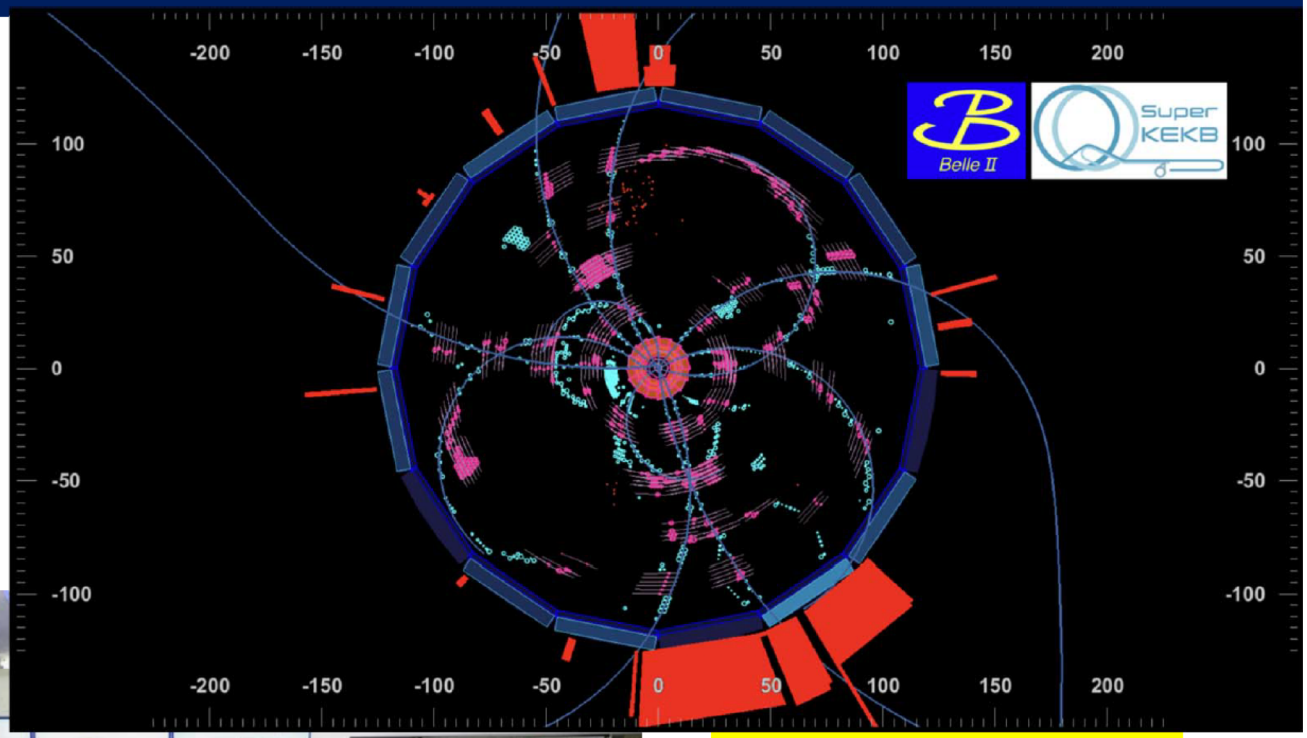
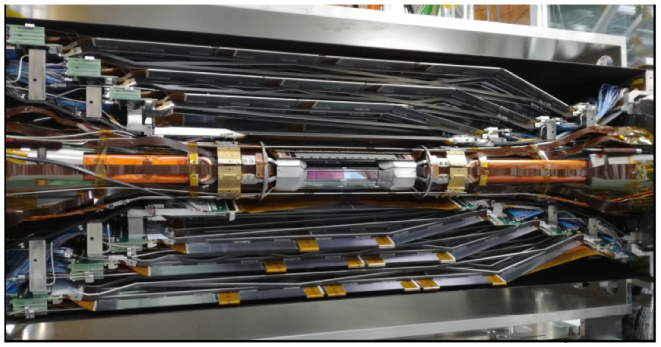
KEK
High Energy Accelerator Research Organization

Phase 3 run started



25/March/2019



S. Bettarini per il gruppo Belle-II Pisa

2 Luglio 2019 - **Preventivi 2020**

SVD in run3 (25/3→1/7)

New SVD leadership
Giuliana Rizzo (Pisa) System Manager
Katsuro Nakamura (KEK) Deputy

- VXD installed in Belle-II in Dec. 2018
- Smooth and stable SVD operation throughout the spring run
- Excellent performance (next slide)

SVD background situation

– Currently the occupancy is ~< 0.3% in physics runs
– Preliminary scaling of the current value gives 1.5% in 2020 (x5) and 2.7% in 2021 (x9)
– Occupancy limit for good tracking performance is 2-3%

Some ISSUES encountered during operations:

- Current increased on a sensor (L6.14.2) when SuperKEKB switched to continuous injection.
  (effect already seen in BaBar-SVT).
  Mechanism understood: surface charge accumulated on L6 p-side and increase of the electric field at the junction side (together with a sensor defect) causes the current increase.
  A mitigation strategy (involving a modified HV configuration) now in place.

- Low voltage power supply board failures happened on three boards so far and required replacement/repair;

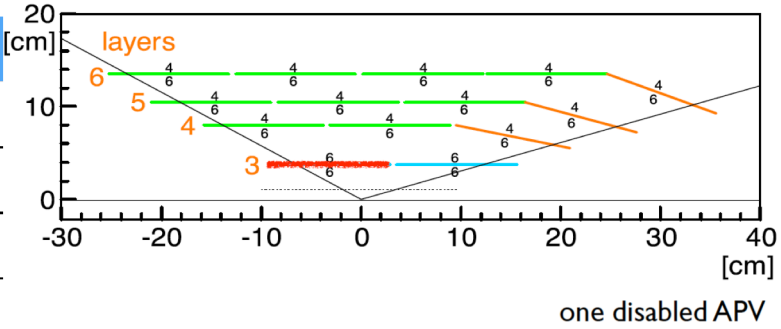
- Radiation accidents following QCS quenches on May 28, Jun 6 and Jun 9.
  Very scary – created O(10) new pinholes but luckily otherwise no permanent damage in SVD!

