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Section: new Mathematics and Art

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DRAWING A CONCEPT FOR SCIENCE COMMUNICATION DESIGN. FIBONACCI SEQUENCE AS A MORPHOLOGICAL TIPOGRAPHIC GRID. *"THE RINGS OF KNOWLEDGE - I.N.F.N. for L.H.C. "* AT C.E.R.N.

(ISTITUTO NAZIONALE DI FISICA NUCLEARE for LARGE HADRON COLLIDER – EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH*)*.

Abstract. For the graphic concept of a science institutional and divulgation book, the editor choosed a mathematical sequence to lead the reader's sight into a visual travel through the pages, in a geometrical game as a metaphor of simmetry, asimmetry an abstract rototranslations. A symbolic form to represent and introduce the open possibilities of new science frontiers.

Key words. communication design, Fibonacci square, graphic concept, geometric drawing, composition, symmetry, sequence, rototranslations, symbolic form.

Mathematics Subject Classification: **(**http://www.ams.org/msc/)
Primary 00A66 Mathematics and visual arts, visualization;
Secondary 11B39 Fibonacci and Lucas numbers and polynomials and generalizations

0.0 First Section

„Focus":

Present ideas proposes multi-disciplinary efforts to be researched or developed in the action-research programs. Established in a multidisciplinary teams in order to run synergic relationships between the different kinds of disciplinary knowledges, talents, cognitive styles, intellectual faculties, research and industrial interests.

0.1 Introduction. CERN (European Organization for Nuclear Research) in Geneva is the largest nuclear physics laboratory in the world, where scientists from twenty countries have spent decades studying the particles that constitute matter, through a series of international programs.

In 2009-2010, a new series of experiments was launched to understand fully the nature of elementary particles and "dark matter". This opened unprecedented opportunities to understand both the forces that hold together the matter of which we are made and the Universe's origins and evolution. This internationally prominent project, one of the most spectacular undertakings in the history of science and an extremely potent drive for industrial innovation, culminated in constructing the giant Large Hadron Collider (LHC), the largest "particle accelerator" in the world. The 27-km long underground ring is equipped with highly sophisticated sensors that can measure subatomic particle collisions with a precision hundreds of thousands of times greater than that of normal microscopes.

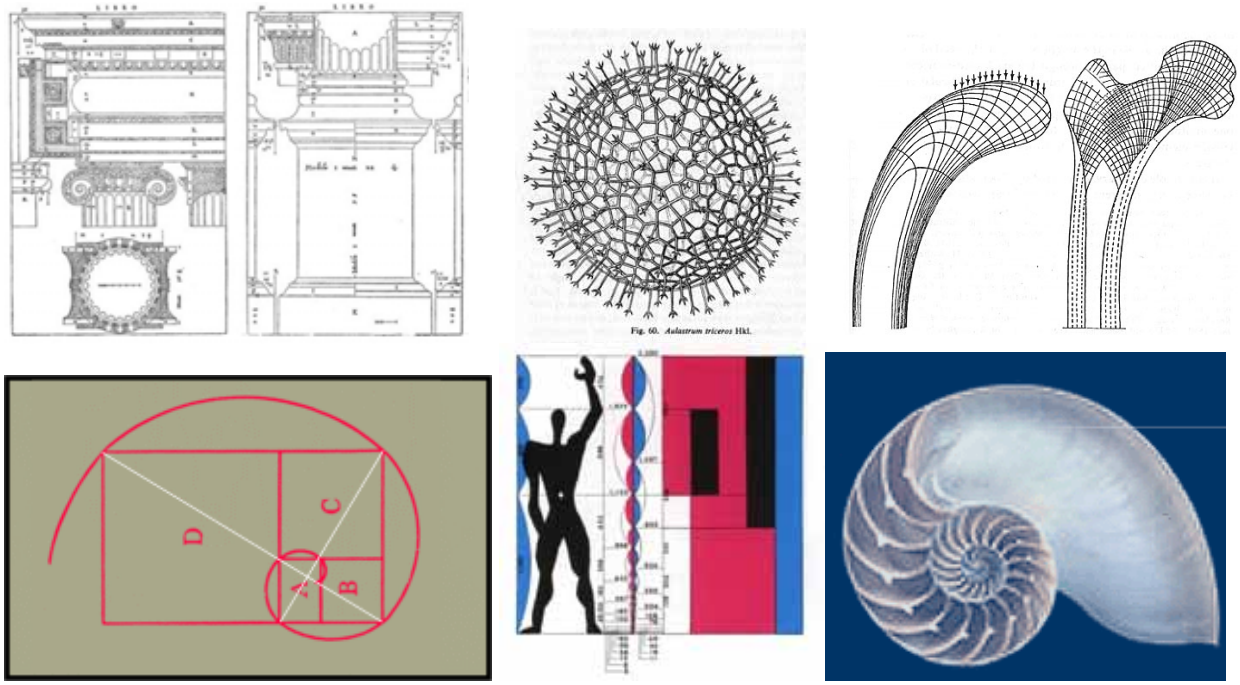
The author of this paper, editor of a specific book, realized a fascinating photographic survey that describes the essential phases of constructing the colossal equipment to perform the four main experiments. It is enriched by a sophisticated, experimental graphic design and the stories of the Italian scientists from the INFN (National Institute of Nuclear Physics), who made vital contributions to the project and constructing the LHC.
The book is completed by descriptions illustrating the important contribution that Italian companies made to this major project, demonstrating Italy's competitive capacity for excellence in the most important technological undertakings in Europe.

1. 0 Communication design.
The design of a book , considered as a permanent document that can visualize and hand down a culture that has made it possible; can synthesize some theoretical concepts and visual values.
Some essential concepts can be identified as the foundation of such a project.
A visual culture is a common heritage that can be participated from different partners of human society, having progressive enrichments from any sides, specially in the relation between arts and science. But some essential elements belongs to the mental way of thinking, so that we can try to found on some simple ideas a common language shared by different di and different reader's target.
Composition - morphology. In design research, as in the analysis of the nature, the representation of the formal structure is a fundamental element of all knowledge. The Identification of a form requires the possibility to confer a formal logical definition of these characteristics.
The page can be regarded as a morphologic unit of a book, and on this first basic element of it can be based on the draft layout.
Symmetry. The traditional ties of the pages of the manual browsing involves the gesture: from a geometrical point of view this means the combination of composition and visual resonance between pairs of pages.
This original bilateral configuration may be used to construct a symmetry factor of much more structured than a simple reflection, being a rotation or rototranslation on the time axis, extending along a free and accessible in the reversible browse a book.
Sequence. The element of the page, duplicate the double page is ordained in the narrative sequence. The entire sequence of pages is designed as a spatial matrix in the readability of the local double page is associated with memory and foreshadowing of the entire narrative sequence.
The unit of **composition** of the page, the **symmetry** in pairs, and **sequence** of the narrative path can be considered as concrete materials, and even abstract concepts, upon which the plan articulates graphically the layout of a book, and the formal perception by the reader.

