Proposal for PhD Topic within Helmholtz Hachwuchsgruppe VH-503

Alexei Raspereza

Joint KA-HH Meeting, 19/04/10

Outline

- **current status**
  - ✔ group members
  - ✔ topics covered
  - ✔ first results
- **ideas and plans**
  - ✘ b-tagging physics analysis
  - ✘ physics analysis
- **topic for PhD thesis, proposal**

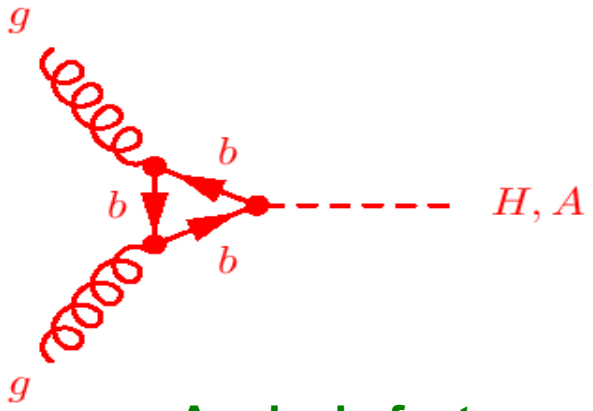
Title of the Project & Main tasks

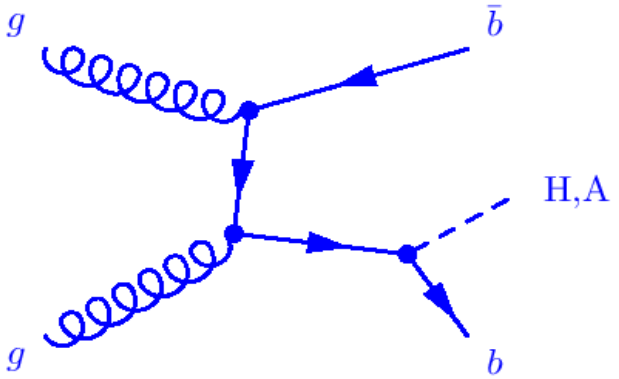
- ***Title : "Probing Electroweak Symmetry Breaking at LHC: Higgs Physics with the CMS Detector"***
- ***Main physics goals***
  - *Search for MSSM Higgs Bosons in gluon fusion and b-associated production processes (study of **Z+jets** production as spin-off result)*
  - *Study of the MSSM Higgs boson couplings to b-quarks*
  - *Study of Higgs-top coupling with pp→Htt process (long term plan)*
- ***Analysis related tasks***
  - *Validation, optimisation and calibration of b-tagging algorithms*
- ***Hardware activities***
  - *operation of the Beam Condition monitor (BCM1F), development and maintenance of BCM1F readout software*

Current Status of the Group

- **Group members (as of April 2009)**
  - Alexei Raspereza (group leader)
  - Roberval Walsh (post-doc)
  - Agni Bethani (PhD student)
- **Currently covered topics**
  - Inclusive MSSM Higgs $\rightarrow \tau\tau \rightarrow \mu\mu$ Analysis (Agni, Alexei)
  - Validation & optimization of b-tagging algorithms (Roberval, Alexei)
  - Validation of tracking software and MC tuning with the strange hadron spectroscopy analysis (Alexei, Agni)
  - BCM1F readout software development and operations of BCM1F (Roberval)

