Highlights & Perspectives

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XXII Rencontres de Blois · 20 July 2010

Historique

HISTOIRE DE

LOVYS XII,

ROY DE FRANCE,

PERE DV PEVPLE, ET DES

choſes memorables aduenües de ſon Regne,

Es années 1499, 1500, & 1501.

TANT EN FRANCE, QVE AV

RECOVVREMENT DV DVCHE' DE MILAN,

en la conqueſte du Royaume de Naples, & autres lieux.

Par IEAN D'AVTON, *ſon Hiſtoriographe.*

Tirée de la Bibliothecque du Roy, & nouuellement miſe en lumiere par THEODORE GODEFROY, Aduocat au Parlement de Paris.

A PARIS,

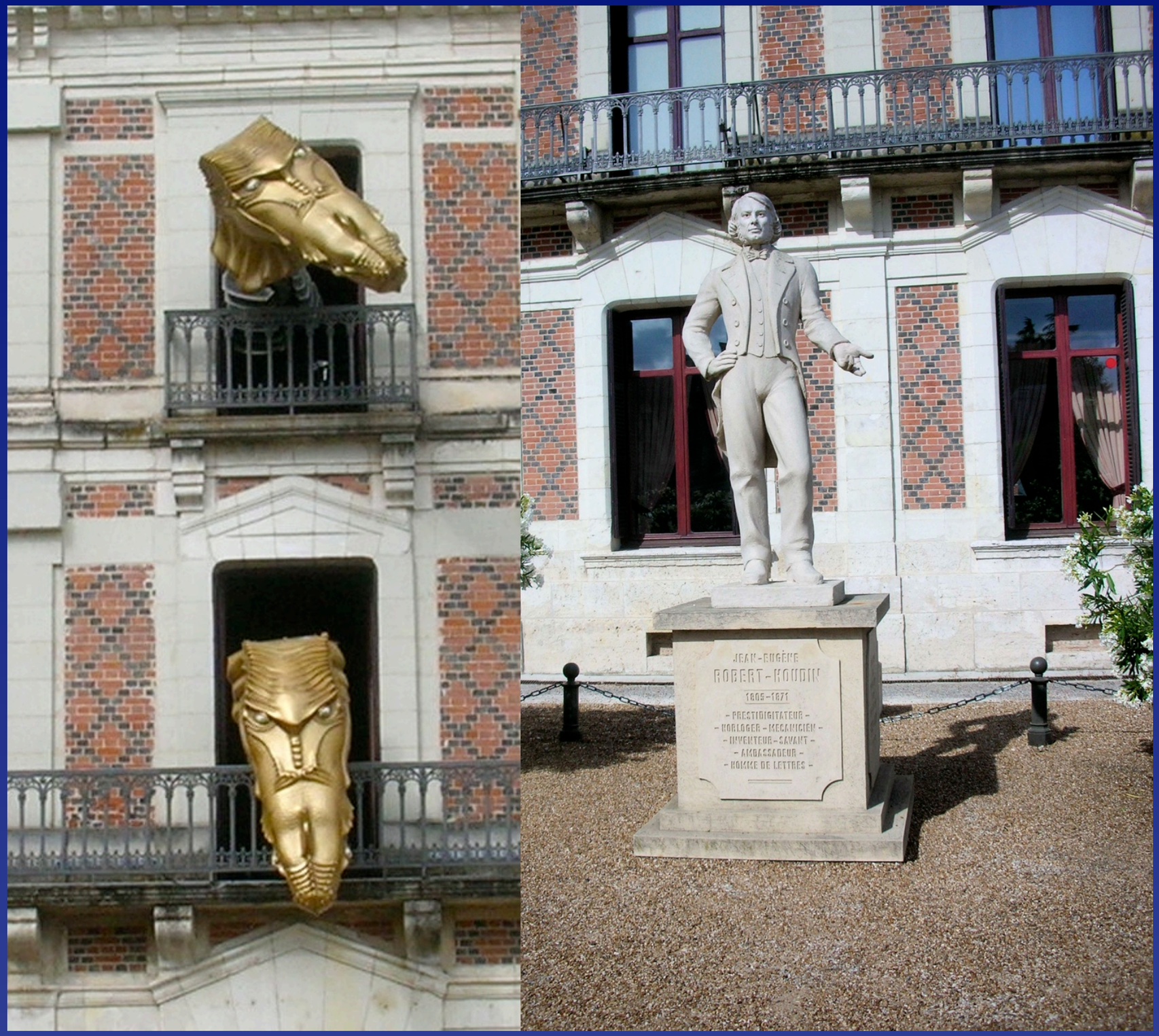
Chez ABRAHAM PACARD, ruë Sainct Iacques, au Sacrifice d'Abraham.

M. DC. XX.

Auec Priuilege du Roy.

Source gallica.bnf.fr / Bibliothèque nationale de France

Jean-Eugène Robert-Houdin (1805–1871)



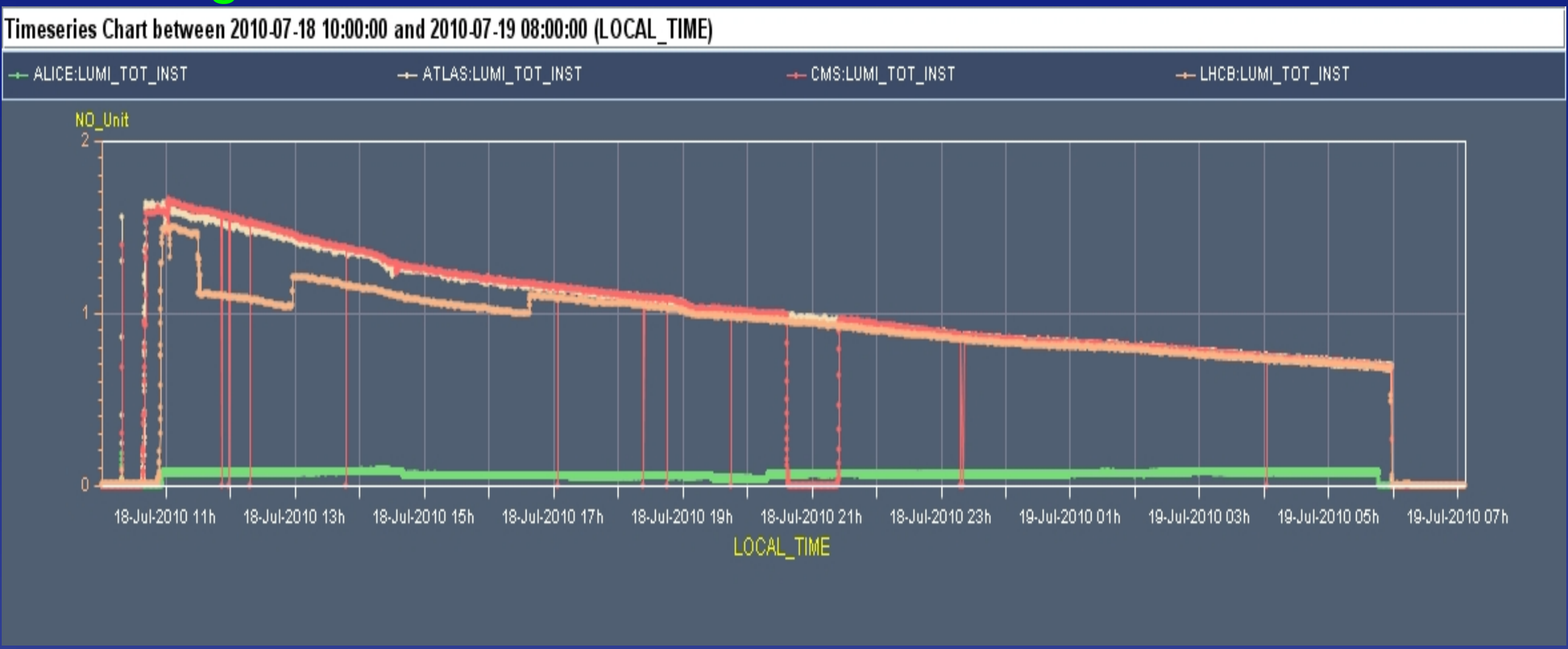
Magie et physique amusante (1877)

Denis Papin (1647–1714)

La marmite de Papin (1769) : BCSM

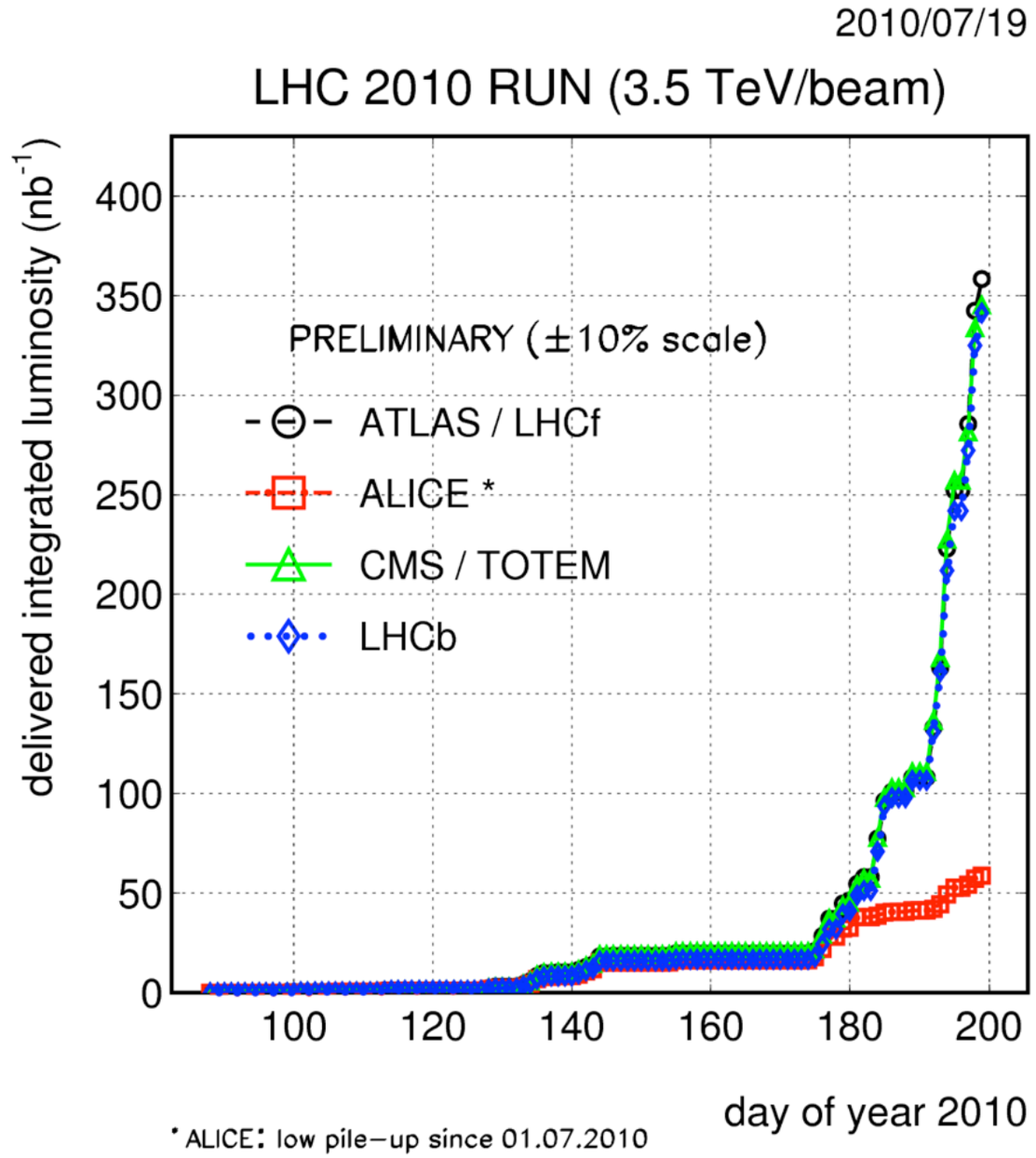
LHC Performance

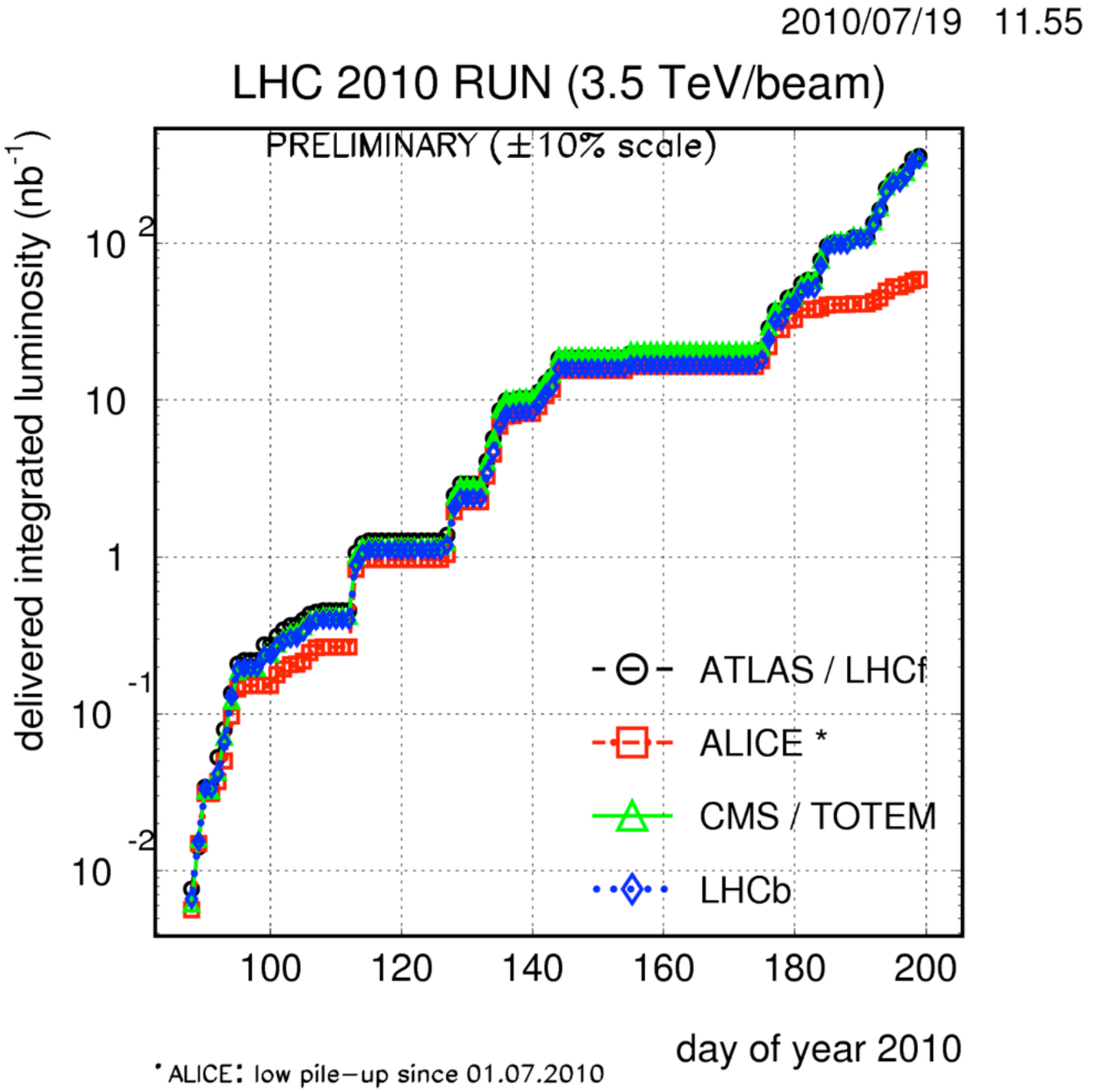
15 July : switch to 13 bunch operation, 9×10^{10} protons/bunch
8 colliding pairs for ATLAS, CMS and LHCb.
Stored energy : 660 kJ.
Peak luminosity : 1.6×10^{30} $cm^{-2}s^{-1}$ for fill 1233 on Sunday.
Longest fill : 19 hours.



