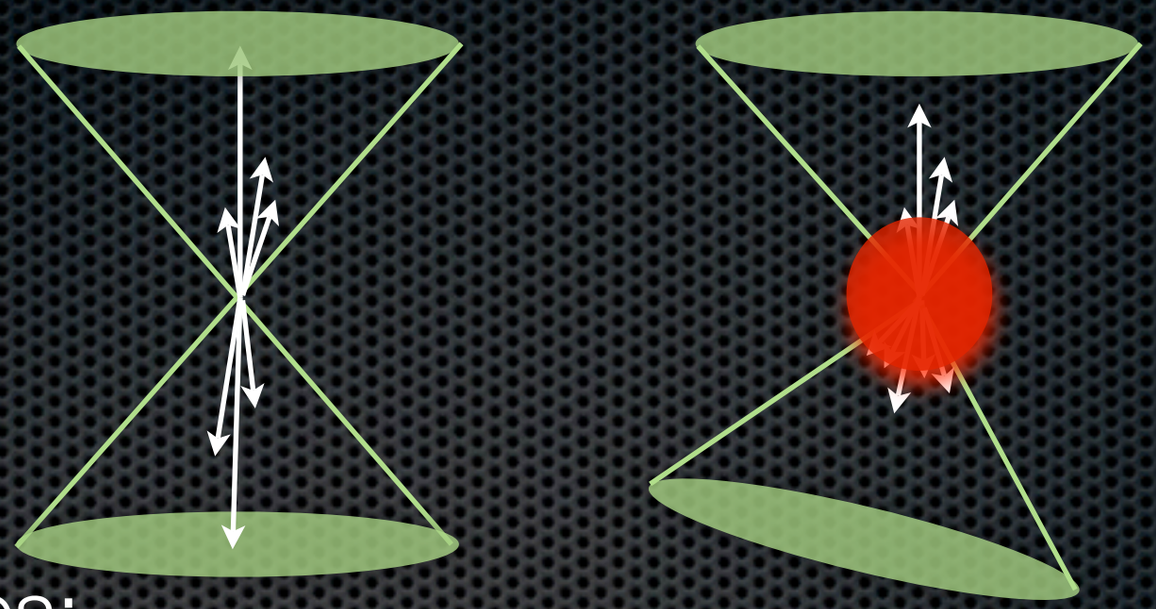
High p_T and photon physics with ALICE

ALICE Physics Working Group 4

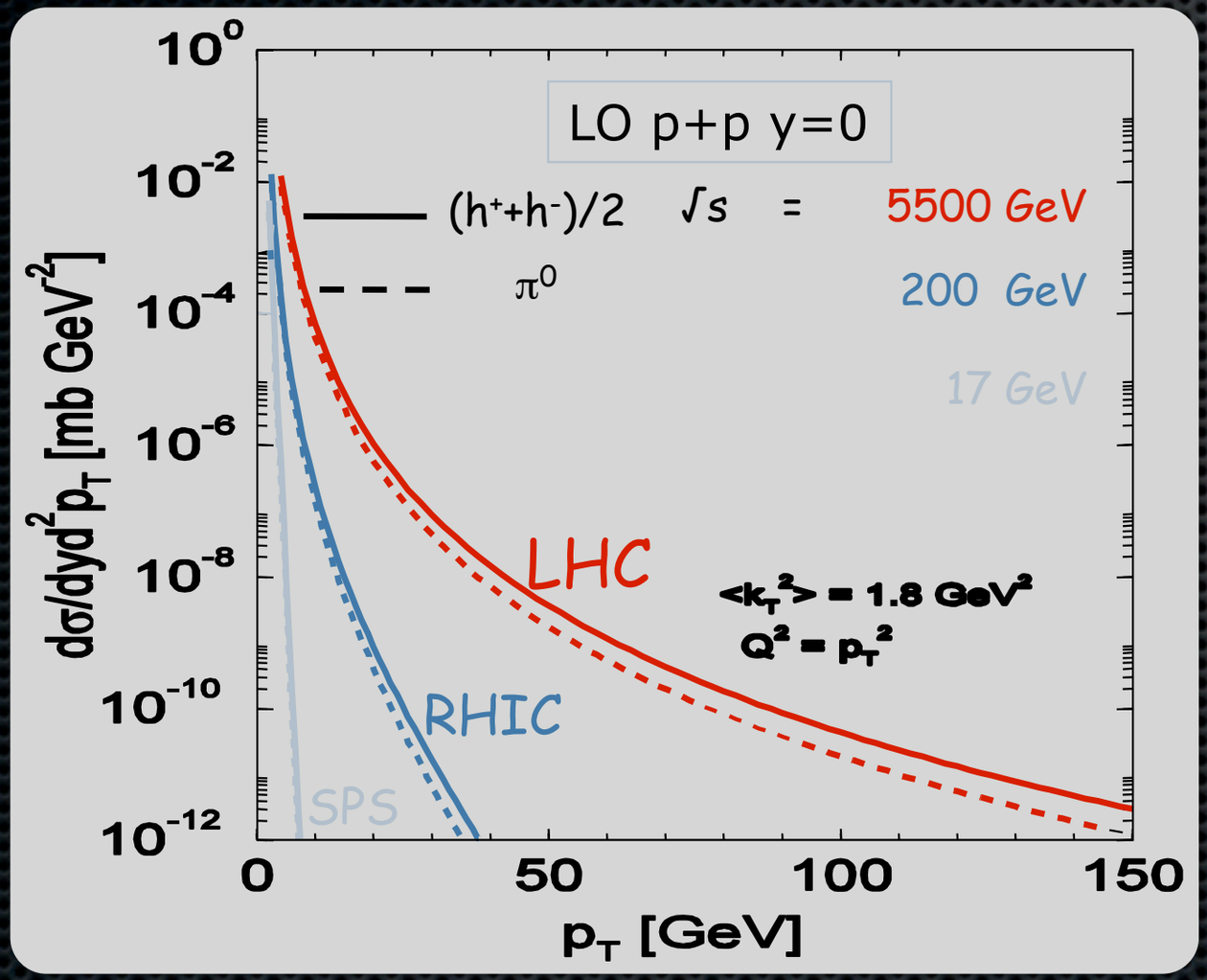
Y.S.@Wuhan, June 2008

The scope



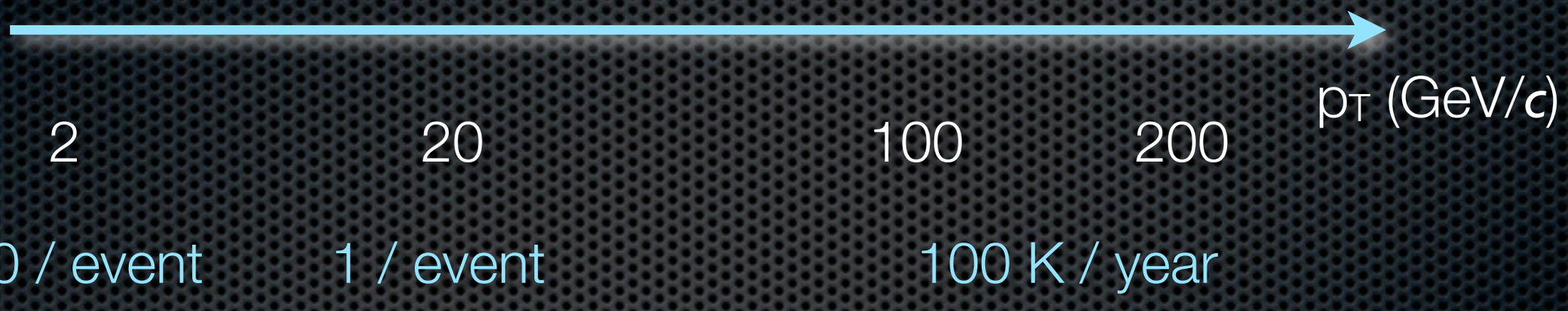
- Exploit jets at LHC energies:
  - High p_T partons produced in hard interactions in the initial phase of the collision...
    - in pp: understand and characterise the probe
    - ...Undergo multiple interaction inside the collision region prior to hadronisation
    - in AA: probe the medium created in the collision

At LHC, hard scattering dominates the particle production ...



- Inclusive p_T spectum of $h^{\pm}$ and π^0, η) → jet quenching
- Particle correlations → acoplanarity, j_T