1.1- Composition - Morphology

"Composition is the organization of the whole out of its parts—the conception of single elements, the interrelating of these elements, and the relating of them to the total form."..."The purpose of composition is to express particular concepts and experiences, and it is successful only when these are fully communicated to the observer" (*Composition* in: Encyclopædia Britannica)

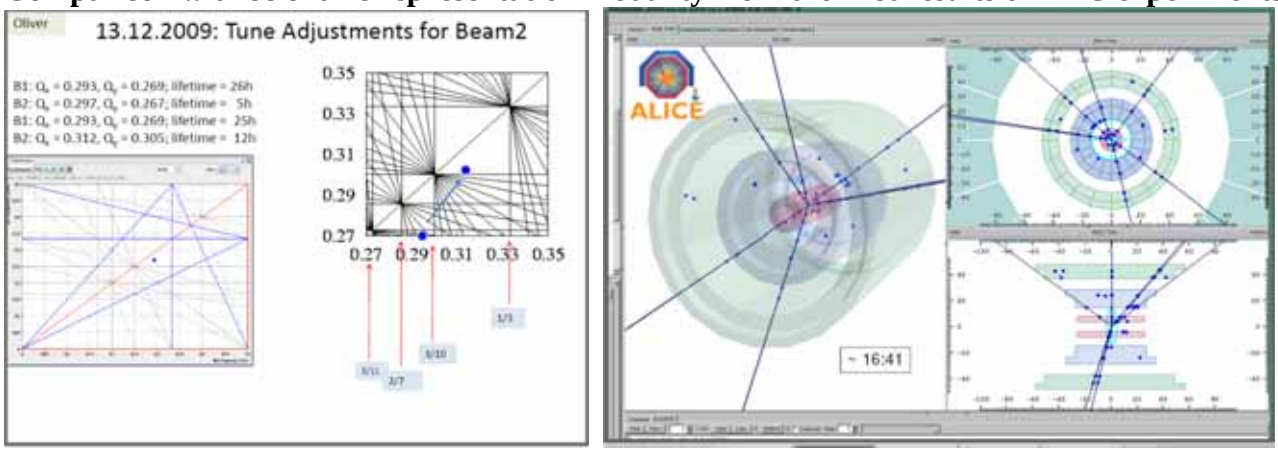
Morphology, or the dimensional qualities related to *form* that define the structure as a geometric configuration, statically and steadily relevant that place its global *shape* in its context.



Andrea Palladio, *I Quattro libri dell'Architettura* 1570
D'Arcy Wentworth Thompson. *On Growth and Form.* 1942
Le Corbusier *Le Modulor* 1948

1.1.1 - Composition - Morphology

Comparison with scientific representation modality from the first results of LHC experiments



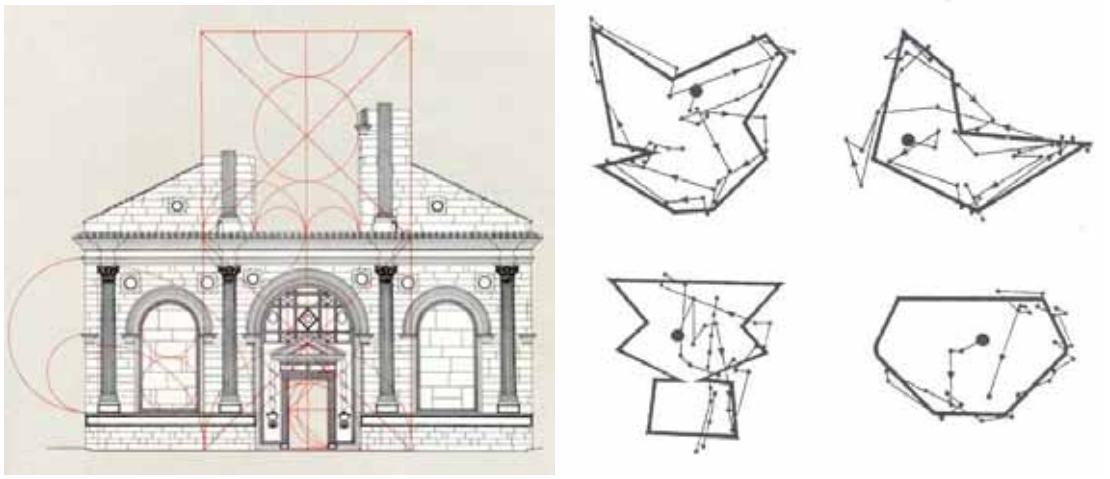
Left: Operating the LHC **with Beam** (on behalf of the LHC team) December 18, 2009
Right: First Physics at the LHC seen through the eyes of ALICE

1.**2- Symmetry / Typology**

Symmetry"In geometry, the property by which the sides of a figure or object reflect each other across a line (axis of symmetry) or surface; in biology, the orderly repetition of parts of an animal or plant; in chemistry, a fundamental property of orderly arrangements of atoms in molecules or crystals; in physics, a concept of balance illustrated by such fundamental laws as the third of Newton's laws of motion." ..." Symmetry in nature underlies one of the most fundamental concepts of beauty. It connotes balance, order, and thus, to some, a type of divine principle."

