LNF activities in ALICE

Pasquale Di Nezza

INFN Frascati

43rd LNF SC meeting 19/01/12

The LNF Group

1. N.Bianchi
2. G.P.Capitani
3. A.Casanova
4. L.Cunqueiro
5. P.Di Nezza
6. A.Fantoni
7. P.Gianotti
8. S.Liuti
9. A.Moregula
10. V.Muccifora
11. A.R.Reolon
12. F.Ronchetti

A.Orlandi (tech)
A.Viticchiè (tech)

12 researchers for 11 FTE
Average participation of 92%

- 2 Period Run Coordinators
- 1 calorimeter expert on call
- 3 shift leaders
- 1 deputy spokesperson in calo MB
- 1 member of the calo MB
- 1 MC CERN-group coordinator
- 1 calorimeter construction coordinator
- 1 “Collider Xtalks group” conv @ CERN

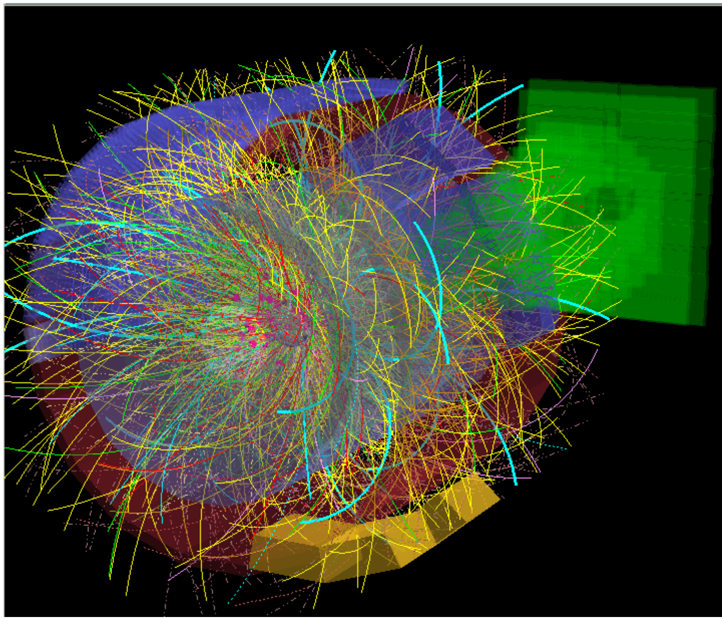
Latest papers:
1) First author, submitted to PLB
2) Co-first author, in advanced status
3) First author, in a very early status, ++

Event statistics per trigger class (status 6 Dec. 2011)

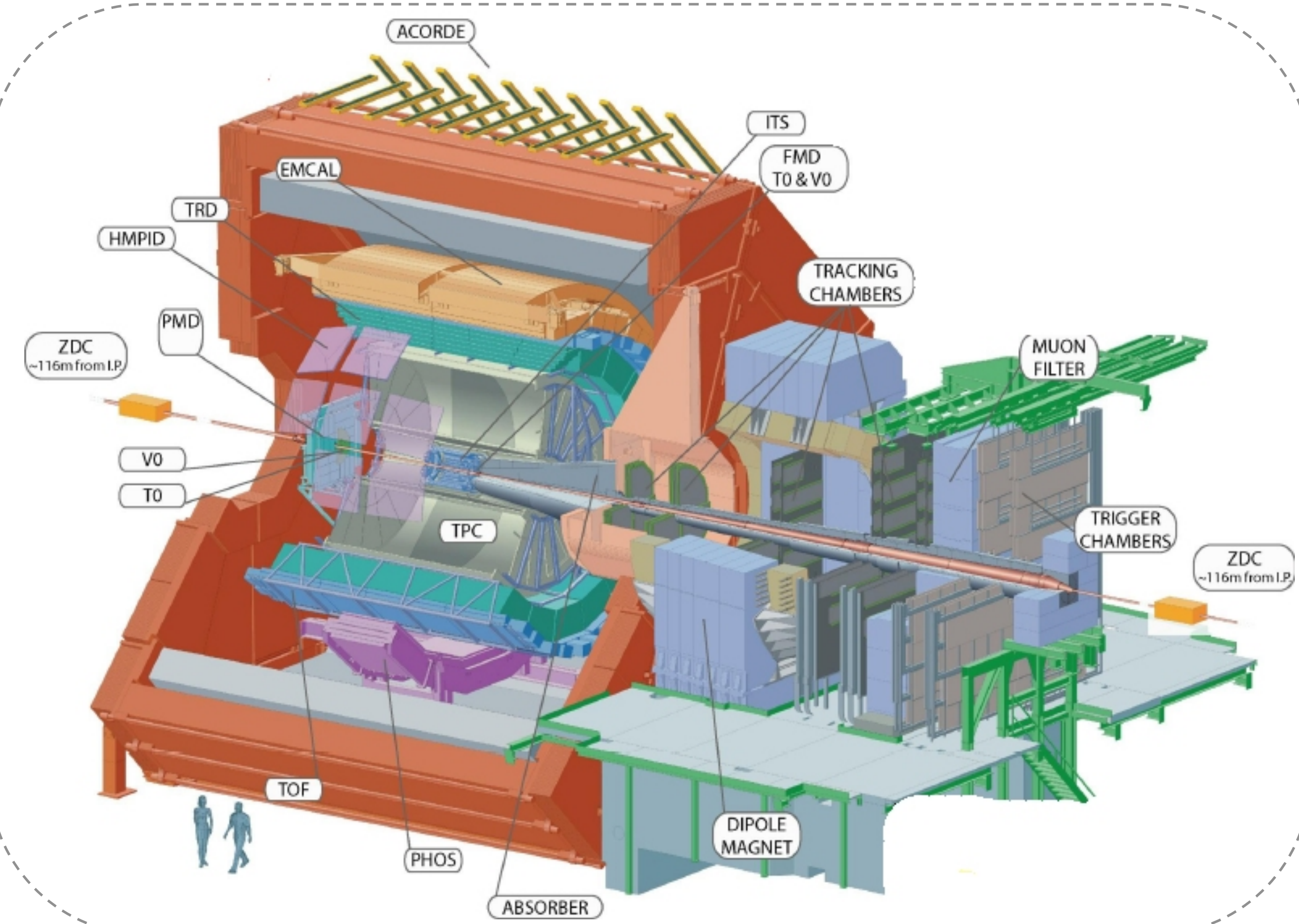
PbPb

Trigger	Events
MinBias	8.3 M
Central	27.5 M
Semi-Central	32.1 M
EMCAL Jet	9.4 M
EMCAL Gamma	7.2 M
Barrel UPC	7.9 M
PHOS π^0	1.9 M
MUON Single	27.9 M
MUON UPC	3.0 M
MUON dimuon	20.0 M

- Trigger mix optimized to enhanced statistics of rare probes
- ~10x more statistics (centrality and rare triggers) collected as compared to 2010

