



Operations in Run 4

IOTA/FAST Collaboration Meeting

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Tuesday, 1330

12-March-2024

Overview

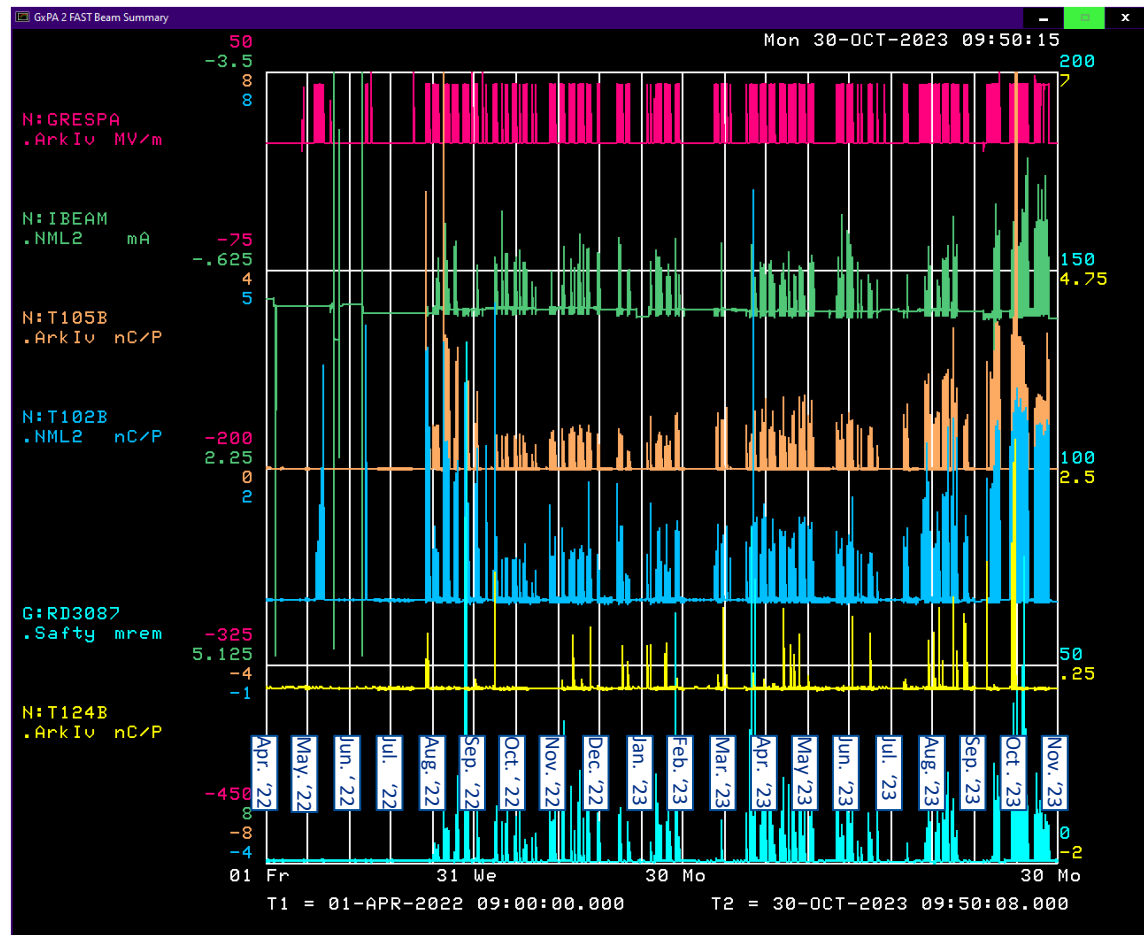
- 18 months, 22 days, ~1 hour
 - Planned runtime: ~6 months
- Very difficult Run
- Long stretches of downtime → massive rush towards the end w/crews running 24/7
- Despite this, we managed to accomplish a great deal and deliver on ~*majority* of promised beam time
 - IOTA150-CLARA – *1st experimental crew to complete shifts this Run: late-May 2023*
 - IOTA150-NIO – *John took >35,000 scans throughout the Run*
 - Installed & commissioned new stripline BPM + kicker system at C-Left in IOTA for IOTA150-NIOLD
 - Preliminary characterization of the LINAC for FAST-GREENS – *Eric. Cropp, November 2022*
 - Trained 5 new Qualified Operators – *John, Brandon, Steve, Mike, Trey*
 - IOTA150-LADR crew demonstrated the ability to run IOTA in Low- α mode
 - Construction of FAST-GREENS Stage-0 beamline underway, despite challenges / delays
 - NEB crew consistently able to accelerate 32 MeV beam using both Capture Cavities and transport it to X121 / LEA
- Post-Run, priority has shifted completely to construction & commissioning of IOTA Proton Injector (IPI)

