The ATLAS and CMS Experiment

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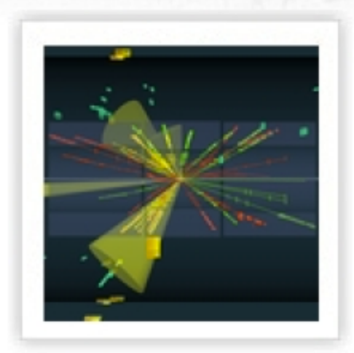


Taller de Altas Energías 2010
2010, Aug 31 -- Sep 11

Lecture Plan

- Introduction
- The LHC Collider
  - Introduction to the LHC
- The experimental challenges at the LHC
  - The experimental solutions
- The “general purpose” experiments
  - The CMS experiment
  - The ATLAS experiment
- First performance results of the experiments
- First physics with the ATLAS and CMS experiments
  - QCD, B-physics
  - EWK/Searches and the outlook

Summary: Challenges

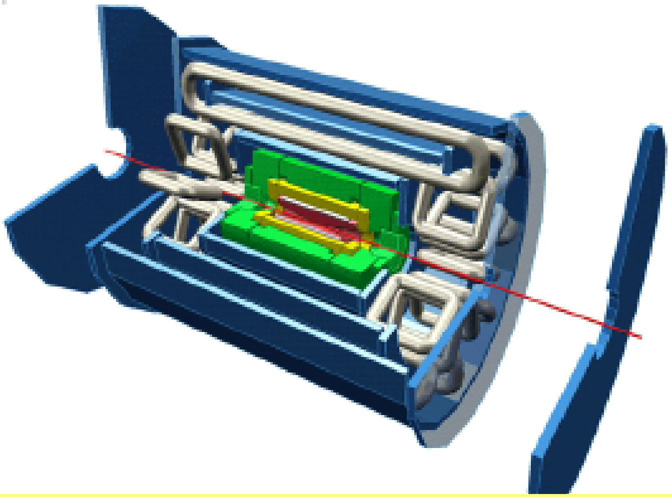
- High event rate and pile-up
  - High granularity: typically 10x more channels compared to present detectors
- Timing/synchronization of 10^8 channels is non trivial
- Event size (> 1 Mbyte)/Computing
  - Limit event rate to 100 Hz, use the Grid
- Trigger reduce event rate from 40MHz to 100 Hz
  - Multi-layered trigger system and pipelined electronics
- Detectors need excellent hermeticity (missing ET), lepton identification, B & Tau identification, jet measurements…
- Detectors must be radiation hard and reliable for ~ 10-20 years…

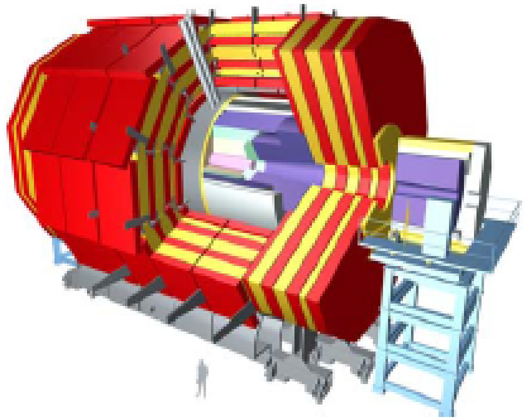
Can it be done?

ATLAS and CMS

General Purpose Detectors at the LHC

ATLAS A Toroidal LHC ApparatuS **CMS** Compact Muon Solenoid





In total about

~100 000 000 electronic channels

Each channel checked

40 000 000 times per second (collision rate is 40 MHz)

Amount of data of just one collisions

>1 500 000 Bytes

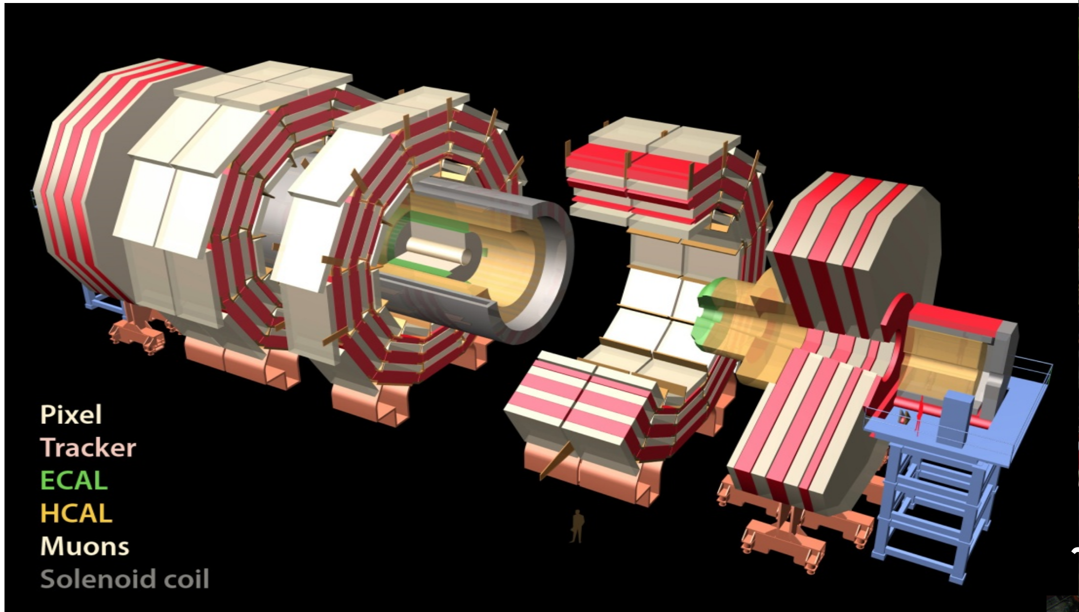
Trigger (online event selection)

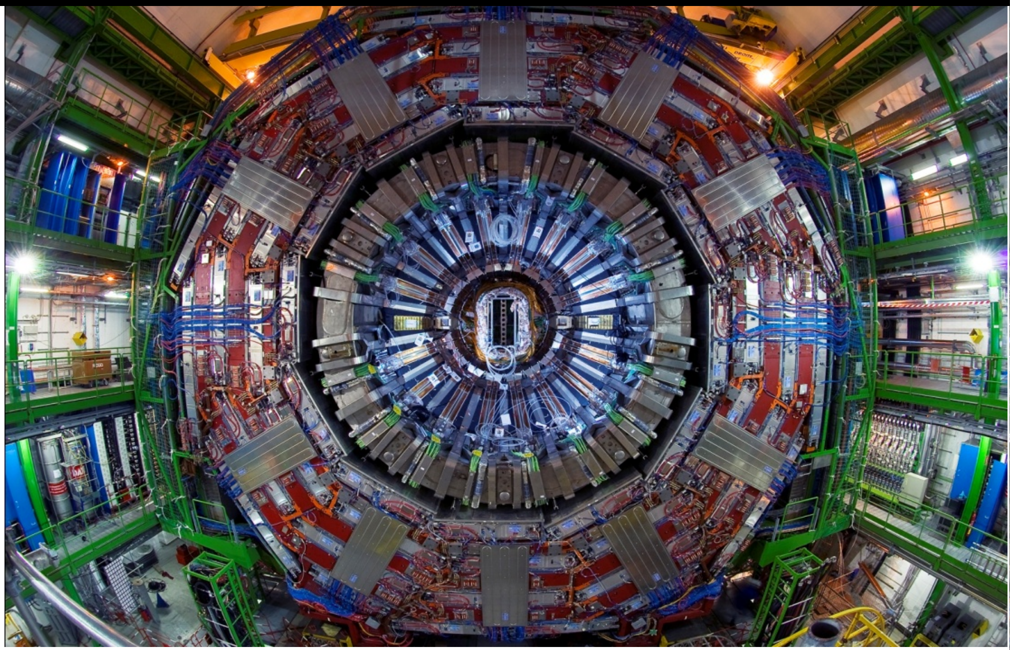
Reduce 40 MHz collision rate to ~100 Hz data recording rate

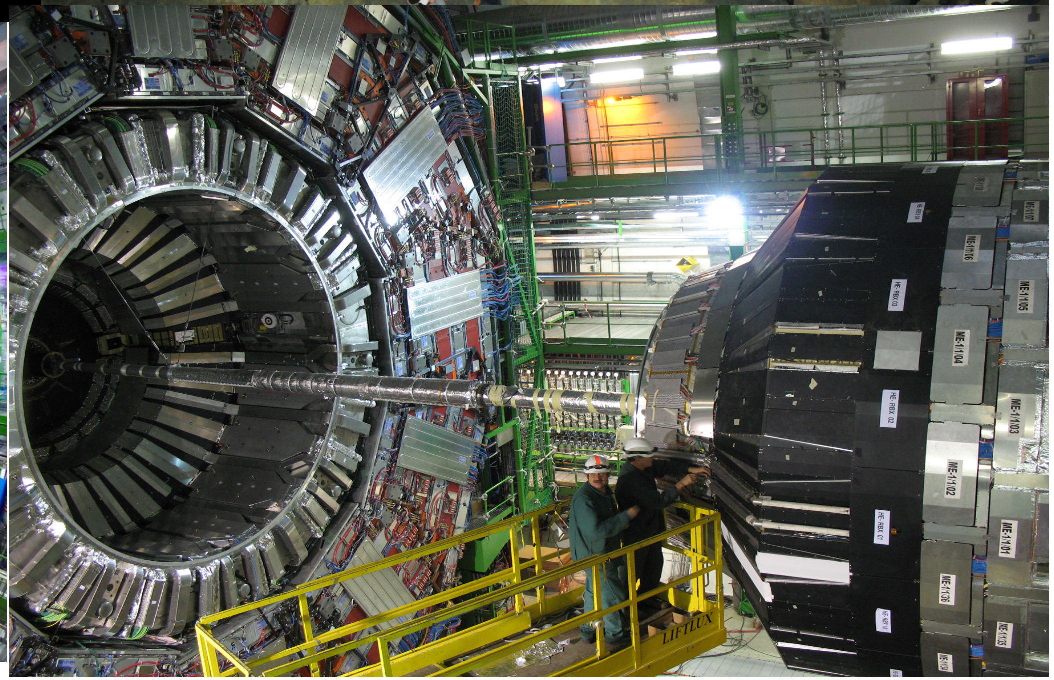
Readout to disk

100 collisions/sec ⇒ pentaBytes of data/year

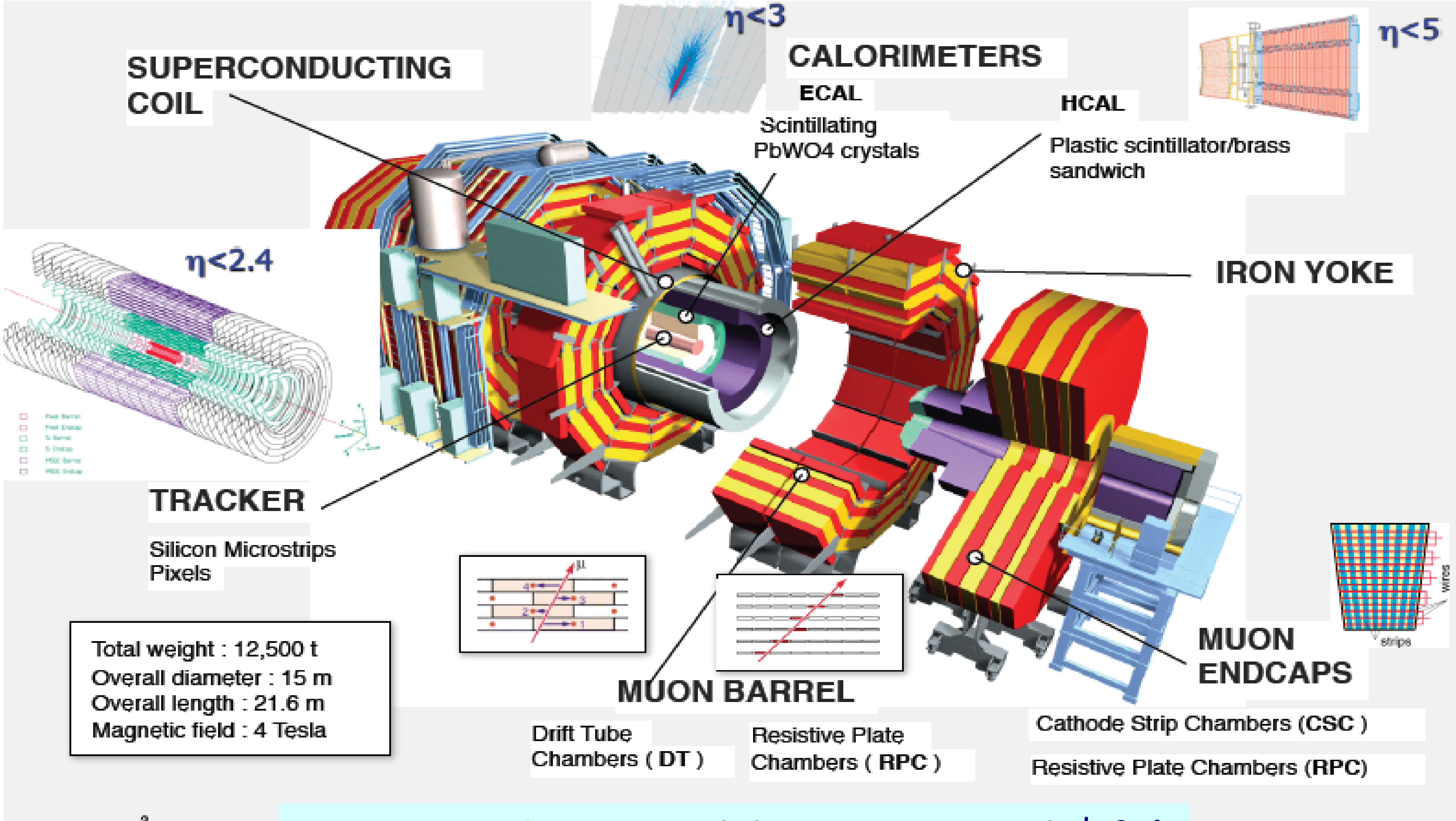
The CMS Collaboration: >3000 scientists and engineers, >700 students from 182 Institutions in 39 countries .







The Modular Design of CMS



Acceptance: Calorimetry $|\eta| < 5.0$ Tracking $|\eta| < 2.4$

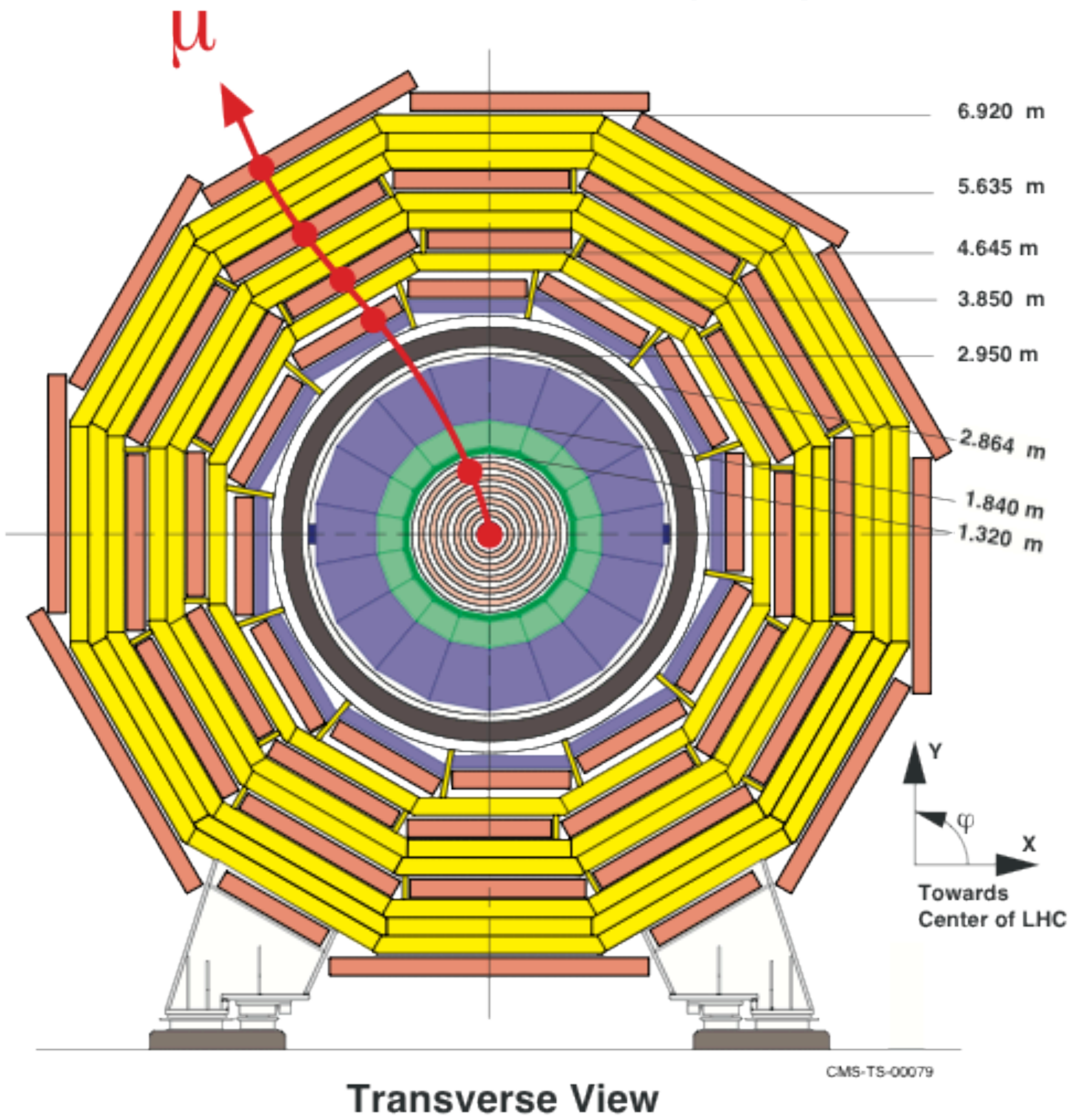
CMS Detector Design Priorities

Expression of Intent (EOI): Evian 1992

1. A robust and redundant Muon system
2. The best possible e/γ calorimeter consistent with 1.
3. A highly efficient Tracking system consistent with 1. and 2.
4. A hermetic calorimeter system.
5. A financially affordable detector.

Compact Muon Solenoid (CMS)

Letter of Intent (LOI): LHCC, TDR in 1994



Strong Field 4T

Compact design

Solenoid for Muon P_t trigger in transverse plane

Redundancy: 4 muon stations with 32 r-phi measurements

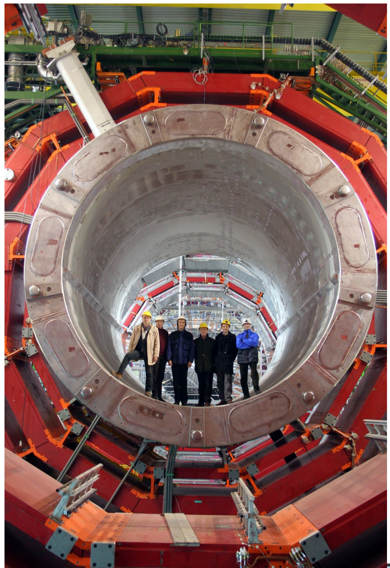
$\Delta P_t/P_t \sim 5\%$ @1TeV for reasonable space resolution of muon chambers (200μm)

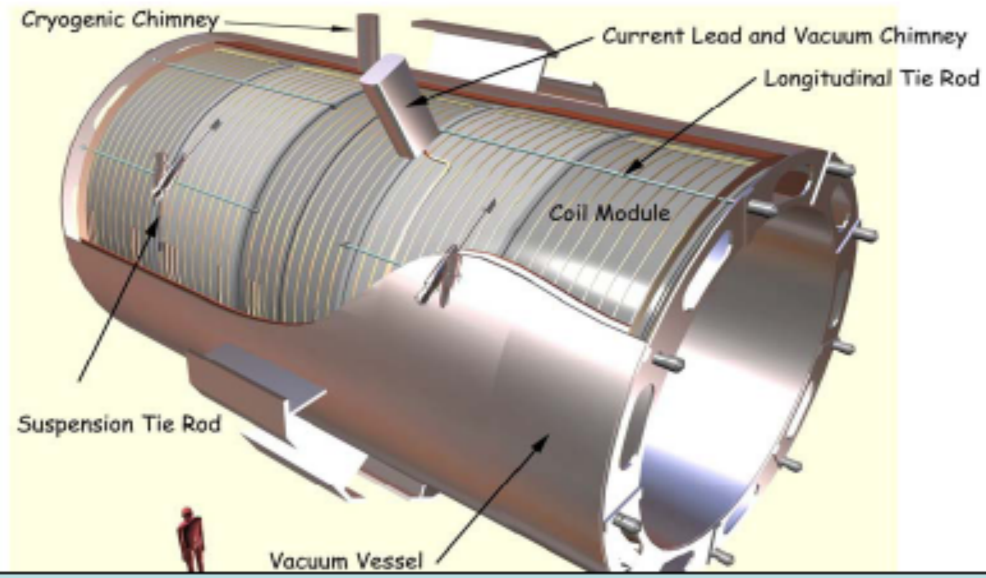
CMS Solenoid

Successfully tested in August '06!!

The largest high field solenoid magnet ever build!!

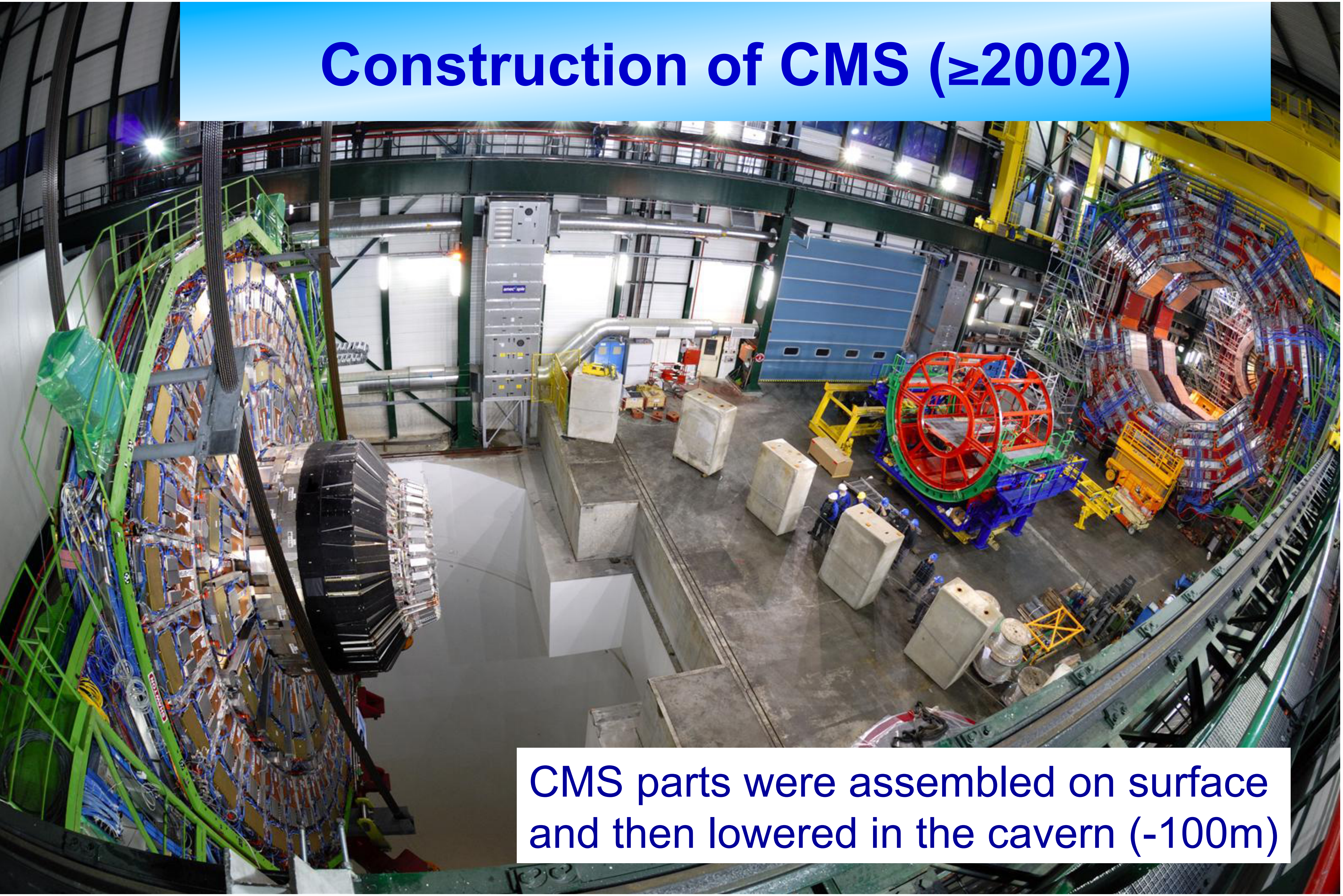
Magnetic length	12.5 m
Free bore diameter	6 m
Central magnetic induction	4 T ≈100,000 times earth magnetic field
Temperature	4.2 degrees Kelvin ≈-269 degrees Celcius
Nominal current	20 kA
Stored energy	2.7 GJ
Magnetic Radial Pressure	64 Atmospheres





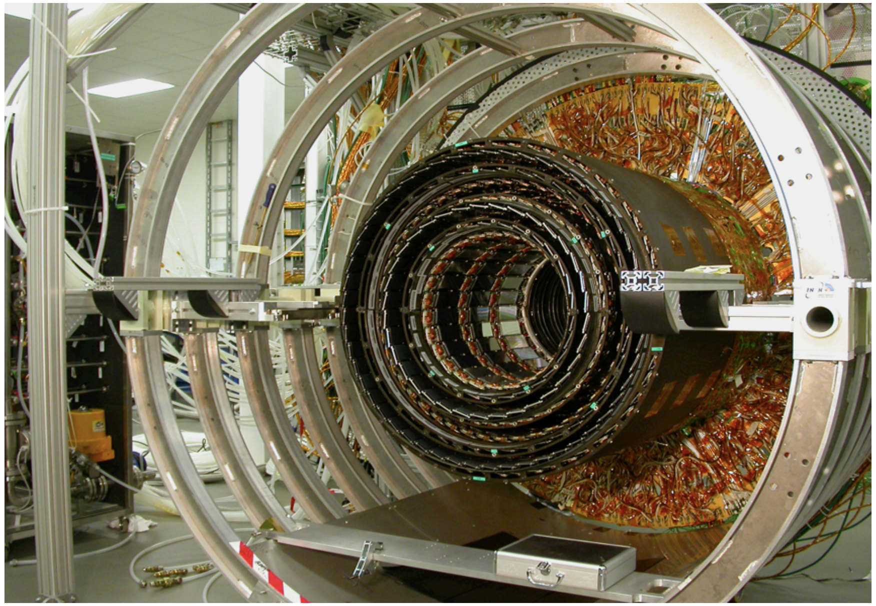
CMS	ALEPH	factor

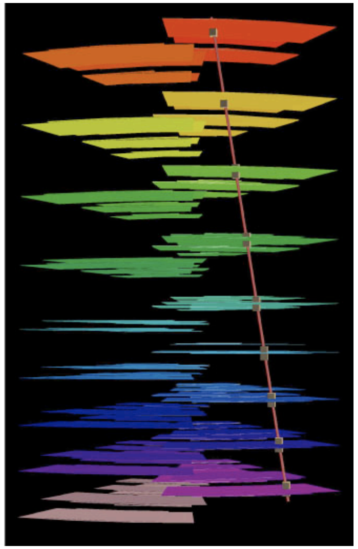
Construction of CMS (≥2002)



CMS parts were assembled on surface and then lowered in the cavern (-100m)

The CMS Central Tracker

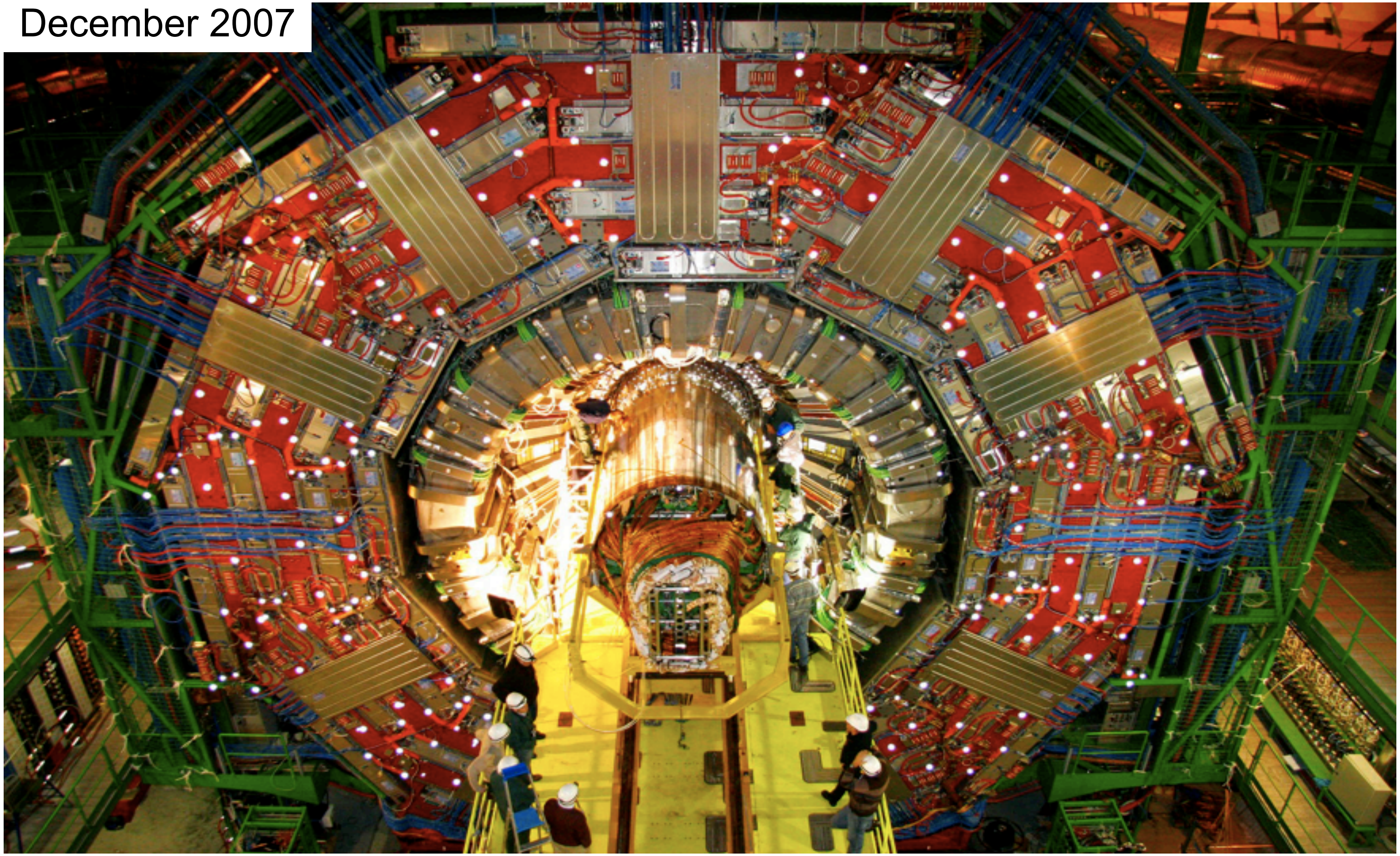




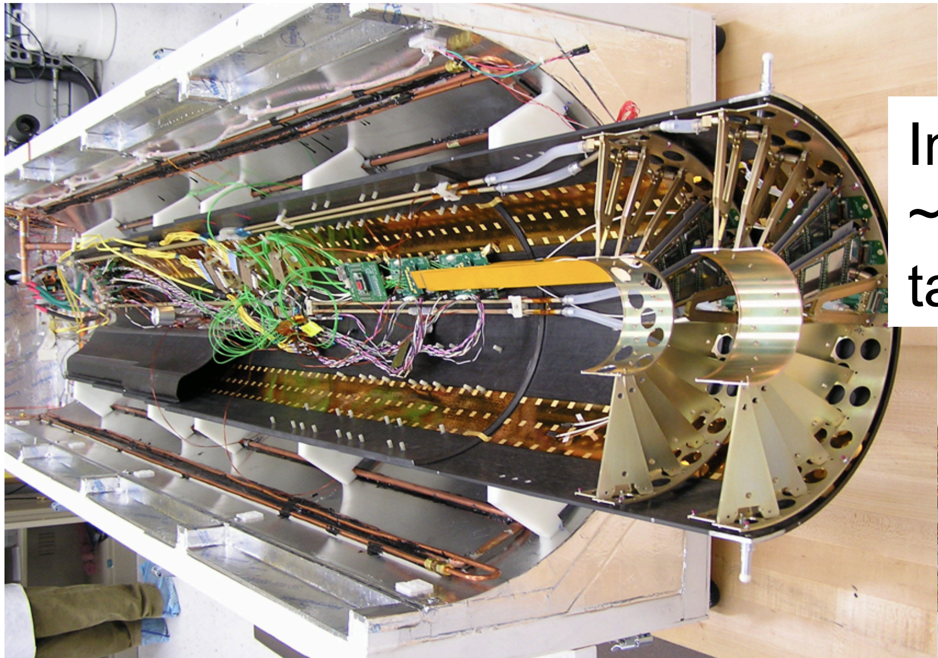
- 200 m^2 silicon detectors (~ tennis court)
- ~ 10^7 read-out channels: silicon strips

