Mathematical model for specification and interoperation between experiments and tools

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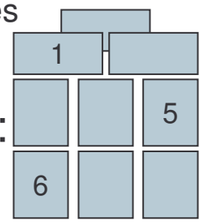
Structure of the presentation:



- The Physics of Information
  - "Information IS physic" a statement with large implications
    - 8000 years ago humans draw pictures on rocks aware of some relation between a cavern's wall and information. 5000 years ago Egyptians started using papyrus and its physics qualities. In our age, associating information with electric and electromagnetic waves brought us the explosion of Information. We know the physics is far richer and need models able to cope up with needs ranging from the huge amounts of data (Nuclear Physics, Observations,…) to the Quantum Information.
  - 1 The Physics-Information Geometry
    - Maps between the worlds of Physics Notation, Coding, Analysis, DataFlow Visualization, …
    - Compare with traditionally manual tasks, with errors and inconsistency originated from the multiple paths tools and ways manually used to represent the same ideas
  - 2 Formal Definitions, The mathematical model for Physics-of-Information
    - Here only the basic collision model is presented. The maths are intended not as a programming system but as a demonstration of the ability to map between the physics and computing worlds.
- Example Scenario, Applications in Neutrino Observations & Nuclear Physics
  - 3 Nuclear Reactions in the Sun, production of neutrino and radiation
  - 4 Quantum Oscillations in the trip from Supernovas, Sun, or Atmospheric production
  - 5 Detection Experiments: Teams, Infrastructures, and Management of processes
  - 6 Detected Data, Processing, Storing, and Information Management
    - Virtual Observatories, GRIDs, GIS & Global Search engines,
  - 7 8 9 Representing Inter-Organizations relationships, Graphical view
    - Relations of dependencies, group, evolution,… between Experiments and Efforts

1. Traditional vs. Physics-Information Geometry

Projects, WBS, …
Processes, DataFlow,
Operation Research,

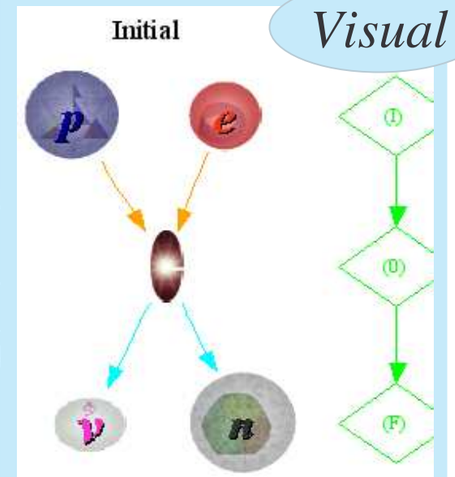
Manage

Nature

Models & Views

Traditional Way:
Many duplicated efforts (graphic, idea, coding, management, analysis,…)
Leads to errors & inconsistencies

Visual



Notation

Initial → Final
p e → ν n

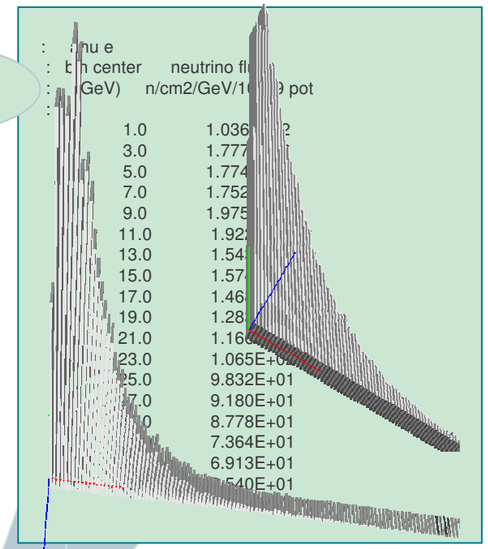
Manifold : x, y, E, Lα, …

Code(s)

#Perl, #Python
(ν,n) = interact (p, e) ;

#C++ #Java
F = p.interact (e) ;
F.v ; F.n;

Data



Automation, using existing Engines & platforms: VRML, GrphViz, Wired/AIDA, …

Mapping for generation of code for REUSING existing tools, engines & platforms: ROOT, Geant, IRAF, JAS, Globes, Fluka, …

Notation

New Model-driven way
1 effort : put ideas in Feynman-stile)
Auto conversion to many tools (from code to analysis)

Information Mechanics

Maths

Elements

-Structures:
Manifolds, Relations, Hilbert, …

Example: Detector

Ex: B Field

- Particles & Operators:
Intersection of Structures' values. Objects.

