Welcoming lecture to LHEP

First open day of the NICA complex

Dr. Alexey Aparin

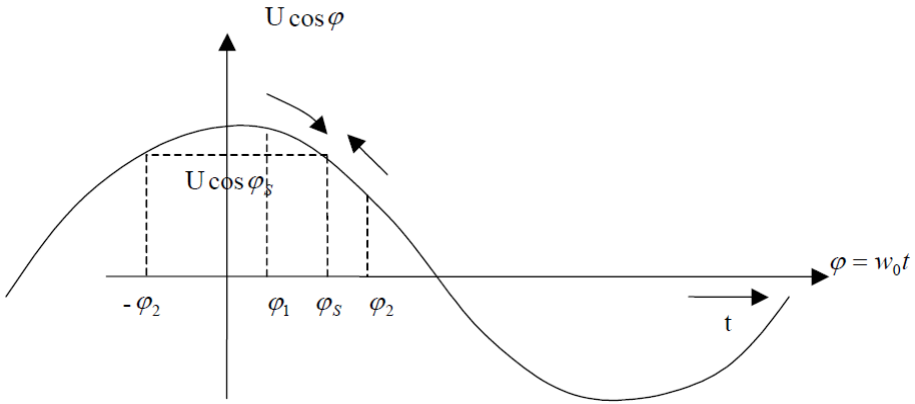
History of the laboratory

V.I. Veksler (1907-1966)

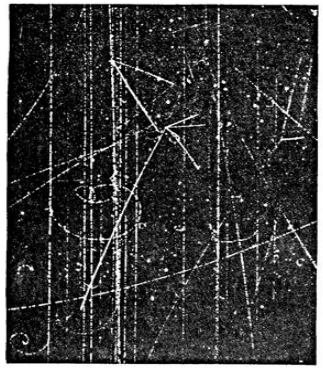
- 1944 Discovery of the phase stability principle by Veksler
- 1953 Foundation of the electrophysical laboratory of the USSR Academy of Sciences
- March 26, 1956 the laboratory of high energies as a part of JINR
- 1957 The synchrophasotron was put into operation
- 1993 Nuclotron – the first superconducting accelerator of nuclei was put into operation
- 2015 First stone of the NICA complex

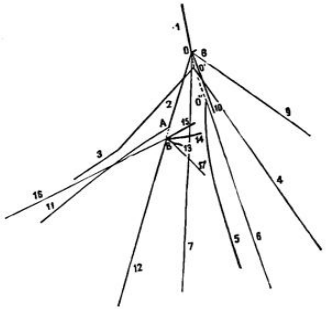
A.M Baldin (1926-2001)

