CMS – QCD csoport

Siklér Ferenc

Nov 9, 2009
QCD Physics Analysis Group

• Szervezet
  – https://twiki.cern.ch/twiki/bin/view/CMS/TWikiQCD
  – Nikos Varelas (UI Chicago) → Siklér Ferenc (Budapest)
  – Vivian O’Dell (Fermilab)

• Alcsoportok
  – Low-\(p_T\)
  – High-\(p_T\)
  – Photons

• Meetingek
  – kéthetente kedden délután
    http://indico.cern.ch/categoryDisplay.py?categId=1313
  – underlying event workshop: MPI@CMS

• Intézmények
  – MIT Boston, Budapest, UI Chicago, Fermilab, U Karsruhe, U Perugia, NU Taiwan, ETH Zürich és mások
<table>
<thead>
<tr>
<th>Name</th>
<th>Code</th>
<th>URL</th>
<th>HN</th>
<th>Status</th>
<th>Contact</th>
<th>ARC Members</th>
<th>IRC_ Readers</th>
<th>PAS</th>
<th>PAPER</th>
<th>Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement of charged hadron spectra in proton-proton collisions</td>
<td>QCD-07-001</td>
<td>www</td>
<td>h</td>
<td>PAS-PUB</td>
<td>P. Eker</td>
<td>show 3 members</td>
<td>no IRC</td>
<td>P</td>
<td></td>
<td>show</td>
</tr>
<tr>
<td>Soft Physics and MB measurement (Remarks: In cooperation with H Group)</td>
<td>AN Notes: 2007/021</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero bias and HF-based minimum bias triggering for pp collisions</td>
<td>QCD-07-002</td>
<td>www</td>
<td>h</td>
<td>PAS-PUB</td>
<td>R. Holls</td>
<td>show 3 members</td>
<td>no IRC</td>
<td>P</td>
<td></td>
<td>show</td>
</tr>
<tr>
<td>Proposal of Zero-bias and MB trigger set-up for analyses (Remarks: In cooperation with H)</td>
<td>AN Notes: 2007/017</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measurement of the Underlying Event in Jet Topologies using Charg ...</td>
<td>QCD-07-003</td>
<td>www</td>
<td>h</td>
<td>PAS-PUB</td>
<td>L. Fanci</td>
<td>show 3 members</td>
<td>no IRC</td>
<td>P</td>
<td></td>
<td>show</td>
</tr>
<tr>
<td>UE Measurement</td>
<td>AN Notes: 2007/034</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measurement of inclusive jet cross sections with CMS at LHC</td>
<td>QCD-06-001</td>
<td>www</td>
<td>h</td>
<td>PAS-PUB</td>
<td>A. Gehler</td>
<td>show 3 members</td>
<td>no IRC</td>
<td>P</td>
<td></td>
<td>show</td>
</tr>
<tr>
<td>Measurement of the inclusive jet cross sections in pp collisions at 10 TeV (Remarks: GREEN)</td>
<td>Samples: 2_1</td>
<td>AN Notes: 2009/058, 2006/033, 2009/034</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study of jet transverse structure using the second moment of Pt ...</td>
<td>QCD-06-002</td>
<td>www</td>
<td>h</td>
<td>PAS-PUB</td>
<td>N. Lin</td>
<td>show 3 members</td>
<td>no IRC</td>
<td>P</td>
<td></td>
<td>show</td>
</tr>
<tr>
<td>Study of jet transverse structure using the second moment of Pt radial distribution</td>
<td>Samples: 2_2</td>
<td>AN Notes: 2008/050</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hadronic Event Shapes at CMS</td>
<td>QCD-08-003</td>
<td>www</td>
<td>h</td>
<td>ARC</td>
<td>N. Weber</td>
<td>show 3 members</td>
<td>no IRC</td>
<td>P</td>
<td></td>
<td>show</td>
</tr>
<tr>
<td>Pseudorapidity distributions of charged hadrons in minimum bias p ...</td>
<td>QCD-06-004</td>
<td>www</td>
<td>h</td>
<td>ARC</td>
<td>C. Veres</td>
<td>show 3 members</td>
<td>no IRC</td>
<td>P</td>
<td></td>
<td>show</td>
</tr>
<tr>
<td>AN Notes: 2008/018</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transverse Momentum Distribution within Jets in pp collisions at ...</td>
<td>QCD-08-005</td>
<td>www</td>
<td>h</td>
<td>ARC</td>
<td>P. Kurth</td>
<td>show 3 members</td>
<td>no IRC</td>
<td>P</td>
<td></td>
<td>show</td>
</tr>
<tr>
