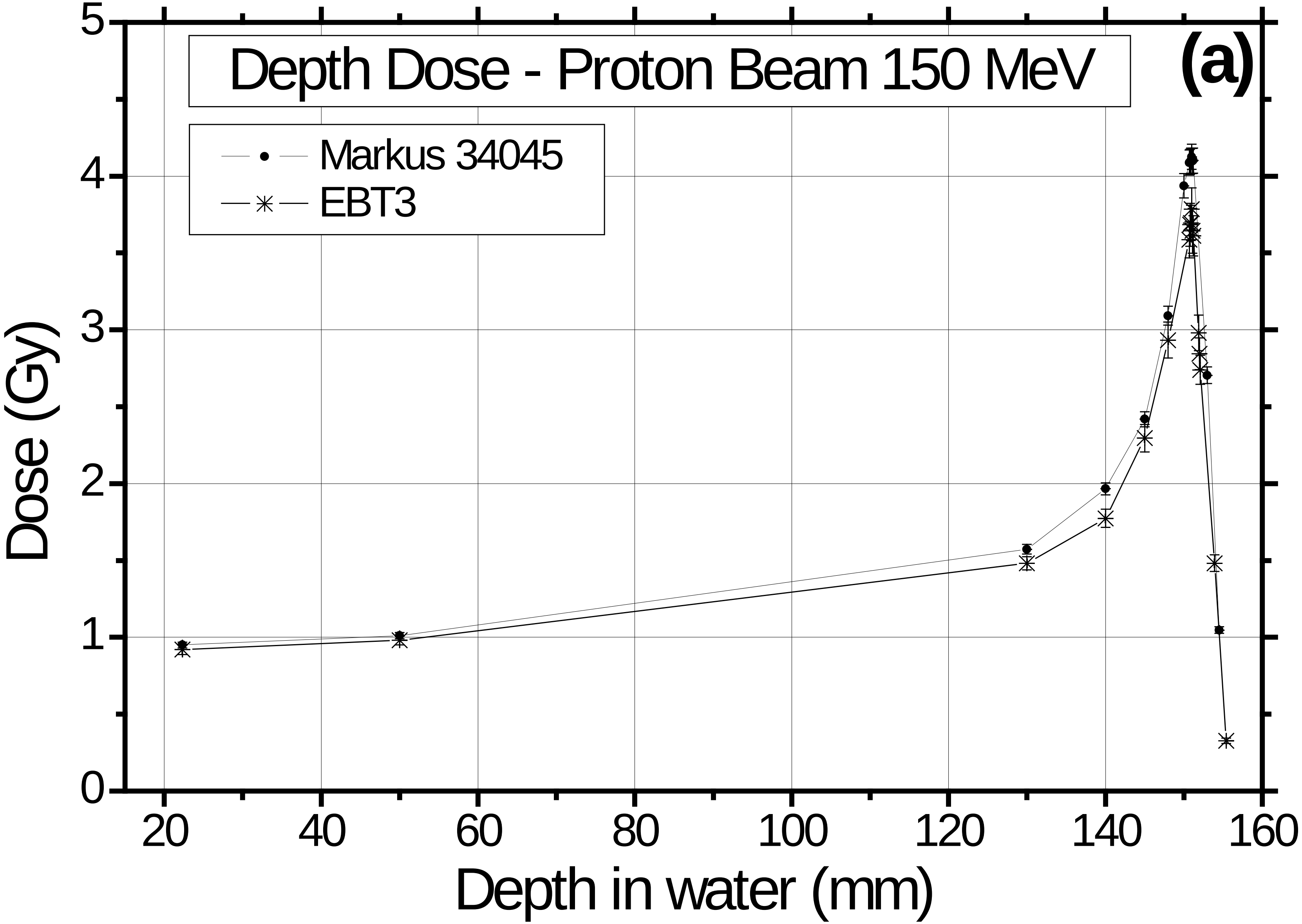
Misure per dosimetria di fasci di protoni ad energie dei MeV

Abstract

Nell'uso di fasci di protoni di alta energia per adroterapia è di interesse la misura della dose rilasciata in acqua a fine range, per energie dell'ordine dei MeV. L'acceleratore Tandem è particolarmente adatto a generare tali fasci. Si intende misurare il potere frenante dell'acqua per protoni di energia di 1-6 MeV mediante misure di perdita di energia in una targhetta liquida di noto spessore.

Inoltre, si intende misurare la curva dose-risposta di film radiocromici utilizzati per la dosimetria protonica.

Paolo Russo, Luigi Campajola, Pierluigi Casolaro, Roberta Castriconi



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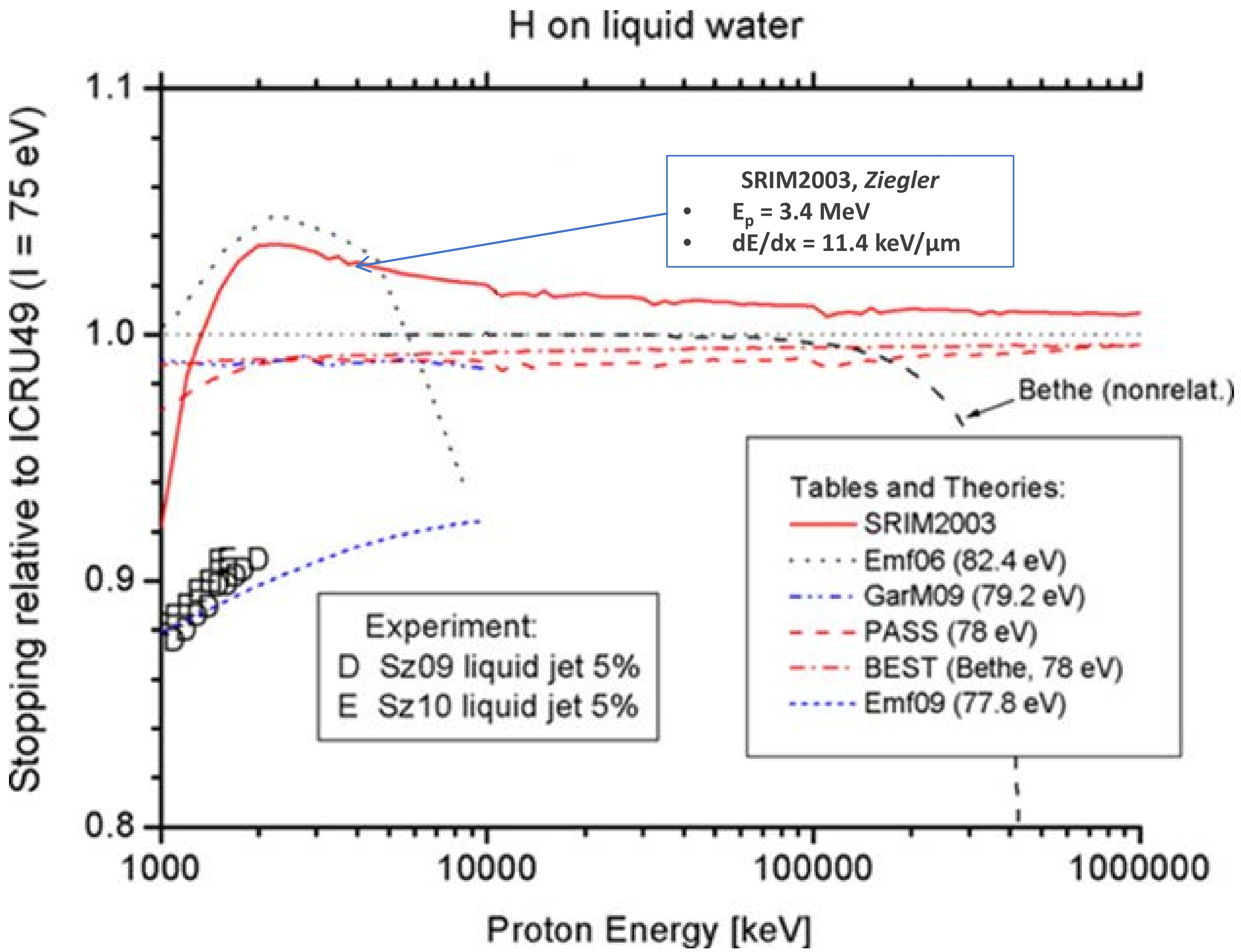
Potere frenante, protoni in acqua liquida