Installation of the Central Tracker in CMS

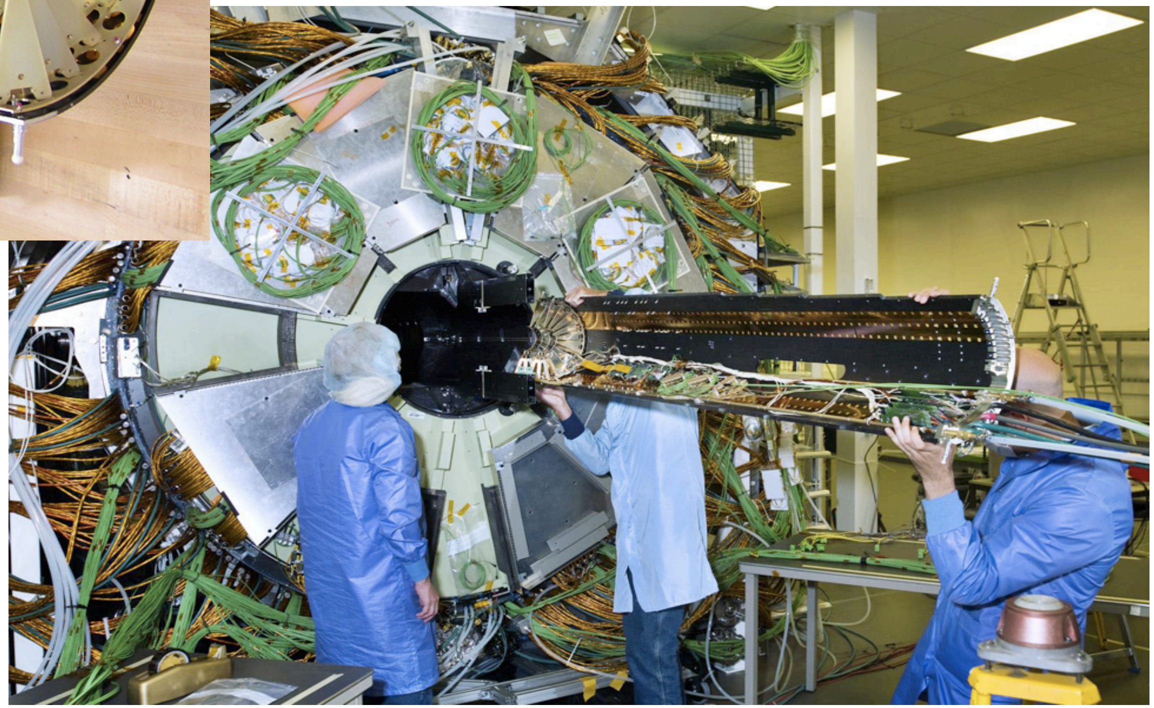
December 2007



Pixel Tracking Detector



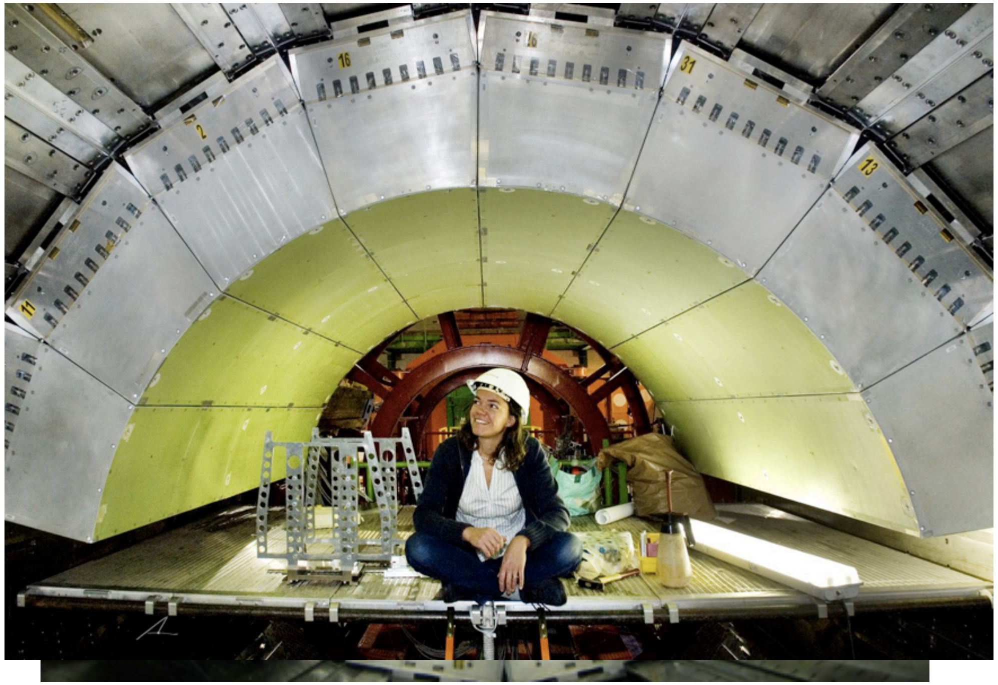
In total 7.10^7 read out channels
~ photo camera with 70 milion pixels
taking 40 million photos per second!!



The CMS Detector: Calorimeters

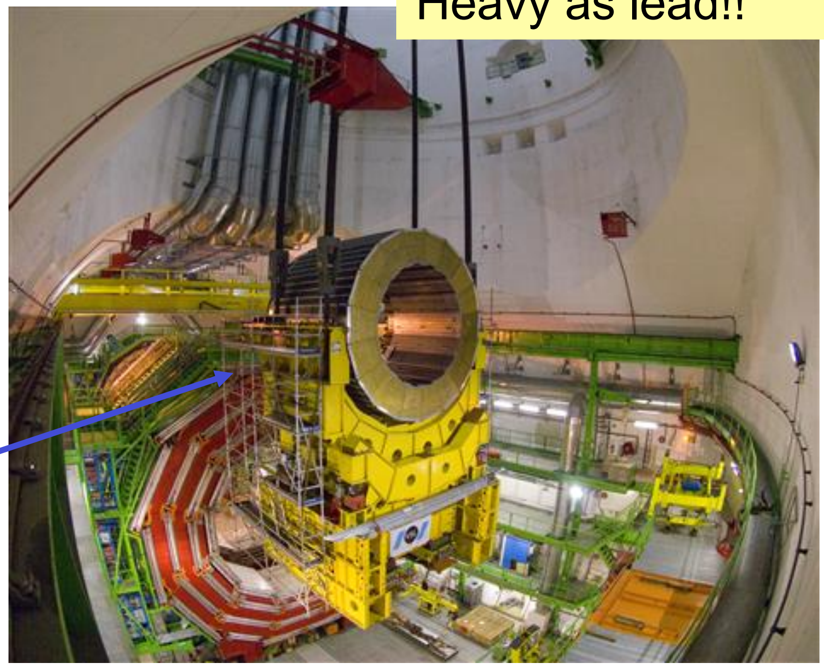
ECAL: Barrel 36 super modules/1700 crystals
Endcaps detectors completed in summer 2008
Total of ~70000 crystals for this detector

Lead tungstanate.
Transparent like glass
Heavy as lead!!



Central ECAL installation in CMS

Hadronic Calorimeter (brass/scintillator)
completed in 2006
Lowering in the experimental hall

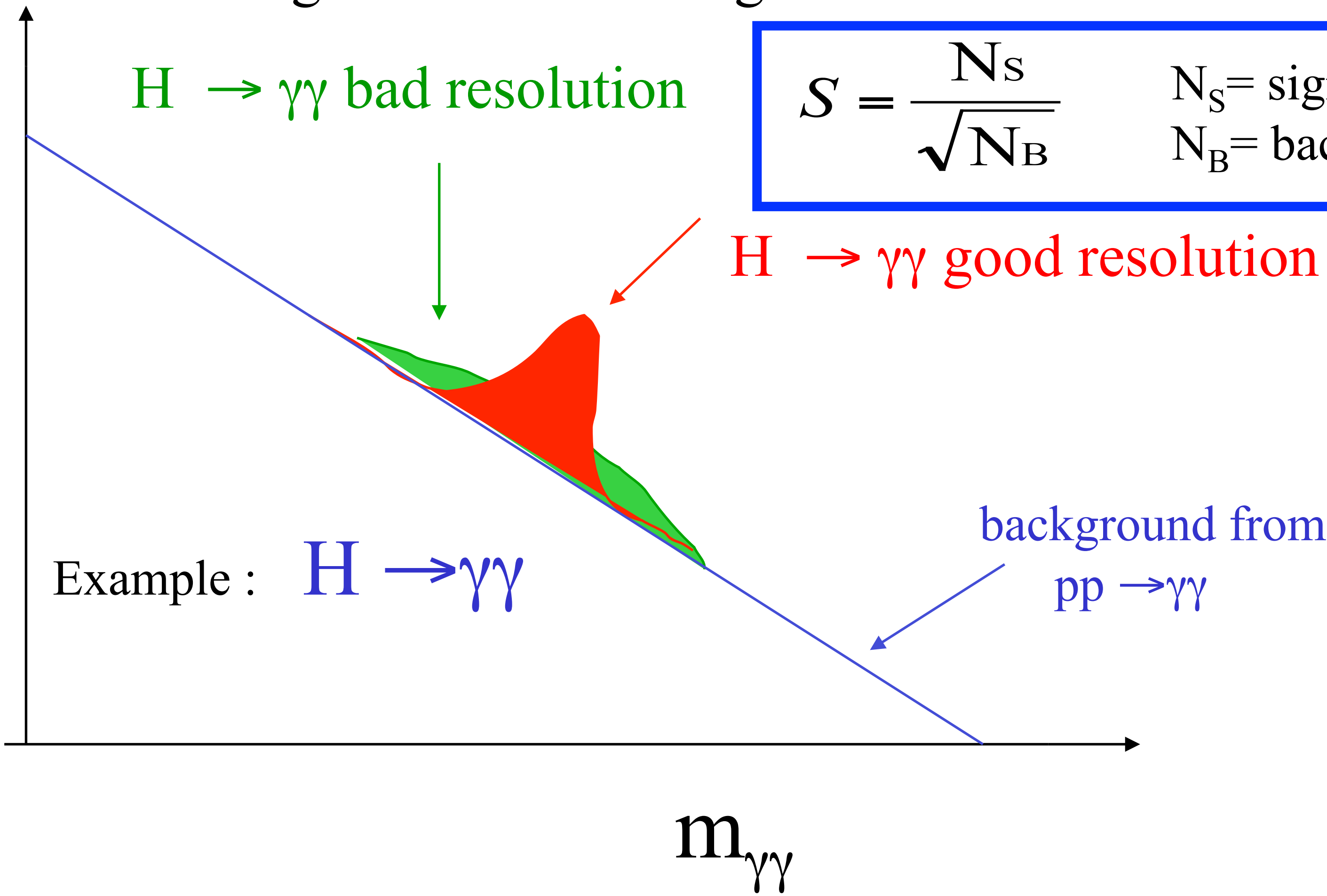


Calorimeter Resolution: eg. for Higgs

- Excellent energy resolution of EM calorimeters for e/γ and of the tracking devices for μ in order to extract a signal over the backgrounds.

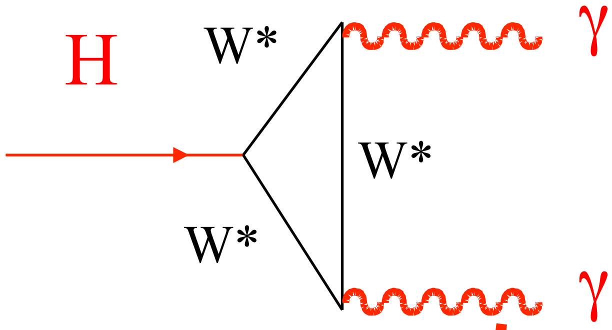
$$S = \frac{N_S}{\sqrt{N_B}}$$

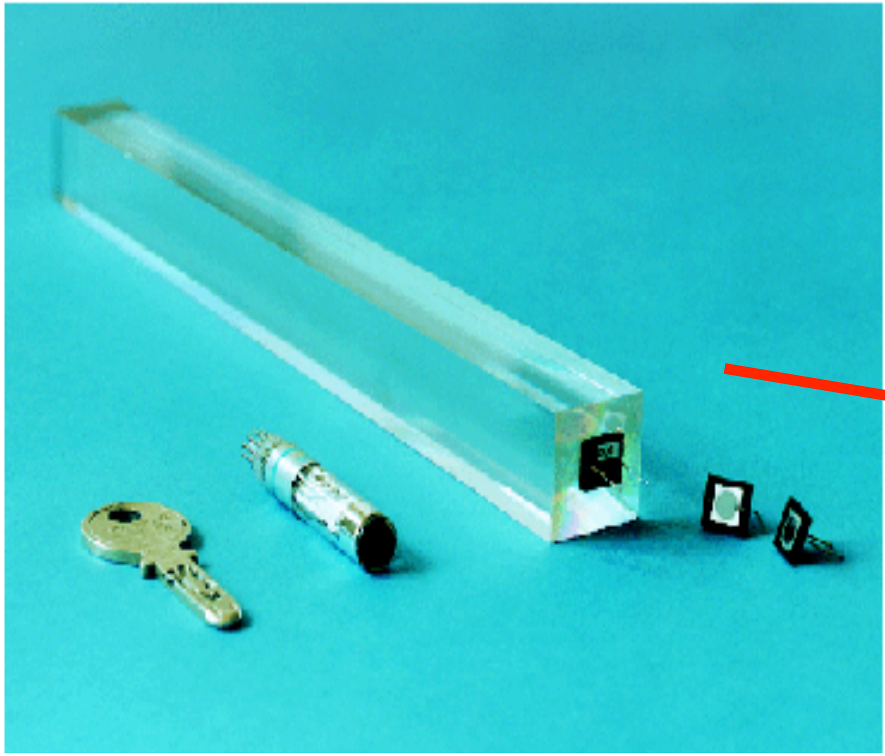
N_S= signal events
N_B= background events

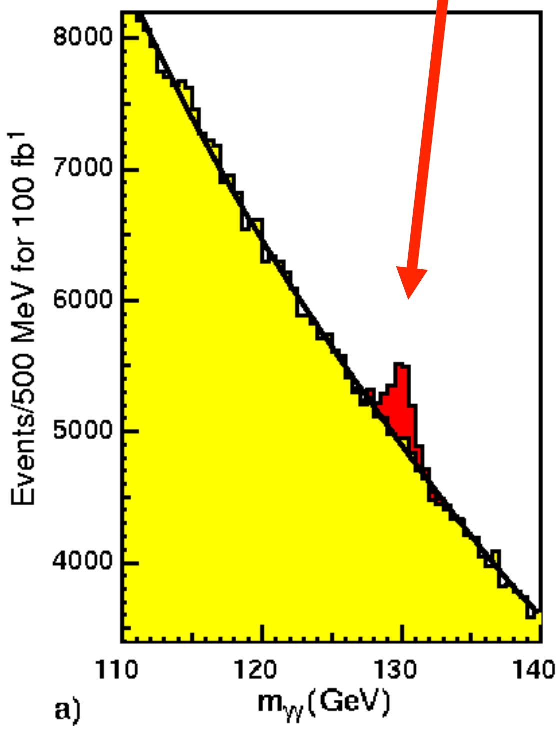


CMS: Lead Tungstanate EM Calorimeter

If the Higgs is light (115-120 GeV) then one of the most promising signals is $H \to \gamma\gamma$ (i.e. 2 photons)



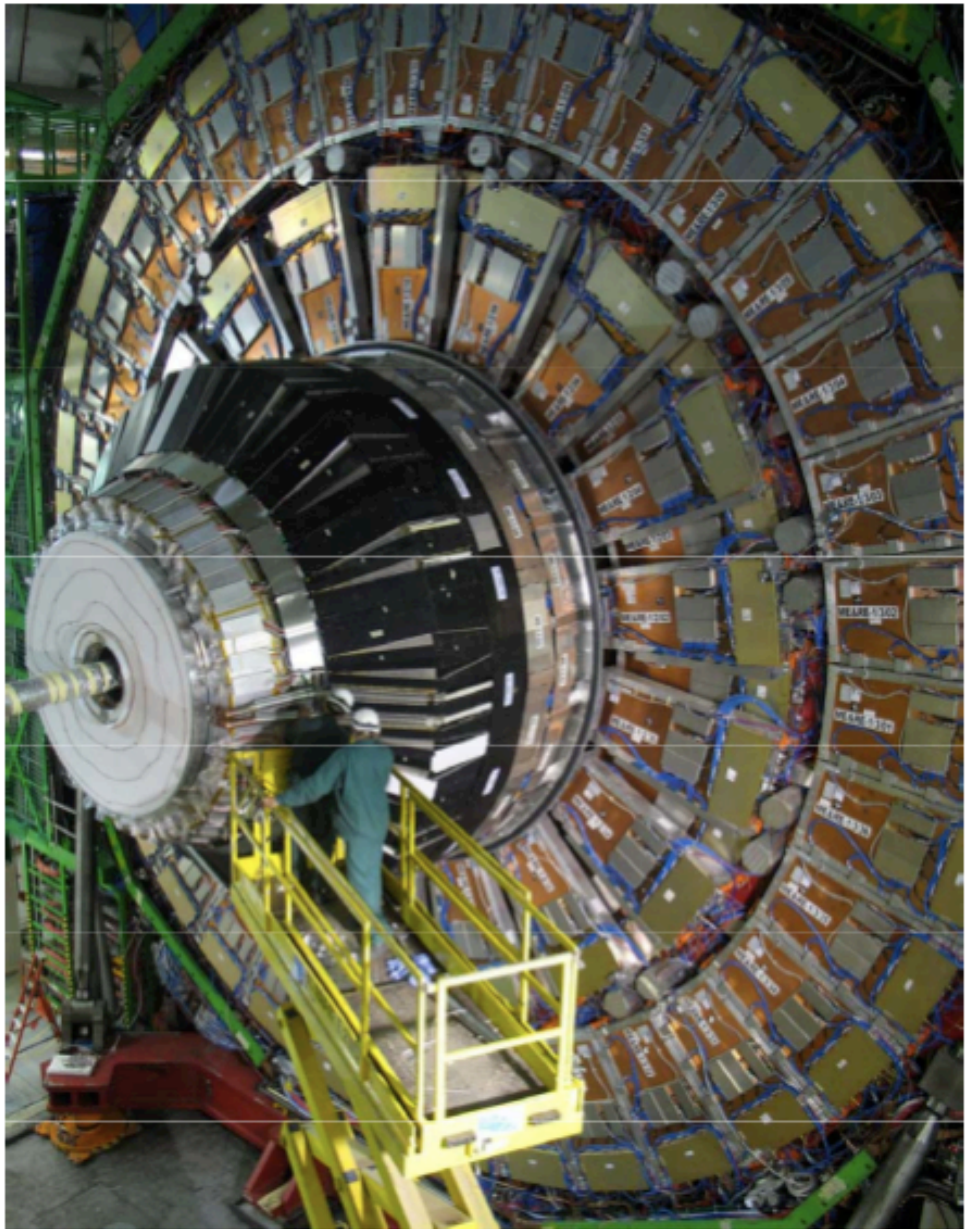




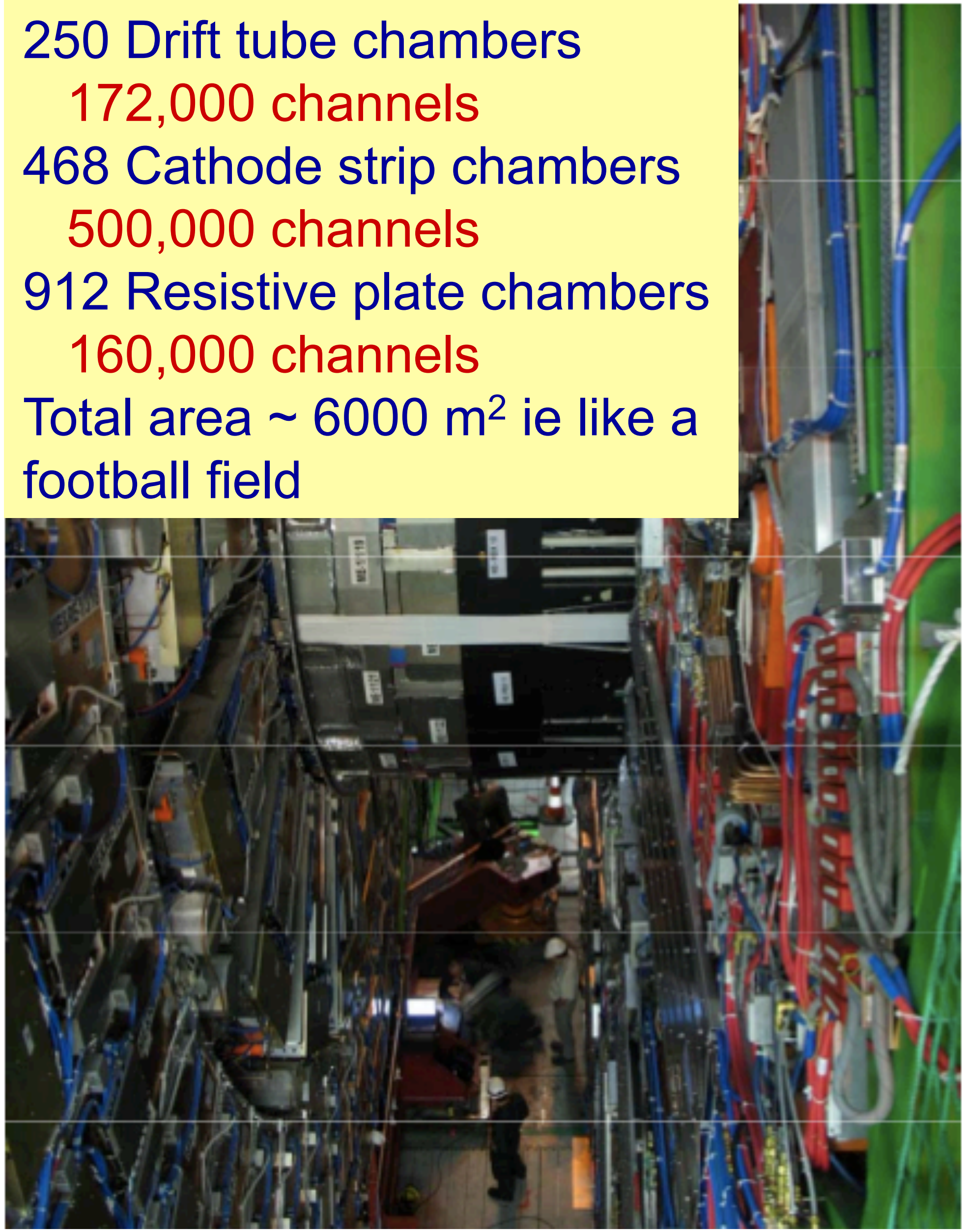
100 fb^{-1}

Excellent calorimetery needed ($PbWO_4$)

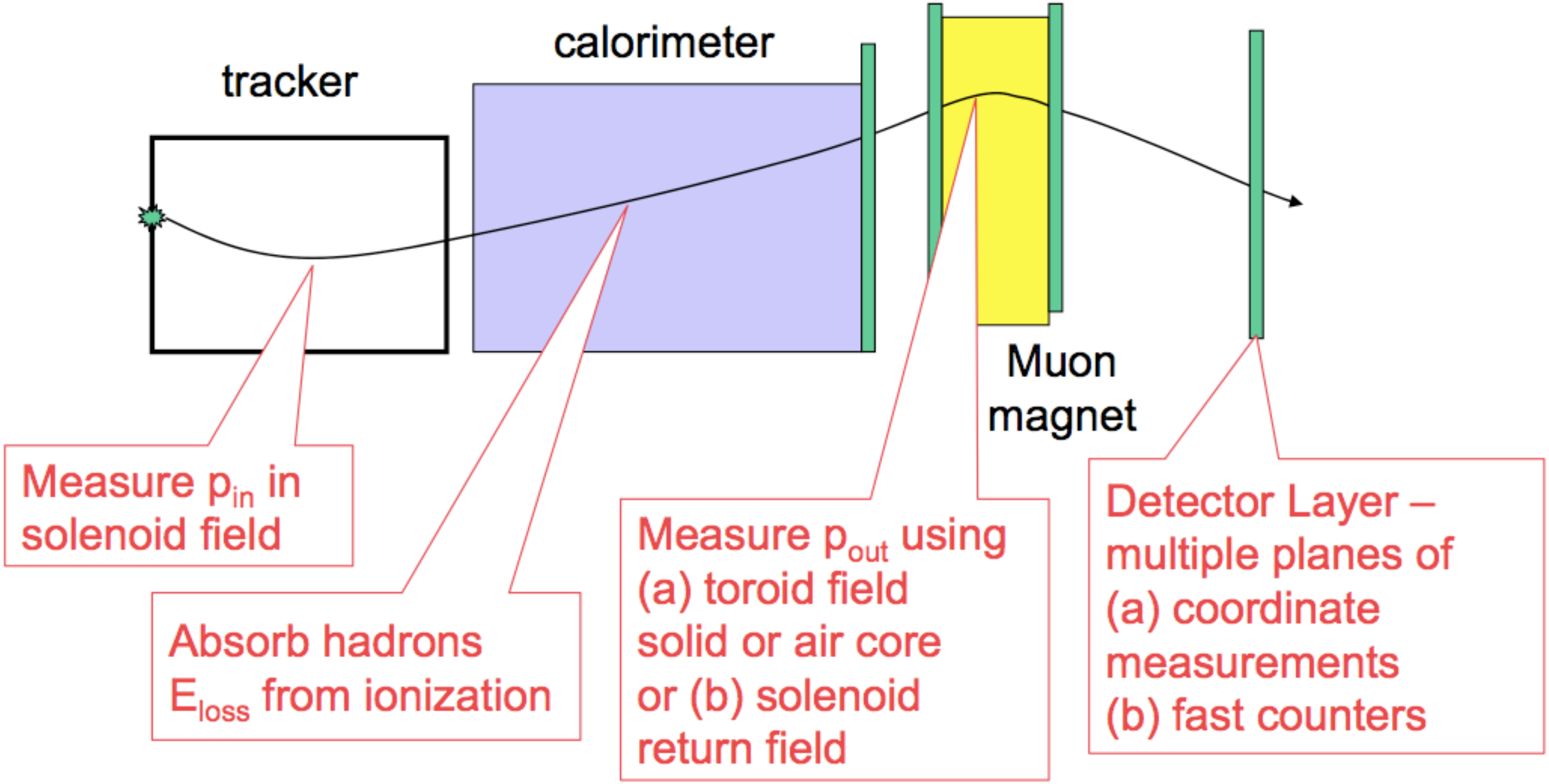
The CMS Detector: Muon Detectors



250 Drift tube chambers
  172,000 channels
468 Cathode strip chambers
  500,000 channels
912 Resistive plate chambers
  160,000 channels
Total area ~ 6000 m^2 ie like a football field

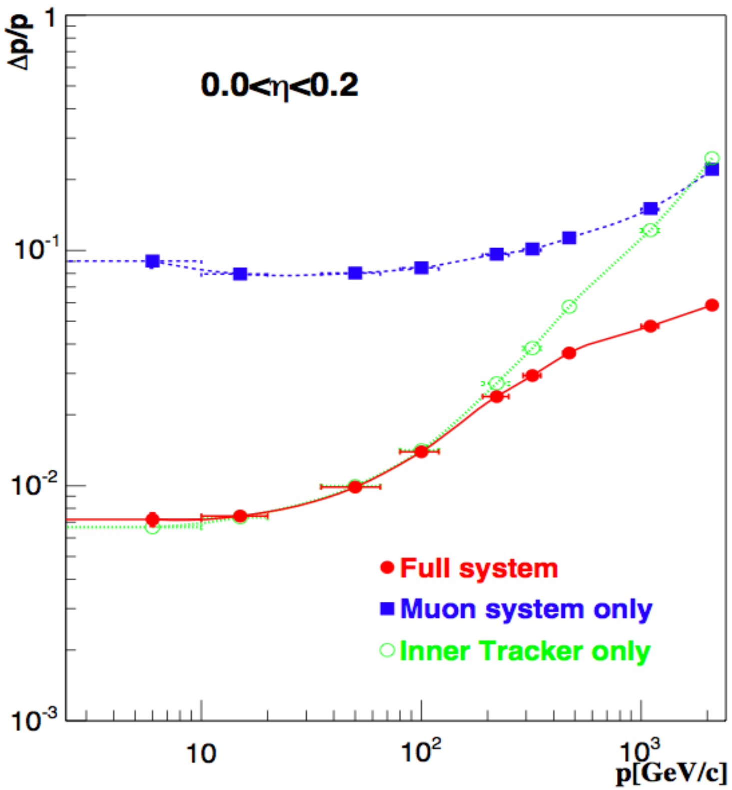


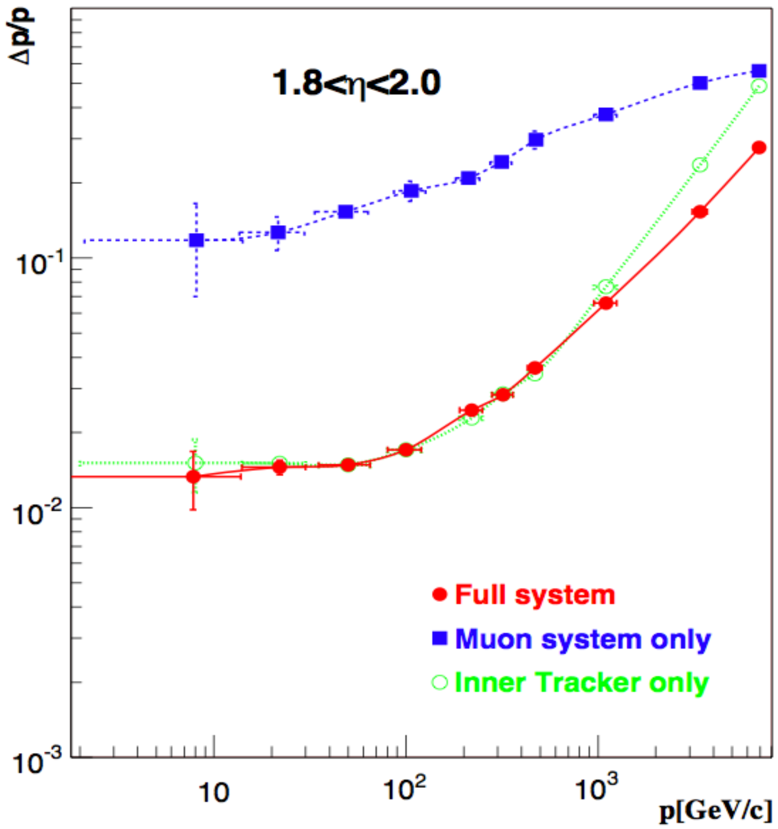
Elements of Muon Detection



Muon Reconstruction (Momentum Res.)

