

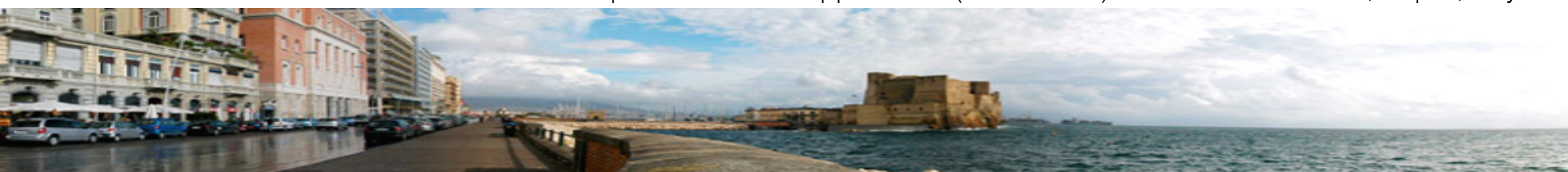
# OpenDose

a Collaborative Effort to Produce Reference Dosimetric Data  
with Monte Carlo Simulation Softwares

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# The Project

“The OpenDose project aims at providing an open database of robust reference S-values, generated from different Monte Carlo codes through an international collaboration.”

## Why?

- For decades, OLINDA1 data (Radar S-values) were used.
- OLINDA1 and OLINDA2 data no longer available on Radar.
- ICRP 103 recommends using dosimetric data computed from voxel-based ICRP 110 models (2 models).
- Some Specific Absorbed Fractions (SAFs) are computed and presented in ICRP 133.
- **No free ICRP S-Values available** to the Nuclear Medicine community.

# The Project

## Challenges:

- **2 ICRP reference** adult **models**, 5 more to come (paediatrics).
  - **140 organ/tissues** (19600 target ← source combinations).
  - MIRD book: ~300 isotopes.
  - ICRP 107: ~800 isotopes.
- big for a single institution !

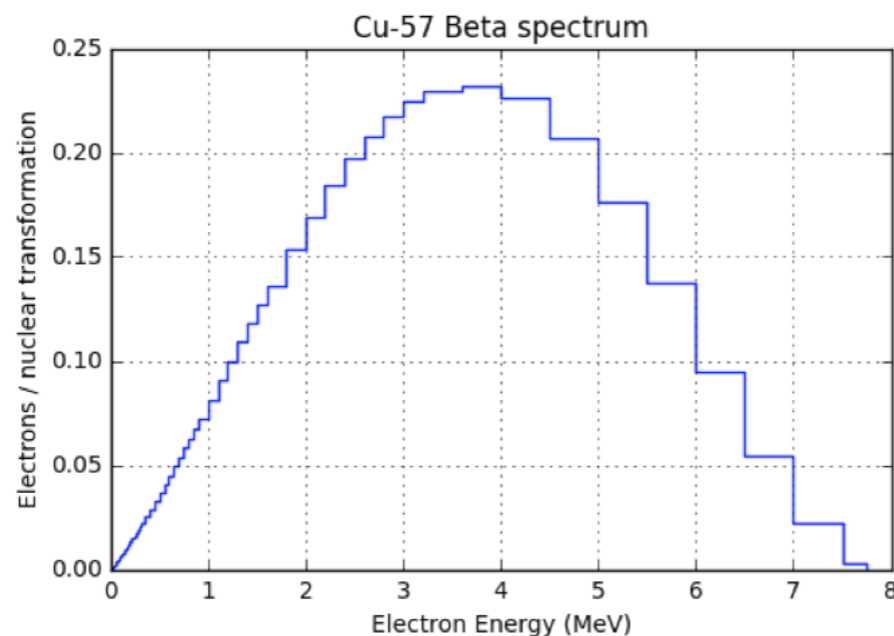
## Proposal:

- **Collaborative work**, everyone is welcome.
- Create a **free database** for the community.
- Data available with associated uncertainties.
- **Website** to easily **access** data.

# The Project

## Proposal:

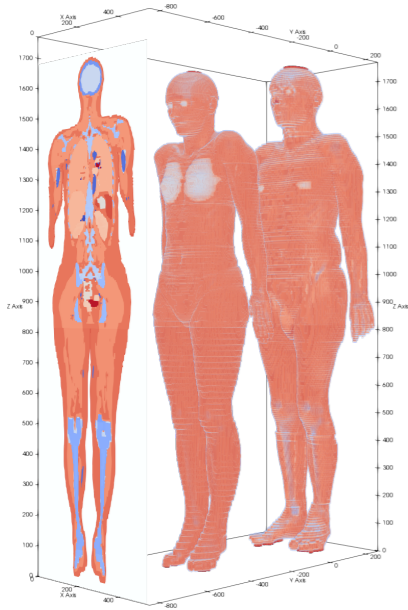
- Computing **mono-energetic SAFs** ?
  - gammas, electrons, (alphas ?)
- S-values generated by integrating over emission spectra.
- Share computation resources between teams,
  - use your own code (**MCNP, Gate, Penelope, EGSnrc, Fluka, ...**).
- Establish some **energy check points** to cross-check results between softwares « **verified data** ».



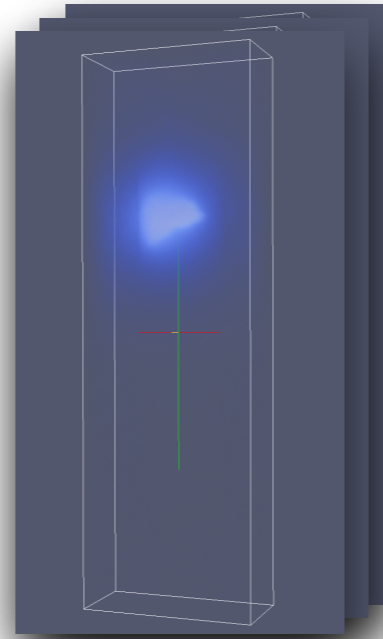
91 energies with a log scale corresponding to MIRD beta emitter energy sampling.

# Framework

ICRP110 phantoms



Absorbed dose (+ uncertainty) maps



for each source, particle, energy

SAFs tables (+ uncertainties)

Energy_MeV	target000	target001	target002
0.005	0.0	8.607745631331213e-06	0.0
0.0055	0.0	7.162995573859466e-06	0.0
0.006	0.0	5.944192504359427e-06	0.0
0.0065	0.0	1.8604394367445052e-06	0.0
0.007	0.0	5.547282091043621e-06	0.0
0.0075	0.0	6.55714264717551e-06	0.0
0.008	0.0	6.8806313600648625e-06	0.0
0.0085	0.0	8.099165671727396e-06	0.0
0.009	0.0	6.807013303008327e-06	0.0

for each source/target, particle, energy

MIRD isotope data

0.55000	6.423E-02
0.59577	0.000E+00
Lu-177	101
0.00000	5.707E+00
0.00010	5.705E+00
0.00011	5.704E+00
0.00012	5.704E+00
0.00013	5.704E+00
0.00014	5.704E+00
0.00015	5.703E+00
0.00016	5.703E+00
0.00018	5.703E+00
0.00020	5.702E+00
0.00022	5.702E+00
0.00024	5.701E+00

MC simulations

Web Database

S-values  
+ uncertainties

PostgreSQL + php + javascript + html

# The OpenDose Collaboration

14 research teams (18 institutes) :



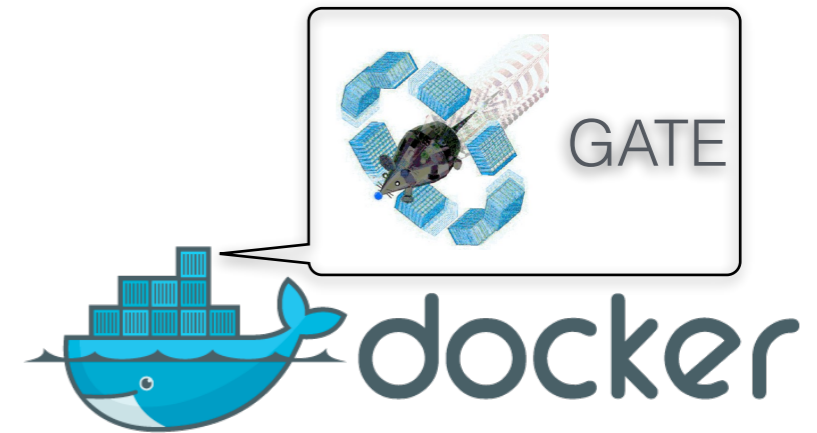
5 Monte Carlo codes :

**Geant4/GATE - Fluka - Penelope - MCNP/MCNPX - EGSnrc/EGS++**

# Simulations @ CRCT

## How

GATE in Docker containers. These containers are complete standalone linux application including Geant4, ROOT and GATE.



