

FOOT: FragmentatiOn Of Target experiment

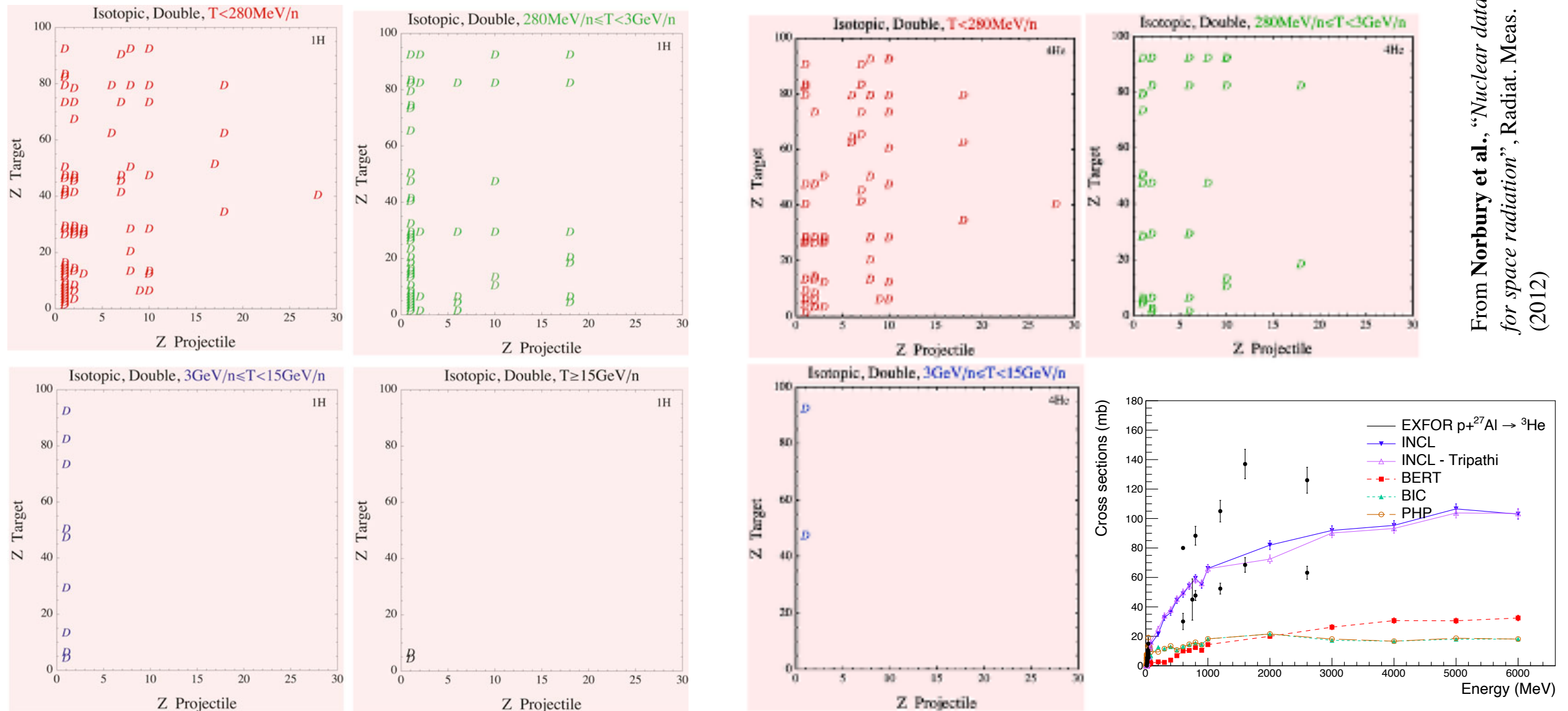
Christian Finck, Alexandre Bigot, Marie Vanstalle
Olivier Lourgo, Violette Guittet
for the FOOT collaboration



Objectives and research challenges(i)

