

The NUOVA OFFICINA ASSERGI: future perspectives beyond DarkSide-20k



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Overview

- The NOA Clean Room infrastructure
- Photo-detector packaging machines
- An example of assembling photosensors for a dark matter detector
- Future plan and perspectives

NOA concept

**CIPE - MasterPlan Restart
Program of Regione Abruzzo**

**PON-MUR Programma
Operativo Nazionale-
Ministero Università e Ricerca**



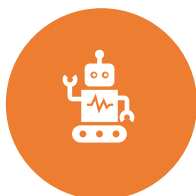
The NOA idea started to be conceived in 2016 and after different phases to achieve the final configuration of room and technical specifications, has turned into reality thanks to the combination of **2** different funds:



This lead to the construction of the NOA facility @LNGS with 3 main goals



Realize a photodetector production area equipped with highly sophisticated packaging machines for the assembly of photosensors in a dust controlled environment



Create a dedicated area for assembling large volume detectors



Realize the implementation of a Rn abatement system (CR operating in a Rn free mode)



**The first 2 goals have been achieved in the framework of the DarkSide-20k project
NOA is an INFN facility managed by LNGS**

NOA location

LNGS site

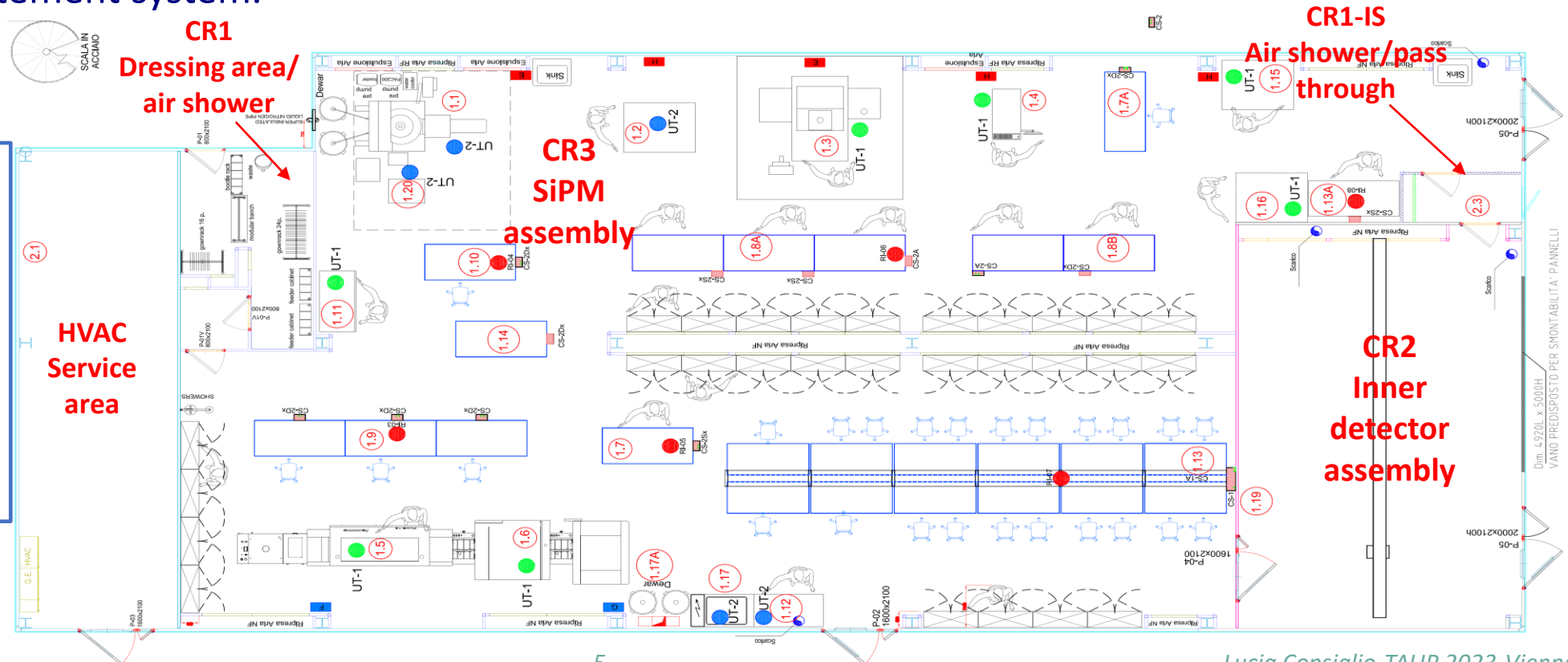


NOA occupancy inside
HALL di MONTAGGIO

NOA Clean Room layout

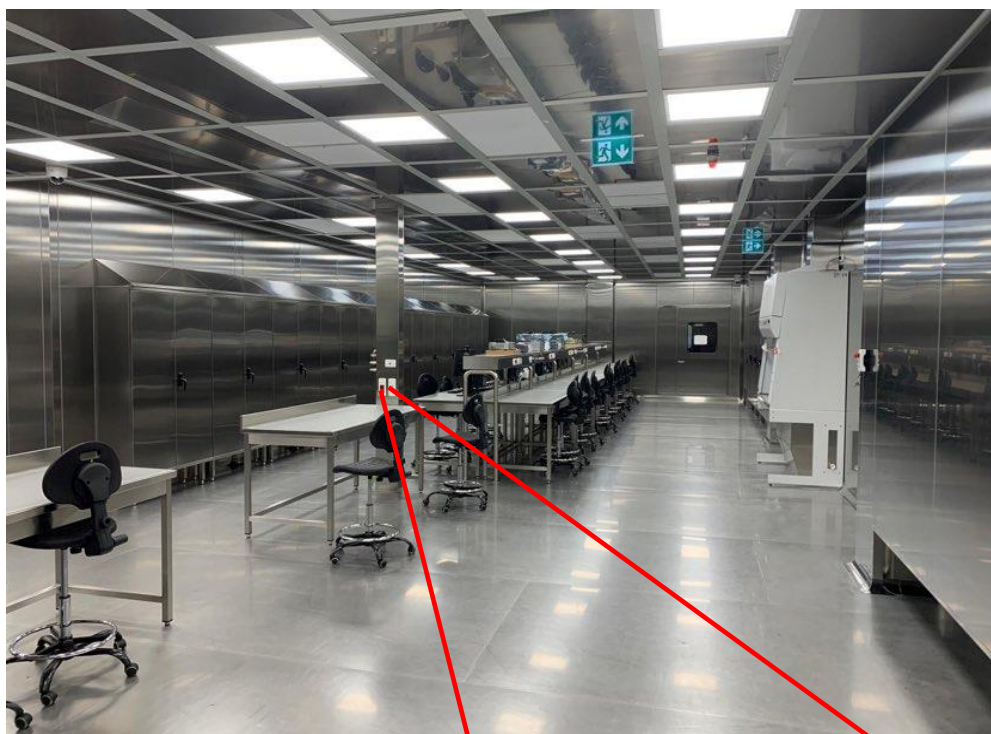
- Class ISO 6 with an overall area -> 420 m²
