LINAC & BTF

E. Diociaiuti and L. Foggetta on behalf of

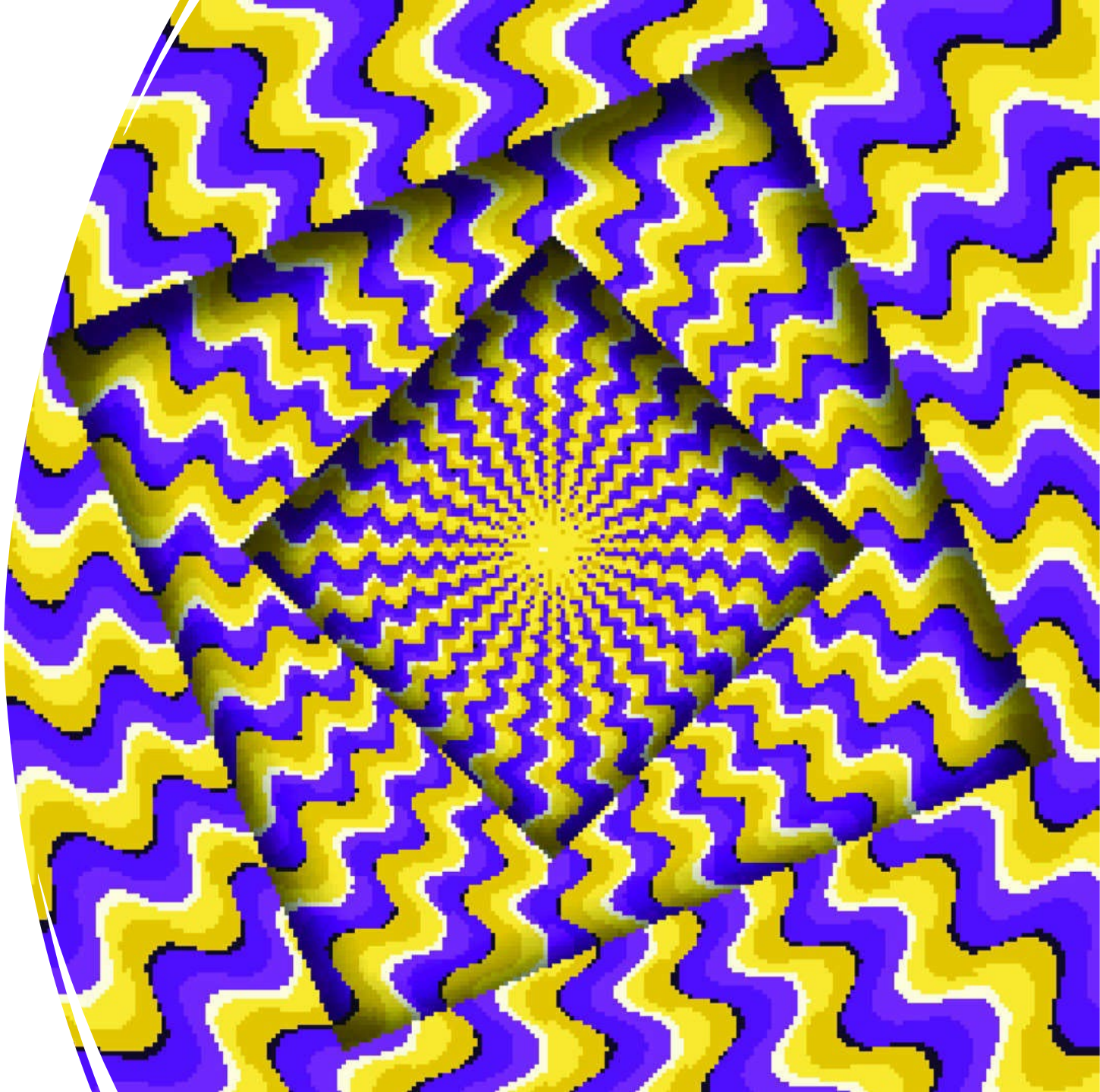
LINAC Group (10FTE: DAFNE LINAC, TEX, SPARC, ROME TECHNOPOLE and other)

BTF Group (3.2FTE: external user, PADME, ASIF2 & EUROLABS)

B. Buonomo (LINAC HEAD and BTF TECH. MANAGER)
F. Cardelli (TEX SCIENT. MANAGER, LINAC STAFF and other coll)
D. Di Giovenale (LINAC & BTF STAFF)
C. Di Giulio (LINAC & BTF STAFF)
E. Diociaiuti (BTF STAFF)
L. Foggetta (BTF SCIENT. MANAGER & LINAC STAFF)
C. Taruggi (PNRR TEX + BTF STAFF)

LINAC Technicians:
R. Ceccarelli, A. Cecchinelli,
M. Ceccarelli, G. Piermarini,
A.L. Rossi, S. Strabioli, R. Zarlenga
***Retired**: M. Belli, R. Clementi*
***Fellowship**: M. Loffreda, E. Romano*

BTF STATUS



LNF – BTF THREE LINES STATUS

BTFEH1 – BTF1 (2 lines)

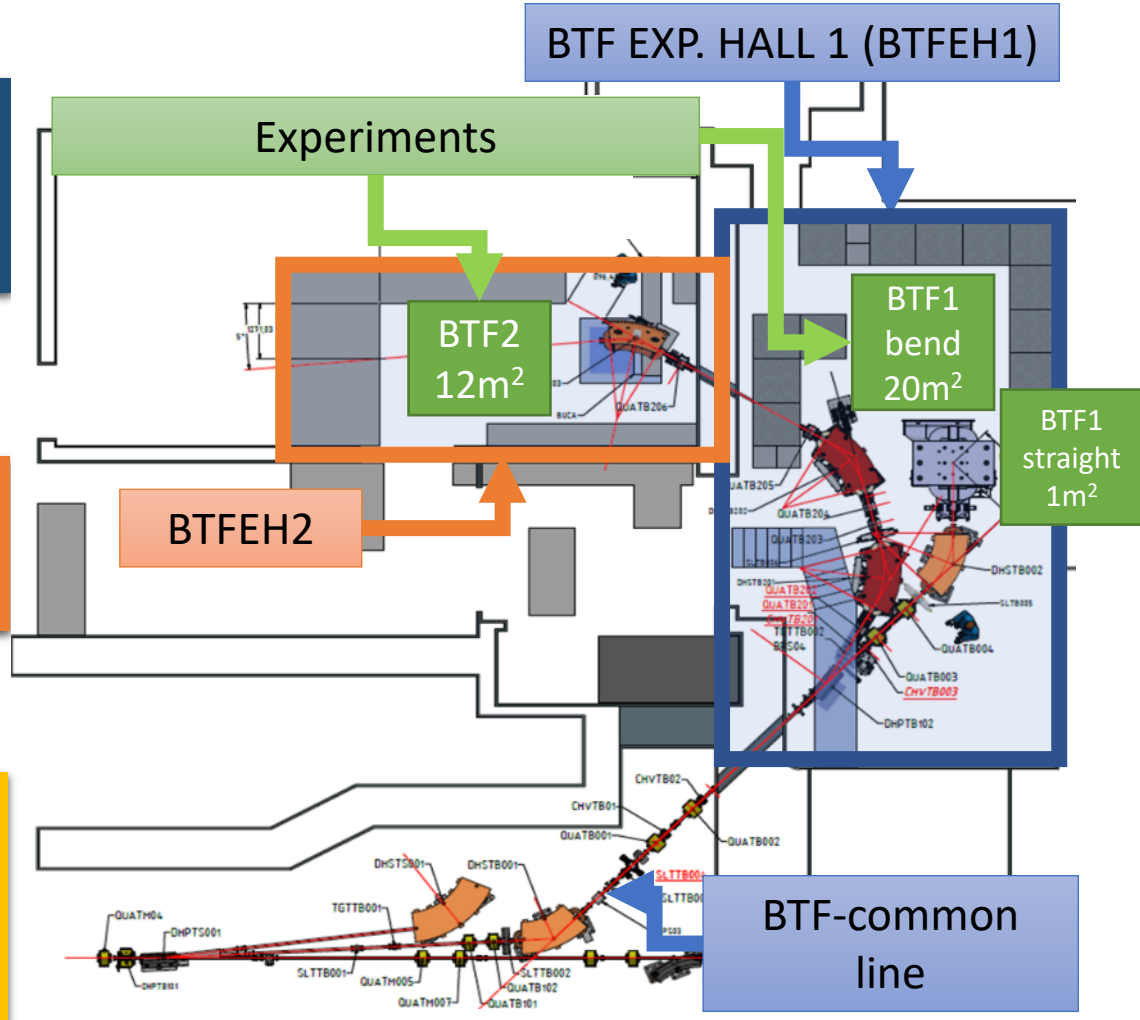
- Hall operational, systems revamped for PADME and two high-intensity projects
- VHEE community interests still persist, two run slot requested for 2025 Q4, one currently ongoing, four team overall in 2024
- Area requested for FIREBALL@LNF. LOI presentation in the morning.

BTFEH2 – BTF2 (1 line)

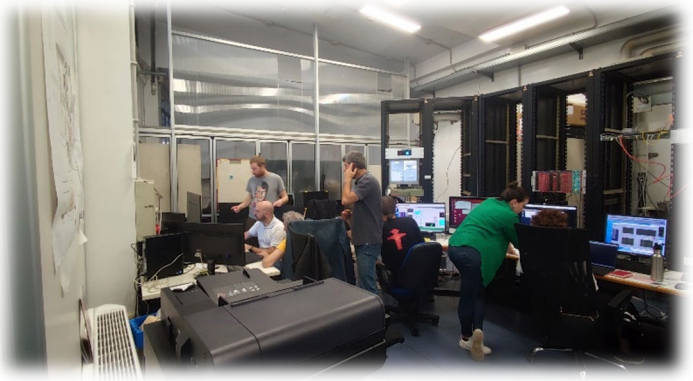
- Hall operational, BTF2 line to external users, PADME
  - No significant fault affecting the 2024 calls
- Improved performance and detectors (low energy beam studies, IC, Genny)

BTFs

- **Booking Software (automated call and user management) operational, extended to other INFN labs.**
- **Involved in EUROLABS Project**
- **Involved in ASIF-2 Project, started in October**
- **Upgrading DCS with EPIX8/Phoebus on the run**
- **LINAC serves only BTF from June, dedicated mode**



2024 CALLS FOR USERS



- **2024 Q1-Q2, Q3 calls**
  - Calls fully booked and committed, from startup to shutdown

- **2024 Q4 mixed call**
  - 11 weeks: 9 with beam availability: 5 for ext. user, 4 PADME
  - **No day loss**
  - **High overbooking for Q4**, slightly late call opening
  - All 24/7 operations except PADME Q4 and maintenance weeks, LINAC needed longer conditioning
  - **Maintenance and tests reduced at minimum in Q4** to match user needs and LINAC implementations

- Withdrawal
  - **2** on Q3, no detector available, converted in beam study for:
    - EPICS test with beam, new detector developing (Gennarino, wide area TPX3, PIC), low energy beam study for PSI and LNL
  - **1** on Q4, no detector available, converted in other queued user

MAINTENANCE AND UPGRADES

Maintenance

- BTFEH2 mains power line layout upgrade (July-Aug)

- **BTFEH1 Crane restored and operational for PADME**
- **BTFEH1 vacuum layout setup variation for PADME**
- **BTFEH1 gas revamping for PADME**

Gating Valve for PADME
Recover of BTF1 straight pump and vacuum improvements
Dismount of PADME Diamond target

- **LINAC Fire extinguisher upgrade**
- **DAFNE area access safety system upgrade**

Done by LINAC Service (July->September)

- **LINAC KLYB replaced with an IN-HOUSE remanufactured one (by LINAC and VACUUM service)**

Foreseen next months

BTFEH1:

- Mains power line 35KW layout upgrade (Elect. Plant Serv. DT)
- Building exterior
- Still need Supervisor link and remote action for vacuum actuators (Elect. Plant Serv. DT)

