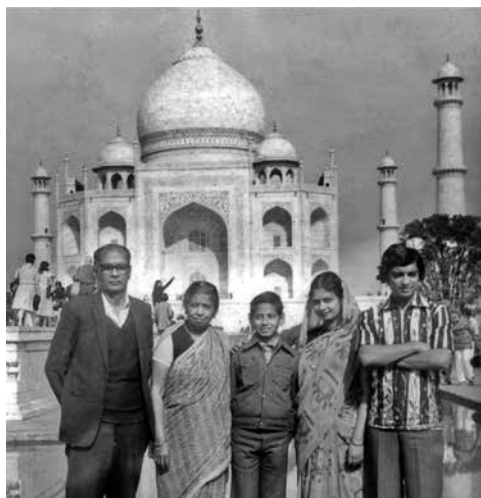




Wedding photograph
 of Vijay and Manik,
 December 1961, Pune
Standing: Anukaka
 (Sadanand Varde),
 Vijay, Ashok,
 Shridhardada
Middle row: Sudha
 Varde with Abhijit,
 Manik, Mothebaba,
 Mothi Aai and Meena
 Vahini
Front row: Jhelum
 (Chingu), Gautam Sr.,
 Leena



Ashutosh at five years, accepting
 first prize in art competition from
 Mrs Mathur, Railway Officers Club,
 Lucknow, 1971.



A visit to the Taj Mahal, Agra, September
 1977. (L-R): Balasaheb, Indutai, Ashutosh,
 Manik and Vilasmama



Ashutosh accepting prizes
for academic excellence:

Top: From Mrs Homi Sethna
in Class 9, April 1980.

Middle: From Mrs
Gursharan Kaur (wife of Dr
Manmohan Singh) in Class
10, April 1981.

Bottom: From Mrs Raja
Ramanna in Class 11,
April 1982.

Cathedral and John Cannon
School, Bombay



Ashutosh's farewell dinner before he set off for America, Badhwar Park Railway Colony residence, Bombay, August 1983. Front (L-R): Manik, Ashutosh and Vijay Kotwal. Back (L-R): Baba Chitnis, Shridhar Kaka, Dr Suma Chitnis and Meena Kaki



Being welcomed in State College, Pennsylvania, USA, September 1983. (L-R): Lalit Maoshi, Parimal, Ashutosh and Dr G.P. Patil



Ashutosh on a holiday with his Aai, Alibaug, July 1985



Ashutosh and Aai at the temple of Philae on the Nile at Aswan, Egypt, February 1990.



Ashutosh, Vijay Kotwal, Manik Kotwal and Jyotsna Maoshi Taggersay in Washington D.C., in front of the White House, March 1992



Ashutosh during his convocation ceremony at University of Pennsylvania, receiving dual degrees of Bachelor of Science (Electrical Engineering) and Bachelor of Science (Economics), 1988.



Inaugurating the Hadron Collider Physics Symposium (2006), organized and chaired by Ashutosh at Duke University.



Ashwini's traditional felicitation at engagement. Back row, Ashwini's younger brother Rahul, and Ashutosh.



Ashutosh and Ashwini (centre) at their engagement ceremony in Mumbai, October 1996. With Deepak Phene and Vinaya Phene.



Ashutosh and Ashwini's wedding, 23 December 1996



Urmila mami, Aai, Ashutosh, Papa and Dilip mama at the wedding reception, December 1996.



Ashutosh and Ashwini at their new house in Durham, North Carolina, May 2000, waiting for the stork to deliver Gautam.



Ashwini and Ashutosh with little Gautam in the Duke University gardens.



A happy family. Standing: Ashutosh and Ashwini. Sitting: Vijay, Gautam at five and a half months and Manik. Durham, February 2001.



Ashwini, Gautam and Ashutosh at Gautam's thread ceremony. Pune, 3 July 2011.





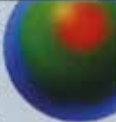



Gautam reciting the scriptures for Lakshmi Pooja during the Diwali festival, with Mo (Manik) and Ashwini-Ashutosh in their Chicago home, 2014.



Gautam with Aao (Vijay), Mo (Manik) and Ashutosh on the steps of Shivneri Fort, Maharashtra, July 2011







PARTICLES OF MATTER QUARKS

These particles make up protons, neutrons and a veritable zoo of lesser-known particles. They have never been observed in isolation.

