

DESY short BBS–2020 Travemünde 12.-14.02.2020

FLASH Status

Mathias Vogt (MFL) for the FLASH–team:

Ph.A., A.B., F.C., Ch.G., J.H., K.H., K.K., J.R.-S., S.S., J.Z., ...

- FLASH 2019/2020
- Highlights from User Run & Studies
- Controls & Operations
- Again: The RF-gun
- Outlook (short term)



Who are “the FLASH Core Team” ?

(In alphabetical order)

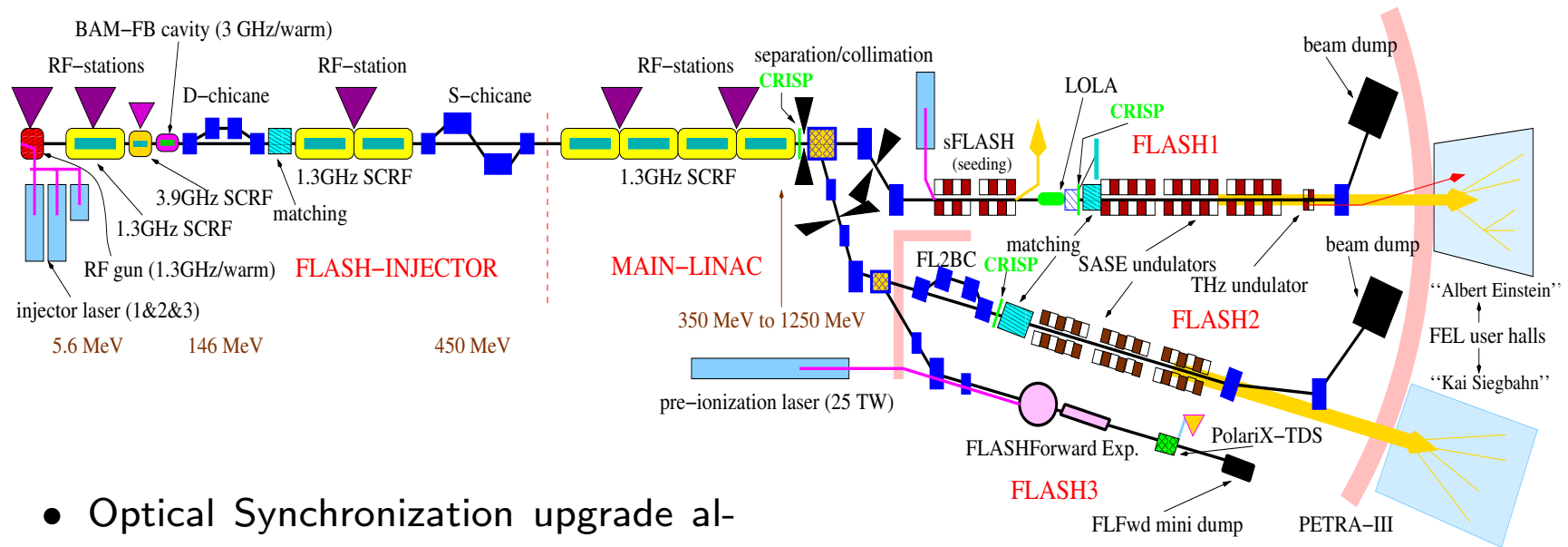
new Philipp Amstutz (MFL) : PhD student : μ -bunching, Vlasov eqs, PF/Tree codes

- Arne Brinkmann (MBB $\leftarrow$ **new**) : technical coordinator, **QA-officer**, shift-leader

new Florian Christie (MFL) : Postdoc : PolariX, short pulse diagnostics

- Christian Grün (MIN): technical coordinator, timing/MPS, FPGAs, operations
- Jürgen Haar (MBB) : technical coordinator, electricity/cooling/AC, safety, shift-leader
- Katja Honkavaara (MPY) : coordination, organization, scheduling
- Karsten Klose (MIN) : technical coordinator, injector lasers, operations
- Juliane Rönsch-Schulenburg (MFL) : coordination, deputy-SSB, beam dynamics, operations
- **Siegfried Schreiber (MFL) : Machine-coordinator**, SSB, safety officer
- Mathias Vogt (MFL) : coordination, beam dynamics, operations
- Johann Zemella (MFL $\leftarrow$ **new**) : FL2020+, beam dynamics, operations

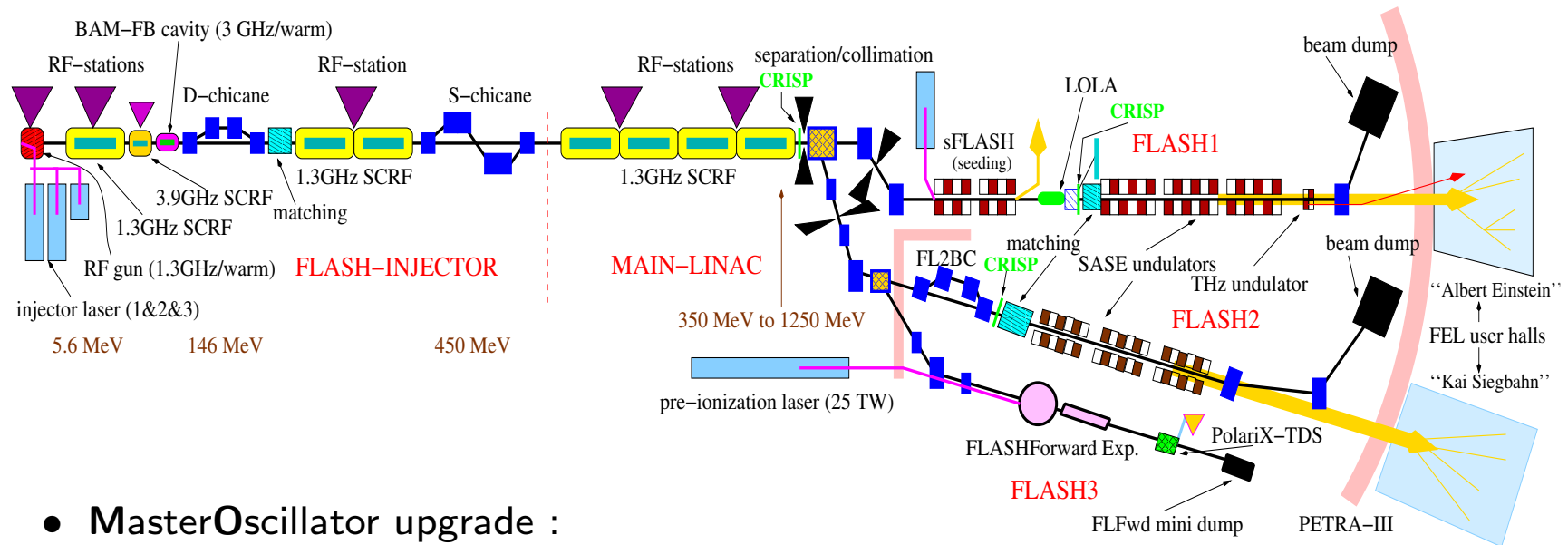
FLASH : 2019/2020



- Optical Synchronization upgrade almost finished
→ BAMs; but not yet **all** lasers connected
- BAMs in FLASH injector upgraded
→ 1UBC2,3DBC2,4DBC3: modern pickups & upgr. electro-optics conn. to upgraded optical sync. links

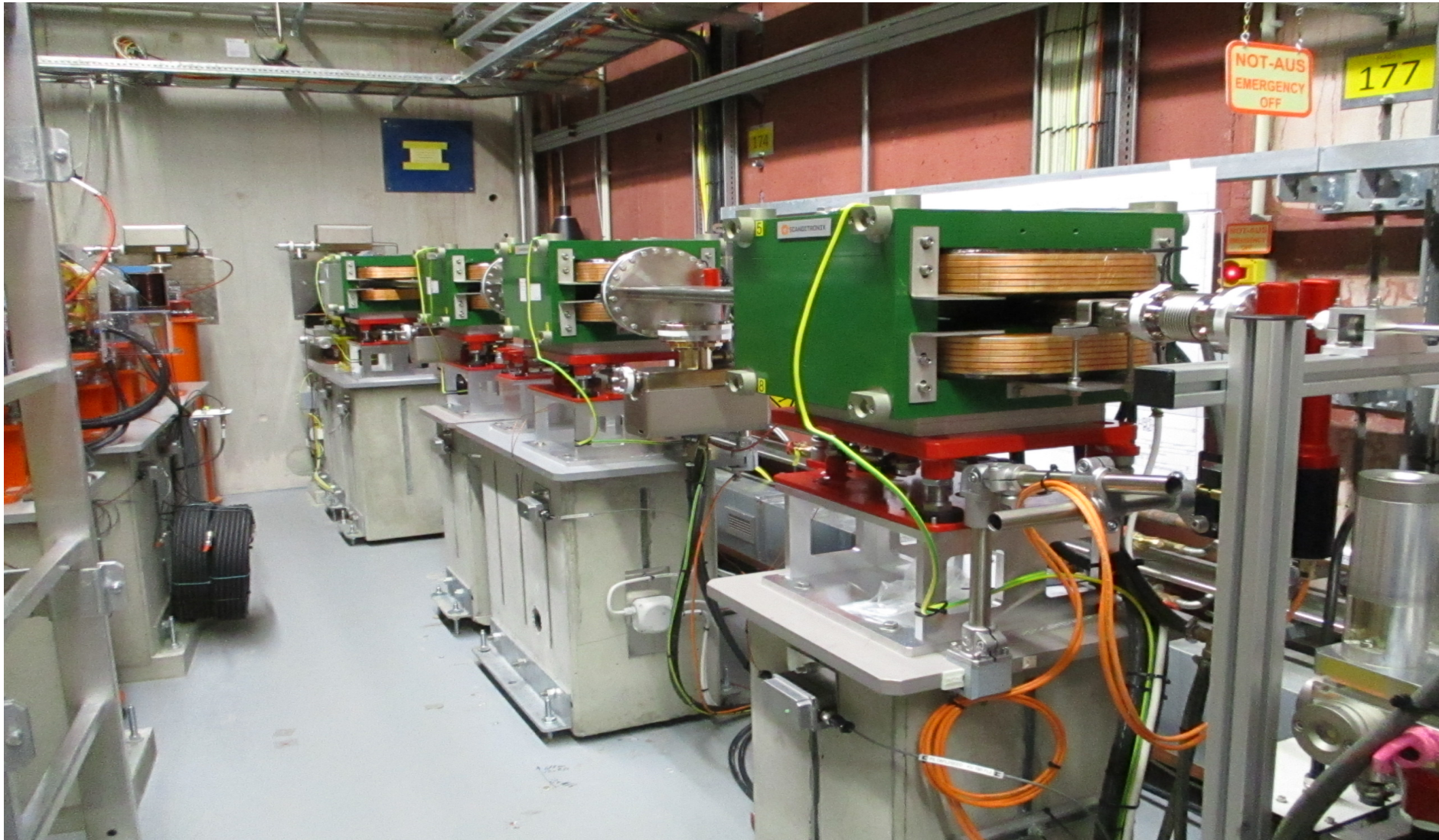
- new BAMs 1SFELC, 8FL2BURN installed
→ to be commissioned
- BAM for FLFwd to be installed