("symmetry" in: Encyclopædia Britannica)

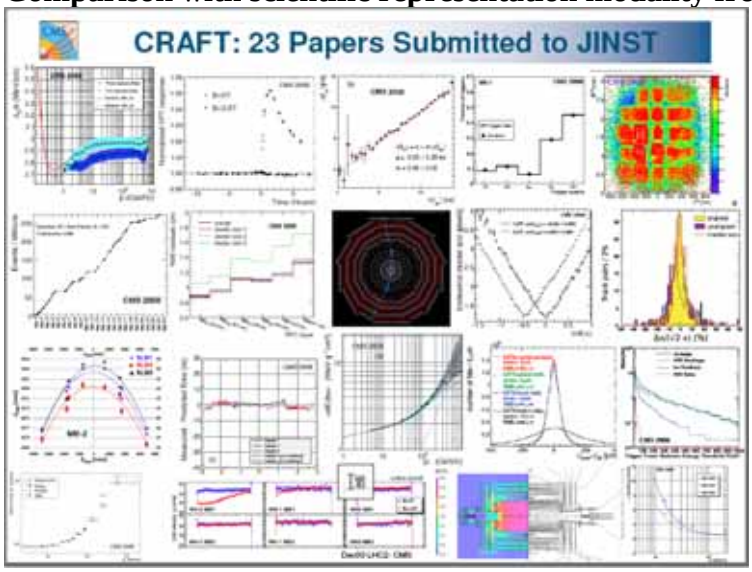
- *Typology*, or the articulation and the *relations* among the parts, the elements and the whole, that make up the object that is being observed as it relates to its intended *function*, with special attention to the potential distributive, systemic and ergonomic valences that permit the physical interaction with social practices, with the dimensions of the human figure and with the surrounding environment.



Left: Leon Battista Alberti, Rimini Tempio Malatestiano. Actual proportional interpretation of the facade.
Right: The eye movement of the observer at the moment of the visual perception of asymmetric and symmetric objects. www.mi.sanu.ac.rs/.../jadrbookhtml/part48.html

1.2.1

Comparison with scientific representation modality from the first results of LHC experiments



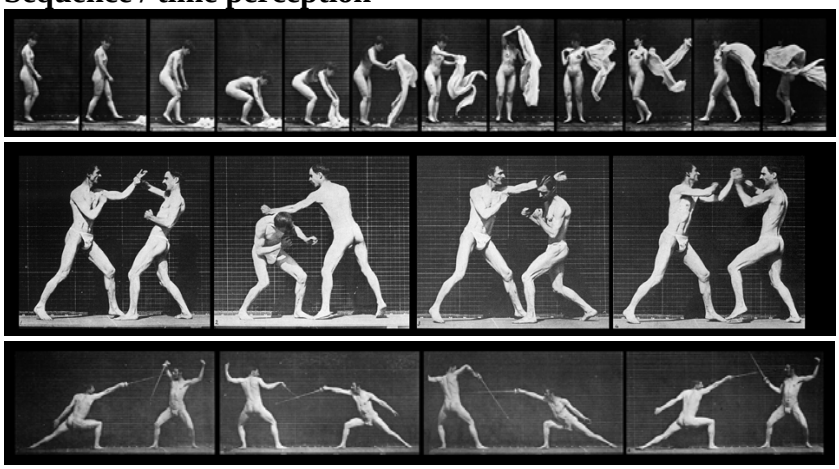
CMS 2nd LHC Status Report CERN 18 Dec'09 T. Virdee On Behalf of the CMS Collaboration

1.3. Sequence / time perception

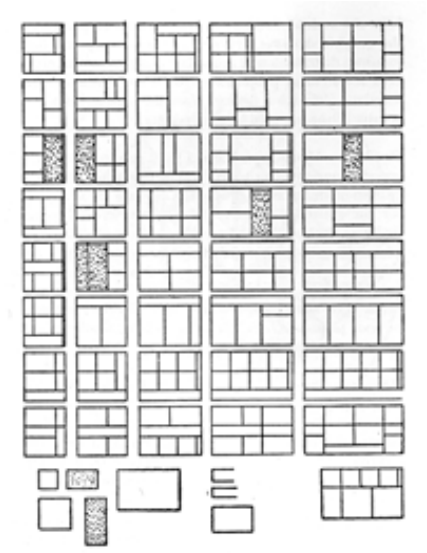
<u>Sequence</u> *(experience of time) "experience or awareness of the passage of time. The human experience of change is complex. One primary element clearly is that of a succession of events, but distinguishable events are separated by more or less lengthy intervals that are called durations. Thus, sequence and duration are fundamental aspects of what is perceived in change." …*
" A given interval always can be subdivided into a sequential chain delimiting briefer durations, as with the regular units that provide empirical measures of time … - … Indeed, human experience is not simply that of one single series of events, but of a plurality of overlapping changes."… " Humans seem to be unable to live without some concept of time." (Paul Fraisse, *experience of time* in: Encyclopædia Britannica)

<u>*Sequence:*</u> a visual journey expresses a particular value in the multiplicity of events that occur over time. The spatial configuration of a sequence becomes a strong opportunity for visual imaging.

Sequence / time perception

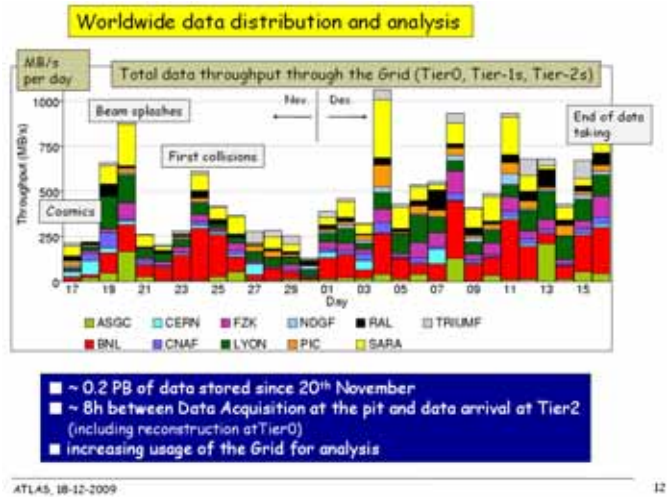


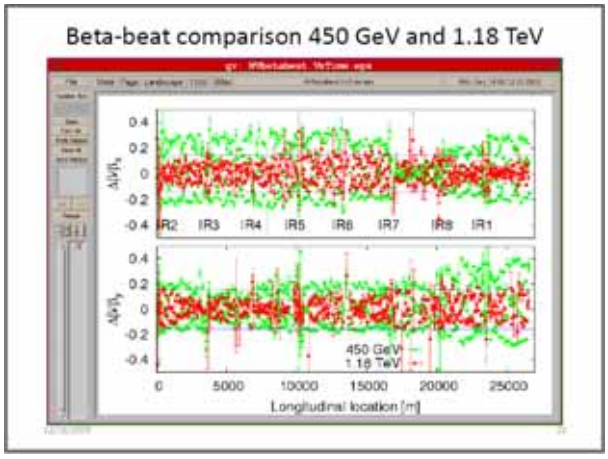
Eadweard Muybridge , *Human Figure in Motion* 1878
(with courtesy of Dover Publications, Inc International Standard Book Number: 0-486-99771-5 Copyright (c) 2007.)



