
# Physics Presentations of this Tutorial

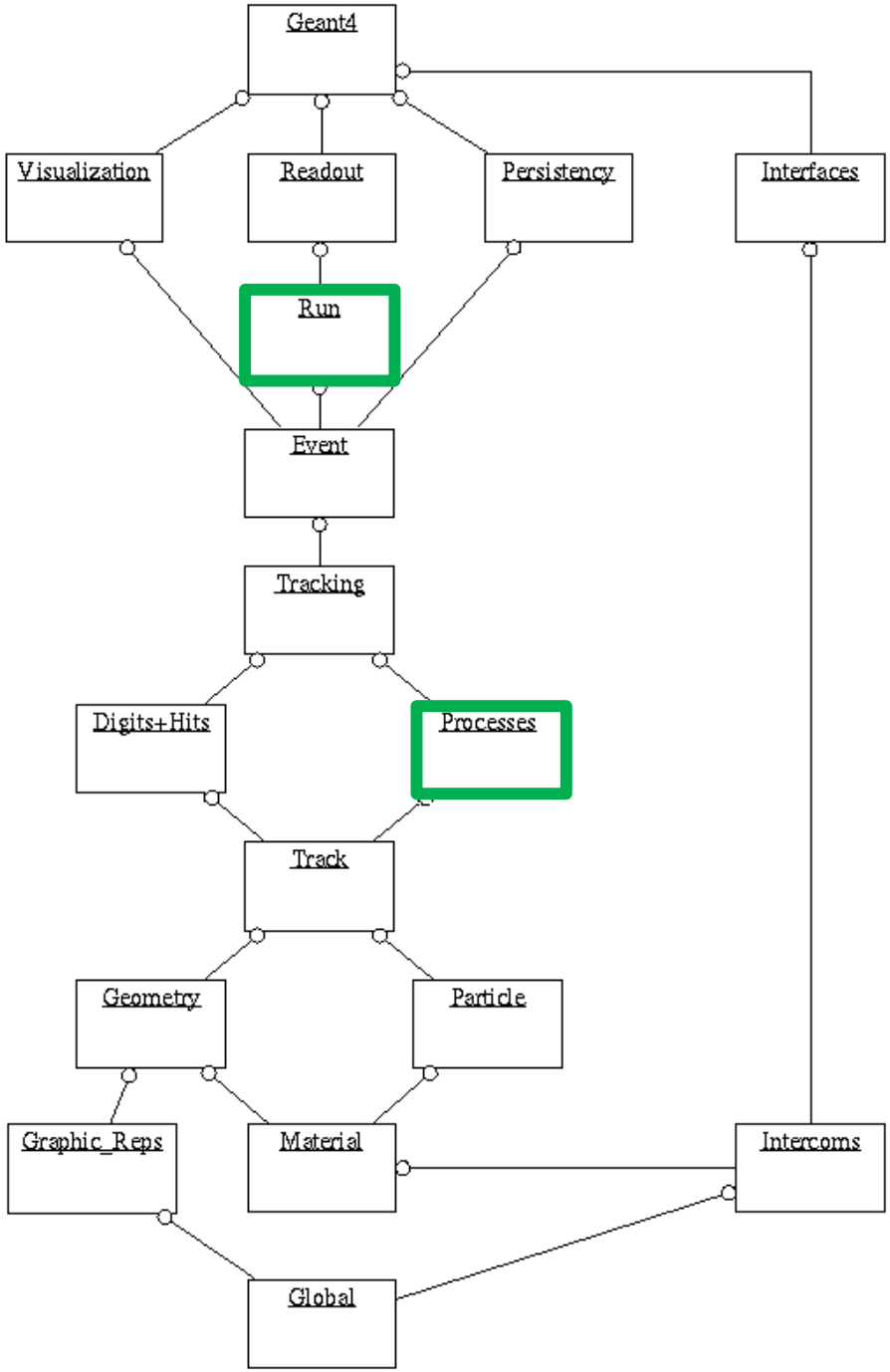
Geant4 PHENIICS & IN2P3 Tutorial,
13 – 17 May 2019,
Orsay

Marc Verderi
LLR, Ecole polytechnique

# Where will we look in the toolkit ?

Main categories and directories involved:

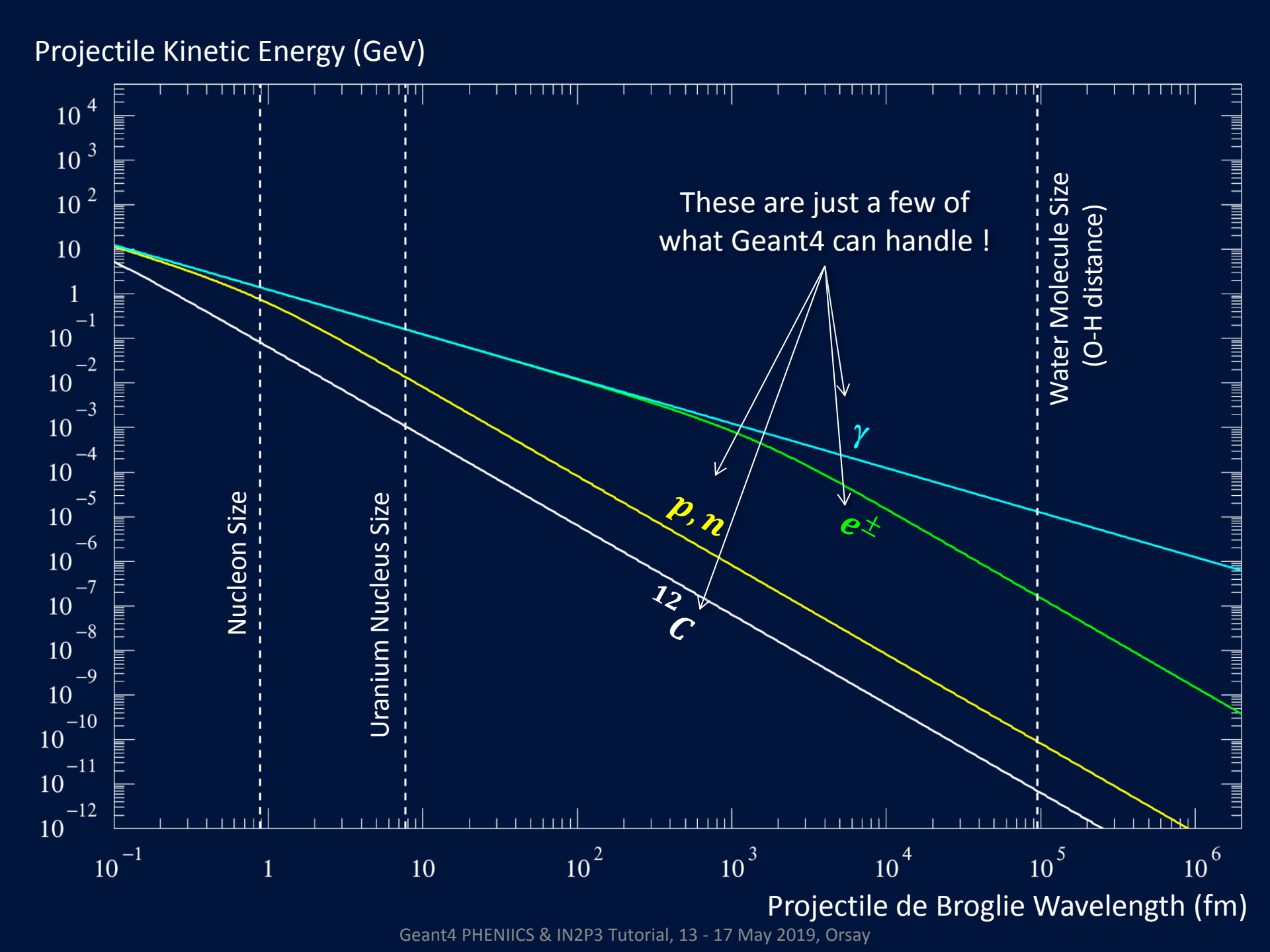
- Processes:
  - geant4/source/processes
- Run
  - geant4/source/run