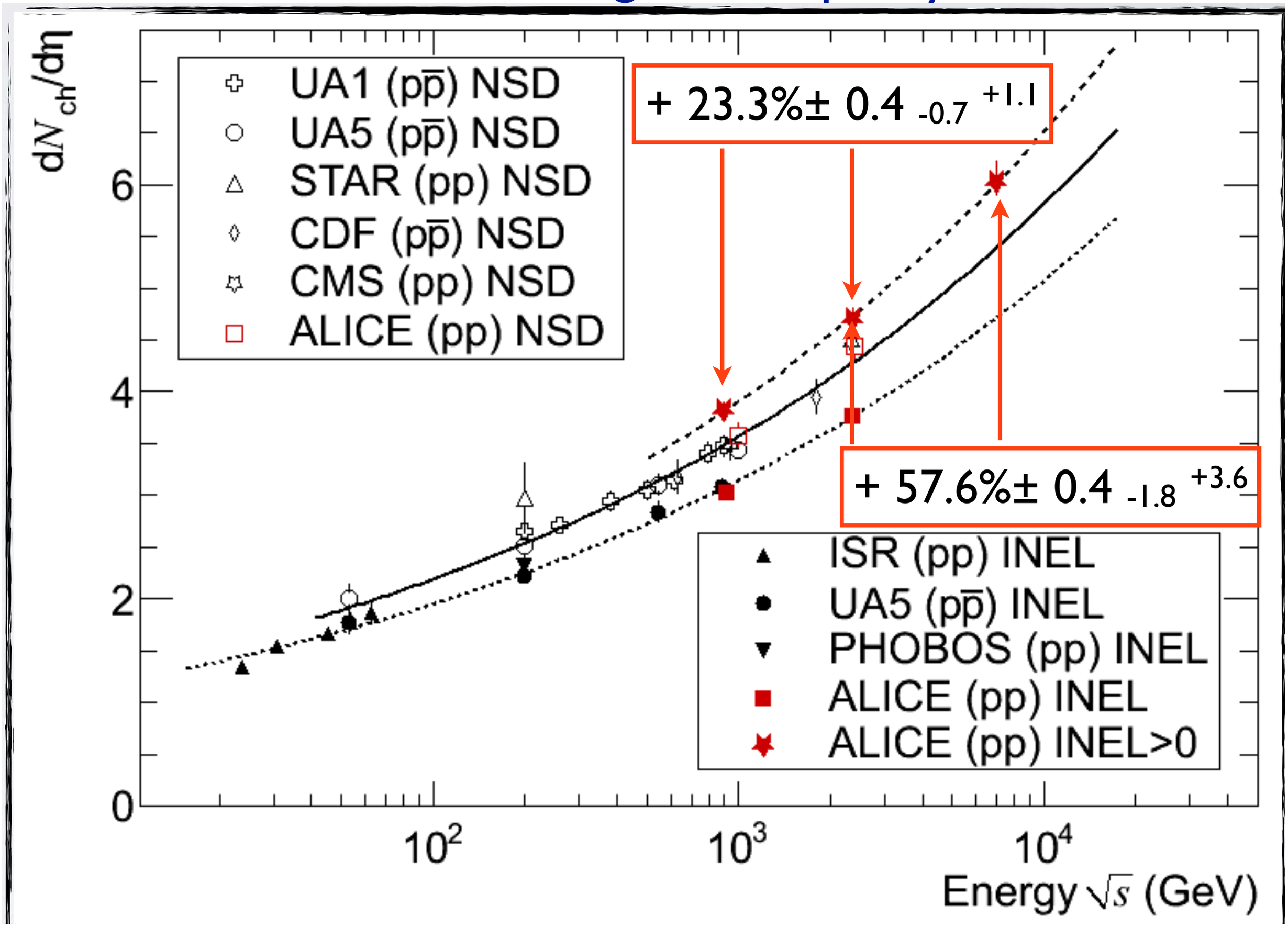
Bunch trains coming in August

LHC Luminosity Evolution
> 350 nb^{-1} delivered

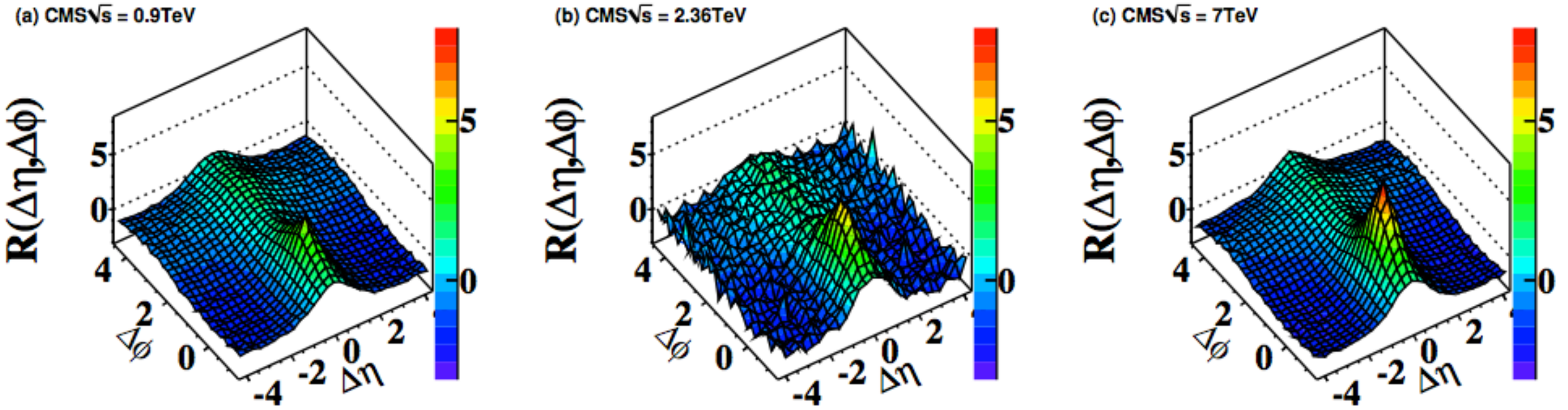




ALICE: Charged Multiplicity

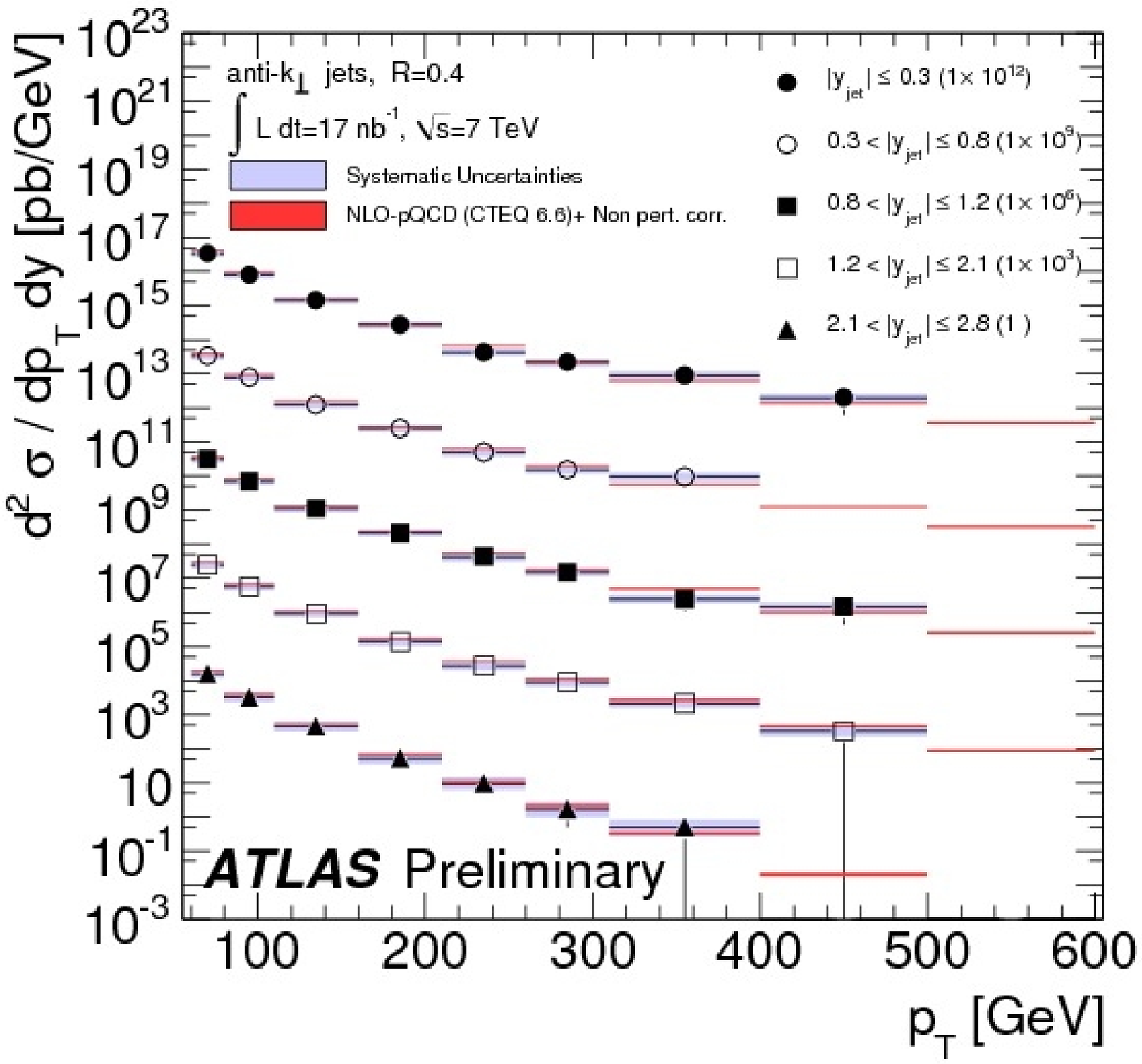


CMS: Two-particle Correlations



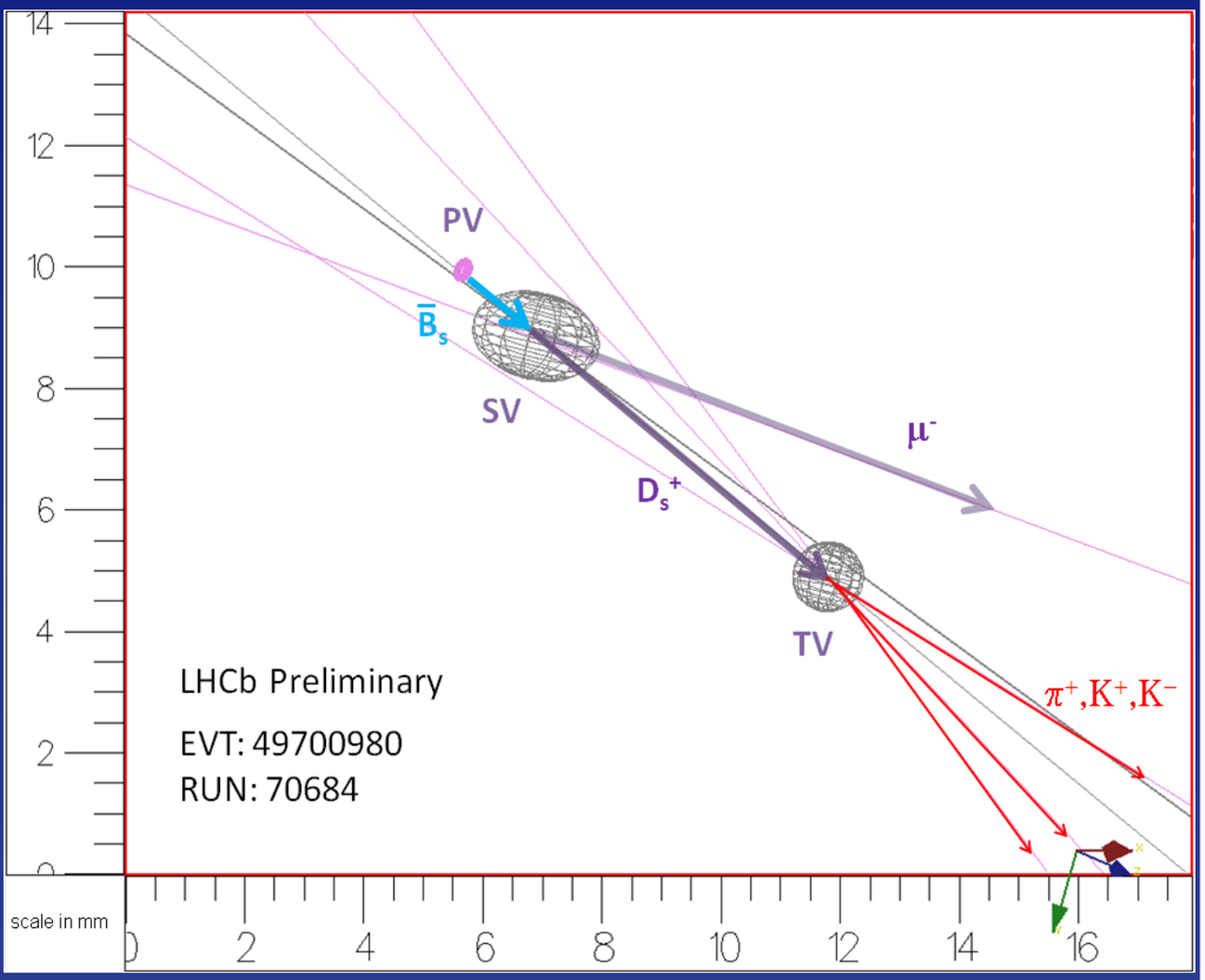
PYTHIA cluster size too small

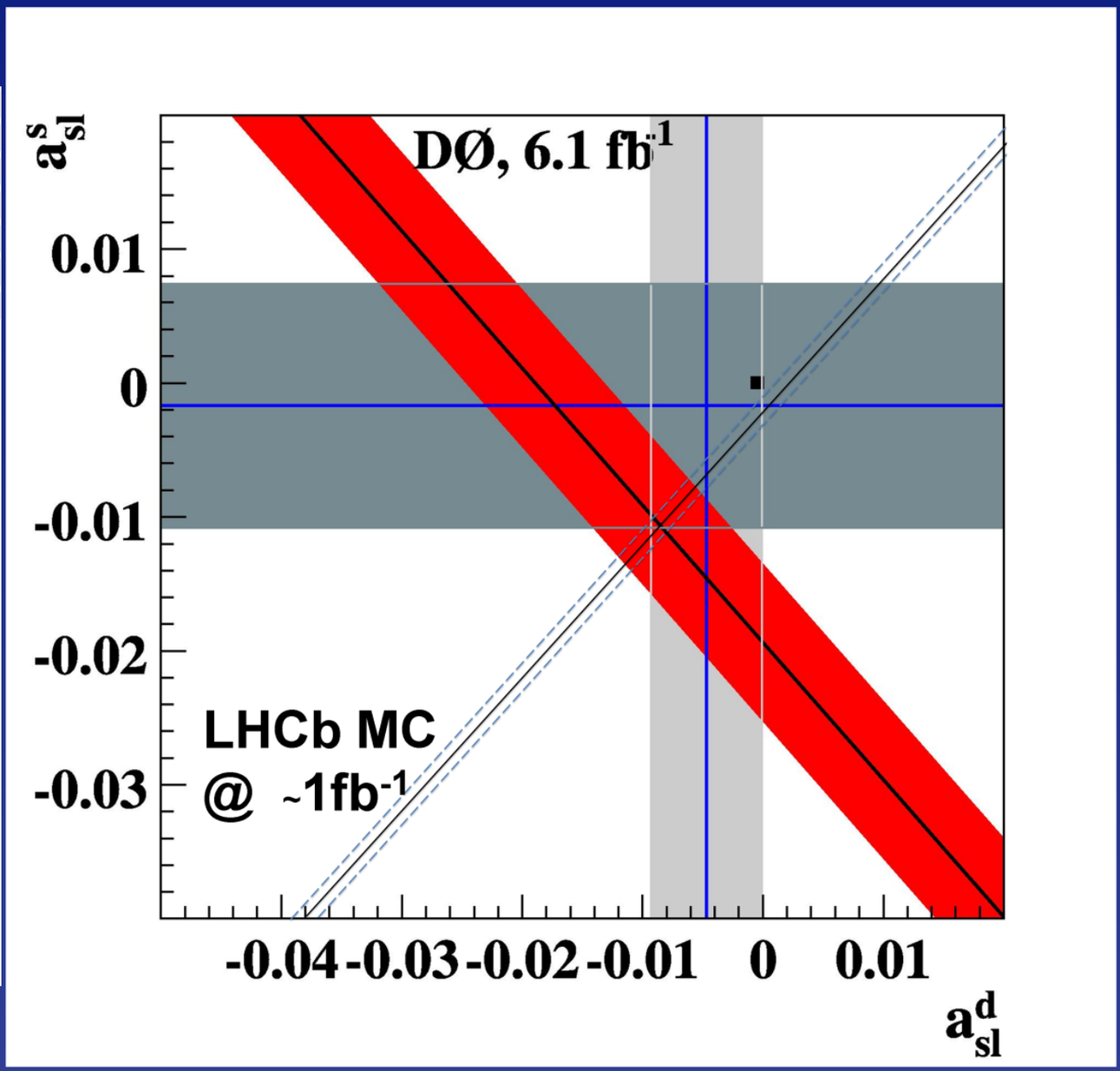
ATLAS Jets


anti-k⊥ jets, R=0.4
∫ L dt=17 nb-1, √s=7 TeV
Systematic Uncertainties
NLO-pQCD (CTEQ 6.6)+ Non pert. corr.
|yjet| ≤ 0.3 (1× 10^12)
0.3 < |yjet| ≤ 0.8 (1× 10^9)
0.8 < |yjet| ≤ 1.2 (1× 10^6)
1.2 < |yjet| ≤ 2.1 (1× 10^3)
2.1 < |yjet| ≤ 2.8 (1)
ATLAS Preliminary
d2σ / dpT dy [pb/GeV]
pT [GeV]
10^23
10^21
10^19
10^17
10^15
10^13
10^11
10^9
10^7
10^5
10^3
10
10^-1
10^-3
100
200
300
400
500
600

LHC*b* Sequential Decay

begin to confront DØ surprise at 100 pb^{-1}



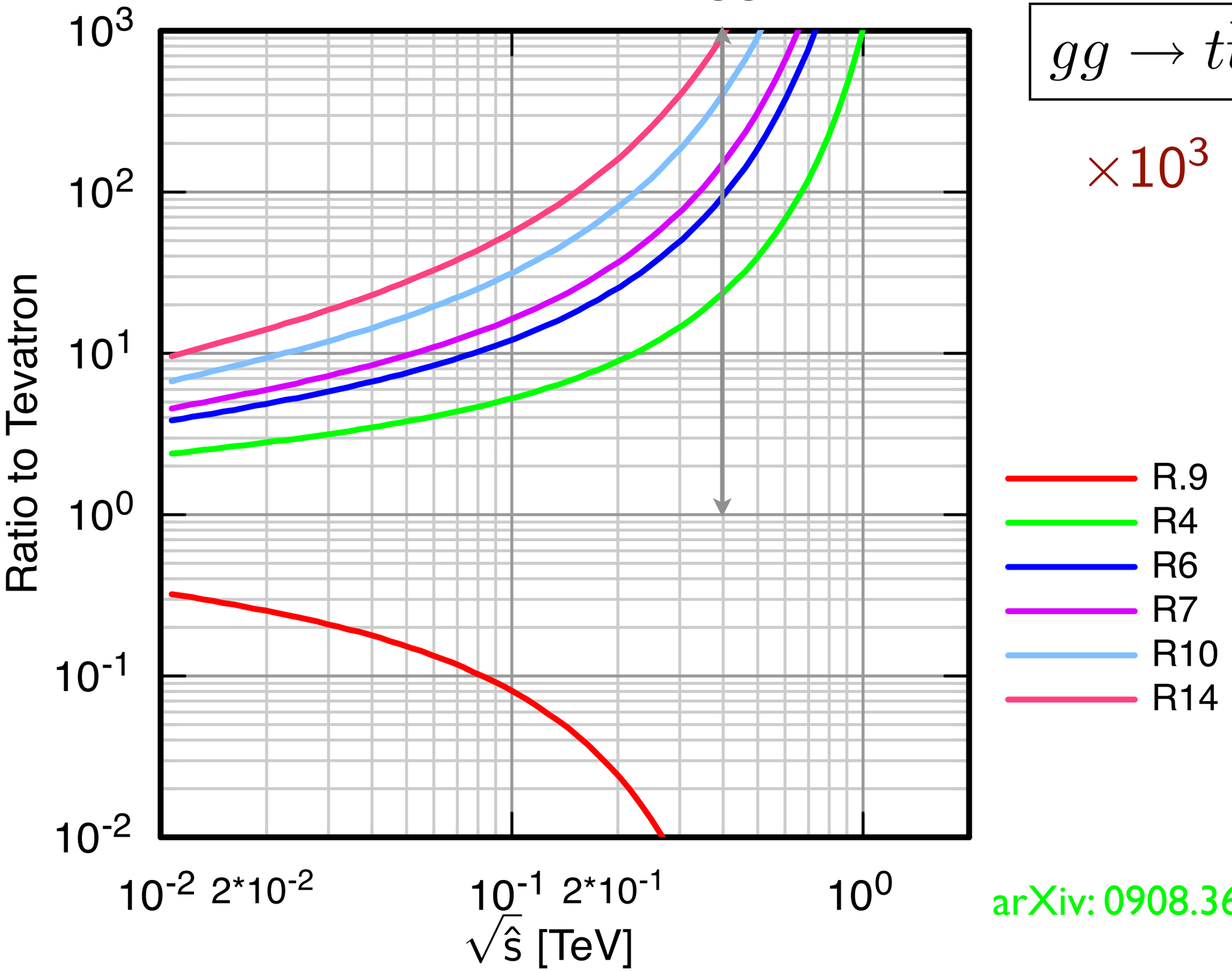


Parton Luminosities

CTEQ6L1: gg

$$gg \to t\bar{t}$$

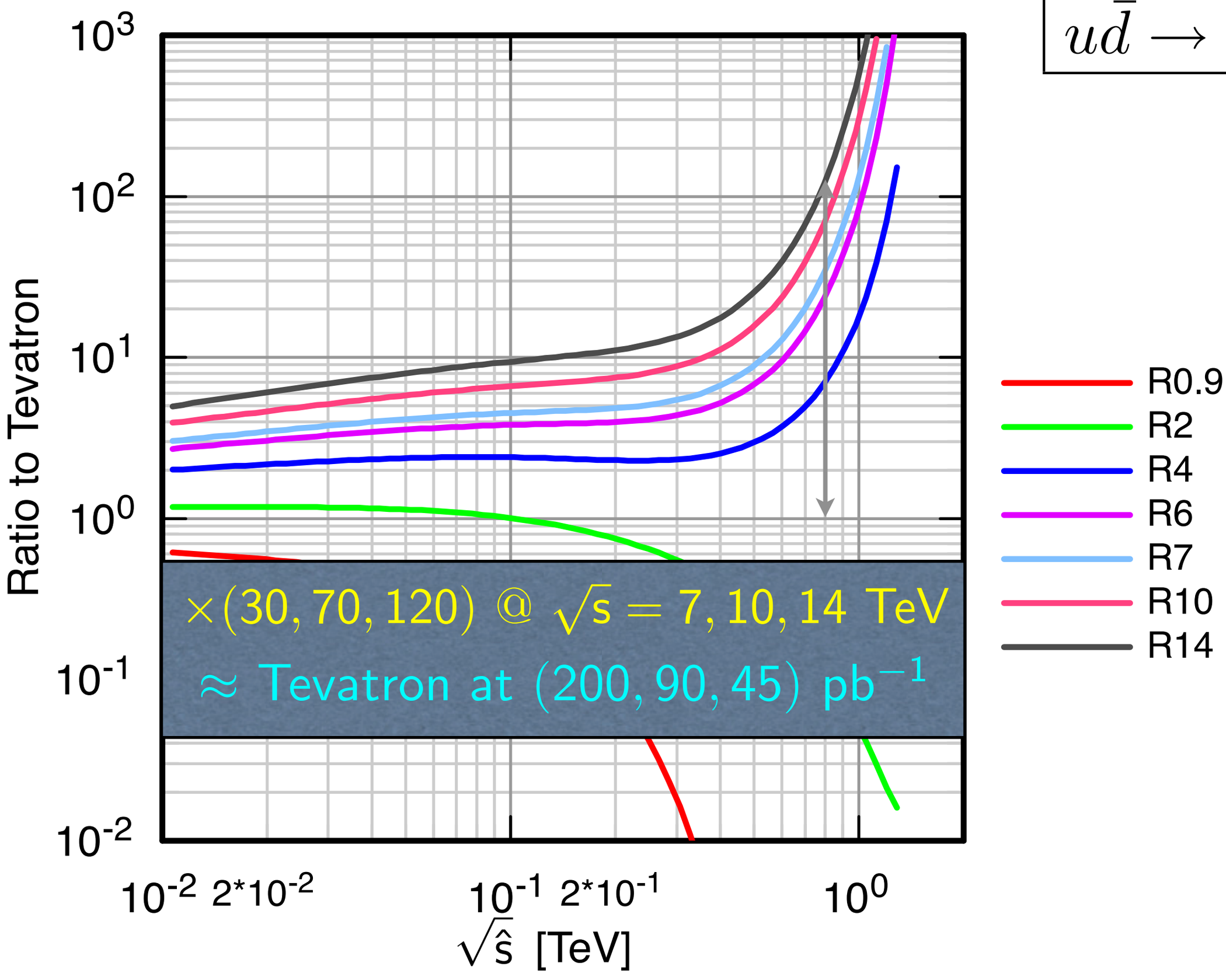
$\times 10^3$



arXiv: 0908.3660

Parton Luminosities

$$u\bar{d} \to W'$$



CTEQ6L1: qq

$qq \to \text{jets}$

Ratio to 2 TeV

10^3
10^2
10^1
10^0
10^{-1}
10^{-2}

$\times(135, 220, 340)$ @ $\sqrt{s} = 7, 10, 14$ TeV

$\approx$ Tevatron at $(44, 27, 18)$ pb^{-1}

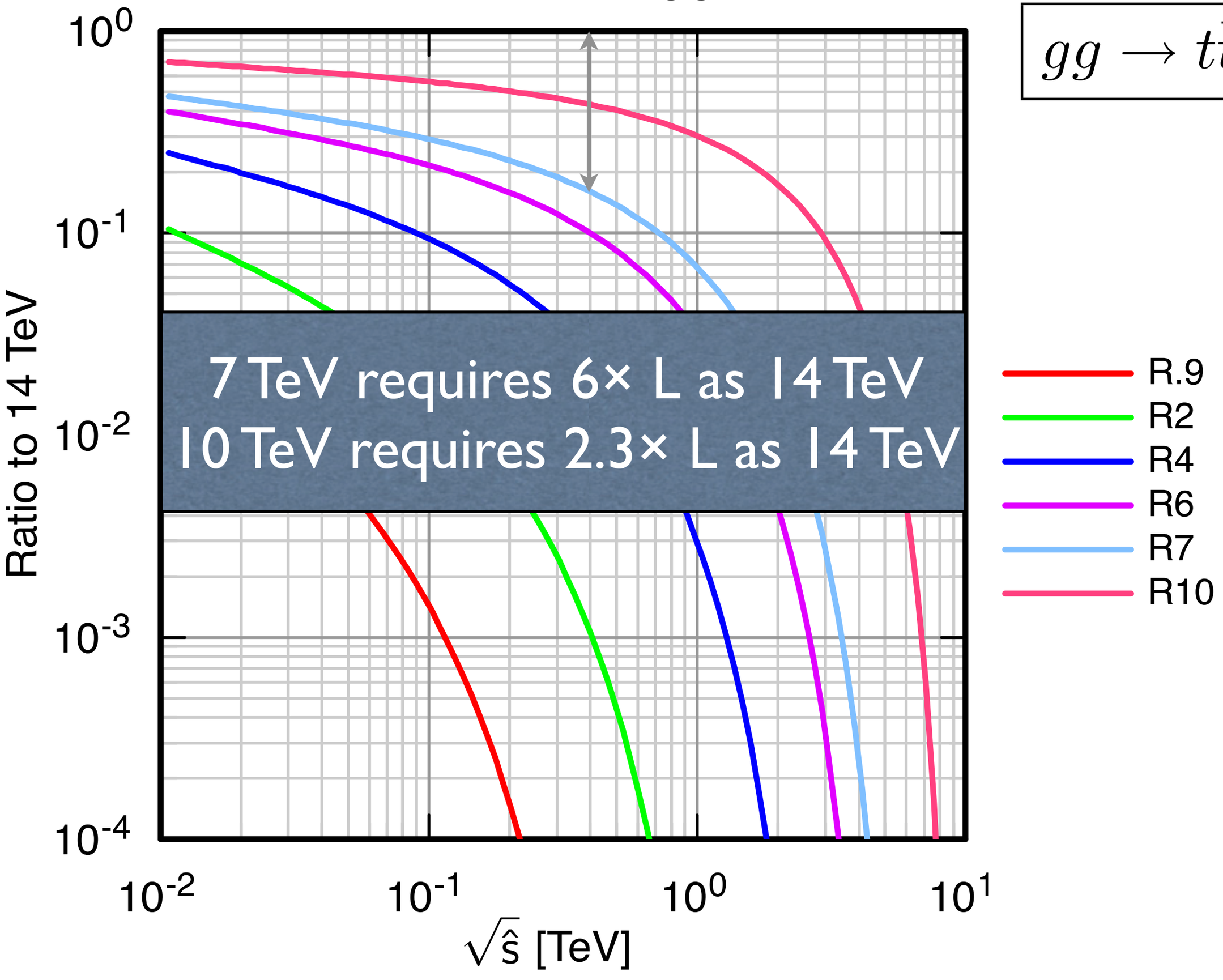
R0.9
R4
R6
R7
R10
R14

10^{-2} $2*10^{-2}$ 10^{-1} $2*10^{-1}$ 10^0

$\sqrt{\hat{s}}$ [TeV]

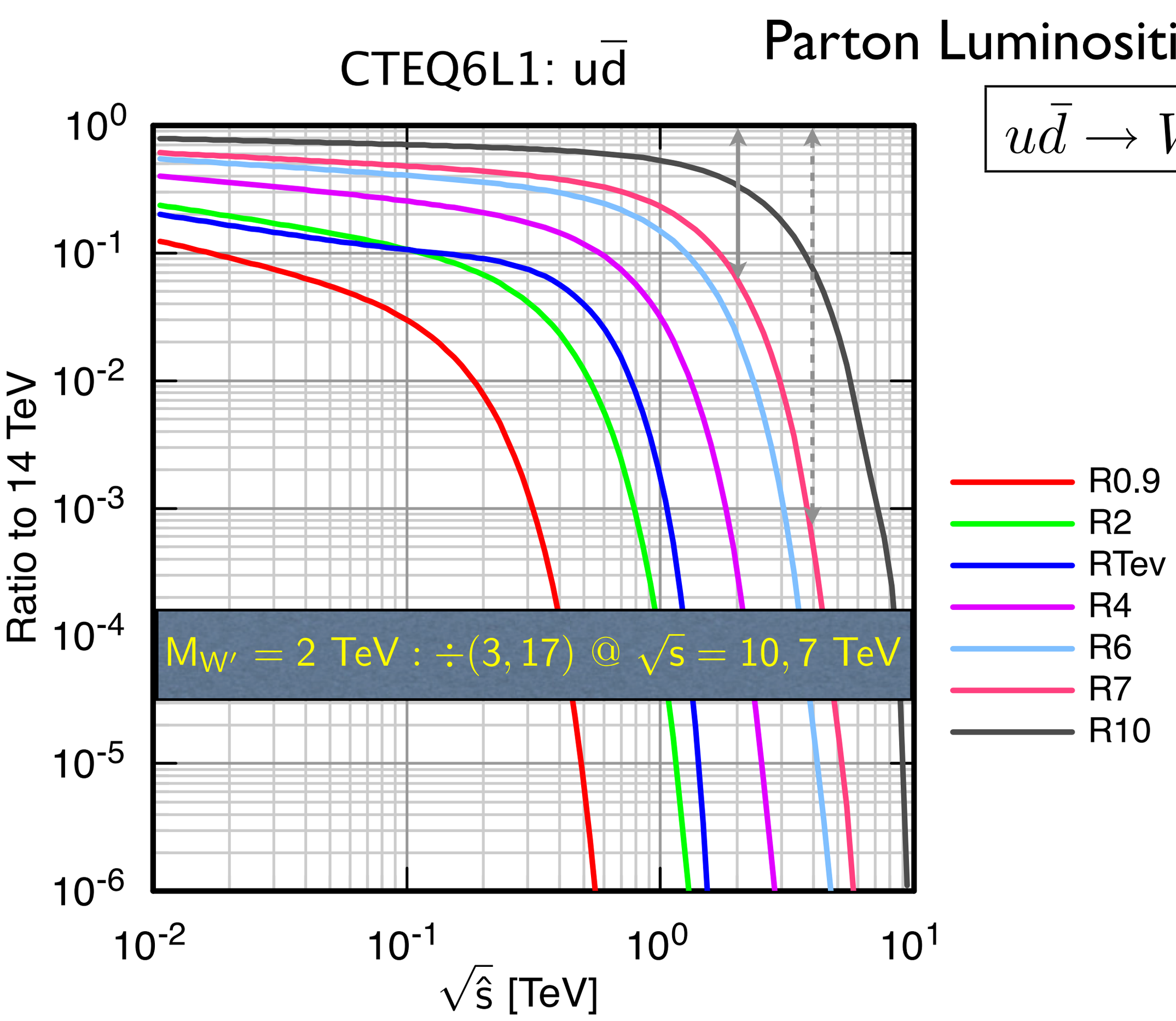
Parton Luminosities

$$gg \to t\bar{t}$$



Parton Luminosities

$$u\bar{d} \to W'$$



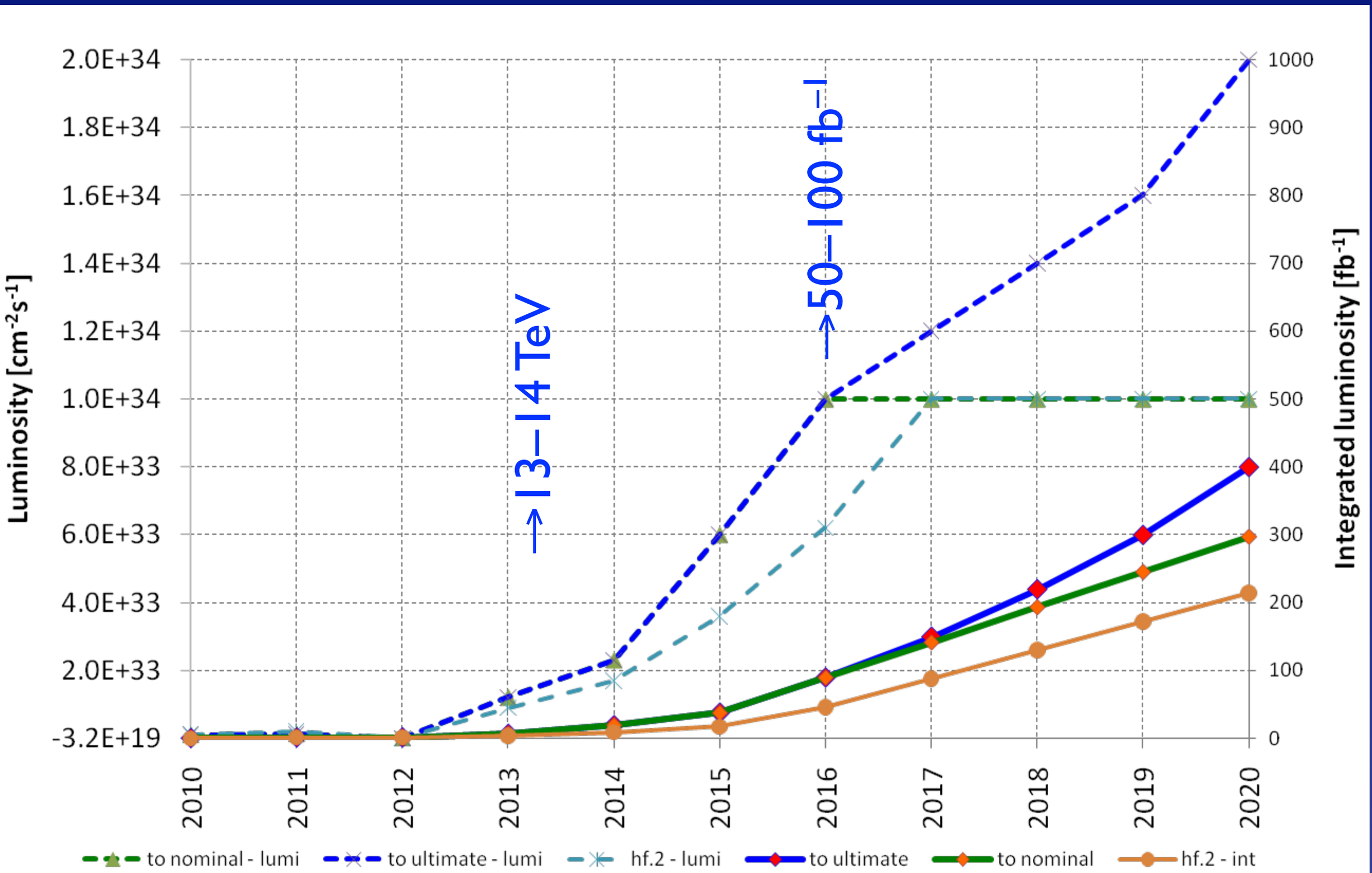
Prospects for early discoveries

(exceed Tevatron reach at few hundred pb^{-1})

