GENERAL INFORMATION

Frank Zimmermann

FCC-ee Optics Design Meeting #188 & 57th FCCIS WP2.2 meeting, 10 July 2024

MTR recommendations on FCC-ee machine

from FCC SAC, FCC CRP, CERN SPC, and CERN FC

✓ **well-defined baseline layout for entire FCC-ee, including optimised e^+e^- injector, especially the linac**

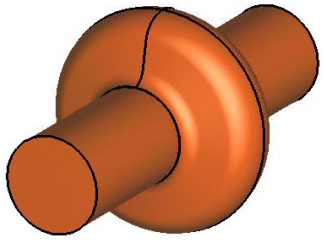
- clarify **order of the energy stages**, with motivation for running order linked explicitly to the physics case

✓ **consolidate design of the RF system** to allow efficient energy-staging, as well as to reduce complexity, risk, and cost; study **options to avoid the 1-cell/2-cell RF cavity reconfiguration between Z and ZH/WW running**

- **alternative beam optics, to improve the dynamic aperture with relaxed mechanical alignment tolerances**
- **develop survey and alignment techniques**, procedures and instrumentation, **to guarantee the alignment of magnets [on the girder] to ~50 μm at 1 σ; develop and apply, in simulations, the whole set of beam-based correction techniques**
- **identify residual risks to achieving the design luminosity, with lessons to be learnt from other facilities like SuperKEKB, and specify required further critical-path R&D**

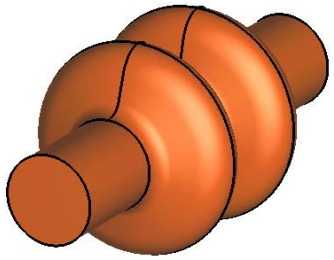
FCC-ee baseline RF configuration so far

Z — 1-cell 400 MHz, Nb/Cu



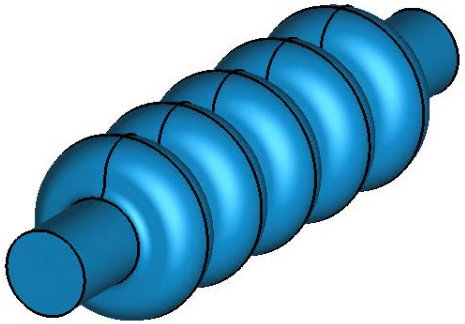
low R/Q, HOM damping, powered by 1 MW RF coupler and high efficiency klystron

W, H — 2-cell 400 MHz, Nb/Cu



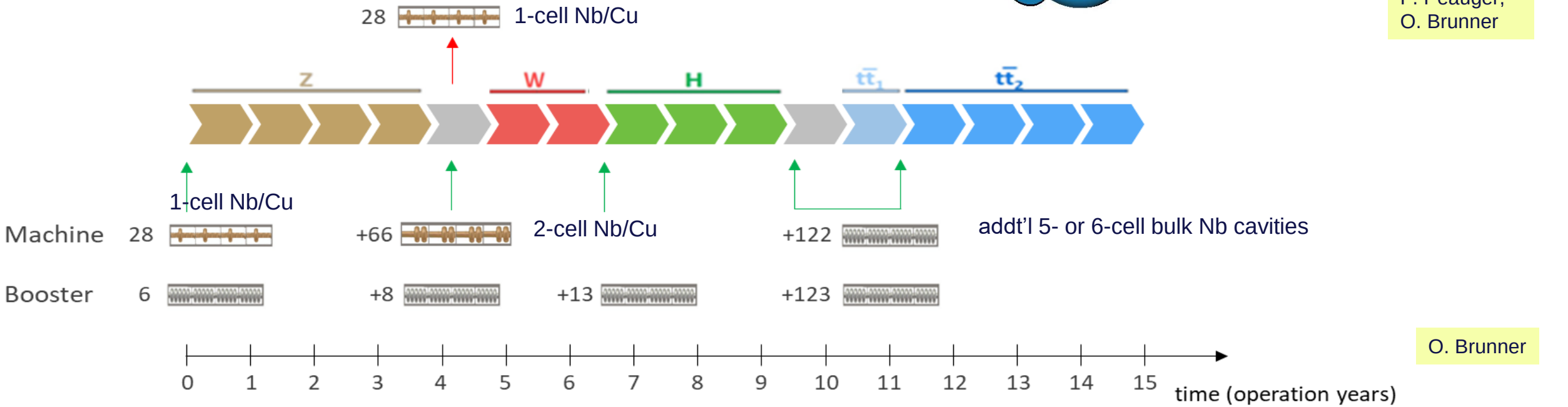
moderate gradient and HOM damping requirements; 500 kW / cavity, allowing reuse of klystrons already installed for Z

ttbar, booster — 5-cell 800 MHz, bulk Nb



high RF voltage and limited footprint thanks to multicell cavities and higher RF frequency; 200 kW/ cavity

