

Experiment TOTEM na LHC v CERN



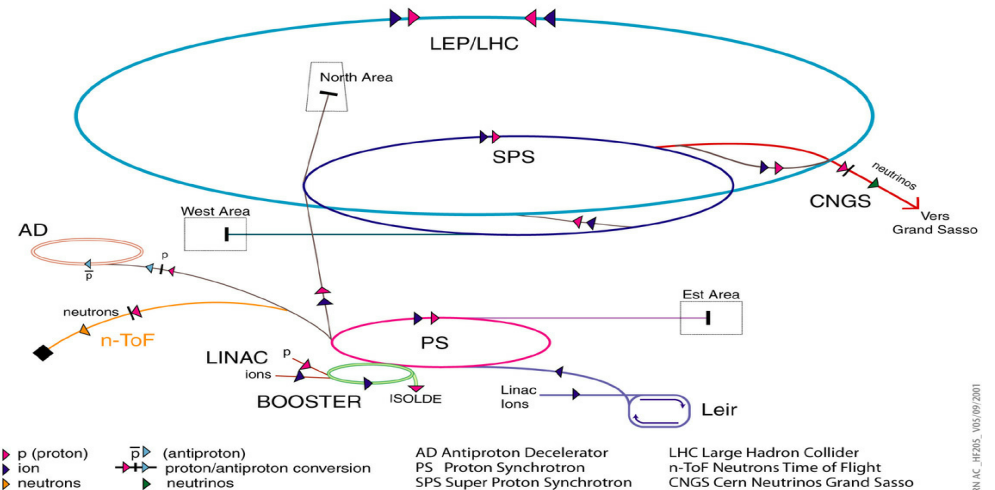
V. Kundrát, Fyzikální ústav AVČR, v.v.i.

CERN Ženeva



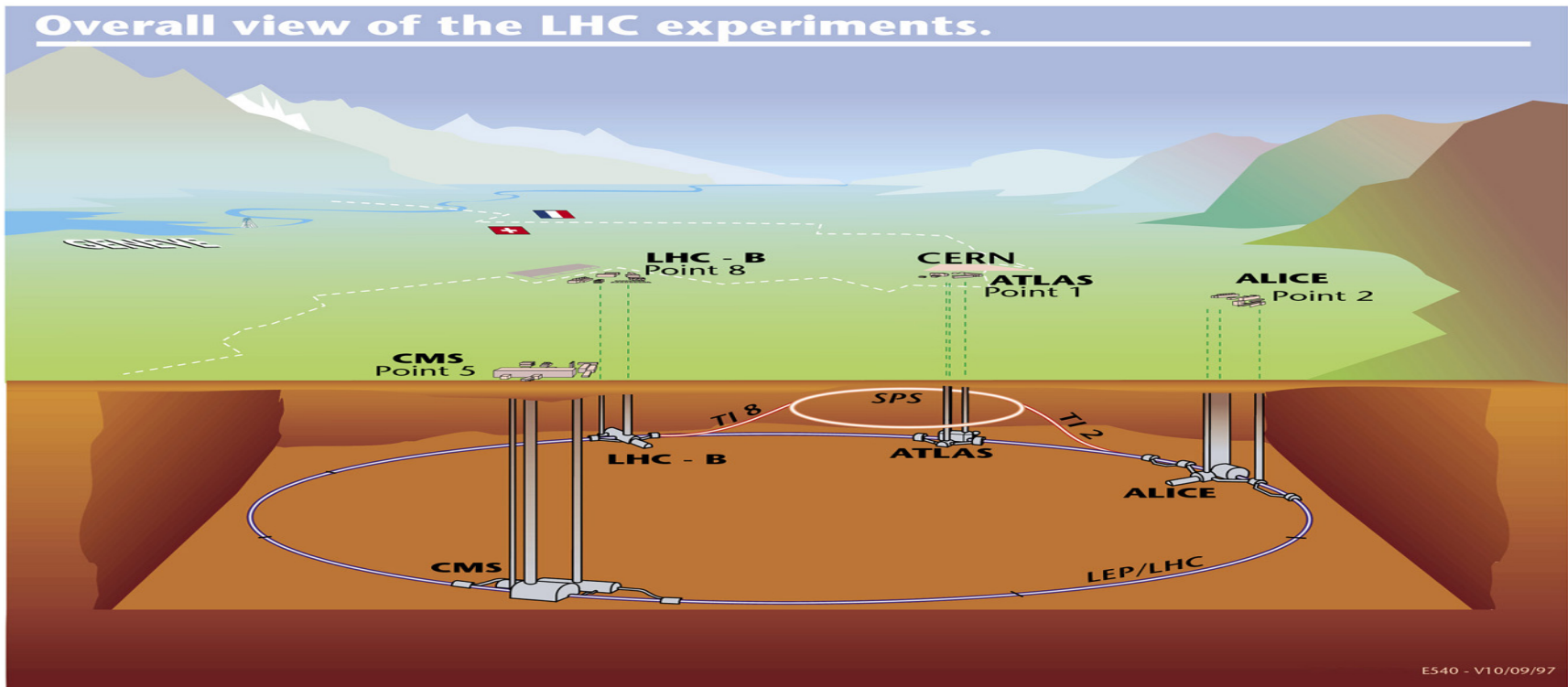
- největší centrum částicové fyziky
- ~ až 4.000 lidí

Accelerator chain of CERN (operating or approved projects)



Experimenty na LHC (Large Hadron Collider)

- ATLAS, CMS, LHCb, ALICE, TOTEM, LHCf (účast ČR ...podtržení)
- obvod urychlovače 27 km



LHC tunel



- pp srážky při energii 14 TeV
- 2808 shluků; každý má 1.15×10^{11} protonů
- 1232 supravodivých dipól. magnetů (1.9 K, 8.33 Te, 11850 A, 27.5 t, 16.5 m, 500 kCHF)
- celkem asi 10^4 magnetů (dipólových, fokusačních)
- vakuum 10^{-10} Torr, isolační - kryomagnety (9000 m^3) a rozvod kapal. helia (5000 m^3), vakuum trubic LHC

Program experimentu TOTEM

(Total Cross Section, Elastic Scattering and Diffraction Dissociation at the LHC)

- pružný rozptyl protonů na protonech: určit totální účinný průřez, luminositu a diferenciální účinný průřez pp rozptylu při energii až 14 TeV
- studium difrakčně produkčních procesů (kanálů) v pp rozptylu při energii až 14 TeV (málo probádaná oblast)

odtud:

- určit totální, elastickou a inelastickou profilovou funkci a stanovit střední hodnoty kvadrátů totálního, elastického a inelastického srážkového parametru – hodnot charakterizujících dosah silných interakcí zodpovědných za totální, elastický a inelastický rozptyl

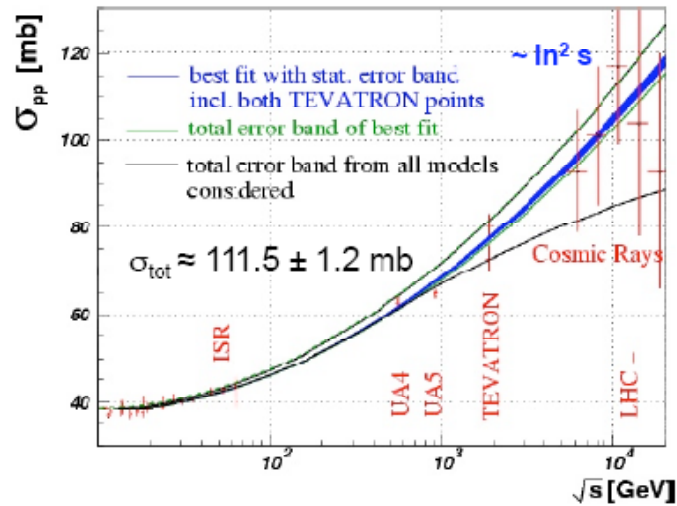
nutno:

- detekovat protony rozptýlené pod velmi malými úhly ... pouze několik mm od osy urychlovače uvnitř trubic LHC na vzdálenostech stovek m od interakčního bodu; detektory „Roman pots“ („římské hrnce“) ... pružný a difrakčně produkční procesy; 147 a 220 m od IP5
- částice rozptýlené do všech směrů (totální účinný průřez) ... teleskopy T1, T2 (uvnitř systému CMS; vzdálenost 10.5 a 14 m od IP5)