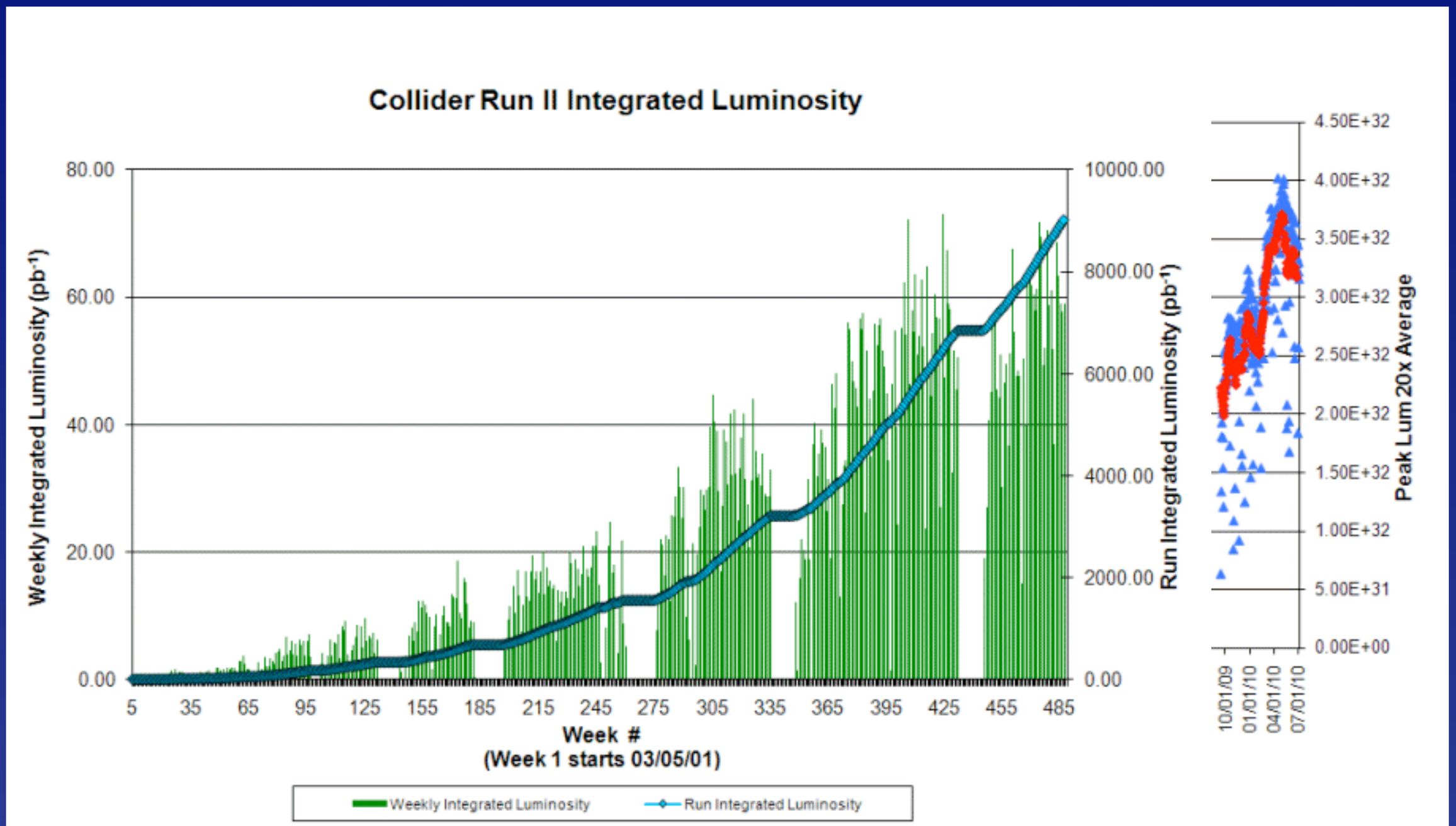
Not so plausible: diquark resonance

Not so implausible: 4th generation quark

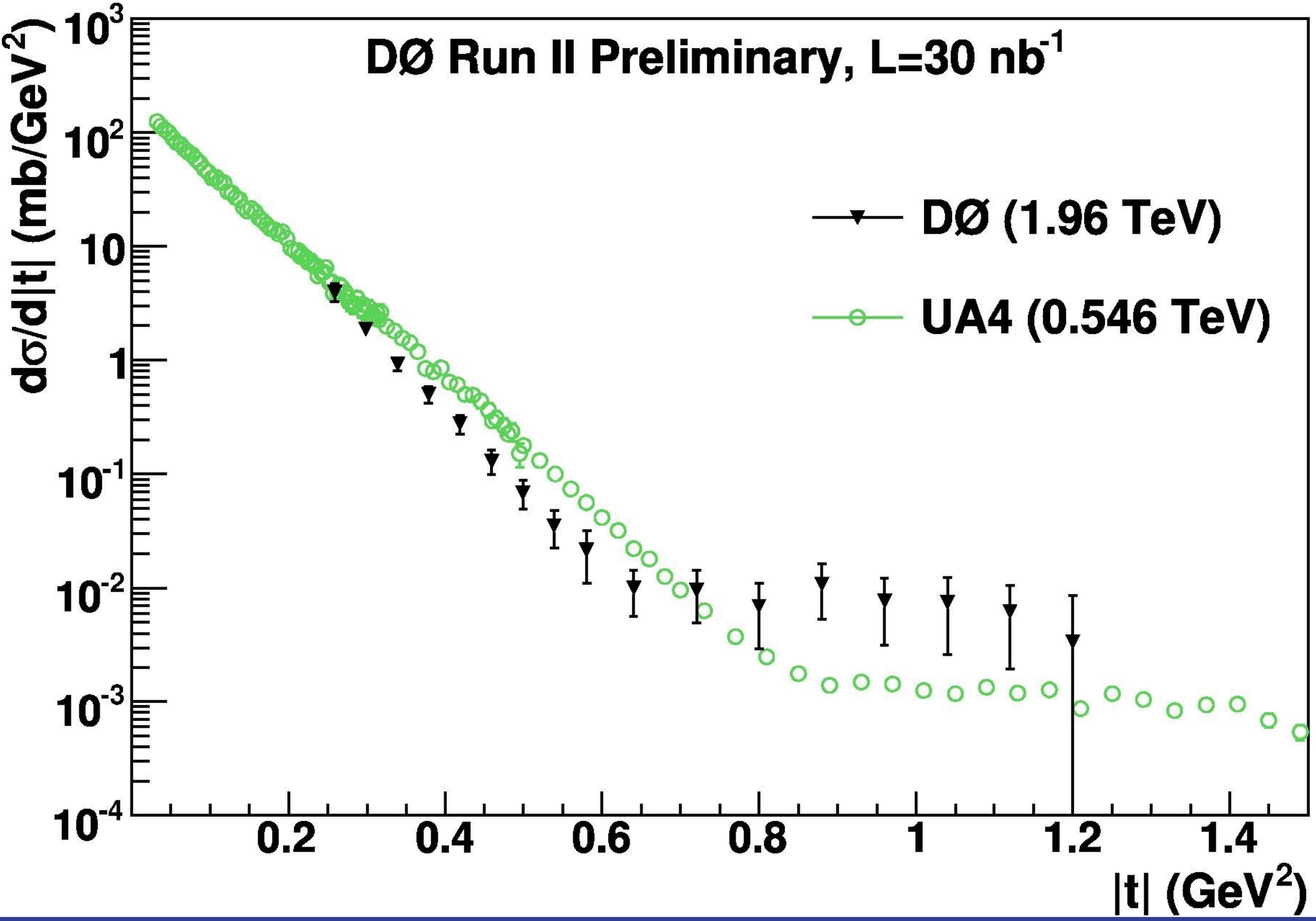
Possible Evolution of LHC Luminosity



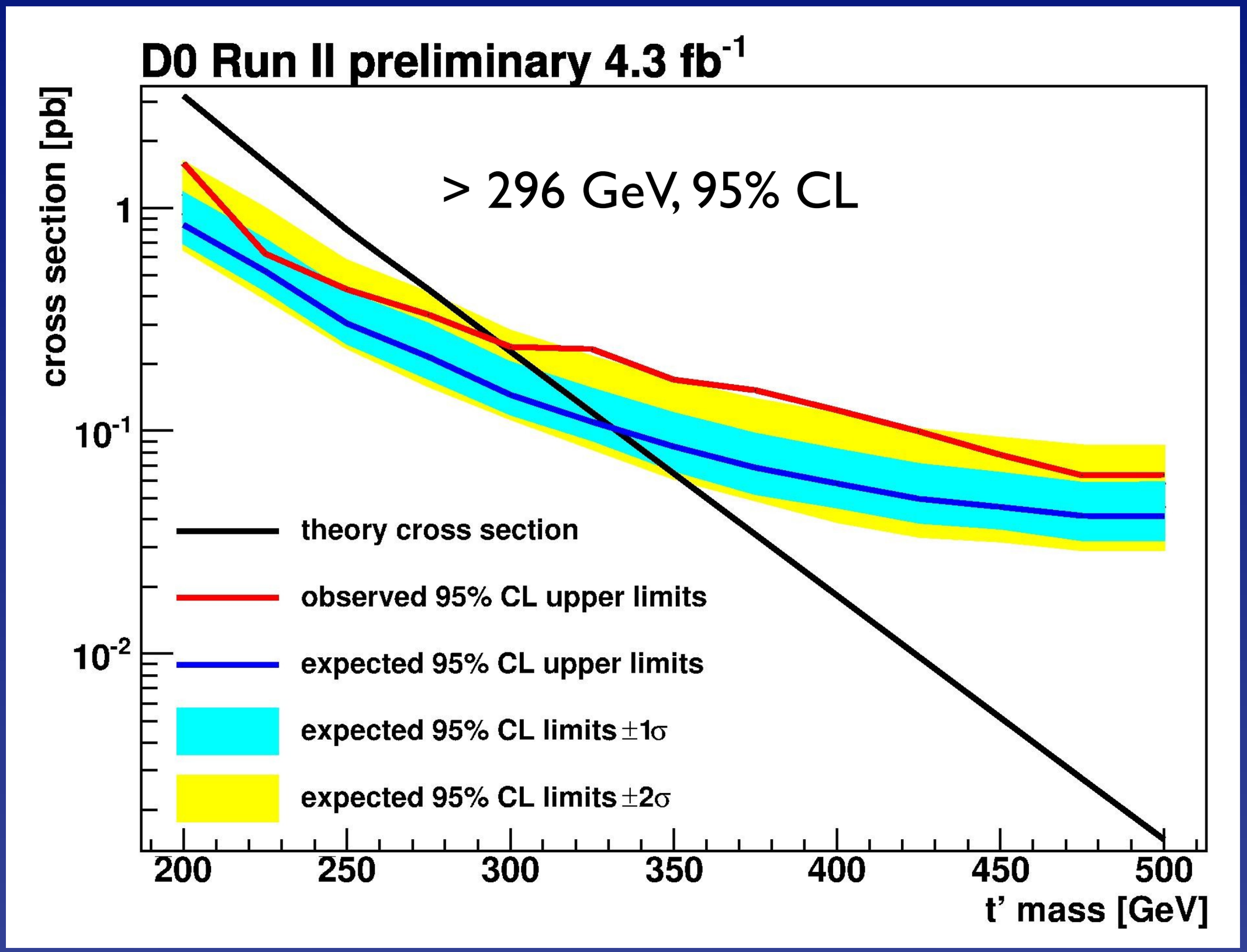
Tevatron Luminosity Evolution



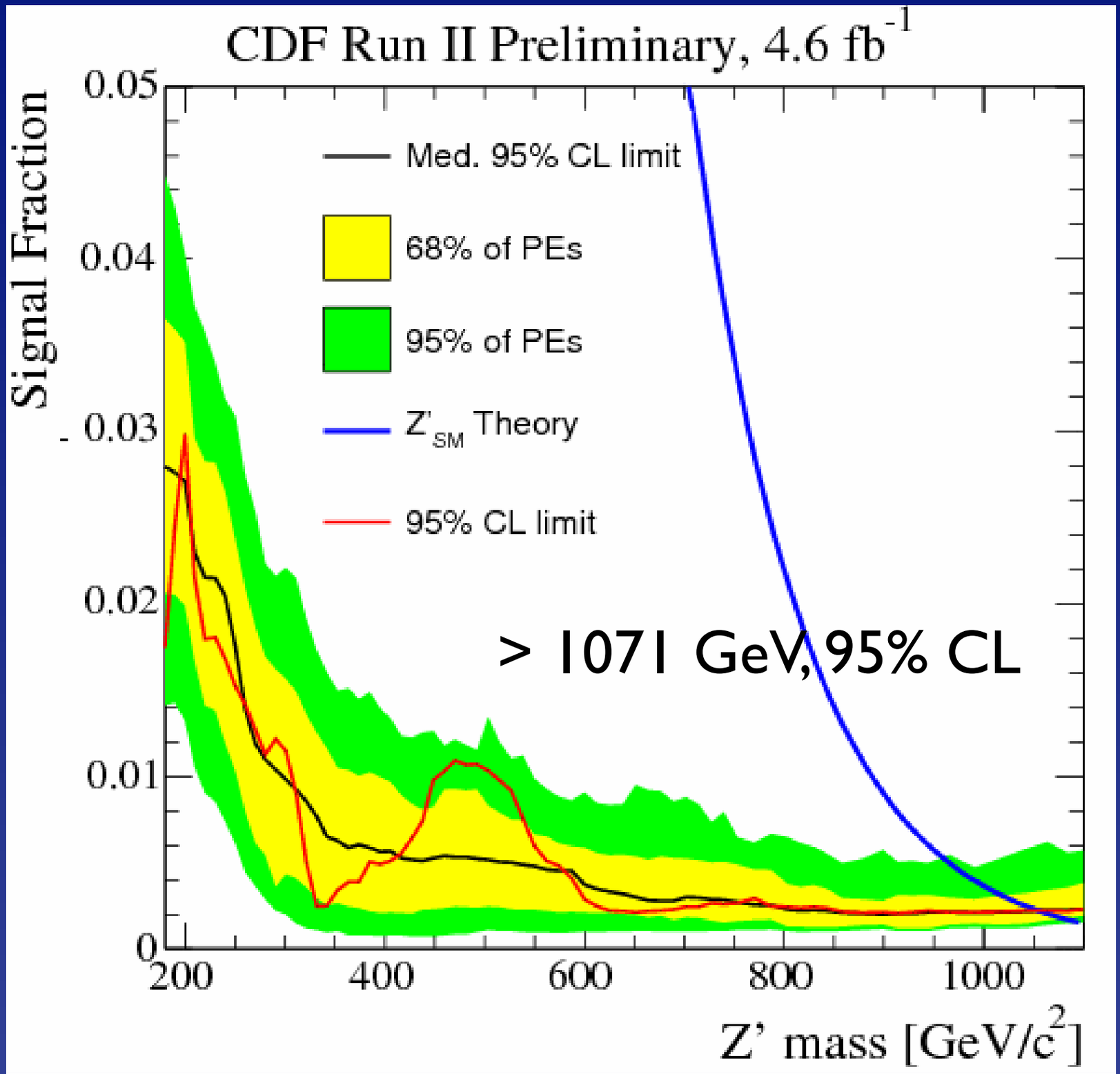
DØ Elastic Scattering



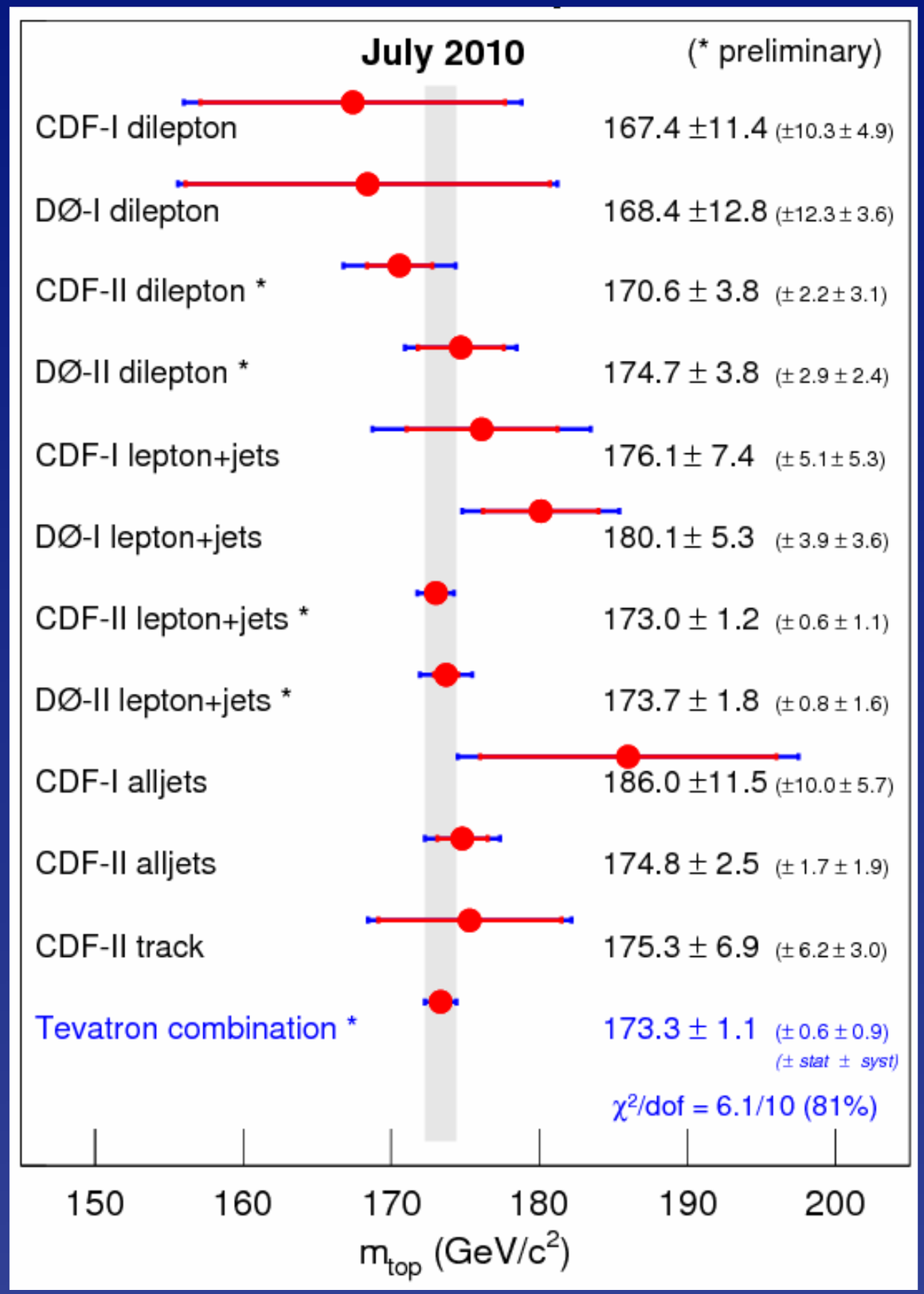
DØ t' Search


D0 Run II preliminary 4.3 fb-1
cross section [pb]
1
10-1
10-2
> 296 GeV, 95% CL
theory cross section
observed 95% CL upper limits
expected 95% CL upper limits
expected 95% CL limits ±1σ
expected 95% CL limits ±2σ
200
250
300
350
400
450
500
t' mass [GeV]

CDF Z' Search (dimuons)



Tevatron Top Mass



$\delta M_H = +10\ \delta m_t$

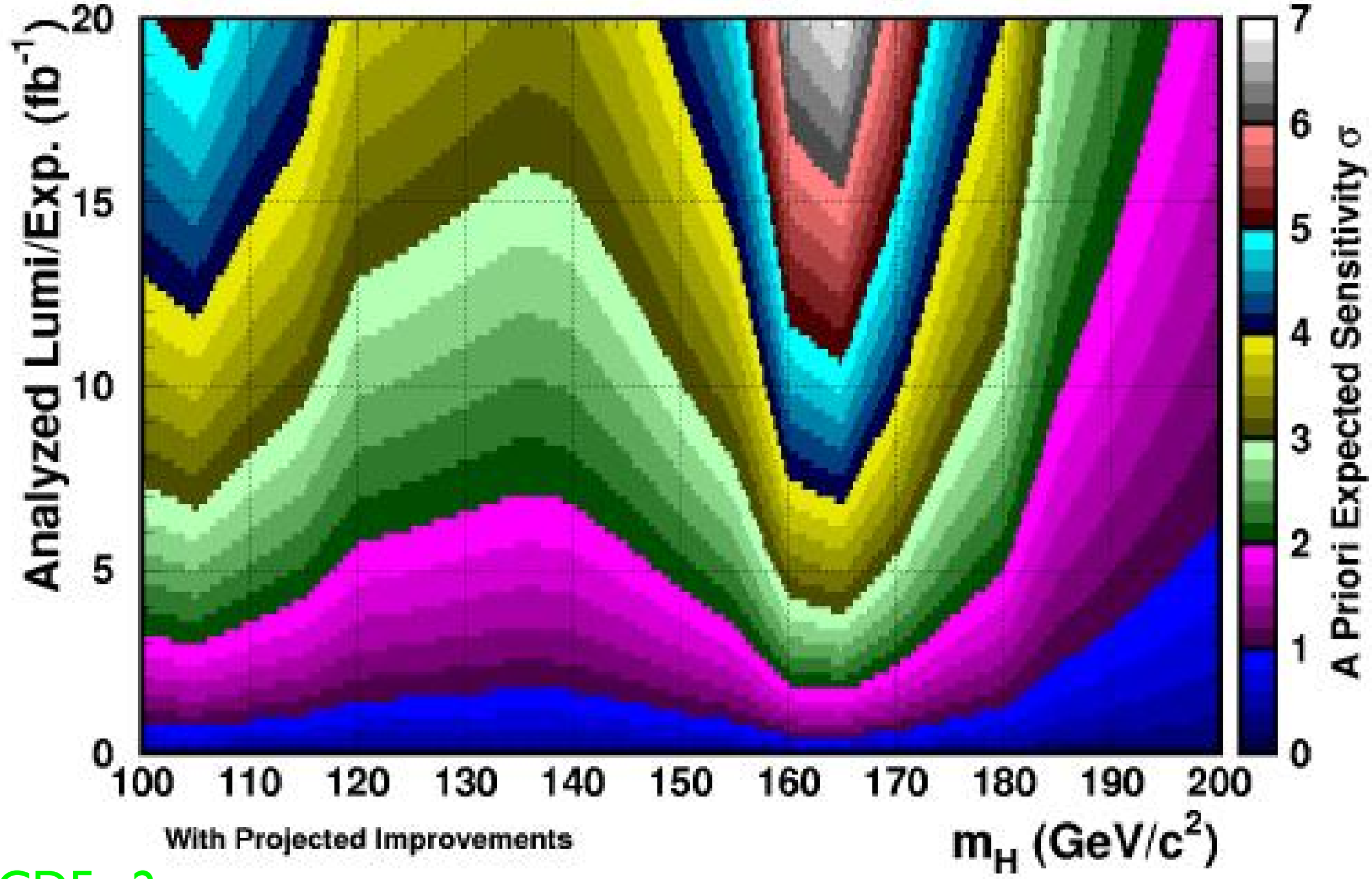
But what is measured?

Tevatron Running beyond 2011?

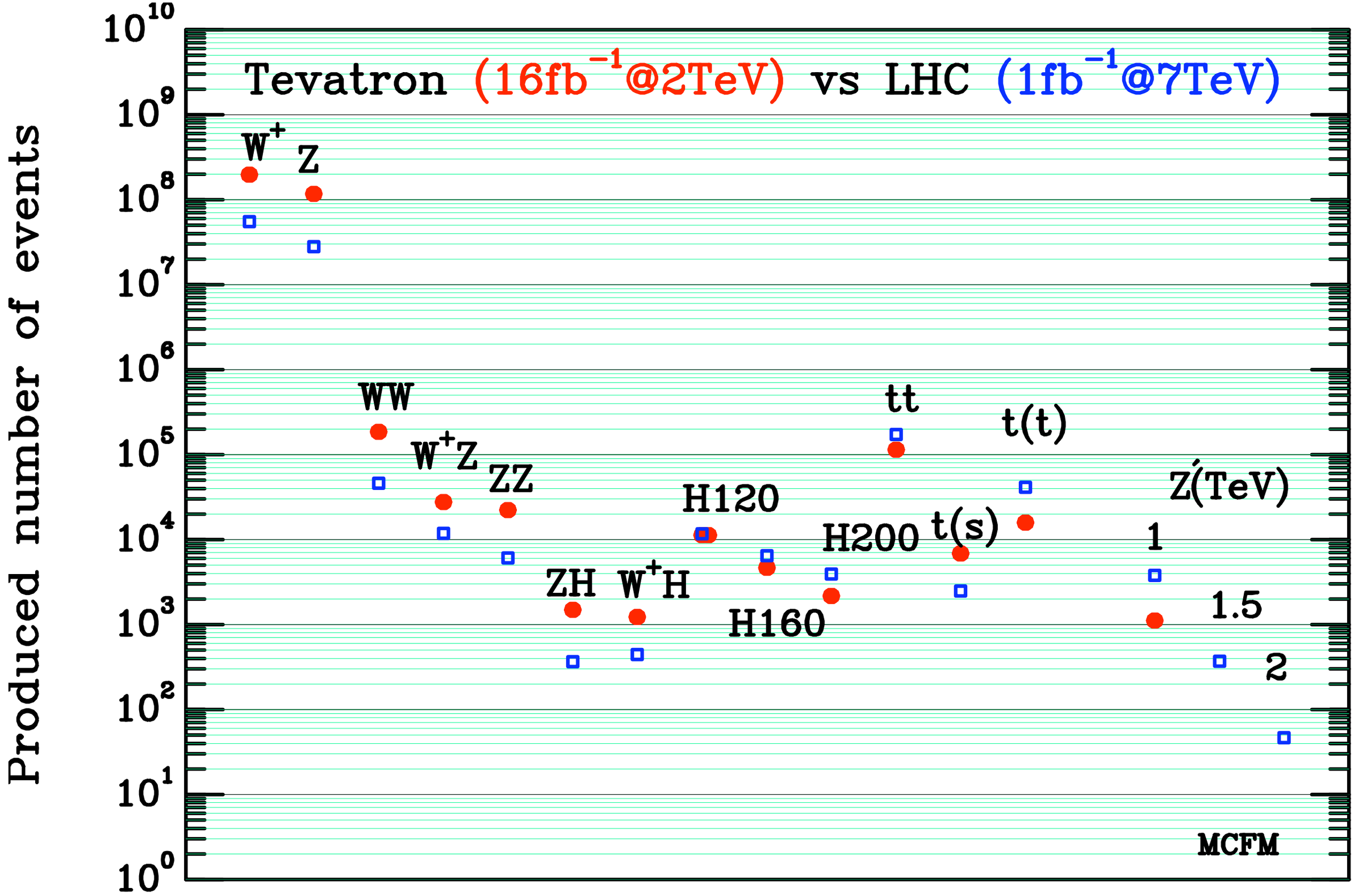
+3 years ➟ 16 fb^{-1} at 2 TeV

Physics Advisory Committee Meets 27 August

Tevatron Higgs-Boson Search Projection



CDF x2


Tevatron (16fb^{-1}@2TeV) vs LHC (1fb^{-1}@7TeV)
Produced number of events
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
W$^+$
Z
WW
W$^+$Z
ZZ
ZH
W$^+$H
H120
H160
H200
tt
t(t)
t(s)
Ź(TeV)
1
1.5
2
MCFM

We do not know what the
new wave of exploration will find

Look broadly!

Object of initial studies is not merely
to tune PYTHIA parameters
(no physical significance)

Isn't "Soft" Particle Production Settled Knowledge?

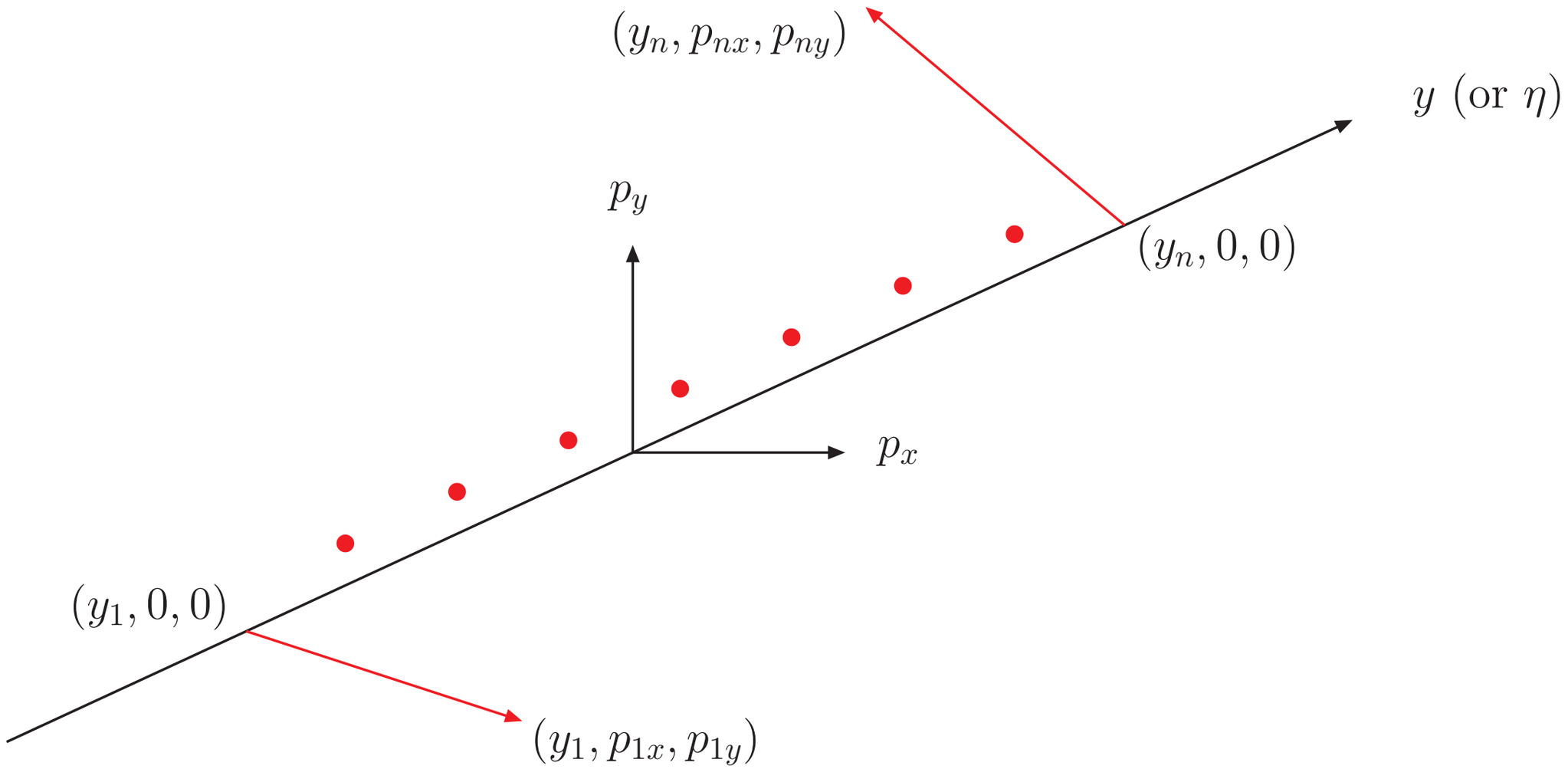
Diffractive scattering + short-range order

- (Not exhaustively studied at Tevatron)
- Long-range correlations?
- High density of $p_z = 5$ to 10 GeV partons
  $\rightsquigarrow$ hot spots, thermalization, . . . ?
- Multiple-parton interactions, perhaps correlated
  $q(qq)$ in impact-parameter space, . . .
- PYTHIA tunes miss 2.36-TeV data (ATLAS & CMS)

Few percent of minimum-bias events ($\sqrt{s} \gtrsim 1$ TeV)
might display an unusual event structure
We should look! How?

