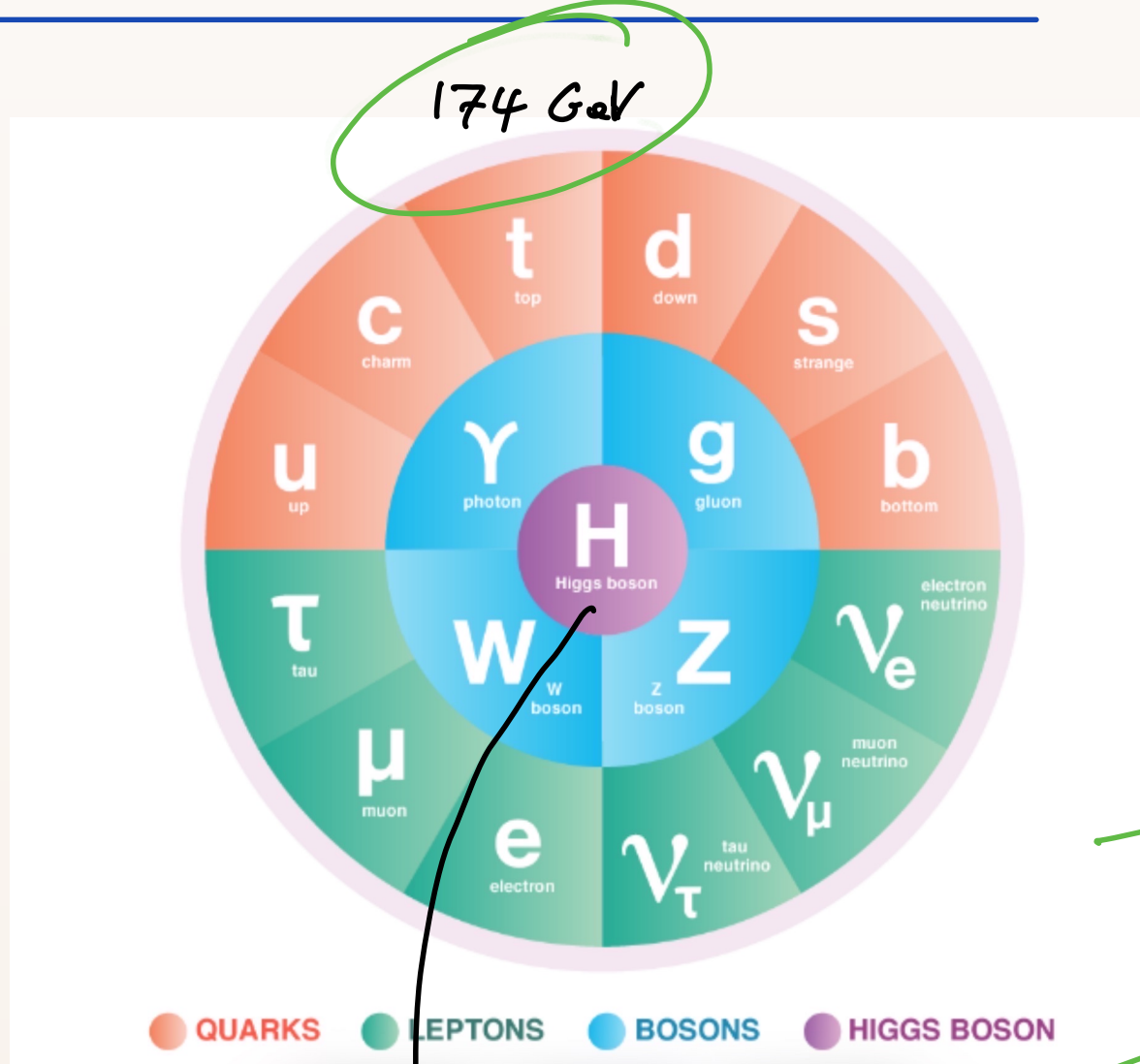


FUTURE COLLIDER FORUM

MAY 1TH 2024

SIMON KNAPPEN
(PHYSICS THEORY)

THE STANDARD MODEL



• WHY 3 GENERATIONS?