UP  u Electric charge: $+\frac{2}{3}$ Mass: 2 MeV Constituent of ordinary matter; two up quarks, plus a down, make up a proton.	CHARM  c Electric charge: $+\frac{2}{3}$ Mass: 1.25 GeV Unstable heavier cousin of the up; constituent of the J/ψ particle, which helped physicists develop the Standard Model.	TOP  t Electric charge: $+\frac{2}{3}$ Mass: 171 GeV Heaviest known particle, comparable in mass to an atom of osmium. Very short-lived.
DOWN  d Electric charge: $-\frac{1}{3}$ Mass: 5 MeV Constituent of ordinary matter; two down quarks, plus an up, compose a neutron.	STRANGE  s Electric charge: $-\frac{1}{3}$ Mass: 95 MeV Unstable heavier cousin of the down; constituent of the much studied kaon particle.	BOTTOM  b Electric charge: $-\frac{1}{3}$ Mass: 4.2 GeV Unstable and still heavier copy of the down; constituent of the much studied B-meson particle.

LEPTONS

These particles are immune to the strong force and are observed as isolated individuals. Each neutrino shown here is actually a mixture of neutrino species, each of which has a definite mass of no more than a few eV.

ELECTRON NEUTRINO  ν_e Electric charge: 0 Immune to both electromagnetism and the strong force, it barely interacts at all but is essential to radioactivity.	MUON NEUTRINO  ν_μ Electric charge: 0 Appears in weak reactions involving the muon.	TAU NEUTRINO  ν_τ Electric charge: 0 Appears in weak reactions involving the tau lepton.
ELECTRON  e Electric charge: -1 Mass: 0.511 MeV The lightest charged particle, familiar as the carrier of electric currents and the particles orbiting atomic nuclei.	MUON  μ Electric charge: -1 Mass: 106 MeV A heavier version of the electron, with a lifetime of 2.2 microseconds; discovered as a component of cosmic-ray showers.	TAU  τ Electric charge: -1 Mass: 1.78 GeV Another unstable and still heavier version of the electron, with a lifetime of 0.3 picosecond.

Fundamental particles of matter depicted pictorially: Quarks and Leptons.

PARTICLES OF FORCE BOSONS

At the quantum level, each force of nature is transmitted by a dedicated particle or set of particles.

PHOTON

Electric charge: 0
Mass: 0
Carrier of electromagnetism, the quantum of light acts on electrically charged particles. It acts over unlimited distances.



Z BOSON

Electric charge: 0
Mass: 91 GeV
Mediator of weak reactions that do not change the identity of particles. Its range is only about 10^{-16} meter.



W⁺/W⁻ BOSONS

Electric charge: +1 or -1
Mass: 80.4 GeV
Mediators of weak reactions that change particle flavor and charge. Their range is only about 10^{-16} meter.



GLUONS

Electric charge: 0
Mass: 0
Eight species of gluons carry the strong interaction, acting on quarks and on other gluons. They do not feel electromagnetic or weak interactions.



HIGGS

(not yet observed)

Electric charge: 0
Mass: Expected below 1 TeV, most likely between 114 and 192 GeV.
Believed to endow W and Z bosons, quarks and leptons with mass.



HOW THE FORCES ACT

An interaction among several colliding particles can change their energy, momentum or type. An interaction can even cause a single particle in isolation to decay spontaneously.

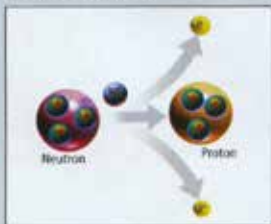
STRONG INTERACTION

The strong force acts on quarks and gluons. It binds them together to form protons, neutrons and more. Indirectly, it also binds protons and neutrons into atomic nuclei.



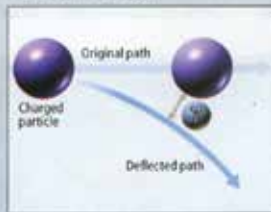
WEAK INTERACTION

The weak interaction acts on quarks and leptons. Its best-known effect is to transmute a down quark into an up quark, which in turn causes a neutron to become a proton plus an electron and a neutrino.



ELECTROMAGNETIC INTERACTION

The electromagnetic interaction acts on charged particles, leaving the particles unchanged. It causes like-charged particles to repel.