<td>(Remarks: Jet Shapes)</td>
<td>AN Notes: 2008/004</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Studies of Multijet Events in CMS at 10 TeV</td>
<td>QCD-09-001</td>
<td>www</td>
<td>h</td>
<td>ARC</td>
<td>K. Nowak</td>
<td>no ARC</td>
<td>no IRC</td>
<td>P</td>
<td></td>
<td>show</td>
</tr>
<tr>
<td>Studies of multijet events in CMS at 10 TeV</td>
<td>AN Notes: 2009/073</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study of Charged Hadron Multiplicity in Minimum Bias pp Collision ...</td>
<td>QCD-09-002</td>
<td>www</td>
<td>h</td>
<td>ARC</td>
<td>Y. Lin</td>
<td>show 3 members</td>
<td>no IRC</td>
<td>P</td>
<td></td>
<td>show</td>
</tr>
<tr>
<td>CMS study of charged hadron multiplicity in minimum bias events (Remarks: GREEN)</td>
<td>Samples: 2_1</td>
<td>AN Notes: 2009/076</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dijet Azimuthal De-correlations in pp Collisions at 10 TeV</td>
<td>QCD-09-003</td>
<td>www</td>
<td>h</td>
<td>ARC</td>
<td>C. Dinglu</td>
<td>show 3 members</td>
<td>no IRC</td>
<td>P</td>
<td></td>
<td>show</td>
</tr>
<tr>
<td>Study of dijet azimuthal de-correlations in CMS at 10 TeV</td>
<td>Samples: 2_2</td>
<td>AN Notes: 2009/104</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measurement of the Dijet Production Ratio in pp Collisions at 10 TeV</td>
<td>QCD-09-004</td>
<td>www</td>
<td>h</td>
<td>ARC</td>
<td>R. Hinds</td>
<td>show 3 members</td>
<td>no IRC</td>
<td>P</td>
<td></td>
<td>show</td>
</tr>
<tr>
<td>Measurement of the Dijet Production Ratio in pp Collisions at 10 TeV</td>
<td>AN Notes: 2009/161</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measurement of the Dijet Mass Cross Section in pp Collisions at 10 TeV</td>
<td>QCD-09-005</td>
<td>www</td>
<td>h</td>
<td>ARC</td>
<td>K. Kousoulis</td>
<td>show 3 members</td>
<td>no IRC</td>
<td>P</td>
<td></td>
<td>show</td>
</tr>
<tr>
<td>Measurement of the Dijet Mass Cross Section in pp Collisions at 10 TeV</td>
<td>AN Notes: 2007/013</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measurement of the Dijet Mass Distribution and Search for New Part ...</td>
<td>QCD-09-006</td>
<td>www</td>
<td>h</td>
<td>ARC</td>
<td>R. Hinds</td>
<td>show 3 members</td>
<td>no IRC</td>
<td>P</td>
<td></td>
<td>show</td>
</tr>
<tr>
<td>Measurement of the Underlying Event in Jet Topologies using Charg ...</td>
<td>QCD-09-007</td>
<td>www</td>
<td>h</td>
<td>ARC</td>
<td>P. Bentein</td>
<td>show 3 members</td>
<td>no IRC</td>
<td>P</td>
<td></td>
<td>show</td>
</tr>
<tr>
<td>Measurement of the Underlying Event in Jet Topologies using Charged Particle and Momentum Densities at 10 TeV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measurement of Hadron Scales of dN/dpT in pp Collisions at 10 TeV</td>
<td>QCD-09-008</td>
<td>www</td>
<td>h</td>
<td>ARC</td>
<td>F. Siker</td>
<td>show 3 members</td>
<td>no IRC</td>
<td>P</td>
<td></td>
<td>show</td>
</tr>
<tr>
<td>Measurement of Hadron Scales of dN/dpT in pp Collisions at 10 TeV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measurement of Pseudorapidity distributions of charged hadrons produced in minima ...</td>
<td>QCD-09-009</td>
<td>www</td>
<td>h</td>
<td>ARC</td>
<td>G. Veres</td>
<td>show 2 members</td>
<td>no IRC</td>
<td>P</td>
<td></td>
<td>show</td>
</tr>
<tr>
<td>Pseudorapidity distributions of charged hadrons produced in minimum bias p-p collisions at $\sqrt{s}=0.9$ and 10 TeV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

http://cms.cern.ch/iCMS/analysisadmin/analysismanagement?awg=QCD
QCD plans for startup – analyses

