

Light, darkness & colors

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CP³-Origins, Danish IAS, Univ. Southern Denmark

CP³ - Origins



Particle Physics & Cosmology

September 09

LHC

CP³ - Origins

Models

Tools

Particle Physics & Cosmology

Cosmology



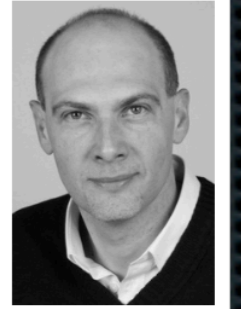
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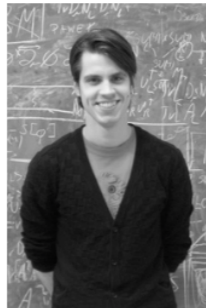
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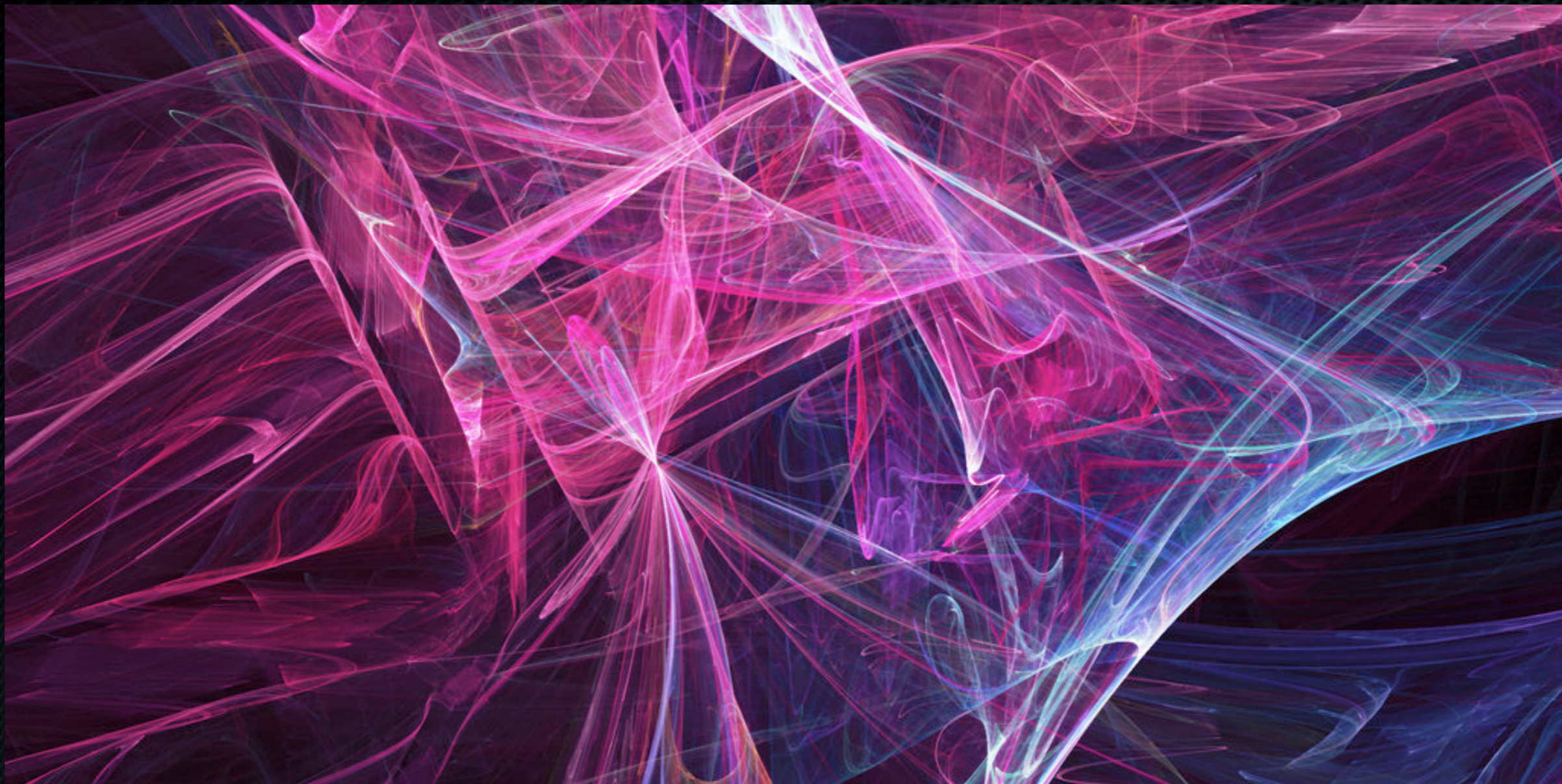
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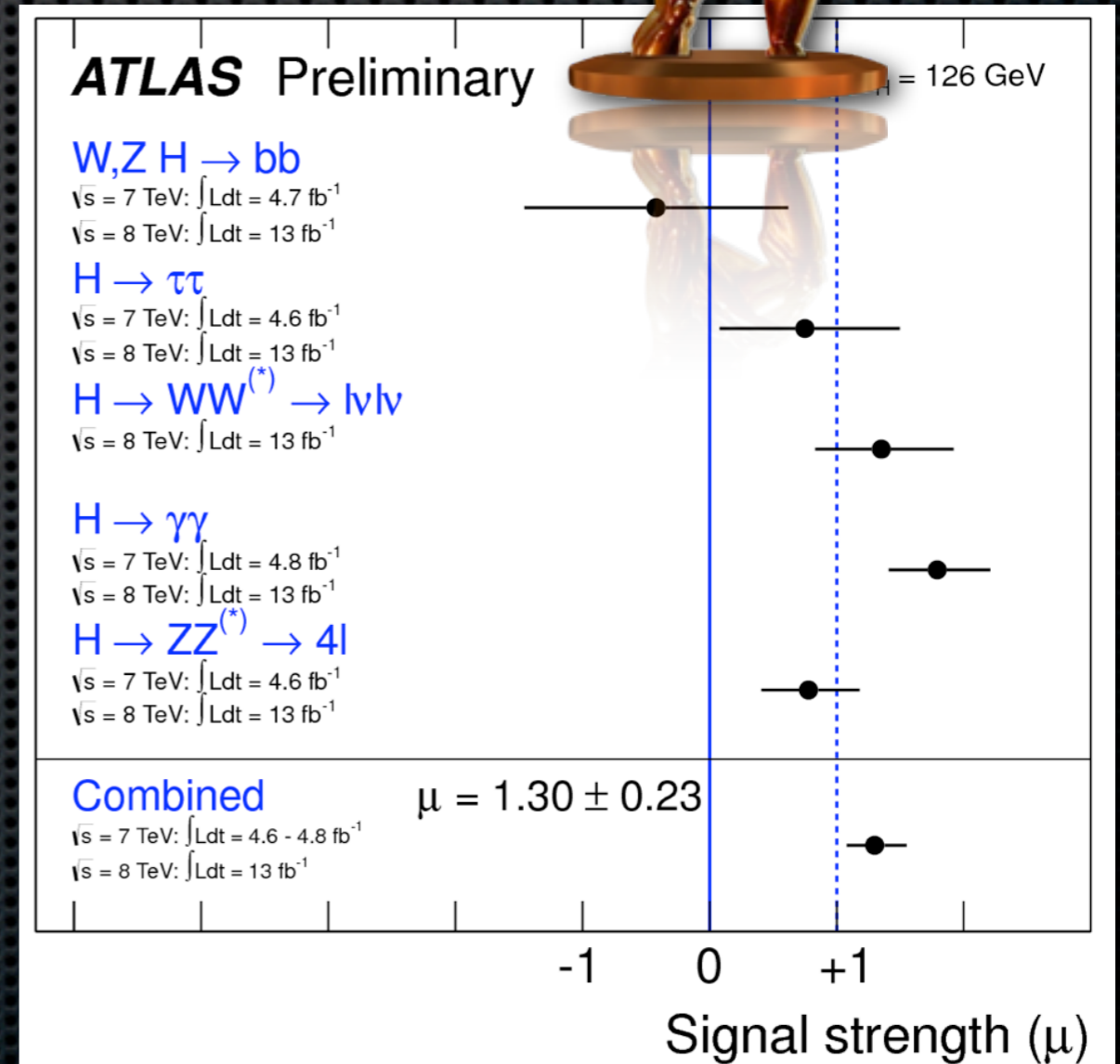
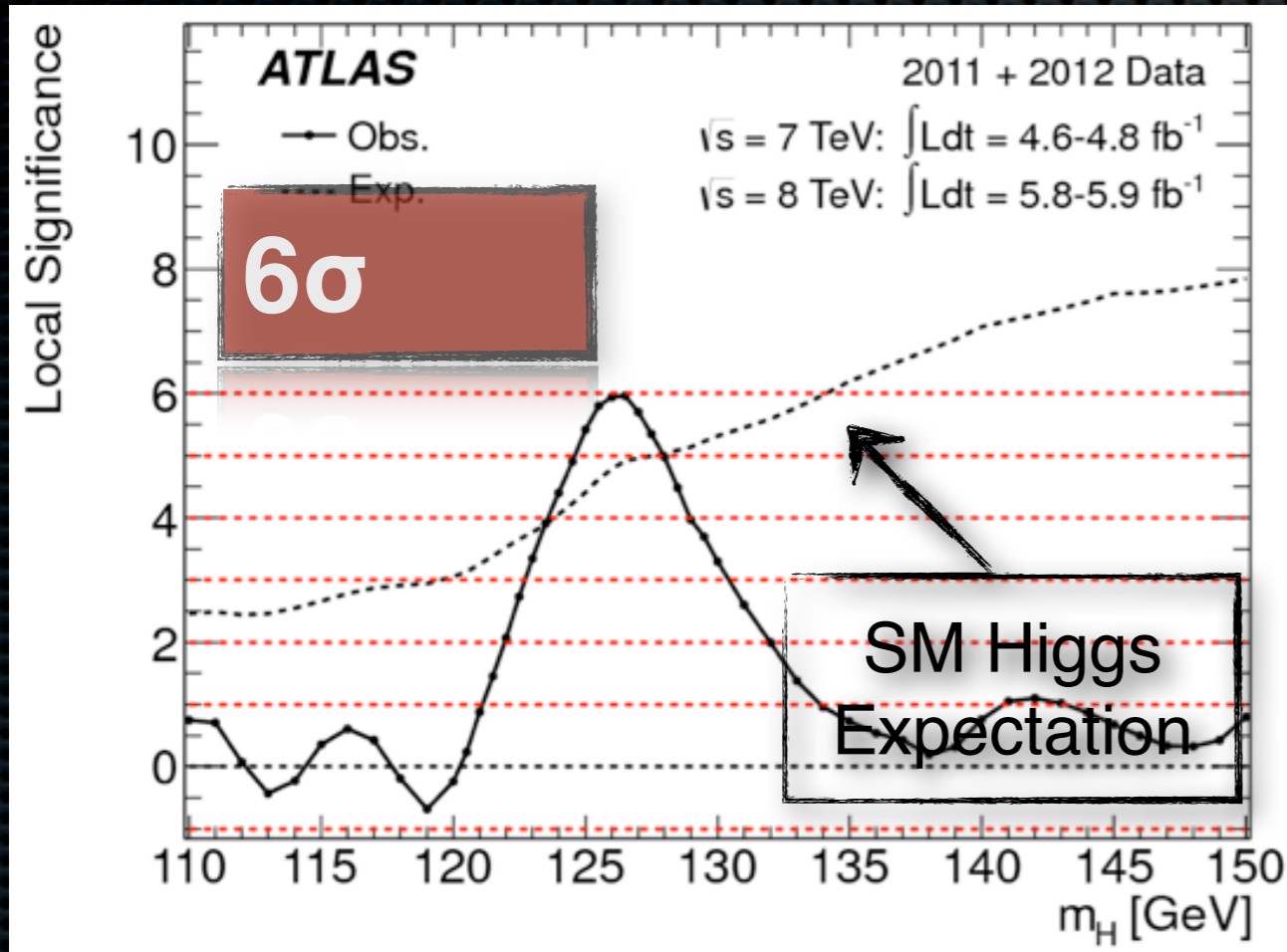
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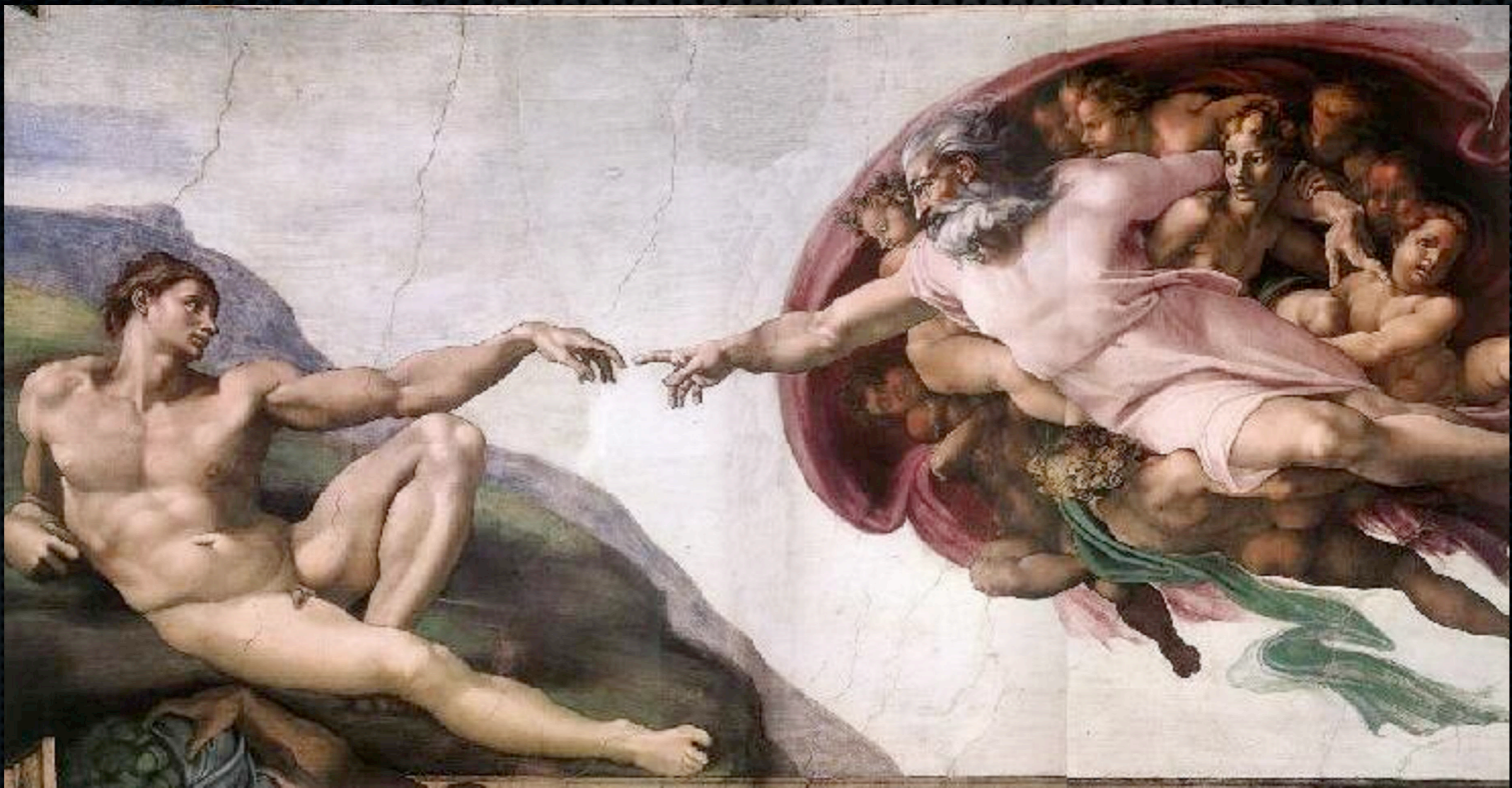
Light

