# Measuring is Knowing

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ex physicist
now: CDC, Leuphana

# Richard P. Feynman on Science and Measurement

Measurements are more than simple operational steps. Measurements require theory, up to the point that the interpretation of a certain reading of a scale is the last step of a very complicated theoretical chain of arguments.

# Measuring very long, „normal“, and very short periods of time

age of very old material, $10^9$ years

how? theory?

$U^{238}$ with half life of $10^9$ years

theory of radioactive decay

everyday events, seconds

pendulum, Galilei‘s mechanics

ultrashort events, $10^{-20}$ seconds

particle physics

the act of measurement

ends in reading a scale

could only be interpreted by a theory

how to measure temperature?

we have instruments

why do they measure „temperature“?

$p*V = n*k*T$

thermometer: Temperature proportional to Volume

how to measure really cold or really very hot stuff?

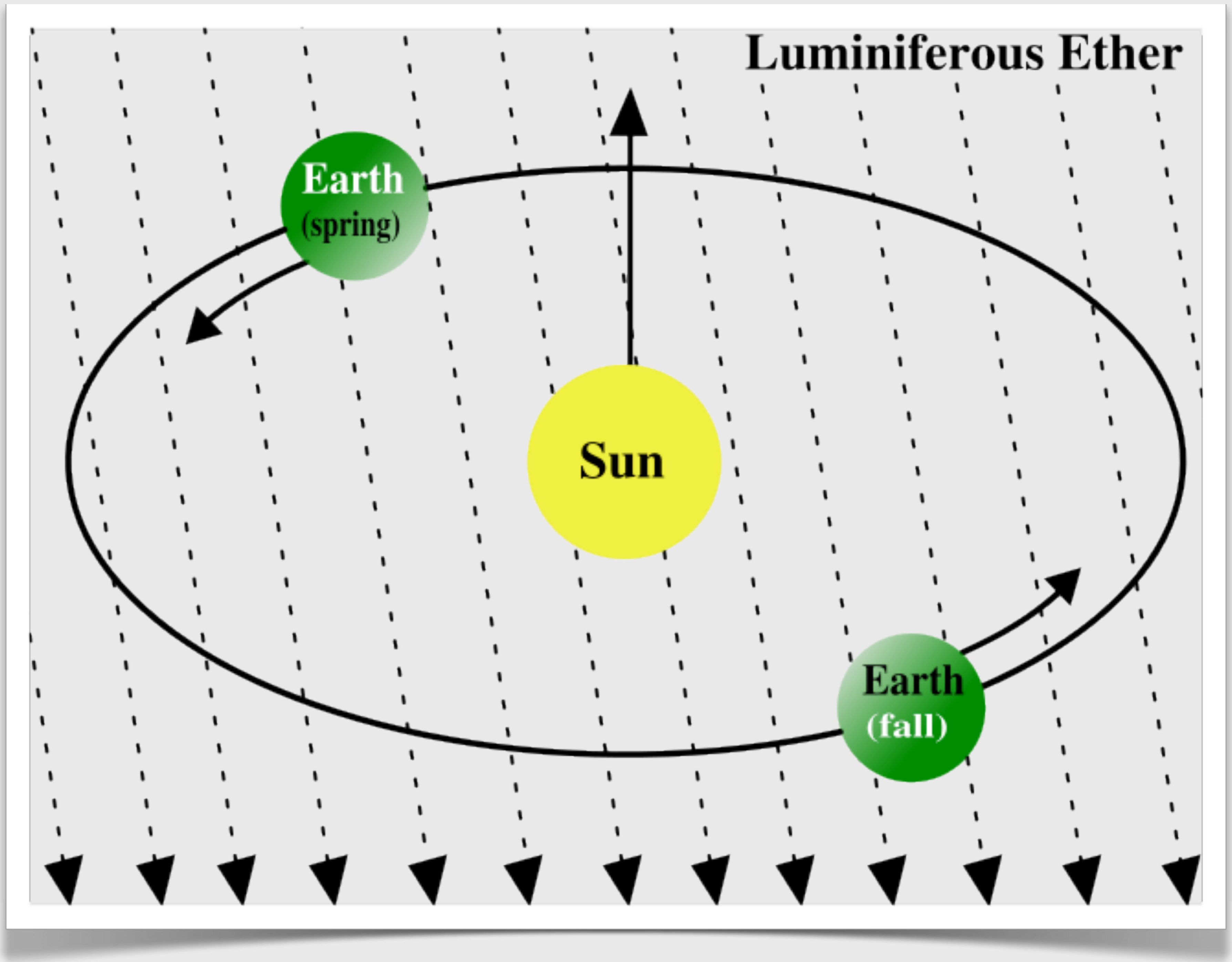
# measurement and theory

without a theory we are unable to measure

# experimentum crusis: measuring the ether

speed of starlight when approaching, sliding by or fleeing the light source?

# The Michelson-Morley experiment 1887




BITTE NICHT BERÜHREN !

## the result

null

no difference observable

speed of light always the same, approaching or fleeing the light source

# the consequence

special theory of relativity, Einstein 1905

speed of light is a universal constant, independent from the motion of the observer

