

Heavy Ion Simulation on Geant4

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Introduction (1)

RAON is the heavy ion accelerator

- By colliding heavy ions to target, RAON is expected to produce rare isotopes.
- Before its start, the colliding process need to be simulated.

Introduction (2)

Geant4

- Geant4 is a Monte-Carlo based toolkit for the simulation of the passage of particles through matter.
- Stands for "GEometry ANd Tracking".

Introduction (3)

Physics List

- The class defined as physics factory in Geant4.
- A physics list is constructed by several physics models.
 - E.g.,
FriTioF +Precompound +BERTini intranuclear cascade
= FTFP_BERT

Introduction (4)

- As the preceding step of experiments in RAON, I run the simulations on Geant4.
- My goal:
 1. Select the proper Physics List.
 2. Simulate the experiments planned in future.

Simulation Setup

- Geant4 version: Geant4.10.0.p02
- CPU: AMD Athlon 64 X2 5400+ (2.8 GHz)
- Beam: Protons (1 GeV momentum)
- Target: cylindrical Uranium Carbide (6 mm thick, 2500 K)

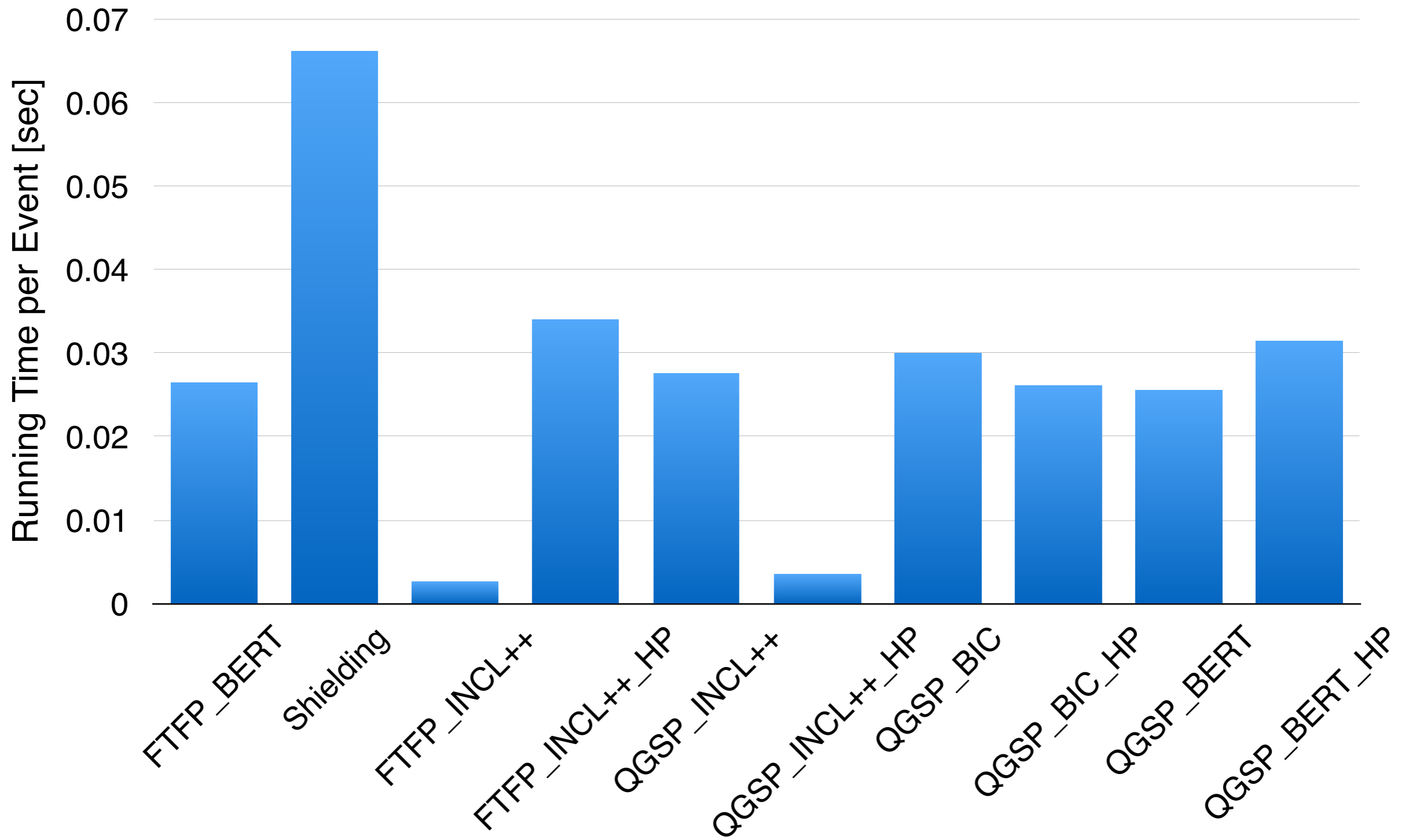
Simulation Results

- Number of Secondary Particles
- CPU Performance
- Caesium isotopes
- Francium isotopes

Number of Secondary Particles

PhysicsList	Beam on	Secondary Particles	Cs	Fr
FTFP_BERT	2,000,000	302,698	2,744	62
Shielding	2,000,000	8,588,472	9,217	8,855
FTFP_INCL++	2,000,000	373,484	2,521	513
FTFP_INCL++_HP	2,000,000	414,821	2,891	547
QGSP_INCL++	2,000,000	373,655	2,528	515
QGSP_INCL++_HP	2,000,000	415,065	2,754	568
QGSP_BIC	2,000,000	302,013	2,420	743
QGSP_BIC_HP	2,000,000	342,695	2,937	789
QGSP_BERT	2,000,000	301,683	2,606	92
QGSP_BERT_HP	2,000,000	369,584	2,986	69

