# WP15.4 - TEST BEAM IMPROVEMENTS AT FRASCATI: STATUS

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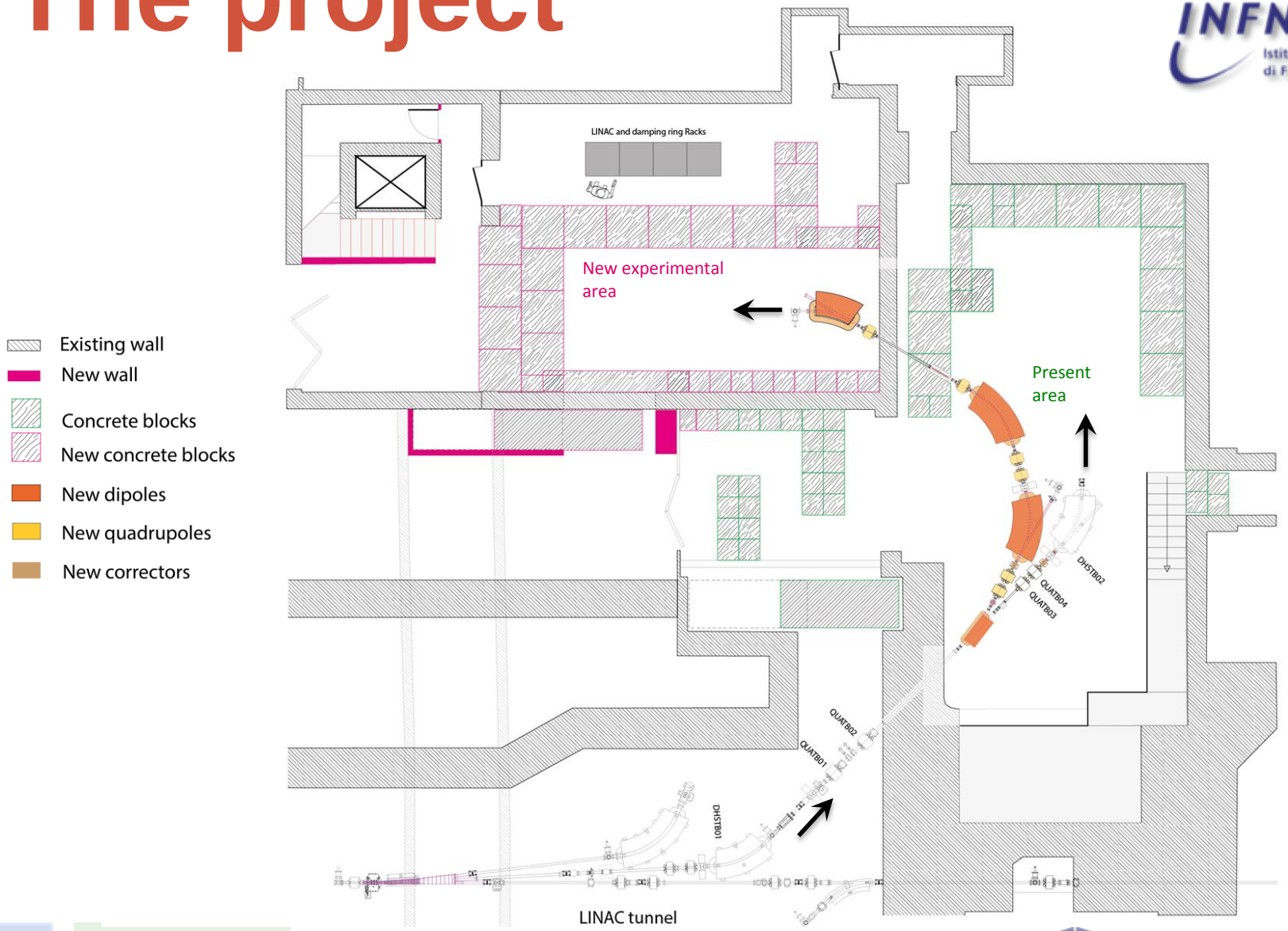
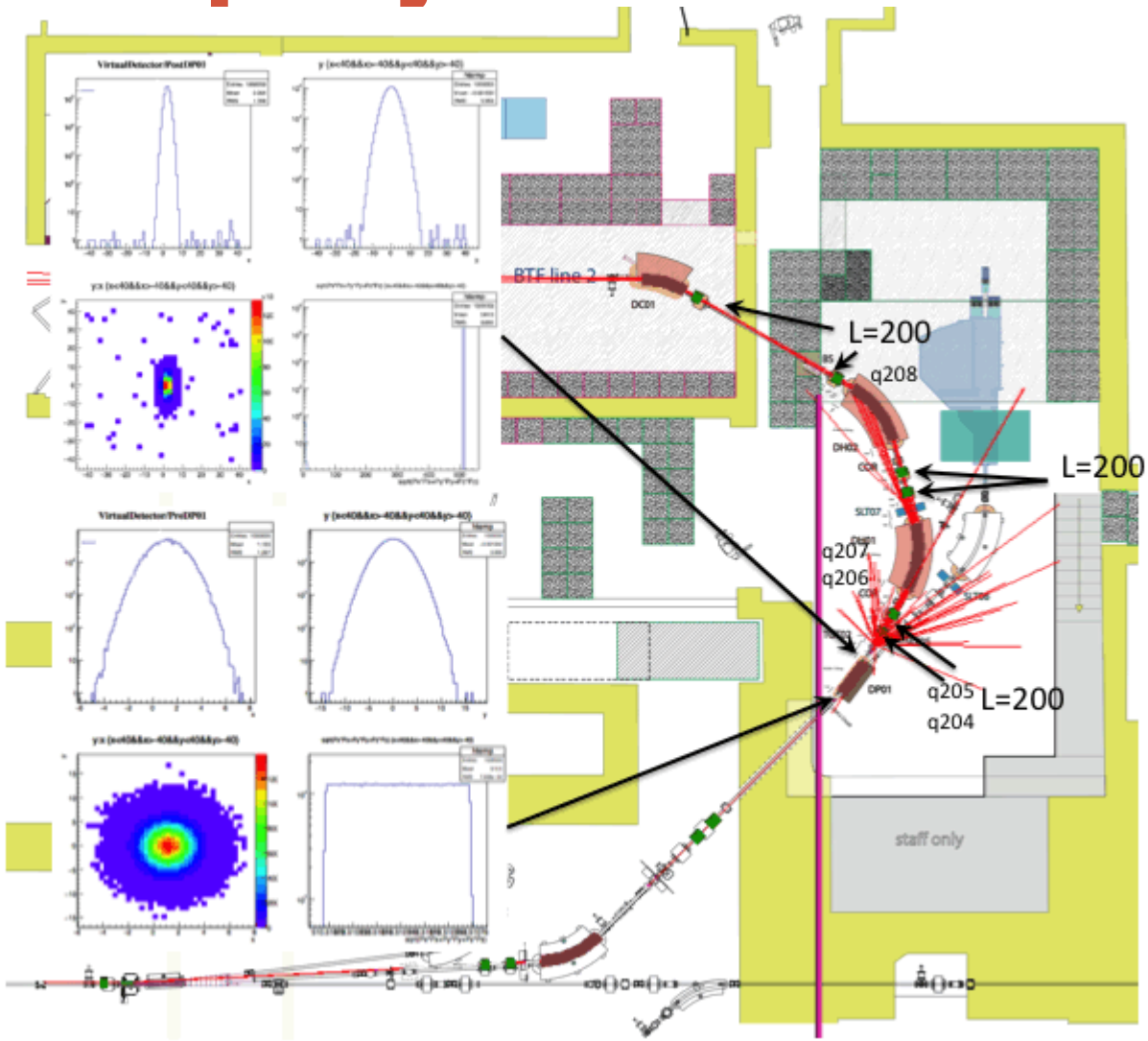
[*]AIDA-2020 (Nov. 1st 2016)

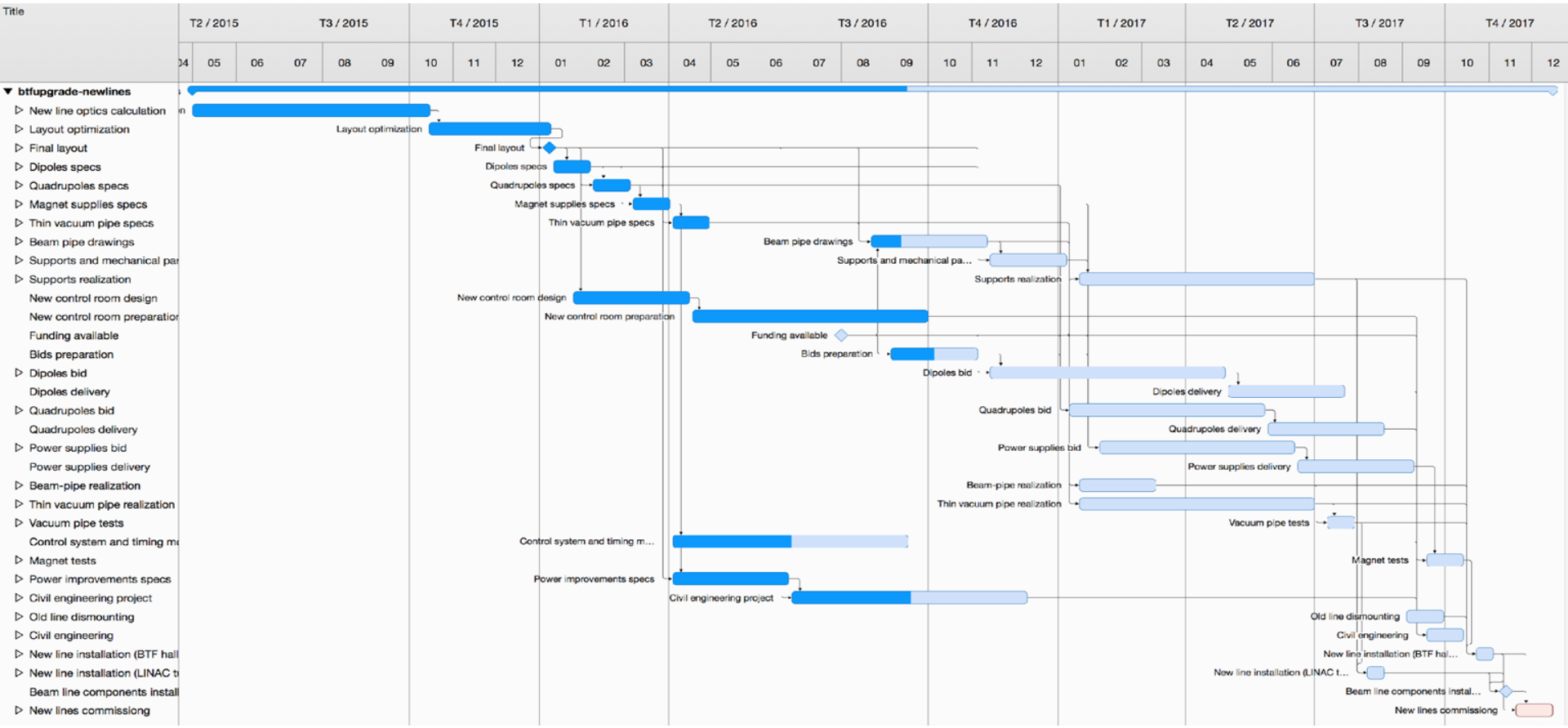
# The project


Existing wall
New wall
Concrete blocks
New concrete blocks
New dipoles
New quadrupoles
New correctors
LINAC and damping ring Racks
New experimental area
Present area
DHSTB02
QUATB04
QUATB03
QUATB02
QUATB01
DHSTB01
LINAC tunnel

