The ALICE Transition Radiation Detector

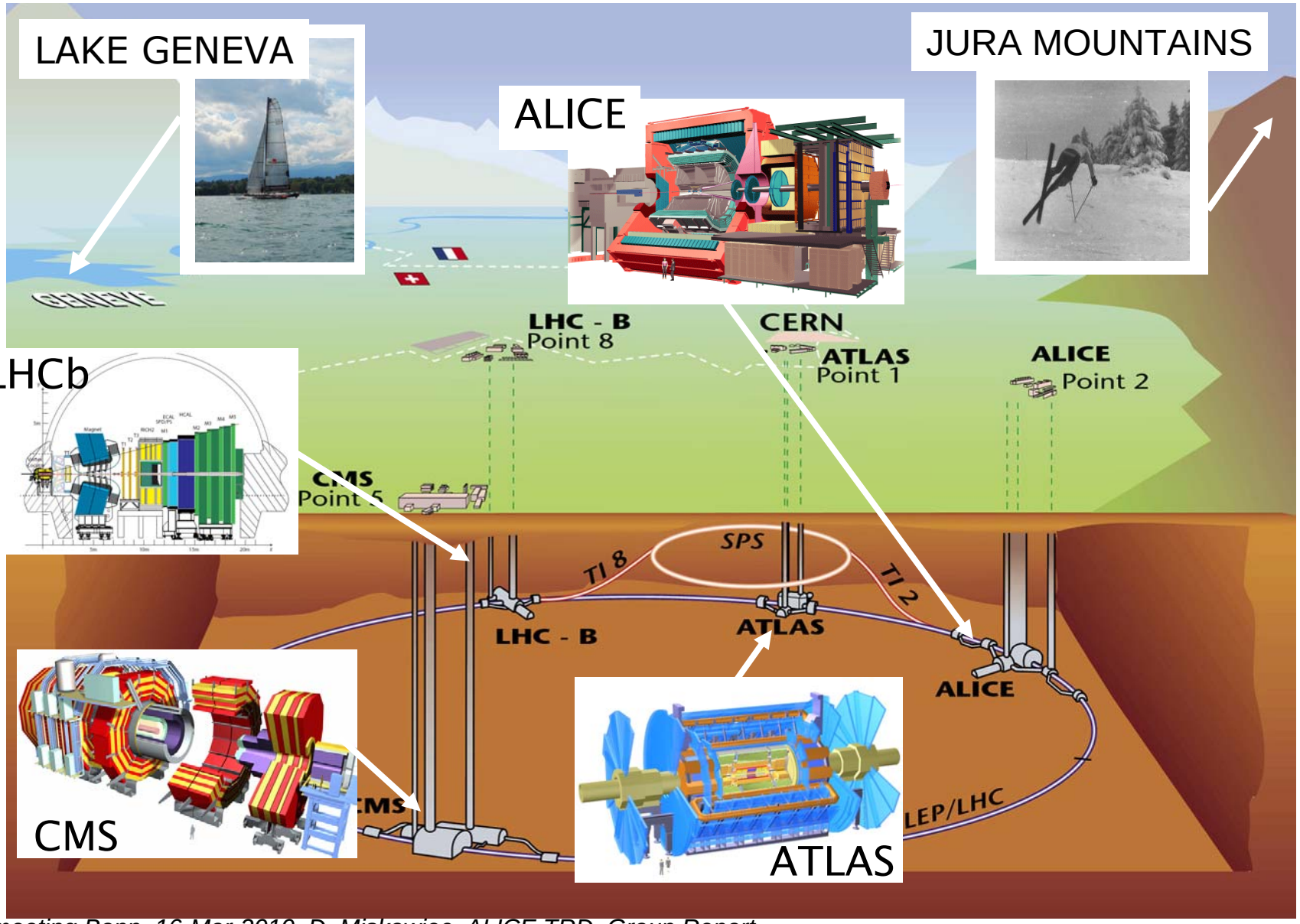
Dariusz Miśkowiec
GSI and EMMI Darmstadt

DPG Frühjahrstagung, Bonn, 16.03.2010, HK 23.1

Outline

- *intro and motivation*
- *construction and installation*
- *commissioning with cosmics*
- *first pp collisions*
- *summary and outlook*

LHC experiments



physics questions at LHC

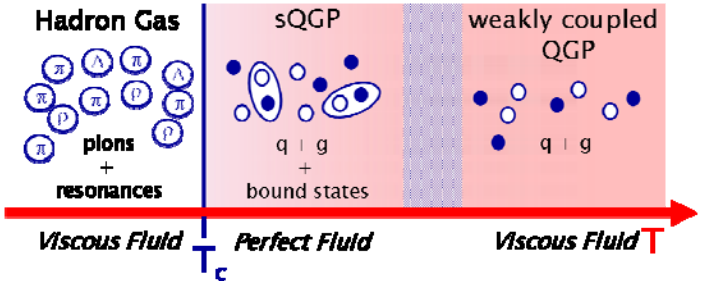
ATLAS, CMS, LHCb:
electroweak symmetry breaking
origin of mass of quarks and gauge bosons
supersymmetric particles
CP violation

ALICE:
chiral symmetry breaking
origin of mass of hadrons
deconfinement
hadronization

ALL:
understanding high energy nuclear interactions
(input needed for cosmic ray studies)

ALICE programme

mission:
create quark-gluon matter
study its properties quantitatively
be prepared for unexpected = be versatile



methods:
spectra and correlations of various particles

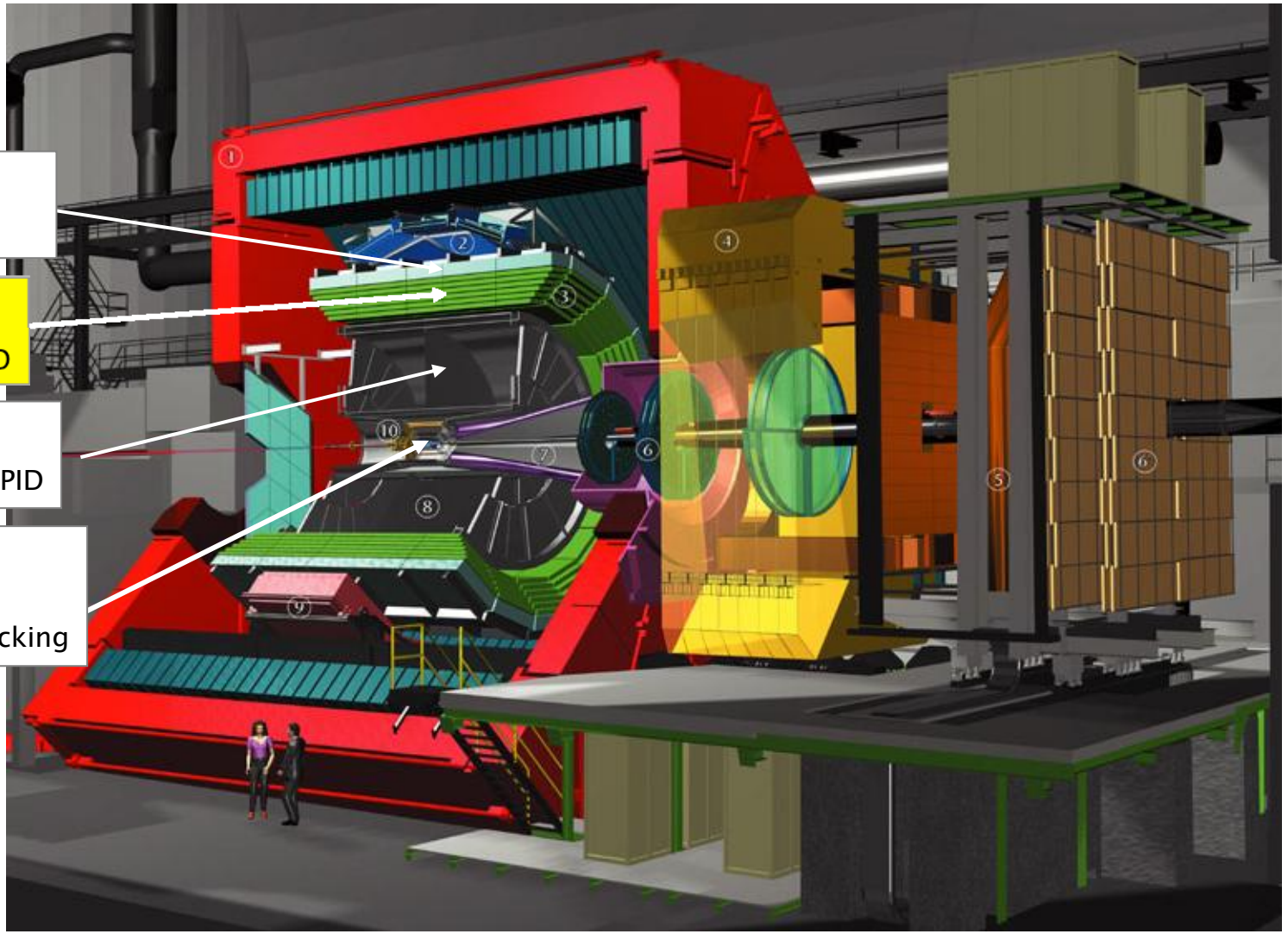
e.g. heavy quarks (open beauty, upsilon-states)
jets in heavy ion environment
weakly interacting probes (Z^0, $W^{\pm}$)

special at LHC:
higher energy density
larger system
more heavy quarks and jets
weak probes W/Z available
access to lower x

	SPS	RHIC	LHC
$\sqrt{s_{NN}}$ (GeV)	17	200	5500
dN_{ch}/dy	~450	~850	1500-4000
ε(GeV/fm^3)	3	5	15-60
τ_{QGP} (fm/c)	≤ 2	2-4	≥ 10

