KOTO実験紹介 (2016)

南條　創

2008

that *CP* violation must be the cause of the asymmetry in the universe. It contains more matter than antimatter. The *CP* violation that the KM Model gives rise to is most probably not enough to explain this phenomenon. To find the origin of this *CP* violation we probably have to go beyond the Standard Model. Such an extension should exist for other reasons as well. It is believed that at higher energies other sectors of particles, so heavy that the present day accelerators have been unable to create them, will augment the model. It is natural that these particles will also cause *CP* violations and in the tumultuous universe just after the Big Bang these particles could have been created. These particles would have been part of the hot early universe and could have influenced it, by an as yet unknown mechanism, to be dominated by matter. Only future research will tell us if this picture is correct.

CP非保存確立したが、
物質優勢宇宙には不足
→ 高エネルギーにCPを破る粒子

2013

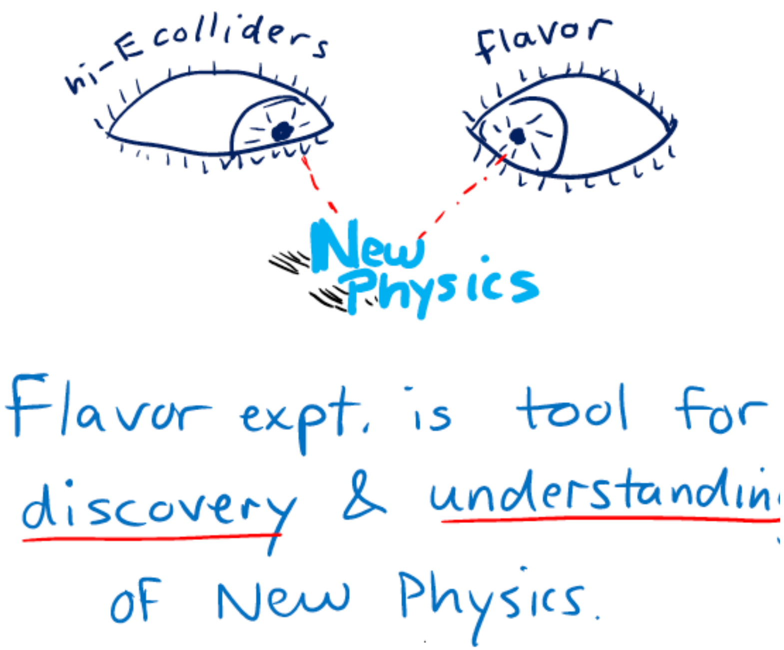
mechanism. The discovery is a milestone for particle physics and a tremendous success for the Standard Model. However, far from closing the book it opens a number of new exciting possibilities: Theorists believe that the SM most probably is but a low-energy approximation of a more complete theory. If this were not so, quantum mechanical corrections to the Higgs mass would drive m_H towards the Planck scale – unless "unnatural" cancellations occur. Therefore, extensions of the SM are proposed, keeping the successful features of the SM but at the same time introducing "new physics" in a way, which stabilises m_H at its low value, which is in accordance with SM expectations (fig. 1). Supersymmetric extensions of the SM predict in their minimal form the existence of five Higgs bosons, three neutral and two charged. The lightest of the neutrals should have couplings similar to the SM Higgs and a mass below 130 GeV/c^2. An alternative is "Little Higgs" models where new strong interactions are introduced at the scale (of tens) of TeV. The lightest scalar in these models also resembles the SM Higgs. In yet other