• WHY IS e SO HEAVY?

• WHERE DOES CP VIOLATION COME FROM?

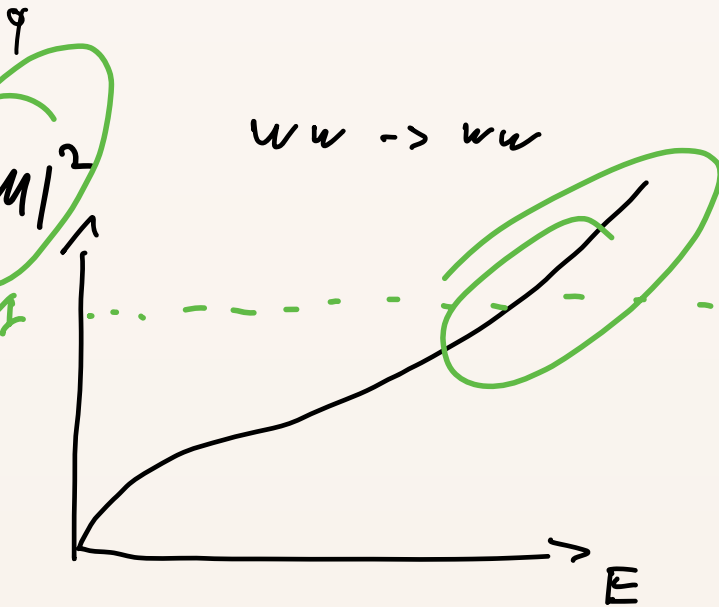
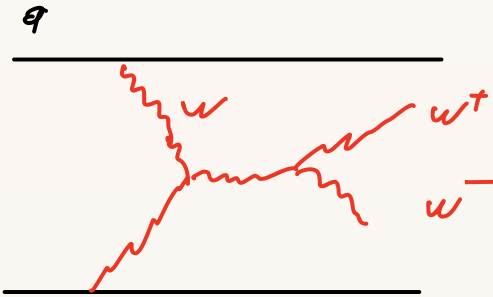
• WHAT IS THE DARK MATTER?

• HOW DO THE FORCES UNIFY?

• WHAT'S UP WITH THE HIGGS BOSON?

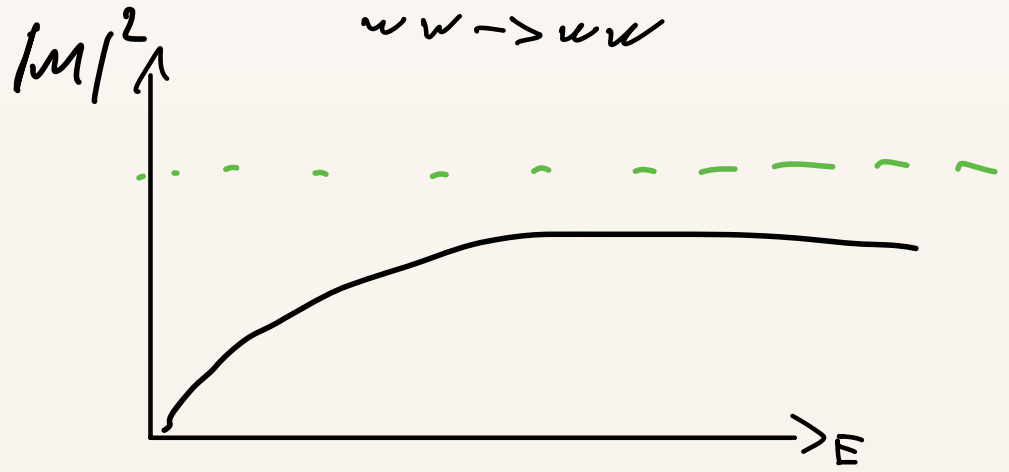
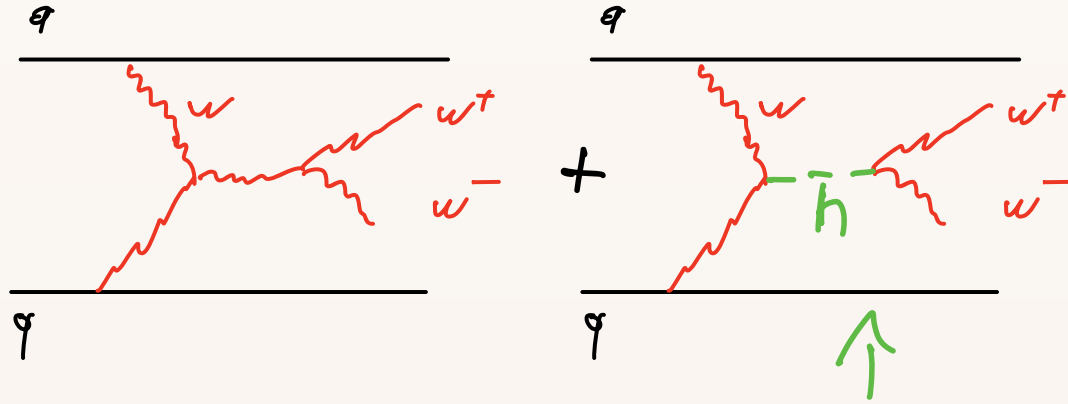
HIGGS BOSON