Phase stability principle



Anti-sigma-hyperon decay





LHEP connections worldwide

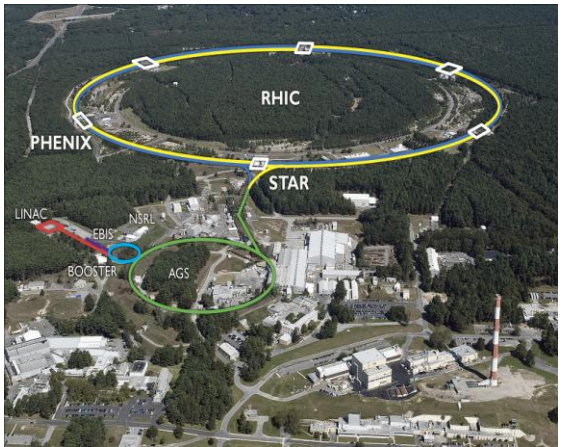
FAIR/GSI

HADES,CBM

LHC,SPS/CERN

LHEP
ЛФВЭ

RHIC/BNL

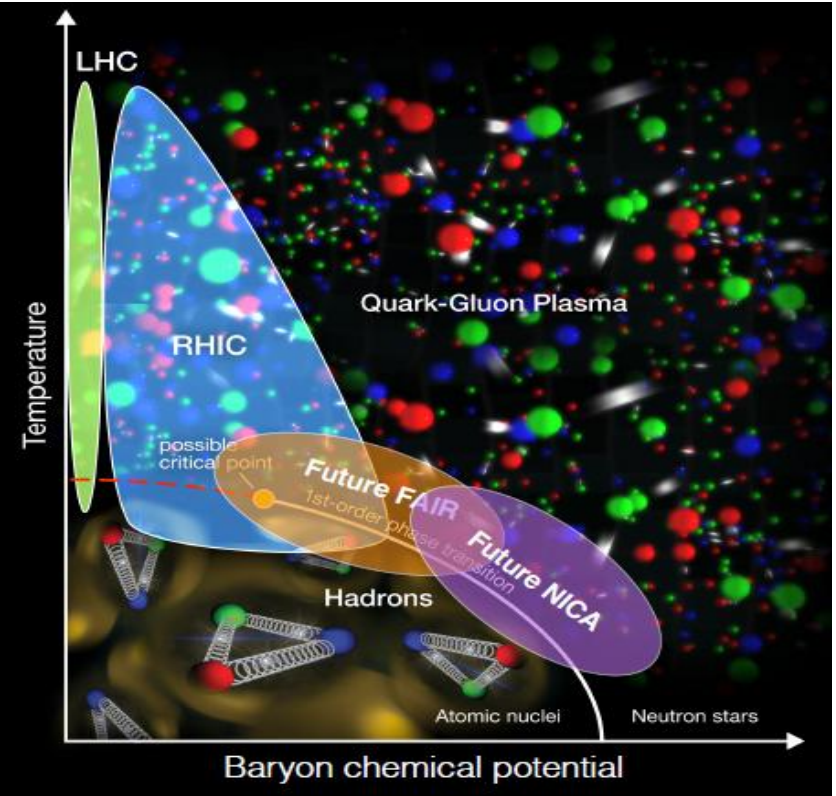


ALICE, ATLAS, CMS,
NA61/SHINE, NA62, COMPASS

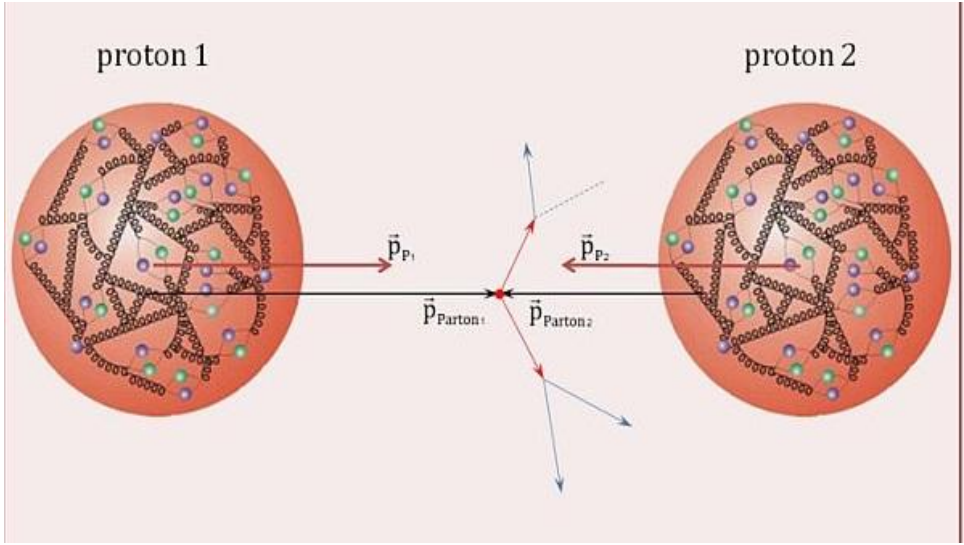
STAR

Proton-proton vs. Nuclei-nuclei collisions

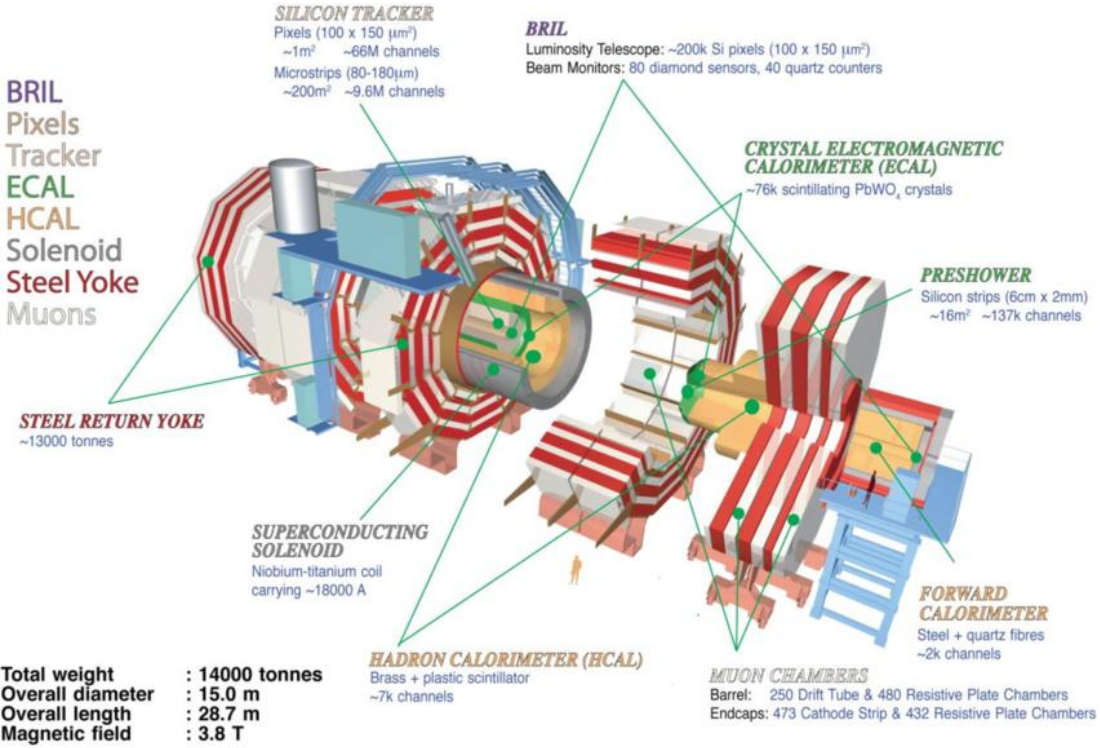
Heavy ion collisions



(polarized) Hadron collisions



CMS

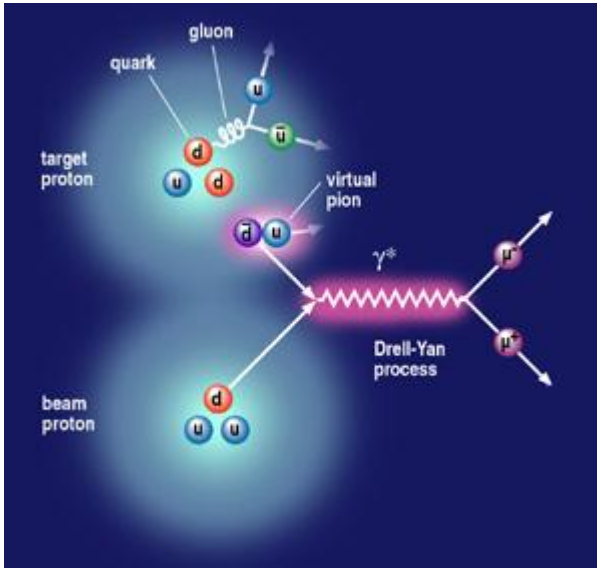


Physics with high-mass di-muons

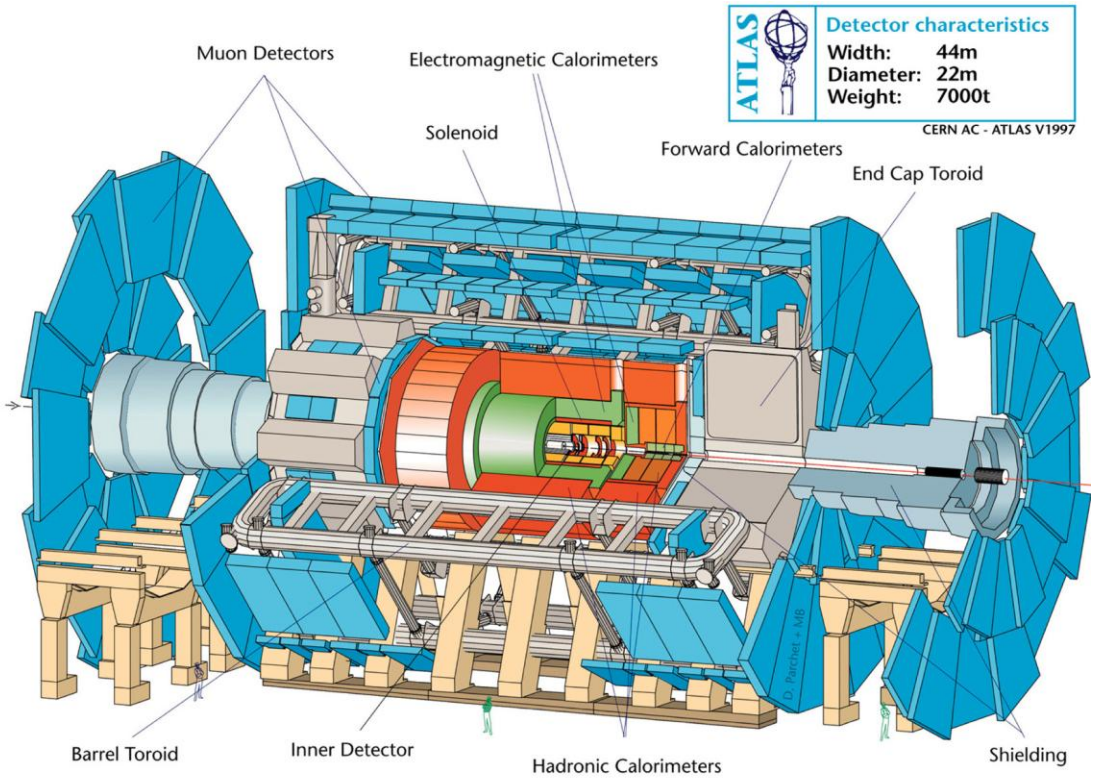
- Drell-Yan study in TeV energy region
- Forward-backward asymmetry
- Weinberg angle measurement

