Jet reconstruction in ALICE using the EMCal

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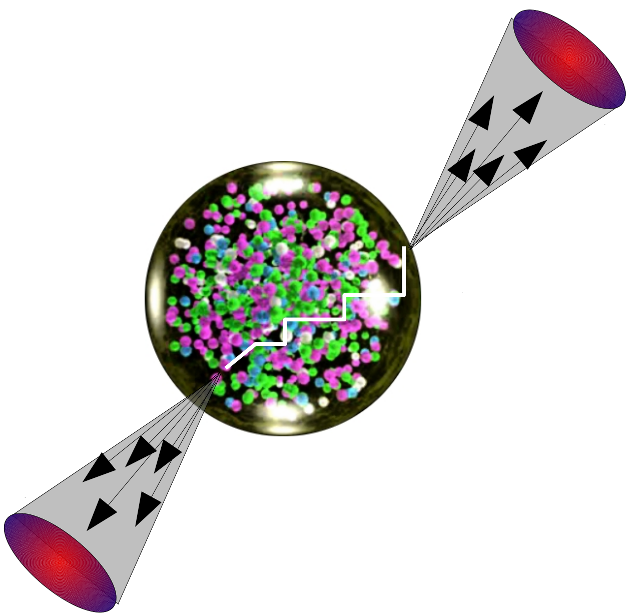
for ALICE