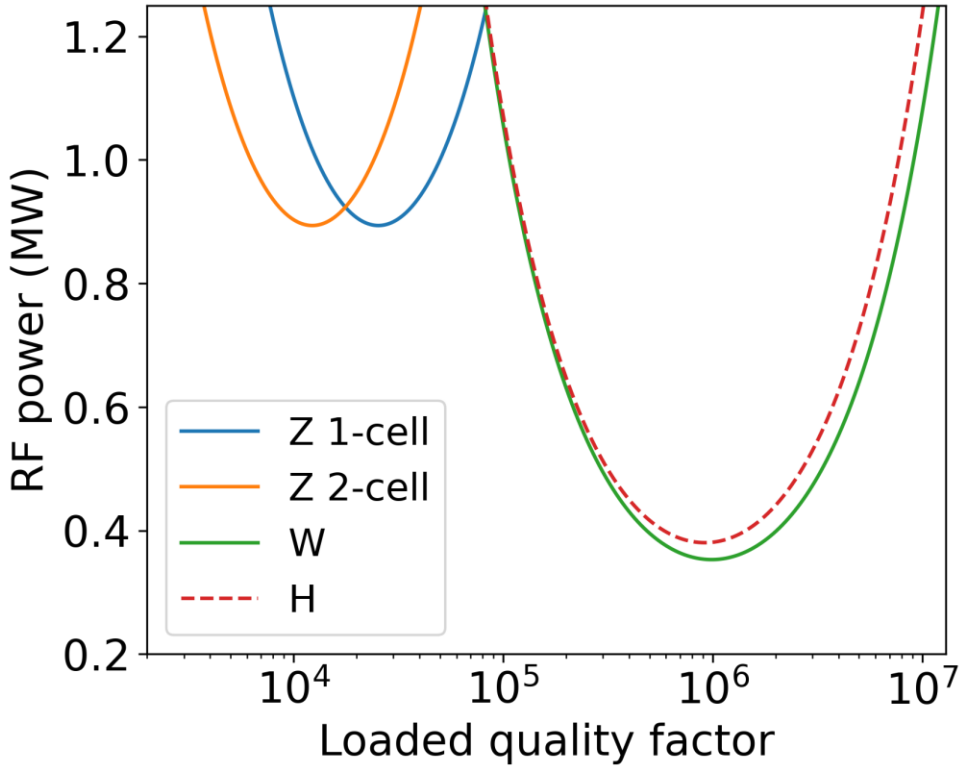
F. Peauger, O. Brunner



O. Brunner

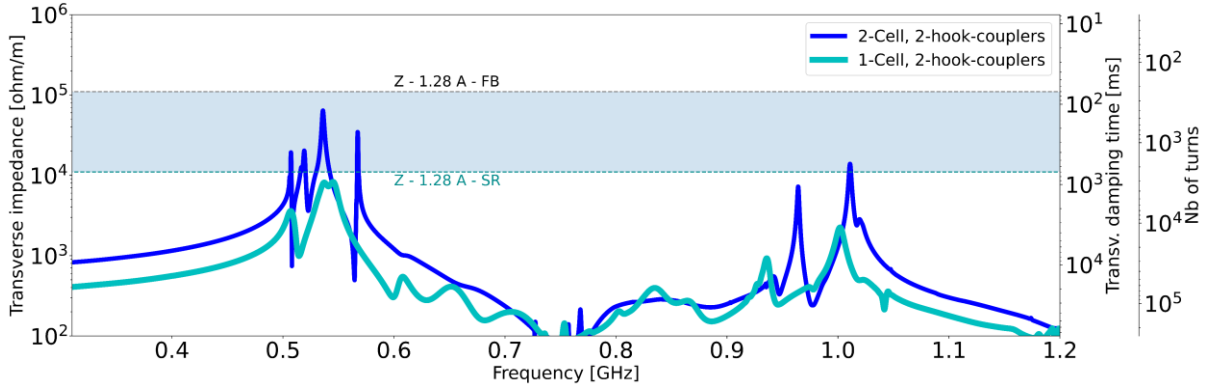
A 2-cell 400 MHz SRF cavity for all energies ?

Input RF power for optimum detuning

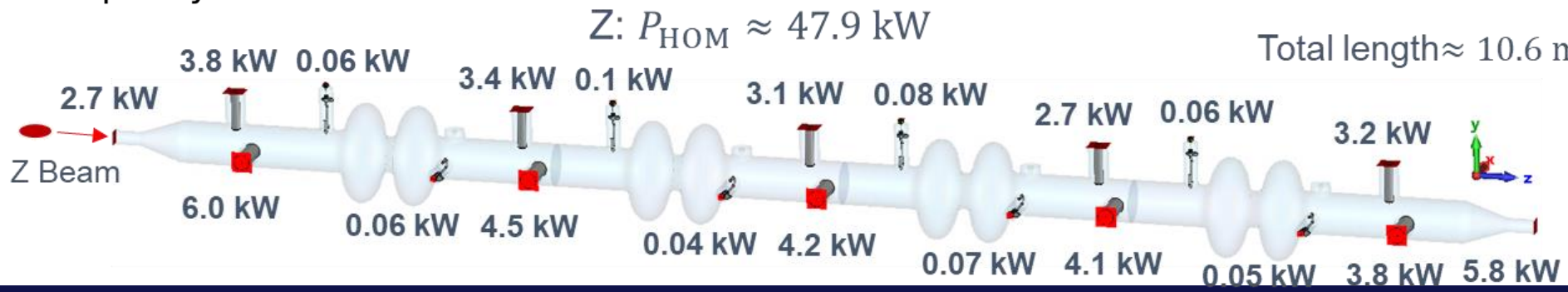


I. Karpov, R. Calaga, E. Montesinos, S. Zadeh, F. Peauger, O. Brunner

- Need for **adjustable/variable fundamental power coupler with wide range of coupling** (2 orders of magnitude)
- Presence of 0-mode requires additional longitudinal feedback
  Transverse feedback needed