# consequences

new theory of space and time

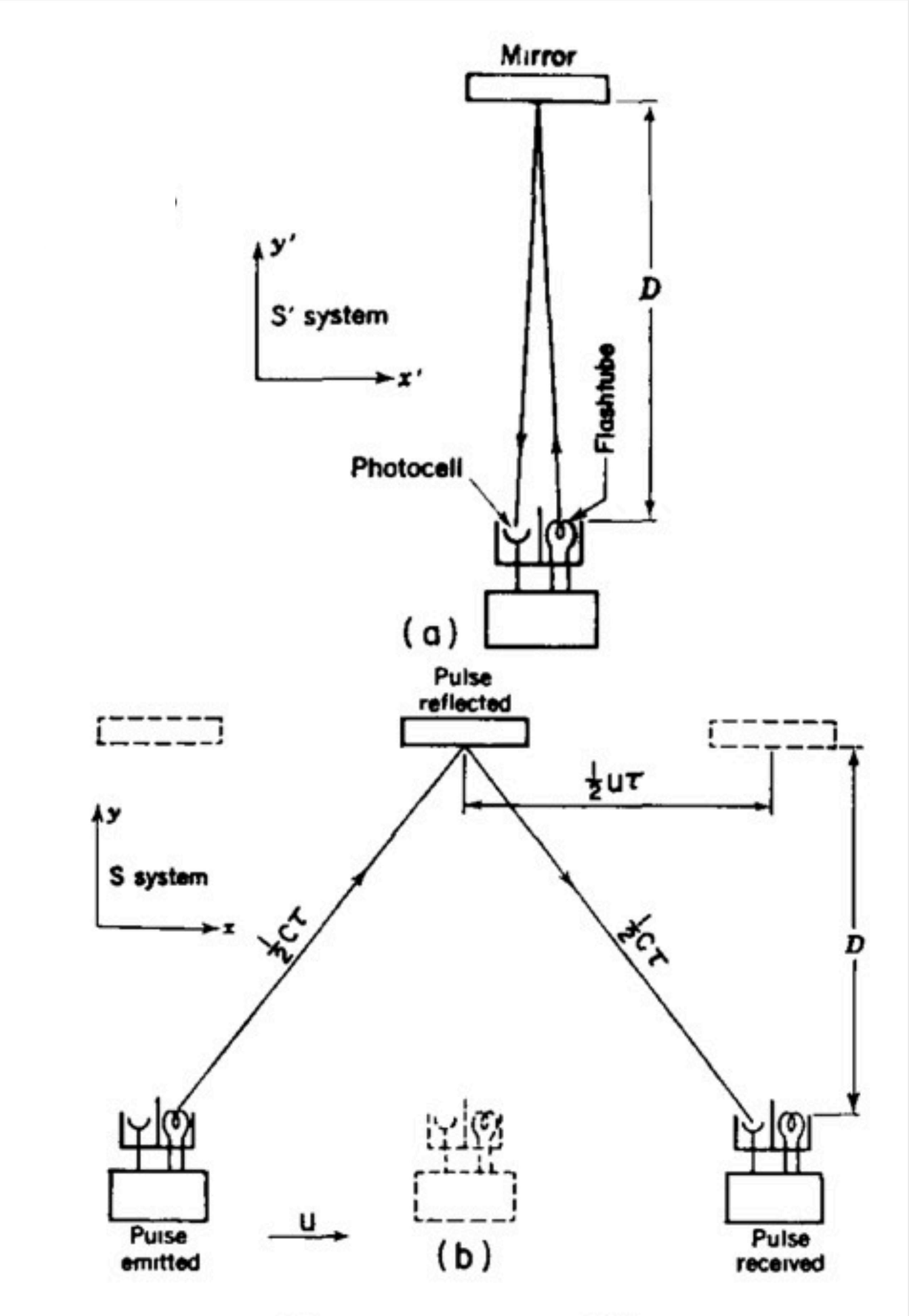
time dilatation

length contraction

no simultaneity

four dimensions of space-time

# measuring with a light clock (Feynman)




speed of light is unchanged, the path between reflection therefore must be longer, the ticks slower: time dilatation!

measurements trigger theory

# It‘s always nice to be lucky: an anecdote

Helium at ultra low temperatures

the lonelyness of a graduate student: me

theorists meet experimentalists

# a double publication

VOLUME 50, NUMBER 14 PHYSICAL REVIEW LETTERS 4 APRIL 1983

## Effect of Gap Distortion on the Field Splitting of Collective Modes in Superfluid $^3$He-*B*

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and

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(Received 2 December 1982)

The field splitting of the real squashing, $J=2$, mode in $^3$He-*B* is shown to become highly nonlinear at large fields as a result of the ellipsoidal deformation of the energy gap. This leads to crossings of the $J_z=+1$ and $J_z=0$ levels with the $J_z=+2$ level. The crossing points depend sensitively on the couplings between the $J=2$, 1, and 0 modes. The theory is in good agreement with the observed field evolution and level crossing as measured recently by Shivaram *et al.*

PACS numbers: 67.50.Fi

The condensate of superfluid $^3$He-*B* consists of *p*-wave Cooper pairs in spin-triplet states $S_z = \pm 1$ and $S_z = 0$. The fluctuations of the corresponding order-parameter components about their equilibrium values give rise to eighteen order-parameter collective modes.[1] These eighteen modes can be classified in terms of total angular momentum $J=0$, 1, and 2. The $J=2$ modes, i.e., the so-called squashing (sq) and real squashing

by the field[2,3] is responsible for the crossing of levels (this effect was not noticed in Ref. 2 because gap distortion was neglected in the numerical calculations and figures). This is similar to the effect of quadrupolar deformation of nuclei on the hyperfine spectrum. We find that in large fields the nonlinear effects of gap distortion on the $J_z = \pm 1$ and 0 states become smaller if coupling between $J=2$ and $J=1$ or 0 is taken into ac-

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## Nonlinear Zeeman Shifts in the Collective-Mode Spectrum of $^3$He-*B*

