CMS

Compact Muon Solenoid

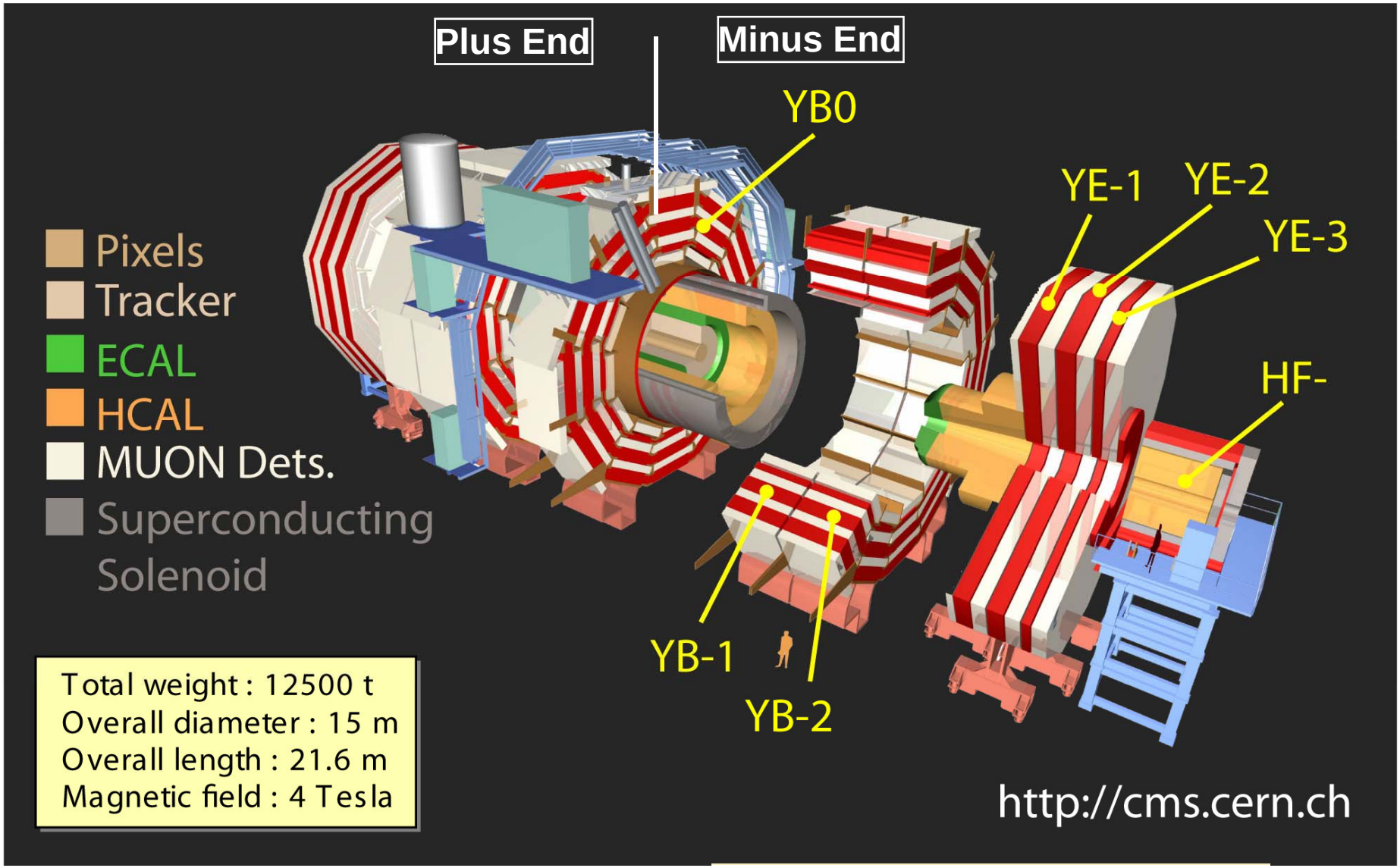
Status
RRB 11 Nov 08

Progress since last RRB
Commissioning Prior to First Beam
First Beam & Observations
Outlook

T. Virdee
CERN/Imperial College

CERN-RRB-2008-096

The CMS Detector



The CMS experiment at the CERN LHC 2008 JINST 3 S08004

The CMS Collaboration

AACHEN-1, AACHEN-3A, AACHEN-3B, ADANA-CUKUROVA, ANKARA-METU, ANTWERPEN, ATHENS, ATOMKI, AUCKLAND, BARI, BEIJING-IHEP, BOGAZICI, BOLOGNA, BOSTON-UNIV, BRISTOL, BROWN-UNIV, BRUNEL, BRUSSEL-VUB, BRUXELLES-ULB, BUDAPEST, CALTECH, CANTERBURY, CARNEGIE-MELLON, CATANIA, CCCS-UWE, CERN, CHANDIGARH, CHEJU, CHICAGO, CHONNAM, CHUNGBUK, CHUNGLI-NCU, COLORADO, CORNELL, DEBRECEN-IEP, DELHI-UNIV, DEMOKRITOS, DESY, DONGSHIN, DUBLIN-UCD, DUBNA, EINDHOVEN, FAIRFIELD, FERMILAB, FIRENZE, FLORIDA-FIU, FLORIDA-STATE, FLORIDA-TECH, FLORIDA-UNIV, FRASCATI, GENOVA, GHENT, HAMBURG-UNIV, HEFEI-USTC, HELSINKI-HIP, HELSINKI-HUT, HEPHY, IOANNINA, IOWA, IPM, ISLAMABAD-NCP, JOHNS-HOPKINS, KANGWON, KANSAS-STATE, KANSAS-UNIV, KARLSRUHE-IEKP, KHARKOV-ISC, KHARKOV-KIPT, KHARKOV-KSU, KONKUK-UNIV, KOREA-UNIV, KYUNGPOOK, LAPP, LAPPEENRANTA-LUT, LEGNARO, LIP, LIVERMORE, LONDON-IC, LOUVAIN, LYON, MADRID-CIEMAT, MADRID-UNIV, MARYLAND, MEXICO-IBEROAM, MEXICO-IPN, MEXICO-PUEBLA, MEXICO-UASLP, MILANO-BICOCCA, MINNESOTA, MINSK-INP, MINSK-NCPHEP, MINSK-RIAPP, MINSK-UNIV, MISSISSIPPI, MIT, MONS, MOSCOW-INR, MOSCOW-ITEP, MOSCOW-LEBEDEV, MOSCOW-MSU, MOSCOW-RDIPE, MUMBAI-BARC, MYASISHCHEV, NAPOLI, NEBRASKA, NICOSIA-UNIV, NORTHEASTERN, NORTHWESTERN, NOTRE DAME, NUST, OHIO-STATE, OVIEDO, PADOVA, PAVIA, PEKING-UNIV, PERUGIA, PISA, POLYTECHNIQUE, PRINCETON, PROTVINO, PSI, PUERTO RICO, PURDUE, PURDUE-CALUMET, RAL, RICE, RIE, RIO-CBPF, RIO-UERJ, RIO-UFRJ, ROCHESTER, ROCKEFELLER, ROMA-1, RUTGERS, SACLAY, SANTANDER, SAO PAULO, SEONAM, SEOUL-EDU, SEOUL-SNU, SHANGHAI-IC, SKK-UNIV, SOFIA-CLMI, SOFIA-INRNE, SOFIA-UNIV, SPLIT-FESB, SPLIT-UNIV, ST-PETERSBURG, STRASBOURG, SUNY-BUFFALO, TAIPEI-NTU, TALLINN, TASHKENT, TBILISI-IHEPI, TBILISI-IPAS, TENNESSEE, TEXAS-TAMU, TEXAS-TECH, TIFR-EHEP, TIFR-HECR, TORINO, TRIESTE, UCDAVIS, UCLA, UCRIVERSIDE, UCSB, UCSD, UNIANDES, VANDERBILT, VILNIUS-ACADEMY, VILNIUS-UNIV, VINCA, VIRGINIA-TECH, VIRGINIA-UNIV, WARSAW-IEP, WARSAW-INS, WARSAW-ISE, WAYNE, WISCONSIN, WONKWANG, YEREVAN, ZAGREB-RUDJER, ZURICH-ETH, ZURICH-UNIV

April 2008: 184 Institutions with about 2930 scientists and engineers

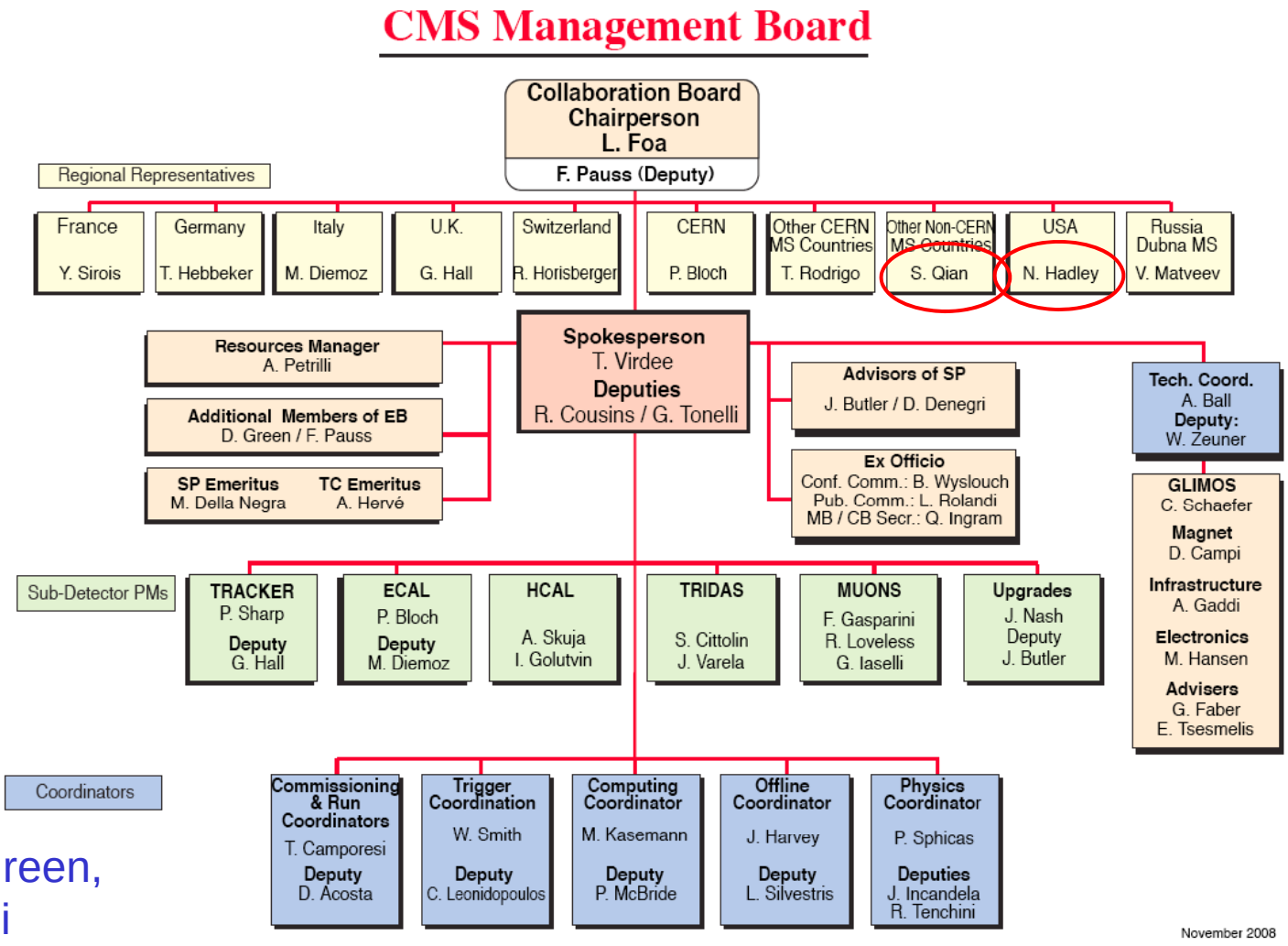
Application for Full Membership (vote in December)

Univ. of Zagreb, Croatia (Mirko Planinic)

Election of the CMS Spokesperson

Mar 2009 for a term of 2 years starting Jan 2010.

CMS Management



From Jan 2009

CB Chairperson: D. Green,
Deputy F. Gasparini

Tracker PM: G.M Bilei

ECAL PM: R. Rusack

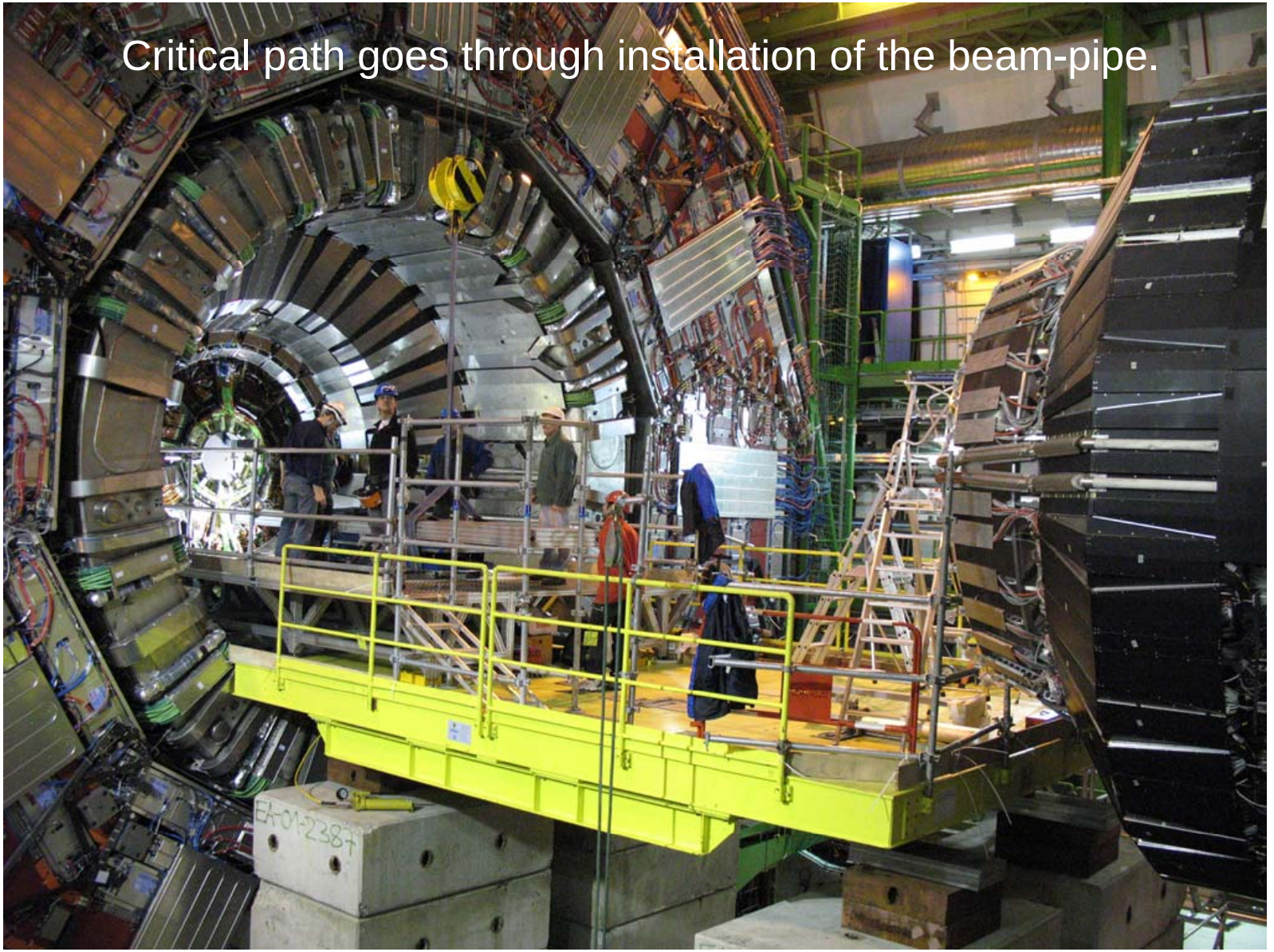
HCAL PM: G. Spalding (from Jun 09)

Muon DT PM: M. Dallavalle

After almost 20 years, from conception, design, construction and commissioning
CMS became a working experiment in September 2008

Illustrate progress towards this major milestone
mostly with photographs

Situation at the Last RRB (Apr 08)



