

OVERVIEW OF COMPUTATIONAL ASPECTS IN PARTICLE PHYSICS

PHILIPP ELLER (IPP)



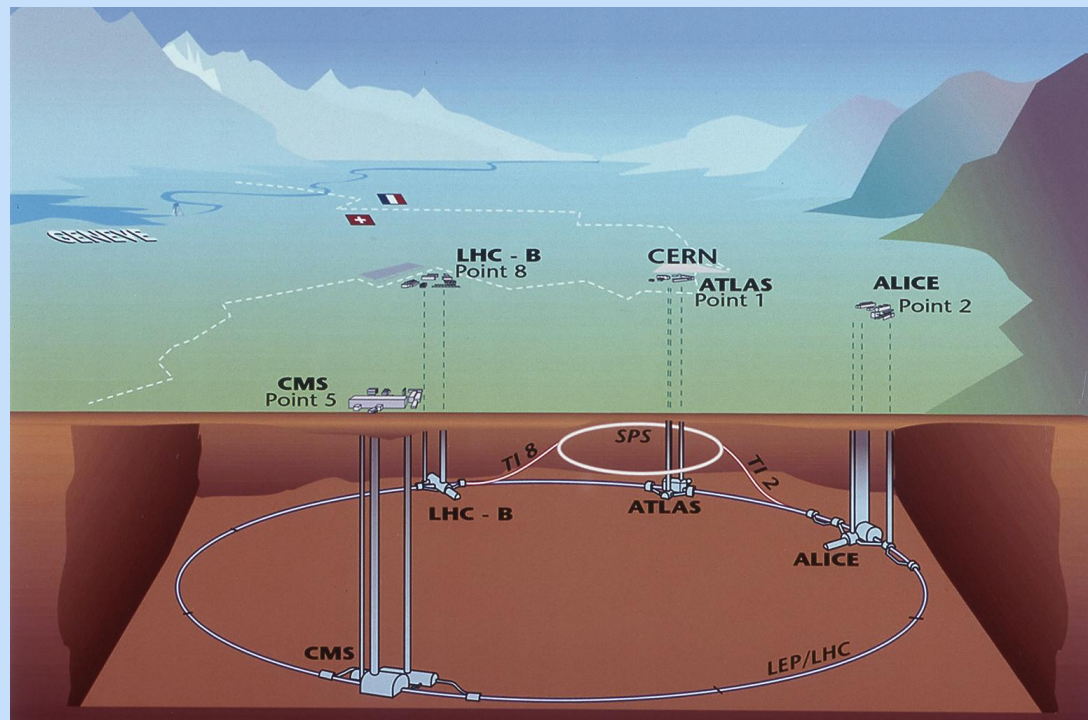
Advanced Scientific Computing Workshop

ETH Zurich

21st February 2014

ETH zürich

- What problems are we faced with in HEP?
- What kind of approaches do we use to solve them?

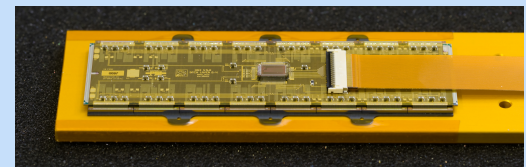
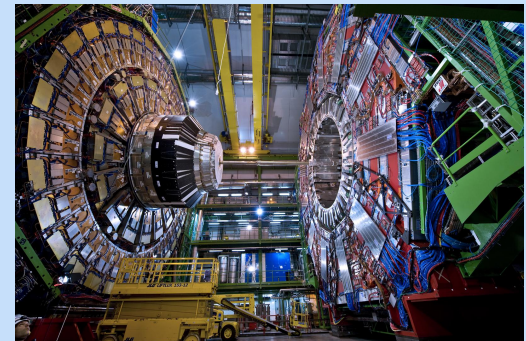
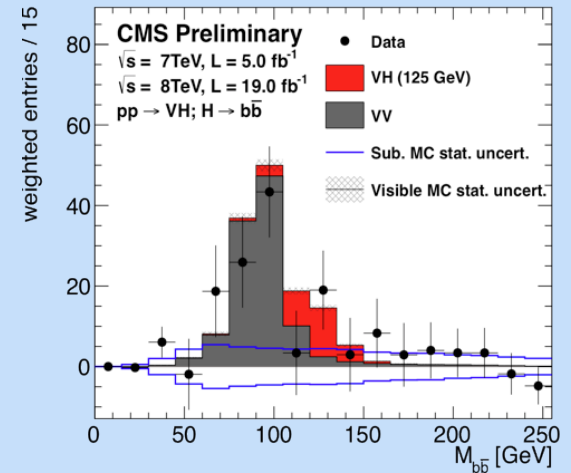


■ 3 projects from IPP

- **Higgs Analysis VHbb** (Grab; Bortignon, Eller, Mohr)
 - CMS data analysis
 - one of the 5 discovery channels at LHC
 - 1/3 of this Analysis carried out at ETH

- **Pixel Detector testing (new CMS Pixel Layer 1 & 2)** (Wallny; Bachmair, Eller, Mohr, Rossini)
 - Pixel Module Readout with custom made hardware
 - Automated Testing

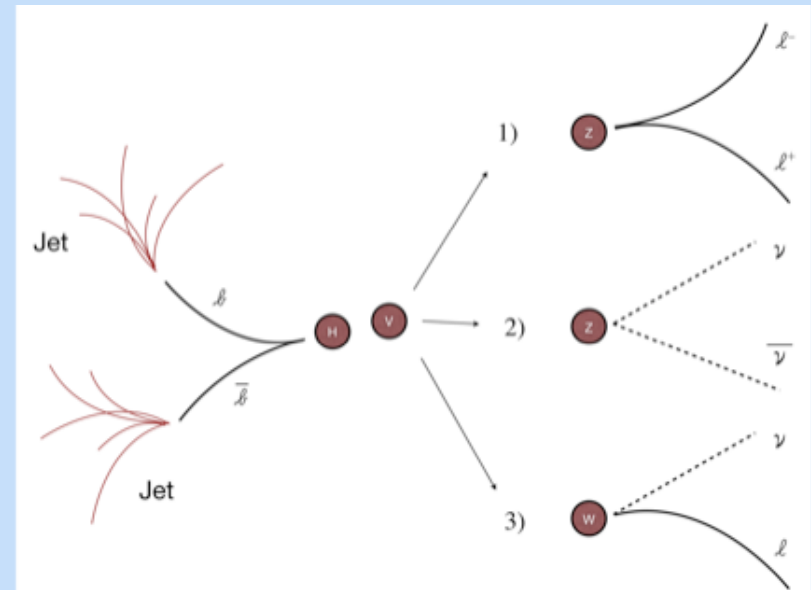
- **Testbeam Analysis RD42** (Wallny; Bachmair, Baeni, Hits)
 - Data from different Testbeams and samples



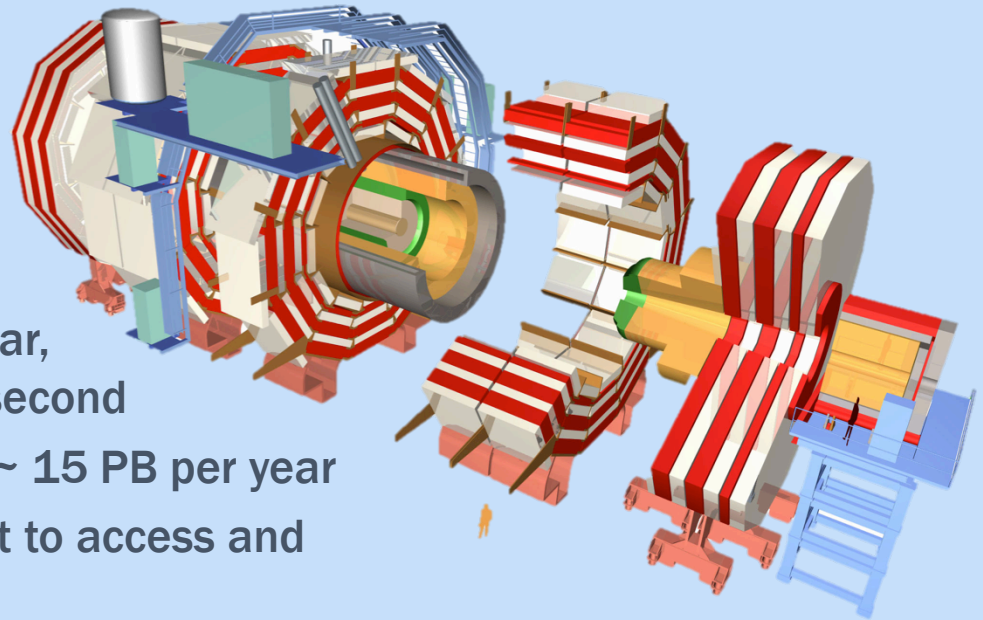
PROJECT 1

■ CMS Data Analysis

- Higgs produce in association with a Vector boson
- Higgs decaying into two b quarks (jets)
- Vector boson decaying into
 - 2 leptons (Z)
 - 2 neutrinos (Z)
 - lepton/neutrino pair (W)
- Analysis divided like that among 3 Groups
- ETH: Z into 2 leptons

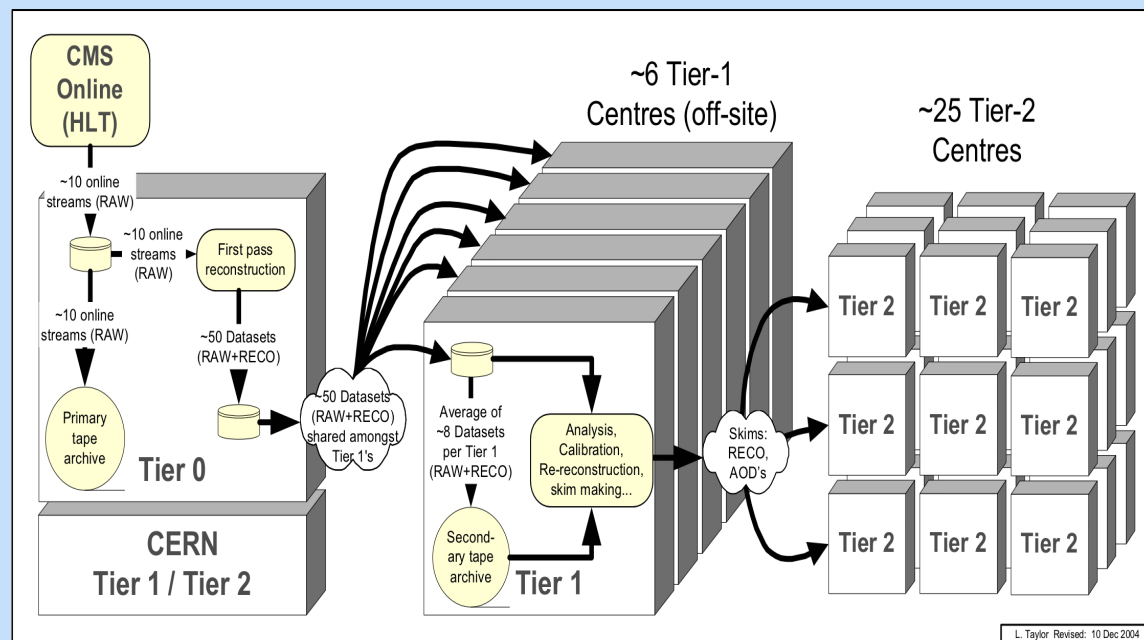


- Large Hadron Collider (LHC) at CERN, Geneva
 - Accelerates and collides protons at unprecedented energies
- Four experiments/detectors around the ring
 - Compact Muon Solenoid (CMS)
 - Records the particles produced in these collisions
 - All this is basically a giant data production machine
 - Numbers for CMS: ~ 5 PB per year, ~ 15 TB per day, ~ 200 MB per second
 - All LHC experiments combined: ~ 15 PB per year
 - Physicists around the world want to access and analyze this data



■ Data stream

- Online Trigger Farm
- Tier-0 (recording and fast RECO)
- redistribution to Tier-1 centers (RECO, storage)
- Tier-2 Centers (subset of data, MC production)
- Tier-3 (Data Analysis, private production, ...)





