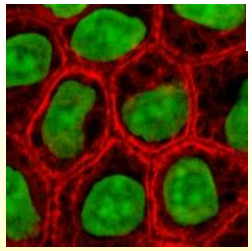
Fysik med ALICE

Nordborg efterskole, CERN, 30. maj 2024

Børge Svane Nielsen, Niels Bohr Institutet, København

Bøgge Svane Nielsen, Niels Bohr Institutet

Naturens byggestene



50 µm
$5 \cdot 10^{-5}$ m

CELLER
Tyve
per mm

Optisk mikroskop

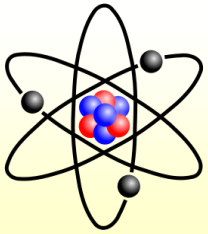
× 10.000

5 nm
$5 \cdot 10^{-9}$ m

DNA
To hundrede
tusinde
per mm

Elektron-mikroskop

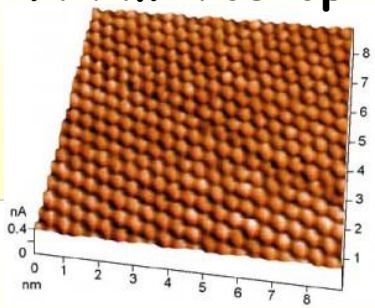
× 50



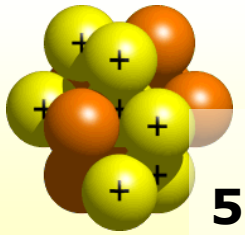
0.1 nm
10^{-10} m

ATOMER
Ti millioner
per mm

AFM mikroskop



× 20.000

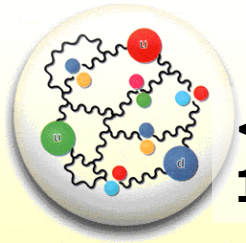


5 fm
$5 \cdot 10^{-15}$ m

ATOMKERNER
To hundrede
milliarder
per mm

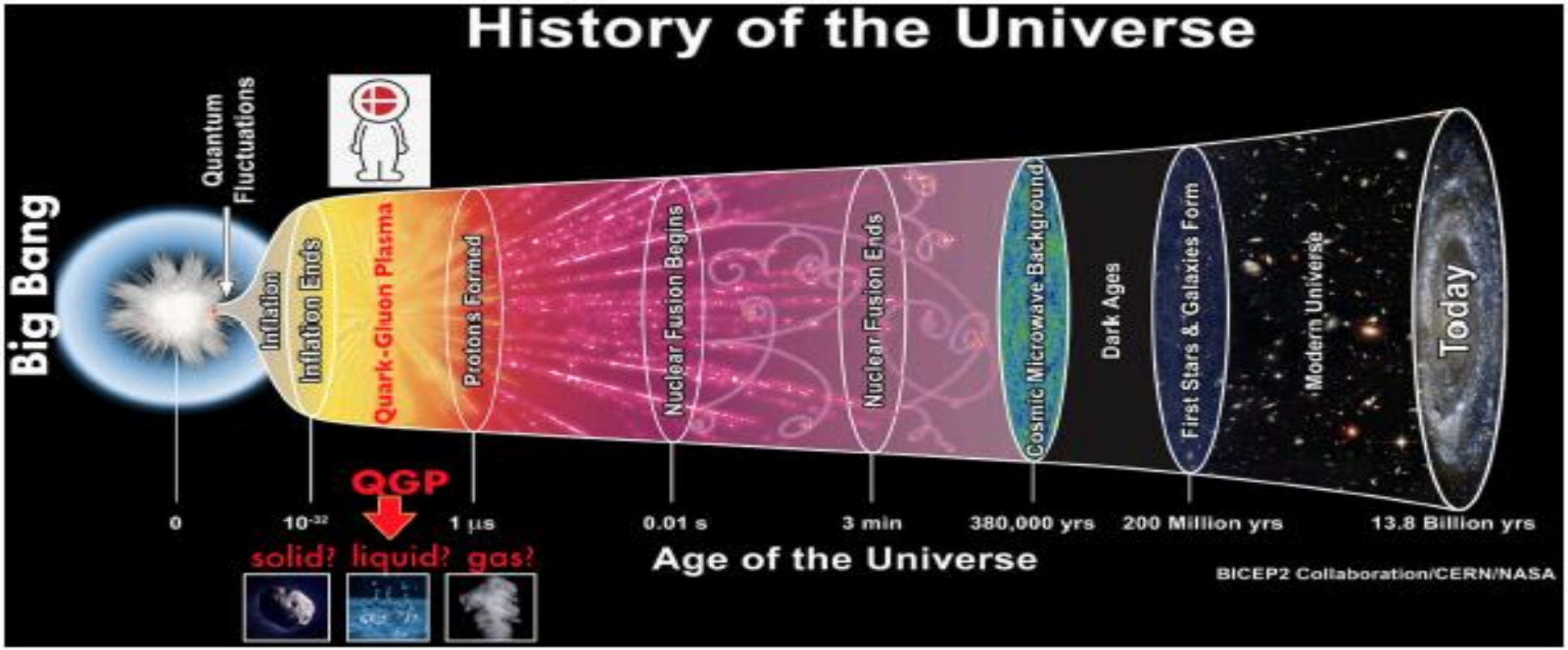
