International Collaboration in Science and Technology in Europe

with LHC experiments and a Helmholtz alliance (EMMI) as main features

Peter Braun-Munzinger, EMMI and Research Division

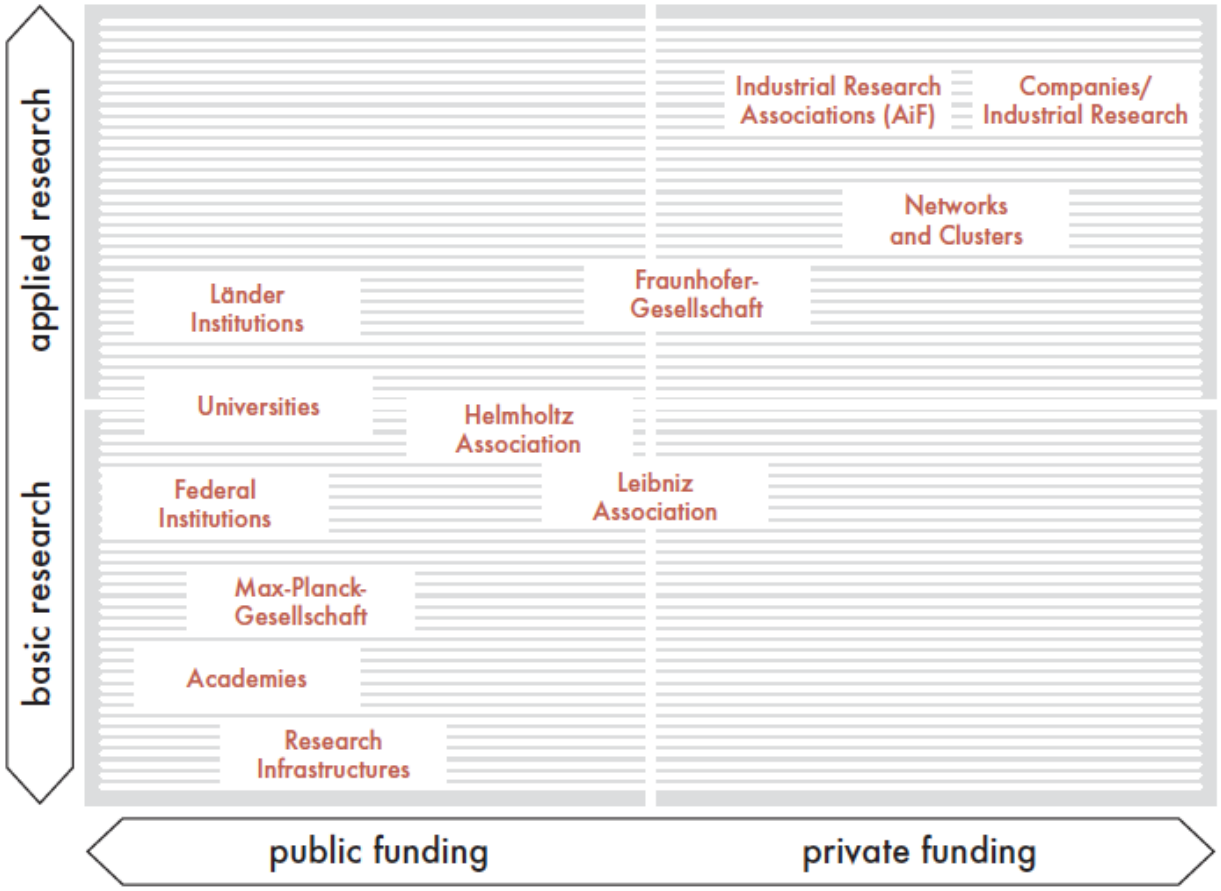
GSI, Darmstadt, Germany

First a few remarks about German/European Science funding

German and European Science Funding System

Overview of Research Performing Organisations in Germany

Research institutions differ in terms of their type of research (basic/applied) and financing (public/private).



Research in Germany

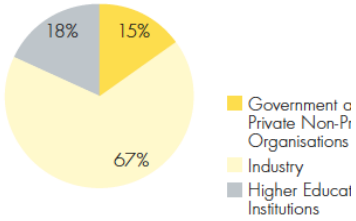
Research Performing Organisations

Science and research in Germany are characterised by an excellent infrastructure, a wide variety of disciplines, well-equipped research facilities and competent staff. Germany offers various forms of research locations: universities, non-university institutes, companies and institutions run by federal or state (Länder) authorities. All in all, there are nearly 1,000 public and publicly funded institutions of science and research and development (R&D) in Germany. Companies also maintain a large number of R&D centres.

In selected fields or regions, these industrial and academic institutions pool their research and development activities in networks and clusters to work more efficiently and to benefit from a higher level of knowledge. Furthermore, cooperation at European as well as international level has become an essential dimension of science and research in Germany.

Research Budget

In 2013 the gross domestic expenditure on research and development (GERD) was roughly 80 billion euros with more than two thirds of research funding spent by industry. Higher education institutions account for 18% of this spending. Federal and state governments and publicly funded non-university research institutions, for example the Helmholtz Centres or the institutes of the Fraunhofer-Gesellschaft, invest 15% of the R&D total.



total R&D budget: 80 Bill. Euro/yr
higher edu.: 14 Bill. Euro/yr
Gov. Inst.: 12 Bill. Euro/yr

Facts and Figures

- Almost 1,000 publicly funded research institutions (2013)
- 605,000 staff in R&D including 361,000 R&D researchers (2013)
- Approx. 500 innovation clusters and networks (2015)
- Gross domestic expenditure on R&D (GERD): 80 billion euros (2013)

More Information

Germany offers various forms of research locations: universities, non-university institutes, companies and institutions run by federal or state (Länder) authorities.
For an overview, visit the Research in Germany website:
www.research-in-germany.org/research-landscape

The research directory "Research Explorer" contains over 23,000 institutes at German universities an non-university research institutions, searchable by geographic locatio subject and other structural criteria
www.research-explorer.de

Two examples as case studies

- The ALICE Experiment at the CERN Large Hadron Collider

- The ExtreMe Matter Institute EMMI; an example of a Helmholtz Alliance

ALICE at the LHC: The scientific idea and focus

Create matter as it existed about a microsecond after the big bang by collisions between relativistic (moving with nearly light velocity) heavy atomic nuclei.