CRAB

- CMS uses a python frontend called CRAB for job creation and submission in a user-friendly way
 - User only needs to specify some minimal information:
 - Configuration
 - Dataset
 - Number of events/jobs
 - Output handling
 - Rest is handled by CRAB
 - Splitting of jobs
 - Finding appropriate sites
 - Submission
 - Basic monitoring
 - Output retrieval
 - CRAB is interfaced with a command line tool



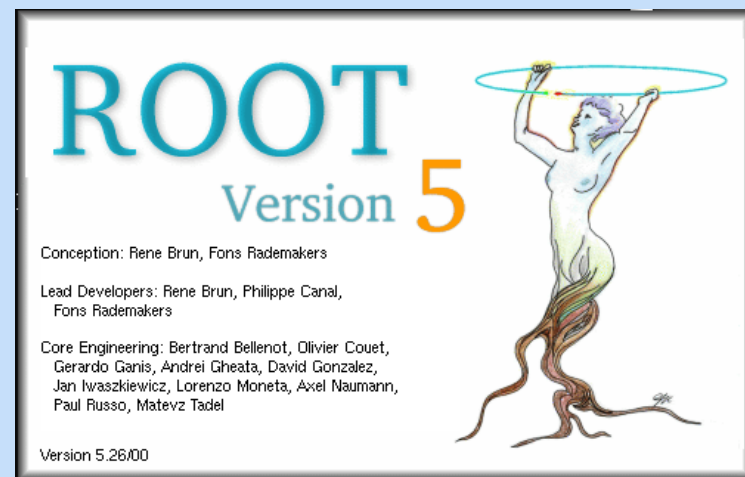
- Tier-3 computing facility for running Analyses for ETH/UZH/PSI
 - computer cluster with
 - 31 worker nodes
 - 336 Cores
 - ~ 1 PetaByte of storage servers
 - located at PSI, Villigen
 - batch job system to run many independent jobs in parallel



<http://wiki.chipp.ch/twiki/bin/view/CmsTier3/Tier3Overview>

- extensive use of ROOT
 - c++ library, developed and maintained by HEP community
 - <http://root.cern.ch/drupal/>
 - data structure (TTree)
 - Histograming, Fitting, Plotting, etc...
 - additional, special packages
 - TMVA
 - RooFit
 - ...

- interfaced with C++ and python





DATA – N-TUPLES

Hundreds of Variables

Millions of Events

* Row	* Instance	* nhJets	* nfathFilter	* naJets	* weightMCP	* hJet_pt.h	* hJet_eta.	* hJet_phi.	* hJet_e.hJ	* hJet_cmva	* hJet_cosT	* hJet_JECU	* hJet_vtxM	* hJet_vtxP	* hJet_vtxE	* hJet_vtxP	* hJet_vtxE	* hJet_vtx3	* hJet_vtx3
* 0 *	* 0 *	* 2 *	* *	* 1 *	* 69.444297	* 1.1374292	* 1.5709012	* 120.27409	* 0.7799046	* *	* *	* *	* *	* 28.698606	* 28.698606	* *	* *	* *	* *
* 0 *	* 1 *	* 2 *	* *	* 1 *	* 27.899406	* -0.088410	* 1.8850653	* 28.892240	* 0.2006135	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 1 *	* 0 *	* 2 *	* *	* 4 *	* 251.89389	* 0.2437592	* 1.7368038	* 260.84024	* 0.7903088	* *	* *	* *	* *	* 115.09912	* 115.09912	* *	* *	* *	* *
* 1 *	* 1 *	* 2 *	* *	* 4 *	* 31.895736	* 0.7850813	* -0.676284	* 43.126297	* 0.6391089	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 2 *	* 0 *	* 2 *	* *	* 0 *	* 69.270683	* -0.591919	* -1.969433	* 82.640235	* 0.8758205	* *	* *	* *	* *	* 26.651199	* 26.651199	* *	* *	* *	* *
* 2 *	* 1 *	* 2 *	* *	* 0 *	* 64.950431	* -1.352931	* 0.2002556	* 135.36070	* 0.0004080	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 3 *	* 0 *	* 2 *	* *	* 2 *	* 126.78032	* -0.611351	* -0.968469	* 155.82357	* 0.7602126	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 3 *	* 1 *	* 2 *	* *	* 2 *	* 110.57797	* -1.06355	* 1.2715027	* 180.08075	* 0.8257845	* *	* *	* *	* *	* 97.259353	* 97.259353	* *	* *	* *	* *
* 4 *	* 0 *	* 2 *	* *	* 3 *	* 130.84272	* 0.4407863	* -3.134294	* 145.31880	* 0.9009301	* *	* *	* *	* *	* 57.231750	* 57.231750	* *	* *	* *	* *
* 4 *	* 1 *	* 2 *	* *	* 3 *	* 32.813808	* 0.7099115	* -2.457713	* 42.516300	* 0.0700240	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 5 *	* 0 *	* 2 *	* *	* 1 *	* 52.989307	* -1.871099	* 1.0271239	* 176.62362	* 0.7696224	* *	* *	* *	* *	* 22.931798	* 22.931798	* *	* *	* *	* *
* 5 *	* 1 *	* 2 *	* *	* 1 *	* 21.169641	* 1.0556626	* -2.714378	* 34.540683	* 0.3596784	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 6 *	* 0 *	* 2 *	* *	* 1 *	* 251.62338	* 0.7623484	* 1.3190584	* 330.25381	* 0.6708984	* *	* *	* *	* *	* 39.327941	* 39.327941	* *	* *	* *	* *
* 6 *	* 1 *	* 2 *	* *	* 1 *	* 108.50310	* 0.4638521	* 1.9681618	* 122.14319	* 0.8448639	* *	* *	* *	* *	* 26.841438	* 26.841438	* *	* *	* *	* *
* 7 *	* 0 *	* 2 *	* *	* 1 *	* 74.966278	* 2.2019221	* -0.072678	* 343.25866	* 0.0234517	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 7 *	* 1 *	* 2 *	* *	* 1 *	* 54.638793	* 1.6633230	* -2.685700	* 149.62896	* 0.6549062	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 8 *	* 0 *	* 2 *	* *	* 1 *	* 84.475883	* 0.0307167	* 0.7372019	* 86.240631	* 0.0936081	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 8 *	* 1 *	* 2 *	* *	* 1 *	* 74.562103	* 0.6010708	* -0.671987	* 89.573921	* 0.8730815	* *	* *	* *	* *	* 26.649311	* 26.649311	* *	* *	* *	* *
* 9 *	* 0 *	* 2 *	* *	* 2 *	* 129.79295	* -0.234822	* 1.0718733	* 134.08258	* 0.0157530	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 9 *	* 1 *	* 2 *	* *	* 2 *	* 40.423973	* -1.412392	* 1.9789307	* 88.208618	* 0.3596784	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 10 *	* 0 *	* 2 *	* *	* 3 *	* 121.94491	* -1.469193	* 1.5468136	* 279.26327	* 0.3596784	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 10 *	* 1 *	* 2 *	* *	* 3 *	* 51.196544	* -0.033274	* 1.3769117	* 51.778736	* 0.1279050	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 11 *	* 0 *	* 2 *	* *	* 3 *	* 36.038181	* -0.808824	* -0.001347	* 49.181415	* 0.9396632	* *	* *	* *	* *	* 26.567981	* 26.567981	* *	* *	* *	* *
* 11 *	* 1 *	* 2 *	* *	* 3 *	* 14.990717	* -1.493982	* -2.737960	* 35.210083	* 0.2053770	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 12 *	* 0 *	* 2 *	* *	* 3 *	* 64.777793	* -2.481100	* 0.2270824	* 390.00973	* 0.7789436	* *	* *	* *	* *	* 208.50349	* 208.50349	* *	* *	* *	* *
* 12 *	* 1 *	* 2 *	* *	* 3 *	* 52.216163	* -1.472387	* 1.8196536	* 120.32574	* 0.9991813	* *	* *	* *	* *	* 44.836154	* 44.836154	* *	* *	* *	* *
* 13 *	* 0 *	* 2 *	* *	* 2 *	* 75.228027	* 2.2534260	* -2.042834	* 362.33560	* 0.0557434	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 13 *	* 1 *	* 2 *	* *	* 2 *	* 64.506034	* 1.1625714	* 2.3347344	* 113.89759	* 0.8457002	* *	* *	* *	* *	* 30.281282	* 30.281282	* *	* *	* *	* *
* 14 *	* 0 *	* 2 *	* *	* 2 *	* 68.045295	* -1.287962	* 2.8067112	* 133.14035	* 0.7123956	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 14 *	* 1 *	* 2 *	* *	* 2 *	* 39.062110	* -2.469691	* 0.7544225	* 232.80937	* 0.8628814	* *	* *	* *	* *	* 61.981906	* 61.981906	* *	* *	* *	* *
* 15 *	* 0 *	* 2 *	* *	* 2 *	* 43.150695	* 0.5234840	* -1.984675	* 50.081230	* 0.4918898	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 15 *	* 1 *	* 2 *	* *	* 2 *	* 18.258411	* 1.9302135	* -1.779714	* 64.415000	* 0.6588943	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 16 *	* 0 *	* 2 *	* *	* 1 *	* 74.994697	* -0.760405	* -0.779534	* 98.460121	* 0.8318580	* *	* *	* *	* *	* 42.399692	* 42.399692	* *	* *	* *	* *
* 16 *	* 1 *	* 2 *	* *	* 1 *	* 59.179515	* -1.504980	* 1.5194699	* 140.24549	* 0.7942532	* *	* *	* *	* *	* 53.354999	* 53.354999	* *	* *	* *	* *
* 17 *	* 0 *	* 2 *	* *	* 4 *	* 73.456604	* 1.7901104	* 0.7390854	* 226.38386	* 0.8430059	* *	* *	* *	* *	* 114.29798	* 114.29798	* *	* *	* *	* *
* 17 *	* 1 *	* 2 *	* *	* 4 *	* 40.654655	* 0.3563944	* -2.574992	* 44.136890	* 0.7903598	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 18 *	* 0 *	* 2 *	* *	* 0 *	* 77.178492	* -0.347485	* 0.7846221	* 82.840957	* 0.9969686	* *	* *	* *	* *	* 55.611225	* 55.611225	* *	* *	* *	* *
* 18 *	* 1 *	* 2 *	* *	* 0 *	* 33.035865	* -1.619883	* -0.963626	* 86.992950	* 0.0434459	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 19 *	* 0 *	* 2 *	* *	* 4 *	* 172.49417	* -1.410227	* 2.7648296	* 374.87310	* 0.6793265	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 19 *	* 1 *	* 2 *	* *	* 4 *	* 19.069362	* 0.6736939	* 2.8830509	* 24.196075	* 0.3596784	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 20 *	* 0 *	* 2 *	* *	* 2 *	* 79.232536	* 0.9336153	* -2.158549	* 117.42236	* 0.6909120	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 20 *	* 1 *	* 2 *	* *	* 2 *	* 33.195957	* 0.1008918	* 1.8615557	* 33.929111	* 0.7340165	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 21 *	* 0 *	* 2 *	* *	* 7 *	* 87.045997	* 0.5578533	* -3.024663	* 102.92668	* 0.9179614	* *	* *	* *	* *	* 41.410503	* 41.410503	* *	* *	* *	* *
* 21 *	* 1 *	* 2 *	* *	* 7 *	* 54.411193	* -0.517702	* -1.712849	* 63.132144	* 0.6183450	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *
* 22 *	* 0 *	* 2 *	* *	* 3 *	* 67.097587	* -0.528943	* 2.2566115	* 78.045059	* 0.6613987	* *	* *	* *	* *	* 0 *	* 0 *	* *	* *	* *	* *