At LHC, high p_T jets and direct photons are abundantly produced

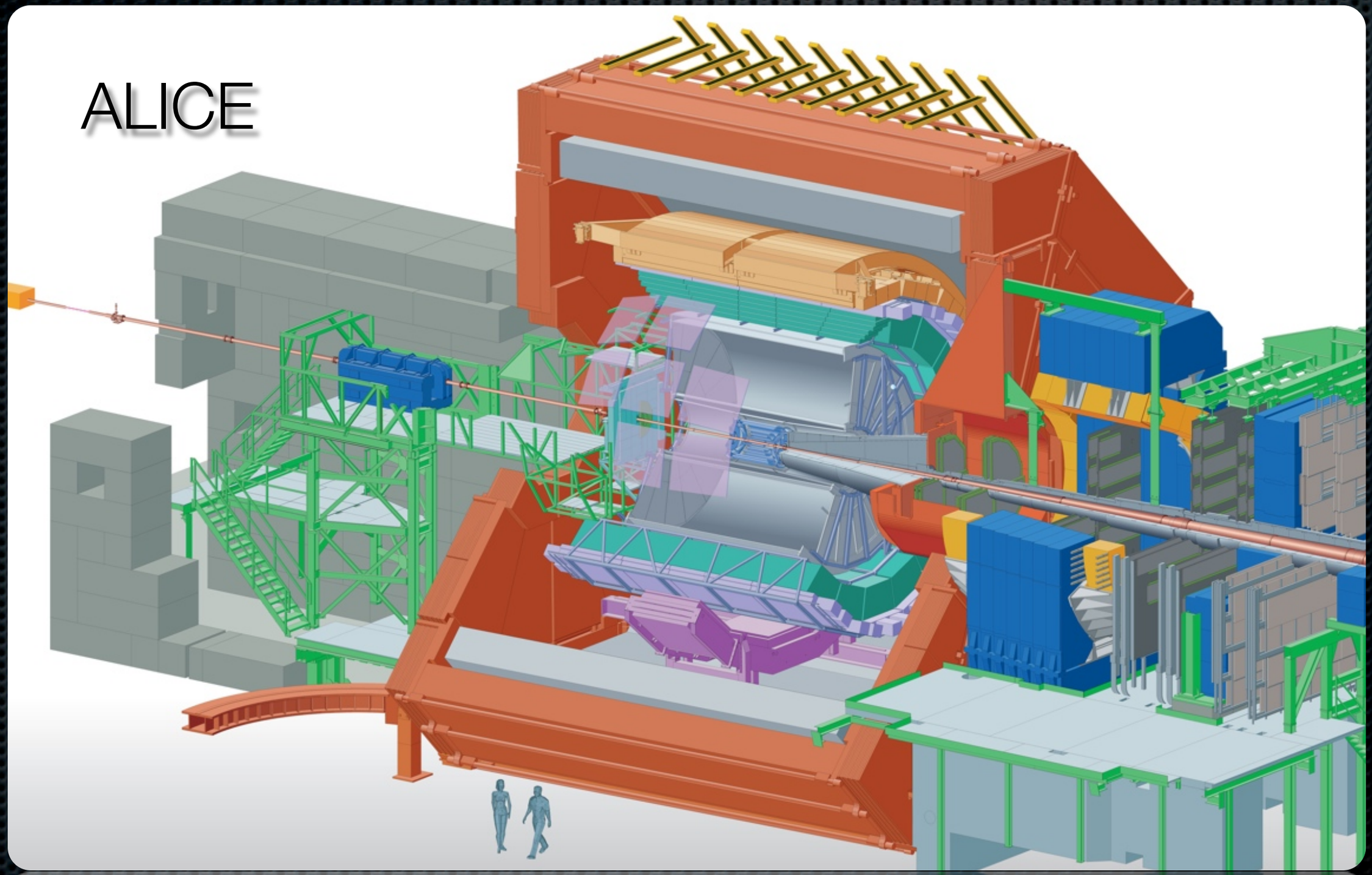


- Inclusive jet, di-jet, photon spectra → pQCD
- Fragmentation function, photon tagging → QCD, medium modification
- Underlying event in pp (low p_T tracking and PID capabilities of ALICE) → PYTHIA tuning, UE in AA

Running scenario

- 2008: no trigger, $h^{\pm}$ only
  - pp@10 TeV, L_{int}=? →5×10^{8} events
- 2009: jet trigger (TRD), photon trigger (PHOS), $h^{\pm}$ only
  - pp@14 TeV, L_{int}=$10pb^{-1}$
  - AA@5.5 TeV, L_{int}=? → enough events for complete soft physics program
- 2010 entering the standard years of running: $h^{\pm}$, h^{0}; jet trigger (TRD&EMCAL), photon trigger
  - pp@14 TeV, L_{int}=$10pb^{-1}$
  - AA@5.5 TeV, L_{int}=$0.7nb^{-1}$

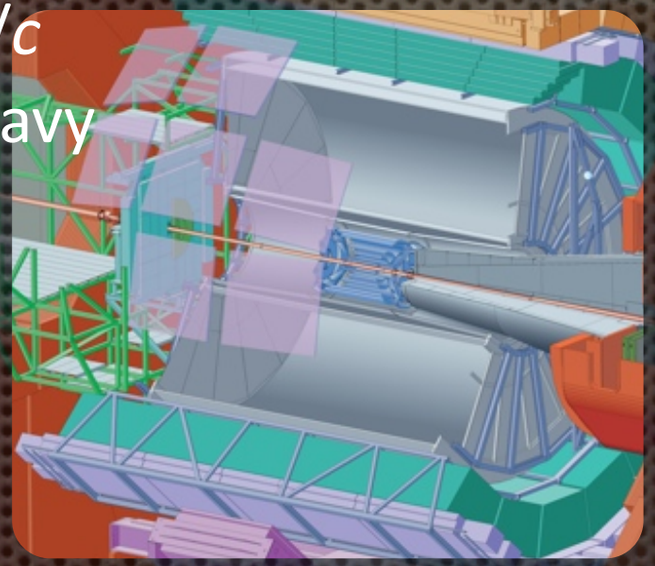
The Instrument



The Instrument

Central Tracking Barrel & PID: ITS, TPC, TRD, TOF

- 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 flavour tagging



The Instrument

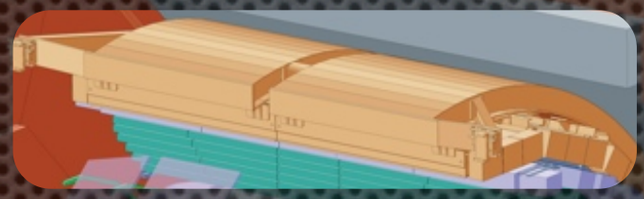
PHOS

- 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: $\Delta x / x = 23\%/\sqrt{E_\gamma}$

