ALICE, NA60+

G. Usai on behalf of INFN-CA GR3

Consiglio di sezione INFN CA, 05/07/2024

Anagrafica gruppo 3

	Ricercatori			
Numero	Nome	ALICE	NA60+	Totale GR
	Bosin Andrea	1.0	0.0	1.0
	Cicalò Corrado	0.7	0.1	0.8
	De Falco Alessandro	0.7	0.1	0.8
	Fionda Fiorella	0.7	0.3	1.0
	Masoni Alberto	0.4	0.1	0.5
	Mulliri Alice	0.5	0.5	1.0
	Sarritzu Valerio	0.7	0.3	1.0
	Usai Gianluca	0.5	0.5	1.0
	Totale FTE Ricercatori	**5.2**	**1.9**	**7.1**
	Tecnologi			
1	Mura Daniele	0.3	0.1	0.4
	Sabayashi Siddhanta	0.7	0.3	1.0
2	Puggioni Carlo	0.4	0.3	0.7
	Totale FTE Tecnologi	**1.4**	**0.7**	**2.1**

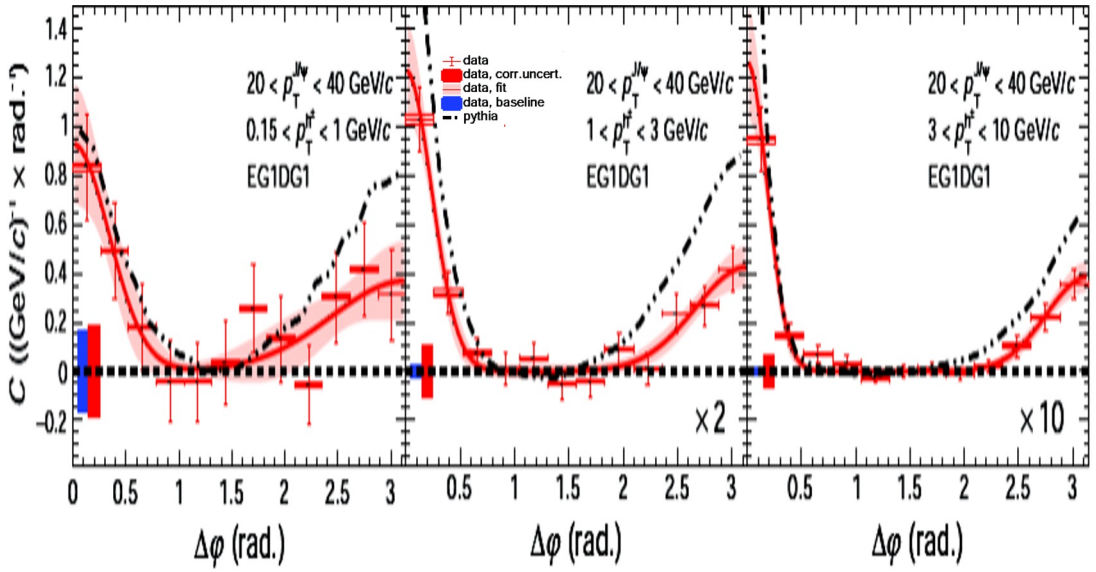
Circa 10 FTE (vanno conteggiati anche 0.9 FTE dal progetto sinergico Tele_Neurart di A. Masoni, C. Puggioni, D. Mura)
Diminuzione di 2 FTE rispetto al 2023 (B. Paul, G. Alocco)

ALICE

Physics analysis 2023/24

Finalization of J/ψ-hadron correlation analysis publication (Lucas's Altenkamper thesis) based on Run 2 data (full pp statistics collected in pp at 13 TeV, including MB and HM / TRD triggered data)

- ❑ Publication in post collaboration round 1, expected to be published by Hard Probes (September 2024)



- J/ψ-h correlation function:

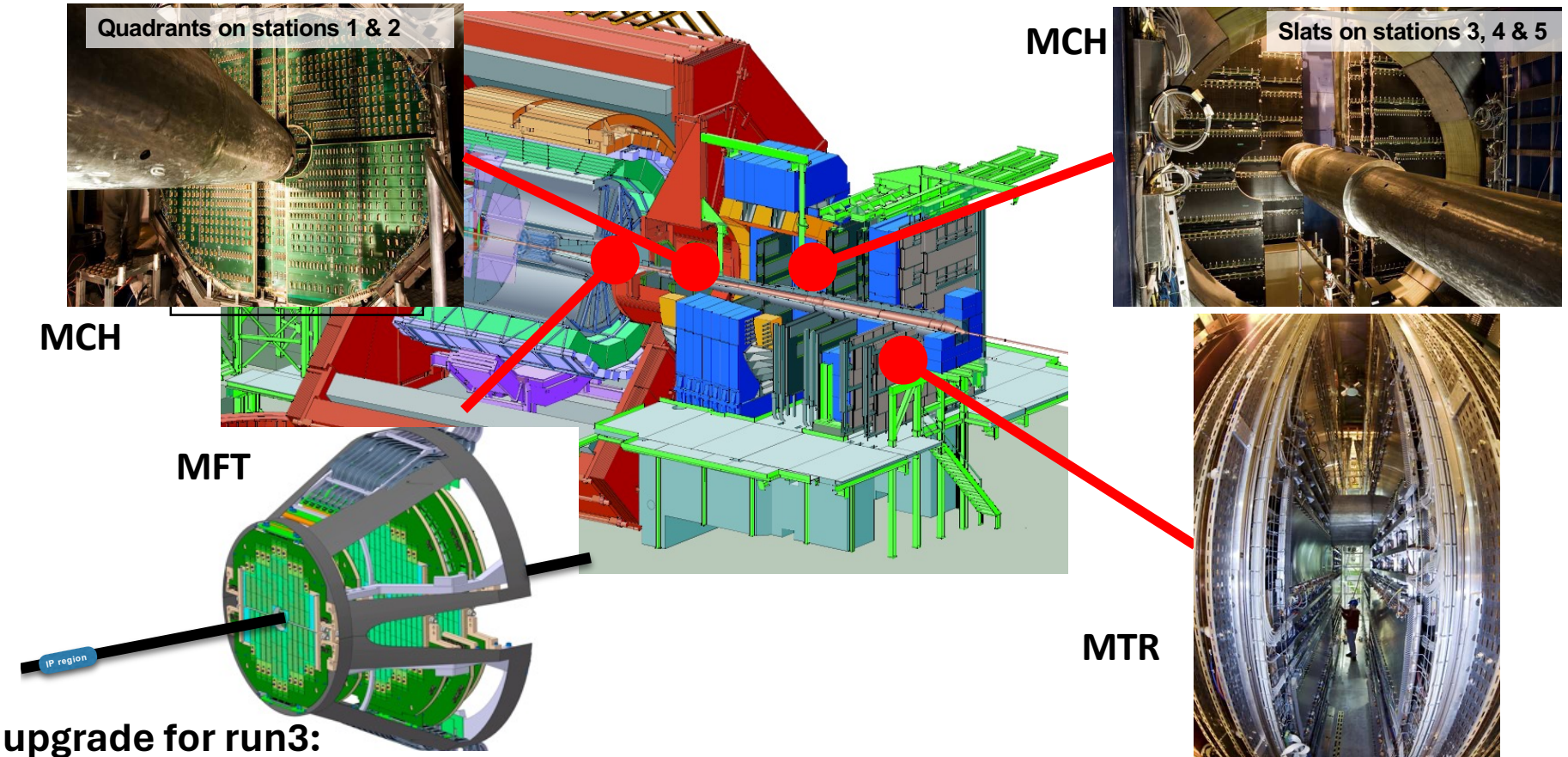
$$C(\Delta\eta,\Delta\varphi;p_{\mathrm{T}}^{\mathrm{J}/\psi},m_{\mathrm{e^+e^-}},p_{\mathrm{T}}^{\mathrm{h}^{\pm}}) = \frac{1}{N_{\mathrm{trig}}}\cdot\frac{S(\Delta\eta,\Delta\varphi)}{B(\Delta\eta,\Delta\varphi)}\cdot B(0,0)$$

Data analysis in pp collisions at 13.6 TeV (Run3 data):

- ❑ Prompt and non-prompt J/ψ separation at midrapidity
- ❑ J/ψ-hadron correlation analysis in pp collisions at 13.6 TeV (Run 3)

F. Fionda: deputy Physics coordinator of ALICE from June 2024

ALICE Muon Arm

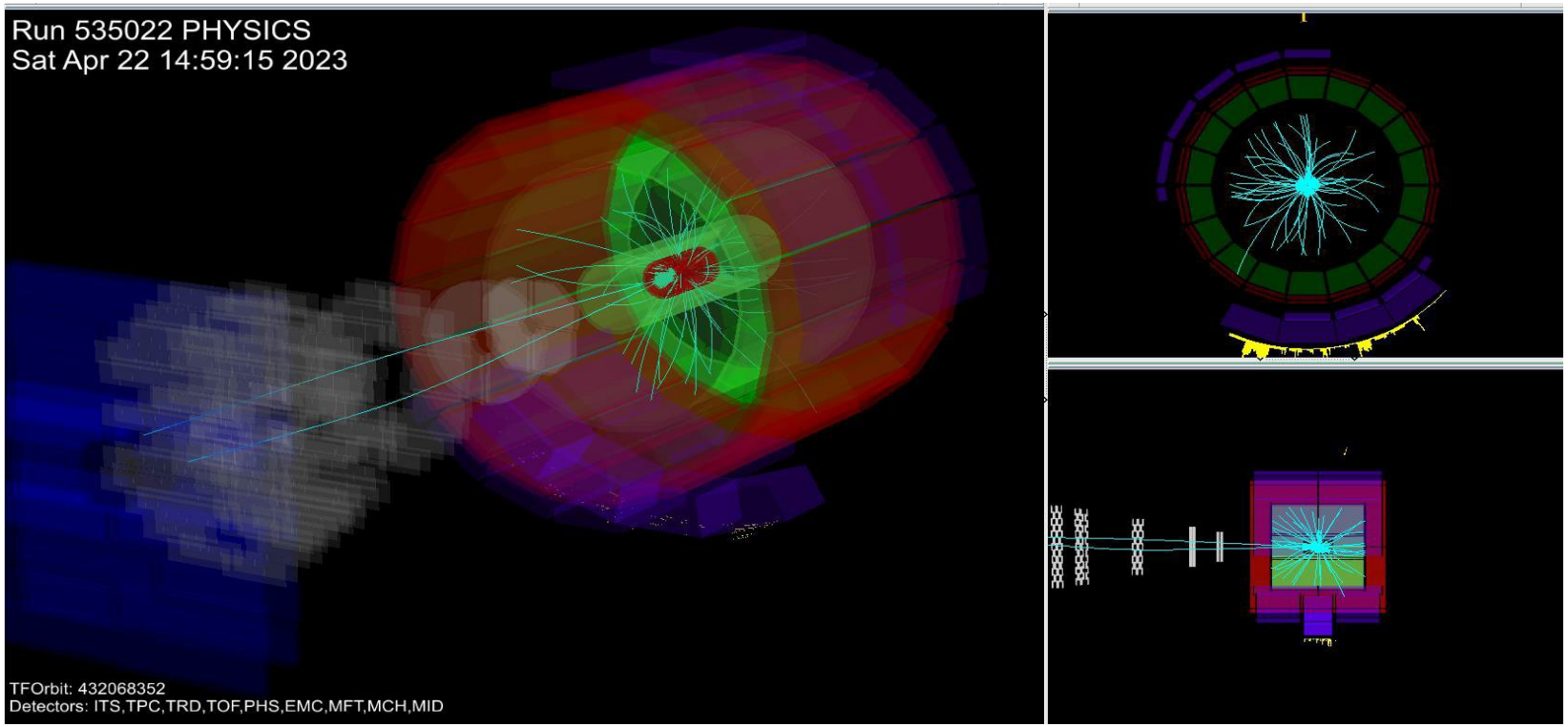


MCH readout upgrade for run3:
FEC: Orsay
FLEX: Cagliari (D. Marras, M. Arba)
SOLAR : Saclay
CRU: India (Kolkata,Aligarh)

