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UPPSALA
UNIVERSITET

Summary of the Experimental Sessions

Search strategies, systematics and analysis tools

cHarged 2008
Uppsala, Sep 19, 2008

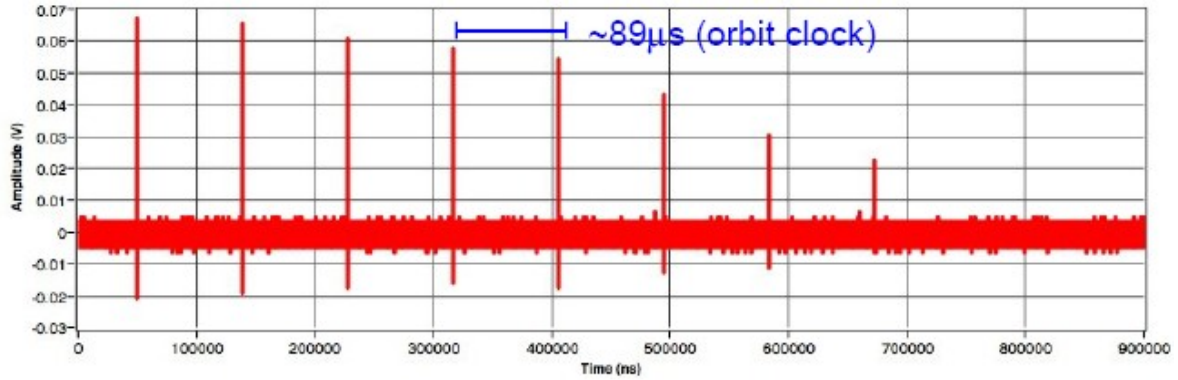
Analysis Tools

- Important tools in H^+ searches:
  - Trigger
  - τ-tagging
  - b-tagging
  - jets/E_T^{miss}
  - leptons

Trigger

- cHarged08 might have been the first public conference where beam-related LHC figures are shown!

F. Winklmeier



- LHC triggers are collecting data and commissioning is in full progress

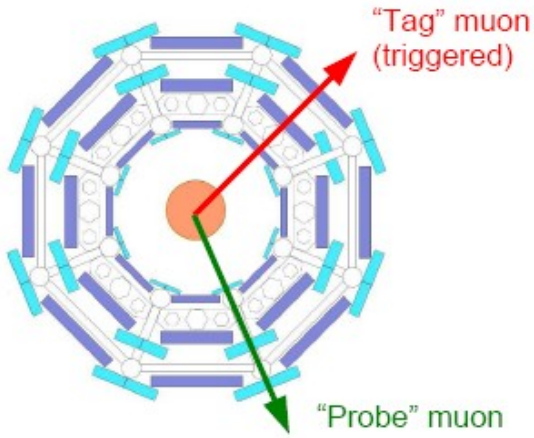
R. Brenner

10E31: XE30_L1_TAU13, XE20_3j20_L1_TAU13
10E33: XE40_3j20_L1_TAU30, XE50_L1_TAU30

- Trigger problem:
  - H^+ studies rely heavily on channels without leptons
  - Single-item triggers will have to high thresholds (ATLAS)
  - Have to rely on "difficult" triggers, e.g. $\tau+E_T^{miss}$
  - low efficiencies in important channels (esp. light H^+)

Trigger Efficiency from Data

- Tag & Probe for e, mu, tau and $\tau+E_T^{miss}$



F. Winklmeier

(1) Clean signal sample ($Z, J/\psi \rightarrow l^+l^-$)

(2) Select track that triggered the event ("Tag")

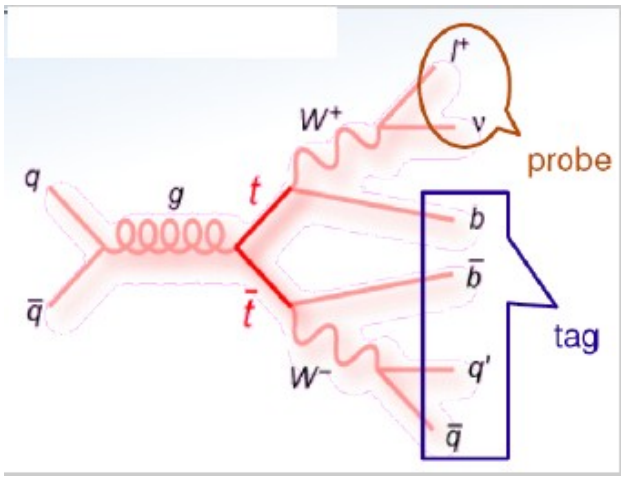
(3) Find other track using offline criteria ("Probe")

(4) Determine efficiency by applying trigger selection on Probe

Need a high purity signal sample
Biases must be checked carefully

- Expected uncertainties with $100pb^{-1}$:
  - e: 1-2%
  - μ: <5%
  - $\tau+E_T^{miss}$: 3% (statistical only)