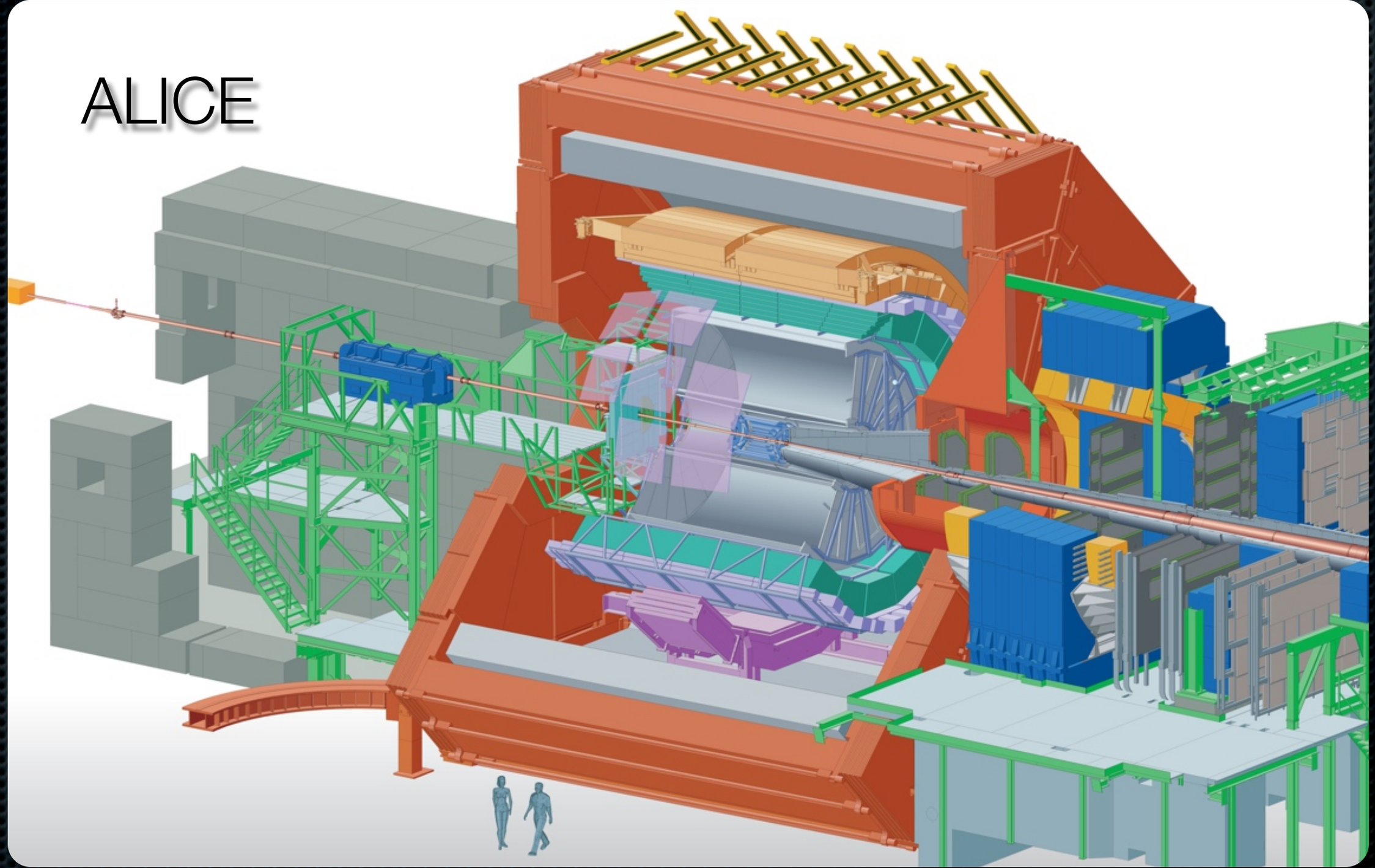
The Instrument

EMCAL

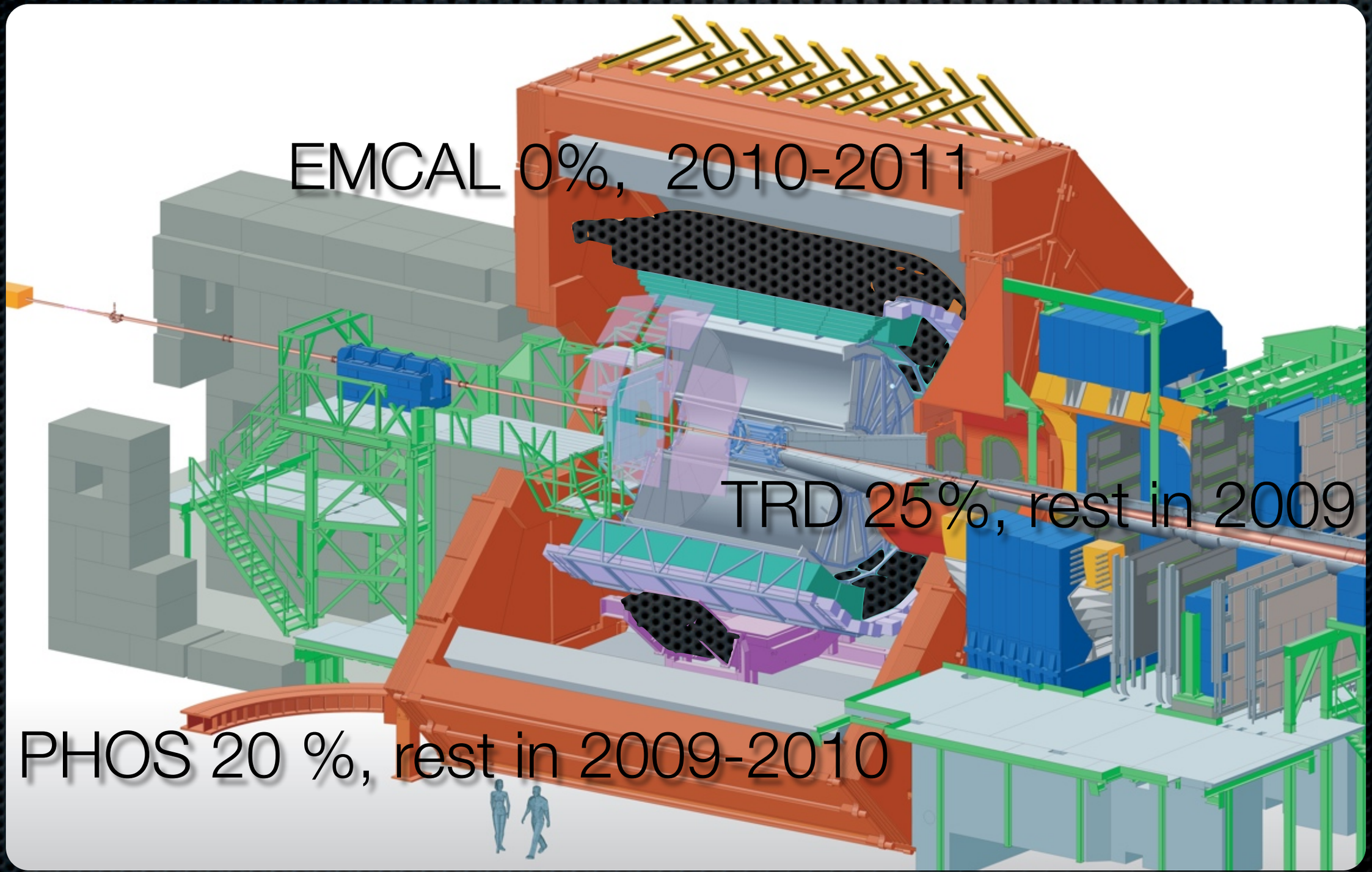
- Energy from neutral particles
- Pb-scintillator, 13k towers
- $\Delta\phi = 107$, $|\eta| < 0.7$
- Energy resolution ~$10\%/\sqrt{E_\gamma}$
- Trigger capabilities



Installed for the first run

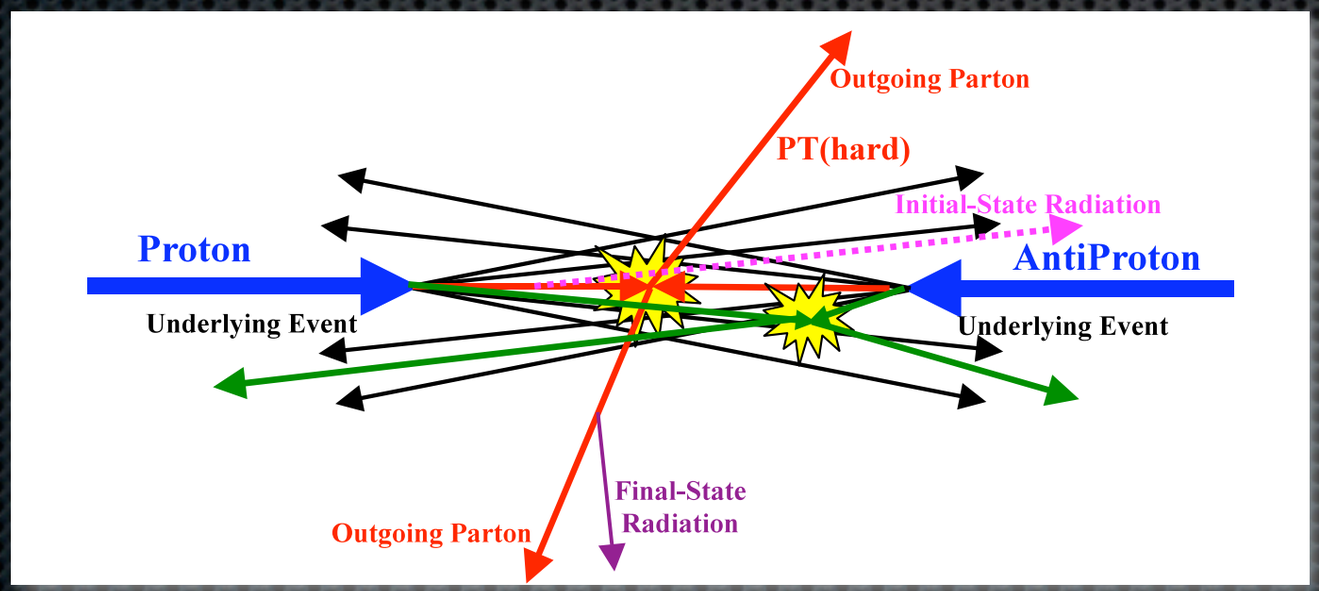


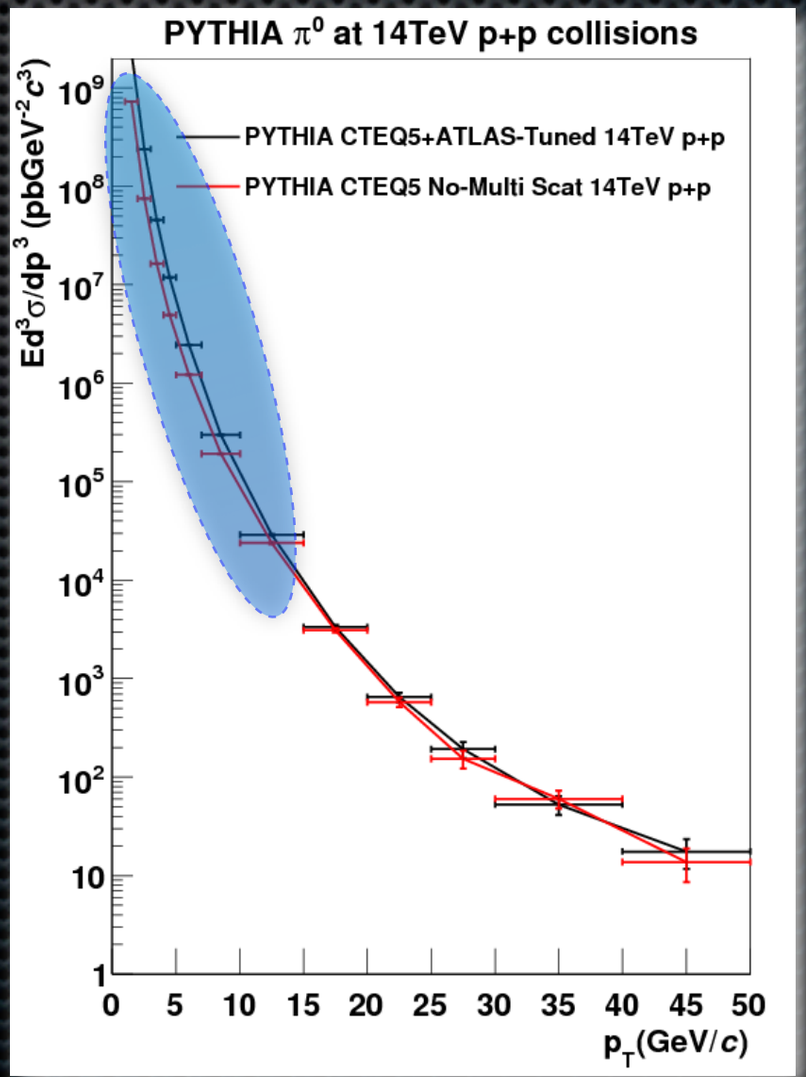
Installed for the first run



First pp physics at 10/14 TeV

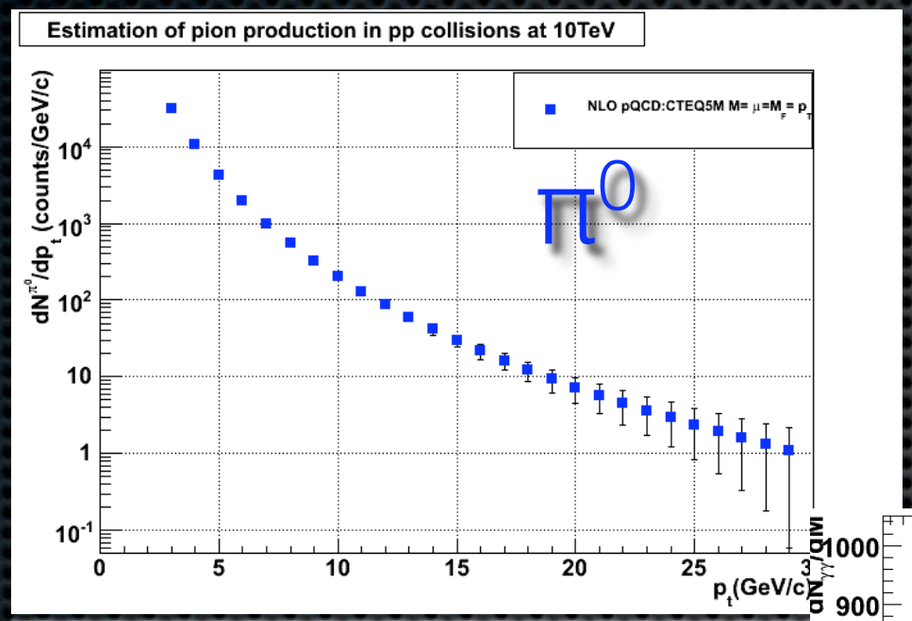
- Inclusive charged and neutral hadrons and direct photon spectrum:
  - Baseline for AA
  - pQCD test, underlying event
  - gluon PDF and FF of gluon jets