DCS: M. Arba

MCH data taking

Smooth operation of MCH during 2022, 23 data taking

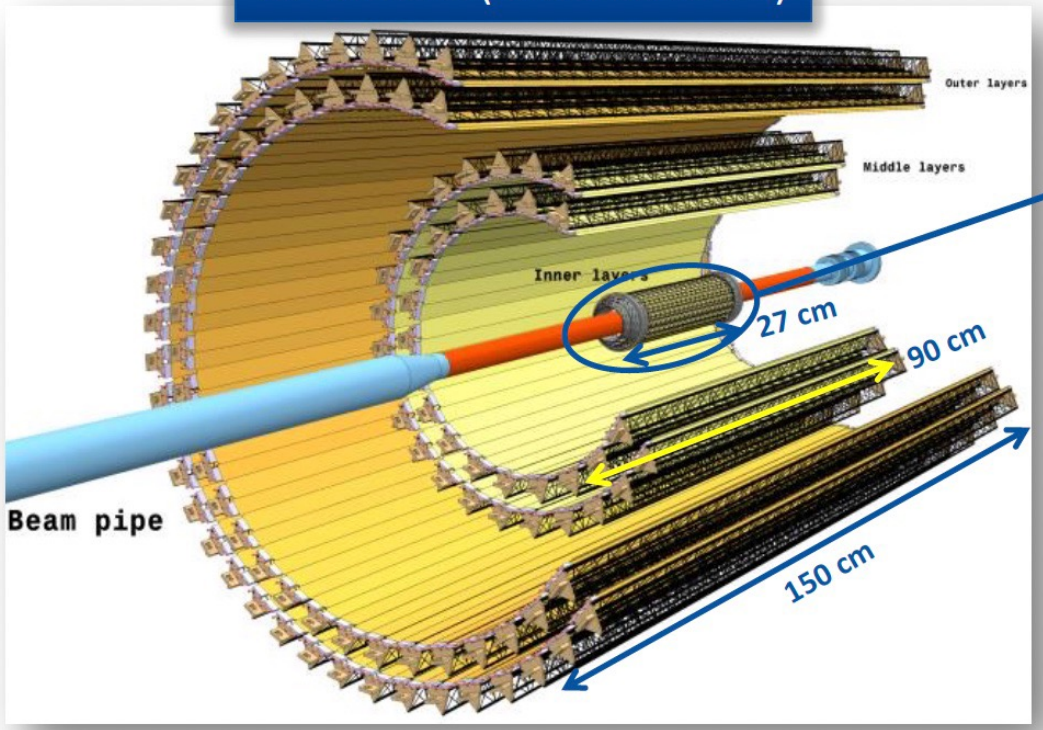


During 2025:

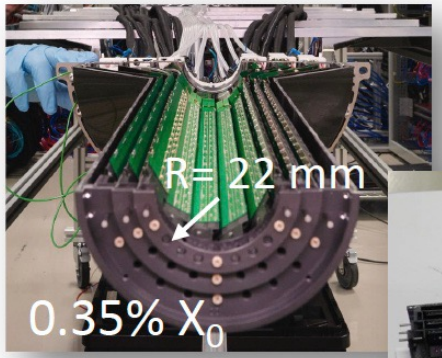
- ❑ Mantainance
- ❑ DCS: electronics configuration, FRED Server (DCS – CRU interface)

ALICE ITS3 Upgrade

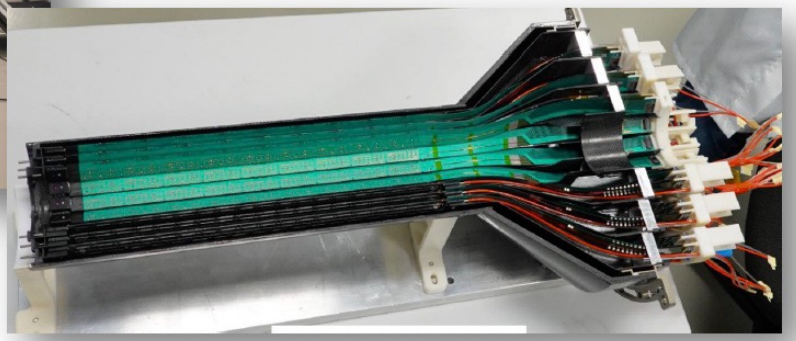
ALICE ITS2 (TAKING DATA)



~12.5 Gpixels, 10 m^2 sensitive area
24120 **ALPIDE** Monolithic Pixel Sensors (CMOS 180 nm)

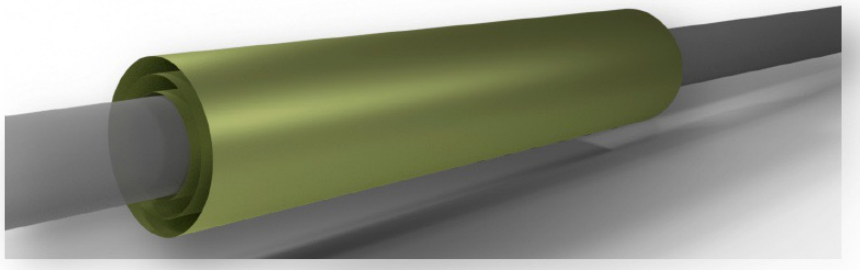


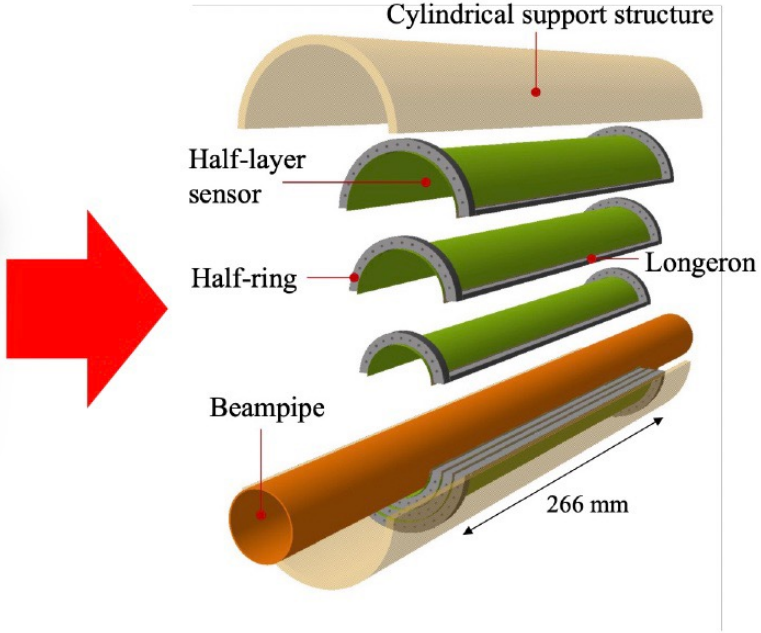
ITS2 Inner Layers

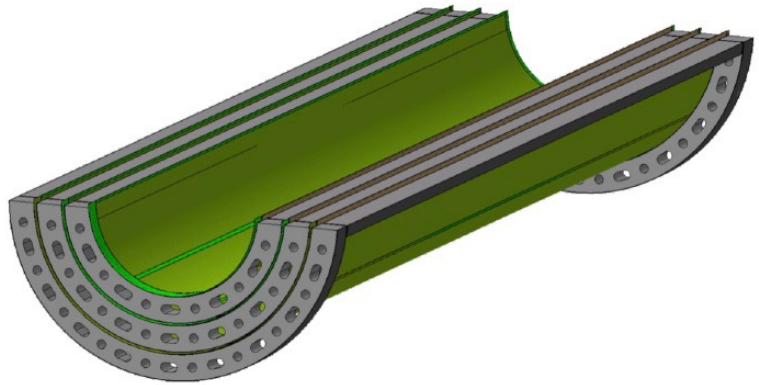


ITS3

ALICE ITS3 Upgrade







Replace the ITS2 inner barrels by real half-cylinders (of **bent, thin** silicon)

Employ wafer-scale MAPS sensors (1 sensor per half-layer) in **65 nm** technology

Minimize material budget and distance to interaction point (0.07% X_0 / layer, 19 mm)

Large improvement of vertexing precision and physics yield

ALICE ITS3 TDR Requirements

3 Cylindrical Layers

Made with **6 curved wafer-scale single-die** Monolithic Active Pixel Sensors

Thinned down to **<50 µm (0.07% X_0)**

Position resolution ~5 µm

-> Pixel pitch **20-25 µm**

Electro-mechanical integration

No flexible circuits in the active area

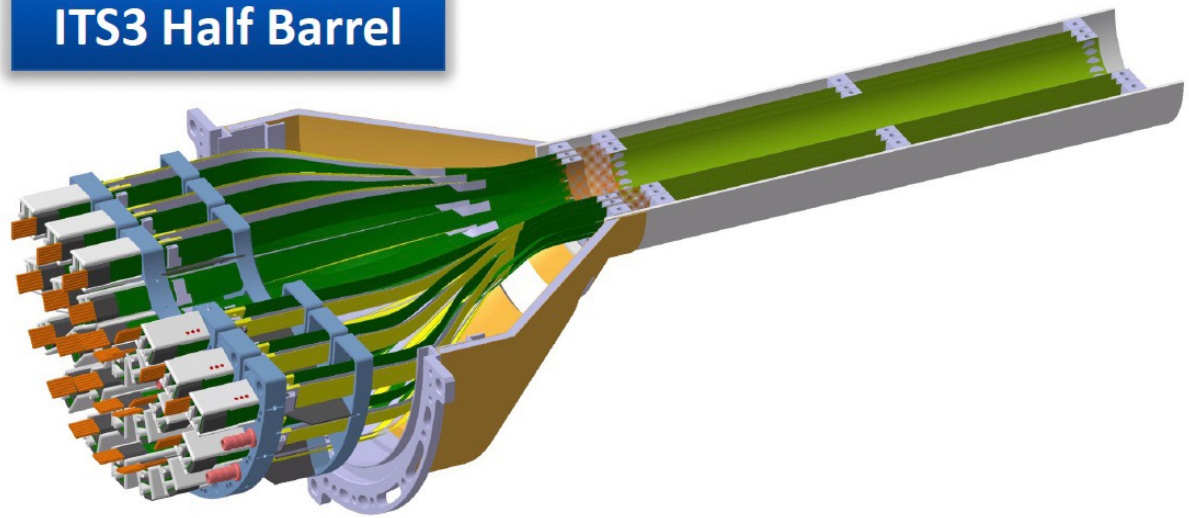
-> Distribute supply and transfer data *on chip,* interconnects only on short edges

Cooling by air flow

-> Dissipate less than **40 mW/cm²** (in sensitive area)

ALICE ITS3 TDR https://cds.cern.ch/record/2890181

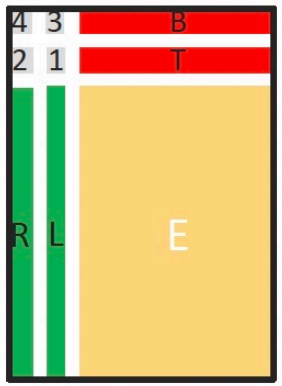
ITS3 Half Barrel



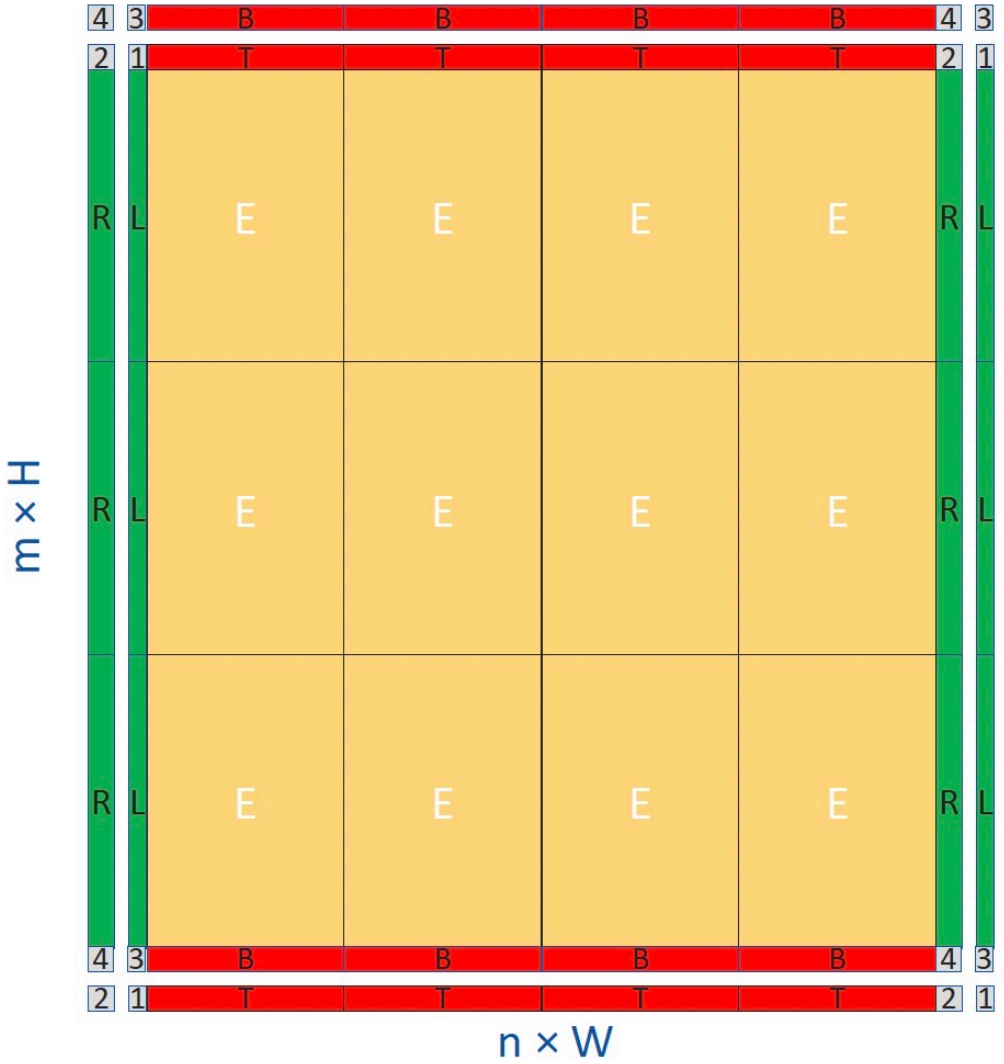
	Requirement
Pb-Pb Interaction Rate	50 kHz
Particle Flux	5.75 MHz/cm^2
Integration time	< 10 µs
TID	<10 kGy
NIEL	1×10^{13} 1 MeV n_{eq} cm^{-2}