Study the properties of big bang matter with 'little bangs' in the laboratory

ALICE: a collaboration of currently 174 scientific institutes from 42 different countries. Total number of collaborating scientists is > 1800.

Specific focus: how to build a major subdetector of the ALICE experiment: the ALICE TPC

For such a major sub-detector project one needs:

- A clear idea concerning the physics and technical requirements
- A scientifically and technically strong (international) collaboration
- A good estimate of the funds and manpower required
- A plan how to raise the necessary funds

How does such an international collaboration of scientists work?

1. loose and horizontal management structure
2. govern by consensus
3. financial and technical oversight by hostlab (CERN)
4. self-motivated staff
5. share successes but also failures
6. keep focus on science and time lines

Next: an overview of the project

The LHC: the highest energy particle accelerator

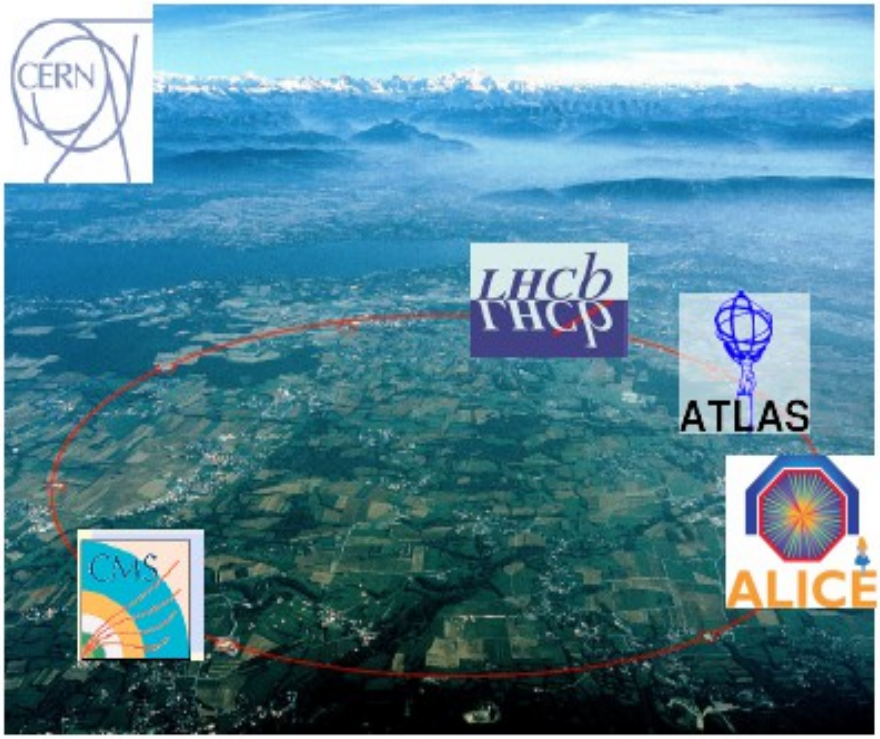
2000 bundles of 10^{11} protons, each about the dimension of a human hair (10 cm long x 25 μm diameter) circulate around the 27 km ring and collide every 25 ns

- if protons and light race around the LHC, light wins by 0.2 mm but energy, not speed is the issue
- each of the colliding proton beams has the stored energy of a Shinkansen or ICE train at 150 km/h (350 MJ) – but the beams only loose 10^{-11} of their energy in each crossing
- in each collision of 2 Pb atomic nuclei a macroscopic amount of energy is released and more than 10000 particles (hadrons) are created

LHC - The greatest technological challenge:

Arial view of the Large Hadron Collider LHC

the start of the LHC experimental program

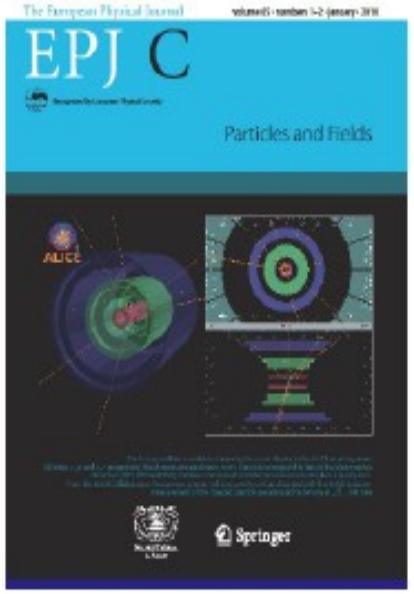


November 23, 2009

First proton-proton collisions at √s=900 GeV

ALICE pseudo-rapidity density

(Nov 28)