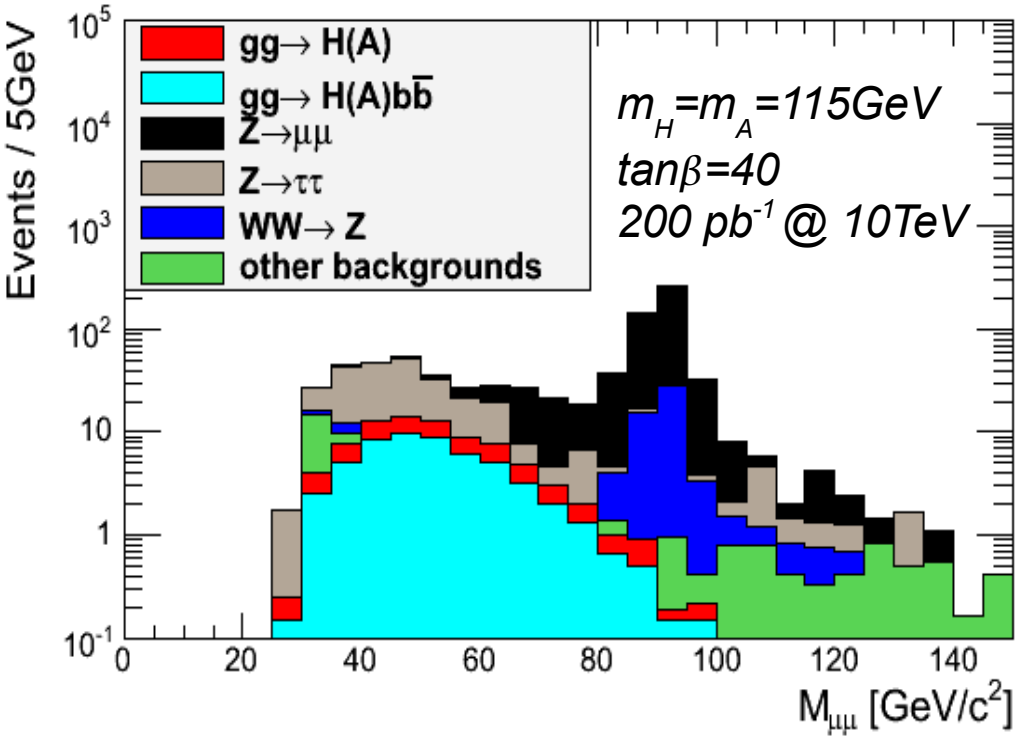
Supersymmetric Higgs Analysis





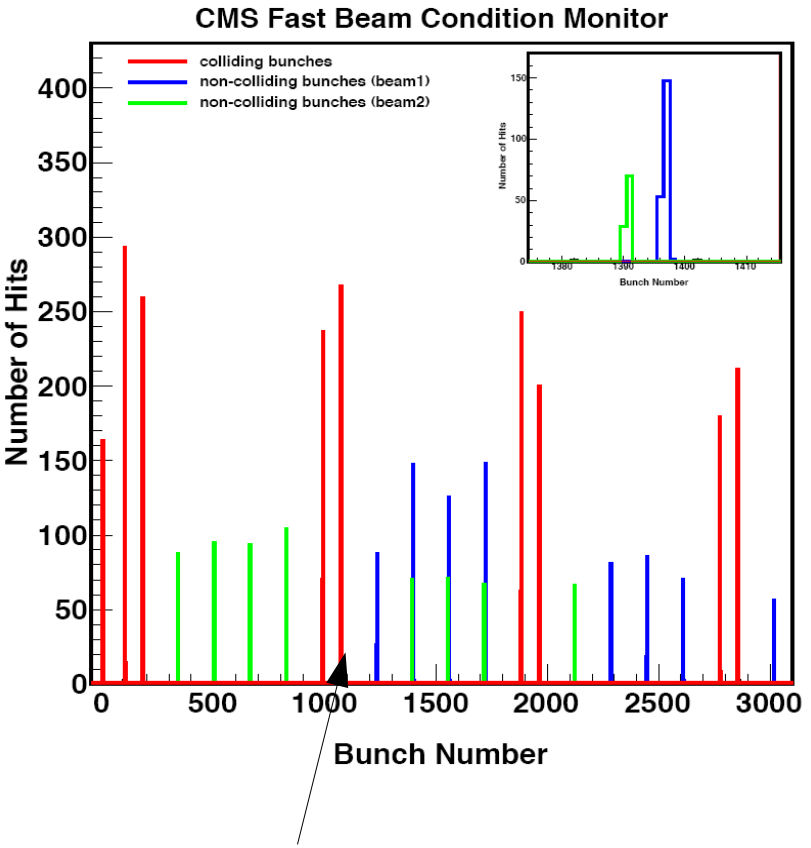
Analysis features : fully inclusive search, no b-tagging!