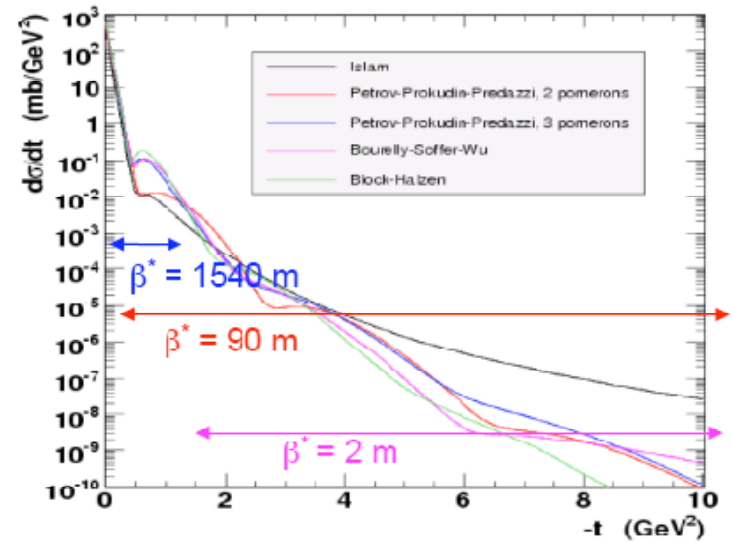


TOTEM Physics

Total cross-section



Elastic Scattering

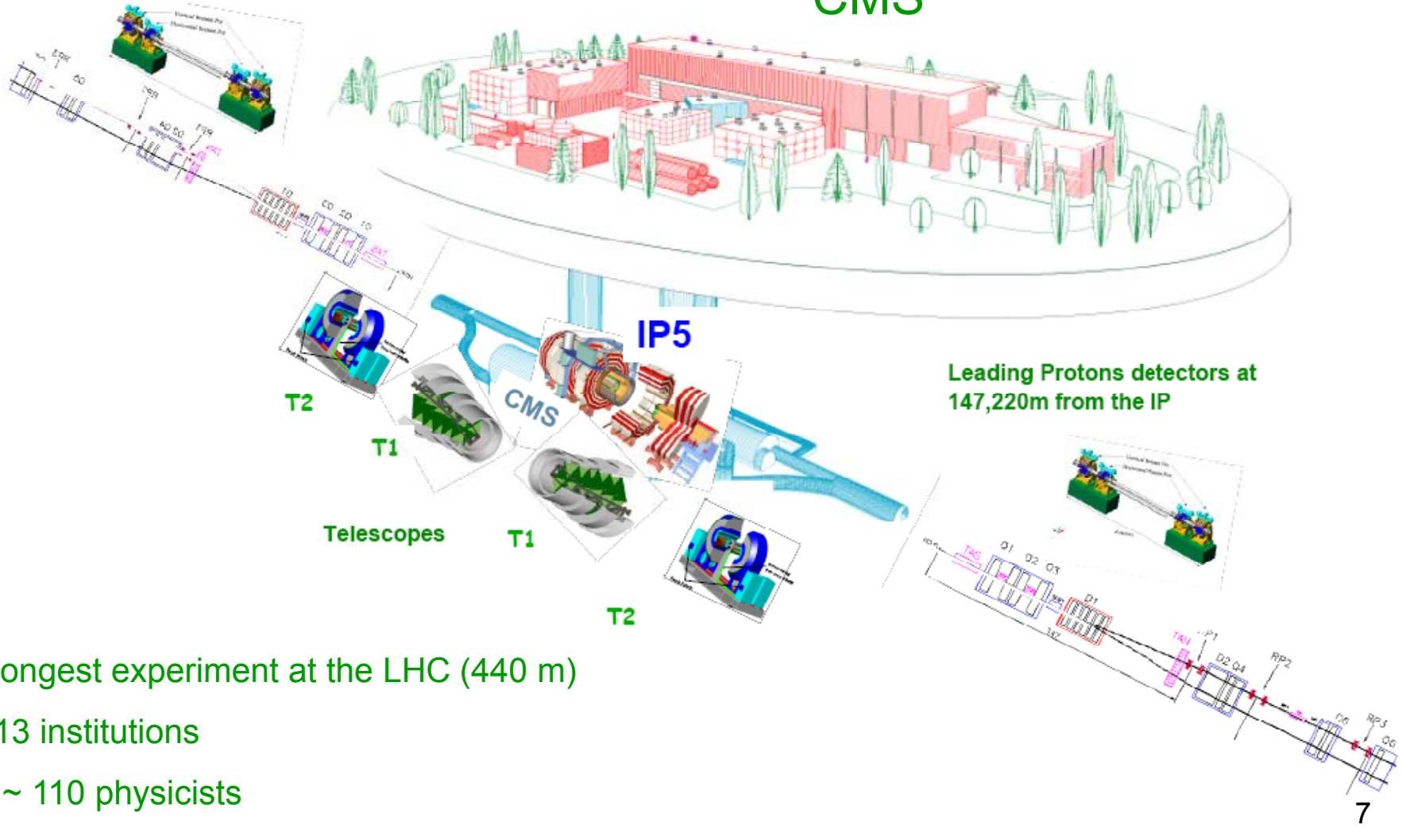




Experimental Layout

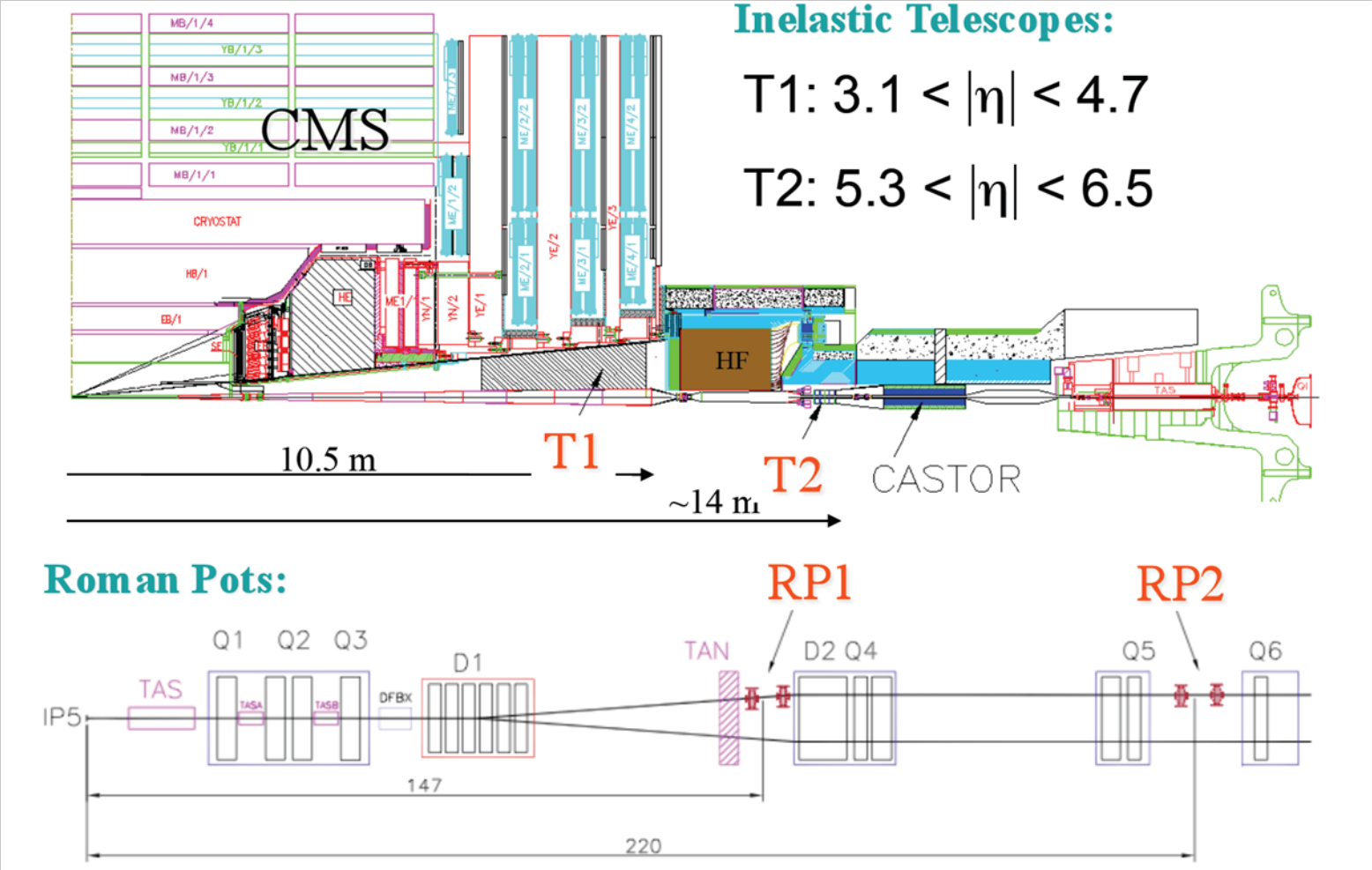
Leading Protons detectors at 147,220m from the IP

CMS

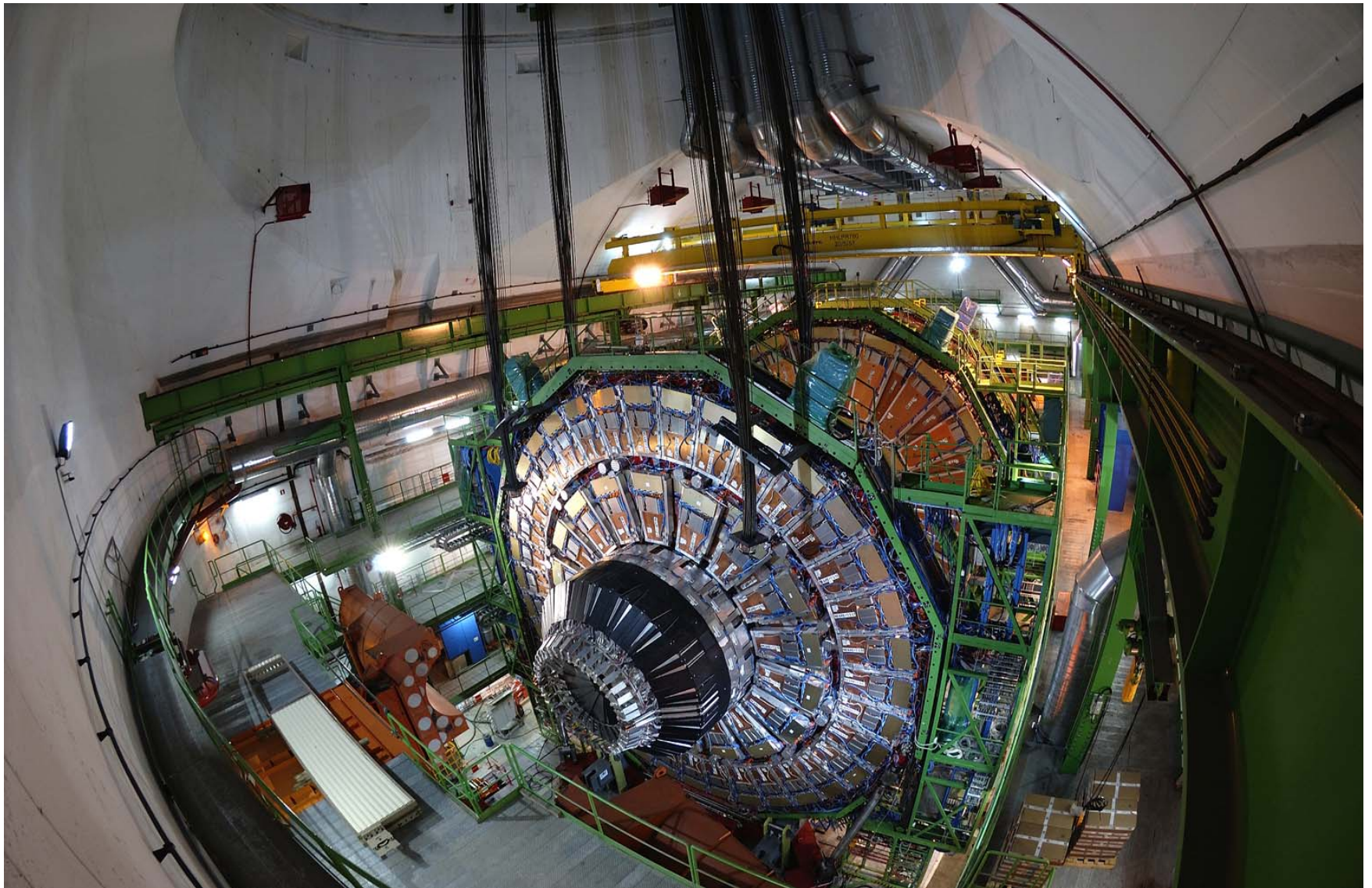


- longest experiment at the LHC (440 m)
- 13 institutions
- ~ 110 physicists

Experiment TOTEM

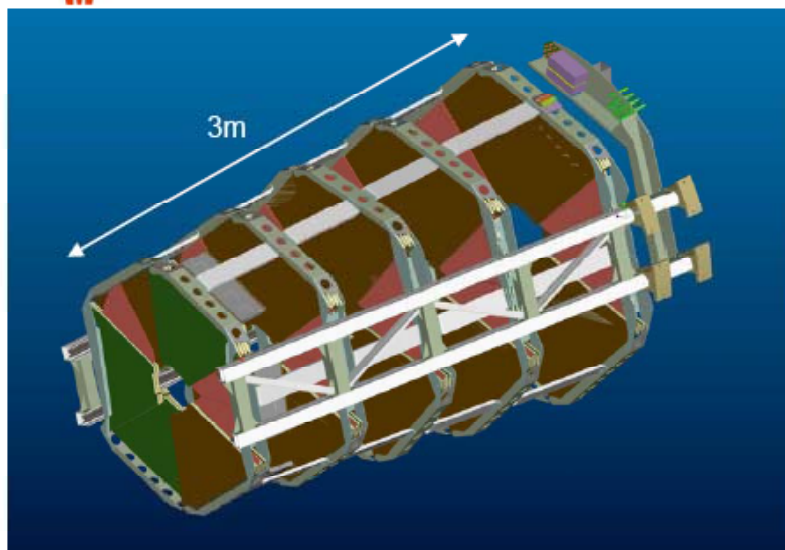


Detektor CMS (Central Muon Solenoid, 15x15x21m, 12500 t)