- CR3 : 3.0 m high and an area of 353 m² : devoted to the SiPM packaging, test and integration
- CR2 : 5.8 m high and an area of 68 m² : devoted to large volume detector assembly
- The design has been conceived in such a way that the air handling system allows to operate CR2 and CR3 separately, both in “normal and ” Rn free” mode.
- Currently no Rn abatement system.

We continuously monitor the Rn concentration in 3 samples points: 2 in CR3 and 1 in CR2 .
Rn level in CR3 -> 6-10 Bq/m³



NOA configuration

CR3 test & assembly area : 25 workstations



Workstation utilities



CR3 utilities



- Electricity (220V, 50Hz) from normal and UPS power supply
- Compressed air
- Low pressure gas nitrogen
- Vacuum
- LAN and telephone lines

- Liquid nitrogen charging station
- High pressure gas nitrogen
- Industrial water
- Refrigerated water (delivery@ 7°C)
- Deionized water
- Two deionized water sinks
- Two chemical hoods

CR2 Floor resistance 2000 kg/m²



NOA packaging area

FORM FACTOR PAC200
CRYOPROBE



AMICRA NOVA PLUS
FLIP CHIP BONDER



2 LEICA MICROSCOPES



HESSE
WIRE BONDER



ADT 7122 DICER



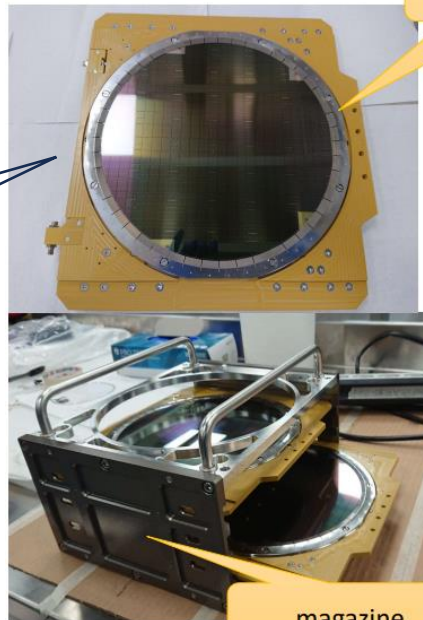
MANUAL
PACKAGING TOOLS:
FRAME MOUNTER
DIE EXPANDER
UV CURING



28/08/2023

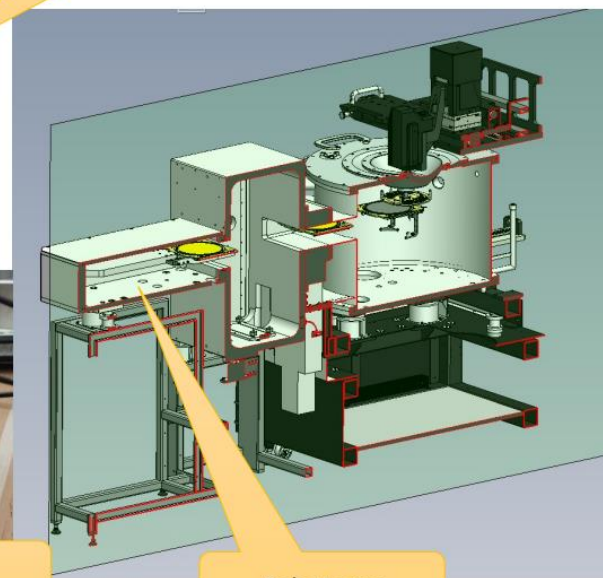
Cryoprobe: a bit of detail

DarkSide-20k Silicon wafer (LFoundry)
200 mm diameter, 550 μm thick ; 264 SiPMs to be characterized at cryogenic temperature



