^{47}Sc production for medical applications: cross-section optimization based on genetic algorithms

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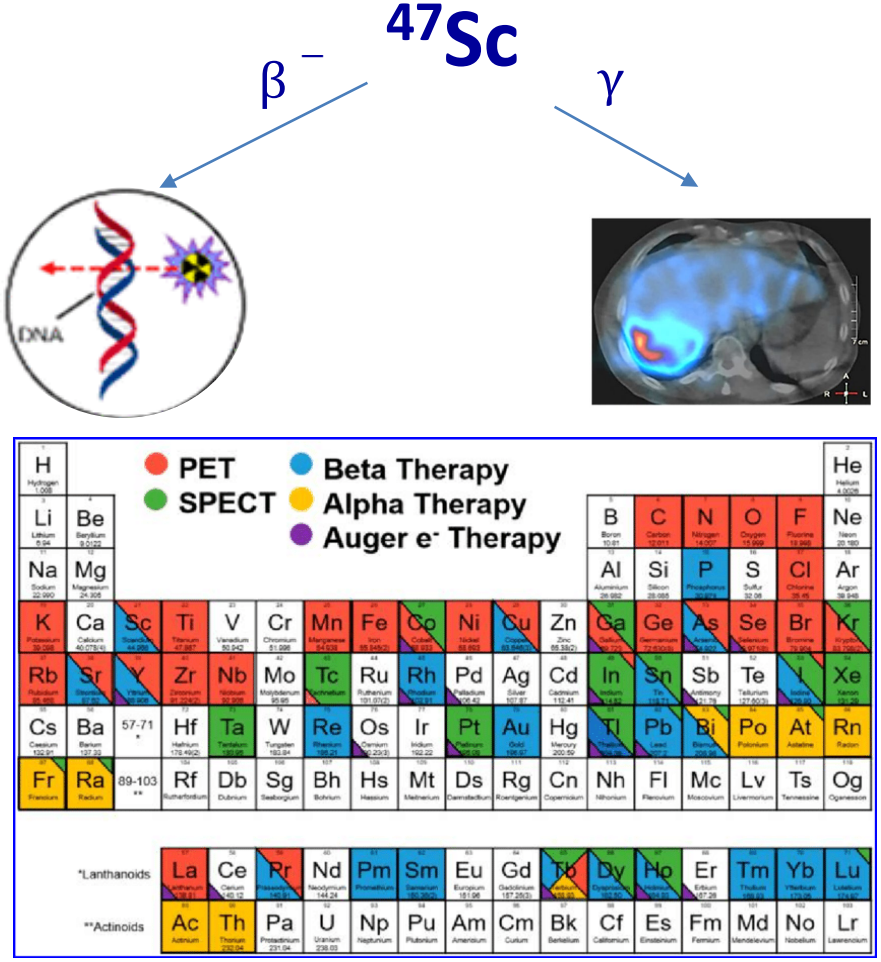
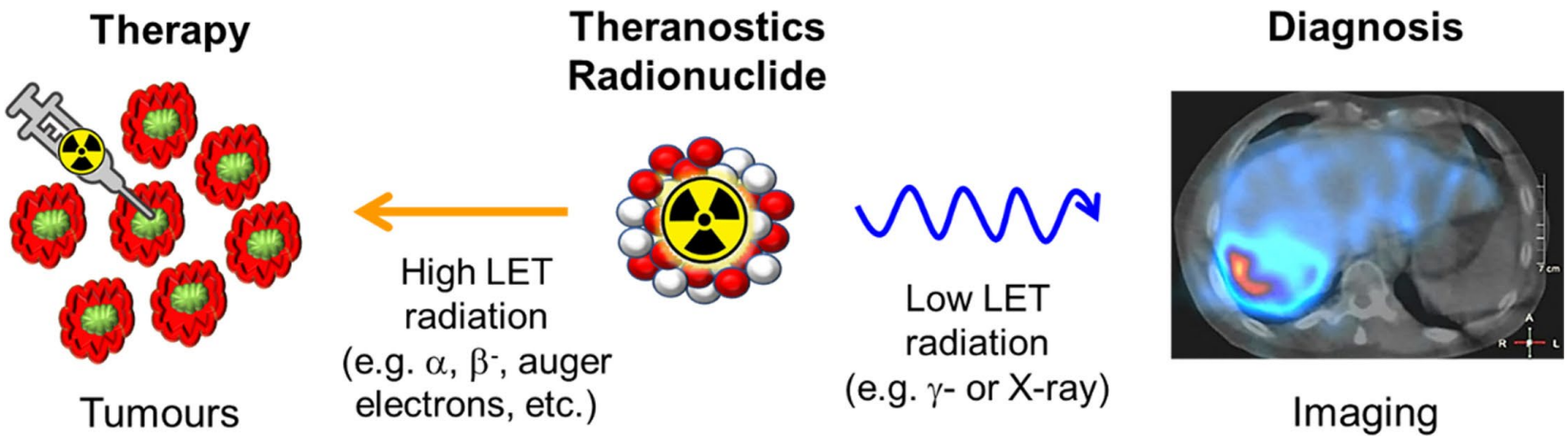