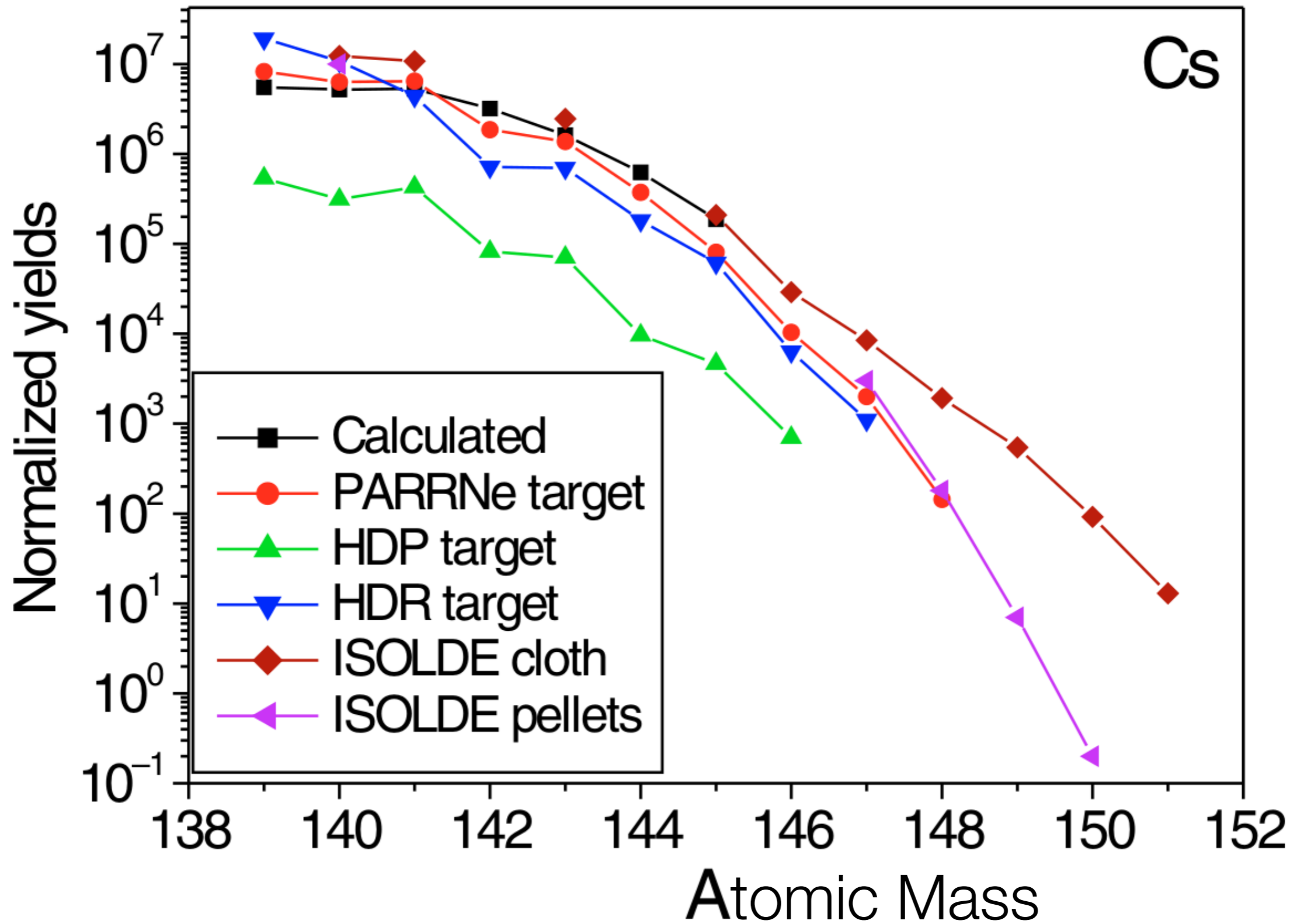
■ AMD Athlon 64 X2 5400+ @2.80 GHz



CPU Performance

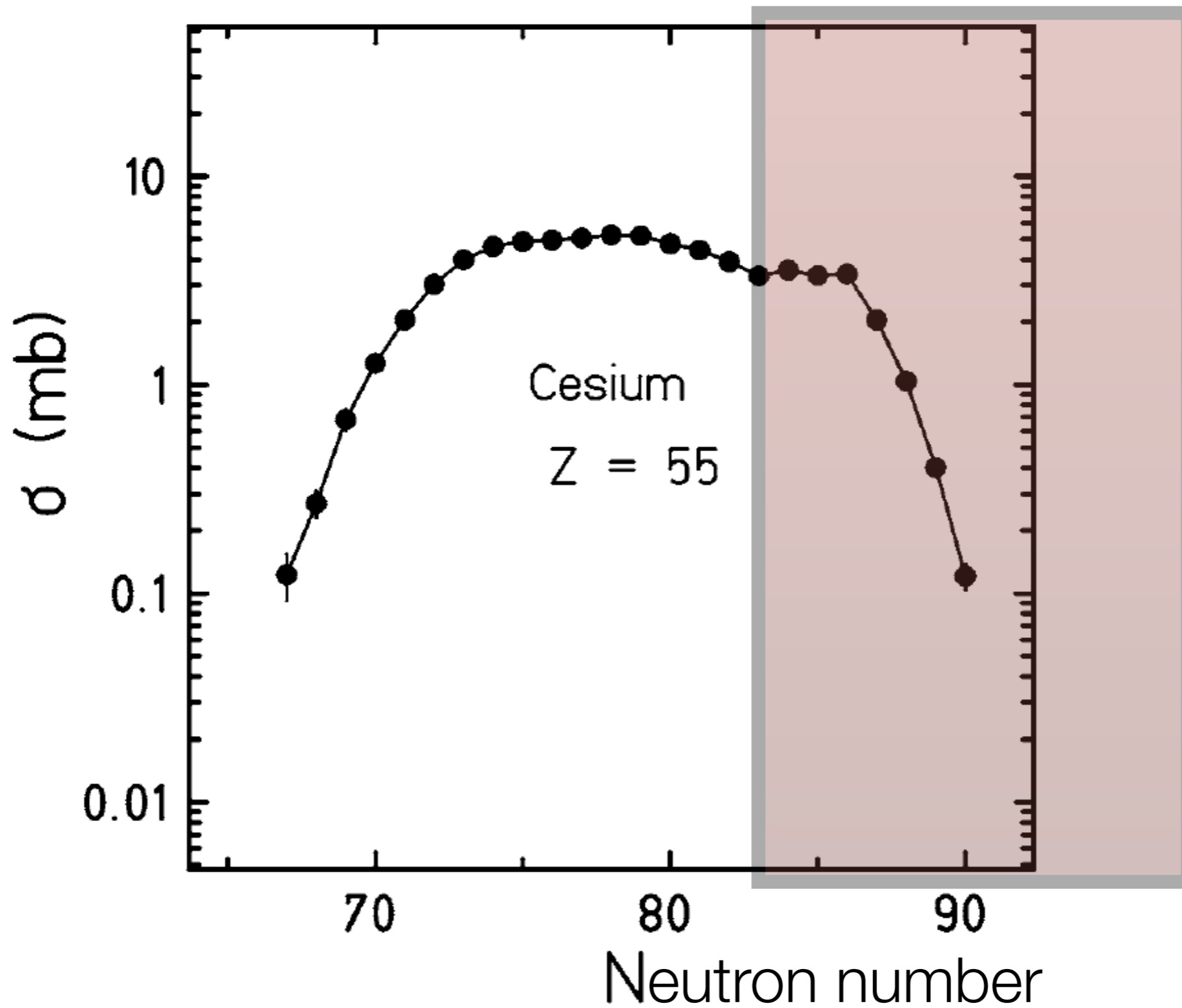
Caesium isotope distribution

- Picked up all the Caesiums in secondary particles.
- Compare with two experiments.