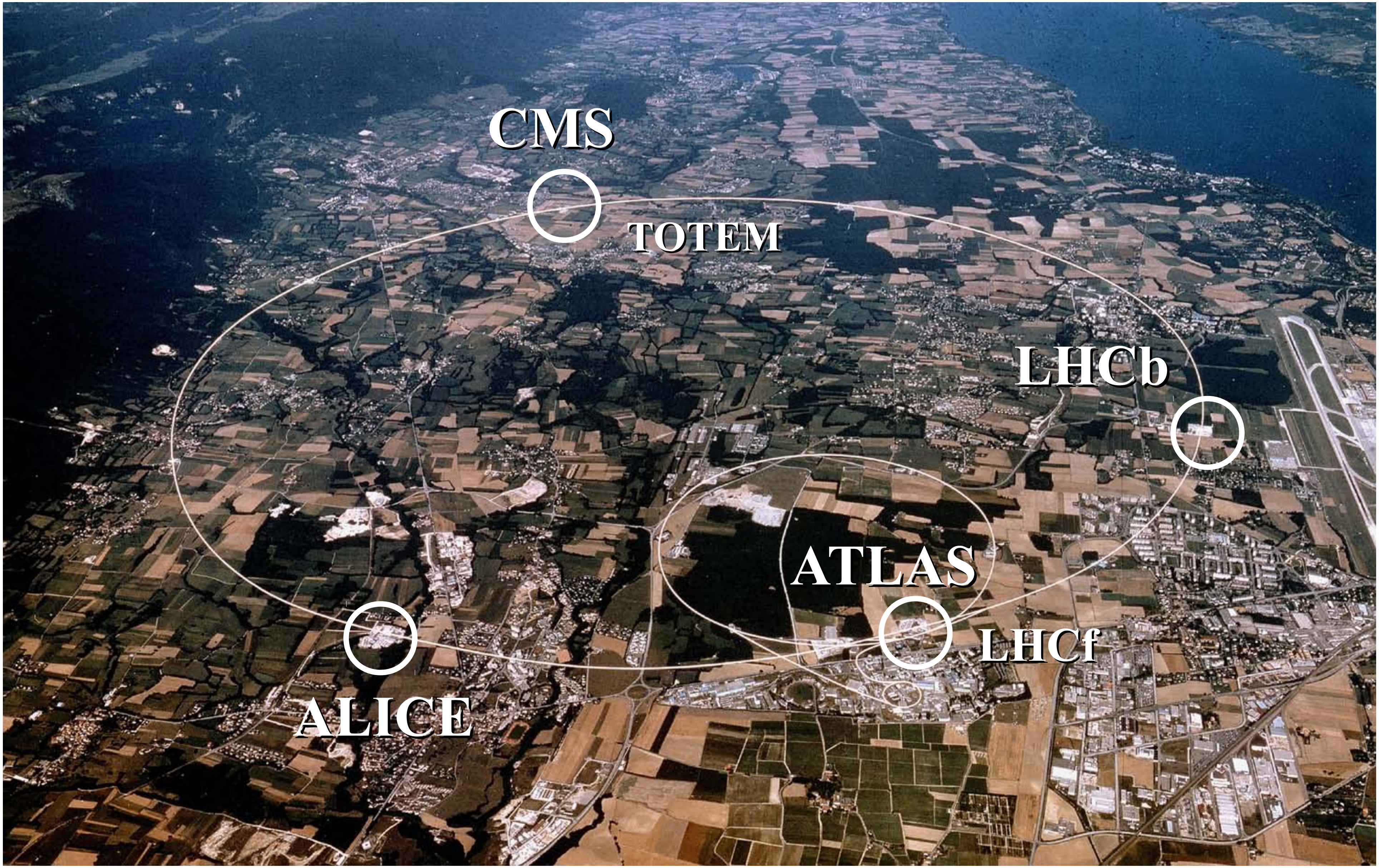
Motivation: Full jet reconstruction

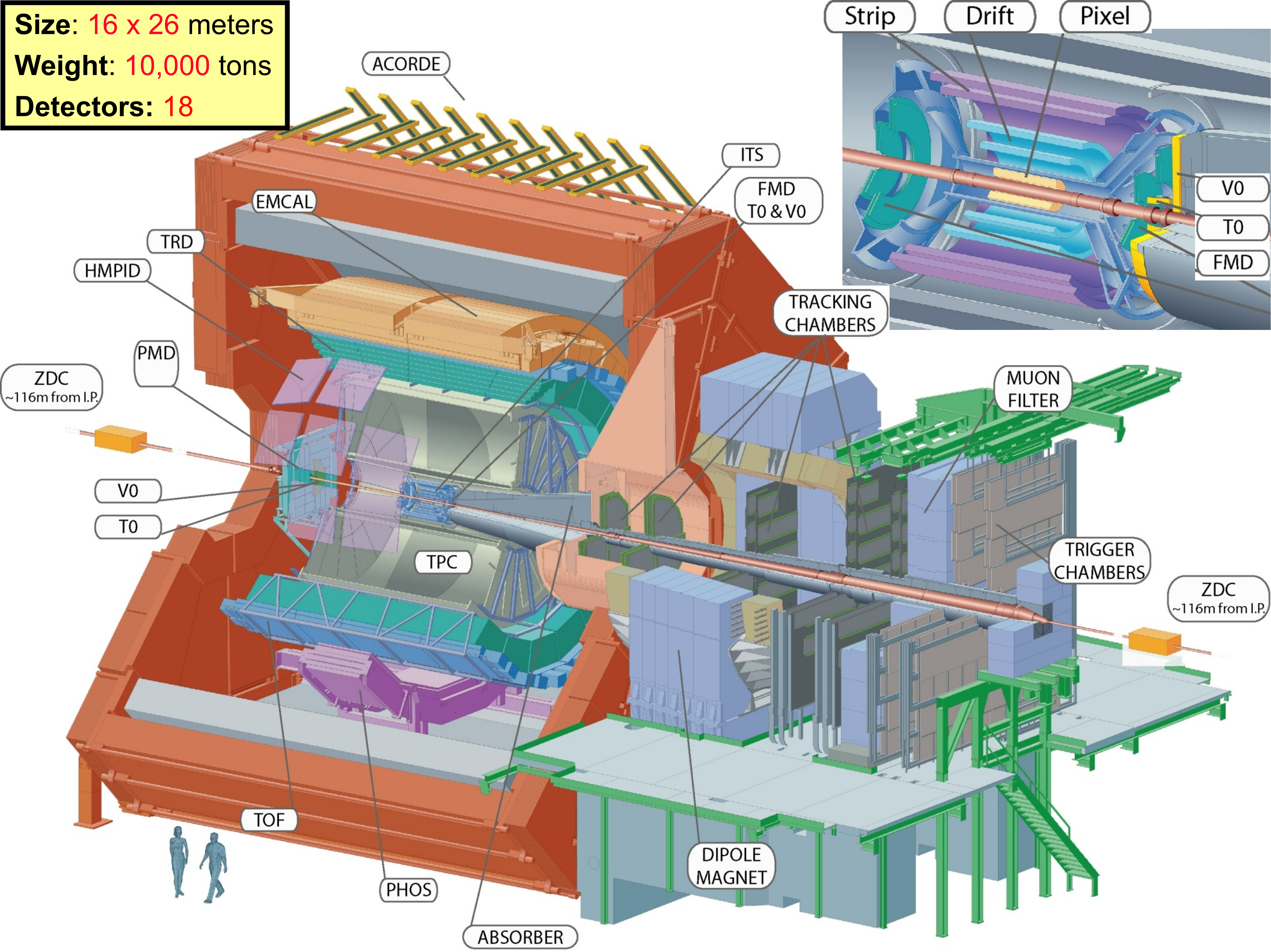
- p+p
  - Tests of pQCD calculations
  - Measurements of momentum distributions of jet fragments
  - Baseline for A+A
- A+A
  - Measurement of partonic energy loss
  - Look for modification of fragmentation
  - Enables studies of energy loss at a partonic level

Challenges

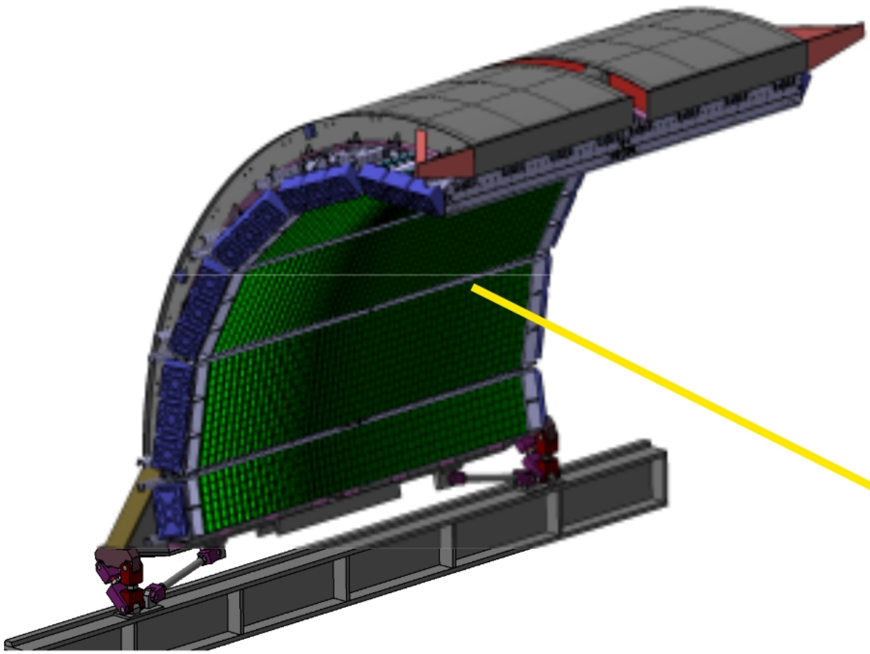
- Background subtraction
  - p+p: pile-up, underlying event
  - A+A: background
    - Simulations are not a good description of background
    - Subject to event-by-event fluctuations
- Multiple algorithms
  - Must compare theoretical and experimental results using the same algorithm
  - Trade-offs between CPU requirements and infrared safety
- Experimental biases
  - Triggering
  - Tracking inefficiency
  - Energy resolution
  - p_T cuts in tracking and calorimetry
  - Edge effects
  - Unobserved particles (ie, neutrons, K^0_L)