^{47}Sc holds potential for dual-purpose radiopharmaceuticals—therapy and diagnostics (theranostics)



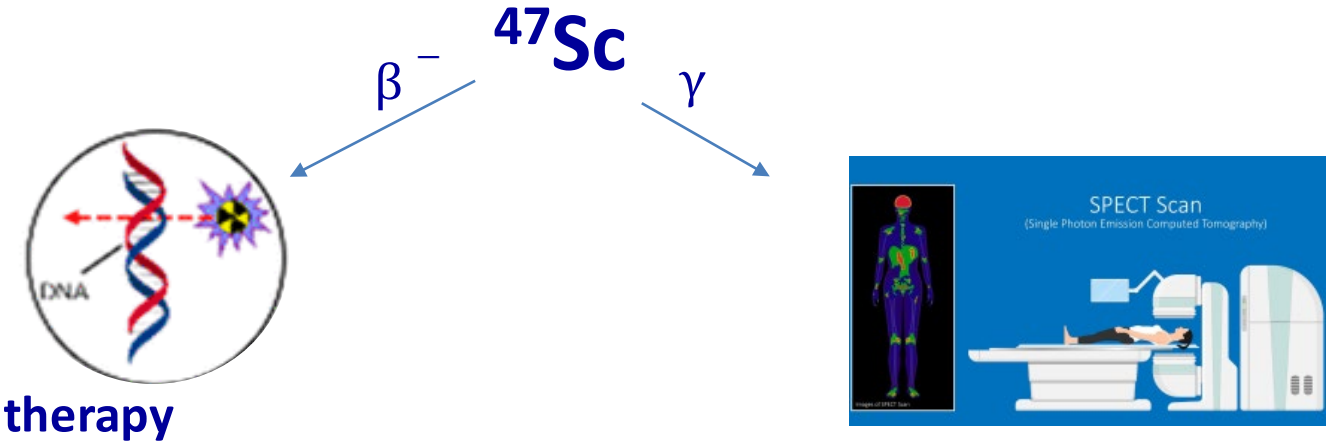
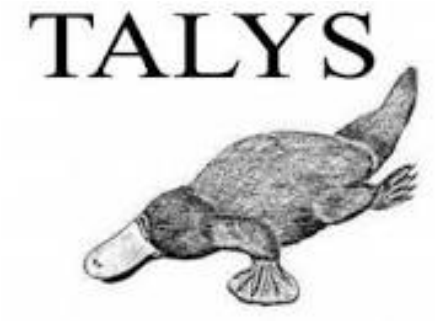


Image is taken from H.Y. Tan et al., Nuclear Medicine and Biology, 90–91, p. 55 (2020)

For the evaluation of the cross sections we used TALYS code



Hartree-Fock level densities from numerical tables

Geometry-dependent hybrid model for the pre-equilibrium process

Level densities are adjusted to experimental data via a scaling function:

$$\rho(E) = \exp\left(c\sqrt{E-p}\right)\rho_{\mathrm{HFM}}(E-p)$$

We optimized 6 pairs of c & p parameters with genetic algorithm to fit a large set of measured cross sections relevant for ^{47}Sc production from ^{49}Ti target

