Trento Institute for Fundamental Physics and Applications

Istituto Nazionale di Fisica Nucleare

Education initiatives in the experimental area of the Trento Proton Therapy Center (Italy)

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Outline

The Trento Proton Therapy Center (TPTC)
- The facility
- The gantries for patient treatment
- The cyclotron
- The experimental area

Trento Smart City Week 2019
- The city event
- The back gantry area and beam distribution area tour
- The experimental area tour with demonstration set-up

Some numbers

Final considerations

Web references about the facility and the city of Trento

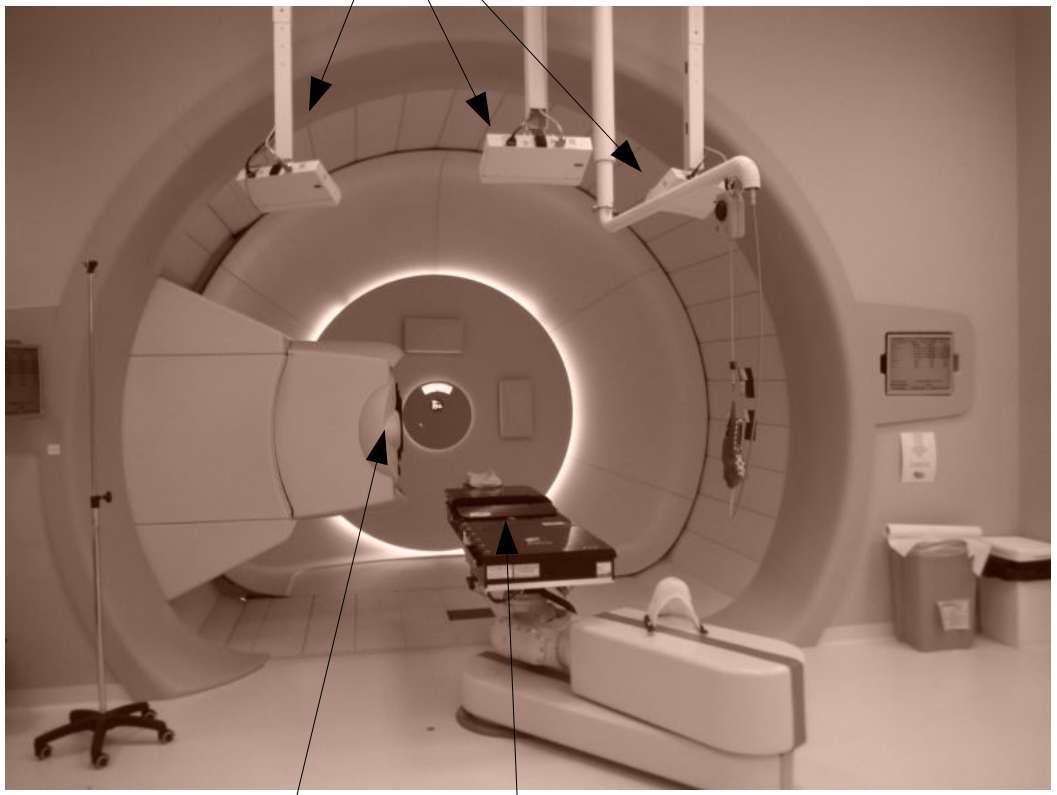
The Trento Proton Therapy Center (TPTC)

The Trento proton Therapy Center (TPTC)
Is a medical facility for hadron therapy
located in Trento, Italy.
It is operated by the *"Azienda Provinciale per i Servizi Sanitari"* (APSS).
https://protonterapia.provincia.tn.it/eng/?/switchlanguage/to/protonterapia_eng

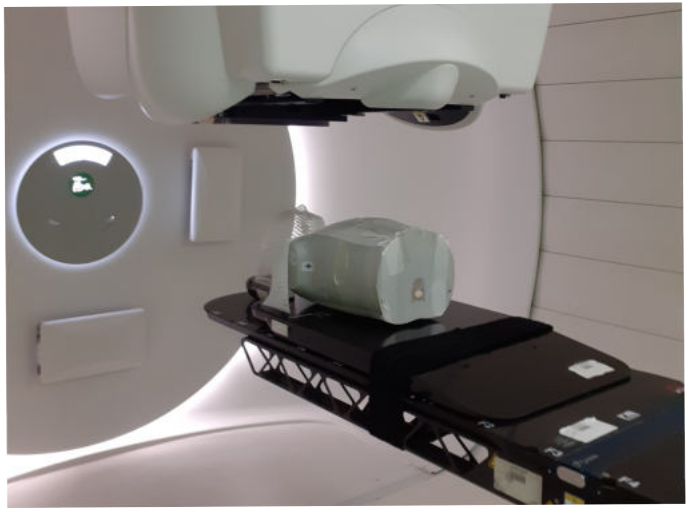
The facility is equipped with two gantry rooms for patient treatment
and an experimental room for physics and biophysics experiments.
Clinical activity started in 2014.
In the first 5 years of activity more than one thousand patients were treated in the center.

