Theoretical particle physics at the LHC Era

Department of Physics

University of Arizona

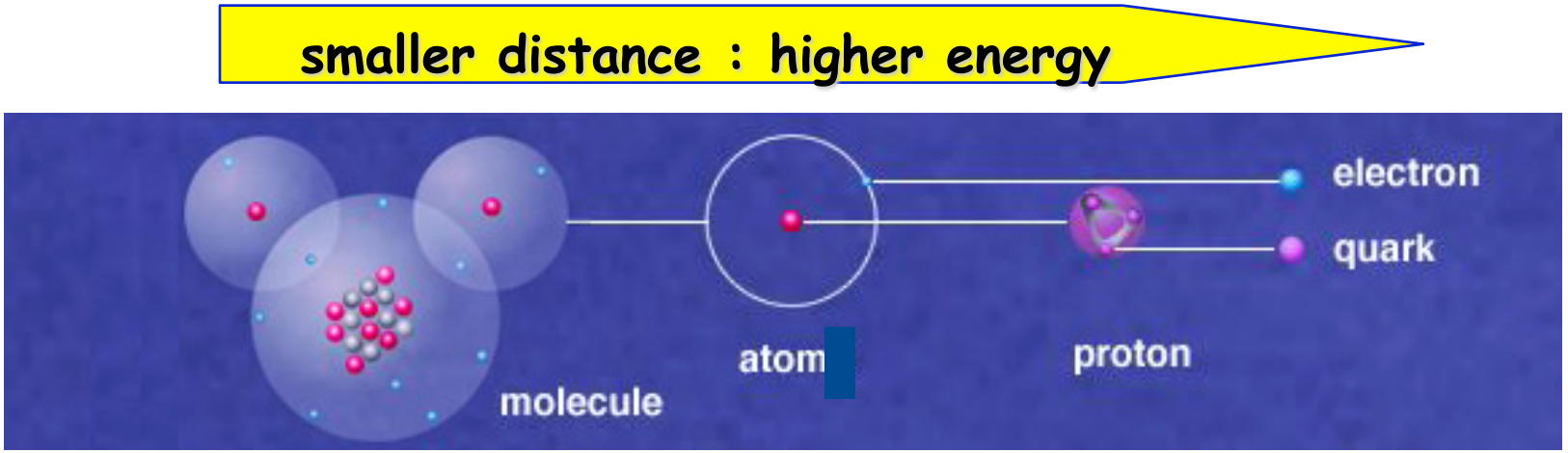
Welcome!

I am Shufang Su.

What's hot in particle physics today?

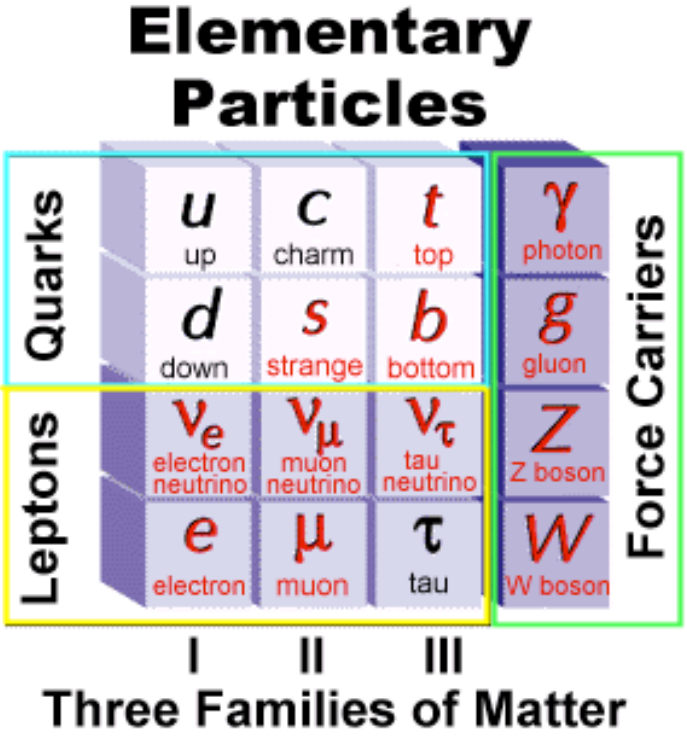
Particles and Forces

- Building blocks of matter -- elementary particles



- Fundamental interactions
  - Gravity
  - Electromagnetic force
  - Weak interaction burning of the sun …
  - Strong interaction holds proton and neutron …

Standard Model of Particle Physics



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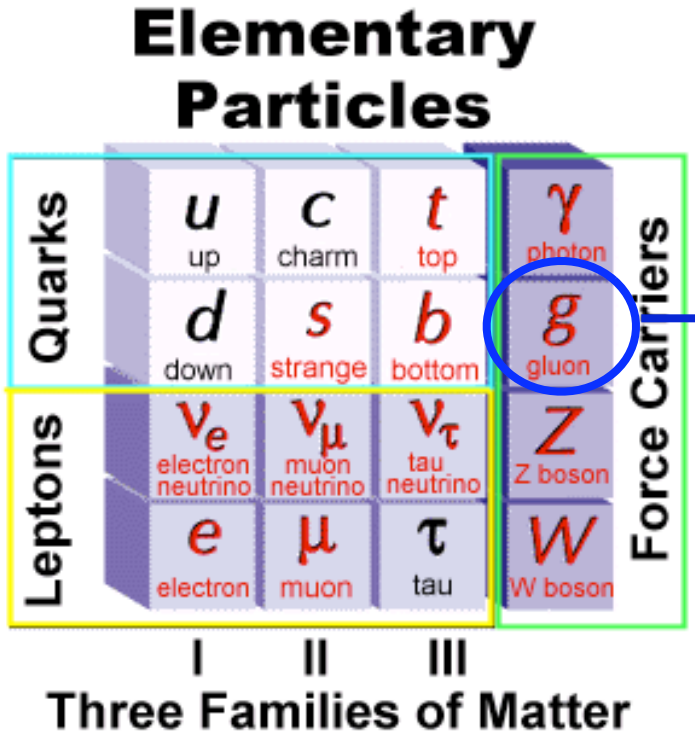

Strong interactions

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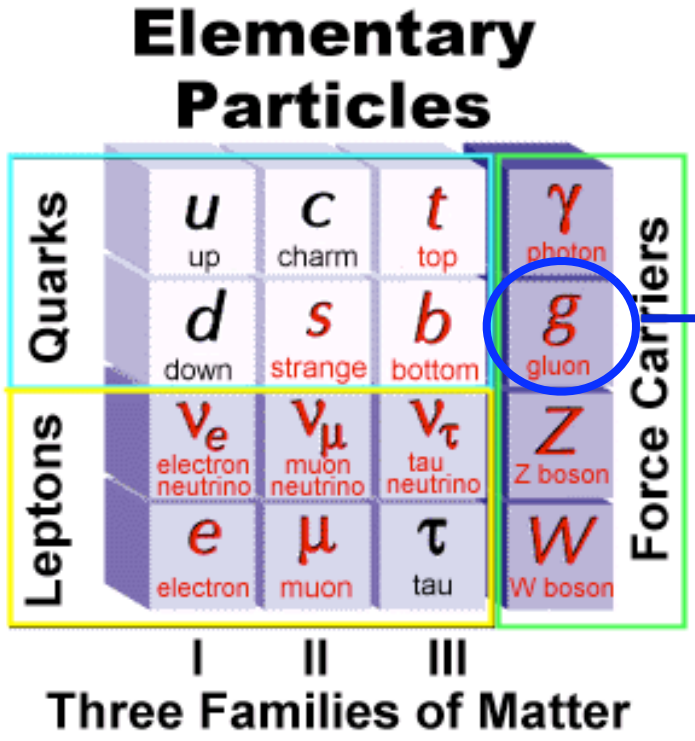

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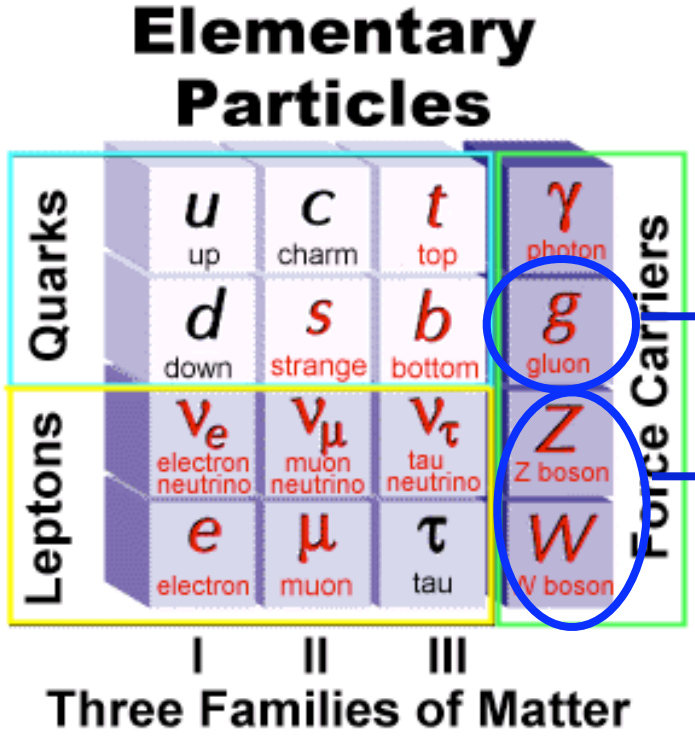
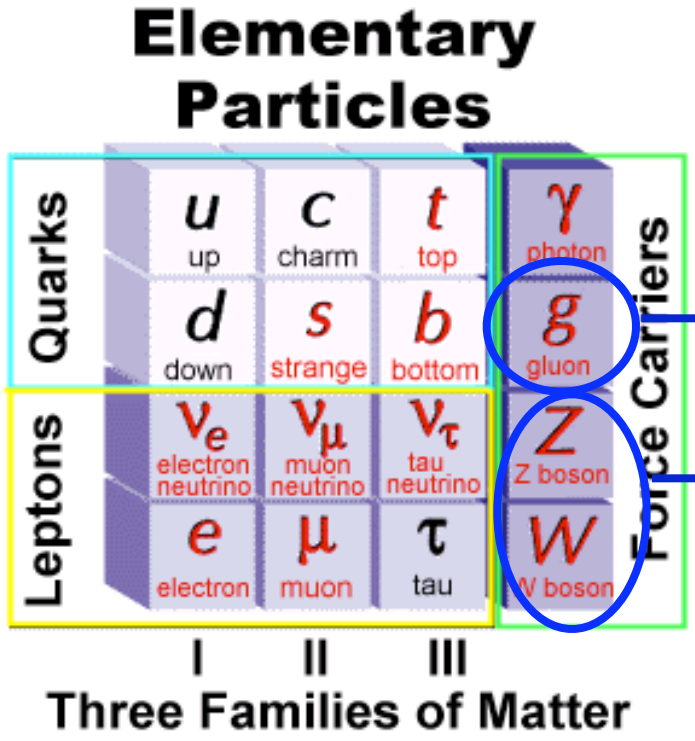