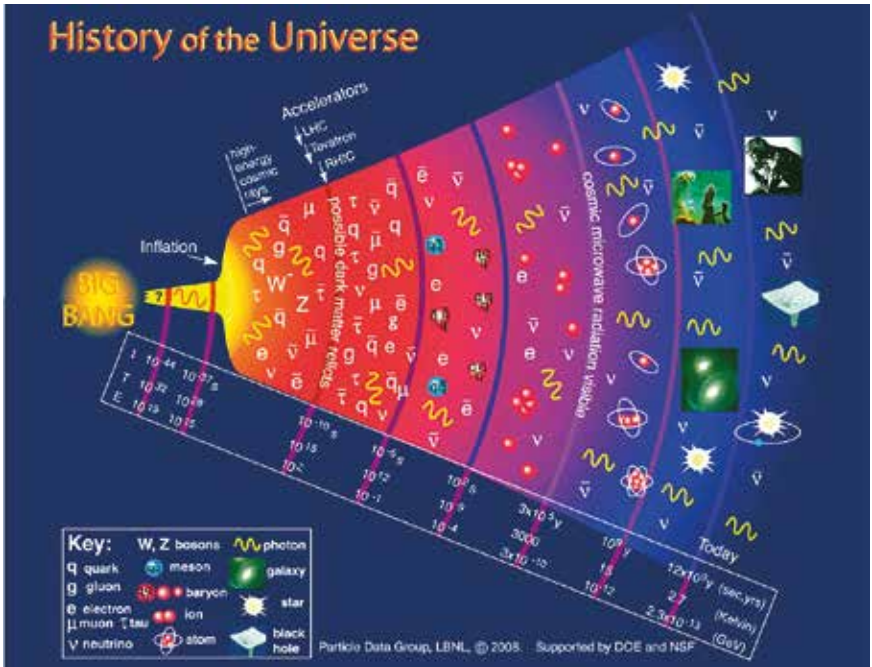


HIGGS INTERACTION

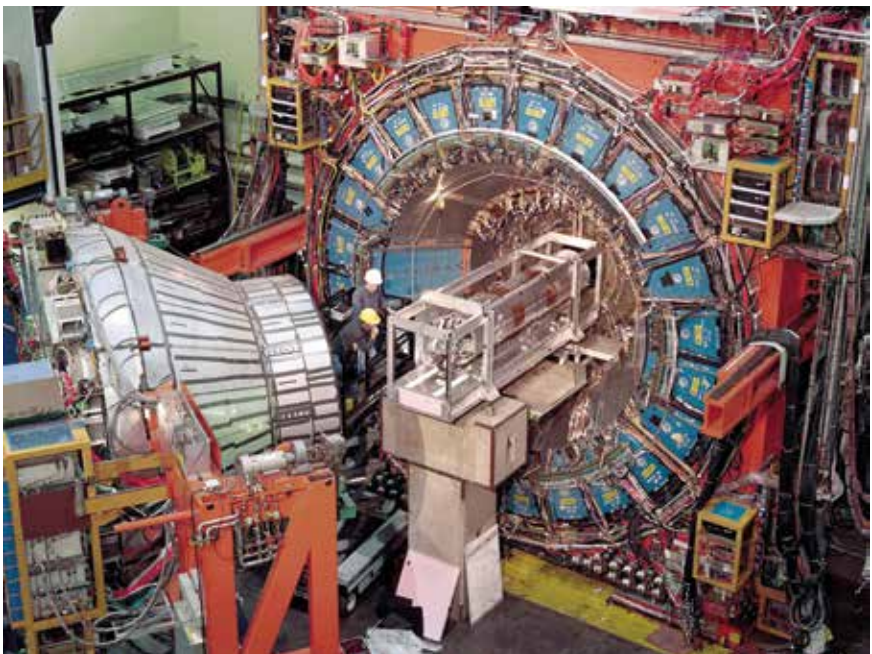
The Higgs field (gray background) is thought to fill space like a fluid, impeding the W and Z bosons and thereby limiting the range of weak interactions. The Higgs also interacts with quarks and leptons, endowing them with mass.



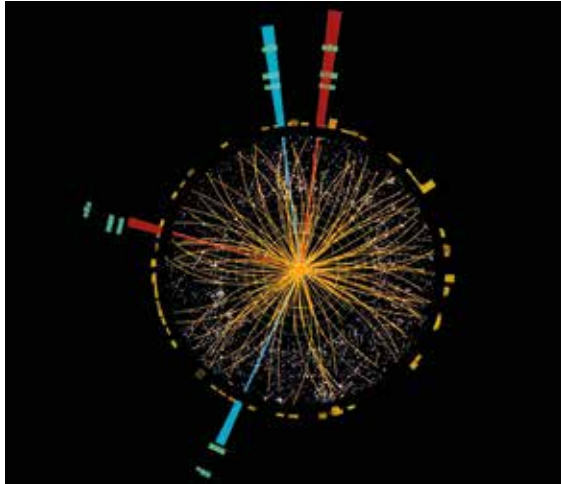
Fundamental mediators of forces. Force-carrying bosons and their interaction with matter particles.