FLASH : 2019/2020

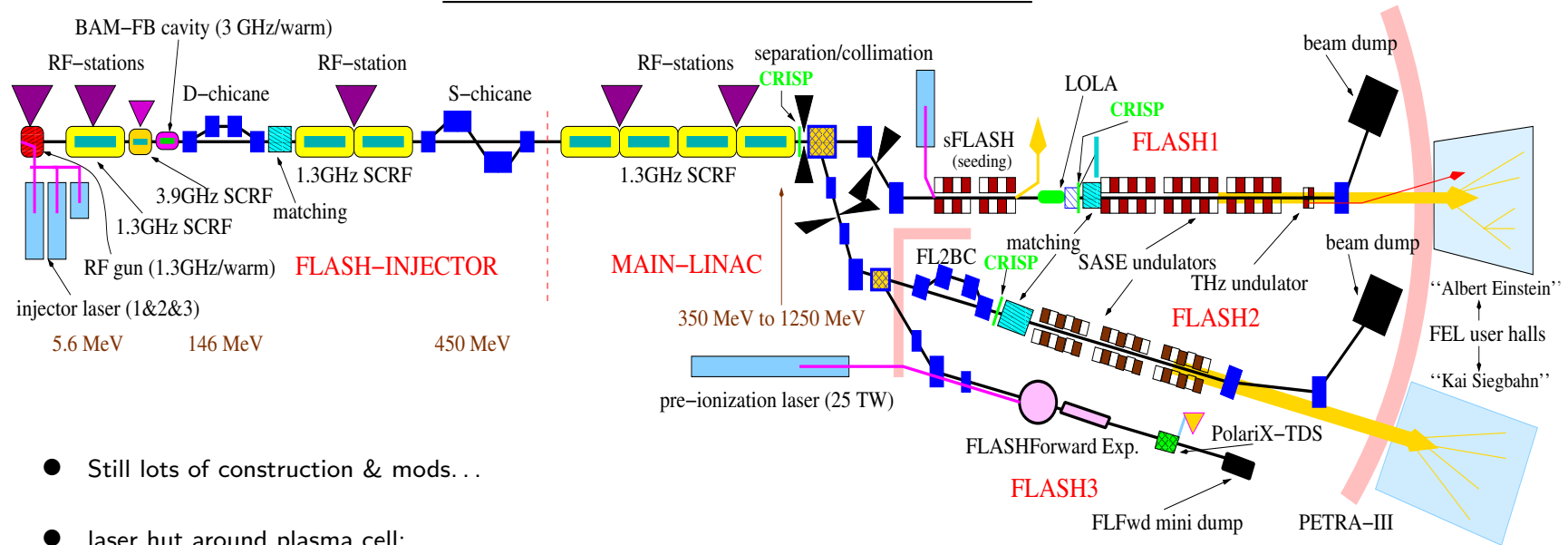


- **MasterOscillator** upgrade :
space cleared in injector hutch
→ new crates on site
→ installation planned in summer
- **FL2BC** installed
& **successfully commissioned**
→ std **FL2** user operation !!
- CRISP/**FLASH2** :
→ improved
= (retractable on-axis screen)
→ **being** commissioned

FL2BC

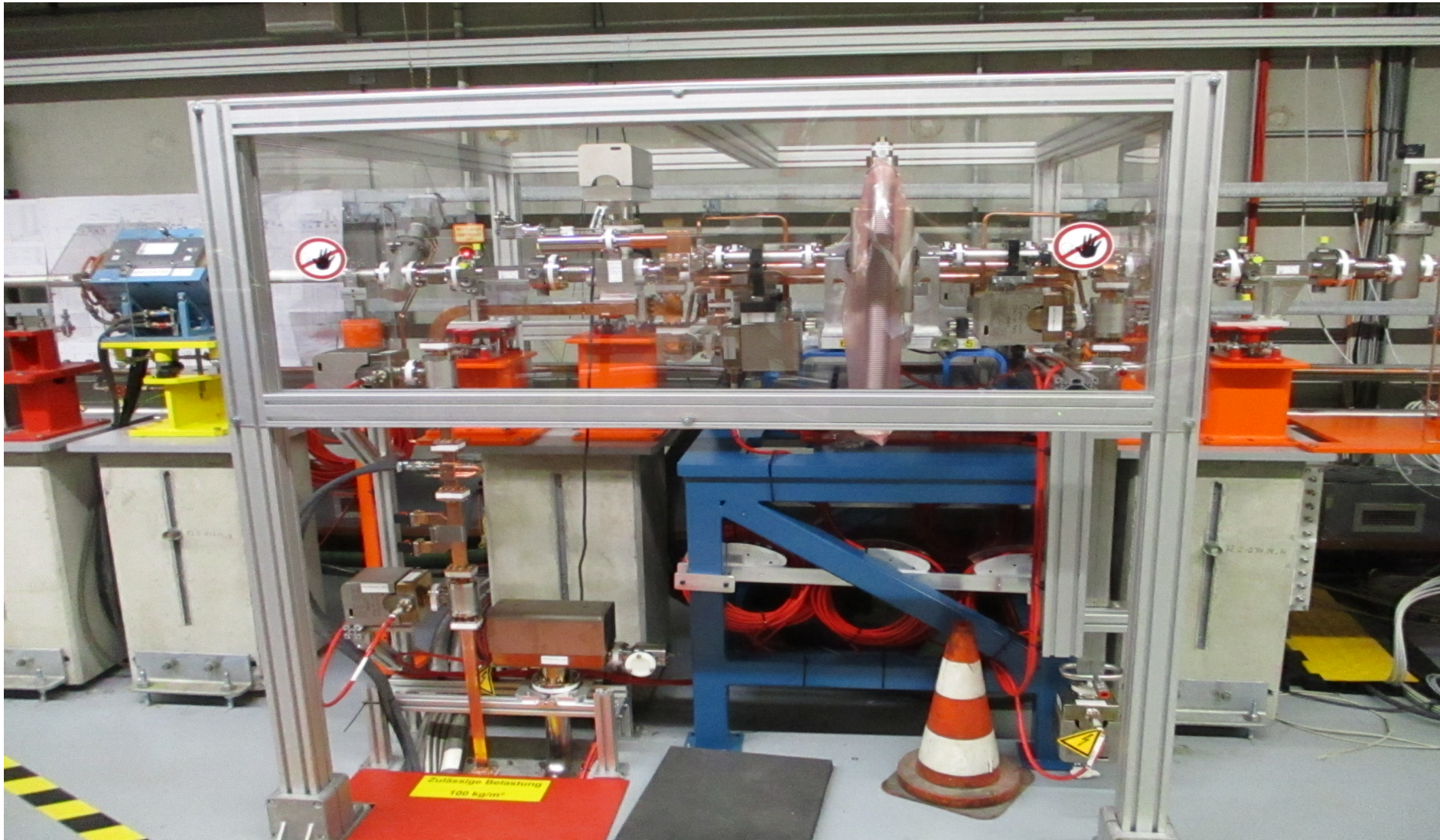


FLASHForward>> 2019/2020



- Still lots of construction & mods. . .
- laser hut around plasma cell:
now w/ officialized laser interlock!
→ tunnel search procedure in this area: 3 search buttons
- See R. D'Arcy's talk yesterday!
- Prototype of PolariX-TDS installed in FLFwd beamline
- See B. Marchetti's talk yesterday!
- Diagnostic beamline w/ FLFwd-miniDump installed on top of potential multibunch dump for FL3

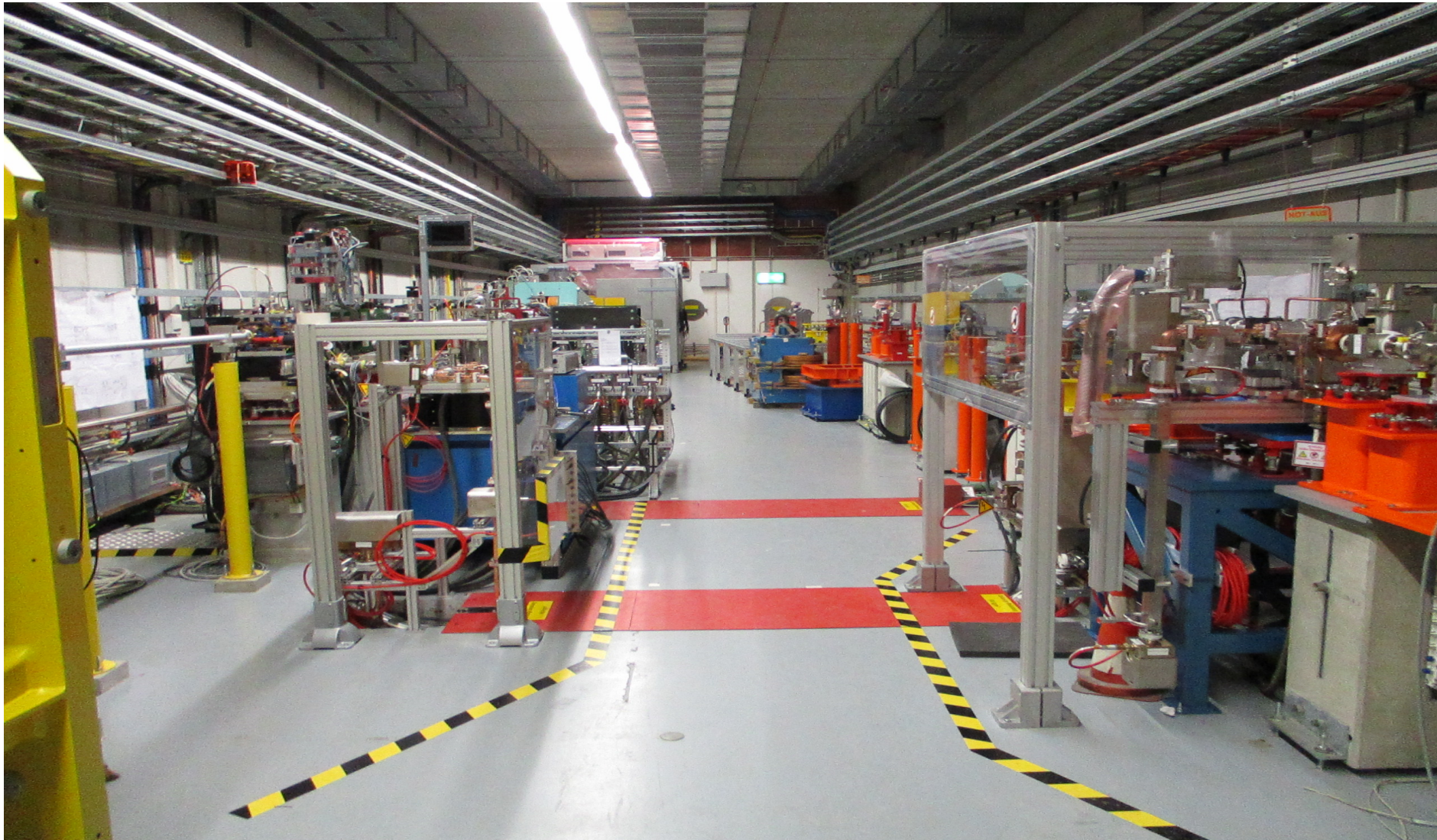
FLASHForward>> PolariX-TDS



FLASHForward>> Mini-Dump (courtesy S.Wesch)



L2R: FL2 → PolariX-Klystron → FLFwd-Mini-Dump → FLFwd-PolariX

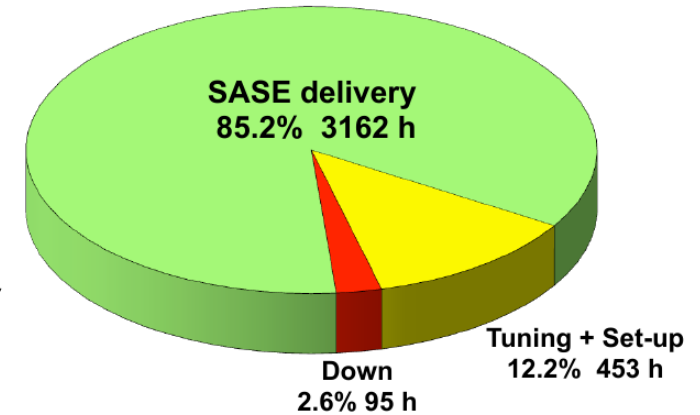
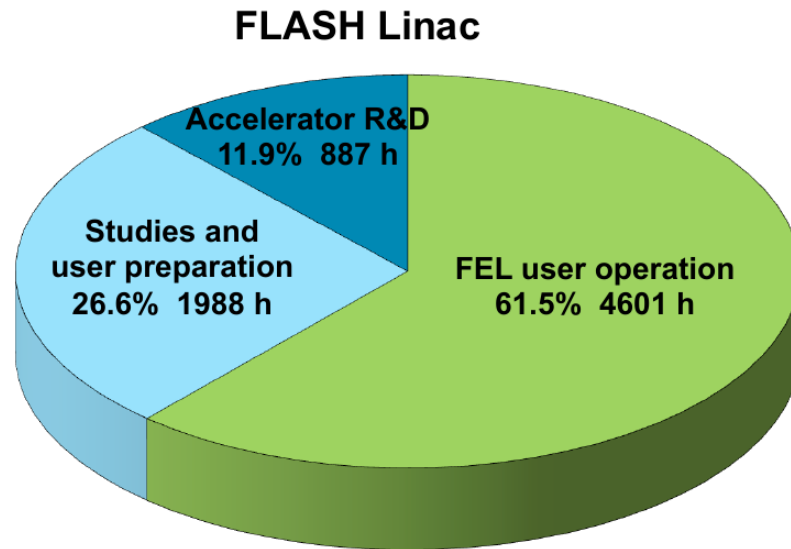


FLASH Run Statistics (courtesy K.H.)

