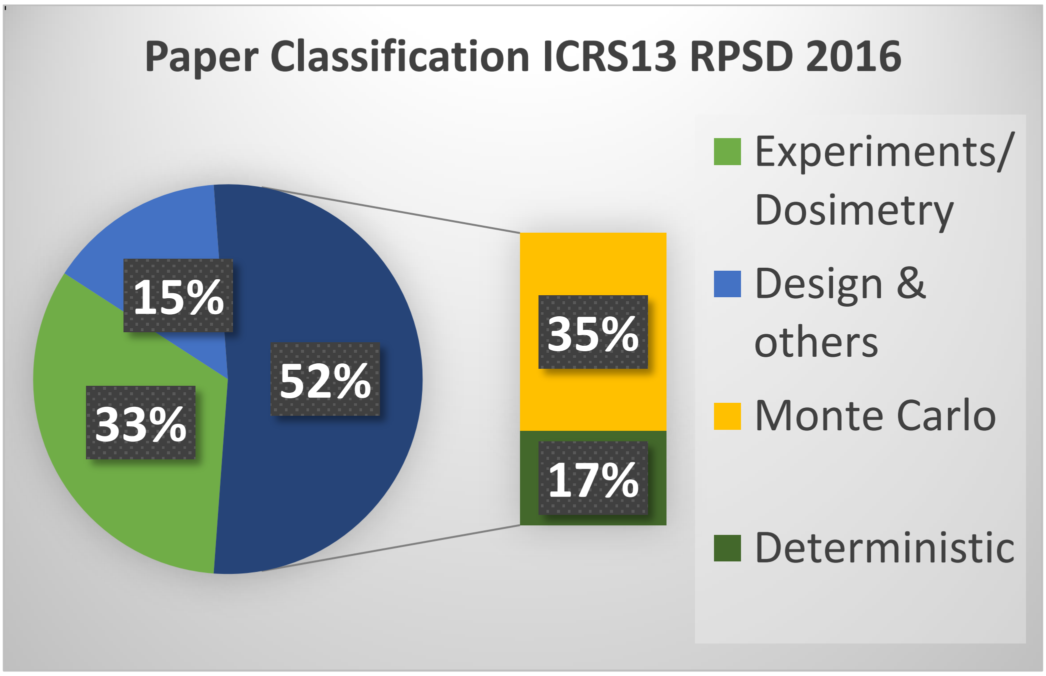
ICRS-13 & RPSD-2016

13th *International Conference on Radiation Shielding*
&
19th Topical Meeting of the *Radiation Protection & Shielding Division*
of the American Nuclear Society -2016

Closing session
Speech of Dr. Enrico Sartori

retired formerly OECD – NEA
Consultant for the CEA, IRSN, Government of Norway
Conference Honorary Chair

What has a person of my age to add to what was shown here already? All the important advancements and issues in radiation protection and shielding have already been shown in the hundreds of presentations and posters.



This pie chart shows an approximate distribution of presentations by general topics: numerical simulation, experiments/dosimetry, measurements and benchmarks and other issues such as design. There are of course correlations among the topics which are not shown here. But this gives you a rough idea.

You see that among the simulation methods the stochastic ones represent 2/3 of the total while the deterministic methods the remaining 1/3. Also here there is some overlap because some use hybrid methods, others carry out multi-physics / multiscale simulations where both methods may be present.

In the following picture you see most of the equations used in nuclear applications – all of them are deterministic.

So, we use for mostly stochastic phenomena, deterministic equations which in majority are solved with stochastic methods. What's wrong about that? There is nothing wrong, it works. Also the deterministic ones work.

Equations used in the computer codes for nuclear power and non-power applications

$$\left(\beta mc^2 + \sum_{k=1}^{3} \alpha_k p_k c\right) \psi(\mathbf{x},t) = i\hbar \frac{\partial \psi(\mathbf{x},t)}{\partial t} \qquad i\hbar\frac{\partial}{\partial t}\Psi(\mathbf{r},t) = -\frac{\hbar^2}{2m}\nabla^2\Psi(\mathbf{r},t) + V(\mathbf{r})\Psi(\mathbf{r},t)$$