NO HIGGS



DISCOVERY

WITH HIGGS



AT LHC ALMOST GUARANTEED

HIGGS PUZZELS

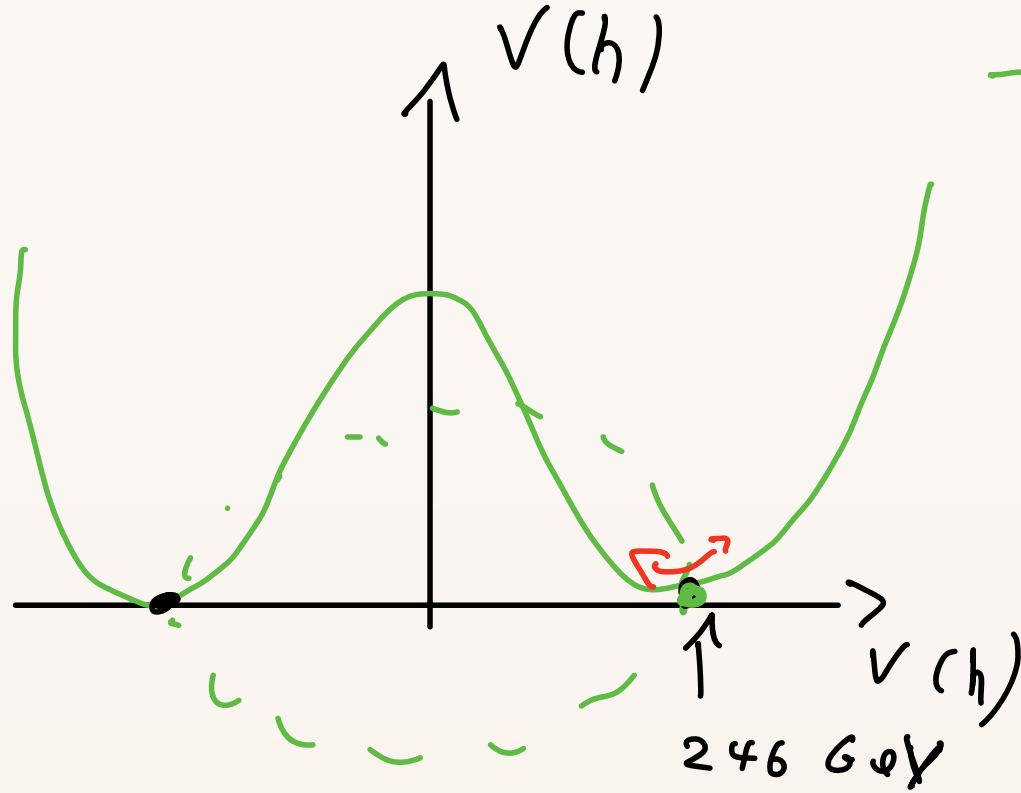
- IS IT ALONE? OR ARE THERE OTHERS?
- IS IT A COMPOSITE PARTICLE?

