

HELIOS

or the need of a
CERN for analogs

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Simulating Gravitation and Cosmology

ETC*, Trento

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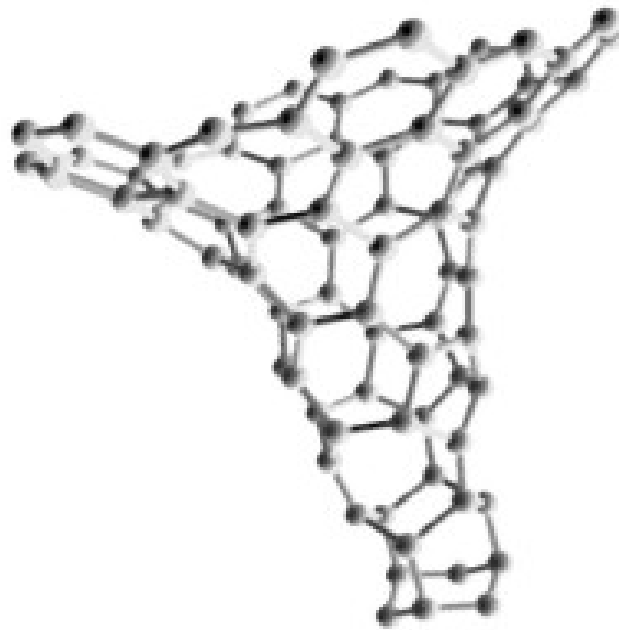
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PLAN

- 0' Our group's work (or why I qualify)
- 5' Why analogs are not used as tests of hep-th?
- 5' HELIOS, scientific goals
- 5' HELIOS, practical issues

Our group @ Charles University





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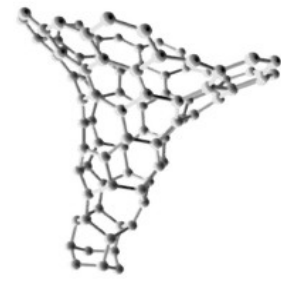


Gaetano Lambiase



Paolo Castorina

**G Lukes-Gerakopoulos, R Gabbrielli, S Taioli, A Zampeli,
P Haman, P Kus**



- **AI, Ann Phys 326 (2011) 1334; EPJ plus 127 (2012) 156**
- **AI, G Lambiase, PLB 716 (2012) 334; PRD 90 (2014) 025006**
- **AI, P Pais, 1901.00116; Ann Phys 398 (2018) 265; PRD 92 (2015) 125005; et al, 1907.00023; IJMPD 27 (2018) 1850080**
- **R Gabbrielli, AI, S Taioli, et al J Phys: CM 28 (2016) 13LT01**
- **AI, IJMPD 24 (2015) 1530013 review**

- **AI, 1902.07096; G Acquaviva, AI, M Scholtz, Ann Phys 387 (2017) 317; PoS (CORFU2018) 206**

- **P Castorina, D Grumiller, AI, PRD 77 (2008) 124034;**
P Castorina, AI, H Satz, IJMPE 24 (2015) 1550056;
P Castorina, AI, IJMPA 33 (2018) 1850211

• **9 PROJECTS CURRENTLY IN PROGRESS**

Why analogs are (still) not used as tests of hep-th?





A noble family of four relations

1. *Symmetry*

$$\mathcal{A}(\Phi) \rightarrow \mathcal{A}(\Phi') = \mathcal{A}(\Phi)$$

when $\Phi \rightarrow \Phi'$.

2. *Duality*

$$\mathcal{A}(\Phi) \rightarrow \mathcal{A}_D(\Phi_D) \neq \mathcal{A}(\Phi)$$

when $\Phi \rightarrow \Phi_D$.

3. *Correspondence*

$$AdS \rightarrow CFT$$

Underlying common structure for 1, for 2, and for 3.