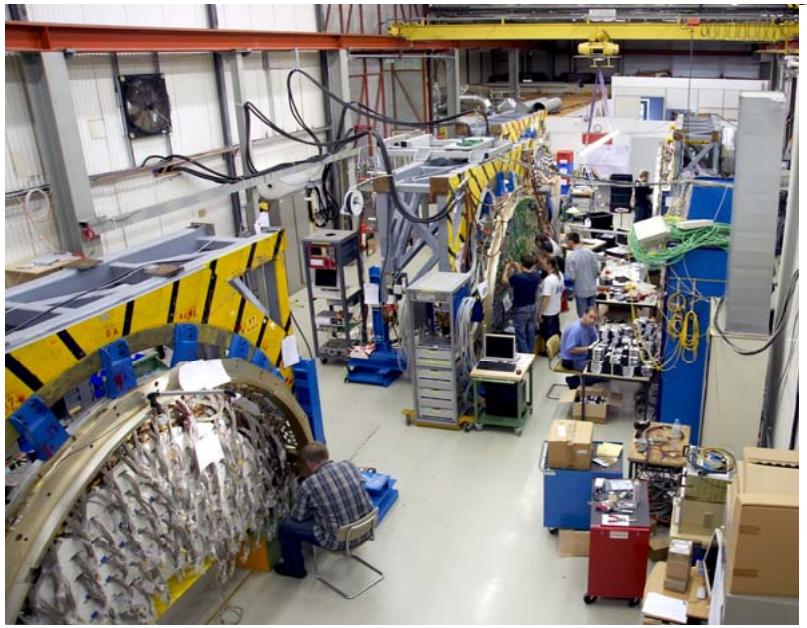
CMS Detector at LHC Startup

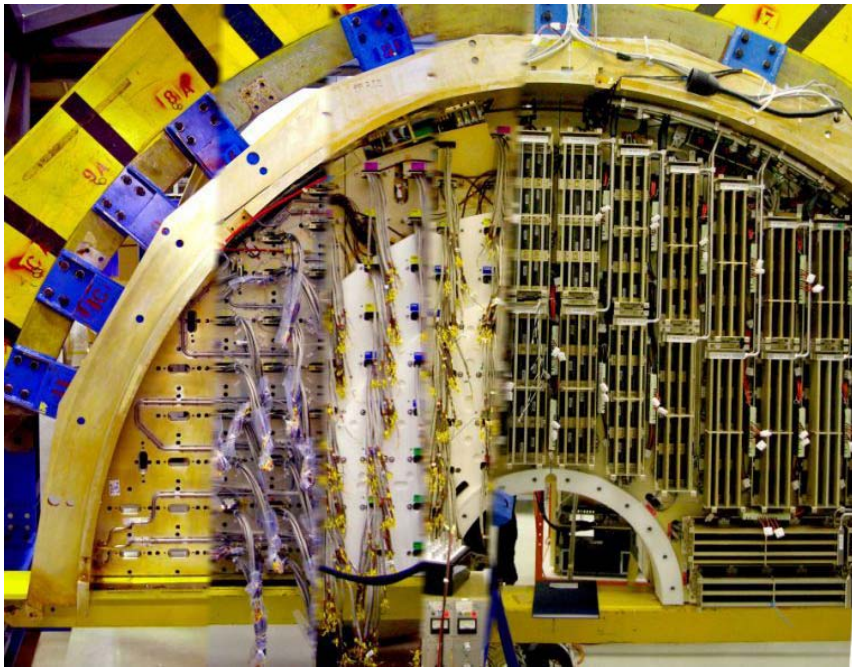
LHC Startup Detector included

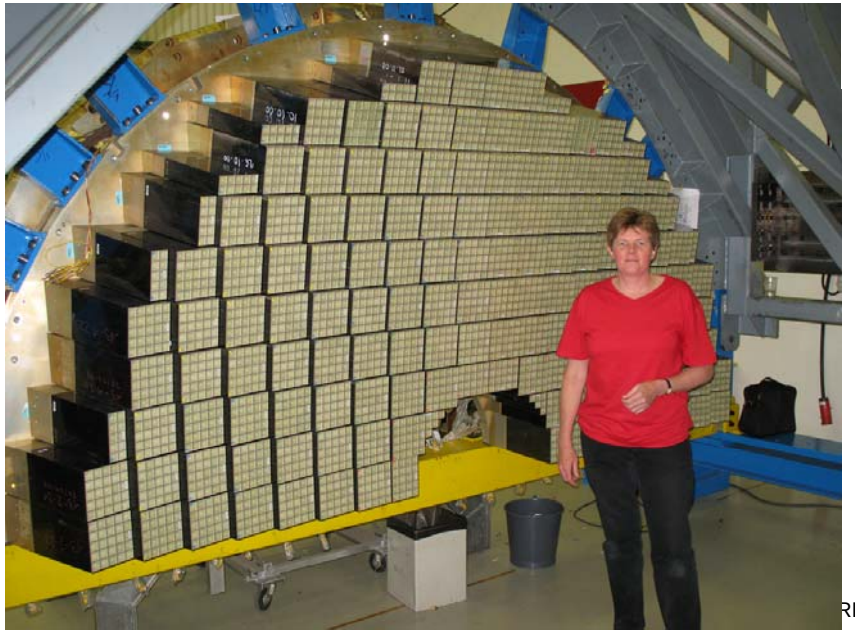
- barrel and endcap pixels, Si strip Tracker,
- barrel and endcap crystals ECAL,
- HCAL (barrel, endcap and forward),
- Muons (DTs, CSCs and RPCs),
- Level-1 Trigger, ~ 40 kHz DAQ

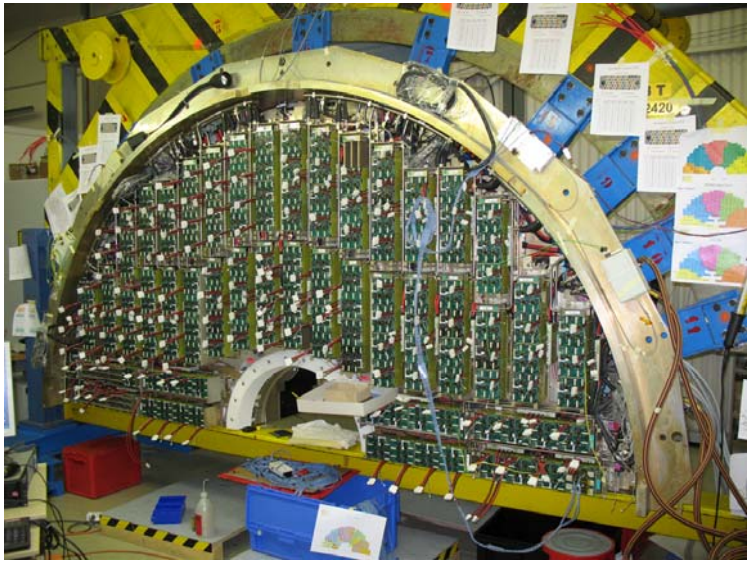
The solenoid and the inner tracking system were kept turned-off for beams

Assembly of ECAL Endcap Dees

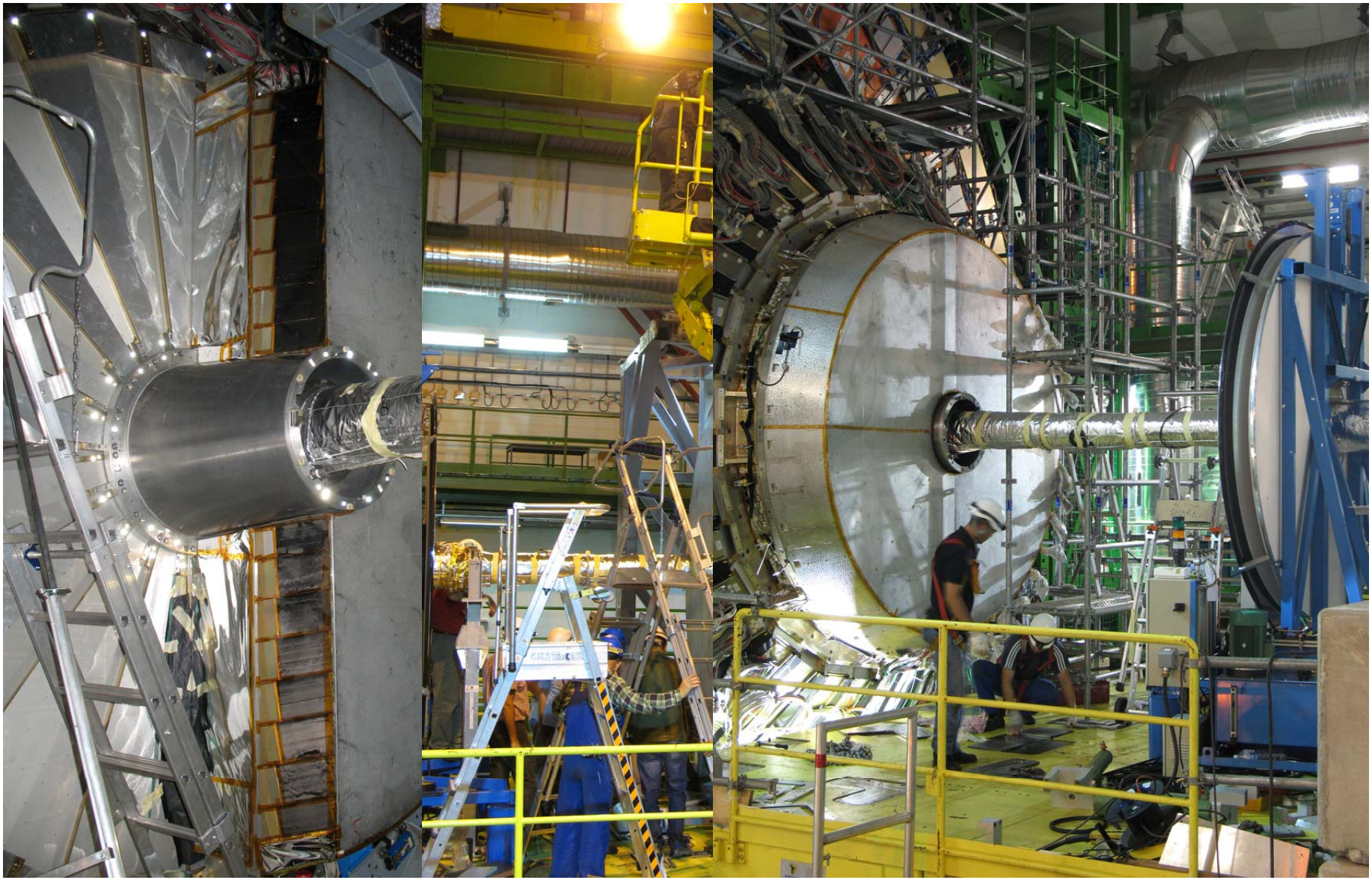




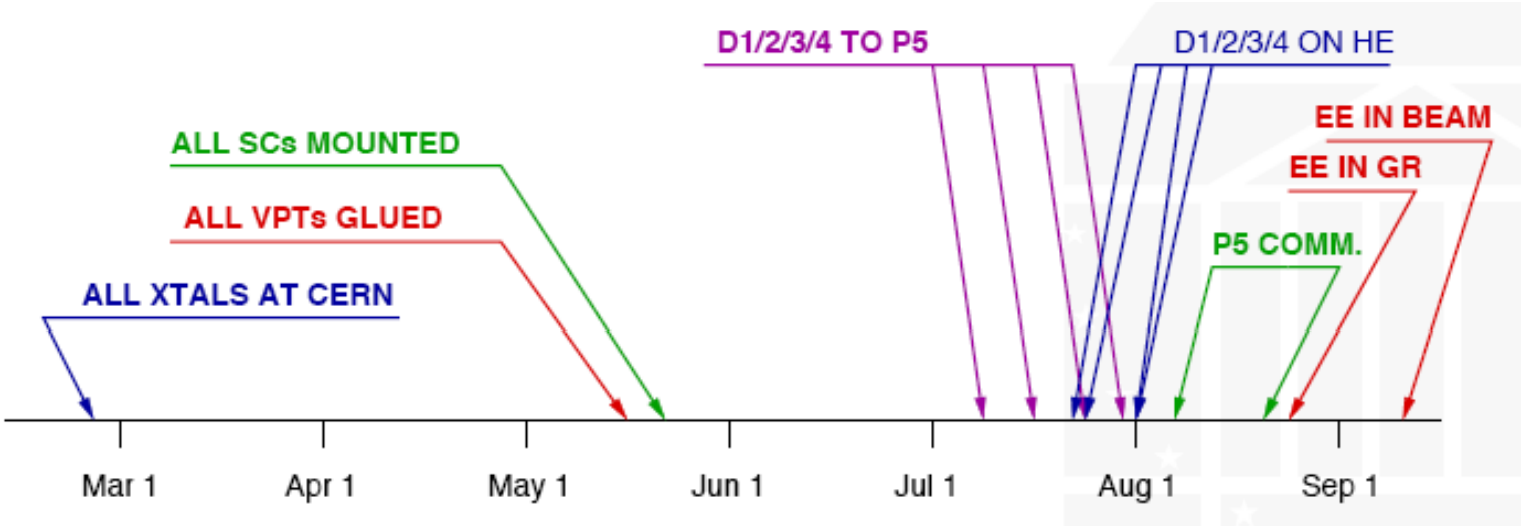




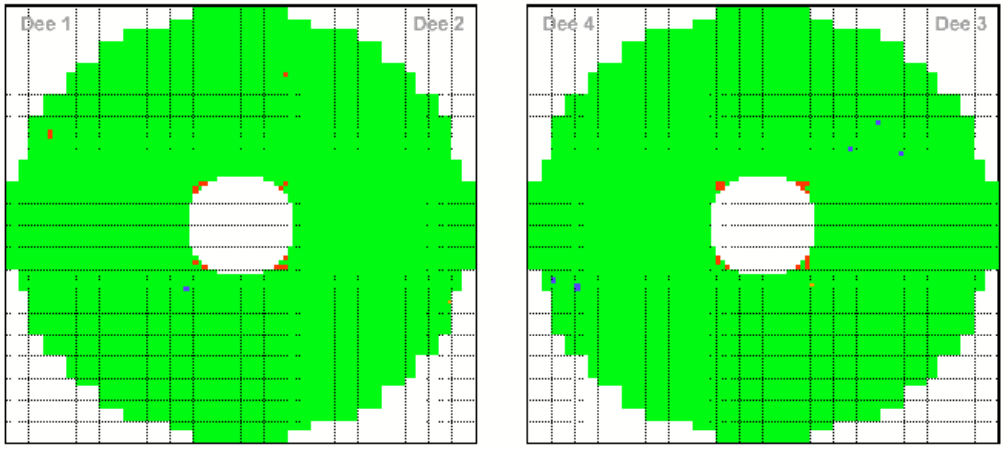
ECAL EE



Completion of the Endcap ECAL Time Sequence

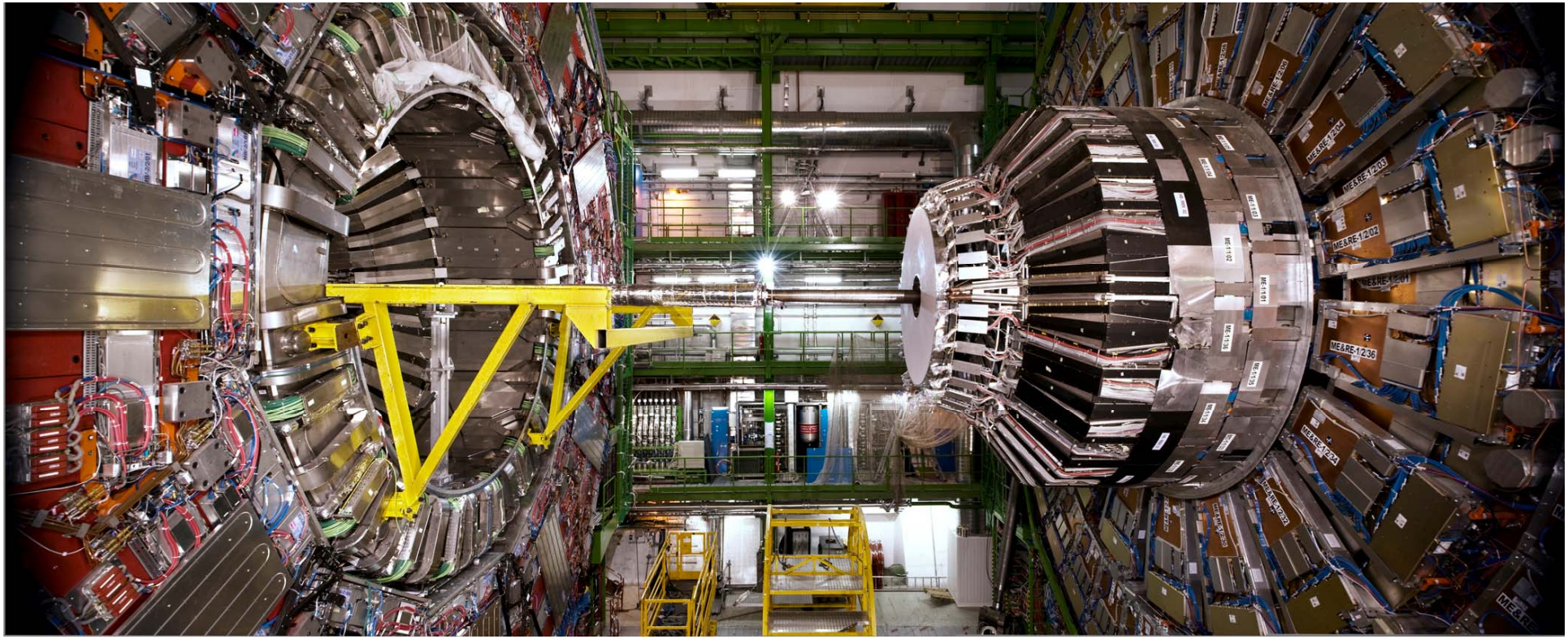


All Channels Operational in Bat 867
Noise Distribution

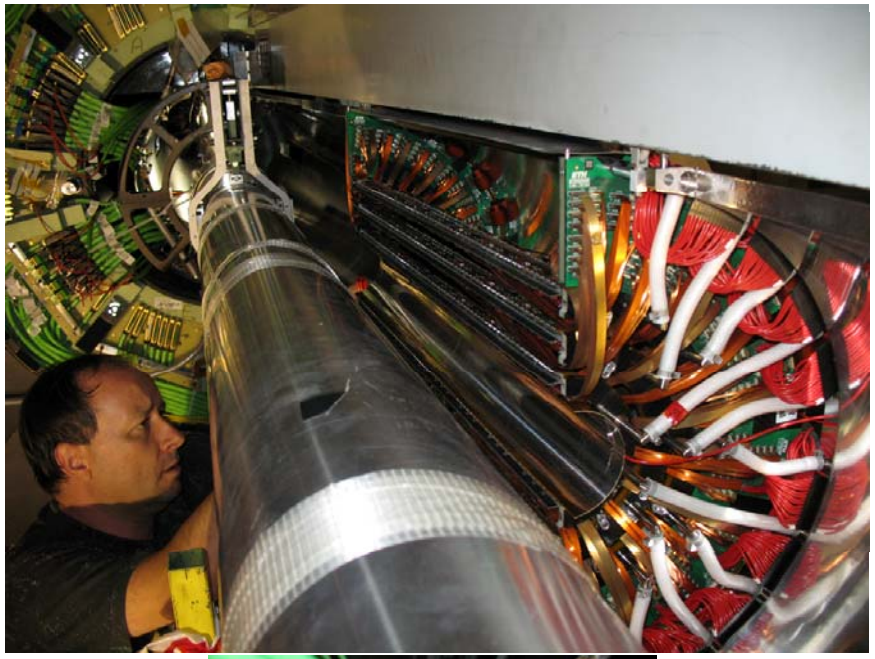


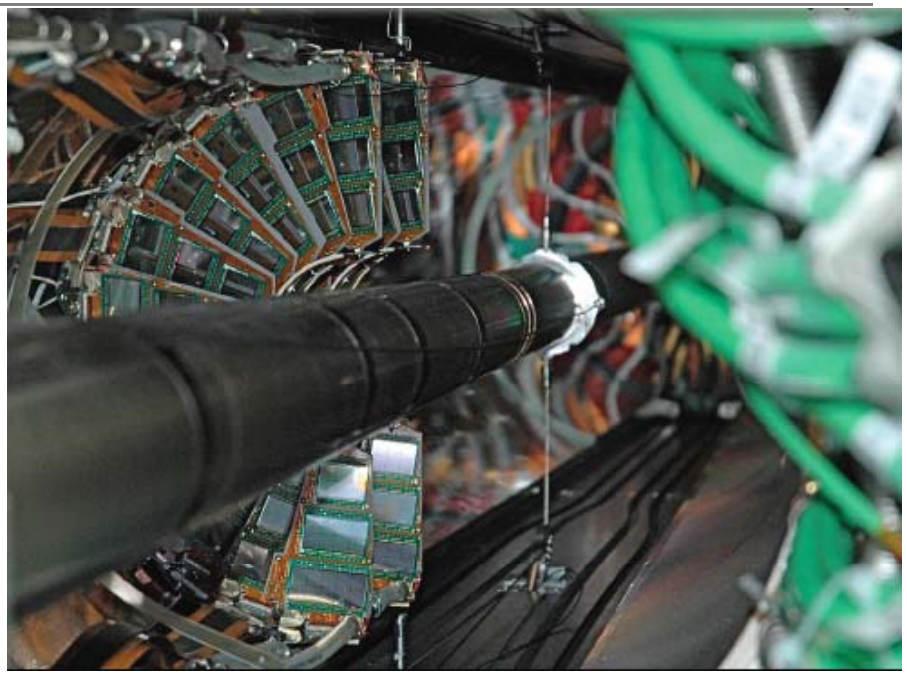
Installation of the Beam-pipe

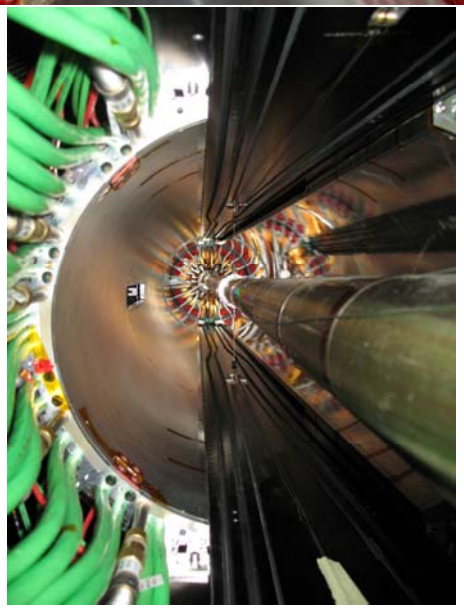
The beam-pipe was installed and baked-out by end June