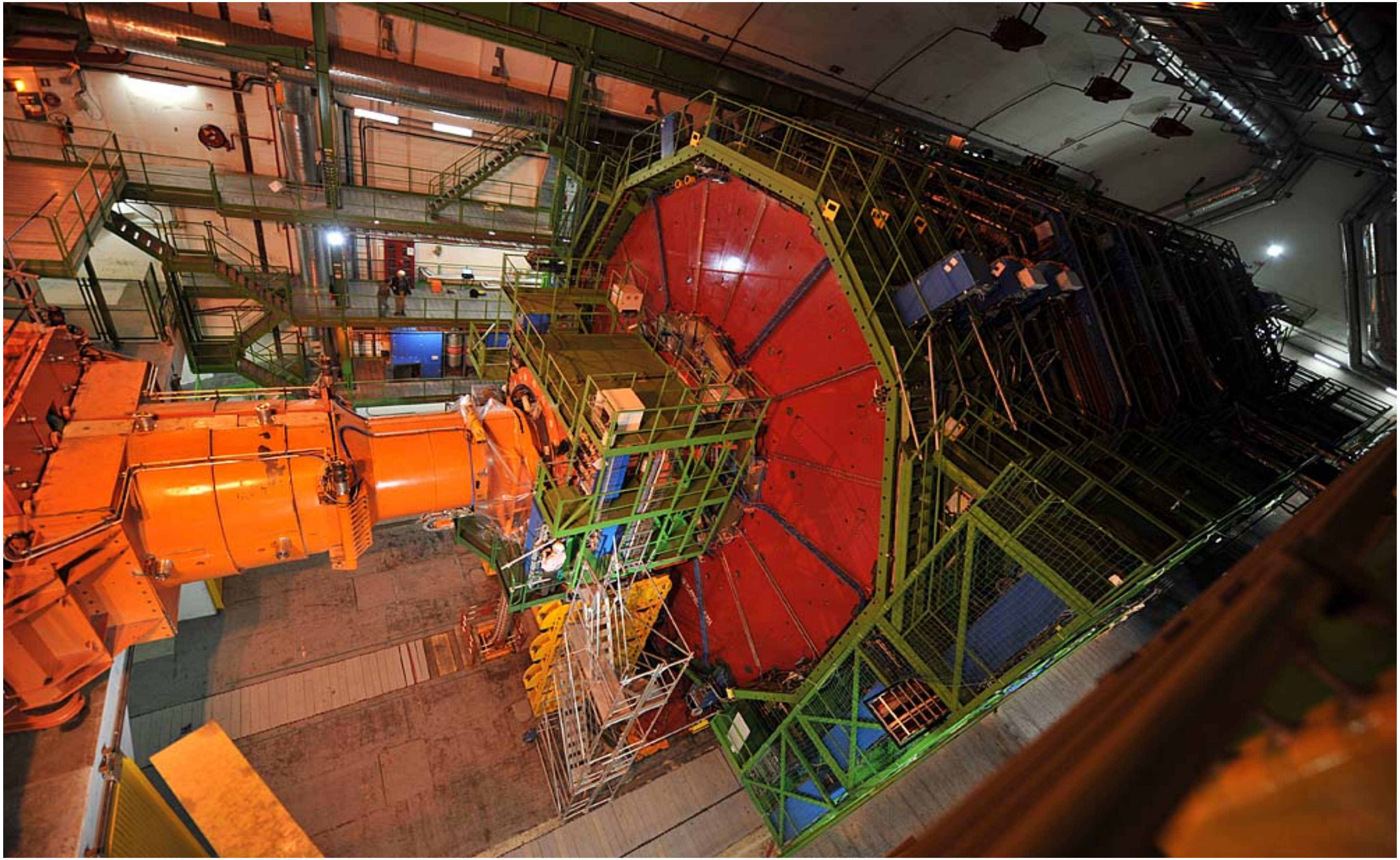
- Stand-alone Muon Reconstruction
  - Muon system only
- Global MuonReconstruction
  - Muon system + silicon tracker



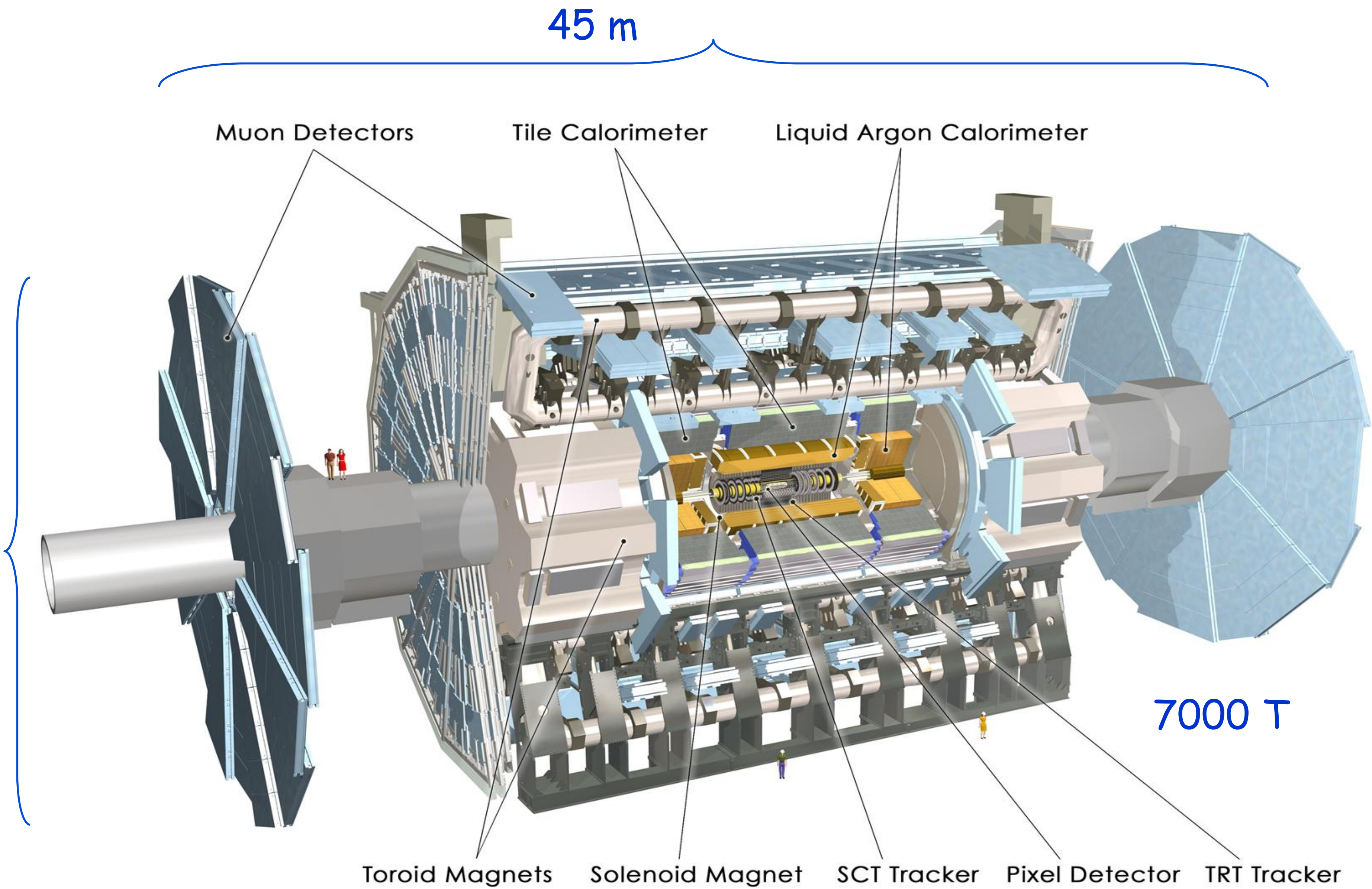



CMS before closure
HE- RBX 04
HE- RBX 03
HE- RBX 02
HE- RBX 01
ME-1/1/07
ME-1/1/06
ME-1/1/05
ME-1/1/04
ME-1/1/03
ME-1/1/02
ME-1/1/01
ME-1/1/36
ME-1/1/35
LIFTLUX

CMS Today: Closed and Ready for Collisions



ATLAS Detector



The ATLAS Collaboration …

… not just a complex detector, but also a very large community of physicists, engineers, students!

Aug 2010:

- ~ 3000 scientists, from
- 174 institutes, from
- 38 countries, from
- from all continents

The ATLAS Detector: An Overview

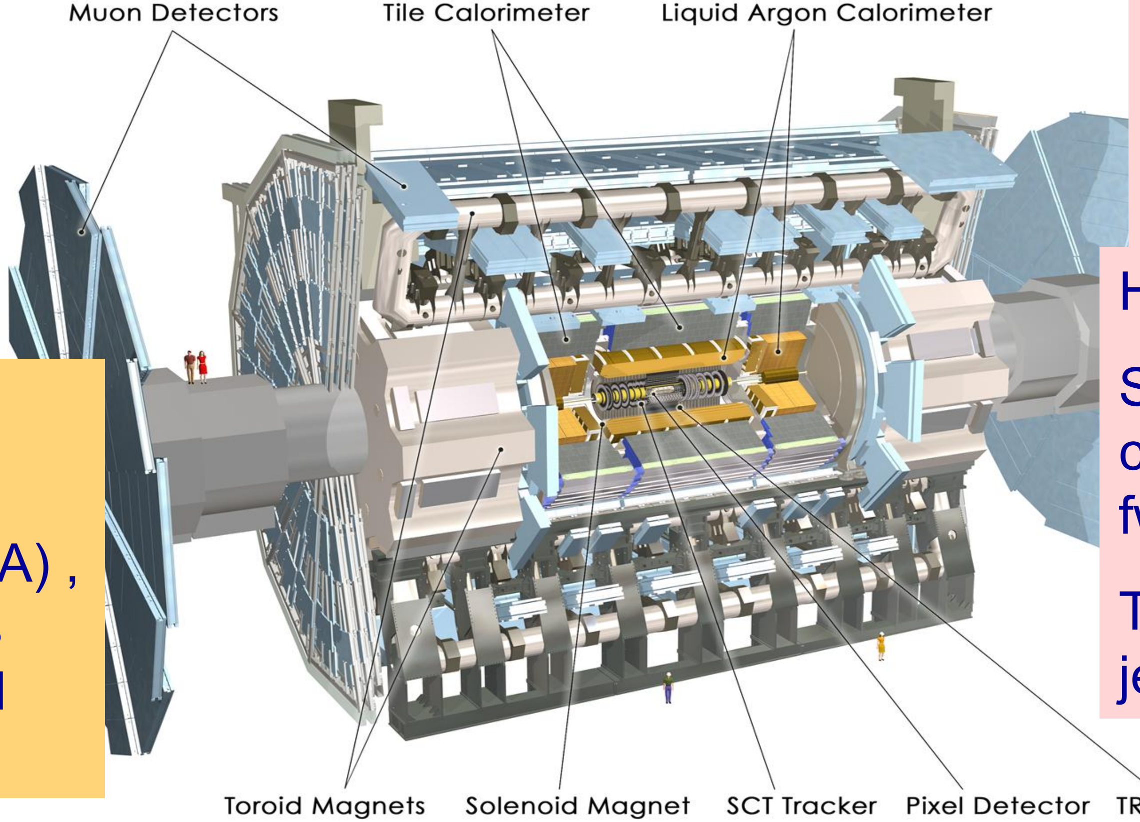
Standalone muon spectrometer (η < 2.7), 3 layers gas based muon chambers, muon trigger and muon momentum determination

EM calorimeter:

LAr/Pb according structure

e/γ trigger, identification + measurement

- 46m length,
- 25m diameter,
- 7000t weight



Hadronic calorimeter:

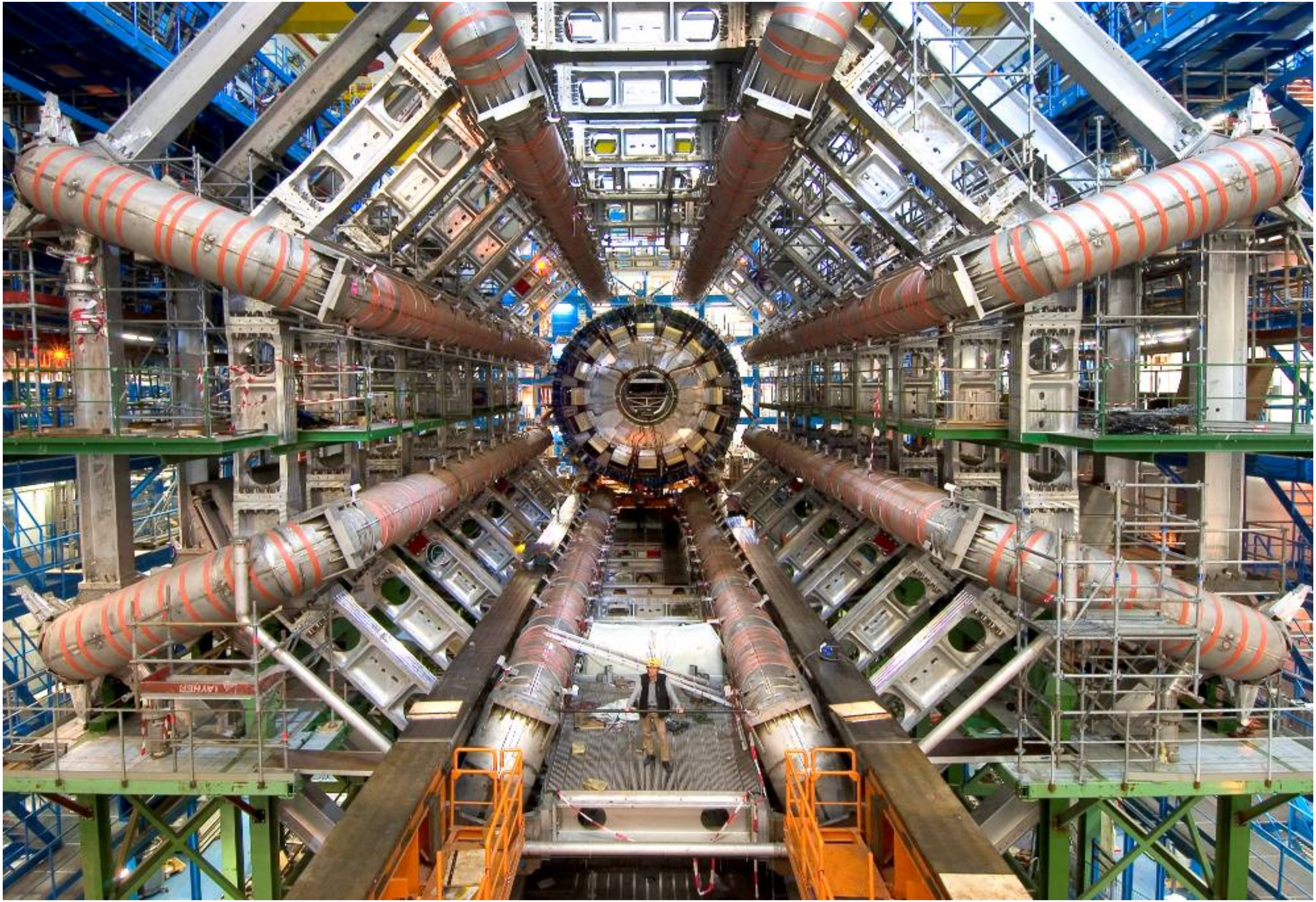
Scint./Fe tiles in the central, W(Cu)/LAr in fwd region

Trigger and measure jets + missing E_t

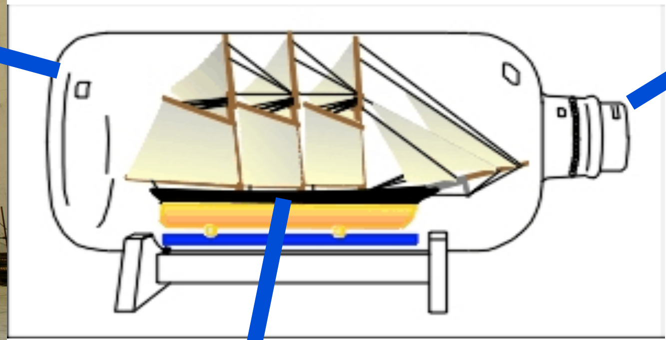
Super-conducting magnets:

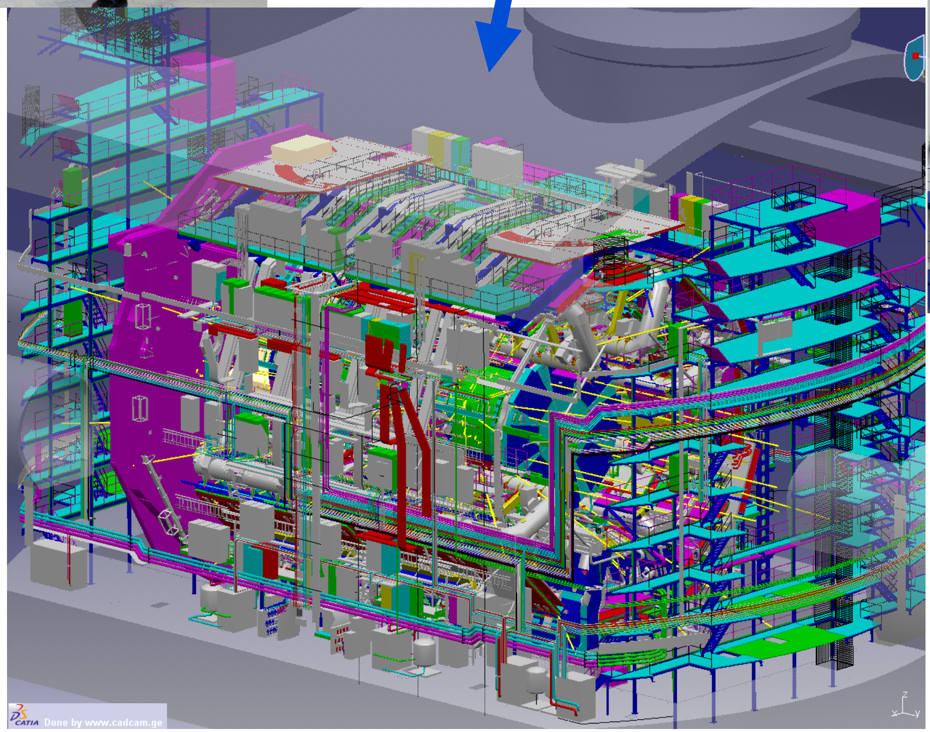
2T Solenoid (7.6kA) , 3 Air Core Toroids (22 kA, peak field strength up to 4T)

Inner Detector: ~10^8 Si Pixels, 6 · 10^6 Si Strips, Transition Radiation Tracker (TRT) – Xe-filled straw tubes interleafed with PP/PE foil for Cherenkov light: precise vertexing, tracking, e/π separation



ATLAS Installation





JUNE 2003

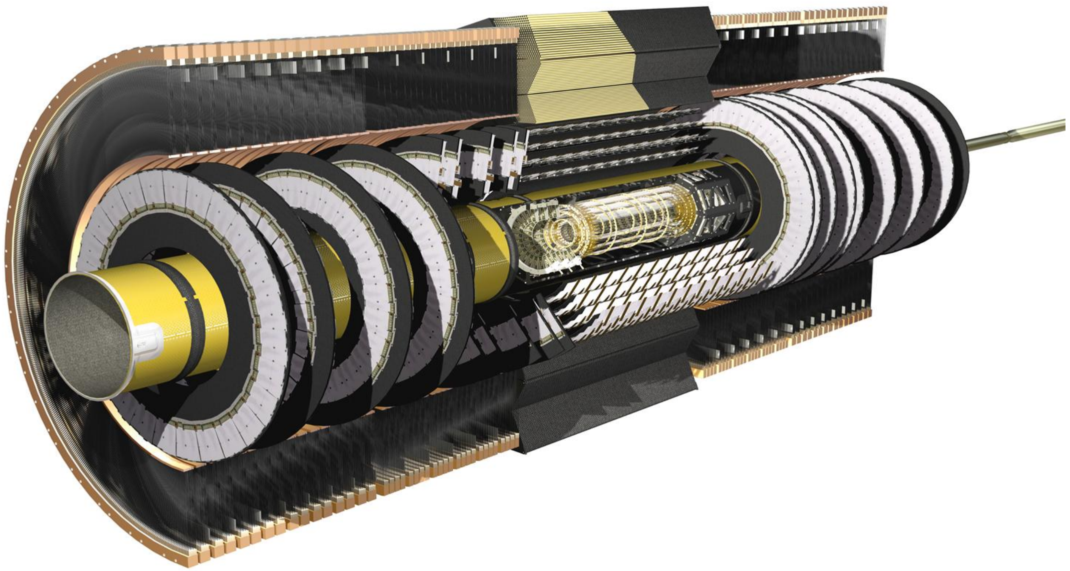
Cavern

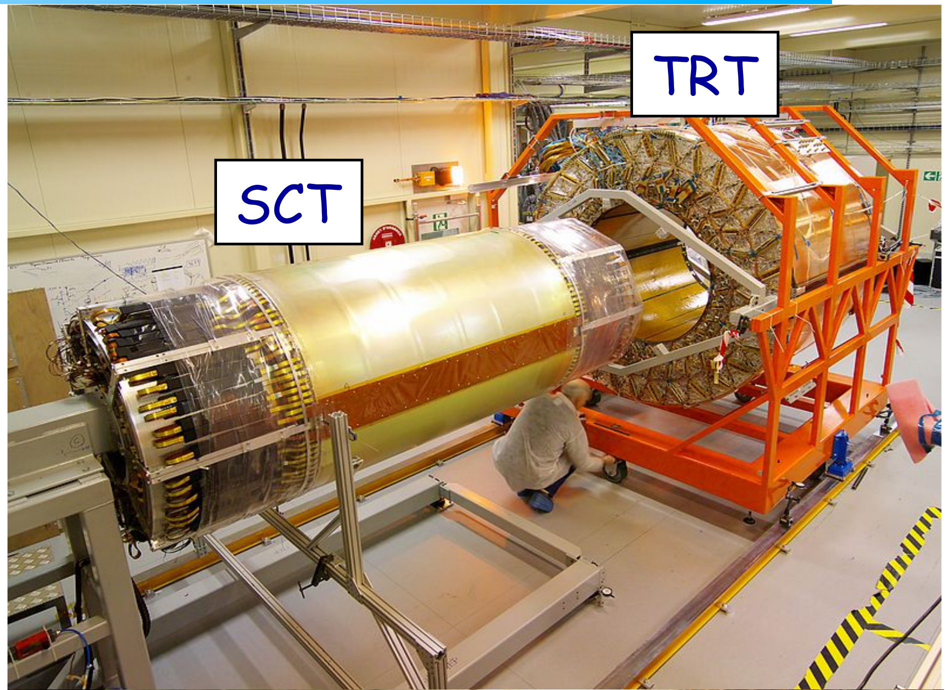
92m underground

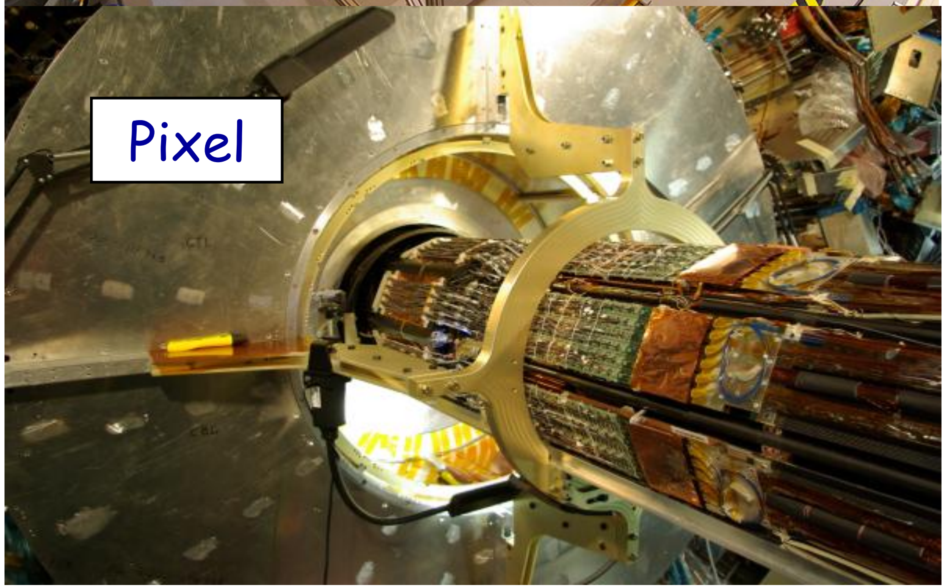
55m long
32m wide
35m high

Inner Detector

Tracking $|\eta|<2.5$ B=2T





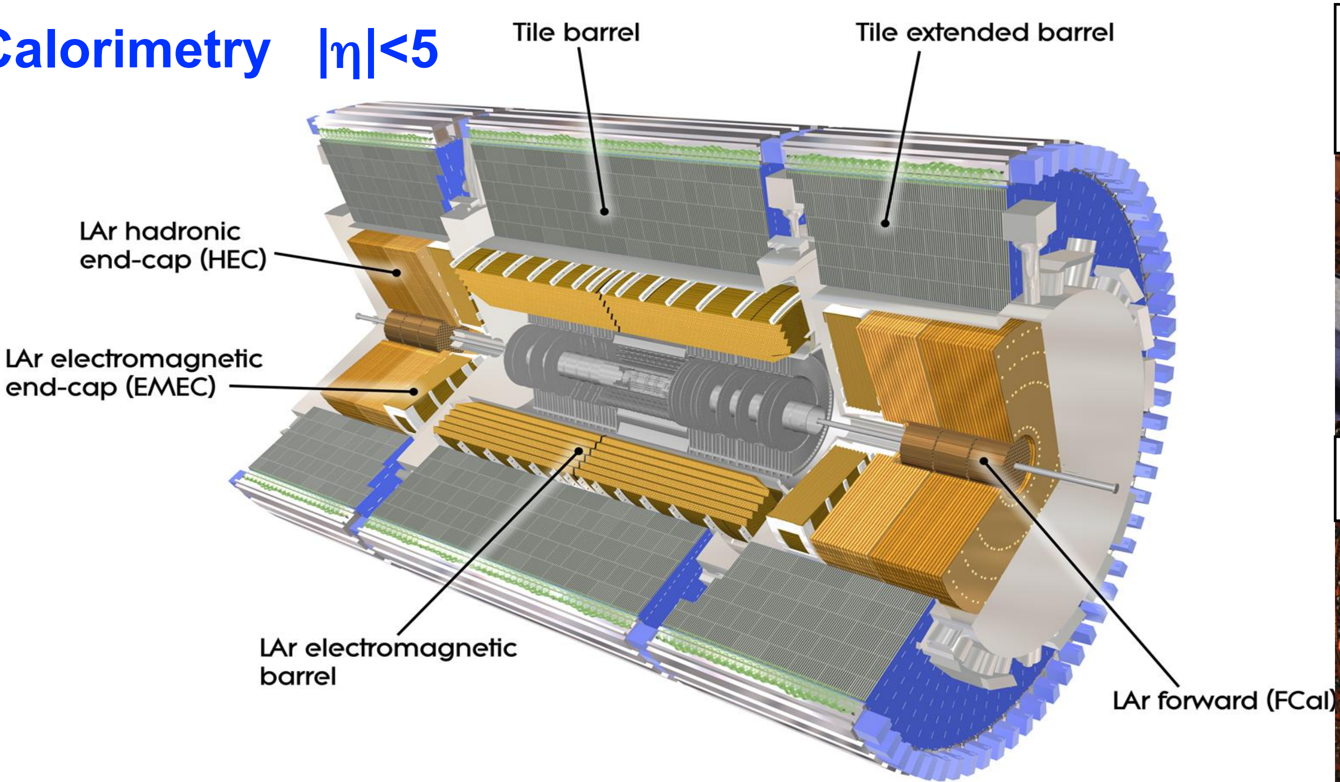


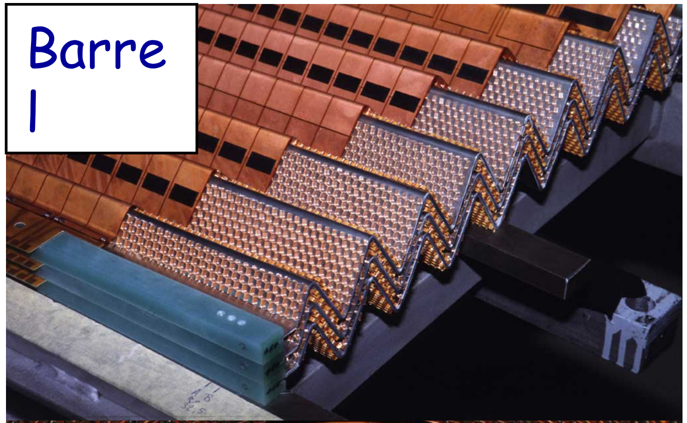
Silicon pixels (**Pixel**): 0.8 10^8 channels
Silicon strips (**SCT**) : 6 10^6 channels
Transition Radiation Tracker (**TRT**) :
straw tubes (Xe), 4 10^5 channels
e/π separation

$$\sigma/p_T \sim 5\times10^{-4}\, p_T \oplus 0.01$$

Calorimetry

Calorimetry $|\eta|<5$

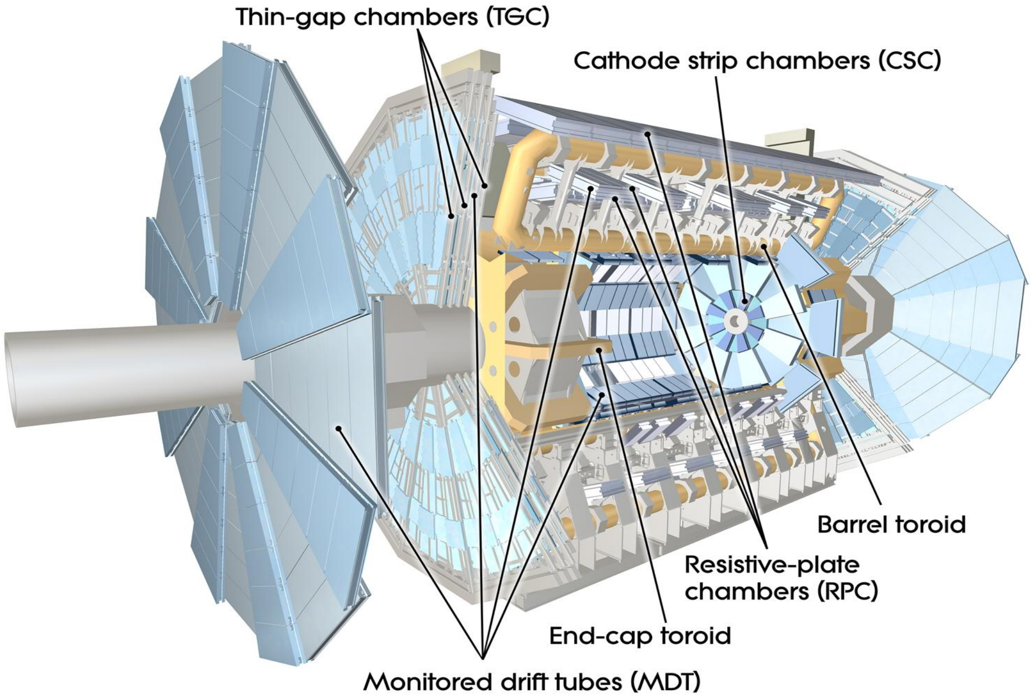




Electromagnetic Calorimeter barrel,endcap: Pb-LAr
~10%/√E energy resolution e/γ
180000 channels: longitudinal segmentation
Hadron Calorimeter
barrel Iron-Tile EC/Fwd Cu/W-LAr (~20000 channels)
$\sigma/E \sim 50\%/\sqrt{E} \oplus 0.03$ pion (10 λ)

