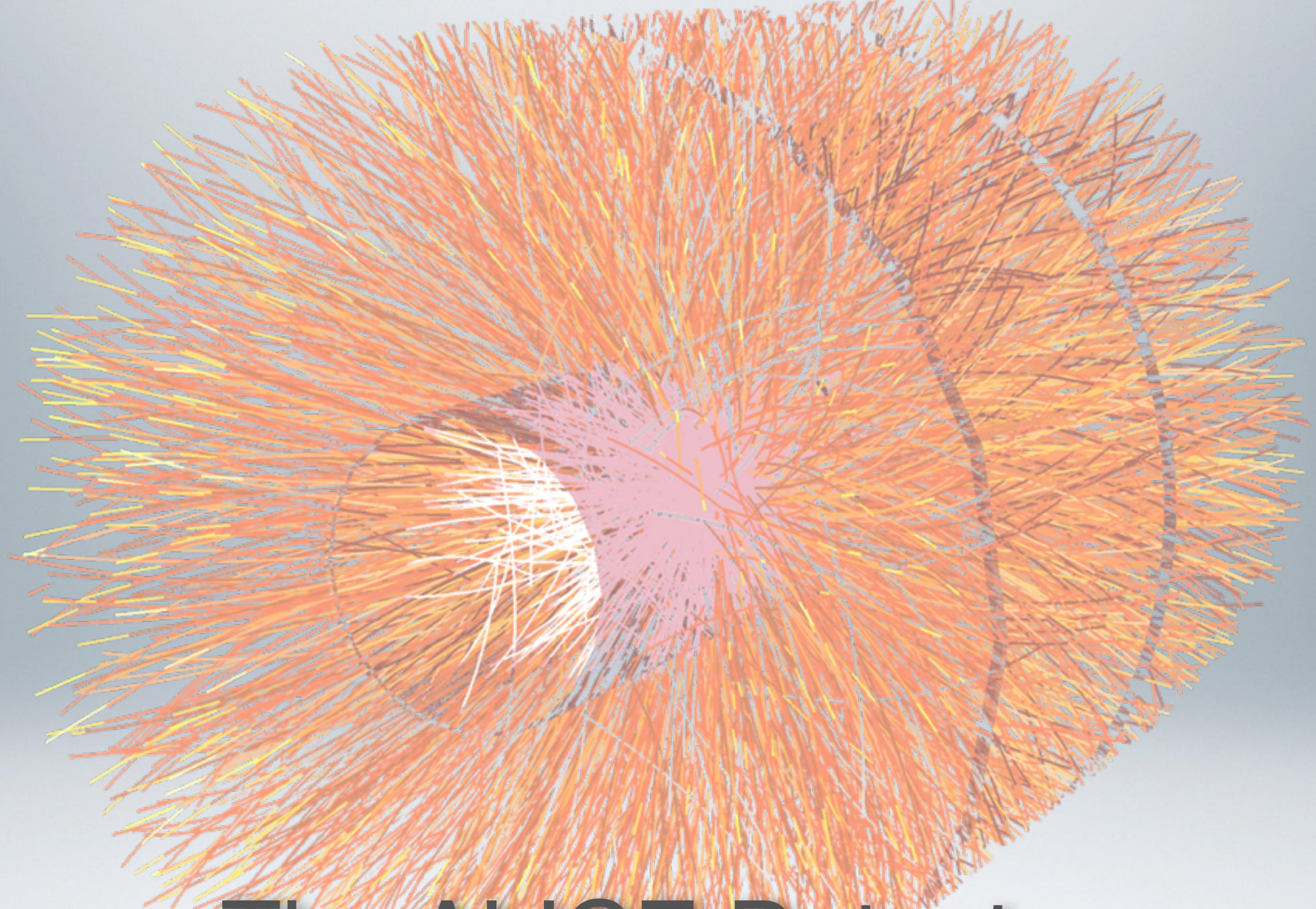


The ALICE Detector

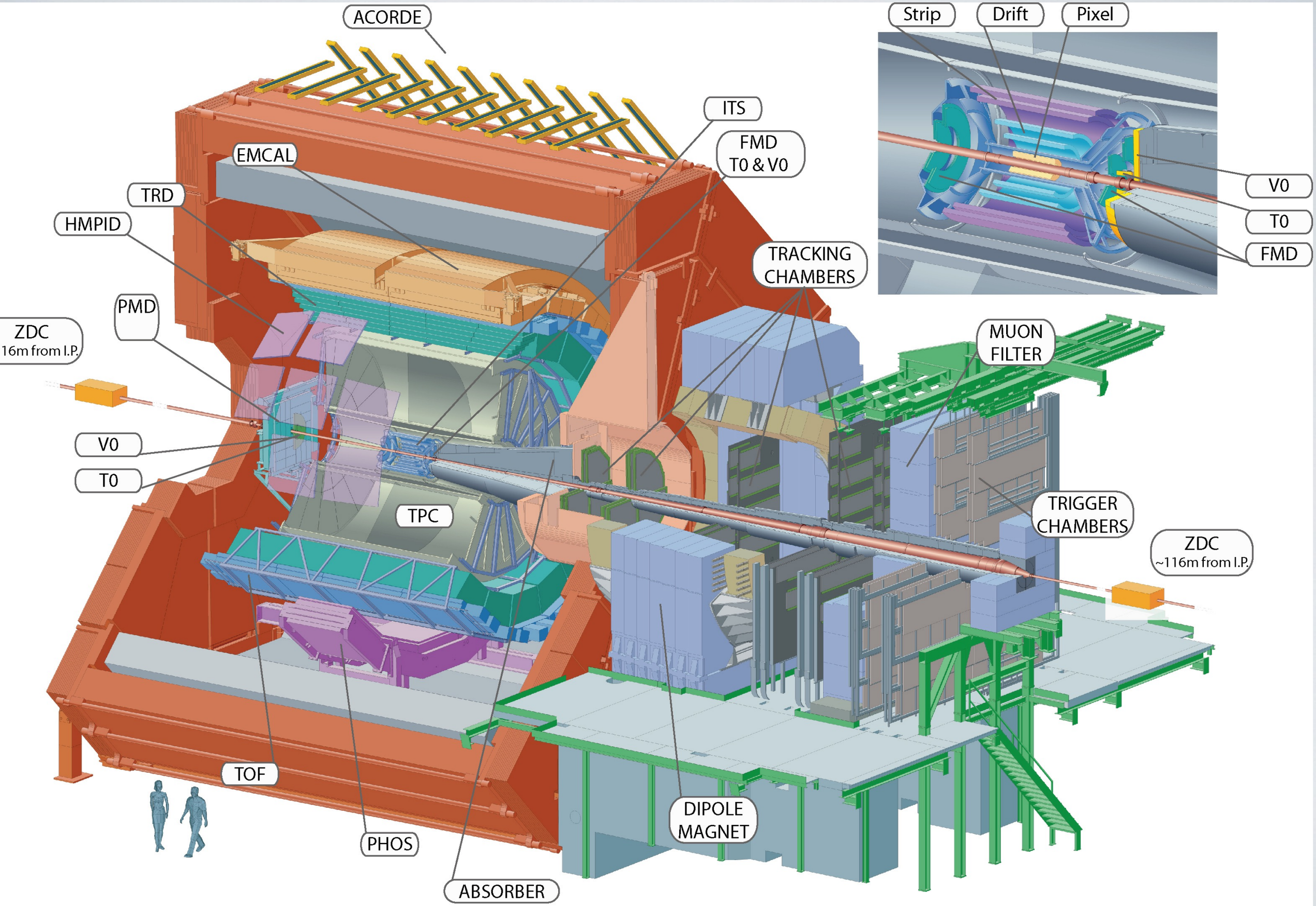
T. Peitzmann (Utrecht University/Nikhef)

Outline

- Intro: ALICE Philosophy and Setup
- Detector Examples:
  - SSD
  - Time Projection Chamber
- Material Budget
- Particle Identification

ALICE Philosophy

- specific requirements for quark-gluon plasma studies
- measure particles originating from thermal system:
  - measure at relatively low momentum
    - weak B-field, low material budget!
  - (representative) sampling of distribution possible
    - no hermeticity required
  - measure strongly interacting particles (hadrons)
    - good particle ID for hadrons
  - triggering often not possible
    - mix of triggered and untriggered measurements


ACORDE
ITS
FMD
T0 & V0
EMCAL
TRD
HMPID
PMD
ZDC
16m from I.P.
V0
T0
TPC
TOF
PHOS
ABSORBER
TRACKING
CHAMBERS
MUON
FILTER
TRIGGER
CHAMBERS
ZDC
~116m from I.P.
DIPOLE
MAGNET
Strip
Drift
Pixel
V0
T0
FMD

Inner Tracking System

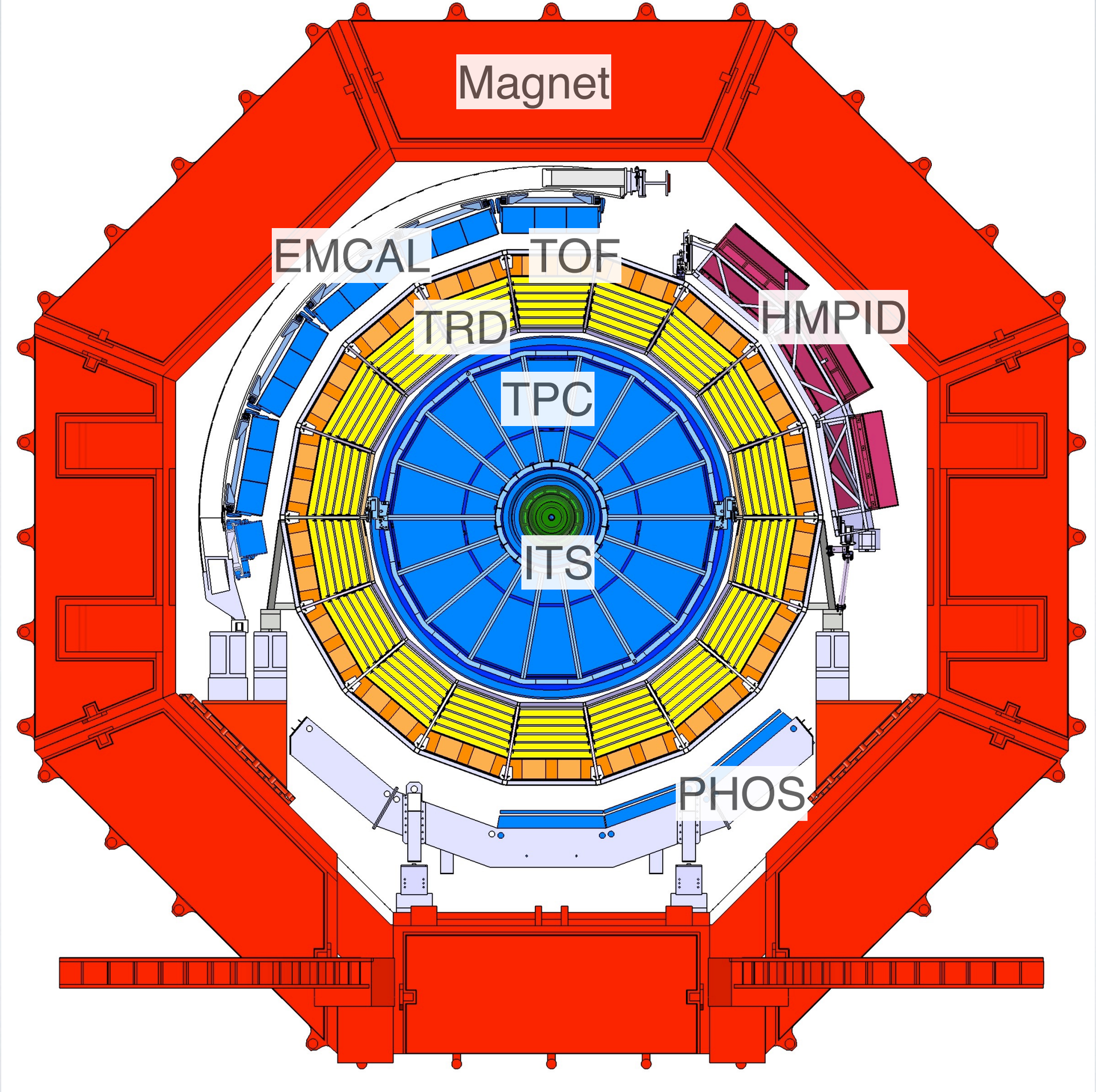
detector	acceptance η	acceptance φ	position	technology	main purpose
SPD I	$\lvert \eta \rvert < 2.0$	full	$r = 3.9$ cm	Si pixel	tracking, vertex
SPD II	$\lvert \eta \rvert < 1.4$	full	$r = 7.6$ cm	Si pixel	tracking, vertex
SDD I	$\lvert \eta \rvert < 0.9$	full	$r = 15.0$ cm	Si drift	tracking, PID
SDD II	$\lvert \eta \rvert < 0.9$	full	$r = 23.9$ cm	Si drift	tracking, PID
SSD I	$\lvert \eta \rvert < 1.0$	full	$r = 38$ cm	Si strip	tracking, PID
SSD II	$\lvert \eta \rvert < 1.0$	full	$r = 43$ cm	Si strip	tracking, PID