# The project


BTF line 2
DCD1
L=200
q208
L=200
q207
q206
q205
q204
L=200
DP01
staff only

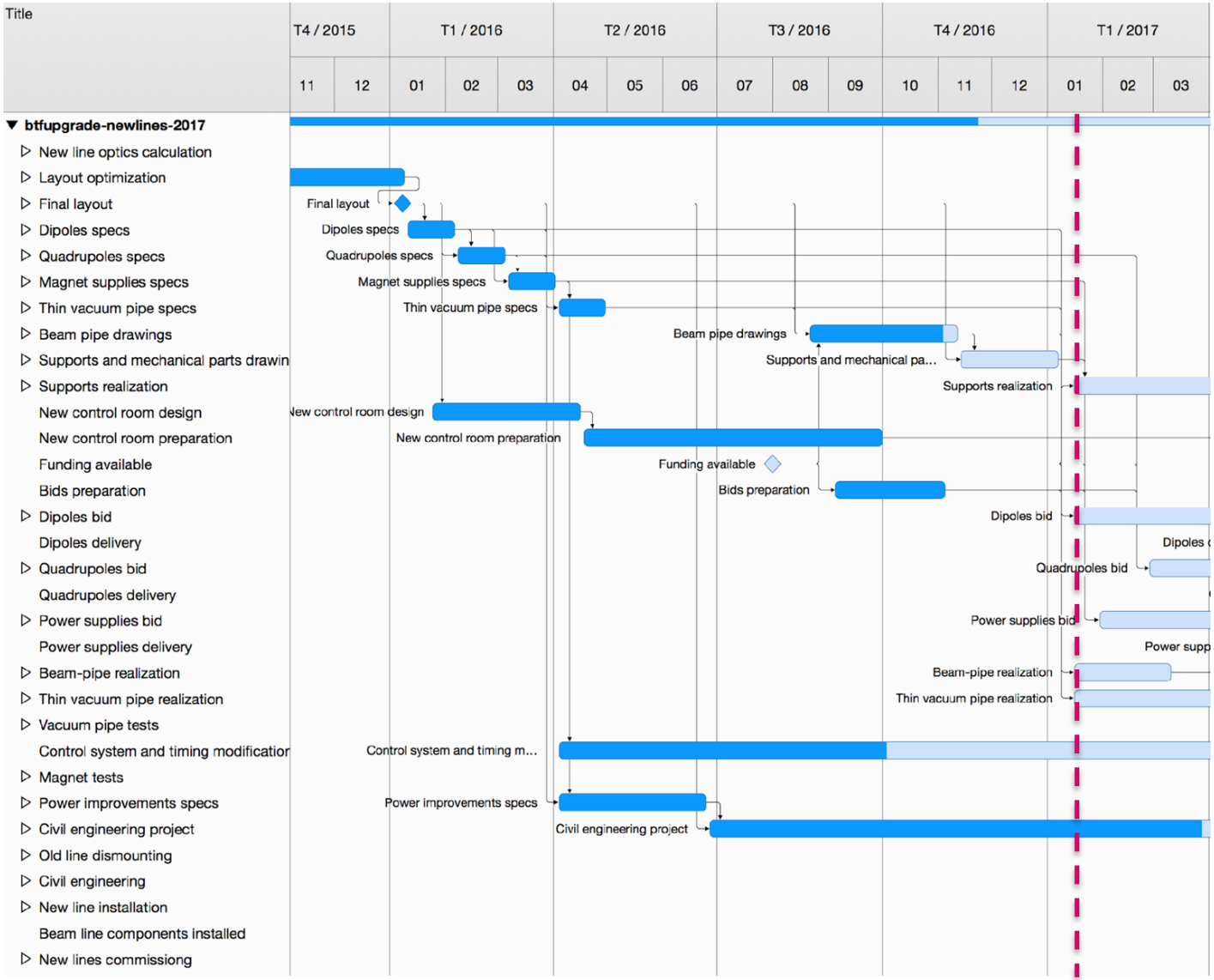
# Schedule


Title
T2 / 2015
T3 / 2015
T4 / 2015
T1 / 2016
T2 / 2016
T3 / 2016
T4 / 2016
T1 / 2017
T2 / 2017
T3 / 2017
T4 / 2017
04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12 01 02 03 04 05 06 07 08 09 10 11 12
btfupgrade-newlines
New line optics calculation
Layout optimization
Final layout
Dipoles specs
Quadrupoles specs
Magnet supplies specs
Thin vacuum pipe specs
Beam pipe drawings
Supports and mechanical par
Supports realization
New control room design
New control room preparatio
Funding available
Bids preparation
Dipoles bid
Dipoles delivery
Quadrupoles bid
Quadrupoles delivery
Power supplies bid
Power supplies delivery
Beam-pipe realization
Thin vacuum pipe realization
Vacuum pipe tests
Control system and timing m
Magnet tests
Power improvements specs
Civil engineering project
Old line dismounting
Civil engineering
New line installation (BTF hall
New line installation (LINAC t
Beam line components install
New lines commissiong

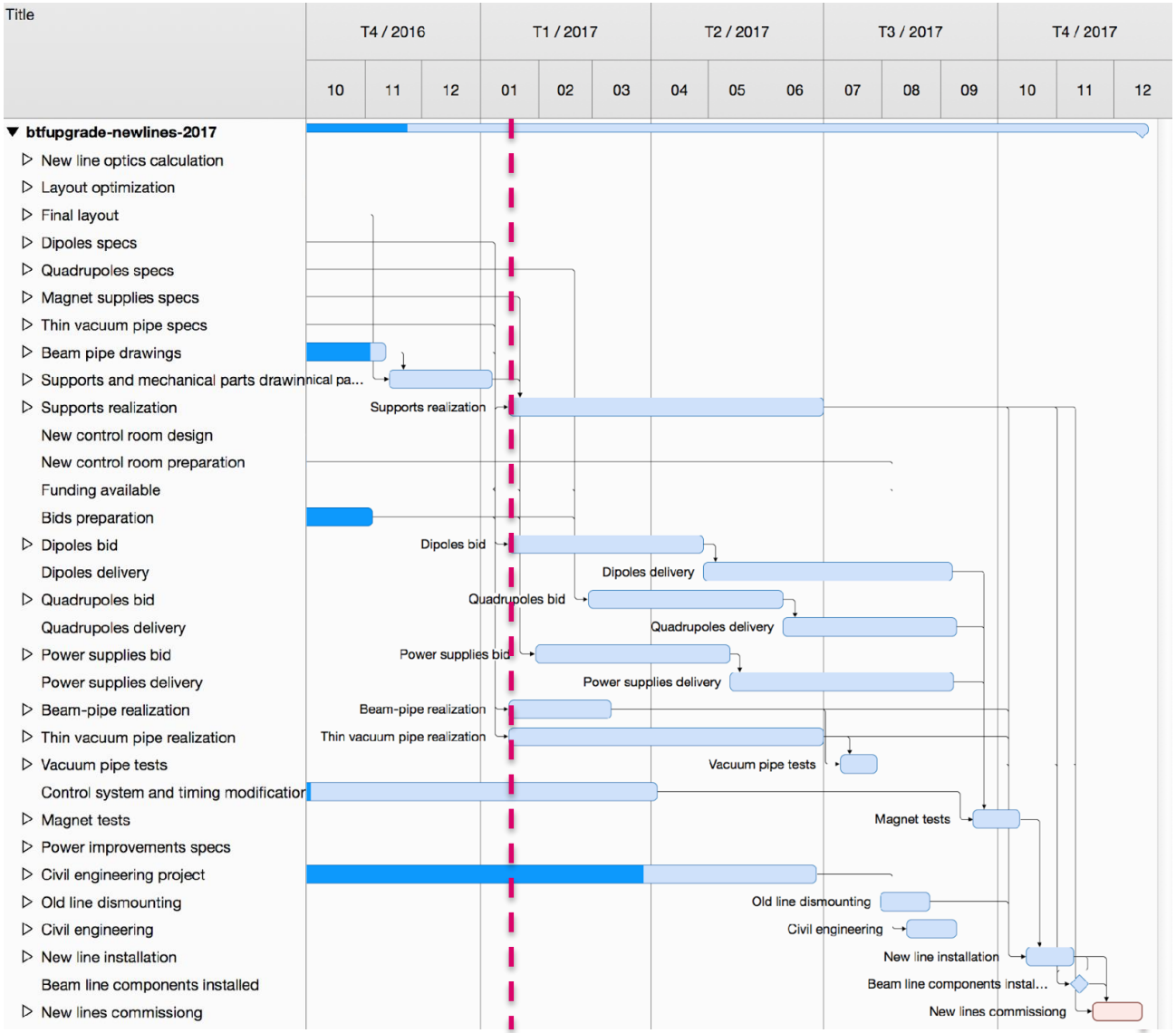
# Status

- All bids for magnets procurement out in a couple of weeks
- This means some delay on the dipoles wrt to the schedule, but should be re-absorbed by the fact that **we will provide to the supplier an advanced (practically complete) design**:
  - Complete magnetic calculation, including beam quality, pole design, iron quality, saturation…
  - Complete design of coils: electrical, mechanical, thermo-hydraulic
  - Complete design of overall mechanical structure (plates, bolts, alignment) and supports
  - No need of modifying the transfer line inside the LINAC tunnel
- Civil engineering preliminary project approved, already working on the executive one (external company)
- BTF closed to the users from **mid July** (apart 2-3 weeks in Sep.)
- Design slightly modified in order to avoid modifications of the line inside the LINAC tunnel
  - Brings interference with the operation of the collider complex to ≈0
  - Easier installation (and alignment)
  - Also requires 1 quad less (slightly increased the gradient of the other quads)
- Vacuum requirements relaxed: the two BTF lines will be separated by the main LINAC vacuum by a 0.5 mm Be window (already existing); design modified in order to host pumping ports