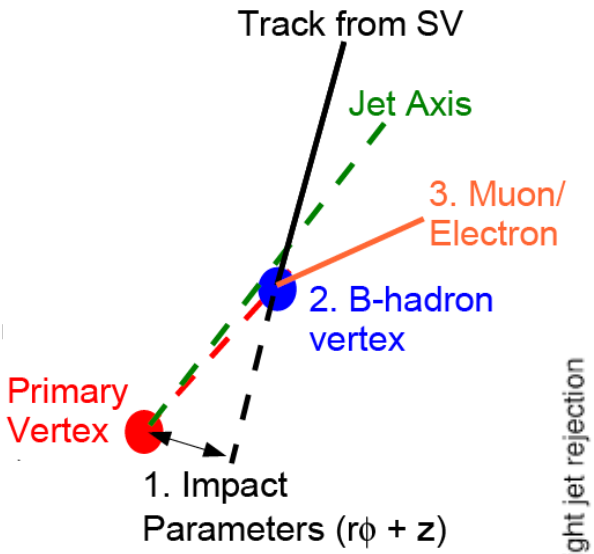
R. Brenner



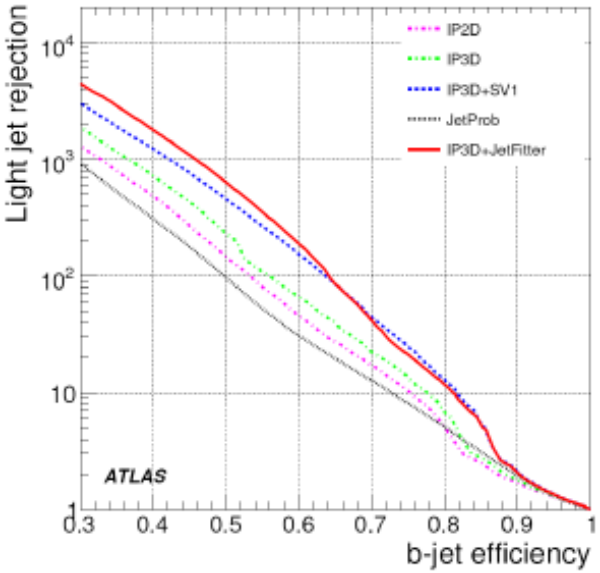
b-tagging

G. Piacquadio

- Approaches:
  - Impact Parameter
  - Secondary Vertex
    (new: JetFitter)
  - Lepton-ID based



- Algorithm performance:



- Efficiency measurement from data:
  - up to 6%, from QCD dijets (50/pb)
  - 8% (stat)+ 3% (syst), from ttbar (200/pb)

τ-tagging

K. Jakobs, 2006

Future steps (work to do for the LHC analyses)

- consolidate τ ID algorithms
  (profit from the rich experience from the TeVatron, TeV4LHC very useful,…)
- work towards a complementary track-based τ ID approach to improve the performance at low PT
- discriminate between various decay channels
- refine and consolidate multivariate analyses
- study further ways to measure the τ tag efficiency from data

τ-tagging

Future steps (work to do for the LHC analyses)

A. Saavedra

The hadronic tau reconstruction in the ATLAS experiment has matured and is stable.

- consolidate τ ID algorithms
  (profit from the rich experience from the TeVatron, TeV4LHC very useful,…) ✔

Tau base reconstruction: the shrinking cone

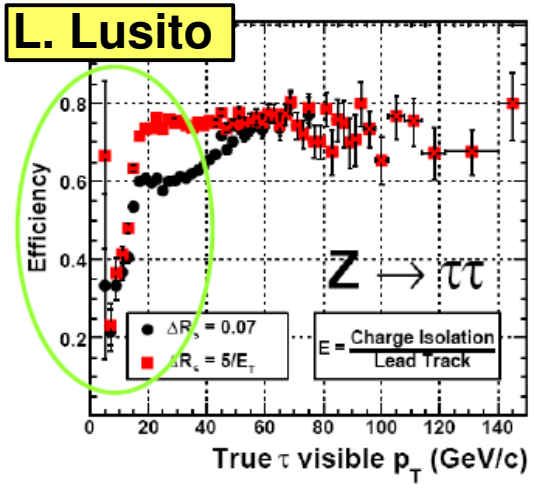
) approach to improve the performance

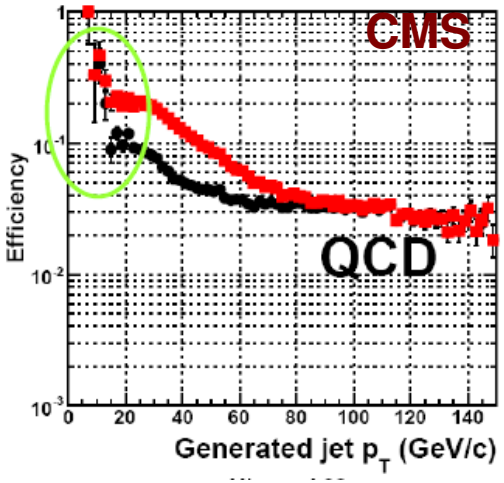
- τ-jets become more collimated at higher energies
- better reconstruction performances achieved with a signal cone size which scales as $5/E_T$ with a min and a max set to 0.07 and 0.15 respectively (marginal efficiencies)