The genetic algorithm is a random-based evolutionary algorithm inspired by Darwin's theory of natural selection

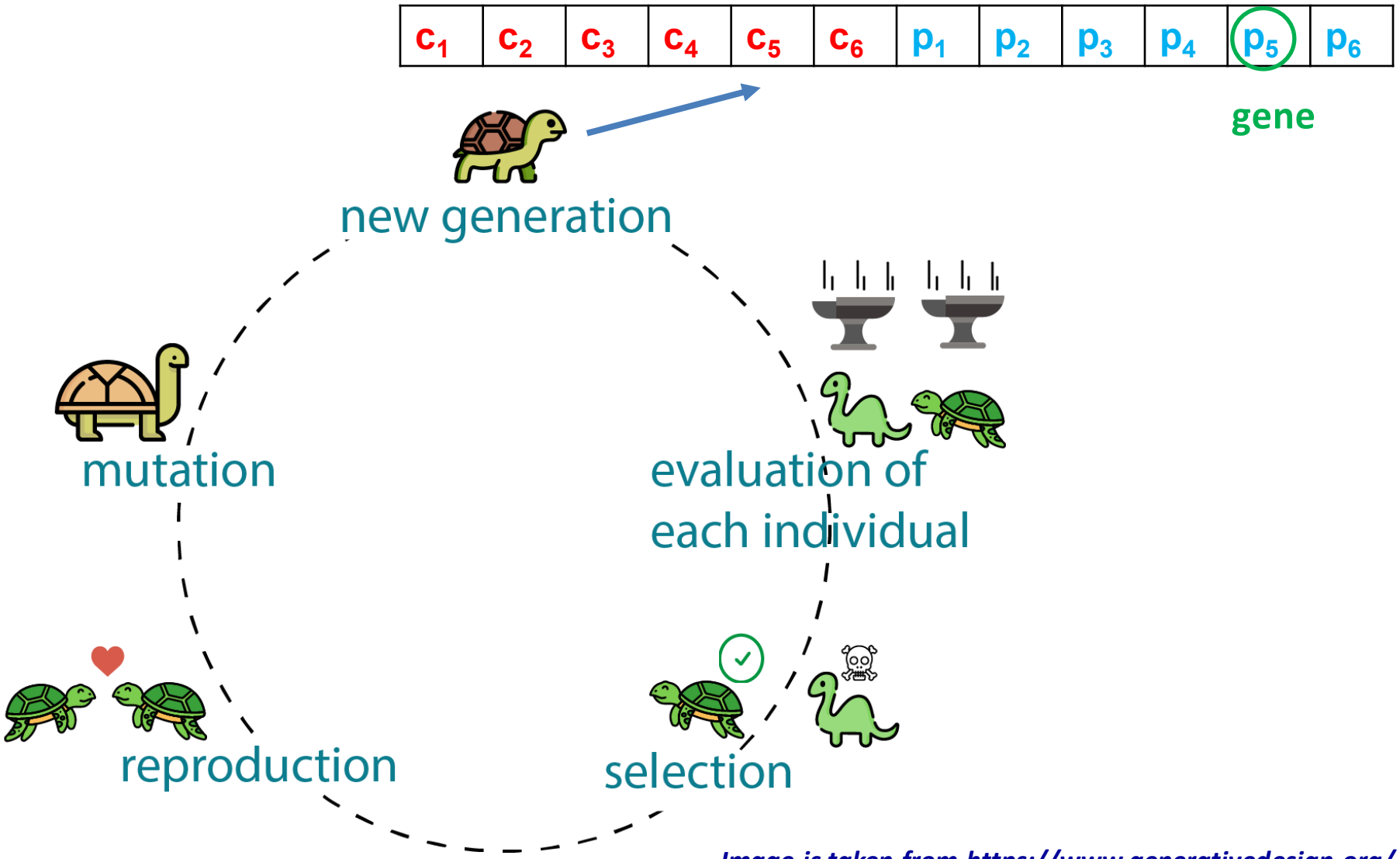
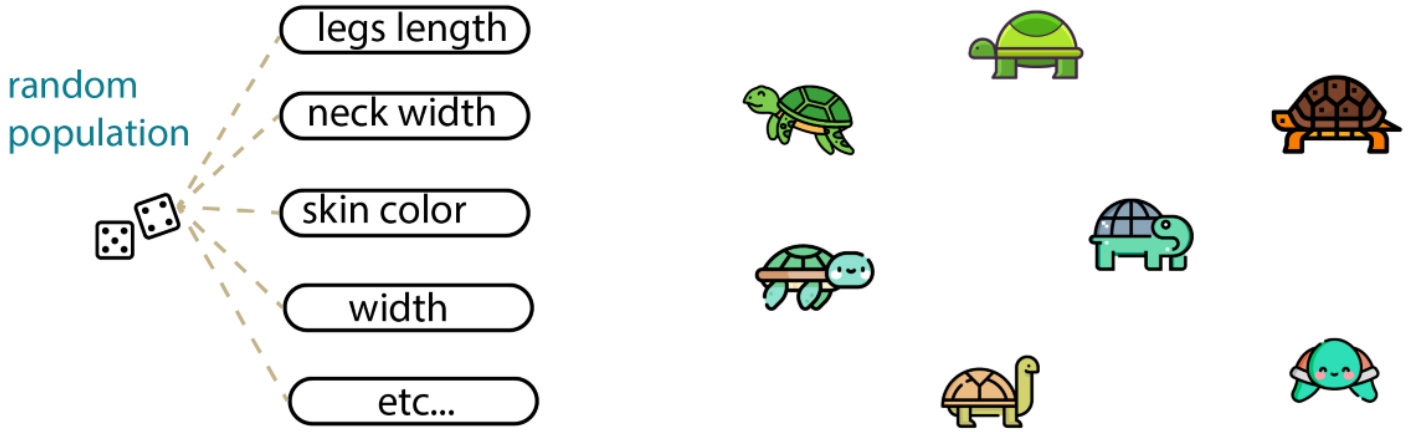