# Updated schedule



# Updated schedule



# Team

**Magnets**

- B. Buonomo, C. Di Giulio, L. Foggetta: line design, simulation and optimization
- F. Iungo, R. Ricci, C. Sanelli, L. Sabbatini, A. Vannozzi: magnetic, electric and thermo-hydraulic calculation and design
- R. Mascio, L. Pellegrino, G. Sensolini: mechanical design
- B. Bolli, S. Martelli, F. Sardone: preparation, measurements, installation

**Cooling and power supply**

- S. Cantarella, R. Ceccarelli, R. Ricci, U. Rotundo

**Vacuum**

- D. Alesini, S. Bini, L. Foggetta, V. Lollo

**Timing**

- A. Drago, A. Stella

**Controls**

- L. Foggetta, C. Di Giulio, A. Michelotti, A. Stecchi

**Radio-protection**

- A. Esposito, O. Frasciello

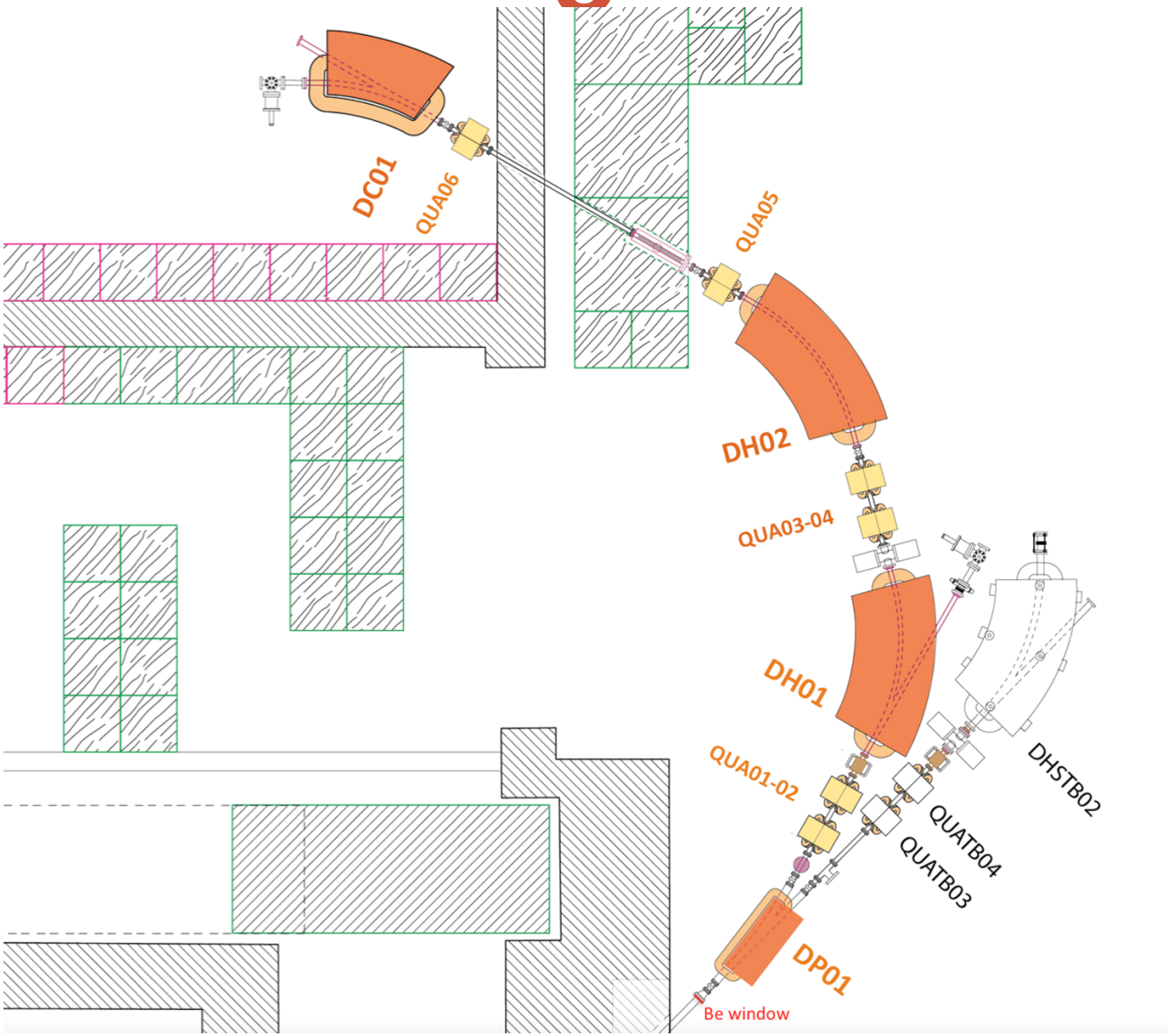
**Civil Engineering**

- O. Cerafogli, S. Incremona

**Diagnostics**

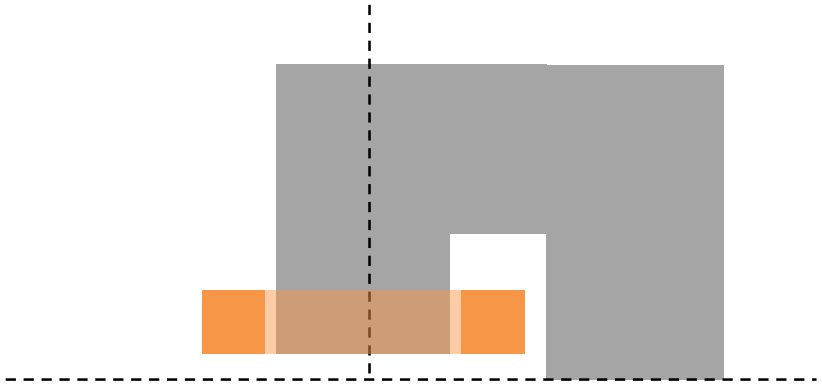
- C. Di Giulio, L. Foggetta, E. Spiriti, A. Stella

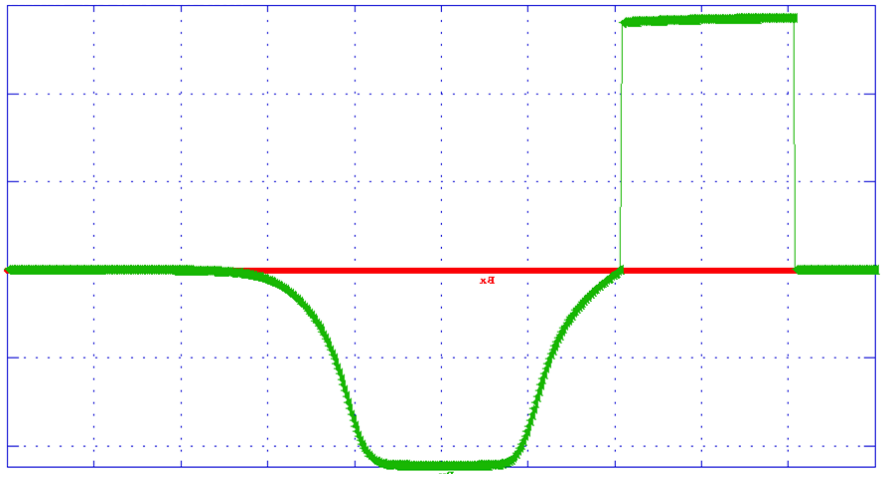
# Magnets


DC01
QUA06
QUA05
DH02
QUA03-04
DH01
QUA01-02
DHSTB02
QUATB04
QUATB03
DP01
Be window

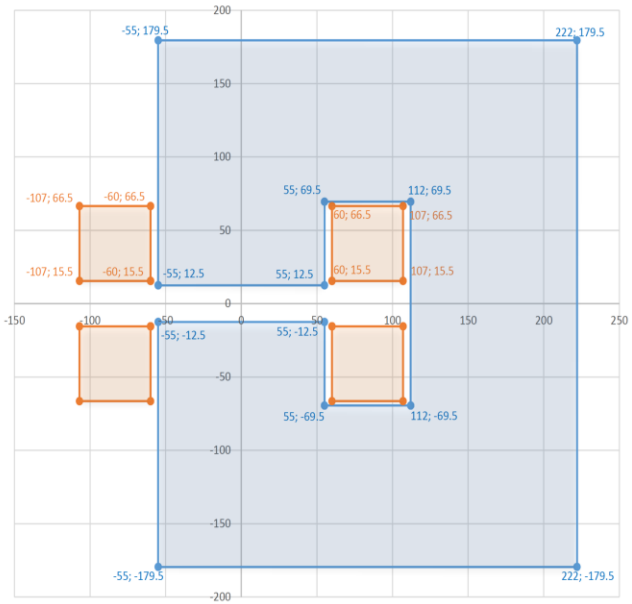
# Fast 15° dipole

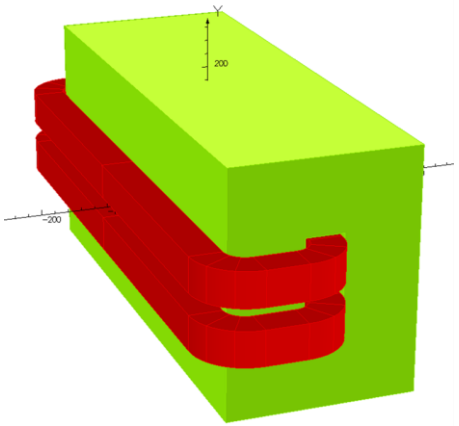
- Study magnetic field in the **gap** (and in the return)
  vs. iron **material**, **size**, **shape**
- Current vs. coil conductor **section**, **length**, **type, n of coils**
- Calculate thermo-hydraulic parameters

