NFRP 2018 - SANDA

SUPPLYING ACCURATE NUCLEAR DATA
FOR ENERGY AND NON-ENERGY APPLICATIONS
2019-2023

WORKPACKAGE 1 –

Developments of new innovative detector devices

Maëlle Kerveno, CNRS/IPHC, Strasbourg (France)

General meeting, remotly, 9-11 February 2021

OUTLINE

WP general considerations

WP milestones and deliverables status

Summary

SANDA

OUTLINE

WP general considerations

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Summary

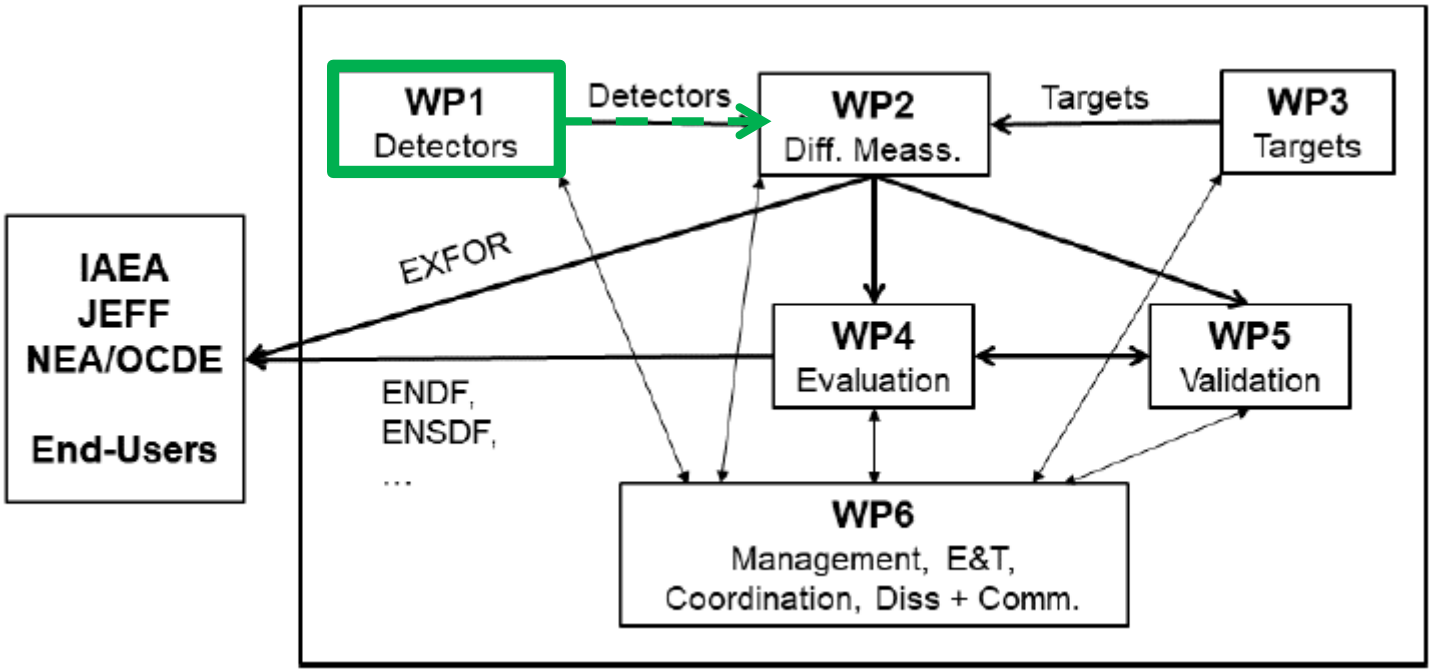
SANDA

WP description

WP 1 in SANDA : Developments of new innovative detector devices

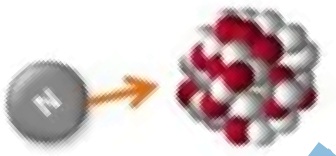
Support the **development of new measurement devices**
which allow **high precision measurements**
for Energy and N.E. applications

-> for an immediate use in the frame of WP2 (~1/3 of tasks)
-> for more long term experiments which need more R&D

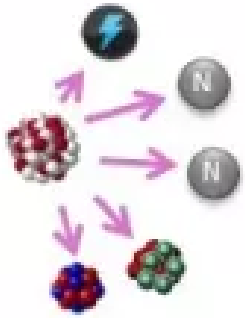


WP 1 Physics case

Better experimental knowledge of neutron induced reactions
Especially on actinides (Energy appl.) or for Non-Energy applications



Fission

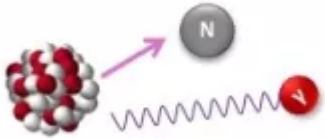


Fission cross section
Fission products
and their decay

Capture

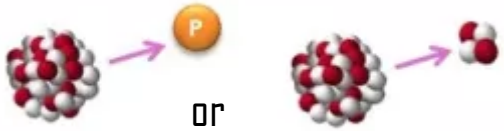
(n,γ) cross section

Neutron emission



Neutron spectrum
(n,xn) reaction XS

Lcp production



(n,lcp) double differential cross section
(N-E applications)

WP 1 Physics case

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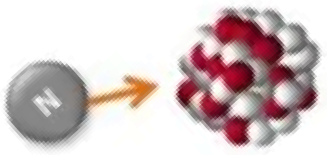
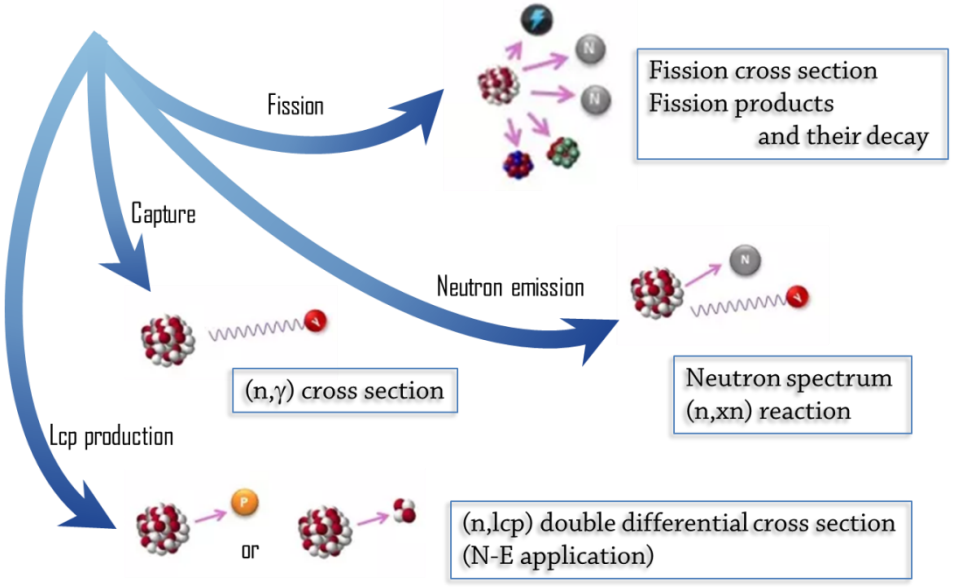