Caesium Isotope Distribution

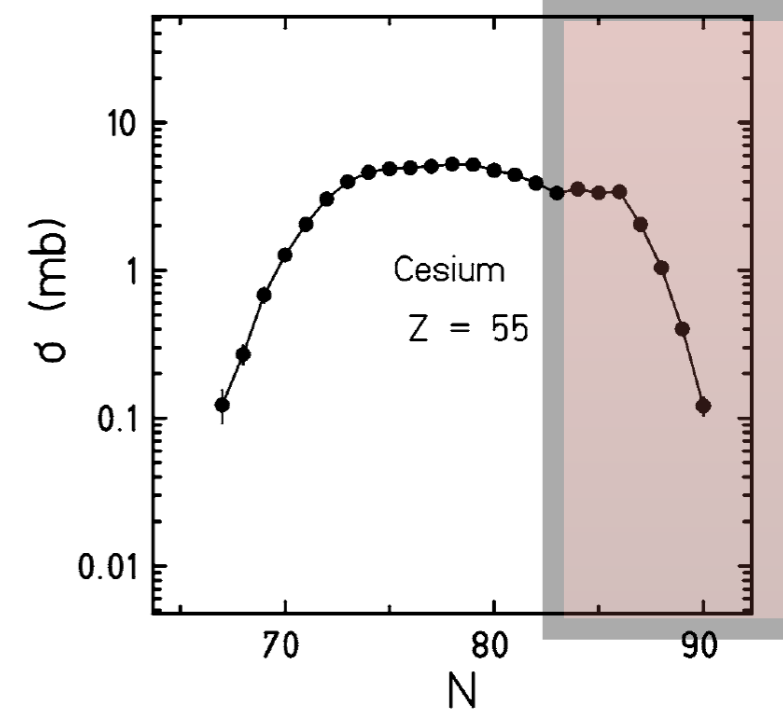
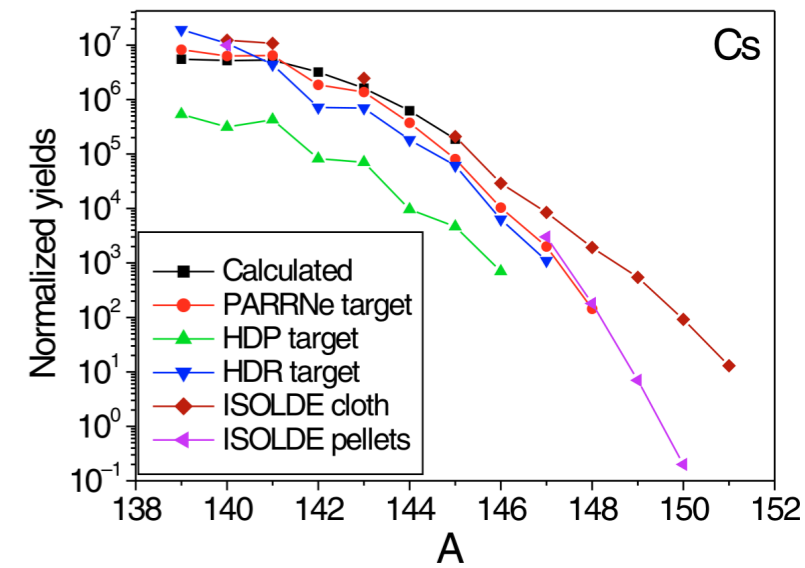
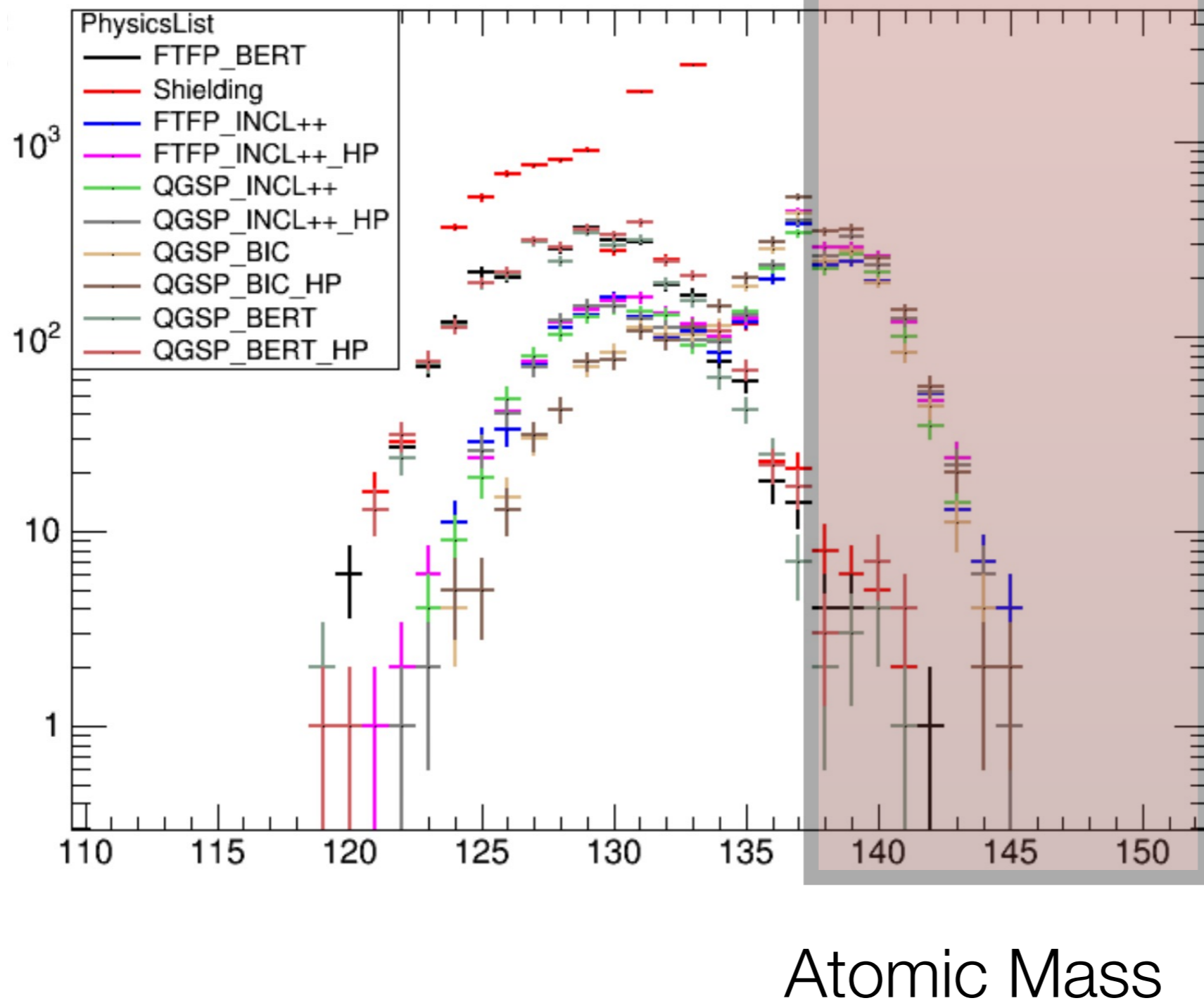
Eur. Phys. J. Special Topics 150, 297–300 (2007)