Trigger for **e/γ** , **jets, Missing E_T**

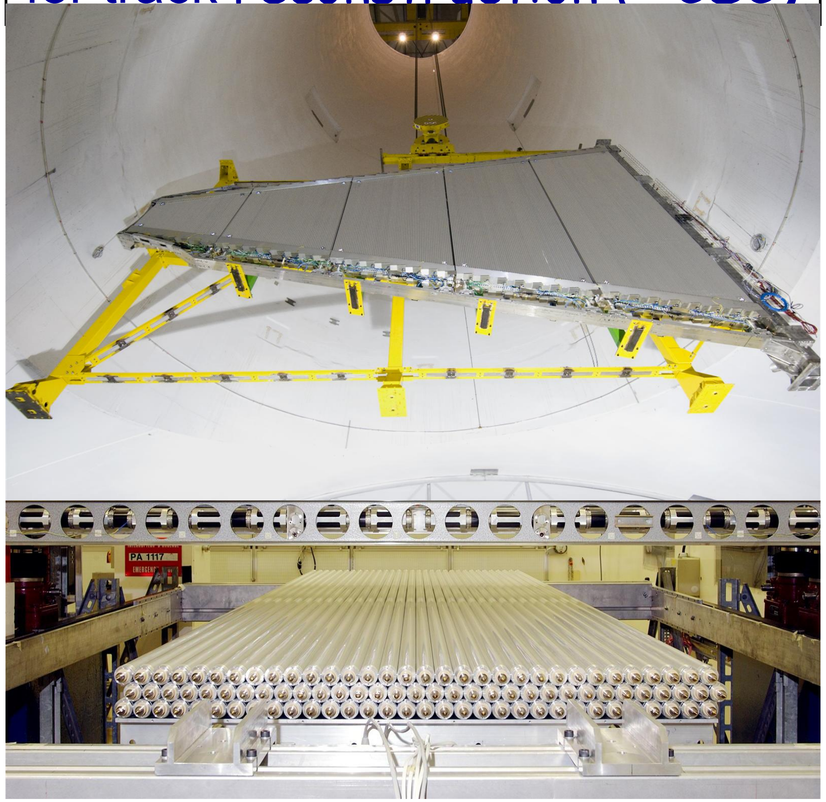
Muon System

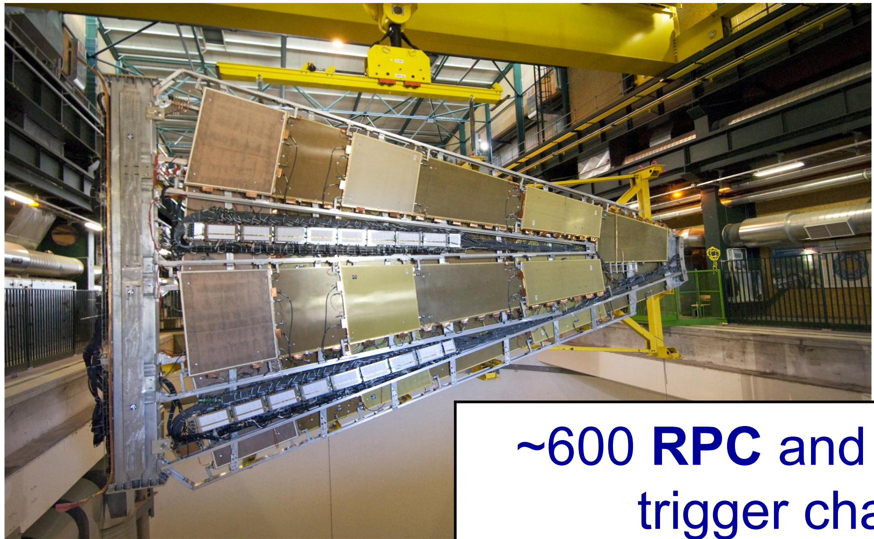


Stand-alone momentum resolution
$\Delta pt/pt < 10\%$ up to 1 TeV

2-6 Tm $|\eta|<1.3$ 4-8 Tm $1.6<|\eta|<2.7$

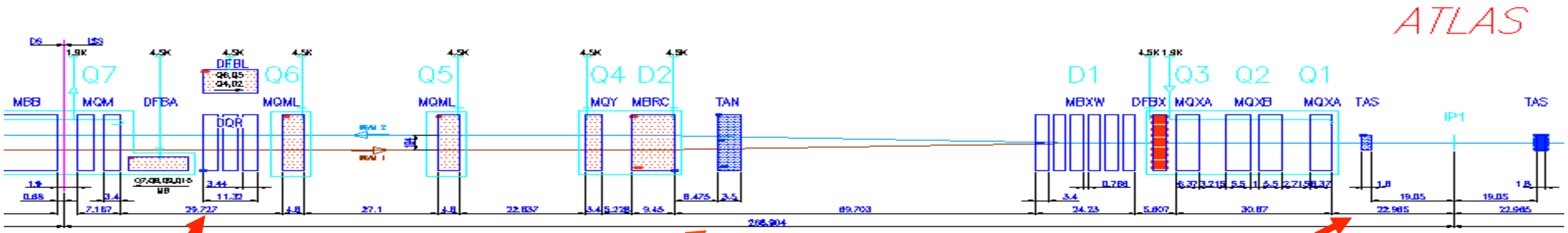
~1200 **MDT** precision chambers for track reconstruction (+ **CSC**)





~600 **RPC** and ~3600 **TGC** trigger chambers

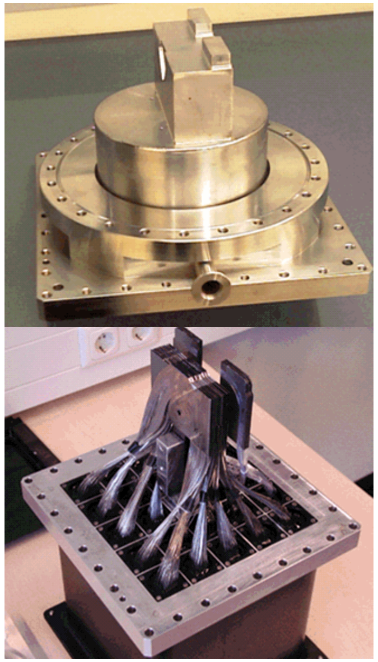
Forward Detectors

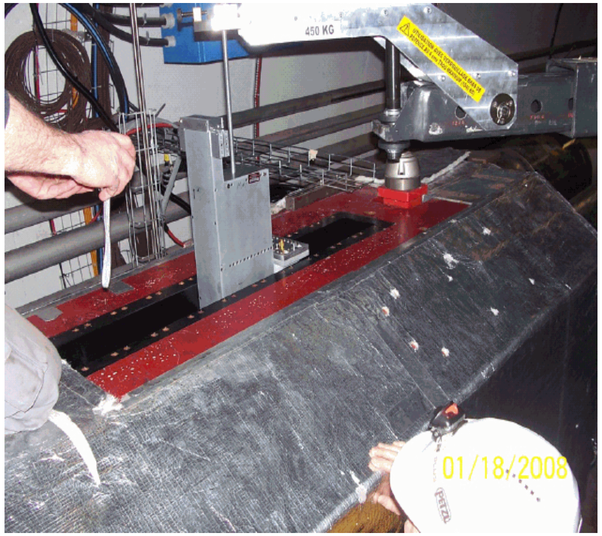


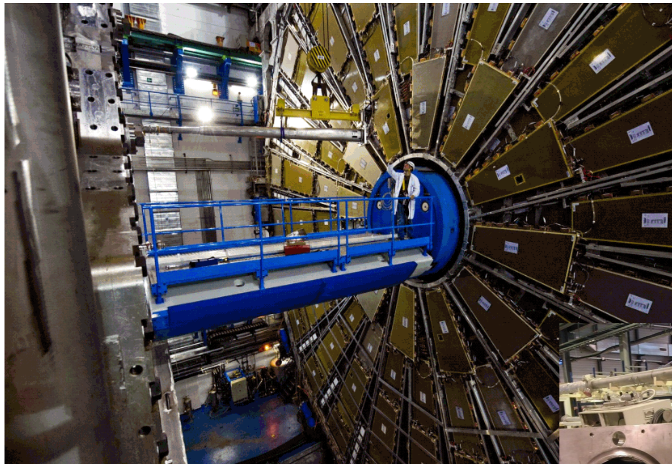
ALFA at 240 m

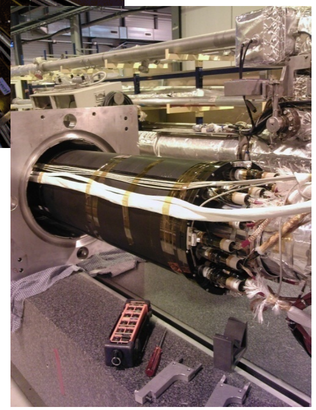
ZDC at 140 m

LUCID at 17









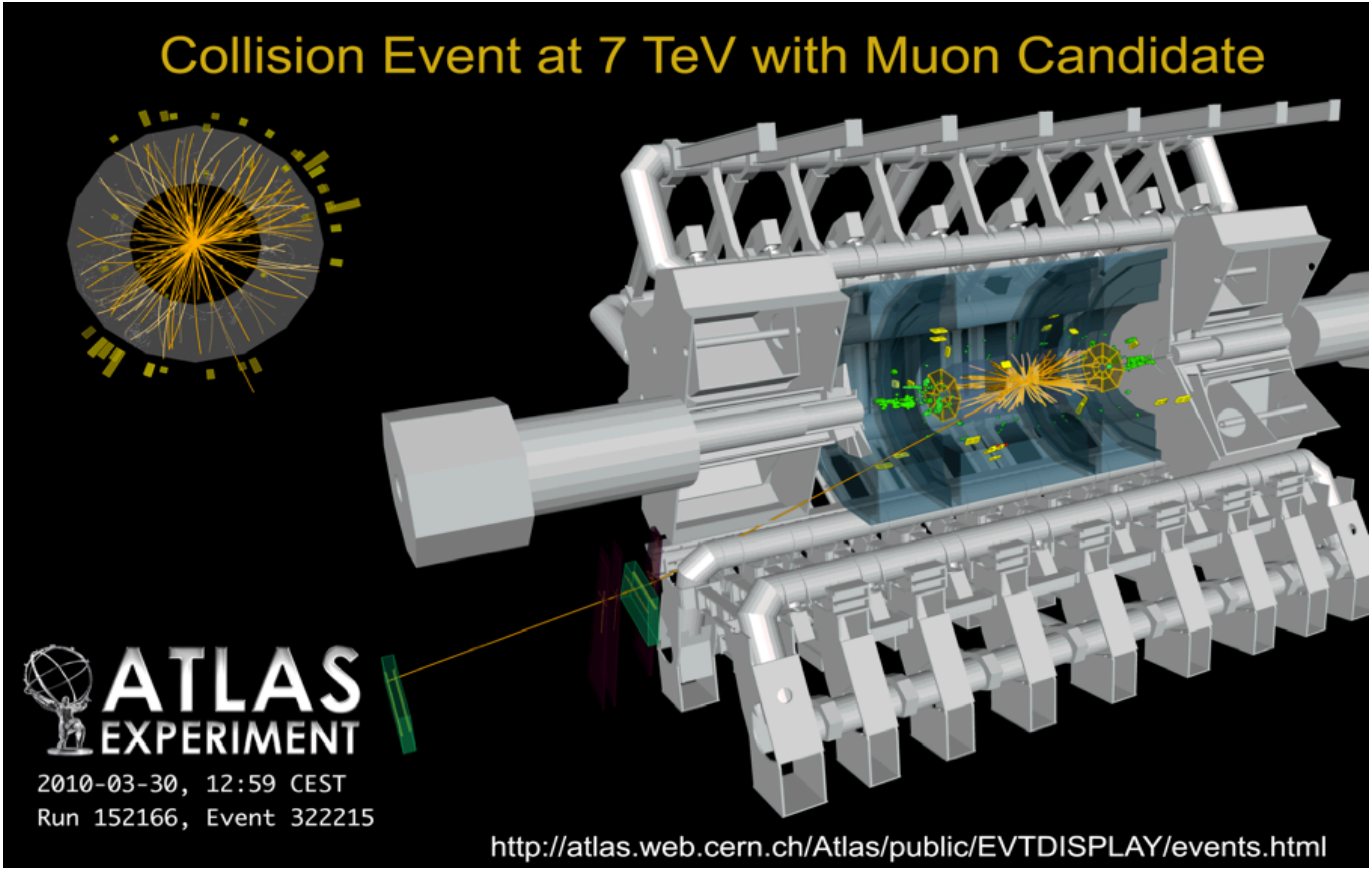
Luminosity Cerenkov Integrating Detector

Zero Degree Calorimeter

Absolute Luminosity for ATLAS

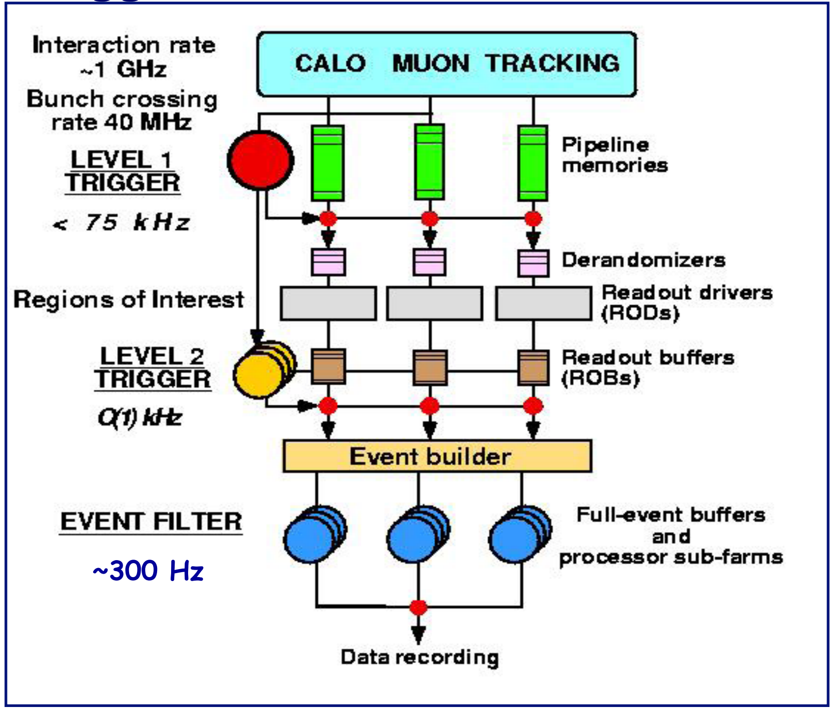
An Historical Moment

Closure of the LHC beam pipe ring on 16th June 2008 (the last piece was the one shown here in ATLAS)


Collision Event at 7 TeV with Muon Candidate
ATLAS
EXPERIMENT
2010-03-30, 12:59 CEST
Run 152166, Event 322215
http://atlas.web.cern.ch/Atlas/public/EVTDISPLAY/events.html

ATLAS Trigger …

Trigger and Data Flow Architecture



Overall recording rate: ~ 300 Hz

Level-1:

- Implemented in hardware,
- Muon + Calo based, coarse granularity
- e, μ, π, τ, jet candidate selection

Level-2:

- Implemented in software
- Seeded by level-1 ROIs, full granularity
- Inner Detector – Calo track matching

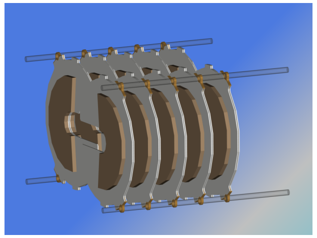
Event Filter:

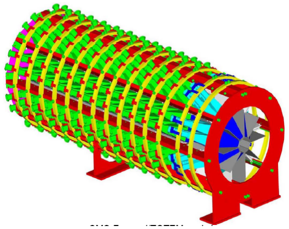
- Implemented in software
- Offline-like algorithms for physics signatures
- Refine LV2 decision
- Full event building

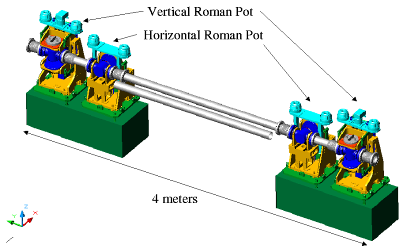
High Level Trigger = **HLT**

(New:) Forward detectors in ATLAS/CMS

TOTEM -T2 CASTOR ZDC/FwdCal TOTEM-RP FP420



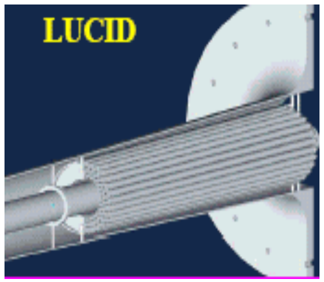


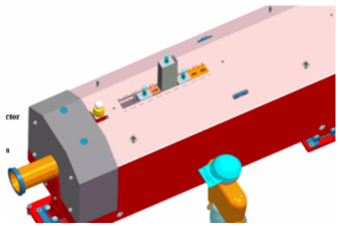


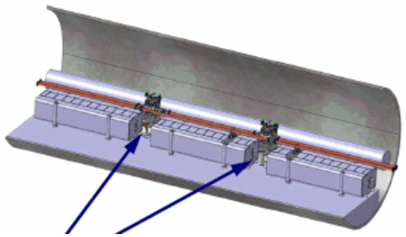
I P 5

14 m 16 m 140 m 147m - 220 m 420 m

I P 1



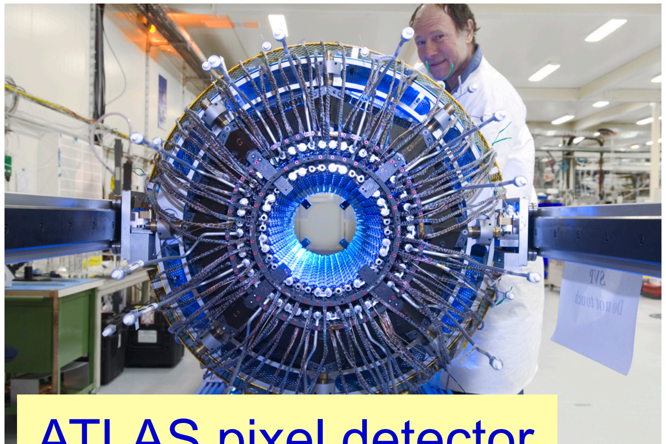




LUCID ZDC ALFA/RP220 FP420

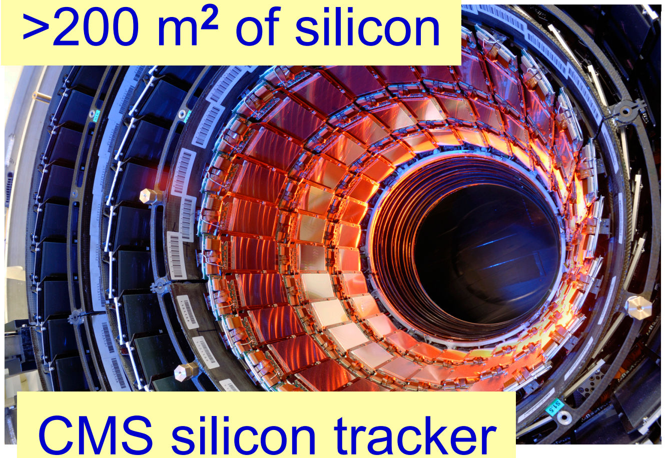
The LHC Detectors are Major Challenges

- CMS/ATLAS detectors have about 100 million read-out channels
- Collisions in the detectors happen every 25 nanoseconds
- ATLAS uses over 3000 km of cables in the experiment
- The data volume recorded at the front-end in CMS is 1 TB/second which is equivalent to the world wide communication network traffic
- Data recorded during the 10-20 years of LHC life will be about all the words spoken by mankind since its appearance on earth
- A worry for the detectors: the kinetic energy of the beam is that of a small aircraft carrier of 10^4 tons going 20 miles/ hour



ATLAS pixel detector

>200 m^2 of silicon

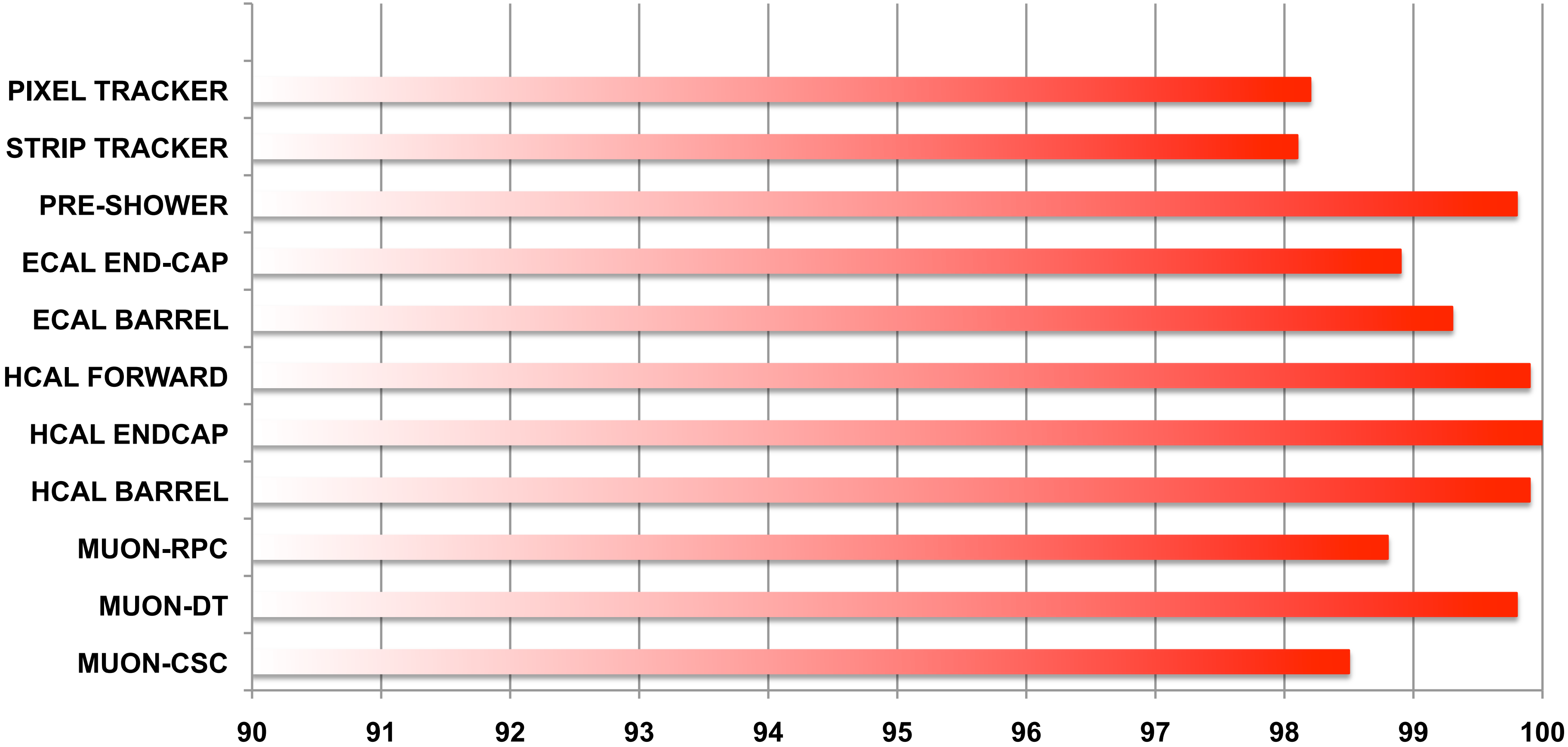


CMS silicon tracker

Object	Weight (tons)
Boeing 747 [fully loaded]	200
Endeavor space shuttle	368
ATLAS	7,000
Eiffel Tower	7,300
USS John McCain	8,300
CMS	12,500

ATLAS and CMS Operation at Startup

CMS Sub-detectors Status

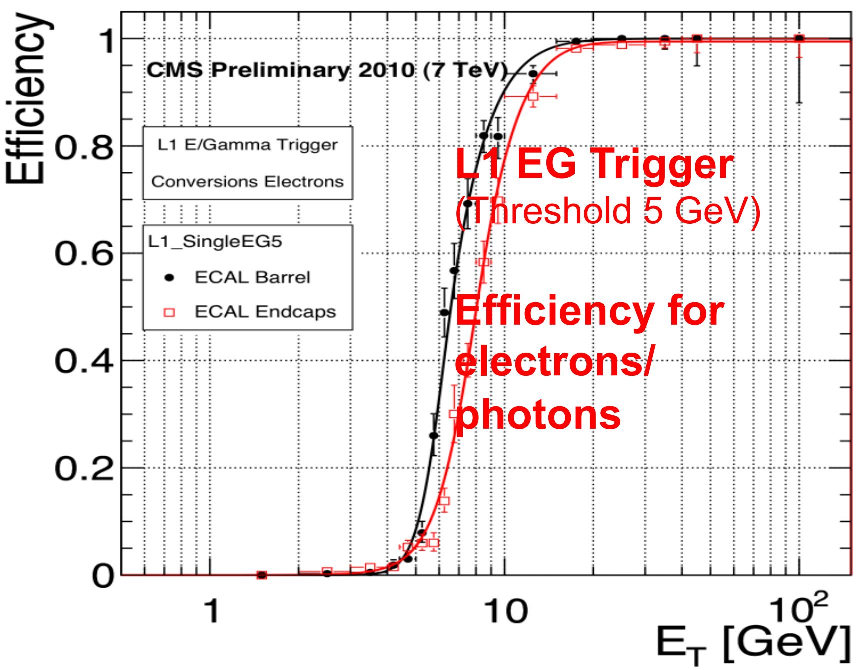


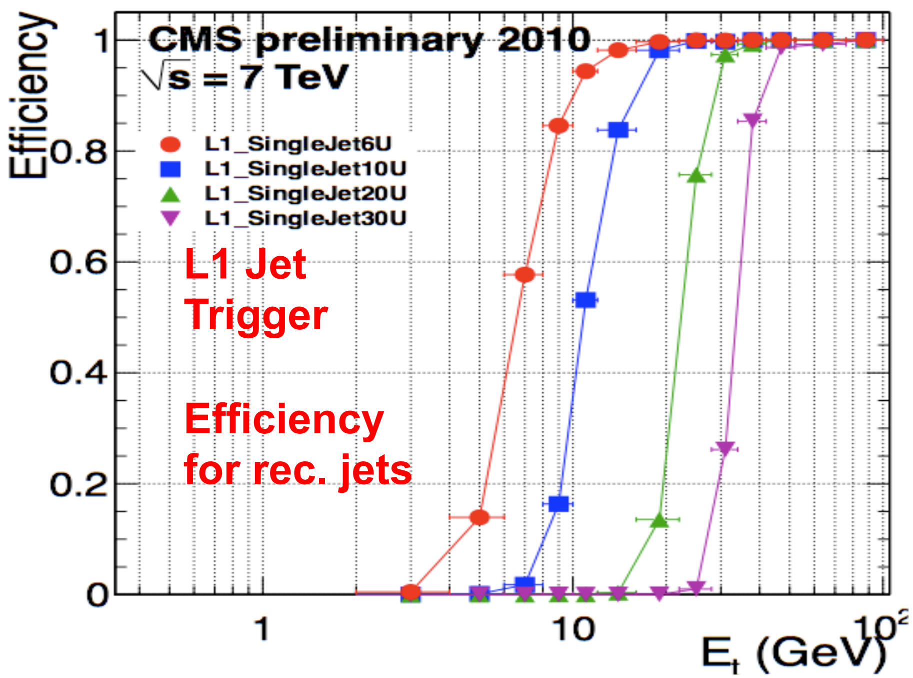
	MUON-CSC	MUON-DT	MUON-RPC	HCAL BARREL	HCAL ENDCAP	HCAL FORWARD	ECAL BARREL	ECAL END-CAP	PRE-SHOWER	STRIP TRACKER	PIXEL TRACKER	
Séries1	98.5	99.8	98.8	99.9	100	99.9	99.3	98.9	99.8	98.1	98.2	

Alignment/calibration status, dead/masked channels mirrored in MC

Trigger/DAQ

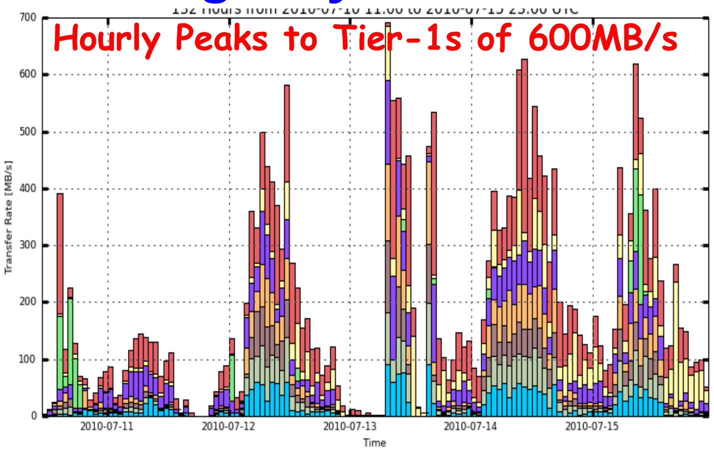
- **L1/DAQ**
  - **L1 ~ 45kHz; Event size at DAQ 500 kB/evt (**after compression in High Level Trigger **~250kB); 200-400Hz of data to storage.**
  - Timing has precision of 1 ns or better
- **All L1 triggers have high efficiency and sharp turn-on curves**

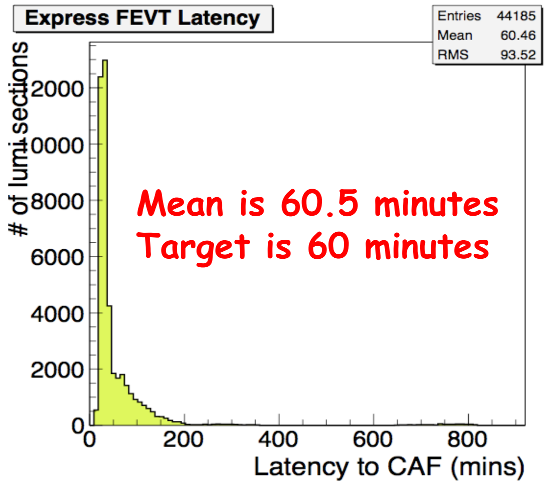


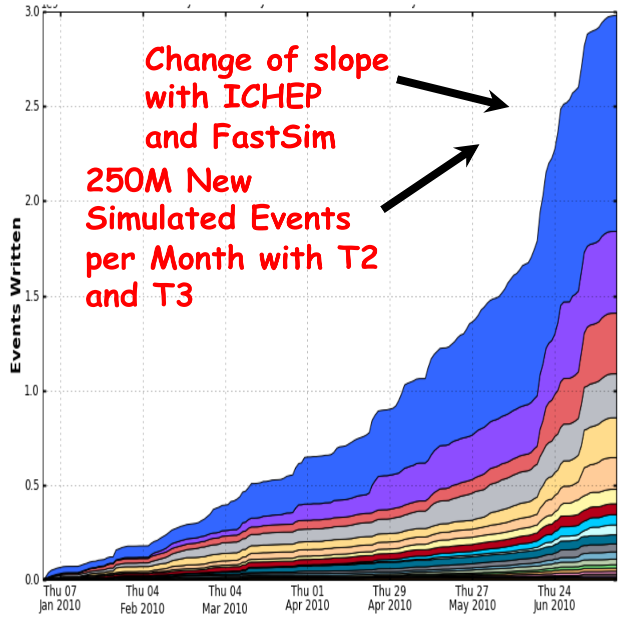


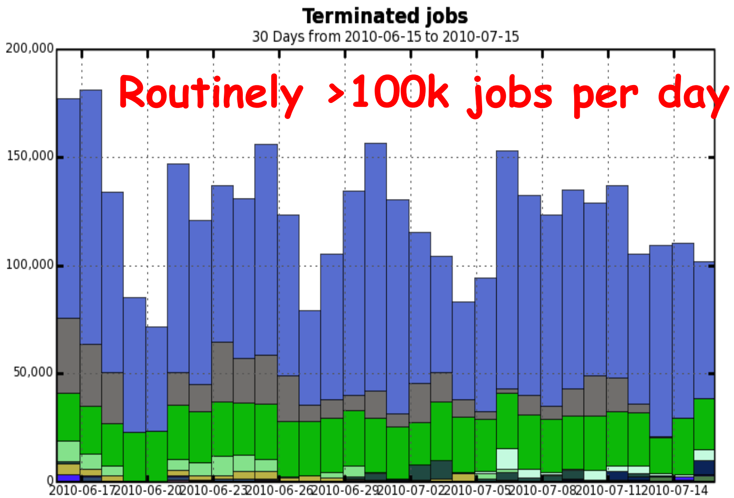
Data Processing, Transfer and Analysis

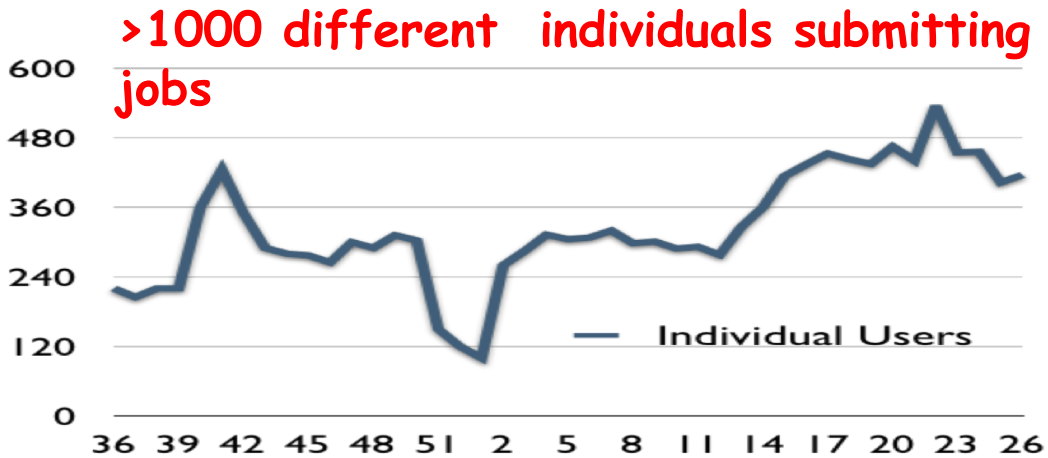
Excellent experience so far: the whole offline and Computing organization + GRID infrastructure Performing very well.