Experimental challenges

For new evaluations

-> new measurements with reduced uncertainties (even on already studied isotopes)

-> new experiments more discriminating and binding for theoretical models

Actinide samples

-> low mass samples : very efficient detector devices needed

-> high resolution for particle discrimination

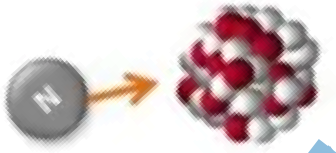
New facilities

-> n_TOF EAR2, SPIRAL2/NFS

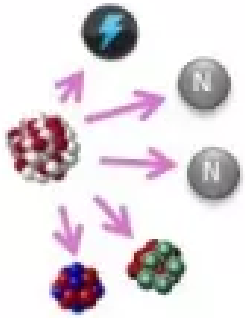
Instrumental work is needed!

WP structure and partners

WP 1 Structure



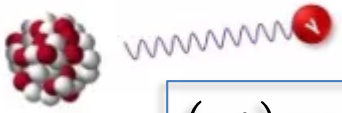
Fission



Fission cross section
Fission products
and their decay

TASK 1

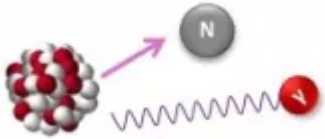
Capture



(n,γ) cross section

TASK 3

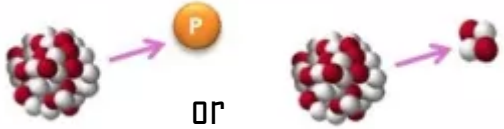
Neutron emission



Neutron spectrum
(n,xn) react. XS

TASK 2

Lcp production



(n,lcp) double differential cross section
(N-E application)

TASK 4

WP structure and partners

WP 1 Structure and tasks

TASK 1

Innovative devices from fission cross section to Fission products decay

Leader : CEA/DRF/IRFU – Frank Gunsing

SUBTASK 1.1.1 new devices for fission cross section measurements

- development of a **micromegas Time Projection Chamber**
  Partner : **CEA/DRF/IRFU** ; project leader : F. Gunsing; collab. TUW, JRC-Geel
- development of a **new Gaseous Proton Recoil Telescope**
  Partner : **CNRS/CENBG** ; project leader : L. Mathieu; collab. CEA/DEN, CEA/DRF/IRFU, JRC-Geel

SUBTASK 1.1.2 new devices for fission products studies

- development of a **new large gas cell** with electric field guidance **for IGISOL**
  Partner : **JYU** ; project leader : H. Penttilä; collab. UU
- coupling of **FALSTAFF with FIPPS @ ILL**
  Partner : **CEA/DRF/IRFU** ; project leader : D. Doré; collab. GANIL, ILL
- build a **new version of BELEN**
  Partner : **UPC** ; project leader : F. Calviño; collab. IFIC
- **new measurement facility** dedicated to the **measurement of half-lives**
  Partner : **CEA/LNE-LNHB** ; project leader : M. Kellet; collab. CNRS/SUBATECH, IFIC

Measurements planned in WP2

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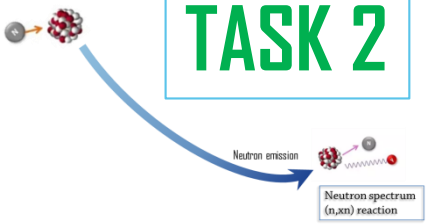
WP structure and partners

WP 1 Structure and tasks



TASK 2 Innovative devices for neutron emission studies

Leader : CERN – Massimo Barbagallo

SUBTASK 1.2.1 Build of a compact fast neutron spectrometer

Partner : **CEA/DEN/CAD** ; project leader : R. Jacqmin; collab. -

SUBTASK 1.2.2 Development of Germanium detectors for (n,xn) measurements at n-TOF

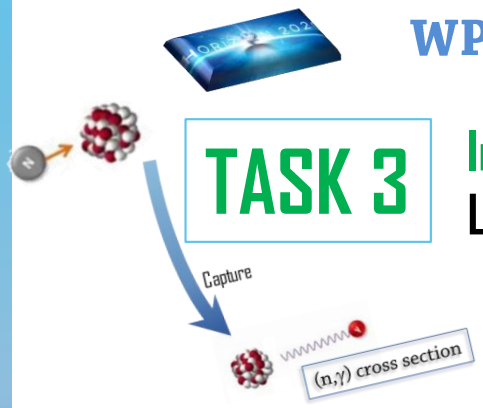
Partner : **CERN** ; project leader : M. Barbagallo; collab. UMANCH., NTUA, UOI., IFIN-HH

SUBTASK 1.2.3 Development of the SCONE detector

Partner : **CEA/DAM** ; project leader : G. Belier; collab. -

WP structure and partners

WP 1 Structure and tasks



Innovative devices for capture cross section measurement on actinides

Leader : CIEMAT – Emilio Mendoza

- Development of **CLYC detector for (n,γ) XS** measurements **@EAR2 n_TOF**
  Partner : **CIEMAT** ; project leader : E. Mendoza; collab. USE
- Extend the **i-TED technique** for measurement on **actinides @EAR2 n_TOF**
  Partner : **UPC** ; project leader : F. Calvino; collab. - IFIC

SANDA

WP structure and partners

WP 1 Structure and tasks

TASK 4

Detectors for non-energy application

Leader : PTB – Ralf Nolte

- **Doub. Diff. XS (n,lcp)** measurements @ **n_TOF from 20 to 200 MeV**
  Partner : **HZDR** ; project leader : A. Junghans; collab. PTB
- **Doub. Diff. XS (n,lcp)** measurements @ **n_TOF from 20 to 200 MeV**
  Partner : **PTB** ; project leader : R. Nolte; collab. HZDR

Measurement planned in WP2

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WP structure and partners

Summary

WP 1

- **8 partners** (CEA, CERN, CIEMAT, CNRS, HZDR, JYU, PTB , UPC)
- **80.8 pm, 476 k€**
- **4 tasks**

TASK 1 2 subtasks, 4 partners (CEA, JYU, CNRS, UPC)

TASK 2 3 subtasks, 2 partners (CEA, CERN)

TASK 3 0 subtask, 2 partners (CIEMAT, UPC)

TASK 4 0 subtask, 2 partners (PTB, HZDR)