Caesium Isotope Distribution

Nuclear Physics A 725 (2003) 213–253

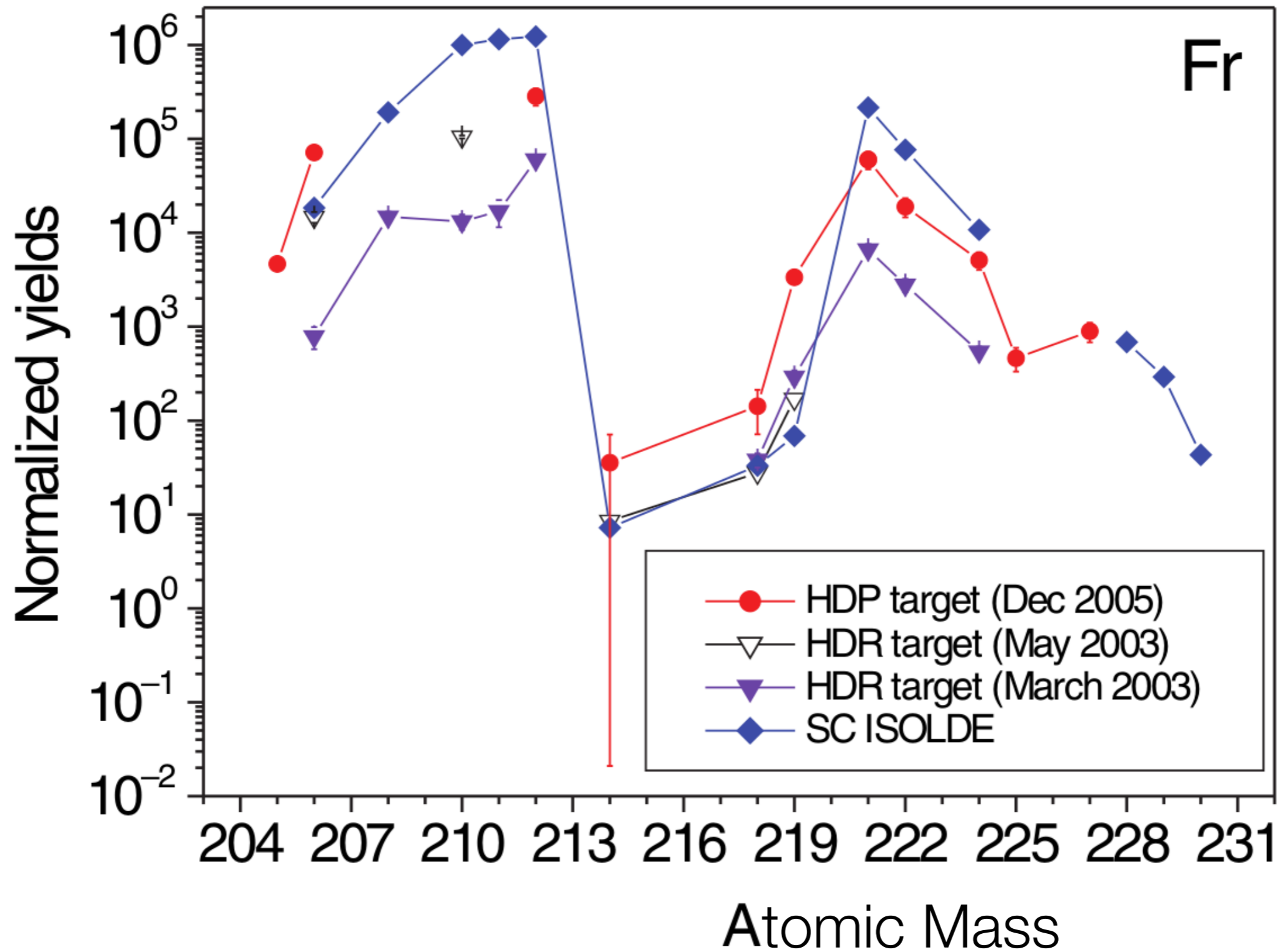
Number of Events



Simulation of Caesium Isotope Distribution

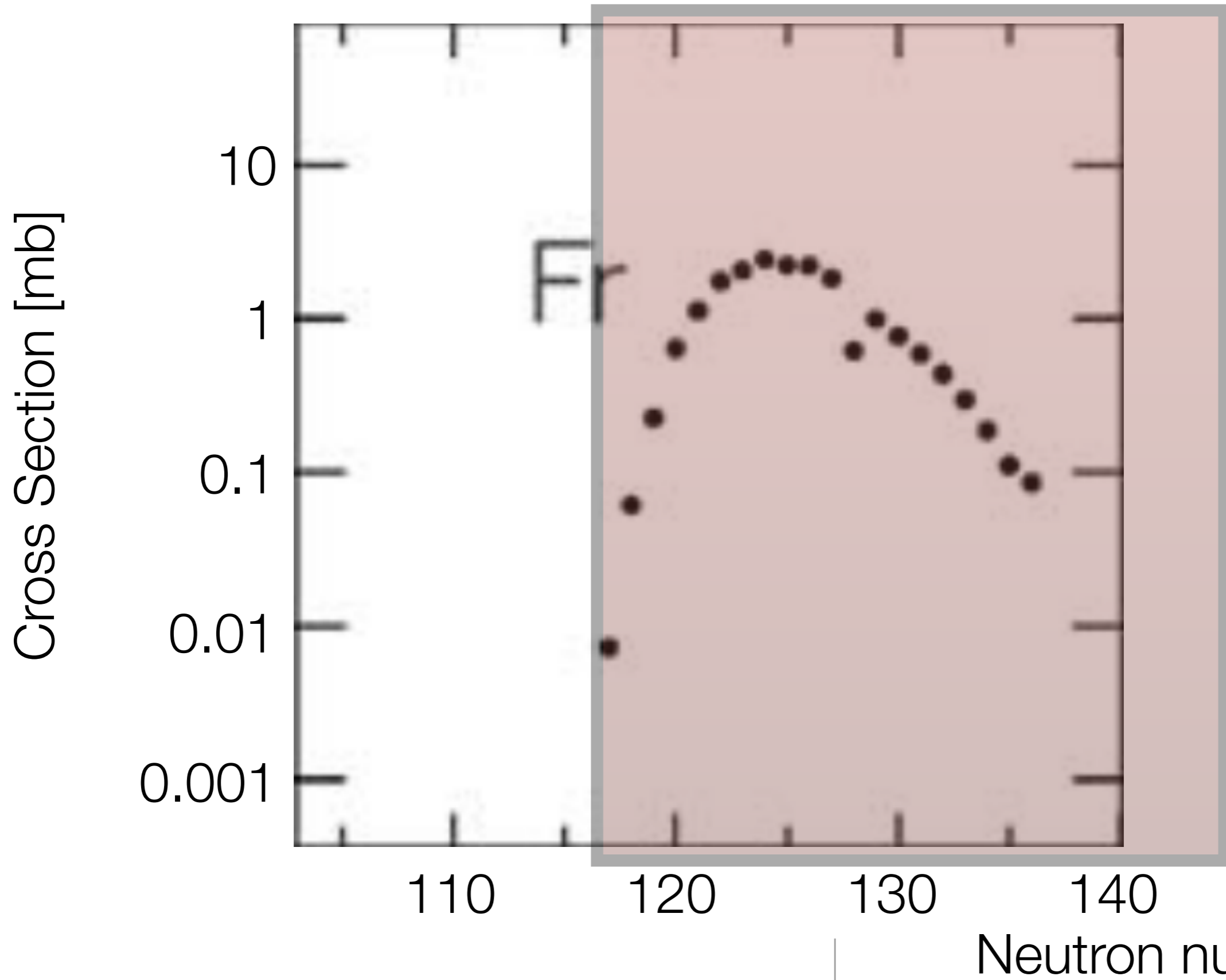
Francium isotope distribution

- Similar to Caesium isotope distribution, picked up all the Franciums in secondary particles.
- Compare with two experiments.



