HCAL/JET/MET Report

Sarah Eno
FSU 10 May 2002
US CMS Meeting

Outline

1. Organization
   - Charge
   - Milestones
   - Organization
2. Work
   - HCAL algorithms/software
   - DAQ
   - Offline
   - HCAL/Jet Calibration Strategy
   - Descoping options
   - HCAL simulation
   - Test Beam Analysis
   - Physics feasibility studies
3. Milestone Status
4. Future
5. My Pet Peeves

Can not present a years worth of work by so many people in so many areas in 20 minutes! Just some of my favorite results in each area…

Charge to PRS Groups

Our Charge: anything that requires data analysis (mostly MC)

- Simulation of the Detector (GEANT3, GEANT4, Fast)
- Simulation of HCAL electronics
- Algorithms for energy extraction
- Algorithms for use in the higher level trigger (HLT)
- Algorithms for offline reconstruction of jets and MET
- Trigger tables and trigger rates
- Strategy for calibrating HCAL and Jets
- Analysis of test beam data
- Study “descoping” options
- etc etc etc

Other PRS groups also include level 1. We have very good communication with our L1 group, but consider them separate and I will not show their results in this talk.

Milestones

Dec 2001

- HLT algorithms for low luminosity
- trigger table for low luminosity

Sorry for the small font…
too many milestones!!!

March 2002

- Calibration strategy understood
- data rates, format, energy extraction algorithms, zero suppression algorithms
- analysis of CPU needs for HLT for low luminosity

June 2002

- complete high luminosity algorithms, trigger table, rate, CPU requirements

Summer 2002

- participate in test beam analysis

Sept 2002

- DAQ TDR finished

Dec 2002

- switch from GEANT3 to GEANT4

Organization

Group Leaders:

Sarah Eno (MD), Shuichi Kunori (MD)

Algorithms, HLT, Physics:

Sasha Nikitenko (Imperial, on leave from ITEP)

HCAL reconstruction:

Salavat Abdullin (MD, on leave from ITEP)

Simulation:

Sunanda Banerjee (Tata)

Calibration:

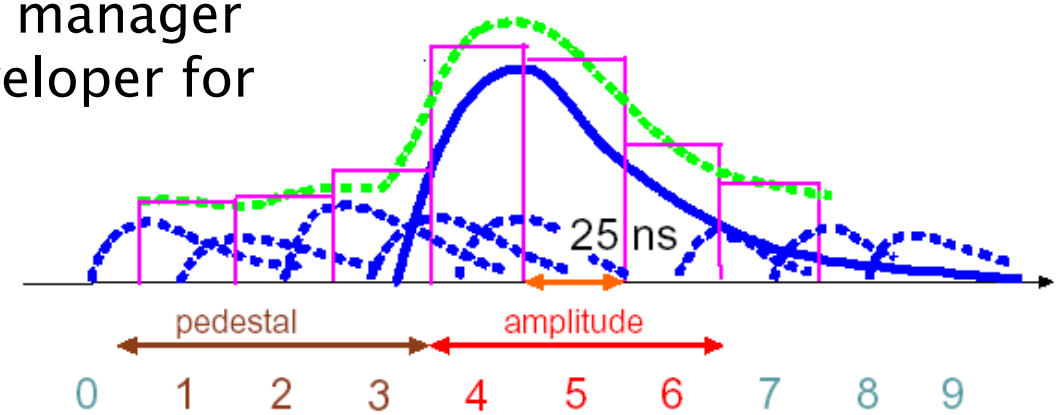
Olga Kodolova (Moscow State)

ITEP/MSU are heart of the group!

May need tweaking. Salavat's group too small, Sasha's too large?

HCAL Reconstruction Software

- New Calorimeter package manager (Vladimir), new active developer for code structure (Bart)
- Trigger Primitives for L1
- HO simulation



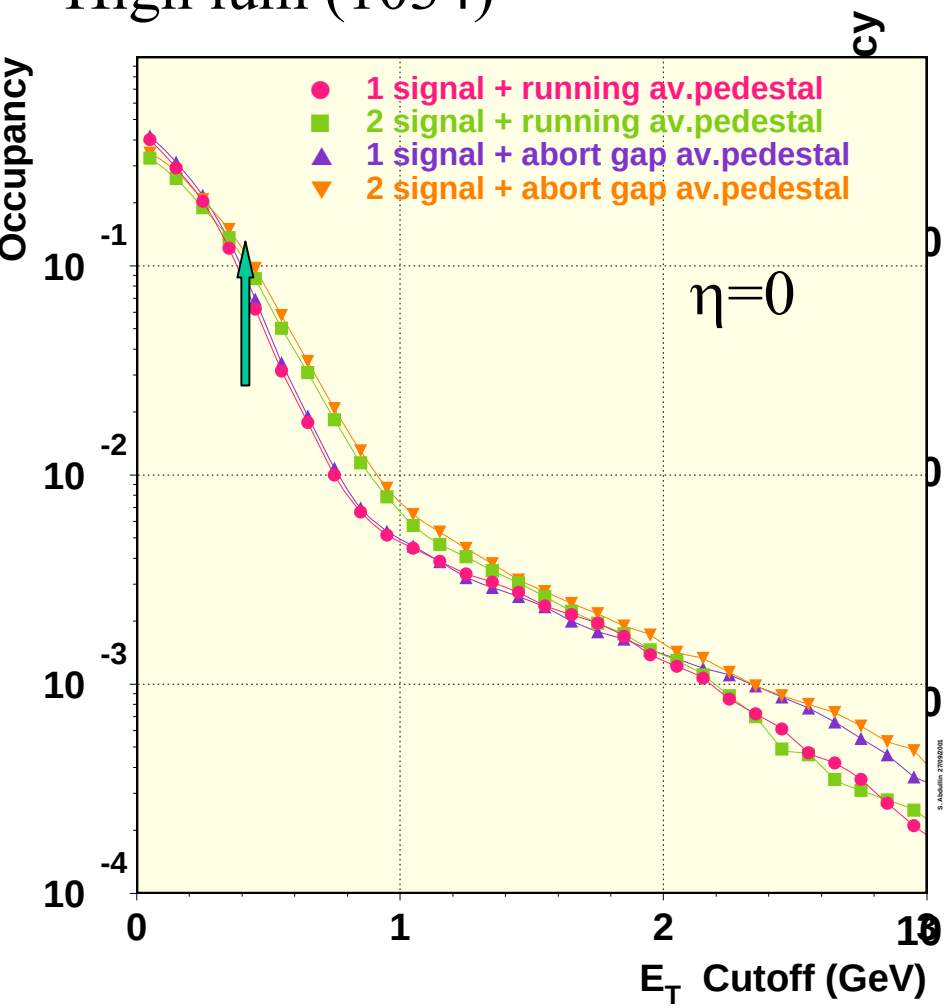
Active* Participants: Salavat (UMD), Dan Green (FNAL), Vladimir Litvin (CIT), Bart Van de Vyver (CERN)