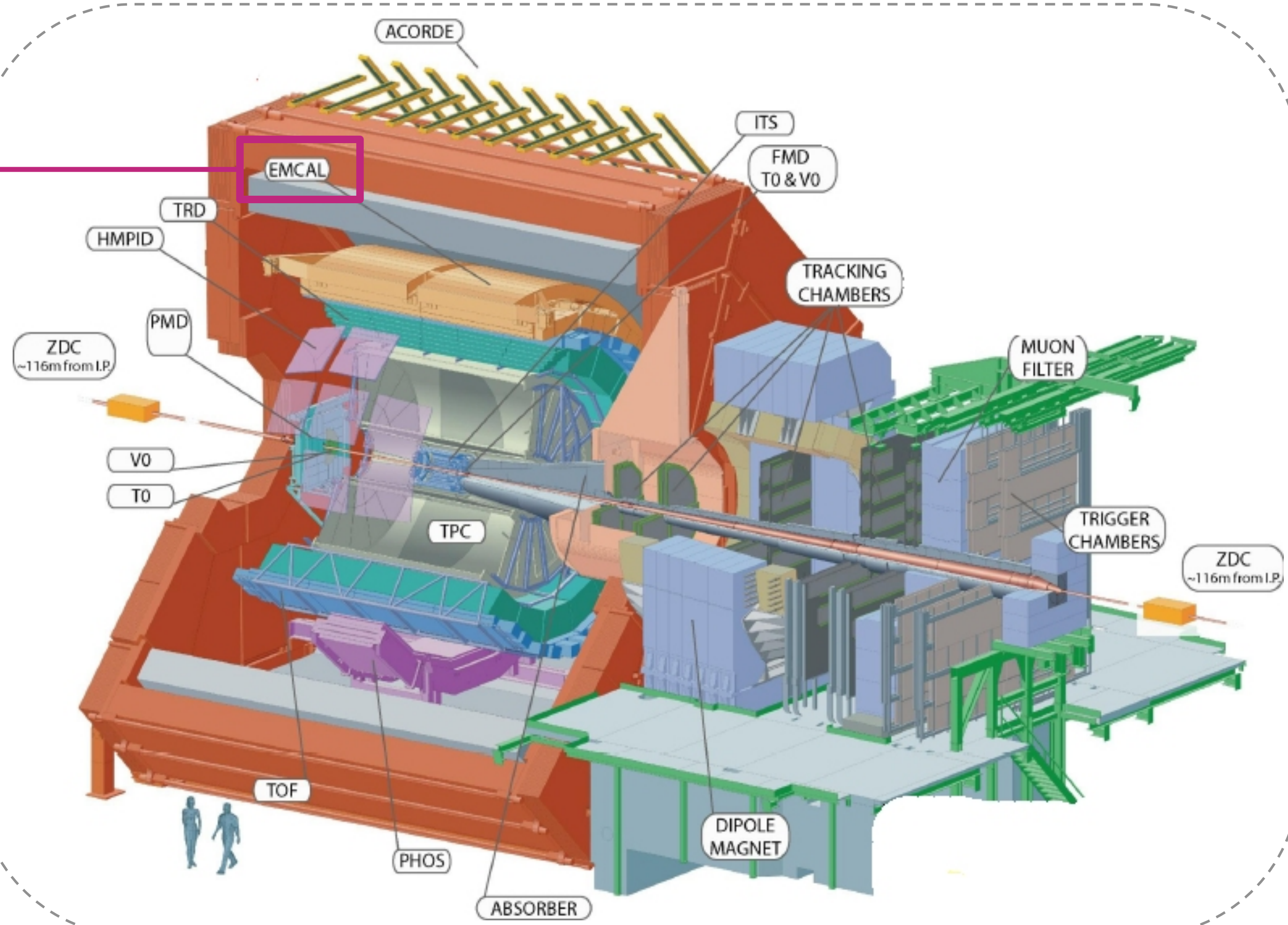


The activity of the LNF group



The activity of the LNF group

Construction of the e.m. calorimeter

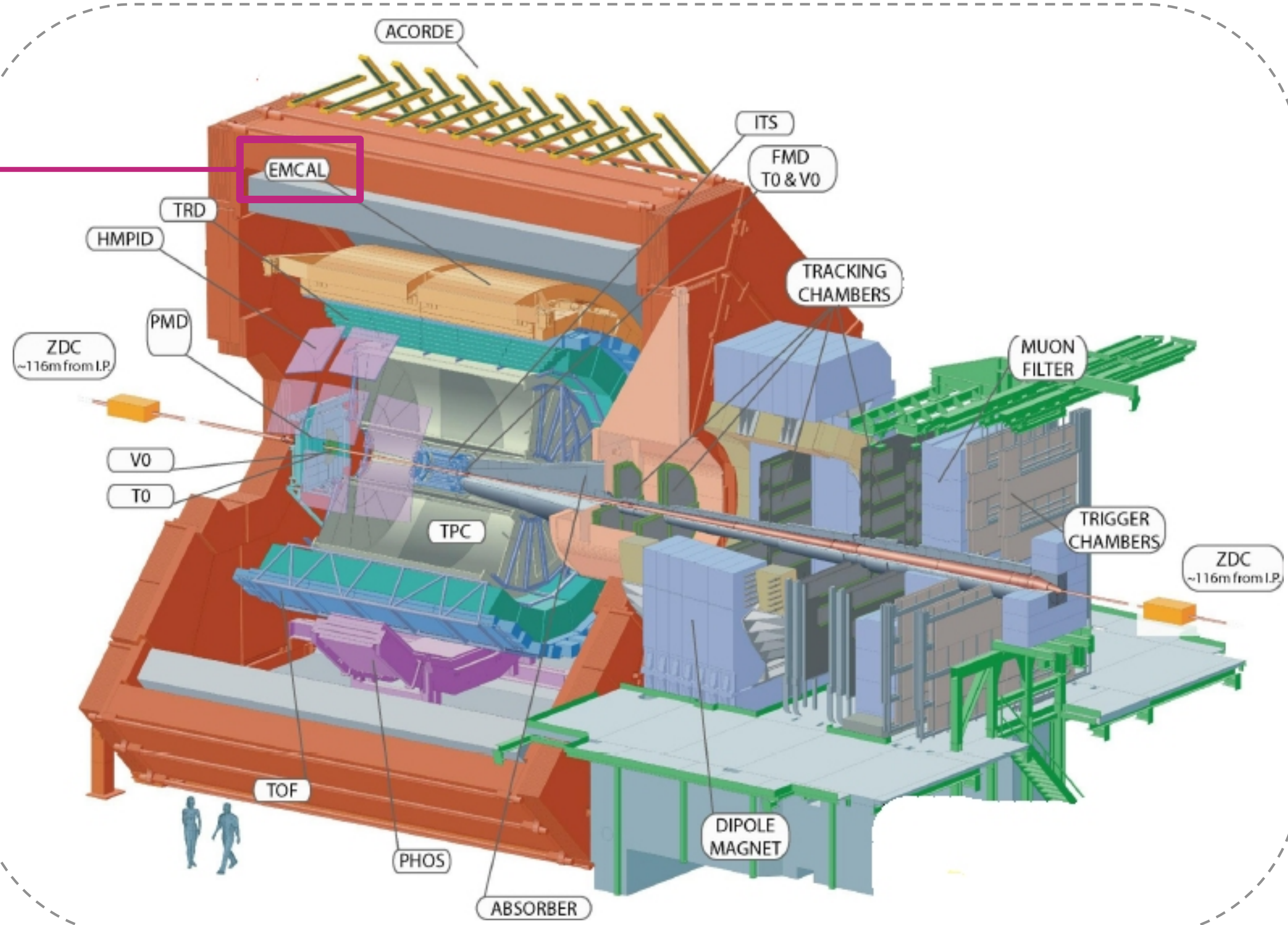


The activity of the LNF group

Construction of the e.m. calorimeter

•Online monitoring
•Offline codes

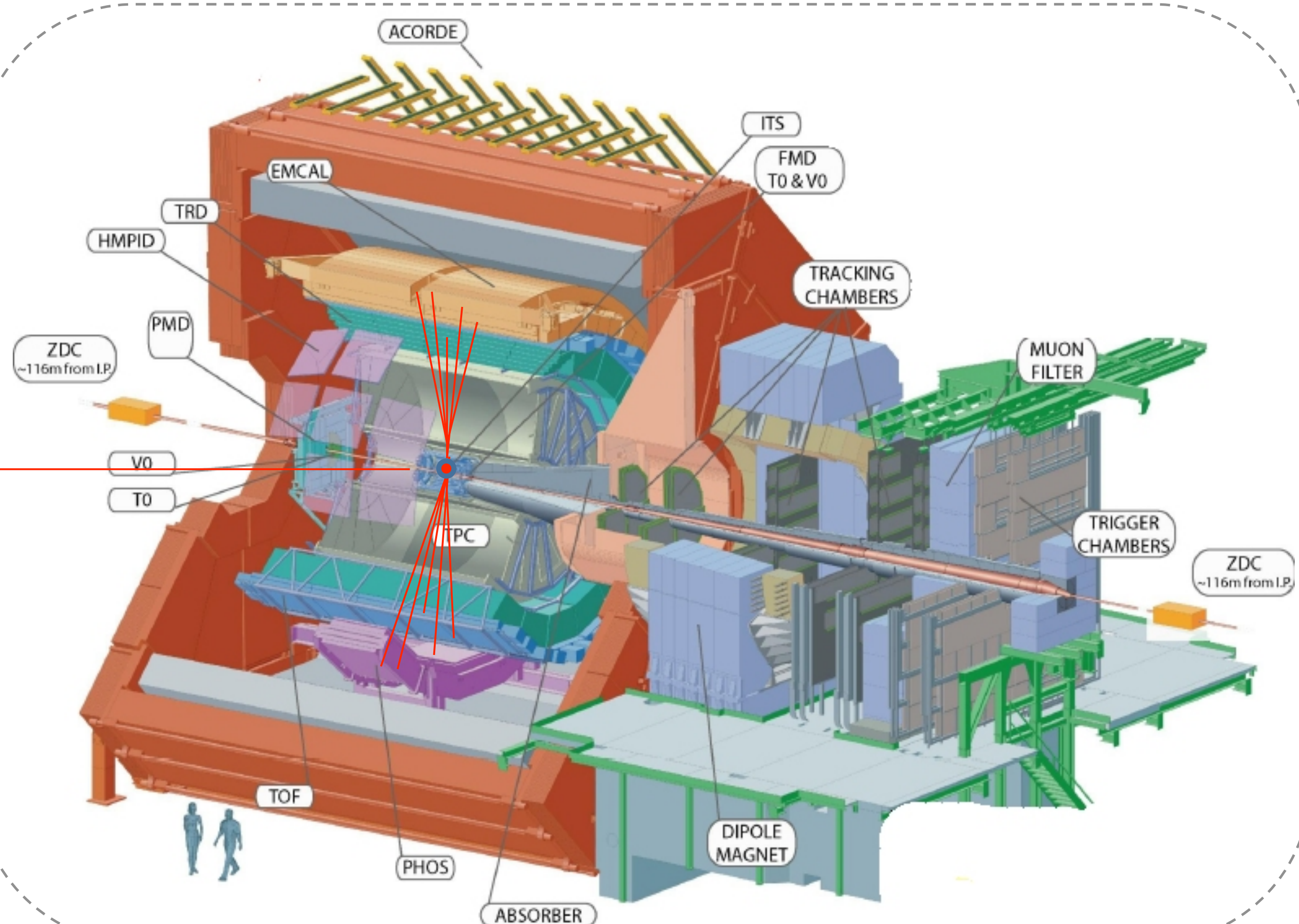
•High Level Trigger



The activity of the LNF group

Jet physics

Jet reconstruction
MC in QGP



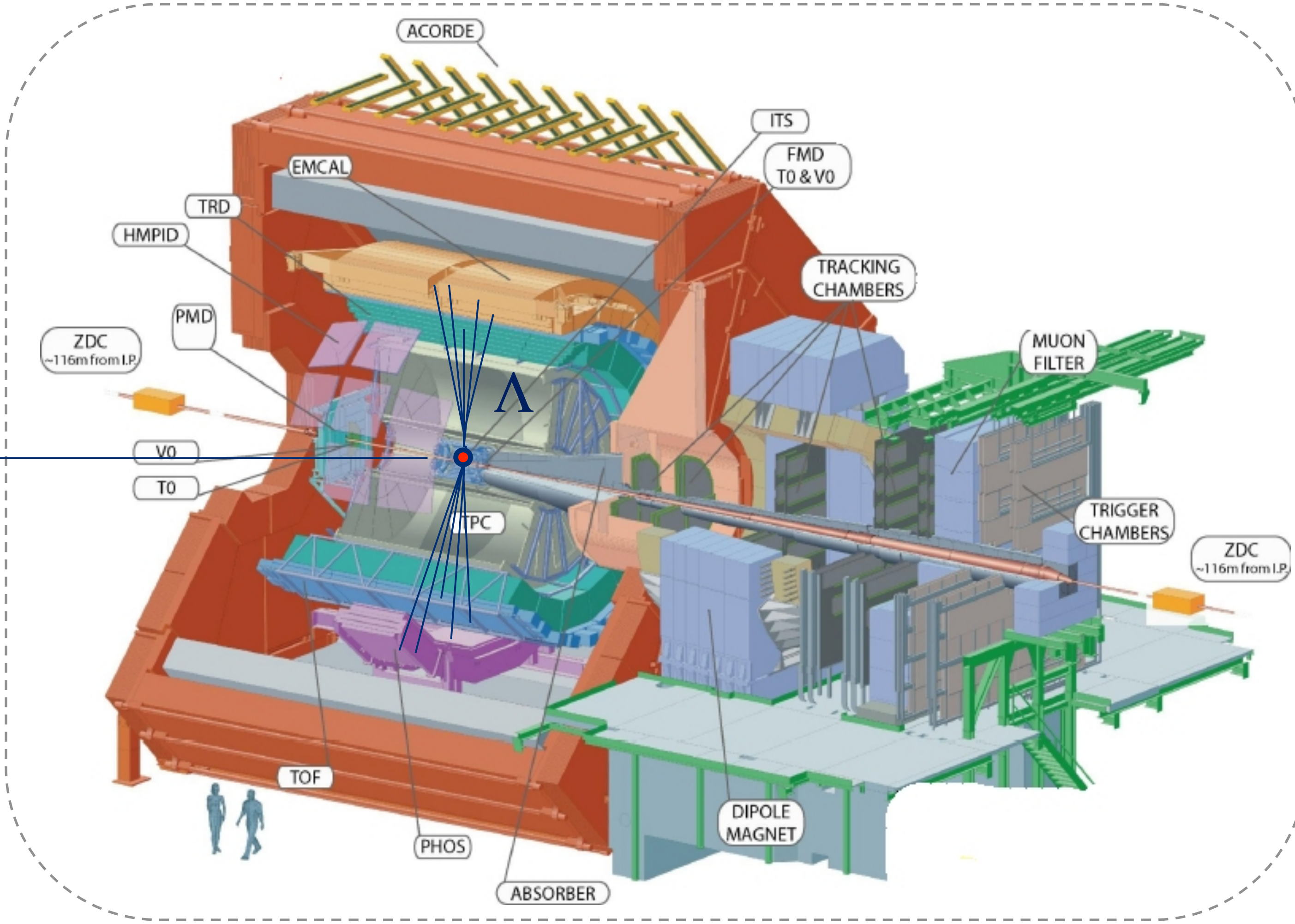
The activity of the LNF group

Jets with associated Λ

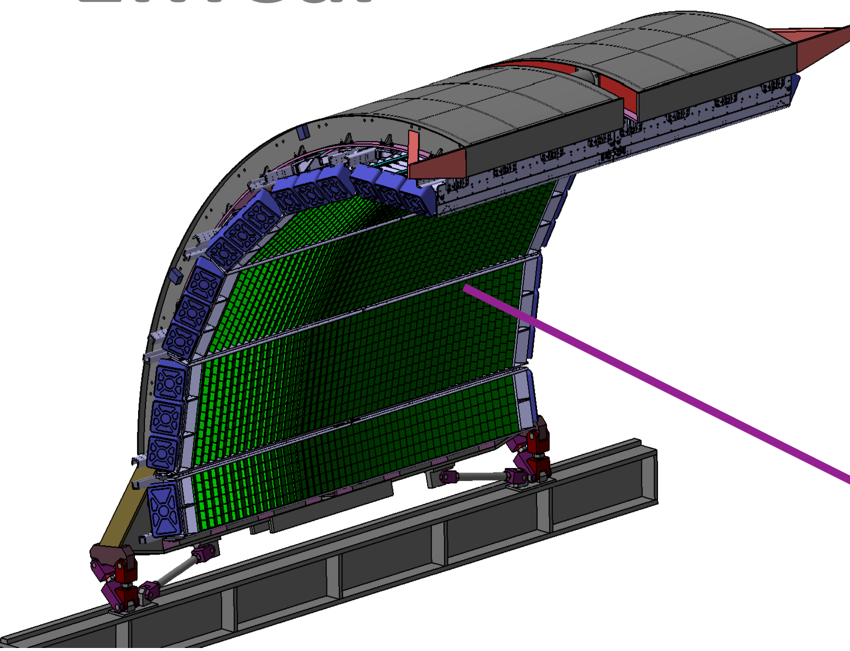
TMDs in pp

Transverse Λ polarization

GPDs in pp



EMCal



France, Italy and USA Collaboration

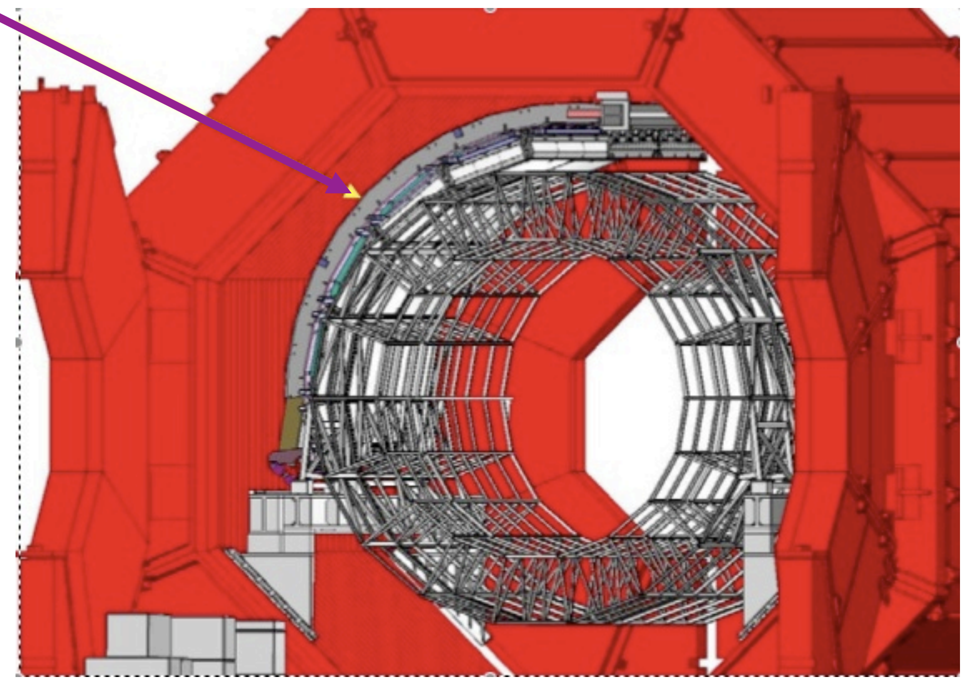
- 7 US Super-Modules (SM)
- 3 EU SMs (Italy and France)
- Construction started in 2008
- 4/10 SM installed in 2009
- Complete installation in 2011