Dawn of a new era

Discovery

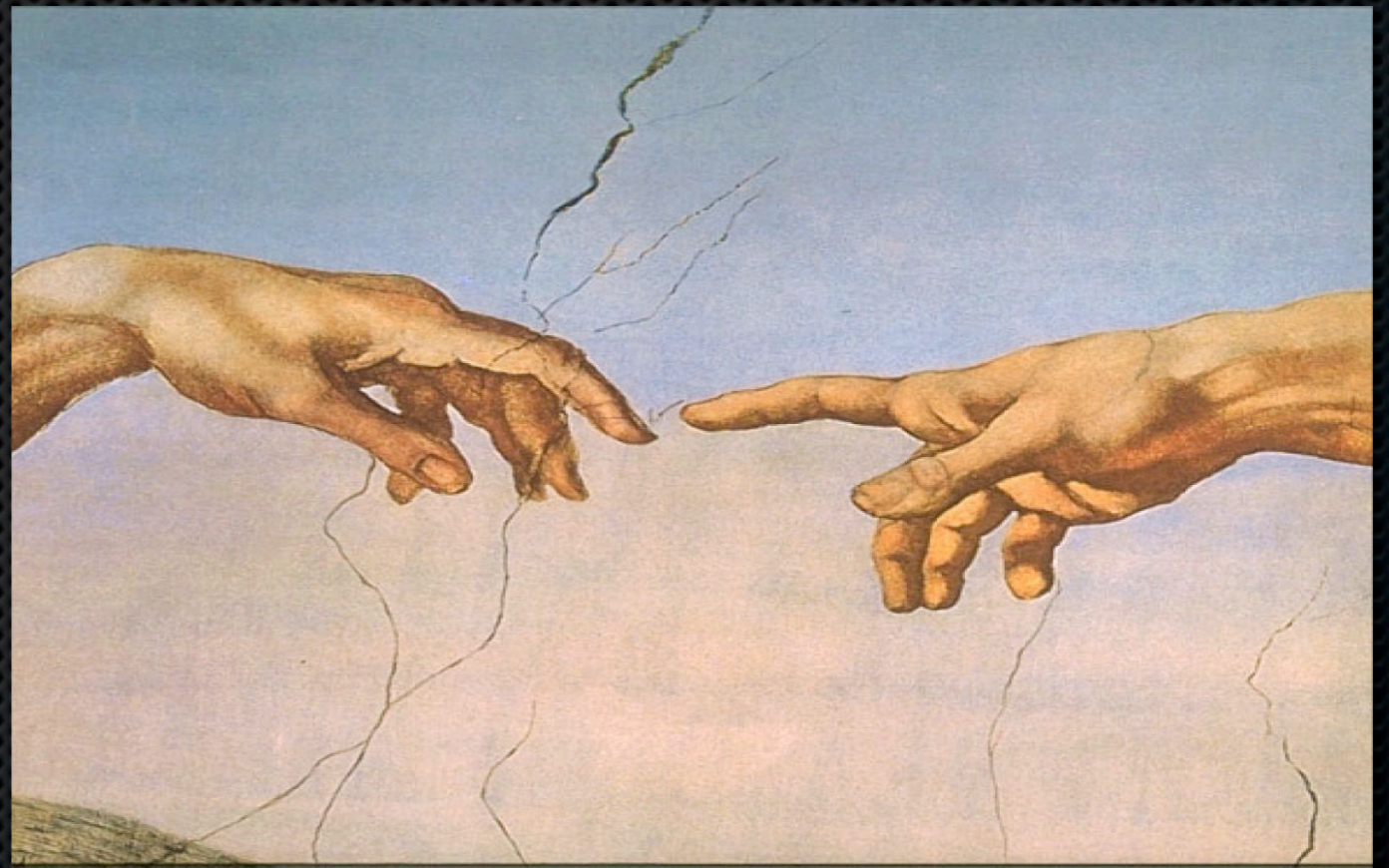


Are we there yet?



Not quite

- ✦ Standard Model?
- ✦ Is the Higgs alone?
- ✦ Are there new forces?
- ✦ Dark side?



'THE CREATION' - MICHELANGELO

Finely tuned Higgs

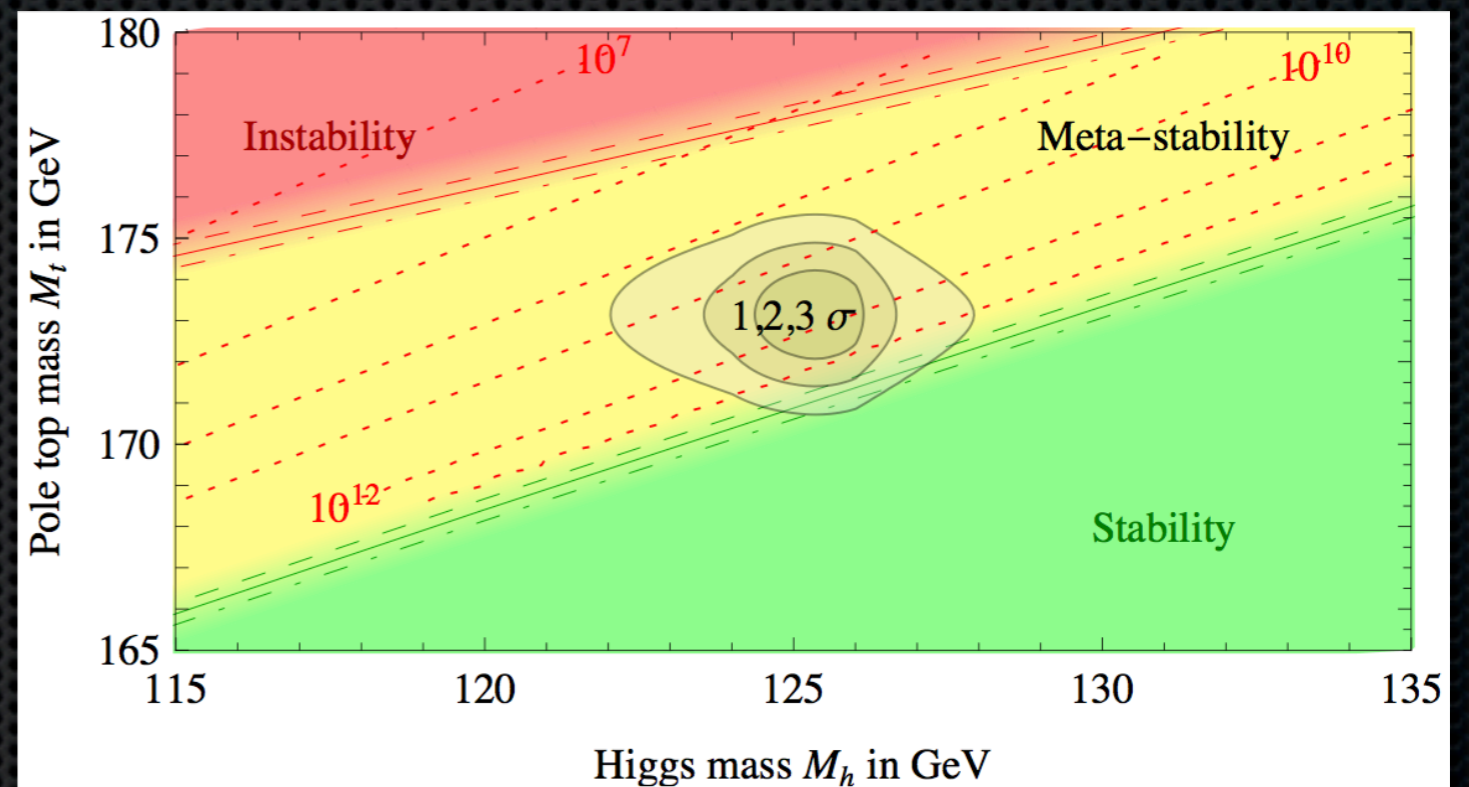
- ✦ Higgs mass is fine tuned
- ✦ 10^{17} heavier than observed!