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OUTLINE

WP general considerations

WP milestones and deliverables status

Summary

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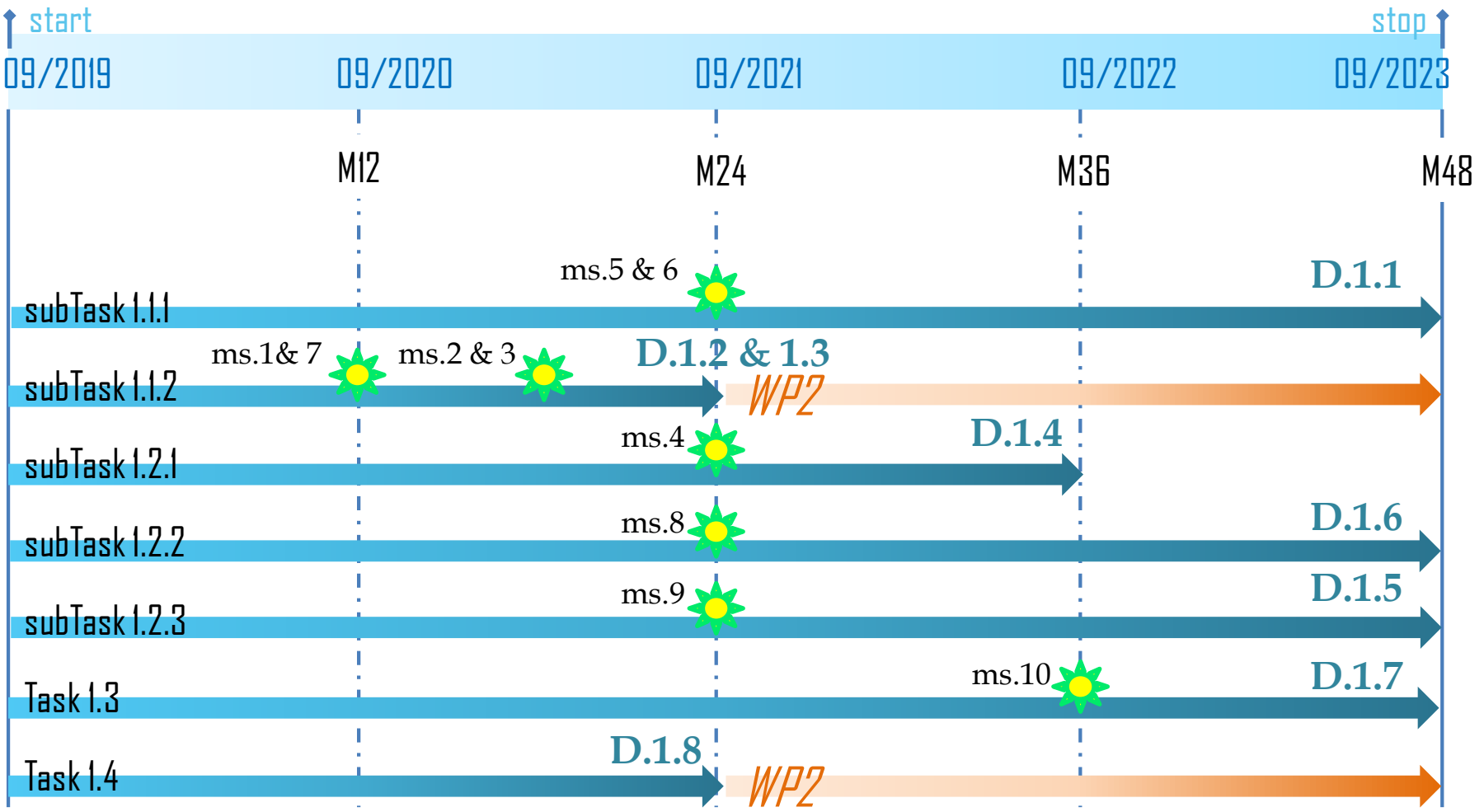
WP milestones and deliverables

Summary : SANDA-WP1 gantt chart (09/2019)



WP milestones and deliverables

Deliverable 1.1 (CNRS)

"Report on the study and construction of new devices for precise fission cross section measurements"

M48

¤ Development of a micromegas Time Projection Chamber for cross section measurements

Taken advantage of the expertise of CEA/IRFU on the development and use of the MicroMegas detector technology for **precise (n,f) XS measurements**

COMMITMENTS :

Use of micromegas as "Transparent" XY beam detector exploiting strip timing (**TPC** mode) to measure **angular distributions** of (n,f) and (n,lcp) **cross sections**

Program :

- Detailed simulations of detector geometry, particle's interactions and trajectories
- Simulation of a physics case
- Preliminary detector design including field degrader
- Contribution for report subtask 1.1.1

CEA ms.6 M24

WP milestones and deliverables

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CEA ms.6 M24

Status @ M18 :

Problem with the recruitment of a post doc who was supposed to work on the simulations
=> delay (12 months) expected for the completion of the simulation. ms.6 affected but not D 1.1

CEA ms.6 M36

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WP milestones and deliverables

Deliverable 1.1 (CNRS)

"Report on the study and construction of new devices for precise fission cross section measurements"

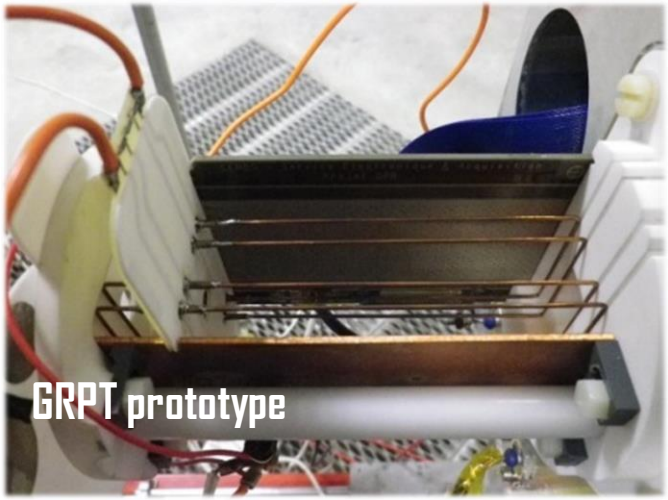
M48

- Development of a new Gaseous Proton Recoil Telescope (GRPT)

Taken advantage of the work already performed in CHANDA in view of the measurement of the quasi-absolute fission **cross section measurement of ^{242}Pu(n,f) relative to H(n,p) scattering** between 200 keV and 2 MeV

COMMITMENTS :

Completion of the GRPT (in view of measurement with 5% accuracy below 1 MeV)



Program :

- End of the construction of the GRPT 2021
- Commissioning 2021-2022
- Ready for measurement 2022-2023

CNRS ms.5 M24

WP milestones and deliverables

Deliverable 1.1 (CNRS)

M48+

"Report on the study and construction of new devices for precise fission cross section measurements"

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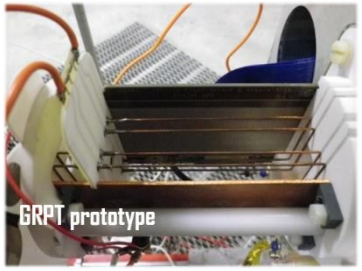


Program :

- End of the construction of the GRPT 2021
- Commissioning 2021-2022
- Ready for measurement 2022-2023