Experimental Program

- **IOTA150-NIOLD** [I-401] – *IOTA Experiment Nonlinear Optics: Landau Damping (N. Eddy & Co.)*
 - 26-SEPTEMBER-2023 → 19-OCTOBER-2023
- **FAST-GREENS** (preliminary) [I-402] – *Gamma Ray High Efficiency Enhanced Source (P. Musumeci, E. Cropp, & Co.)*
 - 8-NOVEMBER-2022 → 5-APRIL-2023 (studies to characterize FAST LINAC ahead of experiment-proper)
- **IOTA150-CLARA** [I-403] – *Coherence Length of Undulator Radiation (S. Nagaitsev, A. Romanov, A. Shemyakin, G. Stancari)*
 - 28-MARCH-2023 → 24-MAY-2023
- **NEB** [I-404] – *Noise in Intense Electron Bunches (S. Nagaitsev, J. Ruan, & Co.)*
 - 25-JANUARY-2023 → 29-SEPTEMBER-2023
- **IOTA150-NIO** [I-405] – *Nonlinear Integrable Optics (A. Valishev, A. Romanov, J. Wieland)*
 - 14-APRIL-2023 → 23-OCTOBER-2023
- **IOTA150-SETI** [I-406] – *Single-Electron Tracking in IOTA (A. Romanov)*
 - 8-JUNE-2023 → 6-OCTOBER-2023
- **IOTA150-LADR** [I-407] – *Low- α Demonstration Research (J. Jarvis, M. Wallbank)*
 - 27-SEPTEMBER-2023 → 22-OCTOBER-2023

Run 4.