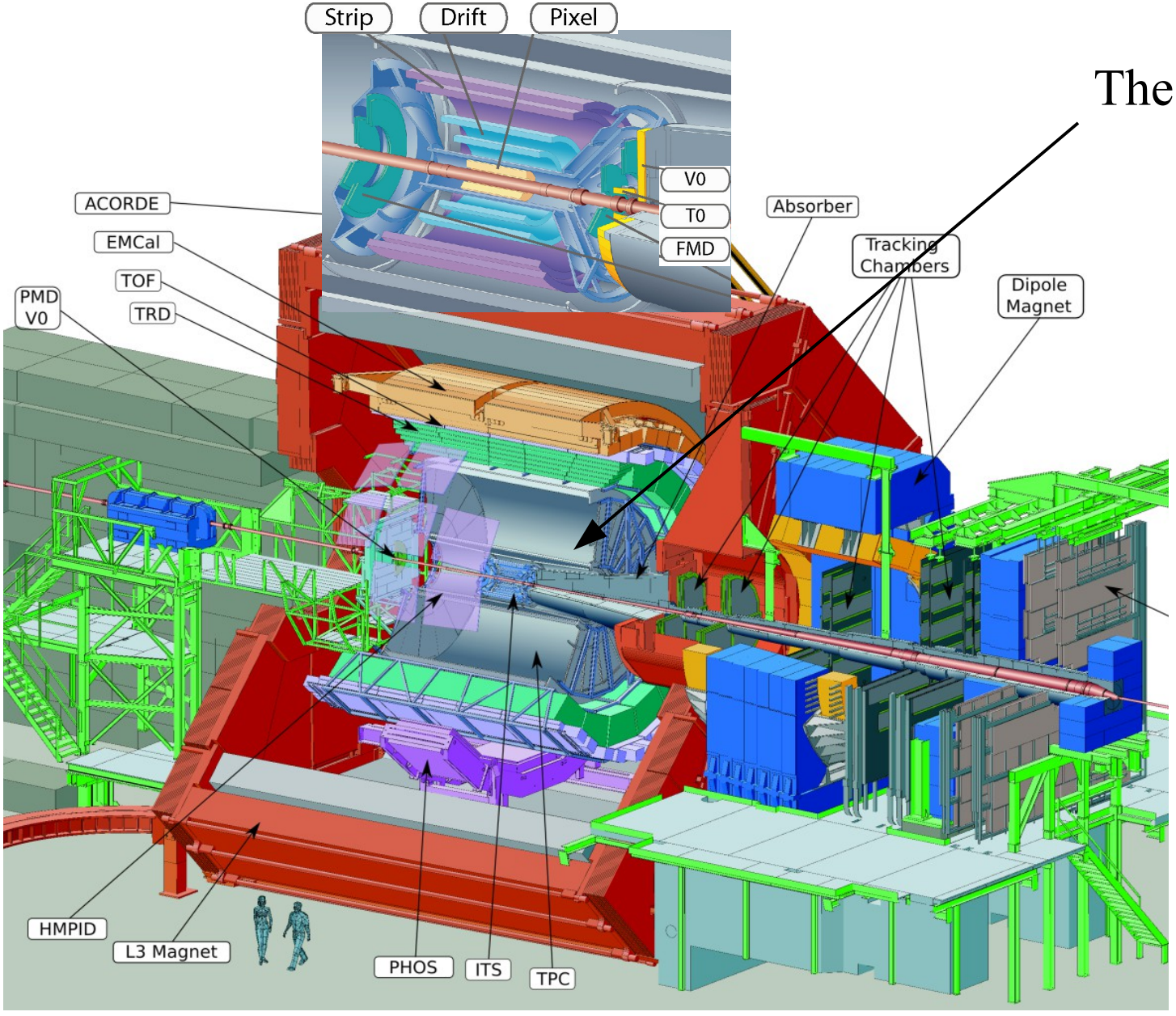


Eur. J. Phys. C65 (2010) 111

Dec 6, 2009 pp at √s=2.36 TeV

Mar 30, 2010 pp at √s=7 TeV

the ALICE experiment: Schematic Setup



The ALICE TPC

Scope of the project

the ALICE Time Projection Chamber TPC:

total investment costs: 15 MEuro

total manpower: >200 man years

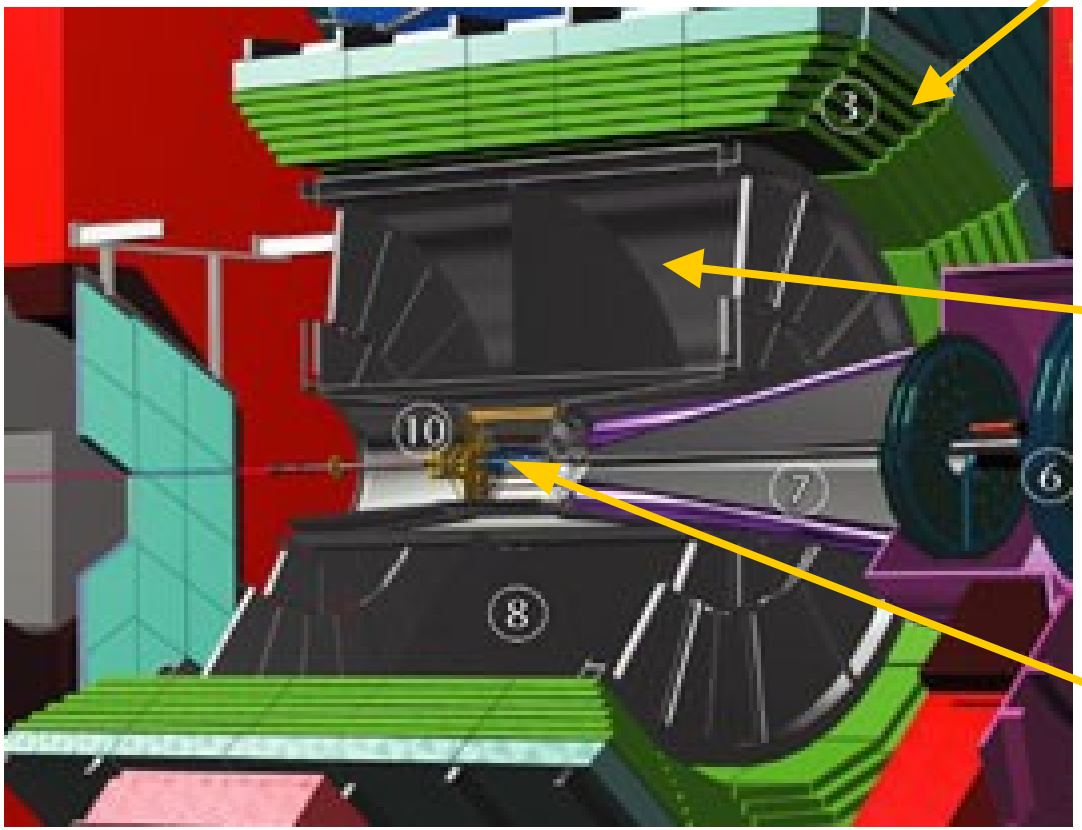
Bergen, Bratislava, CERN, Copenhagen, Darmstadt, Heidelberg, Frankfurt, GSI, Krakow, Lund

funding agencies from 8 countries

cooperation of about 50 scientists, no line management

project took 7 years to build and commission

The TPC in ALICE



TRD
large area Transition Radiation Detector for electron identification

TPC
Time Projection Chamber
large volume, high resolution and high rate tracking device