www.l2pnet.com

Meta - stability

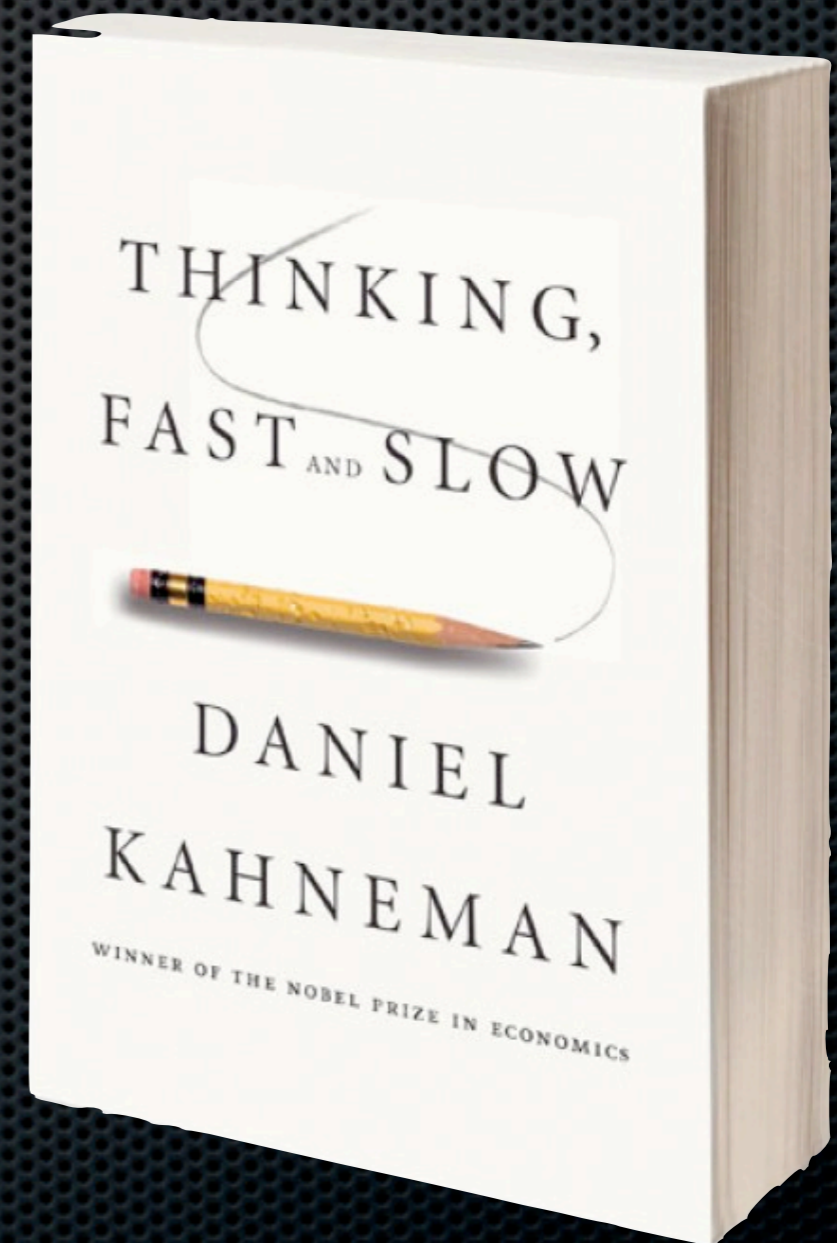
- Quartic Higgs coupling
- Sensitive to top mass



- De grazzi, De Vita, Miro, Giudice, Isidori, Strumia
- Masina

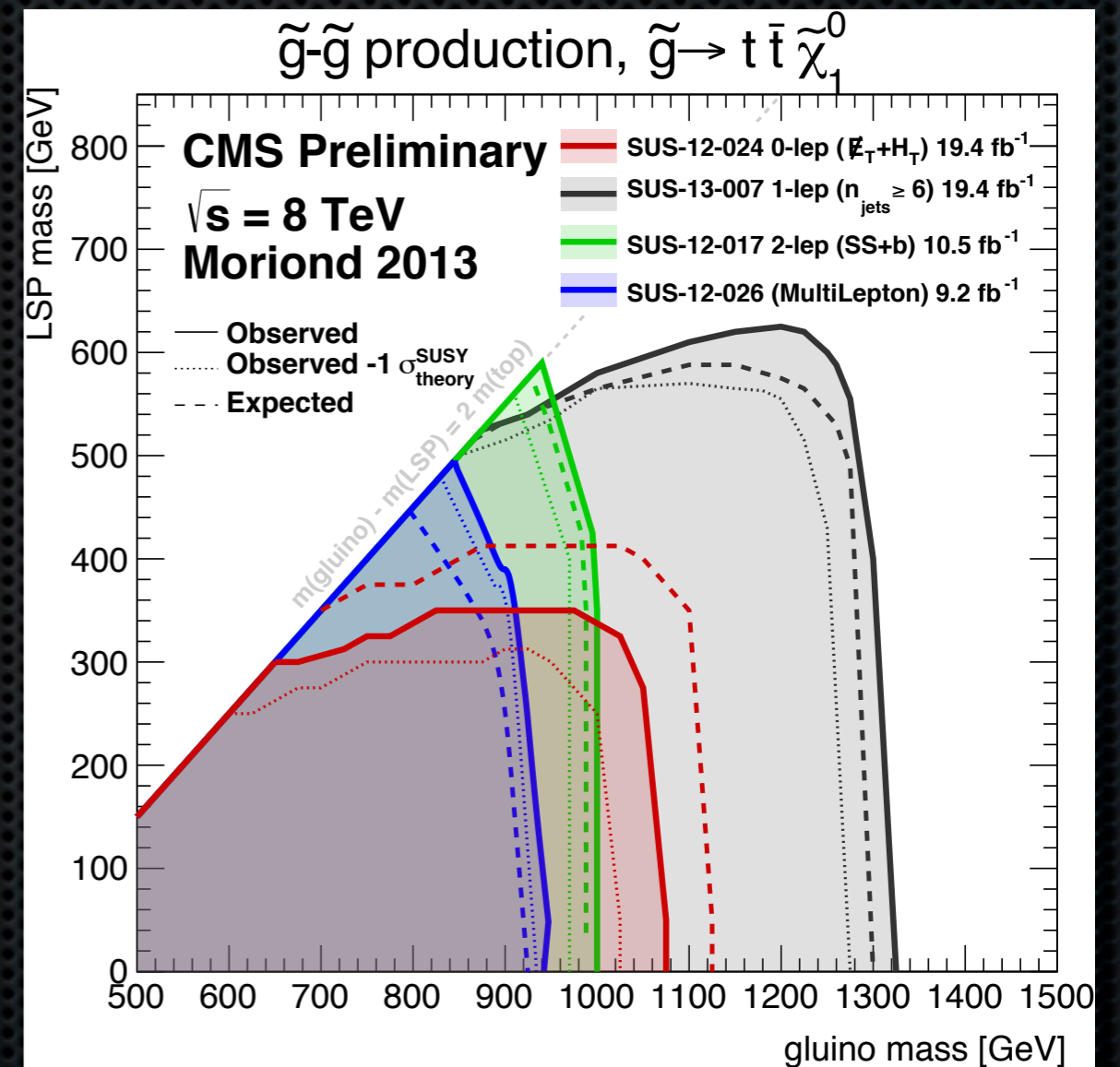
Fundamental?

- Tremendous discovery!
- First time
- Scalars from fermions
- No fermions from scalars
- Susy? Can be emergent



What has LHC not seen?

- ✦ Extra dimensions
- ✦ Any sign of supersymmetry
- ✦ Low scale gravity, i.e. BH



In line with minimal composite dynamics

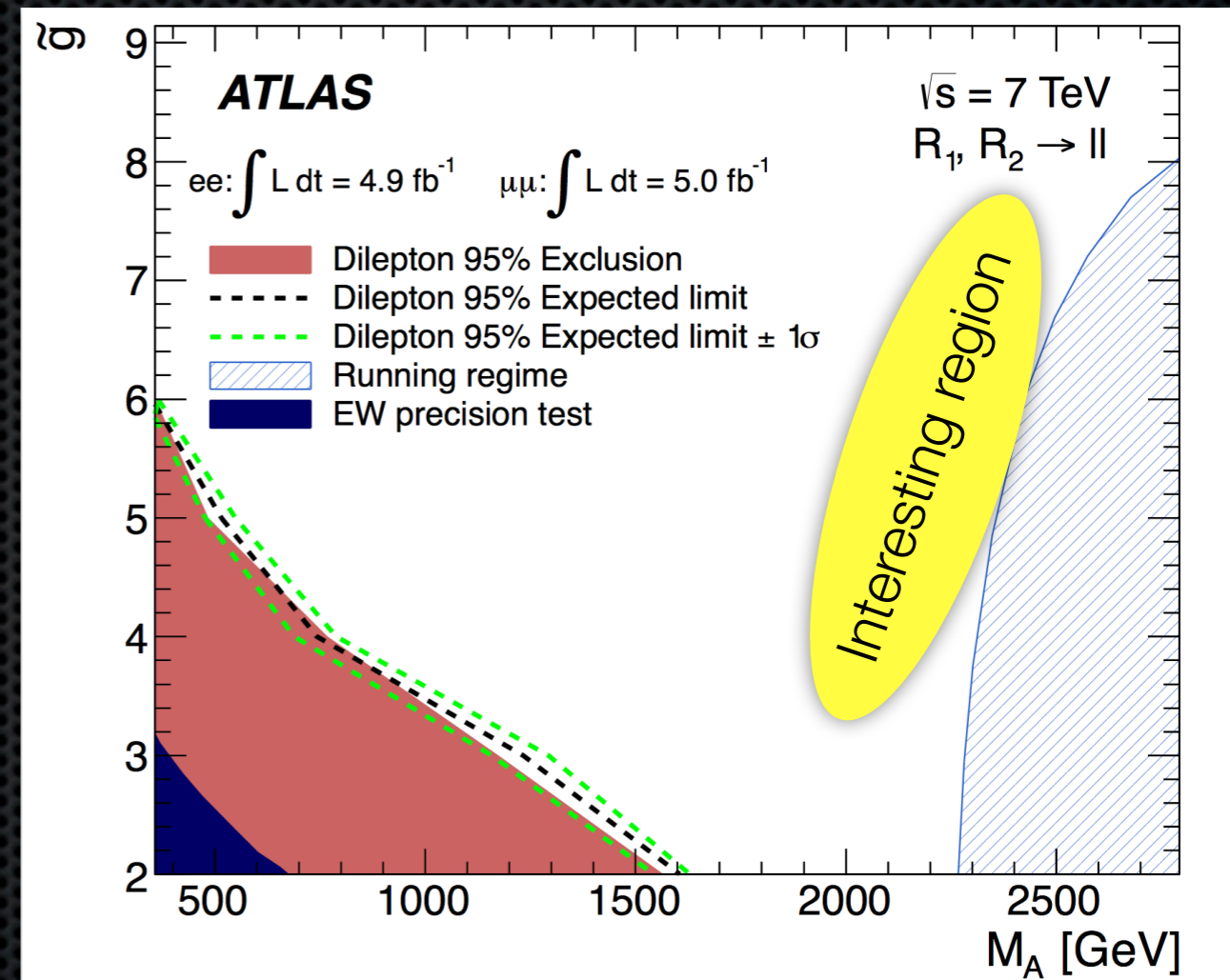
Compositeness

- ✦ Higgs sector [TC, Little Higgs..]
- ✦ SM fermions [preons, ..]
- ✦ Partial: Bosonic/SUSY TC
- ✦ eXtreme [Magnetic SM]



