FOOT
FragmentatiOn Of Target

An experiment for the measurement of the nuclear fragmentation for Particle Therapy DE/Dx e TOF

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5 settembre 2017 – Roma

TOF stop & DE/Dx measurement

Detector structure

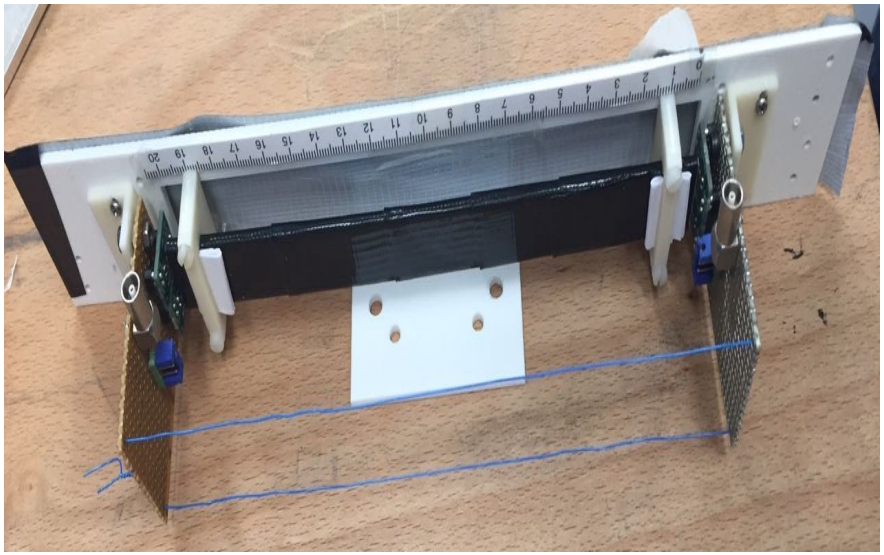
- 20 + 20 plastic scintillator bars arranged in two orthogonal layers. (for direct X – Y position identification)
- Dimensions 20 mm x 400 mm x 3 mm
- Double sided SiPM read-out
- 80 channels read-out in coincidence each-others and with the start counter

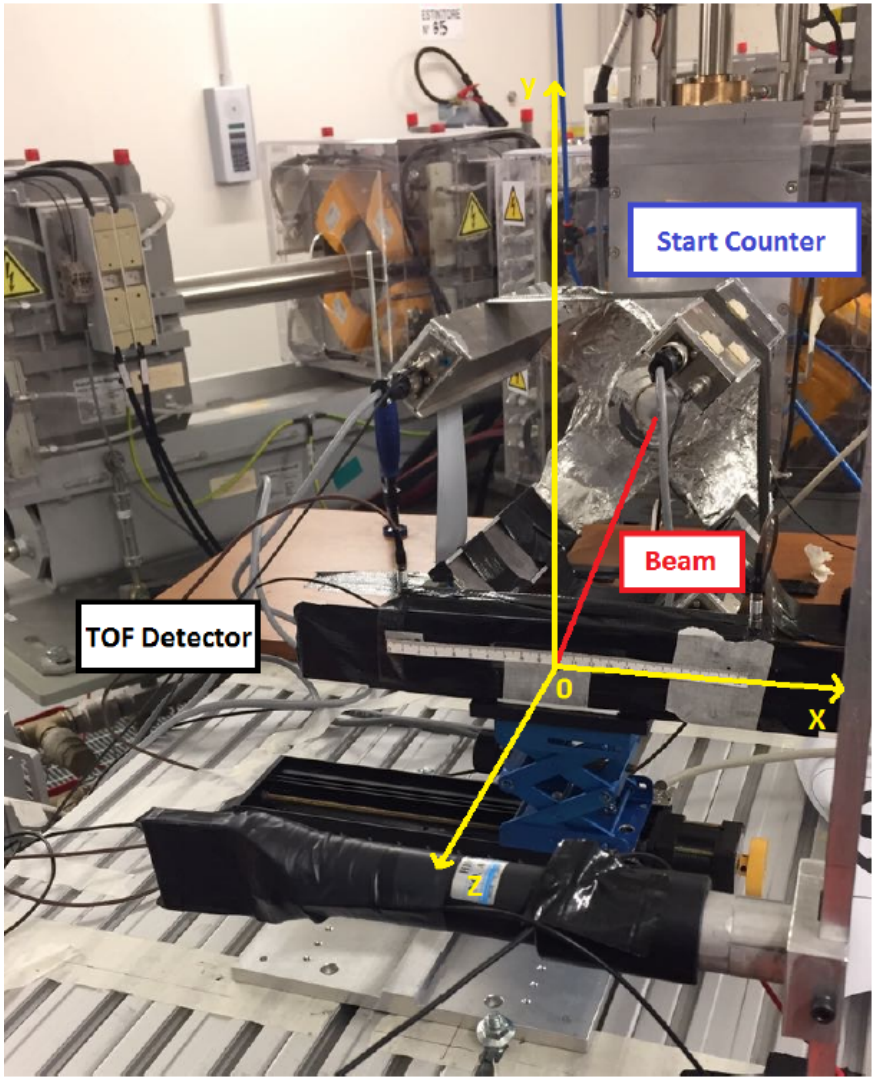
Requested performances

- Time resolution of 70 ps (standard deviation)
- High energy resolution (between 3% and 5%)
- Data rate of 1 kHz/chn
- synchronization with the start counter and with the other detectors of the system