Physics with jets (calibrations, charge multiplicity studies etc.)

Physics with di-muons
new physics in a multi-jet channel

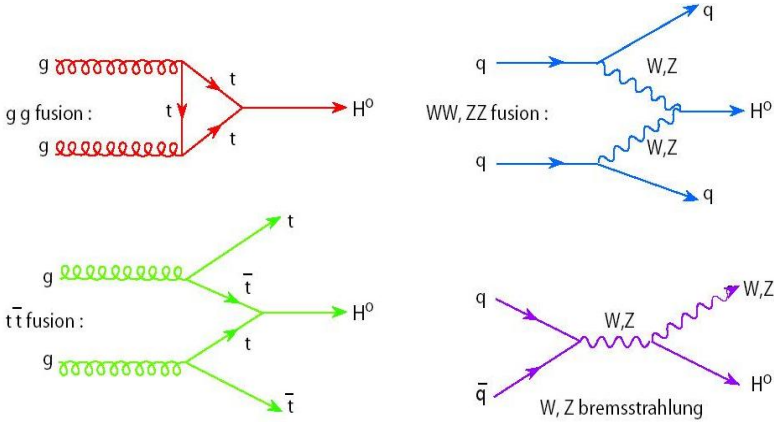


ATLAS



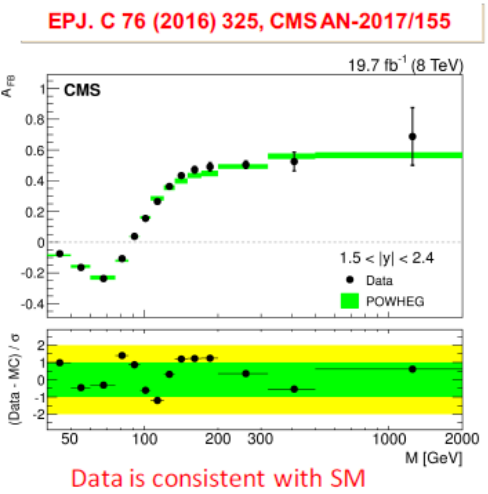
- Search for heavy resonances, decaying into Z/W/H + γ;
- Measurement of vector bosons produced in association with b-jets;
- Search for pentaquark states in b decays at ATLAS
- Study of Beauty mesons and its rare decays
- Measurement of the two-particle Bose-Einstein correlations

Feynman diagrams for Higgs production

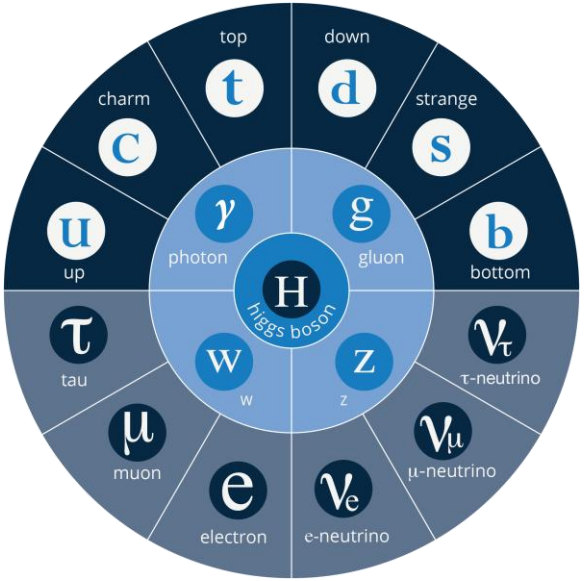


CMS & ATLAS physics

Forward-backward asymmetry



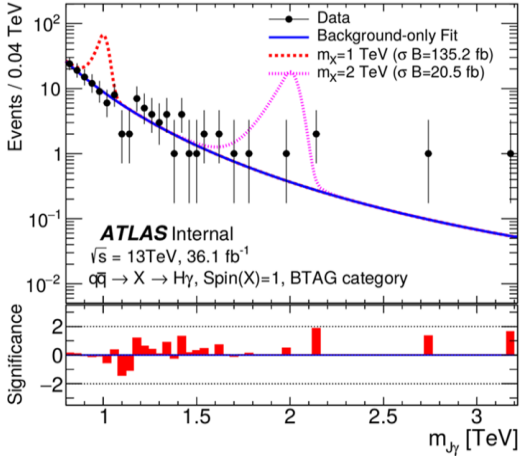
Data is consistent with SM



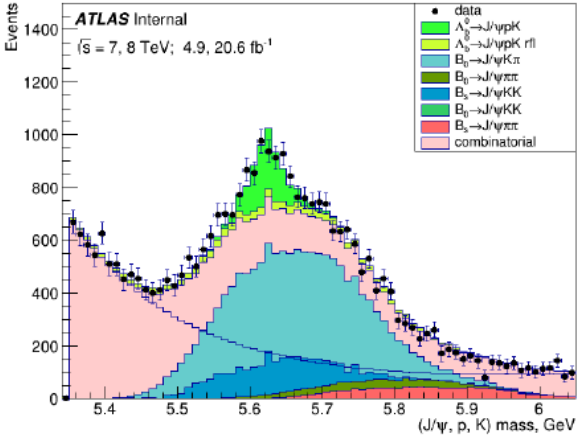
Higgs boson discovery on 4 July 2012 completed the Standard Model

Search for exotics on LHS:
Supersymmetry, superpartners;
Exotic hadrons: pentaquarks, tetraquarks, glueballs;
Micro black holes, etc.