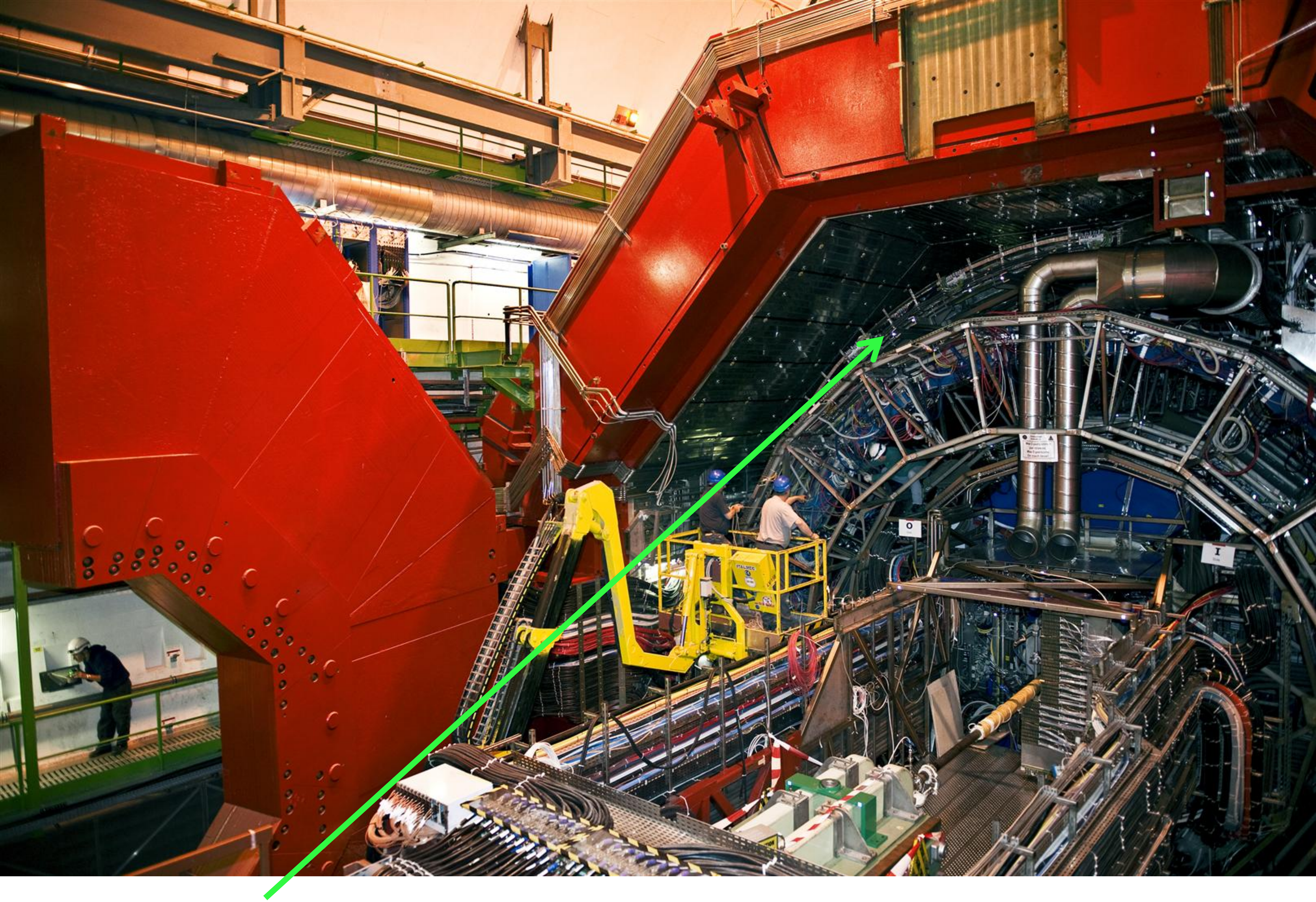
Lead-Scintillator Sampling Calorimeter

$\Delta\eta = 1.4$, $\Delta\phi = 100^{o}$, 20.1 X_0

Shashlik Geometry, APD Photosensor

12k Towers

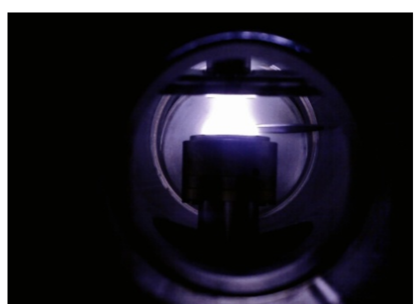




EMCal fully installed in the winter shutdown 2010/11

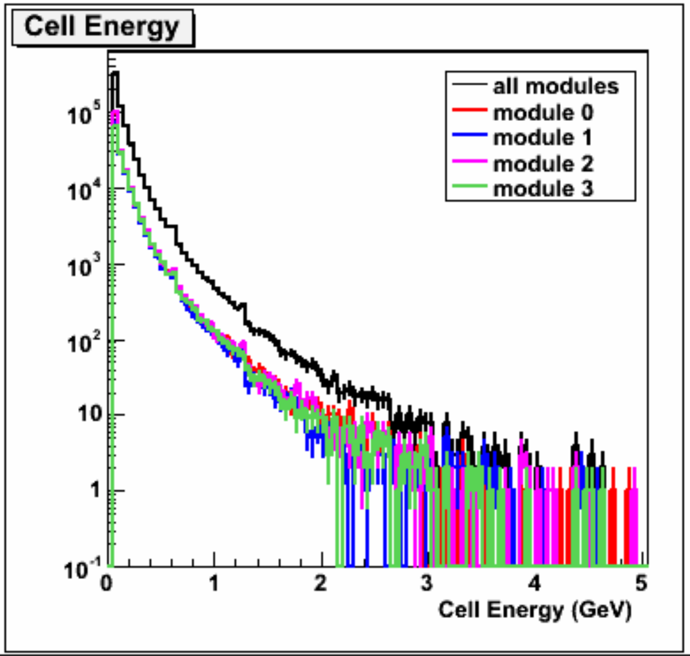
Basic Unit = 4 channels

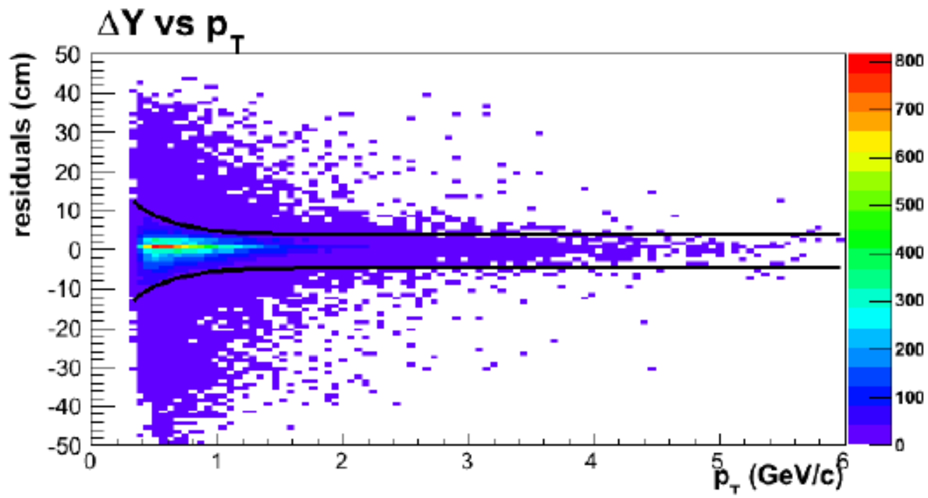
Assembling station (2 on site)

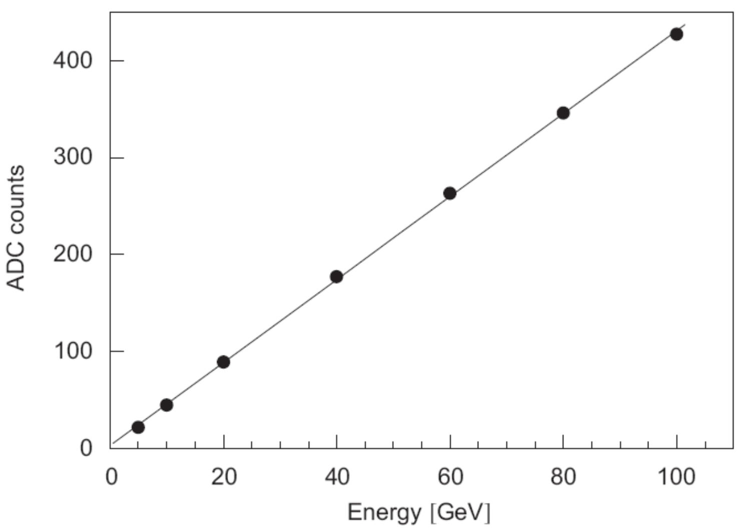


Aluminization of
200k fibers (WLS)

Quick overview on the calo performances







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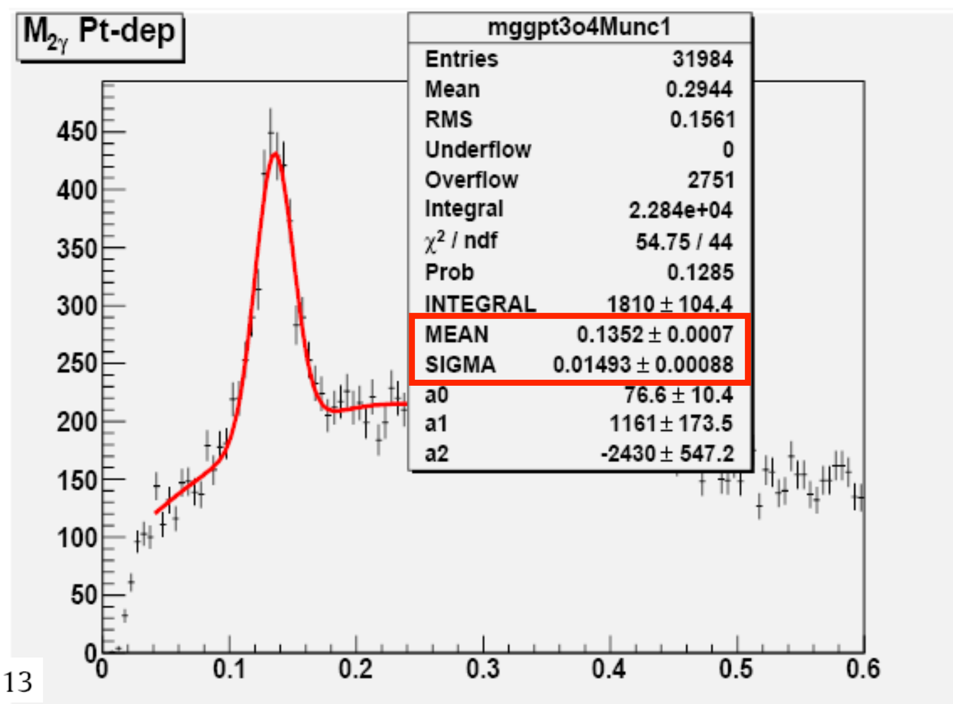
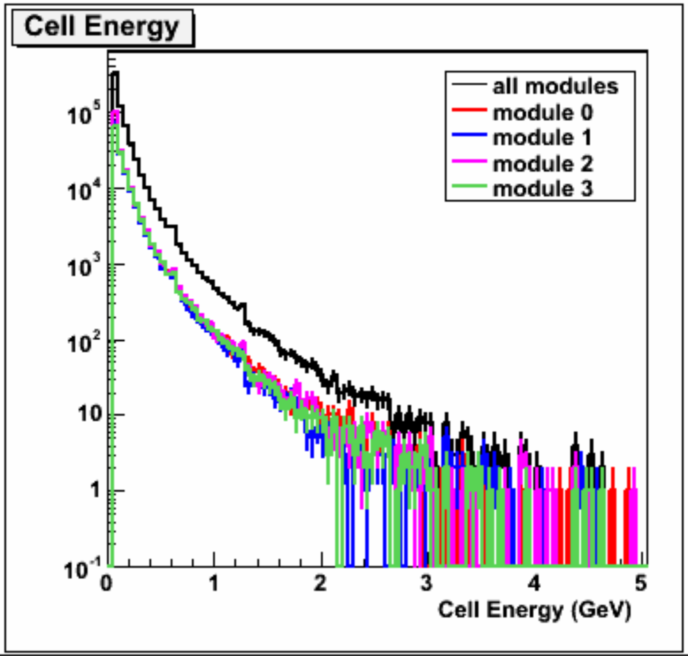
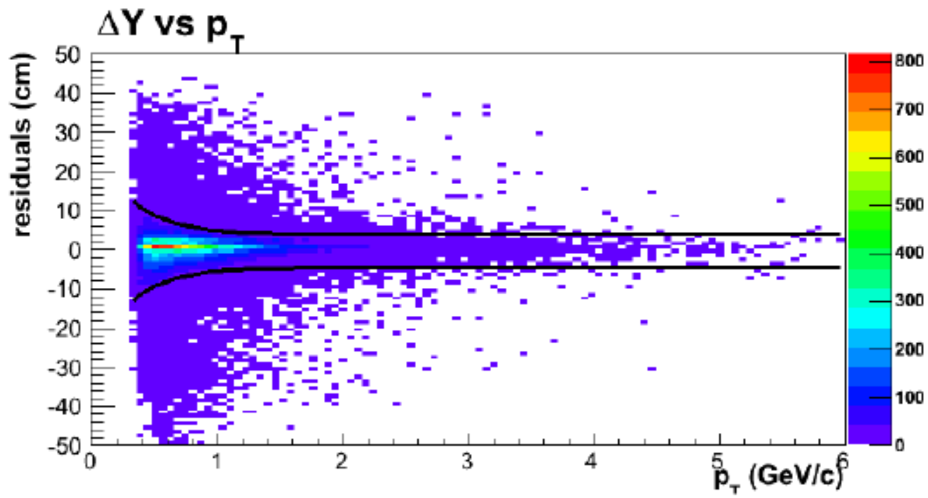
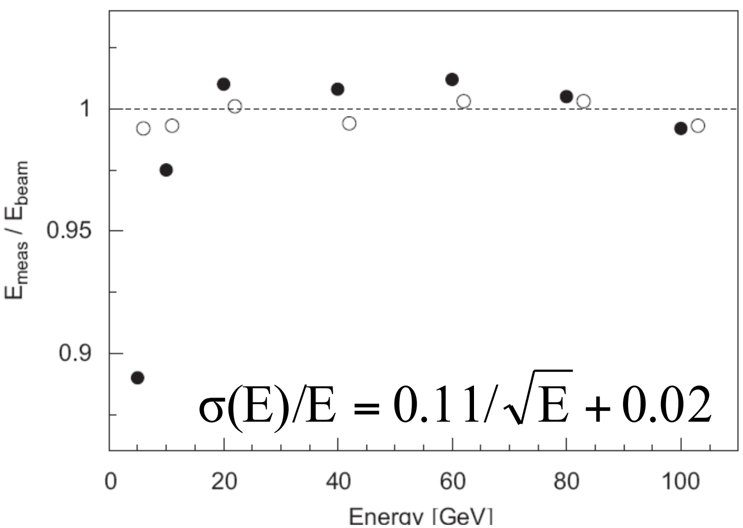