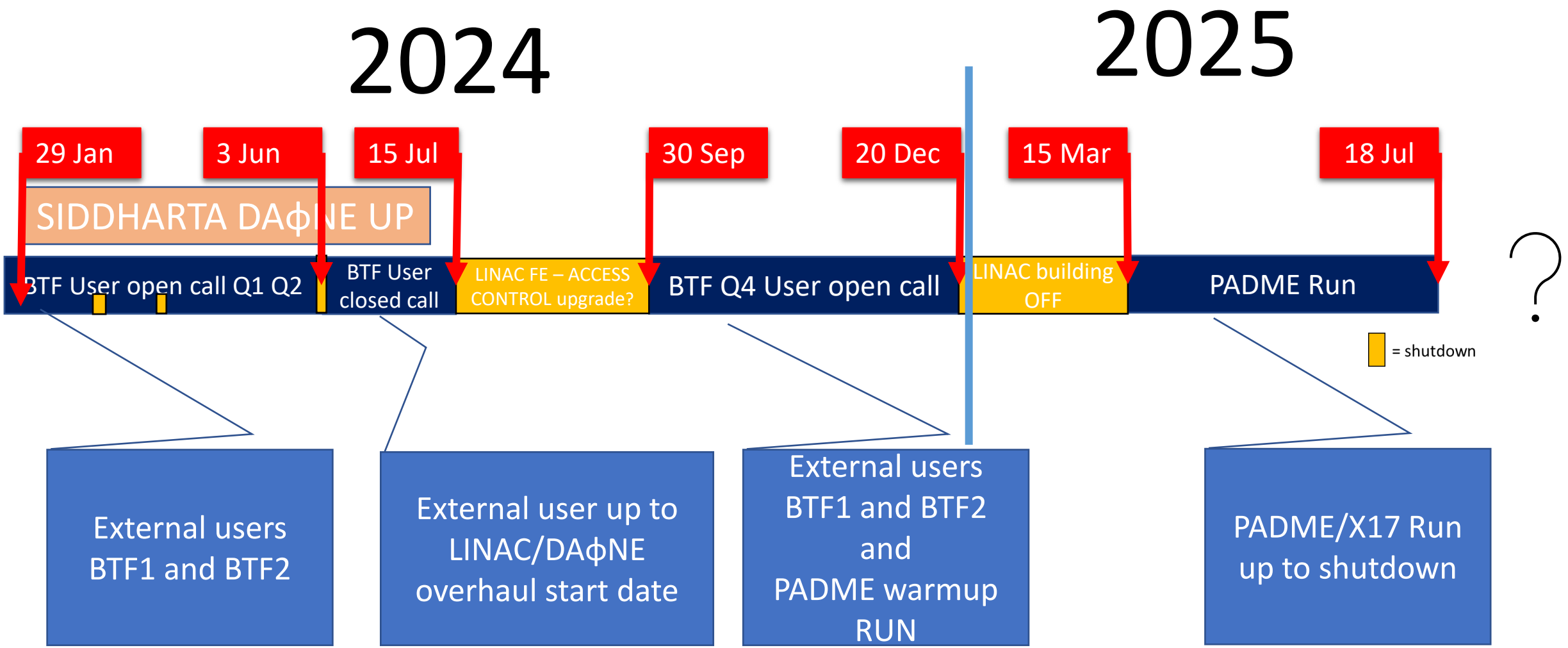
BTF Detectors
- PIC, Calo

BTF DCS
- A big step forward to EPIK$_8$S
- Eleonora Slides

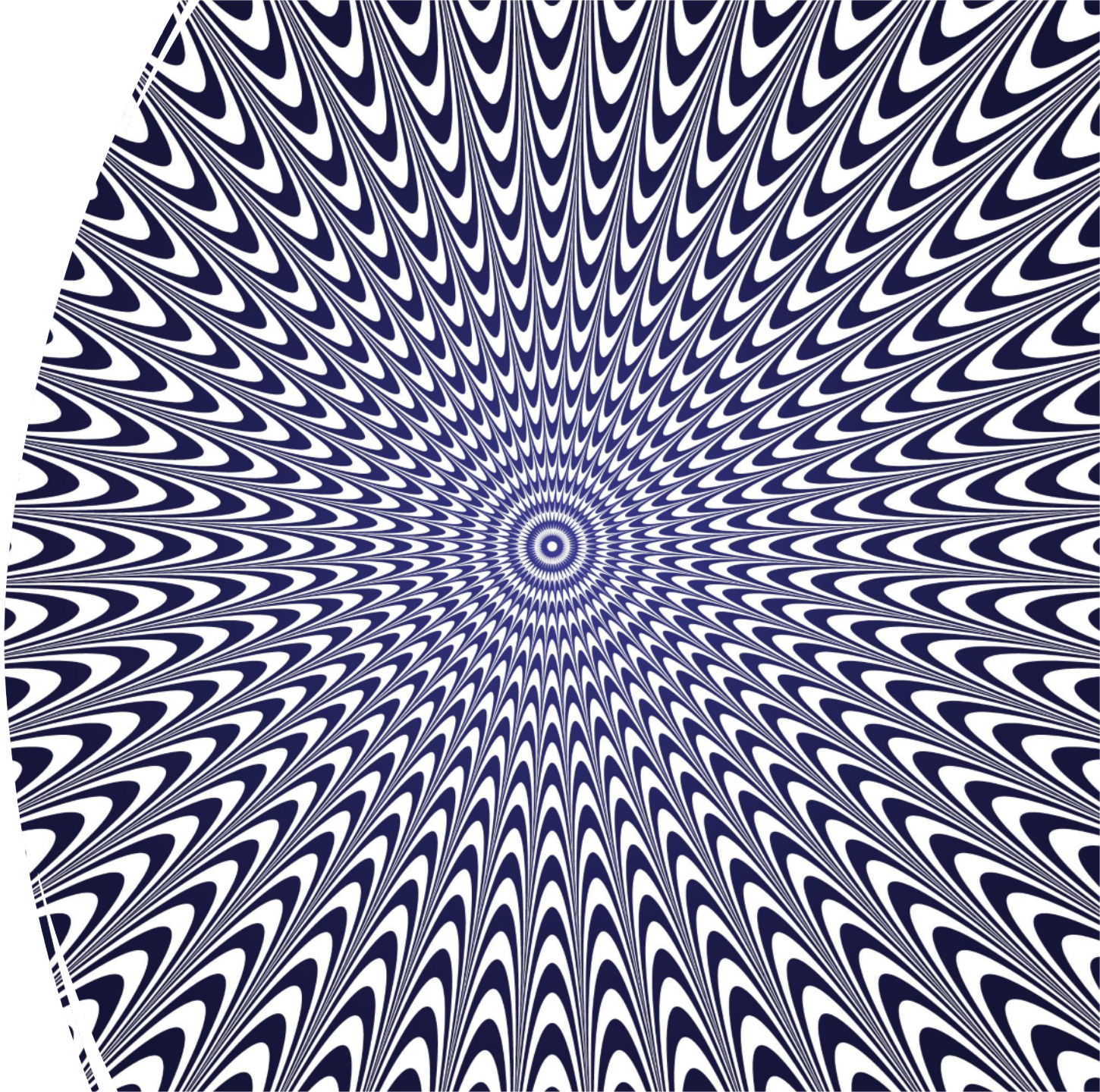
LINAC:

- Fluids maintenances (Fluids Serv. DT)

NEXT DUMMY CALENDAR

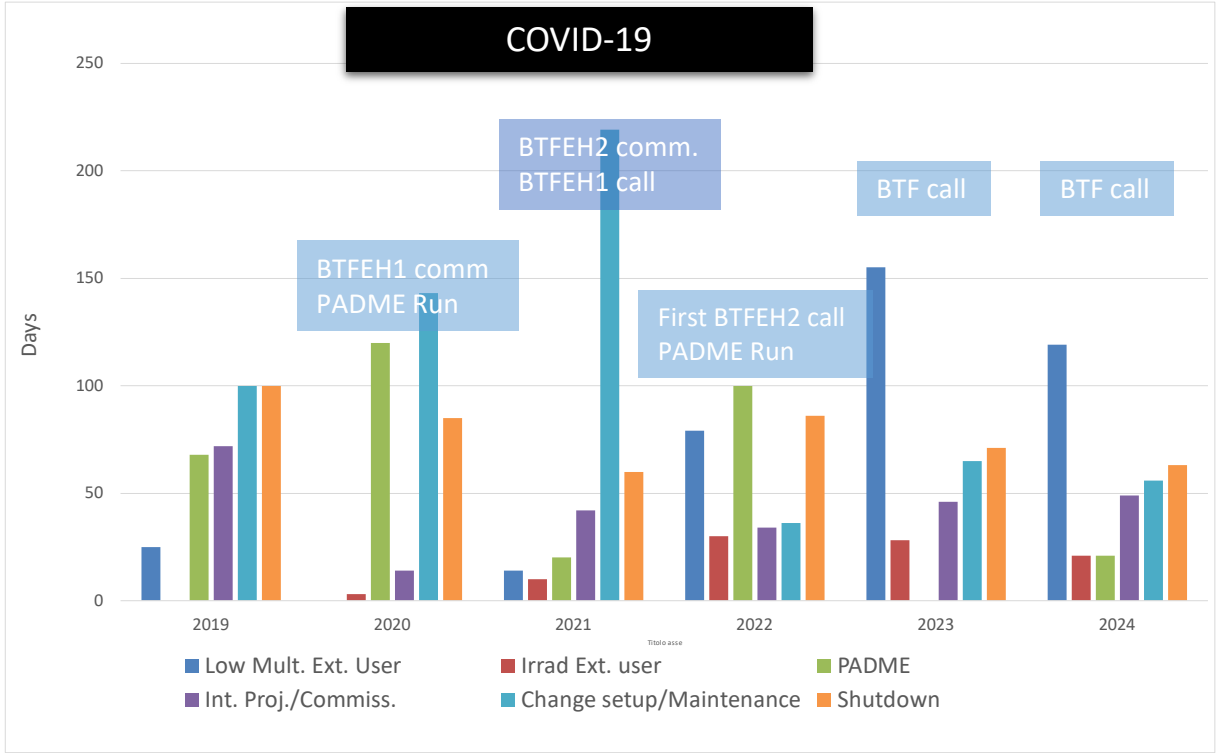


BTF USERS

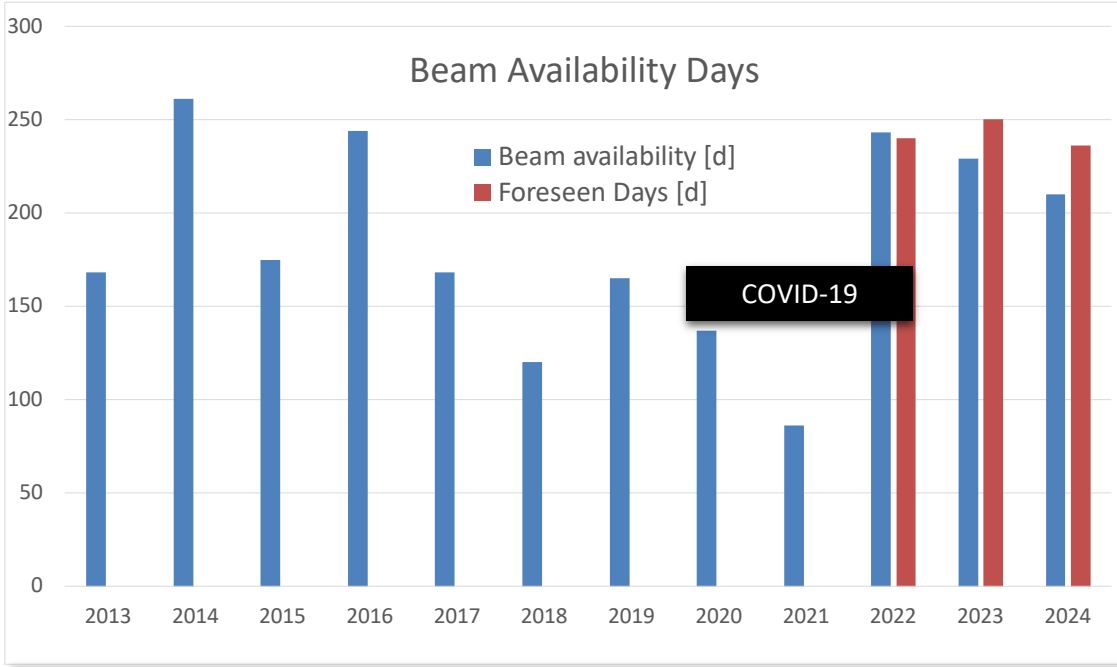


LNF – BTF NUMBERS

2019-2024 Activities



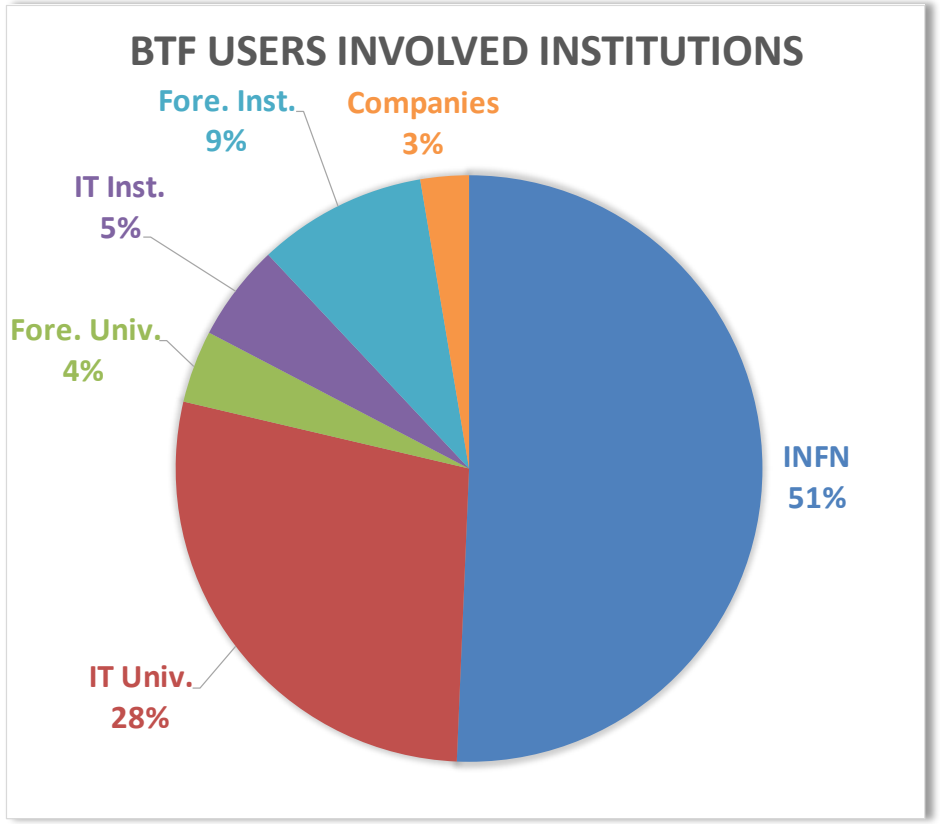
Beam Availability Days (up today)

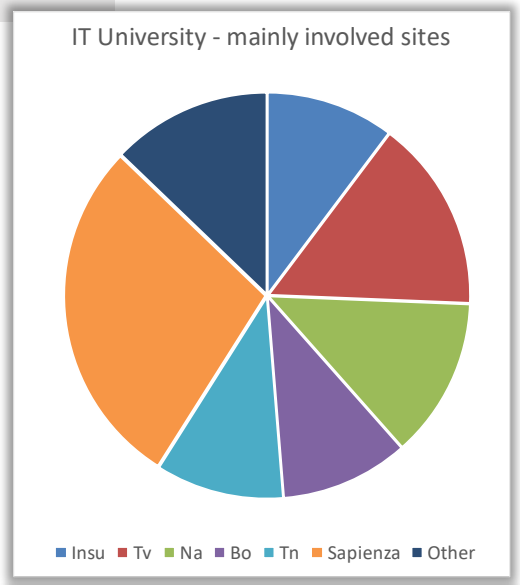


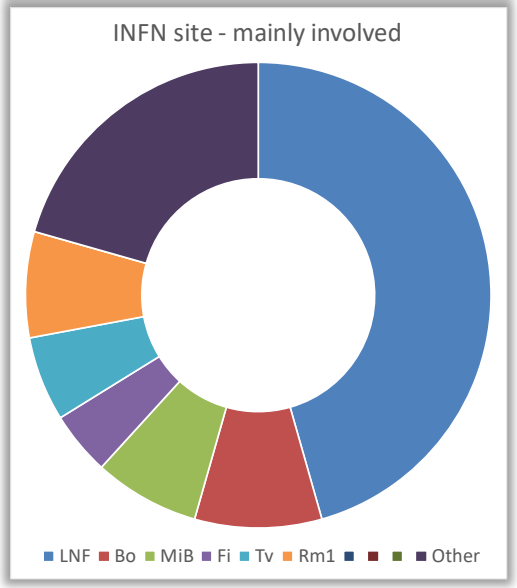
2024 Expected Beam availability days = ~240 almost done
Shift average time = 6d
Average team member number = 7

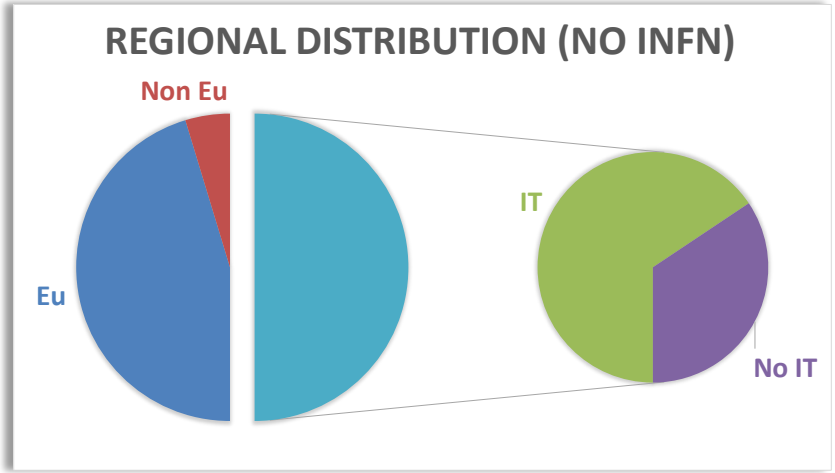
LNF – BTF NUMBERS

2022-2024 Involved Institutions









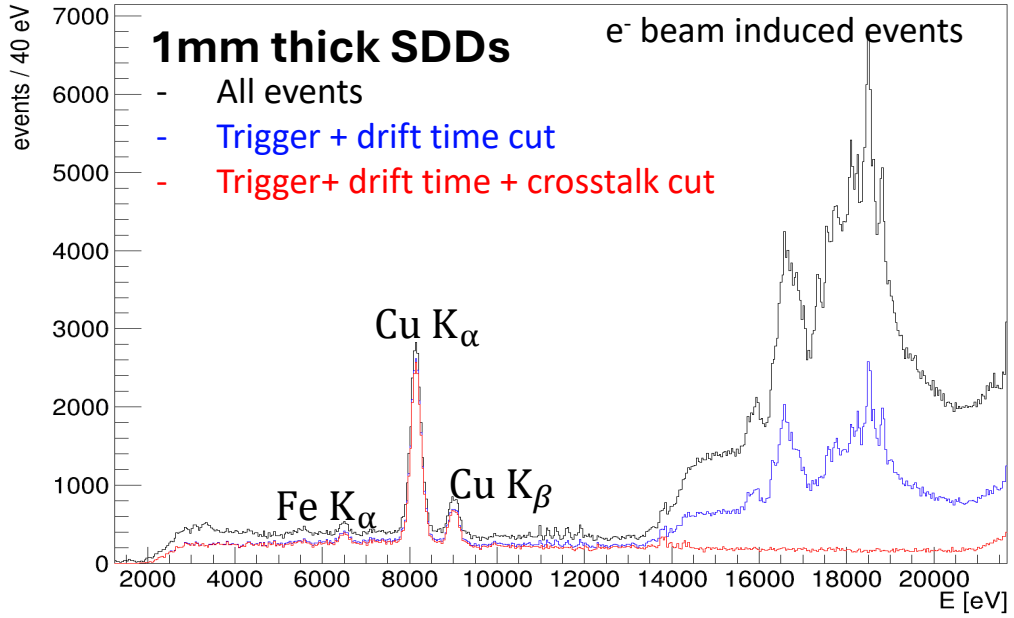
- Good Regional Equalization Between IT Institutions
- Increased prevalence of non IT University

