μ spectrometers at ATLAS and CMS

Our charge:
- Survivability
- Resolution
- Pileup
- Angle/rapidity coverage
- Efficiency
- Jet Resolution
- Jet Separation

6 minutes

The "S" is for "Scary".

ATLAS Resources:

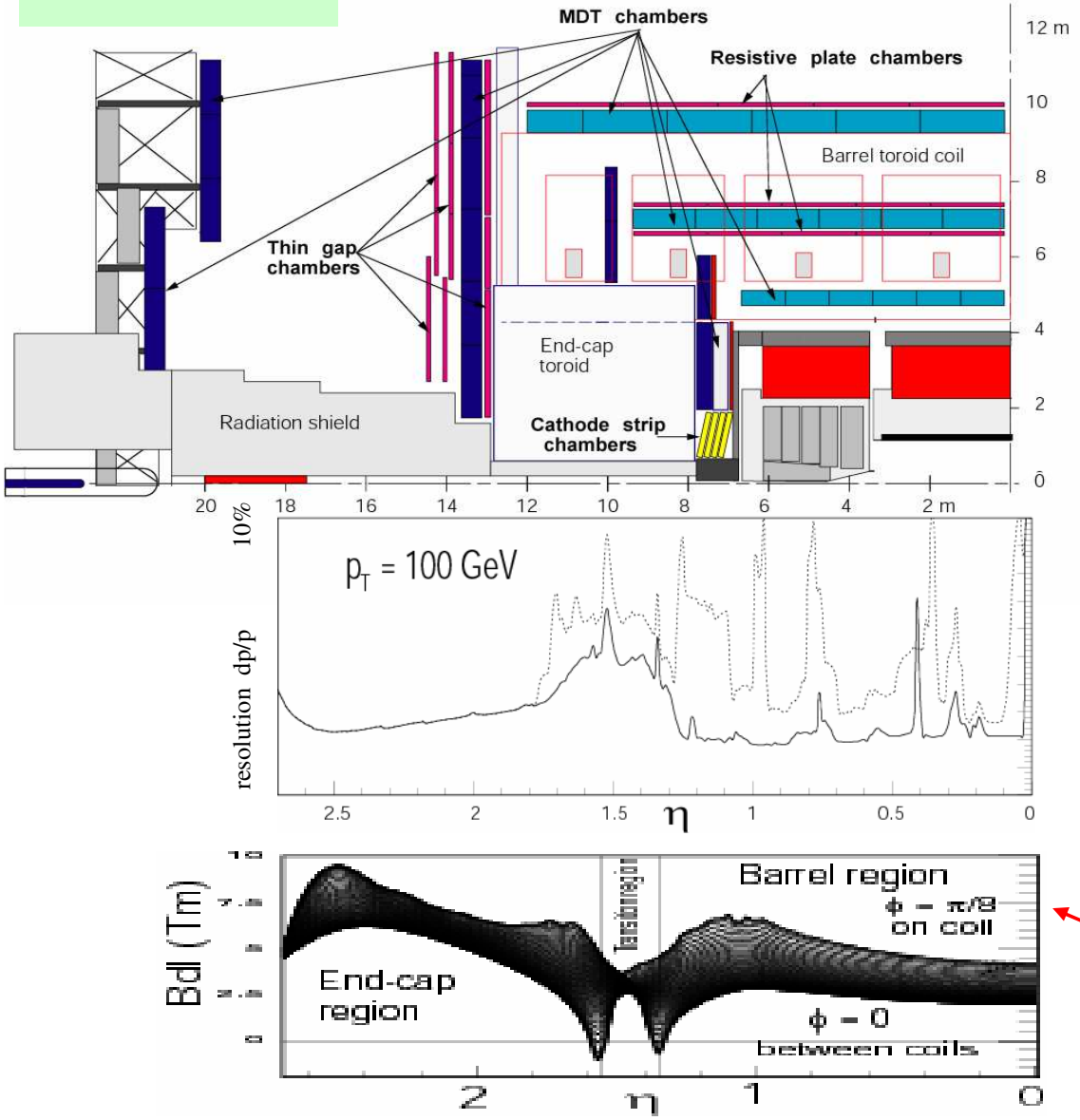
TDR, muon TDR (522 pages)
http://atlas.web.cern.ch/Atlas/internal/tdr.html

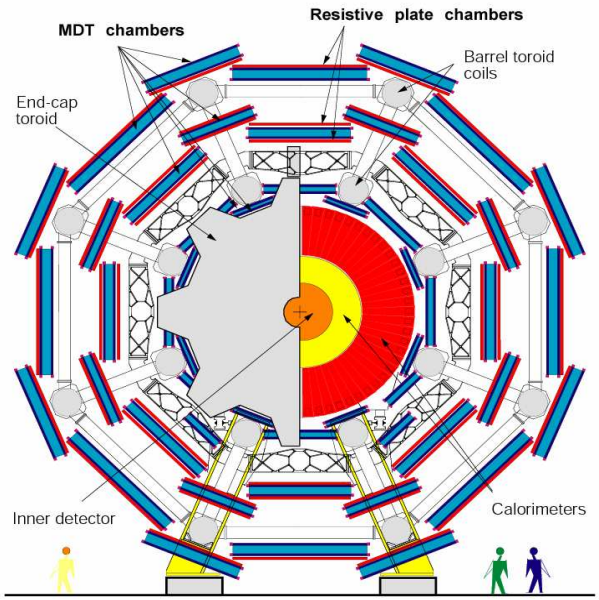
LHCC meeting
http://agenda.cern.ch/fullAgenda.php?ida=a041899
4 muon talks,
+ magnet
+ computing

CMS resources:

LHCC page
http://cmsdoc.cern.ch/docLHCC.shtml
with link to muon TDR (441 pages)
http://cmsdoc.cern.ch/cms/TDR/MUON/muon.html
muon group page
http://cmsdoc.cern.ch/muons.html
LHCC meeting
http://agenda.cern.ch/fullAgenda.php?ida=a043653
3 muon talks
+ magnet

ATLAS





Toroids: barrel, 2 ends

severe field changes at the transition !

ATLAS chambers

acceptance:
tracking: $|\eta| < 2.7$
trigger: $|\eta| < 2.4$

θ is w.r.t beam
η = -ln(tan(θ/2))

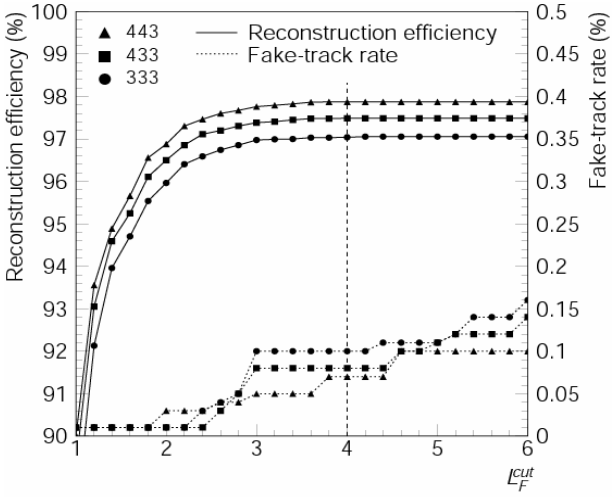
η =			2.4		2.7		1.66	
θ =			10.4^o		7.7^o		21.5^o	
cotan(θ) =	5.4			7.4		2.53		
cos(θ) =	.983			.992		.93		

