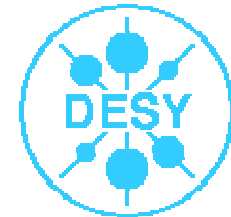


ZEUS potential for Heavy Quarks at HERA II



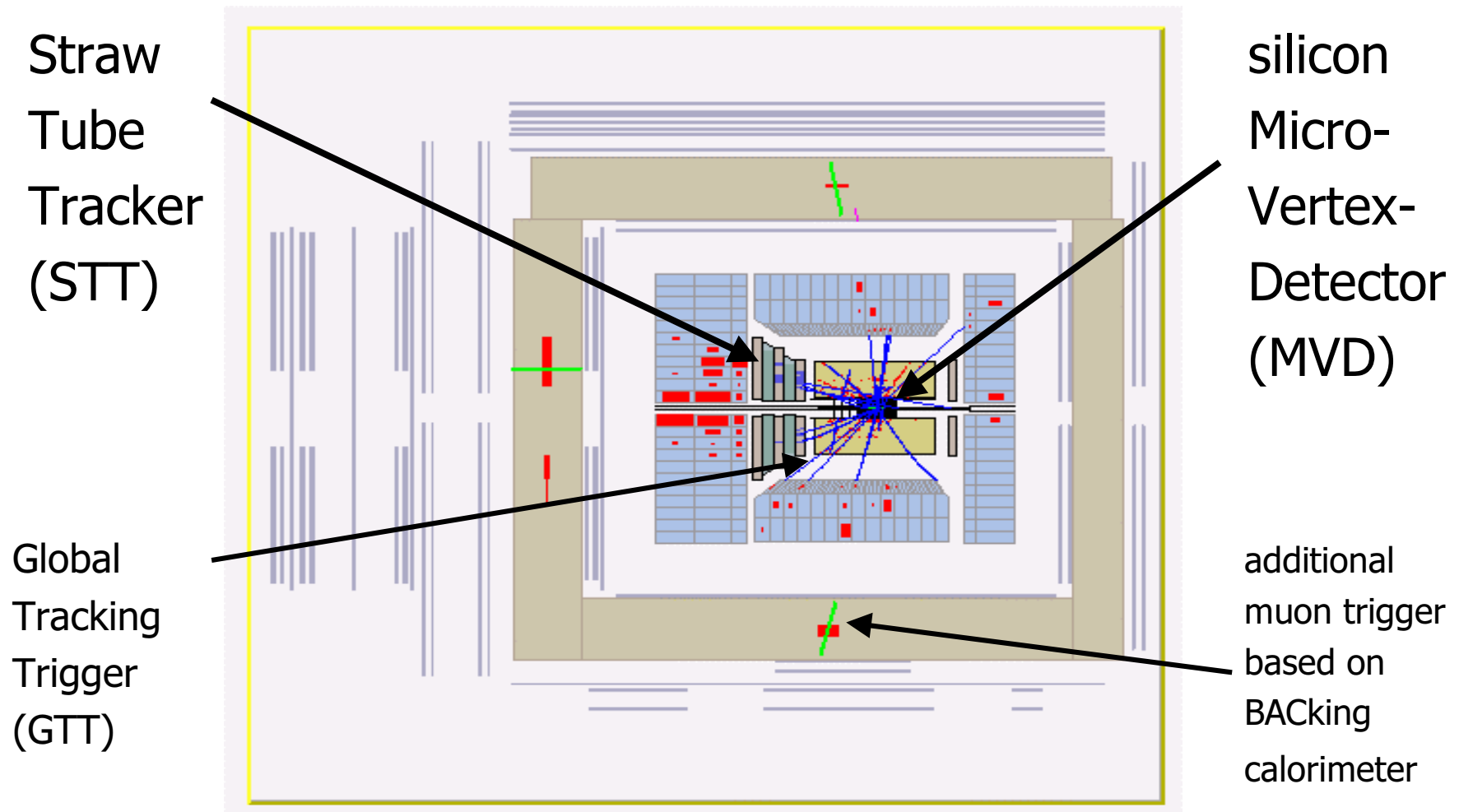
Achim Geiser, DESY Hamburg
for the ZEUS collaboration



Heavy Quark Physics at the Upgraded HERA Collider,
Rehovot, Isreal, 22. Oct. 03

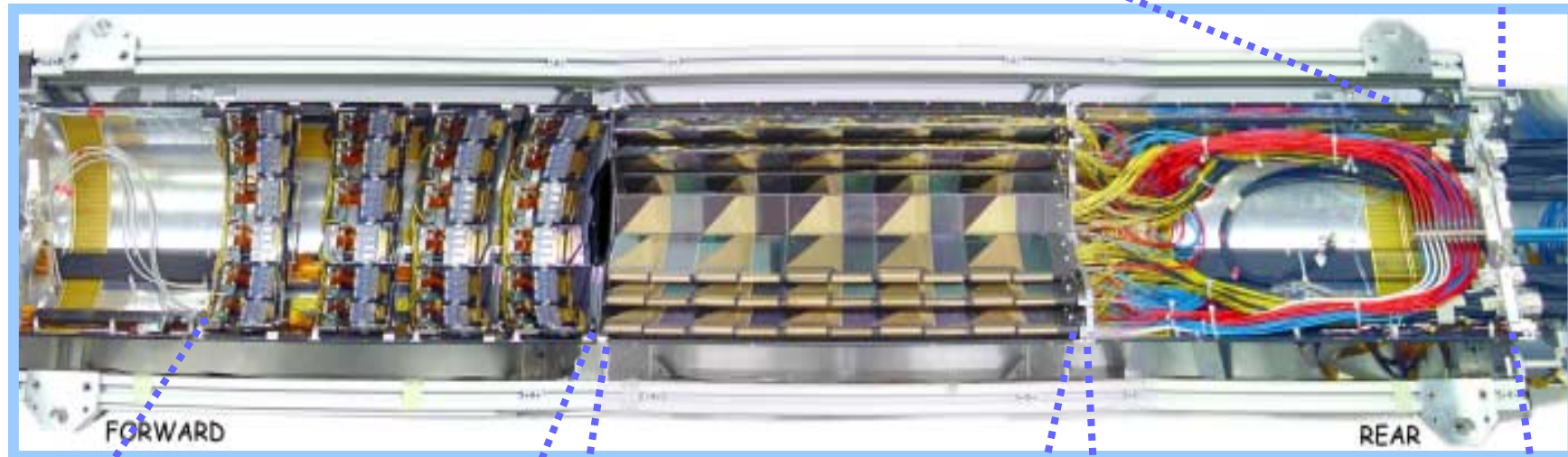
- Detector upgrades and status
- Implications for Heavy Flavour Physics
- Conclusions