ITS

A vertex detector built from 6 layers of Si sensors

The ALICE TPC – a high speed imaging device to register more than 5000 tracks of charged particles created in a collision of 2 Pb nuclei at LHC

with 95 m^3 the largest TPC ever

560 million read-out pixels!

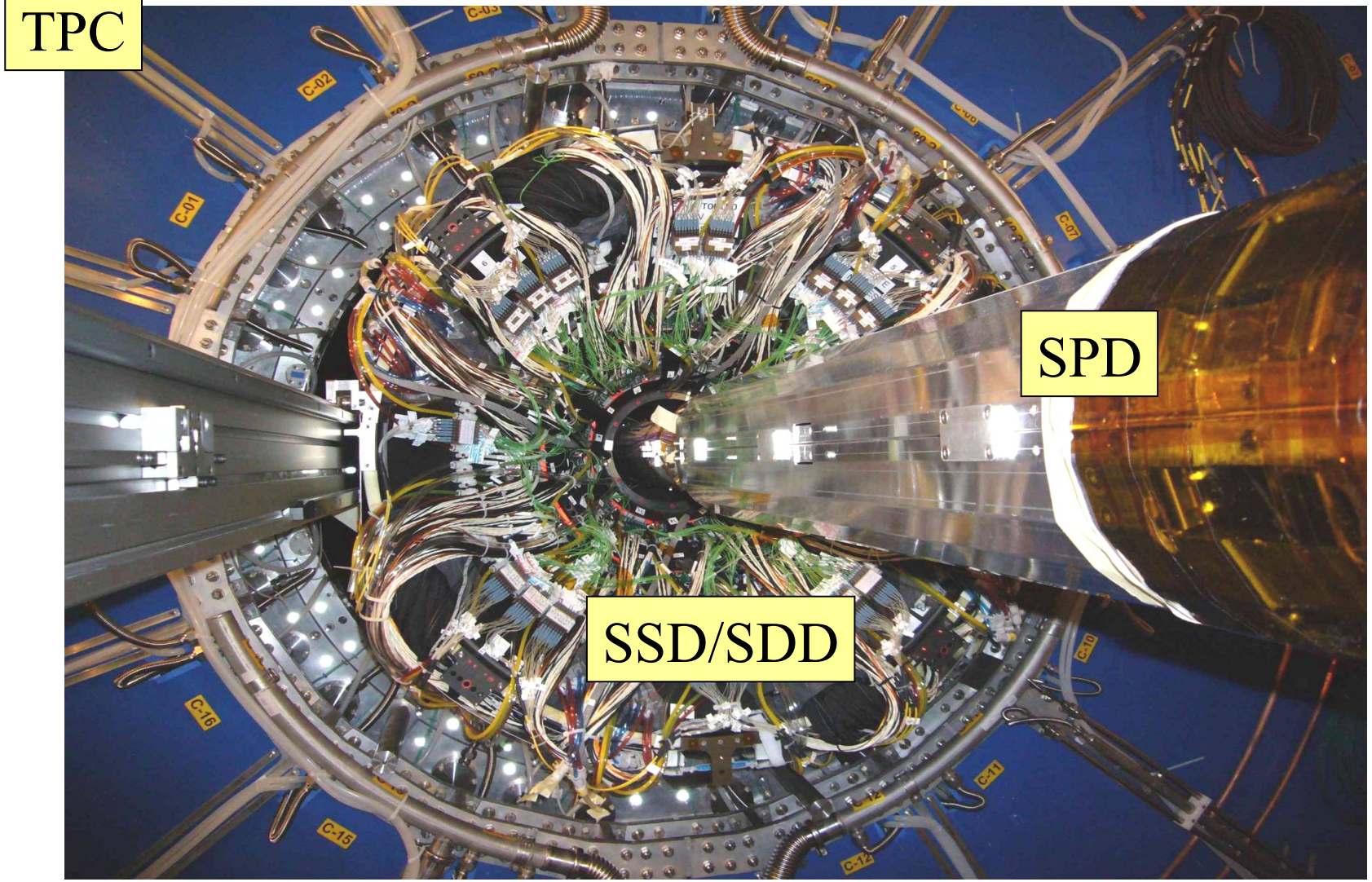
precision better than 500 μm in all 3 dim.

