

One of the

# RECENT NEEDS ON CROSS-SECTION DATA FOR GENERAL-PURPOSE TRANSPORT CODE DEVELOPMENT

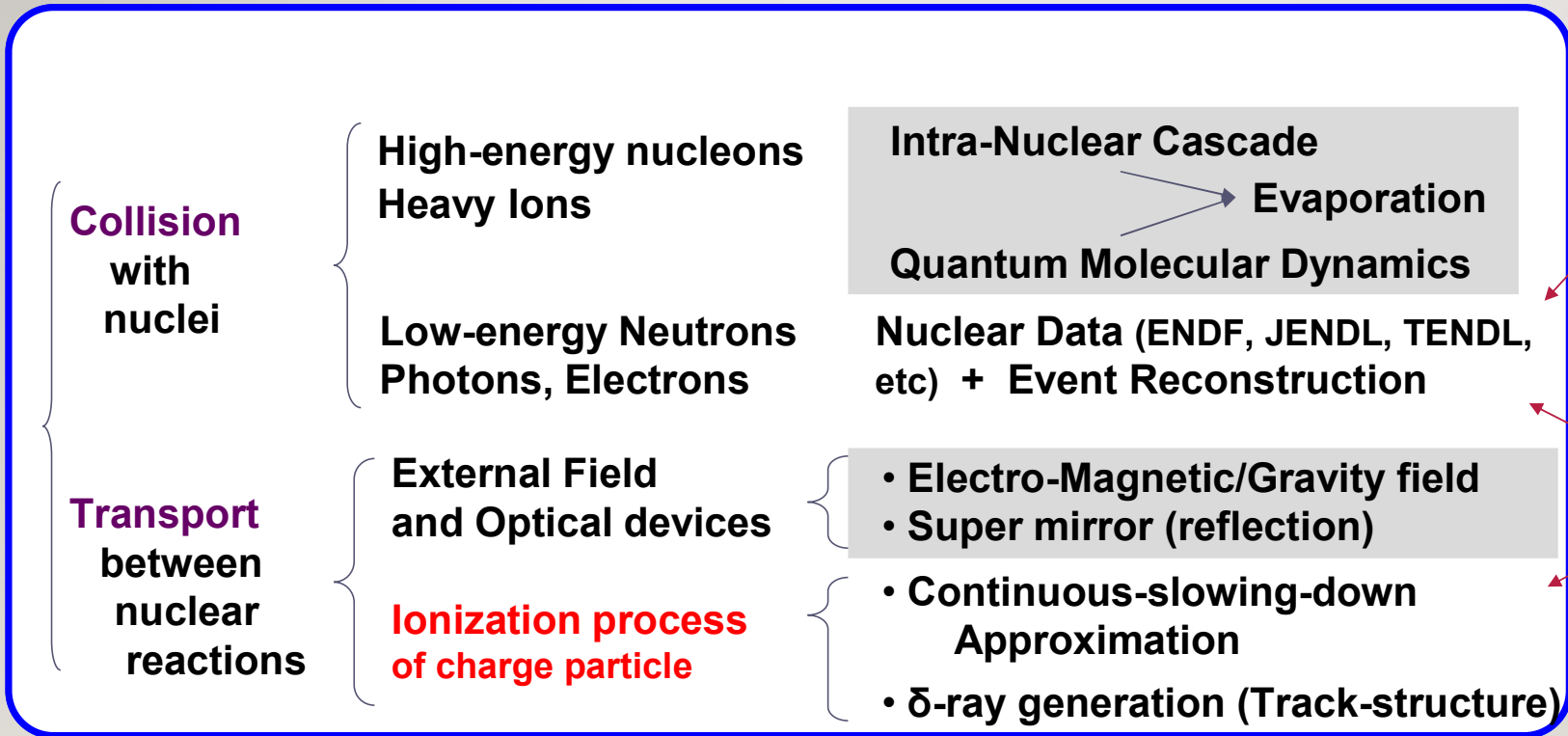
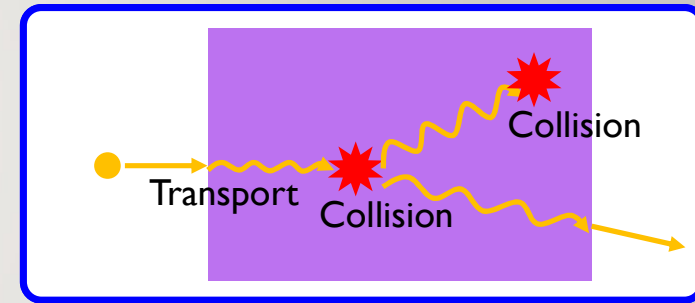
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-- Can you imagine to divert your tool to handle delta-ray production cross sections ? --