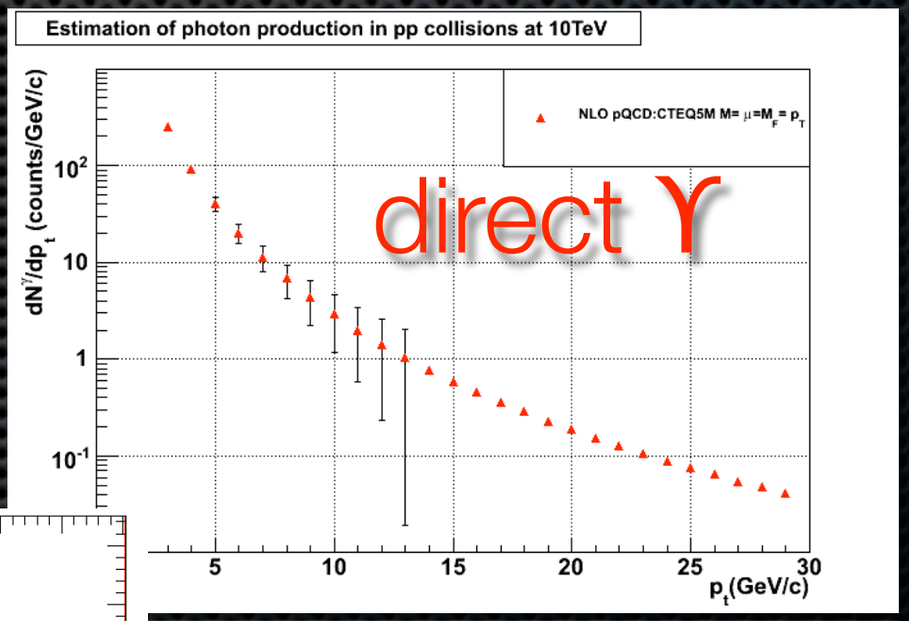


First pp physics at 10/14 TeV

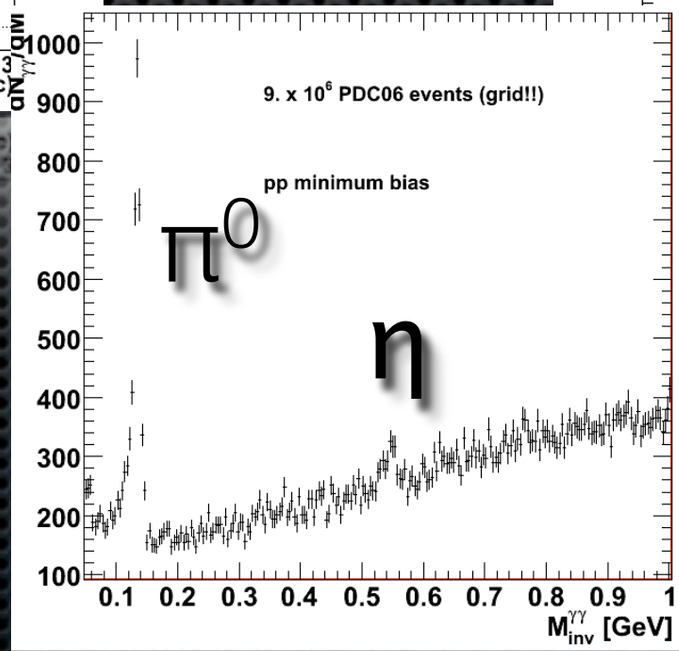
- Inclusive charged and neutral hadrons and direct photon spectrum:



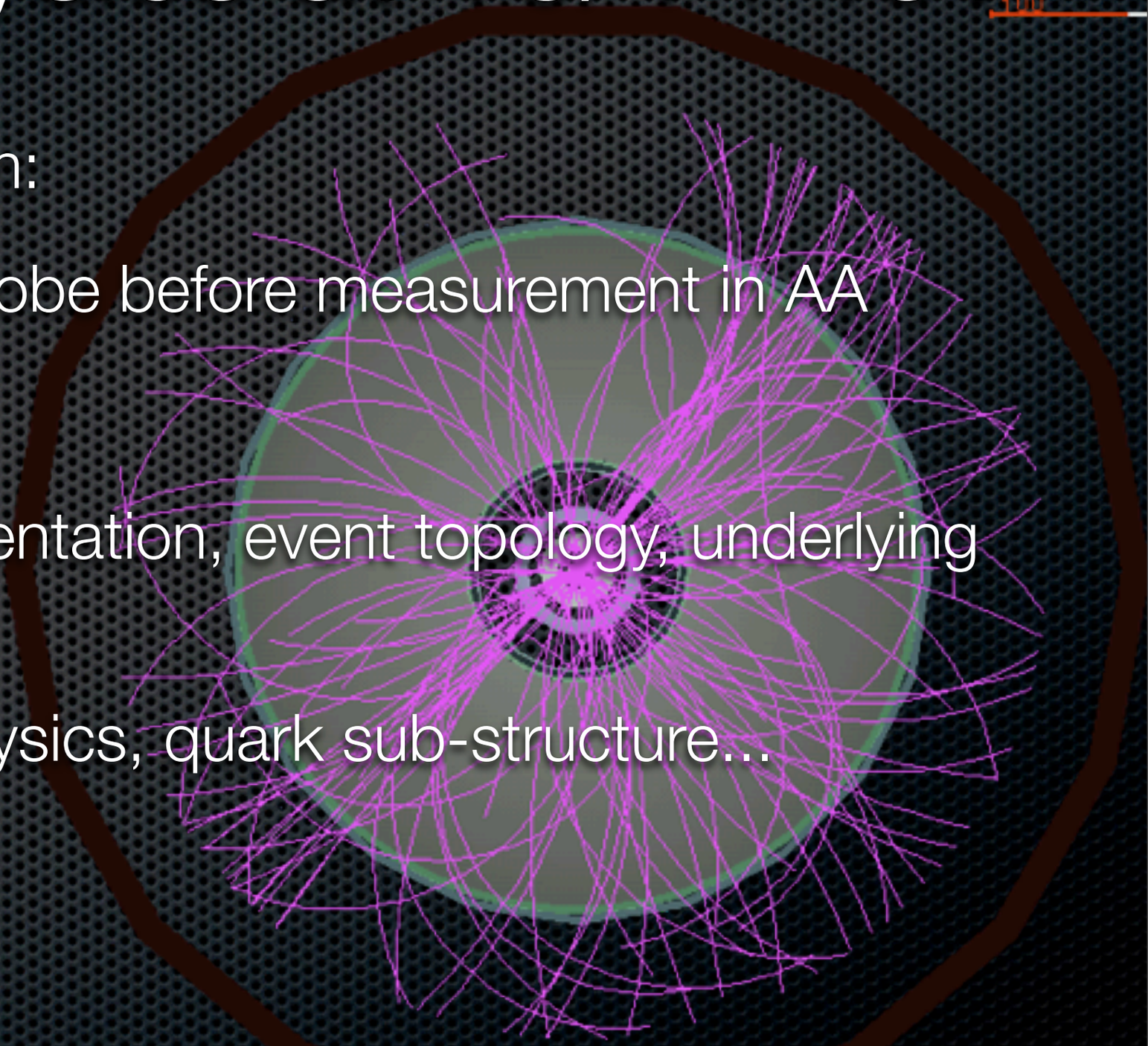
PHOS



Conversion electrons from charged tracks



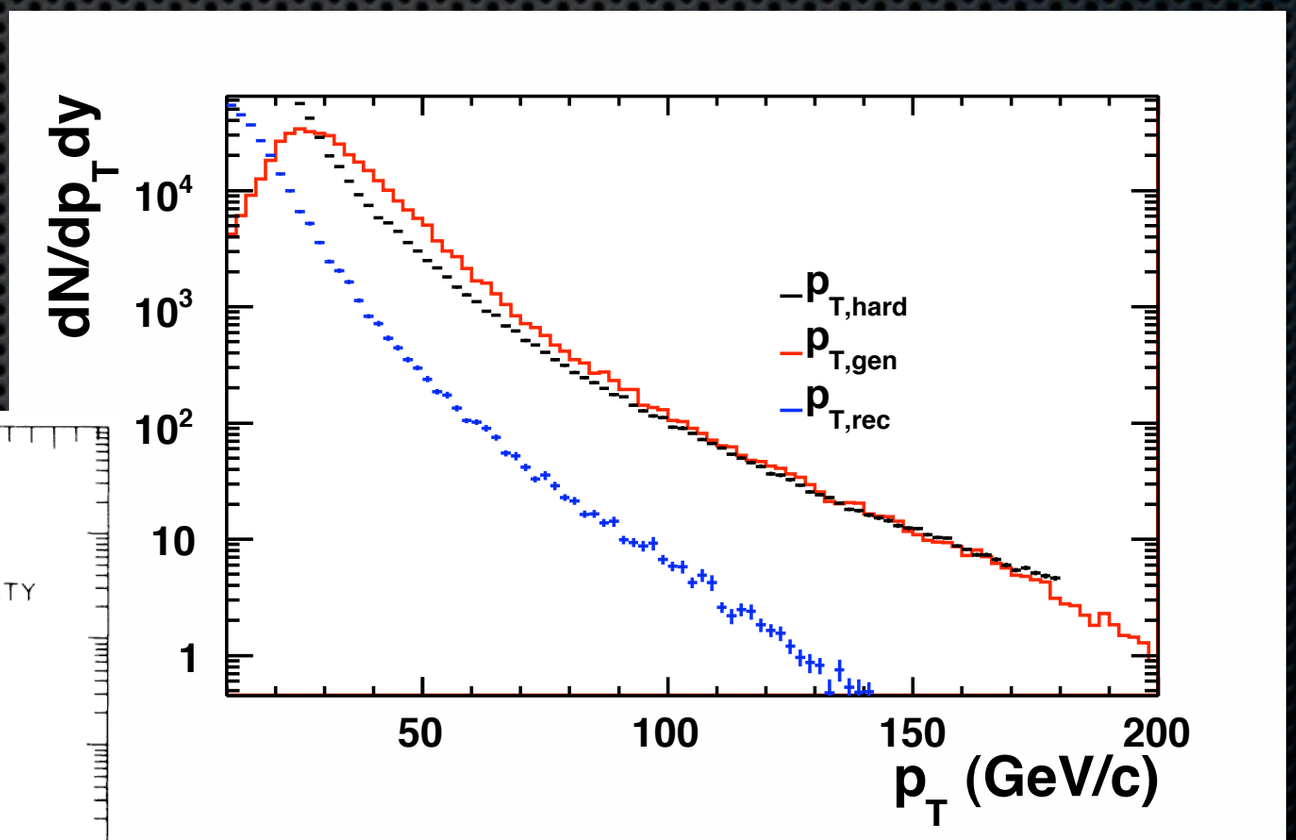
First pp physics at 10/14 TeV



- Inclusive jet spectrum:
  - Understand the probe before measurement in AA
  - pQCD test
  - non pQCD: fragmentation, event topology, underlying event
  - search for new physics, quark sub-structure...