CNRS ms.5 M24

Status @ M18 :

Accelerator breakdown in beginning of 2020 with very long repair time + lock-down restrictions

=> delay (12 months) for the test exp. (02/2020-> 02/2021).

ms.5 affected but also D 1.1 in the same delay

CNRS ms.5 M36

WP milestones and deliverables

Deliverable 1.2 (JYU)

"Report on the design of the large gas cell for IGISOL"

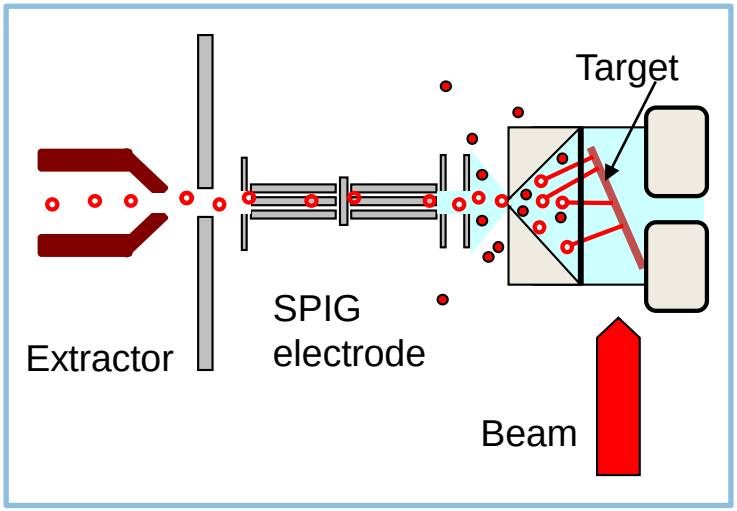
M24

¤ development of a new large gas cell with electric field guidance for IGISOL

Taken advantage of the work already performed in CHANDA for the development of a proton to neutron converter at IGISOL for **neutron fission induced studies**

COMMITMENTS :

Study of a new stopping gas cell with better ions stopping efficiency and faster transport. (expected overall improvement of efficiency of the order of 100)



Program :

- Study, comparison of all the possible technical solutions for gas filled stopping cells with electric field guidance.
- Simulations of the performances (fission product stopping, ion survival) and optimization of cell dimensions, electrode structure and voltage in the IGISOL environment.
- Technical drawing of the new gas cell

JYU ms.2 M18

WP milestones and deliverables

Deliverable 1.2 (JYU)

M24+

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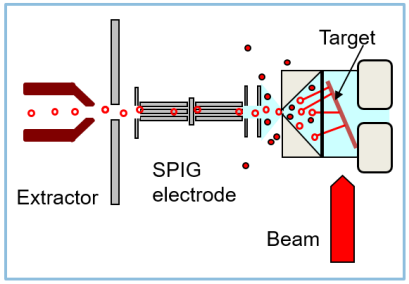

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- Technical drawing of the new gas cell

JYU ms.2 M18

Status @ M18 :

Simulations have not been started yet; information of possible technical solutions has been collected and partly evaluated, but decision of the development line has not been made. Lack of manpower + COVID impact => MS dead line will not be met. Expected delay 8-12 months. Given the difficulties so far, 12 months delay are anticipated for ms.2 and D1.2

JYU ms.2 M30

WP milestones and deliverables

Deliverable 1.3 (CEA)

"Report on the performances of new devices for precise study of fission products and their decay in view of measurements"

M24

- coupling of FALSTAFF with FIPPS @ ILL

Taken advantage of the work already performed in CHANDA for the building of the **new device FALSTAFF for actinide fission fragments studies**

COMMITMENTS :

Prepare a new setup by coupling FALSTAFF and FIPPS @ ILL to provide new nuclear data for fission modeling improvements (fission and deexcitation models, prompt γ-ray spectra with FF A & M, FF angular momentum)

Program :

- Simulations of the coupling of FALSTAFF (fragment kinetic energy and fragment mass after evaporation) and FIPPS (γ-ray cascades from FF)
- Evaluation of performances in view of the measurement at ILL

WP2

CEA ms.1 M12

WP milestones and deliverables

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WP2

CEA ms.1 M12

Status @ M18 :

The first study revealed that for studied Fission Fragments with FALSTAFF and FIPPS, this configuration is not more efficient than FIPPS and active target (see ms.1 report) more tests should have been required; Difficulties to implement FALSTAFF in the FIPPS Casemate; ILL shutdown (1 year) in 2022 => New definition (closely related to the scope of the task and the WP2 project) of the objectives of the subtask is under discussion.

completed

CEA ms.1 M12

WP milestones and deliverables

Deliverable 1.3 (CEA)

"Report on the performances of new devices for precise study of fission products and their decay in view of measurements"

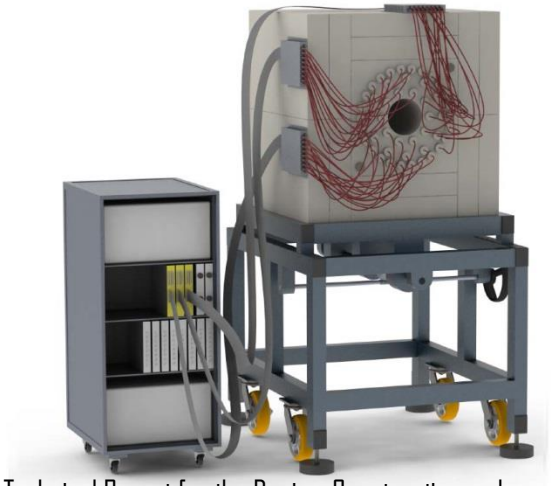
M24

- build a new version of BELEN

Taken advantage of the development performed in CHANDA of the **versatile neutron detector BELEN** dedicated to beta delayed neutron studies

COMMITMENTS :

Optimize the BELEN detector to obtain a device with very high efficiency capability for Pn and low resolution energy spectra measurements



From Technical Report for the Design, Construction and Commissioning of the Beta-Delayed Neutron Detector – BELEN

Program :

- MCNP or GEANT4 simulations of the BELEN matrix responses
- Production of new unfolding codes for Bonner Spheres systems
- Design an optimized geometry for effective rings
- Evaluation of performances in view of the measurement at IGISOL

WP2

UPC ms.7 M12

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WP milestones and deliverables

Deliverable 1.3 (CEA)

"Report on the performances of new devices for precise study of fission products and their decay in view of measurements"

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WP2

UPC ms.7 M12

Status @ M18 :

Simulations are done but due to COVID, the experimental validation with the tubes (in Japan) could not be done yet. Originally ms.5 due for M12 but we detect an error in official document where it is due for M24 (same as D1.3). We agreed to report for ms.7 on M18.