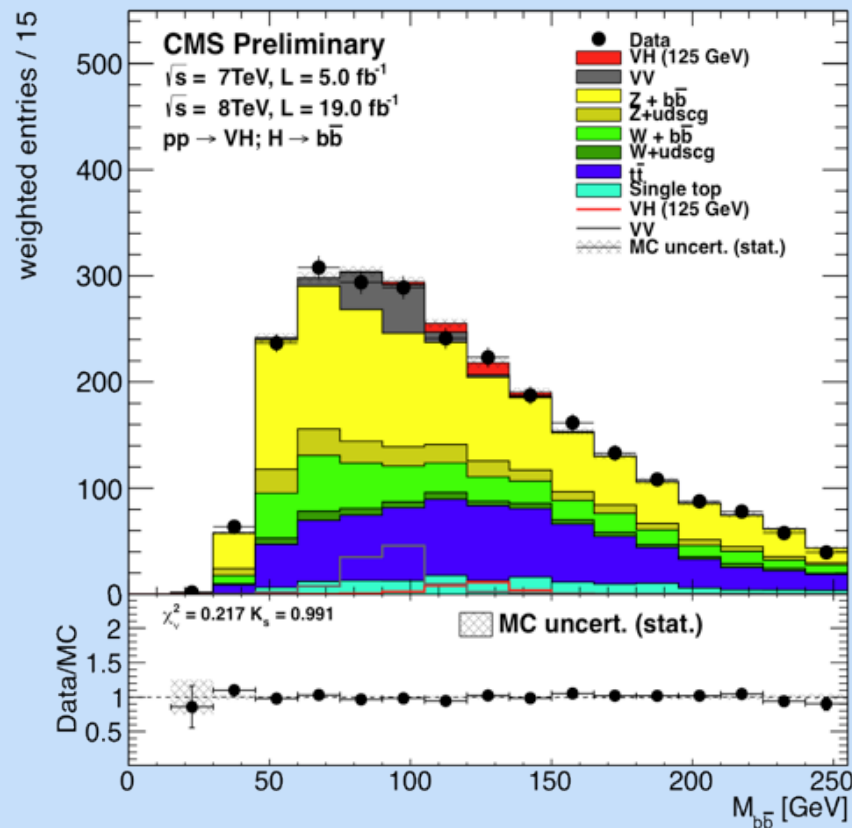


DATASETS

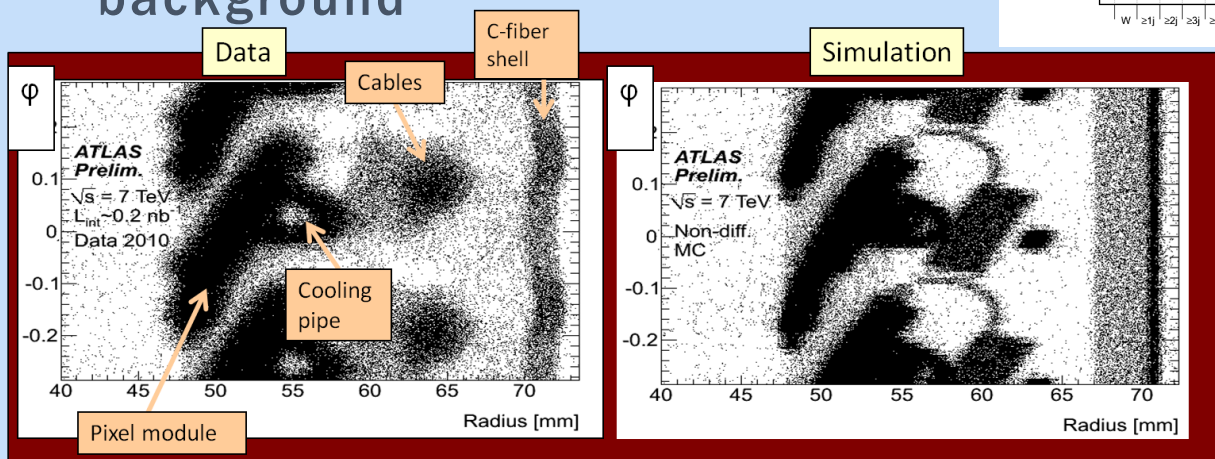
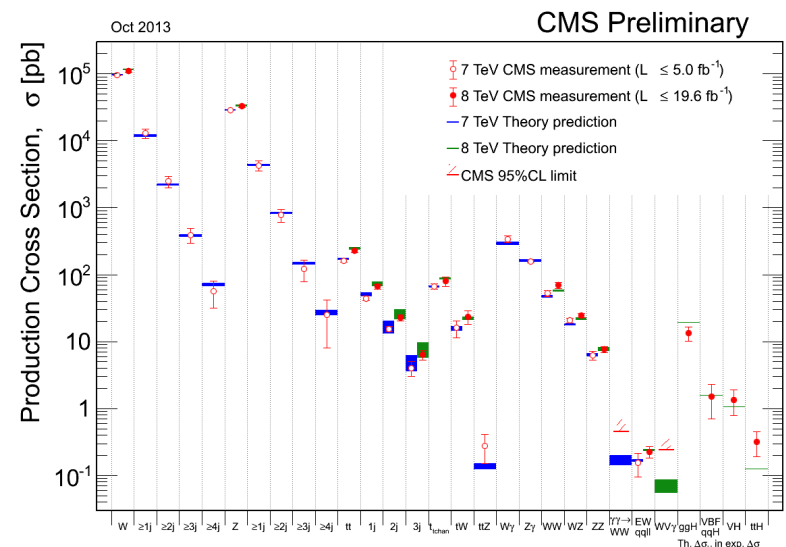
- Skimmed dataset of VHbb Analysis: ~40 GB, including:
 - Signal Montecarlo
 - Background Montecarlo
 - Data

- High throughput calculations
 - independent events
 - in many steps it can be processed event by event
 - use batch job system to run our code on independent subsamples of the dataset in parallel
 - order of 100 jobs
 - only 100 MB – 1 GB per job

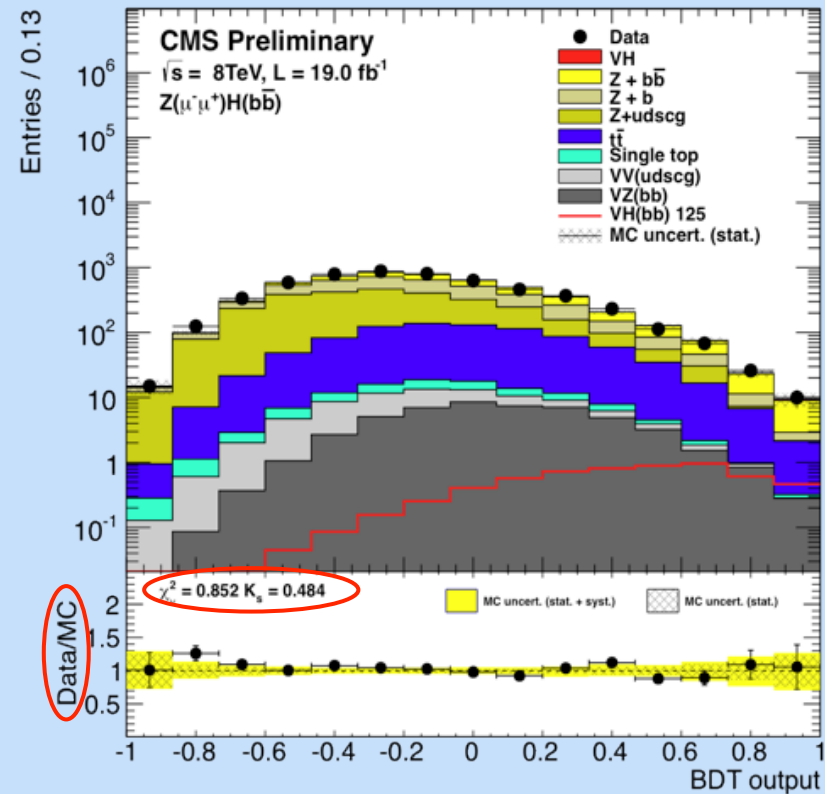
- Example: one Variable for all Events of a specific phase space region (selection) in a Histogram. Here: invariant mass of the $b\bar{b}$ -system



- simulation usually describes data extremely well
 - good understanding of detector and processes
- important since tiny signals are sitting on top of a huge background



- important to monitor that data is described by simulation – DATA/MC comparison
 - χ^2 test
 - K-S test
 - ratio plots





EVENT SELECTION

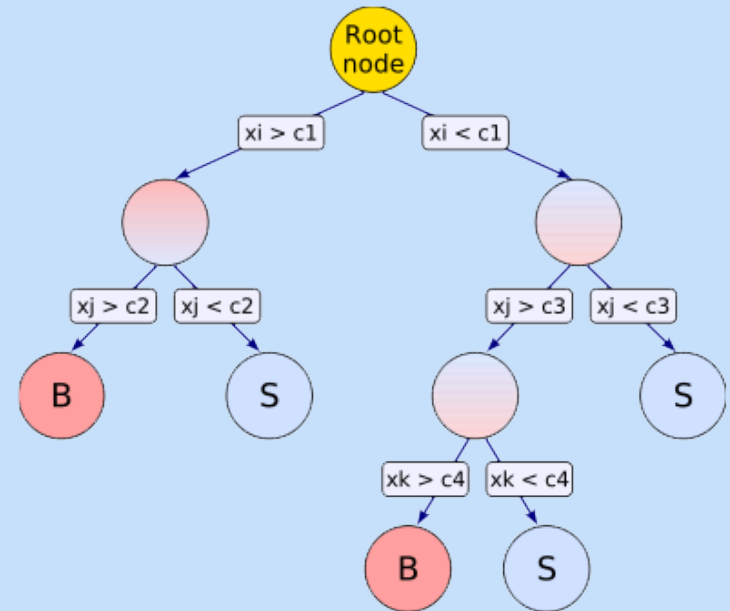
- Cut out a certain “window” of all data
 - for example $|\eta| < 2.4$ (within tracker)
 - or run optimization for a figure of merit in a multi dimensional phase space, e.g.

$$FoM := \frac{S}{1.5 + \sqrt{B} + 0.2B}$$

- Minimization problem
- inclusive Dataset should always be available
 - producing skimmed, cached files among the inclusive samples
 - hash to identify

■ Multivariate Analysis

- most common method in HEP: boosted decision tree (BDT)
- to generate a new, not necessary physical, variable to separate signal from background (discrimination)
 - output between 0 (bkgd) and 1 (signal)
 - Different Goals to optimize for:
 - signal purity
 - exclusion limit
 - efficiency
- to correct a variable (regression)





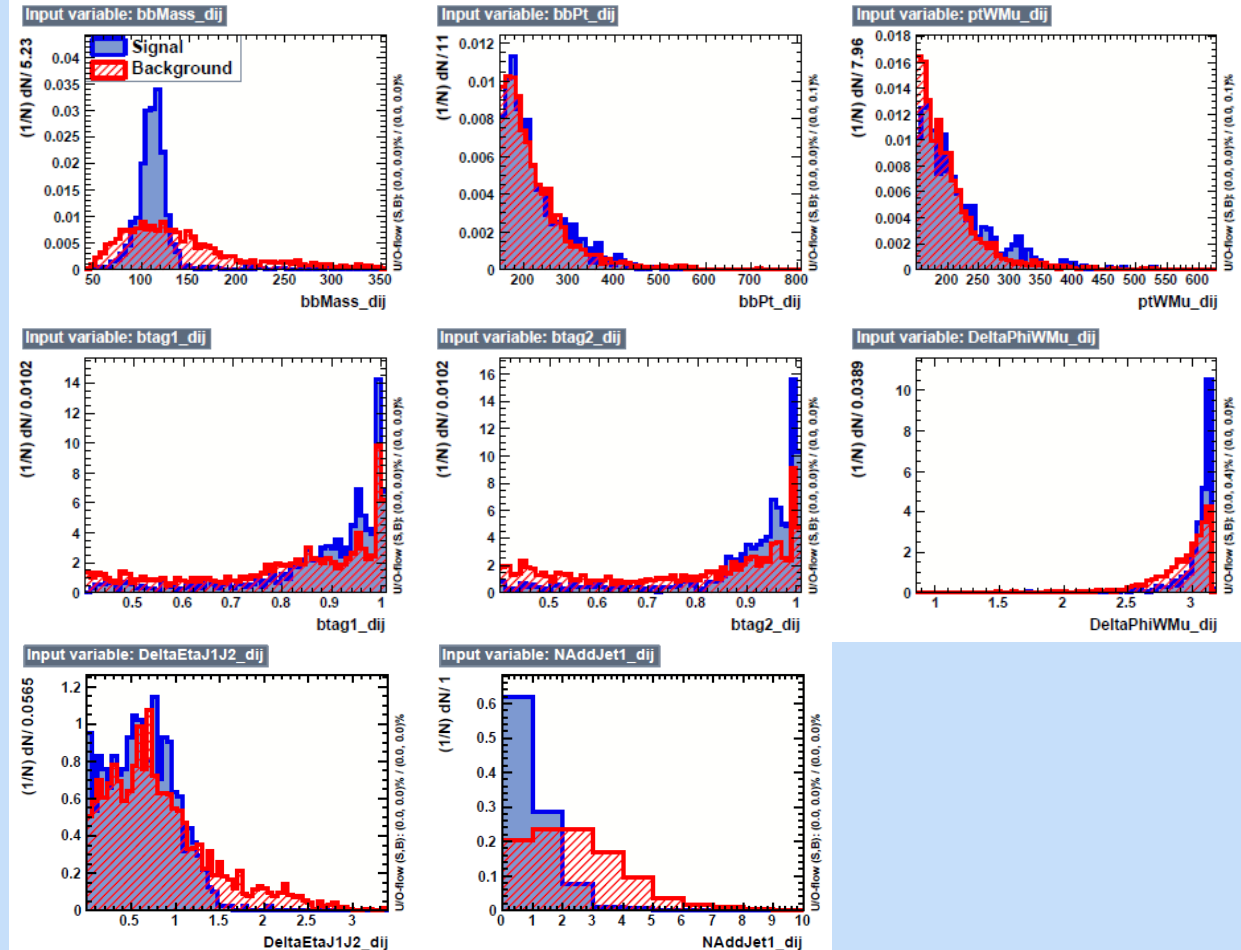
- training (learning) and application of MVA algorithms using TMVA ROOT toolkit
 - many MVAs implemented: Multi layer perceptron, boosted decision tree, fisher discriminant, bayesian neural networks, ...
 - <http://tmva.sourceforge.net/>
- Training on special montecarlo samples, excluded from the further analysis (bias)
- multidimensional parameter space for classifier
 - optimization problem
- see talk of H. Voss



