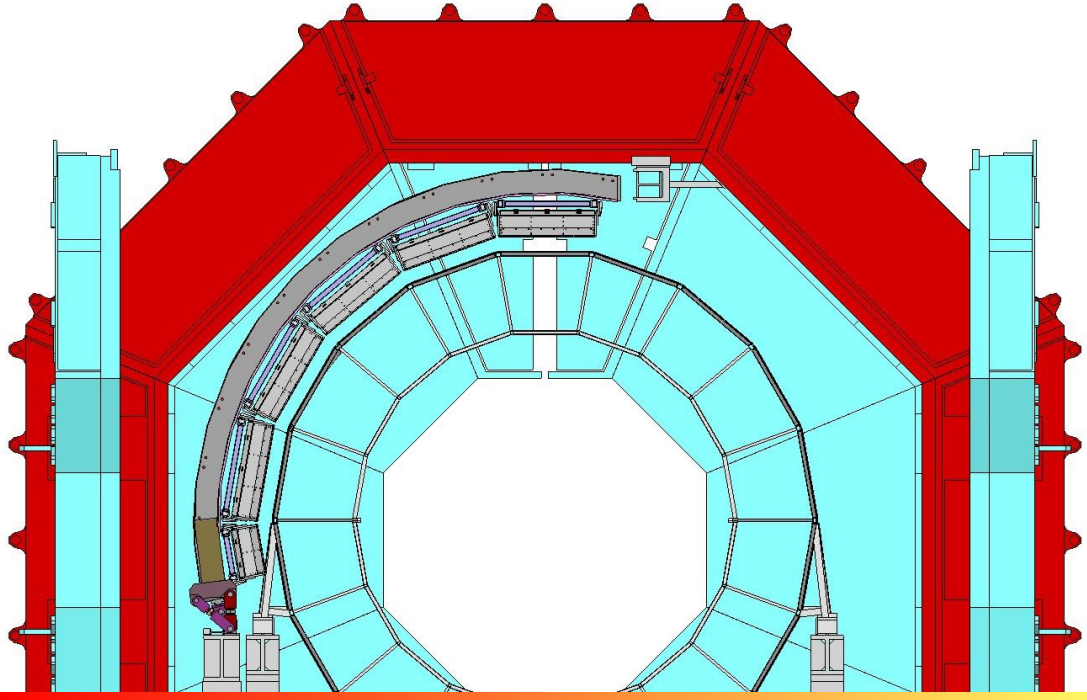
ElectroMagnetic Calorimeter for the ALICE experiment at LHC

Christelle Roy – Subatech



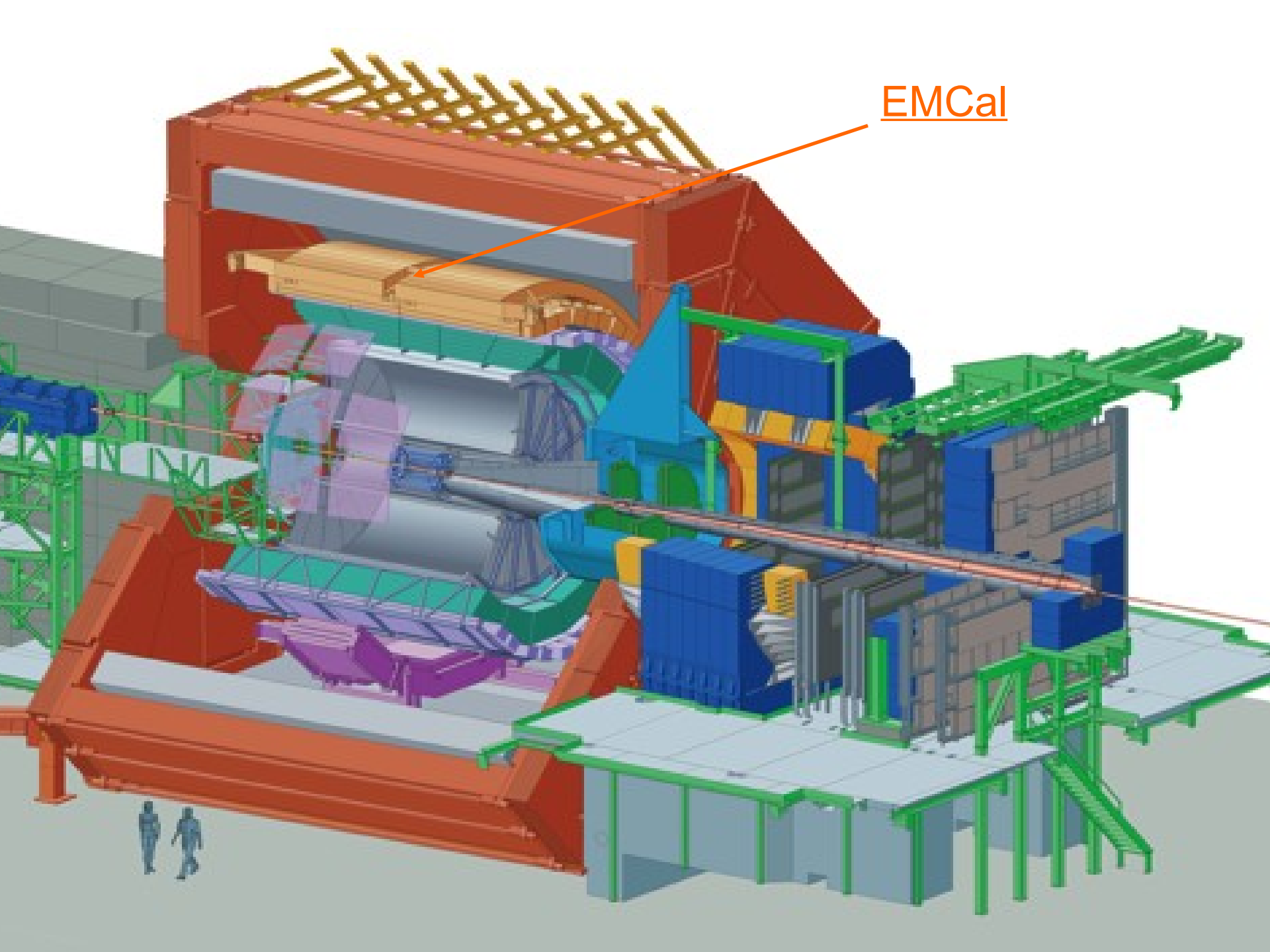
Design

&

Performances

A dedicated tool for high p_t jets and photons

- Provide an efficient and unbiased fast trigger for high energy jets
- Measure the neutral portion of the jet energy
- Improve the jet energy resolution
- Enhance ALICE capabilities
  - For the measurement of high pt particles
  - For observables related to jet-quenching, heavy flavour, ...