Wafer carrier with clamp ring

magazine



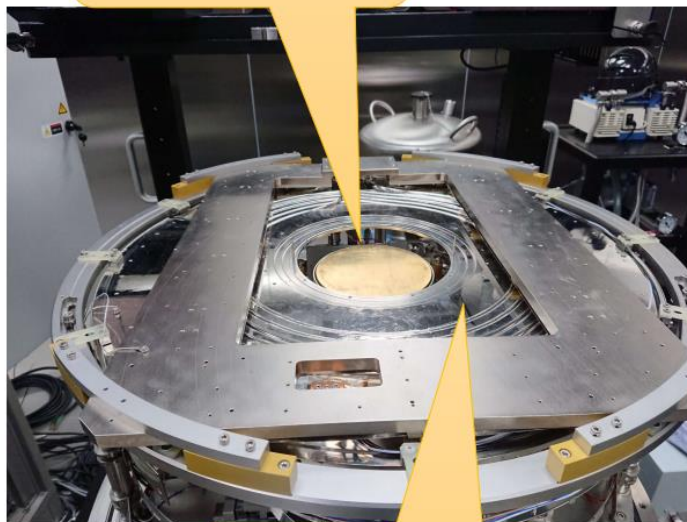
Robot arm



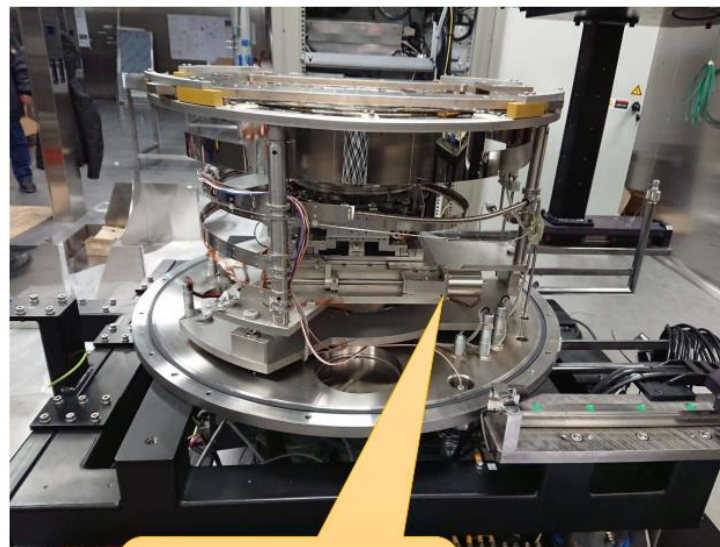
Gate valve

Heater

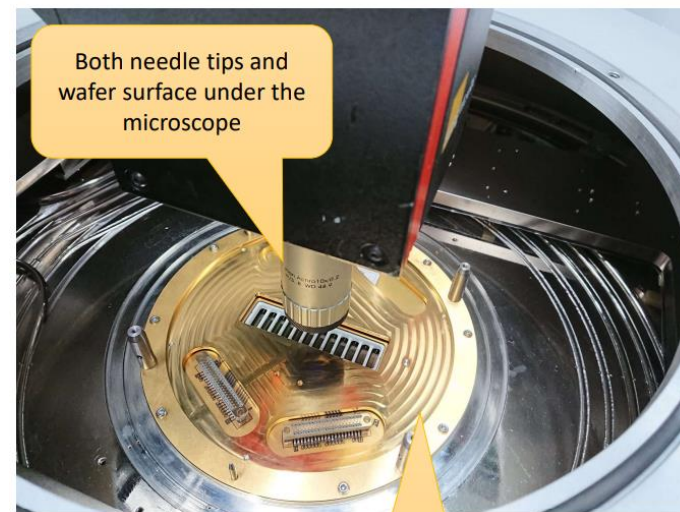
Chuck



ColdShield



X, Y, Z, theta stepping motors to control the movement of the chuck

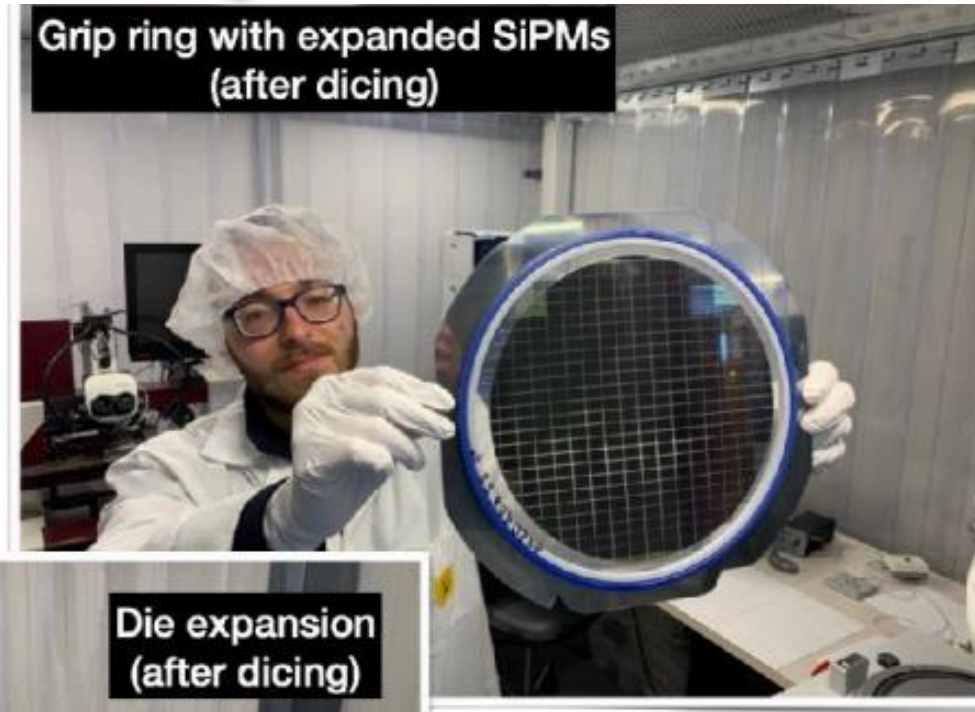


Both needle tips and wafer surface under the microscope

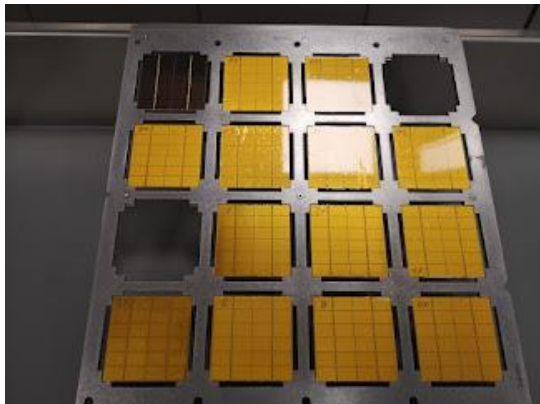
The probe card is fixed above the chuck
The chuck moves up to make "touchdown"