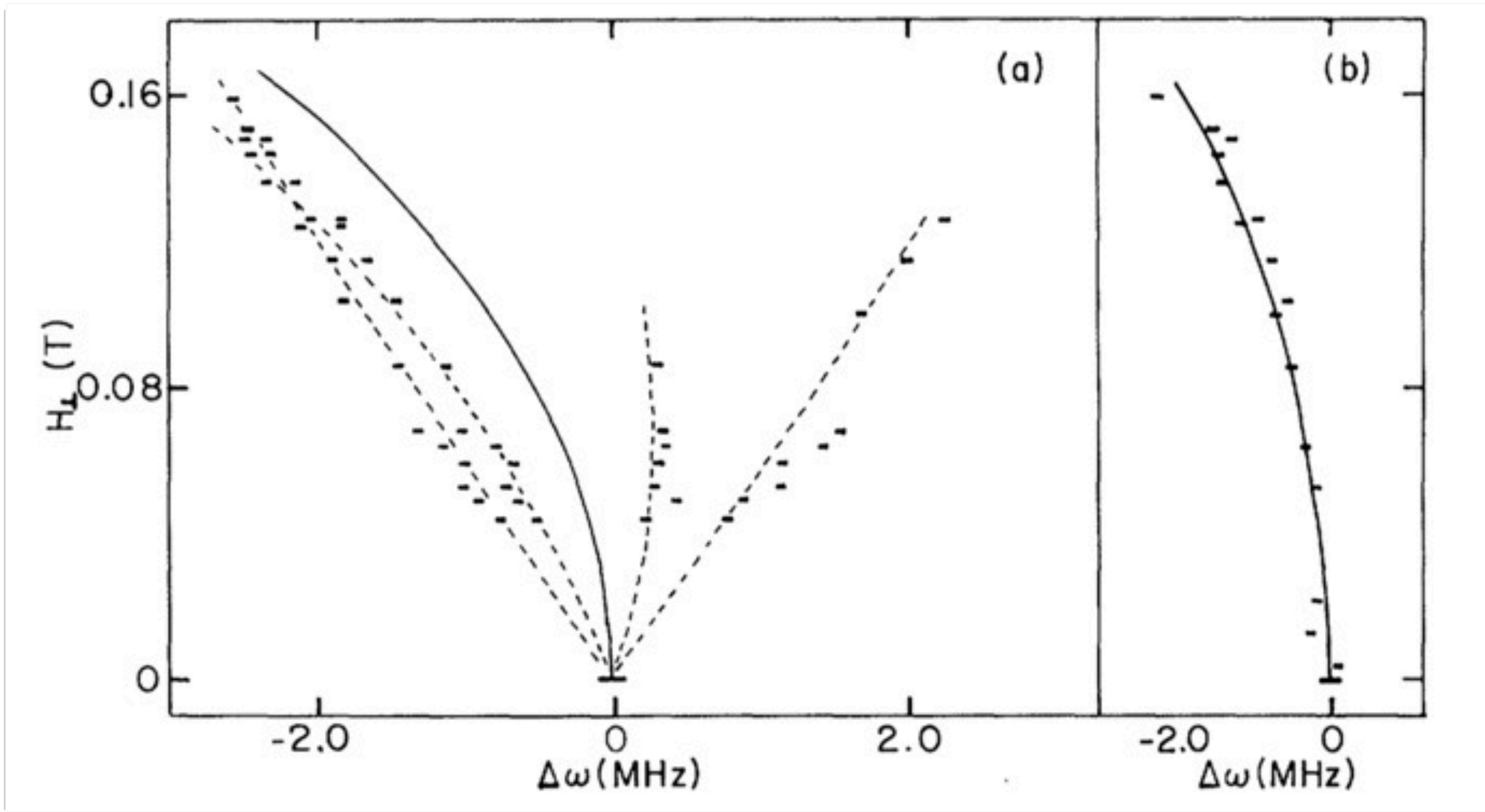
B. S. Shivaram, M. W. Meisel, Bimal K. Sarma,[(a)] W. P. Halperin, and J. B. Ketterson
*Department of Physics and Astronomy and Materials Research Center, Northwestern University, Evanston, Illinois 60201*
(Received 21 December 1982)

Zeeman shifts in one of the $J=2$ order-parameter collective-mode multiplets in $^3$He-*B* have been measured in magnetic fields up to 0.16 T. The observed shifts are extremely nonlinear at higher fields. The extent of nonlinearity decreases as $T/T_c \to 0$ and for a given $T/T_c$ is more predominant at lower pressures and/or frequencies. The observed effects can be attributed to the distortion of the *B*-phase energy gap in the presence of a magnetic field as suggested by Schopohl, Warnke, and Tewordt.

PACS numbers: 67.50.Fi

The ground state in superfluid $^3$He has Cooper pairs in an $l=1$, $s=1$ paired state.[1] The tensorial order parameter that results has eighteen independent components. An equal number of collective modes, associated with fluctuations in

described previously.[5,11] Nuclear cooling of copper wires was used to obtain temperatures down to 0.4 mK. Temperatures in the $^3$He were determined by measuring the magnetic susceptibility of lanthanum cerium magnesium nitrate cali-