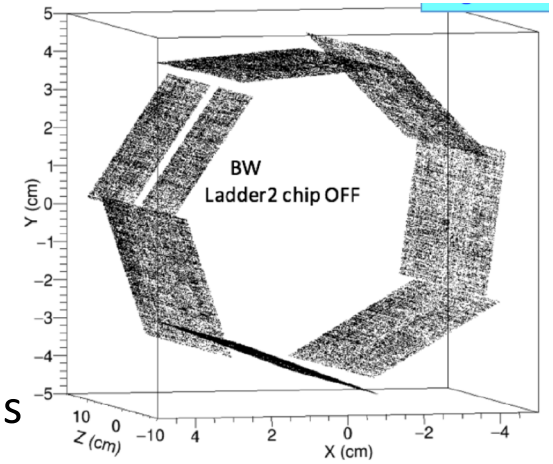
SVD performance

Detector response to particles is excellent

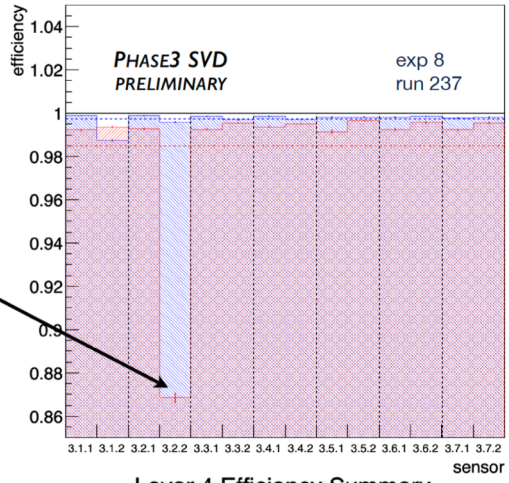
- 1! APV chip disabled (1.2% layer3 dead area)
- 1% masked strips
- energy and signal-to-noise-ratio (>15) in agreement with expectations
- efficiencies above 99% on average and for most of the sensors

efficiency	u/P	v/N
layer3	(99.72 ± 0.04)%	(98.47 ± 0.06)%
layer4	(99.66 ± 0.04)%	(99.34 ± 0.09)%
layer5	(99.61 ± 0.08)%	(99.4 ± 0.1)%
layer6	(99.2 ± 0.2)%	(99.3 ± 0.2)%