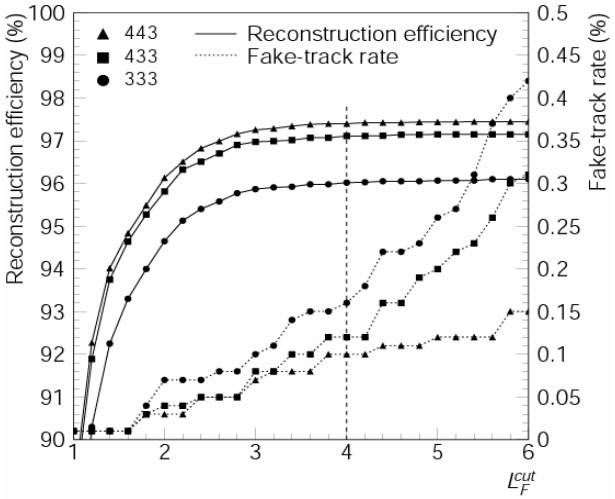
	wire μm	volts	gain	chanls 1000	press bar	time ns	σ(single) μm	σ (s.l.) μm
monitored drift tube	50	3270	2x10^4	372	3	480	80	50
cathode strip chamber	30	2600	1x10^4	61	1	30	60	
							pitch (mm)	
resistive plate chamber	--	8900	?	354	1	1.5	40	
thin gap chamber	50	3100	10^6	320	1	"25"	7-36	
strip				120			14-49	

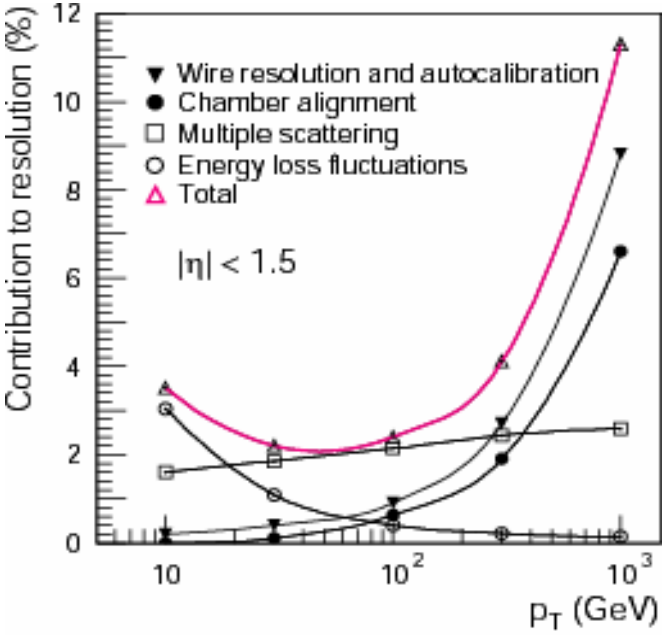
population: 3 radial "stations"

monitored drift tubes	4+4	3+3	3+3	
cathode strip chambers	4+4			very forward
resistive plate chamber	2	2	2	
thin gap chamber	2	2+3		

ATLAS efficiency and resolution



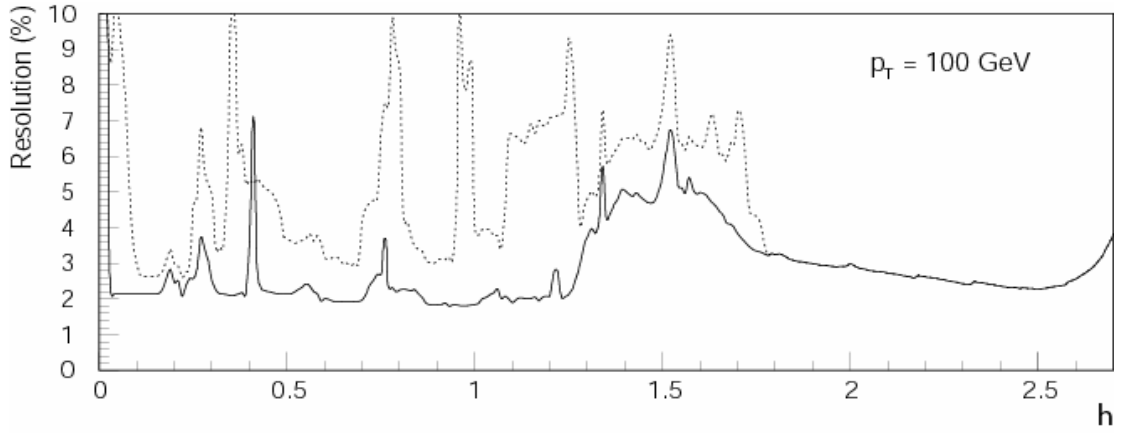




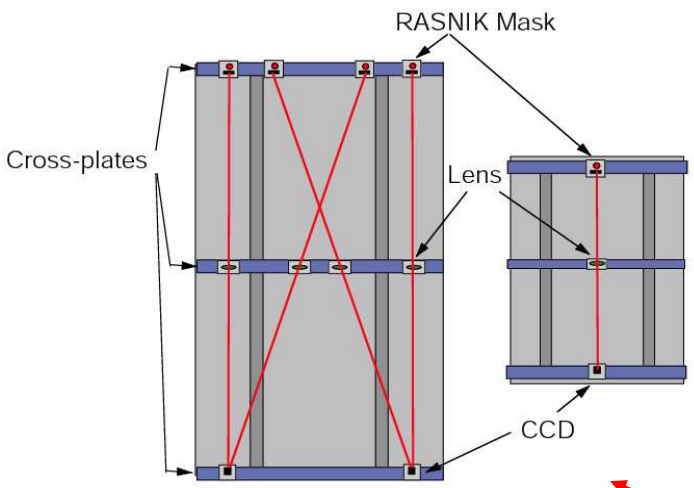
θ is w.r.t beam
η = -ln(tan(θ/2))

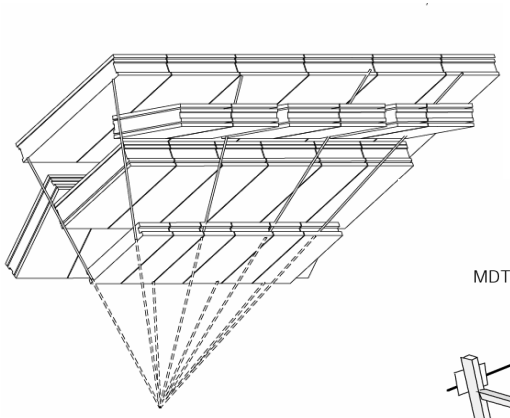
η =	2.4	2.7	1.66
θ =	10.4°	7.7°	21.5°
cotan(θ) =	5.4	7.4	2.53
cos(θ) =	.983	.992	.93

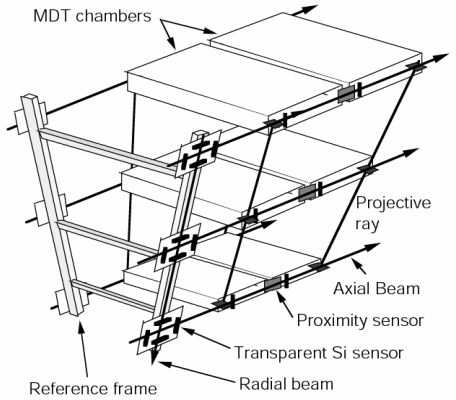
acceptance:
tracking: |η| < 2.7
trigger: |η| < 2.4