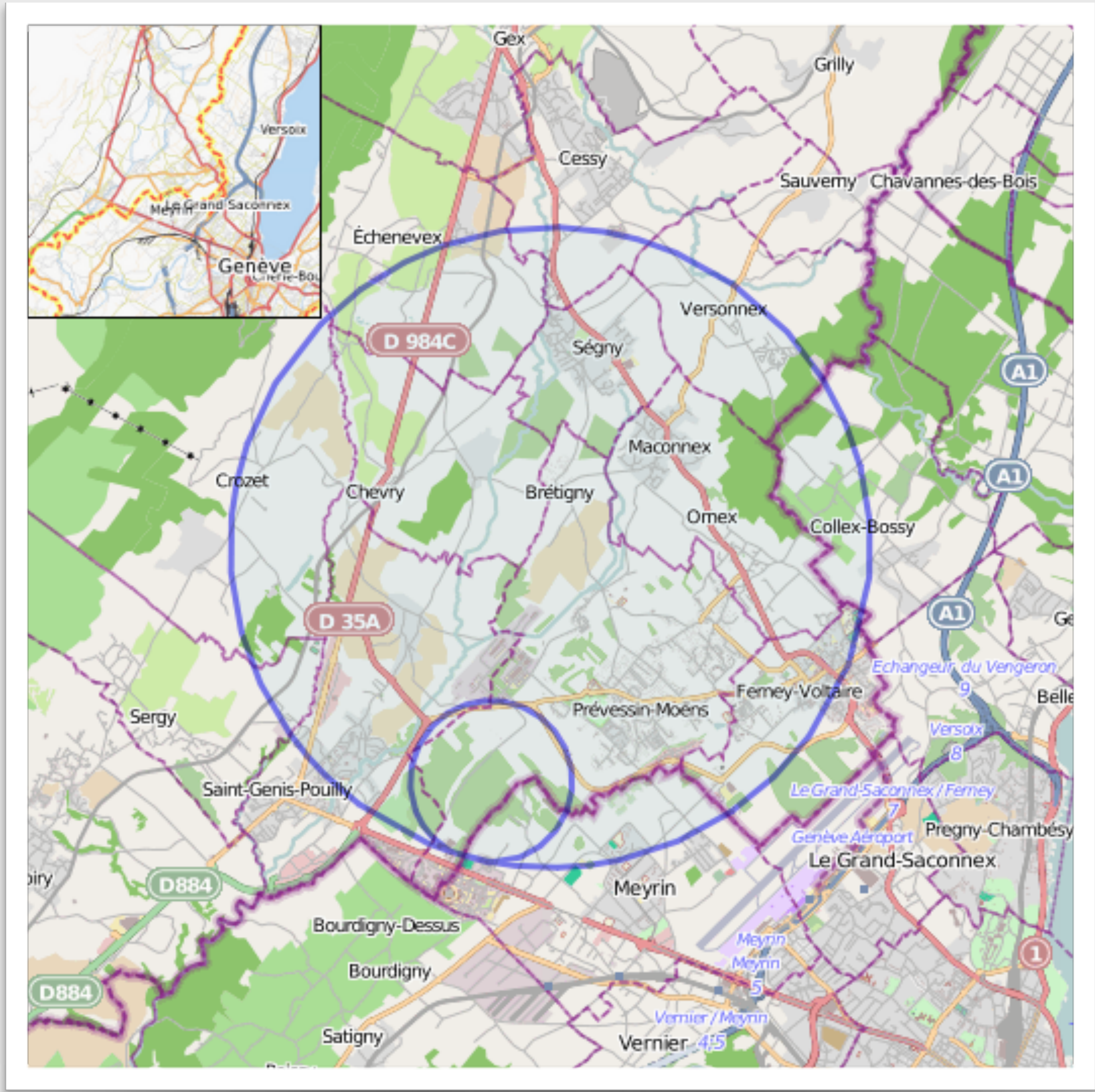



„Recent calculations by Schopohl, Warnke, and Tewordt have shown that the nonlinearity arises from a distortion of the B-phase energy gap.“