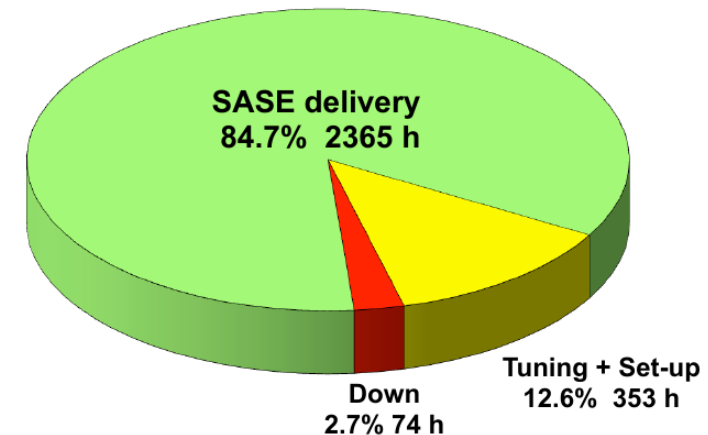
FLASH Operation 2019

FLASH Linac: 7476 Operating hours, 4601 h FEL user operation

FLASH1: 3710 h FEL user operation



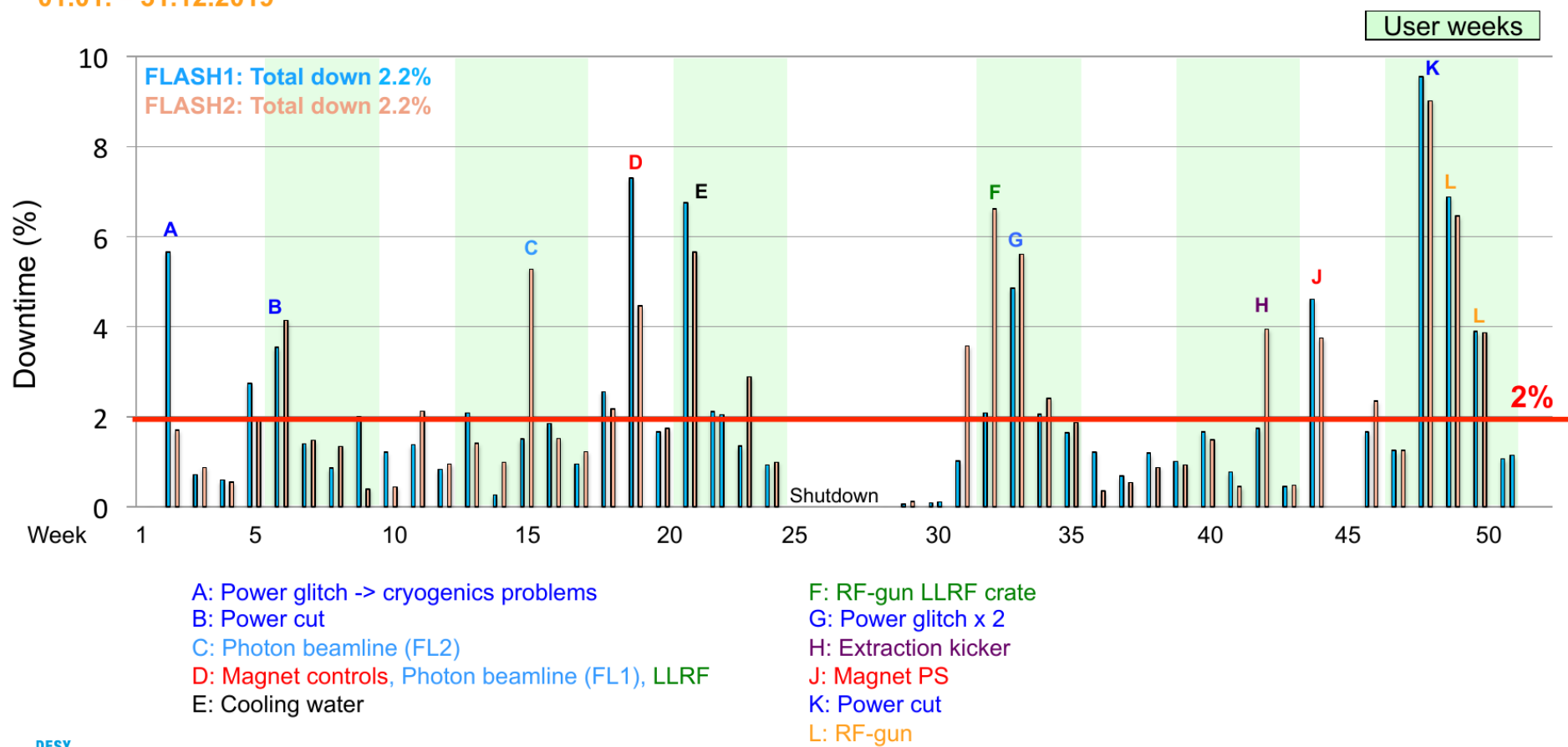
FLASH2: 2792 h FEL user operation



FLASH Downtime Per Week (courtesy K.H.)

