KHuK's View

A. Andronic - University of Münster

- KHuK activities
  - Physics: Questions
    Facilities: CERN, GSI/FAIR
  - Detectors
  - Computing
- Summary

Upfront statement

KHuK

recognizes the importance of deciding now on the next flagship (accelerator) project at CERN

...and supports the KET decisions

(even if the machine may not be of direct/strong relevance to KHuK activities)

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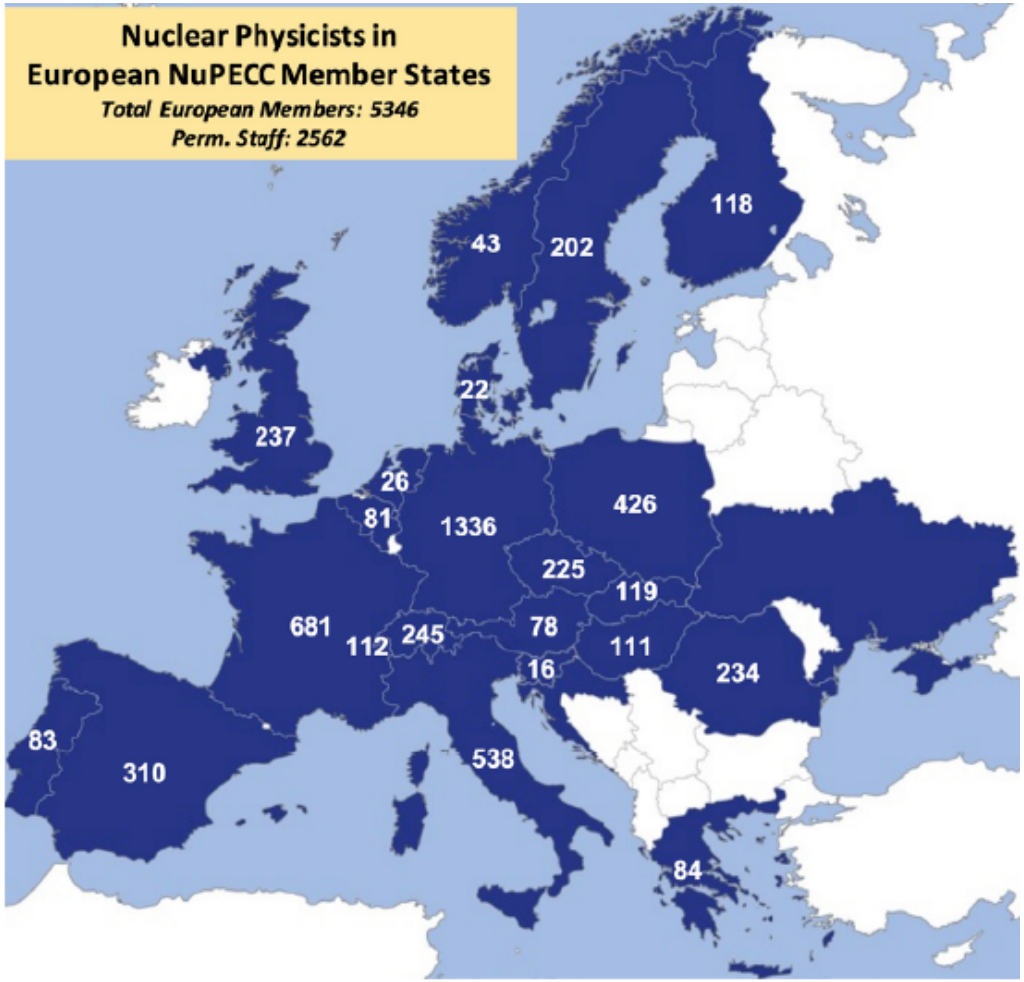
(..."but":)

KHuK has a strong (and not decoupled) physics agenda to pursue in the next decades ...outlined in NuPECC LRP 2024

KHuK: Themes (& european perspective)

- Nuclear structure, nuclear astrophysics
- Hot and dense QCD matter ("Heavy-ion physics")
- Fundamental interactions, symmetries
- Hadronic and electromagnetic probes

some overlap (hadron physics) with
KET-based projects:
LHCb, Belle II



KHuK: Driving questions (NuPECC LRP)

- What is the origin of confinement?
- How do hadrons, nuclei and nuclear matter emerge from the underlying fundamental interactions?
- What shapes can nuclei take, how do nuclear shells evolve, and what role do nuclear correlations play?
- What are the limits of the existence of nuclei, and what phenomena arise from open quantum systems?
- What are the mechanisms behind nuclear reactions and nuclear fission?
- How can we better understand the synthesis of heavy elements and the chemical evolution of the visible universe?
- What is the role of the strong interaction in stellar objects?
- What are the properties of the quark-gluon plasma, what is the qualitatively novel state of nuclear matter at extreme conditions of temperature and density?

