

Patient selection, costing and business development in hadrontherapy

Sandro Rossi
Maria Vittoria Livraga
Paola Mella
Mimoza Strikchani

HITRI*plus* Specialized Course on Heavy Ion Therapy Research

July 5th, 2022



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008548

Outline

Talk sharing:

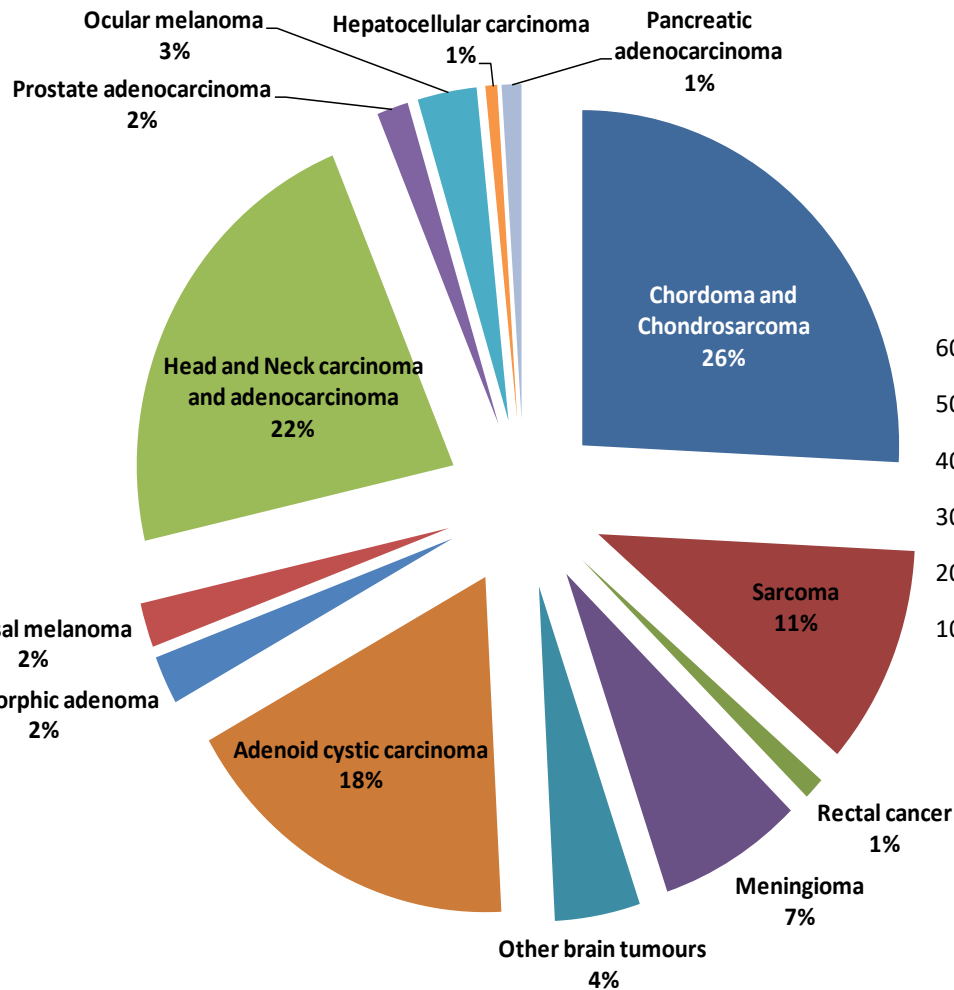
- ✓ **Sandro:** Introduction
- ✓ **Maria Vittoria:** Cost controlling
- ✓ **Mimoza:** Activity Based Costing (ABC) model
- ✓ **Paola:** ABC at CNAO
- ✓ **Maria Vittoria:** Cost Benefit Analysis (CBA)

Sandro's Introduction:

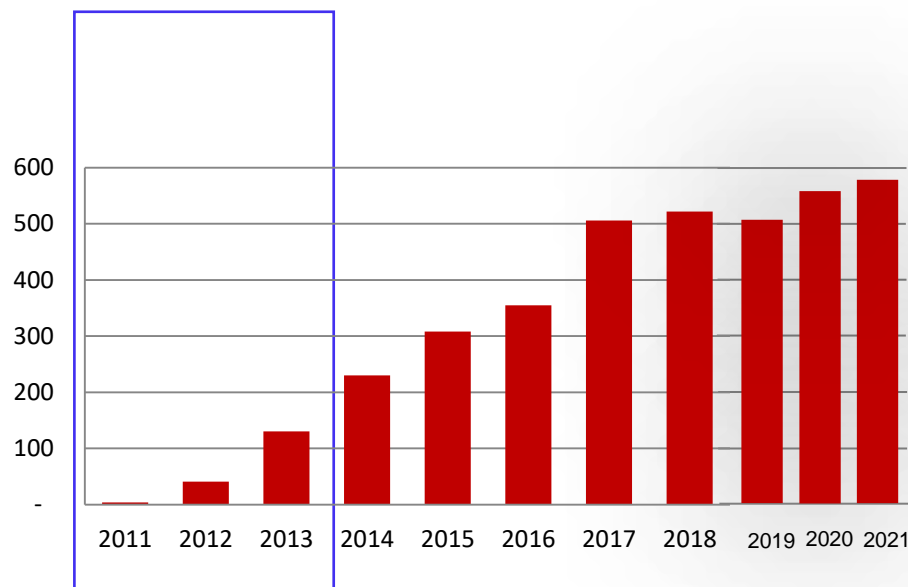
- ✓ Patients selection and recruitment: the CNAO experience
- ✓ Activities at the base of costing
- ✓ Hadrontherapy: situation and business development

Patients treated at CNAO: > 4000

55% carbons – 45% protons



CE clinical trials



Patients per year

Pathologies approved by Italian Health System

1. Chordoma & chondrosarcoma base/spine
2. Meningiomas
3. Brain tumors (trunk)
4. ACC Salivary Glands
5. Orbit tumors including eye melanoma
6. Sinonasal carcinoma
7. Soft Tissue & bone Sarcoma (every sites)
8. Recurrent tumors (retreatment)
9. Patients with immulogical disorders
10. Pediatric solid tumors
11. Tumors for which hadrontherapy guarantees a better dose distribution wrt the best alternative providing a 10% better result in terms of NTCP or TCP (under discussion)

In Italy (60 million inhabitants) estimated cases 1-10:

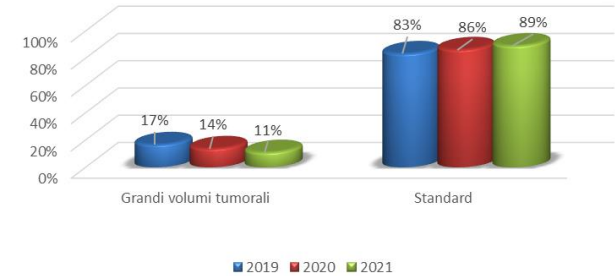
Protons: about 5.000 patients/year

Carbons: about 1.000 patients/year

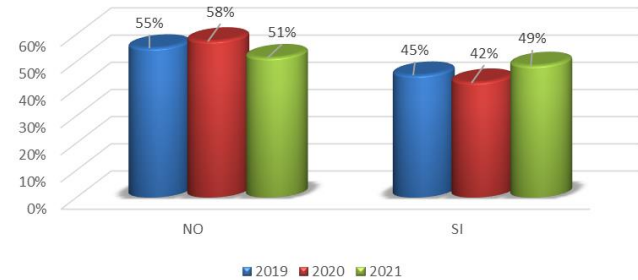
Complicated patients

In year 2021,
62 patients (11%) stopped
 treatments procedure after first visit
 for clinical reasons

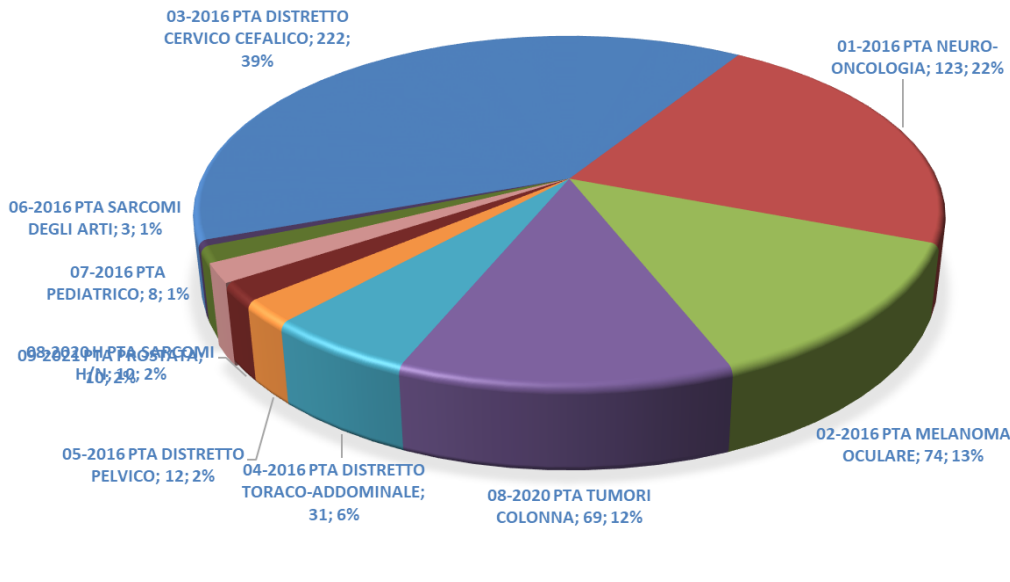
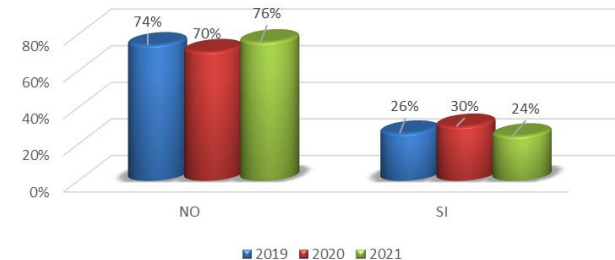
% volumes > 500 cc