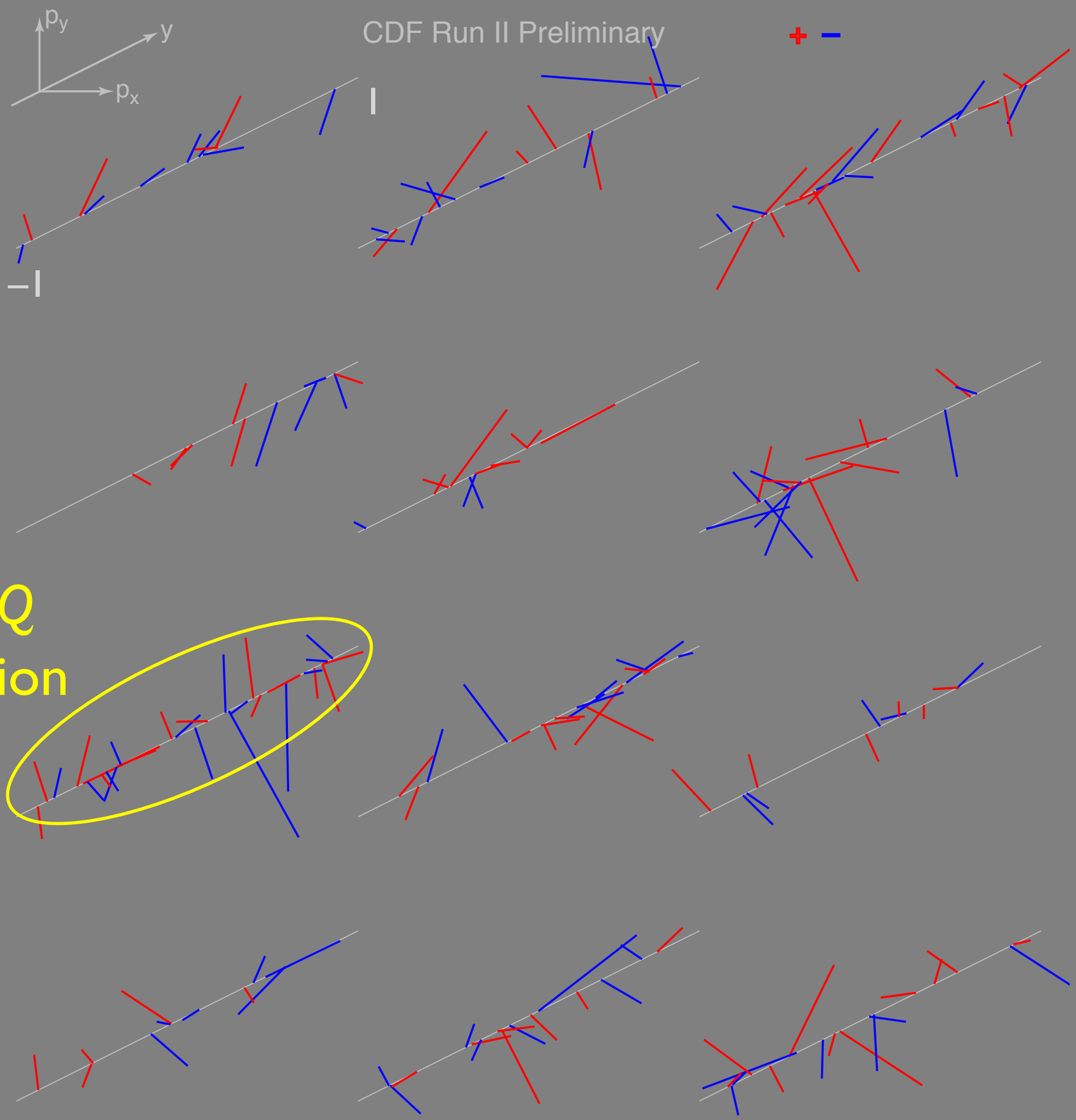
An Informative Event Display

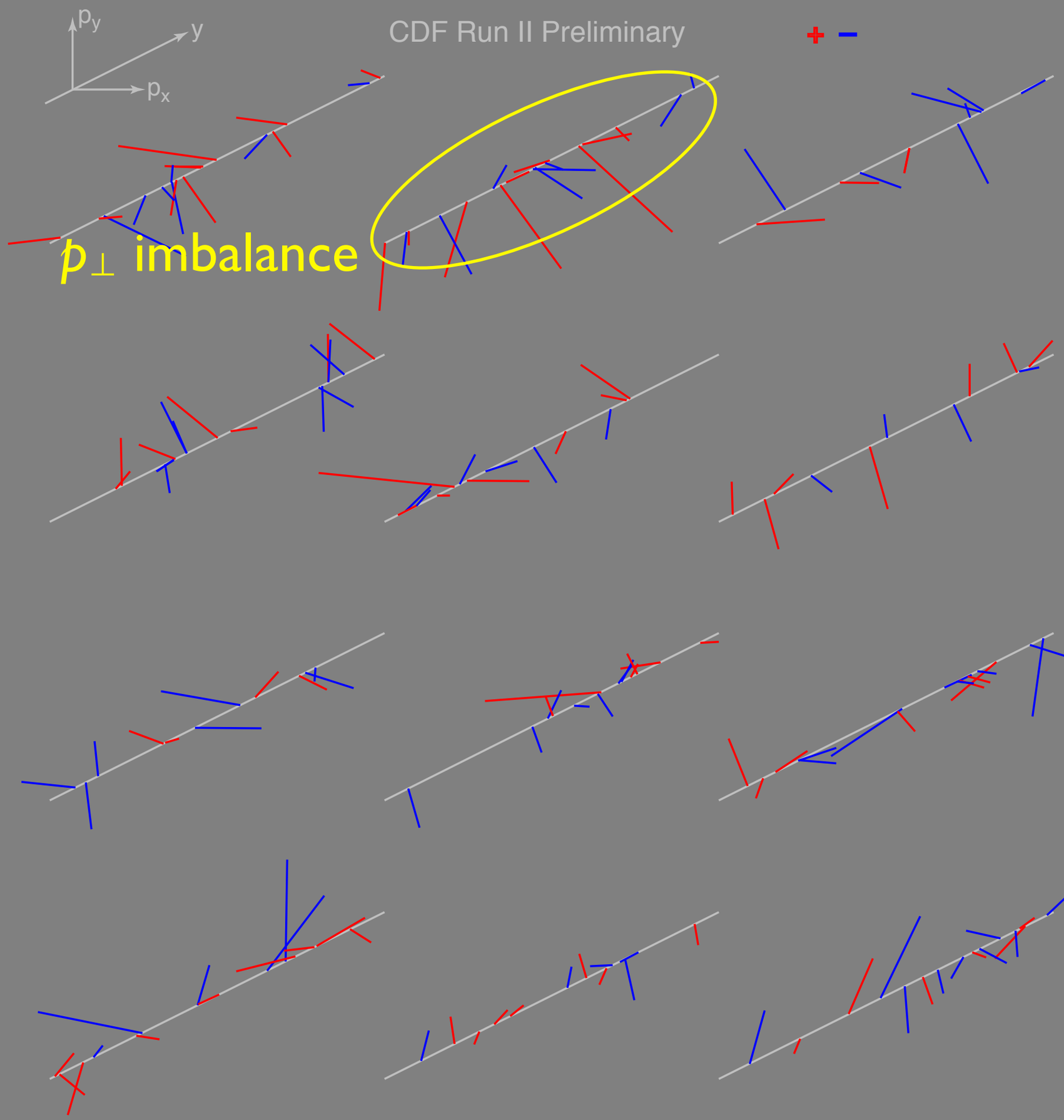
(Avoid pathological attachment to blind analysis!)

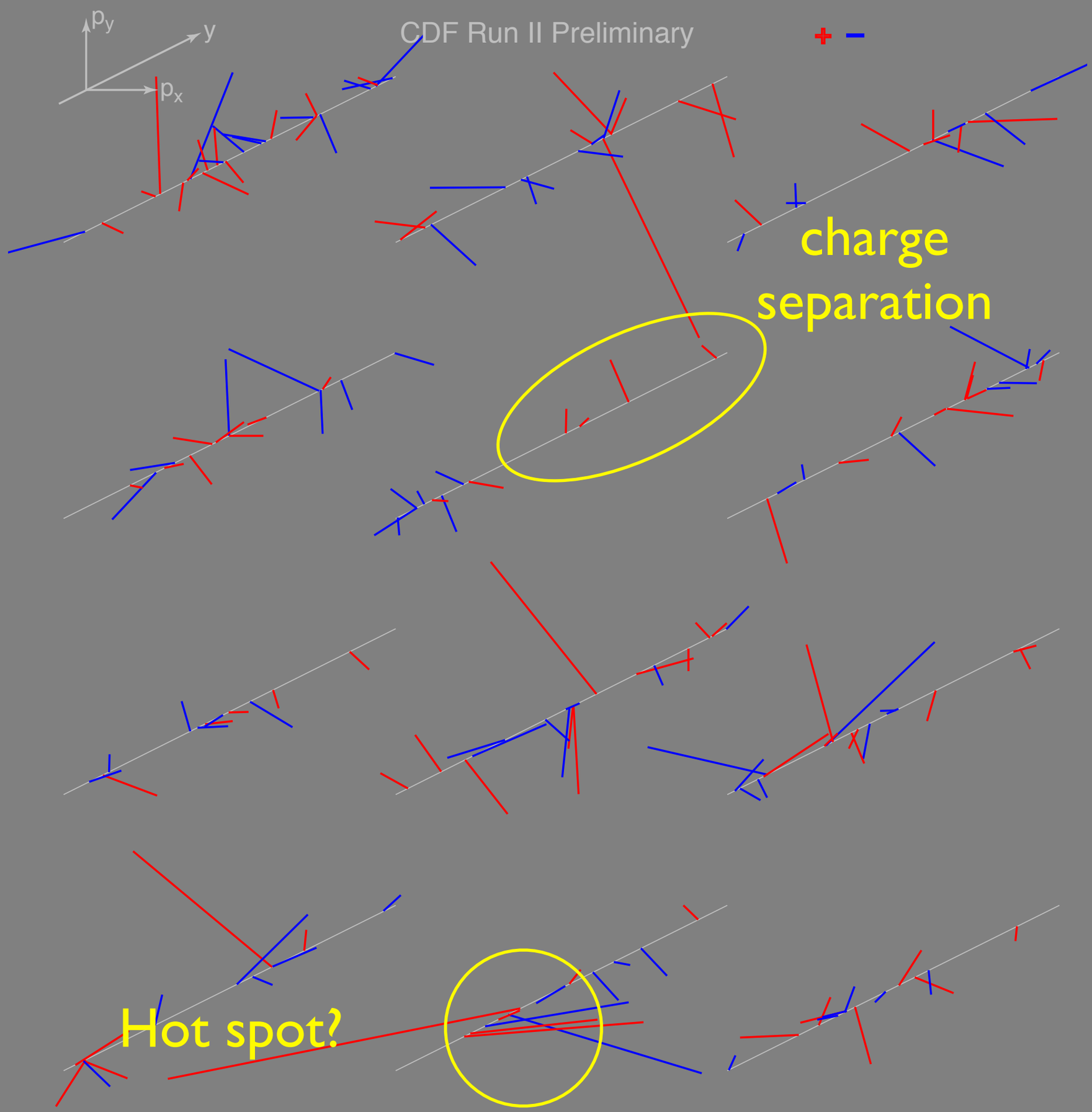


(unwrapped LEGO plot for particles)

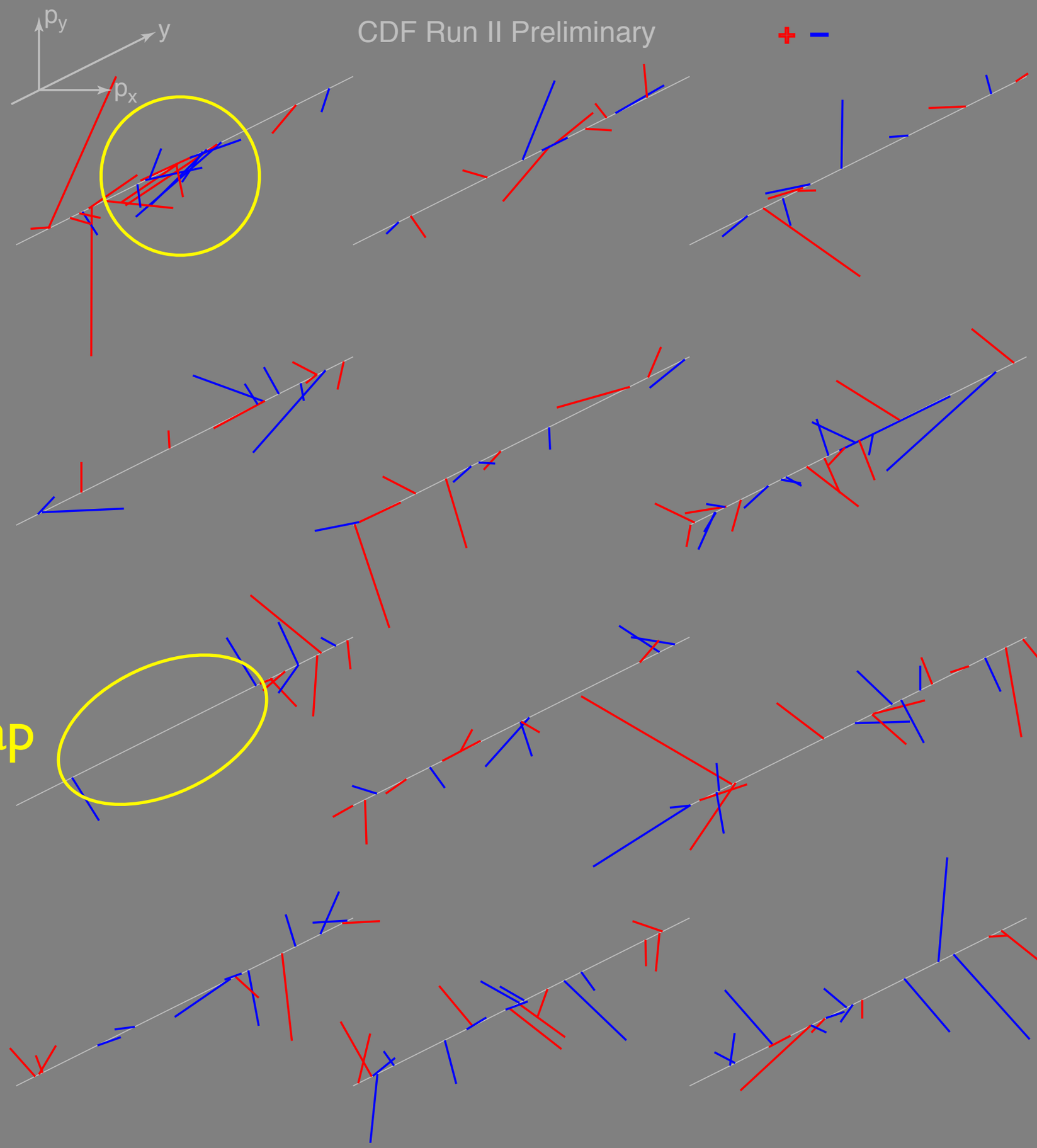
Bjorken, SLAC-PUB-0974 (1971)


p_y
y
p_x
CDF Run II Preliminary
+ −
Local $p_\perp$, Q compensation


p_y
y
p_x
CDF Run II Preliminary
+ −
$p_\perp$ imbalance


p_y
y
p_x
CDF Run II Preliminary
+ −
charge
separation
Hot spot?

Hot spot?



Rapidity gap

I would like to see in 2010-2011

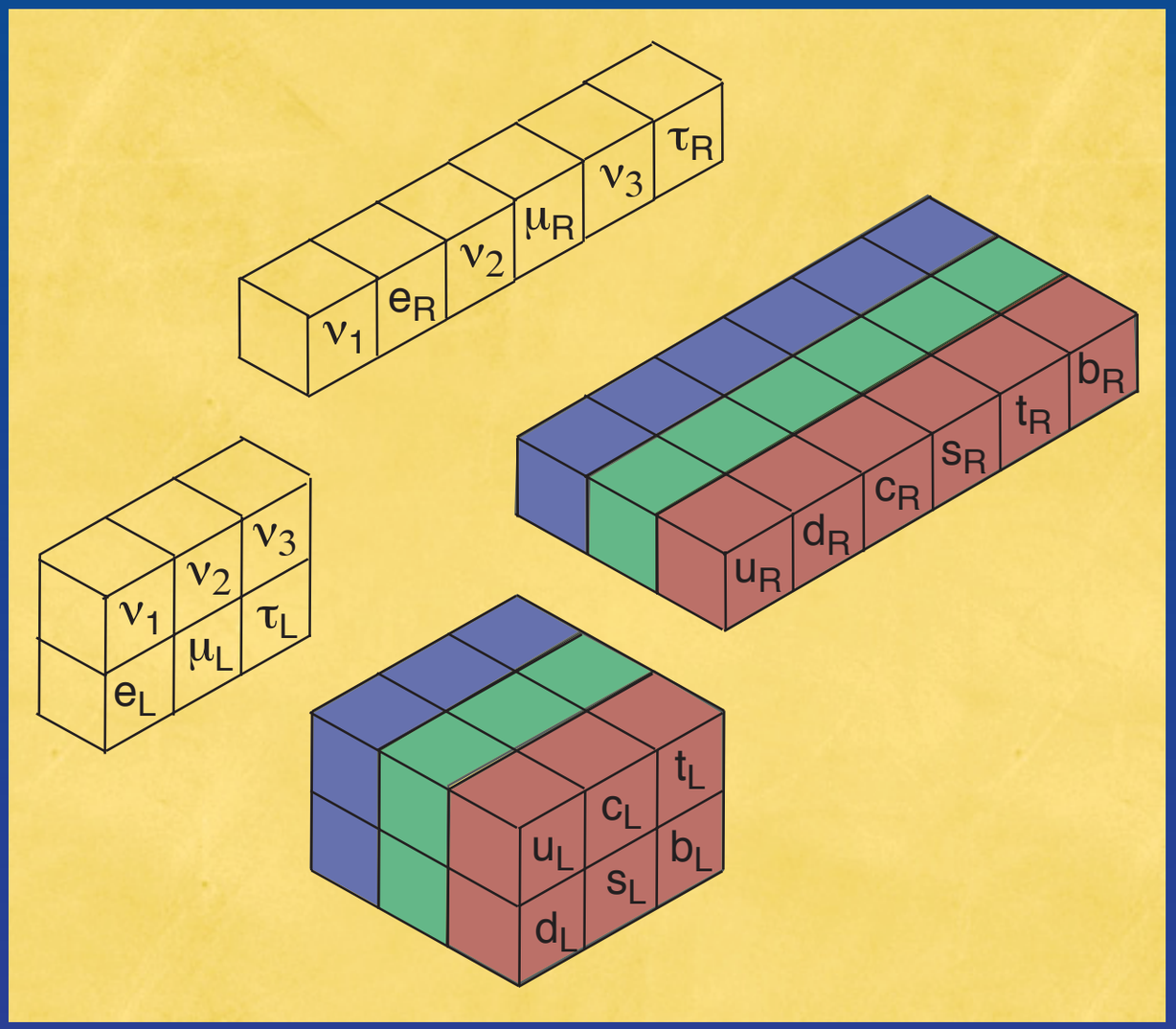
Modest dedicated runs at steps in energy
to survey the nature of particle production:
0.9, 2, 3.5, 5, 7 TeV

Lightly triggered

Engineering value, but also
a chance to discover candidate new physics
that might become the object of
dedicated study in the future.

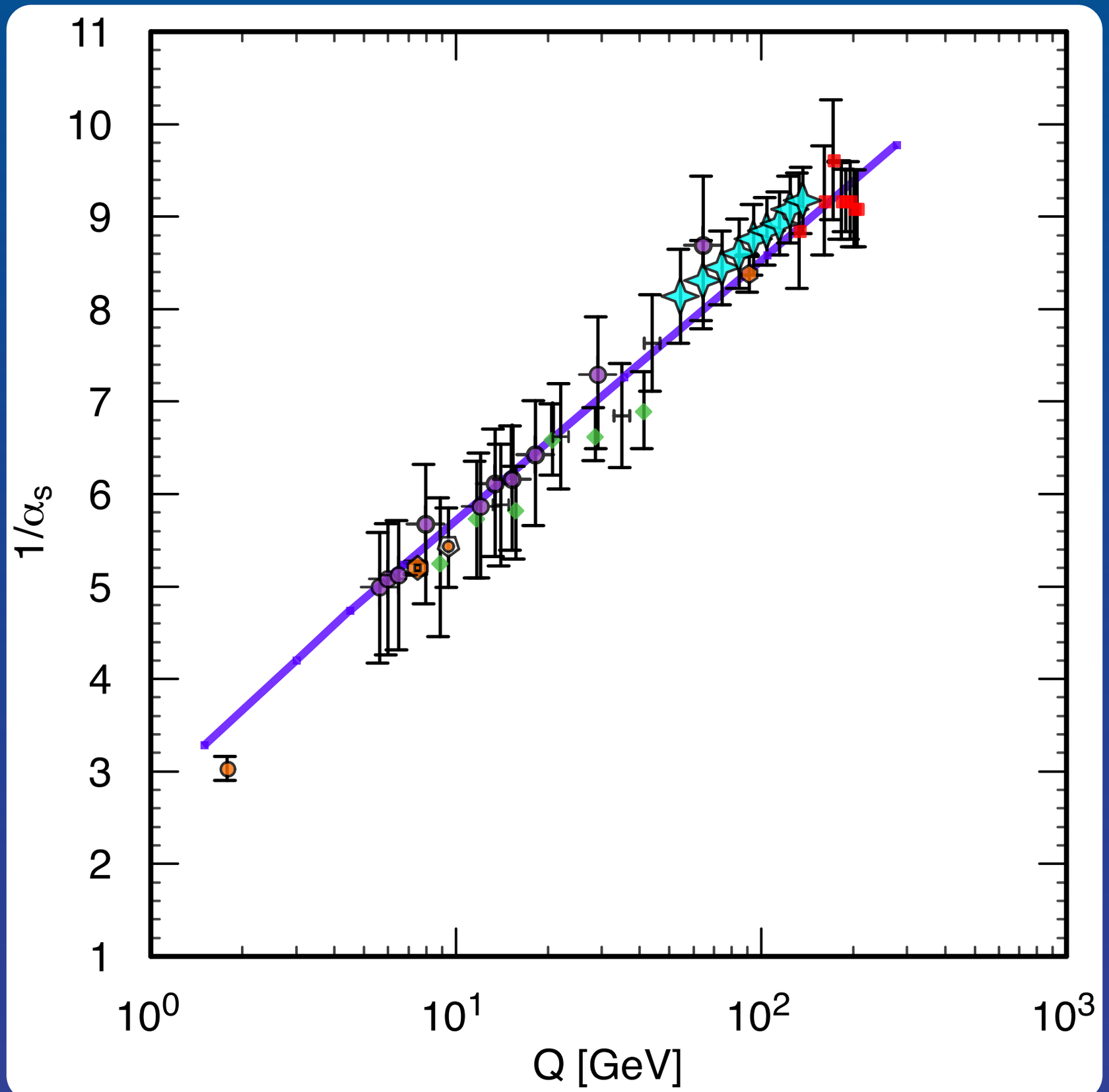
Our Picture of Matter (the revolution just past)

Pointlike ($r \leq 10^{-18}$ m) *quarks* and *leptons*

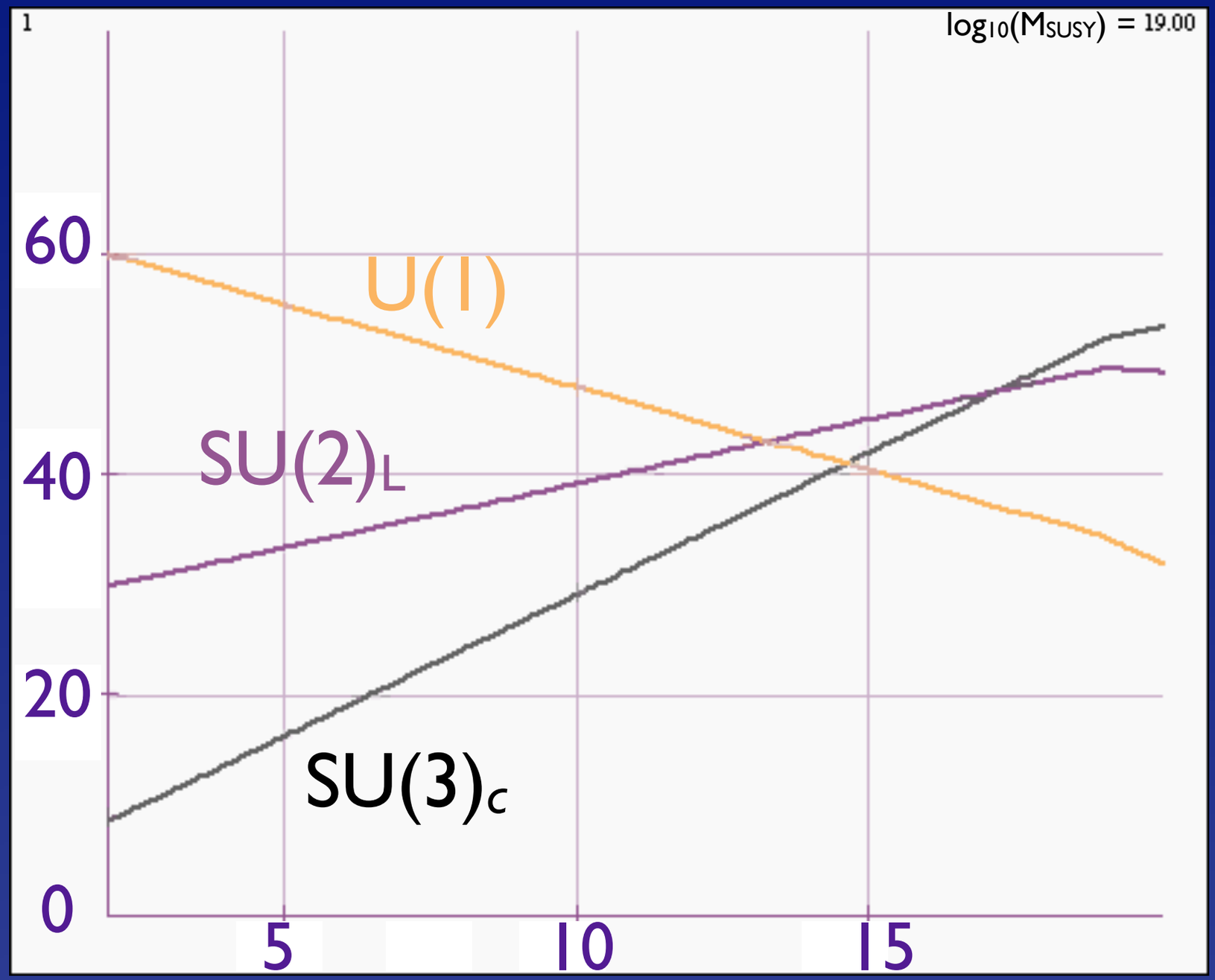


Interactions: $\mathsf{SU}(3)_c \otimes \mathsf{SU}(2)_L \otimes \mathsf{U}(1)_Y$ gauge symmetries

Evolution of the strong coupling "constant"



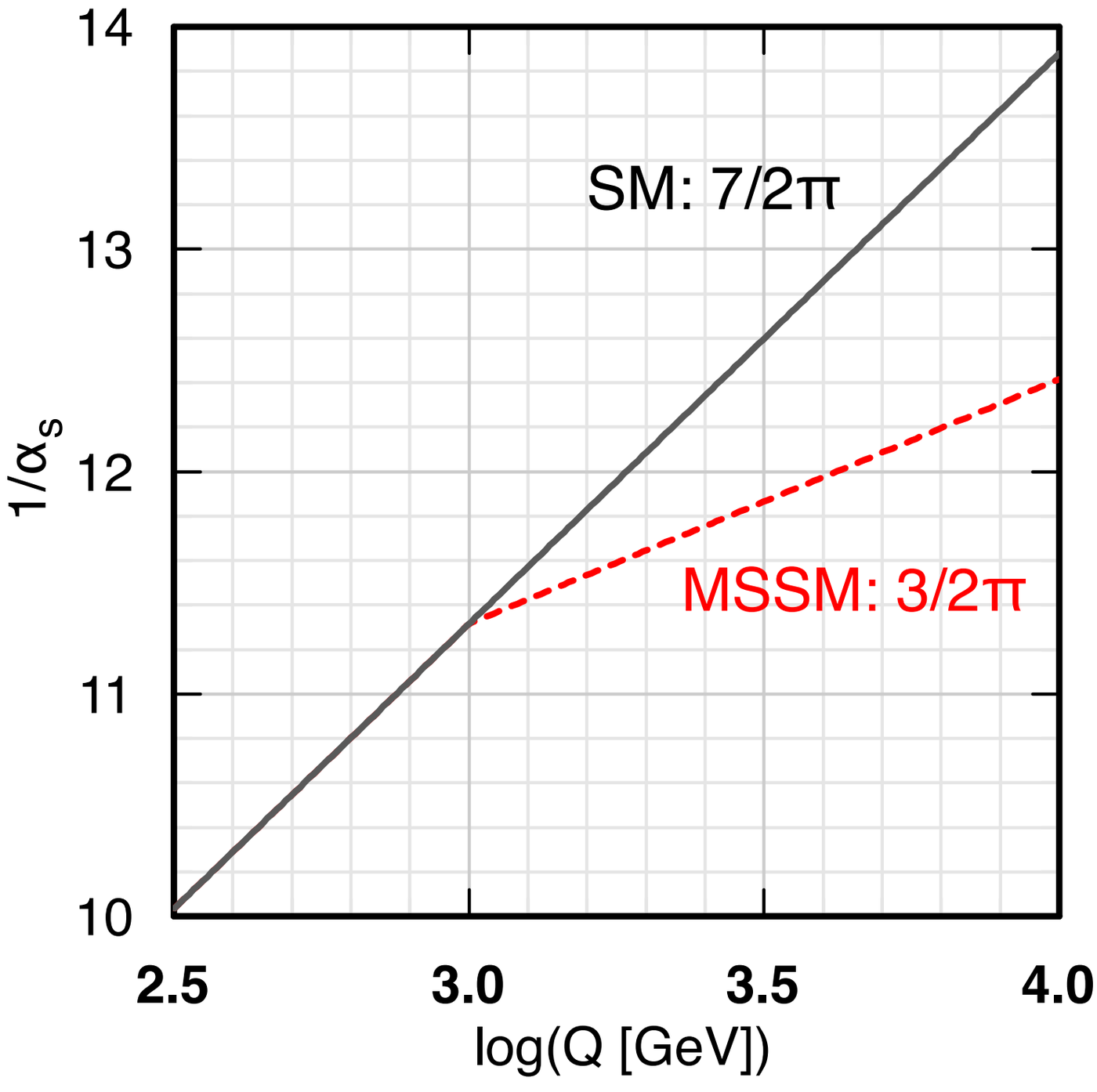
Different running of $U(1)_Y$, $SU(2)_L$, $SU(3)_c$ gives possibility of coupling constant unification



$$\alpha^{-1} = \tfrac{5}{3}\alpha_1^{-1} + \alpha_2^{-1}$$

Can LHC See Change in Evolution?