EMCal

ALICE detectors for high p_t jet, e and γ physics

Tracking-PID : ITS+TPC+(TOF, TRD)

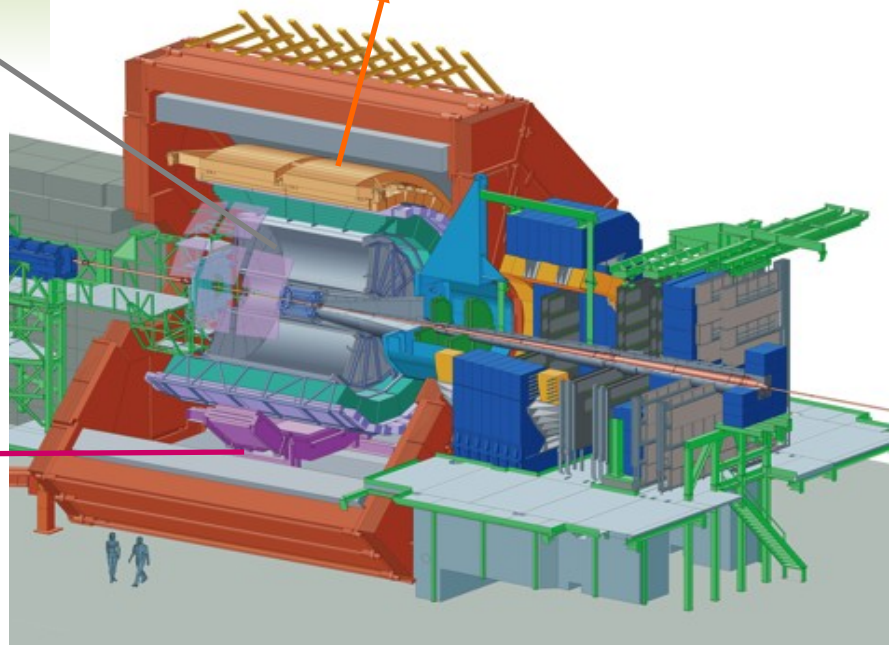
- Charged particles $|\eta| < 0.9$
- Excellent momentum resolution up to 100 GeV/c ($\Delta p/p < 6\%$)
- Tracking down to 100 MeV/c
- Excellent Particle ID and heavy flavor tagging

EMCal

- Energy from neutral particles
- Pb-scintillator, 13k towers
- $\Delta\phi = 110°$, $|\eta| < 0.7$
- Energy resolution ~$10\%/\sqrt{E_\gamma}$
- Trigger capabilities

PHOS

- High resolution electromagnetic spectrometer ($PbWO_4$ crystals)
- γ–Trigger
- $|\eta| < 0.12$
- $220° < \phi < 320°$
- Energy resolution: $\Delta E_\gamma/E_\gamma = 3\%/\sqrt{E_\gamma}$
- Position resolution: $\Delta x/x = 23\%/\sqrt{E_\gamma}$

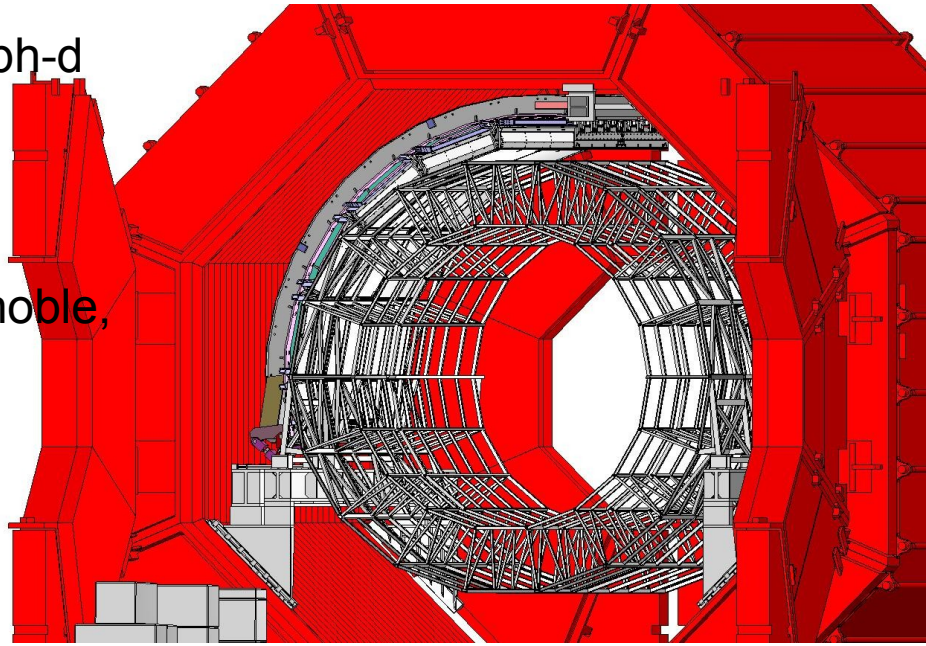


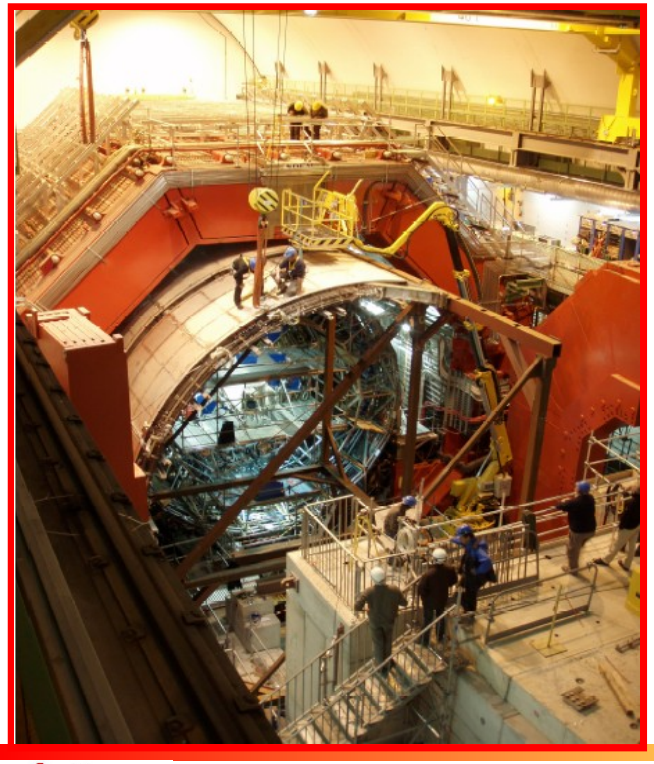
➢ Exploit large kinematics range of jet production at LHC

EMCal – Overview

Collaboration

- EMCal–US : 13 institutes (3 nat. labs), 30 ph-d
  - BNL, LBNL, ORNL, WSU, LLNL, …
- EMCal–Eu : 5 institutes, 30 ph-d
  - Italy : INFN-Frascati, INFN-Catania
  - France : IPHC-Strasbourg, LPSC-Grenoble, Subatech-Nantes