Wafer Scale Sensors with Stitching

Design Reticle (typ. 2×3 cm)



Circuits on wafer



ER1 Submission

Learning design with **stitching** and handling procedures

Submitted in December 2022, 65 nm CMOS Imaging Technology

Two wafer scale stitched sensor chips

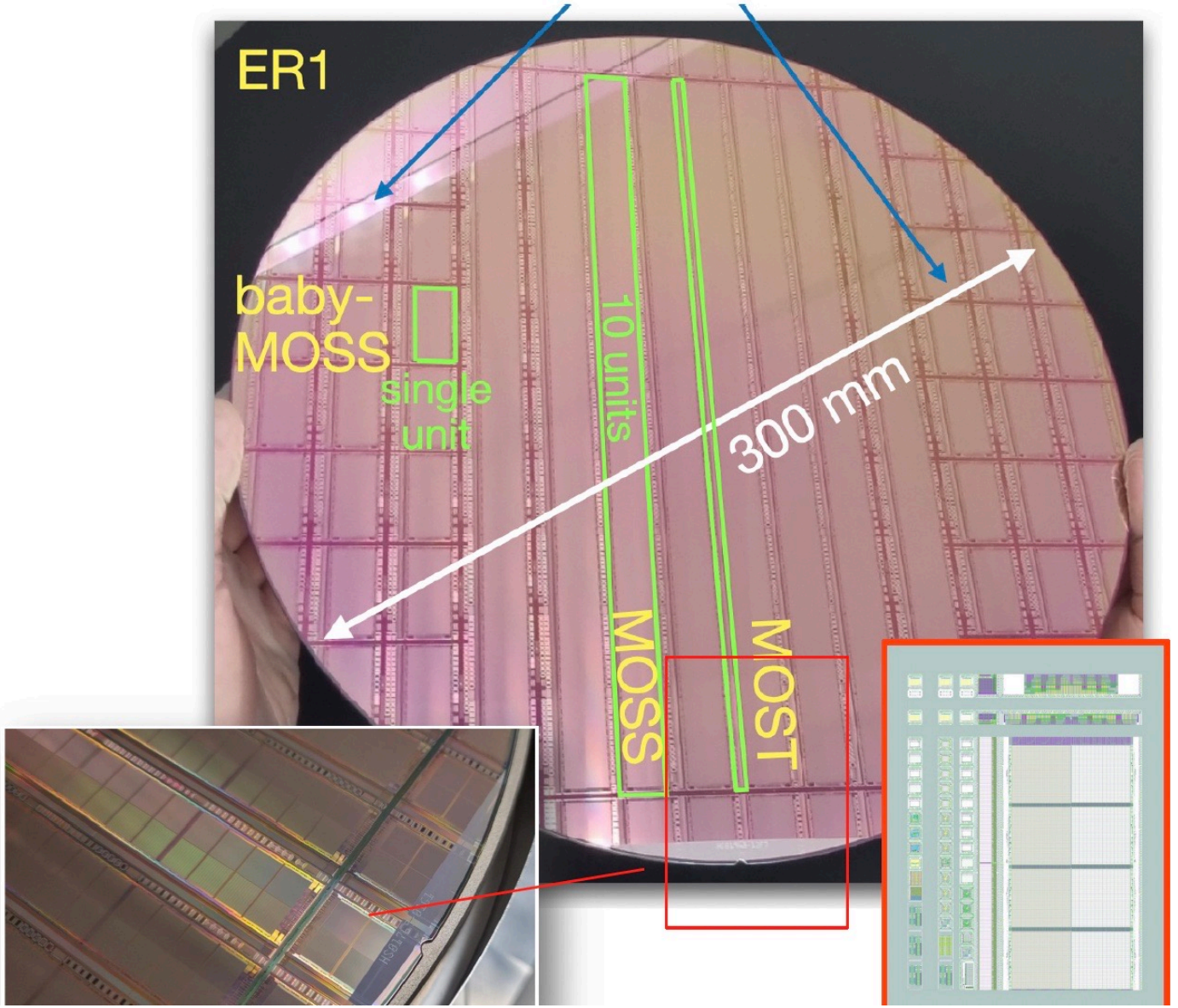
MOSS: 14 mm × 259 mm, 6.72 Mpixels, (22.5 × 22.5 and 18 × 18 μm^2), conservative design, different layout densities

MOST: 2.5 mm × 259 mm, 0.9 Mpixels (18 × 18 μm^2), full density design

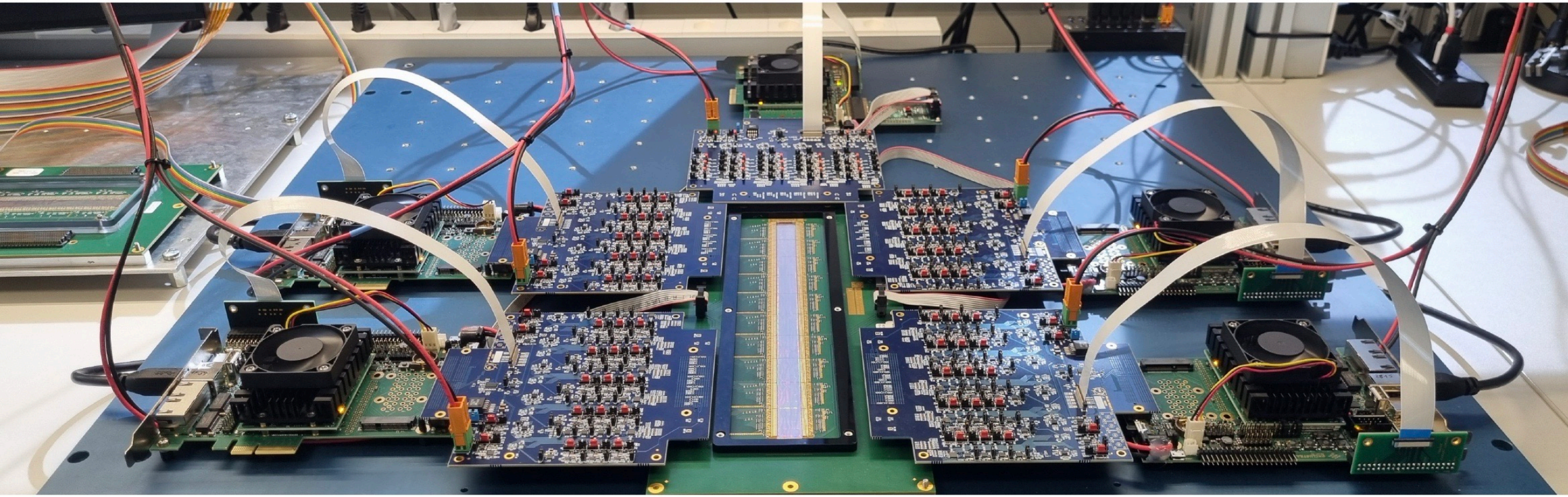
Single stitch devices

Several small test chips (1.5 mm × 1.5 mm)

D. Marras - MOSS digital design



MOSS Tests



MOSS design fully functional

Design concepts and methodology validated

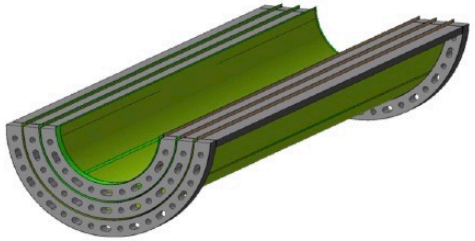
Much learning on yield, handling and performance of a full-scale device

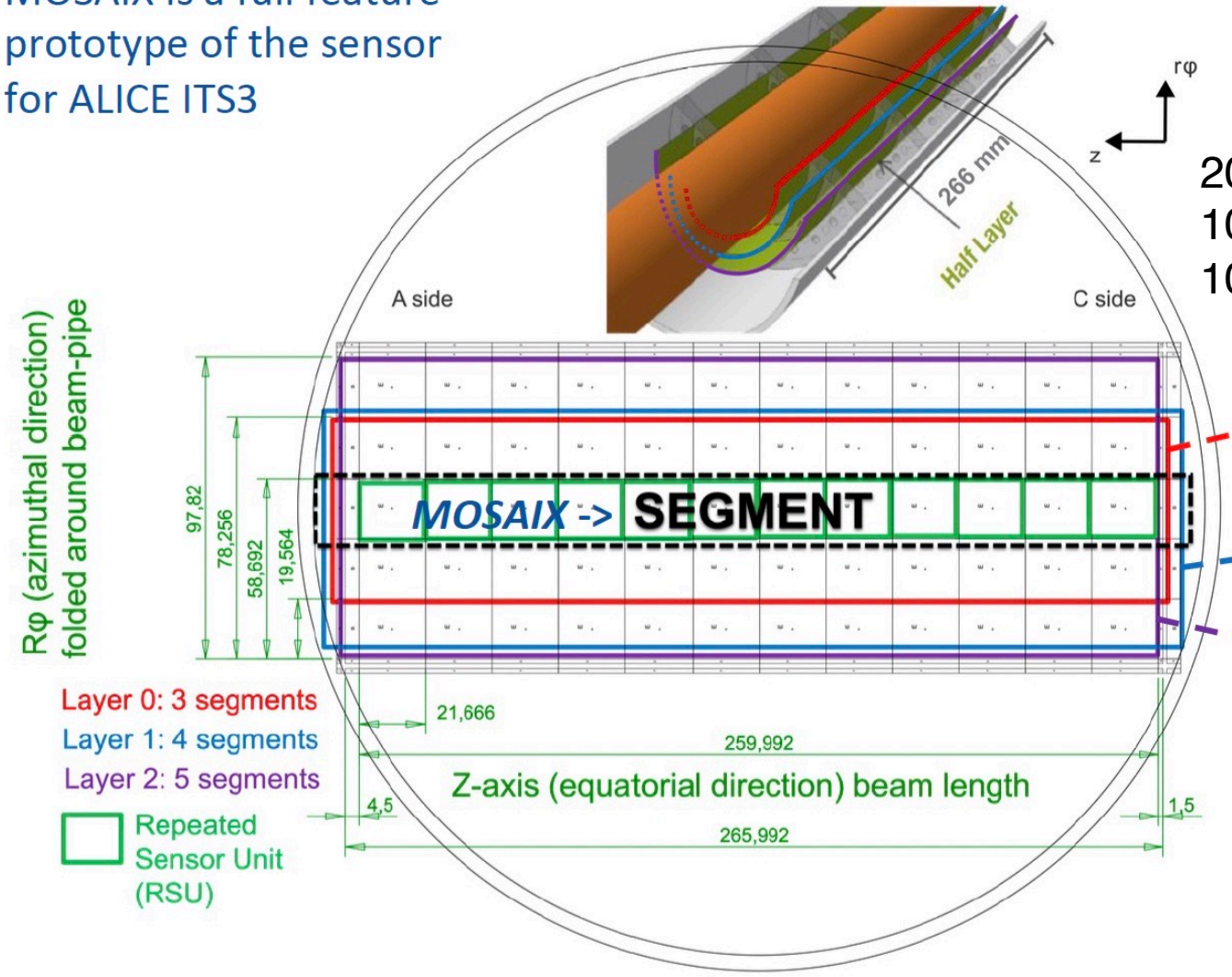
Paved the way for the design of the engineering prototype MOSAIX