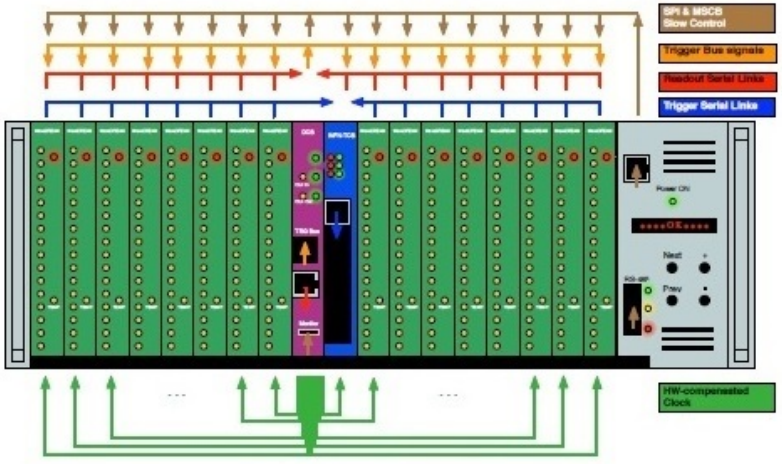
Test beam Trento centro Protonterapia May 2017

- 20x2x0.2 cm^3 Eljen plastic scintillator bar (EJ212), wrapped with teflon
- 4 SiPMs (2 for each side connected in series, AdvanSiD)
- Bias Voltage: 62.8 Volt (BD=26.4 V, OV=5 V)





DAQ



WaveDreams

- MEG II

- 16 acquisition channels

- SiPM power supply

- Amp w Variable gain and PZC

- Bandwidth 900 MHz

- Up to 5 Gs/s

Measurements

Scan	Beam position	Beam energy	SiPM overvoltage	Time resolution
Beam position	[-7,+7], 0.5 cm steps	110 MeV	5 V	with STS1
Beam energy	0 cm	70-230 MeV	5 V	with STS1
SiPM overvoltage	0 cm	140 MeV	2-7, 1 V steps	with μ(STS1,STS2)