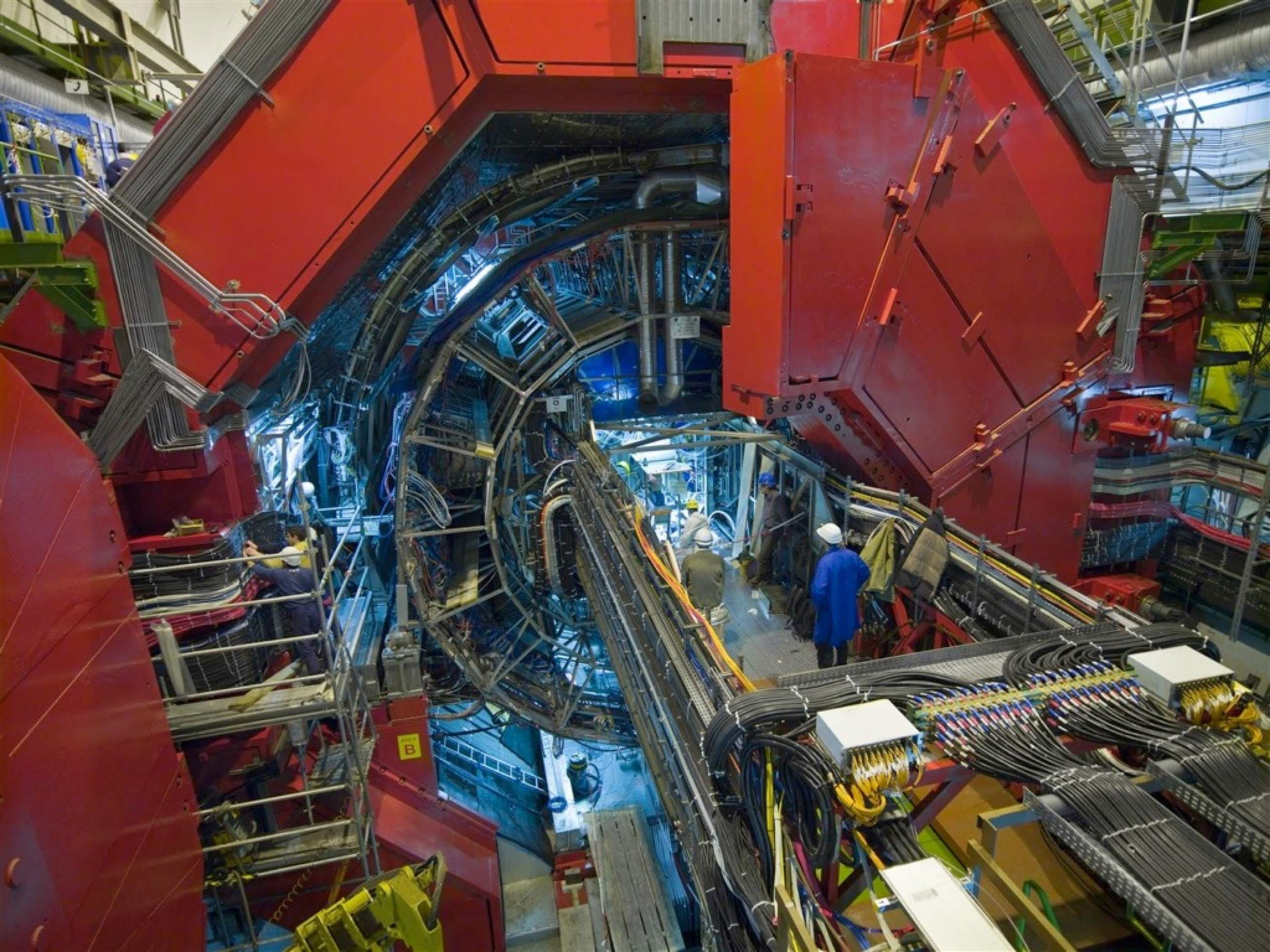
Central Barrel Detectors II

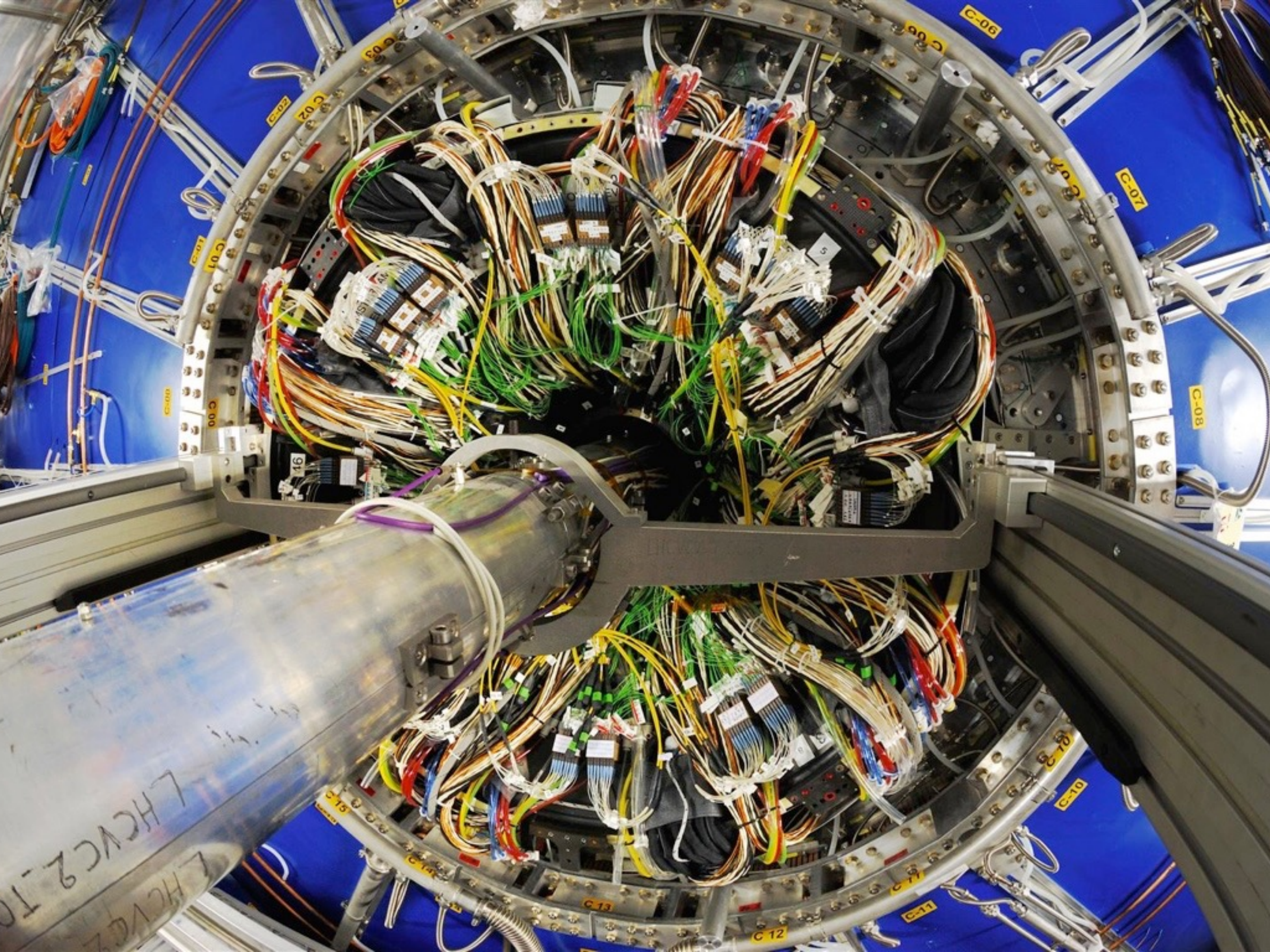
detector	acceptance η	acceptance φ	position	technology	main purpose
TPC	$\lvert \eta \rvert < 0.9$	full	$85 < r/\mathrm{cm} < 247$	Ne drift + MWPC	tracking, PID
TRD	$\lvert \eta \rvert < 0.8$	full	$290 < r/\mathrm{cm} < 368$	TR + Xe drift + MWPC	tracking, e ID
TOF	$\lvert \eta \rvert < 0.9$	full	$370 < r/\mathrm{cm} < 399$	MRPC	PID
PHOS	$\lvert \eta \rvert < 0.12$	$220° < \lvert \varphi \rvert < 320°$	$460 < r/\mathrm{cm} < 478$	$PbWO_4$	photons
EMCAL	$\lvert \eta \rvert < 0.7$	$80° < \lvert \varphi \rvert < 187°$	$430 < r/\mathrm{cm} < 455$	Pb + Scint	photons, jets
HMPID	$\lvert \eta \rvert < 0.6$	$1° < \lvert \varphi \rvert < 59°$	$r = 490$ cm	C_6F_{14} RICH + MWPC	PID

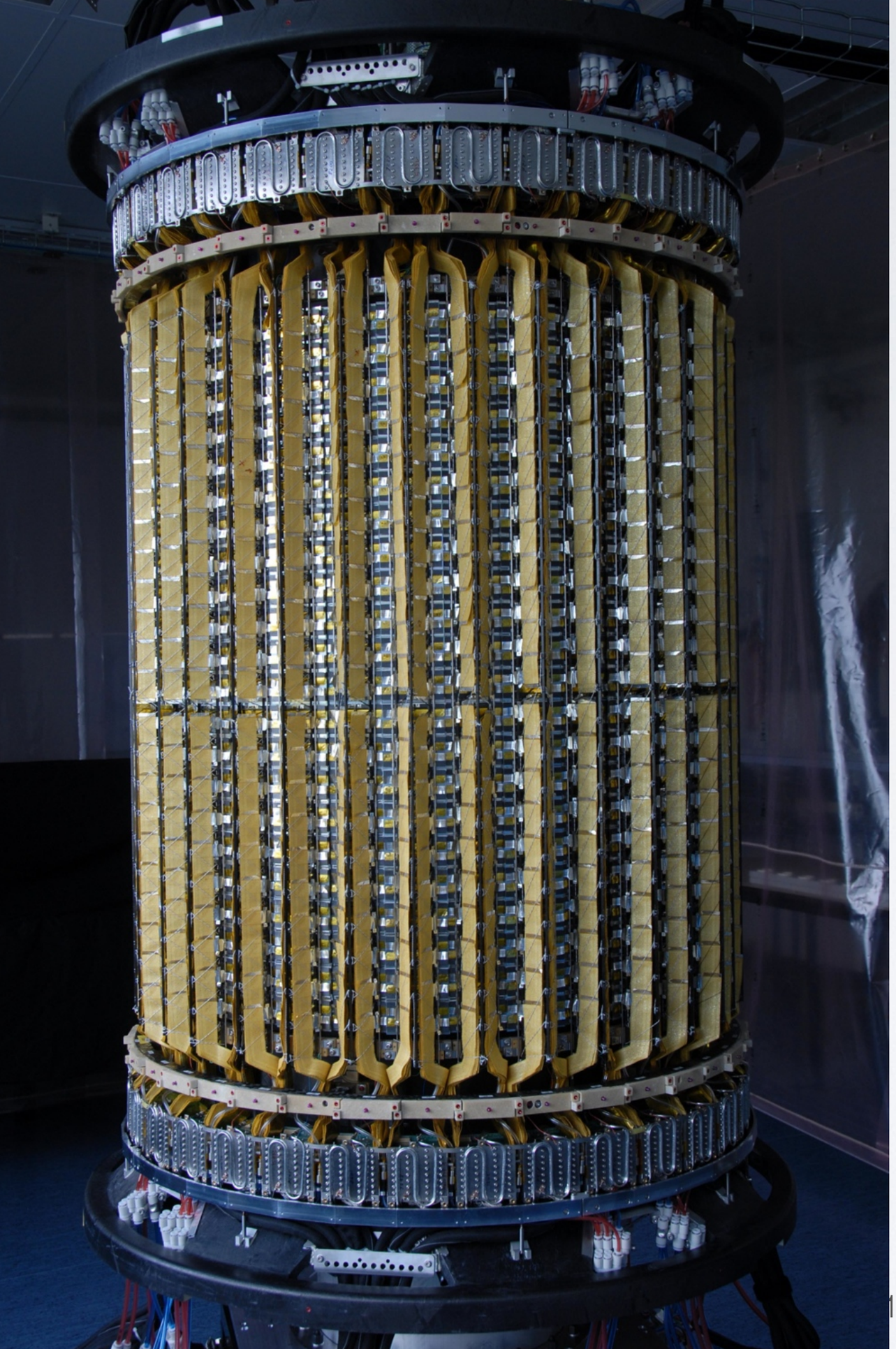
Forward Detectors

detector	acceptance η	acceptance φ	position	technology	main purpose
PMD	$2.3 < \eta < 3.9$	full	$z = 367$ cm	Pb + PC	photons
FMD	$3.6 < \eta < 5.0$ $1.7 < \eta < 3.7$ $-3.4 < \eta < -1.7$	full	$z = 320$ cm $z = 80$ cm $z = -70$ cm	Si strip	charged particles
MCH	$-4.0 < \eta < -2.5$	full	$-14.2 < z/\mathrm{m} < -5.4$	MWPC	muon tracking
MTR	$-4.0 < \eta < -2.5$	full	$-17.7 < z/\mathrm{m} < -16.1$	RPC	muon trigger
V0, T0, ZDC	…	…	…	…	trigger, misc.


