Physics at Columbia
From the Golden Age to the Present.

M. J. Tannenbaum
CC'59, MA'60 PhD'65

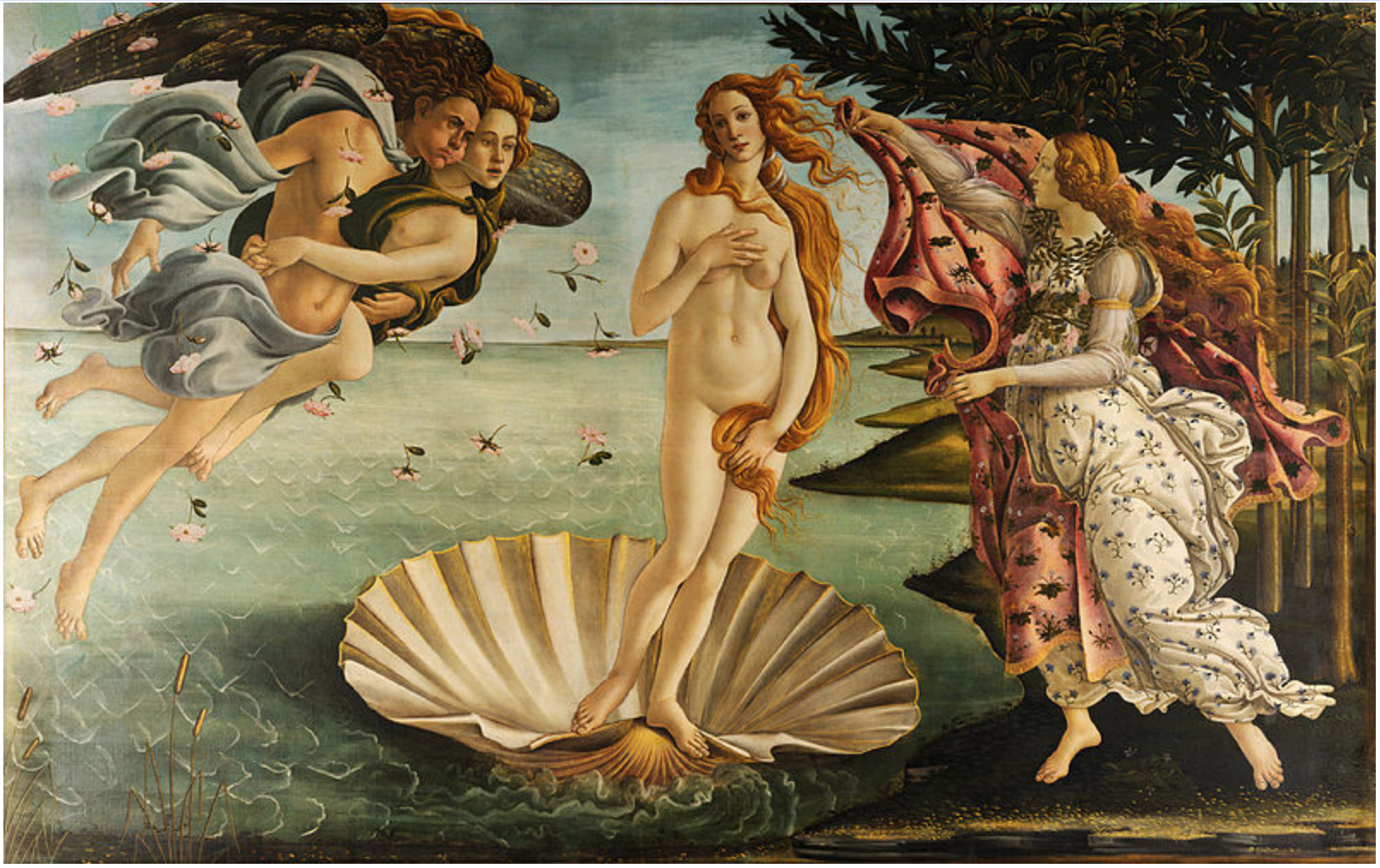
Also see MJT http://physics.columbia.edu/files/physics/content/Tannenbaum.pdf

The Essence of Columbia in 1955 and 2014

- Great teachers who inspire students to study learn and think
- The Core Curriculum which shows college kids how they fit into the long history of cultured mankind by reading, discussing, listening to, seeing works of our most eminent predecessors.
- For Majors: Researchers at the frontier teaching undergraduates

- I went to a meeting in Florence which was held at the University at which Enrico Fermi did his work on what we now call Fermi Statistics. (Spin ½ particles like quarks which are the basis of our present knowledge of matter are called Fermions.)
- I especially enjoyed walking to the center of Florence on a street that passed by the Pitti Palace [full of Botticelli paintings] but equally important by the house of Machiavelli one of my favorite readings in CC.