- 1-April-2022 to 23-October-2023

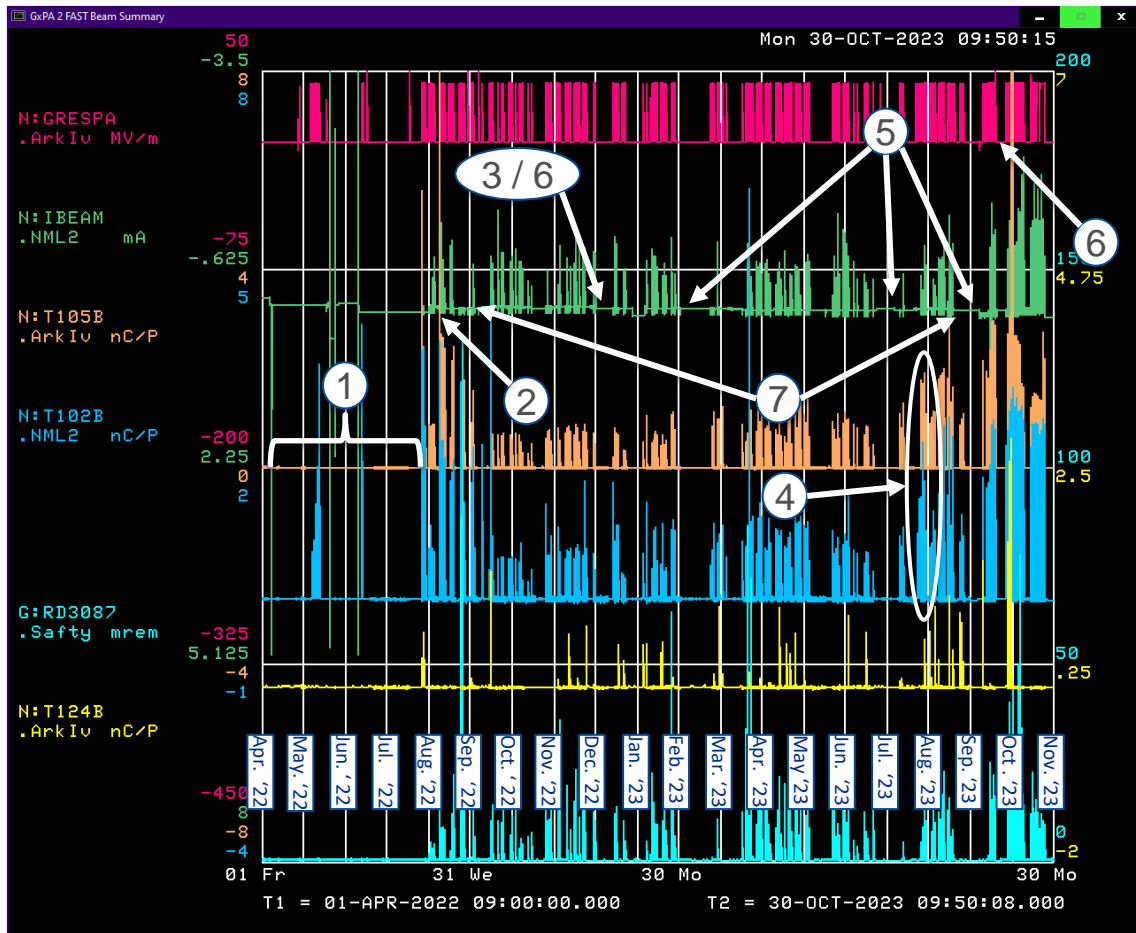


Run 4.

1. Initial Nitrogen shortage
2. 150 MeV beam into orbit
3. ICW pipe break
4. Photocathode conditioning
5. Cryo thermal bumps
6. RF Gun oil processing
7. Outage recovery
8. Sitewide security stand-down*

Will discuss Downtime in more detail on a forthcoming slide

**concurrent w/Thermal bump in July '23*



Things that worked well...