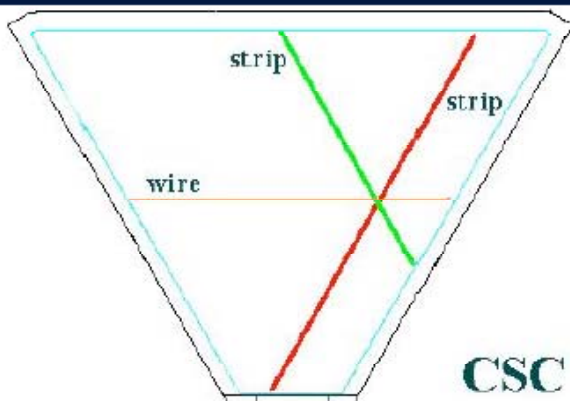




The T1 Telescope



- Cathode Strip Chambers (CSC)
- $3.1 < |\eta| < 4.7$
- 5 planes with measurement of 3 coordinates per plane
- 3 deg rotation and overlap between adjacent planes
- Primary vertex reconstruction allows background rejection
- Trigger with anode wires





The T1 CSC chambers

Production at Gatchina (PNPI): 70 CSCs

Test and assembly done at CERN

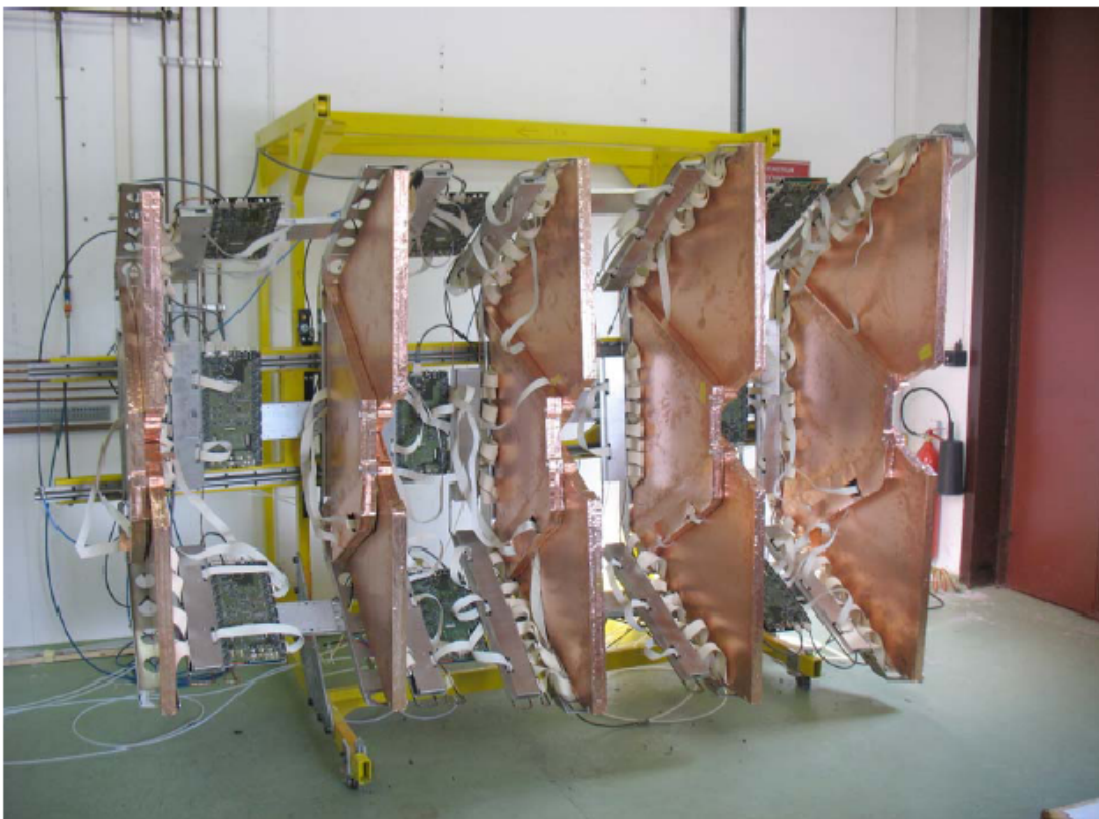




1/4 T1 Telescope complete with CSC chambers

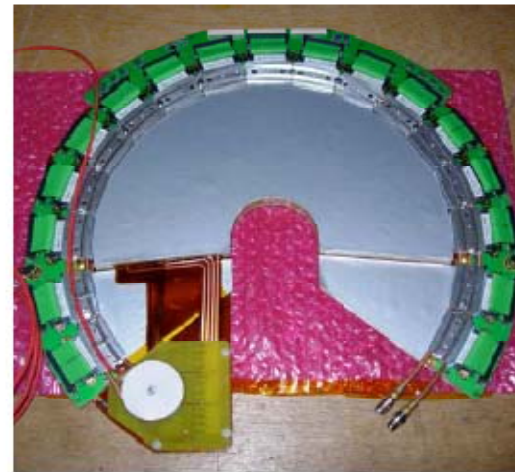
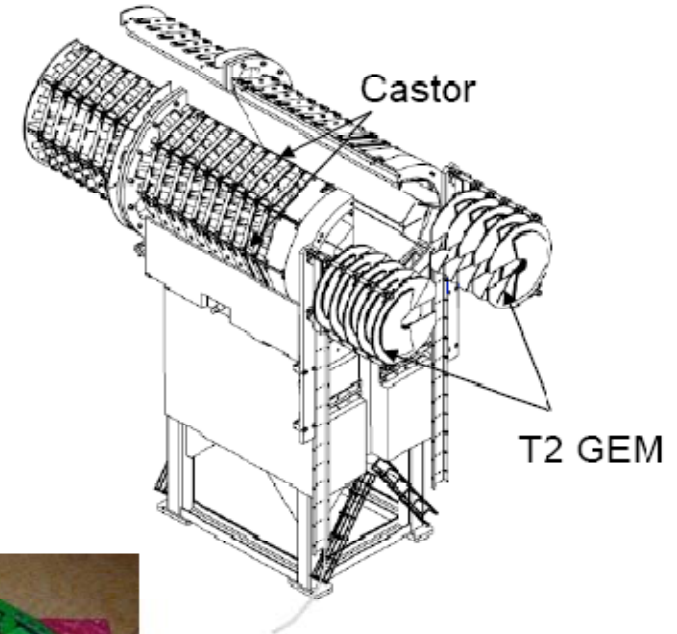
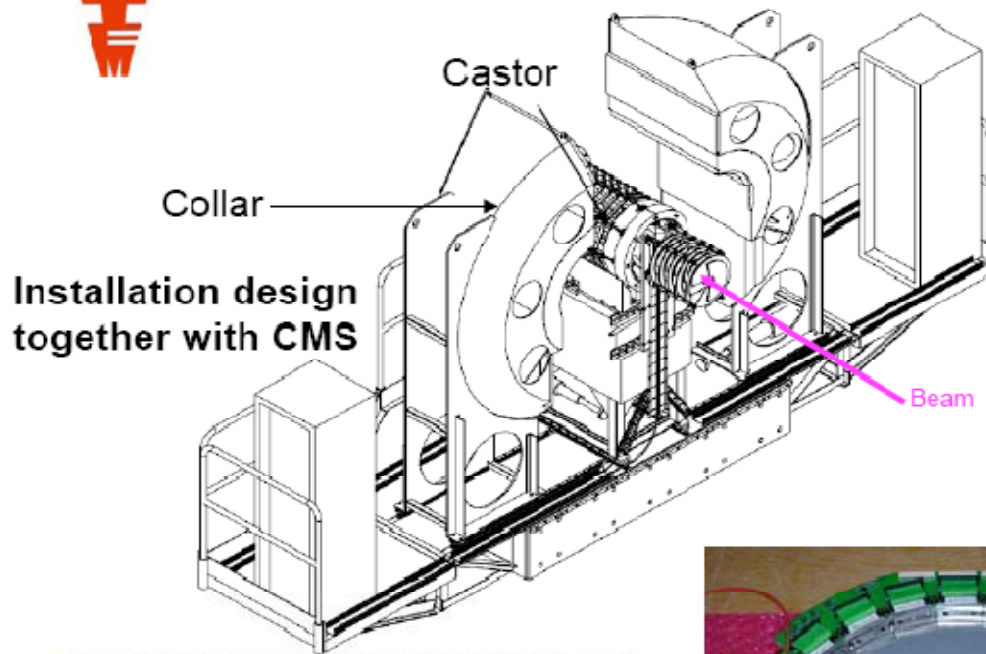
15 CSCs mounted 3 by 3

Tilt between layers





The T2 Telescope



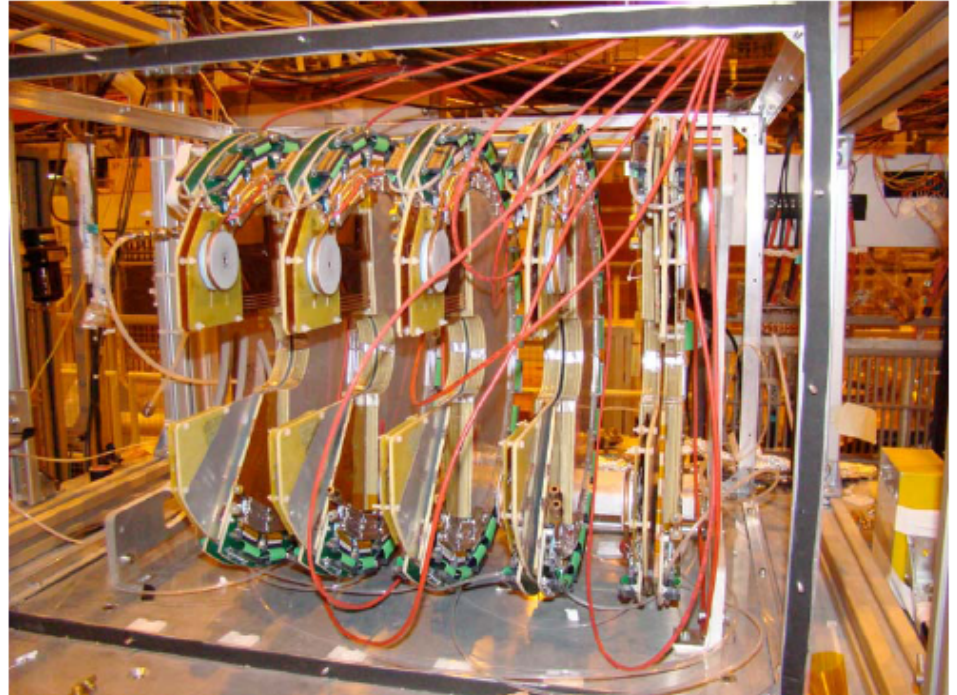
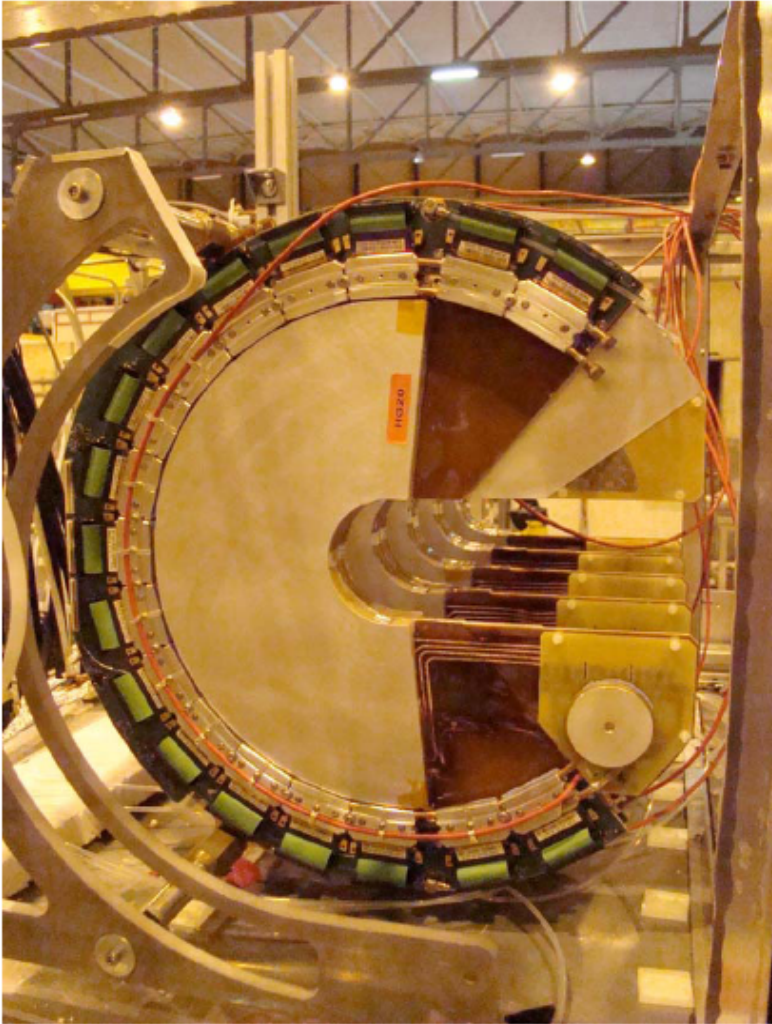
Final GEM chamber

