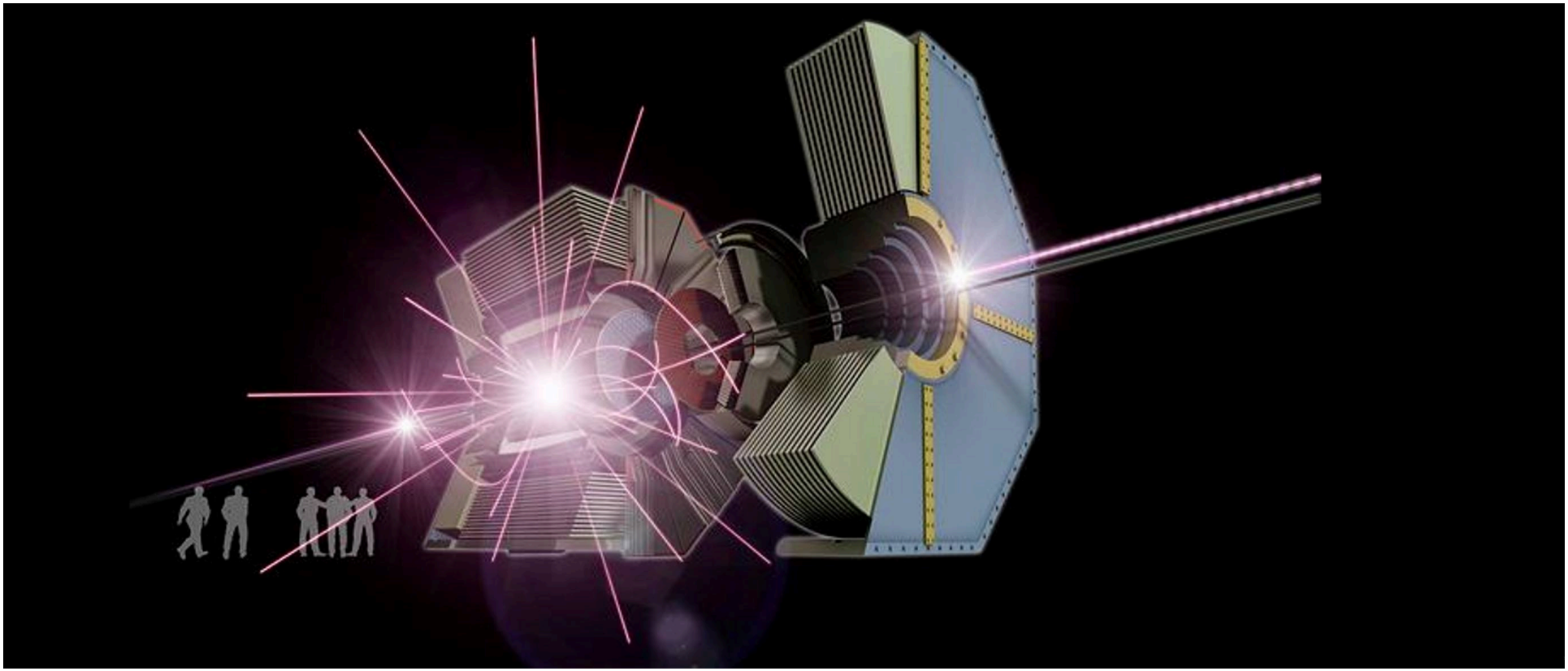
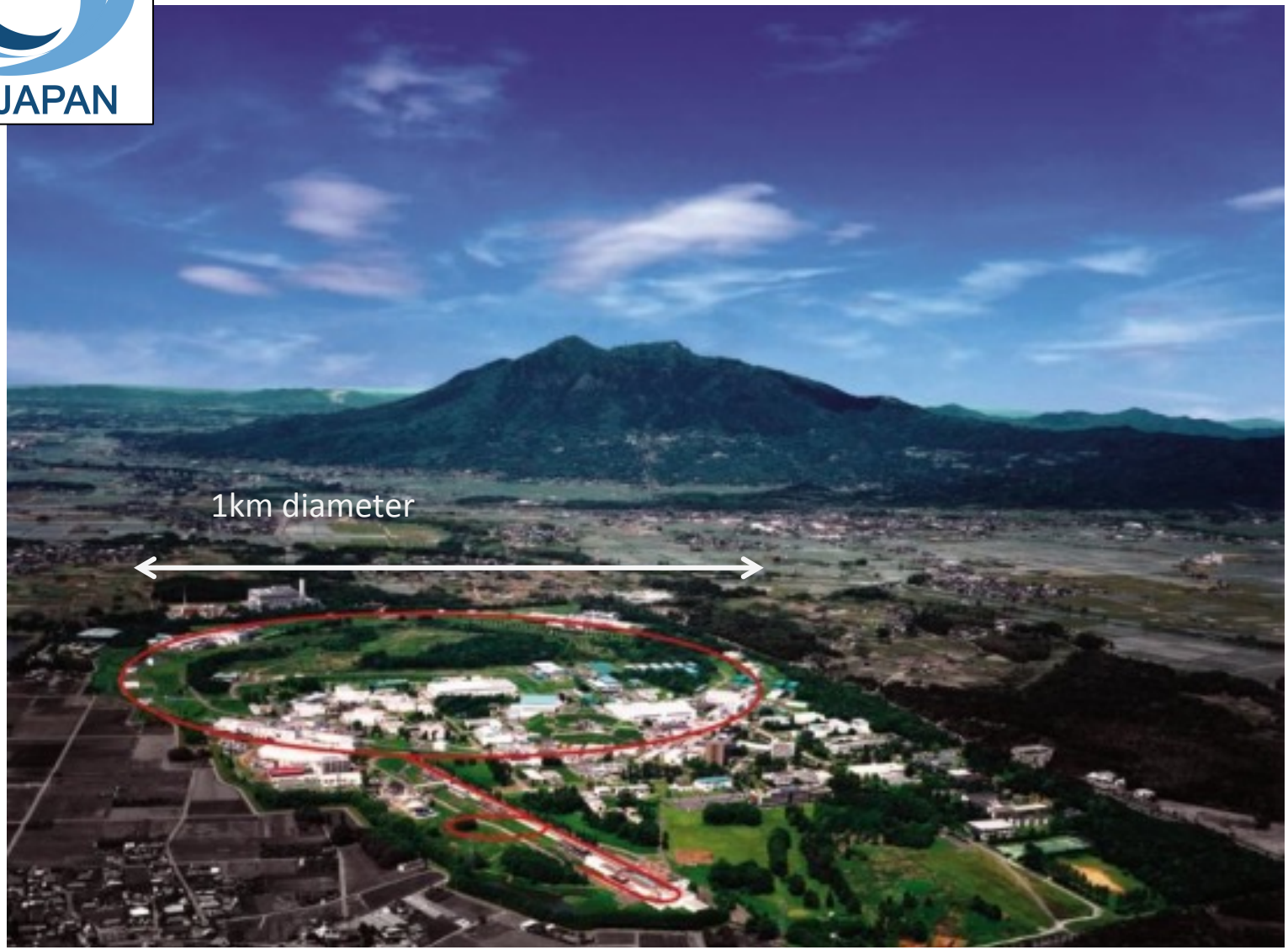
@

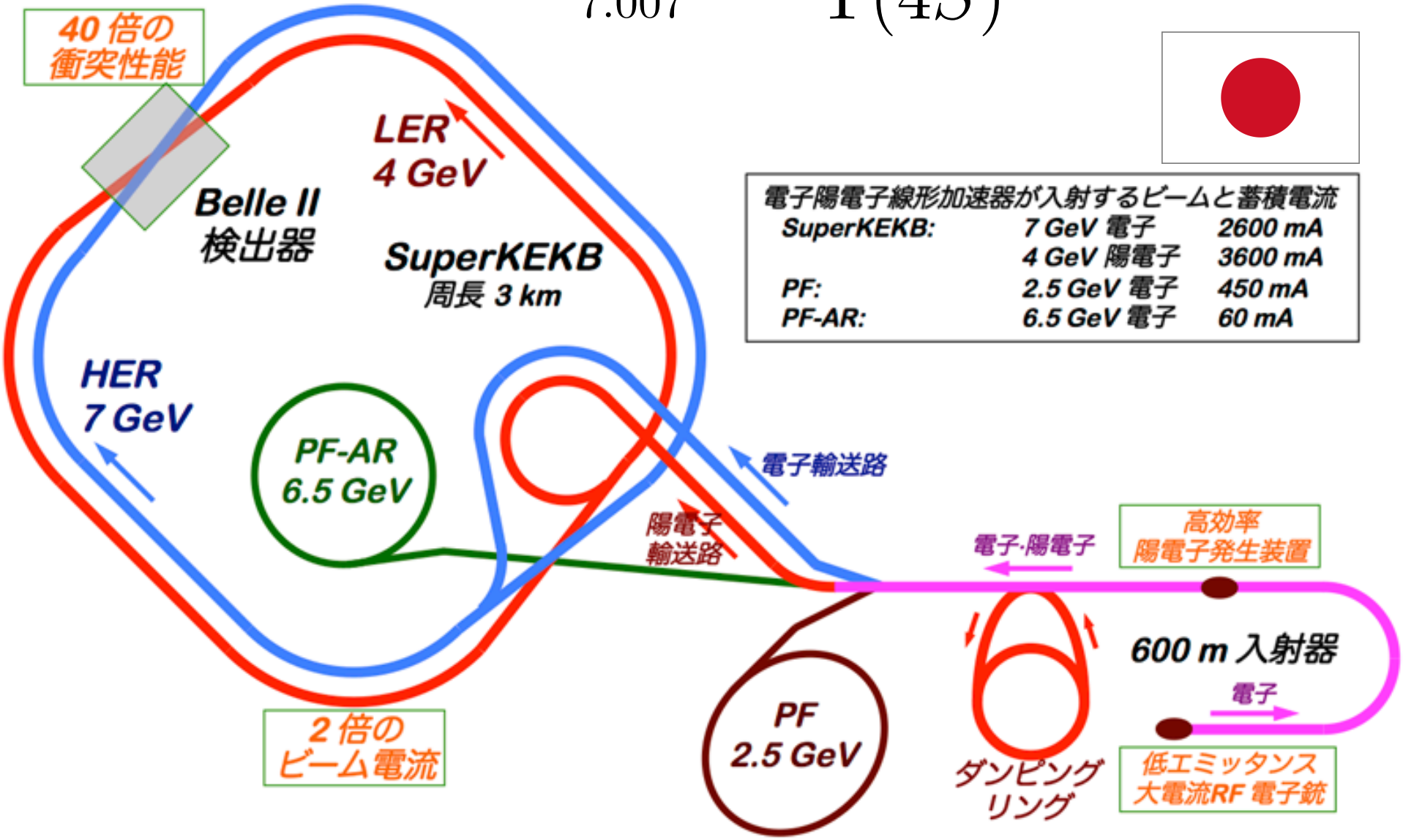
F. Le Diberder
on behalf of the
LAL-IPHC team