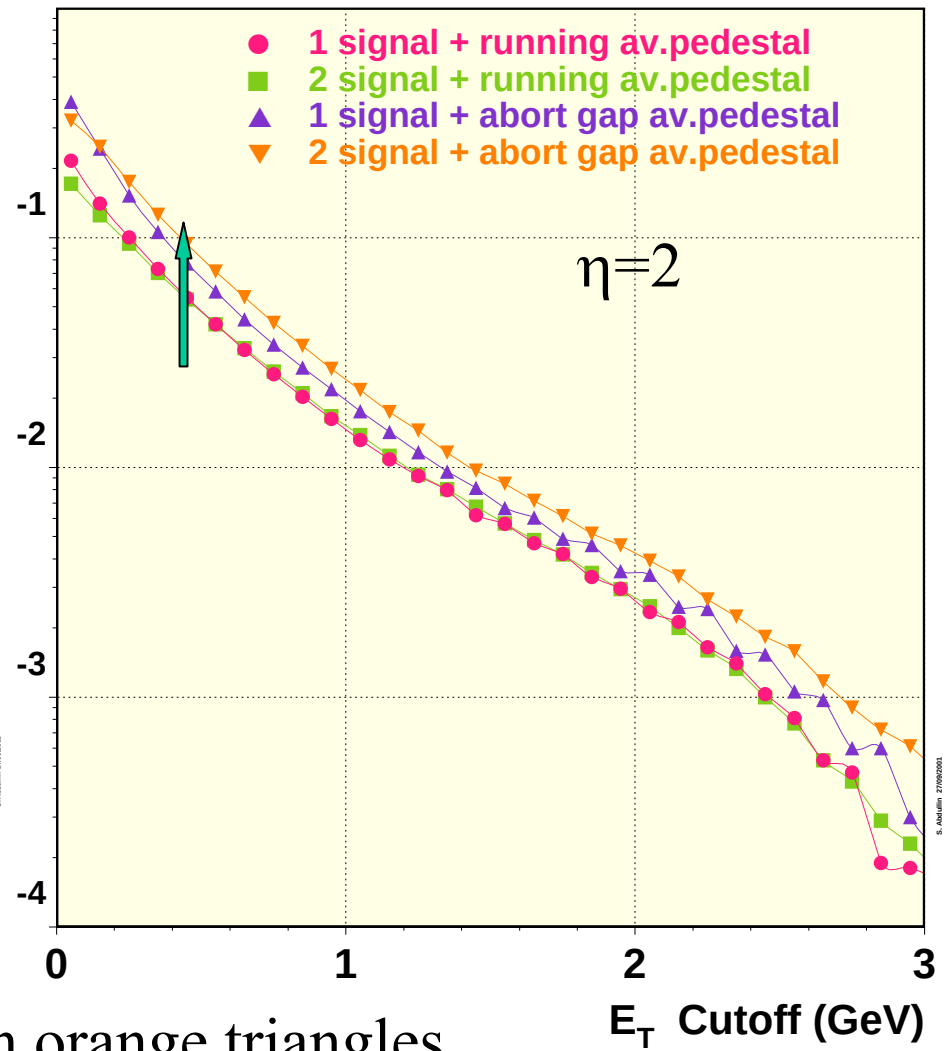
CMS Notes: IN-2002/003, IN-2001/037

*** Active in all transparencies means a person who makes plots that are shown in HCAL/Jet/Met meetings or at the HCAL/Jet/Met sessions during CMS week. Assume approximately one senior type/supervisor per active person, and many experts from related areas who provided information to help the active person. It's the active person who ties all this information together and produces PRS results.**

HCAL Occupancies

High lum (1034)



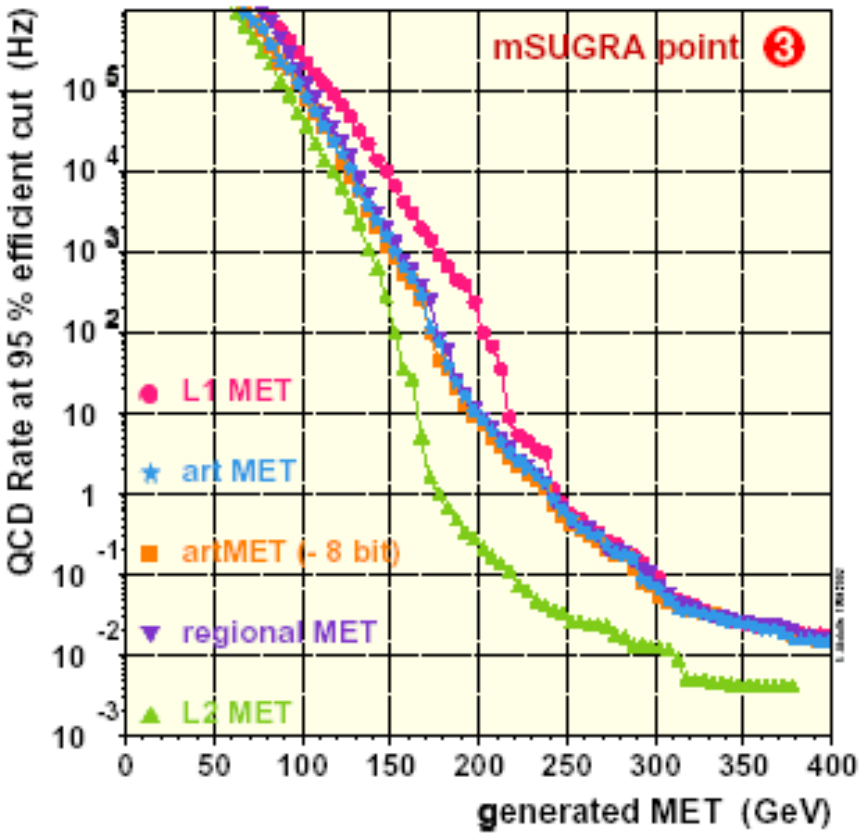


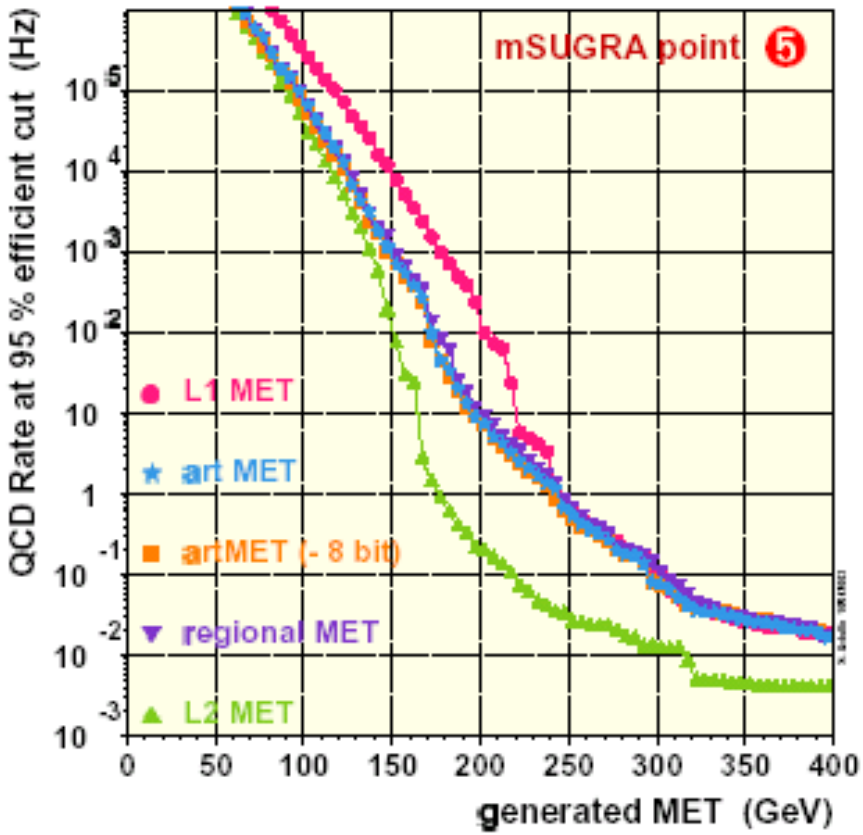
Our current scheme: upsidedown orange triangles

Salavat Abdullin

BC ID

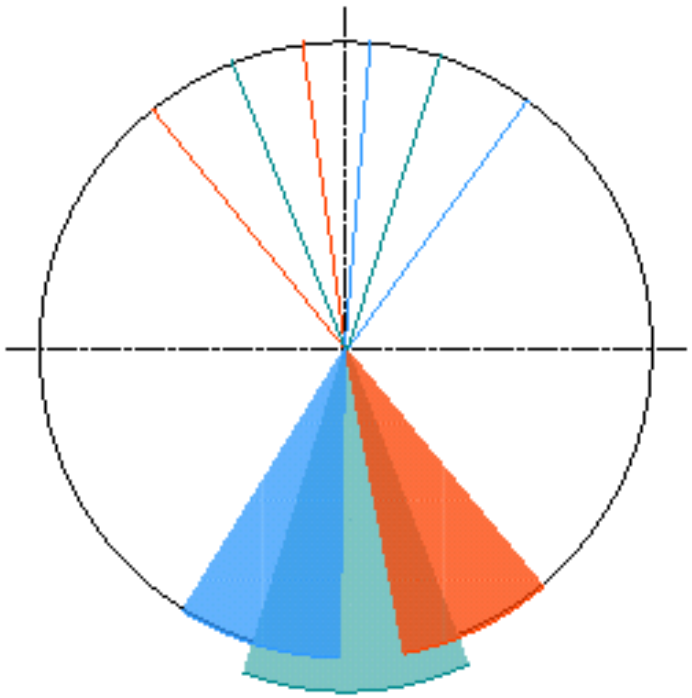
Example of a current topic: for the level 1 trigger, we need to associate energy with a beam crossing. Our current algorithm, however, is hurting our level 1 missing ET. How to fix?

