

BSM @ CERN TH

Roberto Contino

Cern TH Retreat, 5-7 November, 2014

THE GOAL OF OUR RESEARCH

Going *beyond* the current description of the fundamental interactions among particles and resolve the (many) theoretical open issues

- dynamical origin of the weak scale
- Dark Matter in the universe
- Baryogenesis
- origin of flavor
- strong CP problem
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Two directions:

1. Model building
2. study of model phenomenology (including collider phenomenology)

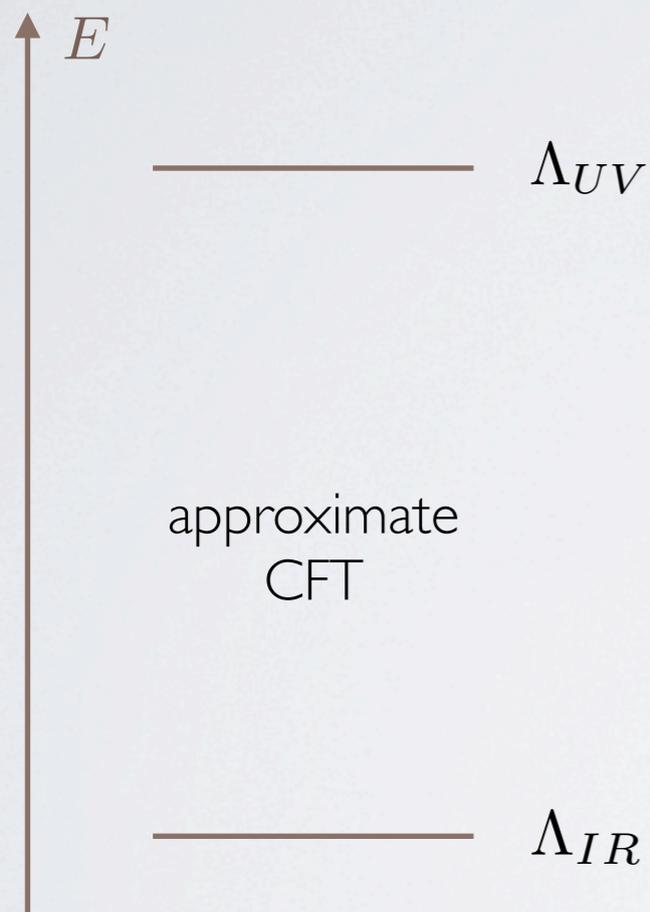
THE PUZZLE OF THE WEAK SCALE

The plausibility of a large separation between UV (microphysics) and IR (macrophysics) scales is connected to the existence of relevant deformations (singlet operators)