New ZEUS detector components



Overview of the ZEUS MVD

All cables in a Faraday cage



The forward section:

- 4 wheels
- each one composed by 2 layers of 14 Si detectors
- Total of 112 hybrids, >50k channels

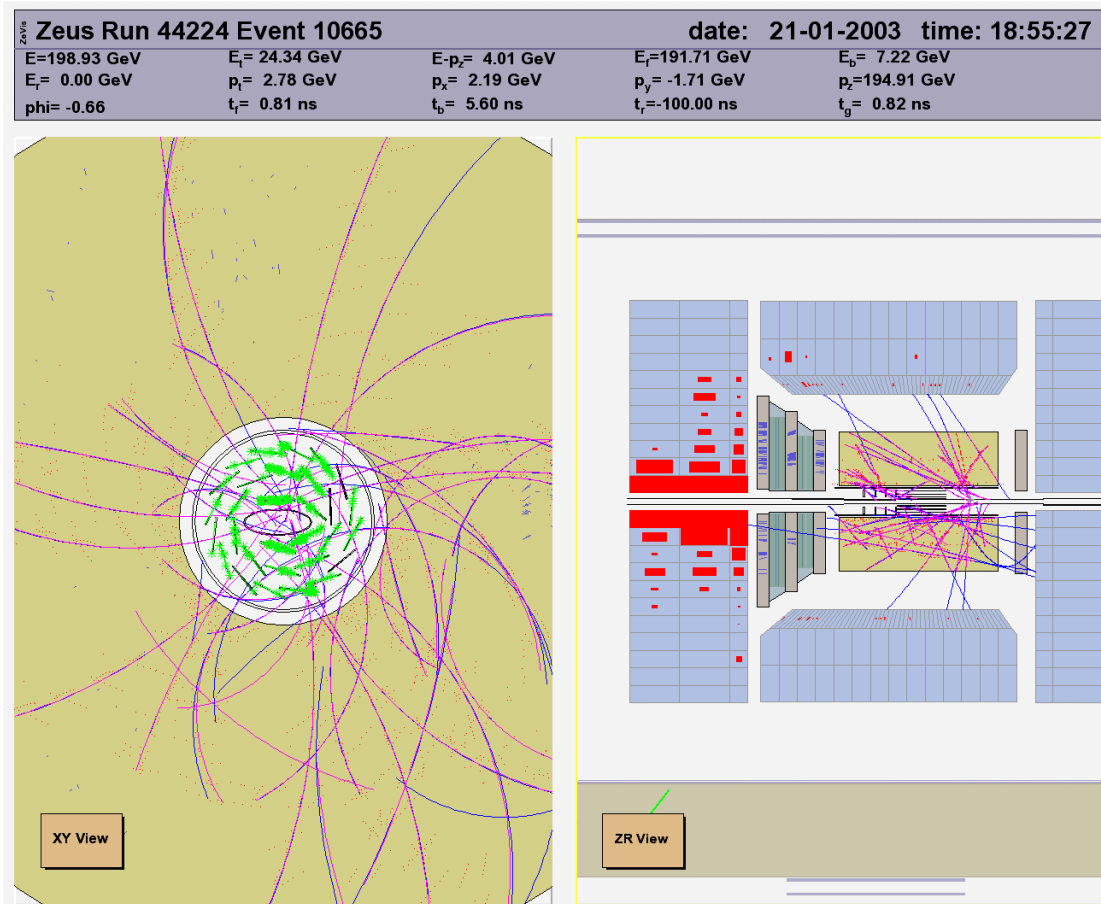
The barrel section:

- 30 ladders
- each one composed of 5 modules of 4 Si detectors
- Total of 300 hybrids, >150k channels

The rear section:

- Cooling pipes and manifolds
- Distribution of FE, slow control and alignment cables

MVD commissioning 2002/3



Winter 2002/2003:

- MVD fully operational, but
- Large backgrounds
- Small luminosity
- Significant radiation dose (but no serious damage)

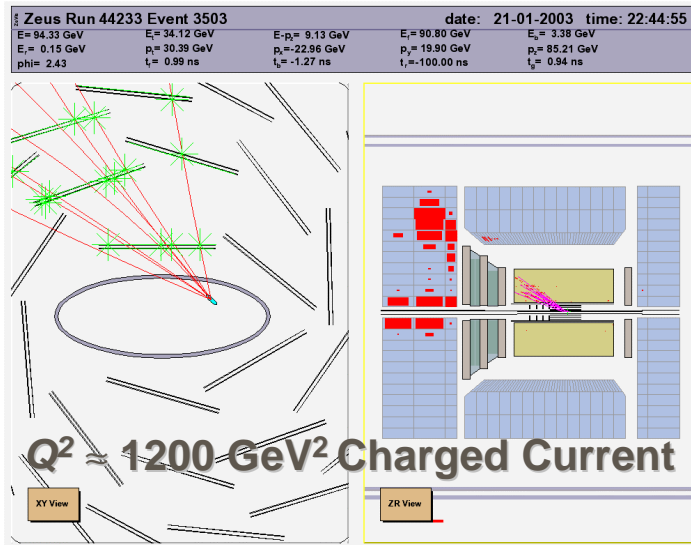
Spring/Summer 2003:

- 18 week shutdown to remedy backgrounds

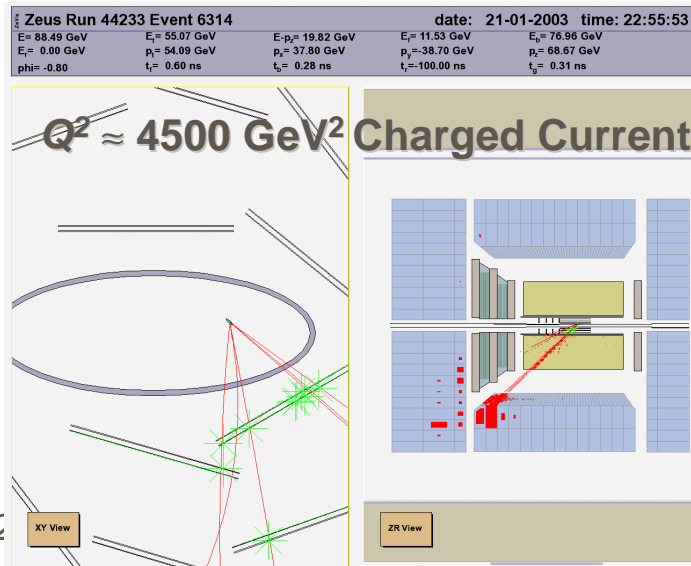
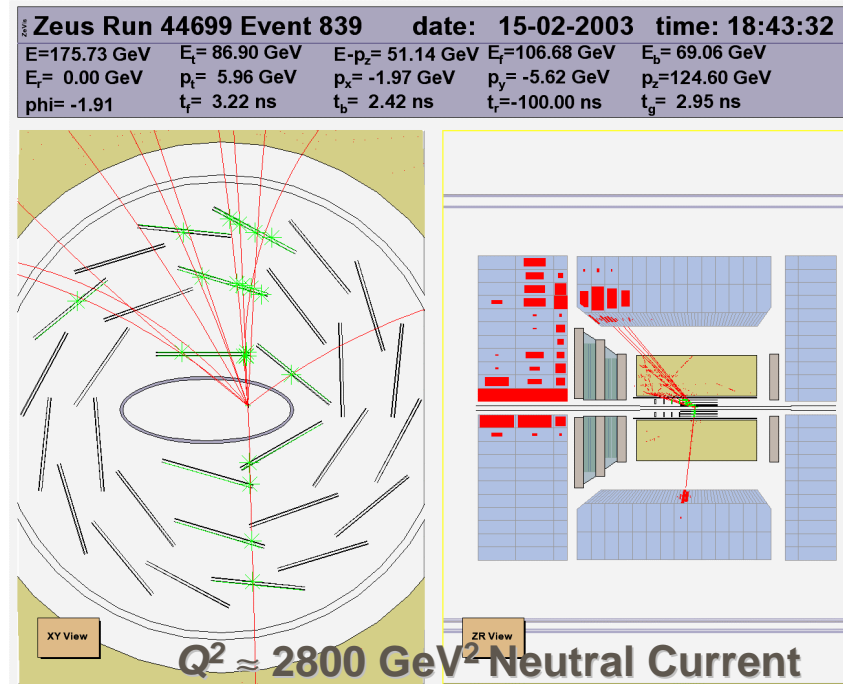
Currently:

- Machine startup
- Vacuum conditioning successful
- First luminosity seen
- Background situation looks promising!

... but also very clean ep collisions:



useful 2002/3 data sets: $< \sim 1 \text{ pb}^{-1}$

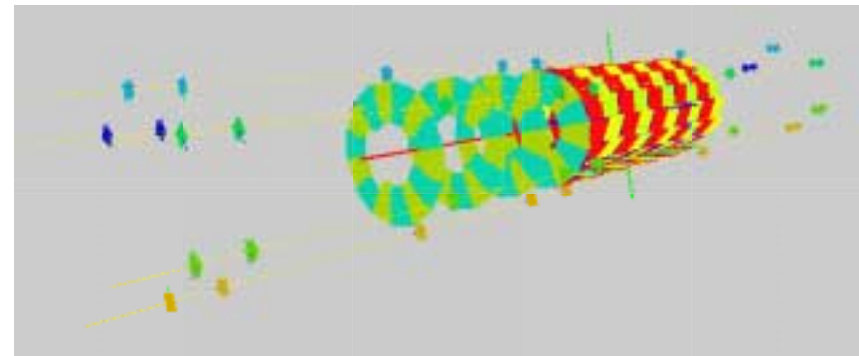
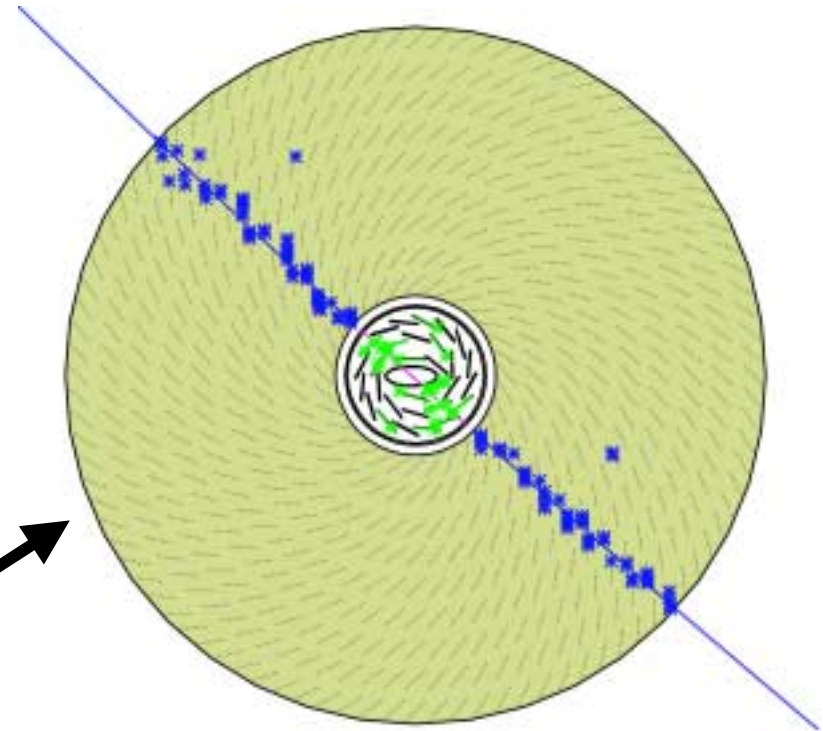