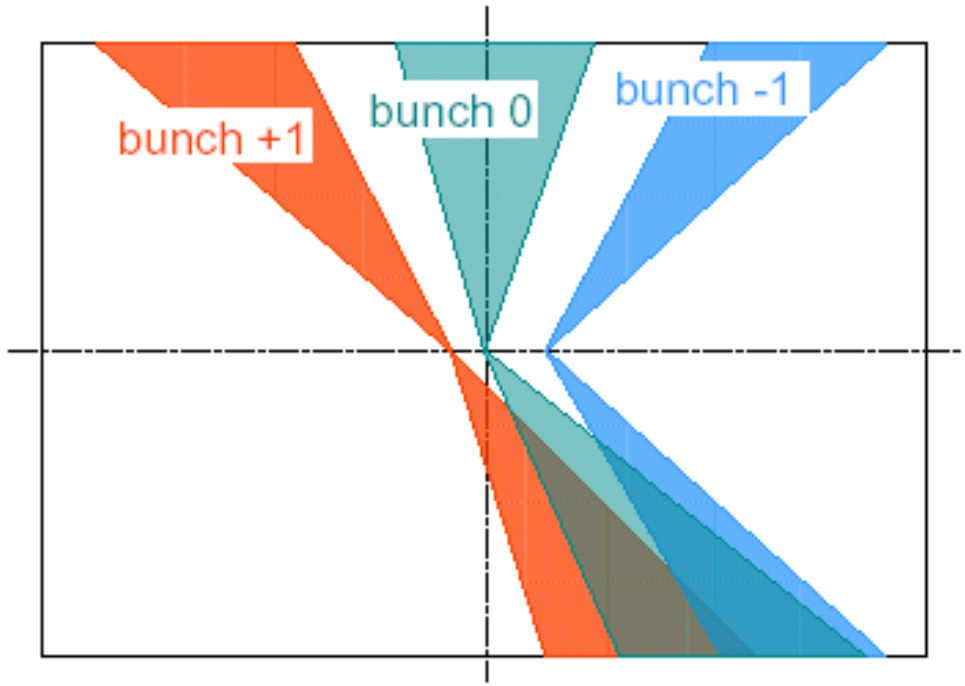




Salavat Abdullin

BC ID



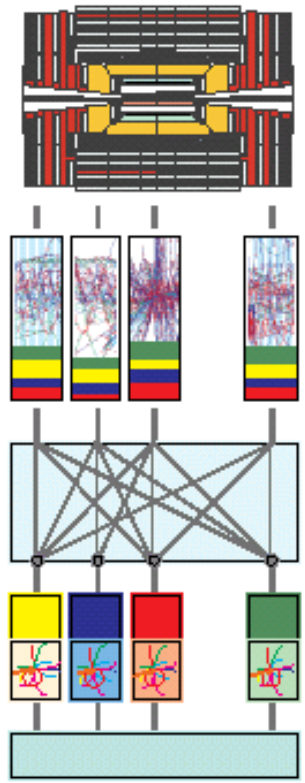


L1 imbalance due to "negative interference"

Salavat Abdullin

Towards the DAQ TDR

- Timing studies
- Jet parameter optimization for speed/efficiency at low E_T
- Algorithms for removing fake jets for HLT
- Jet/Met rates
- SUSY trigger strategy
- Invisible Higgs trigger strategy
- H→t trigger strategy



Active Participants: Salavat Abdullin (UMD), Sasha Nikitenko (Imperial), Jim Brooke (Bristol), Pal Hidas (Hungary), Isa Dumanoglu (Turkey), Alexei Oulianov (Russia), Andrei Krokhotine (Russia), Ritva Kinnunen (Finland), Kajari Mazumdar (Tata)

CMS Notes: IN-2002/008, IN-2002/003

Timing Studies

Budget: 0.3s/event

TimeMe reports from ORCA(message, counts, real cpu time)			qcd 50-80	qcd 120-170	H 500 GeV	H 200 GeV
SUSY events : Jet reconstruction in the entire calorimeter with iterative cone 0.5 , seed threshold 1 GeV* MET reconstruction from ecal+hcal towers.						
Reconstructing_EcalPlusHcalTowerBuilder	1000	201.610 seconds (cpu)	0.200 s/ev**			
Reconstructing_allJets	1000	215.850 seconds (cpu)	0.014 s/ev	0.014 s/ev	0.012 s/ev	0.012 s/ev
L2 MET calculation from towers	1000	5.420 seconds (cpu)	0.005 s/ev			
Tau events : Regional Jet reconstruction for H->2tau->2Jet. Only towers used in cone 0.8 around L1 Tau candidates. Iterative. cone 0.6, no seed threshold						
Reconstructing_1stL1tau	1000	3.710 seconds (cpu)	0.008 s/ev	0.009 s/ev	0.008 s/ev	0.008 s/ev
Reconstructing_2ndL1tau	839	3.510 seconds (cpu)				
Reconstructing_1stL1Cjet	211	0.790 seconds (cpu)				

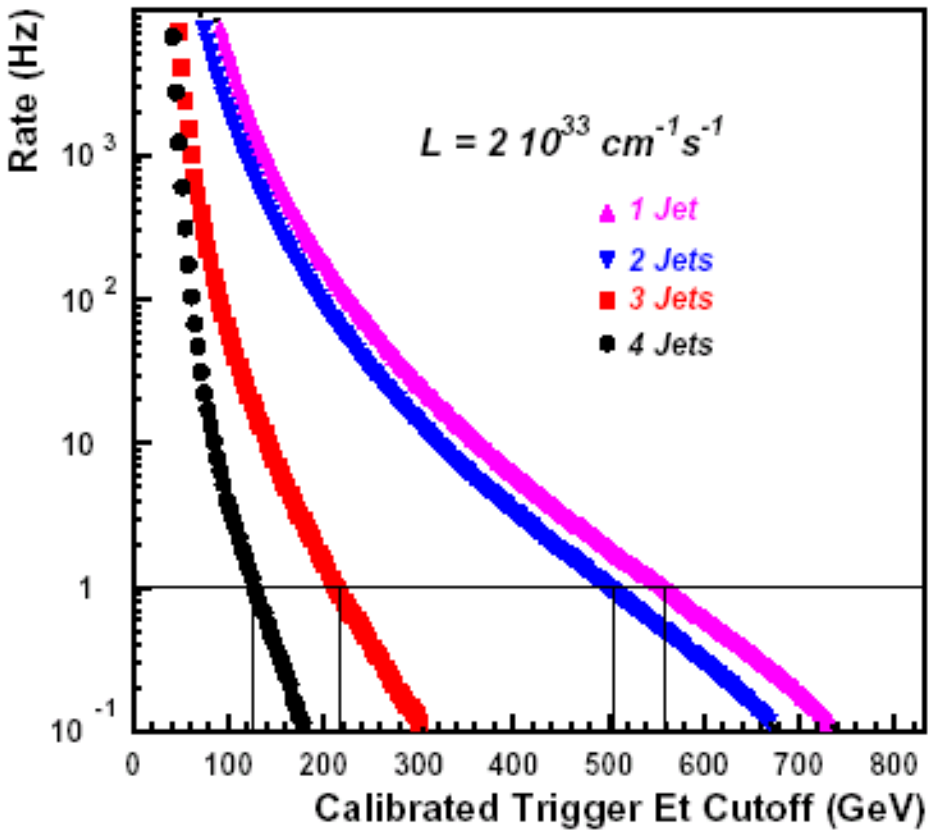
* doesn't include time on Jet energy corrections. should be negligible

Discovered calorimeter "navigation" required optimization. Bart is now working on this.