Magnet
EMCAL
TOF
TRD
HMPID
TPC
ITS
PHOS

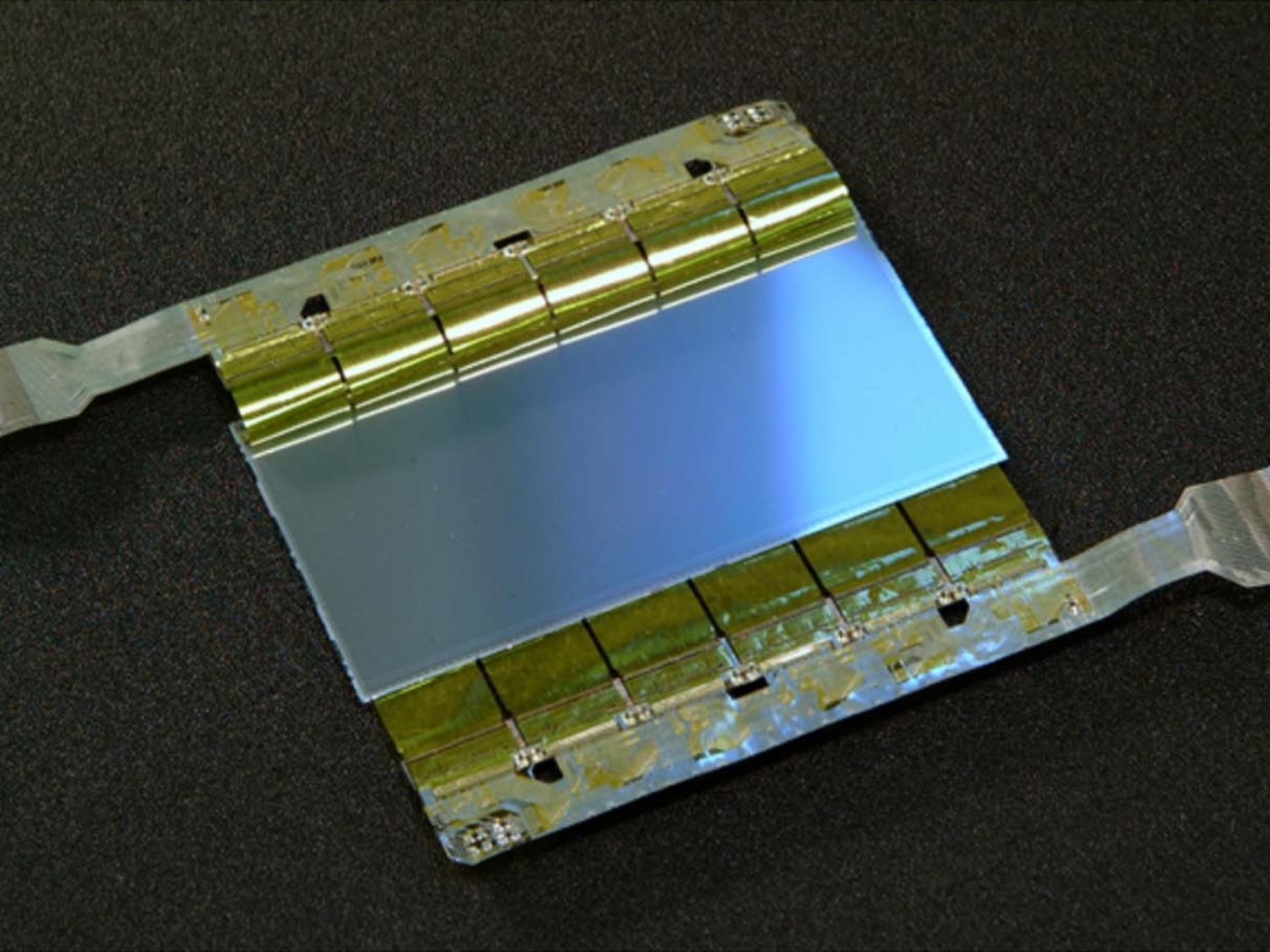



C-06
C-07
C-08
C-10
C-11
C 12
C 13
C-13
C-14
C 14
C 11
C 10
C 00
C-00
C-01
C 01
C-02
C 02
C 03
C 06
C 07
LHCVC2.10

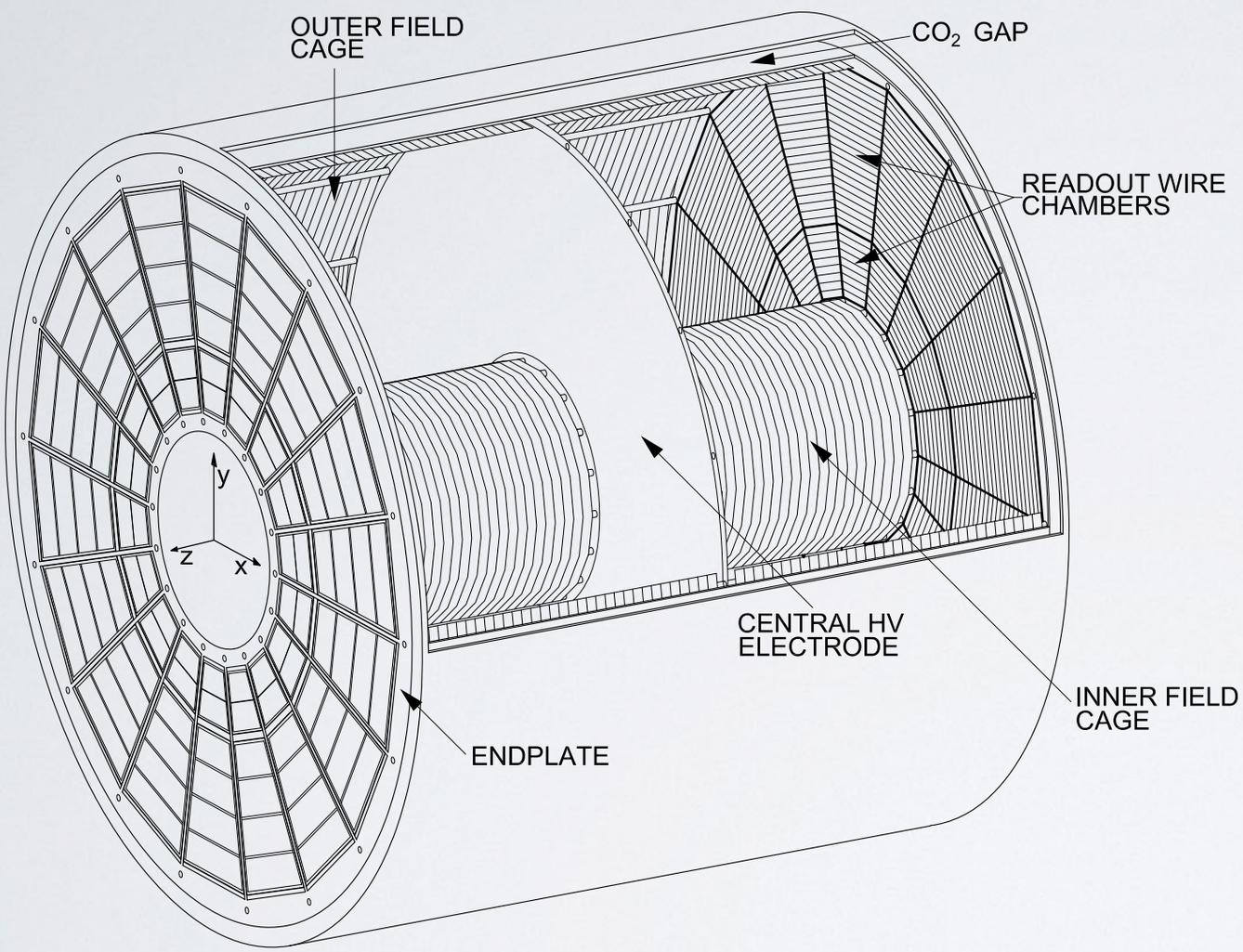


Silicon Strip Detector

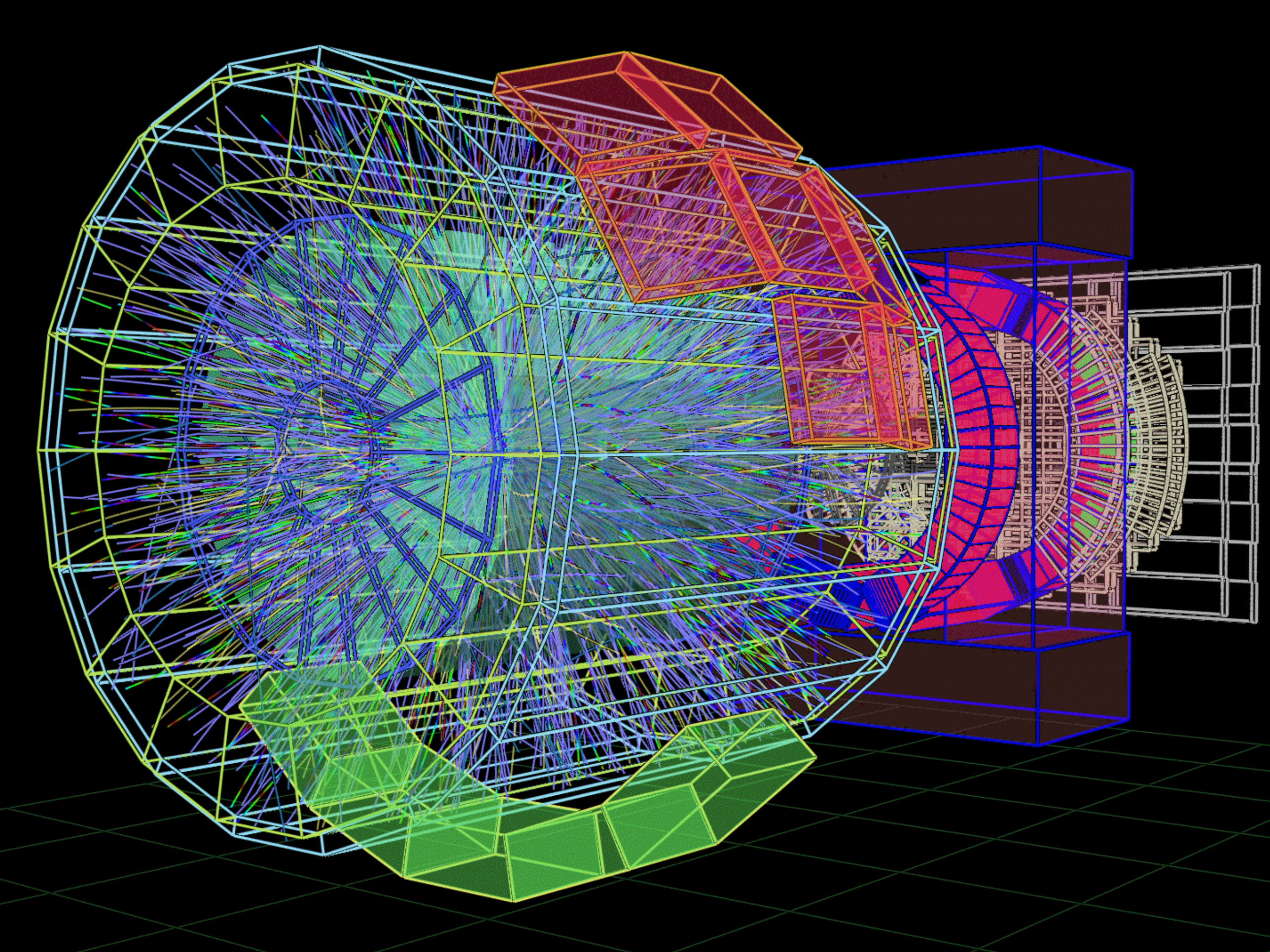
- 2 layers of Si-strip detectors
- total ≈ 2.6×10^6 strips
  - strip pitch 100 μm
- 2 outer layers of the total of 6 layers of the ITS
- built in Utrecht/Nikhef
  - together with Strasbourg, Trieste, Helsinki, Kiev/Charkov, Nantes, St. Petersburg