- Novel analysis searching for MSSM Higgs bosons via decay $H(A) \rightarrow \tau^+\tau^- \rightarrow \mu^+\mu^- + E_T^{miss}$
  - essential contribution to the signal significance (>2σ provided that m_H, m_A < *125 GeV* & tanβ > *30* with integrated luminosity of 200 pb^{-1})
  - analysis caused much interest within CMS Higgs PAG
  - plans with first LHC data: commissioning of the analysis with *Z+jets* process



Commissioning of BCM1F

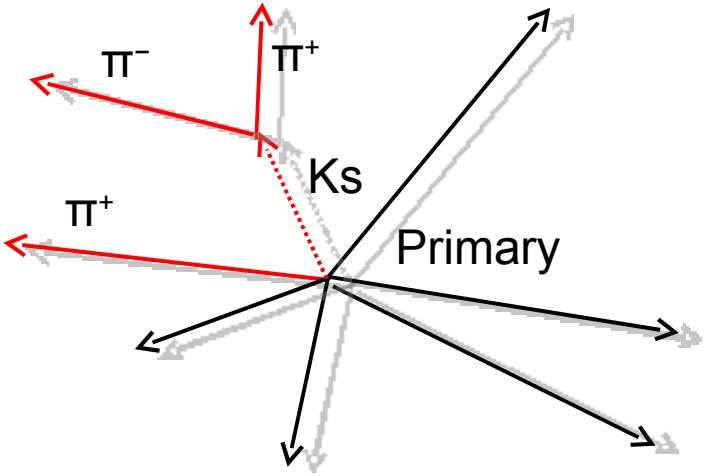
- Radiation hard Beam Condition Monitor (BCM)
  - **part of CMS Beam Radiation Monitor system**
  - **bunch-by-bunch beam diagnostics**
  - **protection of CMS tracker**
- DAQ Software developed by DESY group
  - Readout of Time-To-Digital converters
  - Data storage
  - Data publishing & communication with the LHC control system