Potere frenante: simulazioni

- N: *National Institute of Standard and Technologies*
- S: SRIM
- T: TRIM
- L: LISE

- δ (%) : scostamento %

E_p (MeV)	δ (%) dE/dx H_2O		
	N-S	**N-T**	**N-L**
2.0	-3.6	-26.0	-26.4
2.5	-3.6	-24.2	-16.9
3.0	-3.3	-18.5	-13.0
3.4	-7.5	-18.9	-34.0
3.5	-3.1	-15.2	-10.7
4.0	-2.3	-13.2	-9.3

dE/dx (keV/μm); E_p = 3.4 MeV			
N	**S**	**T**	**L**
10.6	11.4	12.6	14.2

δ (%) anche superiori al 30 %

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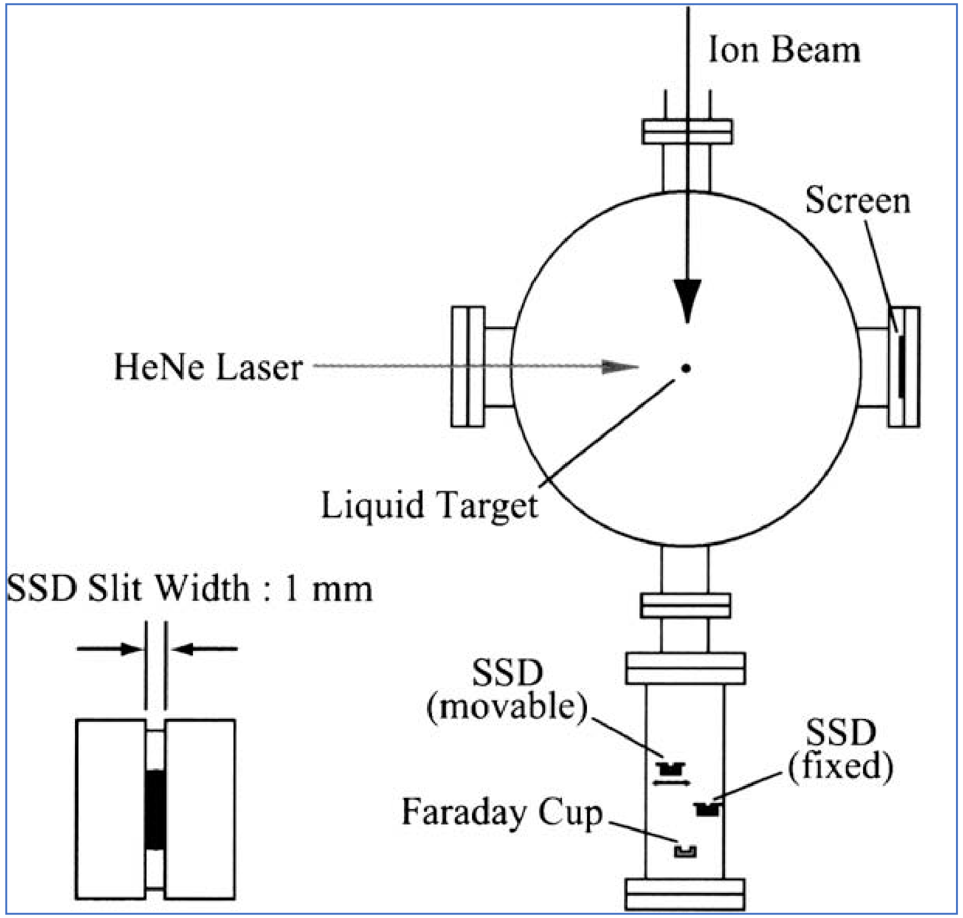
Sezioni d'urto di potere frenante



- p (2 MeV) → H_2O (50 µm)
- Getto di H_2O liquida
- 5-50 mrad
- Rivelatori SSD
- Discrepanza con i dati delle simulazioni ≈ 11%

Stopping cross section of liquid water for MeV energy protons
M. Shimizu et al., Nucl. Instr. and Meth. in Phys. Res. B 267 (2009) 2667–2670