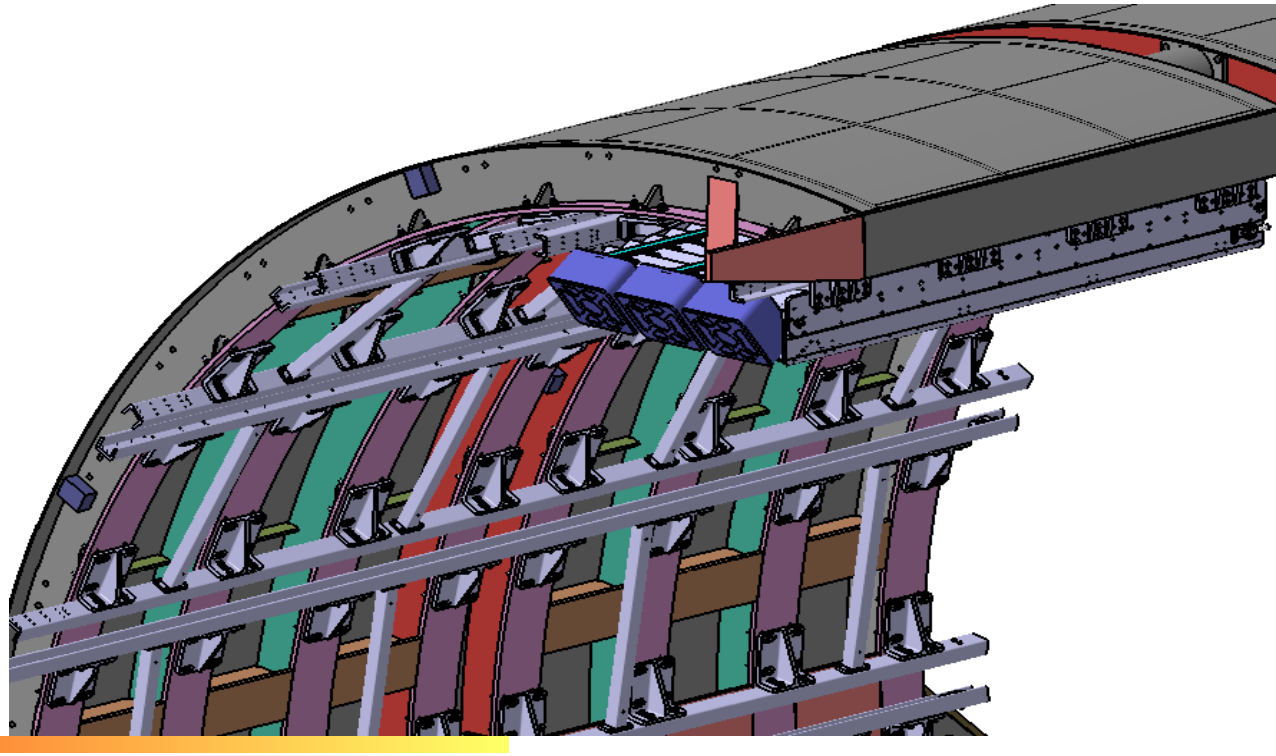




Status

- September 2006 : approved by LHCC
- March 2007 : approved for funding by France/IN2P3
- June 2007 : approved for funding (R&D/tools) and participation to the 1st Eu/SM by Italy/INFN
- January 2008 : approved for funding by the US/DoE

Design



EMCal – Overview

24T Monoshell SupportStructure

Single Super Module

US Scope= 7 2/3 Super Modules

EU scope = 3 Super Modules

EMCal – Overview

24T Monoshell SupportStructure

1/3 Super Module

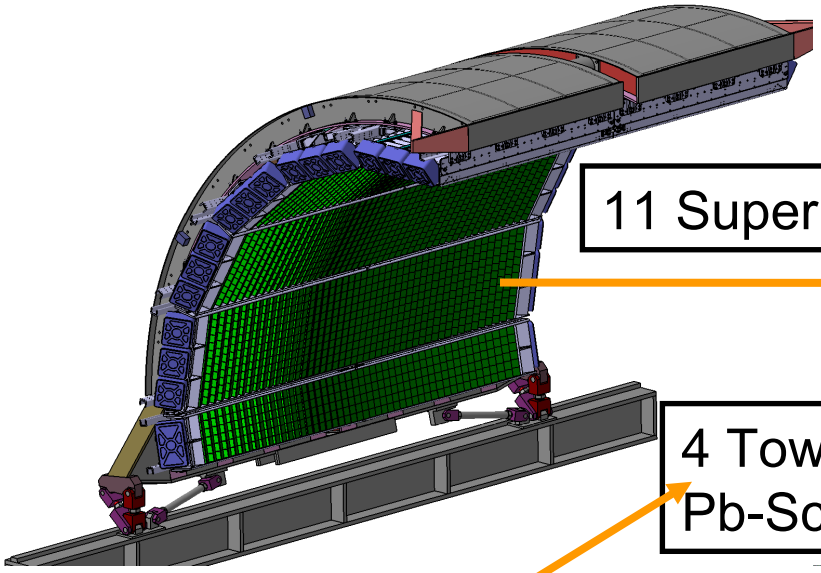
US Scope= 7 2/3 Super Modules

EU scope = 3 Super Modules

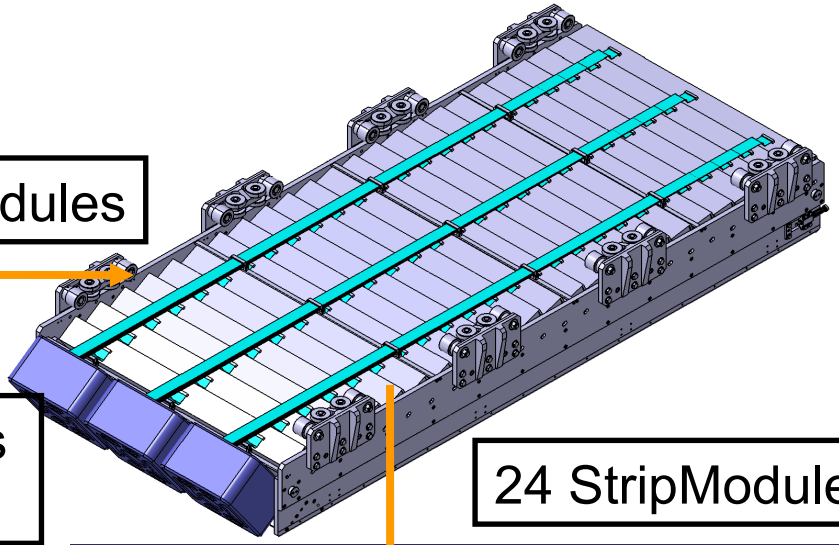
EMCal – Design

Shashlik geometry, APD photosensor
~13K towers ($\Delta\eta x\Delta\phi$~0.014x0.014)

- Lead-scintillator sampling calorimeter
- Large acceptance : $\Delta\eta$=1.4, $\Delta\phi$ =110^o