Tatsuhiko OGAWA

Research Group for Radiation Transport Analysis , PHITS development team  
Japan Atomic Energy Agency

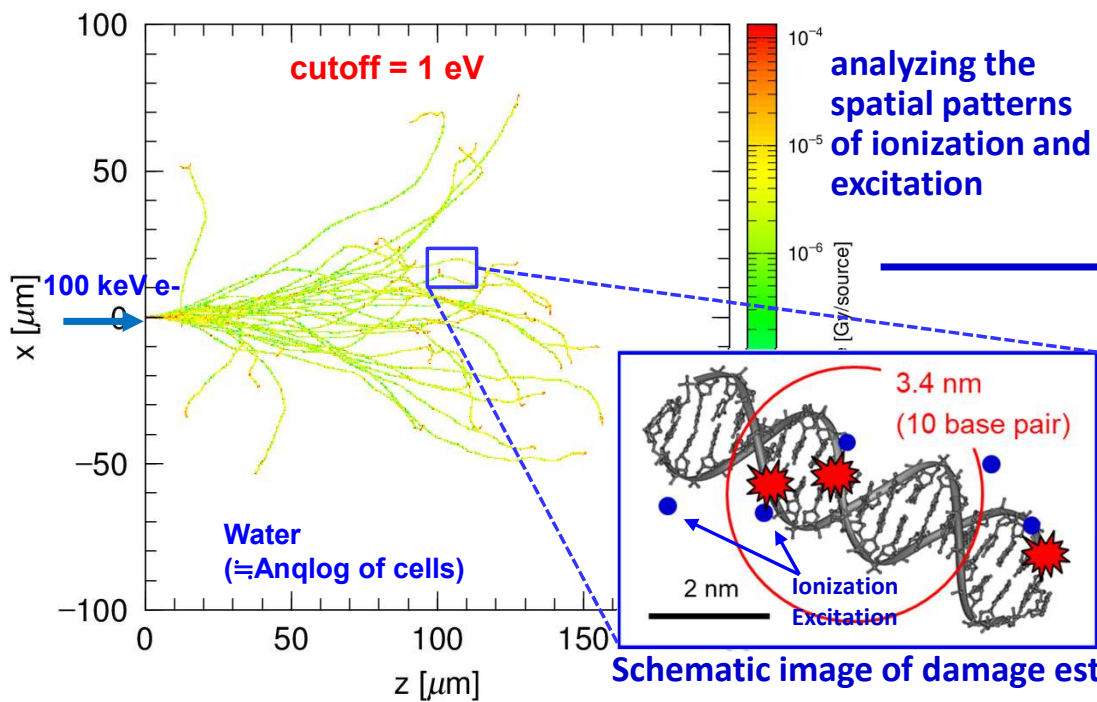
# GENERAL PURPOSE TRANSPORT CODE (FLUKA, MCNP6, MARS, GEANT4, PHITS...)