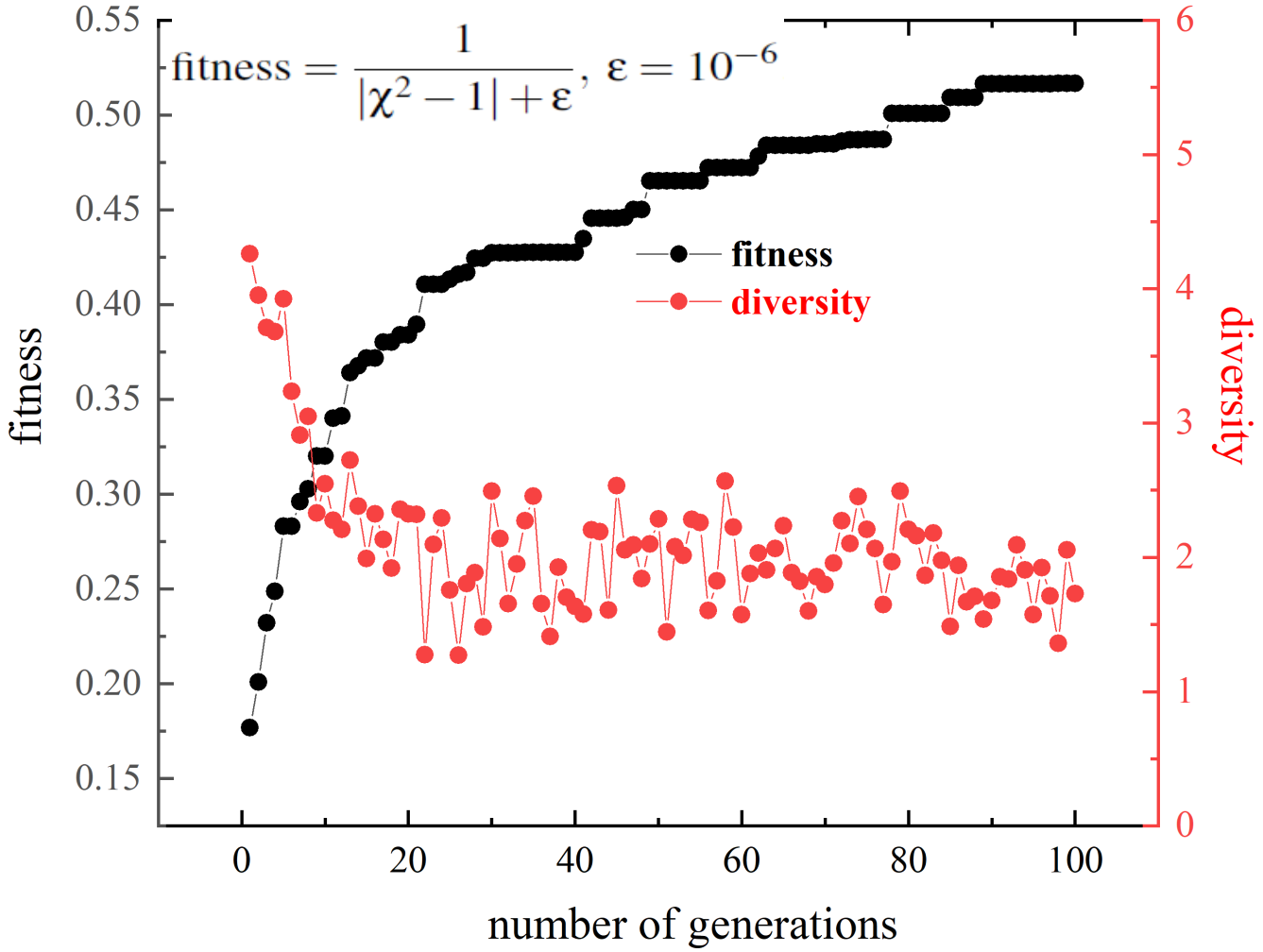
Image is taken from https://www.generativedesign.org/