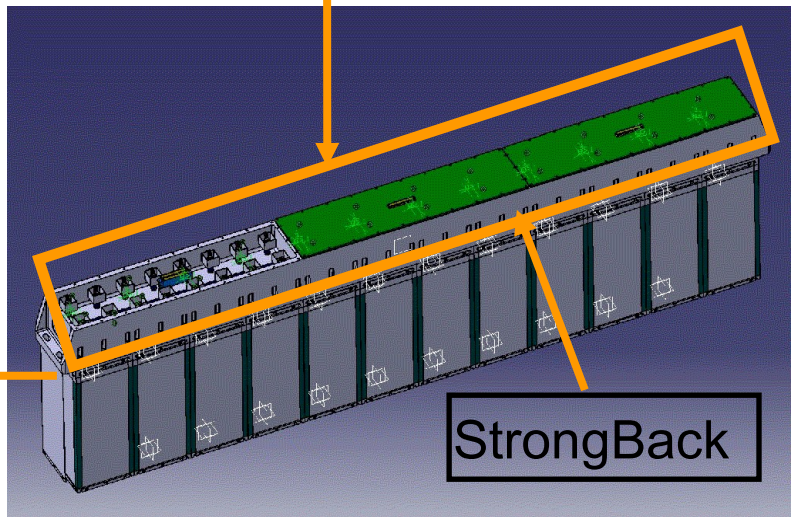
11 SuperModules



4 Towers
Pb-Scint

24 StripModules

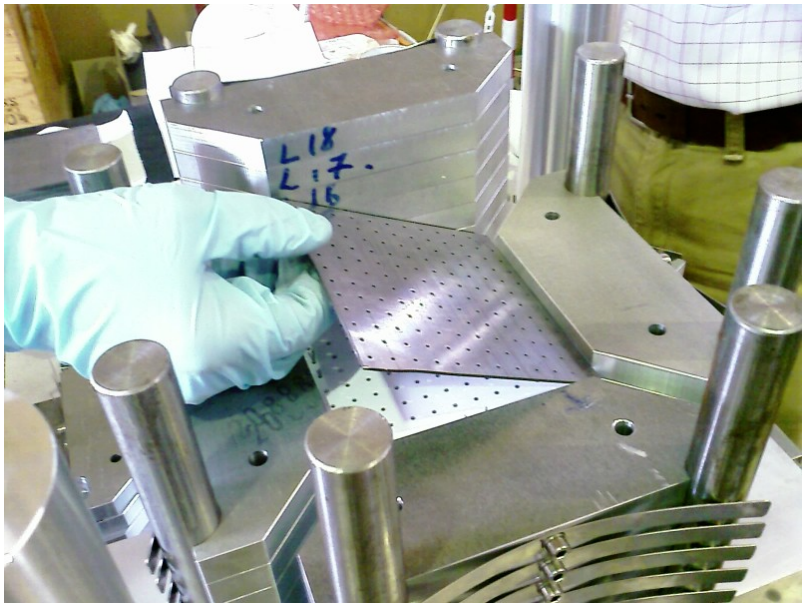
12 Modules



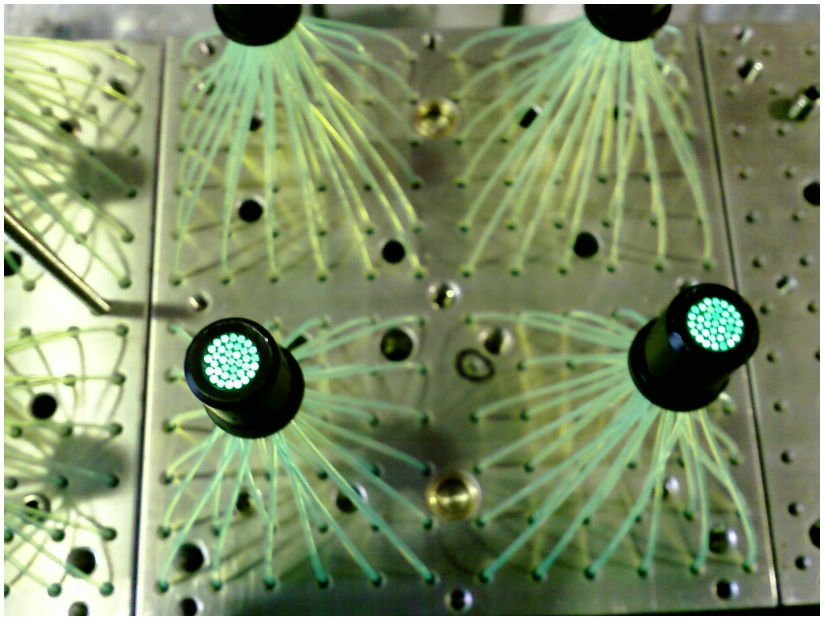
StrongBack

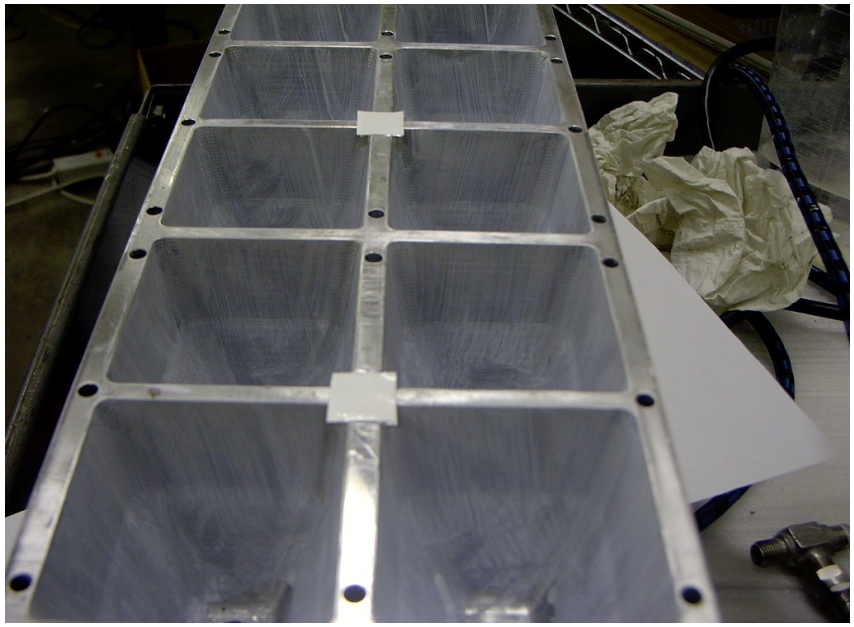
Module

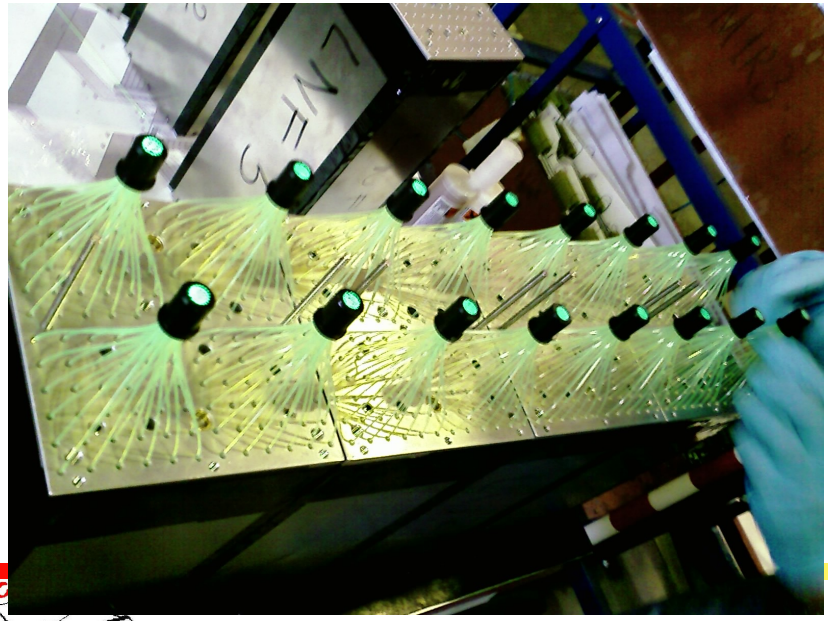
- Single detector : 6x6x25 cm^3 shashlik 1.44mm Pb/1.76mm scintillator sampling
- 77 layers = 20 Xo
- APD readout
- Front End Electronics mainly developed for TPC and PHOS