Francium Isotope Distribution

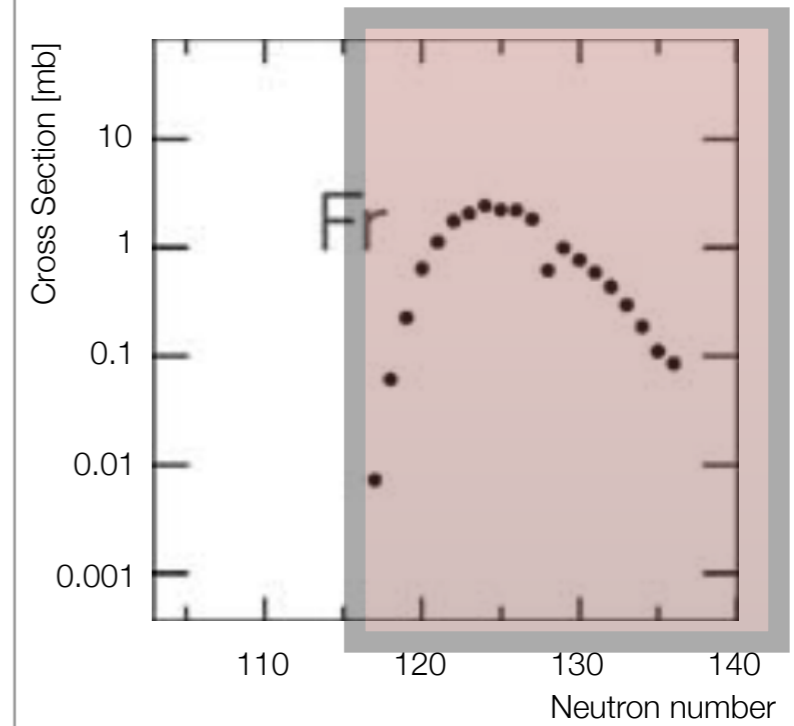
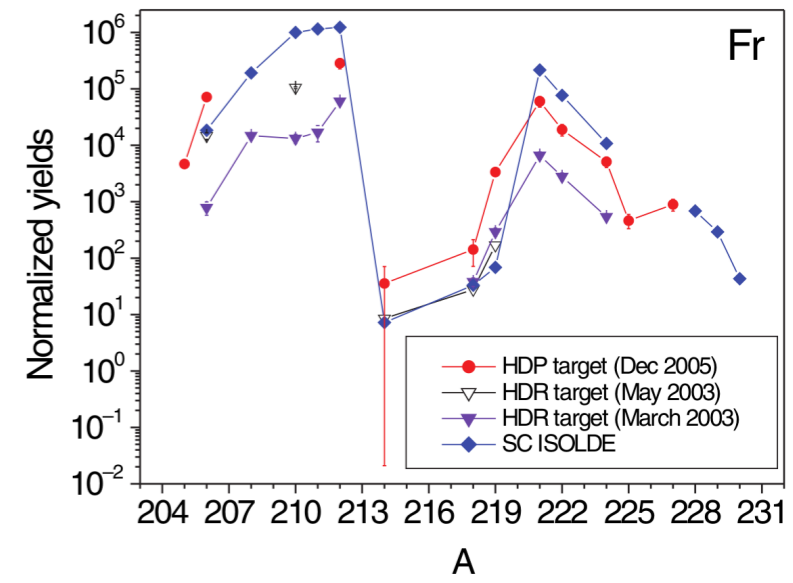
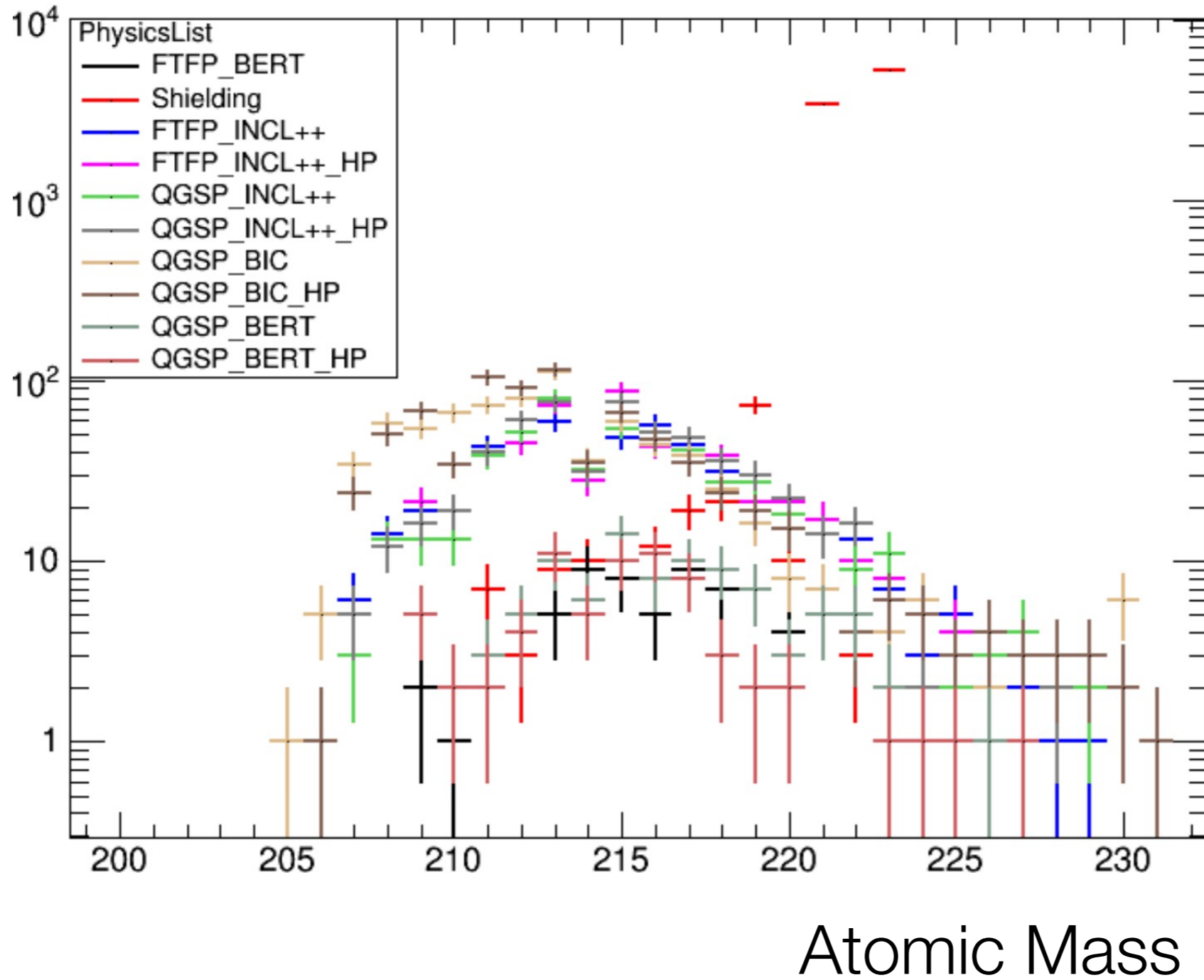
Eur. Phys. J. Special Topics 150, 297–300 (2007)



Francium Isotope Distribution

Nuclear Physics A 724 (2003) 413–430

Number of Events



Simulation of Francium Isotope Distribution

Summary & Plan

- Physics List Selection
 - Cross-Section will be studied to be exact.
- Further researches
 - dE/dx and He isotope distribution is now on progress.
 - $N \rightarrow C$ is planned.