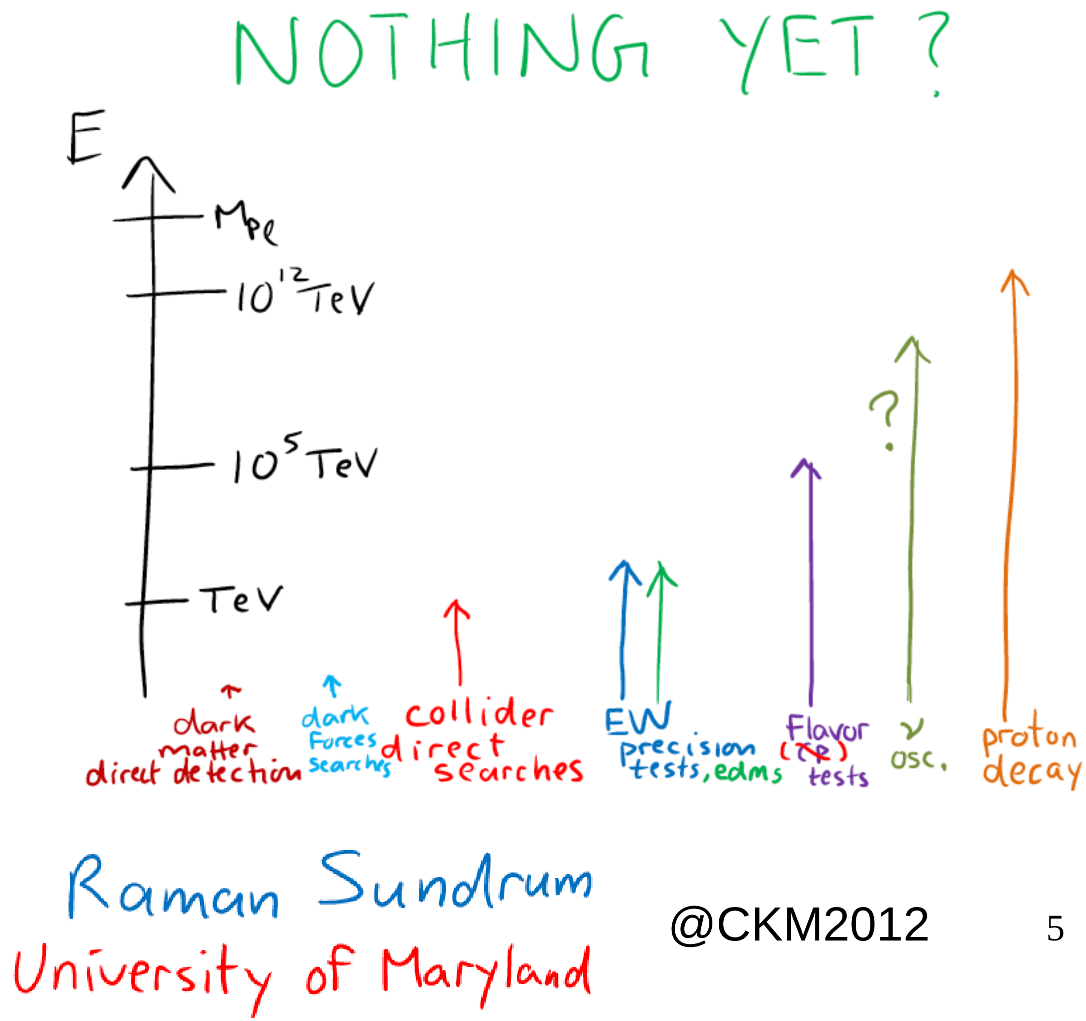
Higgs発見した → Far from closing the book.
高エネルギーにNew Physicsがあるはず。
SUSY, little Higgs, Composite, Extra Dimension,...
Dark matter?

高エネルギーへのアプローチ

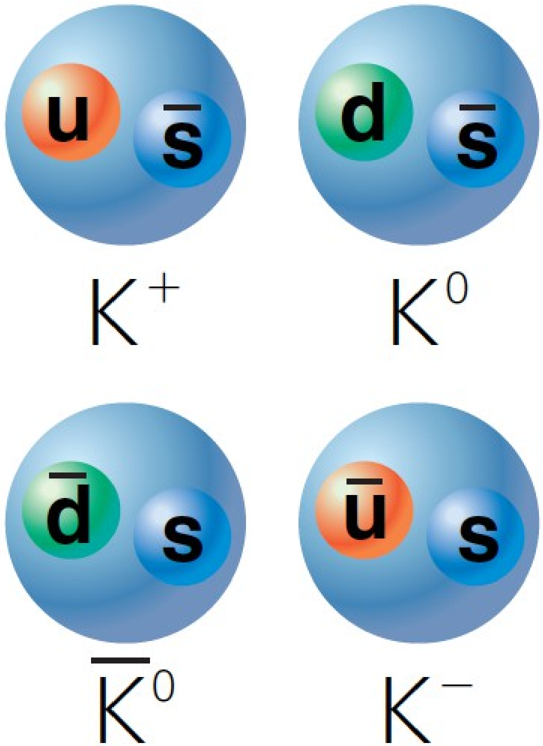
- 直接加速器で粒子を衝突 : High Energy Frontier
- 不確定性原理 : High Intensity Frontier
  - $\Delta E * \Delta t \sim h$
  - 短時間の事象(稀事象) → 高いエネルギースケール
  - 当然標準理論からの寄与 → 強く抑制