Search for BSM candidates production decaying into H+γ

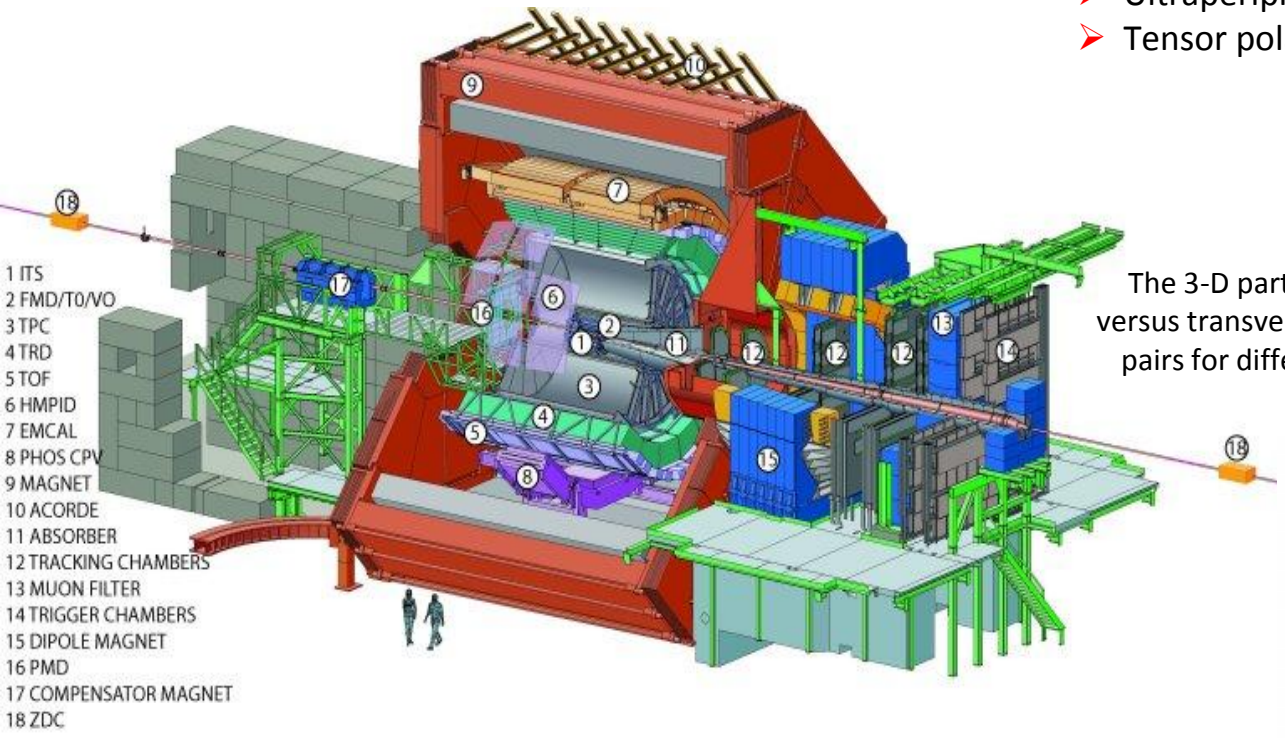


Search for pentaquark in Λ_b decay

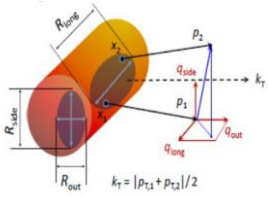


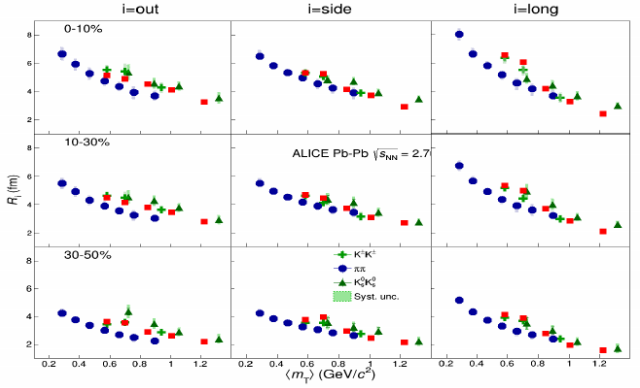
ALICE

- Bothe-Einstein correlations (femtoscopy physics)
- Quarkonia physics
- Ultraperipheral collisions of heavy ions
- Tensor polarizasion physics of vector mesons



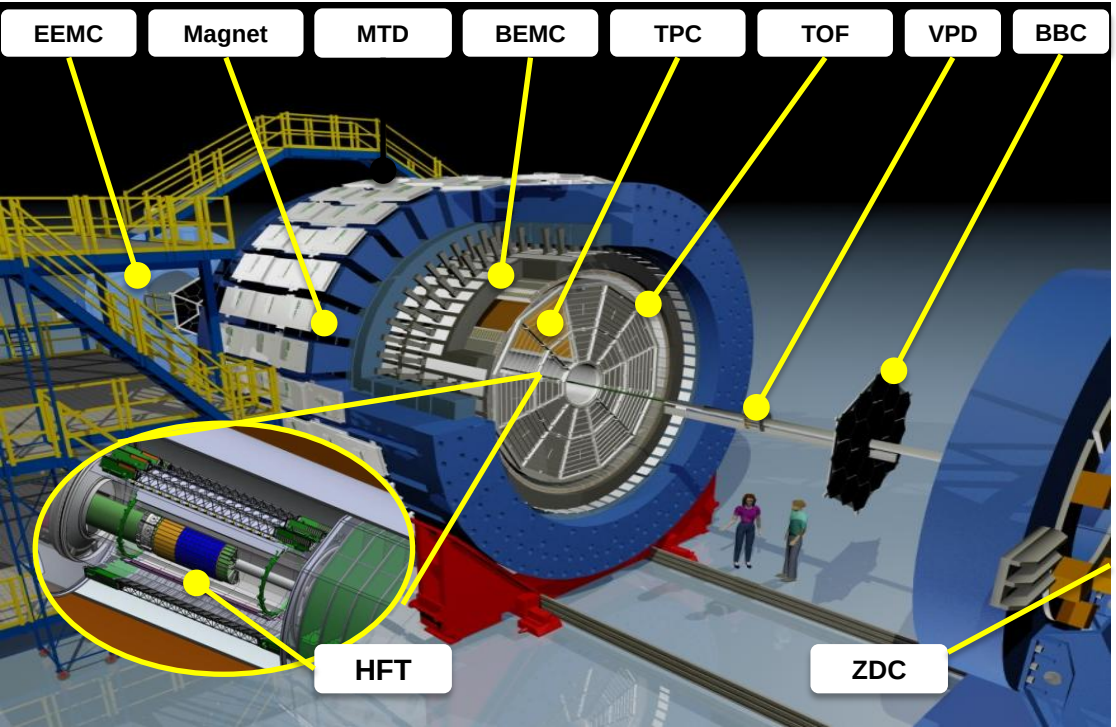
The 3-D particle emission source radii versus transverse mass (mT) for KK and ππ pairs for different collision centralities.