ALL SPIN 0 PARTICLES WE HAVE SEEN SO FAR (e.g. PIONS) ARE COMPOSITE!

- PRECISION HIGGS MEASUREMENTS (HL LHC, FCCee, ...)
- SEARCH FOR OTHER COMPOSITE STATES (HIGH ENERGY MACHINE: $\mu\mu$, WAKEFIELD) OR FCC-hh

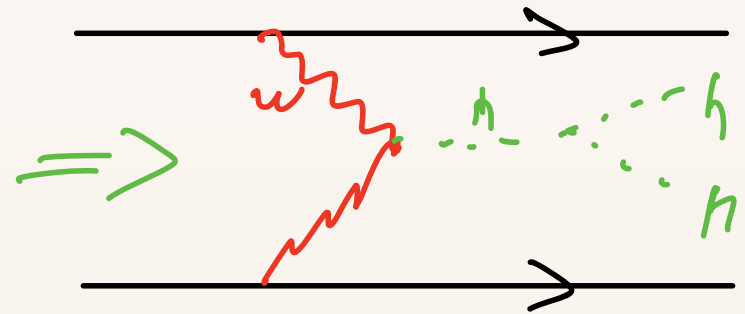
- WHAT MECHANISM SETS THE WEAK SCALE? HIERARCHY

HIGGS POTENTIAL



$$\rightarrow V(\phi) = -\mu h^2 + \lambda h^4 + \dots$$

CAN WE MEASURE μ ?



WE MEASURED THE
MINIMUM + 1TH TERM
IN TAYLOR EXPANSION

REQUIRES HIGH ENERGY,
LOT OF DATA
& LOW BACKGROUNDS

WHAT EXPLAINS THE WEAK SCALE?

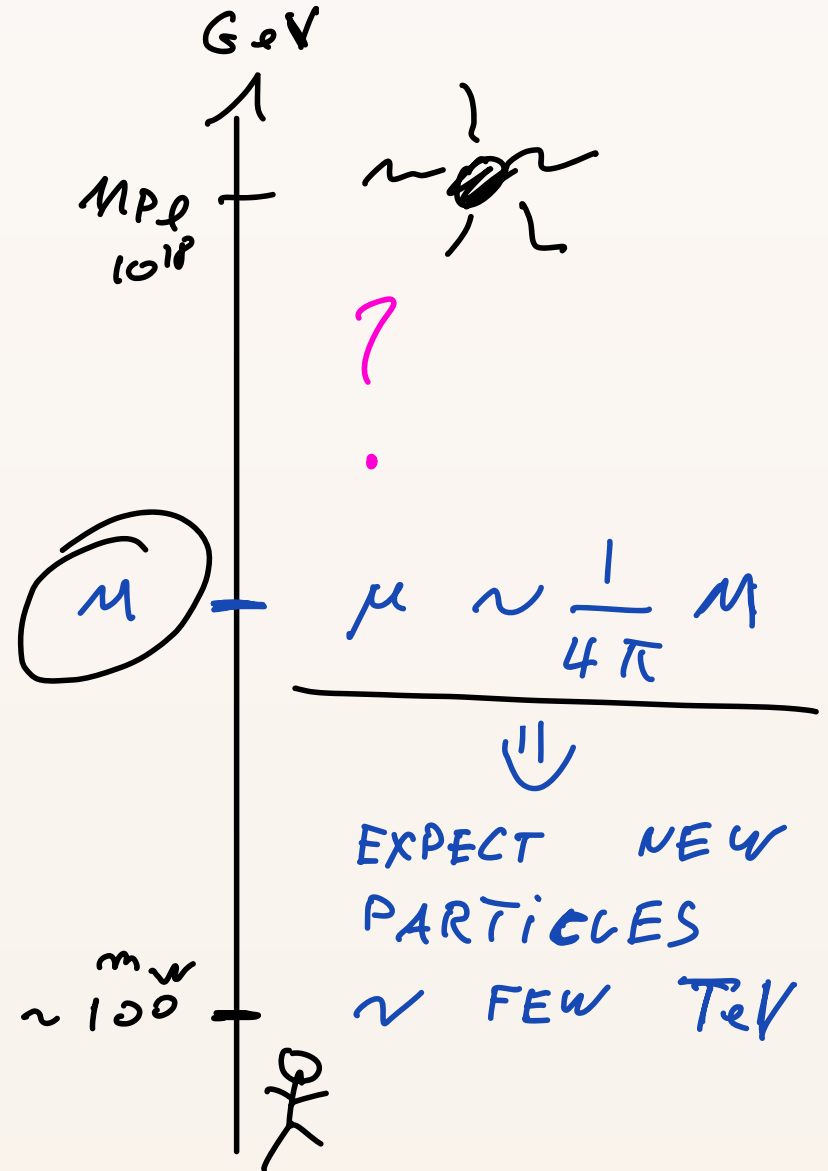
$$V(\phi) = \boxed{-\mu^2 h^2} + \lambda h^4 + ???$$