The Large Hadron Collider



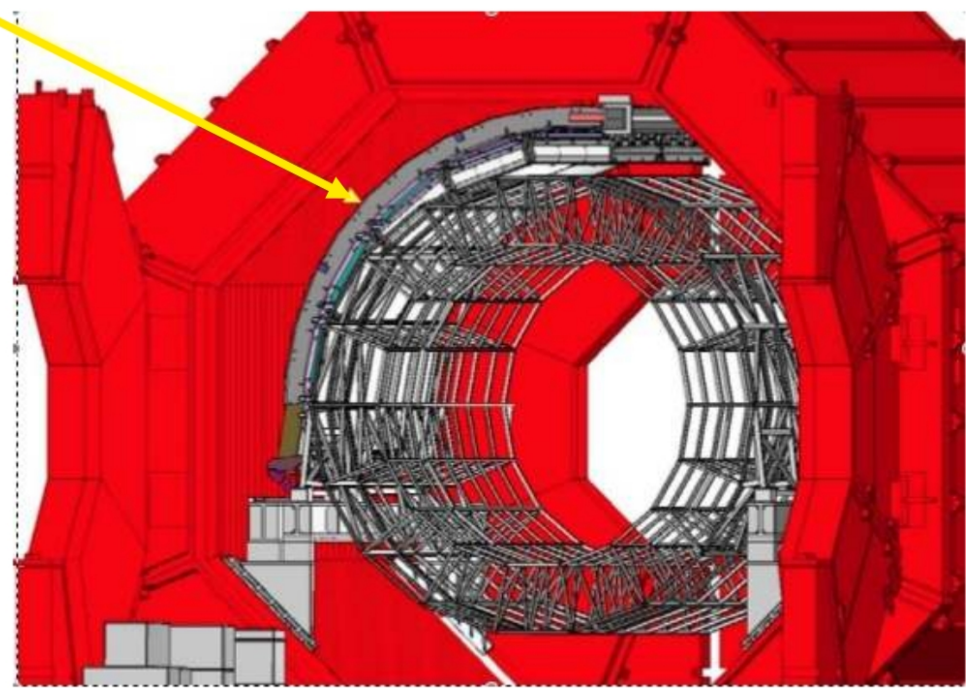

Size: 16 x 26 meters
Weight: 10,000 tons
Detectors: 18
ACORDE
ITS
FMD
T0 & V0
EMCAL
TRD
HMPID
PMD
ZDC
~116m from I.P.
V0
T0
TPC
TOF
PHOS
ABSORBER
DIPOLE MAGNET
TRACKING CHAMBERS
MUON FILTER
TRIGGER CHAMBERS
ZDC
~116m from I.P.
Strip
Drift
Pixel
V0
T0
FMD

EMCal

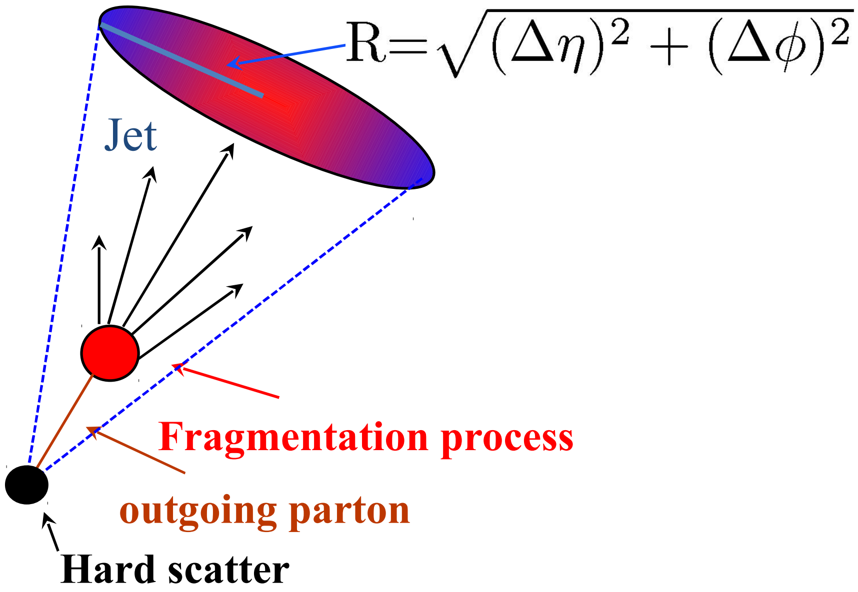


Current coverage:
$\Delta\eta=1.4, \Delta\varphi=39^{o}$ ($R\approx0.3$ max)
Full calorimeter installation during the next long shut down
•Planned for 2012
•May be possible in 2011

- Lead-scintillator sampling calorimeter
- 13 k towers
- Each tower $\Delta\eta X \Delta\varphi$= 0.014 X 0.014
- Shashlik geometry
- Avalanche phototodiodes
- Full coverage: $\Delta\eta=1.4, \Delta\varphi=107^{o}$
- $\sigma(E)/E=0.12/\sqrt{E} + 0.02$
- High level triggering → jet patch trigger



Jet reconstruction algorithms

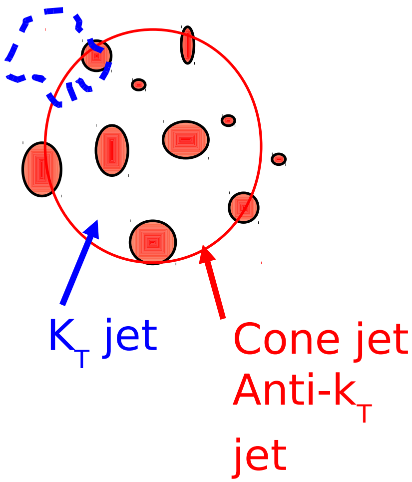


Cone Algorithm:

1. Mid Point Cone: Merging & Splitting
2. SIS CONE
   - Insensitive to "soft" radiation
   - Splitting doesn't change jets
3. Leading Order High Seed Cone (LOHSC)

Sequential recombination:
Cluster pairs of objects close in relative p_T

4. K_T (starting point: low p_T particles)
5. Anti-K_T (starting point: high p_T particles)



6. Gaussian filtering. Y. Lai, B. Cole arXiv:0806.1499

Hard probe rates in ALICE

ALICE hard physics capabilities:

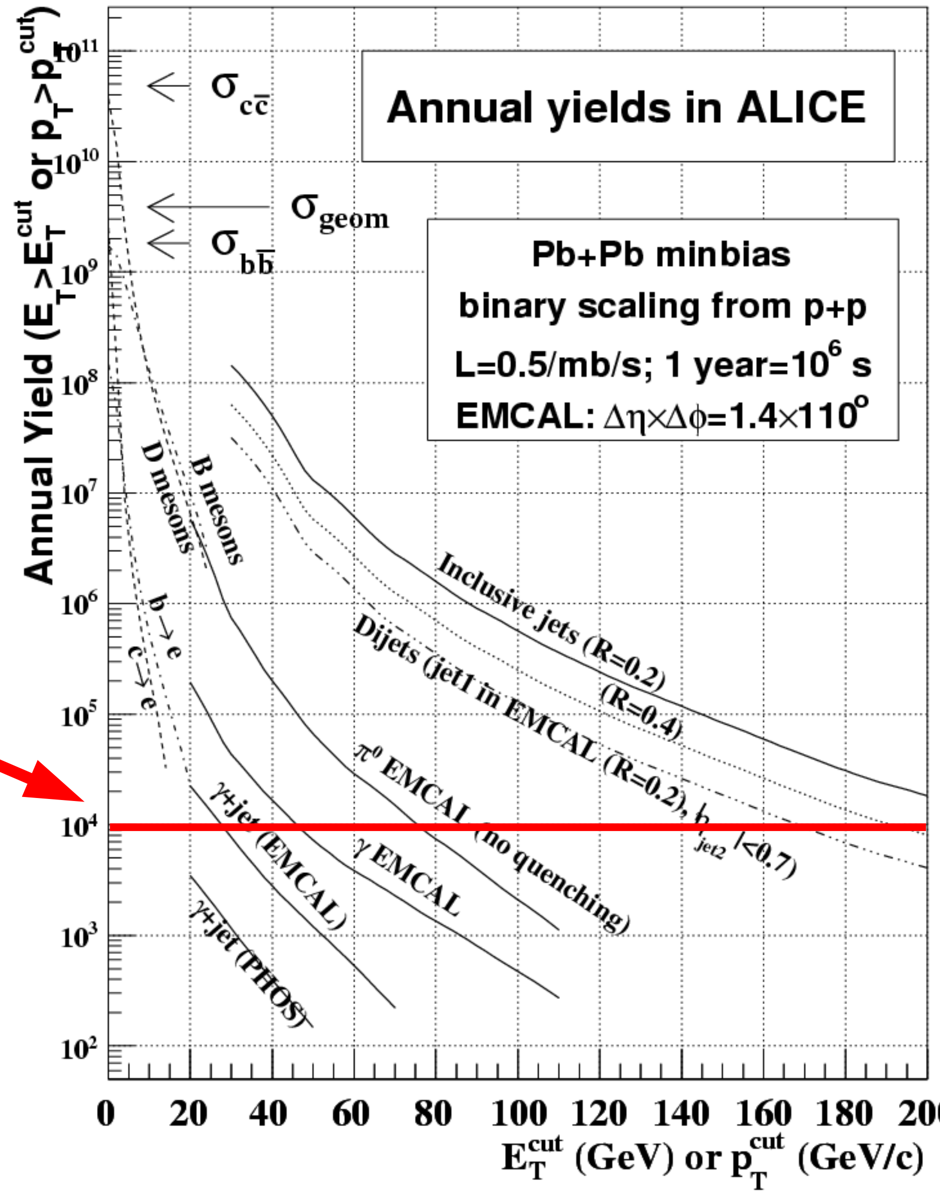
- Electron/hadron discrimination (TRD, EMCal)
- μ measurements(forward muon arm)
- Good γ/π^0 discrimination (EMCal, PHOS)
- Fast trigger on jets(EMCal)

Hard Probes statistics in ALICE:

*10^4/year minbias Pb+Pb at nominal luminosity**

- Inclusive jets: $E_T \sim 200$ GeV
- Dijets: $E_T \sim 170$ GeV
- π^0: $p_T \sim 75$ GeV/c
- Inclusive γ: $p_T \sim 45$ GeV/c
- Inclusive e: $p_T \sim 30$ GeV/c

