A DARK FORCE FOR BARYONS

Ian Shoemaker

BF2011

October 19th, 2011

with Michael Graesser and Luca Vecchi

Los Alamos NATIONAL LABORATORY EST. 1943

OR:

WHY YOU SHOULD LEARN TO STOP WORRYING AND GAUGE BARYON NUMBER

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Dark matter à la Occam

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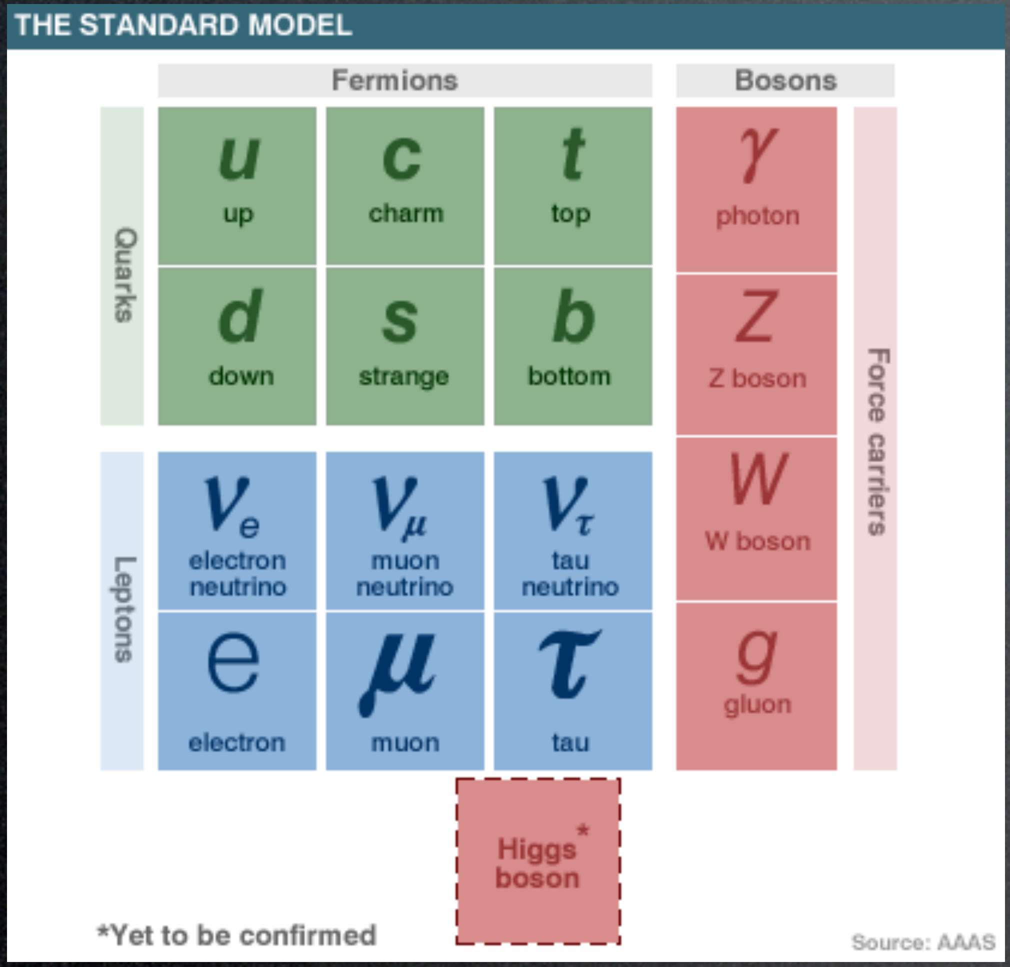

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Visible sector $\sim 17\%$

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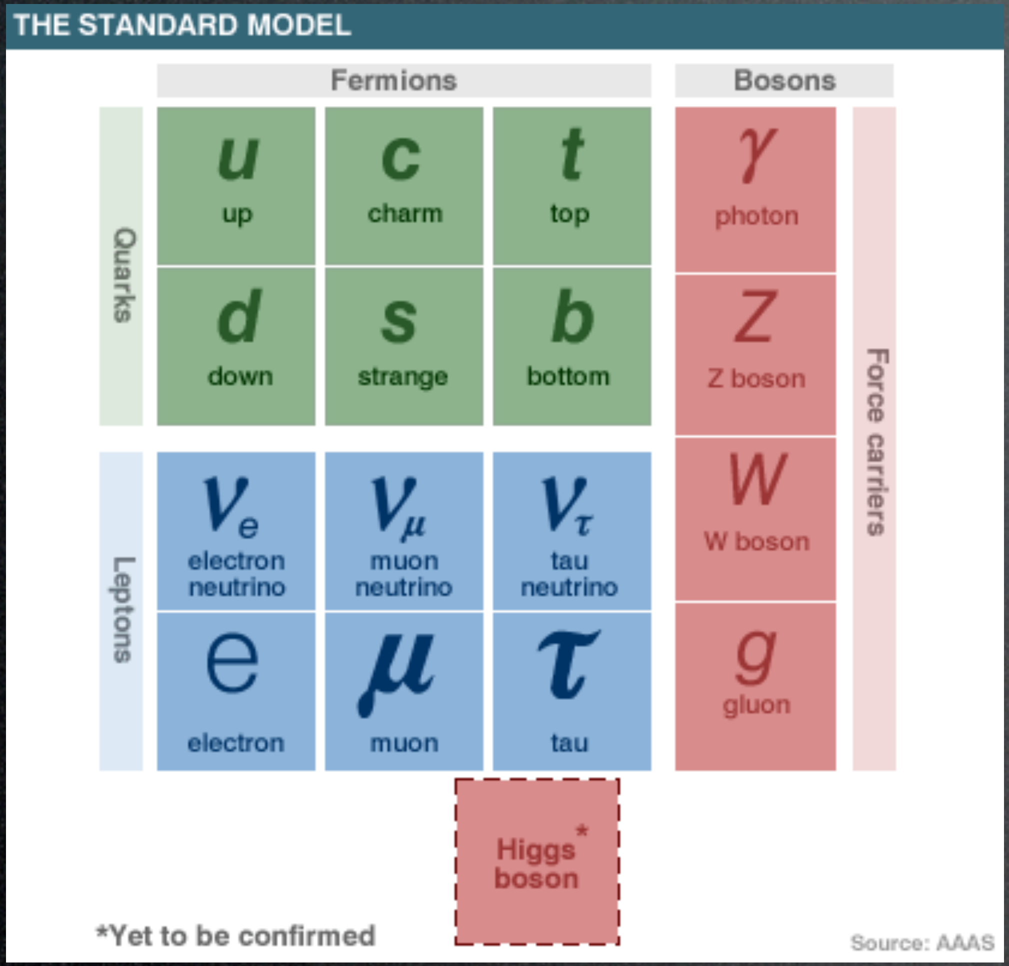

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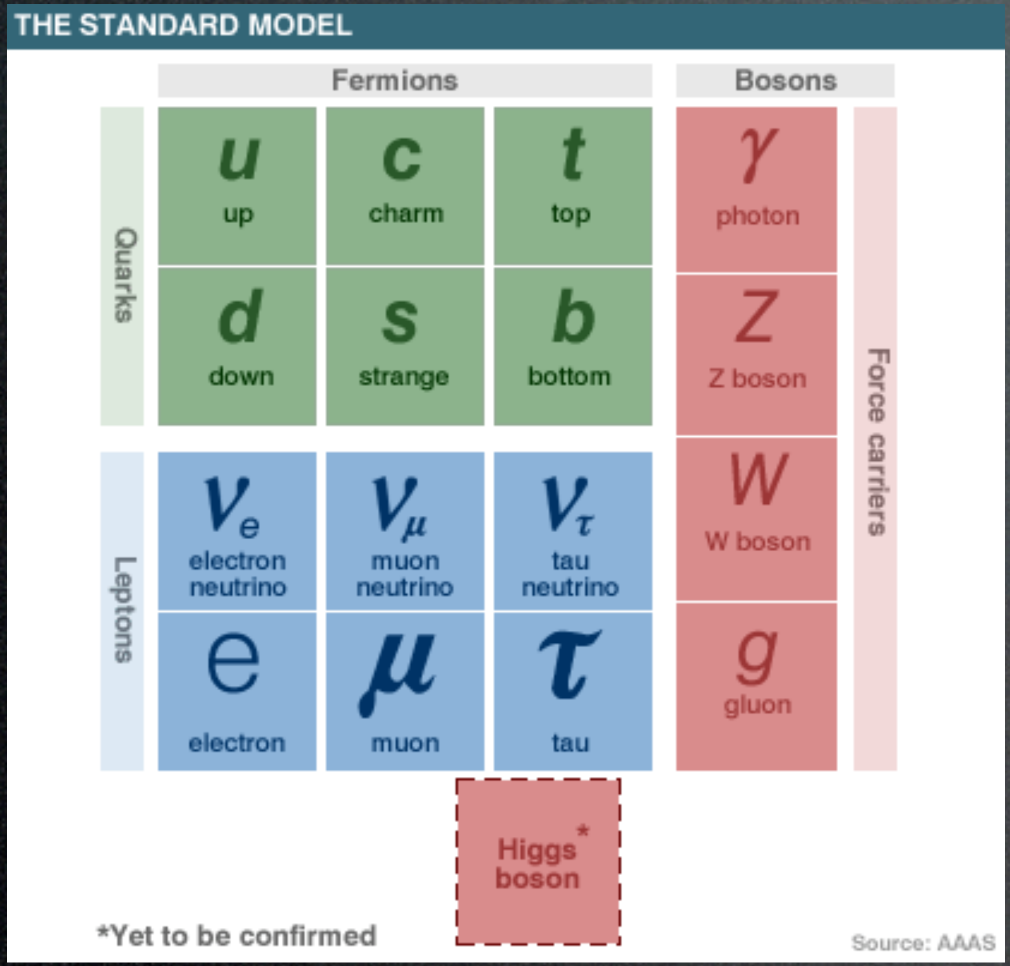

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WIMP

The WIMP "miracle"