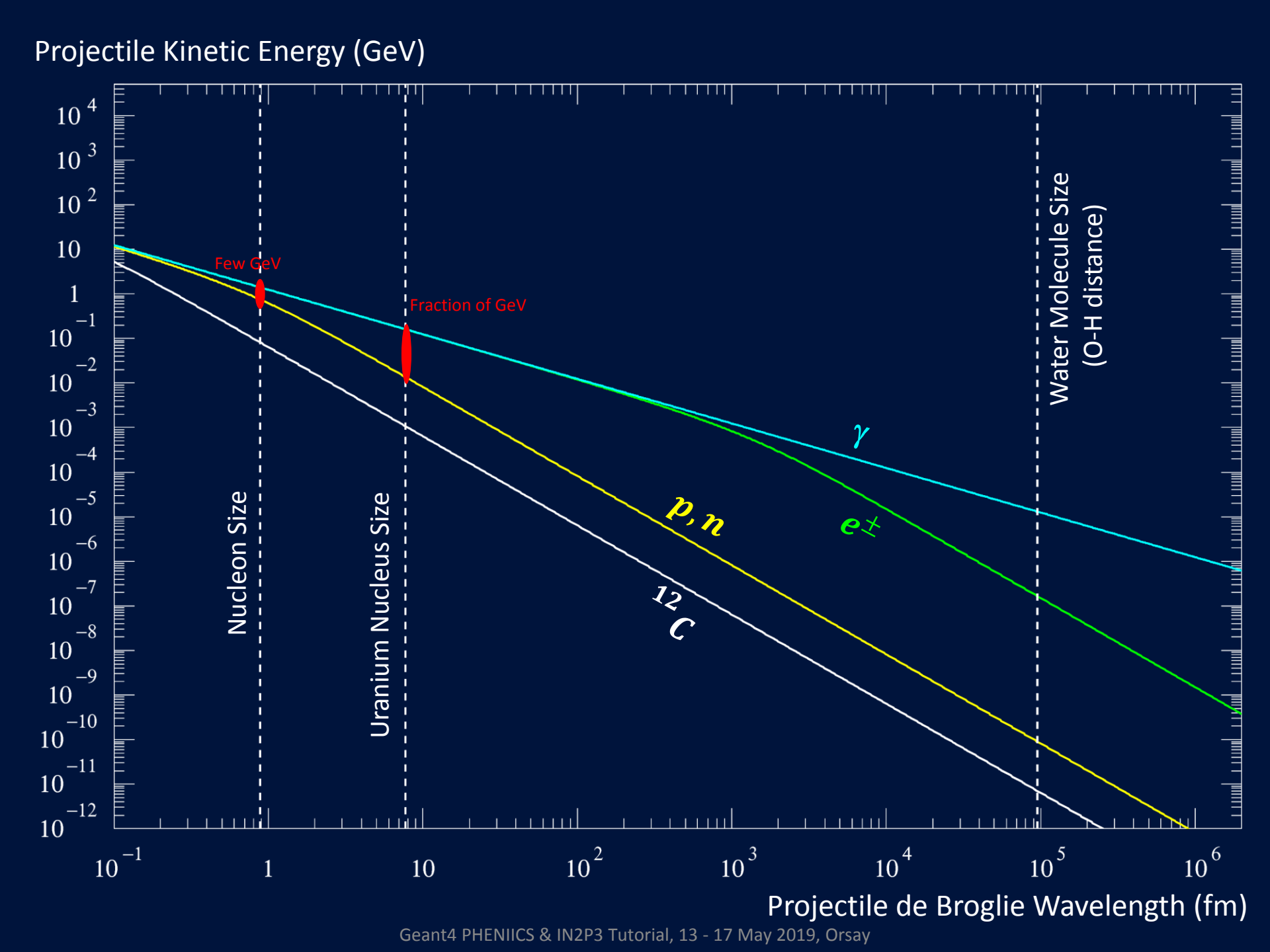


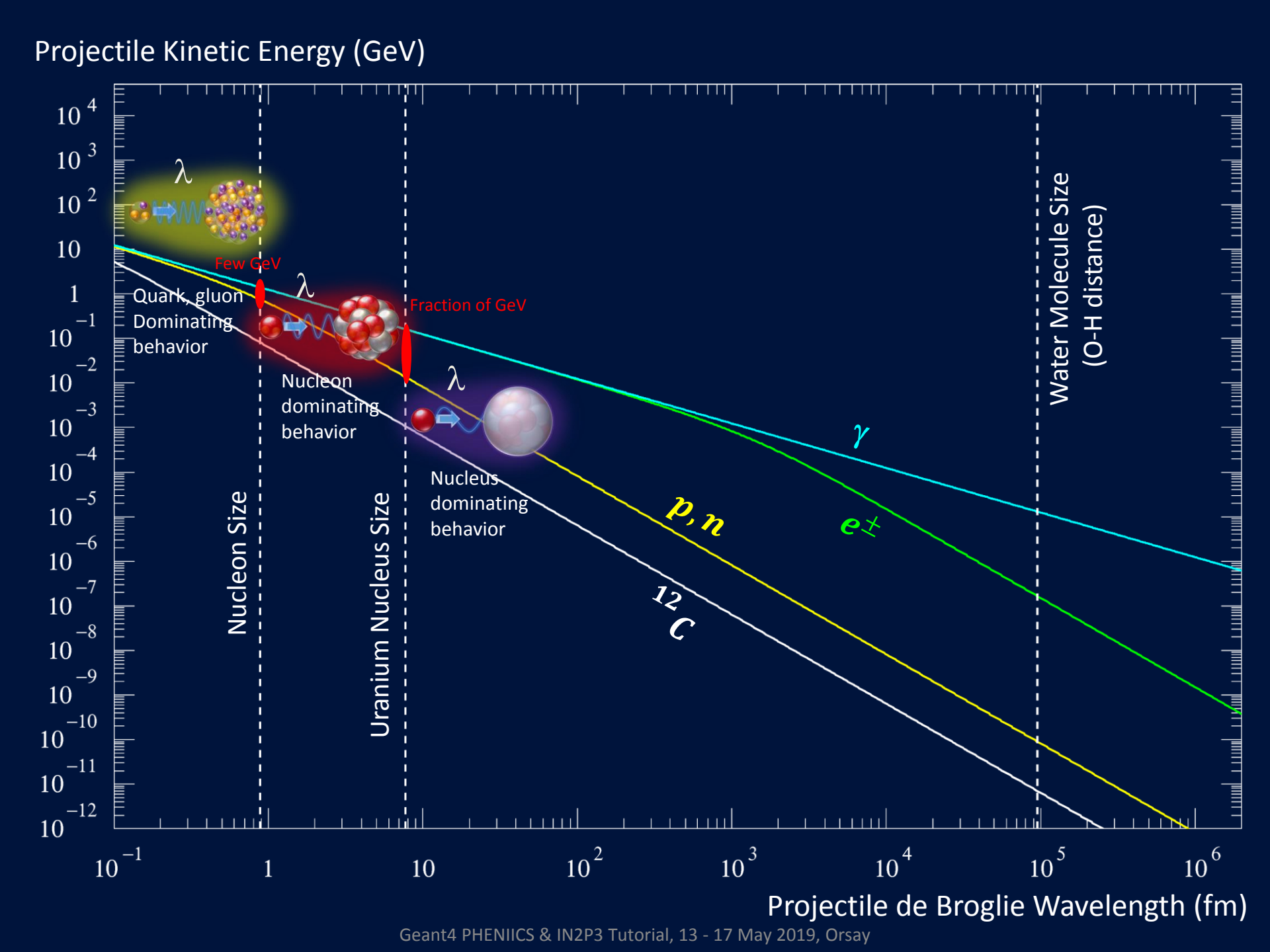
# Overview of physics presentations

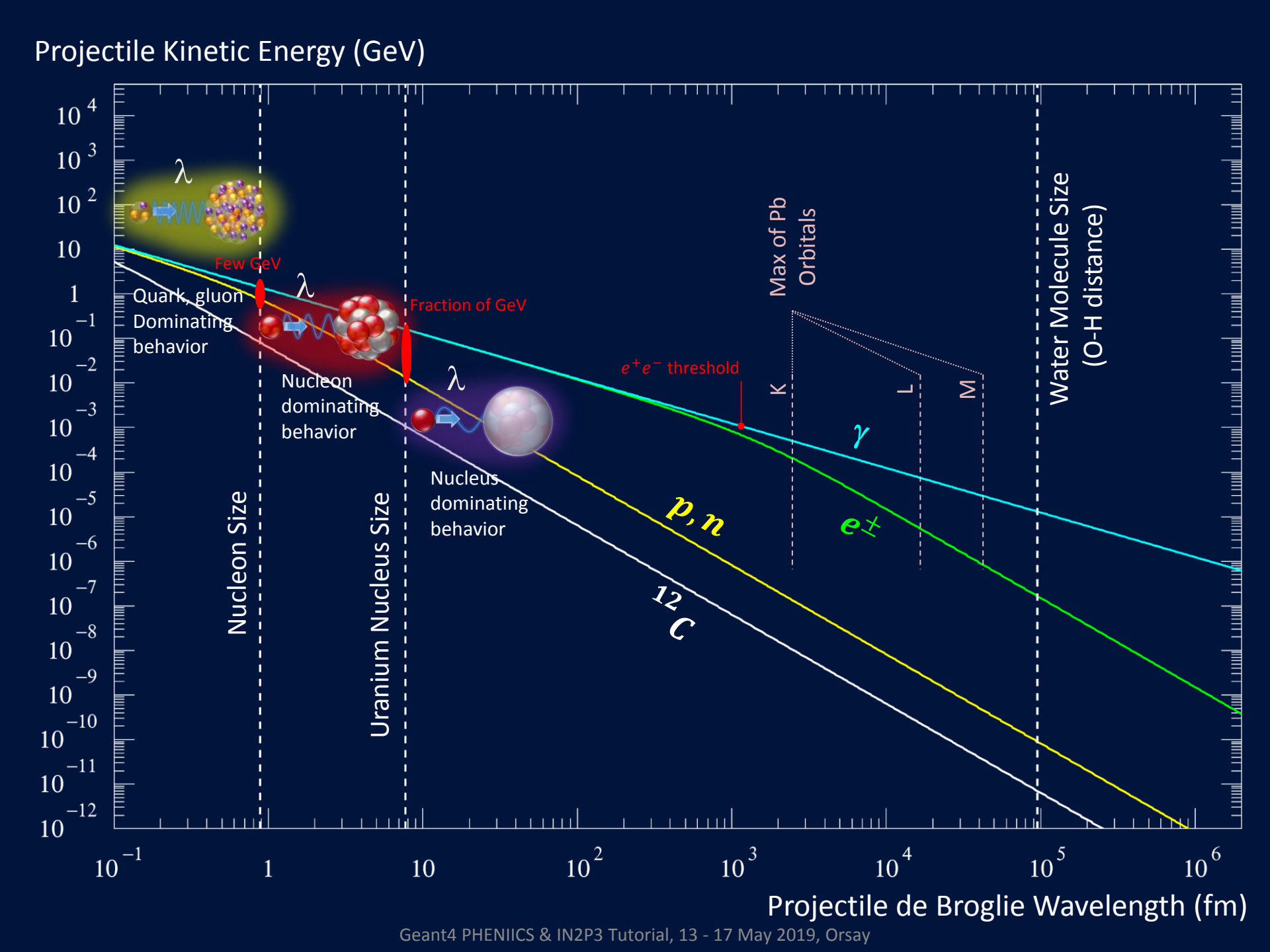
- Today, session IV:
  - This introduction
  - Two “technological-like” presentations:
    - Physics list
    - Physics overview, processes and cuts

