Phase II Running and Plans

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Belle II Italia

Torino, 23-24/5/2018

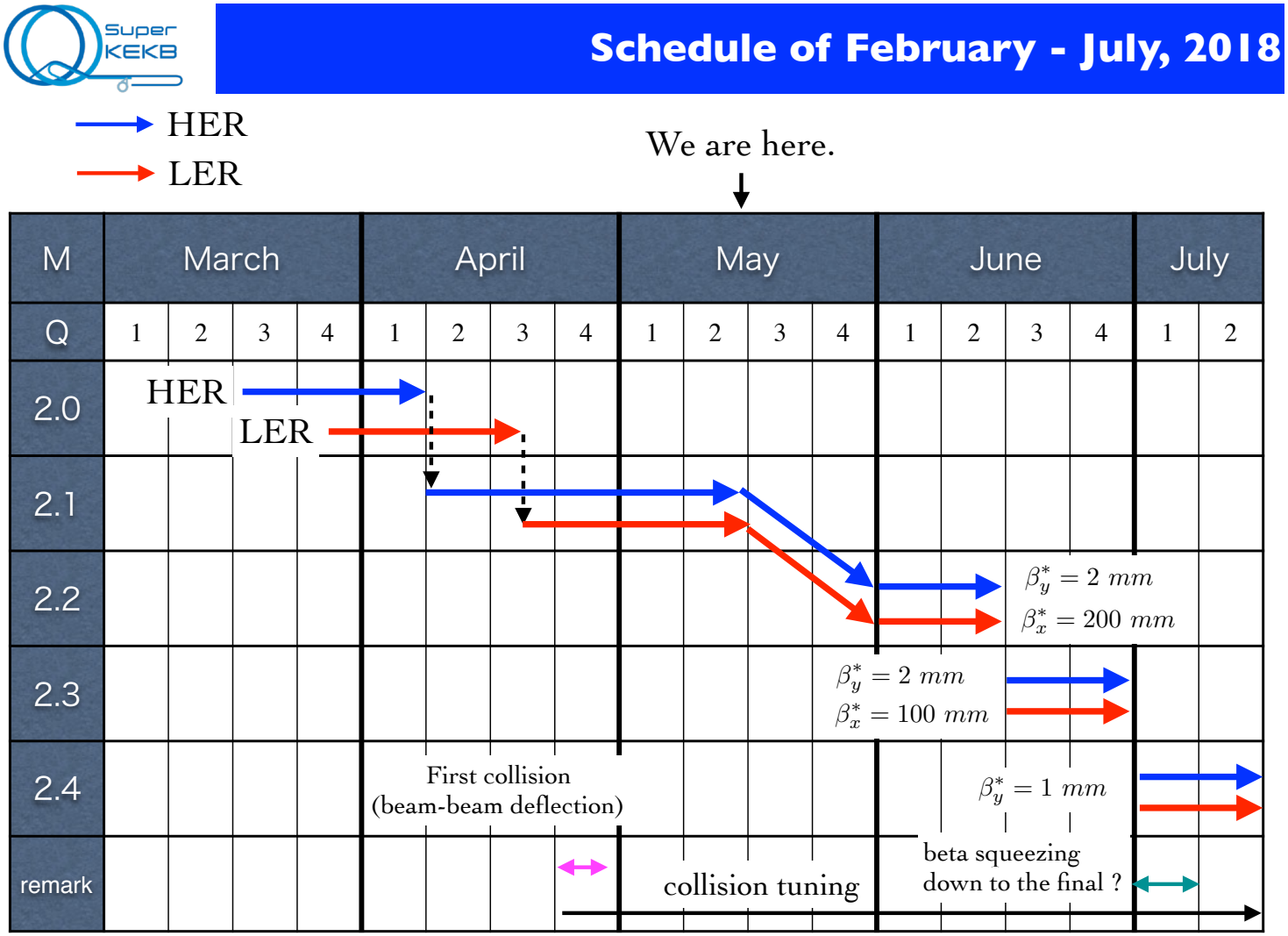
Outline

- Machine Issues and plans
- Detector Issues and plans
- Requirements to close Phase II and move to Phase III
- Scenarios