(* Photo courtesy of the Trento Film Commission)

The TPTC Gantry rooms



In the TPTC oncological patients are treated in the two *gantry rooms* realized by IBA (https://iba-worldwide.com/).
In each gantry The beam spill point (1) can rotate 370 degree, while the exact position of patient on the patient couch(2) is monitored using non-invasive technique like infrared cameras (3).



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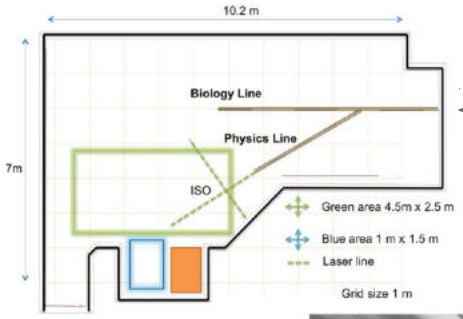
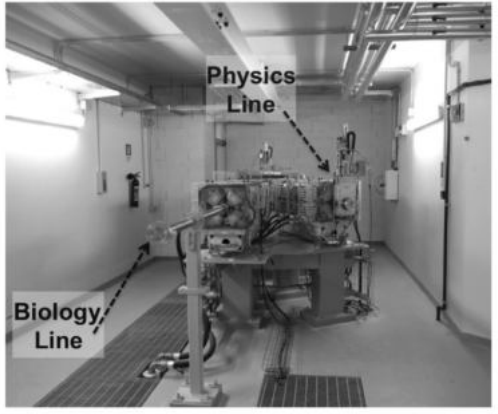
(* Photos by the author)

The TPTC experimental room



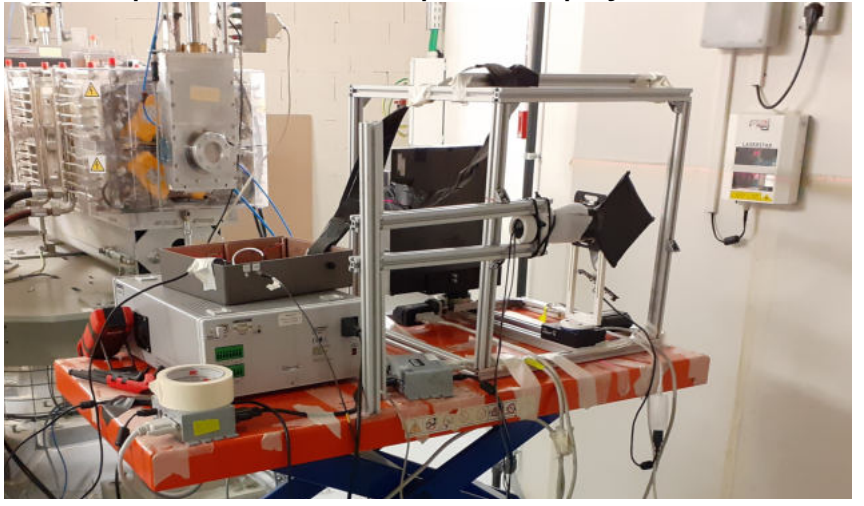
Proton Beam



In the TPTC facility experimental room, **operated by TIFPA-INFN**, there are two identical beamlines for “in air” exposition of biological targets (cells), biophysics measurement or particle physics test-beam:

- the “0 degree” or biological line
- the “30 degree” or physics line

Experimental set-up in the physics line



(* Photo by the author)

See details in ref.1:

F. Tommasino et al. NIM A Volume 869, 11 October 2017, Pages 15-20,

Proton beam characterization in the experimental room of the Trento Proton Therapy facility

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The TPTC Cyclotron

In the TPTC the proton source for both gantry rooms and the experimental area is a commercial 230 MeV cyclotron produced by IBA (https://iba-worldwide.com/)

"The energy of the beam extracted from the cyclotron is 230 MeV and is fixed. The beam extracted from the cyclotron is then focused into a small spot into a variable energy degrader made of graphite, followed by a magnetic analyzer. This energy selection system allows precise tuning of the continuous proton beam, from 60 MeV to 230 MeV, in under a second."