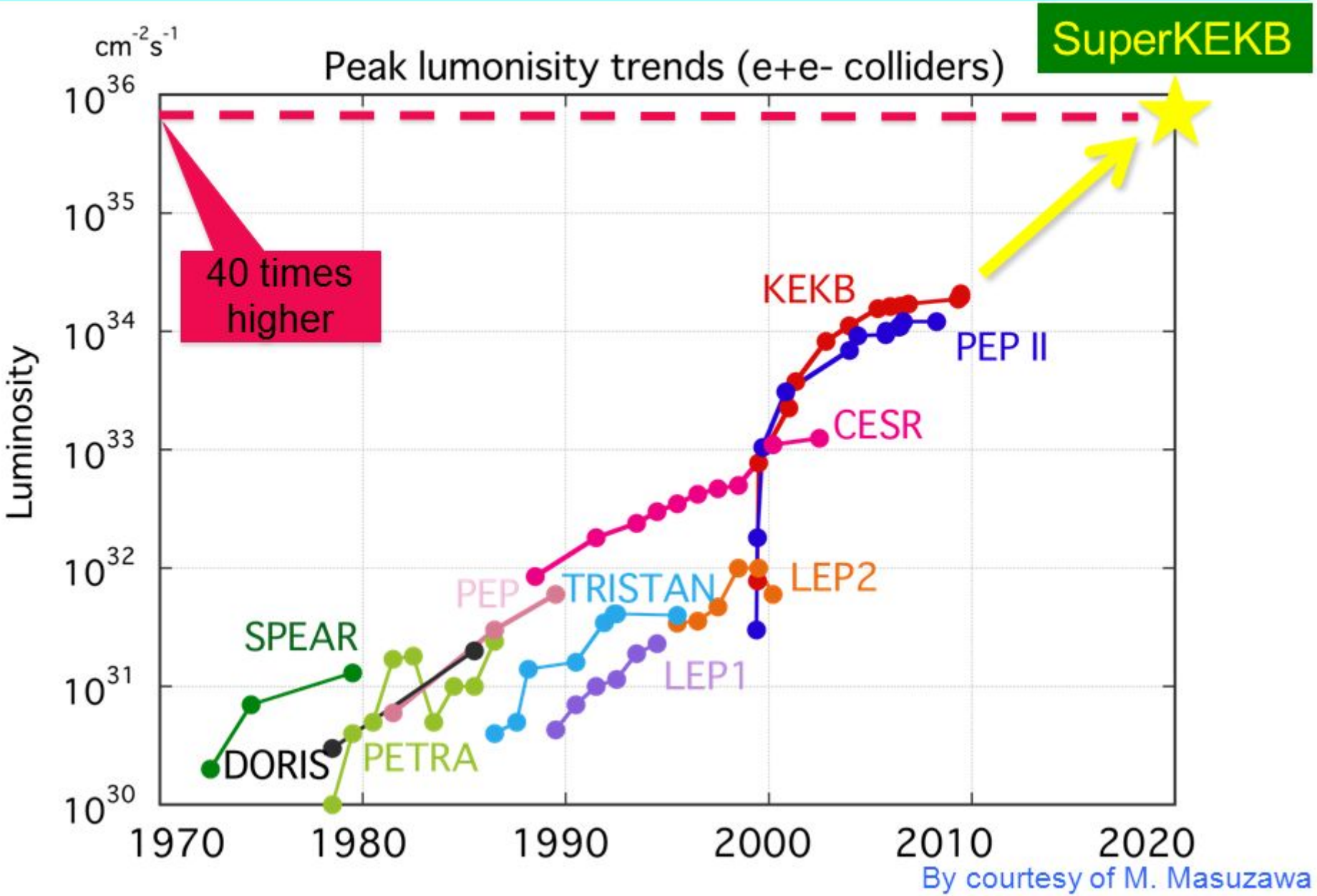
KEK-JAPAN



$$e^-(7\mathrm{GeV}) \underset{7.007}{\overset{83\ \mathrm{mrad}}{\rightarrow\!\!\!\!\leftarrow}} e^+(4\mathrm{GeV})$$



Luminosity trend



How to increase the luminosity?

Super KEKB
uest for BSM

Beam-beam parameter

Lorentz factor

Beam current

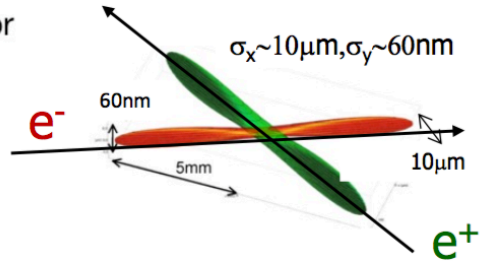
$$L = \frac{\gamma_{e\pm}}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\left(\frac{I_{e\pm}\xi_y^{e\pm}}{\beta_y^*}\right)\left(\frac{R_L}{R_{\xi_y}}\right)$$

Lumi. reduction factor
(crossing angle)&
Tune shift reduction factor
(hour glass effect)
0.8 - 1
(short bunch)

Classical electron radius

Beam size ratio@IP
1 - 2 % (flat beam)

Vertical beta function@IP



(1) Smaller β_y^* ← **"Nano-Beam" scheme**

(2) Increase beam currents

(3) Increase ξ_y

Collision with very small spot-size beams

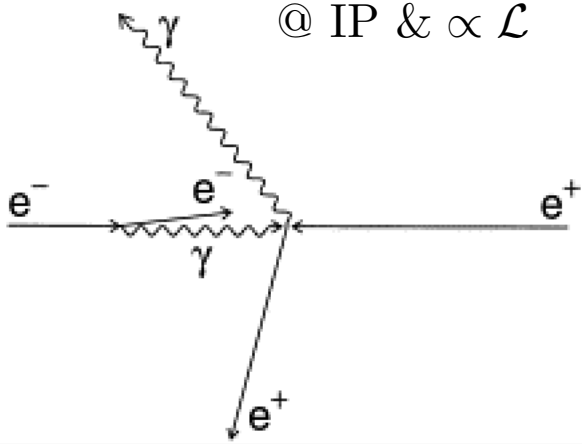
cf. Pantaleo Raimondi (SuperB)

Machine Design Parameters

parameters		KEKB		SuperKEKB		units
		LER	HER	LER	HER	
Beam energy	E_b	3.5	8	4	7.007	GeV
Half crossing angle	φ	11		41.5		mrad
# of Bunches	N	1584		2500		
Horizontal emittance	ε_x	18	24	3.2	4.6	nm
Emittance ratio	κ	0.88	0.66	0.27	0.28	%
Beta functions at IP	β_x^*/β_y^*	1200/5.9		32/0.27	25/0.30	mm
Beam currents	I_b	1.64	1.19	3.6	2.6	A
beam-beam param.	ξ_y	0.129	0.090	0.088	0.081	
Bunch Length	σ_z	6.0	6.0	6.0	5.0	mm
Horizontal Beam Size	σ_x^*	150	150	10	11	um
Vertical Beam Size	σ_y^*	0.94		0.048	0.062	um
Luminosity	**L**	**2.1×10^{34}**		**8×10^{35}**		$cm^{-2}s^{-1}$

Major source of background

radiative BhaBha's @ IP & $\propto \mathcal{L}$

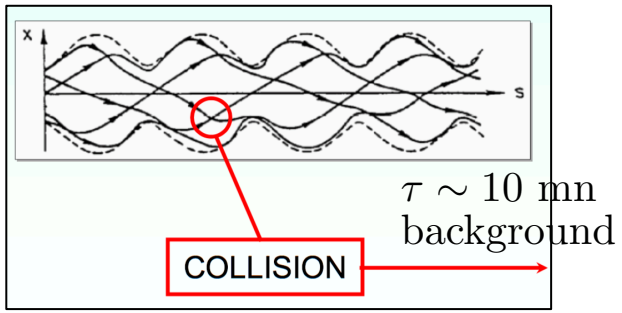


Touschek scattering ⟵ nanobeam

– Intra-bunch scattering, Rate $\propto$ (beam size)$^{-1}$,(E_{beam})$^{-3}$

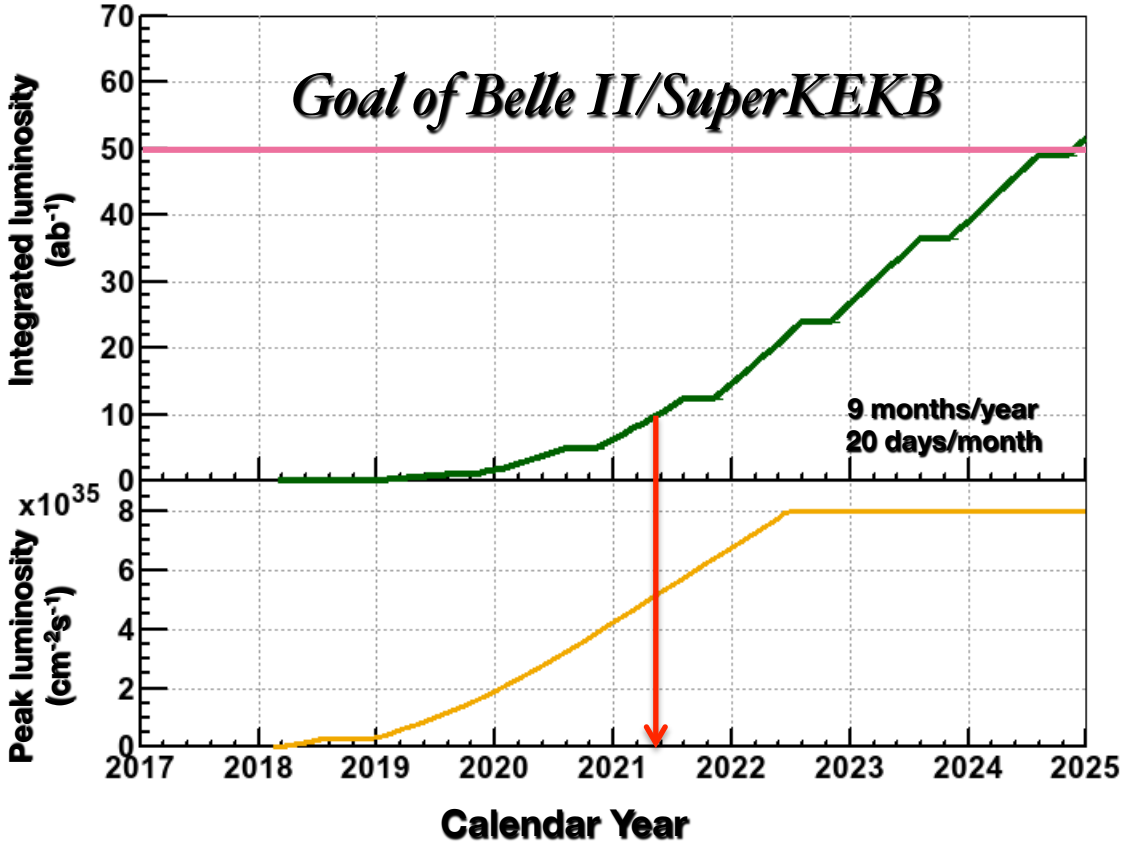
– Most dangerous background at SuperKEKB,

since beam size is x20 smaller ("Nano-beam scheme")