MASS PARAMETER NOT
CALCULABLE IN
STANDARD MODEL

IN ALL KNOWN EXTENSIONS
(e.g. SUPERSYMMETRY)

μ IS EXTREMELY
SENSITIVE TO SHORT
DISTANCE PHYSICS



ELECTROWEAK STATES

HIGGS

$$H = \begin{pmatrix} G^\pm \\ iG^0 + h \end{pmatrix}$$

→ W^\pm, Z LONGITUDINAL MODES

A SECOND HIGGS

(SU(2) DOUBLET)

$$H' = \begin{pmatrix} H'^{\pm} \\ H'^0 + iA'^0 \end{pmatrix} \Rightarrow \text{PHYSICAL STATES}$$

ANY NEW STATE WITH WEAK CHARGE HAS AT
 LEAST 1 ELECTRICALLY CHARGED PARTICLE

DIRECT

PRODUCTION

$e^+ e^-$

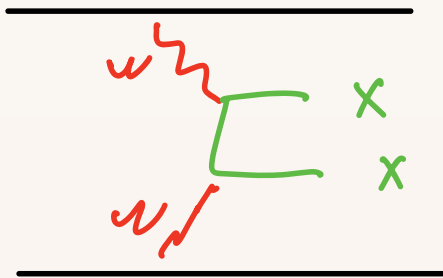
$\mu^+ \mu^-$

$P P (q \bar{q})$

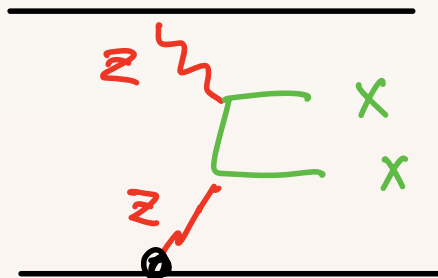
$e^- e^-$

$\mu^+ \mu^+$

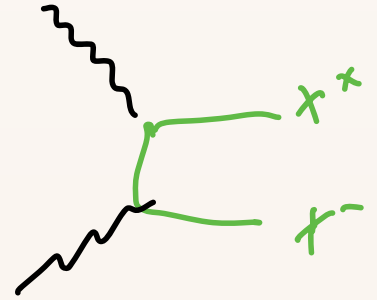
$\gamma\gamma$



$>$



$>$



LUMINOSITY ·

\mathcal{Q}

ENERGY

MATTER

$$(1 - 4 \sin^2 \Theta_w)$$

↑ 0.23