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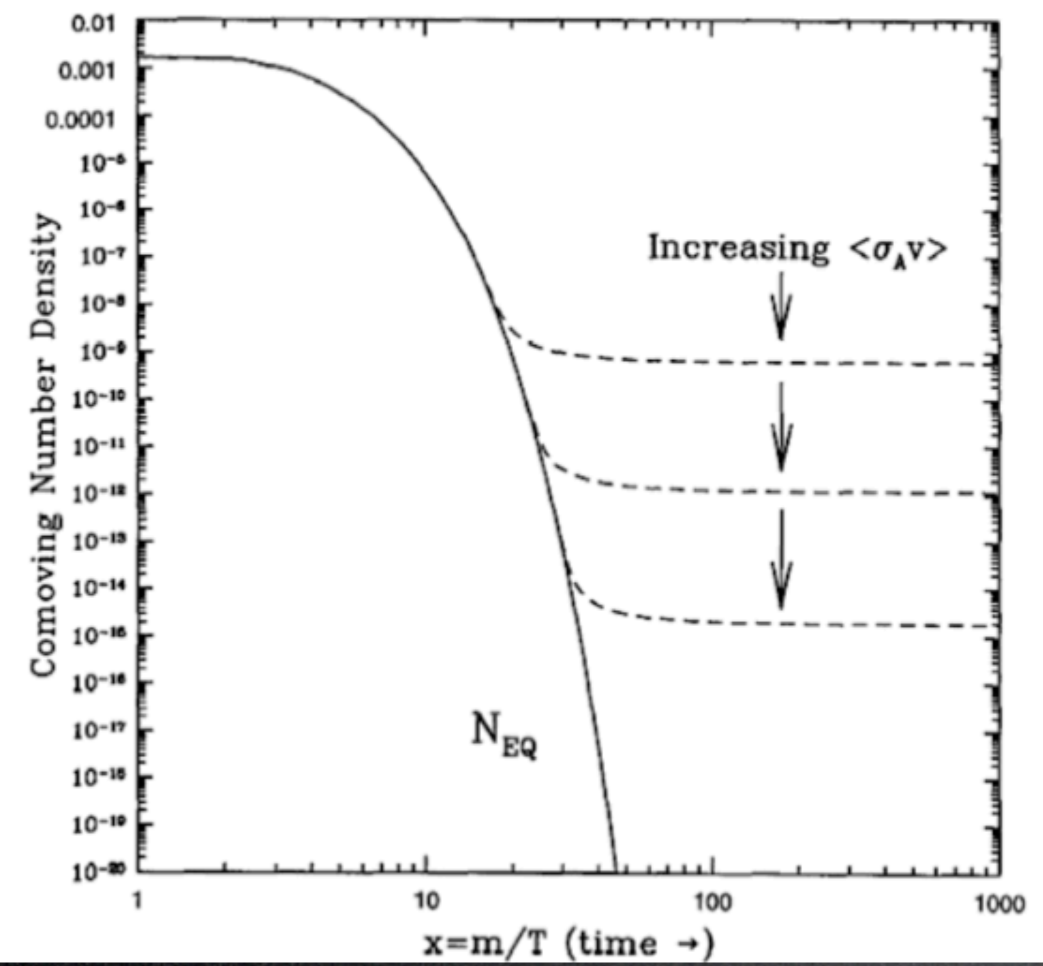

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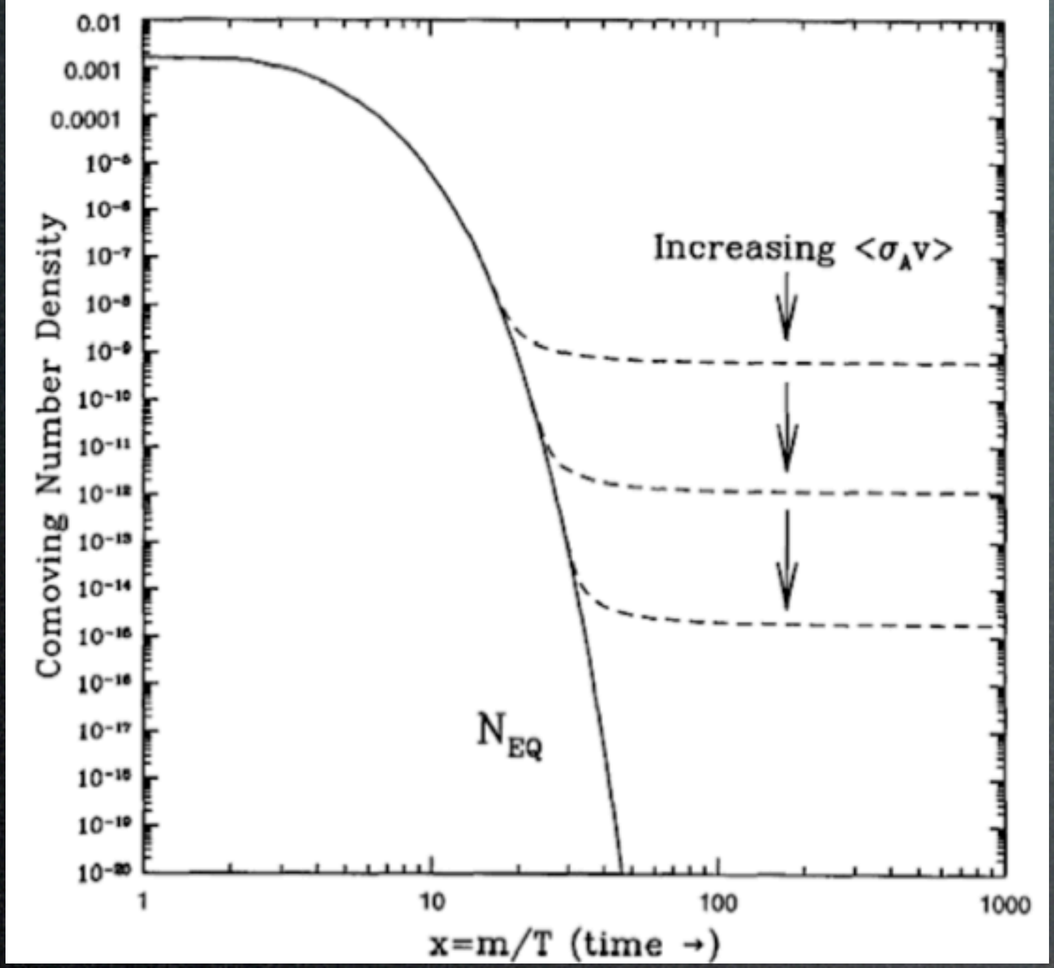

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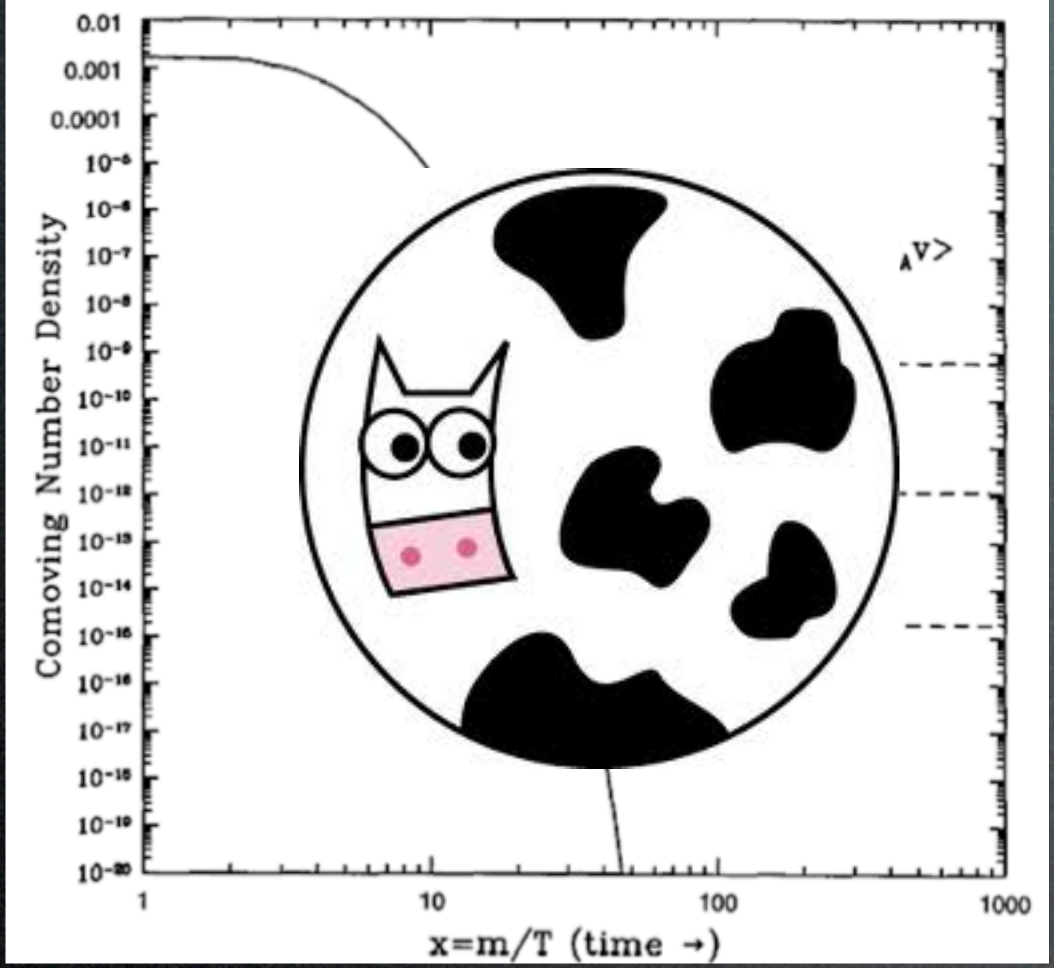

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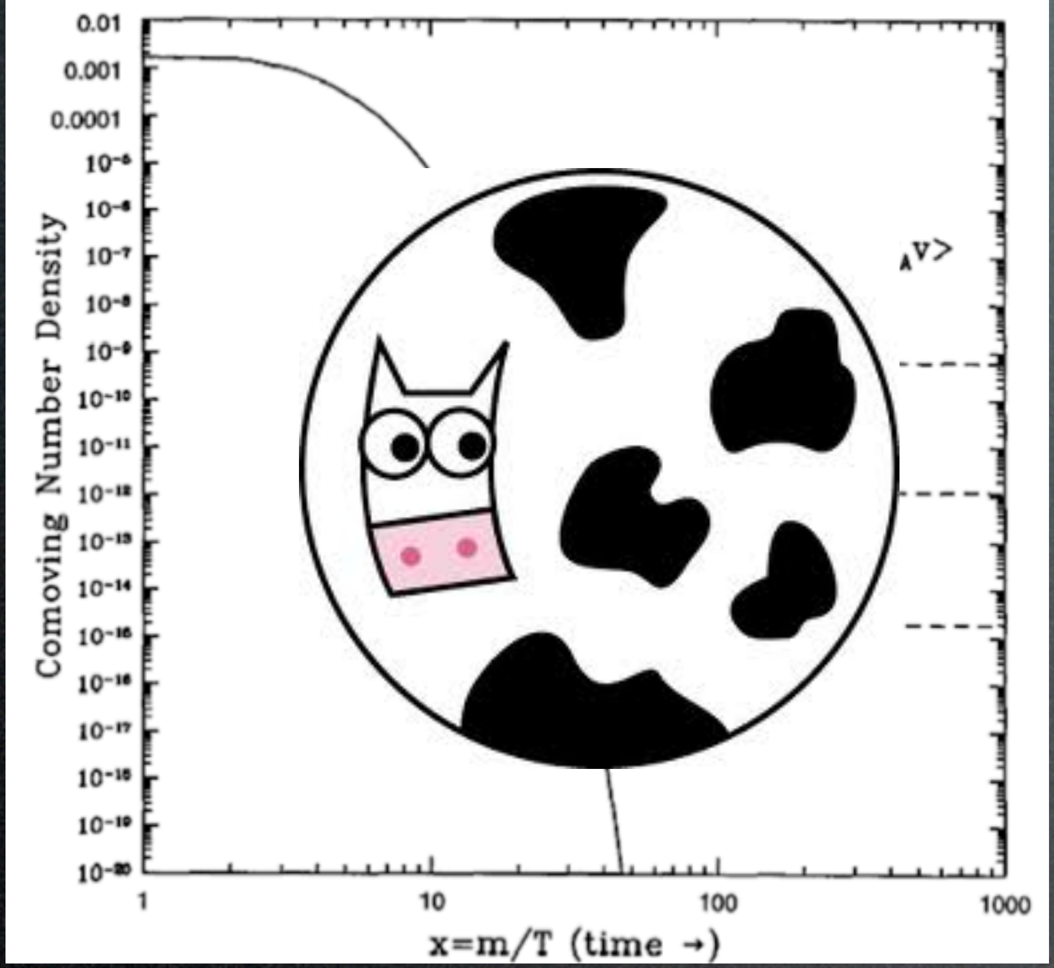

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2. It's stable (or at least very long-lived).

