Accelerator-based high-energy physics at Uppsala University

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Contents

Physics at hadron colliders: D0 and ATLAS

D0 at Fermilab's TeVatron ($p\bar{p}$ collisions at 1.96 TeV):

- Physics analysis: C. Bélanger-Champagne.

ATLAS at CERN's LHC (pp collisions at 14 TeV):

- Physics simulations: E. Coniavitis, M. Flechl.
- Commissioning of the ATLAS Semi-Conductor Tracker (SCT): R. Brenner, N. Bingefors.
- SweGrid and NorduGrid for LHC data-analysis: M. Ellert, M. Nordén.

Group leader: T. Ekelöf.
Guests: B. Mohn (Bergen), A. Sopzack (Lancaster).
Close collaboration with the theory group: G. Ingelman, N. Mahmoudi, J. Rathsman, O. Stål.

Our main interest is the search for charged Higgs bosons, which appear in Two Higgs Doublet Models (five physical Higgs states).

Data-analysis at D0

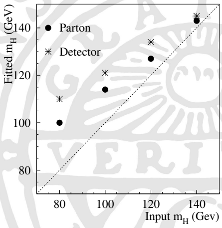
Matrix Element (ME) method:

- Knowing the matrix element of relevant processes, compute the likelihood for an event to be signal or background,
- Powerful statistical method developed to improve the top mass measurement at the end of TeVatron Run I.

Using a modified version of ME for $t\bar{t} \rightarrow$ lepton+jets, can we discover or improve mass limits for $H^{\pm}$ below m_t?

A study was performed on Monte-Carlo $H^{\pm}$ signal and $t\bar{t}$ background samples.

Problems with the discrimination power between $H^{\pm}$ and $t\bar{t}$, as well as a shift in the reconstructed $H^{\pm}$ mass.



Charged Higgs bosons in ATLAS: $m_{H^\pm} < m_t$

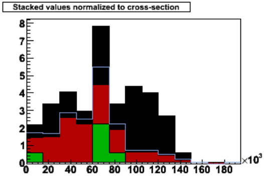
$pp \to t\bar{t} \to (H^\pm b)(W^\mp b)$ with $\begin{cases} H^\pm \to \tau\nu \\ W^\pm \to jj \end{cases}$

Signature: τ-jet, missing E_T, 2 b-jets, at least 2 other jets, no isolated lepton $\Longrightarrow$ first set of cuts.

Hadronic W and top reconstruction + QCD reduction $\Longrightarrow$ second set of cuts.

$t\bar{t}$ background reduction:

- choose 7 variables and extract probability density functions (pdf) from MC for signal and background,
- form a likelihood discriminant using logarithms of S/B pdf ratios, then use one single appropriate cut.



Preliminary results (10 fb^{-1}):
$B \simeq 1800$ events,
$S \simeq 300 - 2000$ events,
depending on m_A and $\tan\beta$.

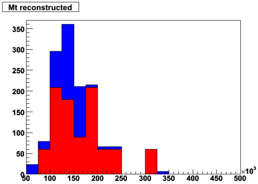
Charged Higgs bosons in ATLAS: $m_{H^\pm} > m_t$

$gg \to tbH^\pm$ and $gb \to tH^\pm$ with $\begin{cases} H^\pm \to \tau\nu \\ t \to jjb \end{cases}$

Signature: 1 hard τ-jet, large missing E_T, 1-2 b-jets, at least 3 other jets, no isolated lepton $\Longrightarrow$ first set of cuts.

Hadronic W and top reconstruction + QCD reduction $\Longrightarrow$ second set of cuts.

$t\bar{t}$ background reduction with likelihood analysis.



Use $H^\pm$ transverse mass for background and significance estimations,
$S \simeq 10 - 100$ events per year, depending on m_A and $\tan\beta$.

Uppsala University is responsible for the editing of the ATLAS CSC note on charged Higgs bosons.

SCT commissioning status on 070912 (1)

The SCT detector is installed in the cryostat:

- Barrel installed in 06 and fully commissioned: 99.97% efficiency!
- Endcap-A installed in May 07, commissioning now: cable, connectivity and off-detector electronics tests are OK, but no analog tests so far (no cooling).
- Endcap-C installed in June 07, commissioning now: all cables and 80% of connectivity tests.

SCT commissioning status on 070912 (2)

Detector and Control System (DCS):

- Barrel DCS reliable, no DCS connected to endcaps,
- Final interlock hardware to be delivered by Uppsala,
- Integrated in wide ATLAS commissioning runs.

Houston, we have a problem:

February and May: failures of the heater that removes the remaining cooling power from the liquid before exiting the inner detector! These failures come from the union where the heater wire joins the wire from the power supply.

Actions:

- Heaters removed from the cryostat bore, far-heater solution (space available after the TRT C-wheels).
- Heaters being refurbished with a new union design, tests in the end of October.
- New control electronics and safety systems for the heater making the system more robust.