Fine-tuning of established algorithms

cy from data

L. Lusito





τ-tagging

Future steps (work to do for the LHC analyses)

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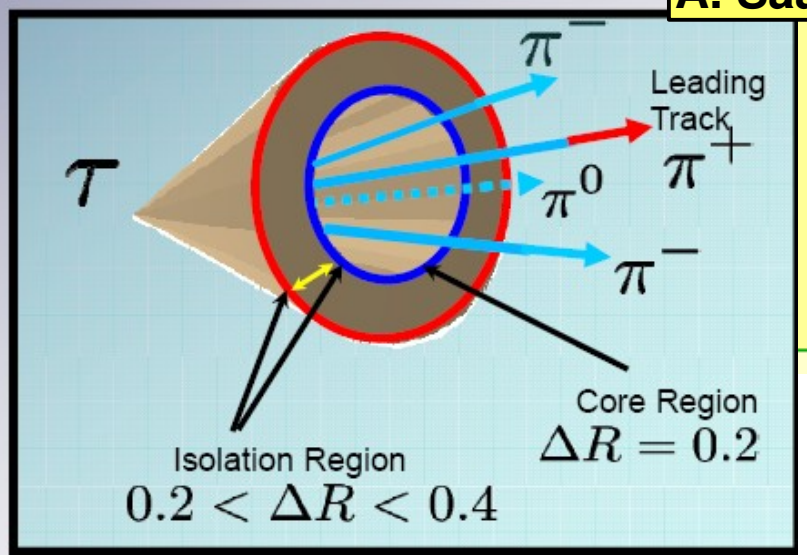
  (profit from the rich experience from the TeVatron, TeV4LHC very useful,…)
- work towards a complementary track-based τ ID approach to improve the performance at low PT
- discriminate b
- refine and cor
- study further v

A. Saavedra

Track Seeded Philosophy:

1. A low track multiplicity region centred about the leading track will contain most of the τ's transverse energy.
2. Only a minimum amount of energy is deposited in an annulus around the core region.

The hadronic τ decay results in visible components such as charged and neutral pions that are well collimated.



τ-tagging

Future steps (work to do for the LHC analyses)

- consolidate τ ID algorithms
  (profit from the rich experience from the TeVatron, TeV4LHC very useful,…)
- work towards a complementary track-based τ ID approach to improve the performance at low PT
- discriminate between various decay channels ✔

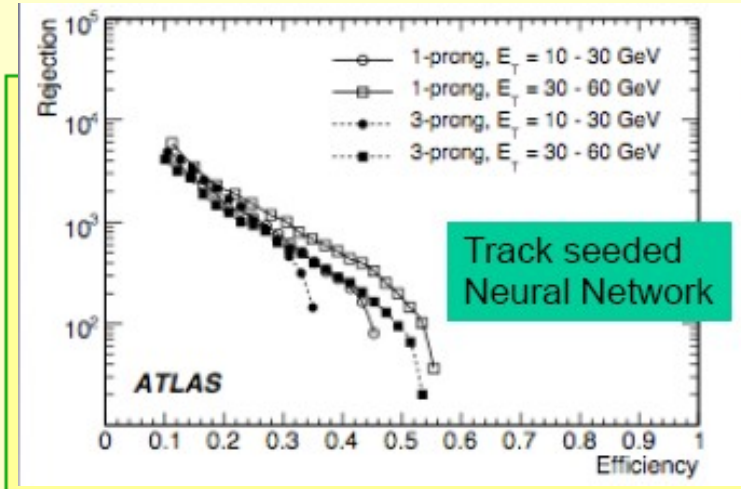
1. If $|E_T^{HCAL+ECAL} - p_T^{track}| < 2\,\sigma_{CALO}$: use **τ ~ track p**, corresponds to $\tau \rightarrow \pi^{\pm} + \nu$
2. If $E_T^{HCAL+ECAL} - p_T^{track} > 2\,\sigma_{CALO}$
   - 2.1 if $|E_T^{HCAL} - p_T^{track}| < 2\,\sigma_{HCAL}$: use **τ ~ track p + ECAL cluster**, corresponds to $\tau \rightarrow \pi^{\pm} + n\pi^0 + \nu$ with charged pion not interacting in ECAL
   - 2.2 if $p_T^{track} - E_T^{HCAL} > 2\,\sigma_{HCAL}$, $\pi^{\pm}$ interaction in ECAL, take the **calo jet**
   - 2.3 if $E_T^{HCAL} - p_T^{track} > 2\,\sigma_{HCAL}$, hadronic jet, **reject**
3. If $E_T^{HCAL+ECAL} - p_T^{track} < 2\,\sigma_{CALO}$: track reconstruction problem, **reject**