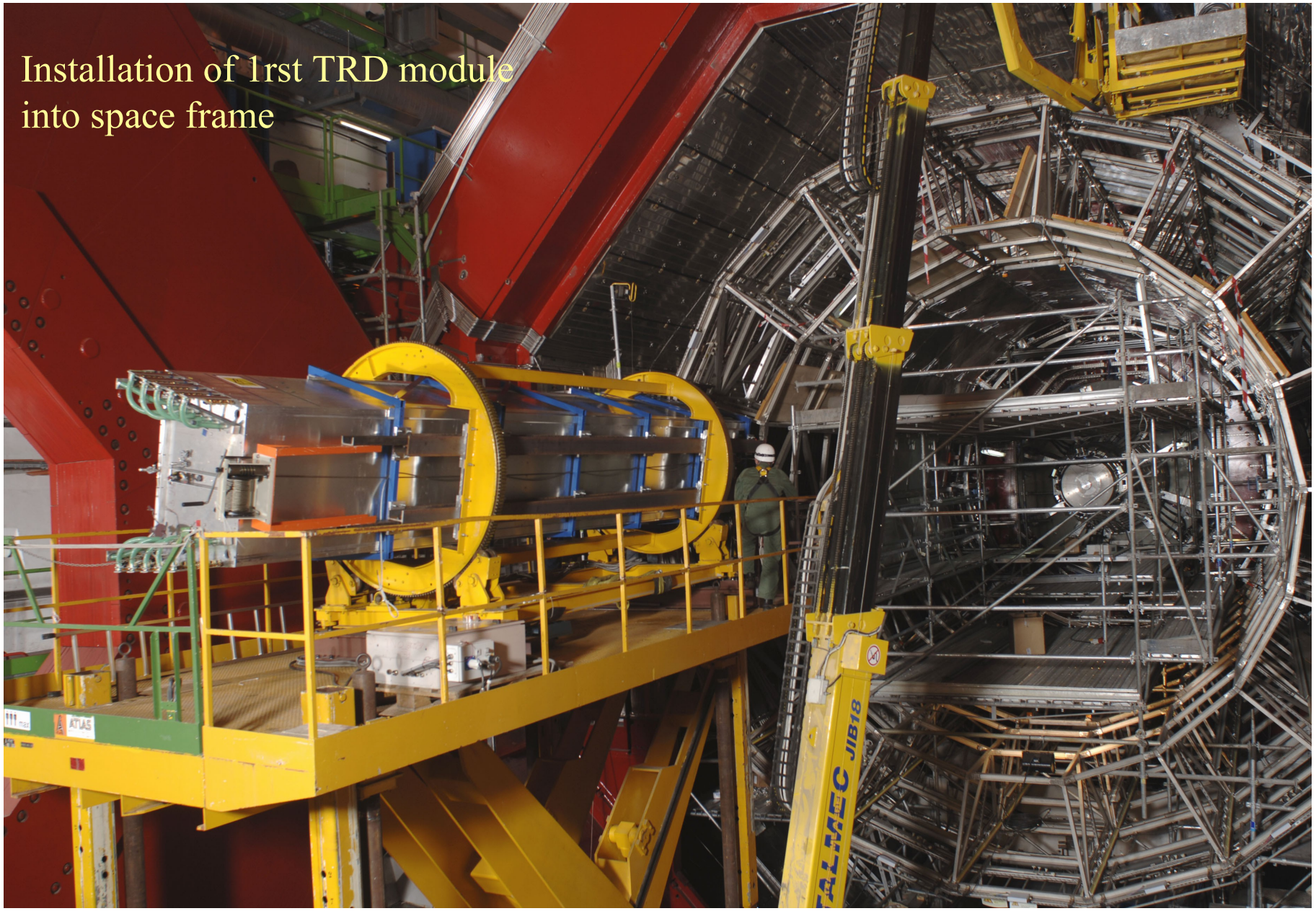
180 space and charge points per track

Working inside before completion of the TPC

complete and calibrated!

ITS russian dolls - sliding the SSD/SDD over the SPD

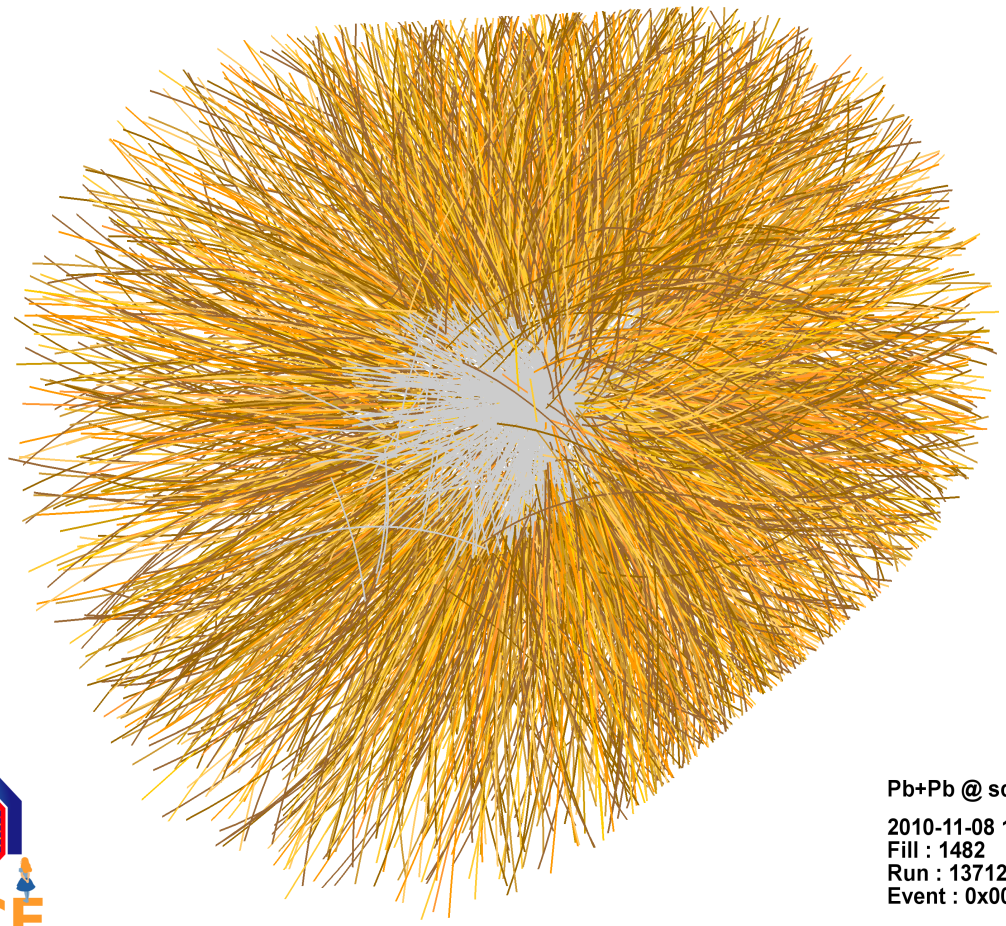



Installation of 1rst TRD module
into space frame
ATLAS
JIB18

first PbPb collisions at LHC at √s = 2.76 A TeV

setup for ion collisions: November 4
first collisions with stable beams:
November 8 until Dec 6

already in Dec 2010
5 publications in PRL and PLB



ALICE

What is needed to organize such a project? (I)