Quick overview on the calo performances







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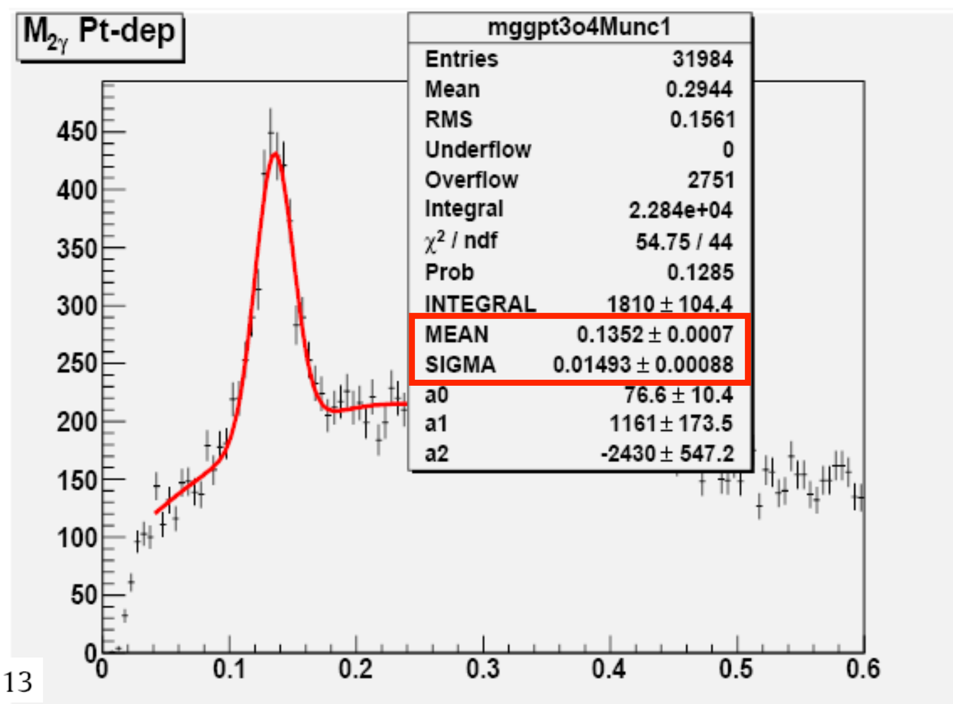
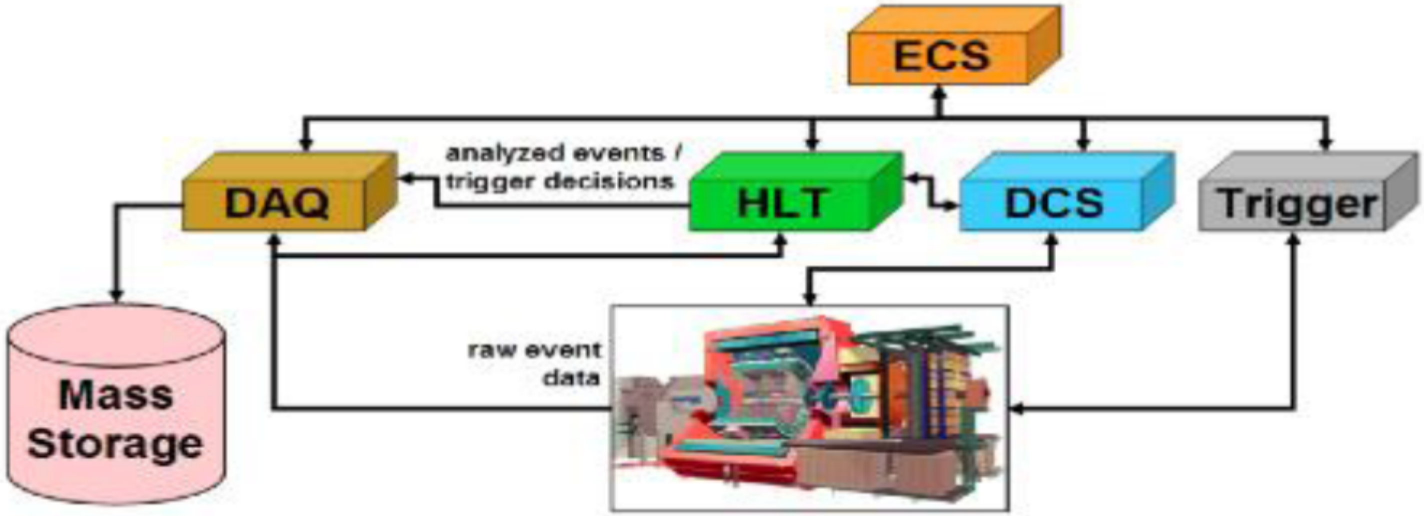


High Level Trigger for EMCal



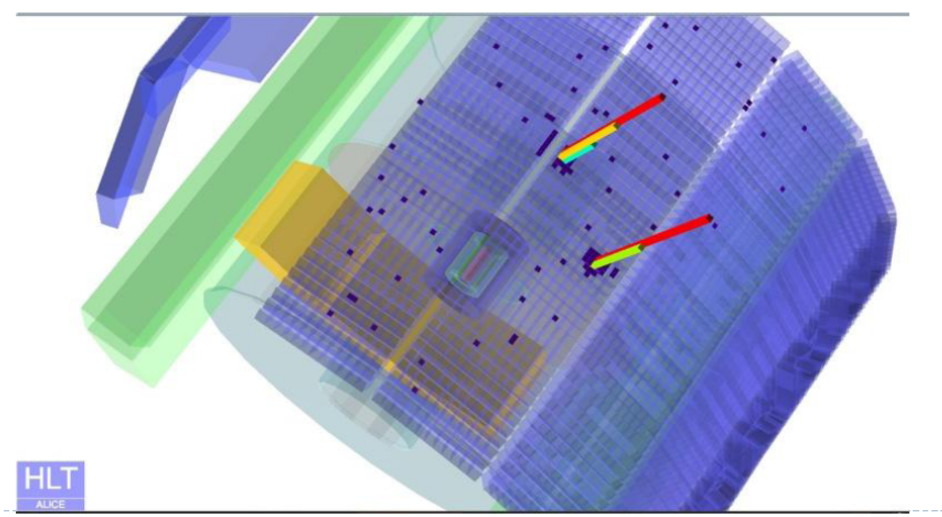
PbPb collisions gives 2 kHz calo tower hit rate

HLT reduces to a 40% EMCal data occupancy

Main HLT strategy:

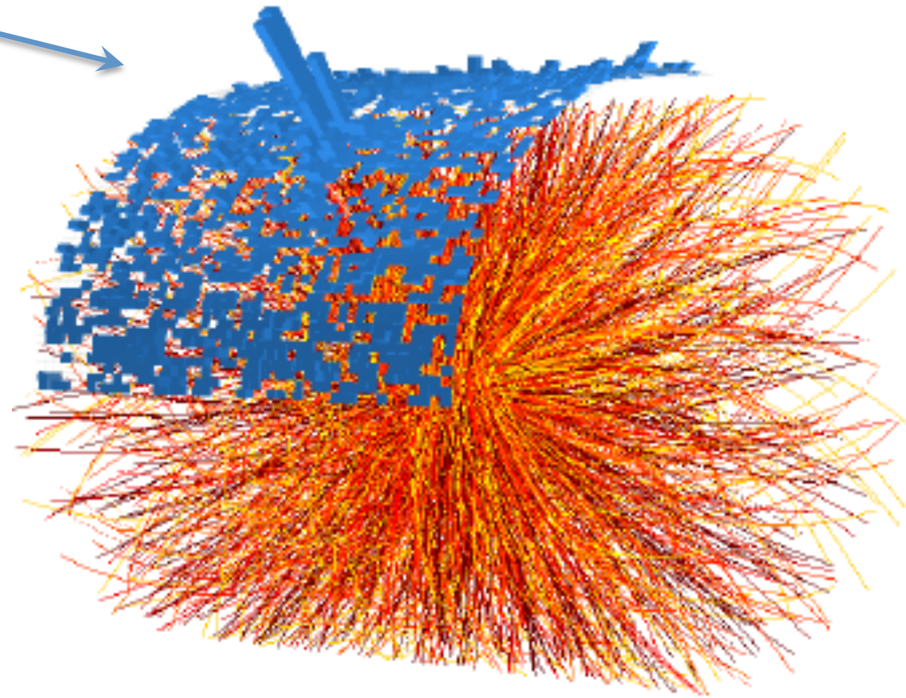
•Reconstruction for calibration and monitoring

•Event rejection using high-E_T (cluster) trigger OR jet trigger



High Level Trigger for EMCal

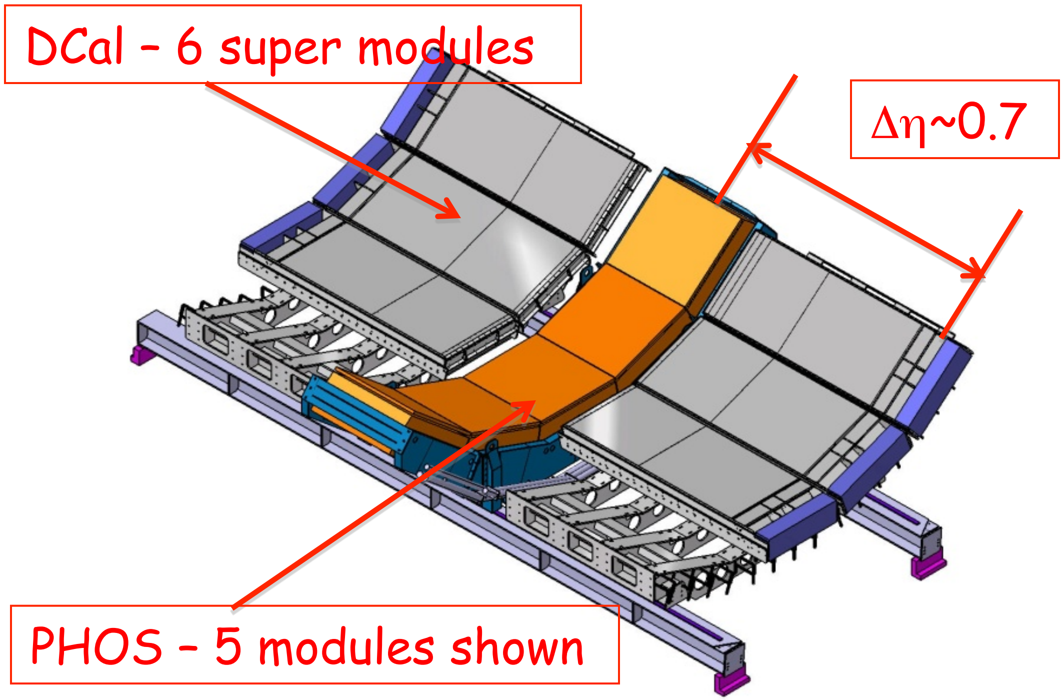
Jet in EMCal triggered by the HLT

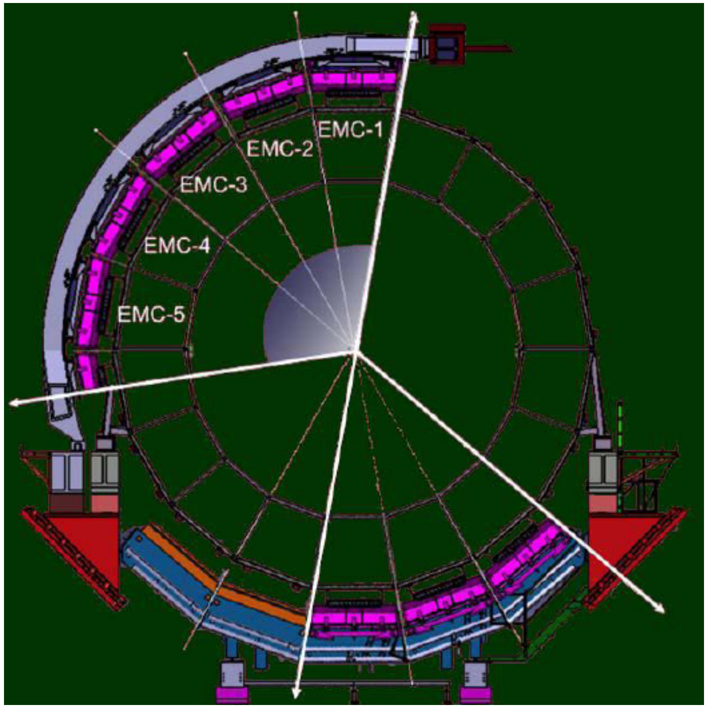


From EMCal to DCal

DCal, the first upgrade approved by the Alice collaboration.