# It took theory to believe in measurement

# Now: Big Science

# CERN



Gex
Grilly
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Chavannes-des-Bois
Échenevex
Versonnex
Ségny
D 984C
A1
Maconnex
Crozet
Chevry
Brétigny
Ornex
Collex-Bossy
D 35A
Echangeur du Vengeron
9
Ferney-Voltaire
Prévessin-Moëns
Sergy
Versoix
8
Saint-Genis-Pouilly
Le Grand-Saconnex / Ferney
7
Genève Aéroport
Pregny-Chambésy
Le Grand-Saconnex
Meyrin
D884
Bourdigny-Dessus
Bourdigny
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Satigny
Vernier / Meyrin
Vernier
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1
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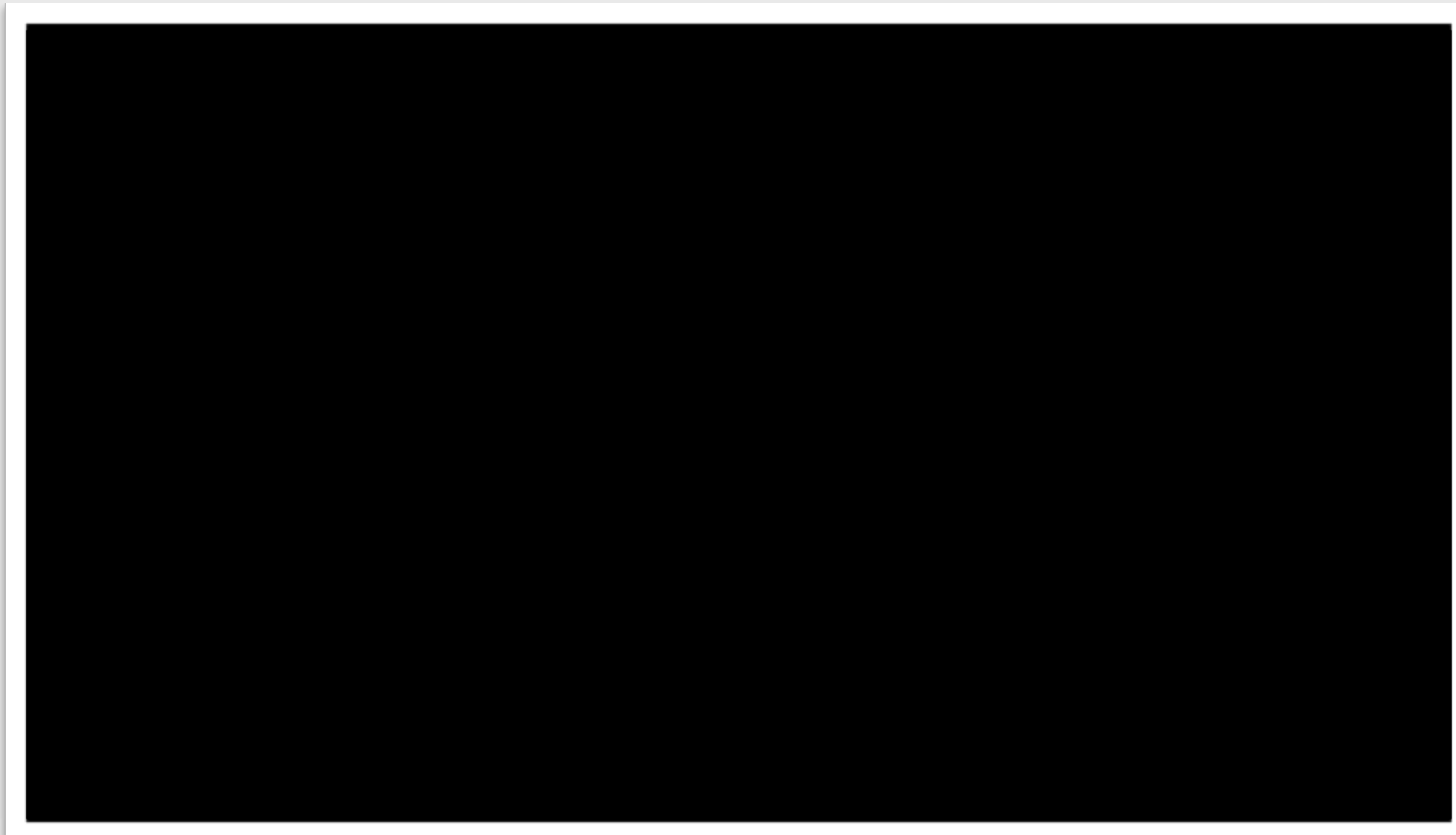
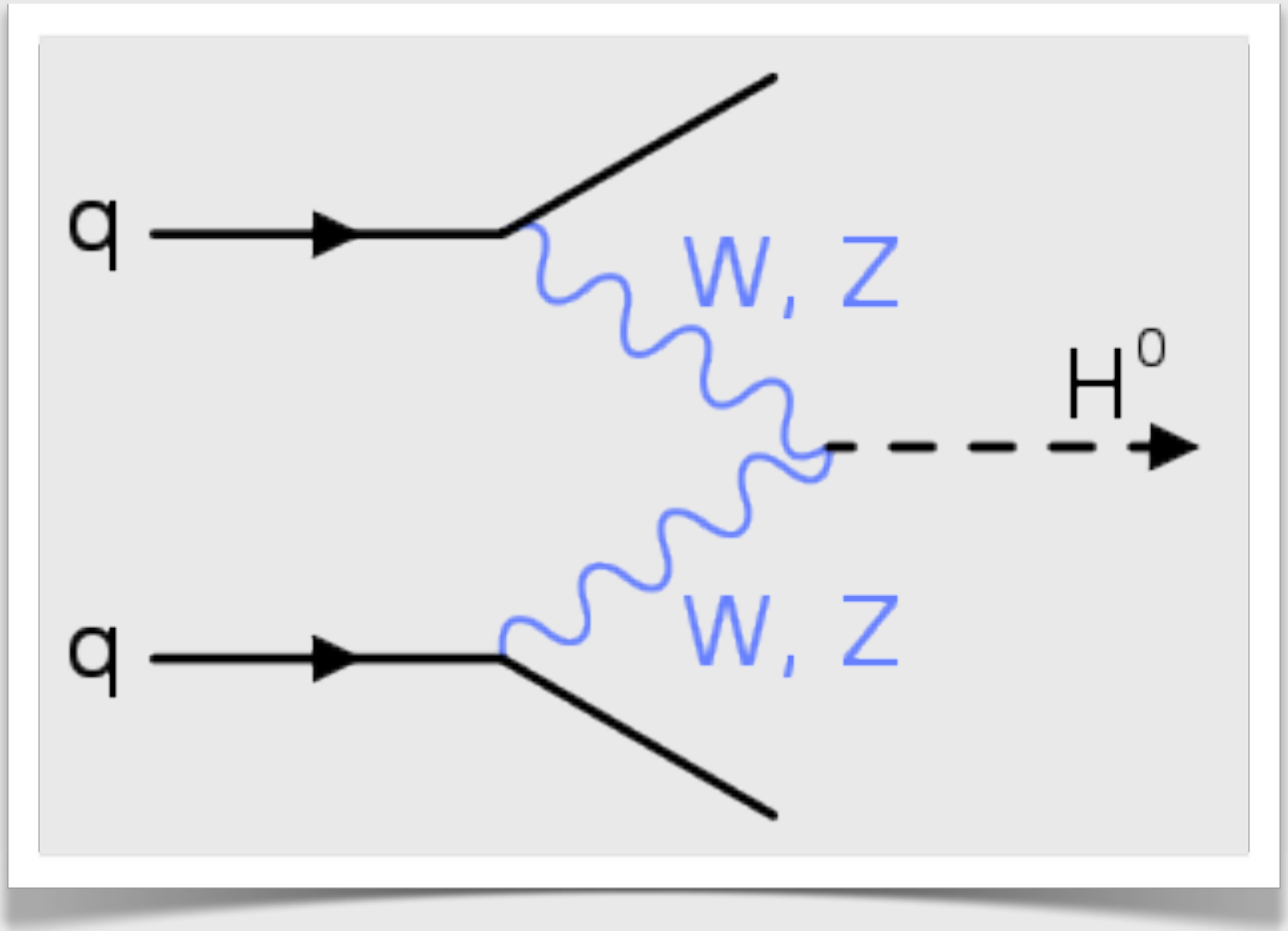
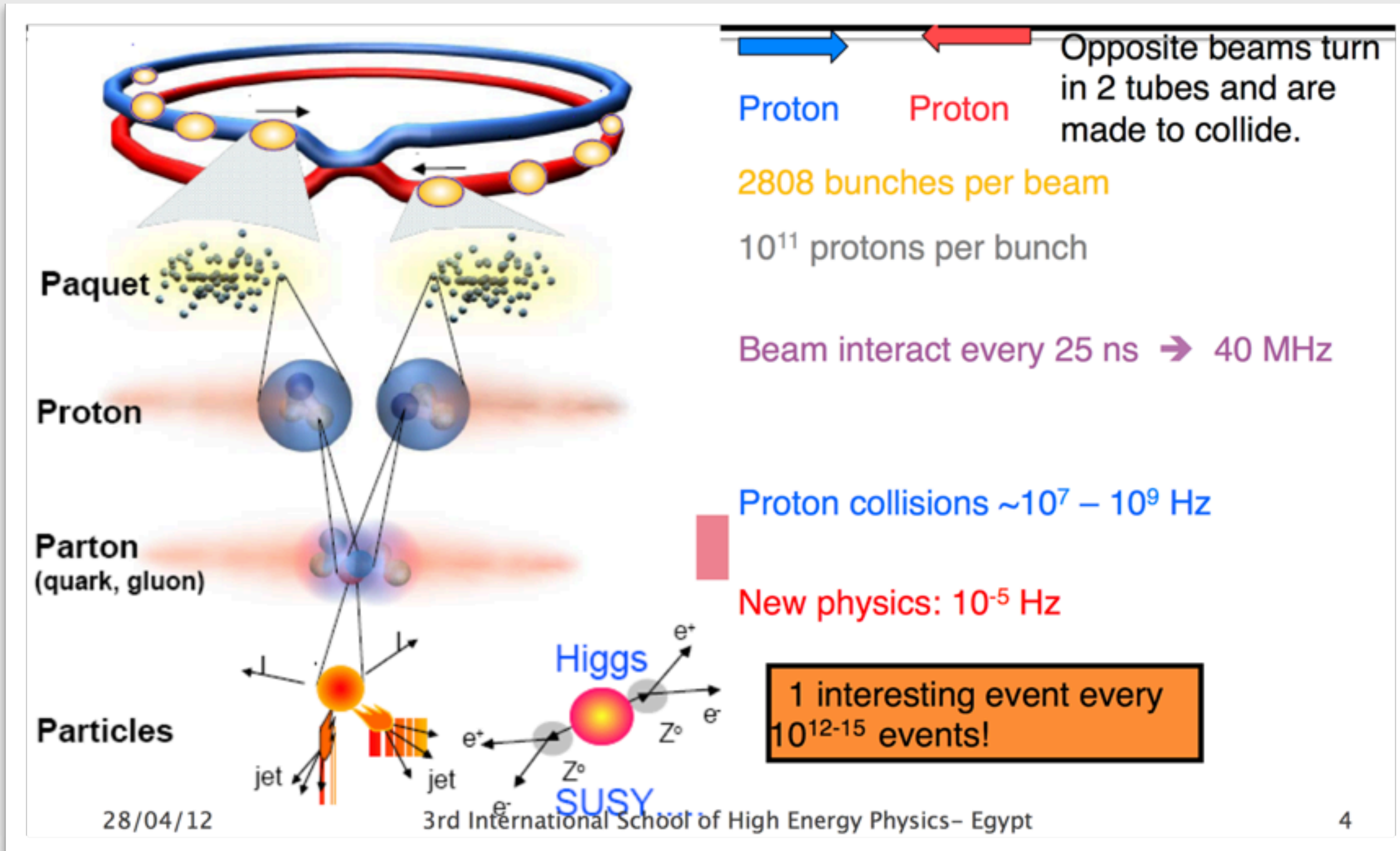
# The quest for the Higgs Boson