<https://hub.docker.com/r/manureva/ubuntu-gate/>

A screenshot of the Docker Hub repository page for 'manureva/ubuntu-gate'. The page shows the repository name, a star icon, and the last push time (19 days ago). It includes navigation tabs for Repo Info, Tags, Collaborators, Webhooks, and Settings. The main content area is divided into two columns. The left column contains a 'Short Description' (GATE, Geant4 and ROOT installed on Ubuntu) and a 'Full Description' (16.04-8.0: Container with GATE 8.0 installed on Ubuntu 16.04) with a bulleted list of components: Geant4 (version geant4.10.03.p01, cmake options: -DGEANT4\_USE\_SYSTEM\_EXPAT=OFF -DGEANT4\_INSTALL\_DATA=ON), ROOT (version 5.34/19), and GATE (version gate\_v8.0). The right column contains a 'Docker Pull Command' (docker pull manureva/ubuntu-gate) and an 'Owner' section showing the profile picture and name 'manureva'.

**In 1 minute you have GATE ready to run!**

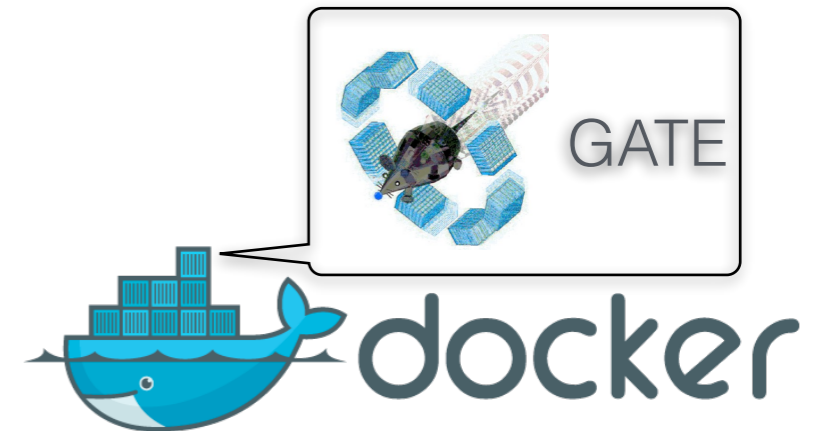
GATE 7.2:  
`docker run -it manureva/ubuntu-gate:16.04-7.2`

GATE 8.0:  
`docker run -it manureva/ubuntu-gate:16.04-8.0`

# Simulations @ CRCT

## How

240 cpu cores.  
GATE 8.0 in Docker containers.



## How many

140 source organs x 91 energies x 2 particle types = 25480 simulations (for one model)

## How much

1 simulation = 3 images of 55 MB  
 $25480 \times 55\text{MB} = 1.4\text{ TB}$

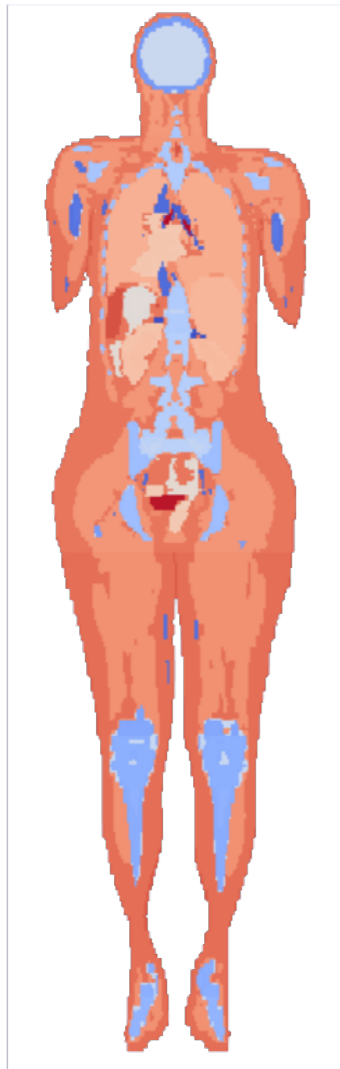
## Performance

1 simulation with  $10^8$  primaries  $\sim$  1 day/core  
 $25480 / 240\text{ cores} = 106\text{ days}$





# First Case Study

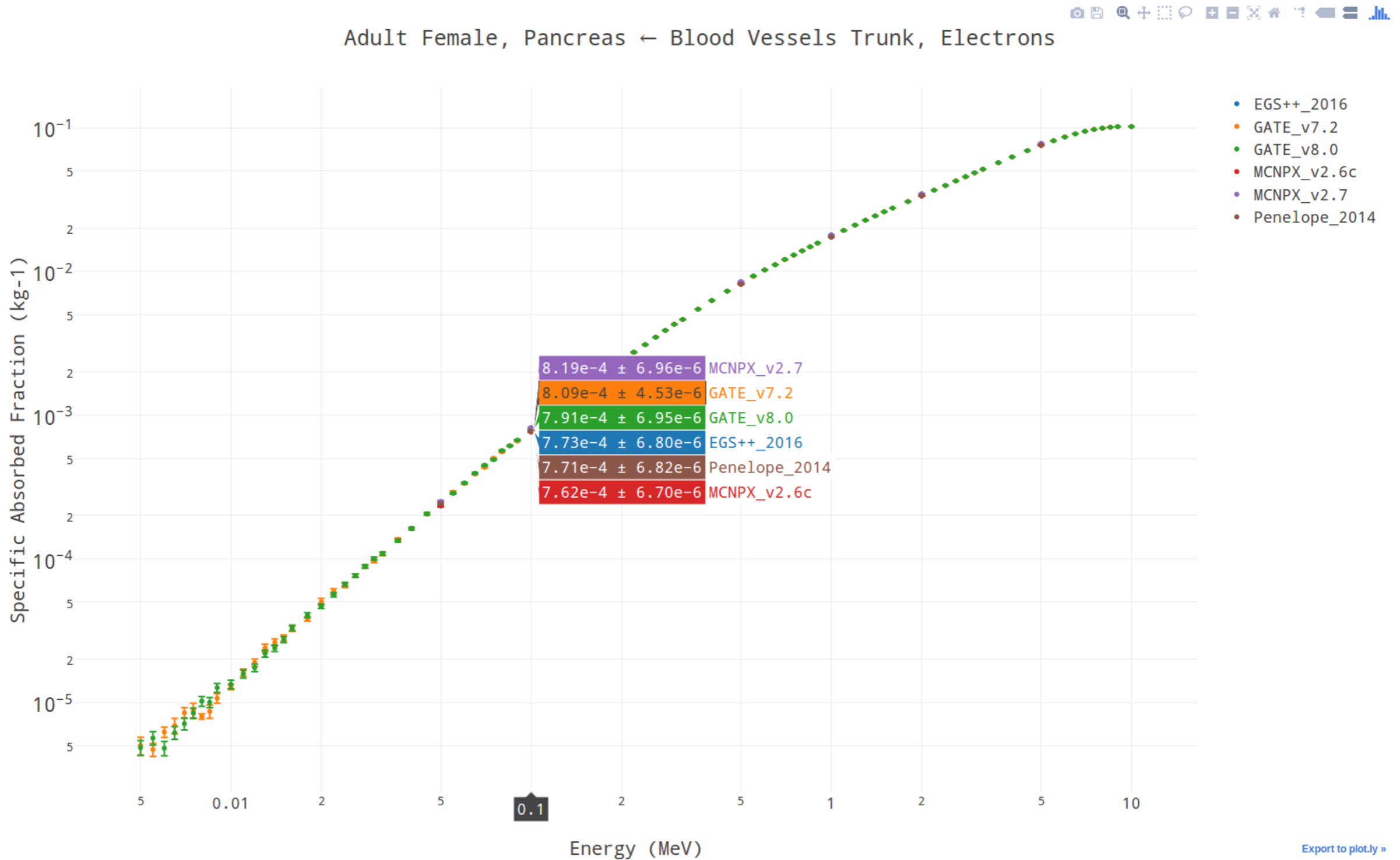


- **1 model:** ICRP 110 Adult Female (ICRP\_v1.2)  
299 x 137 x 348 voxels  
voxel size: 1.775 x 1.775 x 4.84 mm  
140 organs (19600 source-target pairs)  
53 ≠ media
- **2 sources:** Liver, Blood Vessels Trunk
- **2 particle types:** gammas, electrons
- **7 energies:** 0.05, 0.1, 0.2, 0.5, 1.0, 2.0, 5.0 MeV
- **1e8 primaries**