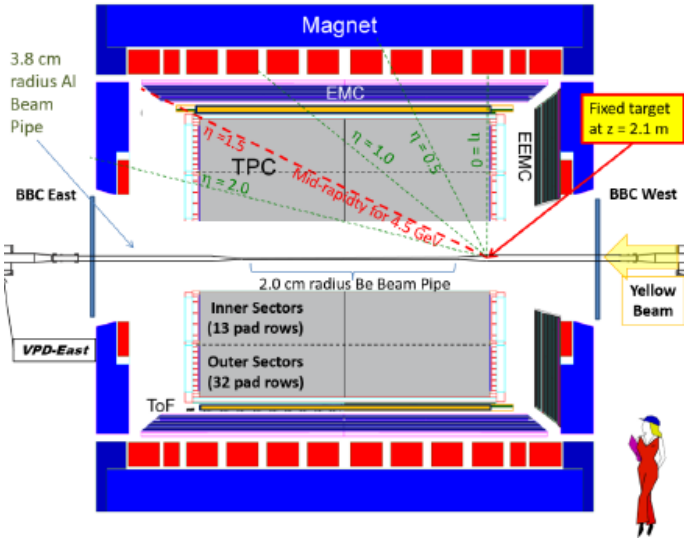


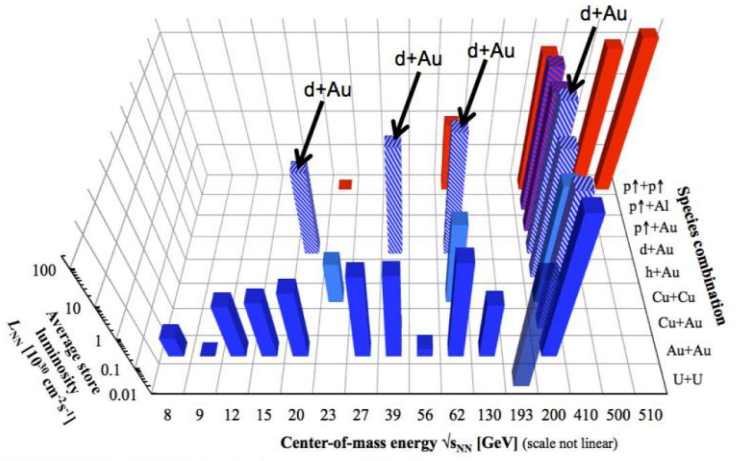


STAR

The primary physics task of STAR is to study the formation and characteristics of the quark-gluon plasma (QGP)







STAR physics

Correlation measurements, global polarization, identity method of reconstruction

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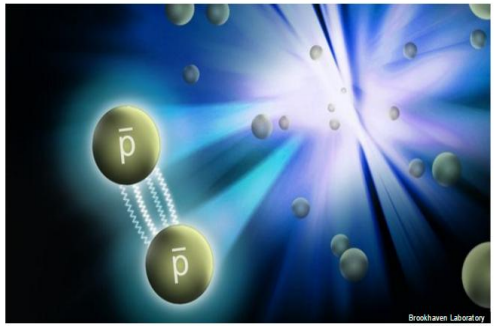
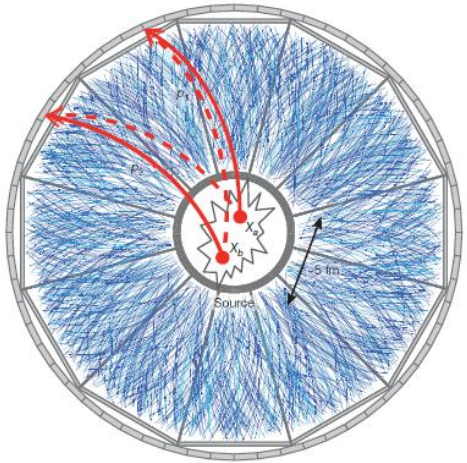
Science & Environment

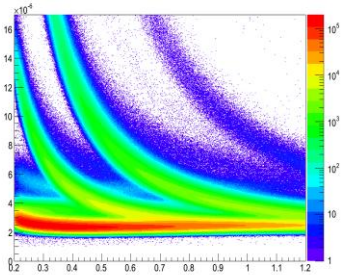
Strong forces make antimatter stick

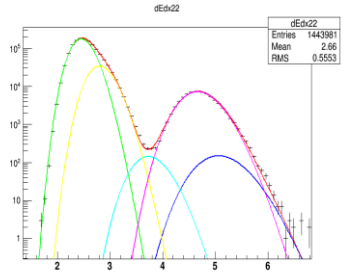
4 November 2015 | Science & Environment

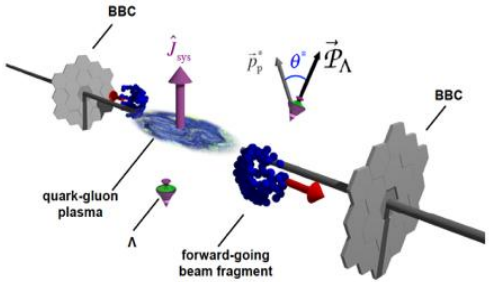


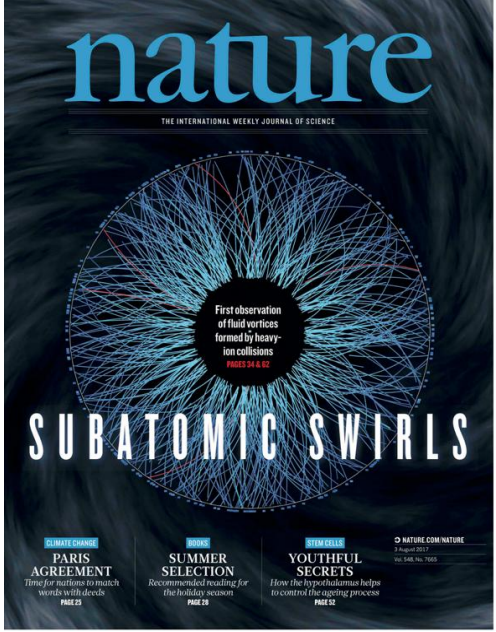
Physicists have shed new light on one of the greatest mysteries in science: Why the Universe consists primarily of matter and not antimatter.