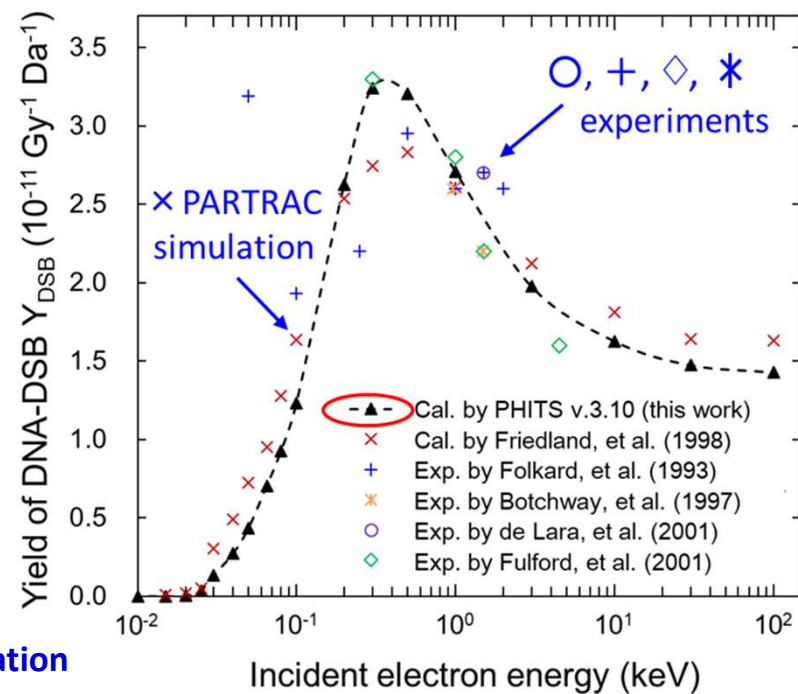
Jean-Christophe mentioned importance of charged particle

### 3 WHY IS $\Delta$ -RAY GENERATION (=TRACK-STRUCTURE CALCULATION) IMPORTANT?

#### Track-structure calculation example



#### [Estimation of strand-break yields]



## 4 WHAT WE NEED FOR TRACK-STRUCTURE CALCULATION

**Cross section** as a function of

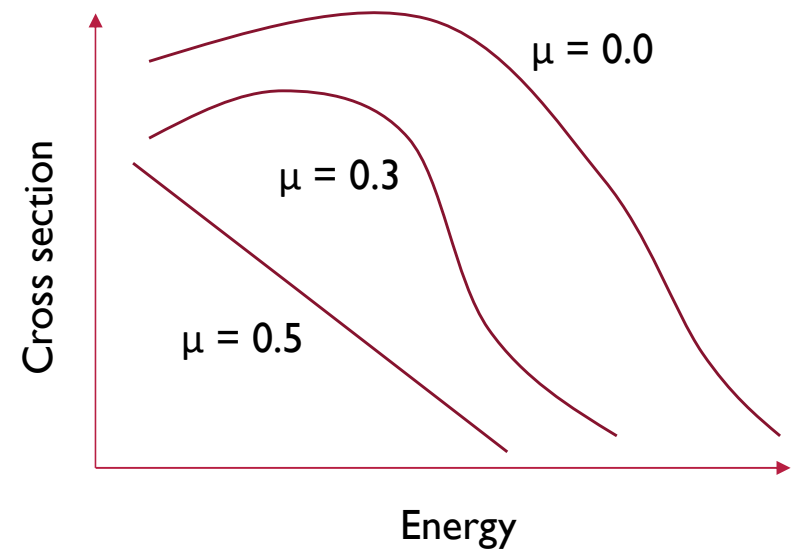
Continuous parameters

- \* projectile energy
- \* outgoing electron momentum
- \* target atom recoil momentum

Discrete parameters

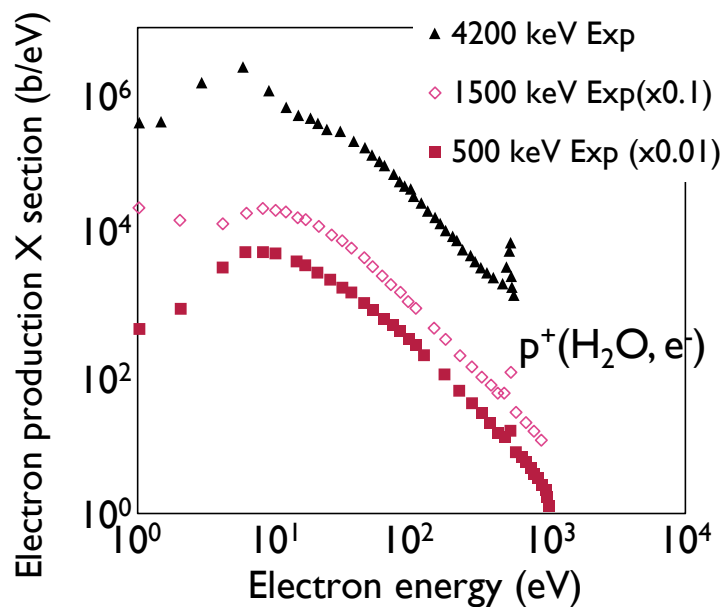
- \* projectile particle species
- \* product excitation state

In this way.....