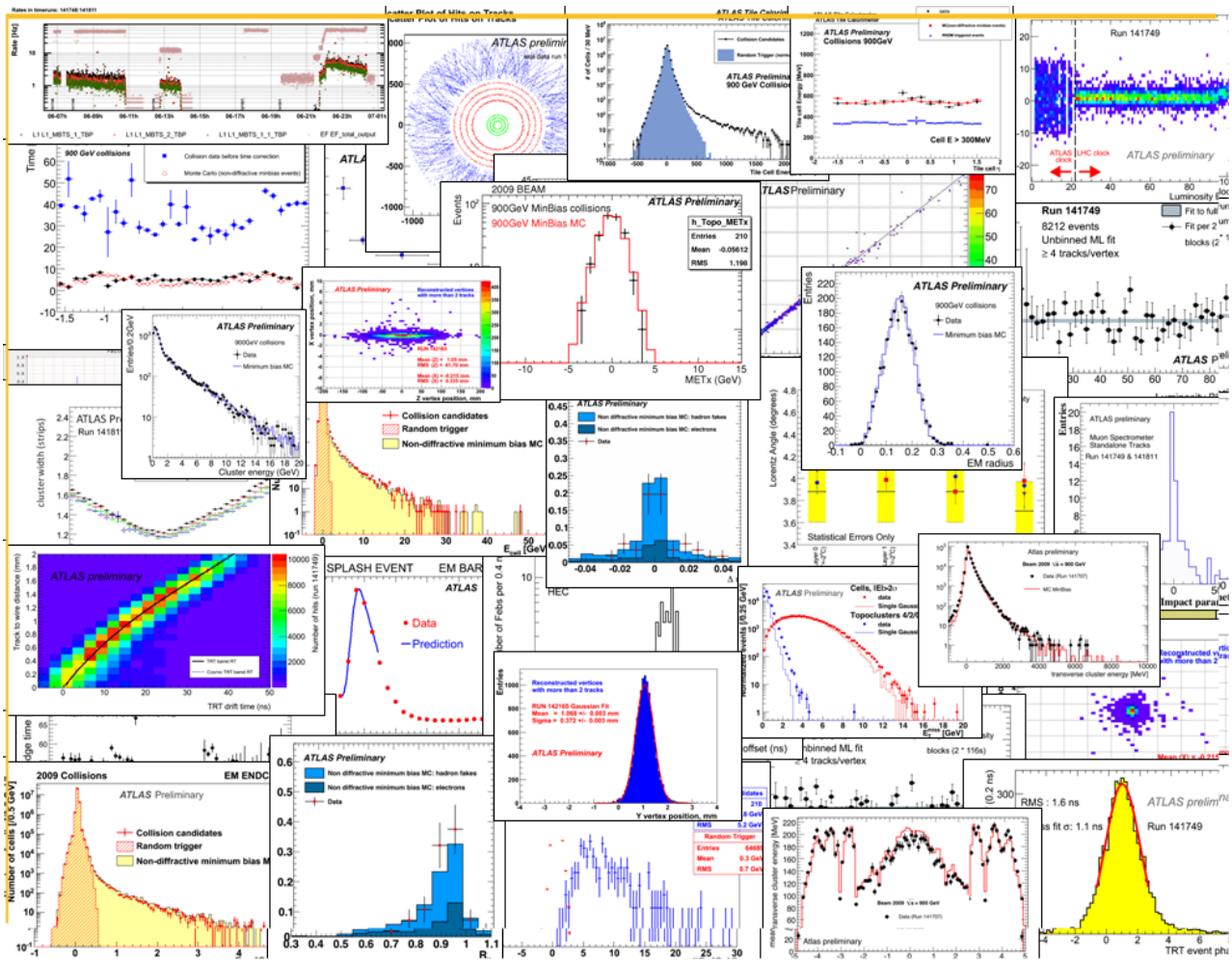
In his book, *The Modulor,* Le Corbusier describes his invention as "a measuring tool (the proportions) based on the human body (6-foot man) and on mathematics (the golden section). A man-with-arm-upraised provides, at the determining points of his occupation of space-foot, solar plexus, head, tips of fingers of the upraised arm-three intervals which give rise to a series of golden sections, called the Fibonacci series."3 (1, 1, 2, 3, 5, 8, 13, etc.)

1.3.1 – Sequence / time perception
Comparison with scientific representation modality from the first results of LHC experiments





Left: ATLAS through first data 2009.12.
Right: Operating the LHC with Beam (on behalf of the LHC team) December 18, 2009



ATLAS through first data 2009.12.

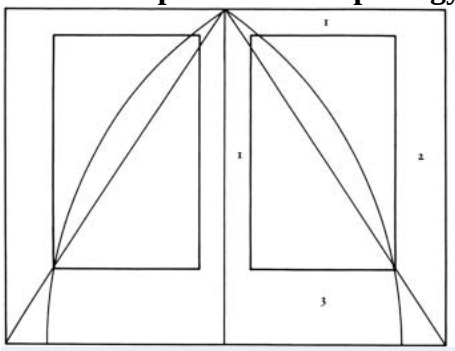
2. 1.
A mathematical format as a symbol for scientific communication;
Geometry and the form of knowledge

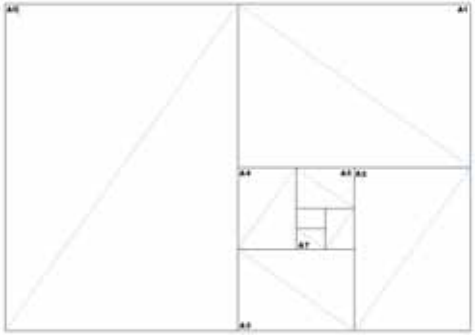
In choosing a graphic solution for the book's layout, studies on the proportions in geometry came to mind. Since its origins, geometry, as a science named for measuring the world, has looked to the relationship between form and number to find the chance of human intelligence to understand and re-create nature in its beauty and harmony.

This scientific approach has its roots in the earliest civilizations and the mathematical sciences. It was expanded on with the theorems of Greek classicism, in which the aesthetic precept is intrinsic to the technical practice of art. Then, it continued along a genealogy between the East and the West through the Renaissance to modernity. The currently available power calculation has developed these original intuitions into fractal geometry, theories of relativity and quantum physics.

Contemporary topologies have crossed the experience of space-time continuity. Yet, this genealogy continues to pay close attention to the possible correspondence between the theoretical concept and the forms of nature, between images of intelligence and design of the world. Considering LHC's perfect circularity, a ring plan with a cross-section of endless series of concentric circles, we naturally designed a square book. Indeed, almost all of CERN's publications are also square!