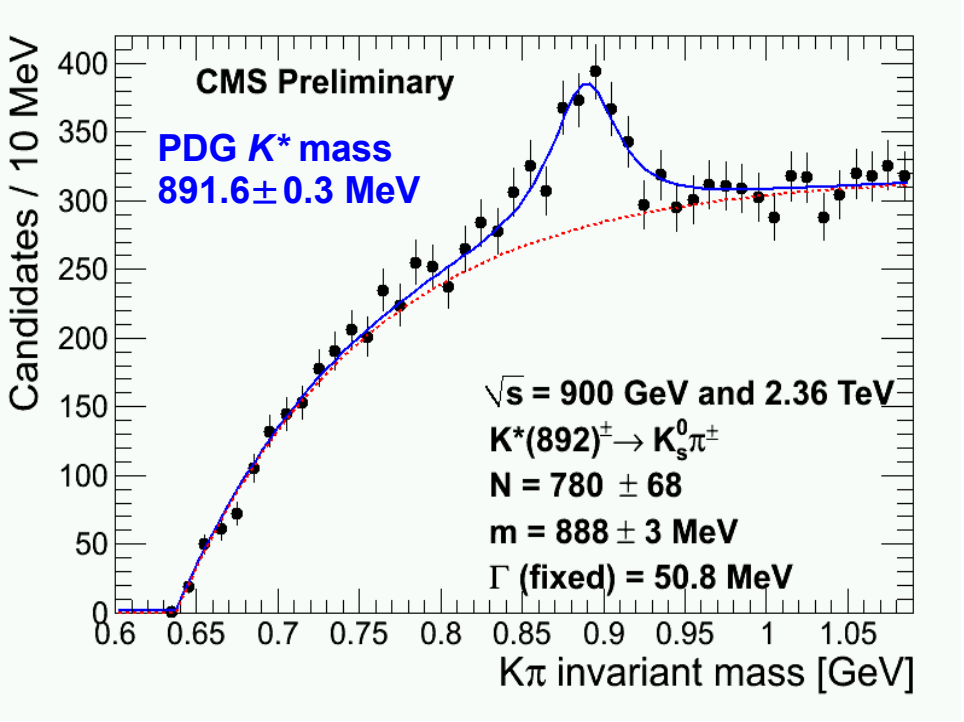


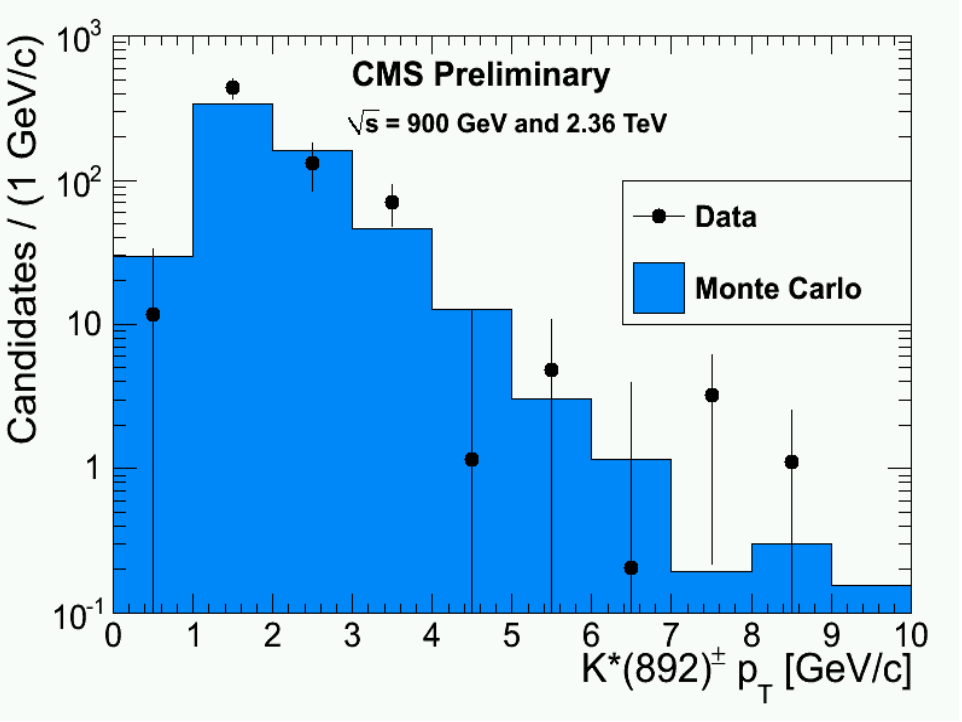
Excellent time resolution allows to resolve every single bunch

Tracking Studies with First Collisions

- Reconstruction of $K^*(892)^{\pm} \rightarrow K^0 s + \pi^{\pm}$ in first collisions at 900 GeV and 2.36 TeV
  - Analysis is a part of the CMS wide tracking validation effort
  - Contribution to the CMS Physics Analysis Summary and planned CMS paper on CMS tracking performance







Ongoing Activities and Plans

- We continued strange hadron spectroscopy analysis with the 7 TeV data. Analysis is intended for
  - validation & optimization of tracking software
  - inputs for the MC tuning (refinement of PYTHIA cards steering production of strangeness in the underlying events)
- Performance studies of the inclusive secondary vertex finding algorithms employed in b-tagging
- B-tagging calibration with *PtRel* method, data driven methods of determination of *PtRel* template for the sample of b-jets
- We intend to develop analysis searching exclusively for the b-associated production of the MSSM Higgs bosons via Higgs decays to tau leptons