Barrel & Forward Pixels

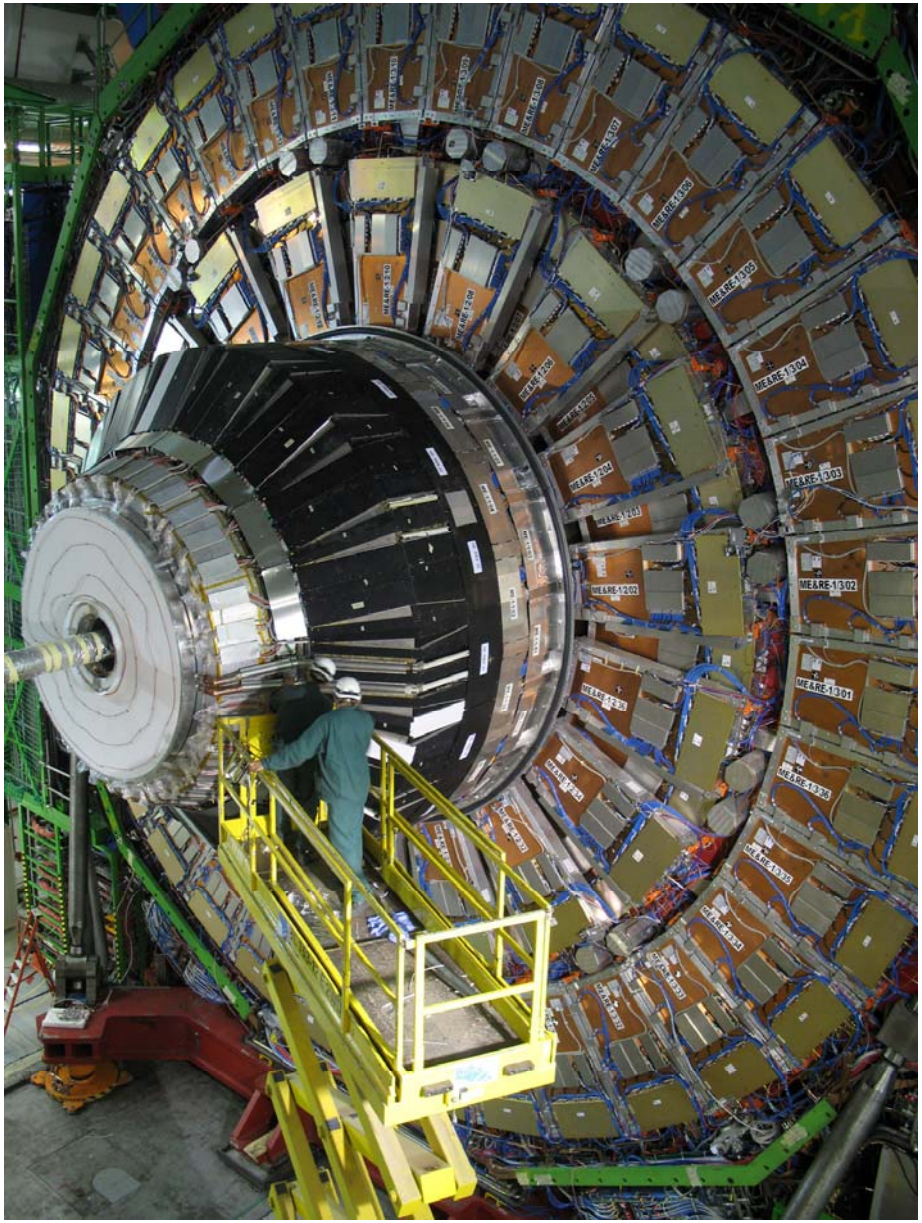


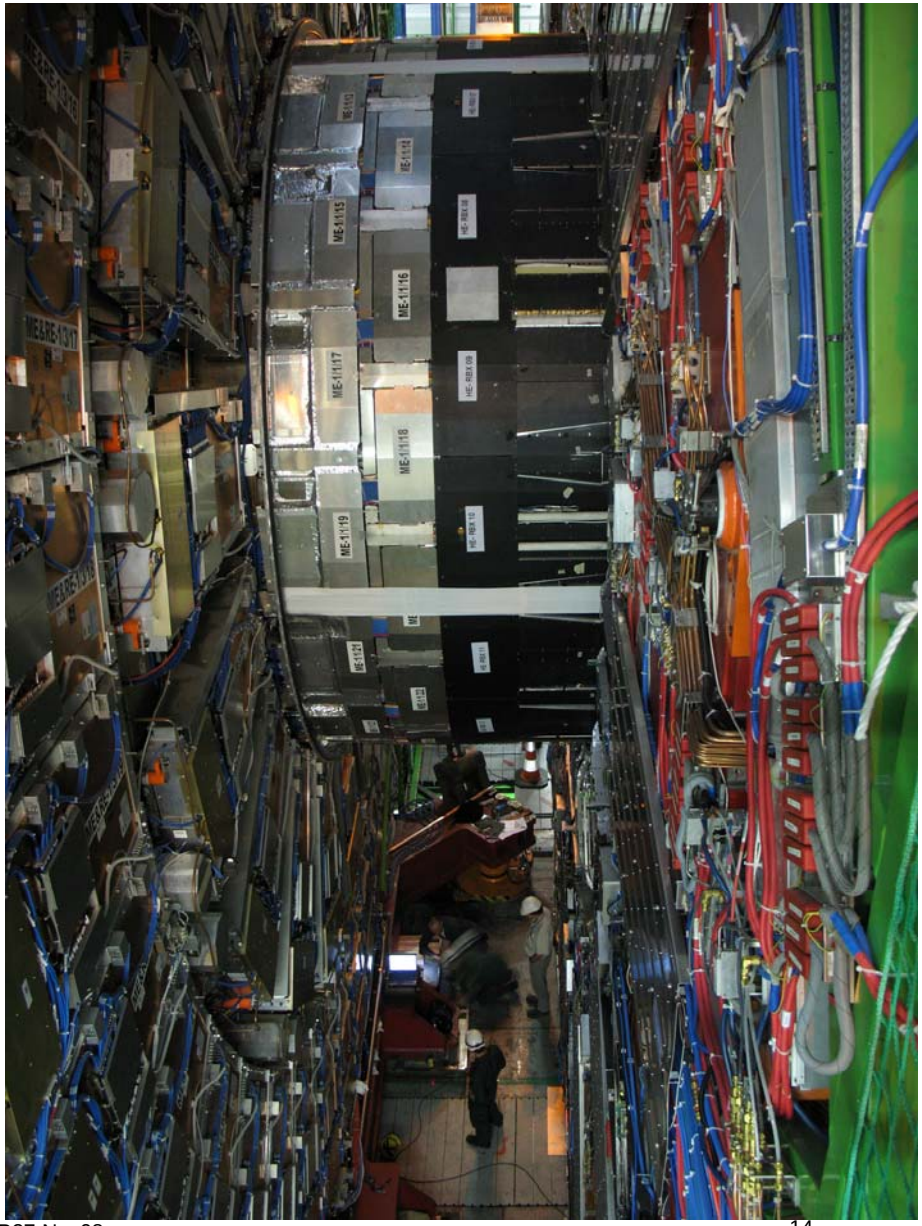




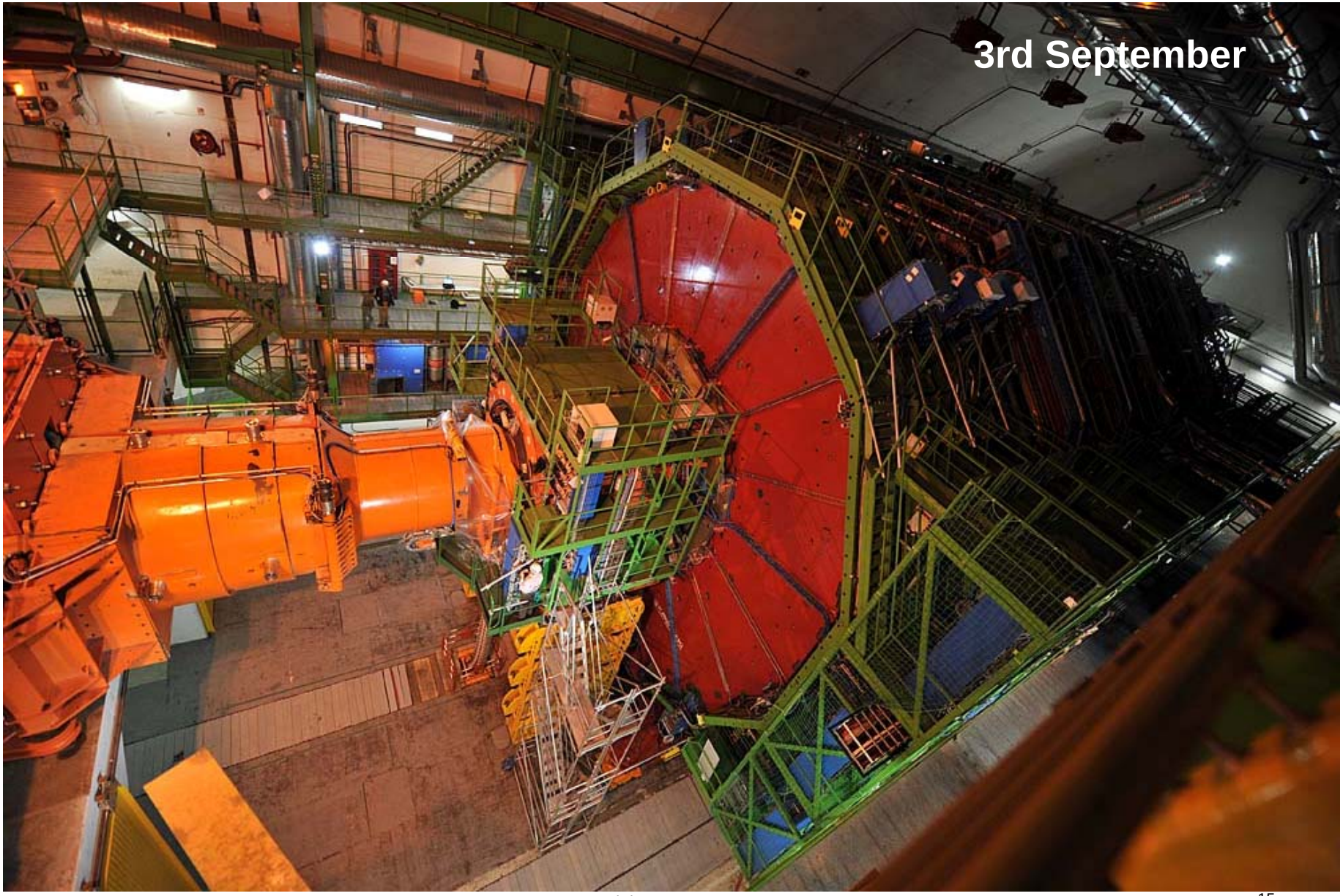
Minus End before Closure

Minus End & Closure





Final Closure



Commissioning of the Solenoid Magnet

- **Before LHC startup solenoid was raised to 3T in final configuration. Coil behaves quite well.**
  - Observed mechanical movement (of CASTOR calorimeter in close proximity of beam-pipe).
  - Gained access into CMS cavern on Monday 6 Oct. Beam-pipe was brought up to atmospheric pressure with Ne gas. CASTOR was then removed.

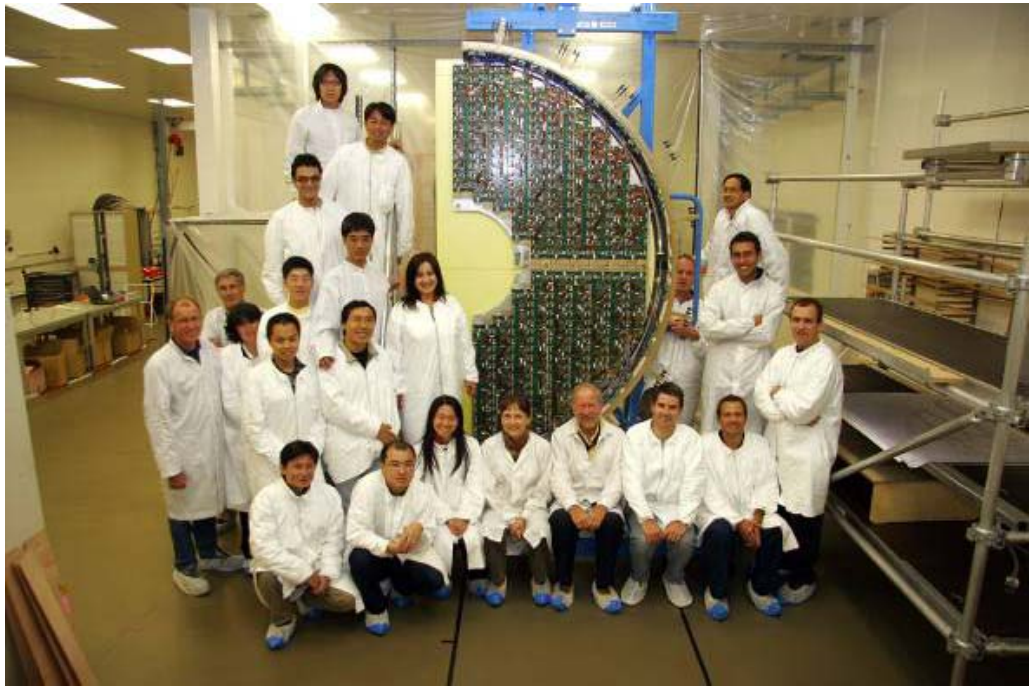
- **With much care the magnet was successfully ramped up to operational field (3.8T) on Friday afternoon 10 Oct.**
- **It has been running at operational field for the last 3 weeks without problems.**
- **Many fringe-field measurements have been made, including in the triplet area.**
- **Measure with final shielding structures. Carry out a fast dump.**

ECAL ES: Preshower Progress

All 520 ladders assembled and stress-tested

Ladders mounted, cabled and tested on 4 of 8 absorbers. All channels (~50k silicon strips) operational.
First two stuffed absorbers tested inside an environment-controlled tent to -15 ºC (in the old “TIF”)

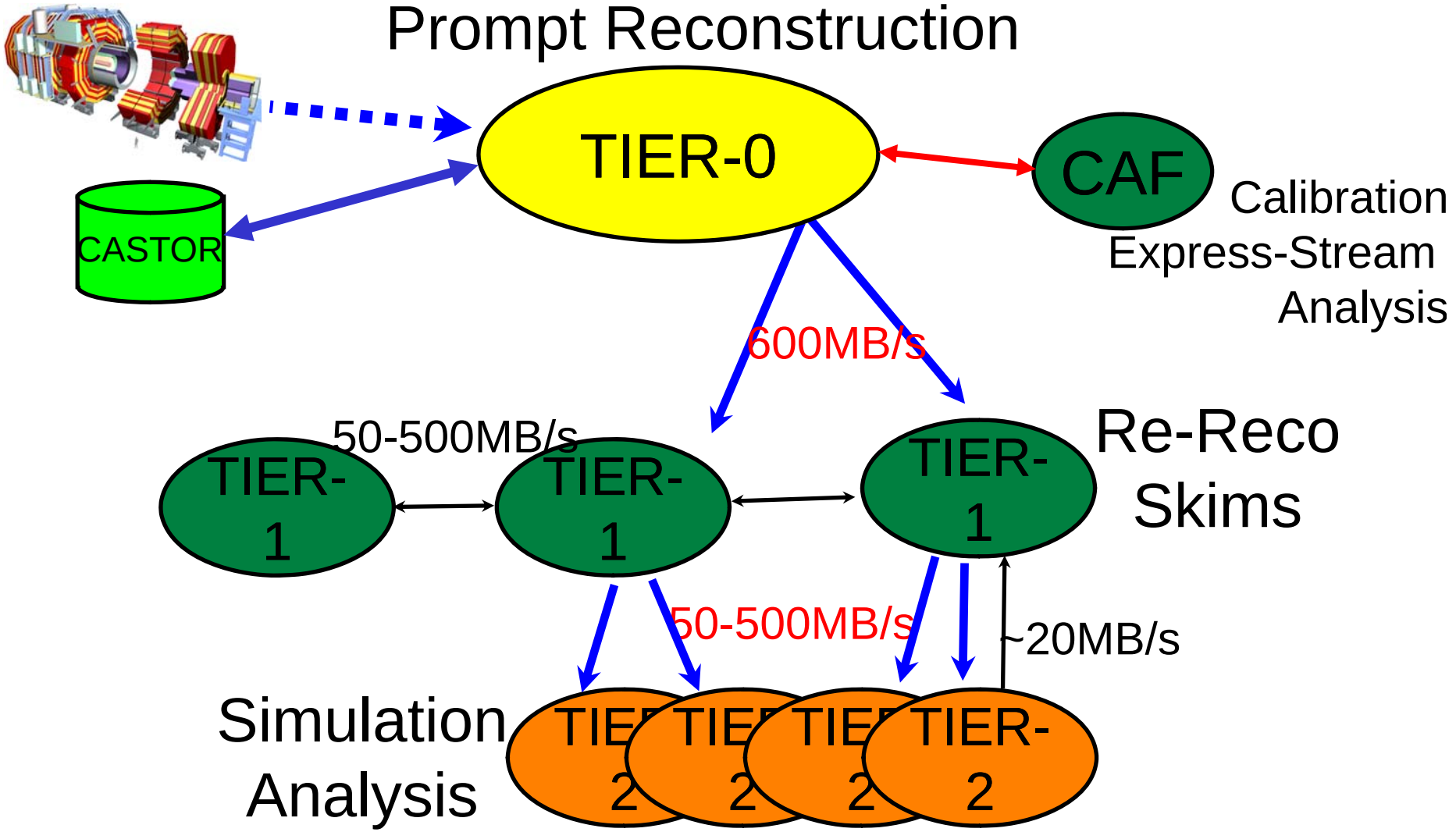
Target: get ES ‘ready for installation’ by beg-Jan 09.