=> No delay for ms.7 but delay anticipated for D1.3

In preparation

UPC ms.7 M18

WP milestones and deliverables

Deliverable 1.3 (CEA)

"Report on the performances of new devices for precise study of fission products and their decay in view of measurements"

M24

- new measurement facility dedicated to the measurement of half-lives

Taken advantage of the expertise of the CEA/LNE-LNHB group in **decay data evaluation and metrology activities**

COMMITMENTS :

Prepare and commission a new measurement facility dedicated to the measurement of half-lives for a range of radionuclides.

Program :

- Developing an automated sample changer for use with an ionization chamber
- Creating the necessary command modules in the LabView environment
- Commissioning of the device in view of measurement in

WP2

CEA ms.3 M18

WP milestones and deliverables

Deliverable 1.3 (CEA)

"Report on the performances of new devices for precise study of fission products and their decay in view of measurements"

M24+

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CEA ms.3 M18

Status @ M18 :

delayed delivery of the new ionisation chamber (COVID), currently being tested prior to characterization. 6 months Master student (2021) and 1 year post doc will strengthen the team.

=> delay (1 year) for ms.3, 6m – 1 year delay anticipated for D1.3

CEA ms.3 M30

SANDA

WP milestones and deliverables

Deliverable 1.4 (CEA)

"Report on the commissioning of a compact broad-band fast neutron spectrometer"

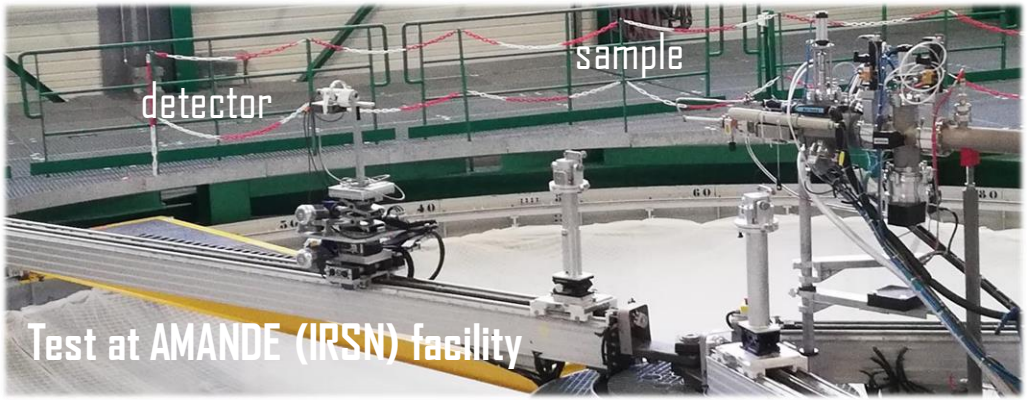
M36

¤ development of a compact broad-band fast neutron spectrometer

Provide a **neutron spectrometer** useable in **many applications**

COMMITMENTS :

Construction of a compact broad-band fast neutron (10 keV – 10 MeV) spectrometer based on a solid organic scintillator (stilbene detector) with its associated electronics



From Augusto Di Chicco, proceedings of ANIMMA 2019 conference

Program :

- Improvement of the PSD procedure
- Study of the anisotropy at very low neutron energy (< 100 keV)
- Calculation of the response matrix
- Tests and commissioning at neutron facility (AMANDE, PTB, ...)

CEA ms.4 M24

SANDA

WP milestones and deliverables

Deliverable 1.4 (CEA)

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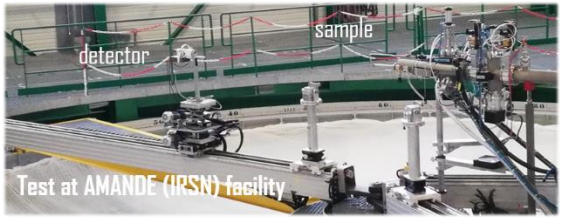

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- Tests and commissioning at neutron facility (AMANDE, PTB, ...)

CEA ms.4 M24

Status @ M18 :

Good progress overall, but detector calibration measurements at PTB have been delayed by 1 year (COVID)

=> delay (3 months) for ms.4 and 6 months for D1.4

CEA ms.4 M27

WP milestones and deliverables

Deliverable 1.5 (CEA)

"Report on the performance of the SCONE setup at NFS"

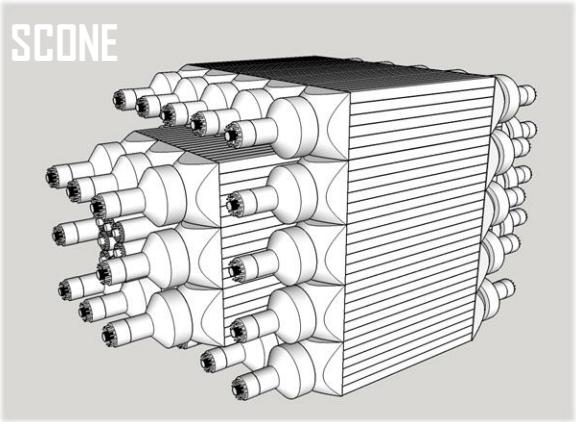
M48

- development of the SCONE setup for (n,xn) reaction studies at NFS

Taken advantage of the expertise of CEA/DAM for **(n,xn) reactions** experimental studies with a new high efficiency detector

COMMITMENTS :

Development of a **new neutron counter based on plastic scintillator** bars wrapped with Gd loaded material (SCONE) for measurements at **NFS facility**



Program :

- Final assembly of SCONE (~900 EJ200 plastic scintillator bars)
- Installation at NFS
- Commissioning of the setup

CEA ms.9 M24

SANDA

WP milestones and deliverables

Deliverable 1.5 (CEA)

M48

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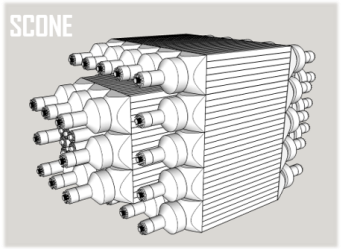


Program :

- Final assembly of SCONE (~900 EJ200 plastic scintillator bars)
- Installation at NFS
- Commissioning of the setup

CEA ms.9 M24

Status @ M18 :

Prototype under construction

=>Small delay (2 months, mainly related to lack of manpower)

no delay for D1.5

CEA ms.9 M26

SANDA

WP milestones and deliverables

Deliverable 1.6 (CERN)

"Report on the performance of the HPGe equipped with newly developed electronics"

