Task 15.4: Improvements of the test beam infrastructure at INFN-LNF

Paolo Valente

INFN Roma

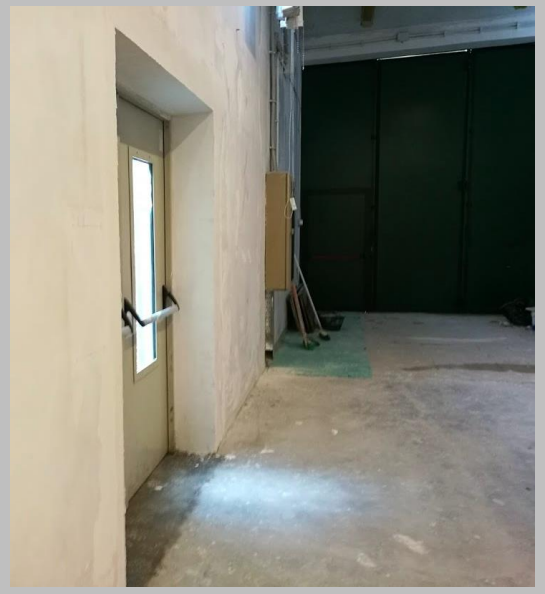
Bruno Buonomo, Claudio Di Giulio, Luca Gennaro Foggetta, Gianfranco Morello

INFN LNF

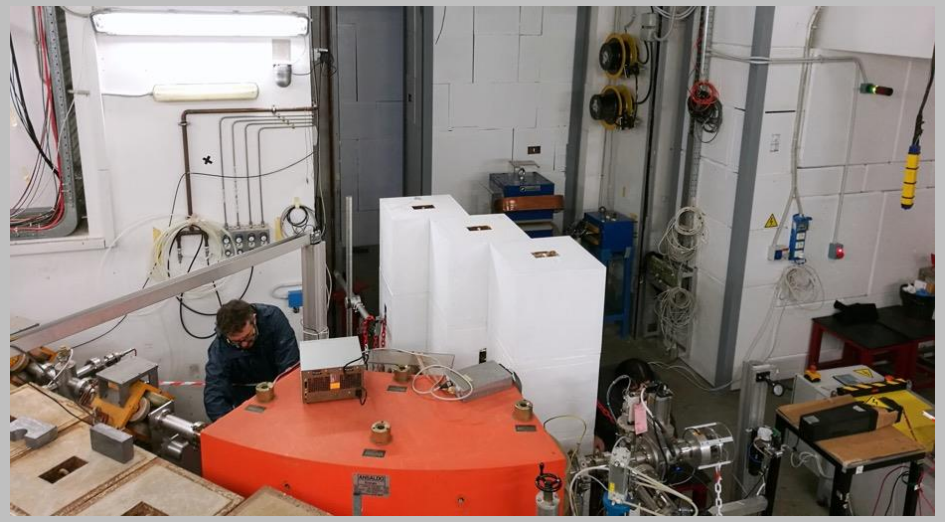






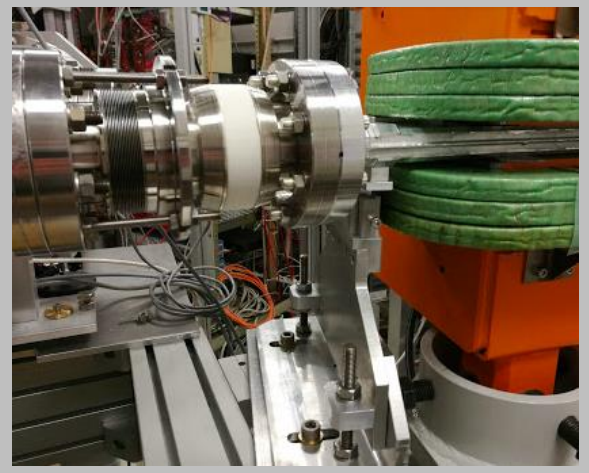



- Civil engineering **completed**

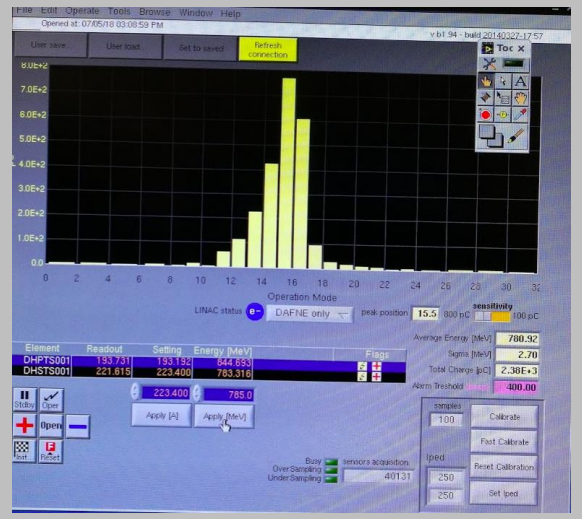


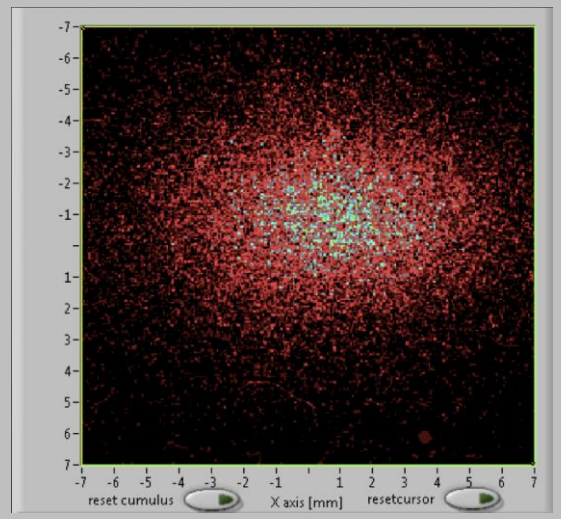
- Old beam-line dismantling **completed**

- New cooling distribution **completed**


- Beam-lines separation and new BTF-1 line **completed**





- Test of new PFN charging power supplies **completed**
- Linac **restarted**
- New BTF-1 line **commissioning done**

(both with short and long beam pulses)

Status

(April ‘18 annual meeting)

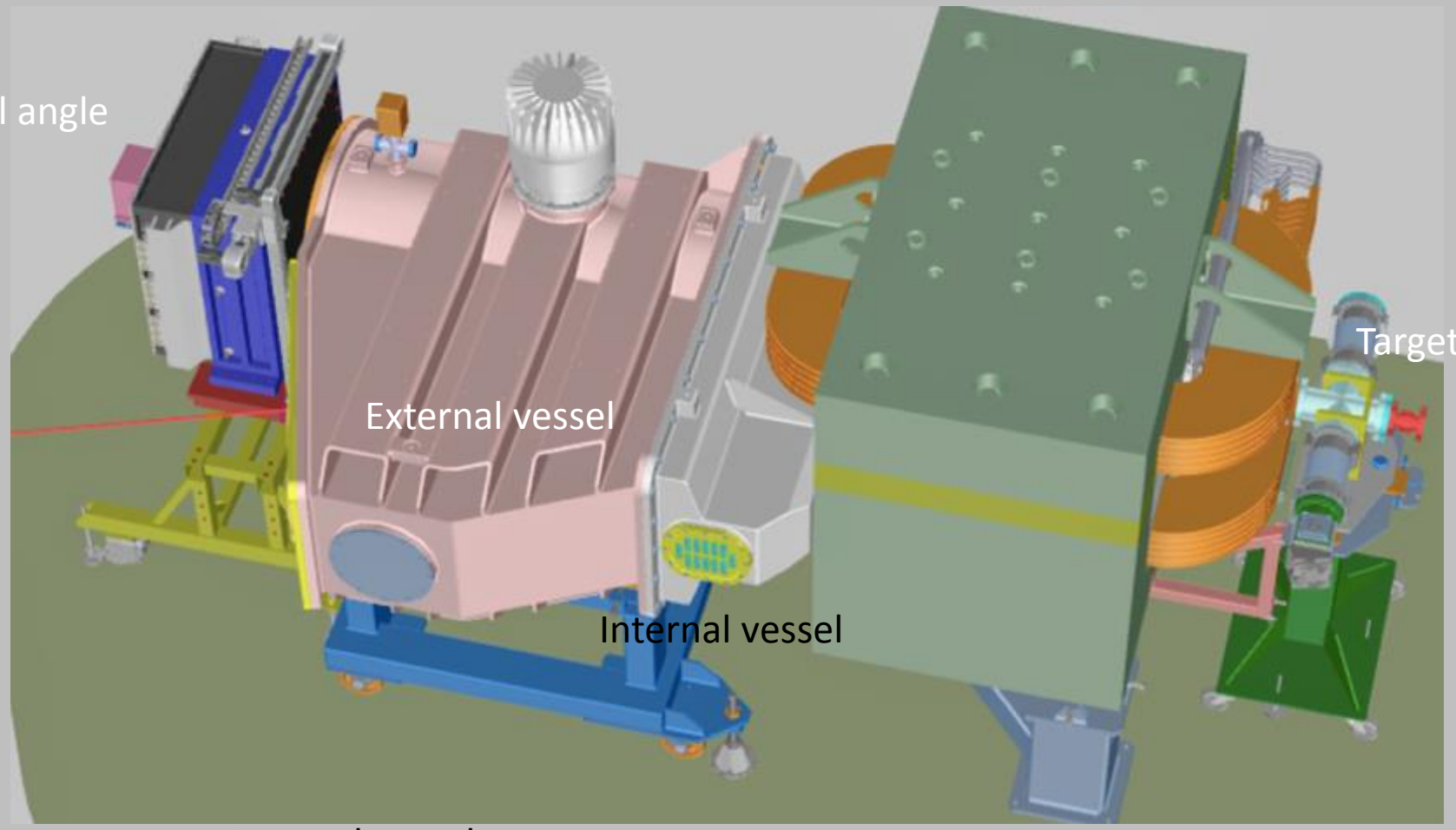
- Schedule and delays influenced by:
  - Funding timing
  - Administrative overhead
  - Interference of infrastructural work with accelerator complex operations
- The main uncertainty comes from the construction of the new magnets
  - All projects started and almost all productions on-going
- Civil engineering on track Done
- Upgrade of cooling, power, services also proceeding Done
- Updated schedule for new beam-lines Done
  - BTF-1 expected restart: June 2018
  - BTF-2 installation and commissioning: first months of 2019
  - Move D15.4 (New Frascati beam line) to M50
- Photon tagging ready, need to be installed on new line
  - Move D15.5 (Photon tagging) to M52