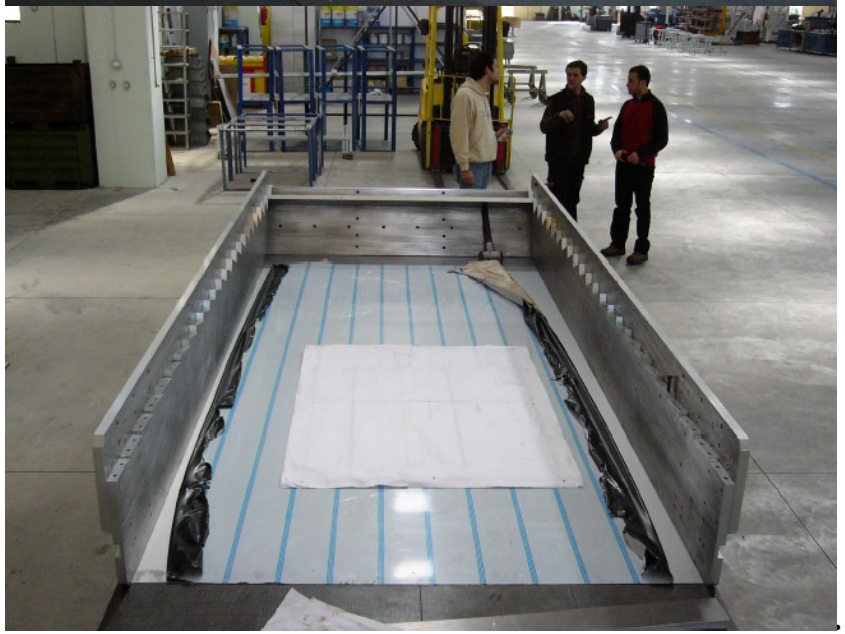
Module to StripModule



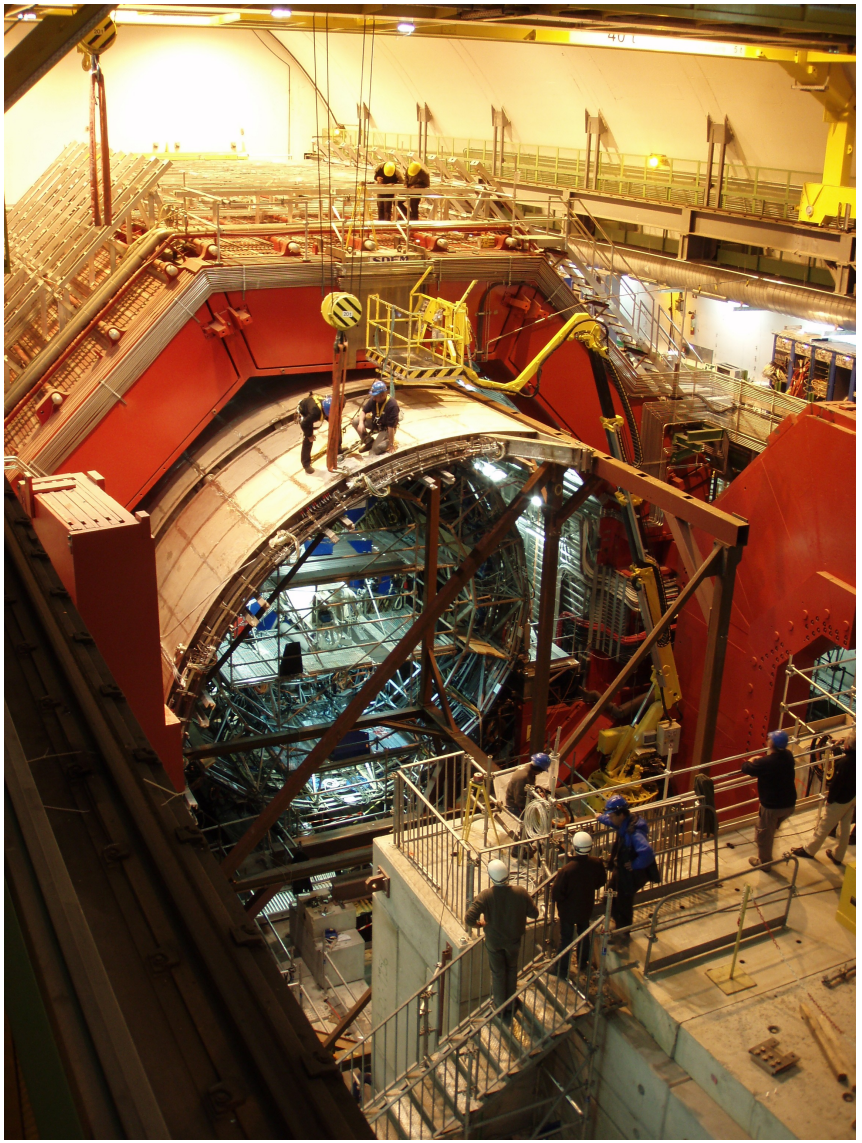




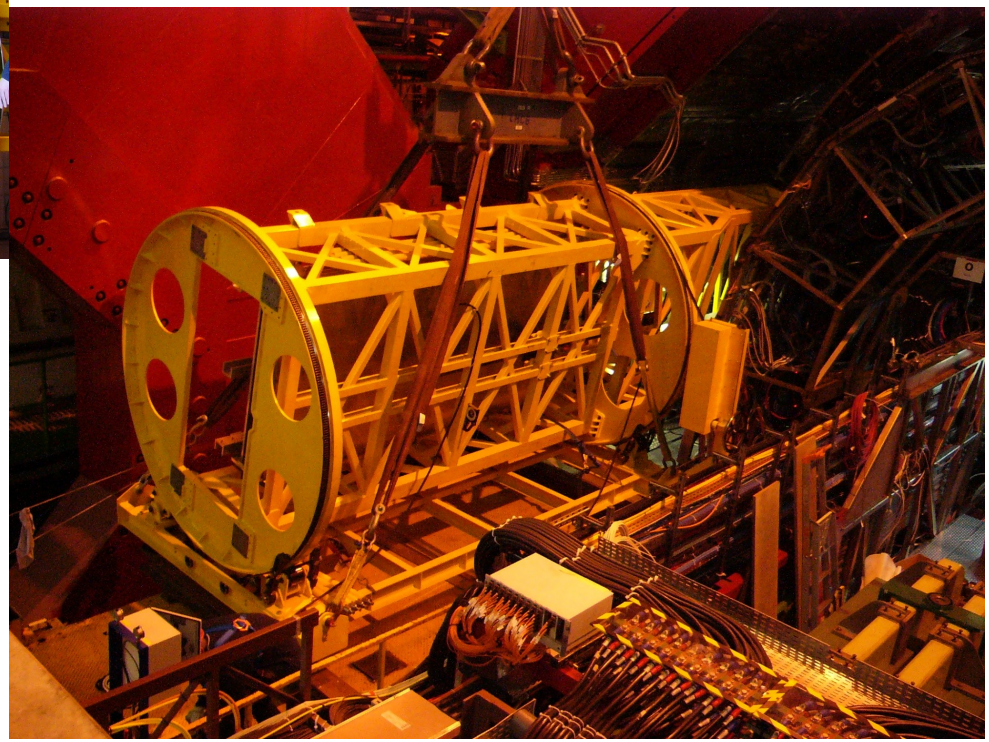
StripModule to SuperModule



SuperModule on CalFrame



SuperModule in ALICE



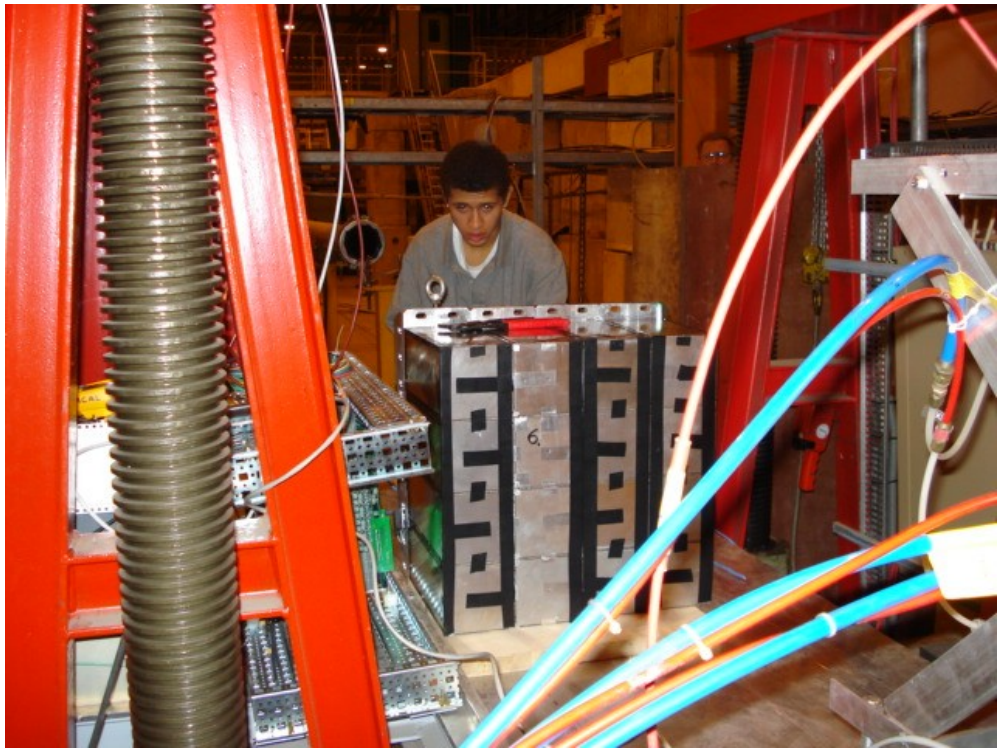
EMCal ⇔ LHC planning

Number of SM installed in Alice depending on the LHC data taking

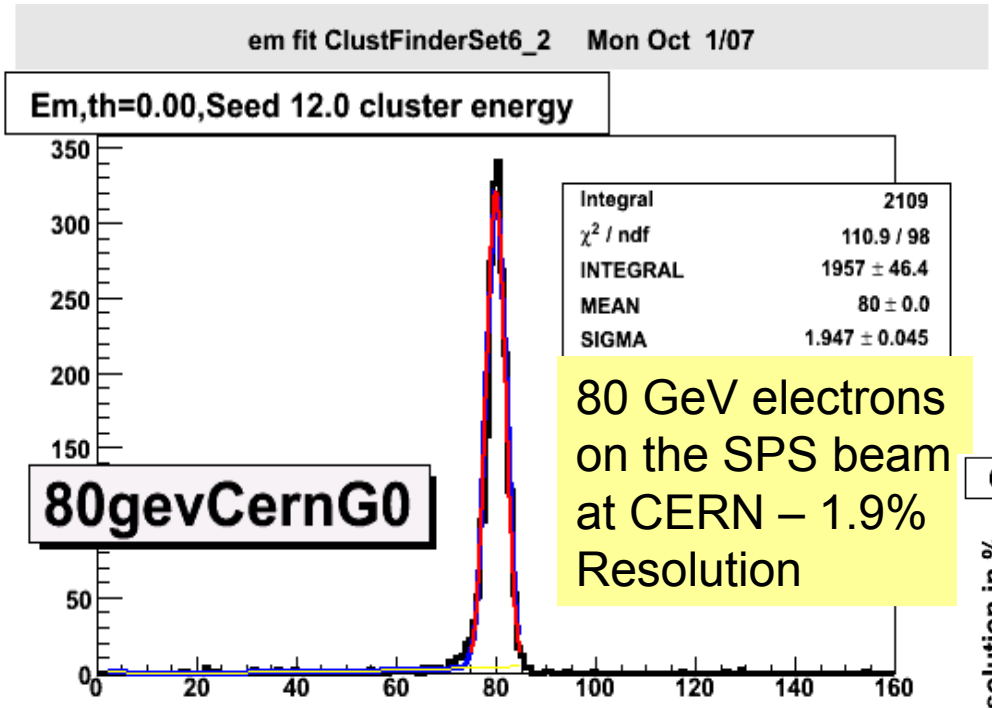
Year	Number of SM TOT = US + EU
2008	0
