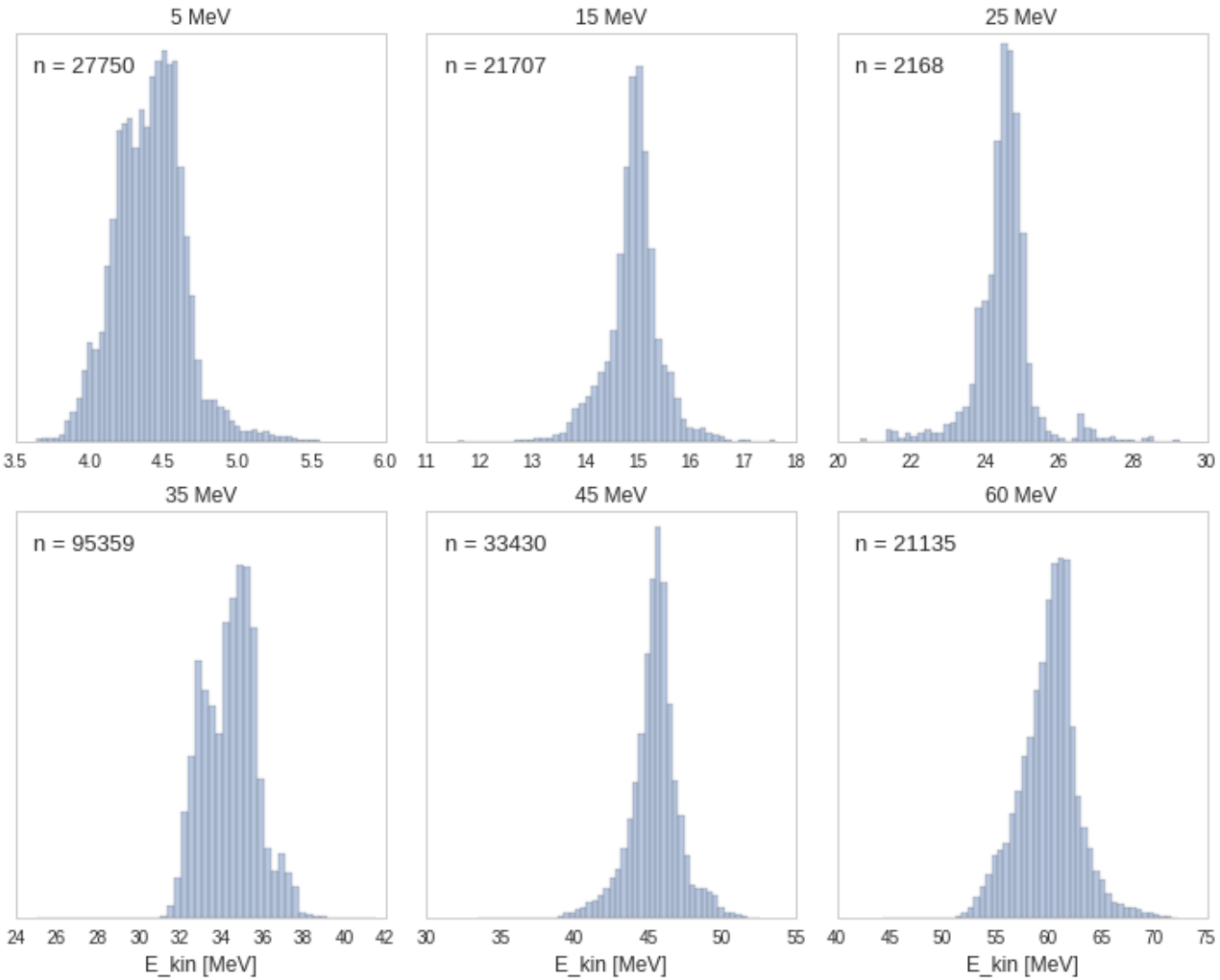
Future development

- More physics insights (RBE, …)
- User-friendly application

https://web2.infn.it/ELIMED/index.php/en/

Back-up

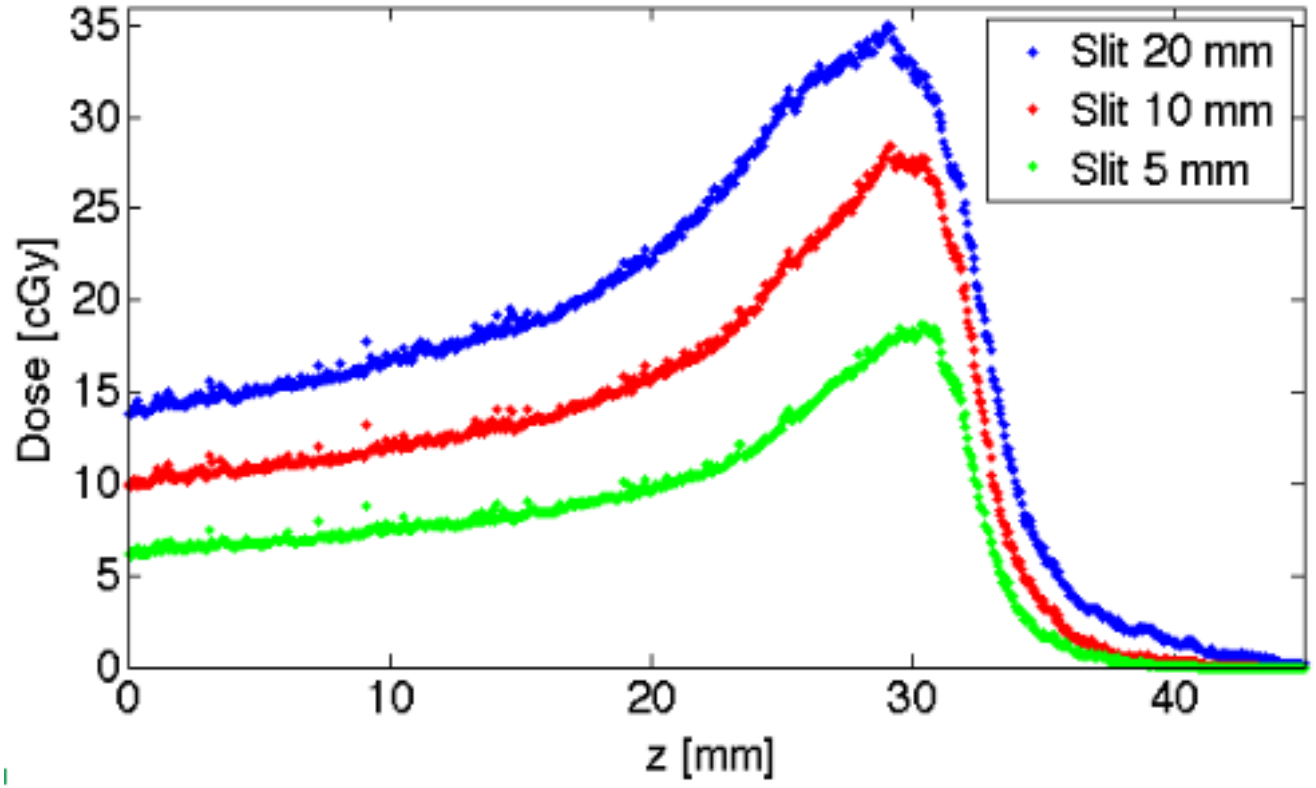
In-air energy spectra



At the kapton window, 10-mm slit width

Results – dose (alt.)

Comparison of depth dose profiles for different slit widths



Source: PIC 2D simulations, 60 MeV configuration