Gating in abdomen

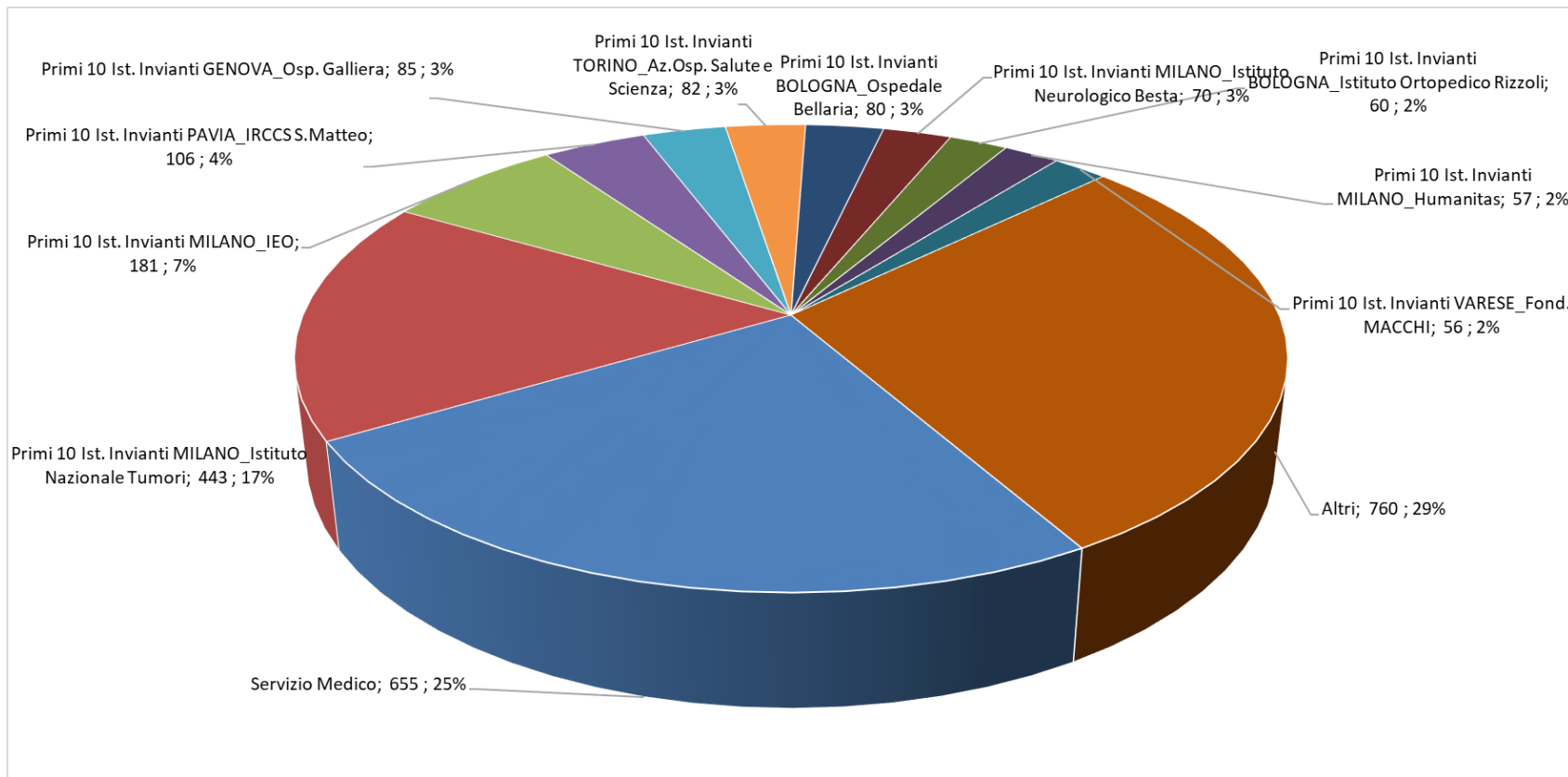


Re-treatments



Patients recruitment in last 5 years (2017-2021)

In Italy hadrontherapy still needs individual approval for HS reimbursement



Medical service
25% ↓

Top 10
46% ↑

Others
29% ↑

Outline

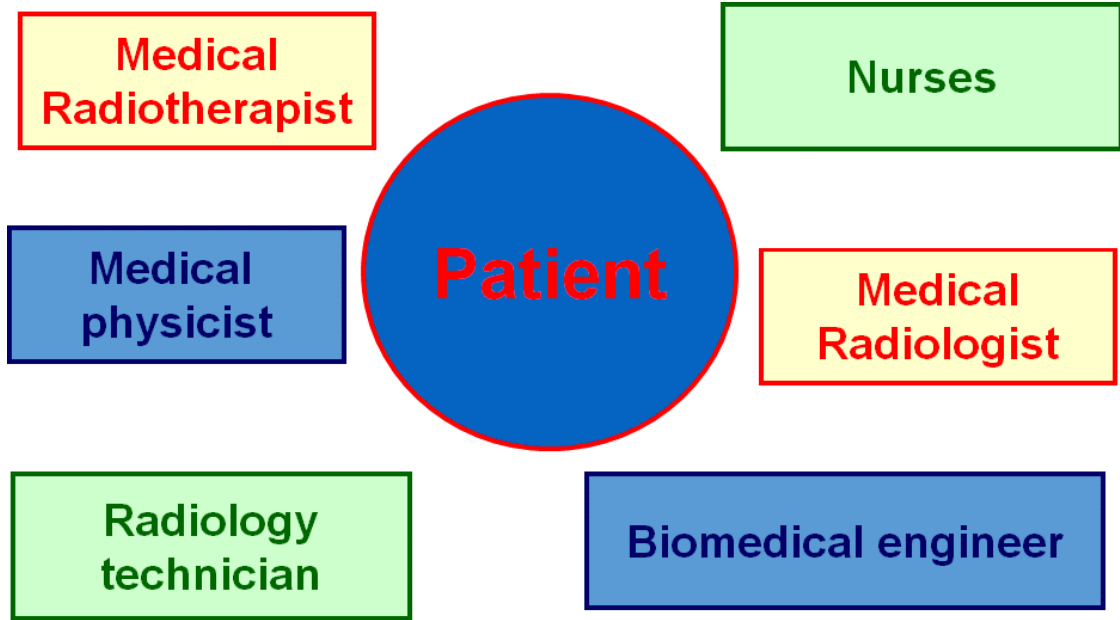
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Patient at the centre




Multidisciplinarity

Multimodality



SURGERY



CHEMIOOTHERAPY



RADIOOTHERAPY



CNAO personnel in 2021

<i>Year 2021</i>	Number
DG and Services	16
DS e Clinical Trial Centre	4
Clinical Department	62
Administration Department	13
Technical Department	38
R&D Department	5
Total	138

Professions:

Radiotherapist

Medical Physicist

Bioengineer

Radiobiologist

Radiation technician

Nurses

Accelerator physicist

Engineer

Technician

Operator

Radioprotection

Safety

Economist

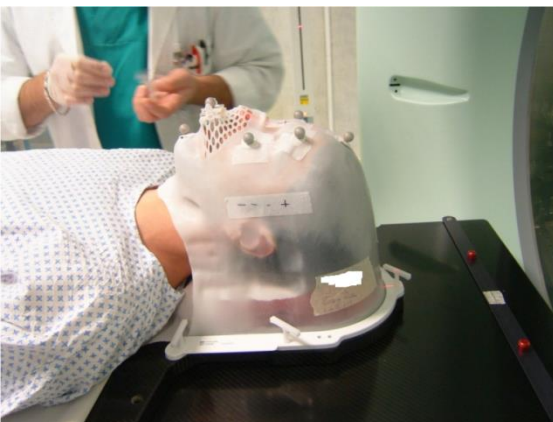
Lawyer

Administrative employee

Communication officer

Regulatory affairs

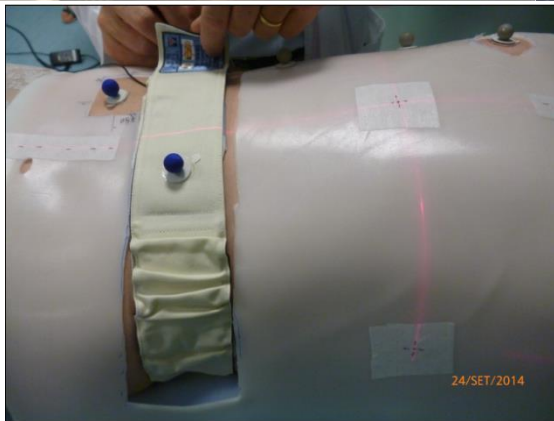
Pre-treatment imaging



CT

NMR

CT/PET



ANZAI and OTS

Moving organs:
4-D treatment
Gating e rescanning

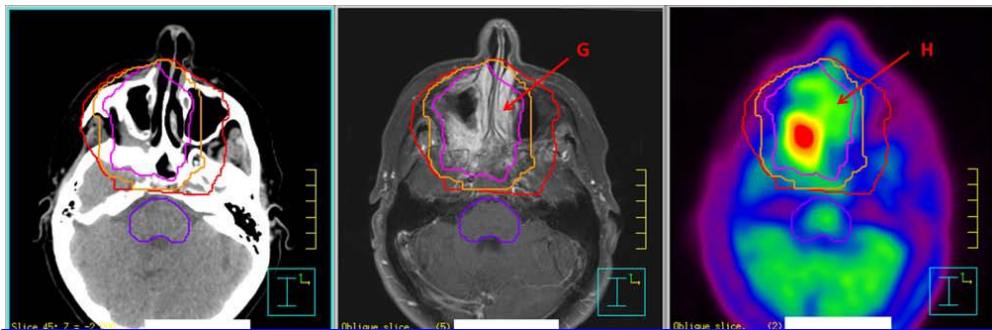


Image fusion

Individual dose optimization algorithm

The screenshot displays the Siemens Monaco radiation therapy planning interface. On the left, the 'TX-PLANNING' sidebar shows the 'Optimization' section for 'PI01_PTV', with 'ProtonEffectiveCompound' selected. The 'Renormalization' section shows a prescription of 'PTV,mean dose,60.00Gy' and a norm factor of 0.997. The central area shows axial and sagittal CT scans with target and organ-at-risk (OAR) contours. On the right, a 'Dose Volume Histogram' (DVH) plot shows the 'PI01_PTV-effective' curve and OAR DVHs for 'Eye right', 'Eye left', and 'Optic ne...'. The x-axis is 'Dose in GyE' (0.00 to 80.00) and the y-axis is 'Volume in cc' (0.00 to 80.00). Annotations point to 'Target D_{min}', 'OAR DVH', and 'OAR D_{max}'. Below the DVH, a table lists 'Dose constraints' for 'Targets' and 'Non Targets'.

Targets					Non Targets				
Volume	Dose [GyE]	Vol. [%]	Weight		Volume	Dose [GyE]	Vol. [%]	Weight	
✓ PTV	60.60	MaxDose	1.00		✓ Brainstem	50.18	MaxDose	1.00	
✓ PTV	59.40	MinDose	1.00		✓ Brainstem	21.64	35.54	1.00	
✓ PTV	60.00	50.00	1.00		✓ Chiasm	52.75	MaxDose	1.00	
✓ PTV	60.00	50.00	1.00						

Need to include management of moving organs and integration of in-room imaging

Goal: robust and adaptive planning on a daily basis

Outpatient treatments

Carbon ions: up to 16 sessions, 4 days x 4 weeks

Protons: up to 35 sessions, 5 days x 7 weeks

Session duration: about 30 min (positioning and verification), 2-3 min beam-on



Costing is an issue ...

Fee definition a different matter



Regione Lombardia
LA GIUNTA

DELIBERAZIONE N° X / 1185

Seduta del 20/12/2013

Attività di Adroterapia

Limitatamente alle attività di Adroterapia erogate dal CNAO di Pavia per protocolli approvati dal ISS, si definiscono le seguenti tariffe in vigore per i trattamenti prenotati a partire dal 1° gennaio 2014:

codice	Descrizione	Tariffa (€)
92.29.N	Stereotassi (1-3 frazioni)	18.000,00
92.29.O	Boost (sino a 6 frazioni)	12.000,00
92.29.P	Ciclo intero	24.000,00

Le precedenti prestazioni sono da considerarsi come dei pacchetti comprensivi di tutte le attività legate al trattamento (visite, tac, rmn, centrature con simulatore, definizioni di volume di trattamento, studi dosimetrici, ecc.). La possibilità di erogare le predette prestazioni a carico del Servizio Sanitario Regionale è subordinata alla messa a contratto della struttura da parte della ASL territorialmente competente che avverrà entro il mese di gennaio 2014.