It will be installed in 2013: extension of EMCal for jet-jet and γ-jet physics



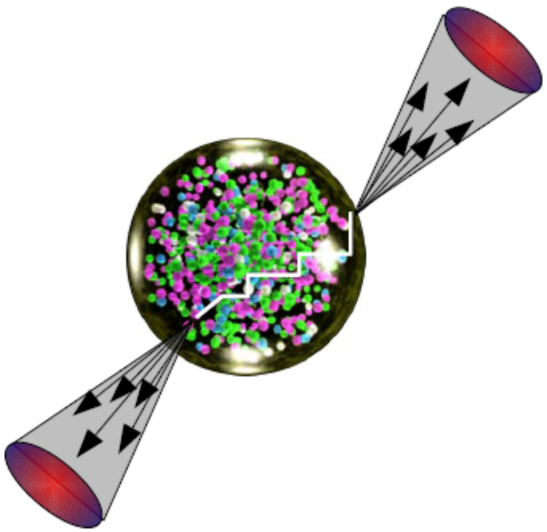


DCAL modules:
same technology than EMCal

LNF contribution with tools, expertise and manpower

Continuing WLS fiber bundles construction: >250 k fibers sputtered

Jets to access to the QGP

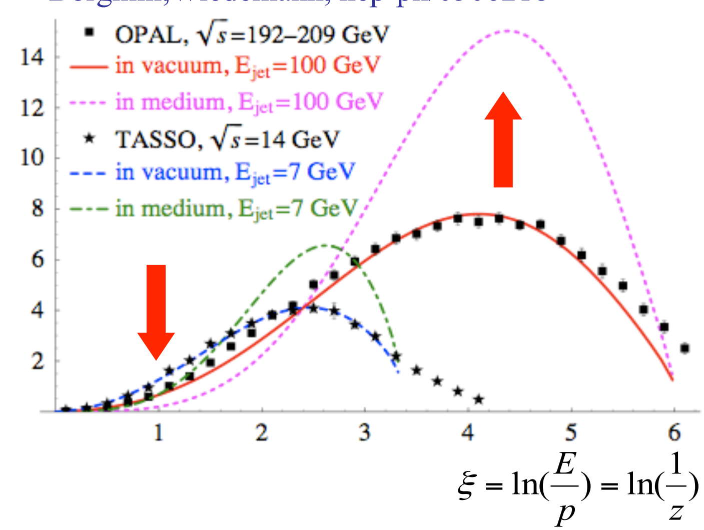


High-p_T partons produced in hard interactions undergo *multiple interactions* inside the collision region prior the hadronization … so they *loose energy through medium induced gluon radiation* → the *jet quenching* as a golden channel to probe the QGP

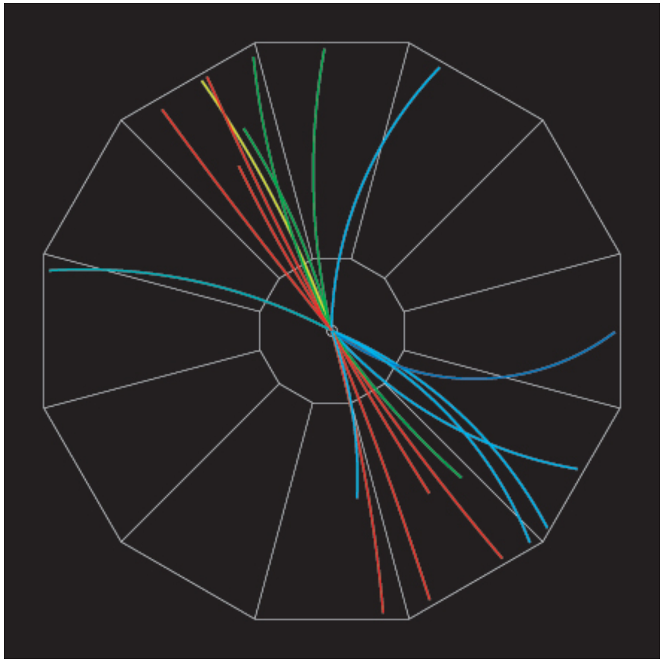
Jet →Jet' + soft gluons + soft hadrons from UE

- Decrease of leading particle p_T (energy loss)
- Increase of number of low momentum particles (radiated energy)
- Increase of p_T relative to jet axis (j_T)
  - Broadening of the jet
  - Out of cone radiation (decrease of jet rate)
- Increased di-jet energy imbalance and acoplanarity.

