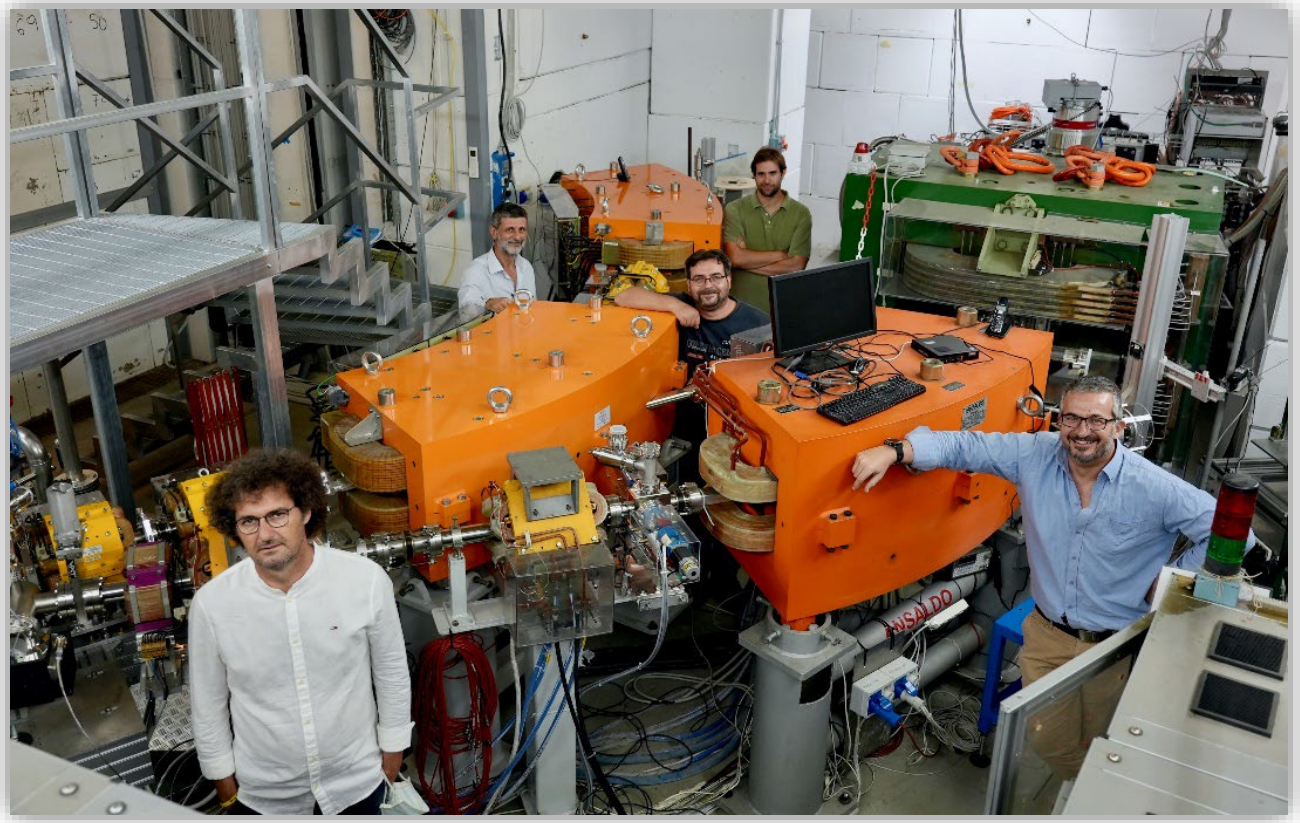
The Frascati Beam Test Facility



Claudio Di Giulio

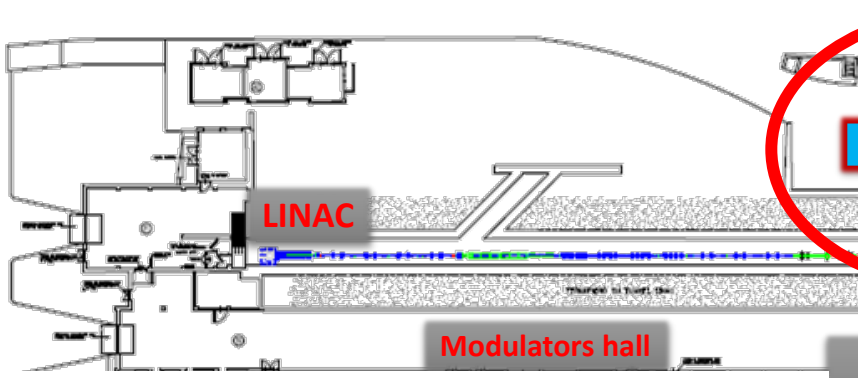
On behalf of the LINAC-BTF team:
L.G. Foggetta
B. Buonomo
D. Di Giovenale
F. Cardelli

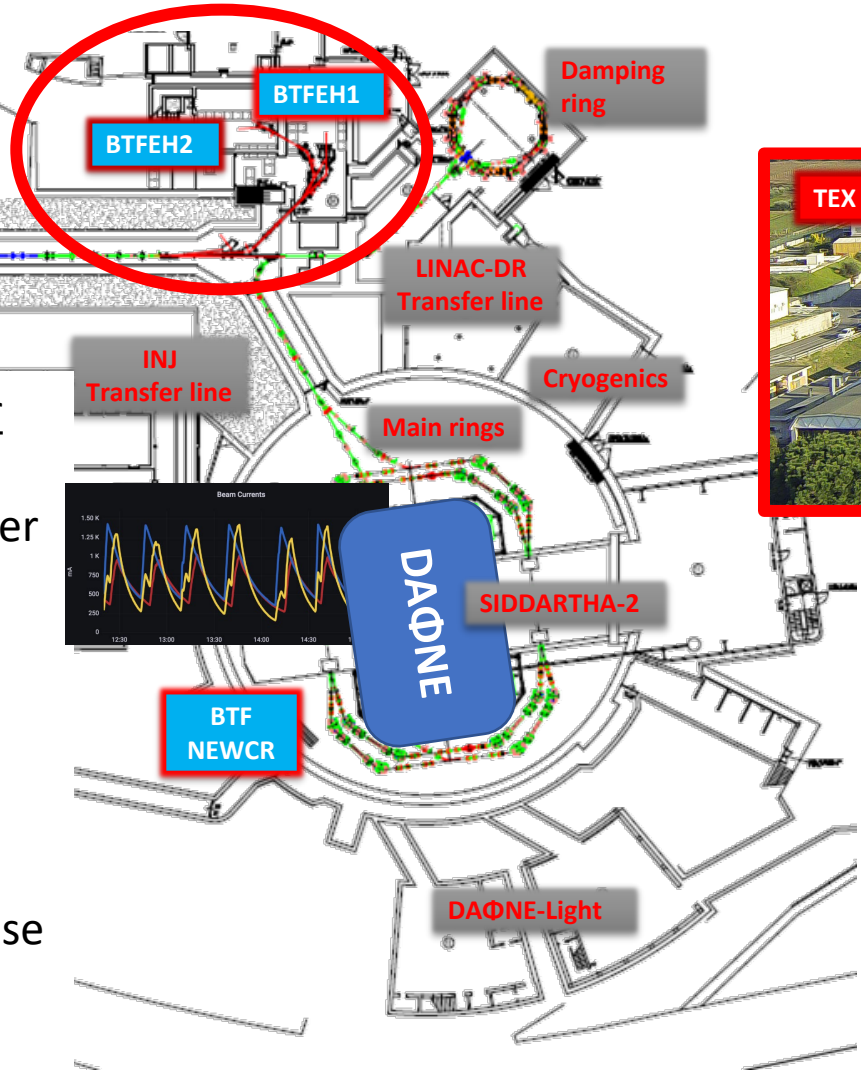
(National Institute of Nuclear Physics, INFN-LNF, Via Enrico Fermi 54 00044 Frascati, Italy)