Machine plans

Ohnishi – 11 May 2018

Schedule of February - July, 2018



Machine plans

Verification of nano-beam scheme

- Beta squeezing is a Top priority. Vertical beta function at the IP is constrained by bunch length in the ordinary scheme, however, "nano-beam" scheme is different. We try to make the vertical beta down to much smaller then bunch length, for example $\beta_y^* = 2$ mm while the bunch length is about 6 mm.
- Squeezing beta will be adiabatic.
  - β_y^* = 8 (now) -> 6 -> 4 -> 2 mm
  - And also the specific luminosity should be higher and/or larger beam beam parameter in the vertical direction than **0.03** at least.
- Toward 10^{34}
  - Increase beam current and luminosity tuning
  - "Luminosity Run" is very important.

Plan (cont'd)

Belle II beam background

- Background study is also Higher priority.
- Background monitor is very important in the control room.
  - We want to use not only injection efficiency but also background information for the injection tuning.
  - Diamond sensors, CLAWS, …., CDC occupancy, hit rates, dark current, ECL counter information, etc. These information should be EPICS PVs and accumulated in our data logging in order to make correlation plots between our tuning parameters and them both online and offline.

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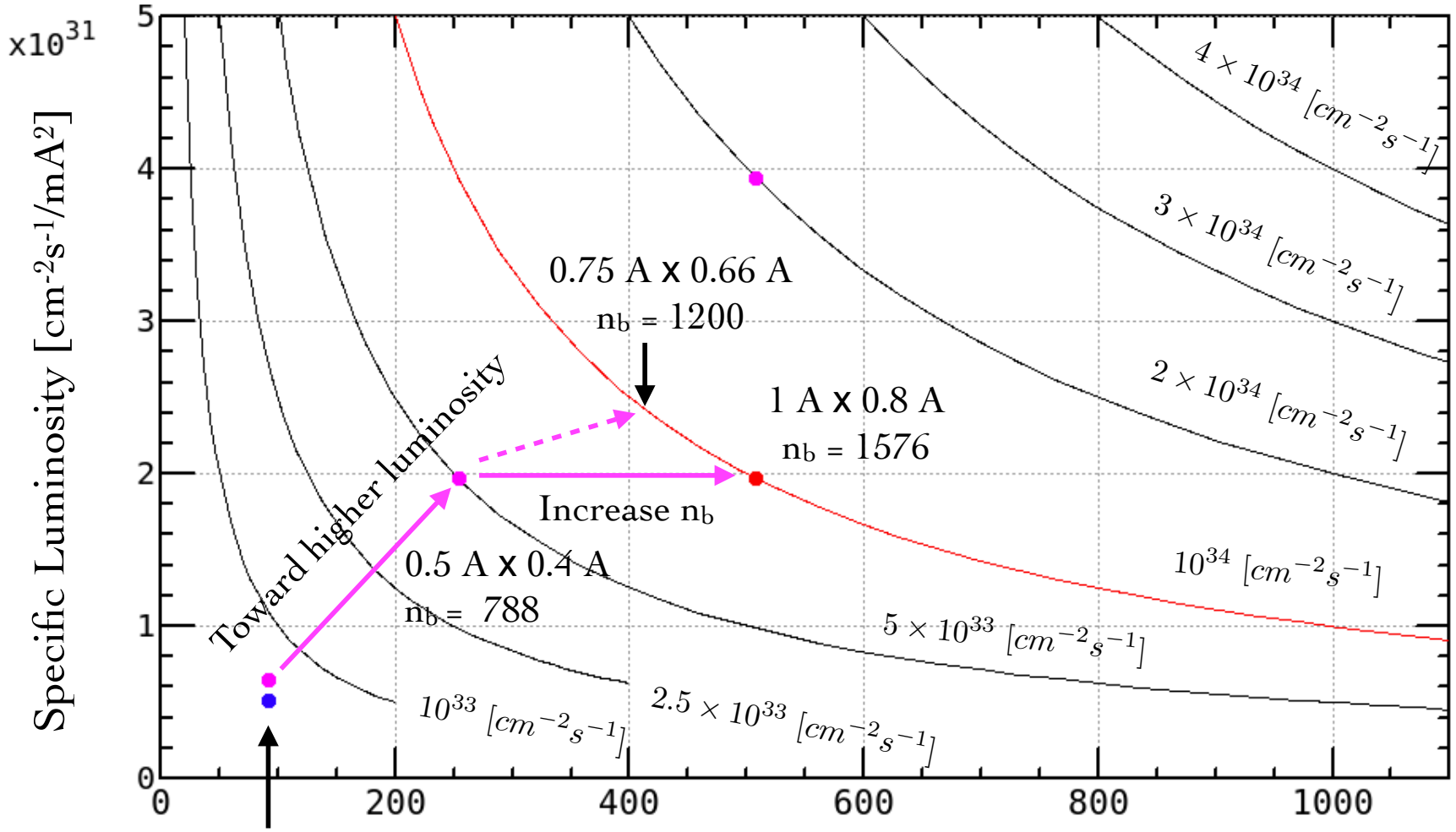
Travel Guide in Phase 2