Sasha Nikitenko

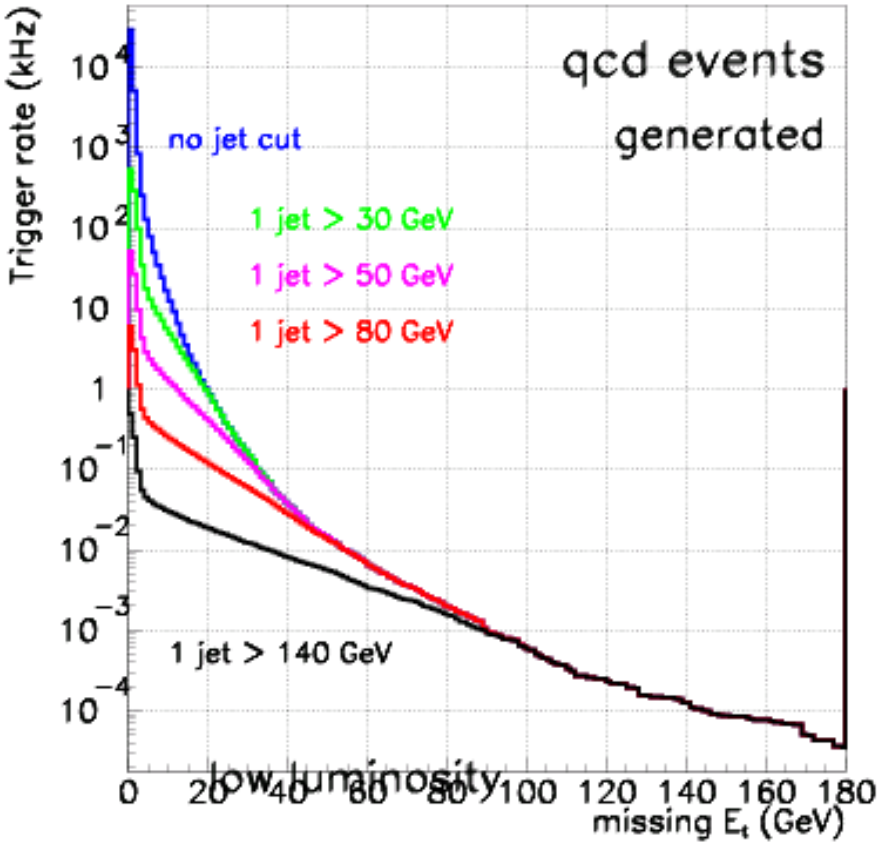
Jet Trigger Rates, Low Lum

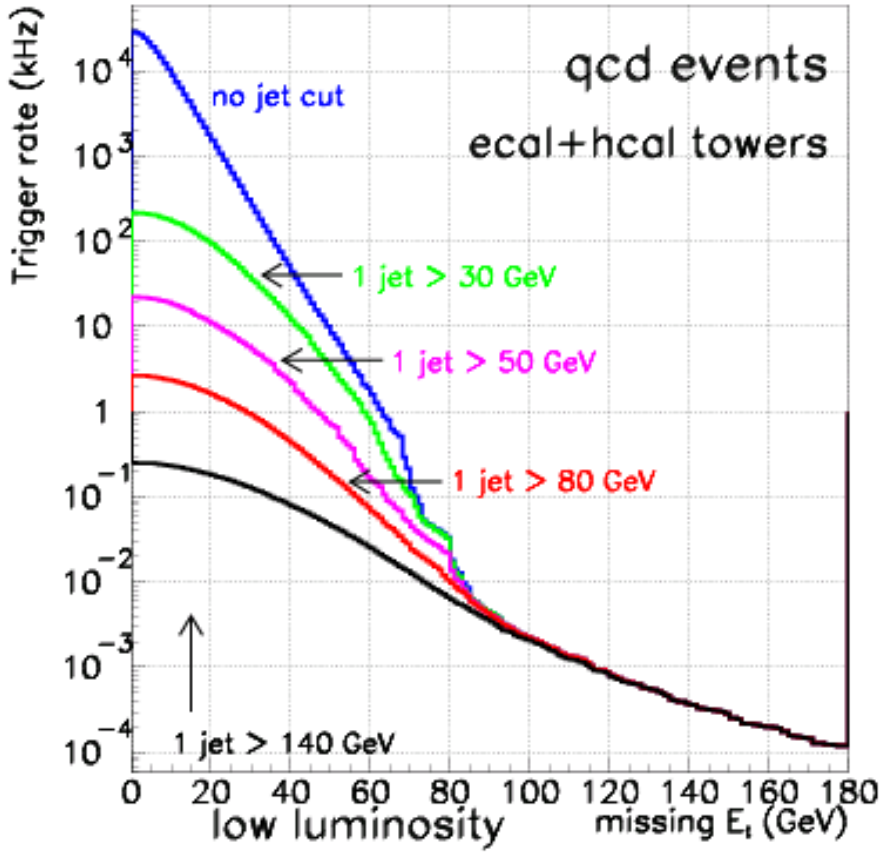
Rates $L = 2 \times 10^{33} cm^{-2} s^{-1}$



	1Hz	10kHz
1 Jet	560GeV	210GeV
2 Jets	505GeV	160GeV
3 Jets	217GeV	107GeV
4 Jets	127GeV	87GeV

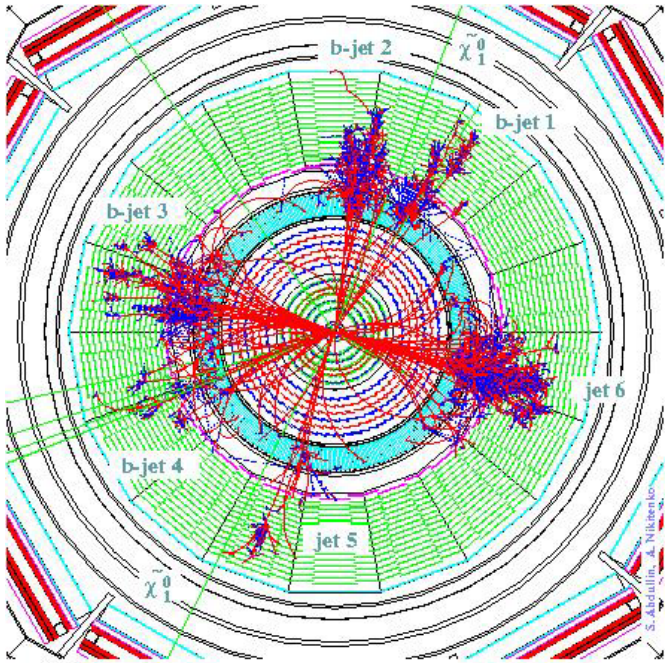
Met Trigger Rates, Low Lum

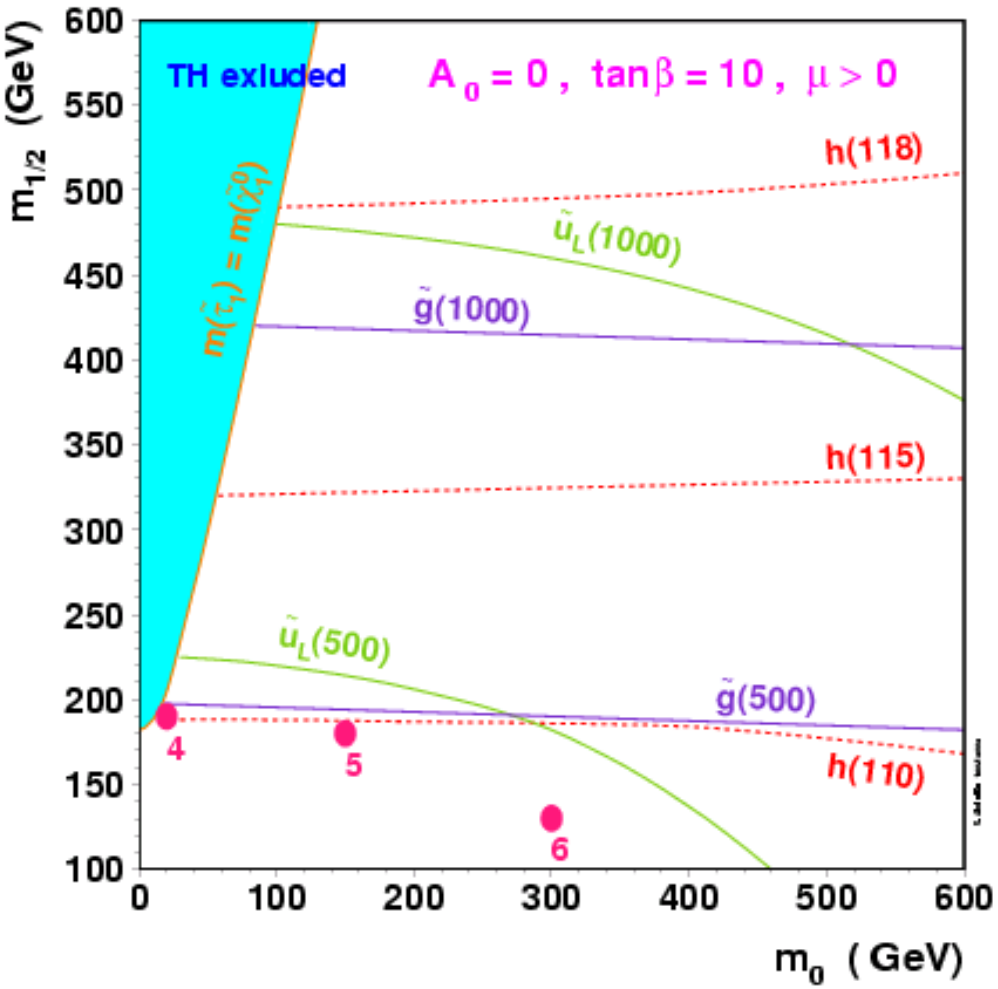




Pal Hidas

SUSY Triggers





Efficiency lowest for points near Tevatron reach. Optimize triggers for efficiency here.