10 triple-GEM planes on each side of the IP to cope with high particle fluxes.

$$5.3 < |\eta| < 6.6$$



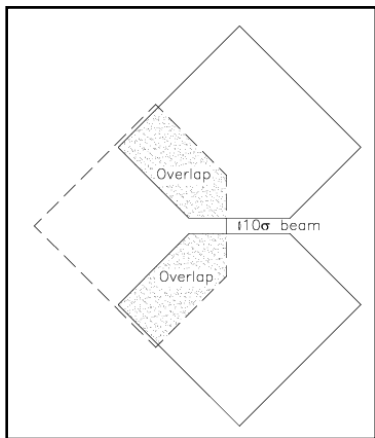
T2 Telescope Assembly in Test Beam



Production at Helsinki (50 GEMs)

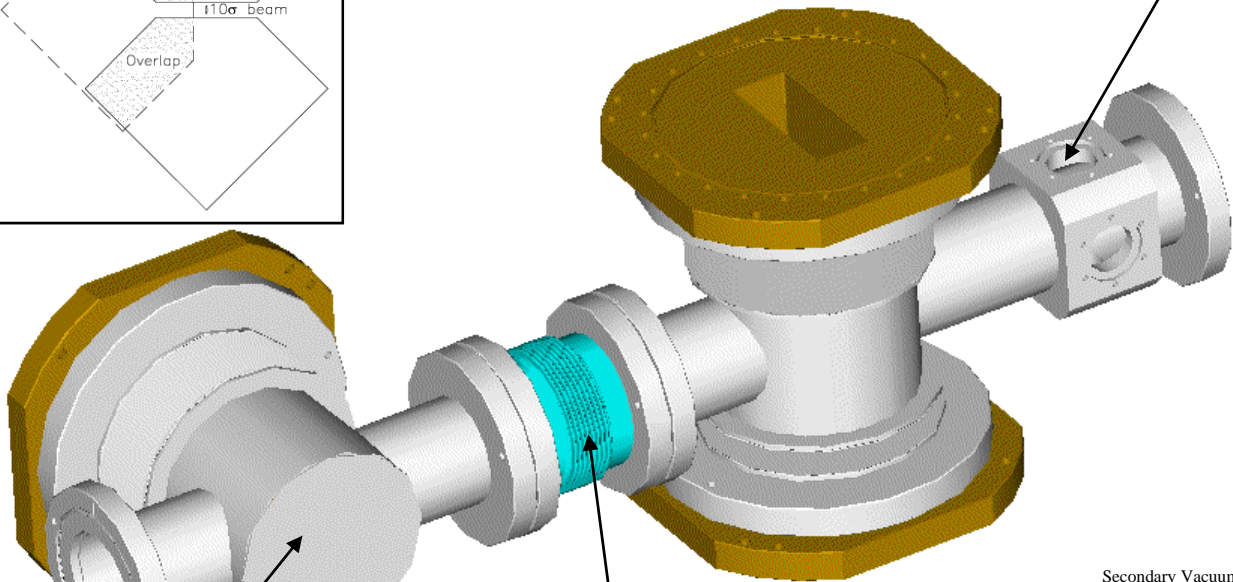
Final assembly at CERN

■ Roman Pot for the LHC: the features



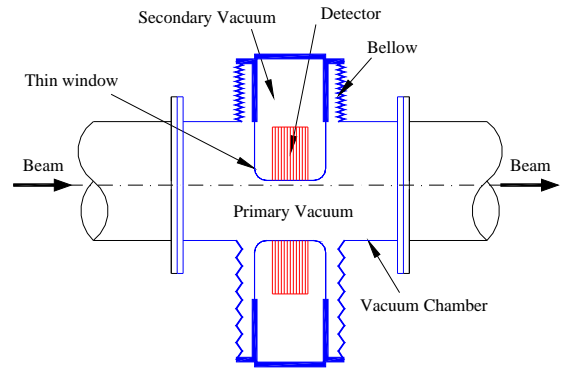