*One year of running = one month of Pb+Pb collisions



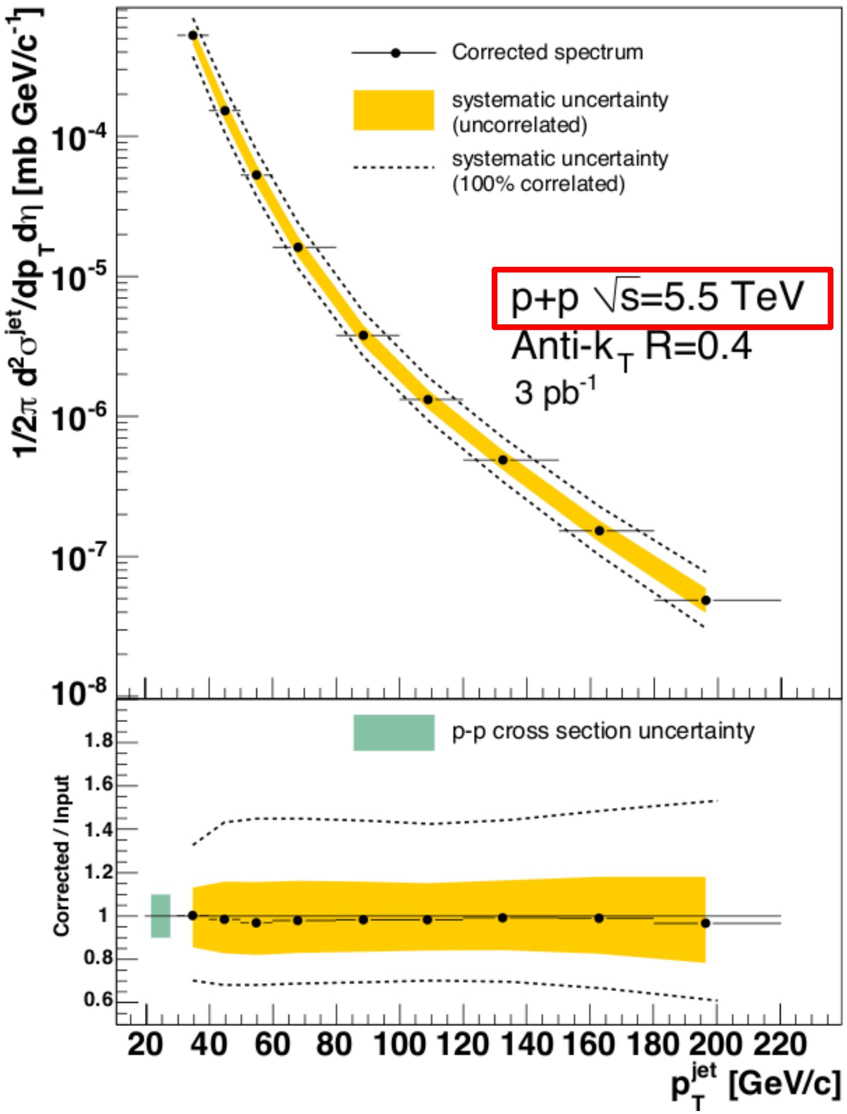
ALICE EMCal Jet Trigger

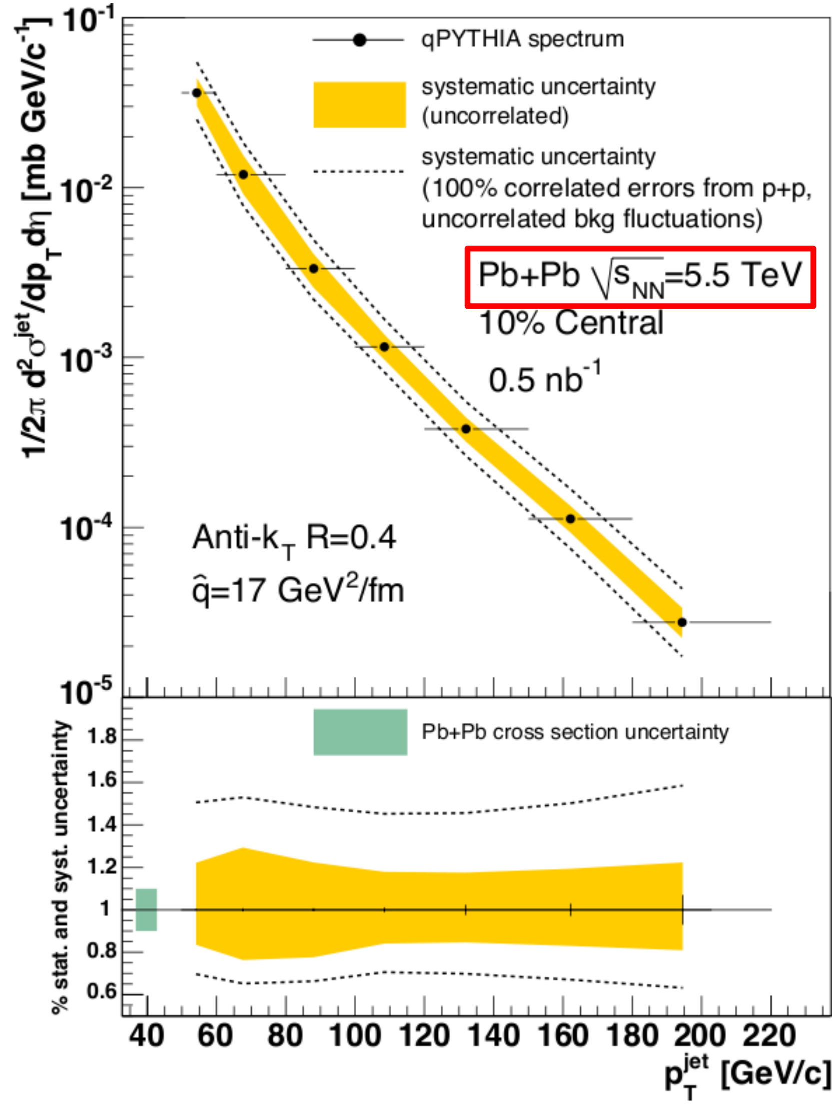
Gain for jets with p_T>100 GeV/c

System	$\sqrt{s}$(TeV)	$L_{mean}(cm^{-2}s^{-1})$	Time (s)	DAQ rate (Hz)	Gain at L1
p–p	5.5	5×10^{30}	10^5	500	110
p–p	14	5×10^{30}	10^7	500	500
Pb–Pb Centrality					
min. bias	5.5	5×10^{26}	10^6	20	21
min. bias	5.5	5×10^{26}	10^6	50	9
min. bias	5.5	5×10^{26}	10^6	100	4
0–10%	5.5	5×10^{26}	10^6	50	5
0–10%	5.5	5×10^{26}	10^6	100	2
60–80%	5.5	5×10^{26}	10^6	50	12
60–80%	5.5	5×10^{26}	10^6	100	6