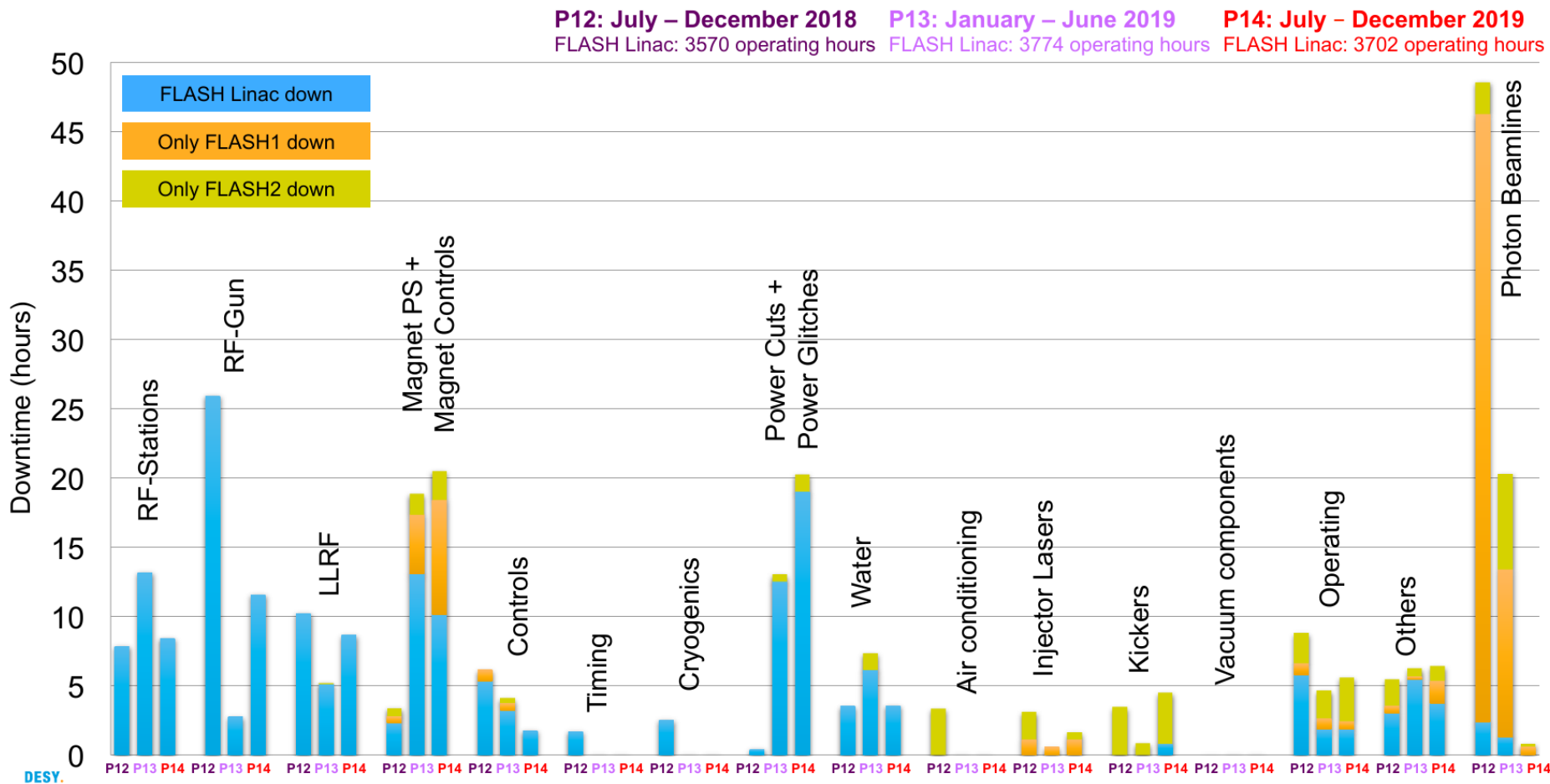
Weekly downtime 2019

01.01. – 31.12.2019

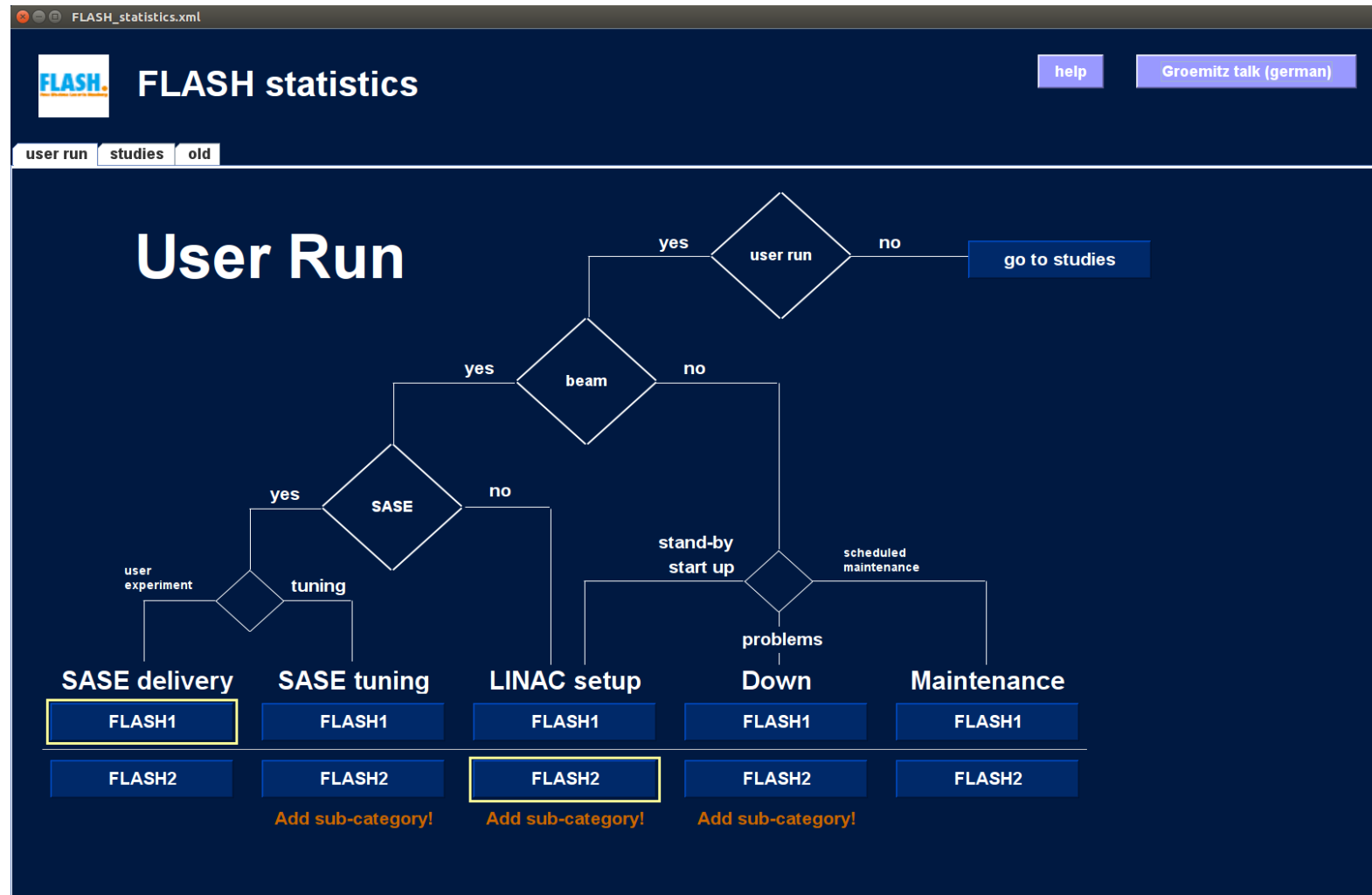


FLASH Downtime Reasons (courtesy K.H.)

Downtime Reasons 2018 - 2019



Before we forget. . .

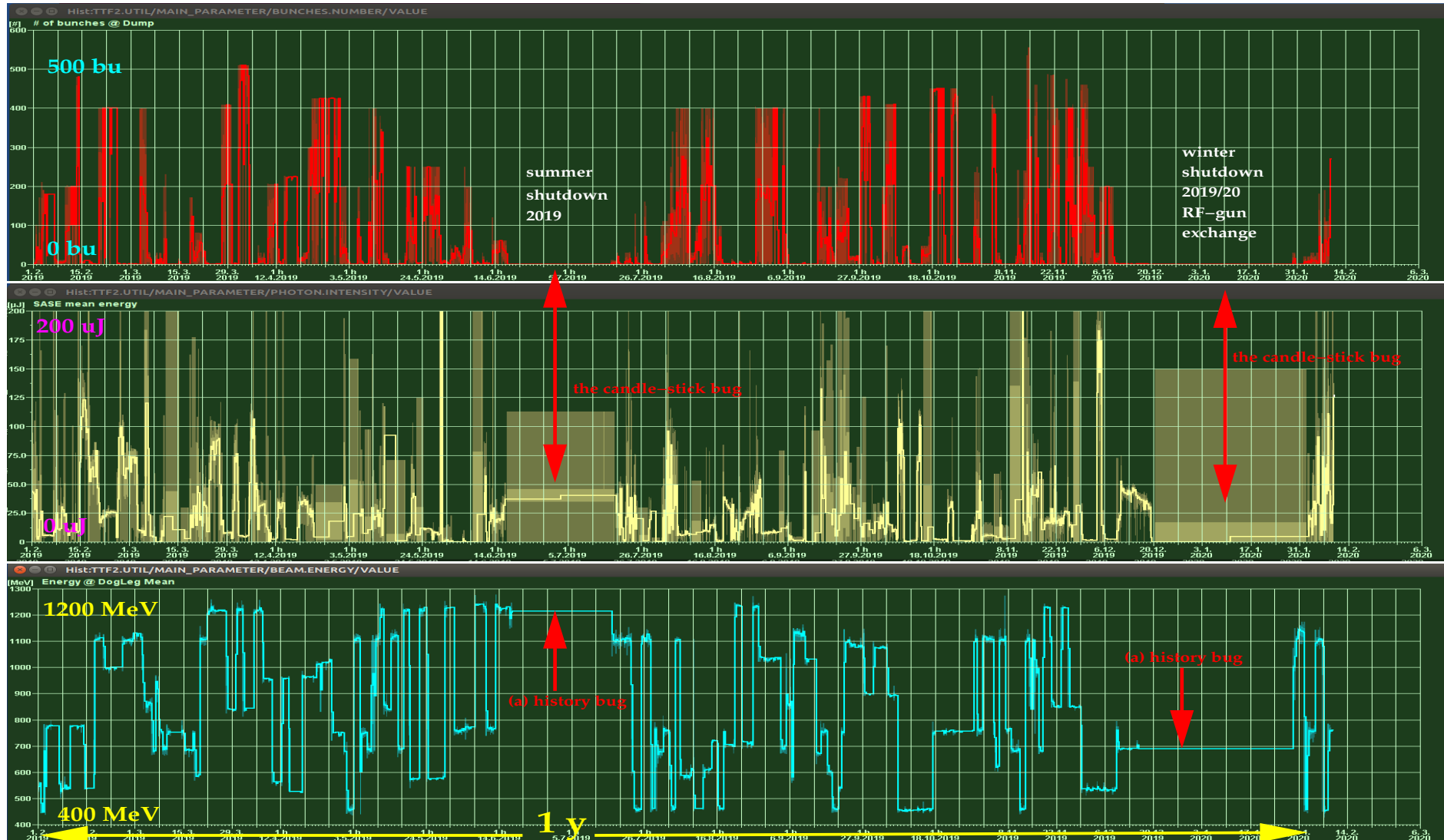


There is now statistics w/o the properly maintaining the statistics database!

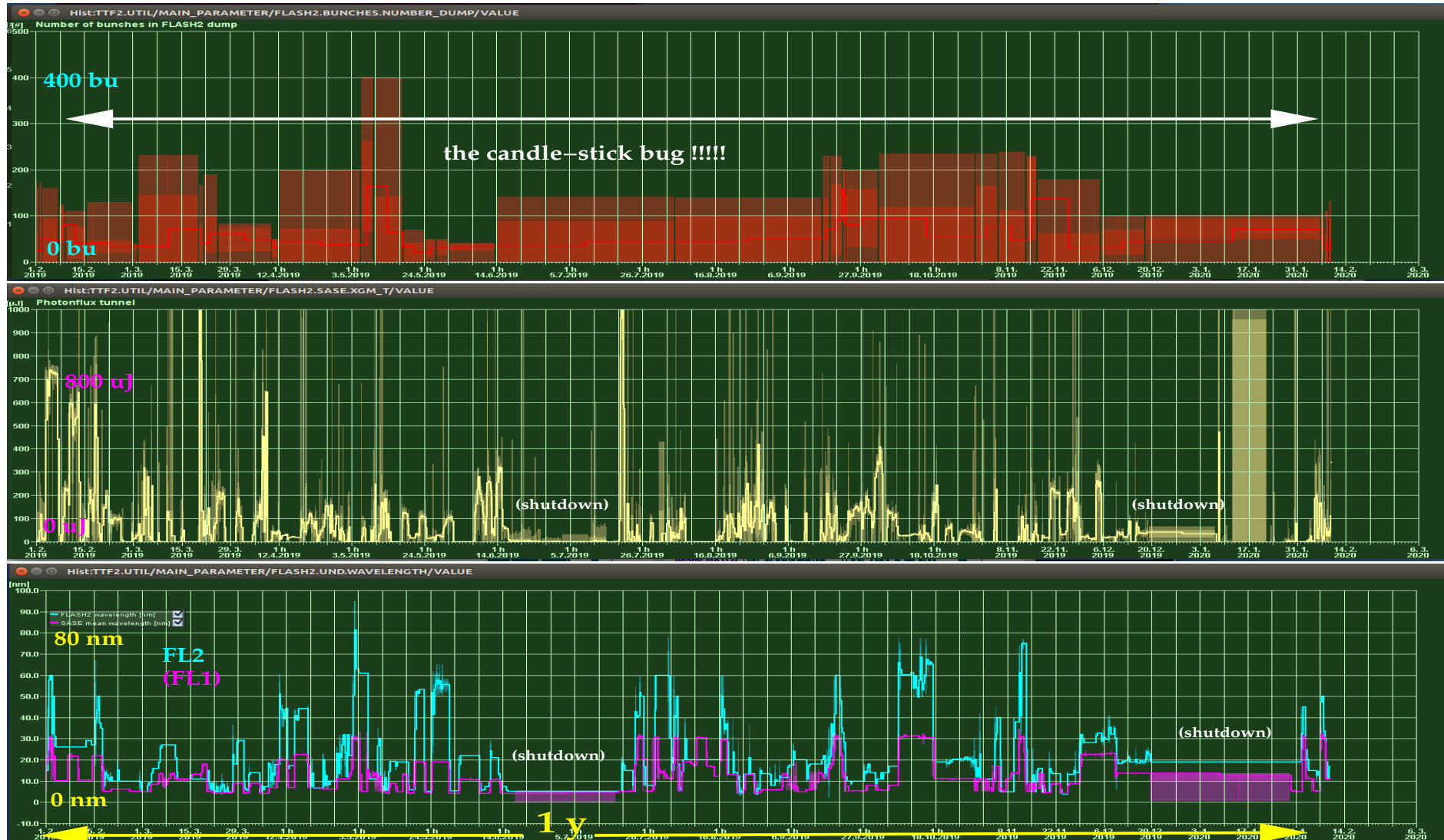
The Power Cut during night shift 2019-11-27 (= 11-28 ~4h)

- Power **cut** not power glitch!
- Hall III was dark !
- Even the BKR was dark !
(for some time)
- Magnet-PS's / RF-stations
/ lasers / timing crates → off
- Many controls servers: hard down
- RF-gun temperature regulation:
rapid cool down from
60°C to 35°C
- took about 11h to get beam back
about 16h 'till SASE delivery
- in the aftermath :
→ some hardware died just a
couple days later:
→ i.e. hard disks,
(crate) power supplies, . . .
→ weird cooling water losses in the
RF-gun water system. . .
(see 11 slides below . . .)