**HERA goal: $\sim 15 \text{ pb}^{-1}$ till december
 $\sim 700 \text{ pb}^{-1}$ till 2007**

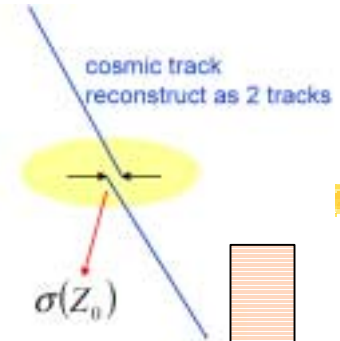
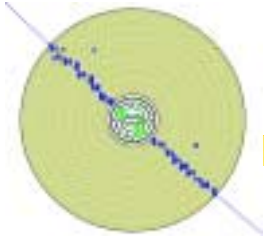
MVD Alignment



- 3 Step process:
 - ⇒ Survey of ladder positions before installation in the lab,
 - ⇒ Further alignment using cosmic data,
 - ⇒ Monitoring of stability using an in situ laser system with semi-transparent position sensors.



Alignment Status



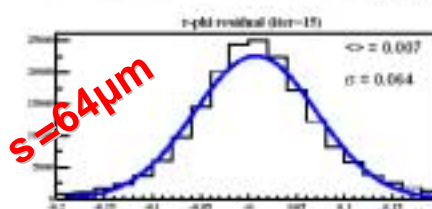
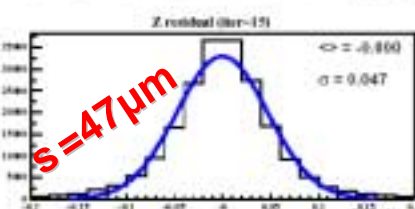
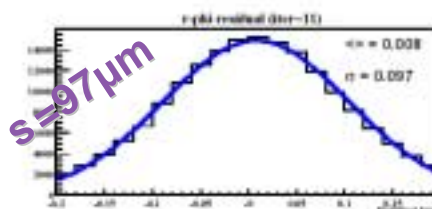
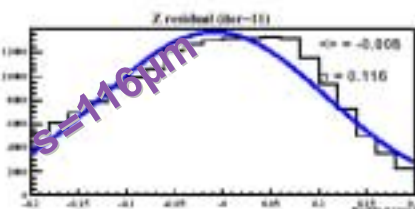
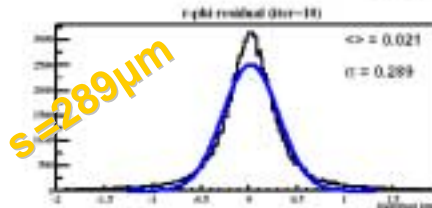
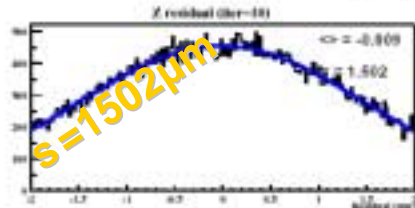
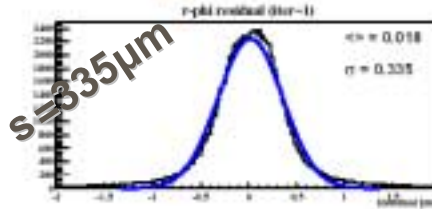
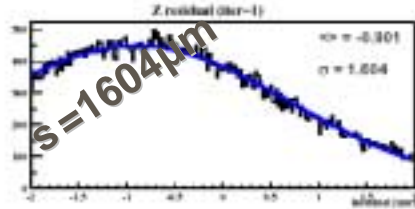
Track Residuals

r-z sensor

r-phi sensor

Global alignment

Internal alignment



Impact Parameter

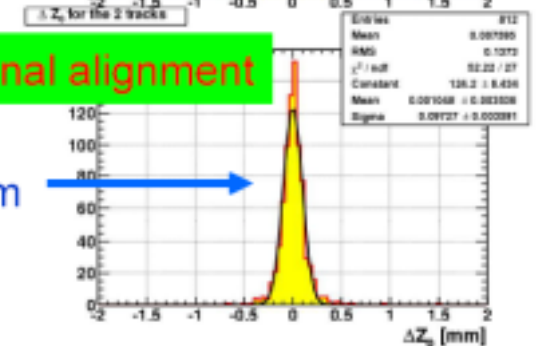
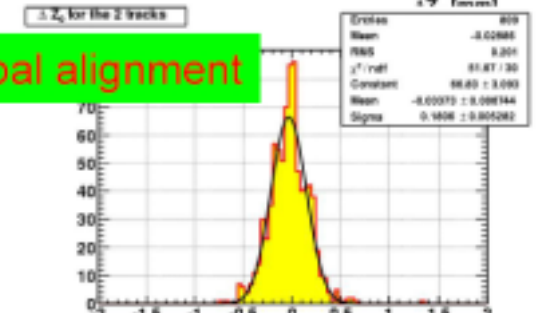
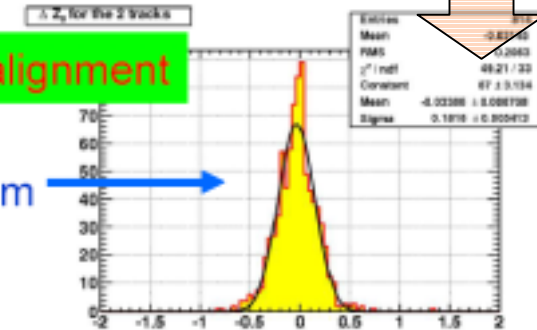
No alignment