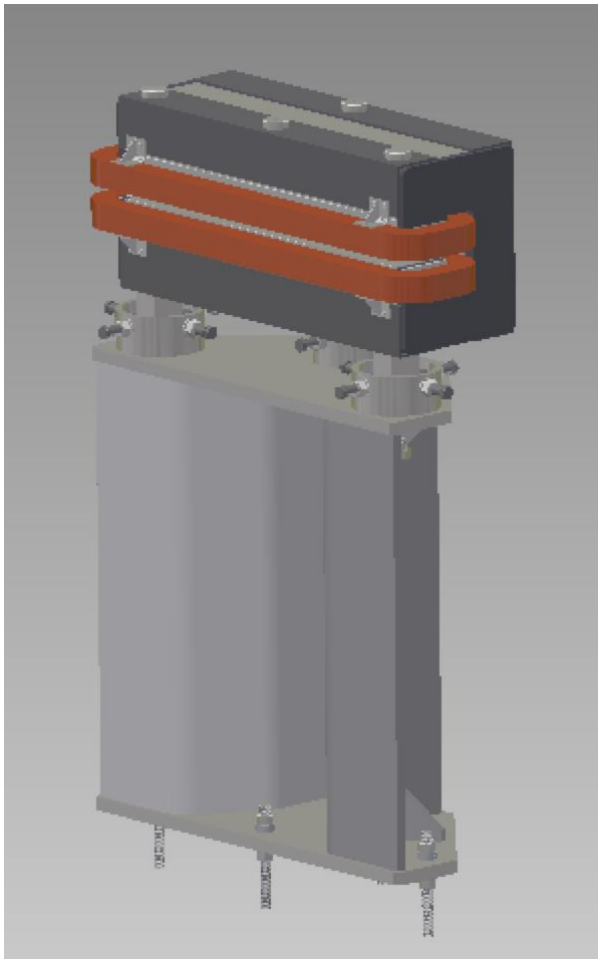




# Fast 15° dipole



# Fast dipole: full specs

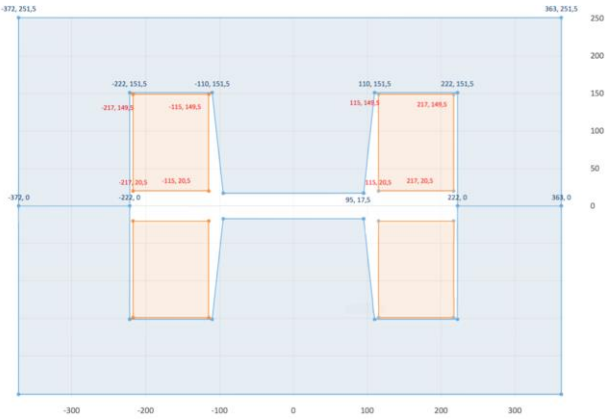
| GENERAL DATA | |
|---|---|
| Beam energy (MeV) | 1000 |
| Curvature radius (m) | 3 |
| Gap (mm) | 25 |
| Pole width (mm) | 110 |
| Nominal flux density (T) | 1,11 |
| Bending angle (deg) | 15 |
| N per pole (turns) | 36 |
| Ampere-turns/pole | 11052 |
| Yoke Width (mm) | 277 |
| Yoke Height (mm) | 359 |
| Yoke Length (mm) | 760 |
| Overall Length (mm) | 329 |
| Overall Height (mm) | 359 |
| Overall Length (mm) | 913 |
| Good Field Region (mm) | ±25 |
| Field quality (ΔB/B) | 6,4E-03 |
| Integrated Field quality (ΔIB/IB) | 2,3E-03 |
| Total weight (kg) | 516 |
| ELECTRICAL INTERFACE | |
| Conductor dimension | 7x7 Φ4 |
| Nominal Current (A) | 316 |
| Nominal Resistive Voltage (V) | 113 |
| Rtot (Ω) | 0,078 |
| Nominal inductance (H) | 0,029 |
| Nominal Power (kVA) | 35 |
| Maximum Line Cable lenght (m) | 20 |
| Proposed cable cross section ( $mm^2$) | 95 |
| Proposed Output PS Current (A) | 330 |
| Proposed Output PS Voltage (V) | 130 |
| Proposed Output PS Power (kVA) | 42,9 |
| WATER COOLING | |
| Number of pancakes per pole | 3 |
| Number of pancake circuits | 6 |
| Number of series circuits | 2 |
| ΔT water (°C) | 15 |
| Maximum Water flow ($m^3/s$) | 0.117 |
| Maximum Water velocity (m/s) | 1,55 |
| Maximum ΔP (bar) | 2,94 |

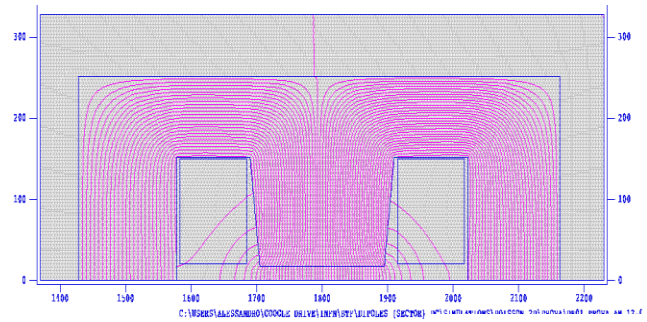
| IRON | | | |
|---|---|---|---|
| V (mm3) | PACK FAC | d (kg/dm3) | Weight (kg) |
| 6,75E+07 | 0,96 | 7,85 | 509 |
| **COILS** | | | |
| V (mm3) | FILL FAC | d (kg/dm3) | Weight (kg) |
| 9.46E+06 | 0,59 | 8,9 | 50 |

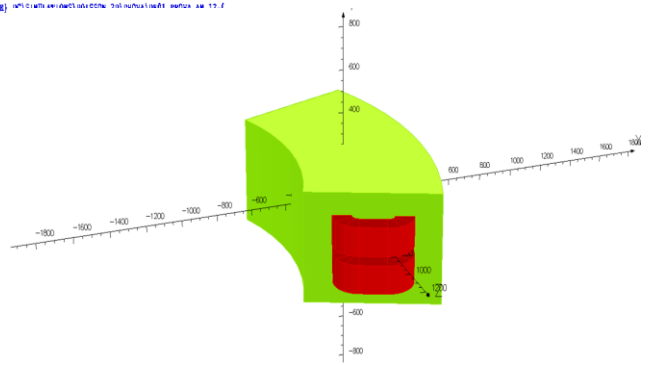
Power supply specs calculated assuming for ramping+stabilization **<100 ms**

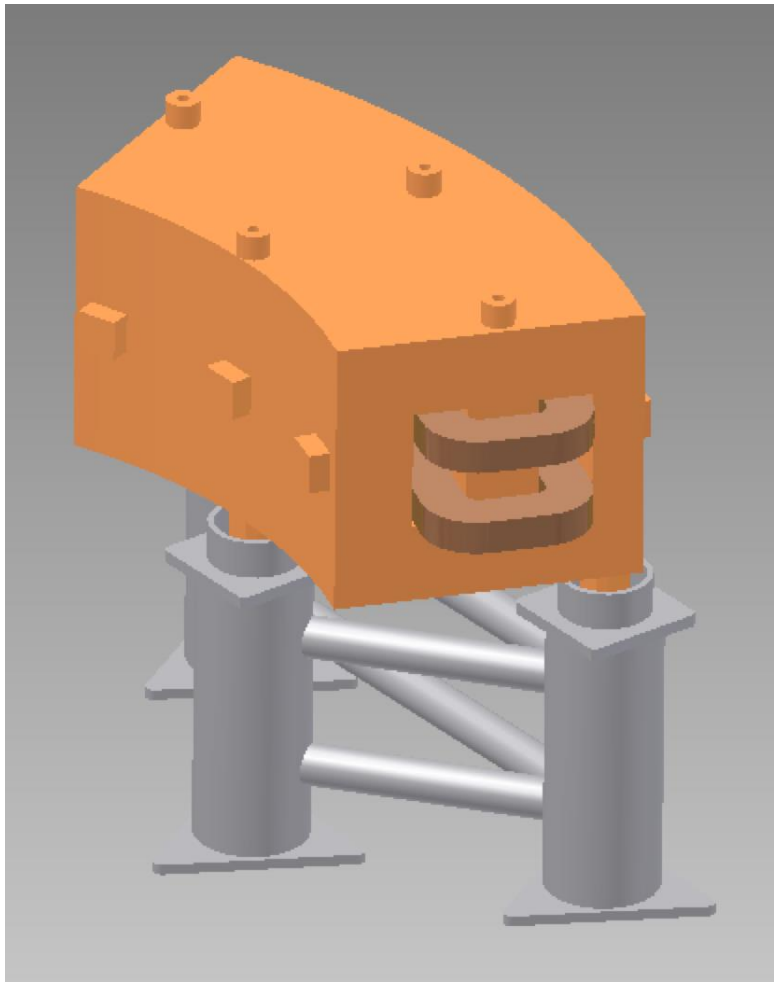
(see modifications to timing)