[Larson, et al. (2010)]

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  3. An indication of an underlying origin.

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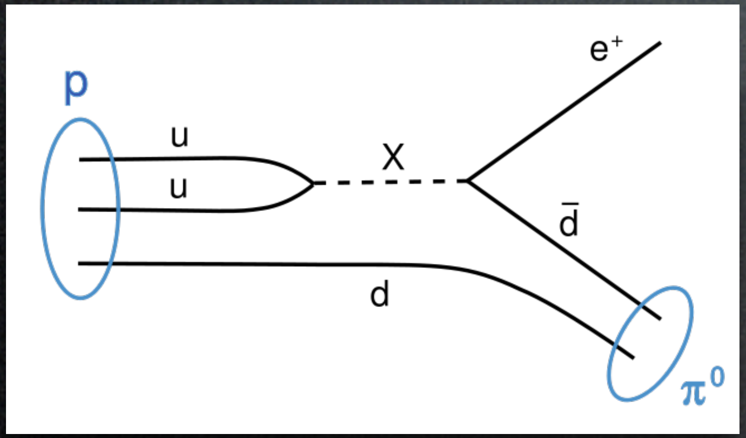

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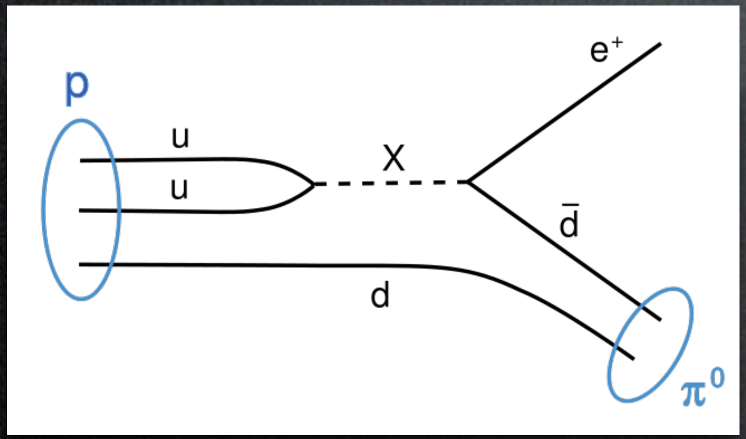
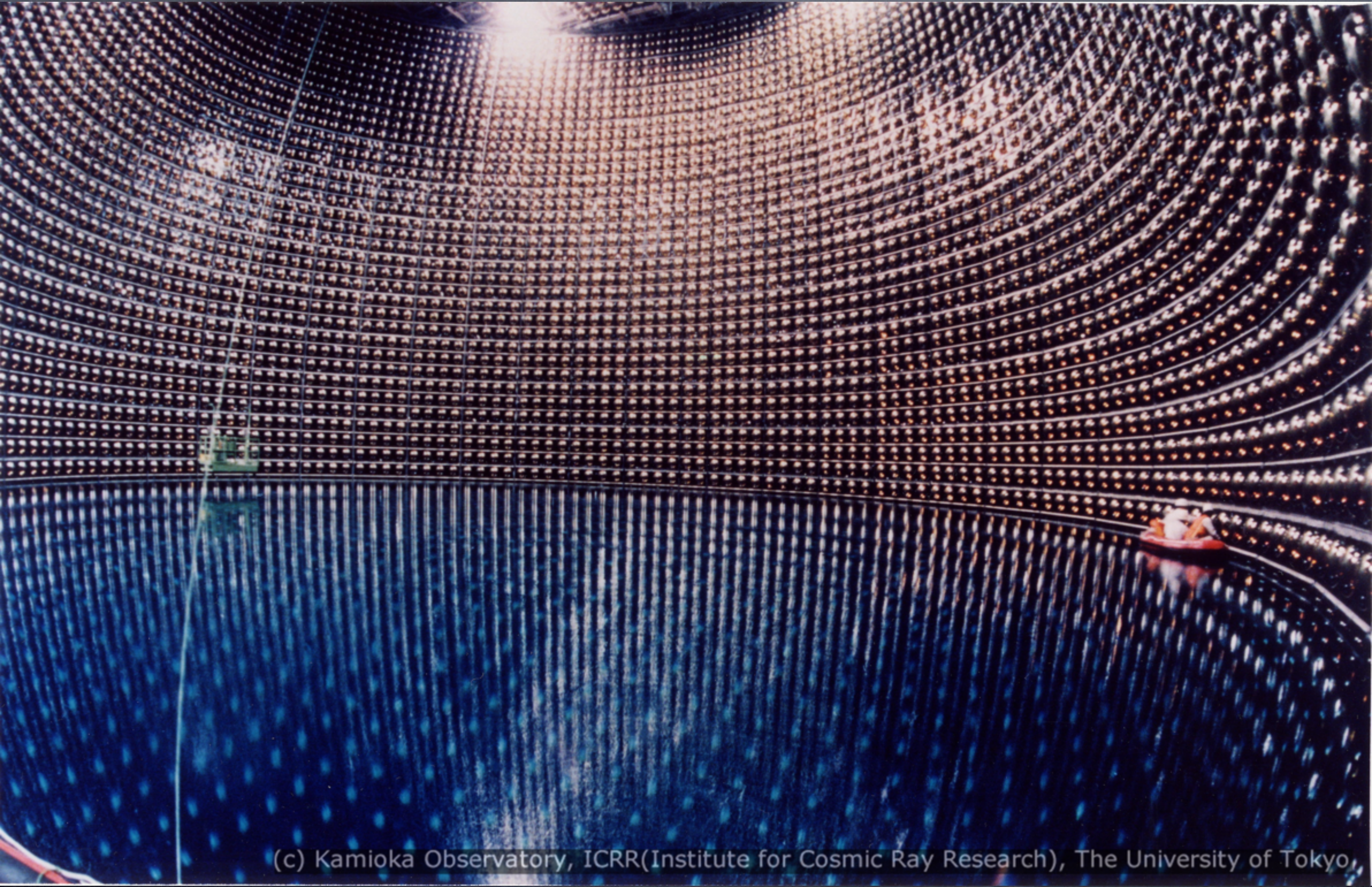


The only problem is...

Super Kamiokande says:



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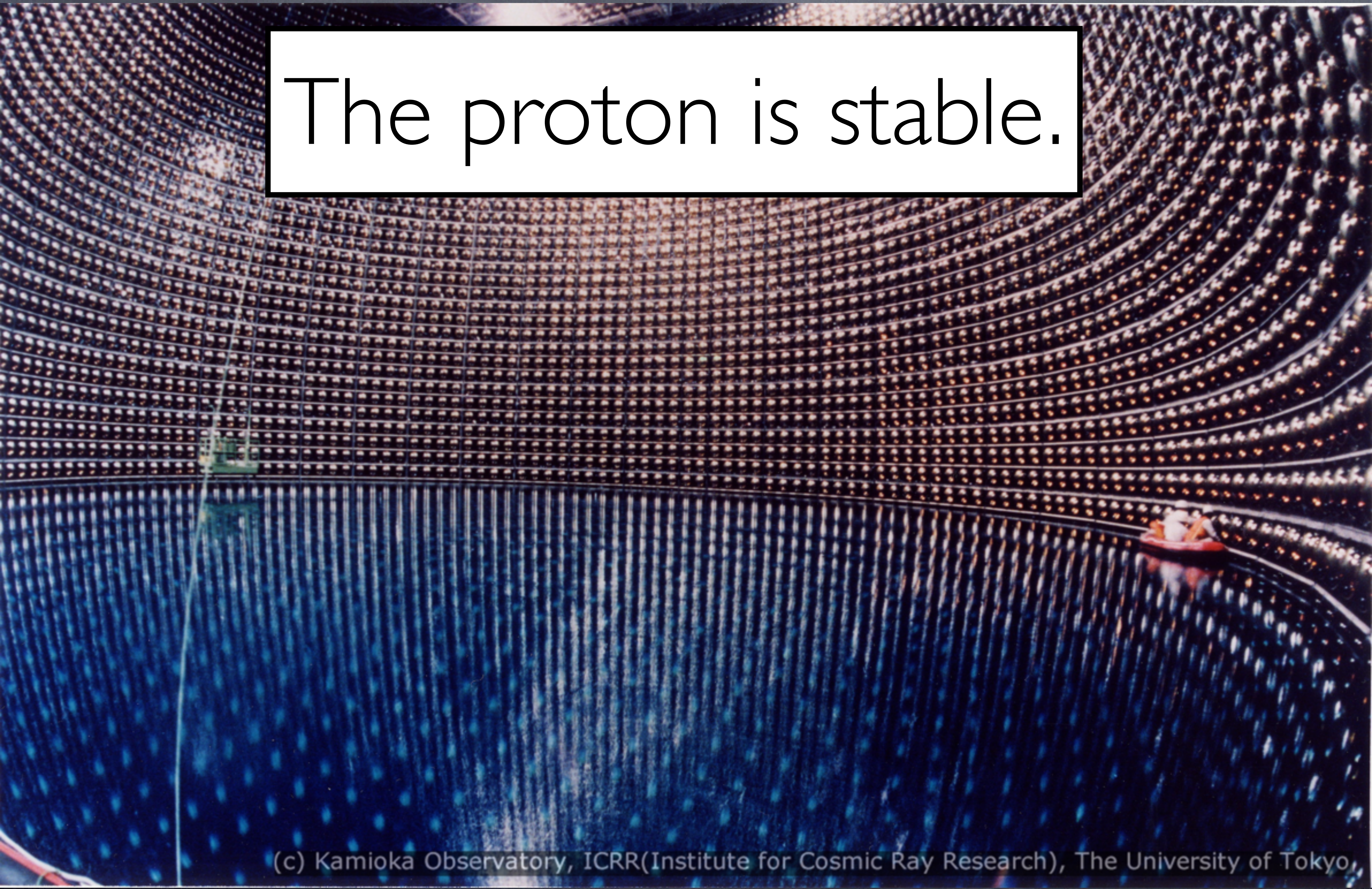