Origin and evolution of the Universe. Credits: Denis Perret-Gallix 2013 J. Phys.: Conf. Ser. **454** 012051



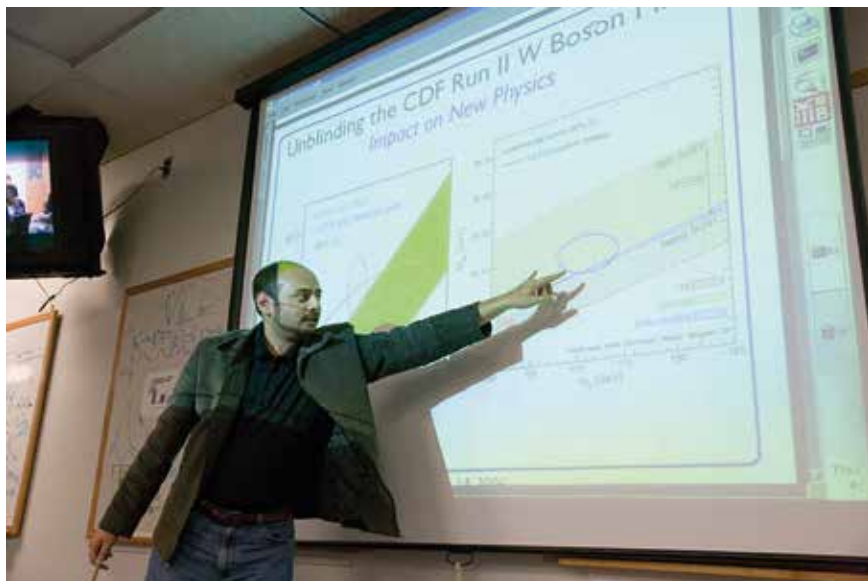
Installation of the CDF experiment at Fermilab. Credit: *Fermilab*.



Detection of a Higgs boson event by the ATLAS experiment operating at the LHC in 2012. *Credit: CERN*



The international D0 Collaboration at Fermilab, with significant participation of Indian scientists. The Indian flag is displayed on the back wall. *Credit: Fermilab*



Ashutosh unveiling the W boson mass measurement to colleagues on December 14, 2006.
Credit: Fermilab.



Ashutosh with his PhD student Heather Gerberich.



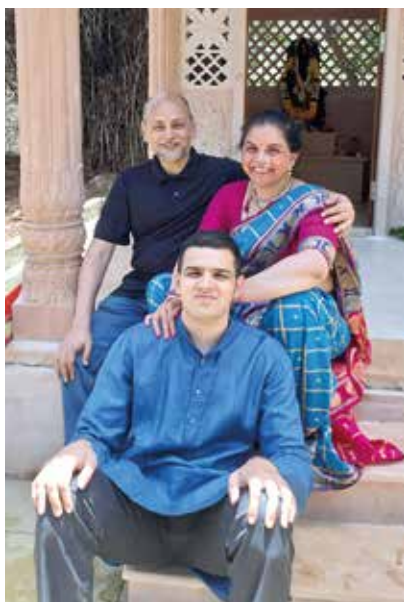
Ashutosh relaxing at Fermilab.



Ashutosh next to Duke Chapel on the university campus.



Building 40 at CERN where Ashutosh conducts research. *Credit: CERN.*



Ashutosh, Ashwini and Gautam at the Hanuman Mandir at our Maval Shrushti Farmhouse in Kamshet, near Pune, 13 June 2022.



Ashutosh with Padma Shri Dr Govind Swarup FRS and Padma Bhushan Dr Vijay Bhatkar, before delivering a public lecture at Abasaheb Garware College, Pune, July 2011.



With Dr William Press, president of the American Association for Advancement of Science (AAAS), at the AAAS Fellow's Ceremony, February 2013.



With Padma Vibhushan Dr Raghunath Mashelkar FRS (centre), July 2011.



With US Congressman Dr William Foster, February 2015.



With US Senator Kay Hagan of North Carolina, May 2009.



Fritz London Professor Ashutosh at the Distinguished Professor Felicitaton Ceremony with Ashwini, Jene Goshaw and senior distinguished professors Haiyan Gao and Robert Bryant, May 2014.



At the Distinguished Professor Felicitaton Ceremony, Ashutosh with senior distinguished professors Alfred Goshaw, Daniel Gauthier, Berndt Mueller, Haiyan Gao and Horst Meyer, May 2014.