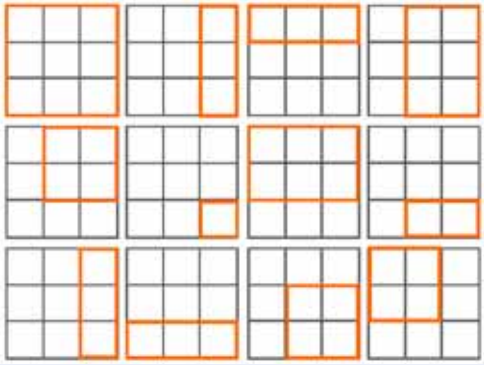
***2*.1.1.- Composition - Morphology** / *graphic solution*





Left. : Page layout and text area: schema of proportion ideals in a medieval manuscript without columns multiple, given by Jan Tschichold in 1953
Right: UNI standard paper format

2.1.2 - Symmetry / <u>Typology</u> / *graphic solution*



The International Typographic Style - ITS (known as the Swiss School) born around the 50s, brought forward the ideas of the Bauhaus. Their thinking was spread through their magazine Neue Grafik in 1958, was a new vision of typography simple and orthogonal with the use of a grid of square modules for layout, font Helvetica, left-aligned text in the body with lowercase primary colors red white and black, and especially the elimination design with the use of photography.

3.1. *Drawing, images and metaphors in scientific communication*

Drawing and images occupy a relevant place among the languages and tools used to communicate science. This type of representation of scientific contents also has a fundamental role in developing the theoretical phase of the research which precedes the communication phase. Every discipline stems from a specific interest and establishes its ambit by naming, through precise definitions, the system of related objects. "Words" identify the "things" of the "world" that one decides to deal with, and the semantic system of representation becomes part of the procedures and of the descriptive, interpretive and pre-figurative methods of the specific discipline (1). The words of science often are not literary expressions, but logical-mathematical paths expressed with alphanumeric formulas, taxonomies, theoretical hypotheses based on observation or requiring further observation to be validated (2). The iconic component becomes particularly important in this type of path and, although it usually takes only the form of para-textual apparatus, when it is adequately conceived, can be critically important and can even shape the thought that generated it.

Among such iconic expressions three main elements can be identified: drawing, image and metaphor.

Drawing Like the alphanumeric letters used in mathematical formulas, or the graphic rendition of projects, or the traces left by physical events on detectors, the impression of gestures marks the concepts and memories, that will be later revisited through projectual or interpretative activities, in graphic form according to specific descriptive codes. Through the formalization process of drawing, events and concepts previously invisible become visible, in accordance with a compositional order that in itself stabilizes the analysis of the object of a research and makes it shareable. Like in geometry, in describing physical phenomena the dot is taken as the essential element used to trace a sequence of events; this minimal reference becomes the starting point for analyzing and investigating their dynamic development (3).

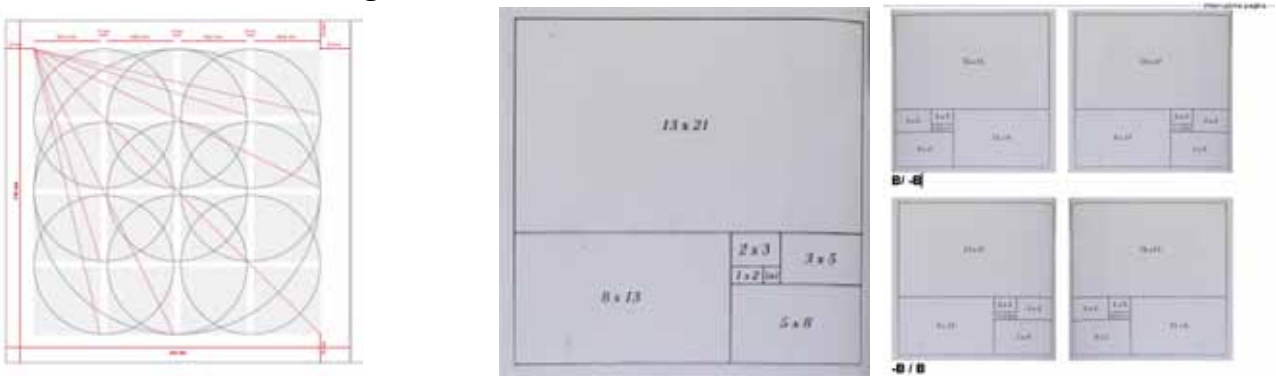
Image. The production of visual artefacts makes the interpretation of the collected data possible. The perception of such data is more focused and the information is integrated with contextual values and aesthetic meaning: thus the data can be appropriate more profoundly and also be shared (4). During the heuristic phase of scientific (and artistic) research, the image is recognized as the mental configuration (even before becoming the visual configuration) of the synthetic comprehension of a problem and its data. Then the interpretation can be further analyzed logically and formally (5). The representation of a real datum (or of a hypothetical datum) can be perceived easier through its image, within a system of shared codes of communication (6).

Metaphor. The classical origin of this rhetorical figure and its use mainly in poetic expressions has kept the scientific epistemology of the early modernity away from this concept, which has recently been reappraised in the analysis of phenomena that cannot be empirically perceived in quantum physics (7). Metaphor is a fundamental cognitive and communicative modality that uses a linguistic procedure n order to define, even if figuratively, the form or the concept of the object that is being studied, by introducing and referring to the figure of another object which is better known. This mode of communication, found both in text form and in iconography, uses an hypothetical model, not only to represent the formal structure of the phenomena, but also to enable the comprehension of the real datum according to specific explanatory hypotheses or at least according to certain elements that make such comprehension possible through shared experiences.

Drawing, images and metaphors can be adopted as a first criterion to understand the multifaceted atlas of images used in scientific communication, and produced by researchers to understand each others in the complex world of "Big Science" (8). Beyond the individual samples and in many strict research protocols, one can undoubtedly find several examples of crossbreeding and nuances among the simple categories that have been introduced as the initial iconological taxonomy of the universe of visual thought.