Strong interactions

Origin of mass

Standard Model of Particle Physics



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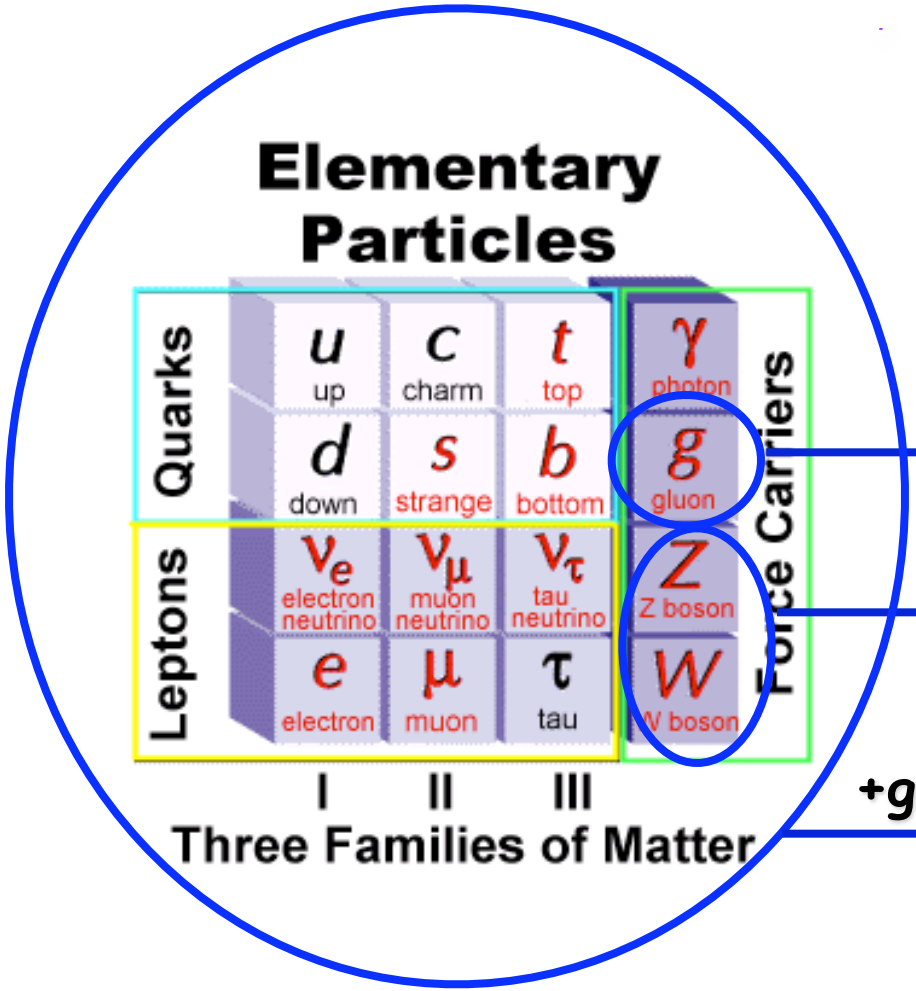

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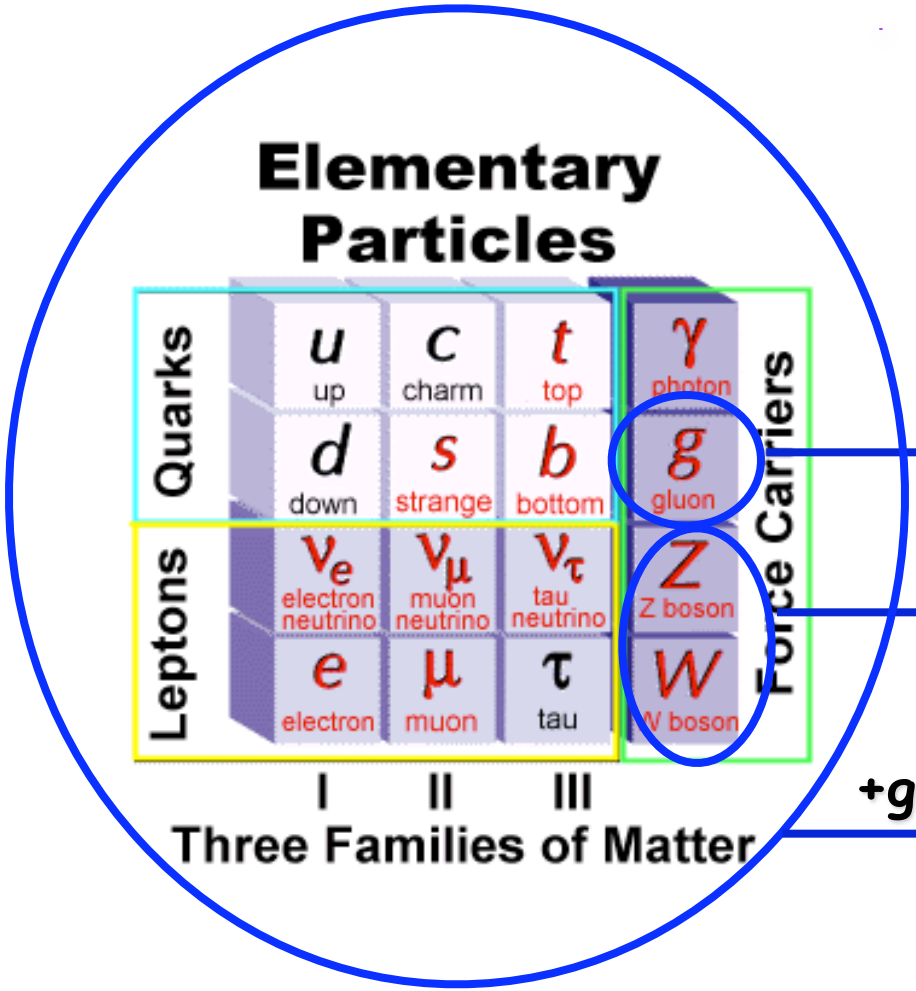
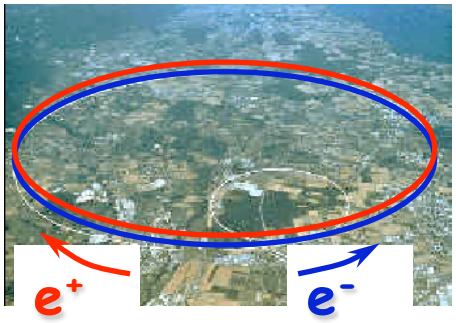


Strong interactions

Origin of mass

Unification

LEP (-2000)



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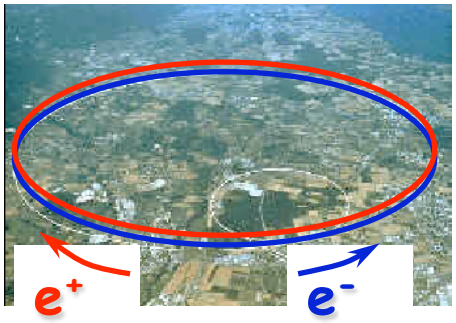
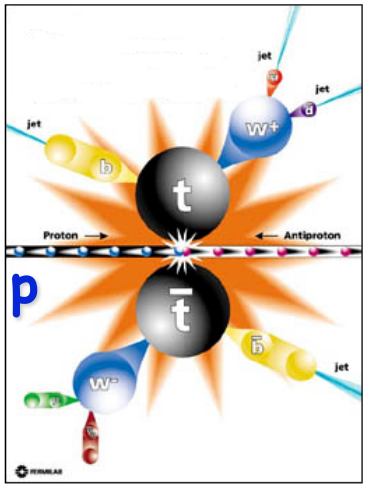


Tevatron (now)



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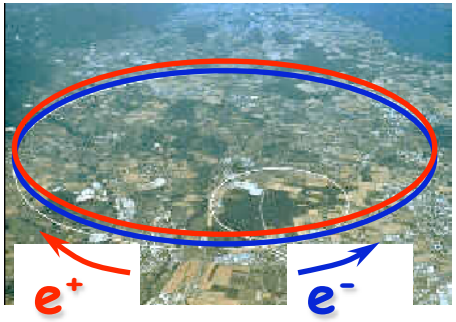

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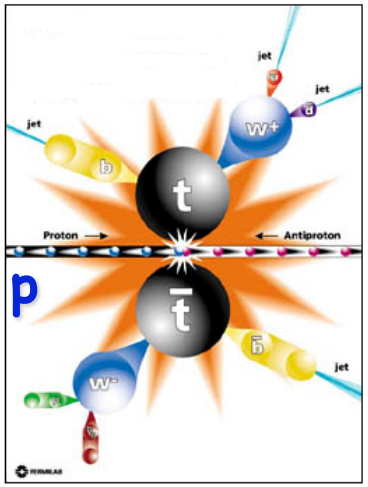
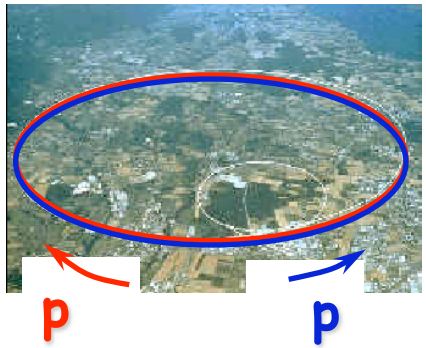


LHC (2008)



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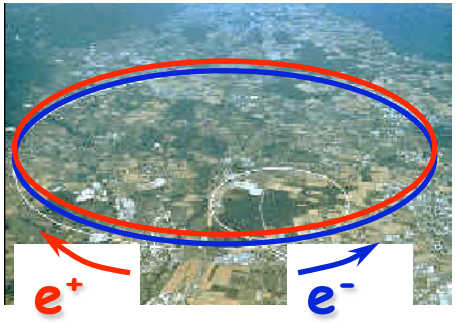

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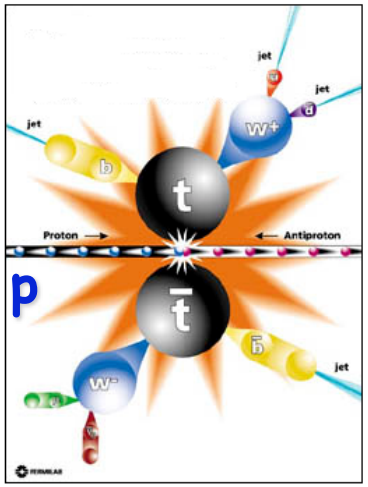