ATLAS alignment







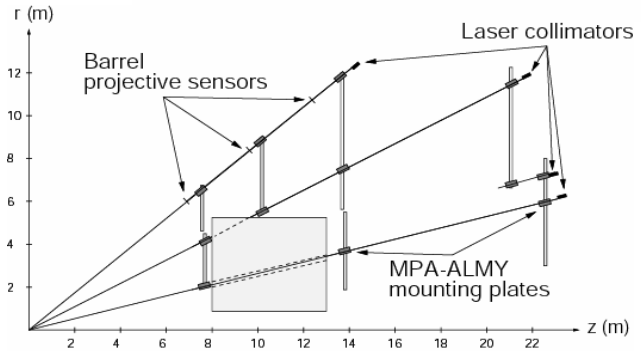
Real-time, internal chamber alignment !

Internal alignment of Monitored Drift Tubes

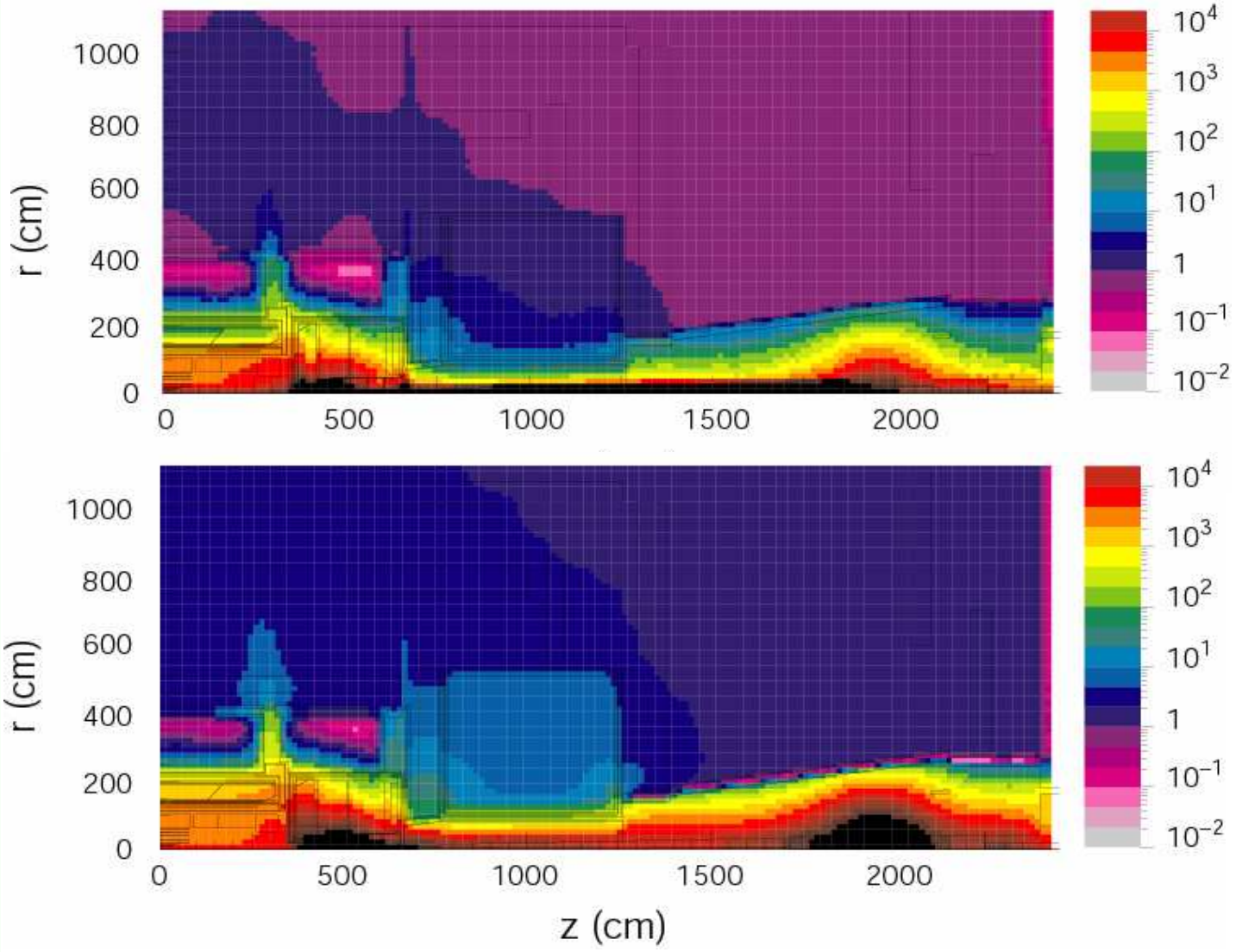
alignment parameters

intrinsic RASNIK sensor	< 1 μm
positioning of sensors	20 μm
global positioning within barrel	300 μm
stability requirements	< 30 μm