4. *Analogy*

$$Equation(1) \rightarrow Equation(2)$$

No underlying common structure considered.



$$\vec{\nabla} \cdot (\kappa \vec{\nabla} \phi) = -\rho_{free}/\epsilon_0$$



“ [...] there are many physics problems whose mathematical equations have the same form. [...] Whatever we know about electrostatics can immediately be carried over into that other subject, and vice versa”

The flow of heat

The stretched membrane

The diffusion of neutrons

Irrotational fluid

Illumination of a plane





“Why are the equations from different phenomena so similar”?

“[...] the thing which is common to all the phenomena is the space, the framework into which the physics is put”.

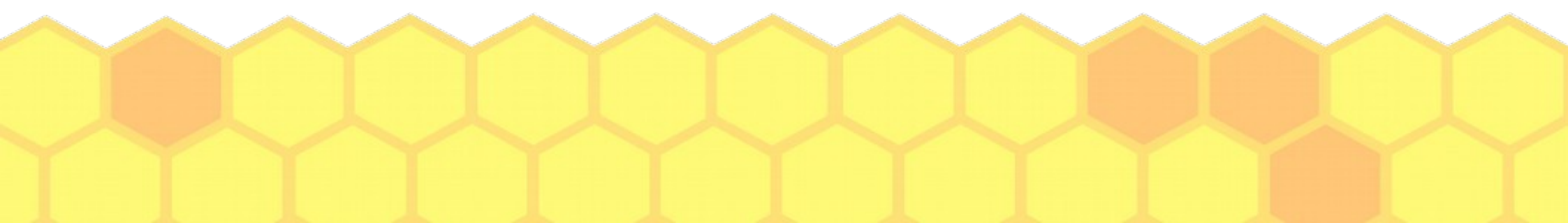
“Are they [the electrostatic equations, ed] also correct only as a smoothed-out imitation of a really much more complicated microscopic world? Could it be that the real world consists of little *Xons* which can be seen only at very tiny distances”?