$\sigma = 180 \mu\text{m}$

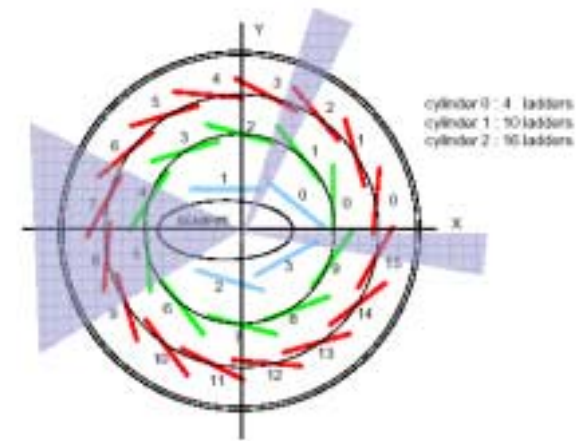
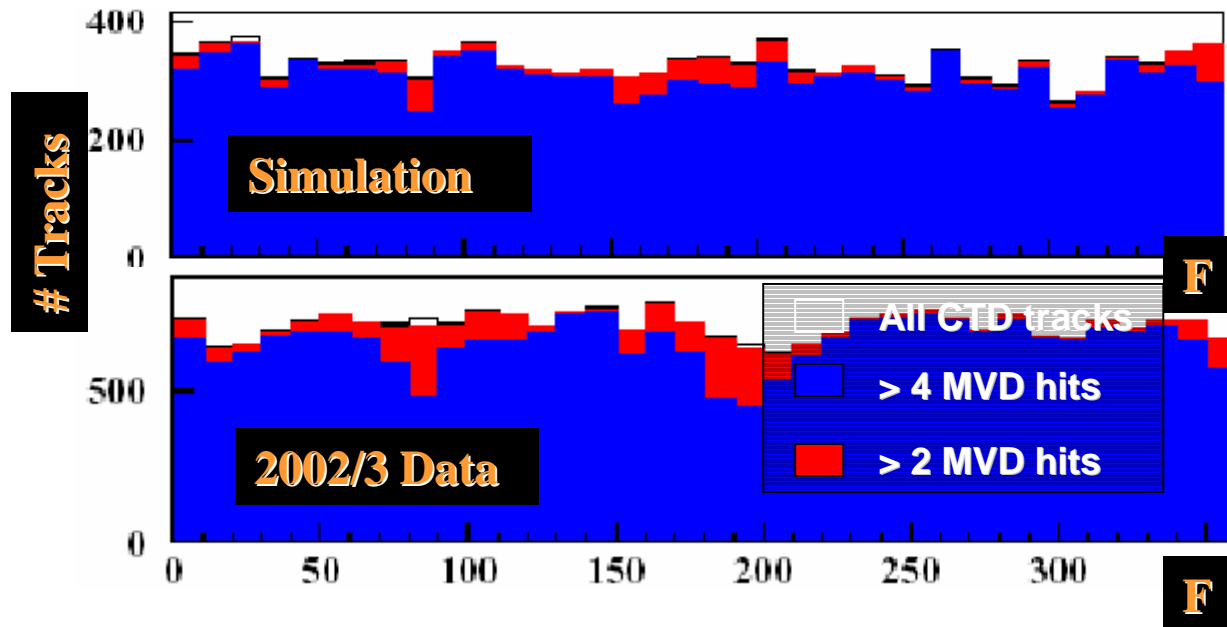
MVD global alignment

