

LHC and its Experiments - on Rubik's Void, with a Black Hole

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Berze Secondary and Middle School



PARTICLE GAMES – STUDENT IDEA

2011: Four basic particle card games

by Cs. Török, Judit Csörgő, T. Cs., BerzeTÖK Science Club in Gyöngyös, Hungary

1. ANTI
2. Cosmic Showers
3. Let's Detect!
4. Quark Matter Card Game

2012: talks, demonstrations and presentations

5. Memory of Quark Matter [arXiv:1303.2798](https://arxiv.org/abs/1303.2798)
6. Find Your Own Higgs Boson [arXiv:1303.2732](https://arxiv.org/abs/1303.2732)
7. Particle Poker (Academia Europaea, Bergen)
8. Particle 66, Machiavelli (CERN Open Days)

2013: talks, demonstrations and presentations

9. Quark Wars: Summer Camp of Berze Science Club, Vesznek
10. Particle Mahjongg - Mártély, Camp of Science Club Movement

2014: WPCF 2014 conference, KRF, Gyöngyös, Hungary

11. Quark Matter on Rubik's Cube
12. Particle Hits! – CERN @ Wigner Open Days, Budapest

2016: Low-x 2016, KRF, Gyöngyös, Hungary

13. LHC Experiments Rubik's Void, with a Black Hole

ELEMENTARY PARTICLES

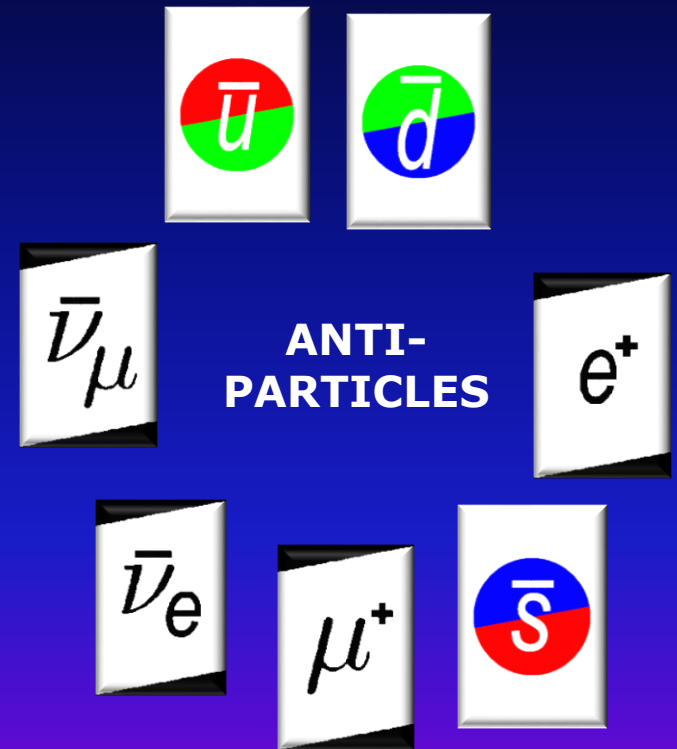
Three generations of matter (fermions)

	I	II	III		
mass →	2.4 MeV/c ²	1.27 GeV/c ²	171.2 GeV/c ²	0	? GeV/c ²
charge →	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$	0	0
spin →	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	0
name →	u up	c charm	t top	γ photon	H Higgs boson
	4.8 MeV/c ²	104 MeV/c ²	4.2 GeV/c ²	0	
	$-\frac{1}{3}$	$-\frac{1}{3}$	$-\frac{1}{3}$	0	
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	
Quarks	d down	s strange	b bottom	g gluon	
	<2.2 eV/c ²	<0.17 MeV/c ²	<15.5 MeV/c ²	91.2 GeV/c ²	
	0	0	0	0	
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	
	ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	Z⁰ Z boson	
	0.511 MeV/c ²	105.7 MeV/c ²	1.777 GeV/c ²	80.4 GeV/c ²	
	-1	-1	-1	±1	
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	
Leptons	e electron	μ muon	τ tau	W[±] W boson	Gauge bosons

ELEMENTARY PARTICLES - PLAYFULLY

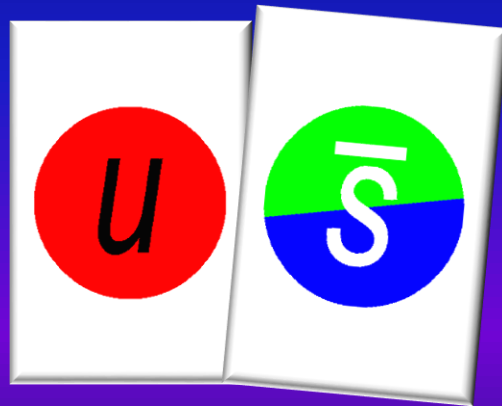
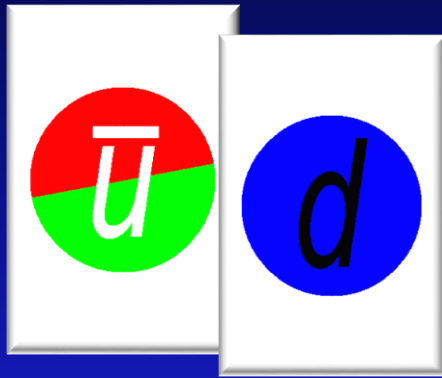
Three generations of matter (fermions)