Luminosity Contour Ohnishi – 11 May 2018



Reaching 1 A is desirable but not mandatory

Beta Squeezing (May 10 - May 16)

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* assumption

	Achieved, May 9		Phase 2.1		Phase 2.1.1		Phase 2.1.2	
	LER	HER	LER	HER	LER	HER	LER	HER
I_L, I_H [mA]	**250**	**220**	**250**	**220**	**250**	**220**	**250**	**220**
n_b	**600**		**600**		**600**		**600**	
β_x^* [mm]	200		200		200		200	
β_y^* [mm]	8		8		**6**		**4**	
$\varepsilon_y/\varepsilon_x$ [%]	**22***		**14**		**10**		**7**	
ξ_x	0.0038	0.0025	0.0039	0.0025	0.0040	0.0026	0.004	0.0026
ξ_y	0.0147	0.0145	0.0184	0.0182	0.0189	0.0187	0.0186	0.0183
I_{bunch} [mA]	0.42	0.37	0.42	0.37	0.42	0.37	0.42	0.37
L [$cm^{-2}s^{-1}$]	4.7×10^{32}		5.9×10^{32}		8.1×10^{32}		1.18×10^{33}	
L_{sp} [$cm^{-2}s^{-1}/mA^2$]	5.2×10^{30}		6.4×10^{30}		8.8×10^{30}		1.29×10^{31}	