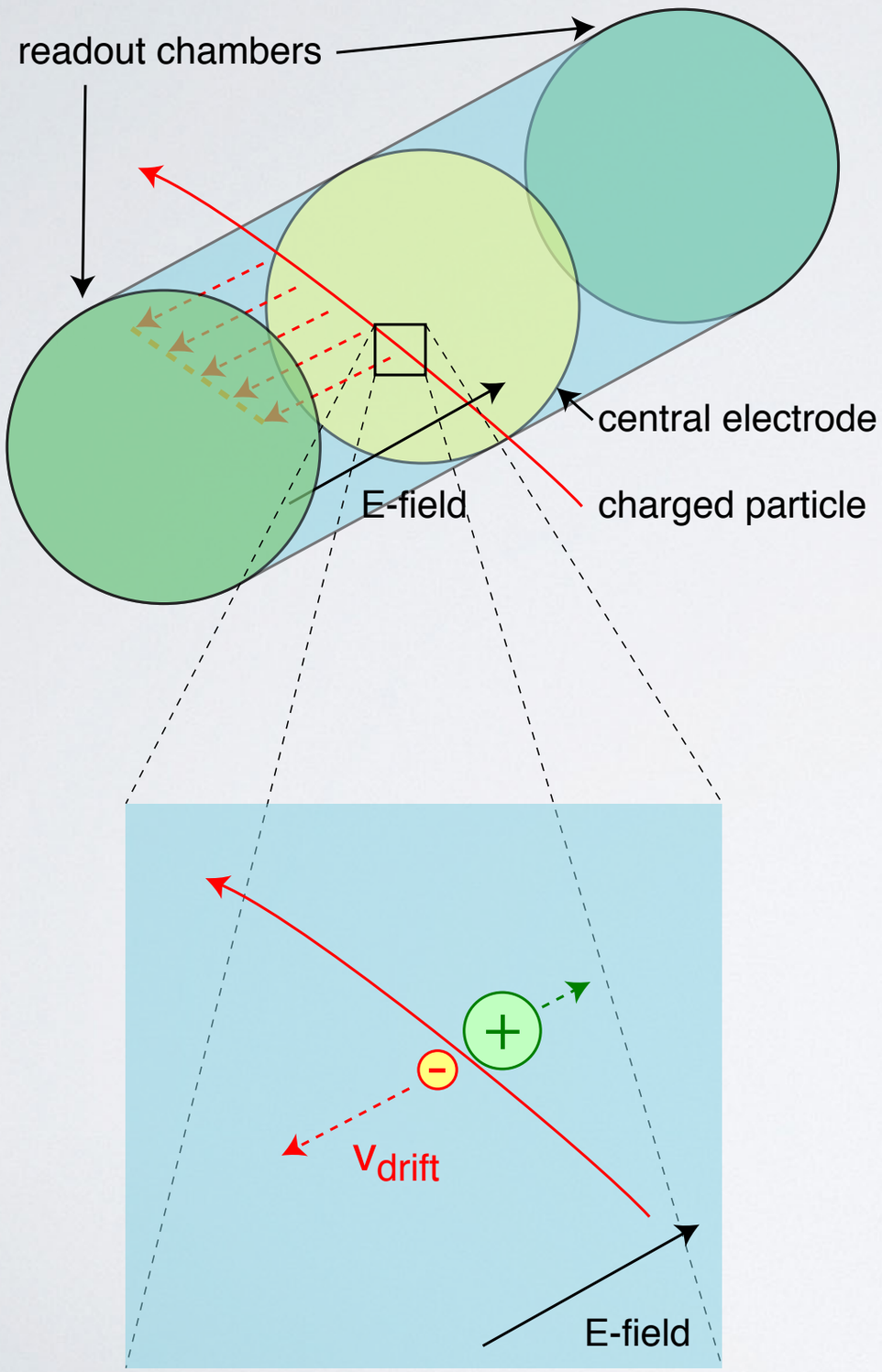
Time Projection Chamber



- large gas-filled drift volume
  - low material budget: 3.5% X_0
- continuous 3D tracking
  - x-y projected on endcaps
  - z from drift time
- good dE/dx measurement
  - up to 159 samples per track
- large data volume
  - ≈25MB/event in minbias Pb–Pb



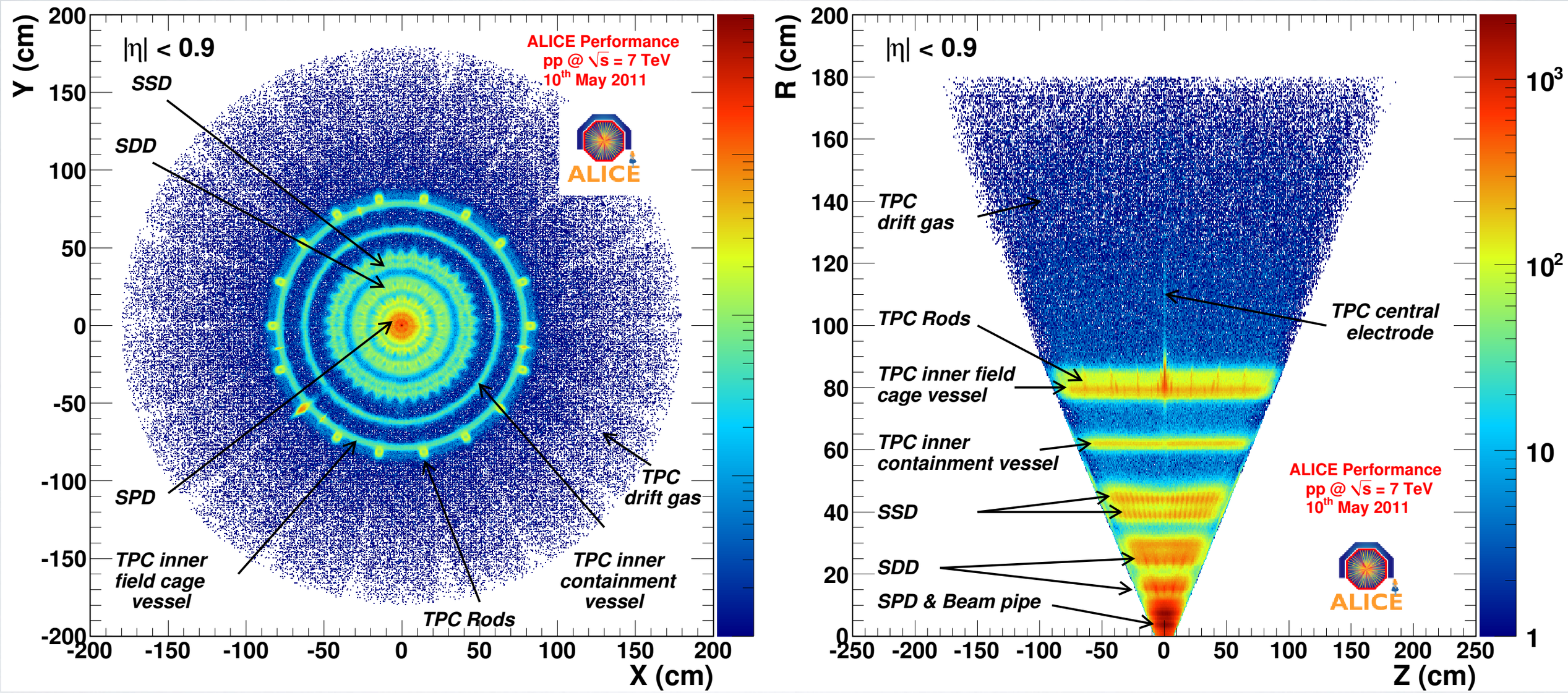
Time Projection Chamber



- E-field parallel to B-field
  - electrons drift to endcaps
  - measurement of charge by MWPC with pad readout
- disadvantages:
  - slow detector: 100μs drift time
  - risk of space charge accumulation through ions
    - gated operation of MWPC
  - needs extreme care with calibration, good knowledge of E-field

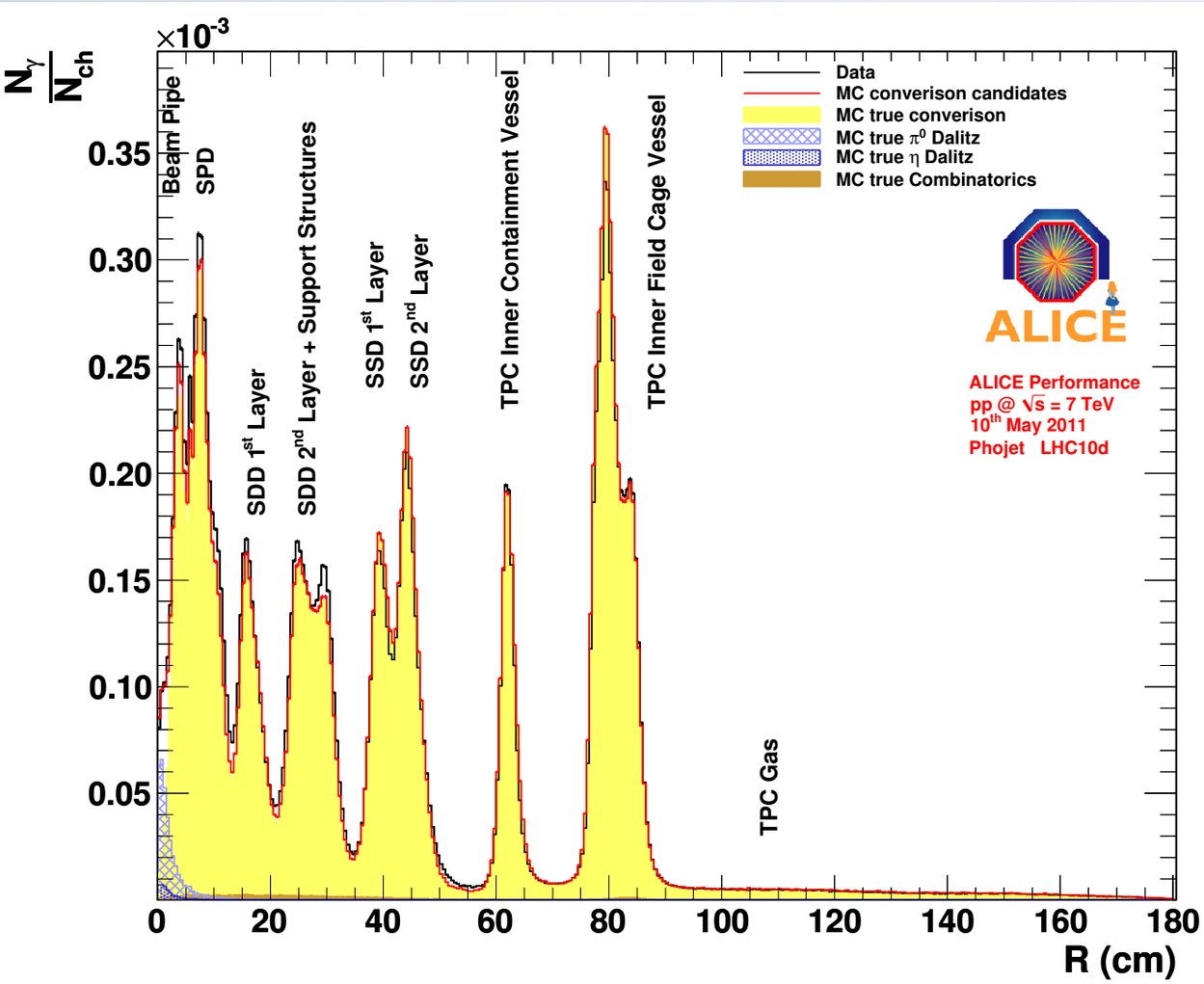
$$|\vec{E}| = 400\frac{\mathrm{V}}{\mathrm{cm}}, \quad \frac{\Delta|\vec{E}|}{|\vec{E}|} = 10^{-4}$$