$\tau \sim 10$ mn background

SuperKEKB luminosity projection



Program length

$\geq$ 10 years

Assume nominal 9 month running per year $\Longrightarrow$ ¥

$(\pm$ syst$)$

The starting date of nominal data taking is now firm : end 2018
The learning curve assumptions are conservative, not “aggressive”

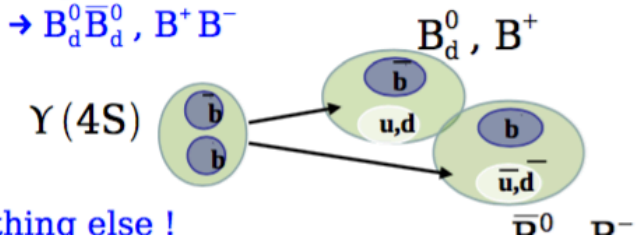
Excellent team of Machine Physicists

MITSUBISHI

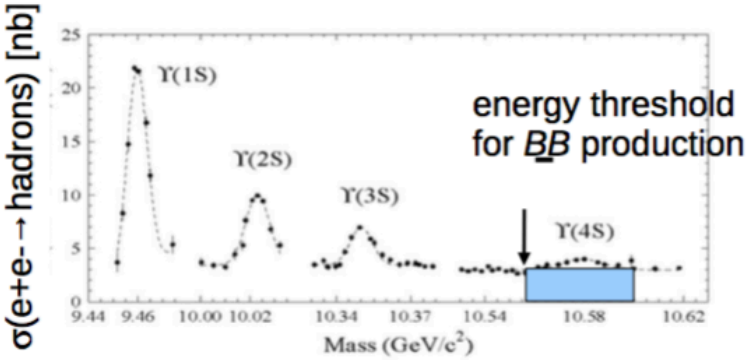
Belle II, a flavour-factory, a rich physics program ...

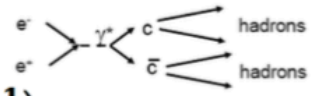
- We plan to collect 50 ab^{-1} of e^+e^- collisions at (or close to) the $\Upsilon(4S)$ resonance, so that we have:
  - **a (Super) B-factory** ($\sim 1.1 \times 10^9$ **$B\bar{B}$ pairs per ab^{-1}**)

''on resonance'' production
$e^+e^- \to \Upsilon(4S) \to B^0_d\bar{B}^0_d, B^+B^-$



- 2 B's and nothing else !
- 2 B mesons are created simultaneously in a L=1 coherent state





  - **a (Super) charm factory** ($\sim 1.3 \times 10^9$ **$c\bar{c}$ pairs per ab^{-1}**)
  - **a (Super) τ factory** ($\sim 1.3 \times 10^9$ **$\tau^+\tau^-$ pairs per ab^{-1}**)
  - with Initial State Radiation, effectively scan the range [0.5 – 10] GeV and measure the $e^+e^- \to$ light hadrons cross section very precisely
  - exploit the clean e^+e^- environment to probe the existence of exotic hadrons, dark photons/Higgs, light Dark Matter particles, ...

Belle II International Collaboration

As of Feb. 2017

23countries/regions
101 institutions
~700 researchers

Europe	281
Austria	14
Czech	7
Germany	106
Italy	74
Poland	10
Russia	46
Slovenia	17
Spain	4
Ukraine	3

Asia			337
Saudi Arabia	3	Korea	42
Australia	36	Malaysia	5
China	27	Vietnam	2
India	39	Taiwan	21
Japan	159	Thailand	2
		Turkey	1

America	117
Canada	23
Mexico	11
USA	83

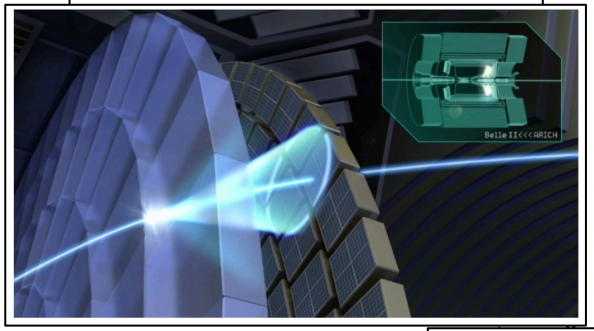
Journée Belle-II

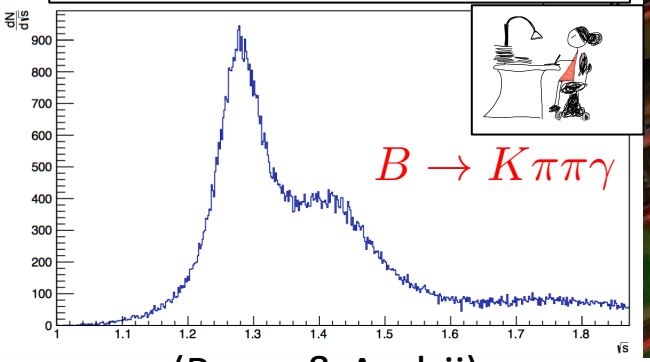
22 mars 2017
LAL
Europe/Zurich timezone

- CS-LAL (22 may)
- CS-IPHC (8 june)
- Belle-II (20 june)
- CS-IN2P3 (22 june)

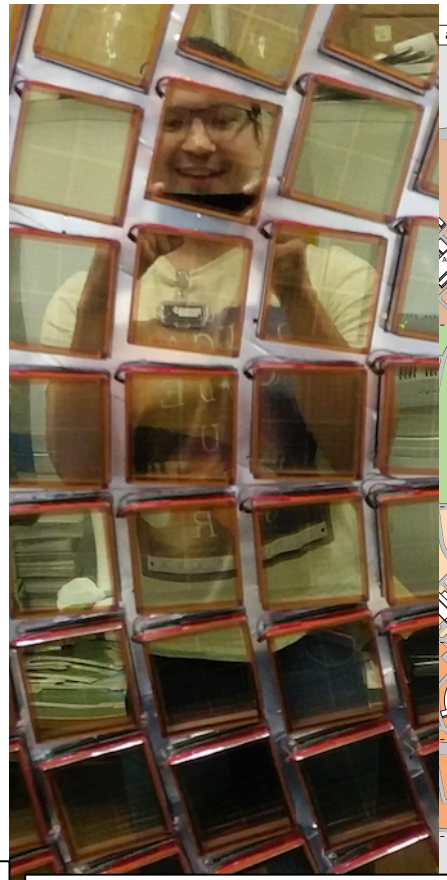
LumiBelle^2

Luminosity Monitoring for Belle II





(Borys & Andrii)

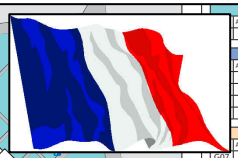


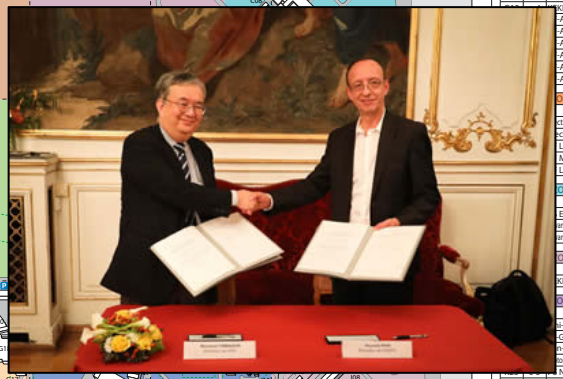
Inter-University Research Institute Corporation

KEK

HIGH ENERGY

France Ambassador
October 11th

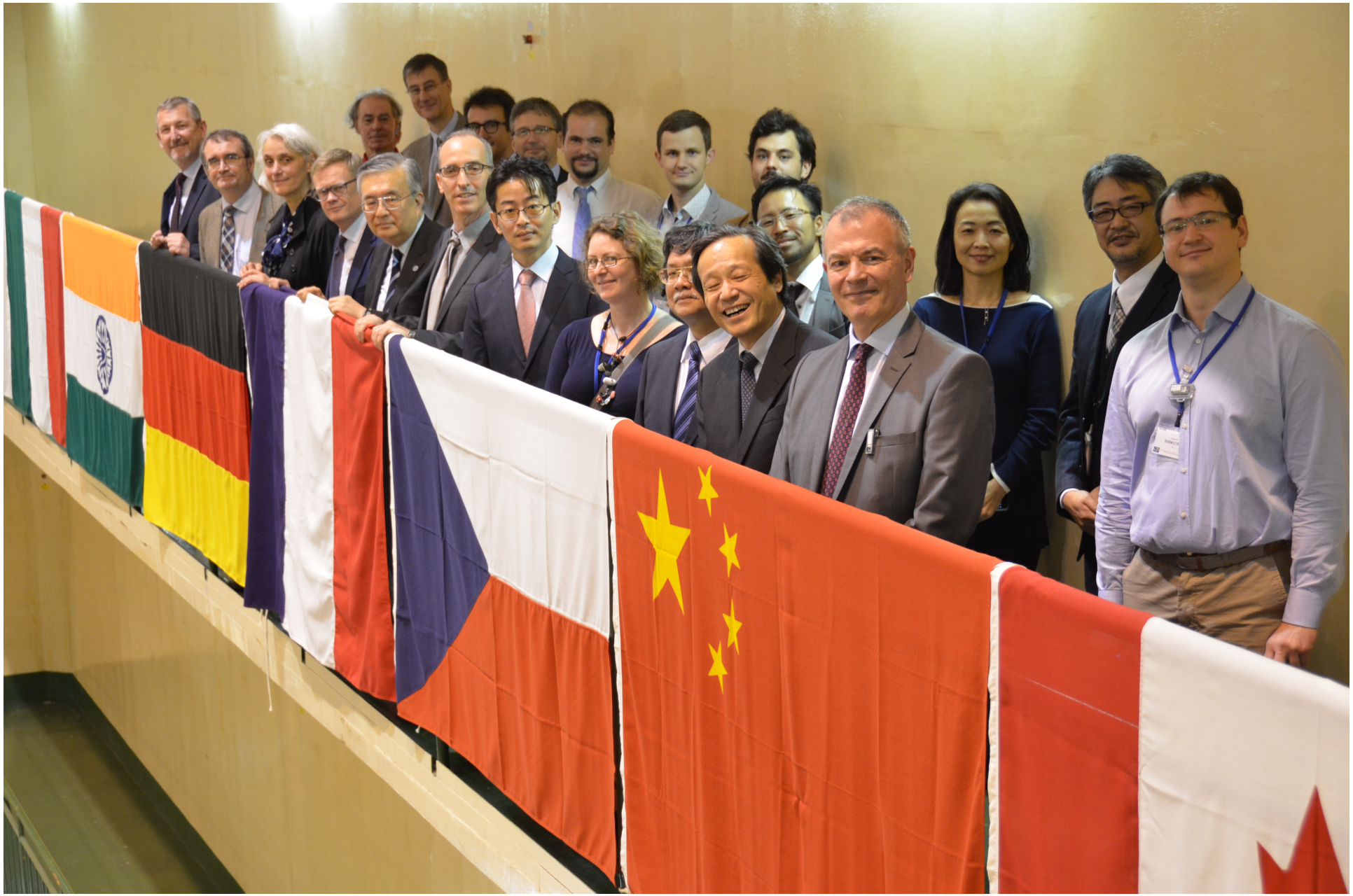




MoU KEK-IN2P3
October 26th

SI
- Computing resources
- Software upgrade

SERDI
- ARICH
- DAQ upgrade (?)



