Flavour Summary of ESPP Symposium, Krakow

Flavour agenda at ESPP

Physics at High Energy Frontier and Flavour Physics

Convener: Y. Kuno, R. Forty (Scientific Secretary)

11:00 **HEF Experiment Results** *35'*

30' + 5' discussion

Speaker: Guenther Dissertori (ETH Zuerich)

Material: **Slides**

no flavour content

11:35 **Flavour and Symmetries; Experiment Results** *35'*

30' + 5' discussion

Speaker: Frederic Teubert (CERN)

Material: **Slides**

high flavour content

12:10 **Charged Lepton Flavor and Symmetry Physics Implications** *25'*

20' + 5' discussion

Speaker: Gino Isidori (Istituto Nazionale Fisica Nucleare)

Material: **Slides**

high flavour content

(both, cLFV and quark flavour)

12:35 - 14:00 Lunch

Convener: K. Desch, M. Diemoz, A. Lister (Scientific Secretary)

14:00 **Implications on Possible New Physics from Direct and Indirect Measurements** *35'*

Speaker: Christophe Grojean (CERN)

Material: **Slides**

no flavour content

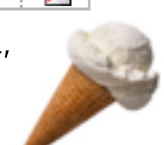
14:35 **Next Step Facilities** *40'*

Speaker: Terry Wyatt (University of Manchester)

Material: **Slides**

low flavour content (ran out of time)

15:15 **Discussion** *1h15'*



small (but positive) flavour content

Discussions were dominated by: what does the Higgs (like) discovery mean for the next collider?

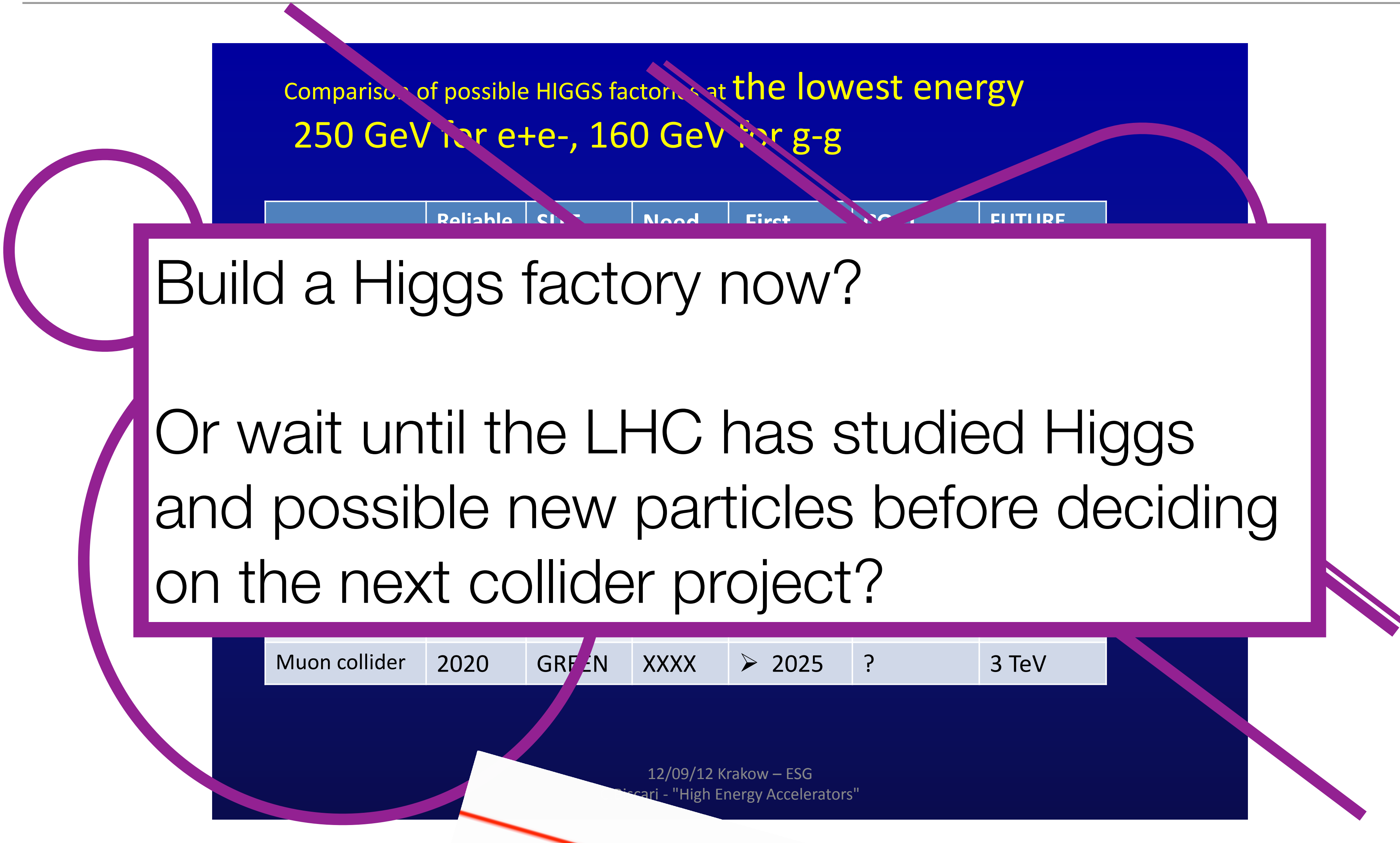
Comparison of possible HIGGS factories at the lowest energy

250 GeV for e+e-, 160 GeV for g-g

	Reliable Technol - TESTS	SITE Ready	Need of R&D	First HIGGS Boson (today T0)	COST Within 50% conf. level	FUTURE energy UPGRADE
ILC	2012	Japan?	X	2020	5	1 TeV
CLIC - klystrons	2014	GREEN	XX	2022	5	3 TeV
LEP3	2012	➢ 2020	X	2024	2	250 GeV
SuperTRISTAN	2012	GREEN	X	2022	3	500 GeV
SAPPHIRE	2016	➢ 2016	XXX	2022	?	160 GeV
New $\gamma-\gamma$	2016	GREEN	XXX	>2022	?	160 GeV
Muon collider	2020	GREEN	XXXX	➢ 2025	?	3 TeV

12/09/12 Krakow – ESG
…cari - "High Energy Accelerators"

Discussions were dominated by: what does the Higgs (like) discovery mean for the next collider?



Build a Higgs factory now?

Or wait until the LHC has studied Higgs and possible new particles before deciding on the next collider project?

One suggestion made some waves:

ILC Plan in Japan

- Japanese HEP community proposes to host ILC based on the "staging scenario" to the Japanese Government.
  - ILC starts as a 250GeV Higgs factory, and will evolve to a 500GeV machine.
  - Technical extendability to 1TeV is to be preserved.
- It is assumed that one half of the cost of the 500GeV machine is to be covered by Japanese Government. However, the share has to be referred to inter-governmental negotiation.

