BTF @ LNF

DAFNE Beam Test Facility (BTF).

From single up to $10^{10}$ e⁻/e⁺ and $\gamma$

B. Buonomo, G. Mazzitelli, L. Quintieri, P. Valente
and many users who help us developing diagnostic and improving the facility
The DAΦNE BTF

The BTF is a $e^-/e^+$ test-beam facility in the Frascati DAΦNE collider complex.

Need to attenuate the primary beam:
- **Single particle** regime is ideal for detector testing purposes
- Allows to tune the beam intensity
- Allows to tune the beam energy

**high current** Linac:
- $1 - 500$ mA $e^-$ $200$ mA $e^+$,
- $1 - 10$ ns pulses, at least $10^7$ particles
LINAC beam attenuation

LINAC Beam 1-500 mA

tunable Cu target: 1.7, 2.0, 2.3 \( X_0 \)

Selected energy (MeV)

N. of particles

detector

W slits

45° magnet

N. of particles

Selected energy (MeV)

G. Mazzitelli – Channeling 2009, Erice, Italy
BTF beam characteristic

Beam (e⁻ or e⁺) intensity can be adjusted by means of the energy dispersion and collimators, down to single particle per pulses.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number</strong> (particles/pulse)</td>
<td>1×10⁵</td>
</tr>
<tr>
<td><strong>Energy</strong> (MeV)</td>
<td>25-500 25⁻¹⁷⁵</td>
</tr>
<tr>
<td><strong>Repetition rate</strong> (Hz)</td>
<td>20-50 50</td>
</tr>
<tr>
<td><strong>Pulse Duration</strong> (ns)</td>
<td>10 1 or 10</td>
</tr>
<tr>
<td><strong>p resolution</strong></td>
<td>1%</td>
</tr>
<tr>
<td><strong>Spot size</strong> (mm)</td>
<td>σₓ,y ≈ 2 (single particle) up to 10×10 (high multiplicity)</td>
</tr>
<tr>
<td><strong>Divergence</strong> (mmrad)</td>
<td>σ′ₓ,y ≈ 2 (single particle) up to 10 (high multiplicity)</td>
</tr>
</tbody>
</table>

Multi-purpose facility:
- H.E. detector calibration and setup
- Low energy calorimetry & resolution
- Low energy electromagnetic interaction studies
- High multiplicity efficiency
- Detectors aging and efficiency
- Beam diagnostics
The BTF has been in operation since 2003. The beam is delivered 24 h/day with an efficiency of 96% but when parassiting DAFNE main operation the duty cycle was degraded ~ 45% due to continuous injection into the main ring. In 2006 a fast pulsed power supply has been installed increasing the duty cycle up ~ 90%.

Beam request in last 4 years (multi users are counted twice):
- 2007 - 224 days
- 2006 - 244 days
- 2005 - 364 days
- 2004 - 282 days

2008 - 124 days up to end of June
Present RUN

148 days allocated over 175 of operation, typical real access 80-90% of allocated time
Equipment: infrastructure

Control room: PCs, Controls console, printer cabling, crate and racks, etc

main entrance: radioprotection wall can be removed on demand

- one meeting room (WiFi)
- one guest office (LAN-WiFi)

Linac tunnel
Equipment: infrastructure

- permanent DAQ TDC/QDC/ADC/scaler/disc. available
- NIM, VME, CAMAC Branch, VME controllers
- ‘Devil’/VMIC VME and CAMAC controller, NIM modules
- Remotely controlled trolley
- Gas system
- HV system...
- crates, rack, etc.

- HV SY2527 (3/4KV neg, 3/4KV pos, 15KV pos)
- 40 ch. CAEN SY127 pos.
- Cabling BTF HALL-BTF CR
- Network: Wi-Fi, dedicated-LAN, WAN, printer
  http://www.lnf.infn.it/acceleratori/btf/

\[ C_4H_{10}, CO_2, Noble\ Gas, C_2H_6 \]
Equipment: Diagnostics

low multiplicity diagnostic (1-100):
  (back detector)

- lead glass, $5 \times 5 \times 35 - 10 \times 10 \times 35$ cm
- PbWO$_4$ crystal $3 \times 3 \times 11$ cm
- lead/scintillator fibers (KLOE type), $25 \times 50 \times 30$ cm
- NaI high resolution $30 \times 30$ cm

  (front/trigger detector/not destructive/tracking)

- multipurpose plastic scintillators $10 \times 10 \times 0.5$, $10 \times 30 \times 0.5$, $1 \times 15 \times 0.5$ cm
- hodoscope; two bundle of 1 mm fiber for a total active area of $48 \times 48$ mm$^2$
- Silicon tracker (high gain)
- 3GEM (Gas Electron Multiplier) detector

2×2 mm spot size in fiber hodoscope

2×2 mm spot size in Silicon XY chamber
Calorimetric counting

The number of produced electrons counted by total energy deposited in a lead/scintillating fiber calorimeter (KLOE type):

- Limited to few tens of MeV, due to energy resolution.