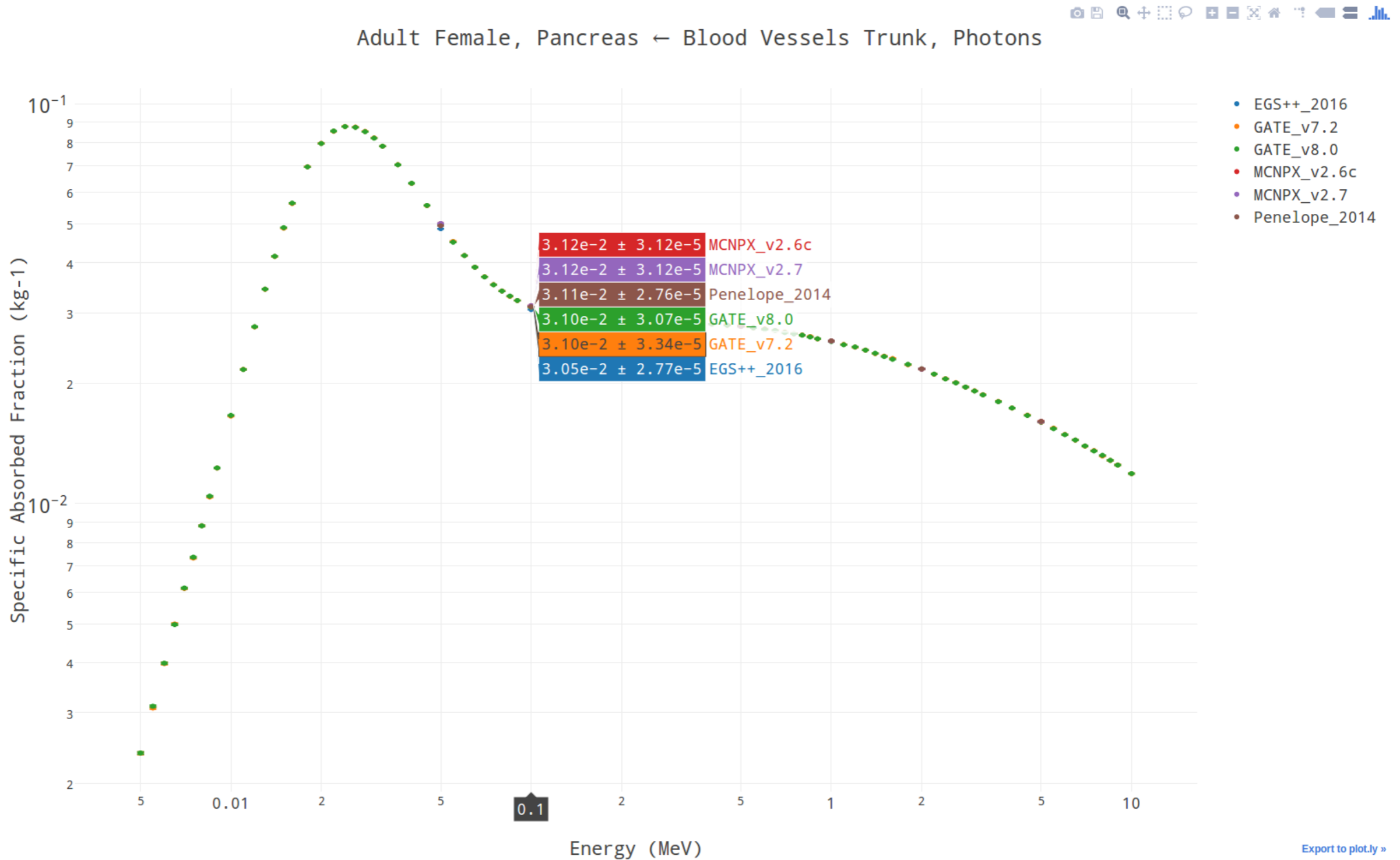
**Each team** simulates these configurations (2 x 2 x 7) according to his/her local software (and parameters).  
For each simulation, **SAFs + uncertainties** are generated for all **140 target ← source combinations**.