Probe-card
2 x 12 array of needles for anode contacts

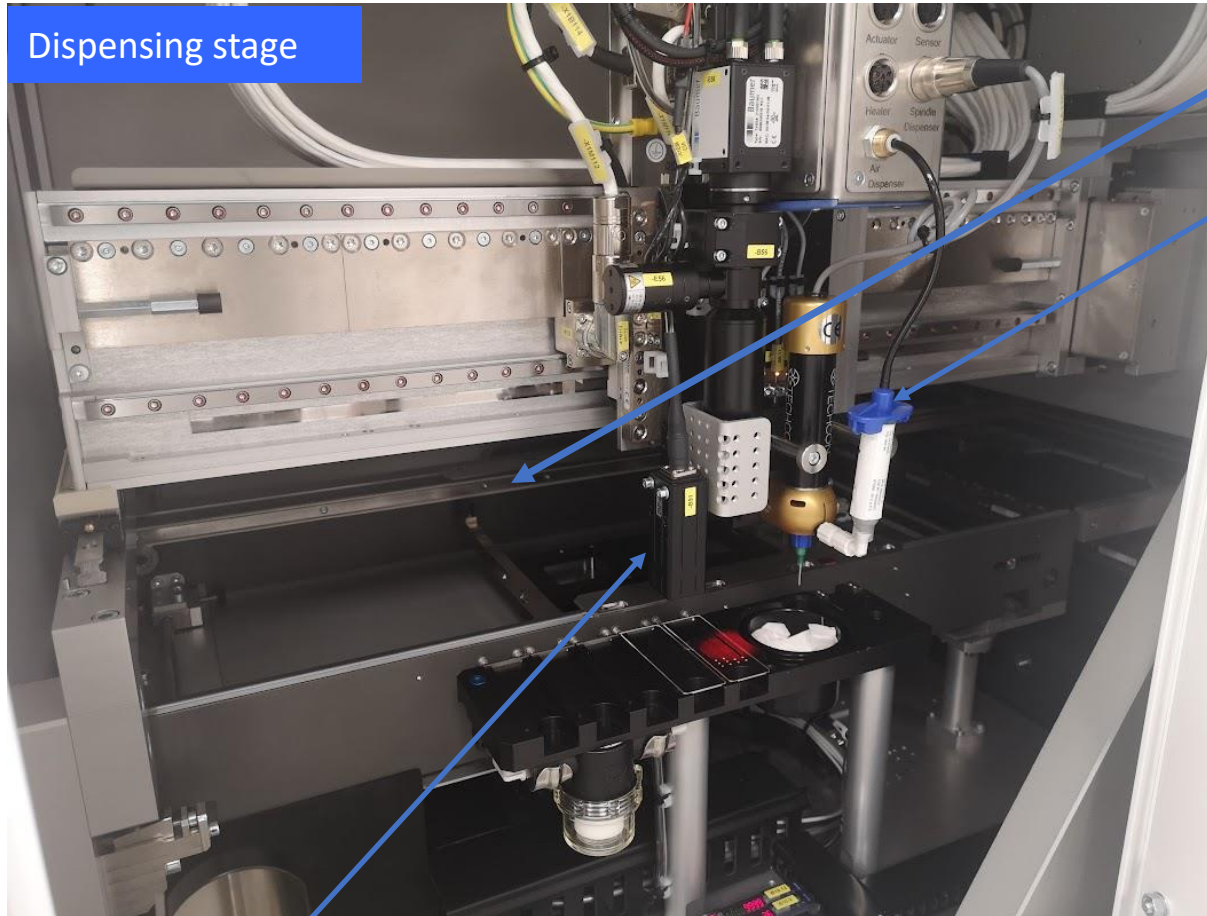
Manual tools: an example of work



Flip Chip bonder: pre-process stage



Frame holder for the DarkSide-20k PCBs each one to be assembled with 24 SiPMs