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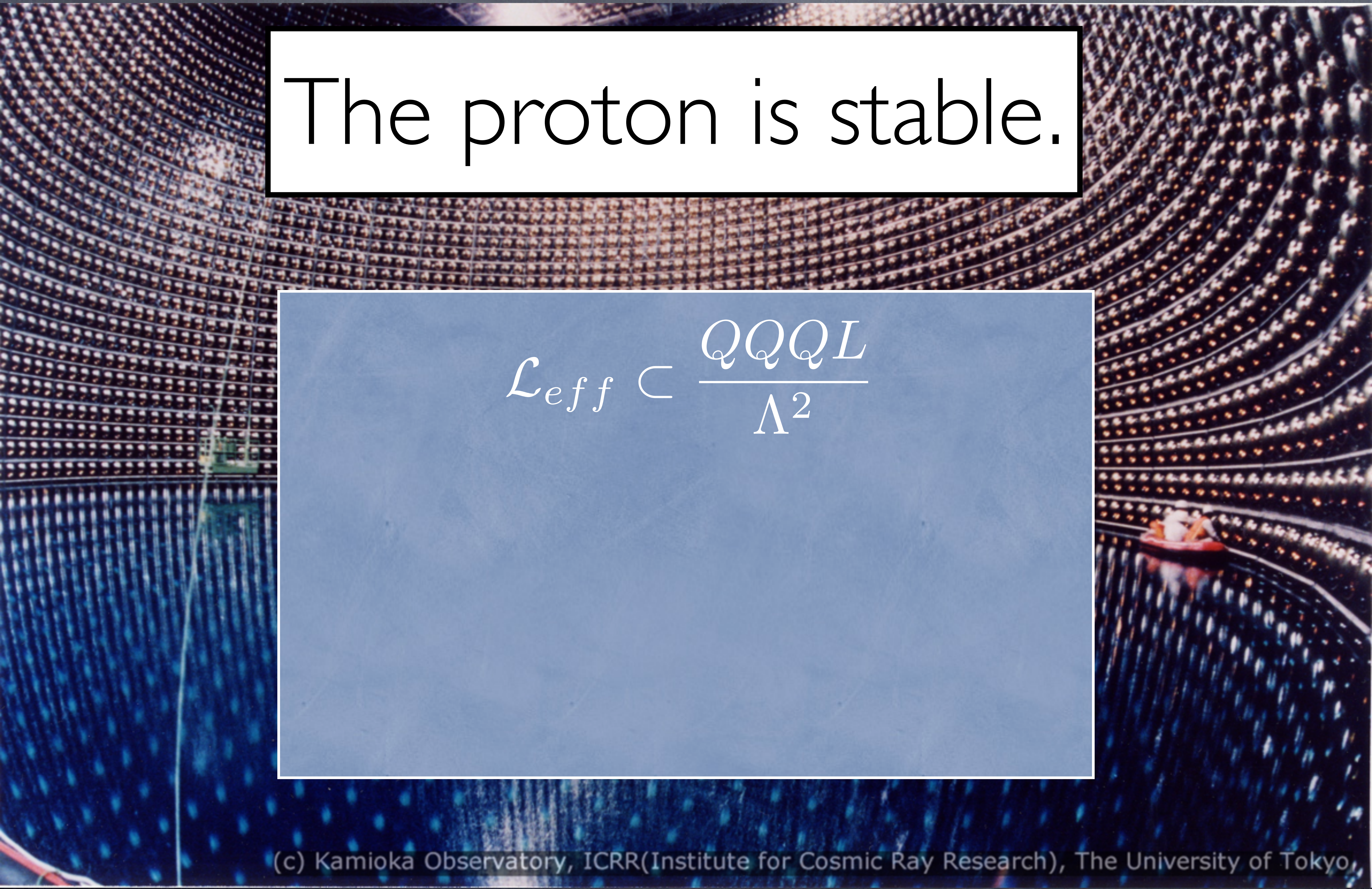

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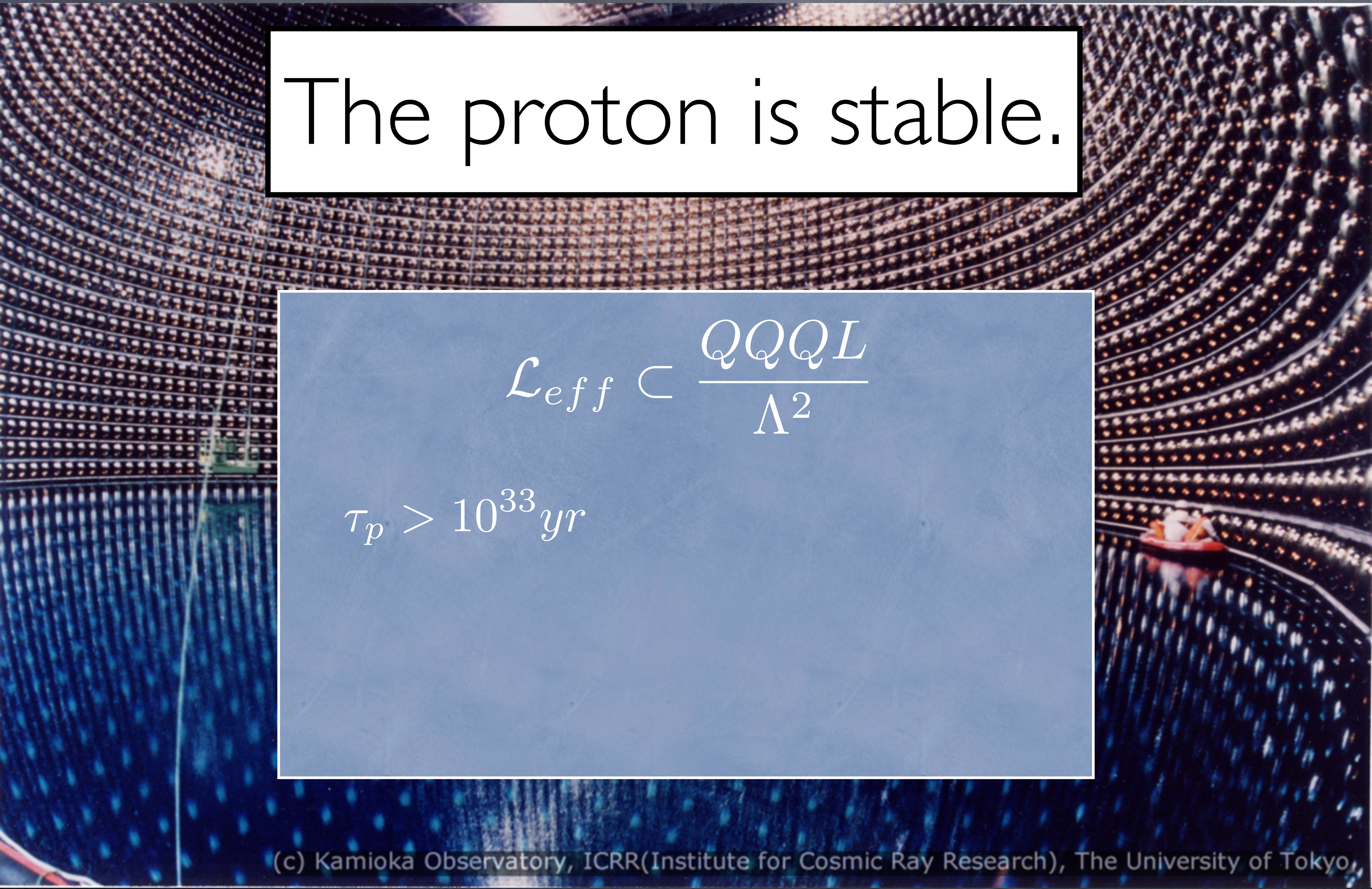

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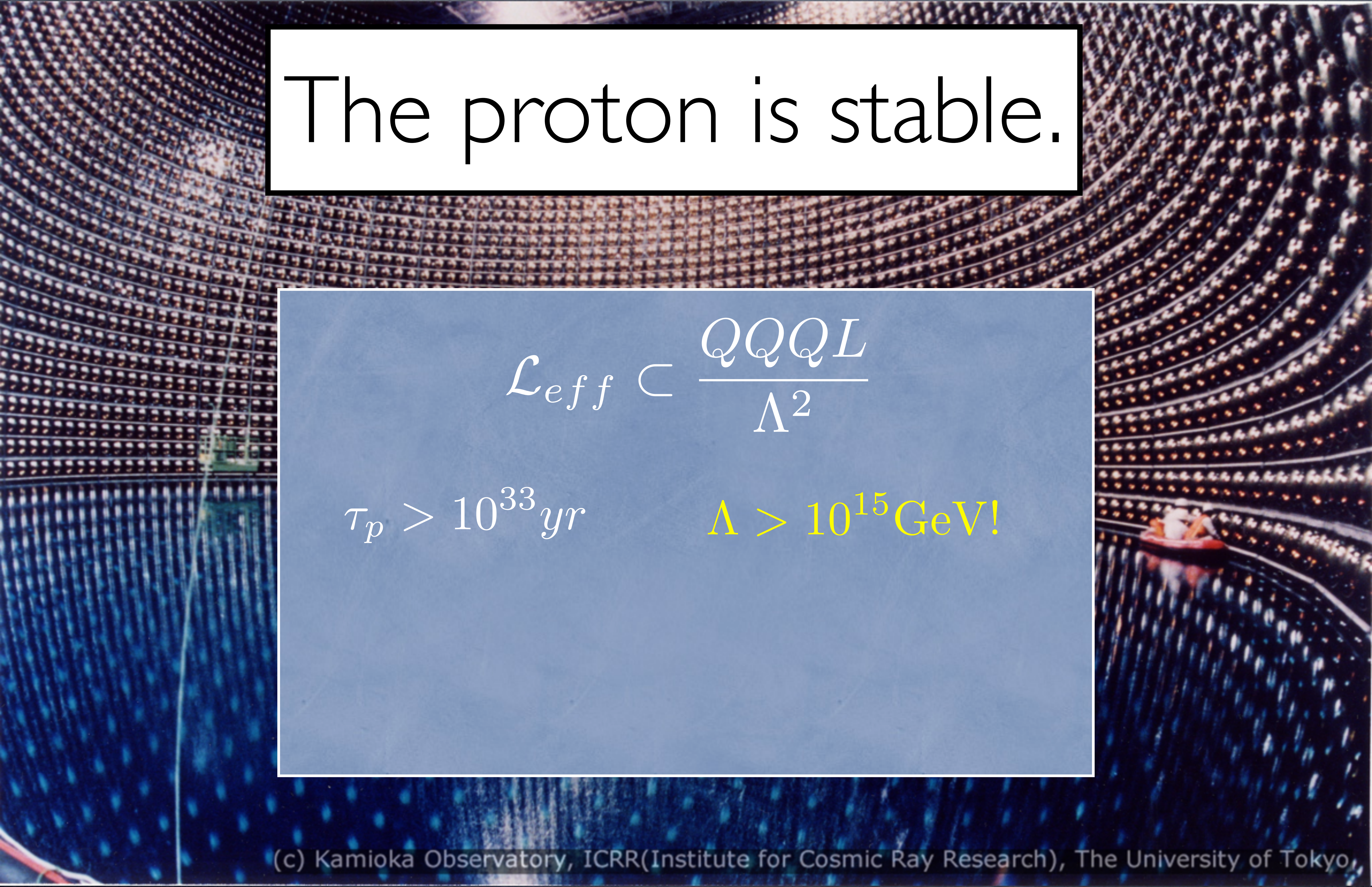