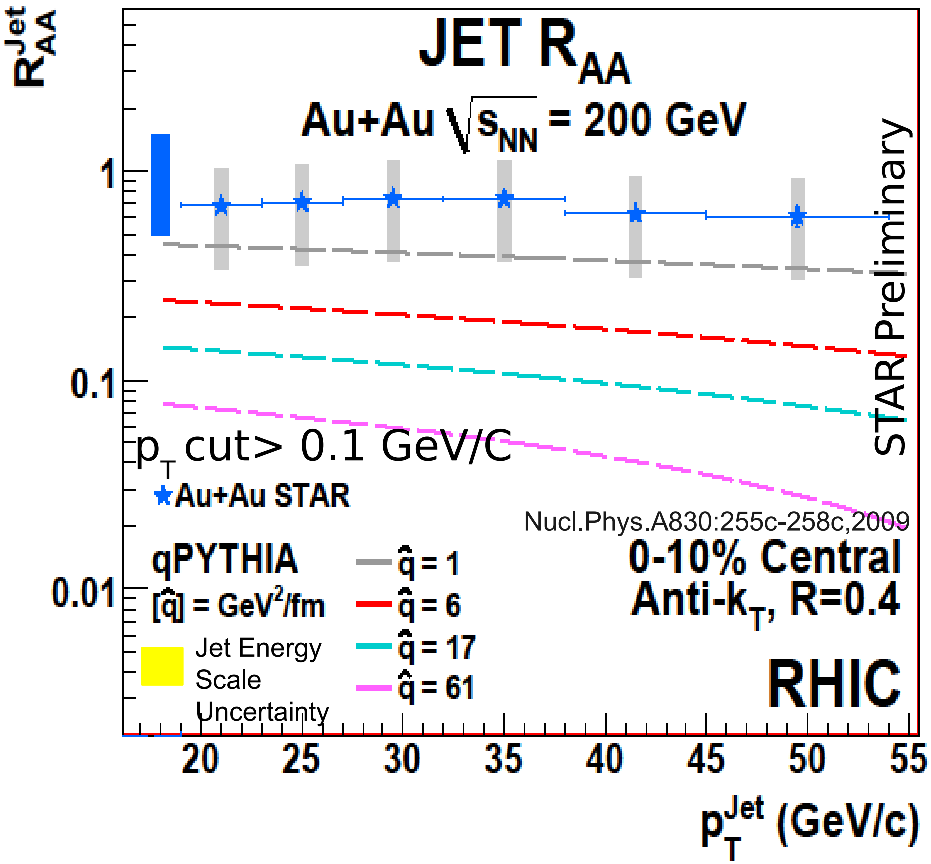
- Based on the simulation results presented in this chapter we find that in order to correct for the trigger bias and recover the full inclusive jet cross sections from the triggered samples with a 5% systematic uncertainty, ALICE will need to record statistics of 25 M minimum bias p–p events and 2 M minimum bias Pb–Pb events. This can be easily accommodated within the ALICE DAQ bandwidth by downscaled minimum bias triggers.