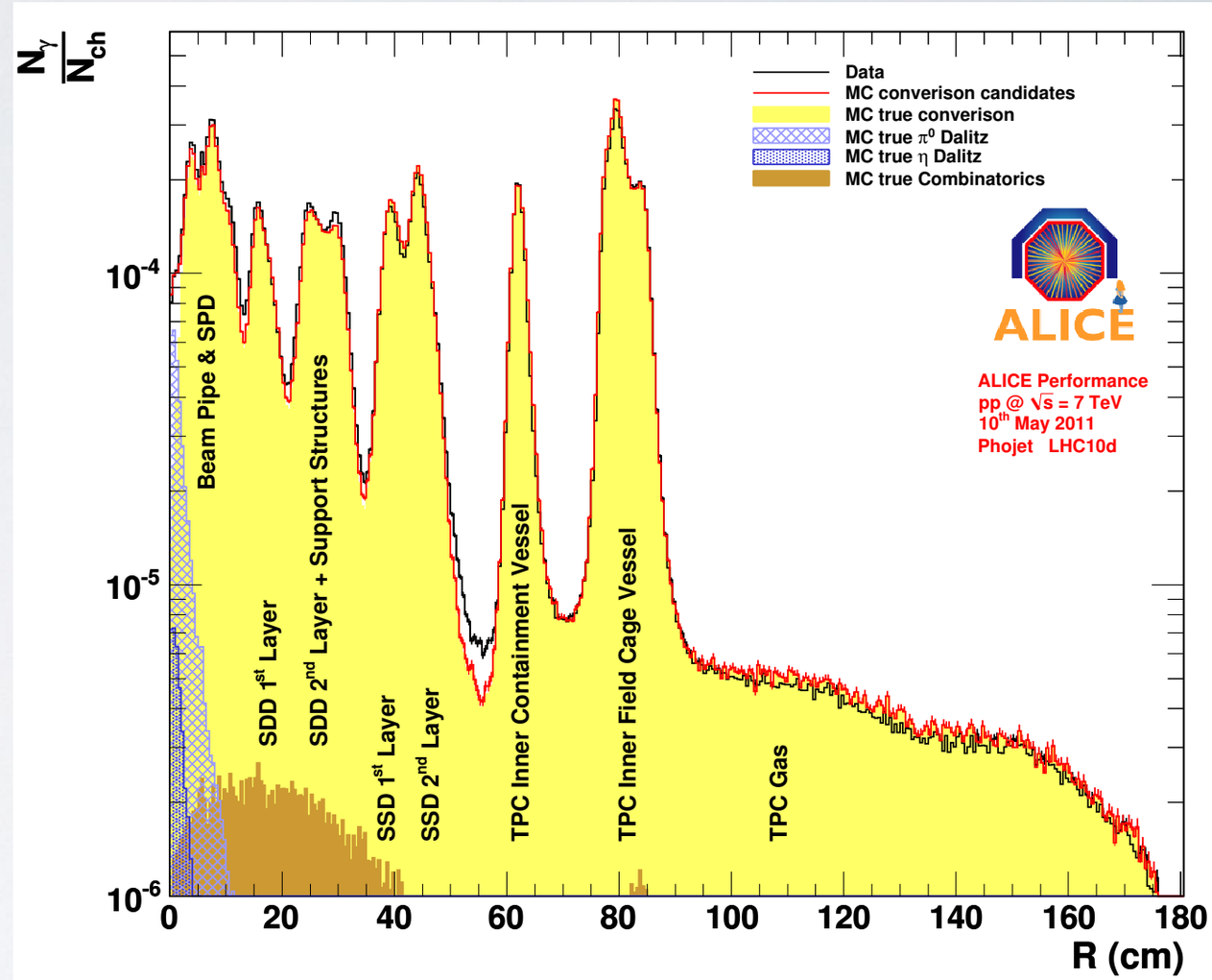
Material Budget



distribution of material can be checked with vertices of photon conversions

Material Budget

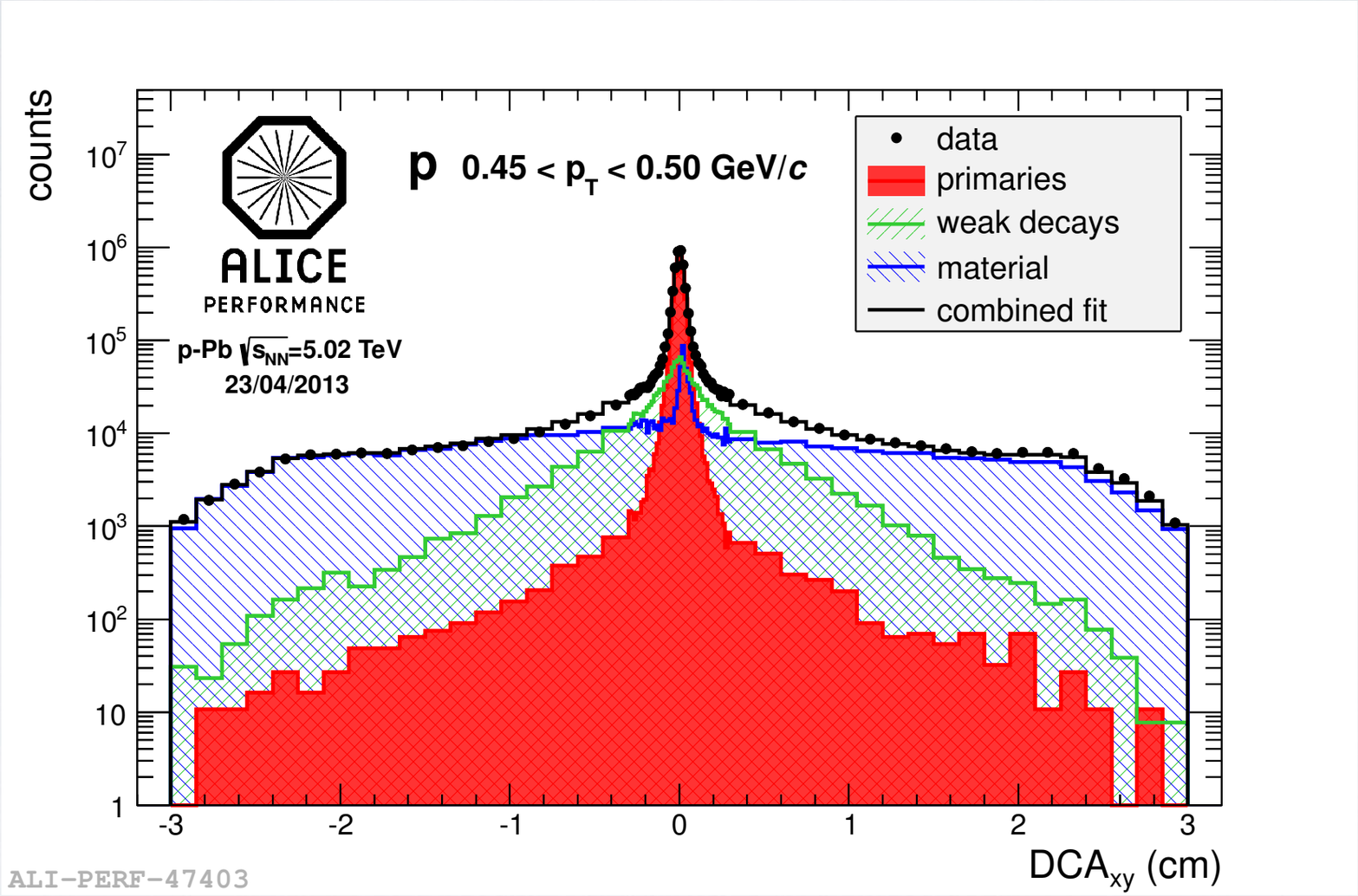




material budget well understood

total material for r < 180cm: ≈12% X_0

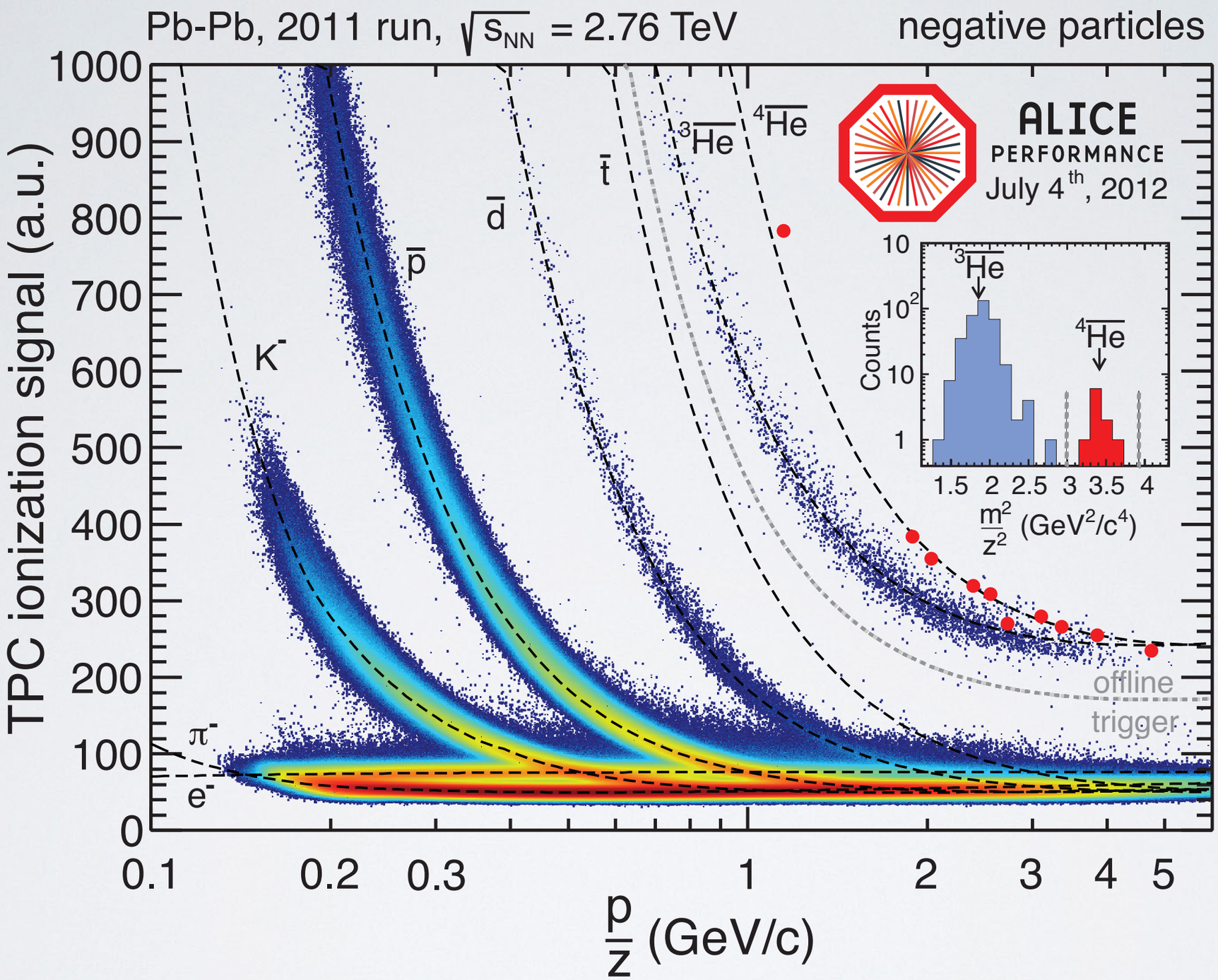
Background Rejection



- example of usage of track impact parameter:
  - large DCA for secondary protons from material
  - crucial for clean PID at low p_T