First pp physics at 10/14 TeV

- Inclusive jet spectrum:
  - Minimum bias trigger
  - 5 ×10^8 events
  - h$^{\pm}$ only

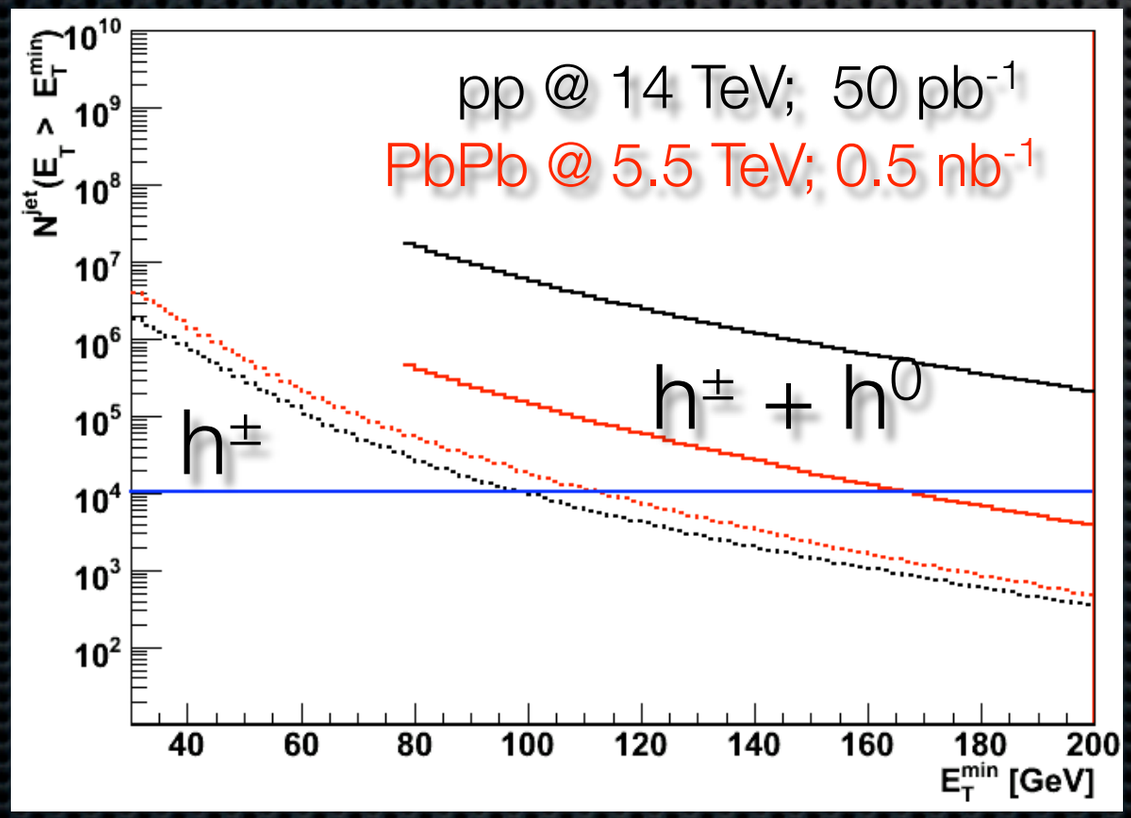


Putting the probes in the medium

- Identify the particles in the high multiplicity environment
- Find the jet in the background of the underlying event
  - Standard algorithm have to be modified (E_{ue}=1.9 in R <1)
    - Smaller cone size (R< 0.4) and p_T cut
    - Subtract UE energy determined outside the jet area
  - Study how the medium modifies the probes: R_{AA}, R_{CP} of single particles, hadron-hadron, γ-hadron correlations

Inclusive jets in AA

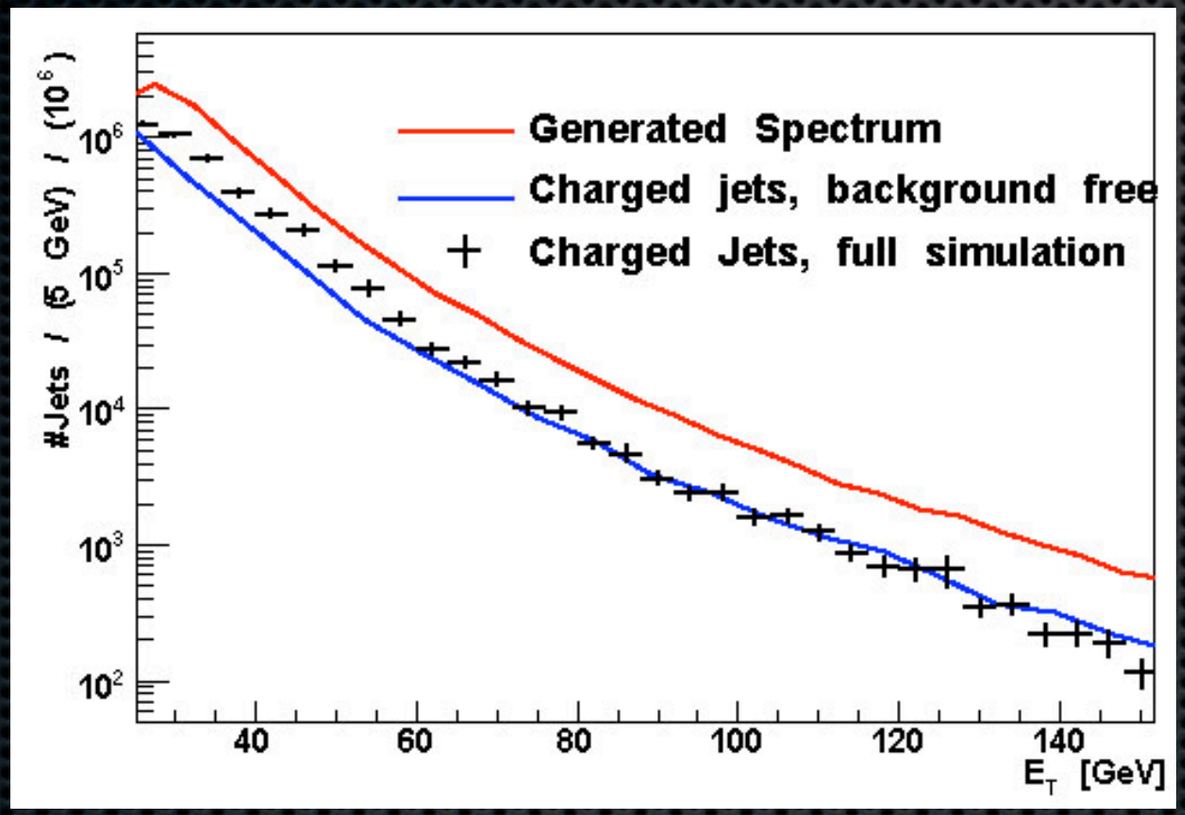
- First PbPb @ 5.5 TeV: $h^{\pm}$, low luminosity ($L \sim 50 \mu b^{-1}$): p_T reach is 100 GeV/*c*
- With h^0 and trigger, p_T reach can be extended to 200 GeV/*c*