Oct. ‘18 to Feb. ’19: 5 months running on BTF-1

- New magnets power supplies delivered, Nov. ’18
- Power cables ready, Dec. ’18
- New bunker completed, Dec. ’18 – Jan. ‘19

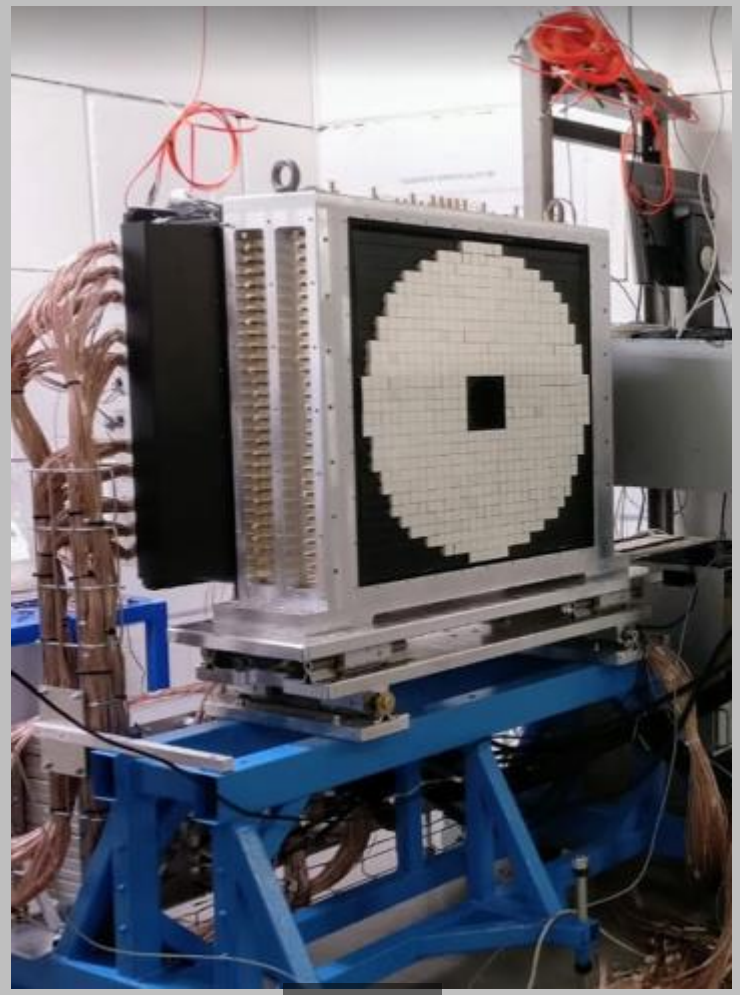
- New DC dipoles (2) expected Jan. ‘19
- New quadrupoles (7) expected Feb. ‘19

First BTF-1 user: PADME experiment



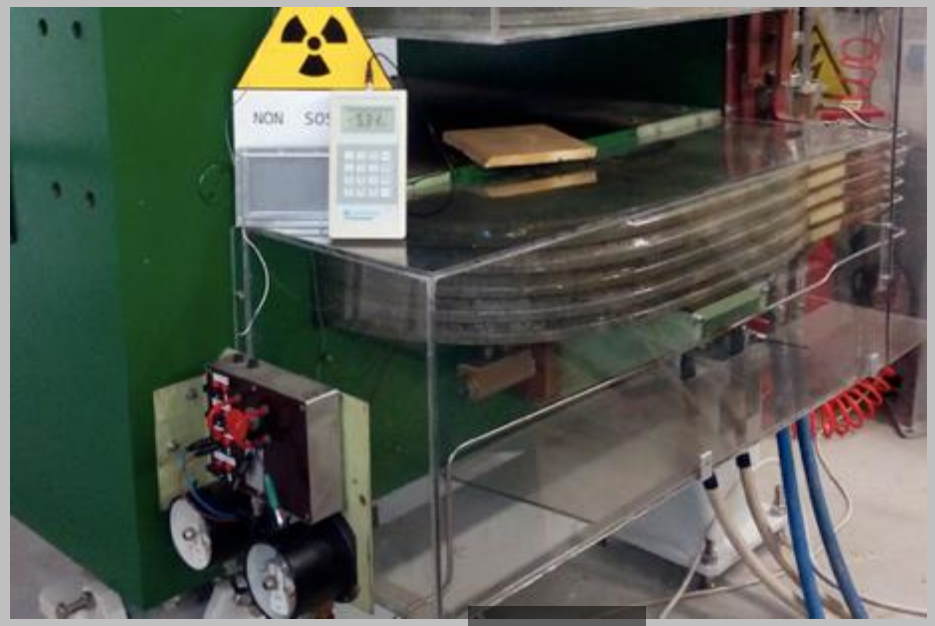
30 May

27 Jun.



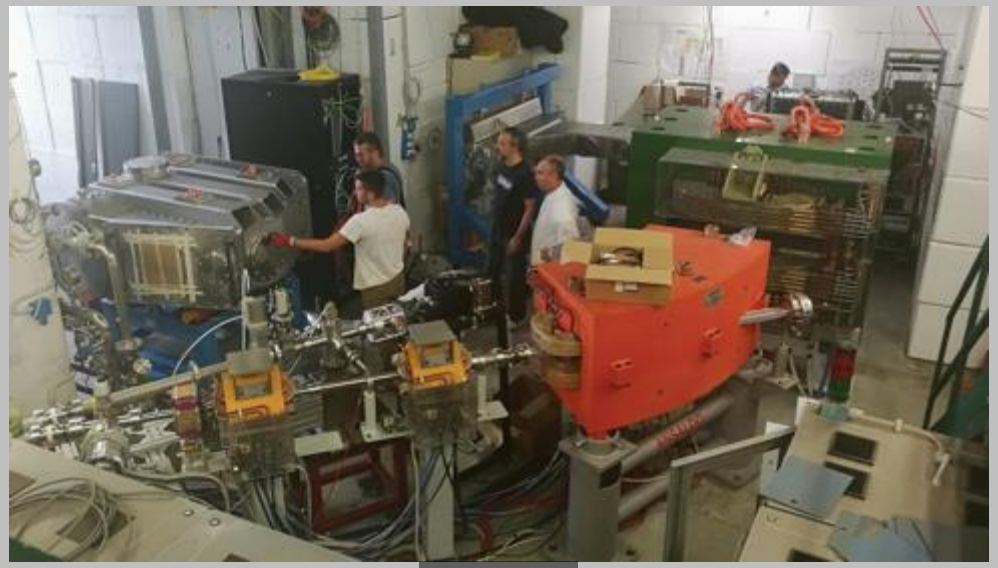
2 Sep.

4 Jun.



13 Jun.

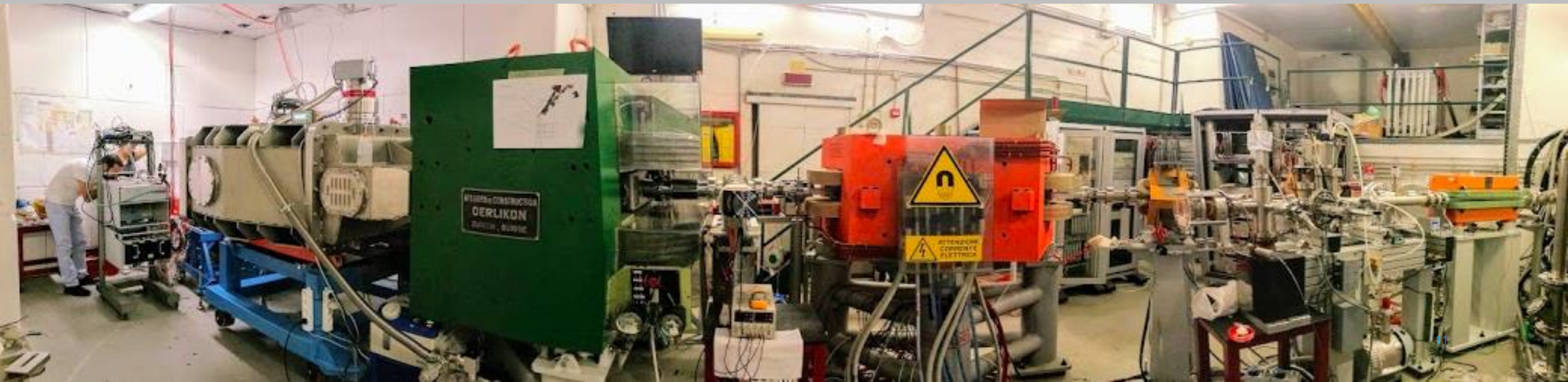
6 Jul.