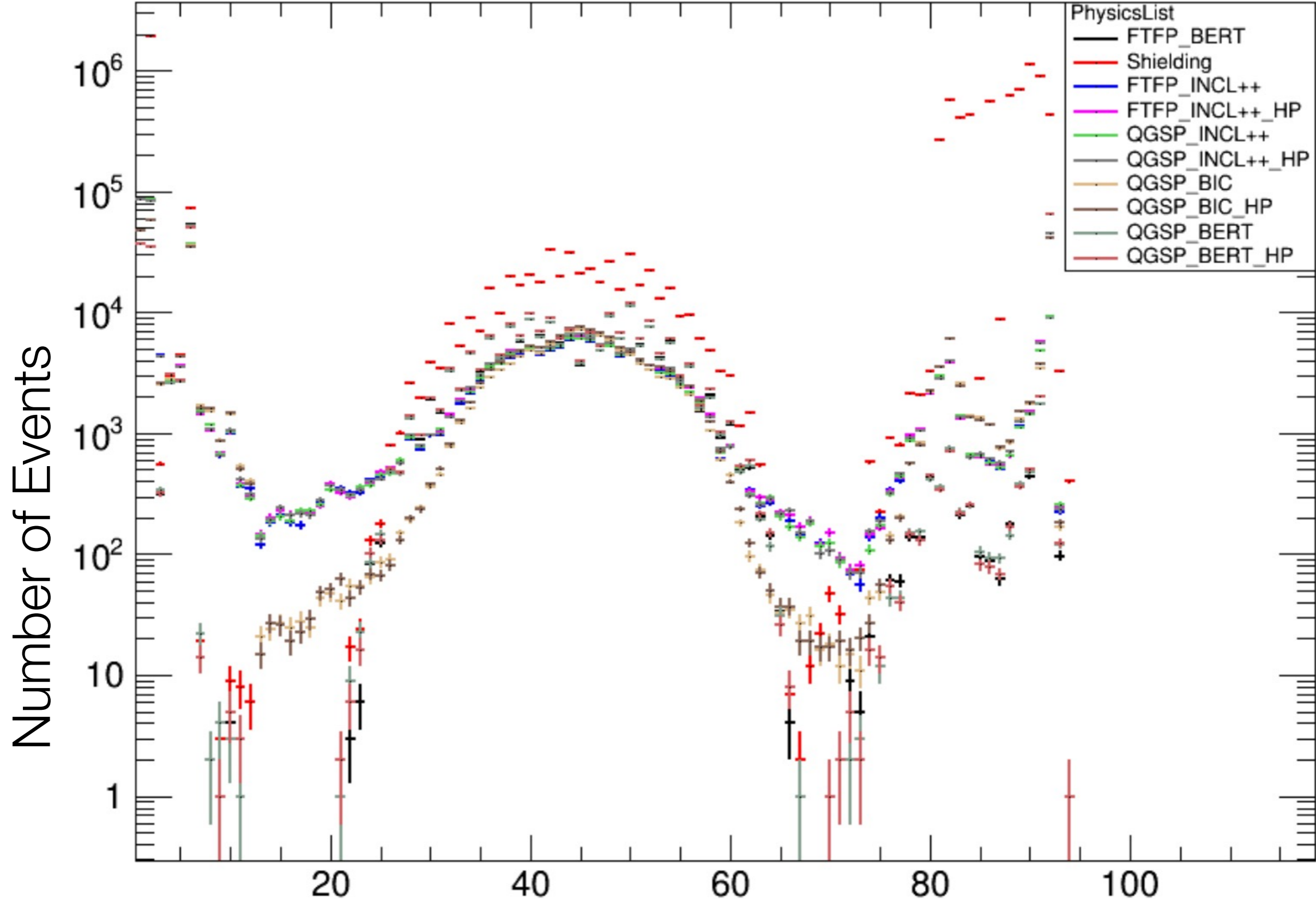
References

1. Eur. Phys. J. Special Topics 150, 297–300 (2007)
2. Nuclear Physics A 725 (2003) 213–253
3. Nuclear Physics A 724 (2003) 413–430
4. K. A. Olive et al. (Particle Data Group), Chin. Phys. C, 38, 090001 (2014)