In this presentation: Pancreas ← BVT and Pancreas ← Liver

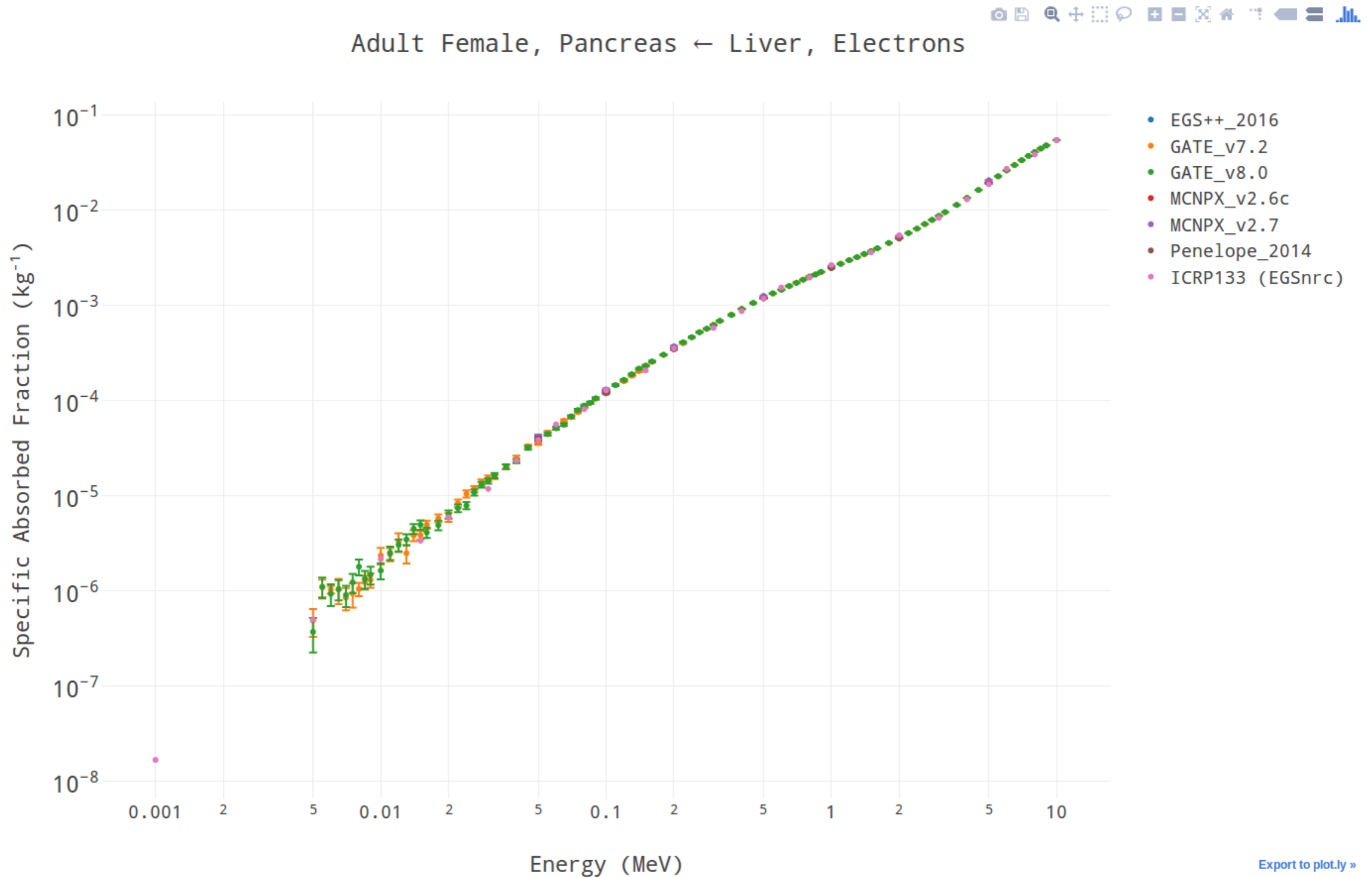
# SAF results



# SAF results



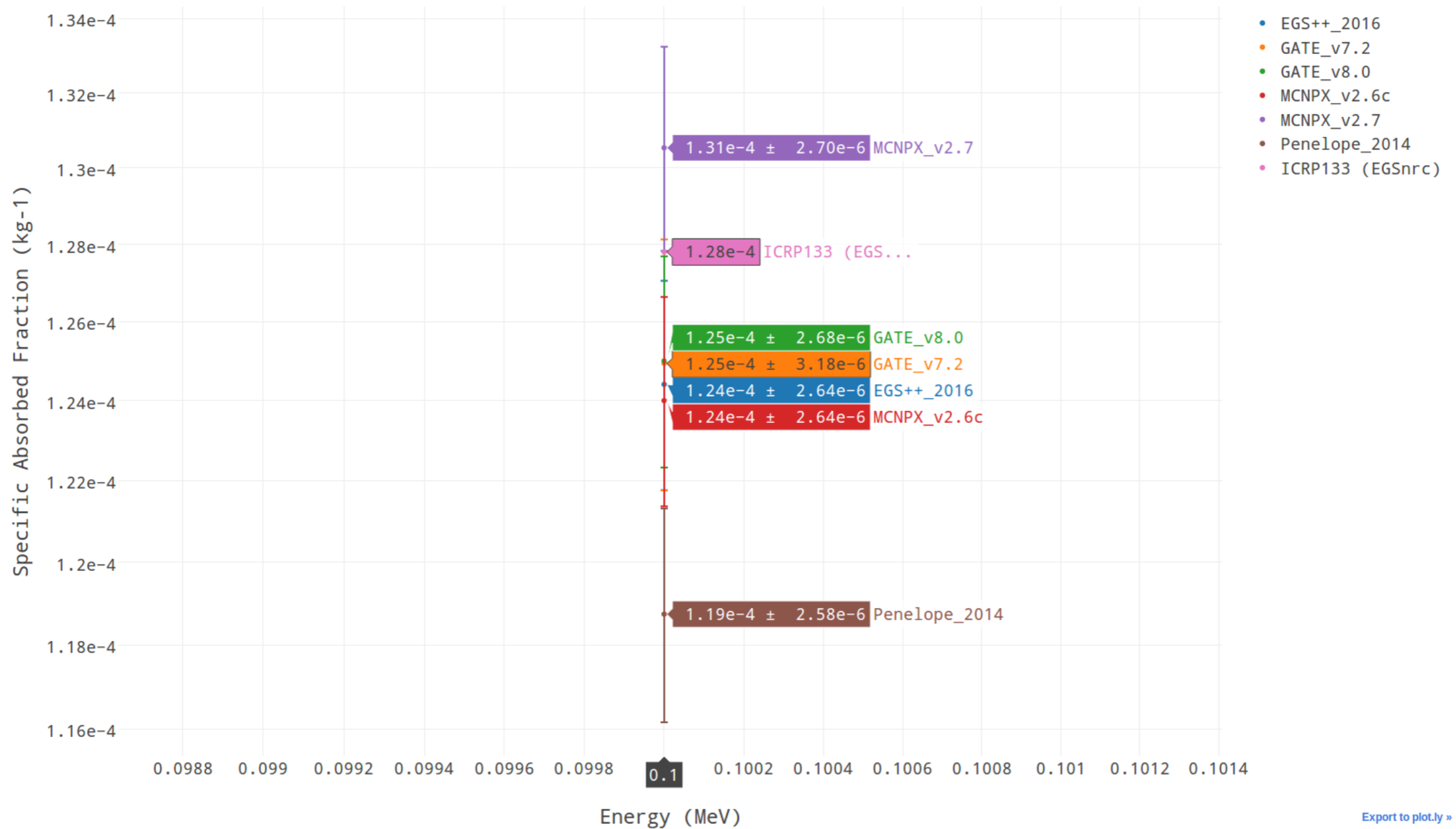
# SAF results



# SAF results

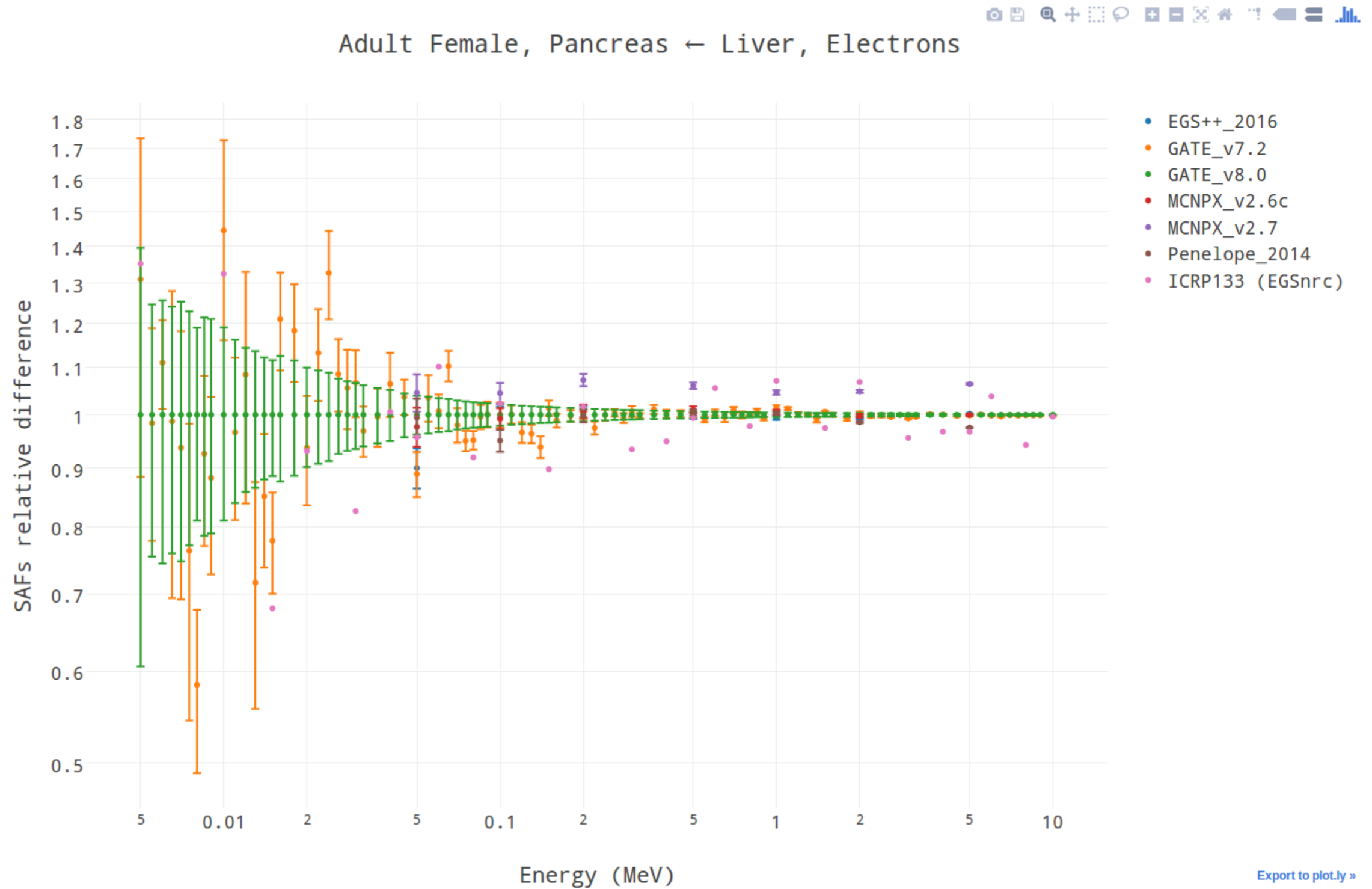


Adult Female, Pancreas ← Liver, Electrons

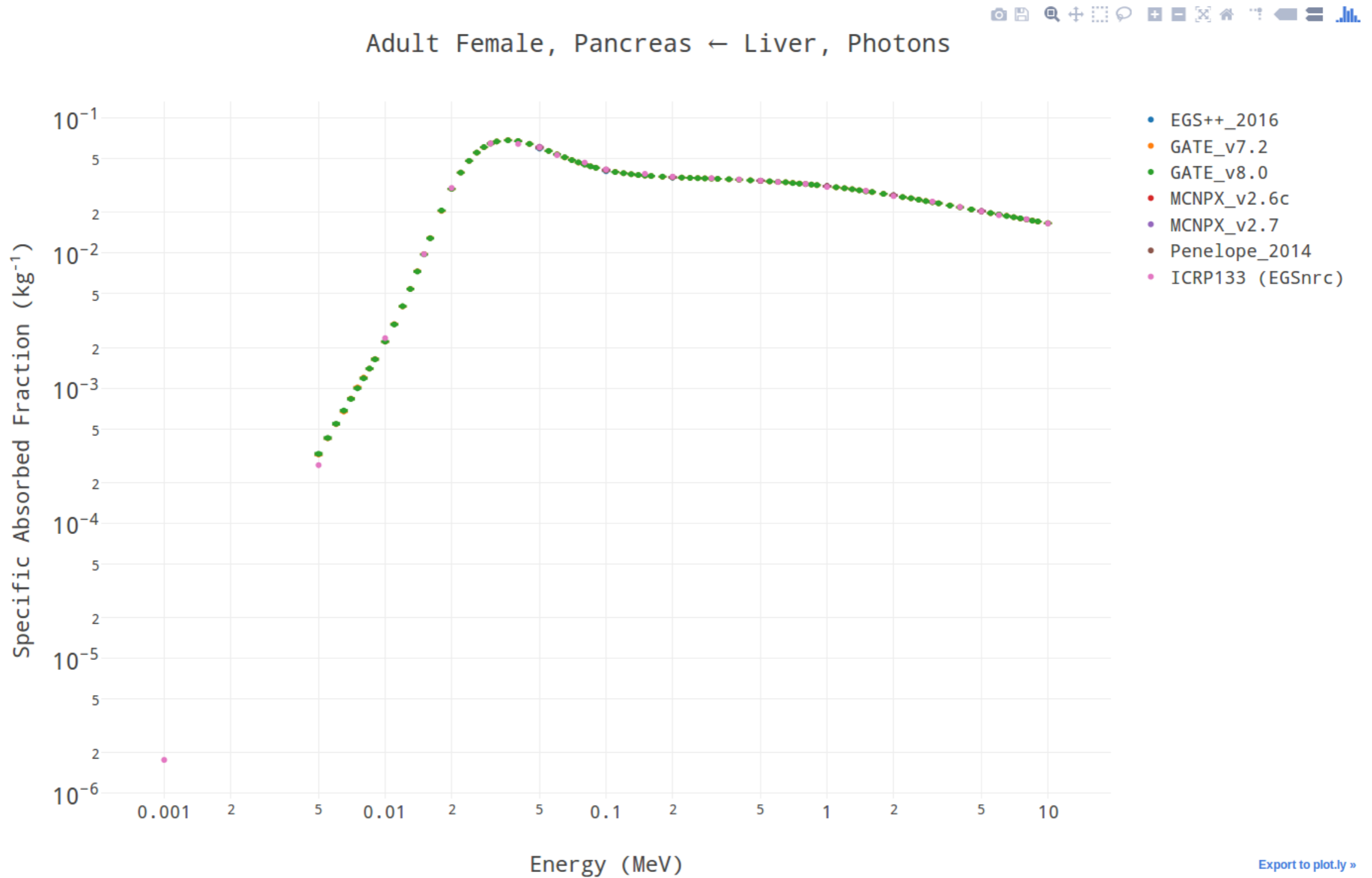


[Export to plot.ly »](#)