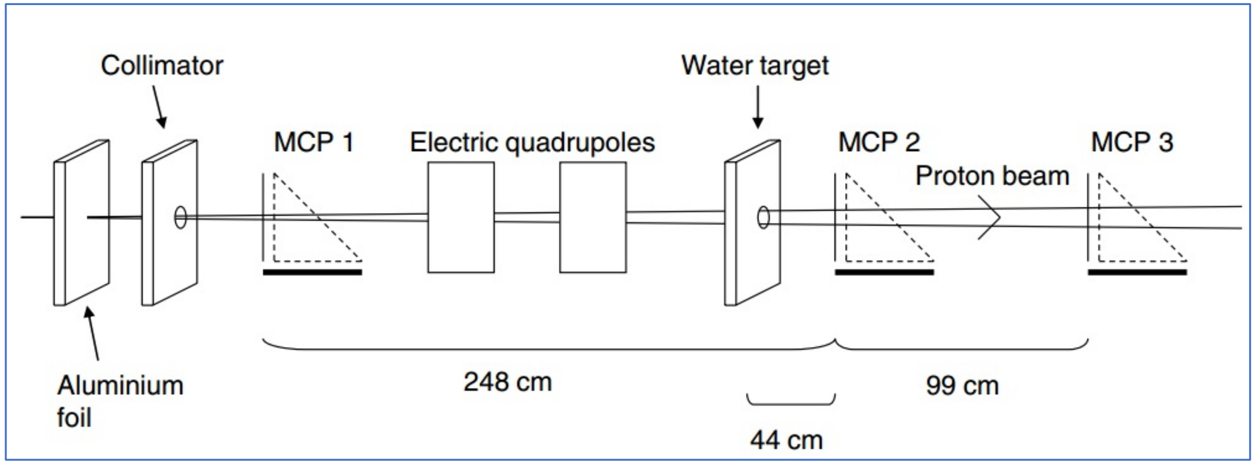
P. Casolaro, Tesi laurea magistrale, Univ. Napoli Federico II, 2015

Perdita di energia di protoni in H_2O liquida

- p (4.7-15.2 MeV) → H_2O
- Tecnica TOF

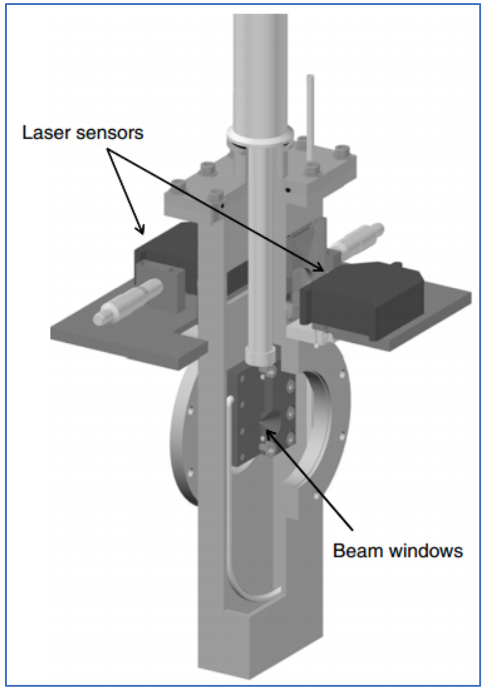
- Rivelatori MCP
- Accordo con la teoria

Setup sperimentale



Energy loss measurement of protons in liquid water
T. Siiskonen et al., Phys. Med. Biol. 56 (2011) 2367–2374

Target di H_2O



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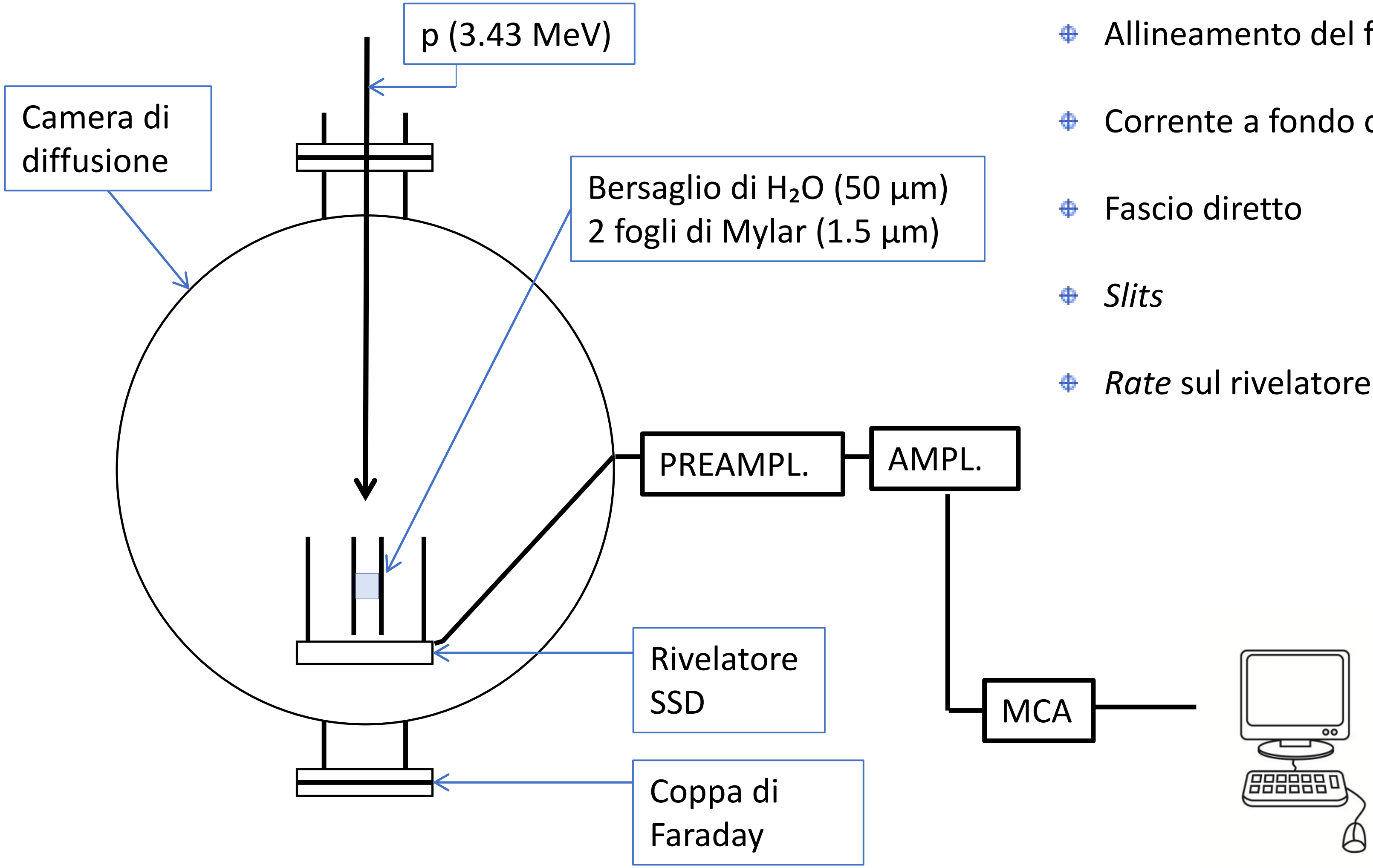
Setup sperimentale Tandem TTT-3



- Allineamento del fascio
- Corrente a fondo canale ≈ nA
- Fascio diretto
- *Slits*
- *Rate* sul rivelatore ≈ 2 kHz