Partikelacceleratorer

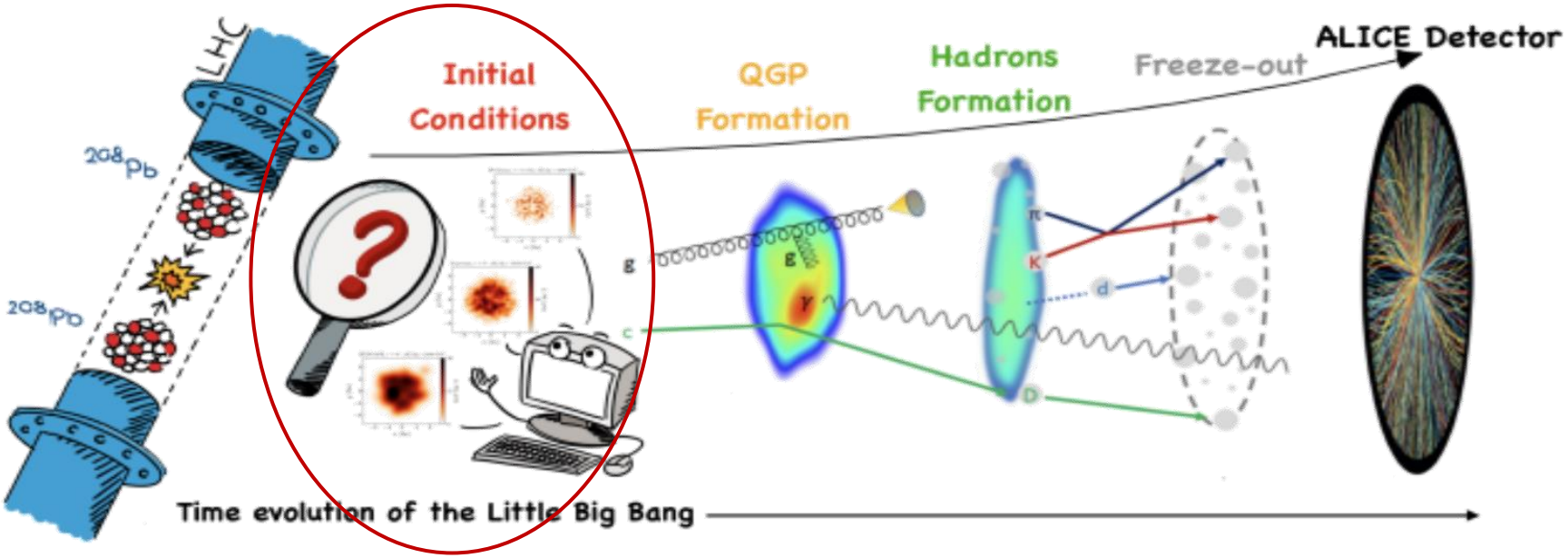
× 2.000



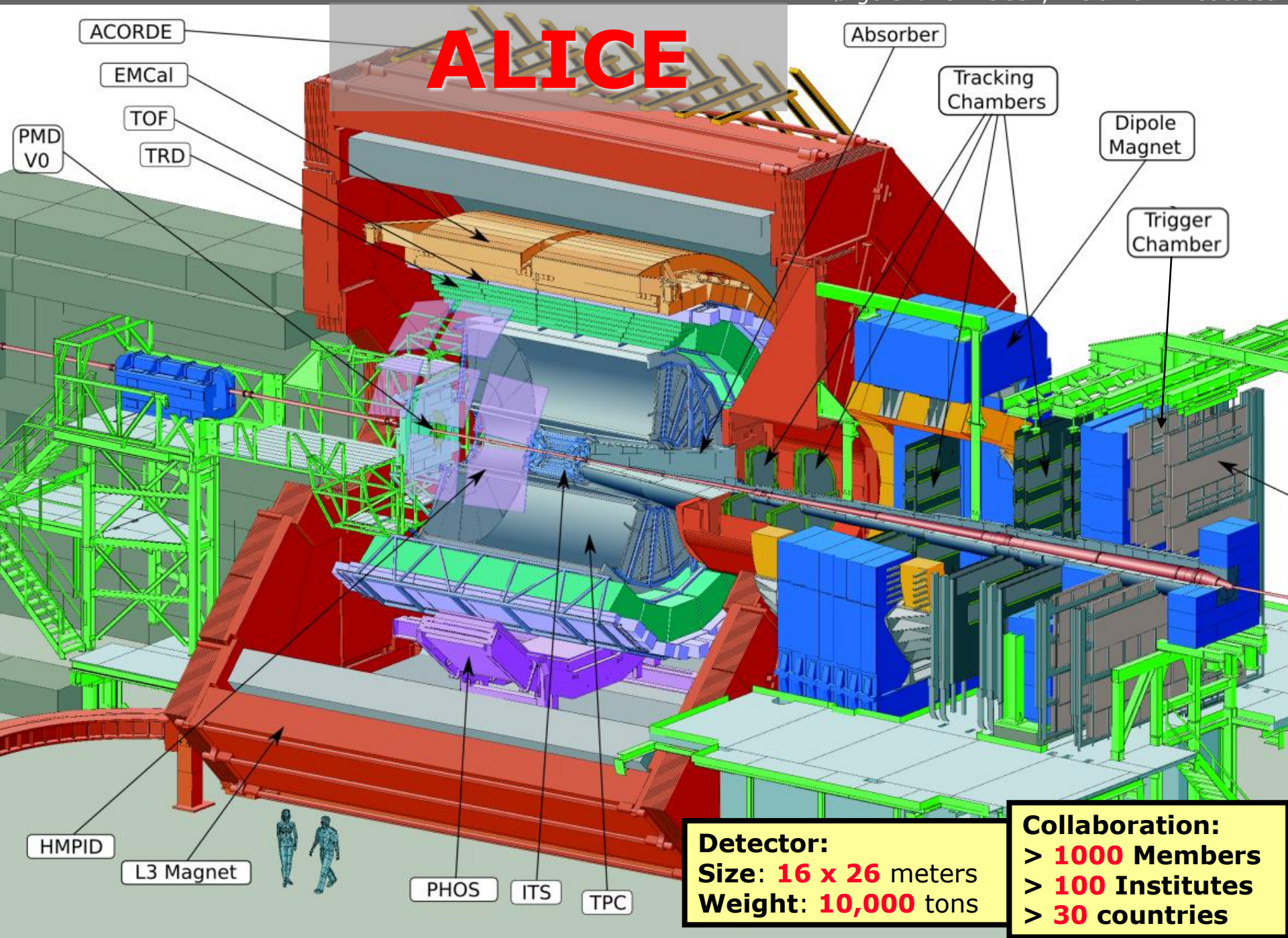
< 1 am
10^{-18} m

Kvarker
Mere end en
million milliarder
per mm


History of the Universe
Big Bang
Quantum Fluctuations
Inflation
Inflation Ends
Quark-Gluon Plasma
Protons Formed
Nuclear Fusion Begins
Nuclear Fusion Ends
Cosmic Microwave Background
Dark Ages
First Stars & Galaxies Form
Modern Universe
Today
QGP
solid? liquid? gas?
0
10-32
1 μs
0.01 s
3 min
380,000 yrs
200 Million yrs
13.8 Billion yrs
Age of the Universe
BICEP2 Collaboration/CERN/NASA

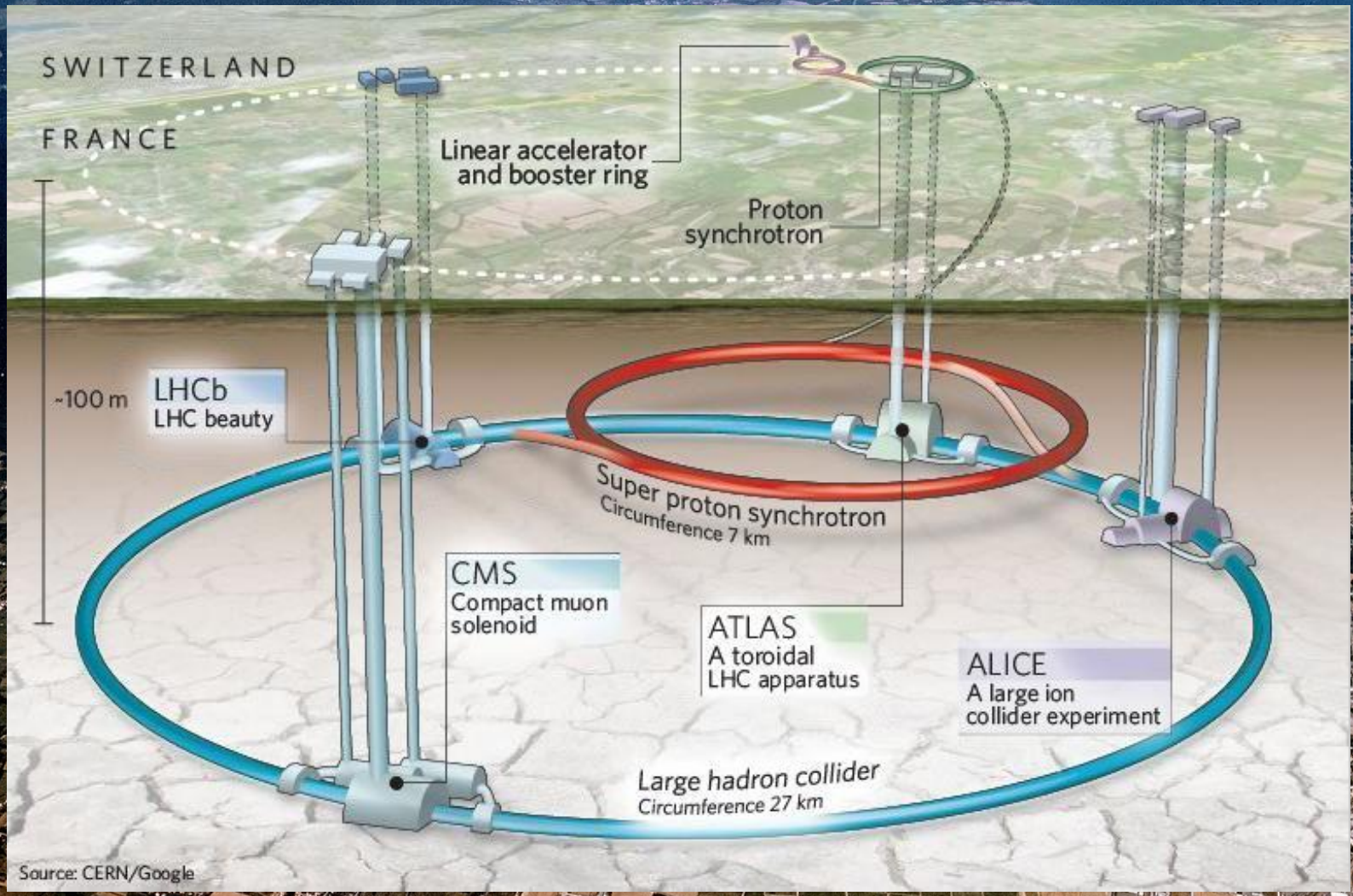

LHC
208Pb
208Pb
Initial Conditions
QGP Formation
Hadrons Formation
Freeze-out
ALICE Detector
Time evolution of the Little Big Bang