BTF2 HI FLUX CONTINUOUS OPERATIONS

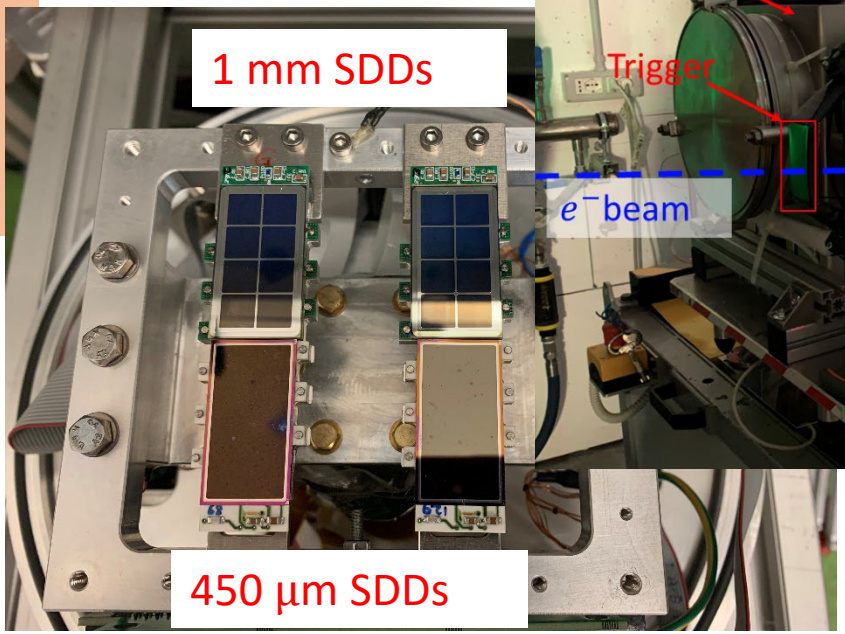
THICK_SDD – Silicon Drift Detectors (Cryogenics)

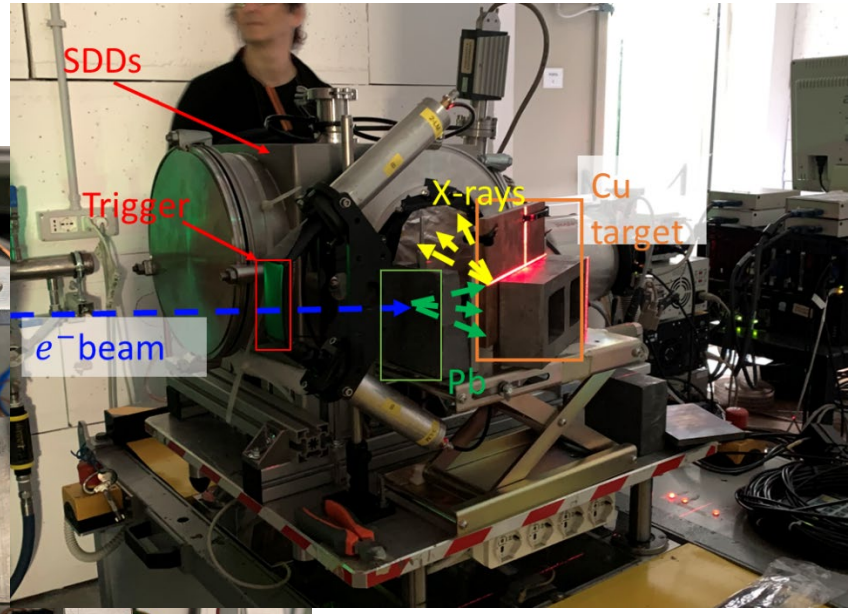
(F. Sirghi (LNF-INFN) et al.)

Spectroscopic measurement with first module by LNF group
Dedicated beam time in June and October 2024 at BTF
Irradiation with e- beam (on target, then X ray on detector) and X-ray sources. **Characterization of the 1 mm SDDs** time response as function of the temperature
Characterization of the energy response:
- new energy range 50 keV
Study of the **energy response in a high background environment**



BTF BEAM single particle STABILITY
6 days long measure without stop, very clean setup





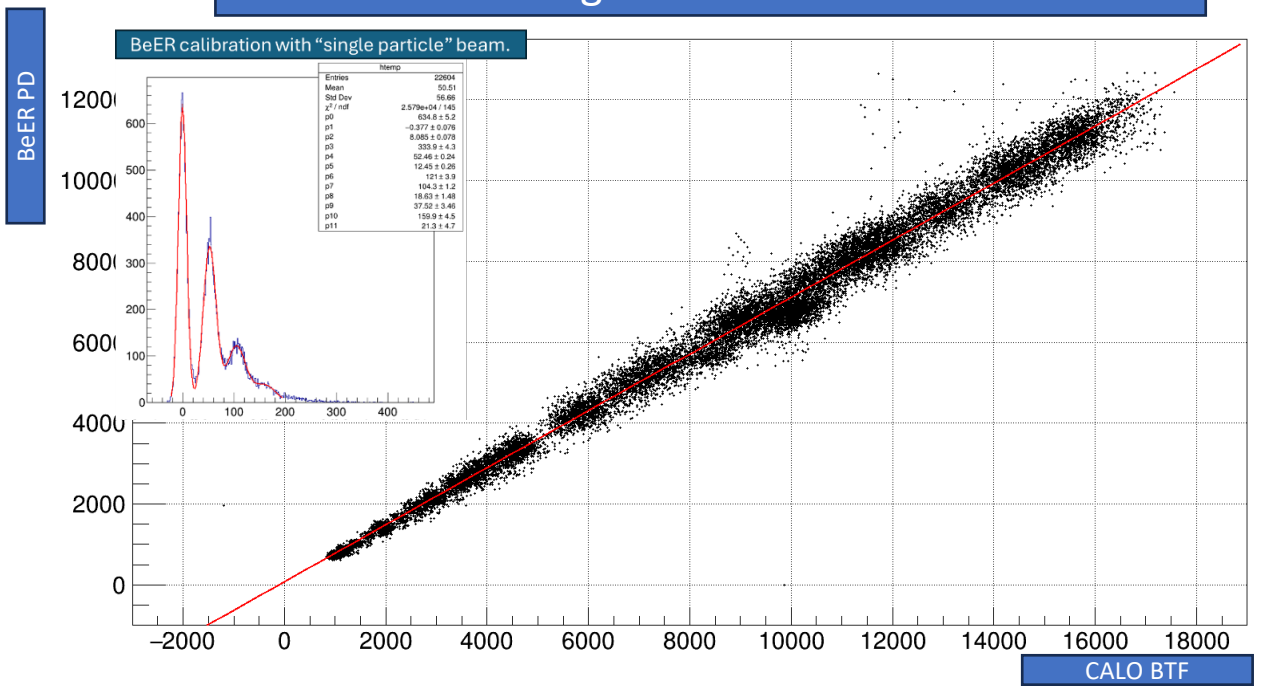
Dedicated beam time in June and October 2024
Different energies and multiplicities (June)
302MeV , m16k, electrons

BTF2 HI RANGE SCANS W SEC. BEAM

BeER (Beam-monitor with Extreme Range)
Photo Diodes (Pr. L. Pacini (FI-INFN) et al.)

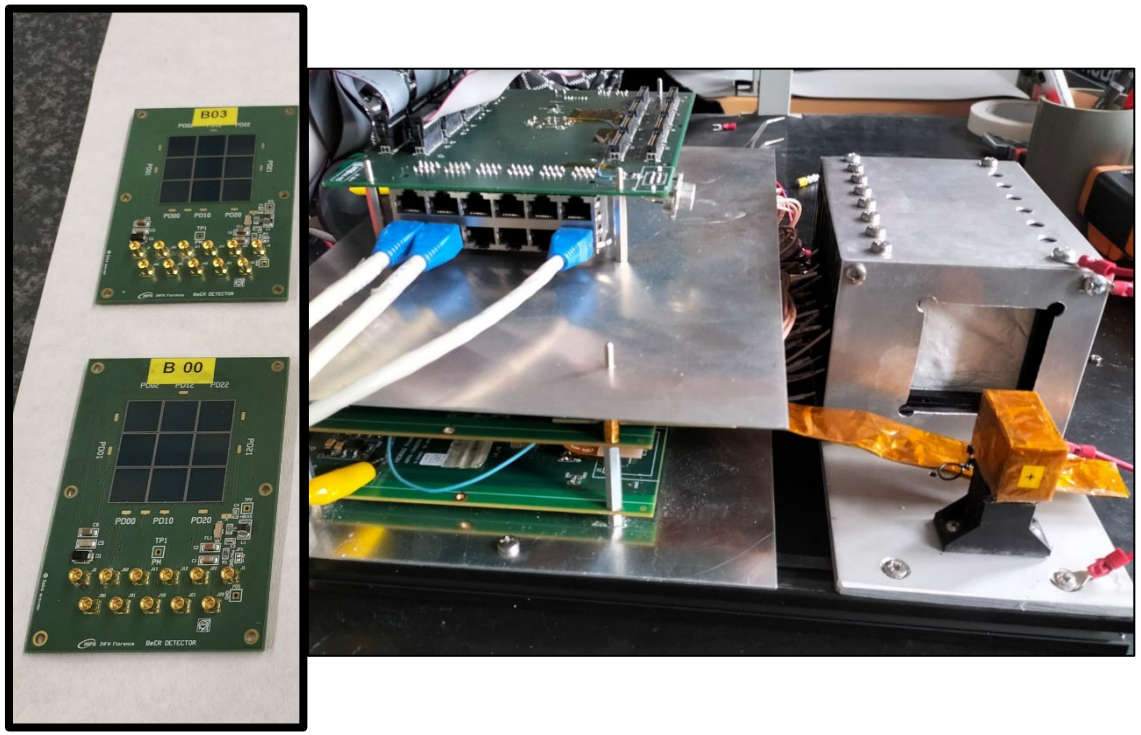
BeER consists of 6 layers made of 3x3 blind PDs (active area of each PD = 1 cm2): Excelitas VTH2110 PDs are silicon PIN diode which are used as ionization detector.
BeER main goals: **easy to use online monitor of high energy nuclei (e.g. SPS ion) and high multiplicity (BTF electron) beams, easy to integrate in users DAQ** to provide event per event information of charge (or number of particles.)

BeER single sensor vs BTF Calo



BTF BEAM FROM SINGLE PARTICLE TO 20k Multi days scan

Large dynamic range confirmed with high multiplicity runs by using BTF CALO information: the detector is capable to count more than 10k electrons. Non-linearity estimation is ongoing.



Pulse sharing beam time in June 2024

302MeV, m1->16k, electrons

2024 DISSEMINATION

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Step increase in dissemination, mostly due to E. Diociaiuti and D. Di Giovenale

Event Type	Target	Number of students/people involved
Professional tutoring	Secondary school professors	50
PhD tutoring	PhD Students/BTF users	22
Undergraduate tutoring	Post High school/University student/BTF users	22
LNF visit guide	University and Secondary school	1125
PCTO (work-school join)	Upper secondary school students	30
Childhood/Teenager tutoring at school	Primary and Lower Secondary school students	357
Lab events	(INTERNATIONAL DAY OF WOMEN AND GIRLS IN SCIENCE, Open day, INSPYRE)	1720

Congratulations to S. Bertelli and her team for their dedicated efforts in accelerating the dissemination of scientific knowledge both within Italy and internationally

2024 SOME CONTRIBUTION CITING BTF

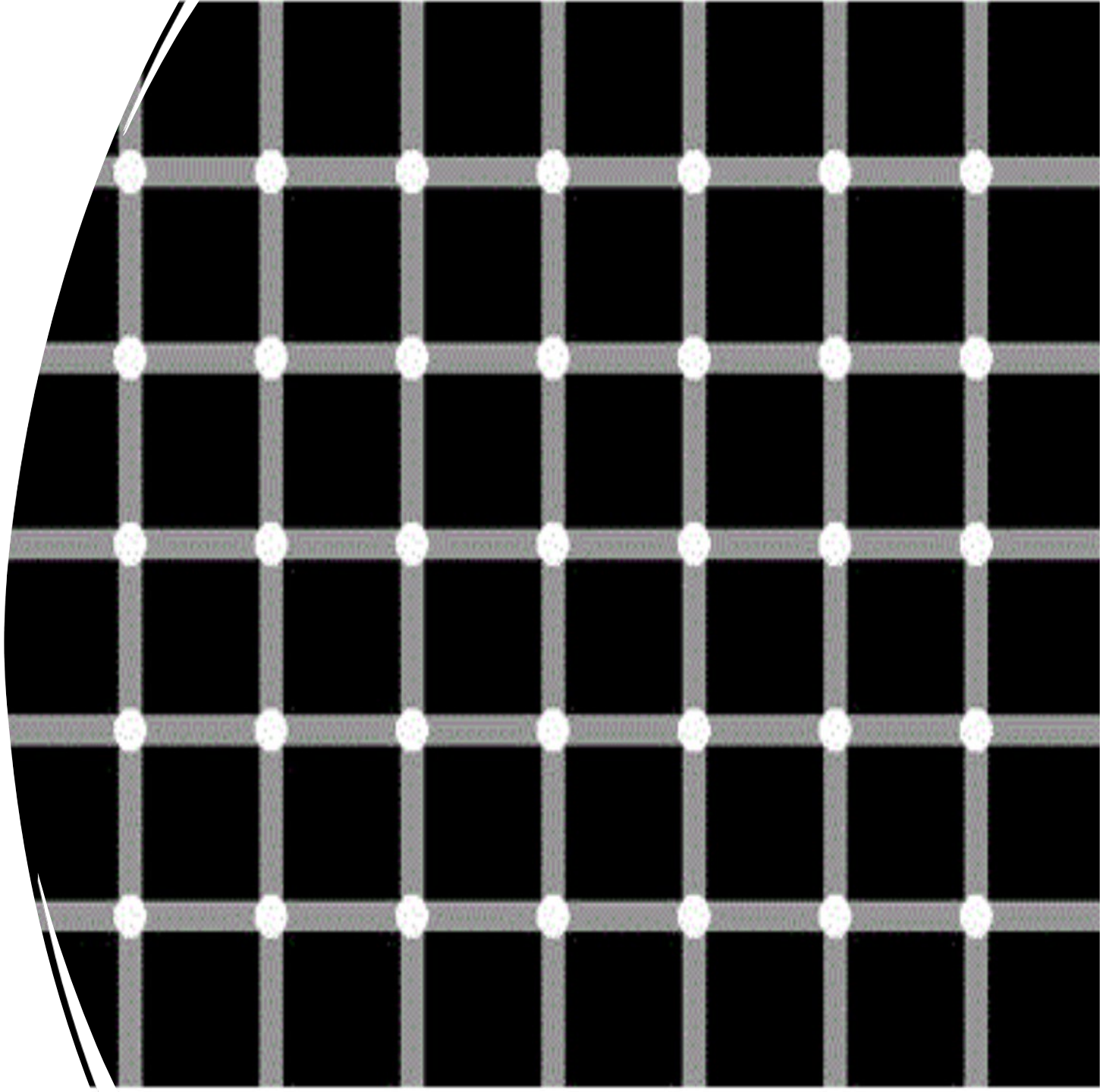
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Cantone, C., Ceravolo, S., Colao, F., Di Meco, E., Diociaiuti, E., Frank, I., ... & Tagnani, D. (2024). R&D status for an innovative crystal calorimeter for the future Muon Collider. *IEEE Transactions on Nuclear Science*.	MUON COLLIDER
Chiti, M., Chiti, D., Chiarelli, F., Donghia, R., & Esposito, A. (2024). Photon and neutron dose evaluation at the Beam Test Facility of the INFN-National Laboratory of Frascati. *Radiation Measurements*, *176*, 107216.	NEUTRON DOSE MEASUREMENT
Antonelli, A., Auffray, E., Brovelli, S., Bruni, F., Campajola, M., Carsi, S., ... & Vallazza, E. (2024). Development of nanocomposite scintillators for use in high-energy physics. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 1069, 169877.	NANOCOMPOSITE Scintillator, MUON COLLIDER, CRILIN
Avoni, G., Benettoni, M., Bruschi, M., Cian, A., Dal Corso, F., Dosselli, U., ... & Zuffa, M. (2024). Development of a sapphire microstrip detector for gamma beam monitoring. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 1068, 169752.	LUXE
Testa, M., De Santis, A., Tinti, G., Paoloni, A., Papalino, G., Felici, G., ... & Rovelli, C. (2024). Direct detection of minimum ionizing charged particles in a perovskite single crystal detector with single particle sensitivity. Nanoscale, 16(27), 12918-12922.	PEROSKIVITE
der Maur, M. A. PEROV: R&D for photodetectors based on Organo-Metal Halide Perovskite materia. LNF NOTE	PEROSKIVITE
Borra, F. Study of the PMTs signals during the first underground run of the LIME prototype for the CYGNO experiment (No. CERN-THESIS-2023-323).	DM SEARCHES, CYGNO, THESIS
Bertelli, S., Bossi, F., Ceravolo, S., Corradi, G., Di Giulio, C., Di Meco, E., ... & Padme Collaboration. (2024). Design and performance of the front-end electronics of the charged particle detectors of PADME experiment. Journal of Instrumentation, 19(01), C01051.	PADME
Cantone, C., Cemmi, A., Ceravolo, S., Ciccarella, V., Colao, F., Di Meco, E., ... & Zuliani, D. (2024). Developing an alternative calorimeter solution for the future Muon Collider: The Crilin design. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 169973.	CRILIN, MUON COLLIDER
Bertelli, S., Bossi, F., Di Giulio, C., Di Meco, E., Dimitrova, K., De Sangro, R., ... & Variola, A. (2024). Beam diagnostics with silicon pixel detector array at PADME experiment. Journal of Instrumentation, 19(01), C01016.	PADME
Mancini, M. (2024). Searching for X17 using resonant production at PADME. IL NUOVO CIMENTO, 100(254), 47.	PADME
Bertelli, S., Bossi, F., Buonomo, B., De Sangro, R., Di Giulio, C., Di Meco, E., ... & Vilucchi, E. (2024). Characterization of the PADME positron beam for the X17 measurement. arXiv preprint arXiv:2405.07203.	PADME
Carsi, S. (2024). Advanced Tracking System for Crystal Physics (No. CERN-THESIS-2024-017).	BENT CRYSTAL, THESIS
d'Elba, L. B. I. PM2021-15th Pisa Meeting on Advanced Detectors-Edition.	VHEE, Conference