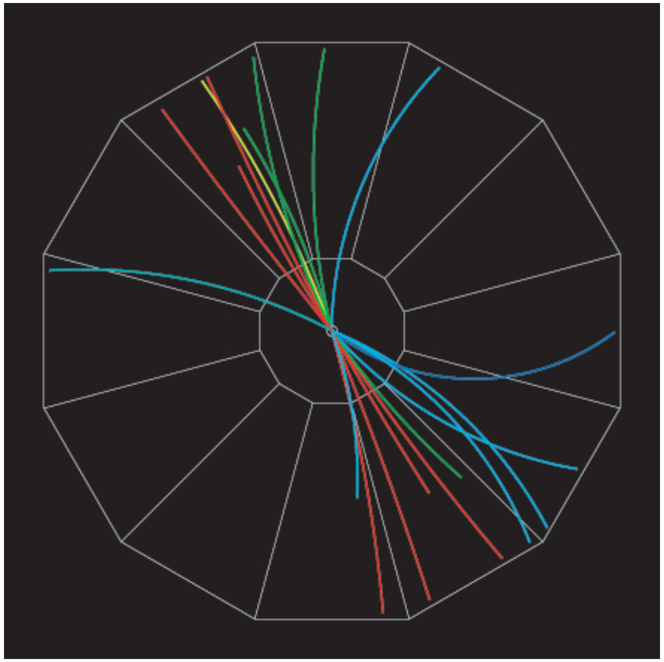
Borghini,Wiedemann, hep-ph/0506218



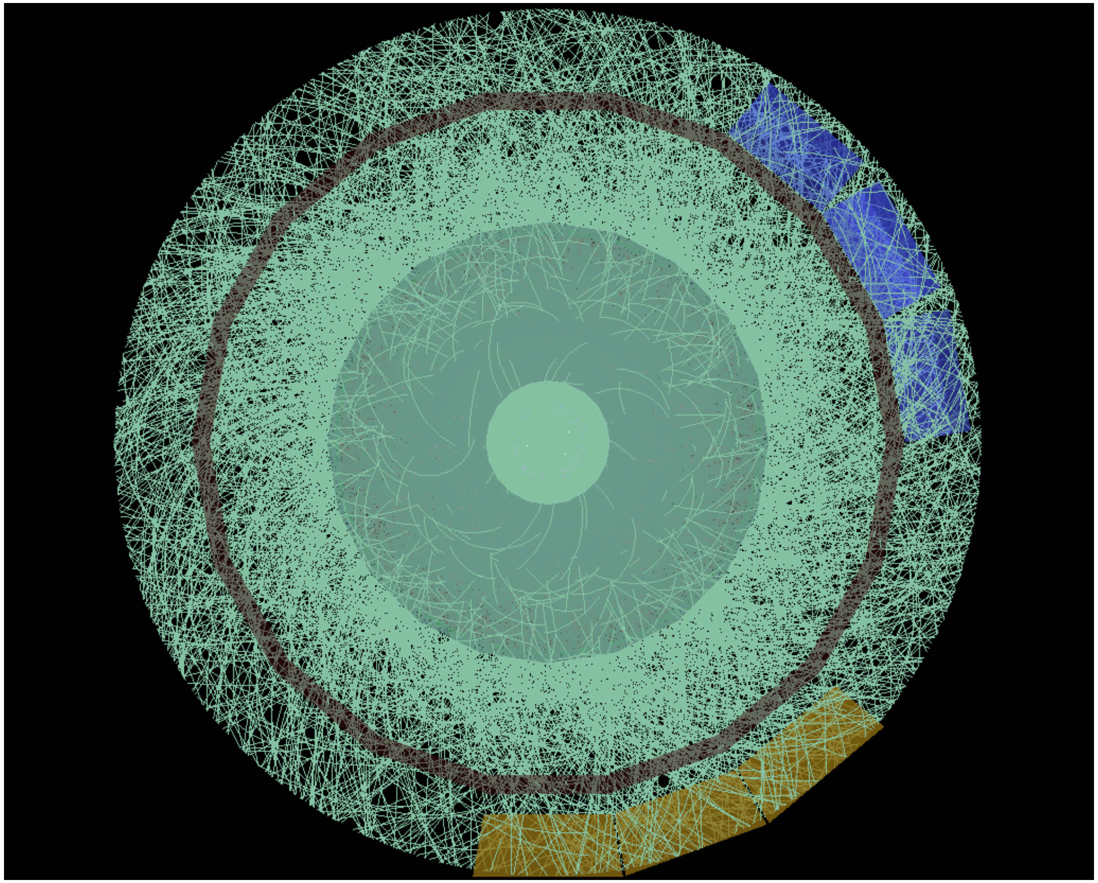
Try to find something like this……



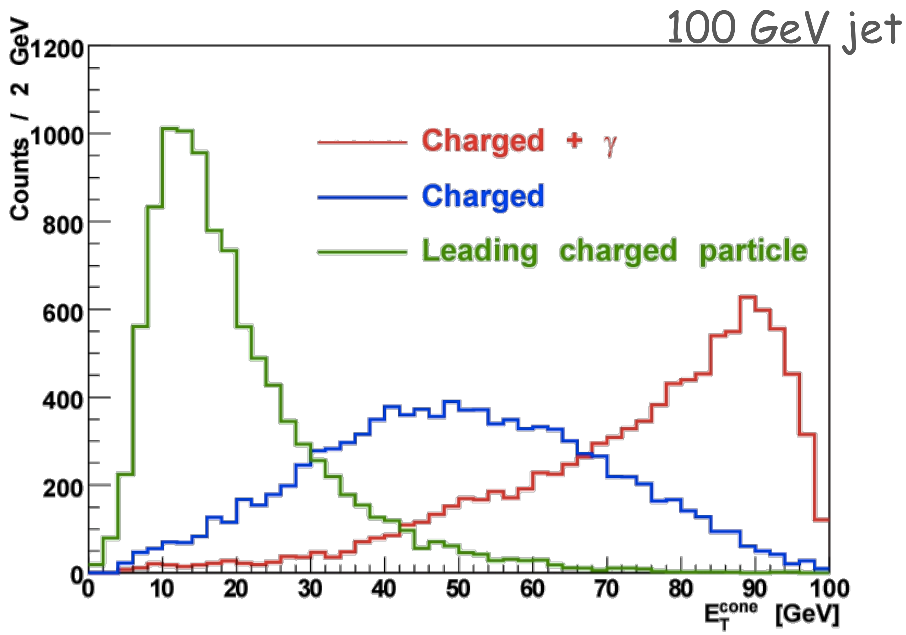
Try to find something like this……

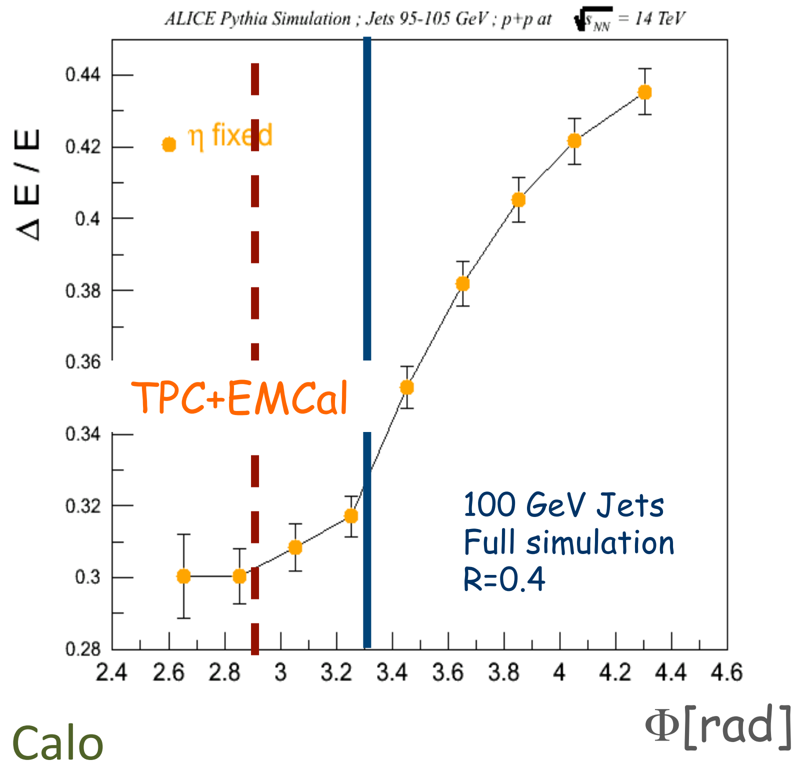


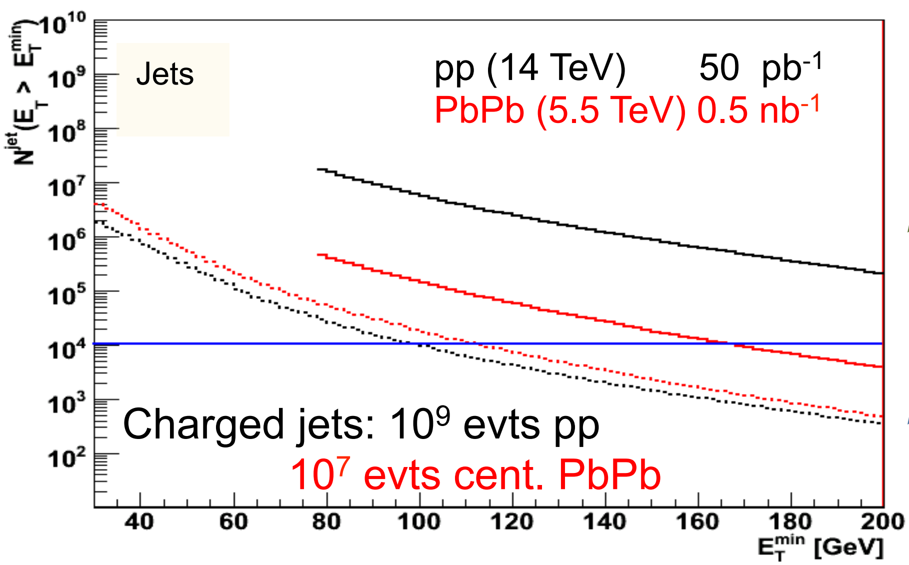
in this !



Role of EMCal in the jet reconstruction







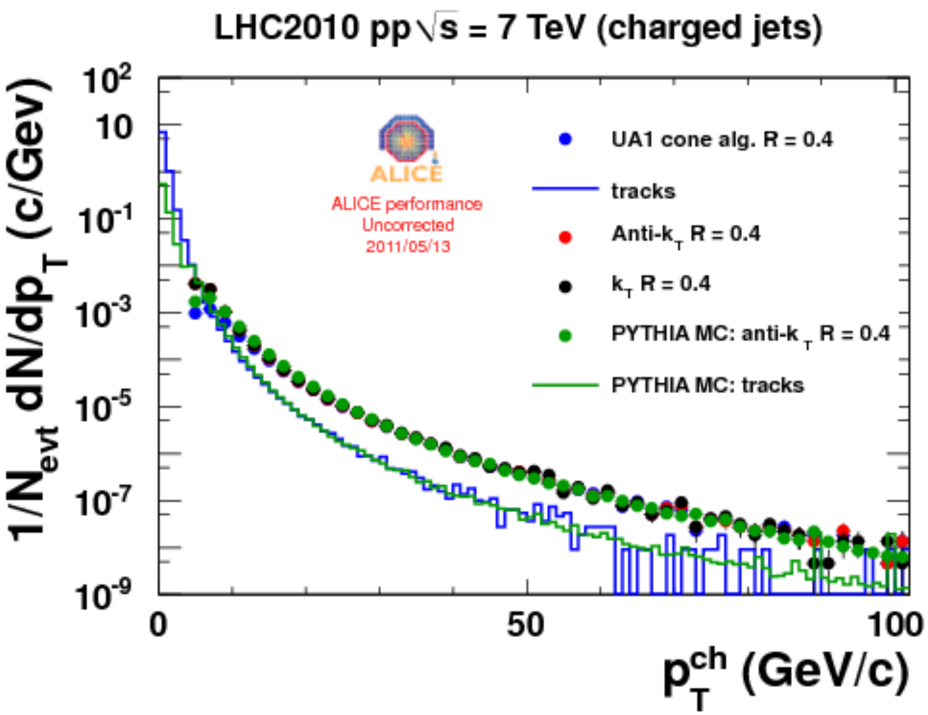
Track + Calo

Charged only

Jet yield in 20 GeV bin

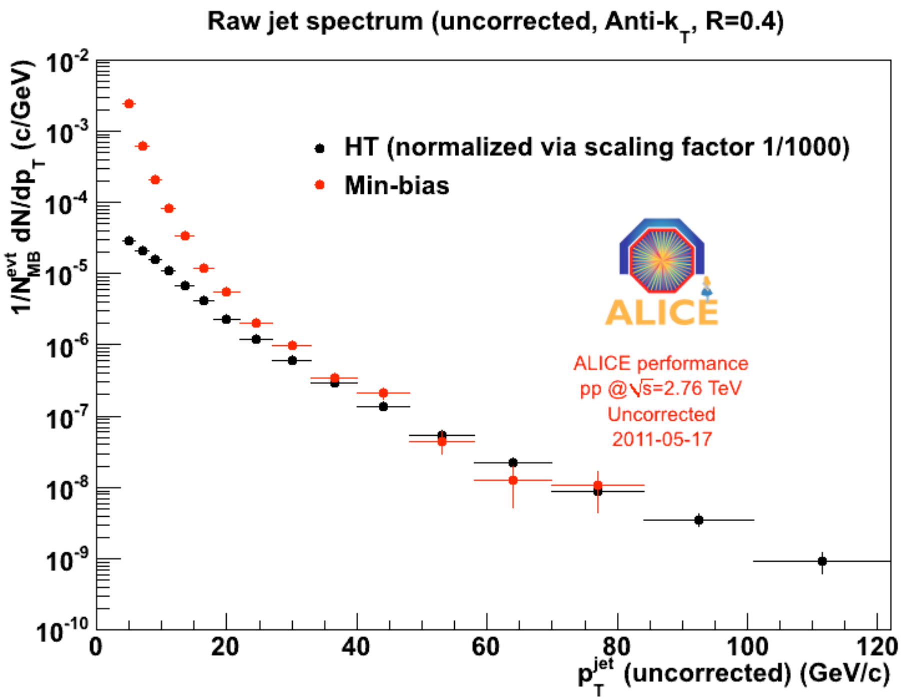
System	jet trigger?	N_{jets} (125 GeV)	N_{jets} (175 GeV)
Pb+Pb cent	y	1.1×10^4	1700
	n	2100	320
Pb+Pb periph	y	410	62
	n	8	1
p+Pb 8.8 TeV	y	2.7×10^4	4200
	n	250	40
p+p 14 TeV	y	6.9×10^5	1.0×10^5
	n	1200	190

Jets in pp



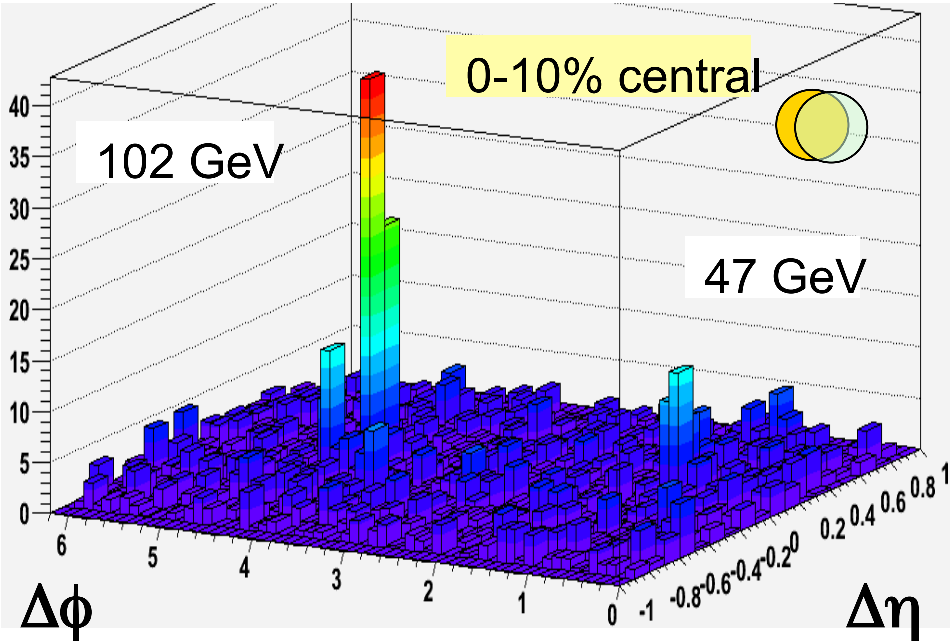
p+p charged jets
well described by PYTHIA