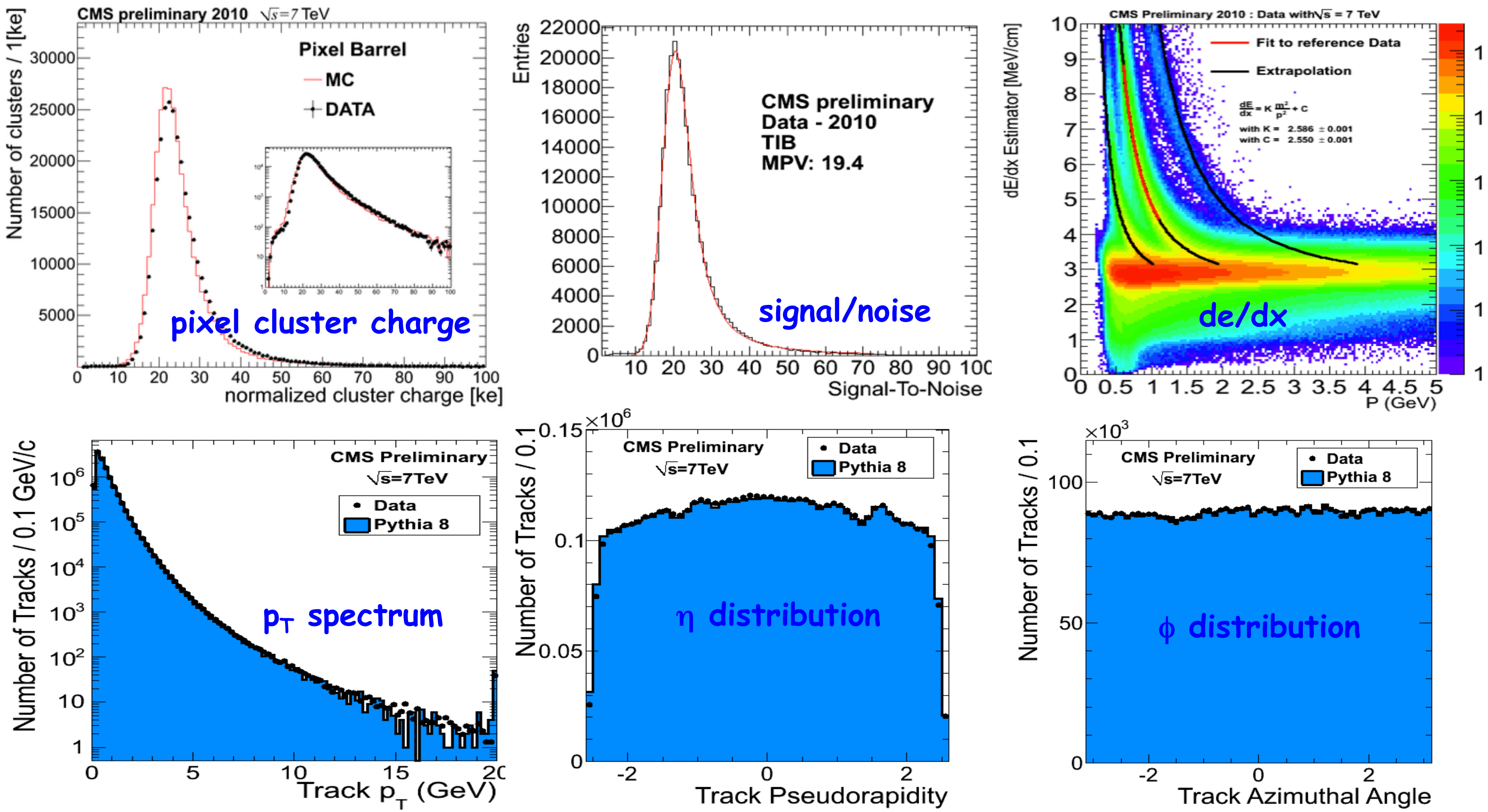






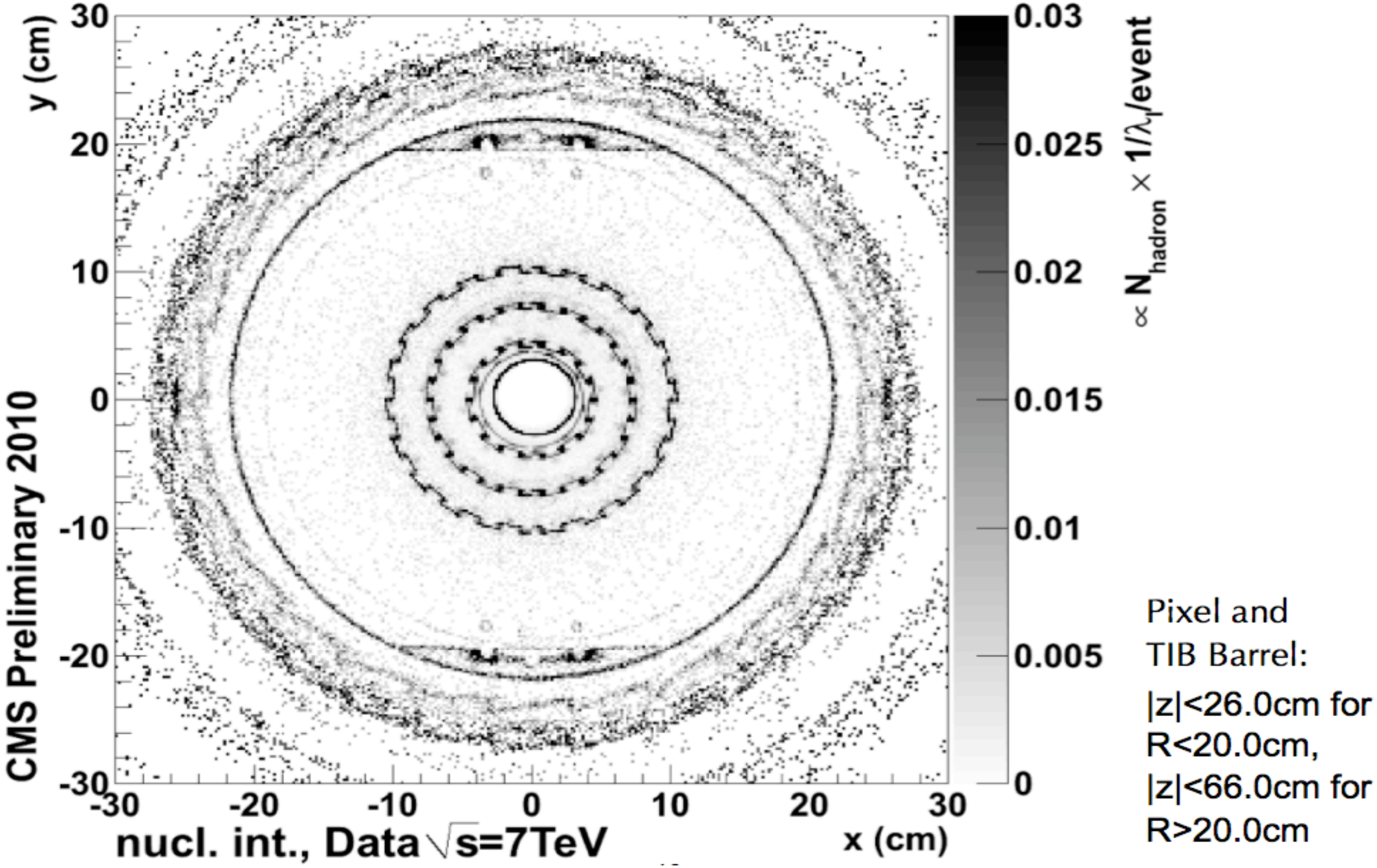


Tracker Performance



Tracker Tomography

Material studies with conversions and nuclear interactions



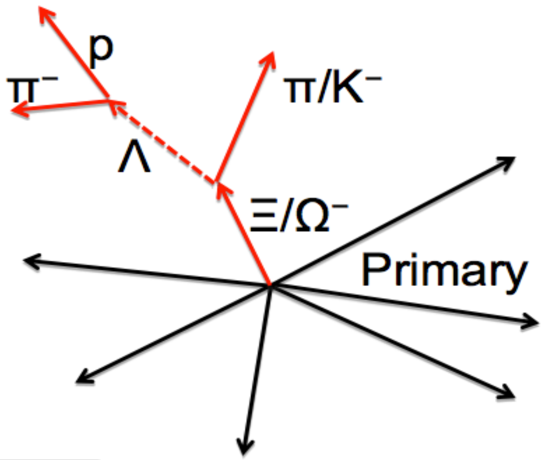
Understanding of the material distribution is important !!

Resonances

$\Omega^{\pm} \longrightarrow \Lambda K^{\pm}$

ΛK^- or anti-ΛK^+ Invariant mass

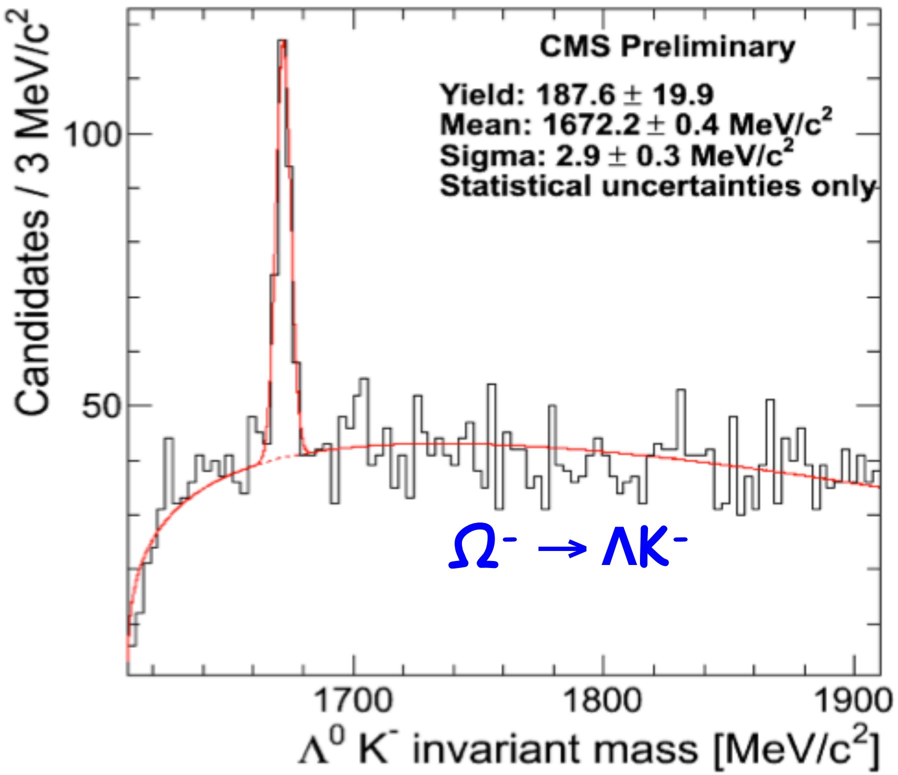
- combinations fit to a common vertex

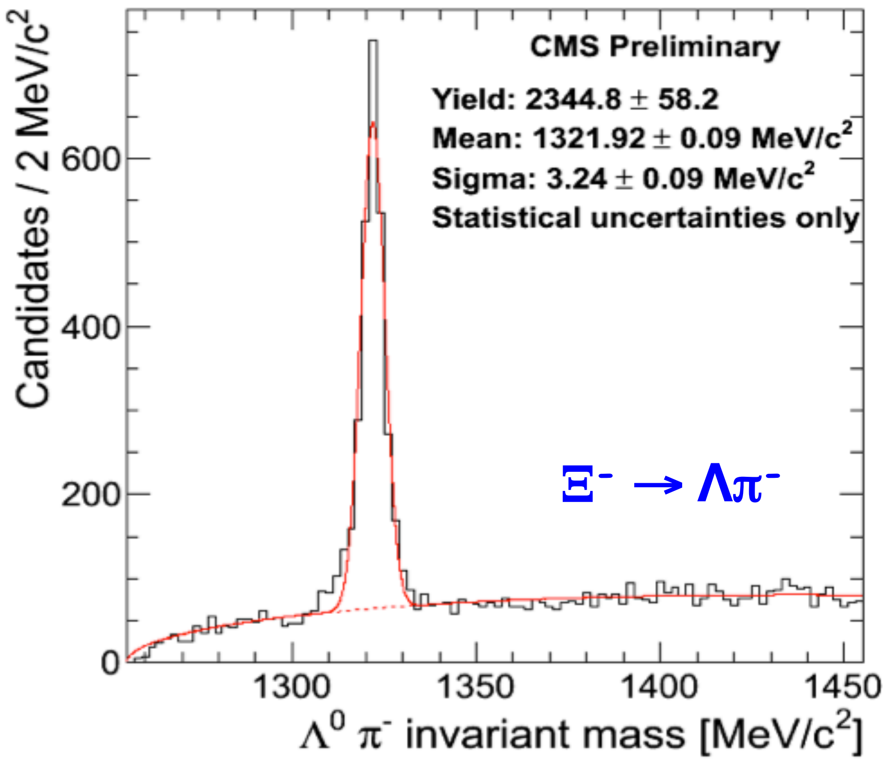


$\Xi^{\pm} \longrightarrow \Lambda\pi^{\pm}$

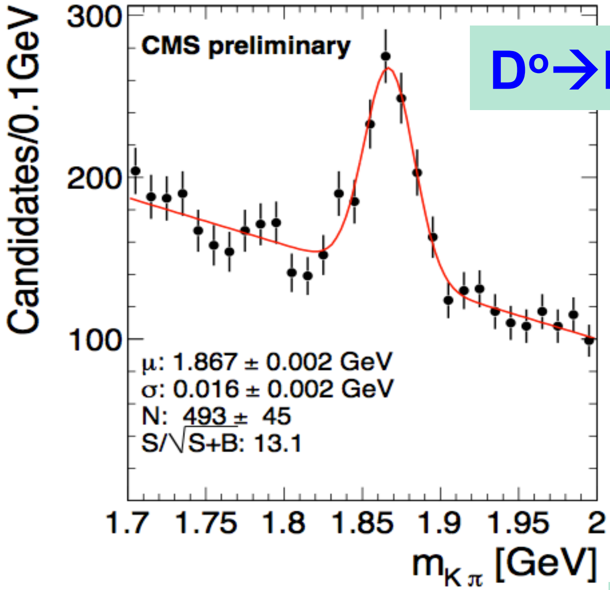
$\Lambda\pi$ Invariant mass

- tracks displaced from primary vertex ($d_{3D} > 3\sigma$)
- Common displaced vertex ($L_{3D} > 10\sigma$)

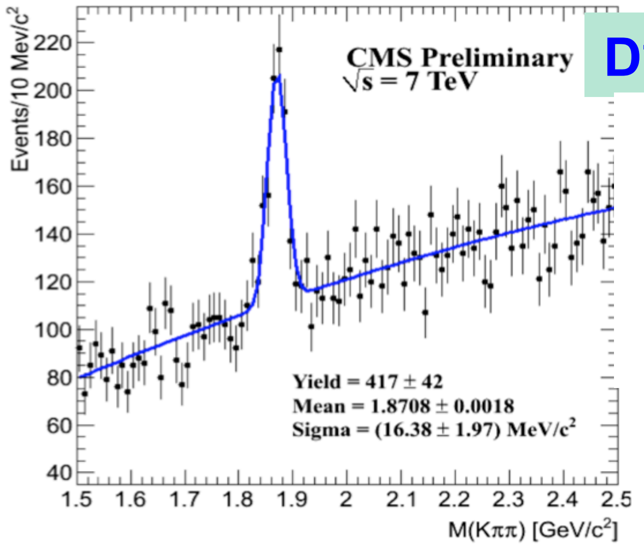




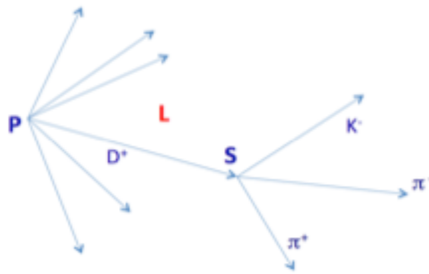
Charm Production



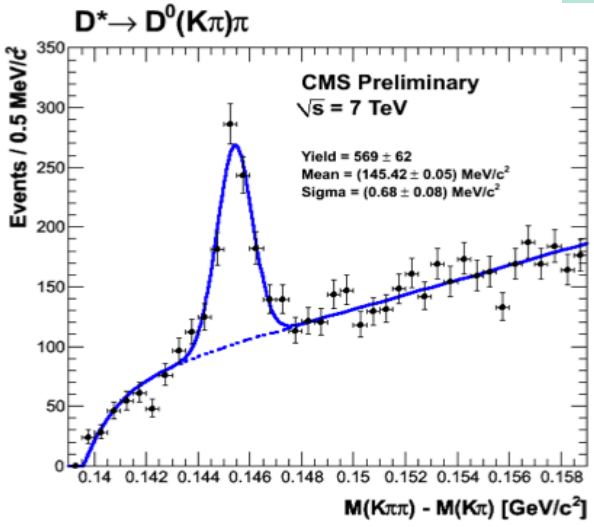
$D^o \rightarrow K^- \pi^+$

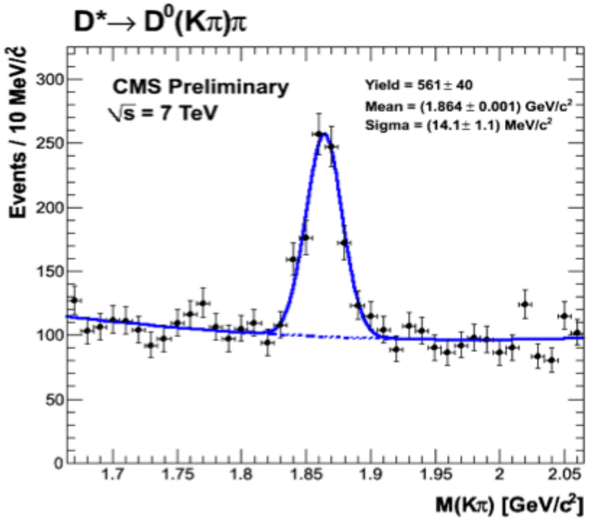


$D^+ \rightarrow K^- \pi^+ \pi^+$



$D^{*+} \rightarrow D^o(K^- \pi^+)\pi^+$

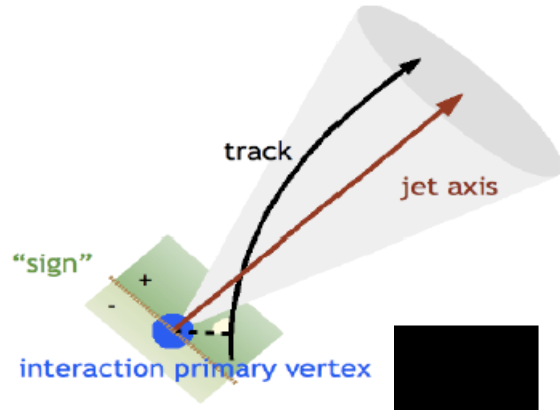




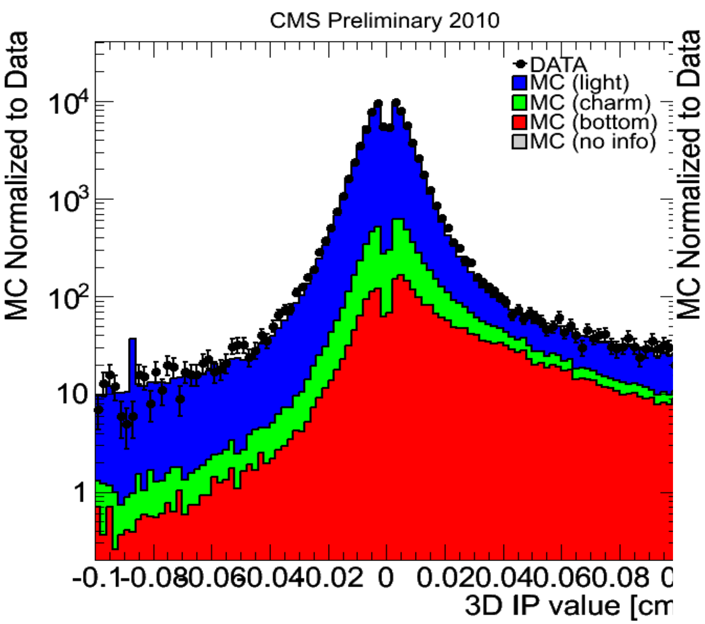
A sign for a well functioning detector…

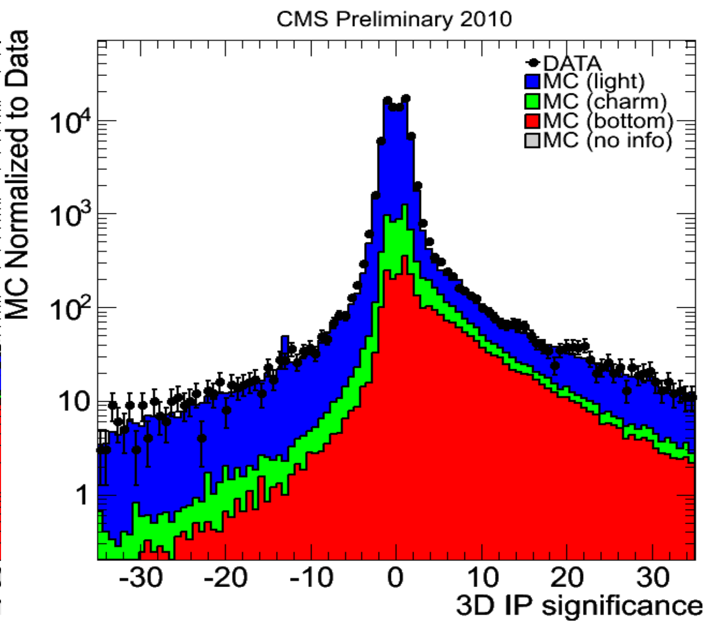
B-Tagging

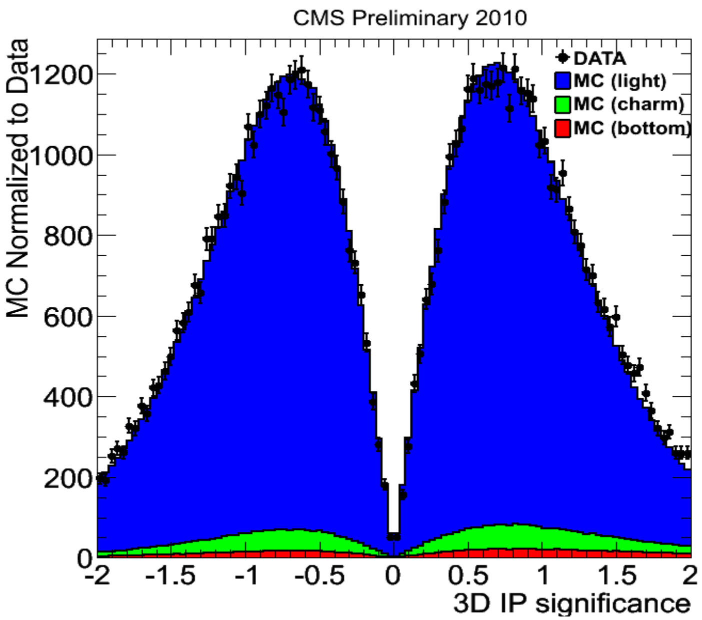
3D impact parameter value and significance (+zoom into ±2 region) for all tracks with Pt>1GeV belonging to jets with p_T > 40 GeV and $|\eta|$ < 1.5 (PFlow Jets anti-k_T R=0.5).



Excellent alignment and general tracking performance

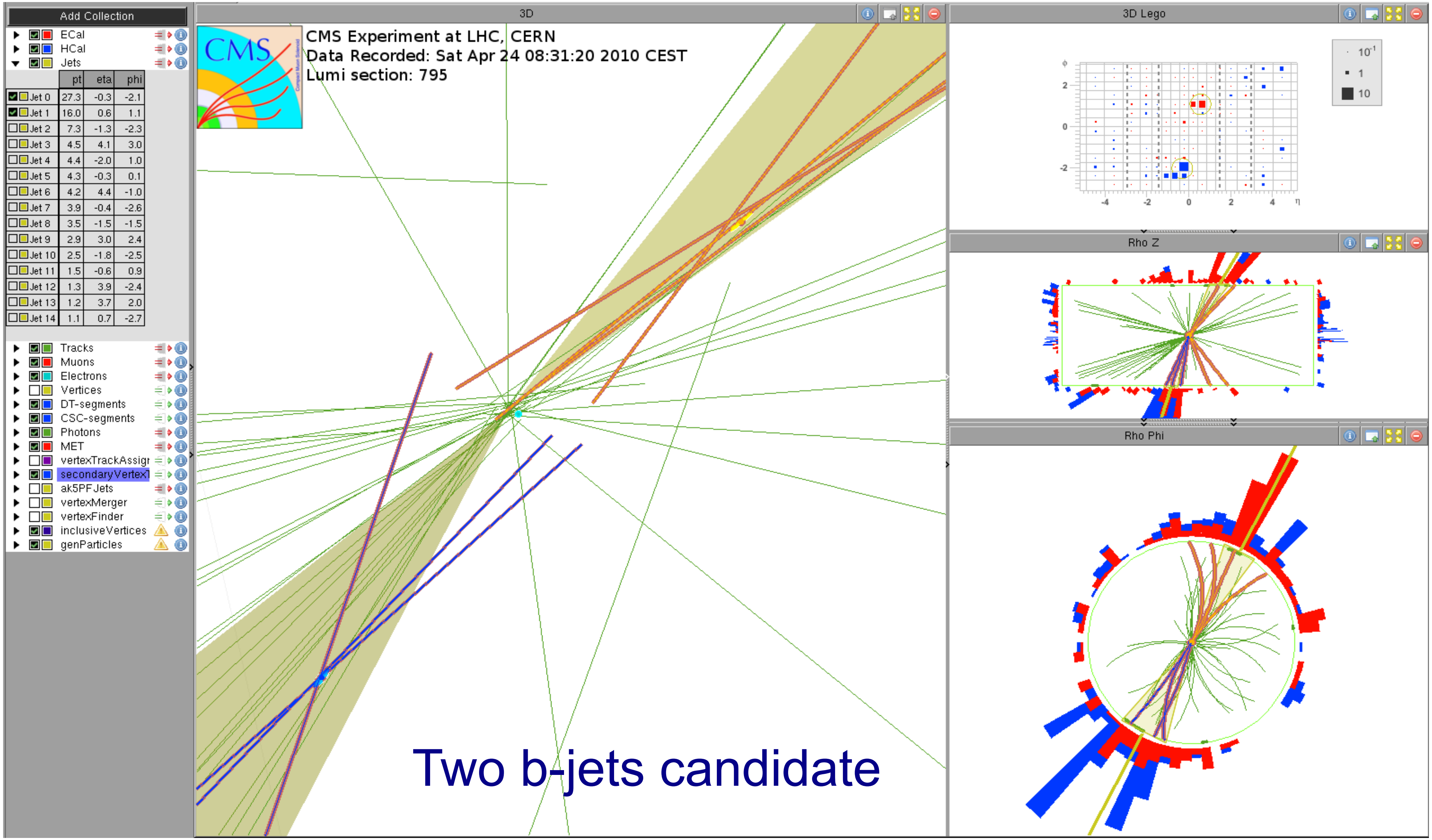


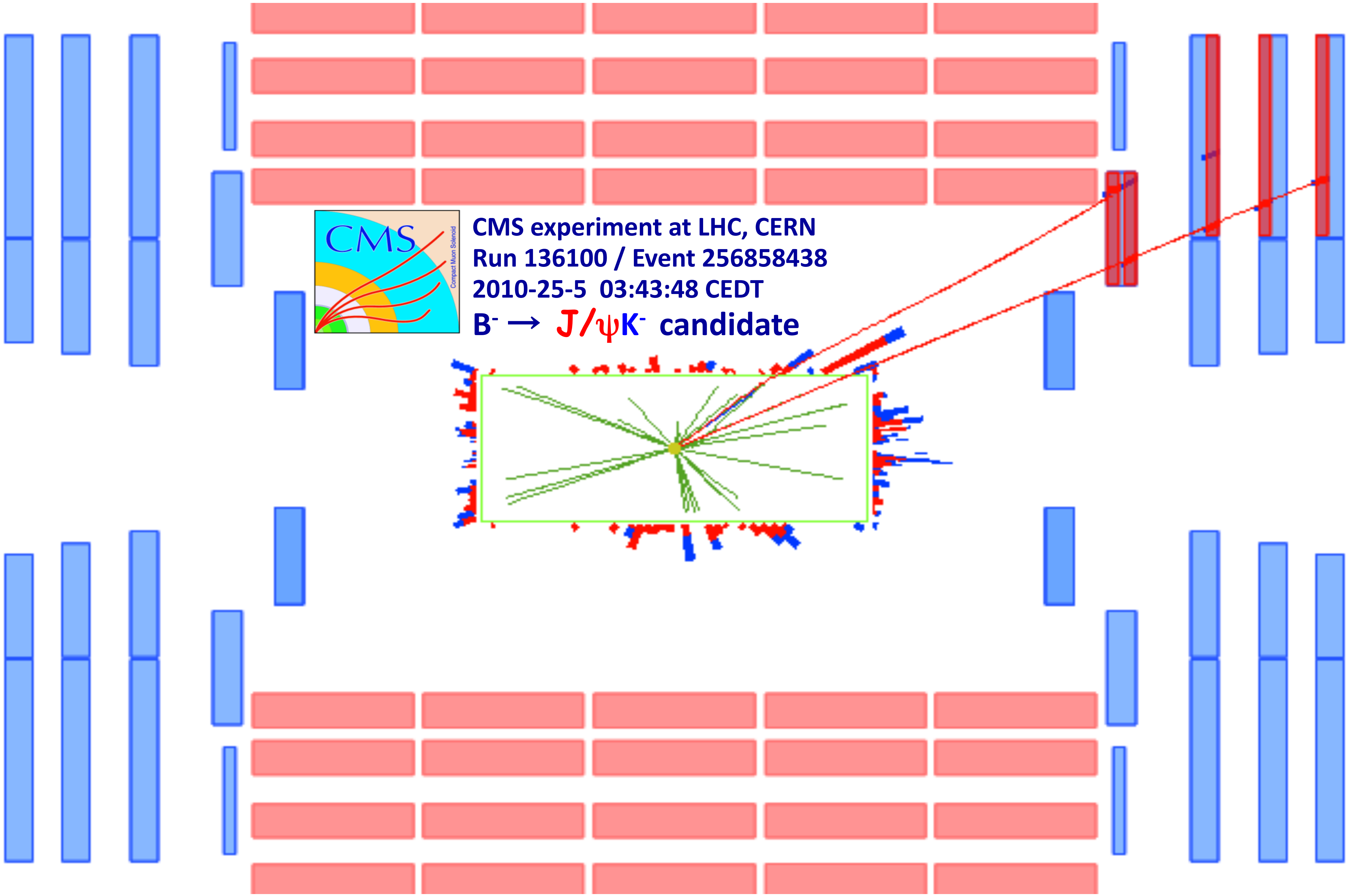




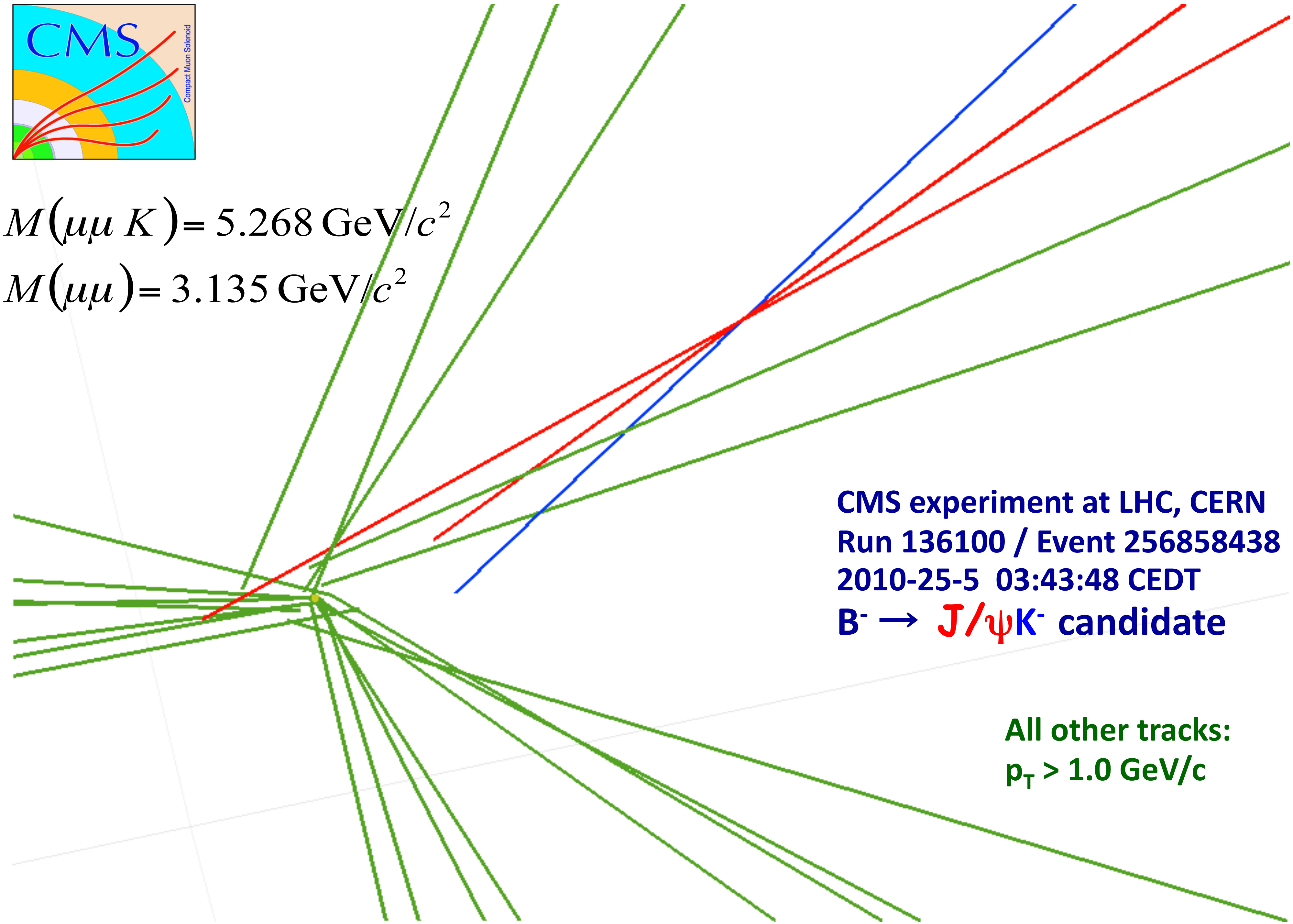
b-tagging can be used for physics already now!!