Around 20 paper citing BTF (Jan. 2024, Nov. 2024)

- Others in the ARXIV or different channels
- Positive feedback to users via sharing BTF live data
- Some detectors are directly developed at BTF in different runs
- BTF beamline scientists provide significant support during the experiment project phase and in understanding data

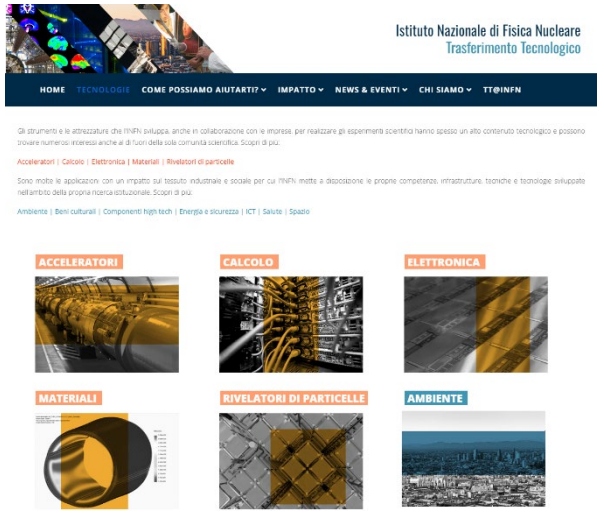
BTF Projects



Project lasting 2025-2027

INFN
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

ASIF – an ASI, ENEA, INFN, UniMiB project with INFN TT



Goal

- Create a national network to support customers and scientific research on radiation hardness assessment for space projects

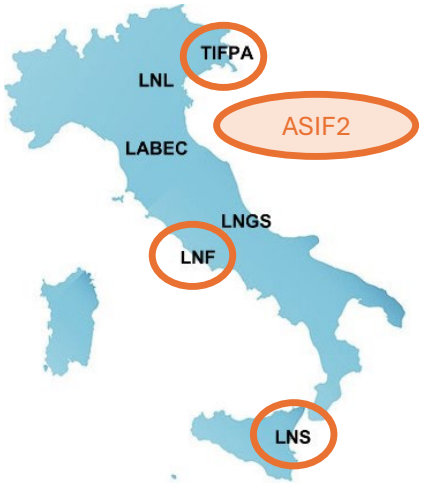
Exploits

- Top-notch research labs and irradiation facilities
- Shared strategic vision from ASI, ENEA, INFN, UniMiB
- Dedicated professionals

ASIF 2 – INVOLVED FACILITIES

INFN facilities

INFN Site	INFaN	Contact E-mail PAC (ask for beam)	Reference/Call Site
CURRENTLY INCLUDED (ASIF-2)			
INFN-LNF	Luca Foggetta	btf_sciresp@lists.lnf.infn.it https://booking.dsi.infn.it/	https://btf.lnf.infn.it
INFN-LNS	Vincenza Bonanno	vincenza.bonanno@lns.infn.it	https://www.lns.infn.it/it/user/come-chiedere-fascio.html
INFN-TIFPA	Enrico Verroi	enrico.verroi@tifpa.infn.it	https://www.tifpa.infn.it/sc-init/med-tech/p-beam-research/
Next Proposal			
INFN-LNL			
INFN-FI (LABEC)			



ASIF 2 – COMMITMENTS ON WP1500

ASIF Implementation of
ESA test requirements – coarse overview

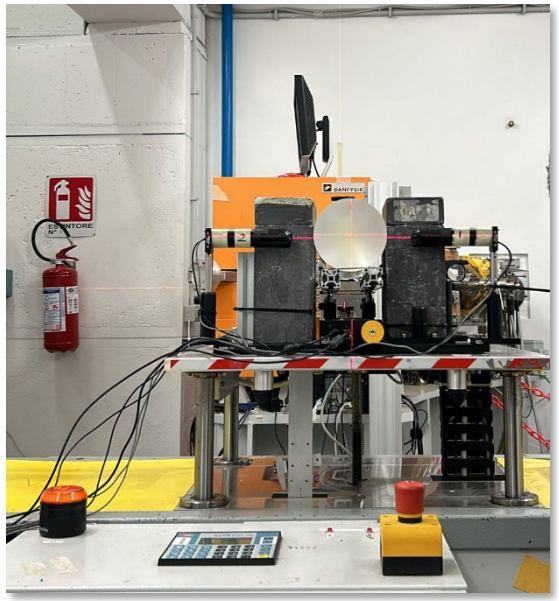
Commitments on WP1500

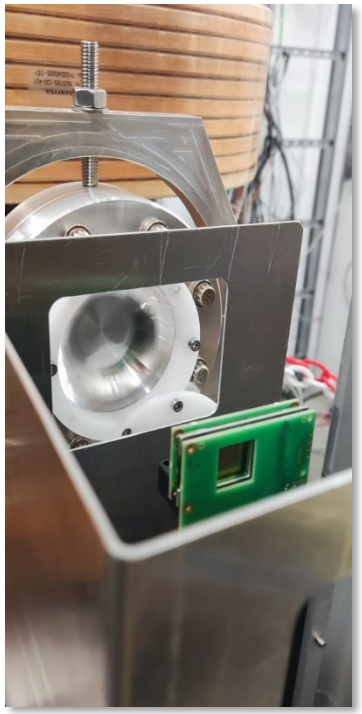
Calibration activities of space detectors with electron beams, exploiting the specific temporal and energetic properties of the BTF.

Feasibility study of irradiation campaigns and radiation damage measurement with electron beams on space components (electronics and sensors).

Maintenance and updating of the test facility and systems for measuring the intensity and fluence of test beam particles

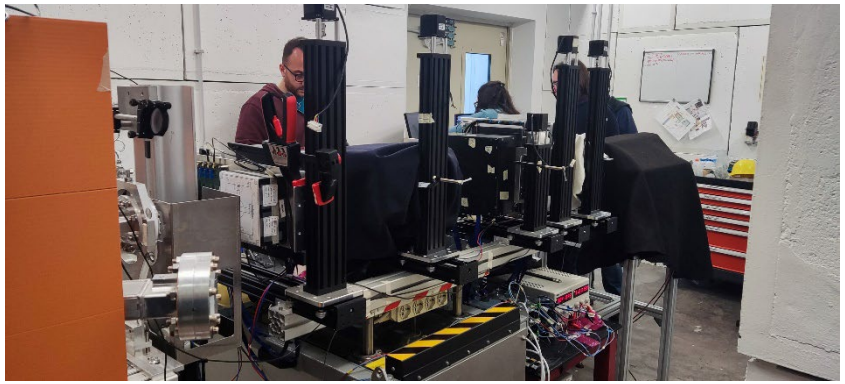
Funding of 83k(personnel, CTER), 32k (infrastructure)





PROJECTS INCOME – 12 MONTHS AFTER

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati



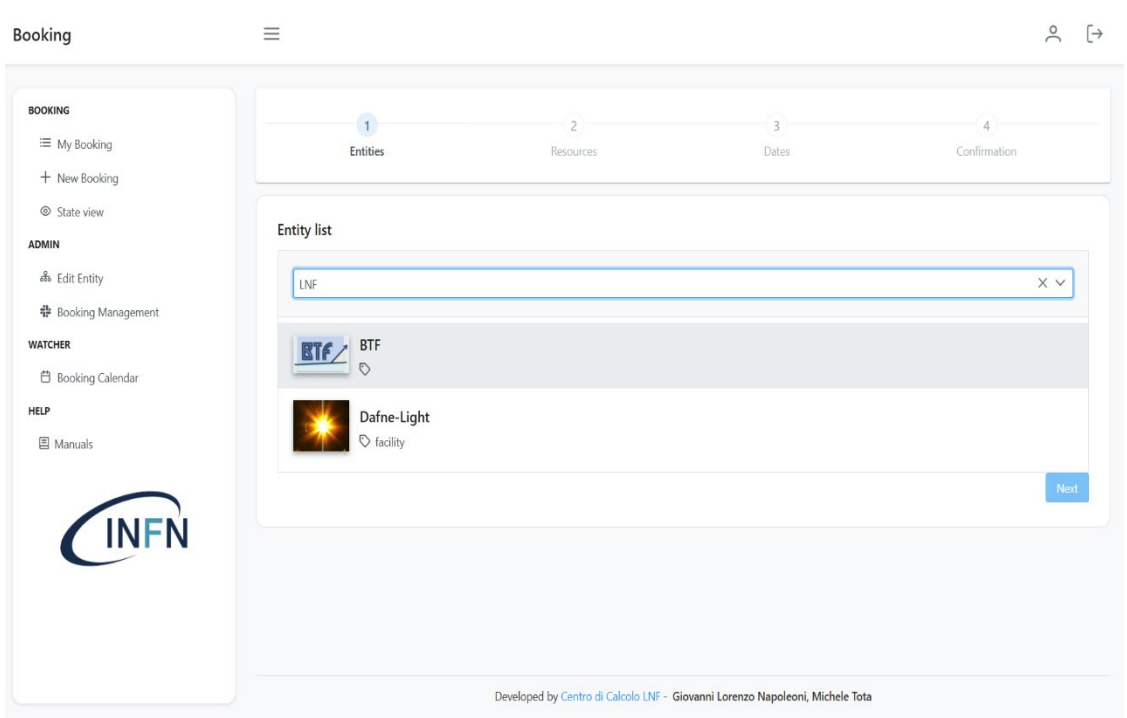
- **ASIF-2**
  - Just started
- **PNRR - Rome Technopole**
  - C. Taruggi in BTF group as synergy with TEX facility
- **EUROLABS**
  - 86k, up to 2026
  - Good levelling in 2024, 4 over 7 week slotted

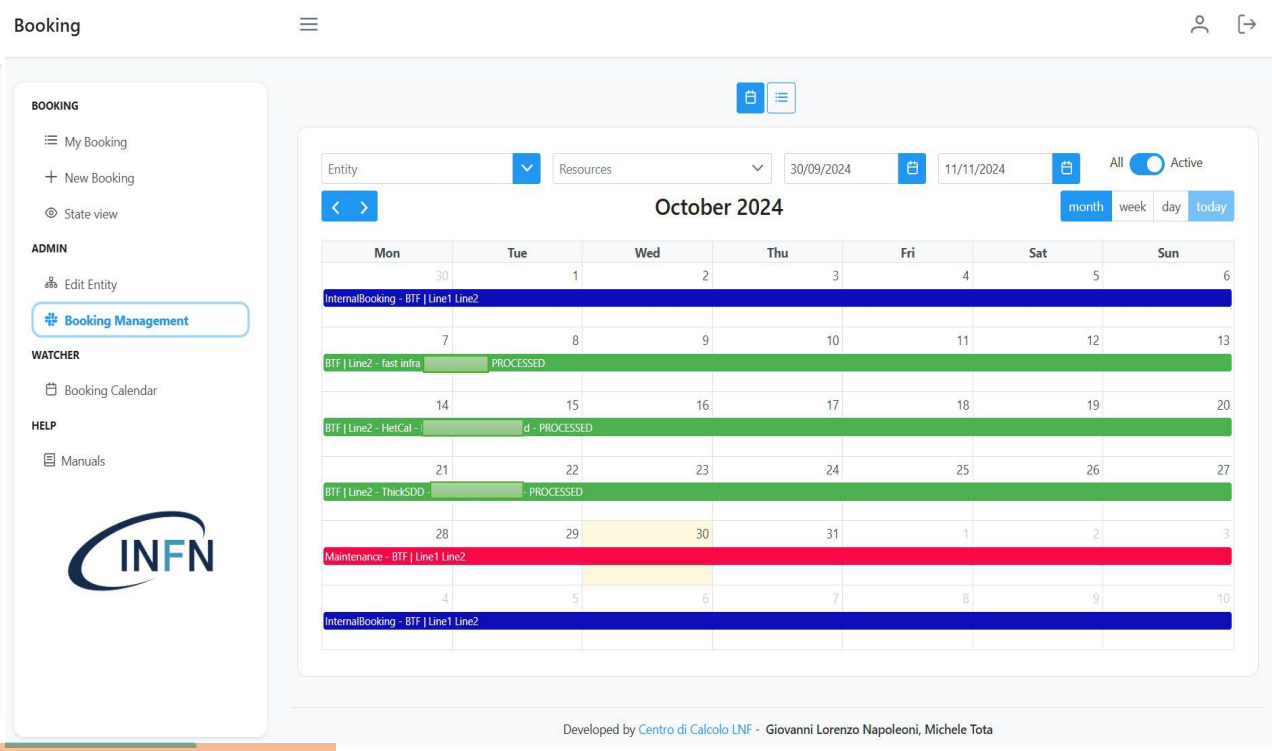
Projects/users want to involve LINAC/BTF for long term collaboration

- Long term plan
- Funding
- People

BOOKING SW

Booking BTF: BTF booking management software based on an automated approval workflow software. Call management.





Implemented New GUI
Three versions with different capabilities in currently in production

Tech note
https://www.openaccessrepository.it/record/143679

Developed G. L. Napoleoni (LNF Computing Center, main dev.), R. Orrú, M. Tota, G.Papalino
BTF group and LNF Secretariats (and bug-finder group):

- AD-Secretariats (M.R. Ferrazza, G. Vinicola, V. Rosicarelli)
- Personnel-Secretariats (G. Dalla Vecchia, F. Triolo, L. Occidente, A. Mininni)

Typical developing time ~3 person-month
(full customization, design-devel-test-debug)
Definitely simple to use, as reported by users

BOOKING SW

Booking BTF: BTF booking management software based on an automated approval workflow software. Call management.