Machine Parameters

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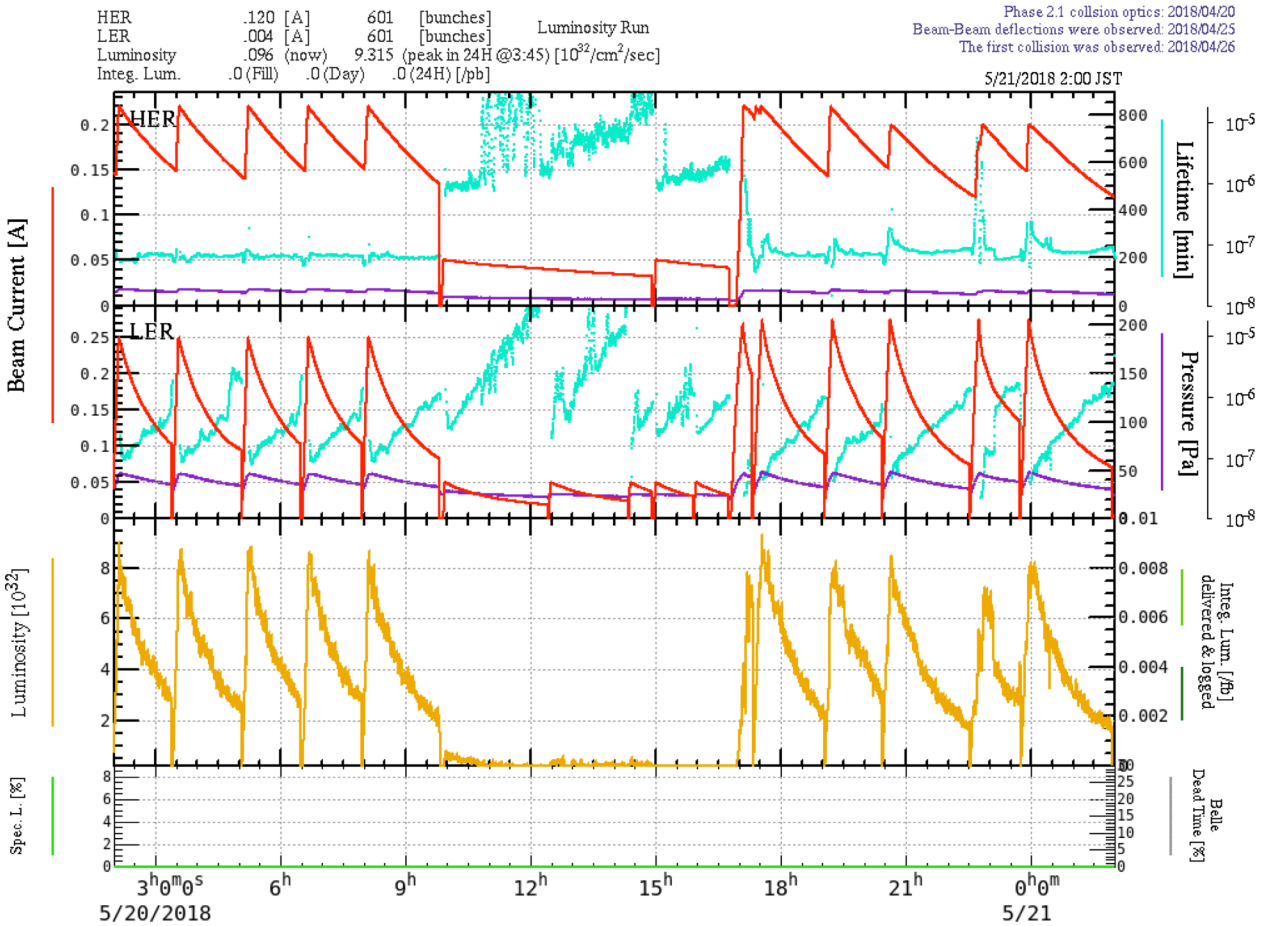
Increase bunch current →

	Phase 2.2						Phase 2.3	
	LER	HER	LER	HER	LER	HER	LER	HER
I_L, I_H [mA]	**250**	**220**	**250**	**220**	**750**	**660**	**750**	**660**
n_b	**600**		**400**		**1200**		**1200**	
β_x^* [mm]	200		200		200		100	
β_y^* [mm]	2		2		2		2	
$\varepsilon_y/\varepsilon_x$ [%]	**3.5**		**3.5**		**3.5**		**3.5**	
ξ_x	0.0041	0.0027	0.0062	0.0040	0.0062	0.0040	0.0031	0.0020
ξ_y	0.0184	0.0184	0.0283	0.0277	0.0283	0.0277	0.0282	0.0276
I_{bunch} [mA]	0.42	0.37	0.625	0.55	0.625	0.55	0.625	0.55
L [$cm^{-2}s^{-1}$]	2.32x 10^{33}		3.5 x 10^{33}		**1 x 10^{34} (tentative target)**		1 x 10^{34}	
L_{sp} [$cm^{-2}s^{-1}/mA^2$]	2.54 x 10^{31}		2.54 x 10^{31}		2.54 x 10^{31}		2.54 x 10^{31}	

Machine tuning on May 18th

- Optics corrections (LER, HER)
  - Usual x-y coupling, dispersion and beta-beats
- Injection tuning
  - LER kicker timing tuning
  - Septum tuning (iida)
    - Septum position (horizontal position of injecting beam)
      - We do not do this tuning usually.
      - This tuning is effective to reduce injection background?
    - Septum angle (horizontal angle of injecting beam)
      - Usual tuning.