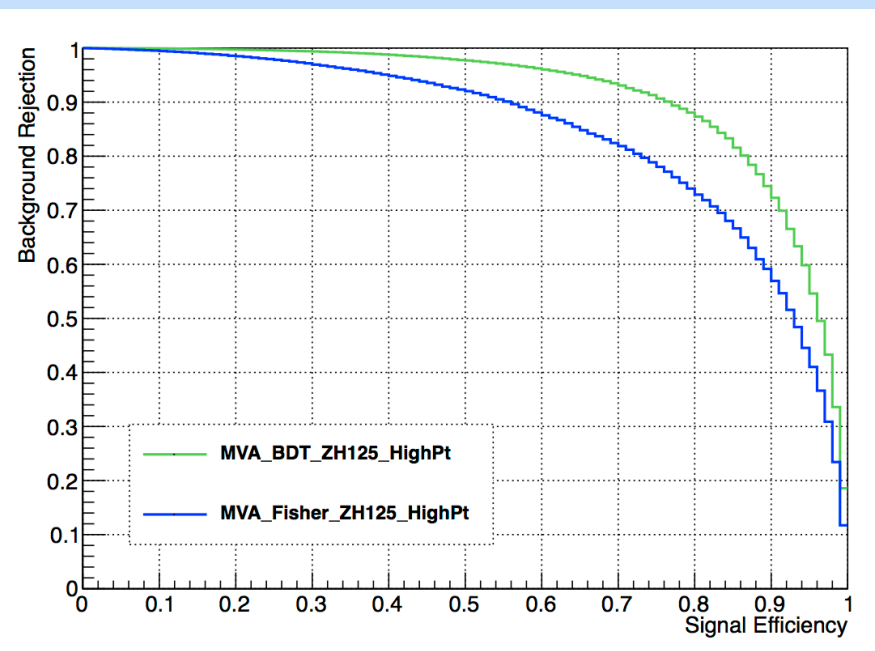
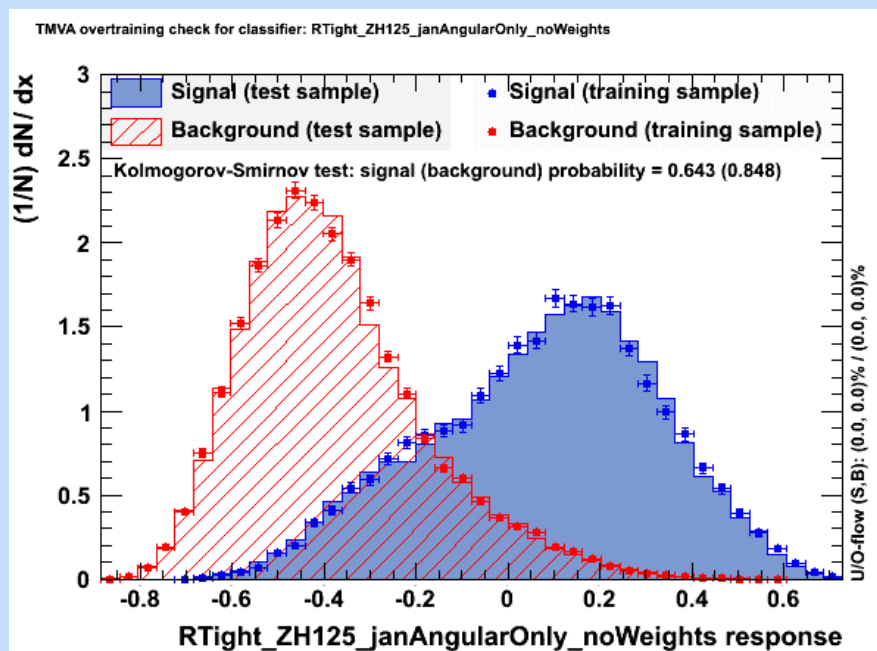
- different variables (20-30) to discriminate signal from background

■ Signal
■ Background

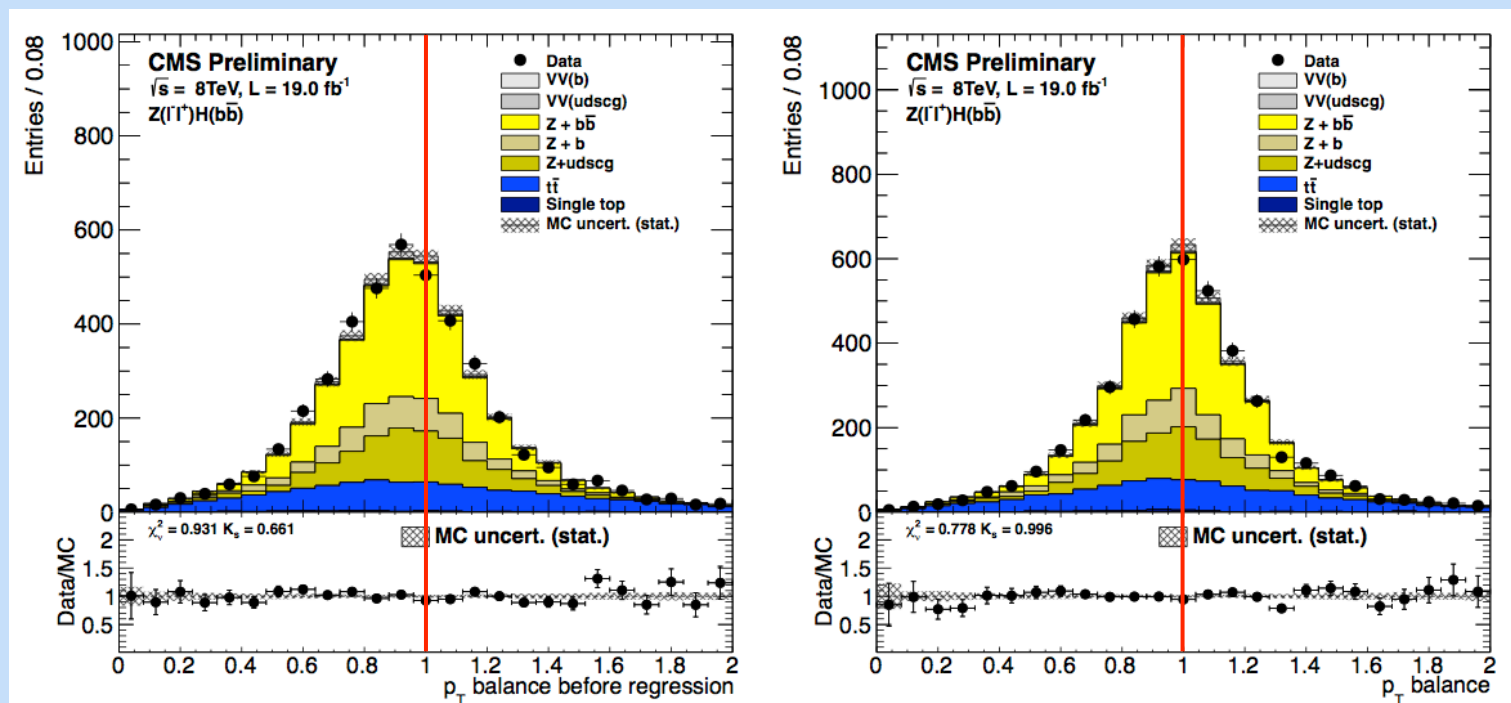
- selecting best variables, highest discrimination power, correlations with other vars



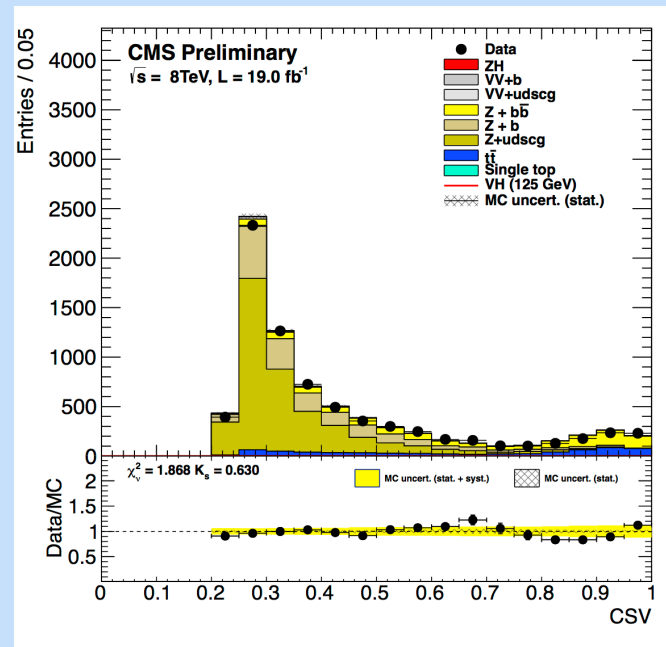
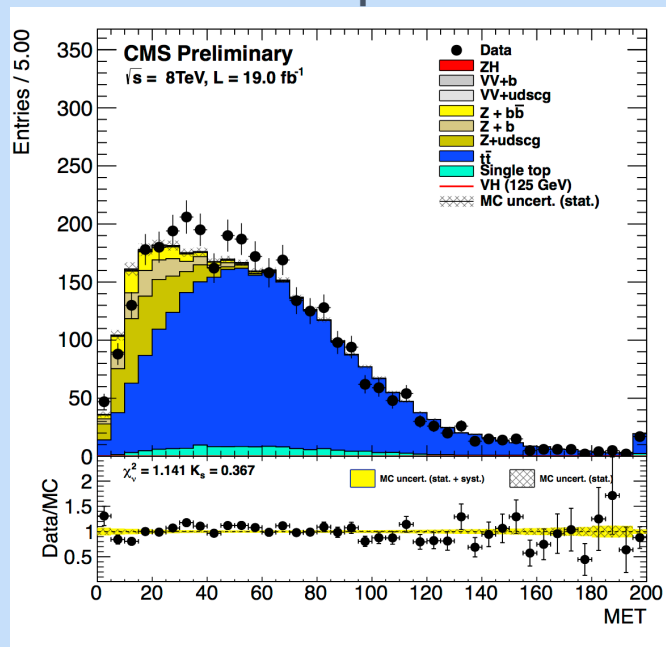
- optimization targeting best background rejection and signal efficiency.
- no overtraining (training samples learned)