6 Sep.

14 Sep.

4 Oct.



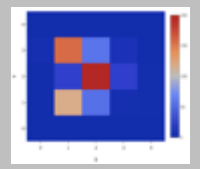
PbF_2 calorimeter

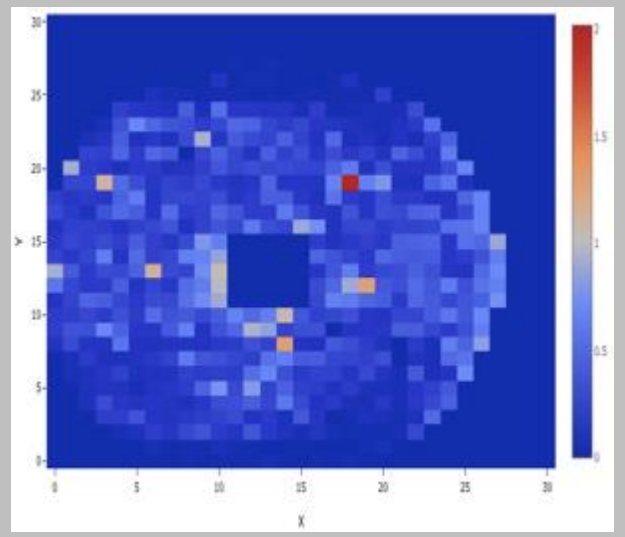
BGO calorimeter

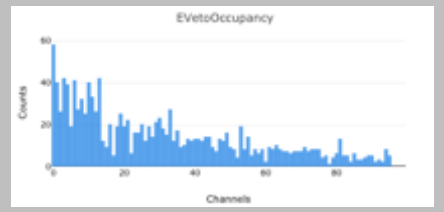
Scintillating bars veto

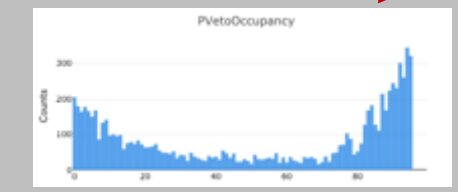
Diamond target

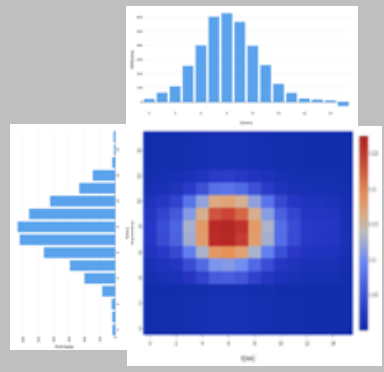
BTF beam

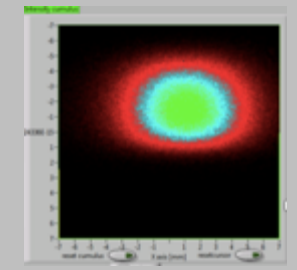


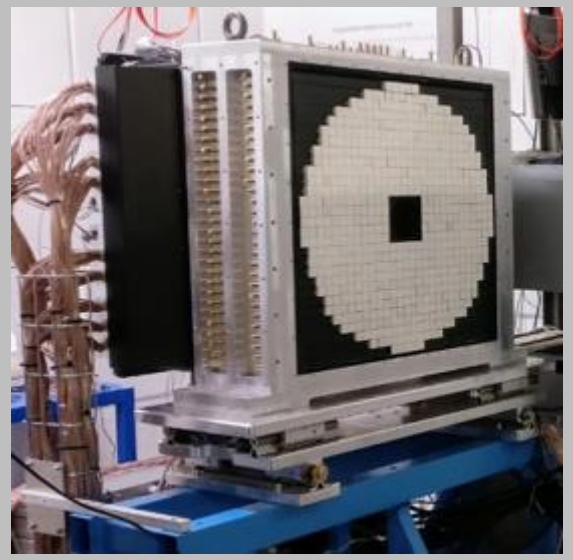


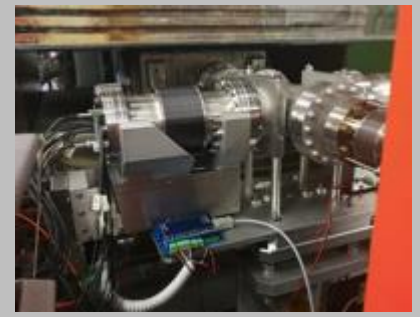










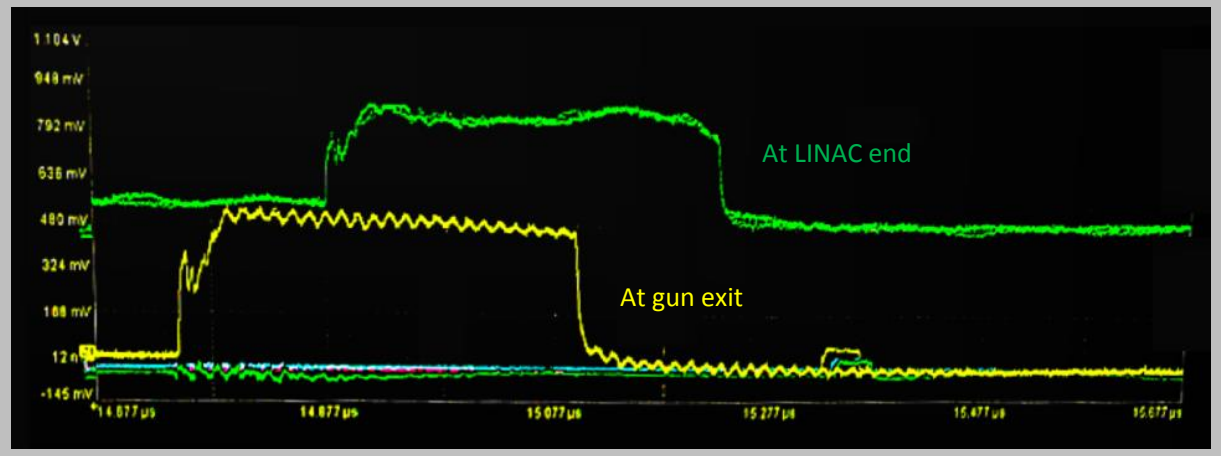


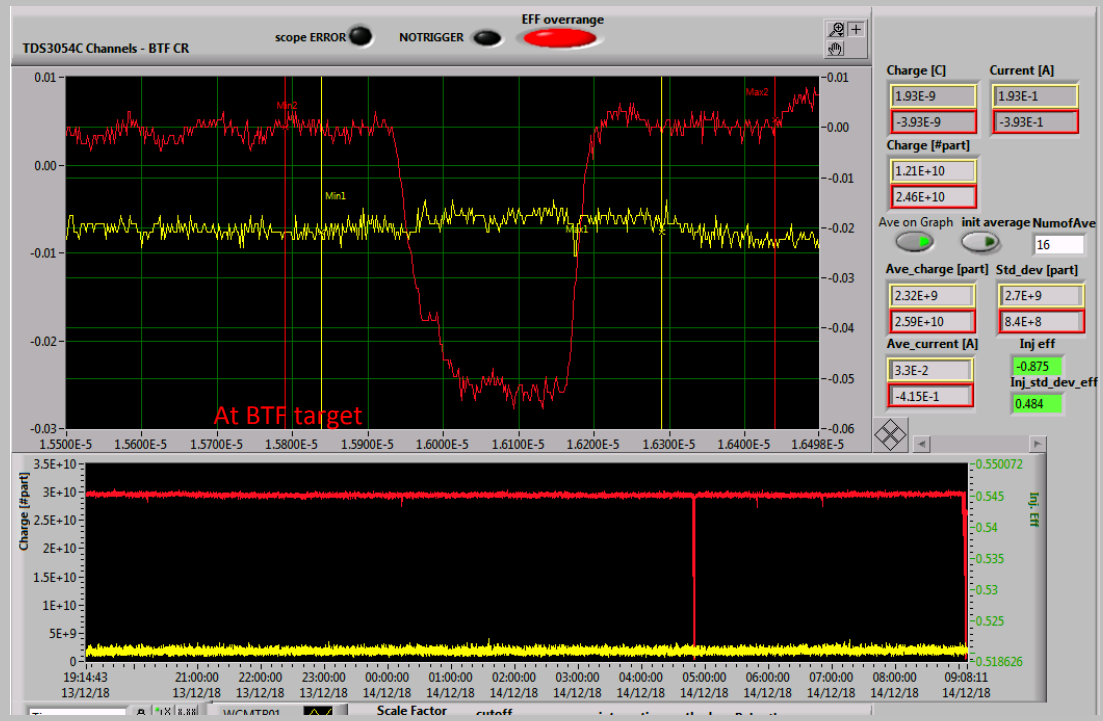
AIDA 2020

BTF

INFN

Long beam-pulse optimization





- SLED'ed RF limits the **effective pulse length** to ~**200 ns** (250 ns at gun)
- **Improvement of DAΦNE hall shielding**
  - Limited to 10k positrons/pulse due to RP limit in the hall
    - Added concrete (50 cm) in front and lead on the top of the "blue wall"
    - Up to **20k positrons/pulse**: nominal intensity for 200 ns long pulses (10^2 positrons/ns density)
- **Continuous optimization of LINAC**
  - Transport optimization (focussing coil, LINAC quadrupoles) for reducing the dose in the tunnel
    - A lot of work in October: great reduction of lost beam due to defocussing along the LINAC for getting the required intensity at BTF target. Hottest point: three-way vacuum chamber downstream of BTF pulsed 3° dipole
  - Optimization of **gun HV** vs. **pulse signal height** (new attenuator) vs. **grid voltage** vs. **timing with respect to RF**
    - From ~20k positrons/pulse with approximately 10-12 μSv/h in BTF hall, corresponding to ~5×10^{10} electrons on BTF target, further improvement **by a factor 2** in present configuration