Higgs factory / ILC

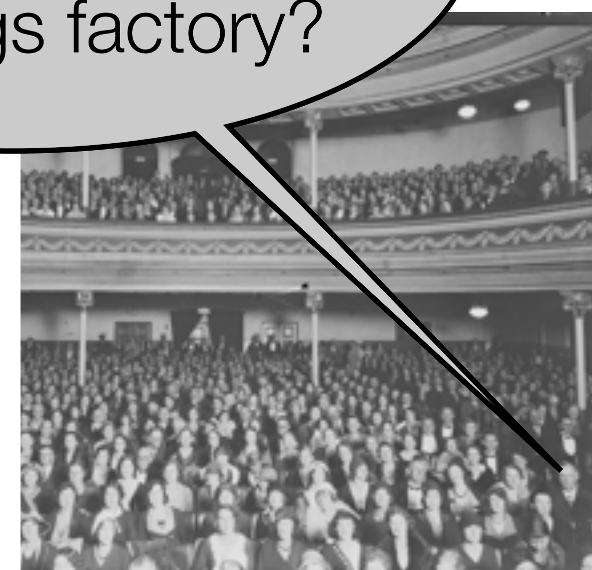
Answers to Tatsuya's questions

Concerning the Japanese LC initiative

- What is the baseline scope?
  - ✓ – Fast realisation of starting with ~250 GeV?
  - Up to t-$\bar{t}$ from the beginning?
  - ✓ – Already 500 GeV from the beginning?
    (NB: LHC was approved to start with less number of magn…
- What is the baseline framework?
  - ✓ – Full global project: 50% host 50% elsewhere including cas… contribution?
  - Full global project with larger host country contribution?
  - A la HERA & LHC, i.e. very strong host laboratory with some "work packages" contributions? (KEK as the host laboratory?)
- What is the baseline for timescale?
  - ✓ – data taking starts ~~≤2025~~ < 2030 (significant overlap with LHC)?
  - data taking starts ≥2030 (no real overlap with LHC)?

T. Nakada Japanese LC Discussion at KEK, Tsukuba, 19 July 2012 European Strategy

Would Japan put up the full cost for the 250 GeV Higgs factory?



What has Higgs factory got to do with flavour?

- As flavour physicists, we should be delighted to get some help with, and a lot of enthusiasm for, the precise investigation of Higgs Yukawa couplings.

..where all the "problems" are hidden in the Higgs potential:

Gino Isidori

$$V(\phi) = - \mu^2 \phi^+\phi + \lambda (\phi^+\phi)^2 + Y^{ij} \psi_L{}^i \psi_R{}^j \phi + \frac{g^{ij}}{\Lambda} \psi_L{}^i \psi_L{}^{Tj} \phi \phi^T$$

- Both approaches investigate these terms. Off-diagonal Yukawa couplings are responsible for flavour changes. Higgs factory measures the rest.

- Full set of measurements clearly essential for our understanding of the SM and, even more importantly, highly sensitive to physics beyond the SM - the common main target. Both approaches share the need for very high precision to maximise BSM sensitivity.

Complementarity between precision flavour and direct searches

Indirect Searches for NP

Frederic Teubert: Flavour & symmetries, experimental results

If the **energy** of the particle collisions is high enough, we can discover NP detecting the production of "real" new particles.

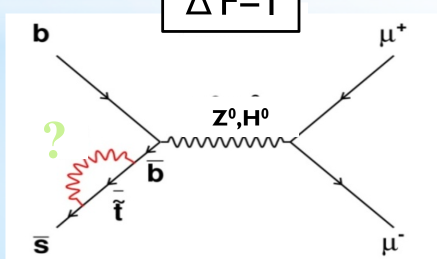
If the **precision** of the measurements is high enough, we can discover NP due to the effect of "virtual" new particles in loops.

Contrary to what happens in "non-broken" gauge theories like QED or QCD, the effect of **heavy (M>q^2) new particles does not decouple** in weak and Yukawa interactions.

Therefore, precision measurements of FCNC can reveal NP that may be **well above the TeV scale**, or can provide key information on the **couplings and phases** of these new particles if they are visible at the TeV scale.

Direct and indirect searches *are both needed and equally important, complementing each other.*

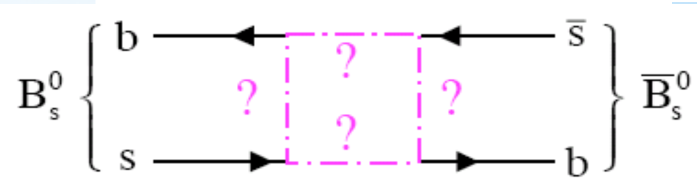
$\Delta F=1$



$B_s \rightarrow \mu^+\mu^-$ Higgs "Penguin"

$\Delta F=2$

$\phi_s \neq \phi_s^{SM} = -\arg(V_{ts}^2)$



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B_s–$\bar{B}_s$ oscillations: "Box" diagram

New Physics

The non-observation of NP in direct searches, as well as the mass of the Higgs, suggest an unexpectedly high mass scale...

New Physics

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Luis Alvarez-Gaume: Theory

It deserves a nice mausoleum...

Naturalness vs Flavour Problem

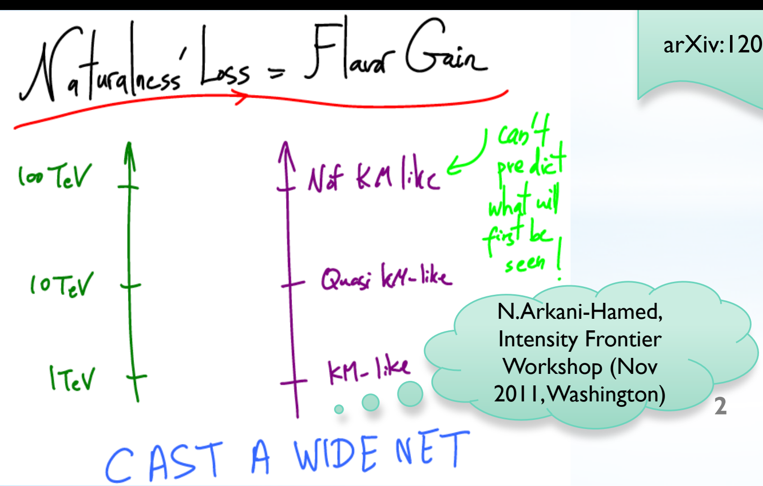
Frederic Teubert:
Flavour & symmetries,
experimental results