	I	II	III		
mass →		1.27 GeV/c ²	171.2 GeV/c ²	0	? GeV/c ²
charge →		$\frac{2}{3}$	$\frac{2}{3}$	0	0
spin →		$\frac{1}{2}$	$\frac{1}{2}$	1	0
name →	u	c charm	t top	γ photon	H Higgs boson
Quarks	d	s	b bottom	g gluon	
			4.2 GeV/c ²	0	
			$-\frac{1}{3}$	0	
		$\frac{1}{2}$	$\frac{1}{2}$	1	
	ν_e	ν_μ	ν_τ tau neutrino	Z⁰ Z boson	
			<15.5 MeV/c ²	91.2 GeV/c ²	
			0	0	
			$\frac{1}{2}$	1	
Leptons	e⁻	μ⁻	τ tau	W[±] W boson	
			1.777 GeV/c ²	80.4 GeV/c ²	
			-1	± 1	
		$\frac{1}{2}$	$\frac{1}{2}$	1	
					Gauge bosons

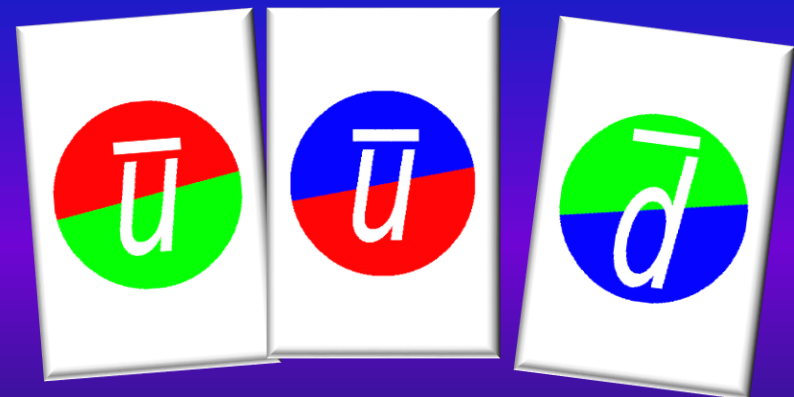
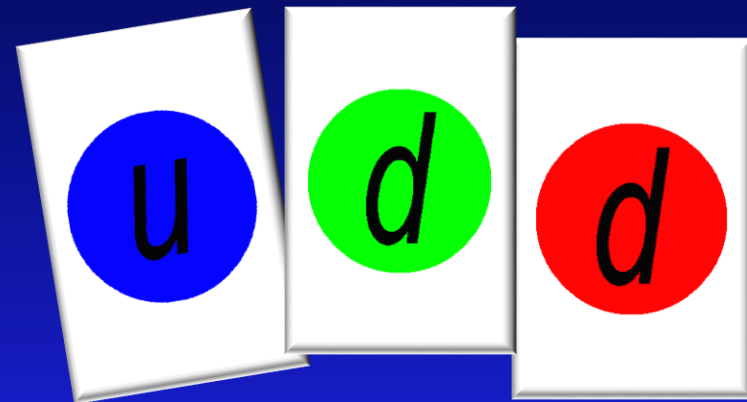


SU(3) COLOR AND OPTICAL COLOR

Mesons



Baryons



QUARK MATTER – ON RUBIK'S CUBE



Perfect Fluid of Quarks – on Rubik's Cube

locally, color is deconfined

globally, color neutral

Red opposite to anti-red (green/blue)

Green opposite to anti-green (blue/red)

Blue opposite to anti-blue (red/green)