Broad experimental and theoretical effort

...also broad in energy: MeV (keV) - TeV [per nucleon]

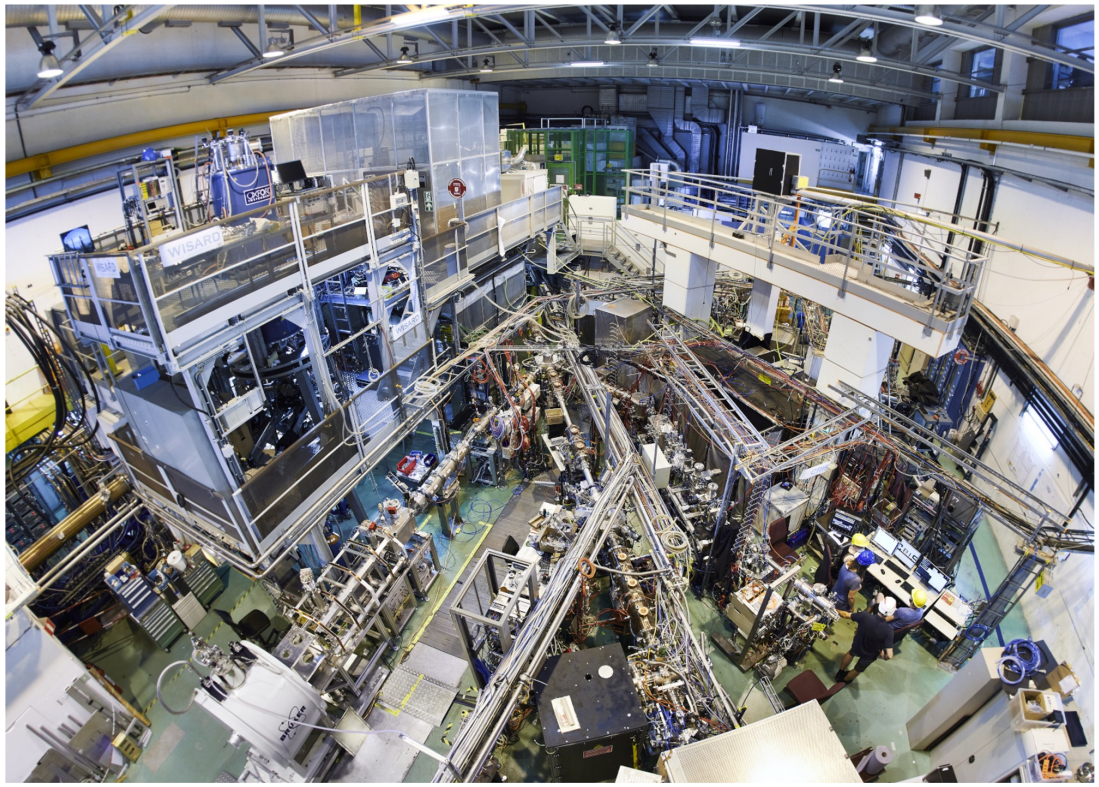
...and with broad societal impact, through applications, ex. PRISMAP

Consortium (23 partners) under coordination of CERN for production and dispatch of non-conventional radionuclides

CERN ISOLDE, AD/ELENA

Shapes of nuclei, nuclear shells, nuclear correlations

Synthesis of heavy elements, chemical evolution of the visible universe



Ground-state properties of nuclei:
ISOLTRAP, COLLAPS, RILIS

Radioactive decay: IDS

Reactions with post-accelerated beams:
HIE-ISOLDE, Miniball

Antiprotons and radioactive isotopes: PUMA

+ Applications:

Medical Isotope Production (MEDICIS)

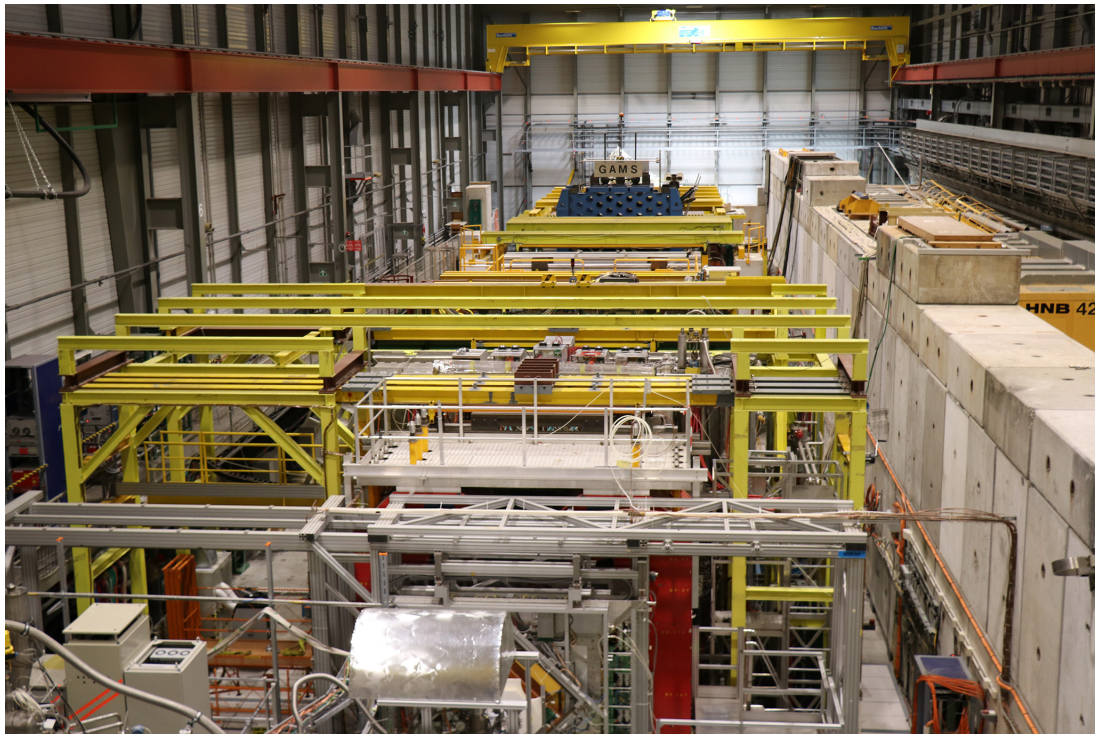
Bio NMR with unstable polarized nuclei (VITO)