SUSY Triggers

Table 7: L2 SUSY trigger optimization results (L2D + L1C criteria)

		MET	J3 & MET	J4 & MET	J1 & MET	J2 & MET	J4 & MET	L2 rate (Hz)
					$\Delta\phi$ (J1,J2) < 150°			
	Cuts (GeV) →	170	60 + 110	120 + 0	190 + 90	40 + 100	80 + 60	
signal efficiency w.r.t. L1 (%)	Point 4	50 (50)	65 (46)	66 (5)	70 (40)	78 (60)	78 (10)	0.26
	Point 5	42 (42)	61 (46)	63 (6)	68 (40)	74 (57)	74 (12)	0.29
	Point 6	17 (17)	37 (33)	41 (7)	45 (20)	51 (36)	54 (13)	0.45
	Point 4R	6 (6)	20 (20)	30 (12)	33 (13)	35 (15)	38 (11)	0.13
	Point 5R	3 (3)	12 (12)	24 (14)	27 (9)	27 (8)	31 (10)	0.13
	Point 6R	2 (2)	6 (6)	13 (7)	14 (5)	15 (4)	17 (6)	0.15
Background rate (Hz)	QCD	0.29 (0.29)	0.95 (0.79)	1.89 (0.99)	2.14 (0.36)	2.21 (0.31)	2.52 (0.48)	
	$t\bar{t}$						0.12	
	W j ($l\nu$)						0.10	
							Σ 2.74	

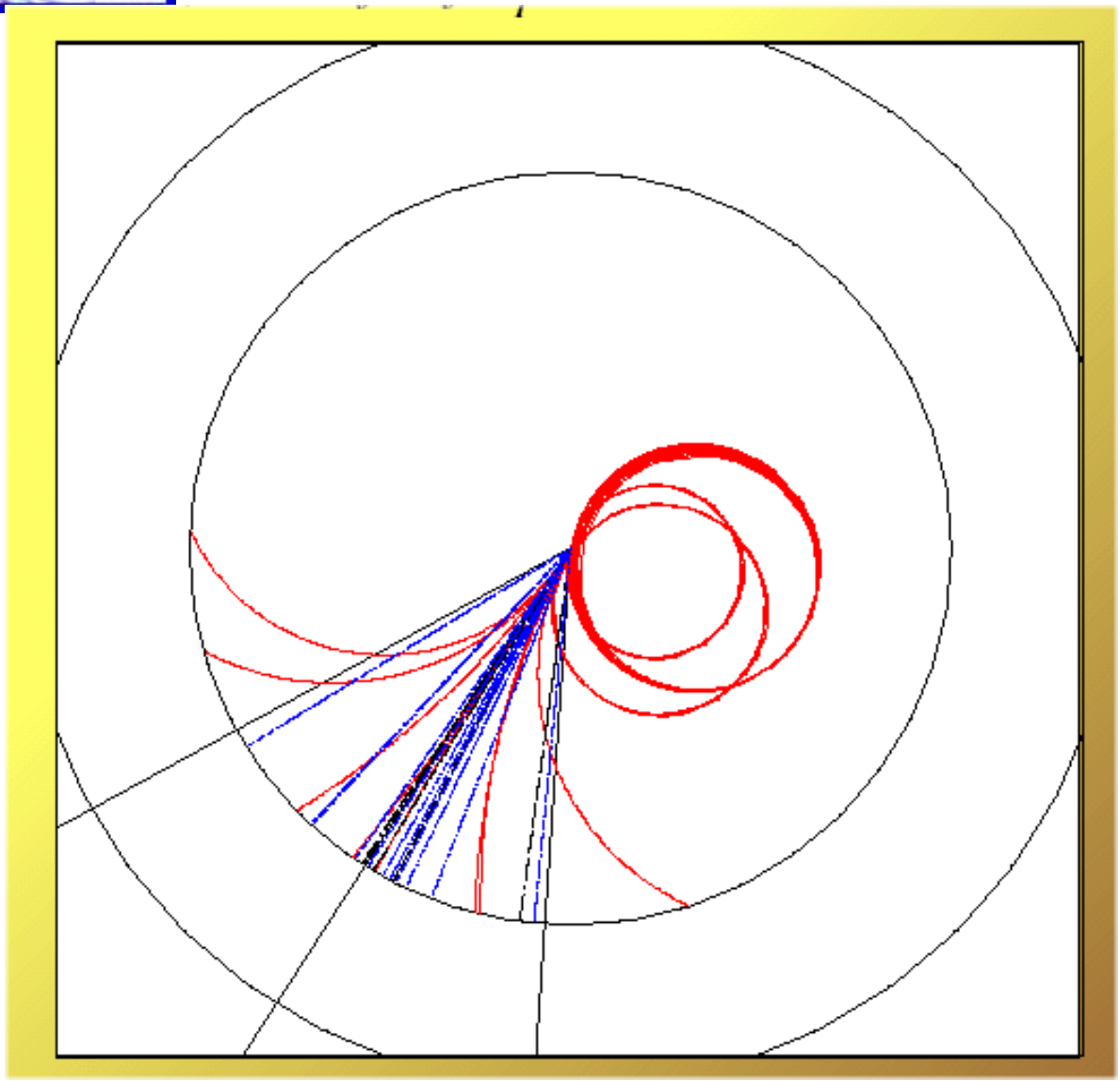
Offline Reconstruction

- Jets with tracking, “energy flow”
- High luminosity jet algorithms
- MET algorithms

Active Participants: Olga Kodolova (Russia), Pal Hidas (Hungary), Alexei Oulianov (Russia), Andrei Krokhotine (Russia), Sasha Nikitenko (Imperial), Irina Vardanian (Russia), Dan Green (FNAL), Hans-Peter Wellisch (CERN)