V. Sarritzu
ER1 and ER2 test system

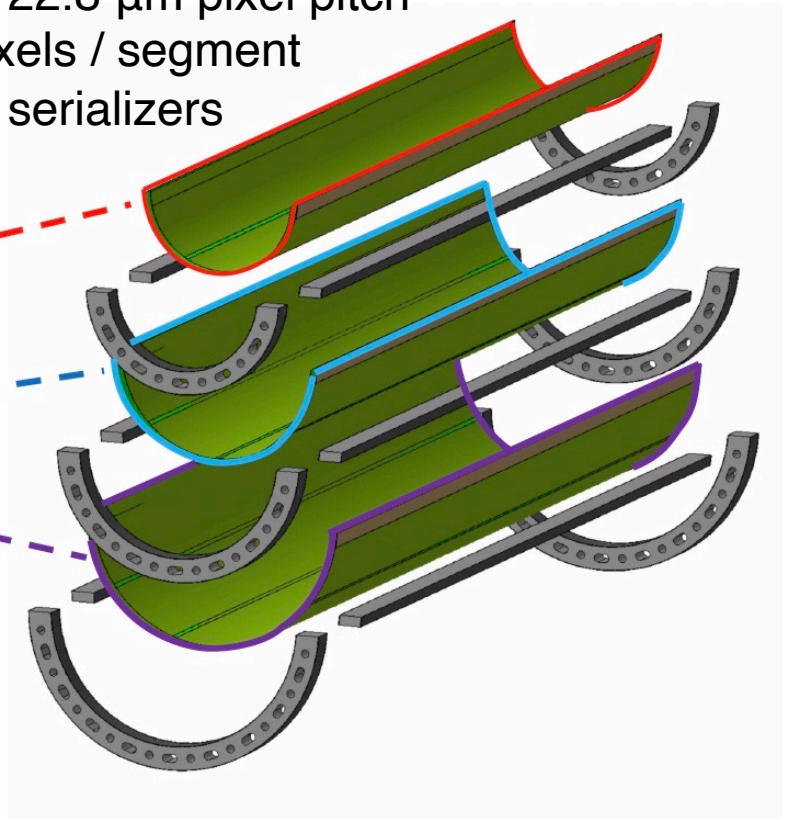
ALICE ITS3 and MOSAIX

MOSAIX is a full feature prototype of the sensor for ALICE ITS3



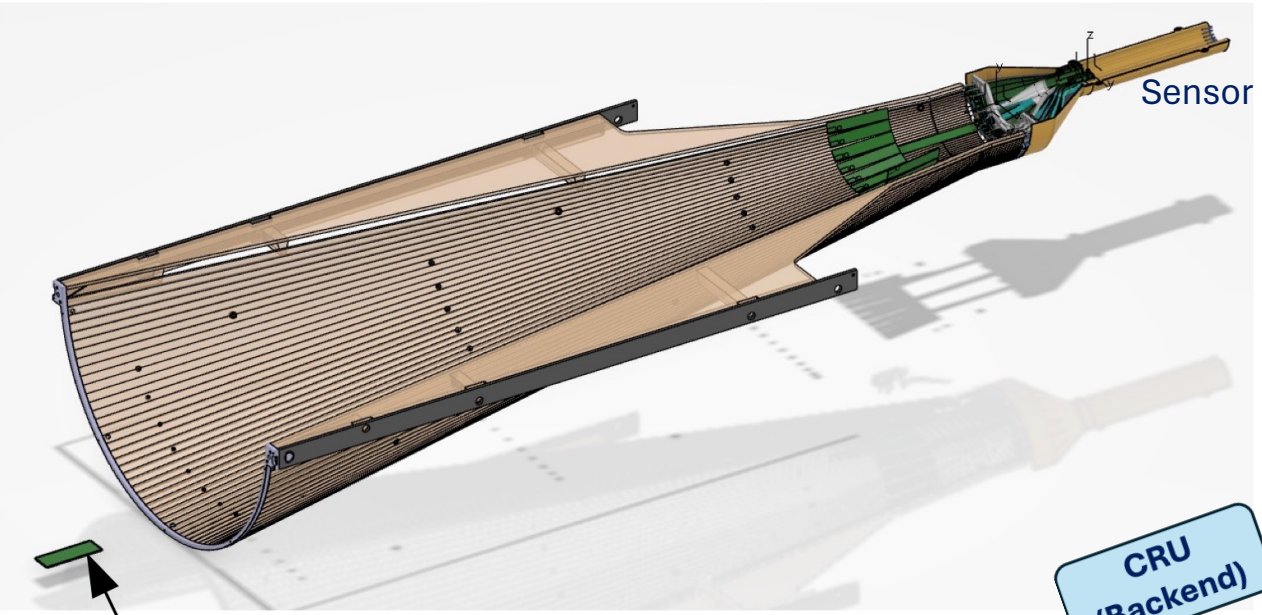


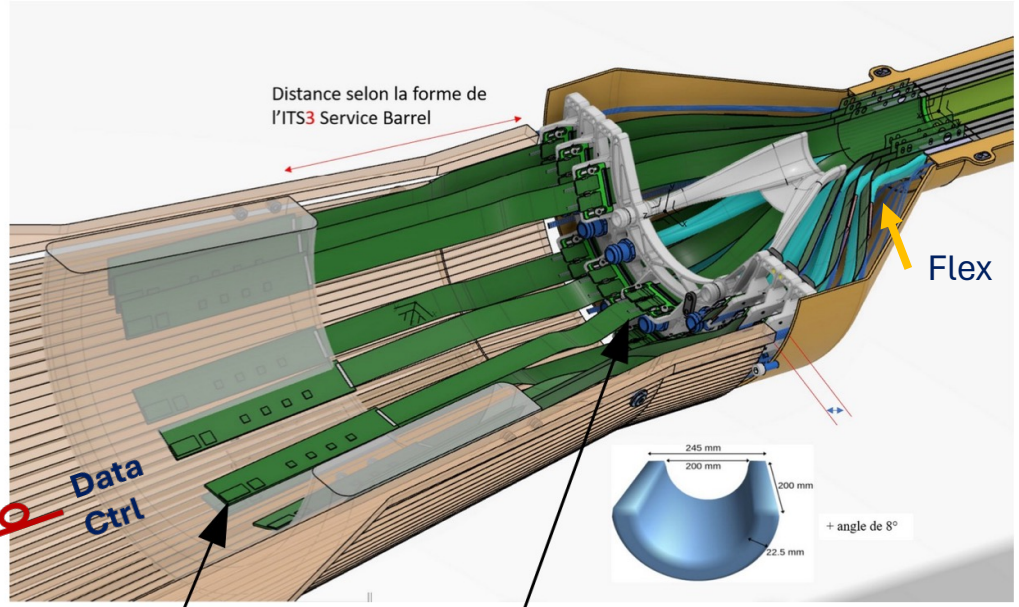
20.8 µm x 22.8 µm pixel pitch
10.73 Mpixels / segment
10.3 GB/s serializers



ER2 submission this year!

Overview of readout system

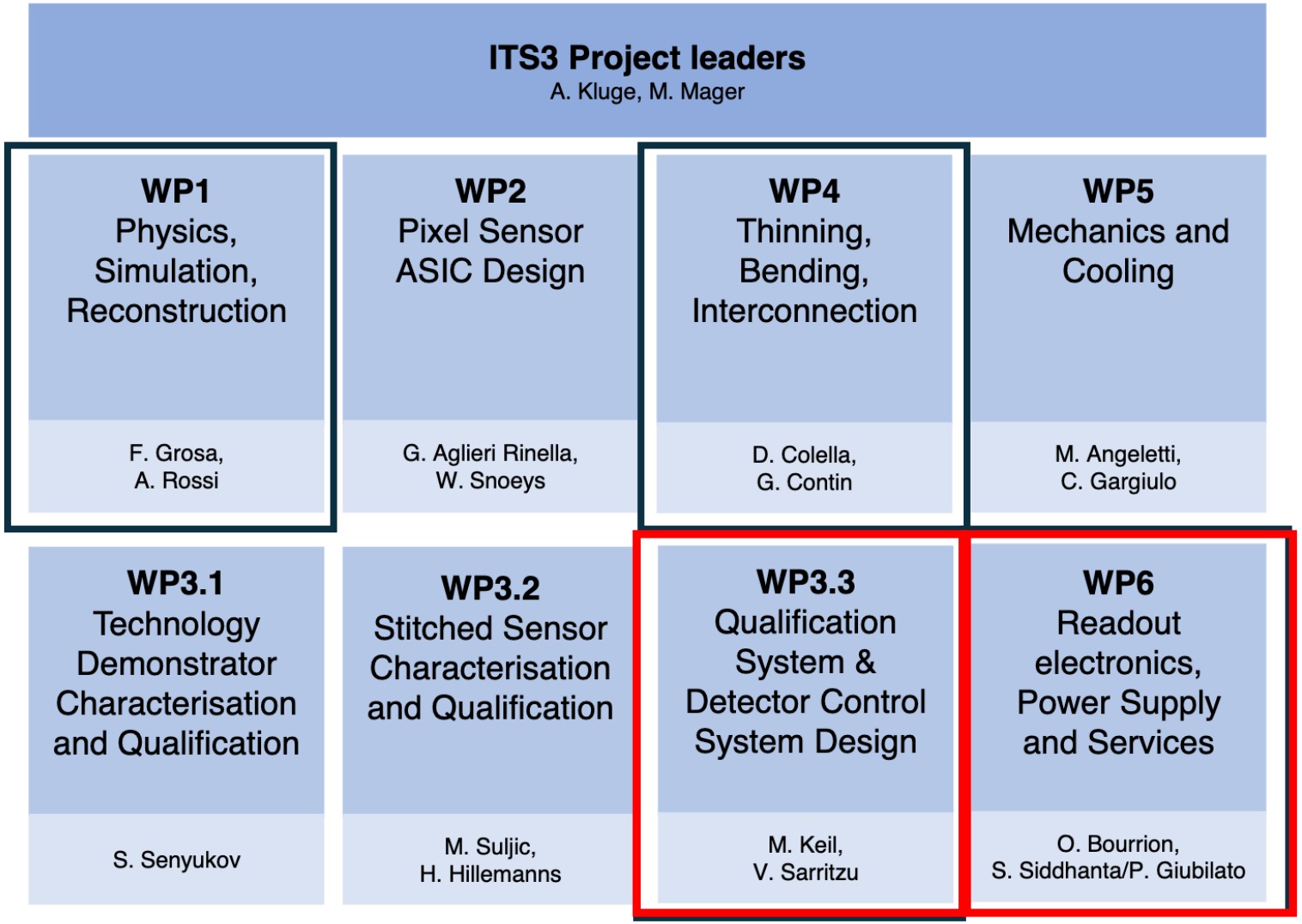




- ❑ Production of DSE: preliminary estimate for request 40 keuro)
- ❑ CRU firmware
- ❑ Test and qualification of full system

S. Siddhanta

ALICE ITS3 – Organization

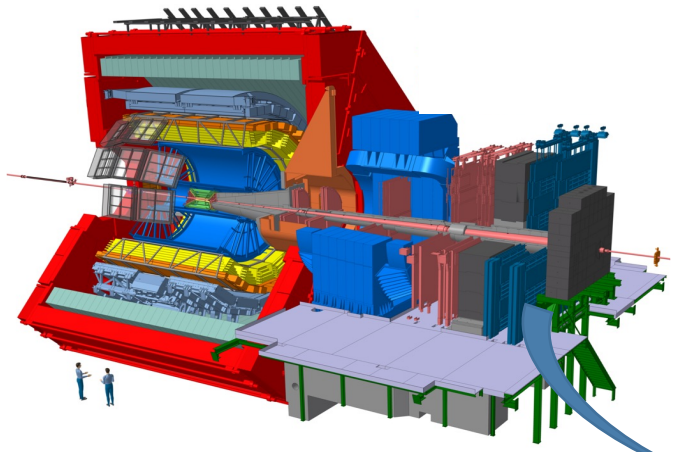


- Recent reshuffling of the organization
- Significant presence from INFN in convener roles

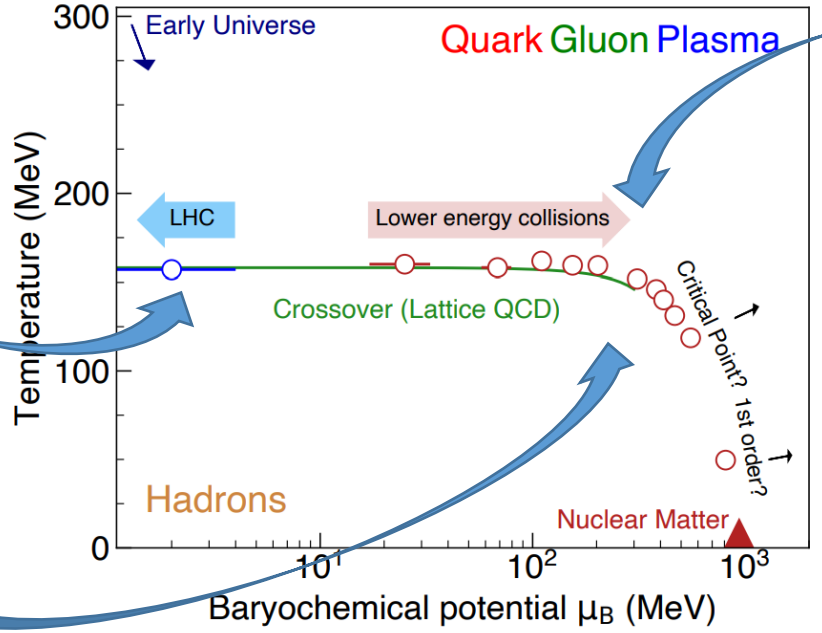
WP1: A. Rossi (PD)
WP4: D. Colella (BA)
G. Contin (TR)
WP3.3: V. Sarritzu (CA)
WP6: S. Siddhanta (CA)
P. Giubilato (PD)