# DC dipoles







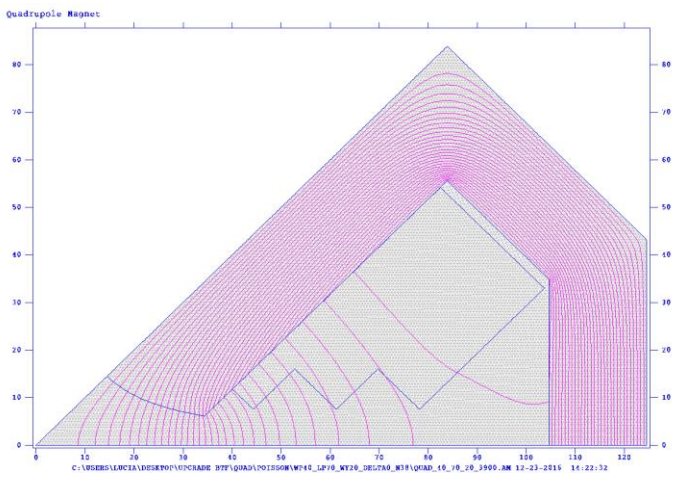


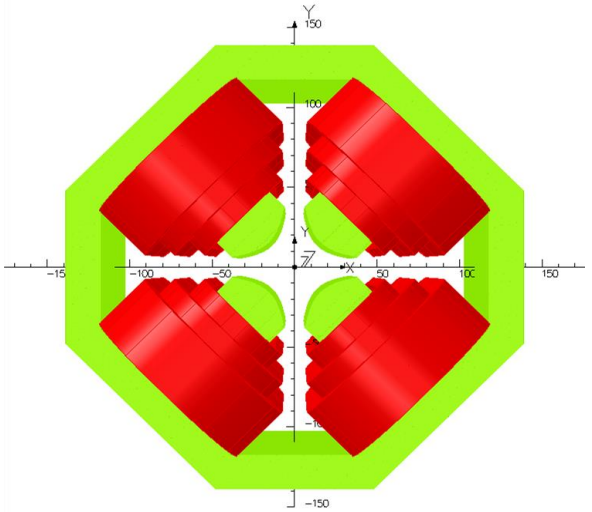
# DC dipoles: full specs

| GENERAL DATA | |
|---|---|
| Beam energy (MeV) | 921 |
| Curvature radius (m) | 1,8 |
| Gap (mm) | 35 |
| Pole width at the gap (mm) | 190 |
| Pole width at the yoke (mm) | 220 |
| Nominal flux density (T) | 1,7056 |
| Bending angle (deg) | 45,00 |
| N per pole (turns) | 120 |
| Iron Width (mm) | 735 |
| Overall Width | 780 |
| Overall Height (mm) | 503 |
| Overall Lenght (mm) | 1672 |
| Good Field Region (mm) | ±15 |
| Field quality (ΔB/B) | 4,29E-04 |
| Integrated Field quality (ΔIB/IB) | 3,78E-04 |
| Total weight (kg) | 4006 |
| ELECTRICAL INTERFACE | |
| Conductor dimension | 9.5x9.5 Φ5.5 |
| Nominal Current (A) | 262 |
| Nominal Resistive Voltage (V) | 72 |
| Rtot (Ω) | 0,276 |
| Nominal inductance (H) | 0,423 |
| Nominal Voltage on magnet (V) with a 10 s raising time (V) | 83 |
| Nominal Power (kVA) | 22 |
| Maximum Line Cable lenght (m) | 20 |
| Proposed cable cross section ( $mm^2$) | 95 |
| Proposed Output PS Current (A) | 280 |
| Proposed Output PS Voltage (V) | 95 |
| Proposed Output PS Power (kVA) | 26,6 |
| WATER COOLING | |
| Number of pancake per pole | 6 |
| Number of Turn per pancake | (10 H 2 V) |
| ΔT water (°C) | 15 |
| Maximum Water flow ($m^3/s$) | 3,44E-04 |
| Maximum Water velocity (m/s) | 1,21 |
| Maximum ΔP (bar) | 3,82 |

| IRON | | | |
|---|---|---|---|
| V (mm3) | PACK FAC | d (kg/dm3) | Weight (kg) |
| 3,99E+08 | 1 | 7,86 | 3140 |
| COILS | | | |
| V (mm3) | FILL FAC | d (kg/dm3) | Weight (kg) |
| 9,5E+07 | 0,599 | 8,9 | 506 |

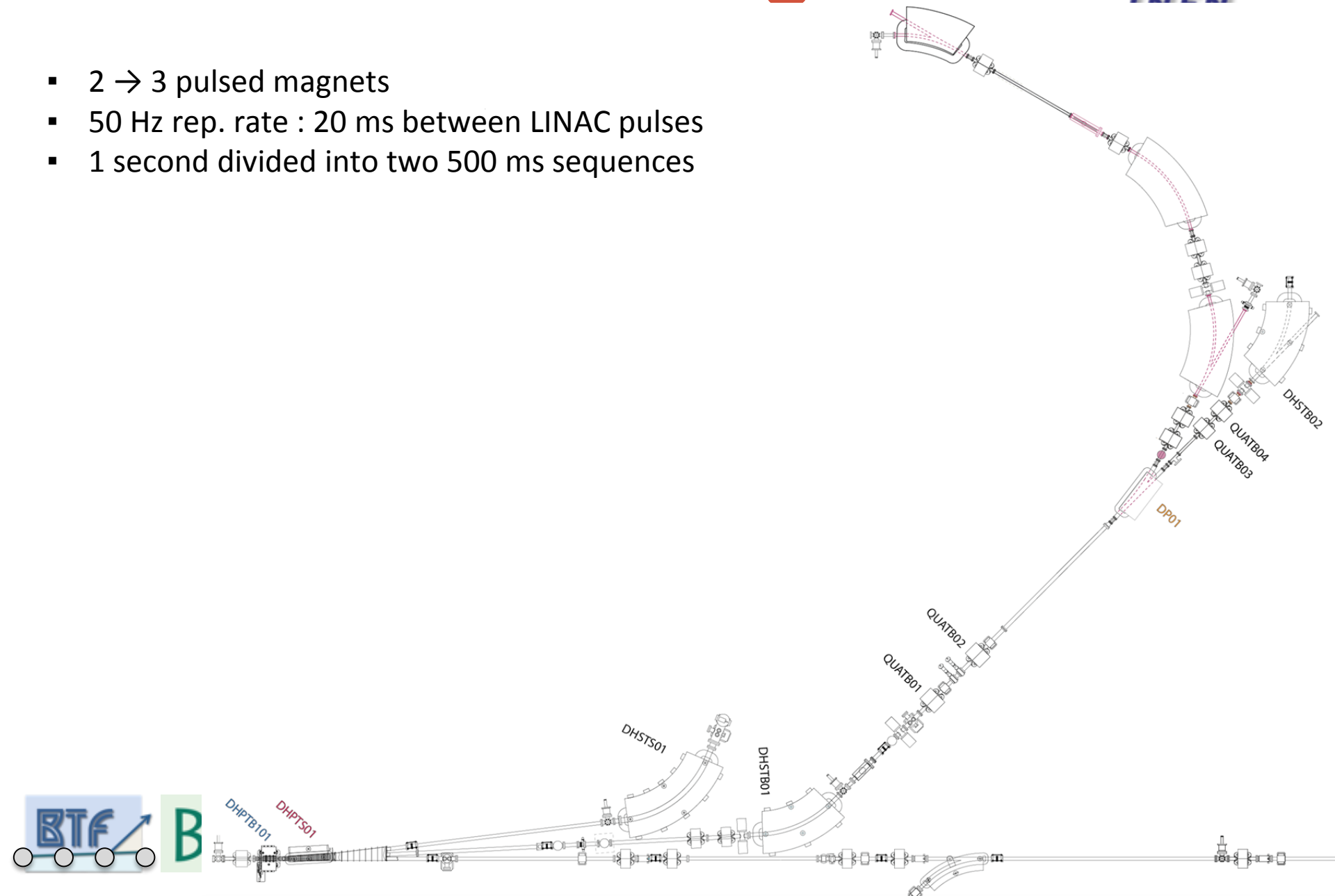
# BTF Quadrupole



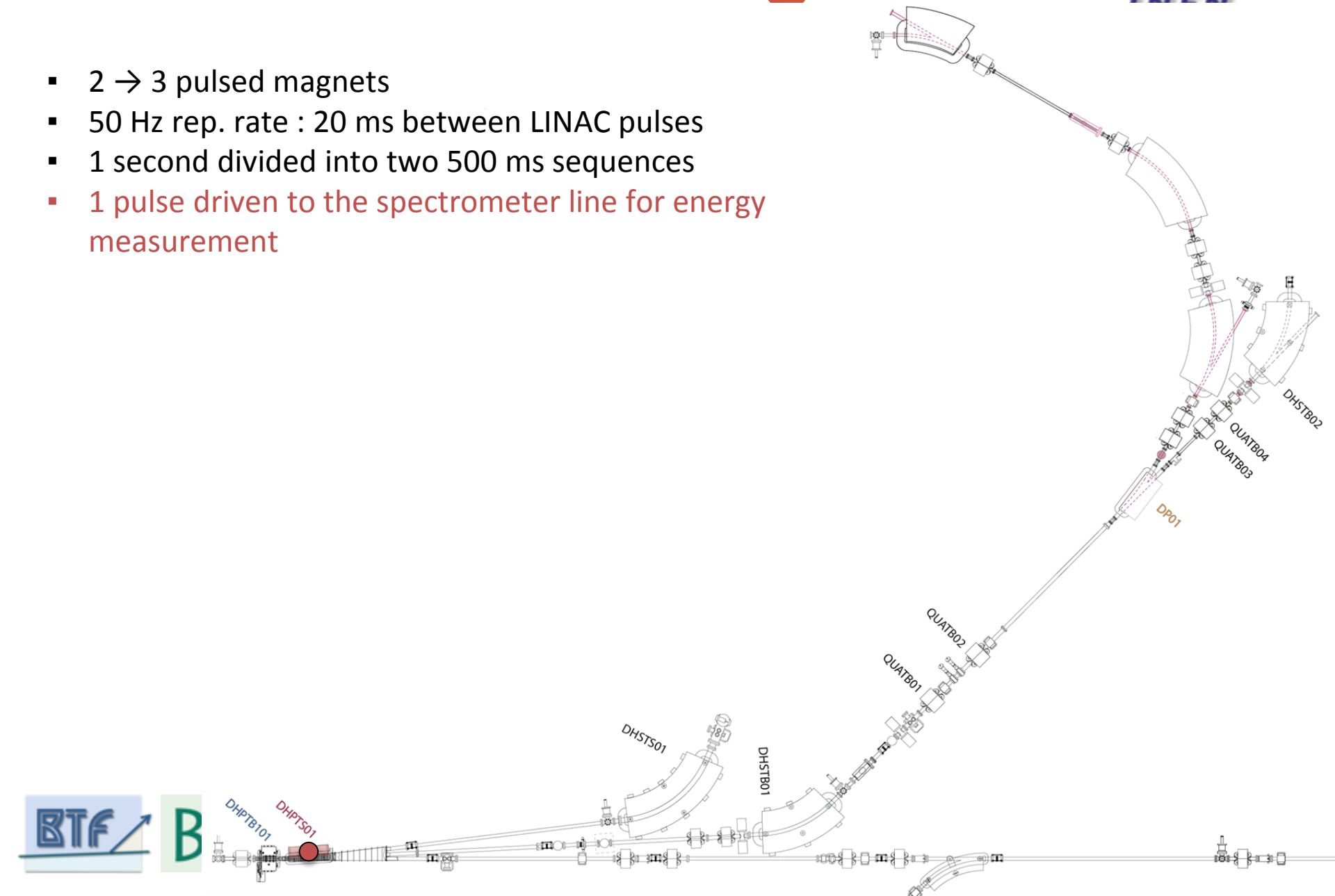
# Timing

- 2 → 3 pulsed magnets
- 50 Hz rep. rate : 20 ms between LINAC pulses
- 1 second divided into two 500 ms sequences