R. Kinnunen, L. Wendland

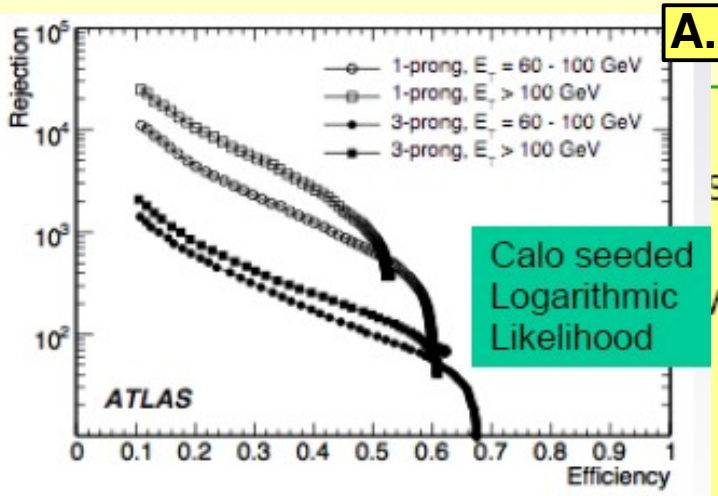
τ-tagging

Future steps (work to do for the LHC analyses)

A. Saavedra



Track seeded Neural Network



Calo seeded Logarithmic Likelihood

seful,…)

ve the performance

- refine and consolidate multivariate analyses
- study further ways to measure the τ tag efficiency from data

τ-tagging

Future steps (work to do for the LHC analyses)

A. Saavedra

The aim for the first 100pb^{-1} is to:

- Optimise the QCD Jet rejection using a real QCD sample.
- Measure identification and reconstruction efficiency using a real tau sample.
- Determine the tau energy scale from data.

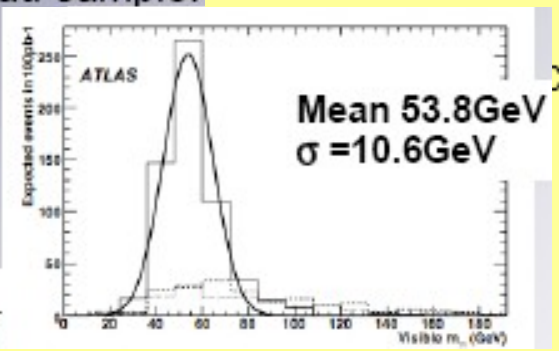
seful,…)

at low PT

ce

- discriminate between various decay cha
- refine and consolidate multivariate analyses
- study further ways to measure the τ tag efficiency from data ✔

$Z \rightarrow \tau_{had}\tau_{lep}$



There is more work going on concerning measuring tau efficiency from data than has been shown at this workshop

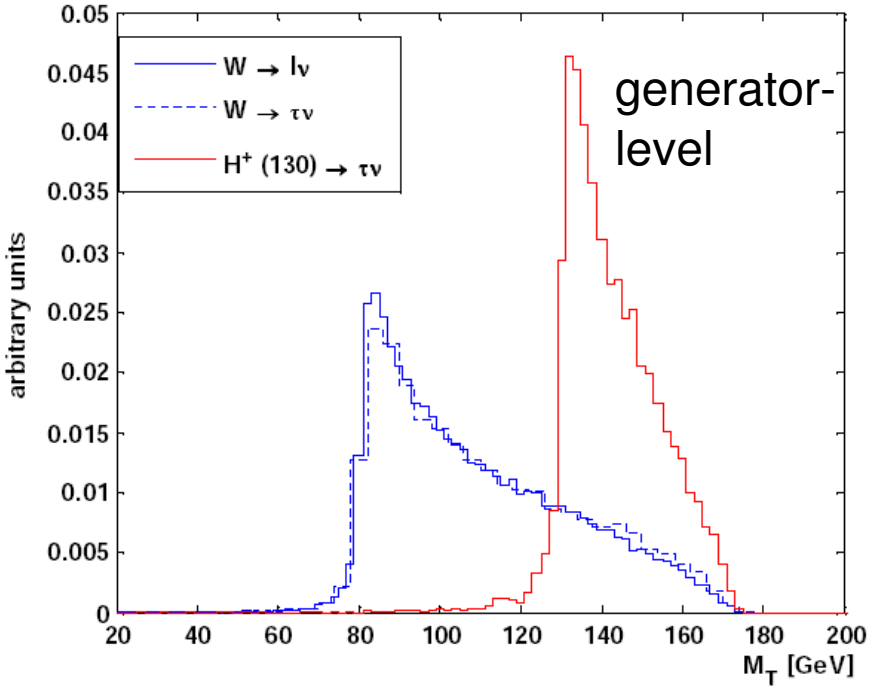
$m_T(H^+)$ in the leptonic tau mode

- Novel generalized transverse mass concept,
- developed in the context of H^+ searches, but applicable also beyond that