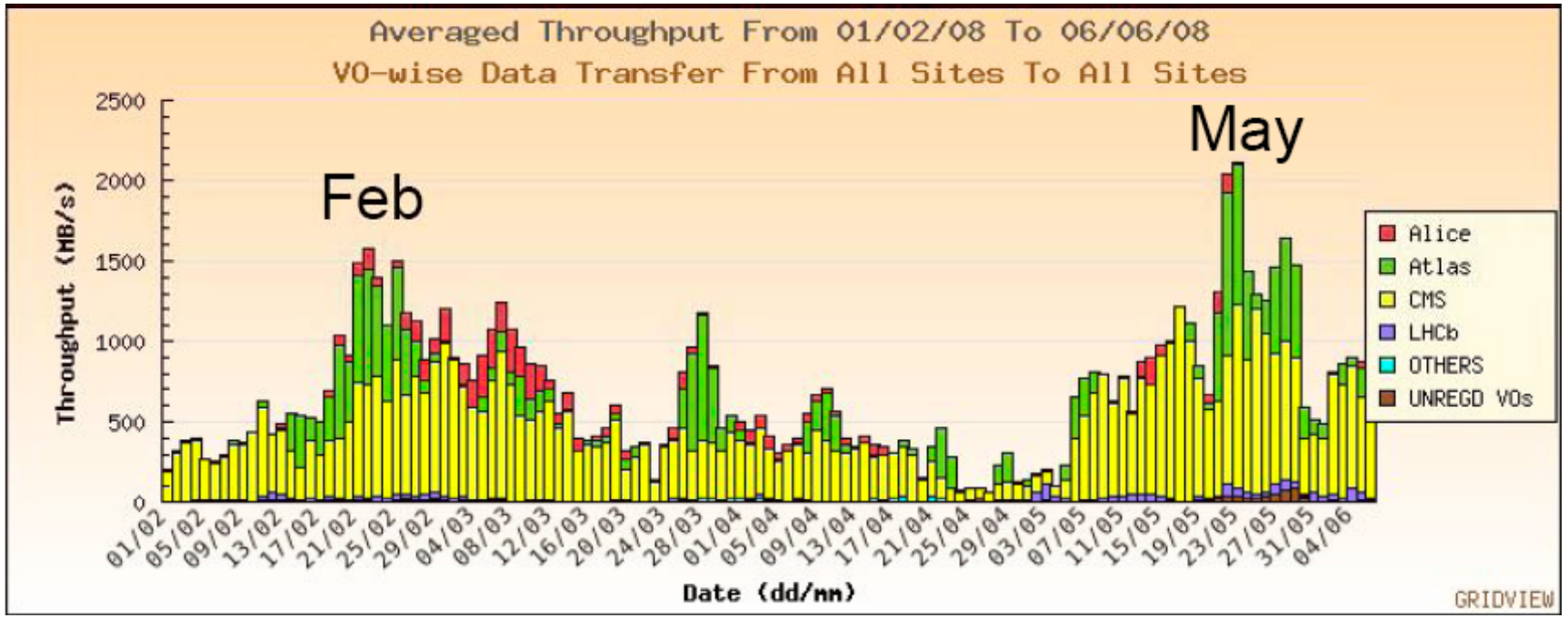
ES prior to moving the absorber into the tent

CCRC08/CSA08 - May'08

The challenge was quite successful



Some Results from CCRC08/CSA08



Wk 1: S43* prompt reconstruction at T0

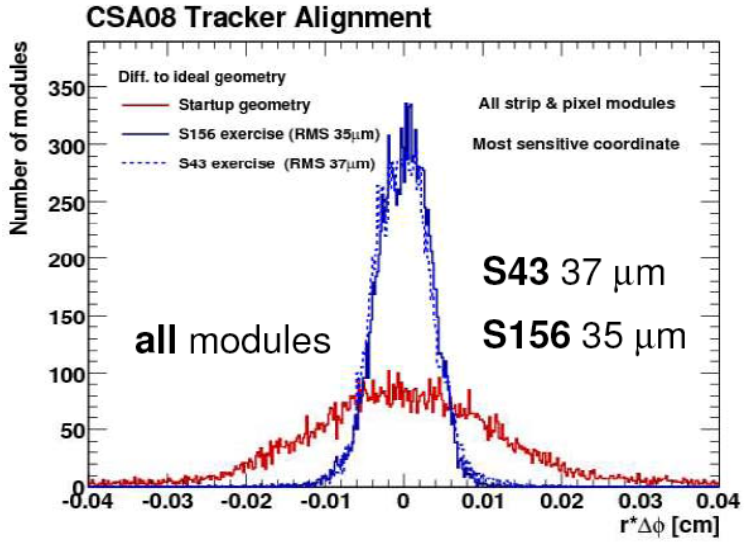
Wk 2: S43 prompt calibration/alignment on CAF
S156 prompt reconstruction at T0

Wk 3: S156 prompt calibration/alignment on CAF
S43 re-reco at T1s using constants from S43

Wk 4: S156 re-reco at T1s using constants from S156

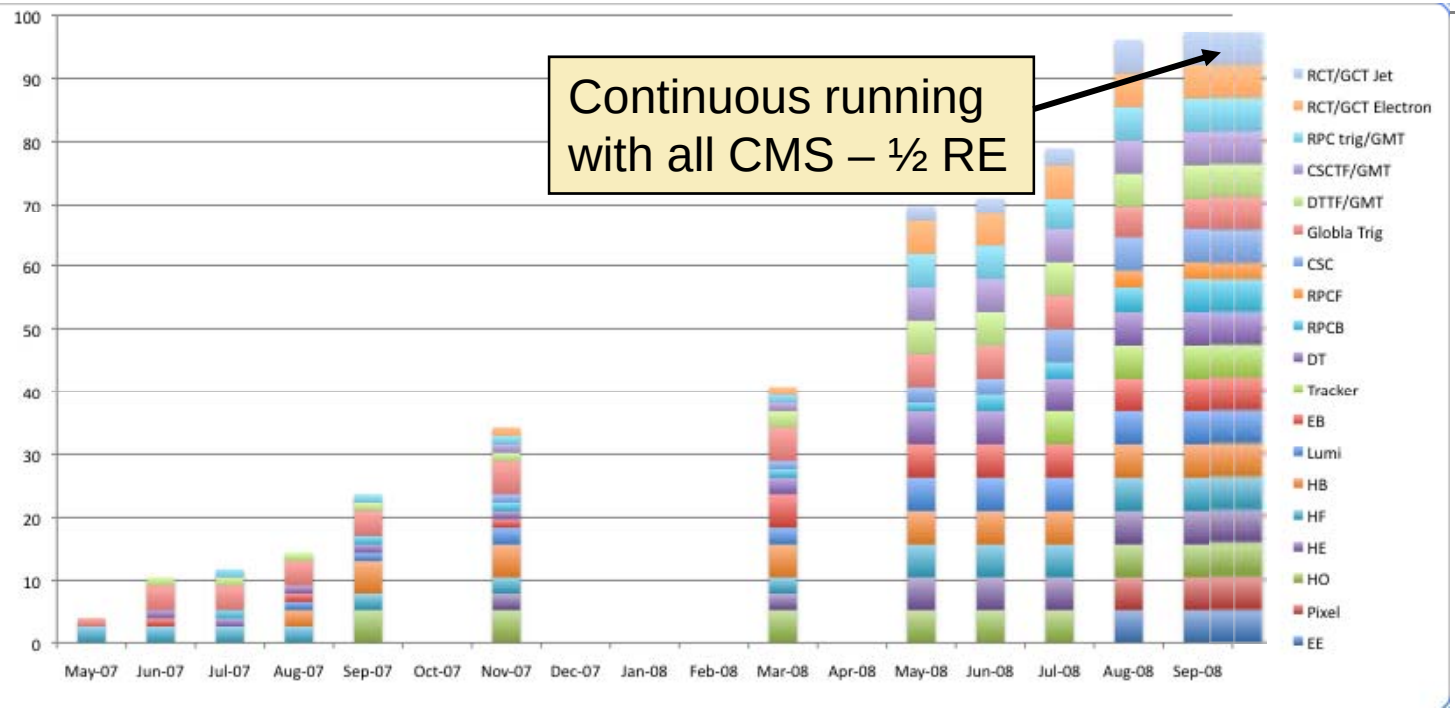
*S43 (1 pb-1): 43 on 43 bunches

**S156 (10 pb-1): 156 on 156 bunches



Commissioning Prior to Beam

CMS Global Runs



CRUZET4 (Cosmics Run at Zero Tesla, Aug08)

- First Global run with final CMS configuration (including newcomers EE and Pixels). Accumulated data more stably. 38 M cosmic triggers logged. A total of ~ 300 million cosmic triggers recorded at 0T.

CRAFT (17 Oct - 11 Nov @3.8T)

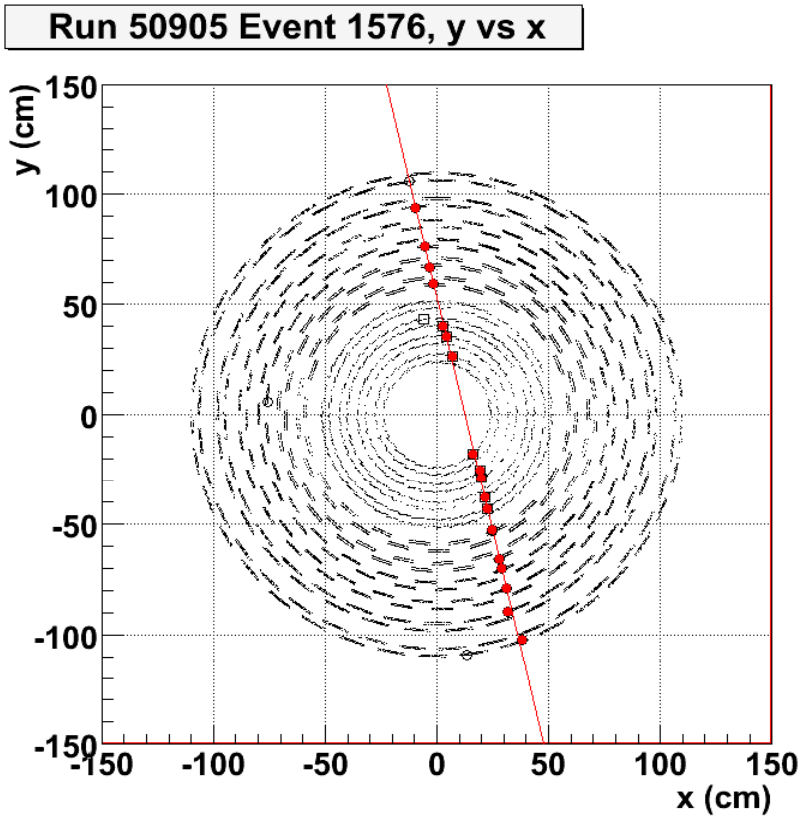
- Global run with final CMS configuration at Operating field (3.8T)
- Around 3000 million cosmic triggers recorded.

Tracker Commissioning

Since last RRB meeting the full Si Tracker has been commissioned & is operating well.

The pixels detector installed, commissioned and operating well.

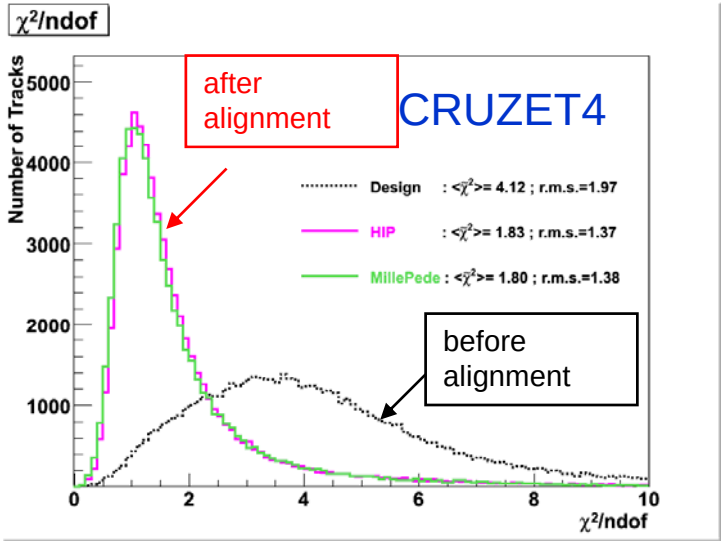
Cooling problems solved (heat exchangers/condensers/pumps changed/refurbished.
Fluid leak rate is still high despite mitigating actions.

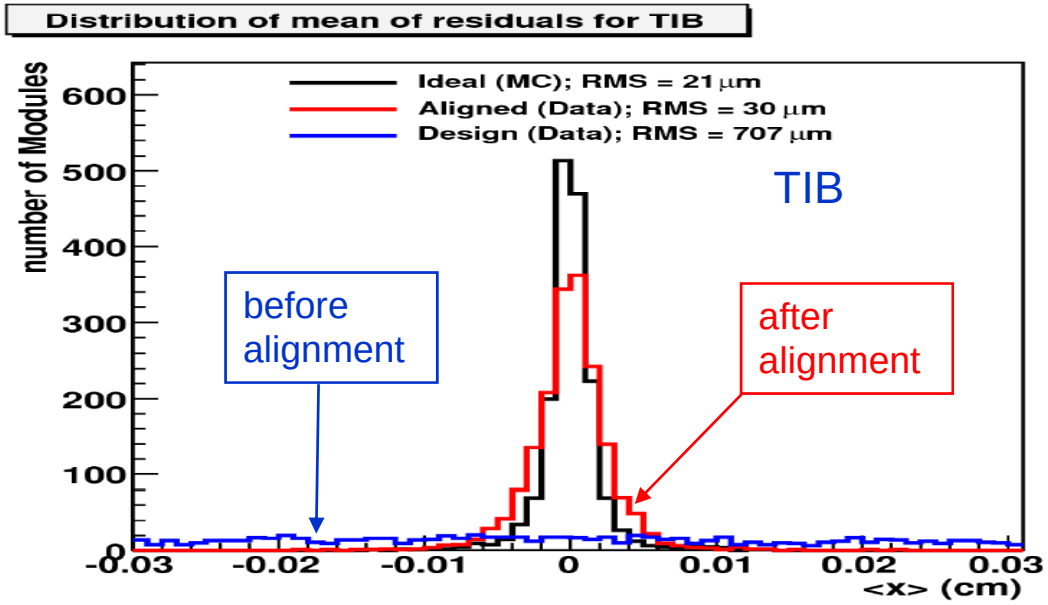


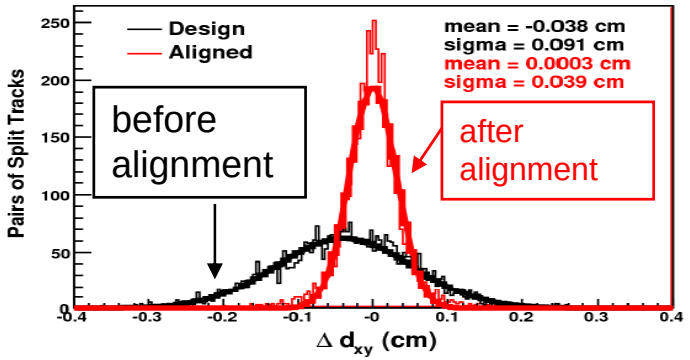
Partition	Modules by design	Modules disabled	Modules in DAQ	Number of connections	Missing connections	% active
TOB	5208	4	5196	12043	19	99.5 %
TIB/TID	3540	0	3481	9012	14	98.2 %
TEC +	3200	6	3183	7506	4	99.4 %
TEC -	3200	2	3192	7535	9	99.6 %