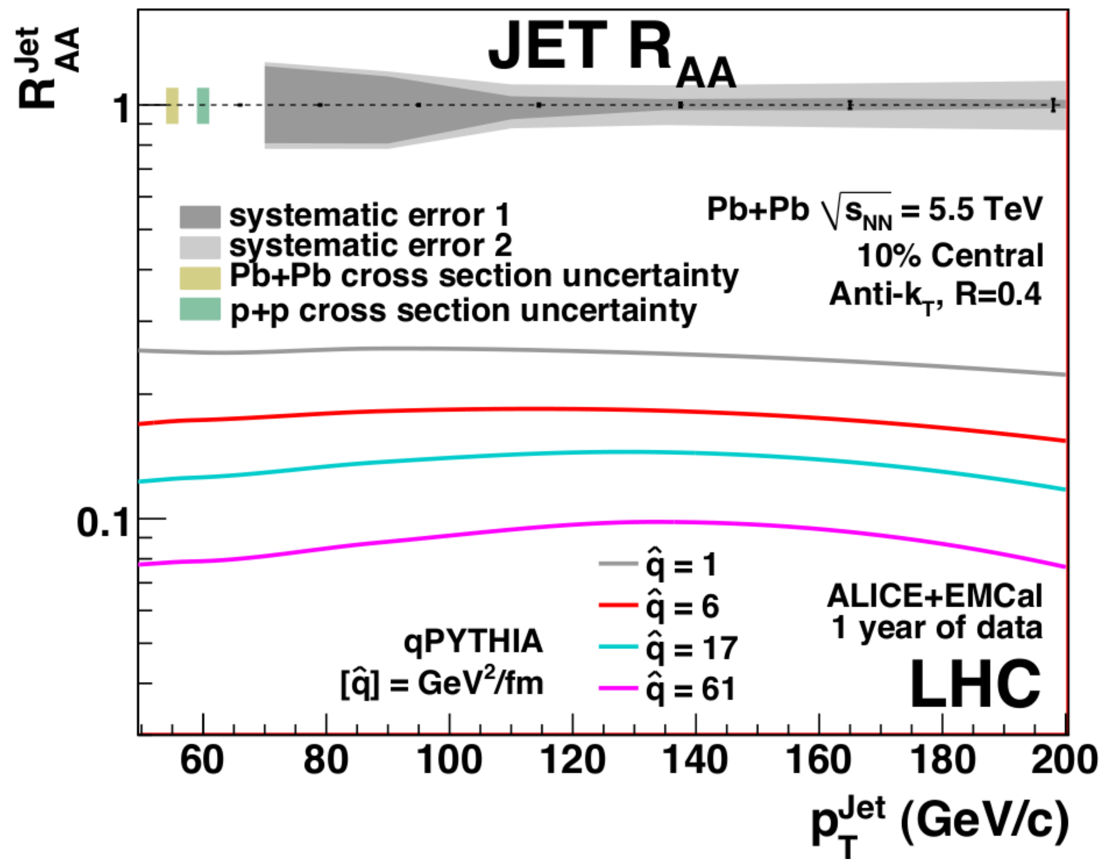
Inclusive spectra





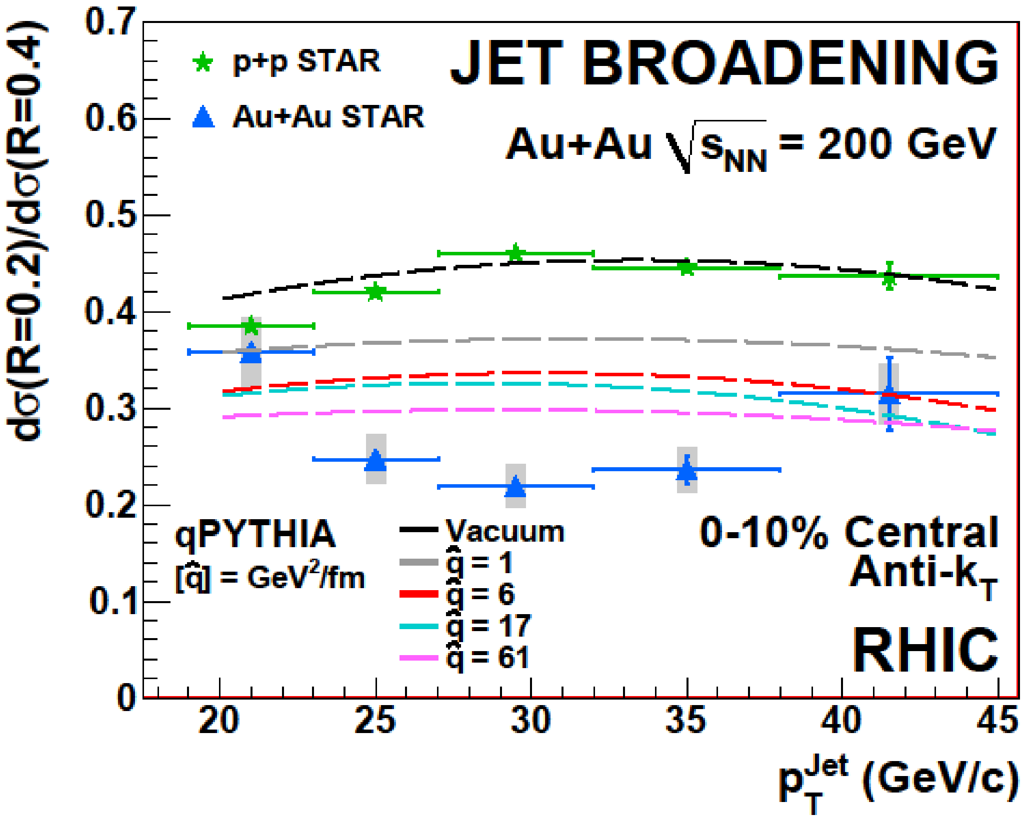
R_{AA}: From RHIC to the LHC

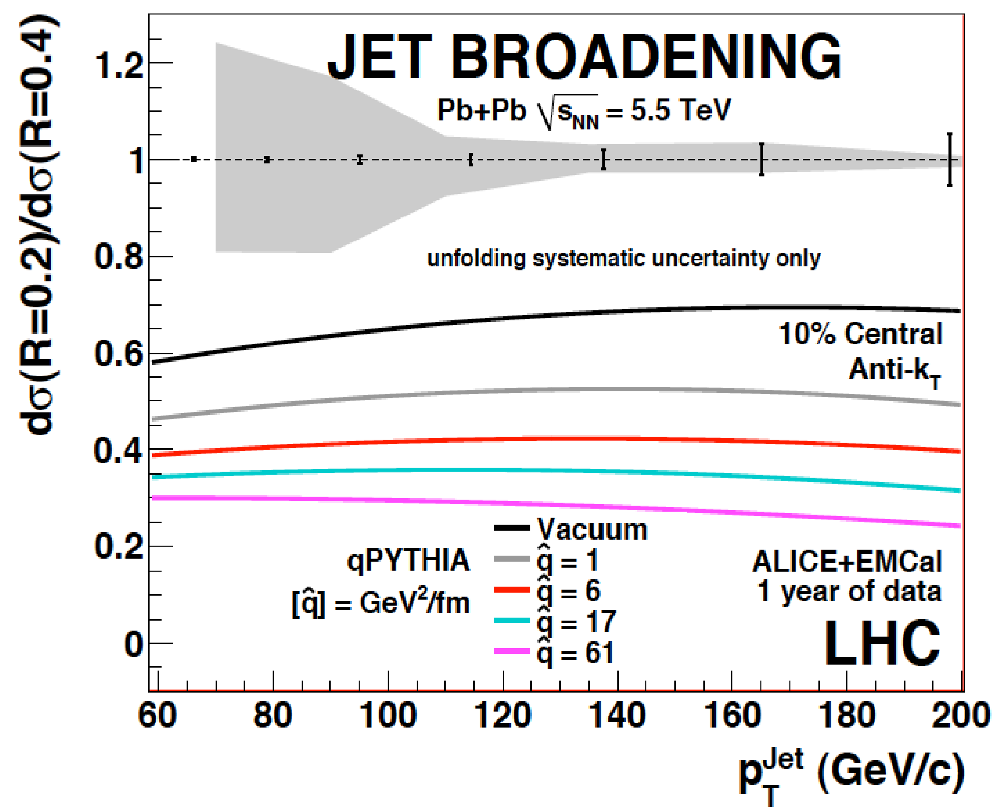




- Much greater kinematic reach at the LHC
- Smaller systematic errors
- Comparison between RHIC and LHC: studies of partonic energy loss at different regions on the phase diagram