2009	2 = 1 + 1
2010	6 = 2 + 2
2011	9 = 3
2012	11 = 1+(2/3)

Performances

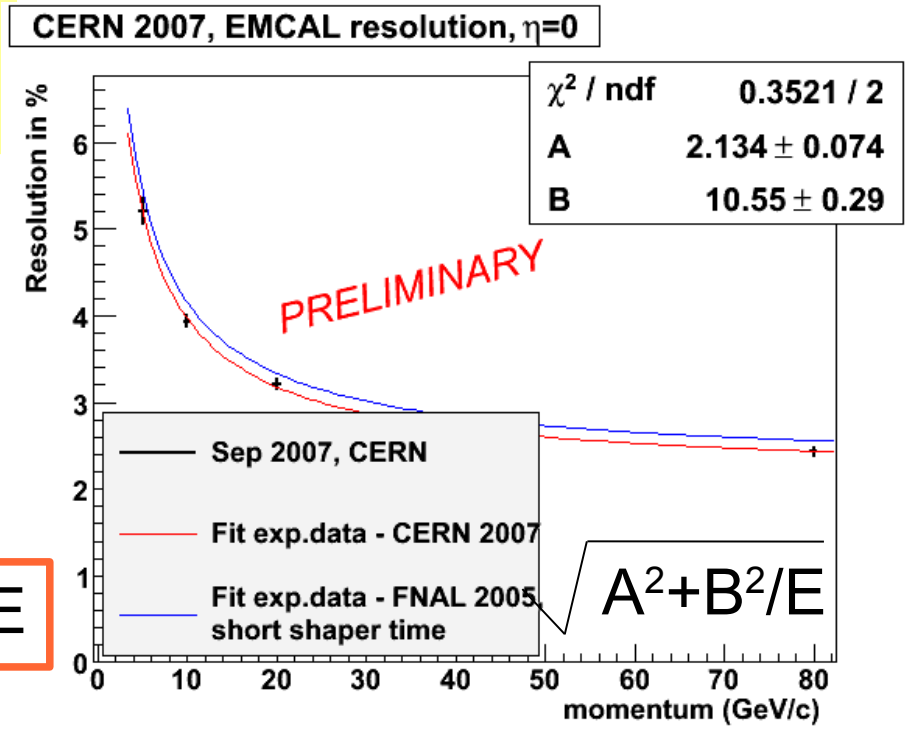
16 modules (8 US, 8 Eu) on the SPS beam at CERN



Resolution



80 GeV electrons on the SPS beam at CERN – 1.9% Resolution



$\sigma/E \sim 10\%/\sqrt{E}$

Jet–trigger simulations

- Simple jet-finder algorithm on the EMCal acceptance
- Energy integrated within a window of n*n subregions which is stepped over the entire EMCal.