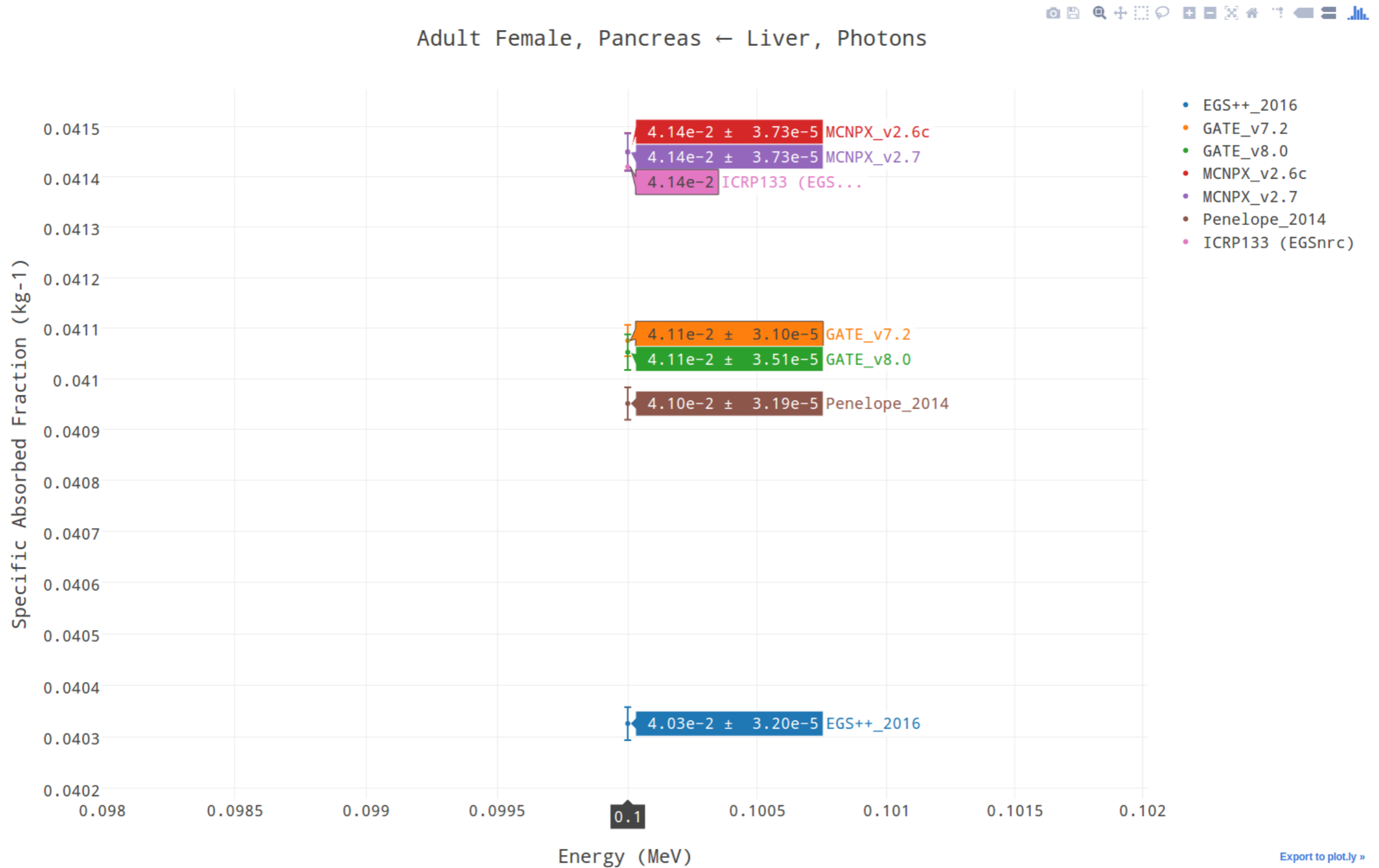
# SAF results



# SAF results

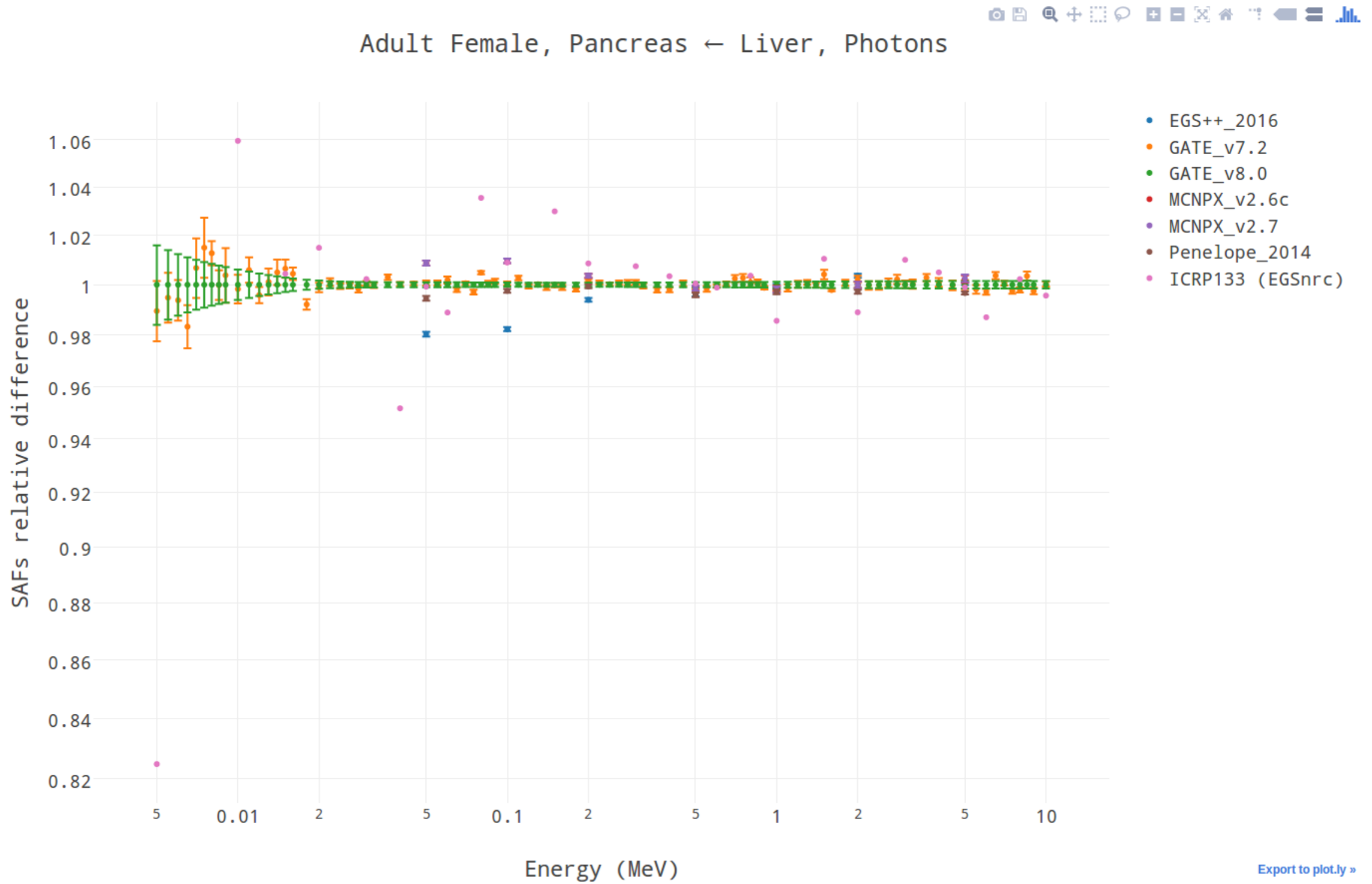


# SAF results





# SAF results



# Conclusion

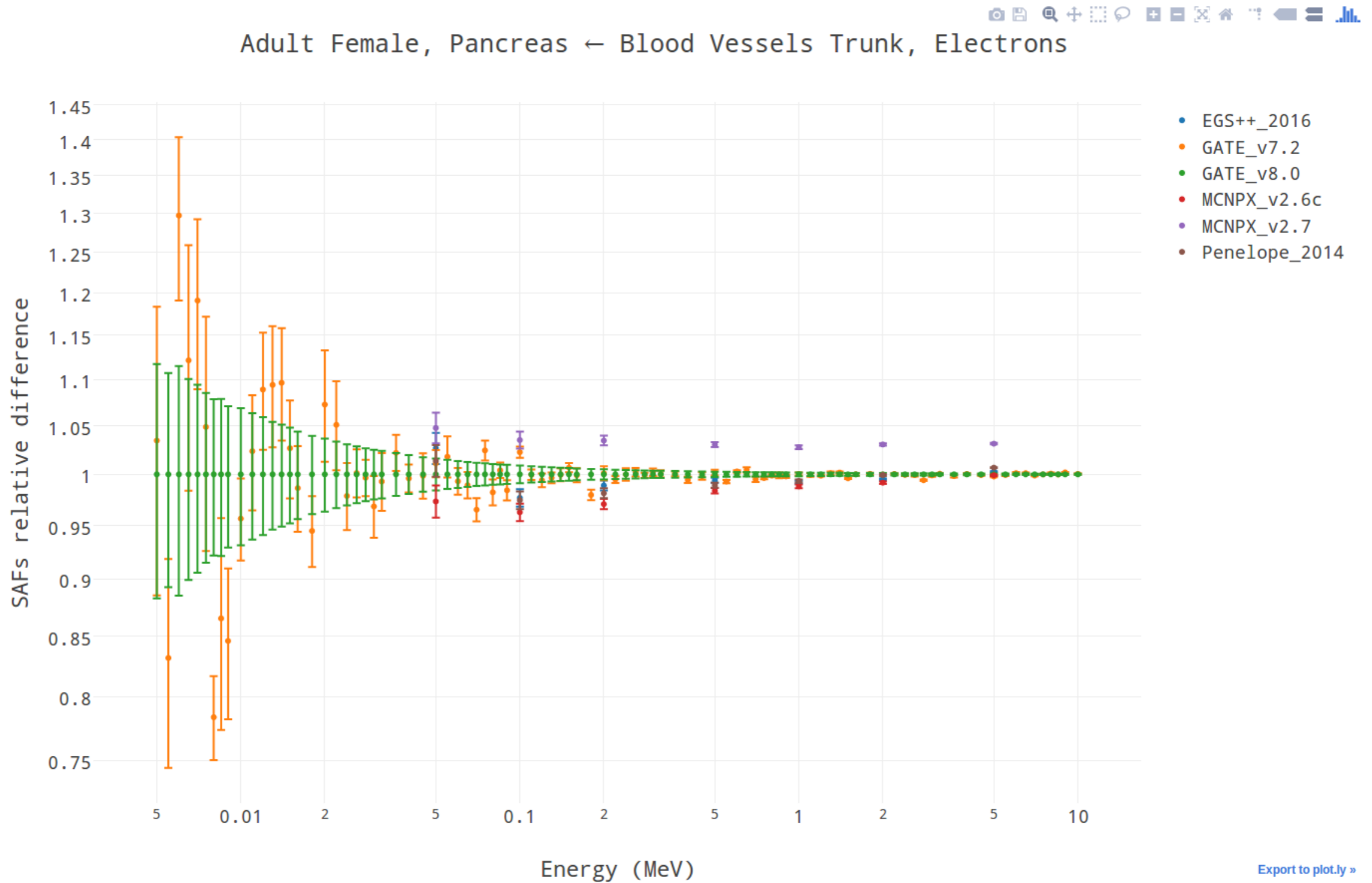
- The collaboration already includes **14 teams** over 9 countries and uses 5 different Monte Carlo codes: **Geant4/GATE, Fluka, PENELOPE, MCNP/MCNPX** and **EGSncr/EGS++**.
- A first test case demonstrated the feasibility and relevance of the concept.
- Production of data for a whole phantom: a few months with ~200 cores.
- The **database and web interface** is under development to distribute the data **publicly**.
- The project is **open to new research teams** (and new codes) + will expand to more computational models and studies.

You are welcome to join !