MVD internal alignment

$\sigma = 100 \mu\text{m}$



MVD Tracking Efficiencies

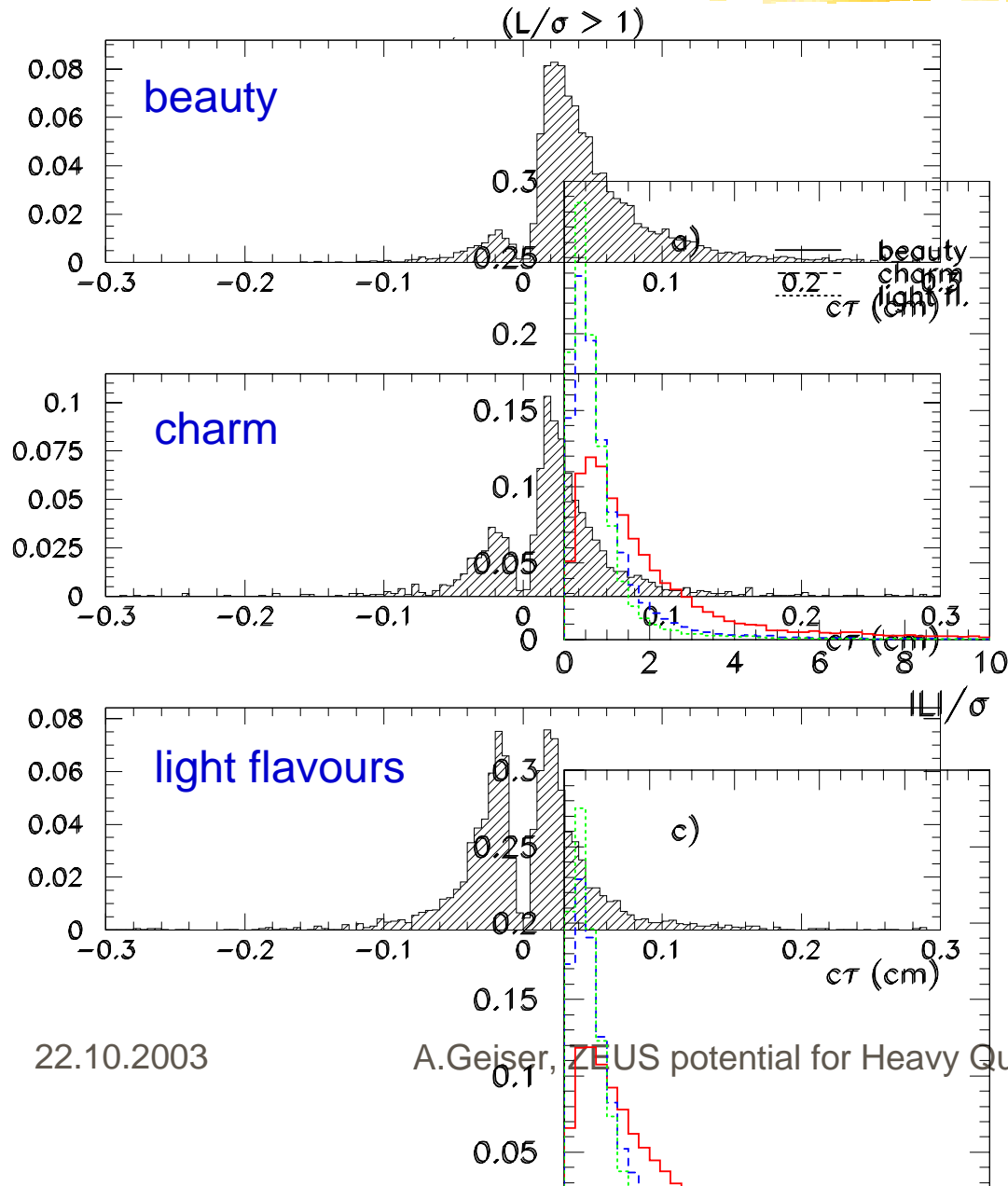


Note: Acceptance holes

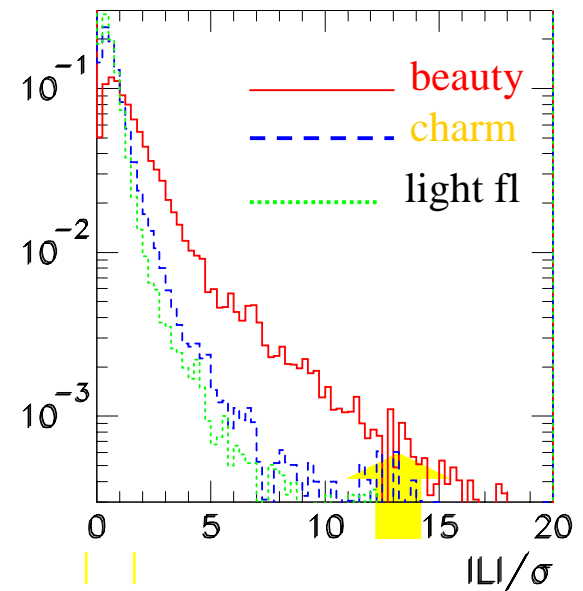
Efficiency estimates from NC DIS: (Tracks in CTD and MVD fiducial)

	> 4 MVD hits	> 2 MVD hits
Data	91.4%	99.3%
MC	93.8%	99.3%

b and c secondary vertex studies



Decay length significance (L/s) distributions from MC



2002/3 data: consistent results, but statistics too low for useful conclusion

Straw Tube Tracker

Goal: extend tracking acceptance into forward region



installed in April 2001

some initial hardware problems
(e.g. cross-talk, blown fuses) repaired during 2003
shutdown