CURRENT ONLINE Version

Beam Test Facility(BTF)

- **More than three years of continuos developing**
- **Almost Two years of continuous operation with users**

DAϕNE-L Facility

- **Software released**
- **In test for final bug correction for Call type**
- **Final release for on demand type**

PLC/UTA remote control

- For Conference room booking related automation control
- Developed for LNF Techical Division, yet to be evaluated

INFN-LABEC developing

- **Released** few month ago
- Collaboration born on INFN-A

REQUESTED Development

FISMEL (LNF)

- **Reservation for radioactive sources**
- Software development in progress

CHNET(Cultural Heritage Network)

- Use booking software for booking facilities and resource for CHNET
- Proposal under evaluation

ASIF-2 (TIFPA-LNS)

- Needs BTF like or extended version

GGI (Galileo Galilei Institute)

- Needs BTF like version

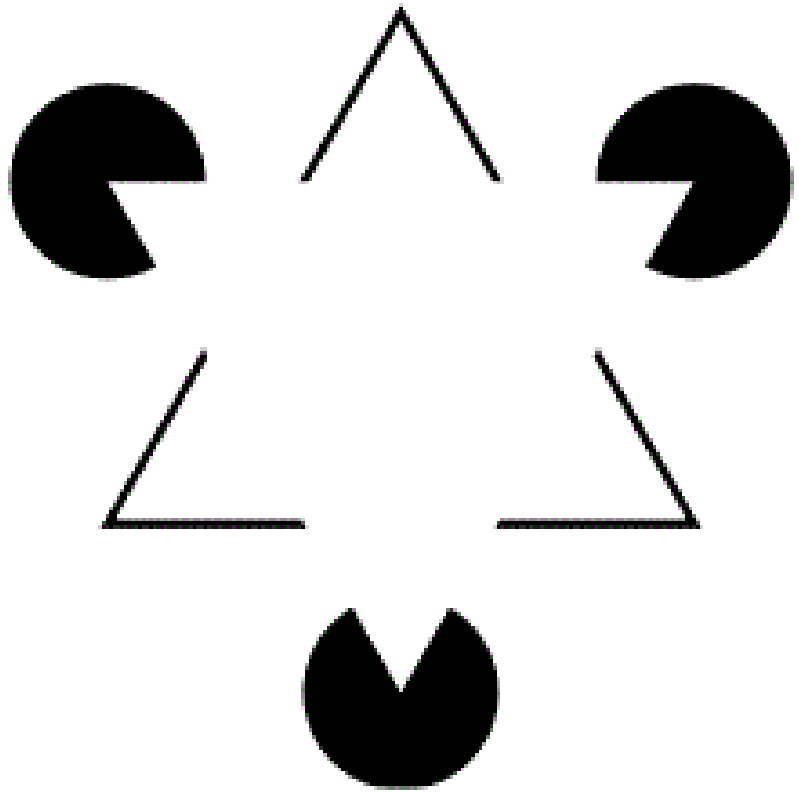
SPARCLAB-EUPRAXIA

- Needs BTF like or extended version

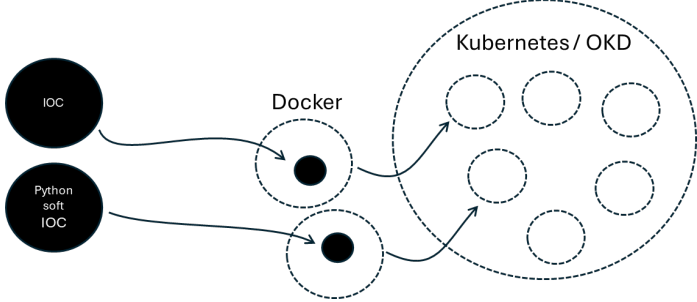
BOOKING SW VERSIONS

Facility Booking Software version	User Type	Booking type	Workflow type	Auth Management workflow	Calendar management	User Management	Reports and Documents Management	Booking period
BTF	External, internal, (GODIVA LoA2)	External user Call, On demand,	BTF like	Management	Open to users selection, management reallocation	Secretariat (automatic creation for INFN association, dynamic)	In the call proposals	Weekly
DAFNE Light	External, internal, (GODIVA LoA1 LoA2)	External user Call, on demand, sample mailing (no ext. team)	BTF like extended	Management, Beamline scientist, PAC	Management allocation	Implicit (user already associated, no automatic role creation)	At experiment ends	Daily Weekly
LABEC	Internal (GODIVA LoA2)	Internal	Linear	Management	Management allocation	None	At experiment ends	Daily

BTF upgrade



BTF NEW DCS DEVELOPING – EPIK8S



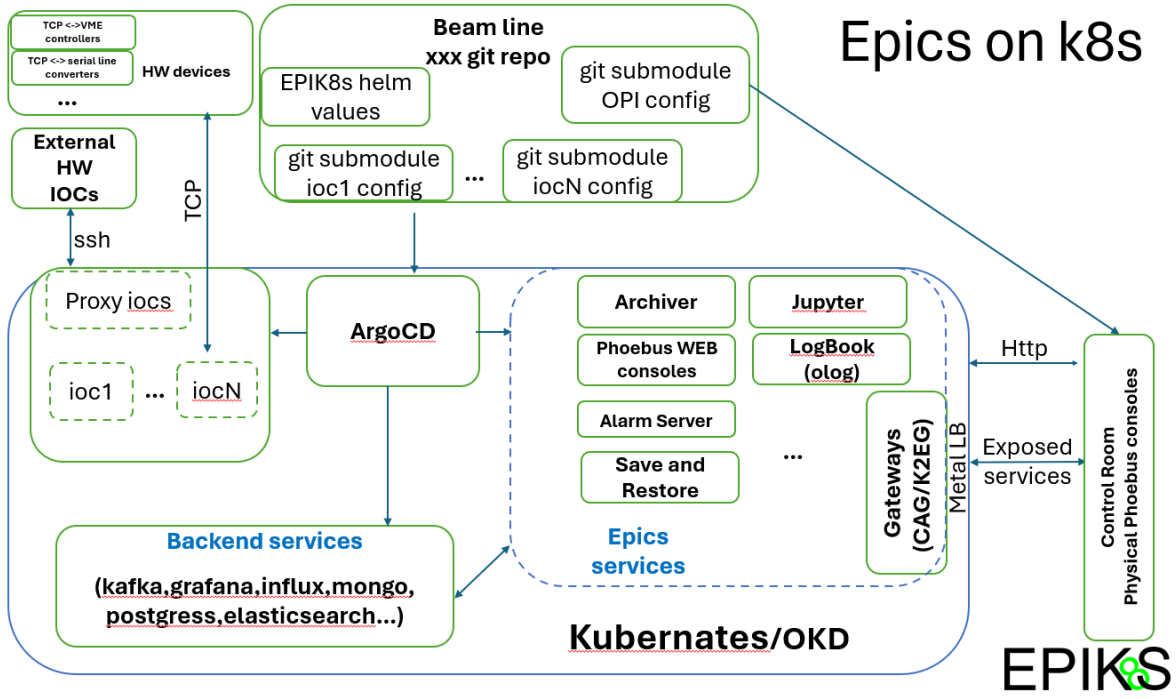
- BTF was fundamental for !CHAOS developing (still in use) starting from 2011
- New standard with EPIK8S standard
- For EUPRAXIA and ELI-NP DCS implementation
- EPICS based **but huge improvement in cutting-edge technologies for systems management** (dockerization and orchestration, even on the cloud) **and tools for users** derived from !CHAOS development

Current tests on:

- MAGNET,
- MOTOR (scrapers),
- TRIGGERED CAMS (flags)

ADDED developing for BTF needs:

- HV crates control,
- PTU sensors,
- LABVIEW to EPIK8S channels (via json)



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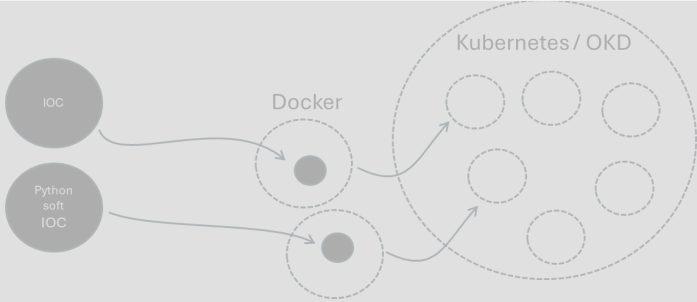

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Special thanks to A. D'Uffizi, R.Esposito, F. Galletti, R. Gargana, A. Michelotti

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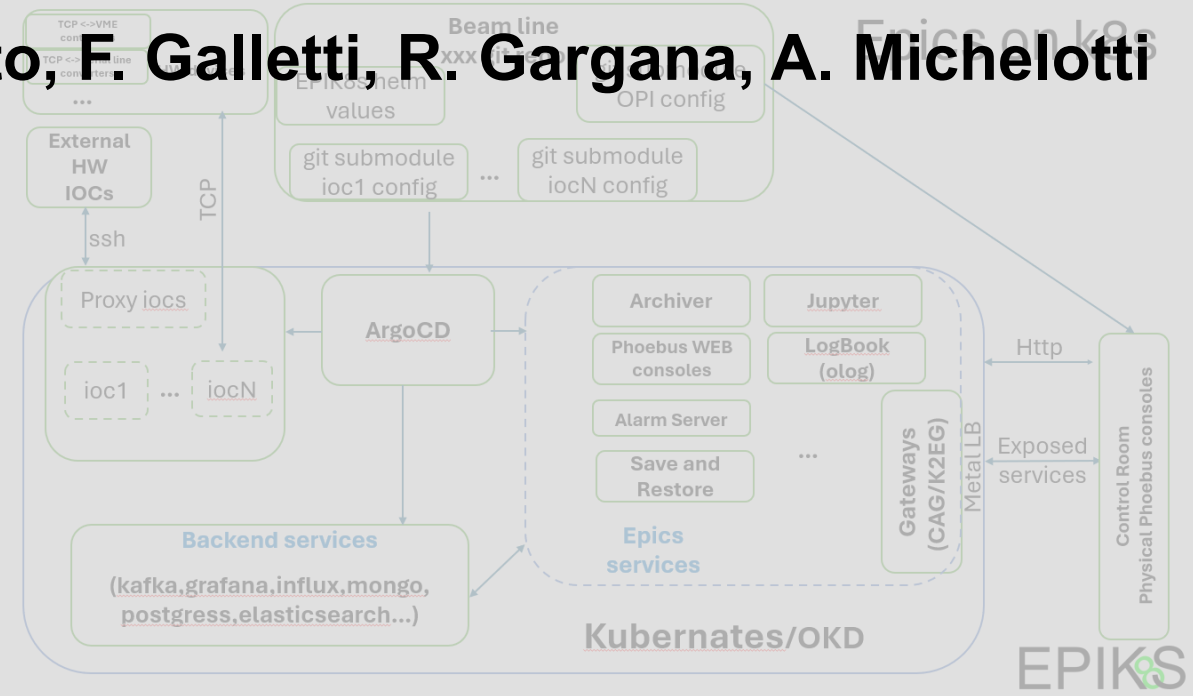
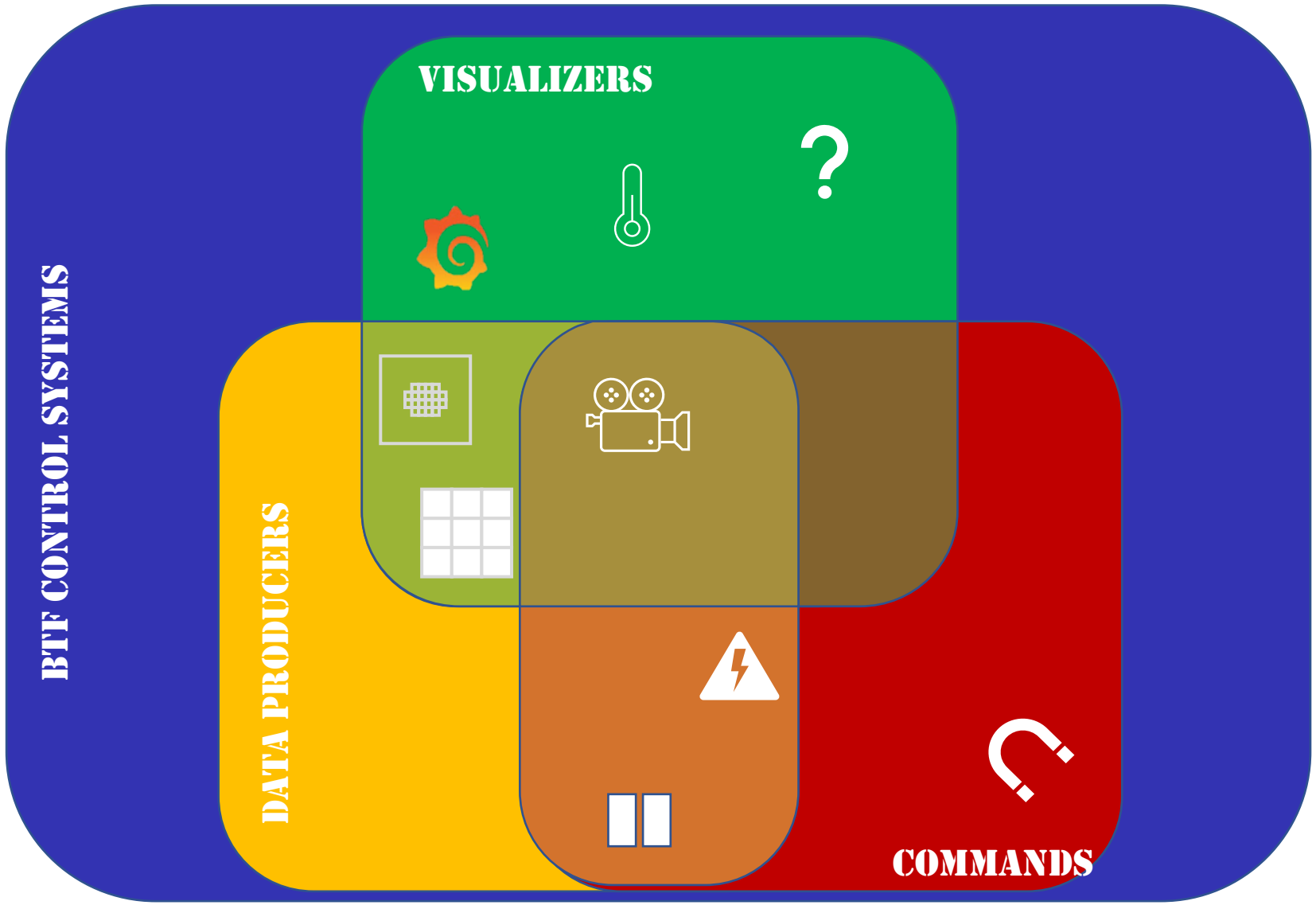


SUMMARY OF THE UPGRADES



EPICS

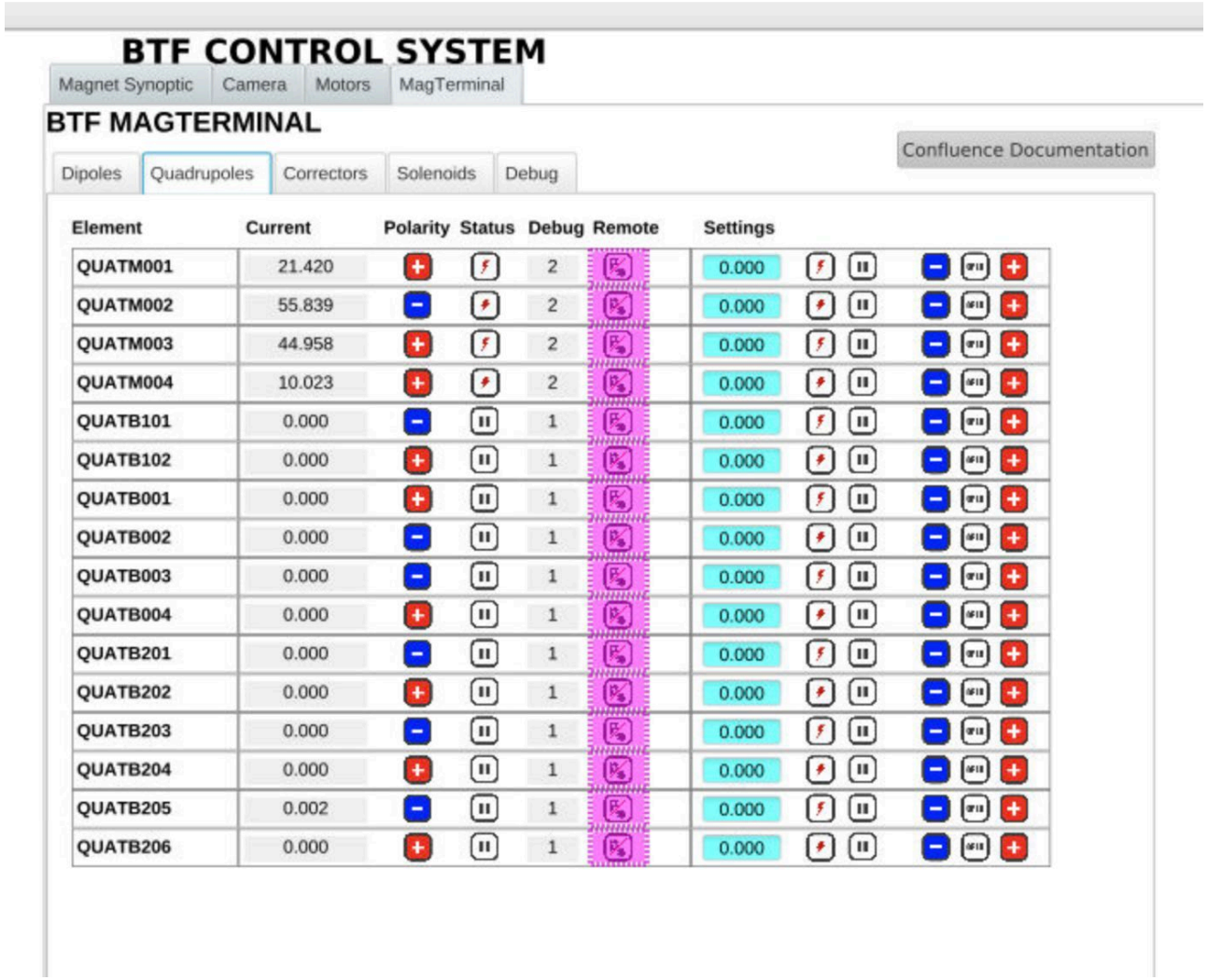
- Magnets
- Scrapers
- Cams
- HV
- PTU+Vacuum