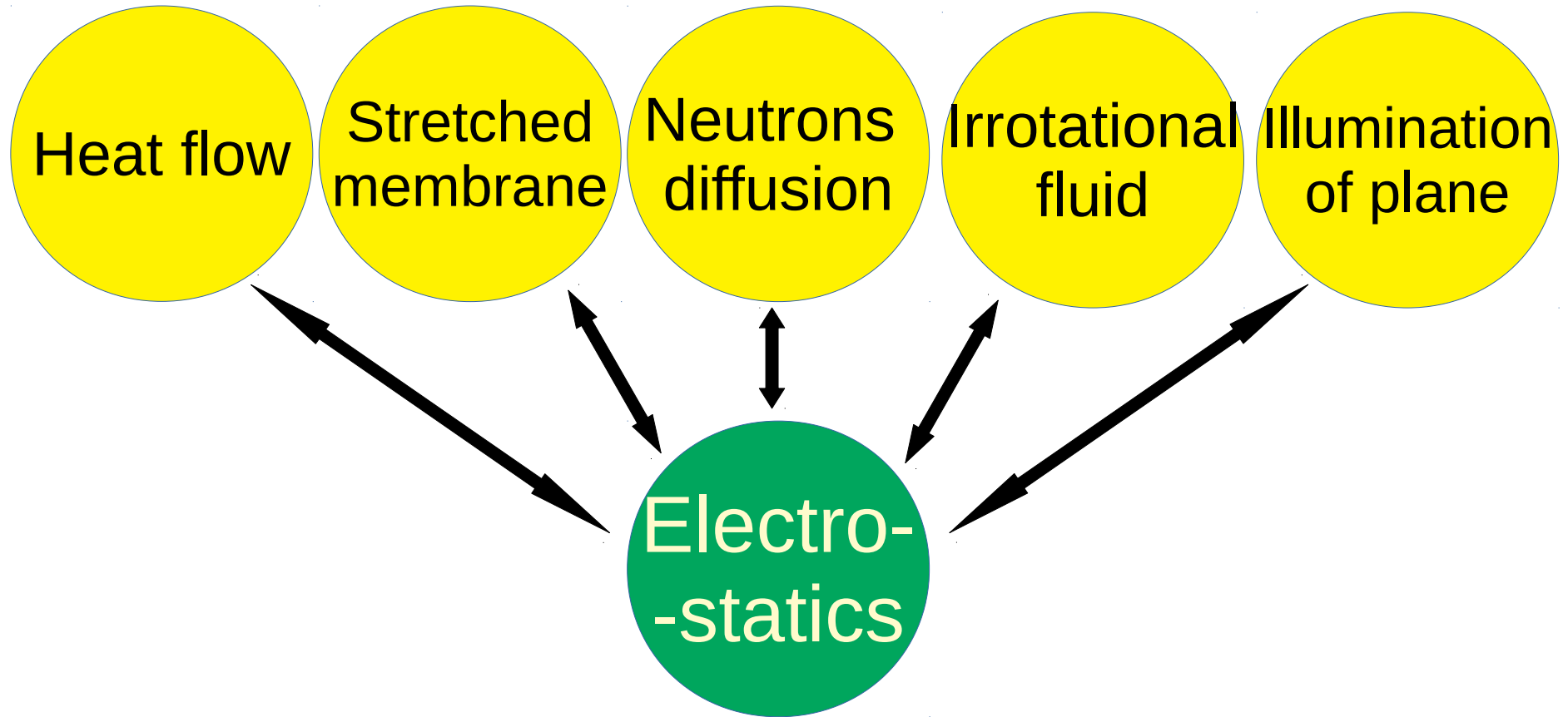
Many years later Bekenstein proposed

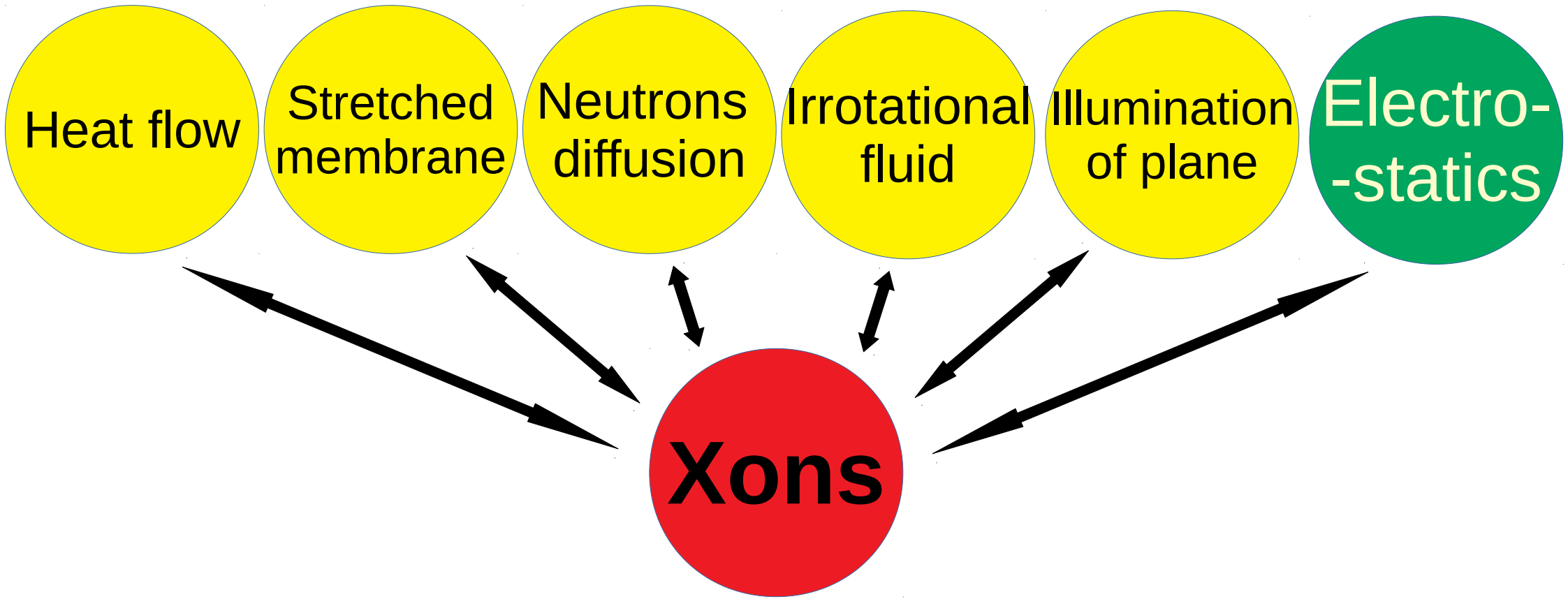
$$S_{\text{anything}} \leq S_{\text{BH}}$$