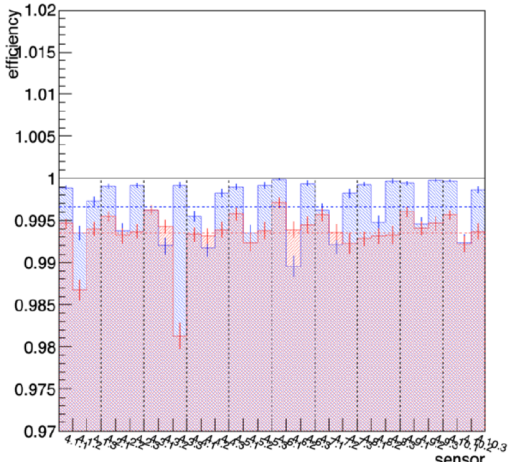


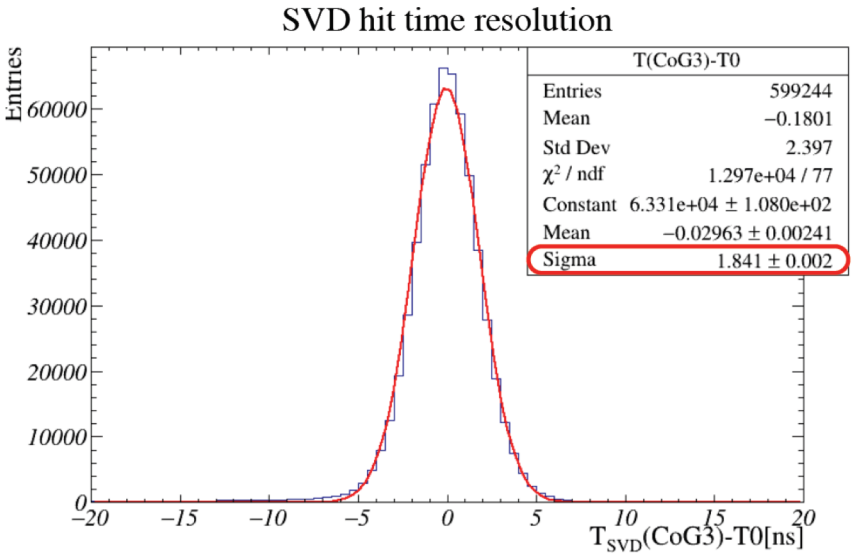


Layer 3 Efficiency Summary



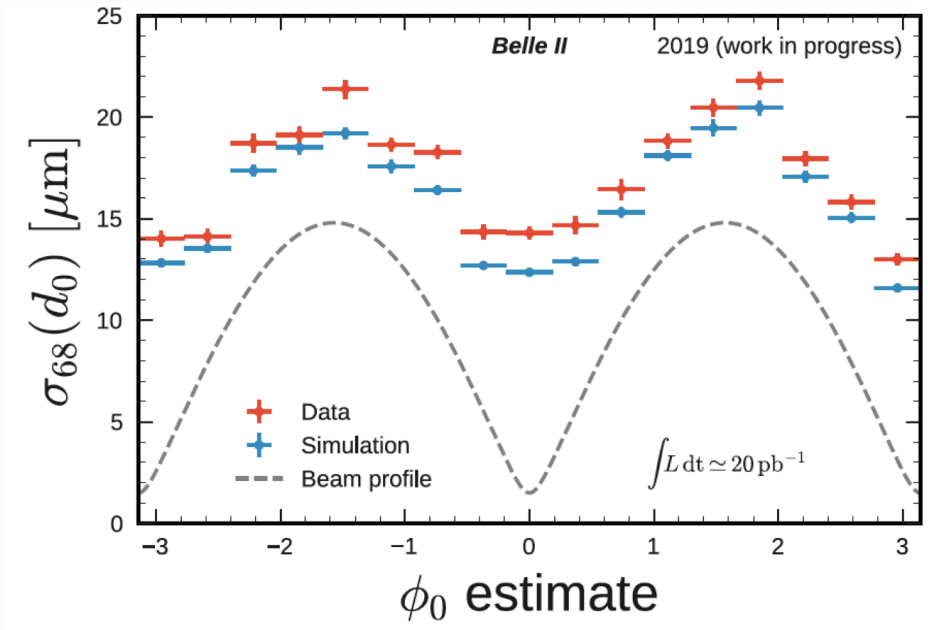
Layer 4 Efficiency Summary

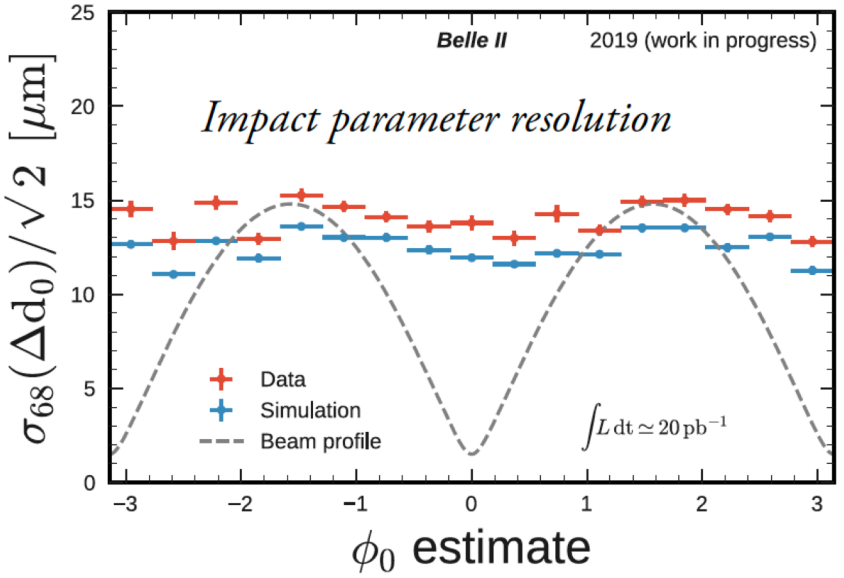




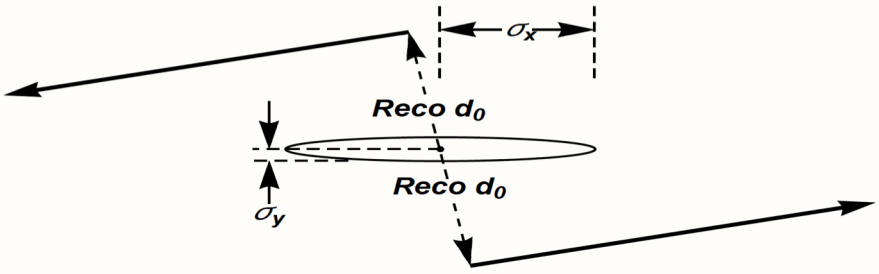
SVD hit time resolution better than 2 ns in Bhabha events. (w.r.t. CDC T0)

Impact Parameter Resolution

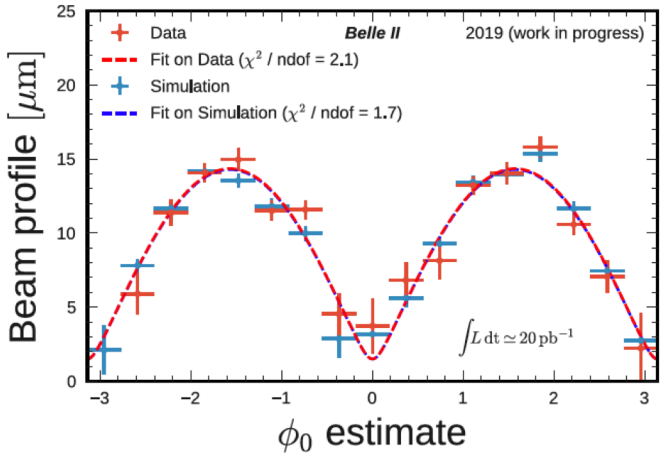




Impact Parameter



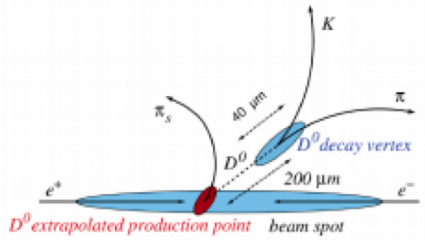
$$\sigma d_{0\text{meas.}} = \sigma_x \sin\varphi_0 \oplus \sigma_y \cos\varphi_0 \oplus \sigma d_{0\text{intrinsic}}$$