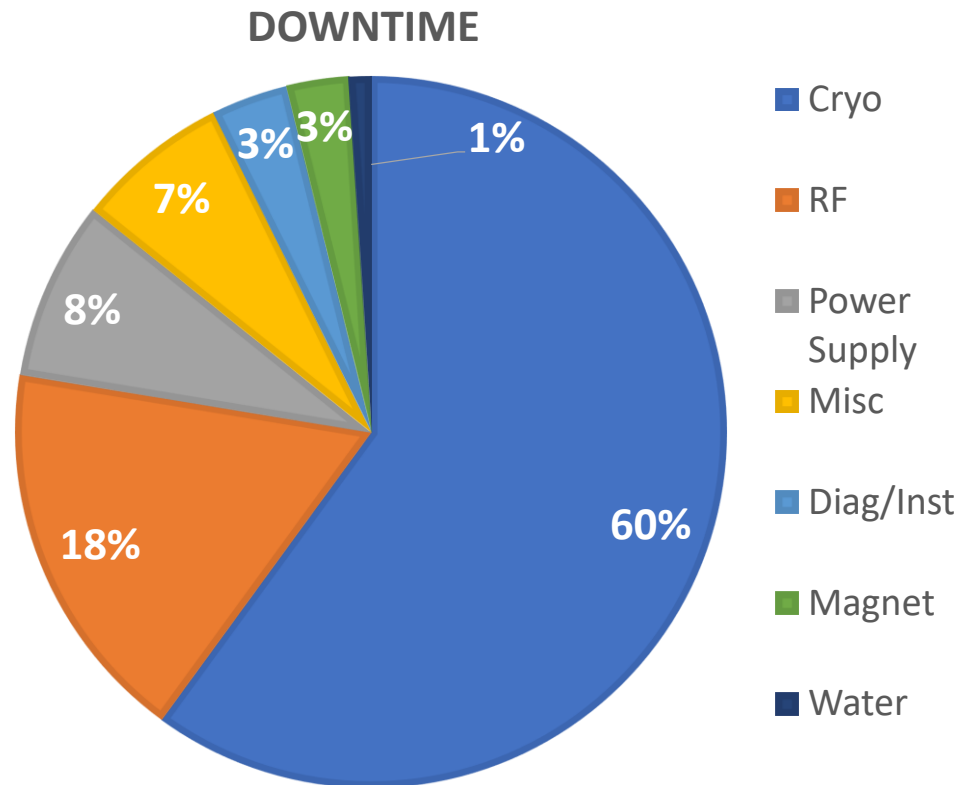
- FAST-Ops Personnel
 - Communication was generally strong throughout Run between EPs / FAST operators & crews for experiments
 - Willingness to push: >>40 hrs/week, weekends, off-hours, remote support
 - Implemented new shift/access scheduling system, attempted to improve inter-departmental communication
- Consistent support / effective cooperation between FAST Facility Ops. & Accelerator Research Dept.
 - IOTA150-LADR crew willing to take primarily off-hours shifts in 11th hour of Run following provisional approval from ISC
 - Effective timesharing
 - Machine studies were rarely an issue to fit into the schedule (e.g. PMT calibrations, 1e⁻ lifetime measurements, LINAC characterization)
 - Communications Upper Management to the Dept. at AD-ARD meetings (via Jonathan, Giulio, Dan)
- EE Support (now: PESD)
 - Nick Gurley, Eric Claypool & Co. for 5 MW systems – *extremely effective, clear communication, consistent availability*
 - Pete Dimovski & Co. for IOTA kickers, bulk supplies – *willing to assist on issues not even under their jurisdiction*
- Commitment to Safety: no major injuries or incidents involving harm to personnel

... and things that didn't.

- Cryogenics
- Fallout from new safety policies, security shutdowns, administrative controls – *typically in the form of delays / downtime*
- HLRF – *primarily both 5 megawatt systems (RF Gun, Cryomodule)*
 - Besides Cryo, 2nd largest fraction of downtime
 - RF Gun pulse transformer oil filtration campaigns
 - CC's had occasional issues however not to the same extent - *ESECON & SSA issues w/CC1, nightmare conditioning CC2 early in Run*
- “Orphaned” systems without support/documentation – *eCool 2A supplies, ESECON, RF Gun H2O loop, ZUP supplies...*
- External support from...
 - Procurement – *punishingly long lead-times across the board, most relevantly w.r.t. contractors, IPI preparation in parallel w/Run*
 - Contractor coordination – *IOTA kicker & IPI cable pulls massively delayed; multiple failed attempts to get electricians onsite*
 - Controls - *w.r.t. pushing updates / taking frontends offline without forewarning; improvement towards end-of-run however*
 - In general: feeling is that we are far out on the border of AD, sometimes not prioritized or considered in impactful decisions
- Enclosure access
 - Cryo access incident – *keys issued, pulled w/o communication w/FCR: crashed all RF systems & IOTA bend dipoles, brief Safety shutdown*
 - UCLA student access incident – *led to ~3 full days of downtime, restrictions on enclosure key distribution*

Downtime

- Majority of downtime was on Cryo.
- RF made up most of the rest...
 - Specifically, HLRF – *EE Support effective in minimizing this*
 - RF Gun dielectric oil, Cryomodule C.S. phase controller
 - CC1 LLRF issues in late-July '23 + Sept. '23
- Power supplies:
 - 2 Amp eCool chassis
 - IOTA injection line (D600/604, Lambertson, IBEND)
 - 300 MeV Bulks can be touchy - *fictitious trips hide real trips*
- “Misc.” primarily composed of safety/security stand-downs
- Instrumentation: BPM hang-ups, Cameras, TPM actuators
- Water → primarily M4R leak, December '22
- *Graphic courtesy of Jamie Santucci*