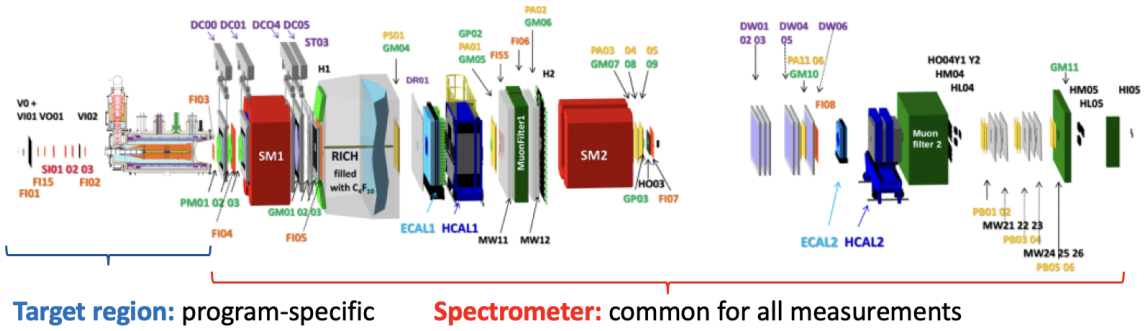
LS3 Upgrade: p driver: 1.4 $\rightarrow$ 2 GeV, 2 $\rightarrow$ 4 μA; upgraded experiments

Long term ideas: Extended experimental hall, Storage ring

AD/ELENA: CPT tests (m/q with Penning traps)

CERN SPS: AMBER





M2 beamline

Hadron structure, antimatter

Phase-I, 2023-2031

- Antiproton production (p-H,D,He)
- Proton radius (μ-p)
- π PDFs (Drell-Yan)

Phase-II, 2031-2041

- K PDFs (Drell-Yan, prompt photons)
- Strange meson spectroscopy
- Meson charge radii

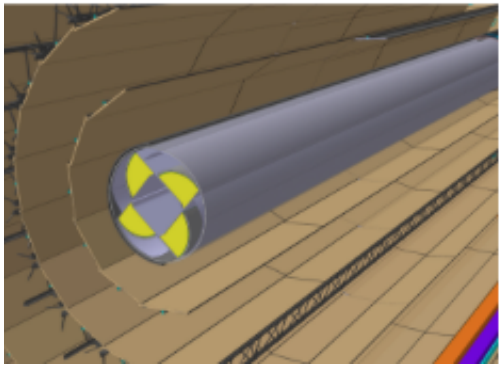
CERN LHC: ALICE 3

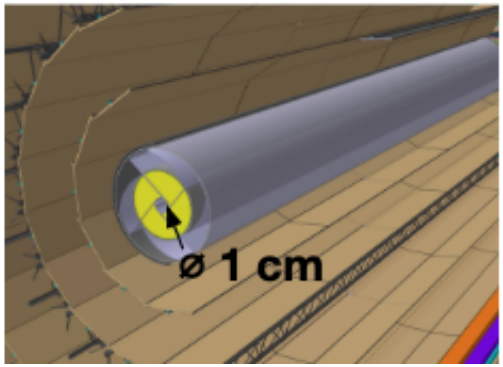
Ultimate diagnosis of inner workings of QGP (multicharm; beauty; photons...)

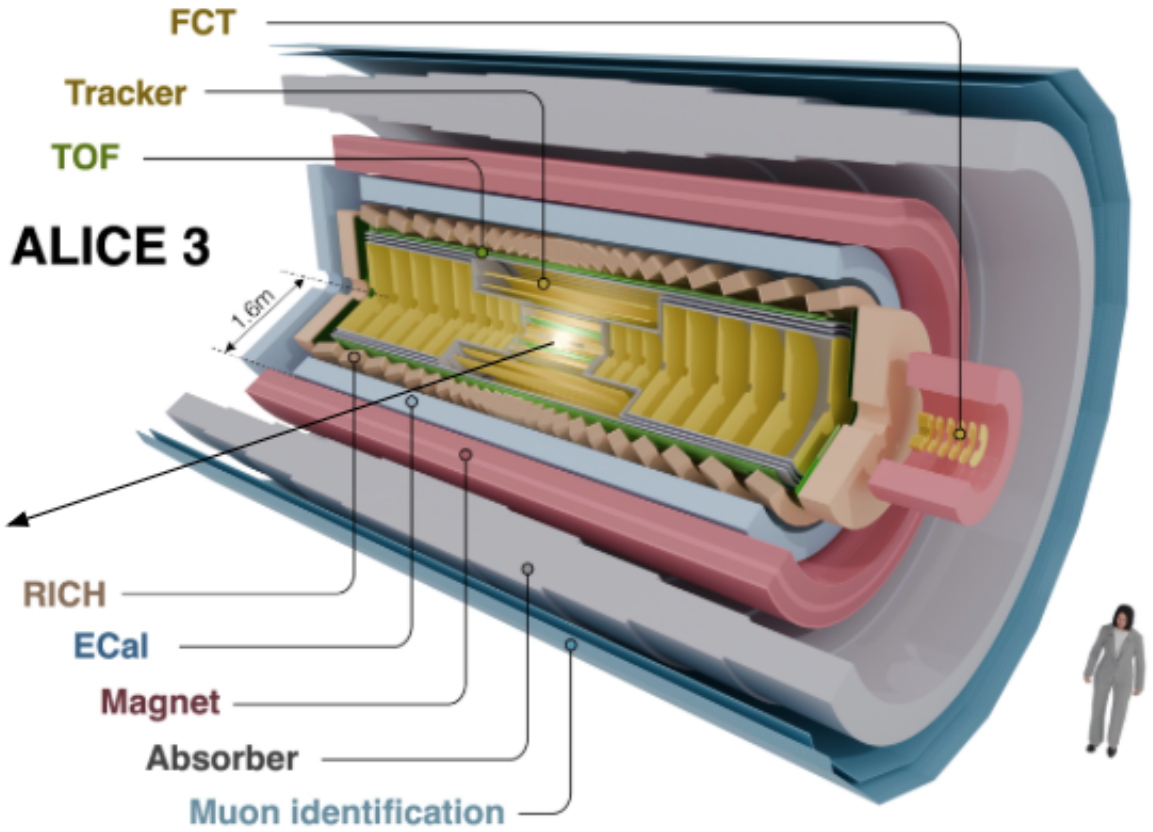
see talk by U.Wiedemann, Collider Workshop, DESY