1. Michel Foucault, Les Mots et les choses*, Paris 1966.*
2. Karl R. Popper, John C. Eccles, The Self and its Brain*, Berlin 1977.*
3. Paul Klee, Pädagogisches Skizzenbuch*, München 1925; idem,* Unendliche Naturgeschichte*, Basel 1970.*
4. Jill Ackerman, Origins, Imitation, and Conventions: Representation in the Visual Arts*, Cambridge, Mass. 2001;*
5. Stephen M. Kosslyn, Le immagini nella mente. Creare ed utilizzare immagini nel cervello*, Giunti, Firenze, 1999; S.T.Moulton, S. M. Kosslyn (2009),* Imagining predictions: mental imagery as mental emulation*, "Philosophical Transactions of the Royal Society" B, 364, 1273-1280. 6.*
6. Giovanni Anceschi, L'oggetto della raffigurazione*, Milano 1992.*
7. Elena Castellani, Verità e scienze fisiche*, in Silvana Borutti Luca Fonnesu (a cura di),* La verità. Scienza, filosofia, società*,Bologna 2005.*
8. Yurij Castelfranchi, Nico Pitrelli, Come si comunica la scienza?*, Roma-Bari 2007.*

4**.1 Final studies and editing solution**



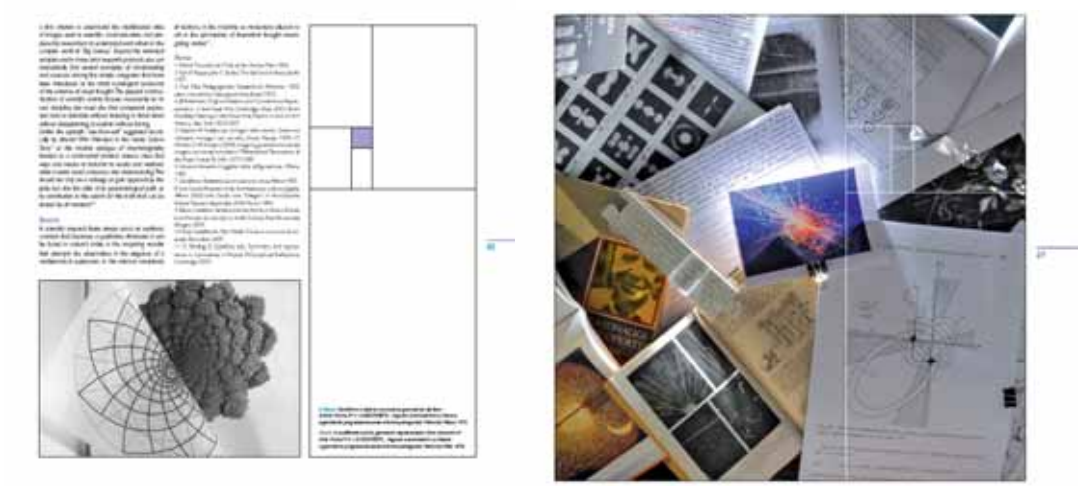
Left: Total Tool _Milano _Buenos Aires _Tokyo; first studies for layouts: Cern | INFN 2008
Right: Fibonacci square, first composition studies (FB 2008)

4.2 The Fibonacci square as a mathematical format

Fibonacci. Geometric composition of the sequence of Fibonacci number form 1 to 21;
Preliminary studies in symmetry for typographic grid (F. Brunetti 2008, with *Laboratorio*, Milano)

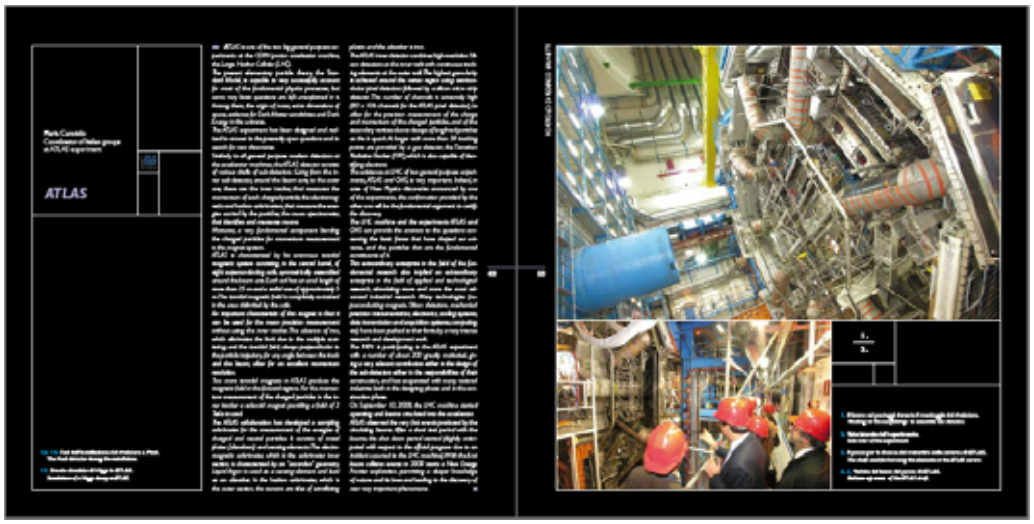
Without going into further detail, we would say that Leonardo Fibonacci's (Pisa, 1170–1250) studies on numerical sequences, unequivocally coherent in mathematical terms and full of evidence in nature (particularly his studies on the composition of the square), struck us as the perfect "format" for a physics book. We faithfully developed a sequence of modules that formed the structure of the graphic layout. Starting from a single small square, the layout expands by progressive additions until it composes a larger square, from which, of course, it can begin again to develop or wrap around itself. This layout can be rotated in all directions and can be conceived both positively and negatively. The juxtaposed pages generate a high degree of compositional variability, allowing for repetitions, simple symmetries and even rotations combined with translations and asymmetries. This lets us take a great variety of paths of visual interpretation following different hierarchical systems, while maintaining the logical-formal sequence of images.
The book's composition is revealed to readers through a sophisticated logical-formal exercise that includes the space of the pages and the time (temporal sequence) in which the different experiments take place. Here follows a selection from the pages of the book.

The architect’s drawing board. Geometry through Natural Science.