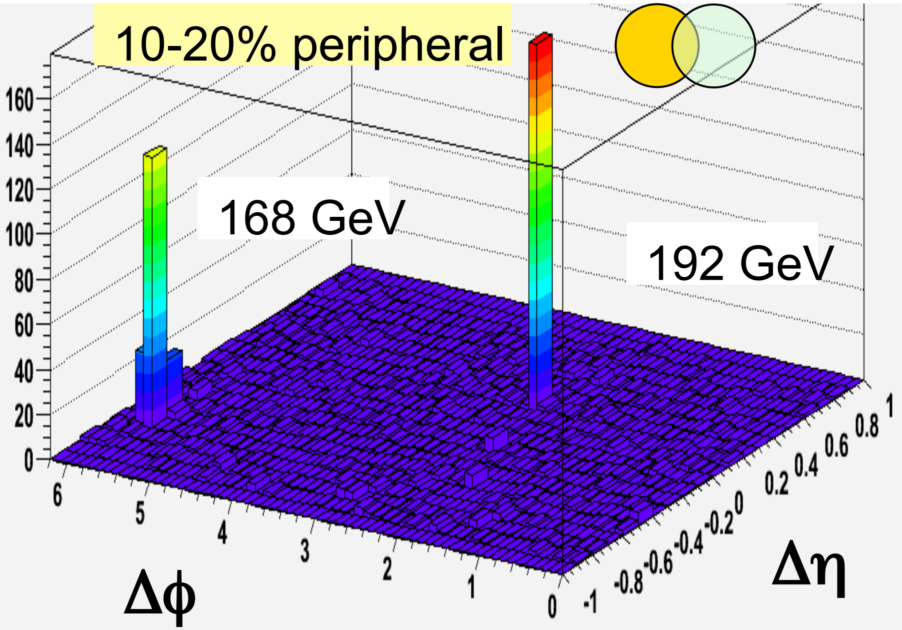
EMCal
Installed in winter 2010/2011



EMCal jet trigger commissioned
in p+p

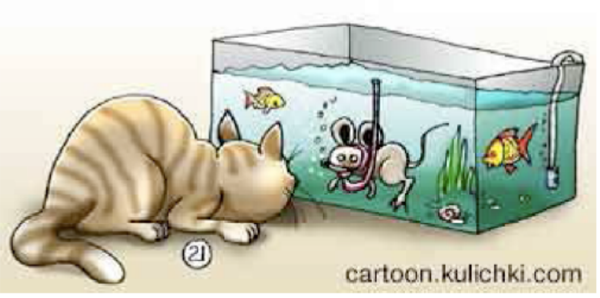
Jets in PbPb



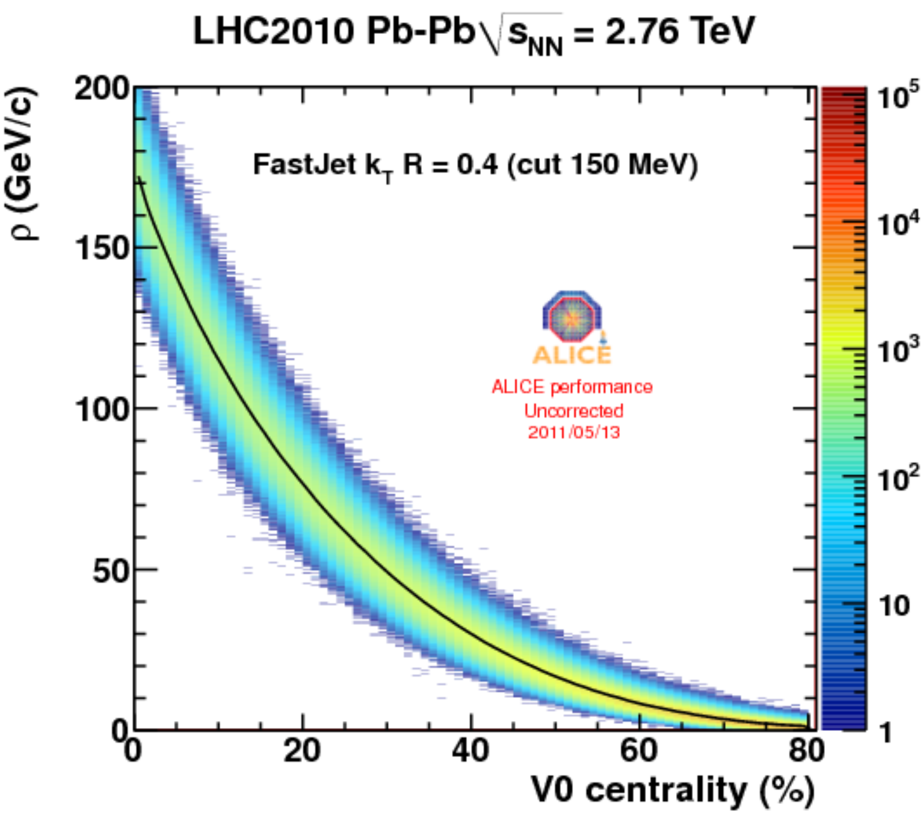


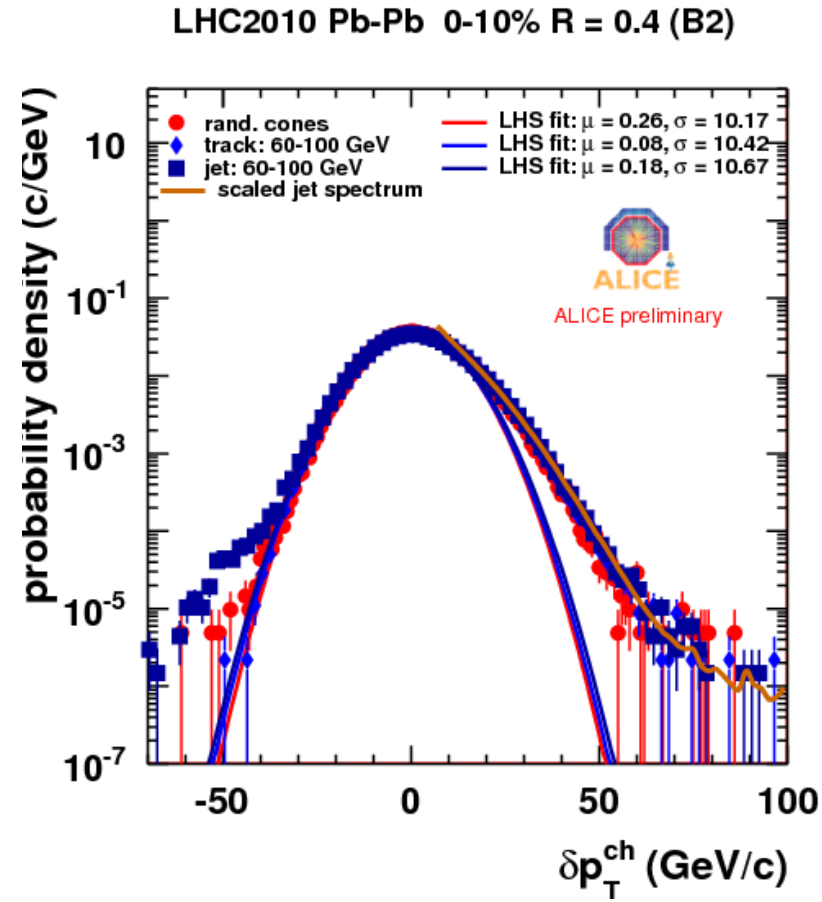
$$\langle \delta p_T \rangle = \langle \delta p_T^{hadronization} \rangle + \langle \delta p_T^{perturbative\_radiation} \rangle + \langle \delta p_T^{underlying\_events} \rangle$$

Wealth of new intriguing phenomena in the medium!



Jets in HI





Large uncorrelated background density in heavy ion collisions
ρ ~ 170 GeV/c in central events

Measure background fluctuations 'in situ':
Random cones, embedding give similar results

not gaussian: tail from jets

σ_{gauss} = 10 GeV/*c* for central events

Jets in heavy ion collisions

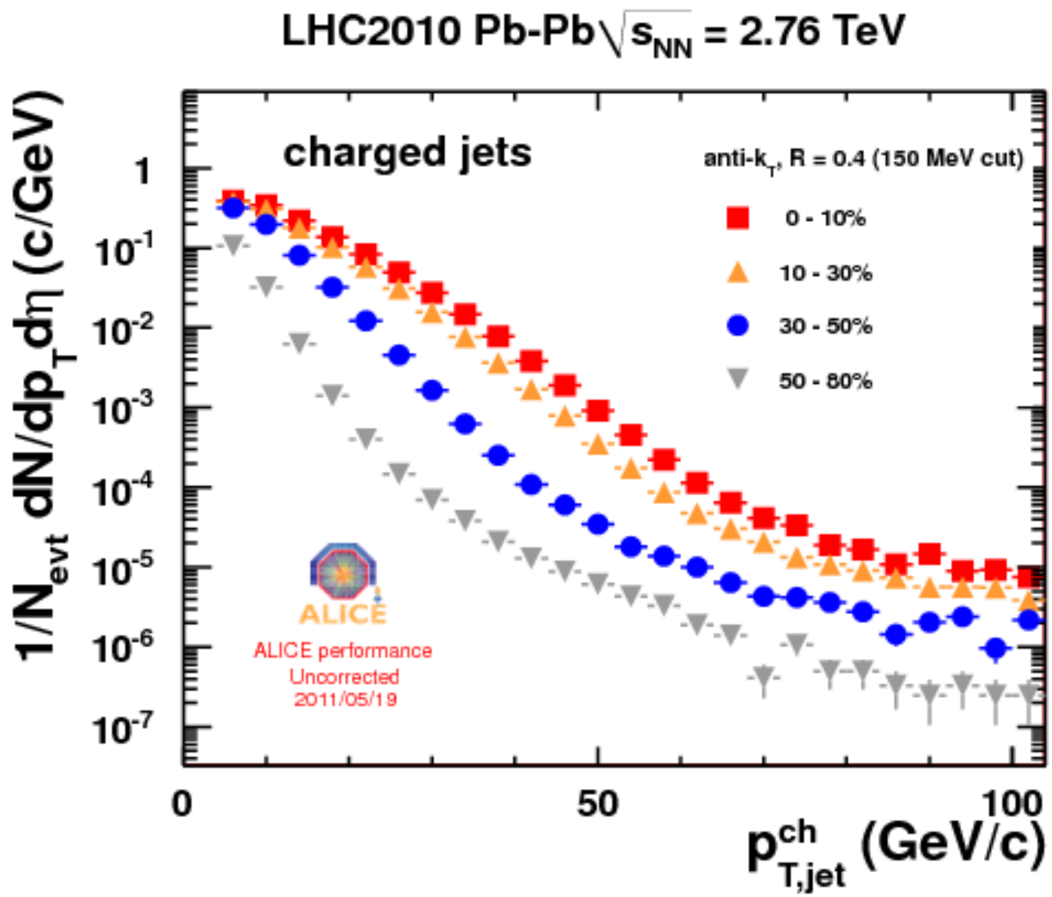
Subtract uncorrelated background:

$$p_{T,jet} = p_{T,meas} - \rho_{bkg} A_{jet}$$

Fluctuations remain after subtraction

Background fluctuation can "simulate" quenching!

Fine unfolding of fluctuations is needed: in progress…



Reconstructed jet spectrum
Dominated by background fluctuations
for p_T < 60-80 GeV/*c* (central events)

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN-PH-EP-To be specified
To be specified

Measurement of Event Background Fluctuations for Charged Particle Jet Reconstruction in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV

LNF First author
Sent to PLB

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN-PH-EP-To be specified
To be specified

Inclusive jet spectrum in PbPb collisions at $\sqrt{s_{NN}}$=2.76 TeV

LNF Co-first author
In preparation

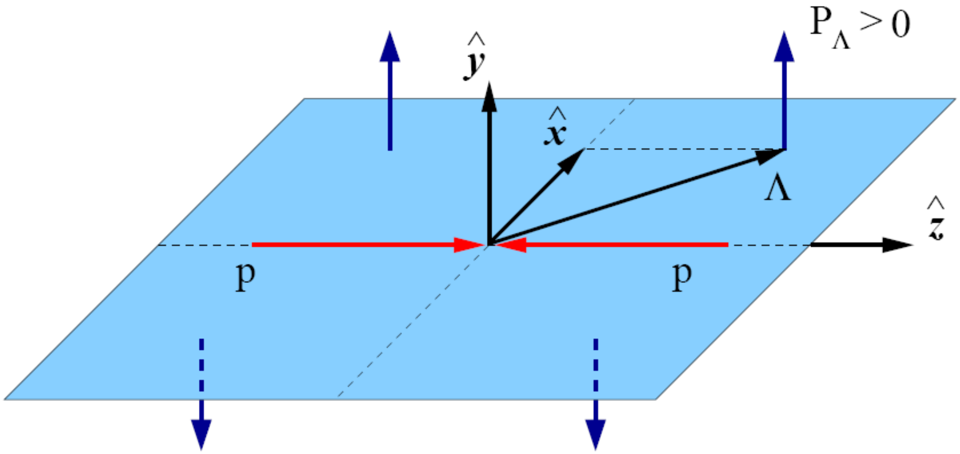
QPythia: a Monte Carlo for the Jet Quenching

LNF in collaboration with the
Santiago University theory group
[Armesto, Cunqueiro (lnf), Salgado]

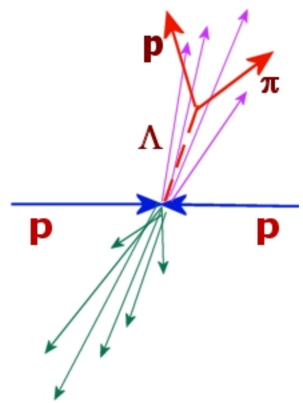
QPythia is a tuning of final state showering routines in Pythia where:

- medium-induced gluon radiation effects enter through medium-modified splitting functions.
- The longitudinal evolution of the shower is taken into account by considering the formation length of the emitted gluons.
- The energy loss and the transverse broadening of the shower are dynamically related by the relevant parameter: $\hat{q}$, the transport coefficient.

Transverse Λ polarization in unpolarized pp scattering

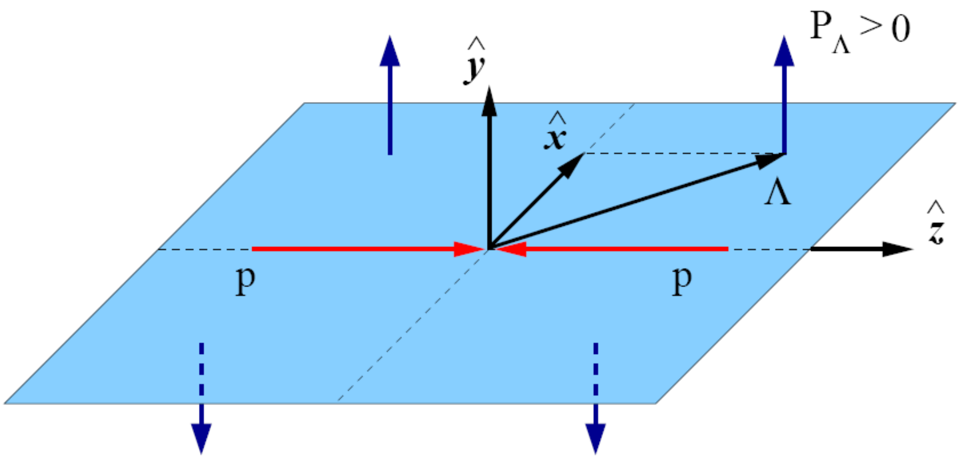


Λ polarization is high only at large x_F.
At ALICE, restricted at midrapidities where x_F is very small (1/pt) … unless



This opens the new channel of the *TMDs* (Transverse Momentum dependent Distribution and fragmentation functions)

Transverse Λ polarization in unpolarized pp scattering



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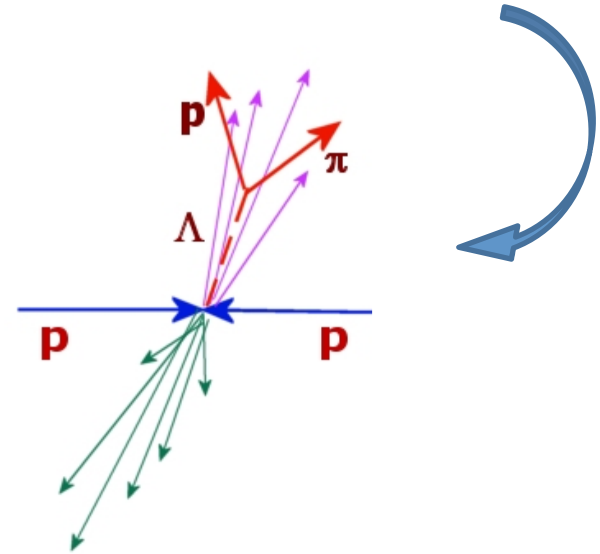
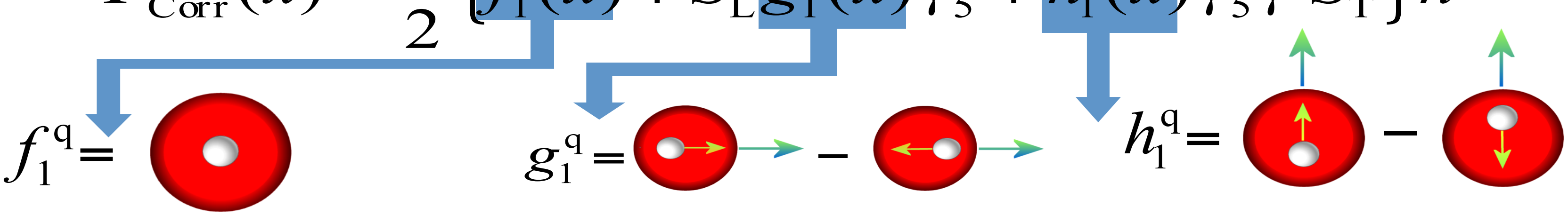