ALICE



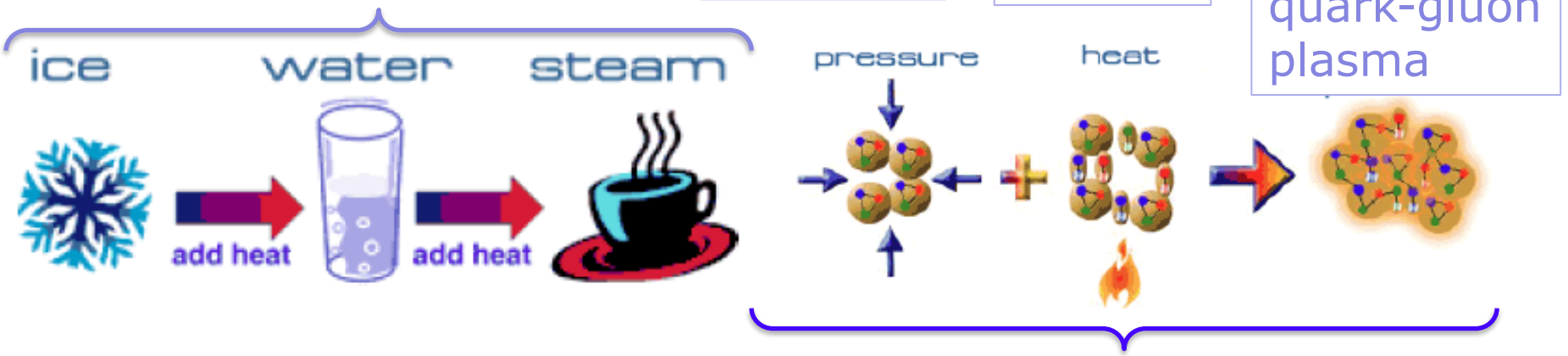
Detector:
Size: **16 x 26** meters
Weight: **10,000** tons

Collaboration:
> 1000 Members
> 100 Institutes
> 30 countries


SWITZERLAND
FRANCE
Linear accelerator and booster ring
Proton synchrotron
~100 m
LHCb
LHC beauty
Super proton synchrotron
Circumference 7 km
CMS
Compact muon solenoid
ATLAS
A toroidal LHC apparatus
ALICE
A large ion collider experiment
Large hadron collider
Circumference 27 km
Source: CERN/Google

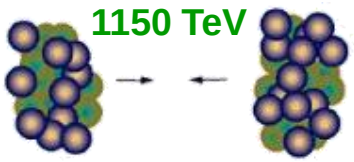
Hvordan laver man Universets "urstof"?

Stof findes i flere faser

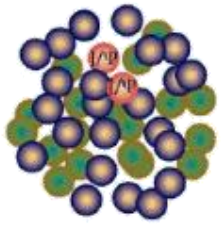


- Er det muligt at smelte atomkerner?
- Hvis vi kan gøre det, kan vi forstå det meget tidlige Univers
- Varme + tryk: Blykerner i en accelerator!

Tunge ioner i LHC

^{208}Pb 

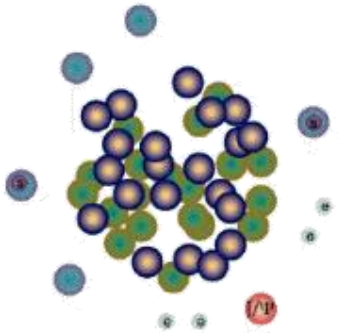
^{208}Pb kollision



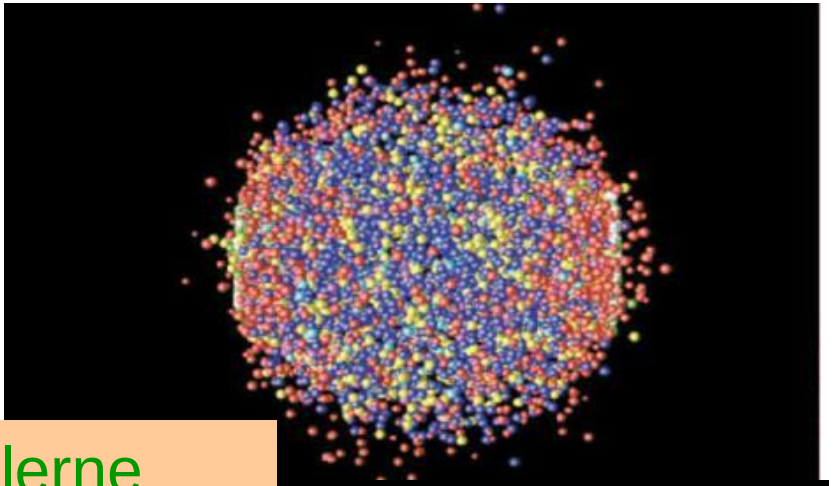
superkerne med
høj energi

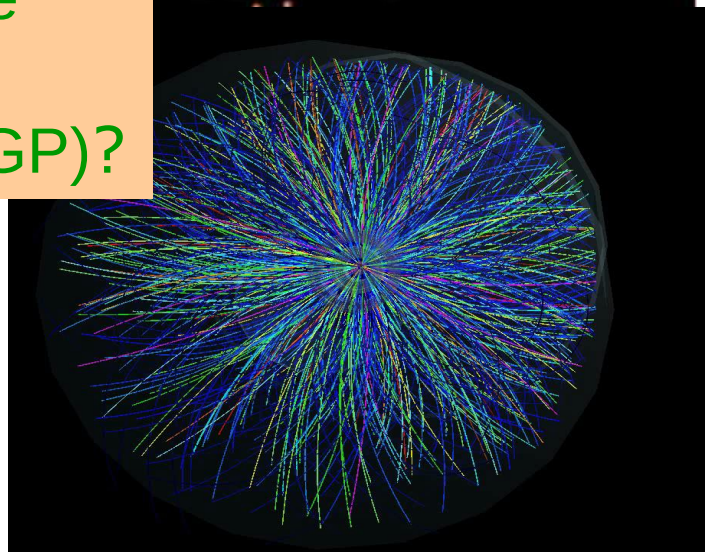
?

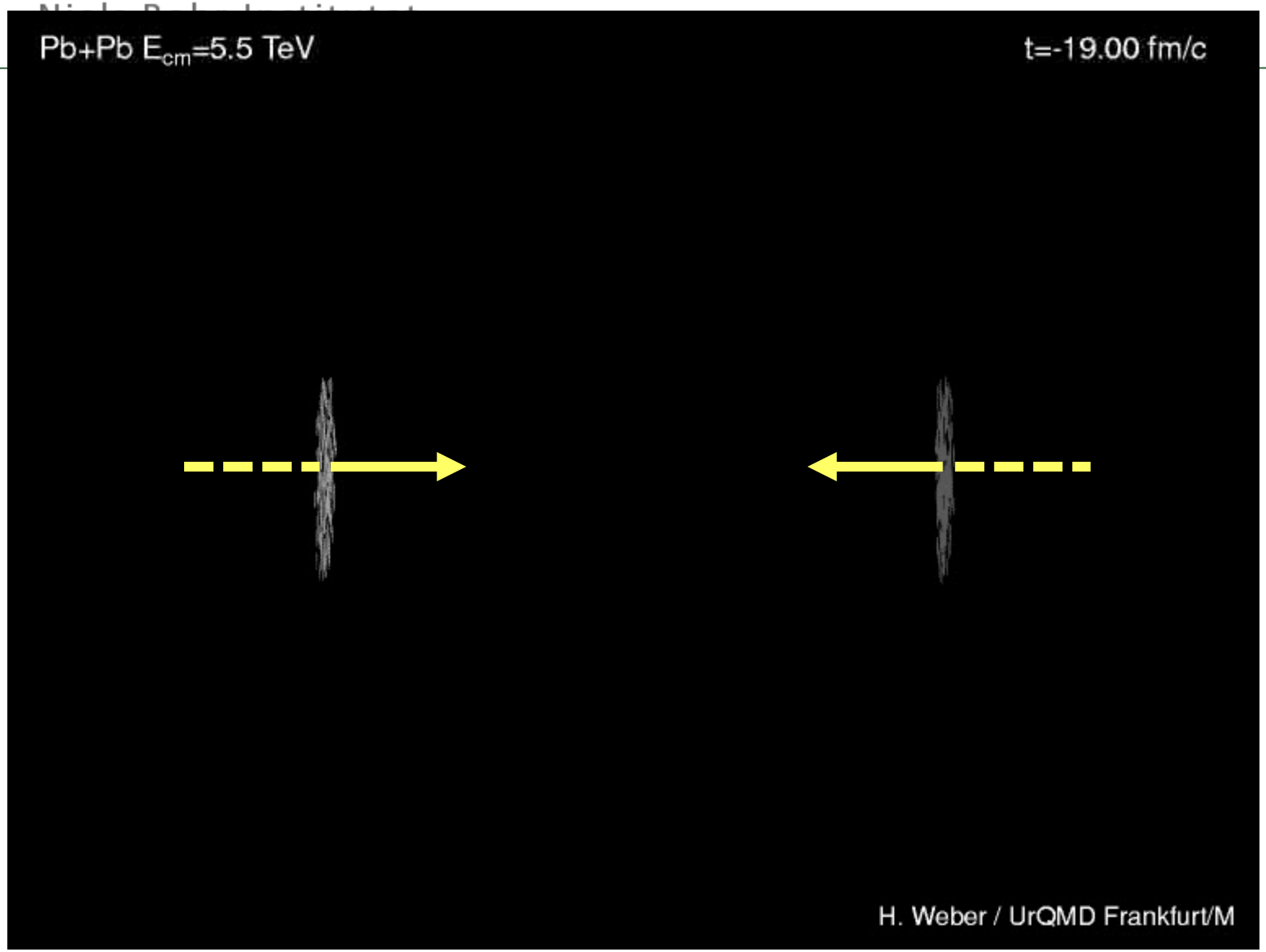
smelter kernepartiklerne
sammen til et
kvark-gluon plasma (QGP)?