PYTHON

- PyFitPix
- PyStatus
- PyGenny

MAGNETS

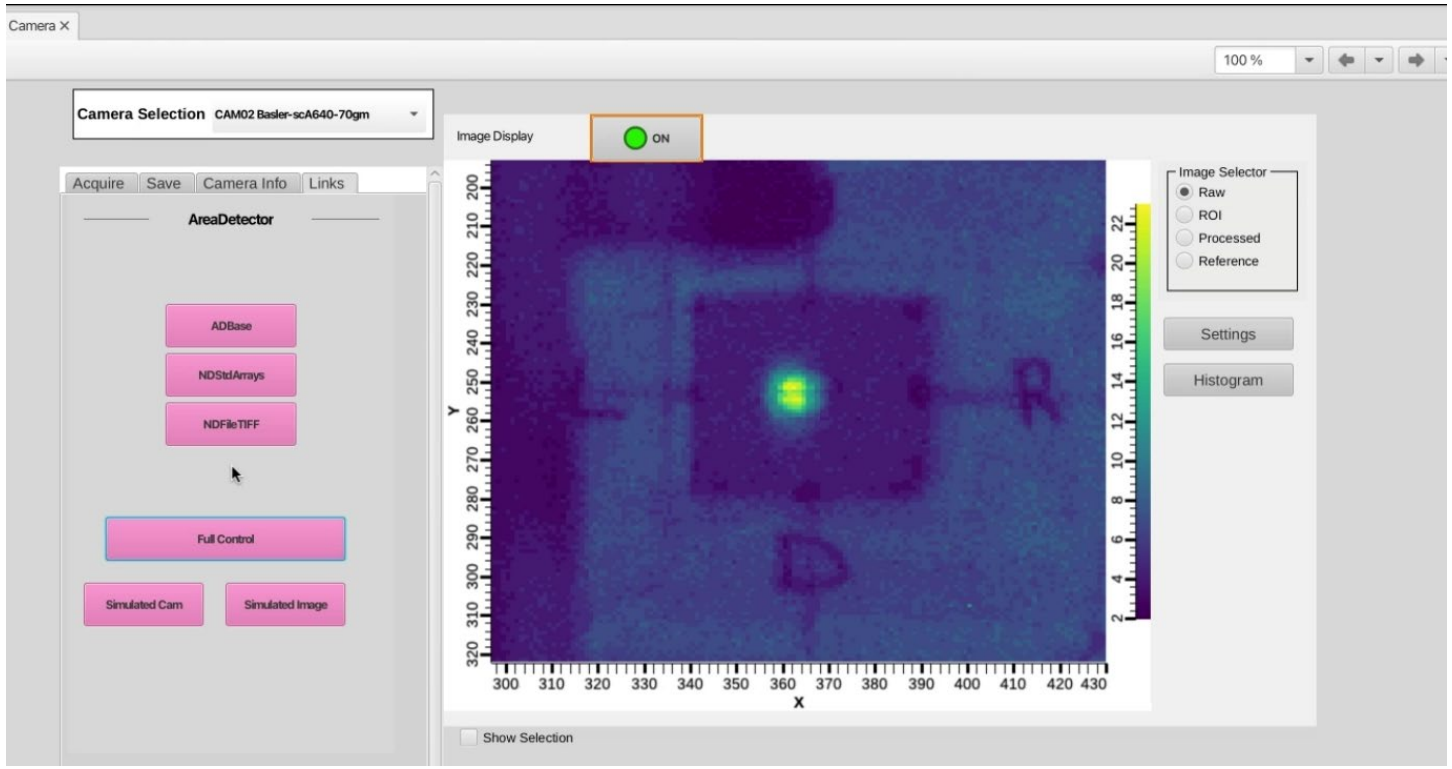
WORK IN PROGRESS

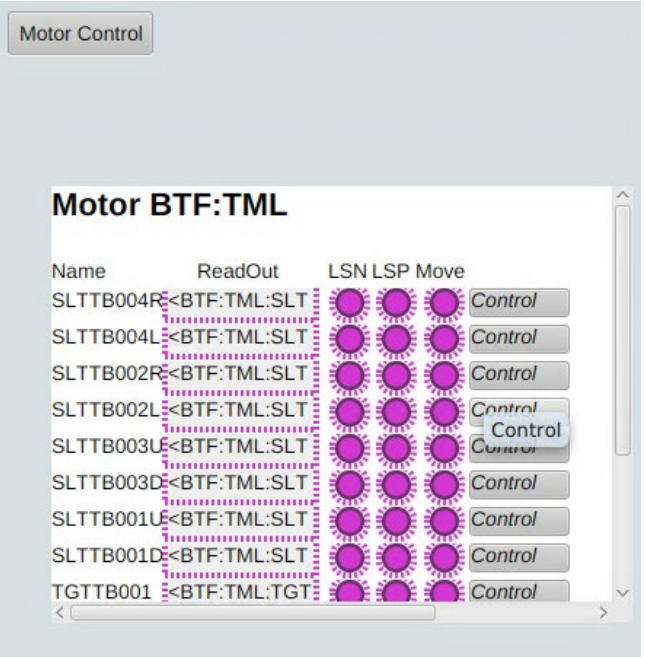


- Refactor for BTF needs, adding new feature
- Not fully migrated yet
  - Implementation still going on
  - Fundamental to maintain compatibility with the current datafiles
  - Working on the possibility to older select dataset

SCRAPER AND CAM

WORK IN PROGRESS

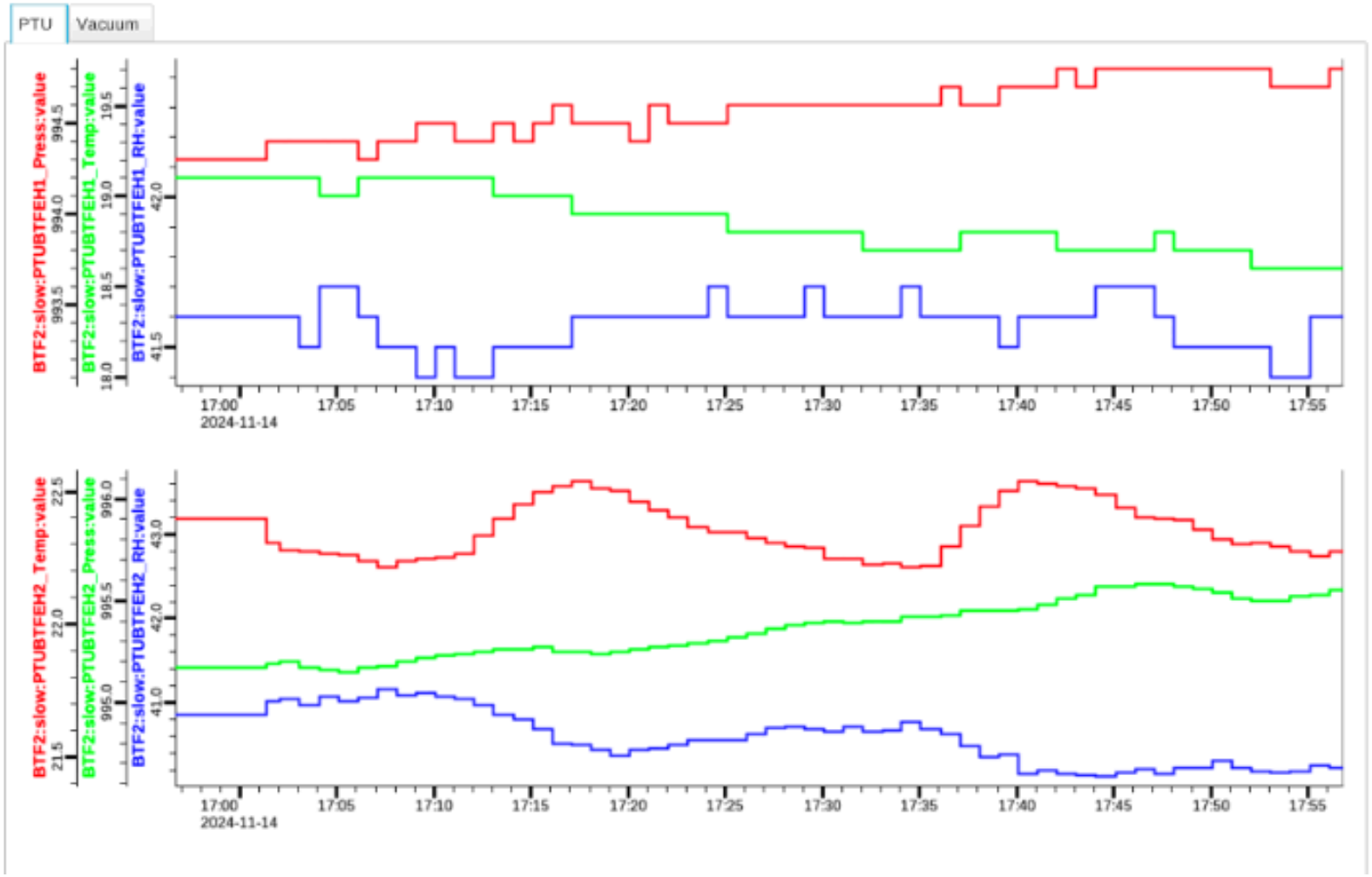




Distributed variables (PV) of the main BTF subservices lead to a better implementation of BTF setup and automation
(Beam steering and easier user setup selection)

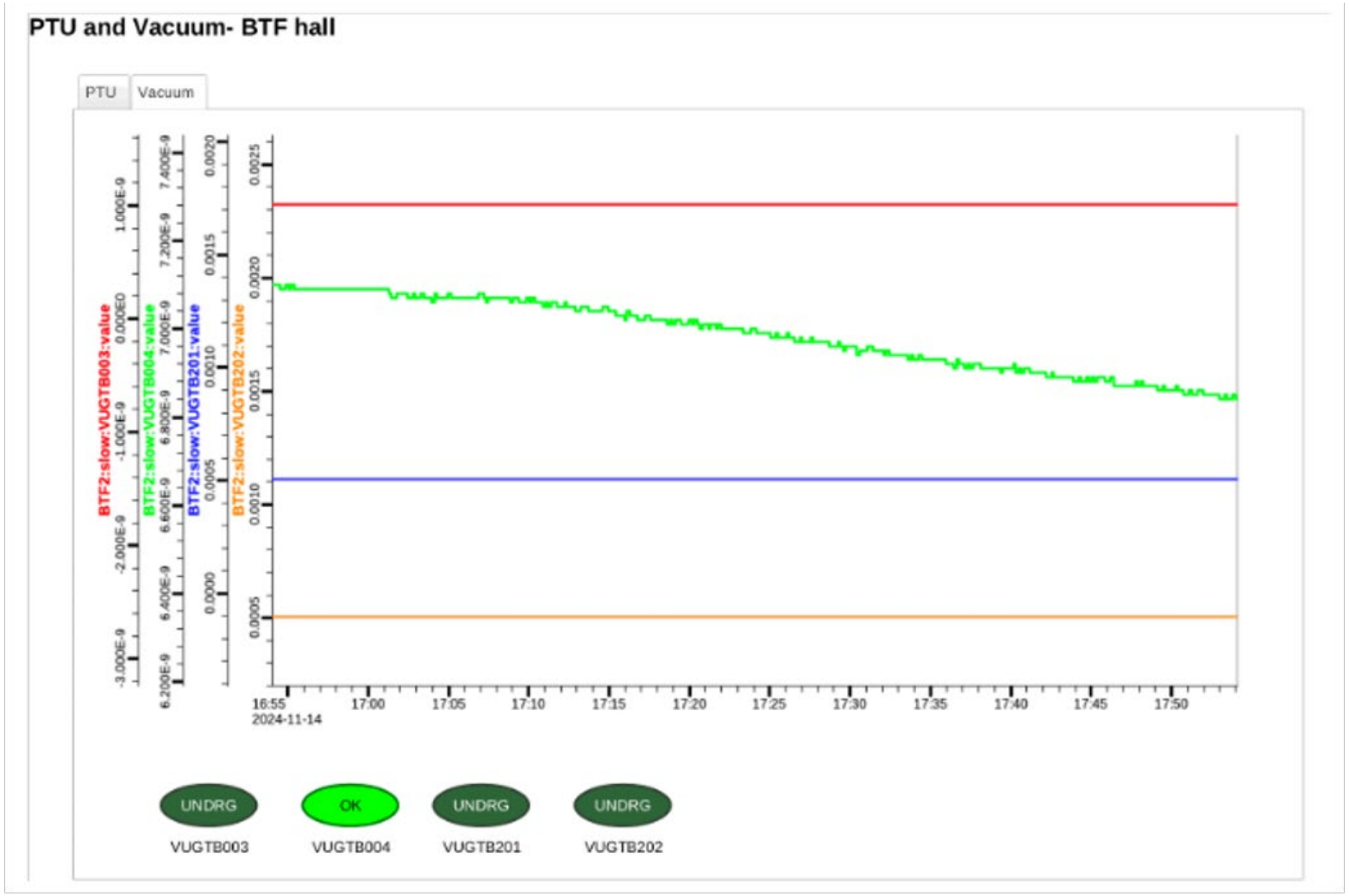
PTU + VACUUM

PTU and Vacuum- BTF hall



- Read PTU status of EH2 from PTU sensor, send a json with this information in Memcached, from Memcached info to PV
- Vacuum : LV producer → Memcached→PV

PTU + VACUUM



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Memcached info to PV

- Vacuum : LV producer → Memcached→PV

POWER SUPPLIES

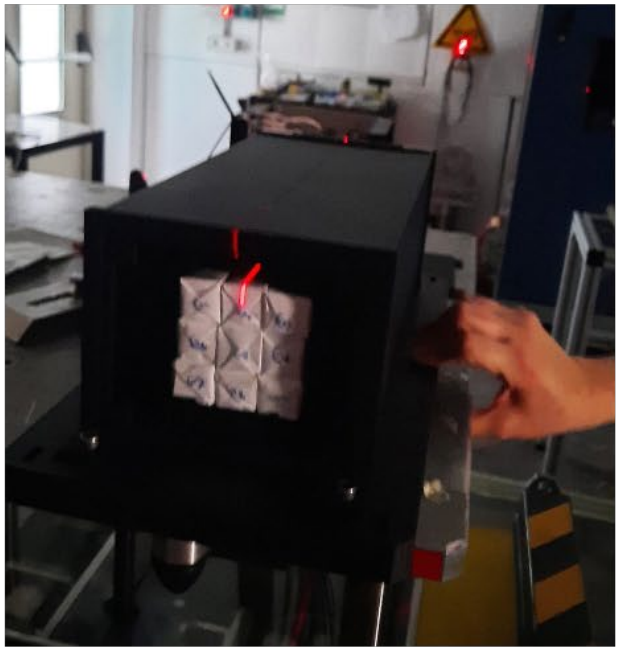
- EPICS IOCs implemented directly by CAEN
- Monitor and Setting of all the boards/channel
- Display the interesting PV vs time