Inconsistencies, Workarounds, and “Magic Wands”

- Most common issues faced daily by FAST-Ops, experiment crews
- System-to-system variation
- Examples:
 - Digital Statuses of some devices very clear w/explicit trip indications, some completely opaque w/raw bits as the only output
 - Alarm handling / reporting – *causes frequent interface & confusion w/MCR-Ops*
 - BiRa / MCOR supplies – *work completely fine for IOTA quads, nightmare to deal with for IOTA octupoles*
 - CC2 & Cryomodule Cavity #5 tuner motor temp monitors dead; no feedback during motor moves
 - MPS randomly enabling Moveable Devices, holds-off reset
 - CC klystron solenoid power supplies – random trips (in principle, fixed for CC2...)
 - Unintuitive behavior, “Magic Wands” – *e.g. CC modulators require “RESET” then “OFF” then “ON” to clear trips...*
- Oftentimes issues of this class are not severe enough to warrant immediate attention
 - To a degree, this is understandable – *“If we are running, then we are running”*
 - Issues often then go unaddressed; beam not inhibited → keep going
 - In some cases however, unaddressed issues deteriorate further to the point of inhibiting beam operations (e.g. CC klystron solenoid faults)
 - And yet, oftentimes there is truly not much we can do (e.g. orphaned system, not our system & experts unavailable)

Example:

```
PA S53 Digital Status<DPM-DPM02 (1%)>
S53 DIGITAL STATUS
PARAM* *SA X-A/D X=TIME Y=N:IBEND ,N:D600 ,N:D604 ,N:ILAM *RESET
*save --- Eng-U I= 0 I= 0 , 0 , 0 , 0 *ON
Once 15_Hz F= 60 F= 600 , 100 , 100 , 600 *OFF
.global .linac .booster .mi .bnb .sy .muon .misc .other..

N:D600 D600 MEASURED I See Alarm Log Ctrl-Menu
More Info
STANDBY/ARM..... OK 1 bit-31..... ONE 1 *On
INTERNAL PS OVER TEMP... OK 1 bit-30..... ONE 1 *Off < *
EXTERNAL INTERLOCK..... OK 1 bit-29..... ONE 1 *Reset< T
FUSE FAULT..... OK 1 bit-28..... ONE 1
PROGRAM FAULT..... OK 1 bit-27..... ONE 1
PHASE LOSS..... NO480 0 bit-26..... ONE 1
INTERNAL PS OVER CURRENT OK 1 bit-25..... ONE 1 Alarm is
INTERNAL PS OVER VOLTAGE OK 1 bit-24..... ONE 1 BYPASSED
LOAD OVER CURRENT..... FAULT 0 BEAM ABORT I ERROR... OK 1 Speech is
RACK SMOKE/HEAT DETECTOR OK 1 BEAM ABORT I MEASURED... OK 1 BYPASSED
MAIN CONTACTOR..... FAULT 0 BEAM ABORT I REFERENCE.. OK 1 Edit
UNDER VOLTAGE..... NO480 0 PS IN REGULATION..... OK 1
GROUND FAULT..... OK 1 FEEDFORWARD ON..... TRIP 0
Magnet Over Temperature. OK 1 FEEDBACK ON..... TRIP 0
DIGITAL FLOW METER TRIP OK 1 PS ON..... TRIP 0
ELECTRICAL SAFETY SYSTEM OFF 0 PS ON REQ..... TRIP 0

Messages
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Digital Status for N:D600

```
PA S53 Digital Status<DPM-DPM08 (0%)>
S53 DIGITAL STATUS
PARAM* *SA X-A/D X=TIME Y=N:IBEND ,N:D600 ,N:D604 ,N:ILAM *RESET
*save --- Eng-U I= 0 I= 0 , 0 , 0 , 0 *ON
Once 15_Hz F= 60 F= 600 , 100 , 100 , 600 *OFF
.global .linac .booster .mi .bnb .sy .muon .misc .other..