- 40%-increase of **HOM power** / cryomodule → **"2-coax concept"**



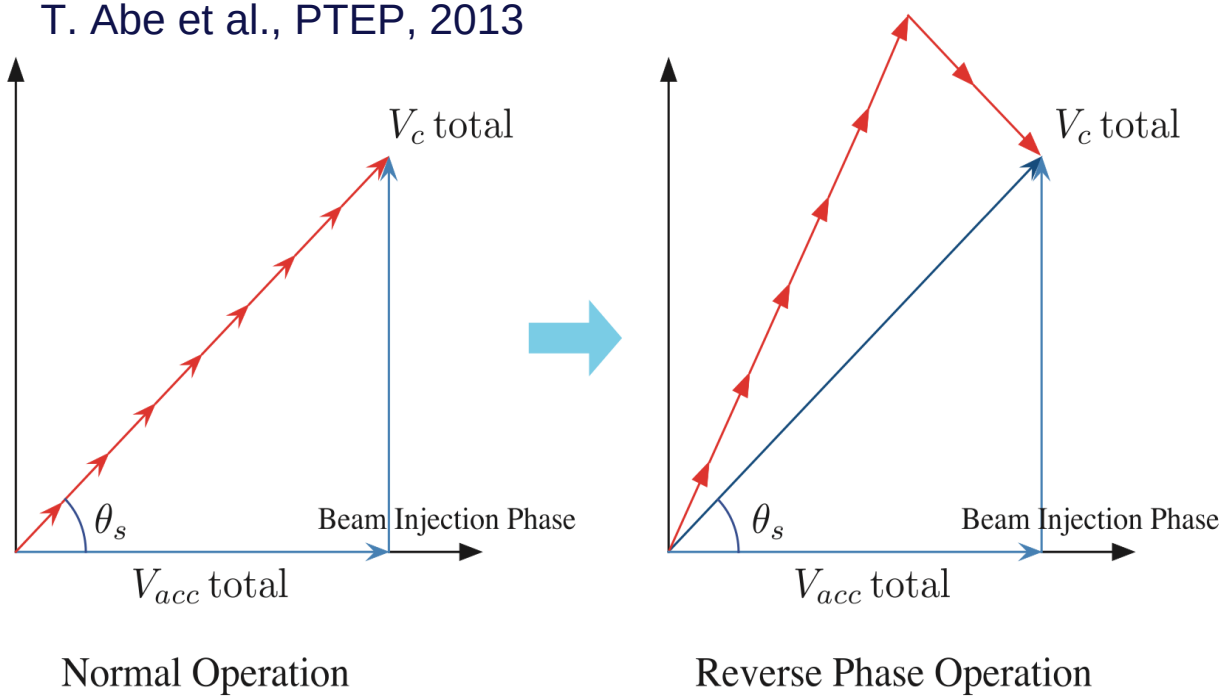
Solution for FCC-ee simplified RF system !

2-cell for all energies

Reverse phase operation (RPO) → higher RF cavity voltage *(Y. Morita et al., SRF, 2009)*

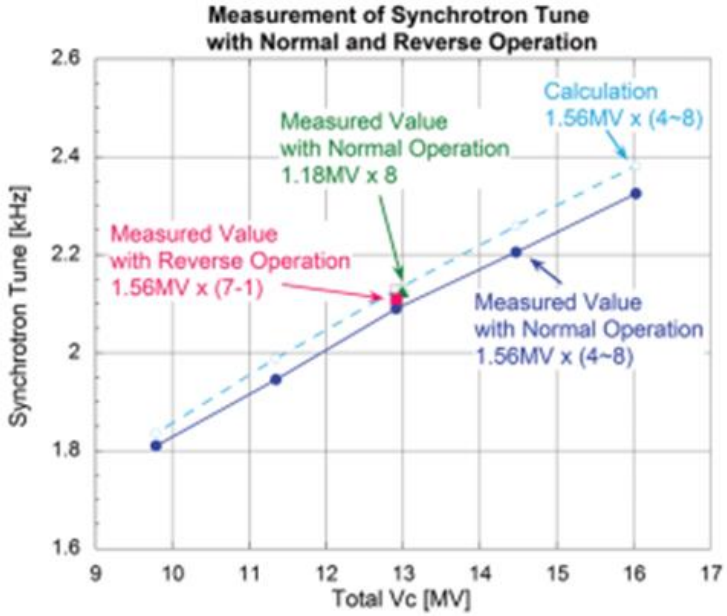
- **Experimentally verified** with high beam loading **in KEKB** *(Y. Morita et al., IPAC, 2010)*
- **Baseline solution for EIC ESR** *(e.g., J. Guo et al., IPAC, 2022)*

T. Abe et al., PTEP, 2013



KEKB HER synchrotron tune measured for several SC cavity configurations. RPO "(7 - 1)" case with1.56 MV/cavity yielded about the same f_s as for 8 in-phase cavities with 1.18 MV/cavity [T. Abe et al., 2013]

$$Q_{L,opt} = \frac{V_{\mathrm{cav}}^2 N_{\mathrm{cav}}}{2V_{tot}(R/Q)I_{b,DC}\cos\phi_s}$$