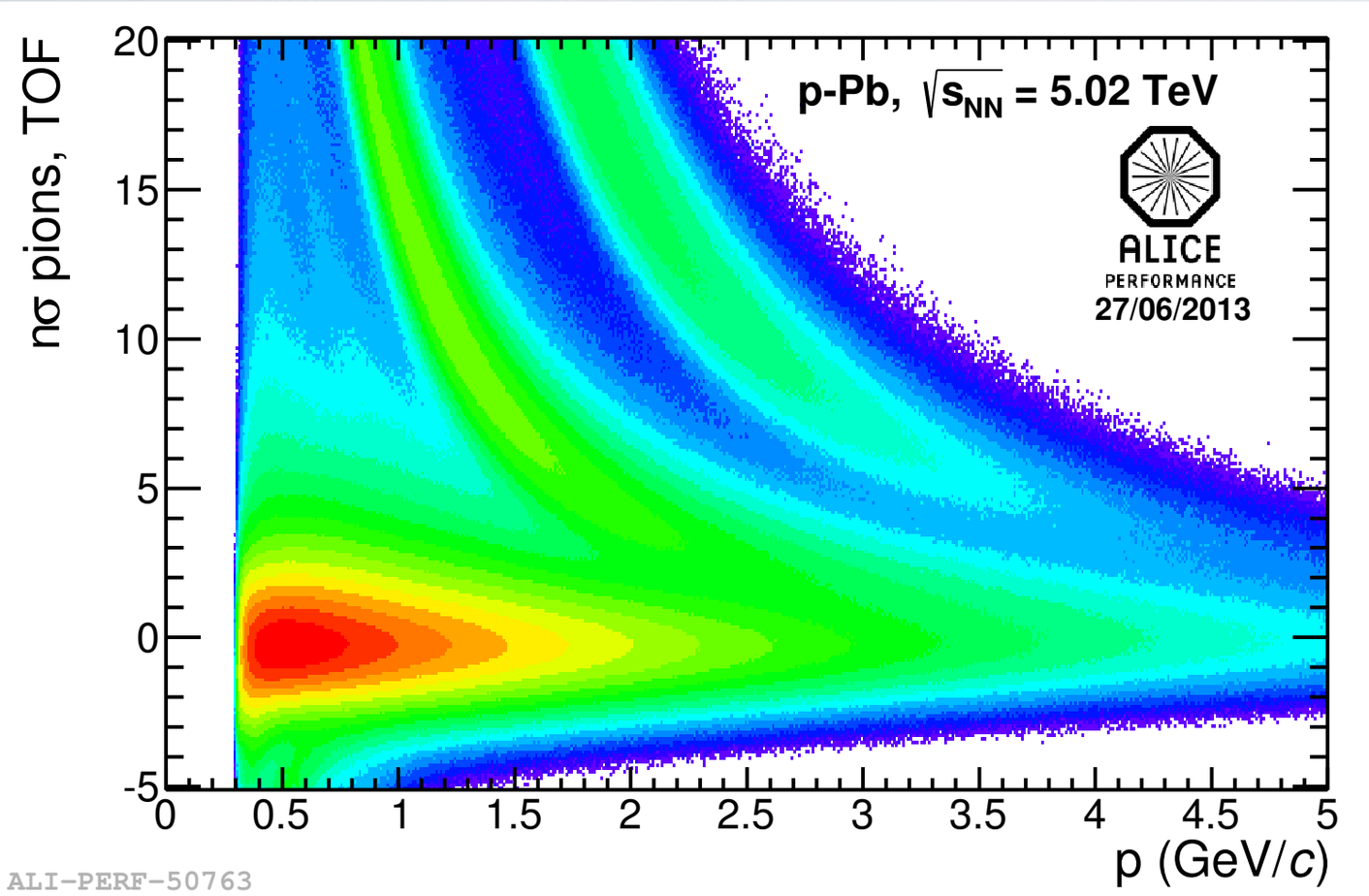
Particle Identification

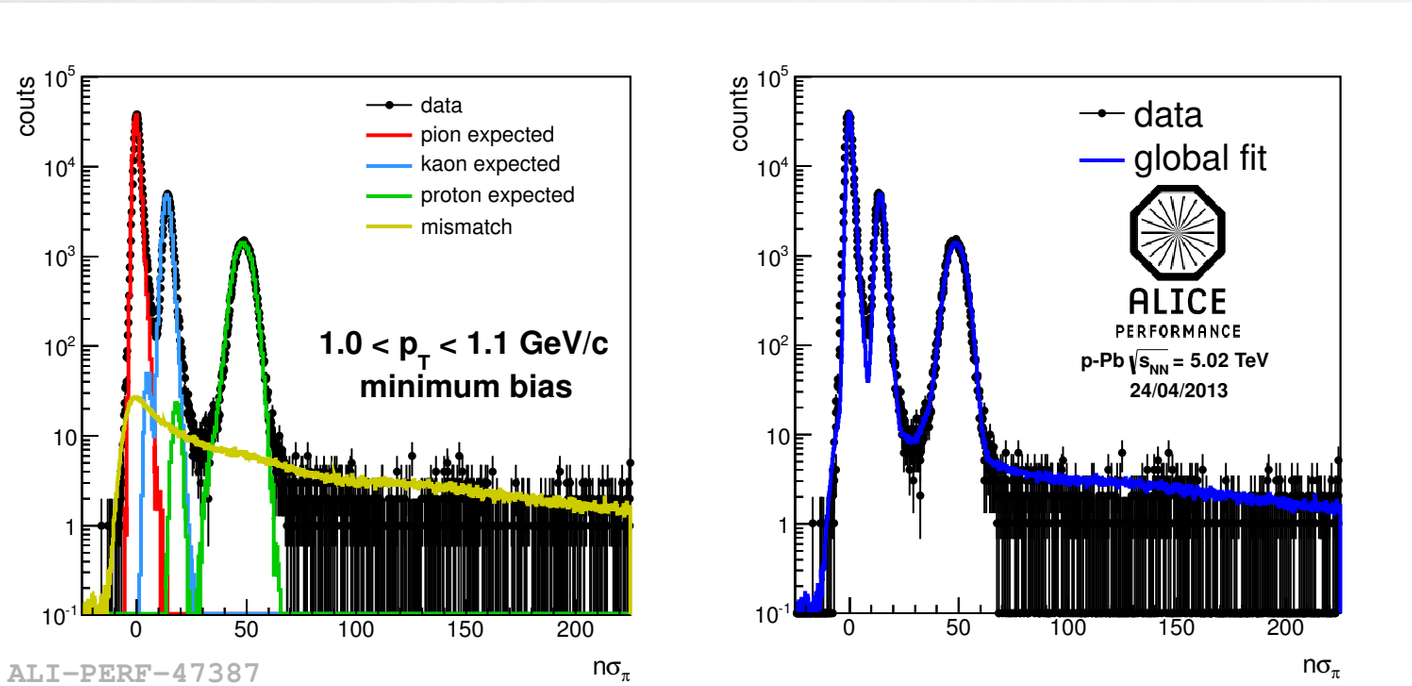
TPC dE/dx



- clear separation from specific energy loss (Bethe-Bloch) at low momentum

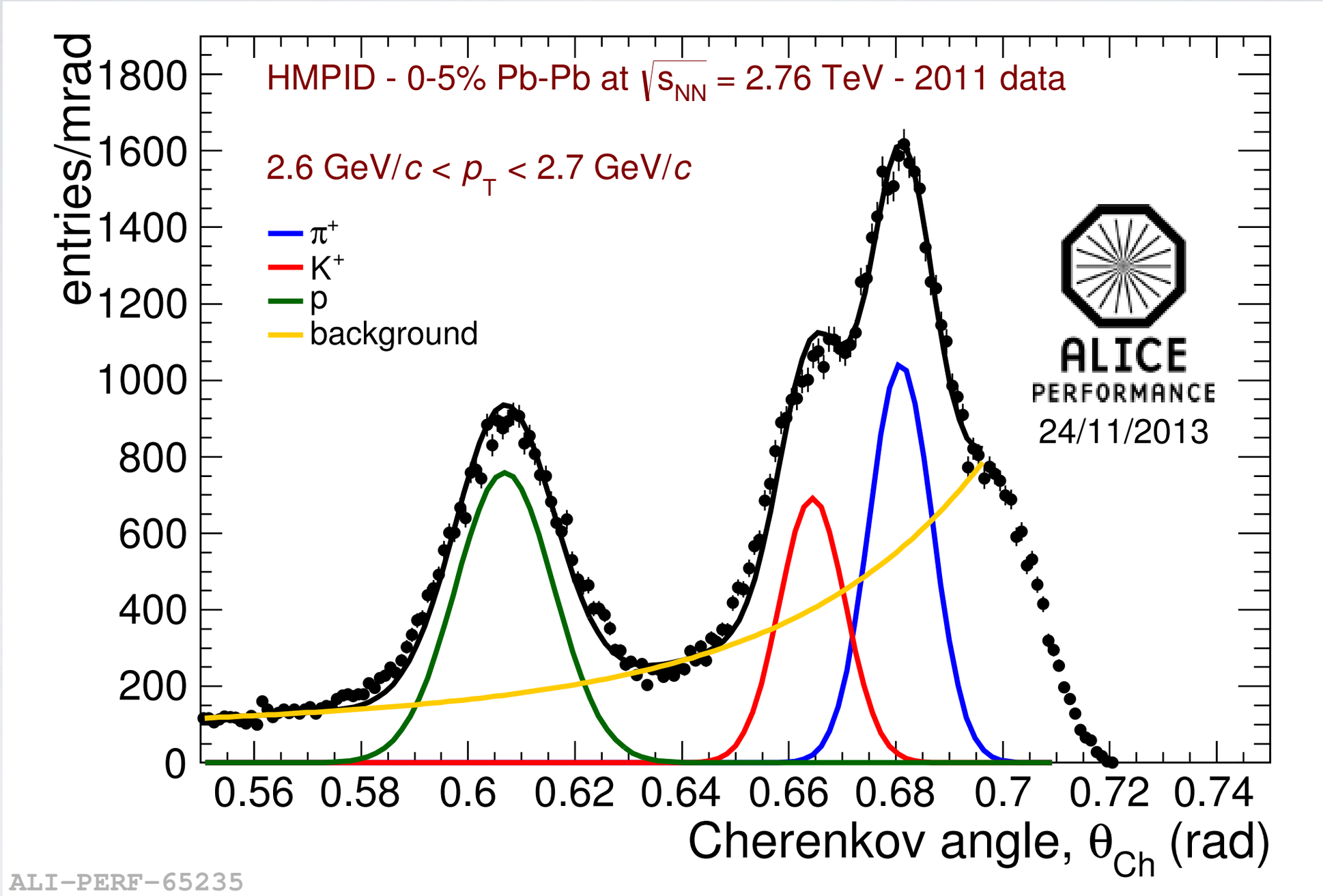
TOF PID





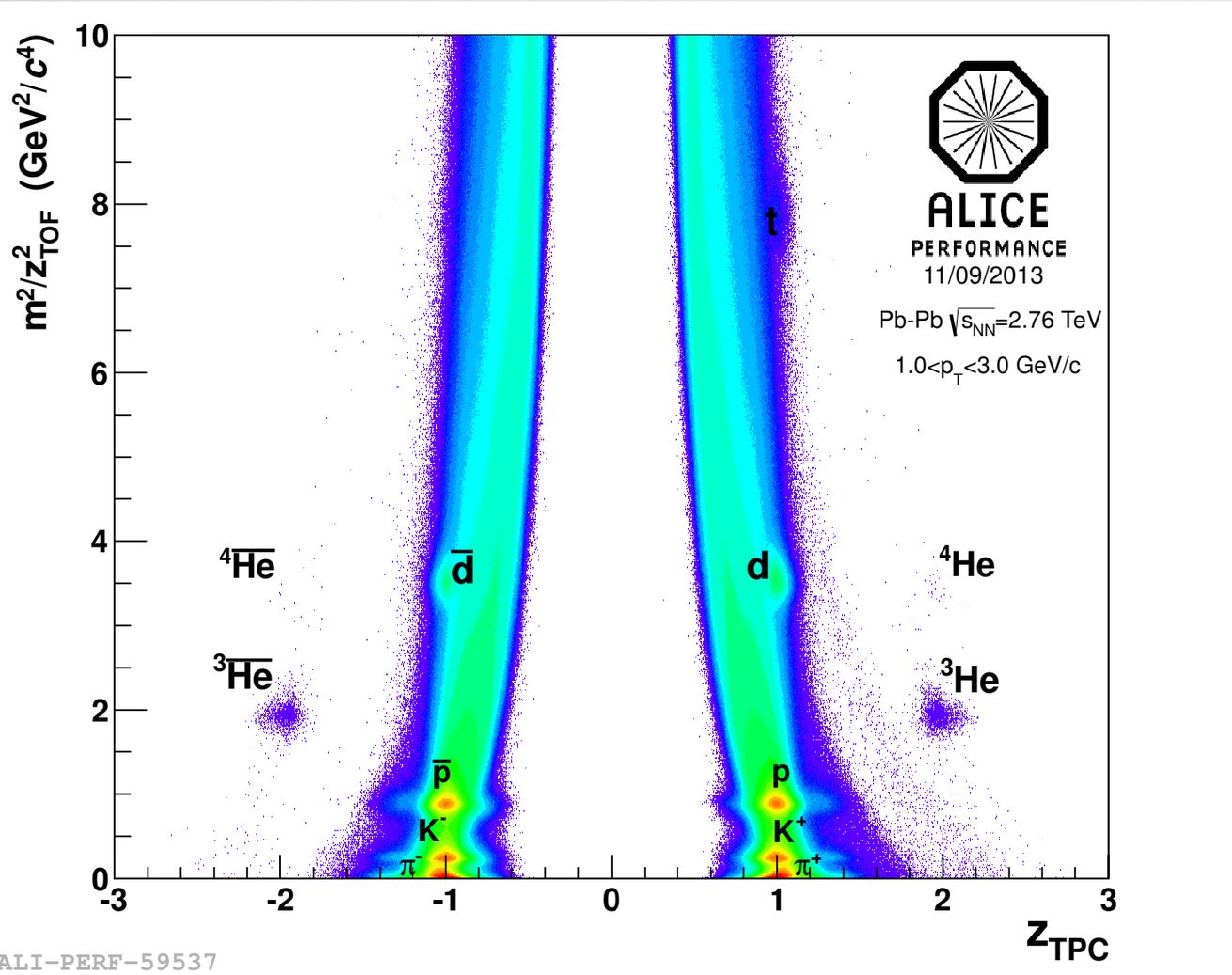
- time of flight measurement with multi-step resistive plate chambers (MRPC)
- extend momentum range of PID from TPC

HMPID PID



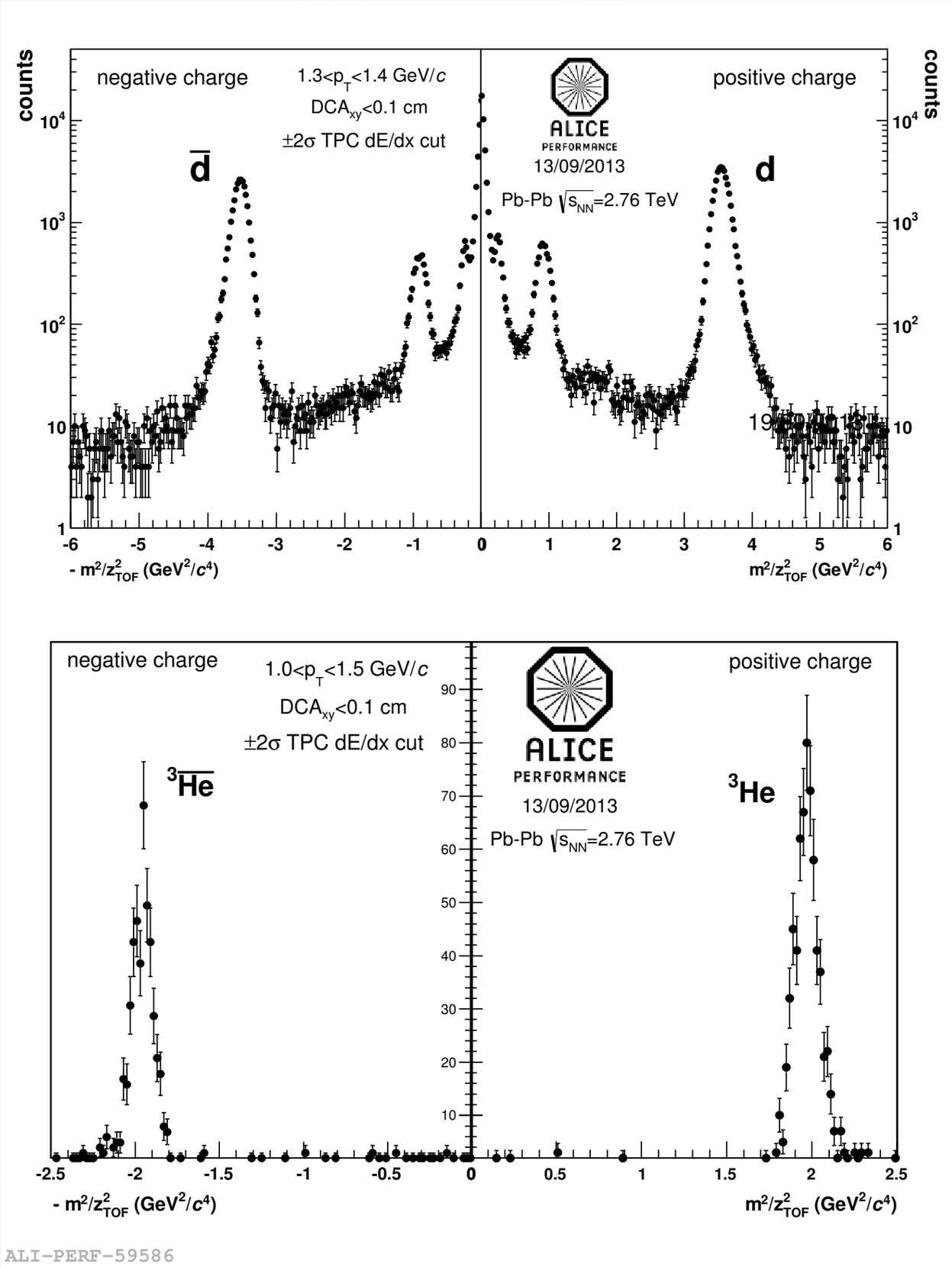
- measurement of ring diameter of Cherenkov rings
  - complementary PID at high momentum