=> **now fully operational**

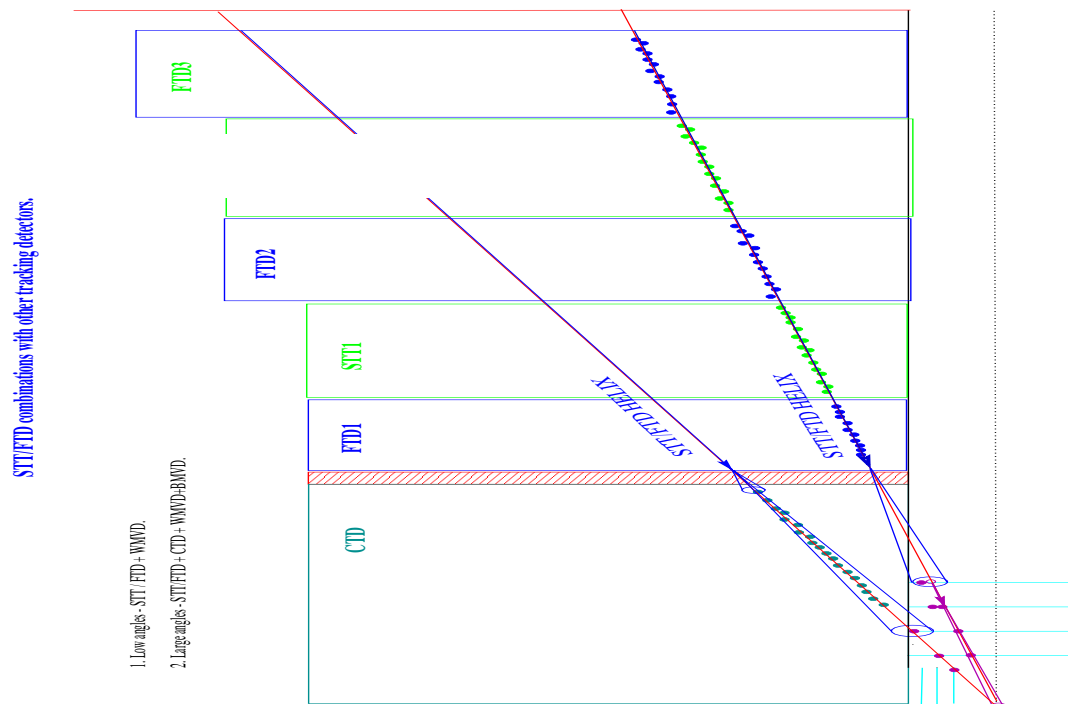
Global tracking

Integration of all tracking systems

Low angles: STT/FTD + WMVD

Larger angles: STT/FTD + WMVD + BMVD + CTD

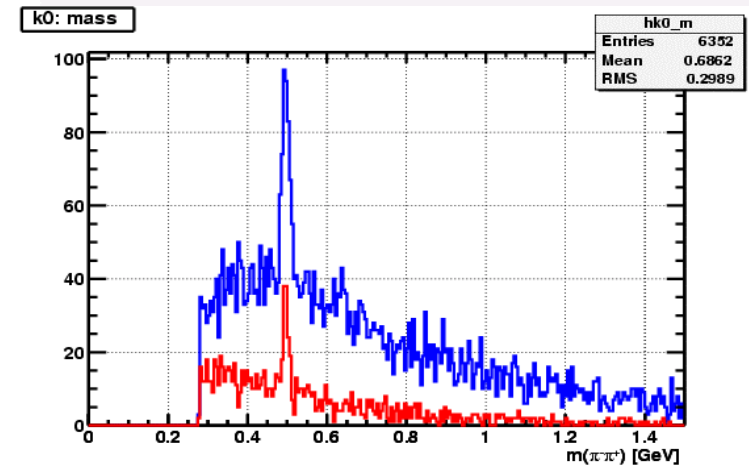
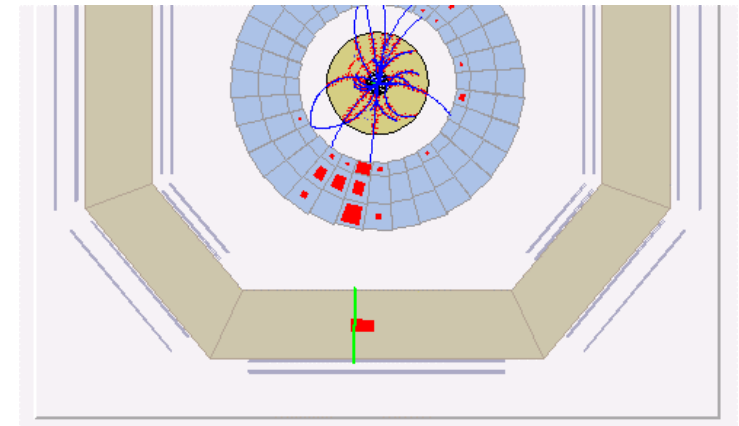
example of helix fits to different components using MC data:



**work
in progress ...**

Other improvements

- Global Tracking Trigger, GTT (CTD+MVD+STT) -> improvement of 2nd level trigger tracking
- backing-calorimeter based muon trigger + offline improvements
 - => expect up to \sim factor 2 improvement of reconstruction efficiency for semileptonic leptons (μ , e)
- generally improved tracking & vertexing from MVD & STT
 - > e.g. improved K^0 efficiency



Hardware Upgrade Summary

- ZEUS MVD has completed the commissioning phase, i. e. design goals have been reached:
 - Reliable and well monitored detector operation (data quality, radiation, alignment),
 - High tracking efficiency (>99%),
 - Precision is approaching the goal (Impact parameter resolution $\approx 100 \mu\text{m}$).
 - STT now fully operational (after repair during shutdown)
Commissioning ongoing
 - other improvements (GTT, BAC trigger, ...) well under way
 - Ready for new data with secondary vertexing capability, improved forward tracking efficiency, improved efficiency for semileptonic leptons
- => great opportunities for heavy flavour physics!

Main HFL Upgrade Physics Goals

■ Tests of perturbative QCD

- Heavy quark mass sets additional perturbative QCD scale
- Measure single + double differential cross sections with single or double heavy flavour tag + compare with predictions

■ Gluon and charm structure of photon and proton

- study charm and beauty content of high ET dijet events with single or double heavy flavour tag

■ High mass vector meson production)

- study e.g. color octet contribution)

■ Strange quark sea of proton) see introductory

- study charm production in CC events) talk

■ Charm structure of pion) Brian Foster

- study charm production in FNC events)

■ Diffractive heavy flavour production)

- study charm production in diffractive events)

■ Exotics)