CMS Notes: IN-2002/020, IN-2002/015, NOTE-2001/040, NOTE-2001/005

Jets with Tracking

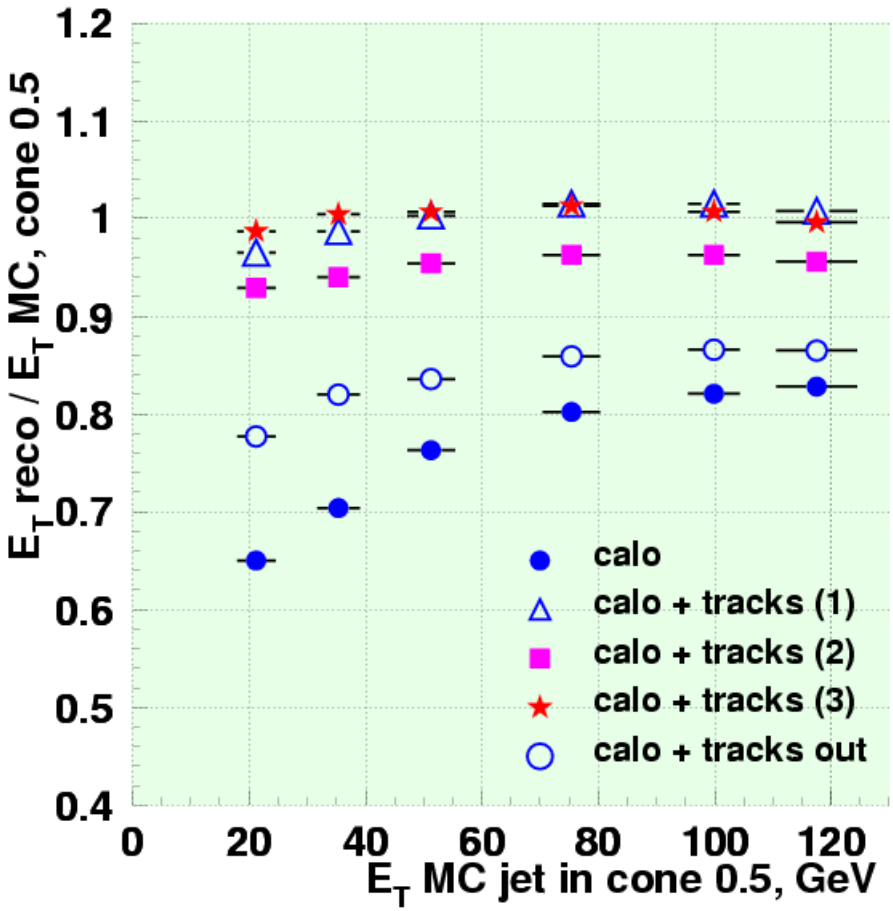


First: Recover the charged tracks (red) that bend out of the cone

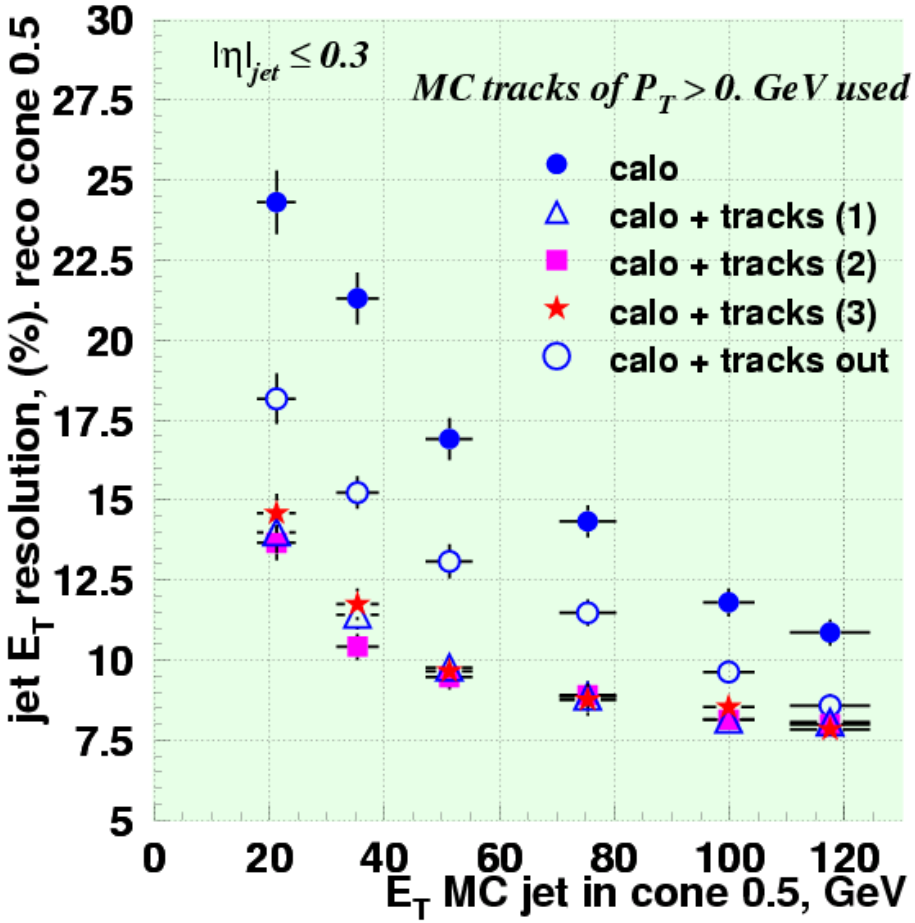
Second: replace even the hadronic energy deposited in the heart of the jet

Energy Flow at Low Lum

IMPROVES ENERGY SCALE!



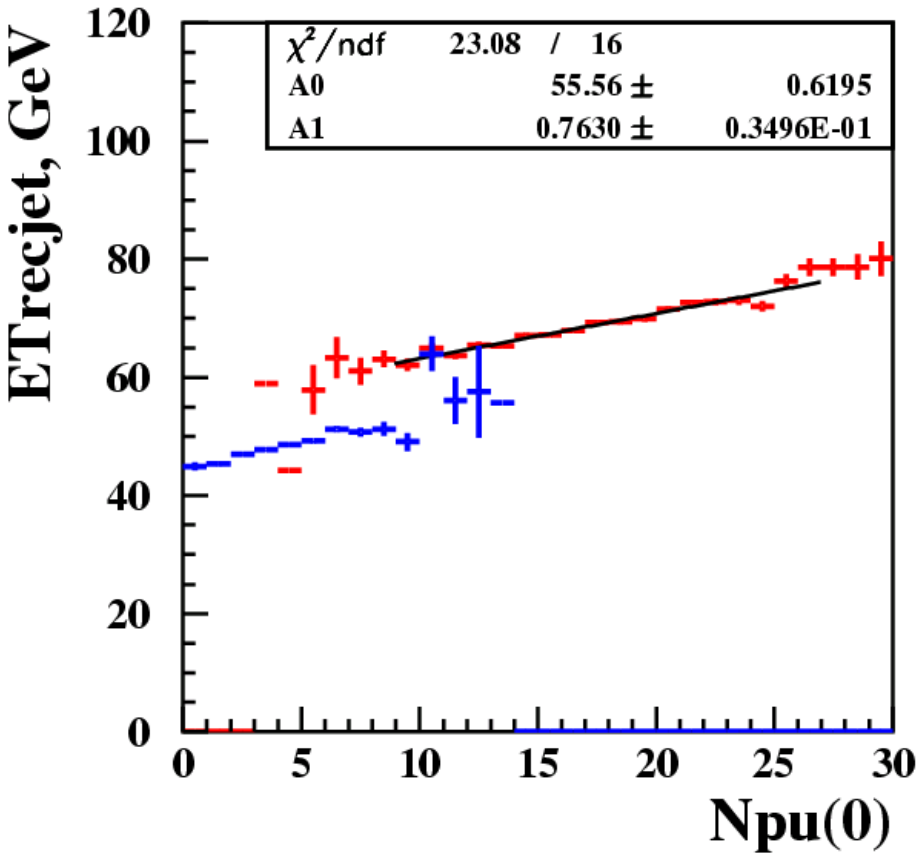
IMPROVE RESOLUTION!



Irina, Olga, Dan, Sasha

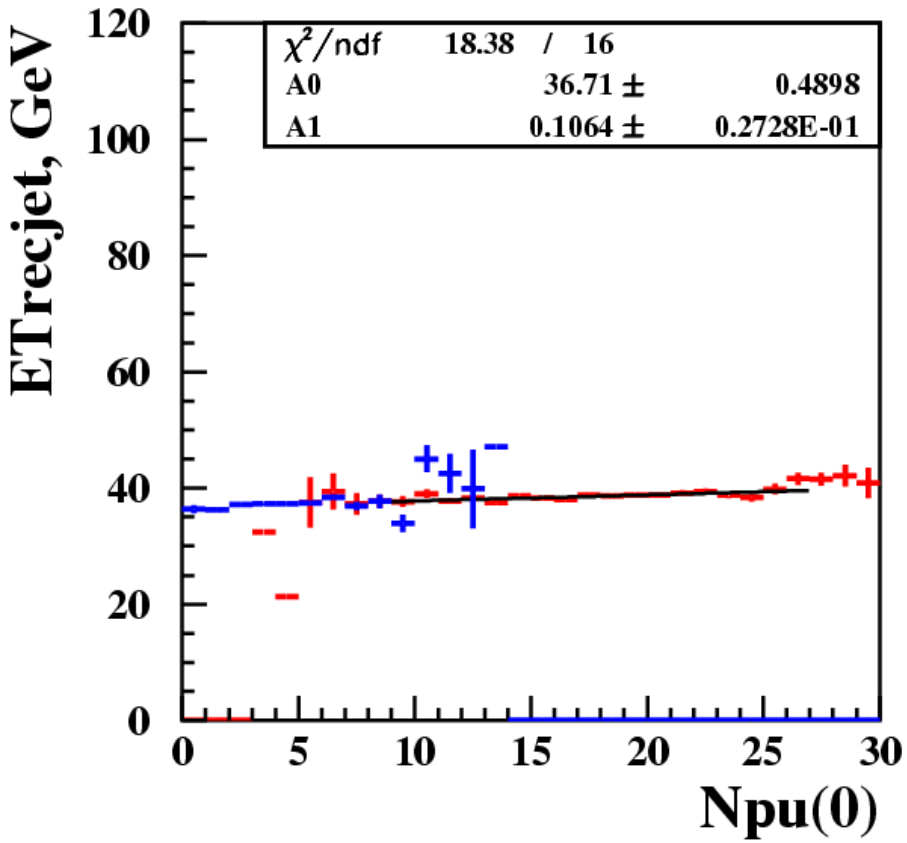
Jets at High Lum

At high luminosity, the amount of energy deposited in the jet cone depends on the number of extra interactions and this degrades jet energy resolutions…



Use the areas in the region of the calorimeter away from the jet to estimate the extra energy due to pileup and subtract this (very oversimplified description of actual algorithm).

