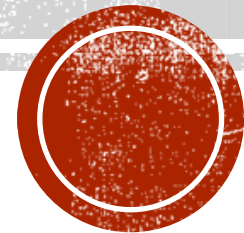


STARS: Supersonic jet Targets for nuclear Astrophysics Radiative capture measurements

D. Rapagnani, PhD

University of Naples "Federico II" and INFN-Na

INFN young research project call n° n. 23246/2021



STARS

GOAL: development of Supersonic Gas Jet Targets for high precision and high sensitivity nuclear reaction measurements \rightarrow $^{22}\text{Ne}(\alpha,\gamma)^{26}\text{Mg}$ and $^{12}\text{C}(\alpha,\gamma)^{16}\text{O}$ in LUNA-MV (progetto premiale)

Working Packages:

1. Design
2. Construction
3. Commissioning

Collaborators

1. University of Naples "Federico II" and INFN (Naples - LNGS and Pisa sections)
2. CIRA
3. CNR-INO

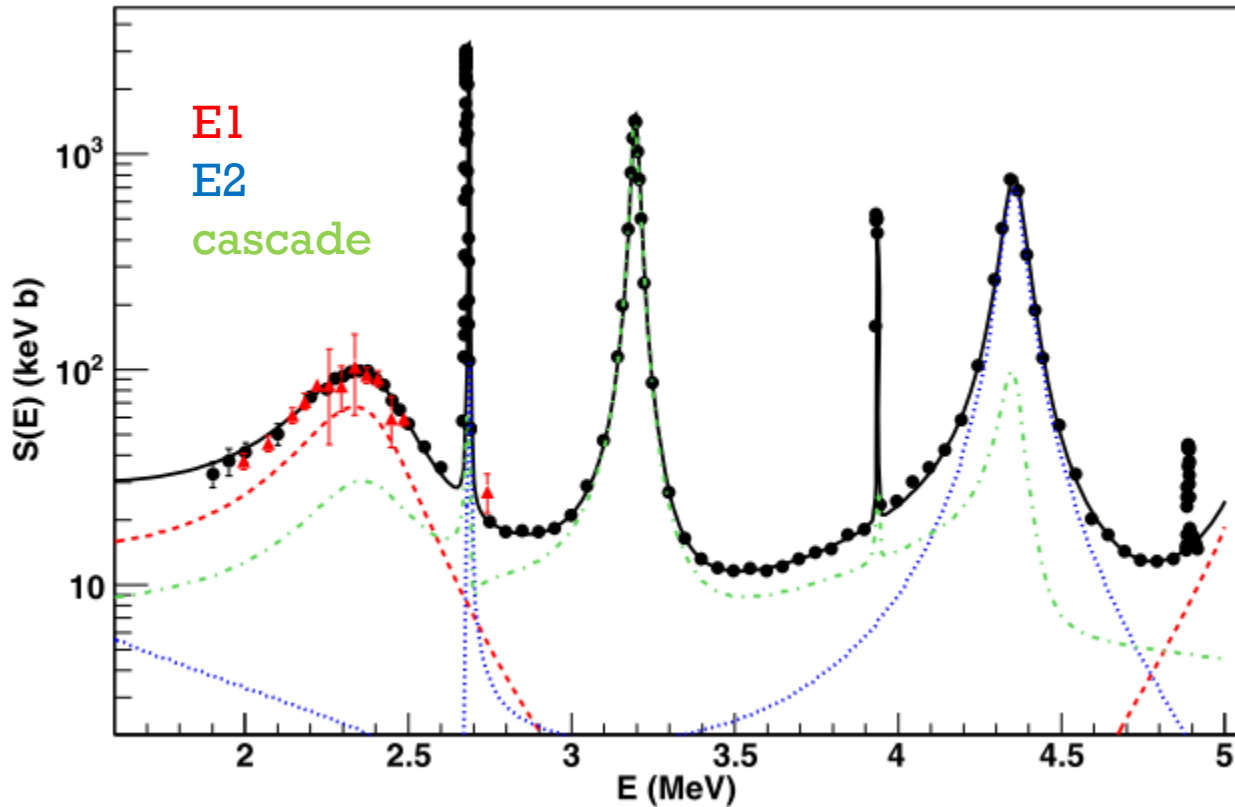
Budget

Risk Analysis



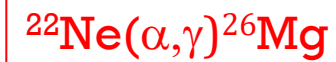
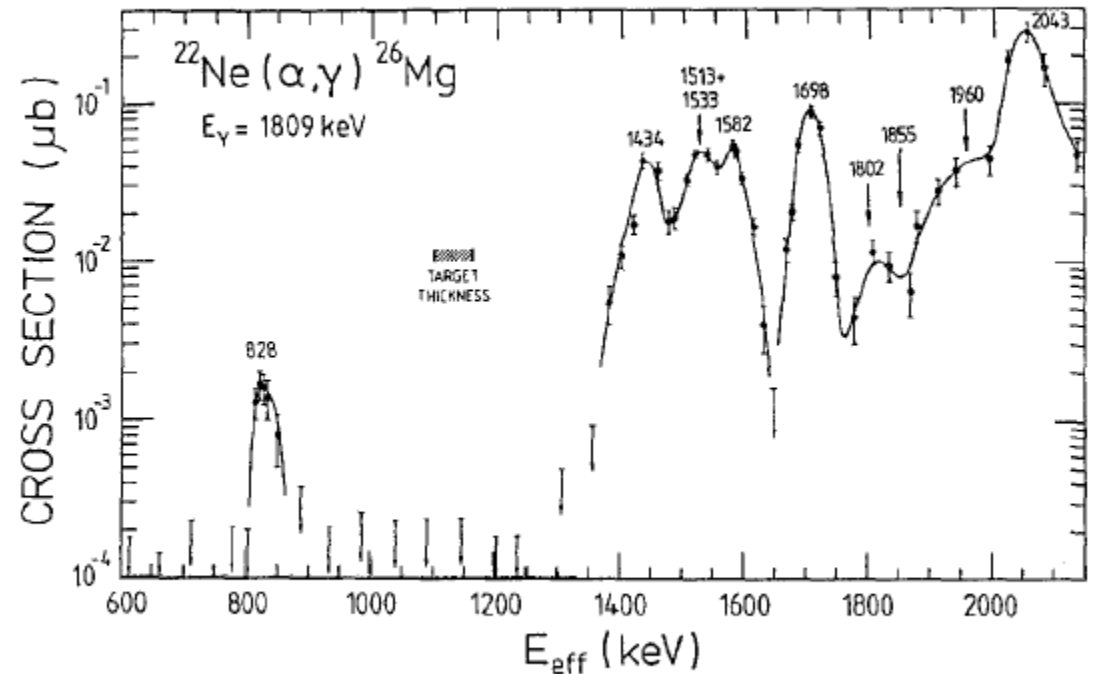
STARS: SCIENTIFIC MOTIVATIONS