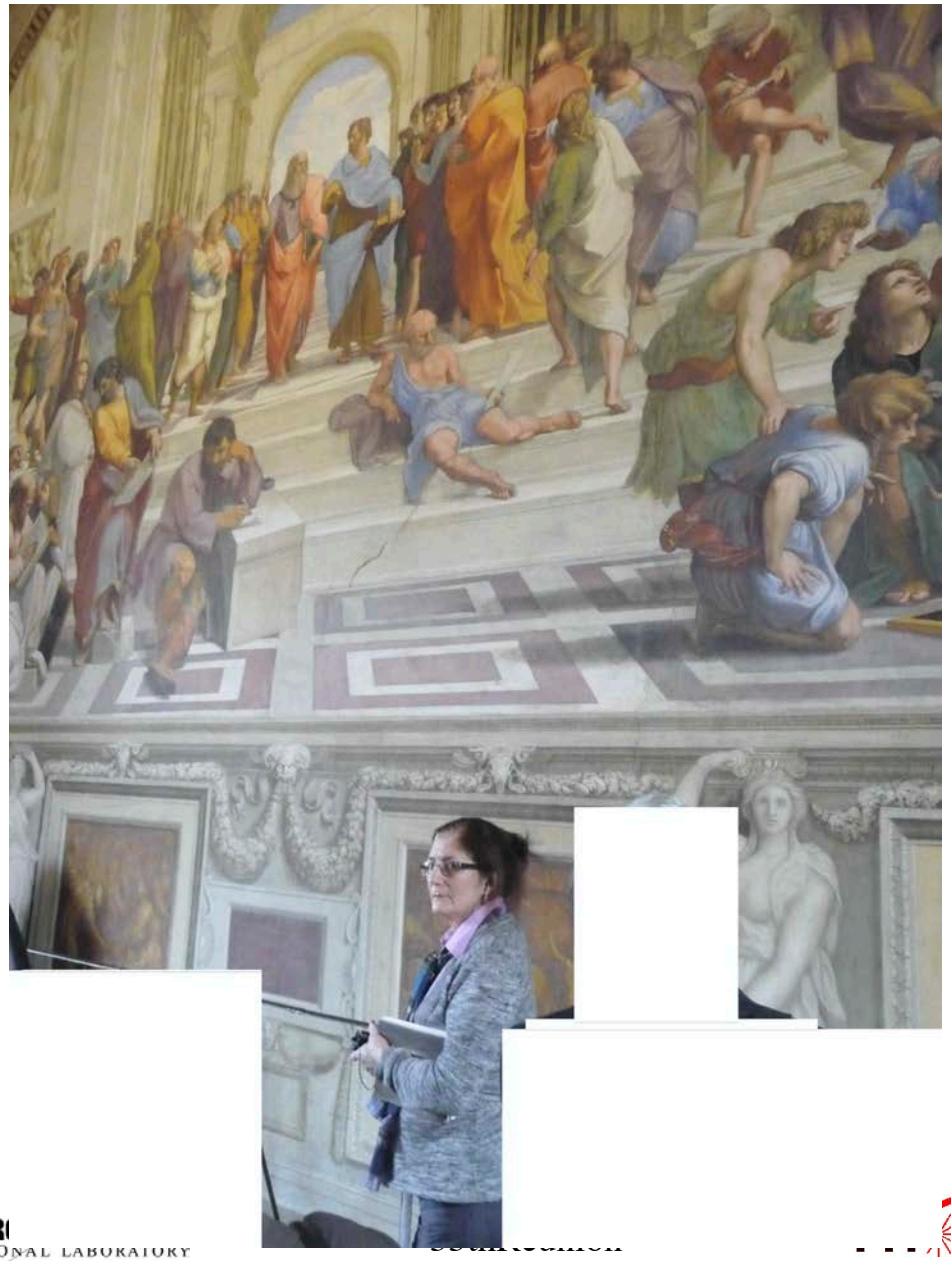
Galileo
Galilei



FYI Botticelli's `Birth of Venus' is in the Uffizi, not the Pitti Palace

During a break at a meeting of the Pontifical Academy of Sciences in the Vatican I found an improved version of Rafael's School of Athens