- Necessary ingredient for H^+ discovery potential in $H+ \rightarrow \tau\nu$, $\tau \rightarrow l\nu$

O. Vitells

$$(m_T^{H+})^2 = \max_{\substack{p_z^{miss}, E^{miss} \\ (p^{miss}+p^b+p^{lep})^2 = m_{top}^2}} [(p^{lep} + p^{miss})^2]$$



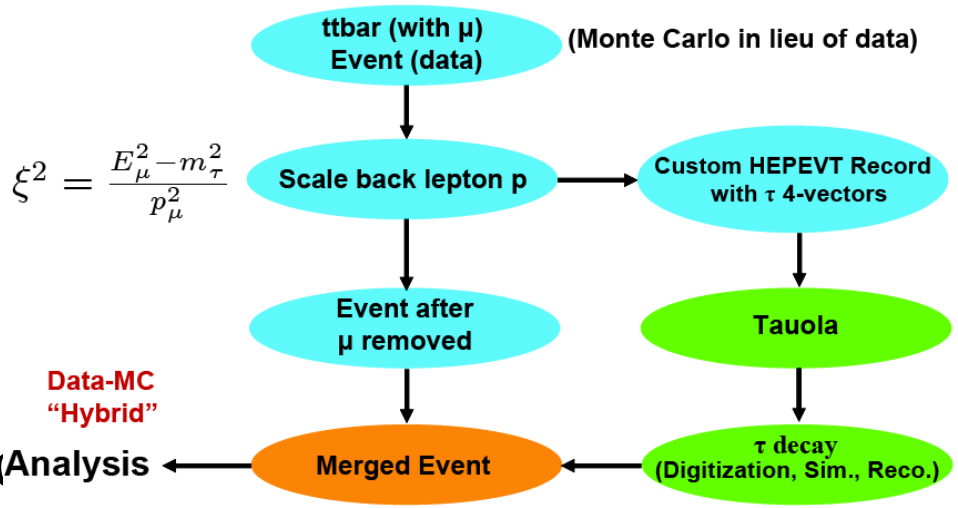
Systematics, Search Results

- Important recent developments in:
  - background estimation from data
  - Evaluation of sensitivies (cross sections, parameter-dependence)
  - H^+ searches

Data-driven Background Estimation

- ttbar (ATLAS): "data-MC hybrid"

T. Vickey



- Generic method to estimate the background for many H^+ channels (and not

- CMS:

Data driven method to measure the tt and W+3/4jet backgrounds due to missing E_T mis-measurement

-Exploits the precise muon momentum measurement in W->μν decays

Plan for optimized study

- replacing the muon with τ

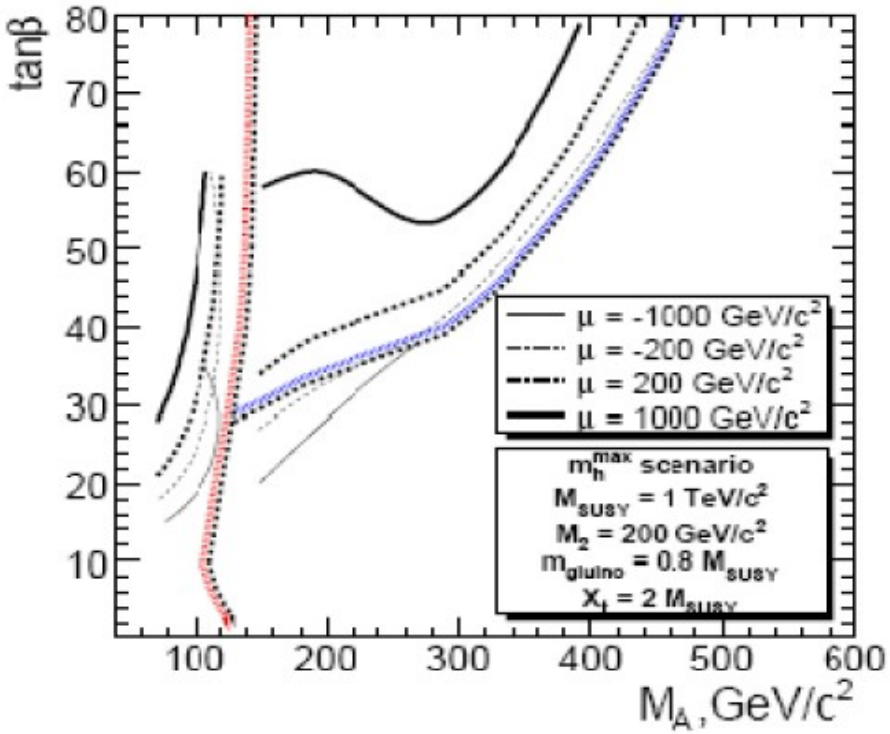
R. Kinnunen

Events in the "signal area" can be obtained with the normalization:

$N^{QCD}(\tau\text{-sel}) = N^{QCD}(\text{QCD-sel}) * \varepsilon(\tau\text{–miss-id})$

Sensitivity Evaluation

- Δ_b: SUSY corrections in H^+ production/decay now taken into account by both ATLAS and CMS (have not been by the time of cHarged08)
- μ: Sensitivity depends heavily on choice of μ.
  - has been evaluated for CMS:

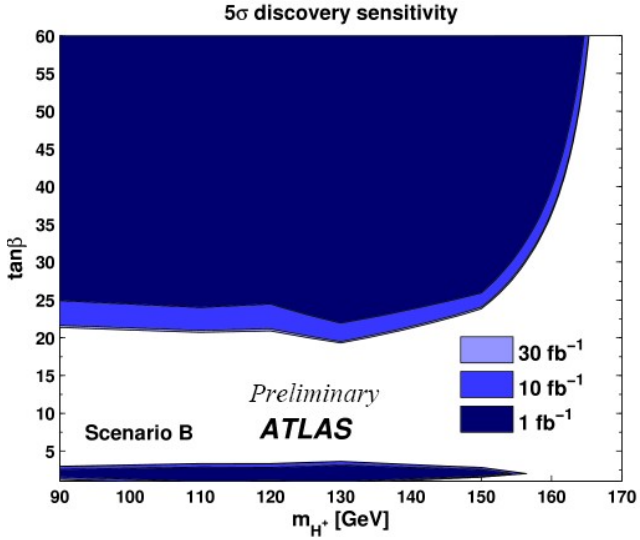


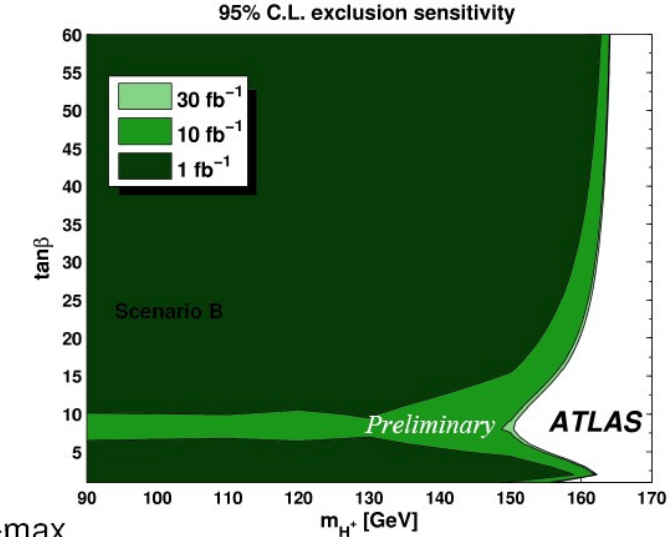
A. Sopzcak, S. Heinemeyer, R. Kinnunen, ...