Ex: CAST

- Interactions & Zones:
Zones of Particle Intersection. Processes.

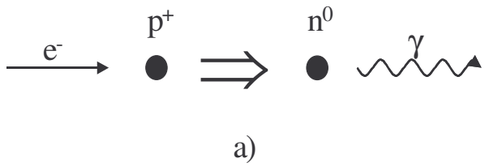
Ex: Observation

Sets of values and its structure,
Xi = { value1, value2, ... } ; ... including Hilbert spaces
Relations: Xi → Xi ; such as value1 < value2 , ...

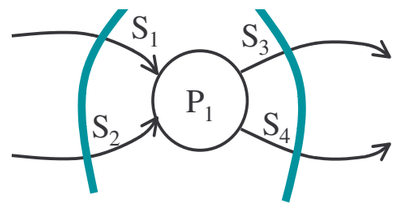
Events/ Observations/ Objects:
$e \in T \times V = X1 \times X2 \times X3 \ldots \times Xd$; ... Including Operators & quantum mixes
Path/ Signal / History of Information flow:
$s \in S = e^{T \times V}$; set of observations, member of power set

Behaviour
$b \in S1 \times \ldots \times Sn$; tuple of possible behavior of n signals
Process / Interaction / Information-Geometry zone
z is any subnet in the set B of behaviors P1 P2 ... PM

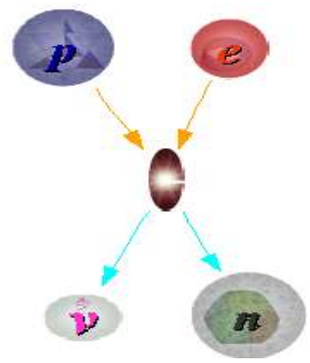
2. Formal Definitions of the Modelling-Particles



a)



b)



A *Particle Observation*, *measurement*, or *object*, e has tag and value, $e \in T \times V = X_1 \times X_2 \times X_3 \ldots \times X_d$

- T and V are the sets of all possible tags and values.
- The tags allows to model precedence relationships, time, and also other key properties.
- $X_1 \times X_2 \times \ldots X_d$ allows adding dimensions like space-time , and others like experiment-site, object-layer ,…

An *observed history* is a set of observations of objects' values at different times (and locations).

- Is a set of particles observations, or equivalently a member of the power set S = eTxV

A particle *Trajectory or path* is the set of space-time coordinates – not values - along its life history.

- is a projection over the T axis (spacetime) of a set of observations. It corresponds to the T(s) defined in the metamodel denoting the set of tags of messages s.

A interaction zone, (in process-space) defined in terms of tuples or vector of N *paths :*