Schuermann et al. 2012 PLB 711



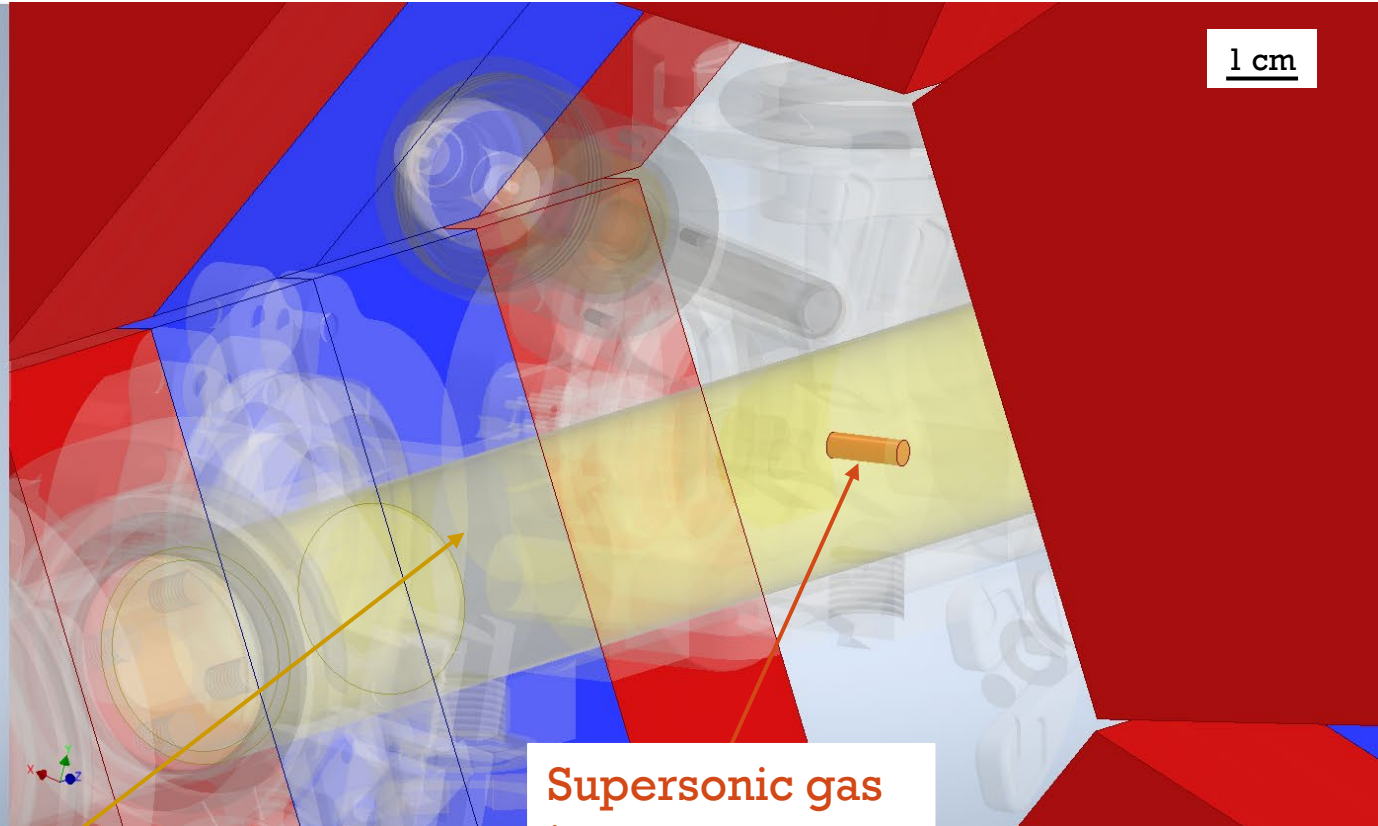
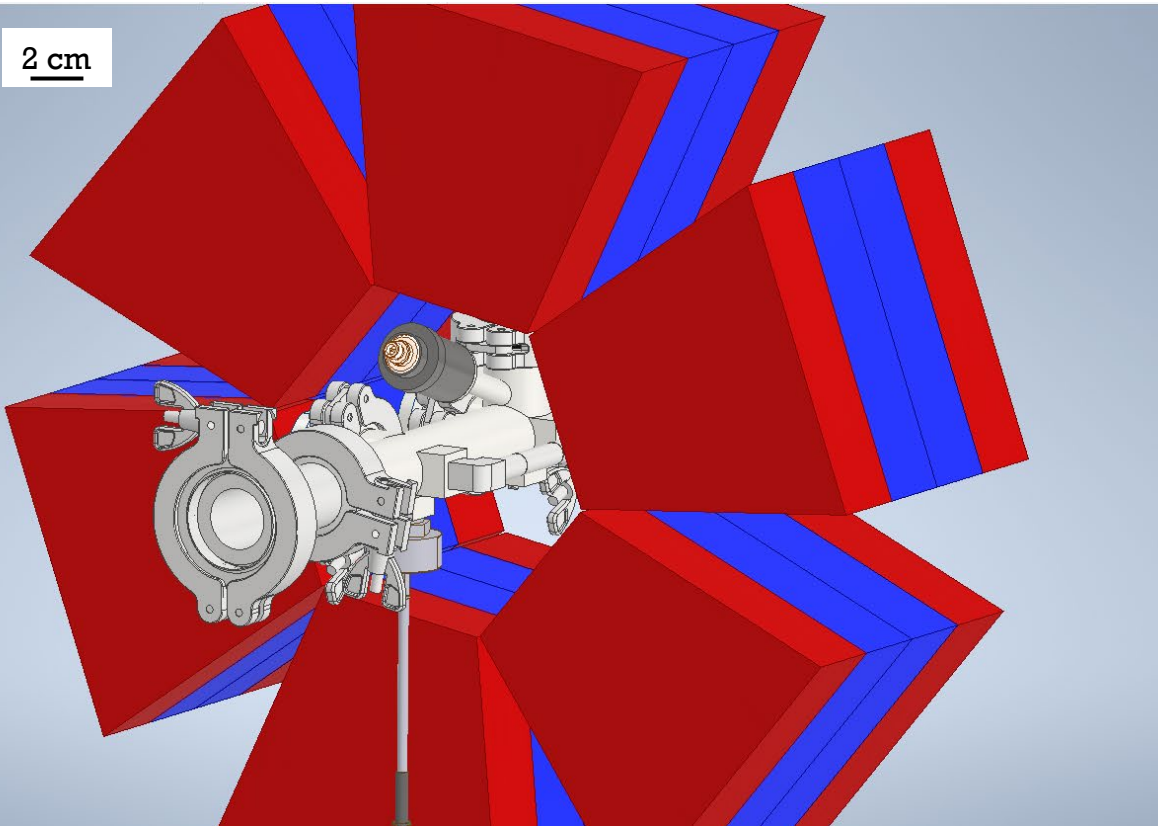
higher angular sensitivity for better
reaction mechanism identification