H^+ Searches

- ttbar → bW bH+ → bqq bτν, τ→hadrons
  - First fullsim study of this channel

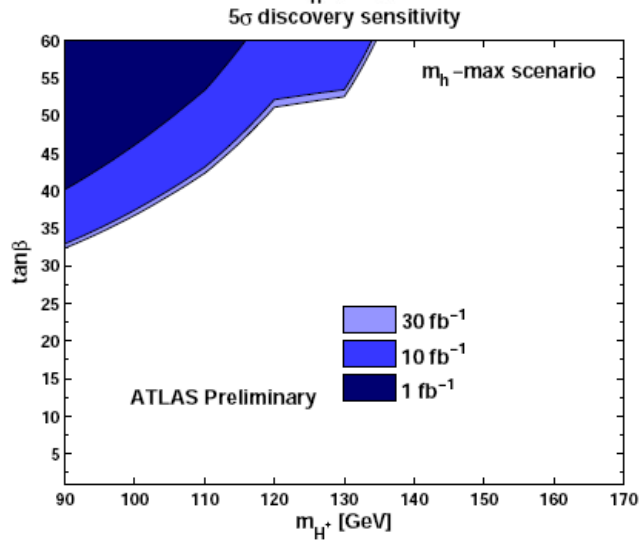
E. Coniavitis

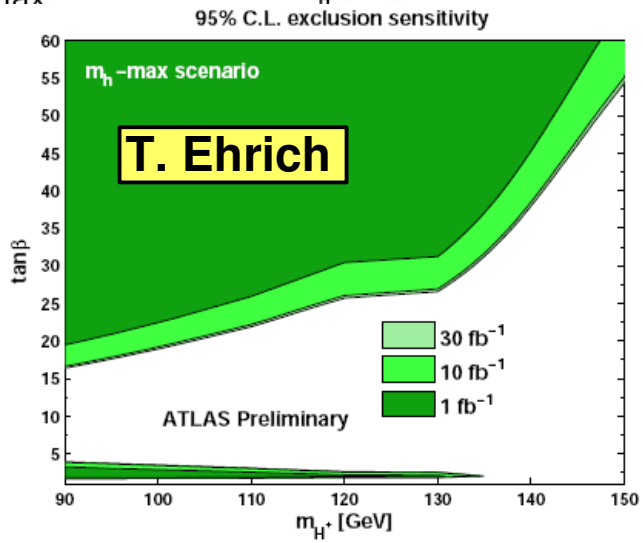




- ttbar → bW bH+ → blν bτν, τ→lep
  - First ATLAS study for 15yrs

T. Ehrich

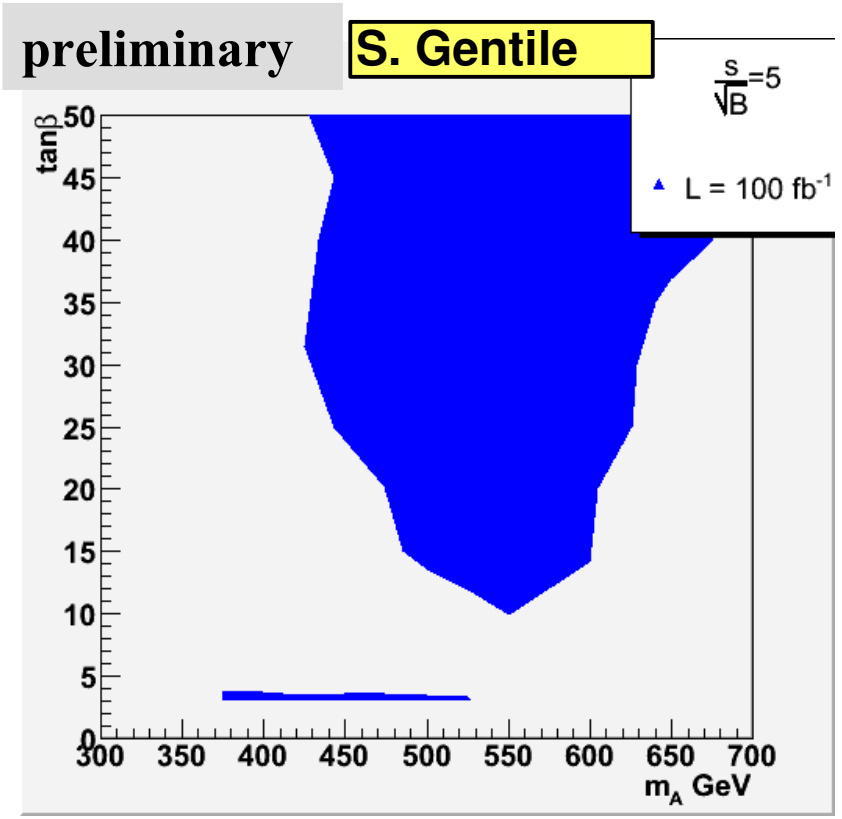




"New" channels for H^+ searches?

- New... or "to be rediscovered"
  - H^+ decays to SUSY cascades

  but also discussed:
  - H^+ produced in SUSY cascades
  - H^+ production with/decay to bosons, e.g. $H^+ \rightarrow WA$



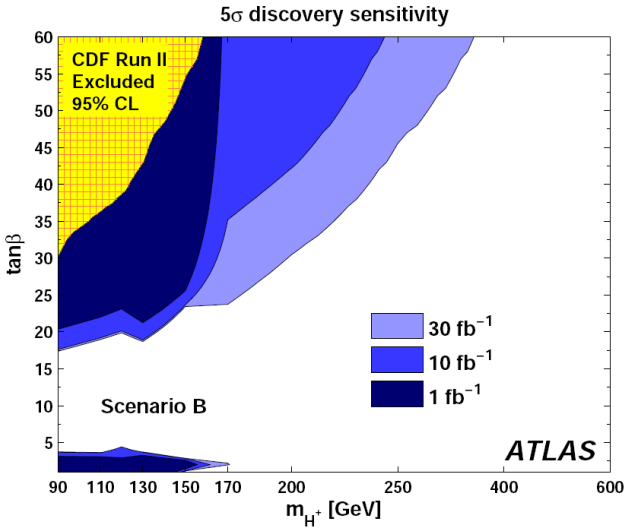
- Can we fill uncovered regions?
- What is the timescale for such searches?
  - e.g.: can it be done before SUSY discovery?