ATLAS upgrade for the Super-LHC

Upgrade of the ATLAS detector planned in 2015:

- The IP quadrupoles will need to be replaced due to radiation damages,
- Increase the LHC luminosity with almost an order of magnitude.

Upgrade of the inner detector with a larger silicon tracker:

- Uppsala plans to participate in the R&D for this upgrade, hope to involve other groups in Sweden.
- Focus on 3D detectors and integration techniques that can make the fabrication of a large area detector much cheaper than before.
- Use R&D at Swedish clean room facilities that can later be offered by industry in Sweden for ATLAS.

Grid in Uppsala

Uppsala is involved in the development of the Grid, a new powerful computing infrastructure, necessary to meet the LHC data challenge.

- Several projects: SweGrid (Sweden), NorduGrid, NGin and NDGF (Scandinavia), KnowARC (EU project within FP6),
- Development and maintenance of ARC middleware (program coupling several clusters on the Grid),
- Nordic Data Grid Facility (NDGF): coordination of the Grid resources for the LHC experiments in the nordic countries.

Accelerator physics at CLIC

Participation in CTF3 commissioning and development:

- Beam instrumentation and CTF3 commissioning: A. Ferrari (researcher), G. Gourie (master thesis).
- Two-Beam Test-Stand (TBTS): M. Johnson (PhD), R. Ruber, V. Ziemann (researchers).

Beam dynamics simulations:

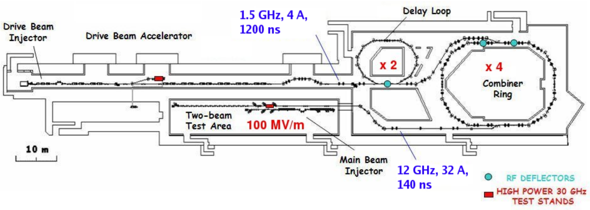
- Emittance preservation at CLIC: P. Eliasson (PhD).
- CLIC post-collision line: A. Ferrari (researcher).

Group leader: T. Ekelöf.

UU initiated the creation of a Center for Accelerator and Instrumentation (CAI). Director: V. Ziemann.

The CLIC Test Facility CTF3

CLIC = future e^+e^- linear collider at 3 TeV, based on the two-beam acceleration technique.
NEW! Gradient = 100 MV/m, RF frequency = 12 GHz.



CTF3 shall test the key concepts of the CLIC technology by 2010 (drive beam frequency multiplication, two-beam acceleration, etc). Uppsala University participates in:

- CTF3 commissioning (Delay Loop & Combiner Ring),
- Monitoring of the bunch frequency multiplication,
- Construction of the Two-Beam Test-Stand.

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Accelerator and high-energy physics at UU

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Hadron colliders

Linear colliders

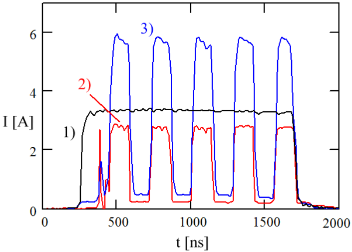
CLIC Test Facility CTF3

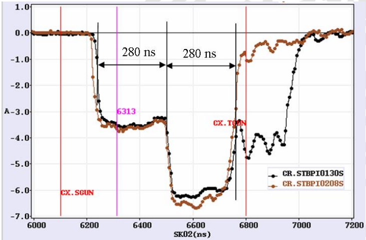
Two-Beam Test-Stand

Beam dynamics at CLIC

CTF3 commissioning in 2006-2007

- The first stage of the bunch frequency multiplication with the Delay Loop was demonstrated in 2006.
- The transfer line TL1 showed a 100% transmission, more detailed beam optics studies are on-going.
- The Combiner Ring is being commissioned, so far a bunch train combination with a factor 2 was achieved.





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Accelerator and high-energy physics at UU

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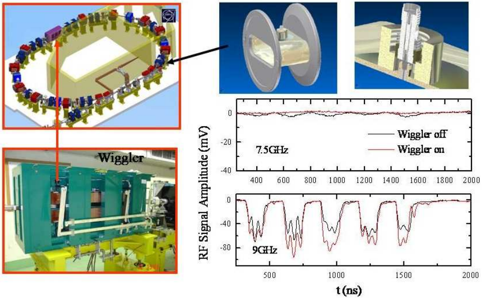
Beam instrumentation: phase monitor (PHM)

Uppsala University has developed a new RF pick-up to monitor the bunch frequency multiplication in CTF3:

- Successful demonstration of the proof-of-principle in the CTF3 Preliminary Phase (2001-2002).
- Monitoring of the bunch frequency multiplication with the Delay Loop in 2006.

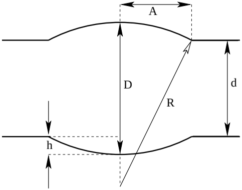


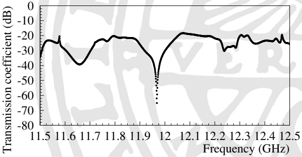
NEXT: upgrade of the PHM monitor for installation in the Combiner Ring [GG grant of 140 kSEK].