From: REVIEW ON CYCLOTRONS FOR CANCER THERAPY,
Yves Jongen, IBA, Louvain-la-Neuve, Belgium
Proceedings of CYCLOTRONS 2010, Lanzhou, China.
https://accelconf.web.cern.ch/Cyclotrons2010/papers/frm1cio01.pdf

(* Photo by the author)

The Trento Smart City Week 2019 Event

Trento Smart City Week 2019 was the 3rd edition of a succesfull event series organized in the city of Trento from 16 to 22 September 2019.

The topic of the events is allow people to know and to experience the many aspects and opportunities of the new digital world.

Since In recent years the presence of digital services like *apps, social networks, online services or simply devices* has become so pervasive in personal relationships, with the Public Administration and with companies, it is important, if not urgent, to have the awareness and correct "instructions for use" for an effective and correct use of these new tools. All these themes summarized in the motto of this 2019 edition of Trento Smart City Week: "Citizens in the digital age".

TIFPA-INFN took part at the event organizing guided tours and demonstration sessions in the experimental area of the Trento Proton Therapy Center in order to demonstrate how advanced tecnology is already present in our everyday life and in order to show effectively the tools used by researchers in building future technology.

See: https://2019.smartcityweek.it/

The back gantry area tour

Gantry rotational support

Because in the event time the accelerator was in shut-down since few days, it was possible for the public to enter in places generally restricted due to the high radiation level.
Visitors were able to see the full impressive mechanical structure hidden in the back of the gantries.

Beam line gantry entry point

(* Photos by the author)

The beam distribution area tour

The walk along the *beam line promenade* was a great success because offered the great opportunity to see directly bending dipoles, focusing quadrupoles and beam separators.

To show elements like these, is probably the easiest way to explain the the complexity hidden inside a beam delivery system.

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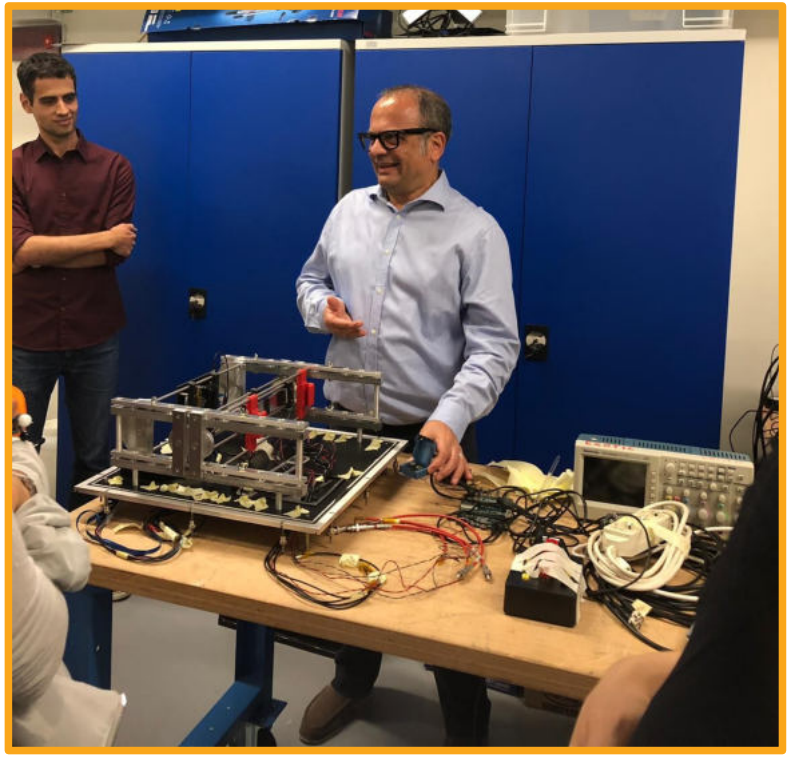
(* Photos by the author)

The demonstration set-up



The demonstration set-up was realized in the experimental area control room with tools used in real data taking, for example trigger scintillators were rearranged as a cosmic telescope while SiPM and silicon pixels were on display over the working tables.

Some Numbers

In four hours around 60 visitors made the tour, bunched in groups of 15 people

Visitors had age ranging from 18 years old up to some ..enties and very different qualifications.

The 70% of visitors were coming from the Trento area and they were at their first visit in the facility.

All of them where enthusiastic of the tour, interested in the place and asking question all the time.

Final Consideration

Considering the feed-back of the visitors,
once again the organizers had the evidence that a reseach facility
is the best place to demonstrate how technology is affecting our every-daylife
and how is important for all the people get involved in the building of the future.