- **Hadrons (low \(p_T\) subgroup)**
  1. Charged hadron density
  2. Charged hadron spectra
  3. Underlying event
     - Next: event by event multiplicity; spectra of identified hadrons

- **Jets (high \(p_T\) subgroup)**
  4. Dijet azimuthal decorrelation
  5. Hadronic event shapes
  6. Dijet mass ratio
     - Next: jet spectrum; dijet mass distribution; dijet angular distribution; jet shapes; multijets; multijet cross-section ratios

- **Photons**
  - Next: photon spectrum

Rich program ahead
1. Charged hadron density \( (dN/d\eta) \)

- The two analyses – pixel hit counting
  - Documents: AN 2008/018, PAS QCD-08-004
  - People: Krisztián Krajzár, Gábor Veres
  - Recent activities
    * cluster based vertex finding, analysis now independent of tracking
    * pixel cluster shape is used for secondary rejection (instead of energy deposit)
    * well separated corrections
    * studying pixel cluster shapes using CRAFT data (talk)

\[ dN/d\eta \text{ can be obtained already with some } 10^4 \text{ events} \]
1. Charged hadron density \( \frac{dN}{d\eta} \)

- The two analyses – tracklet method
  - Draft: [QCD-09-002](#), on track for pre-approval
  - People: Yen-Jie Lee, Yetkin Yilmaz, Yongsun Kim, Ivan Cali, Gunther Roland
  - Recent activities
    * look at hit pairs in barrel layers with small \( \Delta \eta \) and \( \Delta \phi \)
    * background subtraction using data only (sideband method)
    * tracklet based vertex finder, analysis may be independent of tracking
    * also can work in pile-up

Joint publication with pixel hit counting and tracklet based methods
2. Charged hadron spectra \((dN/dp_T, dN/d\eta)\)

- The analysis
  - Documents: AN 2007/021, PAS QCD-07-001
  - People: Ferenc Siklér, Krisztián Krajczár

- Strategy
  * systematics is of major importance
  * high efficiency and low fake track rate
  * as few and as loose cuts as possible
  * obtain correction from data

Follow-up: identified hadron spectra (charged and neutral) using \(dE/dx\) and V0 finders
2. Charged hadron spectra \( (dN/dp_T, dN/d\eta) \)

- **Recent and current works**
  - Study of pixel-track HLT
    (contrib to talk in Trigger)
  - Integration of low \( p_T \) tools into standard tracking sequence
    (contrib to talk in Tracking) with Jean-Roch Vlimant, Boris Mangano
  - Determination of corrections from data
    (talk in Tracking)
  - Improved primary vertex finding
    (talk in B-tag)
  - Fitting pixel clusters, correction for energy deposits below threshold
    (talk in Pixel offline)
  - Optimized energy loss estimation, based of deposited energy in silicon
    (talk in QCD)
  - Particle identification, based on multiple scattering and lost energy
    (talk in Heavy ions)

Wide range of contributions to several DPG/POG groups
3. Underlying event

- **The analysis**
  - Documents: AN 2007/034, PAS QCD-07-003
  - People: Livio Fanó, Paolo Bartalini, Chang You Hao, Andrea Lucaroni, Filippo Ambroglini, Rick Field, Giuseppe Cerati, Yuan Chao

- **Goal**
  - first MC tune based on underlying event observables
  - provide first measurements of underlying event activity at LHC
  - already with 10-50 pb$^{-1}$ first indication for MPI, first MC tune

- **Strategy**
  - use ratio plot (independent of tracking performance)
  - also use independent charged spectra measurement
  - provide first MC tune ($< 10\%$ uncertainty with 1 pb$^{-1}$)
  - use tuned simulated data to estimate performance
3. Underlying event

- Foreseen results
  - charged jet spectrum dependencies mainly related to calorimeter calibration and model tuning
  - uncorrected ratio of transverse activity
  - corrected transverse activity depends on MC/reco corrections
4. Dijet azimuthal decorrelation

- The analysis
  - QCD-09-003, on track for pre-approval
  - People: Cosmin Dragoiu, Leonard Apanasevich, Nikos Varelas

- Goals
  - $\Delta \phi$ distribution of leading jets is sensitive to higher order radiation, without explicitly measuring the radiated jets
  - Jet algorithm: SISCone with R=0.7
  - All generators yield similar distributions
4. Dijet azimuthal decorrelation

- **Corrections**
  - Dominated by jet energy and position resolution effects
  - Smeared generated almost identical to calorimeter jets