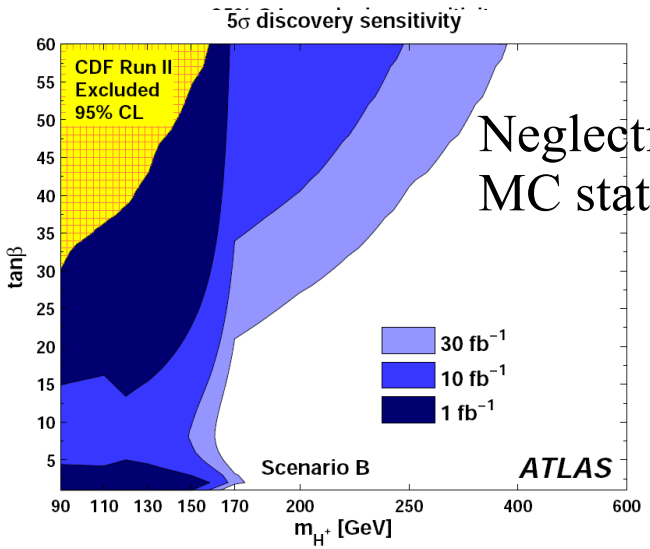
H^+ Searches

- Problems:
  - **Simulation Statistics!**

O. Vitells

> τ controls the statistical error due to MC sample size.
> for large τ this becomes significant, e.g. 1±1 events at L=1fb^{-1}
> becomes 30±30 events at L=30fb^{-1}





Neglecting uncertainty from limited MC statistics

Note: This is an illustration of our ignorance, and perhaps an indication of what is possible – and **not** the ATLAS sensitivity

H^+ Searches

- Problems:
  - **Simulation Statistics!**

O. Vitells

τ controls the statistical error due to MC sample size.
for large τ this becomes significant, e.g. 1±1 events at L=1fb^{-1}
becomes 30±30 events at L=30fb^{-1}

  - Trigger (low efficiencies in absence of leptons)
- Most important requirements:
  - excellent understanding of ttbar (10%-level)
  - *some* understanding of QCD (order of magnitude)
  - High purity in τ-ID, very small tails in E_T^{miss}

Summary (of the summary)

- Tools:

  trigger, τ-tagging, b-tagging:
  - algorithms in good shape and robust
  - efforts now on determining efficiencies from data
    (and optimizing wrt differences MC and data)

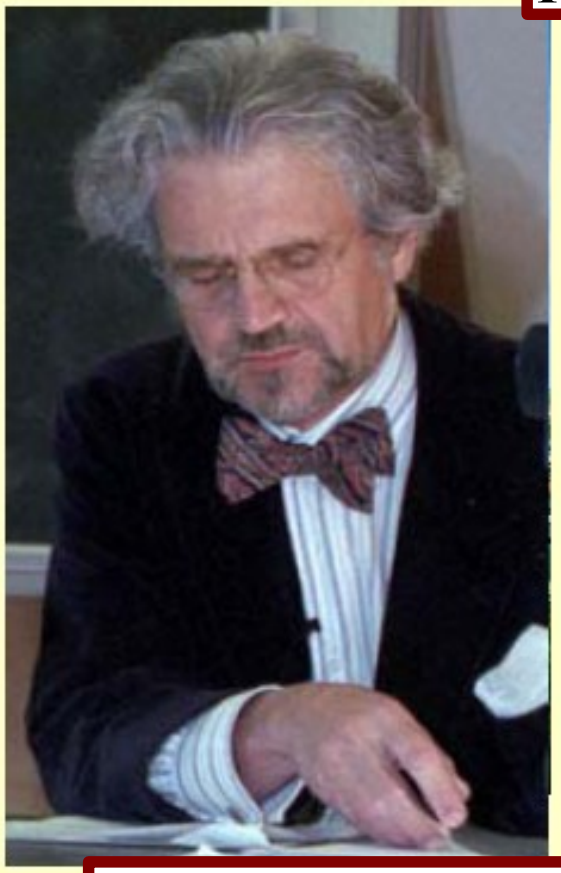
- Searches:
  - Strong interest in *testing new/rediscovering* channels
  - a new level of "realism" has been reached
    (simulation and interpretation),
    ...but it's still simulation. Data is around the corner,
    and experiments are in good shape to react to the
    unavoidable fact that it will not resemble MC

The Last Slide (Really)

K. Jakobs, 2006

Uppsala is a nice place to be, looking forward to forthcoming workshops

I hope everyone agrees to this



Possible Roadmap:

→ 2008: work on tooling (tau, btags, methods to get efficiencies from first data) **indeed**

→ 2010: first results from data …. **still feasible**

→ 2012: I hope that we know whether a Charged Higgs exists or not **So do I.**

regardless of the outcome: we could continue to get lectures on how to drink the Uppsala Schnaps

S. H. did not get as much snaps as he wanted yesterday. He did not share his single malt either, though.

Tord is still the same

A big Thanks to the Organizers (Tord, Johan, ….)

And many thanks to Karl for his work on preparing the session