➡ **Novel and innovative detector concept**

- Compact and lightweight all-pixel tracker
- Retractable vertex detector
- Extensive particle identification TOF, RICH, MID
- Large acceptance $|\eta|<4$
- Superconducting solenoid magnet B= 2 T
- Continuous read-out and online processing







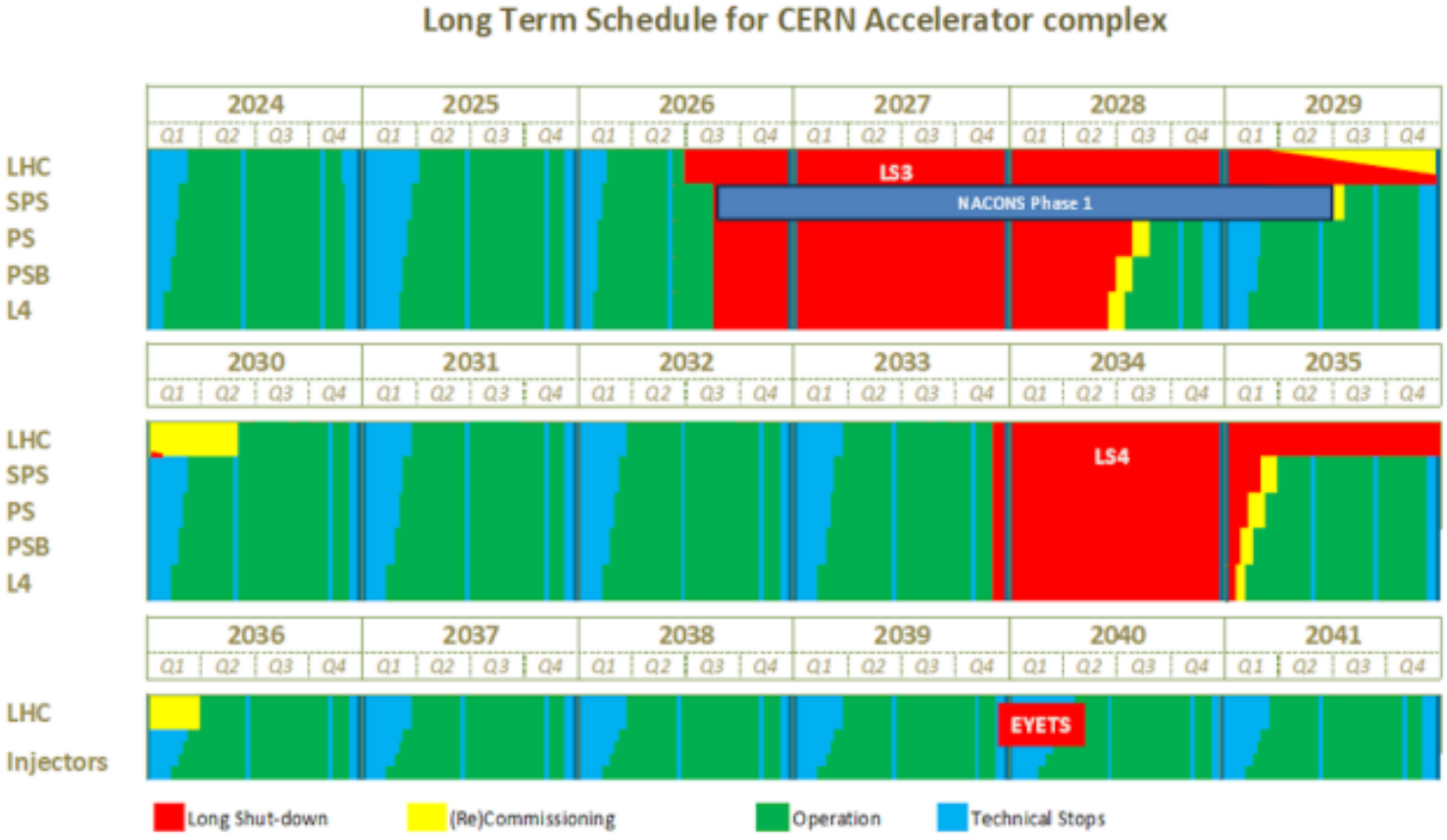
LoI: CERN-LHCC-2022-009

Leading detector R&D: (bended, stitched) MAPS, CMOS 65 nm; CMOS timing

Timelines

ALICE 3 Timeline

- 2023-25: Scoping Document, selection of technologies
- 2026-27: large-scale engineered prototypes TDRs, MoUs
- 2028-33: construction and testing; pre-commissioning
- 2034-35: preparation of cavern, installation