Wolke et al. 1989 Z. Phys. A 334



higher detection efficiency for higher
precision and lower upper limits

STARS: DETECTION EFFICIENCY



Supersonic gas jet target

Extended gas target

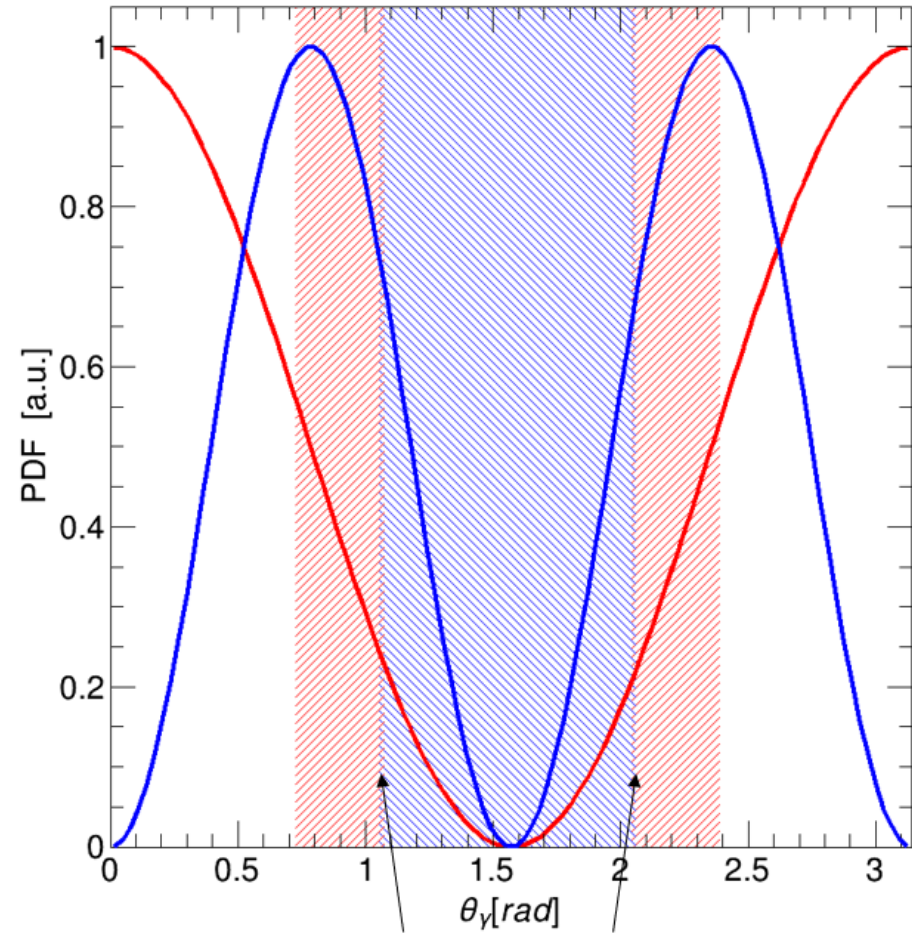
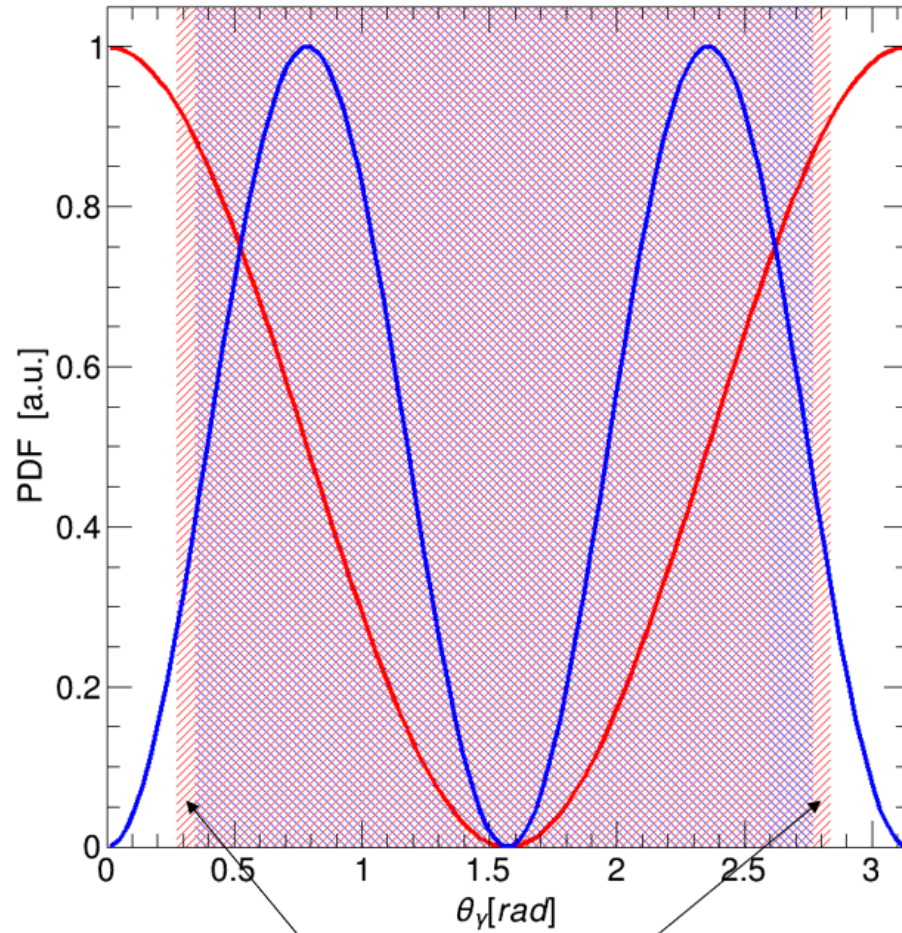