→ RPO potentially allows same optimal quality factor for Z, W, and H modes

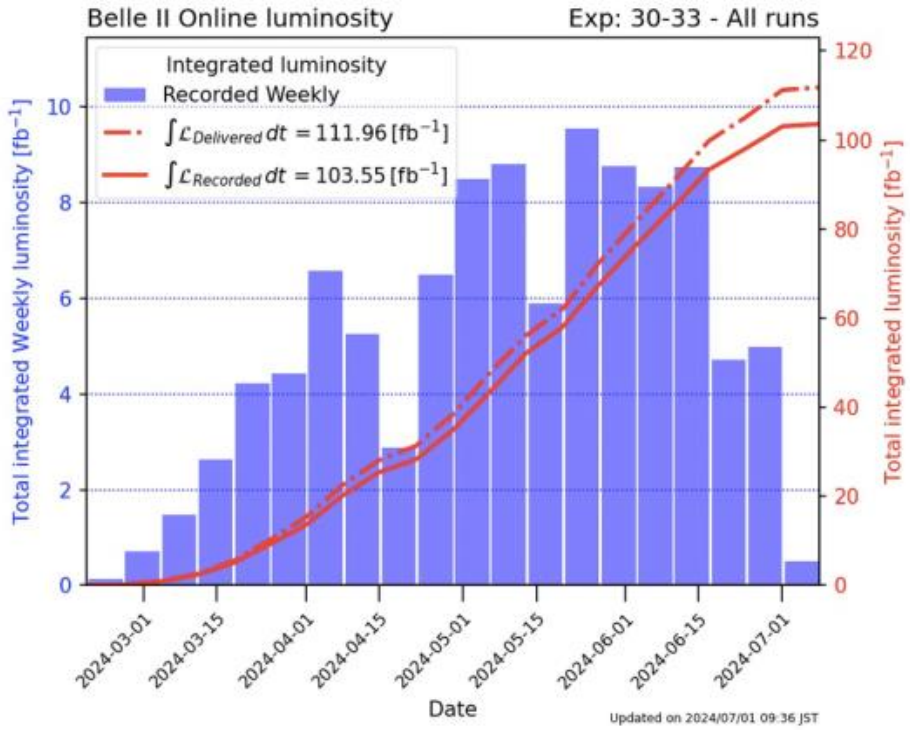
I. Karpov

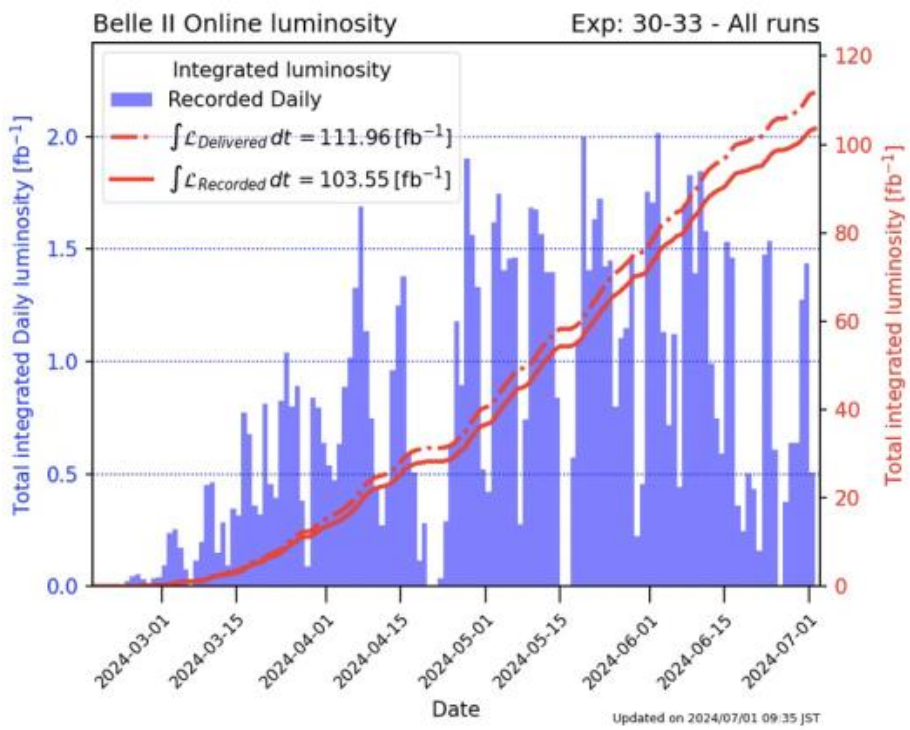
Advantages:

- ❑ Rationalize RF resources during the development process (3 → 2 cavity types)
- ❑ Simplify, shorten the installation sequence (no cryo-module removal)
- ❑ **Great flexibility in physics running modes**
- ❑ Potential savings (cost, manpower, and time)