During a break at a meeting of the Pontifical Academy of Sciences in the Vatican I found an improved version of Rafael's School of Athens



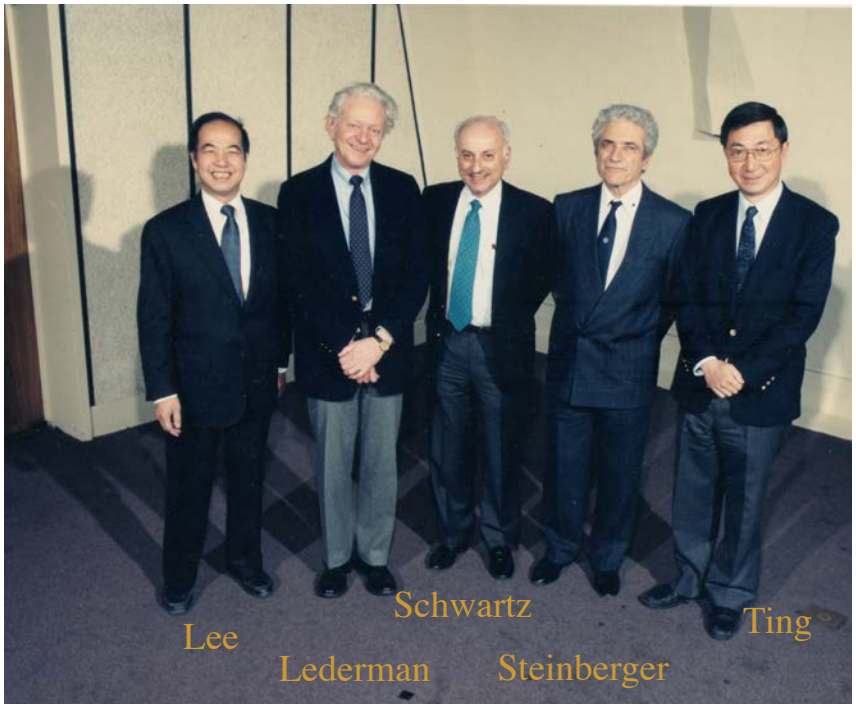
My Physics Teachers at Columbia who had received or would receive the Nobel Prize