Si detectors

Integrated beam position monitor

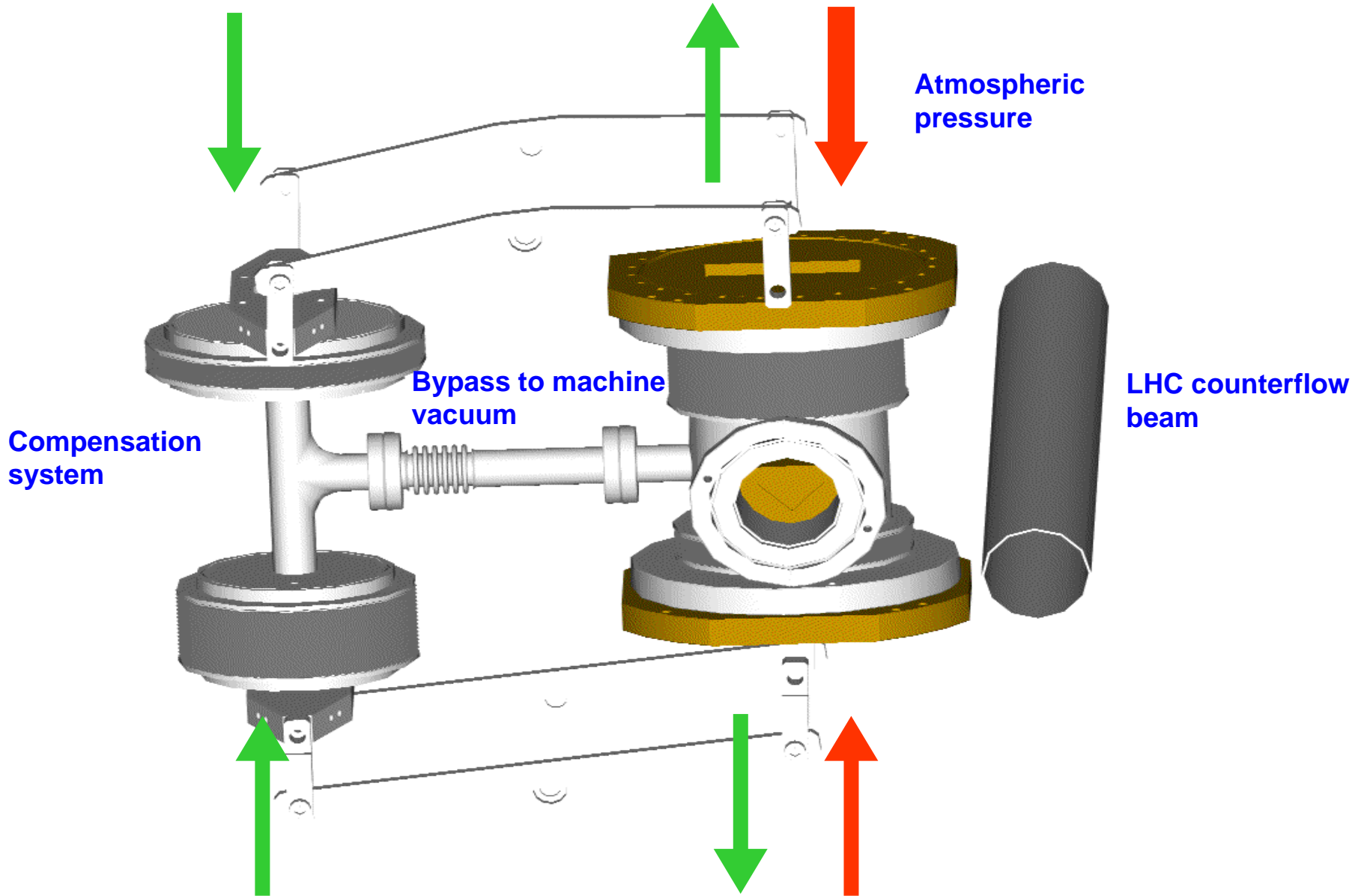


Horizontal Pot : physics, overlap for tracks alignment

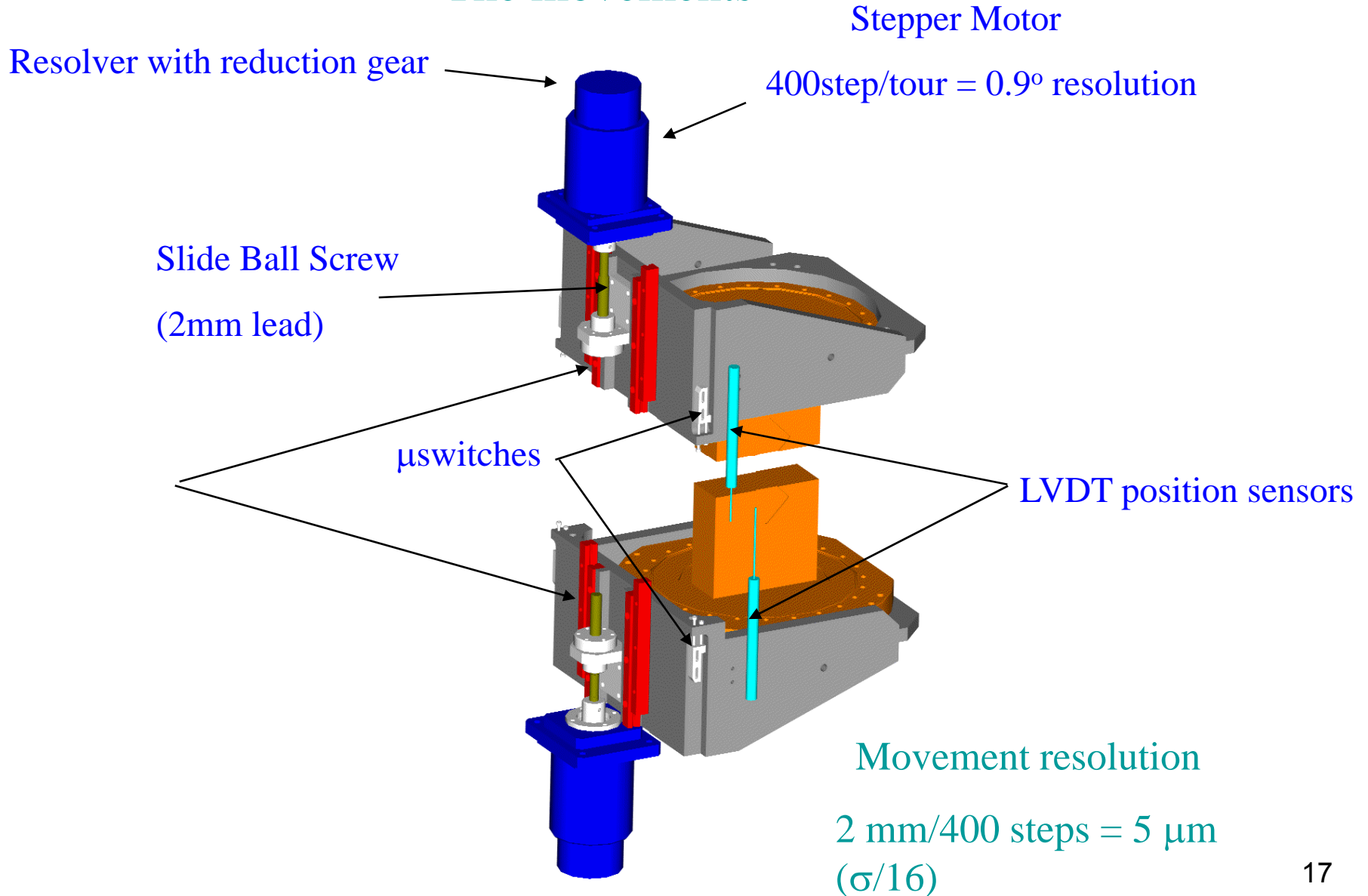
bellow



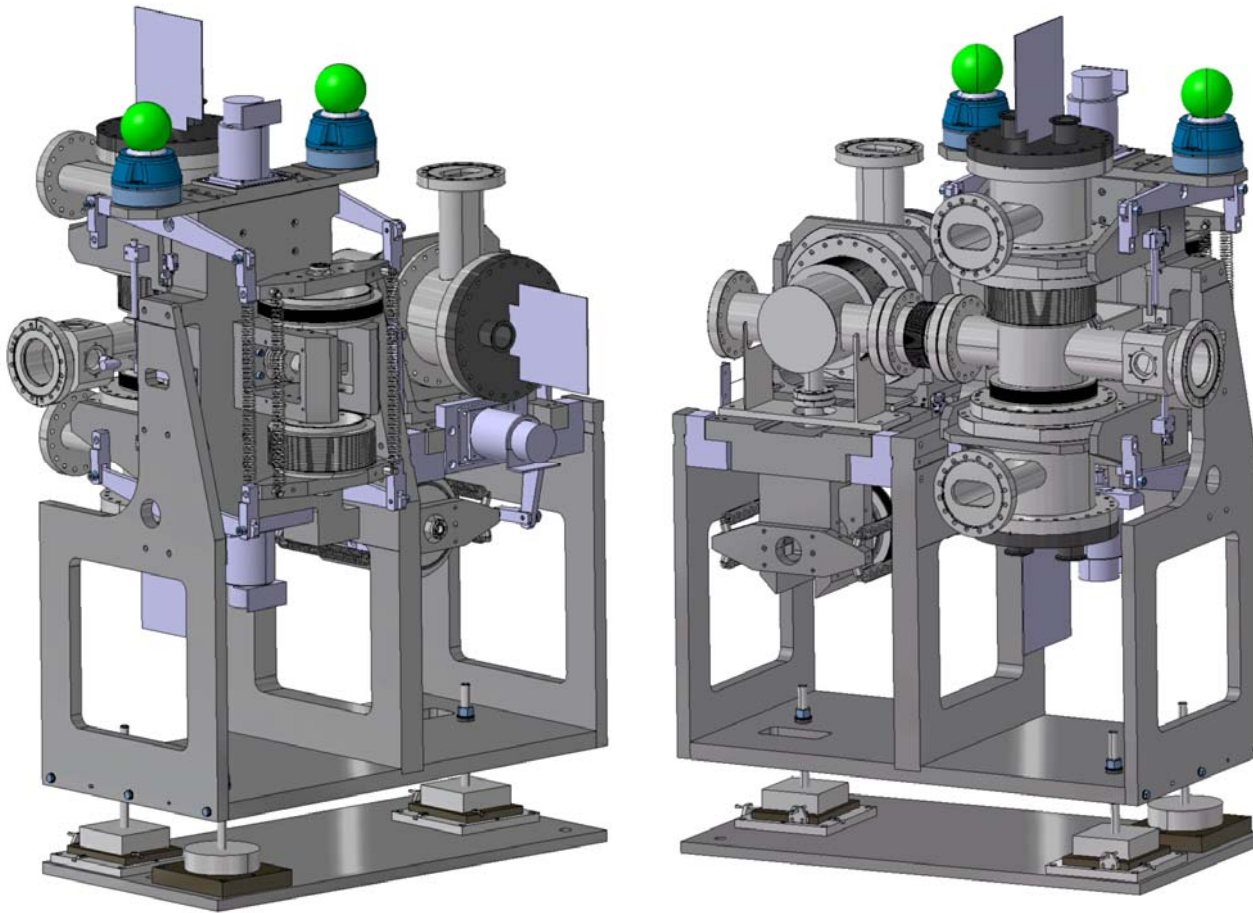
The compensation system



The movements

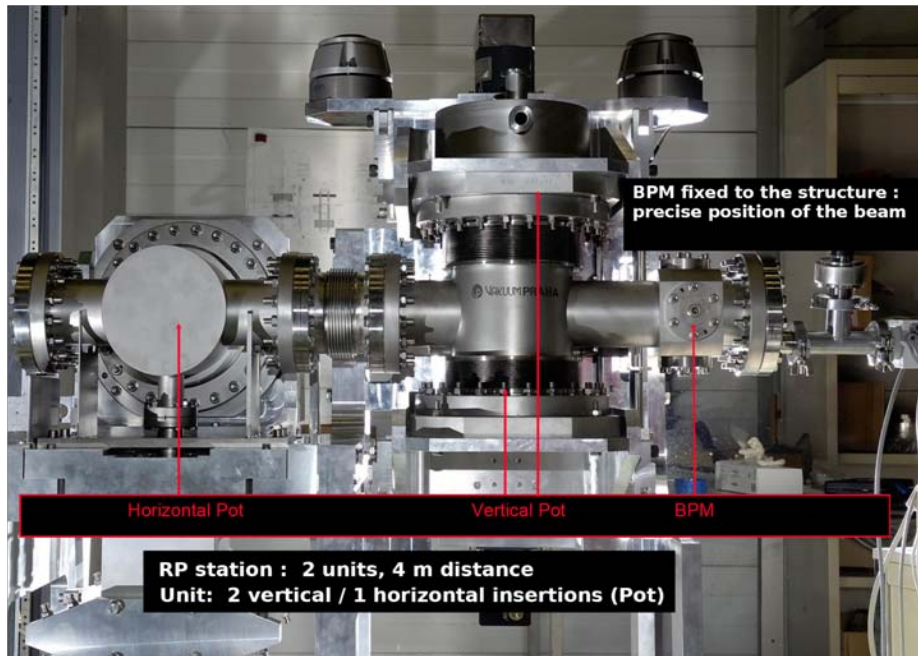


Detektory “Římské hrnce” (Roman Pots)