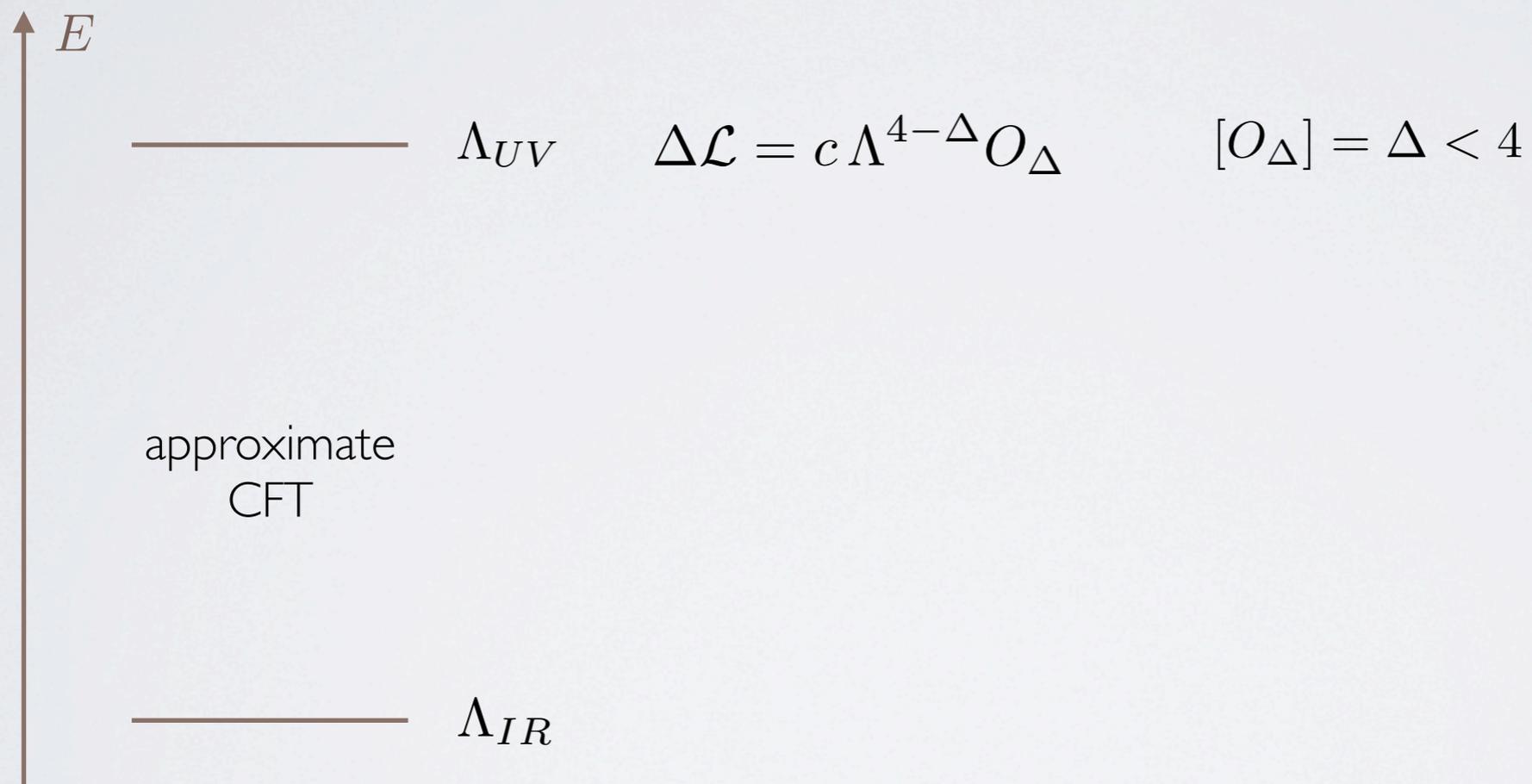
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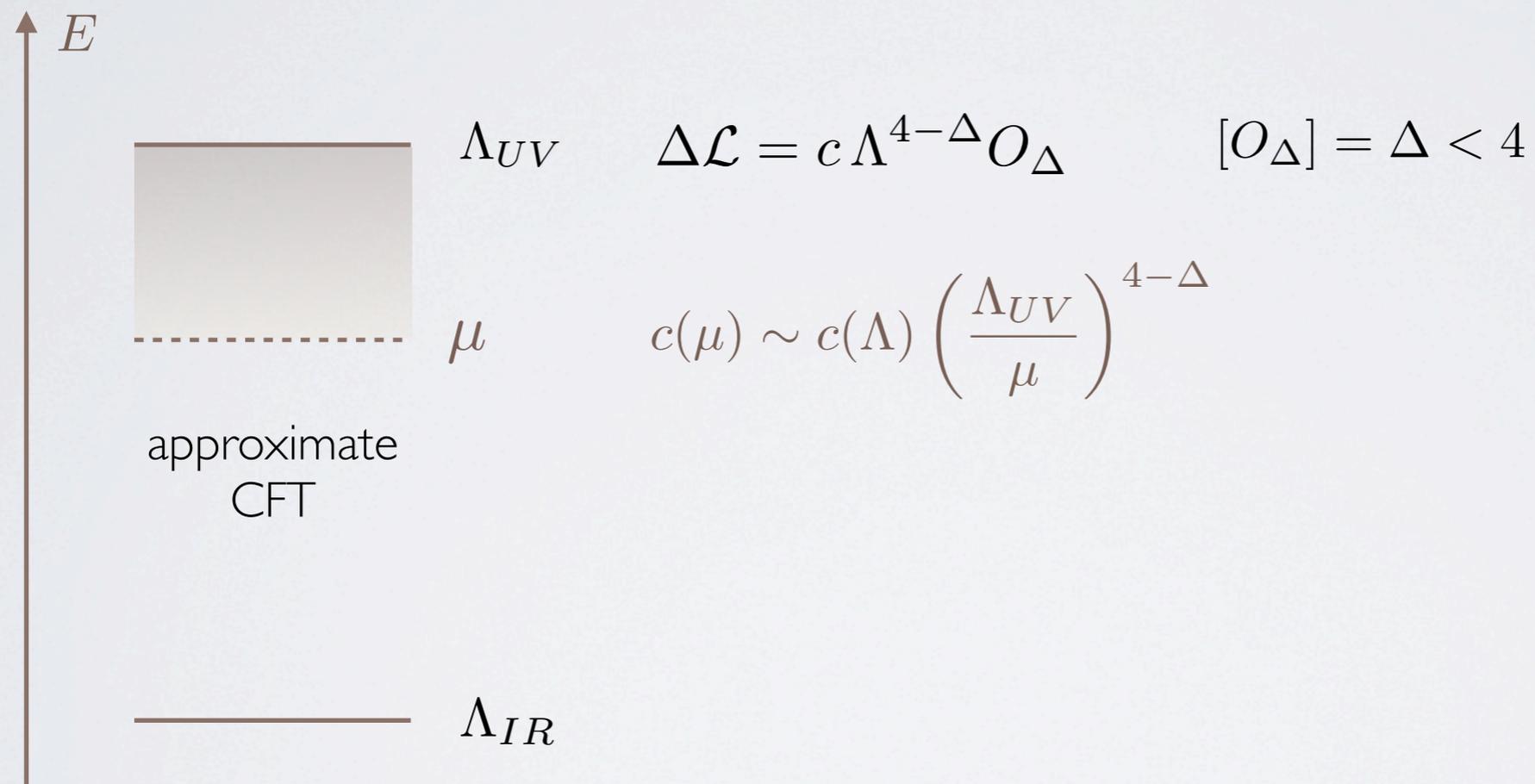