Sophomore: Polykarp Kusch -1955

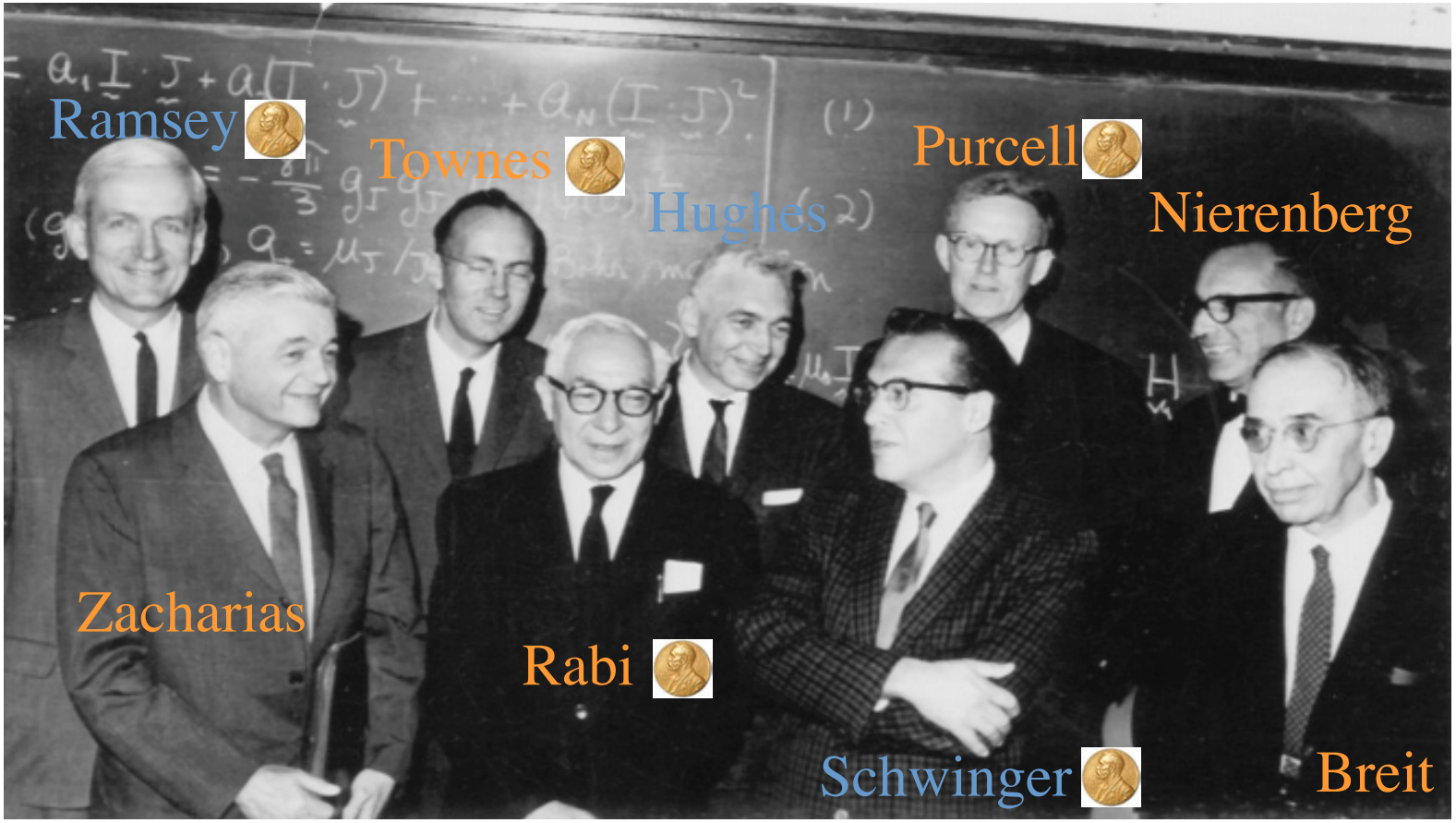
Junior: Charles Townes -1964, Leon Lederman -1988

Senior: Kusch, T. D. Lee -1957, Jack Steinberger -1988

1st Yr Grad School: I. I. Rabi -1944



Rabi and disciples1967-from V.Hughes



Discoveries from this group led from `space quantization' to MRI as well as to Quantum Electrodynamics (Schwinger & Feynman) for which the two principal experimental proofs were done in Pupin. Almost anything electronic that you take for granted came from here.

The Elementary Particles 1955

$$\begin{pmatrix} p^+ & \\ n^0 & \Lambda^0 \end{pmatrix} \qquad \begin{pmatrix} e^\pm & \mu^\pm \\ \nu^0 & \end{pmatrix}$$

Nucleon Lepton

Since then we have uncovered a whole new layer of matter made of quarks and gluons, gained a force and lost a force (due to Steve Weinberg—postdoc here 1957-59) which was proved by last year's Nobel, the Higgs Boson.