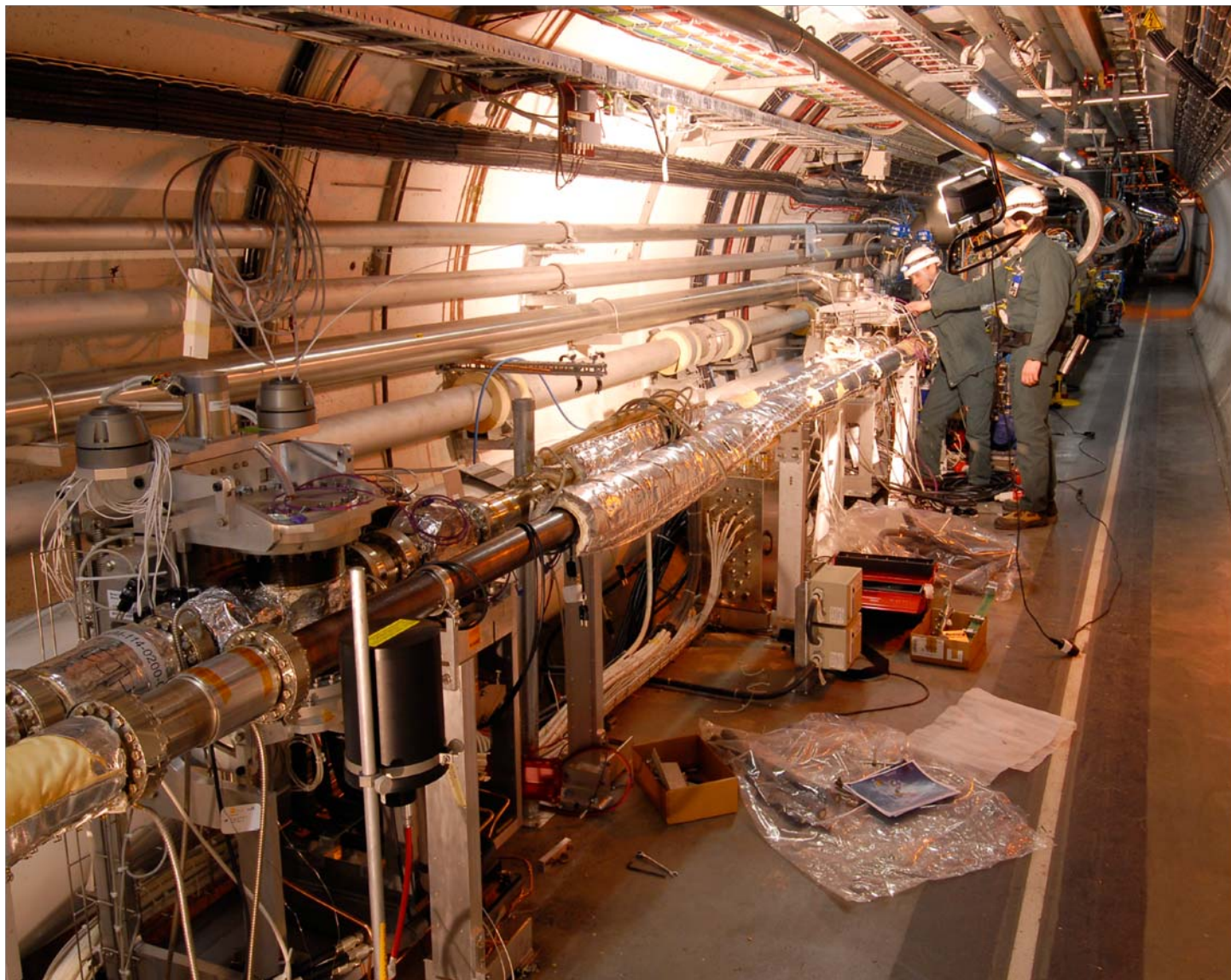


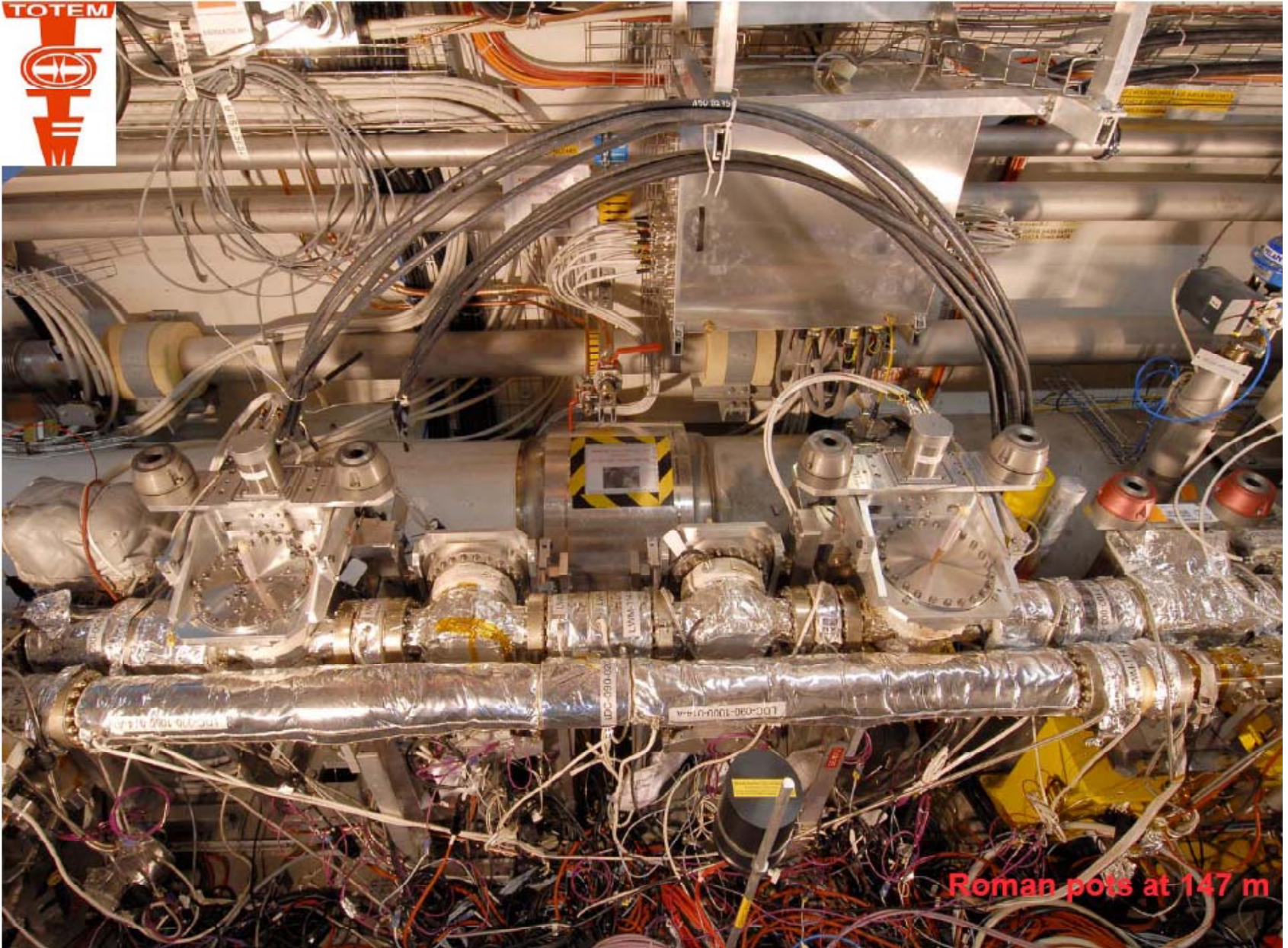
- dva vertikální RP, jeden horizontální
- vakuový kompenzační systém
- posun po 5 μm pomocí krokových el. motorů
- stavitelná poloha

Montáž a testy RP v CERN (vyrobených ve Vakuum Praha)



RP – instalace v tunelu LHC (220 m)

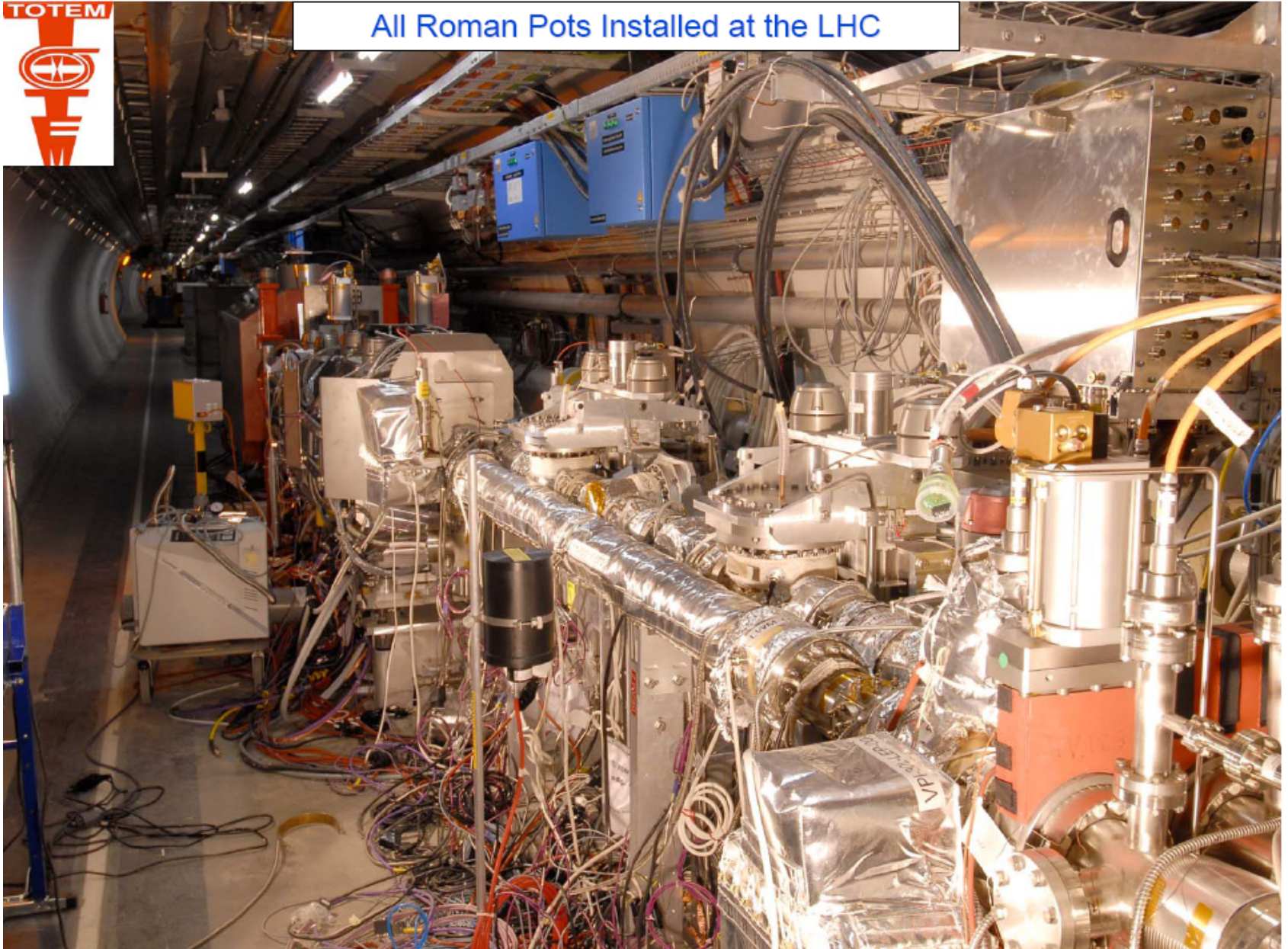




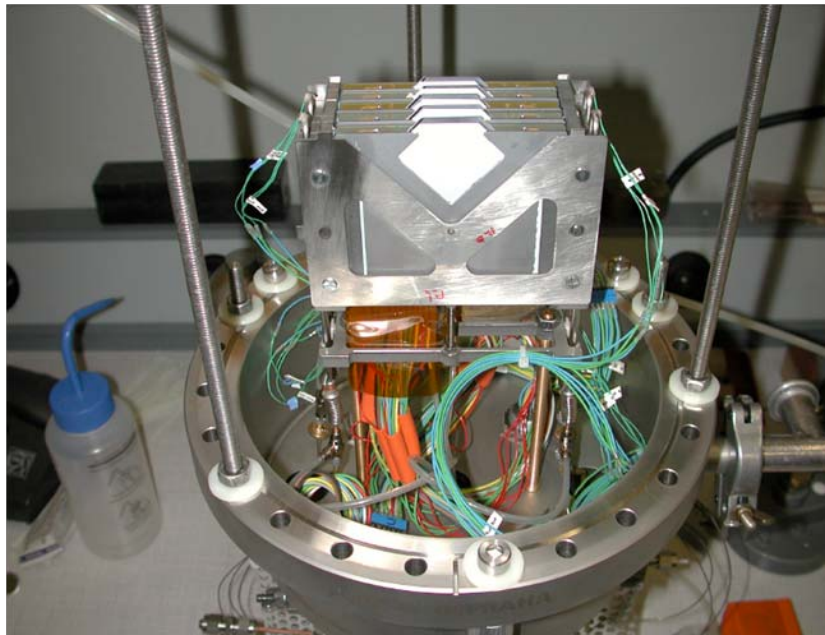
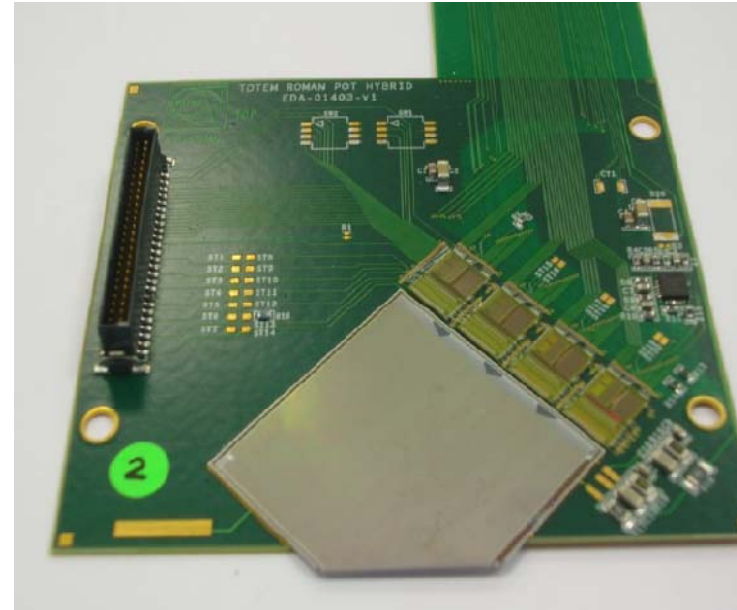
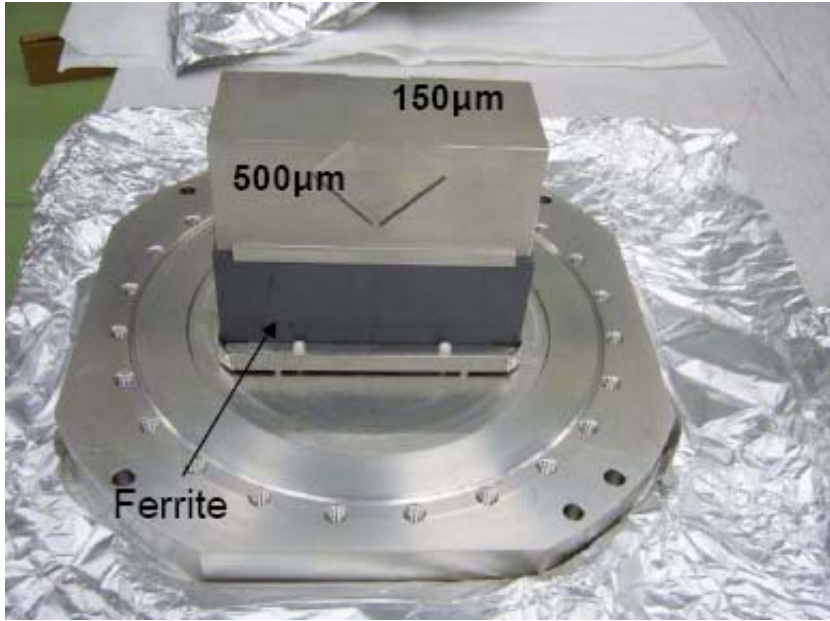
Roman pots at 147 m