- 理論屋さんのスライドから





Kaon



$$K_S \sim \left(\left|K^0\right\rangle + \left|\overline{K^0}\right\rangle\right)/\sqrt{2}$$

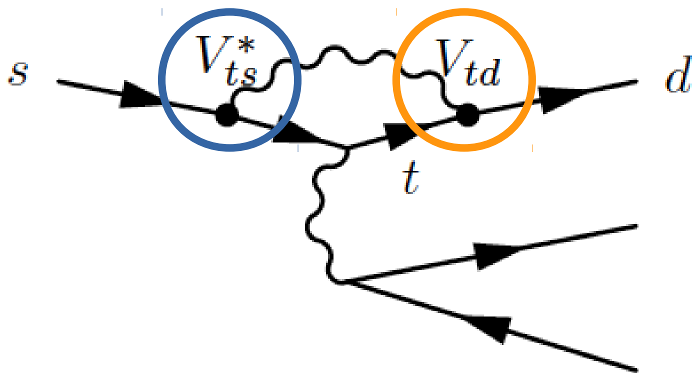
τ~90ps

$$K_L \sim \left(\left|K^0\right\rangle - \left|\overline{K^0}\right\rangle\right)/\sqrt{2}$$

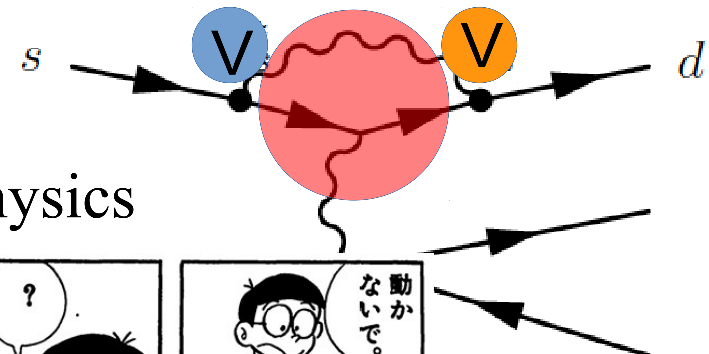
τ~50ns

Blanke '13

Generally Most Powerful!



+ New Physics



$\lambda \sim 0.23$

$$\begin{array}{c} \\ u \\ c \\ t \\ \end{array} \begin{pmatrix} 1 & \lambda & \lambda^3 \\ -\lambda & 1 & \lambda^2 \\ \lambda^3 & -\lambda^2 & 1 \end{pmatrix}$$

d s b

Potential to explore O(100) TeV

×~100

$$\underbrace{|V_{ts}^* V_{td}|}_{K\text{ system}} \sim 5 \cdot 10^{-4} \ll \underbrace{|V_{tb}^* V_{td}|}_{B_d\text{ system}} \sim 10^{-2} < \underbrace{|V_{tb}^* V_{ts}|}_{B_s\text{ system}} \sim 4 \cdot 10^{-2},$$

Origin of CKM = Higgs Yukawa

$$L_Y = -\frac{v}{\sqrt{2}}\left\{\overline{d'_L} Y_d d'_R + \overline{u'_L} Y_u u'_R + h.c.\right\}$$