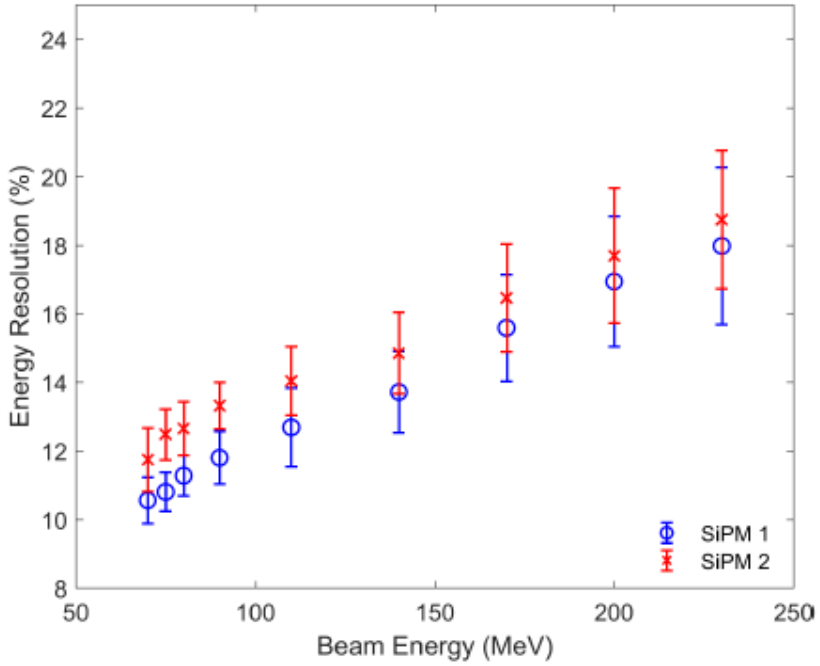
Detector performance evaluation

- **Energy resolution**

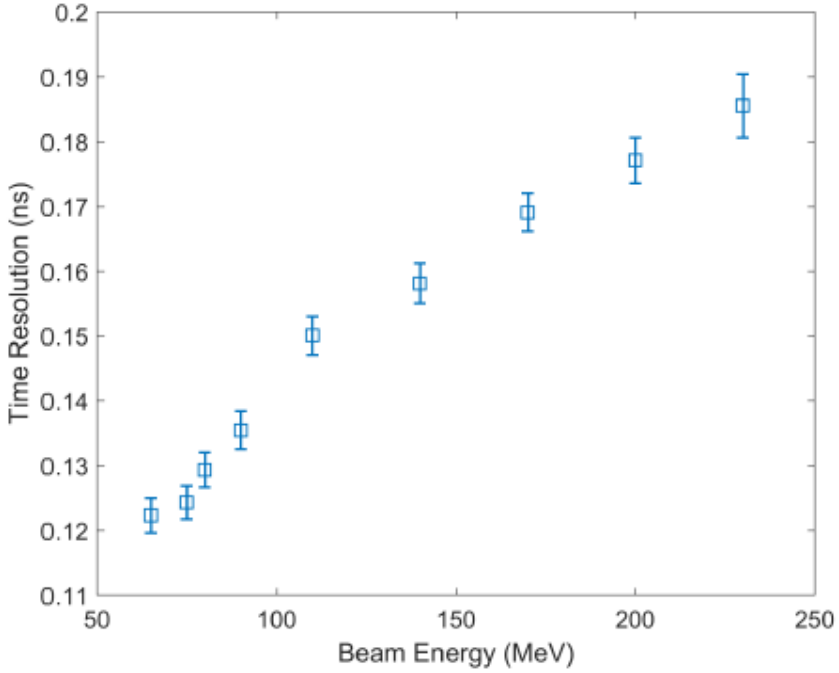
- **Time resolution** Standard deviation of the difference between the average photon arrival time at the ends of the bar and reference time information (STS1 or the average of the 2 STS timestamps)