$$\left[\frac{\partial^2}{\partial \kappa^2} + \frac{2}{\kappa}\frac{\partial}{\partial \kappa} - \frac{\partial^2}{\partial \chi^2} + \frac{2}{\chi}\frac{\partial}{\partial \chi}\right] V(\kappa,\chi) = 0$$

$$\frac{\partial u}{\partial t} = k\nabla^2 u$$

$$\oint_{\partial S} \mathbf{E}\cdot d\mathbf{l} = -\frac{\partial \Phi_{B,S}}{\partial t} \qquad \nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\frac{\partial N(\vec{r},\vec{\Omega},E,t)}{\partial t} = -v\vec{\Omega}.\vec{\nabla}N(\vec{r},\vec{\Omega},E,t) - \Sigma_t(\vec{r},E)vN(\vec{r},\vec{\Omega},E,t) + Q(\vec{r},\vec{\Omega},E,t) + \int_{4\pi} d\Omega' \int_0^{\infty} dE'\Sigma_s(\vec{r},\vec{\Omega}' \rightarrow \vec{\Omega}, E' \rightarrow E)v'N(\vec{r},\vec{\Omega}',E',t)\ldots$$

$$\frac{dQ_i}{dt} = S_i + k_{Q_{i-1},Q_i}\cdot Q_{i-1} - k_{Q_i}\cdot Q_i$$

$$\rho\left(\frac{\partial \mathbf{v}}{\partial t} + \mathbf{v}\cdot\nabla\mathbf{v}\right) = -\nabla p + \nabla\cdot\mathbb{T} + \mathbf{f},$$

Dirac, Schrödinger, nuclear matter, heat conduction, Maxwell, Boltzmann, Bateman and Navier-Stokes

Poor Ludwig Boltzmann, about 130 years ago, he has shown that the macroscopic behaviour of a large amount of microscopic stochastic phenomena can be described with a deterministic equation which is dissipative and not reversible. With this, he made many enemies among the physicist of those times. They argued that the particles were interacting according to the laws of mechanics which was the base on which the whole universe was functioning. Knowing an initial status would allow you to predict in detail all future events. The only reason it could not be done is because of lacking complete knowledge of initial conditions. Philosophers moved in with arguments whether our will was then free or not as everything had in this case been fixed from the start.

There was a mixture of science and ideology, --- it's a bad marriage that leads mostly to divorce. Boltzmann was attacked so violently by so many physicists and intellectuals that some say he committed suicide for that reason others say it was because of depression. Later, Boltzmann was proven to be right. Nowadays he would be a Nobel prize winner.

Somehow the argument was about:

what is reality and what is a model?

When did the little monkey of about 50 000 generations ago become human? And how?

She started to perceive the signals coming from her environment, then to observe them and their pattern, she found analogies among different events, gathered experience which lead to synthesizing the whole into a concept, into an idea and as she discovered that she could modulate sounds the result is what we call today the word, the synthesis of the whole process.

A Word? Or was it a first model of reality constructed through this process, the first acquired knowledge? These conceived words were linked together and a natural language emerged that permitted communication with the others and she could start to simulate what happens if, and transmit it to others. She started then to represent the different ideas with signs, a new abstraction was born.

This was the moment when the little monkey became human: it all started with the process of observation and simulation. She transmitted her genes and capacities to the descendants who became increasingly stronger, more intelligent, and because of this they did survive.

But words and language were not efficient enough to make predictions, although it had helped to produce some useful survival tools. To improve them, quantities needed to be defined, and so she invented the numbers, and in order to manipulate them she invented the universal language of mathematics and she put aside into a corner the magic formulae of hokuspokus and abracadabra.

That permitted the development of technology and 50 000 generations later here we are after this first experience of modelling we call today the word; an incredible development followed, algorithms, computers and ever more sophisticated modelling and an incredible explosion of technological developments have emerged. It is modelling and the following development of technology that made us human and special compared to the other living on our planet.