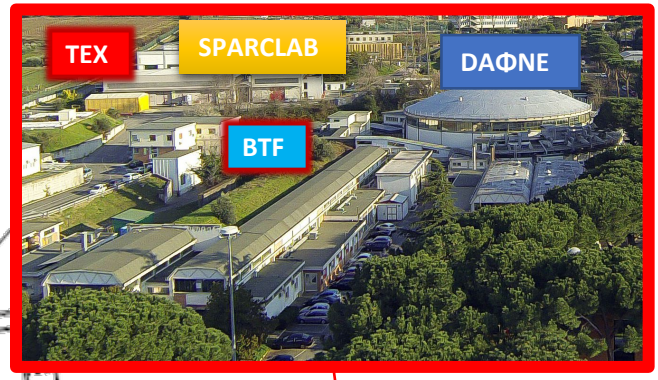
The DAΦNE complex

Laboratori Nazionali di Frascati (LNF)
Frascati (Rome, IT)

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati





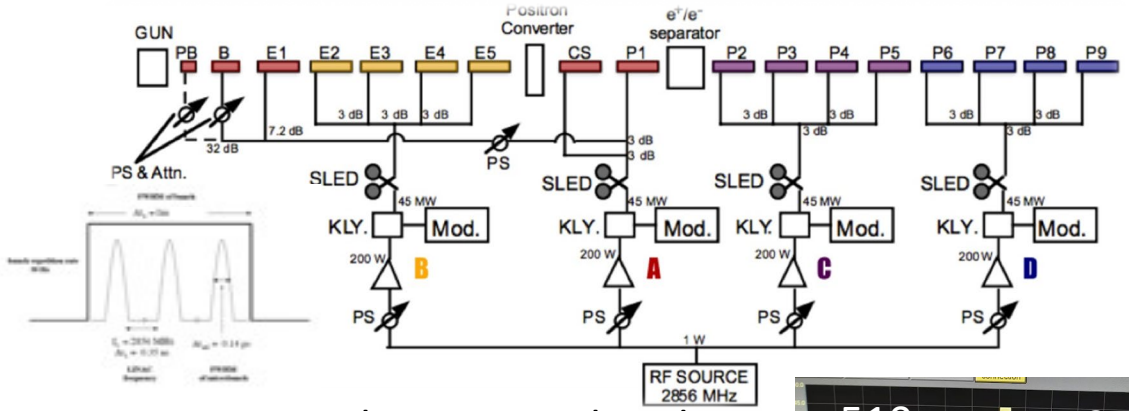


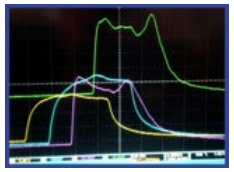
<u>The **Beam Test Facility (BTF)** is an experimental area for users to develop and test particle detector.</u>

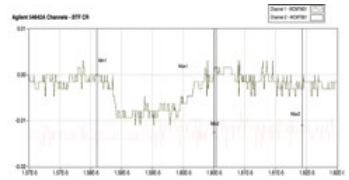
It's in the accelerator DAΦNE complex that is the collider currently in operation in Frascati:

- 1 LINAC (e+/e-)
- 1 Damping ring (common for both beams)
- 2 Main rings approx. 100 m in length
- 120 buckets, high-intensity electron and positron beams (1,5/1 A peak) collides
- two possible interaction points, one is currently in use for the detector SIDDARTHA-2
- Two USERS test facilities:
  - BTF (e-/e+)
  - DAΦNE Light

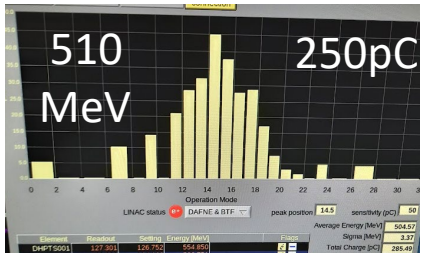
DAΦNE → LINAC → BTF

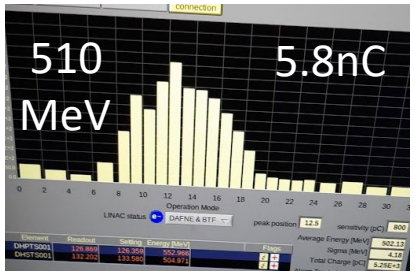


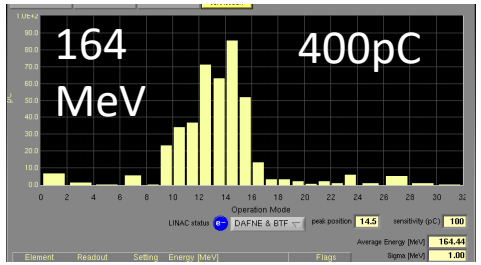




- SLAC Type Traveling wave S-band accelerator (2.865 GHz)
- Driven by
  - Traditional Cathode
  - 120KV electrostatic gun
  - four 45 MW klystrons
  - four SLED peak power doubling
  - 780MeV electron final energy
- Pulsed Machine
  - 10ns bunch envelope
  - repetition rate = 50 Hz.