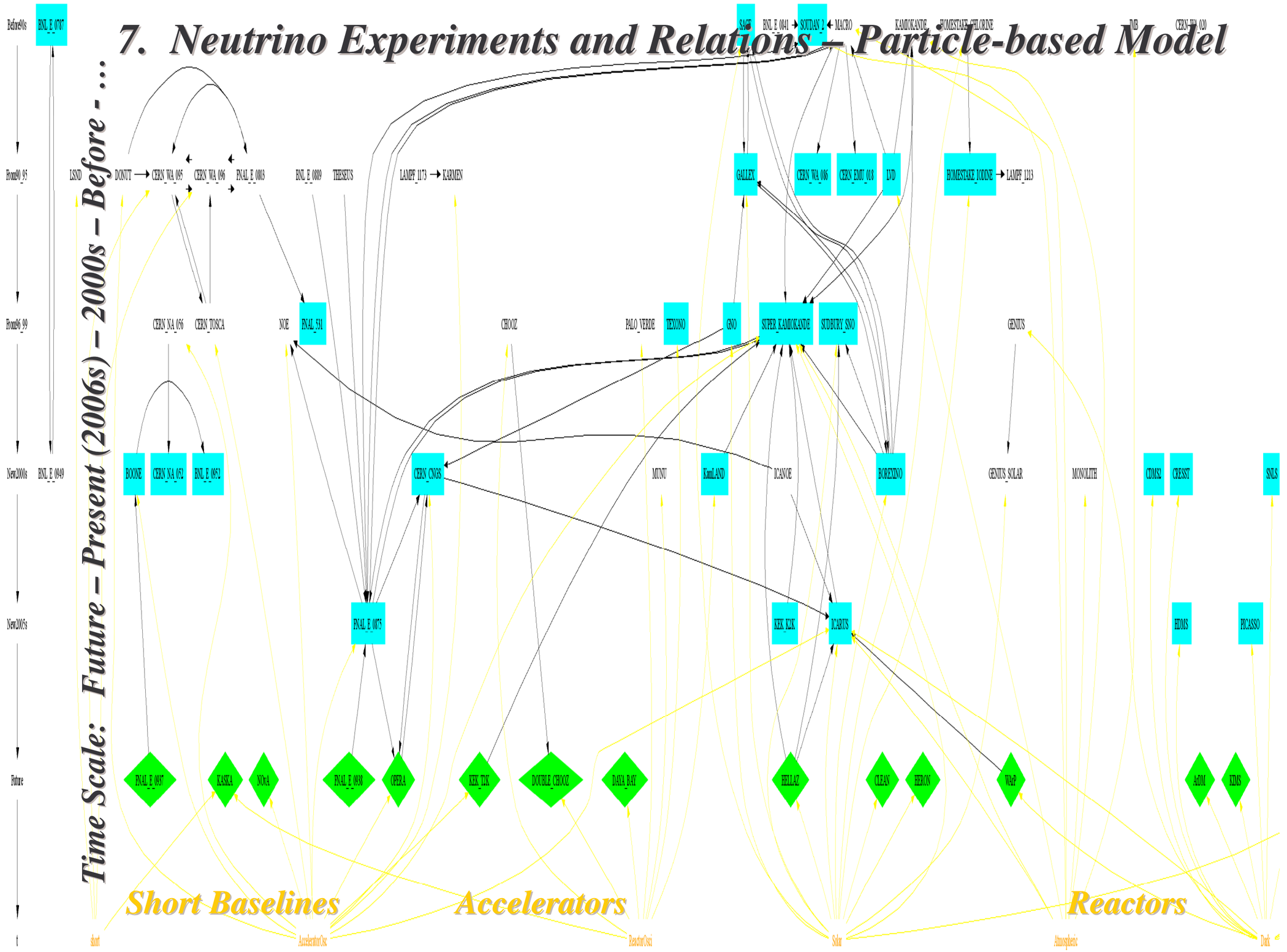
- each vector b belongs to the set of tuples S x ... x S and represents a behavior of a node / network. $b \in S^N$
- A zone z is any subnet in the set B of behaviors P_1 P_2 ... P_M ... And can be called or indexed from 1 to M