All Roman Pots Installed at the LHC

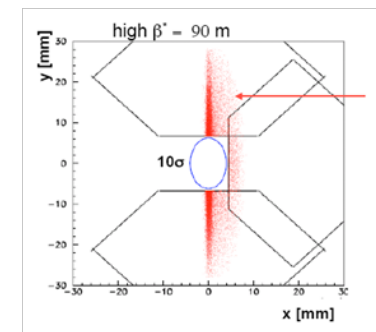


RP – instalace Si detektorů

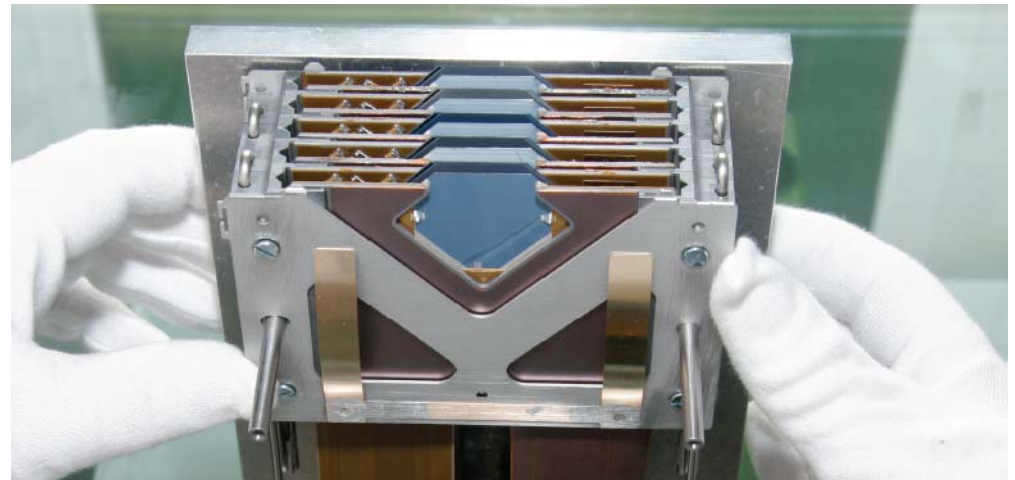
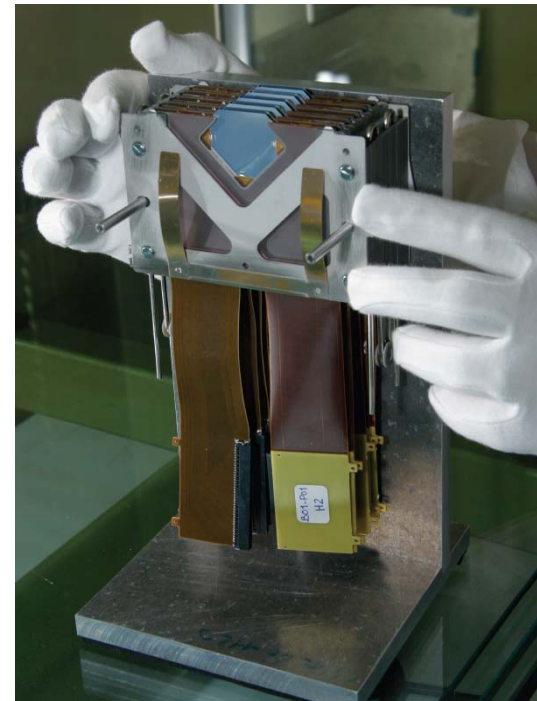
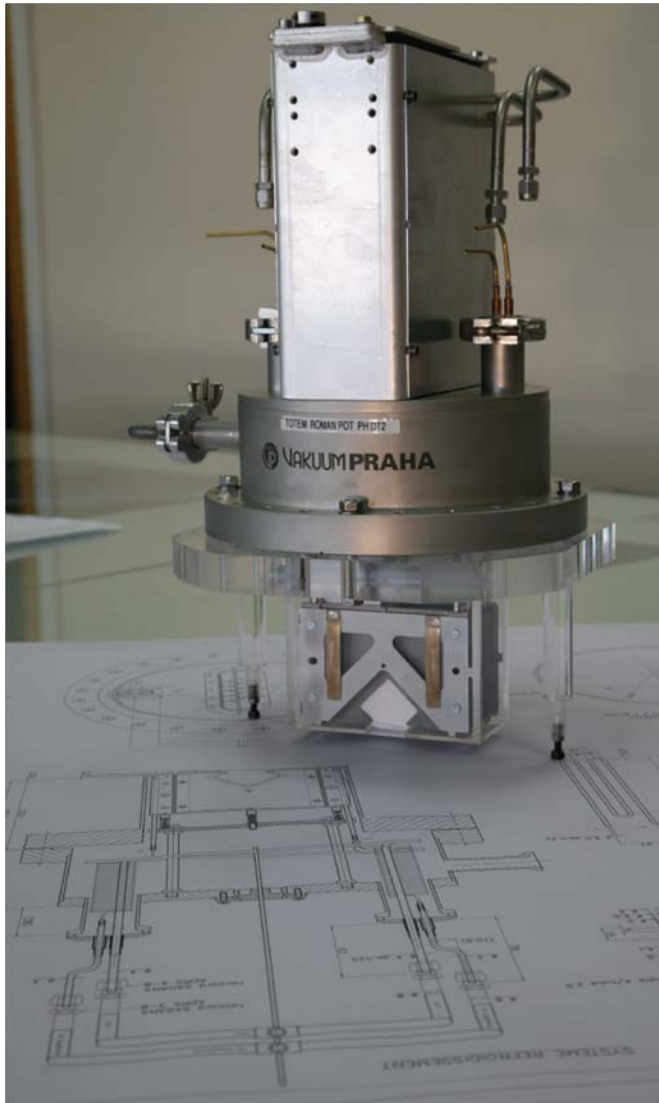


každý RP:

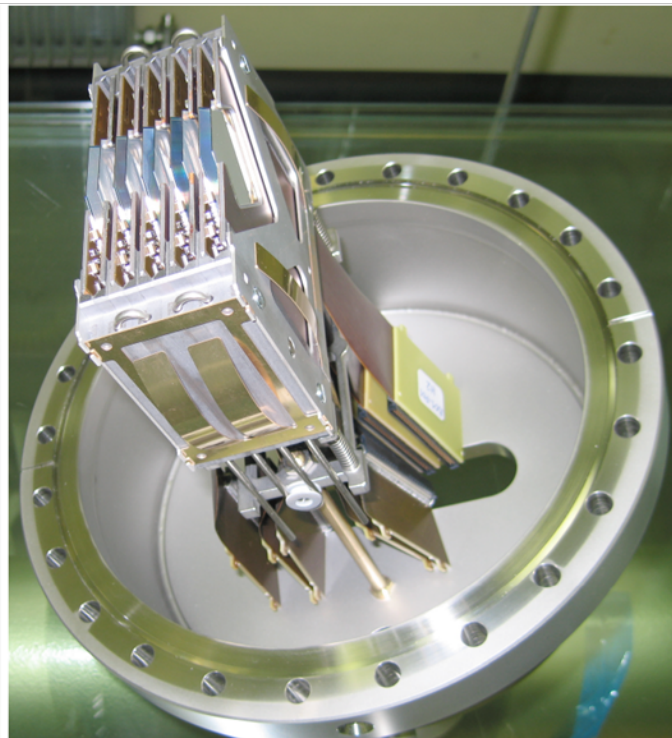
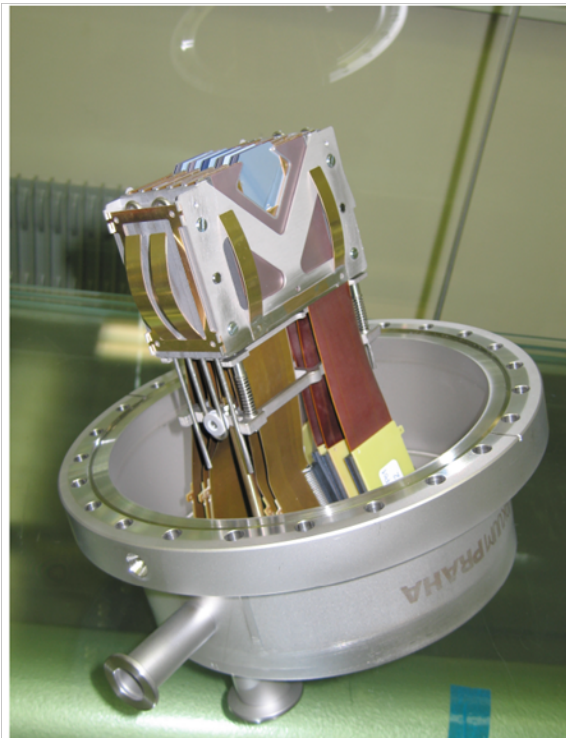
- 10 rovin Si stripových detektorů (512 stripů, 45°)
- rozlišení $20\mu\text{m}$



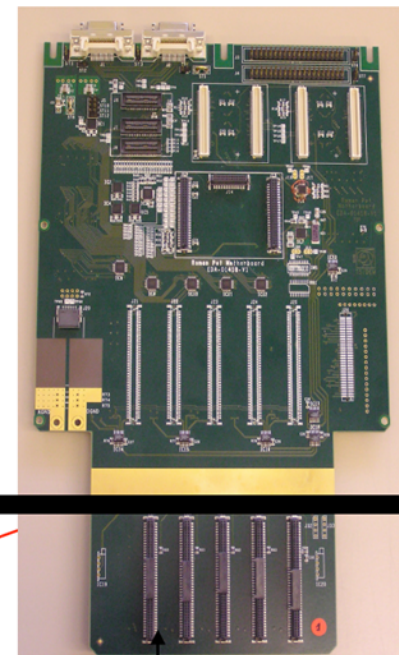
RP – Si detektory



RP - komplex Si detektorů



Roman Pot Motherboard connecting the detector packages in the vacuum to the outside world