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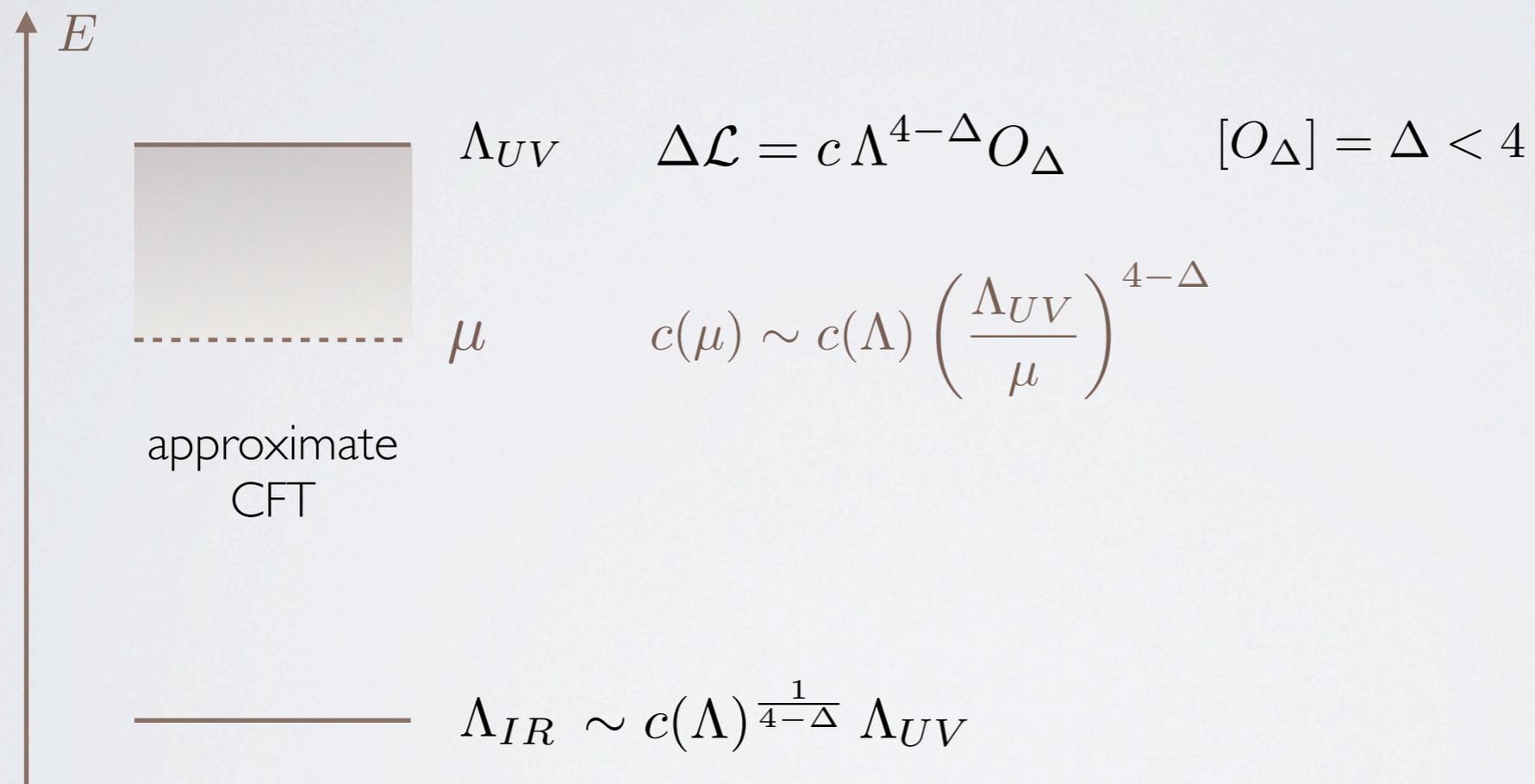