Belle-II versus LHCb : why Belle-II ?

Institution level reason:

1) IN2P3-HEP is strongly present in LHC, in fact only in LHC => diversification
2) Develop collaboration with Japan
3) Funding needs are limited : small group, M&O very low

Physics reason:

1) Two extremely different experiments
   LHCb strengths : huge statistics, boost, all B's produced, detector tuned
   Belle-II strengths : large statistics, boost, very clean events, new detector
   exquisite tagging and π^0 , backgounds much smaller, and of different nature
2) If New Physics is observed in any of the two experiment
   => confirmation by the other is essential (would be delighted to simply confirm)

Sociological reason:

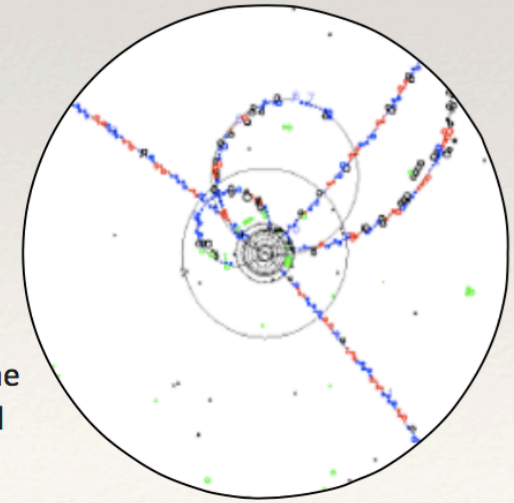
1) (non-aggressive) competition is a plus for the scientific life of an Institute (ATLASCMS)
2) Longstanding ties with KEK (and Japan) for most members of the LAL-IPHC team
3) Belle-II group is not meant to grow large : no threat on LHCb
4) LAL-LHCb welcome the initiative

Remarks : cf. strong European presence in Belle-II (France is a late comer)

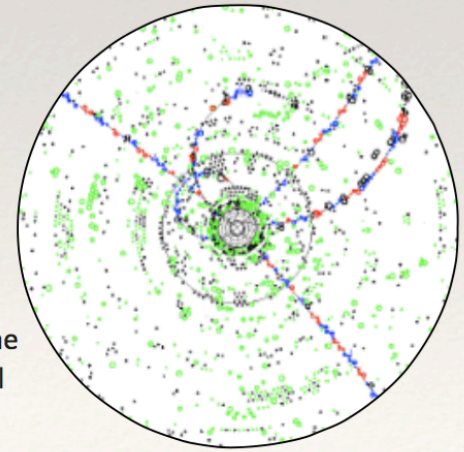
The LAL – IPHC initial team, as of now

Philip	Bambade	LAL	DR
Sviatoslav	Bilokin	IPHC	Postdoc
Leonid	Burmistrov	LAL	IR
Daniel	Cuesta	IPHC	PhD
Emi	Kou	LAL	DR
Francois	Le Diberder	LAL	Pr
Jerome	Baudot	IPHC	Pr
Reem	Rascheed	IPHC	PhD
Isabelle	Ripp-Baudot	IPHC	DR

transverse view of the detector with signal [Belle]



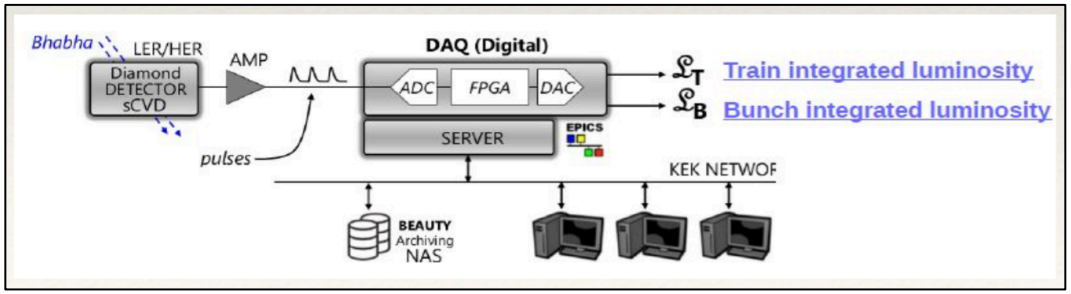
transverse view of the detector with signal [Belle II]



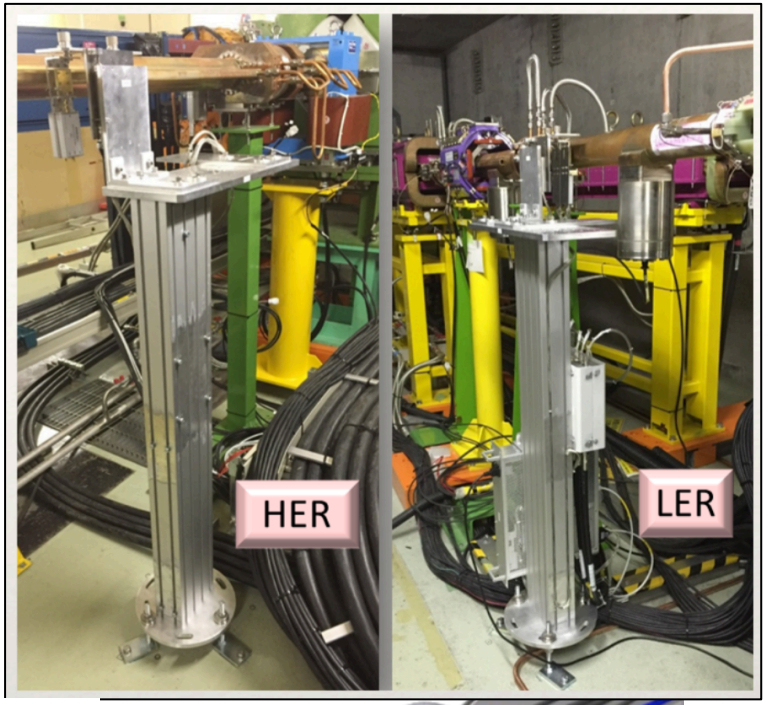
- High luminosity of the collider produces also huge amount of parasite particles:
  - dominate occupancy in inner tracker,
  - damage detectors.

➛ the success of Belle II physics program relies on the control of the beam induced background.

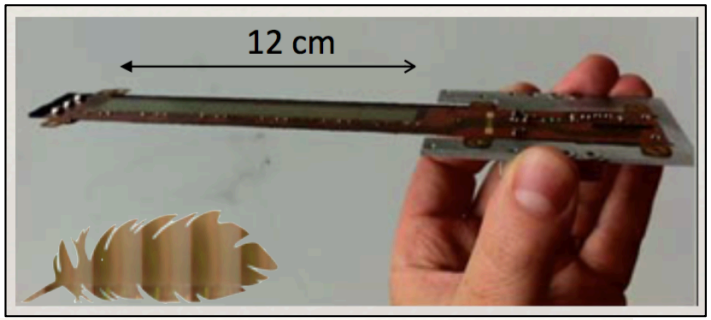
Fast Luminosity measurement Double purpose : Feed-back & (top-up) Monitoring



LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE



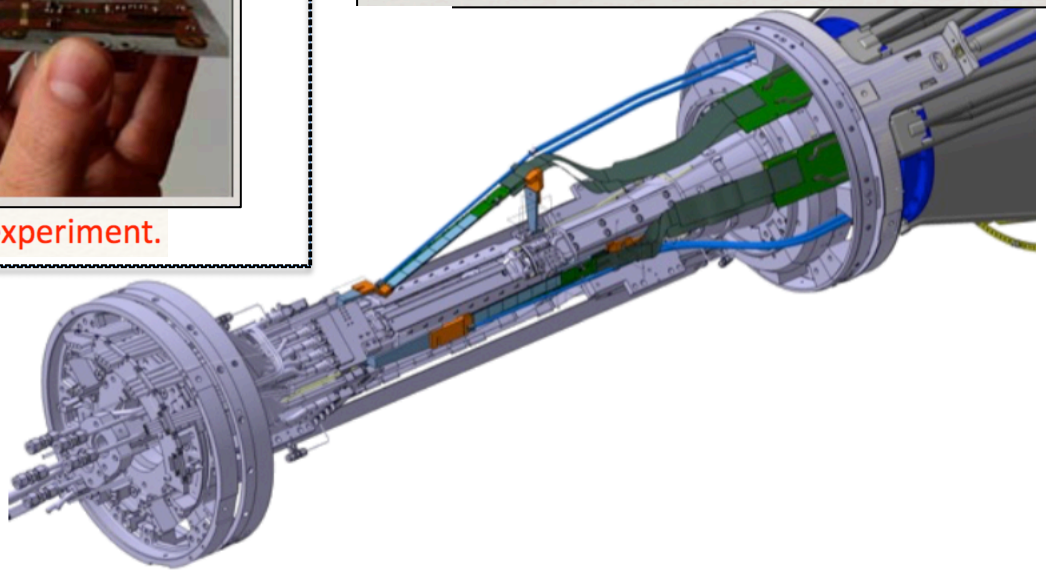
Plume detector : CMOS sensors (16M pixels)