Beam instrumentation: NCR monitor

Uppsala University is now designing a Nearly Confocal Resonator (NCR) pick-up.

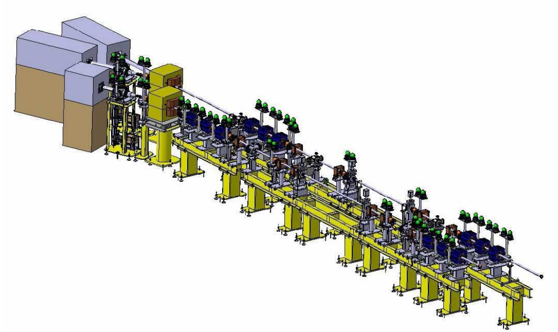
- Rejection of external modes propagating in a pipe: demonstrated and published in 2007.
- Simulation studies of the coupling to a passing e^- beam are on-going (G. Gourie's master thesis).





CTF3 Two-Beam Test-Stand: hardware

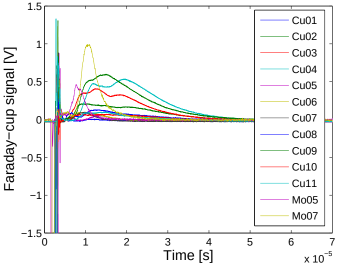
The CTF3 Two-Beam Test-Stand will test the extraction and transfer of RF power from the drive beam, and the acceleration of the main beam.



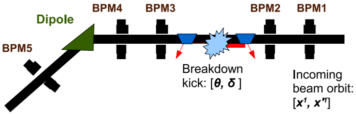
UU designs, constructs and commissions the CTF3 Two-Beam Test-Stand with all components such as magnets, vacuum, diagnostics, support structures. KAW + VR $\rightarrow$ 16.3 MSEK 2006-2010.

CTF3 Two-Beam Test-Stand: physics

The RF breakdown limits the achievable gradient and the reliability of power extraction and acceleration structures.



RF breakdown → fast burst of e^- + slower burst of ions: Coulomb explosion?
Measure the ion current for better understanding of RF breakdown.



RF breakdown → kick of the main beam, with luminosity reduction at CLIC.
Study the impact of the RF breakdown on the beam.

Plans to investigate the surface physics aspects of RF breakdown with electron-microscopy.

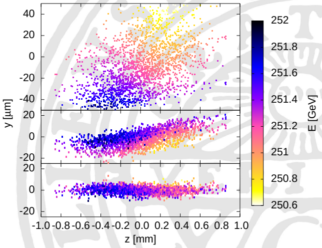
Beam dynamics: emittance preservation

Small element misalignments (μm) in a linac significantly increase the emittance and reduce the luminosity.

- One-to-one steering: use correctors to center the beam in position monitors: E-y correlations are left (dispersion caused by quadrupole misalignements).
- Dispersion free steering: use correctors to reduce the dispersion: y-z correlations are left (wakefields caused by cavity misalignments).

Emittance tuning bumps:

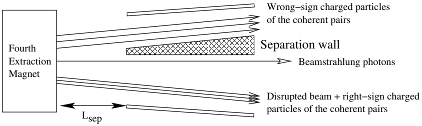
- adjust the cavity positions to minimize the emittance,
- identify optimal displacement patterns,
- study the effect of dynamic imperfections on tuning.

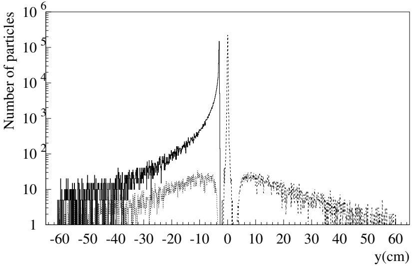


Beam dynamics: CLIC post-collision line

CLIC e^+e^- collisions produce a disrupted beam with long low-energy tails, beamstrahlung photons and e^+e^- pairs.

They must be transported to a dump with minimal losses.





Our design of the CLIC post-collision line has:

- a vertical chicane to separate the 3 outgoing beams,
- transport lines for the wrong-charge particles and the beamstrahlung photons + main disrupted beam.

Conclusions

The collider group in Uppsala is involved in both particle and accelerator physics.

While our D0 activities are being scaled down, we now plan to increase efforts and manpower in order to meet up-coming LHC and ATLAS data-analysis challenges:

- meetings in Uppsala on data-analysis strategies,
- R&D on 3D silicon detectors for the LHC upgrade,
- computation power increase via Swegrid/Nordugrid.

Part of our accelerator physics activities is financed through FP6 (EUROTeV) running until end of 2008.

Our major focus is the Two-Beam Test-Stand and its utilization in order to improve the understanding of the RF breakdown and eventually contribute to improved operation of CLIC (FP7 application).