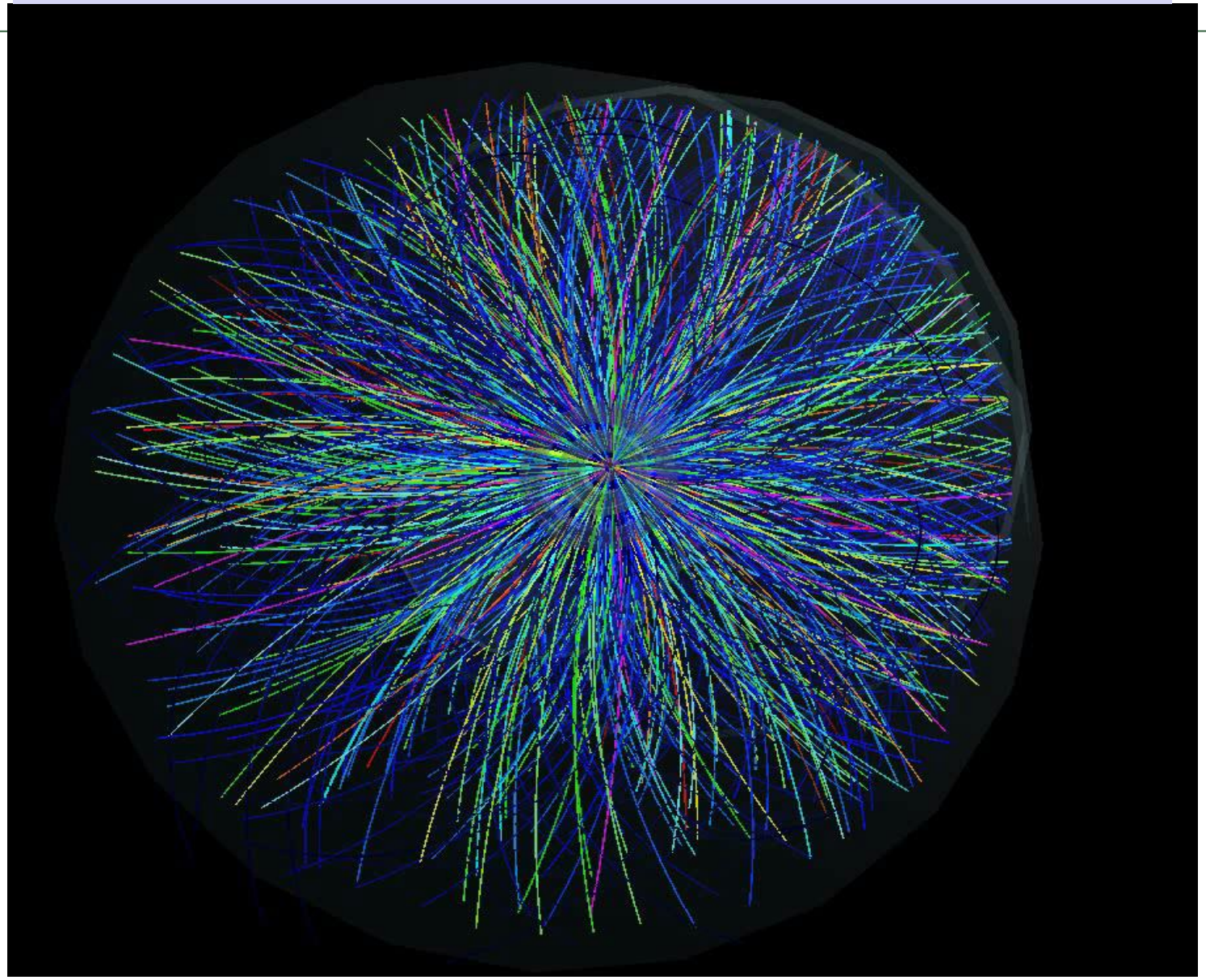
mini Big Bang

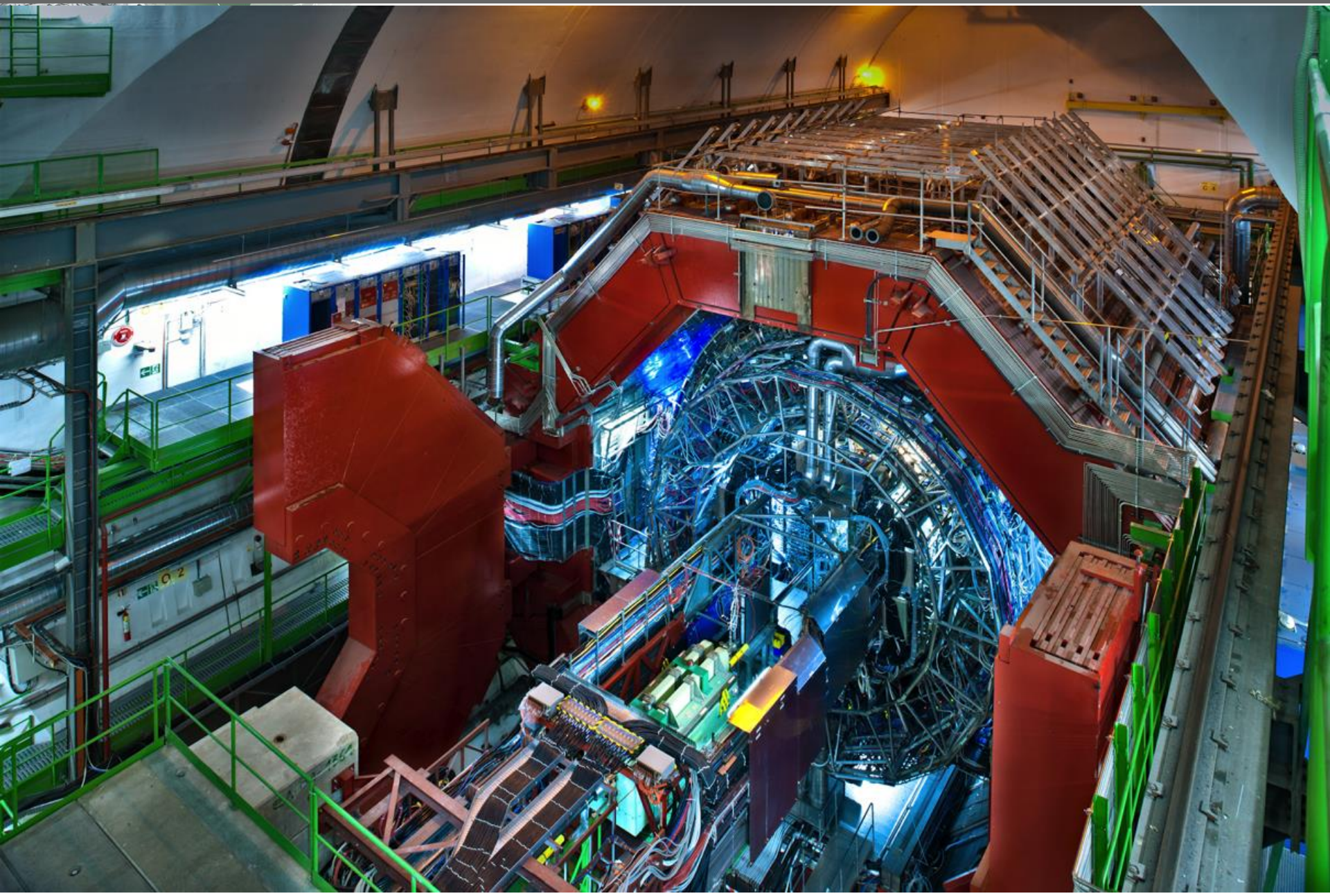





Pb+Pb E_{cm}=5.5 TeV
t=-19.00 fm/c
H. Weber / UrQMD Frankfurt/M

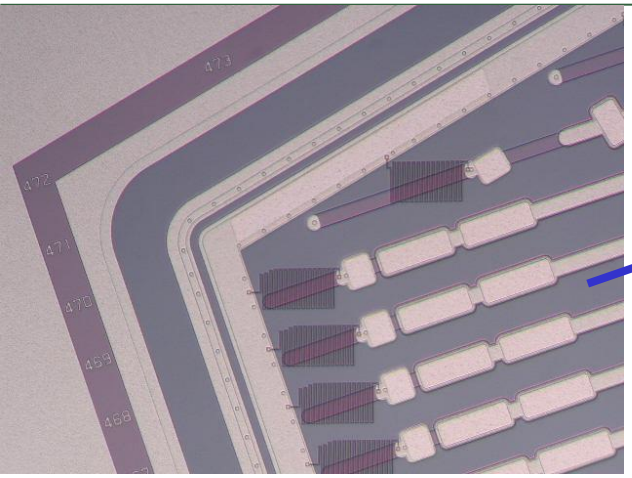
Pb-Pb sammenstød, 574 TeV, set i ALICE

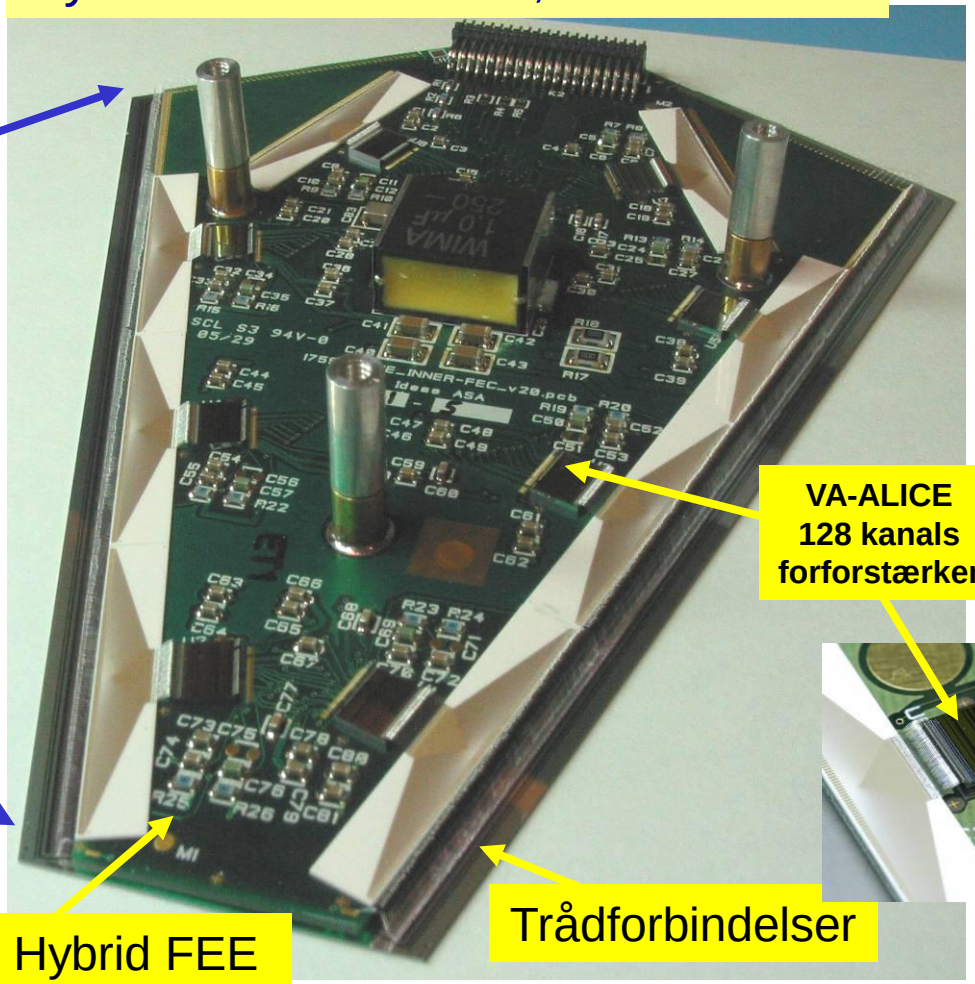


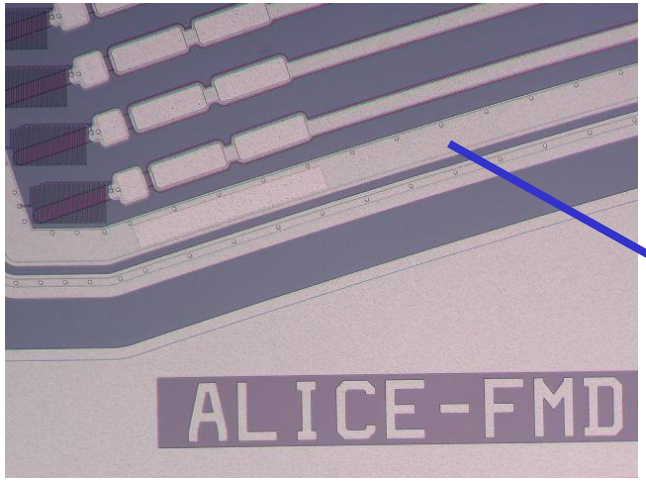


Silicium sensorer og hybrider

Sensorer fra Hamamatsu Photonics
Hybrider fra Ideas AS, Oslo







The principle of the laser system for the TPC

Support rings for
μ-mirror bundles

μ-mirror bundle