Combined PID



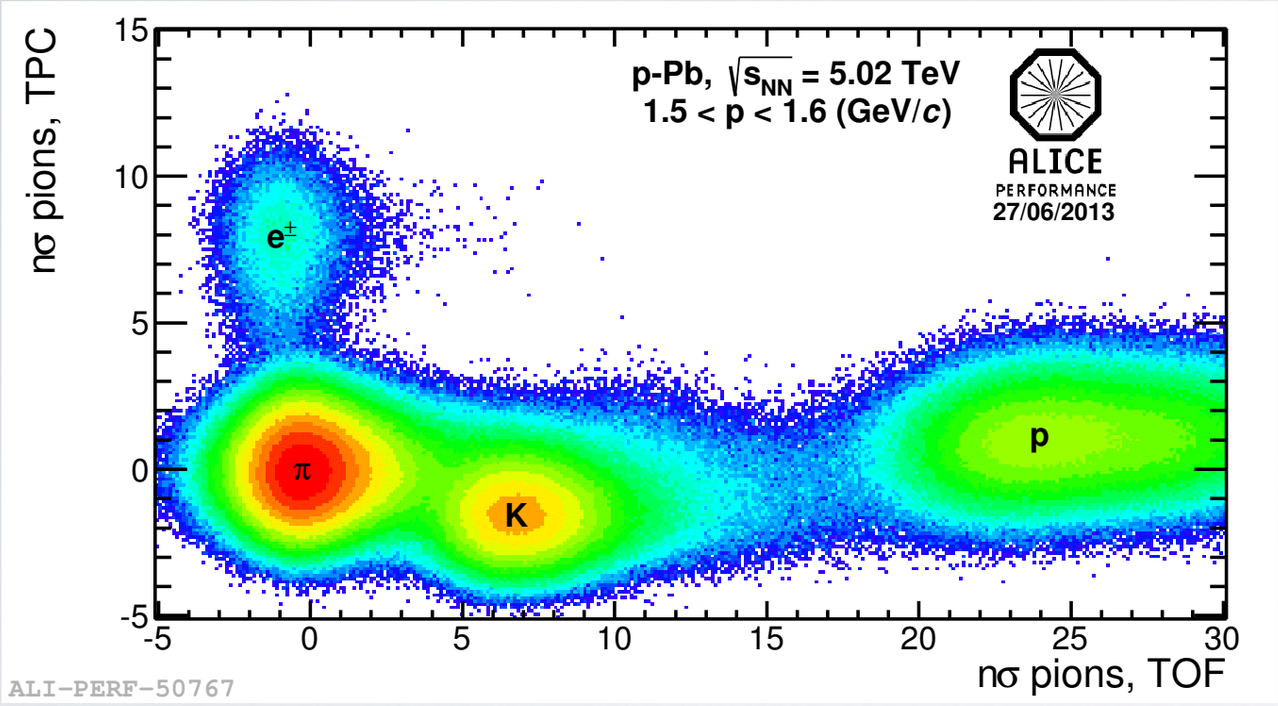
- simultaneous identification from TPC dE/dx and TOF
- very powerful for heavy (exotic) fragments
  - e.g. antinuclei, also (anti)hypernuclei

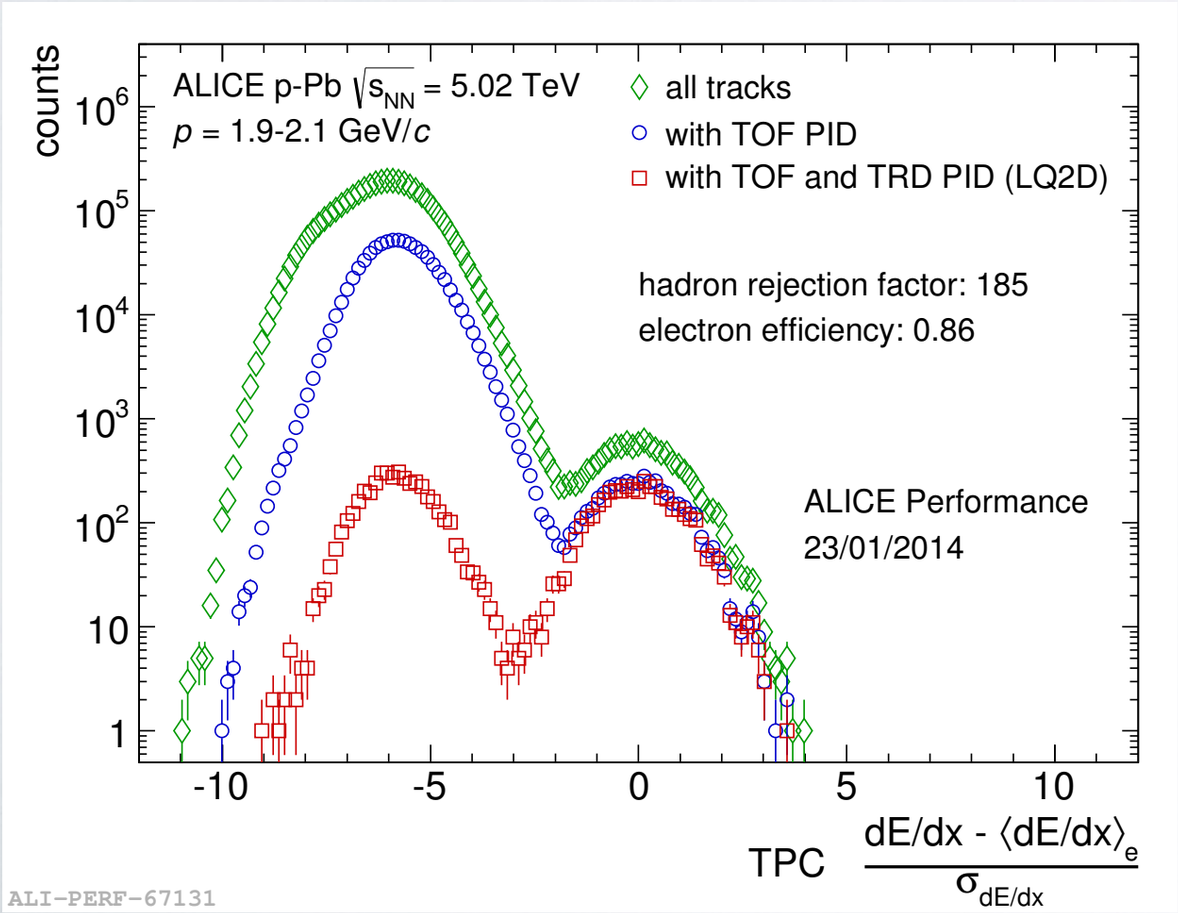
Combined PID



- simultaneous identification from TPC dE/dx and TOF
- very powerful for heavy (exotic) fragments
  - e.g. antinuclei, also (anti)hypernuclei
- heavy-ion reactions best laboratory for heavy anti- or hypernuclei
  - e.g. use for test of C-symmetry

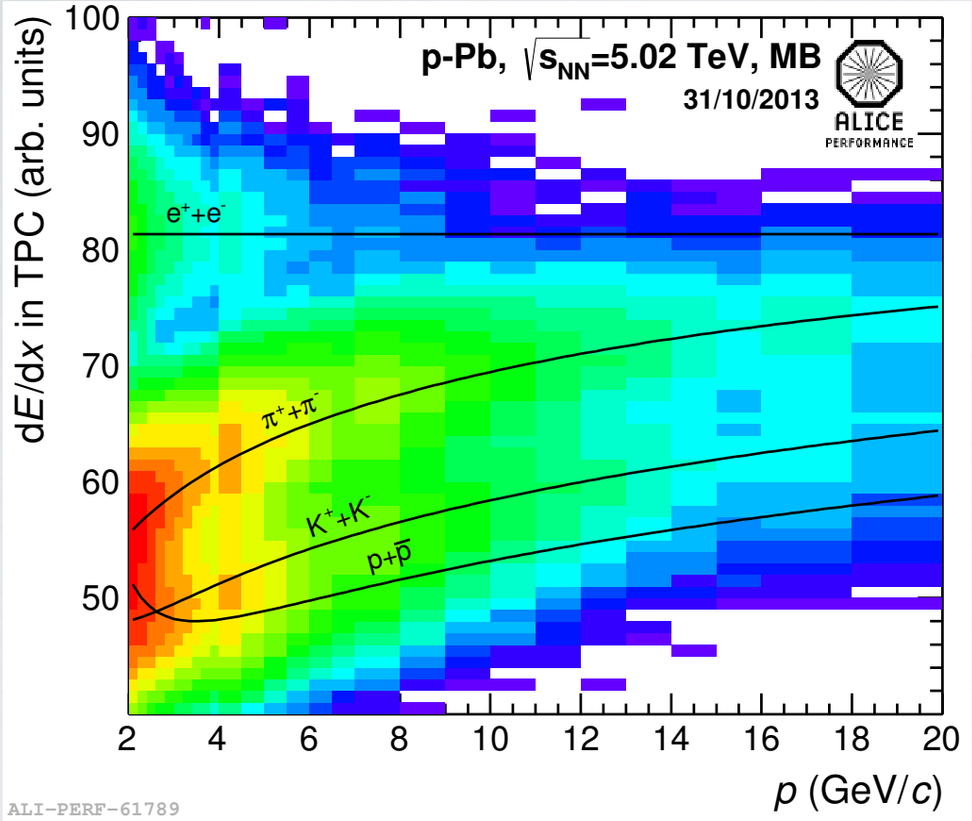
Combined PID

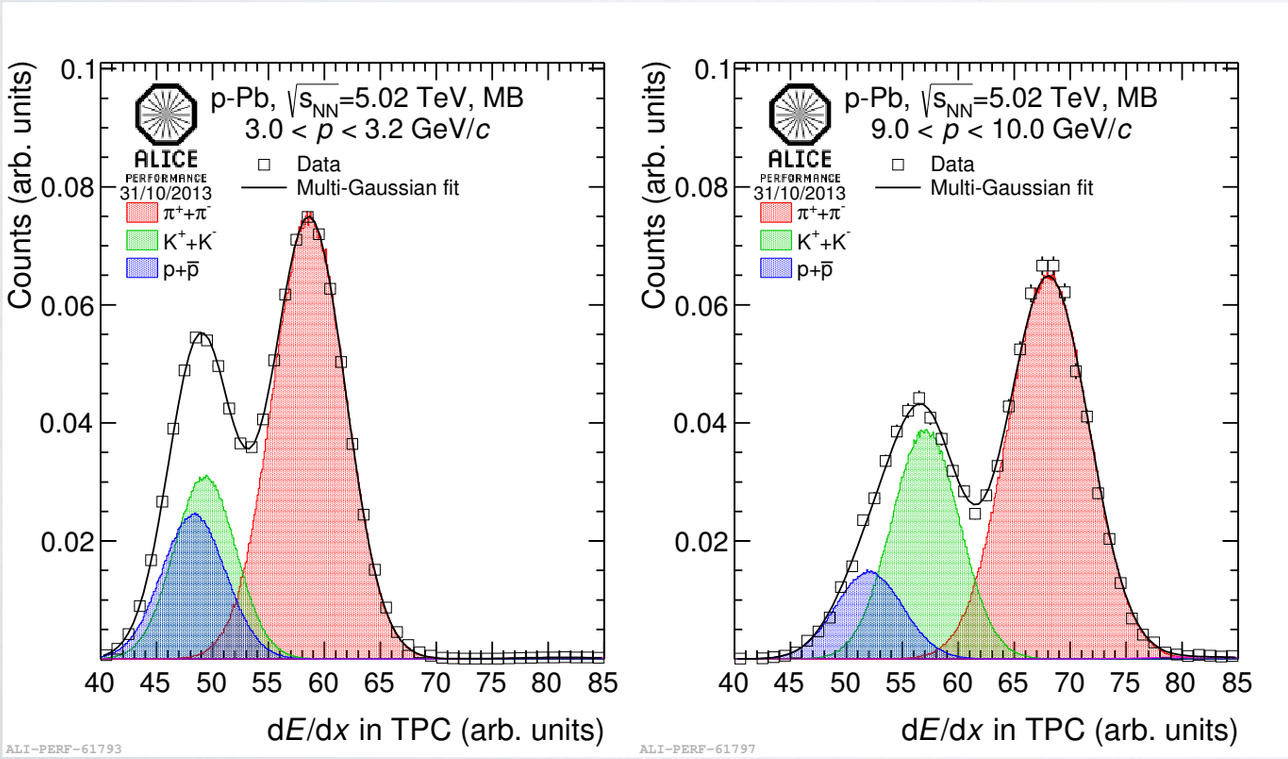




- excellent PID for hadrons
- good PID also for electrons at low p_T
  - here only TPC, no discrimination power from TOF
- further improvement possible from TRD
  - detector completed only in recent shutdown