quarks opposite to anti-quarks

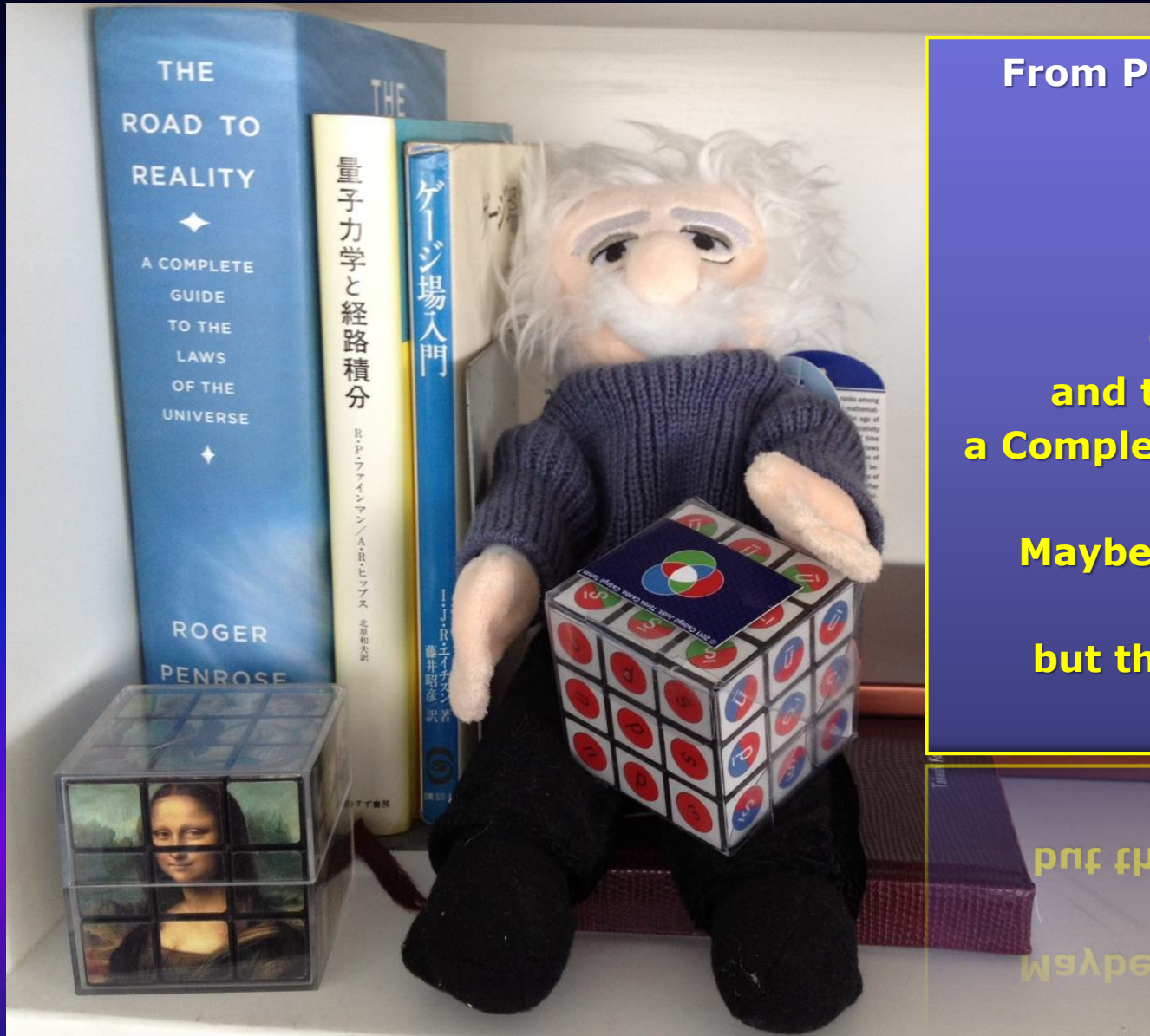
conservation laws

rotates and „expands”

large degree of internal disorder (entropy)