This opens the new channel of the *TMDs* (Transverse Momentum dependent Distribution and fragmentation functions)

$$\Phi^{Tw2}_{Corr}(x) = \frac{1}{2}\left\{ f_1(x) + S_L g_1(x)\gamma_5 + h_1(x)\gamma_5\gamma^1 S_T \right\} n^+$$

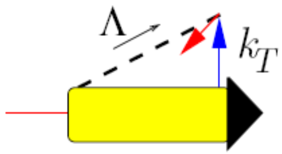


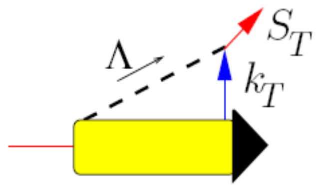
unpolarised quarks and nucleons

longitudinally polarised quarks and nucleons

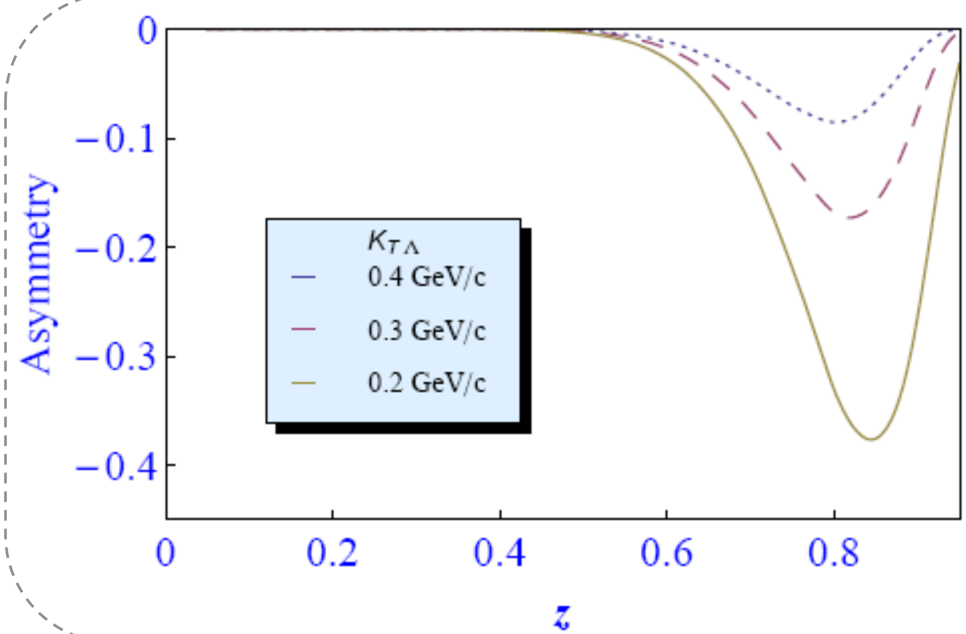
transversely polarised quarks and nucleons

chiral-odd functions

$D_{1T}^{\perp} =$ 

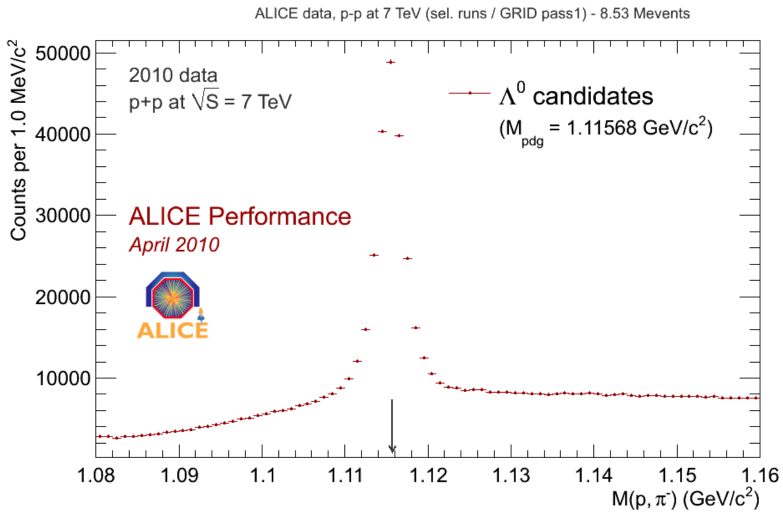
$-$ 

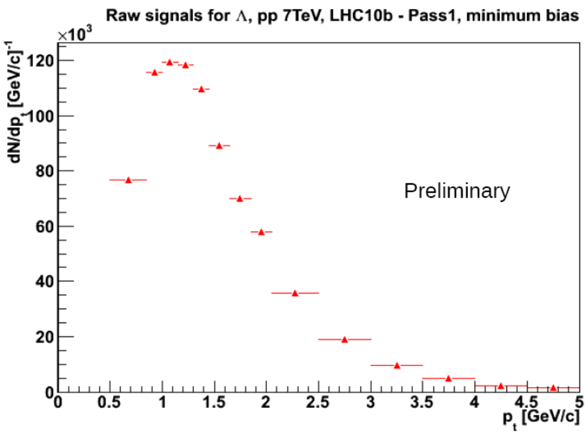
$$\mathrm{SSA} = \frac{d\sigma(+\boldsymbol{S}_\Lambda) - d\sigma(-\boldsymbol{S}_\Lambda)}{d\sigma(+\boldsymbol{S}_\Lambda) + d\sigma(-\boldsymbol{S}_\Lambda)} = \frac{\boldsymbol{S}_\Lambda \cdot (\hat{\boldsymbol{K}}_j \times \boldsymbol{K}_\Lambda)}{z\, M_\Lambda} \frac{d\sigma_T}{d\sigma_U}$$

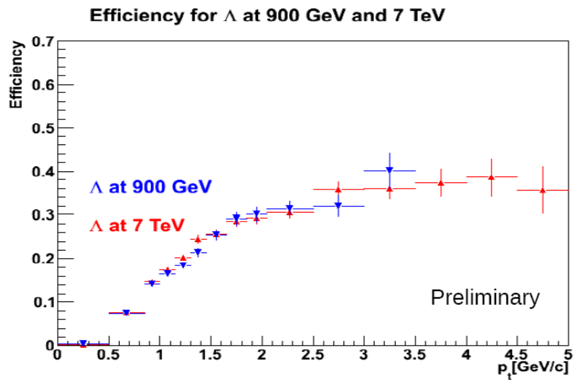


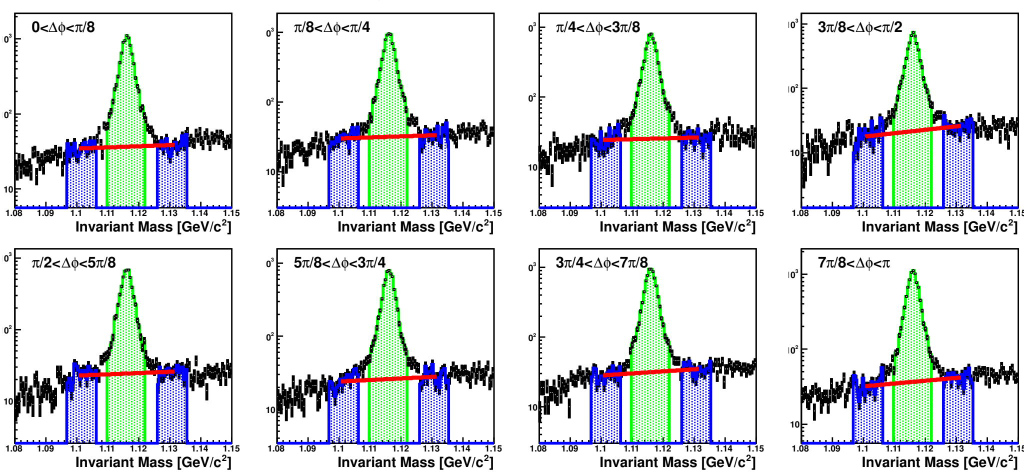
Expected magnitude of the SSA
(D.Boer et al. model, PLB 659 (2008))

Λ pp@7 TeV
(P_Λ up to 16 GeV)

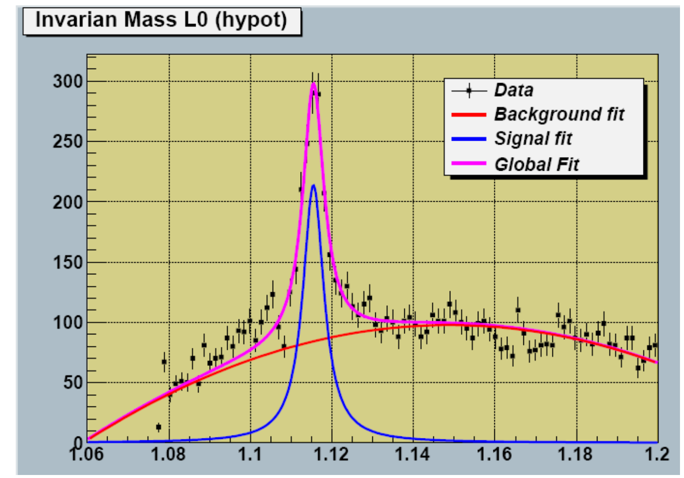








Λ inside jets



Studies of Transverse Hyperon Polarization at LHC Kinematics

Pasquale Di Nezza,[1,*] Gary R. Goldstein,[2,†] and Simonetta Liuti[3,‡]

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[2] Department of Physics and Astronomy, Tufts University, Medford, MA 02155 USA.

[3] Department of Physics, University of Virginia, Charlottesville, VA 22904, USA.

PACS numbers: 13.60.Hb, 13.40.Gp, 24.85.+p

I. INTRODUCTION

A clear-cut prediction of QCD first noticed by Kane, Pumplin and Repko (KPR) [1] is that a net transverse polarization can be produced in light quarks scattering processes which is given by

$$\frac{d\sigma(qq \to q^{\uparrow}q) - d\sigma(qq \to q^{\downarrow}q)}{d\sigma(qq \to qq)} = \alpha(Q^2)\frac{m_q}{\sqrt{s}}f(\theta). \quad (1)$$

The effect is proportional to the hadronizing quark's mass, and it is therefore negligible for light quarks. It can instead be considered a "higher twist" for strange and charm quarks. This observation has been notoriously clashing for several years with experimental results where in numerous cases a large hyperon transverse polarization was found. A longstanding question was raised of whether hyperon polarization data can be interpreted unambiguosly within QCD.

A key to the problem can be found following recent progress made in the interpretation of transverse spin phenomena. As recently noticed in a number of instances involving partons' transverse motion, sizable single spin asymmetries can be predicted within QCD provided one singles out the correct mechanism for the reaction. It was first noticed in [2], that in order to generate a Single Spin Asymmetry (SSA) one needs two components: *i)* the presence of a phase difference at the amplitude level; *ii)* a shift in the kinematical variables that "promotes" the process to leading twist. A phenomenological model was proposed, and GG and Dharma were able to reproduce strange and heavy quarks polarizations.

Remarkably, this is also at the bottom of the TMD paper by Brodsky, Hwang and Schmidt [3], which generated all the hoopla on the gluonic poles.

As surmised also in [4] this class of processes stems from a different property of QCD, defined as KPR factorization, that is to be treated distinctly from the well studied collinear factorization. The interplay between the jets mass distribution and k_T dependence was also considered, although in different terms in Collins, Rogers, and Stasto [5].

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Spin correlations being precise predictions of QCD could in principle provide an alternative testground for the Standard Model (SM). It is therefore now important to investigate their working at the light of recent progress in SIDIS and deeply virtual exclusive processes, by extending the study of hyperon production to LHC kinematics. By extending the kinematical domain this will give us a better handle on both the various scale dependences, and the working of different mechanisms in different hyperon productions regimes (... I have in mind central region vs. large z ...). Another outcome is that one investigates the hadronization properties in novel ways not accessible before [4].

II. TRANSVERSE SINGLE SPIN ASYMMETRIES FOR HYPERON PRODUCTION

In order to produce a phase difference one needs a one loop diagram at the amplitude level. This was for instance accomplished in SIDIS by introducing gluon exchange, giving rise to a final state interaction. In hyperon production the loop diagram can be produced in two distinct ways: at the hard scattering amplitude level, in a process described entirely within PQCD (Figure 1a), and in a process directly involving the soft part (Figure 1b).

The PQCD approach was pursued in Ref.[2]. It is depicted in Fig.1a. The PQCD process, however, could not reproduce the sign and magnitude of hyperon polarization. A soft recombination process modifying the kinematical dependence on the variables x_F, and p_T had to be added. This is shown in the figure by the two dashed lines connecting the initial proton with the final hyperon. A possible issue with this model is the fact that it is higher order in α_S.

In this paper we propose a novel mechanism by which hyperon production is obtained in the target fragmentation region. This is somewhat related to Sivers' papers but it is not the same approach.

I will write the formulae next. We distinguish between the hard and soft loops.

Start from Λ production cross section. The asymmetries will be defined through the helicity amps. This is just to see what ingredients go in the two different processes. Write them later.

Show how factorization works. Factorization into four "blocks" at amplitude level: (1) (proton 1) $\to$ (parton 1); (2) (proton 2) $\to$ (parton 2); (3) hard subprocess;

In preparation

Conclusions

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LNF group, working on:

- hardware (EMCal+DCal)
- online/offline software calorimetry
- jet physics
- QGP phenomenology
- polarized physics in pp
- various responsibilities

with 12 persons at 92% of FTE is fully involved in the project …

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