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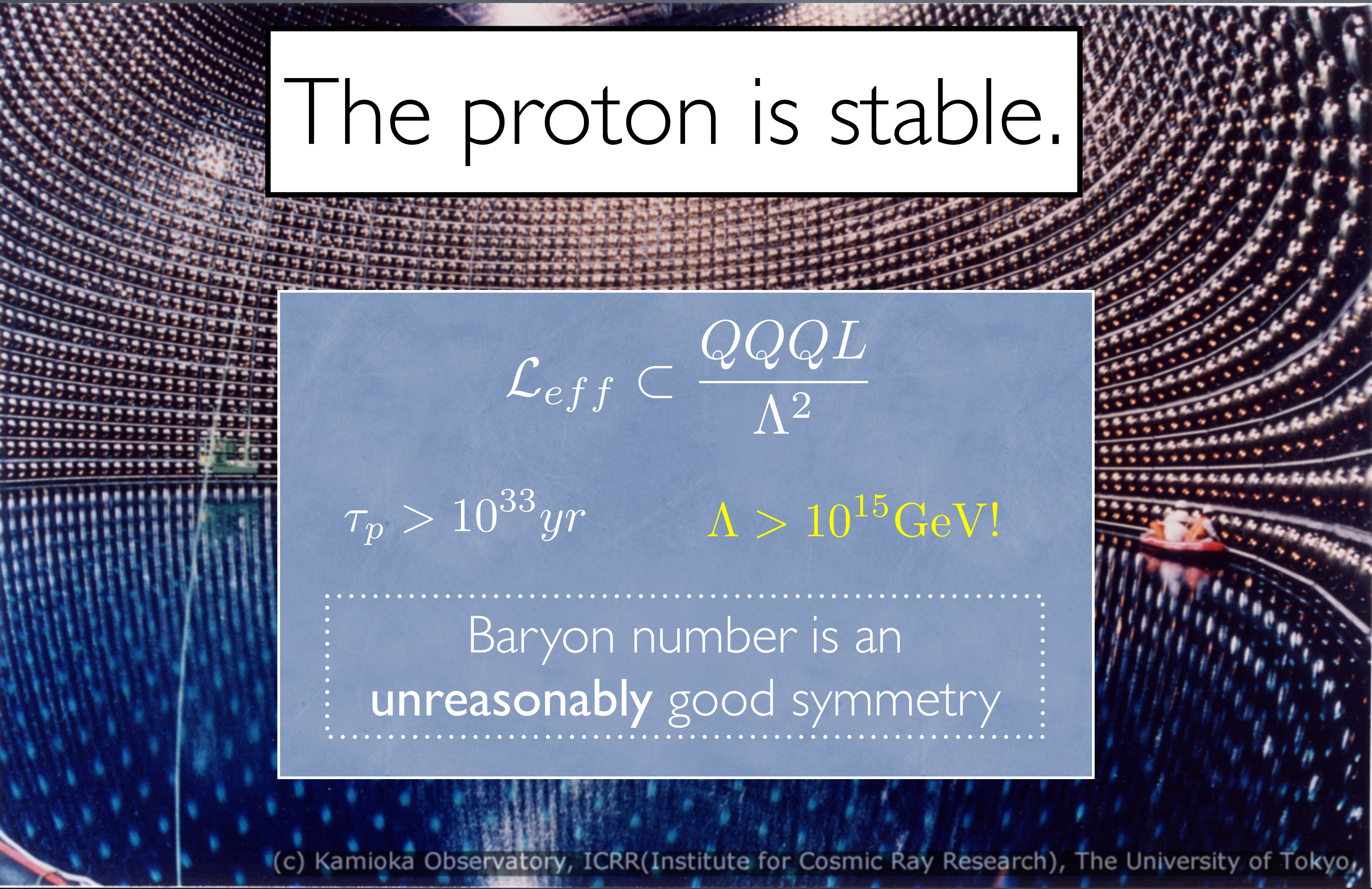
Baryon number is an **unreasonably** good symmetry



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- To avoid stable colored particles, introduce new particle X to facilitate their decay.
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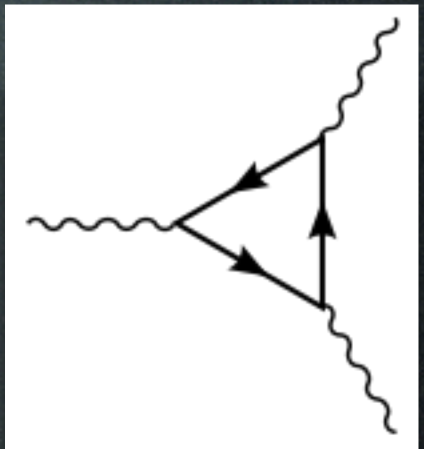
- Baryogenesis *requires* a DM asymmetry.
- Shared gauge interactions with baryons predict novel signatures: monojets and low mass DD.

Gauging baryon number

- Older examples:
  - Carone and Murayama 1994; Bailey and Davidson 1995; Aranda and Carone 1998.
- More recently:
  - Dulaney, Fileviez-Perez and Wise (2010); Buckley, Fileviez-Perez, Hooper, and Neil (2011).

An anomaly-free example



- New chiral states

	$SU(3)_C$	$SU(2)_W$	$U(1)_Y$	$U(1)_B$
Q'_i	3	2	$+\frac{1}{6}$	$-\frac{1}{N}$
u'_{ci}	$\bar{3}$	1	$-\frac{2}{3}$	$+\frac{1}{N}$
d'_{ci}	$\bar{3}$	1	$+\frac{1}{3}$	$+\frac{1}{N}$
L'_i	1	2	$-\frac{1}{2}$	0
ν'_{ci}	1	1	0	0
e'_{ci}	1	1	$+1$	0

N dark generations

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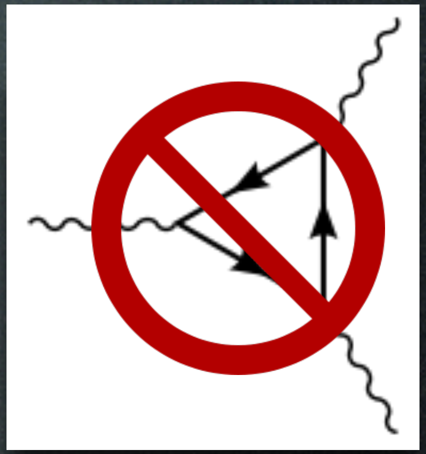

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- Recent work by: Bell, Petraki, IMS, Volkas [1105.3730].

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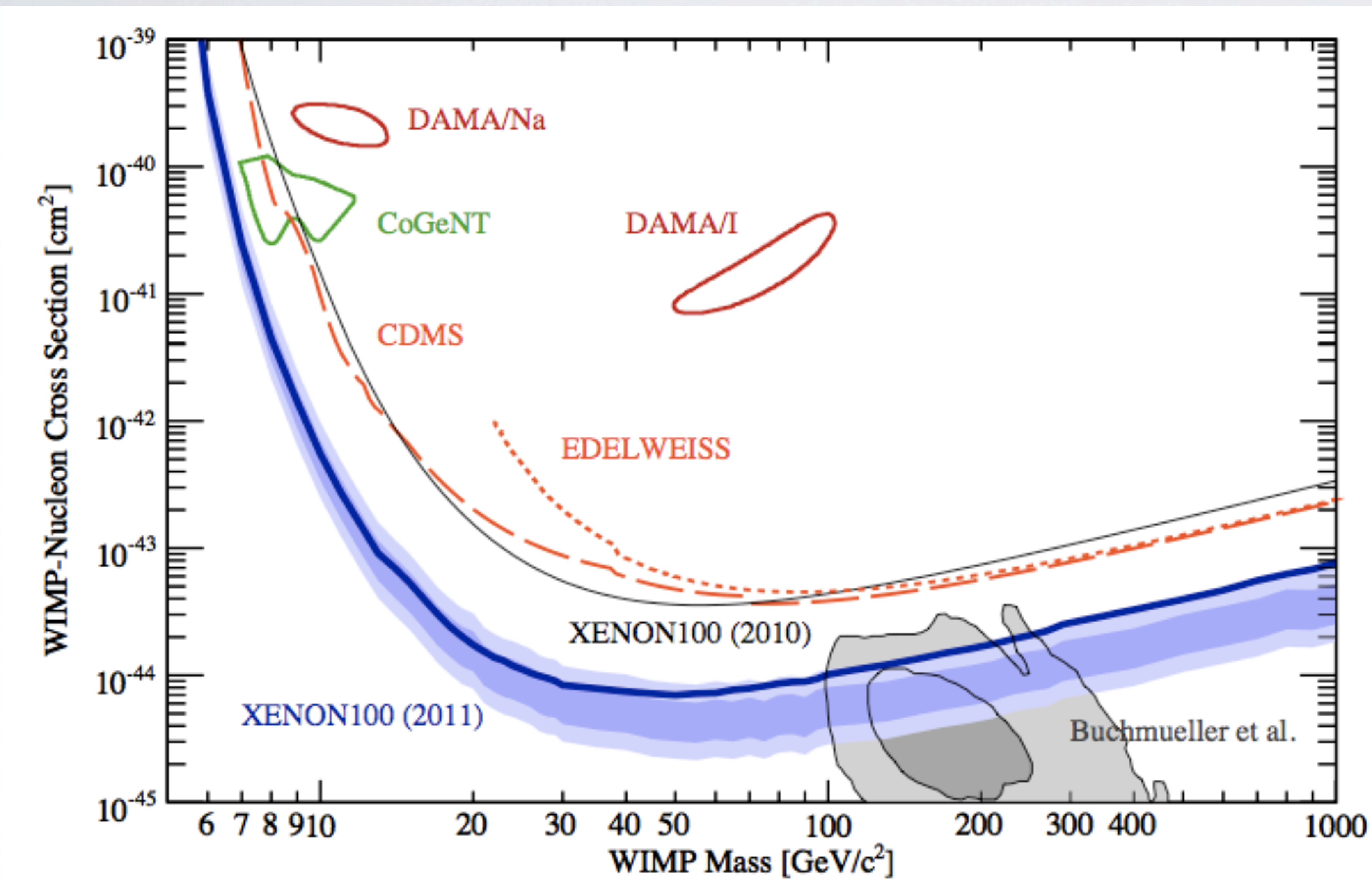