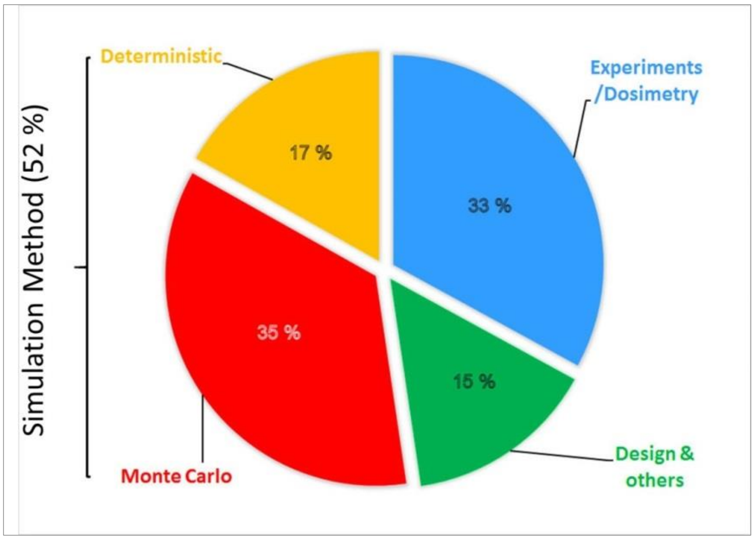
Modelling started with perception and observation and then experimentation, by using the filtered signals coming from the real world. --- In a dream this connection does not exist and there the images are not the reflections of the signals from the real world.

Our human detectors, our senses that are perceiving the signals from the real world are limited in scope and capability just so much as required to survive in our environment here on earth. With technology we have constructed new detectors of additional signals, which we cannot perceive directly, but which are unfolded through instruments and computers into new signals that our senses can then perceive and interpret. This allows us to construct new, more complex models of our real world.

If instead we make simulations with models using computing only, it is like dreaming: the image produced may not correspond to the real world.

It is for that reason that I am so pleased with this conference:

1/3 of the papers are about capturing, unfolding, interpreting signals coming from the real world, from experimentation, dosimetry, benchmark studies, look at the enormous amount of measurements from Fukushima. Only when your simulation is validated against the signals from the real world can you trust it.