STARS: ANGULAR SENSITIVITY

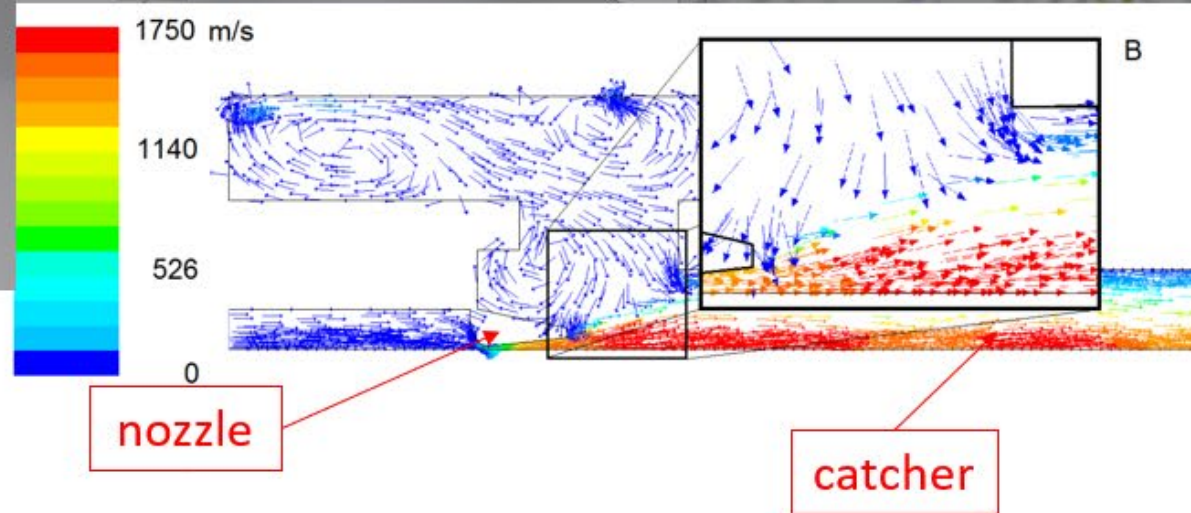
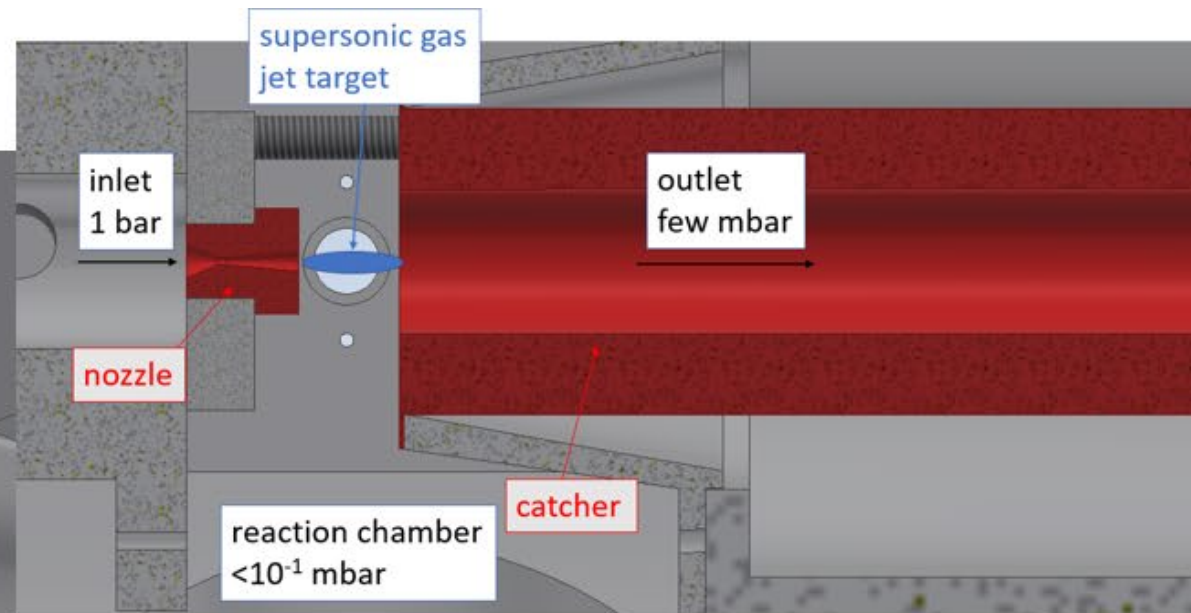
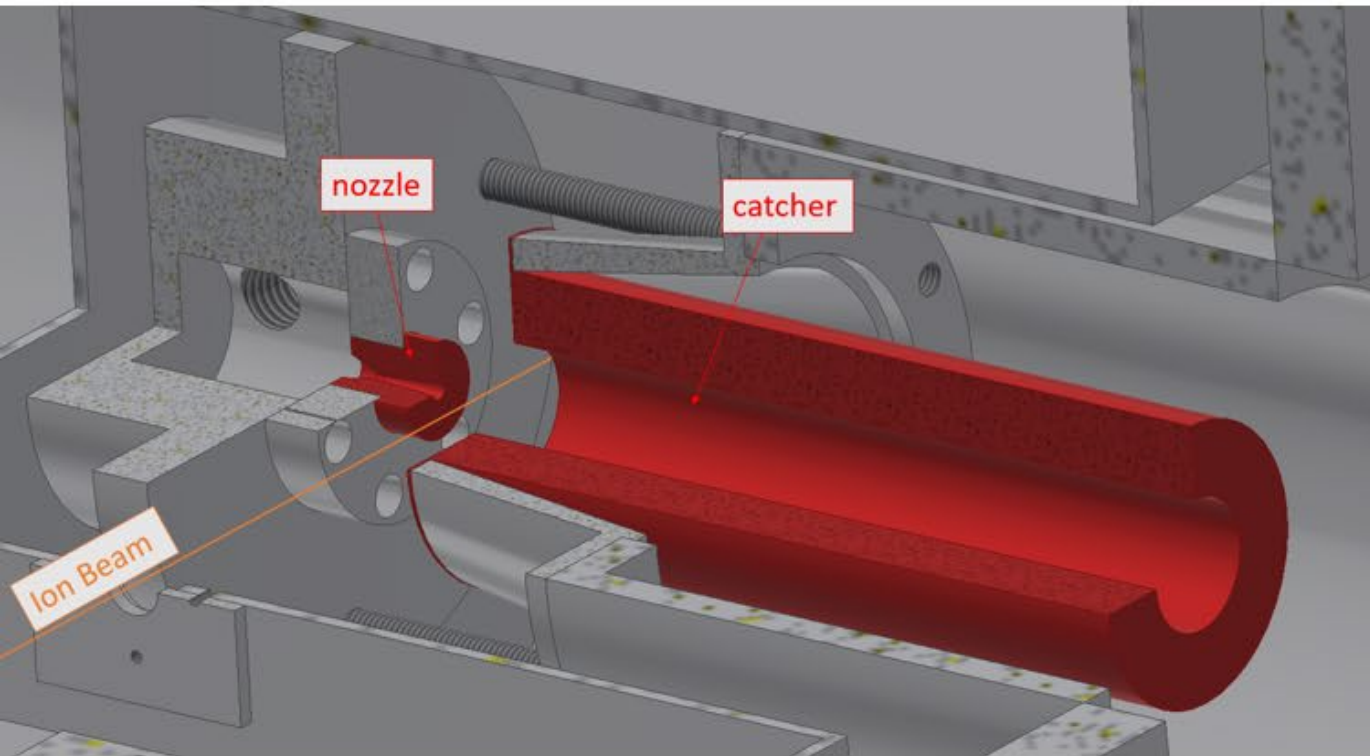
Extended gas target — E1 — E2