ALICE at LHC

height: 16 m ***length 26 m*** ***weight: 10,000 tons*** ***price: 10 € / kg***

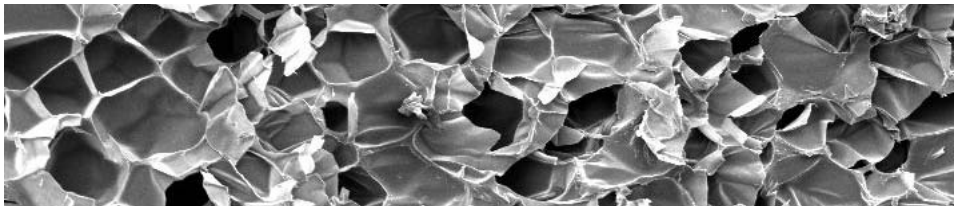


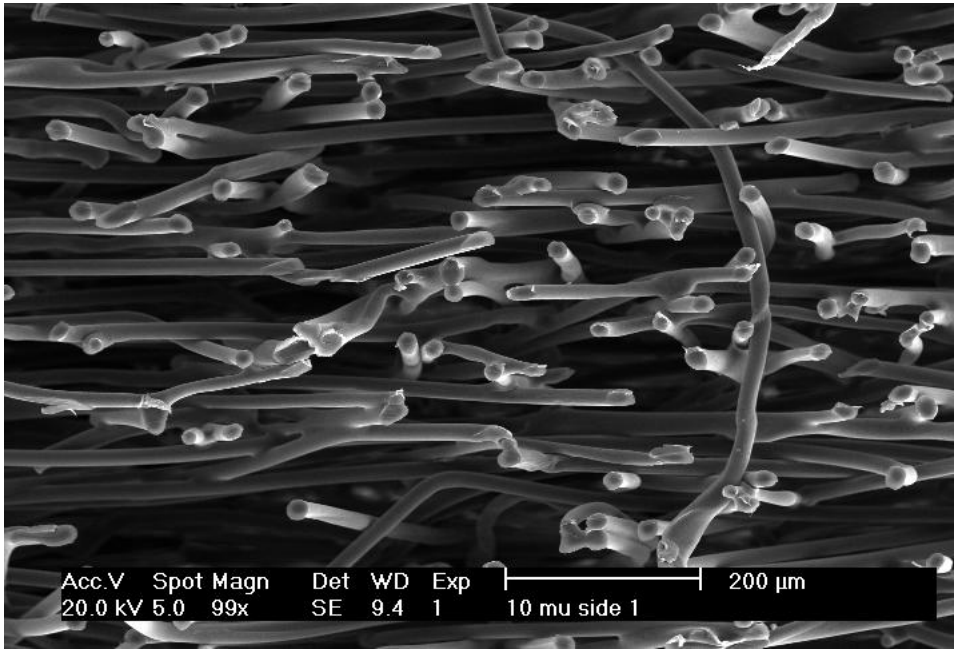
ALICE TRD Collaboration

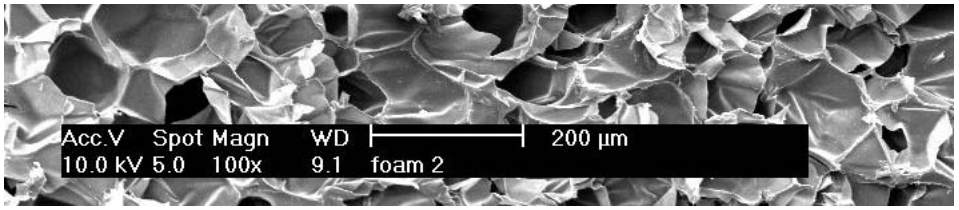
ALICE-TRD-Kollaboration — B. Albrecht[10], M. Al Helwi[8], S. Altinpinar[4], C. Andrei[2], A. Andronic[4], V. Angelov[7], H. Appelshäuser[6], A. Arend[6], I. Arsene[4], G. Augustinski[4], S. Bablok[13], R. Bailhache[6], B. Bathen[10], C. Baumann[6], I. Berceanu[2], A. Bercuci[2], A. Bernhard[6], C. Blume[6], J. Book[6], P. Braun-Munzinger[4], H. Büsching[6], O. Busch[8], V. Cătănescu[2], V. Chepurnov[3], S. Chernenko[3], E.S. Conner[13], P. Constantin[8], J. de Cuveland[7], T. Dietel[10], P. Dillenseger[6], B. Dönigus[4], L. Efimov[3], D. Emschermann[10], S. Esumi[12], M. Fasel[4], O. Fateev[3], M. Freudenberger[4], C. Garabatos[4], H. Gatz[10], P. Glässel[8], R. Glasow[110], H. Gottschlag[10], R. Grajcarek[8], H. Grimm[10], J.F. Grosse-Oetringhaus[10], T. Gunji[11], H. Hamagaki[11], M. Hartig[6], G. Hartung[9], A. Herghelegiu[2], J. Hehner[4], M. Heide[10], N. Heine[10], N. Herrmann[8], D. Hutter[7], M. Ivanov[4], M. Kaiser[6], M. Kalisky[10], R. Keidel[13], A. Köhler[4], C. Klein-Bösing[10], S. Kirsch[7], J. Klein[8], M. Kliemant[6], K. Koch[8], E. Kofler[13], A. Köhler[4], M. Köhler[4], F. Kramer[6], T. Krawutschke[9], D. Krumbhorn[8], M.J. Kweon[8], J. Lehnert[6], H. Leon-Vargas[6], V. Lindenstruth[7], P. Lüttig[6], A. Marin[4], P. Malzacher[4], S. Masciocchi[4], J. Mercado[8], D. Miśkowiec[4], H. Oeschler[5], K. Oyama[8], Y. Pachmayer[8], Y. Panebratsev[3], W.J. Park[4], M. Petriş[2], M. Petrovici[2], N. Pitz[6], A. Pop[2], S. Radomski[8], M. Rammler[10], T. Rascanu[6], P. Reichelt[6], R. Renfordt[6], F. Rettig[7], K. Reygers[8], H. Ricaud[5], R. Romita[4], S. Sano[11], R. Santo[10], C. Şchiaua[2], R. Schicker[8], C.J. Schmidt[4], S. Schmiederer[8], B. Schockert[13], S. Schuchmann[6], S. Schwab[4], K. Schwarz[4], K. Schweda[8], E. Sicking[10], V. Simion[2], H.K. Soltveit[8], J. Stachel[8], A. Steffen[4], A. Takahara[11], M. Tsilis[1], J. Ulery[6], S. Vallero[8], M. Vassiliou[1], W. Verhoeven[10], M. Walter[10], Y. Wang[8], K. Watanabe[12], D. Wegerle[6], J.P. Wessels[10], U. Westerhoff[10], M. Wilde[10], A. Wilk[10], B. Windelband[8], S. Wulff[10], H. Yang[8], V. Yurevich[3], and Y. Zanevsky[3] — [1]University of Athens, Greece — [2]NIPNE Bucharest, Romania — [3]JINR Dubna, Russia — [4]Gesellschaft für Schwerionenforschung, Darmstadt, Germany — [5]Technische Universität, Darmstadt, Germany — [6]Institut für Kernphysik, Johann Wolfgang Goethe-Universität Frankfurt, Germany — [7]Institut für Informatik / Frankfurt Institute for Advanced Studies, Johann Wolfgang Goethe-Universität Frankfurt, Germany — [8]Physikalisches Institut, Universität Heidelberg, Germany — [9]Fachhochschule Köln, Germany — [10]Institut für Kernphysik, Universität Münster, Germany — [11]University of Tokyo, Japan — [12]University of Tsukuba, Japan — [13]Fachhochschule Worms, Germany

134 people, 13 institutions

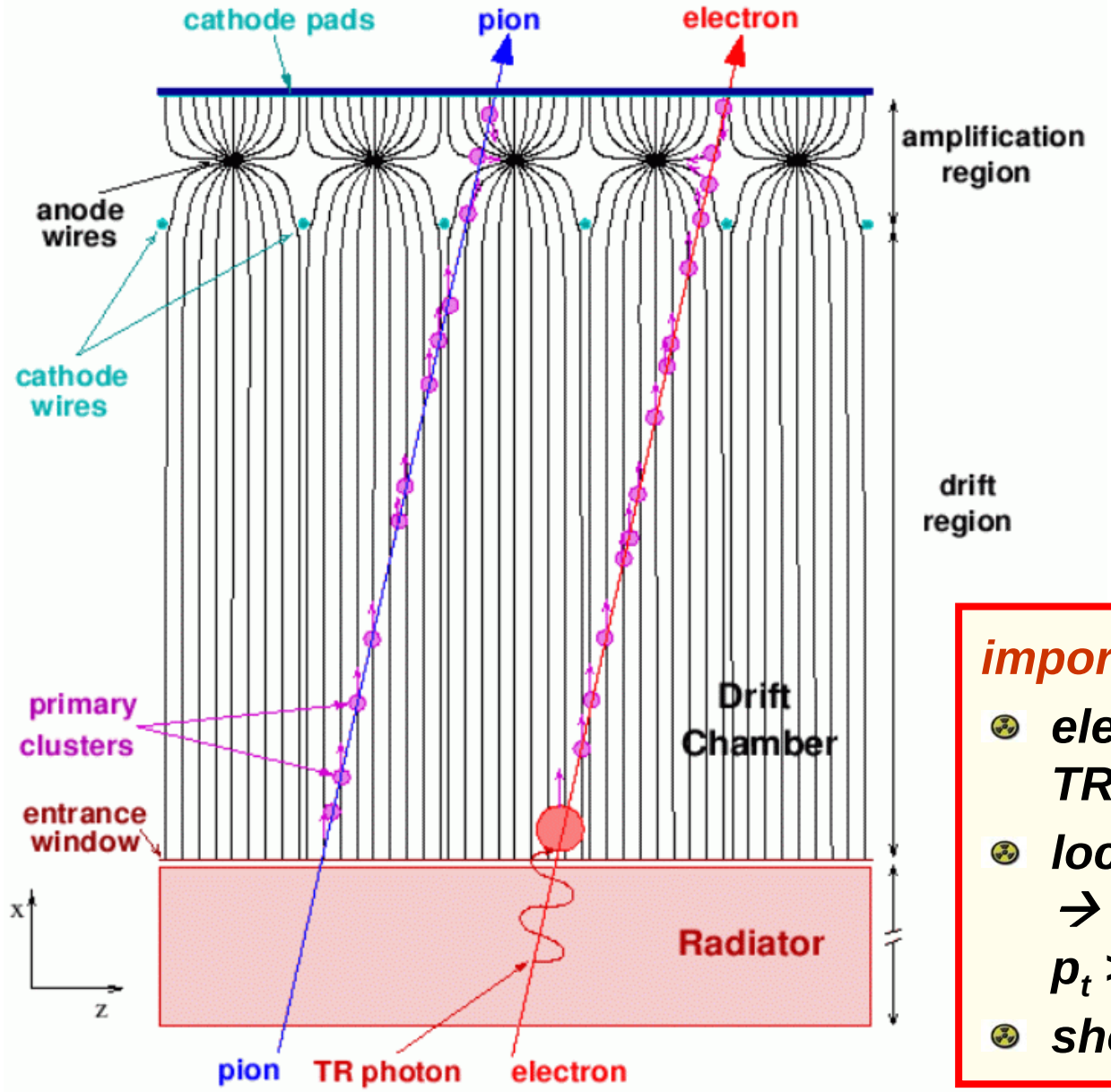
radiator




Acc.V Spot Magn Det WD Exp 200 µm
20.0 kV 5.0 99x SE 9.4 1 10 mu side 1


Acc.V Spot Magn WD 200 µm
10.0 kV 5.0 100x 9.1 foam 2

ALICE TRD, principle of operation



important features

- *electron identification via TR and dE/dx*
- *location far from the vertex → improves pt resolution at p_t > 1 GeV/c*
- *short drift → triggering*