Jets at High Lum



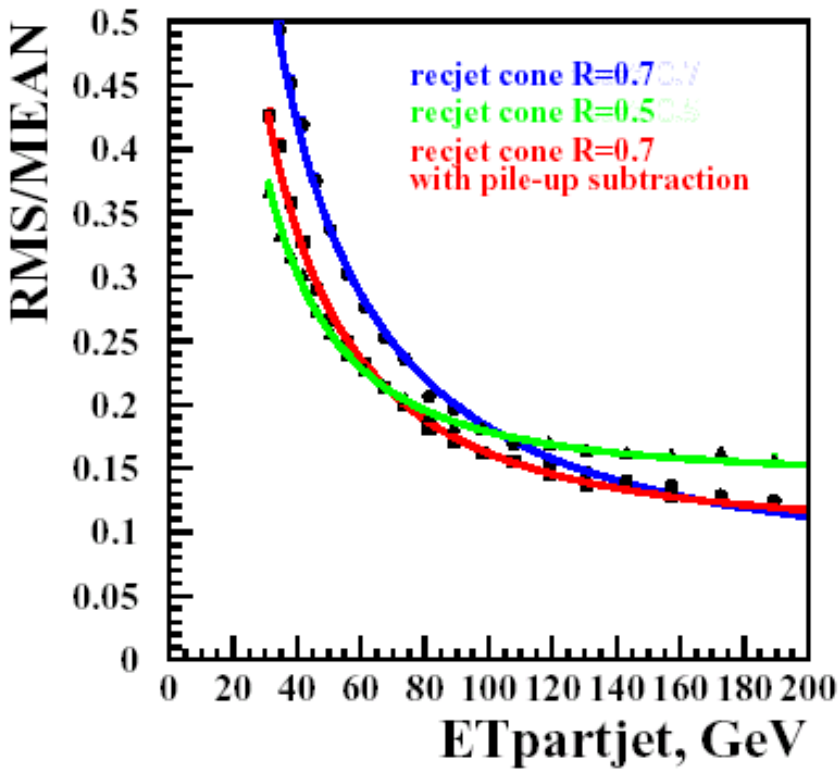
Jet-Finding at High Lum

Jet energy resolution (particle jet cone R=0.7)

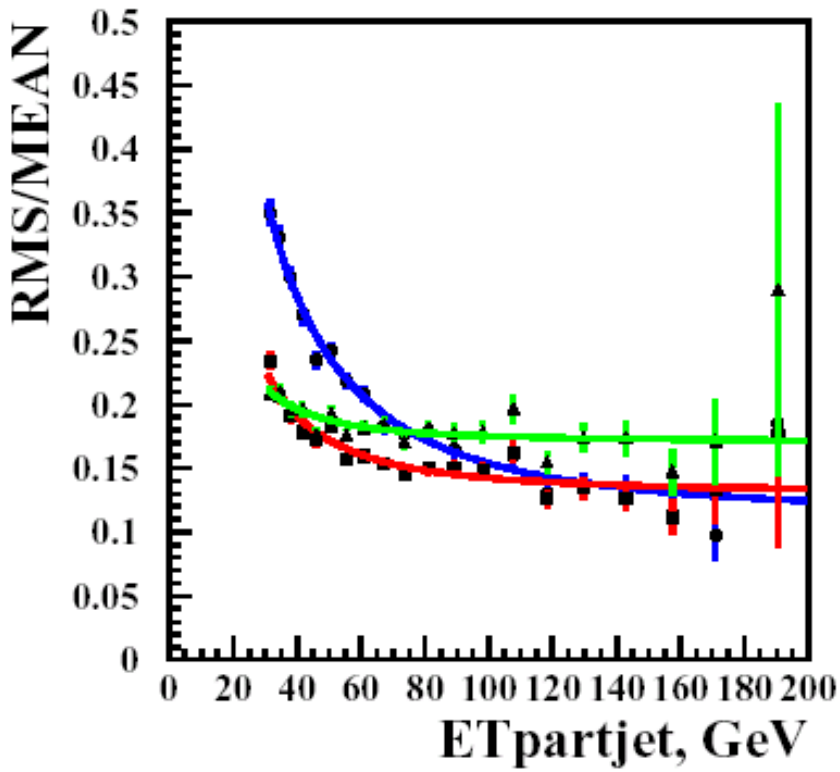
For each algorithm energy scale corrections were calculated and applied, so that

< ETcorr(ETrecjet) > = ETpartjet

eta < 1



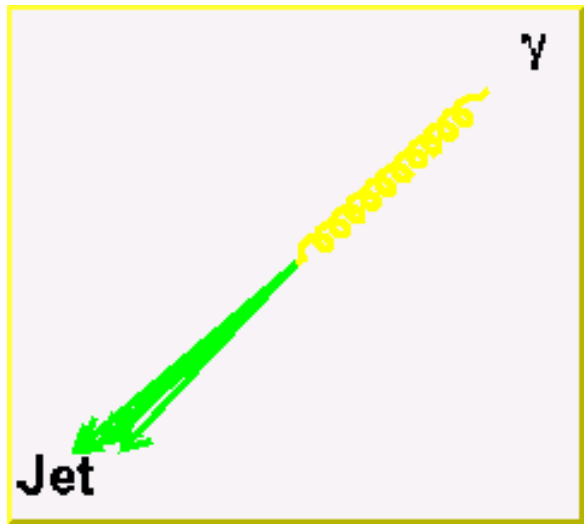
3.5 < eta < 4.5



Irina, Olga, Alexei

HCAL/Jet Calibration

- calibration using gamma+jets
- calibration using Z+jets
- radiation damage to HF
- laser calibration of HB/HE



Active Participants: many, with increasing contact between US and Russia during CMS weeks. Can we move to contact between these meetings? Do we need to?

CMS Notes: IN-2002/014, IN-2001/001

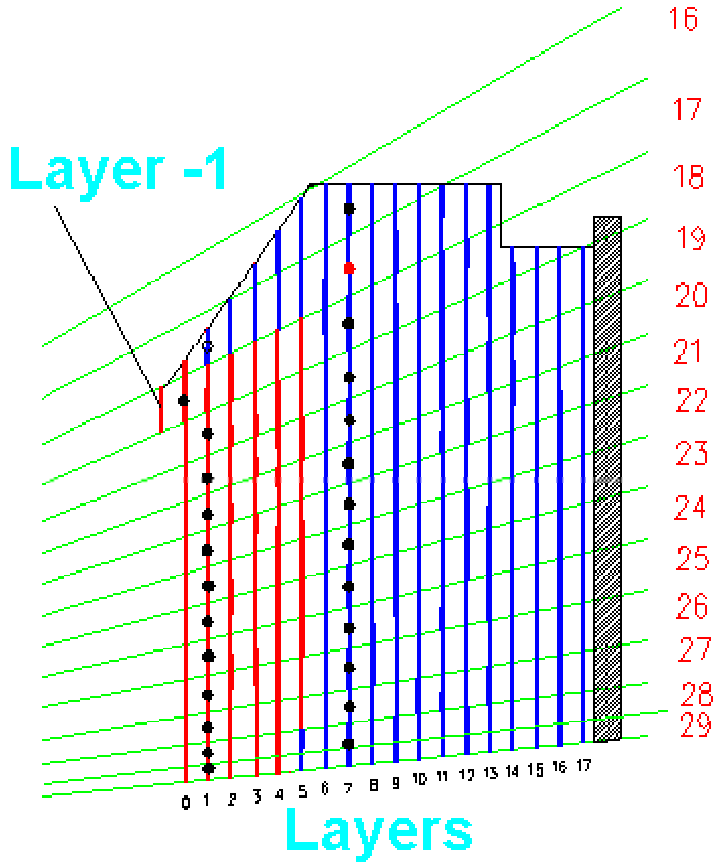
Descoping Options

effect of no endcap ECAL or

jet energy resolutions, MET resolutions

radiation damage

trigger redesign



Segmentation of HE for operation without EE.
Alexei Volkov

Active Participants: Weimin Wu (FNAL), Andrei Krokhotine, Alexei Volkov

CMS Notes: NOTE-2002/004

HCAL Simulation

- verification of CMSIM
- fast MC for jets/MET (JetMetFast)

Turn around time on getting errors investigated slow. Desperately need more involvement in this area by people who can give it a high priority.

Presentations at only 2 CMS/CPT weeks out of 6 in 2001/2002. Need to improve video conferencing to India?

Active Participants: Sashi Dugad (Tata), Sunanda Banerjee (Tata), Kajari Maxumdar (Tata), Pal Hidas (Hungary), V. Kossolov (Russia)

CMS Notes: 0

HCAL Simulation

Summary of comparison between two different releases

CMS Release	121	122
File Name	cms121_muon2_01.hbook	cms122_muon2_01.hbook
Particle ID	5	5
Minimum Eta	0.0435	0.0435
Maximum Eta	0.0435	0.0435
Minimum Pt (GeV)	10	10
Maximum Pt (GeV)	10	10
Minimum Phi	0	0
Maximum Phi	360	360
Mean of Scint. Layer	9.05918	9.05039
Mean of HAC Layer	2.22291	2.22066
Mean of Eta dstbn.	0.0413036	0.0407469
Mean of Phi dstbn.	182.218	179.514
Mean of Time dstbn.	8.04962	7.98234
RMS of Time dstbn.	3.62932	2.09301
Mean E.Loss/Hit (MeV)	1.16468	1.17563
RMS E.Loss/Hit (MeV)	1.97074	1.93468
Mean E.Loss in HAC L01	1.71353	1.72418
RMS E.Loss in HAC L01	0.816064	0.815393
Mean E.Loss in HAC L2A	13.9754	14.2245
RMS E.Loss in HAC L2A	7.79827	7.94415
Mean E.Loss in HAC L2B	1.8157	1.83984
RMS E.Loss in HAC L2B	1.53508	1.47673
Mean E.Loss in HAC L03	4.81806	4.81279
RMS E.Loss in HAC L03	3.69533	3.85939