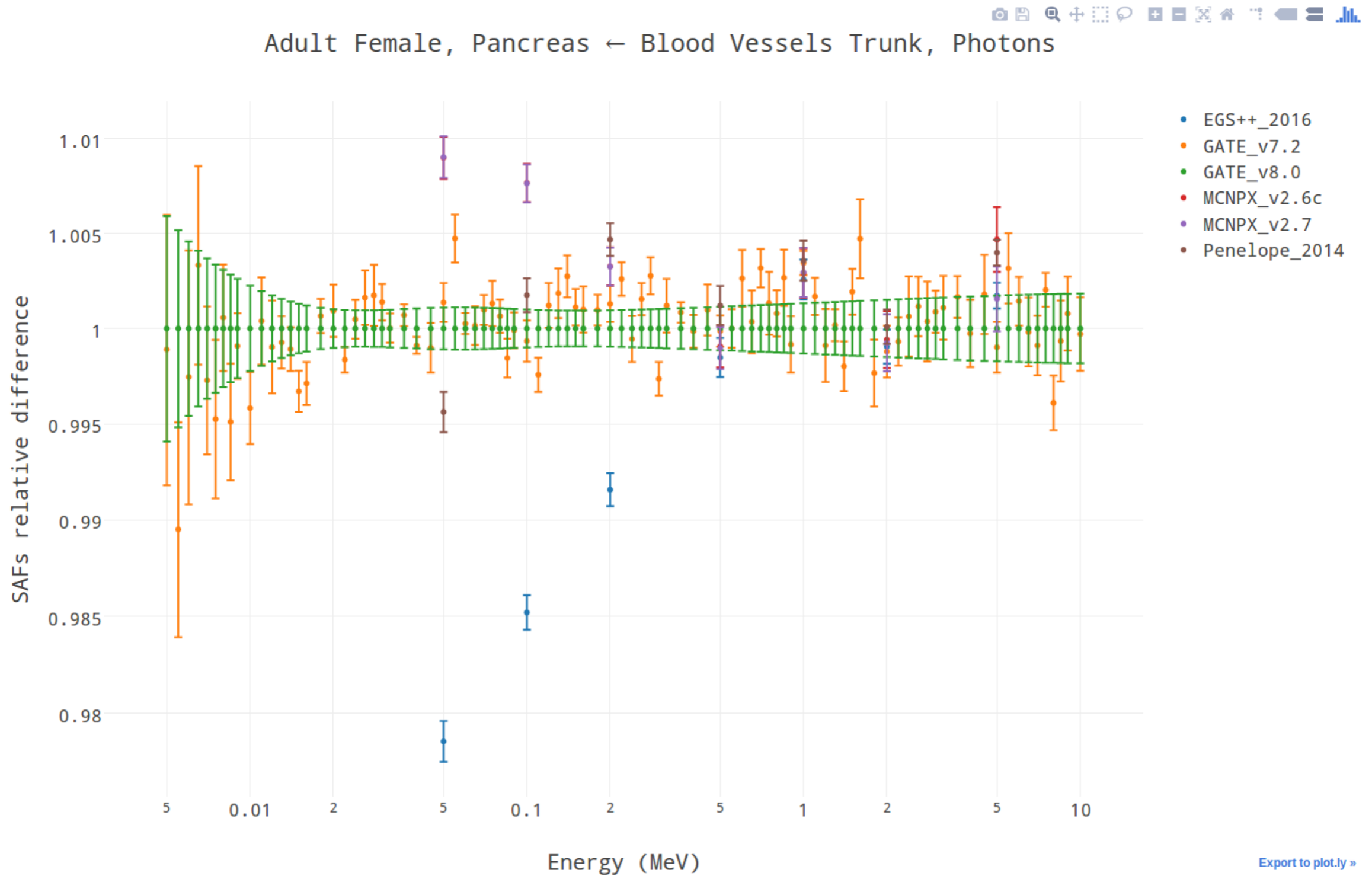


More slides...