AIDA 2020 BTF INFN

BTF-2 line vacuum

Power supplies

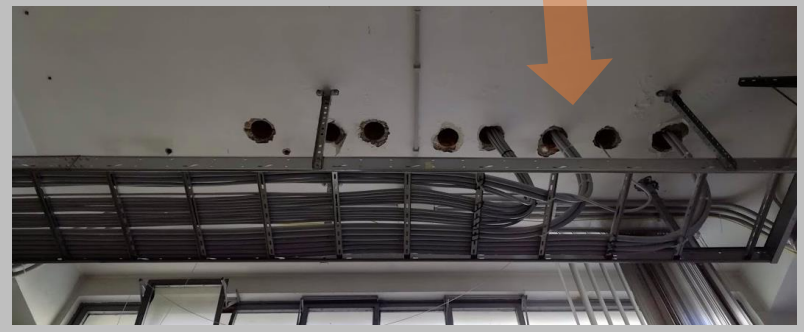
- Quadrupoles

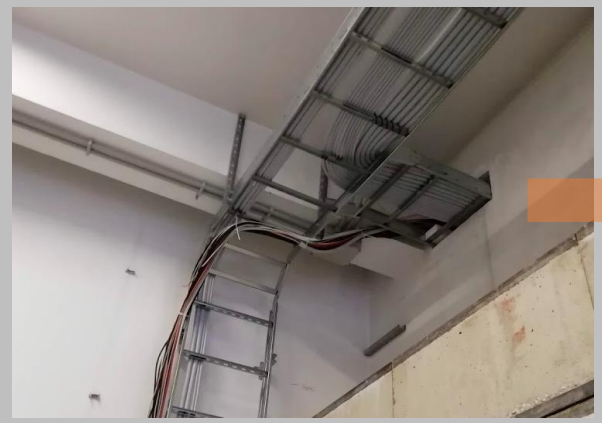
- DC dipoles

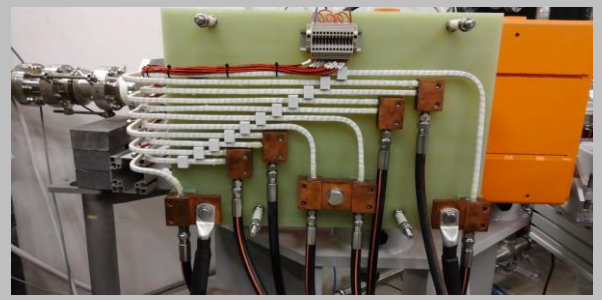
- Fast dipole

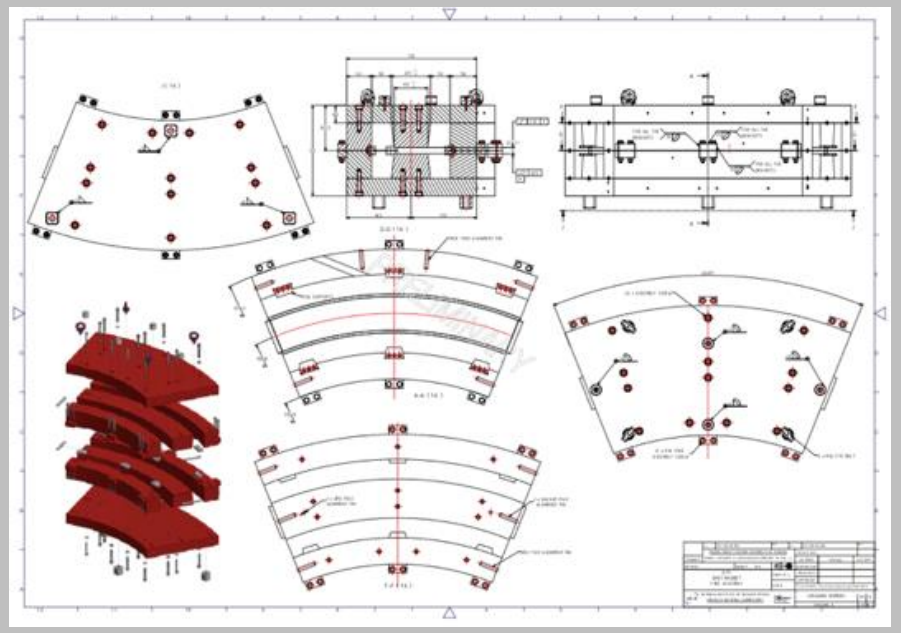
90 ms ramp

Power supplies and cables installation

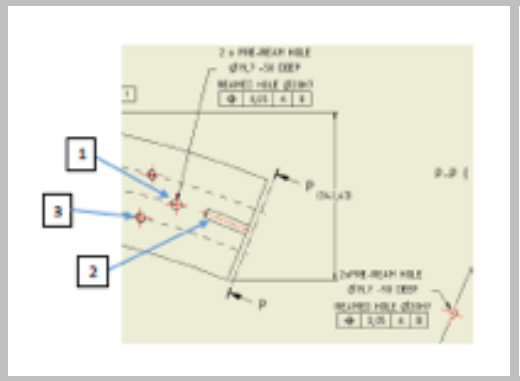


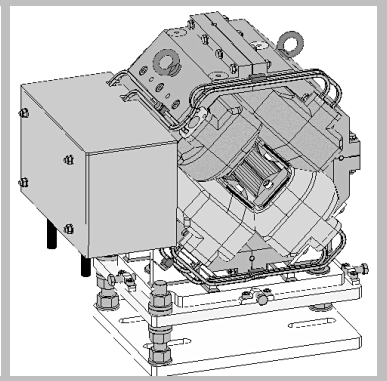




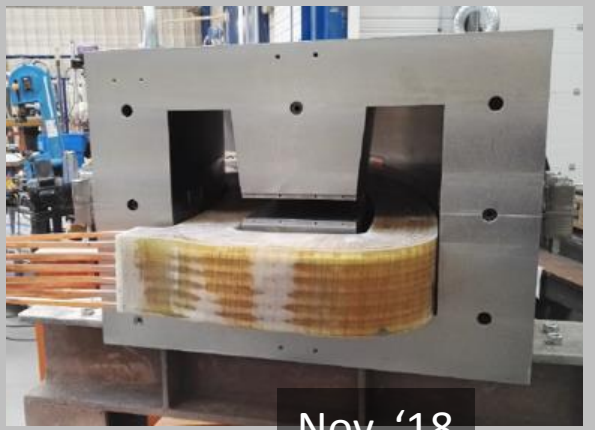


- Fixed some details in the drawings…



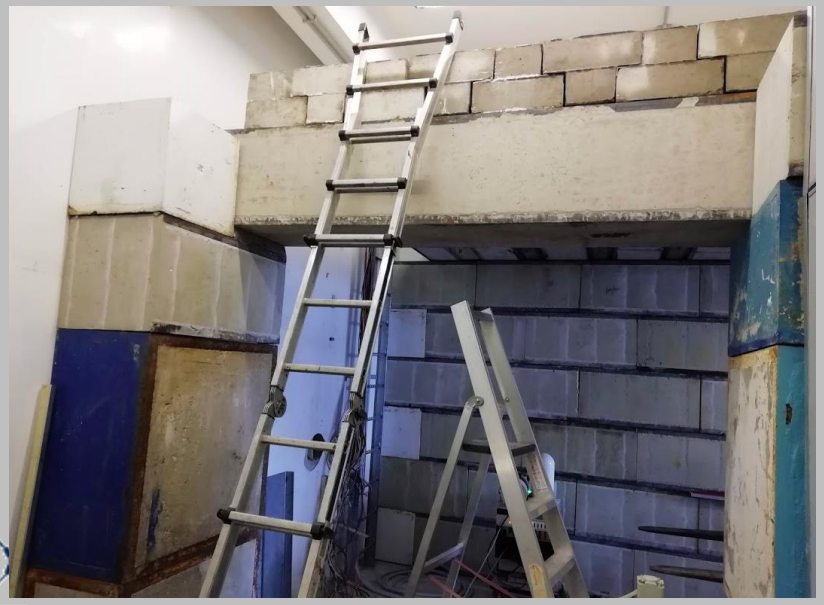


Sep. ‘18



Nov. ‘18

Dipoles elivery expected **this week**



Dec. ’18

WP 15.4 status

Magnets

- ✓ 15° pulsed dipole for beam-splitting: **built, measured and installed**
- ✓ BTF-1 45° DC dipole and quadrupoles : **installed** and **operational**
- ✓ BTF-2 extension magnets: 45° DC dipoles and quadrupoles: **in delivery (Sigmaphi)**

Power supplies

- ✓ 15° pulsed dipole, new DC dipoles, new quadrupoles: **all delivered**
- ✓ Cables: **installed**

Supports and vacuum

- ✓ BTF-1 and BTF-2 branches: **installed**
- ✓ BTF-2 extension: **built**

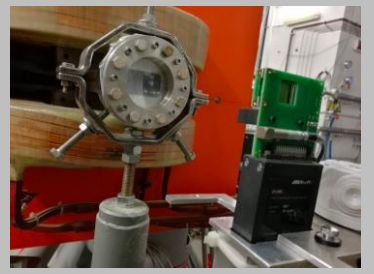
Infrastructure

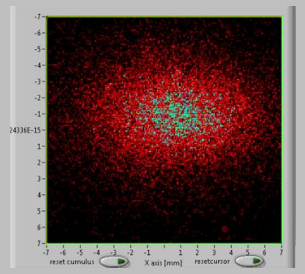
- ✓ Civil engineering and building modifications: **done**
- ✓ Second bunker: **completed**
- ✓ Upgrade of electrical power: **done**
- ✓ Upgrade of conditioning system: tender **assigned**
- ✓ Upgrade of water cooling system:
  - ✓ New distribution system, collectors, valves, interlocks inside building: **ready**

WP 15.4 status

Installation

- ✓ Old beam-line dismantling: **done**
- ✓ Cables re-routing: **done**
- ✓ BTF-1 and BTF-2 branches: **installed** and **aligned**
- ✓ Timing system for split beam-lines: hardware & software **ready**
- ✓ Software development for new magnets: **to be tested**

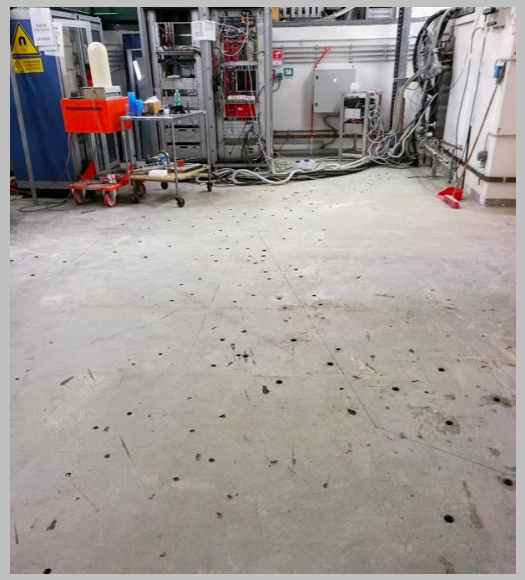




July 2018

Beam

- ✓ LINAC restart after long shutdown: **done**
- ✓ BTF-1 commissioning: **successful**



April 2018

September 2018

MS34 – New Frascati beam line components installed
Delayed from M18 to M41 due to postponed funding: **achieved** (report submitted)

WP 15.4 next steps

BTF-2 branch now ready

BTF-2 line switch-on:

- ✓ **Power supply for beam-splitting dipole ready, cables ready, cooling ready**
- ✓ Beam commissioning: **Jan. ’19**
- ✓ Then ready to open line to users

Magnets

- ✓ BTF-2 extension : 45° DC dipoles and quadrupoles **delivery (Jan. ’19)** and **installation (Apr. ’19)**