Sensitive to new colored particles



(sharp threshold illustrated)

. . . also for $\sin^2 \theta_W$

Electroweak Theory

EW Symmetry is hidden; how?
Something like H couples to W, Z
No evidence yet on fermions

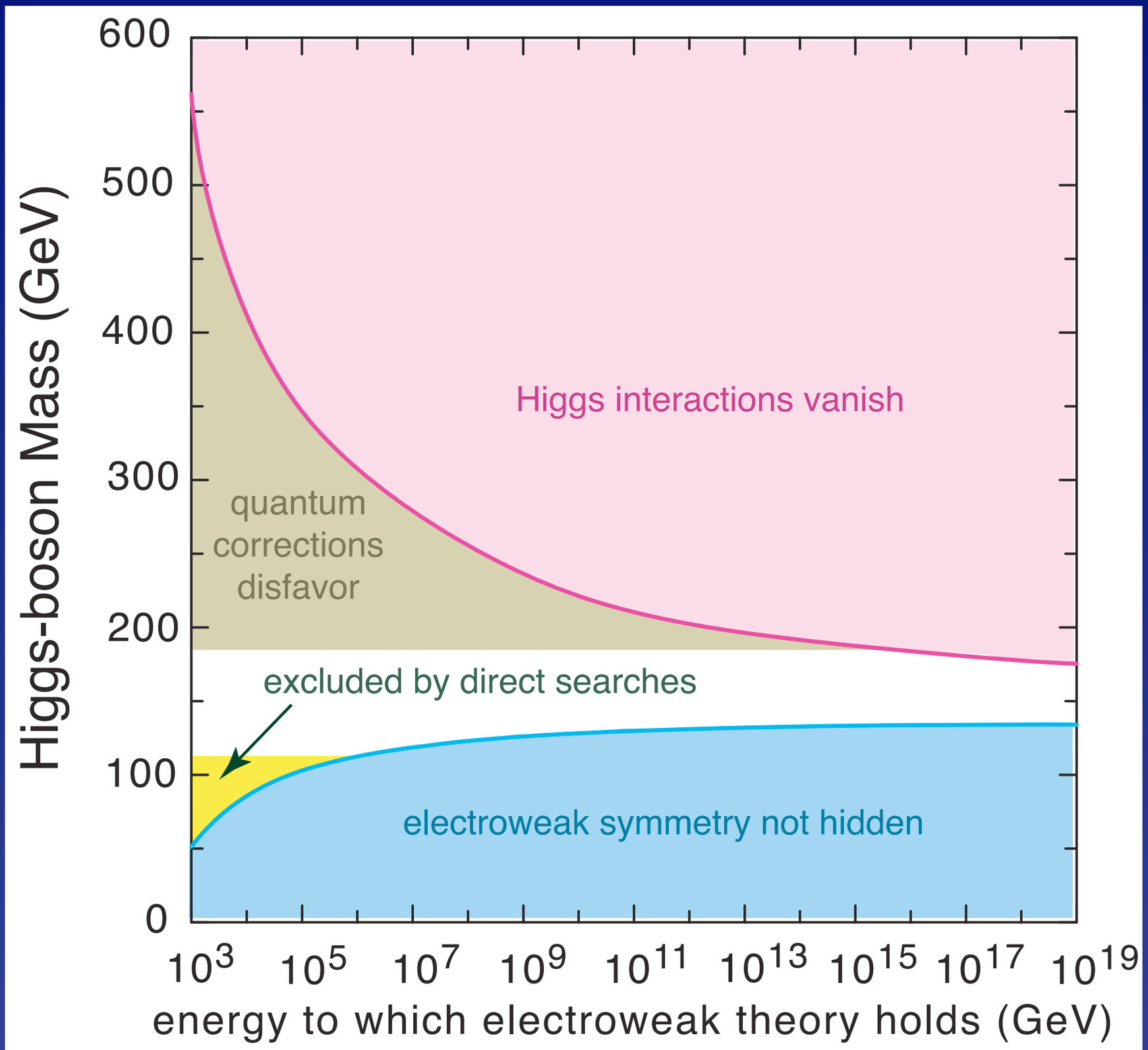
WW scattering: something on TeV scale

Weak coupling or strong dynamics?

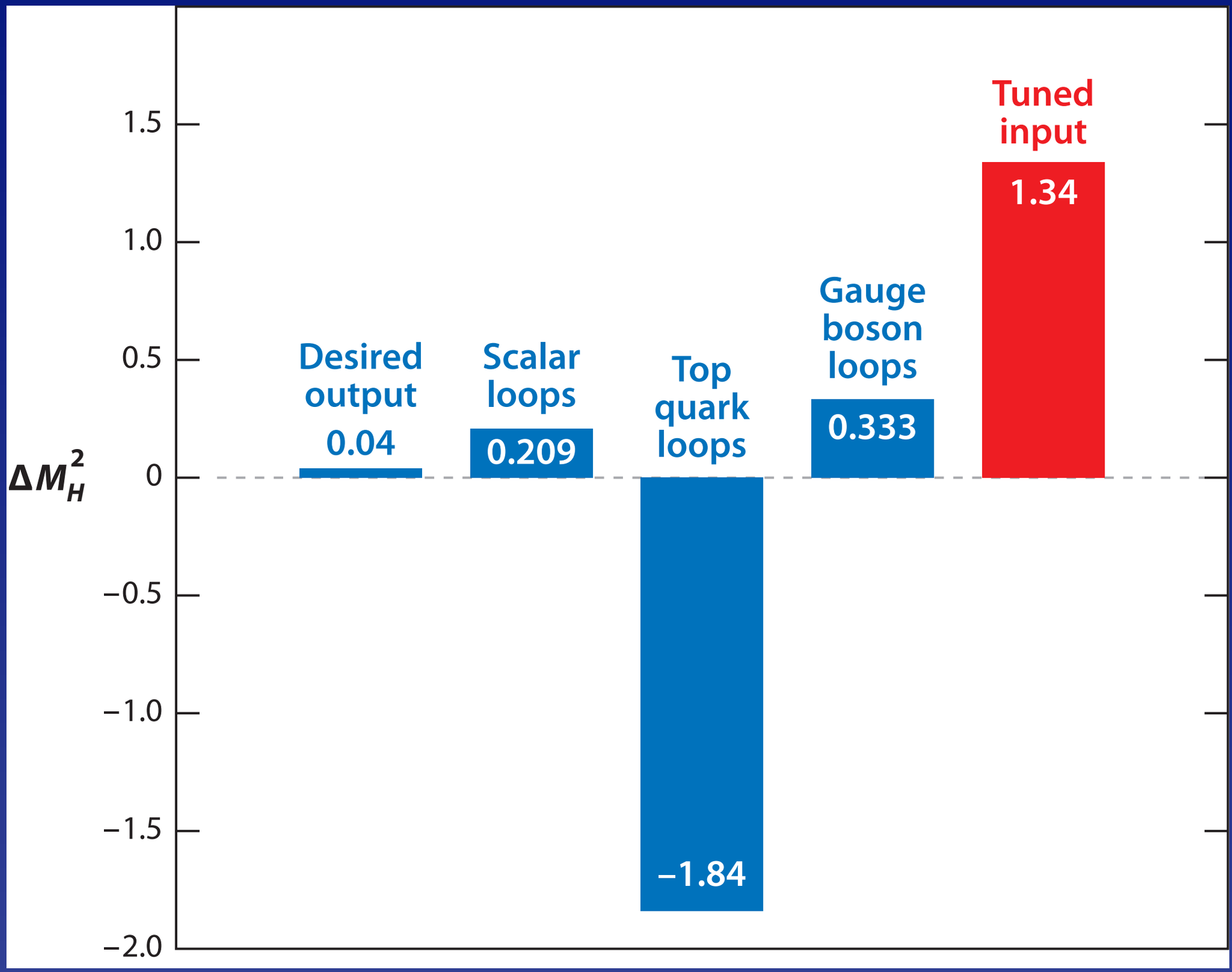
Does agent that hides EW symmetry
also give masses to fermions?

Could put in masses by hand (temporarily)

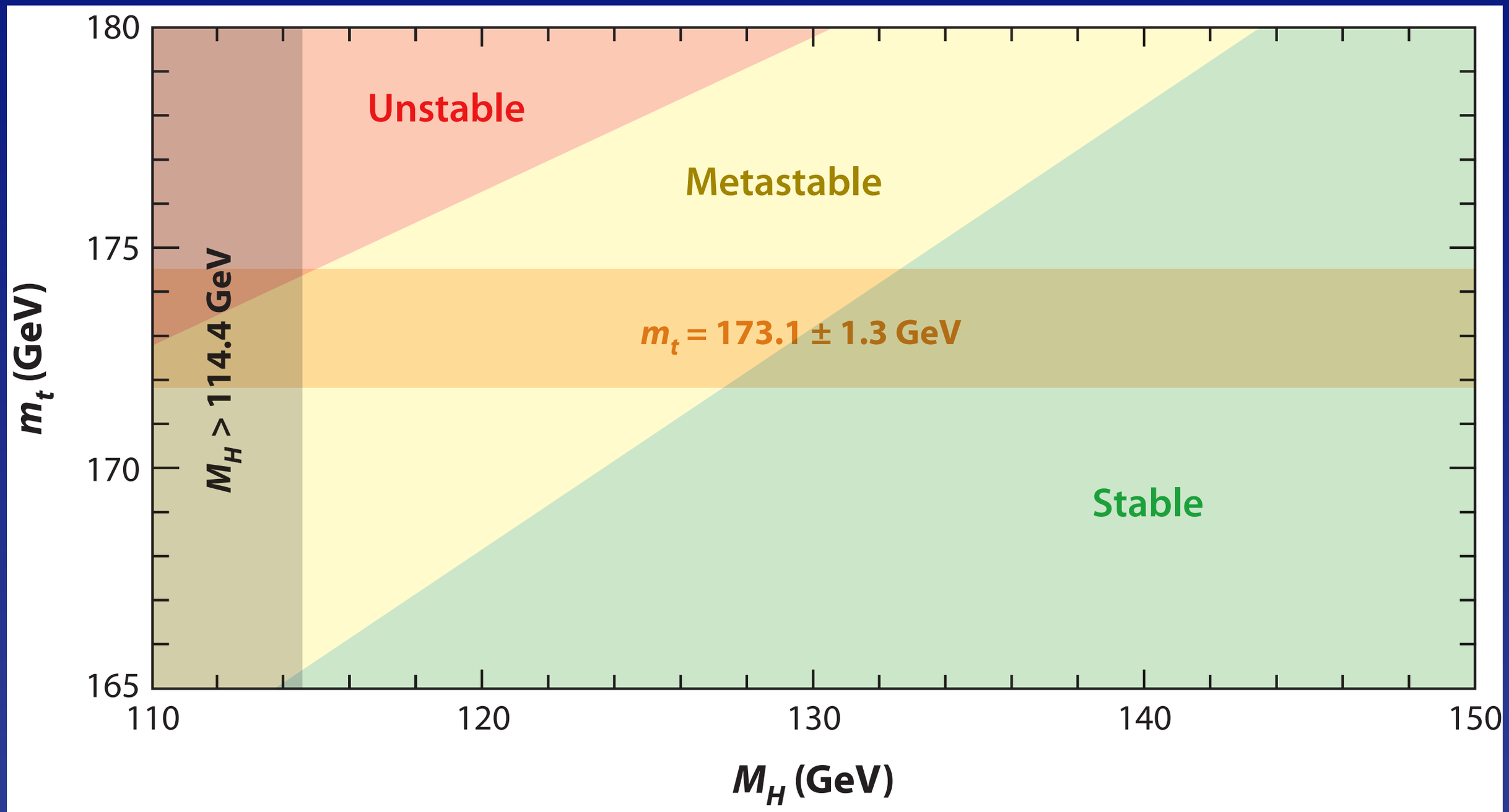
Electroweak theory unlikely to be complete



Hierarchy Problem suggests new physics on TeV scale

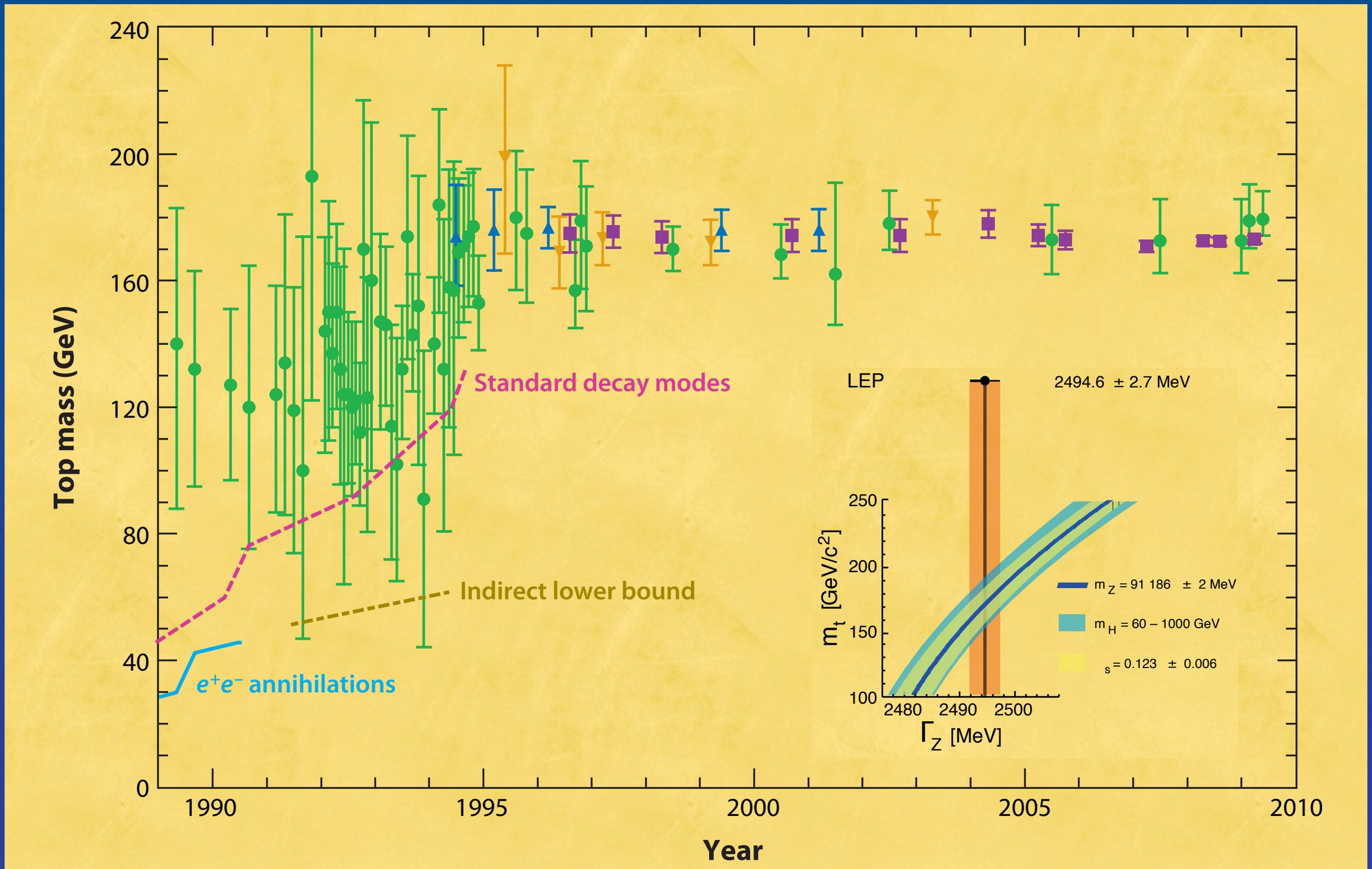


Dead or Alive?