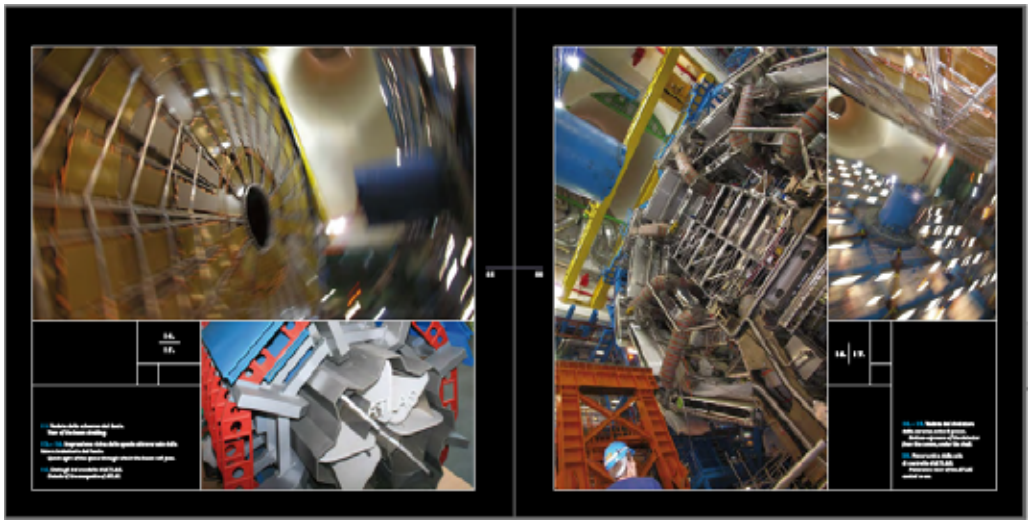


Physicists’ table of representations: genealogies of scientific representations.

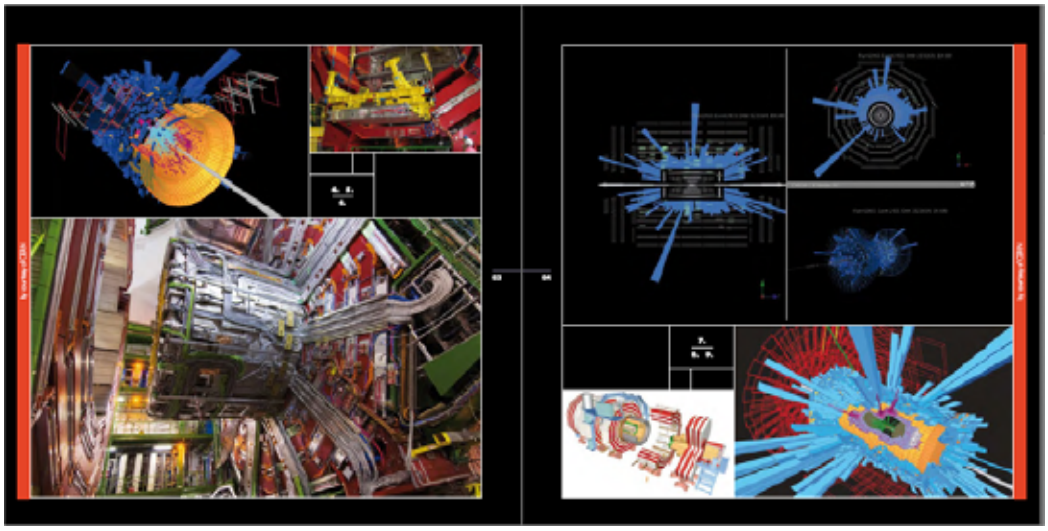
Table of experiment constructions: interpretative and planning drawings.



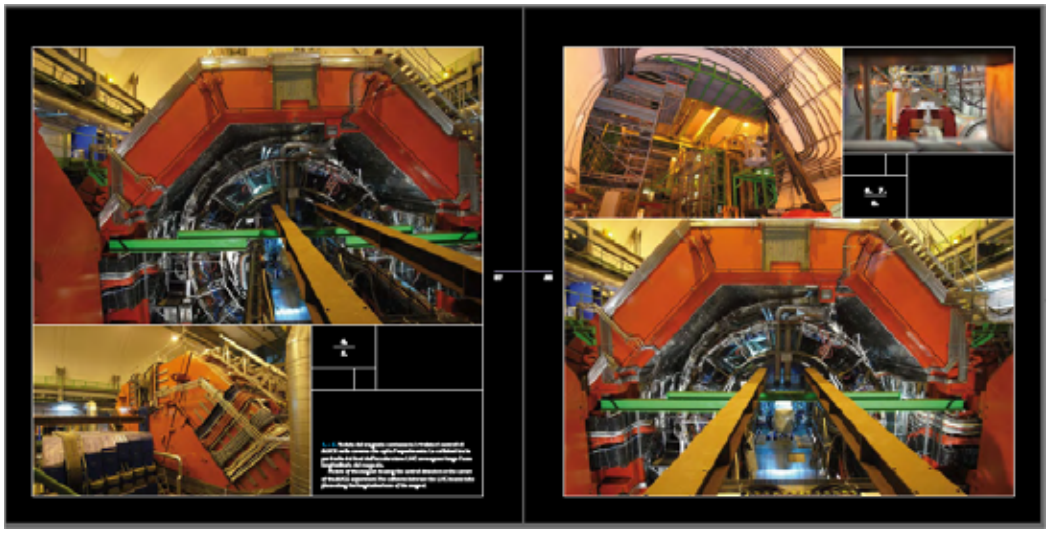
ATLAS experiment at LHC – CERN, commisioning.



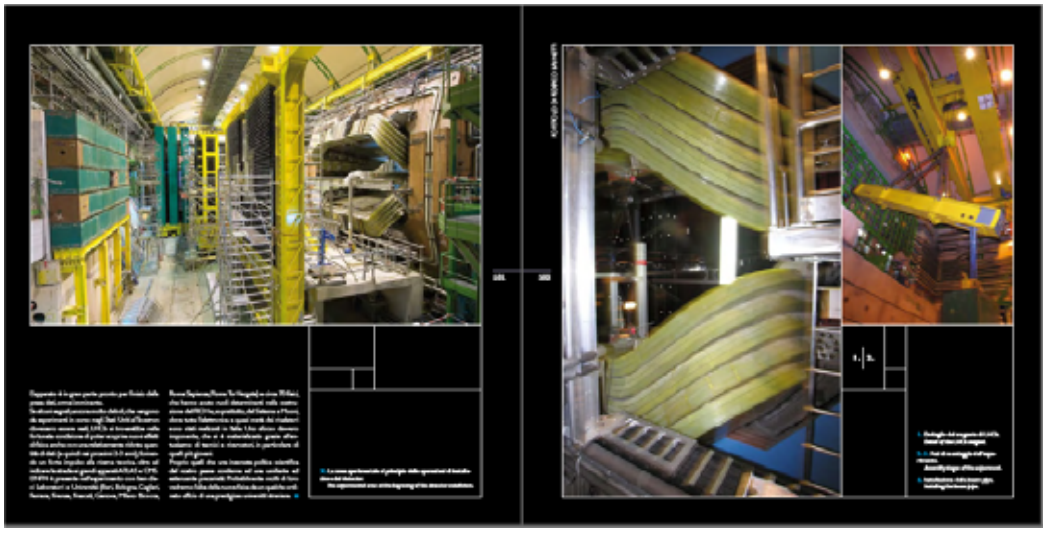
ATLAS experiment at LHC – CERN, commisioning.