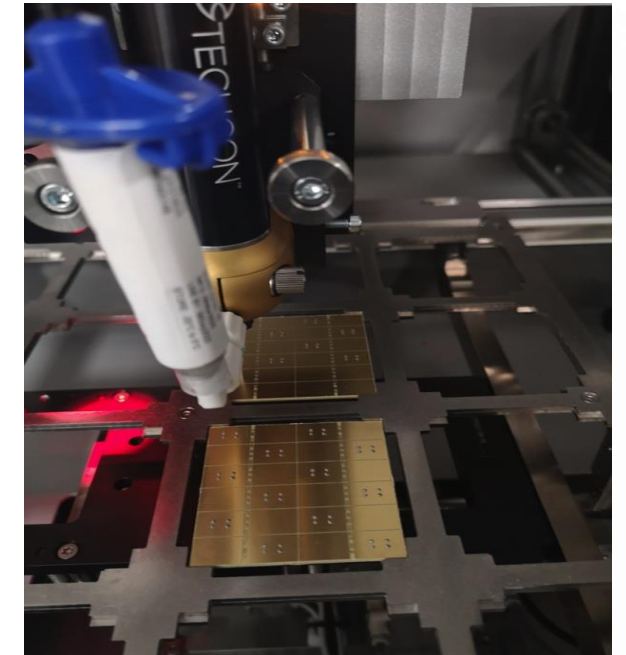
Dispensing stage

Conveyor

Dispenser

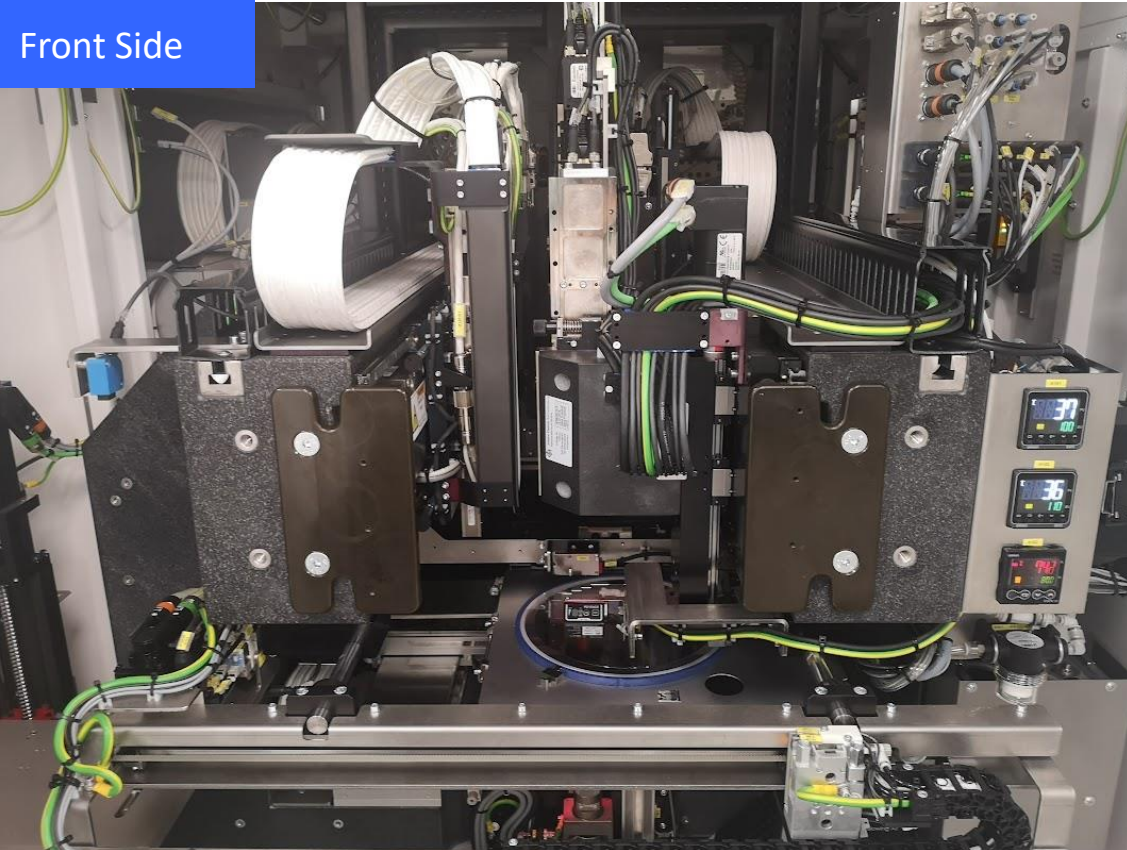
Soldering paste dispensing

Camera



Bonding stage

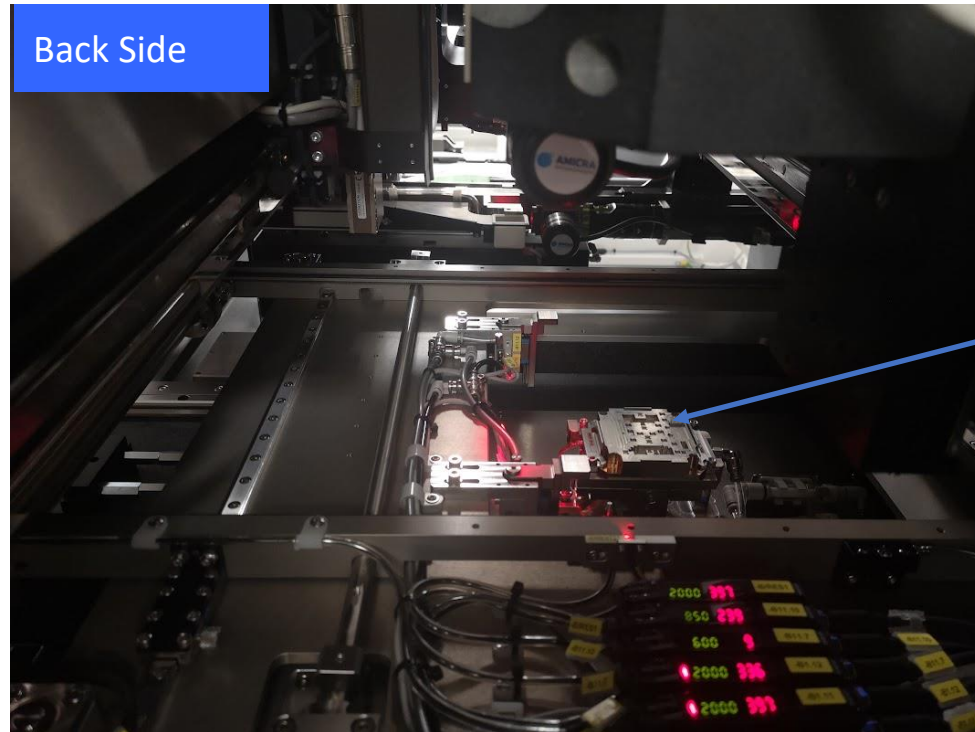