Calorimetric is OK at low intensity, not for high multiplicity beams: e.g. the AIRFLY experiment, designed to measure absolute fluorescence yield in air and its energy dependence, needs:

- Full energy range
- Maximum beam intensity
Beam profile (AGILE Si tracker)

2 layers (x,y) × 384 strips, analog readout

410 μm thick, single-side, AC coupled strips, 121 μm pitch, 242 μm readout pitch

Optimal focusing at 493 MeV, measured spot size: $\sigma \approx 2 \times 2 \text{ mm}^2$

Defocused

Beam spot measured with all transfer line quadrupoles off: 55×35 mm$^2$, limited by vacuum pipe section
Sci-fi profile detector

- A permanent beam position and size monitor needed, both for beam **steering** and **optimization** purposes, and for providing useful information for detector testing, complementing the beam intensity monitors

- Such a position sensitive detector should have:
  - **negligible mass**, not to spoil beam characteristics (energy, divergence, spot size)
  - **good resolution**, as compared to beam typical size (1 mm required)
  - **sensitivity** both for **single particle** (even at low energy) and at **high beam intensity**

- **cladded scintillating fibers**, Pol.Hi.Tech type 0046, 1 mm diameter
  - 4 layers of fibers glued together
  - staggered by ½ fiber to minimize dead zones
Sci-fi profile detector

- Charge weighted profiles for $x$ and $y$ fiber bundles

Consistent with beam image from Silicon tracker
Examples of experimental setup (P326 Prototype inefficiency 200 MeV)

- no tagging
- tagging
- tagging loose

energy spectrum

inefficiency VS threshold

- FC max
- N/Ntot
- FC min
Example of experimental setup (MEG)

- beam exit
- sci-fi profile detector
- detector (MEG test for sci time resolution)
- back detector (NaI calorimeter)
- on line monitor
- e- spectra
- XY beam sci-profile
BTF photon tagged source
AGILE GRID photon calibration

The AGILE Gamma Ray Imaging Detector calibration at BTF is aimed at obtaining detailed data on all possible geometries and conditions. BTF can provide data in the most significant energy region (20-700 MeV).
\( \gamma \) tagging @ BTF

position and direction of the in-coming electrons

Nominal B field

\( e^- \)
$\gamma$ tagging @ BTF

**position and momentum** of the out-coming electrons

*Nota bene*

*Online plots, analysis in progress*

*Increase B field*
Equipment: Diagnostics (con’t)

• medium multiplicity diagnostic (100-10^8):
  (front detector/not destructive)
  • Cerenkov light emission
  • Silicon Beam Chamber (low and tunable gain)
  • Triple GEM TPC (under development)

• high multiplicity diagnostic (10^7-10^10):
  (front detector)
  • low noise (3×10^6 particles) BCM
  • high sensitivity fluorescence flags – cromox, Be, yag:ce
Cerenkov beam monitor

detector, designed and built, in collaboration with the AIRFLY group, based on Cerenkov light emission

- **Cross-calibrated** with calorimetric measurement at low particle multiplicity
- Used to monitor beam intensity at higher intensity
  up $10^4 \div 10^5$ particles, **in the full energy range**

Dynamical range can be further extended:
- calibrated optical filter in front of the PMT
- use air as Cerenkov radiator

detector tested up to $10^{10}$ particles with a cross calibration with BCM
Cerenkov beam monitor

No optical filter

:10 optical filter
(measured attenuation = 0.096)
Compact-Triple Projection GEM

It’s essentially a small TPC with a 3-4 cm drift.
Also high current beam can be monitored in position (TDC) and dE/dX (ADC).

The detector will be realized with standard 10x10 cm$^2$ GEMs inside a G10 box; the readout will be realized with:
- ASDQ (first phase) at CERN for test beam
- then Carioca Cards (second phase) at BTF

Possible DE/Dx measurements (LVDS width proportional to signal charge)

16 samples for each readout
Beam profile
(FLAG fluorescence target)

Flag = metallic high fluorescence plate viewed by a camera
Different fluorescence targets (Be, cromox, yag:ce) for very low current beam diagnostics

Very low current beam image on 1 Inc yag:ce
RAP experiment @ BTF
Background attenuation

A tungsten box is going to be installed in order to shield the high divergent beam coming from the Cu degrader target – an attenuation of ~ 100 is expected by simulation (FLUKA).
Application form to access BTF

Pasquale Di Nezza - INFN, LNF
Flavio Gatti - INFN, Genova
Clara Matteuzzi (Chairperson) - INFN, Milano
Giovanni Mazzitelli (Responsible) - INFN, LNF
Antonio Passeri - INFN, Roma III
Paolo Valente - INFN, Roma I
Beam Test Facility Secretariat: Annette Donkerlo
Access BTF @ LNF

- **btf@lnf.infn.it** for scientific and technical question.
- **btfsupport@lnf.infn.it** for administration problem.

Mailing list
- INFN scientific CN coordinators
- INFN group responsible
- BTF users
technical documentation for **users** and **operators** is available on the web as well as beam request, shift archive, schedule, documentation, virtual logbook, etc.

The BTF was widely used as a TARI facility in the **EU 6th Framework Program**

...and will be involved in the **EU 7th Framework Program**

Thanks for your attention