small shear – illustration of perfect fluidity

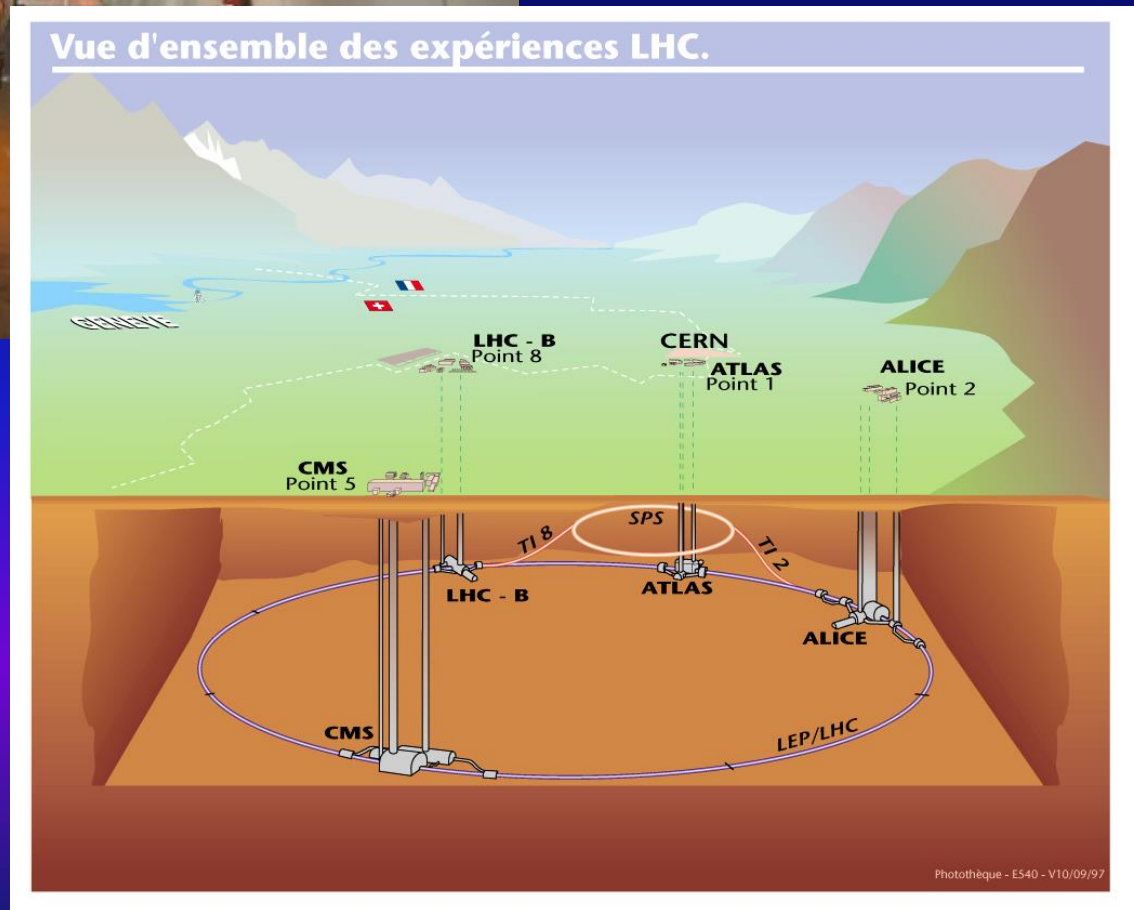
QUARK MATTER – WITH A SMILE



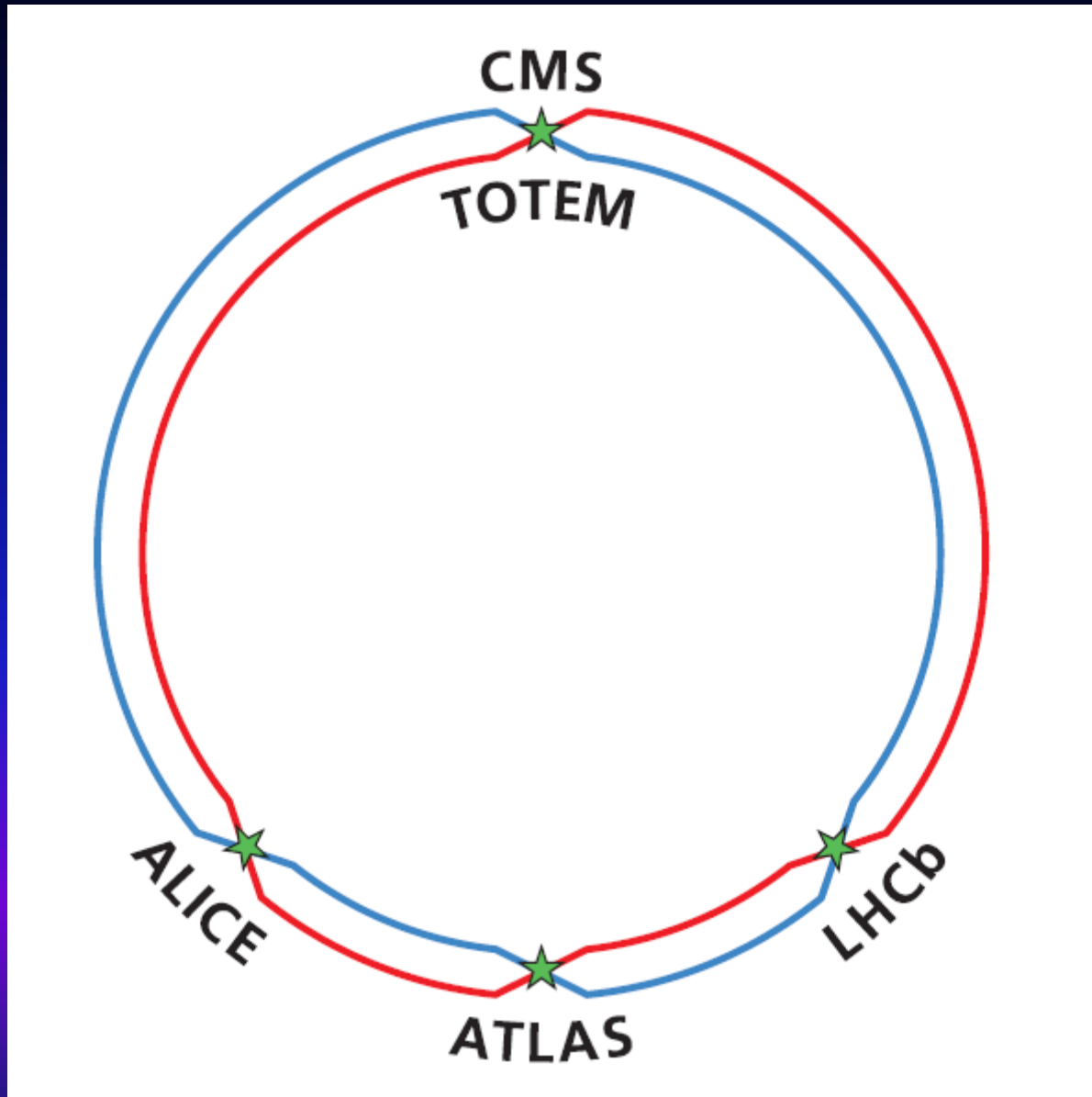
From Professor T. Kodama
(Brazil)
connecting
Albert Einstein,
Mona Lisa Cube,
Quark Matter Cube,
and the Road to Reality:
a Complete Guide to Nature.
Maybe particle games are
not so complete,
but their way is certainly
so interesting.