Infrastructure

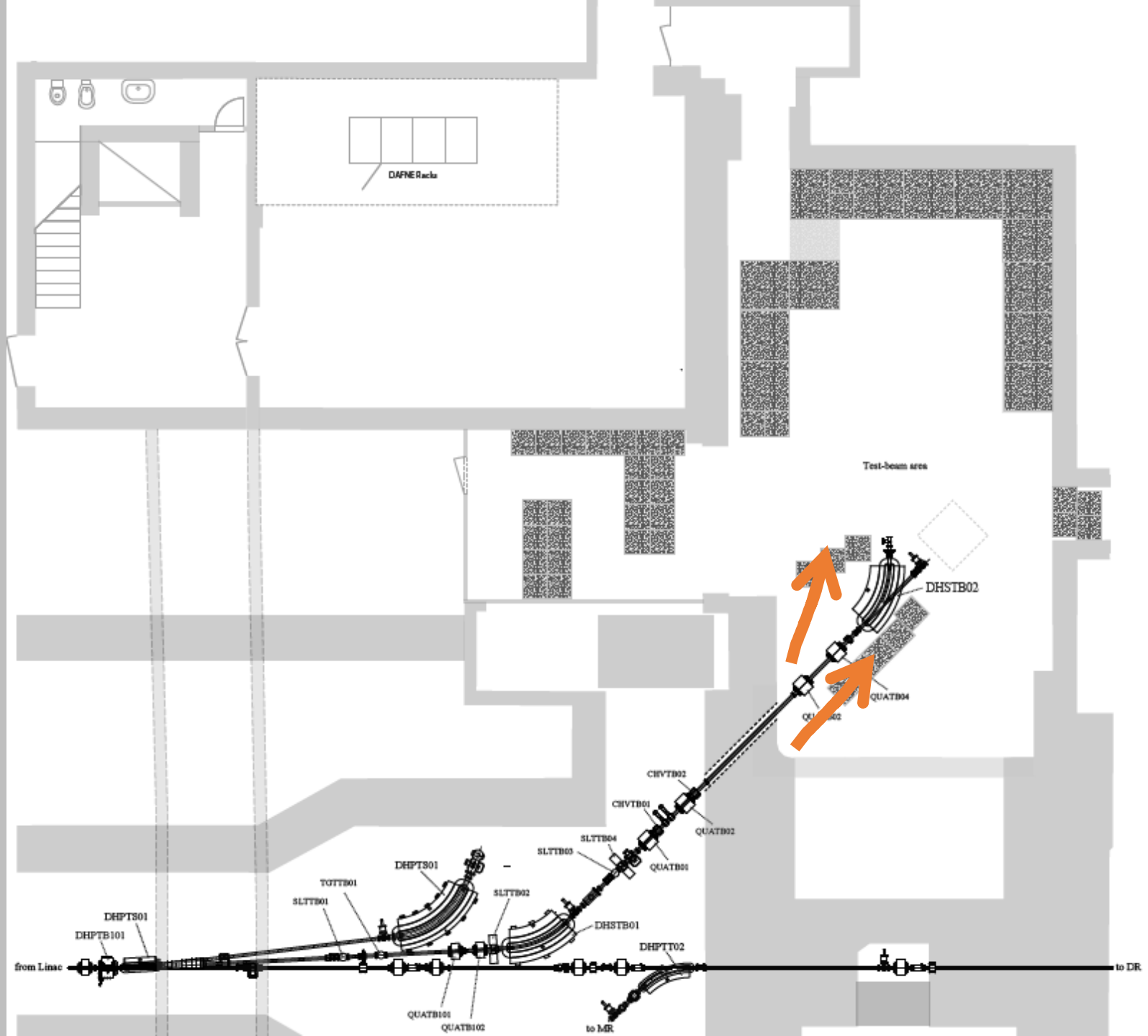
- ✓ Upgrade of conditioning system: **(Mar. ‘19)**

D15.4 – New Frascati beam line

Spares

The project

- Realize a **second beam-line** and experimental hall
- **Consolidate the linac**: extend lifetime of ~10 years



Timeline

12/11/2015: 1st proposal to INFN MAC

16/03/2016: Conceptual design INFN-16-04/LNF, Review of INFN MAC

22/06/2016: Review with CERN warm magnets group

10/10/2016: Final layout of beam-lines

17/01/2017: Meeting with INFN LASA magnets group

01/03/2017: Workshop with industries and ILO in Bologna

06/04/2017: First part of funding available (1.6 M€)

22/06/2017: Status report to INFN MAC

20/09/2017: Start of BTF shutdown

01/10/2017: Second part of funding available (350 k€)

19/12/2017: Start of civil engineering

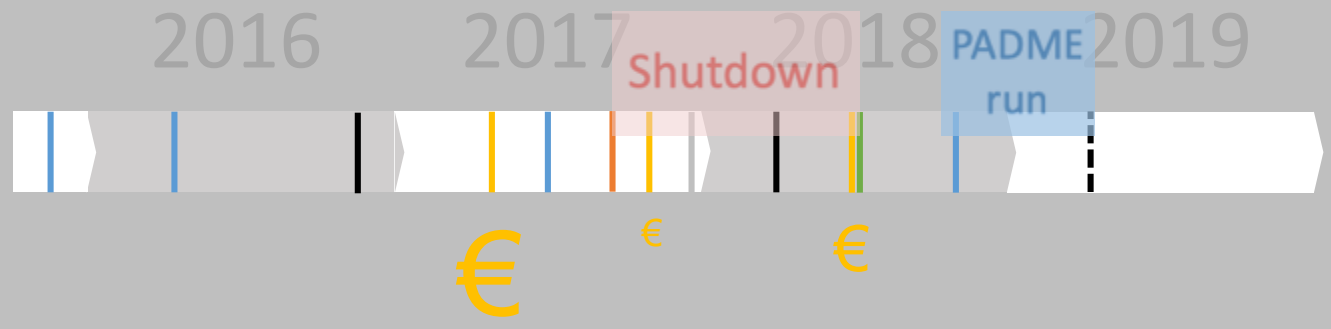
01/04/2018: Start of beam line dismounting

04/07/2018: Third part of funding available (650 k€)

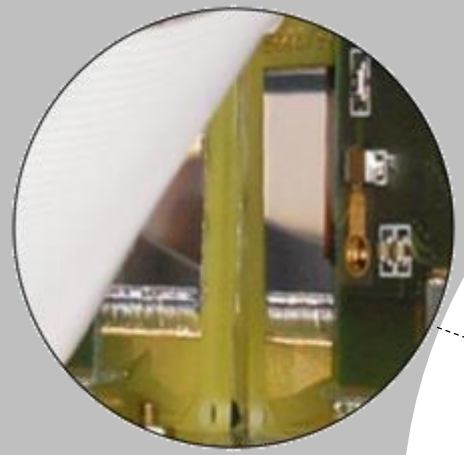
12/07/2018: First beam in BTF-1 line

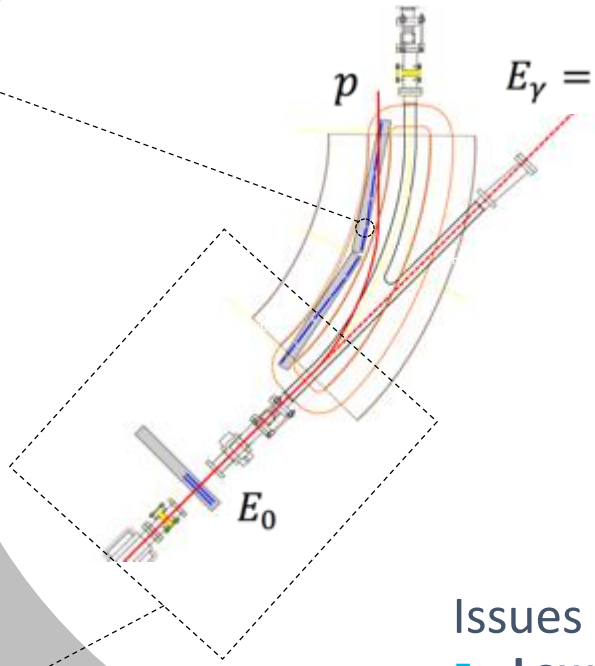
23/10/2018: Status report to INFN MAC

2019: BTF-2 line installation and commissioning



Photon tagging





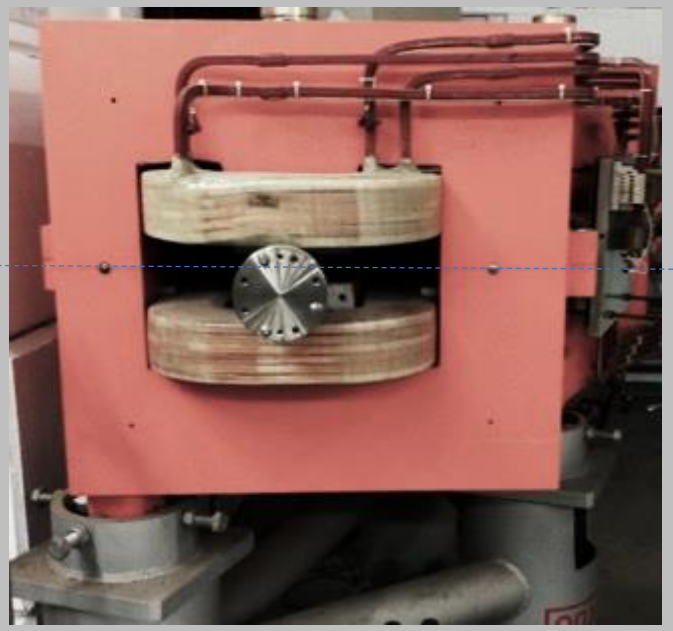
2005: designed and built in collaboration with the AGILE satellite team, with the main purpose of the scientific payload calibration (for gamma astronomy): Silicon trackers + calorimeter