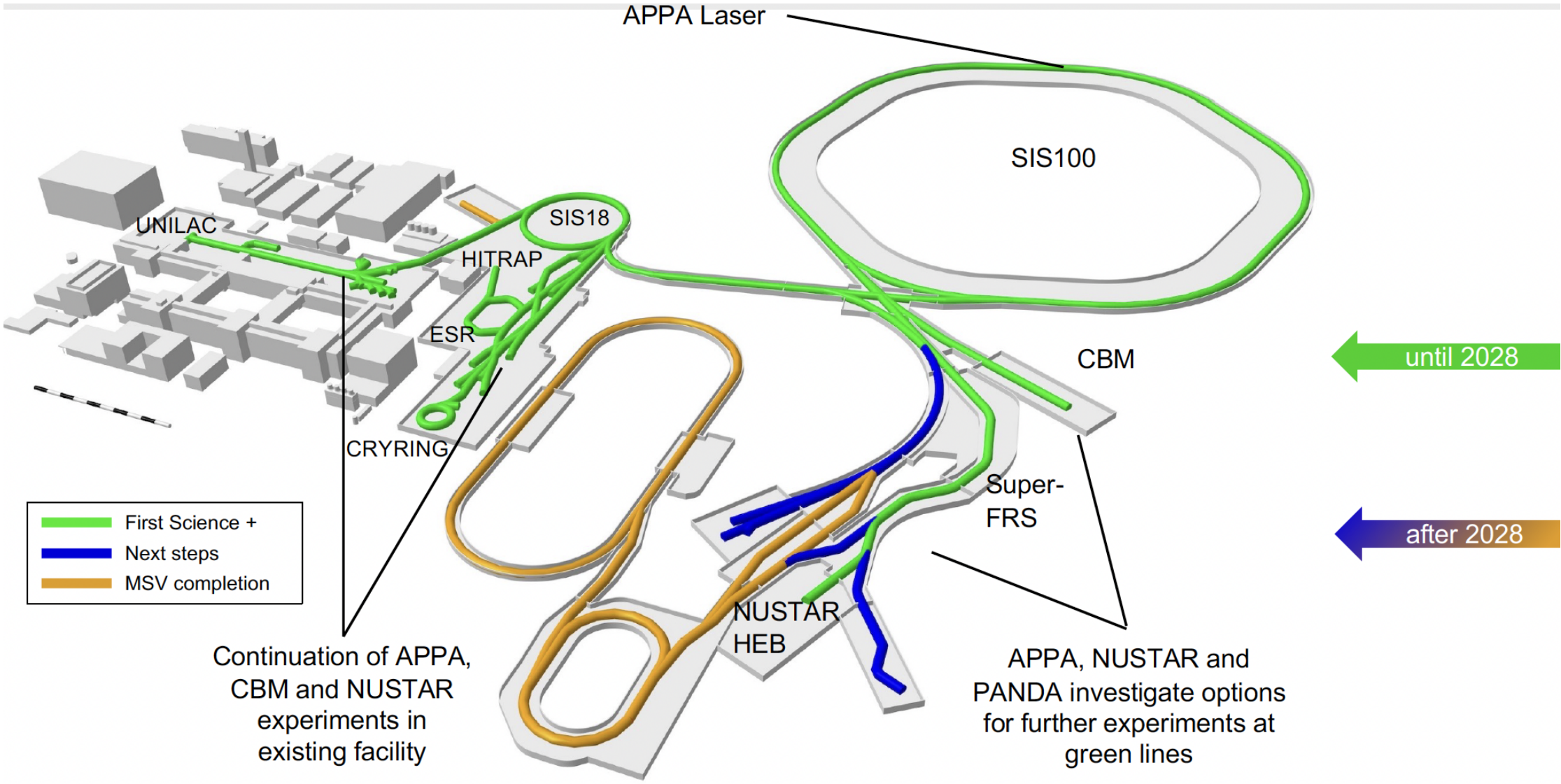


KHuK has principle interest (3D proton structure; gluon saturation physics)

Synergies through ERL developments for MESA (U. Mainz)

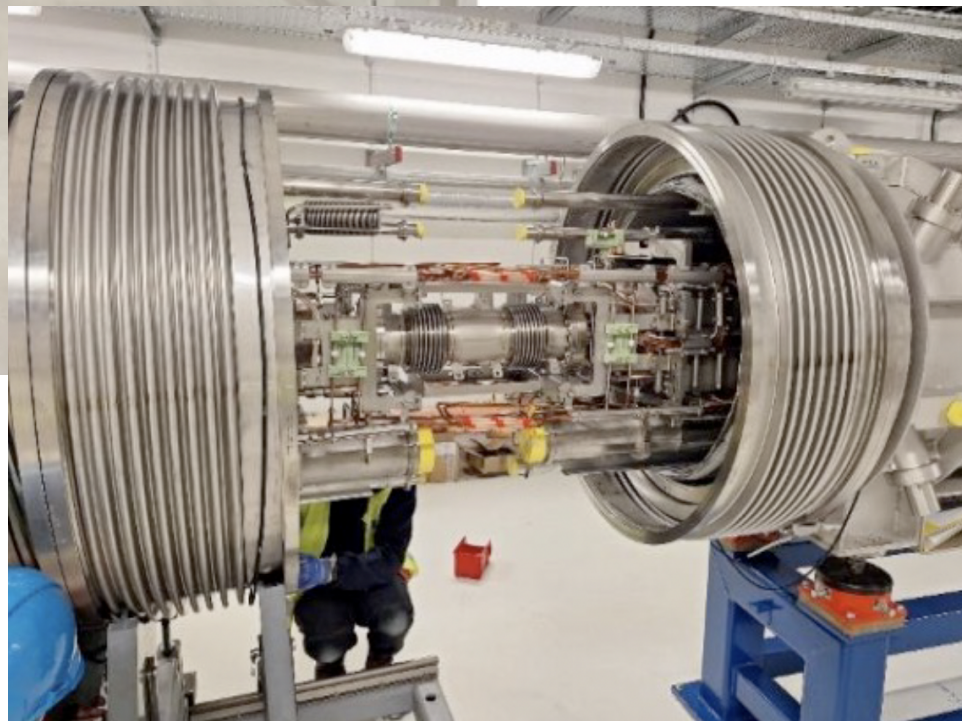
Detector synergies (ALICE 3 as LHeC detector? ...needs a careful look)