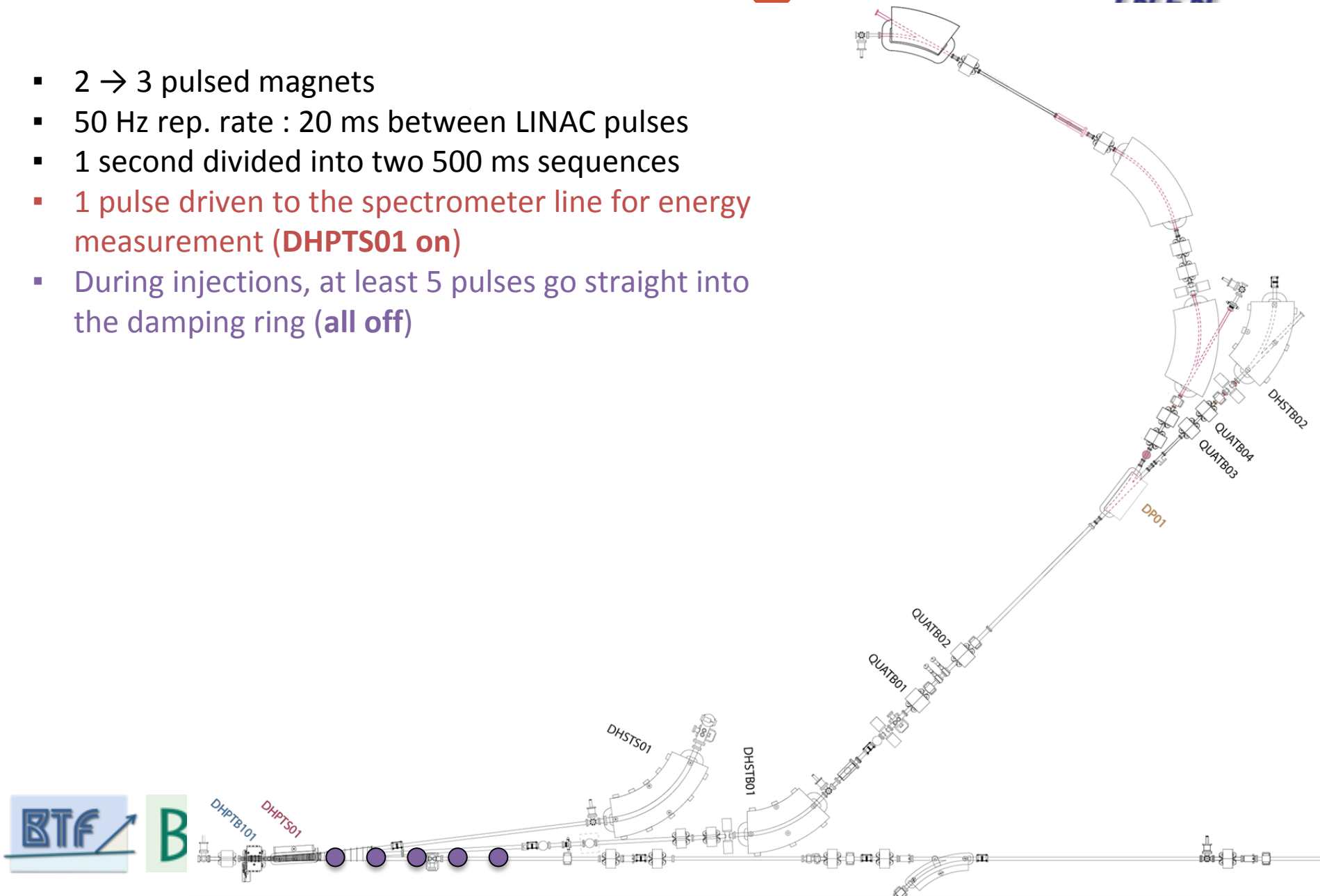
# Timing

- 2 → 3 pulsed magnets
- 50 Hz rep. rate : 20 ms between LINAC pulses
- 1 second divided into two 500 ms sequences
- 1 pulse driven to the spectrometer line for energy measurement



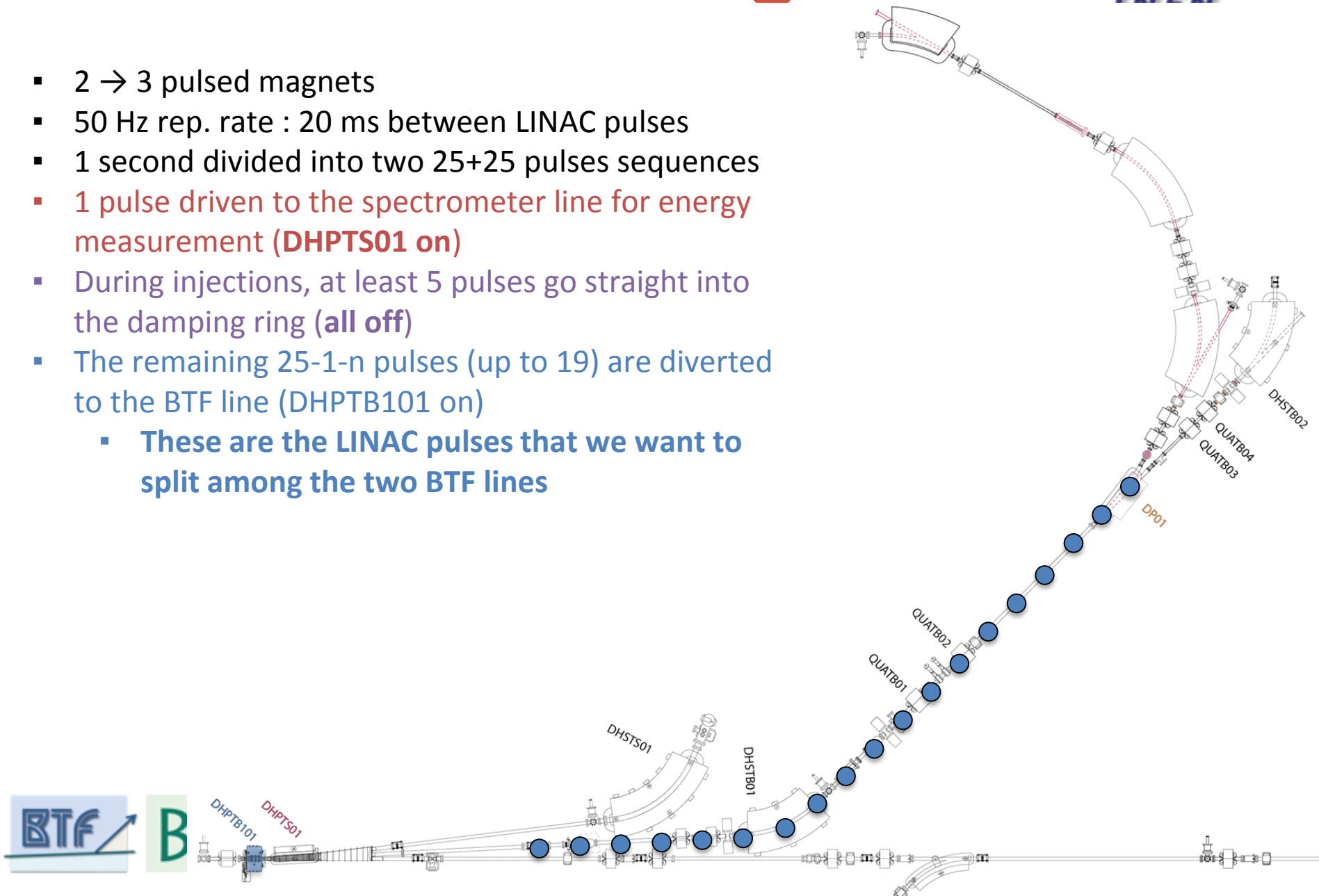
# Timing

- 2 → 3 pulsed magnets
- 50 Hz rep. rate : 20 ms between LINAC pulses
- 1 second divided into two 500 ms sequences
- 1 pulse driven to the spectrometer line for energy measurement (**DHPTS01 on**)
- During injections, at least 5 pulses go straight into the damping ring (**all off**)



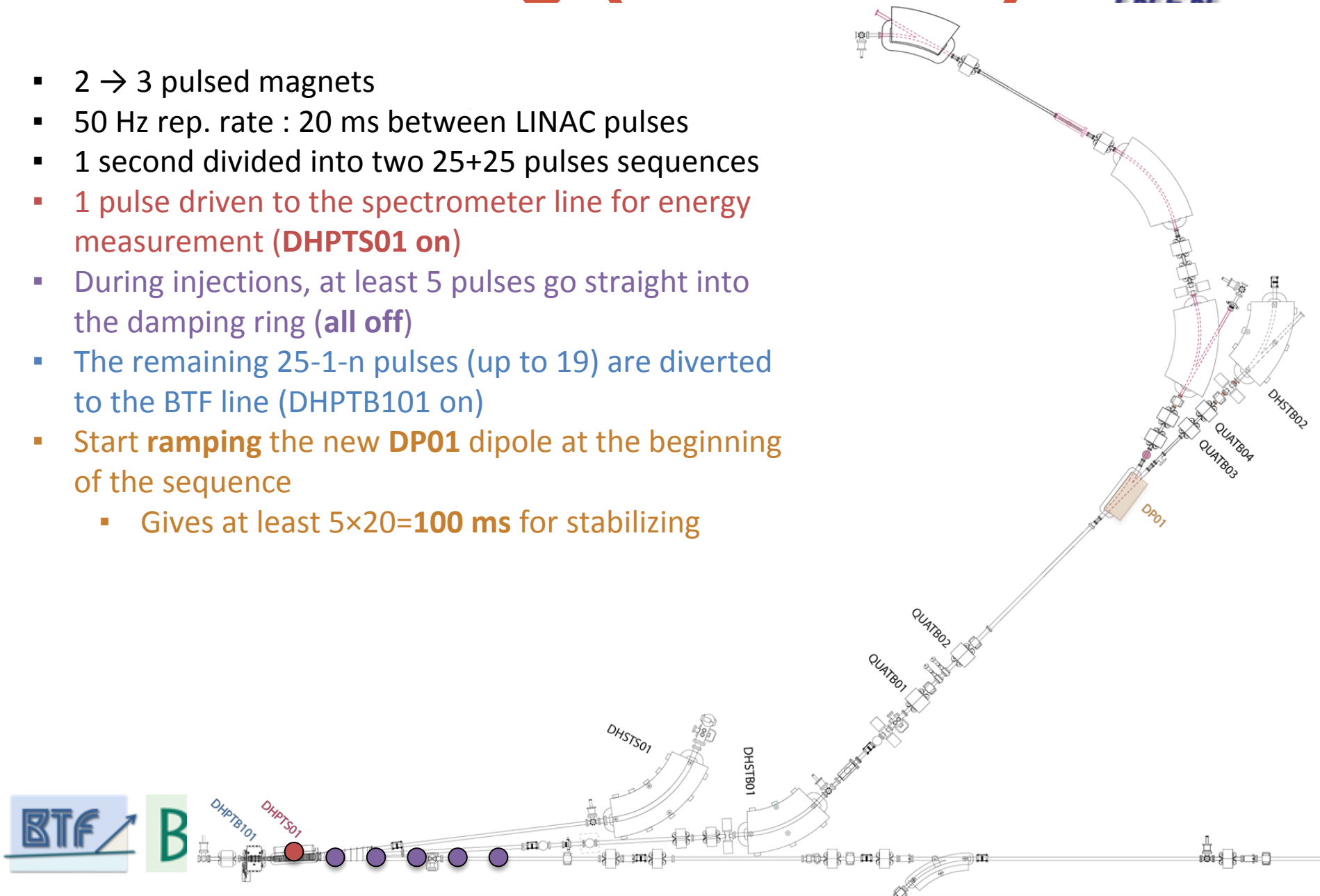
# Timing

- 2 → 3 pulsed magnets
- 50 Hz rep. rate : 20 ms between LINAC pulses
- 1 second divided into two 25+25 pulses sequences
- 1 pulse driven to the spectrometer line for energy measurement (**DHPTS01 on**)
- During injections, at least 5 pulses go straight into the damping ring (**all off**)
- The remaining 25-1-n pulses (up to 19) are diverted to the BTF line (DHPTB101 on)
  - **These are the LINAC pulses that we want to split among the two BTF lines**