□ Cross-section measurement for hadrontherapy and space radioprotection

- Lack of data at energies between 100 MeV/n and 10 GeV/n (energies of interest for space applications)



From Norbury et al., "Nuclear data for space radiation", Radiat. Meas. (2012)

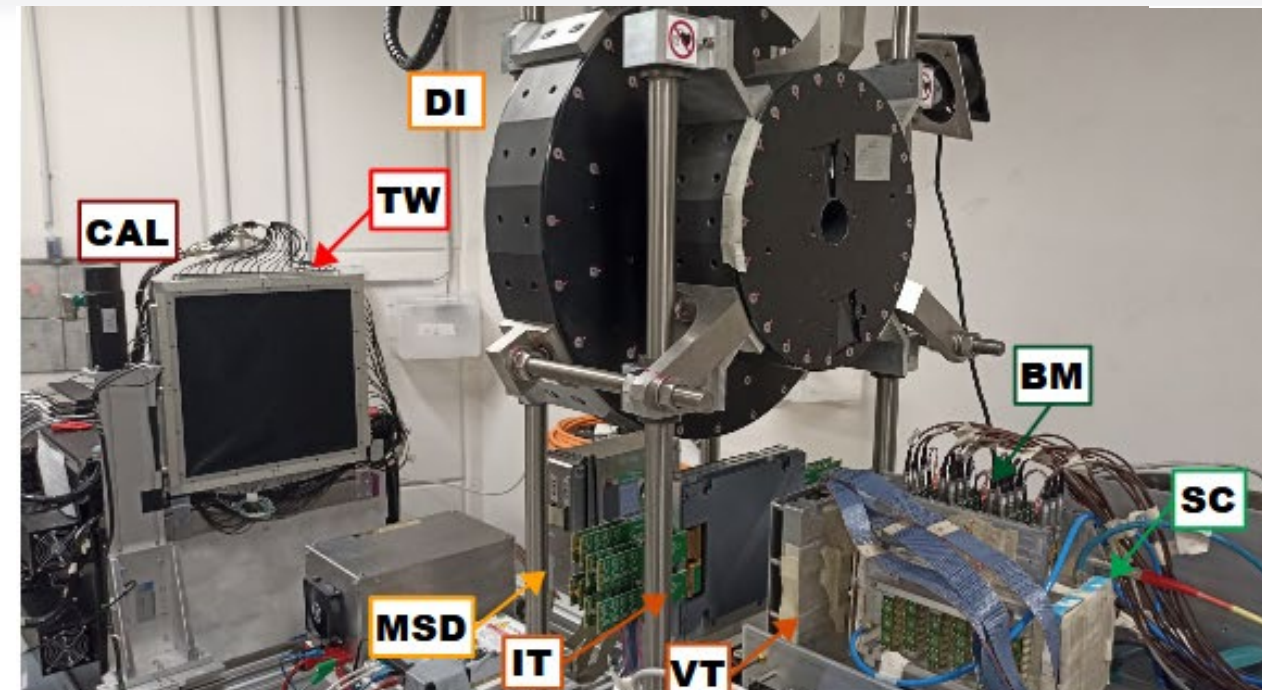
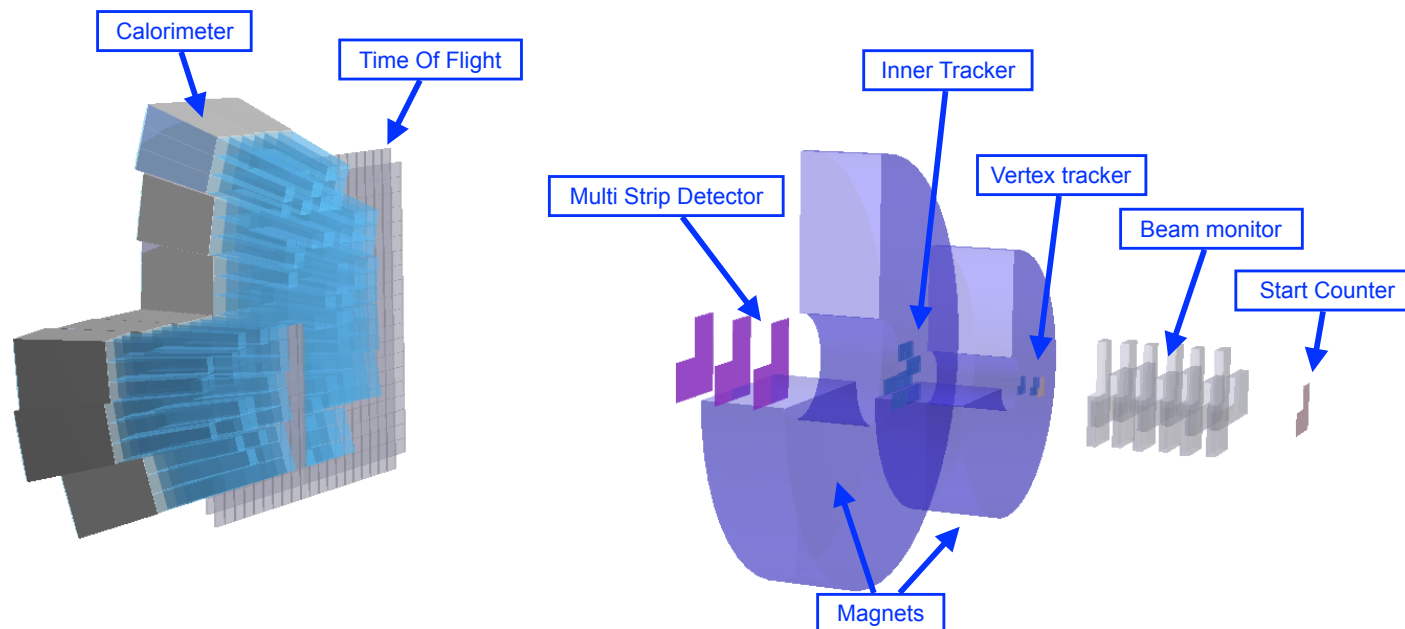
- ➔ For some combination beam/target no data are available
- ➔ MC simulations fail to reproduce experimental data