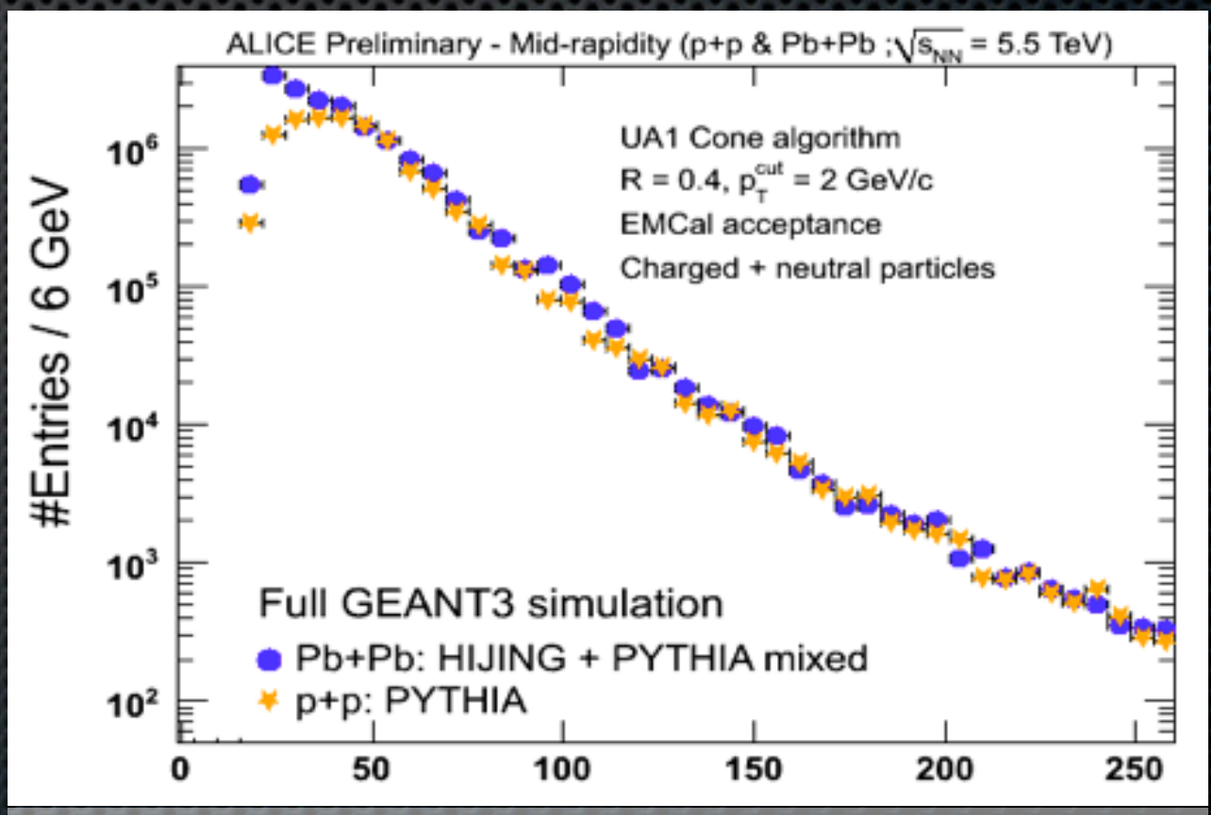
Need EMCAL trigger for reference data

Reconstructed jet spectrum

- Statistics of one month of PbPb running

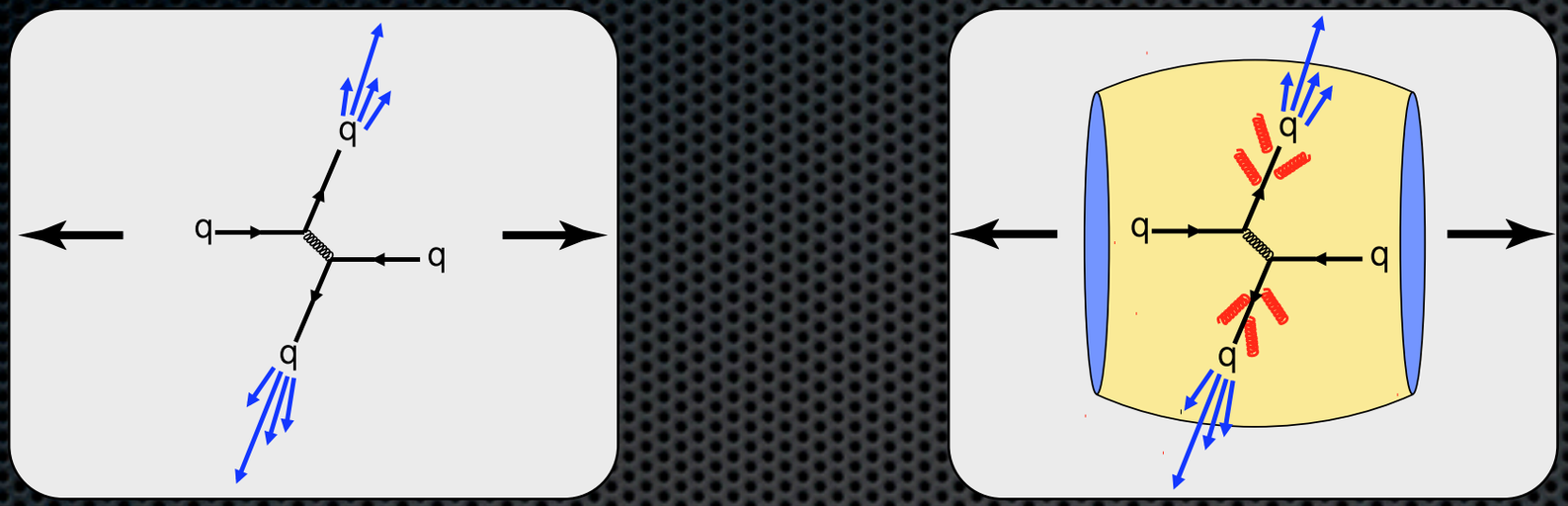


$h^{\pm}$



$h^{\pm} + h^{0}$

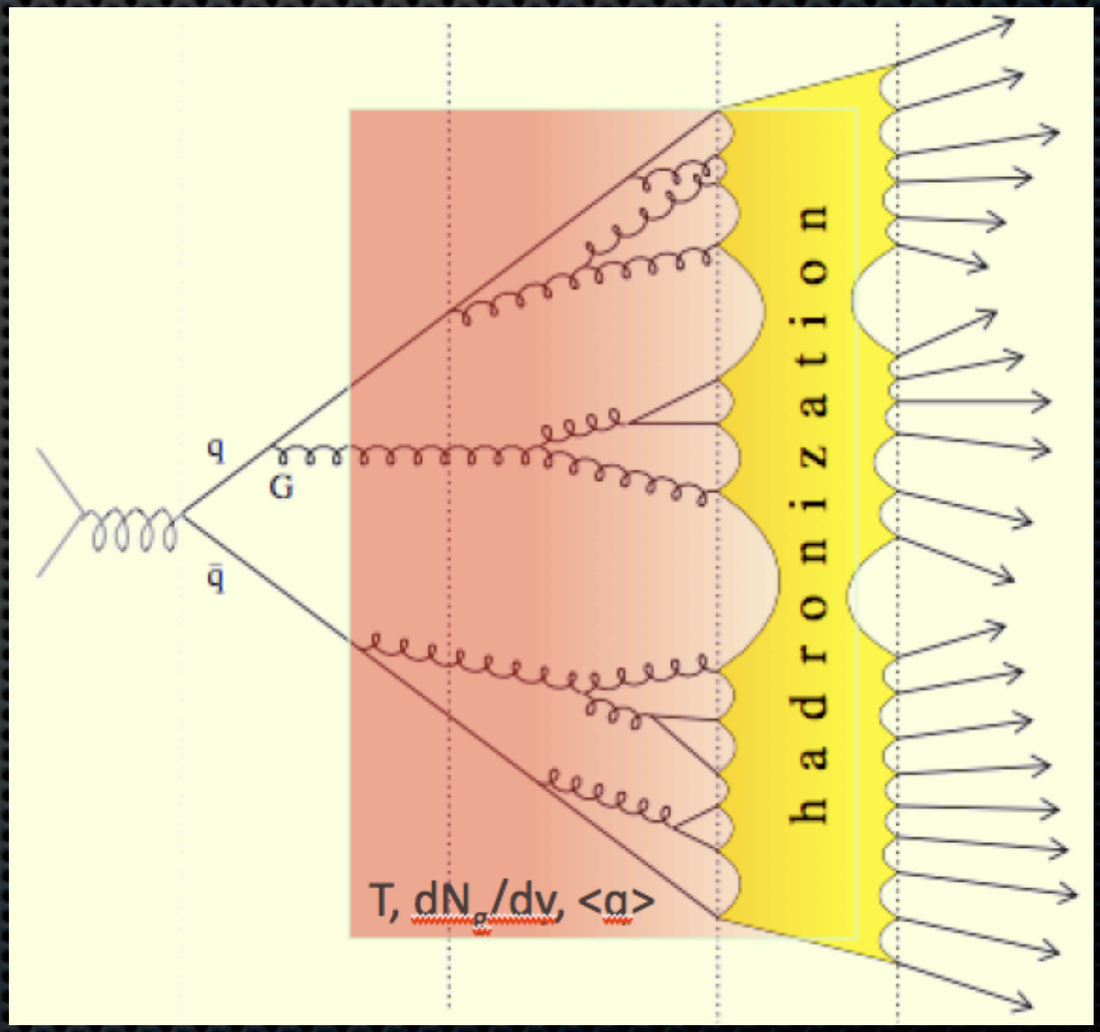
Jets probing the medium in AA



- Jets probe the entire medium
  - $\tau_{formation} \sim 1/Q << \tau_{QGP}$
    - History of medium interaction imprinted in jet structure
- High pT partons undergo multiple interaction prior to fragmentation
  - In particular energy loss induced by gluon radiation