ALICE TRD, physics analyses

- ***electron identification at p_t>1 GeV/c*** → *Markus Heide, HK 58.5*

  J/ψ production, via e+e- decay → *WooJin Park, HK 23.5*

  charm/bottom, via e-hadron correlations → *Sedat Altinpinar, HK 62.7*

  charm/bottom, via single electron spectra

  medium effects, with low-mass dileptons → *Markus Köhler, HK 62.8*

  Z0 production, via e+e- decay

  pi0 production, via γ conversions → *Kathrin Koch, HK 62.4*

- ***improved pt resolution at high pt***

  jet reconstruction → *Hermes Leon-Vargas, HK 62.2*

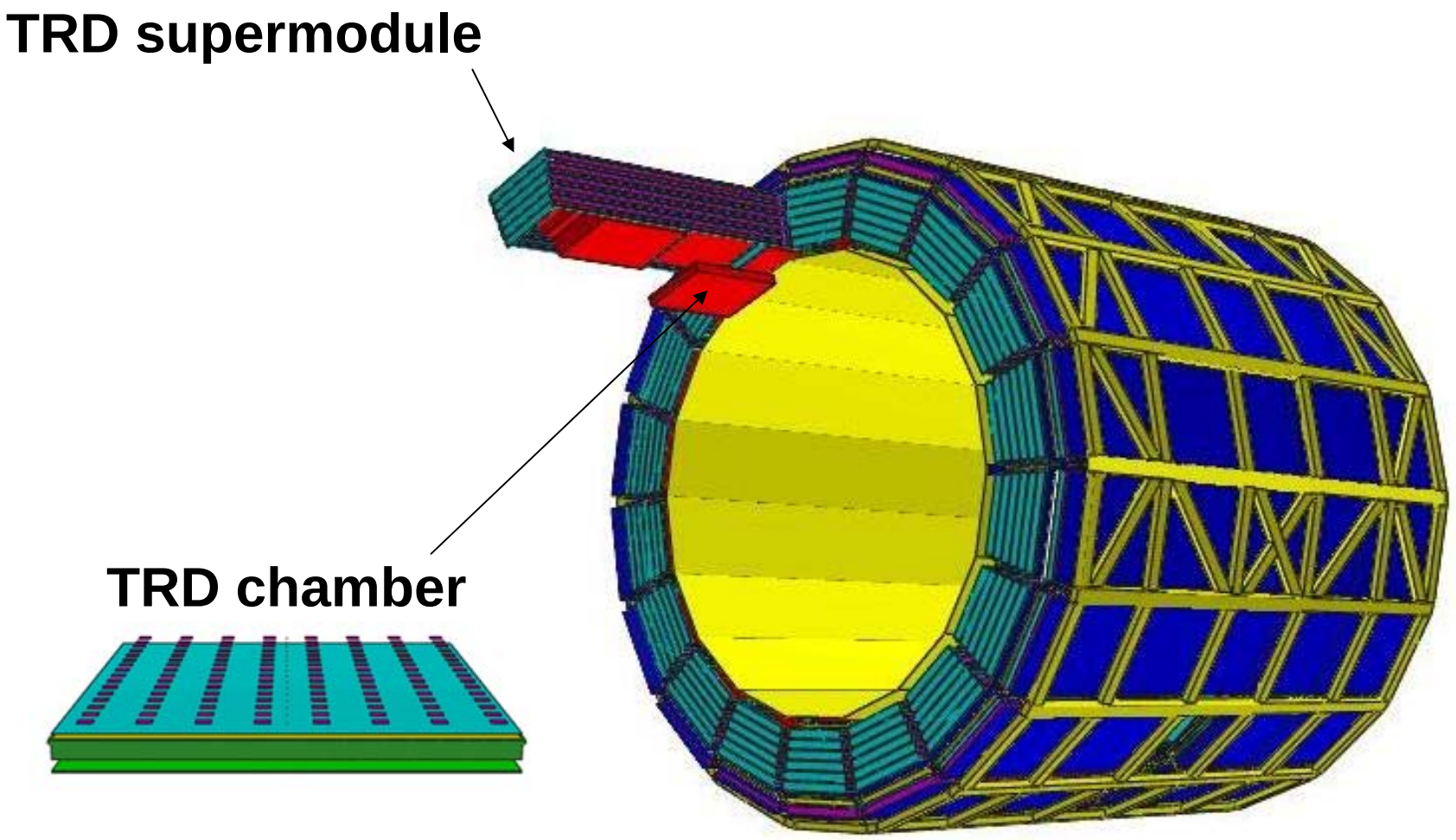
- ***triggering***

  jet trigger → *Jochen Klein, HK 62.3*

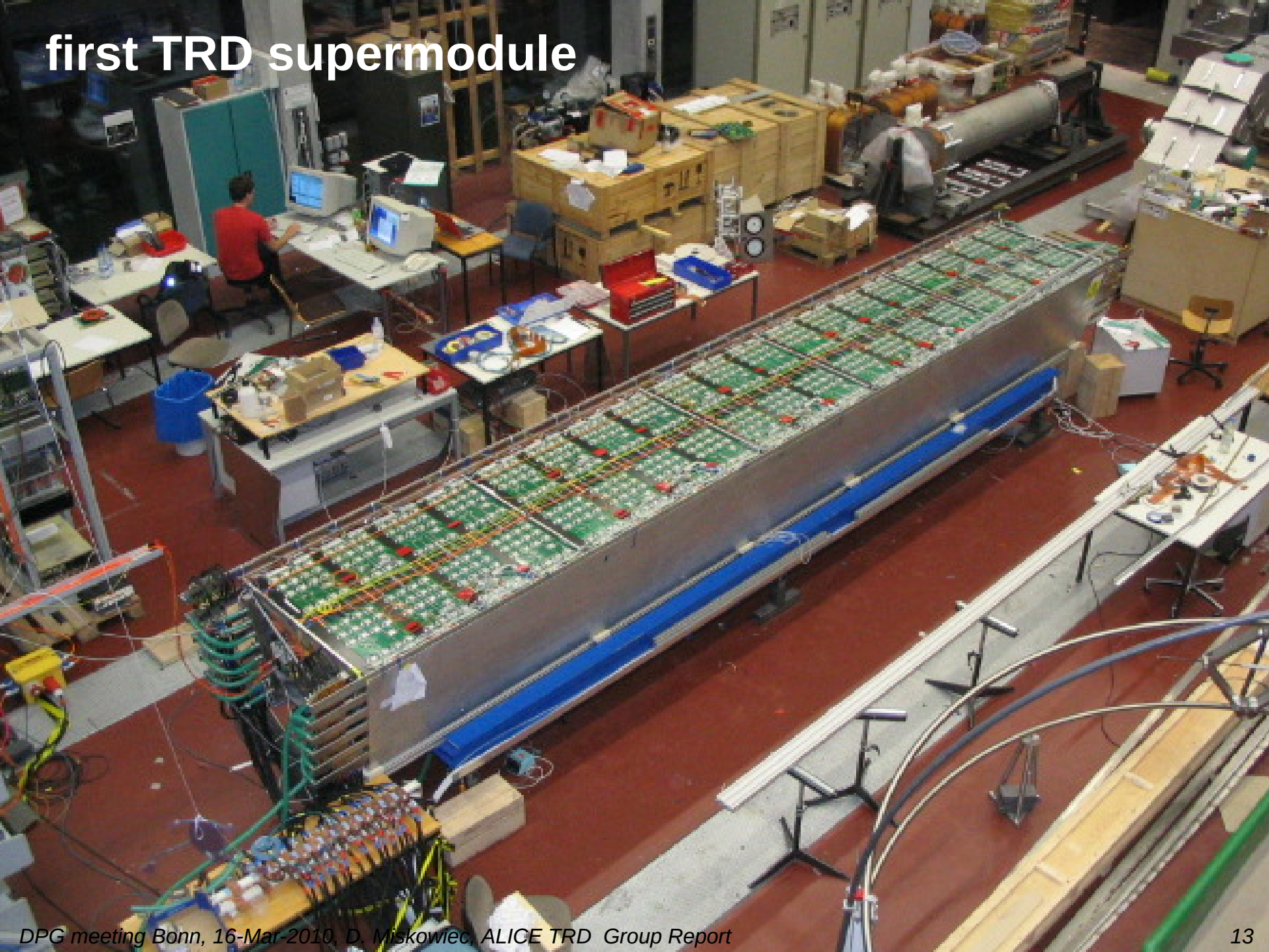
  high level trigger → *Theodor Rascanu, HK 36.2*