Summary of SuperKEKB spring run from Belle II

INTEGRATED LUMINOSITY (PER WEEK/DAY) FOR THE RUN PERIOD 2024A-B





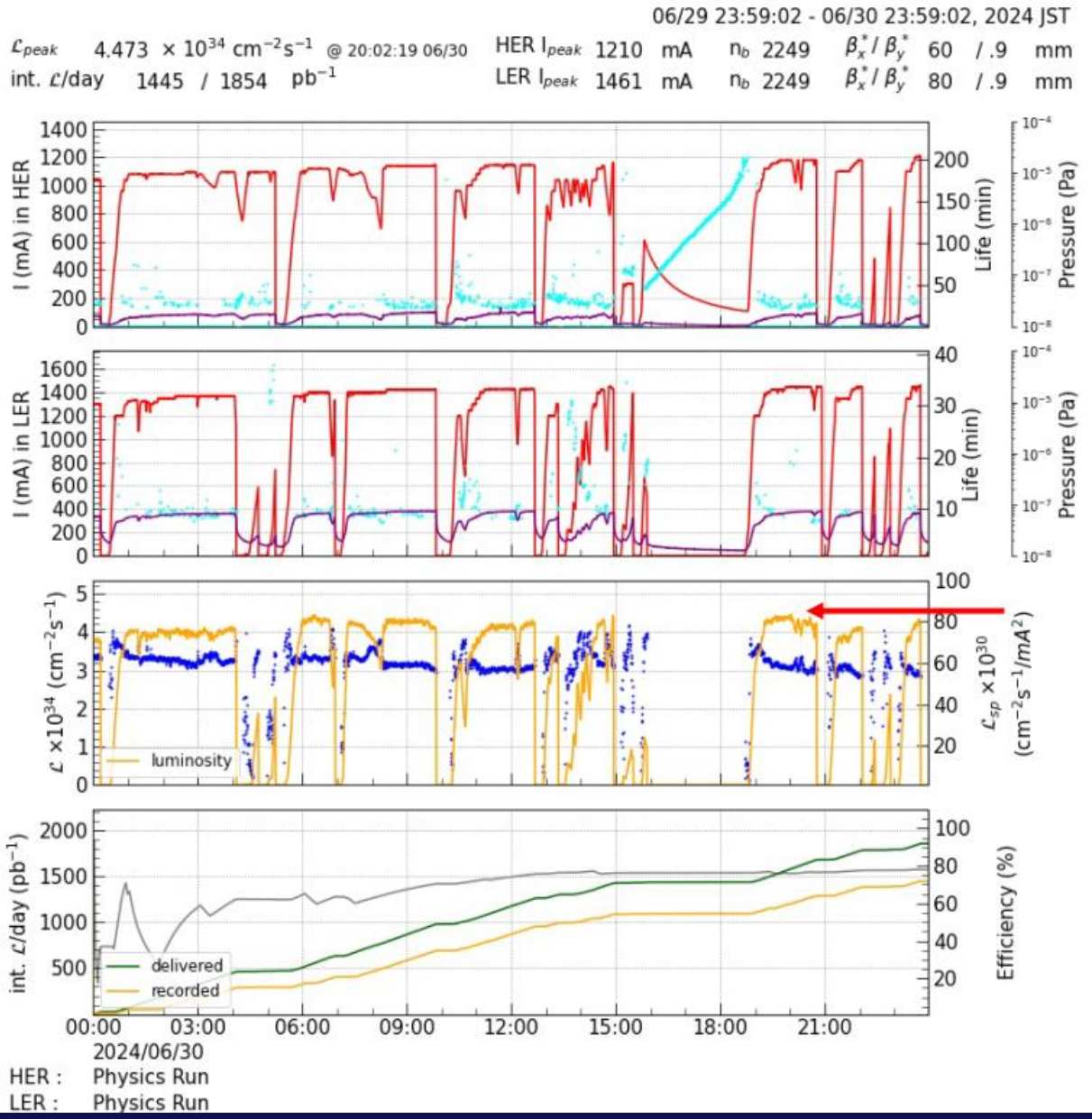
For analyses that do not involve TDCPV, can add an extra 100 fb^{-1}

N.B. machine studies were the priority during this running period.

T. Browder

Integrated ~104 fb^{-1} with Belle II (but a significant fraction ~50% ?? recorded with PXD2 off). Progress on understanding SBLs (Sudden Beam Losses). Knocker "studies" helped. The last running period with β*y =0.9mm grappled with injection difficulties (could not go beyond 1.5 A in LER beam current). Causes: two-bunch injection did not work, product of bunch charge (linac) and ring acceptance was *too low* at high beam currents.

Summary of SuperKEKB spring run from Belle II -2



Reached
L=4.5 x 10^{34}/cm^2/sec with beta*y=0.9 mm.

Machine studies with high bunch currents suggest that L= 8.4 x 10^{34}/cm^2/sec is possible.