The Elementary Particles 1955

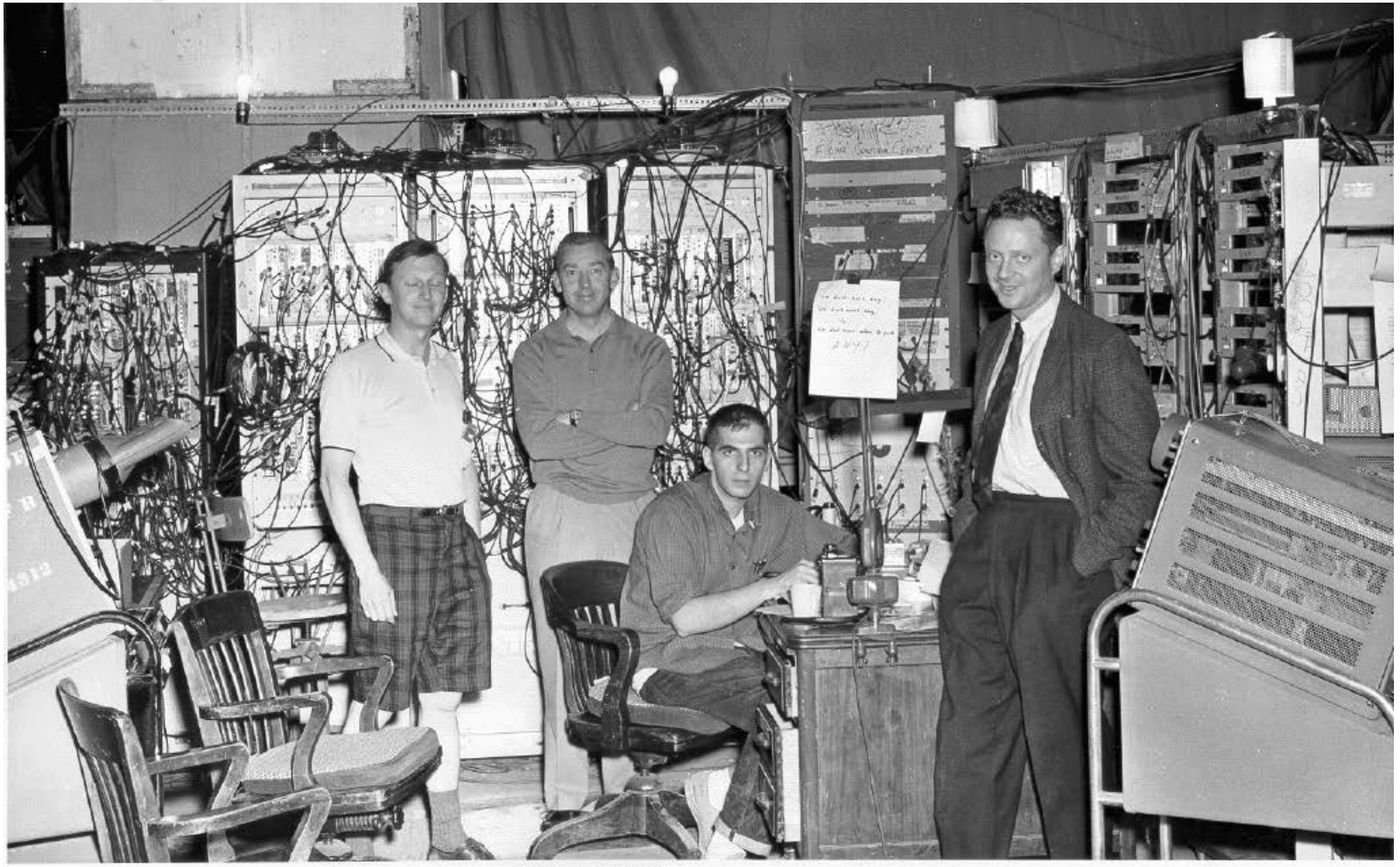
$$\begin{pmatrix} p^+ & \\ n^0 & \Lambda^0 \end{pmatrix} \qquad \begin{pmatrix} e^\pm & \mu^\pm \\ \nu^0 & \end{pmatrix}$$

Nucleon Lepton

Since then we have uncovered a whole new layer of matter made of quarks and gluons, gained a force and lost a force (due to Steve Weinberg—postdoc here 1957-59) which was proved by last year's Nobel, the Higgs Boson.

Just to show off, a photo of Peter Higgs and me and a few others in 2012, days before the announcement of the Higgs Boson Discovery at the CERN LHC.

My Mentors-BNL-AGS floor c. 1963



Tinlot, Cool (ALD), MJT, Lederman

My thesis experiment, muon-proton elastic scattering---"Why does the muon weigh heavy?" We still don't know! Next beam to left: first neutrino exp't (Nobel Prize); on the right, over the accelerator, CP violation (Nobel Prize). Those were the days! The publication had 8 authors (4 more than shown): 2 Columbia, 2 BNL, 4 U. Rochester.