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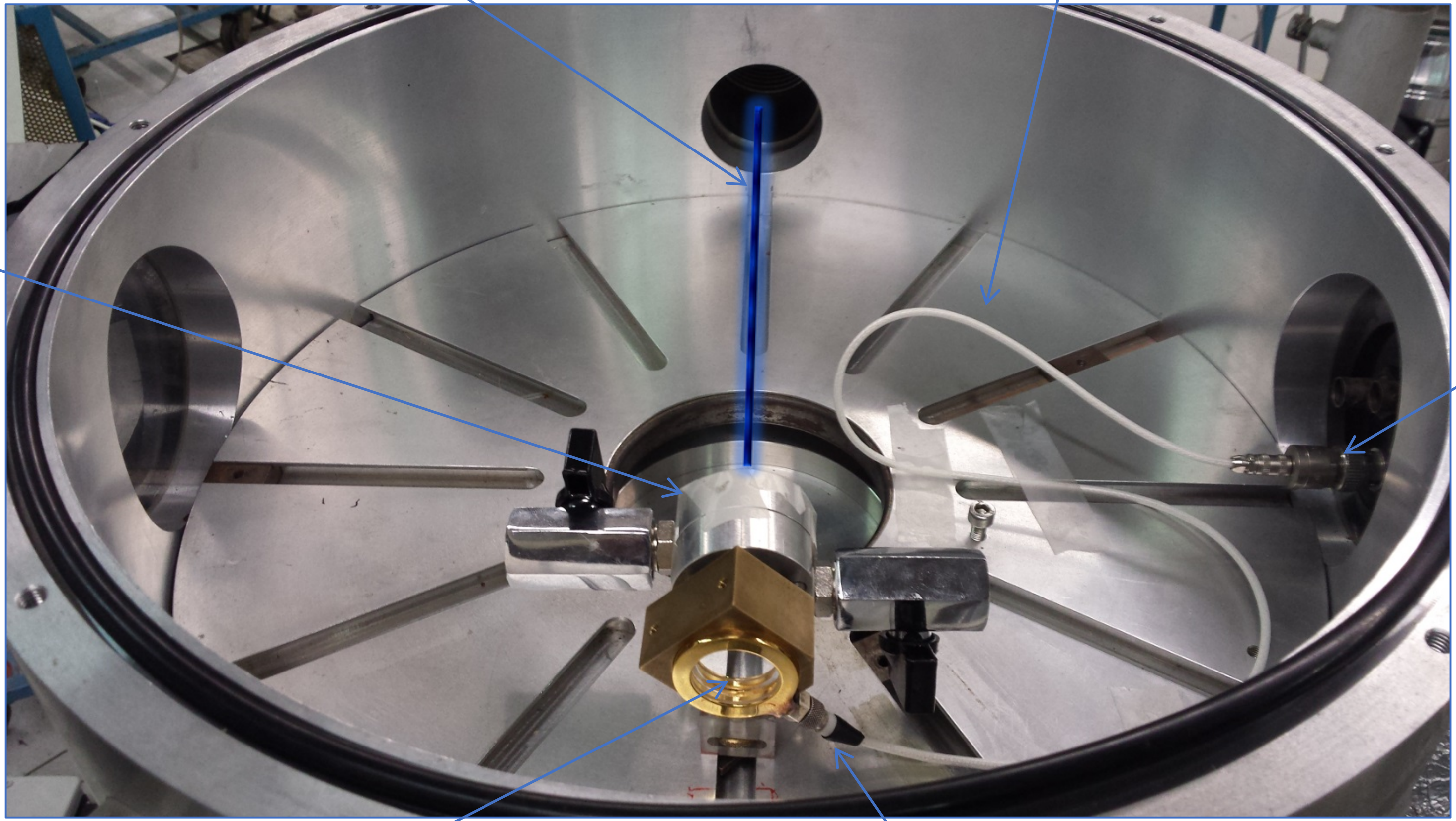
Camera di diffusione



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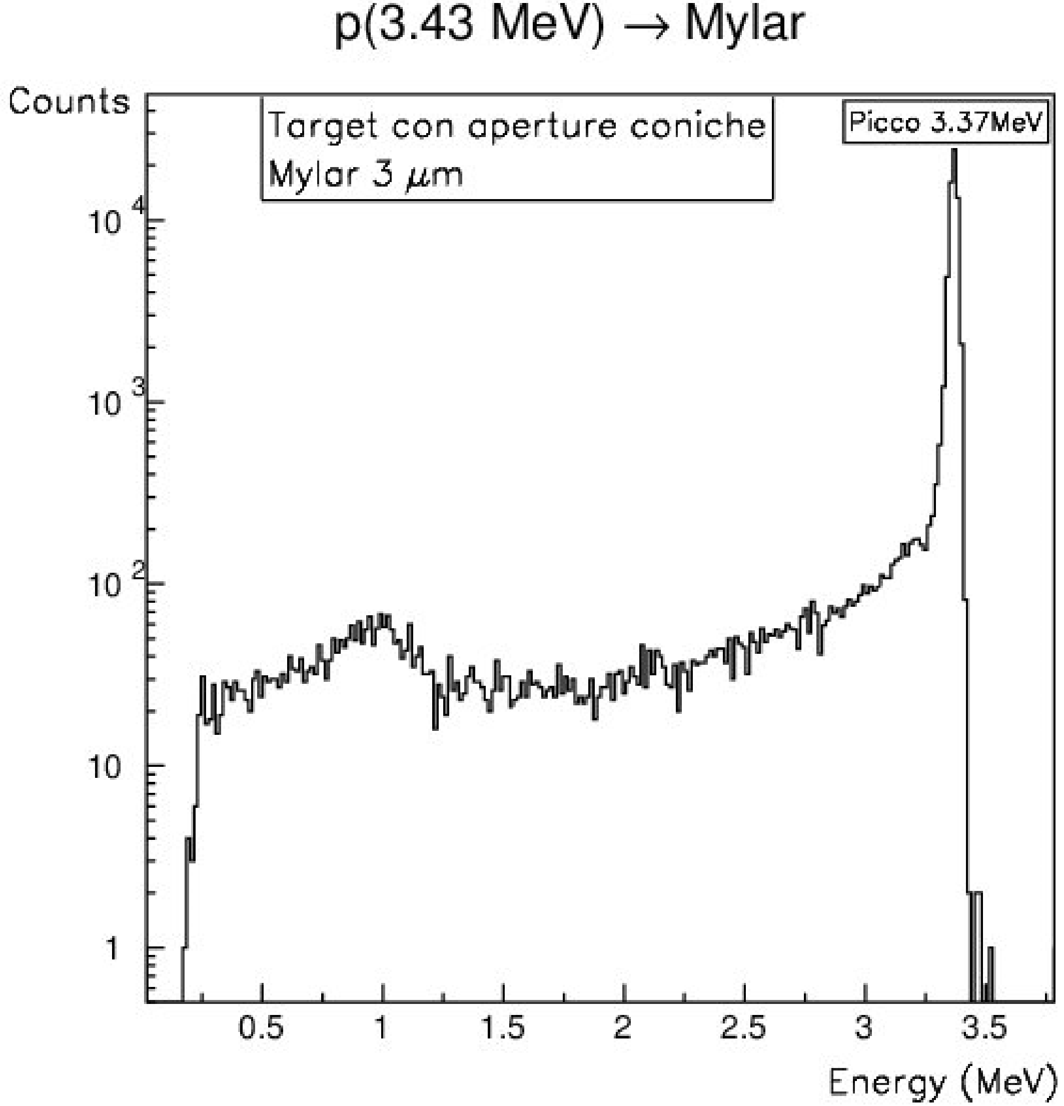
Spettri energetici (2)