leading to a level *X*

$$\dim H_X \sim e^{S_{\text{BH}}} < \infty$$









Further reading:

R Feynman, *Electrostatic analogs*, Feynman Lectures on Physics, Vol II, Chp 12

J D Bekenstein, *Information in the holographic universe*, Scientific American 289 (2003) 58

AI, *Two arguments for more fundamental building blocks*, arXiv:1902.07096

R Dardashti, *Putting analogue experiments on the methodological map*, talk @ Workshop: Analogue Experimentation, Bristol, 16th July 2018



HELIOS, scientific goals





I “Find the Xons”

I.a Search for the ultimate building blocks

I.b Systematically explore the common underlying structure between analogs, thus *Analogy* will rise at the same level of *Symmetry*, *Duality*, and *Correspondence*.

Example: supernova explosions can be simulated in the lab by implosions induced in a plasma by intense lasers *

$$t \rightarrow -1/t \quad \vec{x} \rightarrow \vec{x}/t \quad \text{duality}$$

Only this will eventually convince the whole community that analogs are tests of hep-th.

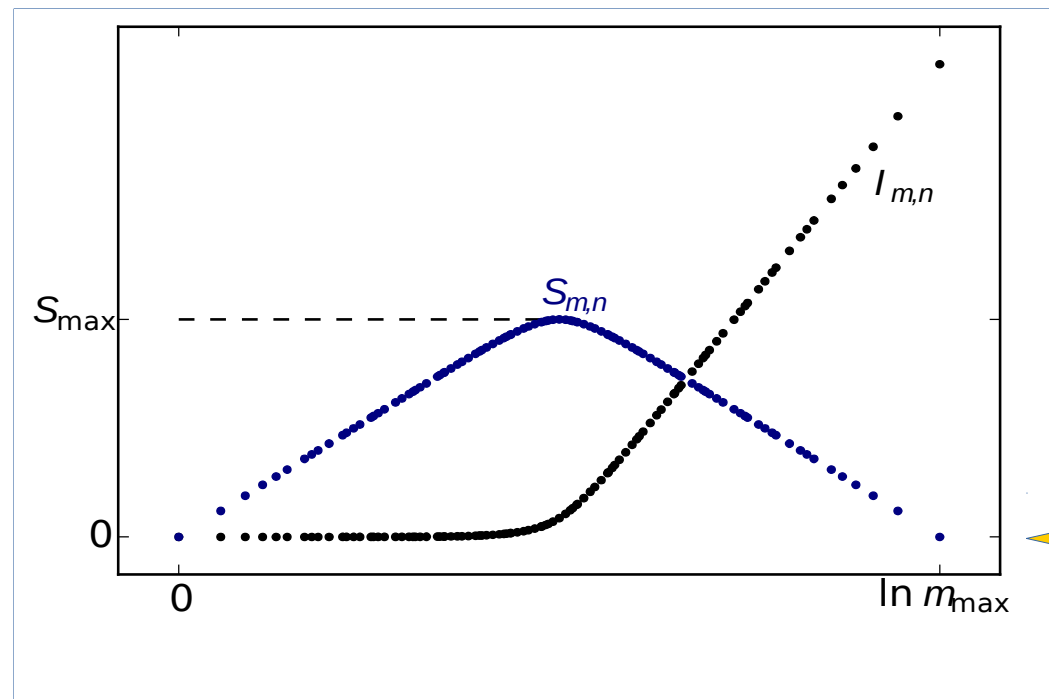
* L O’Raifeartaigh, V V Sreedhar, *The maximal kinematical invariance group of fluid dynamics and explosion–implosion duality*, Ann Phys 293 (2001) 215



II Solve open theoretical debates with analog experiments



Focus on some few open issues, probably the most important being the info loss. Problem: kinematics \rightarrow dynamics?