From Vanstalle, private communication

Objectives and research challenges (ii)

Electronic Setup

- Tracking system: BM+VTX+ITR+MSD
- Downstream: TW & CAL



Mass spectrometer

$$\frac{d\vec{p}}{dt} = q\vec{\beta}c \times \vec{B}$$

$$p = \gamma\beta mc$$

$$E_{kin} = mc^2(\gamma - 1)$$

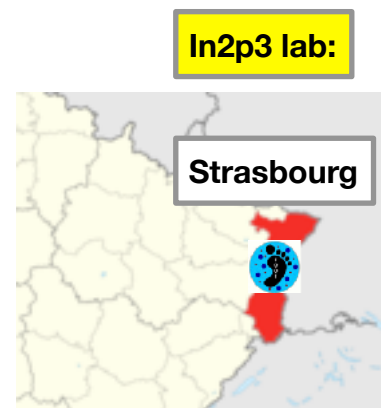
$$\beta = \frac{L}{ToF} \frac{1}{c}$$

Required performances:

- $\sigma(p)/p < 5\%$
- $\sigma(\Delta E)/E < 5\%$
- $\sigma(ToF)/ToF < 100\text{ ps}$

Project structure

- International collaboration (biggest) in X-section measurements



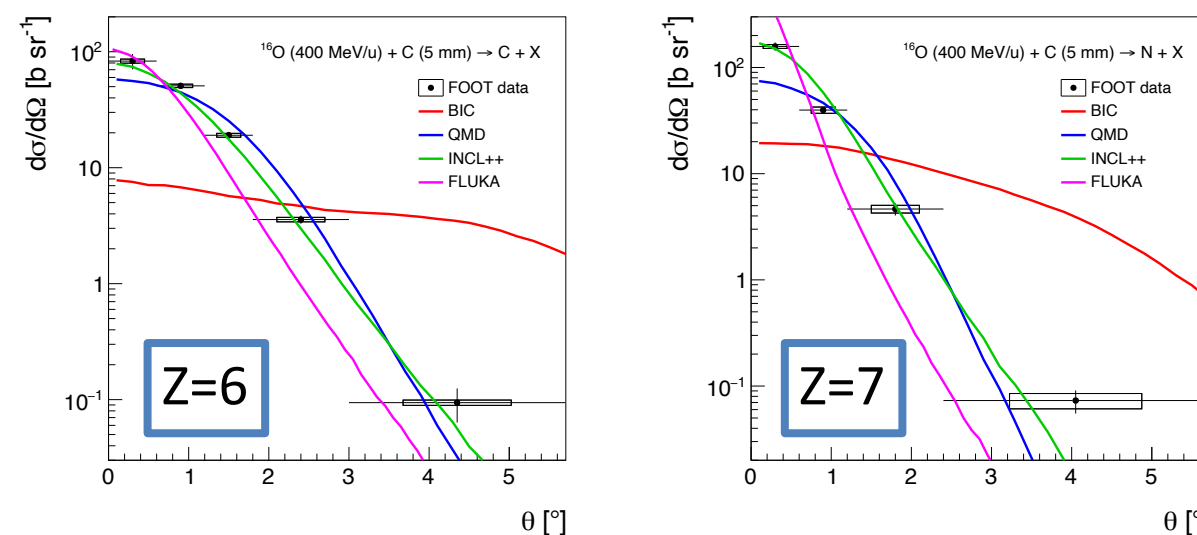
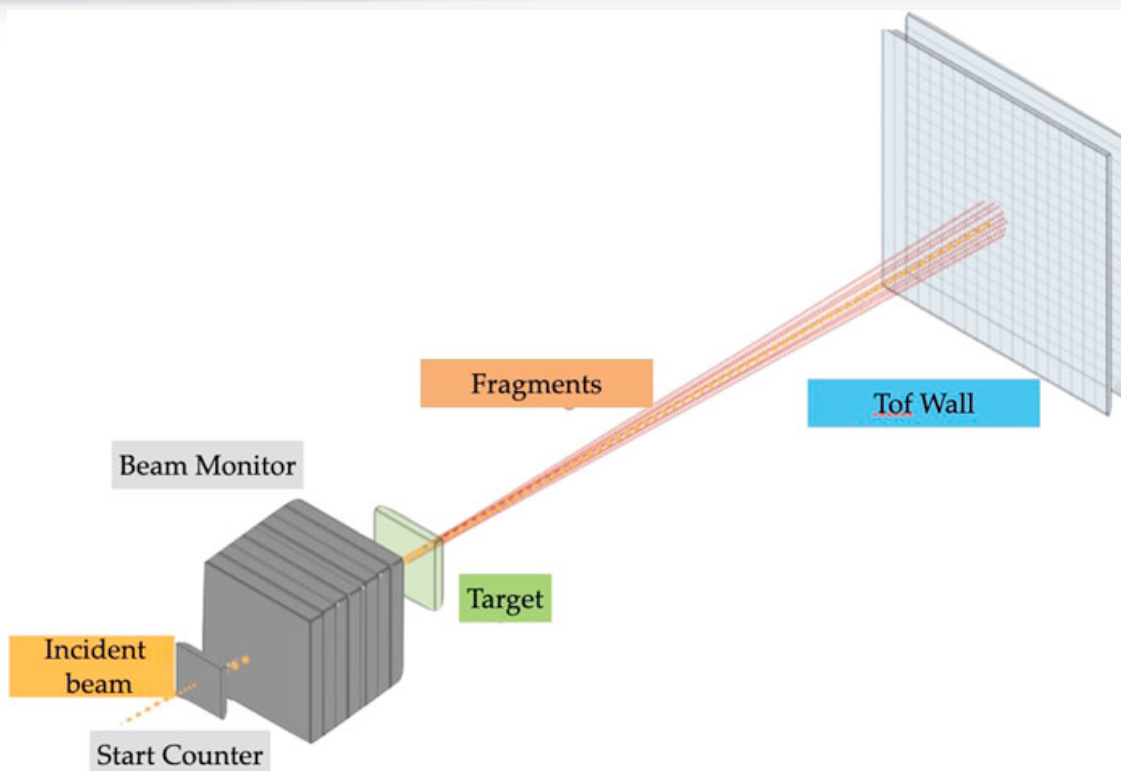
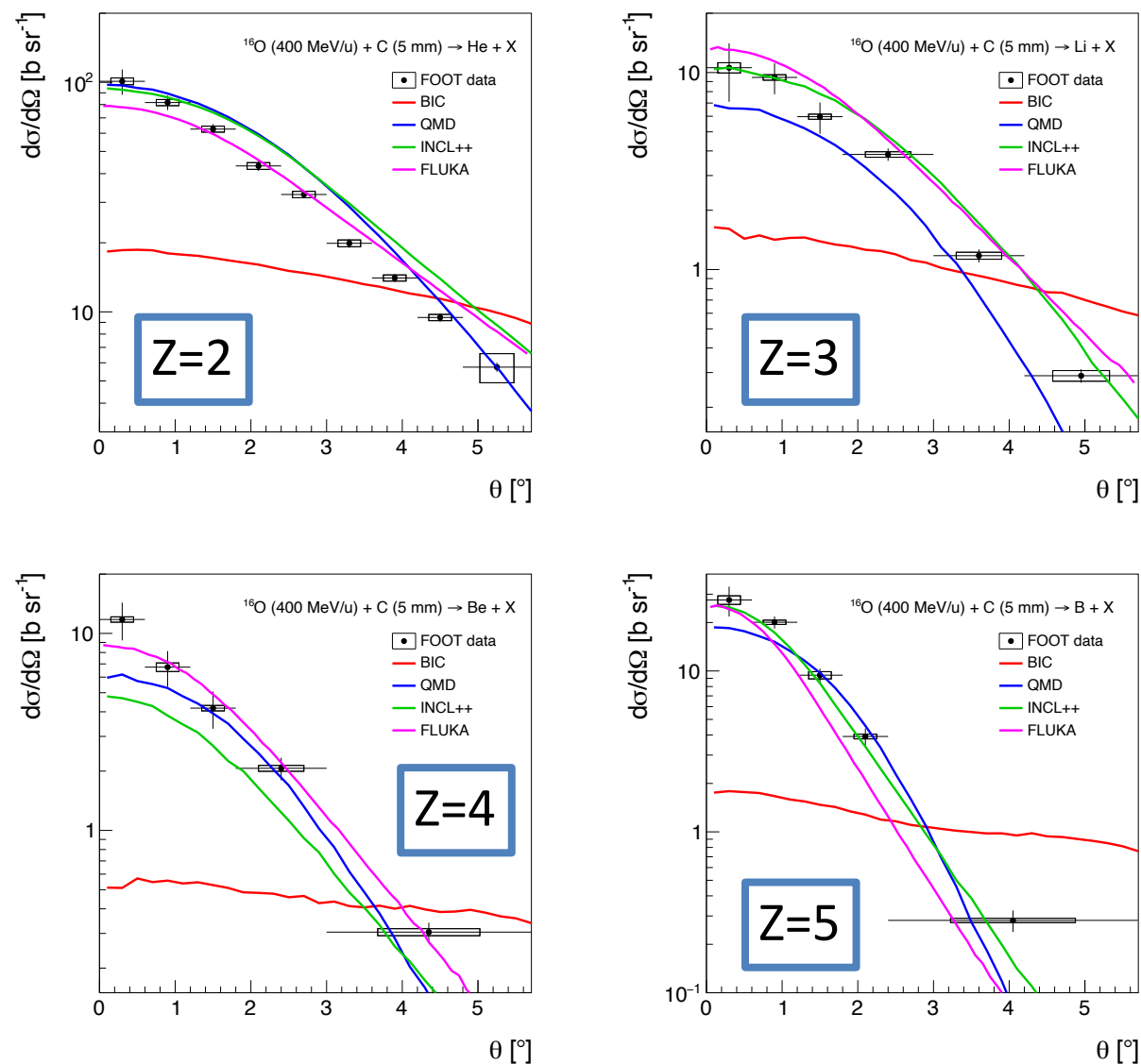
~80 members