FLASH1 Run Parameters 02.2019 — 02.2020



FLASH2 Run Parameters 02.2019 — 02.2020



An Example of Stable & Flexible 2-User Operation (from J.R.-S.'s MAC talk)

Example

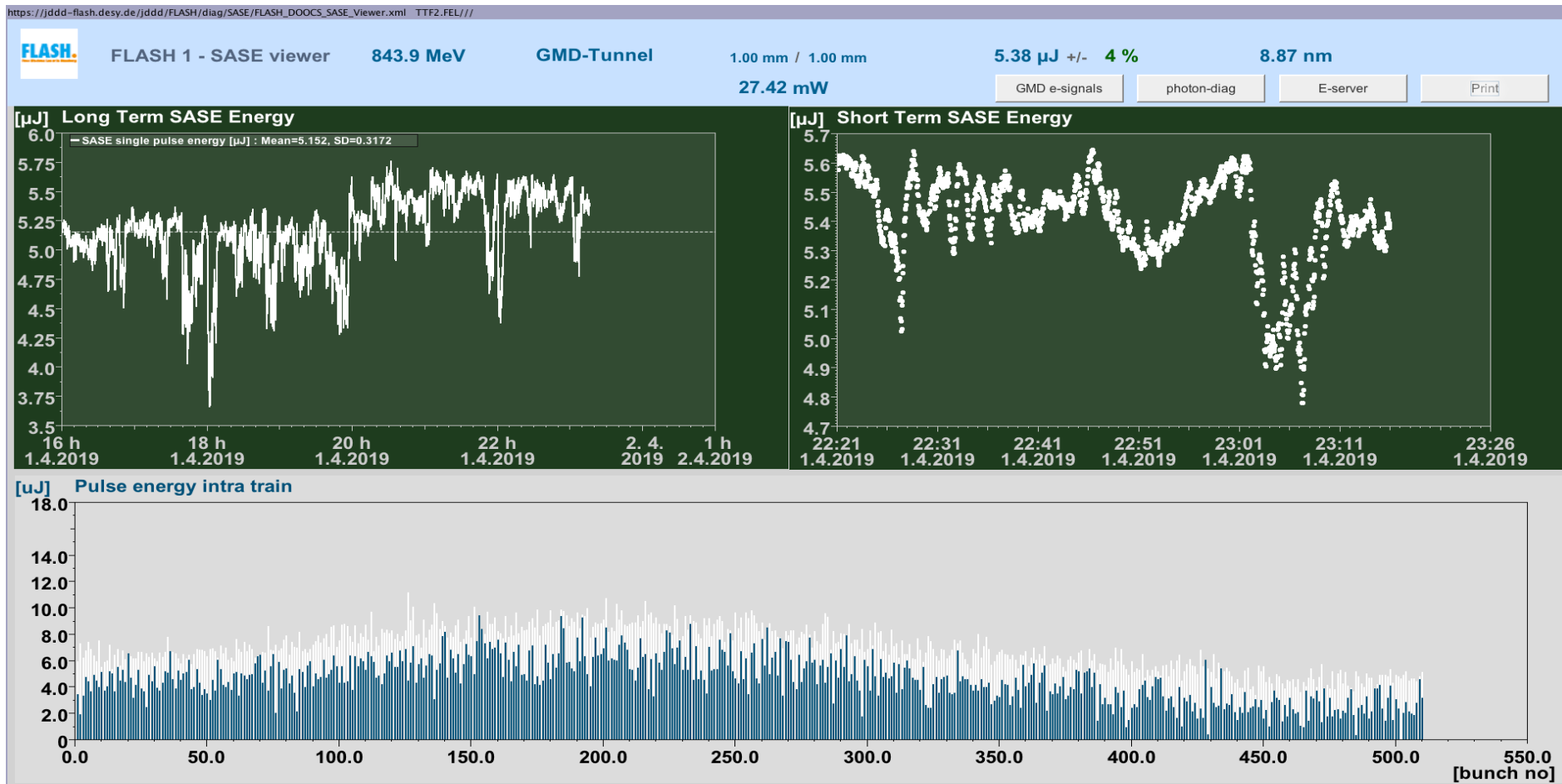
User run

- FLASH1:
Eberhardt/Roth,
8.0 nm,
430 bunches,
1 MHz
- FLASH2:
Mehrjoo,
13.5 nm,
18.0 nm,
1-3 bunches,
1 MHz



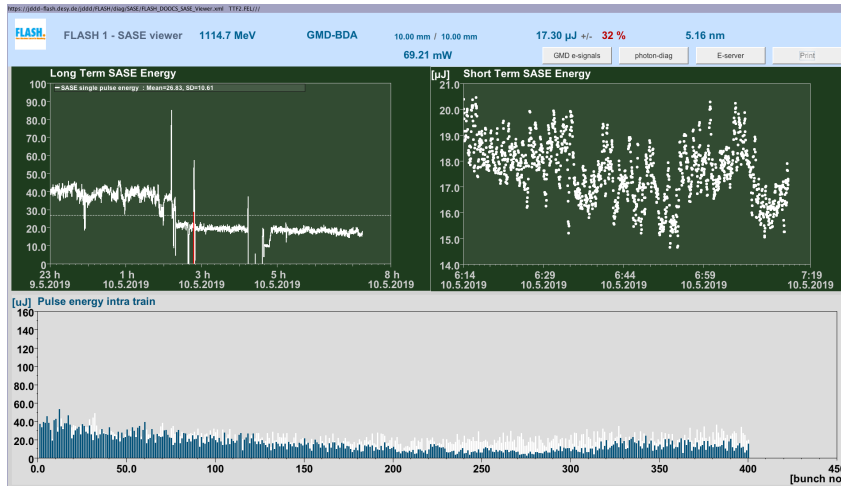
- Both short pulse duration 50 — 100 fs
- Versatility will be even enhanced w/ variable gap undulator for **FLASH1** !!!

Example (2) FL1 alone → 510 bu



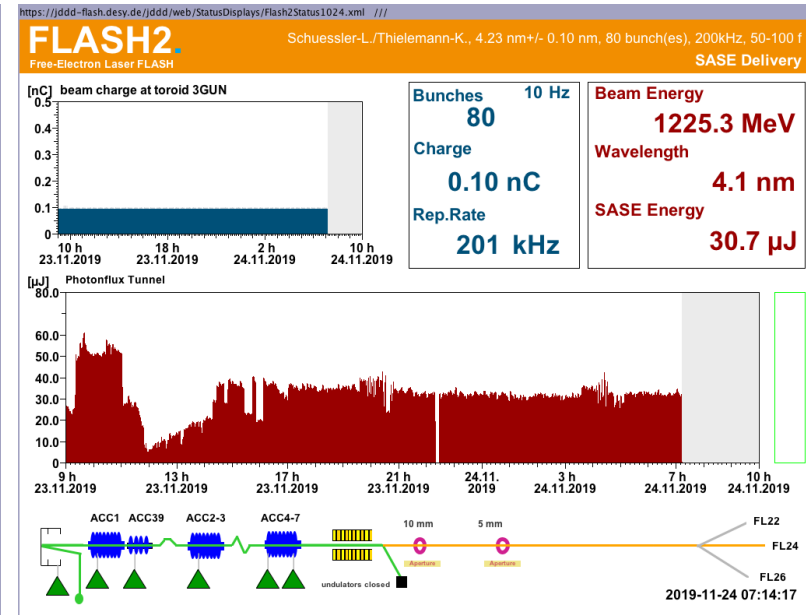
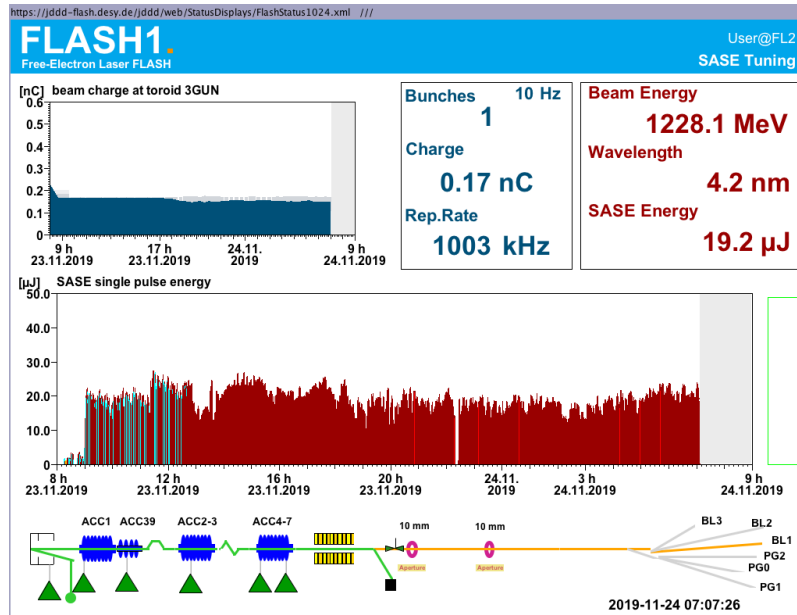
- photon apertures closed to 1 mm (!) // 0.22 nC $\Rightarrow$ medium short pulses
- (2019-04-01)

Example (3) FL1 400 bu 5.1 nm FL2 50 bu 5.0 nm



- Standard bunch charges:
 FLASH1: 0.4 nC,
 FLASH2: 0.3 nC
 ⇒ not short
- “Medium short” wavelengths,
 but FLASH2 shorter
 than FLASH1
- (2019-05-10)

Example (4) FL1 1 bu 4.2 nm FL2 80 bu 4.1 nm



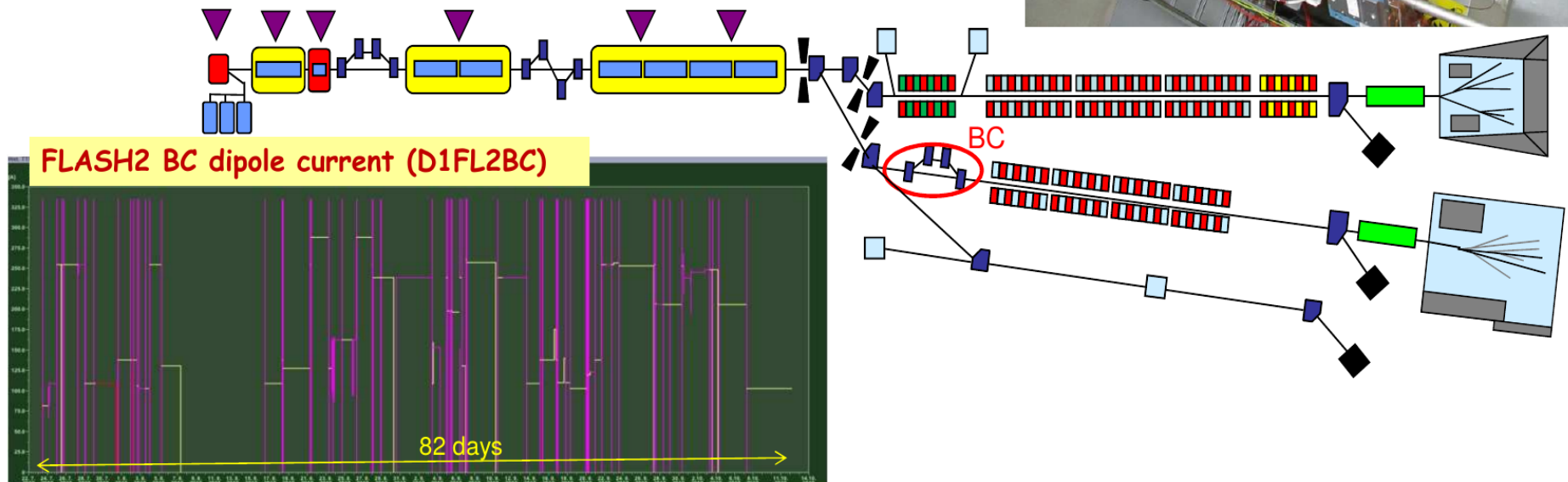
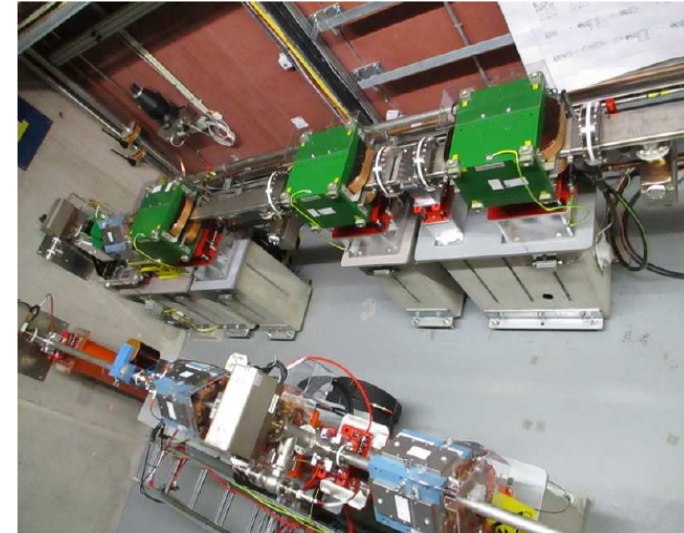
- Both low charge $\rightarrow$ short pulse duration
- **Shortest** wavelength, FLASH2 even shorter than FLASH1
- (2019-11-24)

Studies Highlights : Commissioning of FL2BC (courtesy J.R.-S.)