In the initialization phase, it is important to consider how this initial population might vary



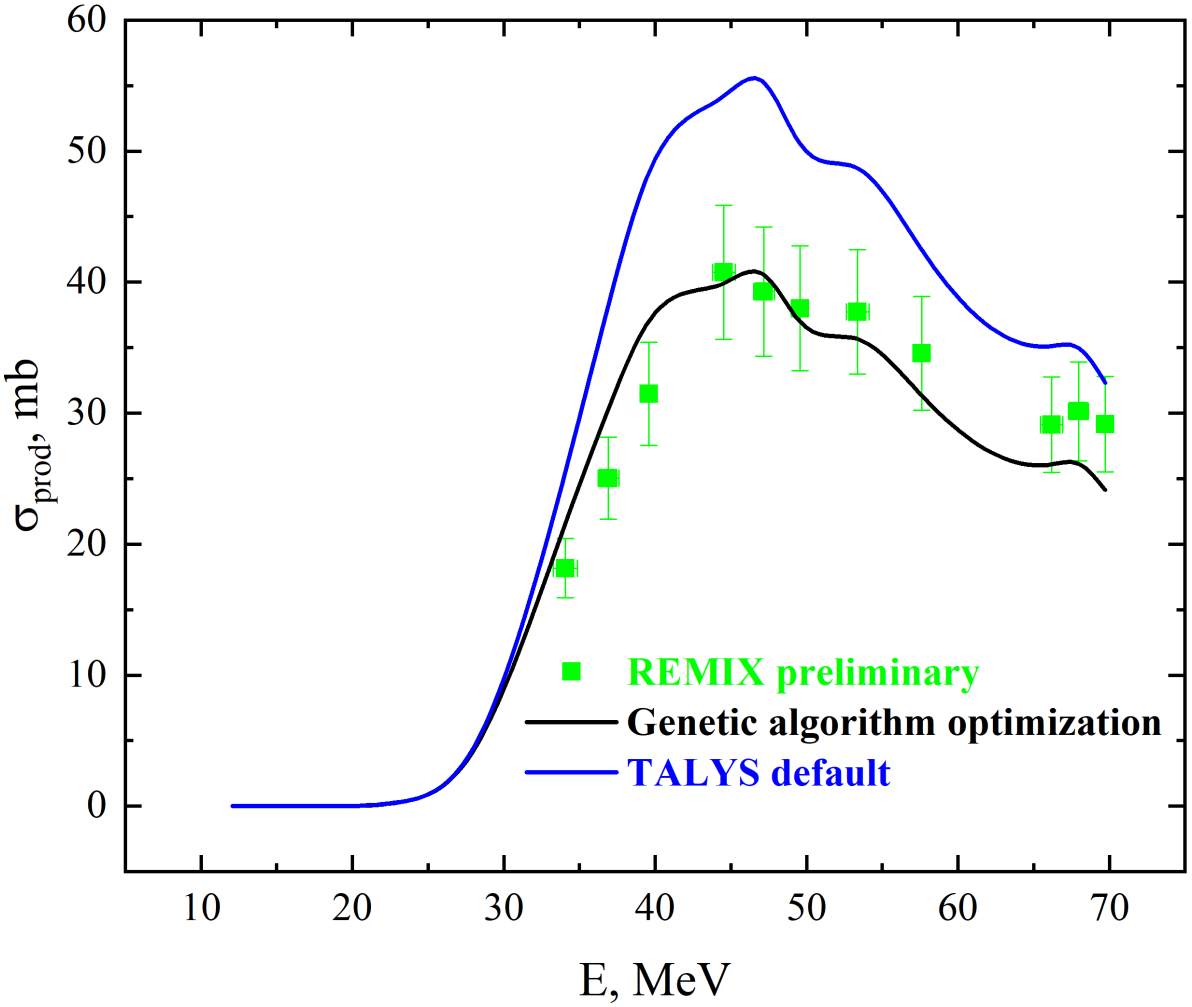
Maintaining population diversity is essential for preventing premature convergence to suboptimal solutions