close far

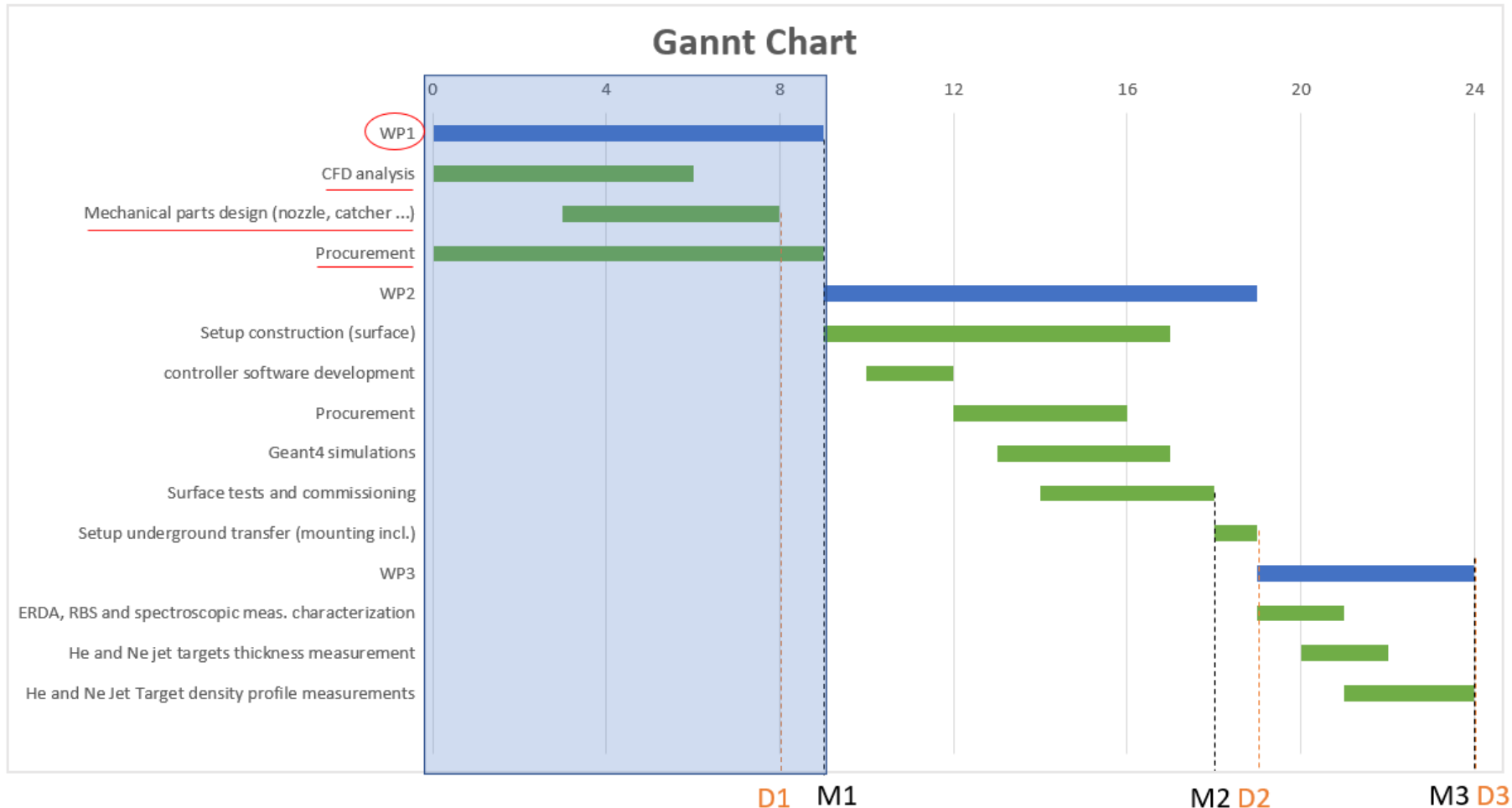
Supersonic gas jet target



STARS: SGJT AND CFD



STARS: PHASE 1 - DESIGN



Months 0 to 9
 3 tasks
 1 Deliverable
 1 Milestone

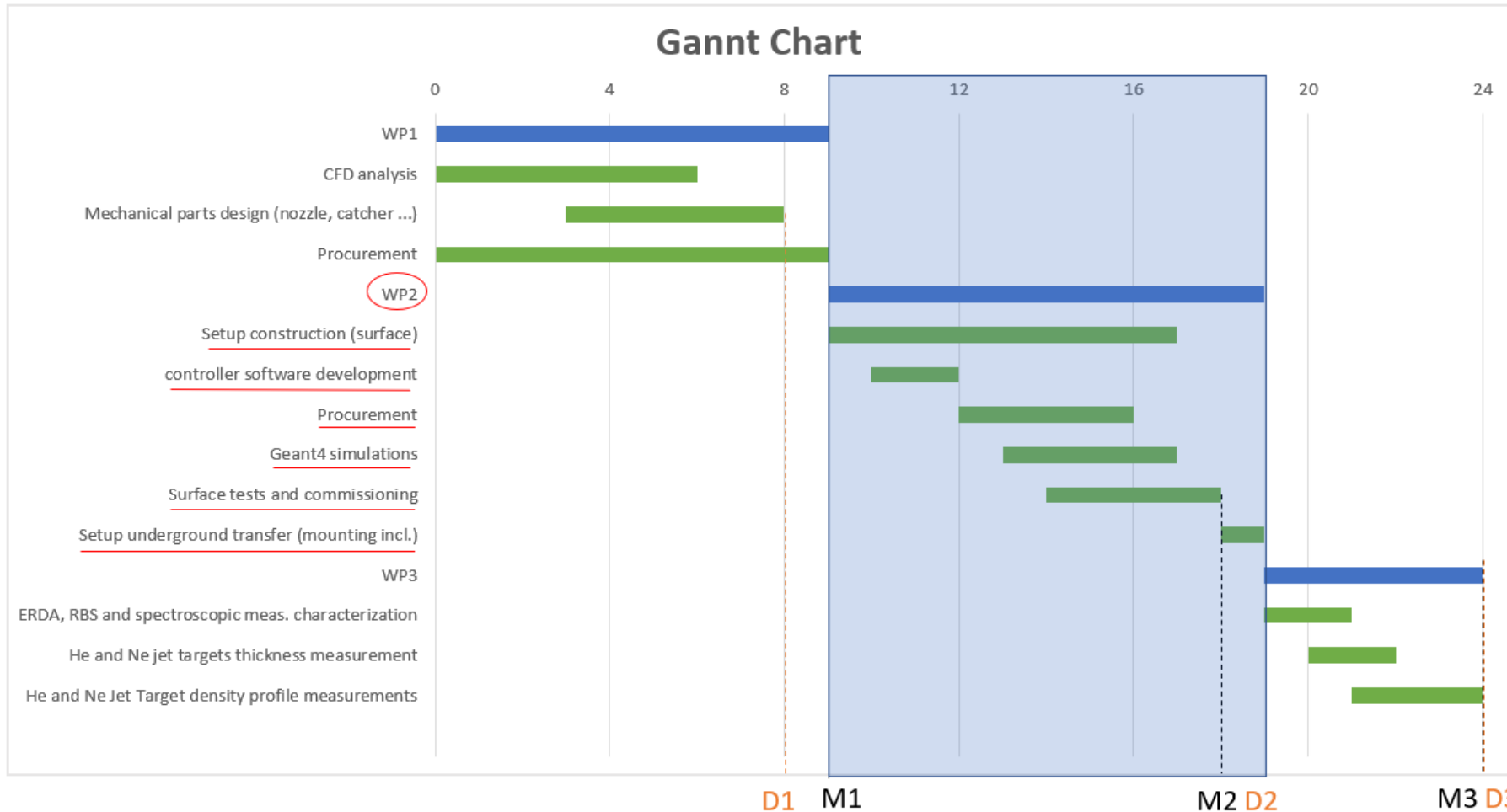


STARS: PHASE 1 - DESIGN

- Innovative Computational Fluid Dynamics estimates to optimal nozzles and catches profiles
- computer aided design of the best nozzles-catchers pairs, of the reaction chamber (to host nozzle and catcher, beam monitor, ccd camera, exhausts and being as much compact as possible) and of the vacuum scheme
- procurement (e.g. high flow pumps, capacitive pressure gauge, mass flow controller)
- ✓ Deliverable: Report on the design (CFD results, drawings of the mechanicals part, 3D of the whole assemble)
- ✓ Milestone: Complete of the design (CFD and CAD) and of the procurement of the custom parts