B-tagging Ready for Physics



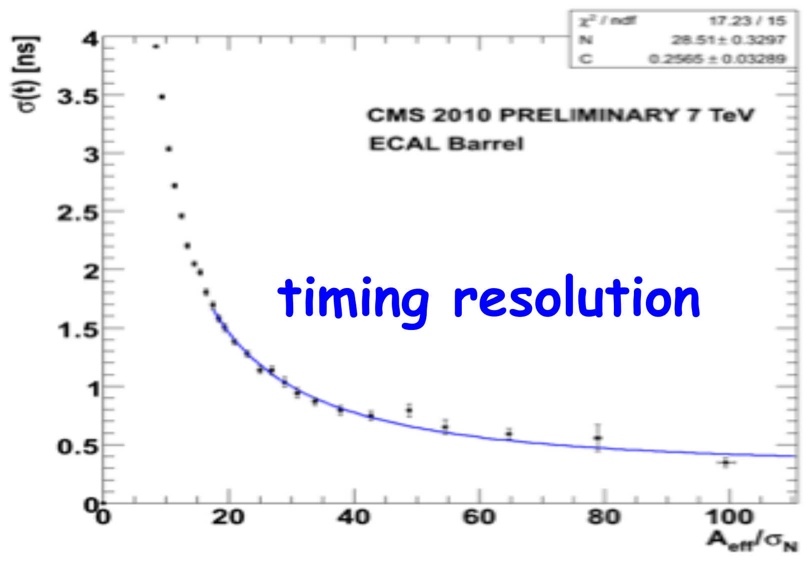


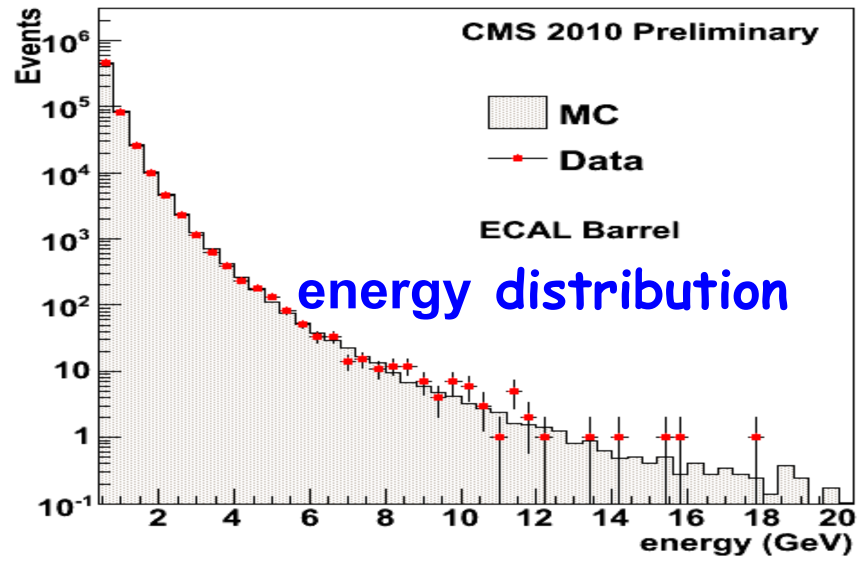
CMS
Compact Muon Solenoid
CMS experiment at LHC, CERN
Run 136100 / Event 256858438
2010-25-5 03:43:48 CEDT
$B^- \longrightarrow J/\psi K^-$ candidate

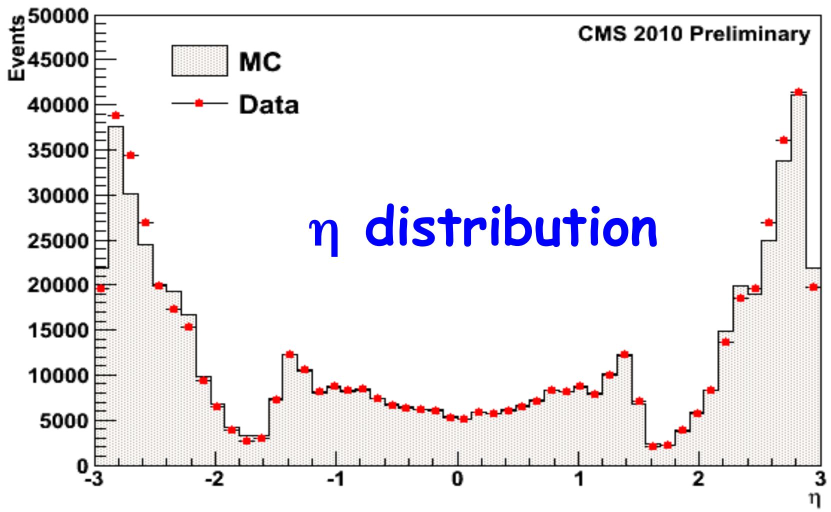


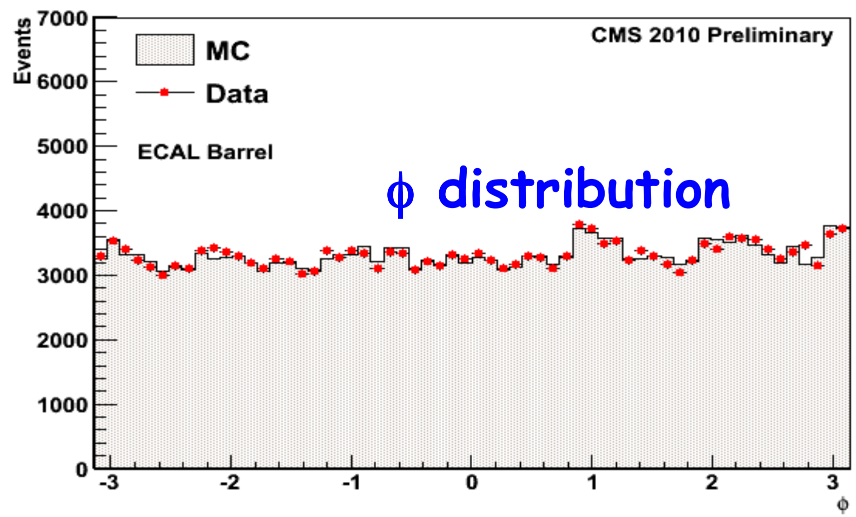
$M(\mu\mu K) = 5.268\ \mathrm{GeV}/c^2$
$M(\mu\mu) = 3.135\ \mathrm{GeV}/c^2$
CMS experiment at LHC, CERN
Run 136100 / Event 256858438
2010-25-5 03:43:48 CEDT
$B^- \rightarrow J/\psi K^-$ candidate
All other tracks:
$p_T > 1.0$ GeV/c

ECAL Clusters: electrons and photons









Low Mass Di-photons: π^0 / η

MC based correction applied according to cluster η and energy

1.46M of $\pi^0 \rightarrow \gamma\gamma$

$P_T(\gamma)$ > 0.4 GeV,

P_T(pair) > 1 GeV

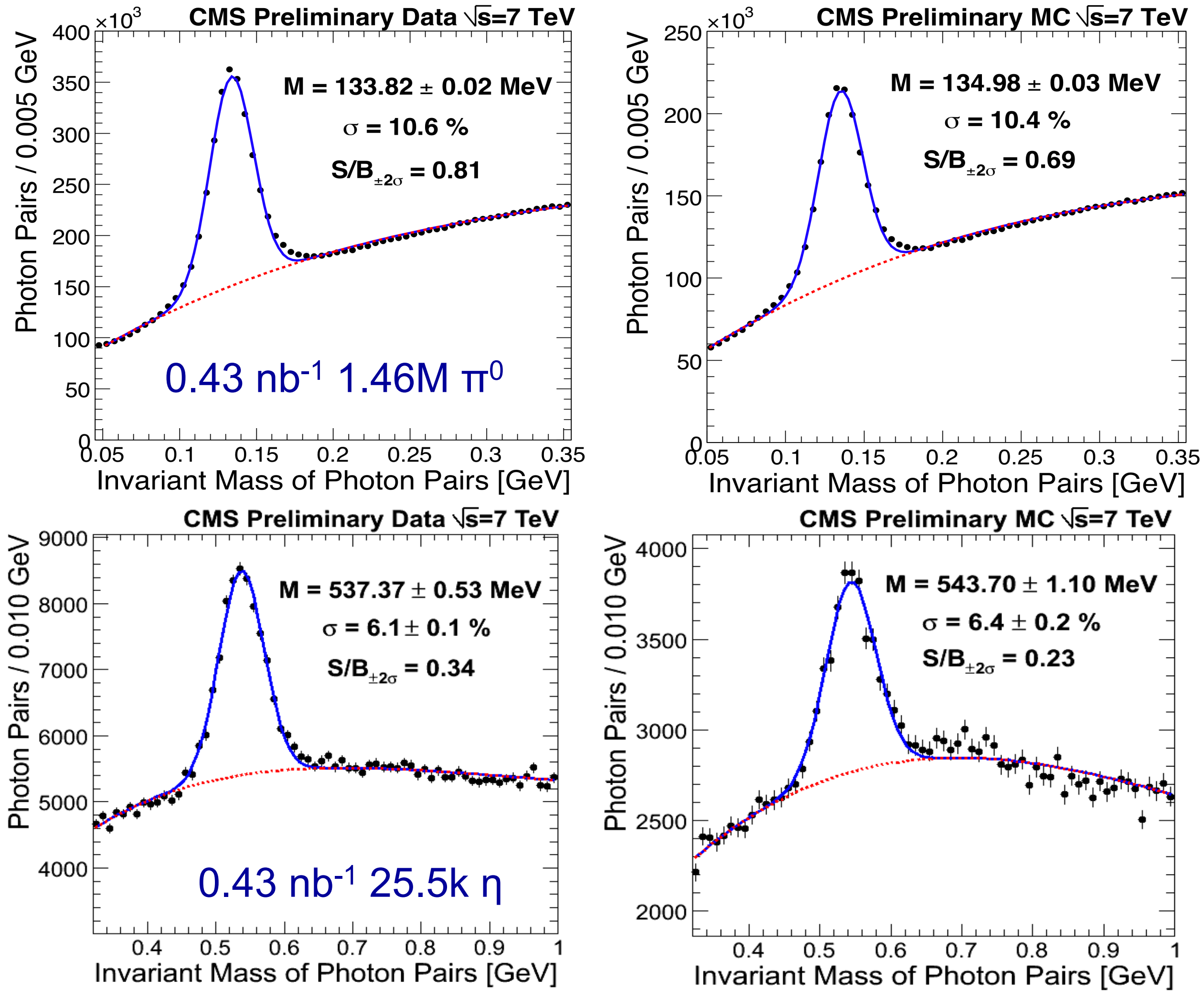
25.5K $\eta \rightarrow \gamma\gamma$

$P_T(\gamma)$ > 0.5 GeV,

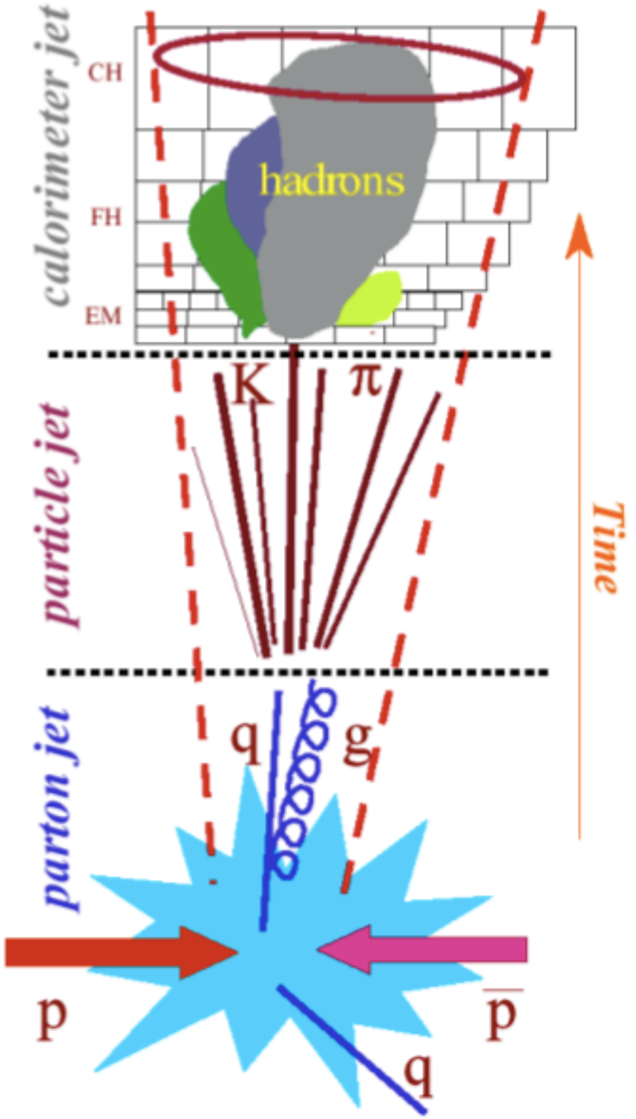
P_T(pair) > 2.5 GeV

Numbers refer to a few % of the currently available statistics.

Very useful tool to inter-calibrate the crystals.



Jet Finding



- **Calorimeter jet (cone)**
  - jet is a collection of energy deposits with a given cone *R*: $R = \sqrt{\Delta\varphi^2 + \Delta\eta^2}$
  - cone direction maximizes the total E_T of the jet
  - various clustering algorithms

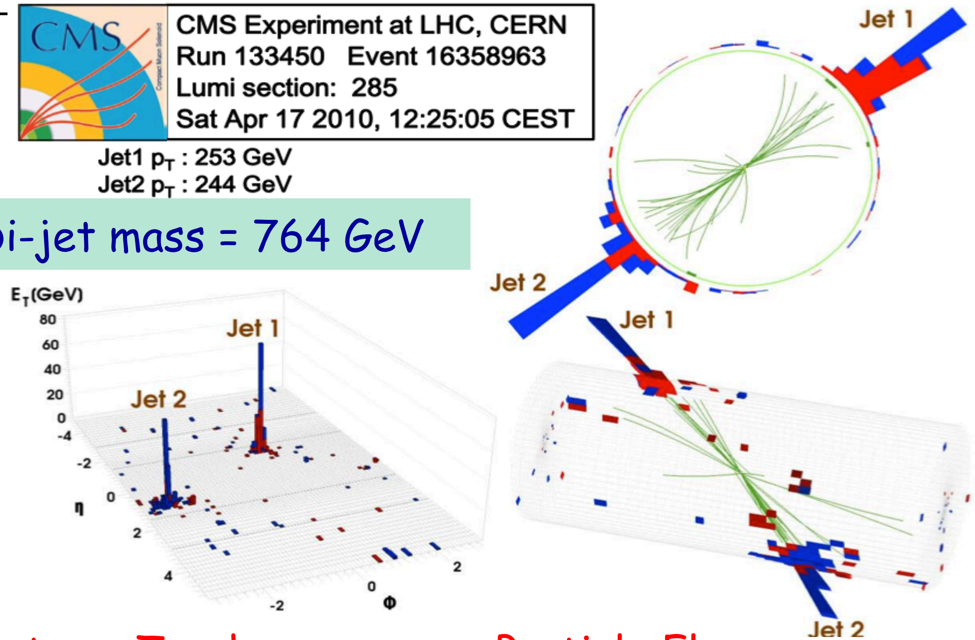
➔ correct for finite energy resolution
➔ subtract underlying event
➔ add out of cone energy

- **Particle jet**
  - a spread of particles running roughly in the same direction as the parton after hadronization

Di-Jet Events

Di-jet selection

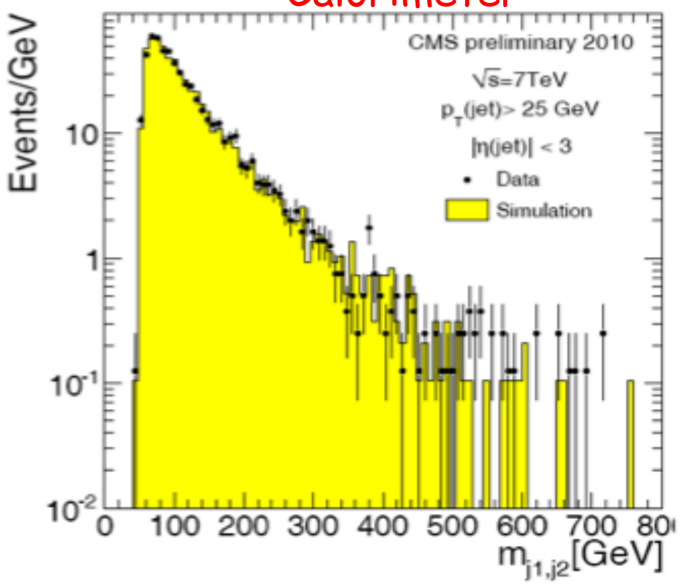
- Jet $p_{T1,2}$ > 25 GeV
- $\Delta\Phi$ > 2.1
- $|\eta|$ < 3



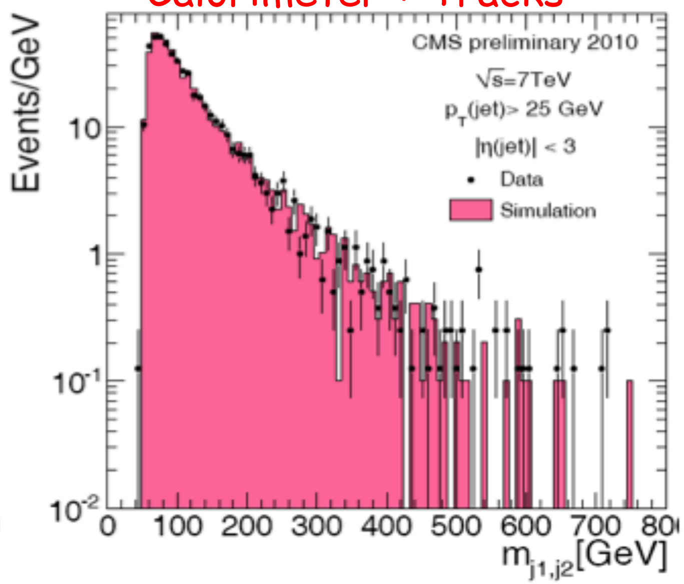
Di-jet mass = 764 GeV

Di-jet mass

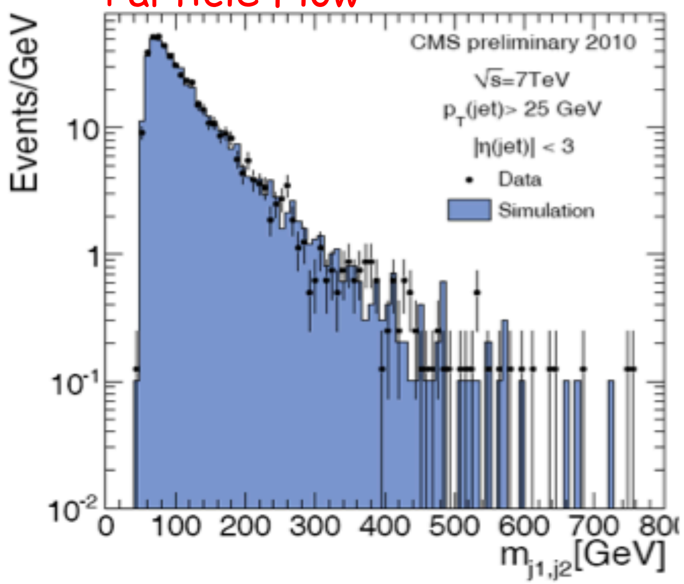
Calorimeter



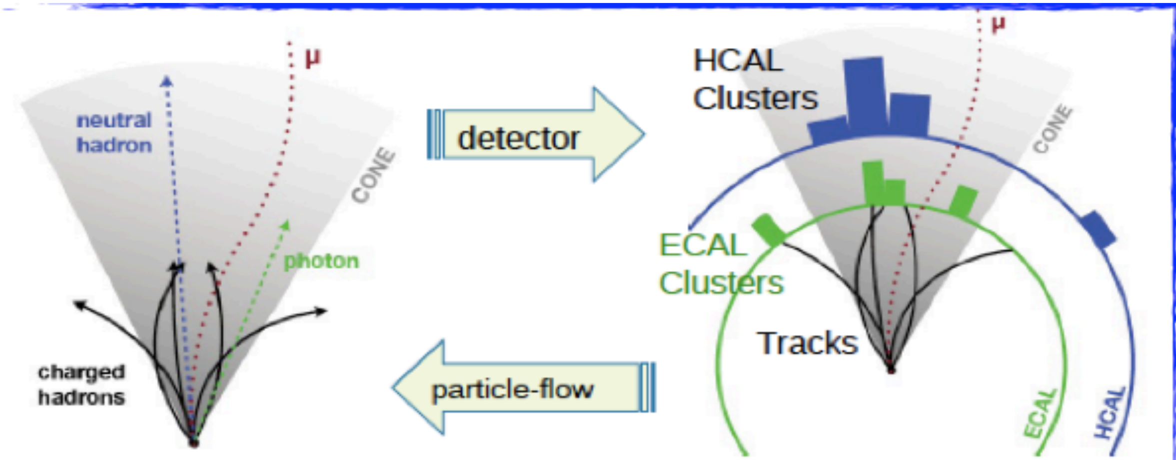
Calorimeter + Tracks



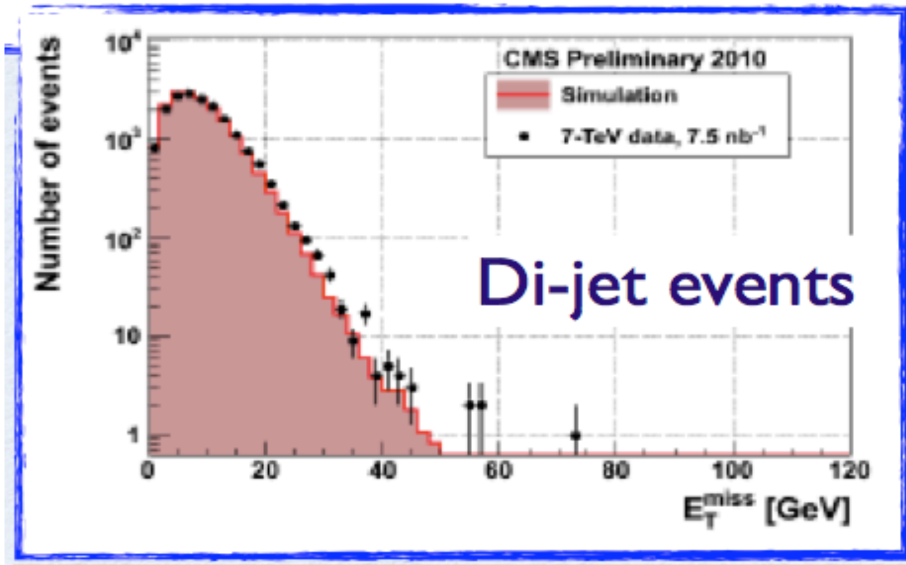
Particle Flow

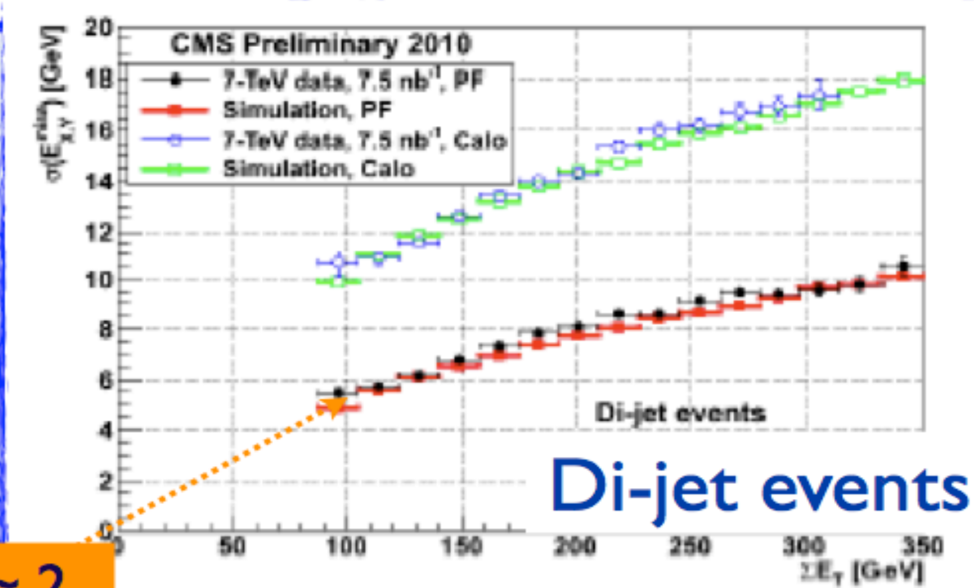


Particle Flow



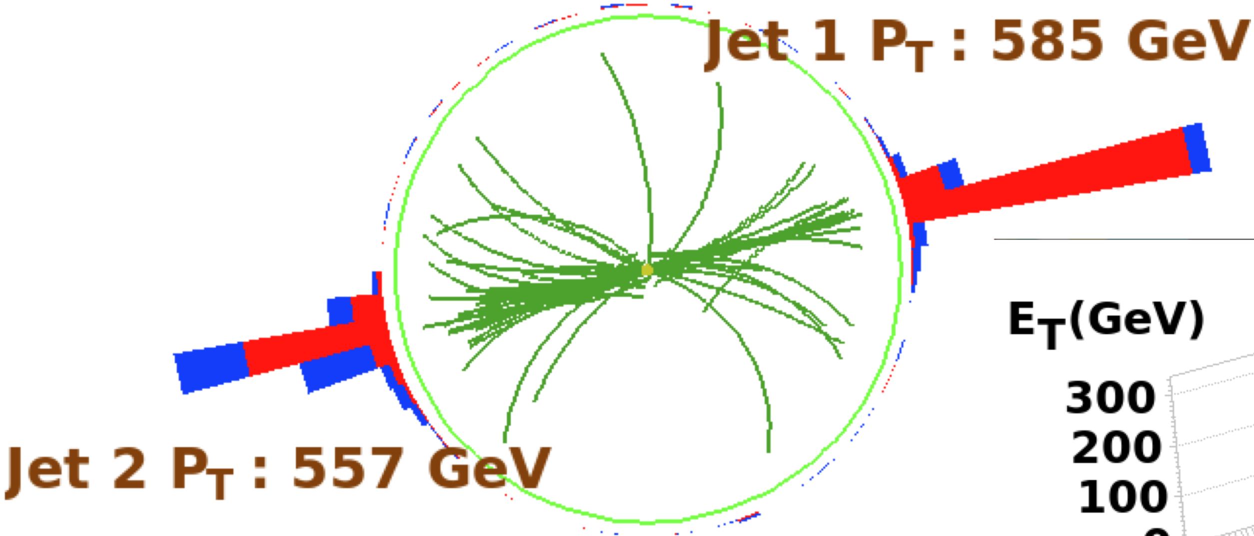
~90% of the jet energy is carried by hadrons and photons. Use Tracking information whenever is possible.