Luminosity (β_y^* = 8mm, 250mA(LER), 220mA(HER))



4.7 x 10^{32}/cm^2/s (May 9th) -> optics correction -> **9.3 x 10^{32}/cm^2/s (May 20th)**

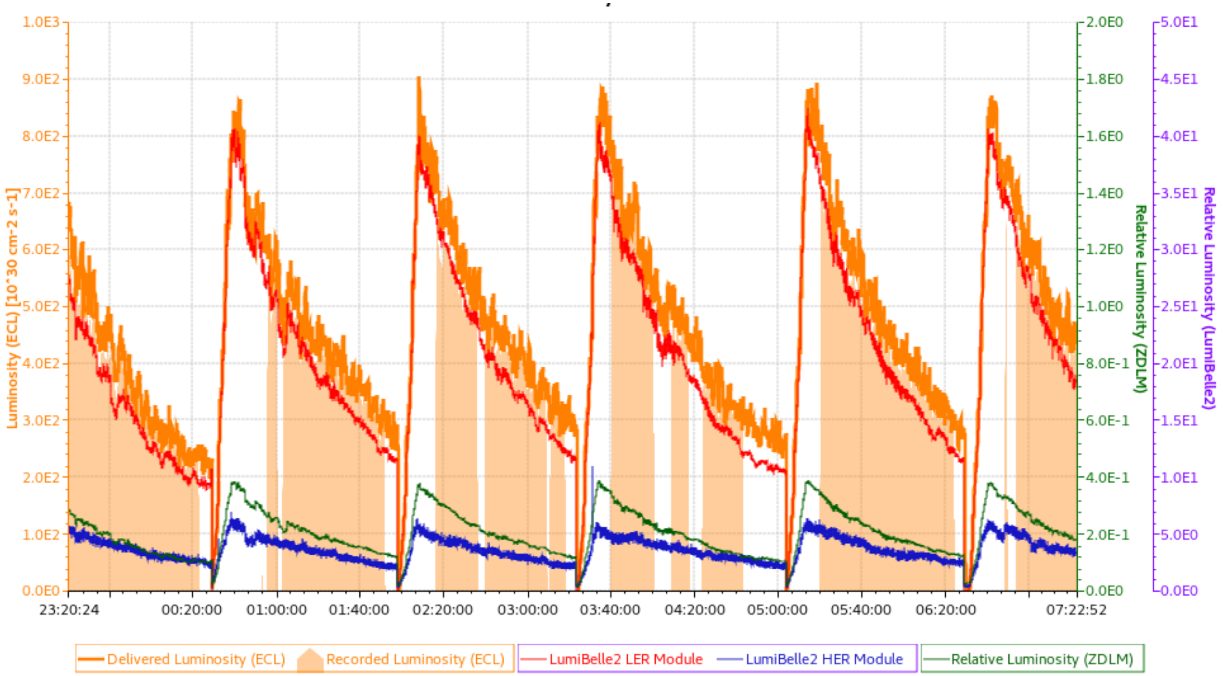
(ξ_{yLER}, ξ_{yHER}) = (0.0175, 0.0113)->>>>>>>>> (0.034,0.022) (assuming $\sigma_{yLER} = \sigma_{yHER}$)

Belle II Status

- Long luminosity runs during weekend
  - Saturday owl: Severe problems with HV Master. Low data collection efficiency
  - Sunday owl: Pretty stable. 5-7 minutes needed to be back in business
  - Monday owl: Slow Control crisis…
- Injection background very low after maintenance runs (< 2 mrad/s).
    - Thanks to LER BT tuning and LER kicker timing
- Background study runs
  - Collimator study
  - HER emittance knob
    - Touschek dominates HER lifetime but not HER backgrounds
- Down time due to QCS problem
  - (1st long) Cosmic ray runs over night.
    - Good data for calibrations.
  - DAQ high stress test
    - We know we have problem.
    - Next step in Phase 2? Dark photon search group should show their picture.