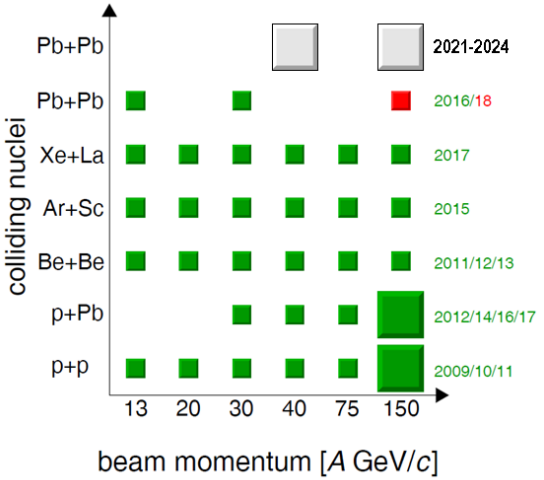


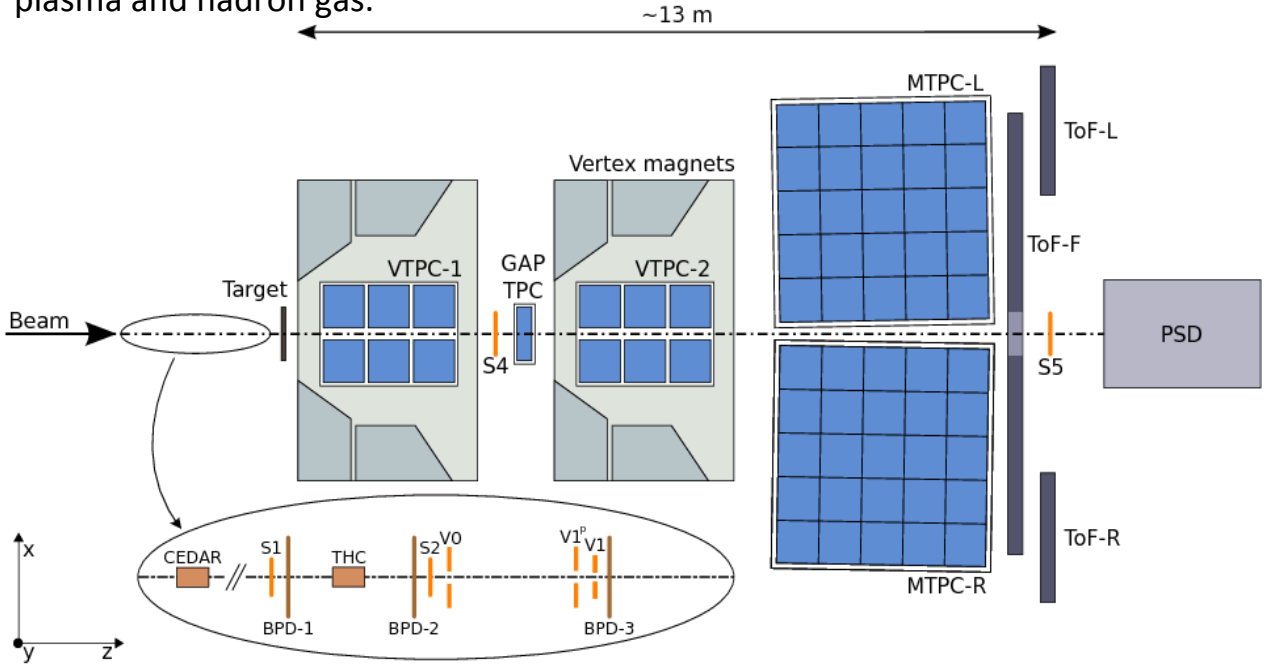


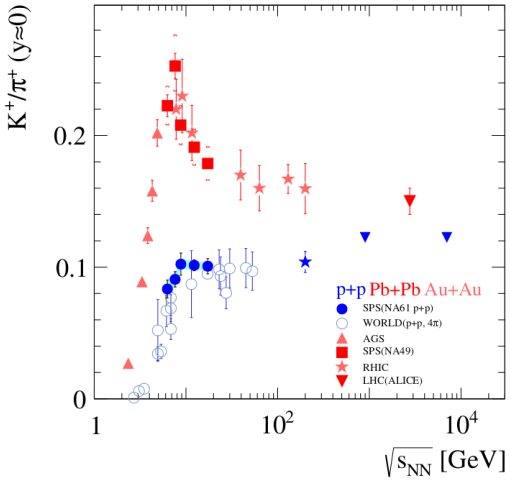


NA61/SHINE

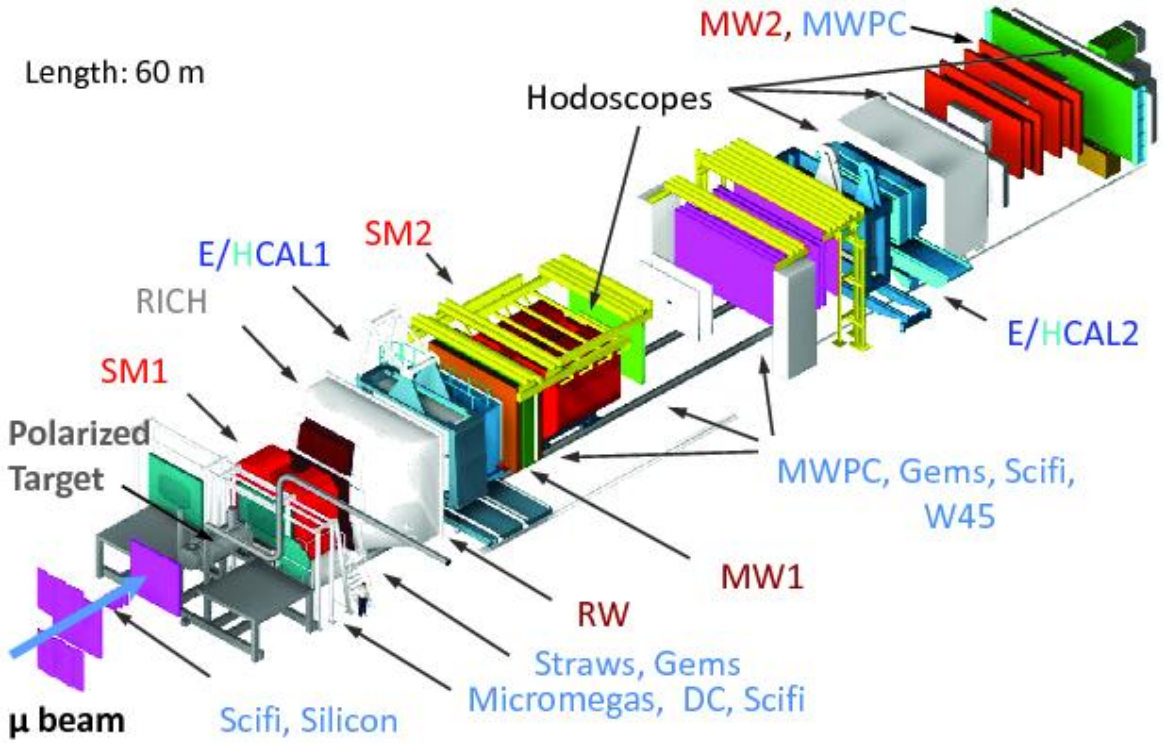
NA61/SHINE aims to uncover properties of the onset of deconfinement by systematic and precise measurements of collision energy and nuclear mass dependence of its signals. It is also looking for evidence of a critical point on the transition line between two phases of strongly interacting matter: quark-gluon plasma and hadron gas.