FLASH2 Bunch Compressor

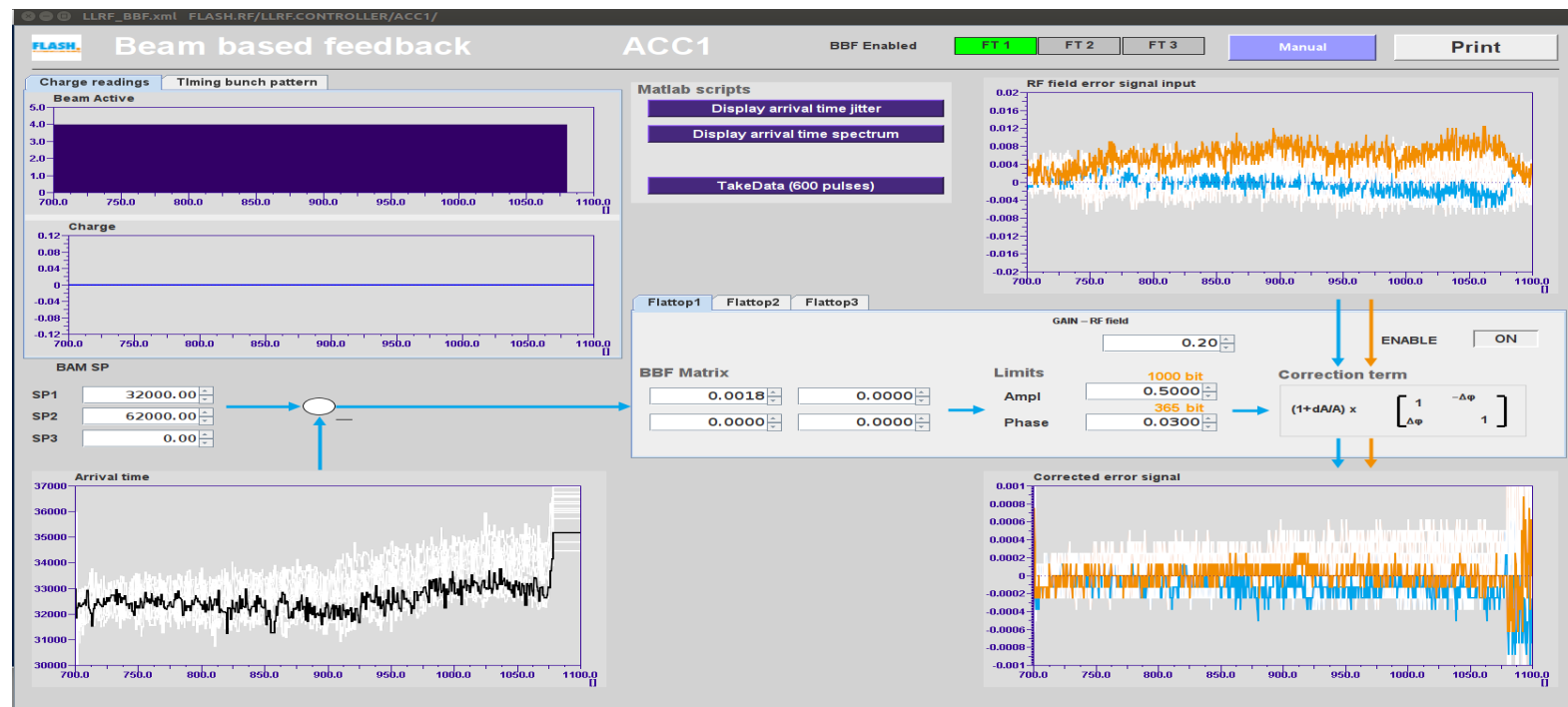
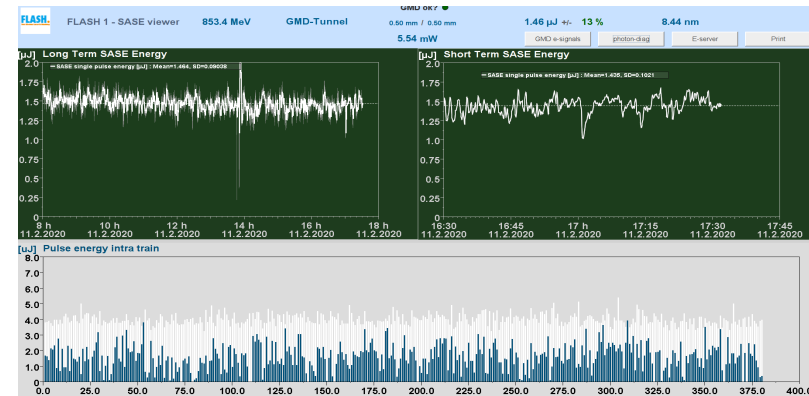
Improves emittance, stability, flexibility, and short bunch generation

- Additional bunch compressor downstream extraction
 - Installed in June 2019, now routinely operated
 - Less compression at lower energies
 - Better control of CSR and space charge effects
 - Simulations show a significant improvement of beam properties



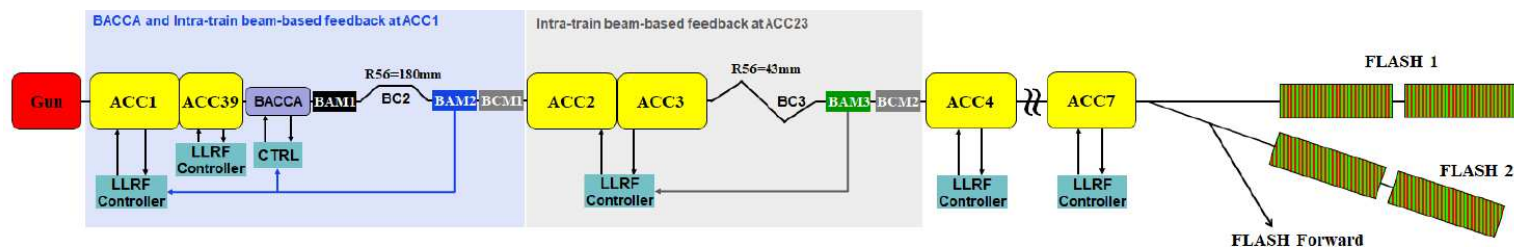
Fast Arrival Time FB : ACC1/23

- Upgraded BAMs & LLRF servers
 - Intra Train ACC1 in std use!
- **BACCA**
- ACC23 still being commissioned.
 - (2020-02-11)



Fast Arrival Time FB : BACCA Commissioning (courtesy J.R.-S.)

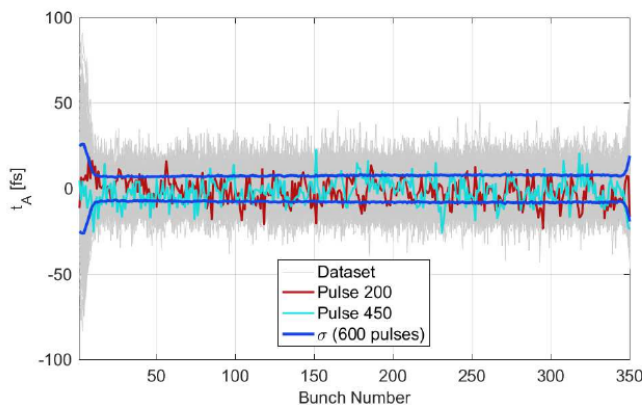
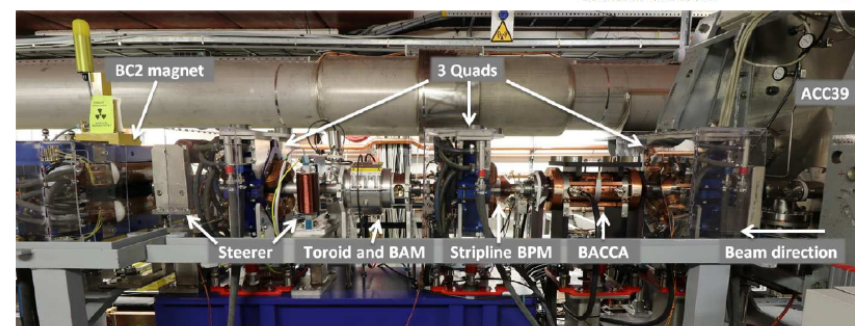
BACCA



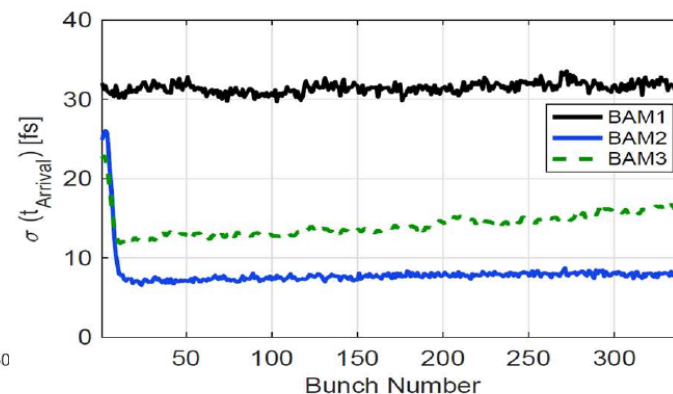
Fast arrival time stabilization towards 1 fs

- Normal conducting, S-band cavity "Bunch Arrival Corrector Cavity"(BACCA).
- Larger bandwidth to improve the arrival time stability below 5 fs
- Commissioning result: arrival time stability improved from 25 fs (rms) to 8.5 fs (rms)
- The steady state value of the arrival time stability is reached within the first 10 bunches (10 μ s for 1 MHz).

Courtesy: MSK,
S. Pfeiffer,
B. Lautenschlager et al.



Mean free arrival time of the second BAM (BAM2).



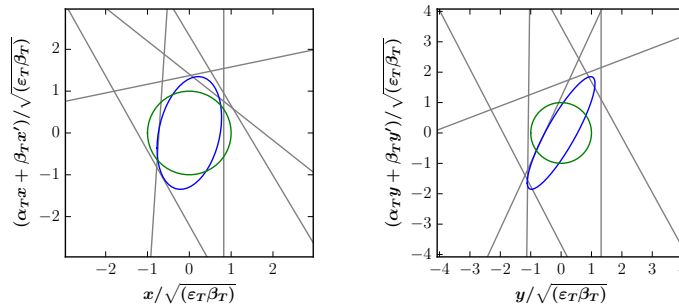
Standard deviation of the arrival time.

- PowerAmp was broken $\rightarrow$ repaired // recomm. next beam time!
 $\rightarrow$ Already updates planned

Optics → Wire scanners



$$\begin{aligned}
 \beta_T &= 15.19 \text{ m} & \beta_M &= 9.05 \pm 0.30 \text{ m} & \beta_T &= 6.67 \text{ m} & \beta_M &= 8.30 \pm 1.01 \text{ m} \\
 \alpha_T &= 1.31 & \alpha_M &= 0.50 \pm 0.03 & \alpha_T &= -0.59 & \alpha_M &= -2.54 \pm 0.26 \\
 \varepsilon_T &= 0.70 \text{ } \mu\text{m} & \varepsilon_M &= 0.70 \pm 0.02 \text{ } \mu\text{m} & \varepsilon_T &= 0.53 \text{ } \mu\text{m} & \varepsilon_M &= 0.53 \pm 0.05 \text{ } \mu\text{m} \\
 m_P &= 1.21 & \lambda_P &= 1.88 & m_P &= 2.34 & \lambda_P &= 4.46
 \end{aligned}$$



- Update of **FL1** Zeuthen-type undulator wire scanners
- w/ new linux based X-FEL-type server
- ... finally (mostly) operational!
- 1st measurement 2020-02-01!