# The Higgs Boson



# Some new physics at CERN



seeing is calculating

Algorithmic selection precedes measurement

Computer simulations enable measurements

# Selection

the amount of data obtained by the LHC experiments is much too big to be processed

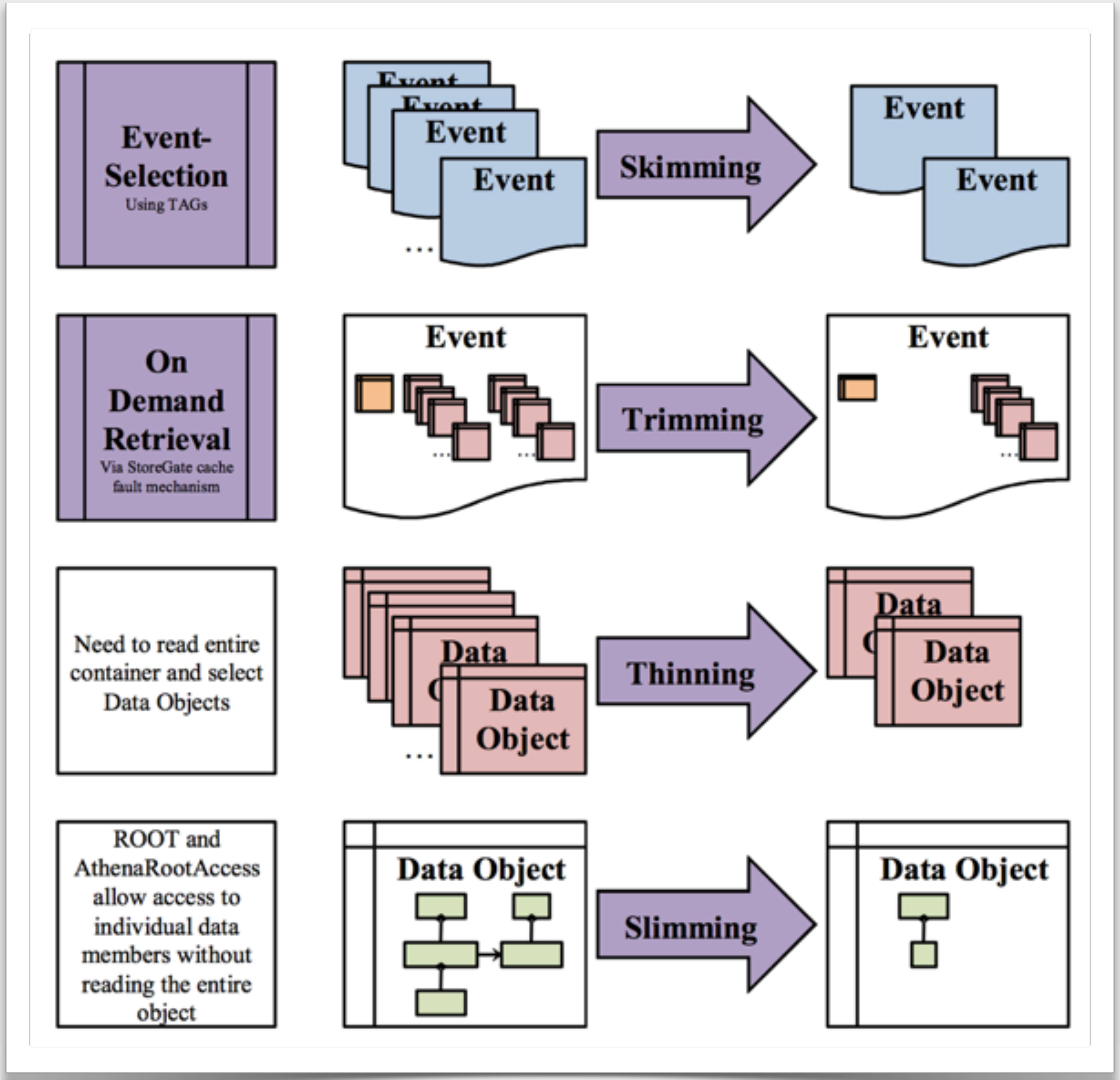
only 1/1000 is kept, the rest thrown away by algorithms

Skimming: Only events that are interesting are kept.