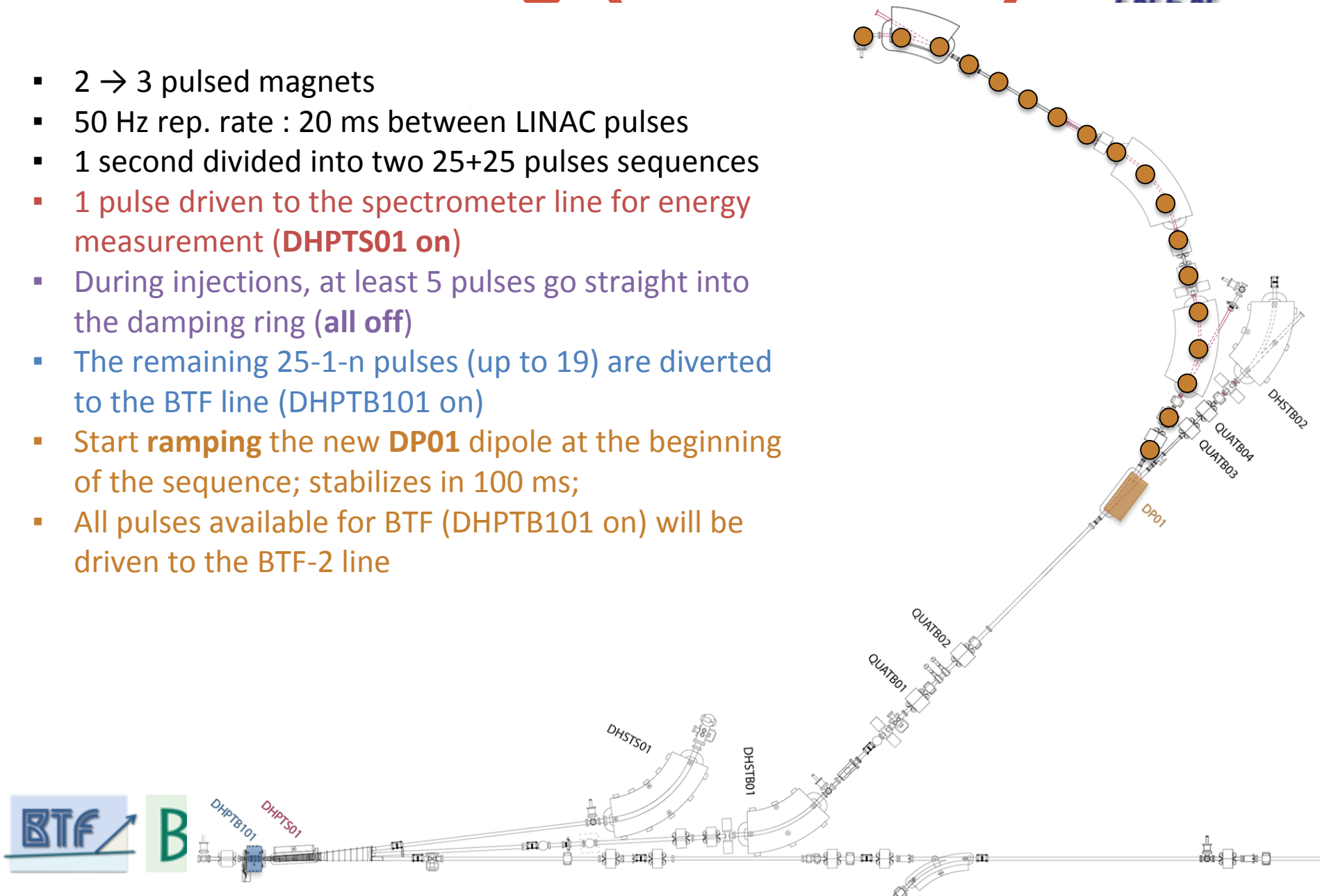
# Timing (modified)

- 2 → 3 pulsed magnets
- 50 Hz rep. rate : 20 ms between LINAC pulses
- 1 second divided into two 25+25 pulses sequences
- 1 pulse driven to the spectrometer line for energy measurement (**DHPTS01 on**)
- During injections, at least 5 pulses go straight into the damping ring (**all off**)
- The remaining 25-1-n pulses (up to 19) are diverted to the BTF line (DHPTB101 on)
- Start **ramping** the new **DP01** dipole at the beginning of the sequence
  - Gives at least 5×20=**100 ms** for stabilizing



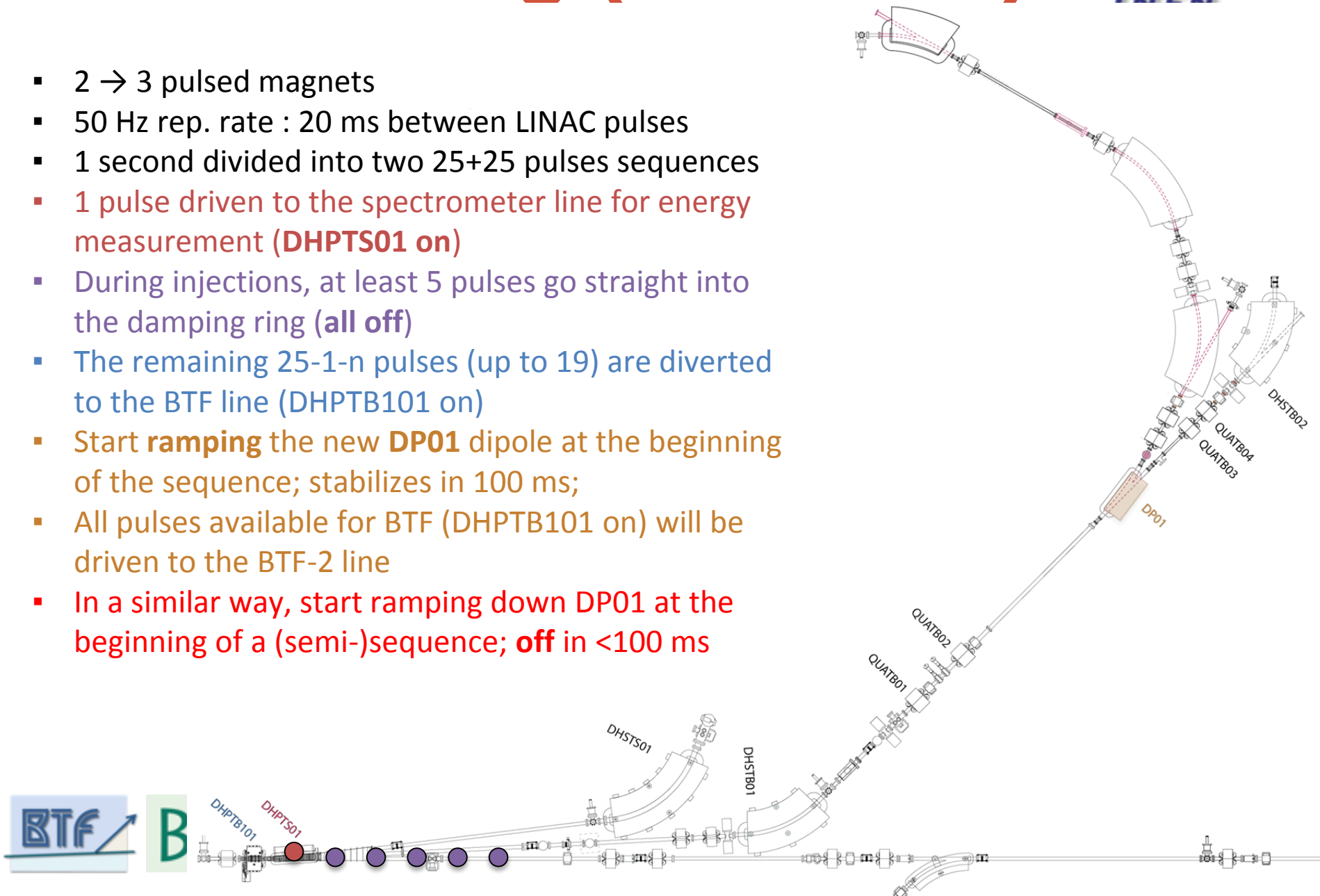
# Timing (modified)

- 2 → 3 pulsed magnets
- 50 Hz rep. rate : 20 ms between LINAC pulses
- 1 second divided into two 25+25 pulses sequences
- 1 pulse driven to the spectrometer line for energy measurement (**DHPTS01 on**)
- During injections, at least 5 pulses go straight into the damping ring (**all off**)
- The remaining 25-1-n pulses (up to 19) are diverted to the BTF line (DHPTB101 on)
- Start **ramping** the new **DP01** dipole at the beginning of the sequence; stabilizes in 100 ms;
- All pulses available for BTF (DHPTB101 on) will be driven to the BTF-2 line