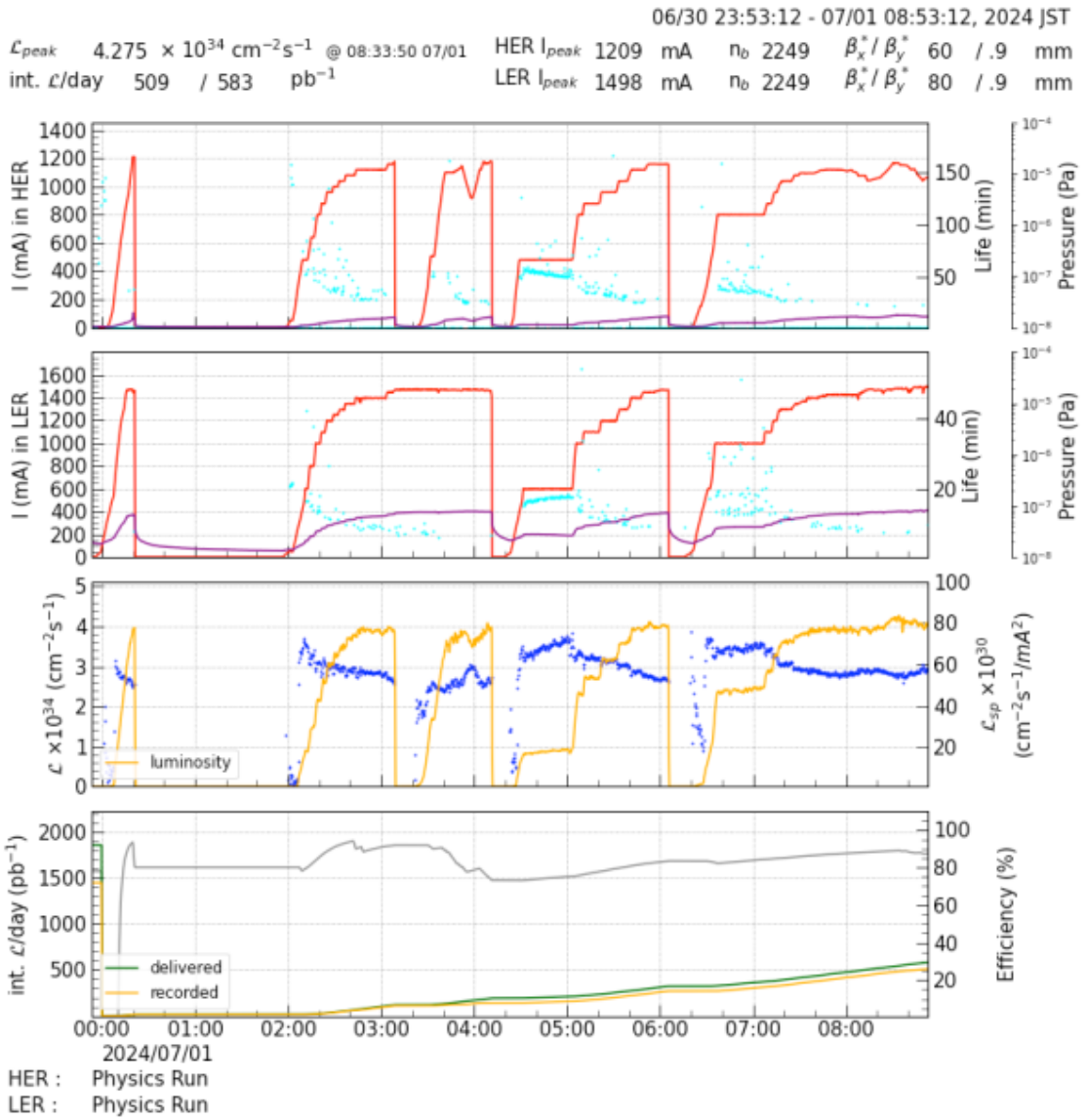
Did not have time to try out beta*y=0.8 mm. But need to fix injection issues first in any case.

Note all of 2022 running and much of spring 2024 running was done with beta*y=1.0mm