Increasing the diversity of the initial population often results in a faster convergence of the fitness function



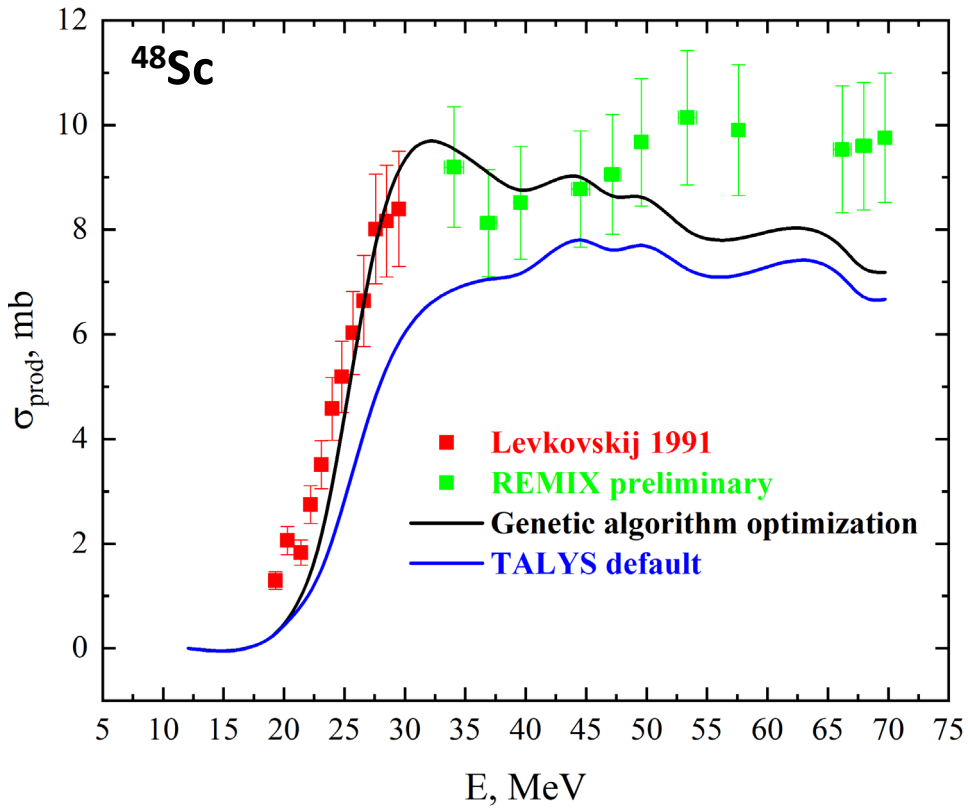
Convergence of fitness function in p-^{49}Ti cross section optimization vs. initial population diversity