Minimal Walking Technicolor

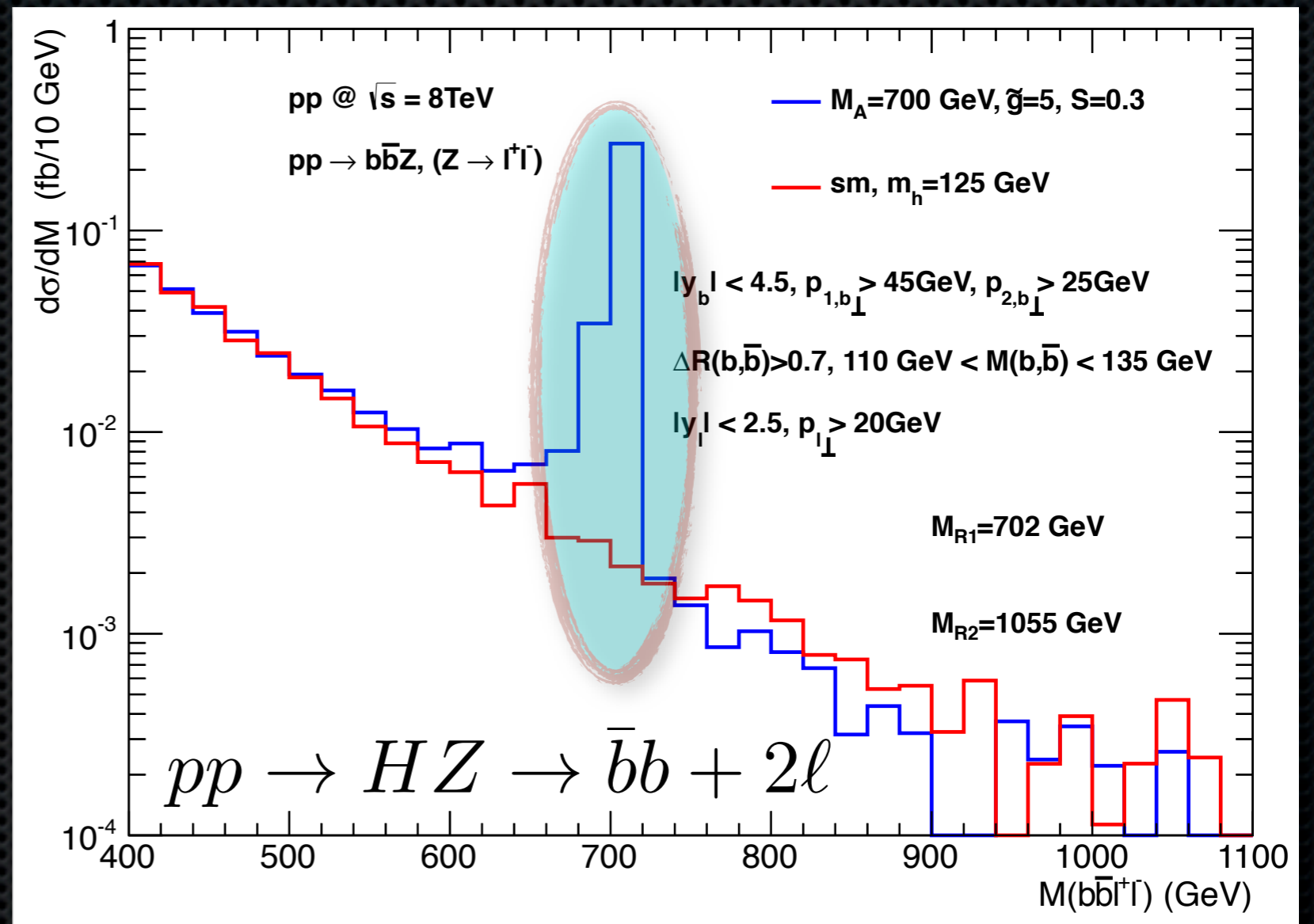
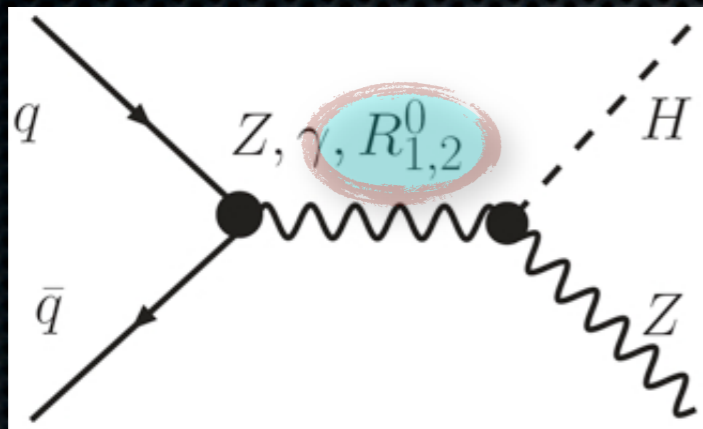
- ✦ Minimal extension of SM
- ✦ Feature light TC-Higgs
- ✦ LHC searching for it
- ✦ Lattice predictions for LHC



**Exclusion plot for MWT technicolor/
axial resonances.**

Foadi, Frandsen, Hapola, Järvinen, Sannino

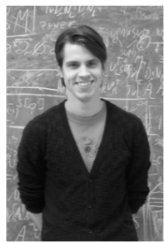
A dream scenario



Discovery of composite states at LHC 2

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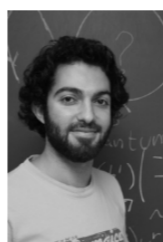
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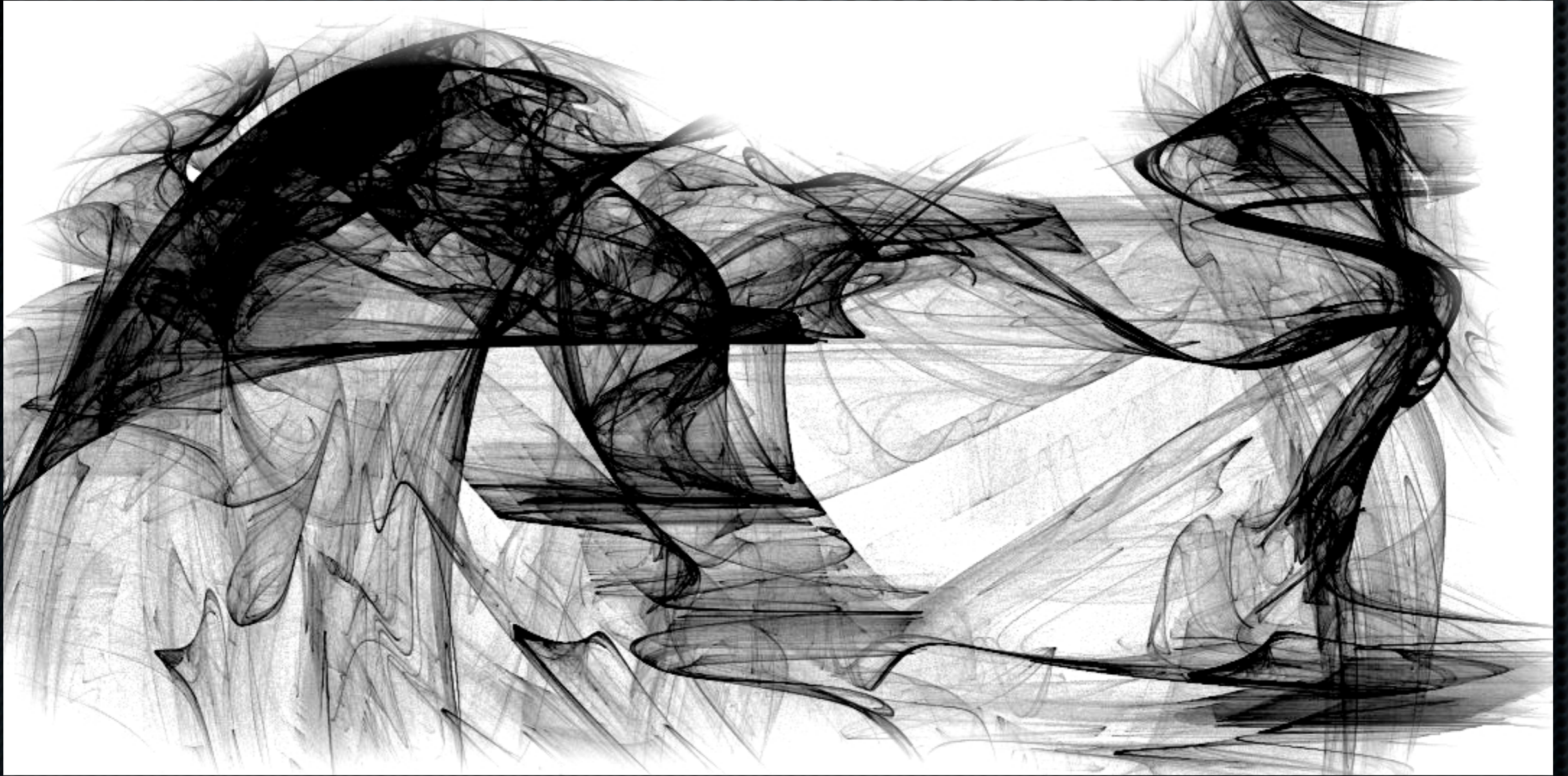


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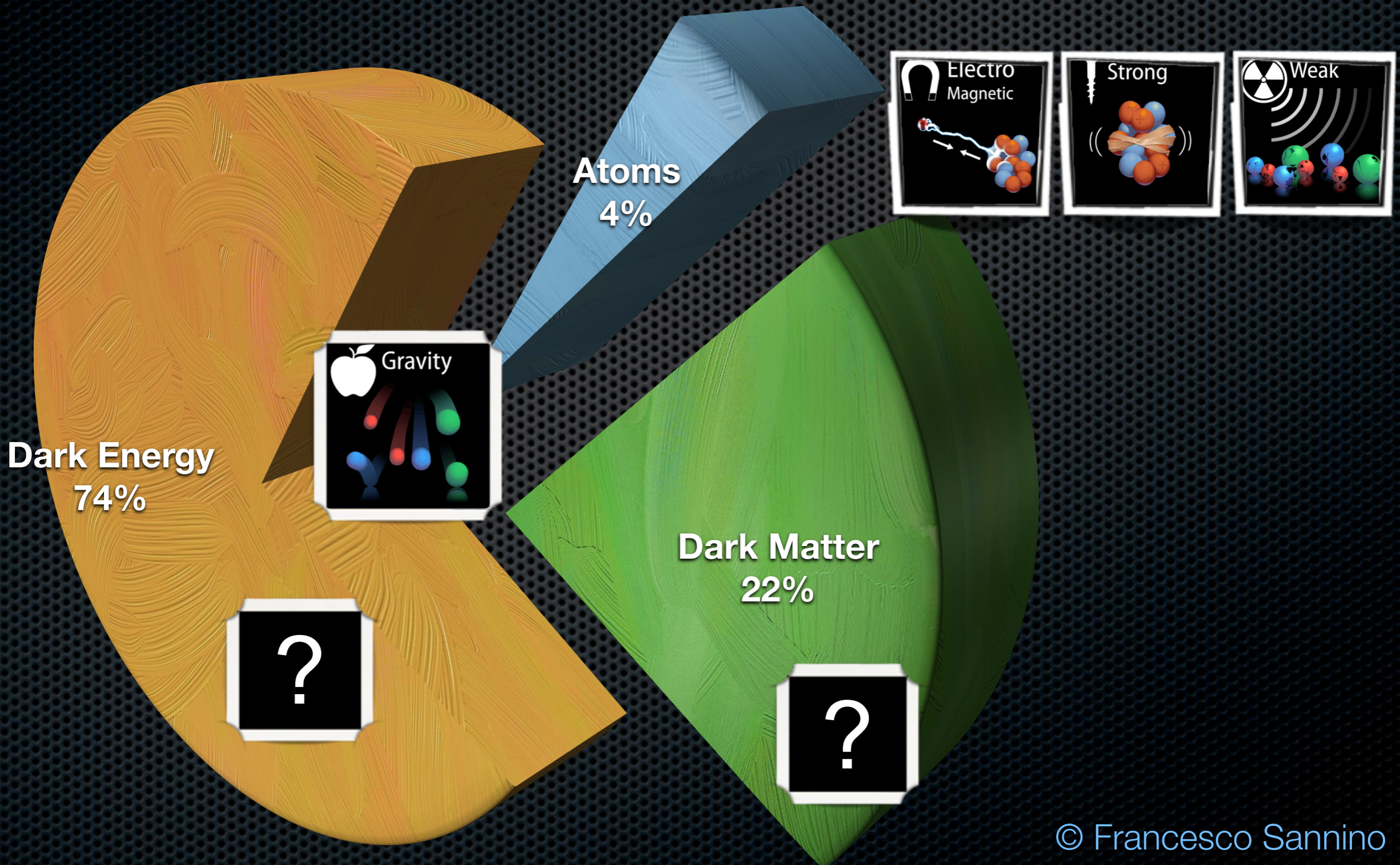
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Darkness