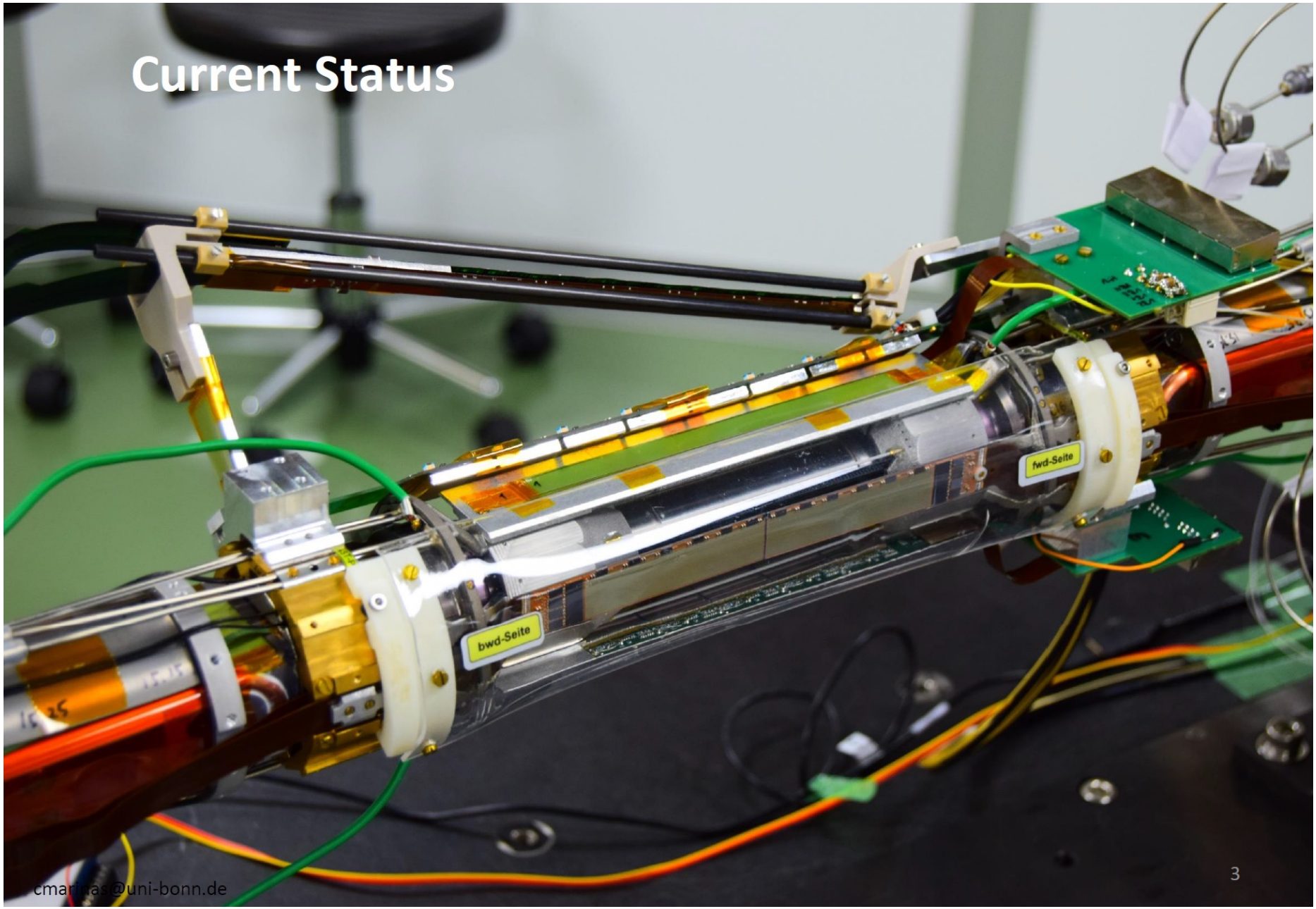
SuperKEKB Commissioning Detector
BEAST II
Belle II Collaboration

BEAST II: Beam Exorcism for A STable BELLE II experiment.

IPHC
Institut Pluridisciplinaire Hubert CURIEN
STRASBOURG

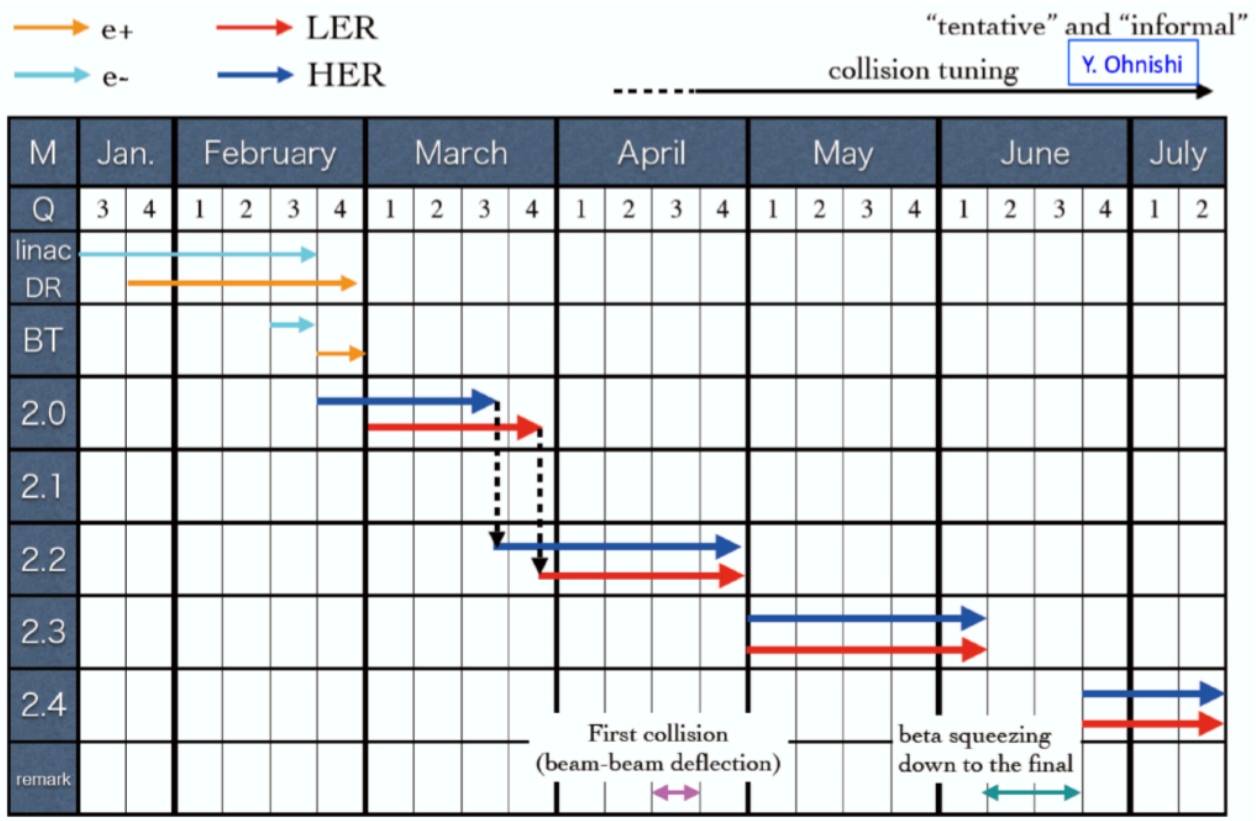


Current Status



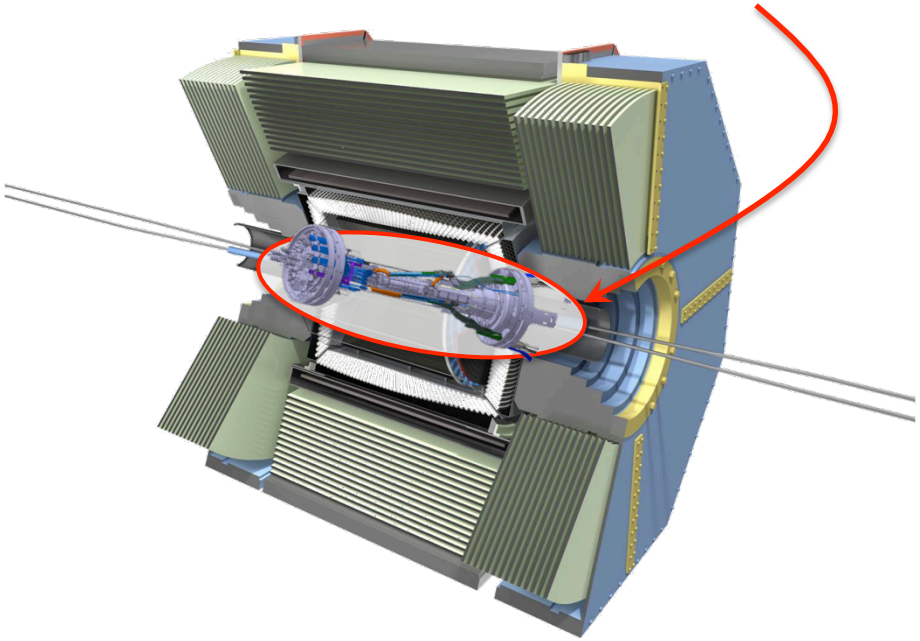
Phase II : Spring 2018

- ~20 fb^{-1}, could be more. Our job to prepare for publications with 2018 data.

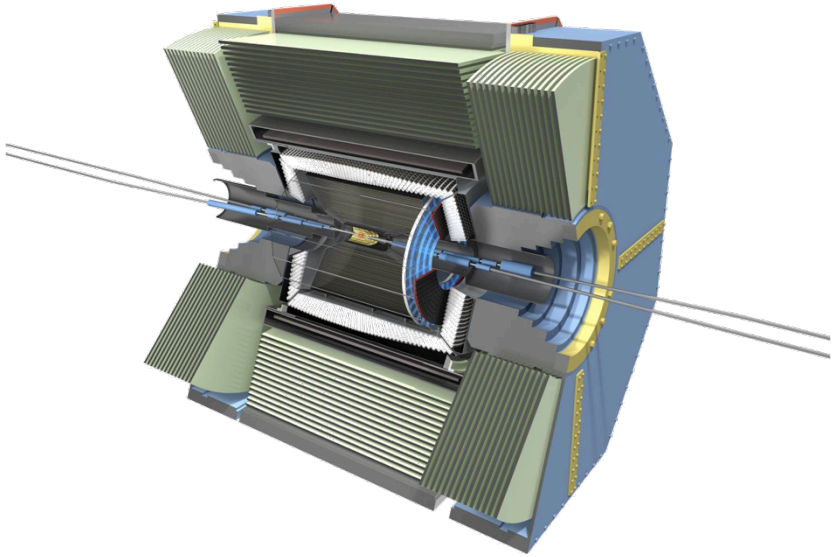


Beam induced background

- Phase 2 = Belle II + BEAST II



- Phase ≥ 3 = Belle II data taking



– Specific beam transport simulations
– Specific set of measurements (BEAST)

– Simulation tuning to reproduce reality
– Bkg in Belle II-det. understood through BEAST

– Prediction of bkg level
– Bkg monitoring with BELLE II-det.

B2TiP

2014 → 2017 → 2019

PTEP

Prog. Theor. Exp. Phys. **2015**, 00000 (646 pages)
DOI: 10.1093/ptep/0000000000

The Belle II Physics Book

Emi Kou[1], Phillip Urquijo[2], The Belle II collaboration[3], and The B2TiP theory community[3]

[1]*LAL*
[2]*Melbourne*

650 pages

The report of the Belle II Theory Interface Platform is presented in this document.