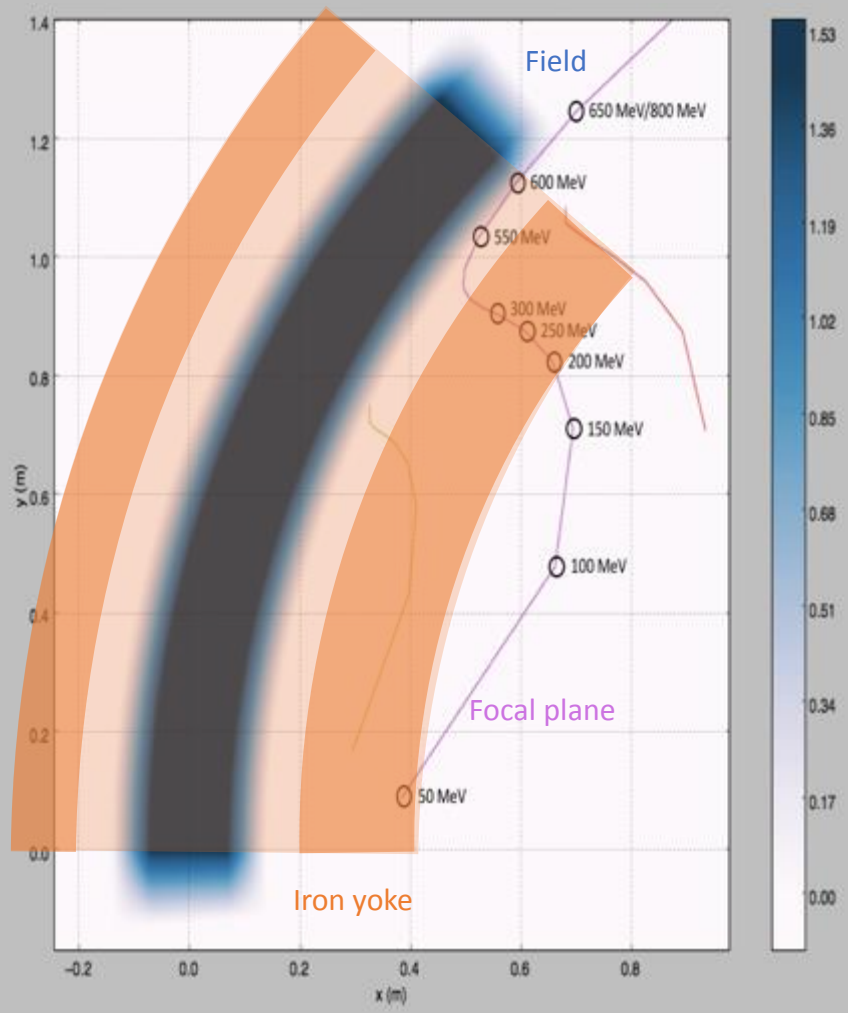
Issues with this configuration:

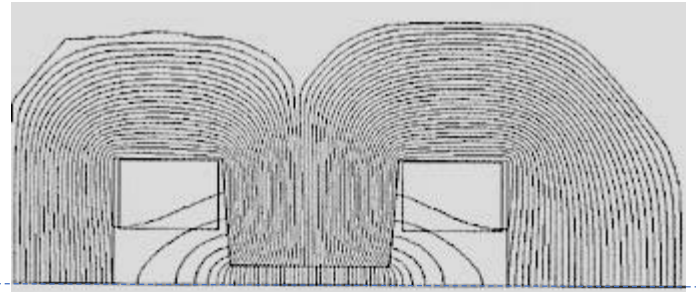
- **Low rate**
  - Due to limitations of **multiplexer** and custom-made DAQ boards
  - Need to select single tracks
- **Spurious events**
  - Scattered electrons hitting tagging modules from behind
  - Showering electrons due to grazing angles
- **Dead channels**
  - Many custom modules with **obsolescent** components
  - Some broken microstrip modules

Photon tagging

DHSTB02: 45° sector dipole
H-shape

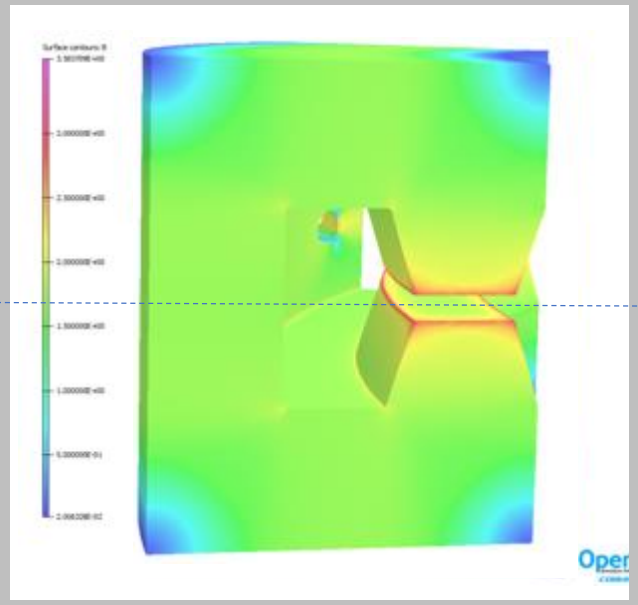


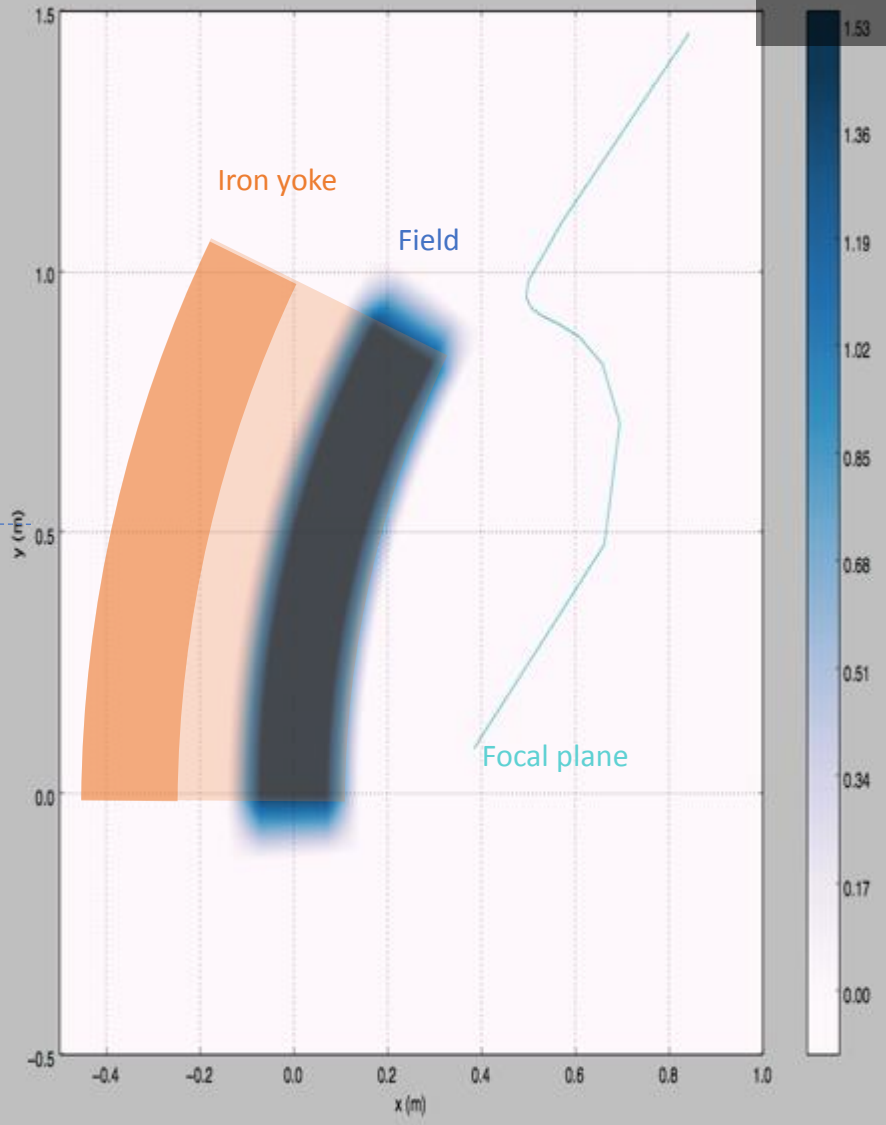


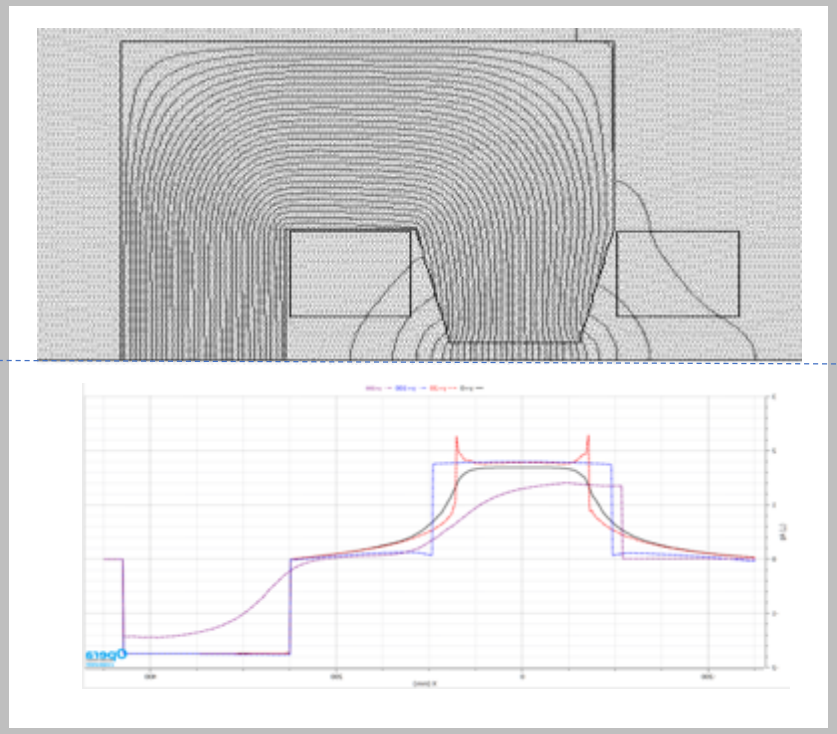


Photon tagging

30° sector dipole
C-shape

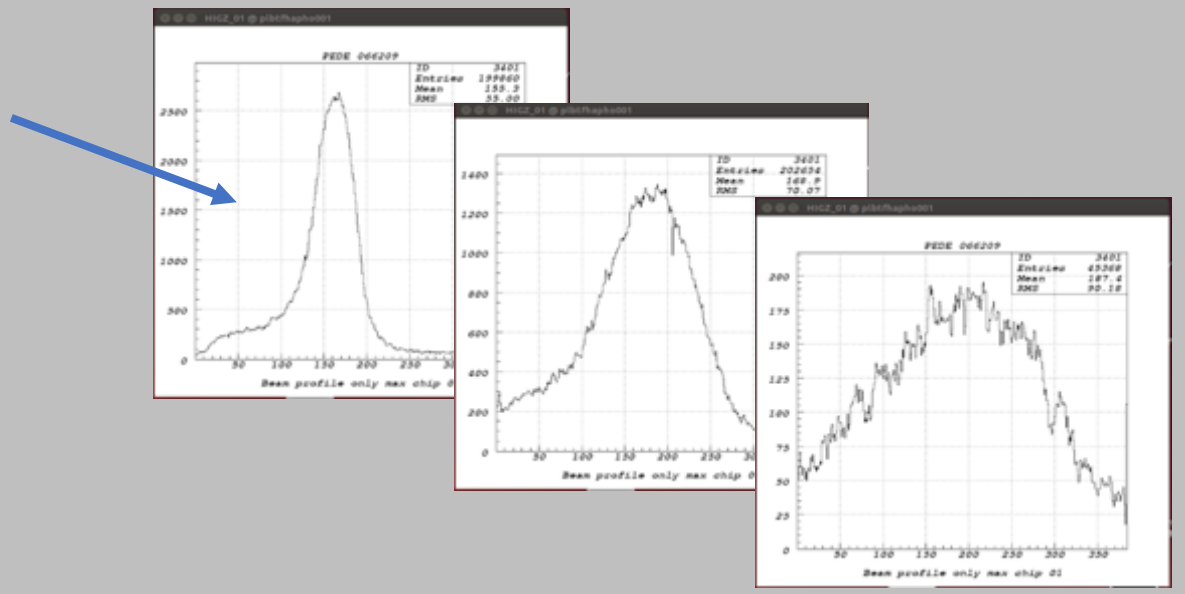






Tagging hardware improvements

- Single SSD hybrid test stand
- SSD tested directly with beam in the DHSTB-02 inner arc
- Good status of most TAA1 chips
- 50 Hz trigger rate