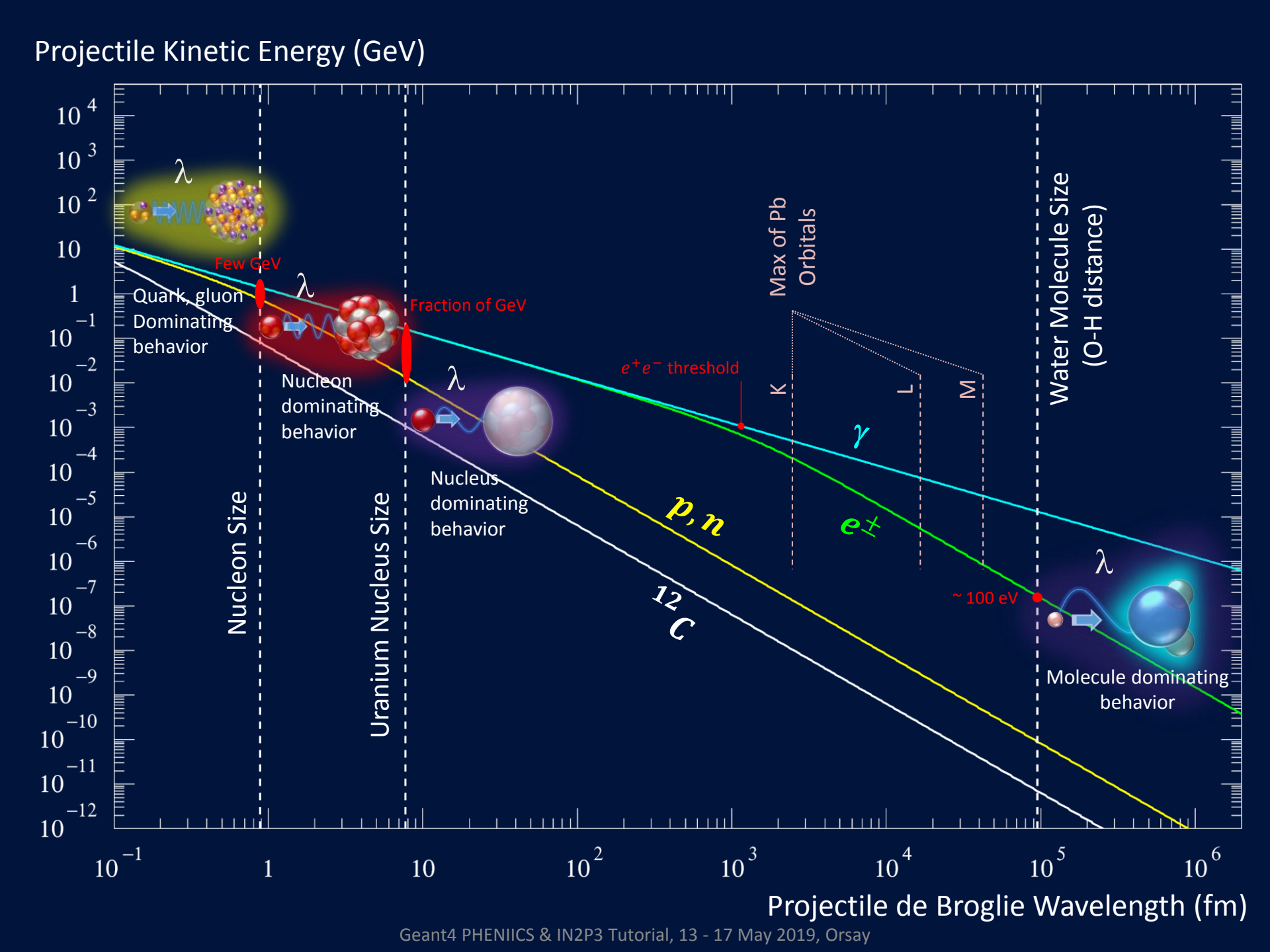
- Thursday & Friday, sessions VII & IX:
  - Actual physics content of Geant4:
    - “Standard” EM physics
    - Low Energy EM physics
    - Hadronic physics
      - The big catalogue of it

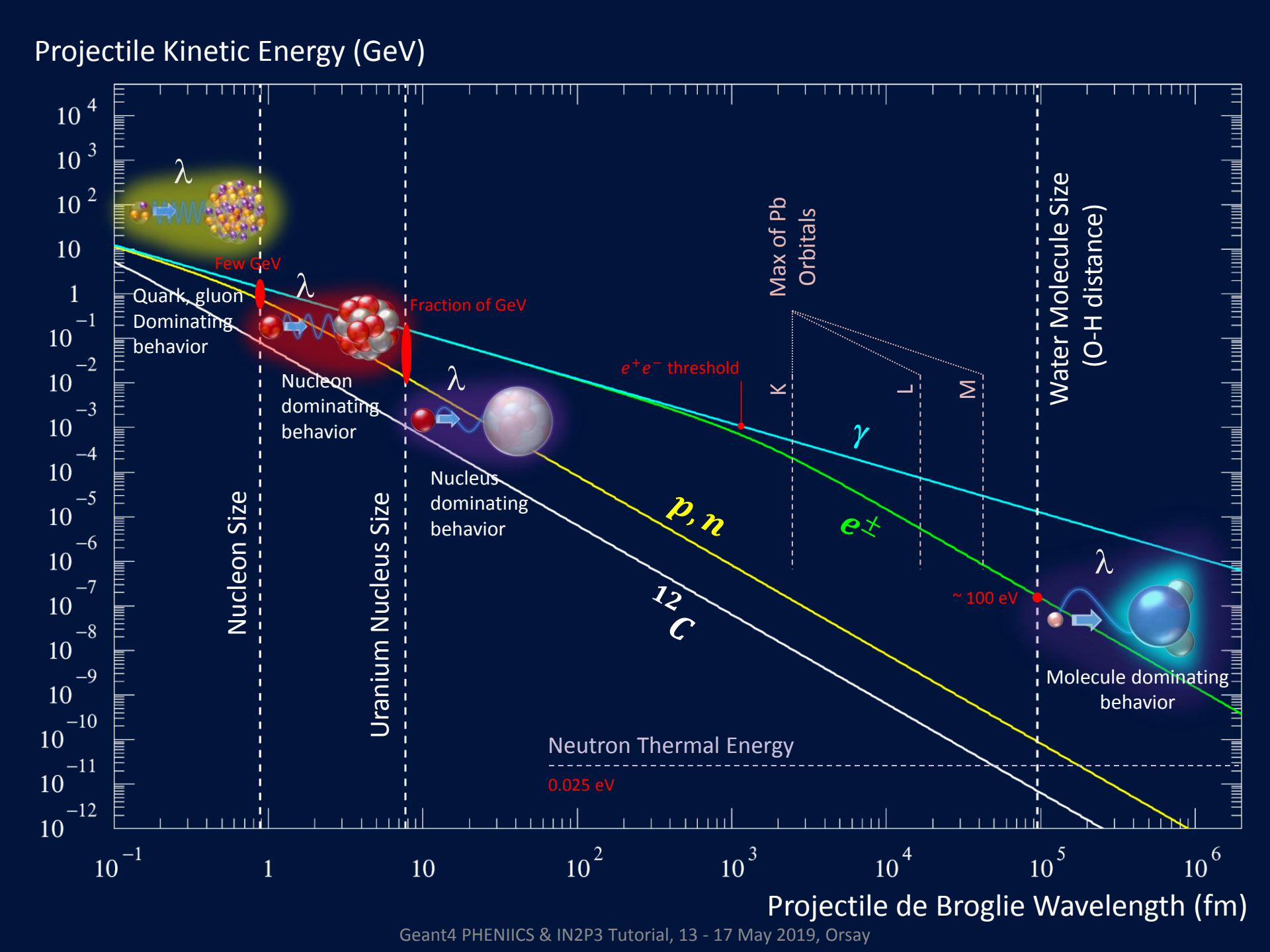

Projectile Kinetic Energy (GeV)
These are just a few of what Geant4 can handle !
Water Molecule Size (O-H distance)
Nucleon Size
Uranium Nucleus Size
γ
p, n
e±
12 C
Projectile de Broglie Wavelength (fm)