STARS: PHASE 2 - CONSTRUCTION



Months 10 to 18
 6 tasks
 1 Deliverable
 1 Milestone

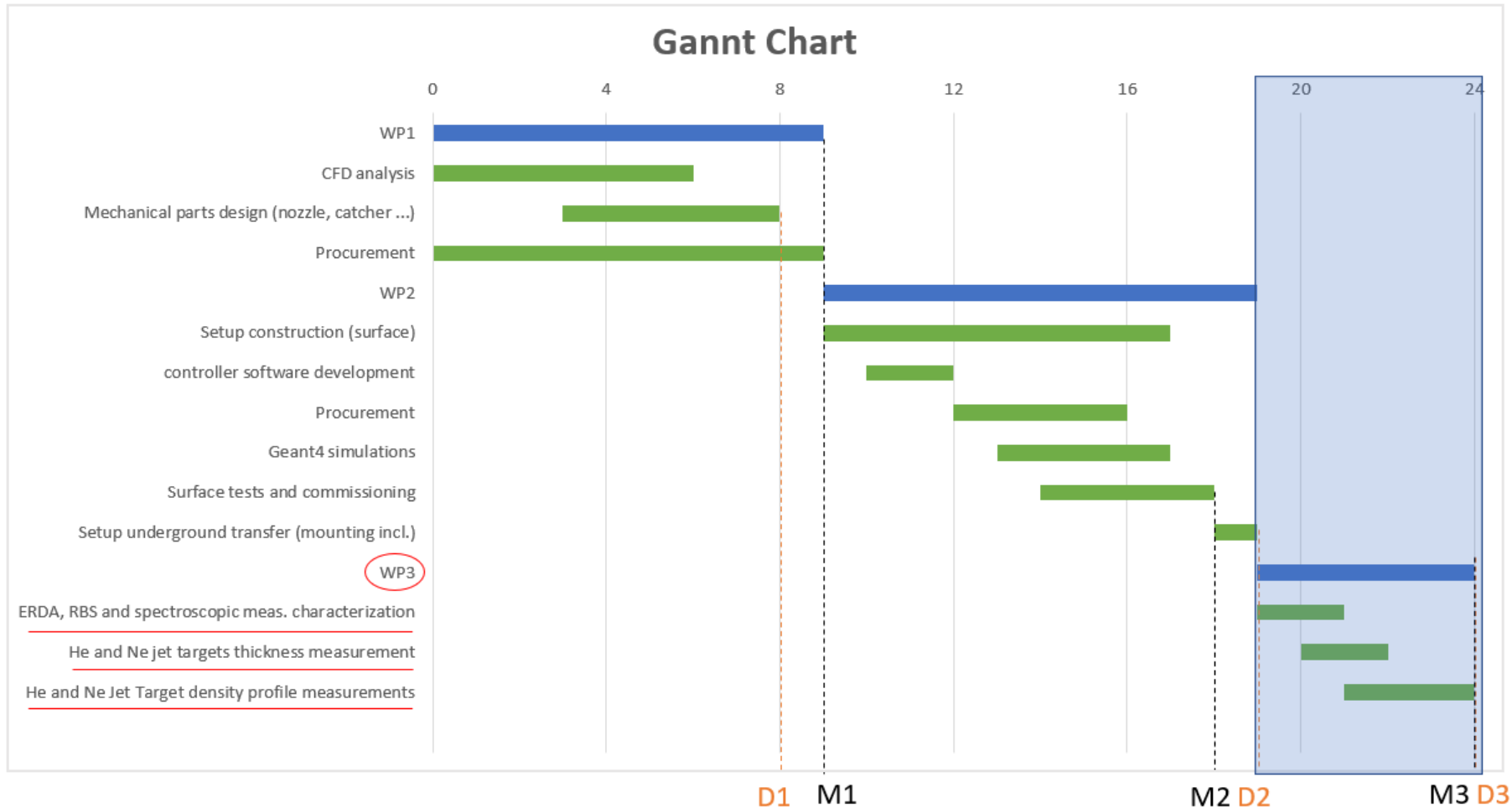


STARS: PHASE 2 - CONSTRUCTION

- in the Laboratory of Nuclear Astrophysics of the University of Naples “Federico II”
- Setup construction
- Development of the controller software
- Procurement of the remaining parts
- Geant4 simulations for WP3 IBA measurements
- Surface tests (comparison with CFD, detectors calibration)
- Setup transfer
- ✓ Deliverable: Report on setup performance, detectors initial characterization and Geant4 simulations
- ✓ Milestone: Surface commissioning complete



STARS: PHASE 3 - COMMISSIONING



Months 19 to 24
 3 tasks
 1 Deliverable
 1 Milestone



STARS: PHASE 3 - COMMISSIONING

- at 3.5 MV accelerator in LNGS
- characterization of ERDA and RBS - detection efficiency and angles
- CCD imaging calibration
- SGJT thickness and density profile estimate with PIGE and optical imaging

- Deliverable: Report on characterization measurements, data analysis and results
- Milestone: SGJT characterization complete