Status of Searches for NP

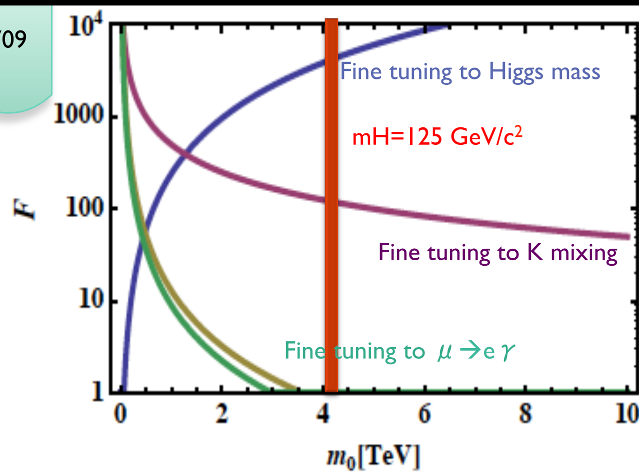
So far, no significant signs for NP from direct searches at LHC while a Higgs-like boson has been found with a mass of ~125 GeV/c^2.

Before LHC, expectations were that *"naturally"* the masses of the new particles would have to be light in order to reduce the *"fine tuning"* of the EW energy scale. However, the absence of NP effects observed in flavour physics implies some level of *"fine tuning"* in the flavour sector → **NP FLAVOUR PROBLEM** → Minimal Flavour Violation (MFV).

As we push the energy scale of NP higher (within MSSM the measured value of the Higgs mass pushes the scale up), the NP FLAVOUR PROBLEM is reduced, hypothesis like MFV look less likely → **chances to see NP in flavour physics have, in fact, increased!**



arXiv:1205.709



Recent experimental results (F. Teubert)

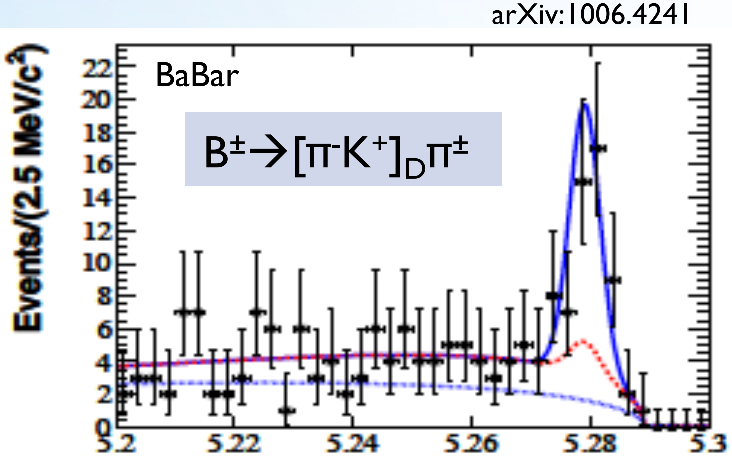
- Recent heavy flavour results dominated by LHCb. Data samples not only large, but also impressively clean, despite challenging environment.

Frederic Teubert: Flavour & symmetries, experimental results

Rule of thumb:*

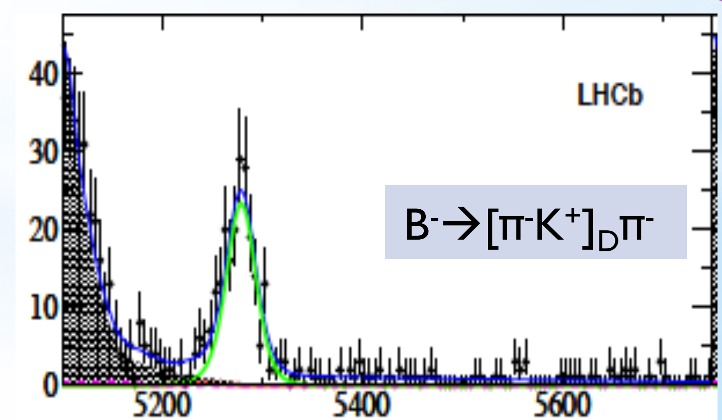
1/fb at 7TeV at LHCb is equivalent to (1-5)/ab at the B-factories before tagging.

arXiv:1006.4241



Energy-substituted mass (GeV/c^2)

arXiv:1203.3662



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Invariant mass (MeV/c^2)

*) Will get twice the heavy flavour x-section at 14 TeV, so this is effectively ca 10% of projected LHCb data (before upgrade)

- However, for channels with neutral/invisible particles in the final state the clean B-factory environment is an advantage.

Flavour Results

Frederic Teubert discusses an impressive set of recent flavour results, including:

- A large number of LHCb results in $B^{\pm}$, B_d, B_s decays, destroying many dreams of new physics esp in the B_s system (for $B_s \to \mu\mu$, also big contribution from CMS).
- B-factories, having completed data taking, continue to produce important results, incl. $B \to \tau\nu$, which is now within ~1.2σ of CKM fit.
- Charm physics, incl CPV (1st evidence at LHCb, confirmed by CDF). NP or SM?
- Precision Kaon physics, incl. 1st results from NA62 (which is under construction!)
- CLFV limits from B-factories (τ), and dedicated $\mu \to e$ experiments (MEG)
- μ, e g-2 and EDM: hint of NP: $\Delta a_\mu = (287 \pm 80) \times 10^{-11}$ (3.6σ) at E821 (Brookhaven), also best limit on $|d_\mu| < 1.9 \times 10^{-19}$ e cm

What next?

Flavour Future

- UK/PPAP input to ESPP: Recommendations on flavour (there is more text in the document):
  - The highest priority is to fully exploit the capabilities of the current LHCb detector so as to maximise its scientific output, especially in probing BSM physics. In addition, investment should be made in the LHCb upgrade to enable full exploitation of the LHC flavour physics potential.
  - Precision experiments in the bottom, charm, kaon, tau and muon sectors that bring complementarity and breadth to the global physics programme should be pursued, along with the associated theoretical work to maximise their impact; global coordination of national- or regional-scale programmes would be desirable.