Projectile Kinetic Energy (GeV)
Few GeV
Fraction of GeV
Nucleon Size
Uranium Nucleus Size
Water Molecule Size
(O-H distance)
γ
p, n
e±
12 C
Projectile de Broglie Wavelength (fm)


Projectile Kinetic Energy (GeV)
λ
Few GeV
Quark, gluon
Dominating
behavior
λ
Fraction of GeV
Nucleon
dominating
behavior
λ
Nucleus
dominating
behavior
Nucleon Size
Uranium Nucleus Size
Water Molecule Size
(O-H distance)
γ
p, n
e±
12 C
Projectile de Broglie Wavelength (fm)

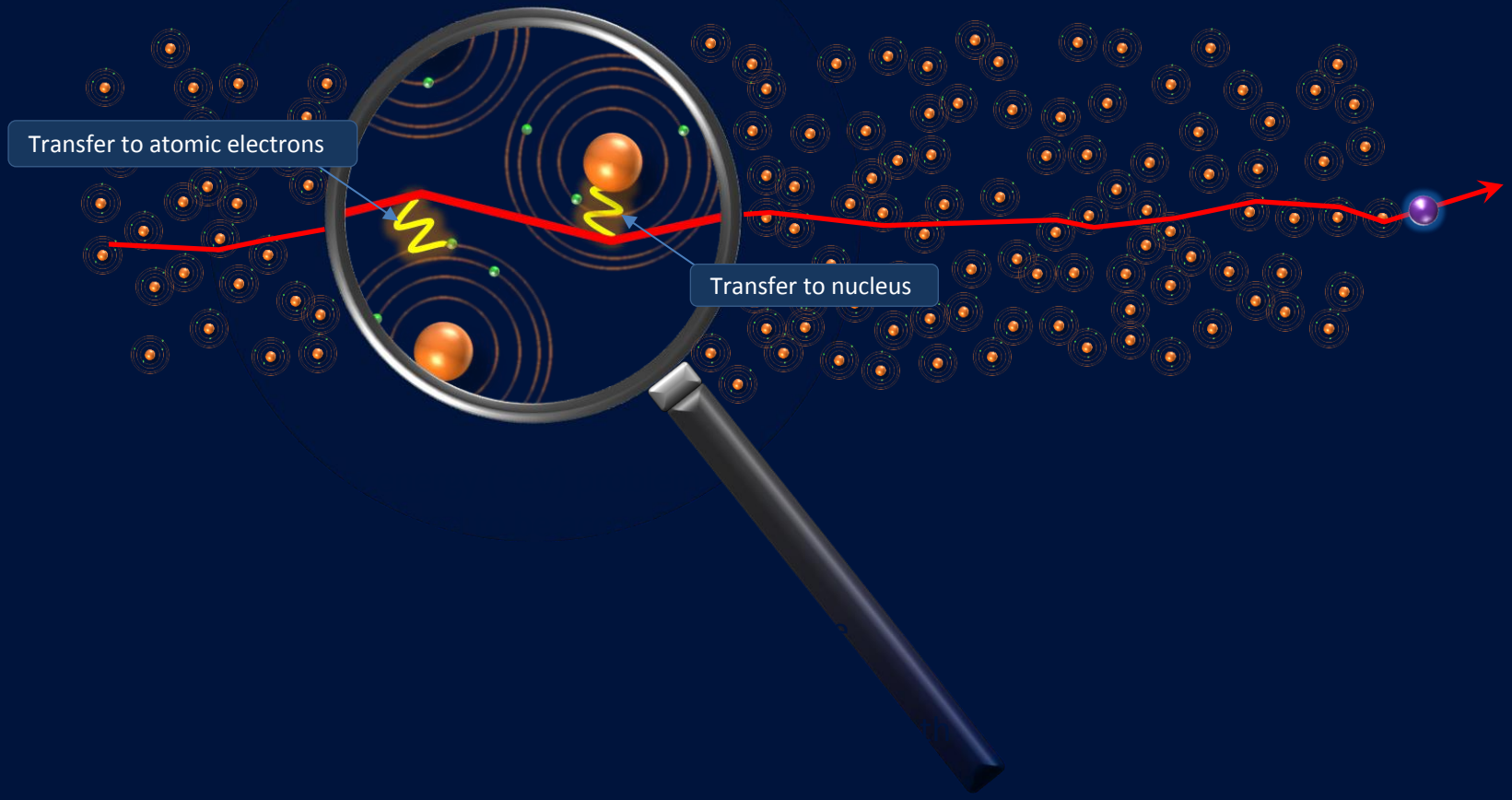

Projectile Kinetic Energy (GeV)
λ
Few GeV
Quark, gluon
Dominating
behavior
λ
Nucleon
dominating
behavior
Fraction of GeV
λ
Nucleus
dominating
behavior
Nucleon Size
Uranium Nucleus Size
$e^+e^-$ threshold
Max of Pb
Orbitals
K
L
M
Water Molecule Size
(O-H distance)
γ
p, n
$e^{\pm}$
$^{12}C$
Projectile de Broglie Wavelength (fm)