- **Sensitivity**
  - Varying values, initial (off, $2.5 \rightarrow 4$) and final state radiation (off, $4 \rightarrow 2.5$)
5. Hadronic event shapes

- **The analysis**
  - Documents: AN 2008/027, PAS QCD-08-003
  - People: Matthias Weber, Filip Moortgat, Günther Dissertori

- **Goals**
  - Normalized variables, robust against jet energy scale and resolution
  - Probe structure of the hadronic final state

Comparison of early data and various Monte Carlo predictions
5. Hadronic event shapes

**Strategy**
- Jet algorithms: inclusive $k_T$ with $D=0.6$ and SISCone with $R=5$
- Hardest two jets are central $|\eta| < 1.3$
- Using only central jets for event shape calculations

**Foreseen results**
- normalized distributions of central transverse thrust and central thrust minor derived from corrected calorimeter jets in several $p_T$ bins

**Recent and ongoing work**
- Use additional jet algorithms and parameters
- Comparison of calojets/JPT jets/PFJets
- Extending analysis
  - use all jets up to $|\eta| < 3$, no restriction on $|\eta|$ of hardest jets; other event shape variables (e.g. jet broadening); use charged tracks
6. Dijet mass ratio

- The analysis
  - People: Kostas Kousouris, Robert Harris, Chiyoung Jeong, Sertac Ozturk, Daniel Miner, Marek Zielinski, Amnon Harrel

- Goals
  - Dijet ratio vs mass can be used to discover new physics early
  - Sensitive to contact interactions and dijet resonances
  - QCD precision measurement only after the jet energy scale is understood

Jet energy scale uncertainty is dominant ($\approx 0.6$ fractional error)
6. Dijet mass and dijet ratio

- **Strategy**
  - Jet algorithm: SISCone with $R = 0.7$
  - At least two jets with $|\eta_1|, |\eta_2| < 1.3$
  - Combined spectrum
  - Unsmearing correction (ansatz, resolution model, fitting function, unsmearing correction factor)

- **Early papers plan**
  - QCD precision measurement is not feasible with 100 pb$^{-1}$ due to the large jet energy scale uncertainty
  - However the reach in mass is almost 2.5 times the Tevatron reach
  - Dijet mass spectrum to check rough consistency with QCD and dijet ratio which is less affected by exp uncertainties and is sensitive to new physics

Check consistency with QCD using first data
Other analyses – inclusive jet cross section

- The analysis
  - Documents: AN 2009/034 (inclusive jets), AN 2009/033 (non-pert corrections), AN 2009/058 (NLO calculations) QCD-08-001, pre-approved
  - People: Kostas Kousouris, Michael Heinrich, Klaus Rabbertz, Andreas Oehler, Keith Rose, Dave Mason, Pratima Jindal

- Goals
  - Measurement possible with first data, a well understood 10 pb\(^{-1}\)
  - Reach beyond Tevatron limit, test pQCD at the TeV scale
  - Strong sensitivity to jet energy scale

- Steps
  - Jet performance: inclusive \(k_T\) with \(D=0.6\) and SISCone it \(R=0.7\)
  - Jet energy corrections: jet L2 relative and L3 absolute, from MC matching
  - Event clean-up: reject events with \(\text{MET}/\sum E_T > 0.3\)
  - Unsmearing corrections
  - Systematic uncertainties
Other analyses – inclusive jet cross section

Experimental uncertainties dominate
Deviations from theory by factor two will be clearly visible
Other analyses – dijet angular distribution

- The analysis
  - People: Agata Smoron, Leonard Apanasevich, Nikos Varelas

- Strategy
  - Insensitive to PDFs
  - Reduced sensitivity to detector effects
  - Errors dominated by jet energy scale
Other analyses – jet shapes (1)

- The analysis
  - People: Natalia Ilina, Vladimir Gavrilov, Olga Kodolova
  - Drafts: AN 2008/30, QCD-08-002, on track for pre-approval

- Goals
  - Estimate quark and gluon fraction from jet transverse structure
  - Distance distributions: $\delta R^2 = \delta \eta^2 + \delta \phi^2$
  - Look at $\langle \delta R^2 \rangle$ vs $p_T$ and $\eta$
  - Bias due to magnetic field and calorimetry

Usage of tracks helps to suppress systematic problems
Other analyses – jet shapes (2)

- The analysis
  - People: Pelin Kurt, Anwar Bhatti, Marek Zielinski
  - Documents: AN 2008/24, PAS QCD-08-005