One of us is already playing a major role in Belle II

- Collaboration wide review to commence ASAP - near end of June.
- Managed by new publication council (see IB meeting)
- Intend to use plots, results from book at summer conferences
- Post as a public report on docs.belle2.org by early July

LHCb DIRAC

LHCb GRID SOLUTION

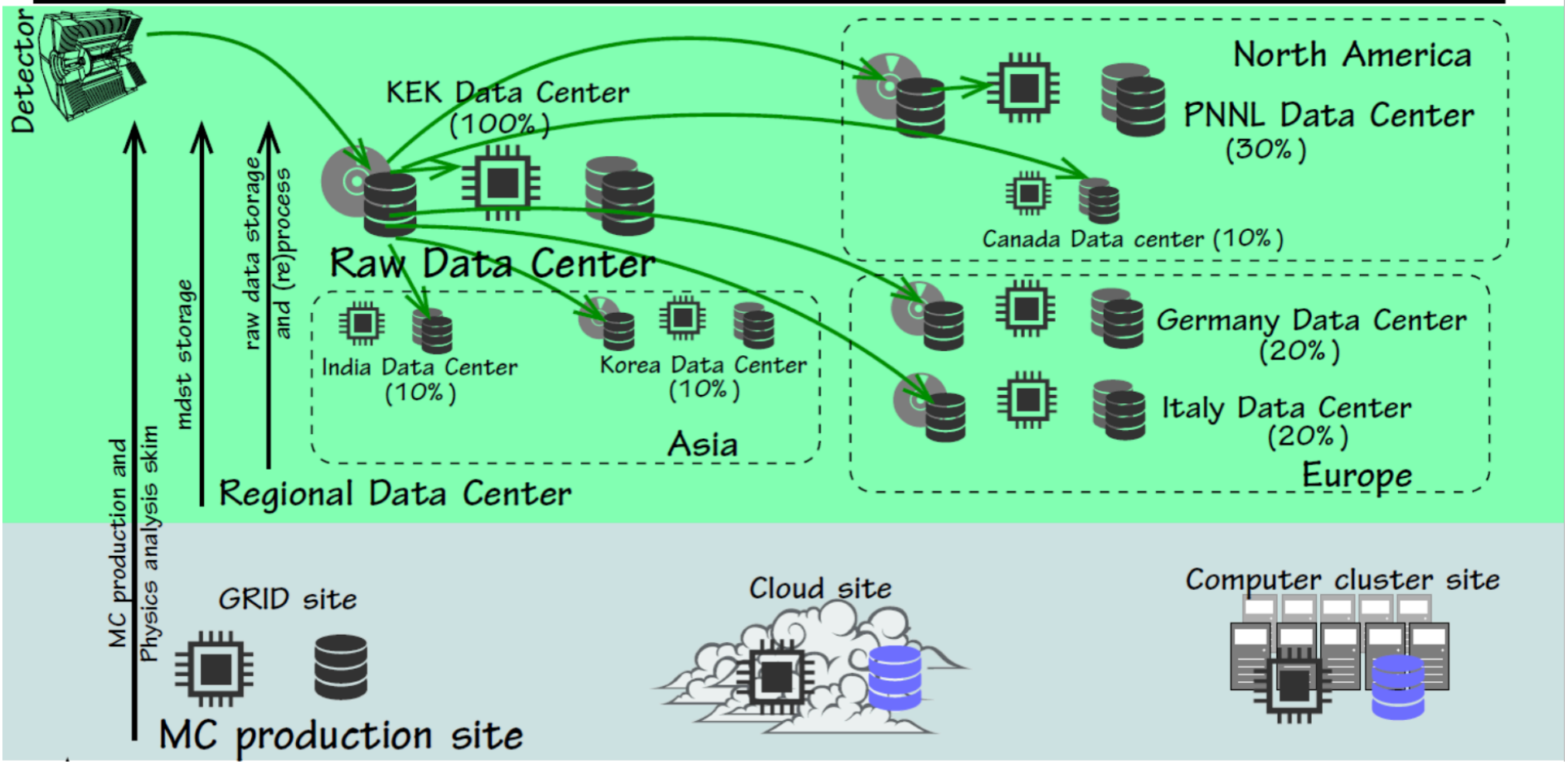
Belle-II relies on DIRAC

Computing Model

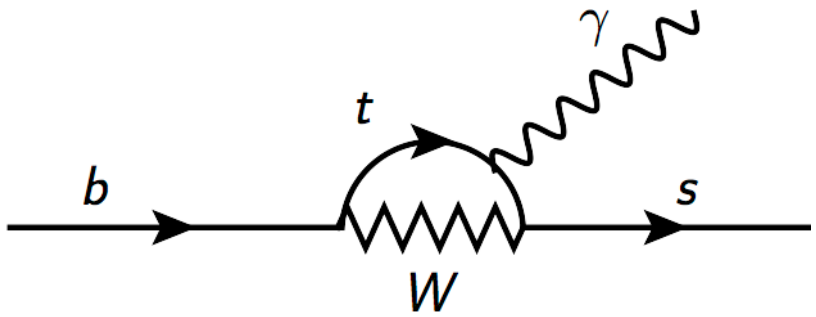
>10 PB of raw data per year

→ Distributed computing model

Share per fraction of PhDs

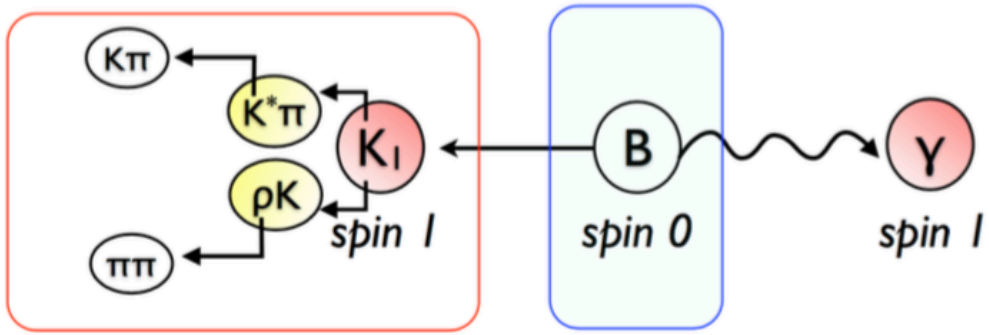


Main motivation : BSM



$$B \to K\pi\pi\gamma_{\leftarrow polarized}$$ (in SM)

$$polarized \rightarrow K\pi\pi \leftarrow B \rightarrow \gamma \leftarrow polarized$$



≥ 3 body final state needed

$$\mathcal{W}^{\gamma}(s_{13}, s_{23}, \cos\theta, \phi)_s \equiv a^{\gamma} + (-2a^{\gamma} + a_2^{\gamma}\cos 2\phi + a_3^{\gamma}\sin 2\phi)\sin^2\theta + b^{\gamma}\cos\theta$$

$a_i^{\gamma}/b_i^{\gamma}$: 3 Dalitz variable function

Wilson coefficients

$C_7'(\gamma_R)$ $C_7(\gamma_L)$

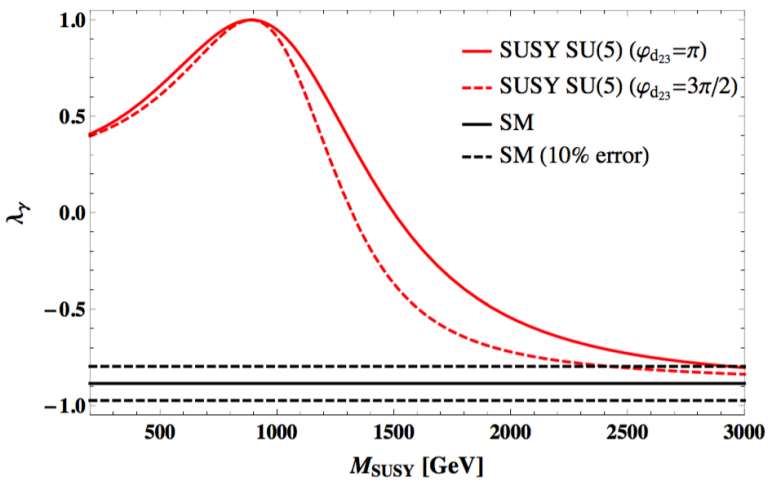
Large pQCD corrections

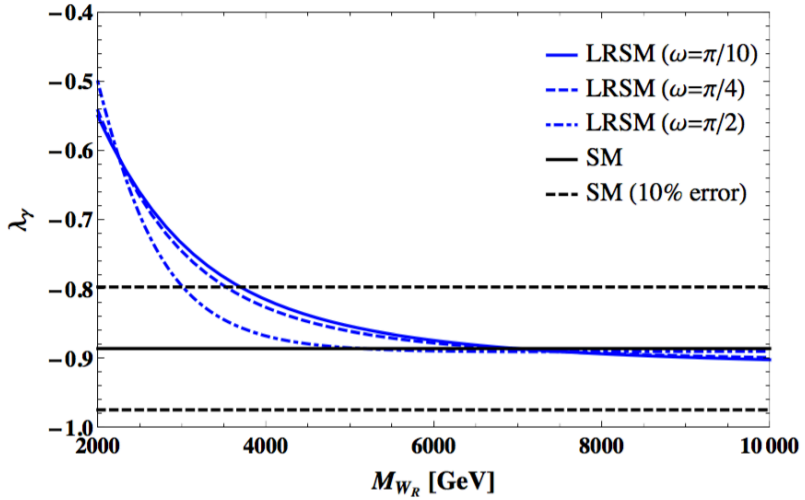
- **State of the art (Theory)**

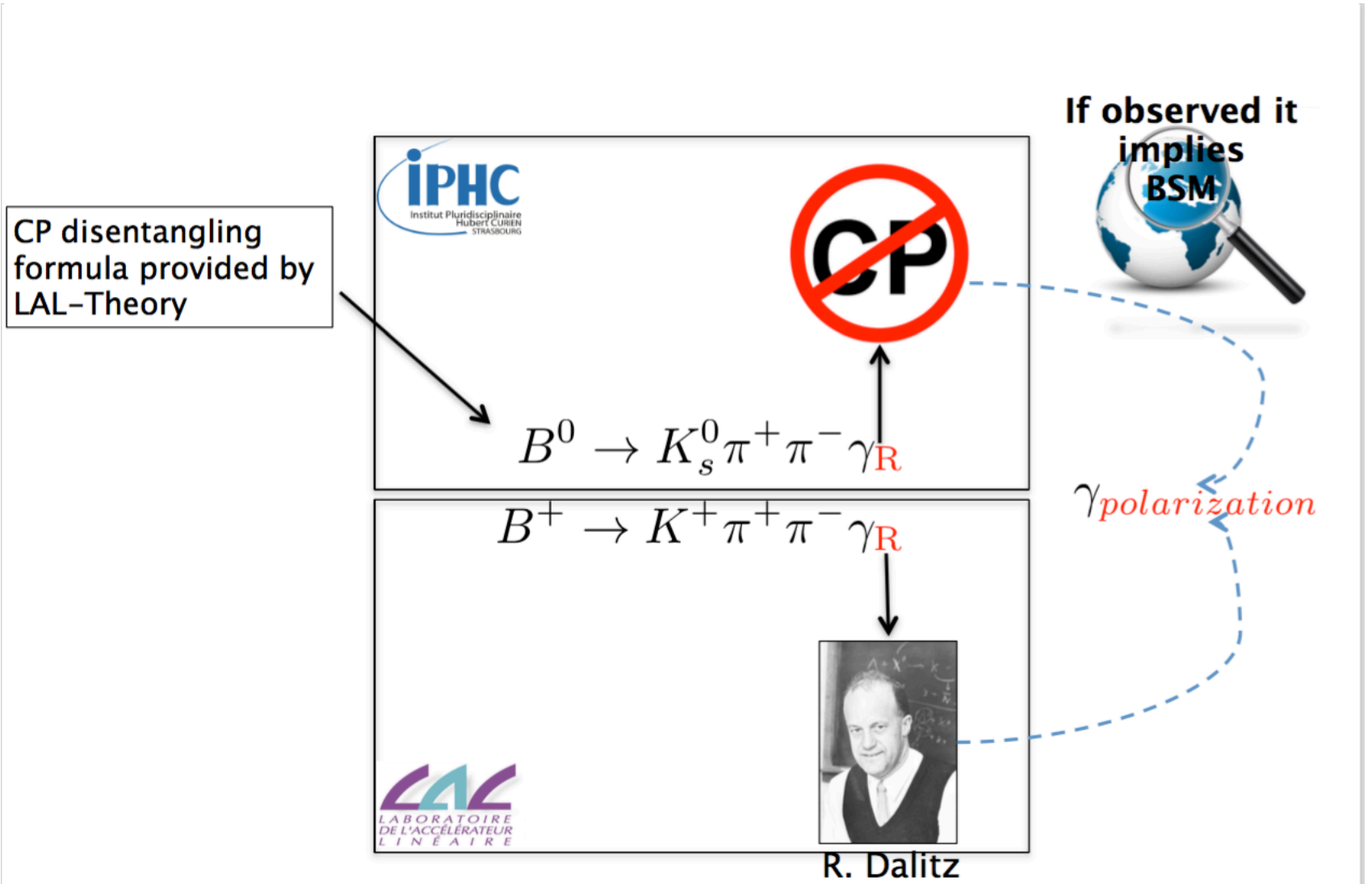
$$\lambda_\gamma = \frac{|C_7'|^2 - |C_7|^2}{|C_7'|^2 + |C_7|^2} \simeq -1 + 2\left|\frac{C_7'}{C_7}\right|^2 = -1 + 2\left(\frac{m_s}{m_b}\right)^2 |\delta|^2 \simeq -1 + 10^{-3}|\delta|^2$$