Flavour Future

- Talk on future facilities talk ran out of time before discussing flavour - the extra time given, concentrated on LHCb upgrade and Super Flavour Factories:

Concluding remarks on heavy flavour

Terry Wyatt:
Next Step Facilities

- LHCb upgrade and next generation B factory physics programmes are largely complementary
  - LHCb dominates most measurements with B_s, b-baryons, decays to final states consisting entirely of charged particles
  - Next generation B factory dominates measurements in final states containing invisible or neutral particles
- Both are likely to make important contributions
- Physics programme of next generation B factories consists largely of refining measurements and searches for rare decays
  - No guarantee of BSM effects – maybe results will be "only" improved limits?
  - Motivation for two facilities (SuperKEKB and Super-B)?
    - C.f. when the first generation B factories were proposed
    - A major new observation was expected (CPV in B^0)
      - Natural to have two experiments to confirm discovery and cross check subsequent measurements

Gino Isidori's top-10 flavour changing measurements

G. Isidori – Symmetry Physics Implications *ESPP Open Symposium* [Cracow, 10-12 Sep. 2011]

Additional material

Top-10 list of key flavor-changing measurements [a (motivated) personal choice]

• $B(\mu \to e\gamma)$	SES $< 10^{-13}$
• $B(\mu N \to eN)$	SES $< 10^{-16}$
• $B(\tau \to \mu\gamma)$	SES $< 10^{-9}$
• $B(B_s \to \mu^+\mu^-)$	$\sigma_{rel} < 5\%$
• ϕ_s	$\sigma < 0.01$
• $B(K^+ \to \pi^+\nu\nu)$ or $B(K_L \to \pi^0\nu\nu)$	$\sigma_{rel} < 5\%$
• $B(B^+ \to l^+\nu)$	$\sigma_{rel} < 5\%$
• $a_{CP}(D \to \pi\pi\gamma)$	$\sigma_{rel} < 0.5\%$
• $\lvert V_{ub}\rvert$	$\sigma_{rel} < 5\%$
• γ_{CKM}	$\sigma < 1^o$

cLFV

B_s

K

B^+

D

B

N.B.: the observables are not listed in order of importance

Flavour Future

Frederic Teubert:
Flavour & symmetries,
experimental results

Interest in precision flavour measurements is stronger than ever. In some sense it would have been very "unnatural" to find NP at LHC7 from direct searches with the SM CKM structure.

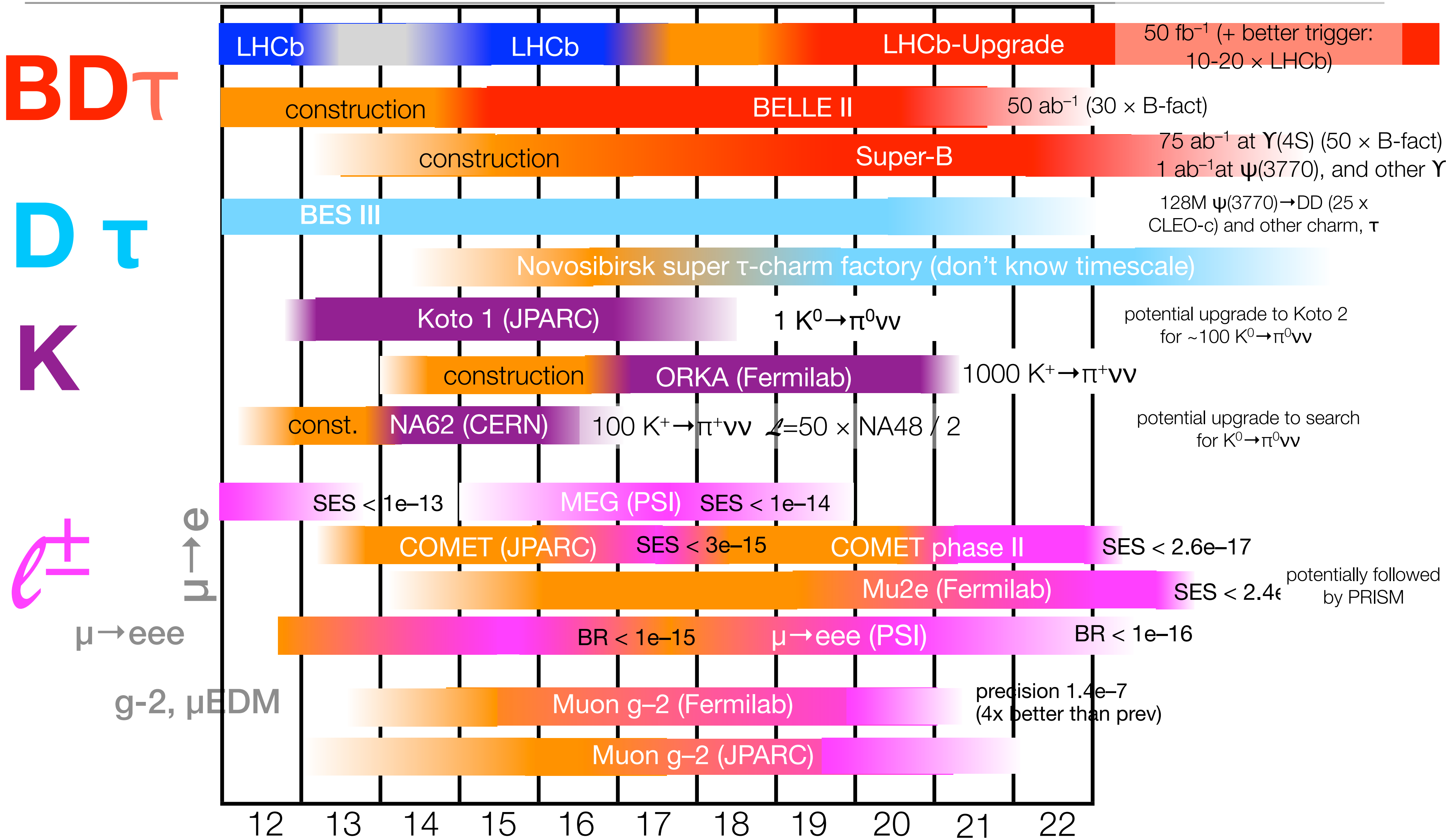
In my opinion, our best chances to find NP in flavour physics are:

- Precise determination of (ρ , η) with tree level processes.
- Precise determination of CP-violating in Δ B=2 processes.
- Improved precision in rare penguins Δ F=1 processes.
- LFV in muon and tau decays.
- EDM