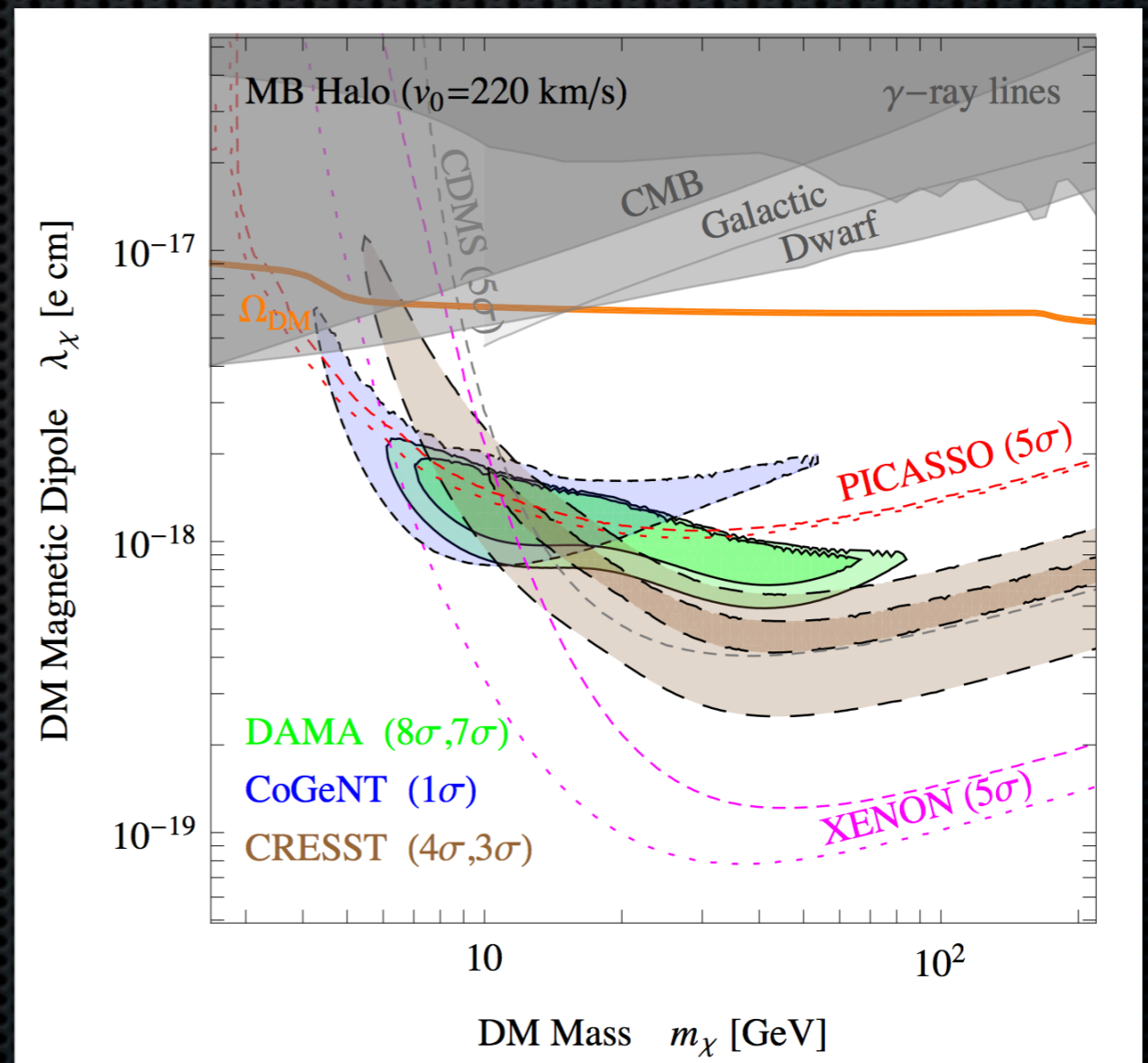
Dark matter, energy and inflation

Much ado for a few percent



Dark matter

- ✦ Model building/
(A)symmetric DM
- ✦ Effective theories
- ✦ Indirect/direct searches
- ✦ Constraints from stars
- ✦ Lattice dark matter



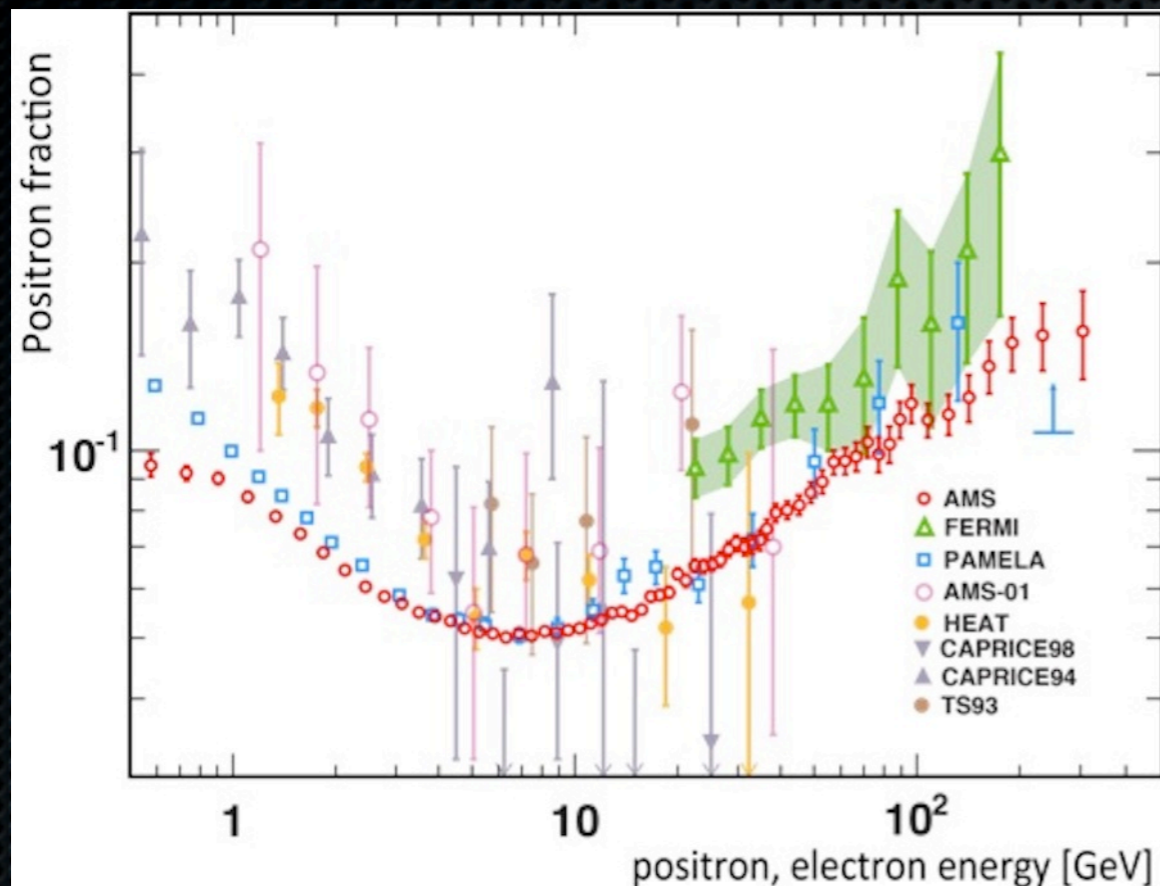
After SUSY, comes SEXy ?

CDMS-II, April 15



- 3 sigma
- Mass around $8.6 \text{ GeV}/c^2$
- Cross section $1.9\text{E-}41 \text{ cm}^2$

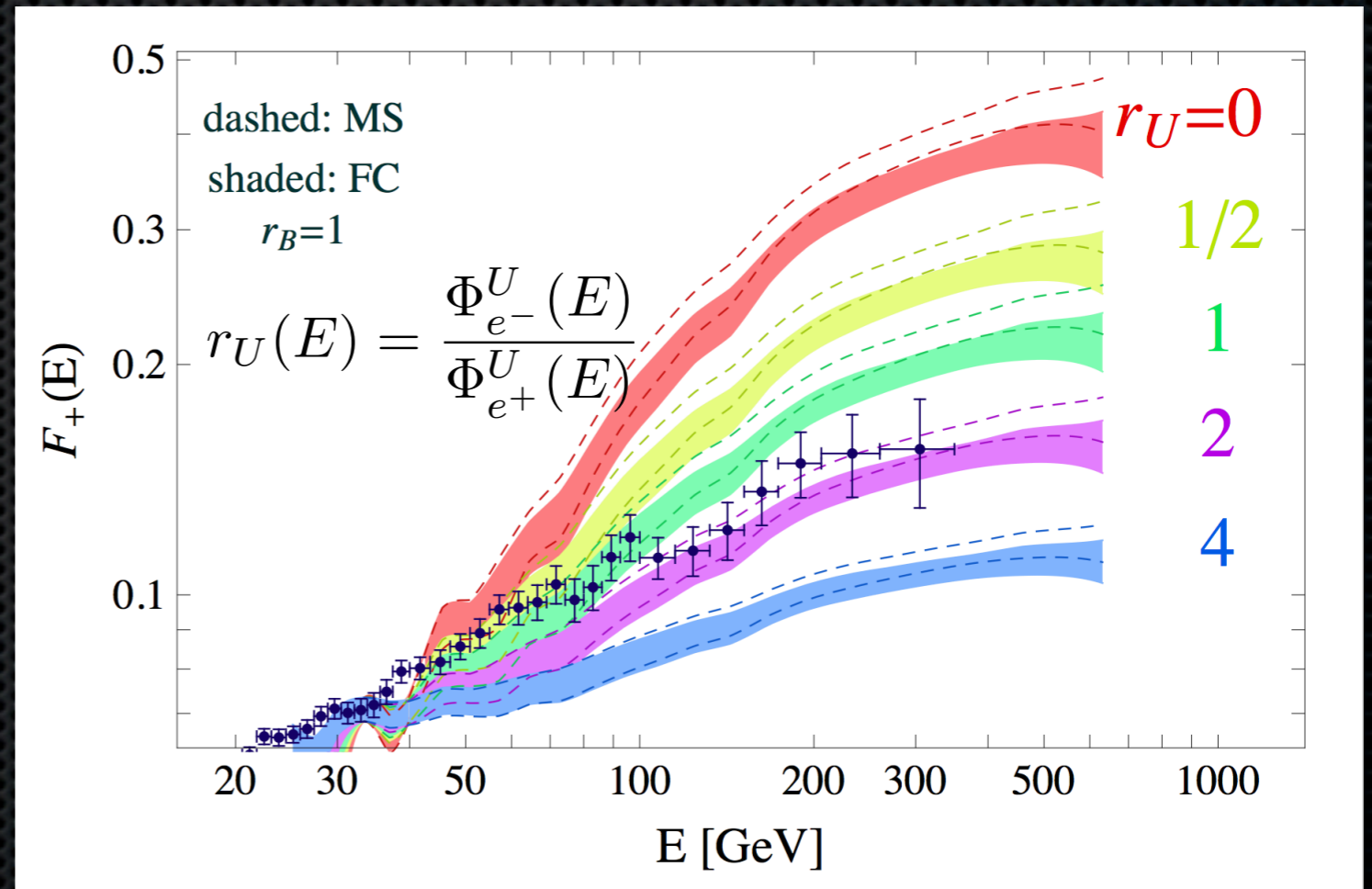
Cosmic rays, April 3



- ✦ Rise in the data
- ✦ Dark matter or astrophysics?
- ✦ Both unknown!

Hints of a charge asymmetry?

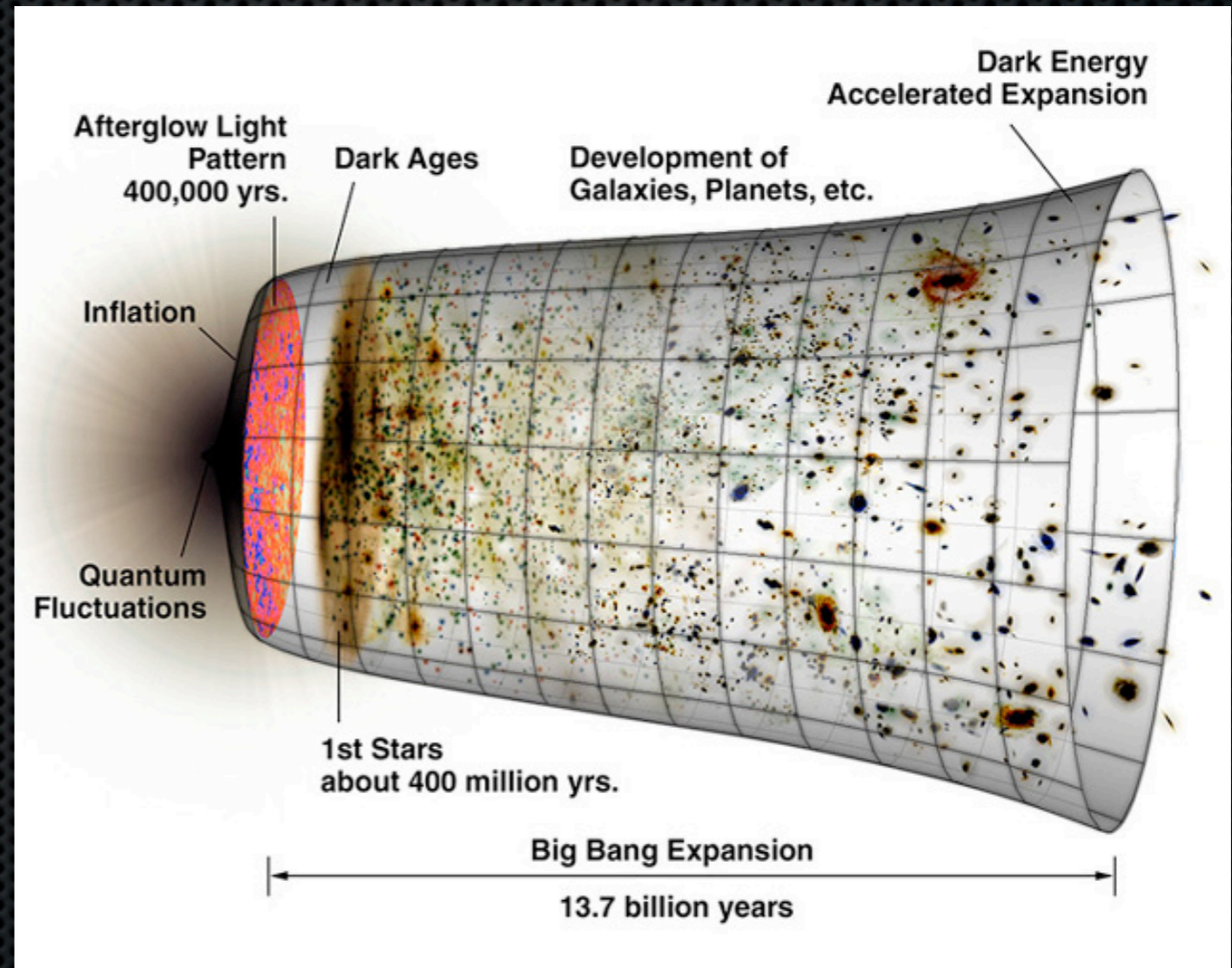
- ✦ More unknown electrons
- ✦ DM or astrophysics?
- ✦ C & P violated in SM