FAIR Complex at GSI Darmstadt



FAIR Complex

Inside FAIR



see More photos, videos

Detector R&D

- Si: MAPS (CMOS 65 nm), timing
- Gaseous (GEMs, RPCs)
- Calorimetry

Very good synergies with KET through:

- BMBF Verbundforschung
- DRDs

Specific for KHuK:

- High-resolution gamma spectroscopy
- Traps

Computing

(experiment and theory)

- High-Performance Computing (incl. GPU-based)

- Algorithms / ML

- Online event selection
- Calibration and monitoring
- Fast access to stored data

Outreach, ...

...for LHC is already "unified" (common FSP office at DESY)

Will continue to be important for both communities

...and so will it be for:

- Open data
- Training
- Diversity

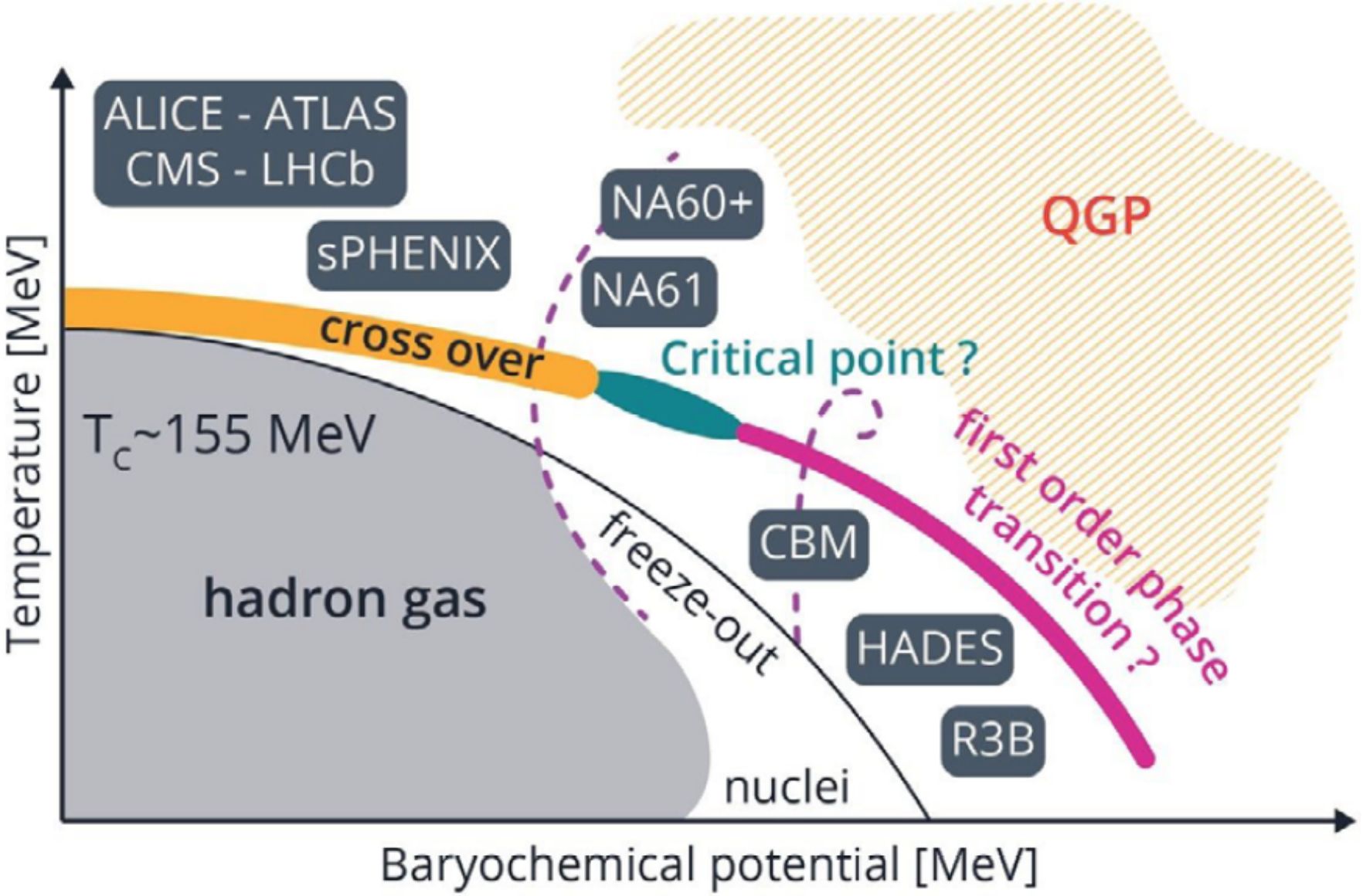
Summary

KHuK

- supports the KET recommendations for ESPP
- pleads for a full completion of planned experiments at CERN (into 2040's)
- envisages the utilization and completion of FAIR (own flagship project)
- sees important synergies concerning detectors, computing, accelerators, and outreach