Front Side



Thermo Compression Bonding:
2 bondheads working in
temperature
die size: 11.8 mm x 7.9 mm

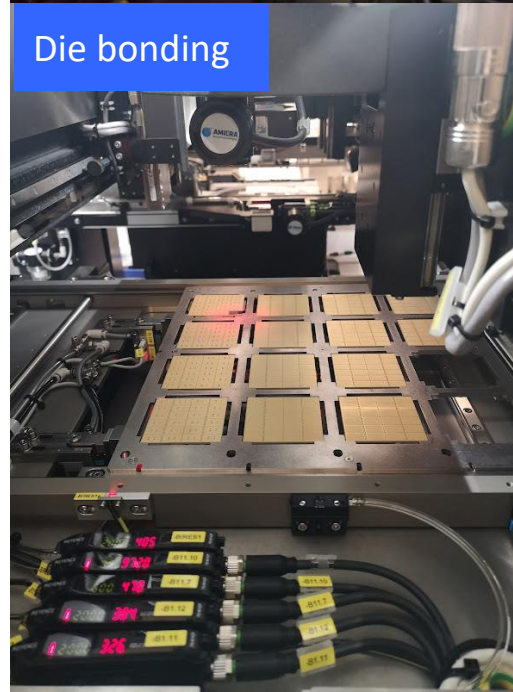
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Back Side