Beam Energy scan

Energy Resolution vs Beam Energy

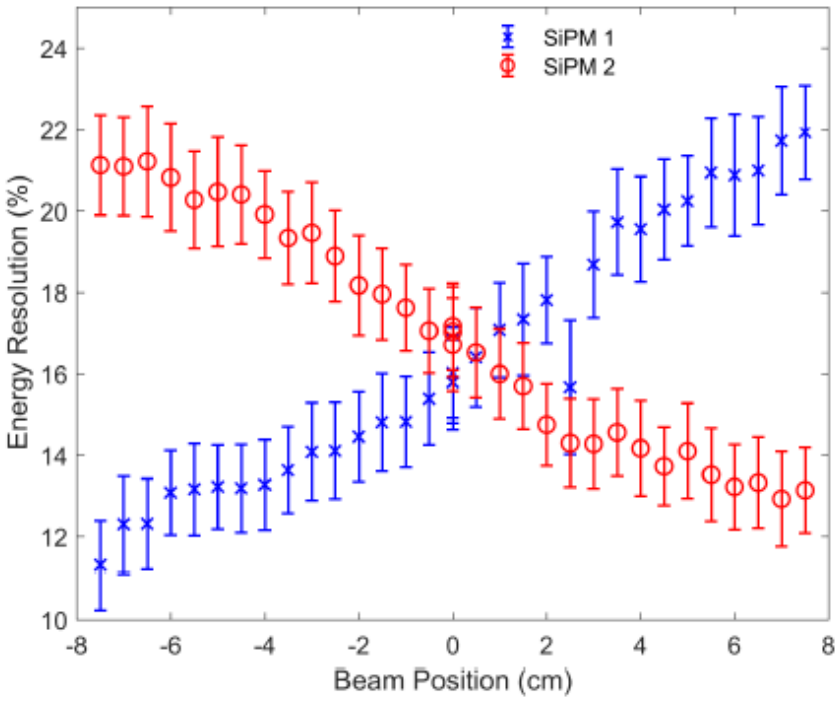


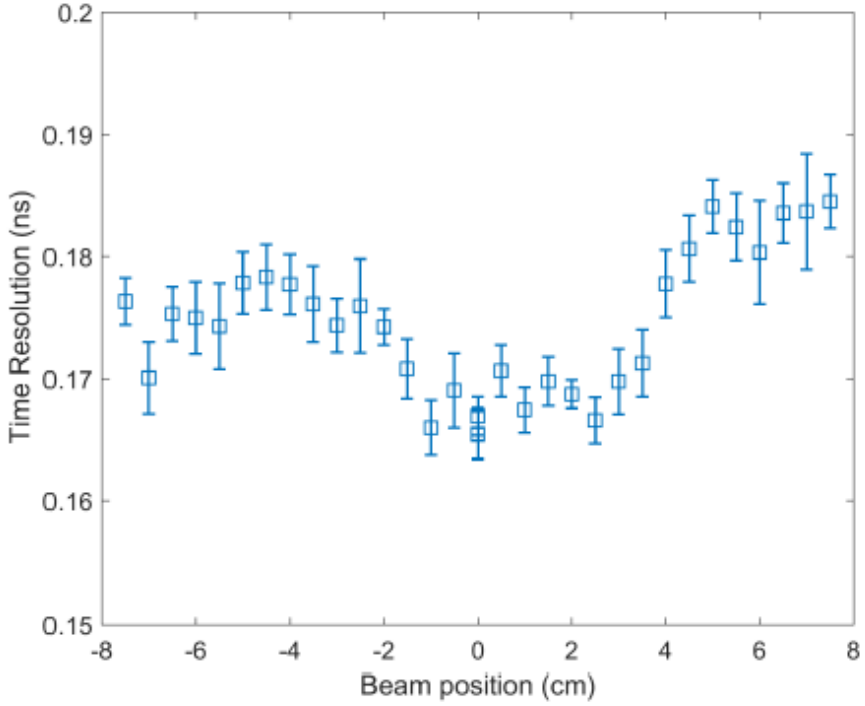
Time resolution between SiPMs and STS1



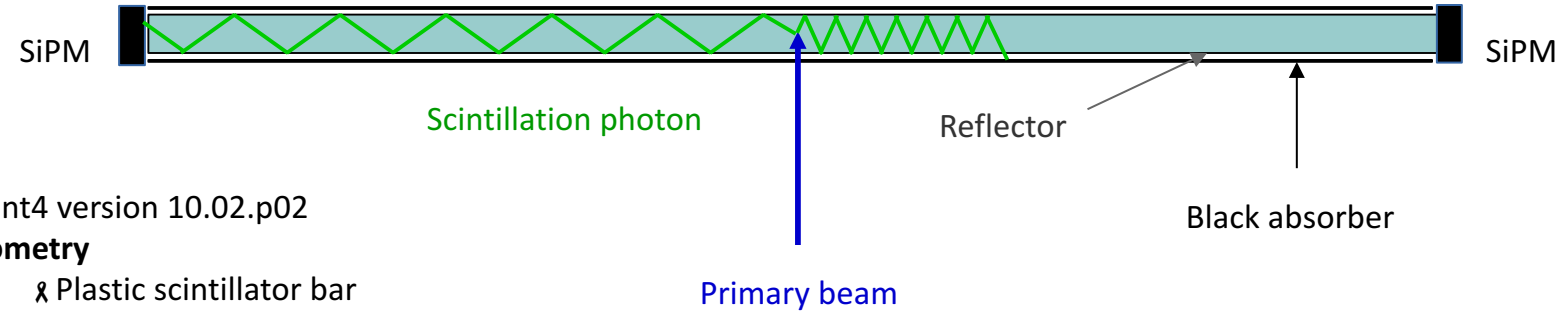
1D scan

E = 110 MeV





Simulations

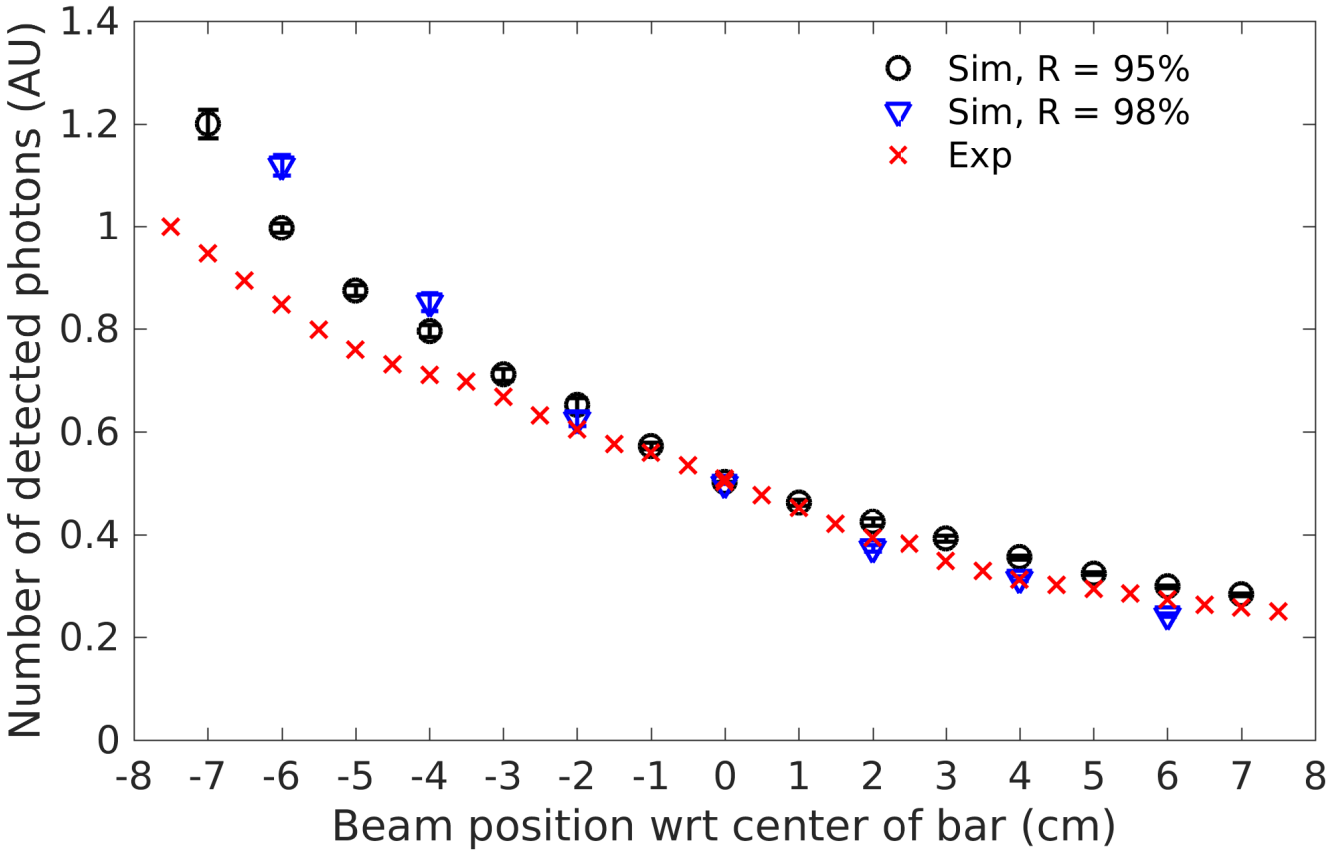


- Geant4 version 10.02.p02
- **Geometry**
  - Plastic scintillator bar
  - Double side SiPM readout
  - Optical coupling
  - Reflector coating
  - Absorbing wrapping
- **Primary** collimated heavy particle beam
- **Physics**
  - Energy deposition in scintillator (FLUKA-corrected)
  - Scintillation process
  - Optical transport and detection

Variable parameters

- Primary particle type, energy and position of incidence on scintillator bar
- Optical interfaces (e.g., reflectivity, type of diffusion – Lambertian/ground, air layers at interfaces – bar/reflector, bar/grease, grease/SiPM