LC

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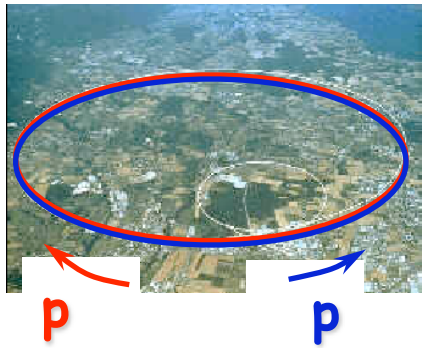

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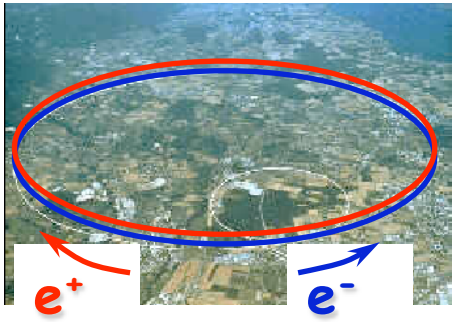

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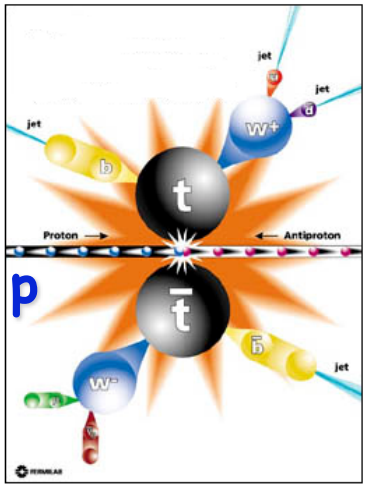

We live in an exciting era when rich data is / will become available

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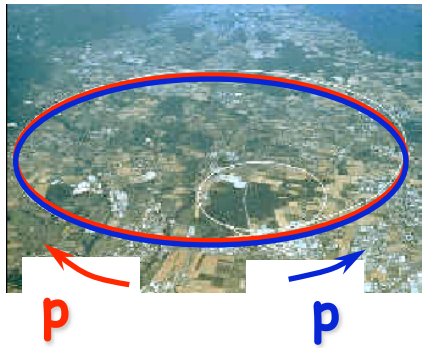

Group

Group Members

- **Faculty:**

Zackaria Chacko

Keith Dienes

Ina Sarcevic

Shufang Su

Doug Toussaint

Group Members

- **Postdocs** (for Dienes, Su and Toussaint)

Current:

Alexei Bazavov (2007) FSU → UA

Brooks Thomas (2007) Michigan → UA

Previous:

Dru Renner (2004-2007) MIT → UA → DESY

Hock-Seng Goh (2004-2007) Maryland → UA → Berkeley

Sabine Hossenfelder (2003-2005) Germany → UA → Santa Barbara

- **Students** (for Dienes, Su and Toussaint)

Sky Bauman
Dienes

Steve Bildstein
Toussaint
(2005)

Chris Krenke
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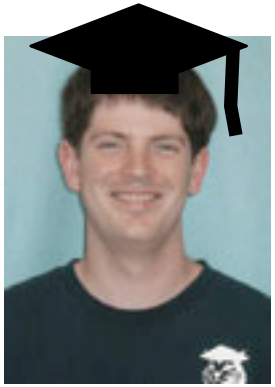

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Dienes
(2007)

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Baran Nosratpour
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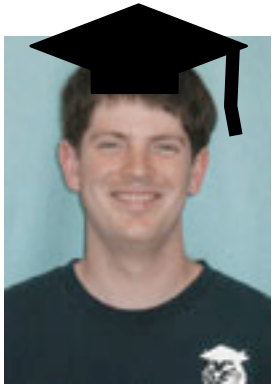

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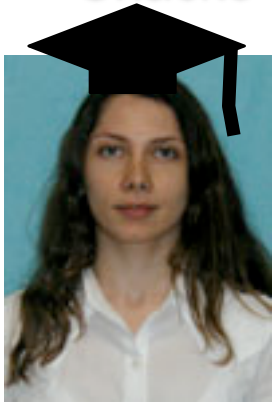


Baran Nosratpour
Chacko

Menika Sharma
Dienes

Vaibhav Wasnik
Dienes

Close research connections to other groups

- **Nuclear physics**

  Barrett, Fleming, van Kolck

- **Heavy Ion**

  Rafelski, Thews

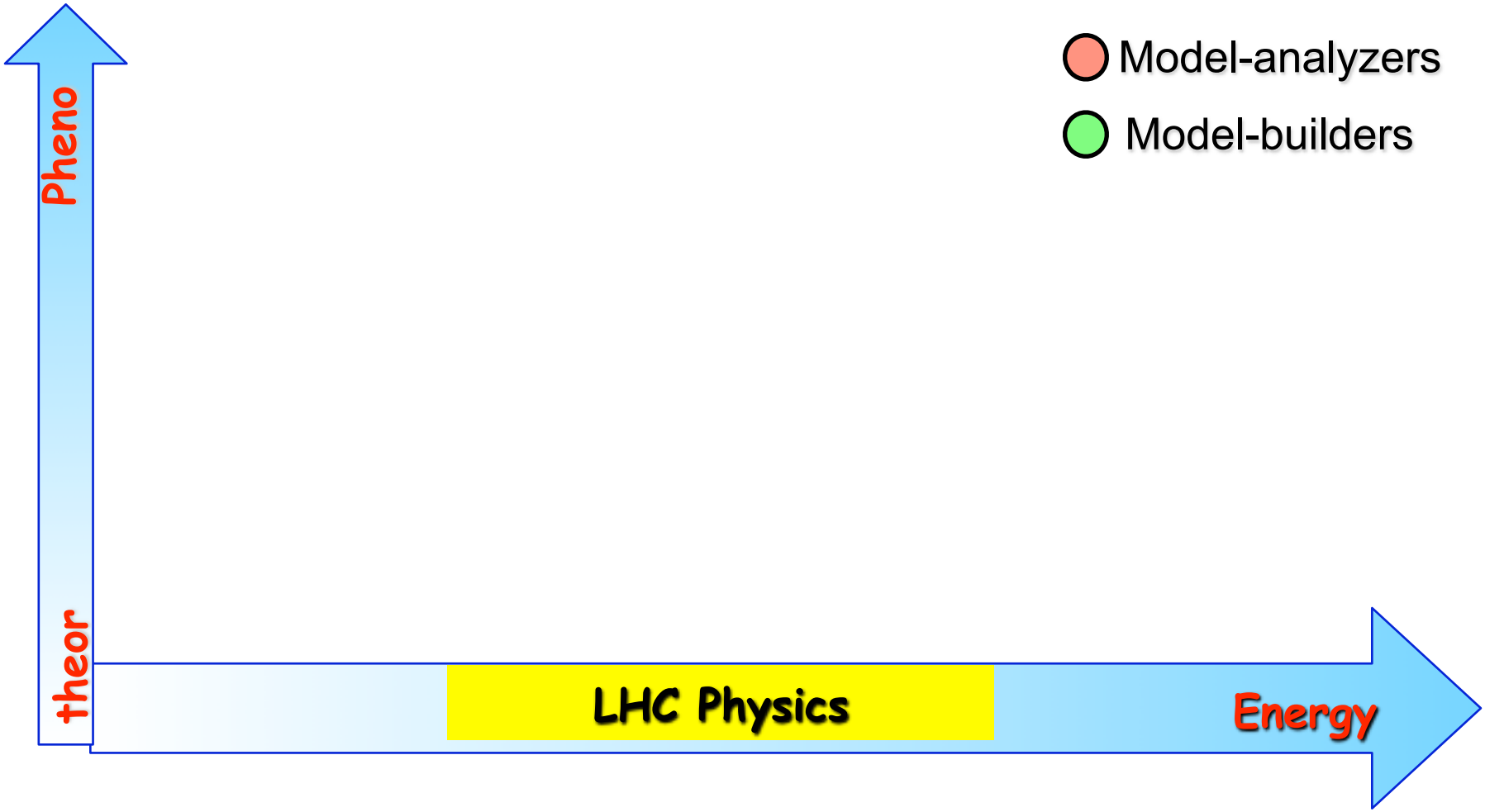
- **Experimental high energy**

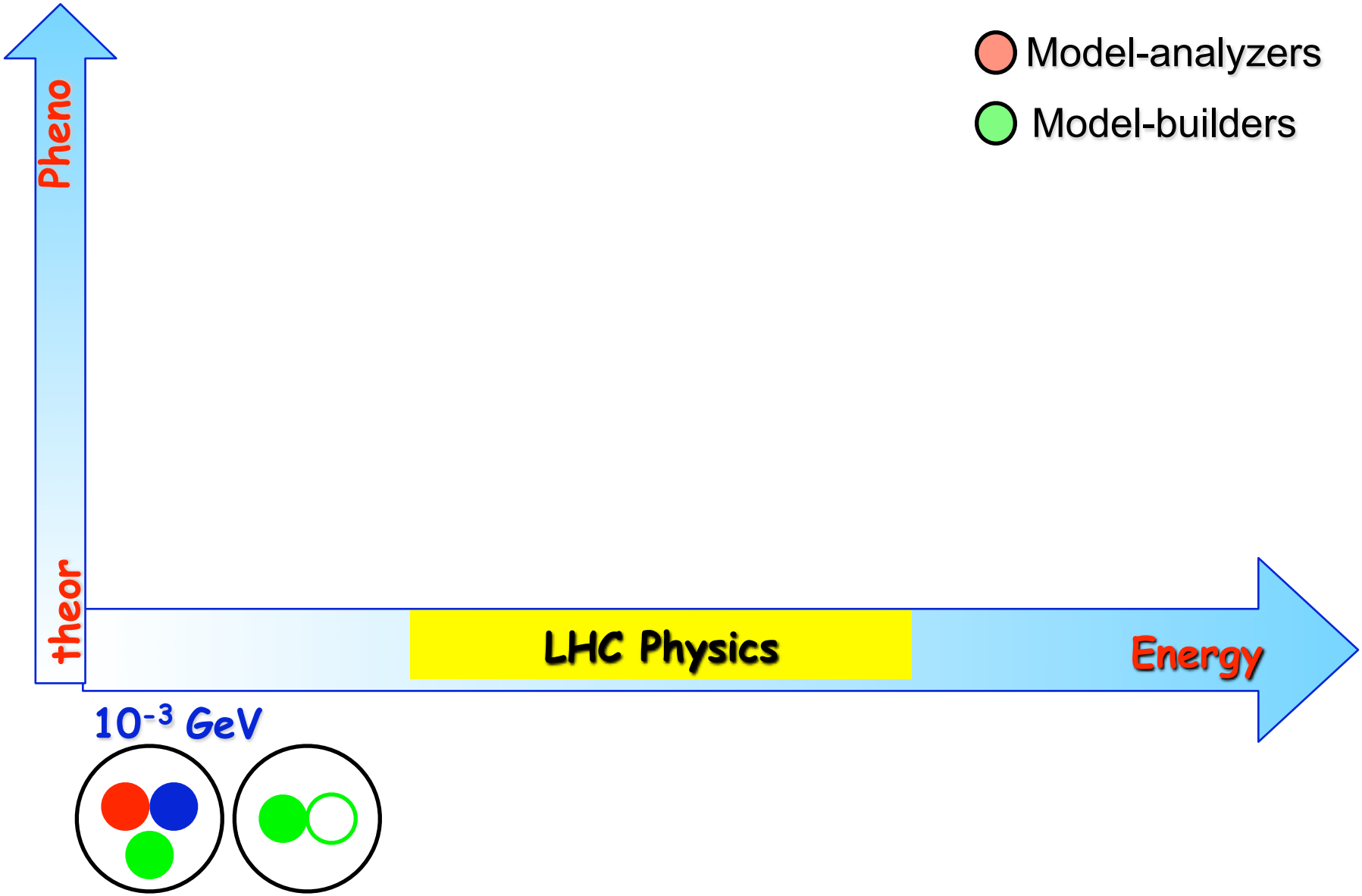
  Rutherfoord, Shupe, Johns, Cheu, Varnes