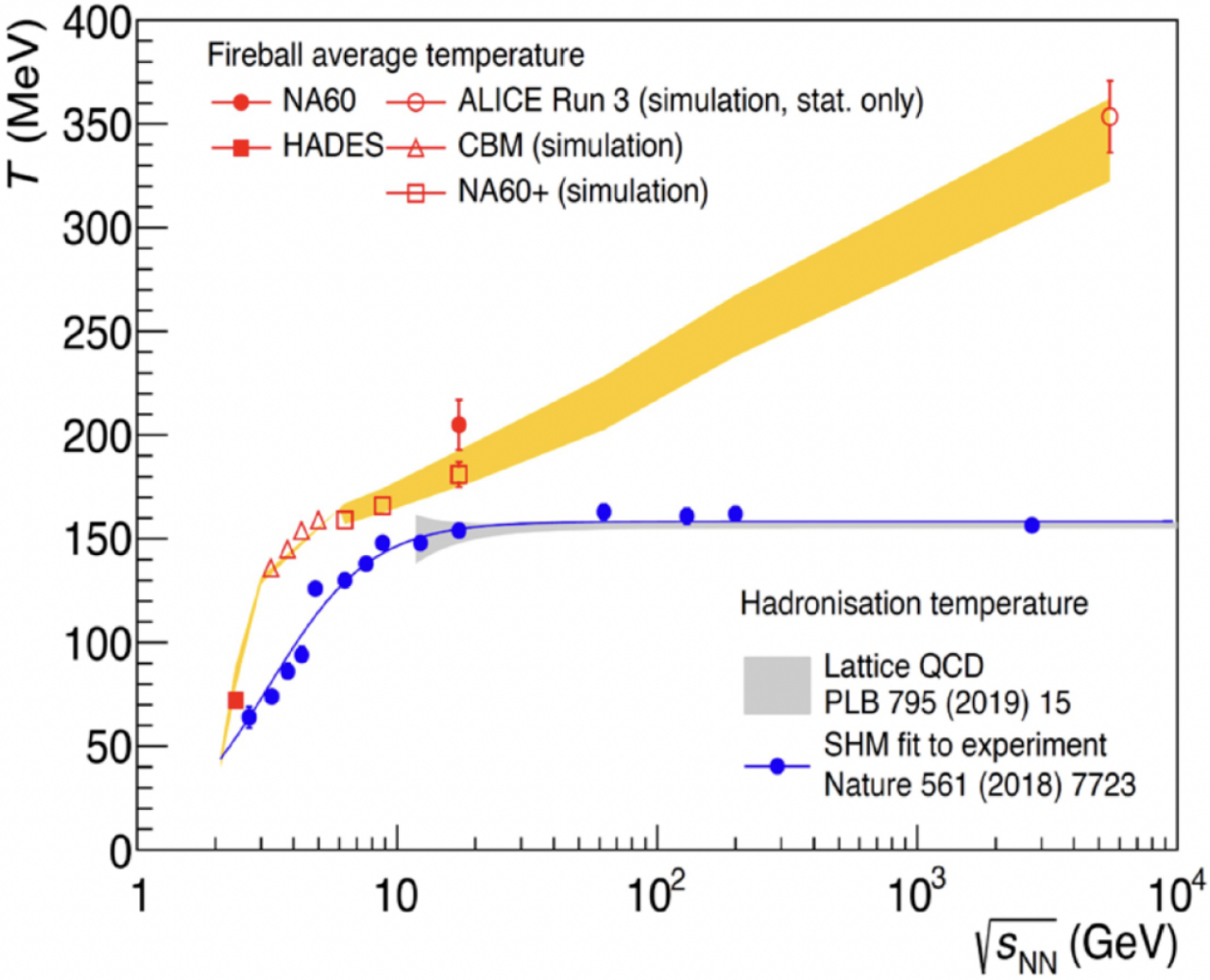
Supplementary material

The QCD phase diagram

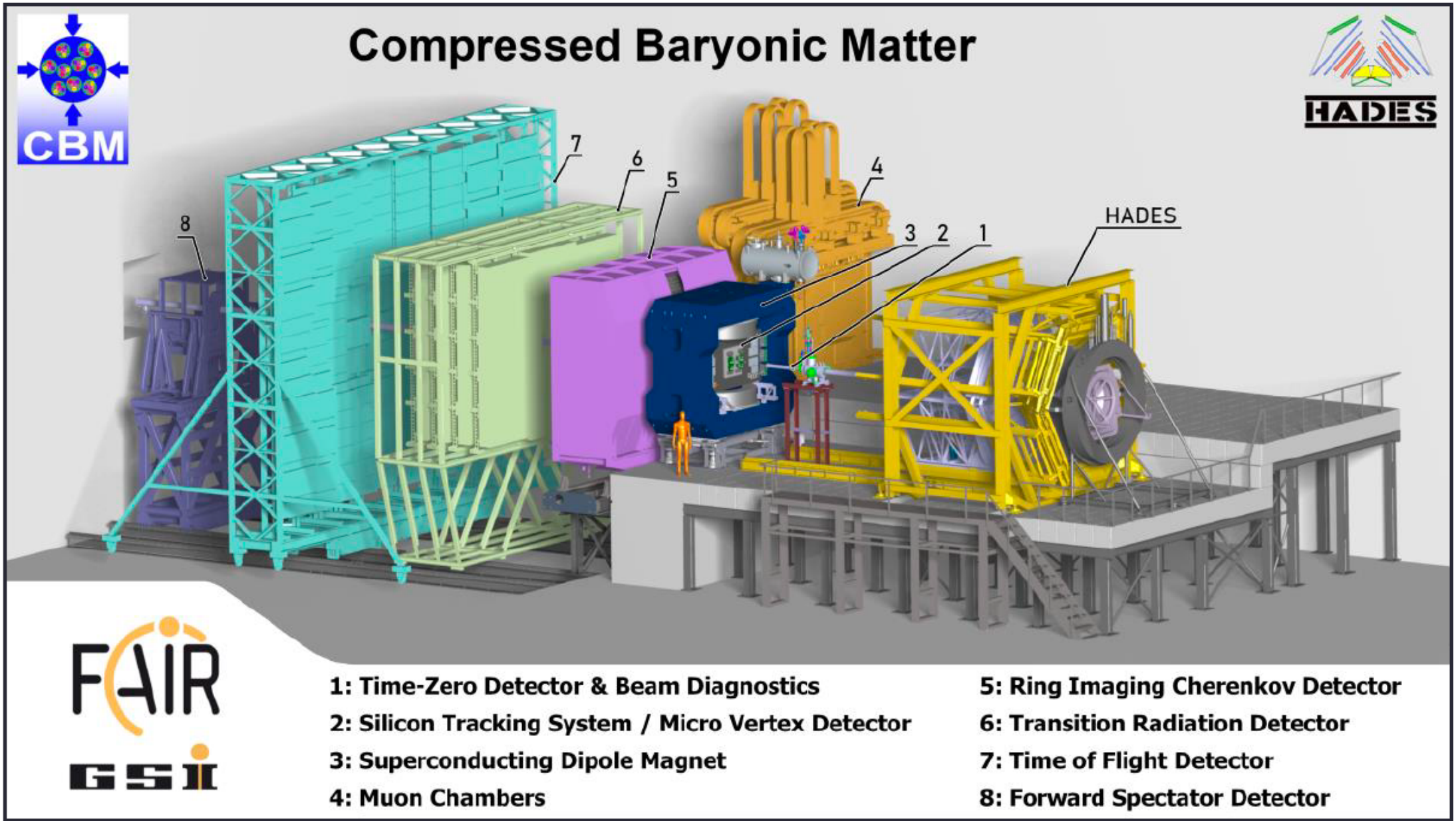


NuPECC LRP

The early thermometer: dileptons