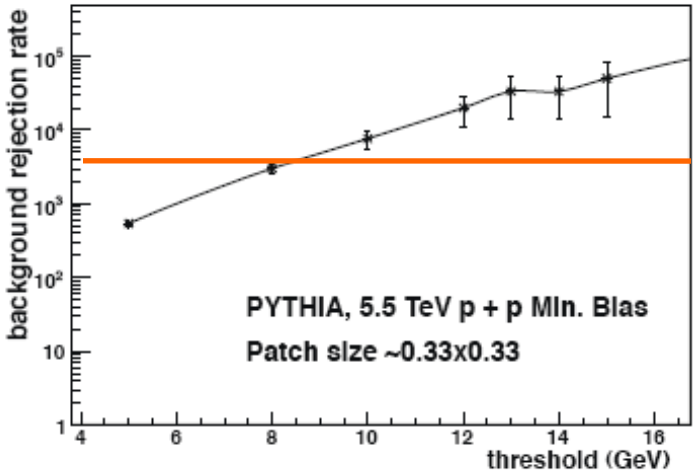
ALICE HLT + DAQ bandwidth constraints

Trigger → rejection

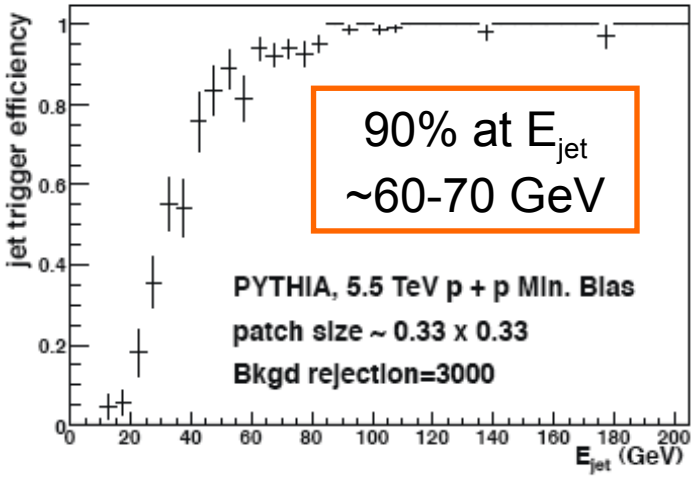
- 14 for PbPb minbias
- 2500-3000 for pp

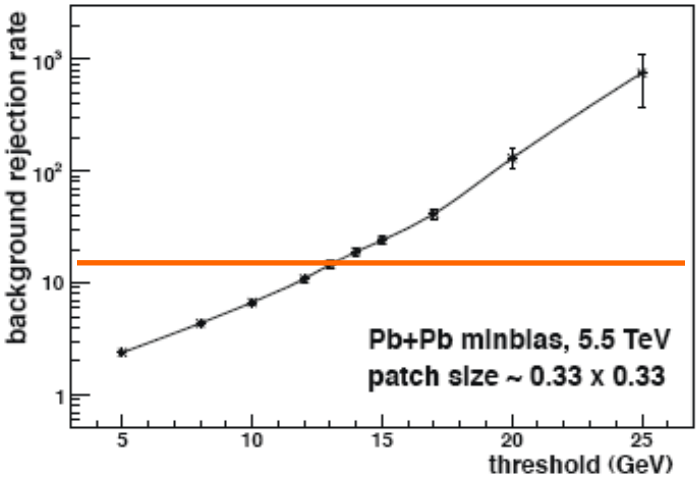
(≡ Extremes in terms of interaction rates vs. event size)

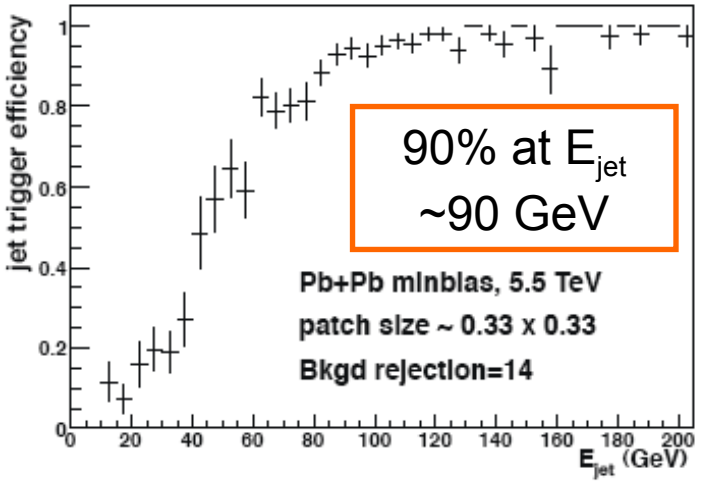
Rejection factor



Efficiency







Jet–trigger simulations

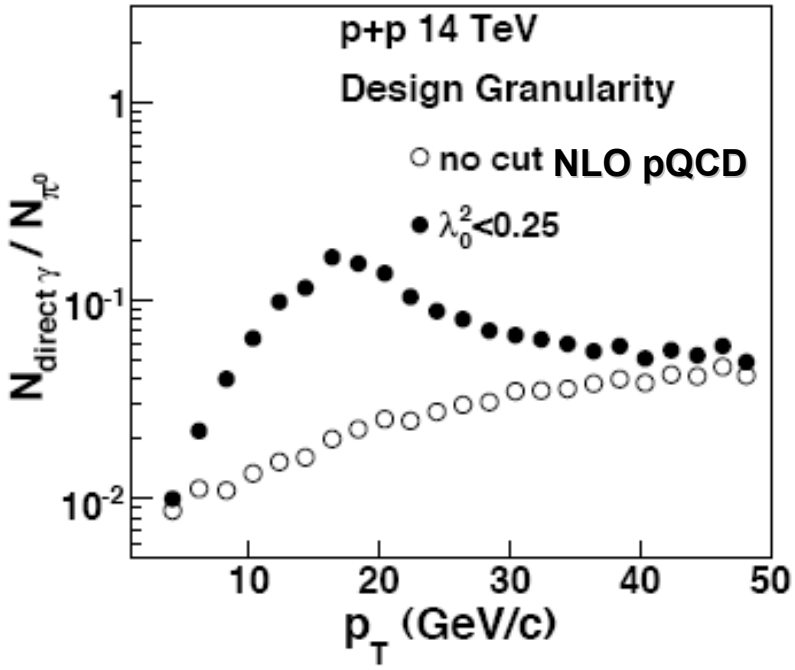
System	jet trigger?	N_{jets} (125 GeV)	N_{jets} (175 GeV)
Pb+Pb cent	y	1.1×10^4	1700
	n	2100	320
Pb+Pb periph	y	410	62
	n	8	1
p+Pb 8.8 TeV	y	2.7×10^4	4200
	n	250	40
p+p 14 TeV	y	6.9×10^5	1.0×10^5
	n	1200	190

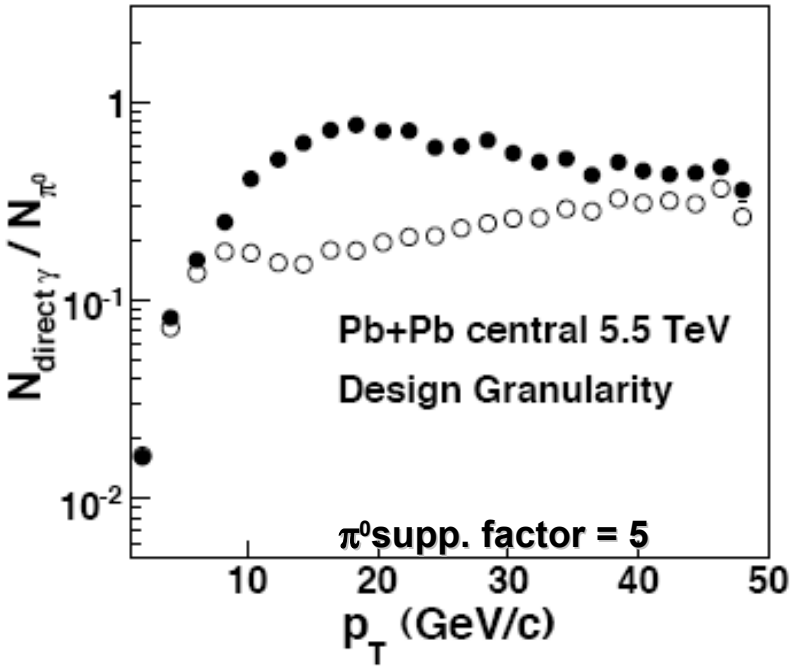
Includes acceptance, efficiency, dead time, energy resolution