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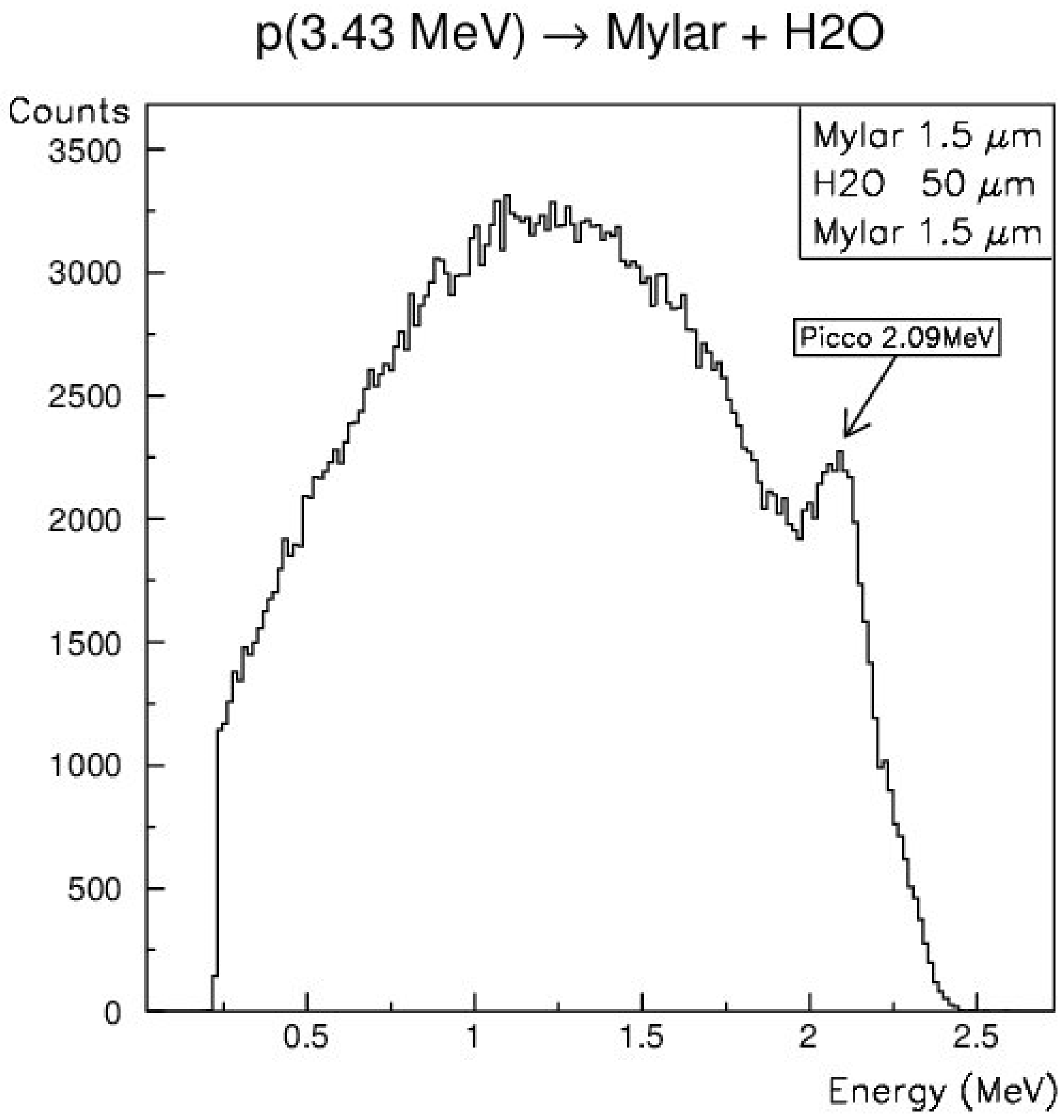
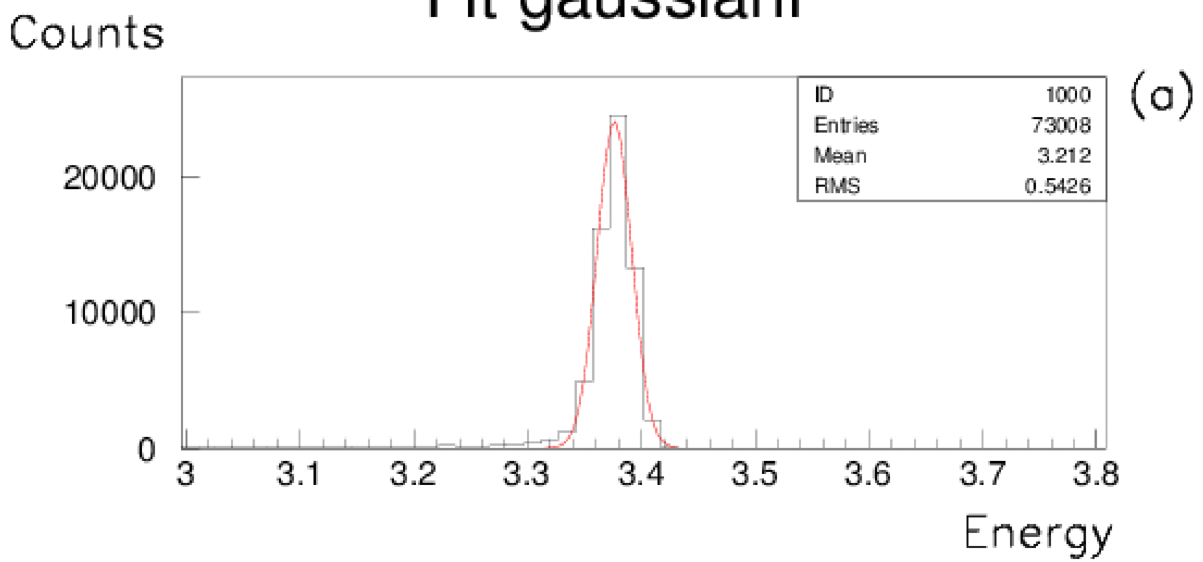
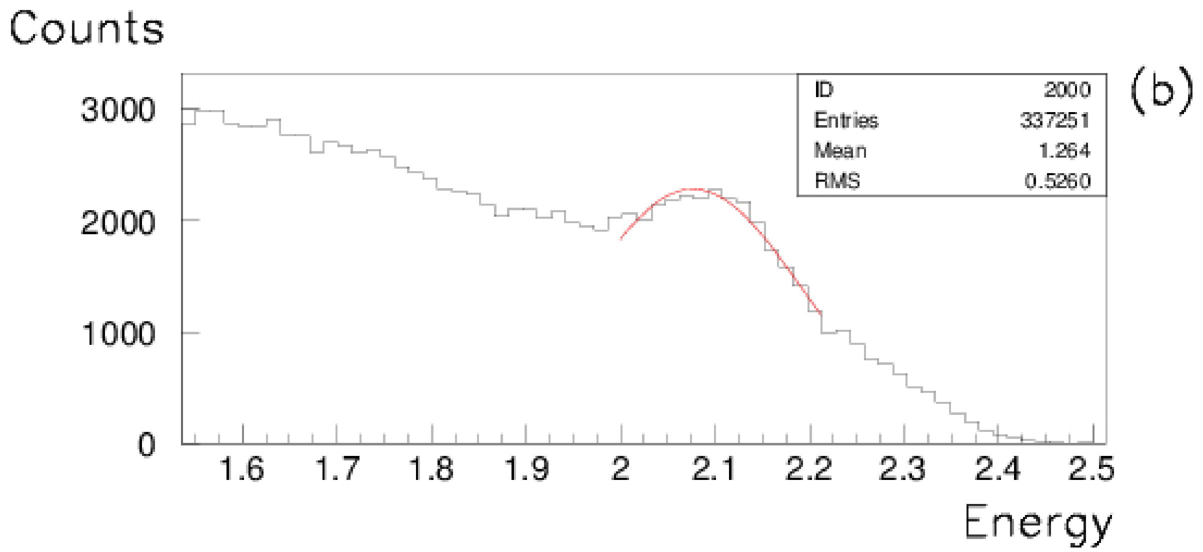
Spettri energetici (3)