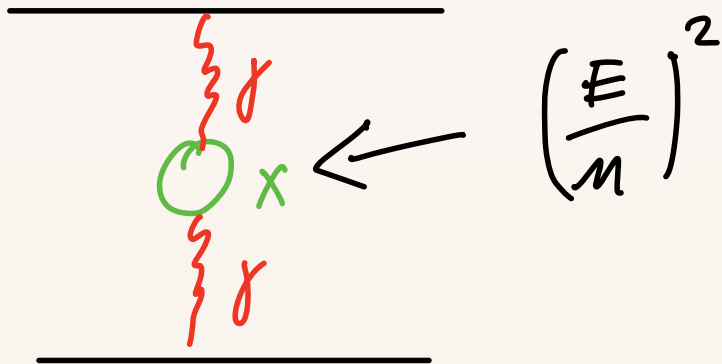
INDIRECT DETECTION

WHAT IF OUR COLLIDER DOESN'T HAVE ENOUGH ENERGY? \Rightarrow PRECISION MEASUREMENTS

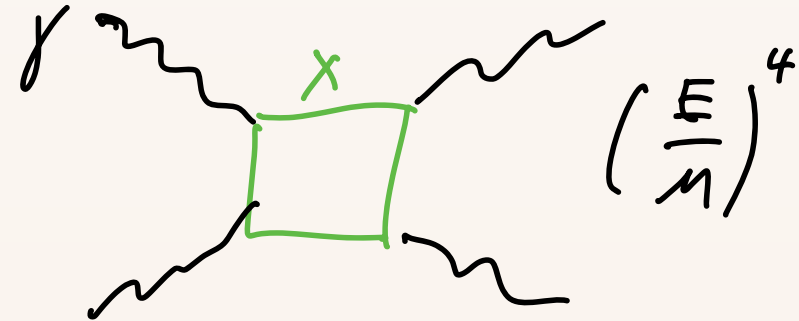
e^+e^- , e^-e^-
 $\mu^+\mu^-$, $\mu^+\mu^+$

$$E < M$$

$\delta\delta$

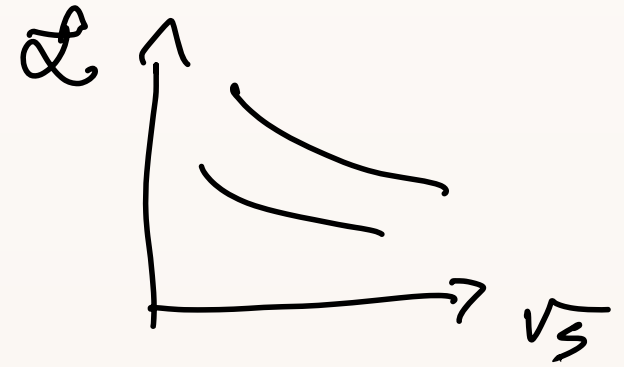


MÖLLER SCATTERING



LIGHT-BY-LIGHT
SCATTERING

TEAM



Weishuang Linda Xu



Inbar Savoray



So Chigusa

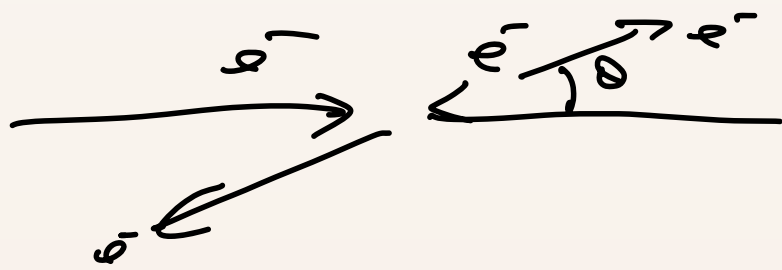


Christiane Scherb



Toby Opferkuch
(faculty at SISSA)

- ATAP : LUMINOSITY PROFILE
- ATLAS : DET. ACCEPT. & RESOLUTION



FOR FCC-00

$e^- e^+$ @ 91 GeV

5×10^{12} Z BOSONS



Kevin Langhoff

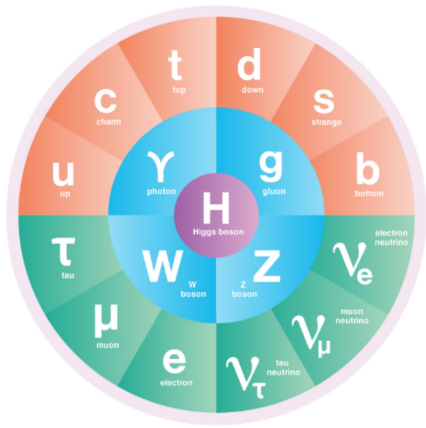
PRECISION Z MEASUREMENTS

VERY PROMISING



Zoltan Ligeti

SEE KEVIN'S TALK DURING TOMORROW'S
ATLAS LUNCH



● QUARKS ● LEPTONS ● BOSONS ● HIGGS BOSON