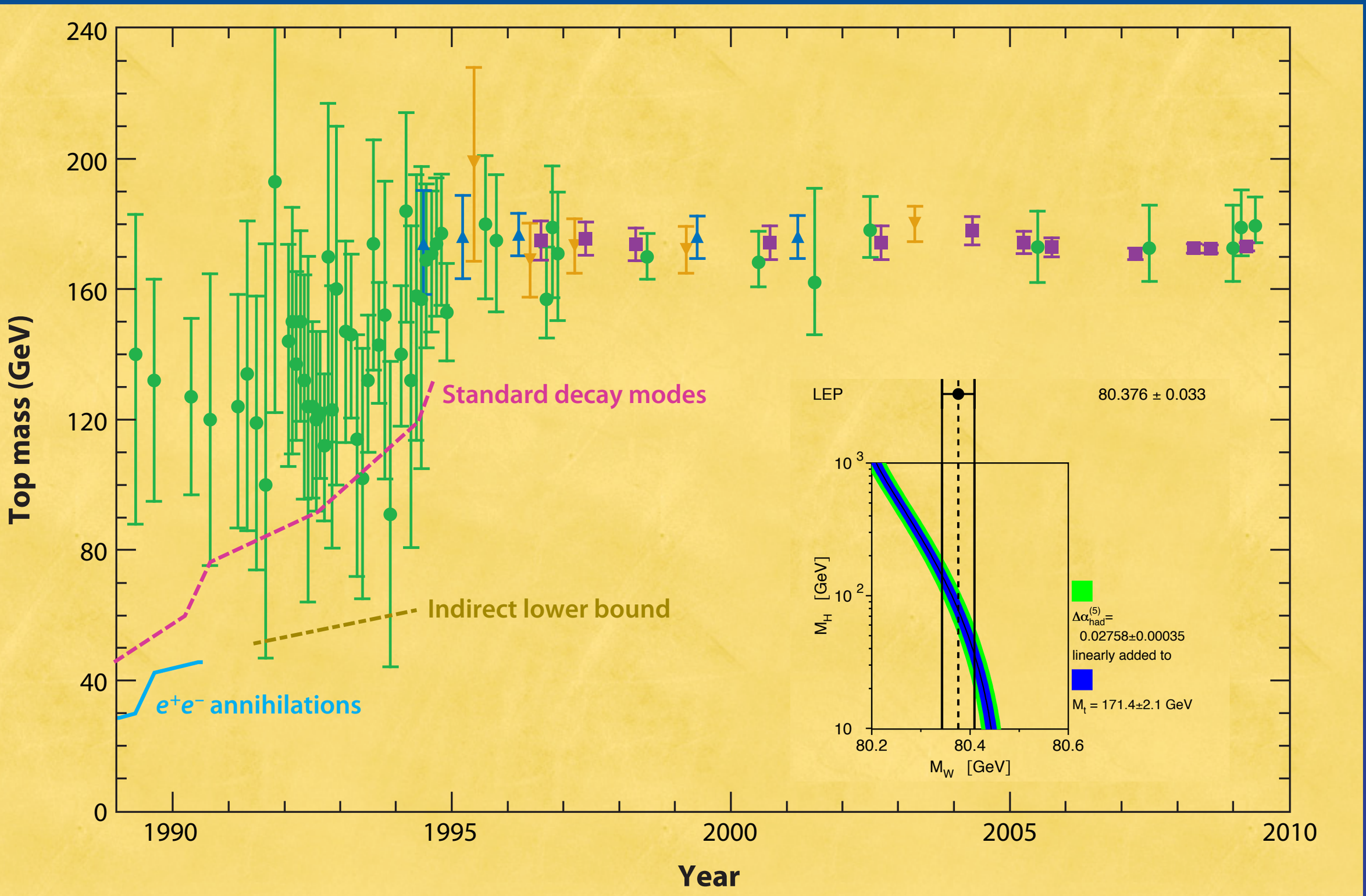


Precision Measurements Test the Theory …

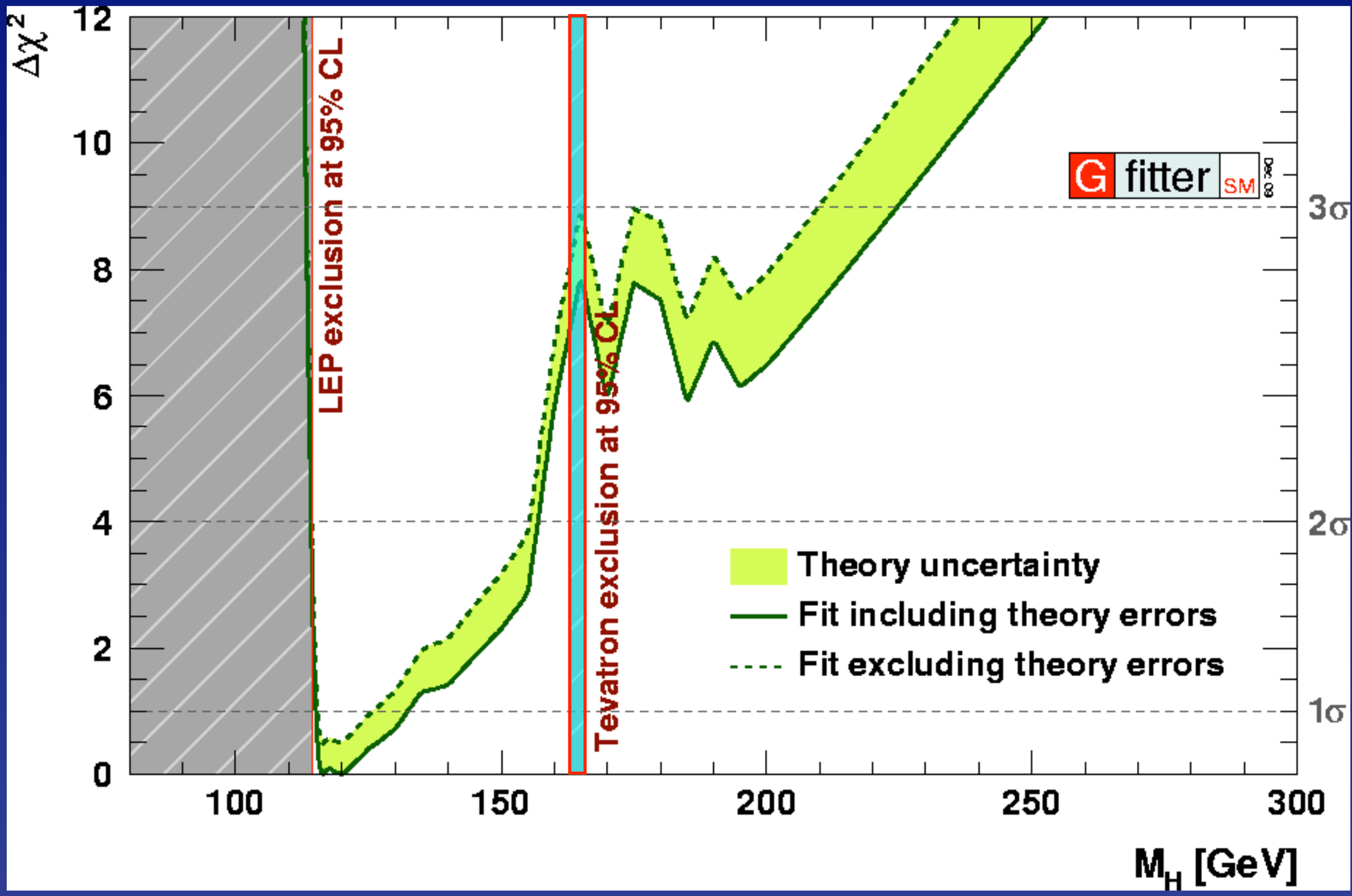
… and determine unknown parameters



… and determine unknown parameters

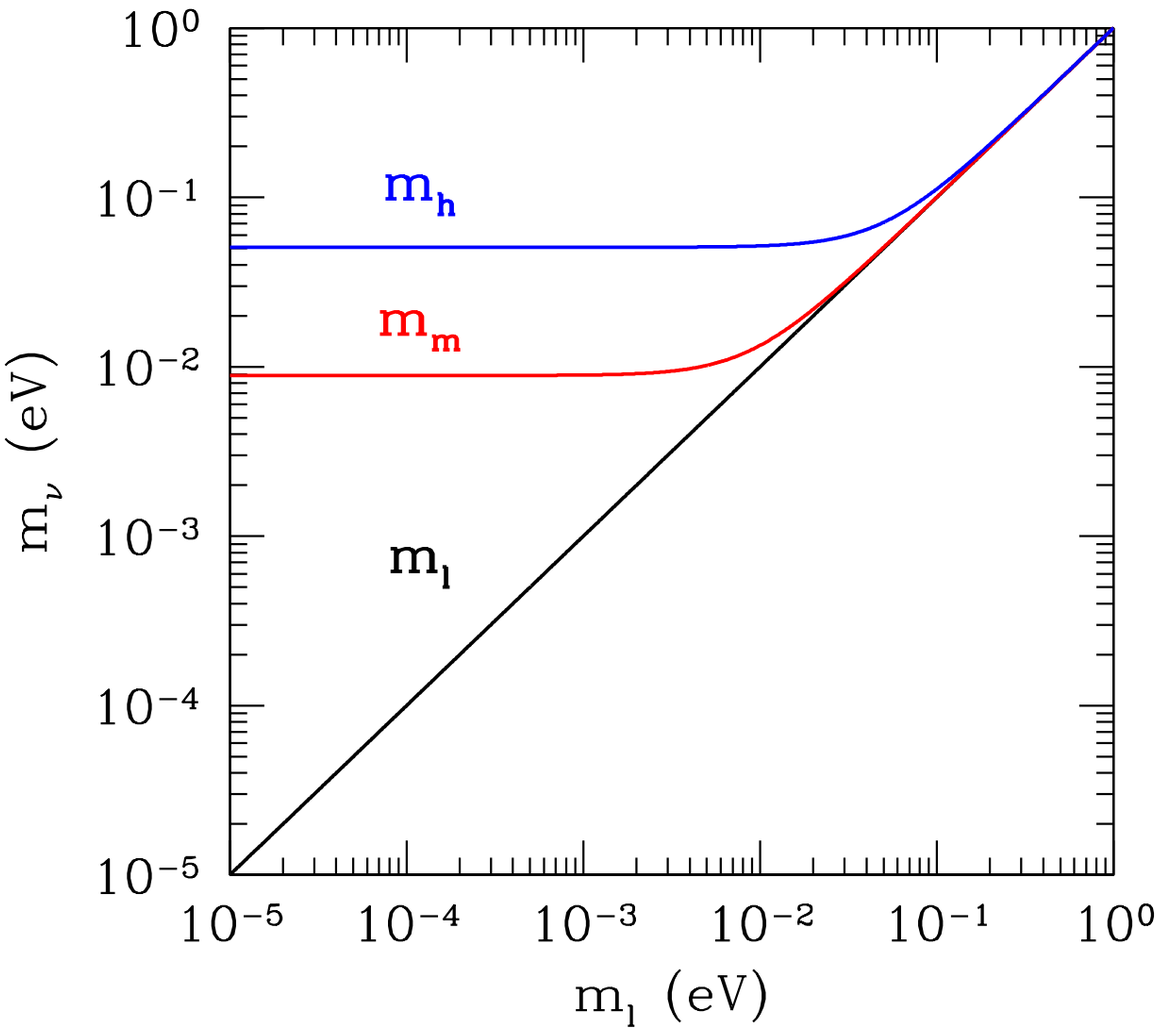


Where the (standard) Higgs boson might be

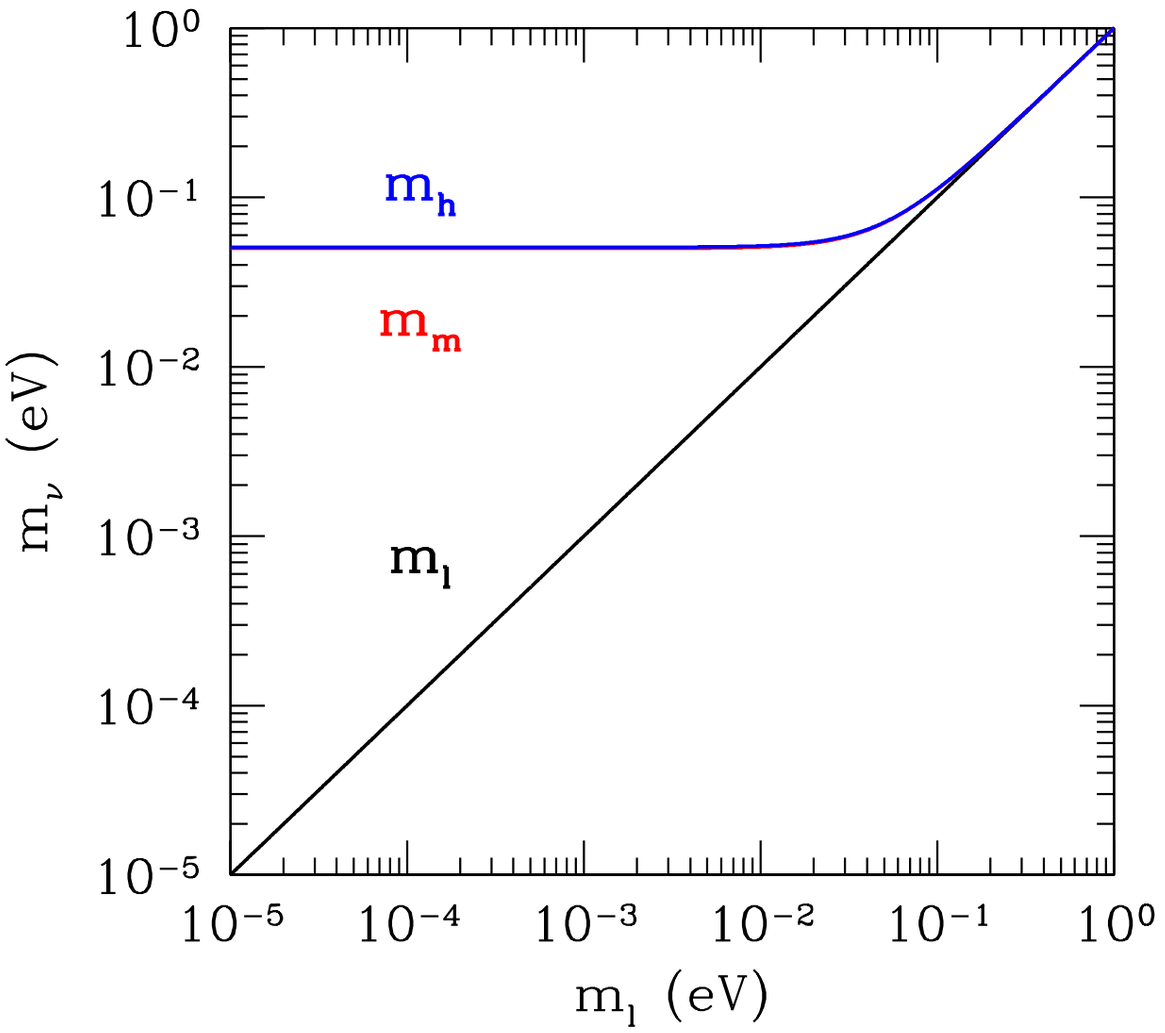


Absolute Neutrino Masses *Unknown*

Normal

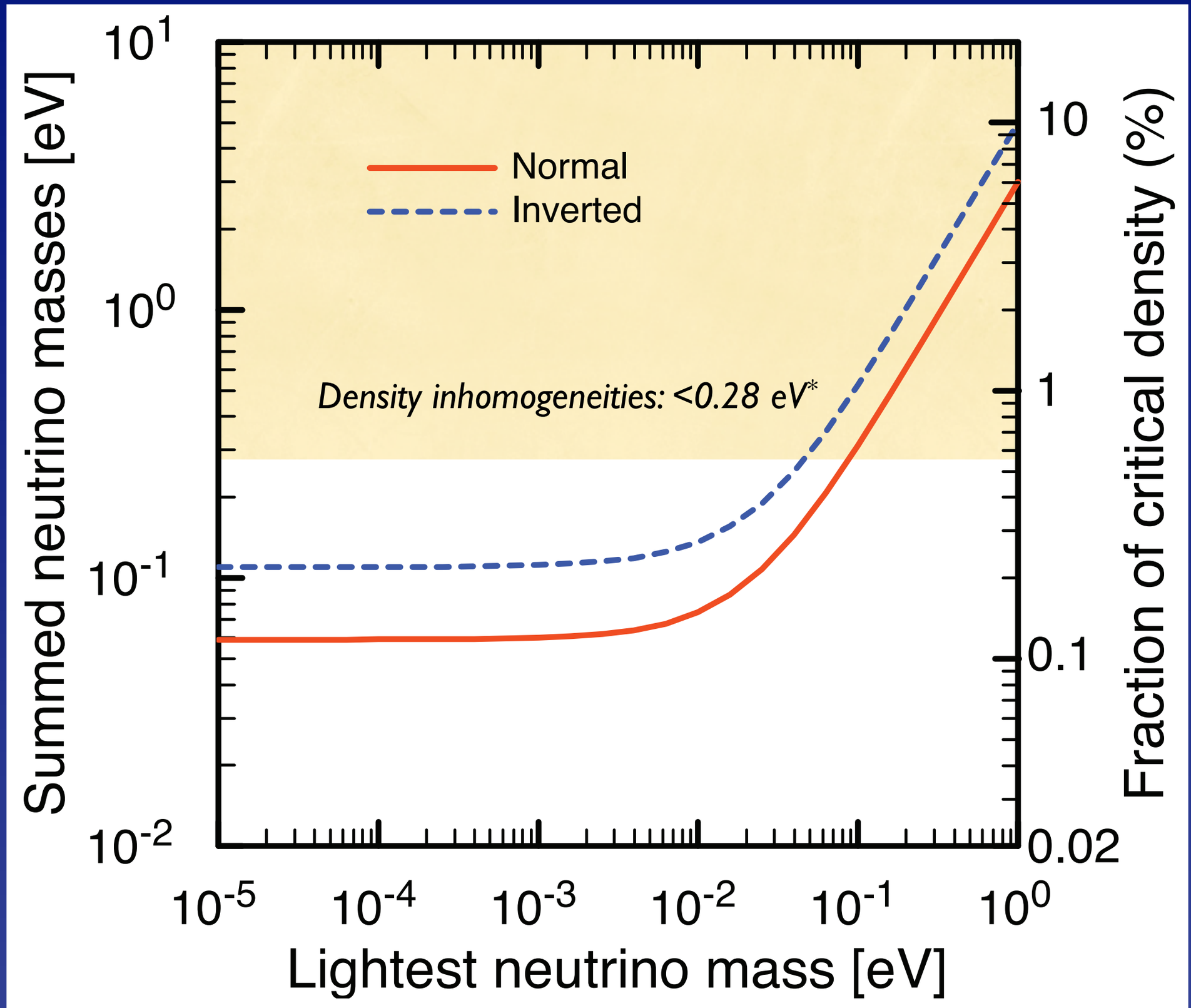


Inverted



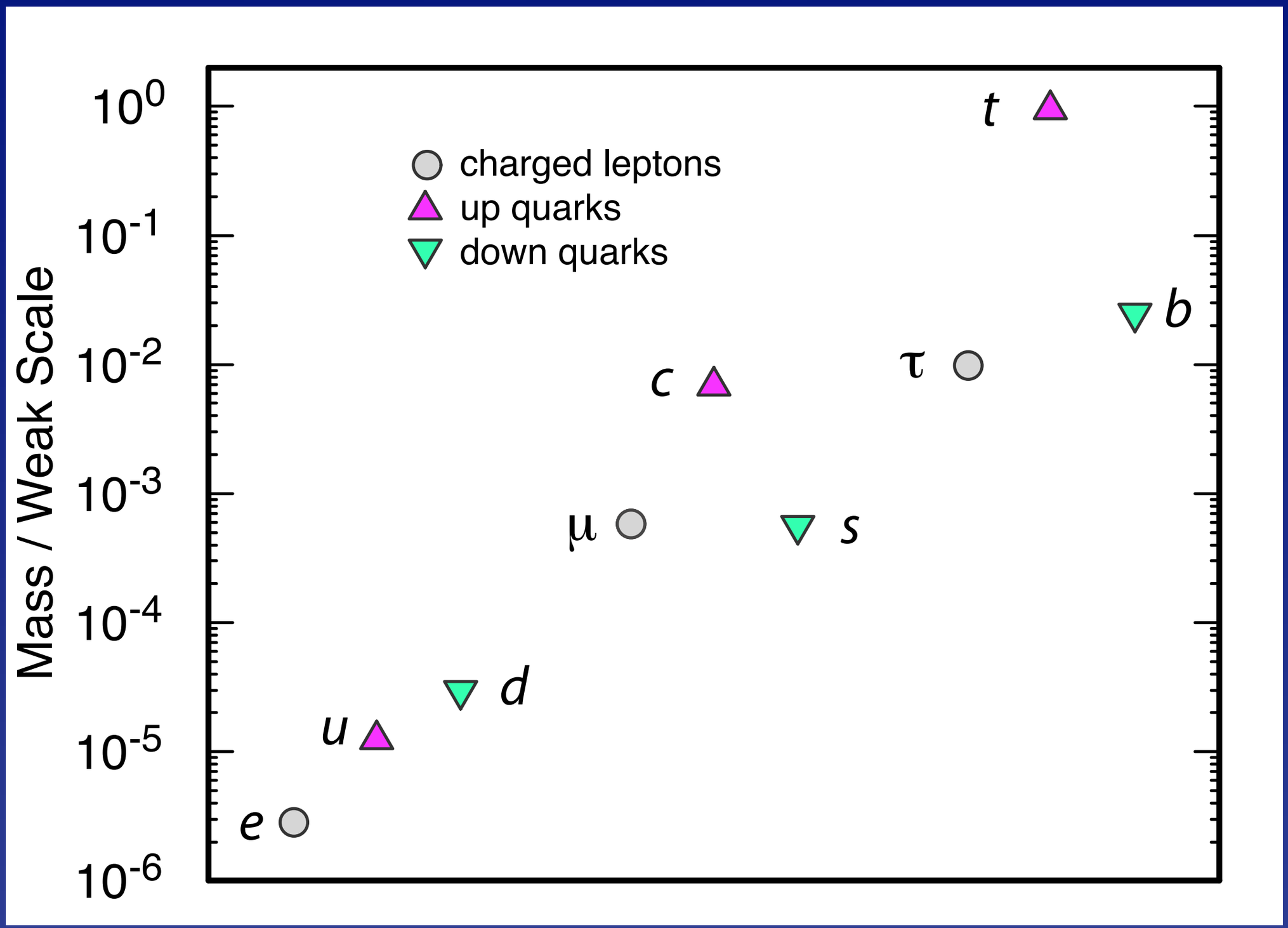
KATRIN (^{3}H decay) goal: 0.2 eV

Neutrinos as Dark Matter



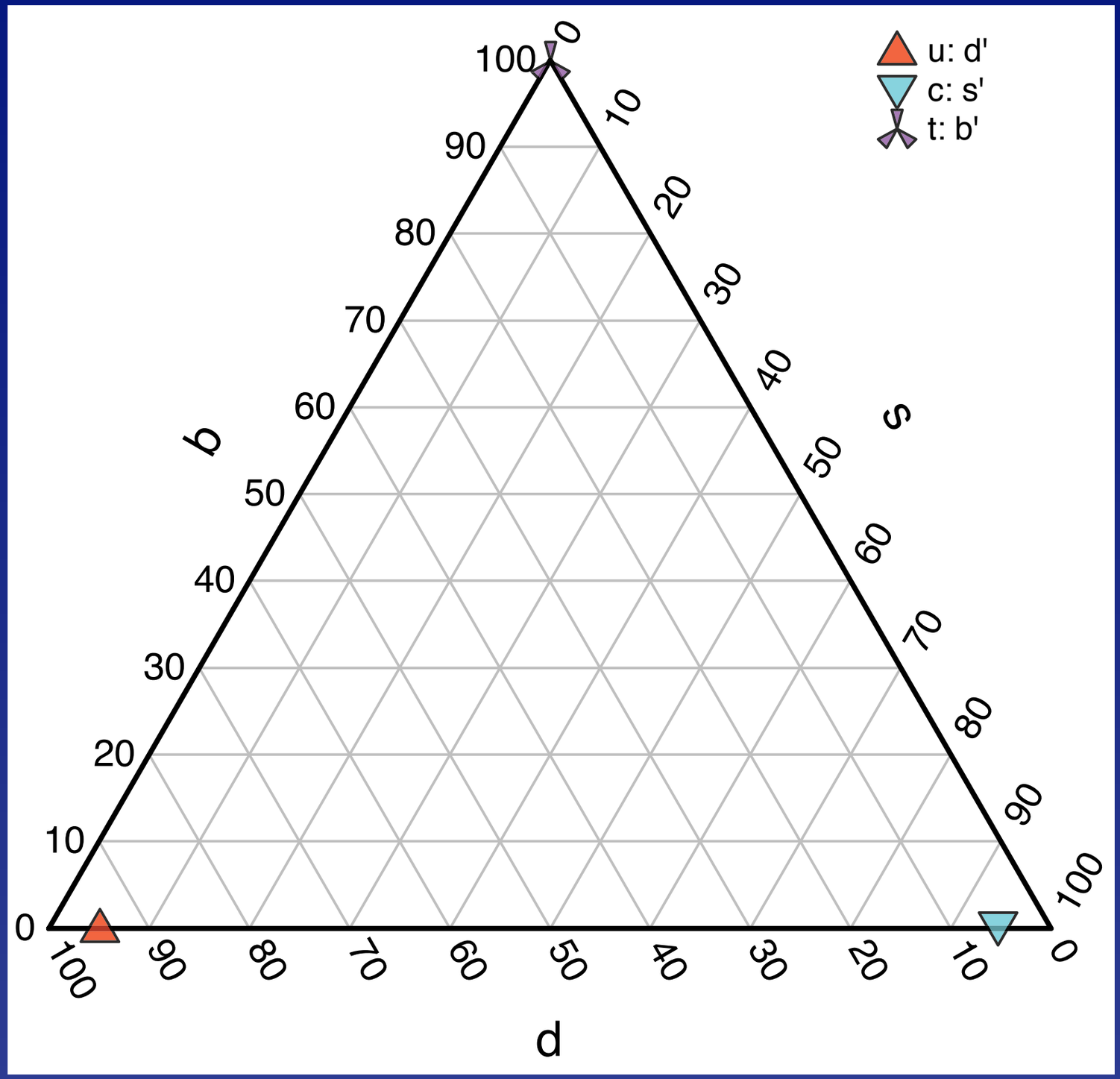
*Thomas et al., PRL **105**, 031301 (2010): < 0.28 eV

Fermion Masses



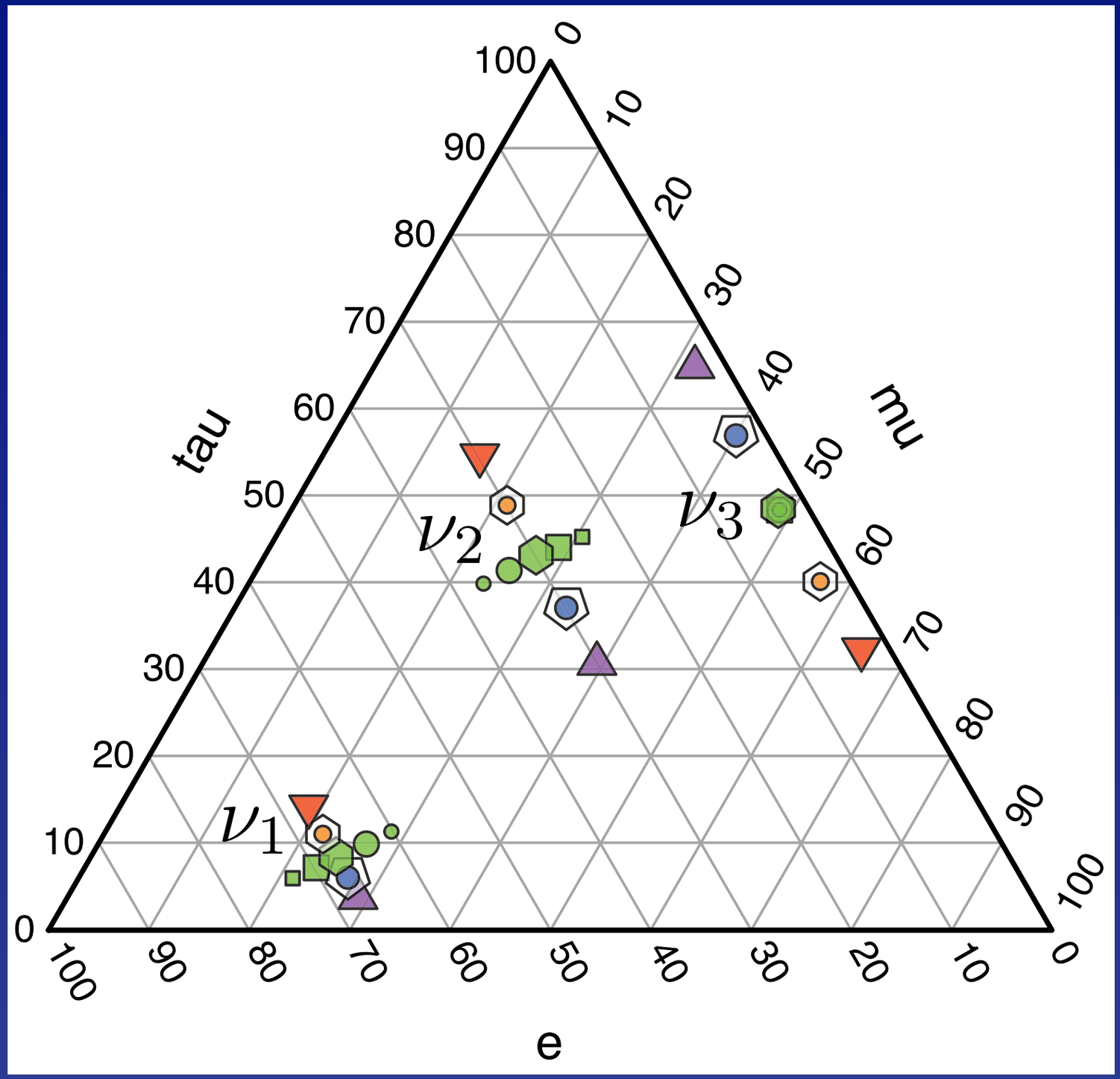
Running mass $m(m)$

Quark family patterns: *generations*

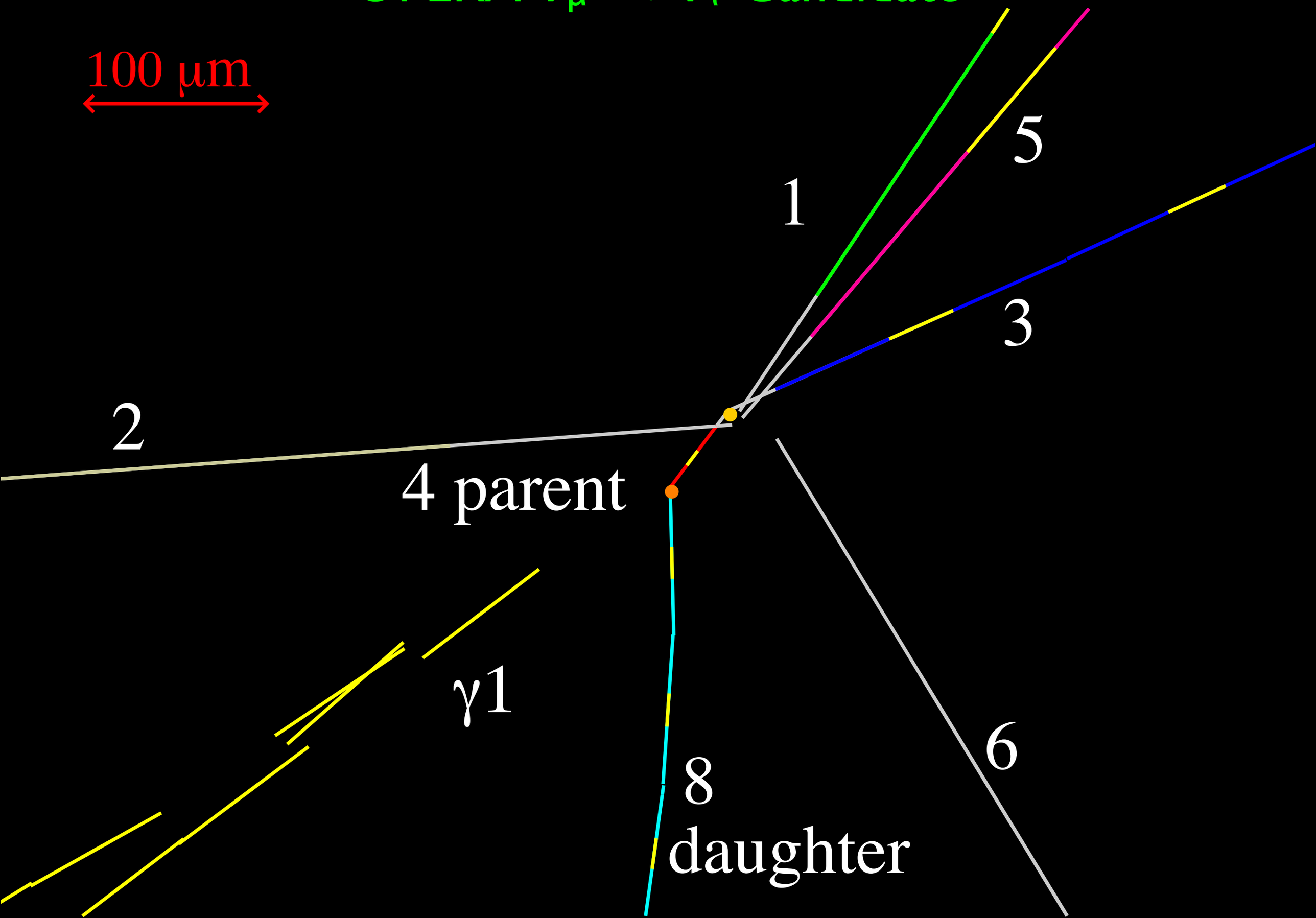


Veltman: Higgs boson knows something we don't know!

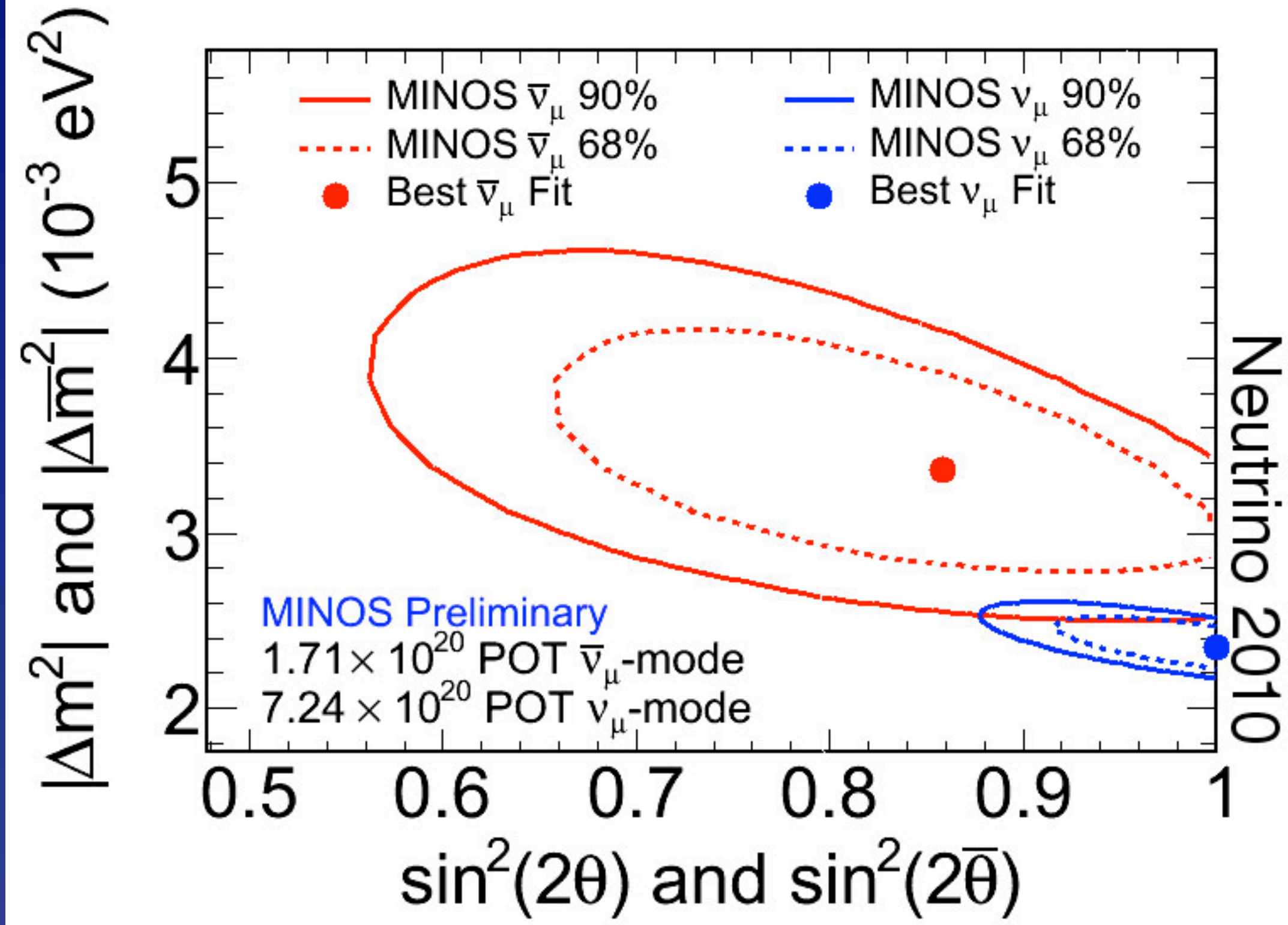
Neutrino family patterns (uncertainties)



OPERA $\nu_\mu \longrightarrow \nu_\tau$ Candidate

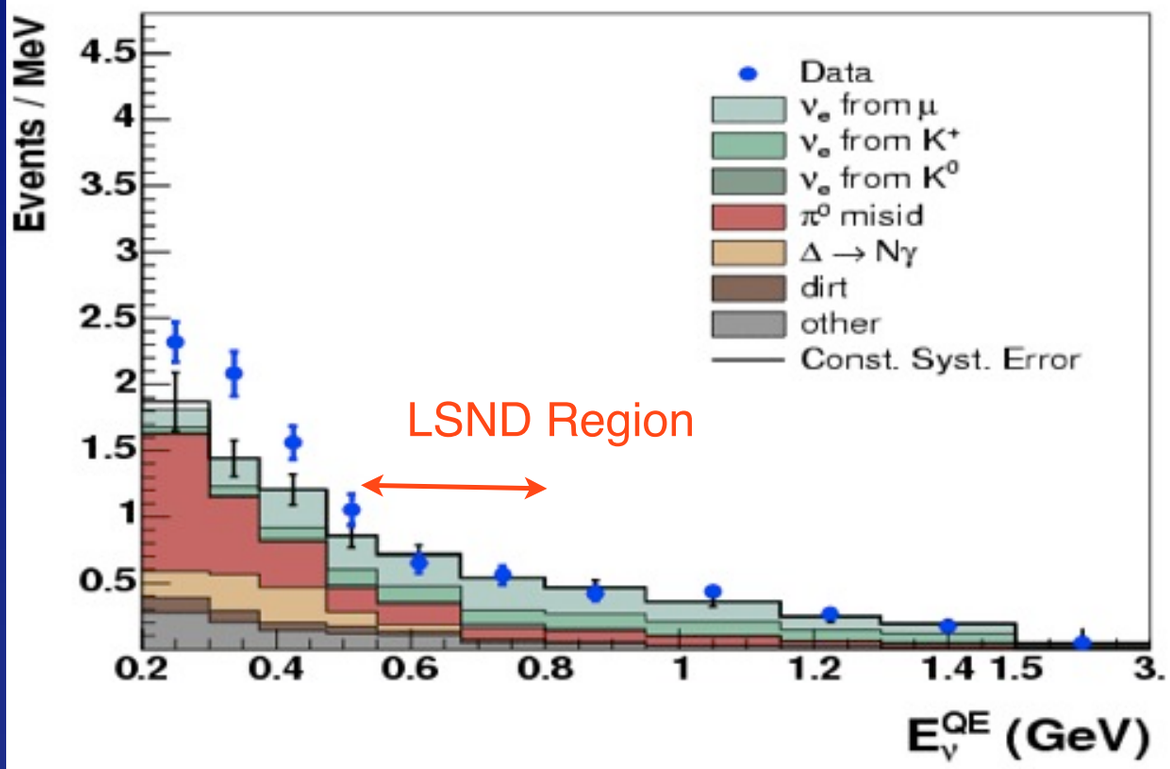


MINOS ν_μ Oscillations

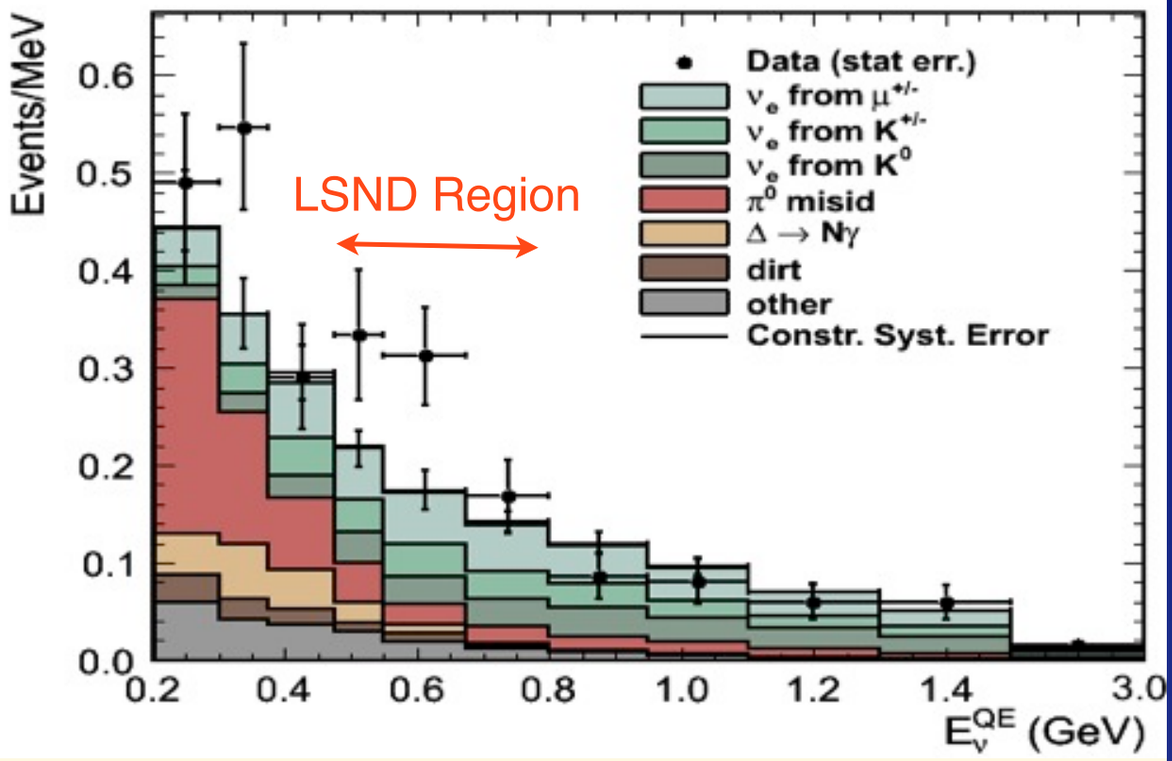


MiniBooNE Status

Neutrinos - 6.5E20 POT



Antineutrinos - 5.66E20 POT



Neutrinos: Excess of electrons (γ's?) below 475 MeV

No excess in the LSND region

Antineutrinos: Small excess below 475 MeV

Excess of events (>2σ) in LSND region

Something is not understood: beam? detector response?

nuclear physics? standard model? new ν physics?