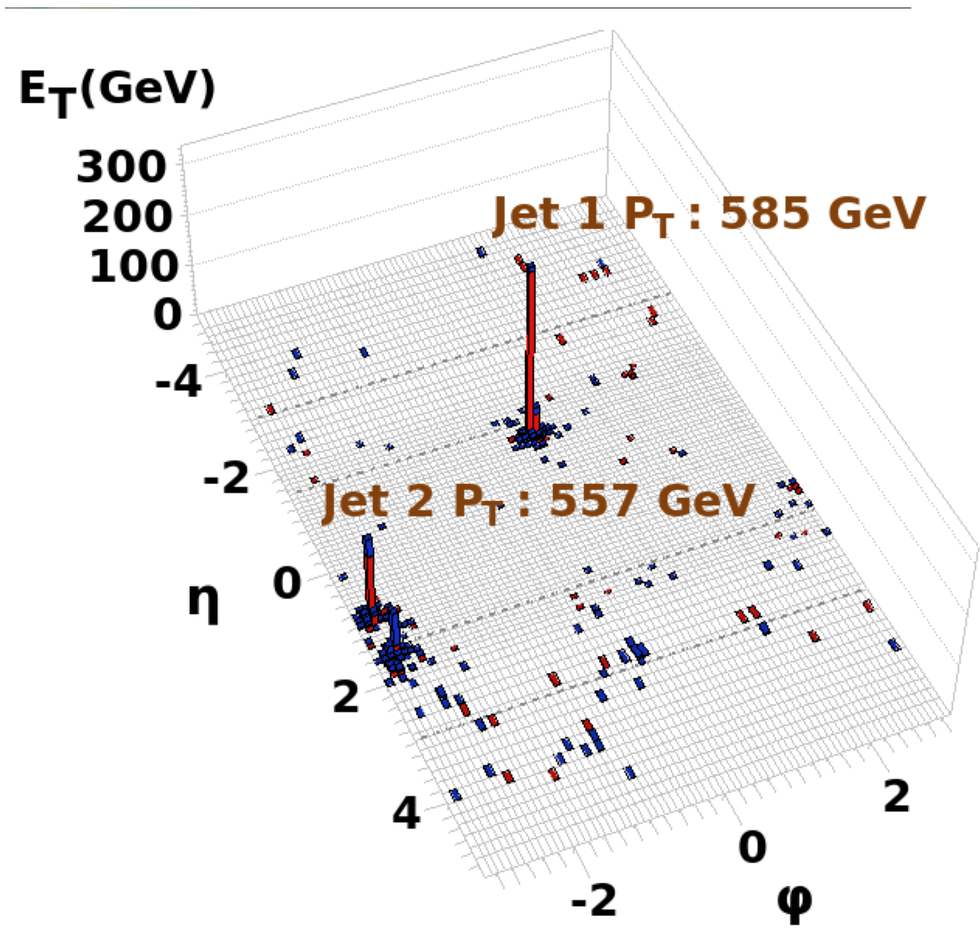




E_T ^{miss} resolution is improved a factor ~ 2 respect to calorimeter based one

Di-Jet Events



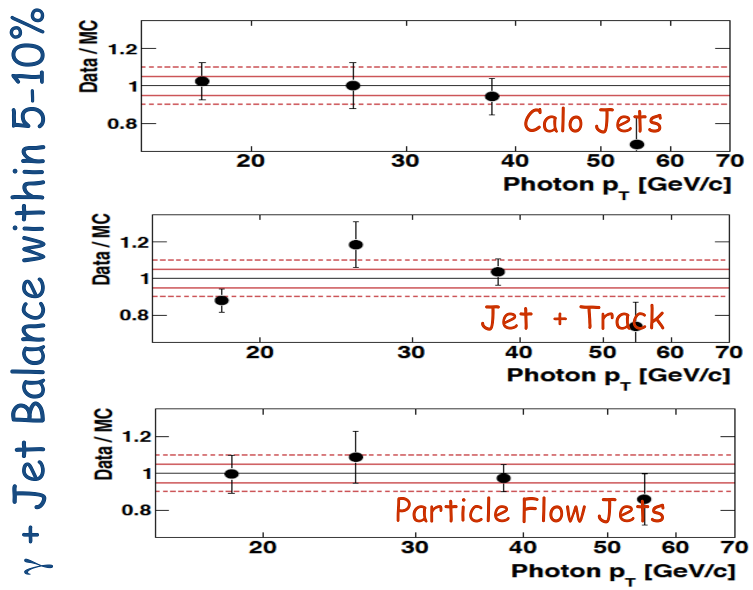


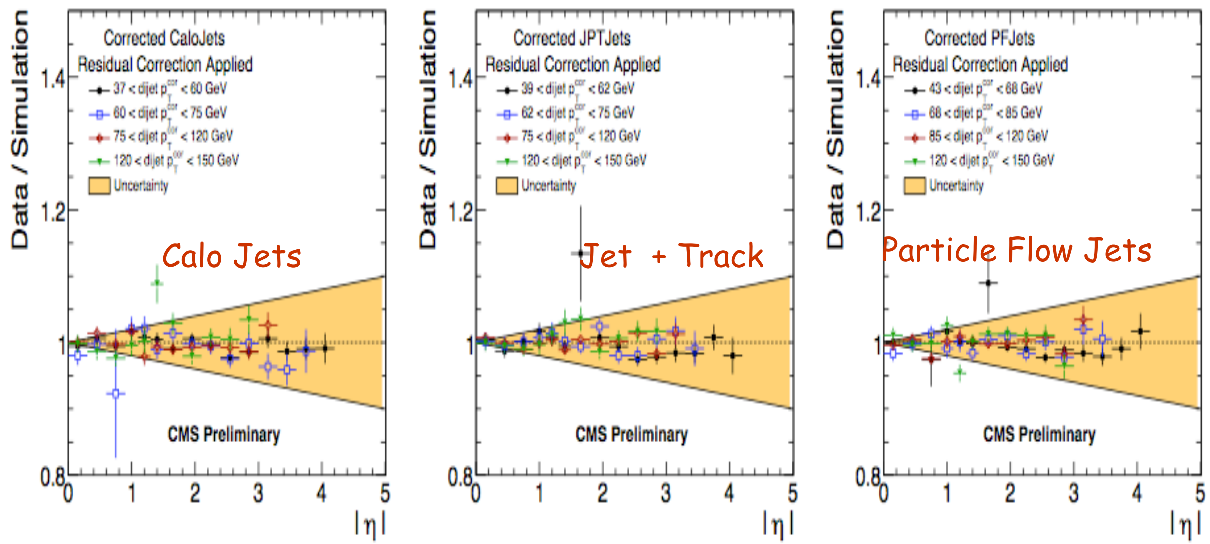
Run : 138919
Event : 32253996
Dijet Mass : 2.130 TeV

The highest mass dijet event in the first 120 nb^{-1} of data

Jet Energy Corrections

- Jets reconstructed with anti-k_T R=0.5 algorithms.
- Three different approaches: Purely Calorimetric, Jet+Tracks, Particle Flow Jets
- Jet Energy Correction performed using MC vs data on single particle response, dijet p_T balance, photon+jet balance.

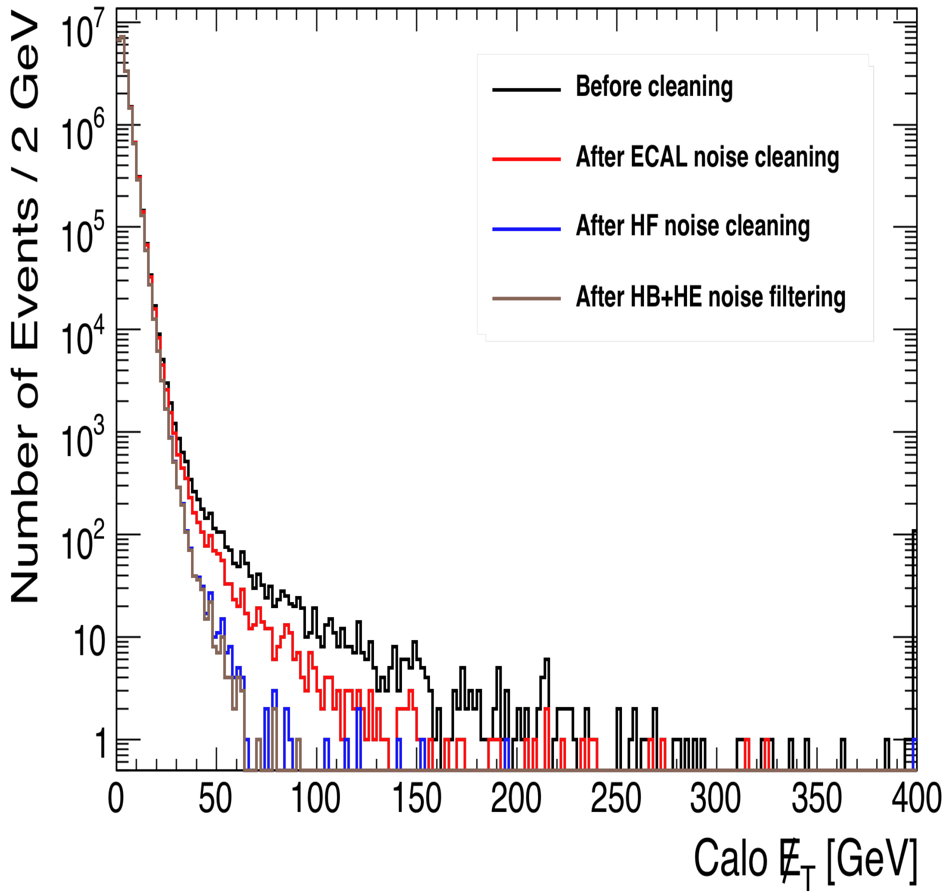


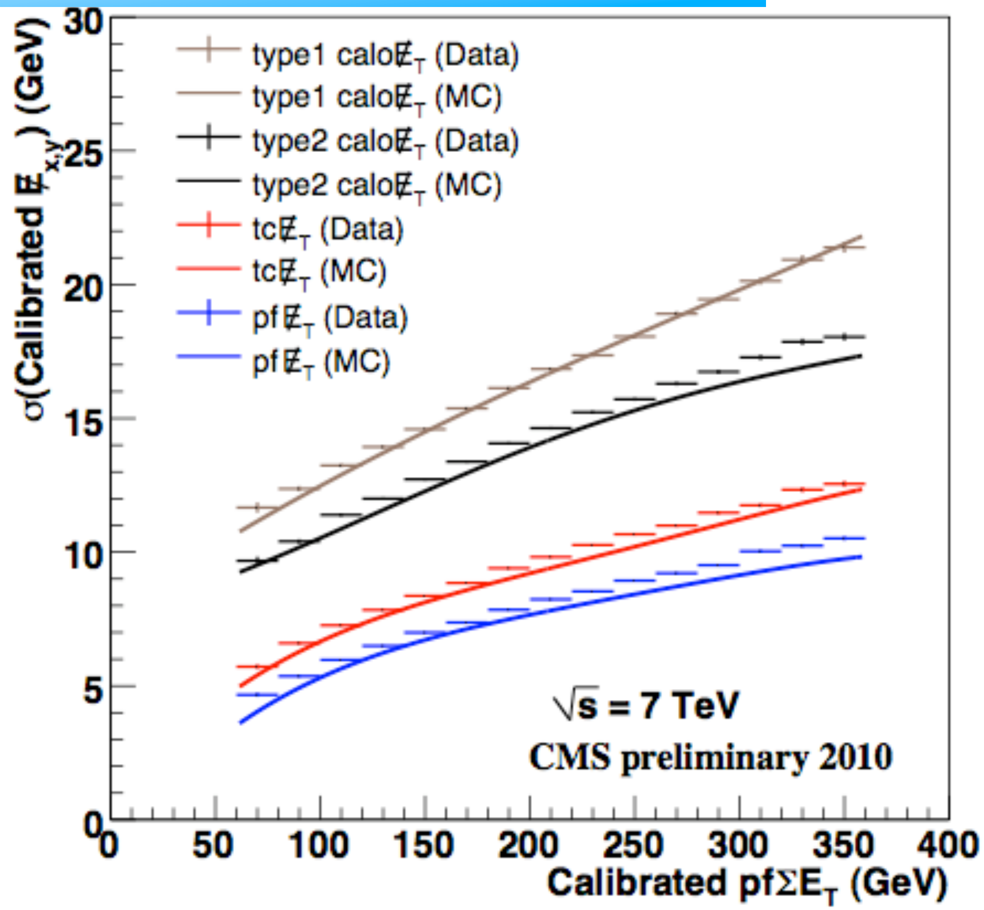


Current physics analysis use a 10% (5%) JEC uncertainties for CALO jets (JPT and PFjets), with an additional 2% uncertainty per unit rapidity.

Our measurements show that this assumption can be considered conservative.

Missing Transverse Energy

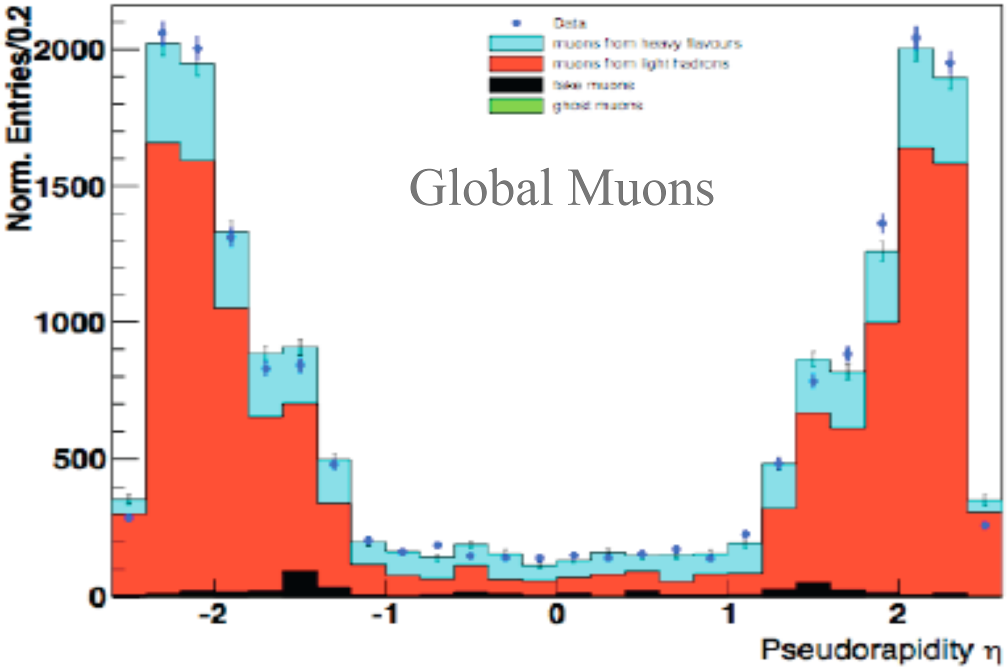


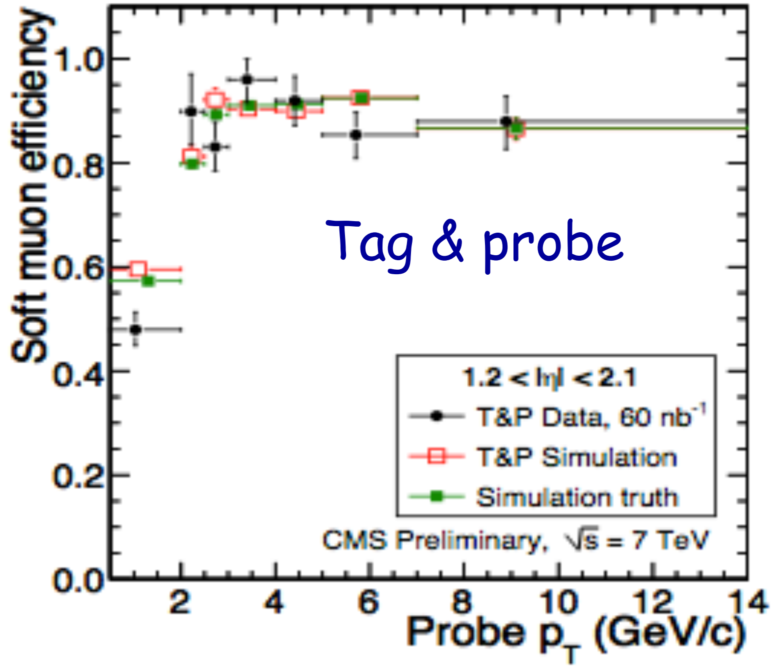


Excellent resolution and small non-gaussian tails. Understanding all sources of erratic noise is very important for cleaning the distributions. MET ready for physics.

Muon Distributions

"Global Muons": matched tracks from Muon system and Tracker





- η distribution dominated by light hadron decay muons (red)
- good agreement with MC prediction, including
  - heavy flavor decays (blue)
  - punch-through (black)

Tag and probe method using J/ψ's

ATLAS Detector Status

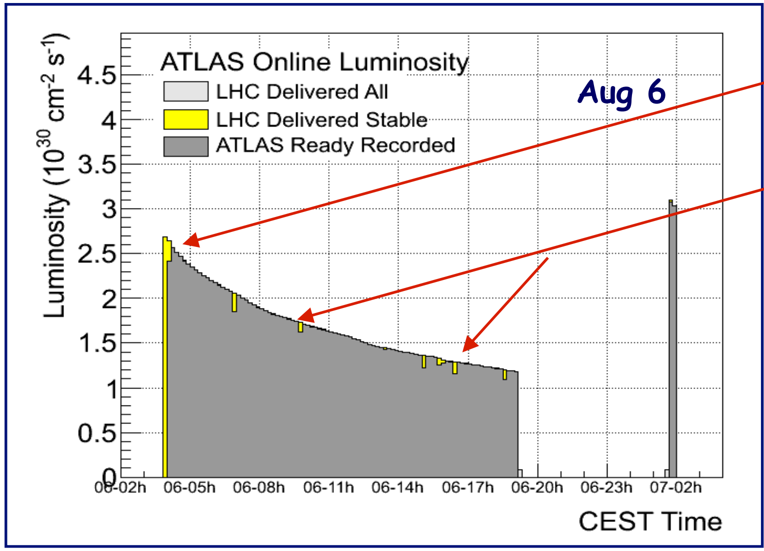
Working fraction of the ATLAS detector end June '10:

Sub-Detector	Number of channels	Approx. operational fraction (%)
Pixels	80 M	97.4
SCT Silicon Strips	6.3 M	99.2
TRT Transition Rad. Tracker	350 k	98.0
LAr EM Calorimeter	170 k	98.5
Tile Calorimeter	9800	97.3
Hadronic Endcap LAr Calorimeter	5600	99.9
Forward LAr Calorimeter	3500	100
LV1 Calo Trigger	7160	99.9
LV1 Muon RPC Trigger	370 k	99.5
LV1 Muon TGC Trigger	320 k	100
MDT Monitored Drift Tubes	350 k	99.7
CSC Cathode Strip Chambers	31 k	98.5
RPC Barrel Muon Chambers	370 k	97.0
TGC Endcap Muon Chambers	320 k	98.6

For all systems > 97% of channels are operational, in addition have built-in redundancy in most systems: Overall detector is performing very well, but a few issues with component failures to watch out for …

Data Taking and Data Quality

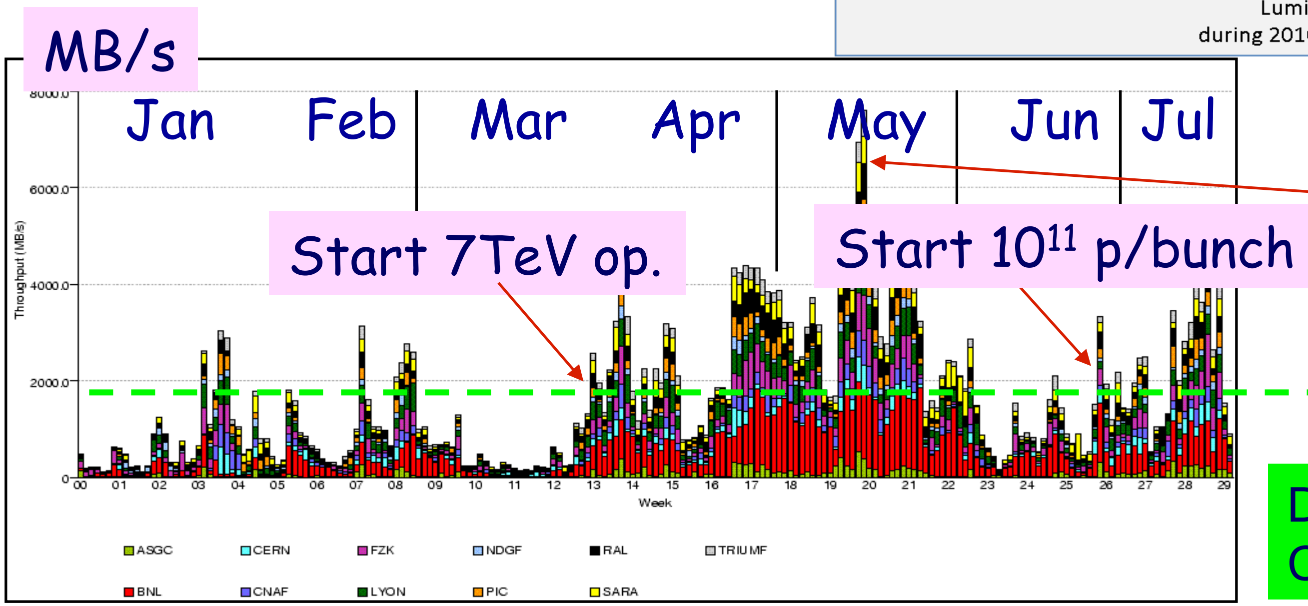
Typical LHC fill …



- Data Taking Efficiency very good
- Few minutes needed for tracking detectors (silicon and muons) to ramp HV when LHC declares stable beams
- Short 'dips' in recorded rate: recover "on-the-fly" modules which would otherwise give a BUSY blocking further events

Inner Tracking Detectors			Calorimeters				Muon Detectors			
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	TGC	CSC
97.7	96.4	100	94.4	98.7	99.3	99.2	98.5	98.3	98.6	98.3

Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams at √s=7 TeV between March 30th and August 14th (in %)



10 GB/s peak rate during data and MC processing ..
More than 1000 users running analysis jobs on the GRID

~ 2GB/s design

Data distribution on the Grid:
Constant impressive duty cycle !

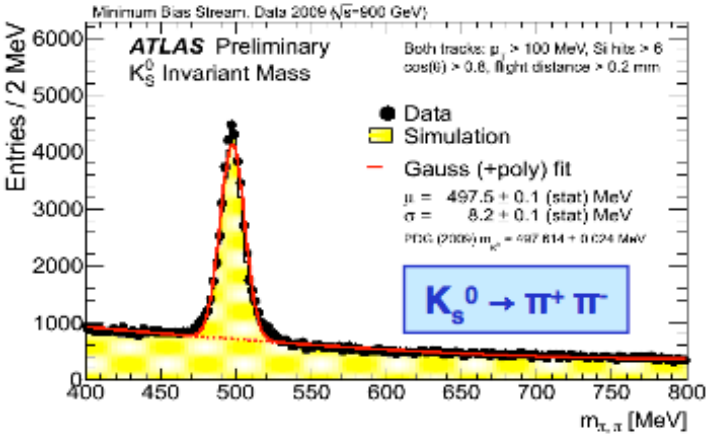
ATLAS Trigger: 2010 Roadmap

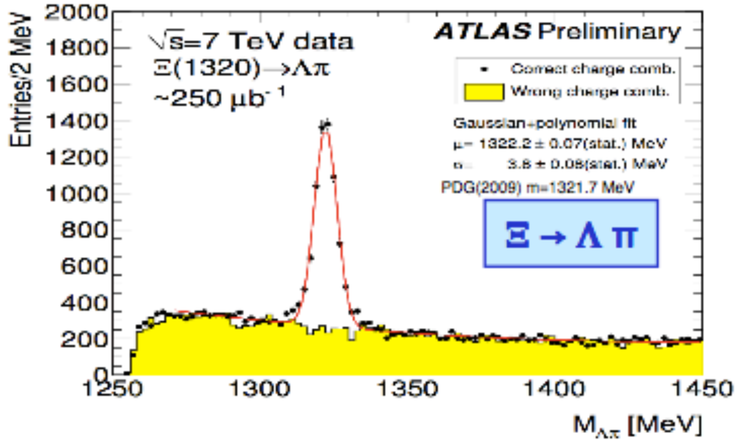
Steps and Status of 2010 ATLAS trigger deployment:

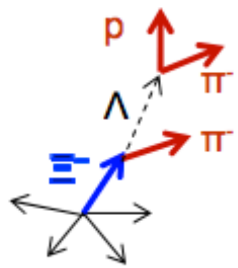
- 10^{27} $cm^{-2}s^{-1}$ – initial collisions
  - minimum bias – hits in scintillator modules located 3.5m from interaction point, all HLT chains in pass thru mode
- L = few 10^{27} … 10^{29} $cm^{-2}s^{-1}$:
  - minimum bias prescaled at Level-1,
  - other level-1 items (largely) un-prescaled
- L > ~10^{29} $cm^{-2}s^{-1}$:
  - activate high level trigger algorithms,
    - starting with low threshold EM triggers, followed by tau and muon chains,
    - running with low Level-1 thresholds
  - high threshold Level-1 jet triggers un-prescaled as long as possible
- L >~ 10^{30} $cm^{-2}s^{-1}$: **trigger menu for 2010 pp-physics – fully deployed**
  - Muon HLT rejection active for lower thresholds (MU0, MU6)
  - E/γ chains: HLT rejection active for all lower, pass thru mode for highest threshold(s)
  - Tau: HLT rejection active, pre-scale single tau HLT triggers as luminosity increases
  - jet HLT algorithms in pass-thru mode,
  - HLT B-physics chains activated, triggers un-prescaled

Tracker Performance in ATLAS

❑ At low pT : from early peaks and cascade decays

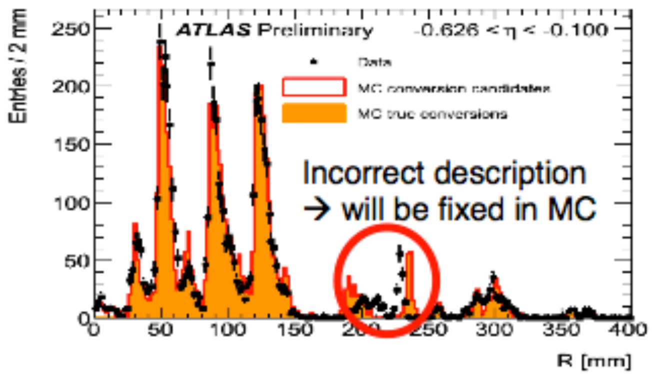






❑ Knowledge of Inner Detector Material

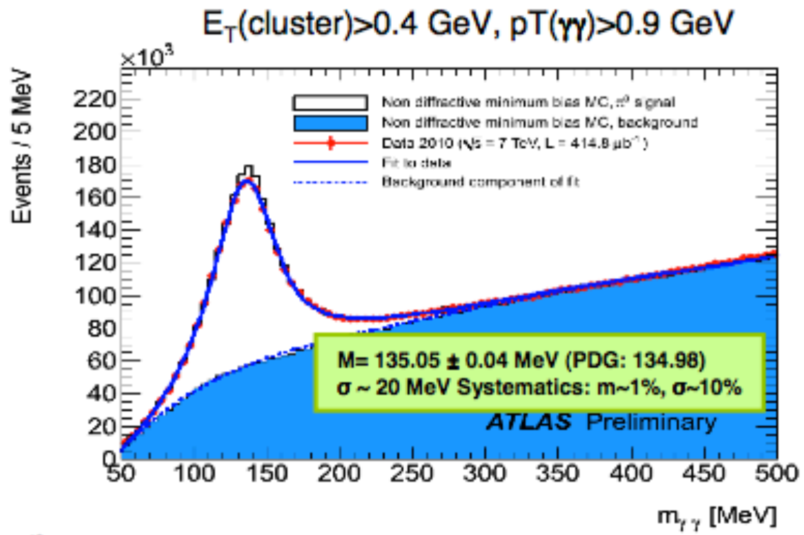
- Looked at using $\gamma \to ee$ conversion and hadronic interaction secondary vertices
- Found some discrepancies data-MC
- Today ~10% level. Ultimate goal: 1%

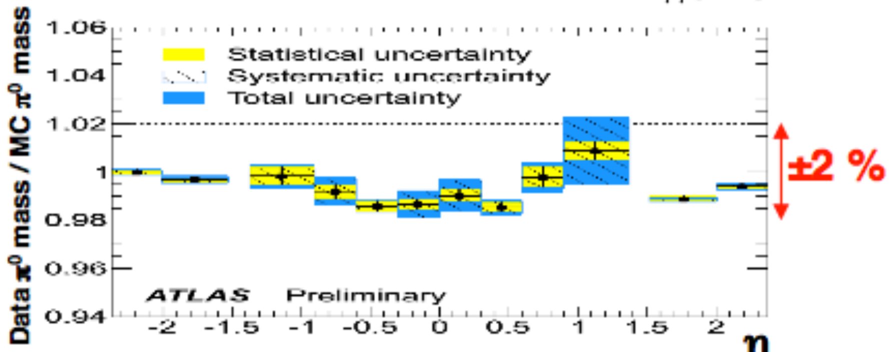


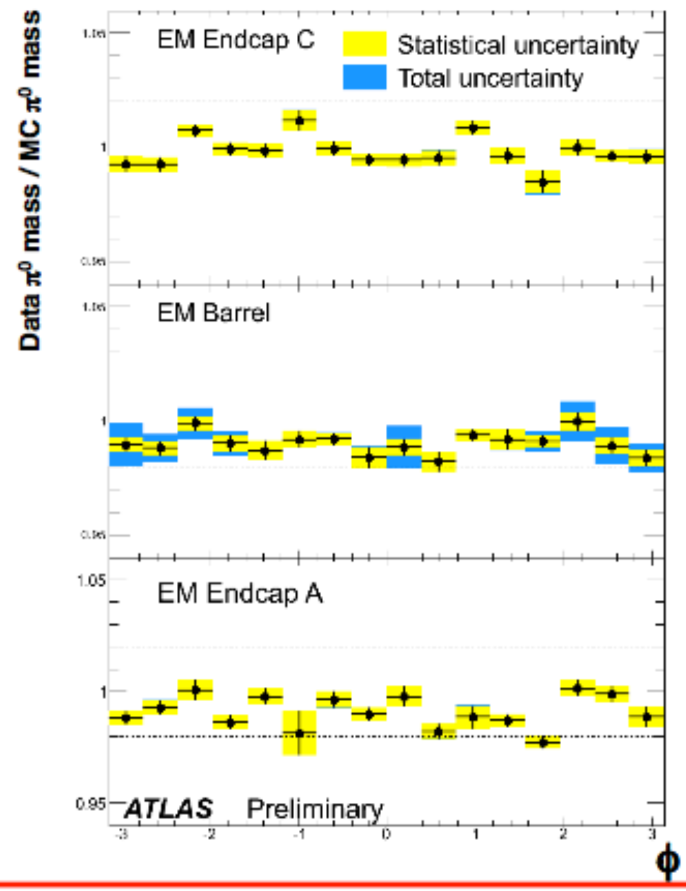
- **Momentum scale known to few permil in low pT range**
- **Inner Detector material known at 10%**

Electromagnetic Calorimeter

❑ Taste of EM calorimeter uniformity with first million of $\pi^0 \rightarrow \gamma\gamma$





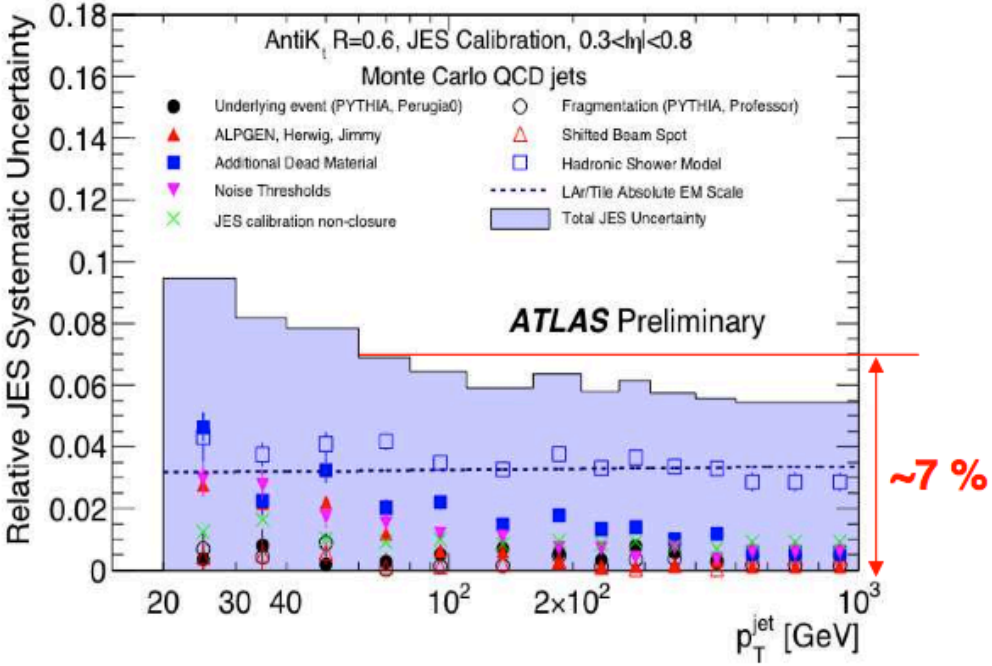


First check of energy scale over η (~ 2%) and EM calo response uniformity in φ (< 0.7%)