- Strategy
  - Jet shapes are sensitive to parton showering processes
  - Provide a good test of Monte Carlos, already with $10 \text{ pb}^{-1}$

Jet shapes reconstructed using calorimeter energies
Other analyses – multijets

- The analysis
  - People: Suvadeep Bose, Sunanda Banerjee, Nikos Varelas
  - QCD-09-001, on track for pre-approval

- Goals
  - vector nature of gluon and gluon self coupling; color factors
  - tests of QCD sensitive to self coupling, based on study of angular correlations in 3-jet and 4-jet events
  - test of the validity of QCD calculations to higher order and probe the underlying QCD dynamics
Other analyses – multijets

- Topological properties

  - $1+2 \rightarrow 3+4+5$
    * Independent variables involved:
      \[ x_3, \ x_5, \ \cos \theta_3, \ \psi^*, \ \cos \lambda \]
    * Jets are boosted to the 3(4)-jet center of mass frame and ordered in descending order of their energies

  - $1+2 \rightarrow 3+4+5+6$
    * Variables: \( x_i, \ \cos \theta_i, \ \cos \theta_{BZ}, \ \cos \theta_{NR} \)
    * Bengtsson-Zerwas angle: angle between the plane containing the two leading jets and the plane containing the two non-leading jets
Other analyses – photons

- Photon spectrum
  - People: Serguei Ganjour, Chia-Ming Kuo, Vanessa Gaultney, Laurent Millischer, Vasundhara Chetluru, Rong-Shyang Lu, Steve Linn

- Signal – Pythia, background – Madgraph, photons vs jets
- Barrel/endcap: e_{cal} < 1.4/15 GeV, h_{cal}/E_T < 0.03/0.13, trackIso < 5.5/6.5 GeV
- In addition select focussed clusters with R9 > 0.93

Trying to extract isolated photon fraction using template method
October exercise
October exercise – QCD

<table>
<thead>
<tr>
<th>acronym</th>
<th>contact</th>
<th>Involved T2s</th>
<th>Input Data Type (3)</th>
<th>Output data Type (4)</th>
<th>Status (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EvShape</td>
<td>Matthias Weber</td>
<td>CSCL (Switzerland), DESY</td>
<td>SD_Jet50U</td>
<td>Histos</td>
<td>Ongoing</td>
</tr>
<tr>
<td>HadronSpectra</td>
<td>Ferenc Sikler</td>
<td>any</td>
<td>MC, SD_ZeroBias, SD_MinBiasPixel</td>
<td>Histos</td>
<td>Completed</td>
</tr>
<tr>
<td>QCDPhotPurity</td>
<td>Vasundhara Chetluru</td>
<td>Caltech, INP3</td>
<td>MC, SD_Photon20</td>
<td>Histos</td>
<td>Completed</td>
</tr>
<tr>
<td>QCDPhotPurity</td>
<td>Vanessa Gaulnney</td>
<td>Caltech</td>
<td>SD_Photon20</td>
<td>Histos</td>
<td>Finished</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Templates-----Purity</td>
</tr>
<tr>
<td>QCDJetEff</td>
<td>Abraham Debenedetti</td>
<td>Caltech, INP3</td>
<td>MC, SD_Photon20, SD_Ele15</td>
<td>Histos</td>
<td>Completed</td>
</tr>
<tr>
<td>QCDcNdEta</td>
<td>Yen-Jie Lee</td>
<td>MIT</td>
<td>MC, SD_ZeroBias</td>
<td>Histos</td>
<td>Completed</td>
</tr>
<tr>
<td>CHJETUE</td>
<td>Livio Fano</td>
<td>ASGC</td>
<td>MC, AOD (ZeroBias, MinBiasPixel, L1Jet15U, L1Jet30U, L1Jet50U)</td>
<td>Histos</td>
<td>Finished</td>
</tr>
</tbody>
</table>

- **Exercises**
  - 2 "first day" analyses, no skimming, using PD (RAW or RECO)
  - 3 group skim + 4 analyses on skimmed SDs
    - [https://twiki.cern.ch/twiki/bin/view/CMS/QCDOct09Ex](https://twiki.cern.ch/twiki/bin/view/CMS/QCDOct09Ex)

- **Meetings**
  - Daily: Vivian O’Dell (Oct 7 Oct 9) and Vasundhara Chetluru (Oct 14 Oct 16)
  - Dedicated QCD group meeting on Oct 13
Skims – $\text{low-p}_T$ group