Fully functional but:

- No auto-triggering feature
- No hardware zero suppression
- No SSD hybrid multiplexing

In collaboration with Michela Prest and Erik Vallazza,
Università Insubria, Como and INFN Trieste

Readout hardware improvements

- New FPGA logic board with an upgraded DC-DC converter (± 7,5V) to drive longer hybrid strip bus cables
- New FPGA board hosts logics for multiplexing 6× (3× each TAA1 ASIC), for an overall 2304 channels (serial)
- New analog and digital data bus layout
- Zero suppression can be implemented
- Self-triggering implemented

6×

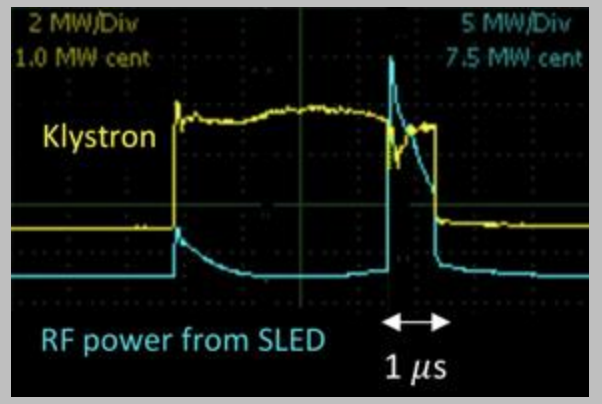
Firmware and software improvements

- New firmware in the ADC board (VME Cyclone Board) implemented for reading 2034 strips digitized data in DMA VME cycle.
- A daughter board in VME Cyclone has been implemented to read and implement TAA1 self-triggering
- New firmware release in the 12 bit ADC board for digitizing up to 2304 TAA1 channels
- New DAQ and data analysis software has been implemented and successfully tested

System ready for installation

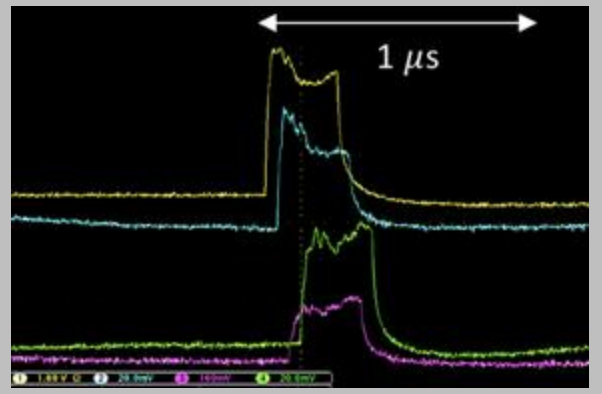
Linac setup for PADME

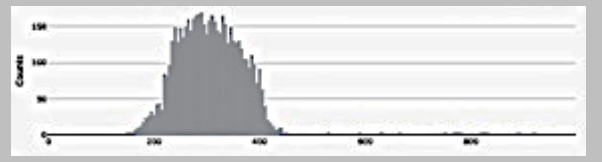
- **Maintenance** after KLOE-2 run: **done**
- Linac restarted in **mid Jun.**, **Sep: '18: beam commissioning** for the PADME run



Beam configuration for **PADME**:

- Positron beam: <u>two possibilities</u>:
  - Production at the linac **converter** and then accelerate with high-energy sections: higher intensity, lower maximum energy, lower background in BTF
  - Produce at the **BTF target**, from highest possible energy electron beam: higher maximum energy, lower maximum intensity and probably higher background in BTF hall
- Longest possible pulse: up to **200 ns**
  - Pulse length for DAΦNE injections: **<13 ns** (damping ring RF: 74 MHz)
- Tunable intensity: **10^4-10^5 positrons/pulse**
- **Energy:** at least **550 MeV**
  - Also 250 and 300 MeV needed (above and below m_X~17 MeV)



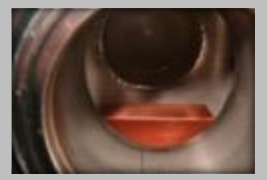


Reminder: BTF operation modes

The beam can be delivered in different modes: **dedicated** or **opportunistic** operations and **with** or **without** attenuating target. Different ranges of beam parameters can be achieved:

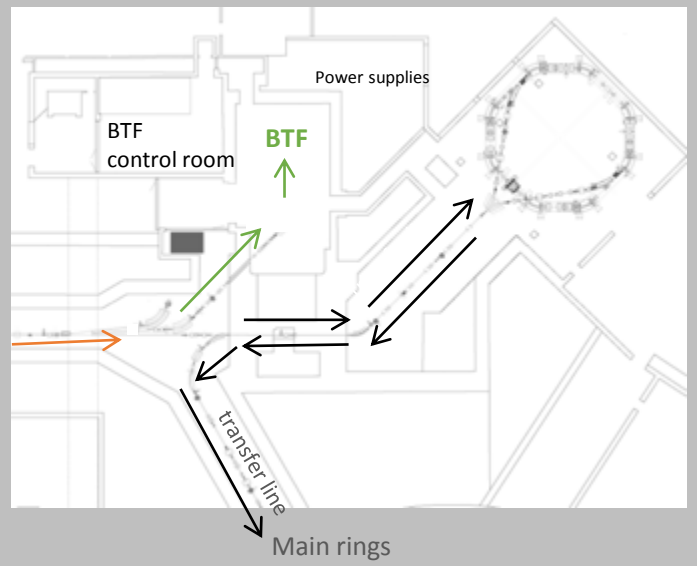
LINAC Conditioned Primary Beam, E_0

- Fixed energy, E_0
  - Steering and transverse tuning
- High current
  - from top current
  - tunable in 6 orders of magnitude



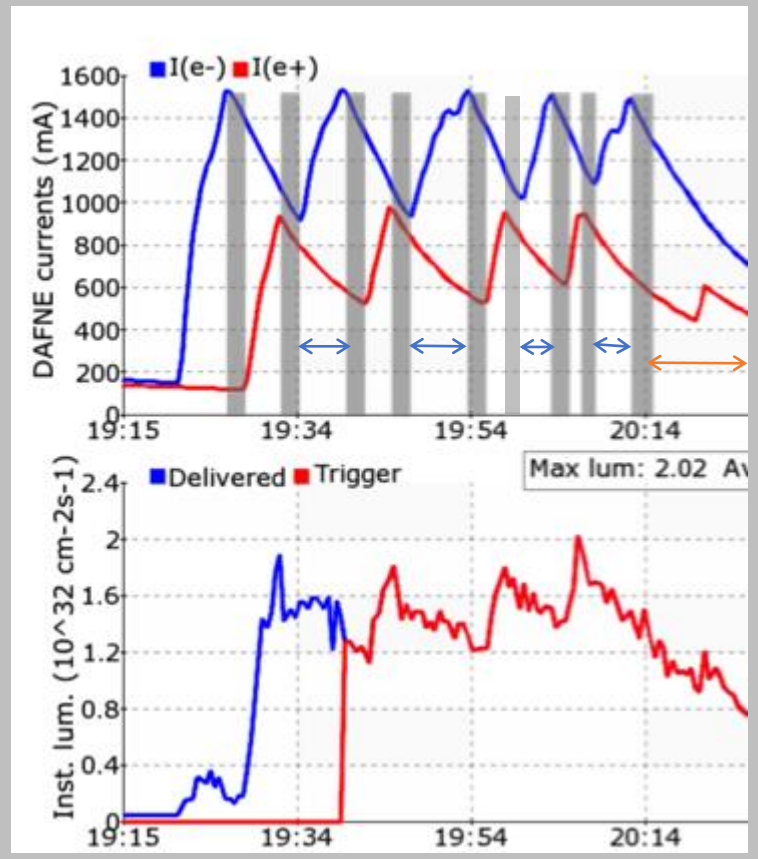
Cu target, 1.7-2-2.3 x_0

- Tunable energy
  - All energies from E_0 to ≈30 MeV
- Tunable multiplicity
  - From max(E) to single particle per shot
- Particle type decoupled from LINAC