Controls and Operations/Operability

+ Split Flat Tops

→ **much more sensible and usable implementation!**

→ much less “discriminating” FL2

→ more versatile: max step depends on transition time

→ but (so far) more buggy...

→ will (hopefully) be fixed in next release.

- Problems w/ jddd history panels.
all used to be nice until... ⇒

— THE CANDLESTICK BUG:

← remember slide on

“FL1/FL2run par’s 2019-2020” !!!

→ **needs** way to **really** switch off!

→ (intervals for statistics seem unfavorable)

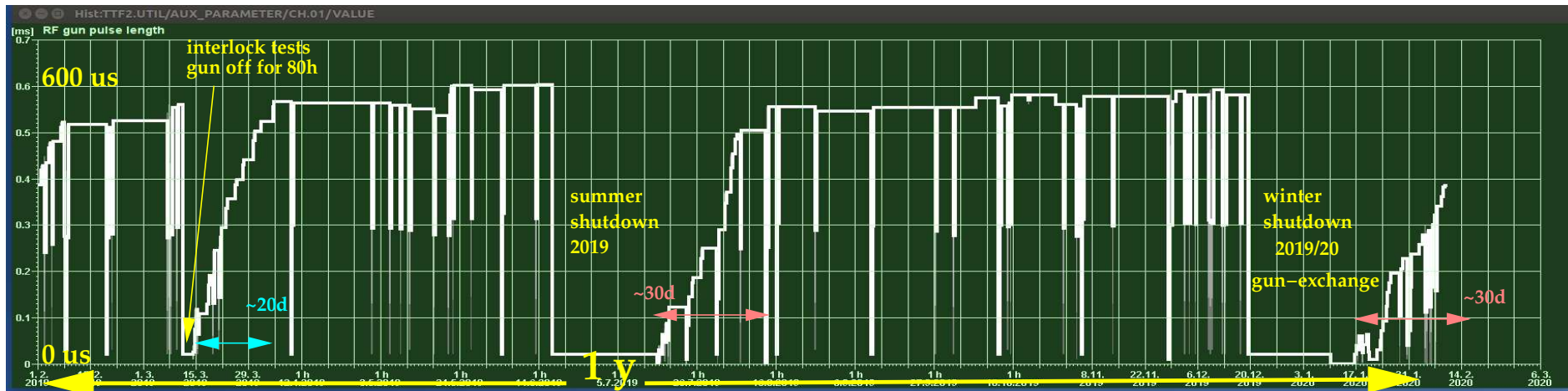
→ if it cannot be fixed ⇒ **REMOVE!**

— Various history bugs:

→ history of certain traces suddenly vanishes

→ x-autoscale update “often” uses only 50% of plot!

Recurring Cast of this Show : our RF-Gun a.k.a. “Incontinentia”⁺



- GUN 3.1 used for 6.5 years
- despite several RF-window changes...
- never any actual “gun-related” (≡ backplane-related) issues
- ... until the power cut during night shift 2019-11-27
- After recovery problems w/ apparent water losses
- Frequent (every 2-4 days) refills required ⇒ ???

⁺: from Monty Python’s “The Life of Brian” (1979).

(courtesy S. Lederer, A. Wagner)

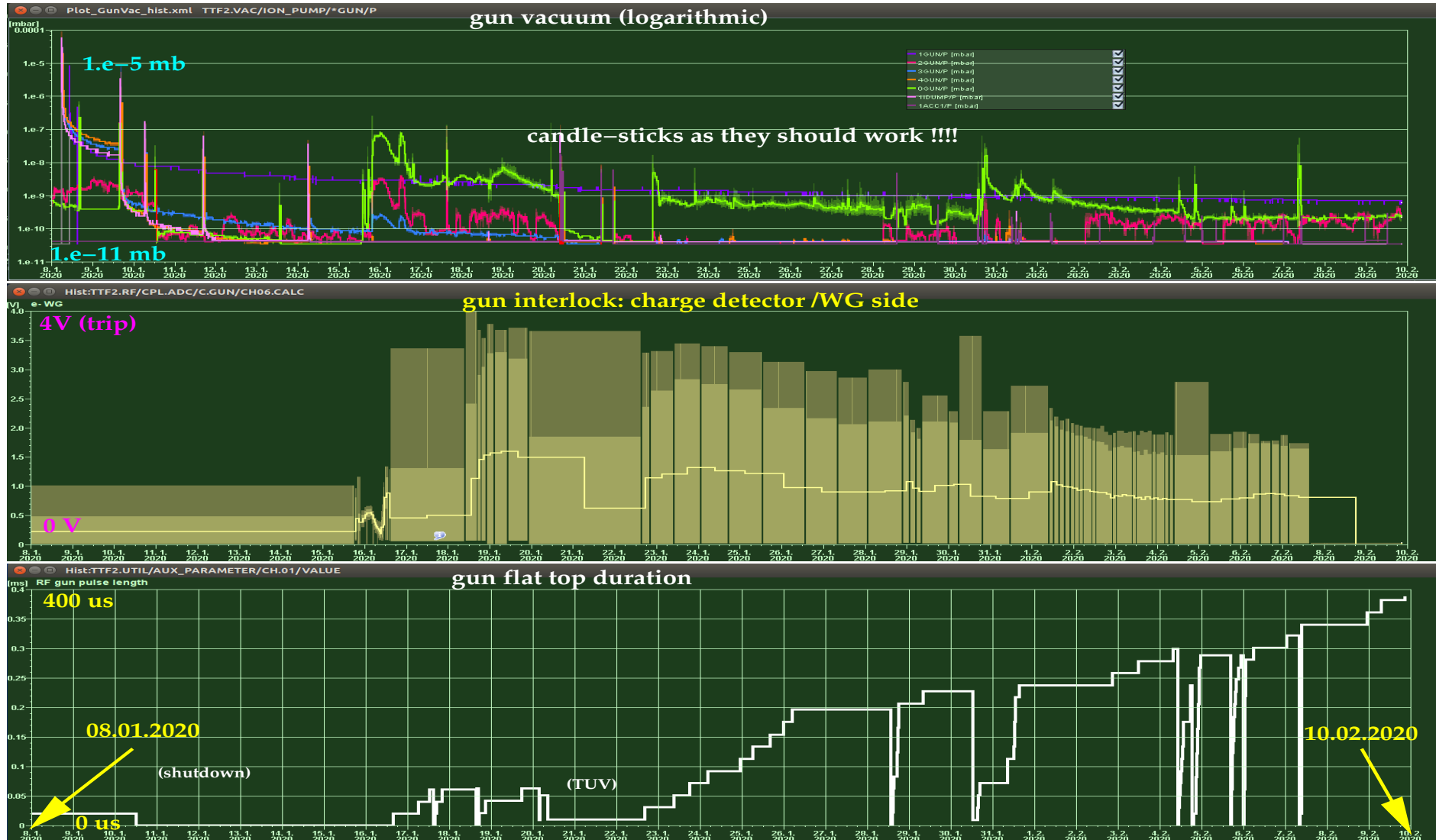
Wasserlecks an Kühlkanal von Gun3.1 05.12.2019



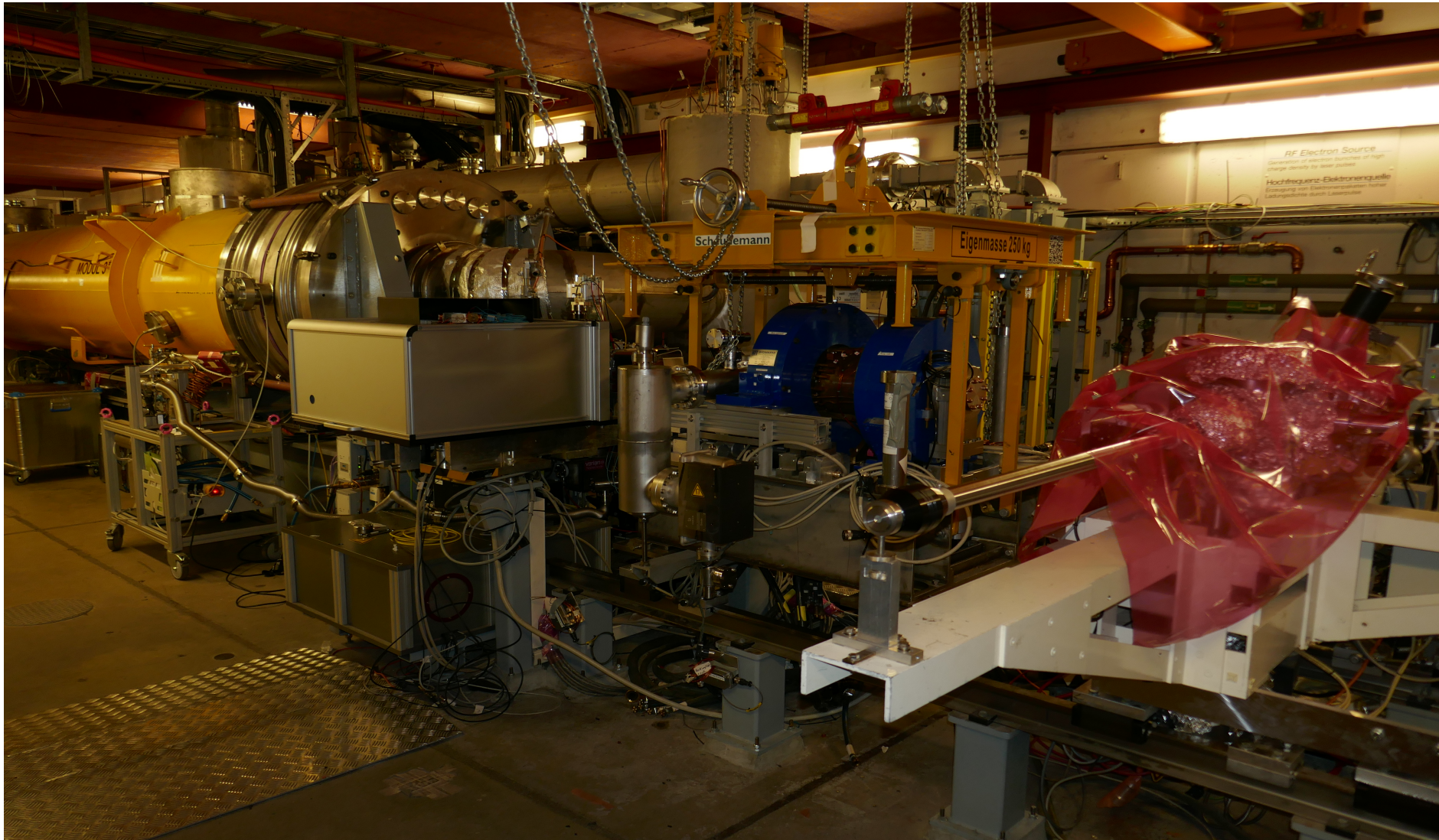
Gun Exchange X-Mas Shutdown 2019/20 & Recovery

- Leak was attempted to fix 2×
→ no “sustainable” success
- Gun change 3.1 → 4.4 decided for X-mas shutdown:
2019-12-19: cathode studies, then
start removal of peripheral HW
2020-01-06: gun 3.1 removed from
tunnel
2020-01-06: gun 4.5 installed at
tunnel, start survey & assembly of
peripheral HW
2020-01-08: vacuum closed
- 2020-01-15: gun start-up,
power checks, initial conditioning
- 1st shift: reached nominal power
w/ short RF pulses
- conditioning strategy:
**continuously apply small steps
to increase flat top**
→ absolutely no problem !
- stable operation: reached flat top
425 μ s on 2020-02-12
→ PWM & FSM (in fast-ramp-up-
mode) enabled