1. the general idea and a dedicated and scientifically outstanding collaboration

2. project structure and coordination

3. milestones and technical follow-up within project

4. monthly review by technical board and management board of experiment into which the project is embedded

What is needed to organize such a project? (II)

1. an organizational structure from the host laboratory (CERN)
    a) for technical oversight on a monthly basis
    b) for budgetary oversight on a bi-yearly basis

2. after approval of scientific part at CERN parallel application for funds by all partners

CERN scientific committees

Scientific Policy Advice to CERN Council

SPC - Scientific Policy Committee

Approval of Experiments at CERN

RB - Research Board
- General Conditions applicable to all Experiments at CERN (updated Feb. 2008)

Experimental Committees

INTC - ISOLDE-Neutron Time of flight experiments Committee (formerly ISC)
LHCC - The Large Hadron Collider experiments Committee
SPSC - The SPS and PS experiments Committee

CERN Resources Committees

Resources Review

LHC RRB - LHC Resources Review Boards

Convened by CERN Director of Research
Members: for each major project:
1 representative plus 1 physicist of each funding agency

Lesson from project TPC

a complex project requiring cooperation of 8 different funding agencies and 10 institutions was realized in time and on budget

½ yearly budget review by funding agencies and CERN

loose and horizontal management structure

technical follow-up by CERN

largely self-motivated staff – share successes **AND** problems/failures

groups deliver in-kind and cash contributions

minimal number of written reports – keep groups focused on delivering the final product

2nd case – the ExtreMe Matter Institute EMMI

An alliance in the framework of the Helmholtz Association (HGF)

ExtreMe Matter Institute EMMI

www.gsi.de/emmi

GSI

EMMI

- founded in 2008 in framework of Helmholtz Alliance (2008 - 2015)
  Cosmic Matter in the Laboratory

HELMHOLTZ ASSOCIATION

Alliance on Cosmic Matter in the Laboratory

- now continued as part of GSI:
  taking the momentum of the alliance into the future

... and its Partners

EMMI

GSI

Westfälische Wilhelms-Universität Münster

Technische Universität Darmstadt

JÜLICH Forschungszentrum

Goethe Universität Frankfurt am Main

Berkeley Lab

RIKEN Nishina Center

JINA

東京大学 The University of Tokyo

UPMC Sorbonne Universités

FIAS Frankfurt Institute for Advanced Studies

Universität Heidelberg Zukunft seit 1386

Max-Planck-Institut für Kernphysik

HGSFP

HGS-HIRe for FAIR Helmholtz Graduate School for Hadron and Ion Research

H-QM Helmholtz Research School Quark Matter Studies

Organisation

13 **Partner Institutions**

Management:

Scientific Director: Peter Braun-Munzinger

Scientific Coordinator: Carlo Ewerz

+ administrative support

32 further experts as **Associated Partners**

Steering Committee (representatives of Partners) as main steering body

Scientific Advisory Committee (8 external experts)

Main Research Areas of EMMI

Matter under extreme conditions of temperature, density and pressure, in particular

- quark-gluon plasma and phase diagram of QCD & new hadronic states
- neutron matter
- plasma physics
- atomic physics and ultracold gases

… and related topics

Aim:
bringing together the best minds from these communities

Emergence of common concepts

Common structures and underlying theoretical concepts for these strongly coupled systems, for example

- from BEC to BCS
- from QGP to ultracold Fermi gases
- from conformal field theory to QCD via black holes (AdS/CFT)
- from neutron star matter to strongly coupled electromagnetic plasmas
- hydrodynamics, turbulence, ...
- ...

Goals

central goal of EMMI:

act as think tank & provide intellectual environment
for extreme matter research (at GSI and beyond)

aiming at:

- interdisciplinary scientific events of highest quality
- strong promotion of early-career researchers
- network among two Helmholtz centres and
  eleven top national and international laboratories and
  universities

EMMI Scientists

- more than 100 senior researchers participating in EMMI, more than 400 scientists in total

- 14 new positions (professorships / tenured) created by partners:
  - 10 at TUD, F, MPI-K, MS, HD, LBNL
  - 4 EMMI Fellow positions at GSI

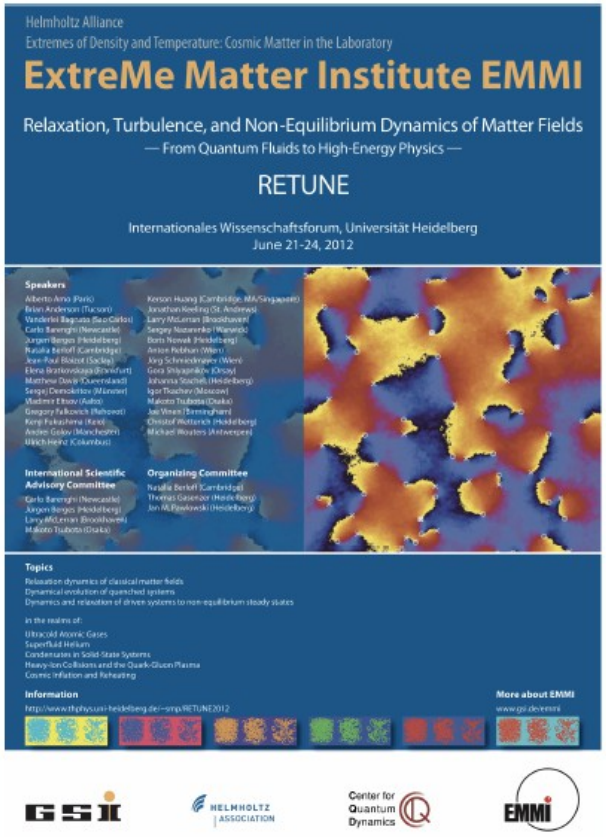
- EMMI supported PhD students associated with surrounding graduate schools (H-QM, HGS-HIRe, HGSFP)