The resolution on the impact parameter on data is better than 15 µm

Data agree with MC within 15%

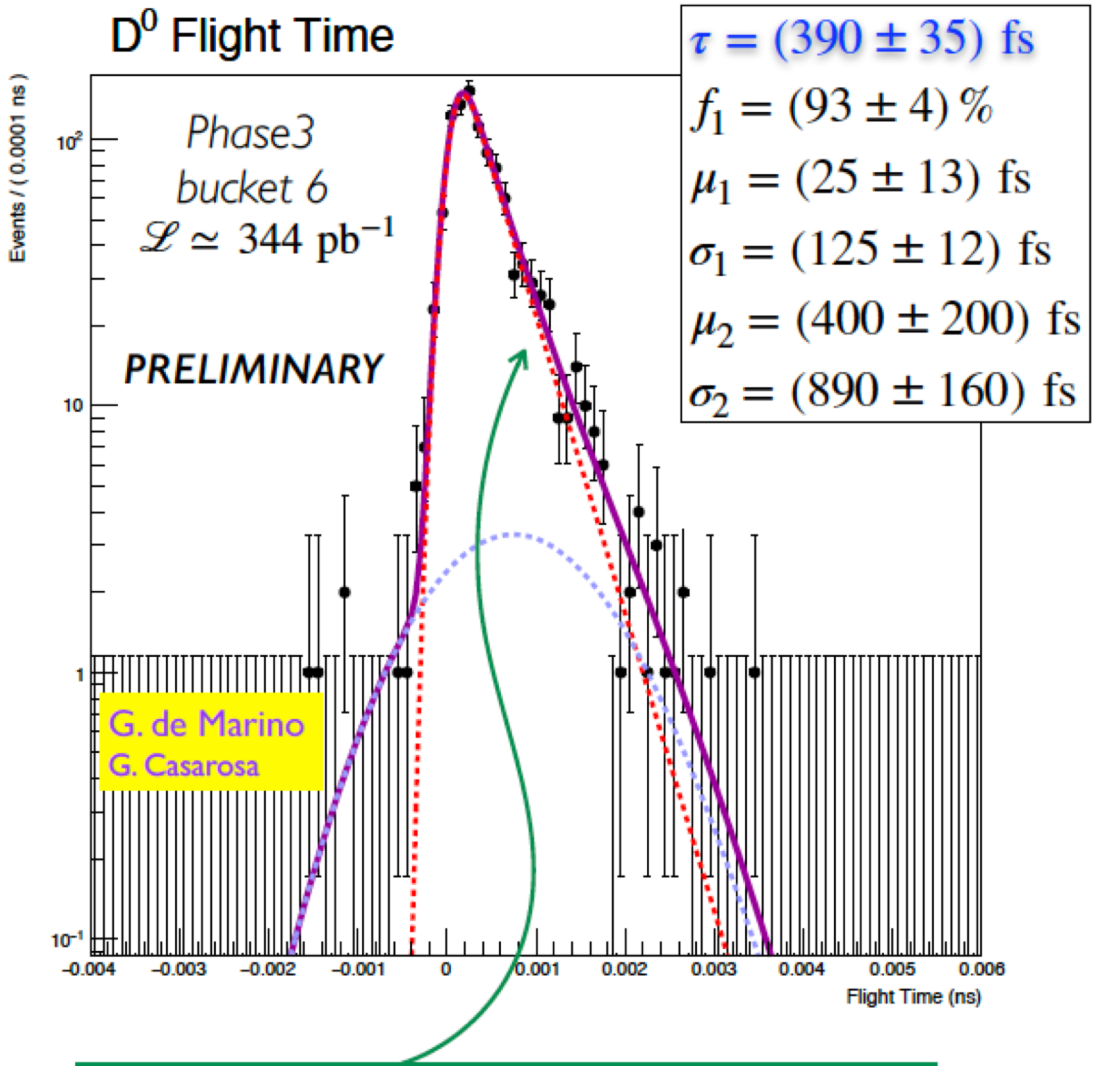
First Evidence of the D⁰ lifetime



Note: Figure not in scale

$D^{*+} \to D^0\pi^+$, $D^0 \to K^-\pi^+$

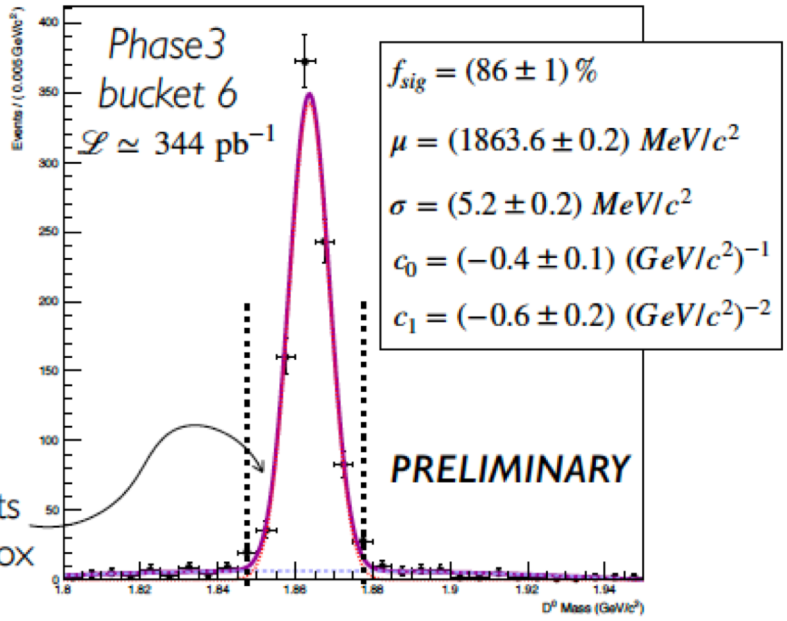
- *D^* calibration monitoring skim*
- *tracks from IP*
- *PID > 0.2 for D^0 daughters*
- *at least one PXD hit for both D^0 daughters tracks*
- *p_{CM} (D^*) > 2.5 GeV/c*
- *TreeFitter with measured IP and m(D^0) constraints*
- *signal region:* $m_{D^0} \in [1.848, 1.878]\ GeV/c^2$, $Q \in [4.54, 7.18]\ MeV/c^2$