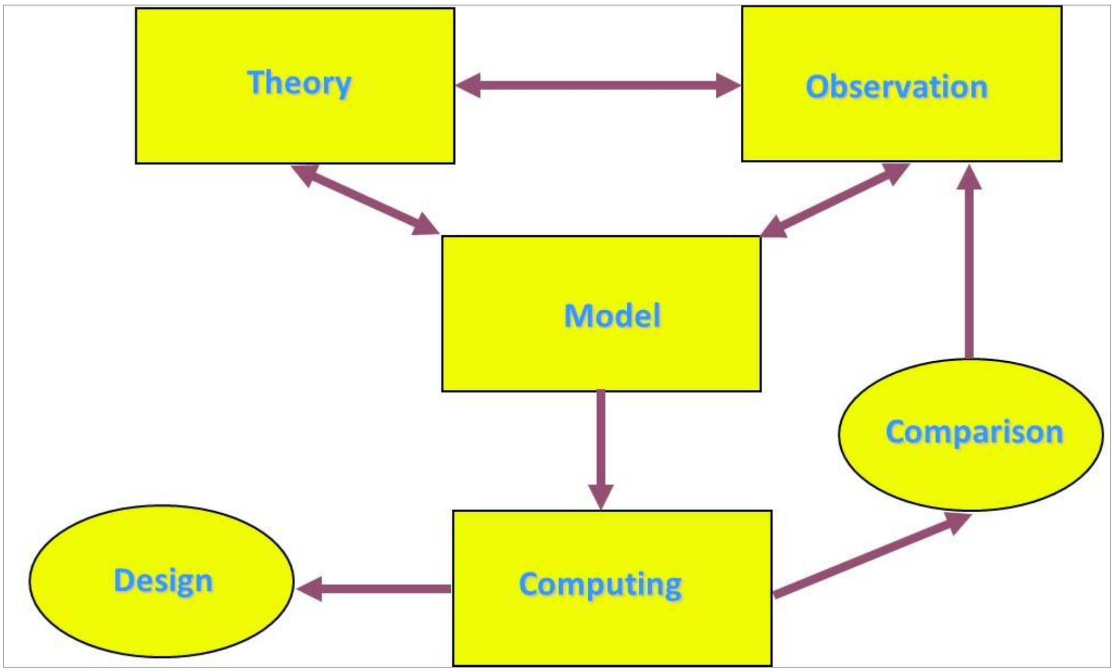


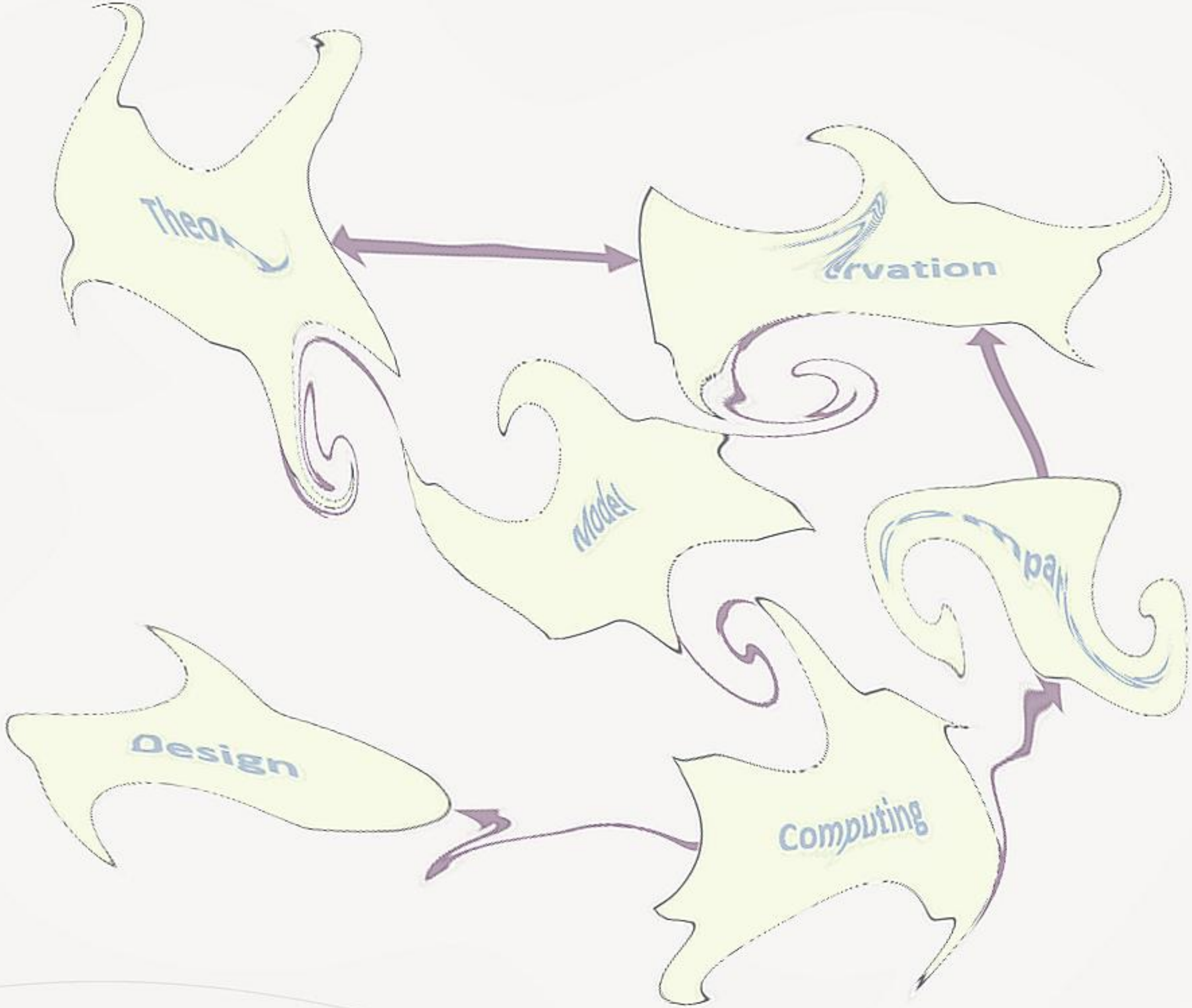
There is a tendency though today, to believe too much in computer modelling results, with the beautiful, colorful graphs and videos that are produced which seem more real than reality. They mostly represent a model, an objective oriented, rough approximation of the world.

A person of my age has only this to add: do not trust your results unless you can prove them right against signals from the real world and do not follow one person I have met saying:

"You know, Monte Carlo results represent the real world better than measurements as they result from the use of the exact and clean laws of physics".

Thank you all for listening to me and I wish you all good luck for the future.




Model
Design
Computing