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Status of Radiation Therapy Equipment

20 105

Countries RT Centres

109

Light Ion Therapy

Click on **Equipment type**, **Income groups** or **Regions** to create your own view. *Ctrl+click to select multiple items*

Equipment type

(Updated on : 08/06/2022 14:10:39)

MV Therapy 14.986

Brachytherapy 3.350

Light Ion Therapy 109

Equipment per income groups

(Updated on : 08/06/2022 14:10:39)

High income (H) 98

Upper middle income (UM) 10

Lower middle income (LM) 1



Regions

WHO regions

Country

Equipment per regions

North America 37

Western Europe 32

East Asia 30

Eastern Europe and Northern Asia 9

South Asia 1

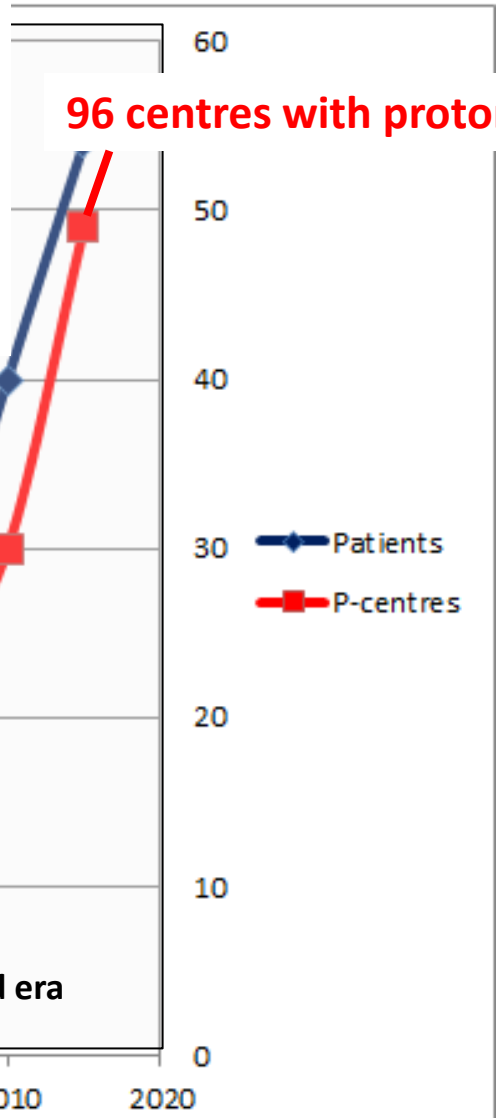
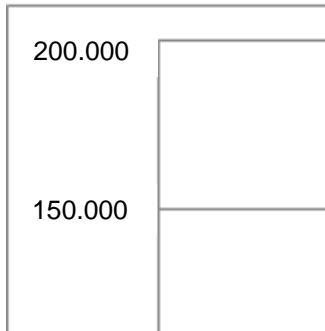
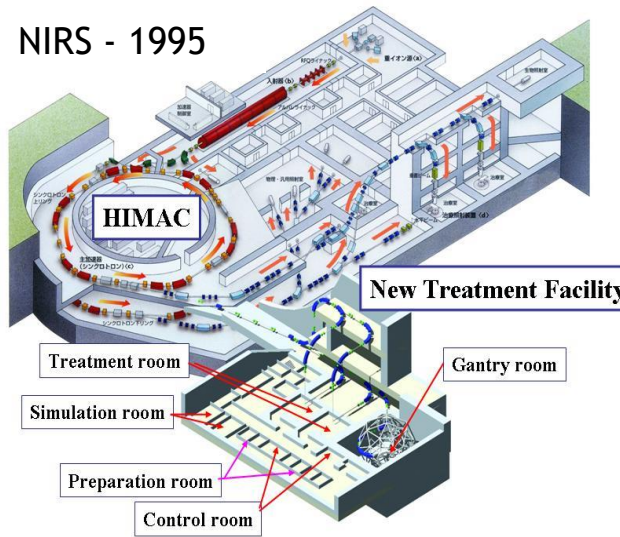


IAEA

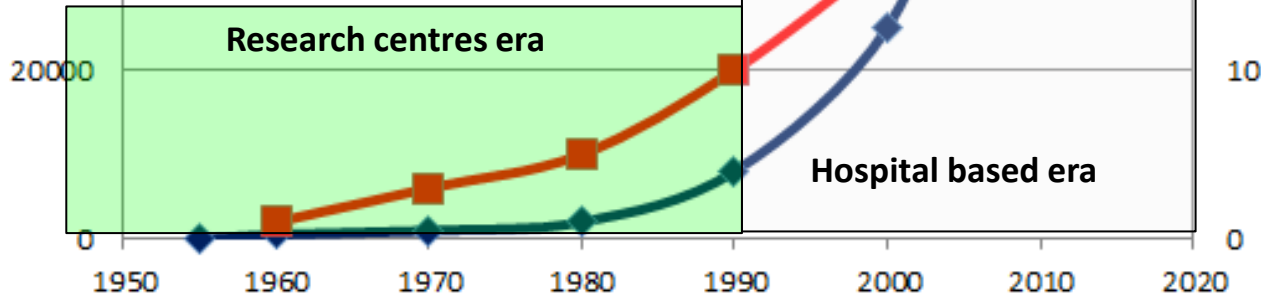
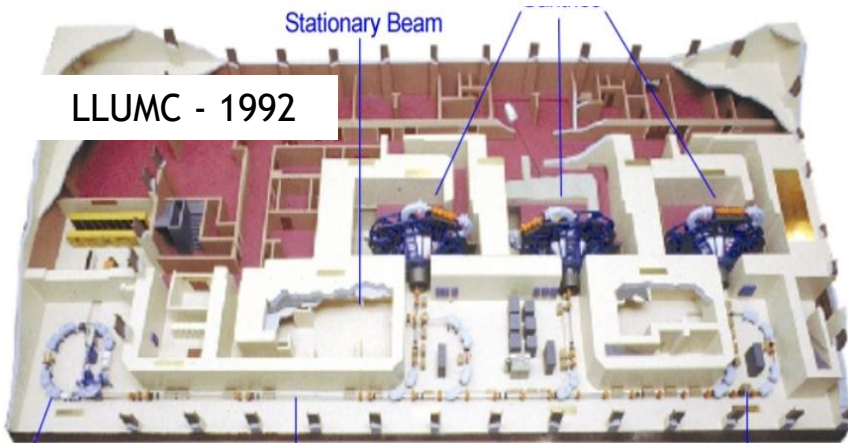
DIRAC

Directory of
Radiotherapy Centres

NIRS - 1995



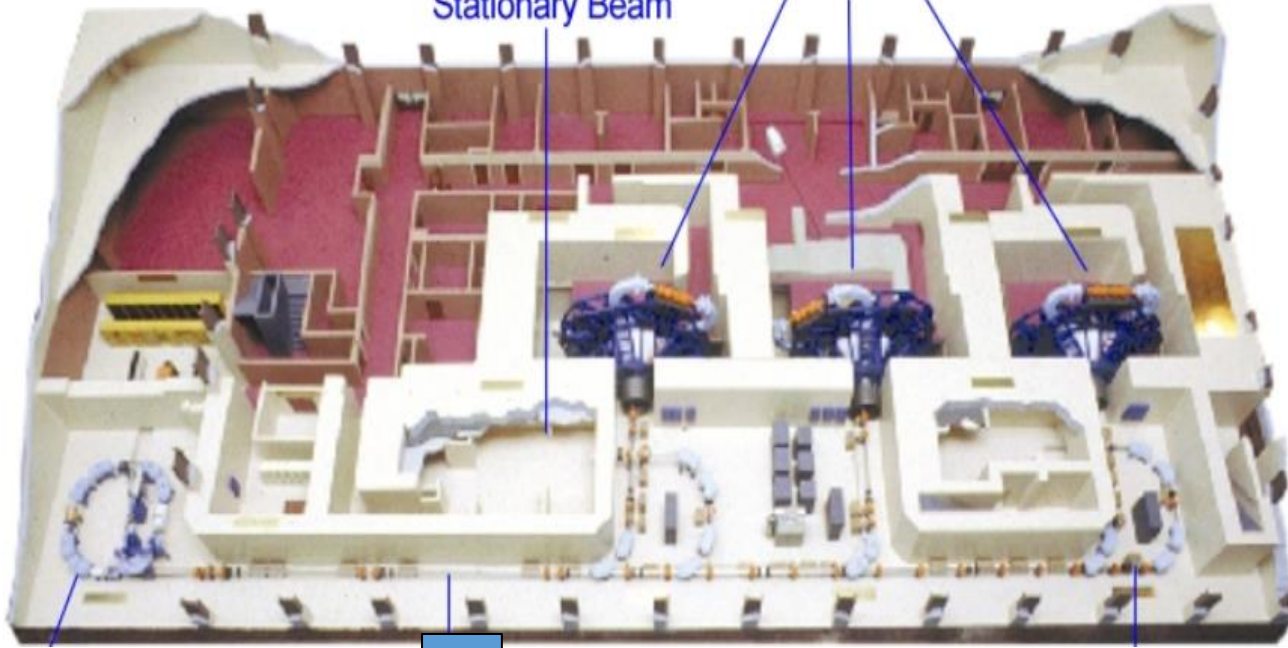
LLUMC - 1992



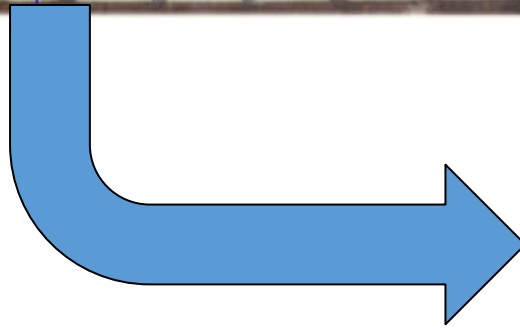
LLUMC - 1992

Stationary Beam

Gantries



Multi-rooms
Large footprint
HT costs (~100 M\$)



Single-room
Small footprint (8-10 times less)
HT costs (~25 M\$)



96 centres with **protontherapy** (+30 in construction)

330.000 patients treated (+40.000/year) [www.ptcog.ch]



MEVION S250
Superconducting

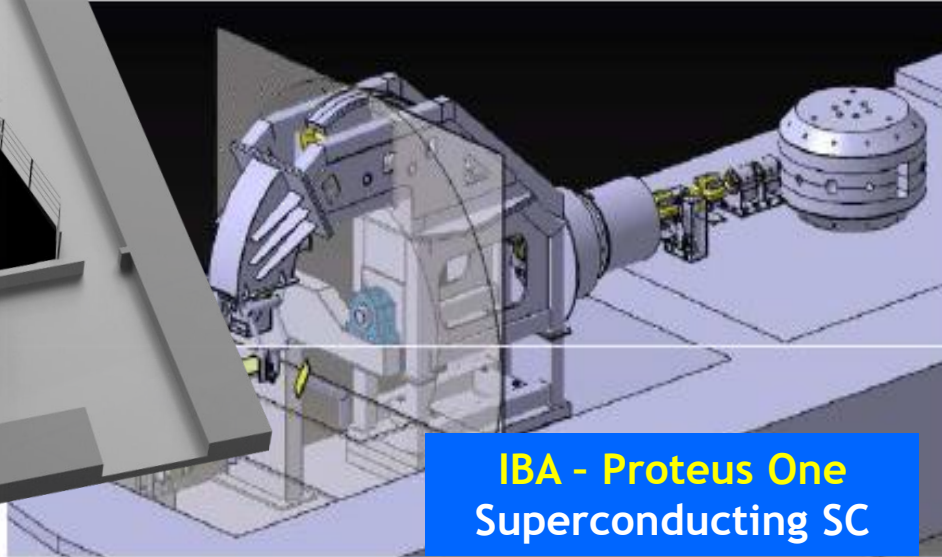


Varian - Probeam
Superconducting SC

Hitachi (synchrotron)

Solution adopted to
expand CNAO facility

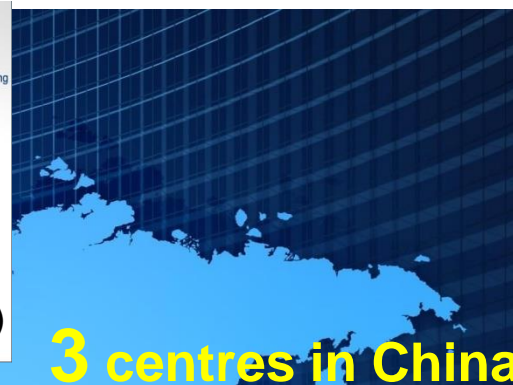
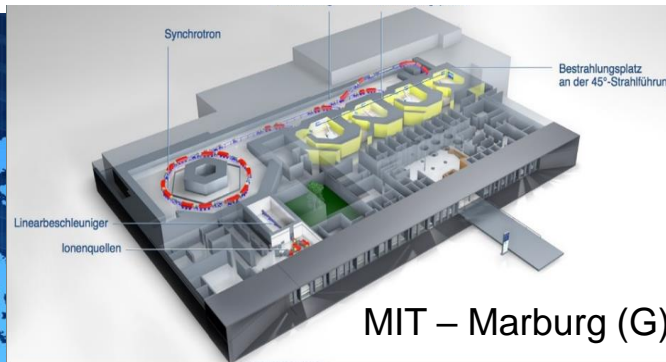
Ready in 2024