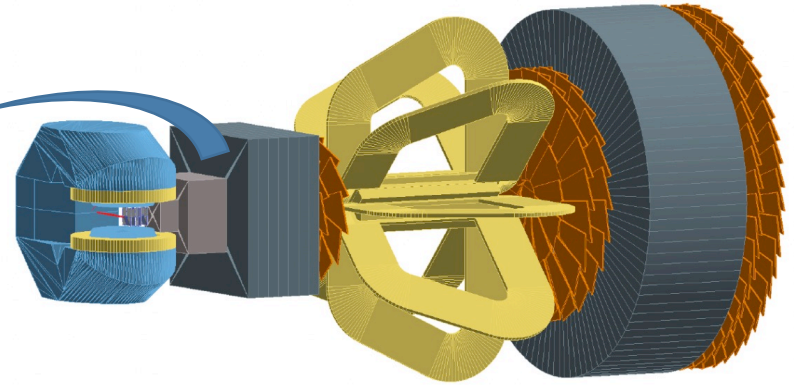
NA60+

NA60+: a new heavy-ion experiment at CERN

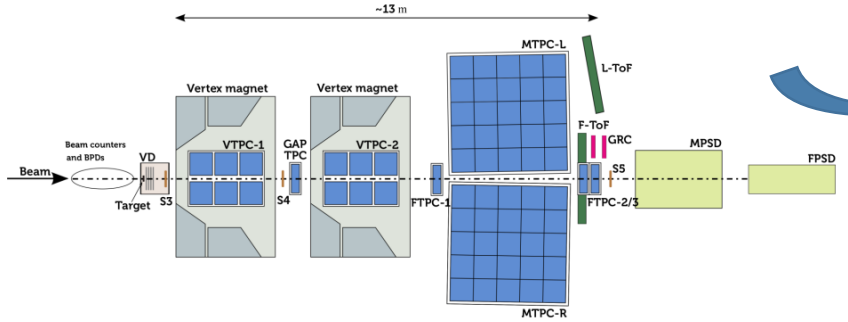


ALICE: general purpose HI detector at LHC: study high T, zero μ_B region
(+ **ATLAS**, **CMS**, LHCb)





NA60+: high-μ_B studies of hard and electromagnetic probes of the Quark-Gluon Plasma at SPS energies



NA61/SHINE: (only) hadron detector at SPS: study intermediate T, finite μ_B region

G. Usai – spokesperson (with E. Scomparin)

Vertex telescope

Muon spectrometer

Stony Brook University

מכון ויצמן למדע
WEIZMANN INSTITUTE OF SCIENCE

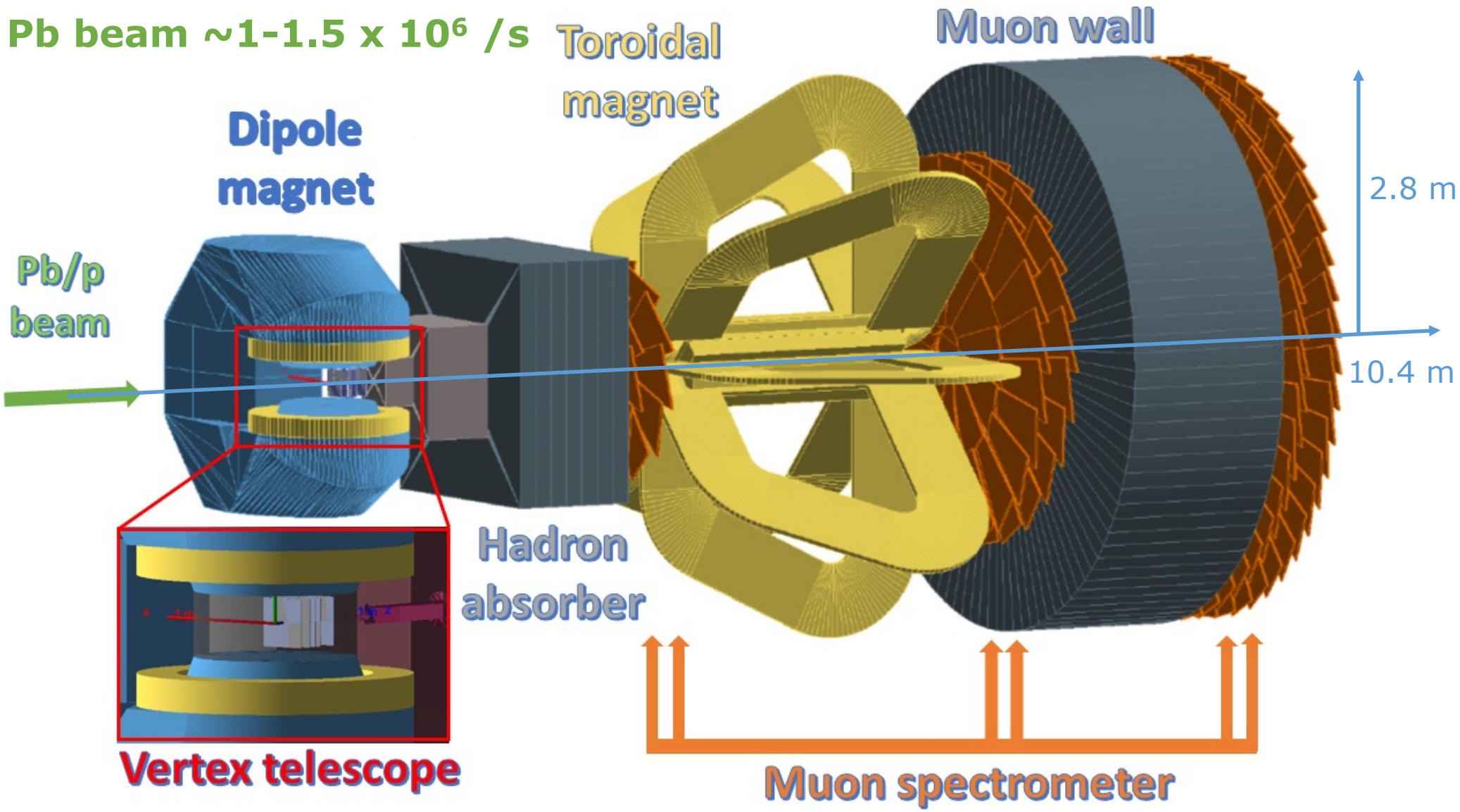
INFN
Istituto Nazionale di Fisica Nucleare

CERN

iP2I
LES 2 INFINIS LYON

RICE

The NA60+ detector



Inspired by the **former NA60** detector (2002-2004)

Measurement of **(di)muon** production and hadronic decays of **strange** and **charm** hadrons

SPS **energy scan from 20AGeV to 150 AGeV**: vary z-position of the muon spectrometer and thickness of hadron absorber

Current schedule

PAST

Project followed by **Physics Beyond Colliders** since its beginning → 2016
Expression of Interest submitted in 2019 (https://cds.cern.ch/record/2673280))

- **Letter of Intent** submitted at the very end of 2022, and presented at the SPSC in 2023 (https://arxiv.org/abs/2212.14452)
  Positive feedback of the **SPSC**

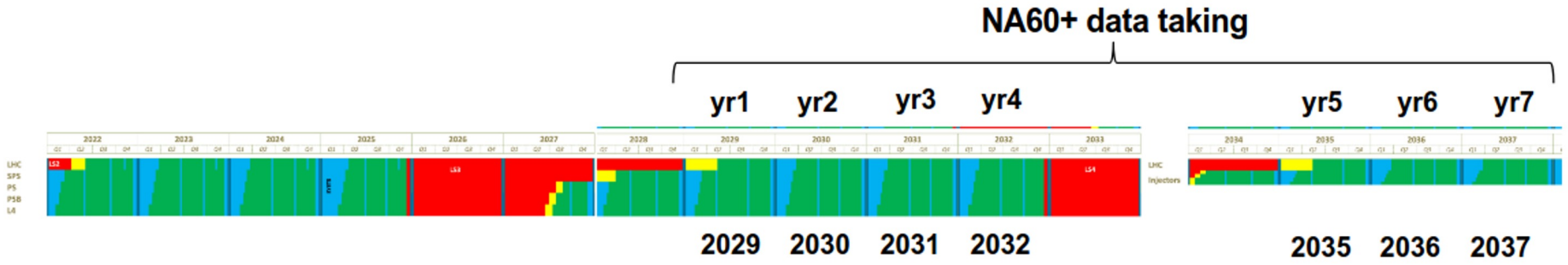
Mentioned in the 2023 **LRP for Nuclear Physics** (US) and 2024 **NuPECC LRP**

6.7 NA60+

The SPSC **recognizes** the fundamental interest of the measurements proposed by the NA60+ collaboration, which are focused on electromagnetic and hard probes of the quark gluon plasma at high baryochemical potential. In order for the project to proceed with the suggested roadmap (starting construction in 2026 and data taking in 2029), the SPSC **would expect to start examining** a proposal by 2024.

FUTURE

- **Technical proposal**: end 2024 - start 2025
- **Construction and installation**: 2026-2029
- **Start data taking**: 2030 (after LS3 – **takes into consideration new schedule**)



Run4 start shifted by one year to 2030

3.3.1.4. Insights from heavy quark and electromagnetic probes

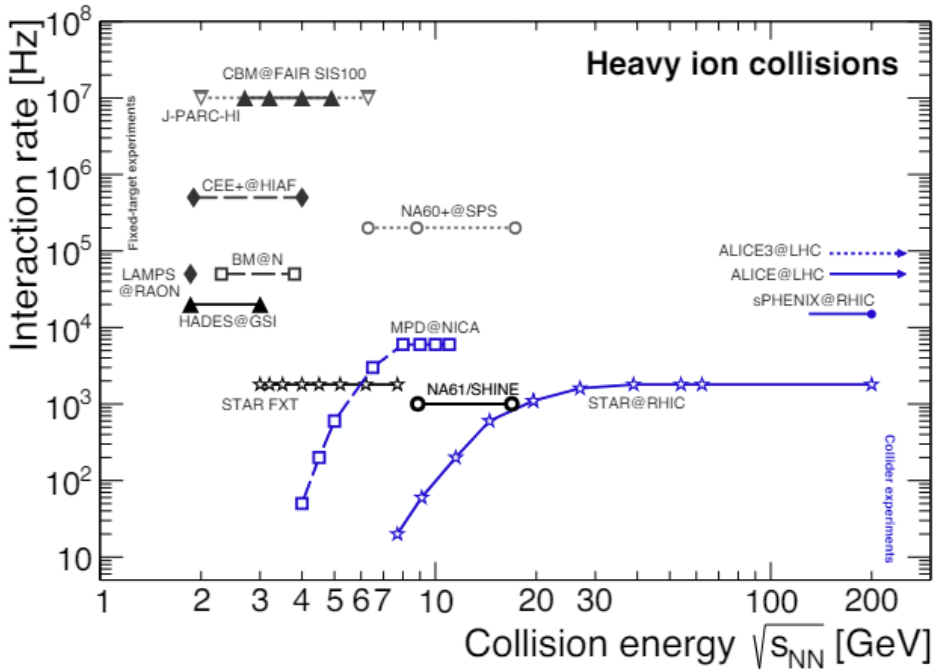
ALICE in Run 3 (2022–2025) and Run 4 (2029–2032), the future experiments NA60+, Compressed Baryonic Matter (CBM) experiment at the Facility for Antiproton and Ion Research (FAIR), and ALICE 3 with its new detector capabilities, will provide high-precision measurements of photon and dilepton production that can be used to study the phase diagram of QCD, the plasma temperature and its time evolution, medium properties such as shear and bulk viscosity and preequilibrium dynamics, as well as chiral symmetry restoration.