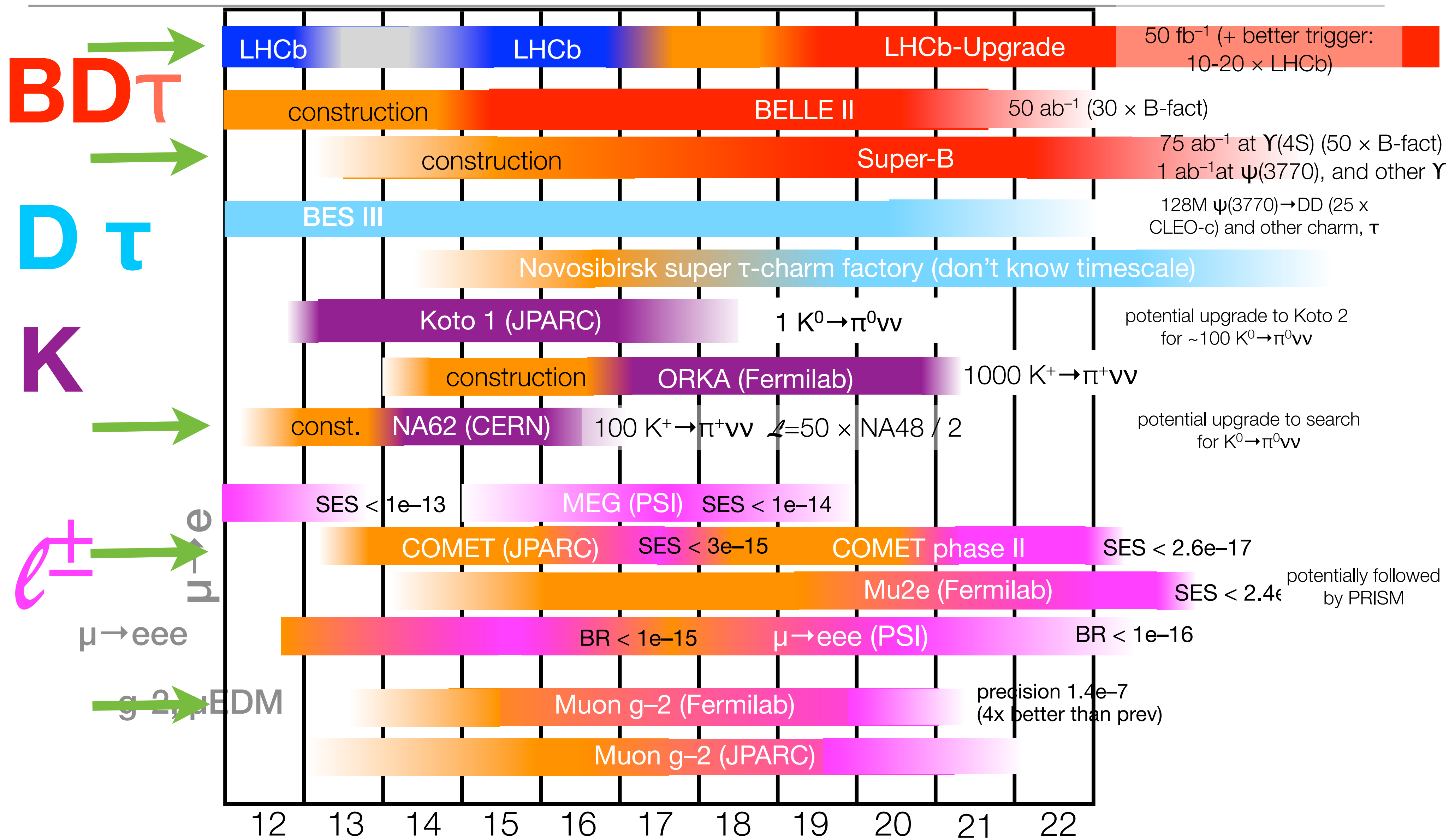
A large part of this program can be performed with upgrades of existing "large" experiments (S-LHCb, Belle-2) while new "smaller" experiments are being proposed for Kaons, LFV and EDM measurements.

There is a priory as many good reasons to find NP by measuring precisely the Higgs couplings as by precision measurements in the flavour sector!

Future Flavour Experiments



Future Flavour Experiments



Summary of Flavour Physics and Symmetry Session

Roger Forty's slide in Tatsuya Nakada's closing talk.

- Recent Progress
  - B Factories (Belle and Barbar) have completed data taking and continue to provide wide range of interesting results, including CP violation and rare decays.
  - LHCb has demonstrated that precision flavour physics is possible at hadron collider
  - High-p_T experiments (CDF, D0, ATLAS, CMS) also doing excellent flavour physics
  - Detailed study made of CP violation and rare decays in B system (now including B_s)
  - NA62 is completing its preparation for precision kaon physics
  - MEG at PSI is improving a search for $\mu \to e\gamma$ at 2.4×10^{-12}
- Open Issues
  - No clear sign of physics beyond the Standard Model in flavour sector, and possible key measurements (a la G. Isidori) are as follows.
    - Φ_s, $|V_{ub}|$, CP angle gamma, B rare decays such as $B_s \to \mu\mu$ and $B \to \tau\nu$
    - CP violation in charm
    - K rare decays such as $K \to \pi\nu\nu$
    - Charged lepton flavor violation (CLFV) eg. $\mu \to e\gamma$, $\mu N \to eN$, $\mu \to eee$, $\tau \to \mu\gamma$, etc.
    - Muon g-2 and EDM (neutron, electron, muon, atom)
- Towards a Strategic Plan
  - Essential to maintain a diverse programme (B, D, K, charged leptons)
  - Flavour experiments typically on smaller scale than Higgs/neutrino, but crucial for search for/understanding of New Physics
  - LHCb and its upgrade form an important part of the exploitation of the LHC
  - An upgraded B Factory will give complementary physics coverage
  - CLFV (μ and τ) and EDM could provide a clean demonstration of new physics

From Roger Forty's slide in Tatsuya Nakada's closing talk.

Towards a Strategic Plan

- Essential to maintain a diverse programme (B, D, K, charged leptons)
- Flavour experiments are typically on a smaller scale than Higgs/ neutrino, but crucial for search for / understanding of new physics
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Backup

Last day: Other regions, and closing discussion

11:00 - 13:00 Status of Other Regions and Closing Discussion

Convener: T. Nakada

11:00 **Americas** *30'*

Speaker: Andrew J Lankford (University of California, Irvine)

Material: **Slides**

11:30 **Discussion** *10'*

11:40 **Asia Pacific** *30'*

Speaker: Prof. Masanori Yamauchi (KEK)