Tracker Alignment

- Alignment constants for CRUZET3 and CRUZET4 obtained with cosmic muons using two algorithms (HIP & MillePede)
- New preliminary analysis: compare parameters of inbound and outbound part of cosmic track







transverse I.P. residual

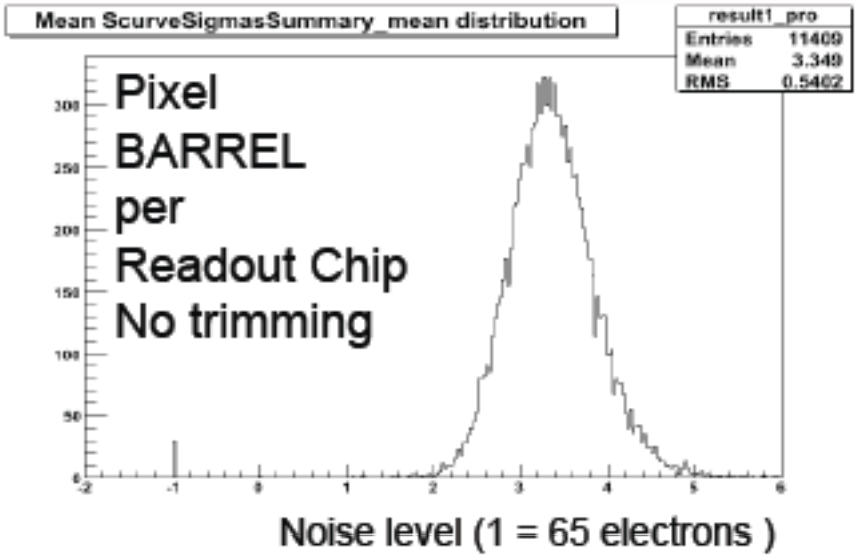
Pixels Commissioning

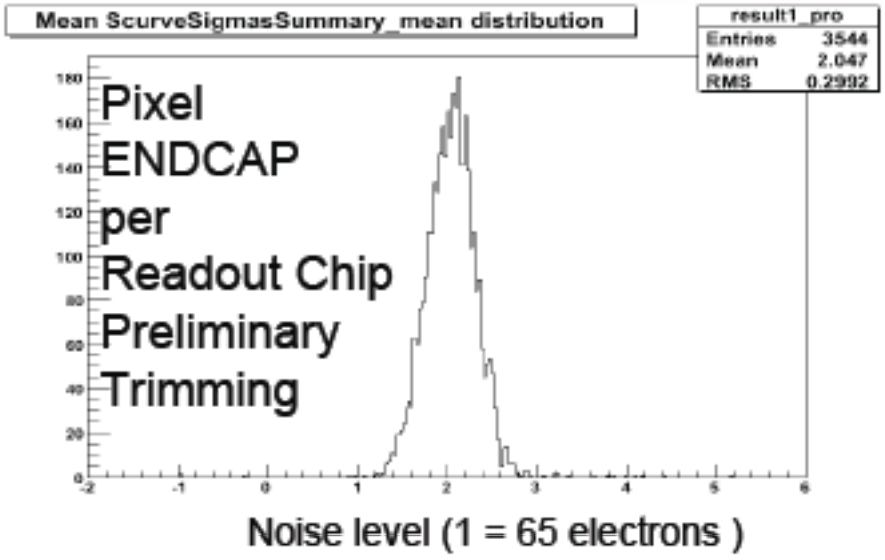
Barrel Pixel Detector:

99.13% **of the Barrel Pixel detector operational (0.35% lost before installation, 0.52% lost after installation)**

Forward Pixel Detector:

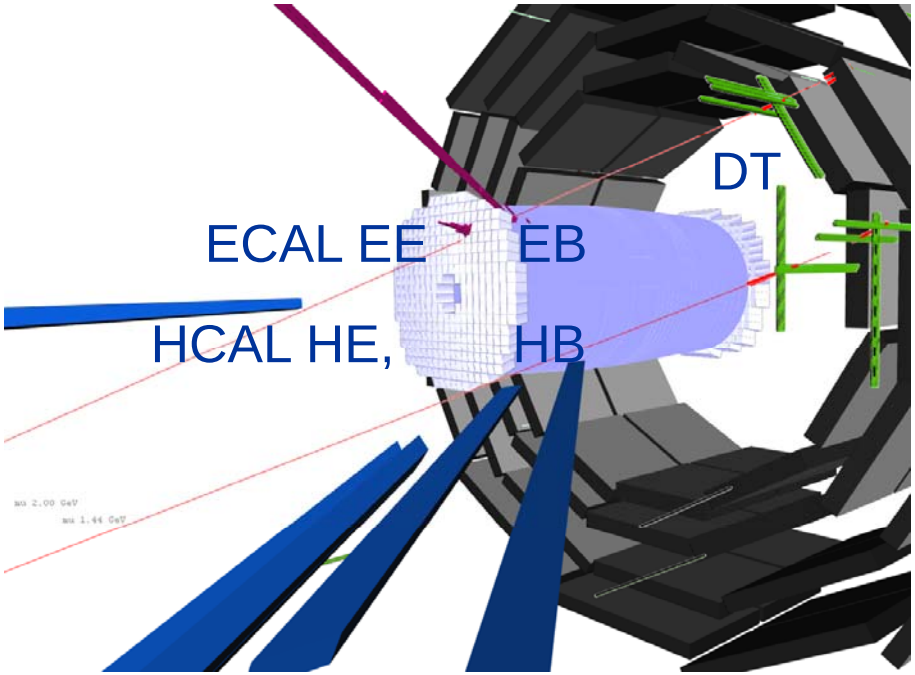
93.98% **of the Forward Pixel detector operational (0% lost before installation, 6.02% LV connection lost after installation)**

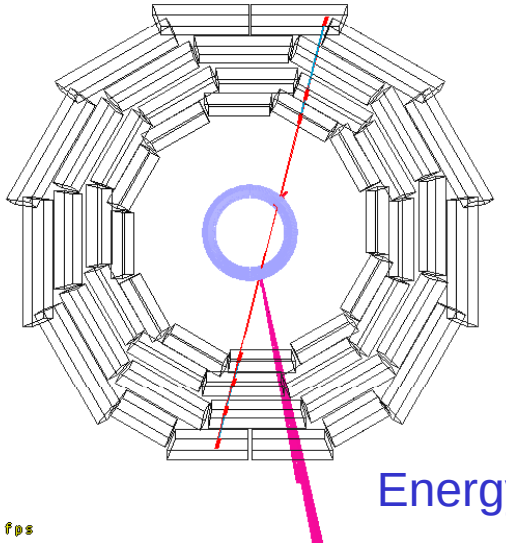




Noise performance is good

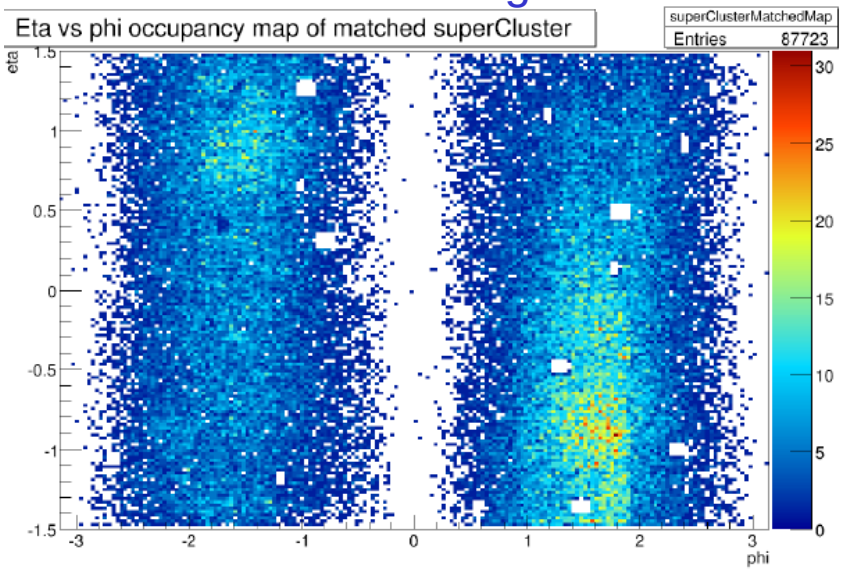
ECAL

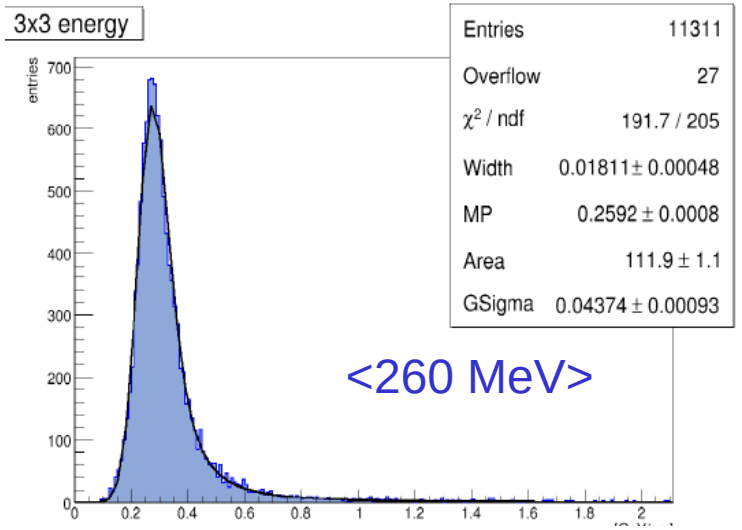




Energy: 250 GeV

ECAL clusters matching muon tracks





<260 MeV>

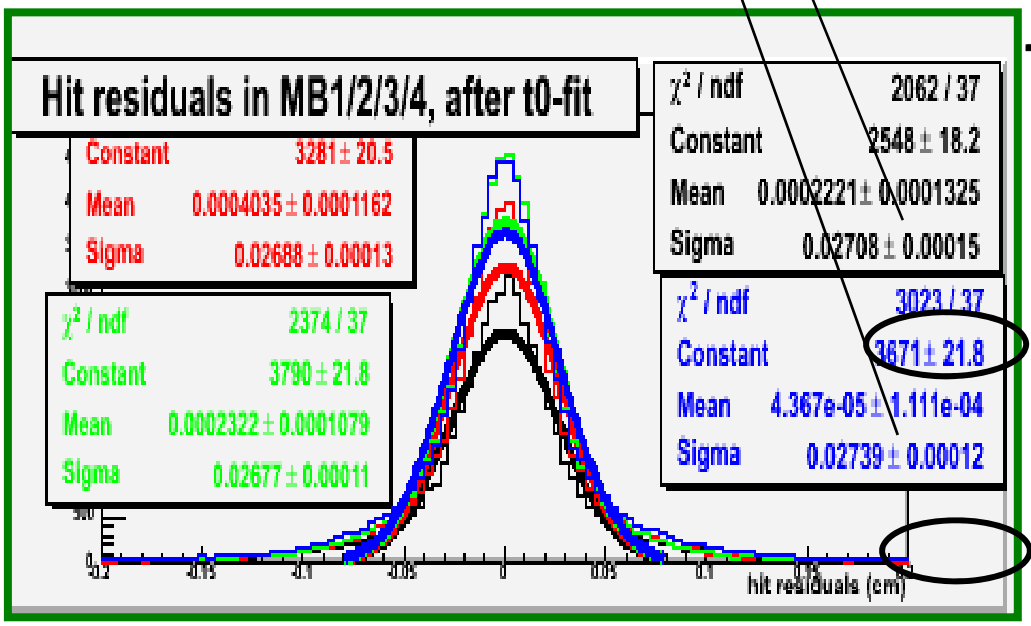
2 GeV

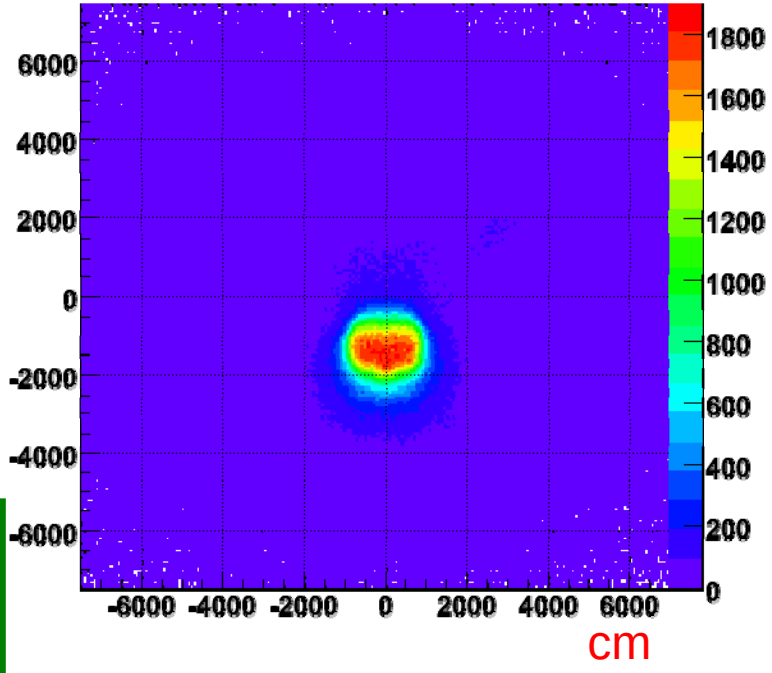
Muon DTs

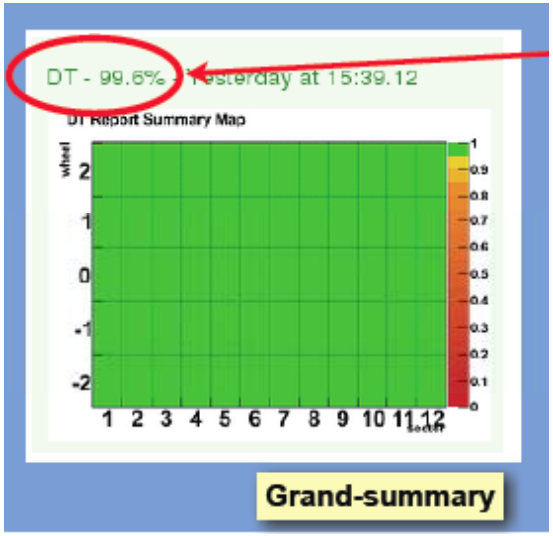
Cosmics tracks extrapolated to the surface (CMS coords)

Can clearly see the shaft !

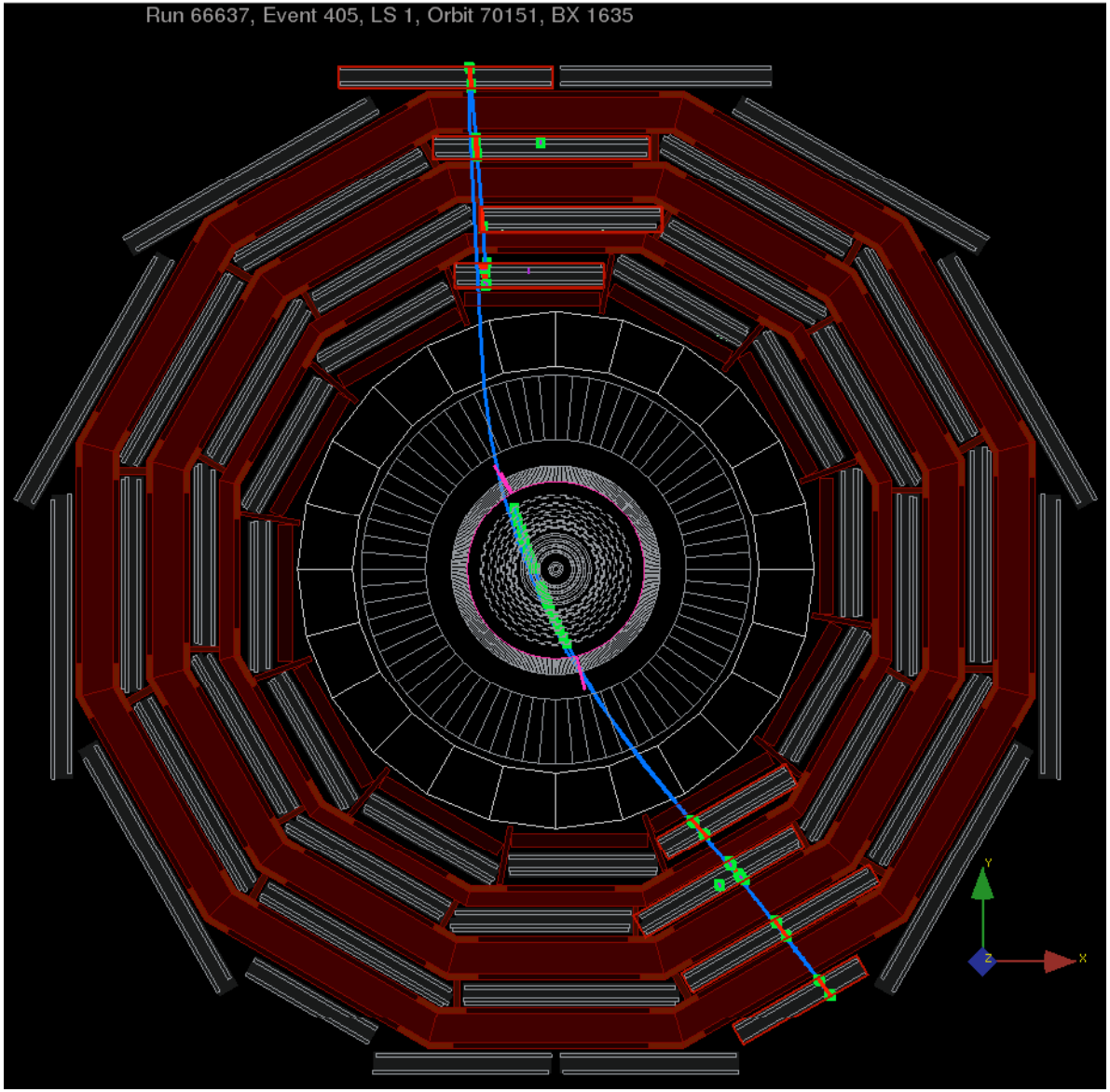
MB1: 271 μm
MB2: 269 μm
MB3: 268 μm
MB4: 274 μm







An Event from CRAFT



http://iguana.web.cern.ch/iguana/docs/pictures1/2008/CRAFT-run66748.gif

Notes from the First Beam

- From September 8 we ran continuously 24/7 until w/e of 20/9
- We routinely readout ALL of the installed CMS detectors in global runs. All needed triggers were operational.
- Beam monitoring equipment ‘appeared’ just in time but worked reliably from Day-1.

First Beams

After almost 20 years of design and construction CMS started taking data with LHC beams.