- Scintillator properties (e.g. light yield, dimension, composition)

Simulation tuning

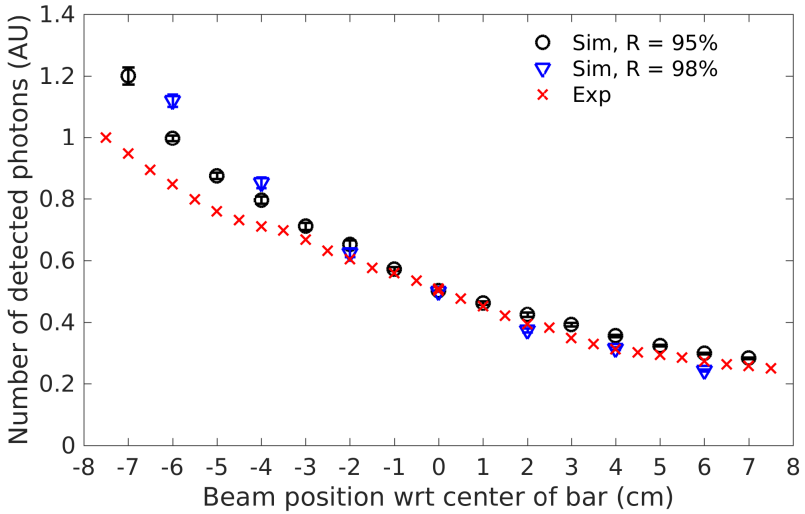


Simulation tuning

- Using data of TIFPA **proton test beam** → scans of beam energy and position

- **Energy scan**
  - A FLUKA simulation (by INFN Milano) is used to rescale the Geant4 number of detected photons for the actual energy deposition in bar ($E_{Fluka}/E_{Geant4} \approx 0.82$)
  - The rescaled simulated number of detected photons is compared to the number measured experimentally in the energy scan
  - This gives a small and constant scale factor between simulation and experimental data: $N/N \approx 0.83$

- **Position scan**
  - The number of detected photons as a function of the beam position is compared
  - We are currently tuning the type of diffusion at the optical interfaces to obtain a better match between simulation and data