Projectile Kinetic Energy (GeV)
Projectile de Broglie Wavelength (fm)
Few GeV
Fraction of GeV
Quark, gluon Dominating behavior
Nucleon dominating behavior
Nucleus dominating behavior
Nucleon Size
Uranium Nucleus Size
Max of Pb Orbitals
K
L
M
Water Molecule Size (O-H distance)
$e^+e^-$ threshold
$\gamma$
$p, n$
$e^{\pm}$
$^{12}C$
~ 100 eV
Molecule dominating behavior
λ


Projectile Kinetic Energy (GeV)
λ
Few GeV
Quark, gluon
Dominating
behavior
λ
Nucleon
dominating
behavior
Fraction of GeV
λ
Nucleus
dominating
behavior
Nucleon Size
Uranium Nucleus Size
$e^+e^-$ threshold
Max of Pb
Orbitals
K
L
M
Water Molecule Size
(O-H distance)
γ
p, n
$e^{\pm}$
$^{12}C$
~ 100 eV
λ
Molecule dominating
behavior
Neutron Thermal Energy
0.025 eV
Projectile de Broglie Wavelength (fm)

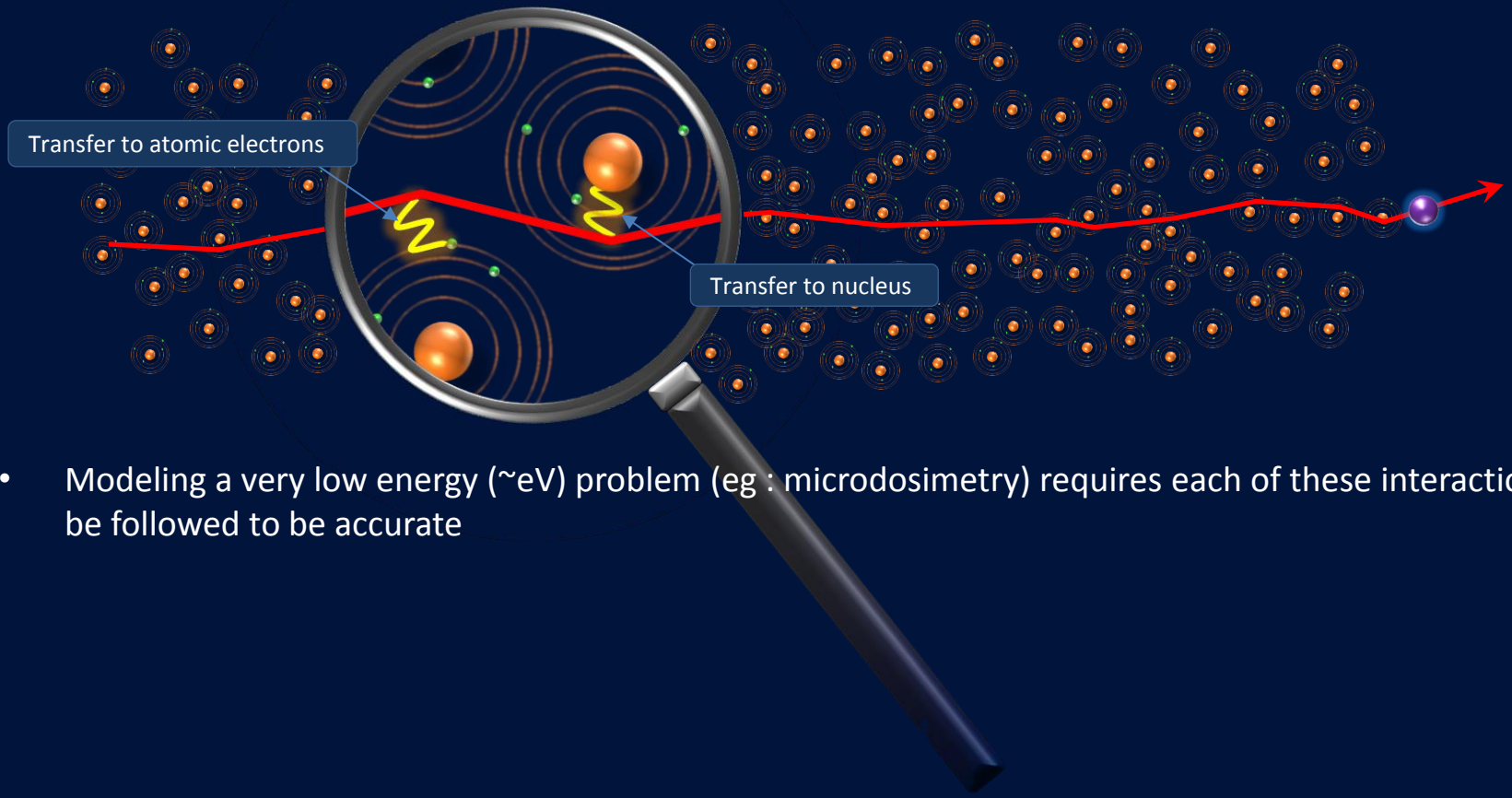
# Point-like interactions → Condensed history

- At theoretical level, interactions are « point-like »
- But interactions with low momentum transfer can occur MANY times
  - Essentially : with each atom “near” the particle path !