N:IBEND IOTA Bend Mag PS Current See Alarm Log Ctrl-Menu
More Info
bit-15 ..... 0 0 *On < .
bit-14 ..... 0 0 *Off
bit-13 ..... 0 0 *Reset
bit-12 ..... 0
bit-11 ..... 0
bit-10 ..... 0
bit- 9 ..... 0
bit- 8 ..... 0 Alarm is
Contactor Status..... Closed 1 0 ACTIVE-OK
bit- 6 ..... 1 0 Speech is
bit- 5 ..... 0 0 BYPASSED
bit- 4 ..... 0 0 Edit
bit- 3 ..... 0
bit- 2 ..... 0
bit- 1 ..... 0
bit- 0 ..... 0

Messages
```

Digital Status for N:IBEND

Communication

- Broader than any hardware or machine issue, arguably the most important aspect of Operations
- Successes & failures throughout the Run: room for improvement
- Failures occur primarily on the border between FAST-Ops., Support Departments, & MCR
 - Coordinating work inside of the enclosure / scheduling accesses
 - Lapses in understanding about which systems are maintained by which group - *e.g. EE Support w/D600/D604/ILAM supplies*
 - Communications w/MCR regarding enclosure access – *e.g. keys issued in April '23 w/o MachineCo. Authorization*
 - Back & forth between Cryo Dept. & FAST-Ops w.r.t. system failures & shifting Run end-date
- Early-on: frequent “empty shifts” with machine running but no experiment crew available to take beam
 - In context of the 24/7 marathon at the *end* of the Run, somewhat painful to consider retrospectively: wasted time
 - Could be improved by having rigid shift schedule setup from the start, fixed roster of experiments earlier in Run
- Towards end-of-Run, lack of unified direction on Run end-date / conditions
 - Conflicting understandings within Dept. & between experiment crews
 - Confusion between FAST-Ops & Support Departments w.r.t. continuously shifting Run end date – *waiting to begin maintenance*

Planned Improvements Ahead of First IPI Run, Next e⁻ Run

- Maintenance of & upgrades to Cryogenics system
- Realignment of IOTA quadrupoles
- Expanded LCW capacity
 - Increased reliability, accommodation of new IPI + FAST-GREENS beamlines
 - Work carried out by AD Water Group
- Overhaul of CC1 & CC2 HLRF systems (modulators, capacitor banks, charging supplies)
 - Carried out primarily by RF Group engineer Rene Padilla, significant progress already made
- Installation of Class-4 laser lab in ESB + transport system into enclosure (to ~D600 region)
 - Primarily for upcoming FAST-GREENS experiment
- HVAC installation in ESB for improved temperature control (IOTA magnet supplies)
- Numerous minor fixes to accelerator systems
 - Shutdown Fixlist has been generated; currently maintained by FAST Ops. Personnel

Summary

- The expertise & dedication of FAST Facility Ops. personnel consistently outweighed the challenges faced
- That said, there are many lessons to be learned & improvements to be made
- Shutdown 2023 provides an excellent opportunity to accomplish critical tasks, carryout well-needed upgrades & maintenance, and to prepare for forthcoming Runs
 - Preventative Maintenance on critical systems (*as described previously*)
 - Update / generate new documentation, procedures
 - Improve critical ACNET device descriptions / statuses
 - Work w/Support Departments ahead of next Run to improve communication: convey how important their assistance is to our success
 - Continue training new Qualified operators ahead of future Runs, for both p^+ & e^- running modes
- The challenges presented by Run 4 should not be viewed purely negatively: they have perfectly exposed areas of our Facility/Operations that require attention, and should be understood as a tool more than anything else as we move forward

**Thanks.
Questions?**