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LHC and its Experiments



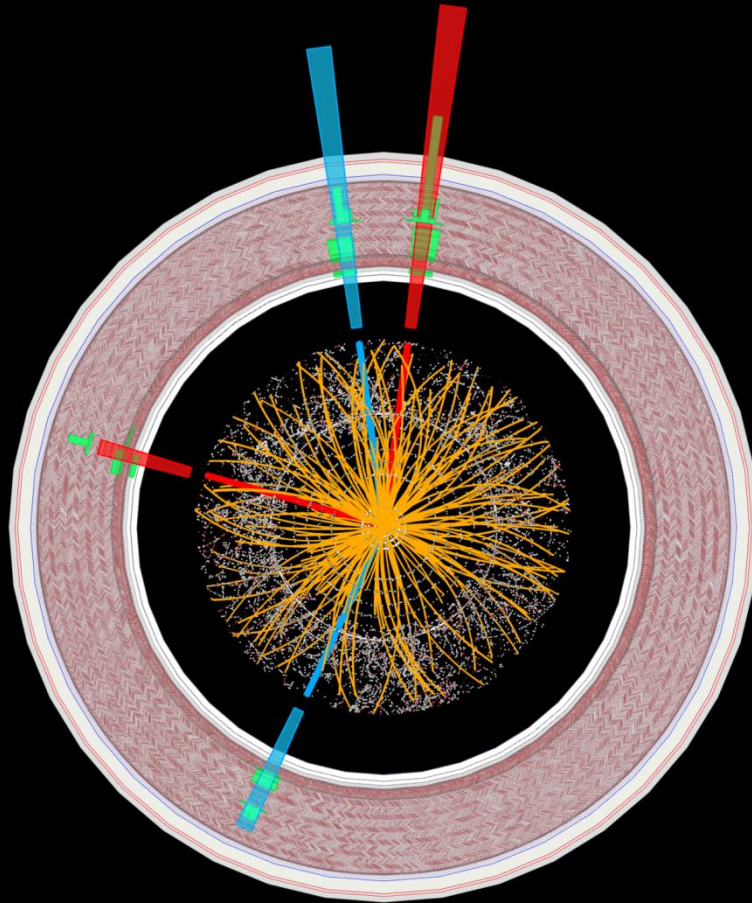
LHC and its 5 major experiments



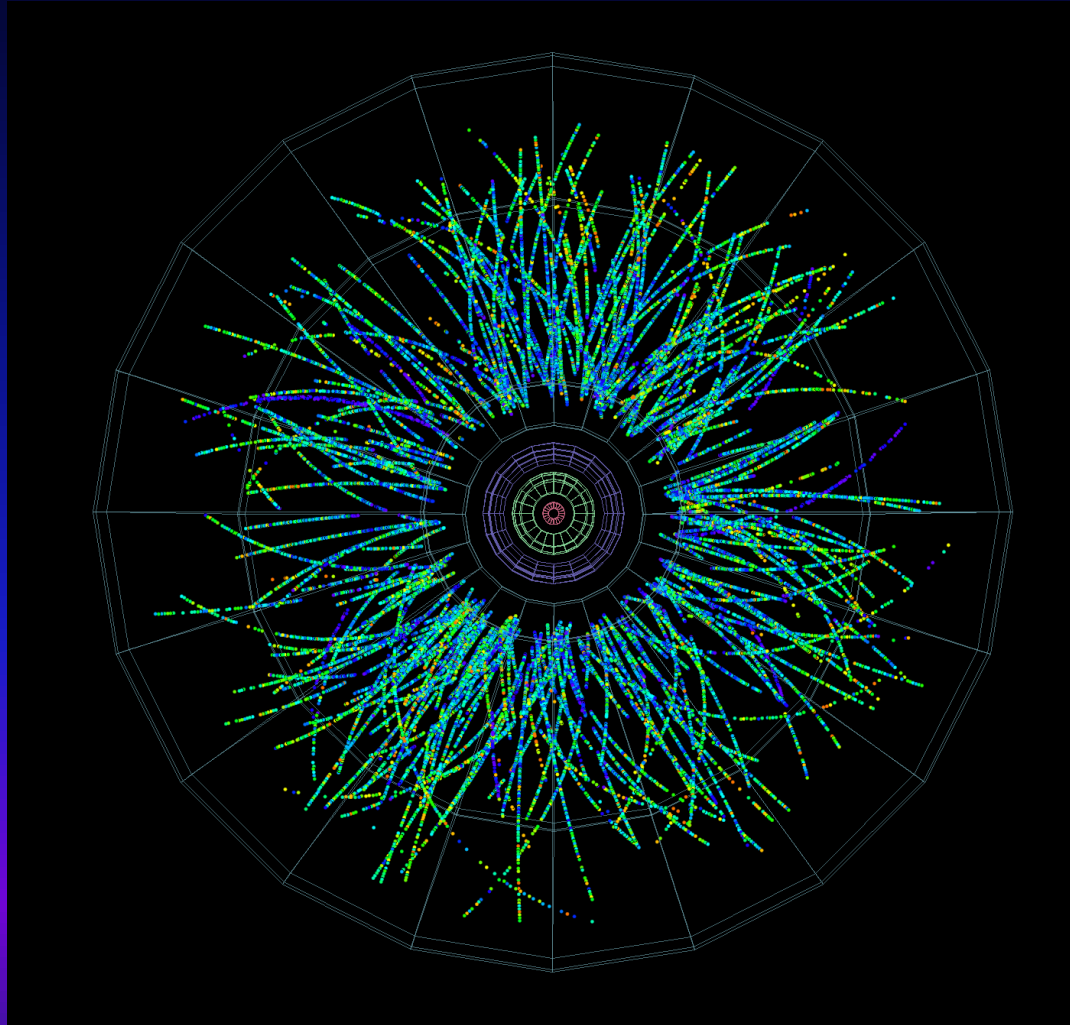