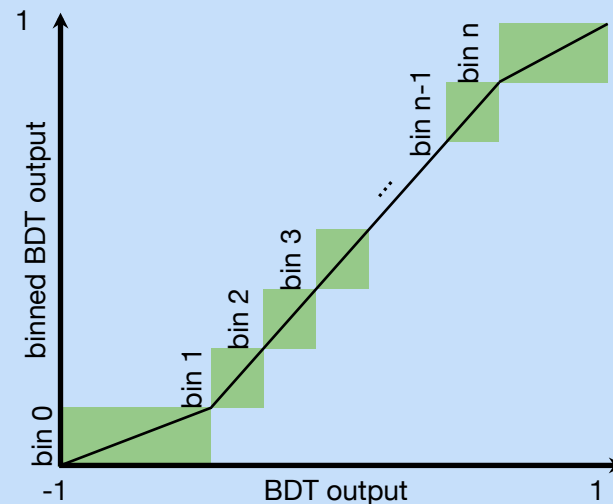
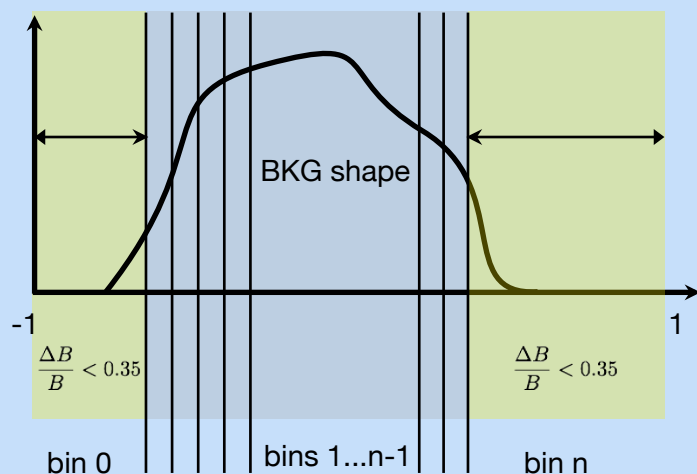
- Use other variables to correct a variable
 - Here correcting the b-jet energy
 - recover from semi-leptonic b decays (neutrino missing)
 - plot: balance of V- vs. H-system p_T before and after regression



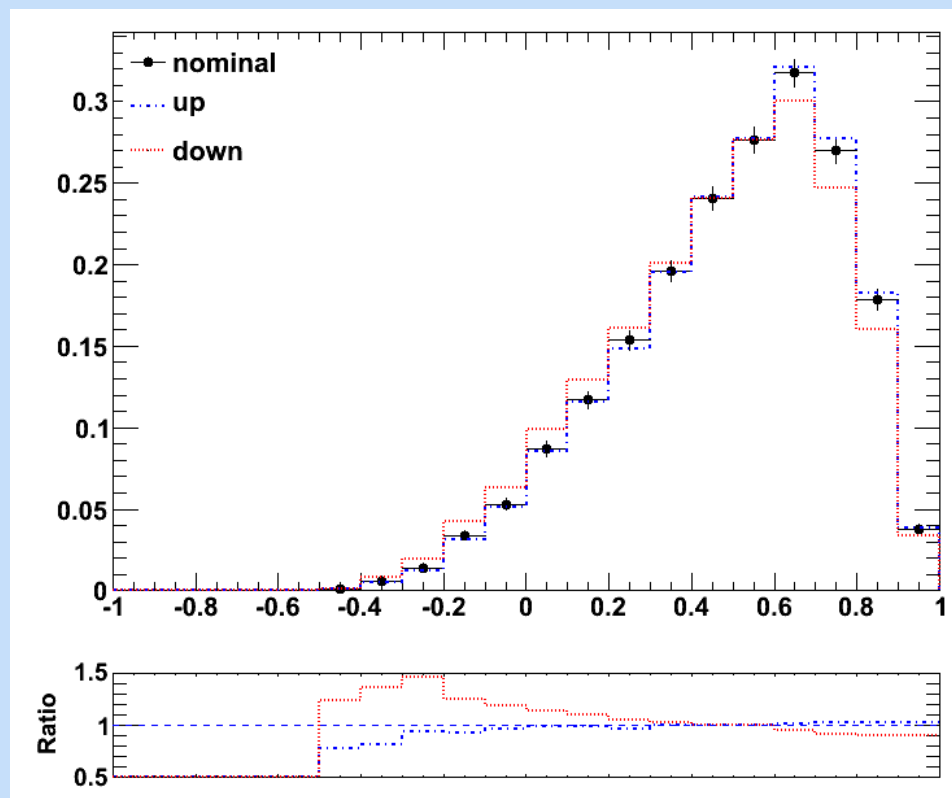
- get scale factors for simulation from fit in mass sidebands
 - extrapolate to signal region
 - simultaneous fits of Drell-Yan (■, ■, ■) and tt-bar (■) backgrounds
 - vary normalization of the 4 processes to best fit the data
 - minimization problem



- bins at distribution tails can have too few entries
 - find the edges of the BDT output
 - require less than 35% stat uncertainty on the BKGd in the first and the last bin
 - rest in between is put in equidistant bins
 - shape is not changed



- different nuisance for final fit
 - statistical uncertainty
 - shape systematics
 - jet energy, b-tagging, ...
 - normalization systematics
 - luminosity uncertainty, scale factors, ...
- correlated and uncorrelated (or anti-correlated) nuisances





FITTING

Channels / Processes

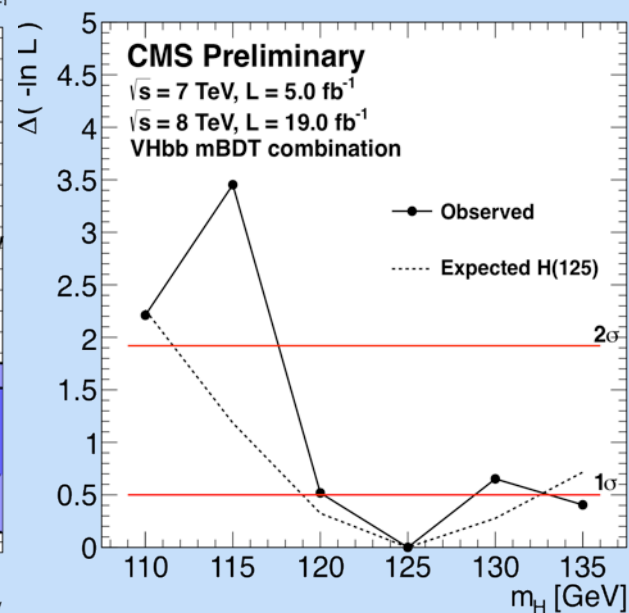
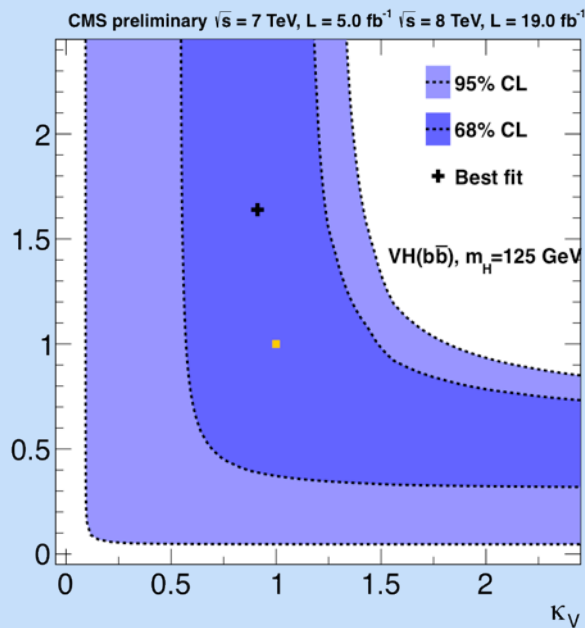
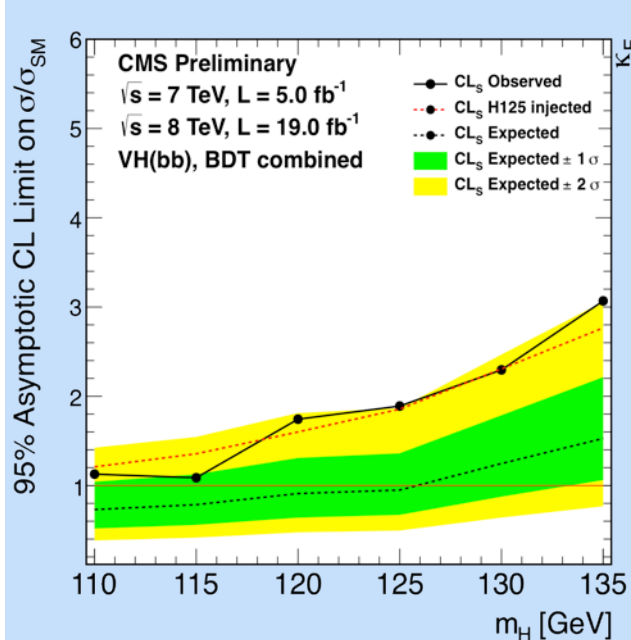
bin	Channels / Processes									
	ZmmHighPt_8TeV	ZmmHighPt_8TeV	ZmmHighPt_8TeV	ZmmHighPt_8TeV	ZmmHighPt_8TeV	ZmmHighPt_8TeV	ZmmHighPt_8TeV	ZmmHighPt_8TeV	ZmmHighPt_8TeV	ZmmHighPt_8TeV
process	ZH	Zj0b	Zj1b	Zj2b	VVLF	VVHF	TT	s_Top		
process 0	1	2	3	4	5	6	7			
lumi_8TeV	1nN	1.05	-	-	-	1.05	1.05	-	1.05	
pdf_qqbar	1nN	1.01	-	-	-	1.01	1.01	-	-	
pdf_gg	1nN	-	-	-	-	-	-	1.01		
QCDscale_VH	1nN	1.04	-	-	-	-	-	-	-	
QCDscale_ttbar	1nN	-	-	-	-	-	-	-	1.06	
QCDscale_VV	1nN	-	-	-	-	1.04	1.04	-	-	
QCDscale_QCD	1nN	-	-	-	-	-	-	-	-	
CMS_vhbb_boost_EWK	1nN	1.02	-	-	-	-	-	-	-	-
CMS_vhbb_boost_QCD	1nN	1.05	-	-	-	-	-	-	-	-
CMS_vhbb_ST	1nN	-	-	-	-	-	-	-	1.29	
CMS_vhbb_VV	1nN	-	-	-	-	1.15	1.15	-	-	
CMS_eff_e	1nN	-	-	-	-	-	-	-	-	
CMS_eff_m	1nN	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	
CMS_vhbb_Zj2b_Z11_SF_8TeV			1nN	-	-	-	1.1	-	-	-
CMS_vhbb_Zj1b_Z11_SF_8TeV			1nN	-	-	1.07	-	-	-	-
CMS_vhbb_Zj0b_Z11_SF_8TeV			1nN	-	1.04	-	-	-	-	-
CMS_vhbb_TT_Z11_SF_8TeV	1nN	-	-	-	-	-	-	1.05	-	-
CMS_vhbb_ZjLF_Z11_exHighPt_8TeV	1nN	-	-	1.02	-	-	-	-	-	-
CMS_vhbb_ZjHF_Z11_exHighPt_8TeV	1nN	-	-	-	1.02	1.02	-	-	-	-
CMS_vhbb_TT_Z11_exHighPt_8TeV	1nN	-	-	-	-	-	-	-	1.02	-
CMS_vhbb_stats_ZH_ZmmHighPt_8TeV	shape	1.0	-	-	-	-	-	-	-	-
CMS_vhbb_stats_Zj0b_ZmmHighPt_8TeV	shape	-	-	-	1.0	-	-	-	-	-
CMS_vhbb_stats_Zj1b_ZmmHighPt_8TeV	shape	-	-	-	-	1.0	-	-	-	-
CMS_vhbb_stats_Zj2b_ZmmHighPt_8TeV	shape	-	-	-	-	-	1.0	-	-	-
CMS_vhbb_stats_VVLF_ZmmHighPt_8TeV	shape	-	-	-	-	-	-	1.0	-	-
CMS_vhbb_stats_VVHF_ZmmHighPt_8TeV	shape	-	-	-	-	-	-	-	1.0	-
CMS_vhbb_stats_TT_ZmmHighPt_8TeV	shape	-	-	-	-	-	-	-	1.0	-
CMS_vhbb_stats_s_Top_ZmmHighPt_8TeV	shape	-	-	-	-	-	-	-	-	1.0
UEPS	shape	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
CMS_vhbb_res_j	shape	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
CMS_vhbb_scale_j	shape	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
CMS_vhbb_eff_b	shape	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
CMS_vhbb_fake_b_8TeV	shape	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