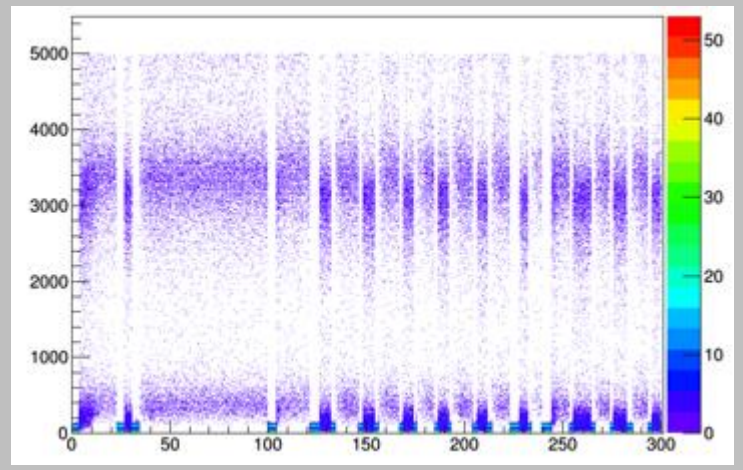


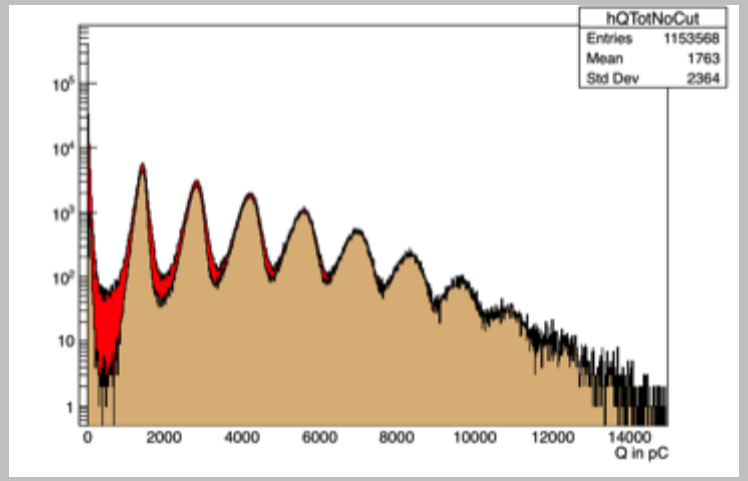
Opportunistic running

- No beam (switch of LINAC polarity)



Example: signal in PADME calorimeter

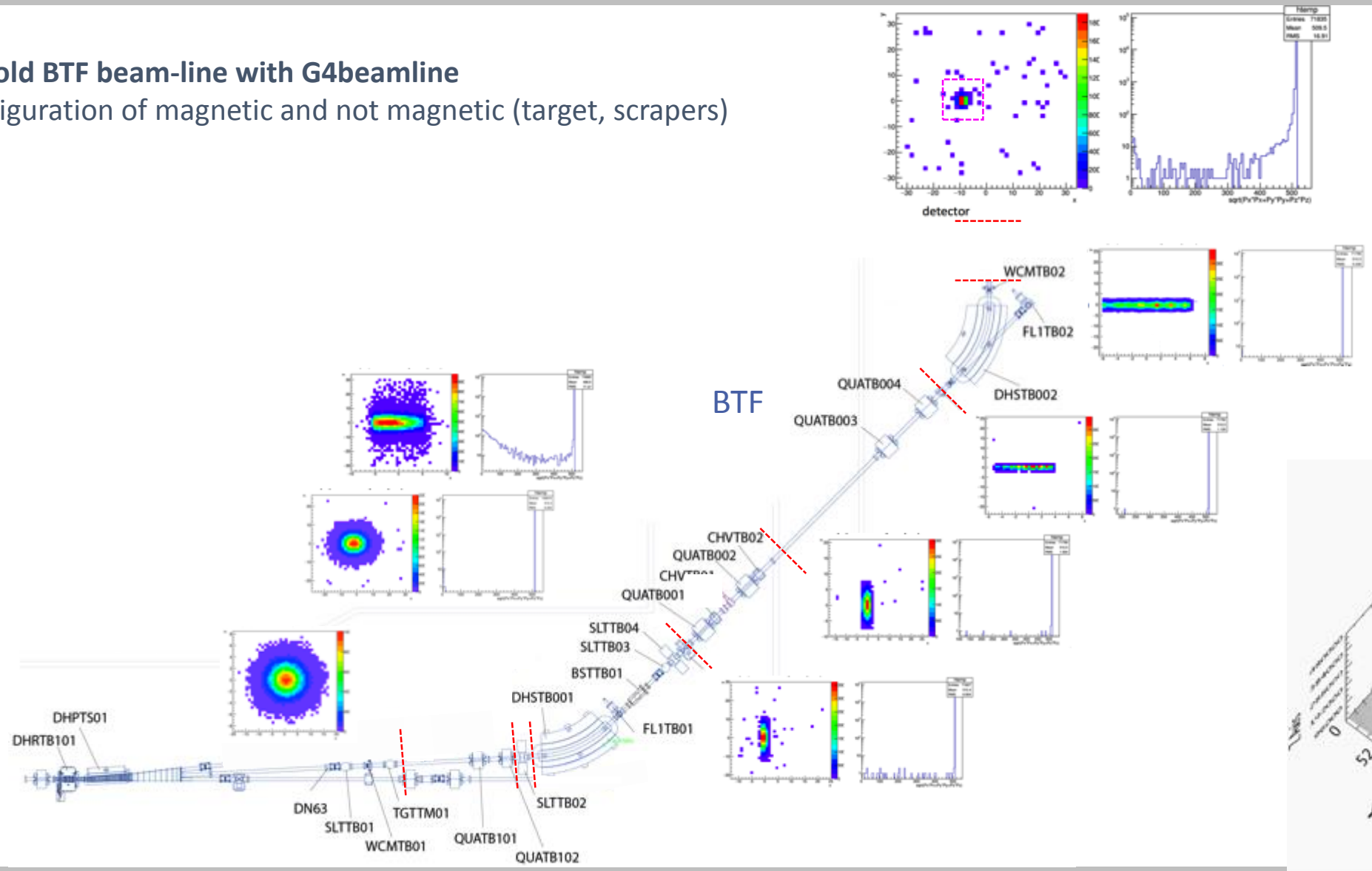




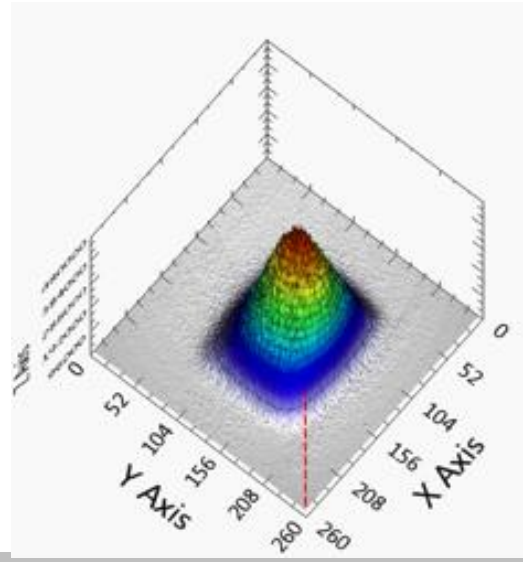
Beam-lines simulation

Simulation of old BTF beam-line with G4beamline

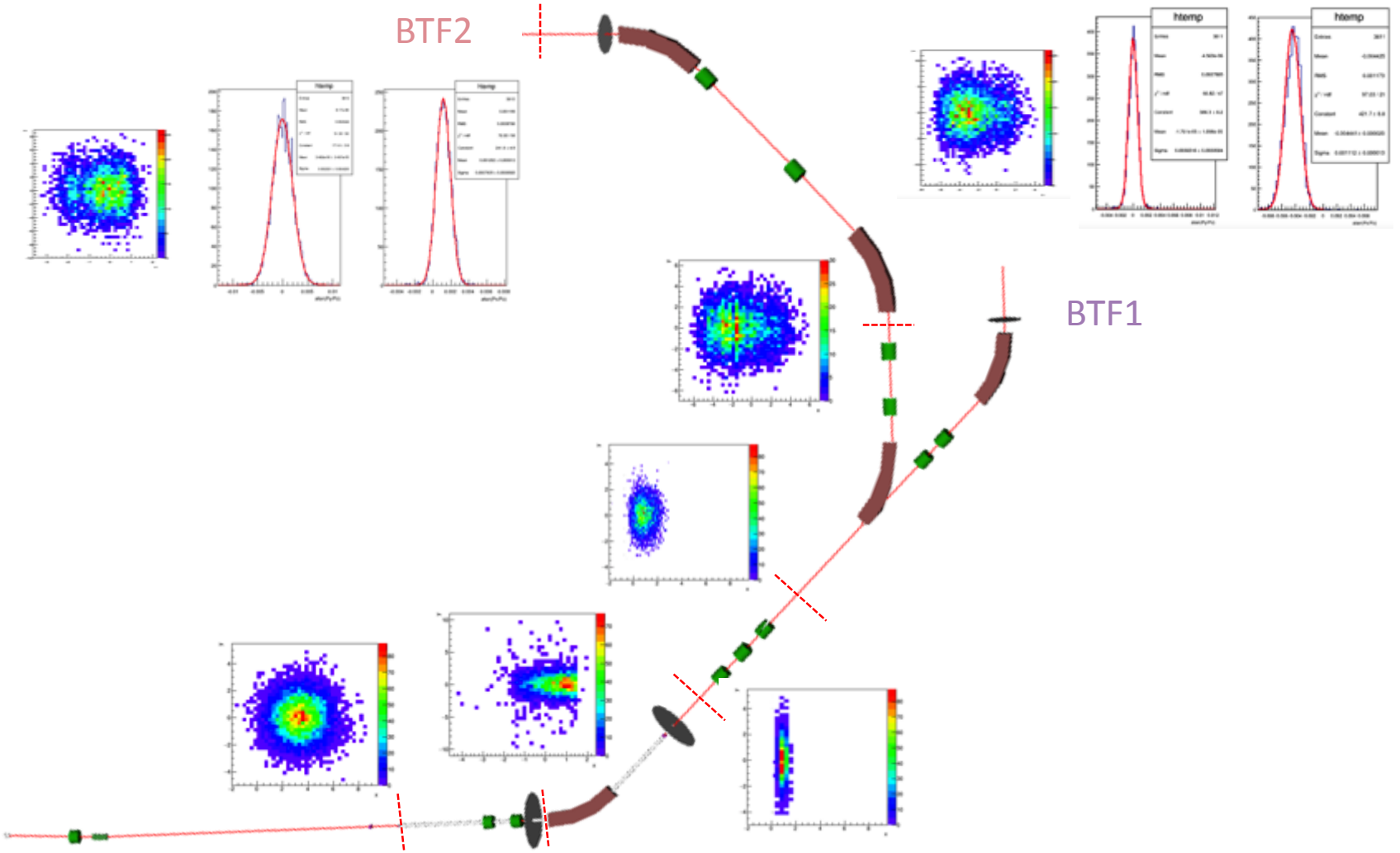
- Actual configuration of magnetic and not magnetic (target, scrapers) elements



Real beam



Beam-lines simulation



Real beam