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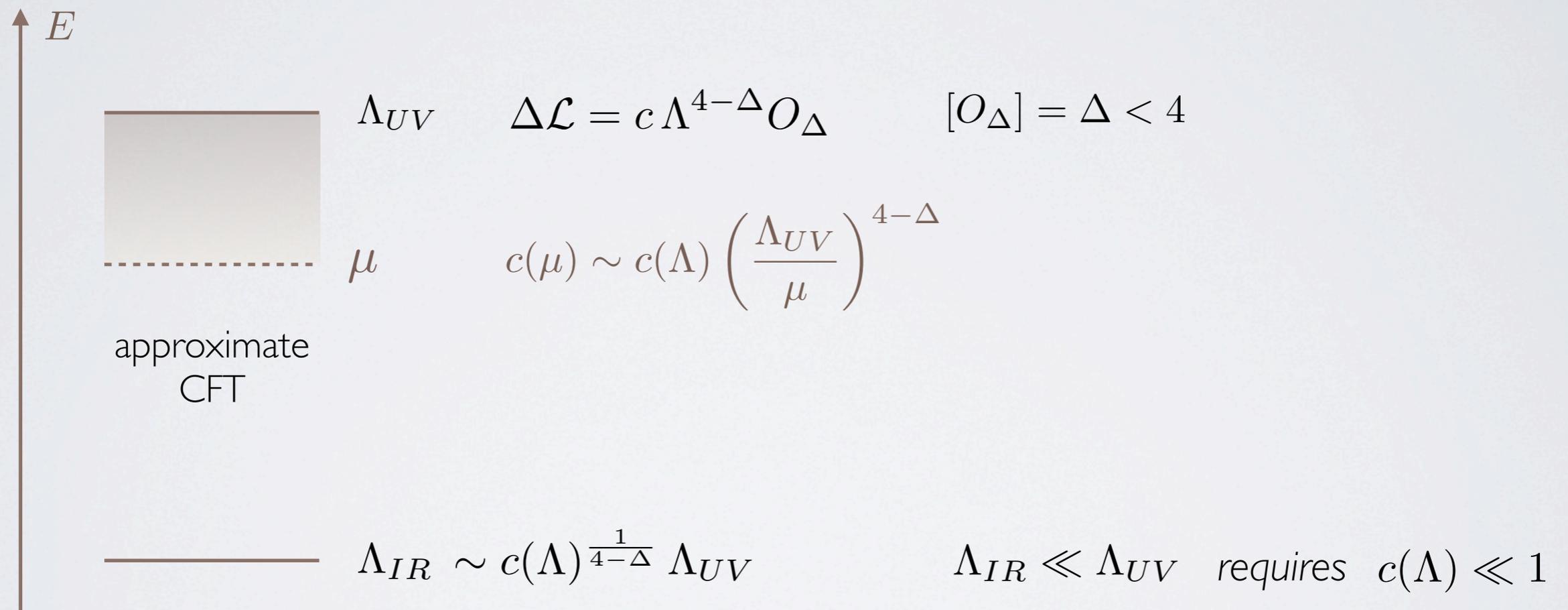
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