Construction and installation

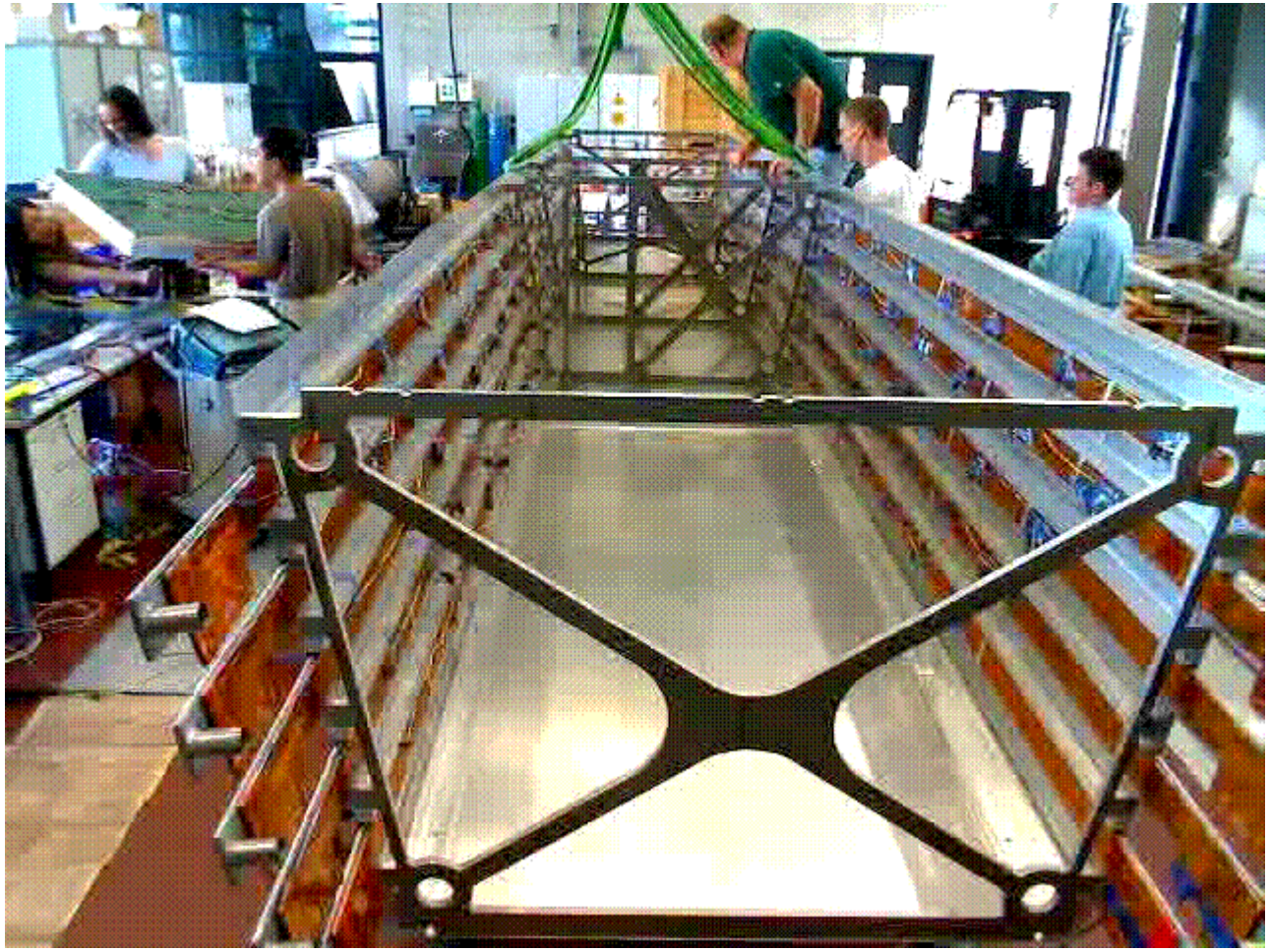
building blocks



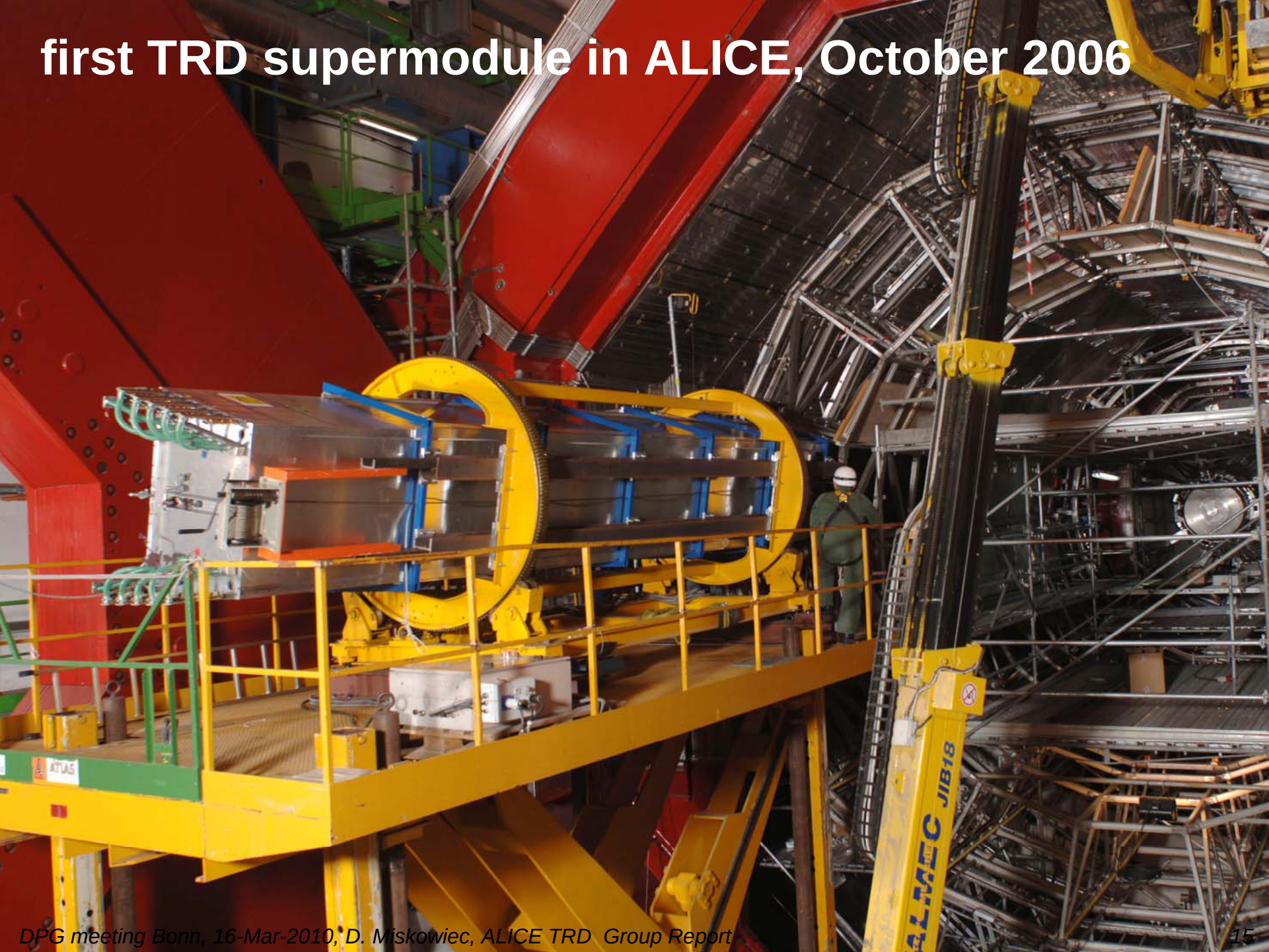
first TRD supermodule

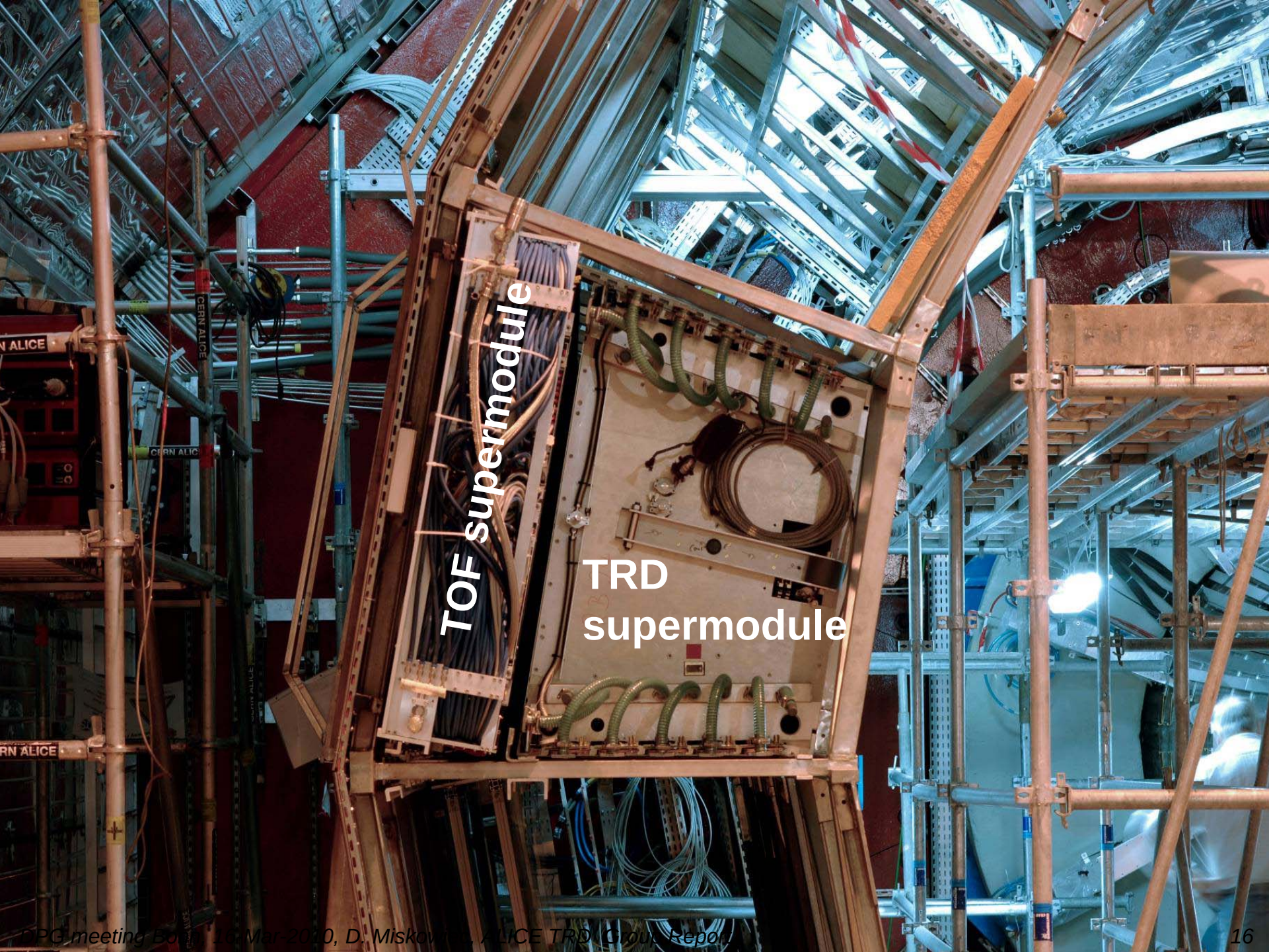


supermodule assembly, Heidelberg



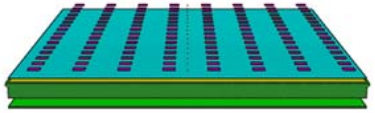
first TRD supermodule in ALICE, October 2006



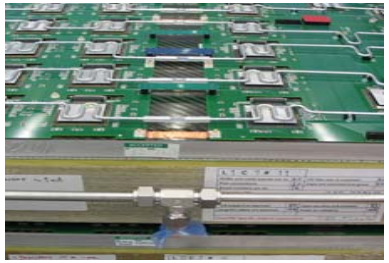

TOF Supermodule
TRD
supermodule

TRD production scheme for the remaining 17 sm's

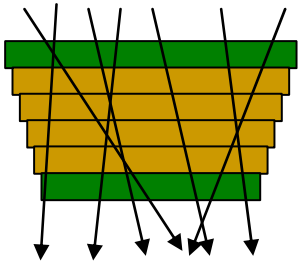
chamber production



electronics mounting



assembling supermodules, cosmics tests alignment



final test, installation in ALICE

Bucharest

Darmstadt

Dubna

Frankfurt

Heidelberg

Frankfurt Darmstadt — ***Münster*** — ***Geneva***

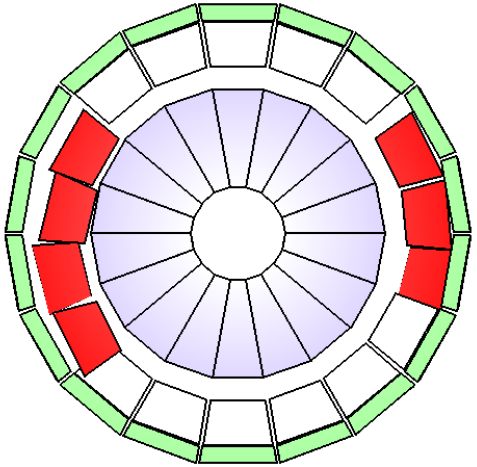
→ Henriette Gatz HK 23.7

TRD implementation

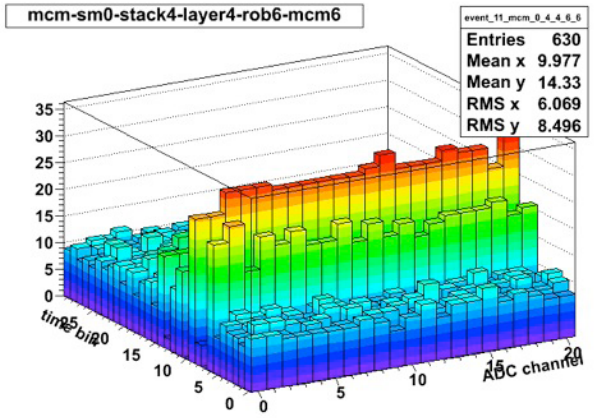
→ pretrigger	Joerg Lehnert	HK 48.4
→ global tracking unit	Dirk Hutter	HK 30.5
→ tracking and PID	Markus Fasel	HK 58.4
→ detector control	Oliver Busch	HK 36.3
→ gas system	Nora Pitz	HK 36.51

present status of the TRD

- *all chambers ready*
- *7 supermodules installed and surveyed*
- *operated in Aug-Oct 2008, continuous operation since July 2009 (including the pp at 900 GeV run in Dec 2009)*
- *GTU trigger (track in TRD) active since 2008*
- *mean noise 1.18 ADC counts – close to theoretical value. However, rare noise events; ongoing effort on reduction*