- **Theoretical astrophysics group**

  Fang, Melia, Ozel, Psaltis

Research


Model-analyzers
Model-builders
Pheno
theor
LHC Physics
Energy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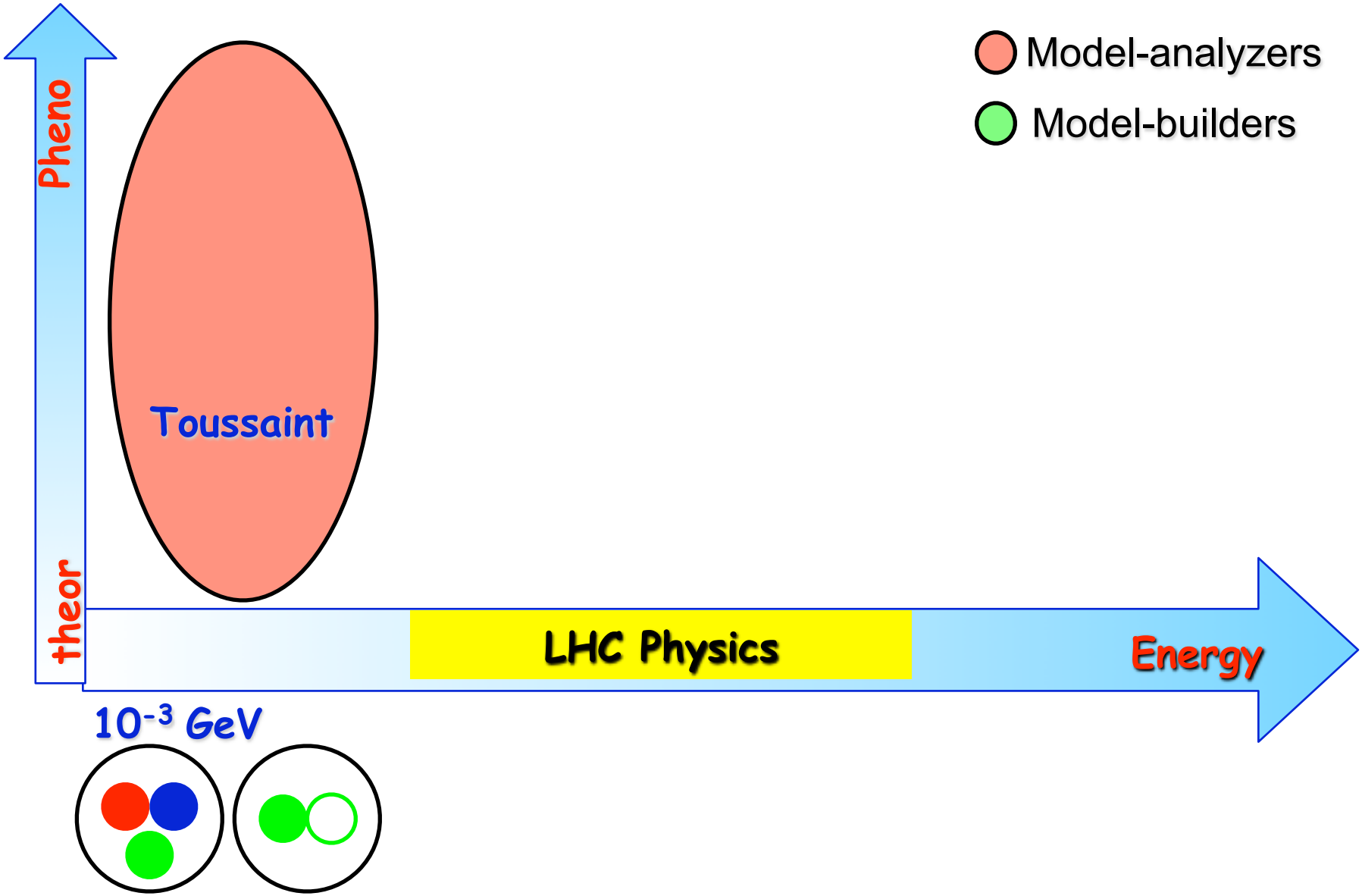
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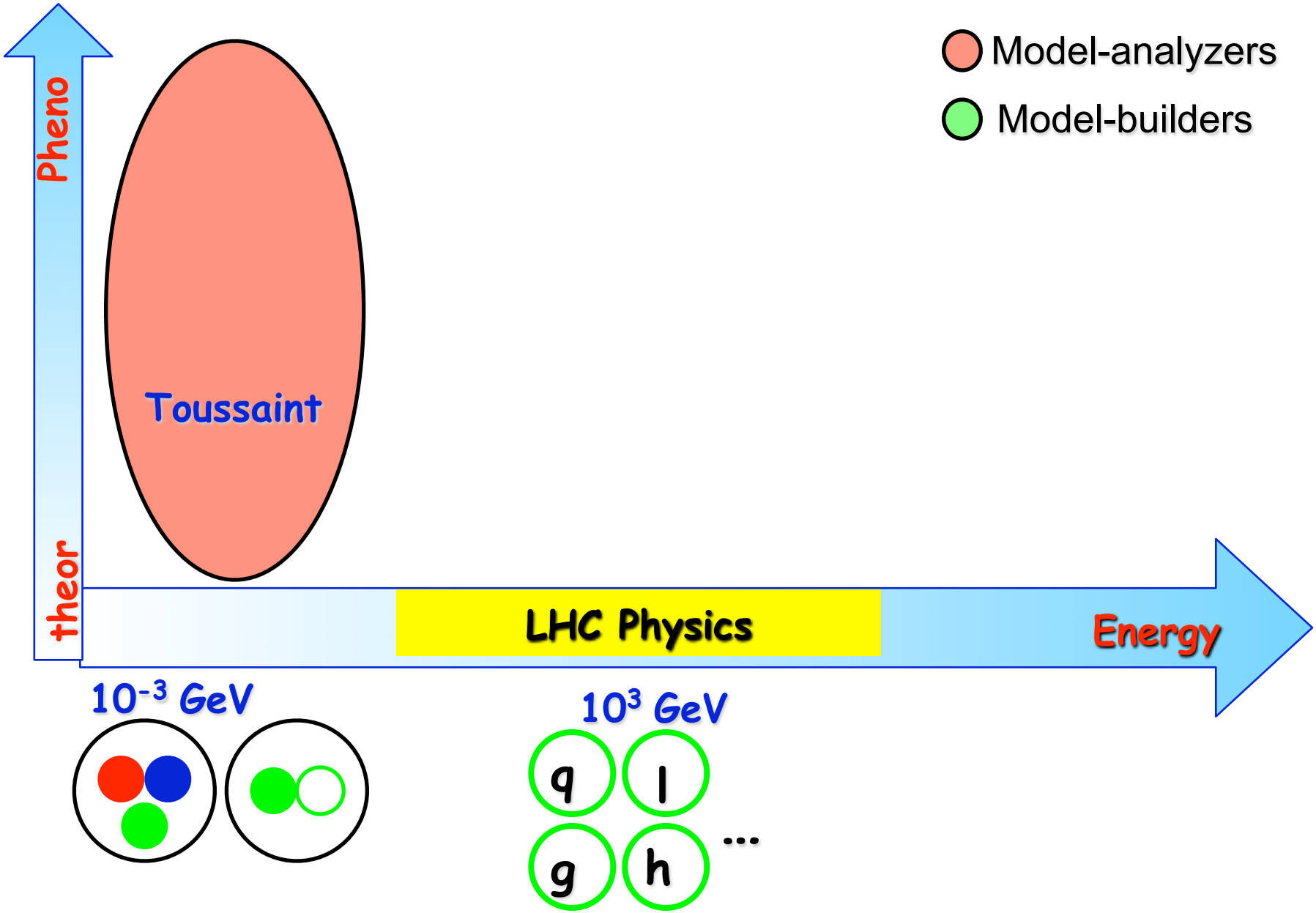
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Energy
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103 GeV