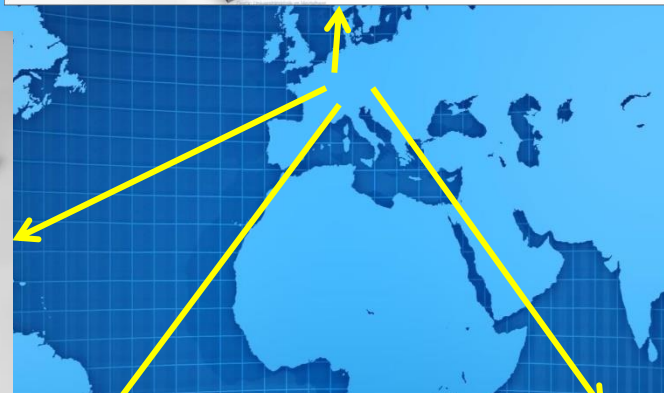
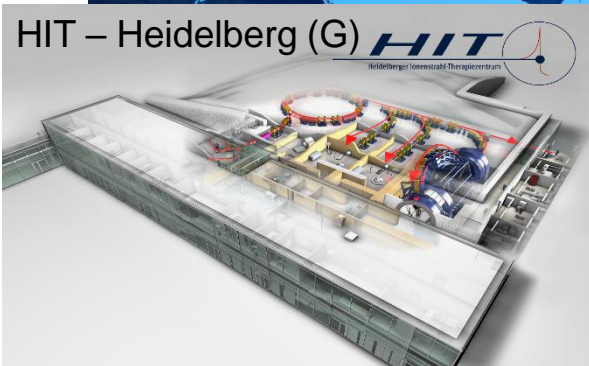
IBA - Proteus One
Superconducting SC

13 centres carbon ions, 6 multi-particle (+5 in construction)

45.000 patients treated (+5.000/year) [www.ptcog.ch]

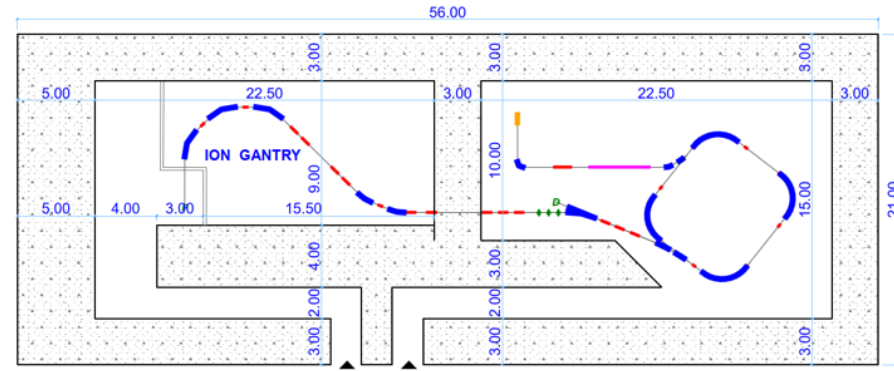
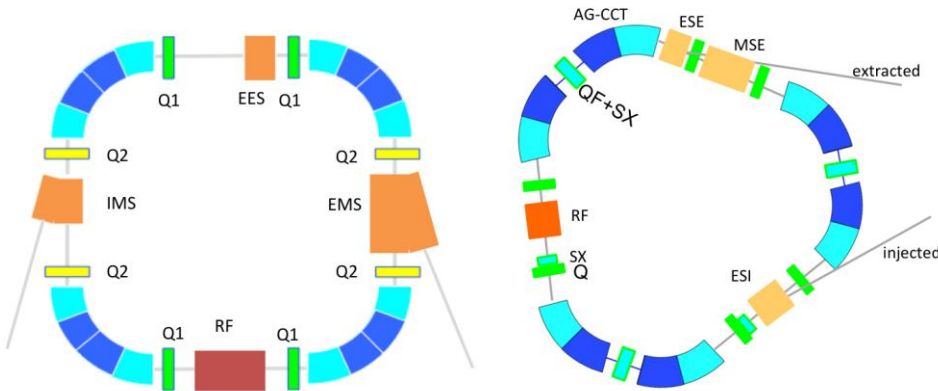


3 centres in China



6 centres in Japan

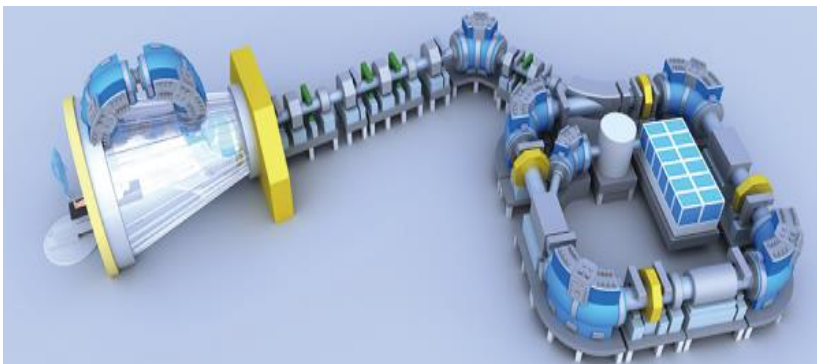




TREATMENT AREA

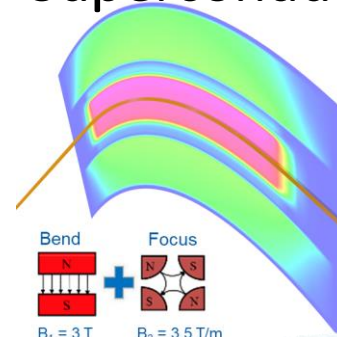
TOTAL AREA : 1176.00m²

Quantum Scalpel 5th Model (10x20 m²)

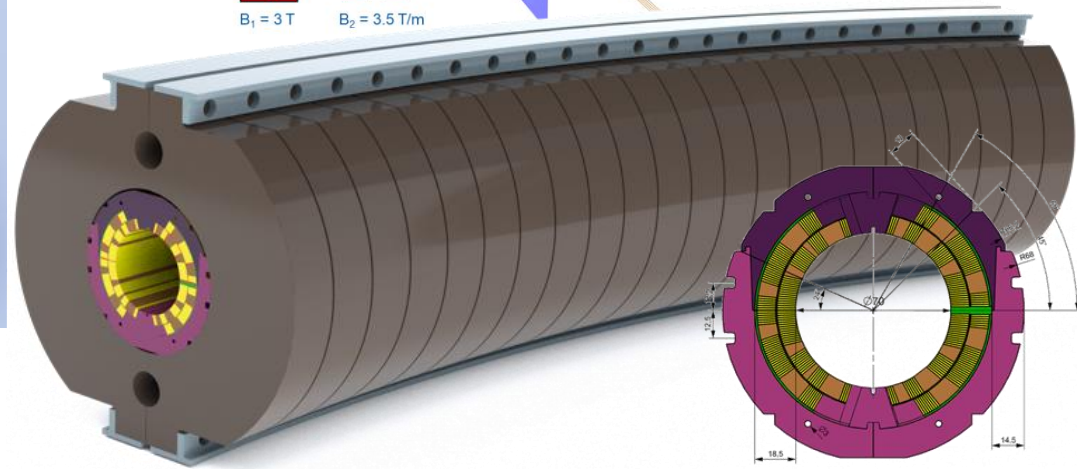


Superconducting Magnet Design

Final design: Dip+Quad
= combined function



Bend $B_1 = 3\text{ T}$ Focus $B_2 = 3.5\text{ T/m}$



20 Years of ENLIGHT: ready for adulthood

FROM THE ENLIGHT COORDINATOR

Manjji Dosanjh



2020 has been no ordinary year. We all had to slow down and even hadrontherapy centres have seen the number of treatments decrease because of the travel restrictions and challenges imposed on the hospital staff by the pandemic. The Coronavirus has impacted all of us, in one way or another. But it didn't stop our studies and even the development of new technologies, such as FLASH. It didn't stop our visionary projects for the diffusion of radiation therapy in developing countries. The online modality was a huge limitation for our social activities.



HIGHLIGHTS
December 2020

We had dreams, we had hopes, we had a vision. Twenty years later, we can proudly say that we have achieved a lot. We are now ready for the next two decades and for adulthood. The challenges ahead of us are neither fewer nor less ambitious than those we faced twenty years ago but we are ready to take them on. Our network is strong and still unique, it has (and, it shares!) the expertise for supporting new projects, for training new experts and for developing new studies. Over the years, we have come closer to patients: our workshops, meetings and conferences have helped our members reduce that gap – "from the lab to bed" – that prevents people from benefiting from the latest, cutting-edge technologies to combat cancer.

2020 has been a challenging year for all people but, in particular, for the cancer patients. Their life was tough enough without the virus. In some cases, diagnoses have been postponed, treatments had to be delayed. Science and medicine, our pillars, have been under the spotlight over the last months and this will continue for many months ahead. However, we know that budget sustainability will be an issue for all of us.

The post-Corona era has started and ENLIGHT will be there to support our members and their dreams, hopes and visions. I send my warmest season's greetings to you and your loved ones! Have a great 2021!

Manjji Dosanjh

3



HIGHLIGHTS
December 2021



HITRI^{plus} PARTNERS

Project start: April 2021- Duration: 4 years



European Organisation for Nuclear Research



GSI Helmholtzzentrum für Schwerionenforschung



Istituto Nazionale di Fisica Nucleare



RIGA TECHNICAL UNIVERSITY



South East European International Institute for Sustainable Technologies



UNIVERSITÄTSKLINIKUM GIESSEN UND MARBURG



UNIVERSITÄTSKLINIKUM HEIDELBERG



L-Università ta' Malta



Philipps Universität Marburg



UPPSALA UNIVERSITY SWEDEN



Wigner



KLINIČKI CENTAR Crne Gore



Jožef Stefan Institute



SENTRONIS a SENIS company



Cyril and Methodius University in Skopje

22 Institutes from 14 EU Countries
(4 CIRT centres, 10 res. inst., 5 universities, 3 SMEs)

www.hitriplus.eu



Heavy Ion Therapy Research Integration

Cost controlling in an hadrontherapy facility The case of CNAO

Maria Vittoria Livraga



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STRUCTURE OF THE ADMINISTRATIVE DEPARTMENT

Area	Tasks	Output	Controls
Accounting	First recording of all documents related to economic transactions	Balance Sheet, P&L, Financial Statement, all fiscal declarations and fulfilments according to law and local rules	Board of auditors, Financial auditors, external National authorities
Clinical Administration	Manage all patients demographic information, agenda, billing, international patients, acceptance desk, external procedure reservations, first reporting of clinical activity	Monthly reporting required by the National Health Authority, all reports related to running activities, specific reports functional to scheduling	External Local Health Authorities, Notified Body for ISO9001, JCI
Controlling	Strategic long term plan, budget, monitor results and produce delta analysis, verification of compliance of each proposal of expenditure with the budget approved, budget and reporting of specific projects funded with external resources (e.g.: HITRI <i>plus</i>)	Business plan, budget, all different types of reports	Board of auditors, Financial auditors, Funding entities (EU, Ministry of Health, Region Lombardy, Others)
Procurement Office	Manage orders of goods and services in accordance with local rules	Orders, documents related to call for tenders, specific reports required by local authorities	Board of auditors, Notified Body for ISO 9001, JCI

WHY PLANNING, PROGRAMMING, CONTROLLING AND REPORTING?