NuPECC LRP2024 Executive Summary

Strongly Interacting Matter at Extreme Conditions

- **Future flagship facilities and experiments**

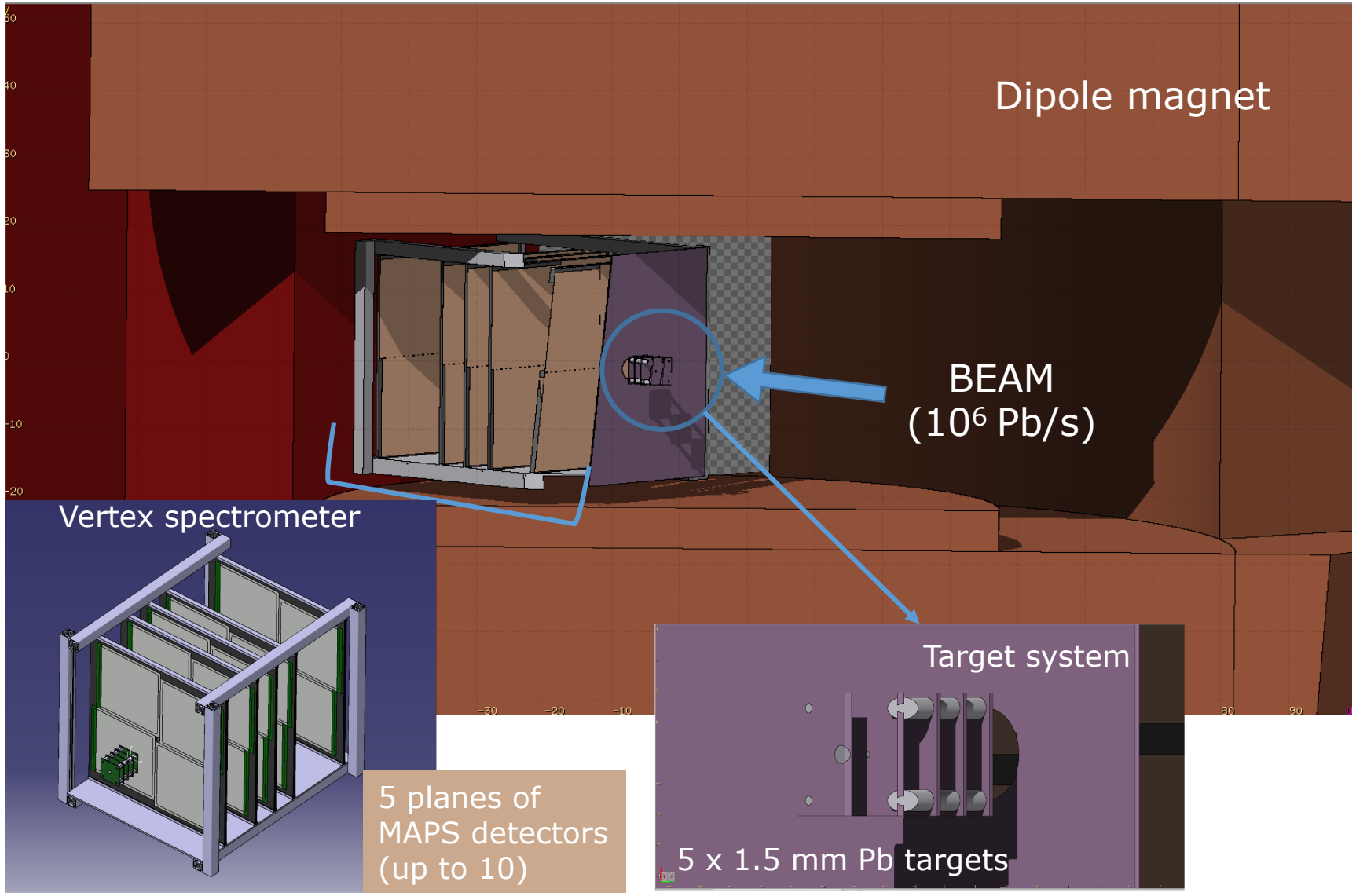
  - The **NA60+** detector at the **SPS** will address the remaining open questions in the electromagnetic and charm sector at the SPS with unprecedented event rates. R&D and construction for this detector deserve strong support.



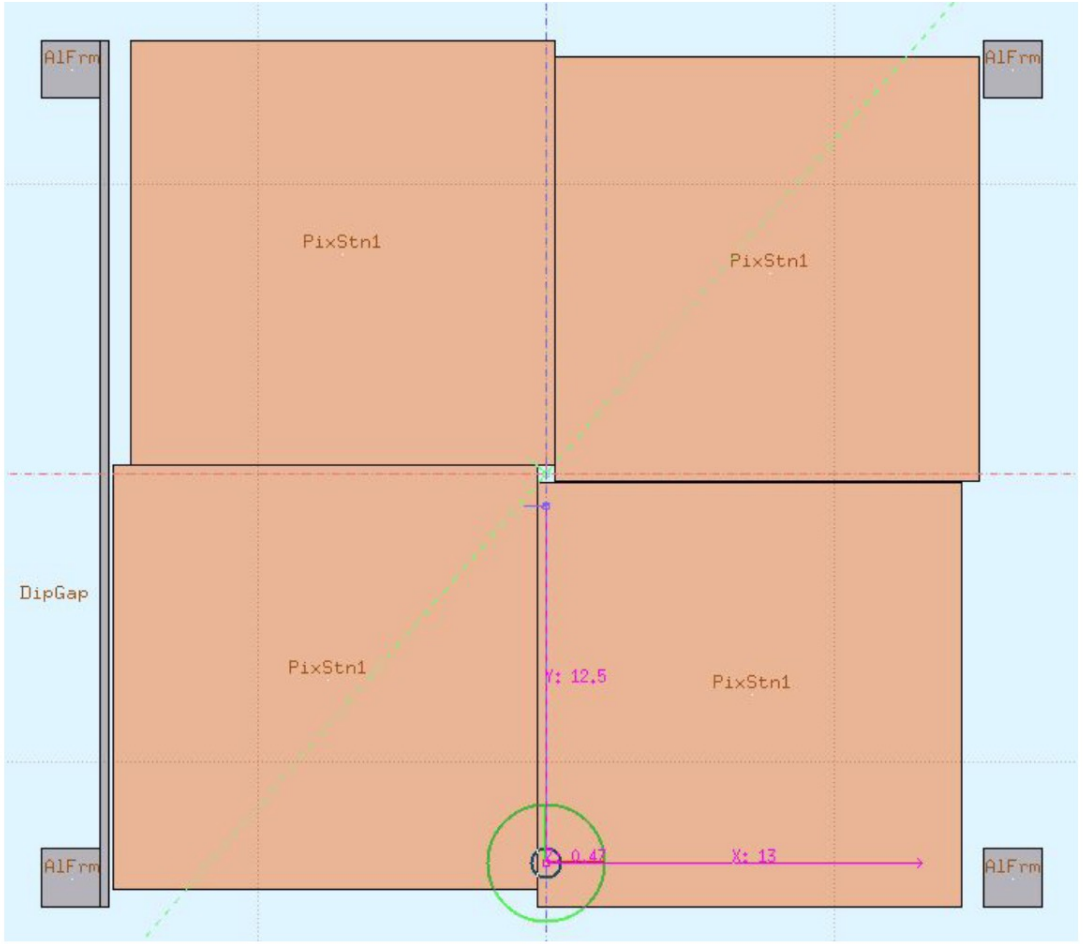
The NA60+ vertex region

MEP48 dipole magnet
Field 1.5 T over a 400mm gap

Stored at **CERN,**
to be refurbished (CERN/EP-DT)

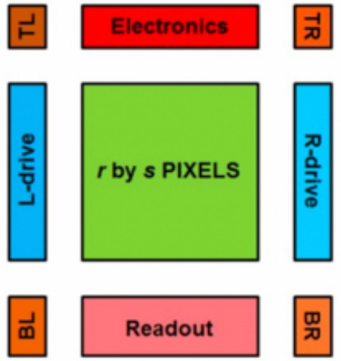


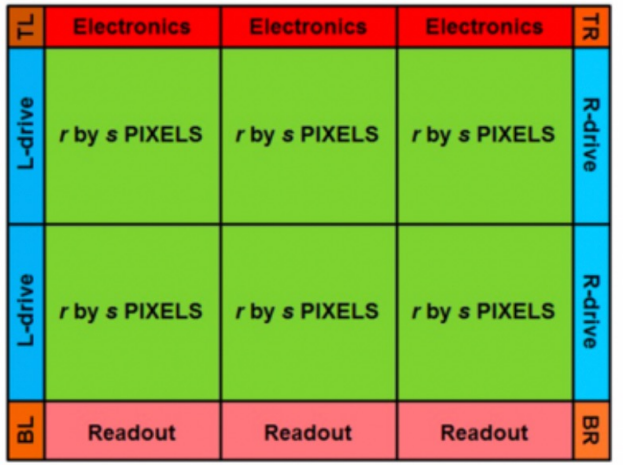
The NA60+ sensor (CA,PD,TO)



~30 cm

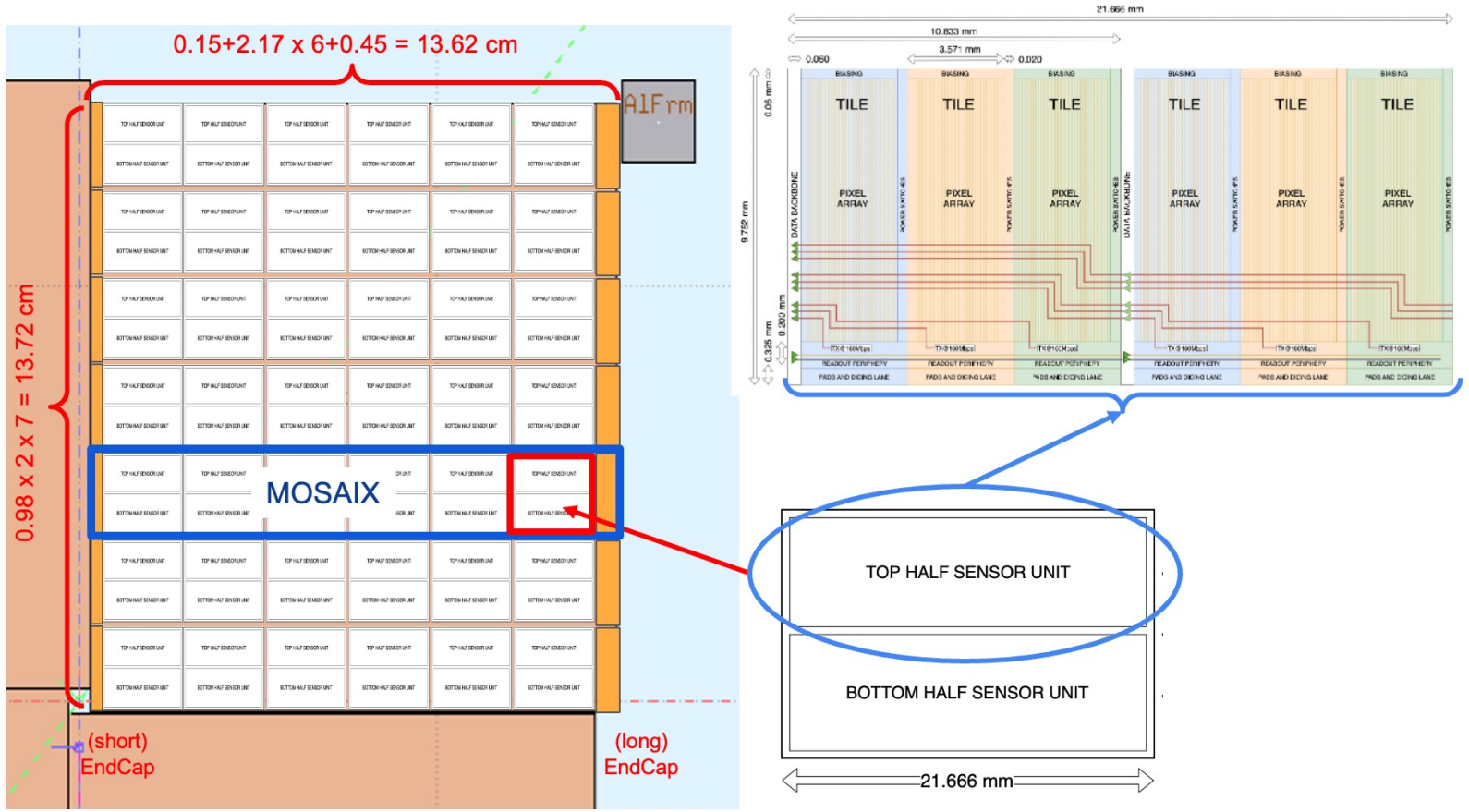
- In the LoI, each vertex telescope station is made up of 4 sensors, 15x15 cm^2 each
- Feb-May 2024: various meetings with ALICE ITS3 designers (G. Aglieri Rinella, W. Snoeys) to discuss the **NA60+ sensor with MOSAIX**
- How does it works for NA60+? → Stitching!