Medium modification

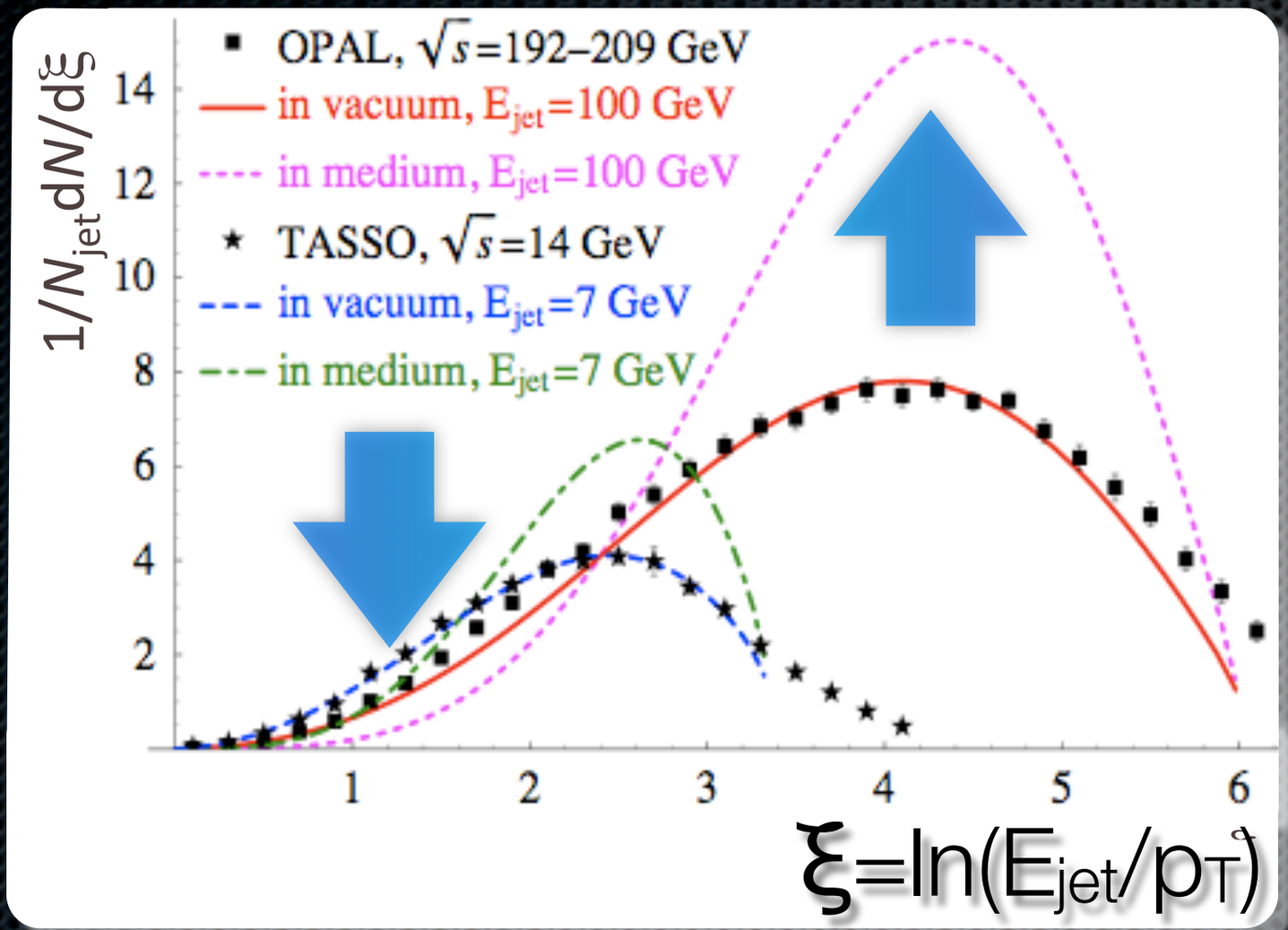
- The evolution of the parton shower changes: gluon radiation, broadening, multiplicity
- The fragmentation process might be modified
- Measure energy loss and phase space distribution of radiated energy over a wide range of jet energies



Medium modification observables

- Decrease the p_T of leading particle: R_{AA}, disappearance of back-to-back high p_T hadron correlation
- Increase number of low p_T particles: reappearance of of back-to-back low p_T hadron correlation
- Increase of j_T (momentum transverse to jet axis), broadening of jet, out of cone radiation: jet quenching in R_{AA}^{jet}
- Increase di-jet imbalance and acoplanarity: γ–jet, hard-fragmentation hadron–jet correlations
- New sources of high p_T photons: γ spectrum, R_{AA}^{γ} and flow

Jet fragmentation function



- Search for an enhancement of high ξ (low p_T)-particles, rather than for the high p_T quenching

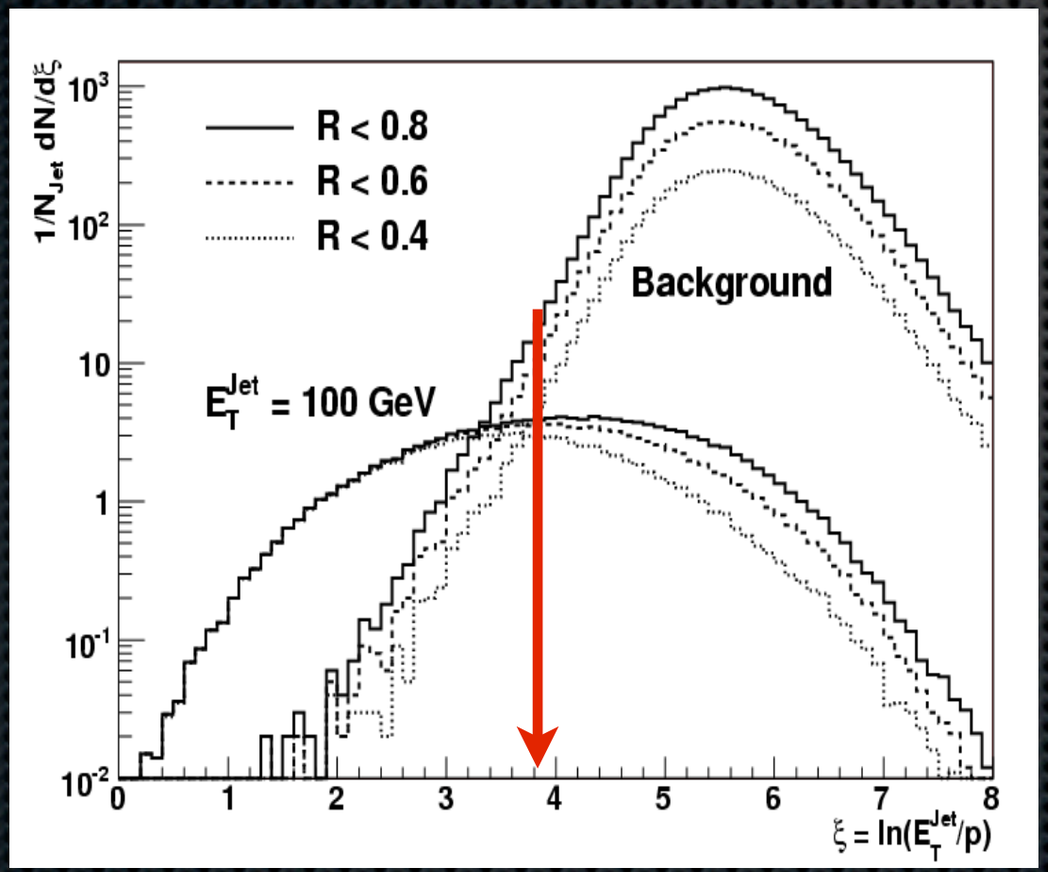
100 50 10 5 4 2 0.2 0.1

p_T (GeV/c)

E_{jet} = 100 GeV

Soft underlying event

- In heavy-ion the high multiplicity soft background hides the medium induced soft jet-particles enhancement

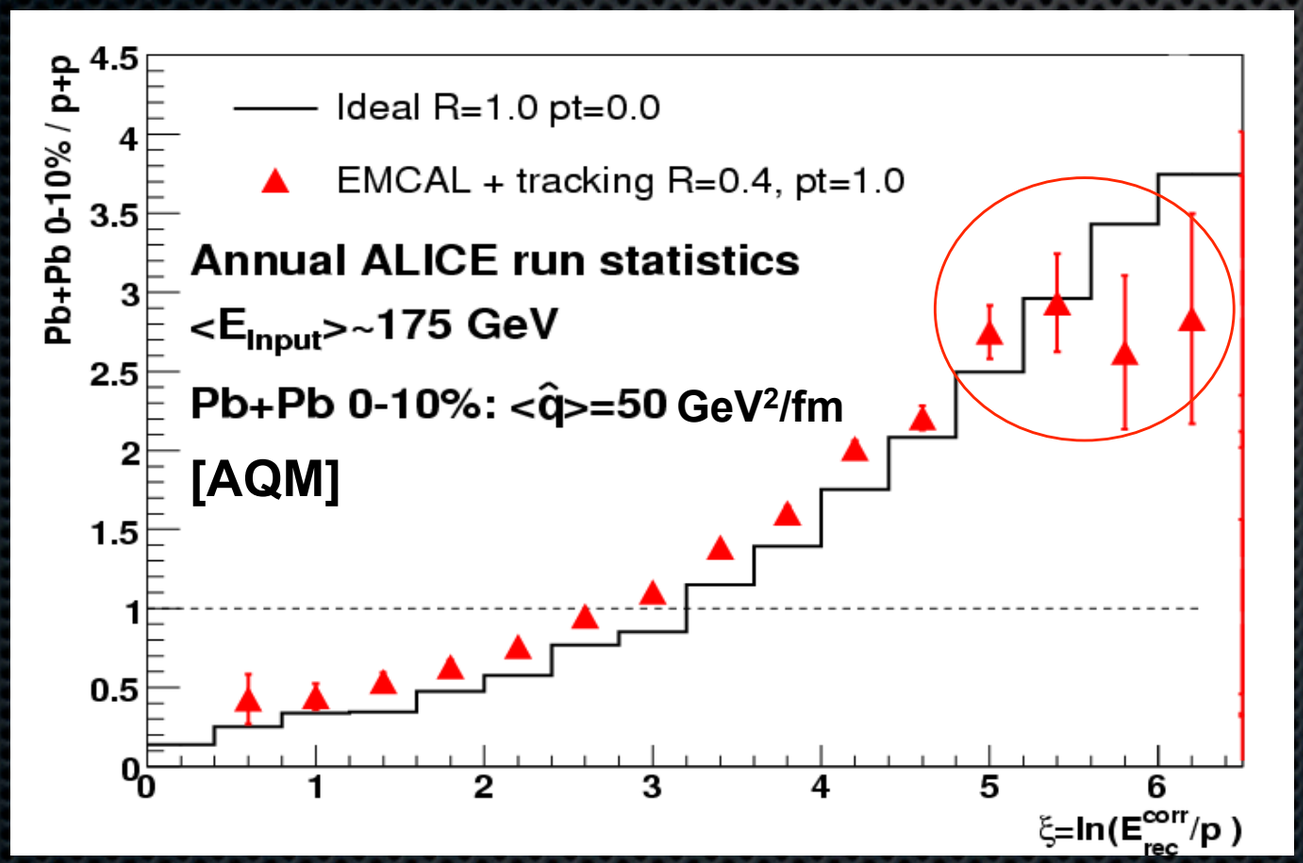


2 GeV/*c*

- Understand
  - background subtraction
  - relative jet energy calibration in pp @ 14 TeV and AA @ 5.5 TeV