Fit gaussiani



$E_0 = 3.37 \pm 0.015\ MeV$



$E_1 = 2.09 \pm 0.11\ MeV$

$\Delta E = 1.29 \pm 0.11\ MeV$

$$S = \frac{\Delta E}{(\Delta x)_{nominale}} = 25.8 \pm 2.2\ keV/\mu m$$

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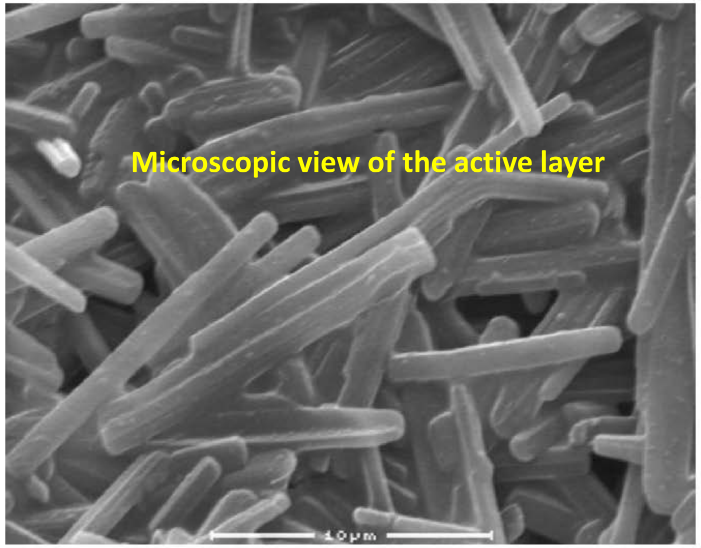
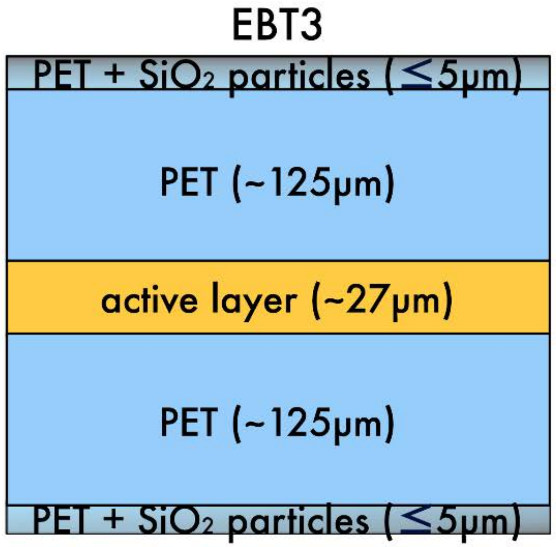
The GAFCROMIC™ EBT3 Dosimetry Film

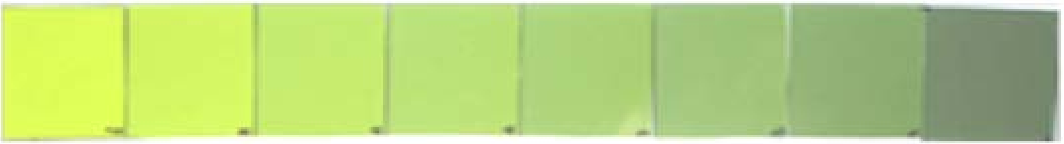
External Beam Therapy – EBT

- 2D dosimetric detector
- High spatial resolution
- Wide dose range (1cGy – 40Gy)
- Near tissue-equivalent
- Energy-independent