Jet broadening





- QPYTHIA not optimized (yet) –do not draw conclusions from shape differences
- Jet energy profile (Au+Au data) BROADENED indicating JET QUENCHING
- Small experimental systematic uncertainties in measurements (ratios from same data set) →a precision measurement in ALICE

Conclusions

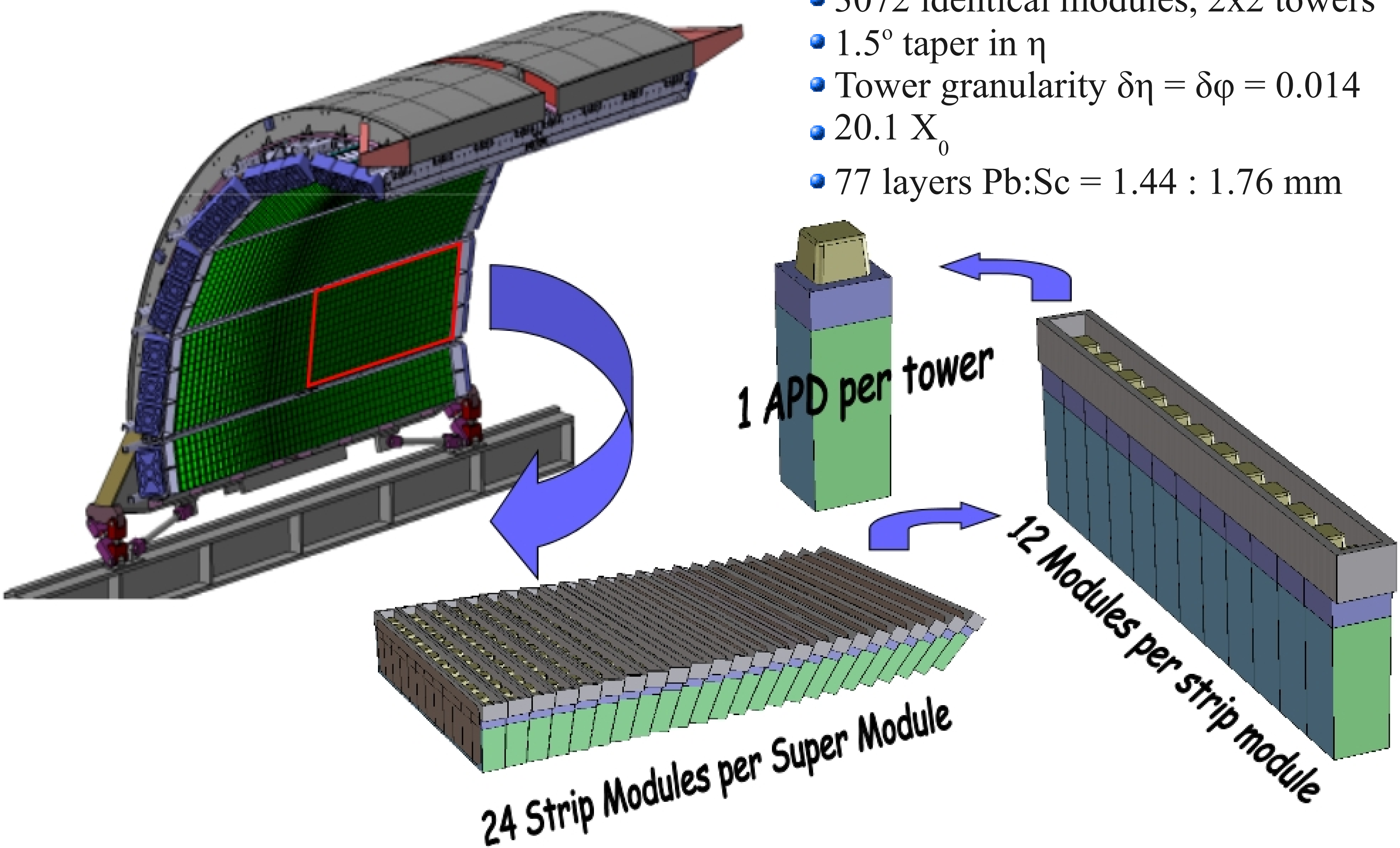
- With the EMCal fully installed ALICE will be able to measure
  - Jet spectra to ~200 GeV
  - R_{AA} for jets
  - Modified fragmentation/jet broadening
- Measurements are enhanced by EMCal triggering capabilities

Thank you!

See Yaxian Mao's talk Wednesday for more on jet physics in ALICE

EMCal Assembly

- 3072 identical modules, 2x2 towers
- 1.5^{o} taper in η
- Tower granularity $\delta\eta = \delta\varphi = 0.014$
- 20.1 X_0
- 77 layers Pb:Sc = 1.44 : 1.76 mm



Inclusive Jets –Systematic Uncertainties

Systematic effect	Incl. cross section sys. uncert.
Common in p+p and A+A	
Tracking distortions (space charge etc.)	unknown
Tracking efficiency	1%
Hadronic and electron energy double counting	3-4%
EMCal energy scale	8-10%
Unobserved neutral energy	13-15%
Underlying event (central Pb–Pb)	
Fluctuations	20% (75 GeV/c), 3% (150 GeV/c)
False Jets	small (>50 GeV/c)