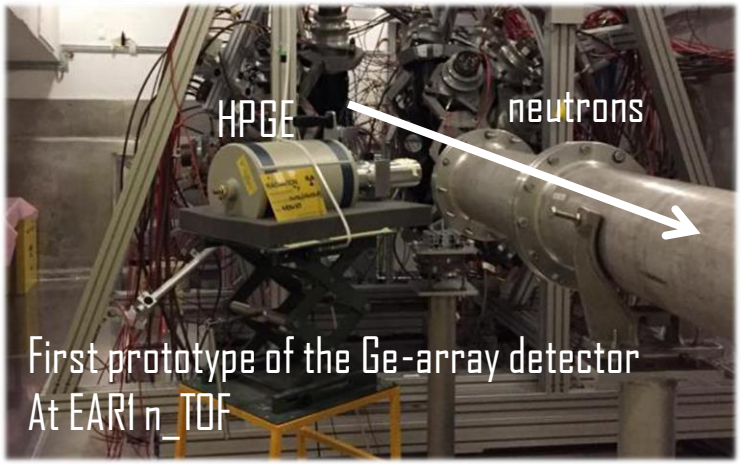
M48

¤ development of Germanium detectors for (n,xn) measurements at n-TOF

Taken advantage of **the high flux of the CERN/n_TOF** facility to study fast neutron reactions

COMMITMENTS :

Development of a new 4 HPGE setup with newly developed electronics to overcome the huge γ-flash preceding the neutron beam



First prototype of the Ge-array detector At EAR1 n_TOF

Program :

- Efficiency and energy resolution characterization of standards and prototype detector (with "isolated" preamp) by GEANT 4 simulations
- Develop and benchmark the PSA code
- Determination of the better choice for the Ge crystal (GEANT 4, FLUKA simulations) and RC or TRP preamps
- Tests of the setup at CERN/n_TOF

CERN ms.8 M24

SANDA

WP milestones and deliverables

Deliverable 1.6 (CERN)

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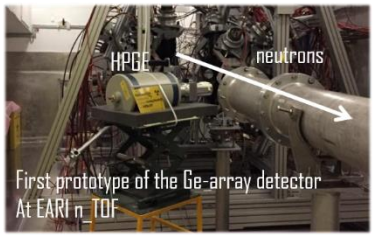

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CERN ms.8 M24

Status @ M18 :

4 months delay for the n-TOF restart (COVID)

=> delay (4 months) for ms.8 but, at this time, no delay foreseen for D1.6

CERN ms.8 M28

WP milestones and deliverables

Deliverable 1.7 (CIEMAT)

"Report on the development and performances of the new detectors for capture cross section measurements at n-TOF"

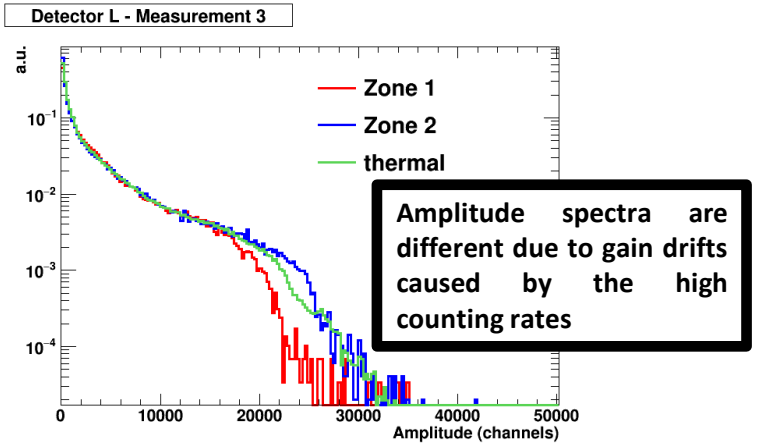
M48

¤ development of s-TED detector for (n,γ) XS measurements @ EAR2 n_TOF

Taken advantage of the CIEMAT **experience with scintillators (organic and inorganic)** acquired in the CHANDA project for (n,γ) measurement at n_TOF EAR2

COMMITMENTS :

Design and test a total energy detector prototype based on segmented CLYC inorganic scintillator adapted to the very demanding characteristics (high counting rates) of the n_TOF EAR2 experimental area and for meas. with actinide samples



Program :

- Characterization of a CLYC prototype detector (source meas. vs MC simulations)
- Test experiment at CIEMAT & CNA (tof) in Seville for neutron detection efficiency determination
- Optimization of the design (crystal size, PMT…)
- Test measurements at CERN on Au sample

CIEMAT ms.10 M36

SANDA

WP milestones and deliverables

Deliverable 1.7 (CIEMAT)

"Report on the development and performances of the new detectors for capture cross section measurements at n-TOF"

M48

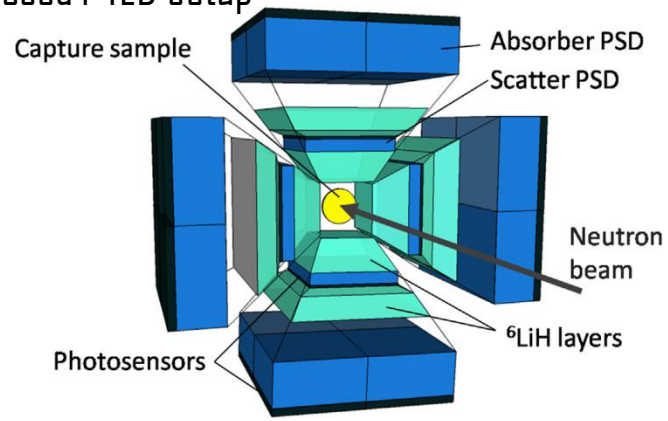
¤ extend the i-TED technique for measurement on actinides @ EAR2 n_TOF

Taken advantage of the work performed on **i-TED technique for (n,γ) cross section meas.** in astrophysics field

COMMITMENTS :

Developed an i-TED (imaging total energy detector) for radiative capture measurement with highly radioactive sample at EAR2 n_TOF

proposed i-TED setup



From C. domingo-Prado, NIMA825 (2016) 78

Program :

- Preparation and commissioning of i-TED at EAR2 n_TOF
- Experimental benchmark at EAR2 n_TOF
- Recommendation on actinides of the NEA HPRL that can be studied with i-TED

CIEMAT ms.10 M36

WP milestones and deliverables

Deliverable 1.7 (CIEMAT)

M48

"Report on the development and performances of the new detectors for capture cross section measurements at n-TOF"

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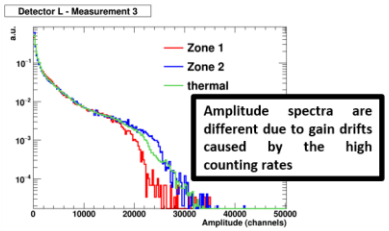

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CIEMAT ms.10 M36

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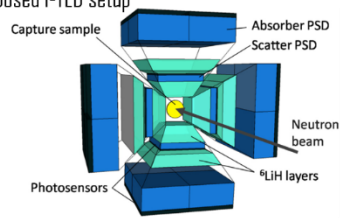

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Program :

- Preparation and commissioning of i-TED at EAR2 n_TOF
- Experimental benchmark at EAR2 n_TOF
- Recommendation on actinides of the NEA HPRL that can be studied with i-TED

CIEMAT ms.10 M36

Status @ M18 :

Some delays in the progress of the project due to limited access to the laboratories and also due to delays in material purchases. Efforts are made to make up for lost time.