- 9 INFN Laboratories
- 12 Italian Universities
- 1 foreign Institut: IPHC-Strasbourg
 - Christian Finck: SW coordinator (SHOE)
 - Marie Vanstalle: head of Editorial Board (til June 2023)
- 2 (+3) Facilities: CNAO, GSI, (Frascati, Trento, HIT)

Relevant facts 2025/26

FOOT @ GSI2021:

- $^{16}\text{O} \rightarrow ^{12}\text{C}$ (5mm) @ 400 MeV/u



R. Ridolfi, M. Toppi, A. Mengarelli, M. Dondi et al.,
Angular differential and elemental fragmentation cross sections of a 400 MeV/nucleon ^{16}O beam on a graphite target with the FOOT experiment
 Phys. Rev. C **112**, (2025) **014610**

- None of the MC models (G4/Fluka) reproduced data
- 8 publications during 2025-2026

Vision 2030

- Physics analysis:
 - Z and/or mass identification for ^4He , ^{12}C and ^{16}O beam at different energies impinging on C and C_2H_4

Electronic setup		
Campaign	Beams Energy [MeV/u] / Targets	Detectors
GSI 2019	^{16}O @ 400 on ^{12}C	SC, BM, TW
GSI 2021	^{16}O @ 200, 400 on ^{12}C , C_2H_4	SC, BM, VTX, MSD, TW
HIT 2022	He @ 100, 140, 200, 220	SC, BM, MSD, TW, CAL
CNAO 2022	^{12}C @ 200 on ^{12}C	SC, BM, VTX, MSD, TW, CAL
CNAO 2023	^{12}C @ 200 on ^{12}C , C_2H_4	SC, BM, VTX, ITR, MSD, TW, CAL + Mag
CNAO 2024	^{12}C @ 200 on ^{12}C	SC, BM, VTX, ITR, MSD, TW, CAL + Mag
CNAO 2025	^{12}C @ 200 on ^{12}C	SC, BM, VTX, ITR, MSD, TW, CAL
		SC, BM, VTX, ITR, MSD, TW, CAL + Mag

- Future campaigns:
 - Nov 2026: ^{12}C @ 0.2 GeV/n on C and C_2H_4 at CNAO (RT)
 - 2027: ^{20}Ne @ 0.4 and 0.7 GeV/n on C, C_2H_4 and Al at GSI (RT+RP)
 - 2028: Asking new beam time at CNAO (RT)

New collaborations

- Discussion with LPSC to join the collaboration (contact: Sara Marcatili)
- Get in touch with Geant4 collaboration:
 - Introduce new model based on measured cross-sections
 - Proposal presented to the Technical Forum of Geant4 (April 2026)
 - Participation of Geant4 collaboration meeting (October 2026)

On going AaP and foreseen (2-5 years)

- Funding 2026: 4 kEuros
- Funding only for travelling per year for 1-2 persons:
 - 2 general meetings (Italy): 2 kEuros
 - 1 campaign (GSI or CNAO): 2 kEuros

Needs 2027

- Funding only for travelling for 1-2 persons:
 - 2 general meetings (Italy): 2 kEuros
 - 1 campaign (GSI): 2 kEuros

Backup