clear exponential decay confirming the excellent resolution achieved with the Belle II VXD!

$\tau_{PDG} = (410.1 \pm 1.5)$ fs

D⁰ Mass



5% bkg events in the signal box

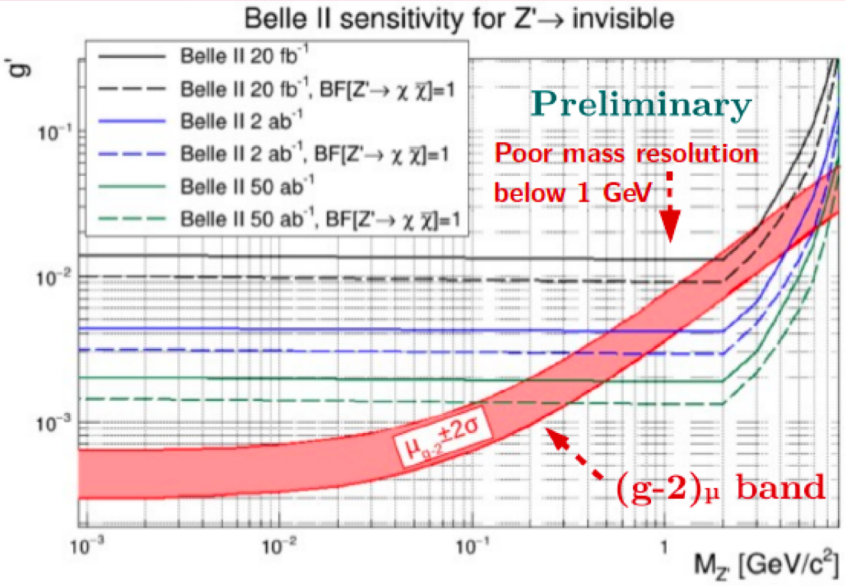
Z' to Invisible: Experimental Signature

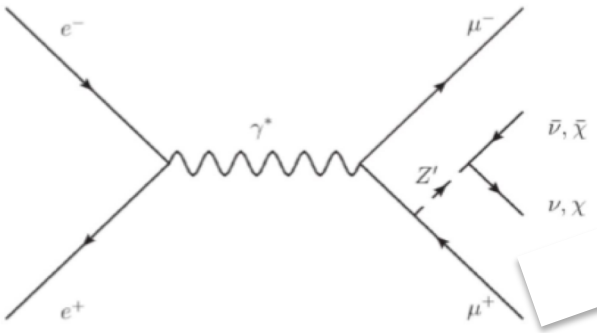
- Reconstruct the recoil against a $\mu^+\mu^-$ pair and looks for a peak in the recoil mass spectrum. (Additionally require nothing in the rest of event)
- Simulated and reconstructed several Z' masses between 0.1 -10 GeV
- Backgrounds mainly from radiative QED processes:

$e^+e^- \to \mu^+\mu^-(\gamma)$

$e^+e^- \to \tau^+\tau^-(\gamma)$

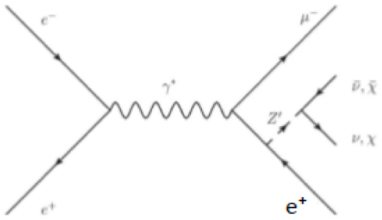
$e^+e^- \to \mu^+\mu^- e^+e^-$





- The above upper limits (90% CL) take into account the calculate Z' cross section, signal efficiencies and background rejection (the selection is NOT optimized yet)
- Visible decays of Z' → $\mu^+\mu^-$ will be competitive in Phase 3 (currently lead by BaBar measurement)

Z' LFV



Look for bumps in recoil mass against a $e^+\mu^-$ pair

LFV Z' (eμ coupling)

$e^+e^- \to e^+\mu^- Z'$; Z' → invisible

$e^+e^- \to e^+\mu^- Z'$; $Z' \to e^+\mu^-$ (no SM background)

Internal document under review:

Search for an invisible Z' in $e^+e^- \to \mu^+\mu^-$ + missing energy final states and background measurement for a search for a Lepton Flavour Violating invisible Z' in $e^+e^- \to e^+\mu^-$ + missing energy final states with Phase 2 data

M. Bertemes,[1,*] M. Campajola,[2,3,*] L. Corona,[4,5,*] G. De Pietro,[6,7,*] E. Graziani,[7,*] G. Inguglia,[1,*] A. Martini,[6,7,*] I. Komarov,[8,*] and L. Zani[4,5,*]

UWG

Convener:
F. Forti

Belle II upgrade Working group organization

The Upgrade working group is formed by representatives of all the detector subsystems and has the mandate to coordinate activities to answer the following questions:

1. Check the impact of $L=5 \times L_{design}$ ($4 \times 10^{36}/cm^2/sec$) on Belle II
2. Review technical solutions for sub-detectors that cannot withstand the expected background levels.
3. Evaluate how much the luminosity can be increased before major detector upgrades are required
4. Observe what machine group will propose as their upgrade plan, and try to accommodate as long as possible

Use 2019 phase 3 data to understand limitation of current subdetectors at higher luminosity

- Up to Belle II design luminosity
- Beyond design luminosity
- Robustness of subdetectors against bursts, quenches, injection noise, etc.
- Trigger limitations in subsystem electronics

Examine technical solutions to extend the detector capability and robustness

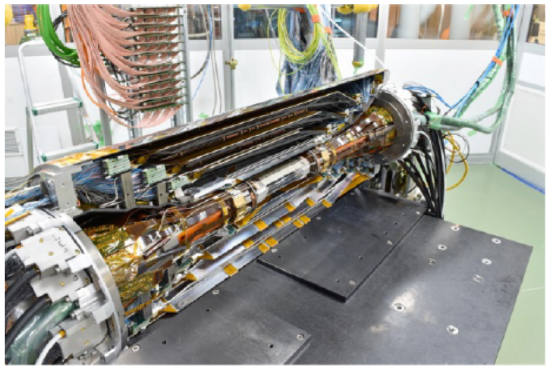
- Short terms: 2-3 years
- Medium term: 4-6 years
- Long term: x5 luminosity upgrade

Explore machine upgrade options and challenges

VXD upgrades

Open Workshop on VXD technologies, CERN 8-10/7/2019

https://indico.cern.ch/event/810687/

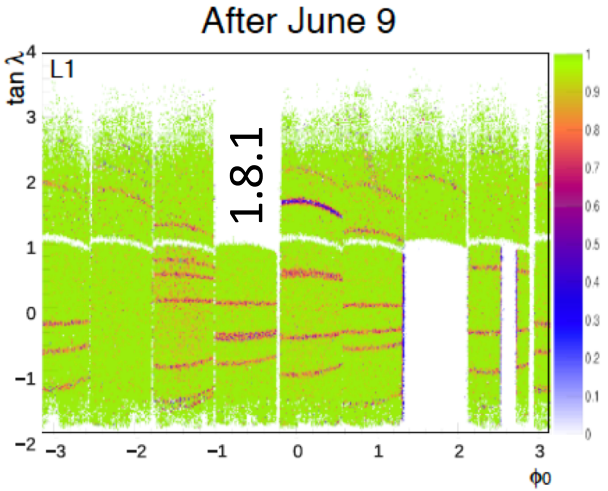


QCS quenches

- QCS quench - [Type-2]
- The event was very fast and no omen.
- The second quench (6/9 22:11) was very severe.
  - ~150 mA out of 660 mA was lost until the beam abort.
  - High radiation dose damaged PXD.
  - Collimator head of D02_V1 (V-type collimator, just upstream of IP) was heavily damaged. (~1.7 mm from beam)
  - Liquid He of QCSR was completely evaporated.
- The stored beam was steered or blew up suddenly!

- The same damage to that in Phase-2.

Damage caused in PXD



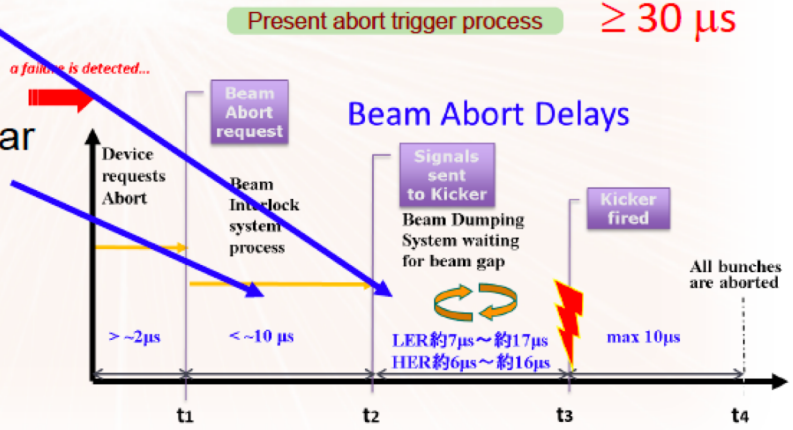
- LER lost ~150 mA within 40μs ⇒ damaged D02V1, QCSR quench and 3 rad accumulated dose
  - all modules triggered OVP
- Module 1.8.1 inoperable: current between clear and gate

[Countermeasures]

- We are considering to shorten the time lag between the abort trigger and the kicker firing, but it is not so easy.

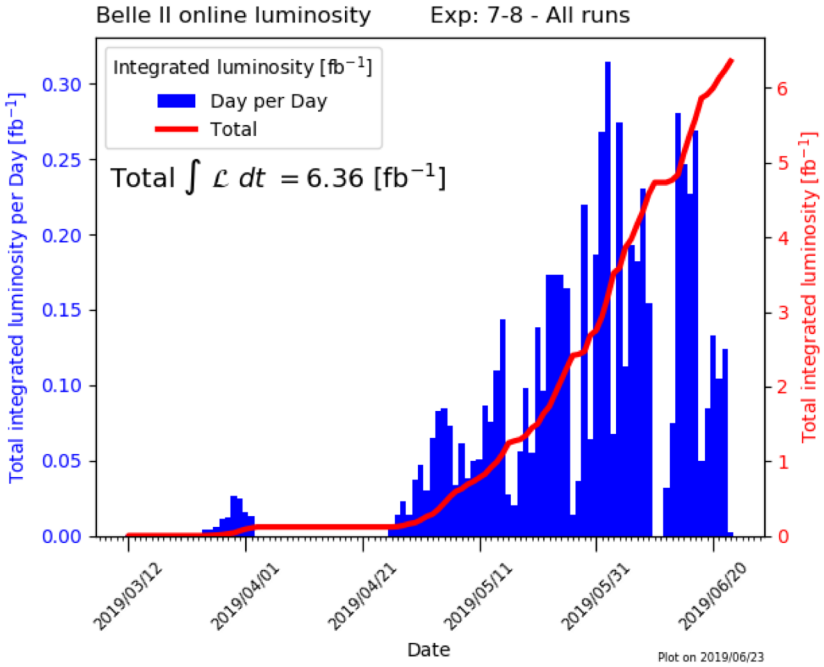
For example,

- Increase the number of abort gaps (~5 μs)
- Detect beam loss near to the kicker system.