Neutrino Questions

Normal or inverted spectrum?
Value of θ_{13}?
Are neutrinos their own antiparticles?
How many mass eigenstates?
Sterile neutrinos?
Electromagnetic properties of neutrinos?
CP violation in neutrino interactions?
Nonstandard neutrino interactions?
Origin of neutrino mass?
More surprises?

We can trust Nature …

Susan Kayser

"It is a part of probability that many improbable things will happen."
— George Eliot (after Aristotle), *Daniel Deronda*

$|V_{ub}|$ comparisons

Latest combined fit to data,lattice $B \to \pi \ell \nu$ $(2.95 \pm 0.31) \times 10^{-3}$

Inclusive, PDG2010 average: $b \to u \ell \nu$ $(4.37 \pm 0.39) \times 10^{-3}$

2.7σ

Difference is a problem and perhaps should be identified as an unattributed uncertainty

- work of multiple experiments, multiple theoretical groups.
- exclusive result relies on non-perturbative normalization input
- inclusive result uses m_b, non-perturbative extrapolations and perturbative corrections

Predictions from CKM fits:

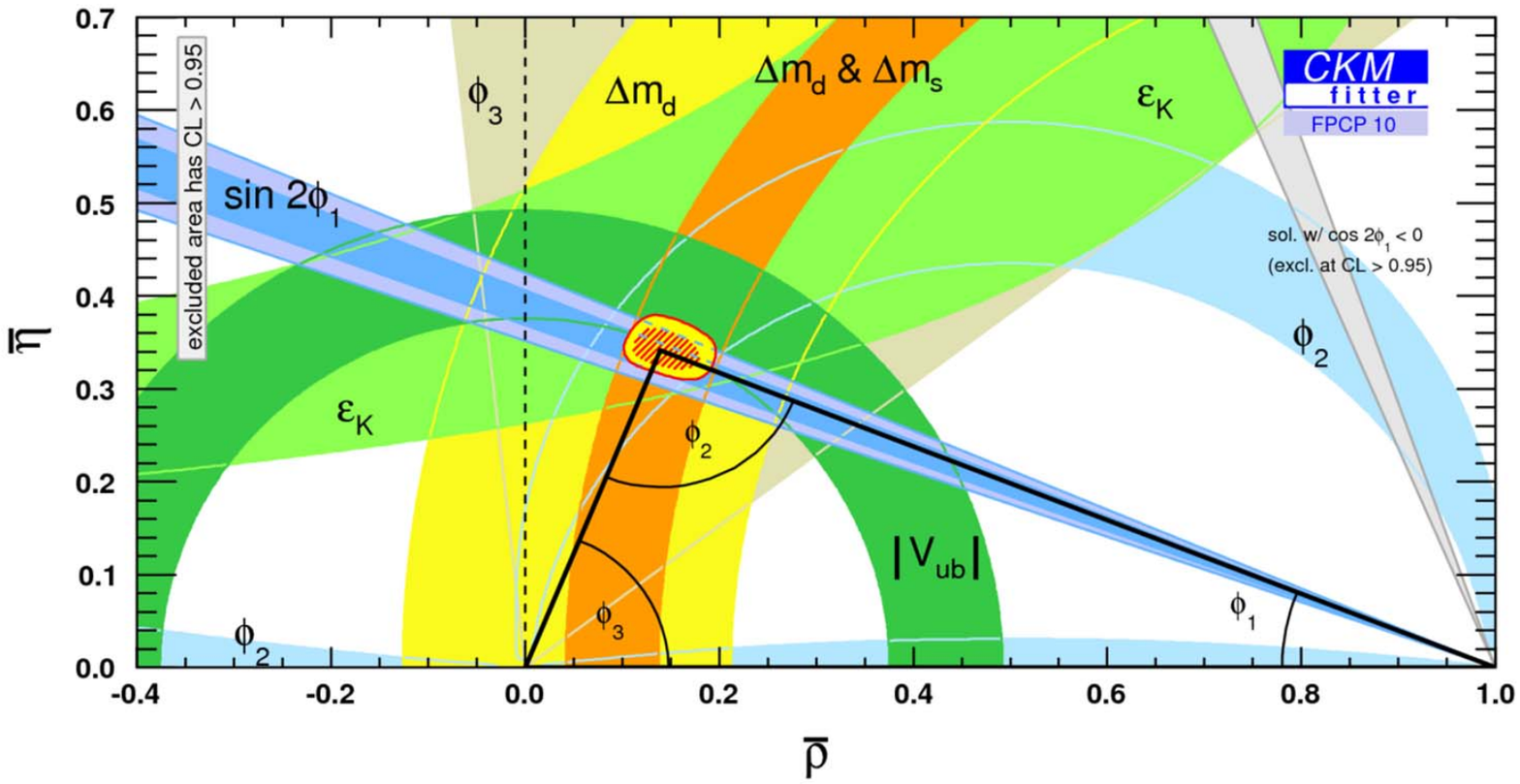
UTFit	**3.48±0.16**	**(ICHEP 2008)**
CKMFitter	**$3.51 \pm {}^{0.15}_{0.16}$**	**(Beauty 2009)**

RH currents? Buras/Gemmler/Isidori 1007.1993

Summary on CP Violation

- CP Violation clearly established, consistent with SM (some „tensions“)

- Significant constraint on the apex of the unitarity triangle, but statistics limited



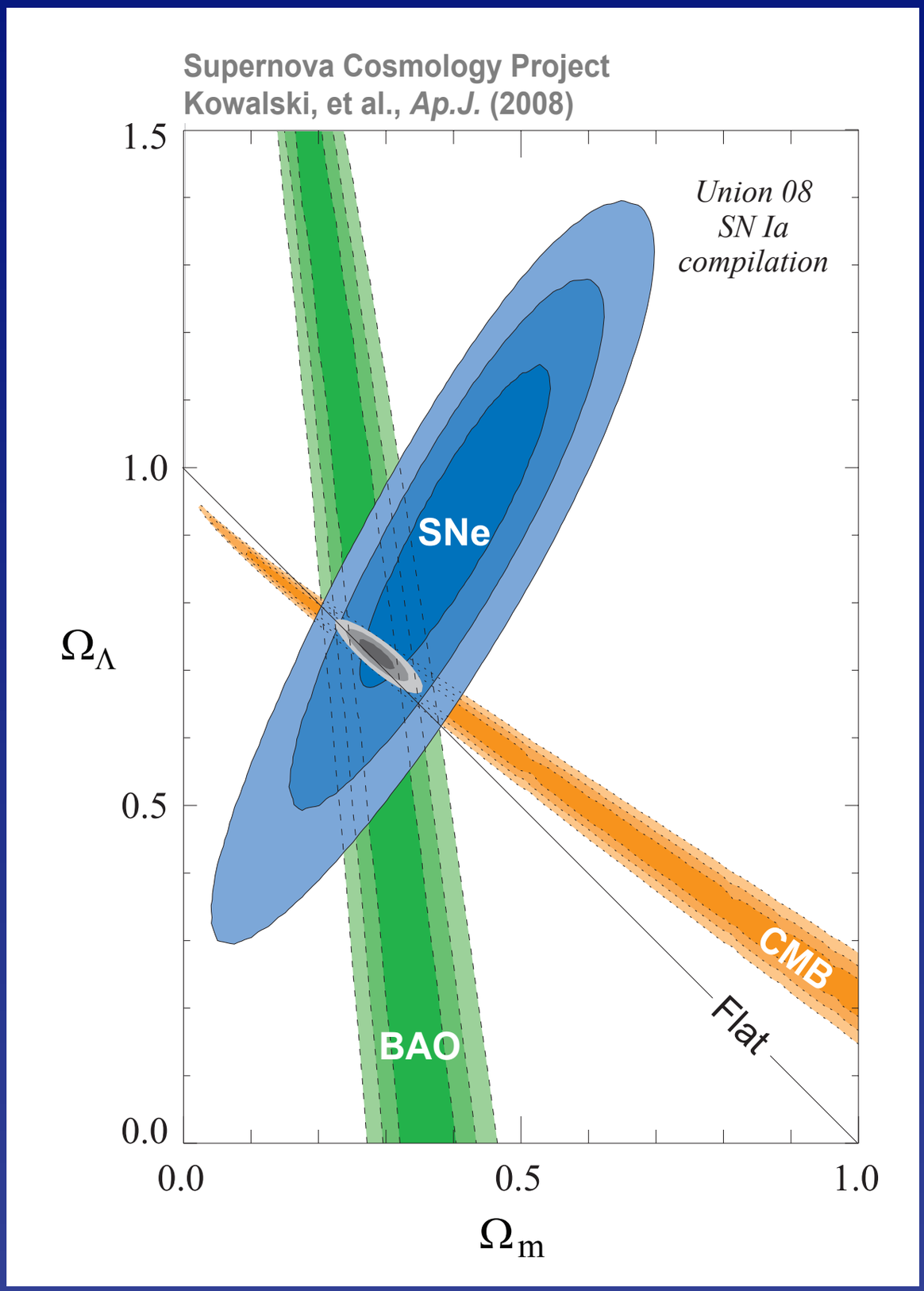
- Need more precision to look for (or establish) New Physics

- Full data sample of Belle (770 M $B\bar{B}$ events) being analysed

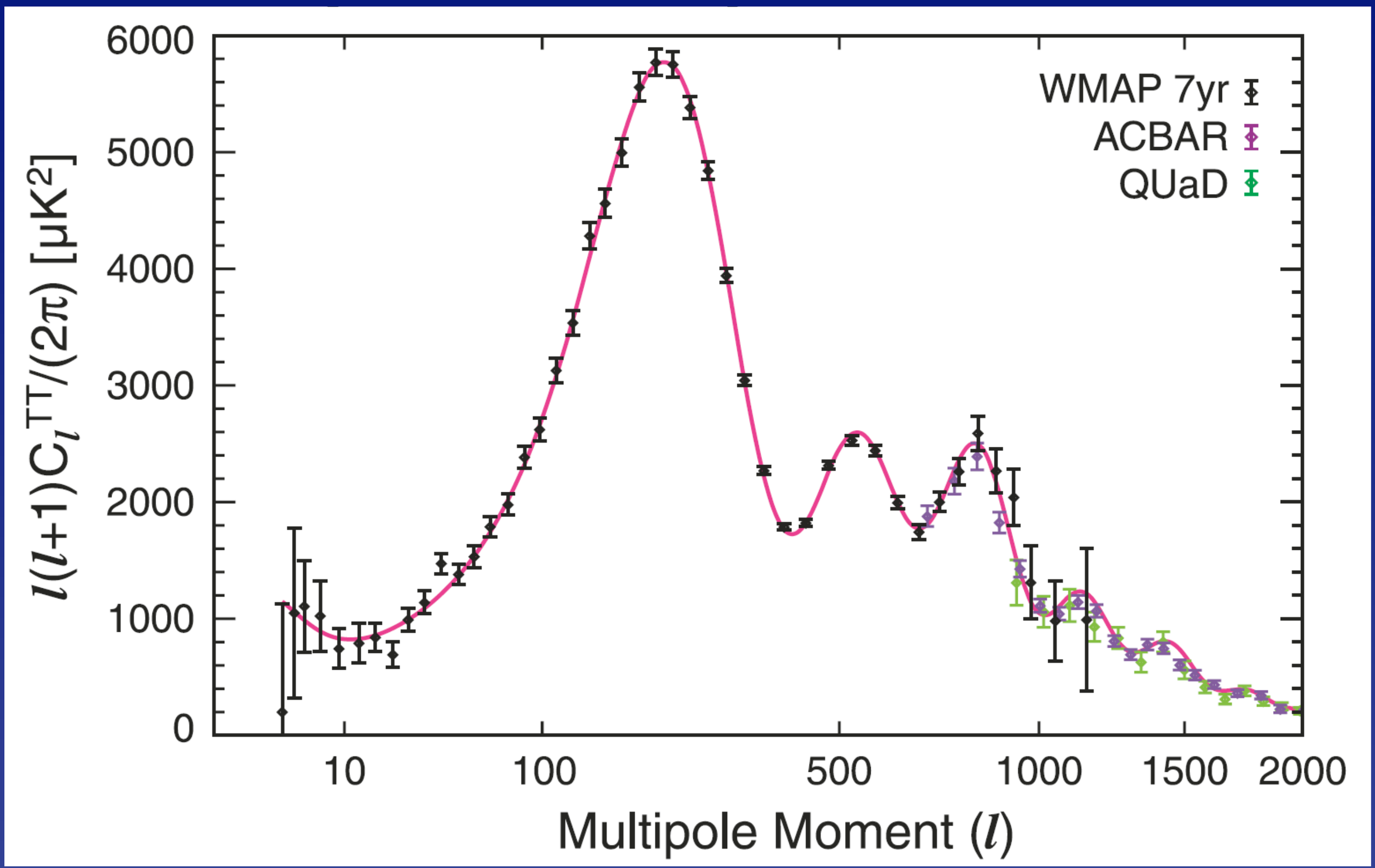
- Next big steps: LHCb (hopefully soon), SuperB Factories (2014)

Super-Belle funded, look for beam April 1, 2014!

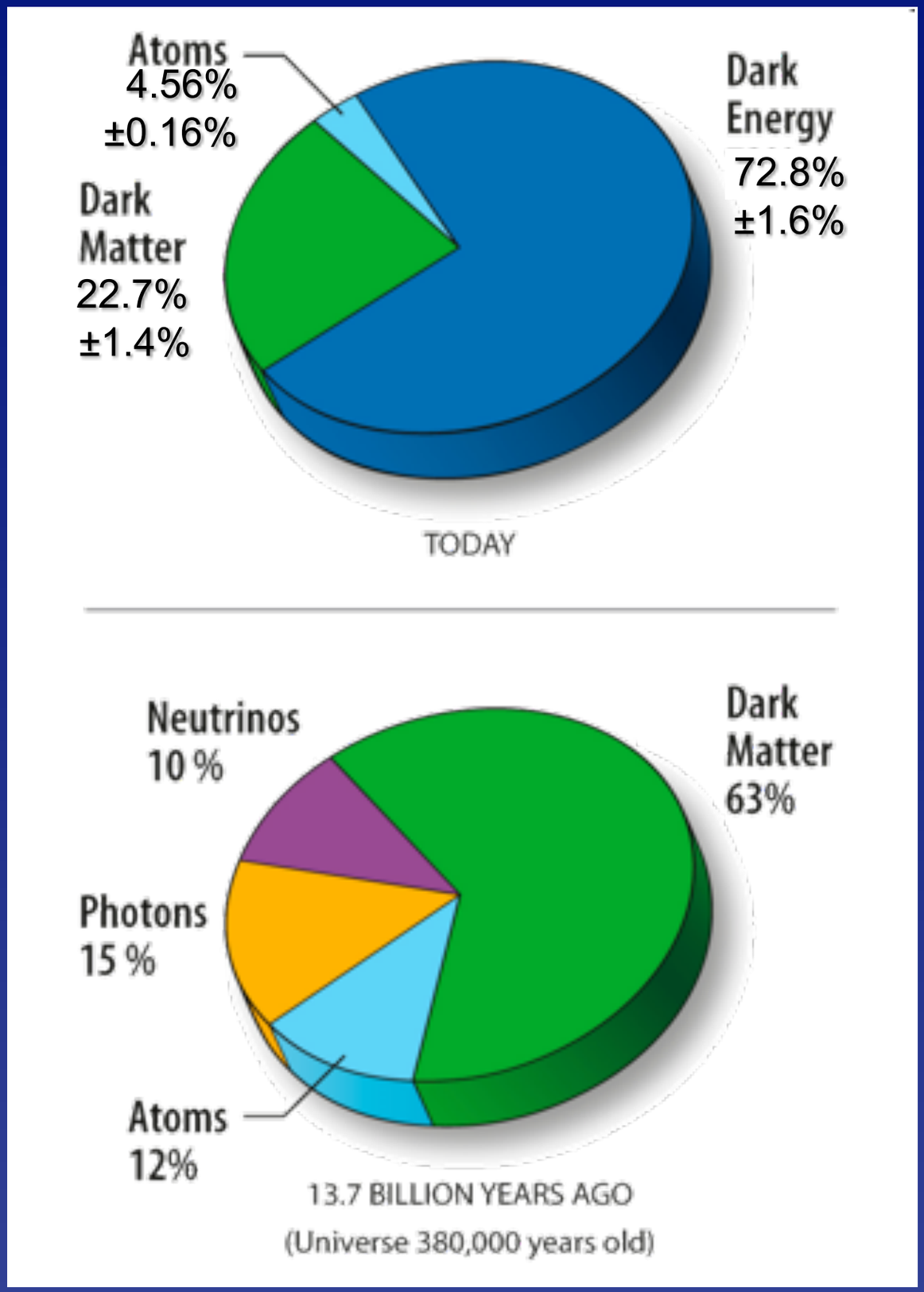
Composition of the Universe

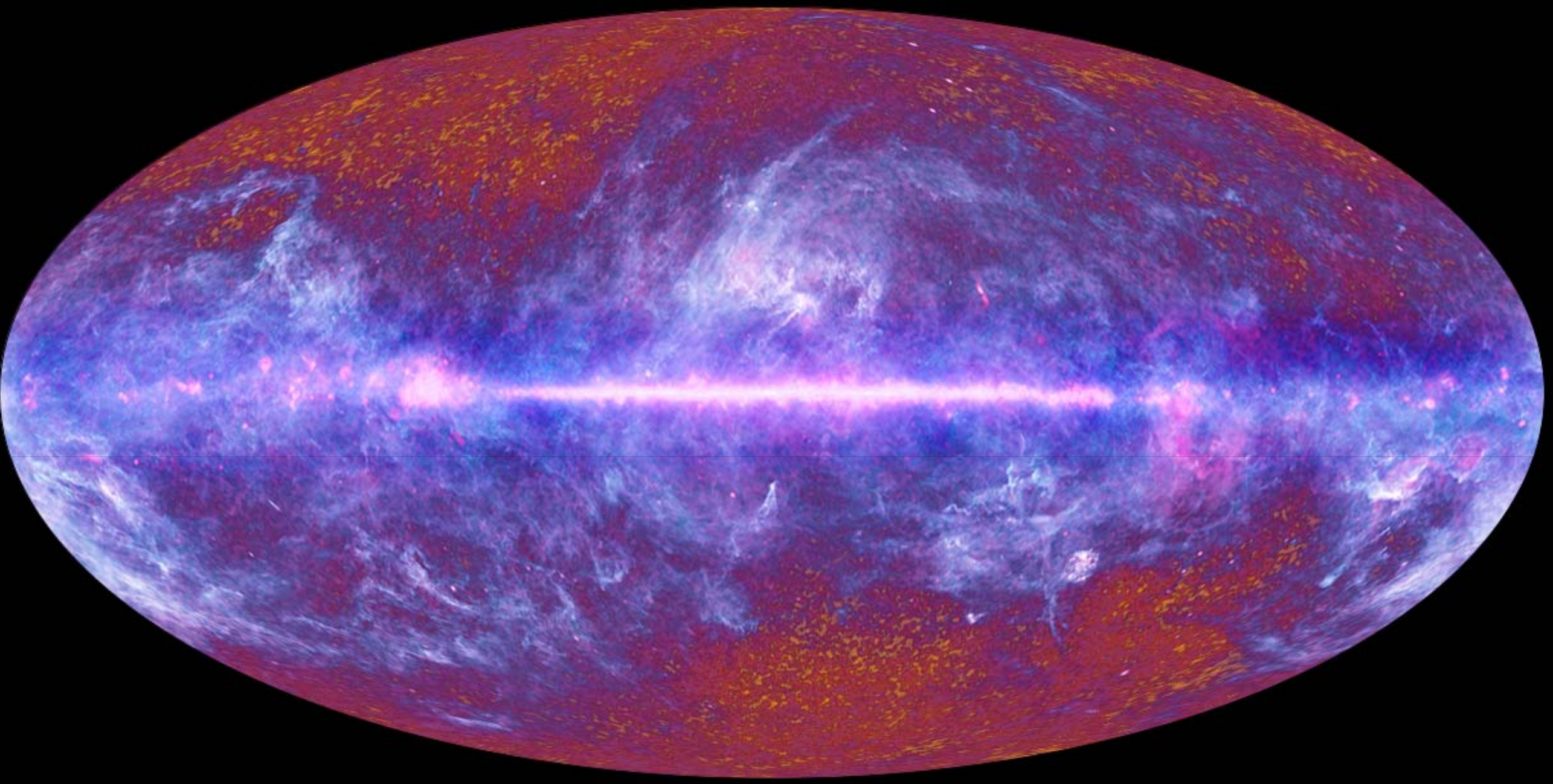


CMB Temperature Spectrum, ca. 2010



Composition Now and Then (WMAP)