STARS: COLLABORATORS

INFN - UNINA

D. Rapagnani (PI)

C. Ananna

G. Imbriani

M. Junker

L. Morales-Gallegos

Expertise

Long-standing experience in setups and measurements with ion beams

Synergy

SGJT for Nuclear Reaction measurements

CIRA

M. DeCesare

A. Schettino

L. Cutrone

Expertise

Long-standing experience in CFD analysis

Synergy

knowledge on small scale system

CNR-INO

L. Gizzi

F. Brandi

L. Abate

Expertise

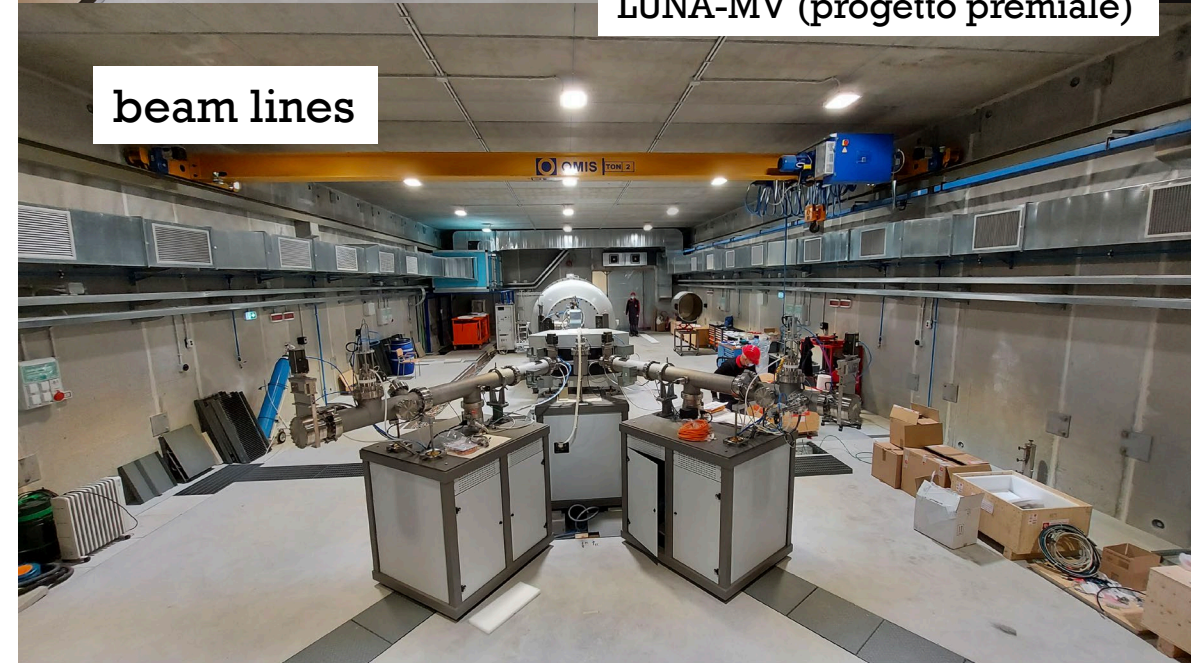
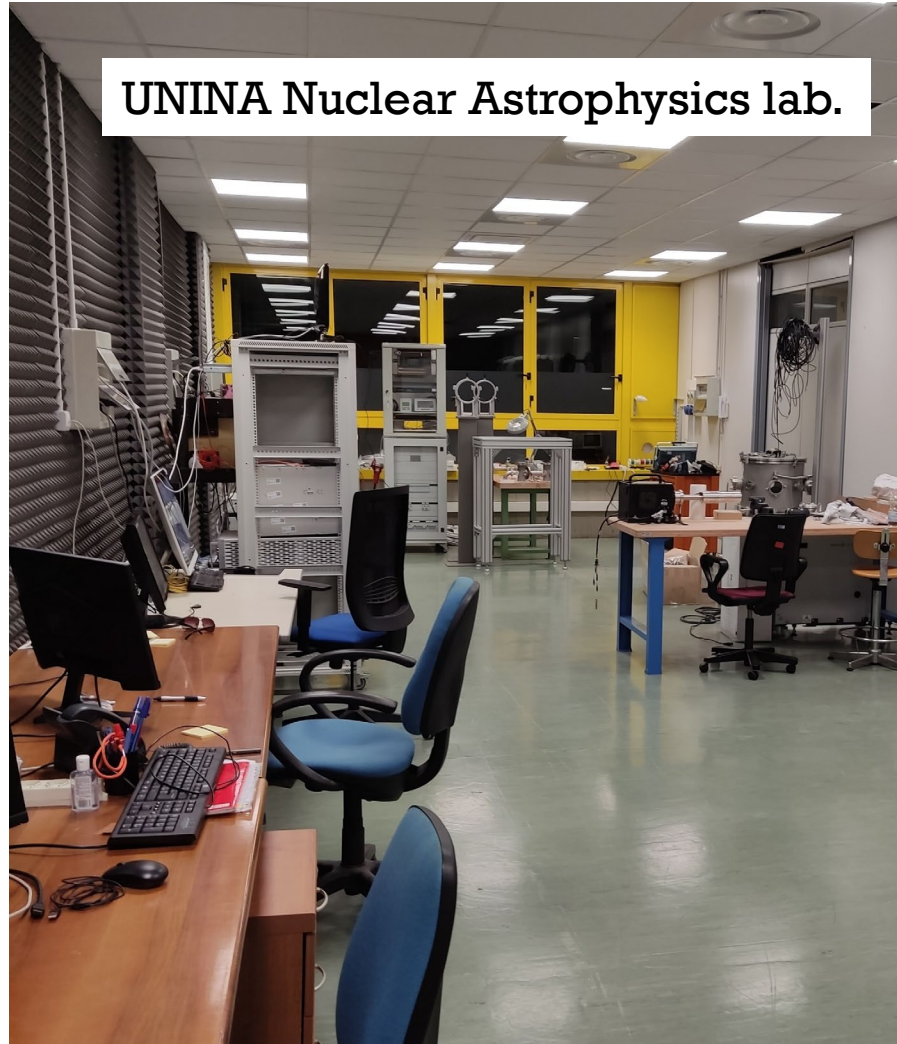
Long-standing experience in optical diagnostic and laser plasma interaction

Synergy

knowledge on SGJT properties for Laser Wake Field Acceleration technology



STARS: COLLABORATORS



STARS: BUDGET

- early procurements to avoid possible delays
- part 1: SGJT related elements (high flow pumps, mass flow controller, ...)
- part 2: measurement related elements (Si detectors and electronics, turbopumps, line valves, ...)

	year 1 (k€)	year 2 (k€)
consumable (e.g. gas, CCD lens, filter and optical fibers, DIO modules)	9.92	10.92
instruments (e.g. pumps, pressure gauges and readers, computer, valves)	64.98	56.04
travels		8.00
tot	74.89	74.96
sum of the project	149.86	



STARS: RISK MITIGATION

Risk	Probability	Contingency plan / Mitigation
Procuring time exceeds the expected one	medium	Having two periods for procuring gives some flexibility. Also elements with need fewer design will be acquired at the very beginning of the project.
Accelerator unscheduled maintenance	high	Data taking requires 3 weeks of beam, over 5 months devoted also to preparation and data analysis. Program is then flexible and shifts can be easily re-arranged.
Procured setup doesn't meet requirements, broke	low	A commissioning test is to be performed and it will be done carefully for each purchase. To beforehand handle a possible break, we will ask for extended warranty to cover the entire project (if not included) and handle this issue like a delayed procuring time (see above).
LUNA-MV facility not ready for measurements	very low	A proposal to perform the commissioning phase at the the Tandem accelerator of University of Campania will be submitted.



Thanks for your attention!

STARS: Supersonic jet **T**argets
for nuclear **A**strophysics
Radiative capture
measurement**S**

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