overall alignment with tracks



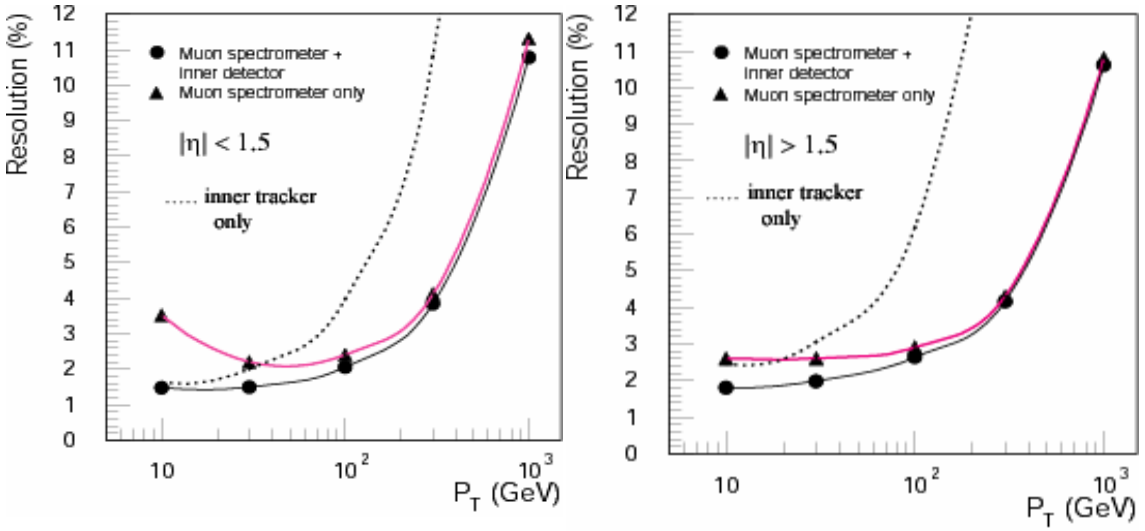
ATLAS, radiation

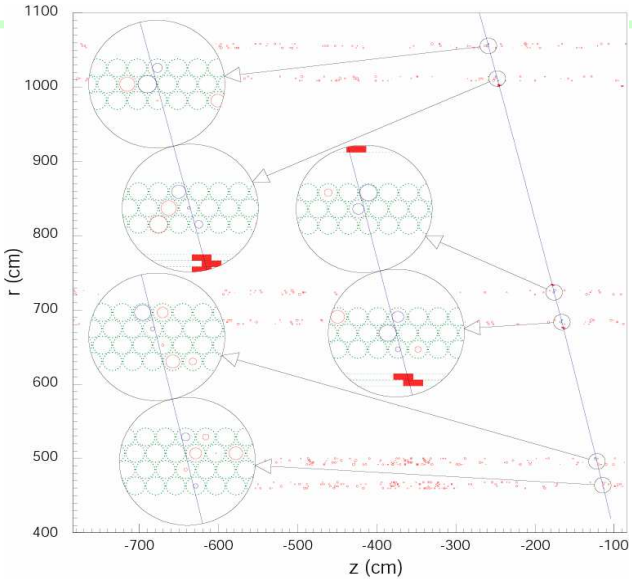


photon flux
kHz/cm^2

neutron flux
kHz/cm^2

ATLAS performance

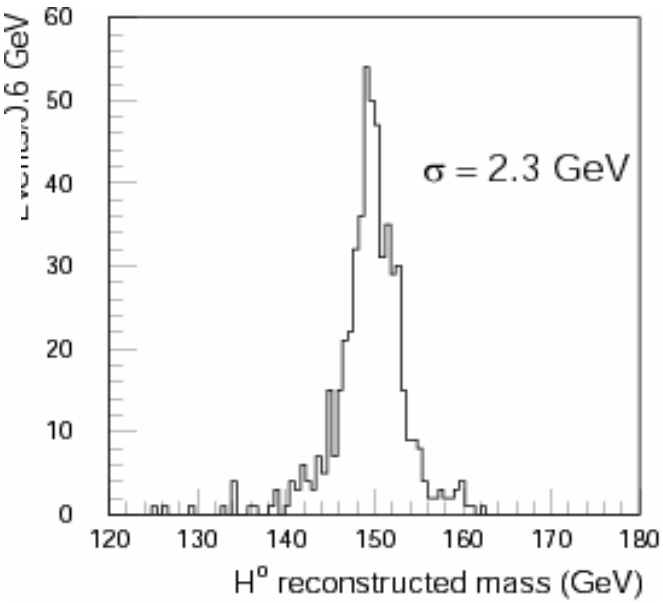




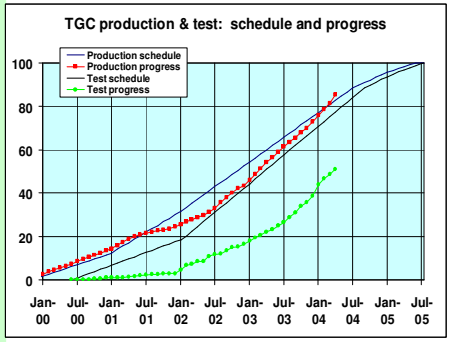
P406: all pat.rec is local

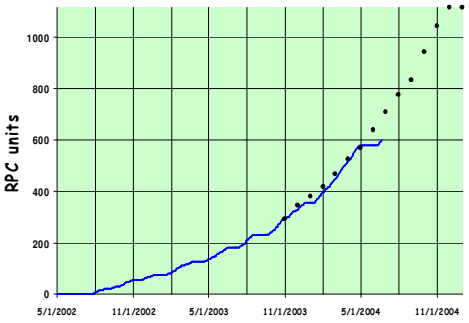
Table 2-1 Principal performance parameters of the muon spectrometer

Parameter	Main physics criteria	Performance desired	Performance actual	Comments
		Momentum measurement		
$\Delta p_T/p_T$ at 20 GeV	$H \rightarrow ZZ^* \rightarrow 4l$	1–2%	~2.5%	Muon spectrometer only limited by energy loss and multiple scattering
			~1.6%	Combined with inner tracker
$\Delta p_T/p_T$ at 75 GeV	$H \rightarrow ZZ \rightarrow 4l$ (MSSM)	1–2%	~2.4%	Muon spectrometer only limited by energy loss and multiple scattering
			~2.0%	Combined with inner tracker



ATLAS, latest review





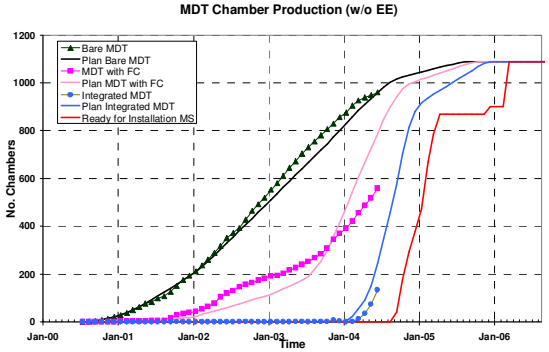
Inner Chamber rail **brackets** have been delivered (392)

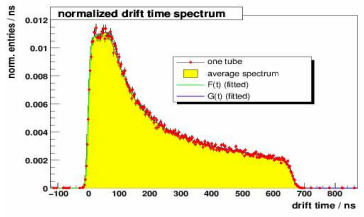
Mid and outer chambers standard **brackets** will be completed in August (448)

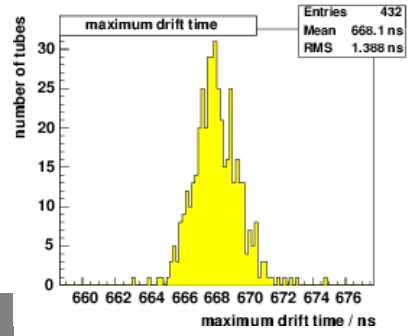
Pre-production of support **brackets** for feet chambers has been made. (Order for 52 to go in weeks).

Order for the reminding 528 **brackets** to go out at the end of summer.

sorry - chamber humor







Chambers are consistent.

T_{max} is longer than expected; does not affect σ.

But,

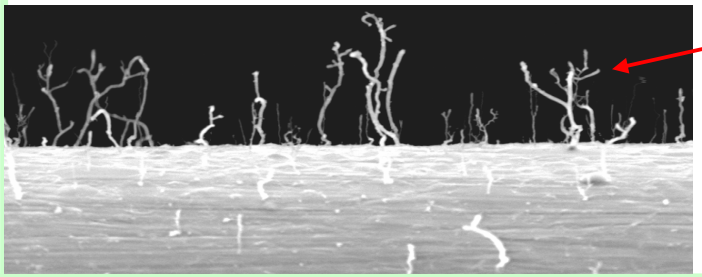
did not present direct measurement of resolution