After Higgs condensation

$$M_d : \text{mass matrix}$$

$$L_Y = \overline{d'_L} M_d d'_R + \overline{u'_L} M_u u'_R + h.c.$$

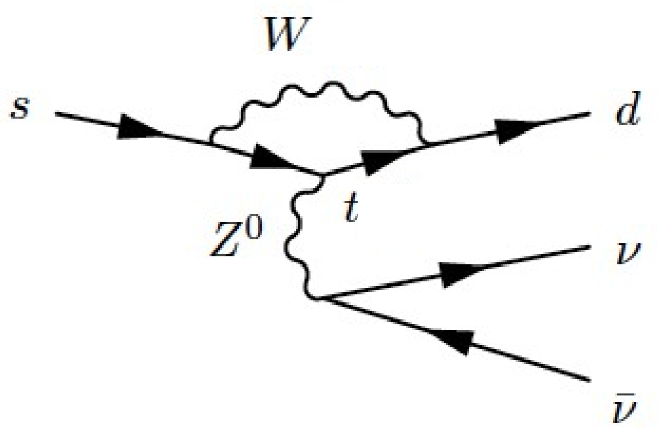
Flavor eigenstate

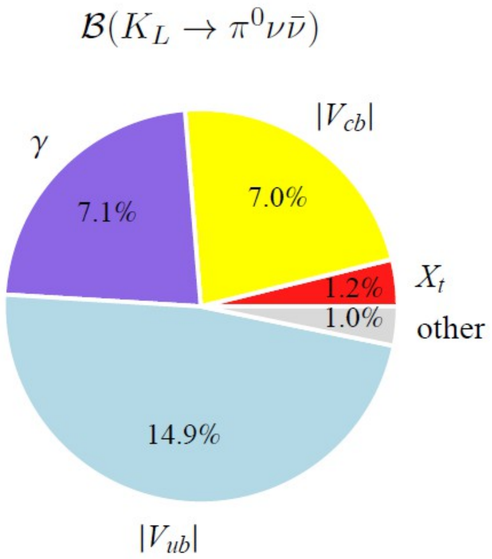
この対角化を繋ぐのがCKM
→ New Physicsでは？

$$(\overline{d_L}, \overline{s_L}, \overline{b_L}) \begin{pmatrix} m_d & & \\ & m_s & \\ & & m_b \end{pmatrix} \begin{pmatrix} d_R \\ s_R \\ b_R \end{pmatrix}$$