III Remedy to the *vulnus* caused by contemporary hep-th (string theory).

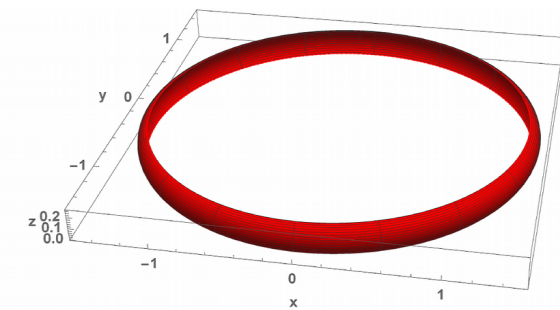
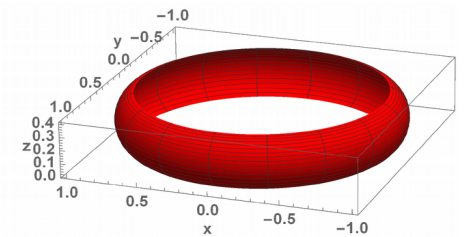


Some form of any theoretical construction can be reproduced in analogs.

Even pure theorists should learn how to put their models into experimental terms.

This applies to everything: SUSY, Strings, Loops, extra dimensions, GUPs, BH physics, and all the hep-th bestiary:

$$[L_m, L_n] = (m - n)L_{m+n} + \frac{1}{12}\hat{c}m(m^2 - 1)\delta_{n+m,0} \Rightarrow$$



HELIOS, practical issues





I The merging of different expertise into one place, with one grand goal, will:

foster new ideas

boost research programs (first hand experience...)

break unnatural knowledge borders *

enhance cross fertilization (more than for CERN)

* btw, borders are all unnatural...

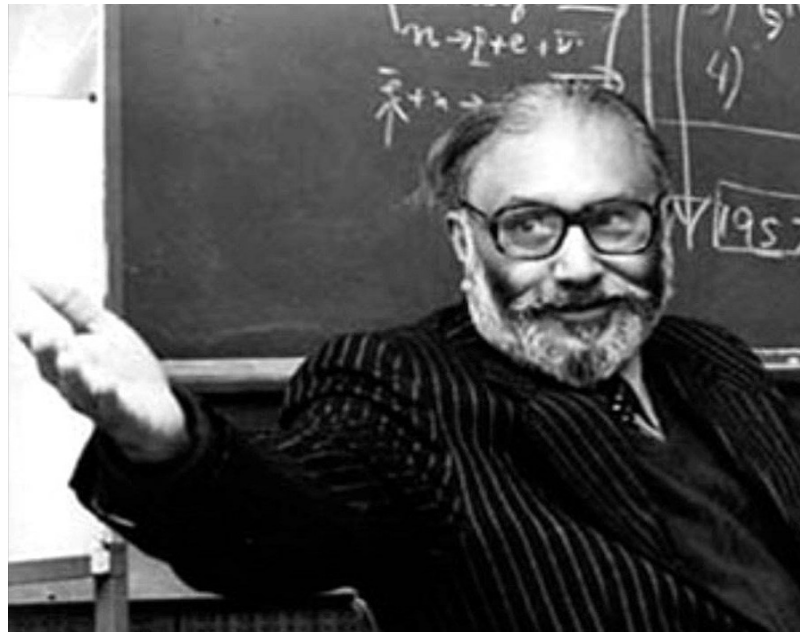


II It should be built with the spirit of Salam's ICTP



That is, scientific excellence and social development of the underdeveloped world.