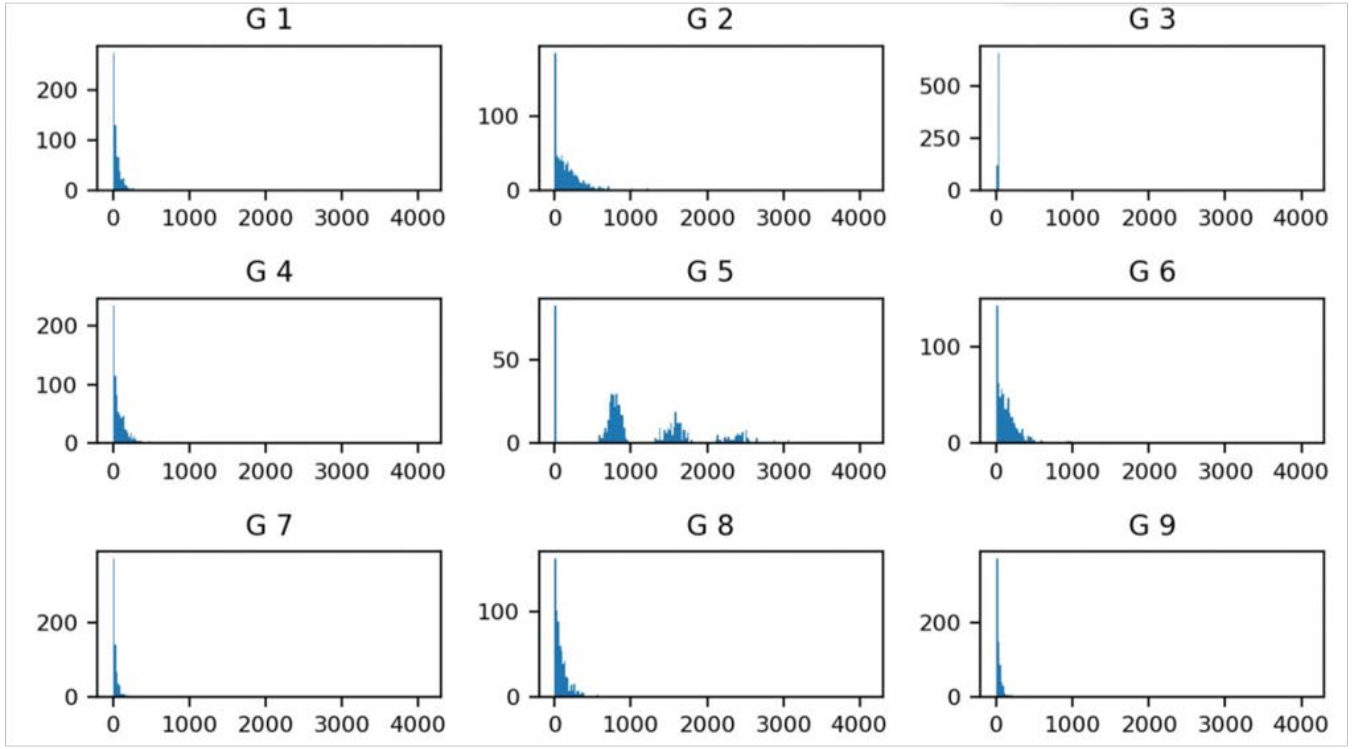
GENNY

WORK IN PROGRESS

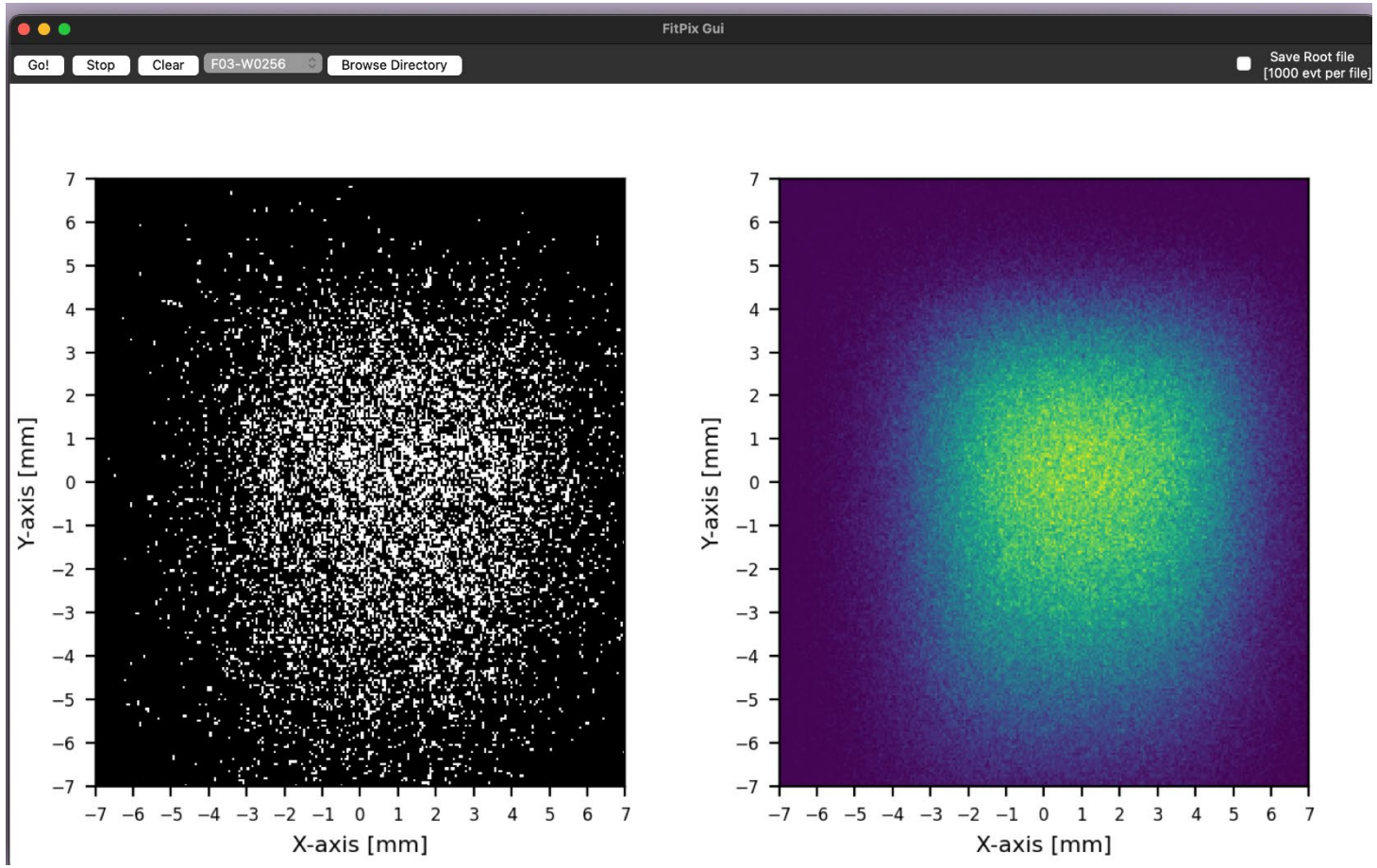
9 BGO crystals readout by 9 PMTs used to measure multiplicity at lower energies

- Get QDC data from Memcached
- Create rootfiles
- Quick Monitor of the channels



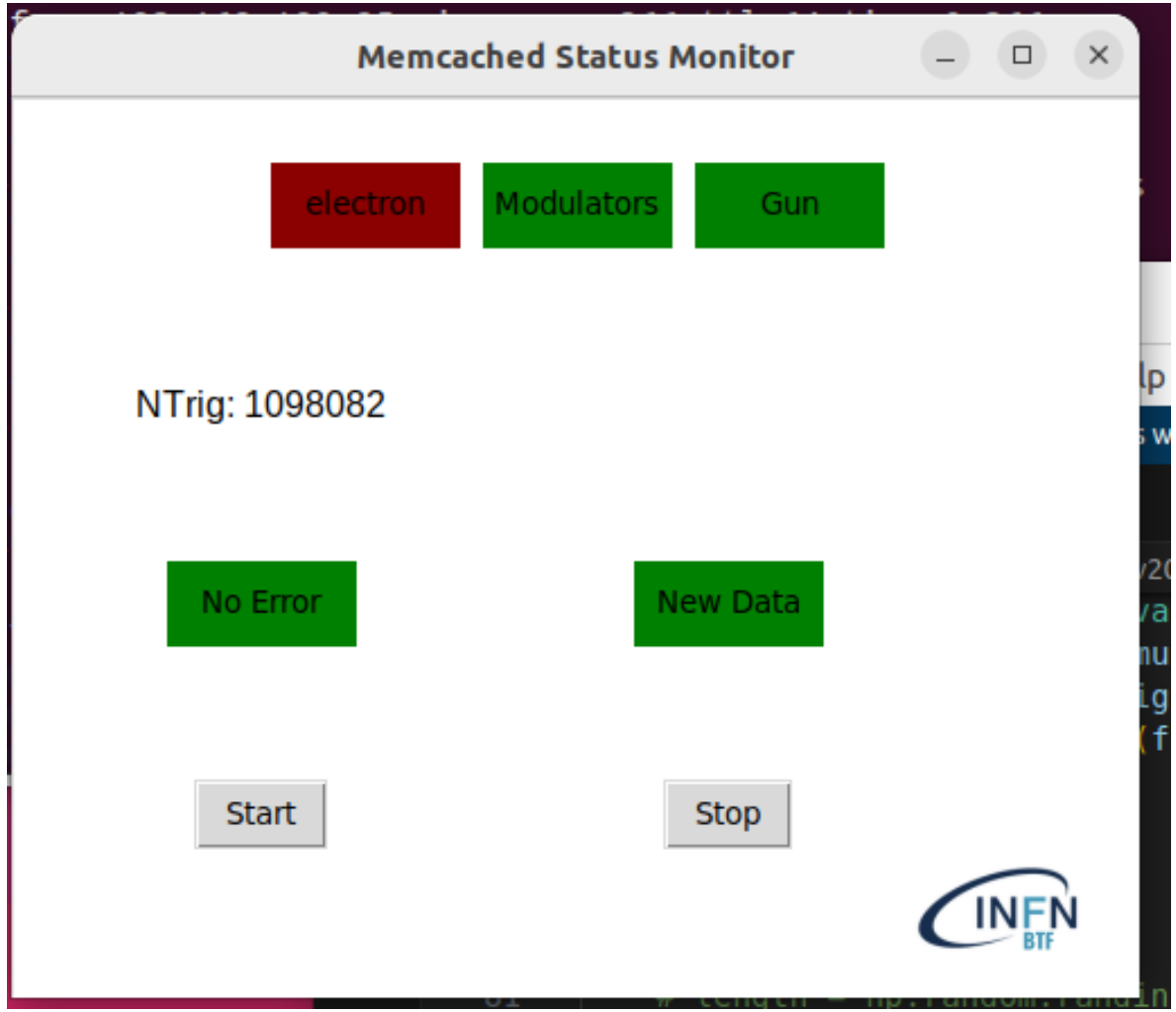


PYFITPIX



- Read pixel on from Memcached
- Similar to LV interface
- Possibility to save the ROOT files containing pixel fired, time, …

PYSTATUS

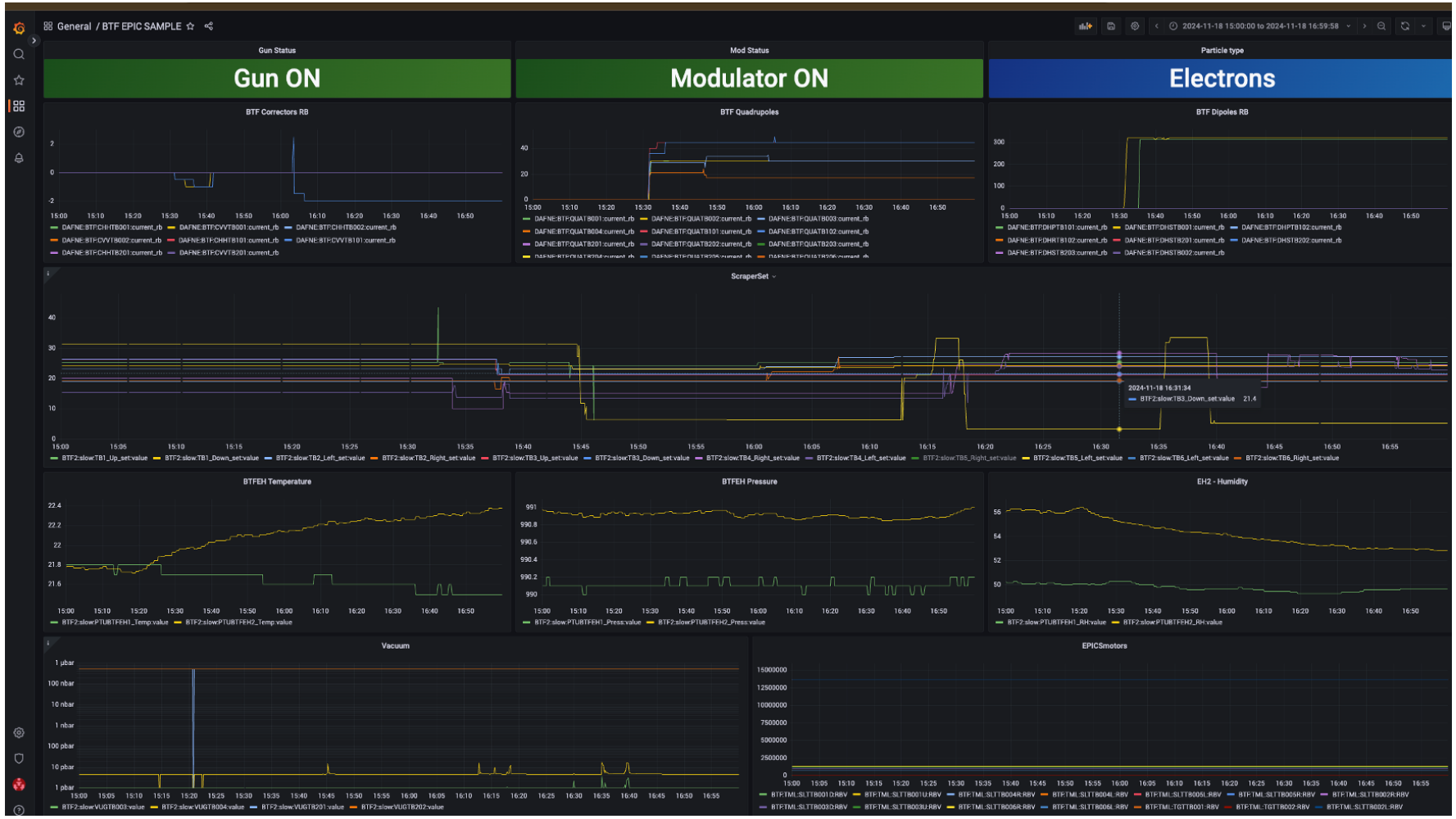


- Read Linac status on from Memcached
  - Particle delivered
  - Mod ON/OFF
  - Gun ON/OFF

GRAFANA

WORK IN PROGRESS

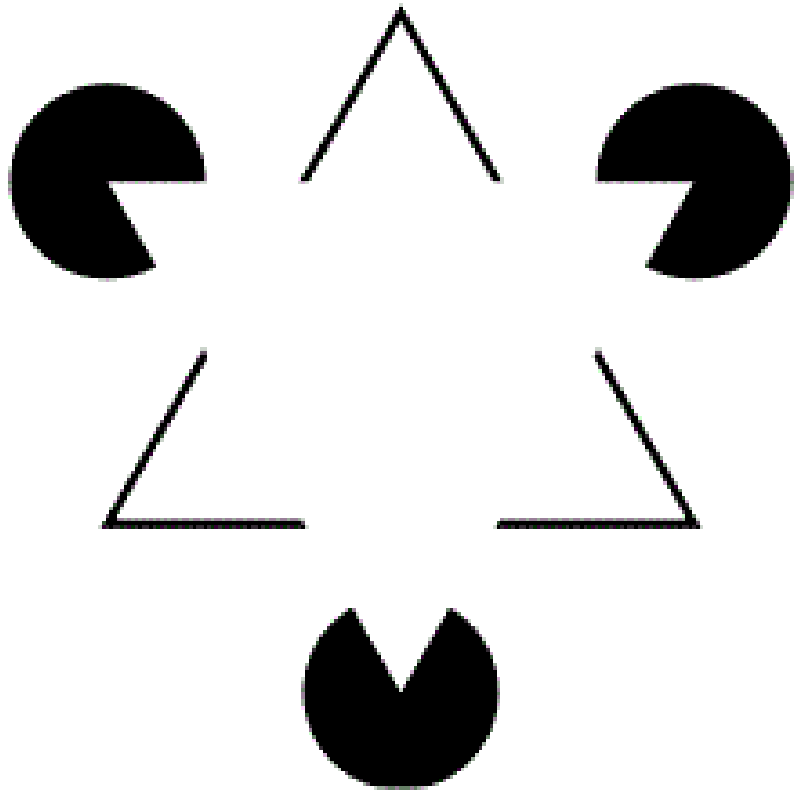
All the significant archived PVs are shown in Grafana



EPIC8S FUTURE PLANS

- Continuing with this hybrid development to include all the BTF controls services to users
- LV impact will be reduced after demonstrating the stability of the overall system
- Include
  - E-Log
  - Post run data sharing
  - High level routine implementation commonly used software and IDE (python3, Jupiter, root,…) using real time machine PV

Discussion



DISCUSSIONS & CONCLUSIONS

- 2024 BTF calls for beam time closed successfully
  - Beamtime run smoothly, few weeks remaining
  - Withdrawals used to exploit new detectors

- Wide scientific area covered by external users
  - VHEE FLASH community interest, medical physics
  - HEP is the highest beamtime allcation
  - Space related project are present
  - But our main goal is new detector developing (PADME, BeER, ThickSDD, Nanocrystal…)