TPC volume

Central Electrode

Narrow laser beams:
20-40 μJ/pulse, ø 1 mm

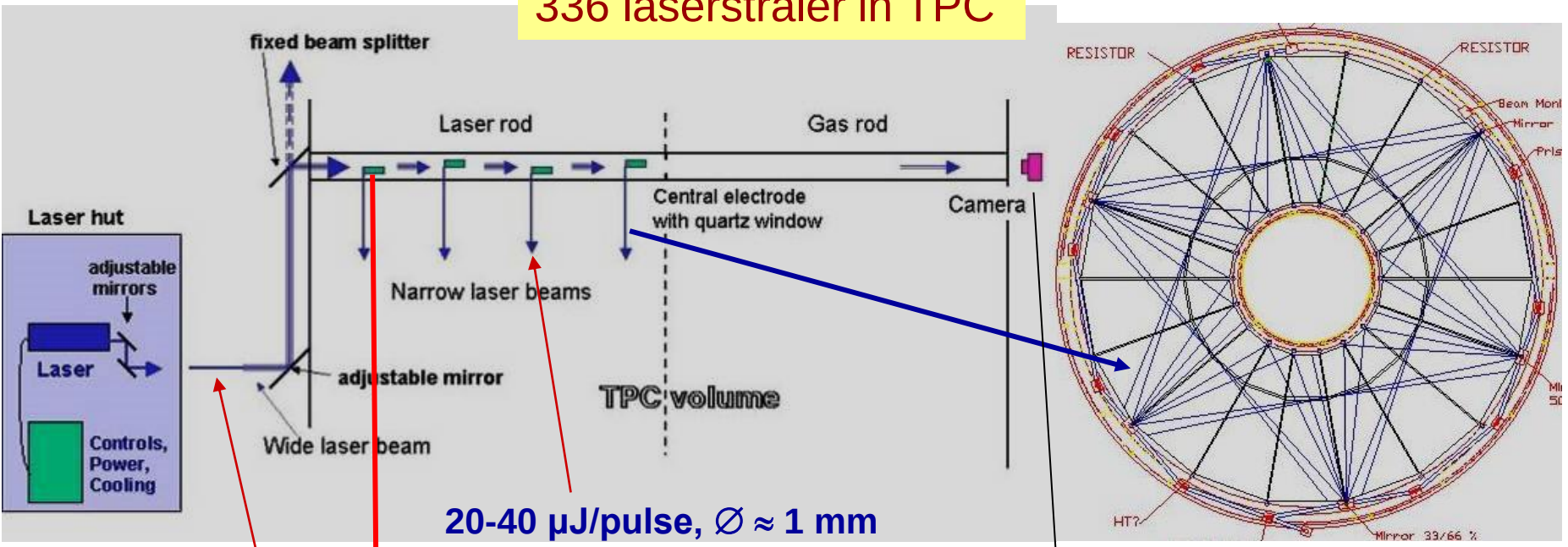
Four shadows of the
μ-mirror bundles

Wide laser beams: 266 nm,
100 mJ/pulse, 5 ns pulse, ø 25 mm

laser beam
splitter
adjustable mirror
prism
camera
rod

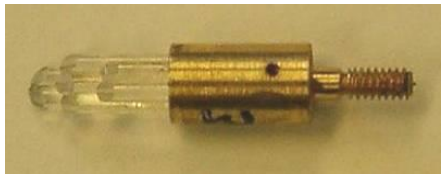
TPC laser kalibration

336 laserstråler in TPC

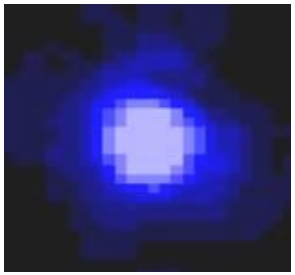


20-40 µJ/pulse, ∅ ≈ 1 mm

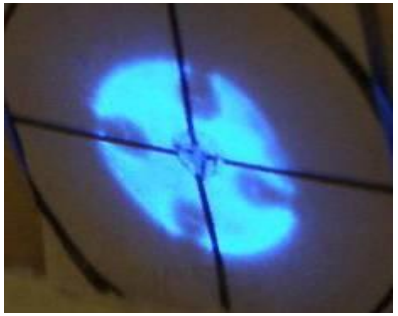
266 nm, 100 mJ/pulse, 5 ns pulse, ∅ ≈ 25 mm