- to take strategic decisions about the development of new activities, new protocols, collaborations with other entities, research programmes, acquisition of new medical devices...
- to monitor the performances compared with goals
- to check if public health reimbursement fees are adequate to cover all the costs of the activity or, in case of a private entity, to state a correct price for the treatment
- to check if the resources already available internally in term of personnel, equipments, spaces etc. are adequate to achieve the goals
- to present the projects to public and private funding entities in order to find external resources
-



PLANNING PROGRAMMING CONTROLLING AND REPORTING

Activity	Time horizon	Description and examples
Planning	Long term (5 or more years)	Phase of realisation and clinical trials years 2001-2013 From the start of the clinical activity to a full running phase 2014-2022 Expansion phase 2019-2024
Programming	Short term (1 year)	Define a budget in a short term referring period in terms of activities, revenues, resources required, costs and cash absorption
Controlling	On a daily basis	Ensure that activity is performed accordingly to budget
Reporting	Different periodic reports according to the object	To compare the result of the activity with the past year results and with goals stated in the strategic plan or in the budget

ECONOMIC INFORMATION FLOW



Interactions of the controllers with the department and the Direction

Data management support to collect and organise information

Procedures and controls



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INFORMATION ABOUT CLINICAL ACTIVITY

Sources and data management support

- Software for demographics, agenda, billing and reporting to external authorities (ADT = Admission Discharging Transfer)
- Software for managing clinical activities (Mosaiq)
- Excel, Power Query and power pivot for the reporting

Track of events

Patients
 Treatments
 Broken treatments
 First consultations
 Follow up consultations
 Follow up imaging

Billing

National Health Insurance
 Private patient
 Other

Type of treatment

Boost (<10 fractions)
 Entire Cycle (16 to 30 fract)
 Eye Melanoma

Patient provenance

Referring Institute, Specialists,
 Self referral patients
 Geographic provenance

Other informations

District of the tumor
 Tumor volume
 Use of Gating
 Retreatment
 Need of Anaesthesia

 .

Beam time for treatment

Beam time/particle with or without organ motion
 Beam time for treatment area
 Beam time for tumor volume

Type of imaging

CT
 MR
 Pet-CT



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INFORMATION ABOUT COSTS AND USE OF THE RESSOURCES

Sources and data management support

ERP able to manage in integrate modality active and passive economic cycle of the resources

- request of goods, services, personnel from departments
 - authorisation process related to the supply
 - orders of goods and services to suppliers and logistic related
 - Invoice, cash receipts and payments
 - assets
 - **multilevel analytic accounting able to cross an analytic chart of account with cost and subcost centers, contracts, budget items expenditure**
 - easy to manage and personalize reporting
- + Different permissions and personalized internal level of authorisation of orders to suppliers

Excel and Power Query are actually the base of implementing the **ACTIVITY BASED COSTING** to determine the standard direct cost of the clinical procedures

EXAMPLE: COST CENTER STRUCTURE

08	SISTEMI/MANUTENZIONI	08.01	Alta Tecnologia generico
		08.02	Installazione e Allineamento
		08.03	Alimentatori
		08.06	Diagnostica di Fascio
		08.07	Linac
		08.08	Magneti Convenzionali e Betatrone
		08.09	Magneti Speciali
		08.10	Nozzle Assembly
		08.13	Radiofrequenza
		08.14	Sistema da Vuoto
		08.15	Sistema di Controllo
		08.16	Sorgenti
		08.17	B-train

22	Progetti GRANTS	22.01	Ulice
		22.02	Partners
		22.03	MEDICIS PROMED
		22.04	OMA
		22.05	OTERO
		22.06	INSPIRIT
		22.07	HITRI PLUS

25	ESPANSIONE	25.01	AMPLIAMENTO EDIFICIO
		25.02	GANTRY PROTONI
		25.03	OPERE STRADALI
		25.04	FISICA MEDICA
		25.05	Radioprotezione
		25.06	GESTIONE PROGETTO
		25.07	BNCT
		25.08	INFRASTRUTTURA IT
		25.09	ARREDI

20	Attivita' commerciale	20.01	MA Dose Delivery
		20.02	MA Chopper Faraday Cup

EXAMPLE OF ANALYTIC CHART OF ACCOUNT

		8.03.01.01	Advisory Board Medico	8.04.02.03.01	Manut. Ordin. TPS e Attrezz. Dosimetrica
		8.03.01.02	Advisory Board Tecnico	8.04.02.03.02	Mat.Cons. per Manut.TPS e Attr.Dosimetr.
		8.03.01.03	Emolumenti CDI	8.04.02.03.03	Manut. Straord. TPS e Attrezz. Dosimetr.
		8.03.01.04	Emolumenti CTS	8.04.02.04.01	Manut. Ordin. Radioprotezione
		8.03.01.05	Emolumenti Collegio Revisori	8.04.02.04.02	Mat.Cons. per Manut. Radioprotezione
		8.03.01.09	Emolumenti Comitato Etico	8.04.02.04.03	Manut. Straord. Radioprotezione
		8.03.01.13	Emolumenti DPO	8.04.02.05.01	Manut. Ordin. Attrezzatura Medica
		8.03.01.11	Emolumenti Organo di Vigilanza	8.04.02.05.02	Mat.Cons. per Manut. Attrezzatura Medica
8.04.01.01.01	Manut. Ordin. Imp. Elettrico	SUB TOT	Organi collegiali	8.04.02.05.03	Manut. Straord. Attrezzatura Medica
8.04.01.01.02	Mat. Cons. per Manut. Imp. Elettrico	8.03.01.06	Costo Personale - Dipendenti	8.04.02.06.01	Manut. Ordin. CAPH
8.04.01.01.03	Manut. Straord. Imp. Elettrico	8.03.01.07	Costo del Personale - Collab. Progett	8.04.02.06.02	Mat.Cons. per Manut. CAPH
8.04.01.02.01	Manut. Ordin.Imp.Termico/Condizionamento	8.03.01.08	Costo del Personale - Progetti UE		
8.04.01.02.02	Mat.Cons. per Manut. Imp.Termico/Condiz.	8.03.01.12	Compensi per libera professione		
8.04.01.02.03	Manut. Straord. Imp.Termico/Condiz.	SUB TOT	Costo del personale		
8.04.01.03.01	Manut. Ordin. Imp. Idrico	8.03.02.01	Consulenze Alta Tecnologia		
8.04.01.03.02	Mat.Cons. per Manut. Impianto Idrico	8.03.02.02	Consulenze Mediche/Fisica Sanit.		
8.04.01.03.03	Manut. Straordin. Imp. Idrico	8.03.02.03	Consulenze Informatiche		
8.04.01.04.01	Manut. Ordin.Imp. Raffreddam.Sincrotrone	8.03.02.04	Consulenze Tecniche Impiantistiche		
8.04.01.04.02	Mat.Cons. Manut. Imp. Raffr. Sincrotrone	8.03.02.05	Consulenze Sicurezza Radioprotezion		
8.04.01.04.03	Manut. Straord. Imp. Raffr. Sincrotrone	SUB TOT	Collaborazioni tecniche e mediche		
8.04.01.05.01	Manut. Ordin. Imp. Trasporto/Movimentaz.	8.04.02.01.01	Manut. Ordin. Alta Tecnologia		
8.04.01.05.02	Mat.Cons. Manut. Imp. Trasp./Movimentaz.	8.04.02.01.02	Mat.Cons.per manut.HT e parti rican.		
8.04.01.05.03	Manut. Straord. Imp. Trasp./Movimentaz.	8.04.02.01.03	Manut. Straord. Alta Tecnologia		
8.04.01.06.01	Manut. Ordin. Accessi	8.04.02.01.05	Parti di ricambio N.I.	4.02.05.02	Investimenti Spares
8.04.01.06.02	Mat.Cons. per Manut. Accessi	8.04.02.01.06	Materiale di laboratorio	4.02.05.03	Investimenti Linea Sperimentale
8.04.01.06.03	Manut. Straord. Accessi	8.01.02.06	Acquisto Gas	4.02.05.04	Investimenti Gantry
8.04.01.07.01	Manut. Ordin. Ascensori	8.04.02.02.01	Manut. Ordin. Imaging	4.02.06.01	Investimenti Edificio Impianti
8.04.01.07.02	Mat.Cons. per Manut. Ascensori	8.04.02.02.02	Mat.Cons. per Manut. Imaging	4.03.04	Autoveicoli aziendali
8.04.01.07.03	Manut. Straord. Ascensori	8.04.02.02.03	Manut. Straord. Imaging	4.05	DA ALLOCARE
8.04.01.08.01	Manut. Ordin. Interfono	8.04.02.03.01	Manut. Ordin. TPS e Attrezz. Dosimetrica	4.06.01.01	Rim.lavori in corso - Costi Sospesi
8.04.01.08.02	Mat.Cons. per Manut. Interfono	8.04.02.03.02	Mat.Cons. per Manut.TPS e Attr.Dosimetr	4.06.02.01	Rim.lavori in corso - Quota Ricavo
8.04.01.08.03	Manut. Straord. Interfono	8.04.02.03.03	Manut. Straord. TPS e Attrezz. Dosimetr.	4.06.03.01	Rim. materie prime
8.04.01.09.01	Manut. Ordin. Antincendio	8.04.02.04.01	Manut. Ordin. Radioprotezione	SUB TOT	INVESTIMENTI e MIGLIORIE
8.04.01.09.02	Mat.Cons. per Manut. Antincendio	8.04.02.04.02	Mat.Cons. per Manut. Radioprotezione	8.05.01.01	Canoni Assistenza/Manutenzione IT
8.04.01.09.03	Manut. Straord. Antincendio	8.04.02.04.03	Manut. Straord. Radioprotezione	8.05.01.02	Canoni Noleggio Macchine Elettronici
8.04.01.10.01	Manut. Ordin. Struttura Edificio	8.04.02.05.01	Manut. Ordin. Attrezzatura Medica	8.05.01.03	Canoni Utilizzo Licenze
8.04.01.10.02	Mat.Cons. per Manut. Struttura Edificio	8.04.02.05.02	Mat.Cons. per Manut. Attrezzatura Medica	8.05.01.04	manutenzioni e ricambi IT compreso I
8.04.01.10.03	Manut. Straord. Struttura Edificio	8.04.02.05.03	Manut. Straord. Attrezzatura Medica	8.05.01.05	Servizi Informativi Vari
8.04.01.11.01	Manut. Ordin. Arredi	8.04.02.06.01	Manut. Ordin. CAPH	8.05.01.06	Manut.Straord. IT - up grade
8.04.01.11.02	Mat.Cons. per Manut. Arredi	8.04.02.06.02	Mat.Cons. per Manut. CAPH	8.05.02.01	Linee Dati
8.04.01.11.03	Manut. Straord. Arredi	8.04.02.06.03	Manut. Straord. CAPH	8.05.02.02	Telefonia Fissa e Mobile
8.04.01.12.01	Varie Manutenzioni Ordinarie	8.04.02.07.01	Man. Ordin. Sis. Sicurezza SIS DIS PIS	SUB TOT	Servizi Informativi /Telefonia
8.04.01.12.02	Varie Materiali Consumo per Manut.	8.04.02.07.02	Mat. Cons. Sist. Sicurezza SIS DIS PIS		
8.04.01.12.03	Varie Manutenzioni Straordinarie	8.04.02.07.03	Man. Straor. Sist. Sicurezza SIS DIS PIS		
SUB TOT	Manuntezioni edificio e impianti	SUB TOT	Manutenzioni alta tecnologia e area clinica		
				8.06.02.02	Canoni Locazione Vetture Aziendali
				8.06.02.03	Carburante
				8.06.02.04	Facchinaggio
				8.06.02.05	Imposte varie
				8.06.02.06	Libri,Riviste,Abbonam. e Sottoscrizioni
				8.06.02.07	Materiale Consumo Vario Uso Ufficio
				8.06.02.08	Affitti e spese Milano
				8.06.02.09	Spese di Rappresentanza
				8.06.02.10	Spese per Automezzi
				8.06.02.11	Spese per Riunioni ed Eventi
				8.06.02.12	Spese Postali e Bollati
				8.06.02.13	Varie
				8.06.02.14	Oneri per la Sicurezza
				8.06.02.15	Altre spese porgetti UE
				8.06.02.16	Pubblicazioni bandi e notifiche ammin.
				8.06.02.17	Servizi e spese per comunicazione
				9.03.01.01	Proventi Straordinari
				8.09.01.01	Oneri Straordinari
				SUB TOT	Servizi e spese generali
				4.07.02 - 4.07.05	Progettazione definitiva
				4.07.04	Direzione lavori
				4.07.05	Validazione progettazione defir
				4.07.06	Validazione progettazione esec
				4.07.07	Collaudo strada
				4.07.19	Collaudo statico
				4.07.20	Collaudo amministrativo
				4.07.08	Consulenze tecniche
				4.07.09	Opere edili
				4.07.09	Opere edili
				4.07.10	Protonterapia
				4.07.11	Opere stradali
				4.07.12	Arredi espansione
				4.07.13	Nuovo laboratorio espansione (
				4.07.14	Infrastruttura IT espansione
				4.07.15	Software clinici espansione
				4.07.16	Hardware generico espansione
				4.07.17	BNCT
				DA DEFINIRE	OIS
				DA DEFINIRE	TPS
				4.08.01	Terza sorgente upgrades di r
				SUB TOT	COSTI PER PROGETTI