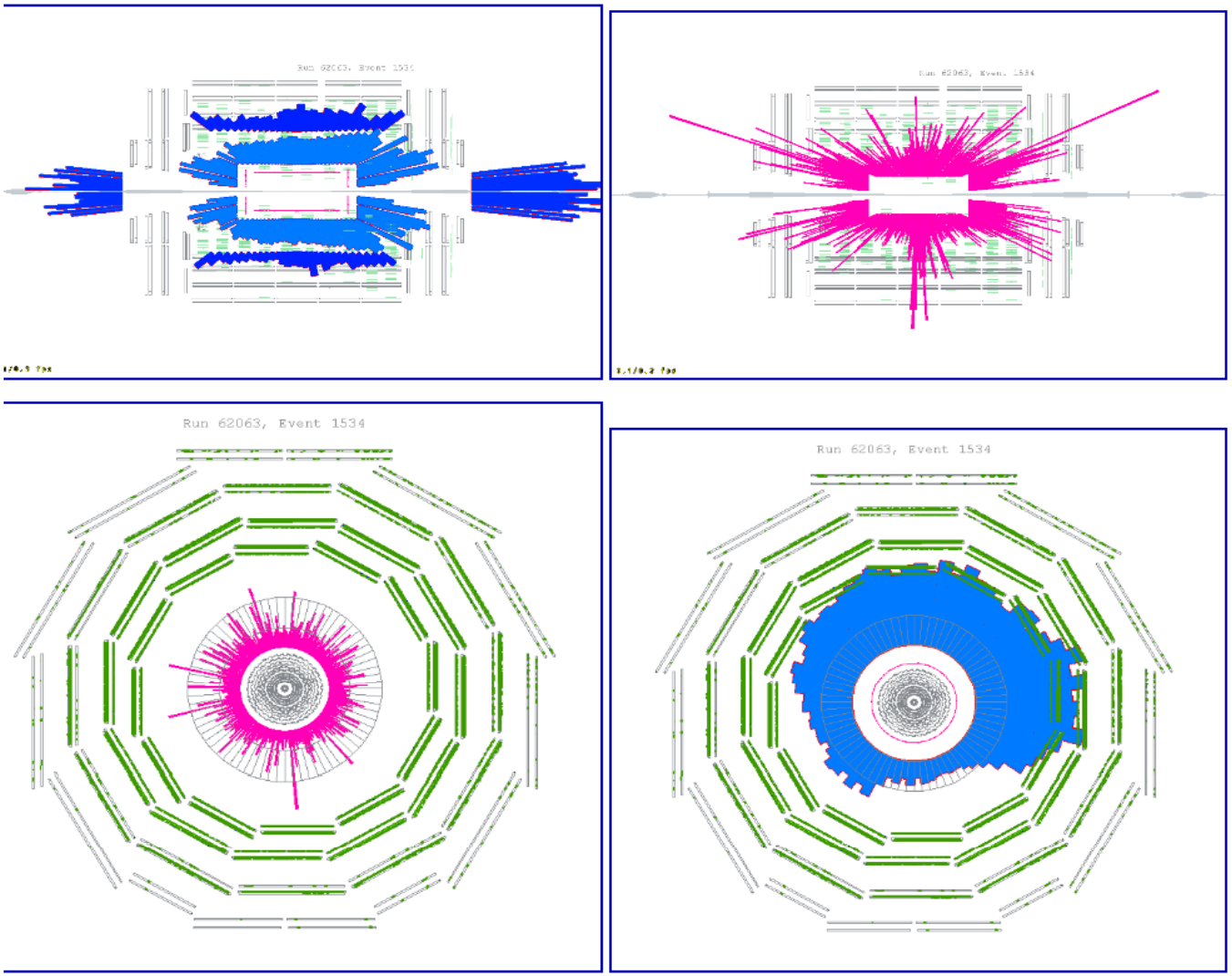
(Much appreciation for the work of the accelerator folks)

- **Sun/Mon, 7-8 Sept.**
  - **Single shots of Beam 1 (clockwise via ALICE) onto collimator 150m upstream of CMS, ~ 1 hour**
  - **Allows synchronization of BPTX trigger (good prep for Wed.)**
- **Tues, 9-Sept**
  - **20 shots of Beam 1 onto collimator 150m upstream of CMS**
- **Wed., 10 Sept.**
  - **Nice splash events observed when beam onto collimators (as before), 100-1000 TeV observed in ECAL-HCAL**
  - **Halo muons observed once beam started passing through CMS**

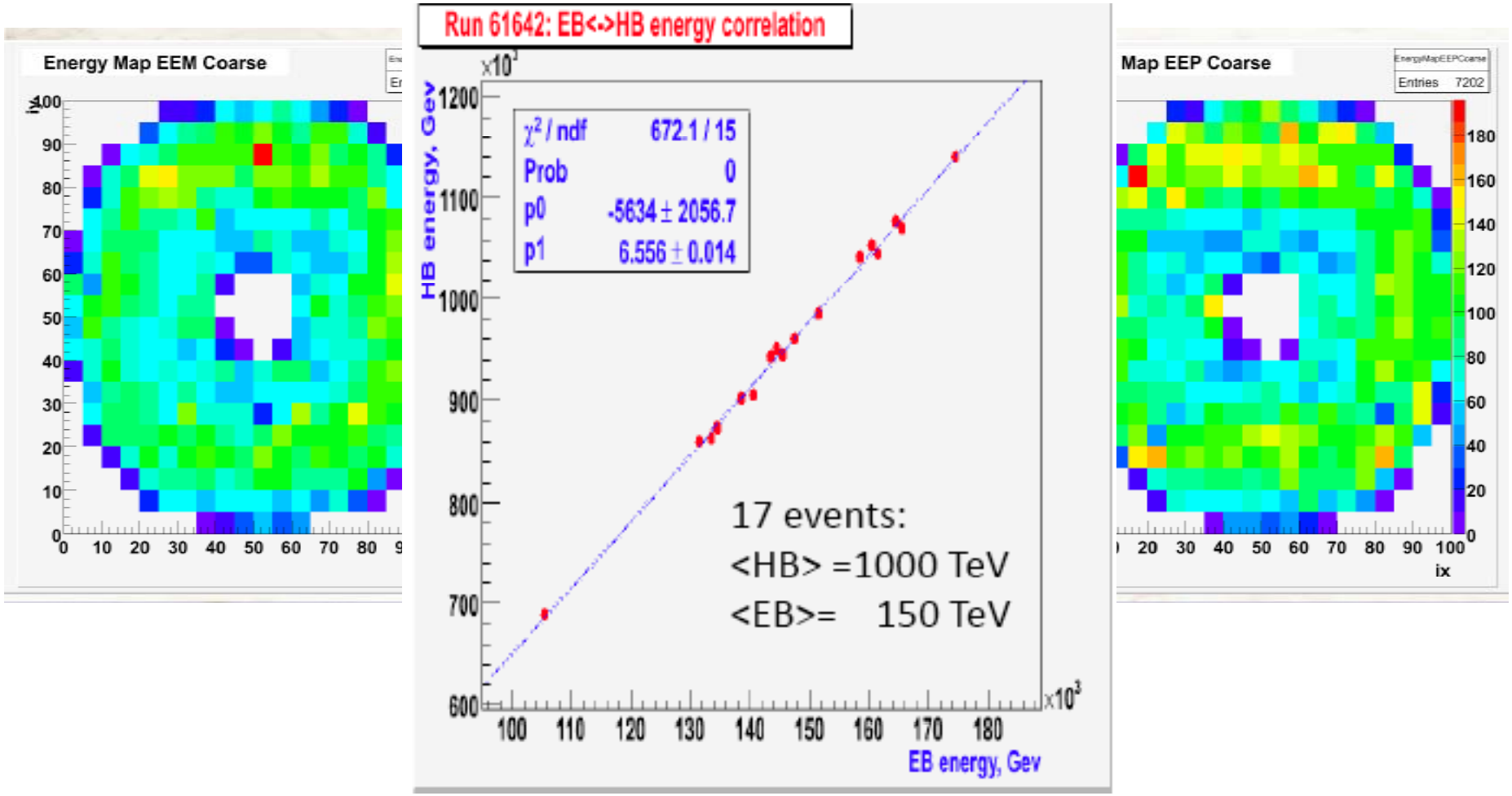
First Events: Collimators Closed

~2.10^9 protons on collimator ~150 m upstream of CMS

ECAL- pink; HB,HE - light blue; HO,HF - dark blue; Muon DT - green; Tracker Off

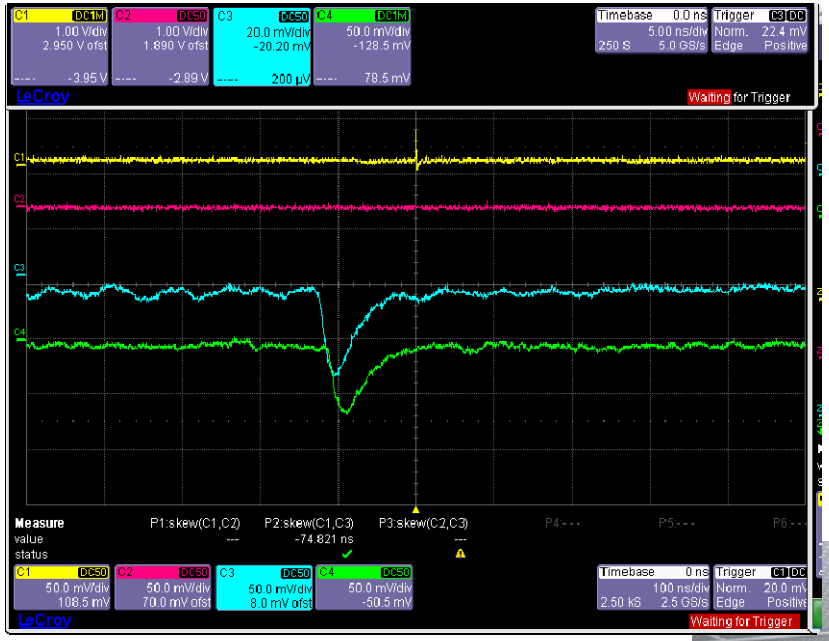


Calorimeters: Collimators Closed

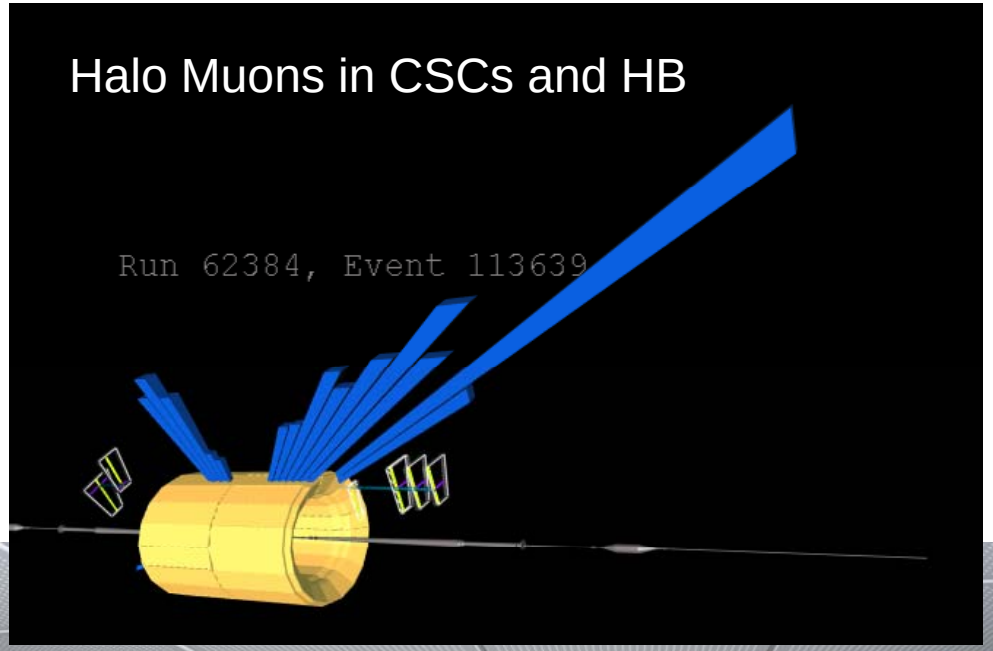


ECAL: Splash events provided a source for overall internal synchronization.
Crystals were time aligned to within 1ns !

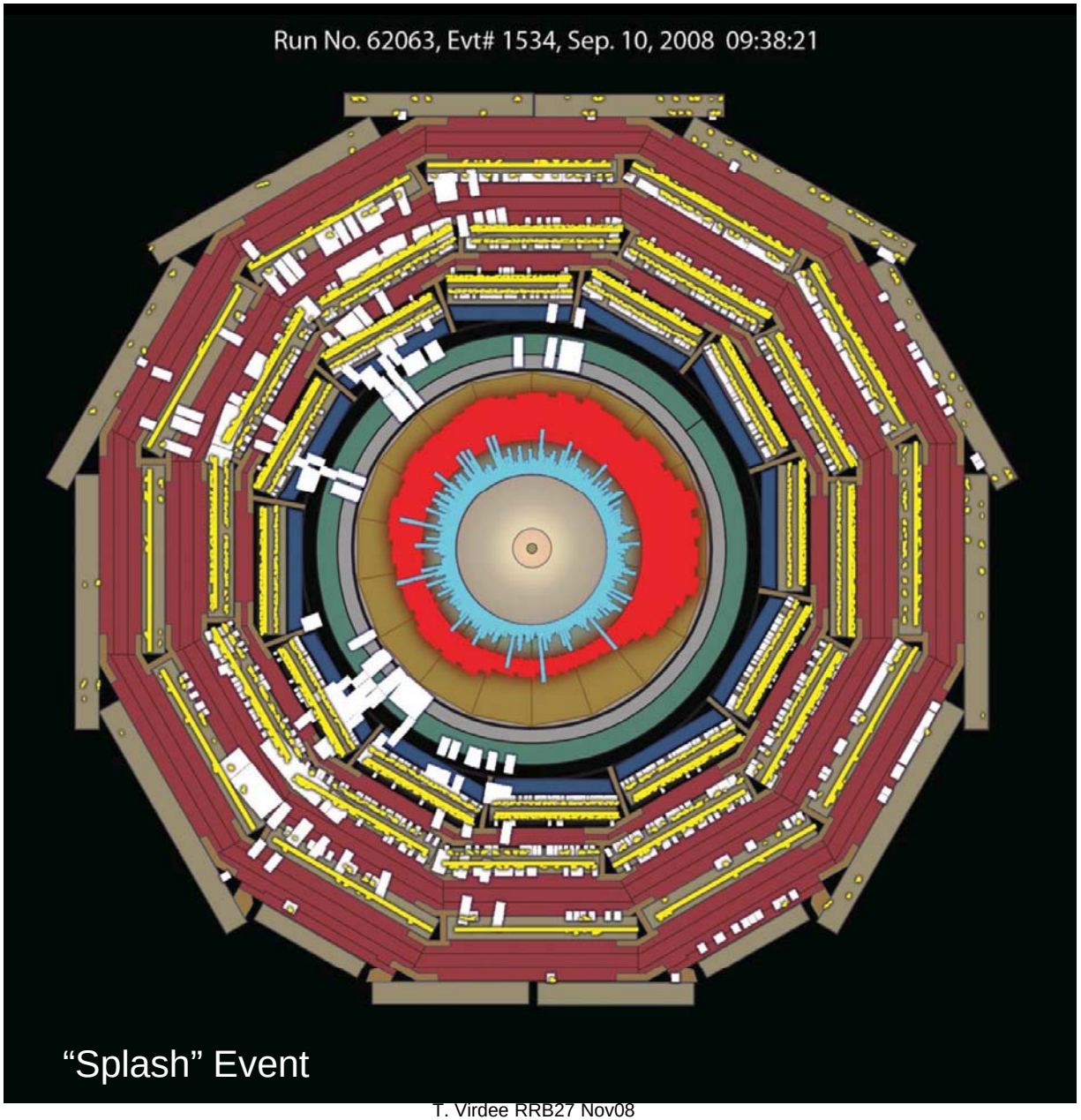
First Events: Beam going through CMS



Beam Pickup (ch1) CMS Beam Condition Monitors (ch 3, 4)