- Details
  - Skimming contact: Yuan Chao
  - Kept objects: low level (pixel and strip clusters, HLT trigger information)
    high level (tracks from standard iterative tracking, vertices, calorimetric jets)
  - For T2–TW the T2–T2 links are not setup for most of the remote sites,
    the published samples cannot be moved (working on that)
  - 1/3 of jobs crashed when running jobs and stage out to distant SE
  - After adjustments usually 1-2% failed (error 8001 or abort)

- Reduction
  - 37% reduction; note that MC info was kept

- Time needed
  - skim jobs can be finished in about 1-3 hours (speed $\sim 10$ k events/job/hour)
  - resubmit failed jobs and wait: 0.5-1 day
  - skim verification: 2 days
  - PhEDEx subscription: 6 hours
  - store service: few days

All steps for 10 TeV and 7 TeV completed
Skims – high-p_T group – QCDJetsSkims

Jet multiplicity

Leading jet $\eta$

Leading jet $E$

QCD_Pt80/Jet50U
Analyses – QCDdNdeta

- Basics
  - Goal: pseudorapidity distribution of charged hadrons in minimum bias
  - People: Yen-Jie Lee, Gábor Veres and Krisztián Krajczár
    [https://twiki.cern.ch/twiki/bin/view/CMS/QCDdNdEtaOct09](https://twiki.cern.ch/twiki/bin/view/CMS/QCDdNdEtaOct09)
  - Two complementary methods (pixel counting and tracklets)
  - This analysis is expected to be done within days after data-taking, 10 k events

- Strategy
  - no skimming, processed SD_ZeroBias at MIT T2

- Observations
  - all jobs run successfully, first plots within hours
  - final result in less than a day for the 10 TeV, improved to 2 hours for 7 TeV
  - assuming that data and MC agree to some extent

---

**Analysis workflow**

- **Step 0**: locate data (PDs and SDs) (10/05 16:30)
- **Step 1**: look at the pixel hit spectrum of those data, compare the Monte Carlo sample and "data" sample. (10/05 17:00)
- **Step 2**: prepare pixel hit trees with the Monte Carlo sample and "Data" sample (10/05 19:00)
- **Step 3**: do analysis, reconstruct hits and tracklets on Monte Carlo sample to obtain the correction factors and background fractions. (10/05 22:30)
- **Step 4**: do analysis on "Data" sample to obtain the background fractions (10/05 22:35)
- **Step 5**: Apply corrections on pixel tracklets / pixel hits. (10/05 22:50)
- **Step 6**: Produce final plots from SD_ZeroBias. (10/06 12:30)
Analyses – QCDdN\textit{d}N/\textit{d}\textit{\eta}

- Plots

Pixel counting

10 TeV plots, with several cross-checks
Now focusing on trigger and data-taking
Analyses – HadronSpectra

- **Basics**
  - Goal: $p_T$ and pseudorapidity distribution of charged hadrons in minimum bias
  - People: Ferenc Siklér, Krisztián Krajczár
  - [https://twiki.cern.ch/twiki/bin/view/CMS/HadronSpectraOct09Ex](https://twiki.cern.ch/twiki/bin/view/CMS/HadronSpectraOct09Ex)
  - This analysis is expected to be done within days after data-taking, 1 M events
  - Some corrections are determined from data

- **Strategy**
  - no skimming, processed SD_ZeroBias at QCD associated T2s

- **Observations**
  - 4 events out of million crashed, problem in hit ordering in reco
  - otherwise fast and successful jobs (50 jobs, 20 k events each)

---

- Step 0: locate data (PDs and SDs)
- Step 1: look at many events with an [event viewer](https://twiki.cern.ch/twiki/bin/view/CMS/HadronSpectraOct09Ex)
- Step 2: prepare cluster shape filter data using low multiplicity events
  - 740 k events were used, [document](https://twiki.cern.ch/twiki/bin/view/CMS/HadronSpectraOct09Ex) (6 MB)
- Step 3: verify impact parameter resolution of pixel tracks
- Step 4: verify geometrical efficiency from data

the standard deviation for the Gaussian shape of the interaction region is fitted as $\sigma_z = 3.820 \pm 0.004$ cm
Analyses – HadronSpectra

Cluster shape

Acceptance

Pixel track impact

Calibrations from data
Analyses – HadronSpectra

- Plots

7 TeV plots

Now focusing on trigger and data-taking
Analyses – CHJETUE

- Plots

10 TeV plots
Analyses – EvShape

- Plots

For anti-kt only compared MadGraph and Pythia
Korábbi és tervezett munkák
Beütések – gyors eredmények