1.5 mm

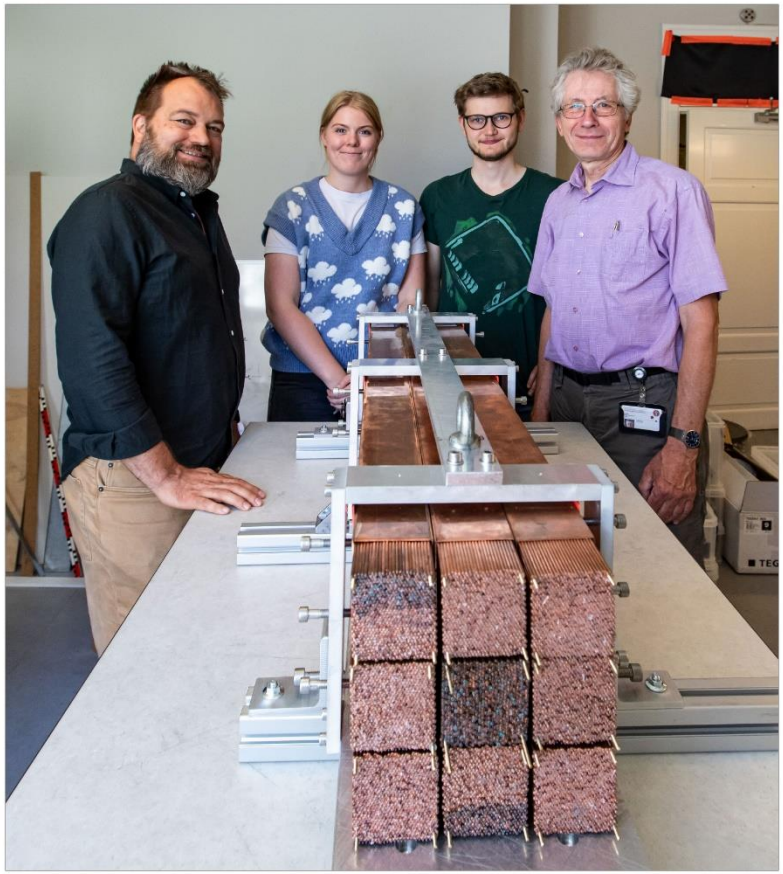


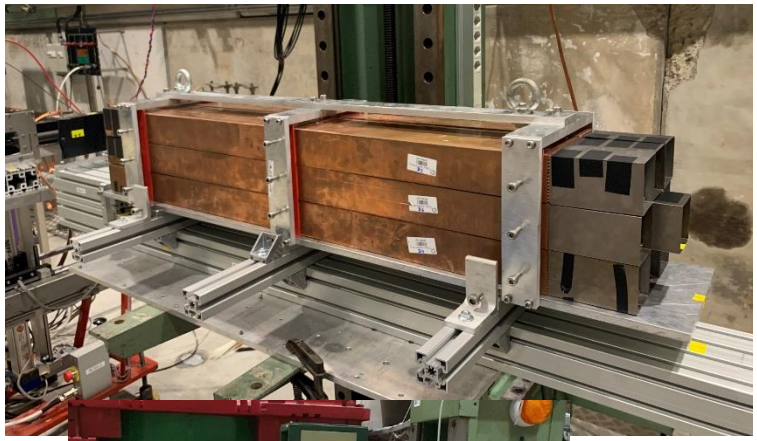
25 mm

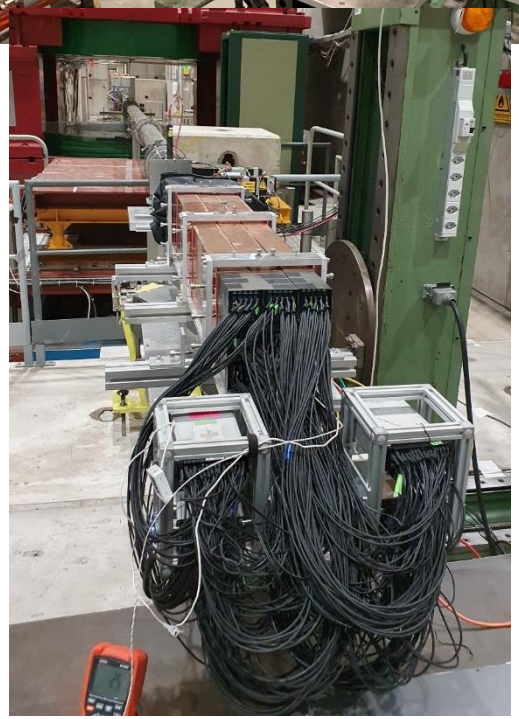


Focal-H: den nye danske detektor