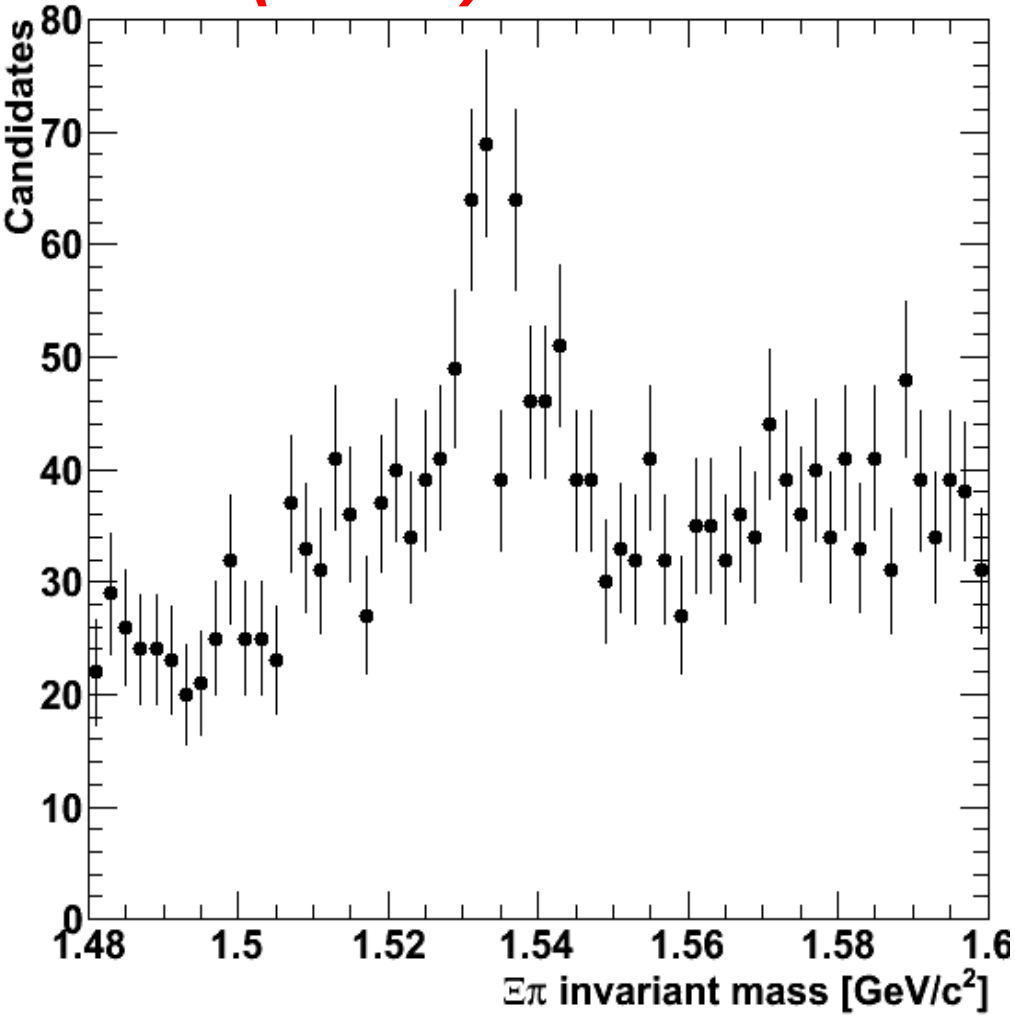
Strange Hadron Spectroscopy

- The scope of study is extended by inclusion reconstruction of
  - $\Xi^0(1530) \rightarrow \Xi^- \pi^+$
  - $\Sigma^{\pm}(1385) \rightarrow \Lambda^0 \pi^{\pm}$
- Corresponding codes are developed and tested on the 7 TeV data
- Comparison of yields and kinematic distributions of strange particles between data and MC