Masina & Sannino

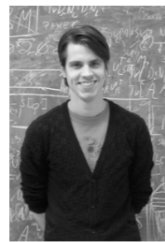
Cosmology

- ✦ Primordial magnetic fields
- ✦ Dark energy
- ✦ Higgs/SM inflation
- ✦ Conformal inflation
- ✦ Composite inflation
- ✦ Black hole info paradox



Darkness unit

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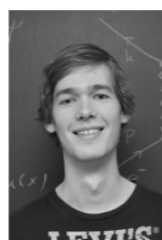
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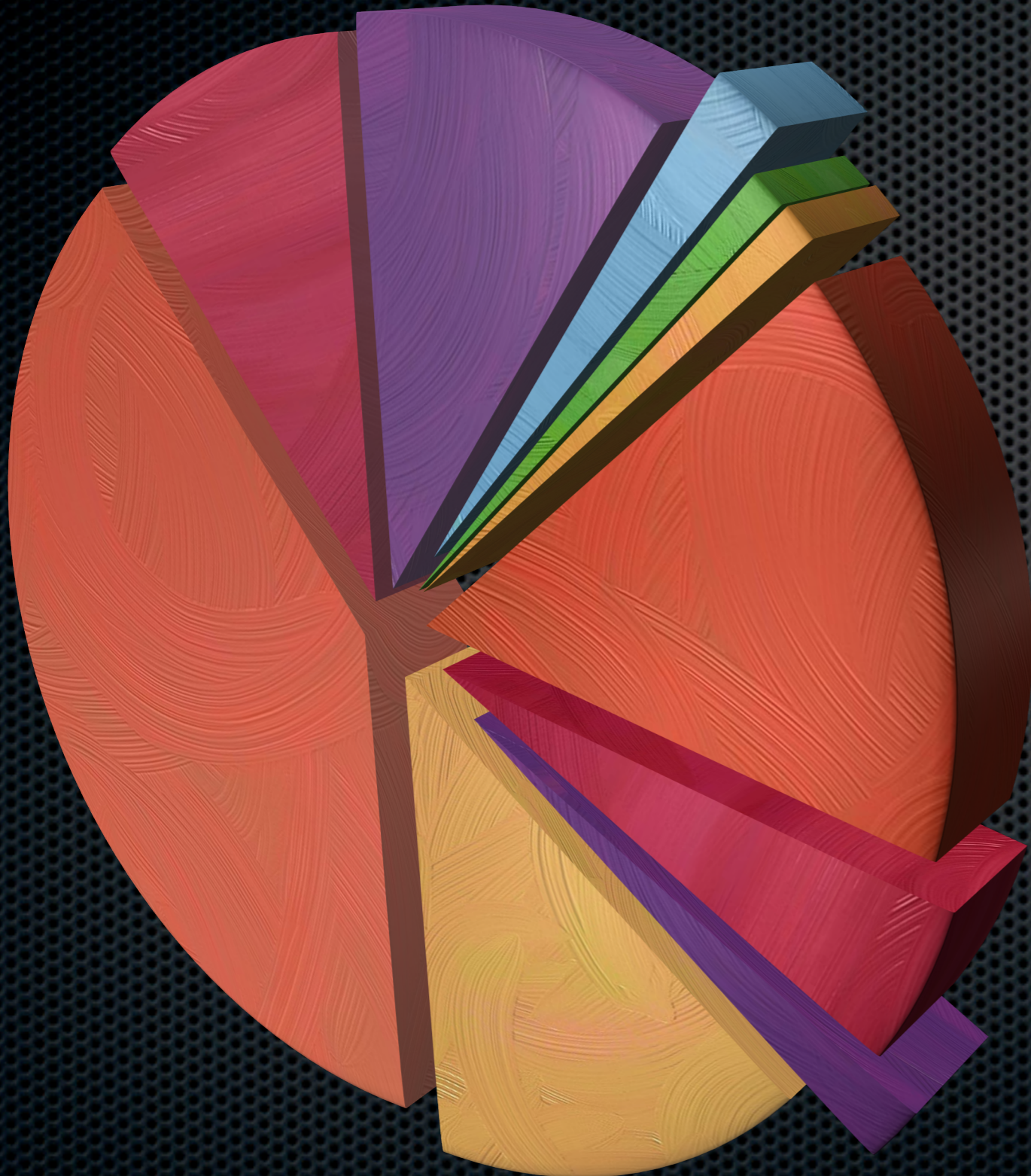
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Colors

Solving strong dynamics

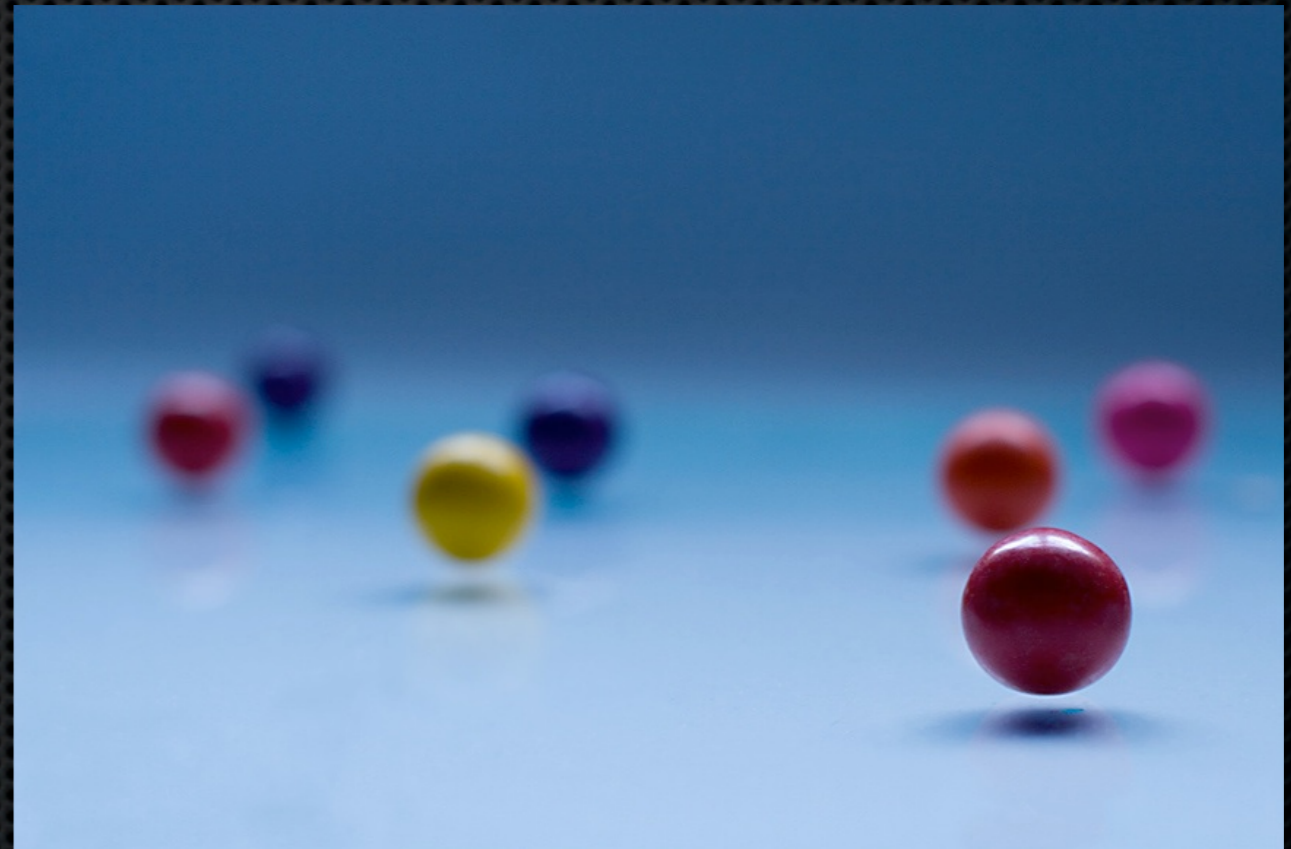
More to discover



- ✦ New weak & strong forces
- ✦ Composite dark matter
- ✦ Composite inflation
- ✦

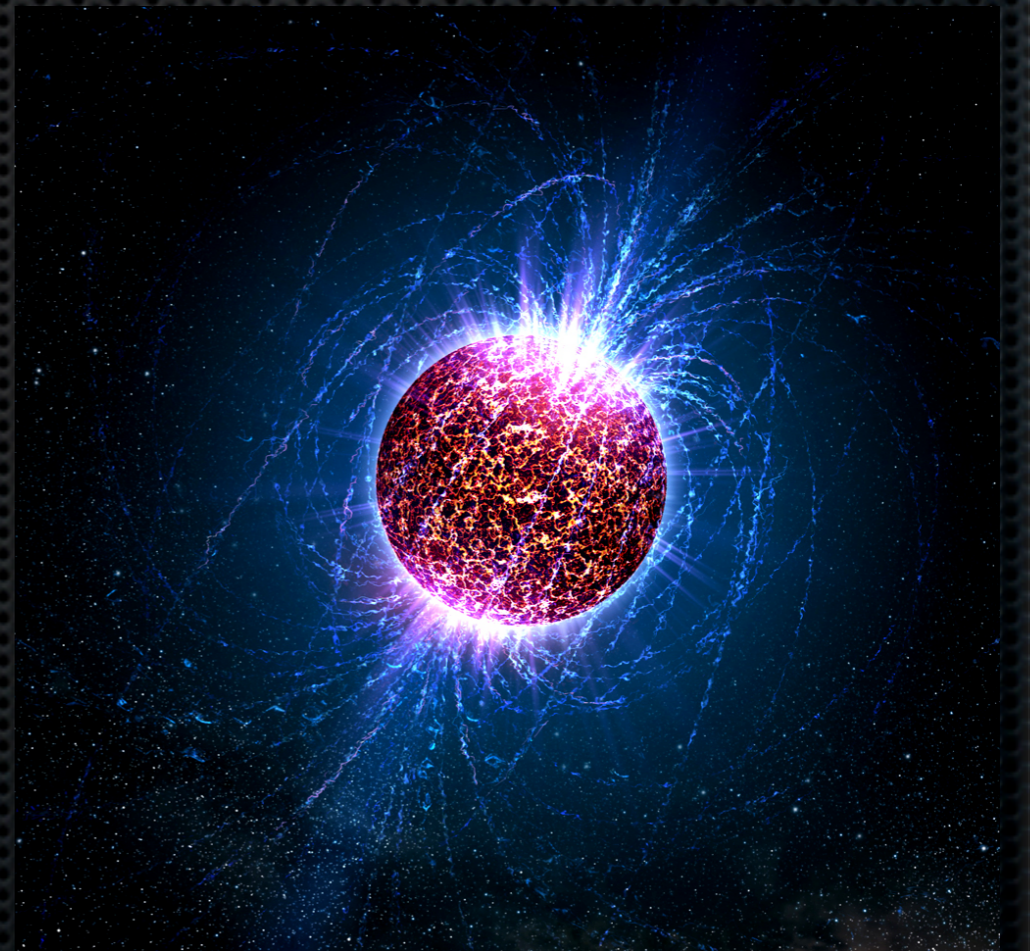
Strong matters

- ✦ What makes the Higgs?
- ✦ What makes dark matter?
- ✦ What makes the inflaton?
- ✦ Are these states composite?