- CMSSW Higgs combine tool
- Hypotheses testing H_0 and H_1
- find values of nuisance parameters for s and s+b hypothesis best describing the data by maximizing the likelihood

nuisance	background fit $\Delta x/\sigma_{in}, \sigma_{out}/\sigma_{in}$	signal fit $\Delta x/\sigma_{in}, \sigma_{out}/\sigma_{in}$	$\rho(\mu, \theta)$
CMS_vhbb_ZjHF_SF_Z11_8TeV	+0.75, 0.84	+0.53, 0.86	-0.14
CMS_vhbb_ZjHF_exHighPt_Z11_8TeV	+0.96, 0.66	+0.72, 0.68	-0.20
CMS_vhbb_ZjHF_exLowPt_Z11_8TeV	+0.35, 0.63	+0.31, 0.64	-0.05
CMS_vhbb_ZjLF_exHighPt_Z11_8TeV	+0.53, 0.55	+0.57, 0.54	+0.03
CMS_vhbb_ZjLF_exLowPt_Z11_8TeV	-0.19, 0.73	-0.19, 0.73	-0.02

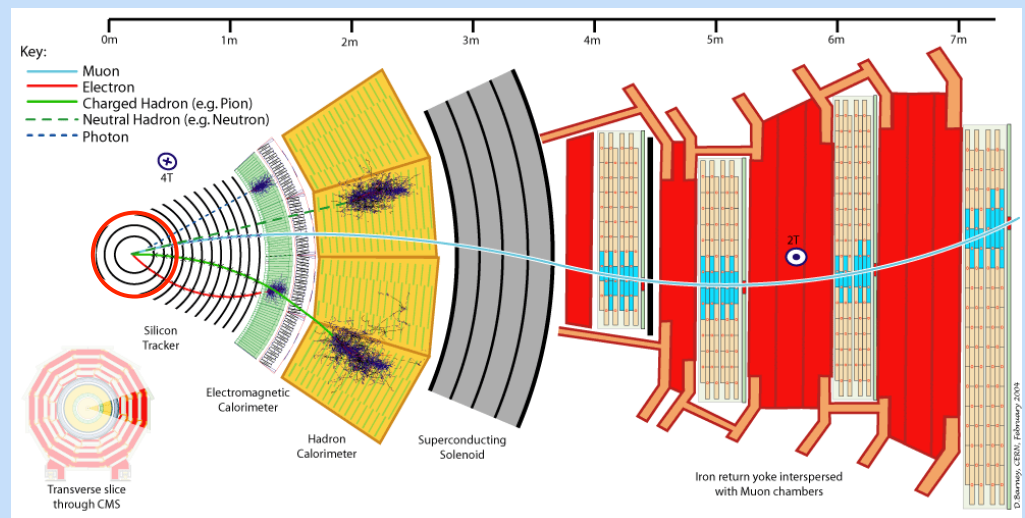
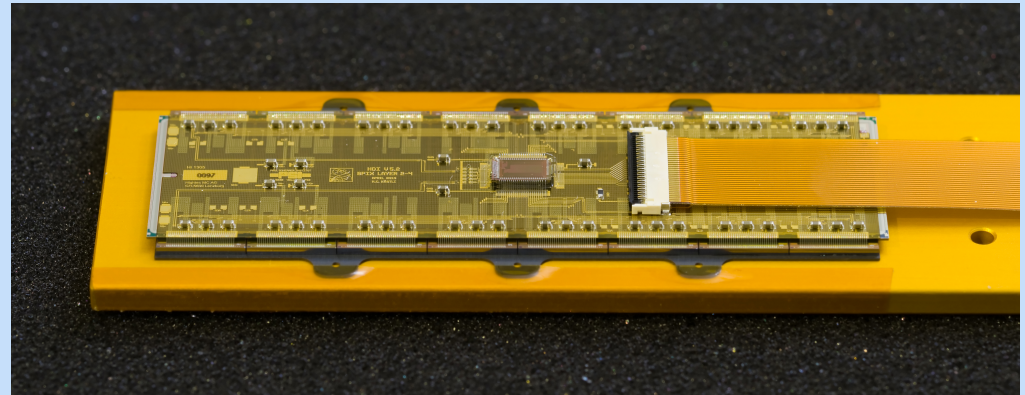
- generate test statistics for profile likelihood or Asimov dataset for asymptotic approximation
- extract CL_s and/or significance and signal strength of excess

- ROOT library to generate plots for publications
 - Histograms, Function graphs, Text elements, ...



PROJECT 2

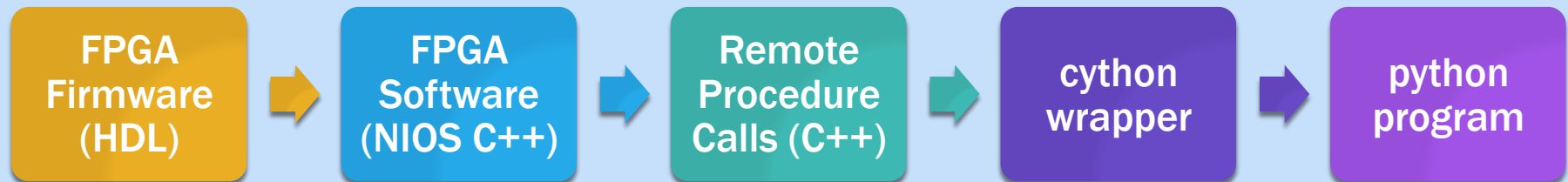
- new Pixel Detector for CMS soon going into production
 - assembled Pixel Modules need to undergo testing
 - order of several hundred modules



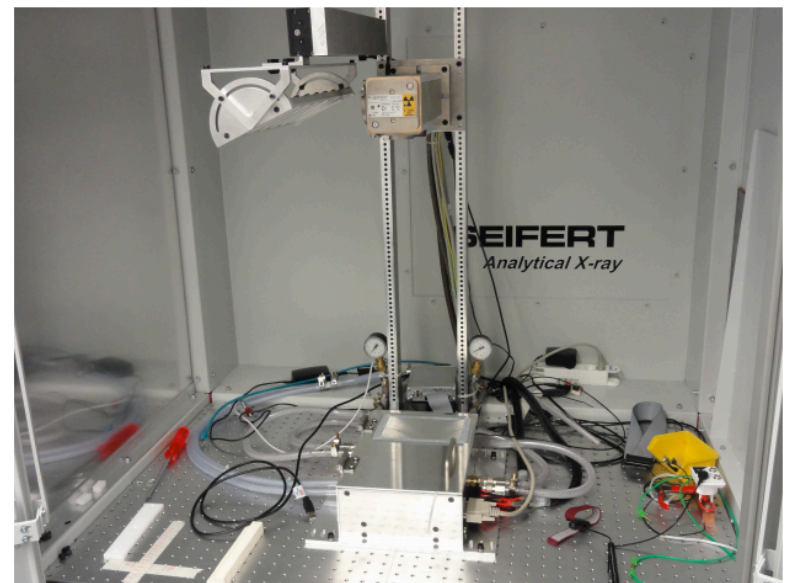
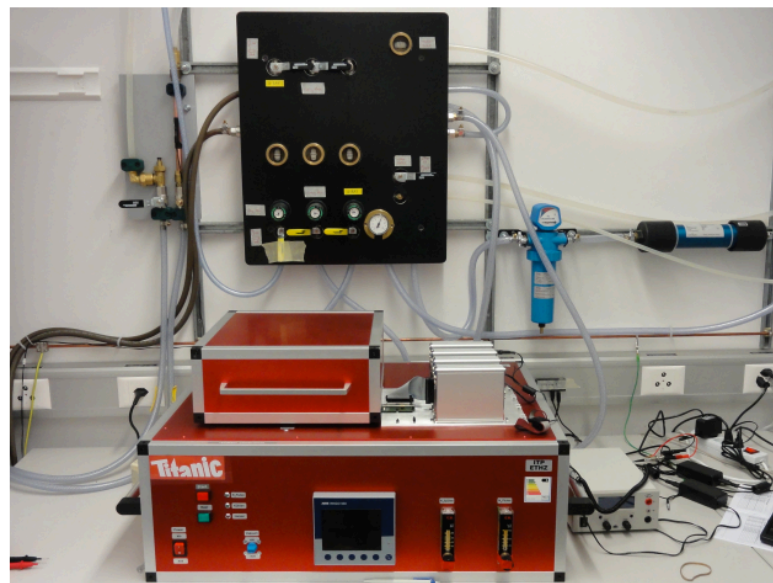
- Using custom made Hardware (digital testboard) from PSI to readout and test our pixel detectors
 - FPGA for controlling and data acquisition (DAQ)
 - NIOS softcore and Computer Software for reading out and processing the data
 - User Interface

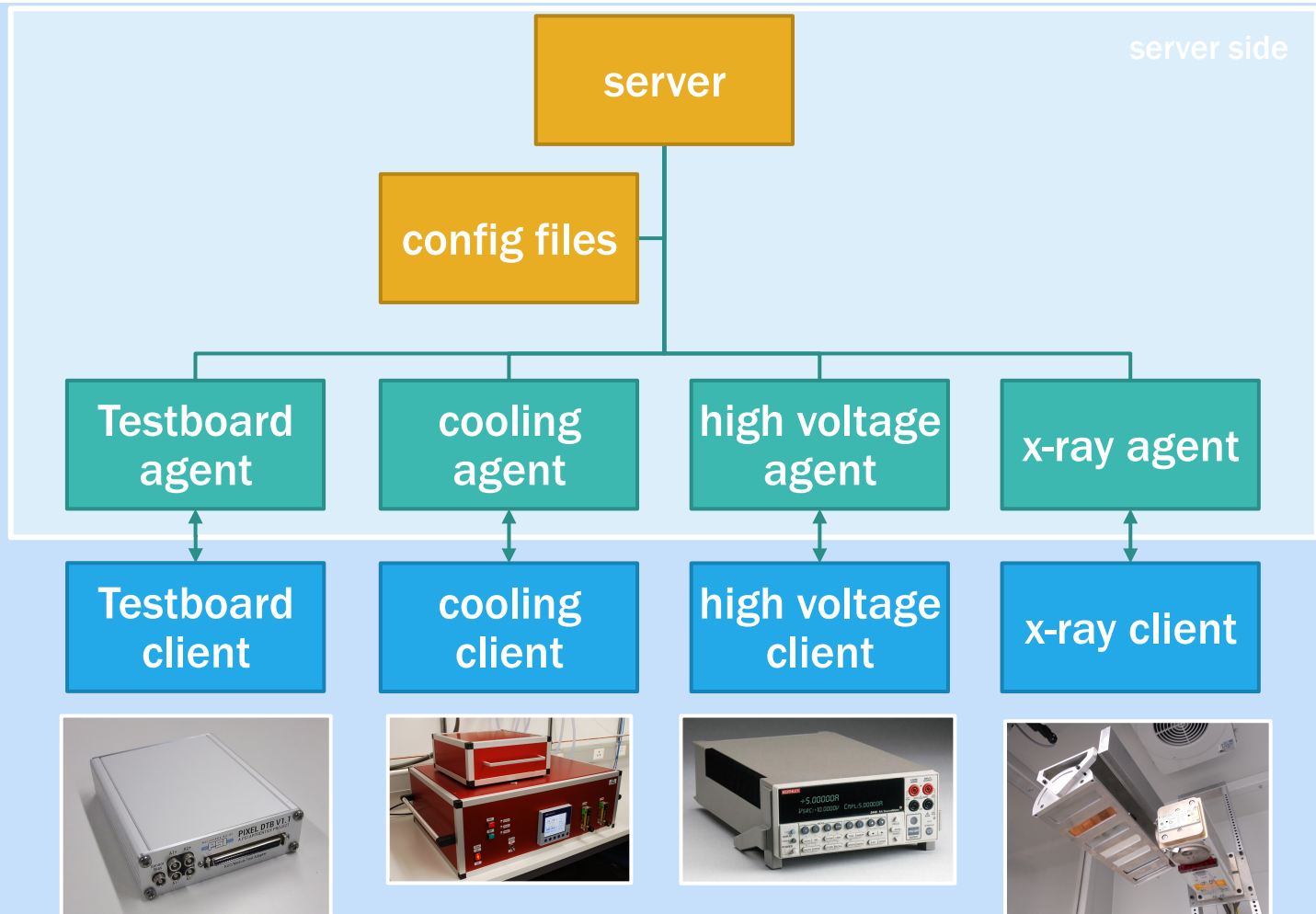


- A Software Framework in several layers using different languages to handle different things
 - Hardware description language for FPGA implementation
 - C++ for low level functionality (close to hardware)
 - python for high level functionality and interface



- Controlling several different lab devices to execute procedure
 - asynchronous Events (server/client structure)
 - error handling (program errors, temperature setpoint, etc...)
 - in/out file handling