	Design	Operational (top)
Electron beam final energy	800 MeV	510 MeV (750)
Positron conversion energy	250 MeV	220 MeV
Positron beam final energy	550 MeV	510 MeV (535)
RF frequency	2856 MHz	
Accelerating structure	SLAC-type, CG, 2π/3	
RF Amplifiers	4 x 45 MW sledded klystrons TH2128C	
Beam pulse rep. rate	1 to 50 Hz	1 to 50 Hz
Beam macropulse length	10 nsec	1.4 ns to 300 ns
Beam spot on positron converter	1 mm	1 mm
Normalized Emittance (mm mrad)	1 (electron) 10 (positron)	1 (electron) 10 (positron)
RMS Energy spread	0.5% (electron) 1.0% (positron)	0.5% (electron) 1.0% (positron)
Output electron current (510MeV)	>150 mA	180 mA (>500)
Output positron current (510MeV)	36 mA	50 mA (>85)

Beam Test Facility Experimetal Hall and lines:

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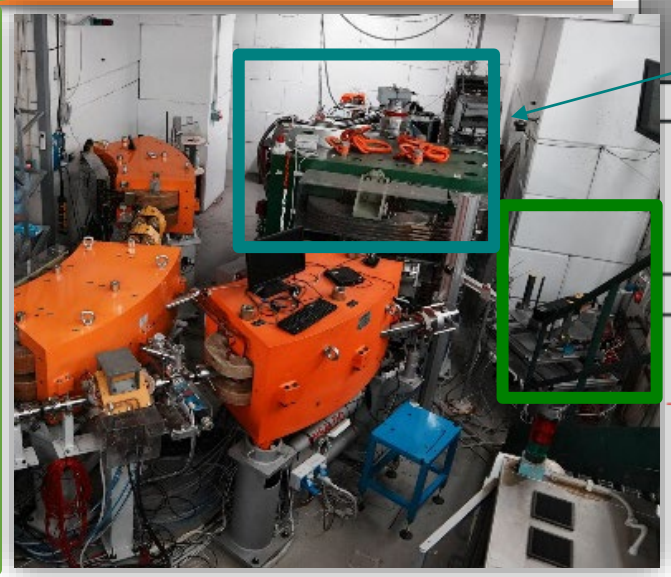
Laboratori Nazionali di Frascati

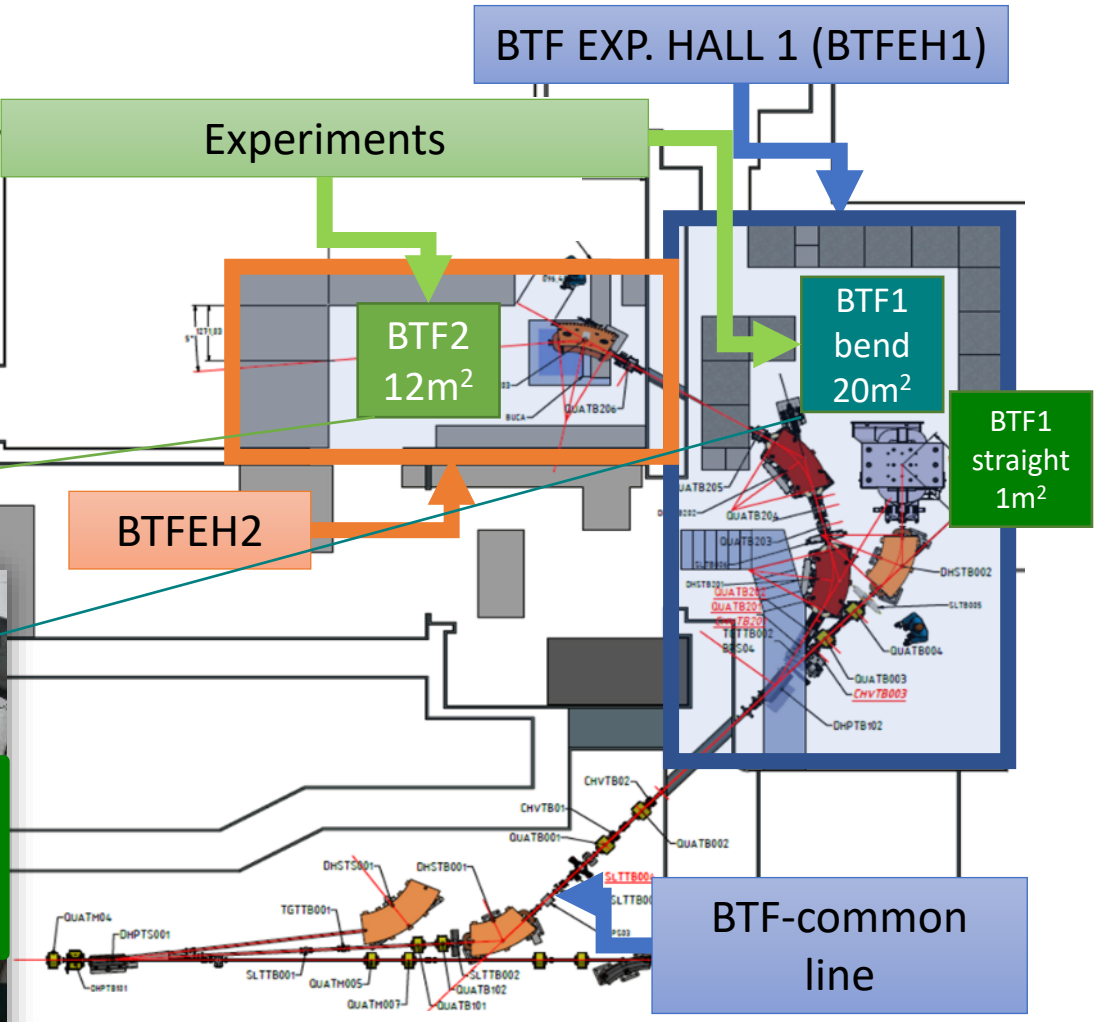
BTFEH1 – BTF1 (2 lines)

- A straight line where an area of 1m^2 with remote controlled table and beam diagnostics for the users. Dedicated at High intensity beam experiment.
- A bended line where an area od 20m^2 is actually used by the PADME experiment (Dark matter search experiment)

BTFEH2 – BTF2 (1 line)

- A 12m^2 Hall operative, with line to external users
- Only secondary beam is used.