misalignment from survey x 20



working at CERN - requirements

always wear safety equipment

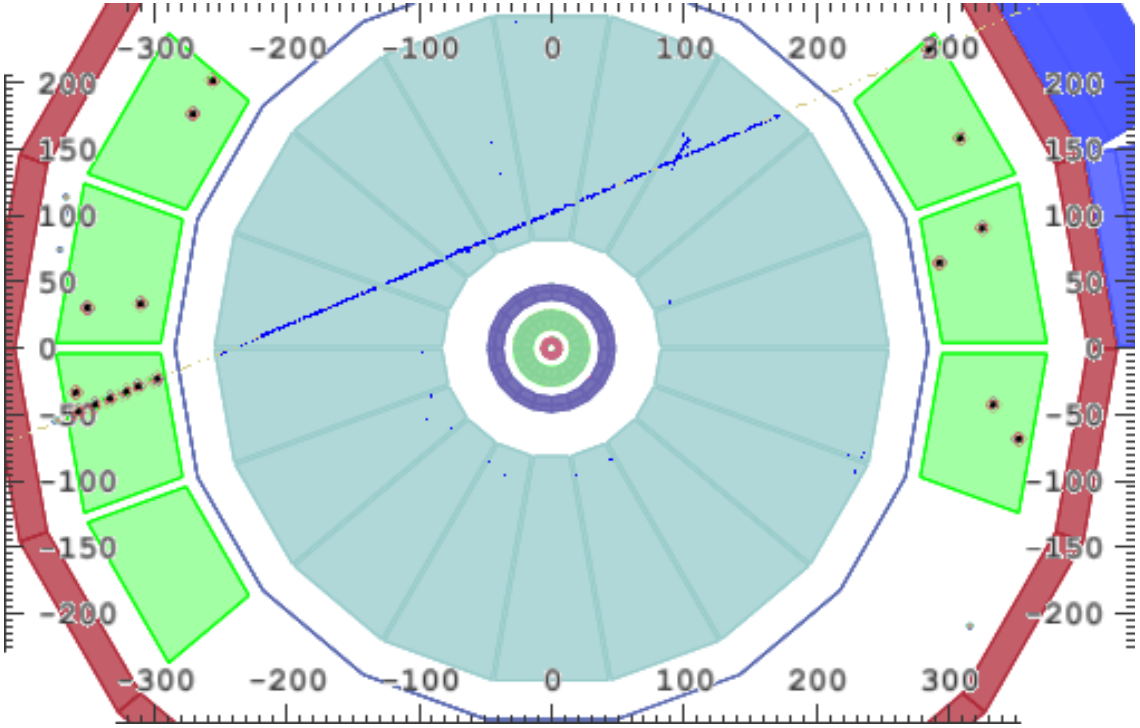
full concentration

be prepared for unexpected

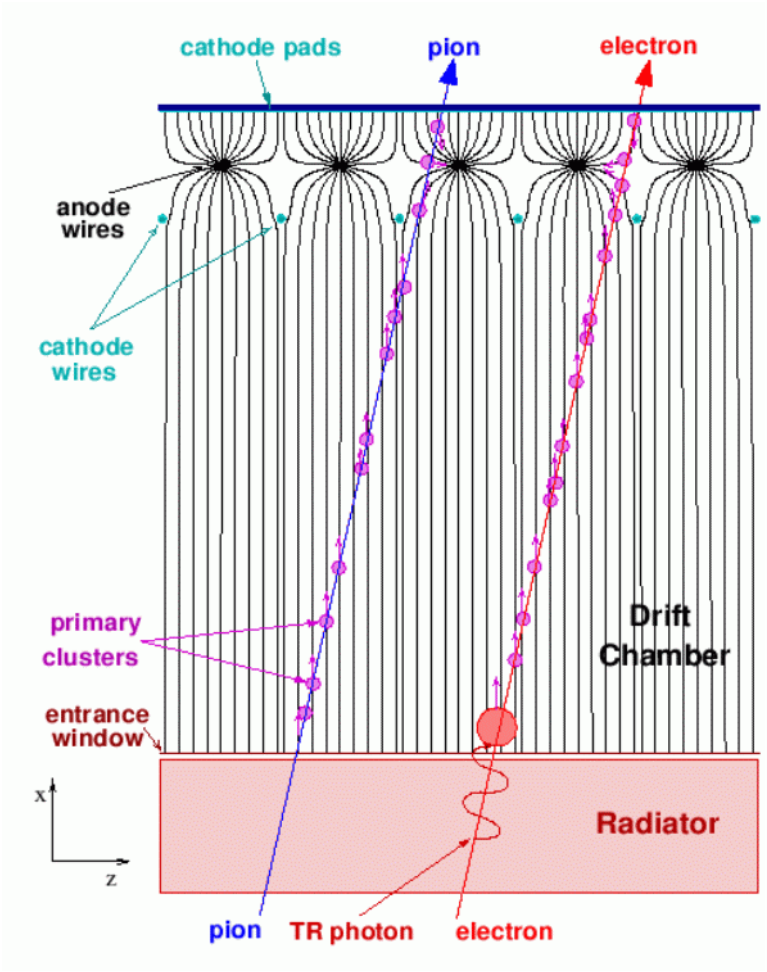
Commissioning and calibration (krypton, cosmic rays)

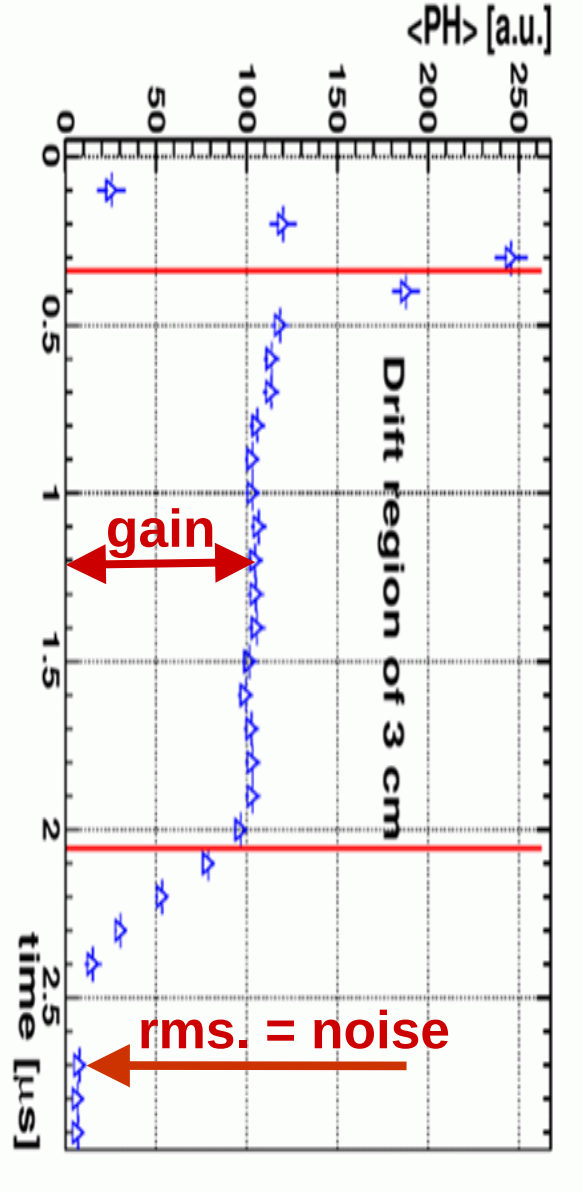
cosmic ray events

- ***Aug-Sep 2008*** ***4 supermodules*** ***0.05 Hz rate*** ***55 k tracks***
- ***Aug-Nov 2009*** ***7 supermodules*** ***0.5 Hz rate*** ***400 k tracks***