• Miért?
  – fontos kérdés: hány részecskék keltettünk? gyors mérés kell

• Hogyan?
  – a töltött részecskék – ha eléggé gyorsak – átmennek az első pixel hengeren
  – 1 beütés $\sim 1$ részecske
  – a kölcsönhatási pont helye és a beütés helye $\Rightarrow \theta$
  – azért nem ilyen egyszer

Korrekciónk
Ponthármasok

- vegyünk pontokat az első és a második hengerről (P₁ és P₂)
- két határoló kört keresünk, melyek átmennek O, P₁ és P₂-n
- inverzió P₁ középponttal és k = P₁P₂ sugárral
- megoldás a P₃ – P₃ íven

Aztán megnézzük a 3D-ben
Beütések szűrése – alak

- **Probléma**
  - tl sok beütés, melyik pont melyik részecskéhez tartozik?

- **Segítség**
  - töltött részecske → leadott energia → klaszter
  - a szilícium vastag (300 µm), a pixelek méretei 150×100 µm²
  - a klaszterek alakja szoros kapcsolatban van a bejövő részecske irányával

Hatékony szűrő
Beütesek helye – pontosabban

- **Mit tudunk?**
  - klaszter? az egyes pixelekben mért energia
  - a bejövő részecske irányát tudjuk (kék nyíl)

- **Hogyan?**
  - thossz $\propto$ energia? mikroszkópikus fizikai modell
  - mozgassuk az áthaladás helyét, hol lesz a legkisebb a $\chi^2$?
Kölcsönhatási pont helye

- Mit tudunk?
  - ismerjük a részecskék nyalábközelpontjának $z$ koordinátáját és annak becsült $\sigma_z$ hibáját

- Hogyan?
  - agglomeratív klaszterezés
  - két részecske $d$ távolsága

\[ d^2 = \frac{(z_i - z_j)^2}{\sigma_i^2 + \sigma_j^2} \]

- először minden egyes részecske egy-egy klaszter
- minden lépésben megkeressük a két legközelebbi klasztert ($d_{min}$) és egyesítjük
- az $j$ klaszter $z$-je és $\sigma$-ja a két klaszter slyozott átlaga
- addig folytatjuk, amíg $d_{min}$ tl nagy nem lesz

Megbízható módszer, nagy ütközési gyakoriságnál is működik
Részecskeazonosítás – energiaveszteség

- Miért érdekes, mit tudunk?
  - milyen részecske? a leadott energia \( \frac{dE}{dx} \) sebességfüggő
  - egy részecskét több pontban mérünk, sok \( m_i = \frac{dE_i}{dx_i} \) érték, nagy szórással

- Hogyan?
  - nézzük a sorbarendezett \( m_i \) értékek slyozott átlagát
  - keressük \( w \) slyokat, ahol a relatív felbontás a legkisebb,  \( \sqrt{w^T V w} \)
  - variációs feladat, \( w \propto V^{-1}m \)

Szeles Sándor (ELTE, V. fizikus), OTDK 2. díj
„Az energiaveszteség mérésének optimalizálása nyomkövető detektorokra”
Részecskkeazonosítás – szóródás

- Miért érdekes?
  - a $dE/dx$ nem mindig mérhető (pl ATLAS pixel detektora), kiegészítő mérés

- Hogyan?
  - ismert fizikai folyamat: többszörös Coulomb szórás
  - mérjük a rétegeken való áthaladás közben az irányváltások szögeit
  - de: van a helymérésnek egy bizonytalansága, van energiaveszteség is
  - Kalman filter, nézzük a $\chi^2$ eloszlását egy tömegfeltételezéssel
First measurements at \( \sqrt{s} = 900 \) GeV
• **900 GeV**
  - Collisions in the 1st week of December, lifetime $\sim 4$ hours
  - About 5 night shifts, magnet on
    - $2 \times 2$ ($5 \times 10^9, 2 \times 10^{10}, 3 \times 10^{10}$) and $4 \times 4$ ($3 \times 10^{10}, 3 \times 10^{10}$)
  - Beam size $\sim 250 \, \mu m$, $\sigma_z \approx 7.5 \, cm$, lumi $\sim 5 \times 10^{27}$

• **2.2 TeV**
  - before shutdown, few shifts, but only ”if things go very well”
Physics at 900 GeV