ATLAS

ATLAS
EXPERIMENT
<http://atlas.ch>

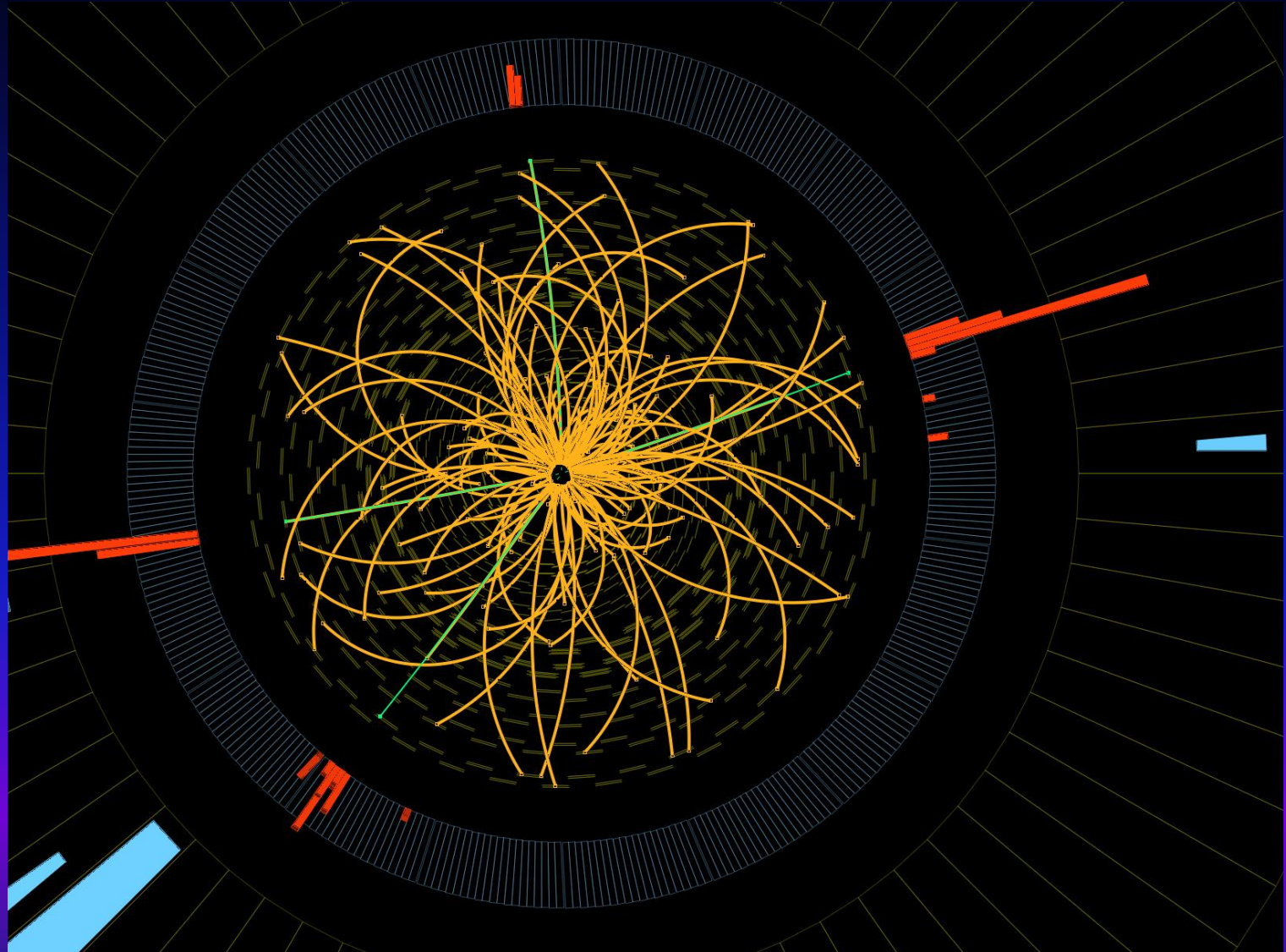
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Time: 20:28:11 CEST