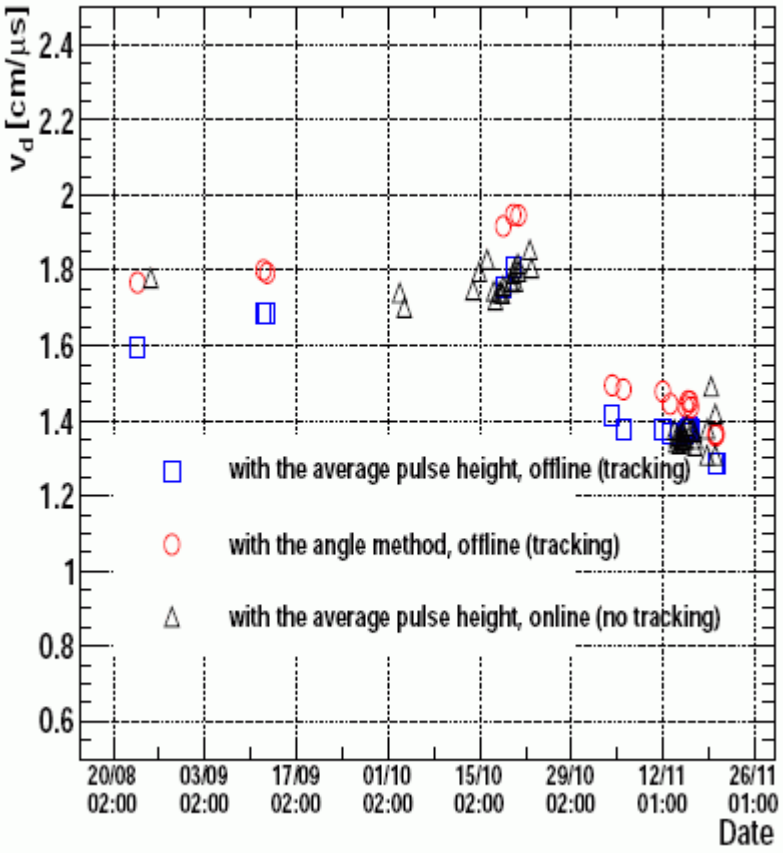
TRD calibration



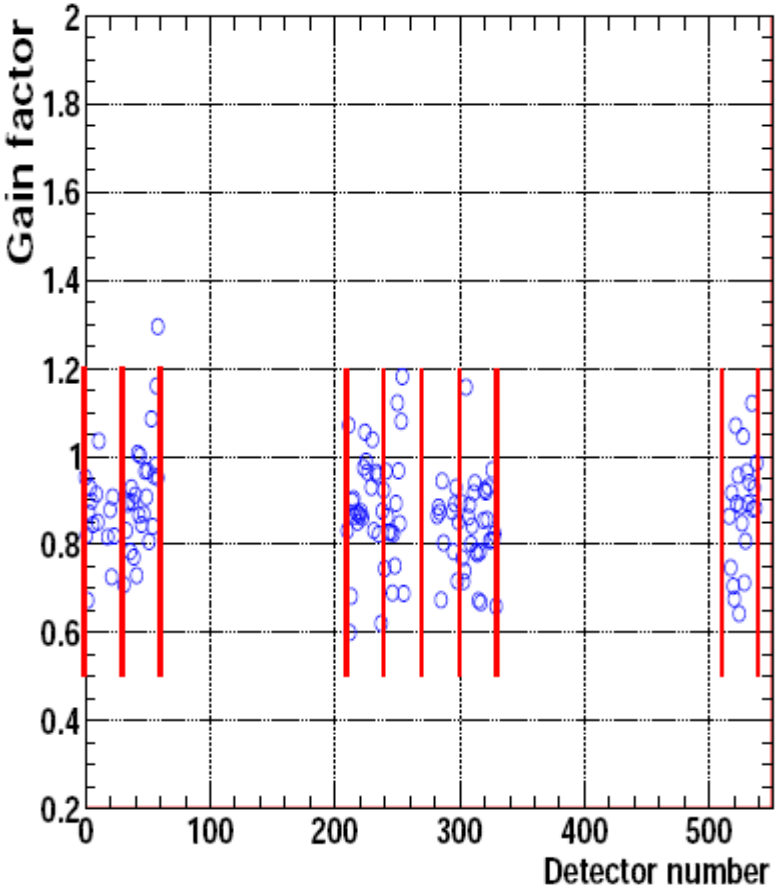


TRD calibration with cosmic data

drift velocity trending



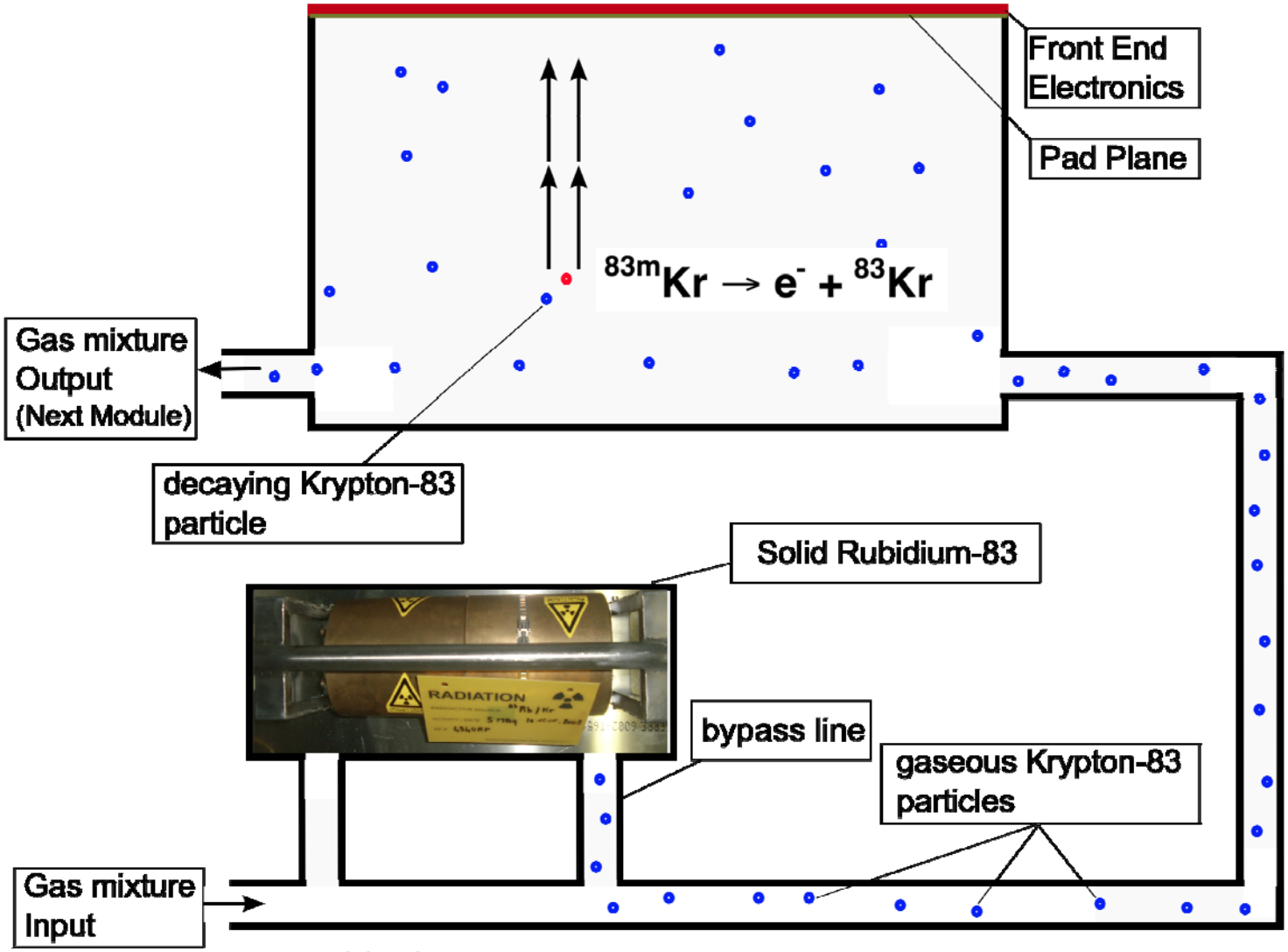
chamber gain factor in run 96287



→ *TRD calibration, Raphaelle Bailhache, HK 30.3*

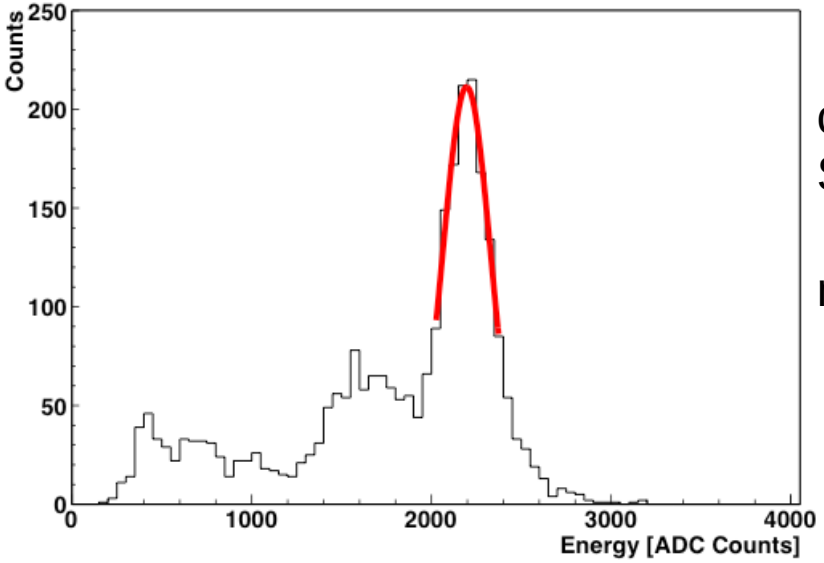
Local gain calibration using radioactive gas