STRUCTURE OF THE ADMINISTRATIVE DEPARTMENT SIZED ON THE ACTUAL NUMBERS OF CNAO

- transactions related to clinical activity of 600 patients per year
- ongoing expansion phase with investment in building and technology
- 2 important projects funded by external entities (CNAO role of coordinator of Hitriplus)

Area	Tasks	FTE
Accounting	First recording all documents related to economic transactions	2
Clinical Administration	Manage all patients demographic information, agenda, billing, international patients, acceptance desk, external procedure reservations	5,5 WORKING ON TWO SHIFTS
Controlling	Strategic long term plan Budget Monitor results and produce delta analysis Verification of compliance of each proposal of expenditure with the budget approved Budget and reporting of specific projects, funded with external resources (e.g.: HITRIplus)	3
Procurement Office	Manage orders of goods and services in accordance with local rules	3,5

14 FTE

Activity-Based Costing (ABC) of hadrontherapy: A review of the literature

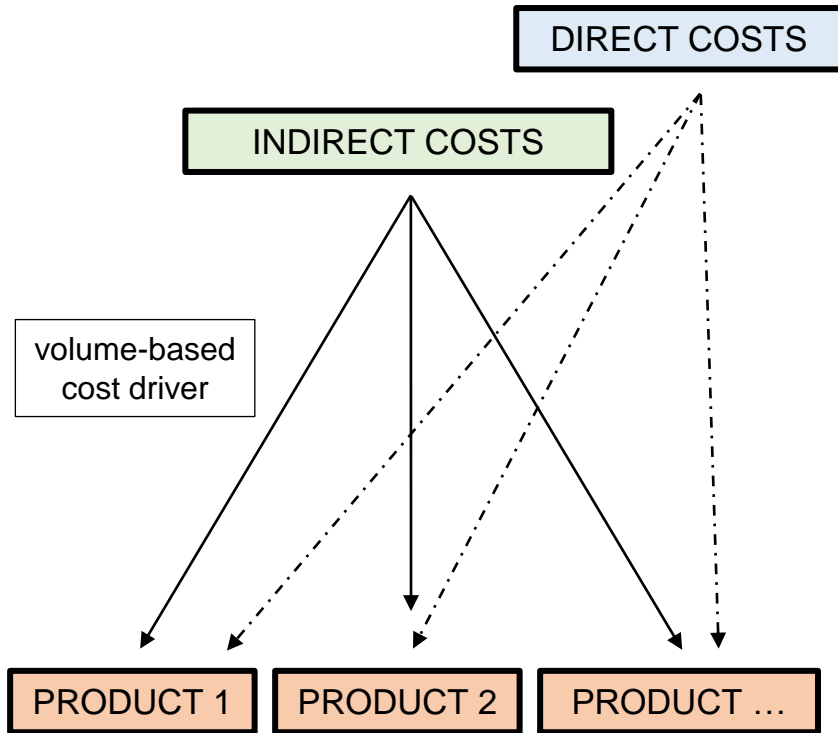
Mimoza Strikchani



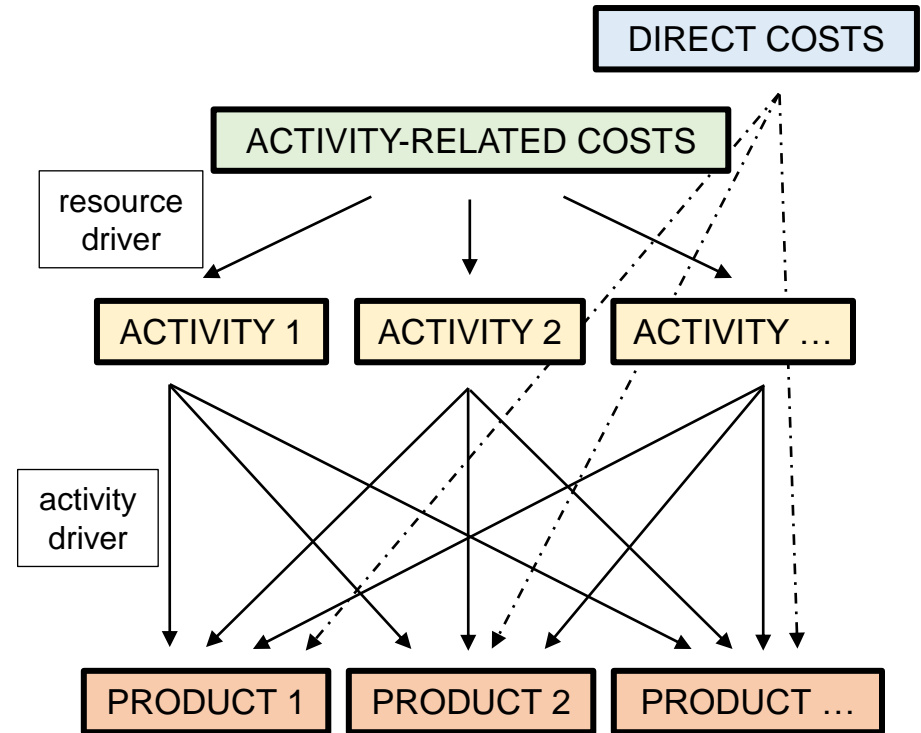
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ABC: theoretical background

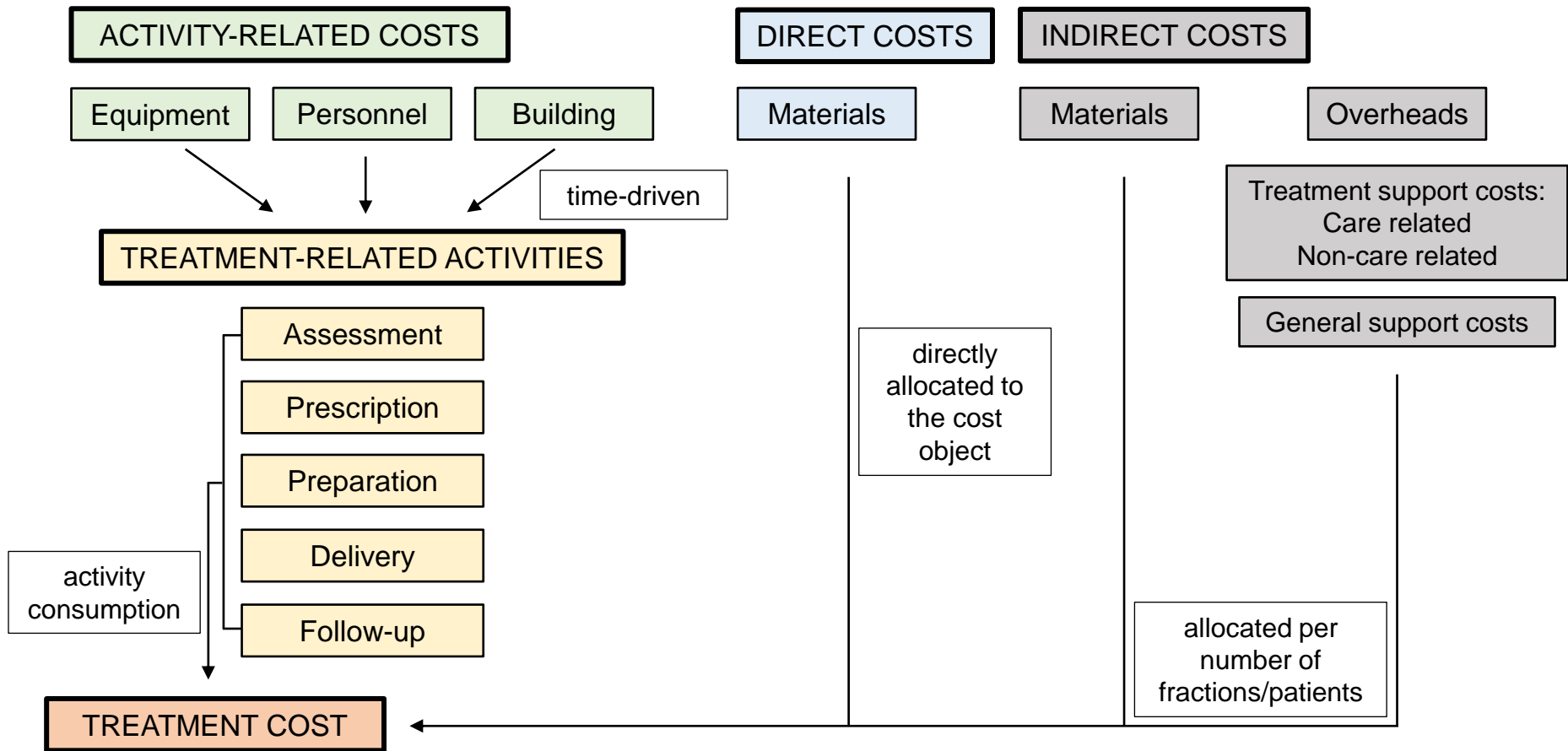
Traditional cost-accounting methodologies



Activity-Based Costing

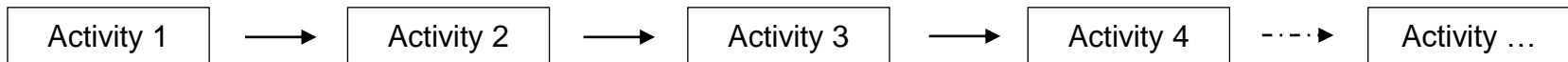


Cost allocation



ABC: activities, resources, times

1. Identify the **activities** (clinical/non-clinical) involved in the delivery of the treatment.
2. Identify the type (personnel, equipment, building)/number of **resources** employed in each activity.
3. Estimate the **time** needed to perform every activity.



The model is refined by taking into consideration the following:

- the **number of times** each activity is performed as well as its **probability of occurrence**;
- the probability for **mistakes** to be made or **unexpected events** to occur during the process;
- the **probability of employing** the resources included in the model;
- patients' characteristics that can influence the **time needed** to perform the activities.

Sources of information: interviews, direct observations, general planning, historical data, guidelines.

ABC: annual cost/annual capacity

4. Estimate the annual cost (€) and the annual capacity (**min**) of the employed resources (personnel, equipment, building), so as to determine their **capacity cost rate** (€/min), and, as a consequence, the cost of each activity.

ANNUAL COST

EQUIPMENT

Depreciation, passive interests, commissioning*, maintenance*, repair*, quality assurance*, upgrades*

* personnel cost

PERSONNEL

Salary, payroll taxes, bonuses, benefits, supervision, training, insurance, travel, office supplies

BUILDING

Depreciation, passive interests, maintenance, repair, utilities, cleaning, cooling and heating

ANNUAL CAPACITY

EQUIPMENT

Working days x minutes of work/day (corrected for the time devoted to: maintenance, repair, commissioning, quality assurance, cleaning)

PERSONNEL

Working days x minutes of work/day (corrected for: holidays, vacations, leaves, breaks, training time, overtime)

BUILDING

Linked to the annual capacity of the equipment and personnel working in the considered spaces

ABC: treatment cost

5. The **treatment cost** can be computed as the sum of:

- the **cost of the activities** involved in the delivery of the treatment (*please note* all the abovementioned elements refining the model);
- the **cost of the direct materials** employed;
- the percentage of the **indirect costs allocated to the treatment**.