- Enhancement by a factor 10 to 60 depending on the collision system
- Trigger highly requires for reference (p-p, p/Pb and PbPb periph)

γ/π^0 discrimination

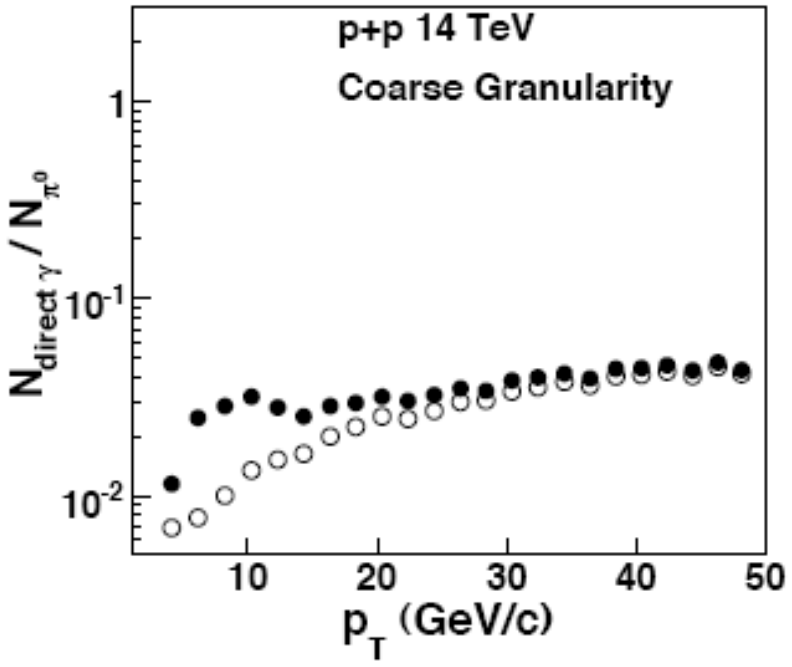
- Used to define EMCal granularity : shower shape analysis method
  - discriminate two merged showers due to a π^0 from a single shower due to a direct photon (improvements using IC)

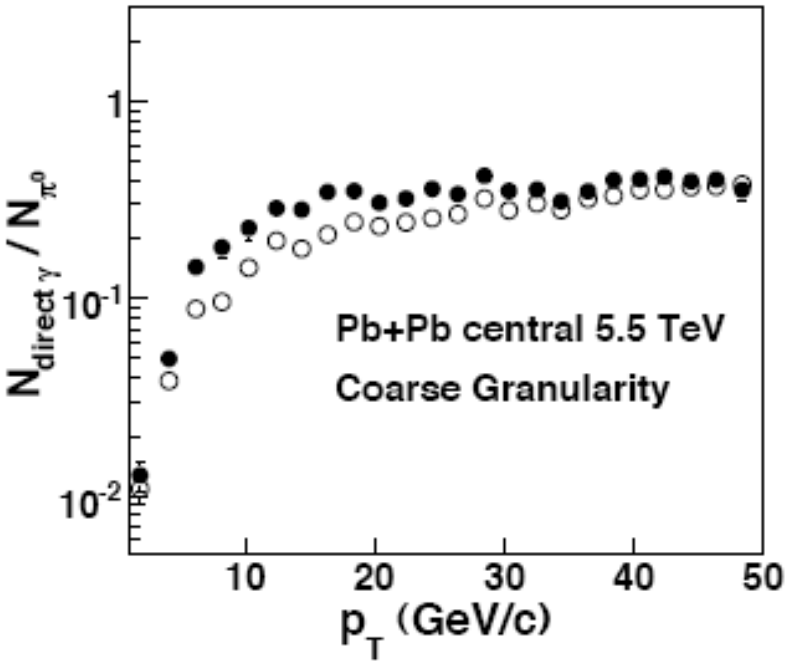




γ/π^0 discrimination

- Used to define EMCal granularity : shower shape analysis method
  - discriminate two merged showers due to a π^0 from a single shower due to a direct photon (improvements using IC)

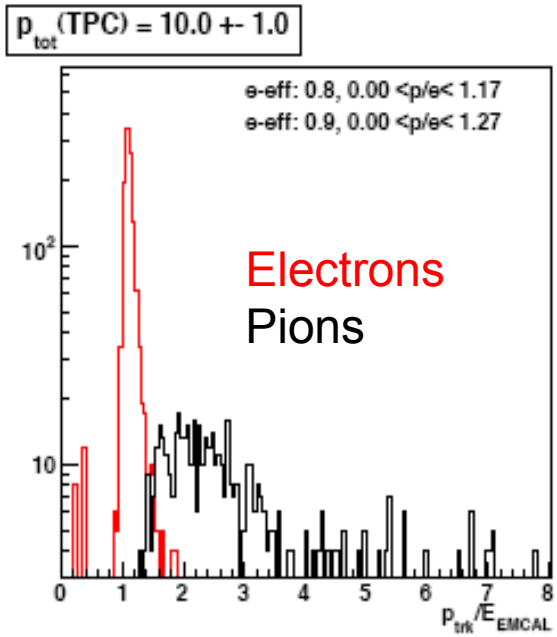


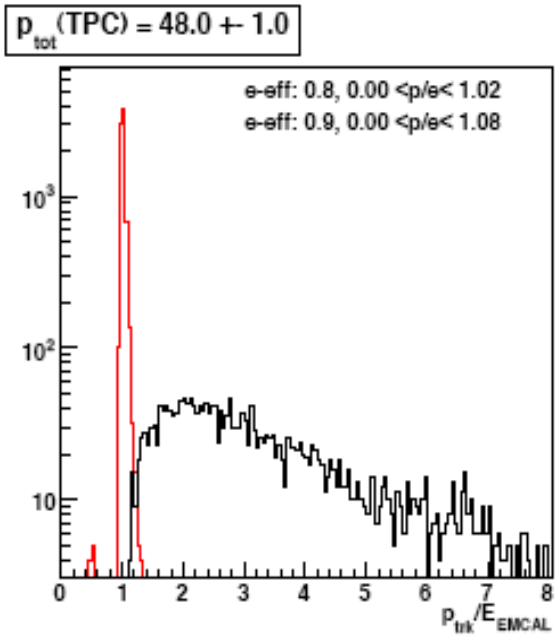


- No significant $\gamma/\ \pi^0$ discrimination improvement
- Reduction by a factor ~2 of the pt range where the π^0 can be identified
- Same EMCal coverage → no saving in material and assembly costs

High p_t electrons/hadrons

- e/h discrimination :
  - p_t < 10 GeV/c : TRD
  - p_t > 10 GeV/c : EMCal
- Electron PID based on p/E
- (TPC-Track) / (EMCal-Cluster) matching





Summary

- EMCal enhances significantly physics performances for jets and photons at high p_t providing to ALICE powerful capabilities for heavy ion collision study via high pt sector
  - Measure and trig on jets, γ, π^0 and electrons
  - Jet triggering necessary to have sufficient statistics in pp, pPb and peripheral PbPb collisions for reference measurement
  - Triggered jets : enable study of response of the medium in lower p_t sector

→ ALICE physics with EMCal