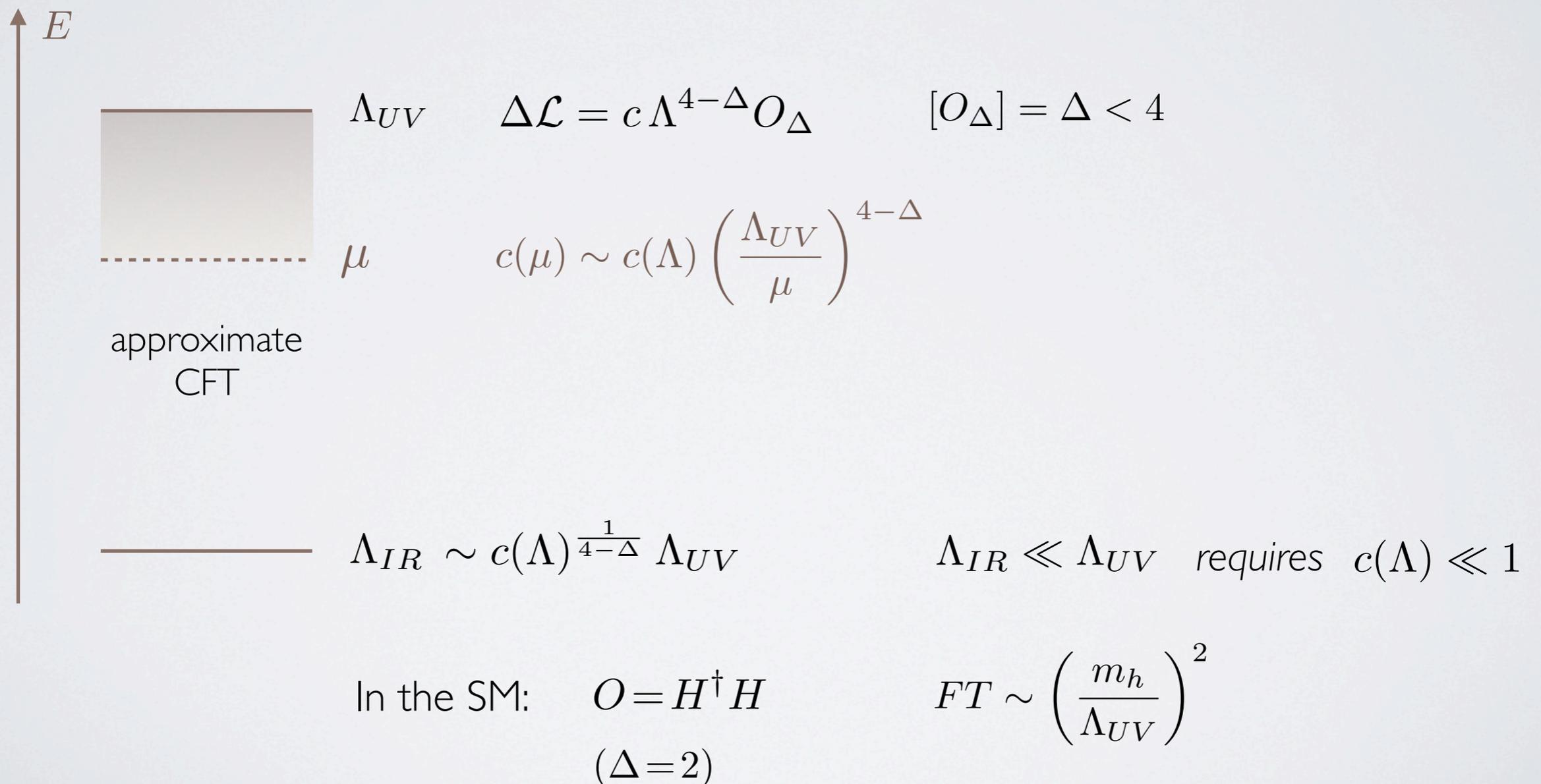
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Two solutions:

- I. SM replaced by a theory with no relevant (unprotected) operators

Ex: Higgs compositeness

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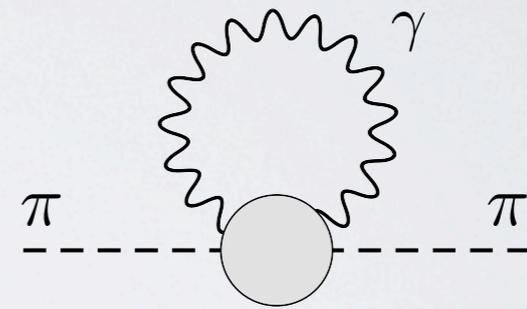
Ex: Higgs compositeness

Analogy with pion mass:

$$V(|\pi^+|) = \frac{3e^2}{32\pi^2} \sin^2\left(\frac{|\pi^+|}{f_\pi}\right) \int_0^\infty dQ^2 \Pi_{LR}(Q^2)$$

$$\langle A^a A^b \rangle - \langle V^a V^b \rangle = \delta^{ab} (P_T)_{\mu\nu} \Pi_{LR}(q^2)$$

$$J_\mu^A(x) J_\nu^B(0) = (\eta_{\mu\nu} \partial^2 - \partial_\mu \partial_\nu) \left[\frac{C_J \delta^{AB}}{(x^2)^2} + \sum_{\mathcal{O}} \frac{\Gamma_C^{AB}}{(x^2)^{2-\Delta_{\mathcal{O}}/2}} \mathcal{O}(0) \right]$$



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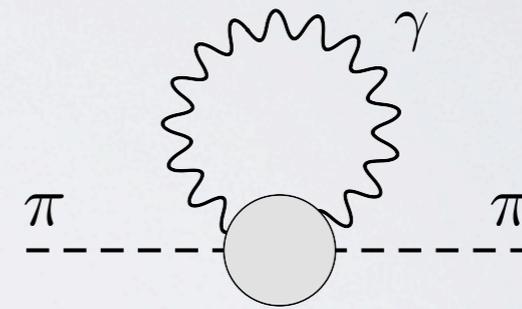
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Degree of convergence depends on dimension of leading operator appearing in the OPE

$$\Pi_{LR}(Q^2) \sim \frac{1}{(Q^2)^{\Delta/2-1}}$$

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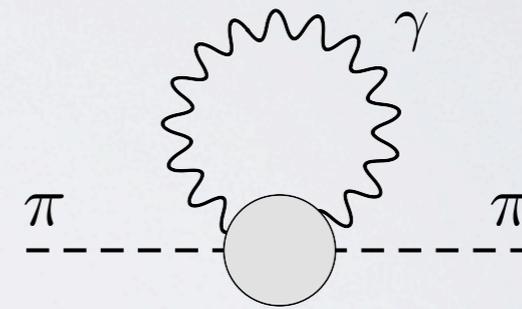
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$$\Pi_{LR}(Q^2) \sim \frac{1}{(Q^2)^{\Delta/2-1}}$$