Luminosity

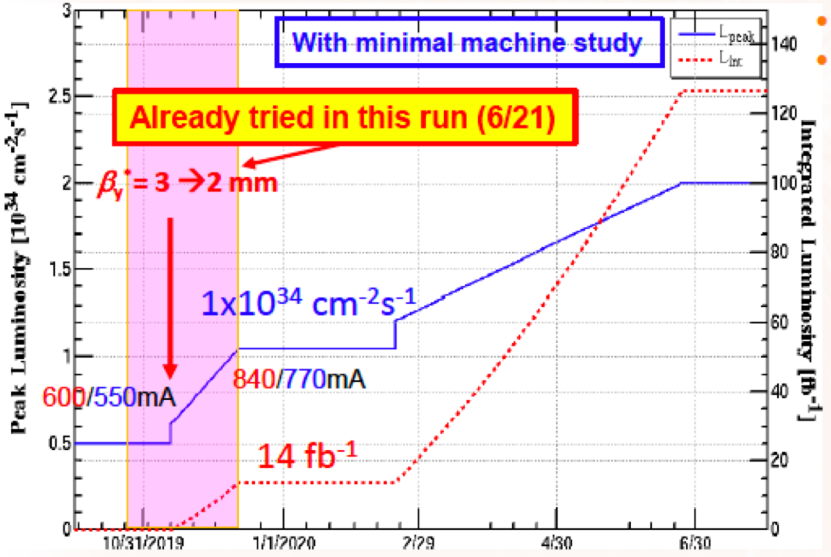
On June 30 SuperKEKB instantaneous luminosity exceeded 10^{34} $cm^{-2}s^{-1}$ during machine study (detector HV in standby)
Beam currents:
I_{LER}=704 mA and I_{HER}=710 mA, #bunches = 1576, beta_y^*=2mm, beta_x^*=80mm.



Commissioning plan

- Autumn run
- 2019 Autumn run will start on 15th, October and will end on 12th, December.
  - Continue the physics run and machine tunings.

Conservative luminosity projection (2019/10-2020/6) [Morita, 2019/6/14]



Potentials:
- Acceleration of β squeezing timing
- Improvement in beam-beam parameter
- Fill pattern optimization

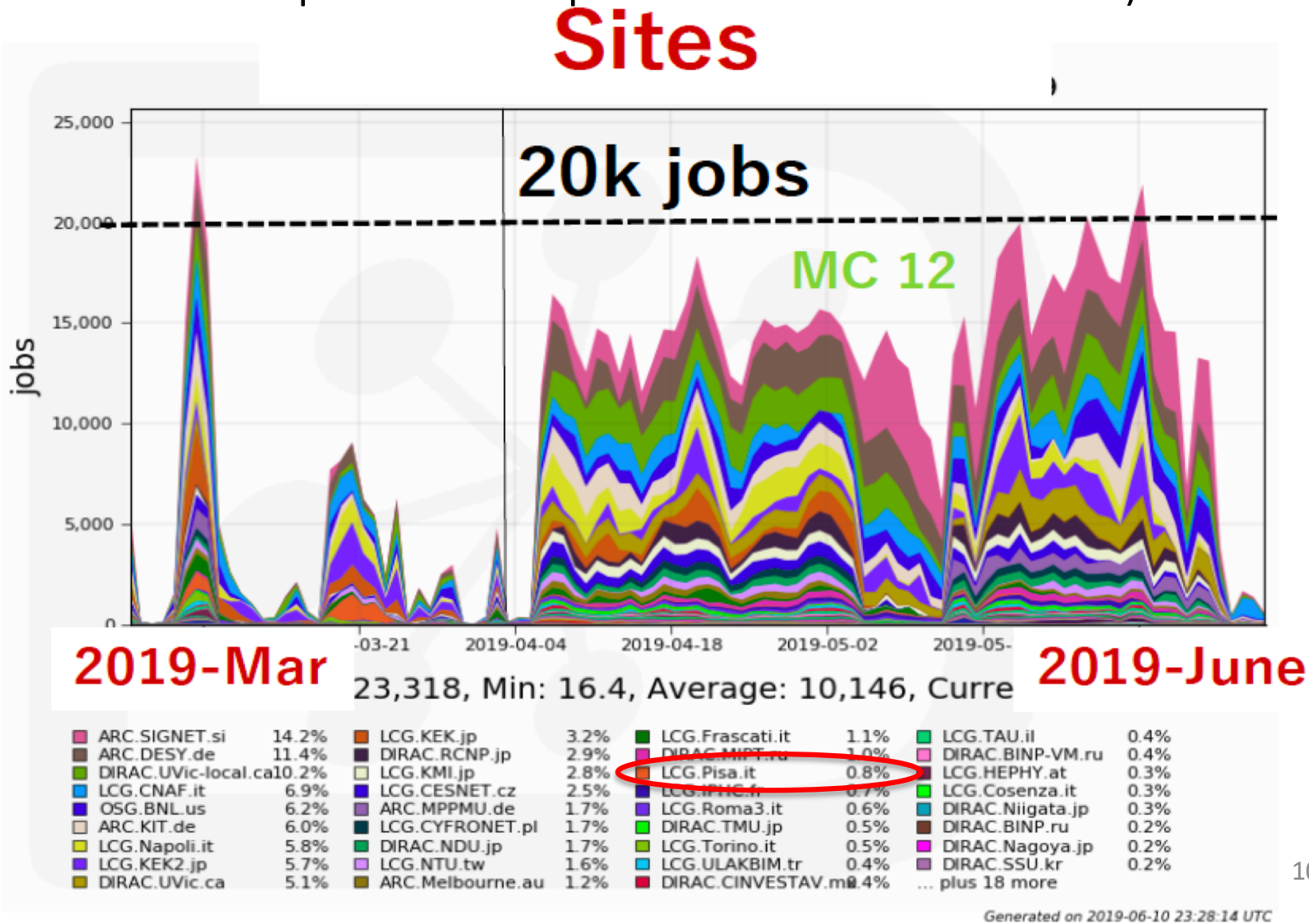
Assumptions
- **Operation modes**
  - Start up: 2020/10/15 - 2019/11/11
    - Vacuum scrubbing: 3 weeks
    - Collision tuning (β_y^* = 2.0 mm): 1 week
  - Luminosity run: 2020/11/11 - 2020/12/12
- **Total occupancy rate ~65%**
  - Available operation time : 90%
  - Occupancy rate of machine: 85%
  - Occupancy rate of Belle II DAQ: 85%
- **Luminosity**
  - Increase in luminosity: Sqrt[3/2] -> (3/2)
  - Beam-beam parameter limit: no increase
  - Beam current: 1.4 times until 2019 end
  - No machine study time