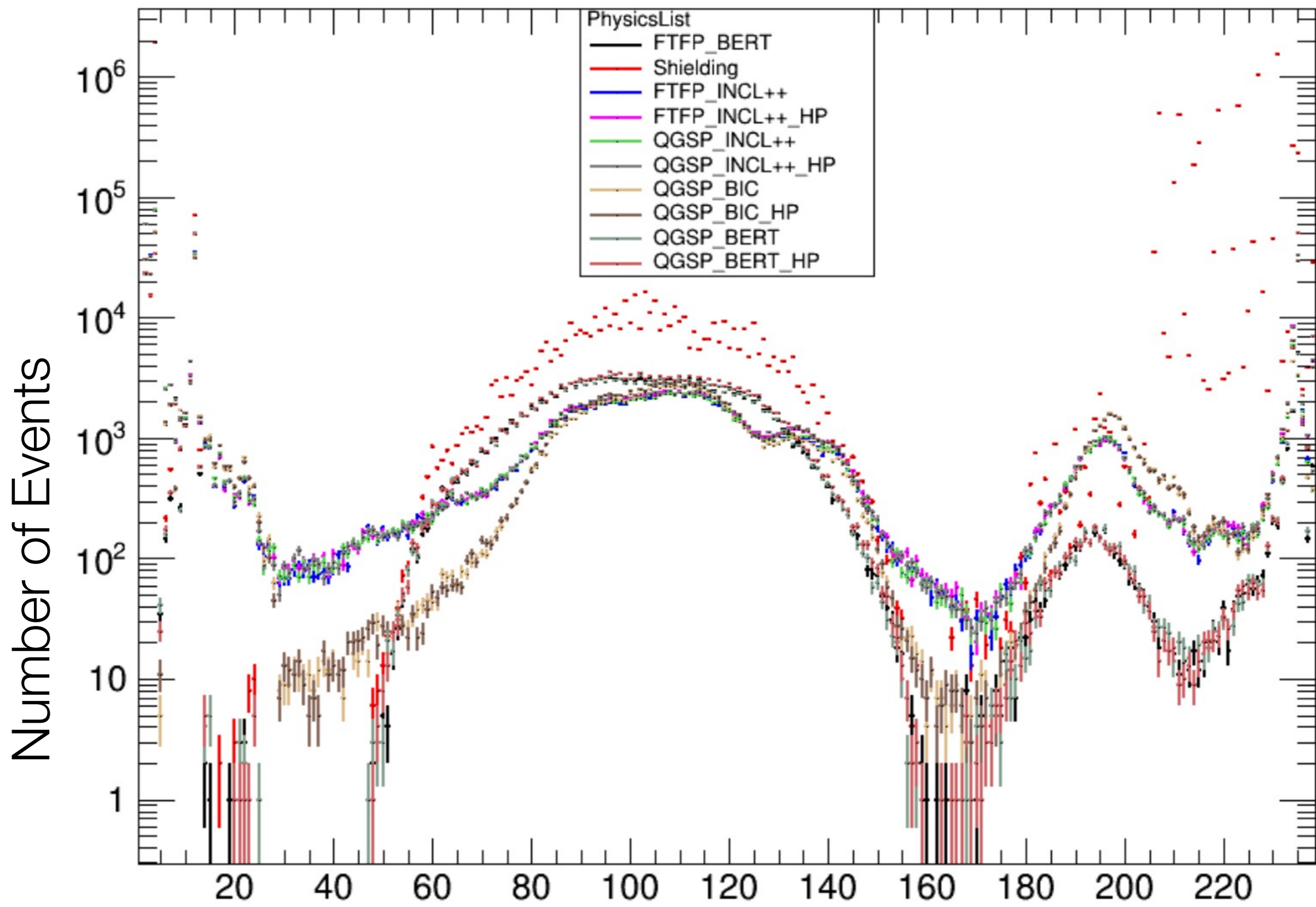
Backup slides

What the words in physics Lists stands for

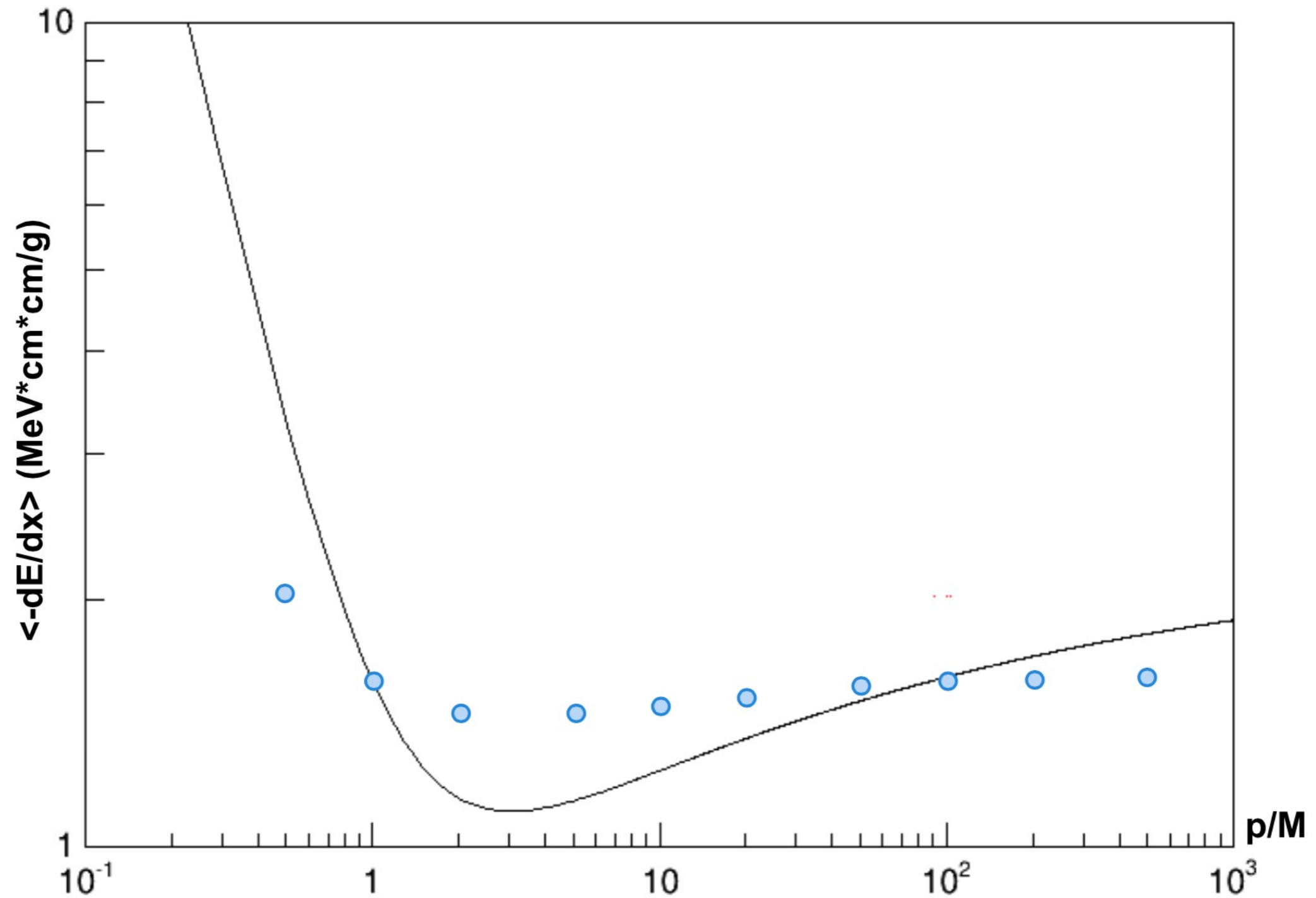
PhysicsLists	
FTF	Fritiof model
QGS	Quark-gluon-string model
P	Precompound model
BERT	Bertini intranuclear cascade model
INCL++	Liège intranuclear cascade model
BIC	Binary cascade model
HP	NeutronHP model
Shielding	FTFP_BERT_HP with Ion Quantum Molecular Dynamics model