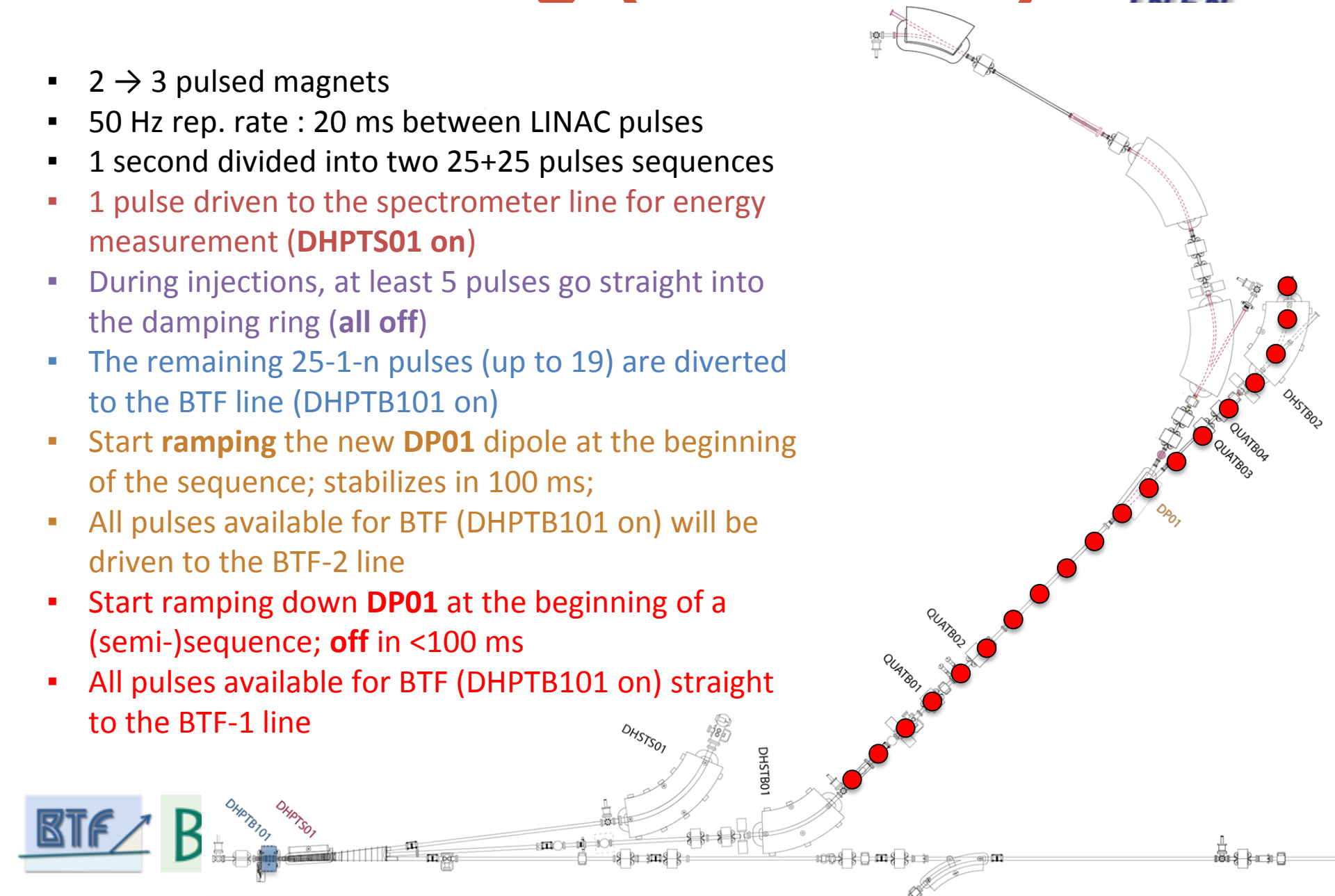
# Timing (modified)

- 2 → 3 pulsed magnets
- 50 Hz rep. rate : 20 ms between LINAC pulses
- 1 second divided into two 25+25 pulses sequences
- 1 pulse driven to the spectrometer line for energy measurement (**DHPTS01 on**)
- During injections, at least 5 pulses go straight into the damping ring (**all off**)
- The remaining 25-1-n pulses (up to 19) are diverted to the BTF line (DHPTB101 on)
- Start **ramping** the new **DP01** dipole at the beginning of the sequence; stabilizes in 100 ms;
- All pulses available for BTF (DHPTB101 on) will be driven to the BTF-2 line
- In a similar way, start ramping down DP01 at the beginning of a (semi-)sequence; **off** in <100 ms



# Timing (modified)

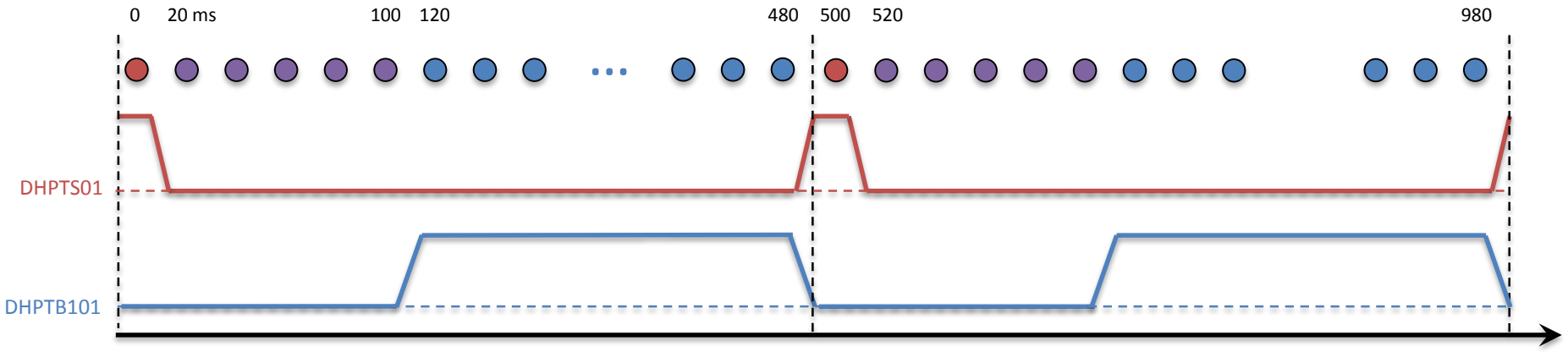
- 2 → 3 pulsed magnets
- 50 Hz rep. rate : 20 ms between LINAC pulses
- 1 second divided into two 25+25 pulses sequences
- 1 pulse driven to the spectrometer line for energy measurement (**DHPTS01 on**)
- During injections, at least 5 pulses go straight into the damping ring (**all off**)
- The remaining 25-1-n pulses (up to 19) are diverted to the BTF line (DHPTB101 on)
- Start **ramping** the new **DP01** dipole at the beginning of the sequence; stabilizes in 100 ms;
- All pulses available for BTF (DHPTB101 on) will be driven to the BTF-2 line
- Start ramping down **DP01** at the beginning of a (semi-)sequence; **off** in <100 ms
- All pulses available for BTF (DHPTB101 on) straight to the BTF-1 line



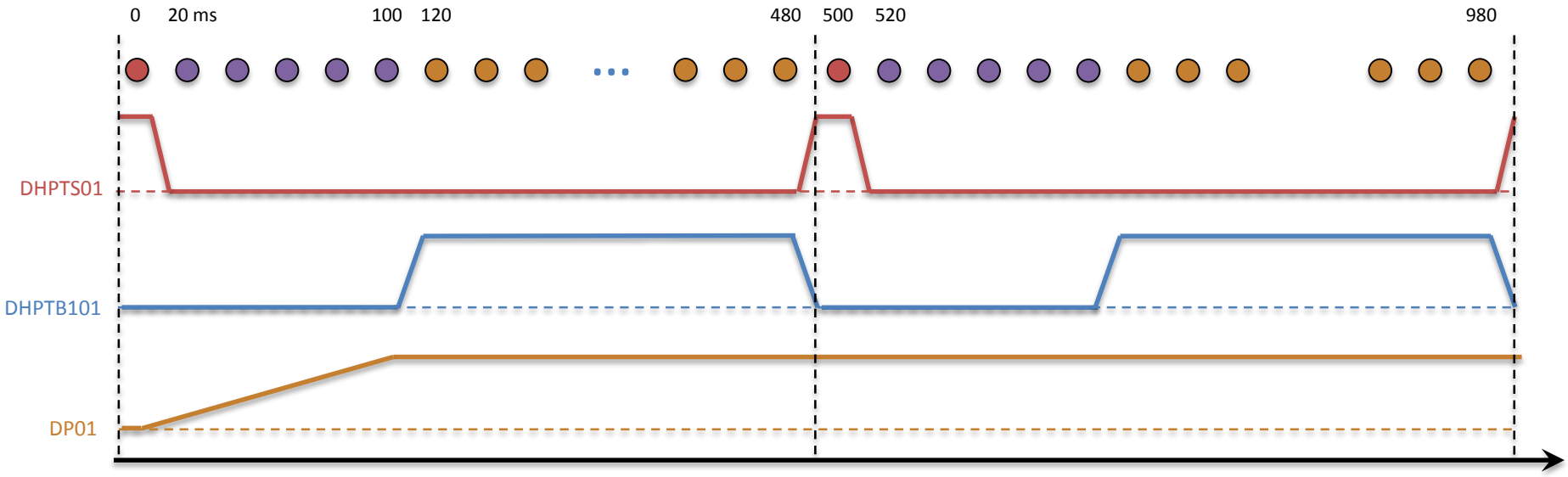
# Timing (modified)

- 2 → 3 pulsed magnets
- 50 Hz rep. rate : 20 ms between LINAC pulses
- 1 second divided into two 25+25 pulses sequences
- 1 pulse driven to the spectrometer line for energy measurement (**DHPTS01 on**)
- During injections, at least 5 pulses go straight into the damping ring (**all off**)
- The remaining 25-1-n pulses (up to 19) are diverted to the BTF line (DHPTB101 on)
- Start **ramping** the new **DP01** dipole at the beginning of the sequence; stabilizes in 100 ms;
- All pulses available for BTF (DHPTB101 on) will be driven to the BTF-2 line
- Start ramping down **DP01** at the beginning of a (semi-)sequence; **off** in <100 ms
- All pulses available for BTF (DHPTB101 on) straight to the BTF-1 line
- No overall duty-cycle loss when running in parallel with the DAΦNE collider
- When running without DAΦNE, i.e. in BTF dedicated mode: loss = (5 pulses)/(49*n), if switching line every n seconds, i.e. **10%** or lower

# Timing diagram (BTF parasitic)



# Timing diagram (switch to BTF-2)



# Timing diagram (switch to BTF-1)