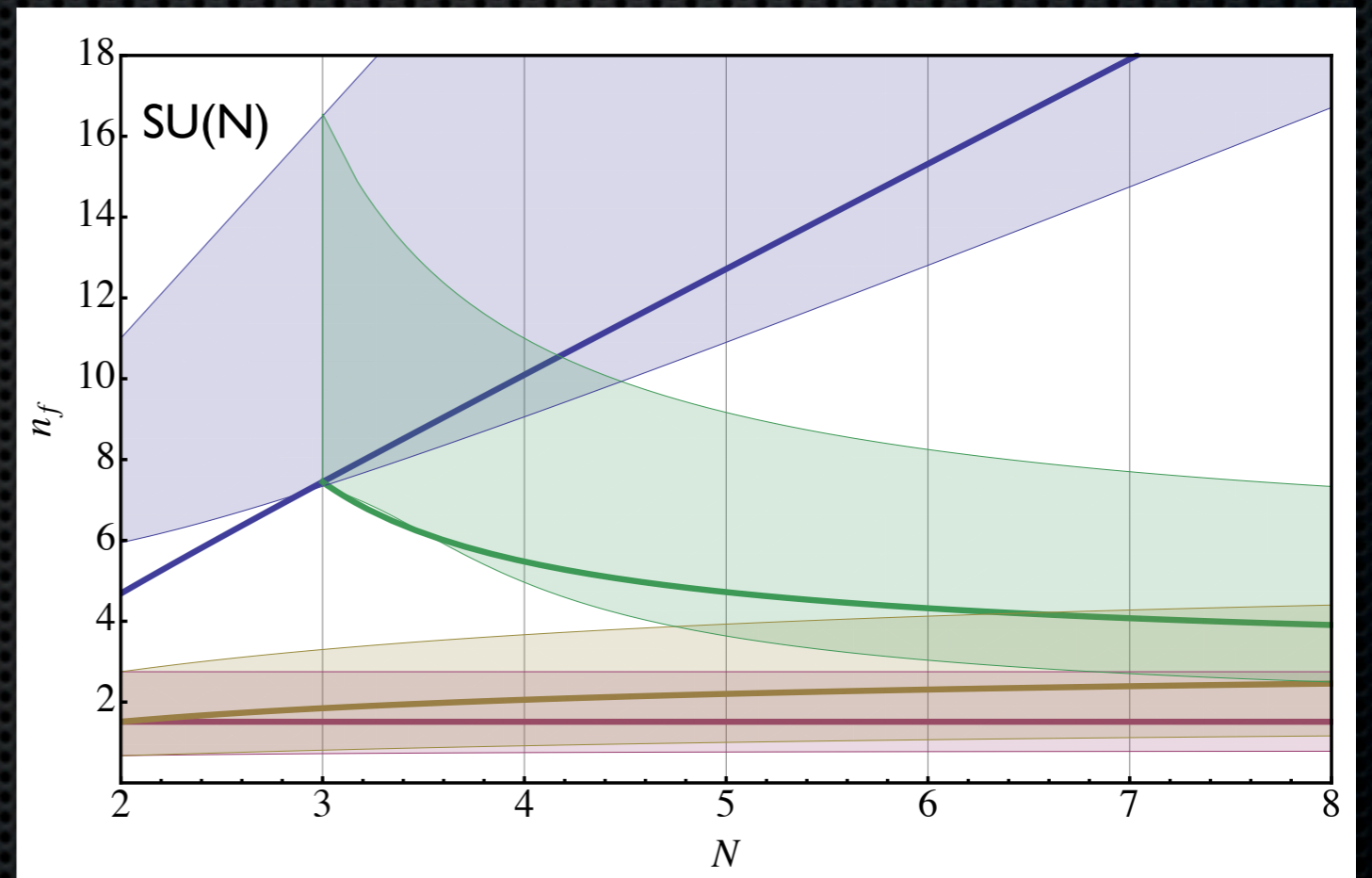
QCD - Nature's example

- ✦ Spectrum
- ✦ Chiral SB vs confinement
- ✦ Matter in eXtreme conditions
- ✦ Gauge - gravity duality
- ✦ Gauge - gauge duality



Beyond QCD

- ✦ Conformal phase diagram
- ✦ Hot conformal theories
- ✦ Walking vs jumping
- ✦ Conformal Gauge-Yukawa
- ✦ Holographic window
- ✦ a-theorem bound
- ✦ Gauge - gauge duality



Sannino, Tuominen
Dietrich, Sannino
Pica, Sannino

Discovered

- Universal phase diagram structure
- Strongly coupled IR FP
- Conformal spectrum
- Asympt. safe FT
- Non QCD dynamics
- Useful a-theorem bound

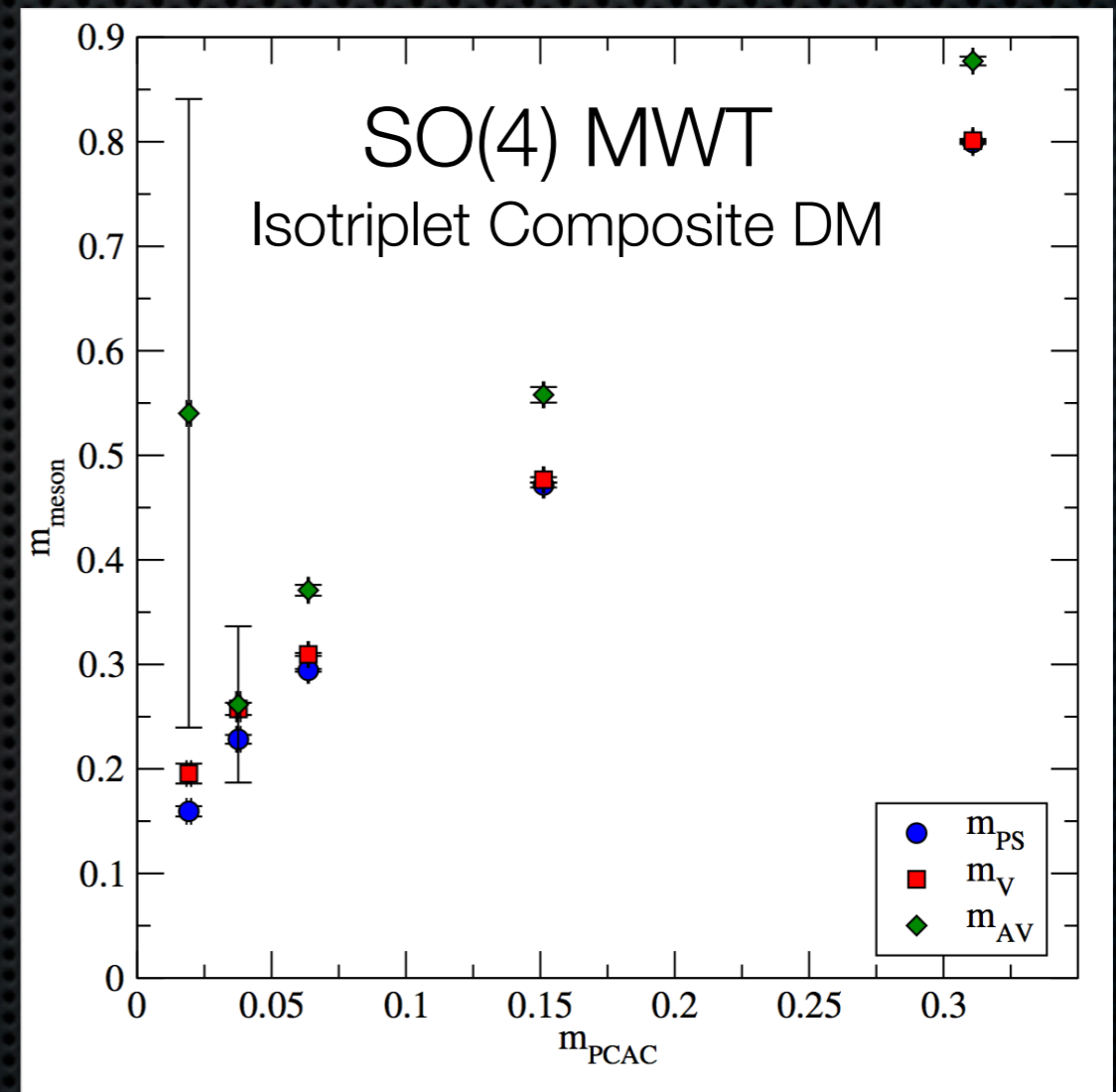
$$n_s + \frac{11}{2}n_f + 62n_v \geq 60n_v \frac{b_0^2}{|b_1|}$$

Antipin, Gillioz, Sannino

4d & nonsusy

Physics

- ✦ Lattice walking spectrum
- ✦ Critical exponents
- ✦ Dark matter on the lattice
- ✦ Precision EW S - bound
- ✦ Composite inflation
- ✦ Much more to come...



Hietanen, Pica, Søndergaard, Sannino

Color unit

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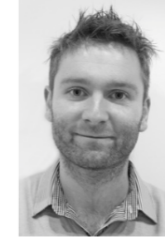
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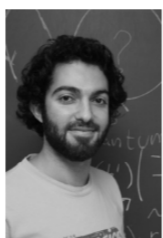
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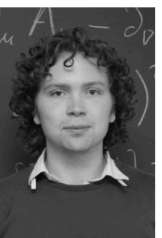
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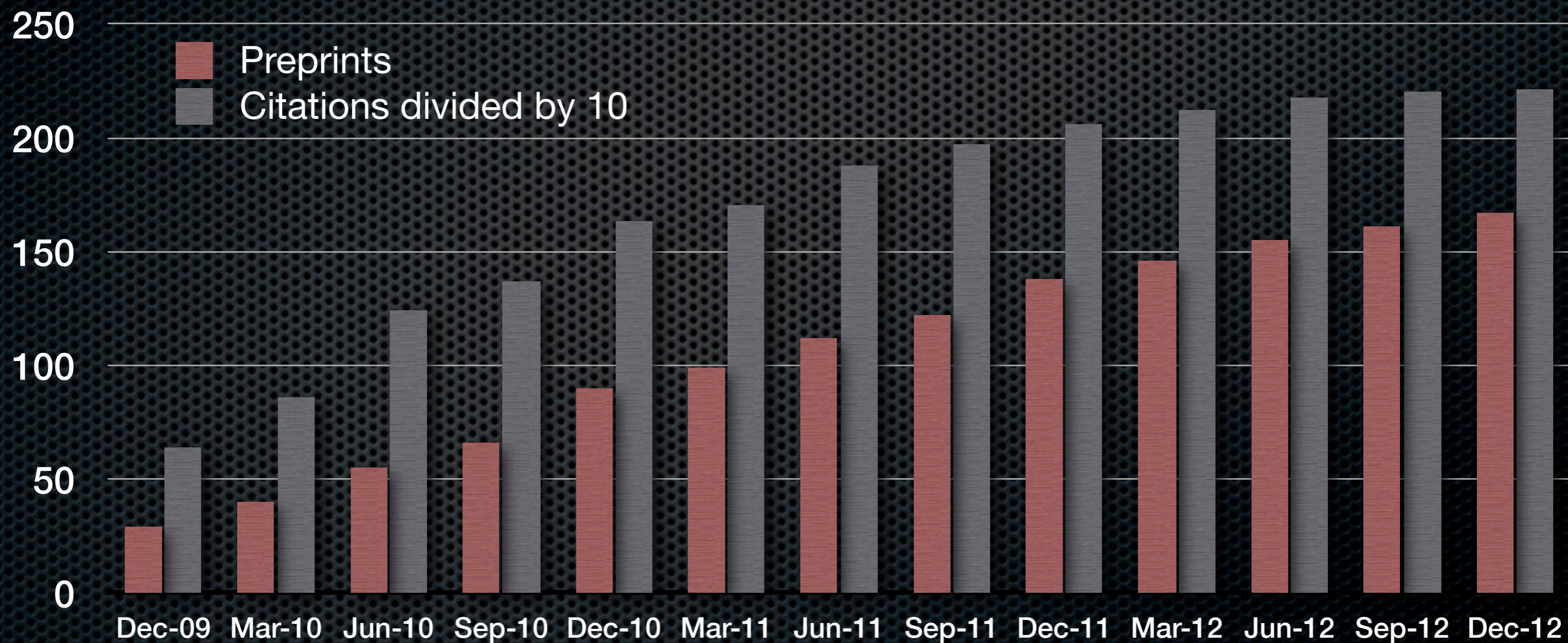
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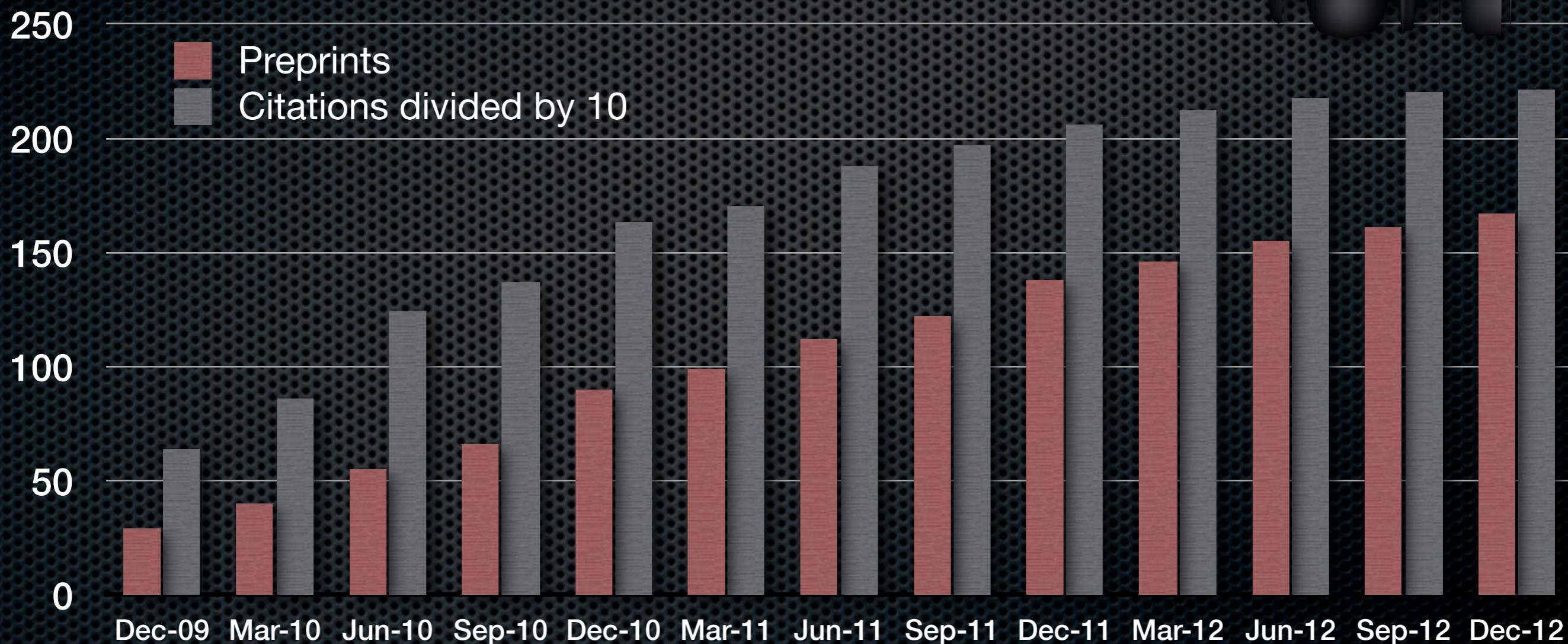
Scientific impact