Hadron Calorimeter

❑ Jet energy scale

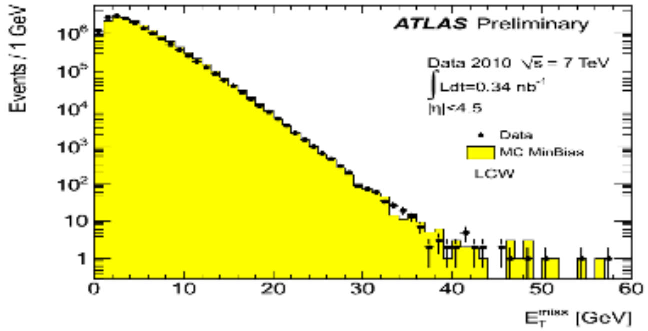
- Presently from MC (based on last 10 years)



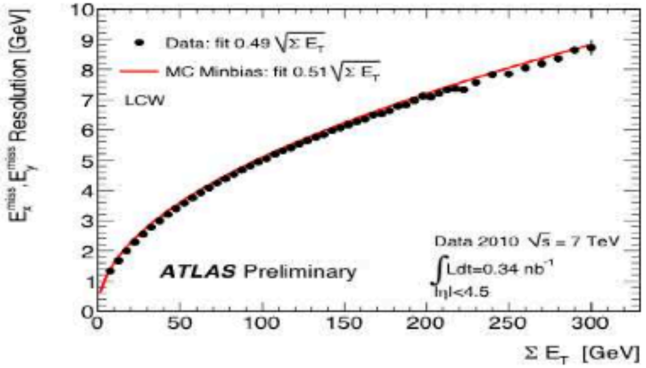
- Soon reduced with γ-jet balance (~1 pb^{-1})

❑ E_T^{miss} resolution and tails

- From Minimum Bias events (E_T^{miss}~0)
- Measured over full calorimeter coverage (360^0 in ϕ, $|\eta|<4.5$, ~200k cells)



No tails

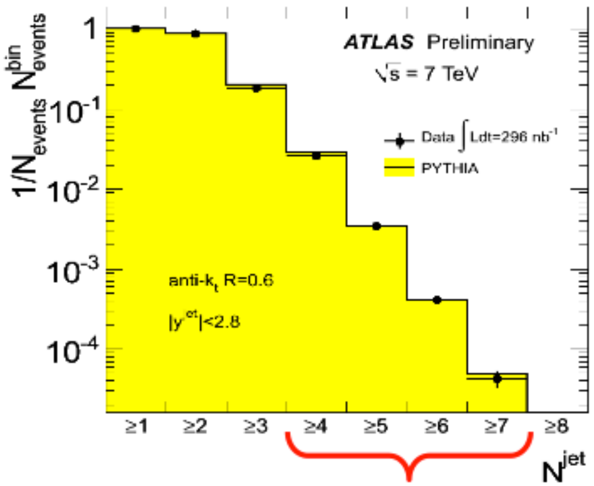


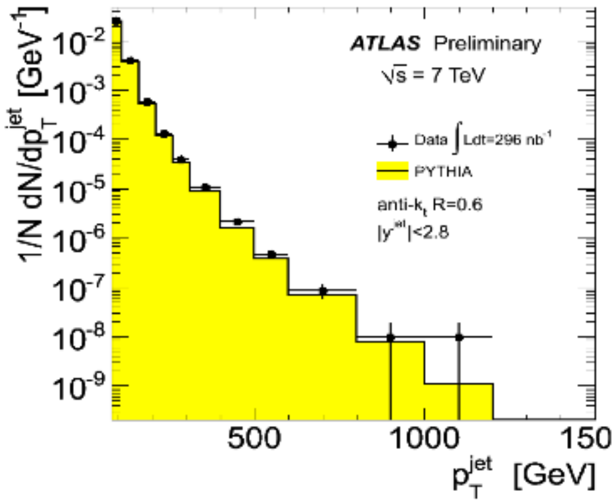
Jet Energy scale known to ~7% for pT>100 GeV. E_T^{miss} under control

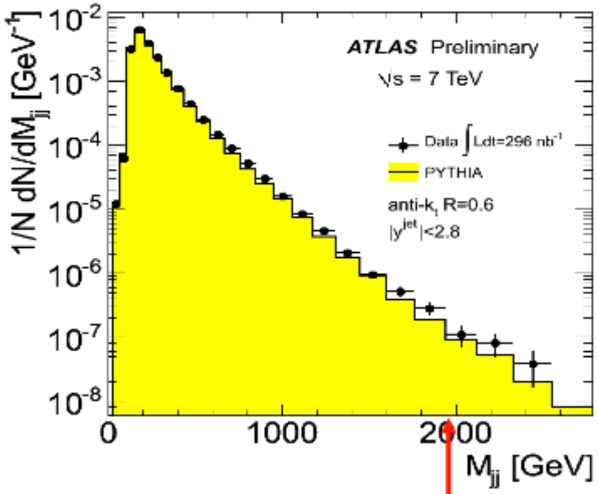
Jet Reconstruction

❑ Full ICHEP stat, MC normalised to data

- Main jet : p_T>80 GeV (and sub-leading jets: p_T>40 GeV) in $|y^{jet}|$<2.8
- Statistical error only







Few Top candidates in !

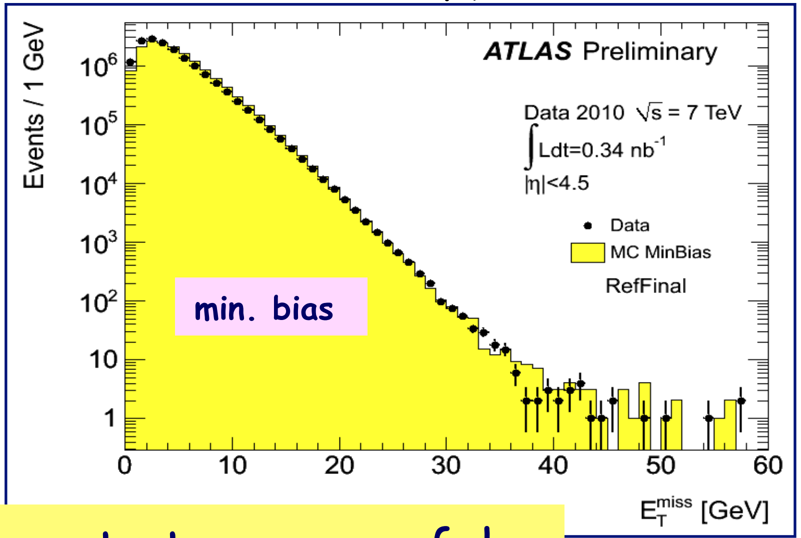
Tevatron √s=1.96 TeV !!

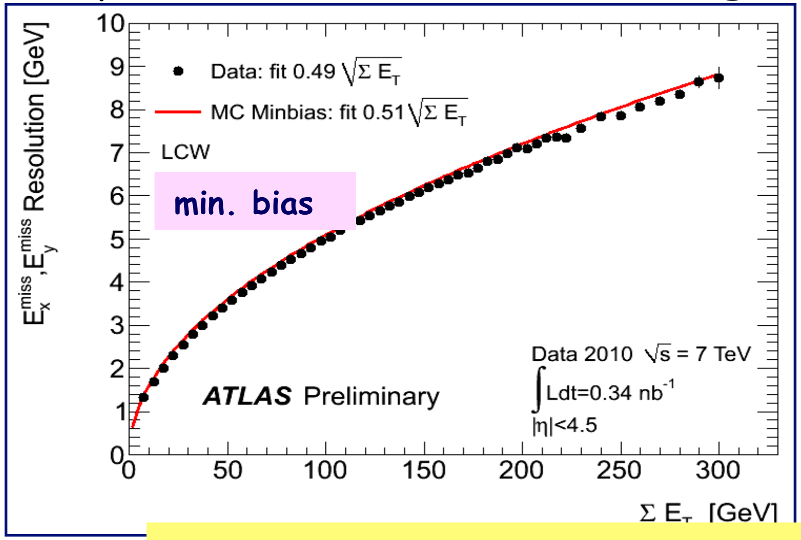
Already start to explore new phase space !

Missing E_T

Missing E_T: Min. bias events and p_t-enhanced L1Calo samples, full calorimeter coverage

Important for SUSY searches ! !

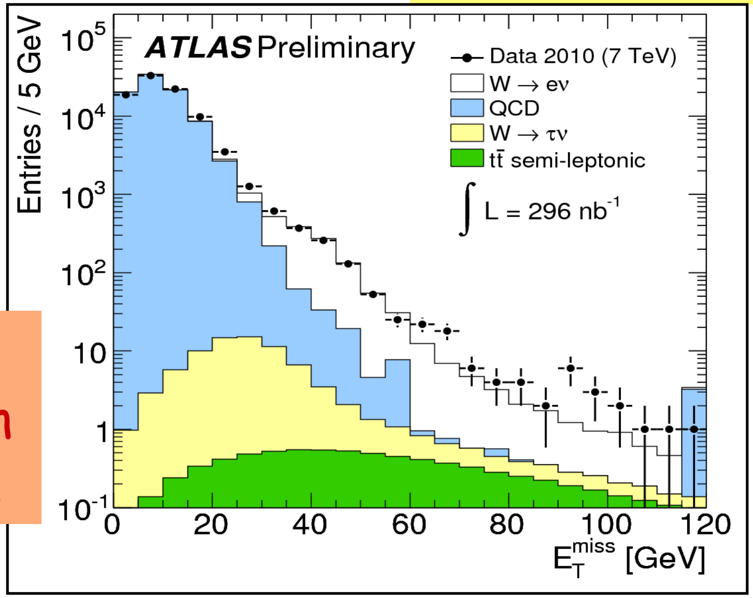




good agreement with MC

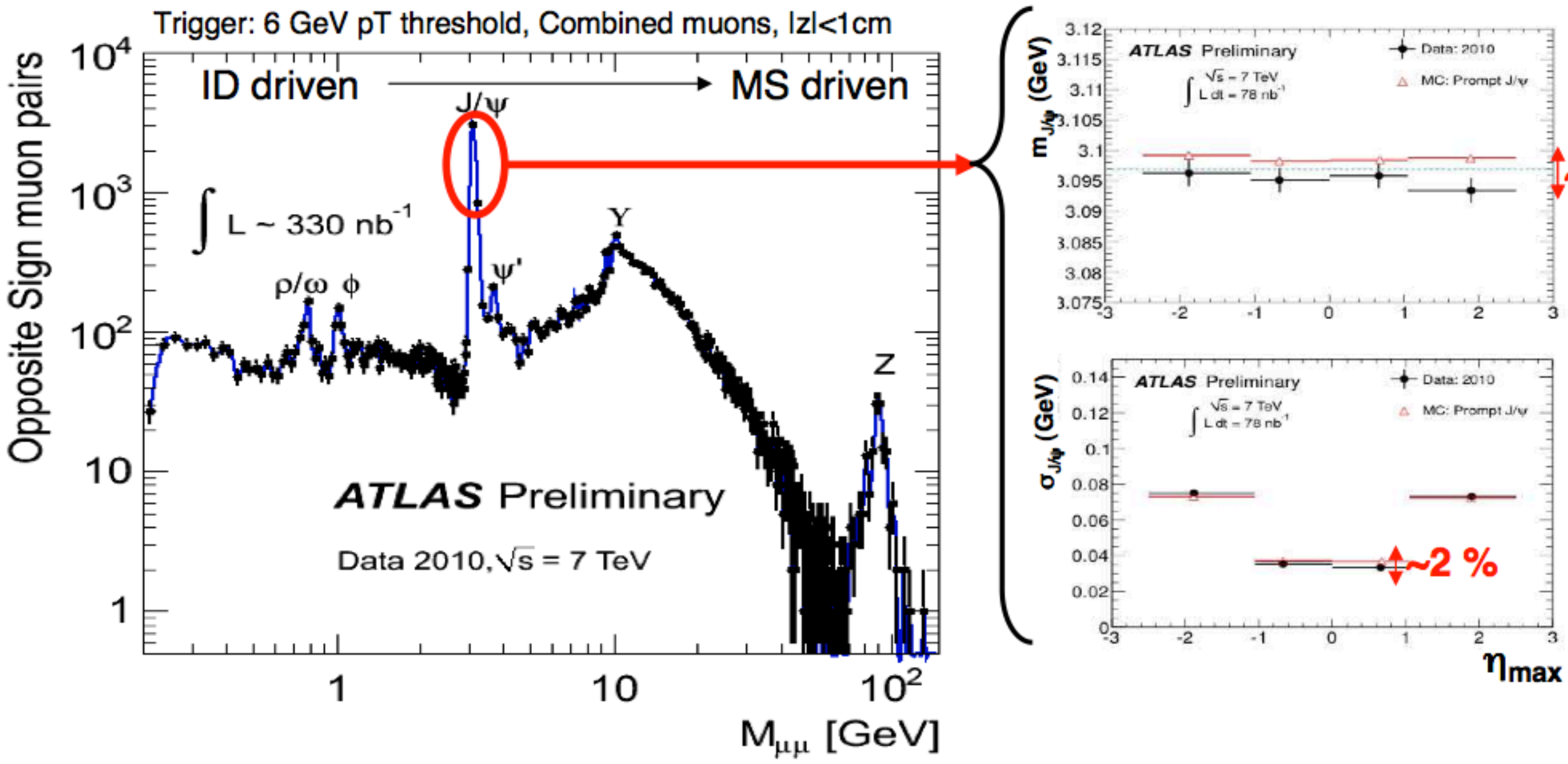
- Jet cleaning cuts to remove fake jets from noisy cells: no tails introduced into the distribution
- No tails introduced by improved calo calibration

Detailed Understanding from W's ..



Muon System

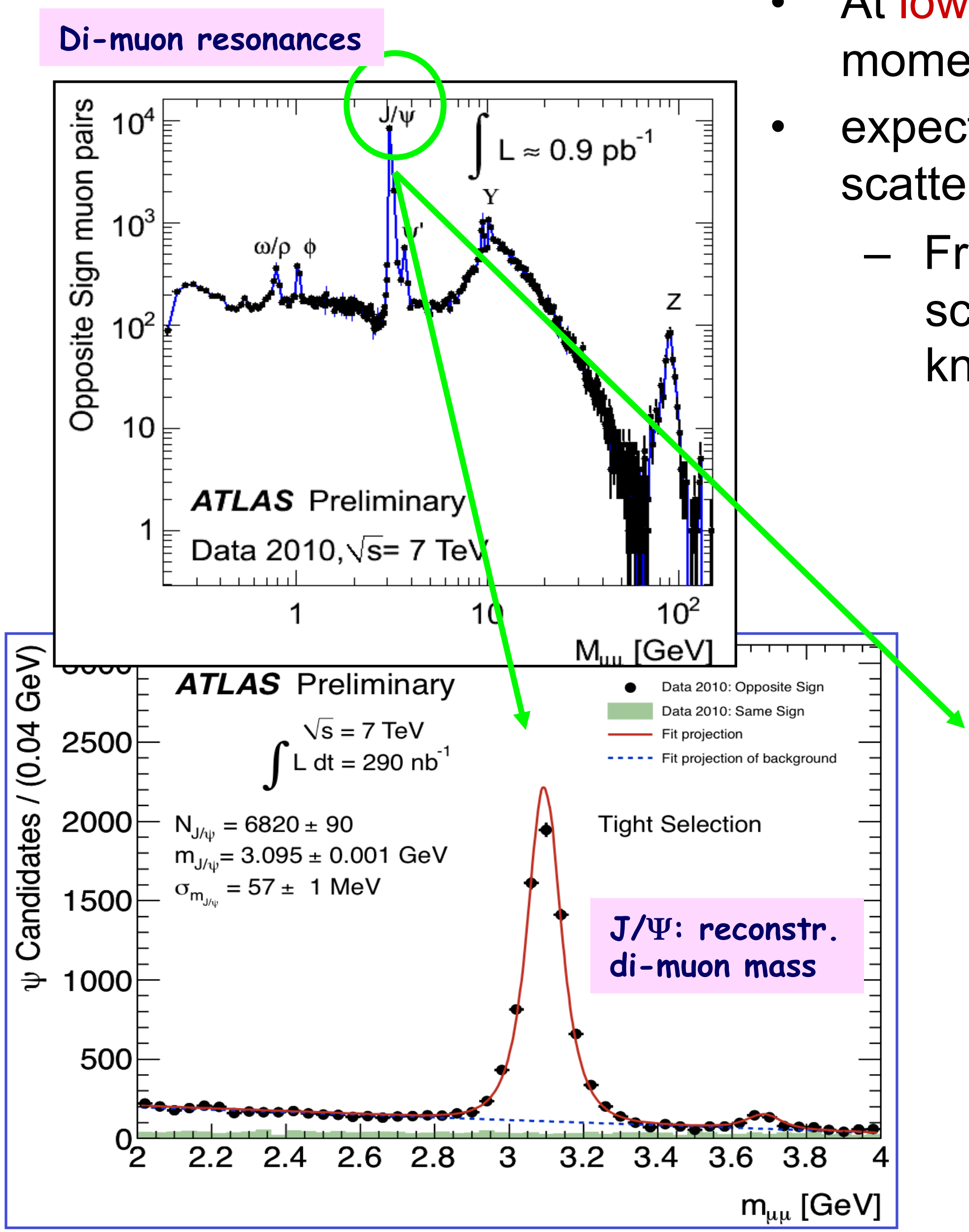
❑ Combined Inner Detector (ID) + Muon Spectrometer (MS) measurement

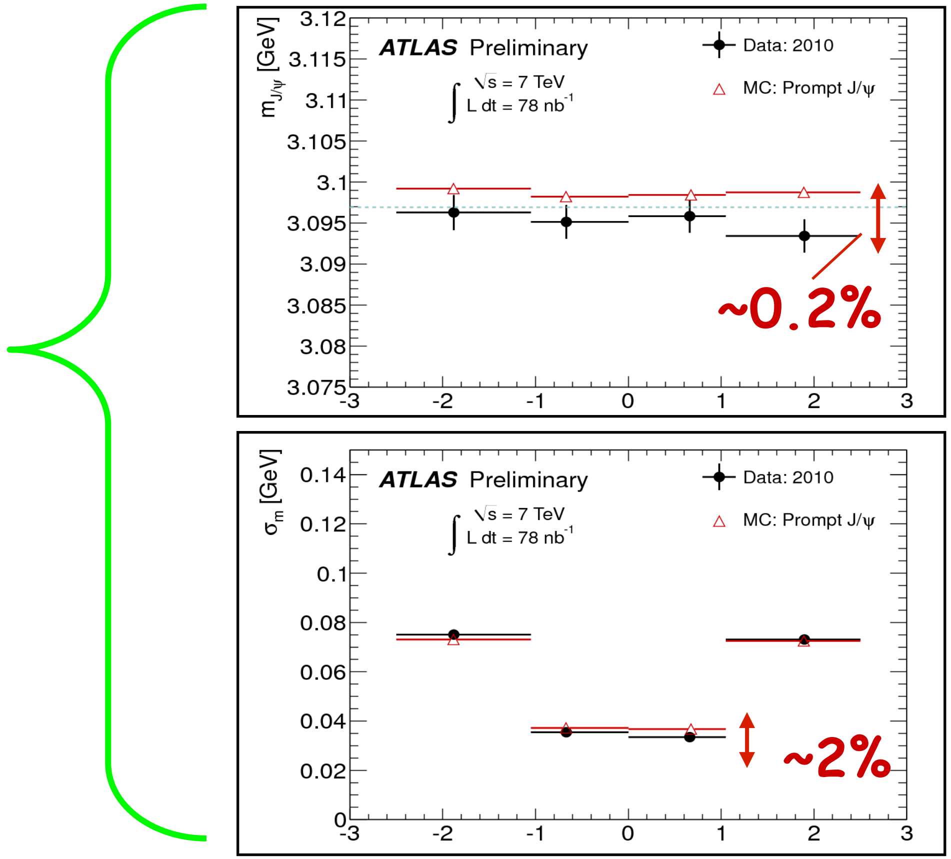


Very good understanding at low pT (high pT needs more data)

Muon Reconstruction

- At low p_t, Inner detector is dominating overall muon momentum resolution,
- expected resolution is ~ 2%, dominated by multiple scattering:
  - From J/Ψ di-muon mass peak: absolute momentum scale known to ≈ 0.2%, momentum resolution known to ≈ 2% for few GeV

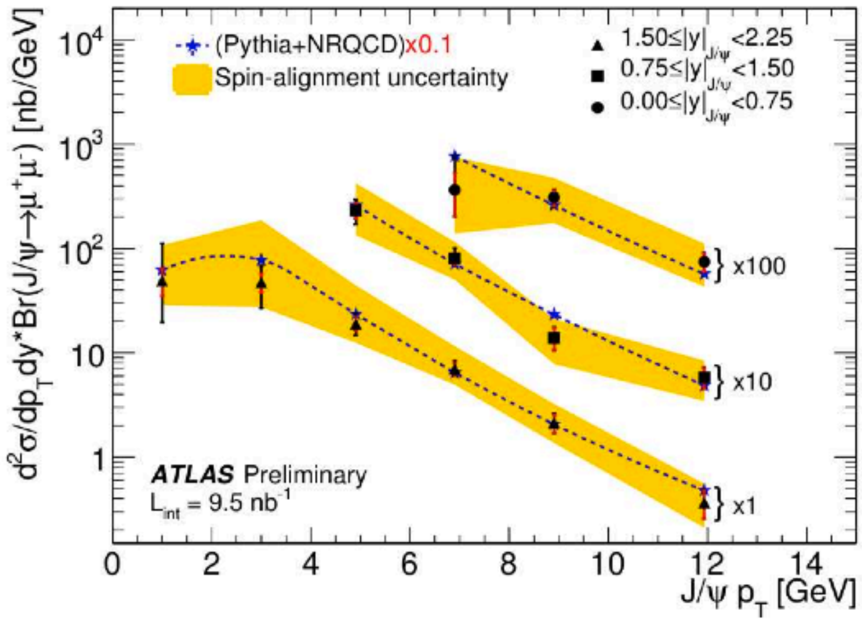




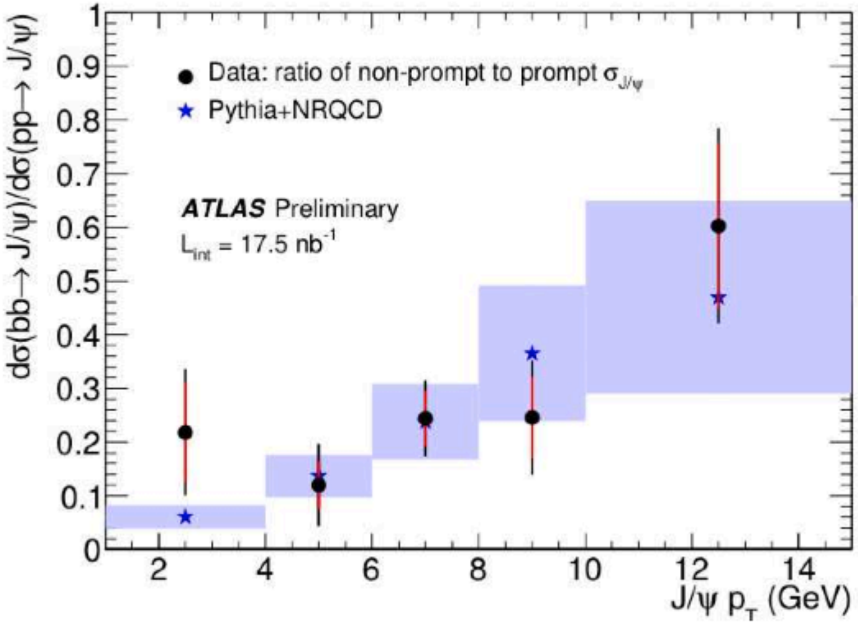
J/ψ Signals

❑ Probe J/ψ production mechanisms

- Differential cross-section in p_T and y bins



- Separate prompt J/ψ from others with: $\frac{L_{xy}\, m(J/\psi)}{p_T(J/\psi)}$.

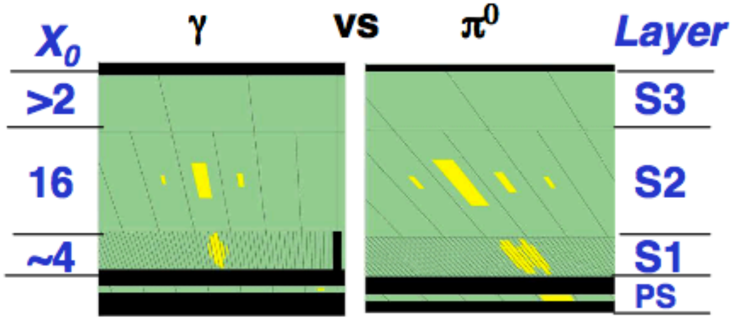


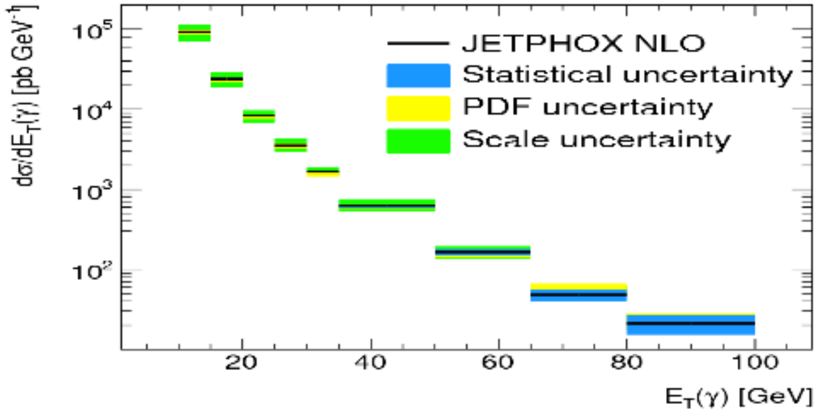
Comparison limited by theoritical uncertainties

Photon Reconstruction

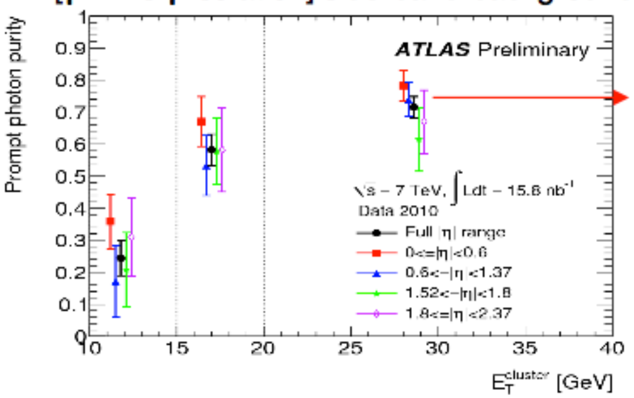
❑ Possible in ATLAS with the fine granular EM calorimeter (π^0 rejection)

- Test perturbative QCD, constraint parton structure function (first step for H,G→γγ search)

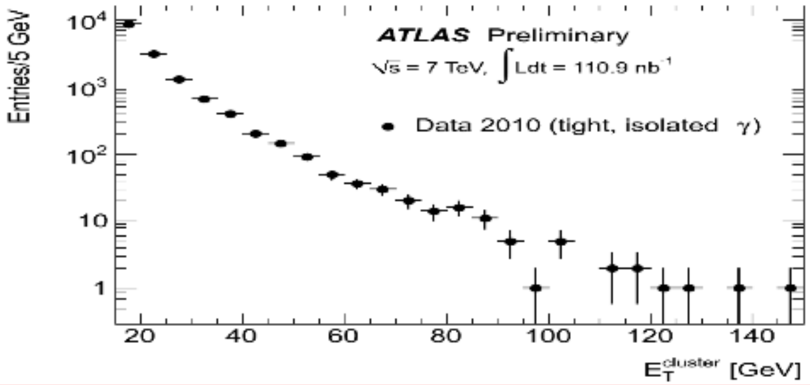




2D [γ ID vs γ Isolation] side-band background subtraction



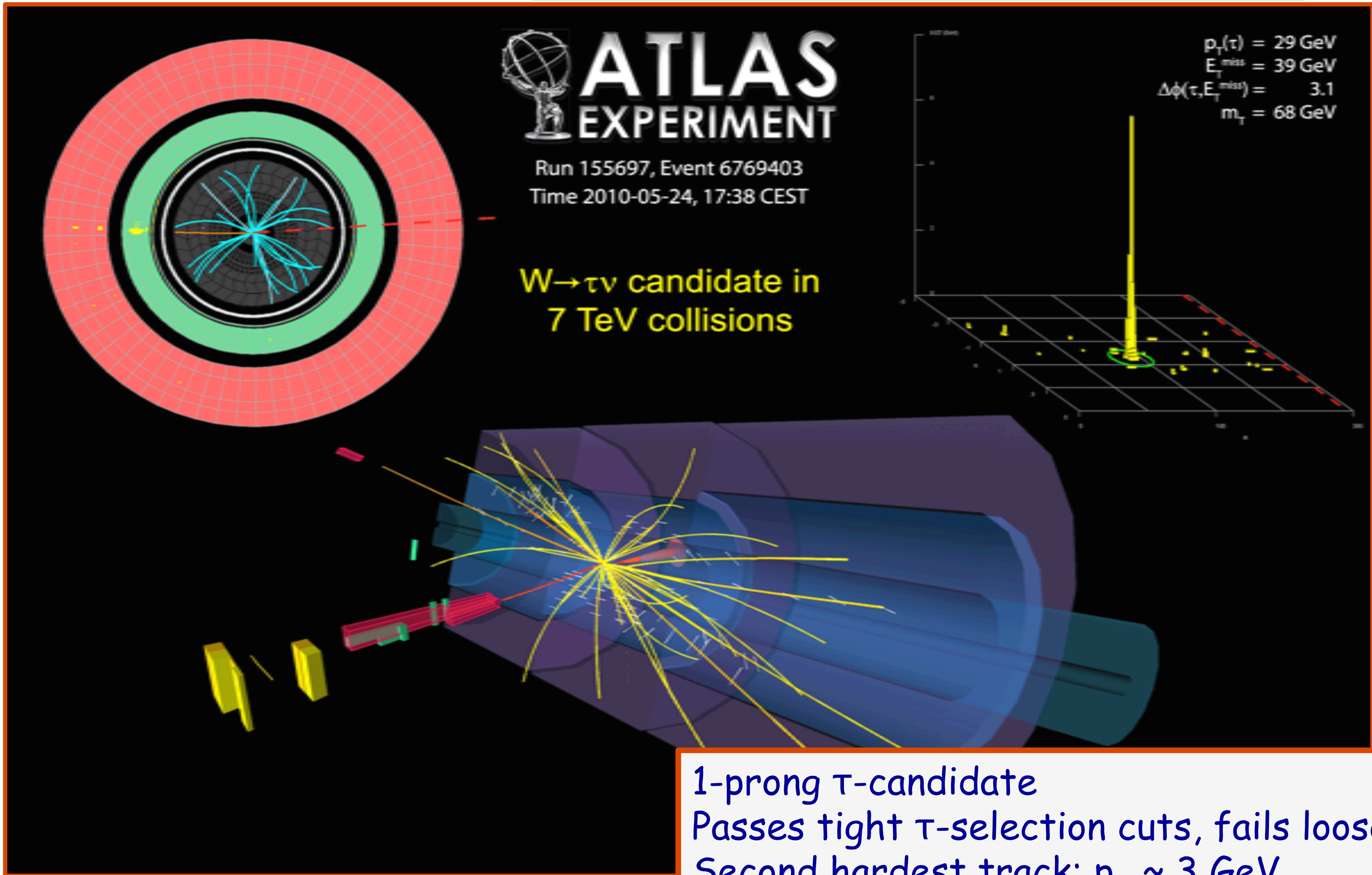
P=72±7 %



Observe ~ 40 prompt γ signal / nb with E_T>20 GeV with a good purity (~70%)

W → τν candidate

W → τν signal more difficult to observe due to softer spectrum and larger backgrounds (jets, W→ eν, Z→ ττ): signal efficiency < 1%, S/B ~ 7



1-prong τ-candidate
Passes tight τ-selection cuts, fails loose e cut
Second hardest track: p_T ~ 3 GeV

The Detectors work well!
Now we can look at the first physics results!!