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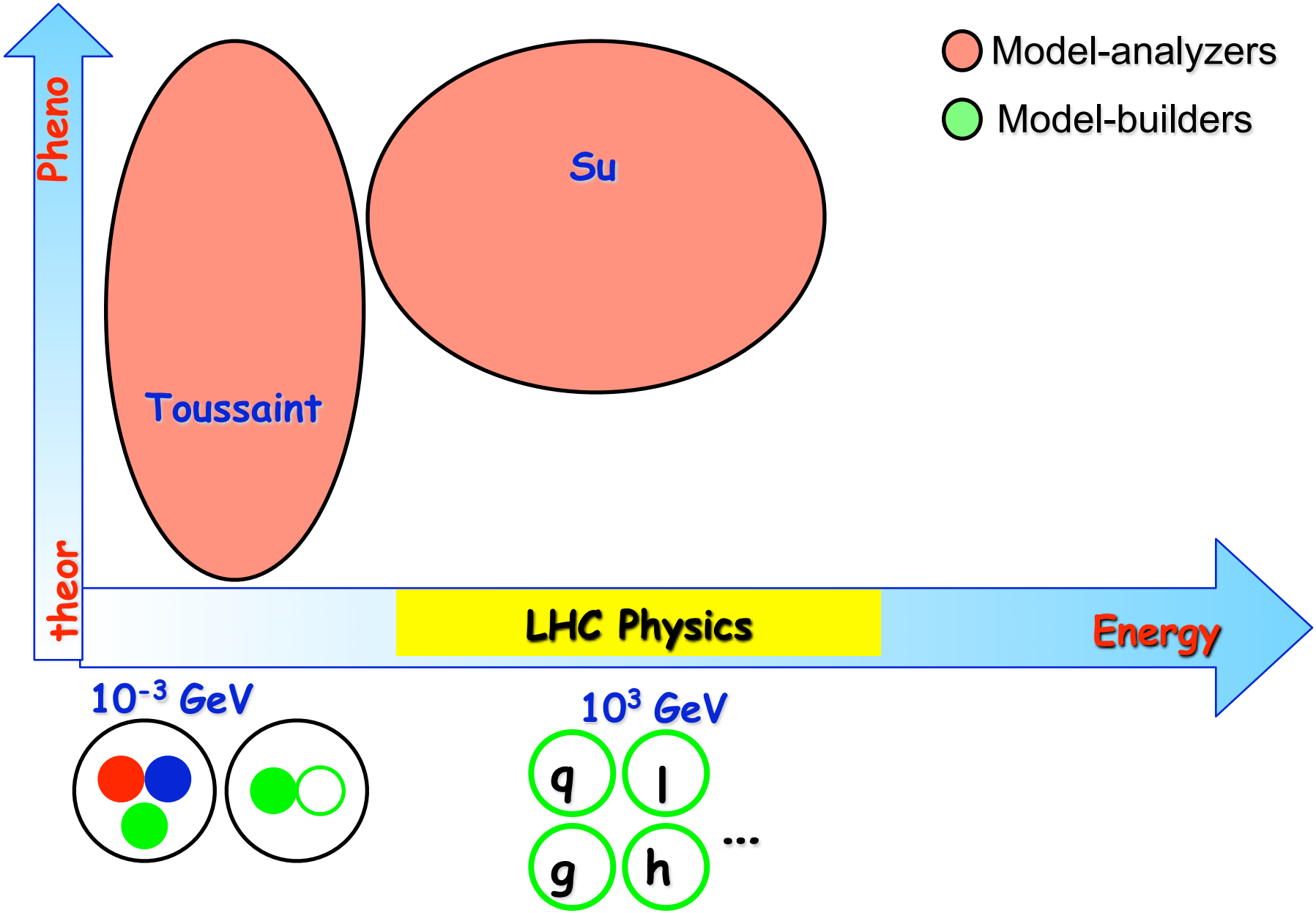
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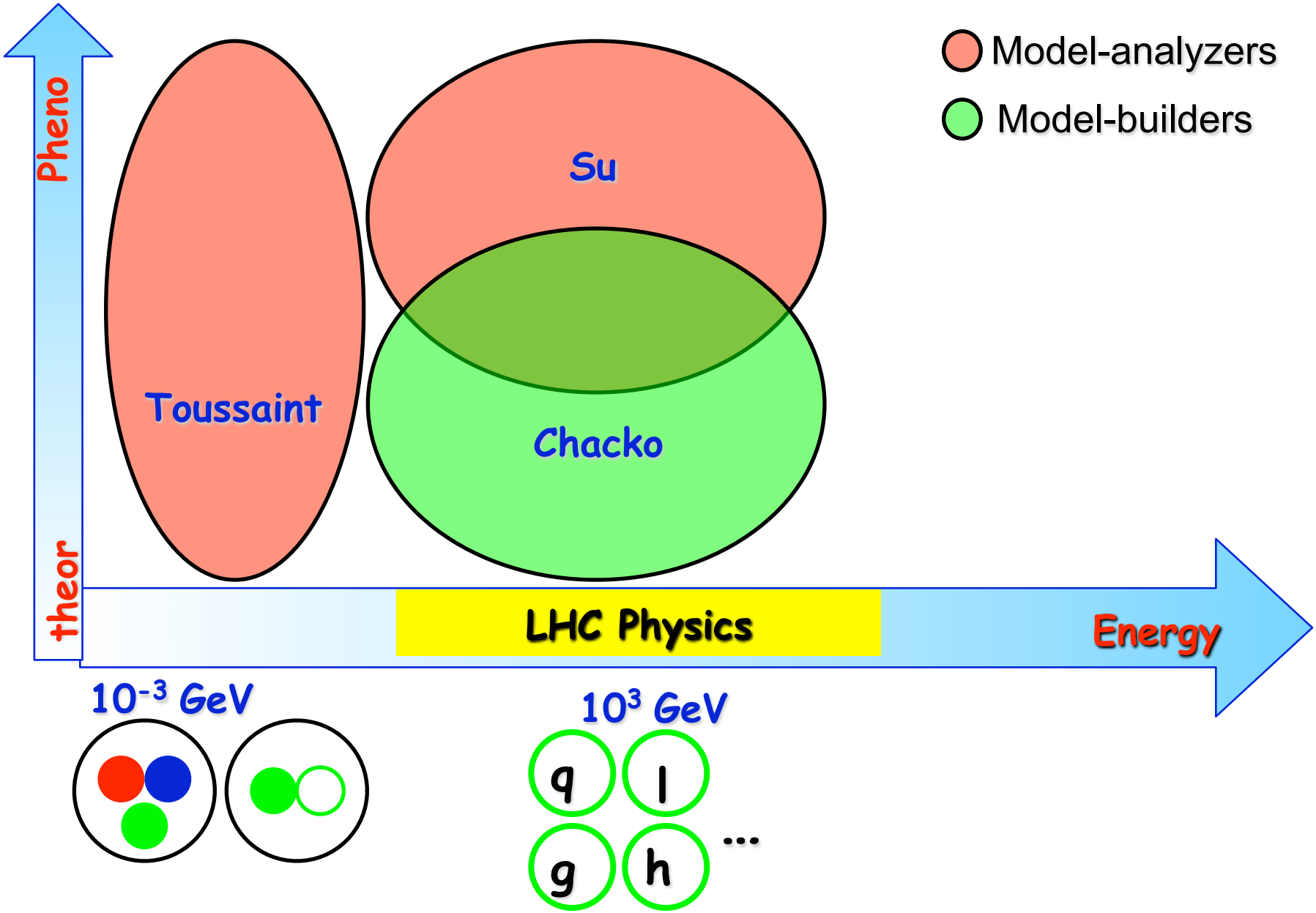
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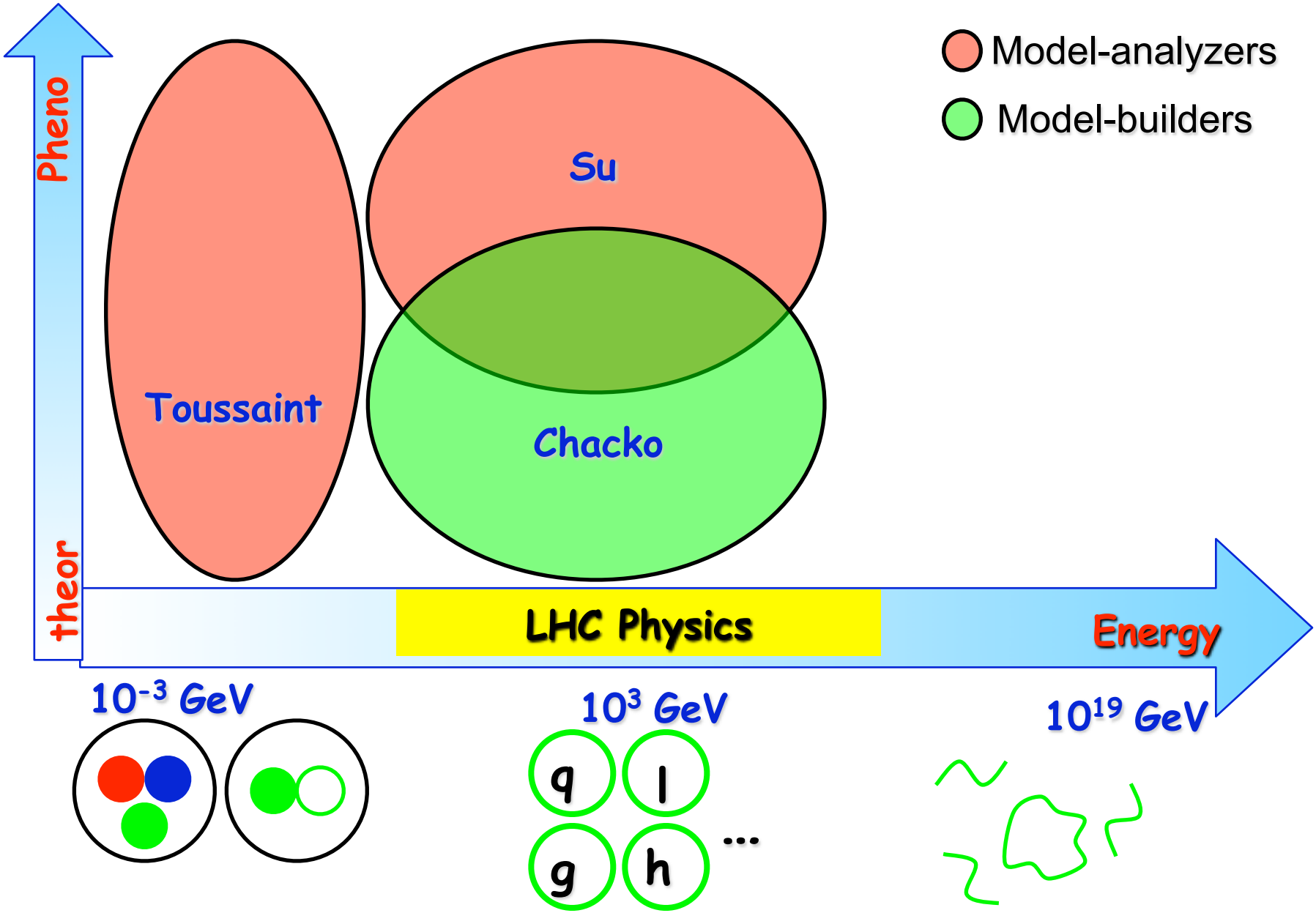
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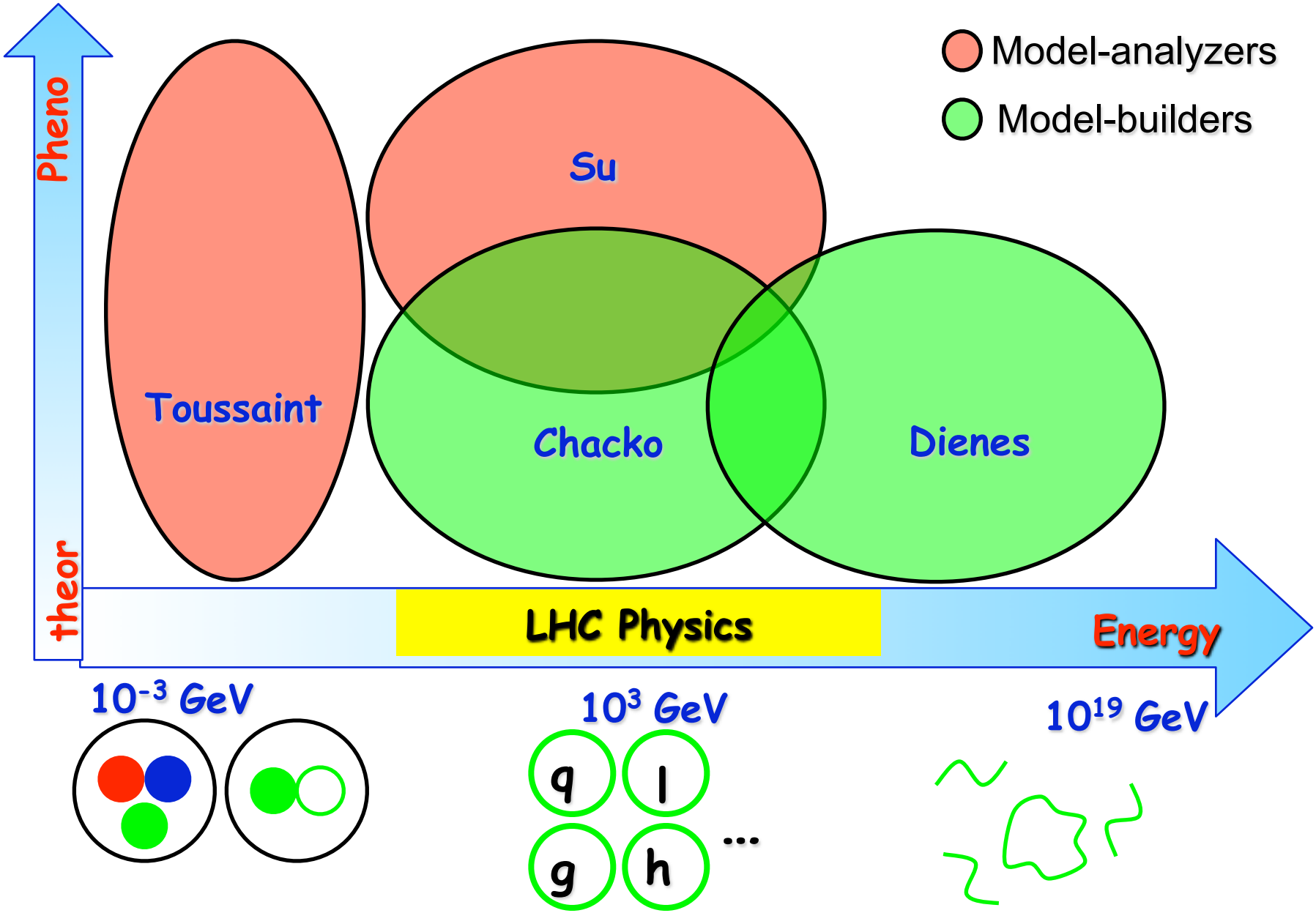
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Lattice QCD at U. of A.