$$\mathcal{O} = (\bar{q}\Gamma_1 q)(\bar{q}\Gamma_2 q) \quad \Delta = 6$$

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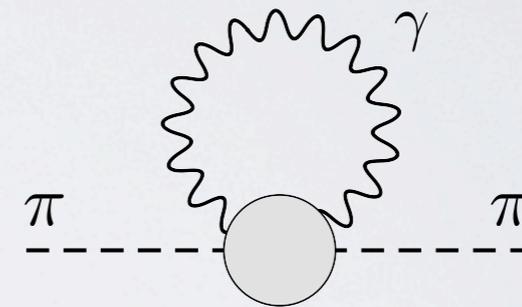
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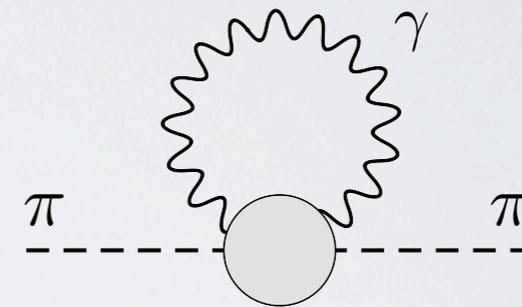
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Notice: $O = \bar{q}(x)q(x)$ contributes at tree level relevant but protected by chiral symmetry



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$\Delta > 4 \rightarrow$ finiteness

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Ex: Higgs compositeness

2. Relevant operators are protected by a symmetry

Ex: Supersymmetry, gauge-Higgs unification

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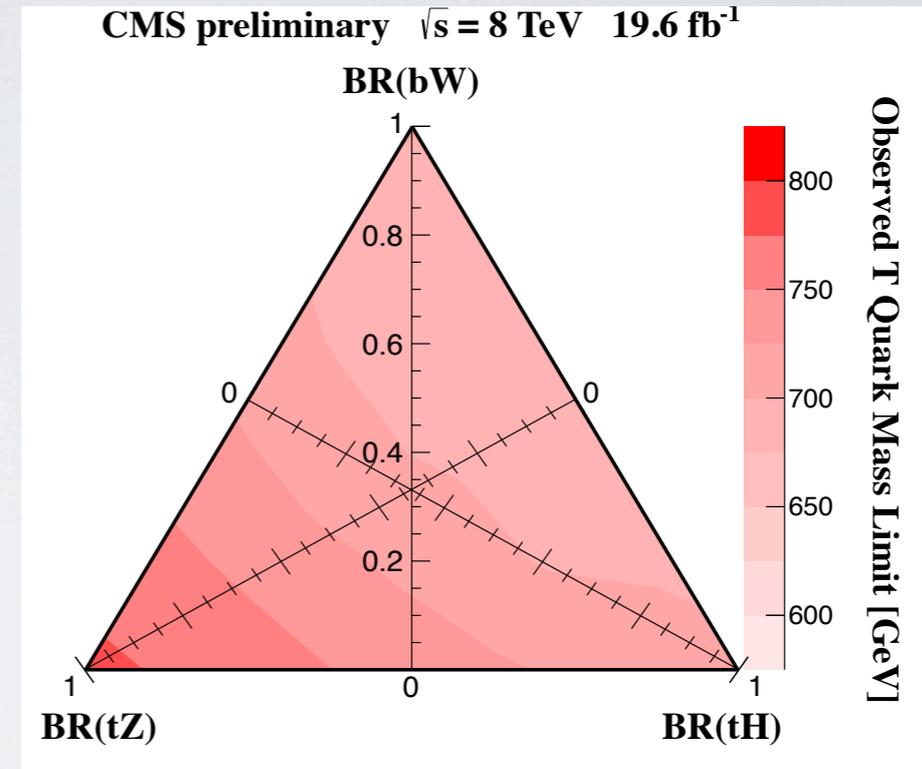
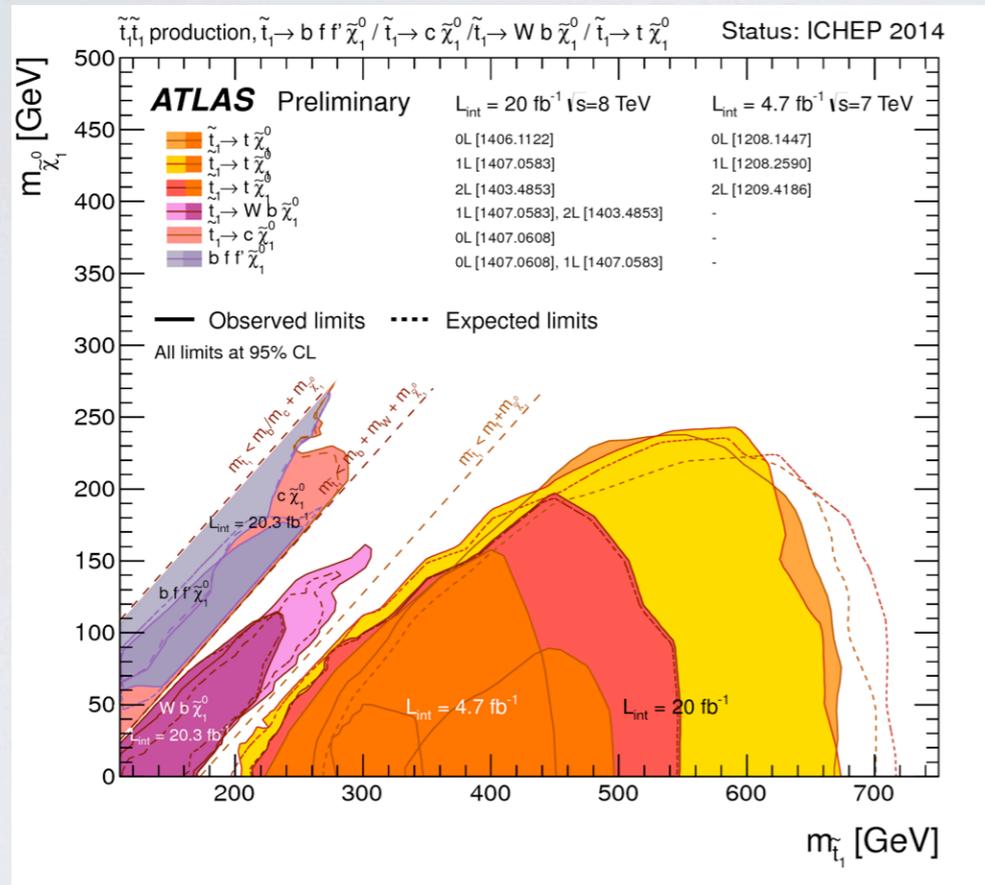
Ex: Supersymmetry, gauge-Higgs unification