=> No delay

CIEMAT ms.10 M36

WP milestones and deliverables

Deliverable 1.8 (PTB)

"Report on the development and performances of the new detectors for non-energy applications"

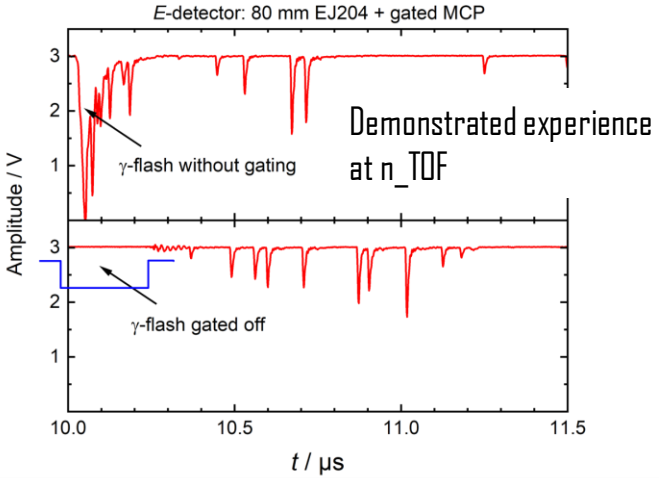
M24

- Double Diff. XS (n,lcp) measurement @ EAR1 n_TOF from 20 to 200 MeV

Taken advantage of the demonstration that the **neutron-induced emission of light charged particles** can be done **up to 200 MeV at EAR1 n_TOF** (^{235}U(n,f)/^{1}H(n,n) exp.)

COMMITMENTS :

Development of a scattering chamber and detector telescopes for H and He ions detection useable at EAR1 n_TOF (good resol., low thresholds, high max. neut. Energy)



Program :

- ΔE & E detectors and PreAmps developments
- Design and construction of a compact vacuum chamber
- Test measurements with prototype det. and electronics (beam facilities HZDR and PTB), final test at a spallation source

WP2

WP milestones and deliverables

Deliverable 1.8 (PTB)

"Report on the development and performances of the new detectors for non-energy applications"

M24+

¤ Double Diff. XS (n,lcp) measurement @ EAR1 n_TOF from 20 to 200 MeV

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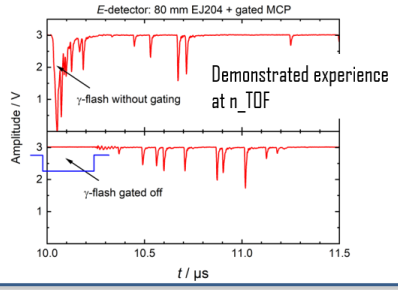


Program :

- ΔE & E detectors and PreAmps developments
- Design and construction of a compact vacuum chamber
- Test measurements with prototype det. and electronics (beam facilities HZDR and PTB), final test at a spallation source

WP2

Status @ M18 :

Travel restrictions impair the cooperation between HZDR and PTB for detector developments, a backlog of projects at nTOF will probably shift the first test beam time to 2022

=> delay (6 months) for D 1.8

SANDA

SUMMARY

¤ **Summary task 1.1**:

- 2 milestones completed (or almost), delays foreseen (due to COVID and others reasons) for the four others with likely impact on the deliverables (up to 1 year delay estimated).
- Only D1.1 present a risk that it couldn't be deliver on due time (~1 year-> **after the end of the project**).
- 2 projects impacted by delays (COVID) are continued in WP2.

- One project has to adjust the contribution in SANDA (due to scientific reasons and unavailability of the foreseen facility). Under discussion between WP and project leaders.

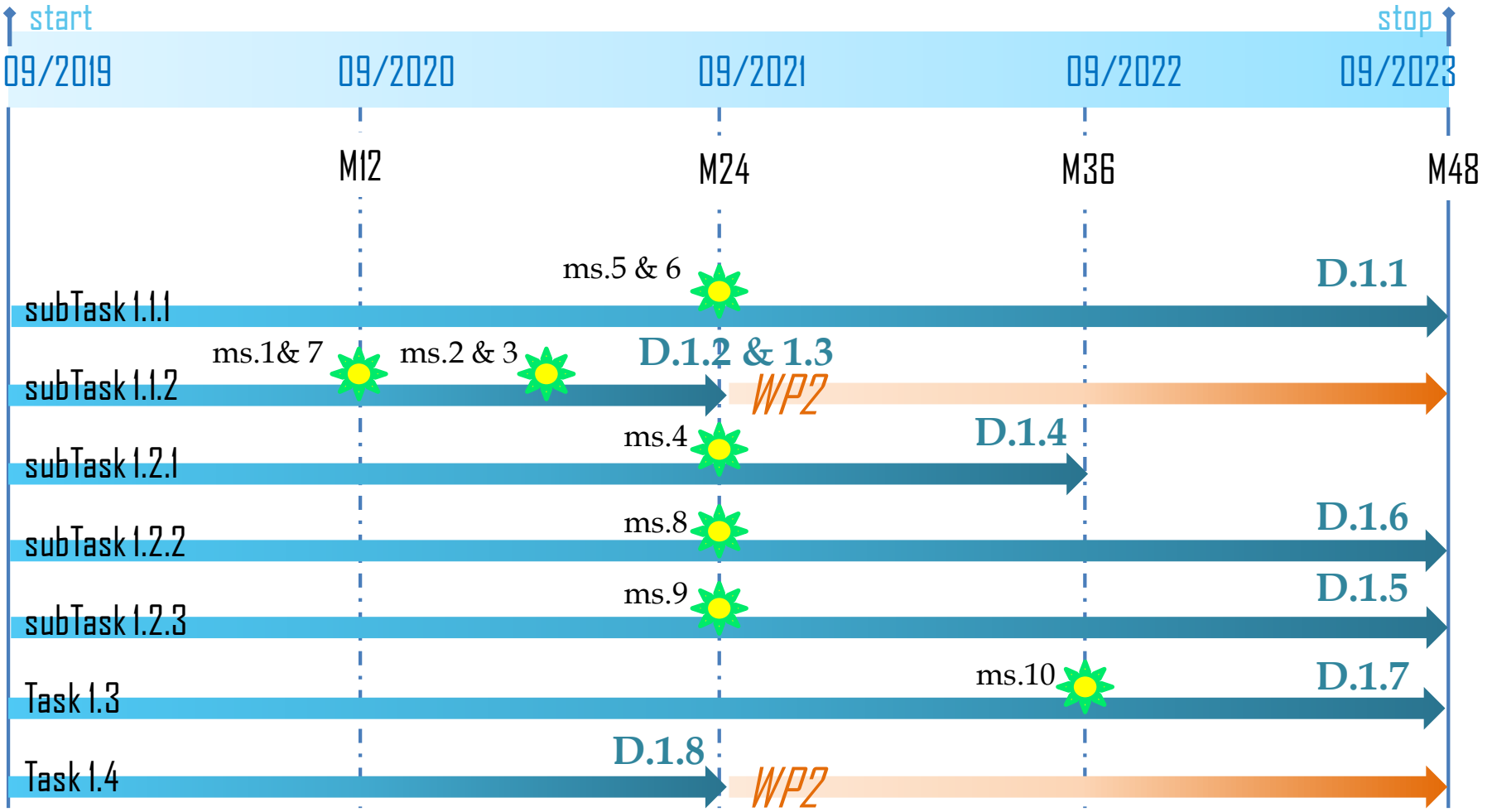
¤ **Summary task 1.2**:

some delays on milestones due the COVID 19 crisis. Only subtask 1.2.1 has a risk to not achieve the deliverable D1.4 in time (M36) (6 months delay estimated).