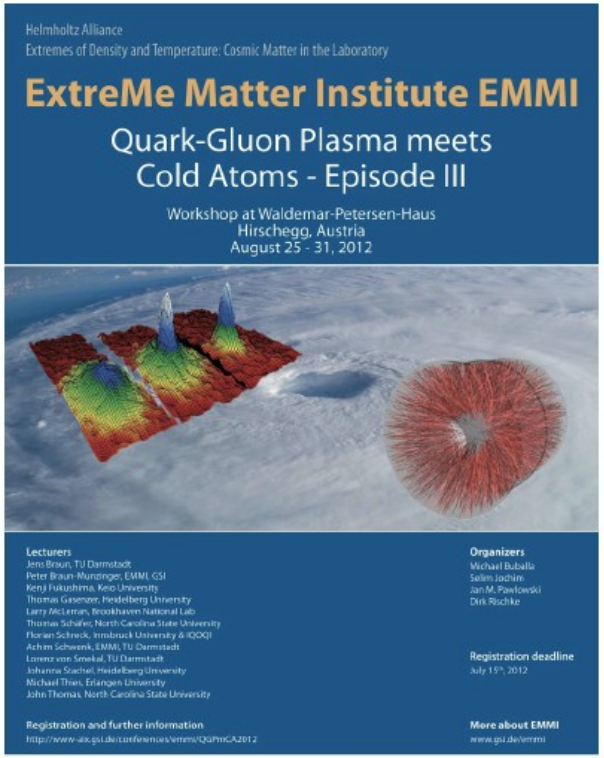
EMMI Programs

- EMMI Workshops
- EMMI Programs
- EMMI Rapid Reaction Task Force meetings (RRTFs)
- joint workshops with ECT* Trento

- Visiting Professor program
- Visiting Researcher program

Interdisciplinary Events: examples





EMMI RRTFs

- concentrates on focussed problem in intense discussion
- 15 - 25 expert participants
- aim: summary of results, optimally with publication on arXiv and/or in journal

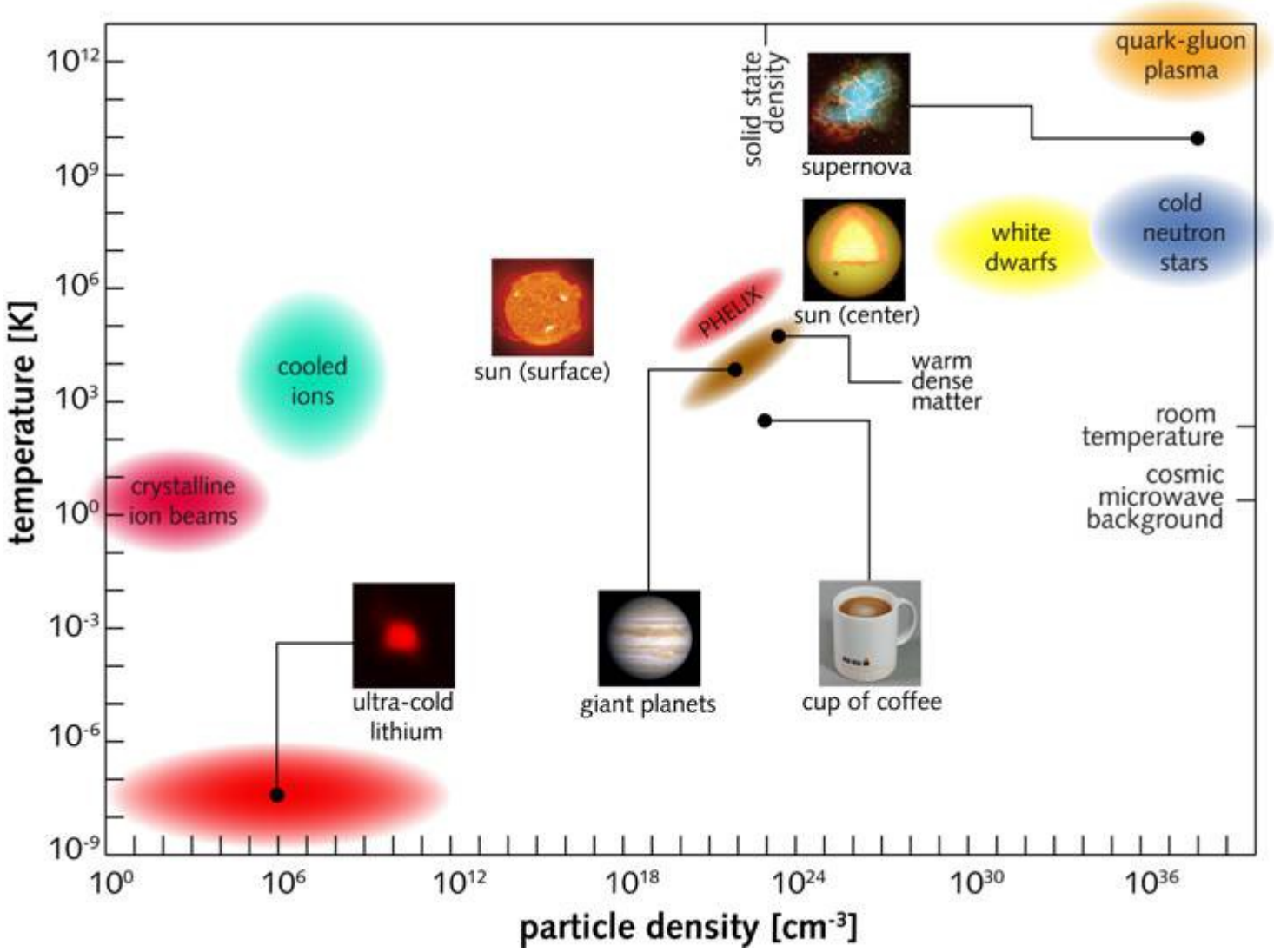
defining the research environment -- extreme matter