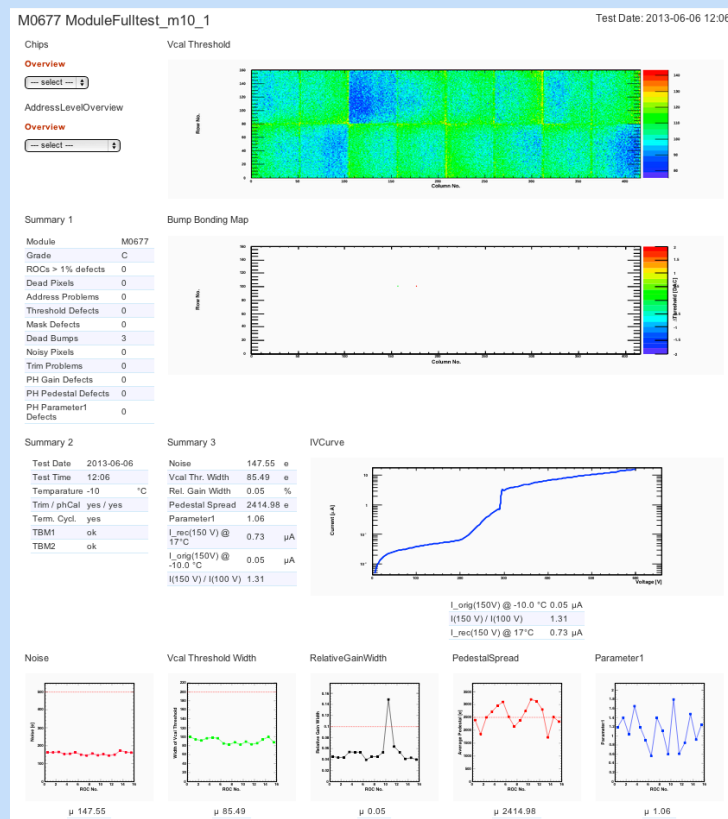


- database to store all production relevant information
 - vendor, part numbers, etc
 - test results
 - grading

Show 25 entries

Module id	Summary id	Center	Date	Qualification type	Grade	Pixel defects
M0110	4460	ETH	2013-06-04T14:09:31	FastQualification	B	0
M0677	4466	ETH	2013-06-06T12:15:33	FastQualification	C	0
M0695	4459	ETH	2013-06-04T11:18:47	FastQualification	B	0
M0823	4451	ETH	2013-05-31T14:38:54	FastQualification	B	1
M0823	4461	ETH	2013-10-30T11:51:36	FullQualification	B	1
M0823	4462	ETH	2013-05-31T14:38:54	FullQualification	B	1
M0827	4449	ETH	2013-05-31T14:38:54	FastQualification	C	0
M0827	4463	ETH	2013-10-31T09:14:20	FullQualification	C	0
M0864	4456	ETH	2013-06-06T12:15:33	FastQualification	B	0
M0865	4457	ETH	2013-10-31T09:14:20	FullQualification	C	1
M0865	4467	ETH	2013-06-03T13:41:41	FastQualification	B	1
M0985	4465	ETH	2013-06-06T12:15:33	FastQualification	C	1
M1170	4450	ETH	2013-05-31T11:29:55	FastQualification	C	0
M1172	4453	ETH	2013-10-30T11:51:36	FullQualification	C	0
M1172	4455	ETH	2013-05-31T11:29:55	FastQualification	C	0
M1187	4448	PERUGIA	2013-10-30T16:59:41	FullQualification	B	0
M1193	4458	ETH	2013-05-31T11:29:55	FastQualification	B	1
M1193	4464	ETH	2013-10-30T11:51:36	FullQualification	B	1
M1205	4452	ETH	2013-10-30T11:51:36	FullQualification	B	0
M1205	4454	ETH	2013-06-03T13:41:41	FastQualification	B	0
M313206-16-03	4446	PERUGIA	2013-11-13T10:44:54	FullQualification	A	29
M7676	4447	PERUGIA	2013-03-05T12:59:14	FullQualification	B	0

Showing 1 to 22 of 22 entries



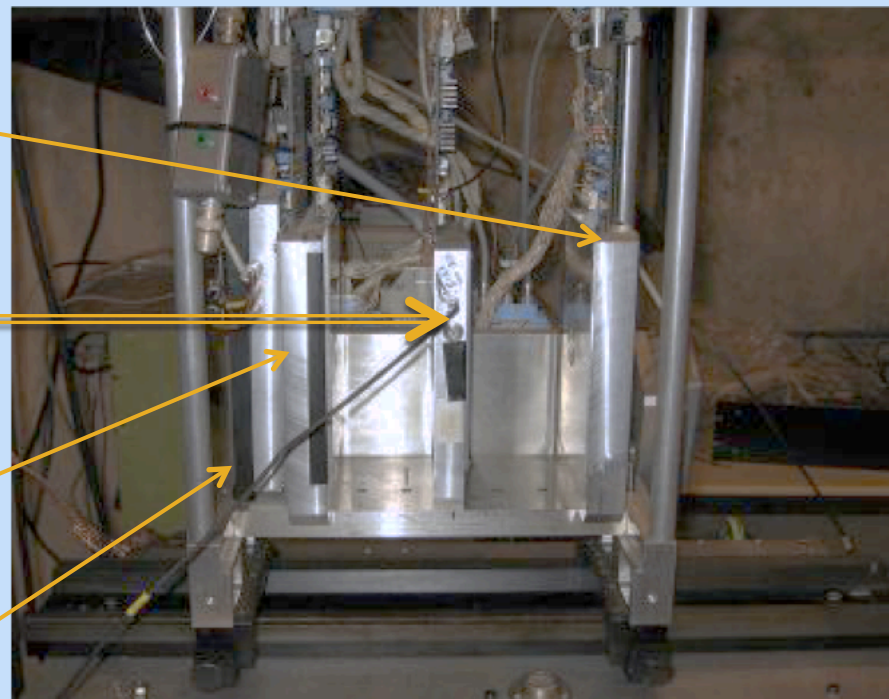
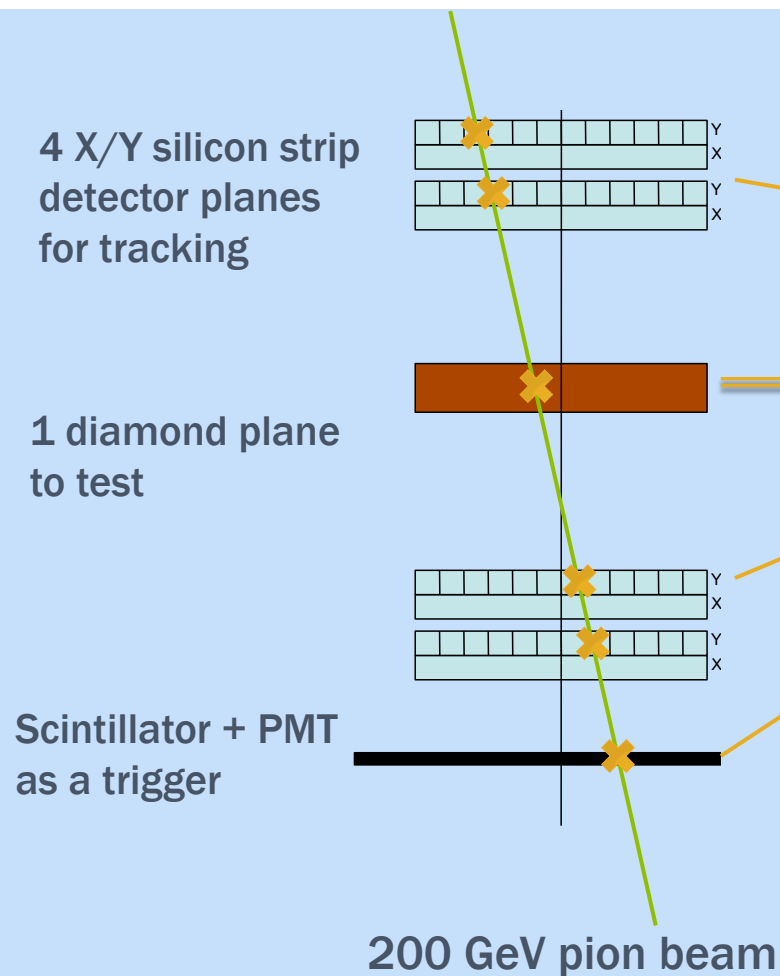


DIAMOND TEST BEAM ANALYSIS

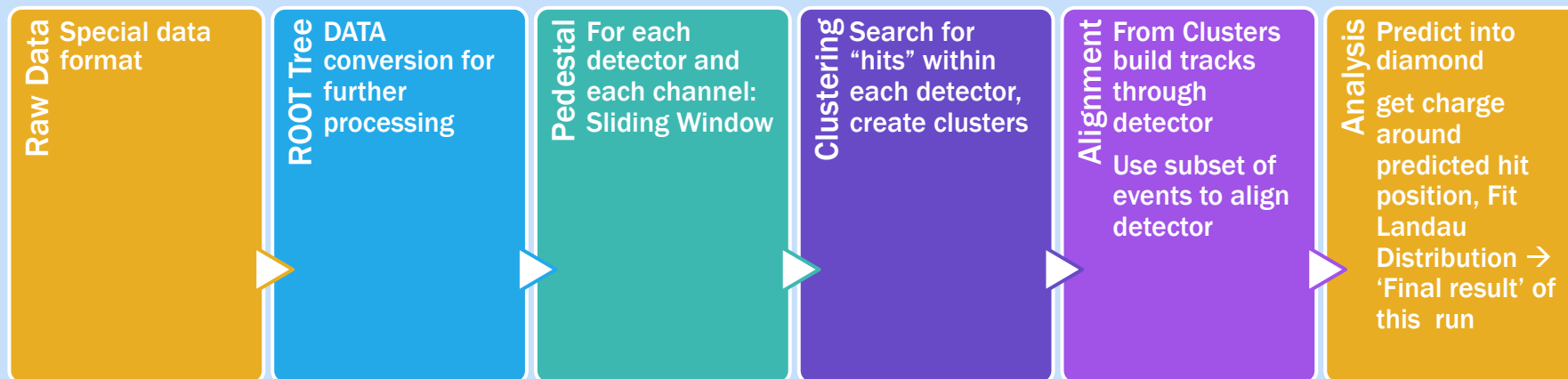
PROJECT 3

■ RD42 collaboration:

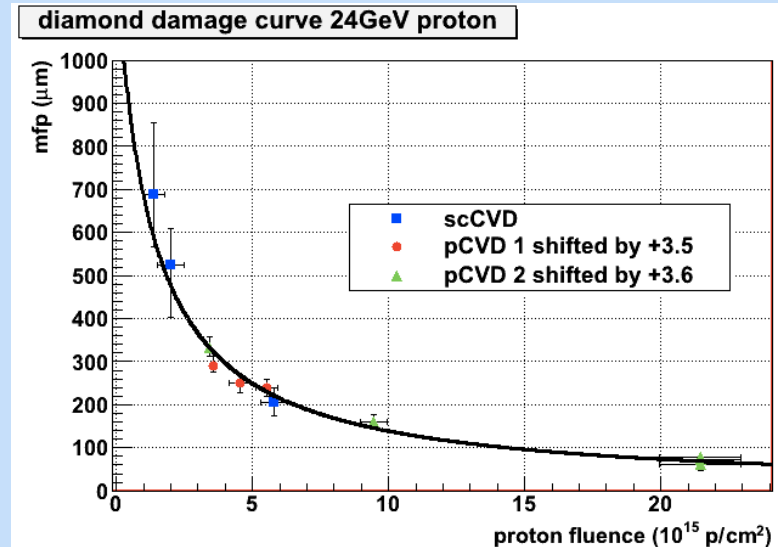
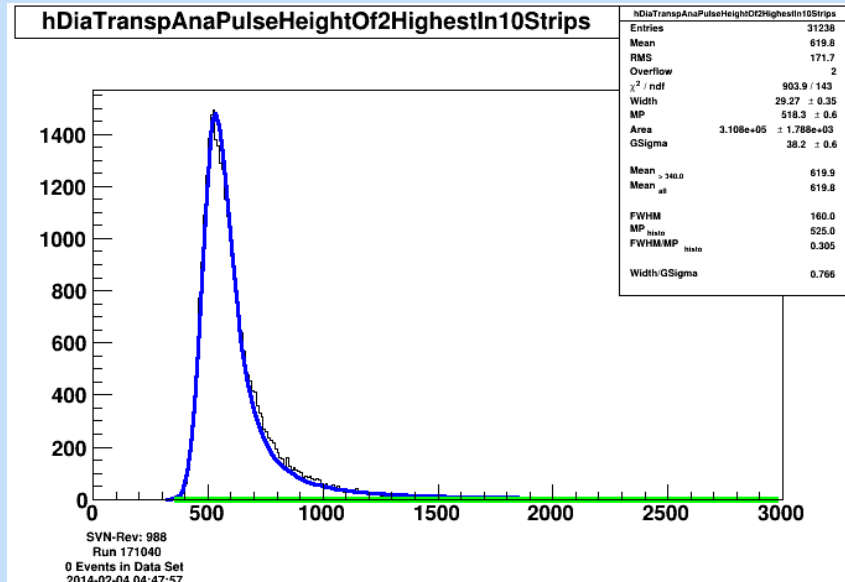
- Development of diamond tracking detectors for High Luminosity Experiments at LHC
- Measure radiation hardness of diamonds in an irradiation program
 - 15 test beam campaigns
 - 21 different diamonds
 - Different kind of irradiations, different fluencies
 - 249 Runs