Beam Test Facility secondary particles beam production:

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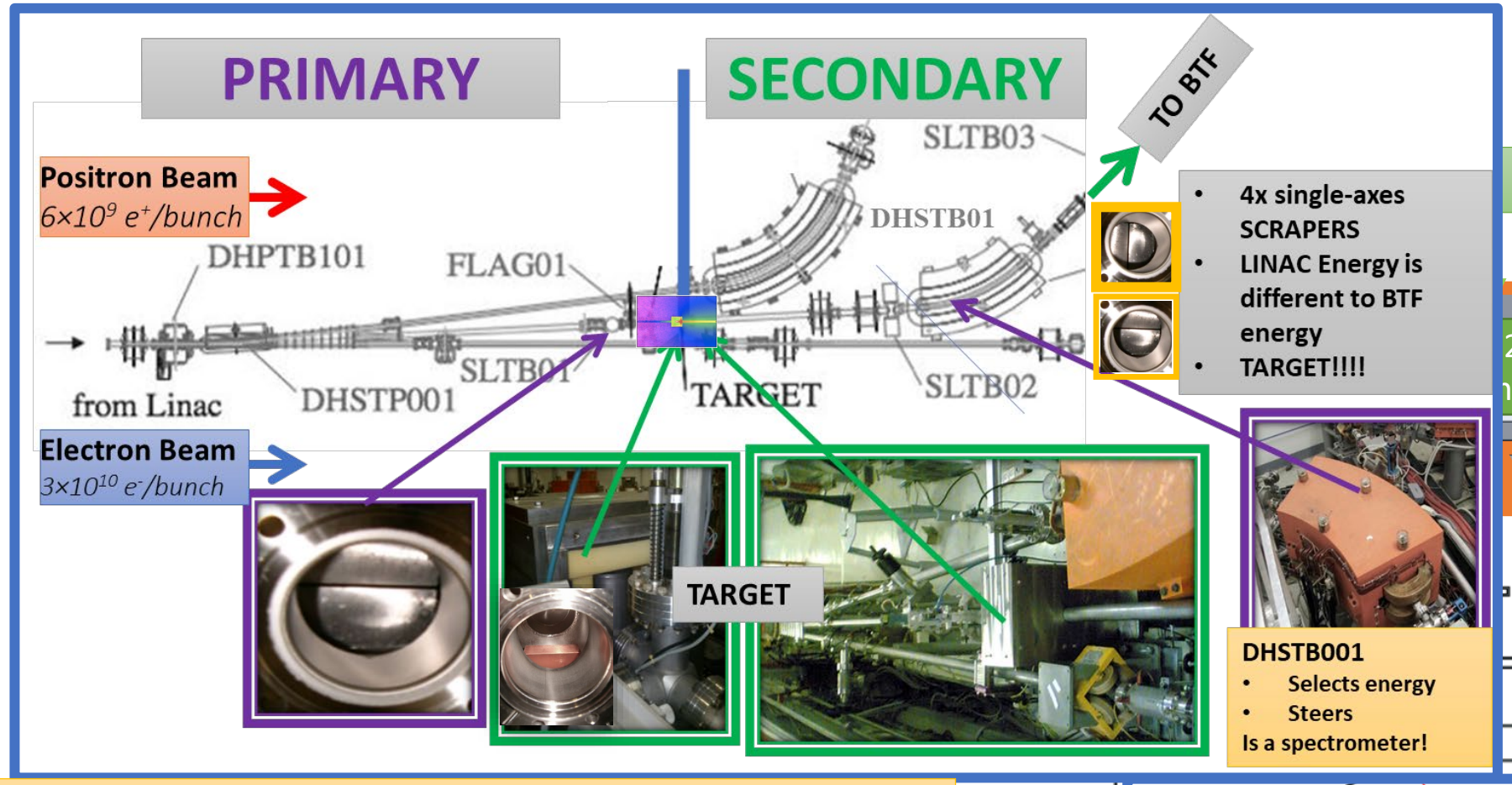
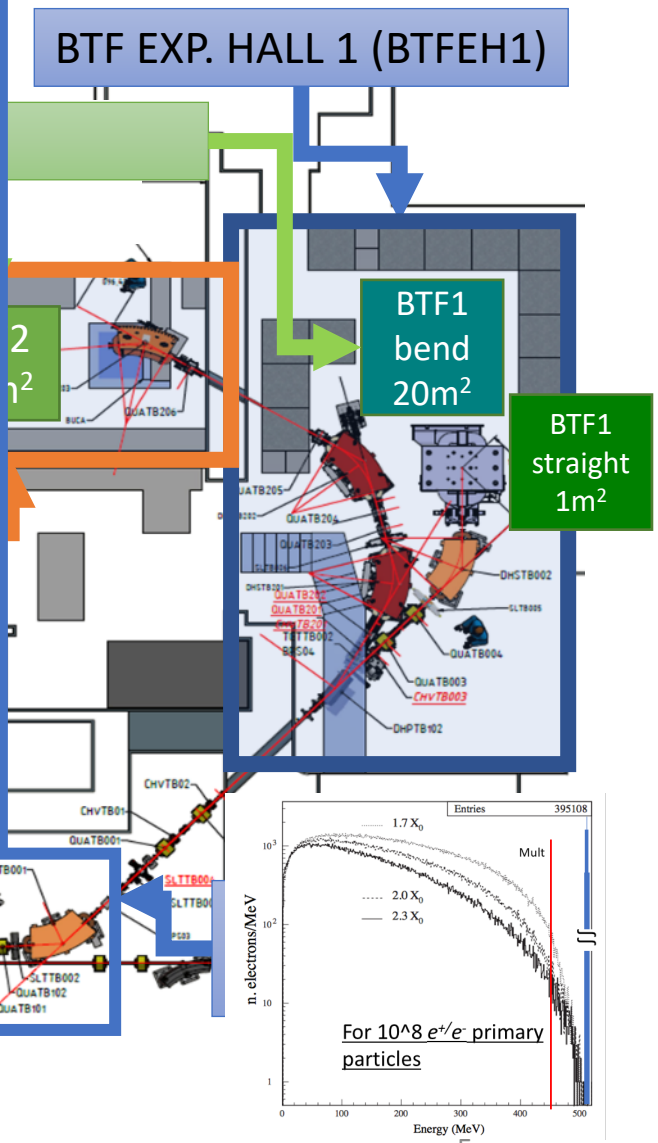
Laboratori Nazionali di Frascati





- Copper target in the middle
- ENERGY and its spread selection! (Scrapers,Dipoles)
- Multiplicity selection! (Scrapers,Dipoles)
- Transverse Scrapers, Quad, Dipoles
- Dipoles and Correctors to match angle and position in the DUT