D. Toussaint

Calculations including dynamical quarks

The MILC Collaboration
14 Physicists, 9 institutions
at Arizona: Doug Toussaint, Alexei Bazavov, Walter Freeman

The Fermilab/MILC Collaboration
add the Fermilab group

The HotQCD Collaboration
High temperature QCD, using the Livermore machines

The USQCD Collaboration
"Collaboration of collaborations" - hardware and software for lattice work

1. Demonstrate control of QCD calculations by calculating known things

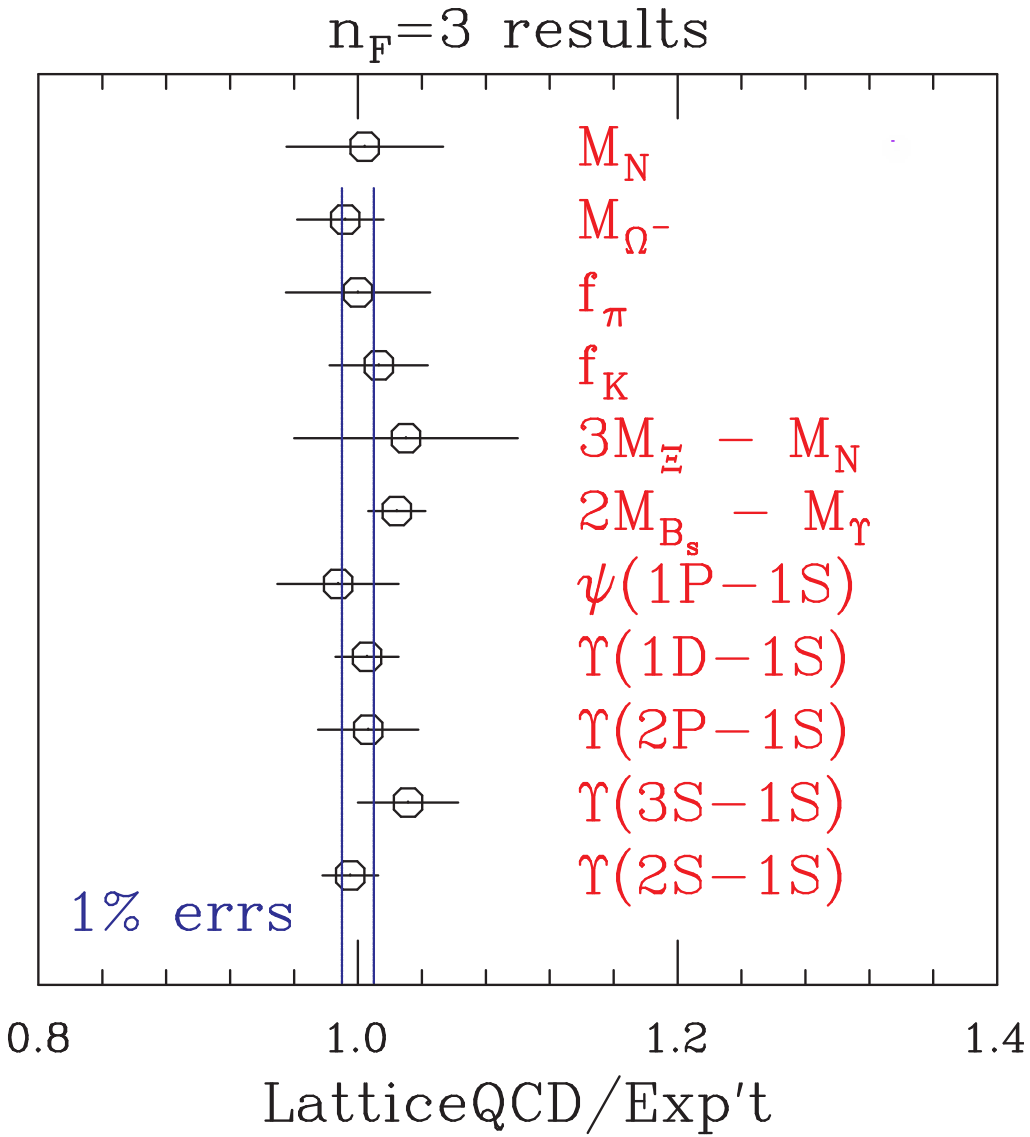
2. Calculate matrix elements needed to find standard model parameters for experiments

3. or maybe beyond the standard model?

4. Understand the workings of QCD (confinement)

5. Hadronic phenomenology, for example low energy constants in chiral perturbation theory

6. Development of techniques for better simulations



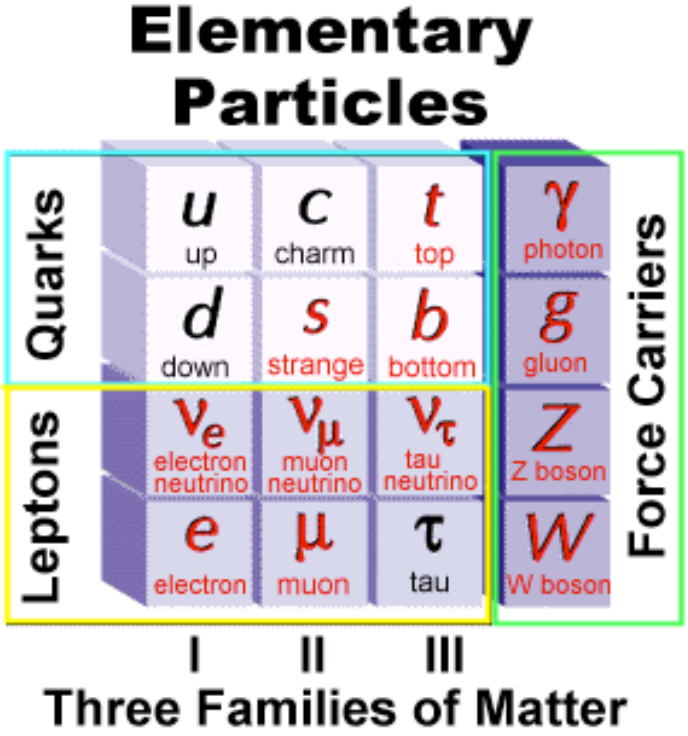
Lattice QCD can now compute some things with accuracy of a few percent.

Ratios of lattice results to experimental values for "gold plated" things.

Electroweak Physics at U. of A

Z. Chacko, S. Su

- Standard Model:
  a successful model
- Many open questions requires
  new physics beyond the SM



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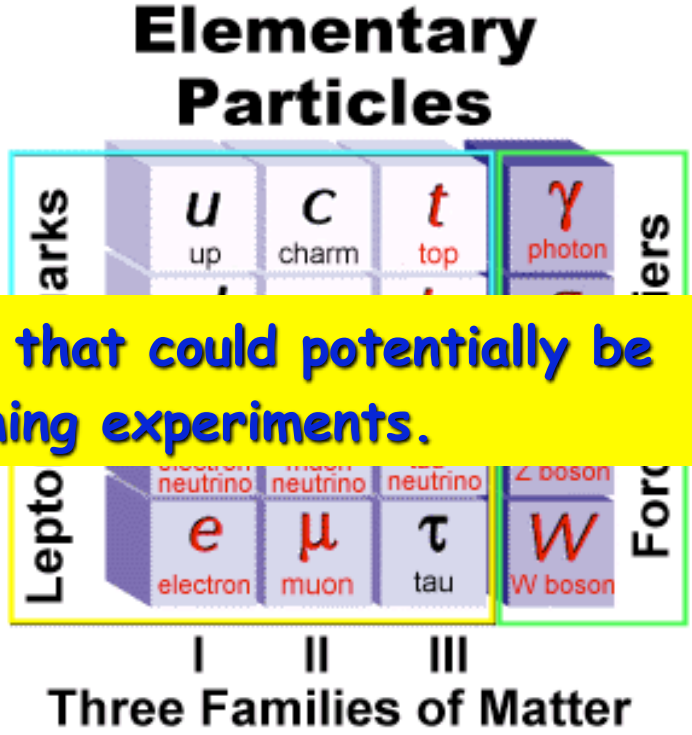

We work on physics beyond the SM that could potentially be discovered in the current and upcoming experiments.

Electroweak Physics at U. of A

Z. Chacko

- Supersymmetry: boson ⇔ fermion, extension of Lorentz symmetry
- Extra dimension: D > 4?
- Grand unification: weak, strong and electromagnetic forces
  ⇒ a single grand unifying force?
- Neutrino physics: origin of neutrino masses?
- Cosmology: past history / future of the universe?
- Modification of Einstein gravity: modifications possible?
  experimental constraints?