⇒ input for PYTHIA tuning

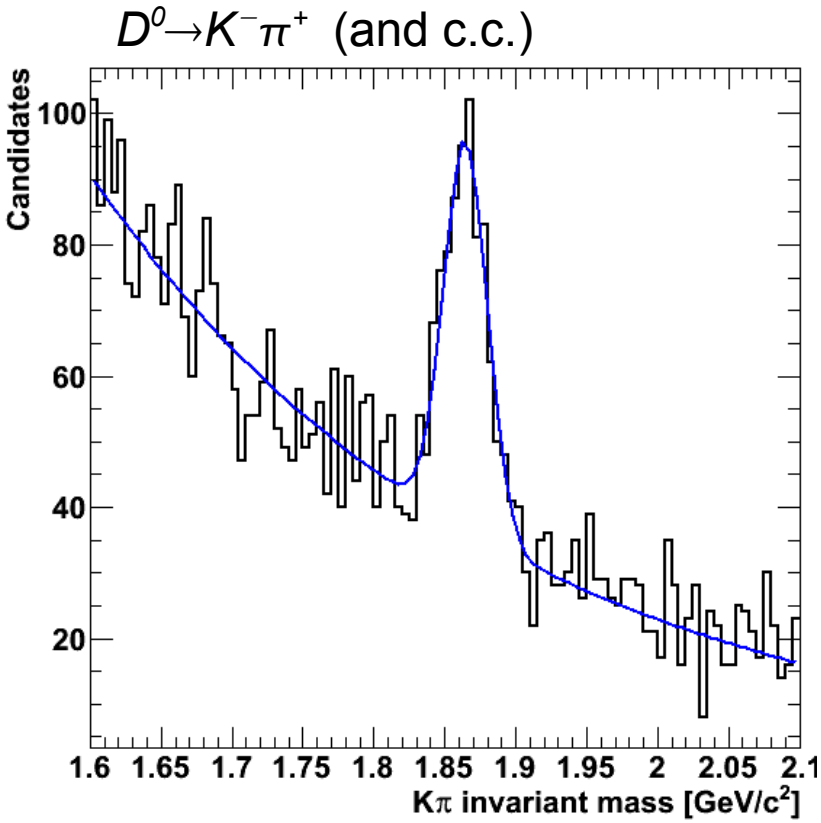
CMS Data & 7 TeV

$\Xi^0(1530) \rightarrow \Xi^- \pi^+$



Validation and Optimization of Inclusive Secondary Vertex Finder

- Idea : use samples of fully reconstructed *D* meson decays with relaxed cuts on decay length significance and vertex fit probability to study and optimize performance of SV b-tagger
- Analysis is started : codes available for the reconstruction of
  - $D^0 \rightarrow K^-\pi^+$ (and c.c.)
  - $D^+ \rightarrow K^-\pi^+\pi^+$ (and c.c.)
- plan to include other decay channels
- manpower needed : **possible area of contribution for new PhD student**



Btag Calibration with PtRel Method
Data-driven Determination of PtRel Template

- PtRel exploits different distributions of PtRel (Pt of muons w.r.t. jet axis) in the samples of b- and udsc-jets
- The weakness of the method : relies upon MC PtRel templates for the sample of b-jets
- Can we derive PtRel template
- Idea: exploit di-jet events with both jets containing muons
- Prob-and-tag approach
- Measure PtRel distributions in the sample of probed jets for the sliding cut on PtRel variable in the tagged jet

Data-driven extraction of PtRel template for the sample of b-jets

- ***Mathematics:***
  - $N(x) = N_{TOT}\left(f_b \int_x^{\infty} g_b(z)dz + (1-f_b)\int_x^{\infty} g_{udsc}(z)dz\right)$
  - $dN/dy(x,y) = N(x)\left(f_b(x)g_b(y)+(1-f_b(x))g_{udsc}(y)\right)$
  - $f_b(x)/(1-f_b(x)) = f_b\int_x^{\infty} g_b(z)dz \Big/ \left[(1-f_b)\int_x^{\infty} g_{udcs}(z)dz\right]$
  - *N(x) – the number of di-jets after applying cut PtRrel > x in the sample of tagged jets; f_b -fraction of b- di-jets in the selected di-jet sample prior cut on PtRel variable; $g_b(x)$ and g(x) – template PtRel distributions in the samples of b- and udsc-jets; $f_b(x)$ – fraction of b- di-jets in the sample after applying cut PtRel > x; dN/dy(x,y) – PtRel distribution (y variable) in the sample of probed jets after applying PtRel > x in the sample of tagged jets*
  - *System can be resolved for $f_b(x)$ and $g_b(x)$ for known $g_{udsc}(x)$*
- **Implementation of this method is the potential task for a new PhD student**

Physics Analysis
Search for b-associated production of MSSM Higgs Bosons

- We intend to complement inclusive search for the MSSM Higgs bosons without employing b-tagging by the analysis of the MSSM Higgs production in association with b-quarks
- Well advanced inclusive analysis can be used used as a starting point (basically we need to add b-tagging requirement)
- The analysis implies involvement in the activities of B-tagging POG:
  - Validation and optimization of the SV tagger with the sample of fully reconstructed *D* meson decays
  - B-tagging calibration with *PtRel* method (data-driven extraction of *PtRel* templates for the sample of b-jets)
- Commissioning of the analysis with the ***Zbb*** production process
  ⇨ contribution to the CMS publication with early LHC data

Proposal for PhD topic

- To keep the research area widely open, the following (a bit unspecific) topic for PhD thesis is proposed
  - **"Heavy Flavor Jet Physics with the CMS Detector "**
    - topic allows for a flexibility in the choice of concrete physics task
    - naturally implies contribution to the validation and calibration of b-tagging algorithms
    - provides possibility to contribute to the CMS publications with early LHC data (measurements of the Z boson associated production with b-jets)
    - basis for the MSSM Higgs analysis employing b-tagging
- Beam Radiation Monitor shifts and BCM1F software maintenance as a service work earning CMS service points