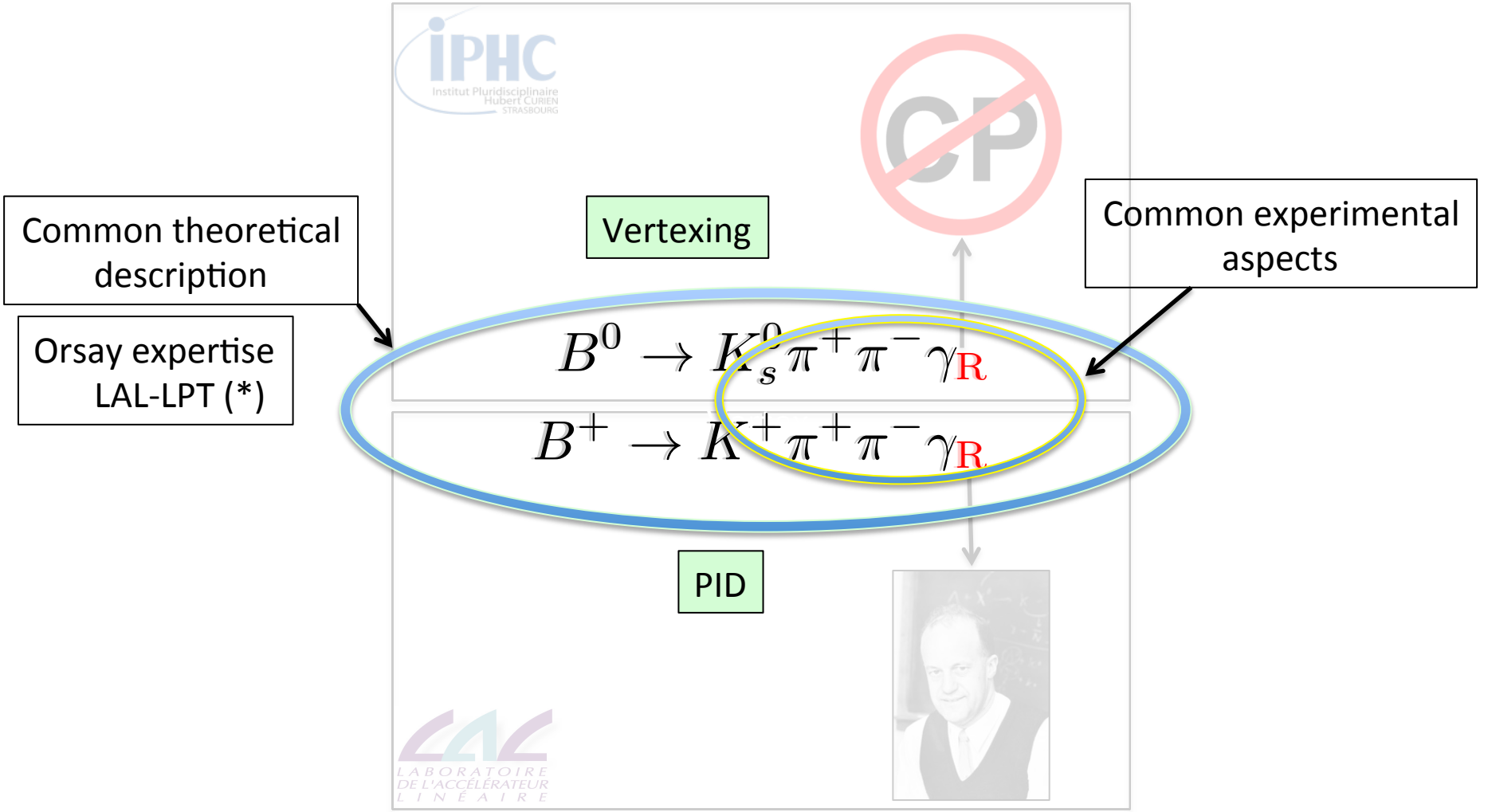
Non-pQCD $\delta_{K^*\gamma} \simeq 0.8(2)$

(guts feeling) $\lambda_\gamma(\mathrm{SM}) = -1$ at most at a few percents level






CP disentangling formula provided by LAL-Theory
IPHC
Institut Pluridisciplinaire Hubert CURIEN STRASBOURG
CP
$B^0 \to K^0_s \pi^+ \pi^- \gamma_R$
$B^+ \to K^+ \pi^+ \pi^- \gamma_R$
LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE
R. Dalitz
If observed it implies BSM
$\gamma_{polarization}$



(*) D. Becirevic, E. Kou, A. Le Yaouanc, A. Tayduganov

Bells and Whistles

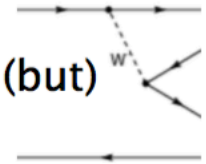
	# for (*) $2\ \mathrm{ab}^{-1}$
$B^0 \to K^0_s \pi^+ \pi^- \gamma_R$	1200
$B^+ \to K^+ \pi^+ \pi^- \gamma_R$	7000
$B^0 \to K^+ \pi^- \pi^0 \gamma_R$	1700
$B^+ \to K^0_s \pi^+ \pi^0 \gamma_R$	1600

(*) $\langle \epsilon_{\mathrm{sel}} \rangle_{\mathrm{BFactory}}$

and the same, but with $\gamma \to J/\Psi$

(laboratory to probe/constrain theory)

$\mathrm{Br} \times 40$ (but)

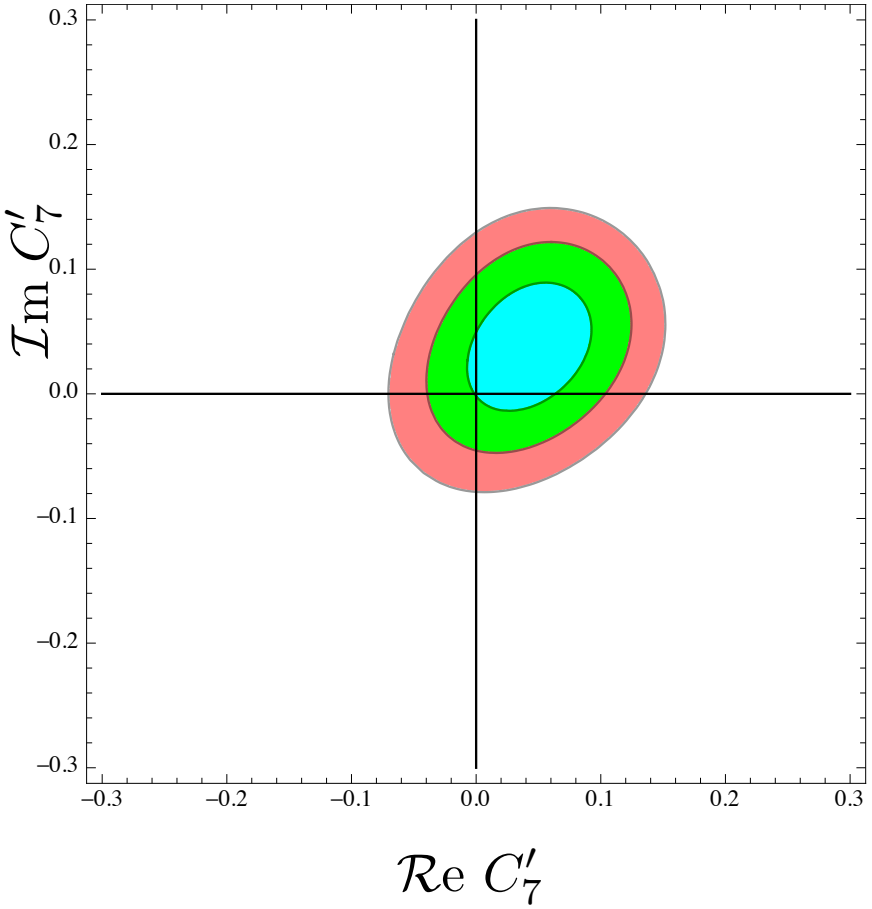


A.Tayduganov, EK, Le Yaouanc, 1604.07708

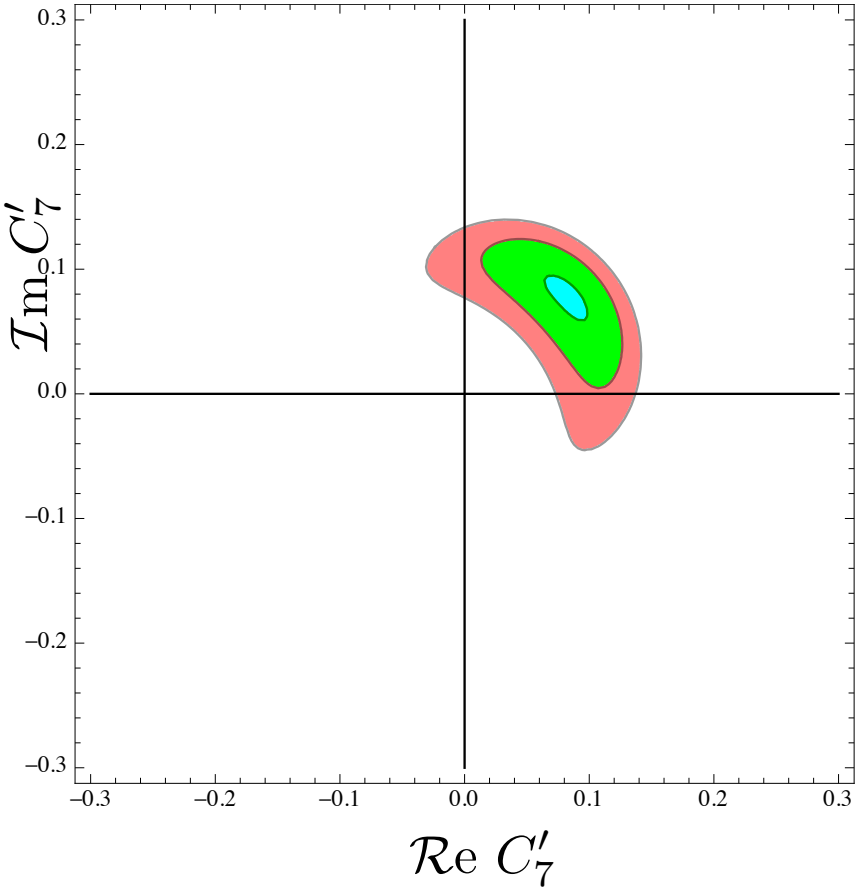
- Theoretical new idea to COPY the Dalitz plot from J/psi -> γ to remove the hadronic uncertainties
- New idea for statistic tricks needed (if succeeded, this has more application, more LAL contribution to fit package?!)!