Web References:

TIFPA-INFN
https://www.tifpa.infn.it/

Trento Smart-city week 2019
https://2019.smartcityweek.it/

Trento Proton Therapy Center
https://protonterapia.provincia.tn.it/eng/?/switchlanguage/to/protonterapia_eng

TIFPA-INFN Activity reports:
http://www.tifpa.infn.it/contacts/downloads/

Web References:

Proton Beam Time Application at TIFPA:
http://www.tifpa.infn.it/sc-init/med-tech/p-beam-research/

Facility Proton Beam Description (ref. 1):
F. Tommasino et al. NIM A Volume 869, 11 October 2017, Pages 15-20, *Proton beam characterization in the experimental room of the Trento Proton Therapy facility*

City of Trento info:
https://www.visittrentino.info/en/trentino/resorts-towns/trento_md_192

MUSE: the Trento Science Museum
https://www.muse.it/en/Pages/default.aspx

Local museums:
https://www.discovertrento.it/en/citta-di-trento/trento-musei

Thank you for your attention and see you in Trento!

Back-up slides

Proton beam parameters from ref. 1

Table 1
Nominal and effective values of the beam energy and corresponding range and maximum flux. The former refer to the energy at the cyclotron exit while the latter are measured in the experimental room at the Isocenter position. Flux measurements in the last column refer to 1 nA beam extraction current. The extraction current can be increased up to 320 nA, and the flux can scale consequently.

Nominal values		Effective valuesat ISO		Flux (p/s)
E (MeV)	R90 (g/cm^2)	E (MeV)	R90 (g/cm^2)	
70.2	4.1	68.5	3.9	3.8×10^6
73.9	4.5	72.4	4.3	–
82.7	5.5	82.3	5.4	7.5×10^6
90.8	6.5	89.5	6.3	9.9×10^6
100.0	7.5	98.6	7.5	1.2×10^7
105.6	8.5	104.2	8.3	–
112.4	9.5	11.2	9.3	2.1×10^7
119.0	10.5	117.8	10.3	2.8×10^7
125.3	11.5	124.1	11.3	–
131.3	12.5	130.3	12.3	2.7×10^7
137.2	13.5	136.1	13.3	–
142.9	14.5	141.7	14.2	3.6×10^7
148.5	15.5	147.1	15.2	–
153.9	16.5	152.7	16.2	4.6×10^7
159.2	17.5	158.0	17.2	5.5×10^7
164.4	18.5	163.1	18.2	–
169.4	19.5	168.1	19.2	7.4×10^7
174.4	20.5	173.4	20.2	–
179.3	21.5	178.2	21.2	9.0×10^7
184.1	22.5	182.8	22.2	–
188.8	23.5	187.4	23.2	1.1×10^8
193.4	24.5	192.3	24.2	–
197.9	25.5	196.8	25.2	–
202.4	26.5	201.1	26.1	1.4×10^8
206.9	27.5	205.6	27.1	–
211.2	28.5	210.0	28.1	1.7×10^8
215.5	29.5	214.2	29.1	–
219.8	30.5	218.4	30.1	2.0×10^8
224.0	31.5	222.9	31.2	–
228.2	32.5	227.4	32.3	2.3×10^8

Beam spot size estimated from a Gaussian fit on the profiles measured in the X–Y plane perpendicular to the beam direction. The spot asymmetry is calculated according to Eq. (1).

E (MeV)	σ_x (mm)	σ_y (mm)	Asymmetry (%)
70.2	6.93	6.91	0.1
73.9	6.63	6.74	0.8
82.7	6.28	6.41	1.0
90.8	6.04	6.15	0.9
100.0	5.63	5.73	0.8
105.6	5.42	5.63	1.8
112.4	5.26	5.43	1.6
119.0	5.05	5.24	1.9
125.3	4.90	5.09	1.9
131.3	4.70	4.88	1.9
137.2	4.49	4.79	3.2
142.9	4.50	4.62	1.3
148.5	4.39	4.52	1.4
153.9	4.23	4.41	2.0
159.2	4.10	4.31	2.5
164.4	4.02	4.19	2.0
169.4	3.93	4.08	1.8
174.4	3.85	4.07	2.7
179.3	3.76	3.92	2.1
184.1	3.71	3.84	1.7
188.8	3.66	3.83	2.2
193.4	3.57	3.74	2.2
197.9	3.48	3.64	2.3
202.4	3.44	3.52	1.1
206.9	3.33	3.44	1.5
211.2	3.33	3.31	0.4
215.5	3.18	3.19	0.1
219.8	3.10	3.08	0.5
224.0	3.04	2.97	1.0
228.2	2.74	2.72	0.2