Mass eigenstate

$K_L \to \pi^0 \nu \nu$





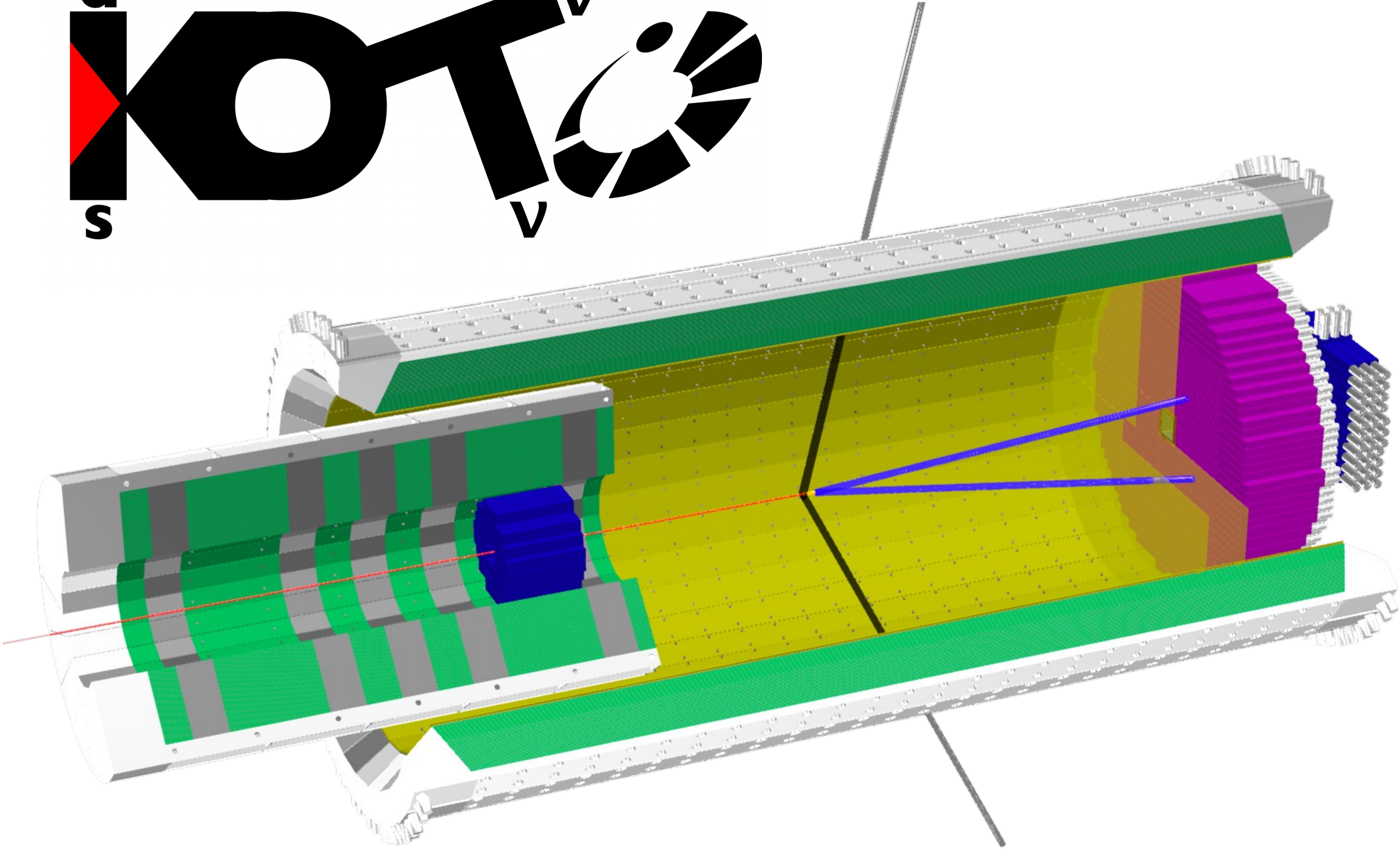
- Rare
- Accurate ~2%
- CP violation

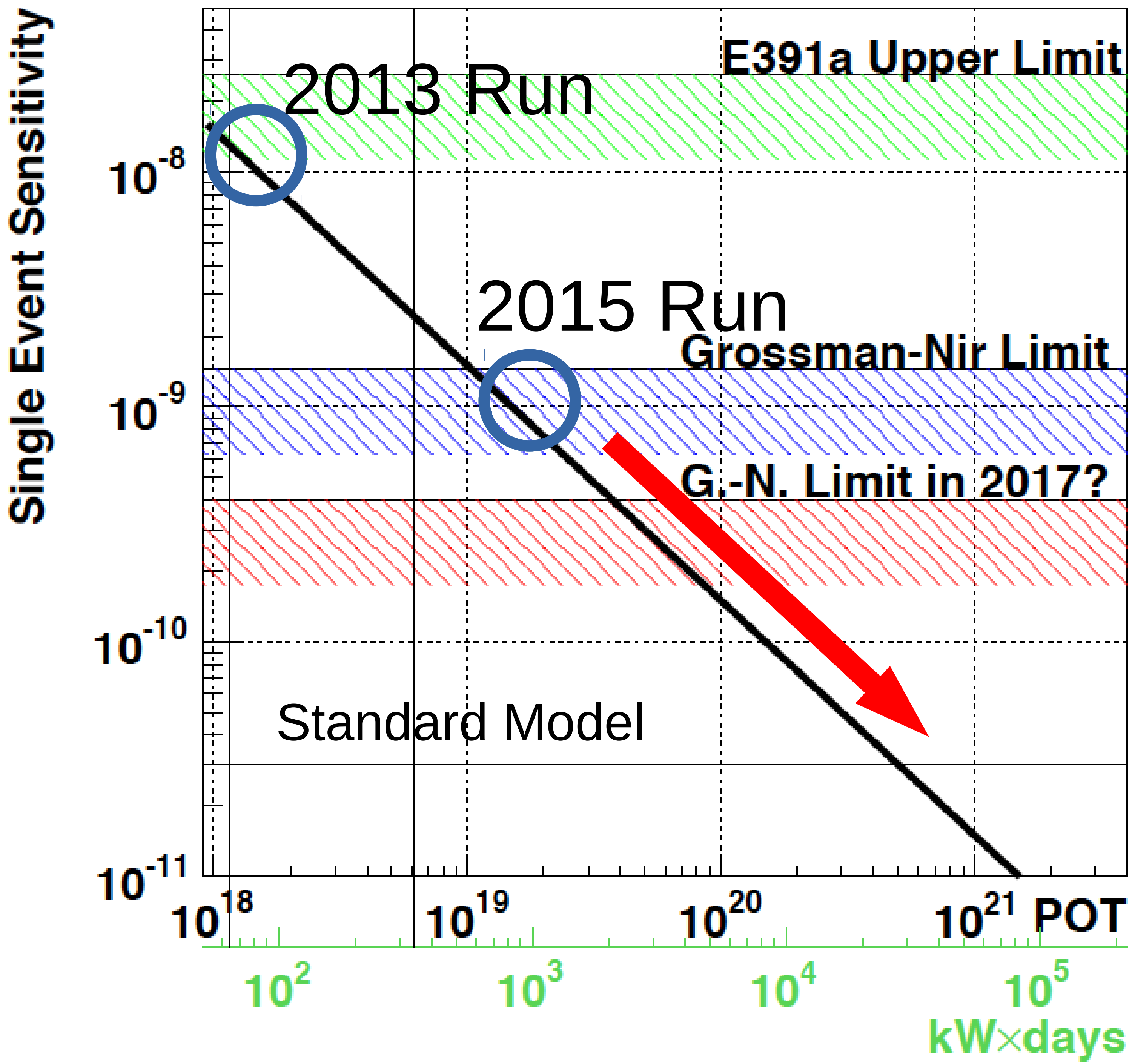
$$Br(\mathrm{SM}) = (3.00 \pm 0.30) \times 10^{-11}$$