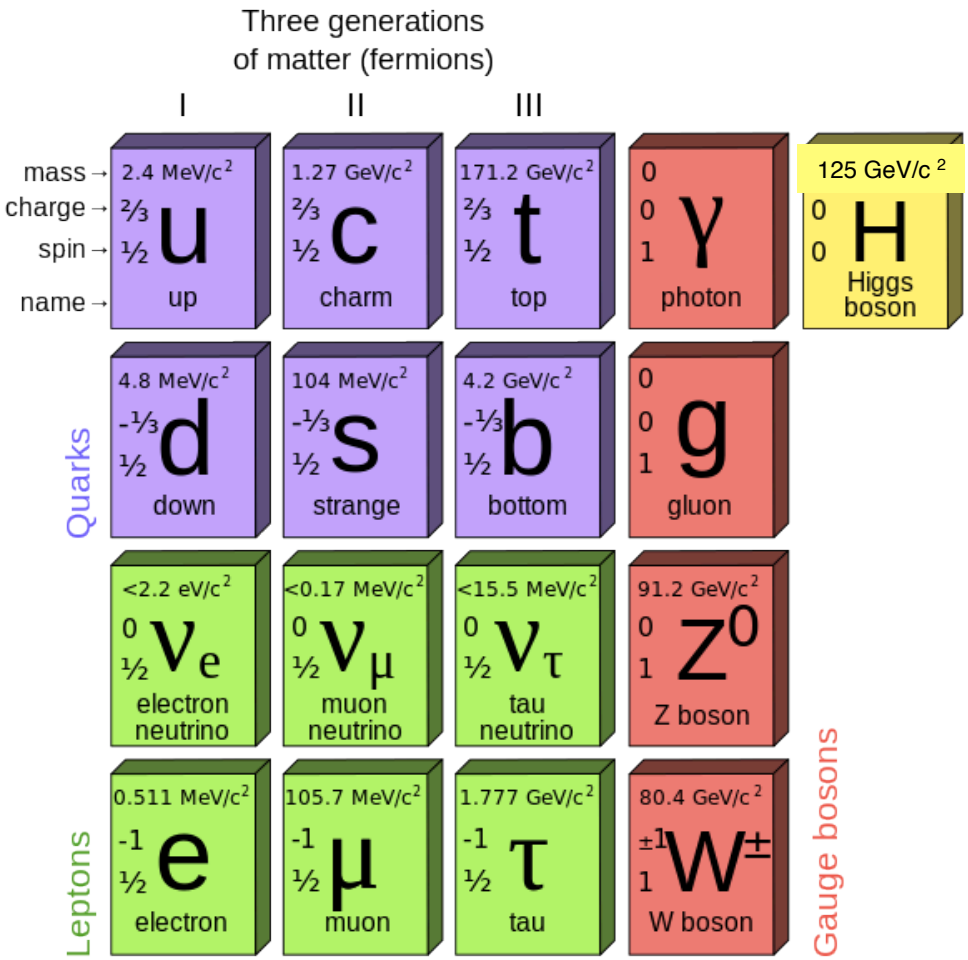
Some of my present collaborators at BNL.

Our latest publication has 393 authors from 61 institutions, 12 countries. LHC is even worse. The two Higgs discovery papers at CERN in 2012 had 2392 and 2900 Authors!

After 59 years, the elementary particles today

- With the Higgs Boson, we now understand the unification of the electromagnetism and radioactive decay force: Quanta are γWZH.

- BUT: we really do not understand this plot: We don't understand the masses of the leptons and quarks (the fermions) and why there are so many. As far as we know, all these particles are point-like, smaller than any size we can measure. We need to probe smaller sizes to understand whether there is a simpler underlying structure!



- The proton (uud) has mass 0.94 GeV/c^2 and a finite radius, 0.8fm

The Relativistic Heavy Ion Collider (RHIC) at BNL is 1 of the 2 remaining colliders-it is visible from space. BNL also has many other facilities