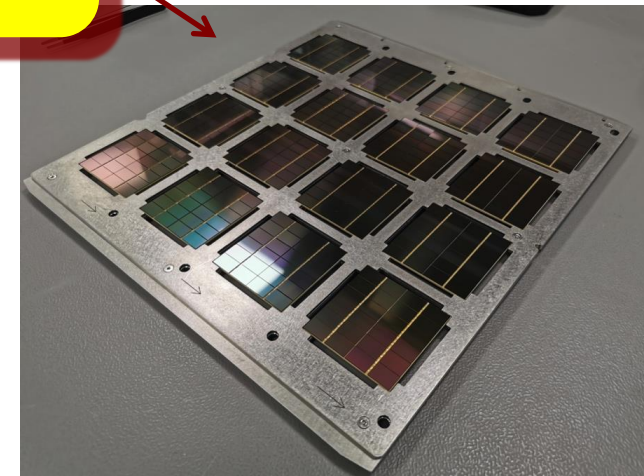
Heater plate
Max T 350°C

Die bonding



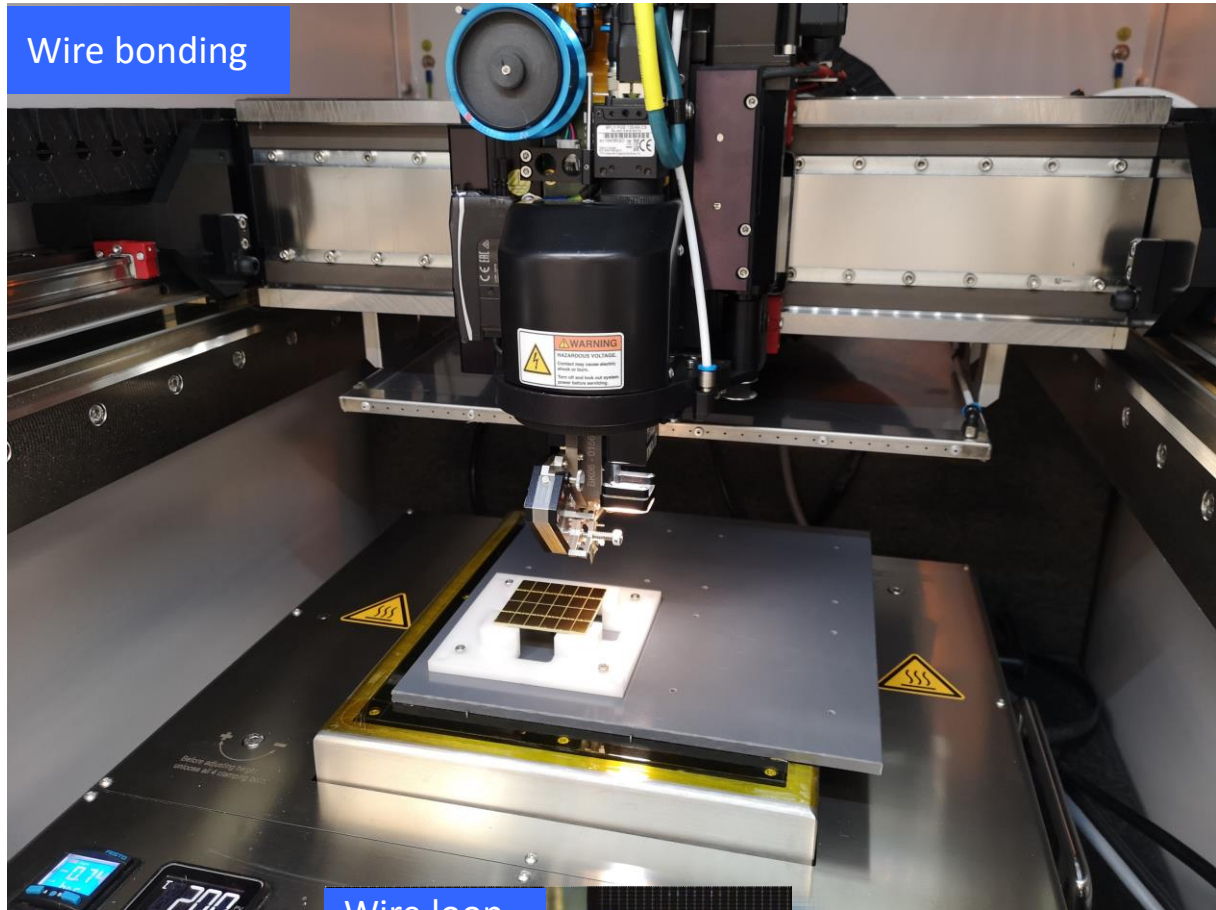
Final Tiles

Ready for wire
bonding

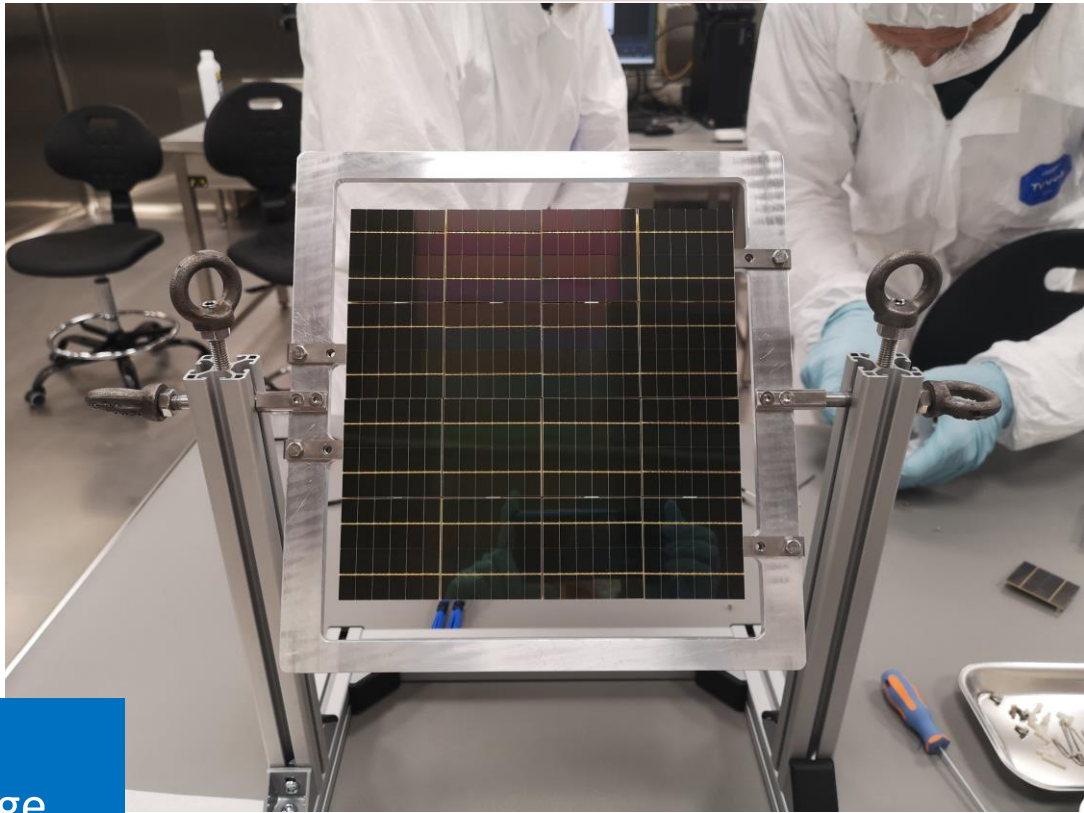


Wire bonder

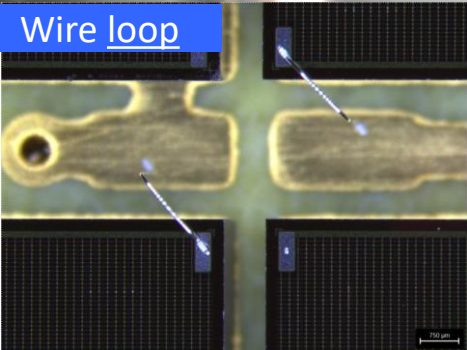
Wire bonding



DS-20k
Photo Detection
Unit



Wire loop



Bond head BJ855
Ultrasonic wedge-wedge
Aluminum wire 25 μ m

NOA infrastructure: next plan

- Optimization of CR operational functions in parallel with the DarkSide-20k activities
- Build a **Radon abatement system** (1 MEuro estimated cost)
- Produce a MoU of the infrastructure in agreement with the LNGS Directorate containing:
 - the access rules;
 - operating procedures;
 - technical aspects and plant design of the CR;
 - description of the packaging machines;
 - cost for running and maintenance.

NOA Staff

L. Liberatore, G. Panella, L. Pietrofaccia
Plants/utilities unit
L. Consiglio, D. Sablone
Packaging unit
R. Tartaglia NOA functional unit

DarkSide-20 people@LNGS

V.E. Camillo, A. Flammini, G. Gallina, K.H. Horikawa, G. Korga, A. Marasciulli, P. Organtini

G. Darbo, A. Jamil, S. Minutoli, M.A. Sabia, P. Salomone

Future perspectives - 1

The NOA facility @LNGS is a clean environment devoted to the production and integration of arrays of photodetectors for low background experiments searching for rare events. The infrastructure can be available to all the research communities interested in this kind of technology or in the field of high density interconnections and industrial fields.

The first NOA “customer” is the DarkSide-20k collaboration until end of 2024.

The machines have been configured according to the specifications designed by DS-20k but there is enough flexibility of adapting the machines to different needs

Future perspectives - 2

Cryoprobe: different probe-card design/technologies are available on the market; continuous contacts with the companies.

Flip Chip Bonder: it's a high precision die bonder for semiconductor advanced packaging that can maintain a placement accuracy down to $\pm 1\mu\text{m}$ @ 3s while bonding with temperatures exceeding 350°C and while also applying high bonding forces (several applications TSV, TCB, 3D IC / 2.5D IC, Flip Chip, Chip on Chip, Chip on Wafer, Chip on Substrate and more...)

Wire Bonder: it is equipped with bond tools for wedge wedge (wire, ribbon) and ball bonding.

We already received requests for the use of the infrastructure by some experimental groups: we are trying to accommodate compatibly with DS-20k activities.

It's **IMPORTANT** to advertise the facility among the scientific research groups and industries.

We are on the way!