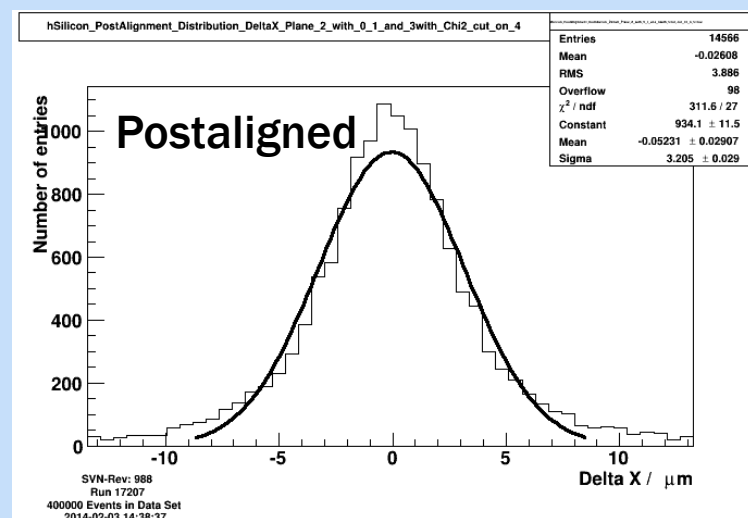
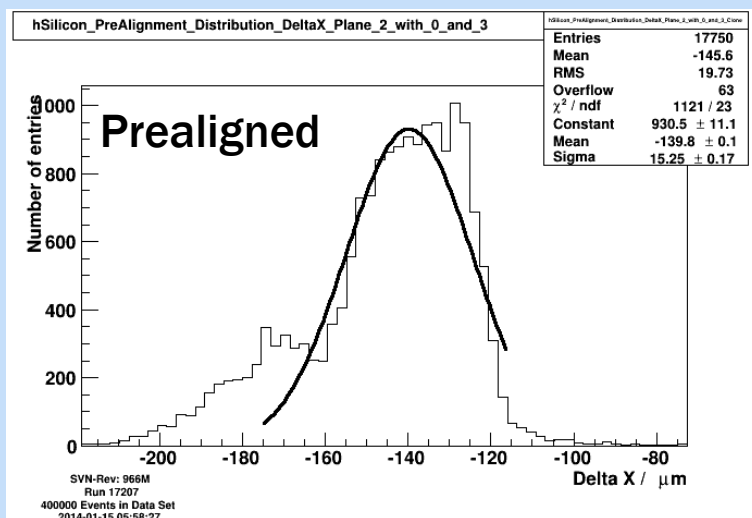
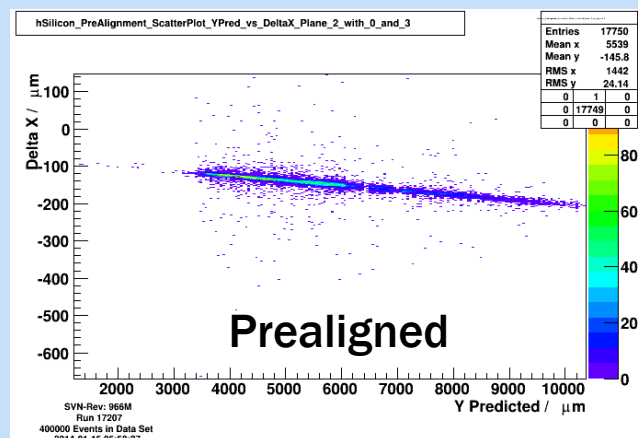
■ Steps from raw Data to final result



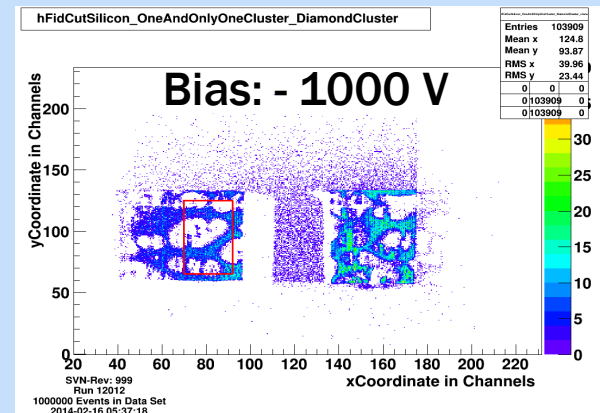
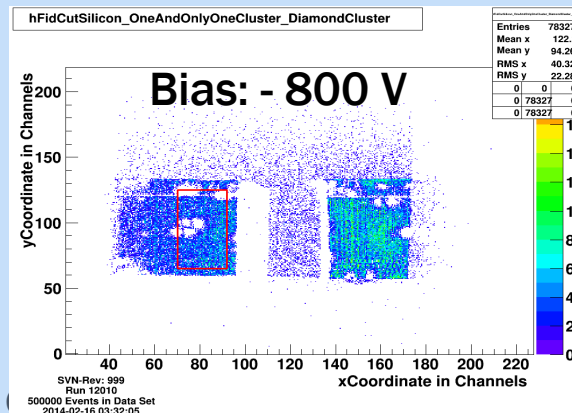
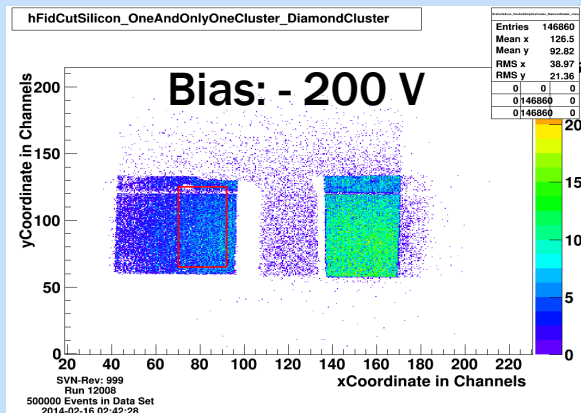
- form a track with the telescope and point into the diamond plane
- Get collected charge around predicted hit position and convert into mean free path
- Extract damage constant



- Iterative procedure
 - Align Silicon planes
 - Tilt correction (slope)
 - Offset correction

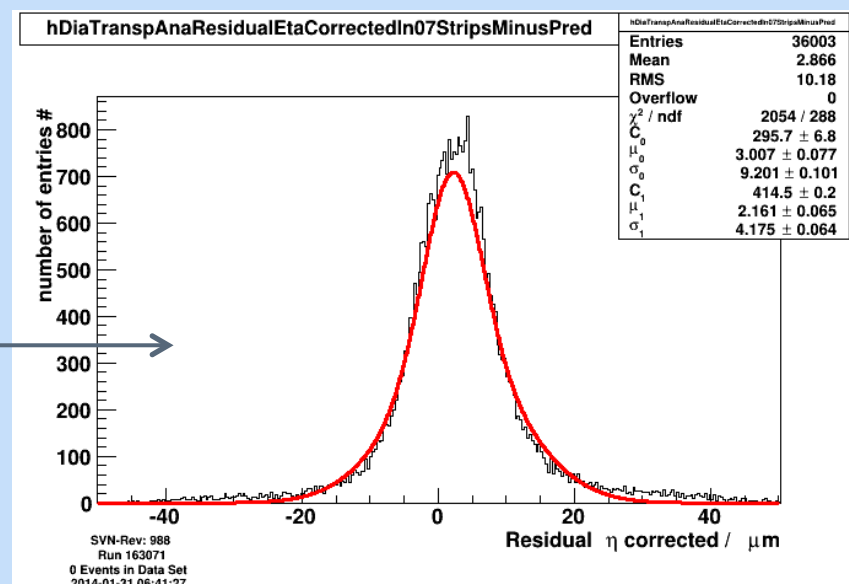
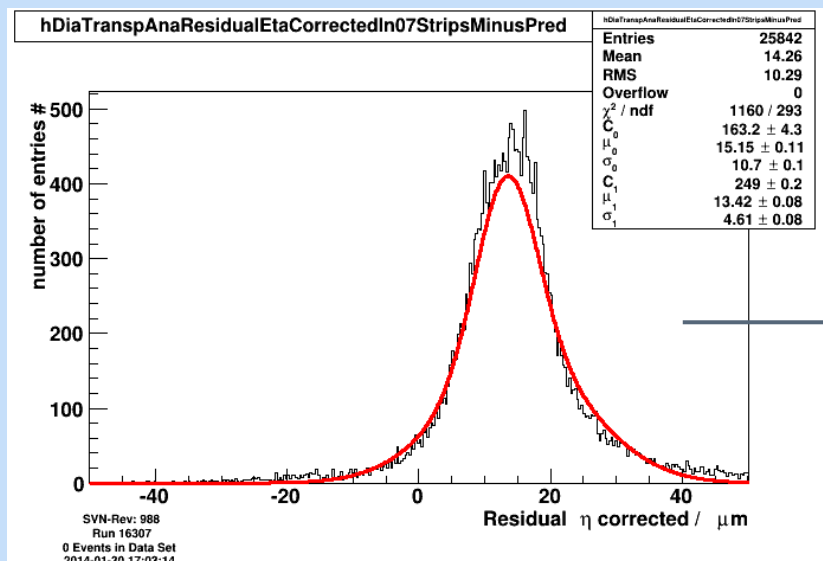


- Test beam campaign
 - with a diamond
 - Different bias voltages



- Areas where diamond is inefficient are created
 - Results are not useable for this study
 - Possible solution: Re-Metallization and than retesting
- Identify such samples and handle them correctly

- After alignment residual between predicted hit position and actual hit position should be centered around 0
- In some runs the residual is off by more than 10 μm
 - identified timing problem, applied correction



- These unknown problems can often only identified by actually looking at plots by eye
 - Supported by automatic analysis scripts
 - Html pages to check most important plots
 - HTML Tables to help identify potential problems

[illegible]

Transparent Analysis||[Summary](#)||[Pedestal](#)||[Clustering](#)||[Selection](#)||[Alignment](#)||[Landaus](#)||[selAnalysis](#)||[TransparentAnalysis](#)||

Run 16307 analysis results - Summary

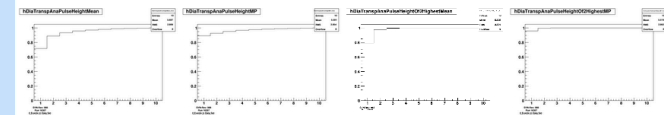
File generated at 1/30/2014 at 17:3:14

[See also Pulse Height Distributions](#)
[See also Resolution Plots.](#)
[See also Eta Distributions.](#)
[See also Eta Integrals.](#)

Pulse Height Distributions

Summary table

number of used channels	1	2	3	4	5	6	7	8	9	10
PulseHeight										
mean	847.1	1048	1099	1129	1147	1158	1167	1173	1176	1179
most probable	868.7	905.2	927.7	943.7	953.5	961.2	966.4	970.4	973.1	975.2
PulseHeight 2 highest channels										
mean	847.1	1048	1070	1072	1072	1072	1072	1072	1072	1072
most probable	868.7	905.2	906.6	906.2	906.2	906.2	906.1	906.1	906.1	906.1





SUMMARY

- Diverse problems for computing in HEP
- Data Analysis
 - high throughput
 - optimization problems
 - multivariate techniques
 - statistical analysis
- Detector
 - hardware communication
 - event driven programming
 - production DBs, overview tables