extreme matter

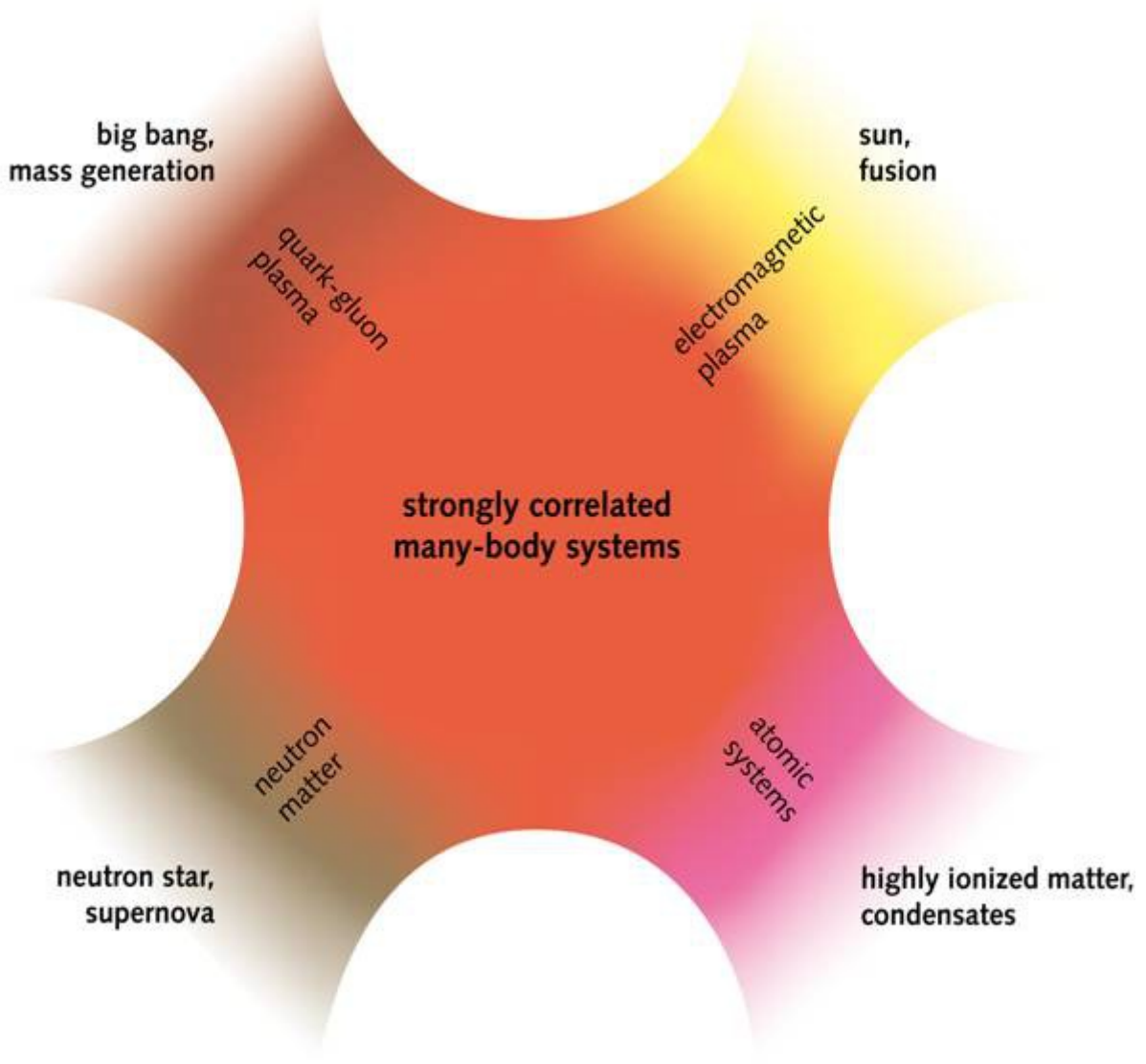
matter under extreme conditions of
temperature, pressure, density

involving many different fields of physics

Physics Similarities and Synergies over a huge Temperature – Density Regime



Scientific Topics and Links



EMMI Research

In EMMI are organized more than 400 scientists from the 13 partner institutions

About 15 EMMI Visiting Professors per year in the EMMI partner institutions

About 300 publications/year and 100 articles in conference proceedings per year

About 15 workshops of various formats per year

Summary EMMI

keep bureaucracy minimal

provide simple structures with efficient financial management

for interdisciplinary projects mix ideas not necessarily technical issues

EMMI as model for effective cooperation across borders

Other collaborations in physics

4 collaborations world-wide using special high performance computers to solve quantum field theories on a discrete lattice of space and time

organized very similarly as experimental projects

mixture of theoretical research and developing special tools for networking and computing

Overall summary

In physics there are many successful international collaborations
Collaborations may involve from 20 – 2500 members
All are organized along similar patterns.

1. a major scientific or scientific-technical goal

2. an organizational structure building on consensus
   generally no line management

3. independent scientific and technical oversight on a regular basis

4. financial oversight via resources review boards

… but

Don't forget scientific and technical excellence !