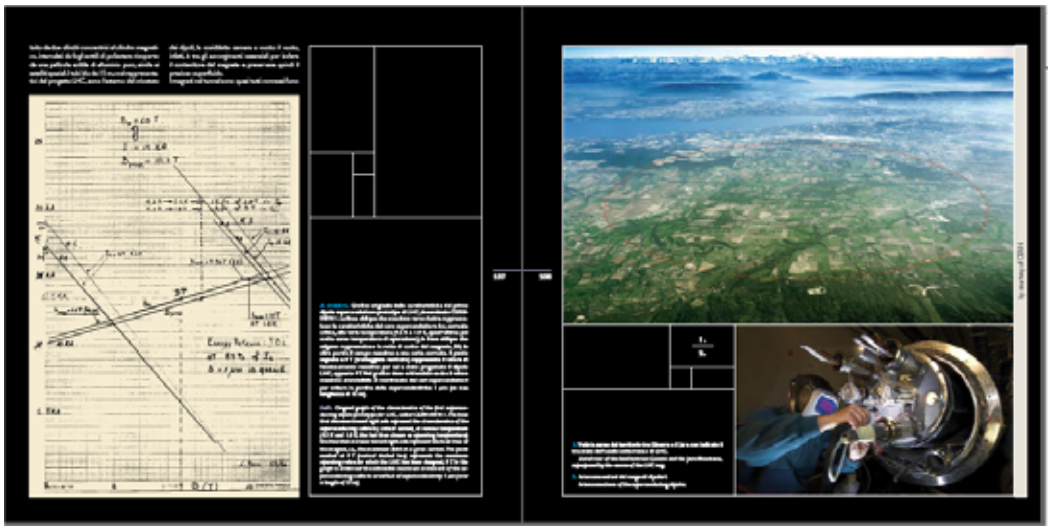
CMS experiment at LHC – CERN, commisioning.



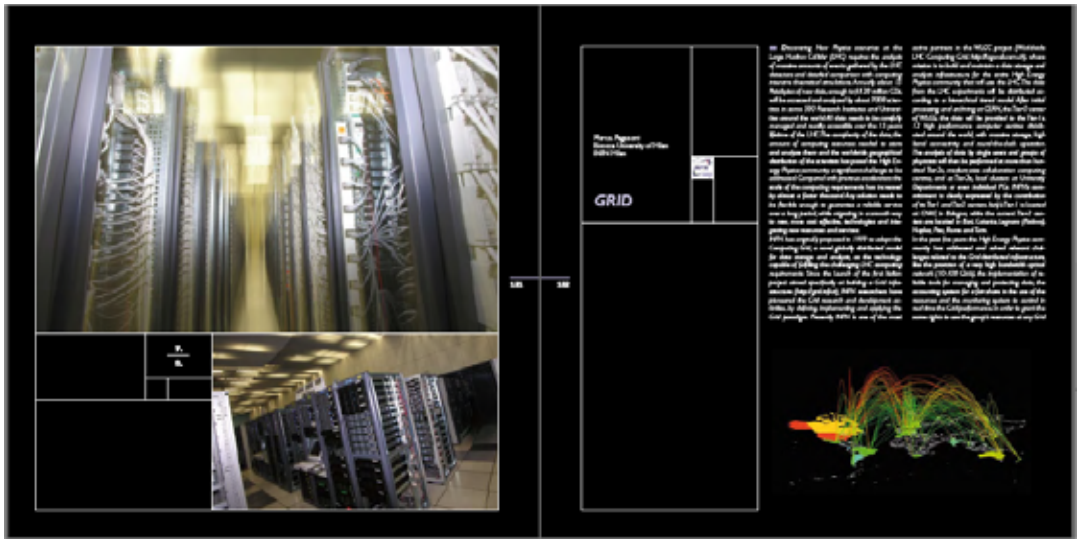
ALICE experiment at LHC – CERN, commisioning.



LHCb experiment at LHC – CERN, commisioning.



LHC machine experiment at LHC – CERN, commisioning.



GRID experiment at LHC – CERN, commisioning.

5.1 Fifth section: open conclusions

A final reversible question: What do we think when we see? What do we see when we think?

The final result of these application of a mathematical concept for a typographical grid for a scientific book has been appreciated by the different stakehorders and kind of readers to whom this work has been conceived. From scientist to designers, from publishers to visual artists.

But essentially demonstrate and symbolize the deep connection that exist, and can be revealed, in the relation between mathematical ratio and perception of beauty, optimization of resources and politeness of order.

But it's safe to say that the most interesting results were received by those who, although well understanding the meaning, you just forgot the ordering rule in the structure of the book, and simply has enjoyed the visual experience during his reading path, leaving to the intuition gather and understand the deep meaning of this natural spontaneity..

Night view of the site of CMS.

Acknowledgement
INFN: Umberto Dosselli, Fernando Ferroni, Romeo Bassoli *for the many conversations that helped get this book off the ground and find its direction.*
And all scientists that shown me their way to search and find the beauty in Nature.
- The book to which tis paper refers was supported by grant from Dipartimento In.D.A.Co Politecnico di Milano and published with title: Federico Brunetti (editor) *GLI ANELLI DEL SAPERE - THE RINGS OF KNOWLEDGE; INFN X LHC. The Italian contribution to the world's largest particle physics research project at CERN, Geneva* Pages 148 - Pictures 350 Size 240 x 240. Milano 2009 Editrice Abitare Segesta ISBN: 9788886116-930 Italian and English text. INFN texts (Istituto Nazionale di Fisica Nucleare): Roberto Petronzio, Pierluigi Campana, Sandro Centro, Maria Curatolo, Marcella Diemoz, Eugenio Nappi, Marco Paganoni, Lucio Rossi, Walter Scandale, Romeo Bassoli.
- Antonella Minetto, coordinatrice Editoriale di Abitare Segesta
- Giulio Ceppi, Facoltà del Design , INDACO Department, Politecnico di Milano
- Italian tecnological companies that supported the realization of this book

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www.ts.infn.it/eventi/ComunicareFisica/presentazioni/brunetti.pdf

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