One workaround:

Environmental selection (aka: the Landscape)

Both solutions require new physics at the TeV scale ...

... but *none* found so far



top/bottom partners in CH: $m_T \gtrsim 1 \text{ TeV}$

stops in SUSY: $m_{\tilde{t}} \gtrsim 700 \text{ GeV}$

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Study of Higgs properties can also probe EWSB dynamics

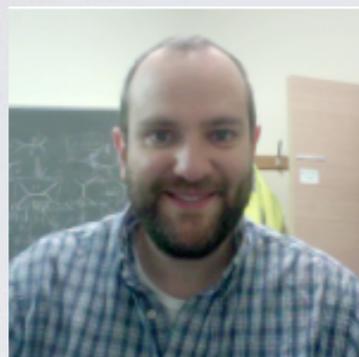
- so far focus has been mostly on on-shell production and decay ($2 \rightarrow 1$)
- next frontier for LHC Run2: measure $2 \rightarrow 2$ to test directly strength of EWSB dynamics (off-shell processes)

Ex: hh , Vh , $VV \rightarrow VV$, $gg \rightarrow VV$, $gg \rightarrow hg$,

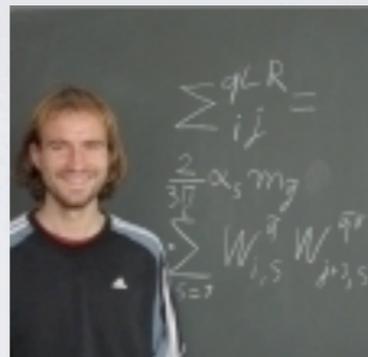
BSM FELLOWS



Aleksandr Azatov '13



Brian Batell '14



Andreas Crivellin '14



Roberto Franceschini '14



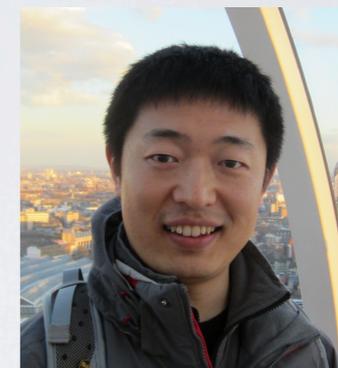
Florian Goertz '14



Ian-Woo Kim '13



Hye-Sung Lee '14



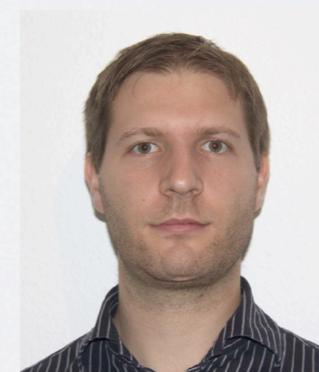
Feng Luo '14



Florian Staub '14



Daniel Stolarski '13

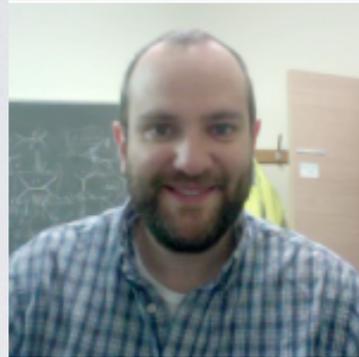


Alessandro Vichi '14

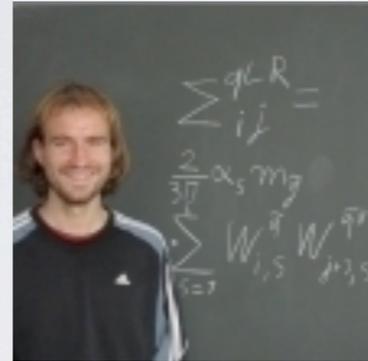
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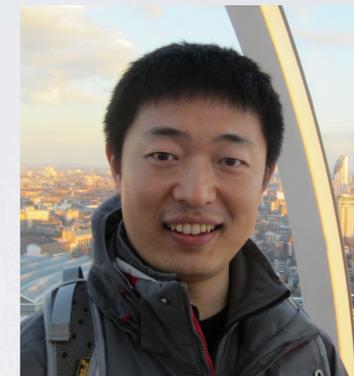
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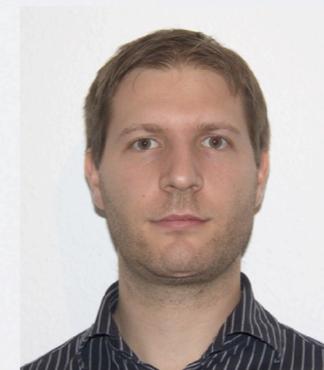
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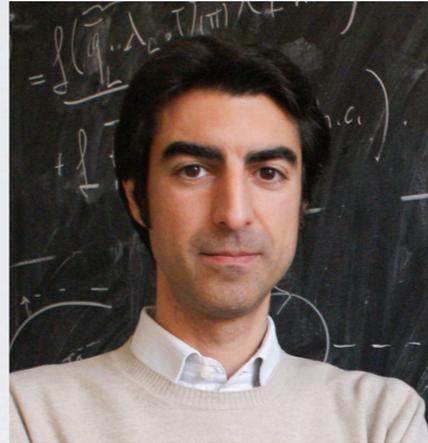


Alessandro Vichi '14

BSM STAFF



Gian Giudice



Roberto Contino 13



Andrey Katz 14



Andreas Weiler 13

ASSOCIATES, REGULAR VISITORS, EMERITI

former permanent staff

- Guido Altarelli
- John Ellis

from nearby EPFL, Lausanne:

- Rakhi Mahbubani
- Riccardo Rattazzi
- Francesco Riva
- Mikhail Shaposhnikov
- Minho Son

Associates and regular visitors

- Alexandre Arbey
- Cliff Burgess
- Giancarlo D'Ambrosio
- Antonio Delgado
- Abdelhak Djouadi
- Nazila Mahmoudi
- Fabio Zwirner

ACTIVITIES/SEMINARS

- Particle and Astroparticle seminars (on Fridays)
- BSM Forum (on Thursdays)
- Collider X-talk (on Thursday mornings)

- FCC-hh meetings and workshops

ABOUT MYSELF

My position: • Joint Cern/EPFL staff

Research interests:

- EWSB and Higgs physics
- BSM model building
- collider phenomenology

Duties:

- organizer of Friday seminars (with S. Frixione and A. Patella)
- convener of the Higgs and EWSB subgroup of the FCC-hh study (with Heather Gray)
- Theory coordinator of Doctoral Program in Physics for Suisse Romande (CUSO) - see: <http://physique.cuso.ch>
- organizer of the GGI Ph.D. school in Theoretical Physics



GGI LECTURES ON THE THEORY OF FUNDAMENTAL INTERACTIONS

Galileo Galilei Institute for Theoretical Physics
Firenze

12-29 JANUARY 2015

GGI LECTURES ON THE THEORY OF FUNDAMENTAL INTERACTIONS

12-29 January 2015

Galileo Galilei Institute for Theoretical Physics Firenze

The lectures are primarily addressed to Ph.D. students in High Energy Particle and Astroparticle Physics. Participation of post-docs is also encouraged. The aim of the school is to give a pedagogical introduction to the basic concepts and tools needed for research, covering the foundations of the subject at a deep and advanced level. Lectures will be given on the blackboard.

The courses will be officially part of the Italian Ph.D. training program for the universities that have joined the initiative. For this purpose there will be the possibility of a final exam with the lecturers.

Deadline for applications is 15 November 2014.

Lectures and topics

FERRUCCIO FERUGLIO (Padova U. & INFN)

Neutrino Physics (9 hours)

MICHAEL PESKIN (SLAC)

Collider Physics (10 hours)

RICCARDO RATTAZZI (EPFL)

Particle Physics & the structure of 4D RG flows (8 hours)

VALERY RUBAKOV (INR & Lomonosov Moscow U.)

Early Universe (12 hours)

GIOVANNI VILLADORO (ICTP)

Axions (6 hours)

Organizers

ROBERTO CONTINO (CERN & EPFL)

STEFANIA DE CURTIS (INFN, Firenze)

MICHELE REDI (INFN, Firenze)

ENRICO TRINCHERINI (SNS & INFN, Pisa)

ANDREA WULZER (Padova U. & INFN, Padova)

Home

Program

Registration form

Staying in Firenze

How to reach us

Tourist info

2014 Program

<http://heidi.pd.infn.it/html/GGI/index.php>