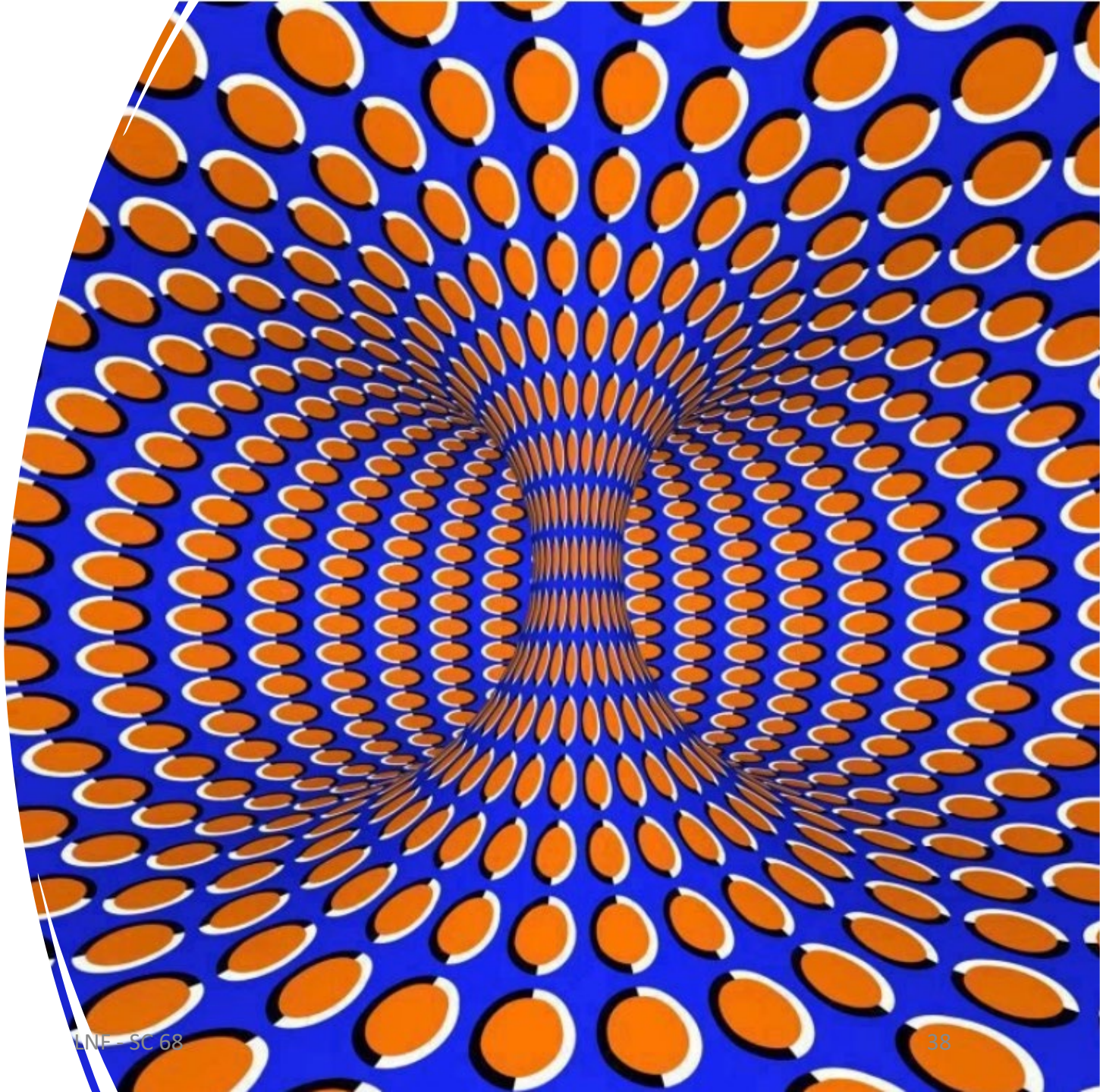
- LINAC/BTF team mainly involved in 2024 for:
  - DAϕNE and BTF operations,
  - TEX,
  - SPARCLAB,
  - Rome Technopole
  - ASIF2 and EUROLABS Projects

LINAC/BTF results have to be shared with all the LNF people involved
- DT and DA services, secretariats and administrations
- Especially the DAϕNE OPERATORS

And, why not, also to users that share knowledge about the cutting edge detector physics and technology

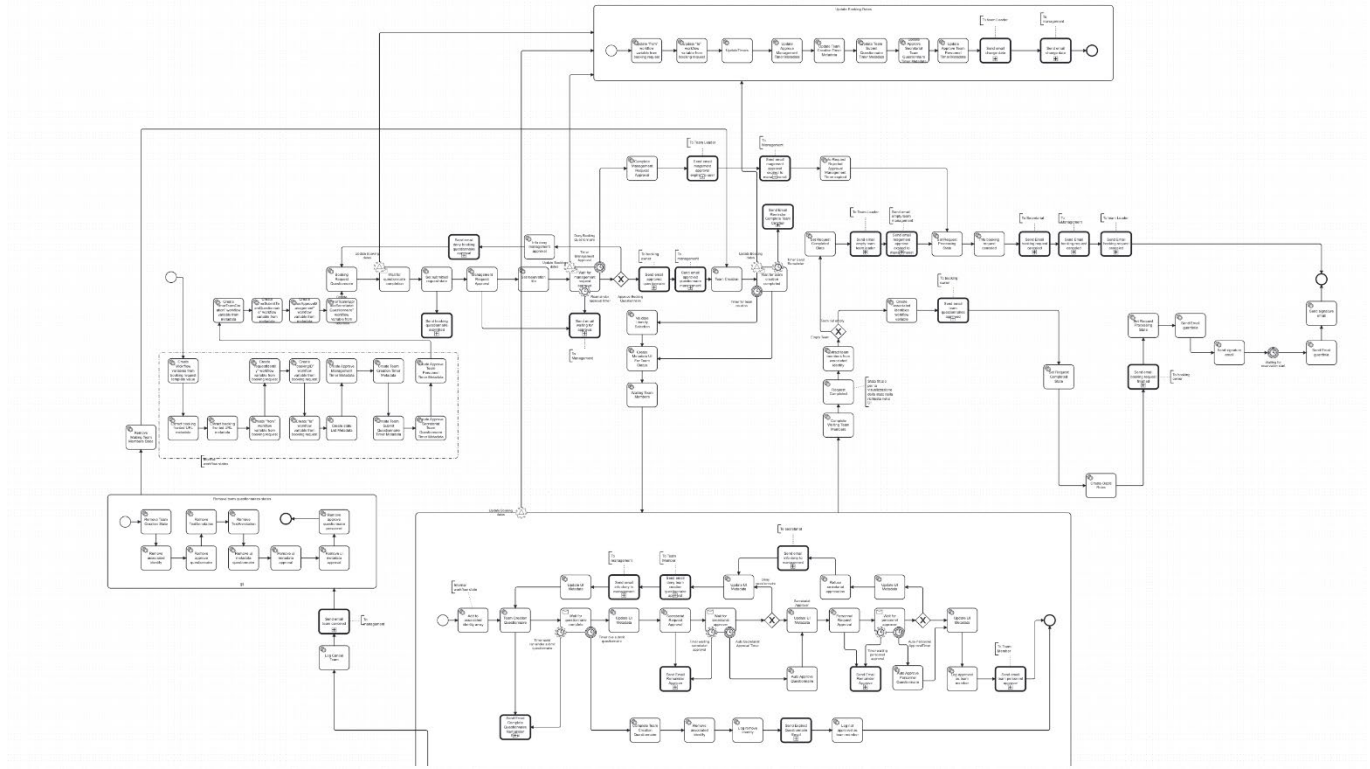
- **FIREBALL LOI**, (E. Los, B. Bingham RAL, G. Gregori Oxford Univ.) **next talk**

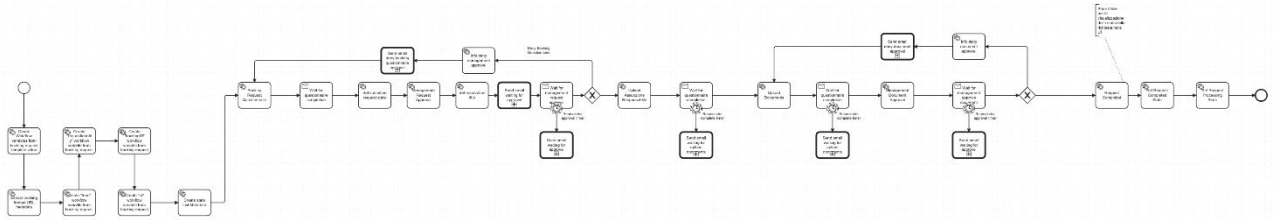
SPARE SLIDE



BOOKING SW

Booking BTF: BTF booking management software based on an automated approval workflow software. Call management.

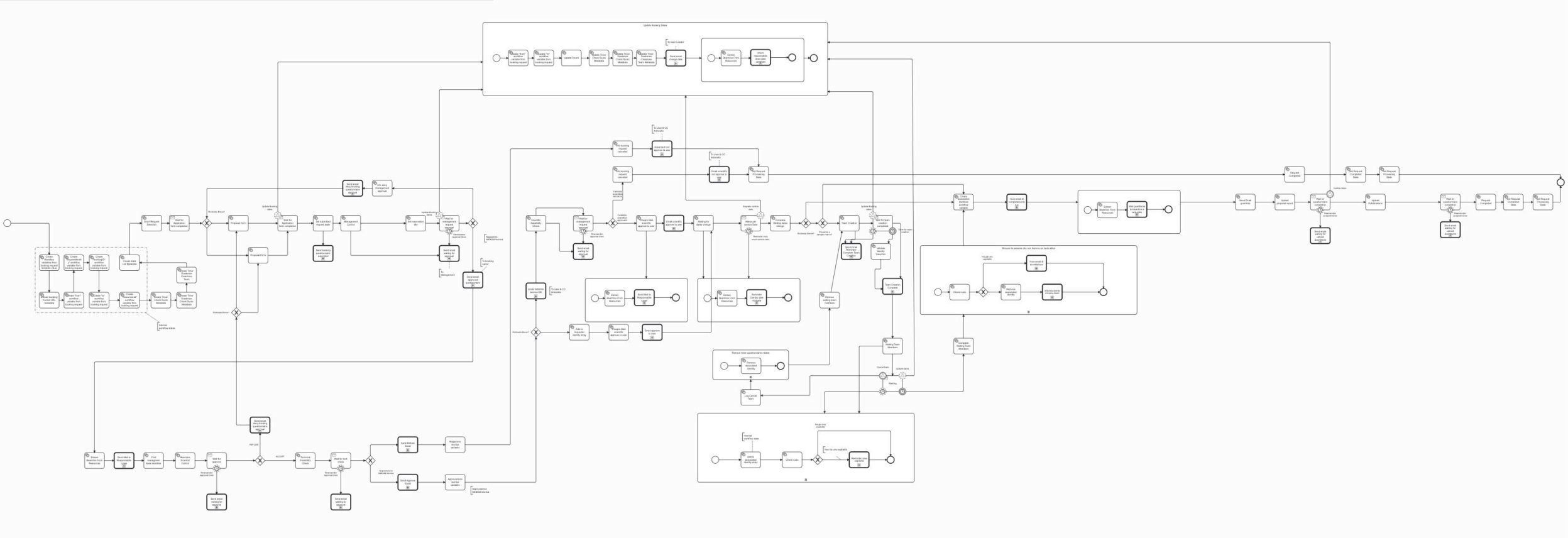




- Weekly, last-minute shift, withdrawal or rebooking manageme
- New GUI
- 400 users in automated managed shift (weekly based) up from
- Over 100 booking successful completed

- Similar aim: internal or indirect users management)
- Booking type
- Many lines: 5 for TANDEM facility

DAFNE-Light

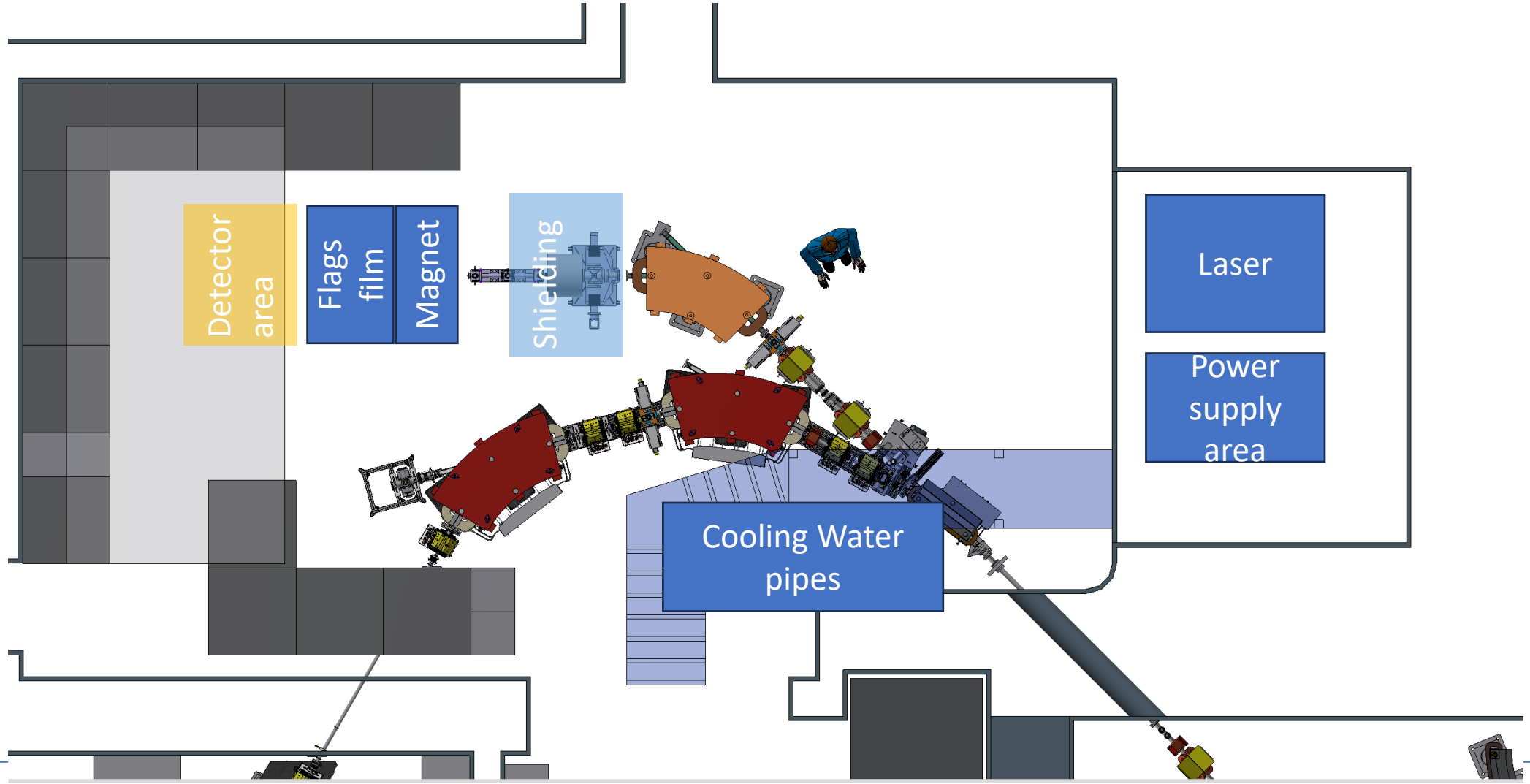


- Very Complex workflow
- Implemented short request booking and sample mail-in booking
- New GUI, with modern UI concept and technologies

FIREBALL@BTF

- Modular implementation in 3 phases
- Few months/ year for data taking and setup
- Compatible with external users' high intensity operation, fixed installation

Needs design, procurement and technician time also from LNF



For further info look in Confluence

- Epik8s, or “EPICS on Kubernetes,” is a framework designed to facilitate the deployment and management of EPICS (Experimental Physics and Industrial Control System) on Kubernetes clusters.

  - **Scalability and Flexibility**: Easily scales across facilities, supporting large and distributed systems.
  - **Simplified Deployment**: Automates deployment using ArgoCD, reducing manual setup time.
  - **Enhanced Fault Tolerance**: Auto-restarts and reallocates services, ensuring consistent system uptime.
  - **Efficient Resource Use**: Containers provide isolated, resource-efficient environments, enhancing performance.
  - **Standardization**: Creates a common platform, simplifying collaboration between research institutes.