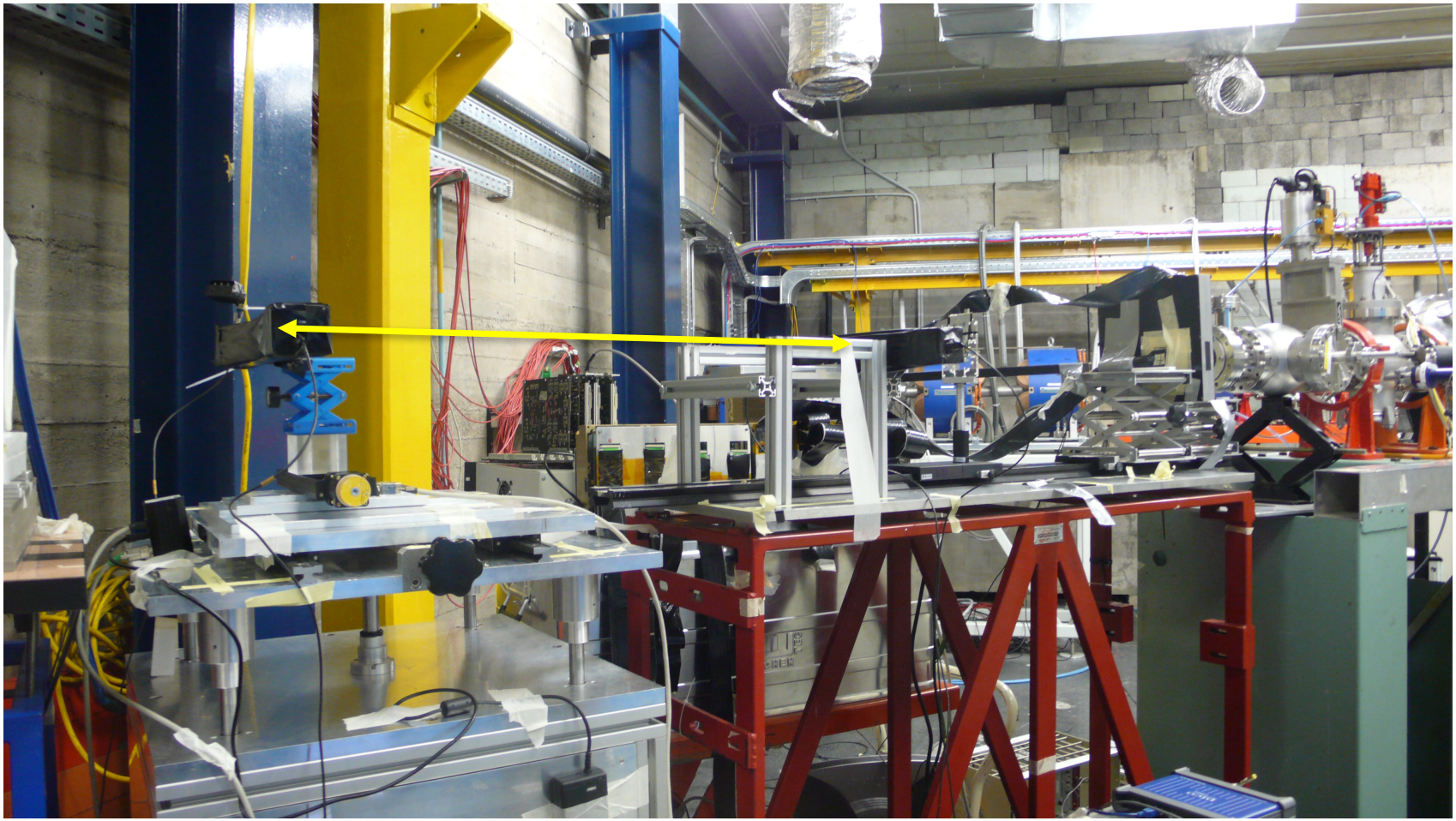
Future steps

- **Tuning**
  - Find the right combination of diffusion processes at optical interfaces
  - Study the effect of air layers between interfaces
  - Study SiPM saturation effects, affecting experimental data
- **Validation**
  - Use a second position scan
  - Use different scintillator bars
  - Use data of future LNS test beam
- **Estimation** of the energy released in the scintillator bar by different particles at 80 MeV