Belle II Status

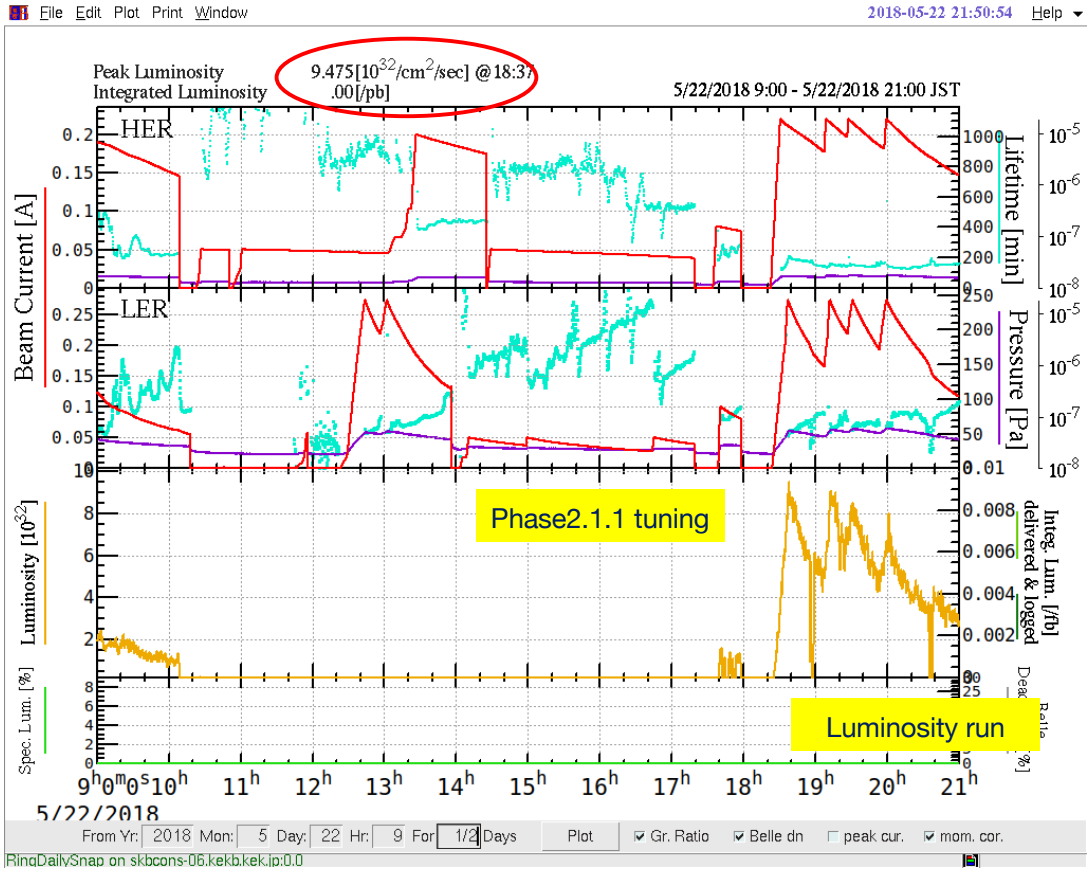
- Running on resonance $\Upsilon(4S)$ from R2 distribution
- New Belle II instantaneous luminosity record: 9×10^{32} cm^{-2} s^{-1}
- Phase 2.1 optics; β^*_y = 8 mm; HER = 200 mA, LER = 275 mA



- But… we have already wasted large fractions of it ☹
- Stability is, indeed, a serious concern

Status Updated

- Moved to Phase 2.1.1 optics; β^*_y = 6 mm (from 8 mm) on May 22.
  - HER = 220 mA, LER = 275 mA
- Belle II background still very low (<2 mrad/s) with new optics.
  - Thanks to optics corrections
- New Belle II instantaneous luminosity record: 9.5x10^{32} cm^{-2} s^{-1}



Priorities in phase 2

(v7 April 24, 2018, Ushiroda-san)

1. Achieve a machine luminosity of O(10^34/cm^2/sec) and see a clear path to further improvement.

2. Examine the VXD background to verify that we can install the VXD ***at the start of phase 3*** and then operate it for the initial first few years of phase 3.

- If the Phase 2 backgrounds are much larger than expected, the plan for design luminosity may have to be modified.
- Comment: these two priorities are mandatory to move to phase 3, but if we do have clear a path to reducing the backgrounds we should progress to Phase 3 even if the current backgrounds are larger than expected.
- Decision and conclusion needs be reached by the June B2GM.