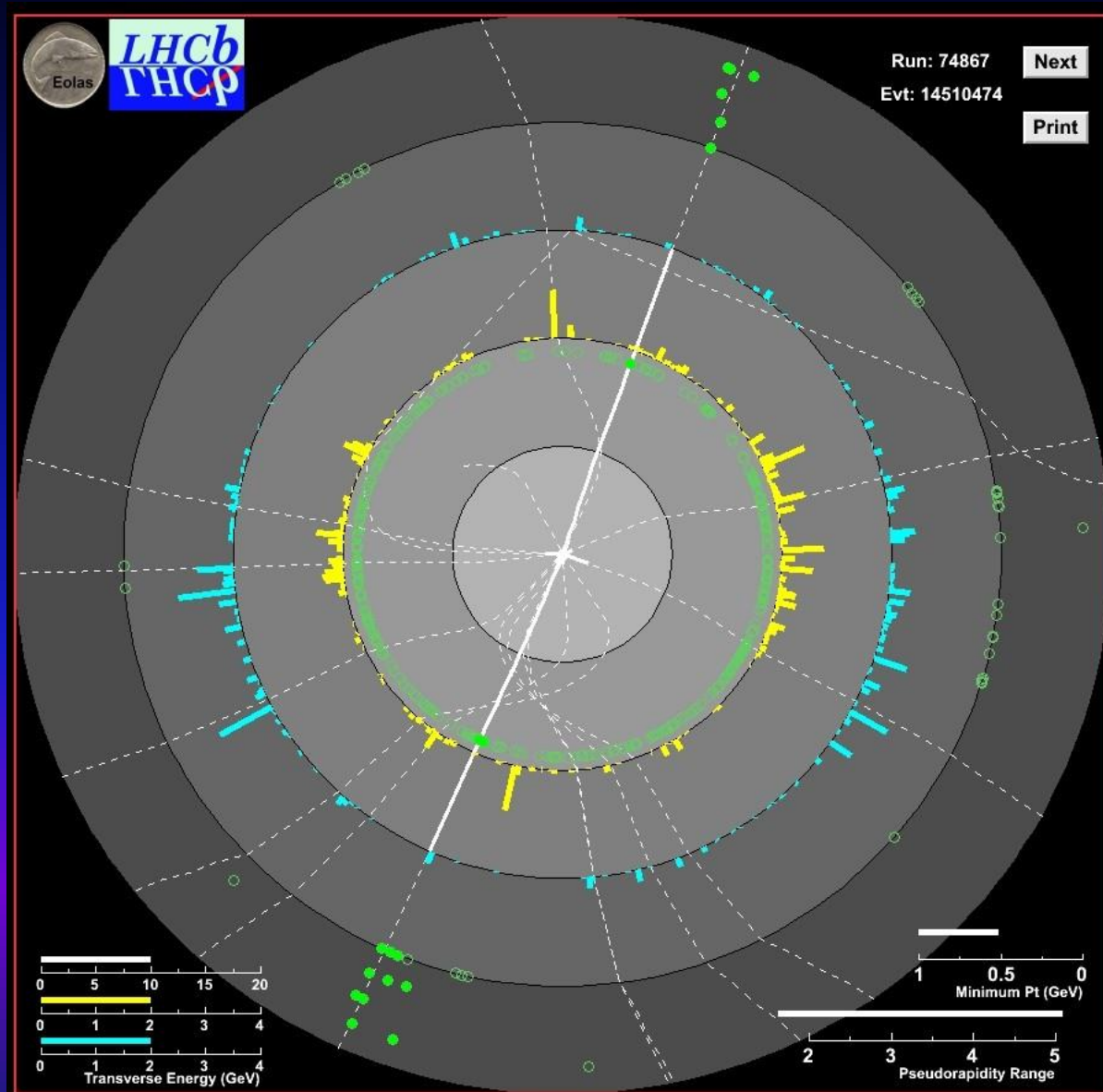
ALICE



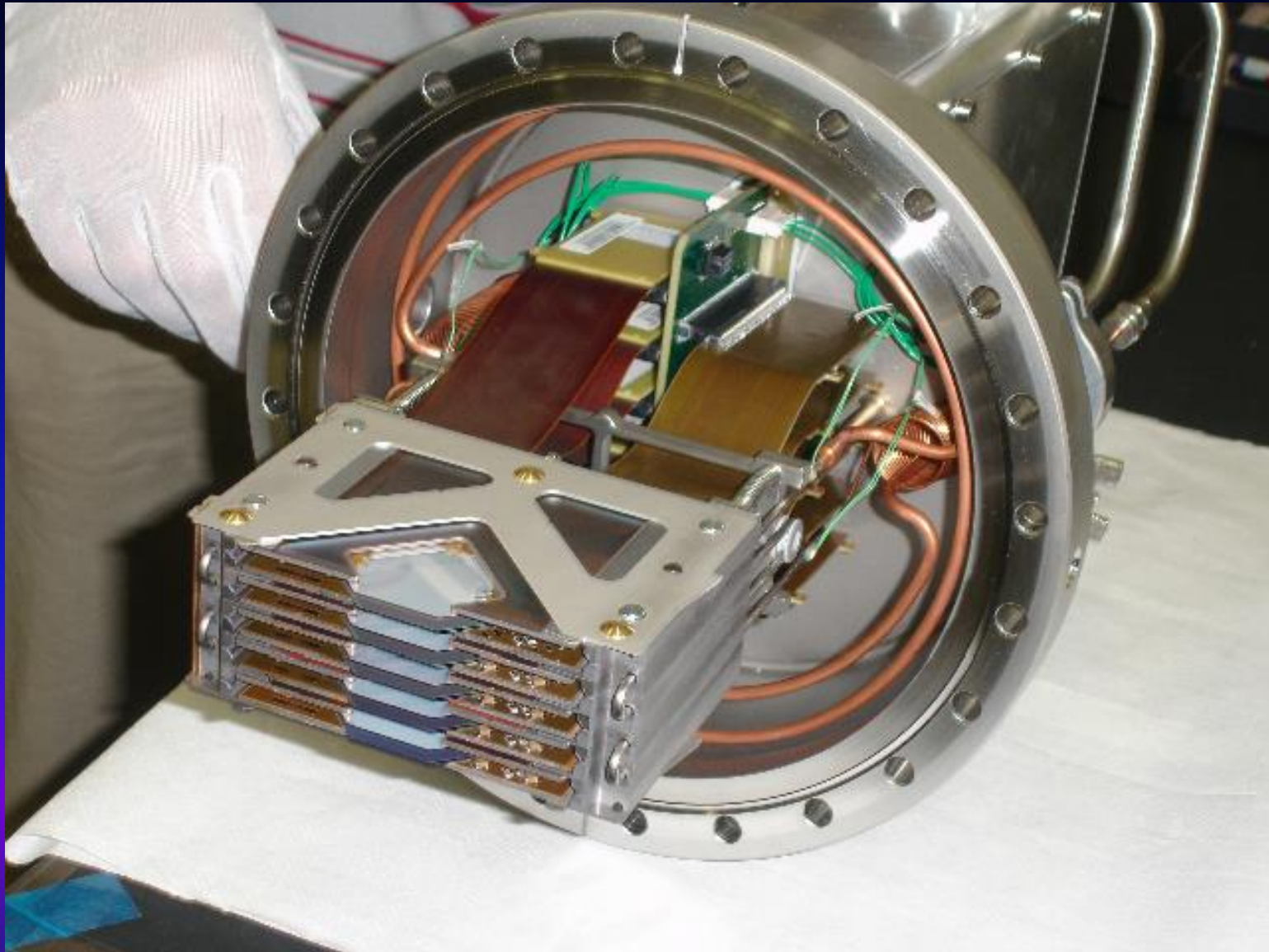
CMS



LHCb



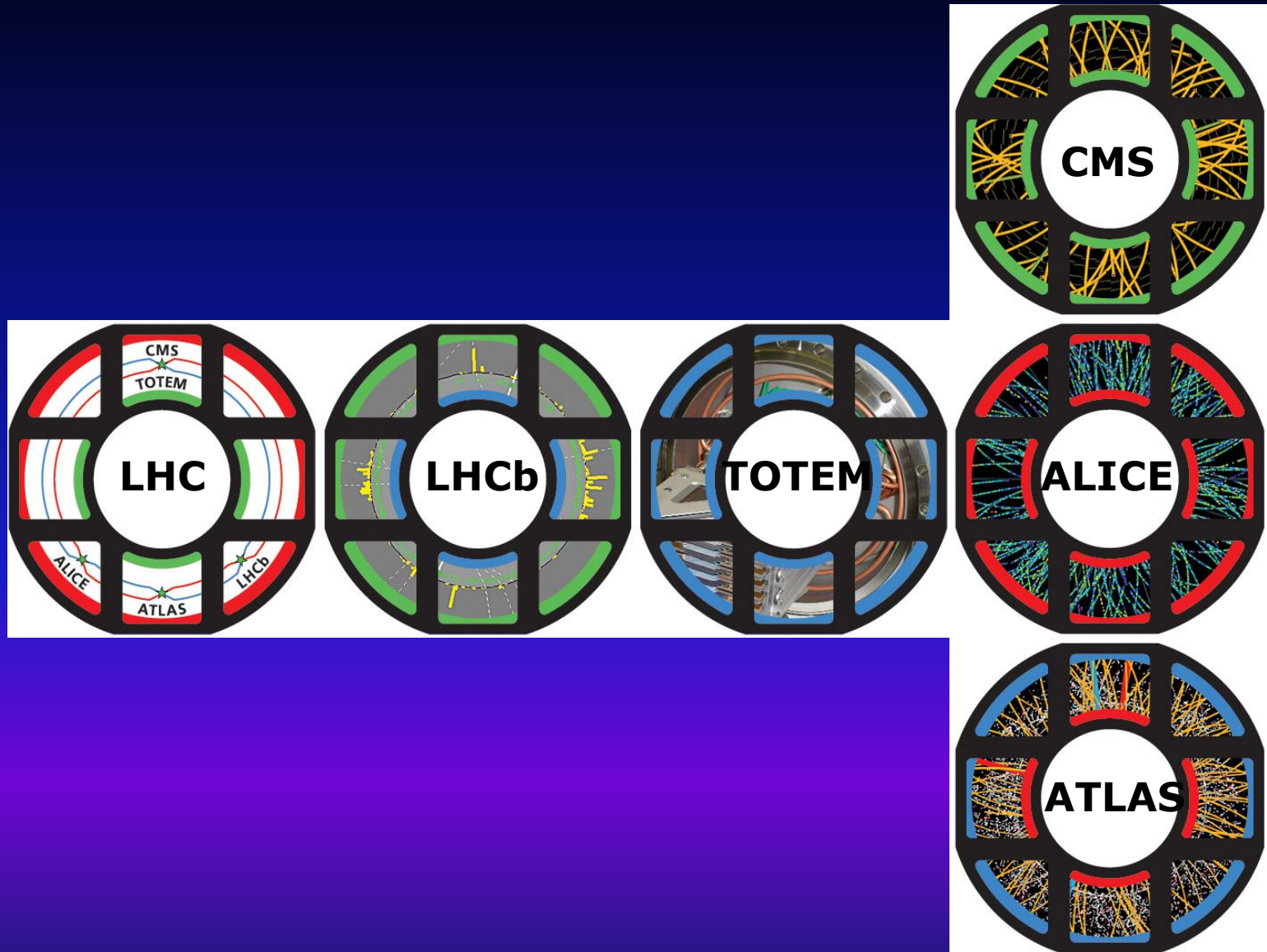
TOTEM



Rubik's Void Cube



LHC Experiments on Rubik's Void



Putting things together: LHC + black hole



Thank you for your attention!



Legal info:

Pictures on the Rubik Void 3x3 and the packing material are derivative works
Rubik company has IP rights for the design and the layout of the Rubik's Void cube.

The pictures layed out on the faces of the Rubik Void 3x3 cube are CERN material.

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Designed © T. Csörgő, presented at Low-x 2016, Gyöngyös, on June 10, 2015.