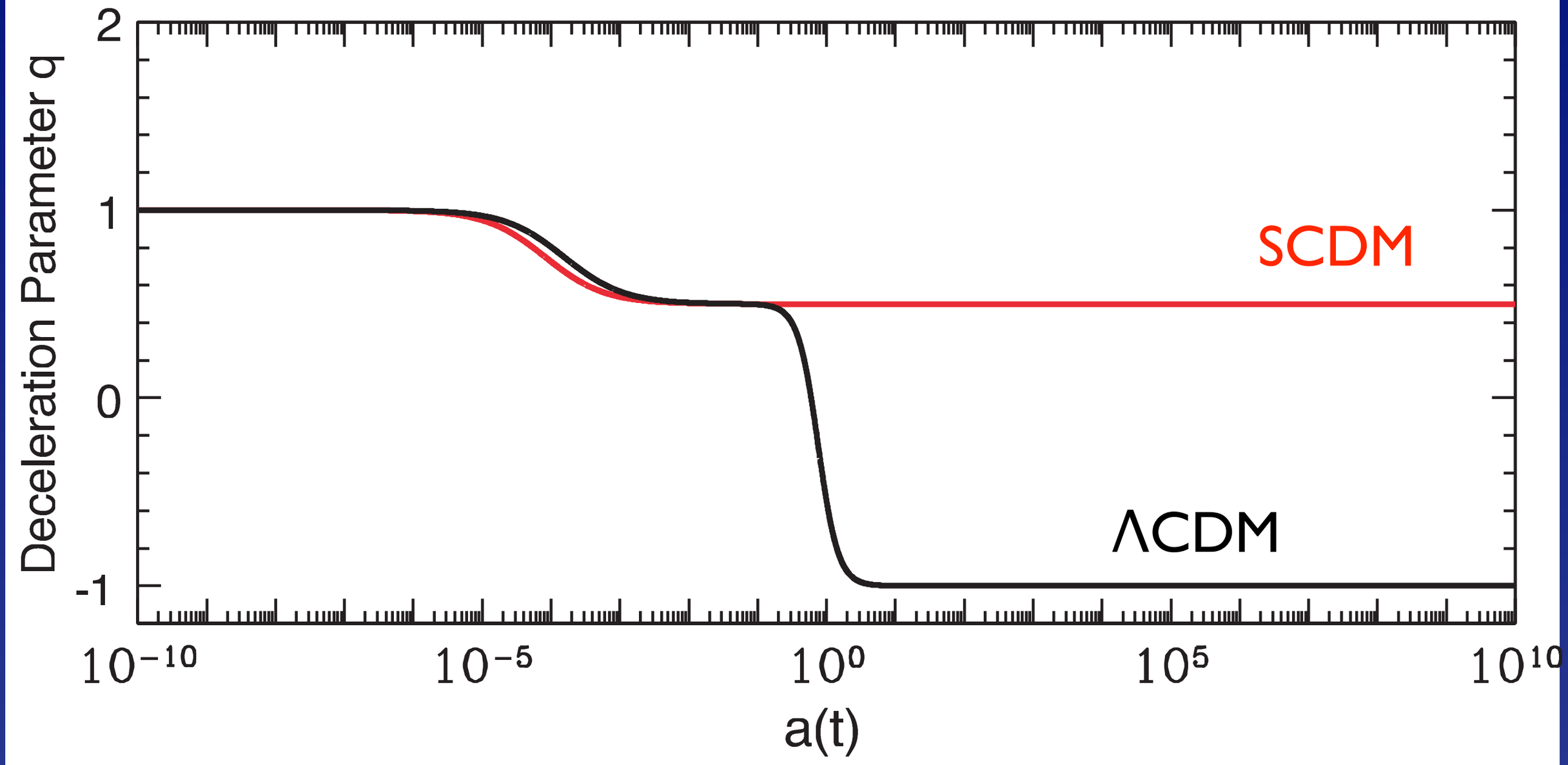




Planck one-year all-sky survey

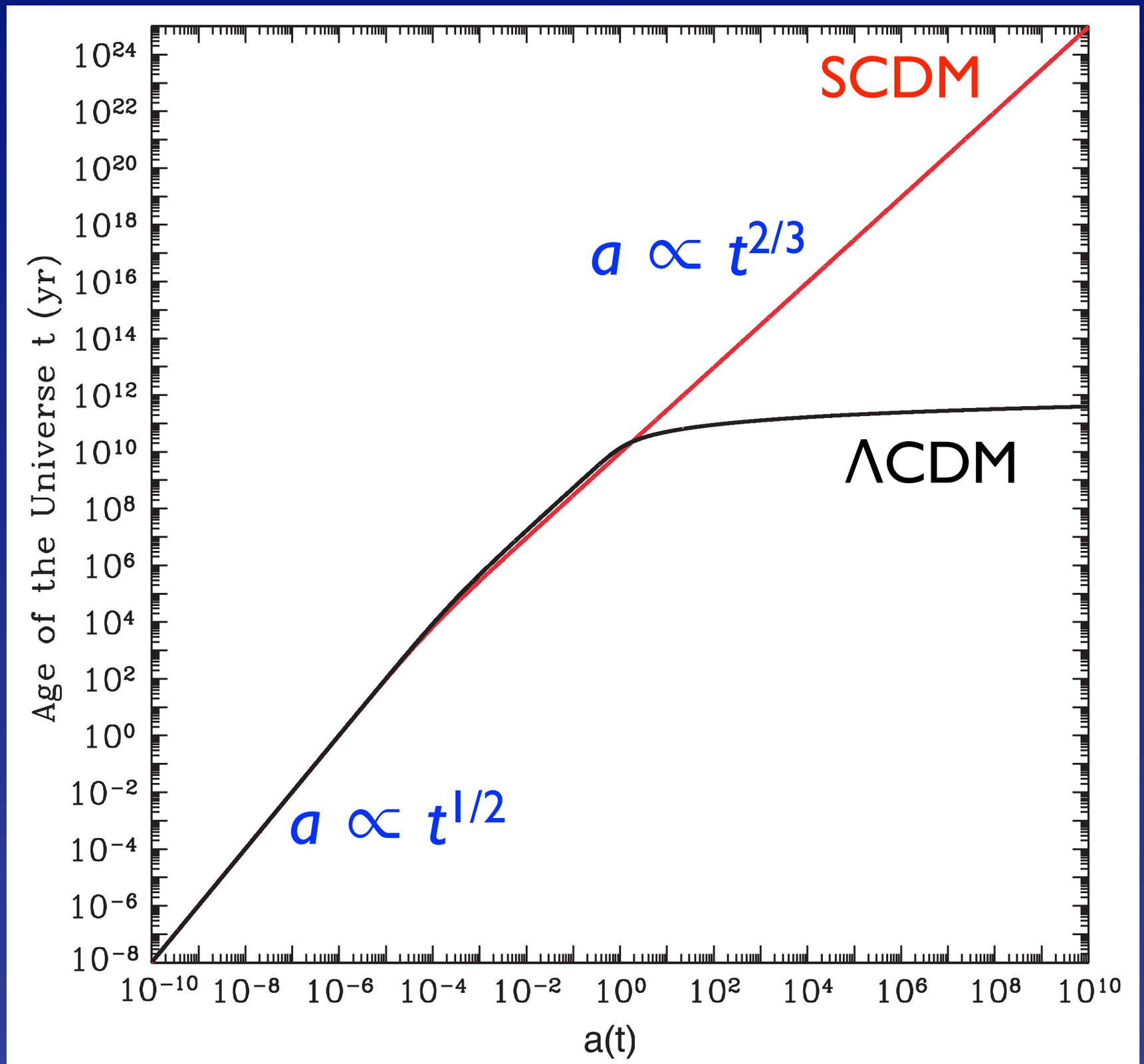
esa

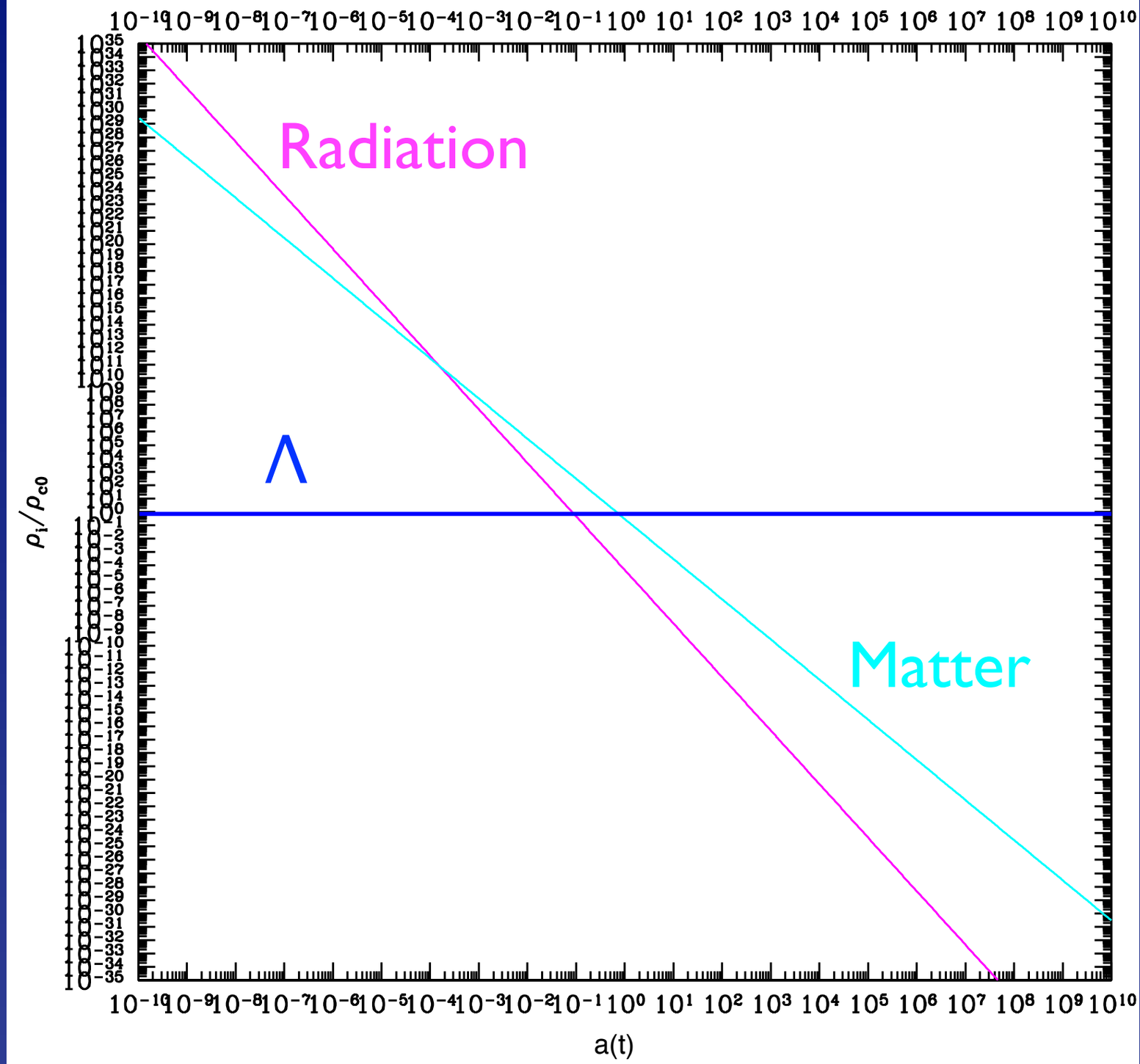
Accelerating expansion has remarkable implications



$$q \equiv -\frac{1}{H^2}\frac{\ddot{R}}{R} = \frac{\Lambda}{3H^2} - \frac{4\pi G_{\rm N}}{3H^2}(\rho + 3p)$$

Accelerating expansion has remarkable implications

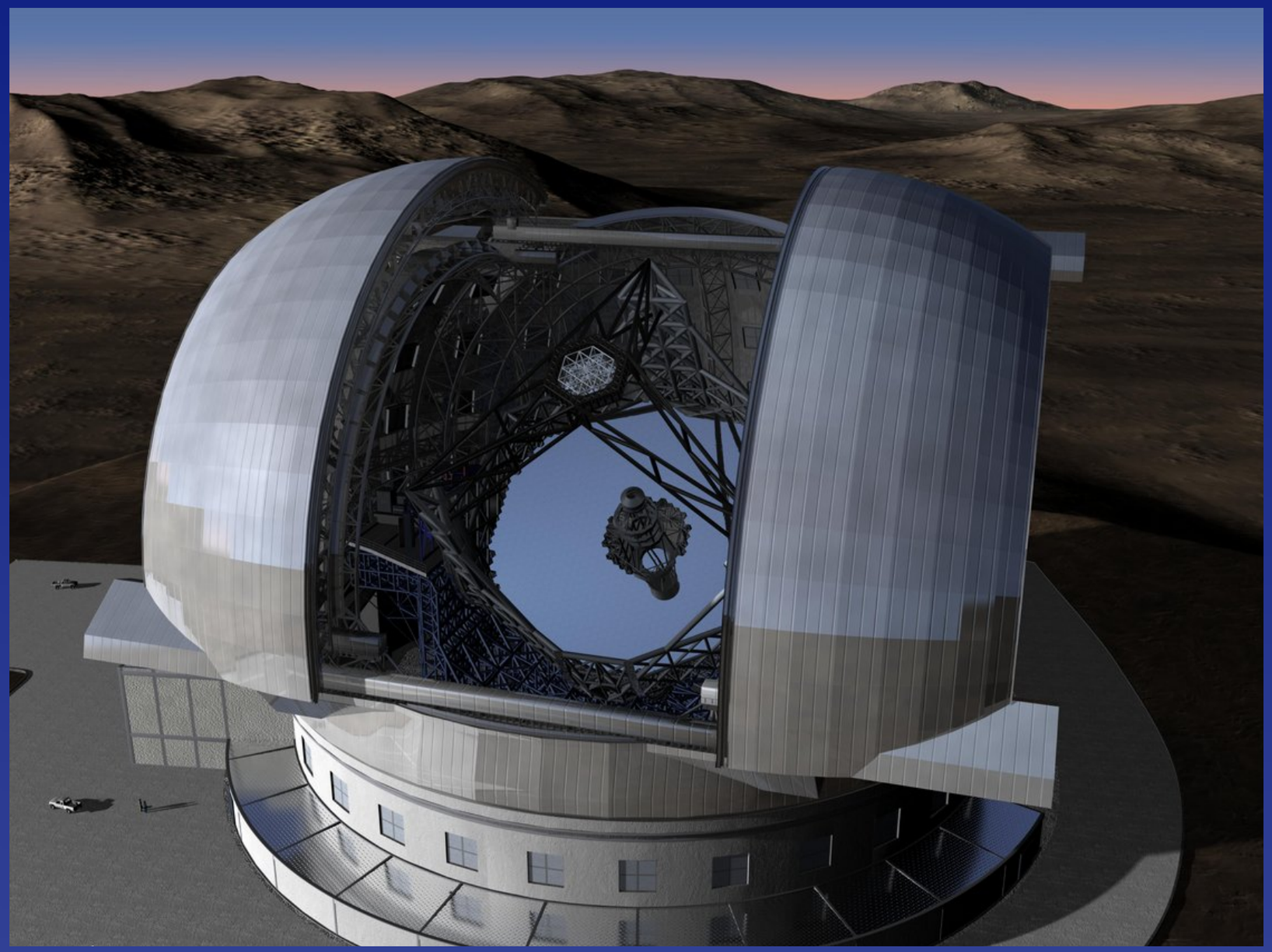



Radiation
Λ
Matter
ρ_i/ρ_{c0}
a(t)

Wouldn't it be wonderful …

to study dark energy over a range in redshifts

E-ELT Proposal to measure dz/d*t*

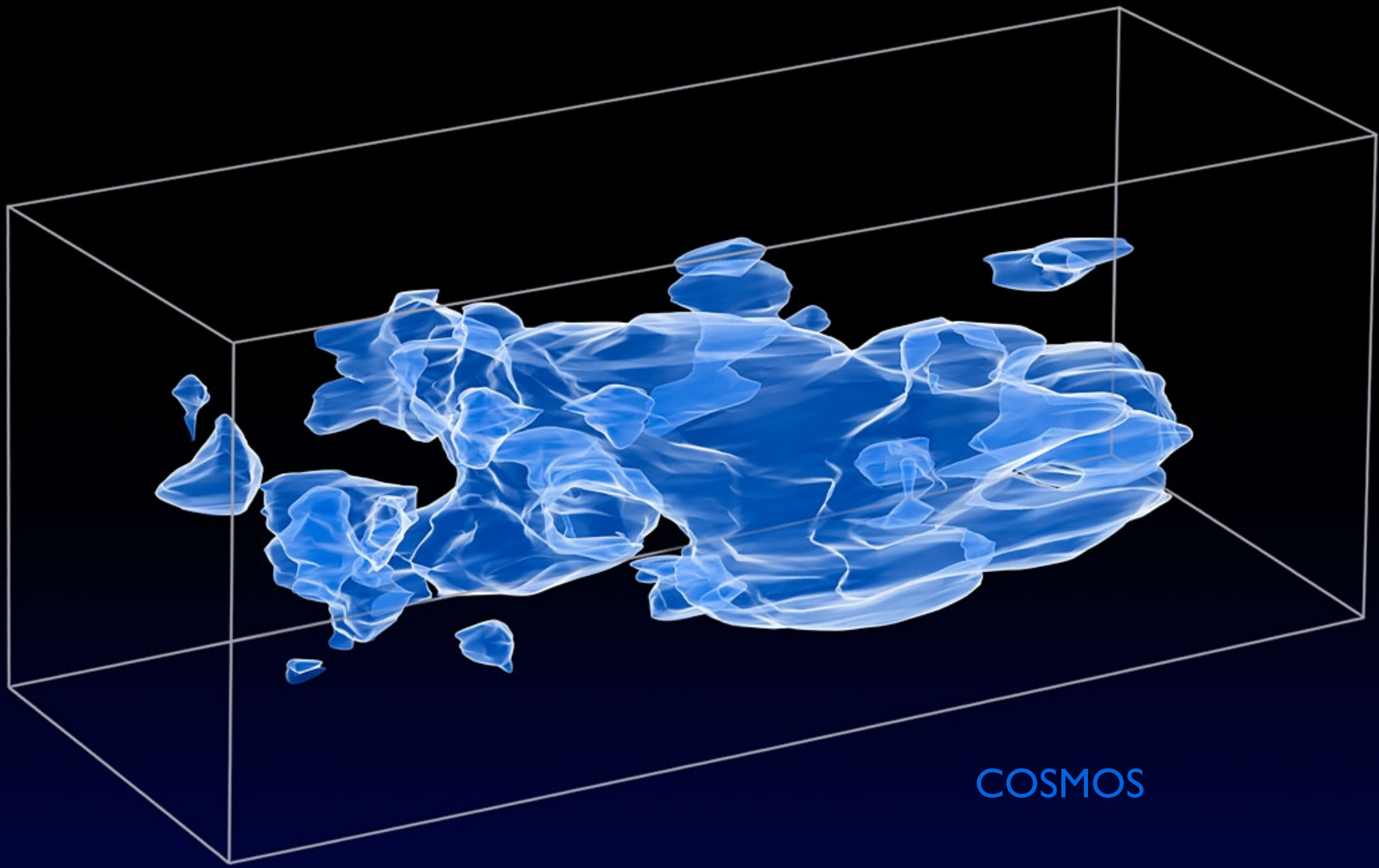


Dark Matter

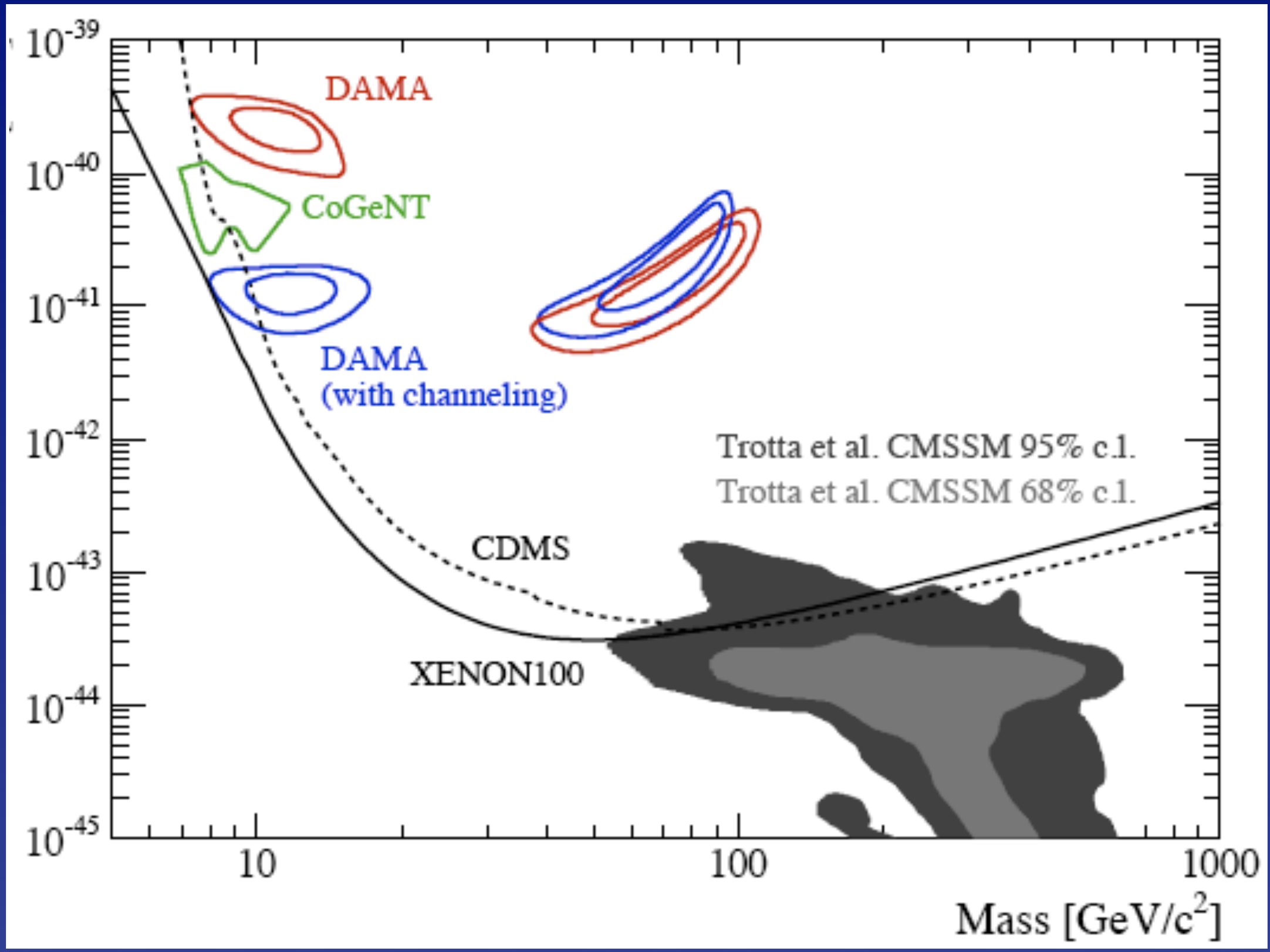
We know it is there (almost certainly)
We begin to know where it is
We know what it is not
We don't know how many species

Passive detection · Indirect detection · Colliders

Is there a signal?
If yes, is it background?
If no, prove you are sensitive.


COSMOS

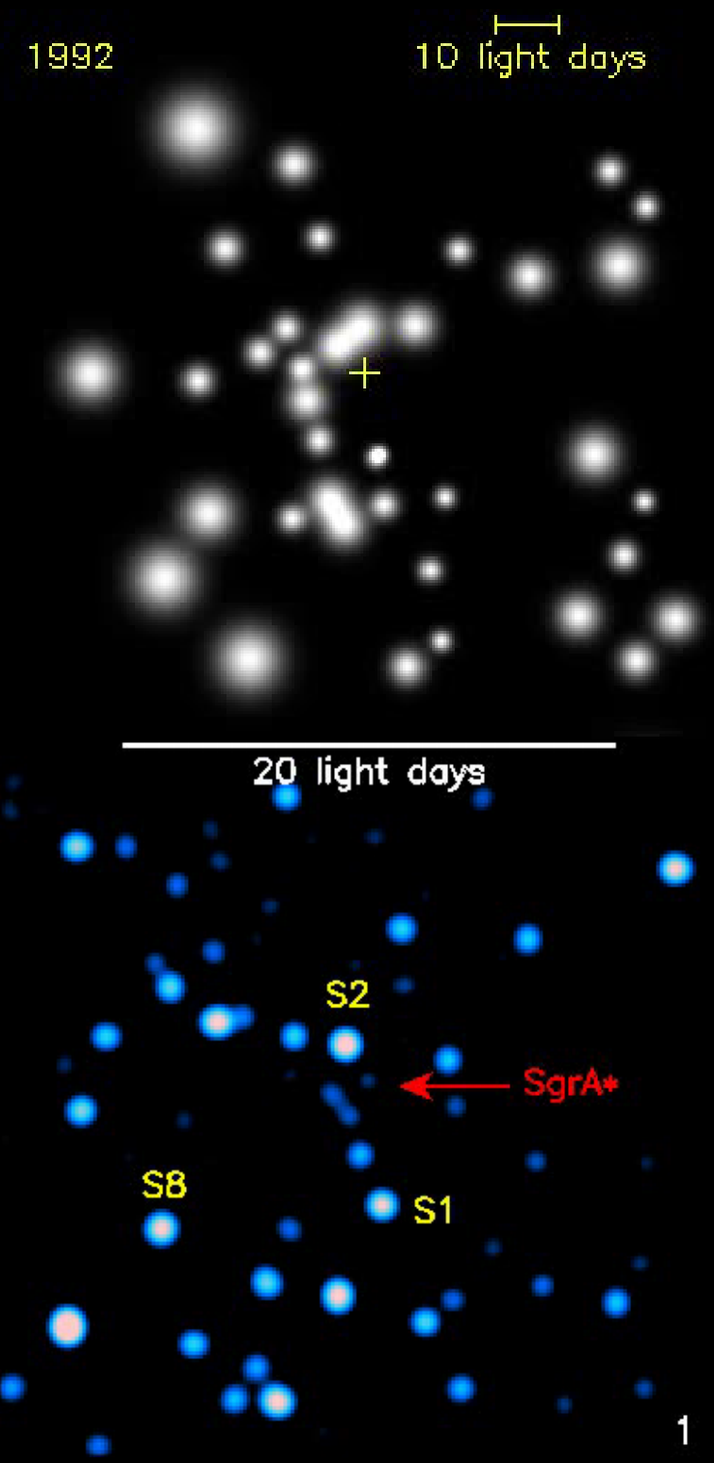
WIMP Search Status



ΛCDM is not a coherent theoretical framework,
but a collection of ideas and inventions.
Not (yet) principle-based.

Remain skeptical
Test foundations
Look for deviations
and more coherent ideas.

“Conventional” Astrophysics: Black Hole at Galactic Center



European Southern Observatory

possible sources :

	$\|h\|$ (galactic)
• Supernova ;	$< 10^{-20}$
• coalescence of binary compact system ;	$< 10^{-18}$
• other burst sources (e.g. magnetars) ;	??
• fast spinning deformed neutron stars ;	$< 10^{-27}$ cw

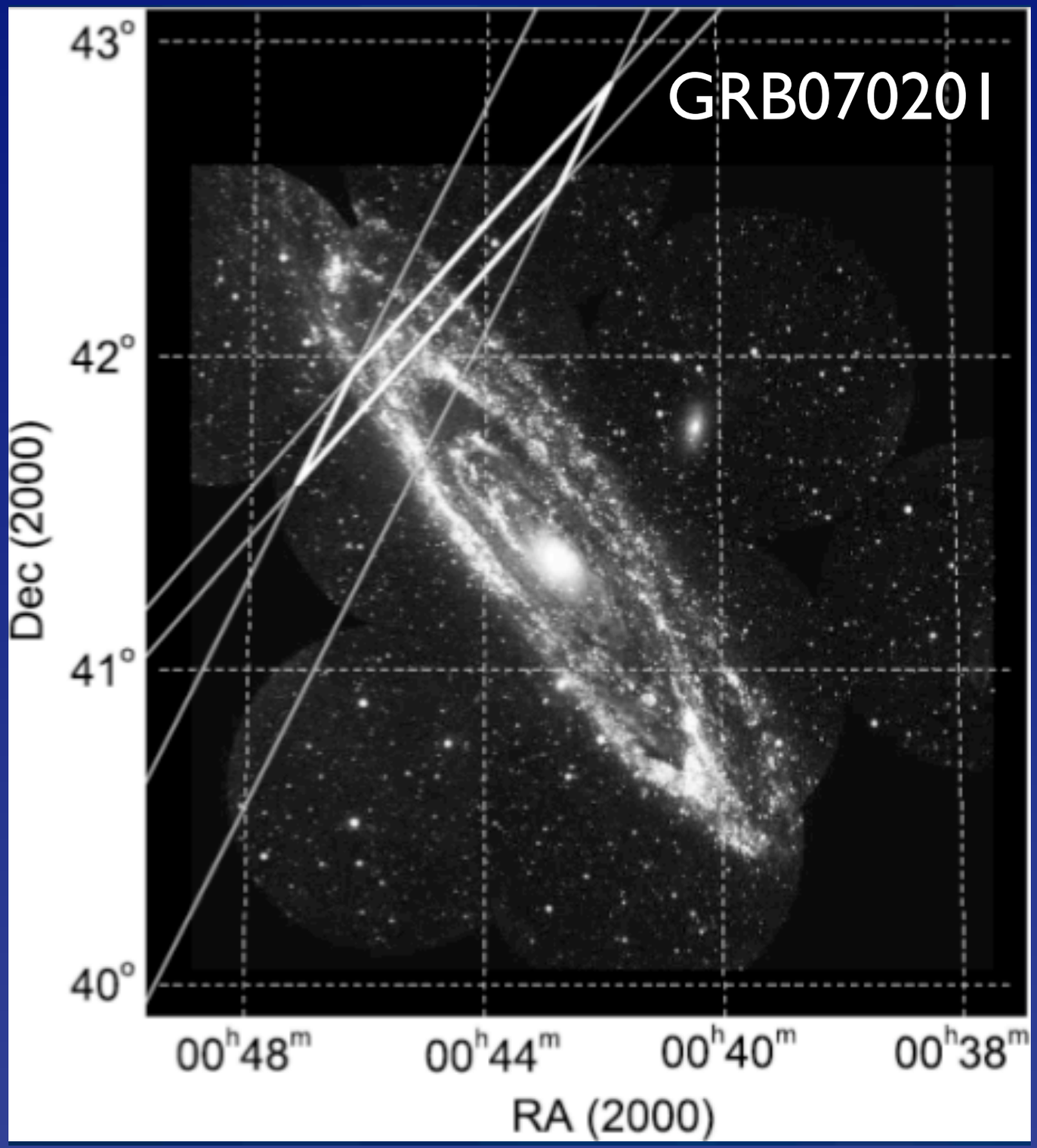
some sources are rare :

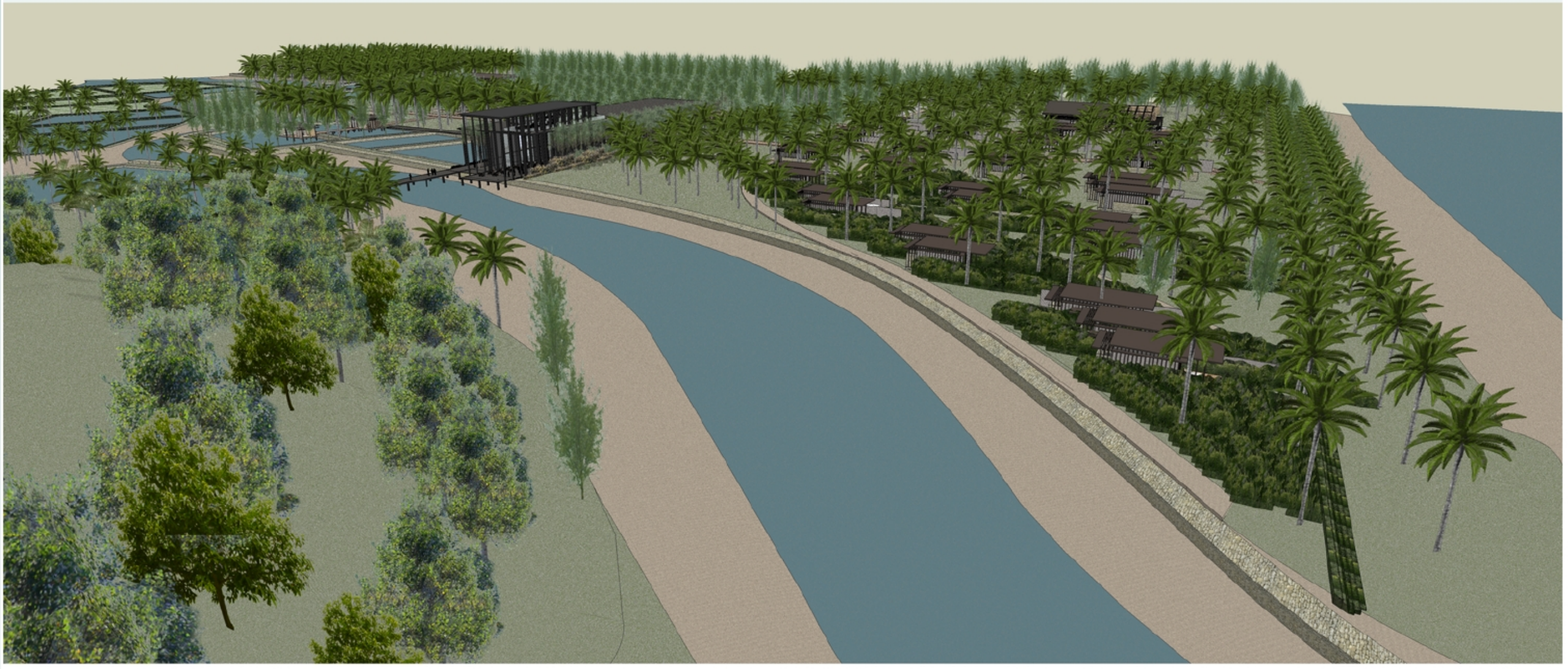
Supernovae: ≈ 1/(100 y * galaxy)

coalescence: ≈ 1/(1000 y * galaxy)

$$|h| = \delta L / L$$

In our future? Gravitational waves as diagnostics for astrophysical phenomena





Perspective axonometrique sur le site
Axonometric view on the site

The way we are living,
timorous or bold,
will have been our life.

— Seamus Heaney

Un très grand merci …

à tous les participants,

aux gentils organisateurs,

à nos amies sauvetrices du secretariat,

au personnel du *Château de Blois*,

à Kim et Van

À très bientôt !

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