More priorities in phase 2

3. Detector commissioning:

- This includes debugging firmware for several sub-systems, stable continuous operation of TRG, DAQ and online systems, with immediate data quality feedback (i.e. DQM). All operations should be performed routinely by two experimental shifters without large teams of detector experts present in the control room. Calibration and alignment of all detector systems is essential. The full dst production scheme with real data (rather MC) will be confirmed.

4. Measurement of backgrounds and extrapolation to Phase III:

- Cross-calibrate the BEAST and Belle II sub-detectors. Decompose the background components from injection and steady-state running. Measure the luminosity dependent and Touschek (single beam) backgrounds and extrapolate these backgrounds to determine occupancies and doses in Phase III under future conditions (and when sub-detectors, readout systems or DAQ components pass their limits.)

5. Detector performance

- Demonstration of mass peaks, momentum, energy and impact parameter resolutions:
  - pi0, eta, Ks, phi, J/psi, D, B, ...
- Confirmation of high efficiency, good resolution for each detector subsystem.
- Verification/calibration of reconstruction software packages:

  a. EM/ECL based particle reconstruction

  b. track reconstruction

  c. lepton ID

  d. hadron, K/pi/p ID

  e. K_L reconstruction and ID

  f. Precision measurements of trigger for low multiplicity measurements. This requires dedicated independent triggers to be run.

  g. Verification/calibration of material mapping is important for the dark sector studies.

6. Physics

6.1 Dark matter search (for which we need a better Bhabha veto than was available in Belle).

- High priority modes are: e^+e^- ->gamma X and e^+ e^- ->gamma (gamma gamma).
- Also may include e+ e- ->mu+ mu- X and e+ e- ->gamma Magnetic Monopole (requires special tracking code)

6.2 Other early physics:

- Precise luminosity measurement
- B and D counting
- Pythia tuning

Verification of performance in the following modes (>20 fb^-1 needed).

- Semileptonic: B->X l nu, B->D* l nu
- Electroweak Penguin: B->K* gamma confirmation
- B Full Reconstruction (FEI)
- Time Dependent CPV in B->J/psi K_S and related modes
- B->D(*) pi
- Charm: D->K_S pi^0, K^- pi+
- Tau: Various SM tau channels including tau->l h- vs tau->l nu nubar.

Phase 2 to Phase 3 transition

- Schedule discussed in the last B2GM still holds in principle
  - July 17: Phase 2 completed
  - End of Aug: QCS extracted. Access to end-cap possible.
  - Early Sep - Nov : ARICH cooling reinforcement
  - Sep - early Dec : VXD cabling and installation
  - mid Dec - mid Feb : IR recovery
  - Phase 3 starts in February 2019
- Bottlenecks:
  - PXD L2 assembly status : Decision by end of May
    - Still rather problematic
  - ARICH cooling reinforcement
    - Not a bottleneck but watching out preparation status

Il bicchiere mezzo vuoto

- Il run di fase 2 presenta molte difficoltà
  - Injection background
  - Limitazioni nella capacità di fare squeezing
  - QCS quenches, beam scraping
  - Problemi nel tuning dell'ottica
- Il run di Belle 2 presenta molte difficoltà
  - DAQ non stabile e che richiede presenza di esperti
  - HV control ancora non ben funzionante
  - Instabilità dello slow control
  - Molte ottimizzazioni di firmware necessarie
  - Il flusso e processing dei dati si inceppa facilmente

....pero'.....

Il bicchiere mezzo pieno

- La macchina sta fornendo luminosita’
  - Intorno a 5-6 pb-1 totali.
- Stiamo prendendo dati ed analizzandoli
- Non ci sono problemi fondamentali con il rivelatore
- Stiamo riscoprendo le particelle note
- C’e’ possibilità di fare fisica con i dati di fase 2
- Rimangono i grossi dubbi su:
  - Riusciremo a raggiungere i requirements di fase 2 per luglio?
  - I PXD riusciranno a superare le difficoltà ed essere pronti per l’installazione in estate?
- Al momento non esiste un plan B chiaro, ma penso che andrà presto sviluppato.