Cost allocation logics:

- **Direct cost:** activity-related costs + direct costs
- **Full cost:** activity-related costs + direct costs + indirect costs
- **Company cost:** activity-related costs + direct costs + indirect costs + company-level costs (management, etc.).

Activity Based Costing approach Implementation at CNAO

Paola Mella



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008548

1st STEP





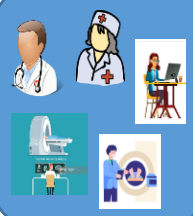






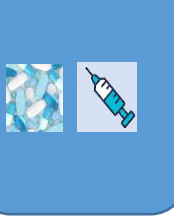
Observation of Patient path in CNAO

in order to define **activities** and **macro activities**

that compose the treatment

STANDARD PATIENT PATH

T
R
E
A
T
M
E
N
T

MACRO ACTIVITIES	ACTIVITIES	ACTIVITY-RELATED RESOURCES (4 categories)			
		Personnel	Equipment	Building	Materials
Assessment	<ul style="list-style-type: none"> • Clinical case initial evaluation • Clinical consultation • Administrative management of patient dossier 				
Treatment	<ul style="list-style-type: none"> • Imaging pre-treatment (MRI, CT,...) • Simulation and Treatment planning • Delivery • Data collection and Research activity 				
Follow-up	<ul style="list-style-type: none"> • Follow-up imaging (MRI, CT, ...) • Clinical consultation 				

DIFFERENT PATIENT PATHS → DIFFERENT RESOURCES ABSORPTION

The observation of different types of treatment brought us to identify different models because the absorption of resources and sub-resources was different.

→ Conclusion: different unitary costs per treatment type

A Proton Paediatric

B Carbon ion standard

C Proton Standard

D - Carbon ion - ACC Salivary Glands

MACRO ACTIVITIES	ACTIVITIES	ACTIVITY-RELATED RESOURCES (4 categories)			
		Personnel	Equipment	Space	Materials
Assessment	<ul style="list-style-type: none"> Clinical case initial evaluation Clinical consultation Administrative management of patient dossier 				
Treatment	<ul style="list-style-type: none"> Imaging pre-treatment (MRI, CT,...) Simulation and Treatment planning Delivery Data collection and Research activity 				
Follow-up	<ul style="list-style-type: none"> Follow-up imaging (MRI, CT,...) Clinical consultation 				

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MACRO ACTIVITIES	ACTIVITIES	ACTIVITY-RELATED RESOURCES (4 categories)			
		Personnel	Equipment	Space	Materials
Assessment	<ul style="list-style-type: none"> Clinical case initial evaluation Clinical consultation Administrative management of patient dossier 				
Treatment	<ul style="list-style-type: none"> Imaging pre-treatment (MRI, CT,...) Simulation and Treatment planning Delivery Data collection and Research activity 				
Follow-up	<ul style="list-style-type: none"> Follow-up imaging (MRI, CT,...) Clinical consultation 				

For example, in Proton paediatric, hospitalization and anaesthesia occur in high % of cases, while Carbon ion standard is typically an outpatient treatment without anaesthesia interventions.

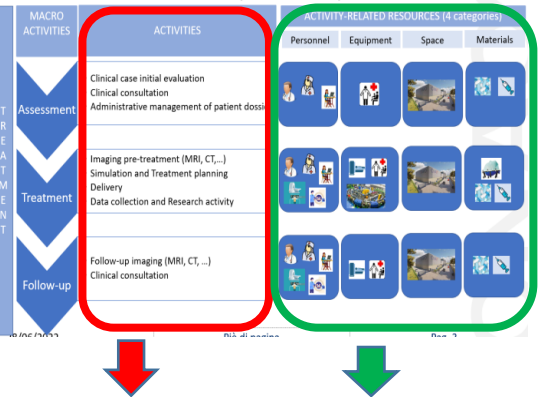


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2nd STEP

Listing all **resources** contained in the activities
(grouped in macro activities)
that compose each patient path in CNAO

HOW TO BUILD A UNITARY COST OF ACTIVITY



Quantification of time/number for each item need

Unitary cost for each item

Correction factor: average probability of occurrence of the item

Cost of Item per Activity
I x II x III

ACTIVITY	RESOURCE CATEGORY	ITEM (personnel category/type of consum./equipment/...)	input h -> Px/Equip./Spaces n. -> Consum./Serv.	ITEM Unit cost €/h -> Px/Equip. €/unit -> Spaces/Cons.	Correction factor	Cost of ITEM per ACTIVITY
First Consultation	PX COSTS	Clinical administration	0,25	€ 28,35	1,00	7,09 €
First Consultation	PX COSTS	Nurse	0,25	€ 24,13	1,00	6,03 €
First Consultation	PX COSTS	Psychologist	0,25	€ 50,00	1,00	12,50 €
First Consultation	PX COSTS	Radiation Oncologist	1,00	€ 50,80	1,00	50,80 €
First Consultation	SPACES	Spaces involved in patient path	200,00	€ 2,00	1,00	400,00 €
Session (adult patinet)	EQUIPM. COSTS	CAPH	0,28	€ 95,53	1,00	26,75 €
Session (adult patinet)	EQUIPM. COSTS	SINCROTRON	0,28	€ 173,49	1,00	48,58 €
Session (adult patinet)	EQUIPM. COSTS	SINCROTRON	0,28	€ 250,00	1,00	70,00 €
Session (adult patinet)	EQUIPM. COSTS	SINCROTRON	0,28	€ 248,09	1,00	69,47 €
Session (adult patinet)	PX COSTS	Radiation technicians	0,28	€ 27,20	1,00	7,62 €
Session (adult patinet)	PX COSTS	Radiation Oncologist	0,28	€ 50,80	1,00	14,22 €
Session (adult patinet)	PX COSTS	Medical Physicist	0,28	€ 50,01	1,00	14,00 €
Session (adult patinet)	PX COSTS	Bioengineer	0,28	€ 29,72	1,00	8,32 €
Session (adult patinet)	SPACES	Spaces involved in patient path	400,00	€ 2,00	1,00	800,00 €
Session (adult patinet)	CONSUM&SERVICES	Drug	1,00	€ 5,00	0,10	0,50 €

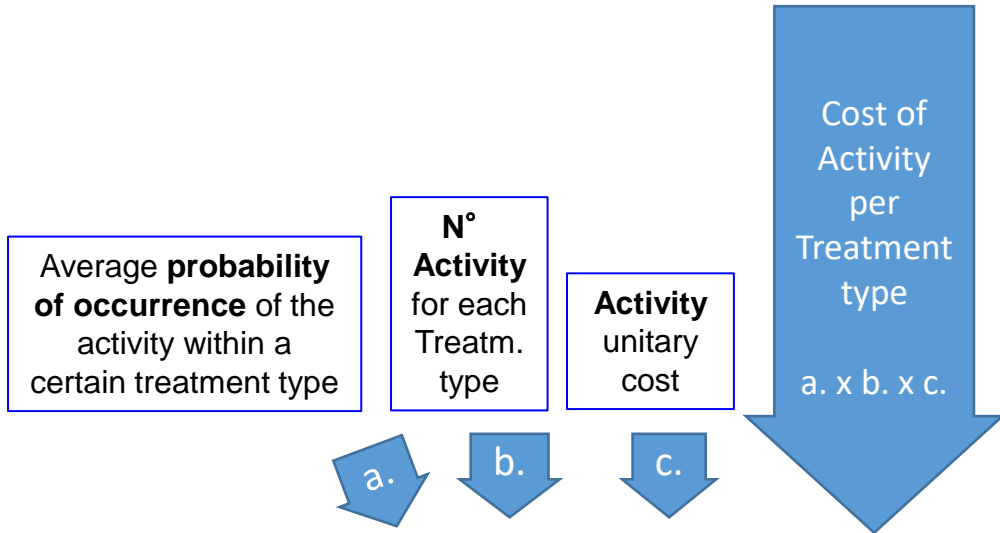
Each row is an item that composes the bill of the activity

3rd STEP

Sum up of the cost of items by activity

→ **Unitary Direct cost per Activity**

HOW TO BUILD A UNITARY COST OF TREATMENT TYPE



TREATMENT TYPE	MACRO ACTIVITY	ACTIVITY	Frequency (always, optional)	Probability of occurrence	ACTIVITIES per TREATM. TYPE	ACTIVITY Unitary cost	Cost of ACTIVITY per TREATM. TYPE
Carbon ion standard	Assessment	First Consultation	always	100%	1	€ 91	€ 91
Carbon ion standard	Treatment	CT	always	100%	1	€ 199	€ 199
Carbon ion standard	Treatment	MRI	optional	93%	1	€ 258	€ 240
Carbon ion standard	Treatment	CT PET in Cnao	optional/alternative	0%	1	€ 438	€ -
Carbon ion standard	Treatment	CT PET in external facility	optional/alternative	11%	1	€ 14	€ 2
Carbon ion standard	Treatment	Anesthesia	optional	2%	1	€ 255	€ 4
Carbon ion standard	Treatment	Other procedures in external facility	optional	100%	1	€ 498	€ 498

4th STEP

Sum up of the cost of activities by treatment type

→ **Unitary Direct cost per Treatment type**

EXAMPLES OF UNITARY COSTS OF TREATMENT TYPE

TREATMENT TYPE		Carbon ion standard	
MACRO ACTIVITY	ACTIVITY	Cost of ACTIVITY per Treatment type	
Assessment	Case evaluation from "Servizio Medico"	€	10
	Case evaluation from "International patient"	€	1
	Case evaluation from "Referring MD"	€	30
	Internal Case discussion	€	50
	Multidisciplinary Case discussion	€	10
	First consultation	€	90
	Managemente of admin dossier for foreign patient	€	2
	Managemente of admin dossier for pt to be authorised	€	60
Assessment Total		€	253
Treatment	CT	€	50
	CT with contrast agent	€	80
	Anesthesia	€	5
	MRI	€	1
	MRI with contrast agent	€	160
	CT PET in Cnao	€	-
	CT PET in external facility	€	2
	Other procedures in external facility	€	500
	Preparation plan	€	1.150
	Consultation for consent signature	€	50
	Session (adult patient)	€	4.420
	Anesthesia in session (adult patient)	€	50
	Intra-treatment consultation	€	130
	Check CT	€	70
	Check CT with preparation of a new mask	€	40
	Replanning - 1	€	80
	Replanning - 2	€	10
	Replanning - 3	€	-
	Data entry Quality of life	€	1
	Data entry Trattamento REDCAP	€	2
Data collection for clinical trial	€	6	
Treatment Total		€	6.807
Follow-up	CT	€	700
	CT with contrast agent	€	1.030
	MRI	€	10
	MRI with contrast agent	€	2.120
	CT PET in Cnao	€	-
	CT PET in external facility	€	20
	Consultation	€	520
	Second opinion of external imaging	€	130
	Data entry Follow up REDCAP	€	80
	Data collection for clinical trial	€	5
	Reaserch activity	€	7.870
	Follow-up Total		€
Total		€	19.545