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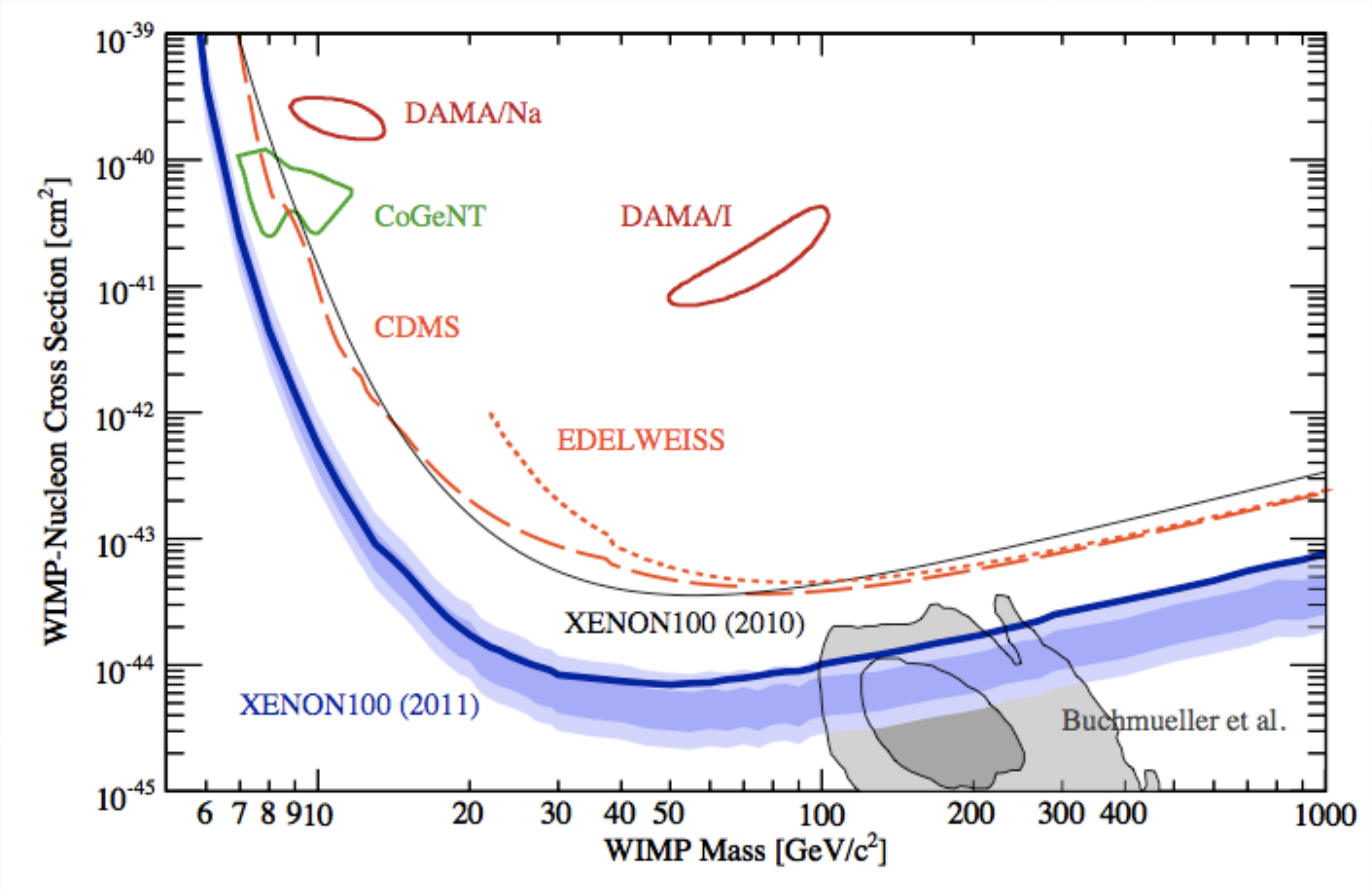

annihilation physics

↕

DM-quark scattering

RECOIL SPECTRUM

$$\frac{dR}{dE_R} = \frac{N_T \rho_\odot}{m_X} \int_{|\vec{v}|>v_{min}} d^3v \; v f(\vec{v}, \vec{v}_\oplus) \frac{d\sigma}{dE_R}$$

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[Lisanti, Strigari, Wacker, Wechsler (2010)]

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[Lisanti, Strigari, Wacker, Wechsler (2010)]

High-velocity tail is important for light DM.

RECOIL SPECTRUM

VECTOR CASE:

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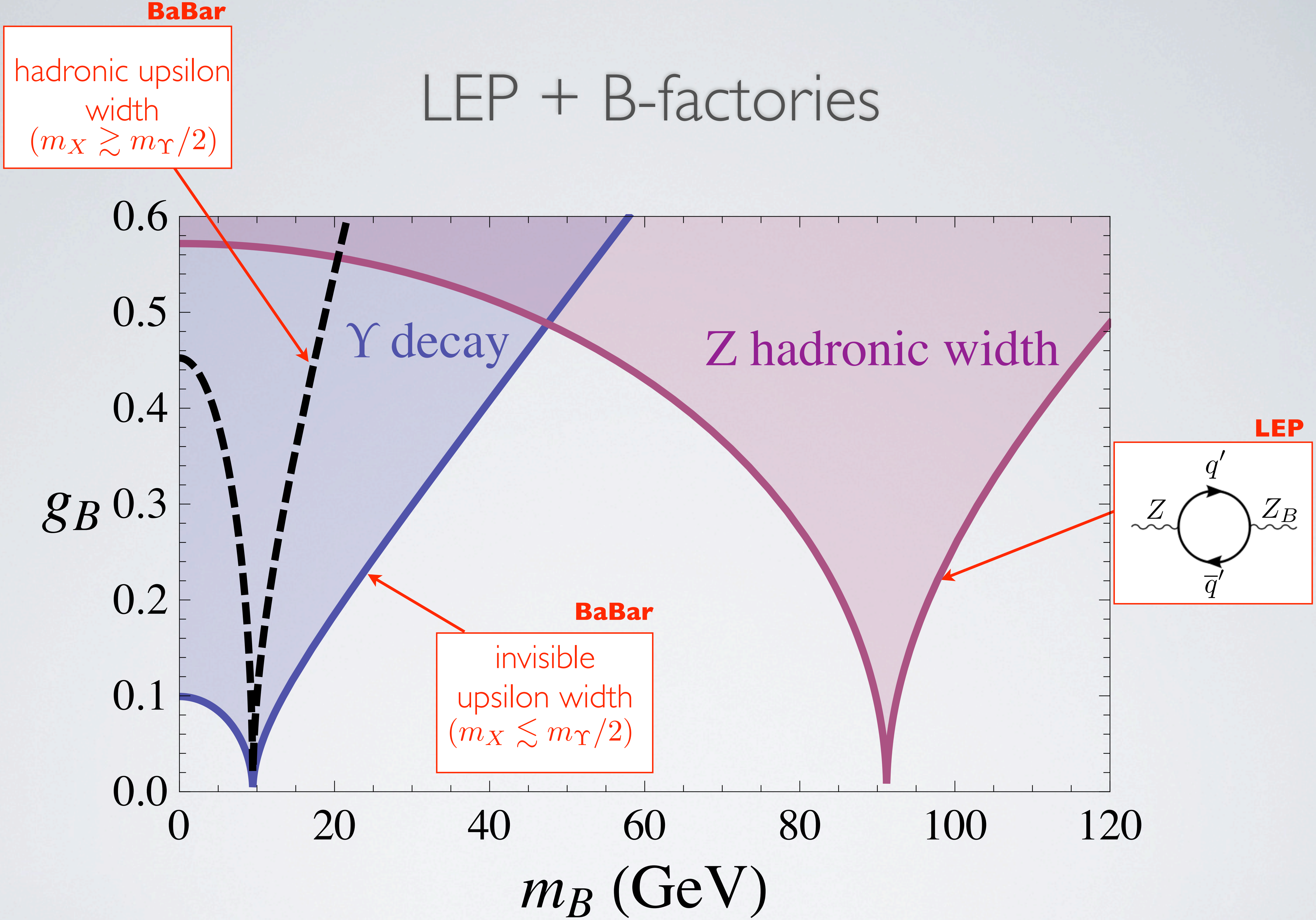
LEP + B-factories



Monojets at the Tevatron

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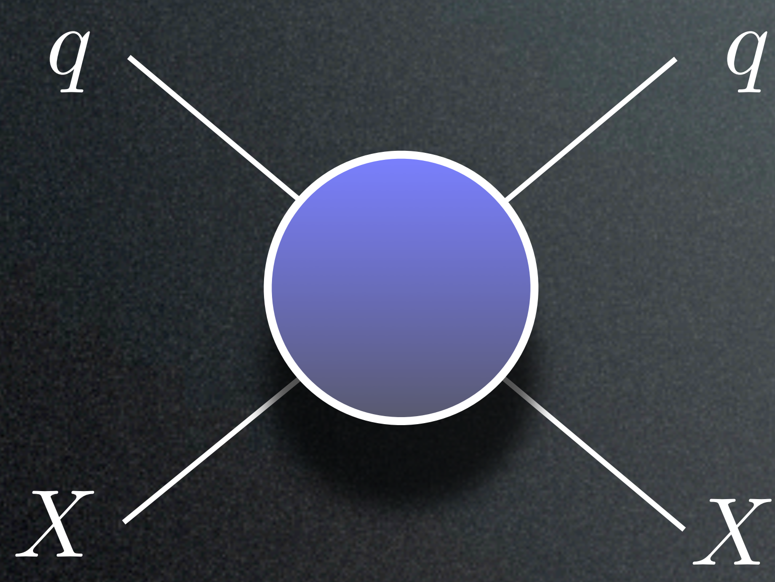