Sub-zones and Special-zones,

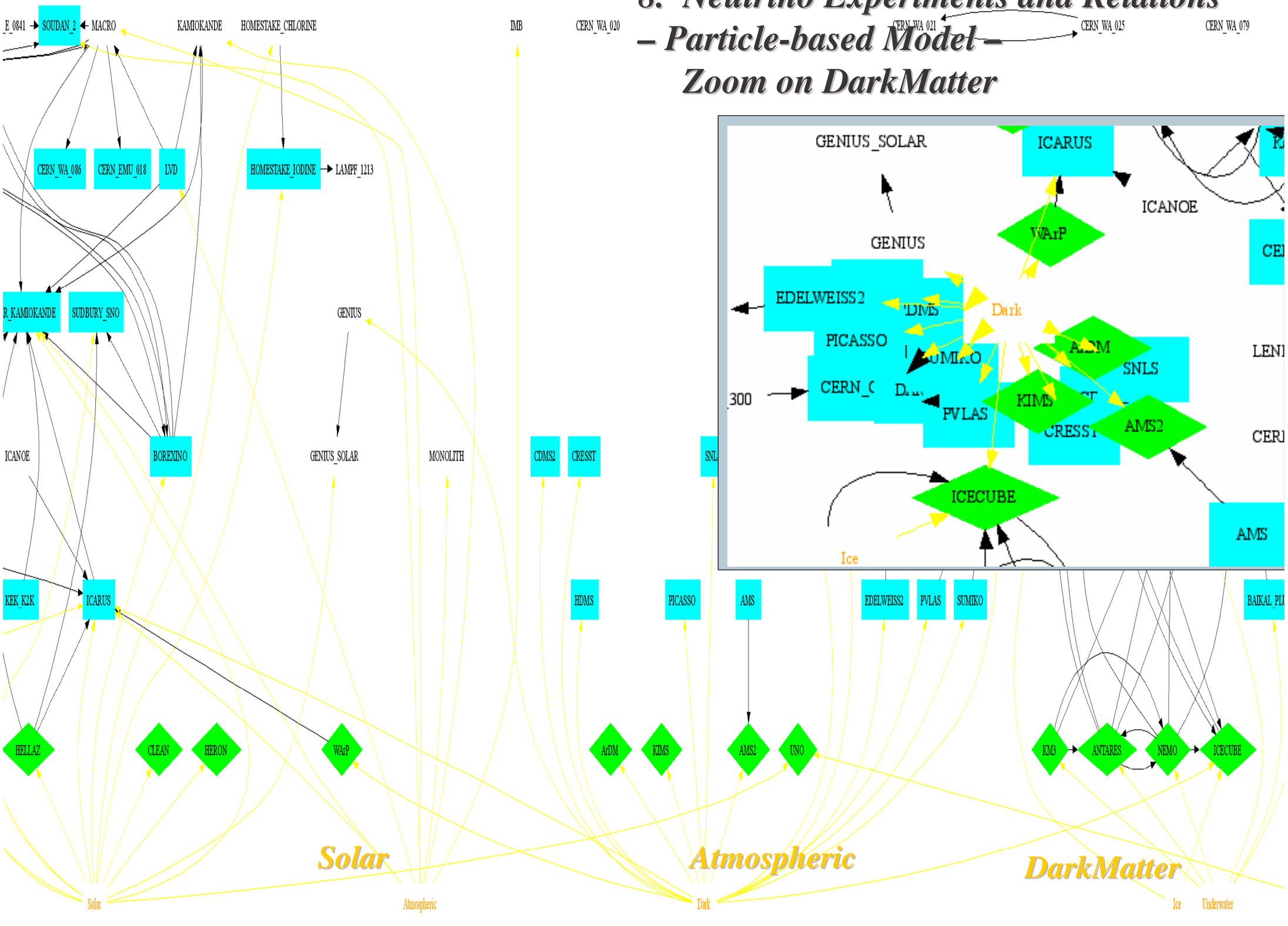
- Among the set of all possible behaviors can have as element a process representing the entire system.
- As subset, a bigger zone that can have smaller zones and object-particle details included inside it.
- *A link, a communication channel, (* equiv*alent to a connection in the computer framework, C ⊂ S^N ,)*
  - *zone with two (or more) particle paths (messages flows) in the N-tuple always identical.*
  - *model equally a link from production to detection in longbaseline experiments, or the net links for processing data*
  - *In a link we model flows of messages/ particles carrying the information exchange*
- An interface, corresponds to A sub-zone of a link, map equally provision lines as coupling channel,

- *Maths matching and extending the meta-model of E. Lee & A. Sangiovanni. A Framework for Comparing Models of Computation, IEEE Trans. on Computer Aided Design Of Integrated Circuits and Systems, 17(12), 1998*

7. Neutrino Experiments and Relations – Particle-based Model



8. Neutrino Experiments and Relations – Particle-based Model – Zoom on DarkMatter



9. Relations among Neutrino Experiments Based on The Physics-Information model

Zoom on DoubleBeta Decay