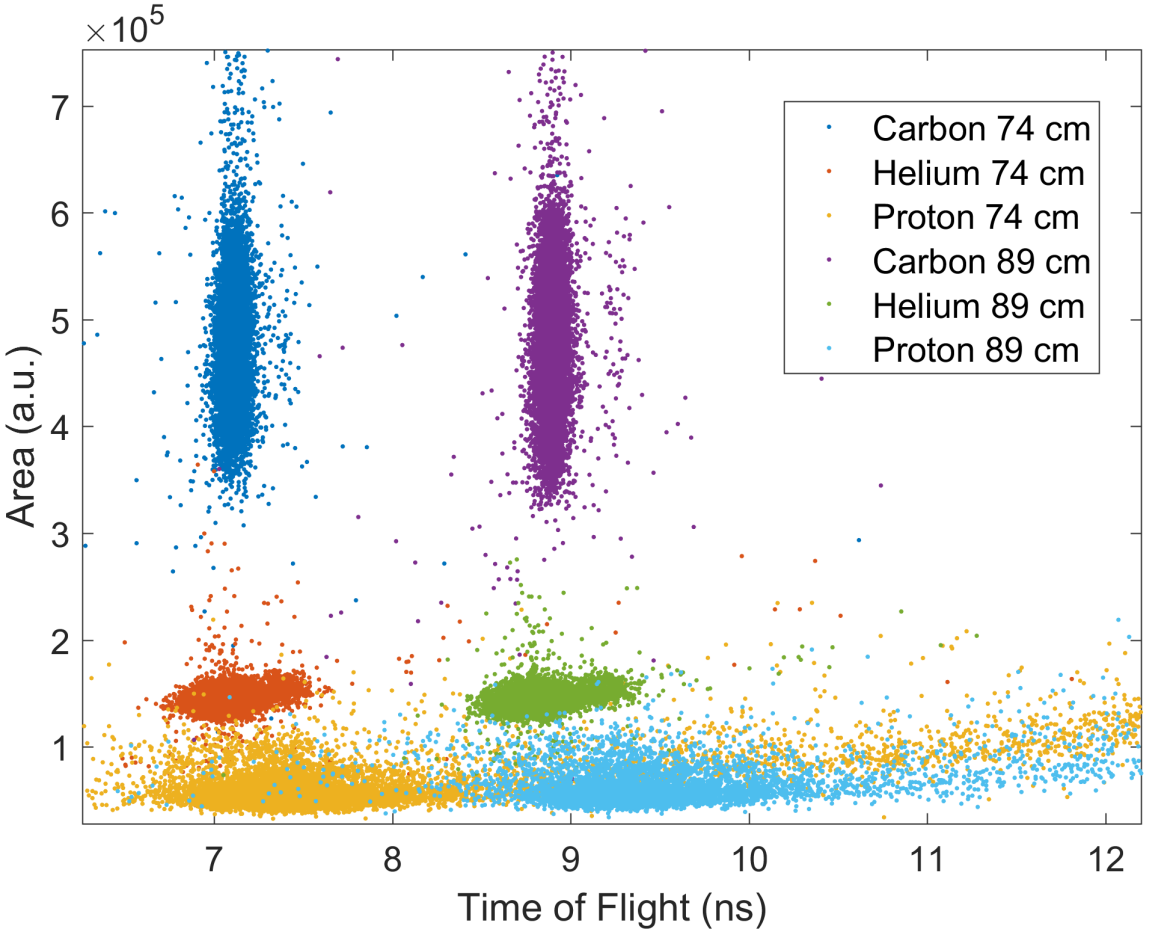
Attivita' 2018

- Second half 2017
  - Test beam a LNS (new bars, particle ID)
  - Tuning and validation of the MC simulations
  - Bars specs freezing
- Workplan 2018
  - Development and test hybrid boards
  - Test final prototypes
  - Procurement bars, sipm, hybrids
  - Mechanical structure
  - Start production, test and assembly