Atomic Number Distribution

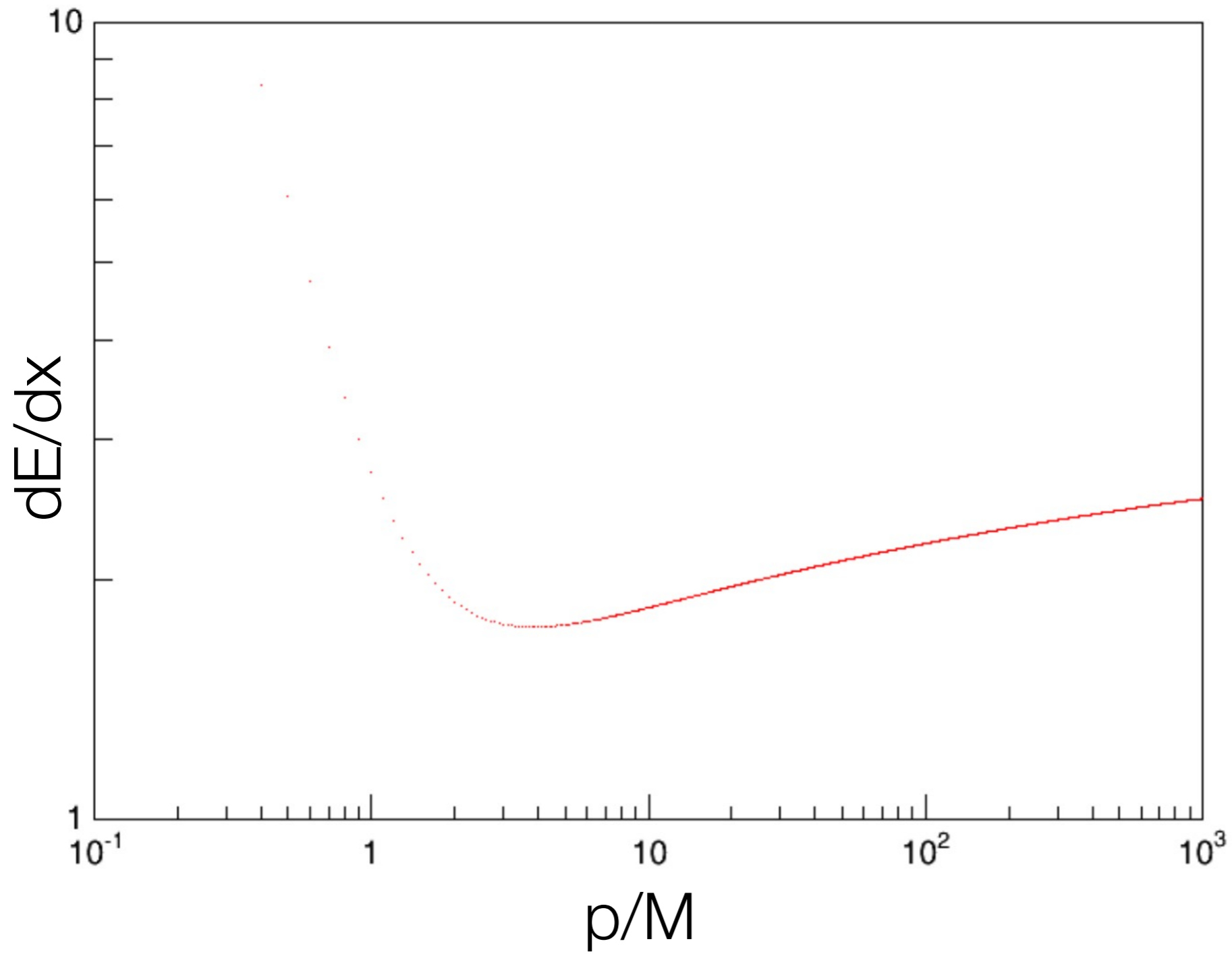


Atomic Mass Distribution

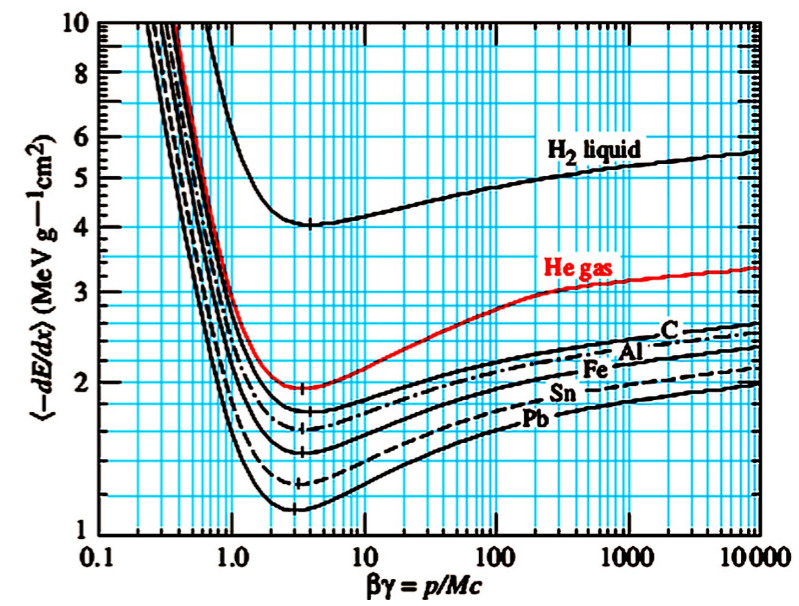


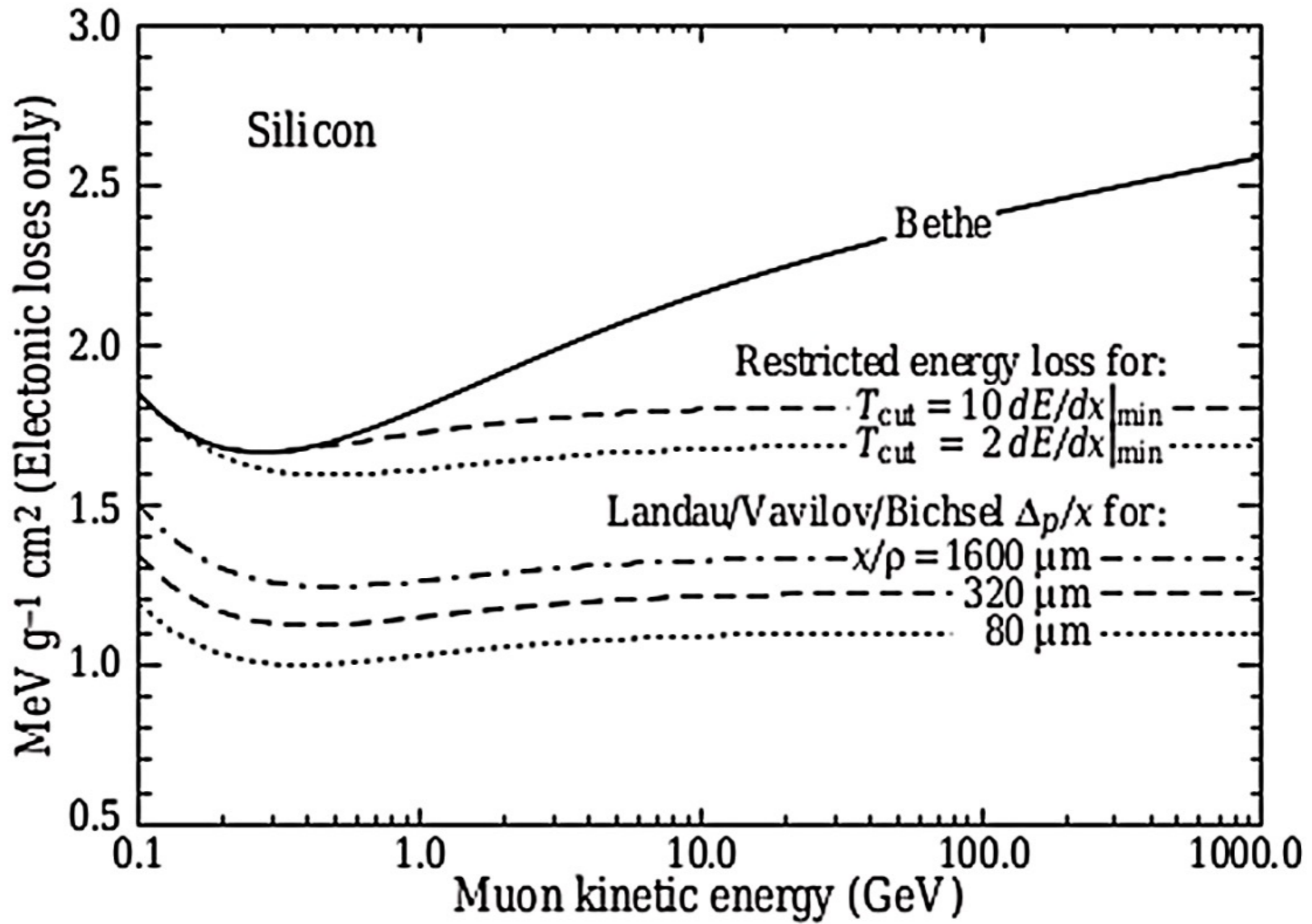
dE/dx of Uranium Carbide

calculated with Bethe equation



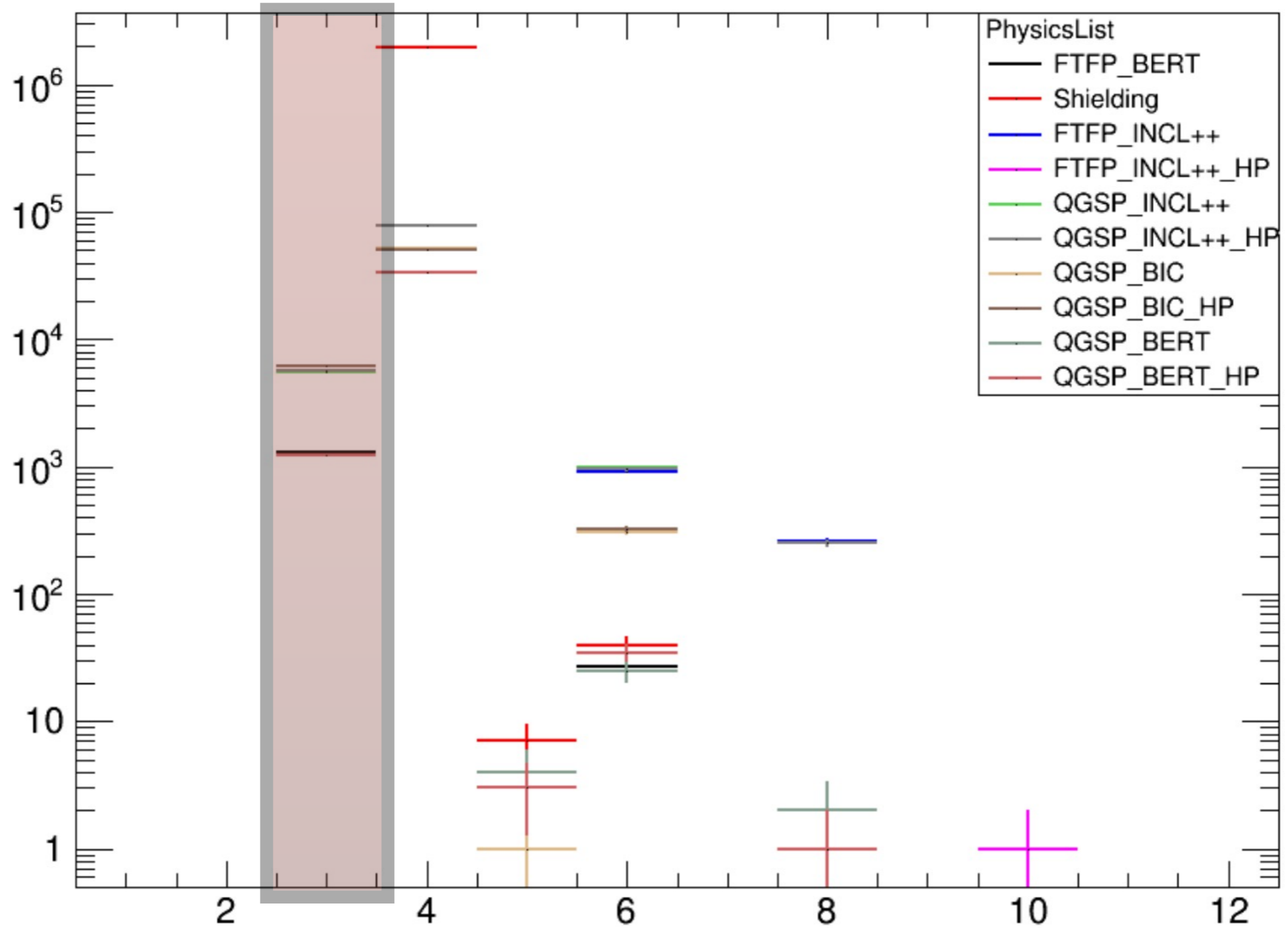
Simulation of dE/dx of Carbon





Restricted dE/dx

Particle Data Group



Helium Isotope Distribution