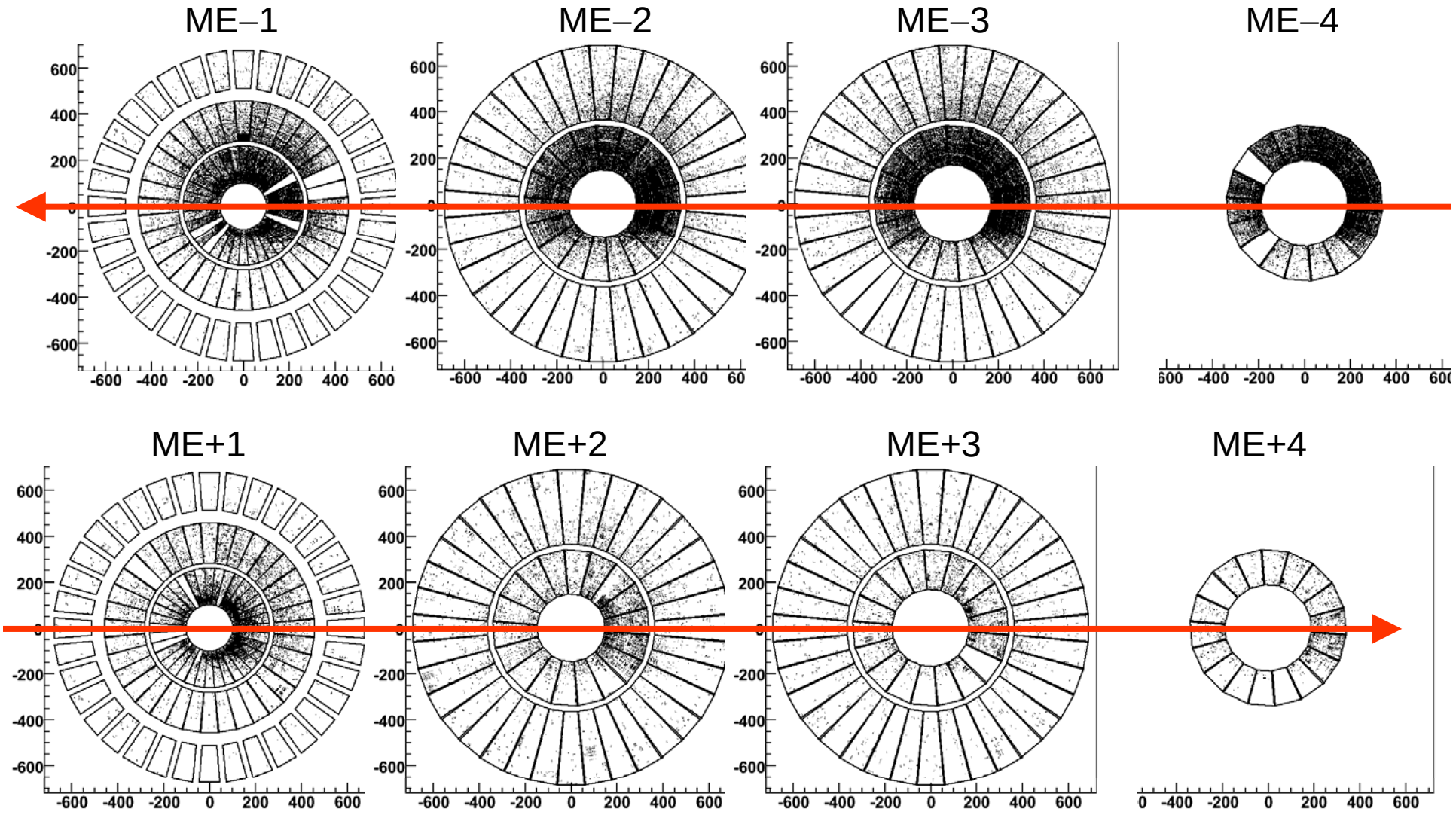


Run 62063, Event 1534, 10 Sept. 09:54



"Splash" Event

Beam Halo Events



Level-1 Trigger

First beam passing through CMS

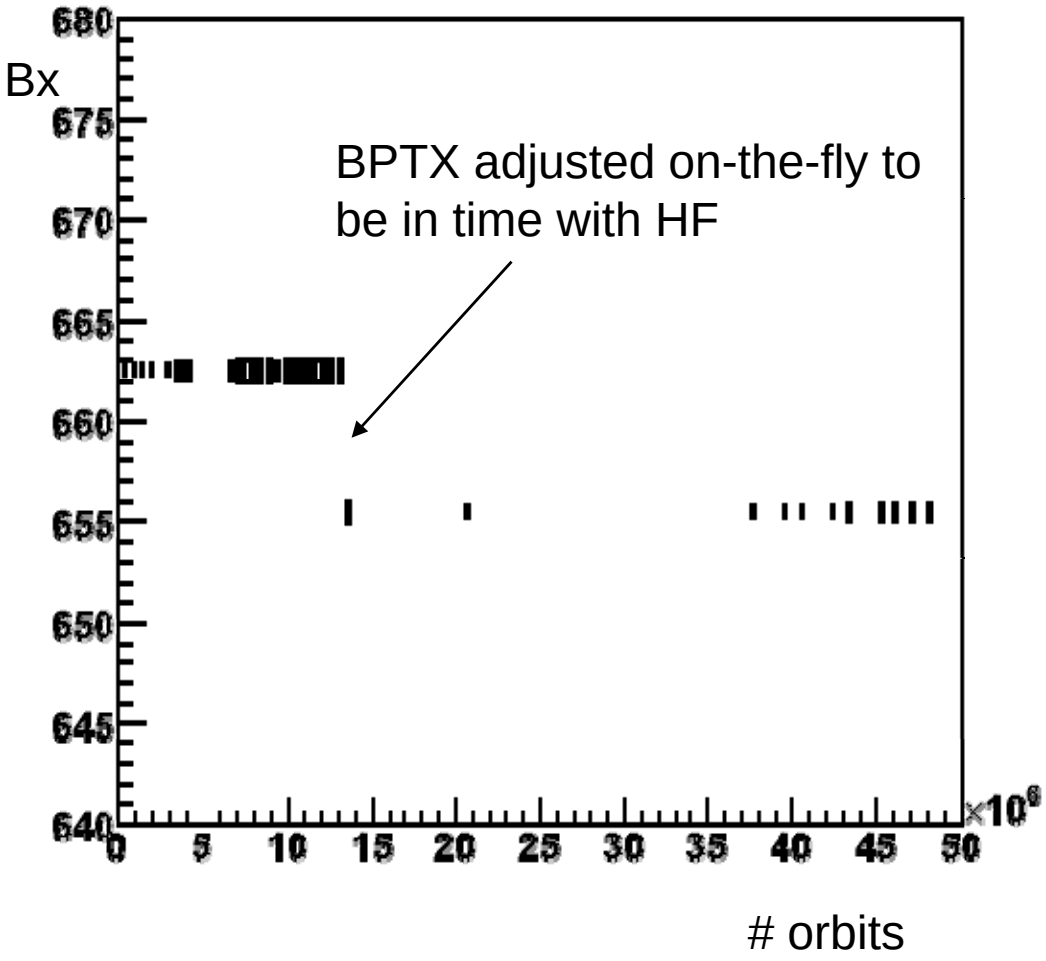
Triggers used:

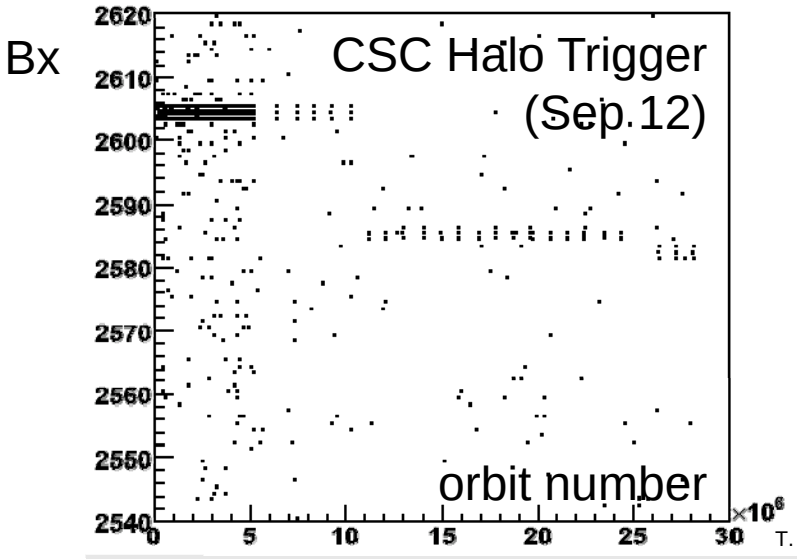
BPTX+
added temporary delays to allow to time in with physics triggers

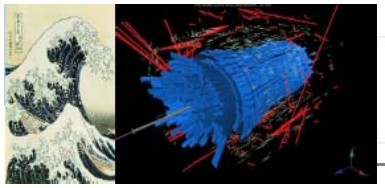
CSC halo (reference)

HF technical trigger
during beam passage almost no signal from beam

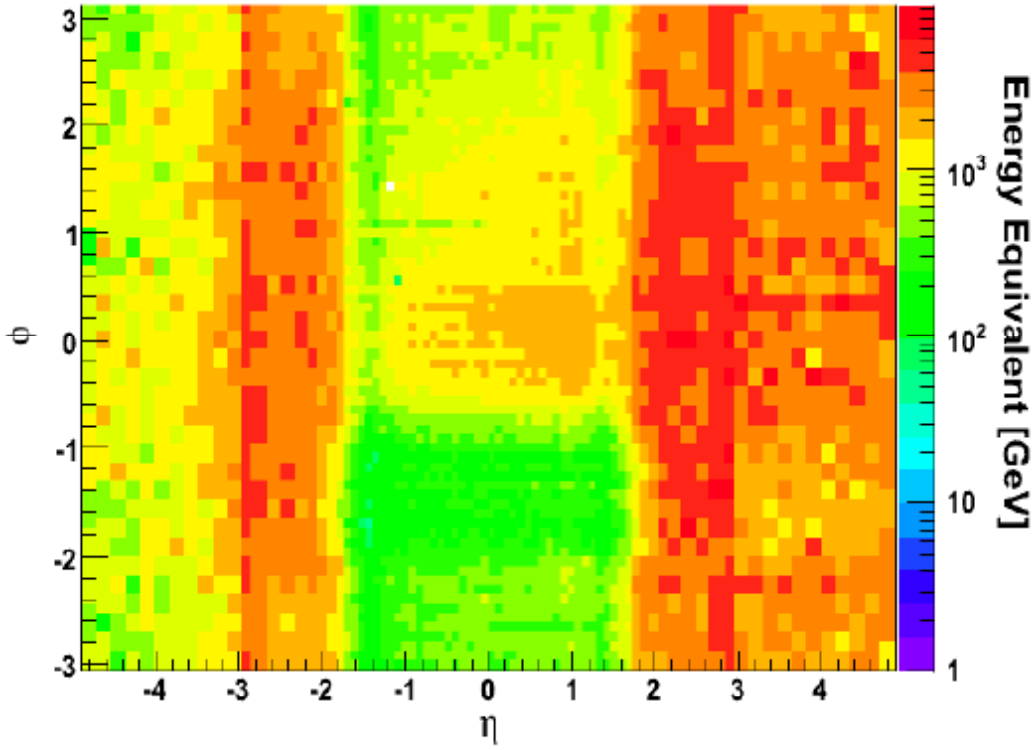
Run 62064 - BPTX+ trigger (Sep 10)



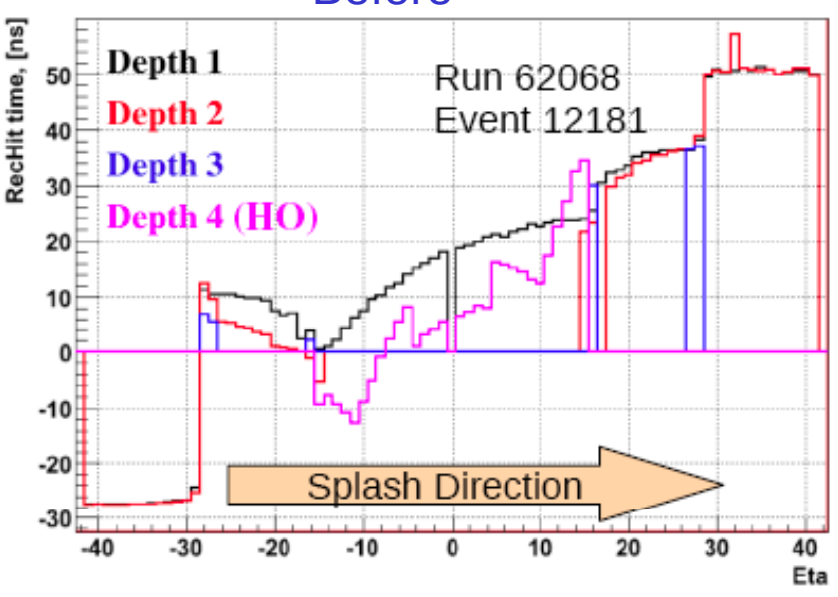


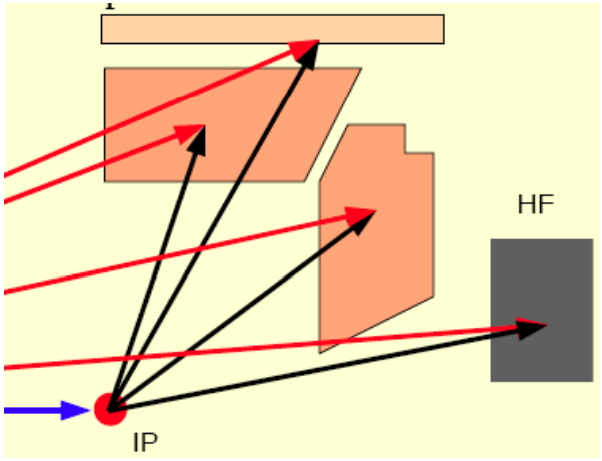


HCAL (Splash Events)