Buras '15

$$\mathcal{A}(K_L) \propto \mathcal{A}(K^0) - \mathcal{A}(\overline{K_0}) \propto \mathrm{Im}(\mathcal{A}_{s \to d})$$

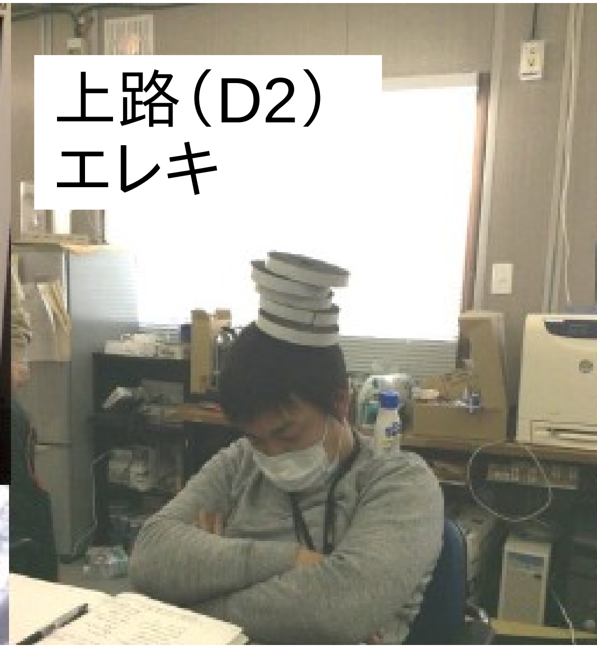
Direct limit : $Br(K_L) < 2.6 \times 10^{-8} (90\% C.L.)$