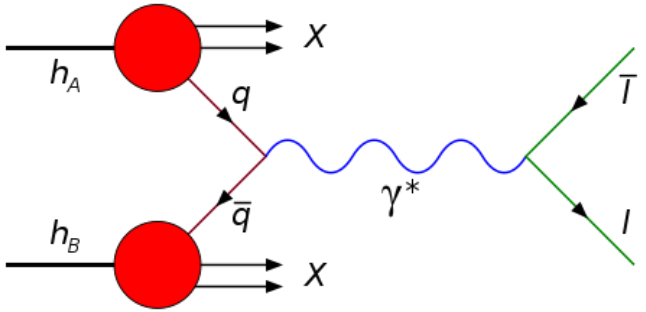






COMPASS

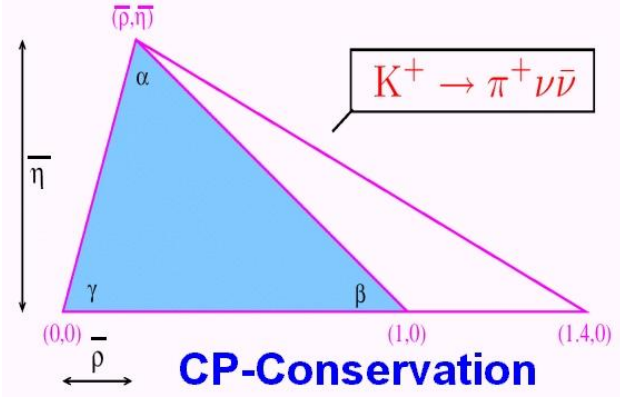


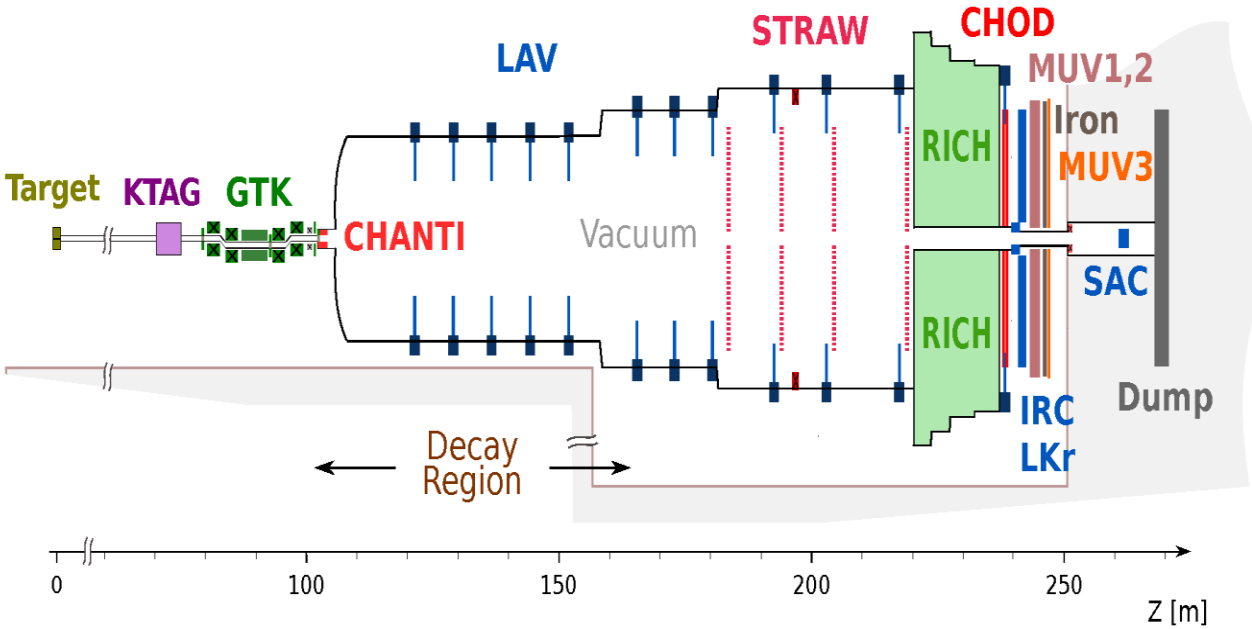


COMPASS program consists in a set of measurements to study the structure of hadrons in Deep Virtual Compton Scattering (DVCS), Hard Exclusive Meson Production (HEMP), SIDIS, Polarized Drell-Yan and Primakoff reactions. In 2012 the data to study the Primakoff reaction were taken. The first (pilot) run for the DVCS measurement was also achieved. The first-ever polarized Drell-Yan measurement with a beam of negative pions and a polarized proton target was successfully performed in 2015.

NA62

The "golden decays" $K^0 \to \pi^0 \nu\bar{\nu}$ and $K^+ \to \pi^+ \nu\bar{\nu}$ give an opportunity to make a very sensitive tests of SM, as their probabilities are directly related to parameters of Cabibbo-Kobayashi-Maskawa matrix.