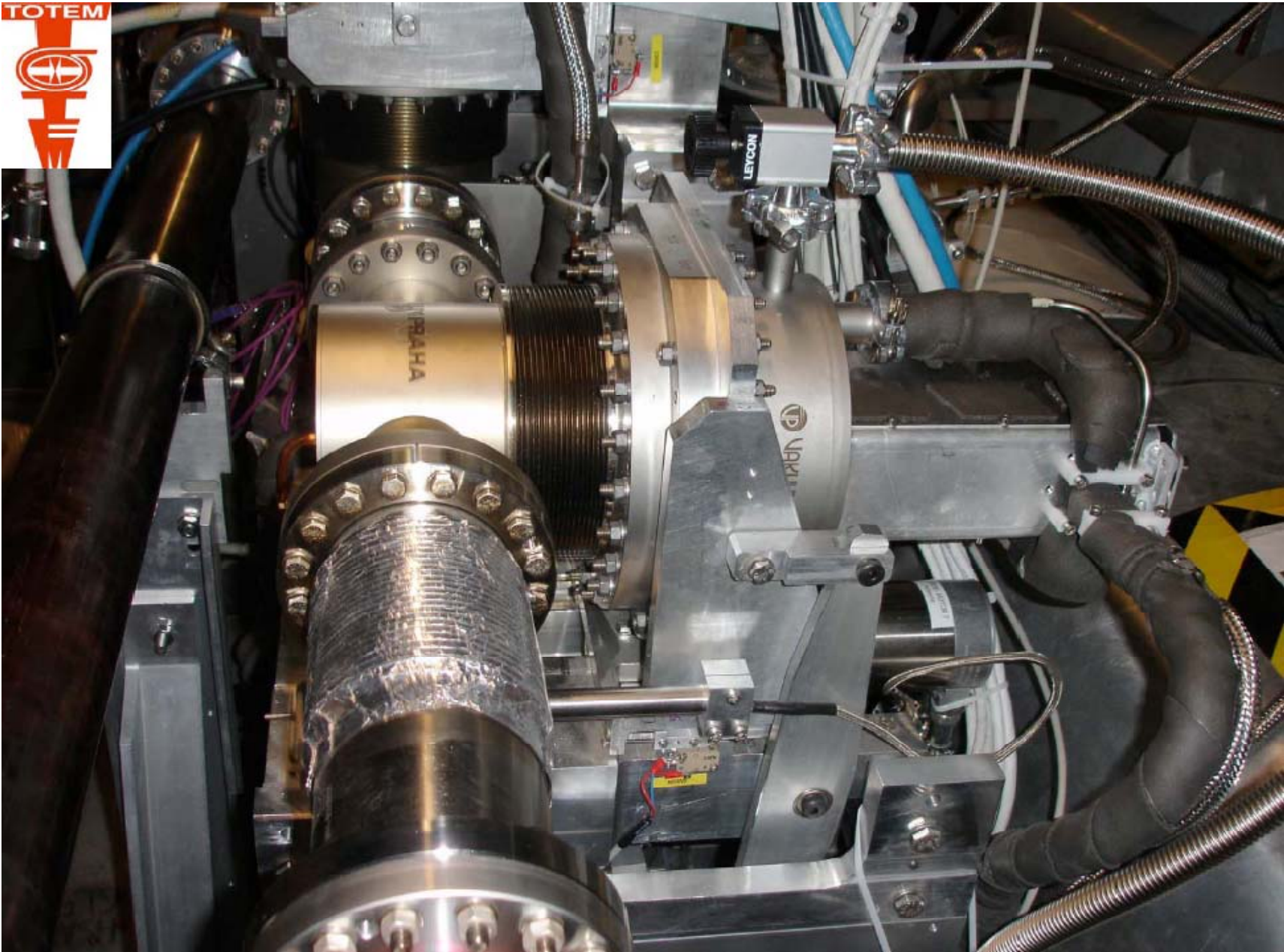
To be installed in the tunnel by beg. of May.
3 more assemblies to be mounted before
LHC start-up.

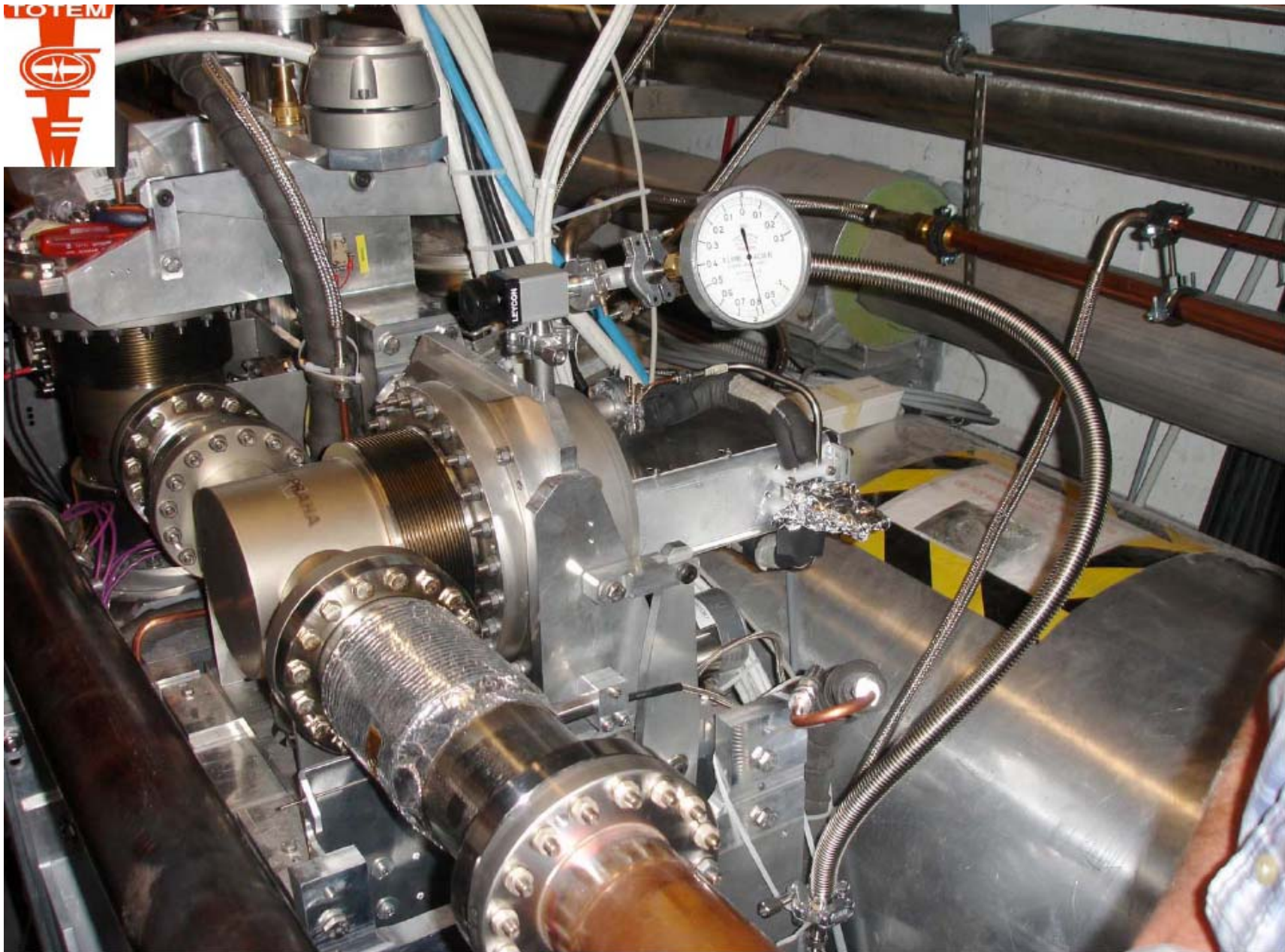
Roman Pot Motherboard completed and currently under test.

Vacuum flange

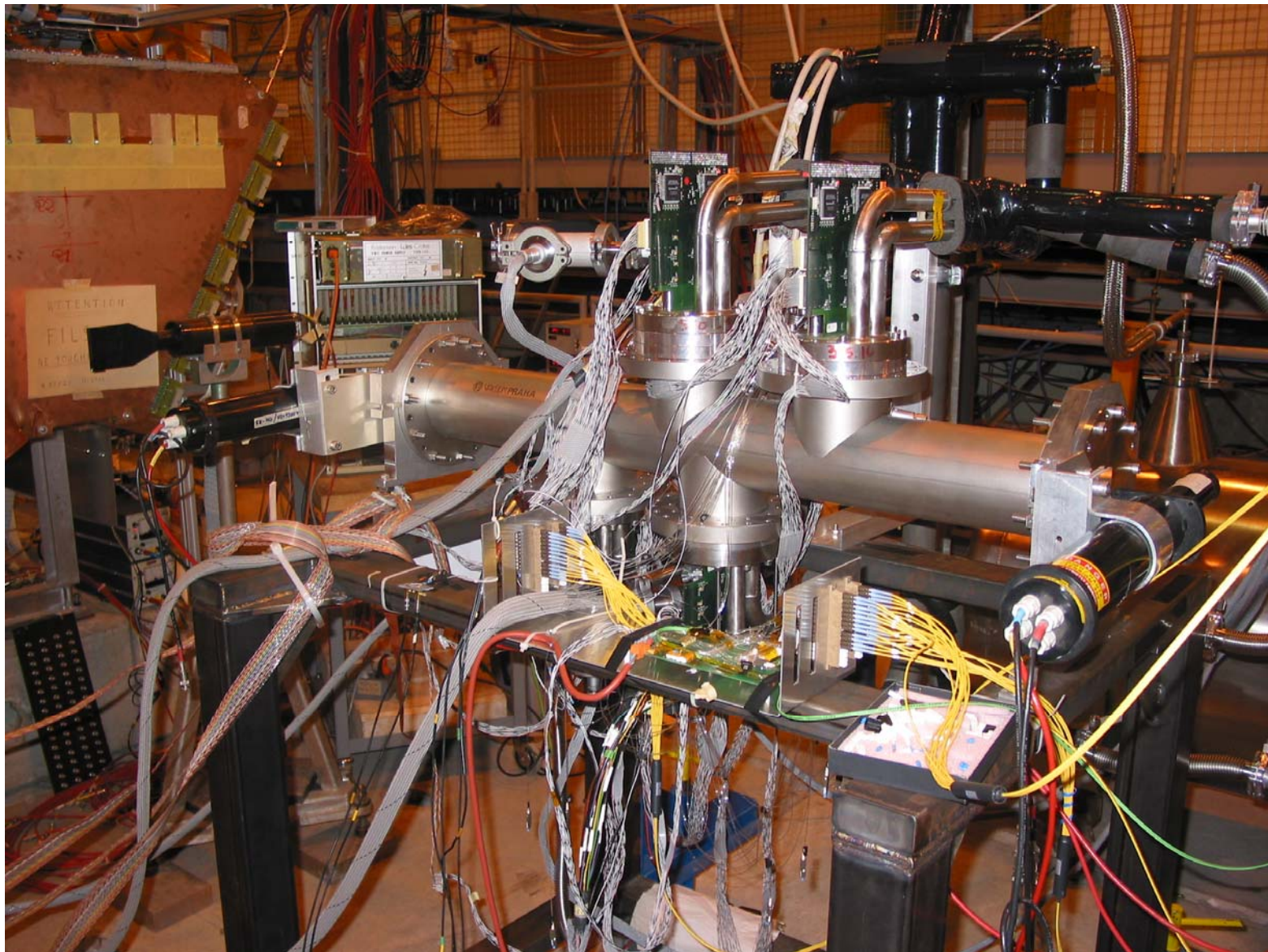
Feed-through

Connectors to detector hybrids





Testovací komora Si detektorů





The CERN TOTEM group is very grateful to Pavel Hedbavny and the team from Vakuum Praha for their excellent work in constructing the Roman Pot units for the TOTEM experiment. The collaboration between CERN and Vakuum Praha was very fruitful and successful. During 2 years the exchange of knowledge and the transparency in information was a benefit for both partners. For CERN it was a pleasure to work with Vakuum Praha.

Many thanks again

K. Eggert
TOTEM spokesperson

E. Radermacher
TOTEM Technical Coordinator

-
- poprvé, kdy česká firma dodala do CERN části vlastního urychlovače