Individual Drift Time Spectra for each Tube

- Electronics test
- Low noise level
- Single tube response
- r-t relation

Homogeneity of Chamber

- Along each tube
- All tubes in a layer
- All layers



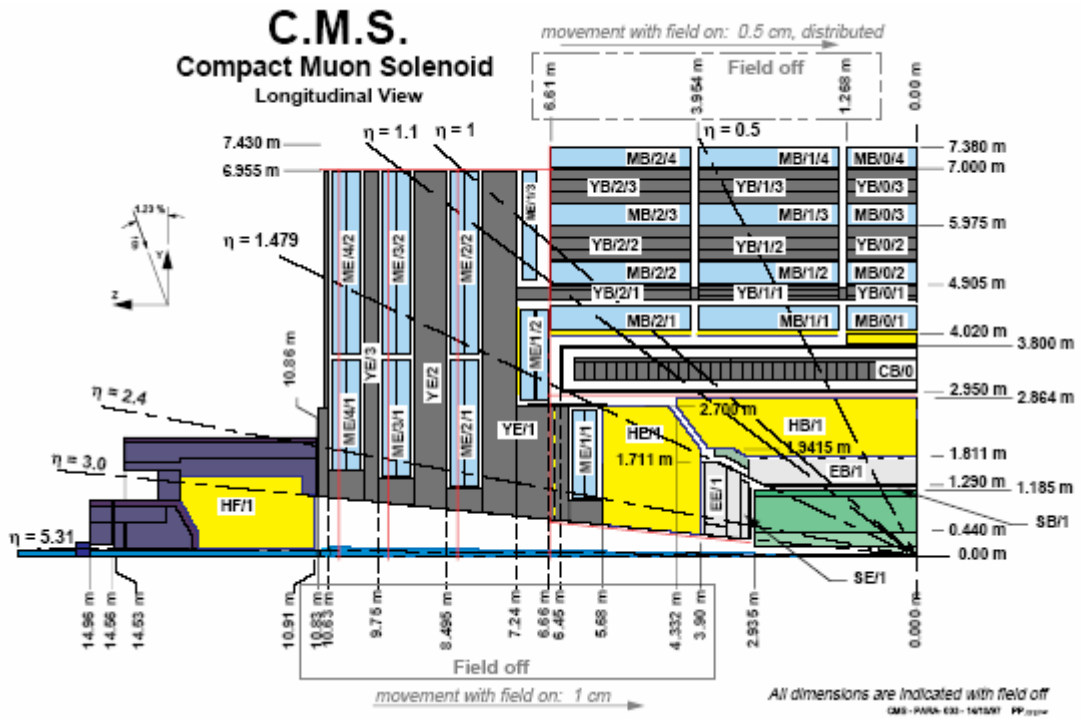
Well, that is honest !

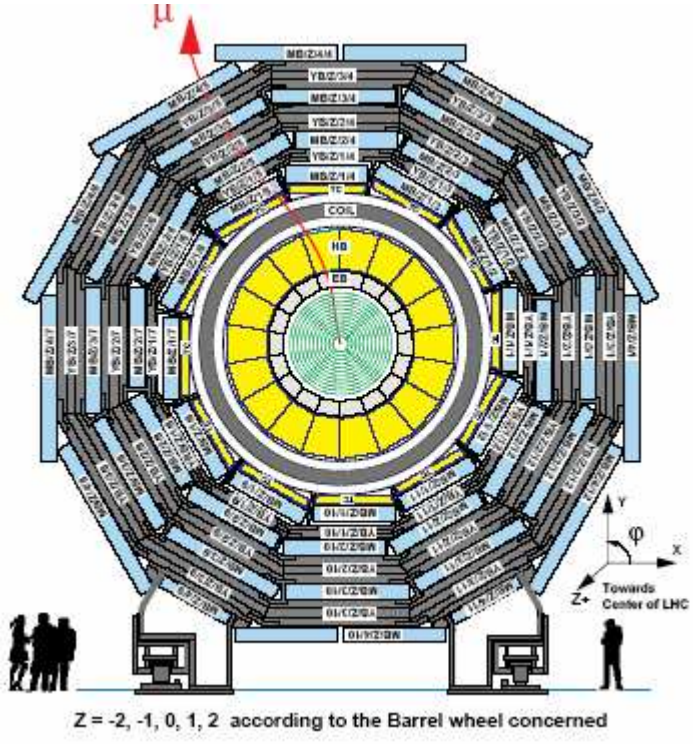
•12 MDT tubes (10%) show slight loss in gain within first 10 cm from gas inlet; no ageing in remaining MDTs.

• Pulse height loss developed within first 4 weeks of operation, afterwards: stable plateau

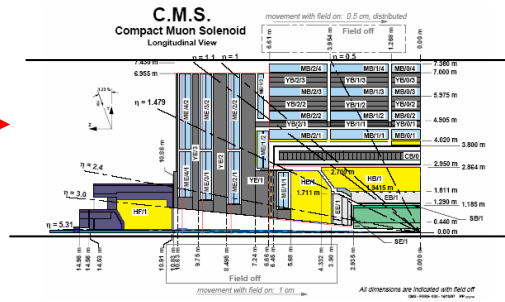
• Ageing, as in previous study, caused by Si-O needles on the anode wire

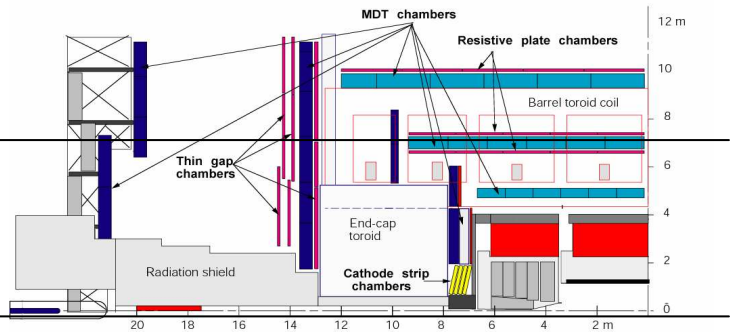
CMS





CMS, side-by-side with ATLAS !





CMS, chambers

acceptance:
tracking: $|\eta| < 2.4$
trigger w/RPC: $|\eta| < 2.1$

θ is w.r.t beam
η = -ln(tan(θ/2))

η =	2.1	2.4	1.66
θ =	14.0^O	10.4^O	21.5^O
cotan(θ) =	4.0	5.4	2.53
cos(θ) =	.970	.983	.93

	wire μm	volts	gain	chanls 1000	press bar	time ns	σ(single) μm	σ(s.l.) μm
drift tube				195		400	250	100-150
cathode strip chamber	30	3000		273		50		75-150
	50	4100						
anode (2.5 10^6 wires)…..…..……210								(1700-6000)
resistive plate chamber	--		9000	160		3	pitch 10-40mm	

population: 4 radial "stations"

drift tubes	4rϕ +4z +4rϕ	4rϕ +4z +4rϕ	4rϕ +4z +4rϕ	4rϕ +4z +4rϕ
cathode strip chambers	3	2	2	2
resistive plate chamber	2	2	1	1 barrel
	1	1	1	1 forward

CMS efficiency and resolution

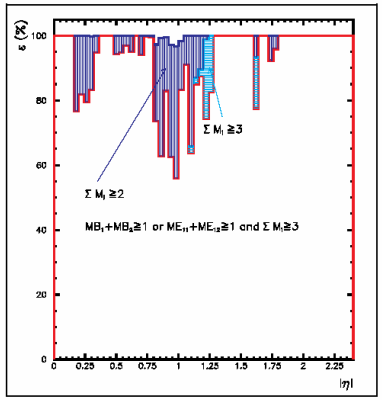


Fig. 2.1.2: Muon system geometrical acceptance shown for the following three requirements: three or more stations, including at least one of the first two barrel stations or the first endcap station; any three stations; and any two stations.

Efficiencies in the barrel region ($0 \leq |\eta| < 0.8$) for track fitting in the stand-alone muon system with the vertex constraint for several values of p_T by the number of track segments successfully used.