Trimming: Removal of data

Thinning: Removal of individual objects

Slimming: Removal of parts of an object




Supporting High-Performance I/O at the Petascale:
The Event Data Store for ATLAS at the LHC, Peter van Gemmeren & David Malon

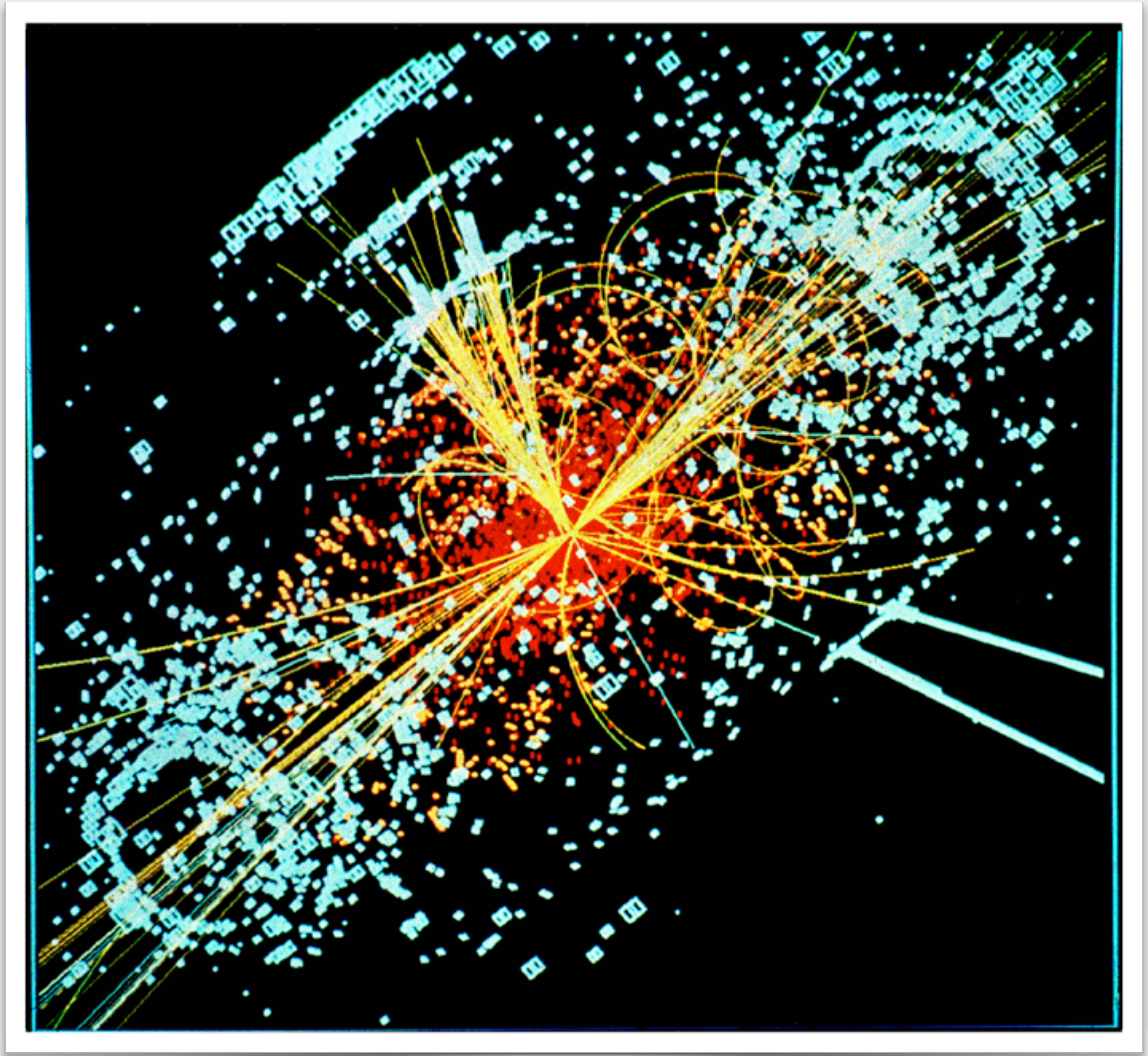
# How would a Higgs Boson show up?

We would never see it directly

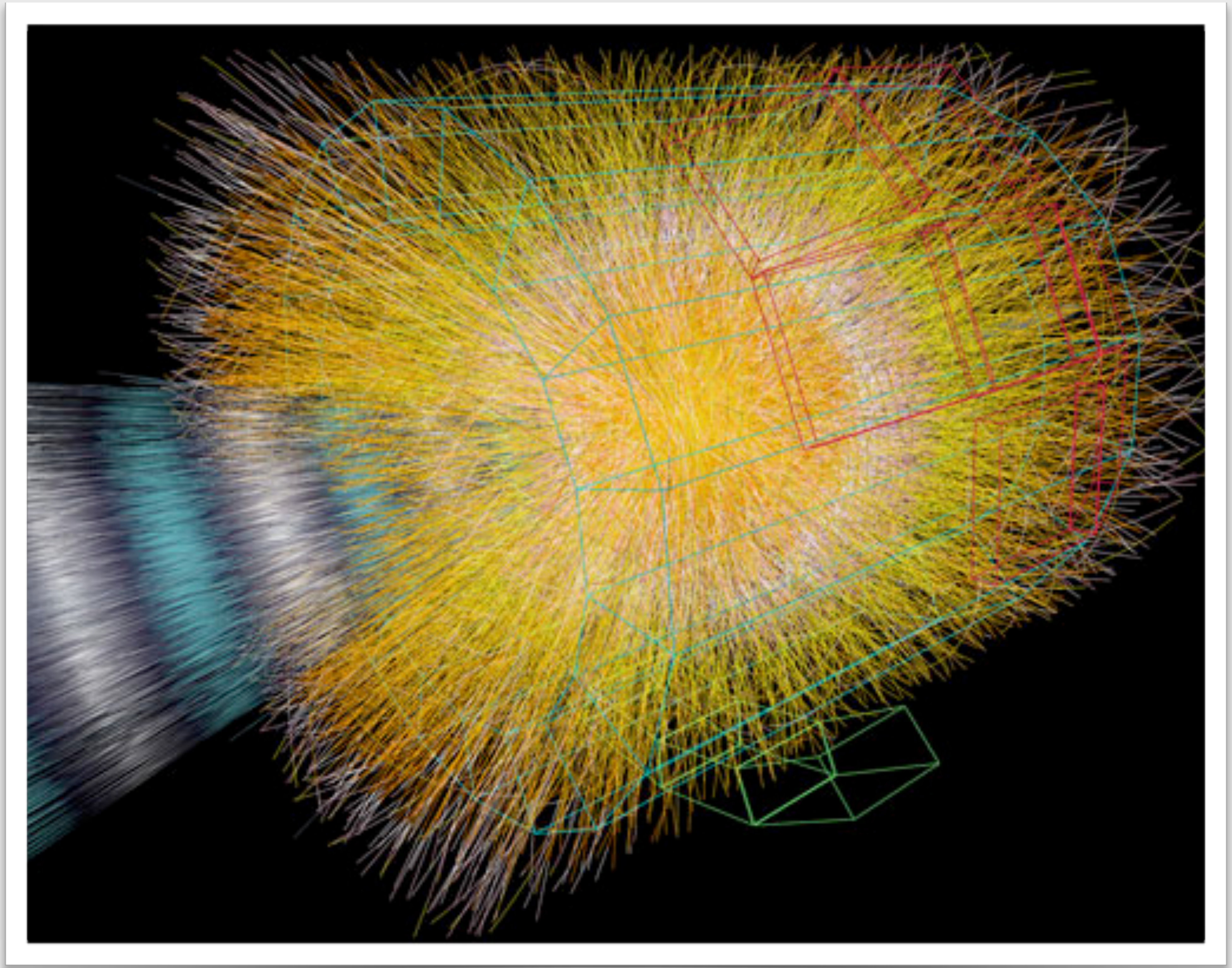
The Higgs only lives for $10^{-22}$ seconds