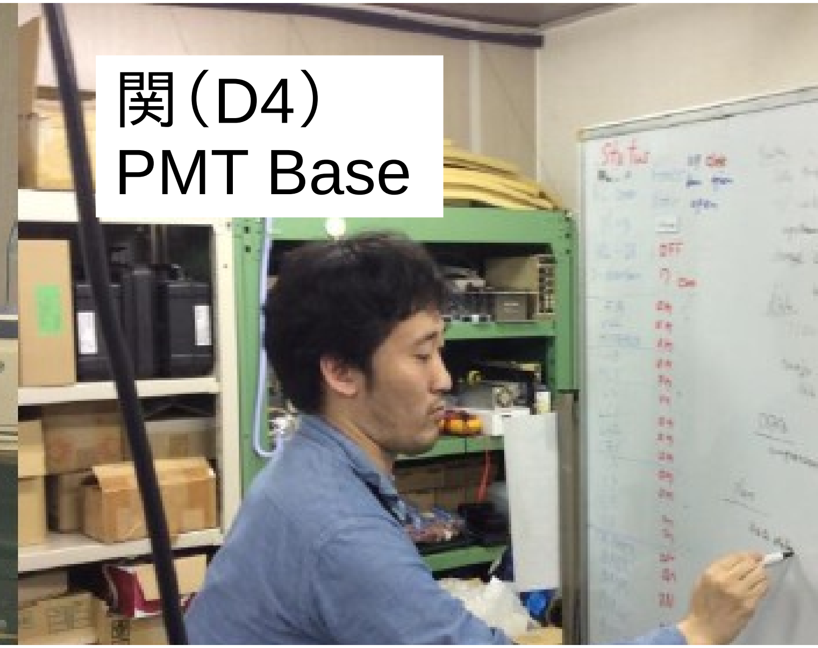

Single Event Sensitivity
E391a Upper Limit
2013 Run
2015 Run
Grossman-Nir Limit
G.-N. Limit in 2017?
Standard Model
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{18}
10^{19}
10^{20}
10^{21} POT
10^{2}
10^{3}
10^{4}
10^{5}
kW×days

KOTOの人々

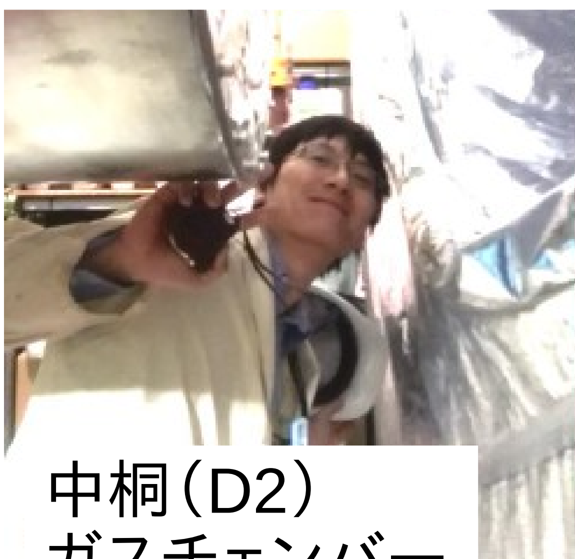
河崎
（教務補佐員）
Pure CsI
波長変換ファイバー



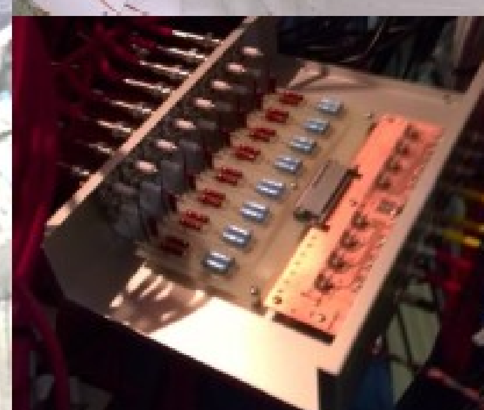
上路（D2）
エレキ



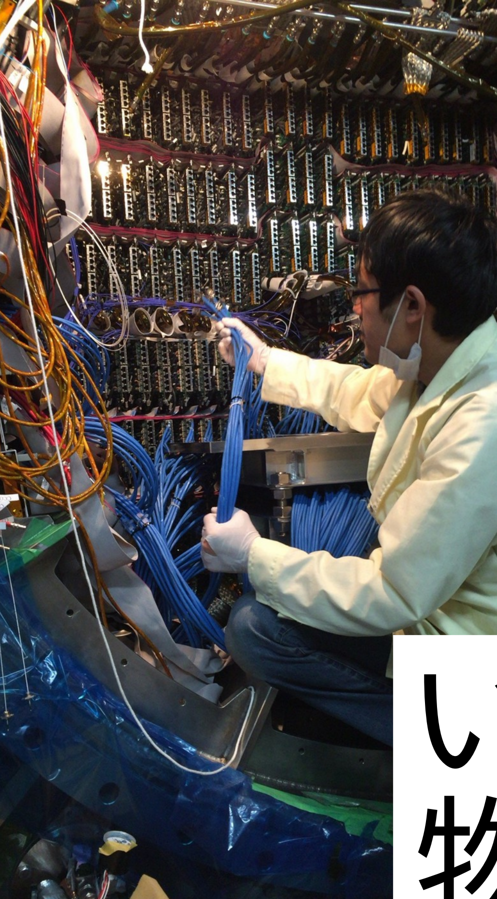
関（D4）
PMT Base



中桐（D2）
ガスチェンバー



篠原（D1）
チェレンコフ



いっしょに研究、物理を楽しみましょう