T. Browder

Summary of SuperKEKB spring run from Belle II -3

Efforts to go beyond 1.5 A in the LER were not successful

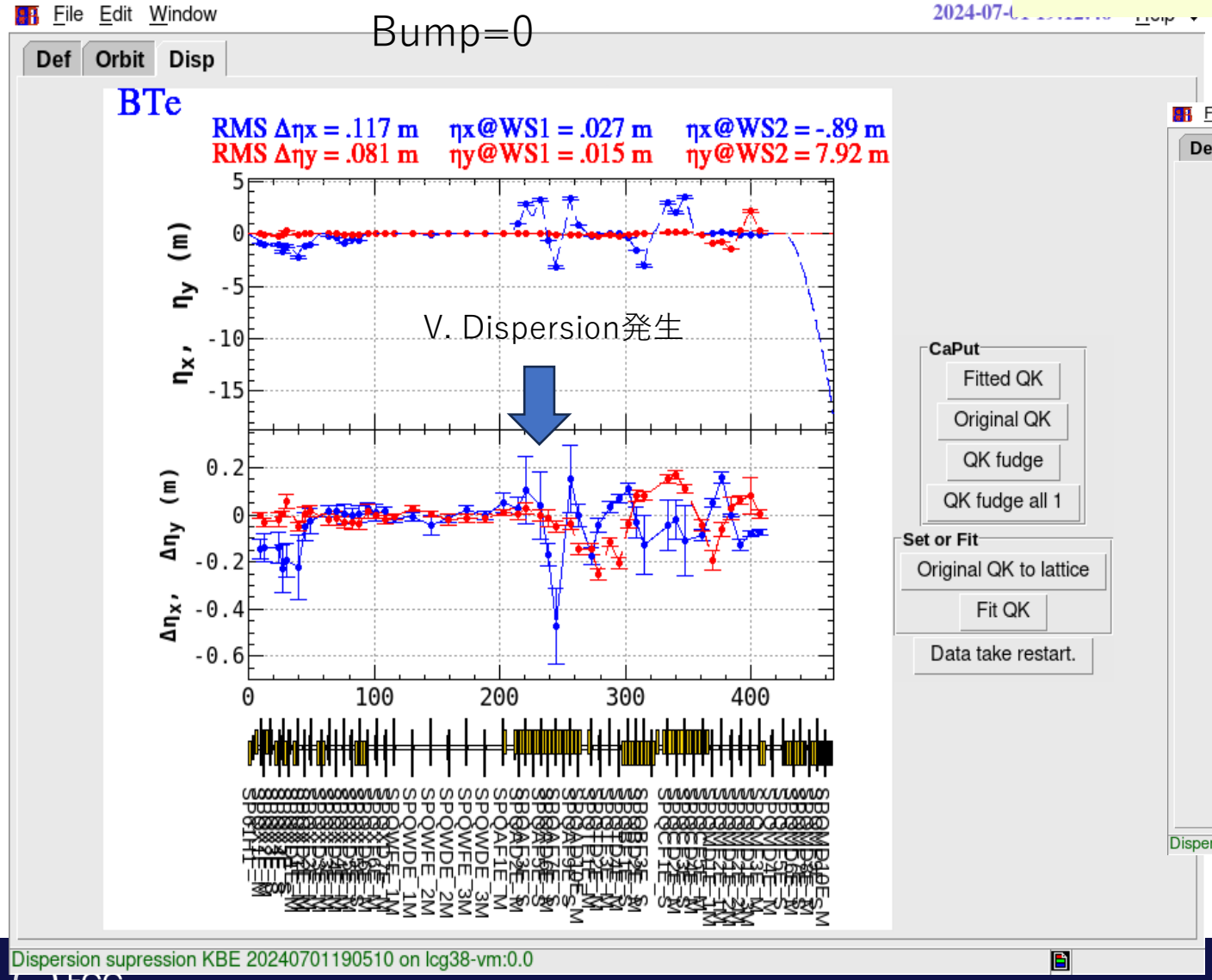


T. Browder

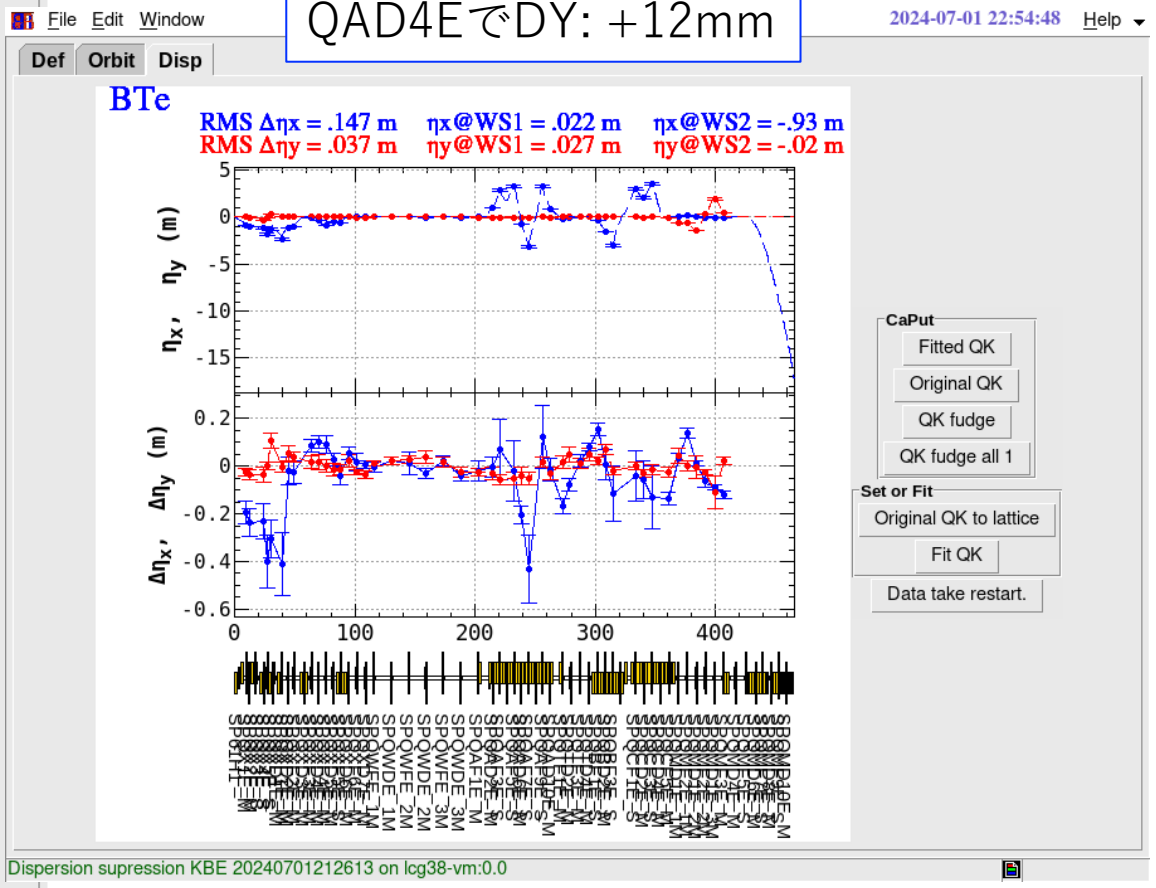
Progress with understanding e- blow up in BT line