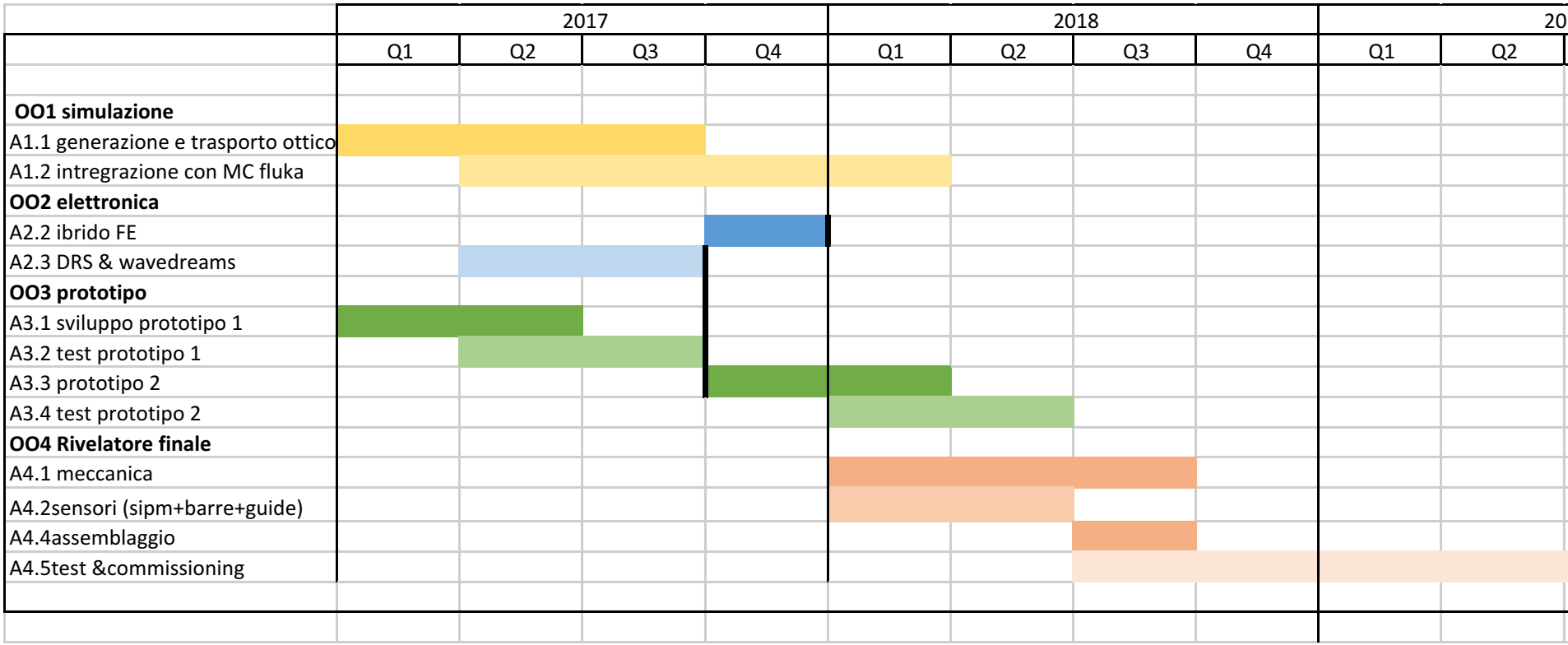
Set-up LNS



Particle ID


×10^5
Area (a.u.)
Time of Flight (ns)
Carbon 74 cm
Helium 74 cm
Proton 74 cm
Carbon 89 cm
Helium 89 cm
Proton 89 cm

gantt


2017
2018
20
Q1
Q2
Q3
Q4
Q1
Q2
Q3
Q4
Q1
Q2
OO1 simulazione
A1.1 generazione e trasporto ottico
A1.2 intregrazione con MC fluka
OO2 elettronica
A2.2 ibrido FE
A2.3 DRS & wavedreams
OO3 prototipo
A3.1 sviluppo prototipo 1
A3.2 test prototipo 1
A3.3 prototipo 2
A3.4 test prototipo 2
OO4 Rivelatore finale
A4.1 meccanica
A4.2sensori (sipm+barre+guide)
A4.4assemblaggio
A4.5test &commissioning

Preventivi 2018

MISSIONI	1. 1 presa dati a Trento centro di protonterapia x 7 giorni x 3 persone (vitto, alloggio e viaggio)	4.00	
	2. 1 presa dati a Heidelberg HIT x 7 giorni x 3 persone (diaria e viaggio)	4.00	
	3. 2 meeting di collaborazione x 3 giorni x 2 persone	3.00	
	4. 1 presa dati dati a catania LNS x 7 giorni x 3 persone (spese di vitto, alloggio e viaggio)	4.00	
	5. 3 meeting di lavoro x 2 giorni x 4 persone (spese, vitto, alloggio e viaggio)	5.00	20.00
CONSUMO	1. 1 data concentrator board	2.00	
	2. 1 trigger board	2.00	
	3. 50 barre di scintillatore (44 per rivelatore finale + 6 per prototipi e spare) plastico EJ200 o equivalente dimensioni 400x20x3 mm^3	18.00	
	4. CRATE per alimentazione wavedream boards, data concentrator board e trigger board	2.00	
	5. 7 wavedreams boards (6 per equipaggiare tutto il rivelatore TOF + 1 spare) per campionamento e digitizzazione segnali dei sipm	10.50	
	6. 300 sipm per equipaggiare 46 barre di scintillatore (264 sipm occorrenti per equipaggiare tutto il rivelatore TOF piu' spare)	12.50	
	7. connettori e cavi SMA	4.00	
	8. materiale per supporto meccanico rivelatore TOF	2.00	
	9. metabolismo di laboratorio	2.00	55.00
INVENTARIO	1. Source Measurement Unit 200 V, 100 pA 9e.g. Keithley 2450)	5.50	
	2. Low Voltage Power Supply (duale +5V -5V con lettura individuale della corrente, e.g. Keysight E3649A o equivalente)	2.00	7.50
TRASPORTI	1. spese di trasporto per materiale test beam	2.00	2.00

Persone e richieste servizi

	Posizione	FOOT (%)
N. Belcari	PA	50
M.G. Bisogni	PA	60
E. Ciarrocchi	Ass	100
L. Galli	Ric- INFN	20
A. Kraan	Ric-INFN	50
M. Morrocchi	Ass.	40
S. Muraro	R3-INFN	30
V.Rosso	PA	50
G. Sportelli	RTDA	30
TOTALE	FTE	4.3

supporto del

- servizio elettronico: 0.1 FTE per sviluppo ibridi FE del DE/TOF
- Servizio progettazione meccanica: 0,3 per disegno meccanica DE/TOF e meccanica esperimento
- Officina meccanica: 0,2 FTE