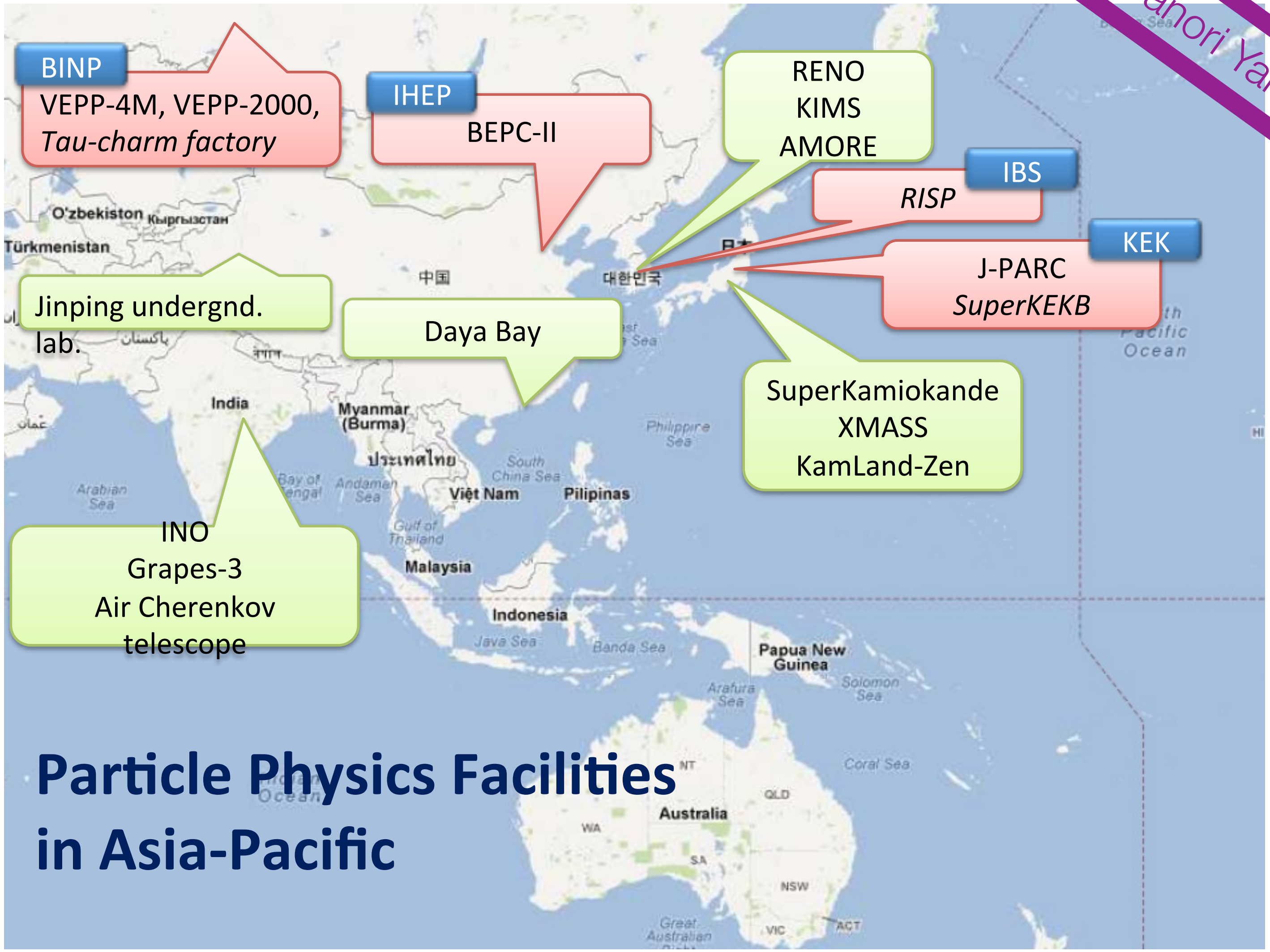
Material: **Slides**

12:10 **Discussion** *10'*

12:20 **Closing Discussion** *40'*

Material: **Slides**

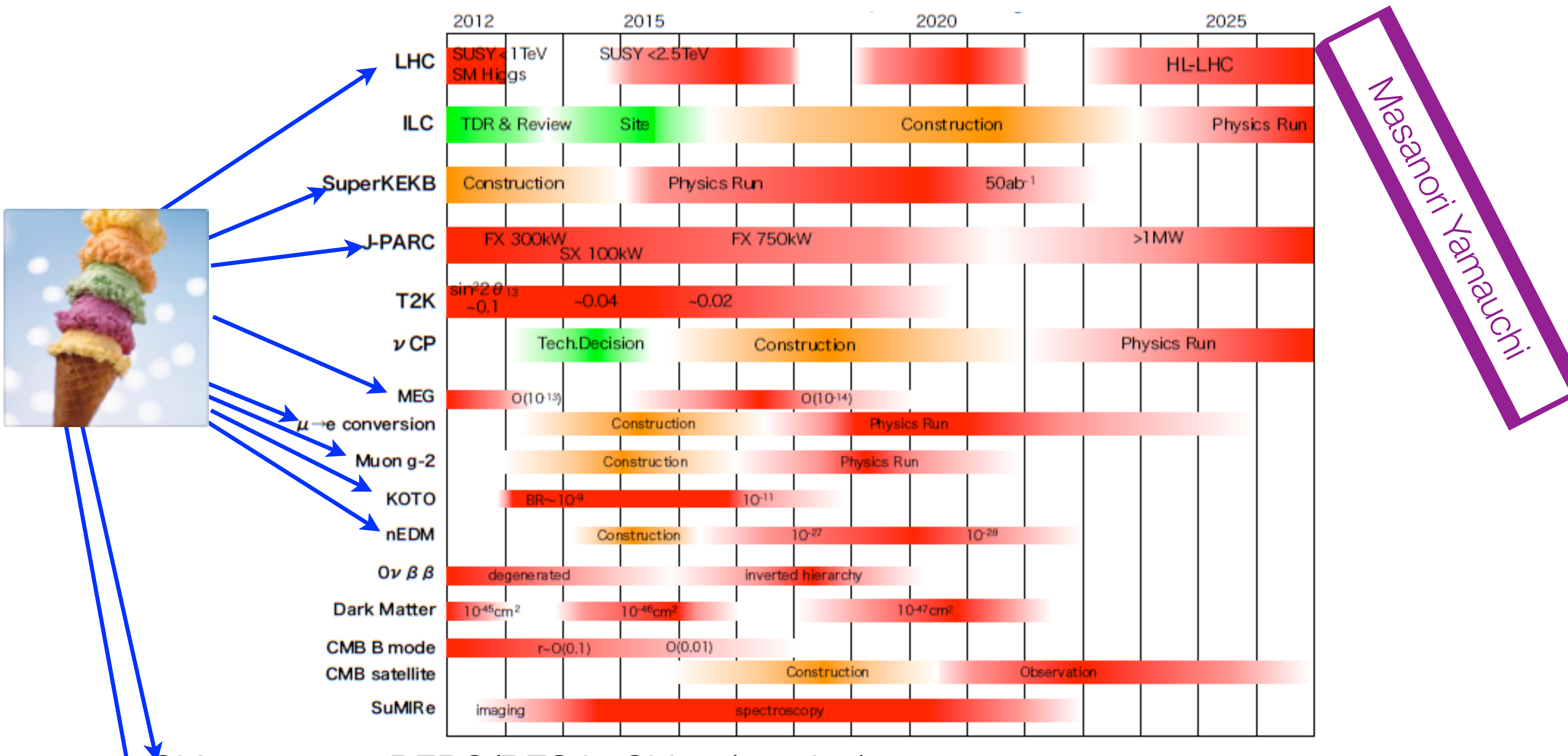
Asia Pacific



Masanori Yamauchi

Asia Pacific

Time line of particle physics program in Japan



China: BEPC/BES in China (running)