• Which physics?
  – What can you do with data taken
    * at low collision probability per BX (∼ 0.01)
    * within a single shift (several shifts are needed for latency scan)
    * with an open trigger?
  – Look at processes with high cross-section
  – \( p+p \rightarrow X \), distributions of produced particles
    \( \eta, p_T < 6 \text{ GeV}/c \), charge, particle type, event-by-event multiplicity

• Is it known, unknown?
  – Measurements at the same energy exist, by UA1 and UA5
  – But with different collision system: \( p + \bar{p} \)

We will have a cross-check and a new measurement at the same time
  Also remember competition (A*)
Physics at 900 GeV

Plot from Particle Data Book

Publications

Also see https://twiki.cern.ch/twiki/bin/view/CMS/PhysicsWith900GeV
Analyses and papers

• dN/d\( \eta \) from 1 or 2 pixel hits
  – Early paper QCD-09-009, based on QCD-08-004 and QCD-09-002
  – Gábor Veres, Yen-Jie Lee
  – Weekly meetings, covering also common issues w/ track analysis
    https://twiki.cern.ch/twiki/bin/view/CMS/DNdEtaWorkingGroup
  – Paper under review: got written comments from ARC

• dN/dp_T and dN/d\( \eta \) with tracks
  – Early paper QCD-09-008, based on QCD-07-001
  – Ferenc Siklér, Krisztián Krajczár
  – Paper under review: v7 uploaded, comments answered

Successful participation in OctX, now focus on first data taking
See paper report today: Early papers on QCD physics
Analyses – triggers

- **No bias**
  - ZeroBias: uses BPTX (beam pickup timing exp)
    Trigger on b+b, but to study and subtract background
    need b+0 and 0+b as well, under implementation

- **Minimum bias**
  - HLT_MinBiasPixelTrk: at least one pixel track reconstructed
    $0 < |\eta| < 2.5$, INEL efficiency 83%, negligible background
    depends on pixel hit efficiency, to be determined
  - HLT_MinBiasBscOr: at least one beam scintillation counter fires
    $4 < |\eta| < 4.5$, INEL efficiency 93%, contribution from background
    depends on counter efficiency, to be determined

Detailed study on possible triggers and their overlaps (Y-J Lee)
Additional works are being done on both trigger families
Analyses – 900 GeV plots

Only 10 k events, not statistics limited

With ZeroBias $10^6$ BX (a shift), with BscOr only $10^4$ BX needed

How to share trigger bandwidth?
Analyses – 900 GeV plots

1 M events, reach out to 6 GeV/c

With BscOr or PixelTrk $10^6$ BX needed (a shift)
Detectors

- **Pixel**
  - 1.6% of the channels disabled
  - Latency scan is mandatory to set proper timing, it will take few shifts during collisions: 25 steps, 20 mins each

- **Strip tracker**
  - 93-99% availability depending on subsystem, partly recoverable
  - Timing scan can be done in parallel with pixel

- **Physics needs?**
  - Timing calibration? Hit efficiency will not be perfect in 2009
    Has to be estimated from real data, resp of the analysis groups
  - Alignment? For the lower $p_T$ values not critical, with reasonable alignment position error

Detectors are in good shape
Analyses – efforts

• Monte Carlo production
  – Pythia6 Atlas tune is not recommended (wrong energy dep)
  – Proposal is produce with Pythia6 (D6T: 10 M, Pro-Q20: 2 M) and Pythia8 (version 8.108: 1 M) at both 900 GeV and 2.2 TeV
  – Likely re-reco of simulated data needed with latest conditions

• Corrections
  – Obtain from data, also cross-check MC, if possible
  – Trigger : measure BSC hit efficiency from deposit distribution
  – Pixel : deduce hit efficiency by comparing pairs and triplets
  – Tracker : measure acc+eff (e.g. envelope method); pixel track impact, cluster shape compatibility with low multiplicity events

  Also thinking on DQM needs (fast event check, vertices)
Presentations

- **Cross-group**
  - Tracker DPG Forum: Plans for first collisions (29 Oct)
    - Physics studies (G Veres)
  - Trigger Studies Group: Joint Physics-Trigger meeting (2 Nov)
    - Minimum bias triggers for startup (C Roland, C Loizides)
    - Minimum bias PixelTrk trigger (K Krajczár) with a detailed study of beam-gas and beam-halo induced backgrounds

- **Within PAG**
  - Working group (2 Nov) : dN/deta meeting
  - QCD meeting (10 Nov) : report on 900 GeV preparations
  - HI meeting (16 Oct) : Spectra PInG (status)

Analyzers are in contact with key groups