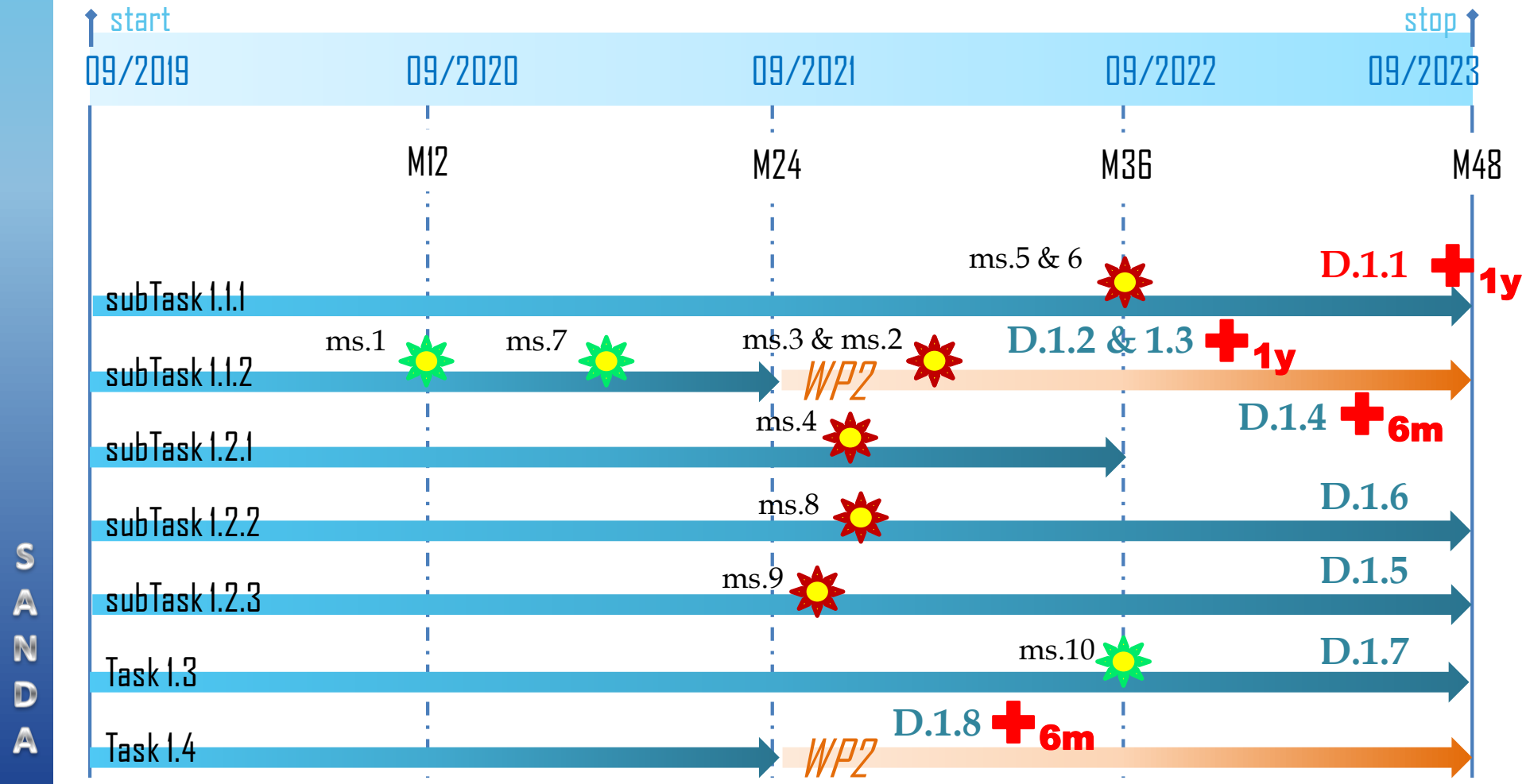
¤ **Summary task 1.3**: at this date, despite impact of COVID, no delay is expected.

¤ **Summary task 1.4**: 6 months delay for D1.8 but the project continues in WP2.

Summary : SANDA-WP1 gantt chart (09/2019)



Summary : SANDA-WP1 gantt chart (02/2021)



SUMMARY

¤ Despite the very difficult situation of the continuing pandemic,
each group works to keep up the goals on schedule.
They adapt as soon as possible with new working methods (remote experiment if facility offers such a support).

¤ Thanks all WP1 colleagues to keep the project on line and for their active participation to the preparation of this meeting!

¤ I give them the floor to review the scientific progress of their project.

Thank you for your attention…

SANDA

OUTLINE

10:20 → 13:00 **SANDA WP 1 Innovative detectors**

Developments of new innovative detector devices

Président de session: Maelle Kerveno

10:20	**Introduction and status of WP1: Developments of new innovative detector devices** Orateur: Maelle Kerveno	15m
10:35	Break	20m
10:55	**T1.1.1: Study and construction of new devices for precise fission cross section measurements** Orateur: Ludovic MATHIEU (CNRS)	15m
11:10	**T1.1.2: Design of the large gas cell for IGISOL** Orateur: Heikki Penttilä (University of Jyvaskyla)	10m
11:20	**T1.1.2: Performances of new devices for precise study of fission products and their decay in view of measurements** Orateur: Paco Calvino Tavares (Universitat Politecnica Catalunya (ES))	15m
11:35	**T1.1.2: Performances of new devices for precise study of fission products and their decay in view of measurements. Part II** Orateur: Dr Mark Kellett (CEA)	10m
11:45	**T1.2.1: Commissioning of a compact broad-band fast neutron spectrometer** Orateur: Dr Robert Jacqmin	10m
11:55	**T1.2.2: Performance of the HPGe equipped with newly developed electronics** Orateur: Massimo Barbagallo (CERN)	10m
12:05	**T1.2.3: Performance of the SCONE setup at NFS** Orateur: Dr G. Belier	10m
12:15	**T1.3: Development and performances of the new detectors for capture cross section measurements at n-TOF** Orateur: Emilio Mendoza Cembranos (Centro de Investigaciones Energéti cas Medioambientales y Tecno)	15m
12:30	**T1.4: Development and performances of the new detectors for non-energy applications** Orateur: Ralf Nolte (PTB)	15m
12:45	**Additional Q&A**	15m