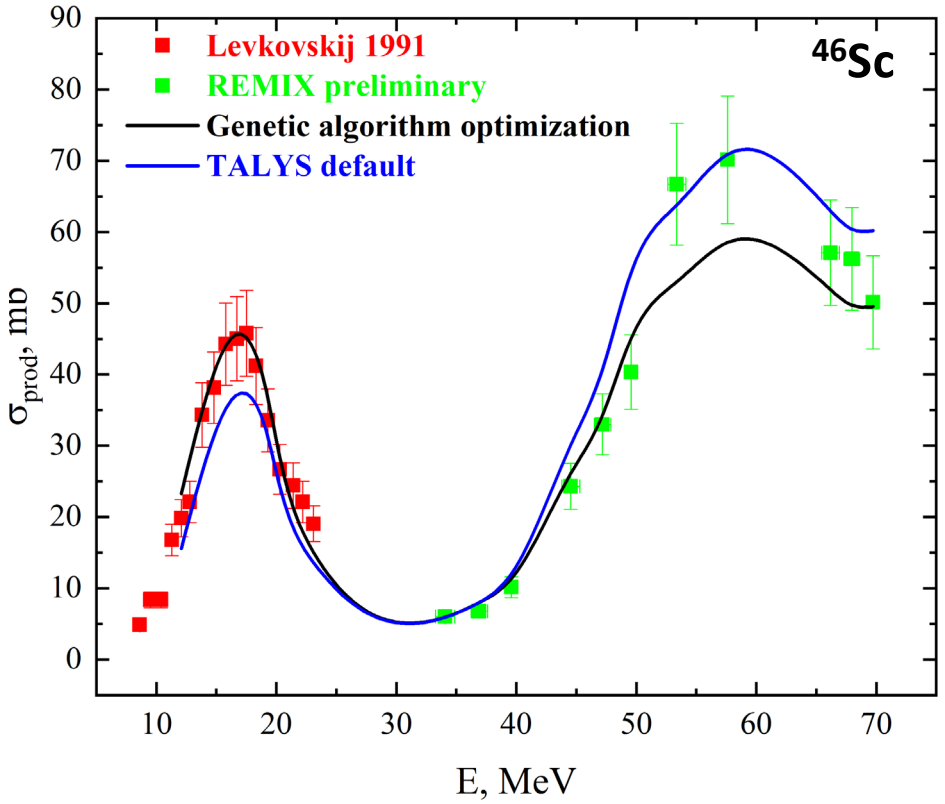
Genetic algorithm optimization yields a superior cross-section fit compared to the default TALYS model



Fit of the ^{49}Ti(p,n2p)^{47}Sc cross section using GA optimization for level-density parameters compared to default LD model 4 values