EBT3 film pieces after irradiation at different doses



Material composition: ***percentages by atom***

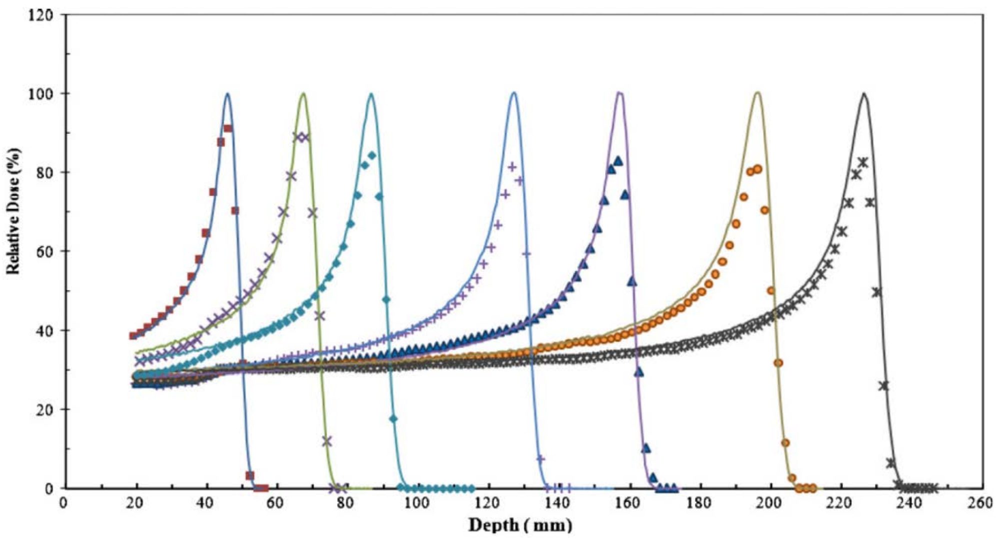
EBT3	H	Li	C	N	O	Na	S	Cl	K	Br
Act. Layer	58.2	0.8	29.2	0.1	10.7	0.1	0.1	0.9		
PET	36.4	–	45.5	–	18.2	–	–	–		
PET + SiO_2	PET = 99.986,	SiO_2 = 0.014								

The Film Response to Ions– Quenching

Ion irradiations produce an inhomogeneous dose deposition and a quenching effect in the film response occurs (track structure theory). The film response depends on the kinetic energy of the ions and corresponding linear energy transfer (LET) of the radiation.

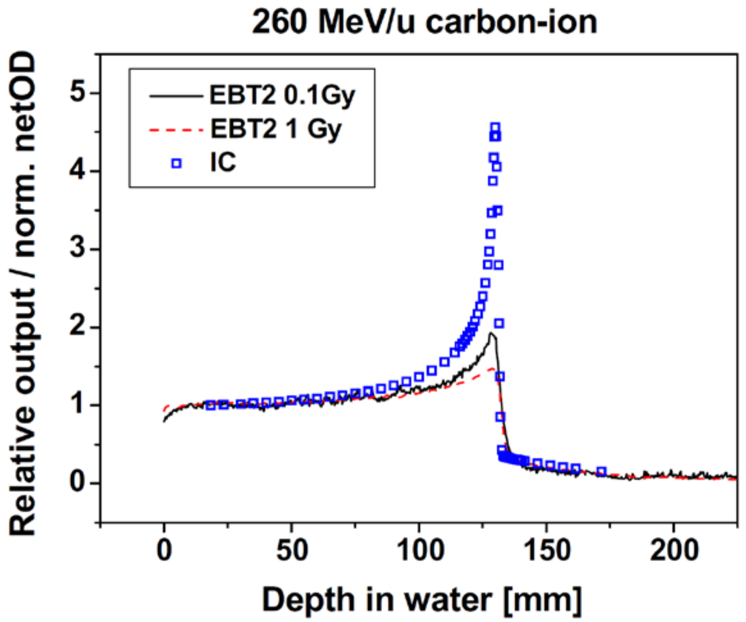
Response to Proton beams

- Depth-dose curves in water – EBT vs. IC
- Energy range 78 – 186 MeV (50–230 mm)
- 10–20% dose reduction at Bragg peak



Response to Carbon ion beams

- Depth-dose curves in water – EBT2 vs. IC
- ^{12}C ions 260 MeV/u (125 mm)