Russia: tau-charm in Novosibirsk (planned)

Also: Russia & China both participate in LHCb

Flavour projects in the Americas:

USA: Now exploiting the LHC **35-40% of HEP research**

- **LHC has been one of largest investments of U.S. in HEP ever.**
- **U.S. participation in ATLAS, CMS, LHCb, ALICE & accelerator**

Cut from Andrew J Lankford's slides

Strategy:

LHC luminosity upgrades

Phase 1: U.S. contributions to **detector upgrades**

Phase 2 – HL-LHC: U.S. contributions to **accelerator & detector upgrades**

US Flavour programme (at current or emerging facilities) includes:

B, D: LHCb/upgrade (see above), BELLE, BELLE II
D: BES III
Kaons: KOTO
Leptons: Mu2E, g-2

my summary collated from Andrew J Lankford's slides

Longer term US programme clear emphasis on Project X

Non US flavour: Brazil: LHCb; Canada: SuperB

Flavour Future: CLFV, EDM

G. Isidori – Symmetry Physics Implications *ESPP Open Symposium* [Cracow, 10-12 Sep. 2011]

Gino Isidori: CLF & Symmetry Physics Implications

☆ *The key role of LFV and EDMs*

The recent MEG bound, $BR(\mu\to e\gamma) < 2.4\times10^{-12}$, and its final sensitivity ($\sim10^{-13}$), can be taken as reference values to estimate potentially interesting levels for future LFV searches in different channels:

$\mu\to e\gamma$ — $< 2\times10^{-12}$

same flavor → $\mu\to 3e$, $\mu N\to eN$ — $O(\alpha/\pi)$ suppression if dipole dominated — $\lesssim 10^{-14}$

same dynamics → $\tau\to\mu\gamma$ — $\lesssim 4\times10^{-9}$

enhancement of
$O(10^3)$ [CKM hierarchy]
$O(10)$ [PMNS hierarchy]

Key observables & planned exp. Limits:

- $\mu\to e\gamma$ — 5×10^{-14} [PSI/MEG-II]
- $\mu\to 3e$ — 10^{-16} [PSI/μ3e]
- $\mu N\to eN$ — 10^{-15}-10^{-17} [JPARC/COMET]; 10^{-16}-10^{-18} [FNAL/Mu2e]
- $\tau\to\mu\gamma$ — 2×10^{-9} [S-Bfactory ($50ab^{-1}$)]
- $\tau\to 3\mu$ — 10^{-9}-10^{-10} [S-Bfact., S-LHCb]

Gino Isidori's top-10 quark flavour measurements

G. Isidori – Symmetry Physics Implications *ESPP Open Symposium* [Cracow, 10-12 Sep. 2011]

▶ *Future prospects*

"Minimalistic" list of the key (low-energy) quark flavor-violating observables:

- γ from tree ($B \to DK$, ...)
- $|V_{ub}|$ from exclusive semi-leptonic B decays

→ Clean (tree-level) determination of the main SM inputs [key ingredient to improve the precision of $\Delta F=2$ tests]

- $B_{s,d} \to l^+l^-$ — Higgs-mediated FCNCs [$\sigma(f_B) < 5\%$ (from lattice)]
- CPV in B_s mix. [ϕ_s] — New CPV (SUSY, ...) [$\sigma(S_{\psi\varphi}) \sim 0.01$]
- $B \to K^{(*)} l^+l^-, \nu\nu$ — Non-standard FCNCs [$\sigma(A_{FB}) \lesssim 5\%$]
- $B \to \tau\nu, \mu\nu$ (+D) — Scalar charged currents [$\sigma(f_B) \to 5\%$ (from lattice)]
- $K \to \pi\nu\nu$ — Best probe of non-MFV [$\sigma(BR) \lesssim 5\%$]
- CPV in charm — Key window on up-type dynamics [more work on the th. side]

Terry Wyatt

Results of LHCb projections

Type	Observable	Current precision	LHCb 2018	Upgrade ($50\,\mathrm{fb}^{-1}$)	Theory uncertainty
B_s^0 mixing	$2\beta_s\ (B_s^0 \to J/\psi\ \phi)$	0.10 [30]	0.025	0.008	~ 0.003
	$2\beta_s\ (B_s^0 \to J/\psi\ f_0(980))$	0.17 [32]	0.045	0.014	~ 0.01
	$a_{\rm sl}^s$	6.4×10^{-3} [63]	0.6×10^{-3}	0.2×10^{-3}	0.03×10^{-3}
Gluonic penguins	$2\beta_s^{\rm eff}(B_s^0 \to \phi\phi)$	–	0.17	0.03	0.02
	$2\beta_s^{\rm eff}(B_s^0 \to K^{*0}\bar{K}^{*0})$	–	0.13	0.02	< 0.02
	$2\beta^{\rm eff}(B^0 \to \phi K_S^0)$	0.17 [63]	0.30	0.05	0.02
Right-handed currents	$2\beta_s^{\rm eff}(B_s^0 \to \phi\gamma)$	–	0.09	0.02	< 0.01
	$\tau^{\rm eff}(B_s^0 \to \phi\gamma)/\tau_{B_s^0}$	–	5 %	1 %	0.2 %
Electroweak penguins	$S_3(B^0 \to K^{*0}\mu^+\mu^-; 1 < q^2 < 6\,\mathrm{GeV}^2/c^4)$	0.08 [64]	0.025	0.008	0.02
	$s_0\,A_{\rm FB}(B^0 \to K^{*0}\mu^+\mu^-)$	25 % [64]	6 %	2 %	7 %
	$A_{\rm I}(K\mu^+\mu^-; 1 < q^2 < 6\,\mathrm{GeV}^2/c^4)$	0.25 [9]	0.08	0.025	~ 0.02
	$\mathcal{B}(B^+ \to \pi^+\mu^+\mu^-)/\mathcal{B}(B^+ \to K^+\mu^+\mu^-)$	25 % [29]	8 %	2.5 %	~ 10 %
Higgs penguins	$\mathcal{B}(B_s^0 \to \mu^+\mu^-)$	1.5×10^{-9} [4]	0.5×10^{-9}	0.15×10^{-9}	0.3×10^{-9}
	$\mathcal{B}(B^0 \to \mu^+\mu^-)/\mathcal{B}(B_s^0 \to \mu^+\mu^-)$	–	~ 100 %	~ 35 %	~ 5 %
Unitarity triangle angles	$\gamma\ (B \to D^{(*)}K^{(*)})$	~ 10–12° [40, 41]	4°	0.9°	negligible
	$\gamma\ (B_s^0 \to D_s K)$	–	11°	2.0°	negligible
	$\beta\ (B^0 \to J/\psi\ K_S^0)$	0.8° [63]	0.6°	0.2°	negligible
Charm *CP* violation	A_Γ	2.3×10^{-3} [63]	0.40×10^{-3}	0.07×10^{-3}	–
	ΔA_{CP}	2.1×10^{-3} [8]	0.65×10^{-3}	0.12×10^{-3}	–