N. Iida, T. Yoshimoto, Y. Funakoshi, K. Oide

Bump=0



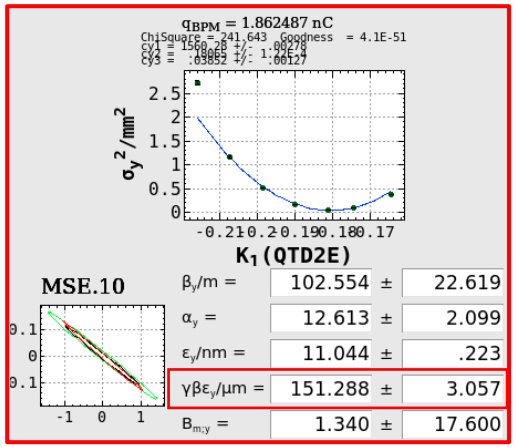
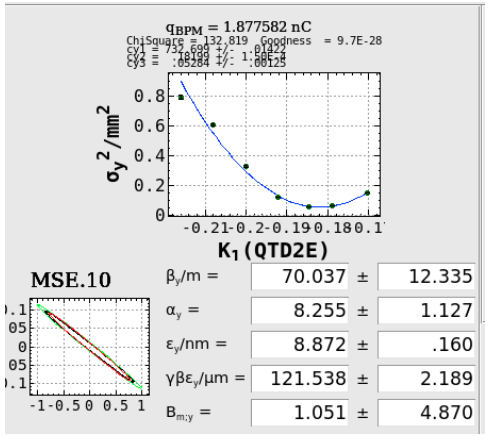
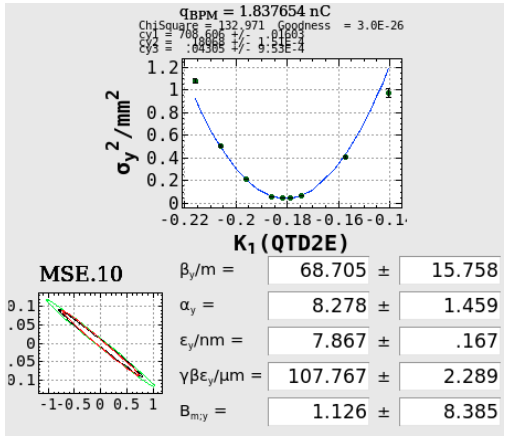
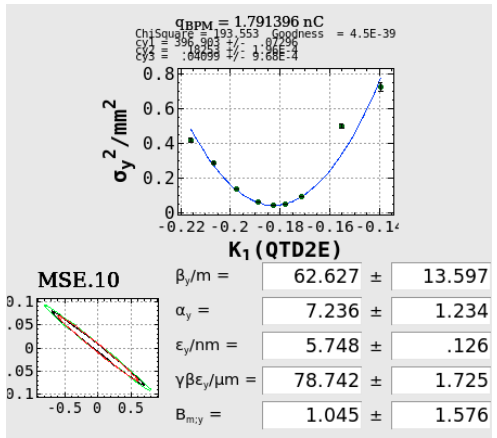
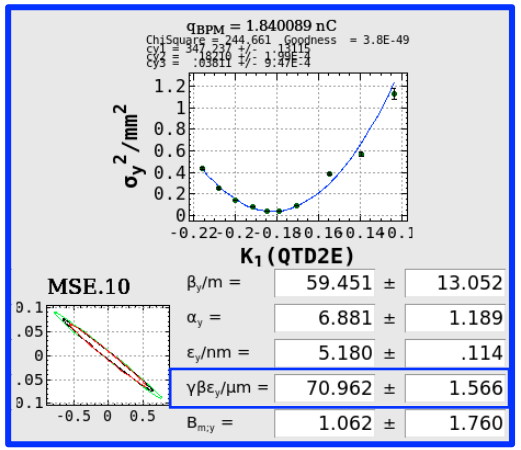
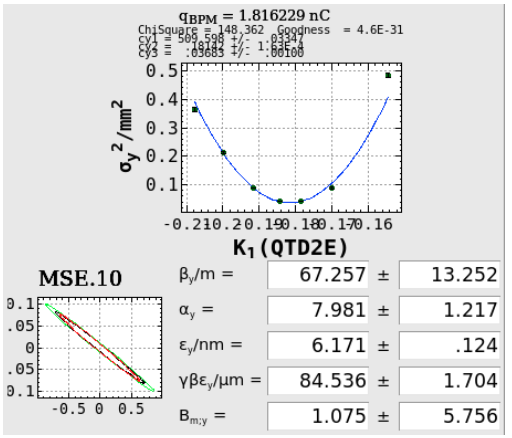
QAD4EでDY: +12mm



Emittance measurement at MSE.10

Measurement: T. Yoshimoto

2nC

	no Bump	QAD4EでDY: +11mm	QAD4EでDY: +12mm	QAD4EでDY: +6mm, QAD6EでDY: +4mm
Tailあり				
Tail補正 PY_A1_M PY_13_5 でMSE.10での Tailがなくなるように 調整(今井氏)				

N. Iida, T. Yoshimoto, Y. Funakoshi, K. Oide

Today’s agenda

14:00 → 14:10 **General Information** — 10m

Speaker: Frank Zimmermann (CERN)

14:20 → 14:35 **Update on the GHC lattice** — 15m

Speaker: Dr Katsunobu Oide (Universite de Geneve (CH))

Optics_Oide_24071...

14:35 → 14:55 **Report on IP Feedback studies at SuperKEKB** — 20m

Speaker: Mr John Patrick Salvesen (University of Oxford, CERN)

15:00 → 15:20 **Non-Linear Optics Measurement at SuperKEKB** — 20m

Speaker: Mael Le Garrec (Goethe University Frankfurt (DE))

2024-03-13_KEK_Co...

15:25 → 15:35 **Optics tuning working group update** — 10m

Speakers: Jacqueline Keintzel (CERN), Rogelio Tomas Garcia (CERN)

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