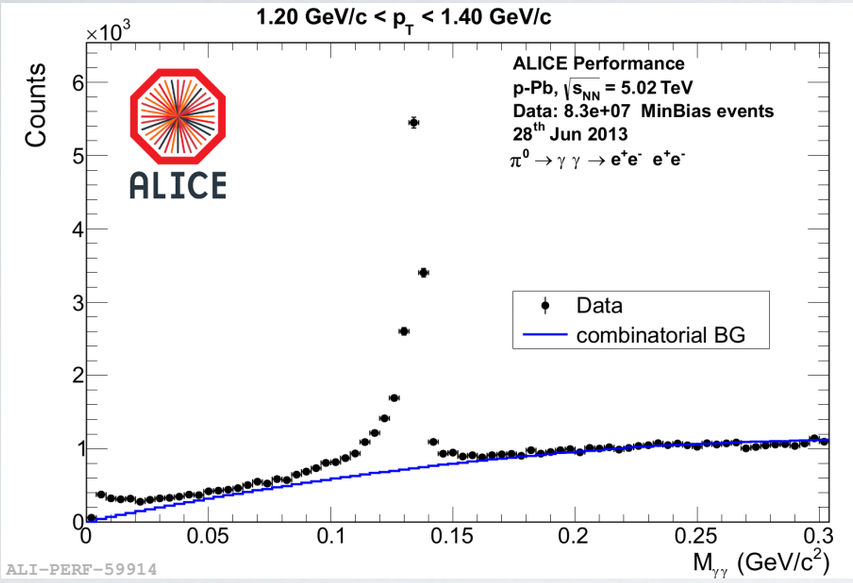
Limits of PID

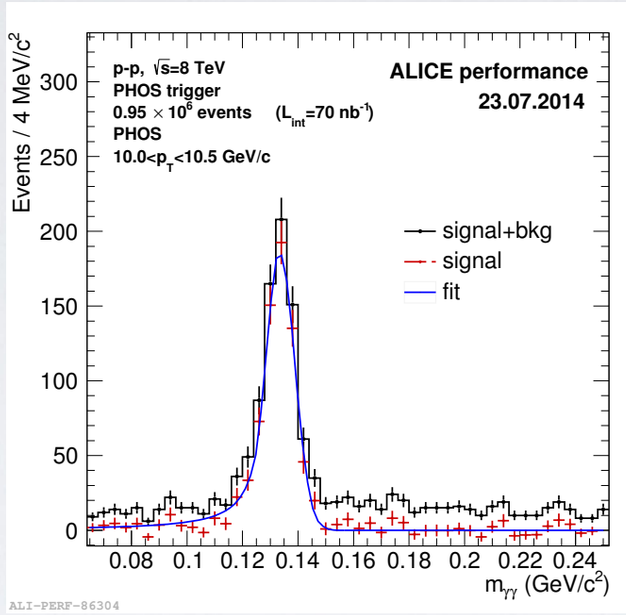


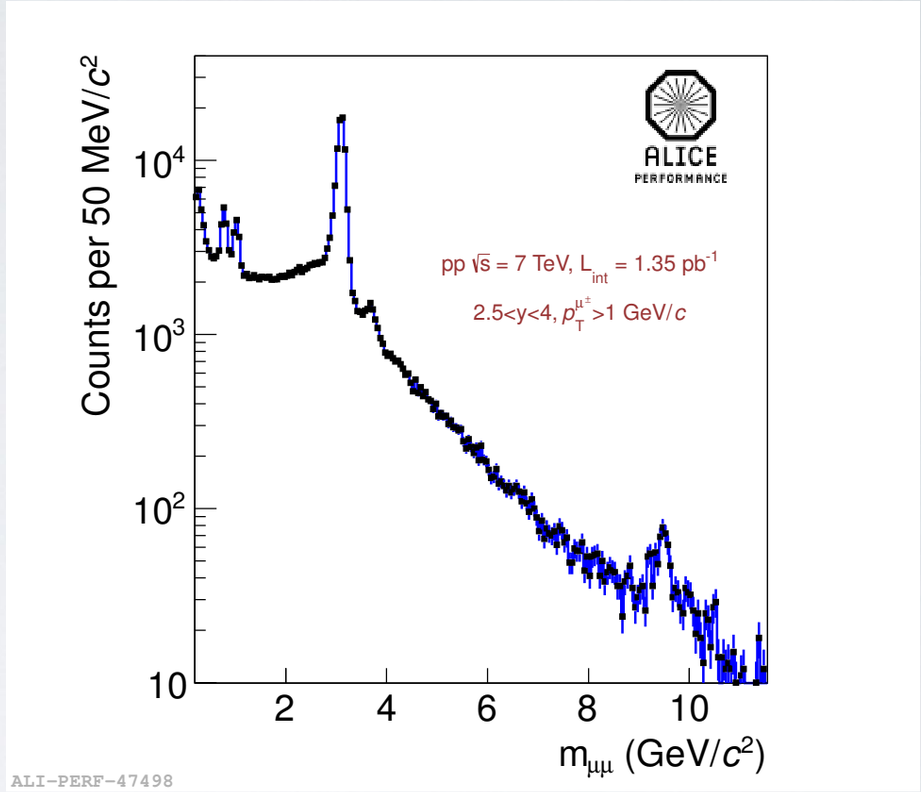


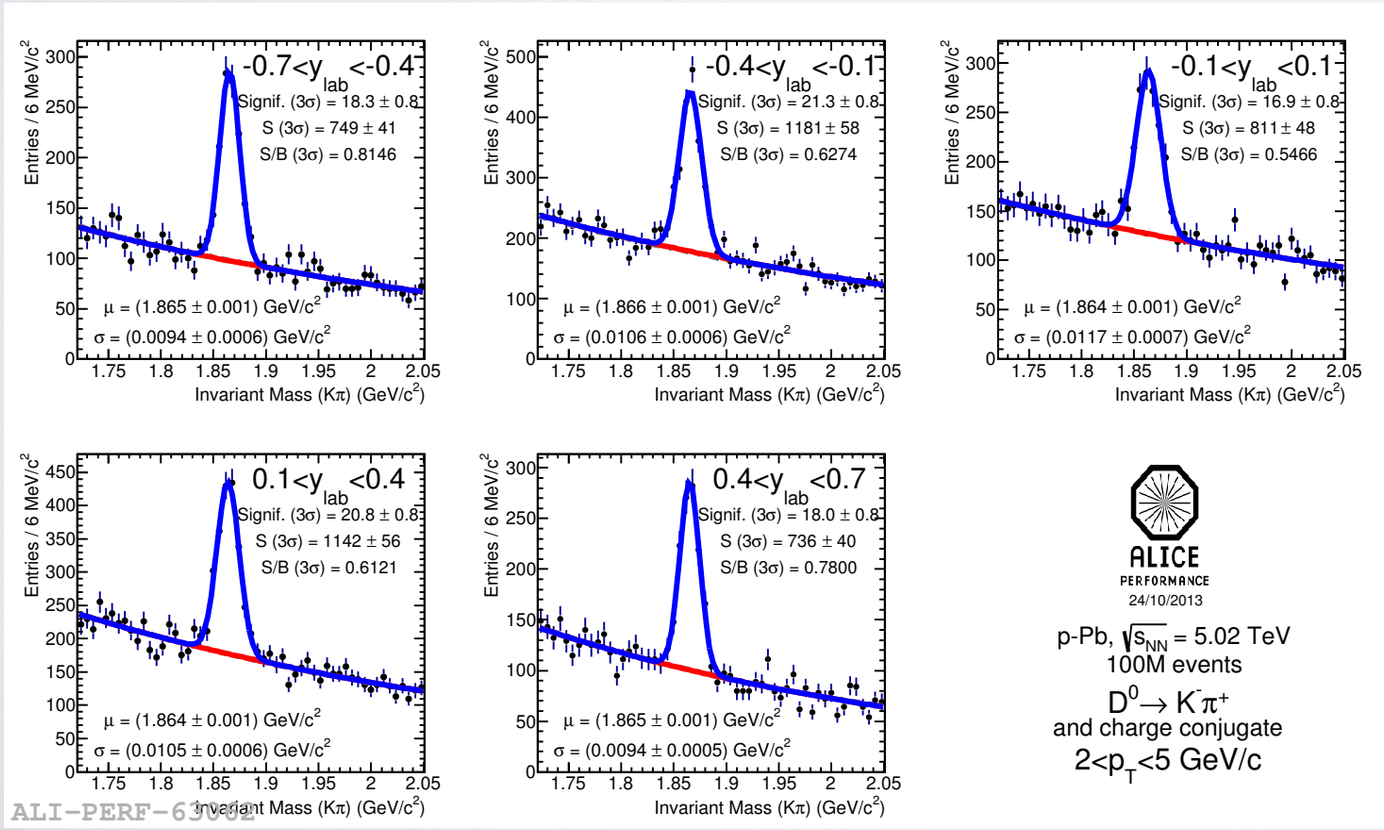
- hadron PID at high p_T
  - TOF not useful
  - dE/dx in TPC: relativistic rise
    - PID of pions possible
    - other hadrons (K,p): statistical PID

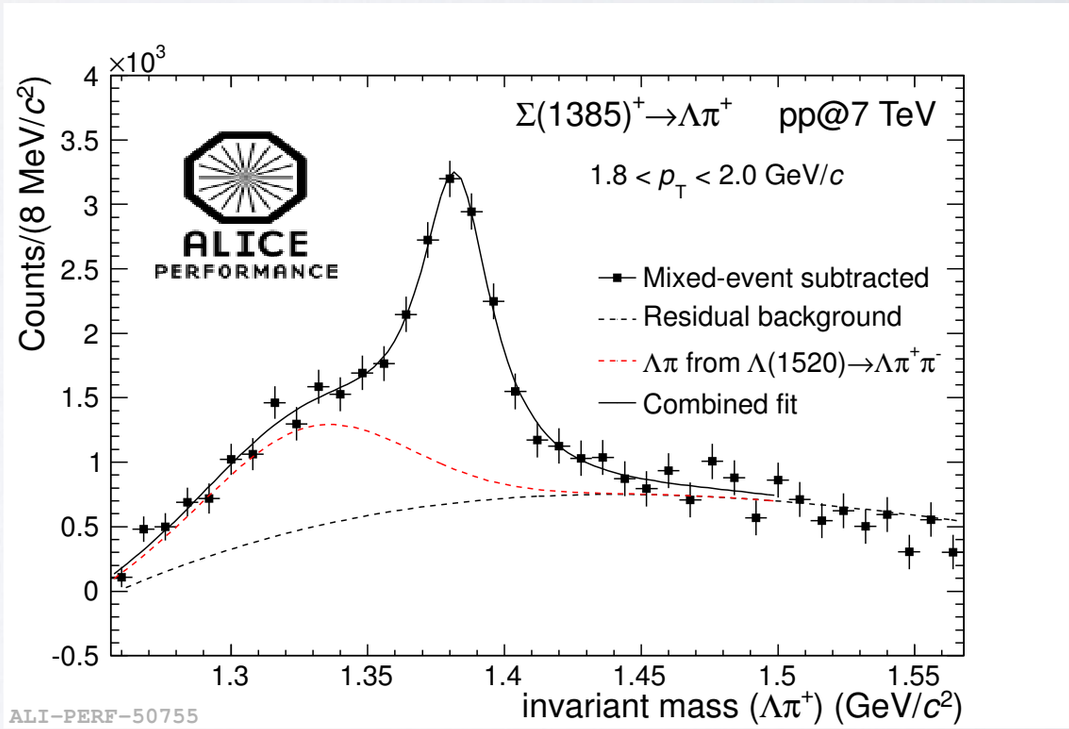
Other Examples of PID











Summary

- ALICE detector optimised for low p_T probes and particle identification
  - low material budget
  - good and redundant PID for hadrons
- detector philosophy implies
  - limited acceptance
  - low event rate (but high data rate to tape!)
  - significant fraction of non-triggered running