	Track losses (%)		Successful track fits in barrel (%)				Resolution
p_T (GeV)	Fewer than 2 segments	Failure of fit	Number of track segments 2	3	≥4	Total	$\Delta p_T/p_T$ (%)
1000	6.2%	20.4%	27.6%	32.5%	13.3%	73.4%	18.6%
500	3.8%	12.8%	29.4%	34.2%	19.8%	83.4%	15.2%
300	3.2%	7.2%	28.5%	38.6%	22.7%	89.9%	12.3%
100	1.5%	1.1%	31.0%	39.5%	26.9%	97.4%	9.3%
10	5.0%	11.6%	33.4%	32.6%	17.4%	83.4%	8.9%

There seams to be some loss here,
but the text acknowledges
there is refinement to be done in the
pattern recognition

CMS alignment

Alignment design parameters and component statistics.

Intrinsic sensor accuracy	<5 μm
Accuracy of barrel chamber positioning	<150-350 μm
Accuracy of endcap chamber positioning	<75-200 μm
Number of Rasnik systems	12
Number of MPA sensors	546
Number of video-camera detectors	612
Number of proximity measurements	1404

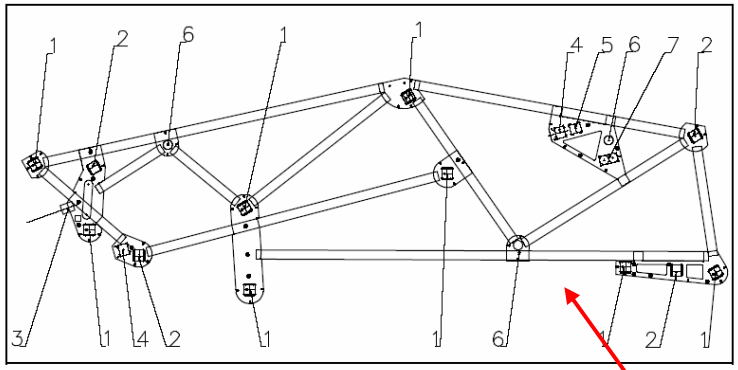


Fig. 7.2.3: The design of the 3/-/1 MAB. 1: Camera box for chamber measurement; 2: Camera box for diagonal connection; 3: Camera box for z measurement; 4: Transparent sensors for the link; 5: Tiltmeter; 6: Fixation; 7: Endcap link connection.

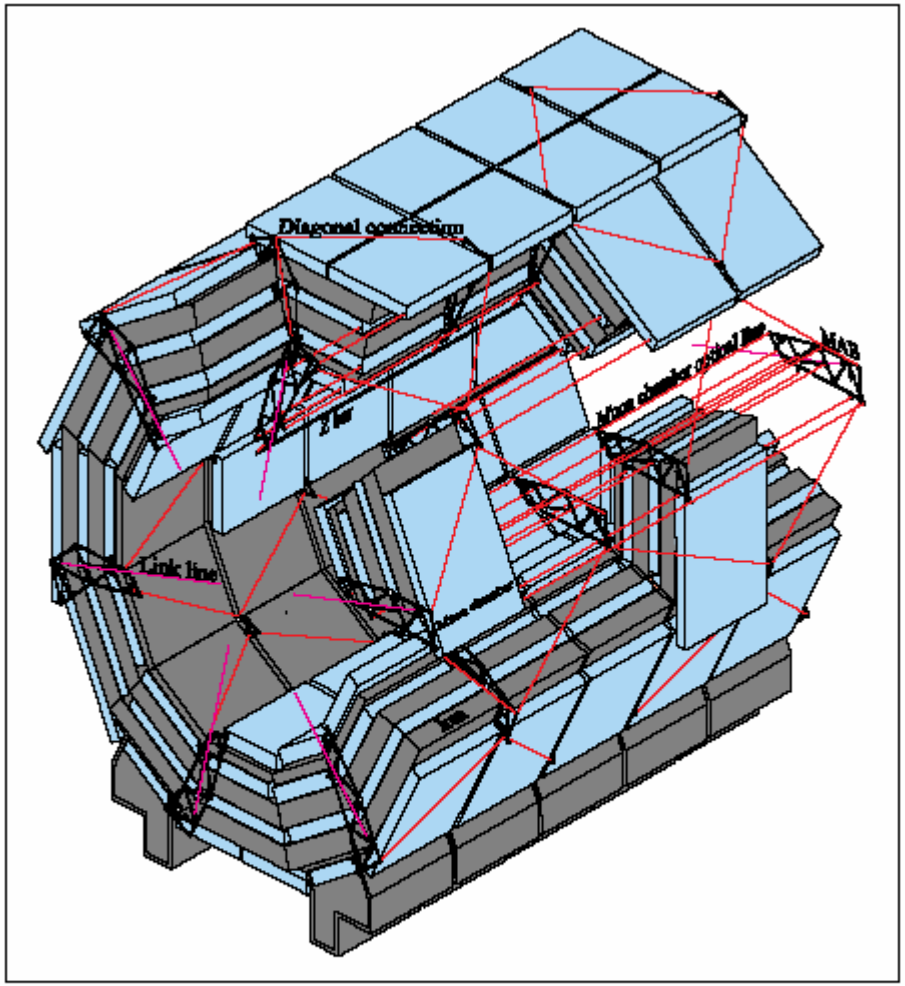
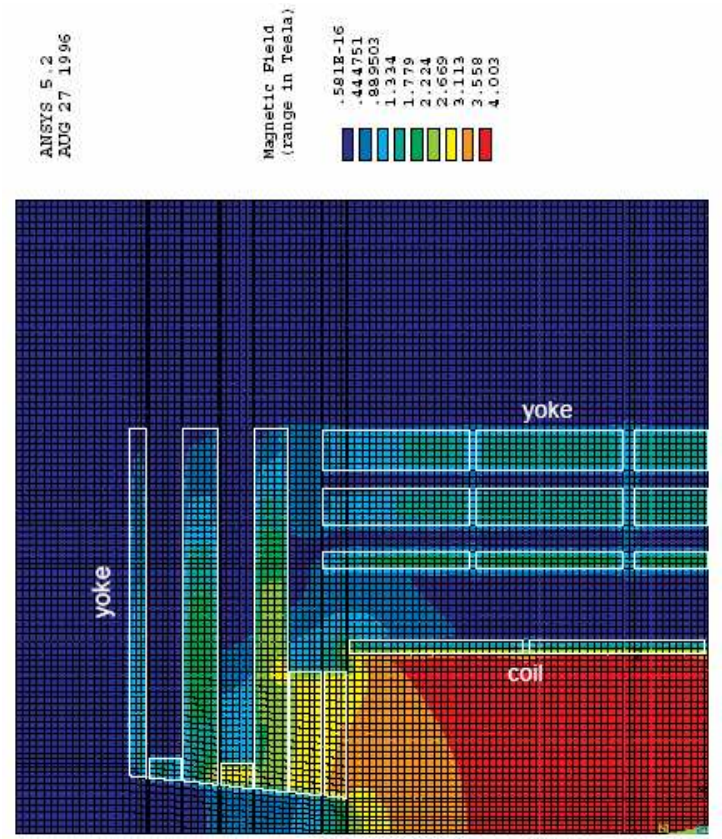