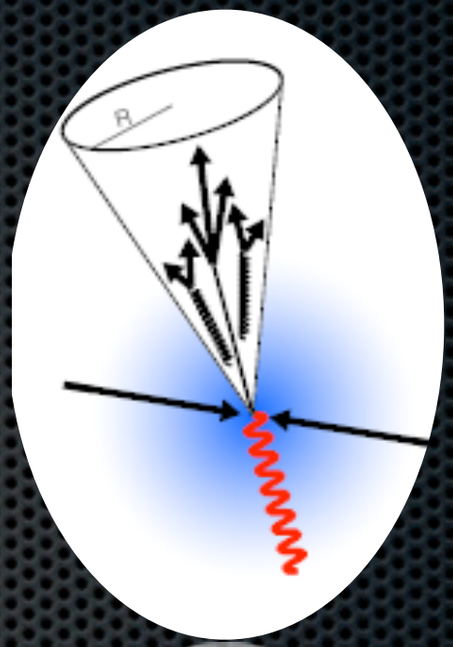
Medium modification factor

$$R_{AA}(\xi) = \frac{1/N_{jet}^{AA}\, dN^{AA}/d\xi}{1/N_{jet}^{pp}\, dN^{pp}/d\xi}$$



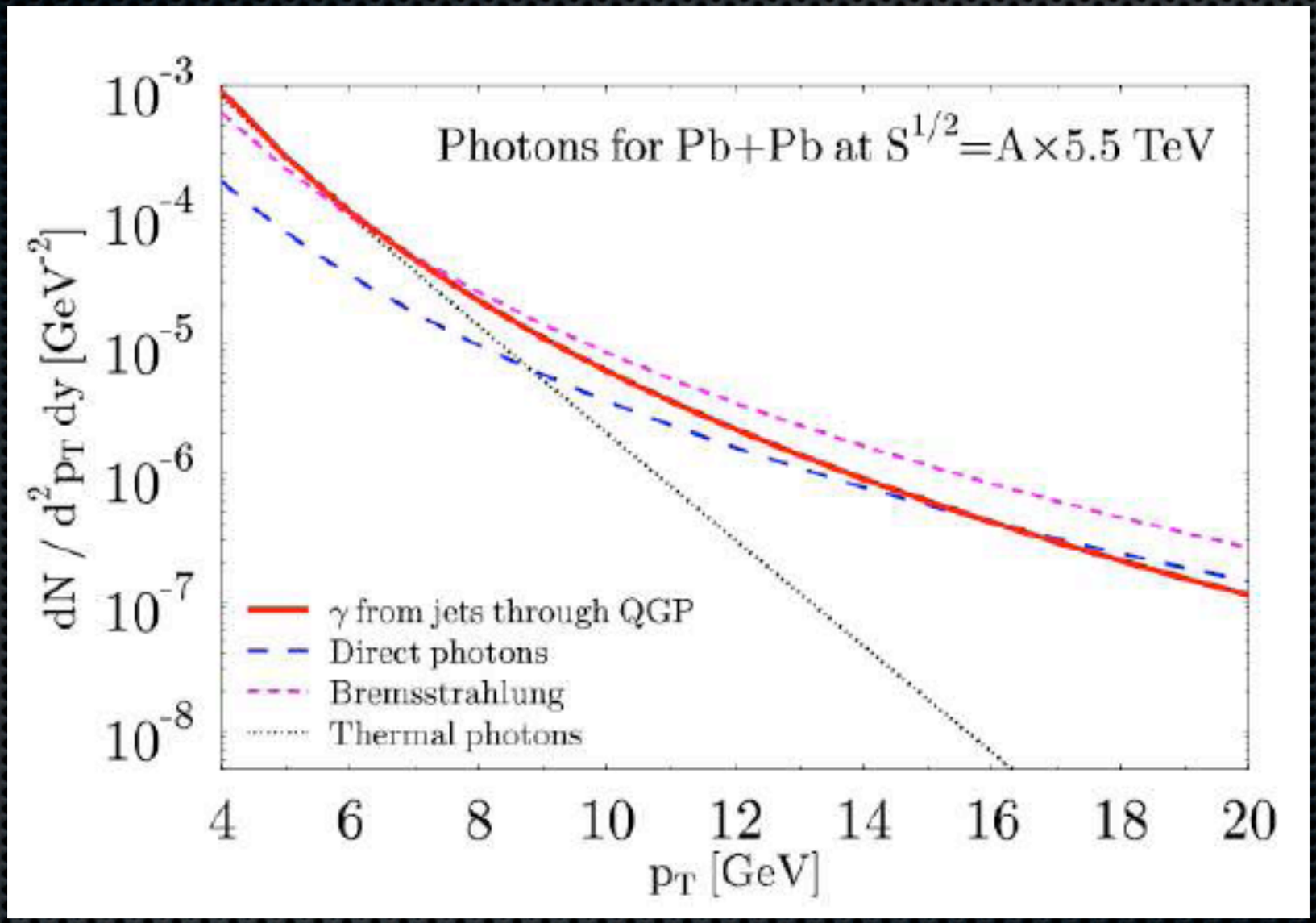
- Robust signal, but: underestimation (R, p_T^{cut}) of jet energy biases $z=p_T/E_{jet}$ toward lower values
- Need complementary measurements:
  - Jet shape (out of cone radiation)
  - Jet R_{AA}
  - Calibrated jets (γ–jet)

Get the jet energy right



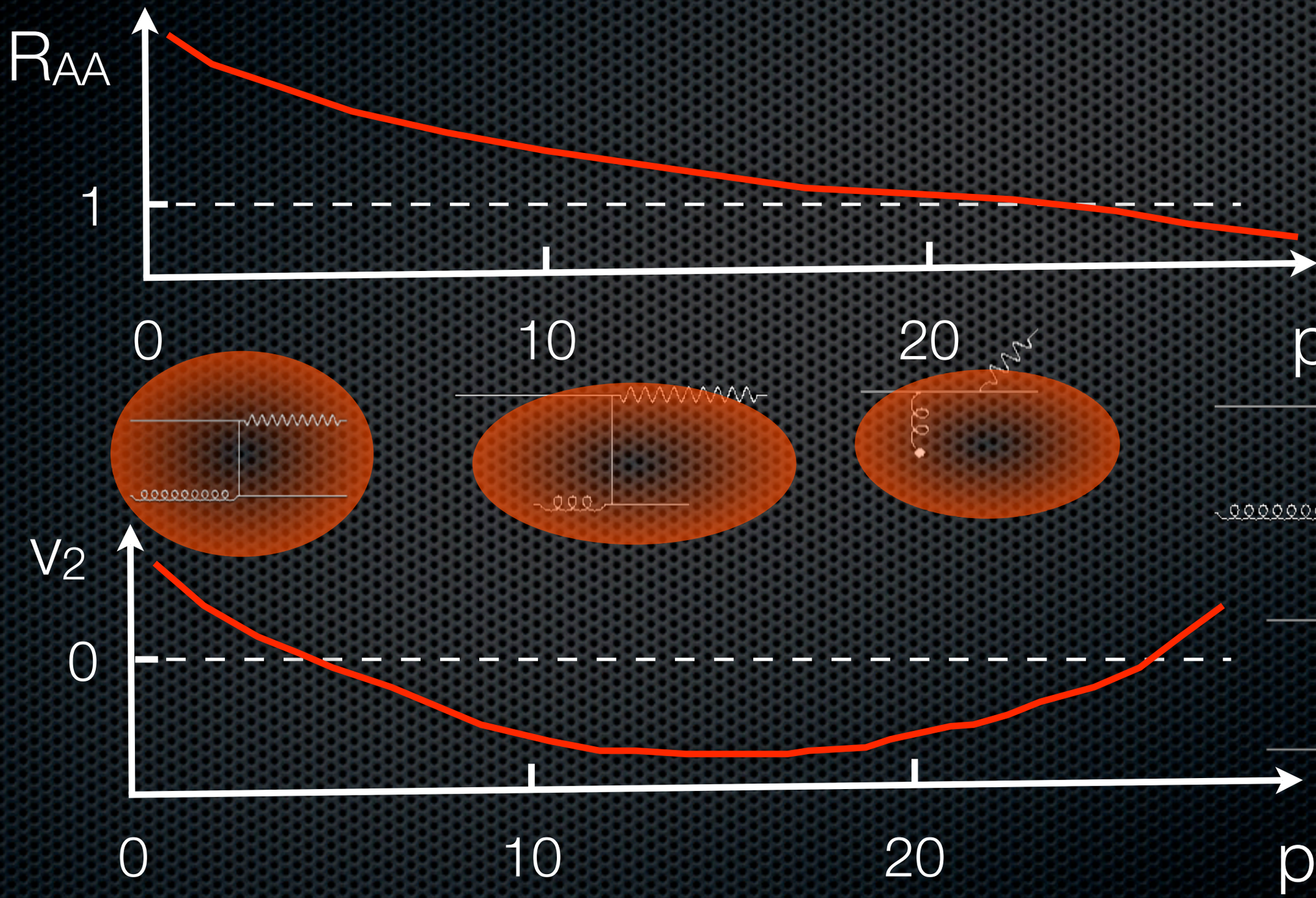
- Tag the jet with the direct prompt photon emitted back-to-back
  - Solves the jet energy calibration problem
  - Gives access to low energy jets: $E_{jet} < 50$ GeV/c
- Measure the jet fragmentation function of the photon-hadrons imbalance distribution
- One can also tag jet with isolated high p_T hadrons (hard fragmentation)

Photons generated by the medium



Thermal — Bremsstrahlung & Conversion — pQCD

Photons generated by the medium



Conclusions

- First high p_T physics in p+p
  - Inclusive $h^{\pm}$, h^0 and jet spectra
  - Underlying event: ALICE unique contribution
  - A new regime: High multiplicity events
- In Pb+Pb
  - Jets can be reconstructed against the large background
  - ALICE ideally suited to study modification of jet fragmentation down to low ξ, including PID
  - Complemented by γ-jet correlations in the region 20 GeV< E_t< 50 GeV
  - The rich world of photons