$$
\begin{aligned}
A_{\rm T}^{(2)} &= -0.23 \pm 0.23 \pm 0.05 \\
A_{\rm T}^{\rm Im} &= +0.14 \pm 0.22 \pm 0.05 \\
S_{K_s\pi^0\gamma} &= -0.16 \pm 0.22 \\
{\rm Br}_{B\to X_s\gamma} &= (3.43 \pm 0.22)\ 10^{-4} \\
\mathcal{A}^{\Delta} &= -0.98 \pm 0.54
\end{aligned}
$$

Current Constraints



Room for ~ 70%



5 dimensional kinematical variables

1 night on laptop?!

Statistics tricks play ground!

5 parameter fit

$$E = \begin{pmatrix} 0.034 & -0.133 & -0.021 & -0.067 & 0.007 \\ & 0.040 & 0.260 & 0.630 & -0.320 \\ & & 0.019 & 0.395 & -0.470 \\ & & & 0.680 & -0.405 \\ & & & & 0.180 \end{pmatrix}$$

← Photon polarization
← K1(1270)/K1(1270) separation
← $(K\pi)_{s\text{-wave}}$ contributions
← K1 mixing angle c.f. (60±10)°
← Damping factor c.f. (4±0.5)

Preliminary result!

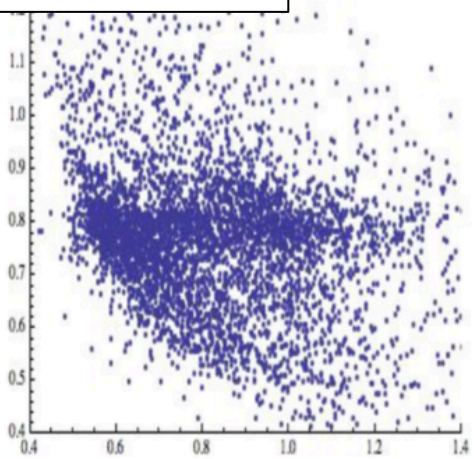
At ~3% level sensitivity to all 5 parameters (5k events)!

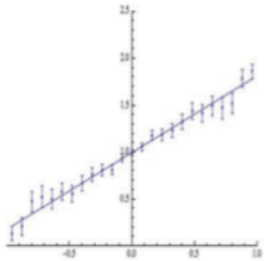
- Fast fitting time -> many theoretical checks possible
- This trick can be applied to many other places (LAL contribution to fit package)

E. Kou & F. Le Diberder

First Look 2016

Matrix Element Method





Some tricks are similar to the ones used for the measurement of the tau polarization at LEP

$\sim 2\ \mathrm{ab}^{-1} \simeq 2020$

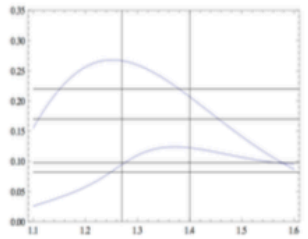


Figure 23: The widths Γ as a function of s (GeV^2).

$$\begin{bmatrix} v_0^{\text{fit}} & \Gamma_{\text{cst}}^{\text{data}} & \Gamma_{(s)}^{\text{data}} \\ \Gamma_{\text{cst}}^{\text{theory}} & 0.782 & 0.829 \\ \Gamma_{(s)}^{\text{theory}} & 0.773 & 0.834 \\ \delta v_0 & -0.009 & -0.005 \\ \langle \delta v_0 \rangle & -0.003 & +0.006 \\ \sigma_{\delta v_0} & 0.010 & 0.010 \end{bmatrix}$$

Internship report (Laboratoire de l'Accélérateur Linéaire, 16 August - 28 October 2017)

Studying the photon polarization with $B \to K\pi\pi\gamma$ angular analysis in the Belle II Experiment

Author:
Borys KNYSH

Supervisors:
Dr. Francois LE DIBERDER
Dr. Emi KOU

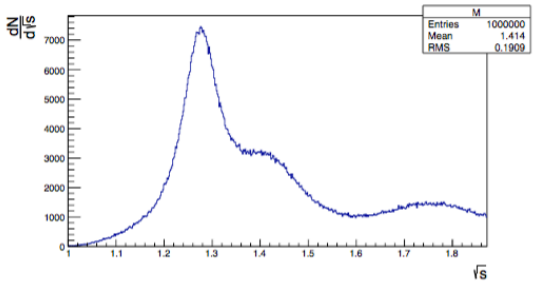


Figure 3. *Simulation with neutral mode* $K_{res} \to K^0\pi^+\pi^0$.

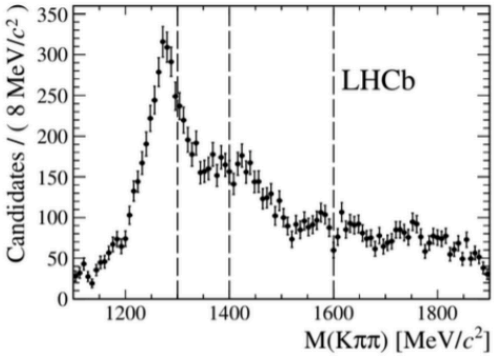


Figure 4. *LHCb plot [5]*

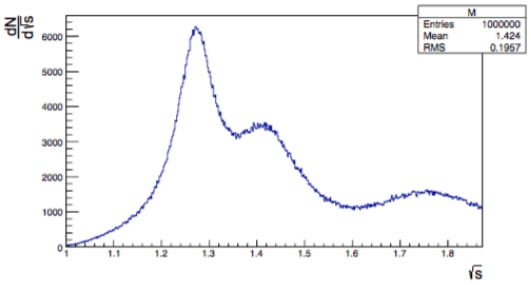
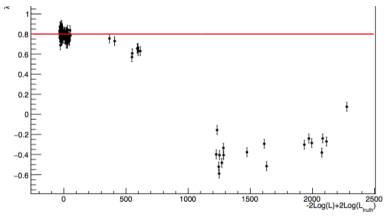


Figure 5. *Simulation with charged mode* $K_{res} \to K^0\pi^-\pi^+$.



(<- started to tackle multiple solutions
and performed model independent fit ->)

Figure 10. λ vs. ΔL : huge χ^2-values are observed

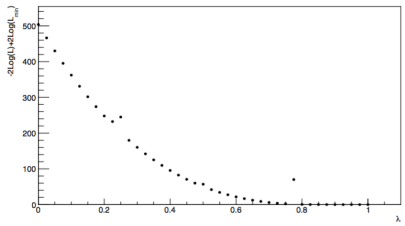


Figure 7. $\lambda_{min}|_{\chi^2=2.7} \approx 0.75$ *with splitting phase space*

The "GamaPola" software

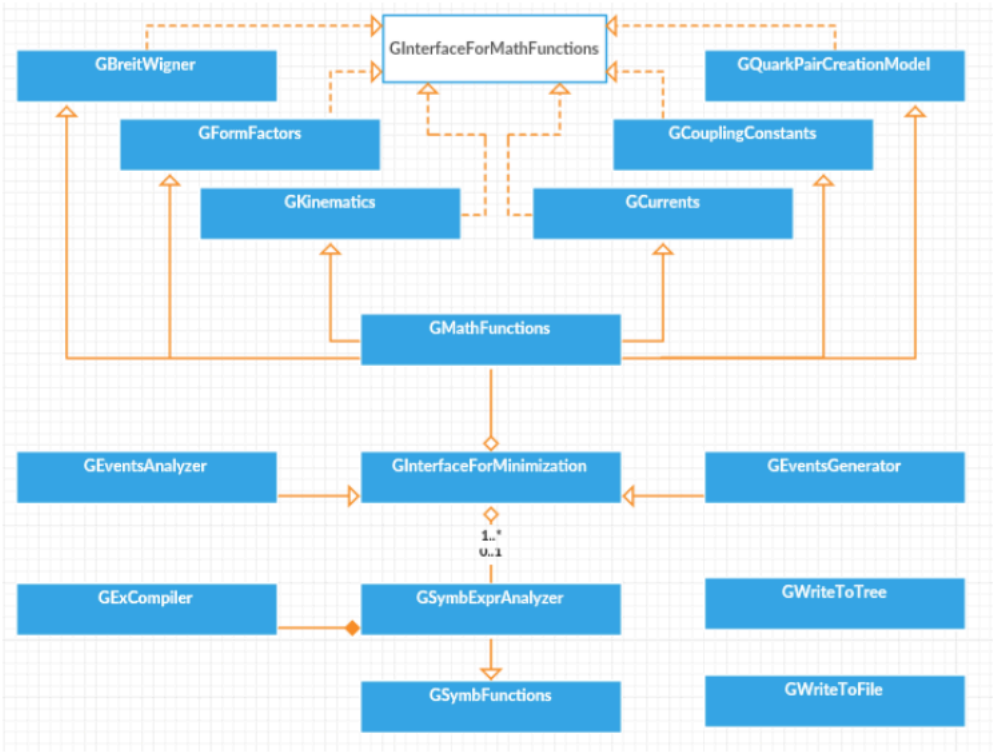
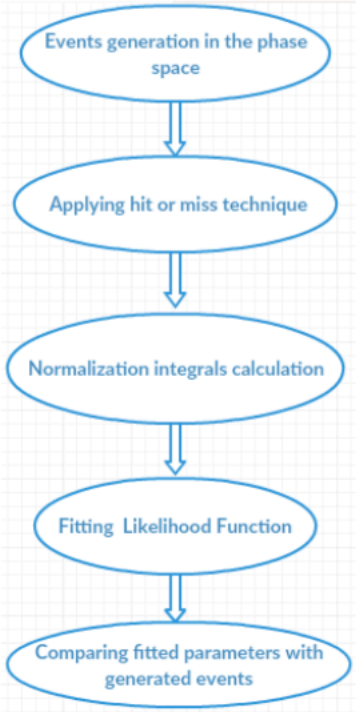


Diagram of the classes of used software

How it works?



Simplified algorithm

Summary : Belle-II started in France

DAQ upgrade ?

SVT upgrade ?