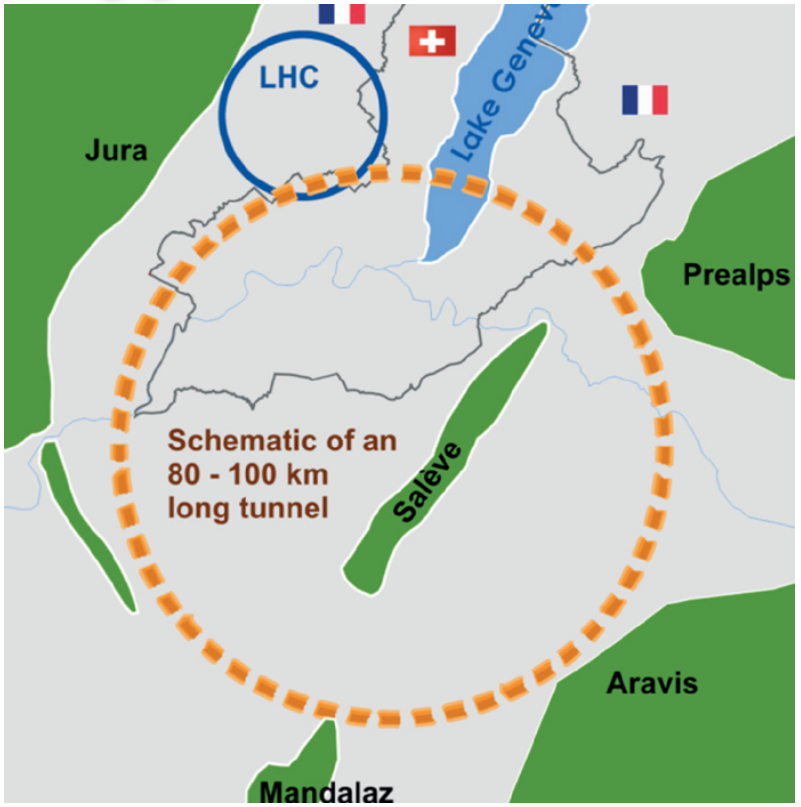
The LHC at CERN, Geneva, SZ

is more than 160ft underground, so sketched on this figure

To probe Smaller Distances we need Higher Energies i.e. Bigger Machines

My favorite proposal is by CERN in Geneva who built the LHC and now proposes to build a 4 times larger machine passing under Lake Geneva: Cost >> $15B.

Note that after WWII and the development of Nuclear Fission and the A-Bomb, Rabi led the way to start laboratories for basic Nuclear Science in the U.S. (BNL) and Europe (CERN) beyond the scope of any University.



CERN had all the former enemies, Britain, France, Germany, Italy, Benelux, Nordic . . working together doing peaceful nuclear research**. CERN's budget is set by treaty.**

We've come a long way since 1955: from physics as an individual sport to a team sport. Columbia no longer dominates but is still a big player at CERN and still among the top rank in Physics although now Stony Brook is more important at my lab, BNL, where we have the only other high energy particle collider in the world-we collide Nuclei. Maybe when Manhattanville is completed Columbia can concentrate more on Physics. There is recent progress:

A new Theory Center has started construction

Rendering

Columbia University – The Pupin Theory Center August 21, 2013

An International Conference starts here Sunday

JUNE 2-7, 2014
Columbia University
New York, NY

Hosted by:
Brookhaven National Laboratory
Columbia University

CONFERENCE CHAIRS
G. Bernardi, *LPNHE-Paris*
G. Mitselmakher, *Florida*
S. Rajagopalan, *BNL*
M. Tuts, *Columbia*

SCIENTIFIC SECRETARY
H. Okawa, *BNL*

INTERNATIONAL ADVISORY COMMITTEE
P. Campana, *CERN/Frascati*
T. Camporesi, *CERN*
D. Charlton, *Birmingham*
D. Denegri, *CEA Saclay*
T. Dova, *La Plata*
F. Gianotti, *CERN*
P. Giubellino, *Torino/CERN*
P. Grannis, *Stony Brook*
J. Incandela, *UCSB*
P. Jenni, *Freiburg/CERN*
J. Lykken, *Fermilab*
M. Martinez, *ICREA/Barcelona*
L. Ristori, *Pisa*
K. Safarik, *CERN*
G. Wilkinson, *Oxford*

CONTACT
lhcp2014@bnl.gov

PROGRAM COMMITTEE
F. Antinori, *Padova*
S. Dawson, *BNL*
K. Einsweiler, *LBNL, co-chair*
T. Gershon, *Warwick*
G. Giudice, *CERN*
P. Koppenburg, *Nikhef*
G. Landsberg, *Brown, co-chair*
C. Mariotti, *Torino*
M. Neubert, *Mainz*
M. Papucci, *Michigan*
F. Petriello, *Northwestern/ANL*
K. Terashi, *Tokyo*
R. Van Kooten, *Indiana*
C. Vellidis, *Fermilab*
E. Vercellin, *Torino*

LOCAL ORGANIZING COMMITTEE
C. Bee, *Stony Brook*
H. Gordon, *BNL*
H. Ma, *BNL*
J. Parsons, *Columbia*
S. Rajagopalan, *BNL*
M. Tuts, *Columbia*

CONFERENCE SECRETARIAT
C. Potter, *CERN*
J. Winsten, *Columbia*
W. Yu, *BNL*

www.bnl.gov/lhcp2014

U.S. DEPARTMENT OF ENERGY · NSF · BROOKHAVEN NATIONAL LABORATORY · CERN · COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK · Stony Brook University