NA60+ sensor: MOSAIX

Realistic NA60+ sensor floorplan now available: 13.62 x 13.72 cm²



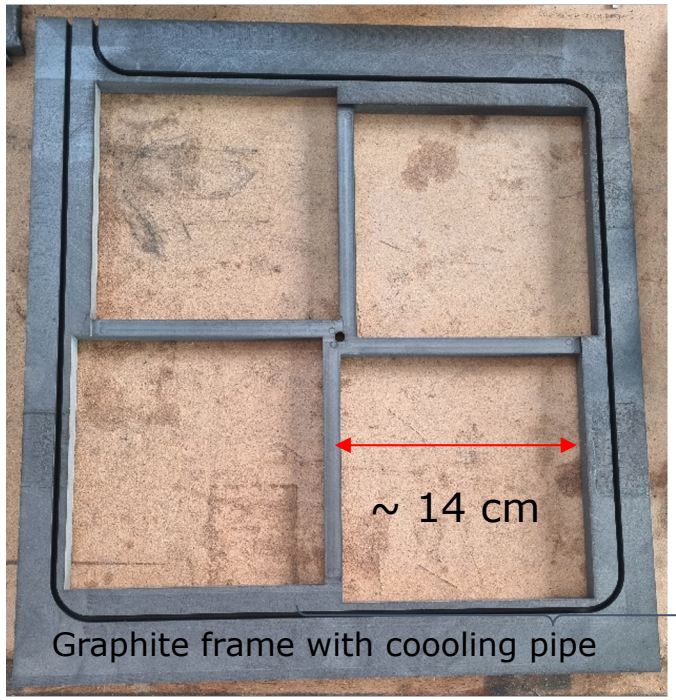
- MOSAIX with **6 stitched RSU**
- **7 MOSAIX** replicated vertically
- Powering and data transmission from right side

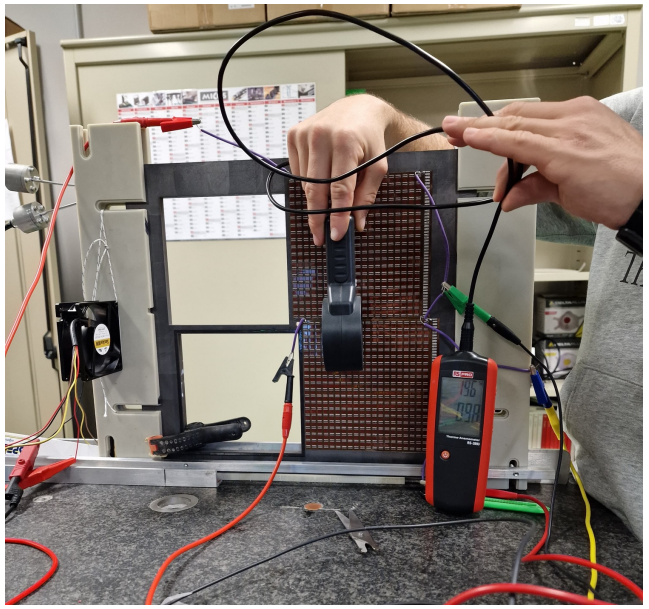
- One large sensor per wafer

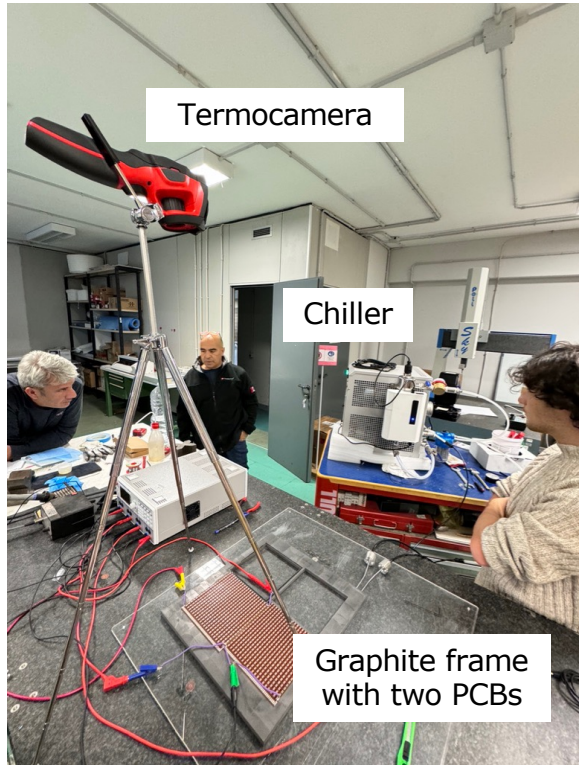
- Maximum rate: **6 MHz/cm²**
  → **ok** for 1-1.5x10⁶ Pb/s (Fluka simulations)

Mechanics/cooling for the vertex spectrometer

Sensors will be glued on a **graphite frame** → very good heat conductor





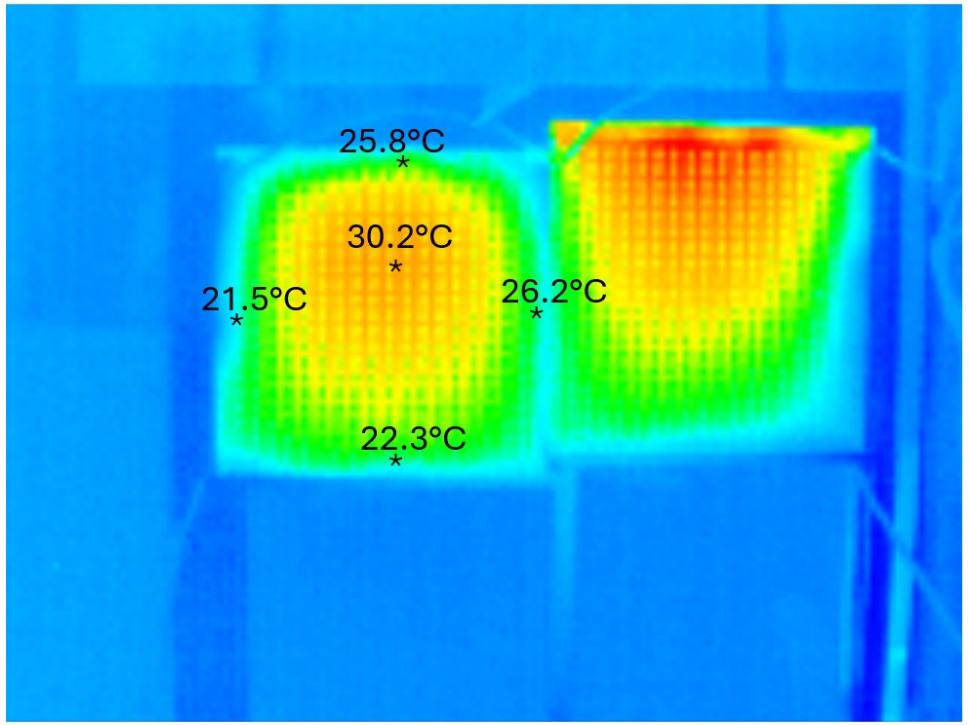


- **Air/water cooling** studied with ANSYS/COMSOL simulations
- **Power consumption** based on specifications for the MOSAIX sensor
- Experimental measurements **using PCB with resistor array** that mimics MOSAIX power dissipation

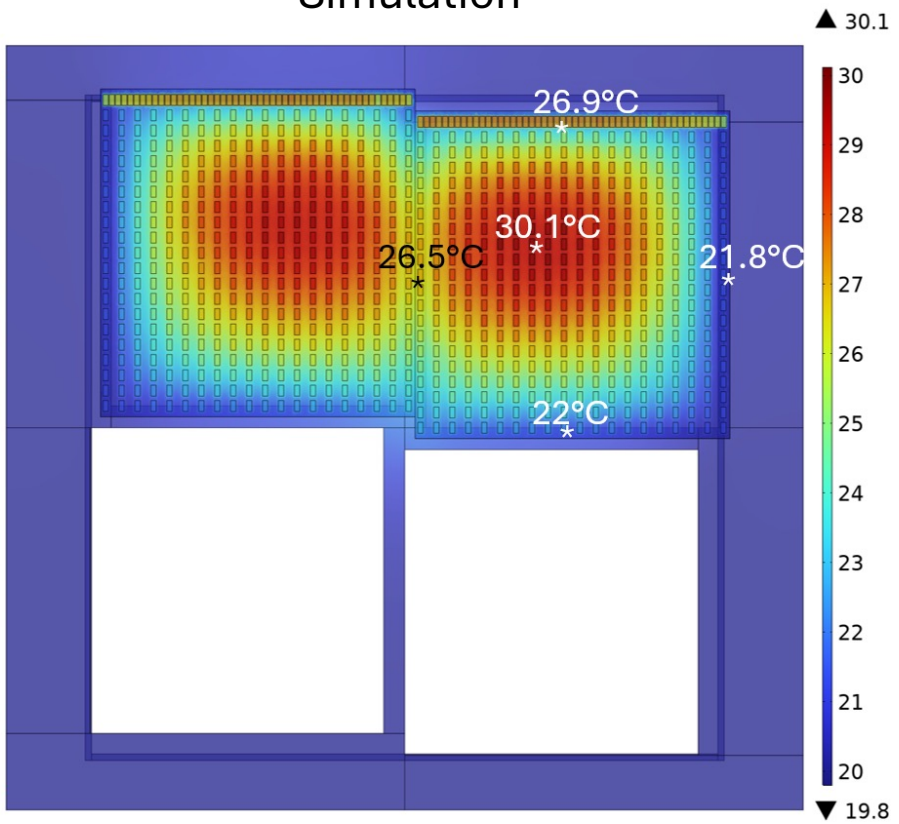
M. Arba, D. Marras, G. Galimberti, M. Tuveri
A. Mulliri, A. Marcia (master student)

Test set-up: simulation vs measurement

Lab measurement

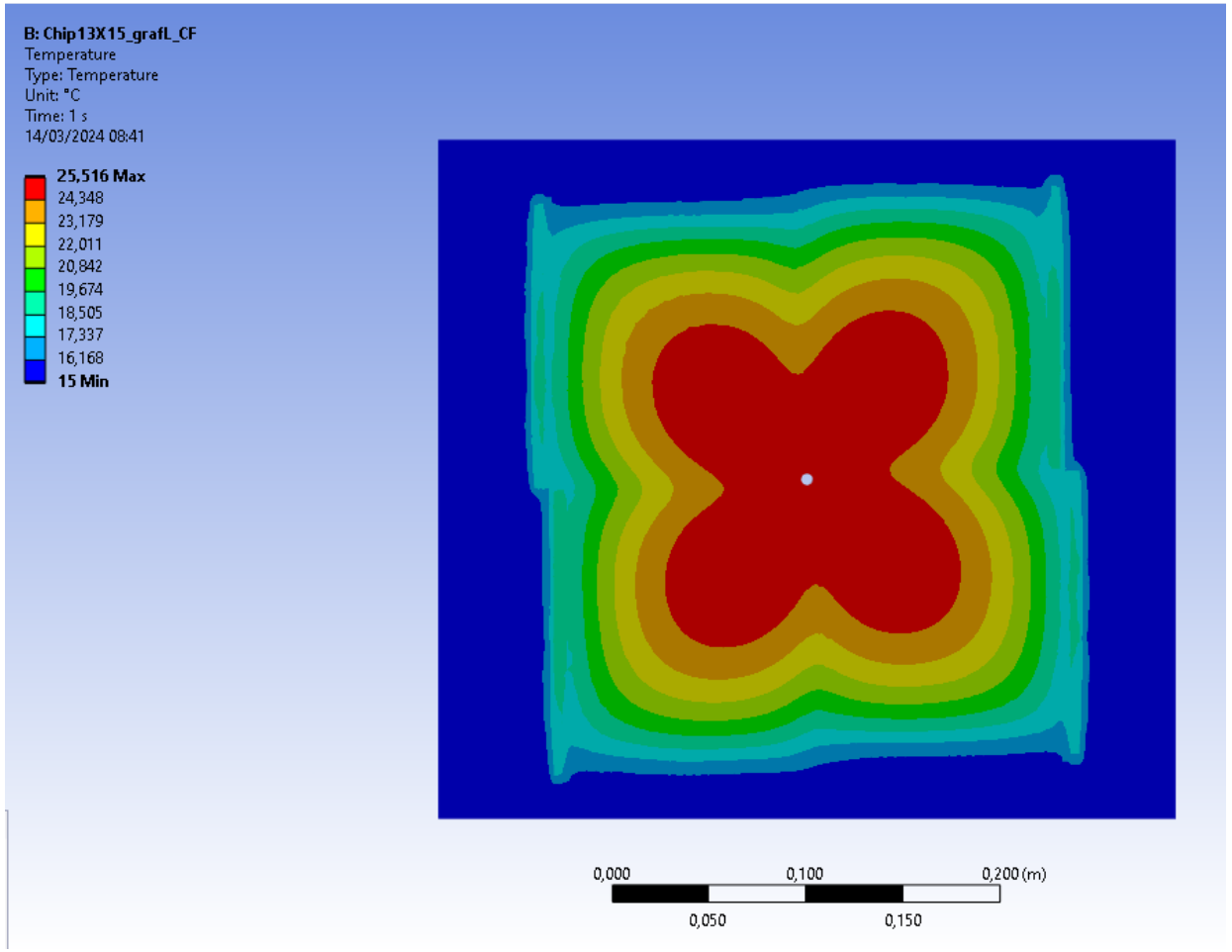


Simulation



- ❑ **Preliminary results** → details on materials modelled in COMSOL
- ❑ **Quantitative agreement** → **simulation parameters validated**