- All measurements show steady improvement with increasing integrated luminosity
- Uncertainties are statistical only
- Systematics most likely to be significant for a^s_{sl}, A_Γ and ΔA_{CP}
- Theory uncertainties will also become significant for a number of observables

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Flavour Session Discussion

- Short discussion on flavour, focussing on heavy flavour.
- Experiments: LHCb, LHCb-upgrade, and Super flavour factories. Importance of LHCb upgrade emphasised, as well as complementarity of LHCb upgrade and SFF's. (Pierluigi Campana & Francesco Forti)
- Complementarity between Higgs and flavour sector (Gino Isidori)

Future prospects

"Minimalistic" list of the key (low-energy) quark flavor-violating observables:

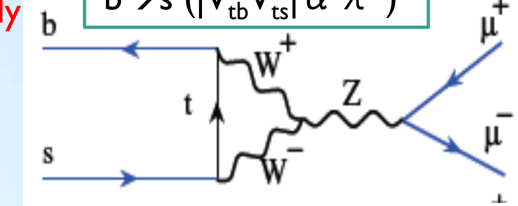
- γ from tree ($B \to DK$, ...) — S-LHCb
- $|V_{ub}|$ from exclusive semi-leptonic B decays — S-Bfactory [SuperKEKB & SuperB]
- $B_{s,d} \to l^+l^-$ — S-LHCb + ATLAS & CMS
- CPV in B_s mix. [ϕ_s] — S-LHCb
- $B \to K^{(*)} l^+l^-$, $\nu\nu$ — S-LHCb / S-Bfactory
- $B \to \tau\nu$, $\mu\nu$ (+D) — S-Bfactory
- $K \to \pi\nu\nu$ — Kaon beams [NA62, KOTO, ORKA]
- CPV in charm — S-LHCb / S-Bfactory

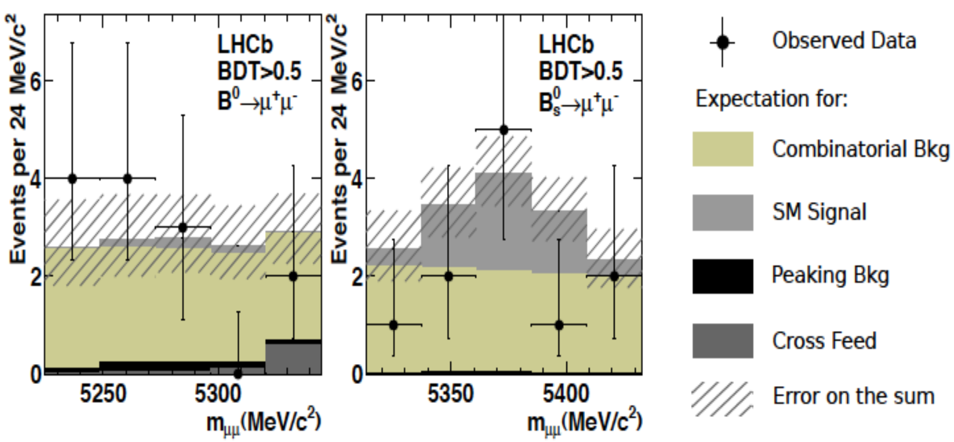
Δ F=1 Higgs penguins in b→d,s transitions: B decays

The pure leptonic decay of the B mesons is well predicted theoretically, and experimentally is exceptionally clean (in particular for B_s, peaking background is very small).

Within the SM, $BR_{SM}(B_s \to \mu\mu) = (3.2 \pm 0.3) \times 10^{-9}$ (arXiv:1208.0934)
$BR_{SM}(B \to \mu\mu) = (1.0 \pm 0.1) \times 10^{-10}$

$b \to s$ ($|V_{tb}V_{ts}| \alpha\ \lambda^2$)





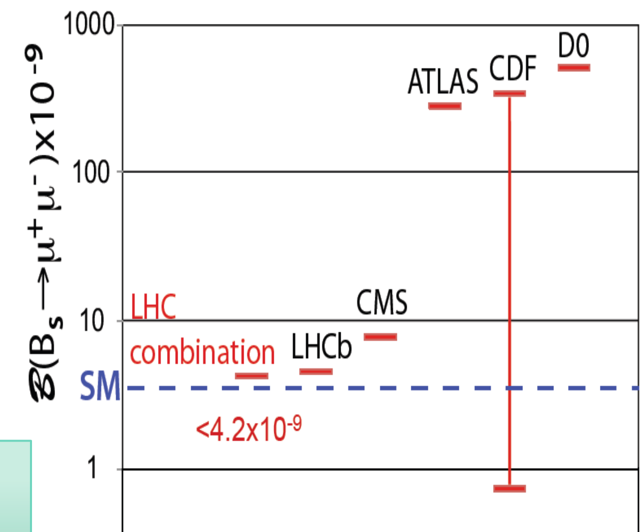
Limits for B^0 at 95% C.L.

- CDF
  $BR(B^0 \to \mu^+\mu^-) < 4.6 \times 10^{-9}$
- CMS
  $BR(B^0 \to \mu^+\mu^-) < 1.8 \times 10^{-9}$
- LHCb
  $BR(B^0 \to \mu^+\mu^-) < 1.0 \times 10^{-9}$

Limits for B^0_s at 95% C.L.

- D0
  $BR(B^0_s \to \mu^+\mu^-) < 51 \times 10^{-9}$
- CDF
  $BR(B^0_s \to \mu^+\mu^-) < 31 \times 10^{-9}$
- ATLAS
  $BR(B^0_s \to \mu^+\mu^-) < 22 \times 10^{-9}$
- CMS
  $BR(B^0_s \to \mu^+\mu^-) < 7.7 \times 10^{-9}$
- LHCb
  $BR(B^0_s \to \mu^+\mu^-) < 4.5 \times 10^{-9}$

95% confidence level limits



LHCb and CMS are the experiments **with highest sensitivity:** *1/fb(LHCb)~7/fb(CMS)* as in 2011 analysis.

Preliminary upper limits (95% CL)
LHC combination: $BR(B_s \to \mu\mu) < 4.2 \times 10^{-9}$, $BR(B \to \mu\mu) < 8.1 \times 10^{-10}$

The probability that the observed number of B_s candidates is in agreement with **background only is 5%** (i.e. **~2σ evidence**)

Measurement of $BR(B_s \to \mu\mu)$ very soon. Next improve precision O(5%) and measure ratio $BR(B \to \mu\mu)/BR(B_s \to \mu\mu)$