Electroweak Physics at U. of A

S. Su

Working on similar stuff as Chacko.

However, focus on

Theory ⟷ Experiments

Electroweak Physics at U. of A

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Particle physics ⟷ Astrophysics

Electroweak Physics at U. of A

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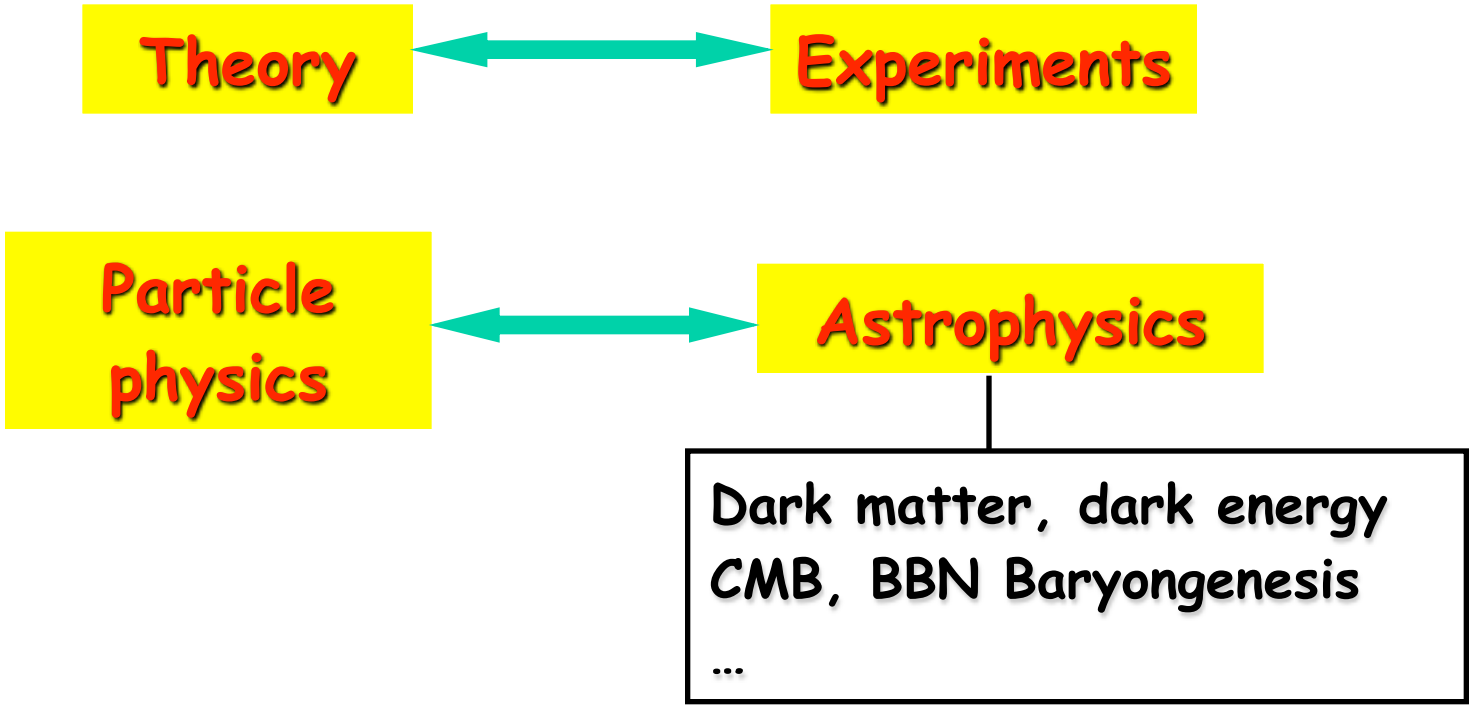

String Phenomenology at U. of A

K. Dienes

String Phenomenology

String Phenomenology at U. of A

K. Dienes

- the "interplay" or "meeting-ground" between Planck-scale physics and TeV-scale physics
- the "art" of using the new insights from string theory in order to understand, explain, and predict what physics at next energy scale is going to look like

String Phenomenology

String Phenomenology at U. of A

K. Dienes

String Phenomenology

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String Phenomenology

Standard Model

- choice of gauge group
- number of generations
- masses
- mixings, etc …

String Phenomenology at U. of A

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Extensions to SM:

- SUSY
- GUT's
- hidden sectors
- technicolor…

String Phenomenology at U. of A

K. Dienes

Formal Issues:

- string vacuum selection
- non-pert. dynamics
- string duality
- new mathematical structure …

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String Cosmology:

- role of dilaton
- effects of light d.o.f.'s
- extra dimensions
- CC problem …

String Phenomenology

Standard Model

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Research related Activities

Research related Activities

- Seminars, colloquiua and Visitors
- Group meetings
  - journal club (with nuclear theory group)
  - brown bag lunch (with nuclear theory group)
  - discussion group on dark energy and early universe
    (with theoretical astrophysics group and astronomy dept.)
- Summer schools and conferences
  - lecture at summer schools, etc.
  - plenary talks at conferences/workshops
  - organize conferences/workshops
    SUSY03, LATTICE06, "Rethinking Gravity", string landscape workshop ...

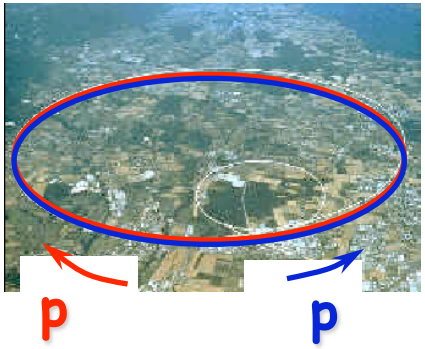
Urgent Need

Urgent Need

Replacement of Chacko !

LHC Era

LHC (2008)

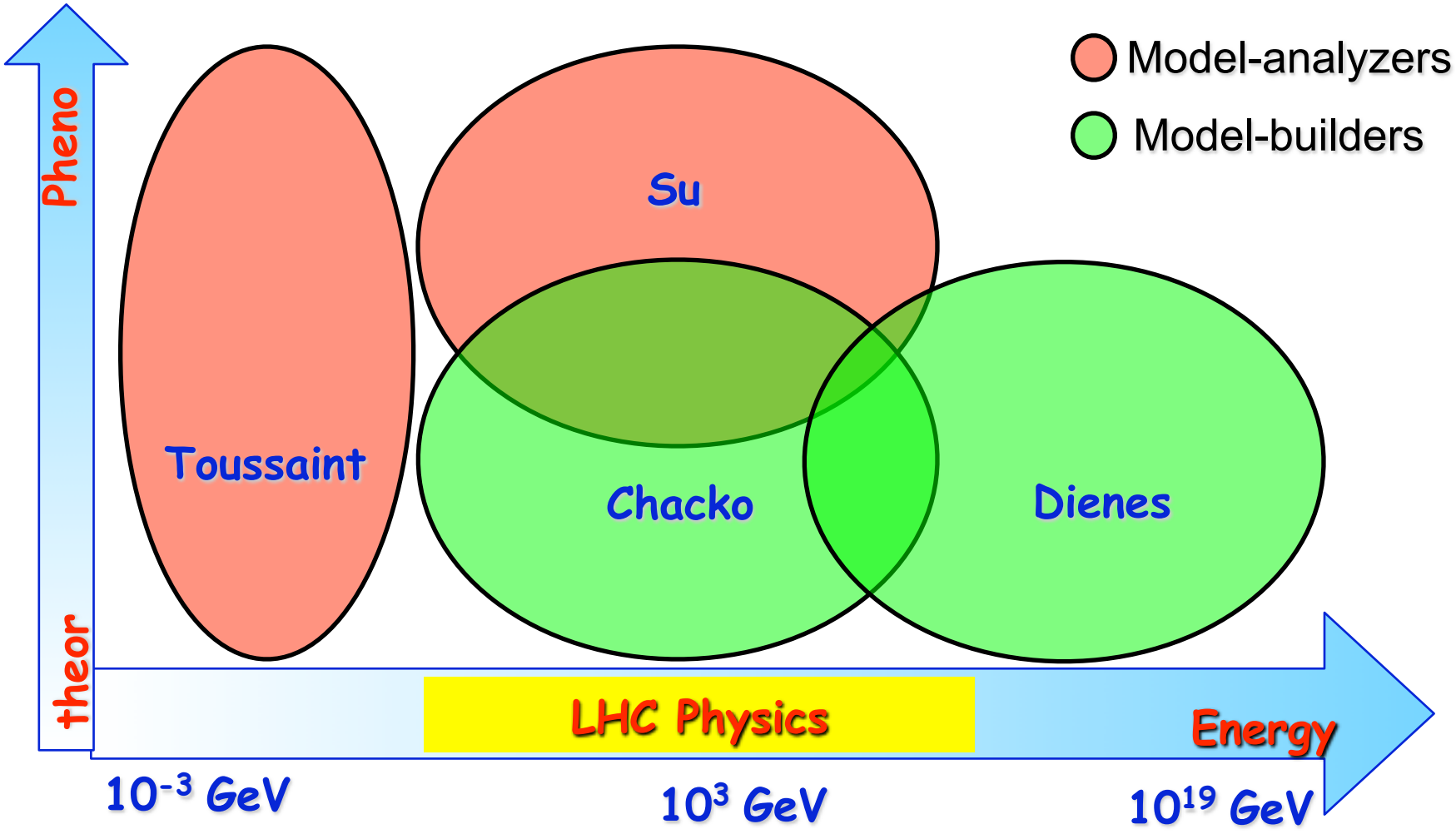


- LHC (2008): golden era for particle physics
- Theoretical particle physics: critical
  - what to expect ?
  - How to interpret ?