Test Beam Analysis

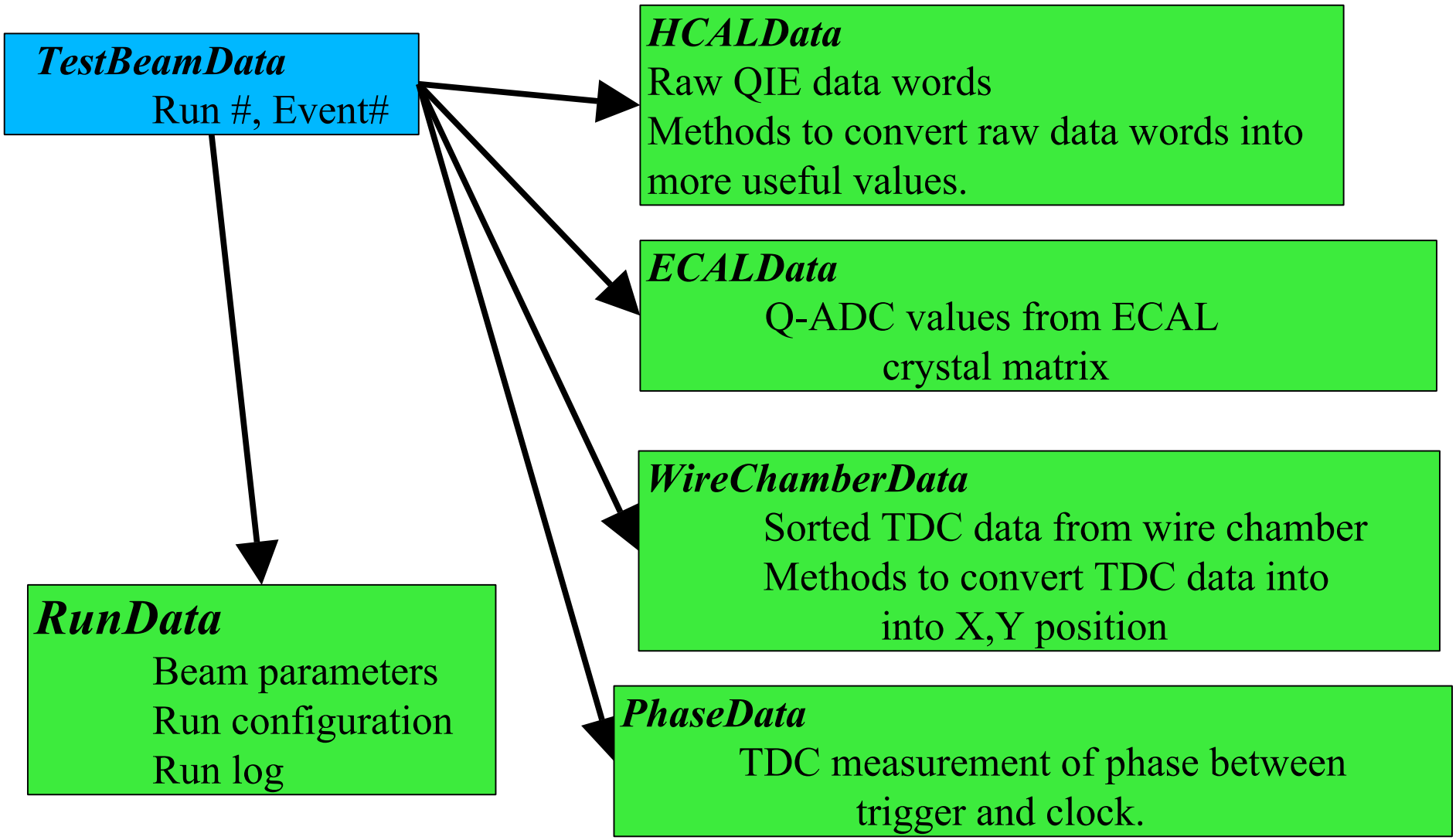
HCAL Test Beam Data Store

- ROOT-IO-based data storage
- Base data object with run/event #, additional branches for the subdetector data
- Classes will be made available to read and process the Test Beam data
- Basic philosophy: keep the raw data and provide C++ methods to process it.

Documentation:
http://flywheel.princeton.edu/~jmmans/HTBDAQ

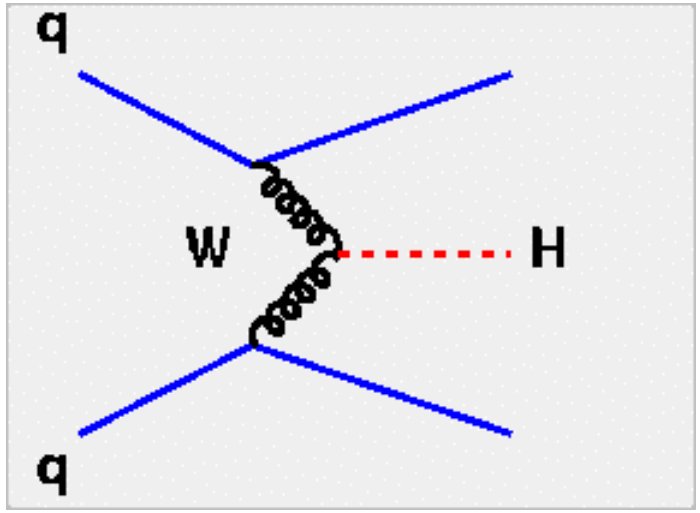
Active Participants: Chris Tully, Jeremiah Mans (Princeton)

Test Beam


TestBeamData
Run #, Event#
HCALData
Raw QIE data words
Methods to convert raw data words into more useful values.
ECALData
Q-ADC values from ECAL crystal matrix
WireChamberData
Sorted TDC data from wire chamber
Methods to convert TDC data into into X,Y position
PhaseData
TDC measurement of phase between trigger and clock.
RunData
Beam parameters
Run configuration
Run log

Physics Feasibility Studies

- Invisible Higgs
- Higgs to tau
- charged higgs
- qqH, H->emu



"physics" done by institutions associated with HCAL. Sometimes present results during Jet/Met sessions in CMS week.
Not well integrated into "group". Not clear it should be.

Active Participants: Sasha Nikitenko (Imperial), Mehmet Zeyrek (Turkey), Nural Atchurin (Texas Tech), Shuichi Kunori (MD), Weimin Wu (FNAL), Dan Green (FNAL), Kajari Mazumda (Tata), Ritva Kinnunen (Finland)

CMS Notes: don't know all. Am not told always, so don't end up on our results page

NOTE 2002/016 (Mehmet)

Milestone Status

Dec 2001

- HLT algorithms for low luminosity need study of calibrated MET
- trigger table for low luminosity acceptable

March 2002

- Calibration strategy understood acceptable
- data rates, format, energy extraction algorithms, zero suppression algorithms need work here on resolutions versus zero threshold suppression, where to set pedestal, what to do about bc id? Manpower a real issue
- analysis of CPU needs for HLT for low luminosity acceptable

June 2002

- complete high luminosity algorithms, trigger table, rate, CPU requirements especially need manpower on high luminosity MET algorithms

Milestone Status

Summer 2002

- participate in test beam analysis we have a plan

Sept 2002

- DAQ TDR finished

Dec 2002

- switch from GEANT3 to GEANT4 don't know

Future

After DAQ TDR this September, move into a new (ill-defined?) future. What should we be working on at T- 5 years?

Some known issues:

- testing jet splitting/merging. Test Tevatron RunII cone algorithm. Understanding best cone algorithm for offline.
- met with calibration
- met with tracking
- calibration data base integration into ORCA
- development of fast simulation for physics TDR
- moving away from PAW to C++-based replacement
- pedestal studies
- good/new ideas on jets/met at high luminosity
- integrate tracking into MET calculation within ORCA

My Pet Peeves

- US participation is small! Attendence at the other PRS group meetings is typically 5x that in for the HCAL/Jet/Met meetings. Most attendees are not US (5 regular US attendees, 2 are from the level 1 group)

- Other group's leaders are full time CMS. May explain their large attendance, more cohesive structure.

May need tuning. Communication from some parts limited to collaboration meetings (or less). How can we get more of a "community" going, with active intellectual exchange outside of our national/regional/university/friendship groups? The other PRS groups have 5x greater attendence (ecal has 65 people who occasionally attend, b/tau 45) → community

Conclusion

- Jet/Met will meet its milestones, but just barely (Especially thanks to the Russians!!!)

- We need more manpower, especially to study high luminosity issues.

- Need to sustain the energy over next 5 years.