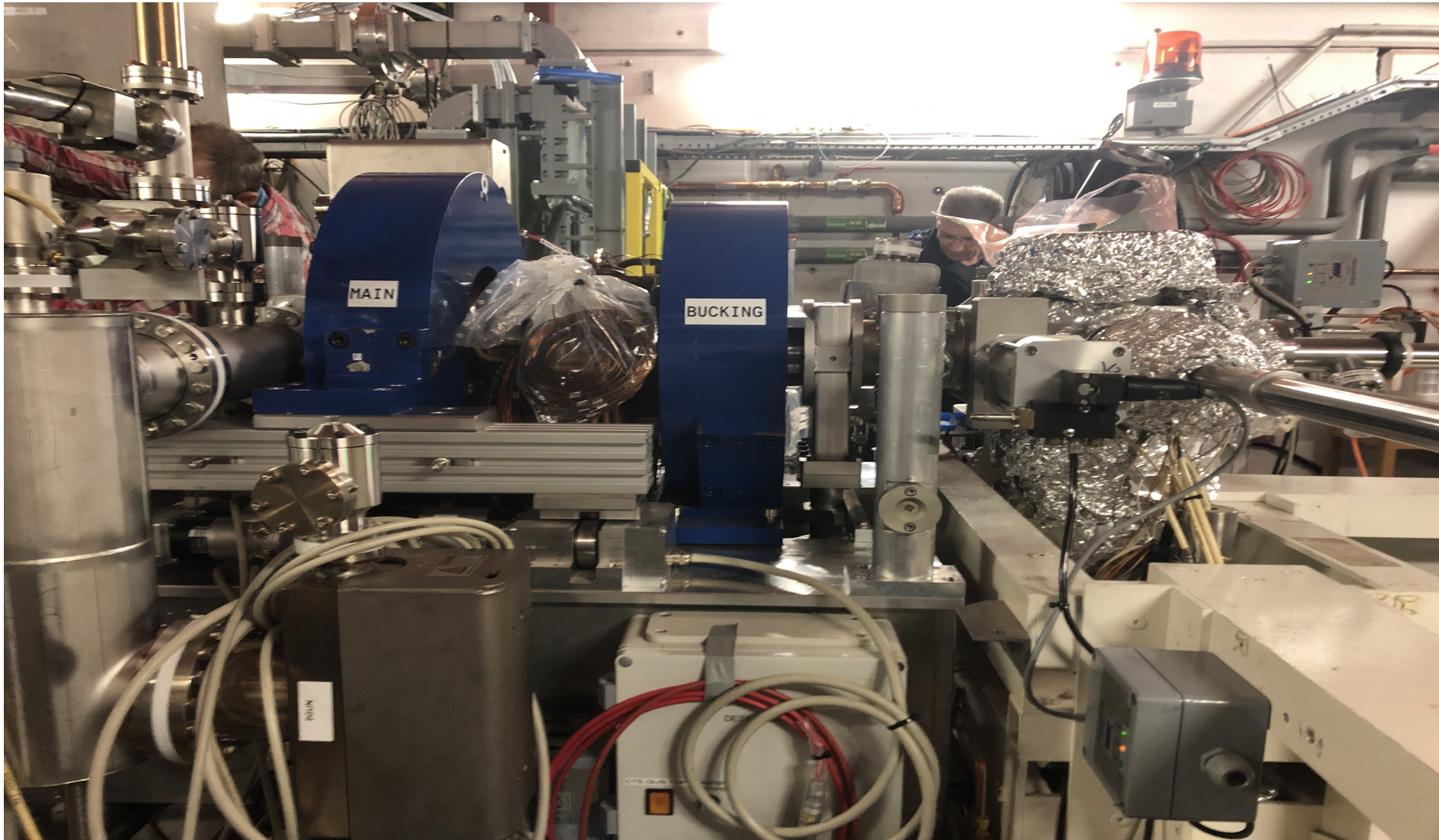
Gun Recovery



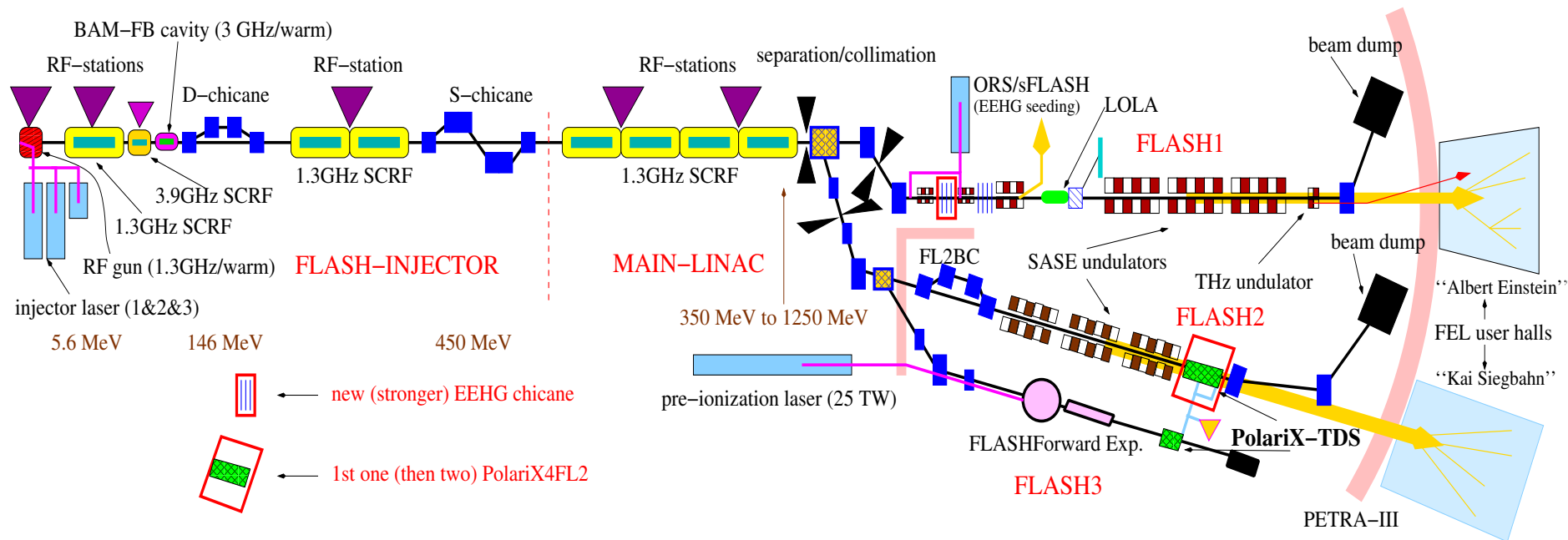
Gun 3.1 in FLASH Tunnel 2020-01-04



Gun 4.4 in FLASH Tunnel 2020-01-08



Short Term Outlook



- more BAMs
- more optical sync. links
- finish new MO
- 1st PolariX-TDS for **FLASH2** → summer

- 2nd PolariX-TDS for **FLASH2** → ~2021
- new EEHG chicane for **sFLASH** → summer
→ demonstrate EEHG-seeding at sFLASH around 30 nm
- **More in Siggis talk after the coffee break!**

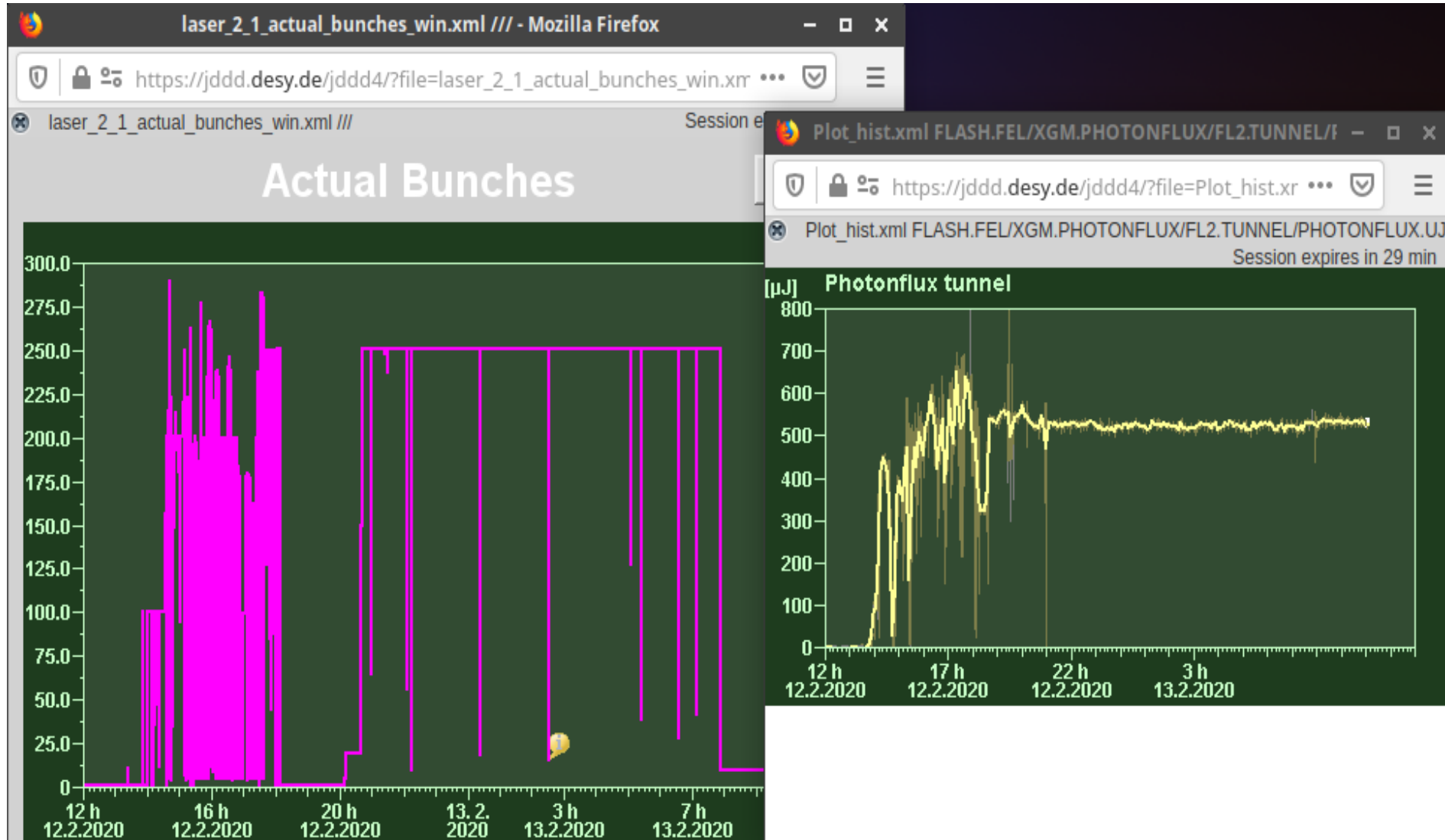
Summary

- FLASH had a very successful year 2019!
- ...until the big power cut on 11-28 :-)
- Incontinent RF gun exchanged successfully and in minimal time in X-mas shutdown.
- RF gun conditioning absolutely smooth
- Last Monday (02-10) started w/ first users ([FLASH1](#)) w/ 380 bunches at PG photon beamline ($\Rightarrow$ strong demands on stability and uniformity)

→ Null Problemo!



This Morning 10:00 : FLZ Bunches & SASE 1-DayHistory



A big thank you to **all**, who participated and helped in operations, maintenance, development of FLASH, and in the planning and design of the future of FLASH, and in particular to those which intend to keep doing this!!!

and ...

Thank you for Listening!