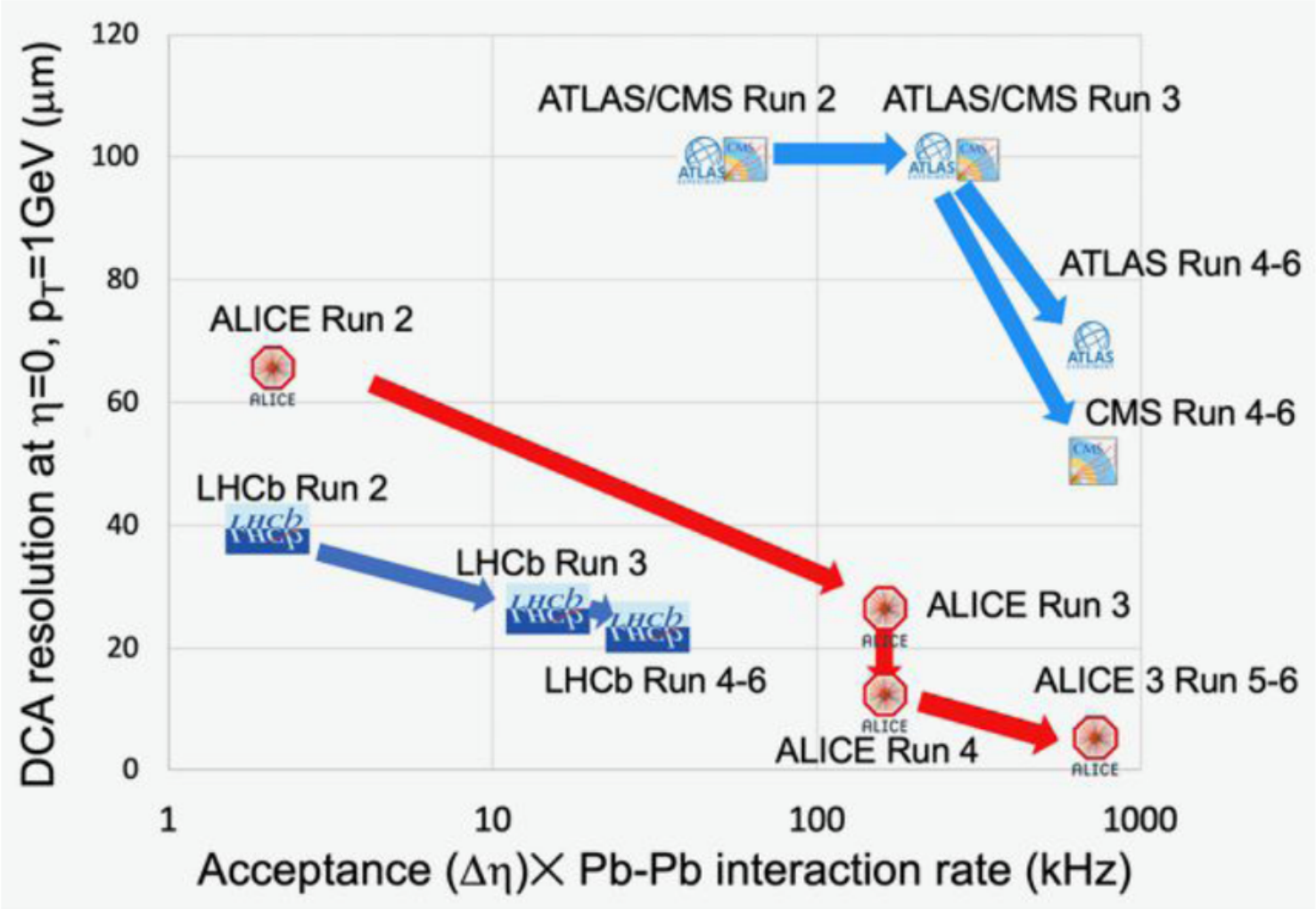


CBM Detector



Challenges: event rates up to 10 MHz; huge variation in occupancy (fixed-target)

The LHC experiments



NuPECC LRP