# Point-like interactions → Condensed history

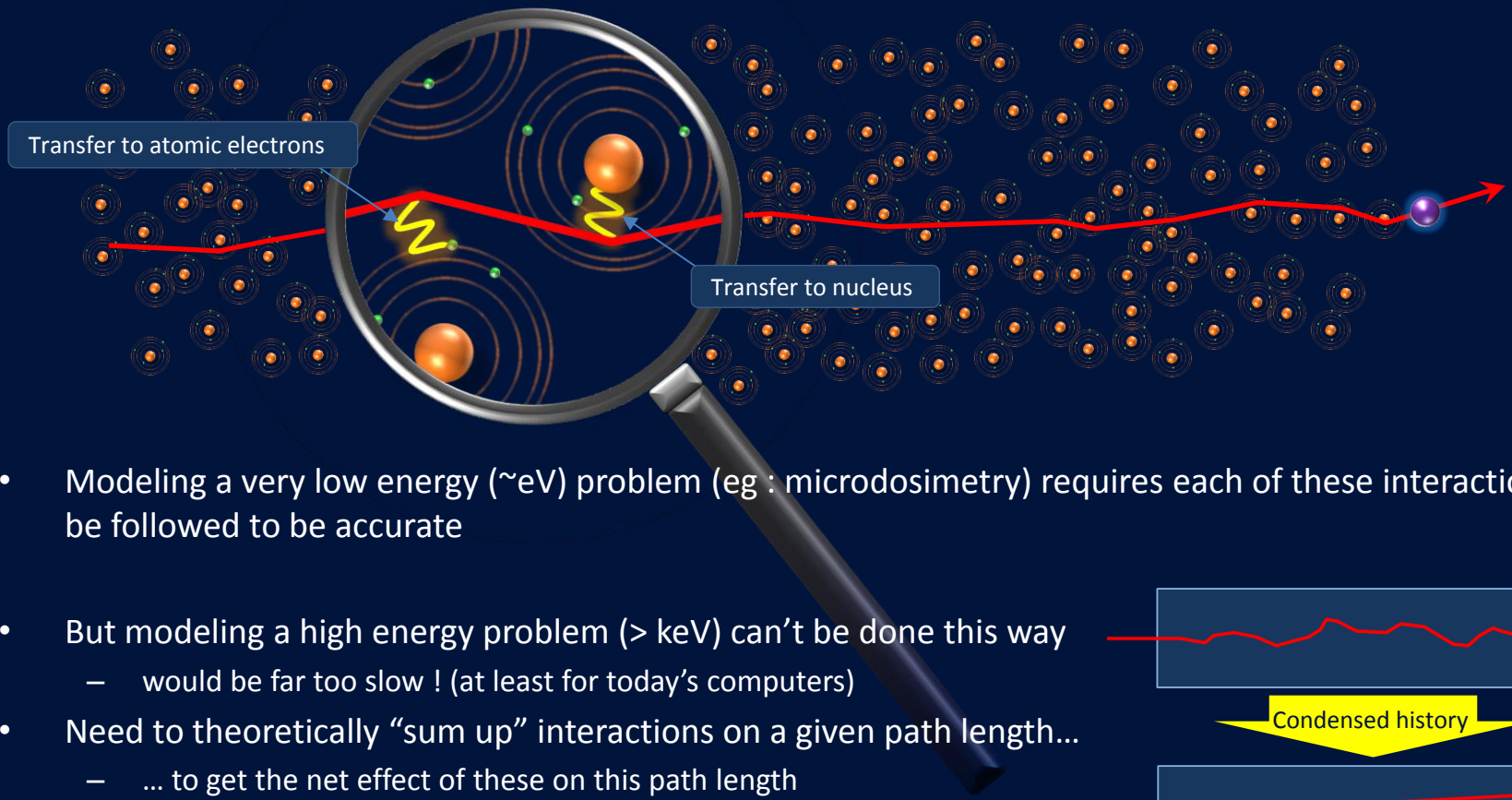
- At theoretical level, interactions are « point-like »
- But interactions with low momentum transfer can occur MANY times
  - Essentially : with each atom “near” the particle path !




- Modeling a very low energy (~eV) problem (eg : microdosimetry) requires each of these interactions to be followed to be accurate

# Point-like interactions → Condensed history

- At theoretical level, interactions are « point-like »
- But interactions with low momentum transfer can occur MANY times
  - Essentially : with each atom “near” the particle path !




- Modeling a very low energy (~eV) problem (eg : microdosimetry) requires each of these interactions to be followed to be accurate

- But modeling a high energy problem (> keV) can’t be done this way
  - would be far too slow ! (at least for today’s computers)
- Need to theoretically “sum up” interactions on a given path length…
  - … to get the net effect of these on this path length




- This is the “condensed history” approach

# Coping with complexity…

- Physics complexity is large:
  - Lot of particle types
  - Lot of different particle-matter interaction types
    - And which are totally different depending on energy

- In a physics code package, we have to decide of
  - how we model the point-like physics interactions
  - how we model the condensed history and under what conditions
  - how we make all these working together

- And we should think this in term of “use cases”:
  - Use cases are determined by users : you !
  - HEP, medical, space, radioprotection, security companies, etc. have interest in some aspects

# In the two next presentations

- We present the physics modeling of Geant4
  - In its “technological” aspects
- You don’t necessarily need to know all of these
- But you must have some understanding of it
  - For at least picking the physics options you need
- Last but not least, as a toolkit, Geant4 is not “frozen”
  - You can always extend it in general
  - And extend it with your own physics code in particular
    - In this case, the next two presentations are just a starting point !