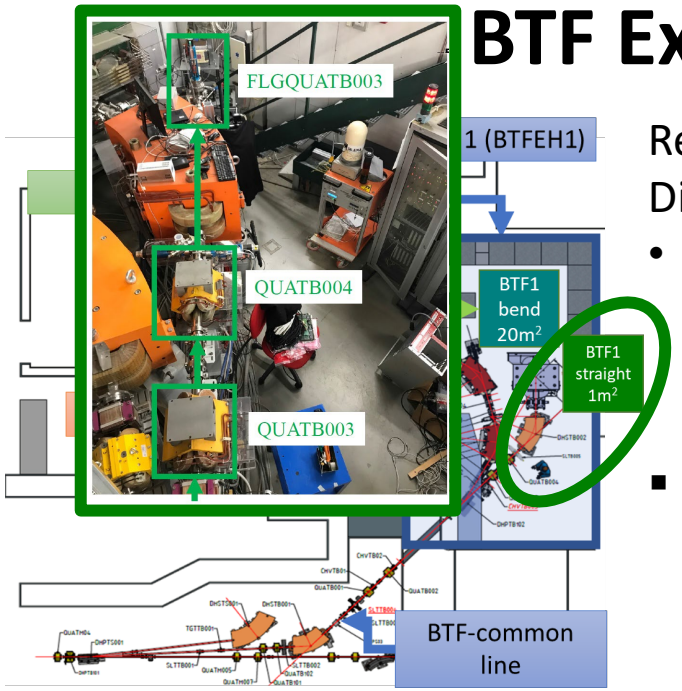
BTF Beam Parameters

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Parameters	BTF1 Time sharing		BTF1 Dedicated		BTF2 Time sharing	BTF2 Dedicated
	With Cu target	Without Cu target	With Cu target	Without Cu target	With Cu target	With Cu target
Particle	e^+ / e^- (User)	e^+ / e^- (DAΦNE status)	e^+ / e^- (User)		e^+ / e^- (User)	
Energy (MeV)	25–500	510	25–700 (e^-/e^+)	167–700 (e^-) 250–550 (e^+)	25–500	25–700
Best Energy Resolution at the experiment	0.5% at 500 MeV	0.5%/1%	0.5%(Energy/mult dependent)		1% at 500 MeV(Energy/mult dependent)	
Repetition rate (Hz)	Variable from 1 to 49 (DAΦNE status)		1–49 (User)		Variable from 1 to 49 (DAΦNE status)	1–49 (User)
Pulse length (ns)	10		1.5–320 (User)		10	10
Intensity (particle/bunch)	$1–10^5$ (Energy dependent)	10^3 to $1.5x10^{10}$	$1–10^5$ (Energy dependent)	1 to $3x10^{10}$	$1–10^4$ (Energy dependent)	
Max int flux	$3.125x10^{10}$ part./s				$1x10^6$ part./s	
Exit Beam waist size (m1, mm)	0.5–55 X / 0.35–25 Y (vacuum window dependent)				0.6x0.6(Energy/mult dependent)	
Divergence (mrad)	Down to 0.5				Down to 0.5	

- Pulsed **electron** and **positron** beams (up to 49 pulses/second)
- Wide range: from 10^10 down to single particle per bunch, continuous energy selection
- Different ranges of parameters in the **two running modes**:
  - Dedicated: only when DAΦNE collider in shutdown, exclusive BTF users
  - Time sharing:
    - DAΦNE spare pulse injections mode via DHPTB101 pulsed magnet
    - Beam top parameters defined by DAΦNE injections

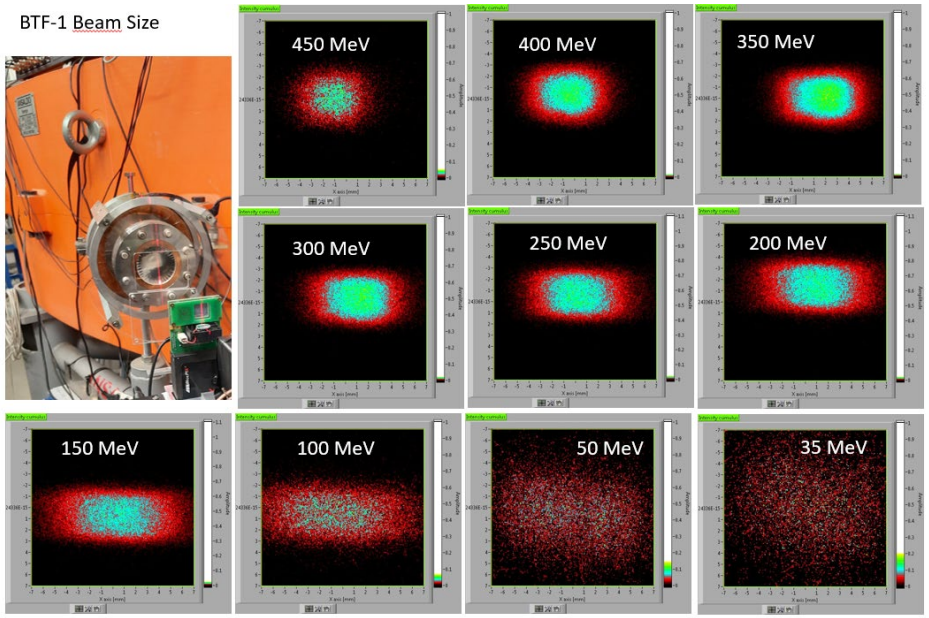
BTF Experimental Hall 1 Straight Line (BTF1-S)



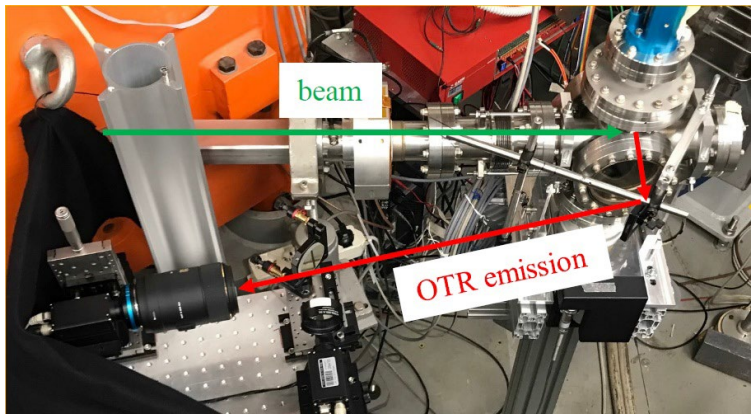
Remote controller table X,Y

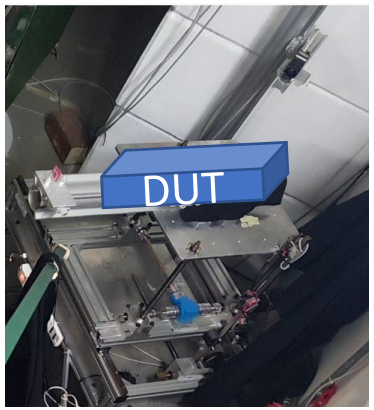
Diagnostics:

- For high charge beam:
  - ICT as charge monitor
  - OTR as size monitor
  - Flags
- For low charge beam:
  - FitPiX
  - Calorimeter PbWO3

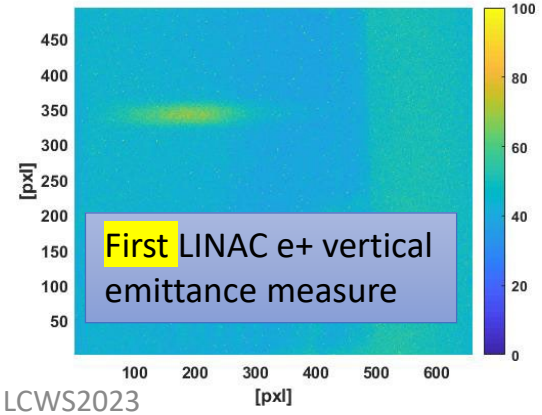


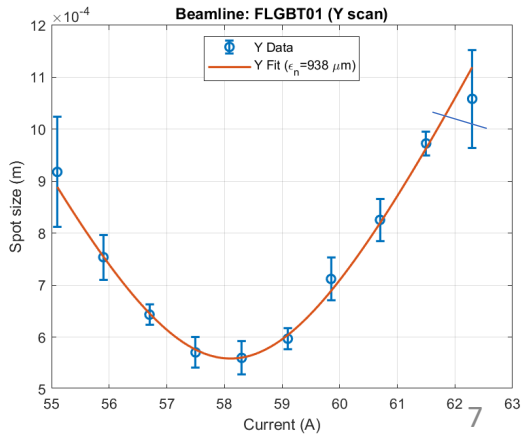
~20 bunch per second with maximum of 1E10 particle per second electron and positron.



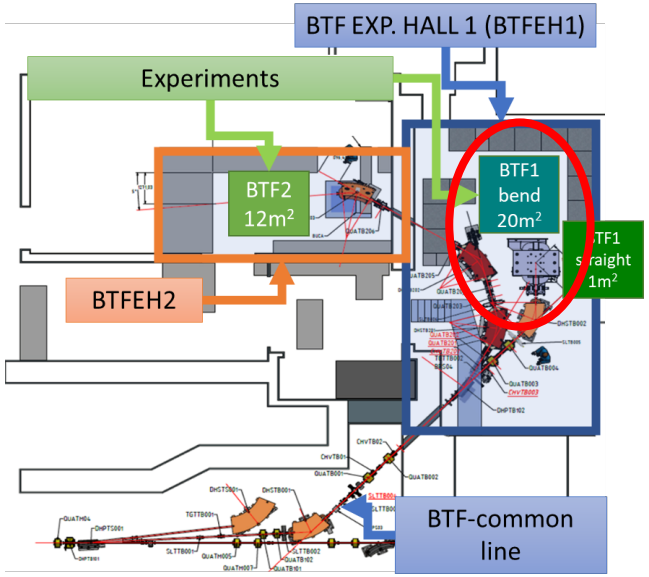


POSITRON Beam = 497 MeV/10ns/4,7pC
Vertical emittance (rms) 0,93±0,32 mm x mrad





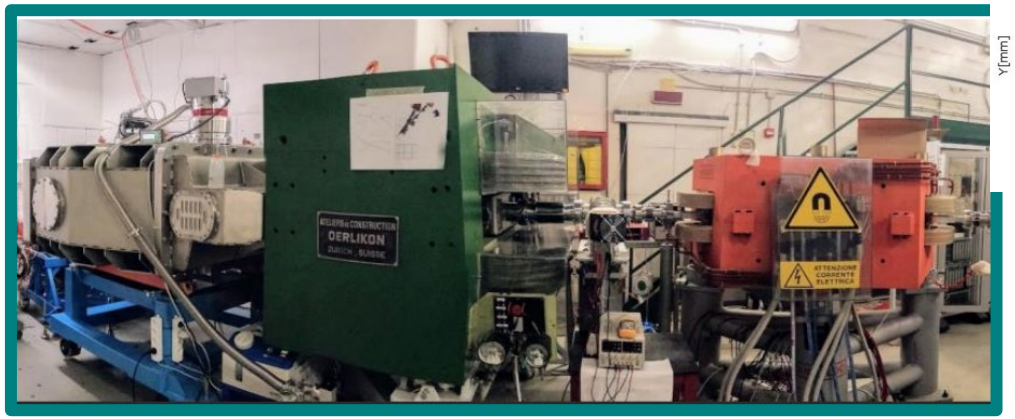
BTF Experimental Hall 1 Bent line (BTF1-B)



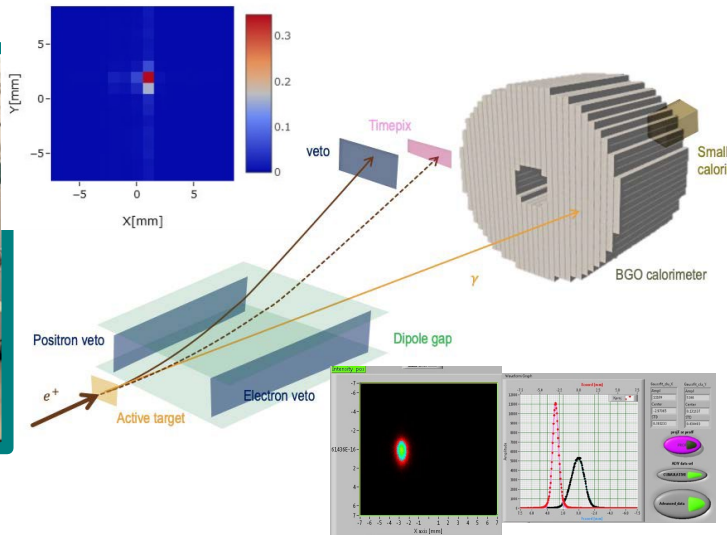
Actually, devoted to PADME(X17) Experiment.