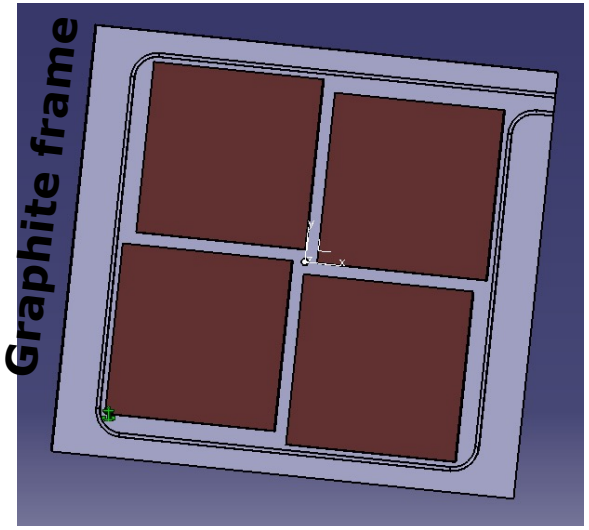
Simulation of the sensor planes



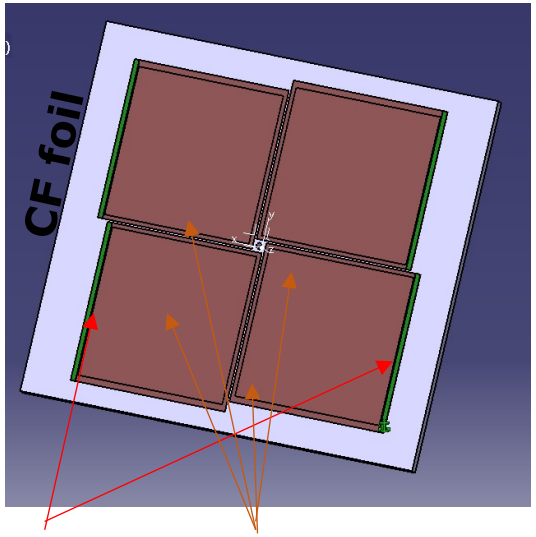
Sensors: silicon (148 W/mK)
Frame: graphite (100 W/mK)
CF K13D2U 0,4mm
Heat Flux: 7910W/m² on sides,
400 W/m² in the centre

Tambient **18**°C
cooling tubes all around (wall temperature **15**°C)
Air α= 10W/m²K- V=1m/sec

BACK VIEW



FRONT VIEW



791 mW/cm² 40 mW/cm²

- **Air** (1 m/s) + **water** cooling
- **Graphite frame** and a 0.4 mm **carbon fiber** foil

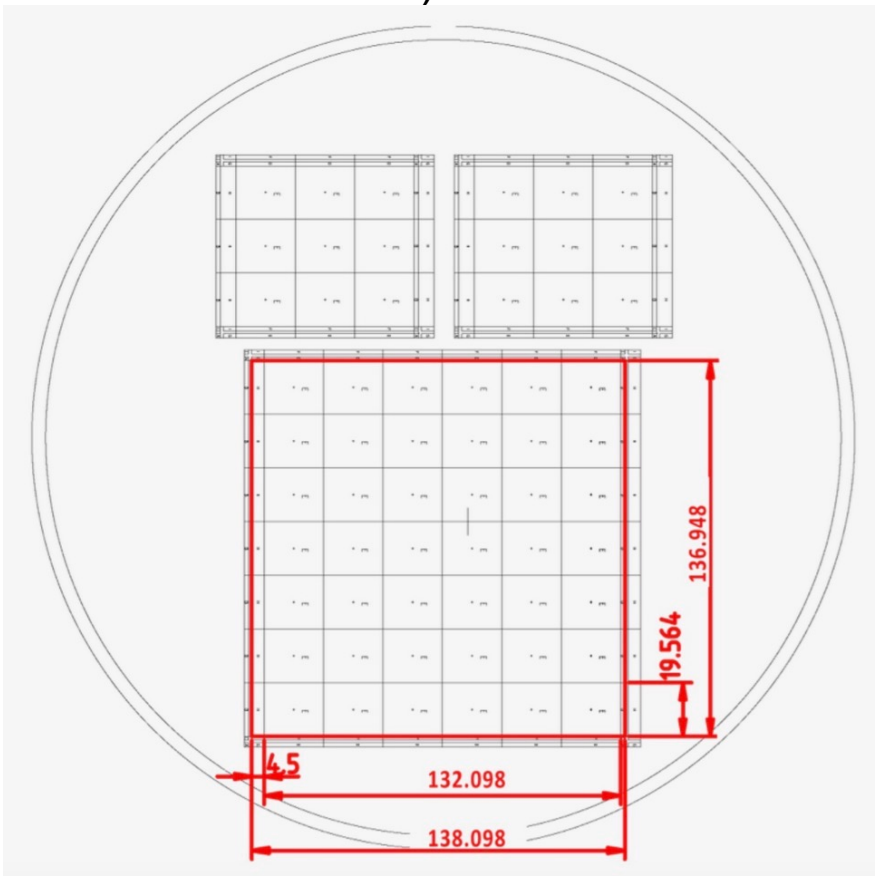
Production of Si sensors for NA60+

- A dedicated **stitching plan** is needed for our application: placement of the repeated sensor units on the silicon wafer
  - The estimated cost is about 100 kEuro

- Silicon wafers: 700 μm thick
  → they must be thinned to 50 μm and diced
- The estimated production cost per wafer is 8 kEuro
- There is a minimum quantity of 12 wafers in an order

Production of 12 wafers requires a
budget of about 200 kEuro

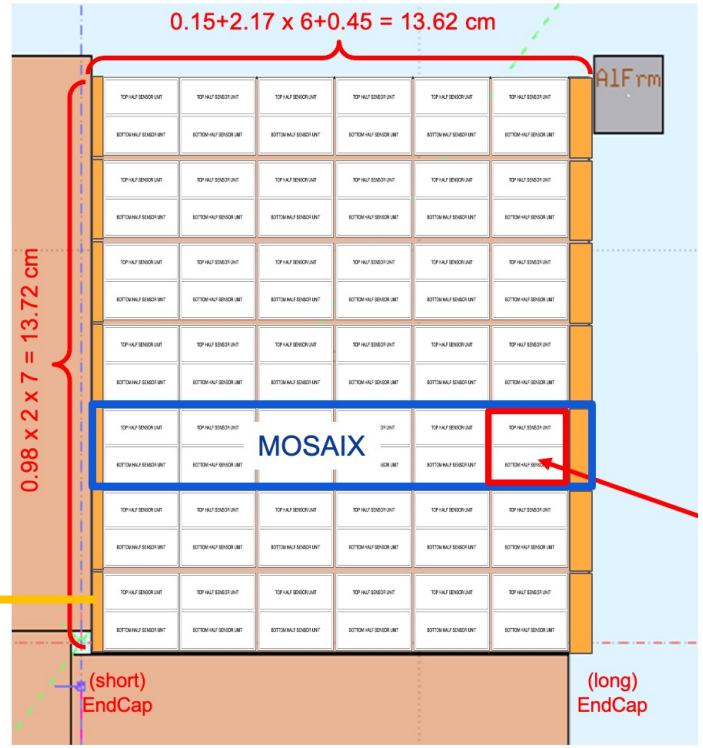
Stitching plan (1 sensor 6x7 RSUs + 2 sensors 3x3 RSUs)

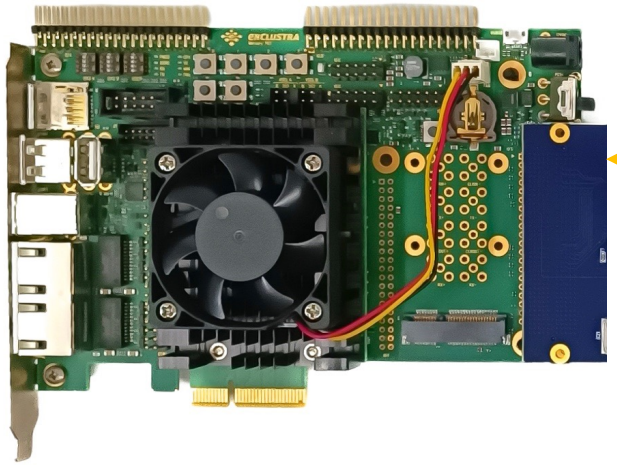


Test readout system for NA60+ Mosaix

- **Test readout system** developed within ALICE ITS3 (important responsibility from CA/PD – important synergy with NA60+)

- Commercial board **ENCLUSTRA**:
  - FPGA-based readout with high speed serial link capable of full readout of a MOSAIX (8 serial links)
  - USB3 interface to PC
  - Cost per board: 2 kEuro → **15 kEuro for a system of 7 boards**





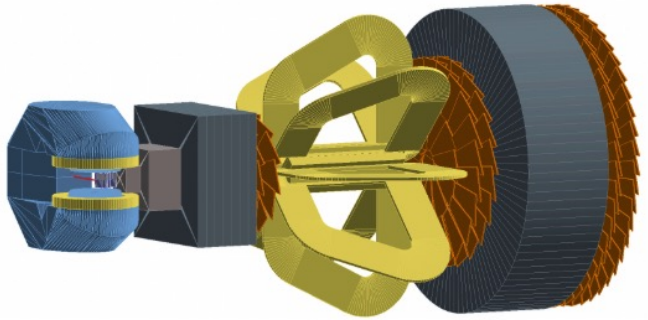
- Parallel readout of the 7 segments of full sensor with 7 independent ENCLUSTRA boards

- **Powering**
  - Lab power supplies → **5 kEuro**

The “big” milestone: the NA60+ proposal

Study of rare probes of the Quark-Gluon Plasma at SPS energy

EXPERIMENT PROPOSAL



Abstract

We propose a new fixed-target experiment for the study of electromagnetic and hard probes of the Quark-Gluon Plasma (QGP) in heavy-ion collisions at the CERN SPS. The experiment aims at performing measurements of the dimuon spectrum from threshold up to the charmonium region, of hadronic decays of charm hadrons, and of strange hadrons and hypernuclei. It is based on a muon spectrometer, which includes a toroidal magnet and six planes of tracking detectors, coupled to a vertex spectrometer, equipped with five planes of Si MAPS immersed in a dipole field. High luminosity is an essential requirement for the experiment, which needs an incident beam intensity of 10^6 incident ions/s, assuming a ~ 10 spill in a ≤ 40 s supercycle. The collision energies range from $\sqrt{s_{NN}} = 6.3$ GeV ($E_{lab} = 20$ A GeV) to top SPS energy ($\sqrt{s_{NN}} = 17.3$ GeV, $E_{lab} = 158$ A GeV). This document presents the physics program, the experimental set-up including integration and radioprotection studies, the expected physics performance. An evaluation of the costs, their sharing between the participating institutes, the construction and running timeline are also presented.

Version 0 - June 13, 2024

- Aiming at a **first version by the end of the year**
- Finalization and presentation to the SPSC not later than the first half of 2025
- Recent progress on technical aspects makes us confident that this milestone can be satisfied
- Still looking for a few more groups to reinforce manpower/contributions
- **Continuation of support of CSN3** mandatory for the approval

Richieste preliminari

ALICE

- **Missioni (keuro)**:
  - 8 - MCH
  - 10 - ITS3
  - 28.5 - turni
  - 24 - attività generali
  - 3.5 - responsabilità

75 keuro

- **Consumo (keuro)**:
  - 5.5 - auto CERN x turni e oncall
  - 1.5 - interventi su MCH (e ZDC)
  - 40 - readout ITS3 (schede SCB, SIB)

45-50 keuro

- **Richieste impegno servizi**:
  - 10% Mauro per DCS Muon Tracking
  - 10% Marcellino per interventi su ZDC

Richieste preliminari

NA60+

- **Missioni (keuro)**:
  - 40 - test-beam, collaboration meeting, meeting CERN, collaborazione CA-TO-PD
- **Consumo (keuro)**:
  - 220 keuro - produzione sensori, schede di readout

- **Inventario (keuro)**:
  - 5 - alimentatore

- **Richieste impegno servizi**:
  - 20% Mauro - meccanica pixel
  - 20% Marcellino - meccanica pixel
  - 30% D. Marras meccanica pixel, readout