We could only measure the effects of its existence at the end of a chain of events

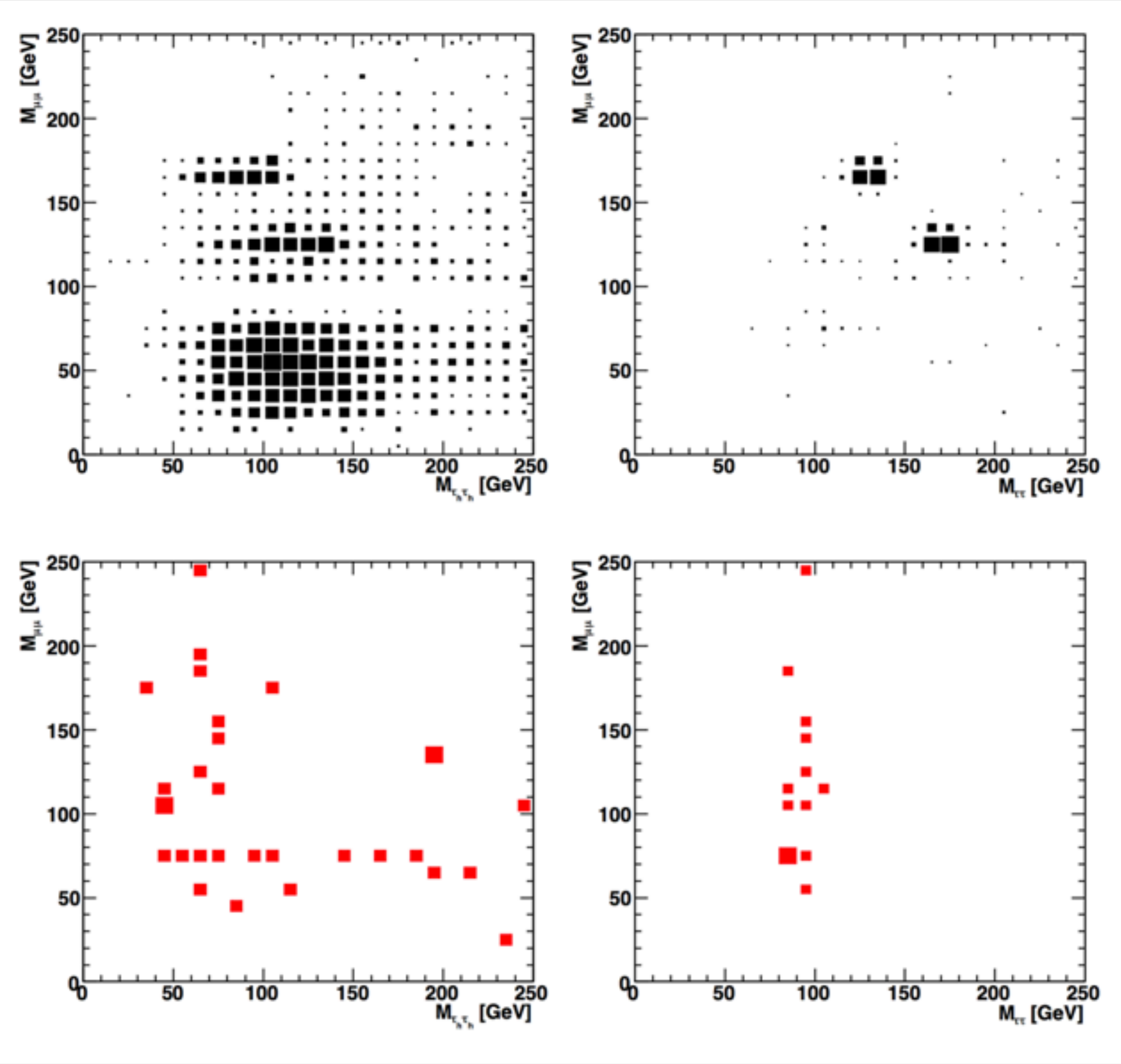
# simulation of the existence of a Higgs Boson



# looking for events that look similar



# what scale to read?




Multi-$\tau$ signatures at the LHC in the two Higgs doublet model
Shinya Kanemura, Koji Tsumura, and Hiroshi Yokoya

what is the connection between theory, measurement, and simulation?

the classical point of view of a Noble Price winner

# Richard P. Feynman on Science and Measurement

# Is this the case?

guess -> experiment that causal?

„directly compare to“ ??

much more complicated

circular process

theory, experiment & simulation deeply intertwingled measuring is very much knowing

*finis*