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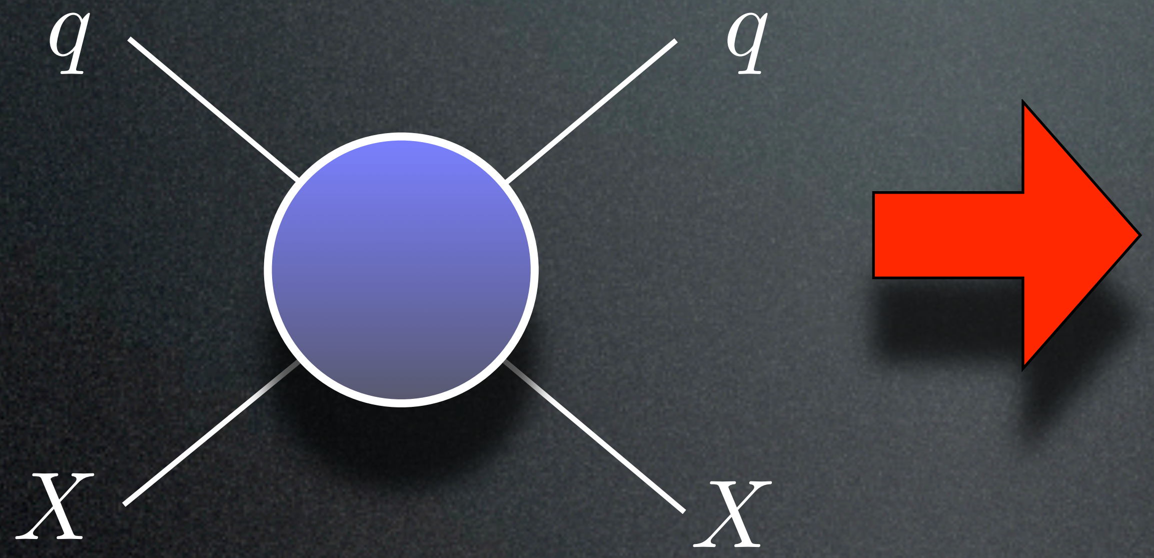

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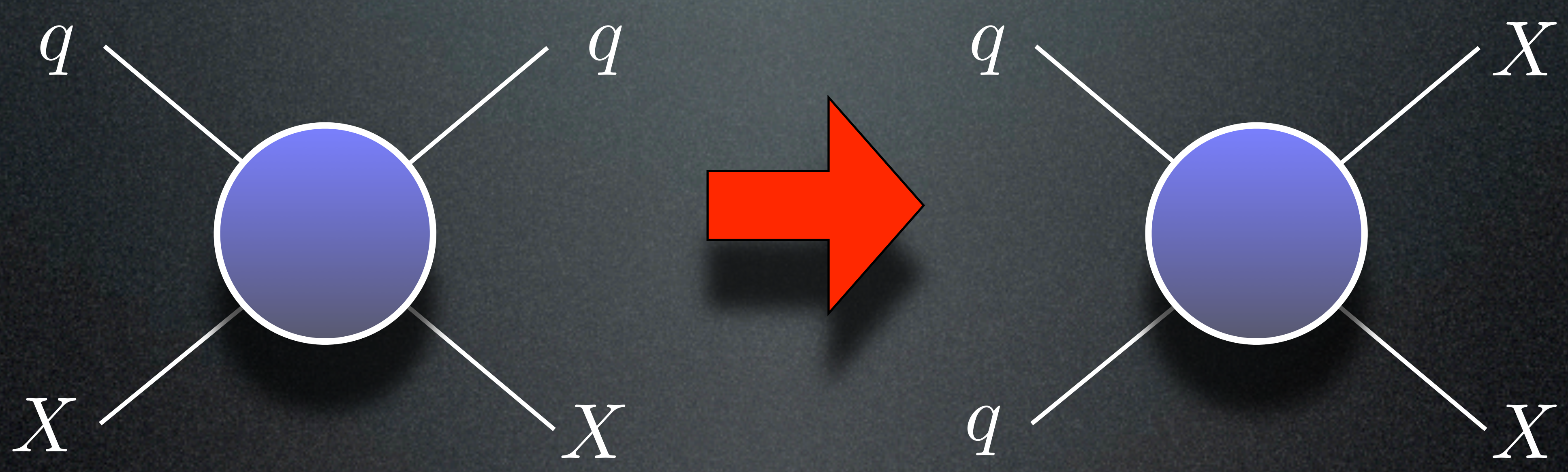

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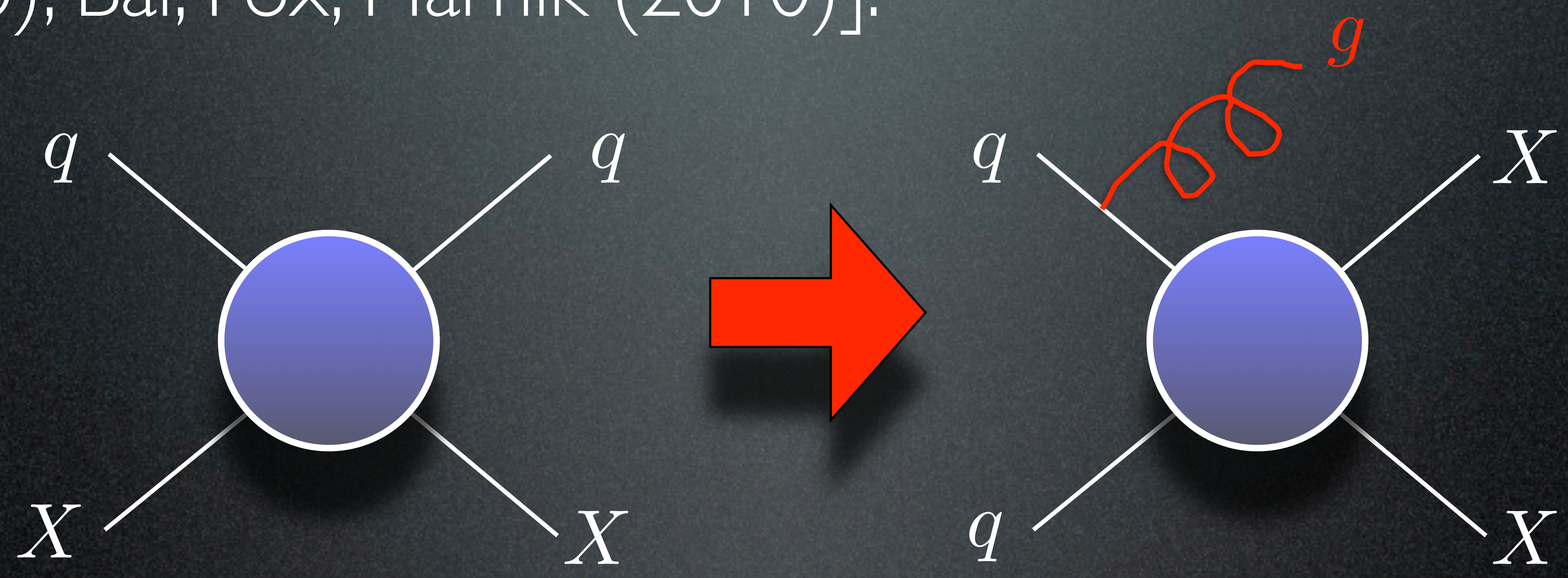

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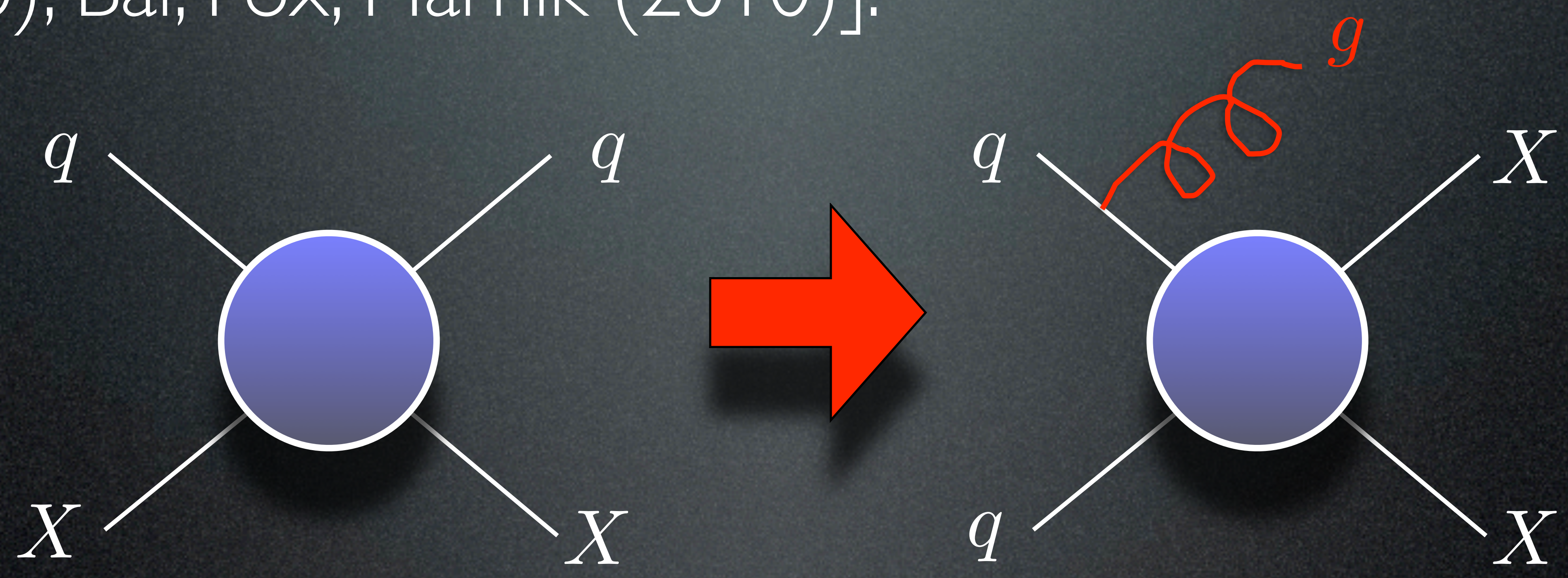