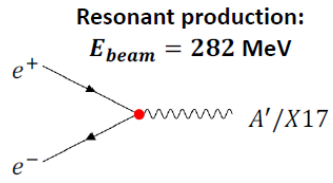
The PADME experiment (Positron Annihilation into Dark Matter Experiment) at Laboratori Nazionali di Frascati of INFN aims to search for a “Dark Photon” using **positron on target collision** at the DAΦNE Beam Test Facility.
PADME use the missing-mass technique to be:

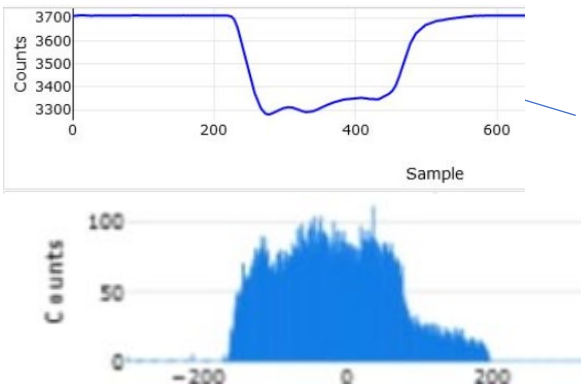
- Sensitive to low-mass dark photons in the range ~ 20 MeV, with a positron beam energy of ~ 500 MeV.
- A dedicated scan to X17 was recently concluded with Energy Scan around of **282MeV pulse length >300 ns about 3000 positron per shots**



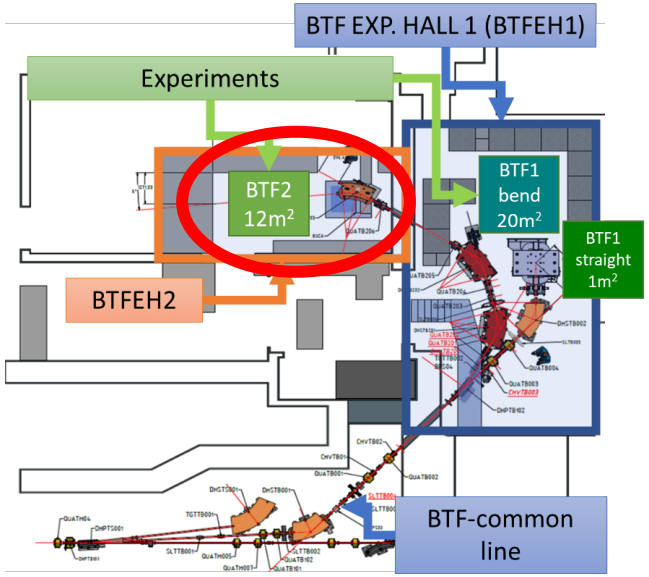
For details: F. Bossi *et al.*
Phys. Rev. D **107**, 012008 – Published 30 January 2023







BTF Experimental Hall 2 Bent Line (BTF2-B)

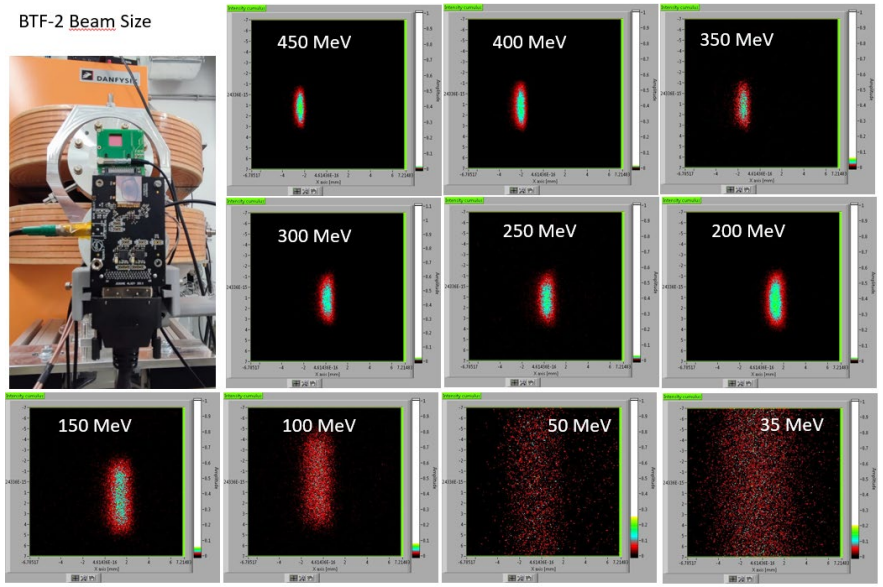


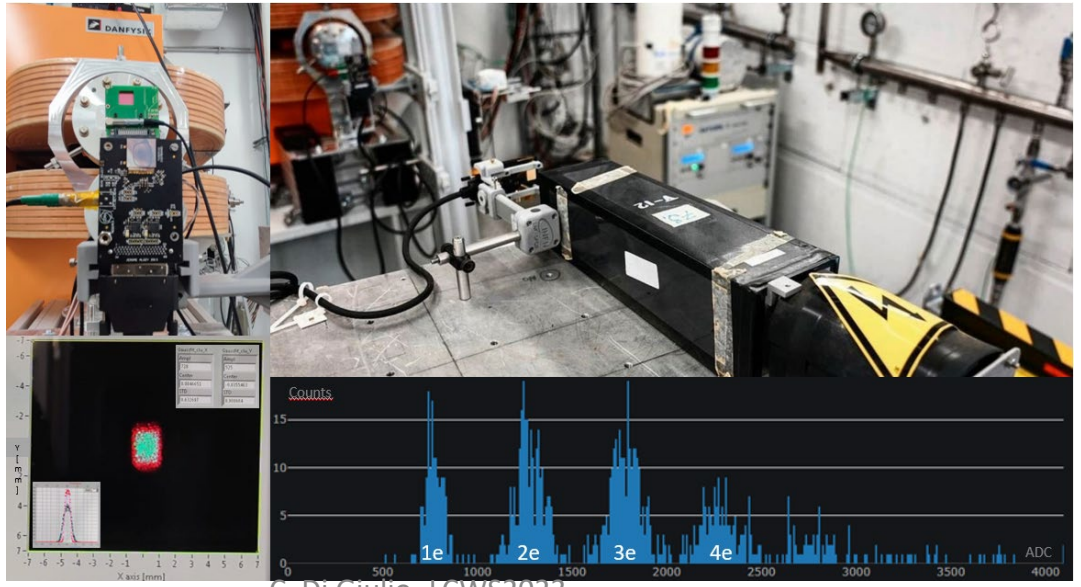
- Remote controller table X,Y

Diagnostics:

- For high charge beam (1E6 max):
  - Calorimeter
- For low charge beam:
  - FitPiX
  - TimePix3
  - Calorimeter PbWO3