Integral Luminosity Plan:

- 13.9 fb-1
  2019-10 → 2019-12
- 112.8 fb-1
  2020-01 → 2020-07

Computing in Pisa

- Pisa sede della farm interattiva di Belle2-IT
- La produzione di MC «limitata» dallo storage disponibile (entro luglio prevista installazione spazio disco acquisito con fondi dedicati 2018)



Pisa Manpower 2020

N	Nome	Posizione	%	Responsabilita'
1	Batignani G.	PO	50	
2	Bettarini S.	PA	100	Resp.Loc. & SVD-IT coord.
3	Casarosa G.	RTDA	100	SVD SW Coord., Charm Phys. Coord.
4	Corona L.	PhD Student	100	
5	Forti F.	PO	100	Belle2 Upgrade, QCG-SVD
6	Paladino A.	Ass. Ric. Unipi	100	
7	Paoloni E.	PA	50	Tracking Coord.
8	Rizzo G.	PA	100	SVD manager
9	Vicarelli L.	Ass. Ric. Unipi	20	
10	Wiechczynski J.	Ass. Ric. INFN	100	SVD unpacker
11	Zani L.	PhD Student	100	Analisi e SVD-SW tools
			9,2	Tot. FTE phys.
			84	<%> phys.
	Mazzoni E.	Techn INFN	20	computing PI

Vedi richiesta per Techn INFN A.T. /prog. mecc.

Laureando (magistrale in Fisica): G. De Marino

Richieste economiche 2020

System	Sede	capitolo	Cat	Motivazione	[kE]	sj?	anticipo	Descrizione
SVD	PI	missioni	D	Turni di sotto-rivelatore (SVD)	7			SVD 1 local shifter (8.5 mesi: startup+running) * frazione Pisa/All-SVD (~13%) = 1.1 m.u. (33 gg, turni shifter locale di 3-4 gg consecutivi ciscuno, ~5 persone impegnate)
SVD	PI	missioni	C	SVD manager	5			G.Rizzo
SVD	PI	missioni	D	SVD commissioner durante la presa dati (I semestre 2020)	24			4 m.u. fisico/a
SVD	PI	manut	D	Manutenzione annuale Power Supply crates, boards e PDP di SVD	6		no	ordine inserito nell'accordo quadro INFN-CAEN. III anno di attivazione.
SVD	PI	apparati	A	Boards spares SVD (3LV, 1HV, 1Vsep)	20		si	come da offerta updatata CAEN (-> ordine diretto per esistenza di accordo quadro)

Physics	PI	missioni	C	Charm Physics Convener	5			responsabilità Casarosa
Tools	PI	missioni	C	Tracking Convener	5			responsabilità Paoloni
(PHT)	PI	missioni	A	3 F2F Tracking meeting in EU	8			3 meeting x 4 persone a 0.7kE (richiesta by EP 2020)

Richieste di metabolismo su consumo/missioni come da algoritmo Gr.I
Richieste di turni generali rivelatore (8 mesi di running) su sede del Rappr. Nazionale (PISA~20% tot Belle2-IT →12 kE)

Richieste ai servizi di Sezione

Amm.ne:

- il progetto Jennifer2 (2019-2023) richiede il monitoring/resoconto dei secondments;

Alte tecnologie:

- 2 settimane di missione per due tecnici a KEK: la baseline non prevede interventi nel 2020 (installazione PXD e TOP nel 2021); possibile interventi sull'SVD, cabling e/o i Power Supply;
- Coinvolgimento del servizio per attività su u-channel cooling nell'ambito dell'upgrade a pixel del VXD; riprendere l'attività fatta per SuperB: simulazioni termiche, progettazione struttura meccanica di supporto e cooling, test sperimentali su primi prototipi nel lab. TFD: Bosi, Massa 30%.