→ *Mustapha Al Helwi, HK 36.8*



Local gain calibration using radioactive gas

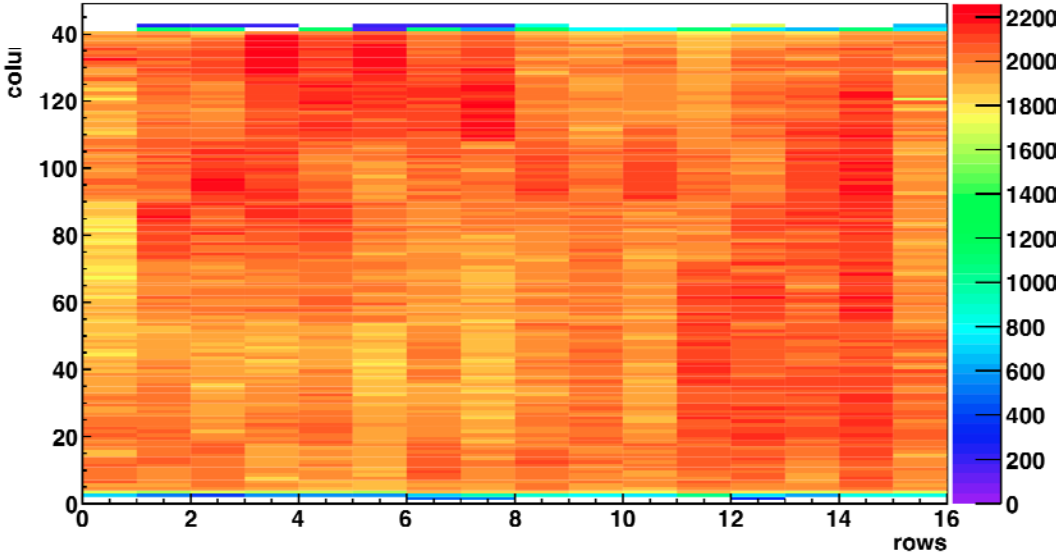
→ *Mustapha Al Helwi, HK 36.8*



charge distribution for pad
SM08-S0L1 - row03 - col006

measured with Ar CO_2

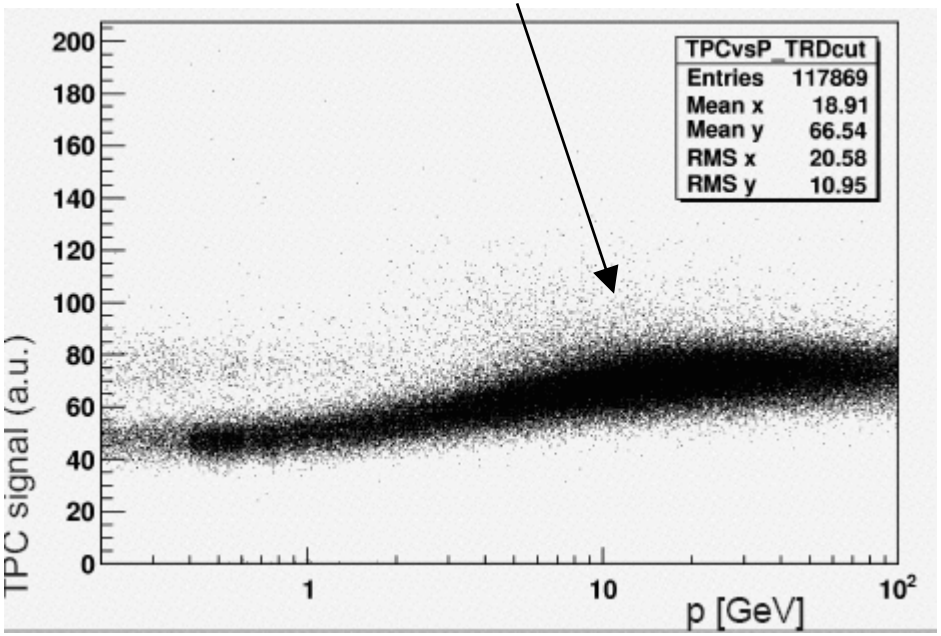
gain map of chamber SM08-S0L1

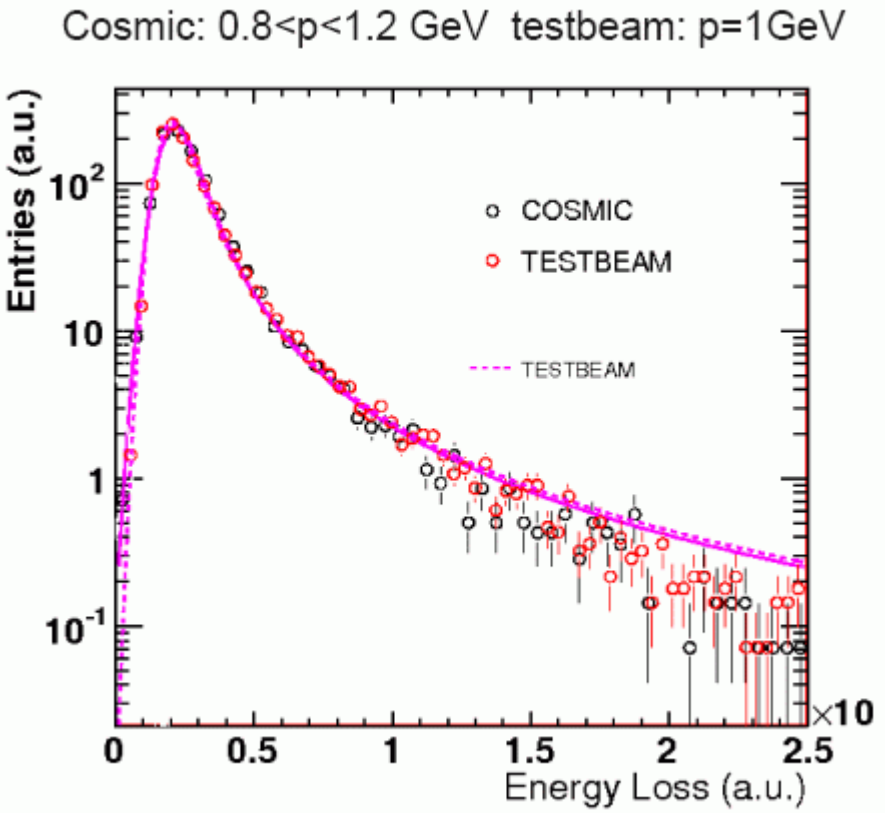


TRD response to high p_t muons

Thorsten Heusser, MinJung Kweon, Xianguo Lu, Heidelberg

muons identified via dE/dx in the TPC

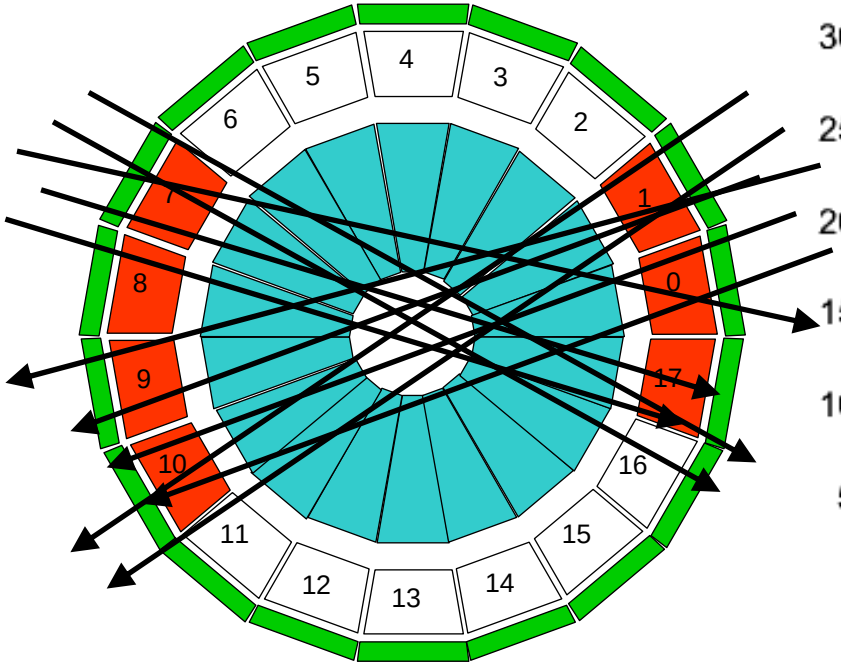




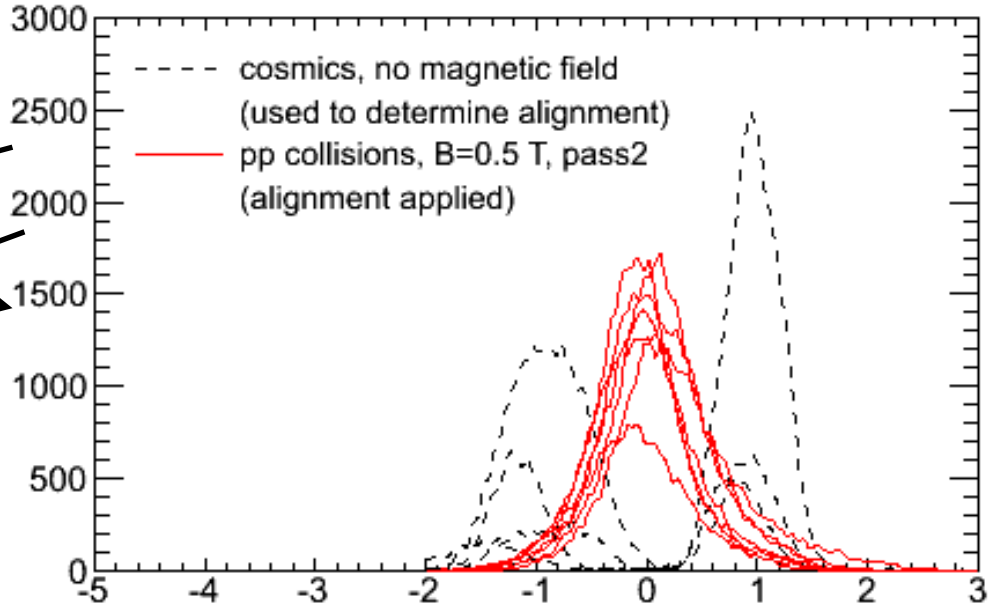
TRD alignment w.r.t. TPC

→ TRD alignment, Sebastian Huber, HK 58.2

cosmic muons



7 supermodules before and after alignment



$r\varphi_{TRD} - r\varphi_{extrap.\ TPC}$ **(cm)**

pp collisions

first collisions in ALICE, Nov 23, 2009

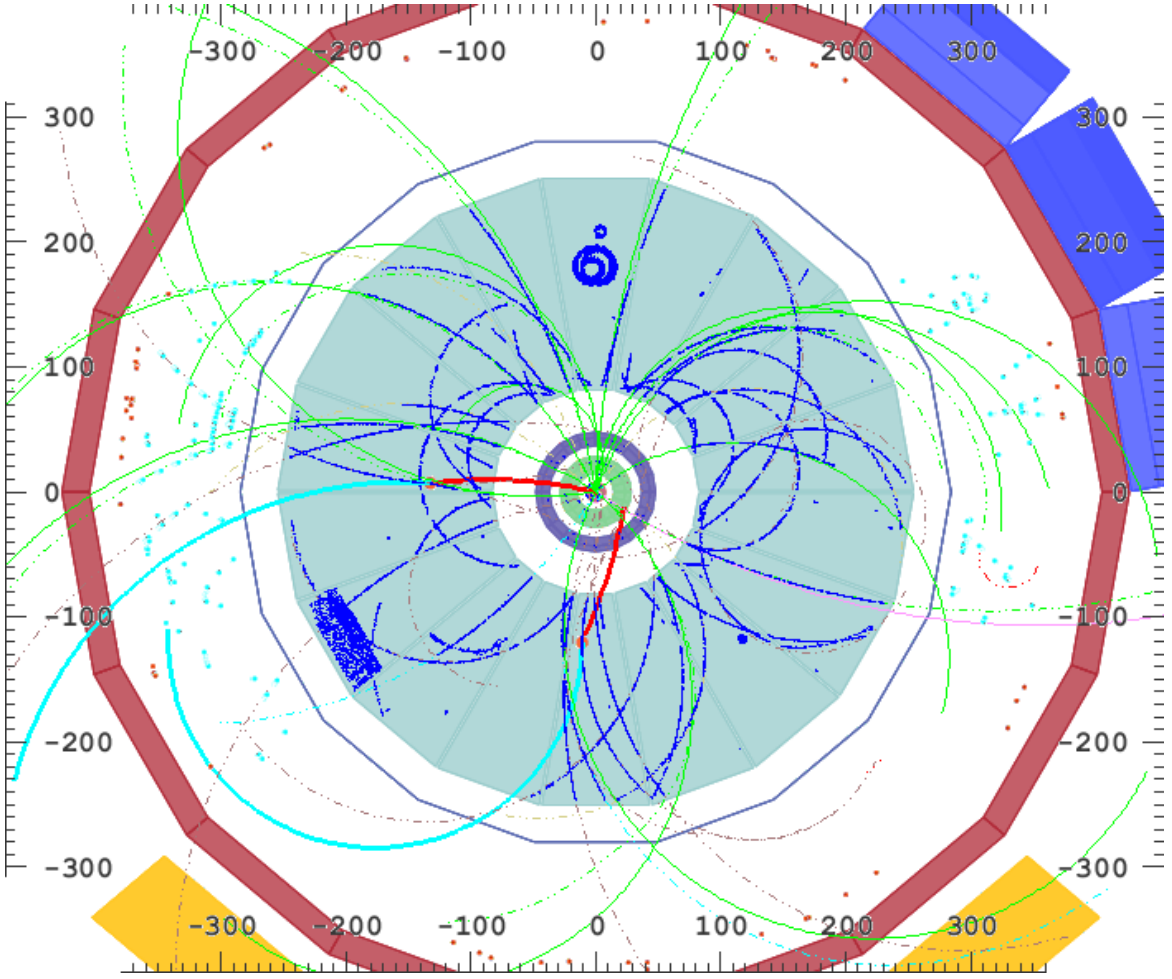
- ***Nov 23, 2009 first collisions seen with ITS***

- ***Nov 28, 2009 first LHC physics paper submitted by ALICE, charged particle multiplicity***

→ Yvonne Pachmayer, HK 35.1
→ TRD performance, Ionut Arsene, HK 23.4
→ GTU performance, Stefan Kirsch, HK 30.4

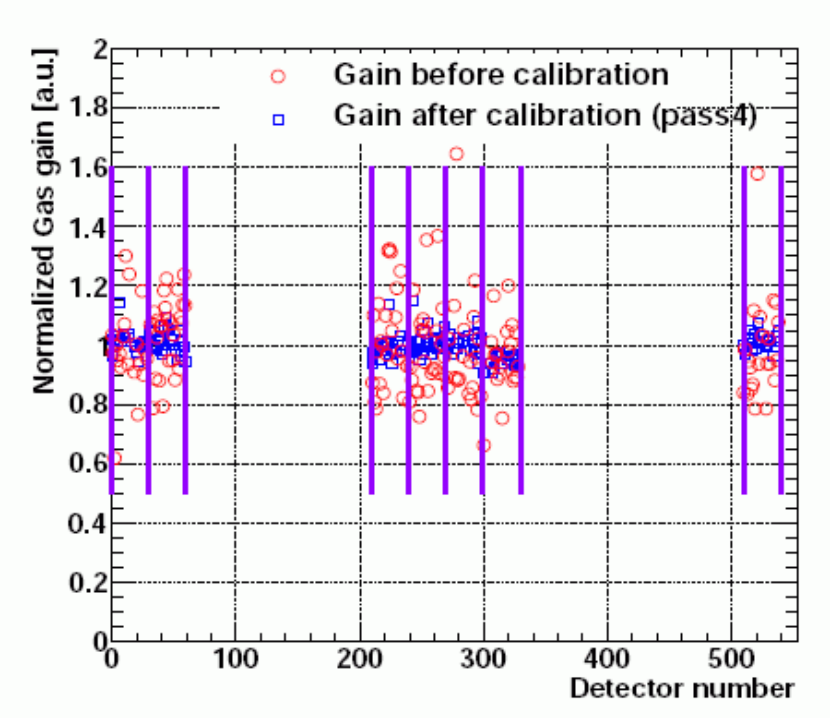
first stable collisions in ALICE, Dec 6, 2009

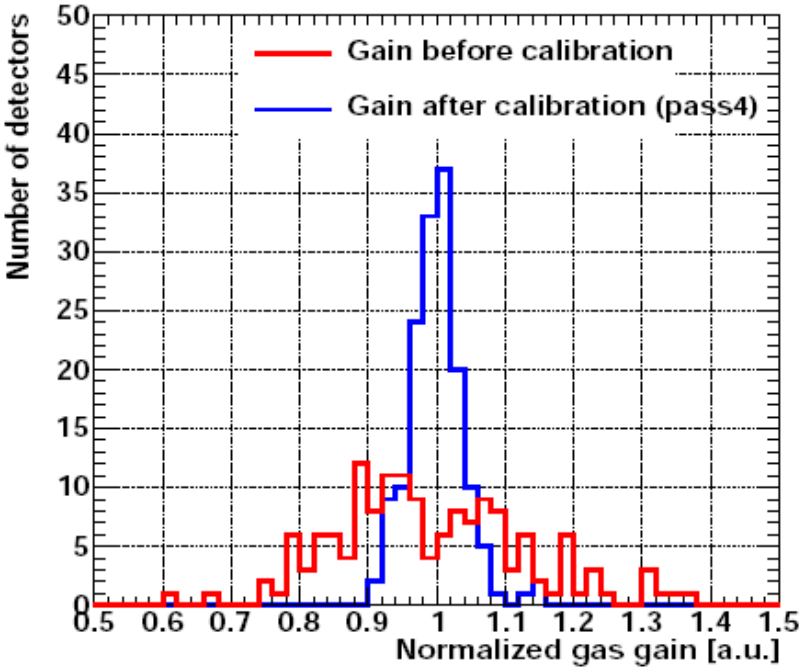
- ***Dec 6, 2009 beams declared "stable"***
- ***first collisions seen with TPC and TRD***