All the data provided to the user by a Memcached server

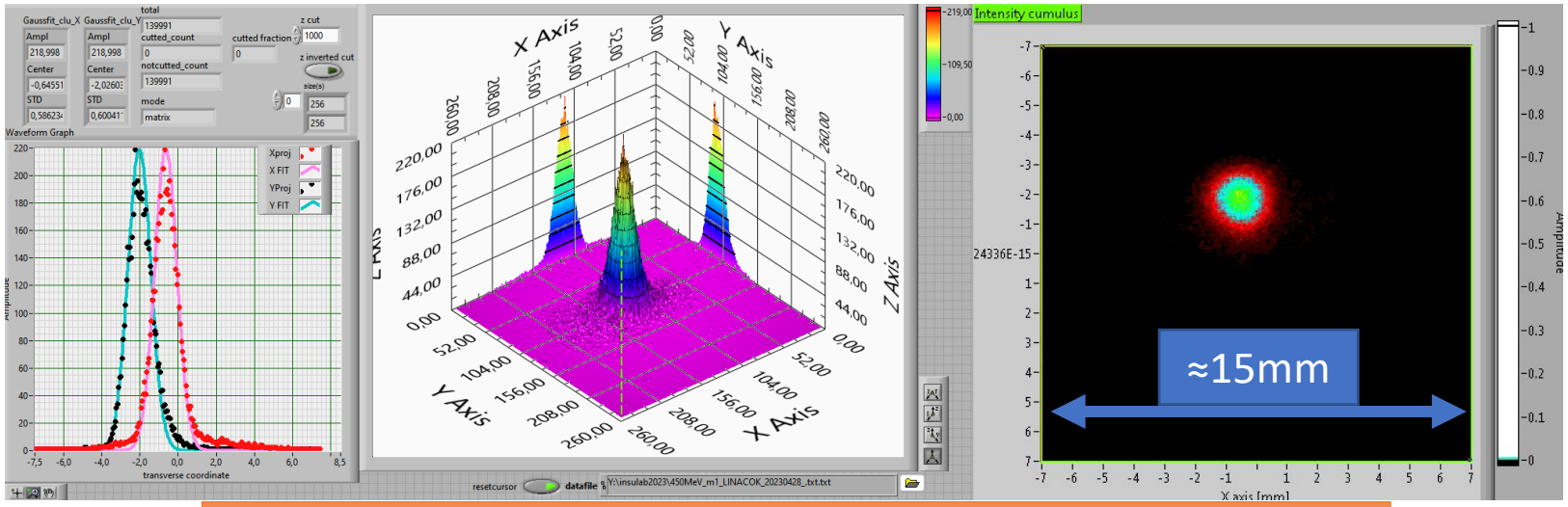




~20 bunch per second with maximum of 1E6 particle per second.

Usually secondary beam.

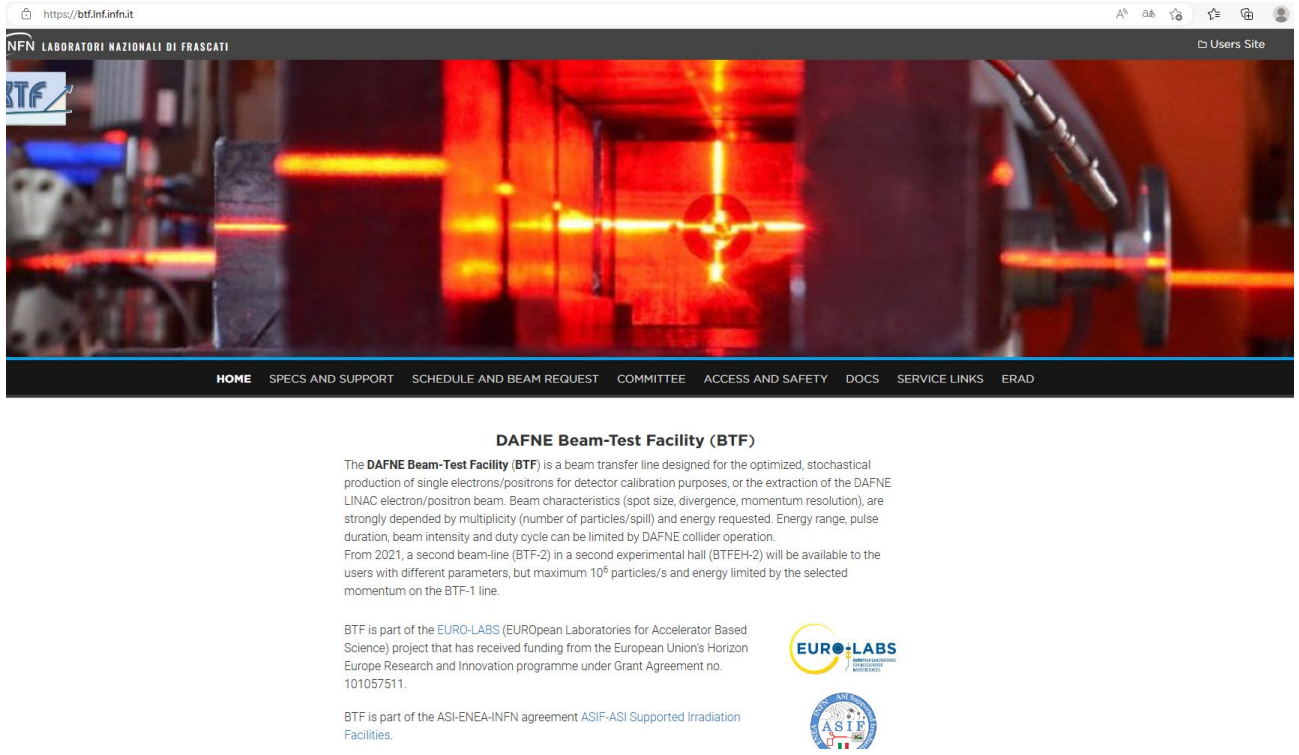
Current single particle best beam BTF2



450MeV, 0,6x0,6mm^2, single particle electron beam@BTF2
Cumulative plot, rep rate 20Hz, ~2h exposure

Beam Test Facility for users:

- 2 Calls for year: users selected by a Scientific Commette
- 1 week or 2 week for Users
- more info on [BTF – DAFNE Beam-Test Facility (infn.it)]



Conclusions:

- The BTF of INFN @Frascati labs, near Rome in Italy is an opportunity for the developers of particles detector to test their device developed for the future colliders with electron and positron beam without cost if is for scientific purpose.

- Next Users call will be open in June 2023 for the Sept-Dec2023 beamtime.