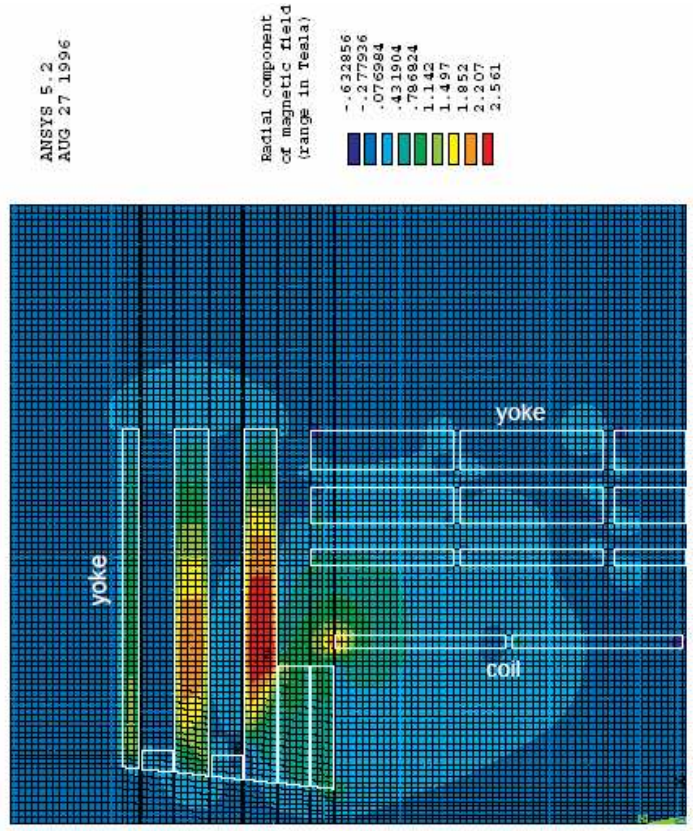
Fig. 7.2.1(color): Barrel Muon position monitoring scheme. The system is based on rigid mechanical structures (36 *MABs* and 6 *Z-bars*), optical connections between them (*diagonal connections*, connection between MABs and Z-bars) and optical connections between MABs and barrel muon chambers *(muon chamber optical lines)*. The position of the Barrel Muon system with respect to the Central Tracker is located via *Link lines* (6 on each side).

I think it is some kind of camera positioning gizmo.

CMS, field



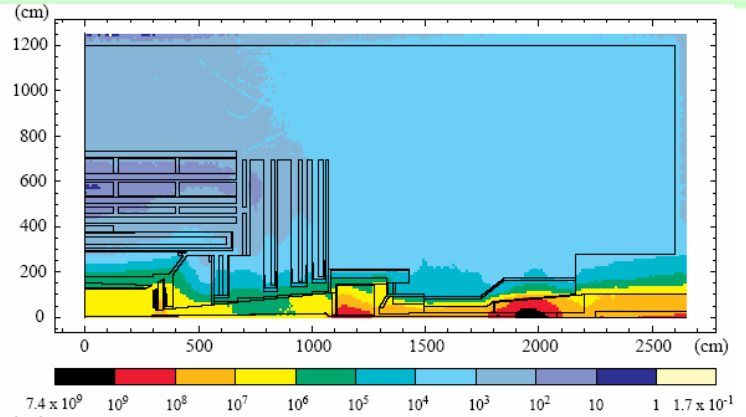
Longitudinal field



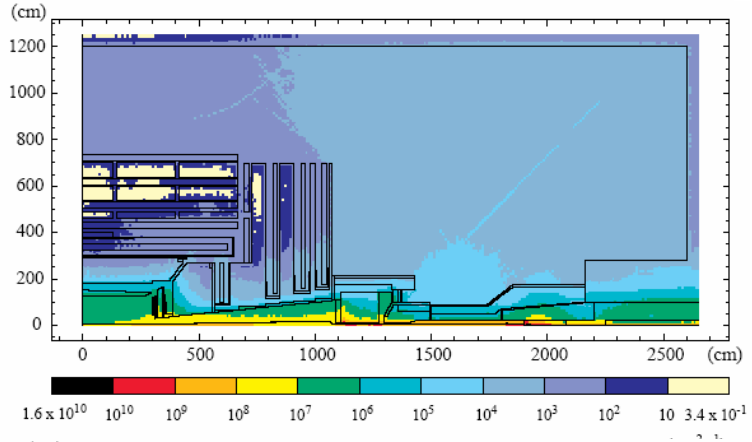
Radial field

CMS, radiation

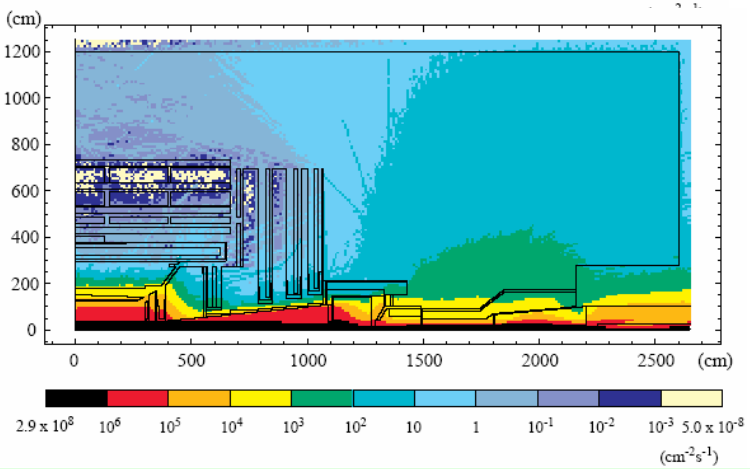
neutron flux
Hz/cm^2



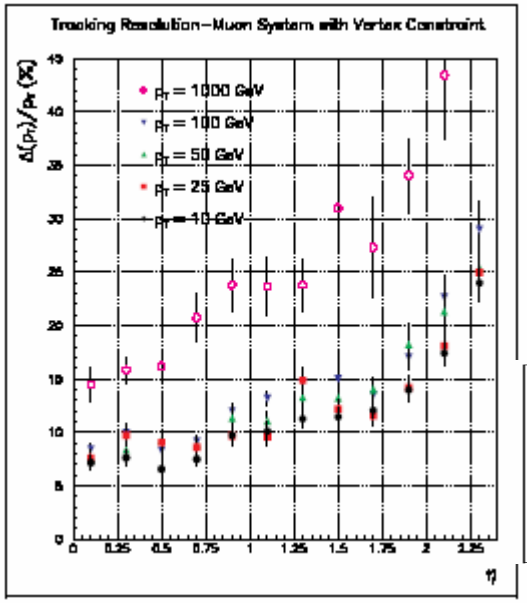
photon flux
Hz/cm^2

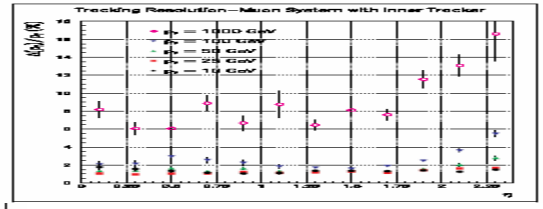


charged flux
Hz/cm^2



CMS, performance





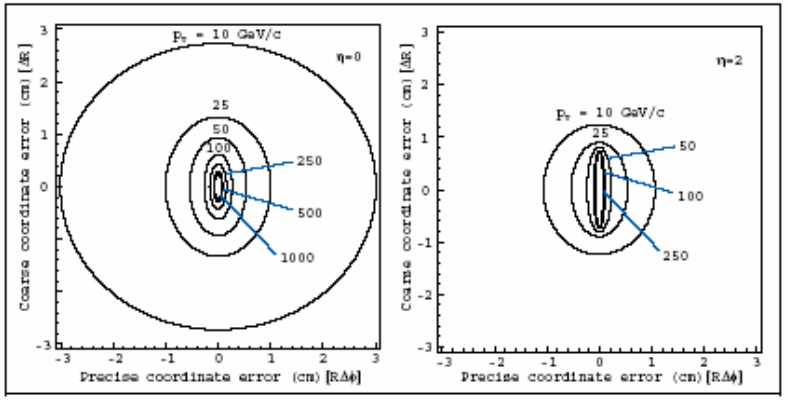


Fig. 2.3.7: Extrapolated position error ellipse for muons at η=0 and η=2.