For Arizona to maintain its influence and impact in the overall LHC enterprise

↓

a strong HEP theory group!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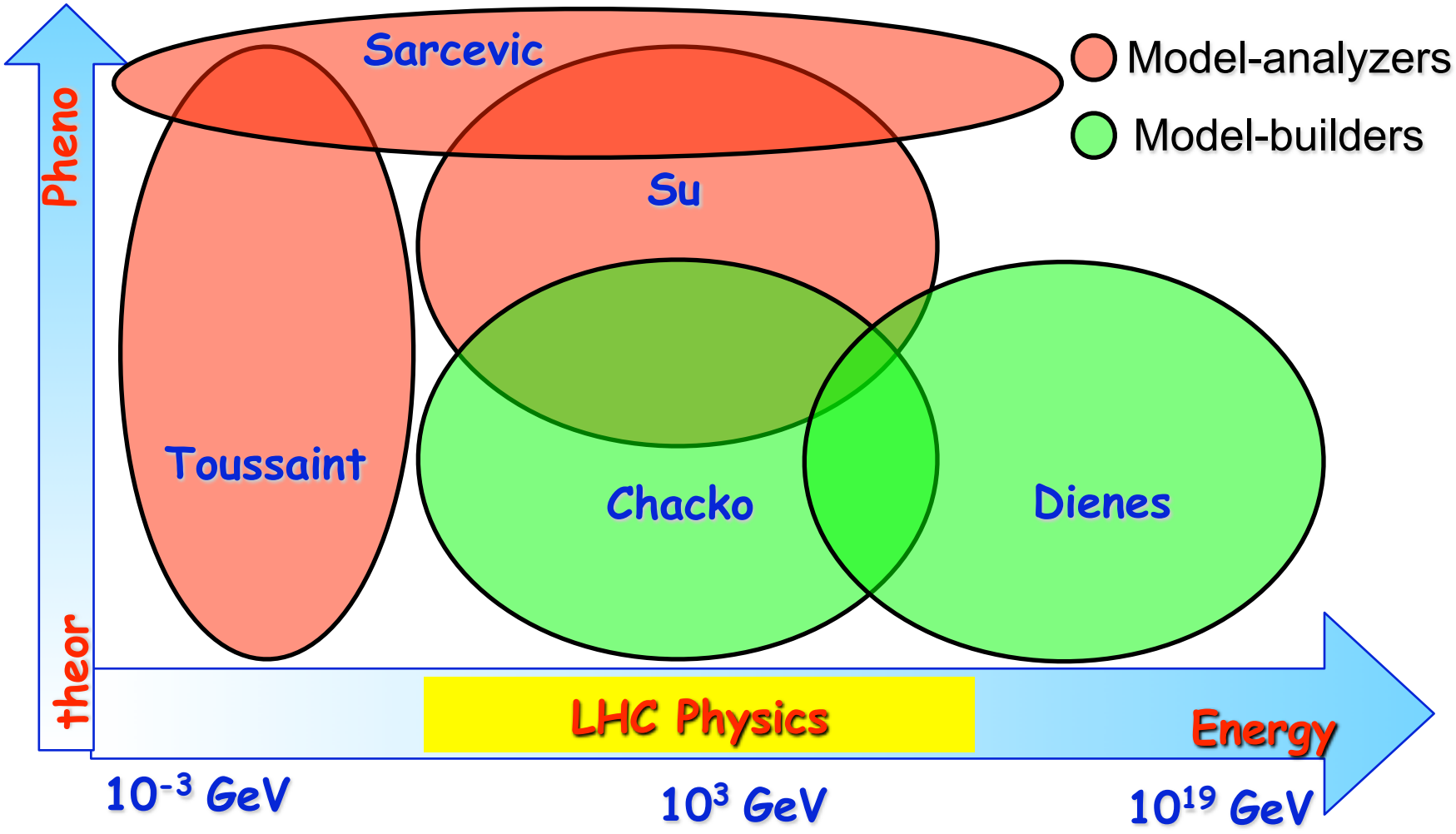
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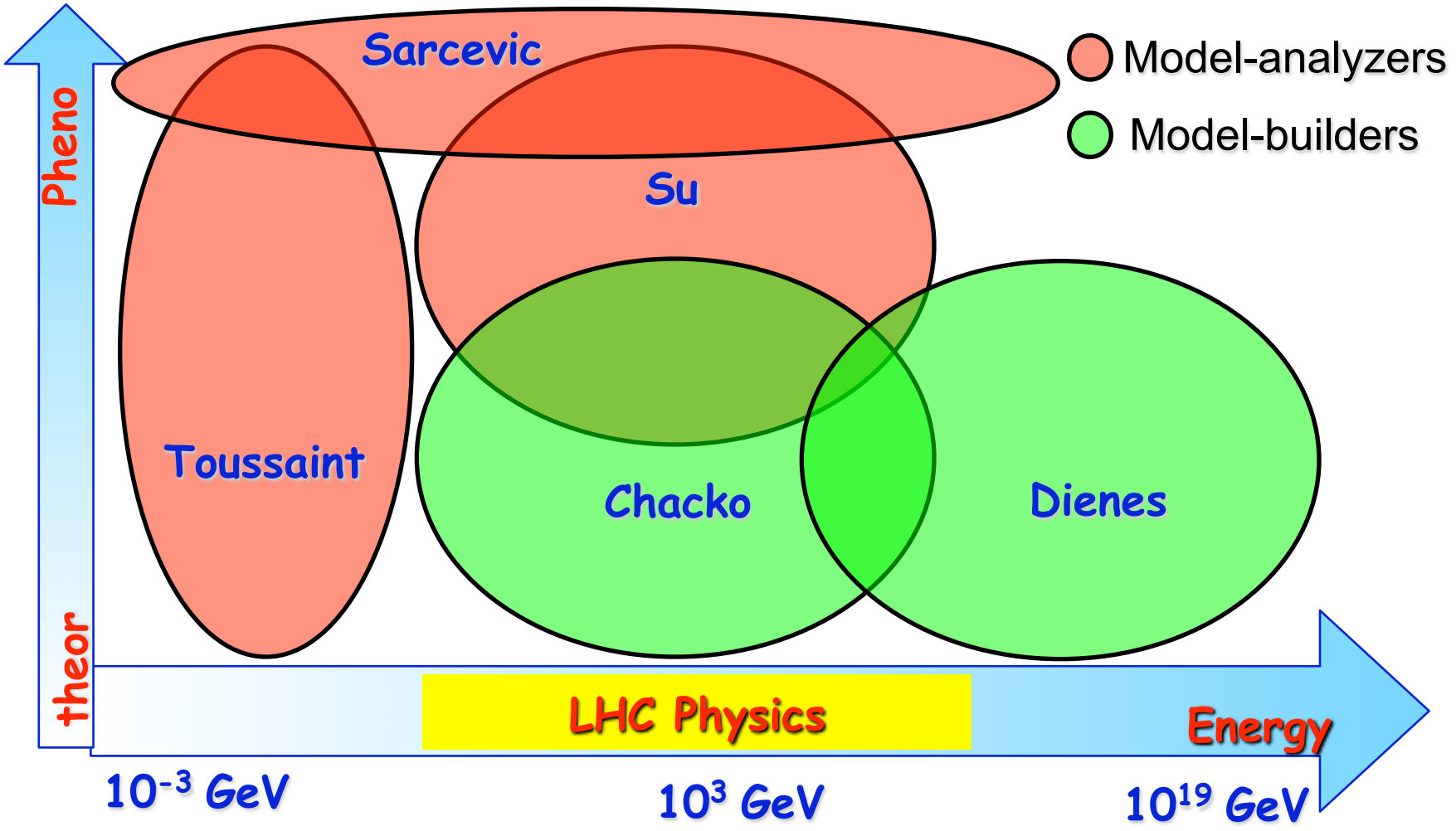
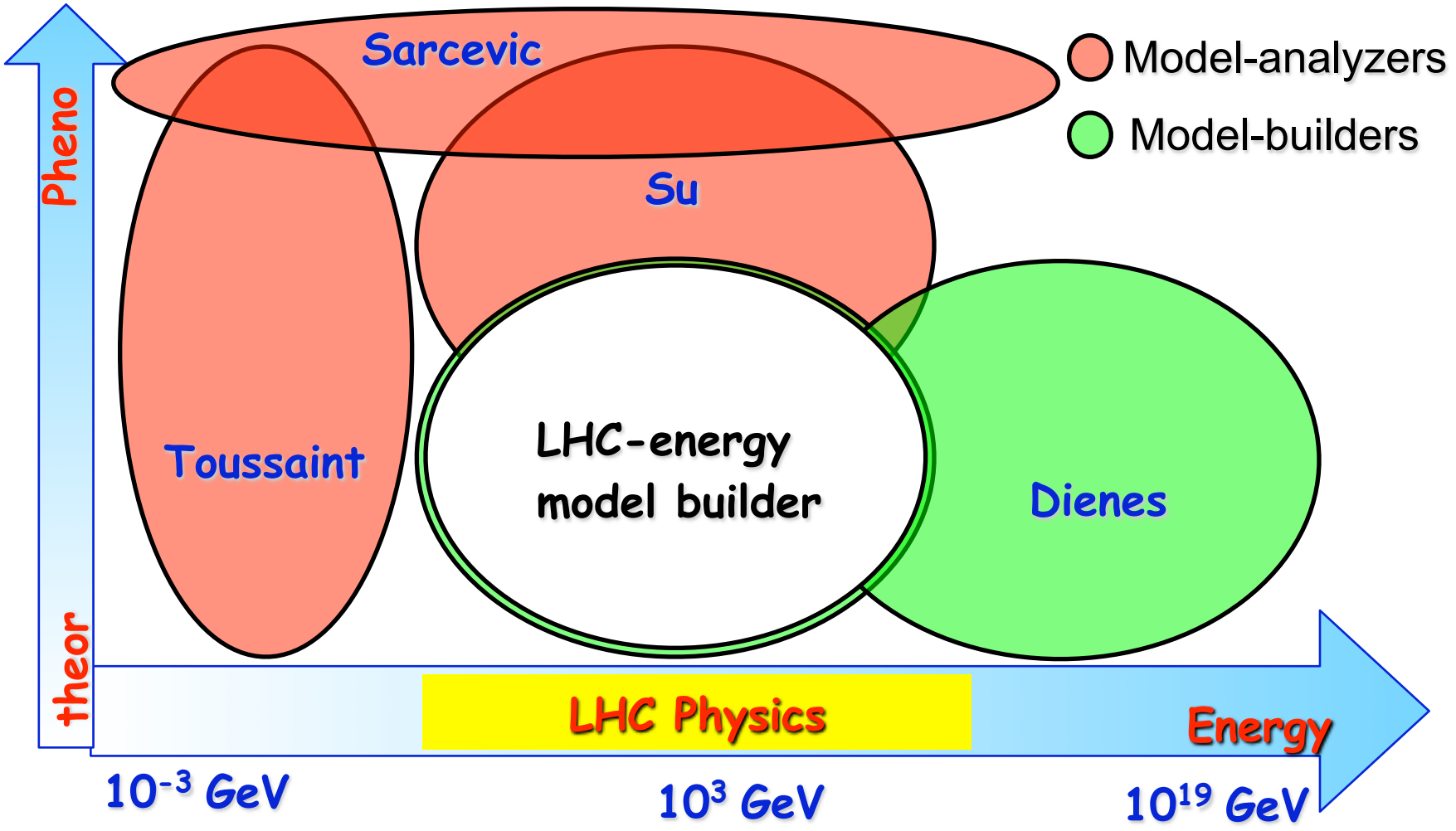


HEP theory group has been highly successful by any measure of excellence!



HEP theory group has been highly successful by any measure of excellence!

This can not wait!

- Imminent turn on of LHC (finally!)
- Remain competitive with other universities
- Danger of "further external raid",
  "melt-down" of HEP theory group
- Minimal start-up, immense payoff
- Sustain current grant support
- Aggressive, "smart" hiring over past decade
- Department-wide agreement: top priority

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- Department-wide agreement: top priority

Need to move aggressively right now.

Thanks!