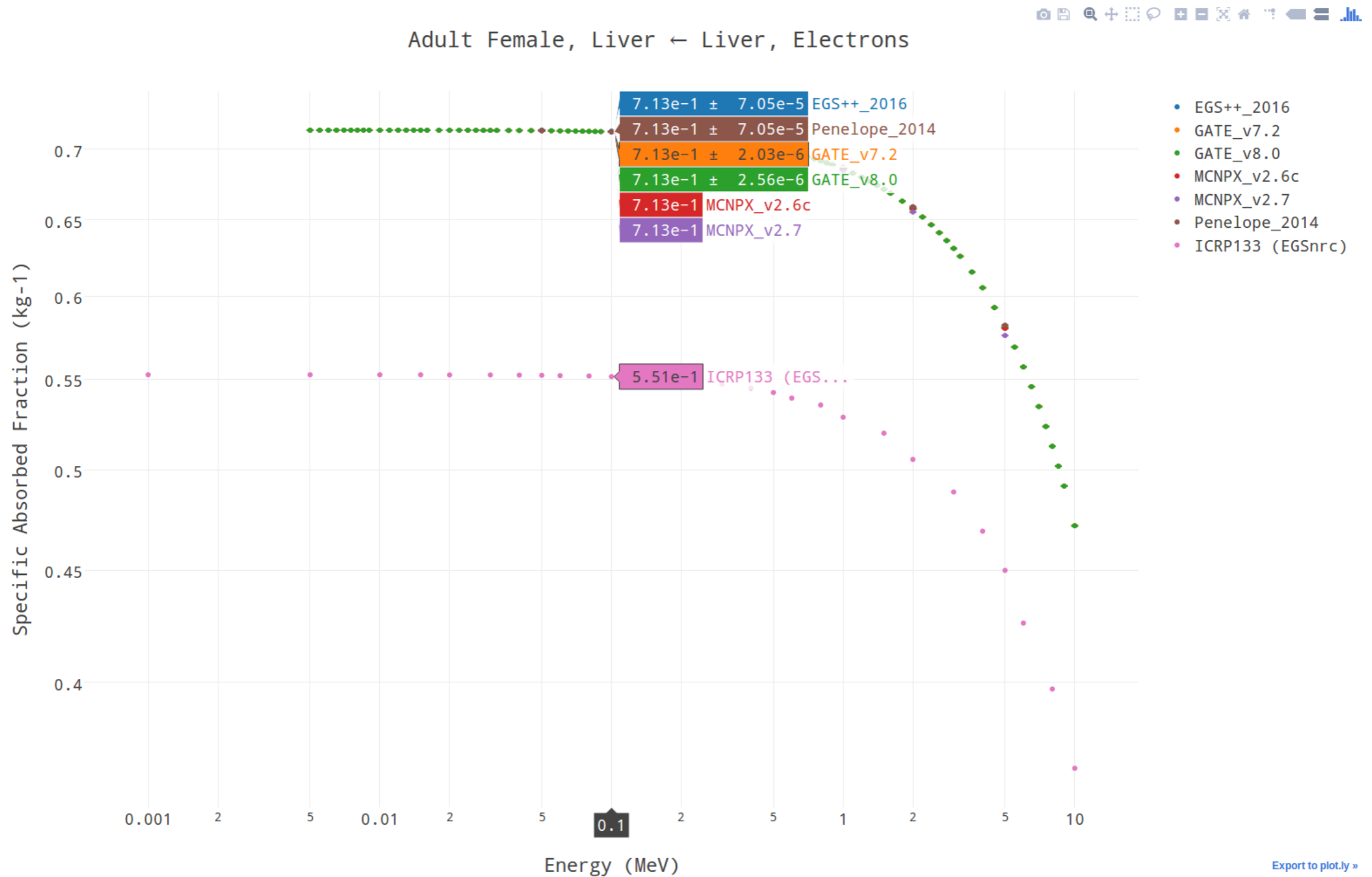
# SAF results



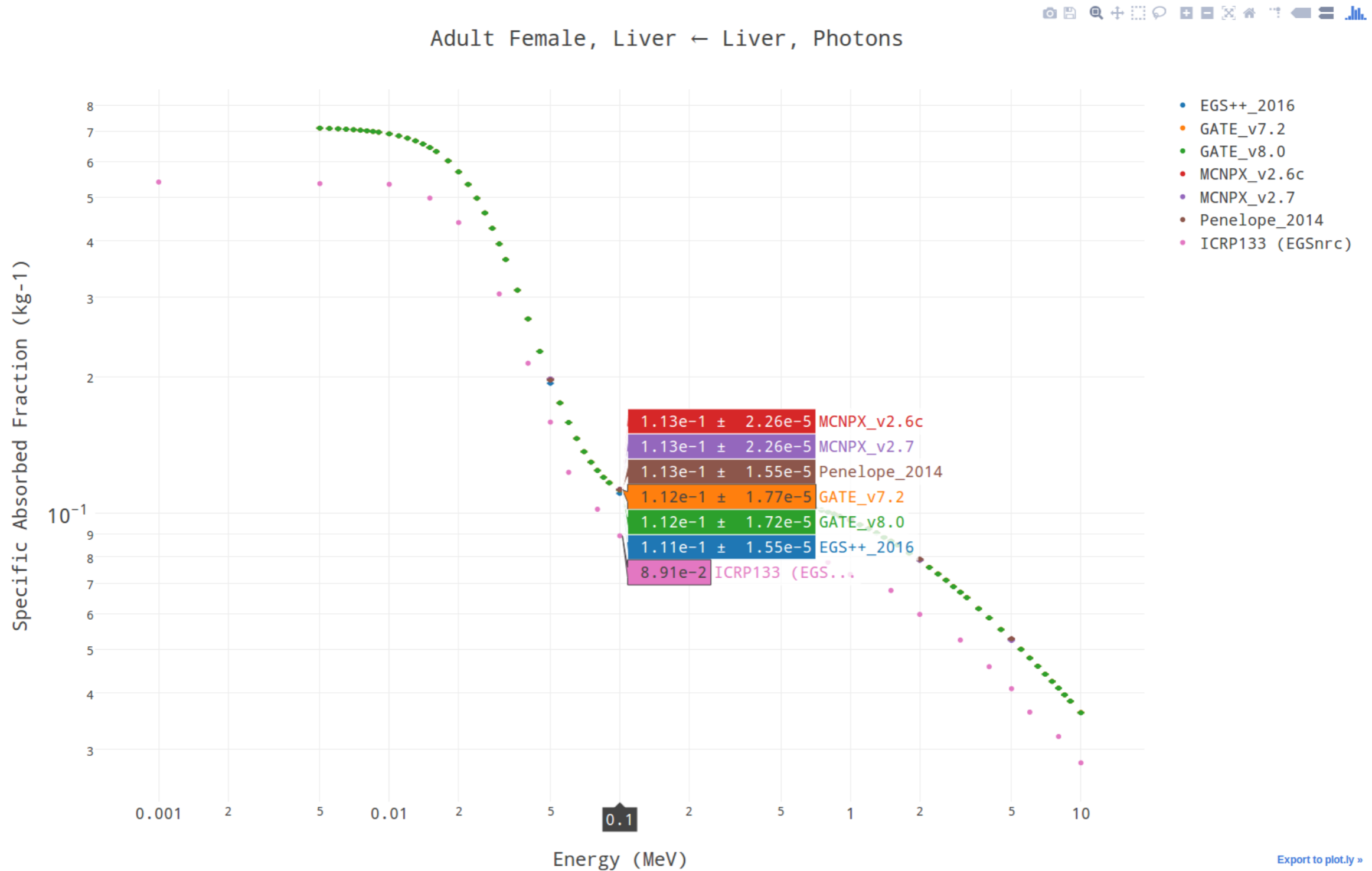
# SAF results



# Comparison with ICRP 133

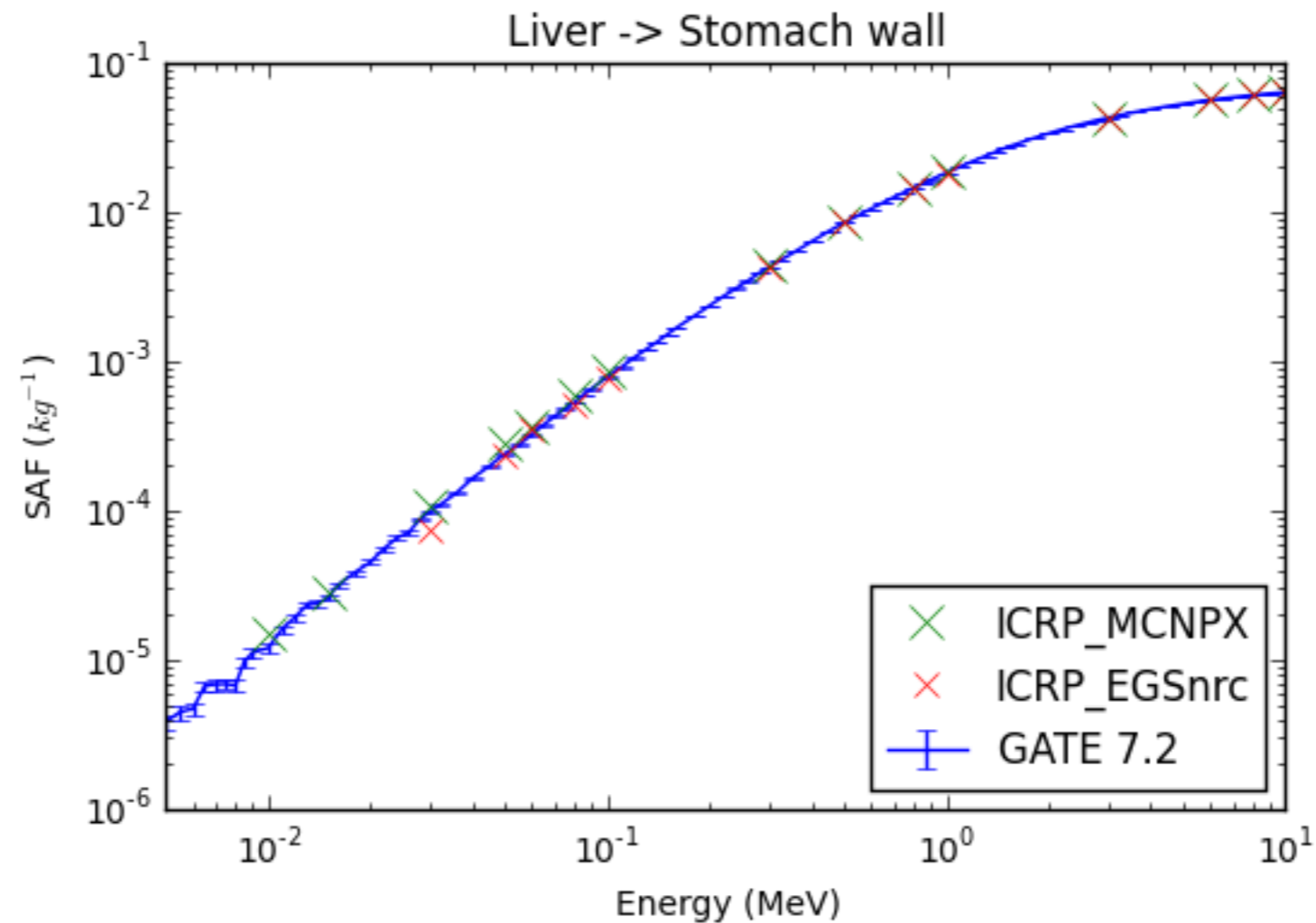


# Comparison with ICRP 133



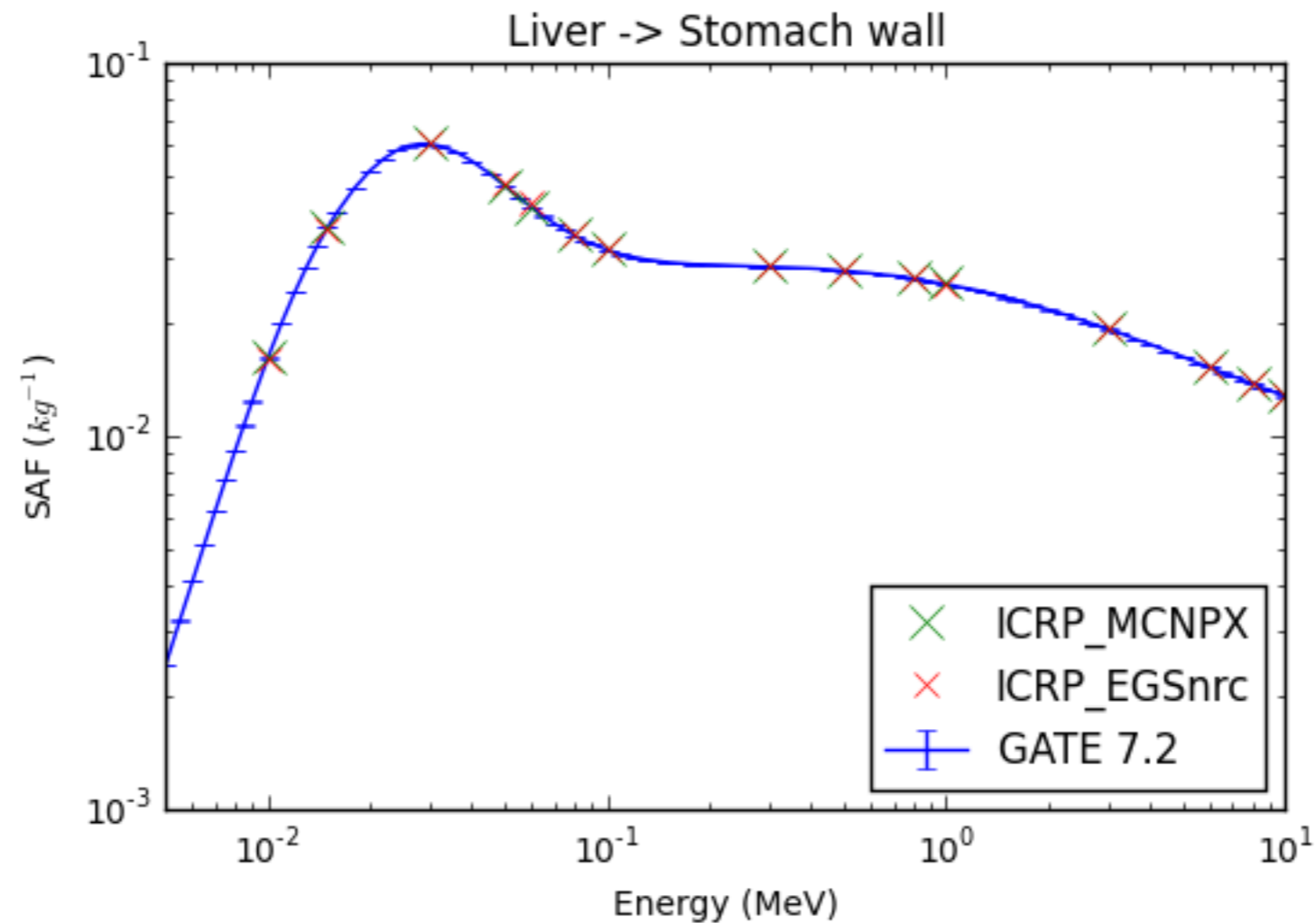


# Comparison with ICRP 110



Specific absorbed fractions for mono-energetic **electrons** for source region liver and target region stomach wall.

# Comparison with ICRP 110



Specific absorbed fractions for mono-energetic **photons** for source region liver and target region stomach wall.