Staying ahead of the game

Cumulative number of preprints & citations per quarter



Cumulative number of preprints & citations per quarter



High impact, in 3.5 years

- ✦ 8 papers in PRL
- ✦ Several top cited
- ✦ 130 published, (150 preprints)
- ✦ 1 Book, several reports
- ✦ 126 invited/plenary talks
- ✦ Partner with ~60 major intl. institutes



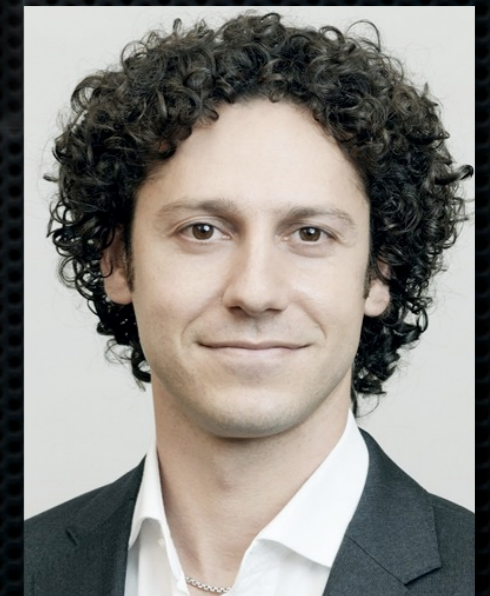
X-Activity, in 3.5 years

- ✦ 77 Journal clubs
- ✦ 83 CP³ Lectures on the Tube
- ✦ 20 Meetings
- ✦ 8 CP³ Mini courses
- ✦ 3 Retreats
- ✦ 7 Genius program events
- ✦ 12 Danish IAS lectures



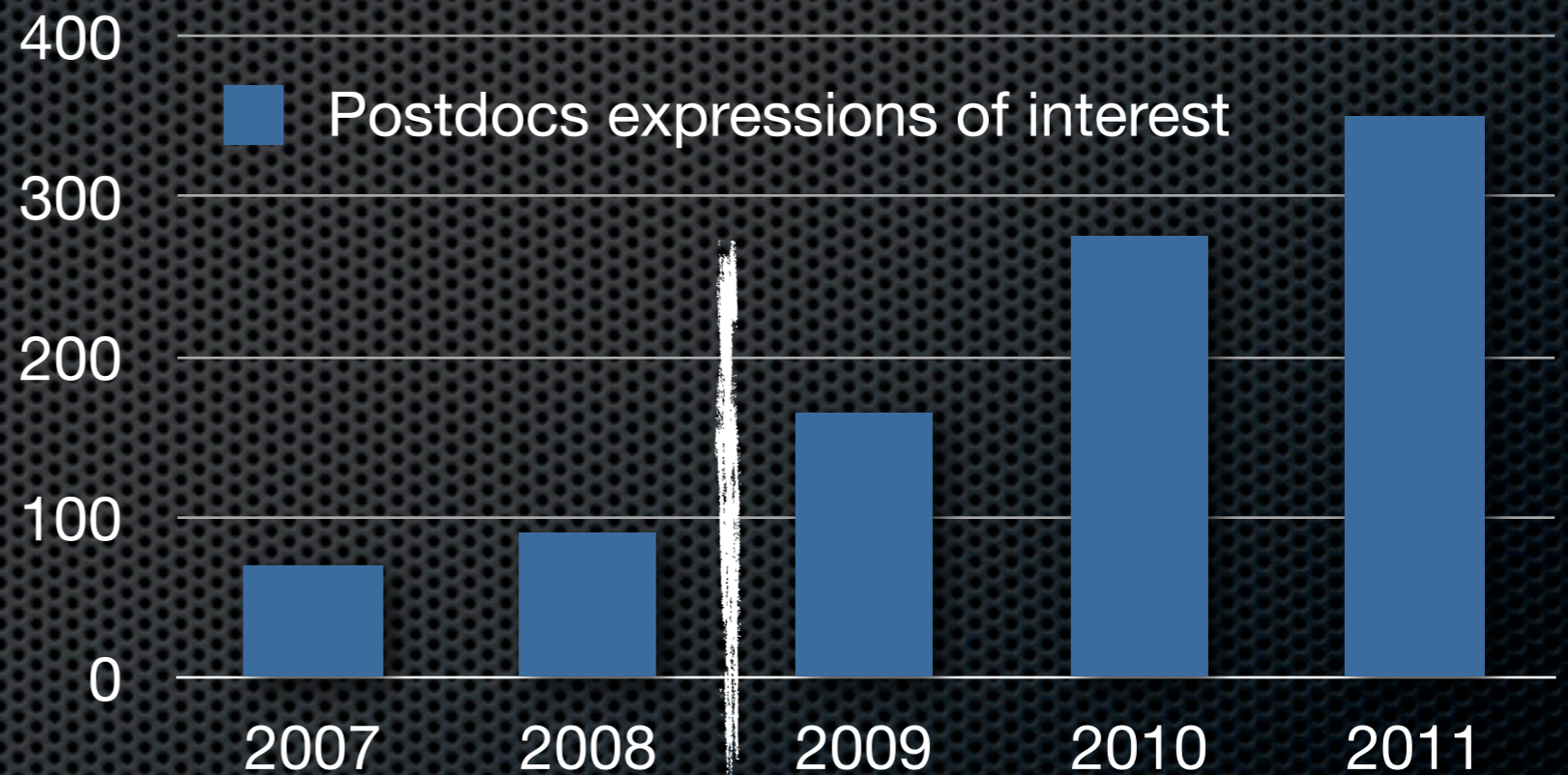
Selected prizes & grants

- ✦ 2 PRACE grants
- ✦ 2 Lundbeckfonden
- ✦ Elite researcher prize
- ✦ 2 sapere aude
- ✦ Master & bachelor prizes



The right investment

- ✦ Strong reputation
- ✦ Original ideas
- ✦ Ambitious goals
- ✦ Elite training
- ✦ A lot of fun ahead!



- ✦ 3 x number of physics students
- ✦ Jobs @ Cambridge, UCLA, Durham PPP, Berkley, Harvard ...

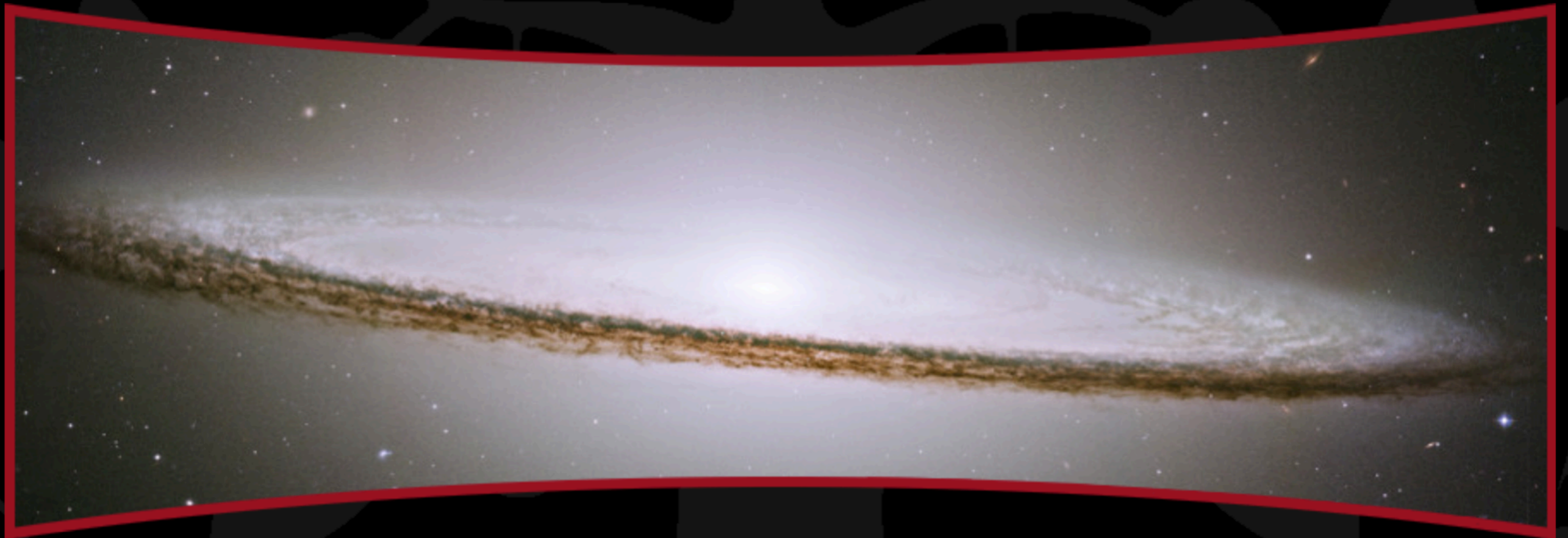
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[Making Science Documentaries a Success](#)

[After Higgs: The hunt for new physics](#)

Events

[Apr 15 at 14:15: Holographic thermalization at intermediate coupl...](#)

[Apr 19 at 12:00: CP³ Journal Club](#)

WE CANNOT SOLVE OUR PROBLEMS
WITH THE SAME THINKING
WE USED WHEN WE
CREATED THEM

- Albert Einstein