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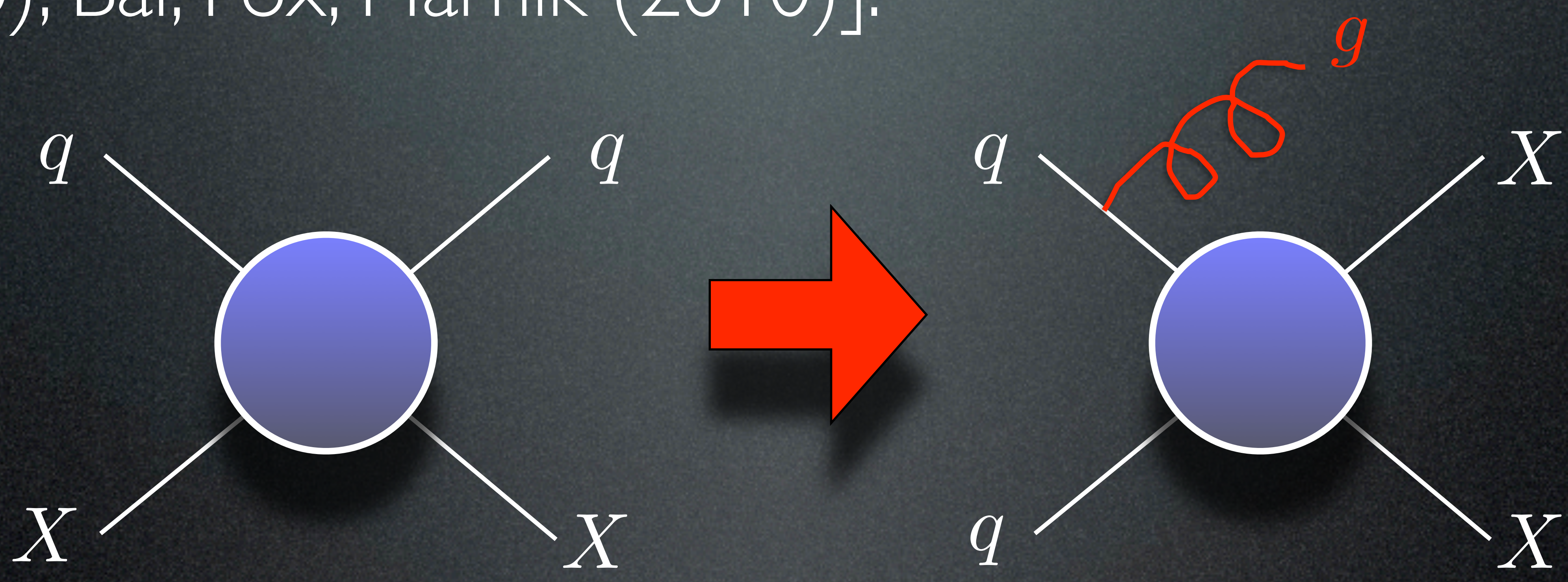

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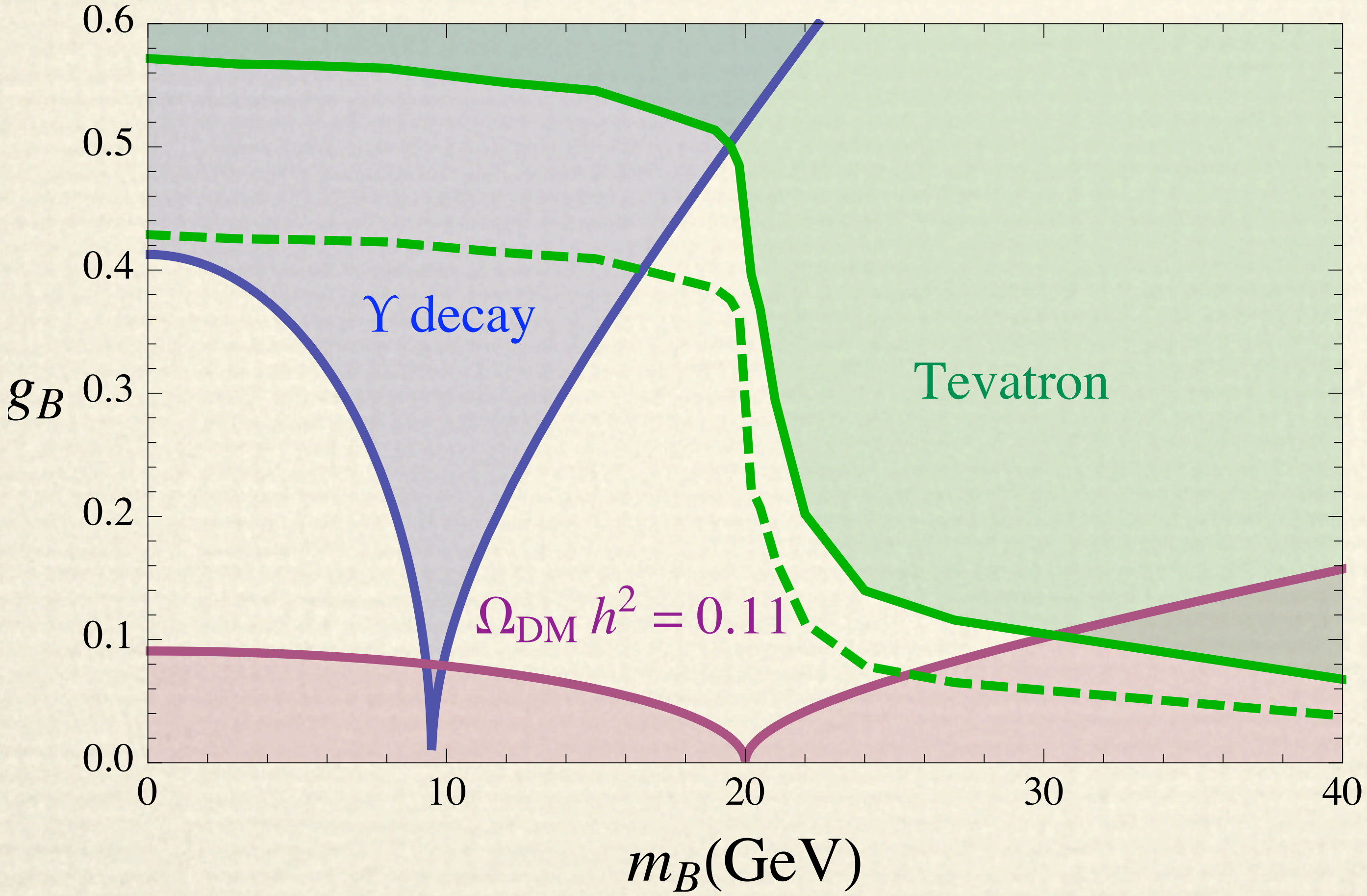
$\boxed{\text{See Luca's talk.}}$

Combined constraints: axial case

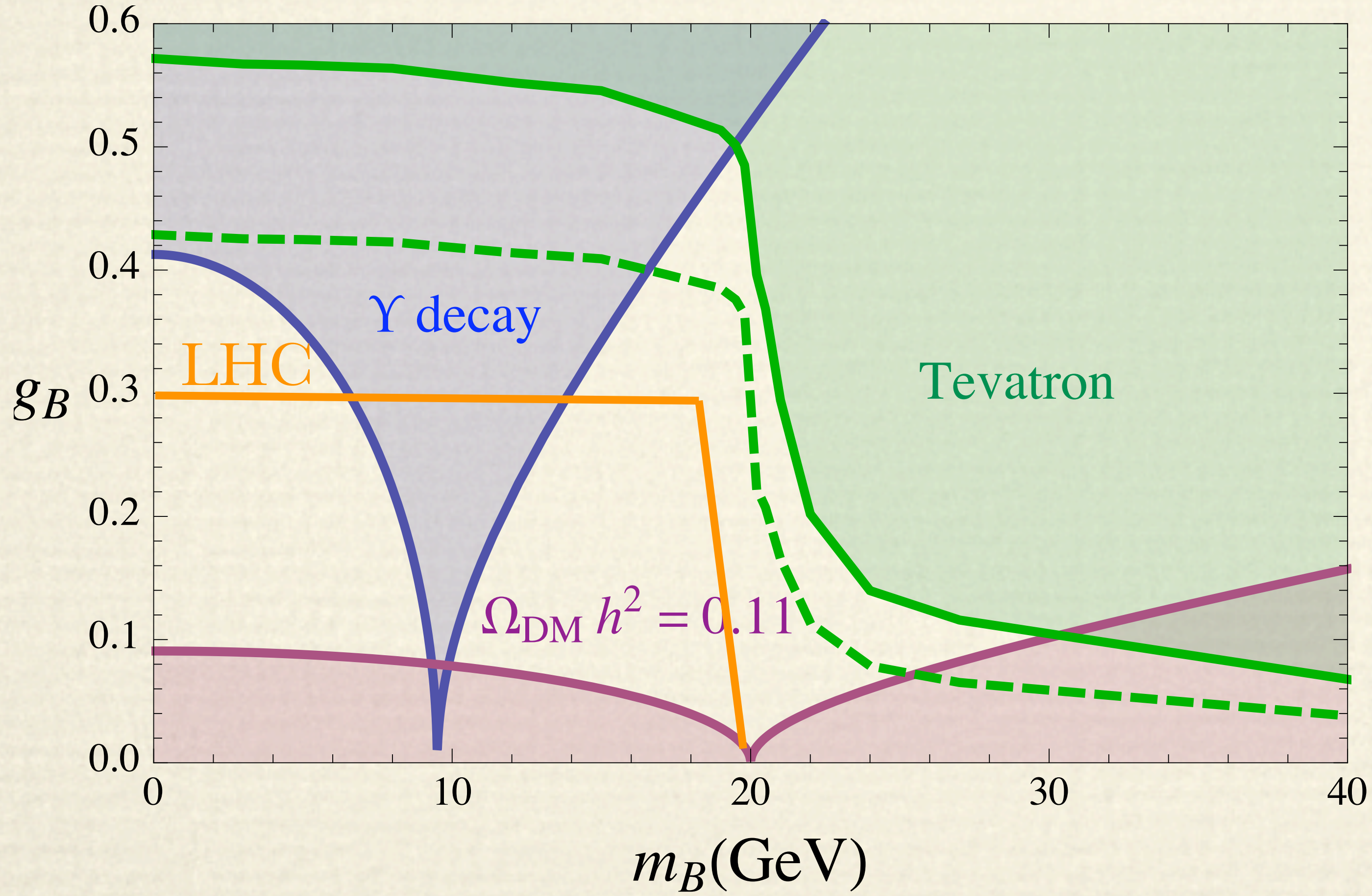
$$D^\mu X = \partial^\mu X + i g_B \left(\cancelto{0}{q_V} + q_A \gamma^5\right) Z_B^\mu X$$



$m_X = 10$ GeV

Combined constraints: axial case

$$D^\mu X = \partial^\mu X + i g_B \left(\cancelto{0}{q_V} + q_A \gamma^5 \right) Z_B^\mu X$$



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CONCLUSIONS

- Gauging baryon number saves the proton + automatic DM candidate charged under baryonic force.
- Simultaneous generation of dark and visible asymmetries.
- Consistent with bounds from B-factories, LEP, mono-jet Tevatron searches, and direct detection for:
    - GeV-scale DM with a GeV-scale mediator.
- LHC and direct detection will probe much of the remaining parameter space.

EXTRAS

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Decay operator ↔ asymmetry transfer operator