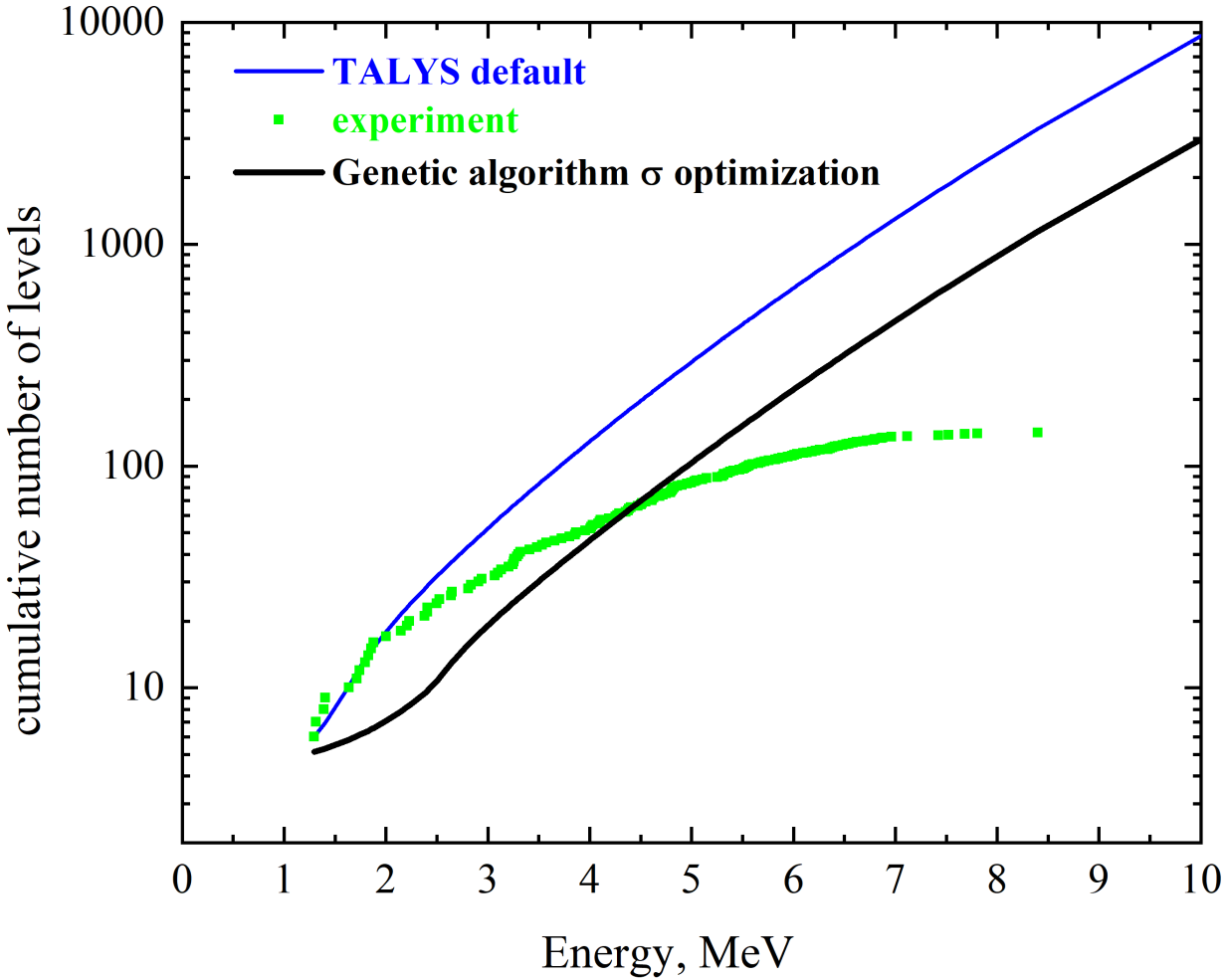
With the genetic algorithm, we successfully fit the cross-section data for the production of 9 radionuclei





Fit of the ^{49}Ti(p,n2p)^{46,48}Sc cross section using GA optimization for level-density parameters compared to default LD model 4 values

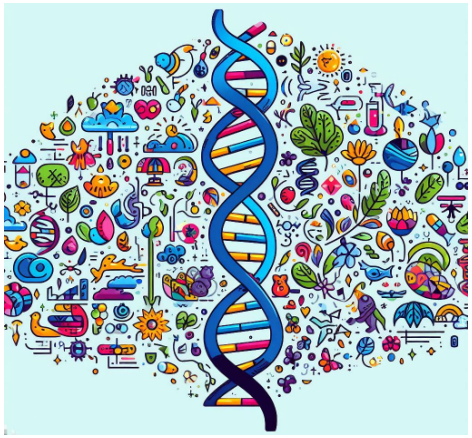
TALYS default model better describes the low-energy nuclear level density of ^{47}Sc as it was tailored to fit the cumulatives



Cumulative nuclear levels for ^{47}Sc compound nucleus:

GA-optimized vs. LD model 4 defaults

The combination of genetic algorithm and TALYS is a powerful optimization tool for enhanced cross-section accuracy



Genetic algorithm

powerful optimization tool