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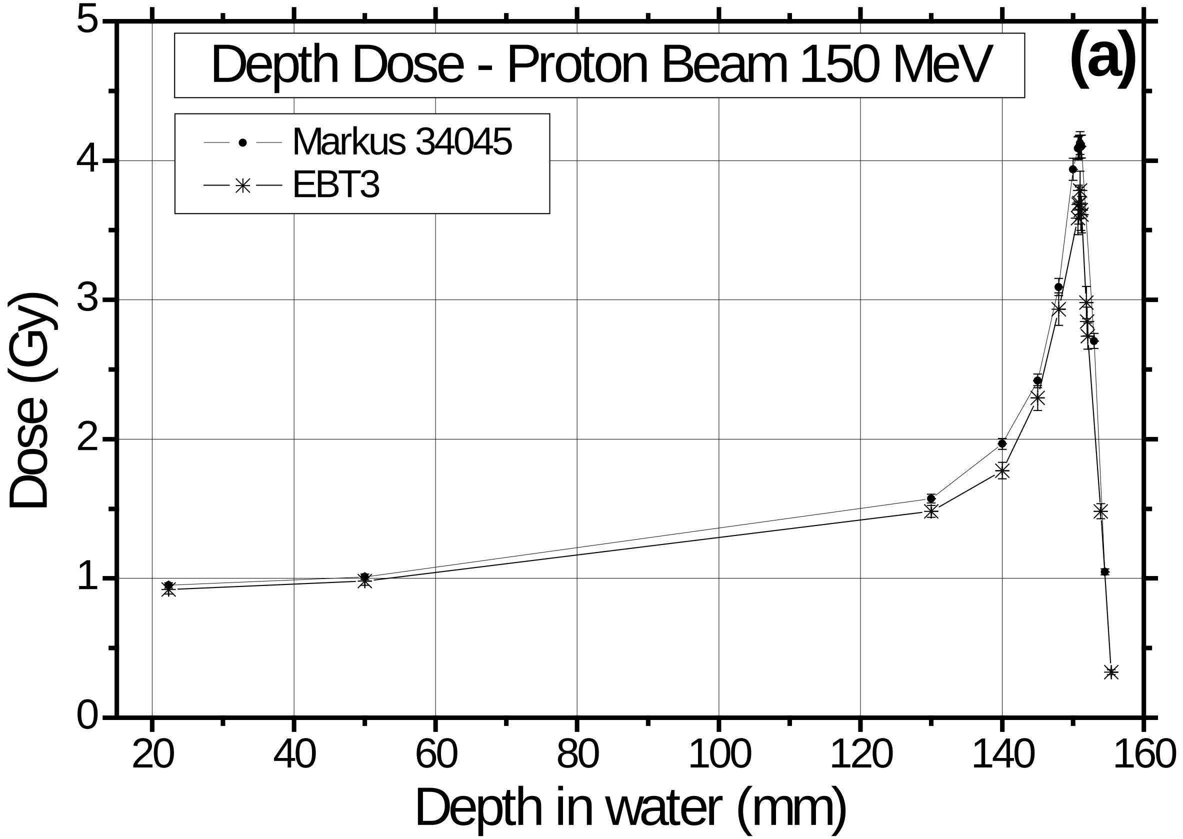
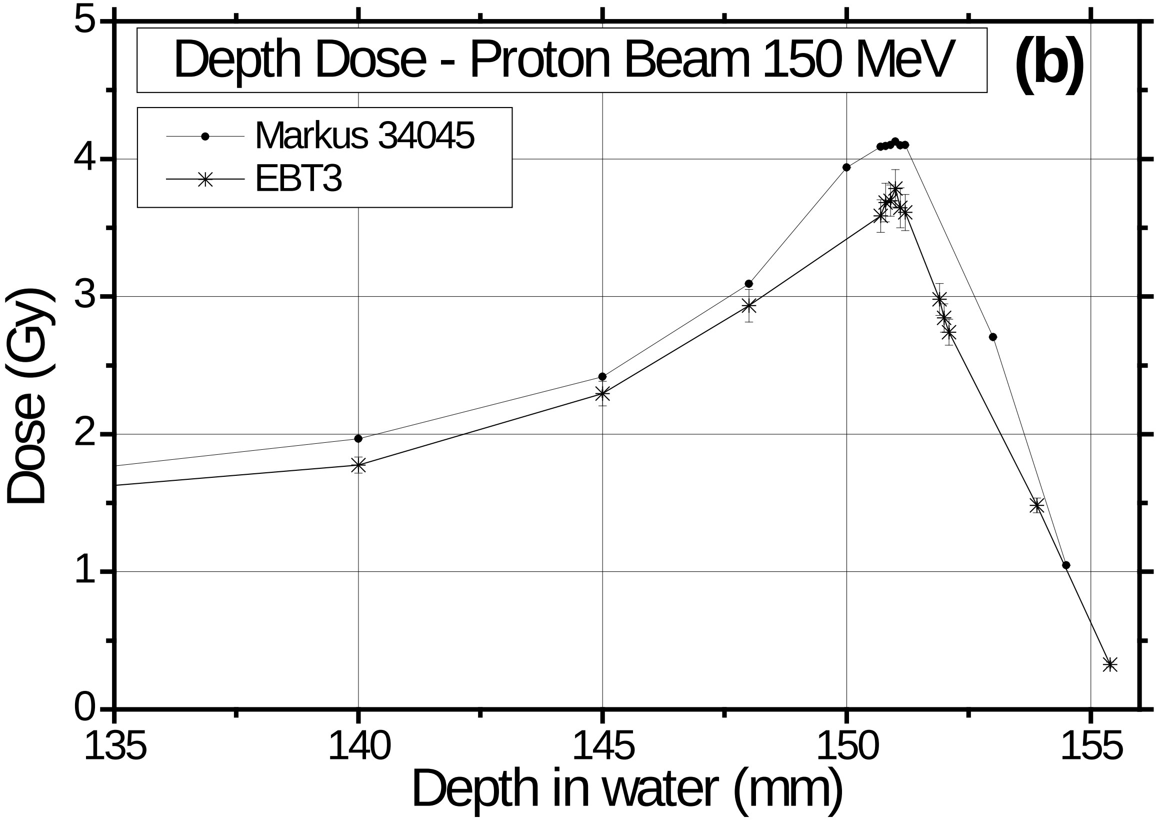
Depth-Dose Curve in Water for PROTONS

Average dose ratio EBT3 vs. Markus chamber in the Bragg peak region
$\mathbf{0.90 \pm 0.04}$ (under-response of about **10%**)

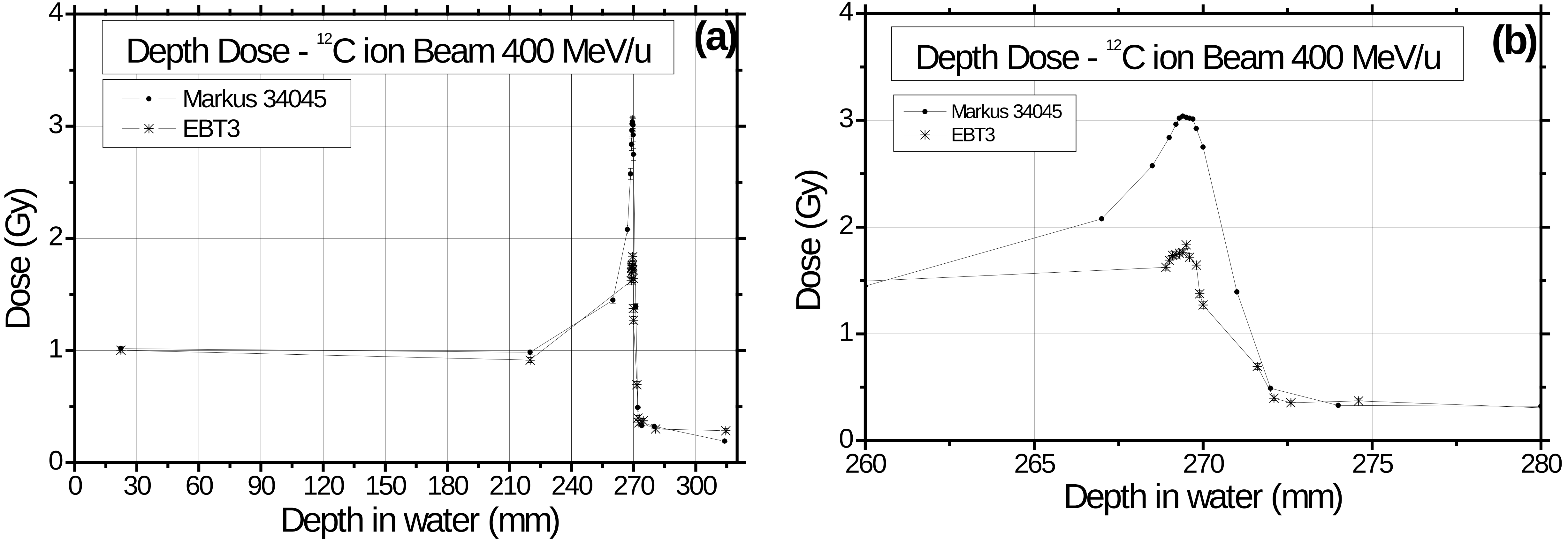




R. Castriconi et al, Phys Med Biol **62**, 377-393 (2017)

Depth-Dose Curve in Water for ^{12}C ions

Average dose ratio EBT3 vs. Markus chamber in the Bragg peak region
$\mathbf{0.58 \pm 0.02}$ (under-response of about **40%**)



R. Castriconi et al, Phys Med Biol **62**, 377-393 (2017)

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