TREATMENT TYPE		Proton standard	
MACRO ACTIVITY	ACTIVITY	Cost of ACTIVITY per Treatment type	
Assessment	Case evaluation from "Servizio Medico"	€	10
	Case evaluation from "International patient"	€	1
	Case evaluation from "Referring MD"	€	30
	Internal Case discussion	€	50
	Multidisciplinary Case discussion	€	10
	First consultation	€	90
	Managemente of admin dossier for foreign patient	€	2
	Managemente of admin dossier for pt to be authorised	€	60
Assessment Totale		€	253
Treatment	CT	€	50
	CT with contrast agent	€	80
	Anesthesia	€	5
	MRI	€	1
	MRI with contrast agent	€	160
	CT PET in Cnao	€	-
	CT PET in external facility	€	2
	Other procedures in external facility	€	500
	Preparation plan	€	1.150
	Consultation for consent signature	€	50
	Session (adult patient)	€	7.740
	Anesthesia in session (adult patient)	€	90
	Intra-treatment consultation	€	190
	Check CT	€	70
	Check CT with preparation of a new mask	€	40
	Replanning - 1	€	80
	Replanning - 2	€	10
	Replanning - 3	€	-
	Data entry Quality of life	€	2
	Data entry Trattamento REDCAP	€	10
Data collection for clinical trial	€	1	
Treatment Totale		€	10.231
Follow-up	CT	€	700
	CT with contrast agent	€	1.030
	MRI	€	10
	MRI with contrast agent	€	2.120
	CT PET in Cnao	€	-
	CT PET in external facility	€	20
	Consultation	€	520
	Second opinion of external imaging	€	130
	Data entry Follow up REDCAP	€	80
	Data collection for clinical trial	€	5
	Reaserch activity	€	790
	Follow-up Totale		€
Totale complessivo		€	15.889

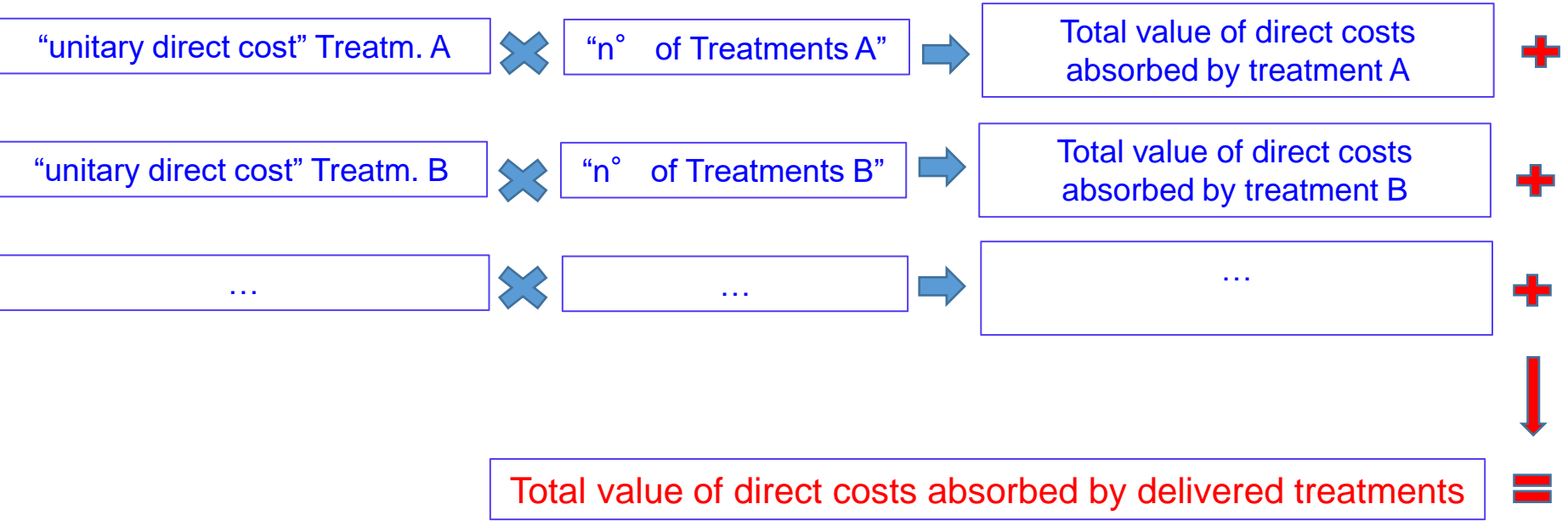
5th STEP

Definition of **yearly treatments by type**
and **multiplication for the unitary direct cost** of treatment type

TOTAL VALUE OF DIRECT COSTS

- ❑ definition of a “unitary direct cost” for each type of treatment based on ABC approach as above
- ❑ definition of the number of clinical procedures yearly delivered by the facility (per type of treatment)

Treatment type	N°
A - Proton pediatric	50
B - Carbon Ion standard	250
C - Proton standard	200
D - Carbon ion salivary glands	80
...	...
Total	580



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6th STEP

From **Unitary Direct cost per Treatment type**
to **Unitary Company cost per Treatment type**

COMPANY UNITARY TREATMENT COST

To the previously calculated Unitary Direct cost per treatment type we can add also the following Indirect Structure costs (“Overhead”):

- Top management e collegial bodies
- Financial interest
- Not clinical Advisory
- Legal expenses
- Other General services and overhead

→ All these costs could be allocated on the treatment cost

→ Literature may help in defining the best way of allocation of these residual costs on the single treatment.

COMPANY UNITARY TREATMENT COST

Results of our previous study (2015) presented to the National Health Ministry:
Unitary company costs per treatment vs current NHS tariffs at which Cnao is reimbursed

	Treatment mix	Unitary Company cost	Current NHS tariffs
Carbon Ion Entire cycle (V < 1000 cc)	187	€ 32.000,00	€ 24.000,00
Carbon Ion Entire cycle (1000 < V < 2000 cc)	56	€ 41.600,00	€ 24.000,00
Carbon Ion Entire cycle (T > 2000 cc)	113	€ 41.600,00	€ 24.000,00
Carbon Ion Boost	27	€ 16.000,00	€ 12.000,00
Carbon Ion Stereotactic	100	€ 24.000,00	€ 18.000,00
Proton Entire cycle	60	€ 18.000,00	€ 24.000,00
Proton Entire cycle - Eye melanoma	150	€ 12.000,00	€ 12.000,00
Proton Boost	57	€ 12.000,00	€ 12.000,00
Total n. of treatments	750		

--> *Optional addendum of treatment linked to complex pathology*

Gating	75	€ 10.000,00	€ 10,00
Replanning	75	€ 5.000,00	€ 10,00
Ritrattamento	128	€ 5.000,00	€ 10,00

Despite the significant part of company costs per treatment that remain without coverage, Ministry of Health's final decision was for a low fixed reimbursement fee, with no distinction between protons and carbon ions.

The difference to a full coverage of complexity of carbon ions has been balanced with a lump yearly contribution

Cost Benefit Analysis of Hadrontherapy

Maria Vittoria Livraga



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008548

Cost Benefit Analysis

«Cost-Benefit Analysis is an analytical **evaluation technique** adopted by international institutions and governments in public **decision-making** on the economic viability of projects, programmes, policies or regulatory initiatives by, first, **identifying all the costs and benefits** and, second, by **measuring them through a monetary value of the welfare change attributable to them** (Boardman et al. 1996, Florio 2014). The purpose of CBA is to support a more efficient allocation of resources demonstrating the **convenience for society of a particular decision against possible alternatives** (including the ‘do nothing’ or ‘business as usual’ alternatives)»

Under CBA, the costs and benefits associated with an investment project over a given long-run timeframe are expressed in monetary units, and the sign of the net benefit is used as the decision criterion

Why is hadrontherapy an object of CBA?

The high costs associated with hadrontherapy are mainly due to the fact that it needs significant capital investments for equipment such as accelerators, beamlines and gantries as well as buildings hosting the facilities, but hadron therapy faces the challenge of delivering a cost-effective, high-precision cancer treatment.

Year	Title	Commissioned by	Performed by	Status
2015	Cost–benefit analysis of applied research infrastructure. Evidence from health care	EIB - European Investment Bank	University of Milan, Economics and Management DPT	Concluded

In the framework of a study assessing the impact on welfare of big and high expensive technology research infrastructure. University of Milan choose CNAO as case study, for the particle accelerator specifically designed to provide medical treatment and research.

The expected net present value of research infrastructures ($ENPV_{RI}$) over the time horizon \mathcal{T} is defined as the sum of all measurable benefits associated to any actual or possible use of the research infrastructure, plus a non-use (existence) value of scientific discover B_n , net of socio-economic costs valued at shadow prices and discounted at the social discount rate r .

***Cost–benefit analysis of applied research infrastructure. Evidence from health care
Giuseppe Battistoni, Mario Genco, Marta Marsilio, Chiara Pancotti, Sandro Rossi, Silvia Vignetti***



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CBA model applied to CNAO

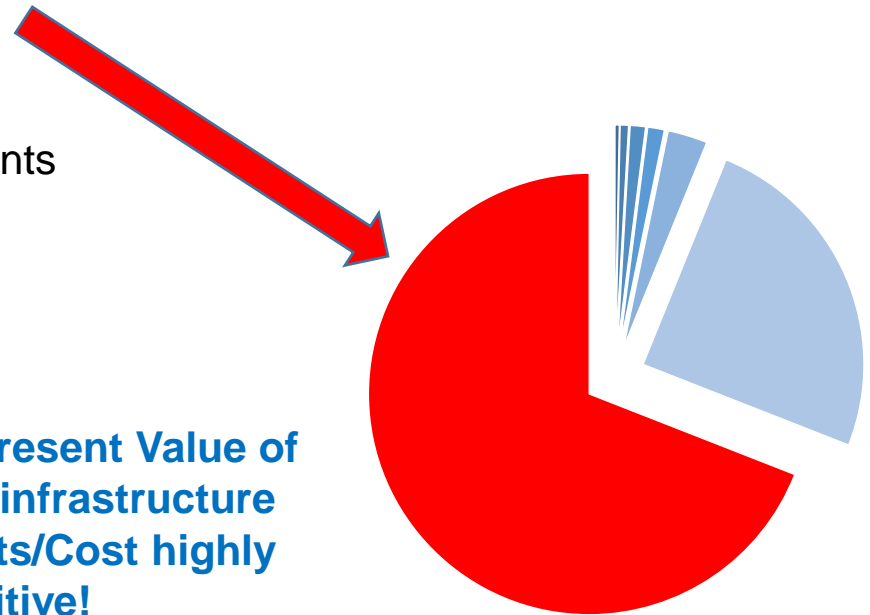
Working Hypotheses

- **Unit of analysis:** all the structure hosting the particle accelerators and the other areas functional to the proper functioning of the clinical facility
- **Time Horizon:** 2001-2031
- **Prices:** Euro at 2013 constant prices
- **Social Discount rate:** constant at 3%

Benefits

- Applied research benefits on patients
- Technological spillover
- Knowledge Creation
- Revenues on beam use and sell of components
- Human Capital benefit
- Cultural outreach

**Positive Net Present Value of
the research infrastructure
Ratio Benefits/Cost highly
positive!**



Type of health benefits

- ➔ • **Full recovery:** i.e. the patients treated gain the same life expectancy of the average healthy population
- ➔ • **Increase in life expectancy:** Treated patients gain some additional year of life. This benefit can also be combined with an effect on the quality of life
- ➔ • **Better quality of life:** Lower level of pain and suffering and no effect on life expectancy

Each Protocol has been matched to a type of benefit, and for each protocol has been identified the counterfactual, the range of patients, the number of years gained, and the quality factor of life

Year	Title	Commissioned by	Performed by	Status
2021	Progetto Analisi Costi Benefici Adroterapia	CNAO	Università Bocconi- Cergas	In progress

Aim

Study focused on clinical aspects, that takes into consideration cost and benefits related to hadrontherapy implementation and management- **The aim is to highlight with an economic measure the better quality of life assured by hadrontherapy and the costs of alternative therapy (if existing) for the patients, their caregiver and for the National Health System.**

The study is particularly focused on Carbon Ion Therapy

Year	Title	Commissioned by	Performed by	Status
2021	Working group on Protontherapy	Ministry of Health	Agenas (Agenzia Nazionale per i Servizi Sanitari)	In progress

- Projects for developing the number of dedicated hadrontherapy centers are now rapidly increasing in Italy, in reason that a proton therapy market has developed and these accelerators can be purchased on the market. That's why proton therapy compared to carbon ion therapy is much more developed and much more conventional.
- Need to review the reimbursement fees stated for hadrontherapy
- Need to define the rules of patient access to protontherapy



THANK YOU



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