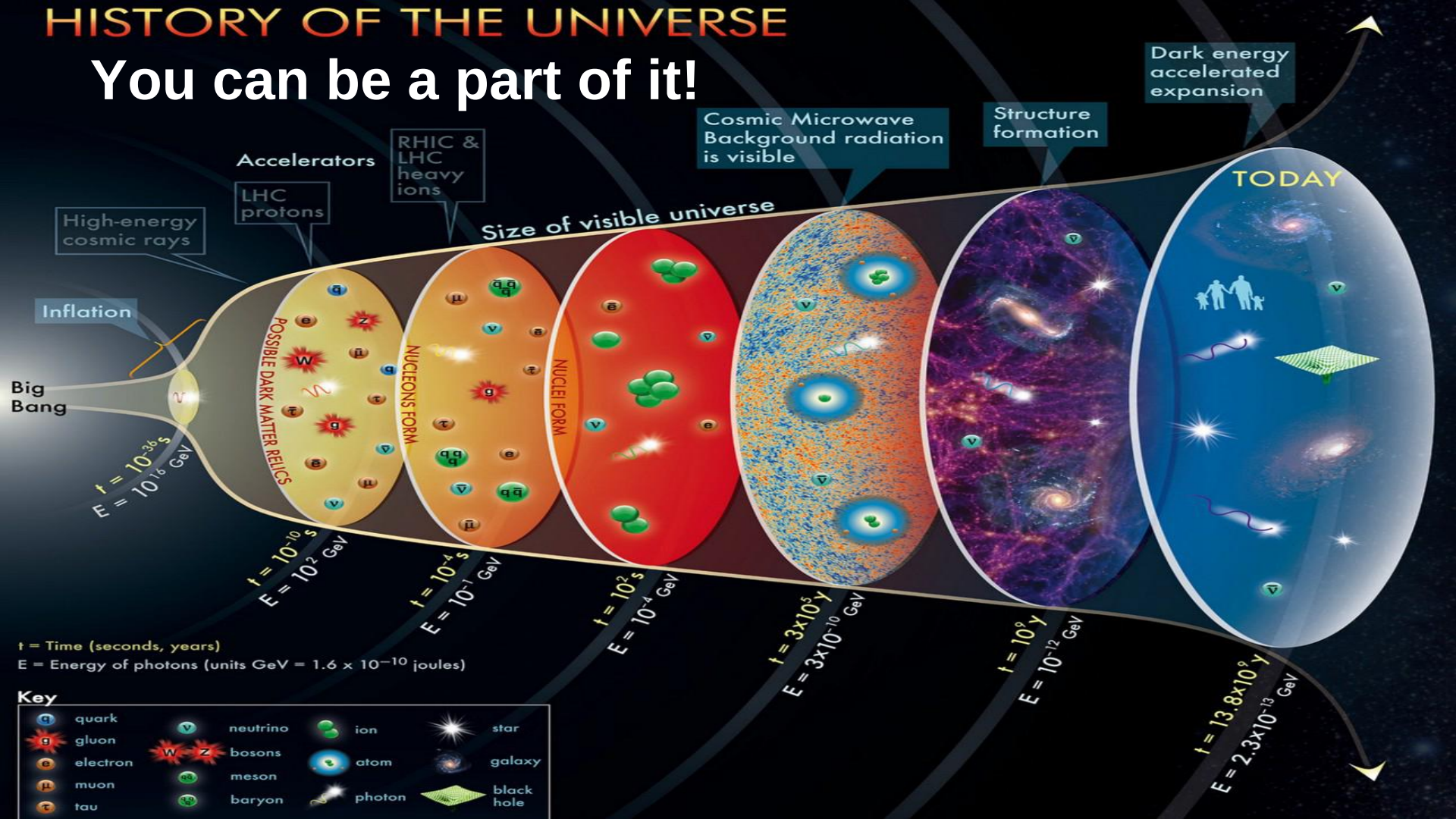




The currently available experimental result is based on **7 events**

[BNL, K decays at rest. Phys. Rev. D 79, 092004 (2009)]:

BR($K^+ \to \pi^+ \nu\bar{\nu}$) = (17.3+11.5–10.5) ×$10^{-11}$


HISTORY OF THE UNIVERSE
You can be a part of it!
Dark energy accelerated expansion
Cosmic Microwave Background radiation is visible
Structure formation
Accelerators
RHIC & LHC heavy ions
LHC protons
High-energy cosmic rays
Size of visible universe
TODAY
Inflation
Big Bang
POSSIBLE DARK MATTER RELICS
NUCLEONS FORM
NUCLEI FORM
t = 10^-36 s
E = 10^16 GeV
t = 10^-10 s
E = 10^2 GeV
t = 10^-4 s
E = 10^-1 GeV
t = 10^2 s
E = 10^-4 GeV
t = 3x10^5 y
E = 3x10^-10 GeV
t = 10^9 y
E = 10^-12 GeV
t = 13.8x10^9 y
E = 2.3x10^-13 GeV
t = Time (seconds, years)
E = Energy of photons (units GeV = 1.6 x 10^-10 joules)
Key
quark
gluon
electron
muon
tau
neutrino
bosons
meson
baryon
ion
atom
photon
star
galaxy
black hole

Backup slides

Femtoscopy

Single- and two- particle distributions:

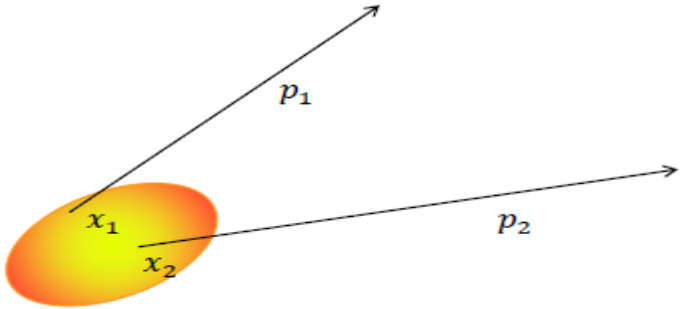
$$P_1(p) = E\frac{dN}{d^3p} = \int d^4x S(x,p)$$

S(x,p) – emission function: the distribution of source density probability of finding particle with given x and p

$$P_2(p_1,p_2) = E_1E_2\frac{dN}{d^3p_1 d^3p_2} = \int d^4x_1 S(x_1,p_1) d^4x_2 S(x_2,p_2) \Phi_2(x_2,p_2|x_1,p_1)$$

Correlation function

$$C(p_1,p_2) = \frac{P_2(p_1,p_2)}{P_1(p_1)P_1(p_2)}$$



Sov.J.Nucl.Phys. 35 (1982) 770
Yad.Fiz. 35 (1981) 1316-1330