TRD chamber calibration with pp collision data

- *240 TRD chambers calibrated for gain, drift velocity, time offset*
- *gain calibration most difficult (requires reconstruction)*
- *HV adjusted to equalize the parameters in future*





→ *TRD calibration, Raphaelle Bailhache, HK 30.3*

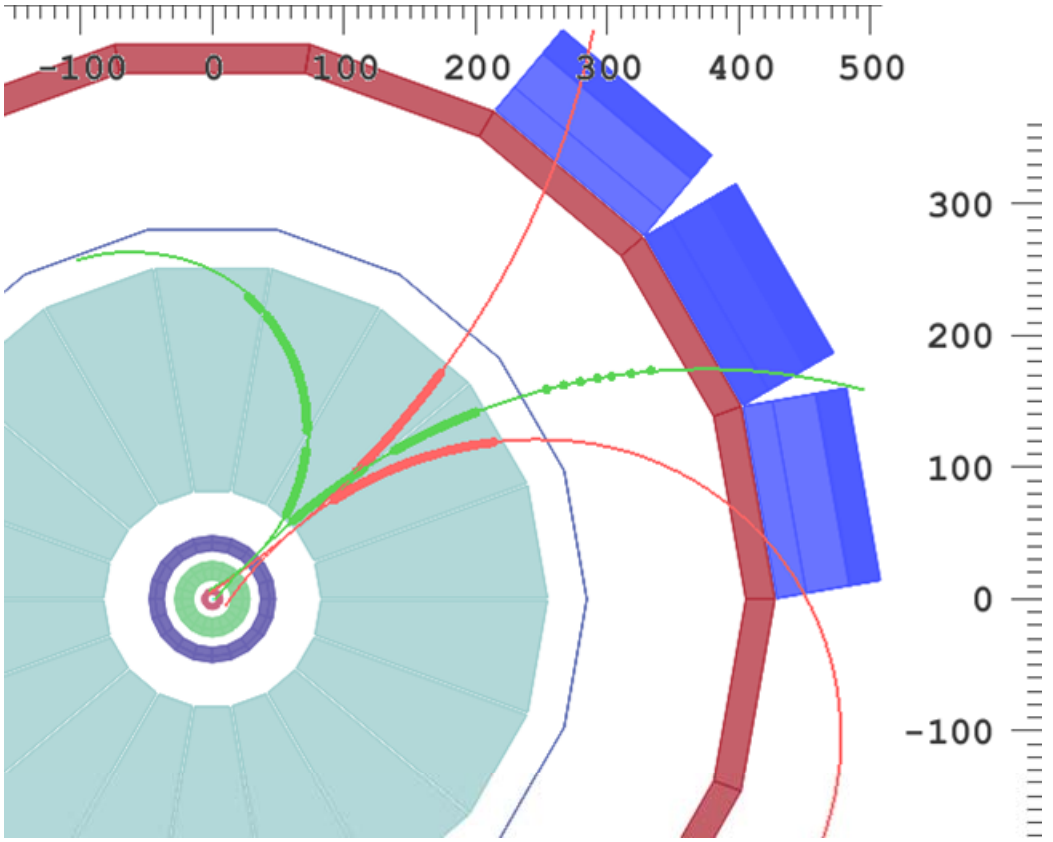
TRD response to pions and electrons

reference pion and electron tracks taken from decays

$$K_S^0 \rightarrow \pi^+ \pi^-$$

$$\gamma \rightarrow e^+ e^-$$

recognized by vertex and invariant mass



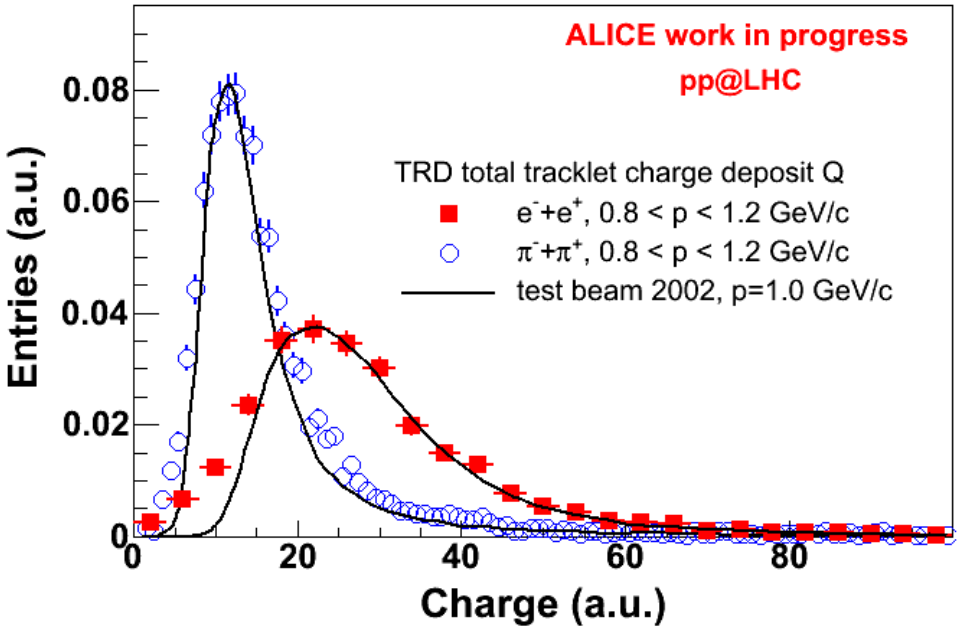
TRD response to pions and electrons

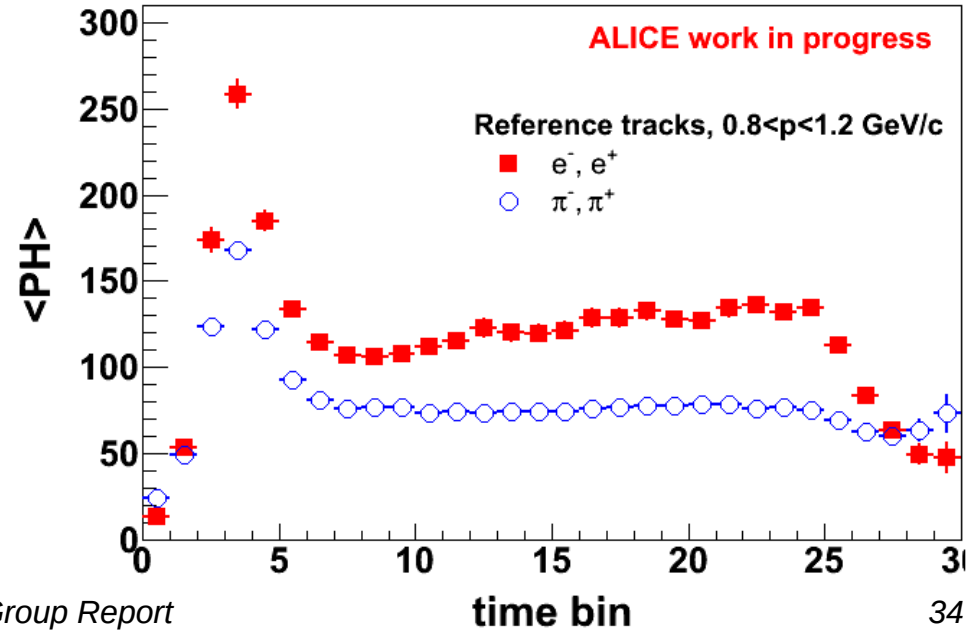
TRD response to identified pions and electrons from pp at 900 GeV (points)

compared to

tests performed with pion and electron beams performed at the PS in 2002 (line)

→ ***TRD performance, Ionut Arsene, HK 23.4***





summary

- ***TRD 7/18 installed and operational***
- ***the rest to be installed in 2011/2012***
- ***the detector works nicely but requires continuous effort of many people***

…and outlook

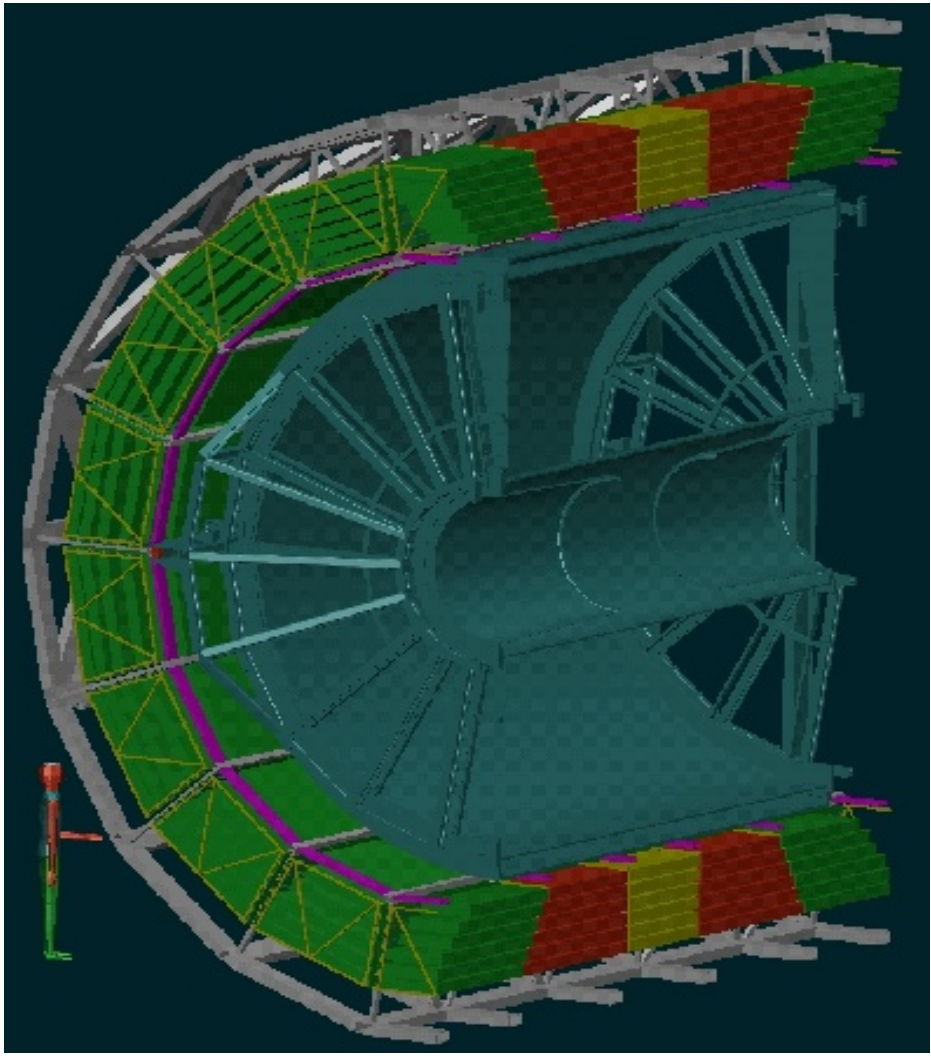
operating/control/calibration on their way to become automatic

backup

Overview of TRD

- *electron identification and trigger*
  - *quarkonia → e^+e^-*
  - *charm and beauty*

- *540 chambers in 18 supermodules*
- *total area: 736 m^2 (3 tennis courts)*
- *gas volume: 27.2 m^3 Xe-CO_2*
- *resolution: ($r\varphi$) 400 μm*
- *number of read out channels: 1.2x10^6 (30 million pixels)*
- *275 000 on-detector CPUs process raw data to reconstruct tracks of 6 segments in 6.5 μs for L1 trigger*
- *70 kW power dissipation → water cooling*



- *chamber production finished, 8 supermodules in 2009, completion 2010*

Brief history of TRD supermodules, as of Nov 2009