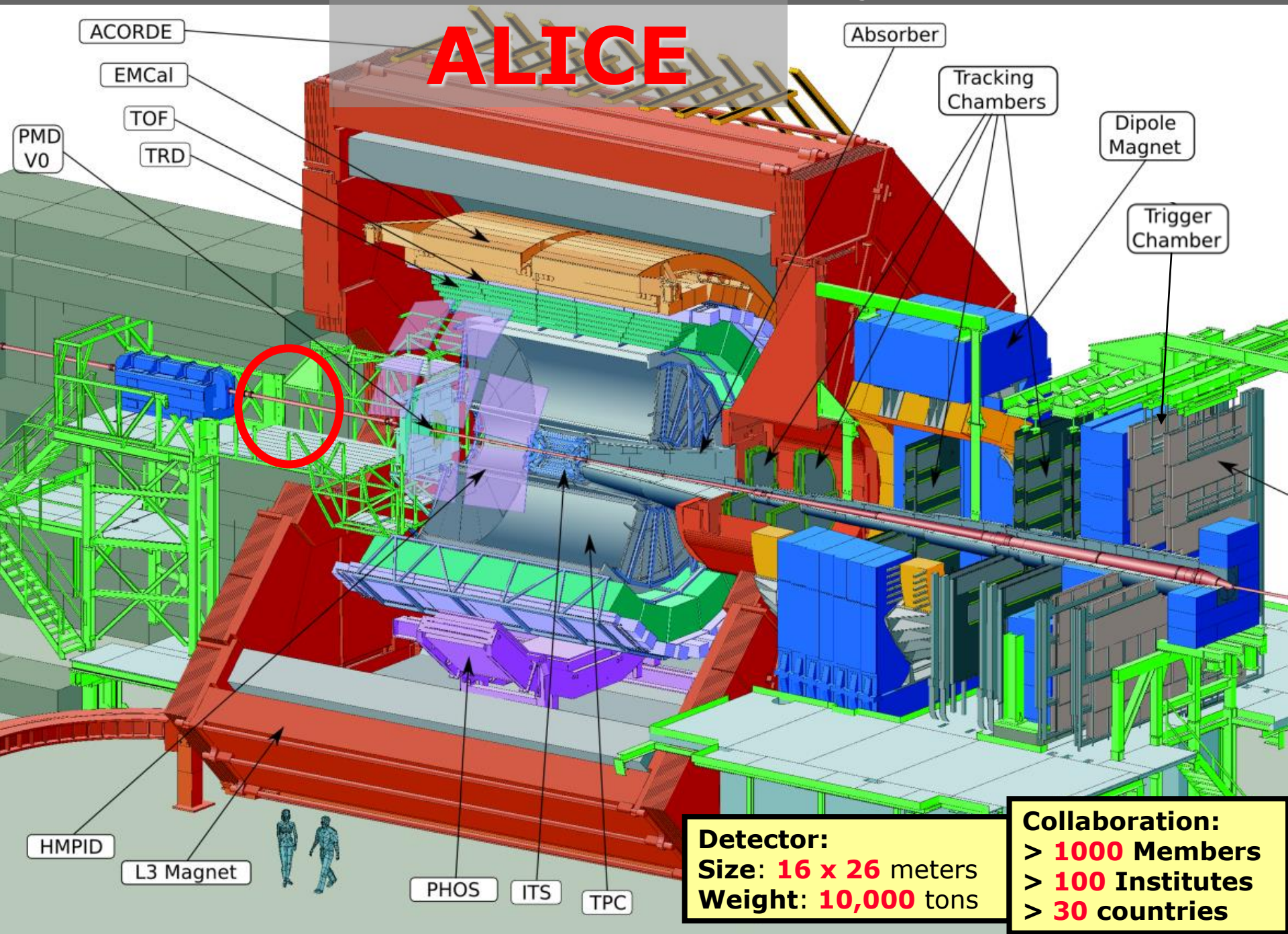
Kobber-scintillator hadronisk kalorimeter







ALICE



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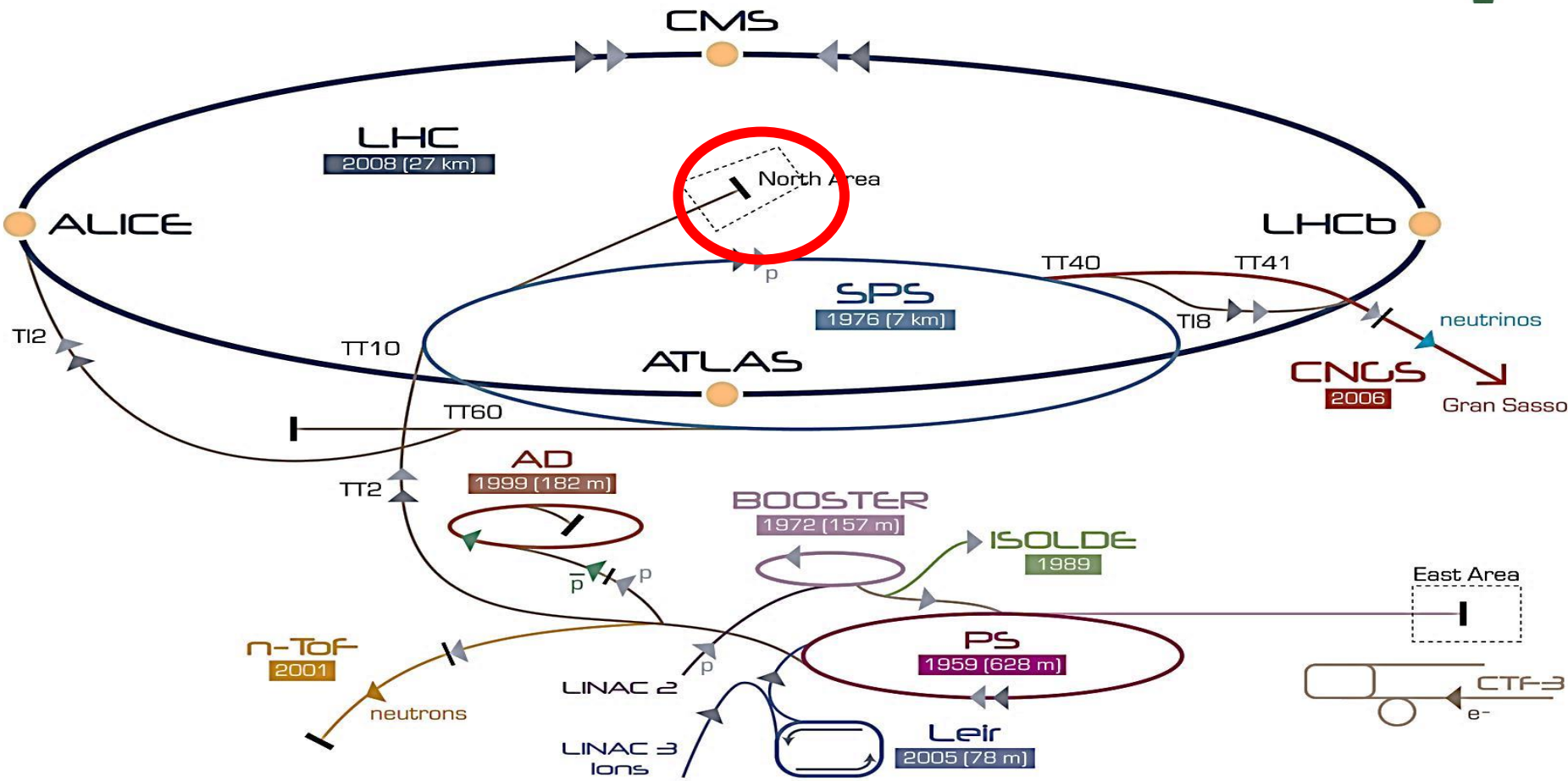
Test beam i North Area