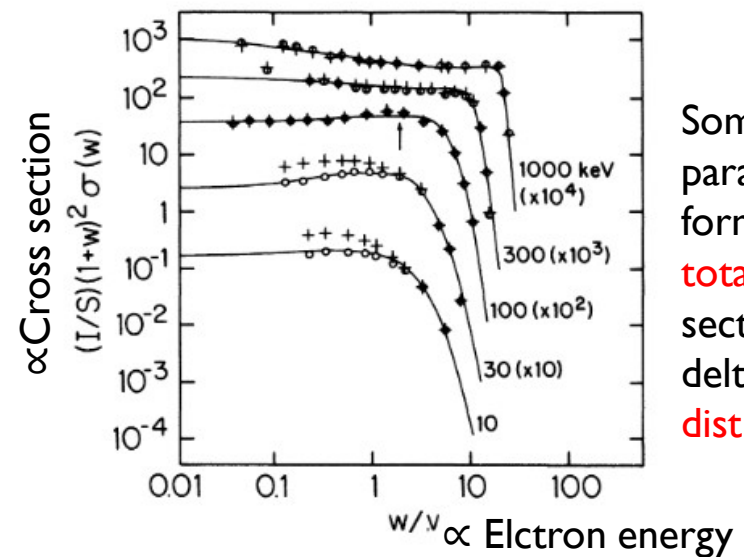
# 5 CURRENT STATUS OF DELTA-RAY PRODUCTION CROSS-SECTIONS

- Measurement data\*



Some 100 measurement data on energy/angular Distribution of  $e^-$

- Systematics Formula\*\*



Some parameterization formulae to fit total cross sections, and delta-ray energy distribution

\* W.E. Wilson et al; Differential cross sections for ionization of methane, ammonia, and water vapor by high velocity ions, J. Chem. Phys. 80, 5631 (1984)

\*\* M.E. Rudd et al; Differential crosssections for secondary electron production by proton impact, PHYSICAL review A. 38, 6129 (1988)



# 6 NUCLEAR REACTION DATA AND ATOMIC REACTION DATA ARE **ANALOGOUS**

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## • Nuclear data

- Nuclear structure (level, Spin, Binding energy, ...)
- Cross section (total, elastic, inelastic)
- $S(\alpha, \beta)$
- Projectile (neutron, proton, photon, ion, e-, etc)
- Products (neutron, proton, photon, alpha, He-3, target recoil, etc)
- Residue (A, Z, Isomeric state, ...)

## • Atomic data

- Atomic structure (level, Spin, Ionization energy)
- Cross sections (total, elastic, inelastic)
- Chemical form correction
- Projectile (ions, electrons, positrons)
- Product (electron, positron, bremsstrahlung, target recoil)  
Negligible below 1 keV (Track-structure domain)
- Residue (Electron orbit vacancy = isomeric state)

← Same →

← Same →

← Same →

→ Easier →

→ Easier →

→ Easier →



# 7 MY PROPOSAL

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Sophisticated nuclear reaction data



Developing atomic data for track-structure calculation



State-of-art methodology



Tools and formats developed for **nuclear** reaction data  
(GNDS, ENDF, FUDGE, FRENDY, AMPX, DeCE, etc)

**Diverting the tools  
to cultivate the field  
of delta-rays**

## 8 SUMMARY

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- General-purpose transport codes are reaching out track-structure calculation (event-by-event eV-range delta-ray production by charged particles)
  - Important for radiation biology (also detector physics, semiconductors, etc)
- Measured cross section data, cross section fitting formulae are available
- Atomic data are analogous to nuclear data
  
- Your tools can be useful to handle track-structure cross sections
- This is just a proposal from nuclear data outsider. Your suggestions, questions are very much appreciated to elaborate this idea.