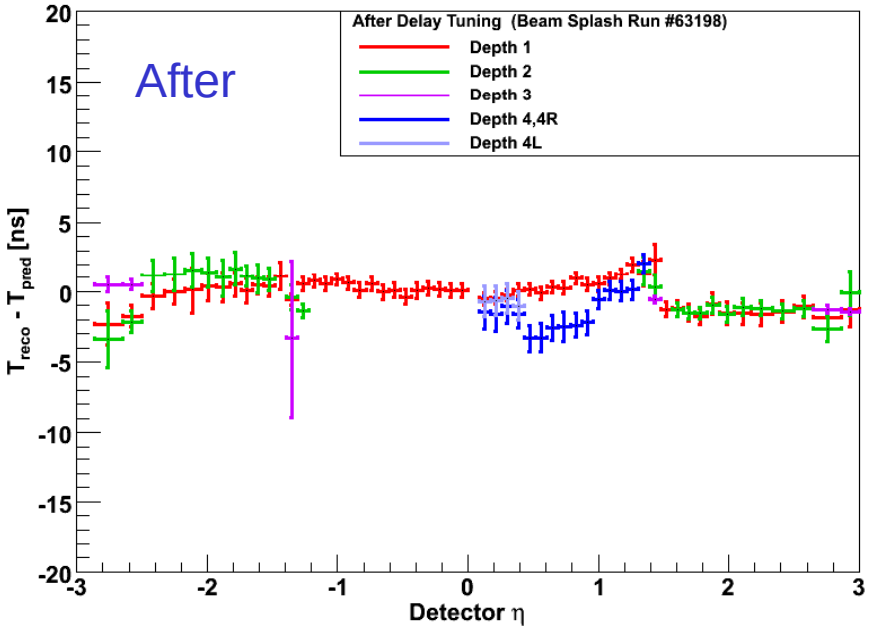


Before

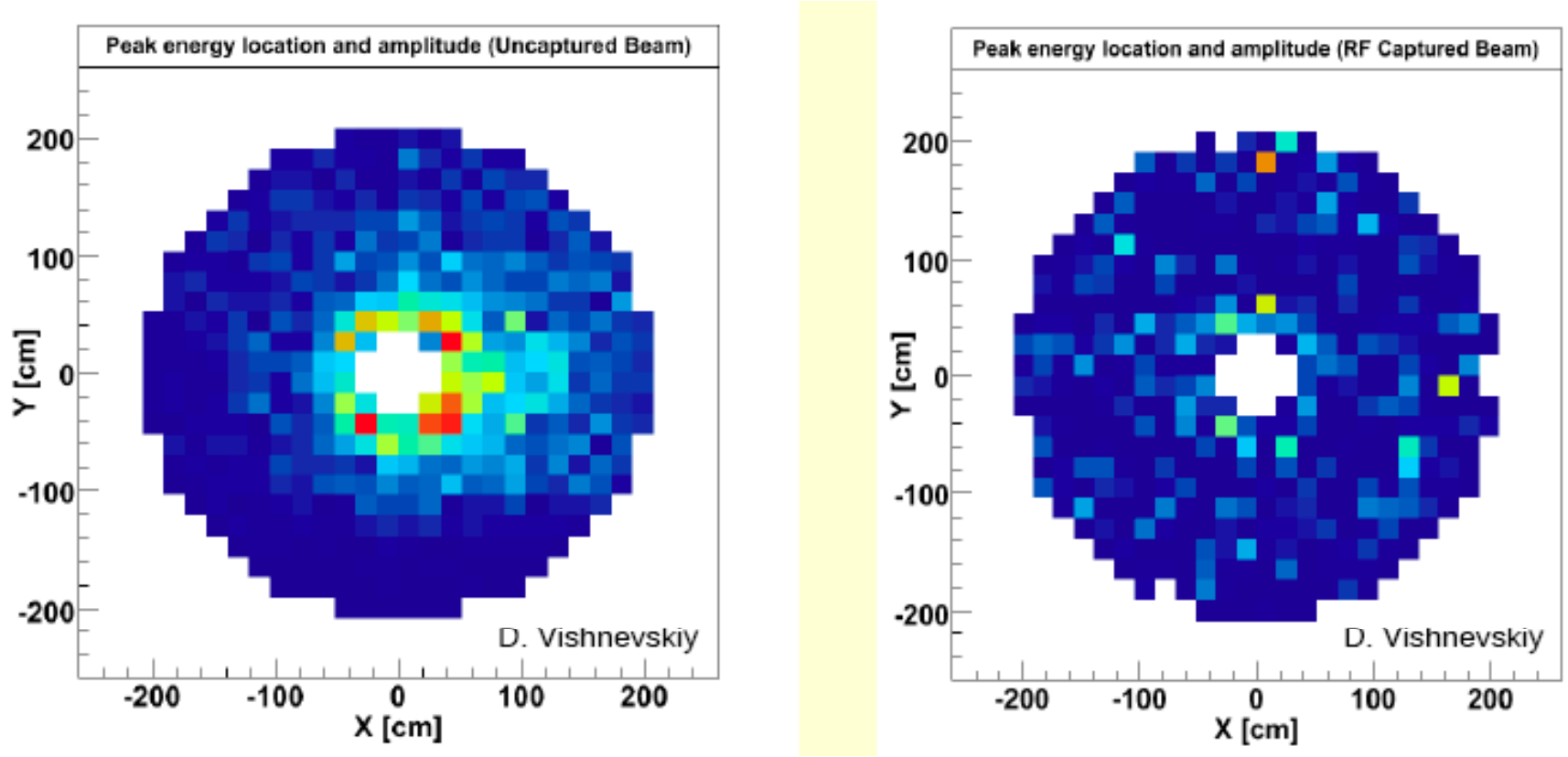




After



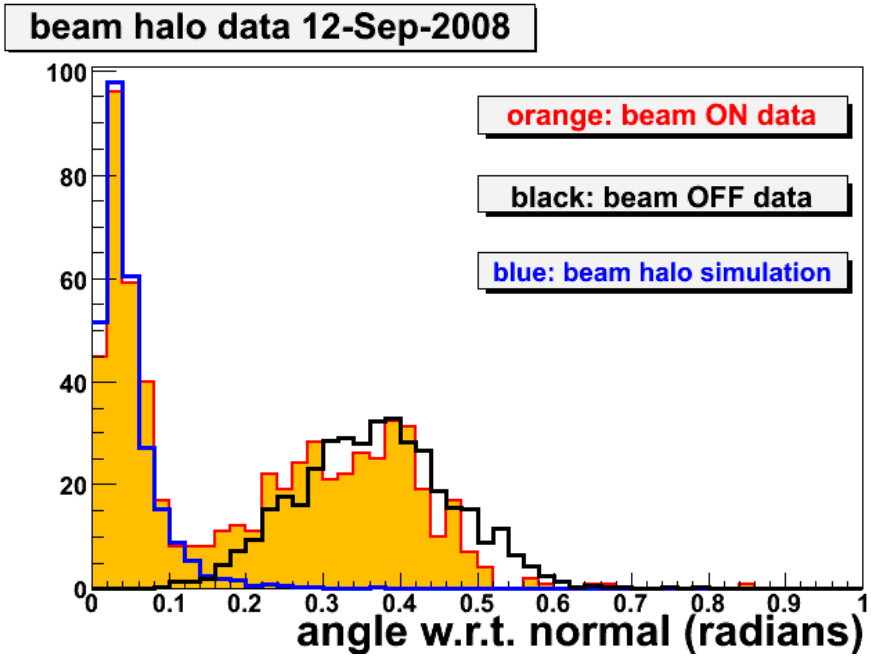
Circulating Beam: Beam Halo Events

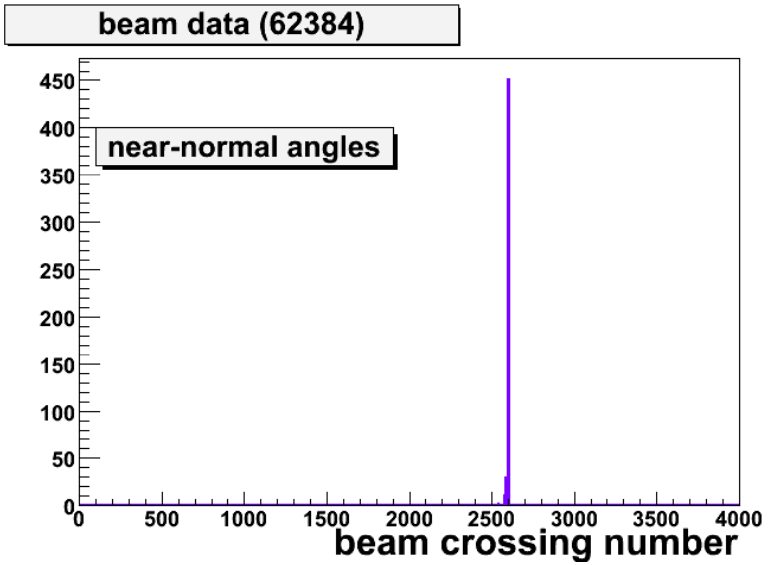


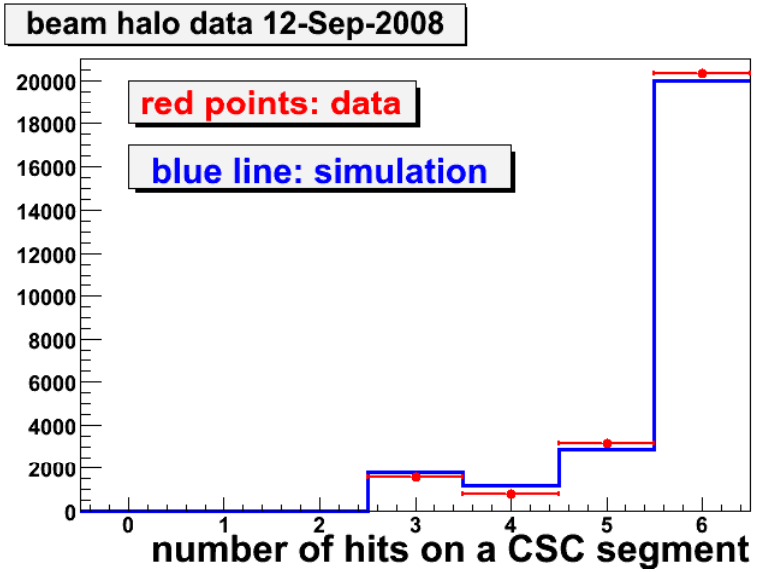
HCAL Endcap: un-captured (lhs) and captured beam (rhs)

Muon CSCs: Single Beam

Reconstructed track angle w.r.t. the transverse plane



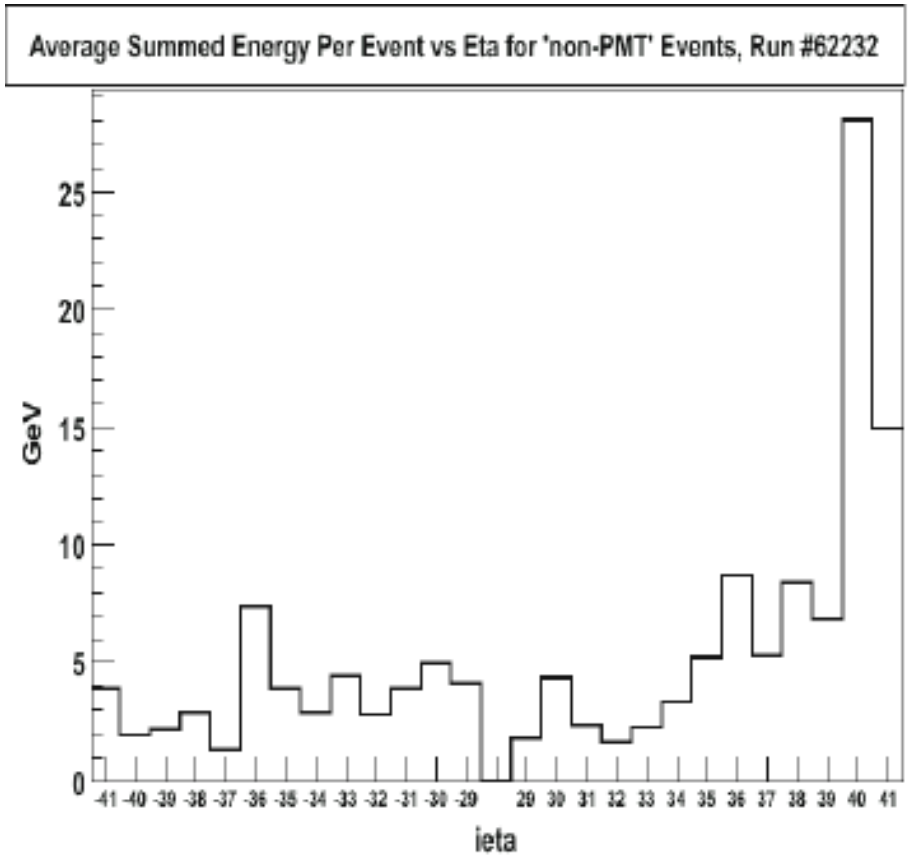


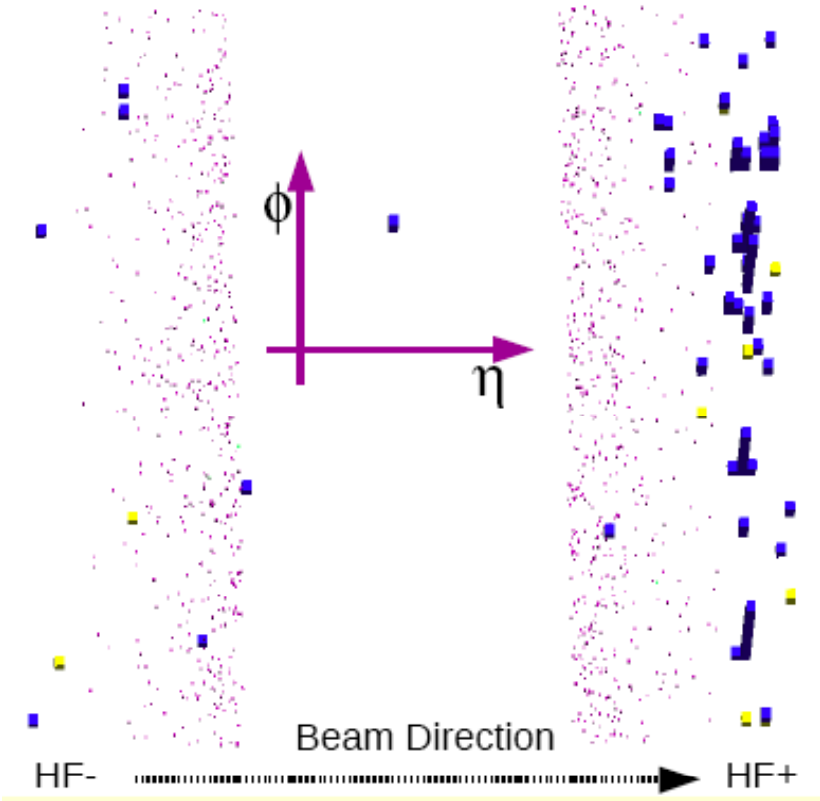


Reasonable description of beam ON data: combination of

- **beam halo**
- **cosmic rays**

Beam-Gas Events ?

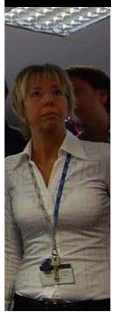


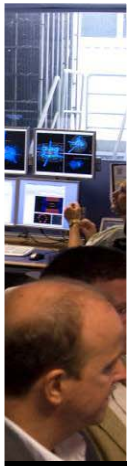


Distributed Operations

CMS Remote Operations Centre at Fermilab

CMS Experiment Control Room





High definition permanently-running video links between operations centres

CMS Centre at CERN: monitoring, computing operations, analysis

Activities During Shutdown

Main Lines for CMS

- **Current Global run ended this morning.**
  Take 300 Mevts at operating field (3.8T)
  Run the whole experiment round-the-clock for ~ 1 mo.
- **Start opening the experiment on 17th Nov. (a little earlier than foreseen).**
- **General/CMS obligatory annual cooling maintenance before Xmas**
- **Followed by a programme of carefully selected repairs interleaved with installation of the Preshower detector in February.**
  Tracker cooling - issue of high leak rate.
- **Examining a planning that has CMS closed around mid-May**

(will tailor the intervention programme to keep sufficient contingency and allow a CRAFT'09 before LHC beam)

Progress & Plans in Software, Computing and Preparation for Physics

- **Software & Computing Infrastructure prepared:** The final releases for LHC08 data taking deployed. Simulation (full) of the 10 TeV datasets completed.
- **Preparation for physics prior to Sep 19: everything and everyone had been directed towards the imminent arrival of data. Now:**
  - **Continue work on early publications**
  - **Continue the 900 GeV analyses – to completion**
  - **Start analyses with the 10 TeV samples**
  - **Restart Monte Carlo analysis approvals**
    - Update some of our results (especially for 10 TeV)
    - Need to tend to needs of younger collaborators working on theses and limited-term positions
- **Continue Physics Studies**

  Fastsim: (~0.5 Bevts) assume 10 TeV, inst. Lumi up to 10^{32}, $50pb^{-1}$.

  Prepare CMSSW3_0 and generate samples for LHC re-start

LHC Inauguration

Visit of the French PM Fillon and Minister Pecresse

Le CERN, et singulierement le LHC, constitue la plus grande experience scientifique ce siecle et symbolise l'existence d'une civilisation humaine. (PM Fillon in CMS Livre d'Or.)

Conclusion

The dedicated and strenuous efforts of many over the summer allowed a powerful CMS detector to be prepared for LHC startup.

After almost 20 years of design and construction CMS started taking data with LHC beams.

All indications are that sub-detectors, online, offline, computing and analysis systems are performing well.

CMS became a running experiment !

Preliminary Statement of Accounts

Table 2

CERN-RRB-2006-105

	PhDs (1)	MoU Funding 2002 (2)	CTC1 RRB15 Oct02 (3)	CTC2 RRB20 Apr05 (4)	Constr. Funding 2006 (5)	STEP 1 Low Lumi (Constr.) (6)	STEP 2 DAQ (PhD) (7)	STEP 3 Rest (PhD) (8)	Total Design Lumi (9)	
Austria	11	3,900	600	275	4,775	211	45	171	427	
Belgium	27	5,000	870	300	6,170	272	111	420	803	
Brazil	9				0	0	37	140	177	
Bulgaria	5	600	0	0	600	26	21	78	125	
CERN	72	85,200	13,500	4,800	103,500	4,569	297	1,119	5,984	
China	13	4,315	500	300	5,115			*in kind RPC*		
Croatia	7	280	49	20	349	15	29	109	153	
Cyprus	3	600	106	0	706	31	12	47	90	
Estonia	2	90	16	6	112	5	8	31	44	
Finland	12	5,000	870	300	6,170	272	49	187	508	
France CEA	14	5,600	1,687	445	7,732	341	58	218	617	
France IN2P3	38	19,700	2,000	2,000	23,700		*2,000*	*0*	*2,000*	*Pledged*
Germany BMBF	41	17,000	2,709	1,100	20,809	919	169	637	1,725	
Germany DESY	5				0	0	*2,000*	*0*	*2,000*	*New Colla*
Greece	17	5,000		0	5,000	221	70	264	555	
Hungary	6	1,000	58	0	1,058	47	25	93	165	
India	26	4,400	300	500	5,200			*in kind RPC*		
Iran	3	510	700	0	1,210			*in kind RPC*		
Ireland	1				0	0	4	16	20	
Italy	181	55,000	8,927	4,000	67,927	2,998	746	2,813	6,557	
Korea	12	1,315	500	147	1,962			*in kind RPC*		
Mexico	5				0	0	21	78	98	
New Zealand	3				0	0	12	47	59	
Pakistan	3	2,445	230	149	2,824			*in kind RPC*		
Poland	12	3,000		0	3,000	132	49	187	368	
Portugal	5	2,000	300	140	2,440	108	21	78	206	
RDMS	72	18,862	2,211	1,657	22,730	1,003	297	1,119	2,419	
Serbia	3		450	0	450	20	12	47	79	
Spain	34	6,000	1,350	450	7,800	344	140	528	1,013	
Switzerland	30	86,500		200	86,700	0	124	466	590	
Taipei	11	2,330	410	0	2,740	121	45	171	337	
Turkey	18	1,000	58	0	1,058	47	74	280	401	
UK	49	9,100	918	3,000	13,018	575	202	762	1,538	
USA	418	104,320	12,800	1,868	118,988	5,252	1,722	6,497	13,471	
Sum	**1,168**	**450,067**	**52,119**	**21,657**	**523,843**	**17,530**	**8,400**	**16,600**	**42,530**	
Requested			**63,000**	**32,000**						

Reminder from April 08 RRB

We report the accounts wrt the **global financial plan** up to 2010 submitted to the RRB in Oct 2006 comprising 3 steps to complete the CMS detector.
Step 1: complete low luminosity detector (17.5 MCHF for crystals, CF, C&I)
Step 2: complete the DAQ (8.4 MCHF).
Step 3: upgrade to design-luminosity detector (16.6 MCHF).

The rescoping of the forward RPC (RE) system was also proposed.

Extracted from April RRB presentation:
CMS closure now expected at the end of June (instead of autumn last year)

Extra time has been used (amongst other things) to:

- carry out installation with reduced risk (following a more natural sequence)
- introduce several trial tests, again to lower risks and anticipate future problems

Lowering operation was extended to reduce risks to operations in UX

Overcosts of gantry crane contract & extension of rental period (40 kCHF/mo)

Extended use of manpower has incurred extra costs (manpower runs at ~ 300 kCHF/mo).

CMS Closed for LHC Startup at the end of August (including the ECAL endcaps)

Statement of Accounts

Here we concentrate solely on activities funded in Step 1

Step 1

Crystals: No additional deficit wrt that foreseen in 2006.

Common Fund: additional deficit of 0.69 MCHF is mainly due the rental of the heavy lifting crane (0.560 MCHF).

C&I: additional deficit of 4.046 MCHF is mainly due to the extra 11 months of commissioning and integration (3.466 MCHF))

We propose to cover the additional deficit of ~ 4 MCHF by using the **Step 2** funds. We believe that **we can attain full DAQ/Filter Farm capability** by using the remaining Step 2 funds and the replacement slices funded through M&O Cat A.

Therefore CMS is not requesting any additional funds wrt the original request made in October 2006.

Status of Funding the Three Steps

	Step 1	Step 2	Step 3	Comment
Austria	**211**	**45**	**171**	
Belgium-FNRS	136	56	**311**	
Belgium-FWO	136	56	**109**	
Brazil	n.a.	**37**		
Bulgaria				Awaiting response
CERN	4,569	297	1,119	
China	Endcap RPC	Endcap RPC	Endcap RPC	
Croatia	15	**29**	**109**	
Cyprus	**31**	**12**	**47**	
Estonia	5	8	31	
Finland	272	49		Funding in 2010 and 2011
France-CEA	341	58	218	
France-IN2P3	n.a.	2,000	n.a.	
Germany BMBF	919	169	637	
Germany DESY	n.a.	2,000	n.a.	
Greece				News in Nov RRB
Hungary				Discussing
India	Endcap RPC	Endcap RPC	Endcap RPC	Request Submitted, News in Nov RRB
Iran	Endcap RPC	Endcap RPC	Endcap RPC	Discussing
Ireland	n.a.	4	16	
Italy	2,500			Step 1 likely to be partially covered
Korea	Endcap RPC	Endcap RPC	Endcap RPC	
Mexico	n.a.			Awaiting Response
New Zealand	n.a.	12		Discussing Step 3
Pakistan	Endcap RPC	Endcap RPC	Endcap RPC	
Poland	132	49		
Portugal	108	21		
RDMS-DMS				Discussing
RDMS-Russia				Discussing
Serbia	20	**12**		
Spain	344	140		
Switzerland	n.a.	124	466	
Taipei	121	45		
Turkey	47	74		
U.K.	575	202	762	
USA-DoE/NSF	5,252	1,722		
Sum	**15,734**	**7,221**	**3,996**	
Requested	**17,530**	**8,400**	**16,600**	
% covered	**90%**	**86%**	**24%**	

Bold: Input since April 2008 RRB

Pledged

Step 1, 2, 3

90%, 86%, 24%

RE - Upscope in 2 phases
We have conducted an EDR.
We will soon be launching production of components for the RPCs.

FUNDING Countries	**Contributions kCHF**	**Comments**
Belgium	420	Likely to use its Step 3 funds for RPC system
China	**500**	
India	800	Request made. News in Nov.
Iran		Discussing. Request made in Oct. 2006 RRB was for 800 kCHF
Korea	405	
Pakistan	1250	

Conclusion on Finances

CMS is very grateful to all the Funding Agencies, including CERN, for the support provided over the long construction period.

Especial thanks to the outgoing CERN Management for their constant support and CERN for help in providing cash-flow.

CMS has reviewed the costs of the **startup detector** and has made a provisional estimation of the accounts. The deficit is somewhat larger than previously anticipated but can be accommodated within the costs of the low luminosity detector **with the crucial assumption that all agencies pledge funds requested in October 2006** as far as the Steps 1 and 2 are concerned.

CMS is not requesting any additional funds with respect to the original request of October 2006.