HELIOS does not need titanic technological/engineering efforts, so it could be build in less developed parts of the world (I have my bet).



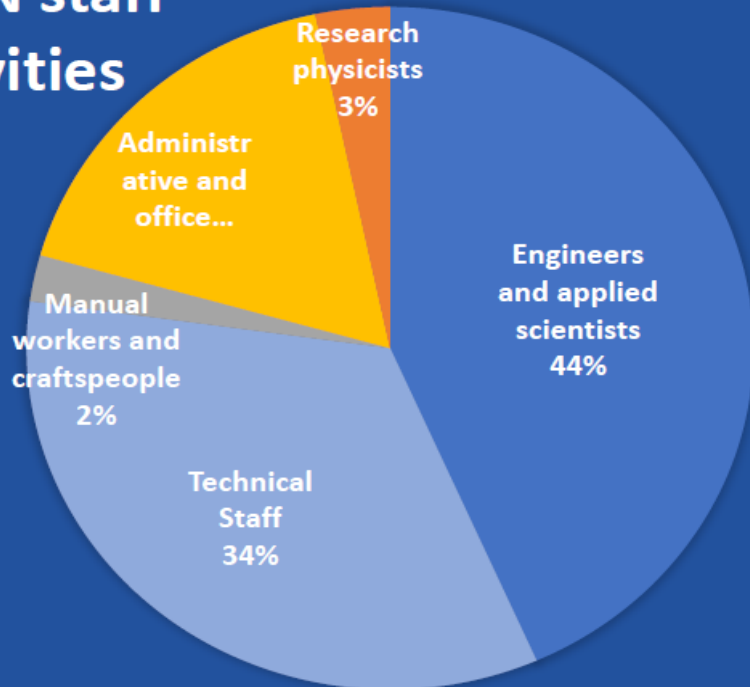


CERN key figures

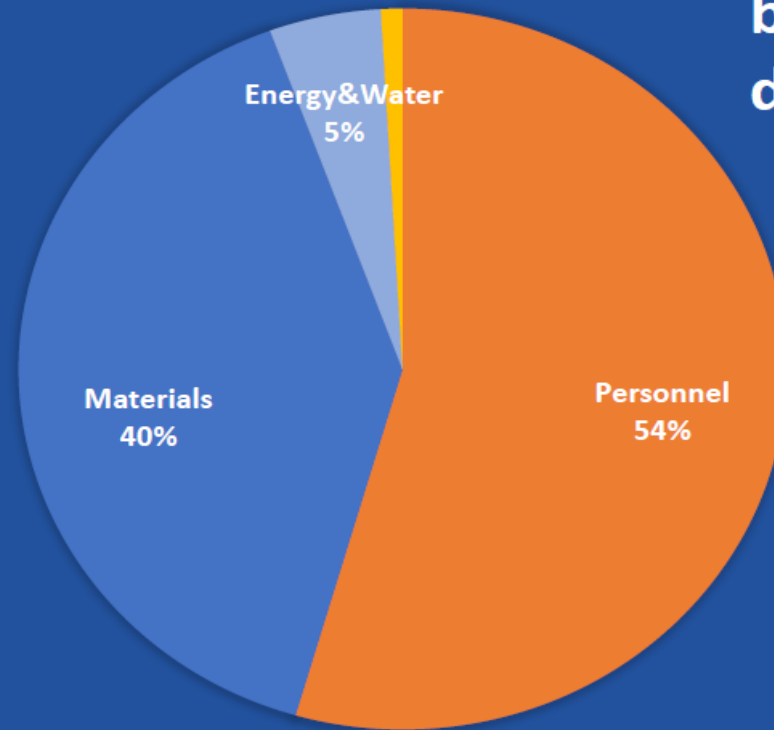
- ~ 2600 staff
- ~ 1800 other paid personnel
- ~ 13000 scientific users

CERN Budget (2018) ~ 1150 MCHF

CERN staff activities



CERN budget distribution



1 033 000 000 EUR