something to do with matching to inner tracker

The approach is that the resolution is significantly improved by using the inner tracker information.
This is in contrast to ATLAS.

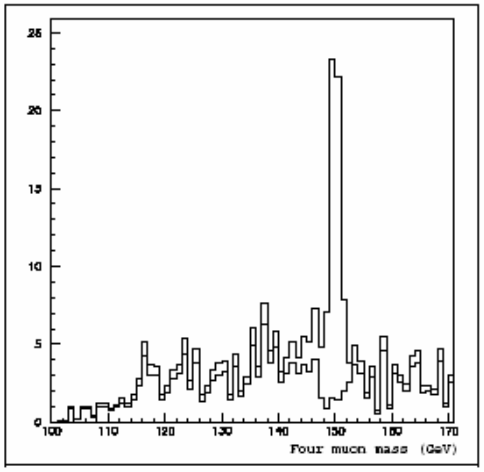
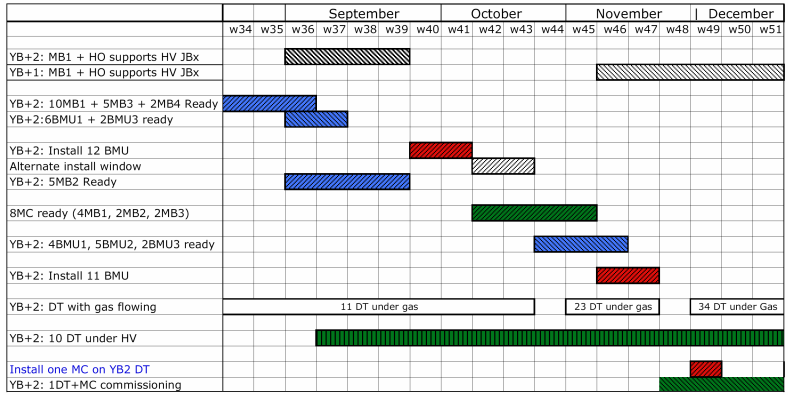
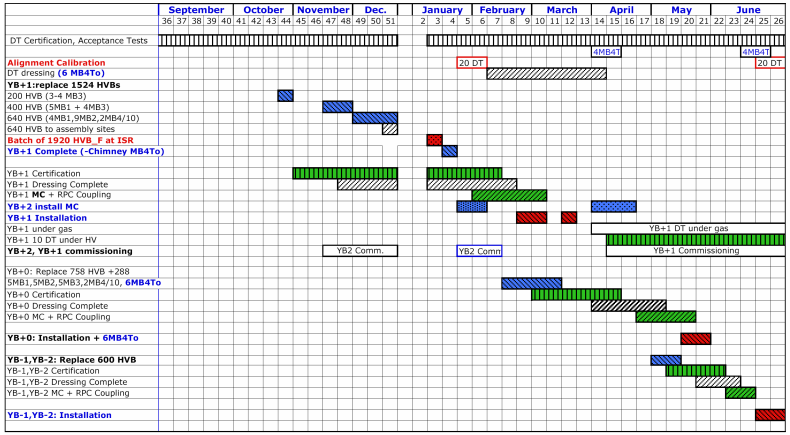
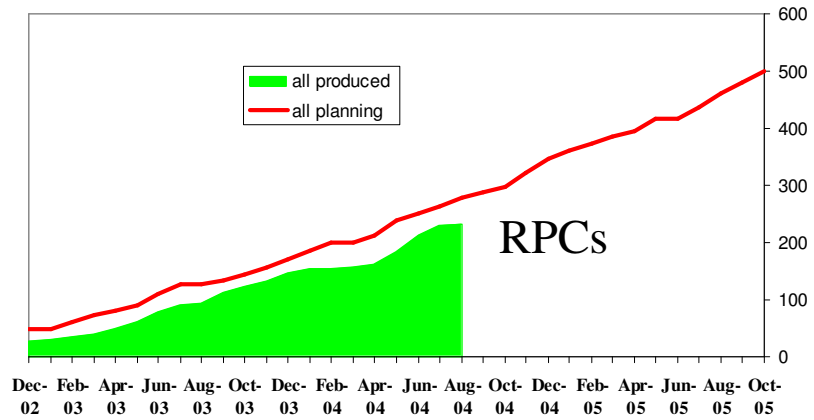


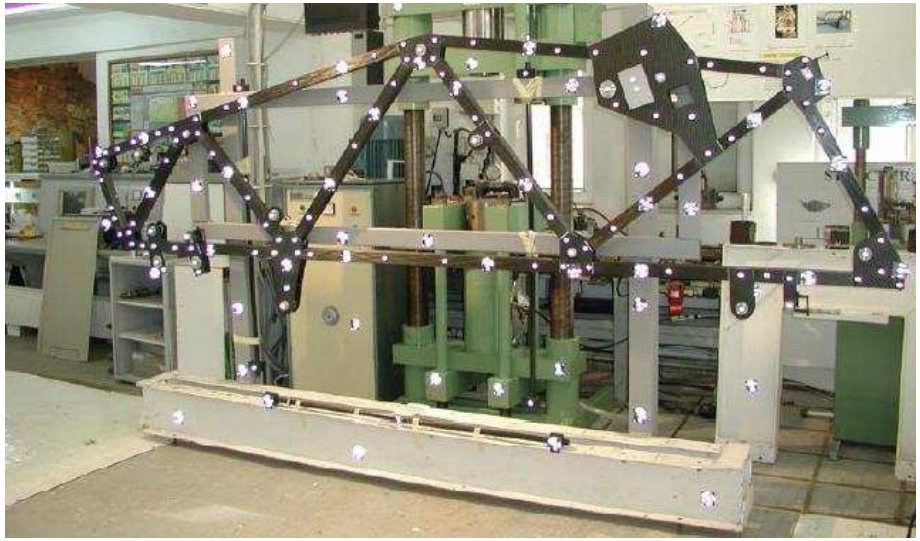
Fig. 2.5.1: Reconstructed mass distribution with background of H^0 (150 GeV) → ZZ*, ZZ* → $\mu^+\mu^-\mu^+\mu^-$ for L = 10^5 pb^{-1}.

CMS, latest review









Many charts !
There is a picture of the alignment thing.

But,
I did not find anything on
reconstruction efficiency refinements.