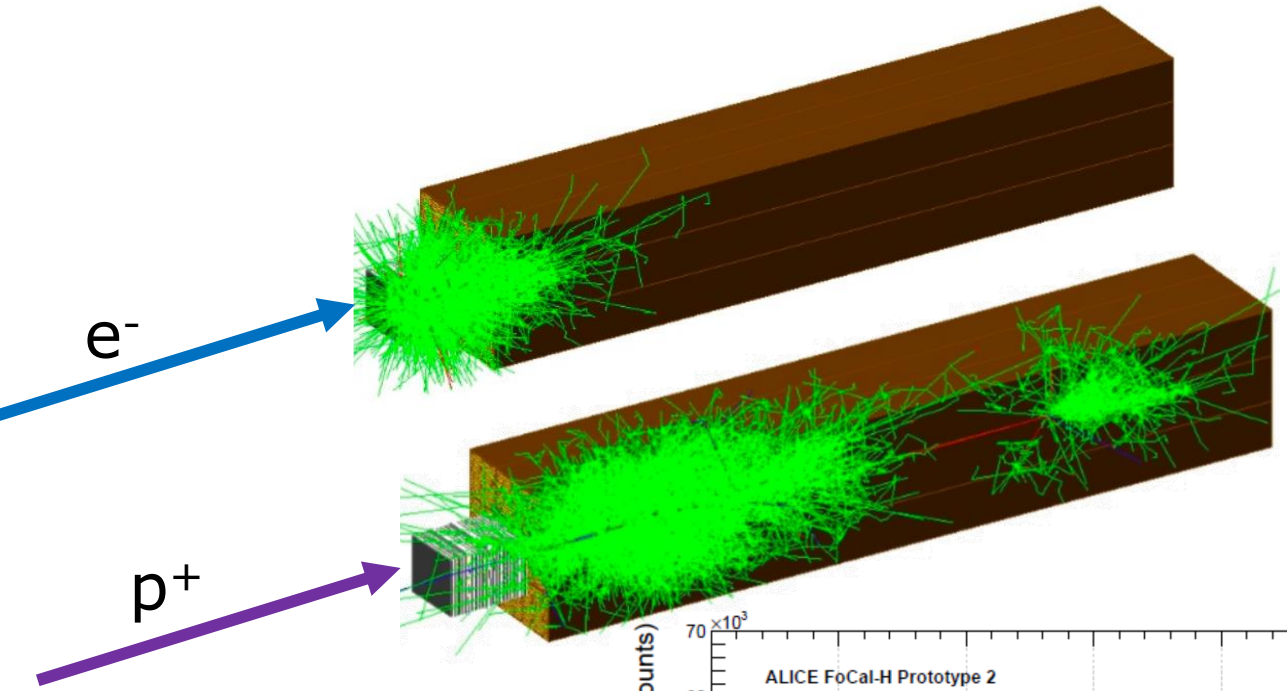


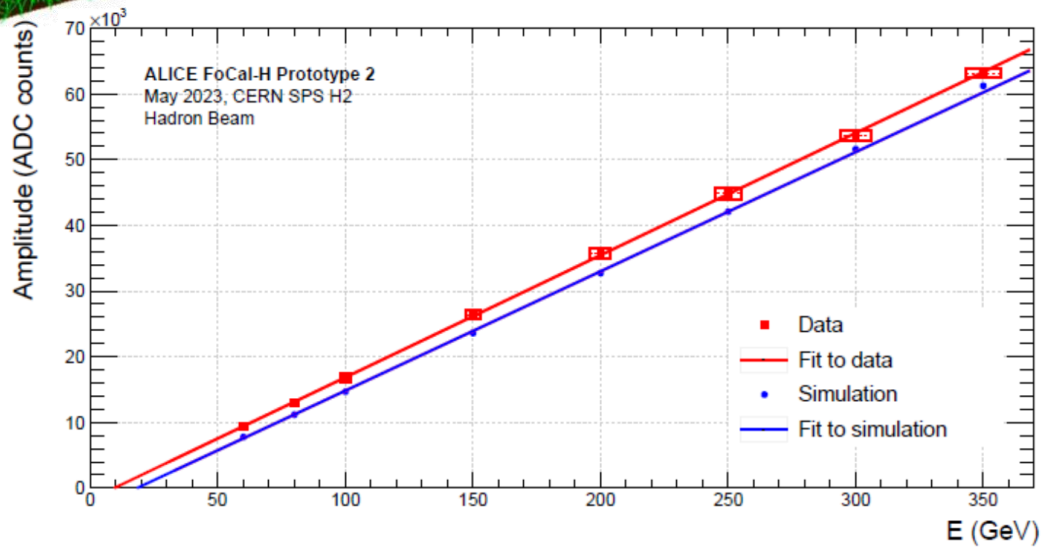
LHC Large Hadron Collider SPS Super Proton Synchrotron PS Proton Synchrotron

AD Antiproton Decelerator CTF-3 Clic Test Facility CNGS Cern Neutrinos to Gran Sasso ISOLDE Isotope Separator OnLine DEvice

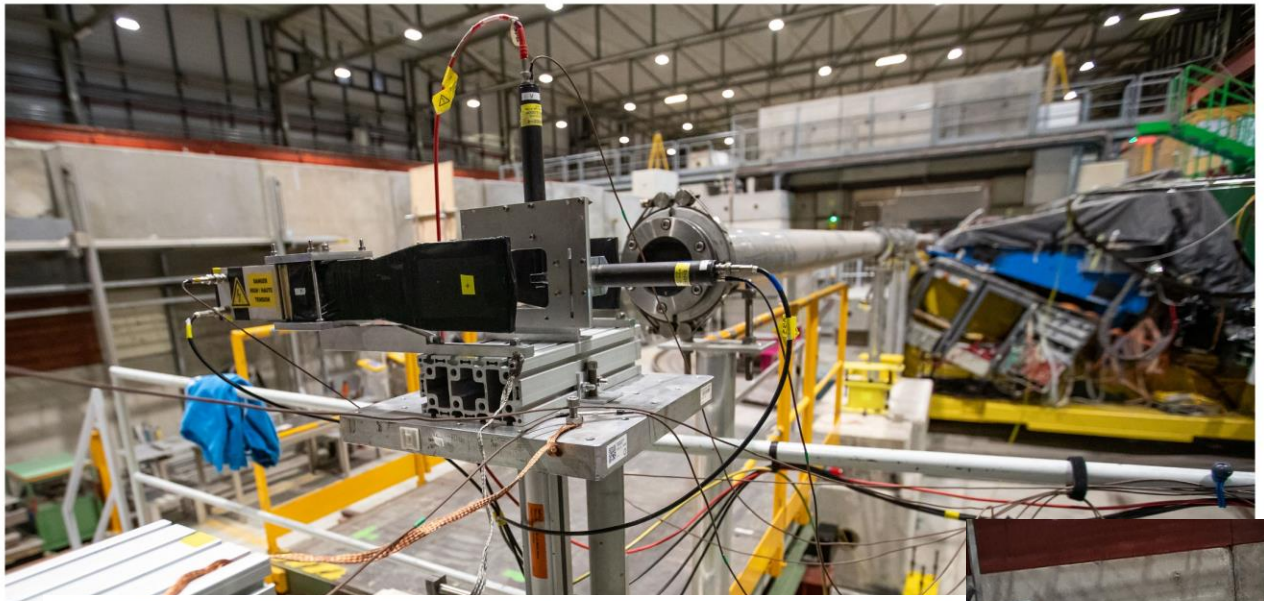
LEIR Low Energy Ion Ring LINAC LINear ACcelerator n-ToF Neutrons Time Of Flight

Focal = E + H kalorimeter



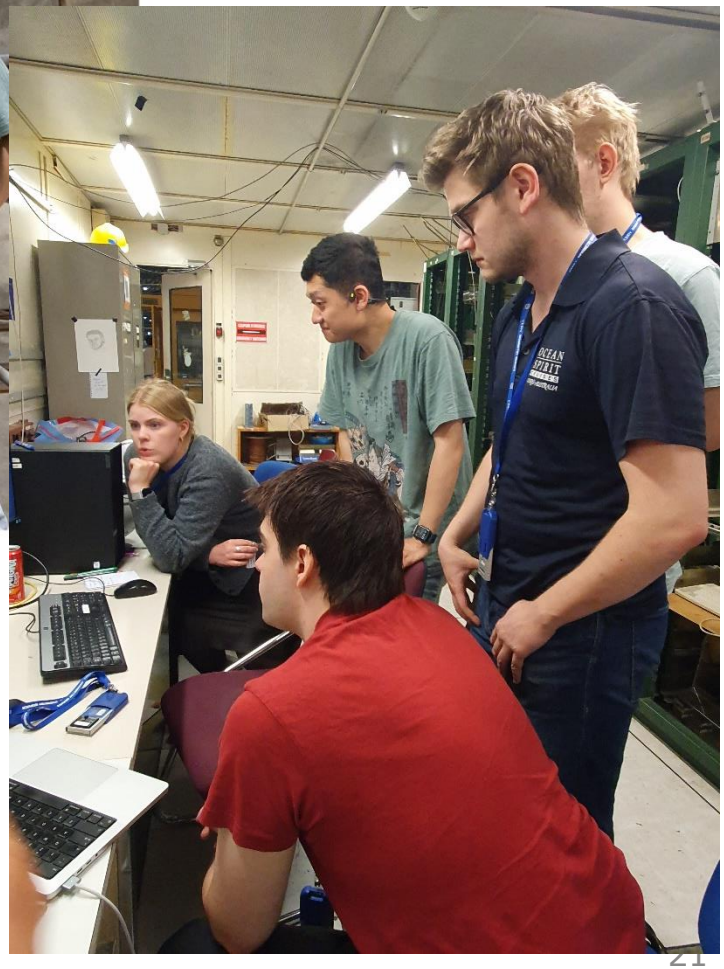


Test beam i North Area



Test beam i North Area

Test beam i North Area



Test beam i North Area

Mange tests inden man er færdig:

1. September 2021
2. Juni 2022
3. September 2022
4. November 2022
5. Maj 2023
6. Oktober 2023
7. Maj 2024
8. September 2024 …….