Single Beauty tag: Test of QCD

Example: beauty in photoproduction

Current analysis

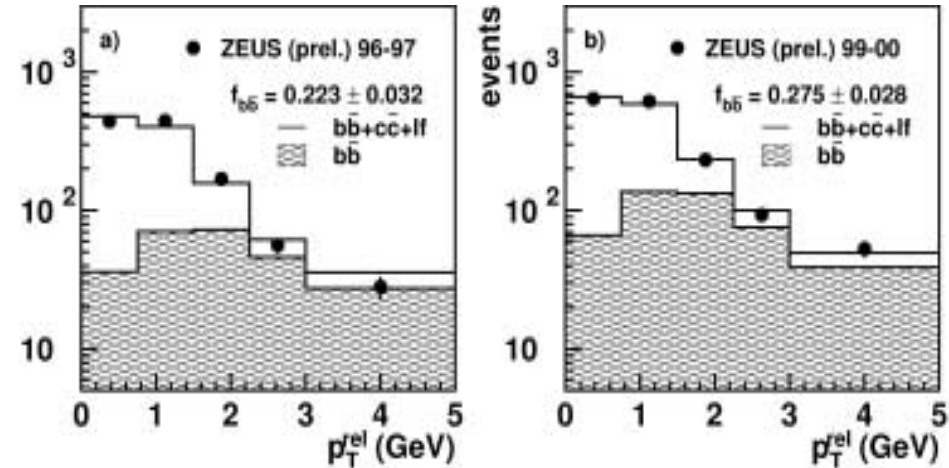
2 jets $ET > 6,7$ GeV

muon $pt > 2.5$ GeV or $p > 2/4$ GeV

~3000 events, 25% beauty

$p_{Trel} > 2.25$ GeV:

~240 events, 80% beauty



Upgrade analysis (very preliminary)

prospects from exploratory MC study: relax muon and jet cuts

=> increase beauty signal sample by ~ factor 10

increase bg by ~ factor 100

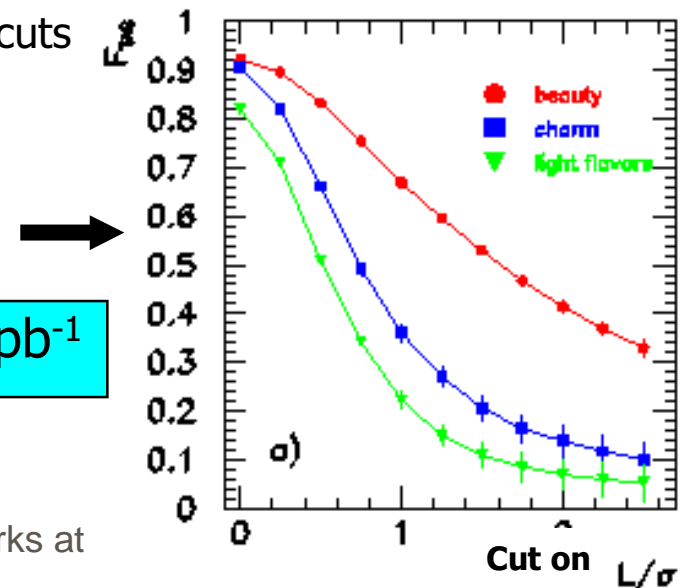
reduce bg to previous level using MVD

=> lose ~ factor 2 efficiency

net gain: ~ factor 5 => in business with ~20 pb⁻¹

similar arguments for DIS, b -> e, b -> hadrons

efficiency for MVD L/σ cut



Double Heavy Flavour tag: Test of $Q\bar{Q}$ correlations

Examples: $D^* + \mu$, $\mu + \mu$

Current $D^* + \mu$ analysis

$pt(\mu) > 1.4$ GeV, $pt(D^*) > 1.5$ GeV

~ 34 events $D^* + \mu$ from same b

~ 15 events $D^* + \mu$ from different b's

~ 60 events $D^* + \mu$ from different c's

muon efficiency + luminosity will increase,
but will stay statistics limited

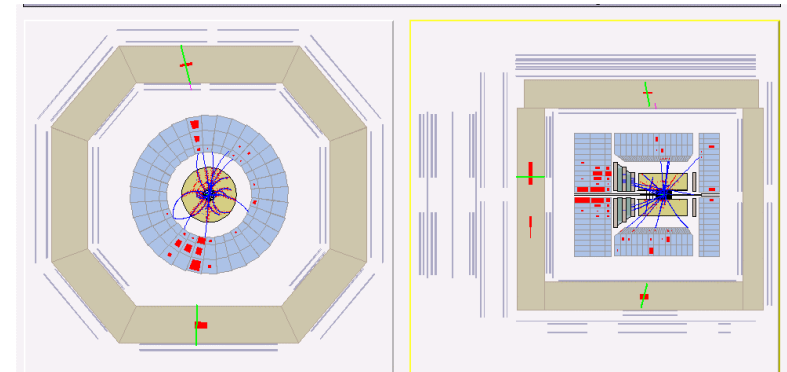
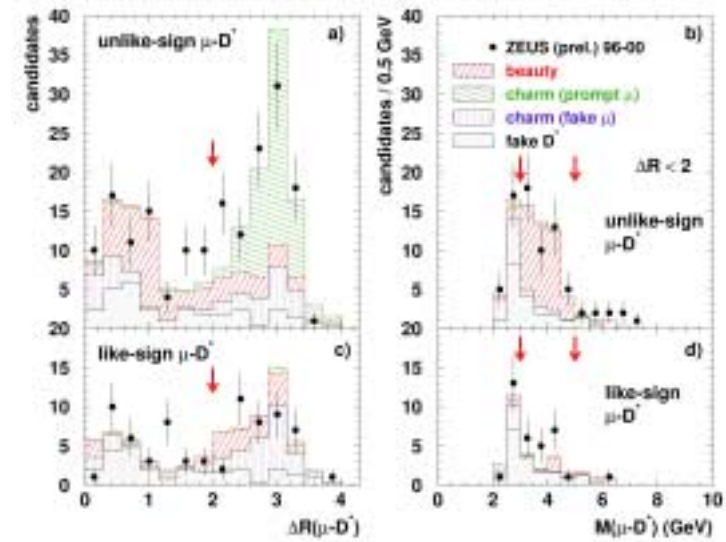
Upgrade dimuon analysis

prospects from exploratory study:

2 low pt muons (no explicit jet requirement)

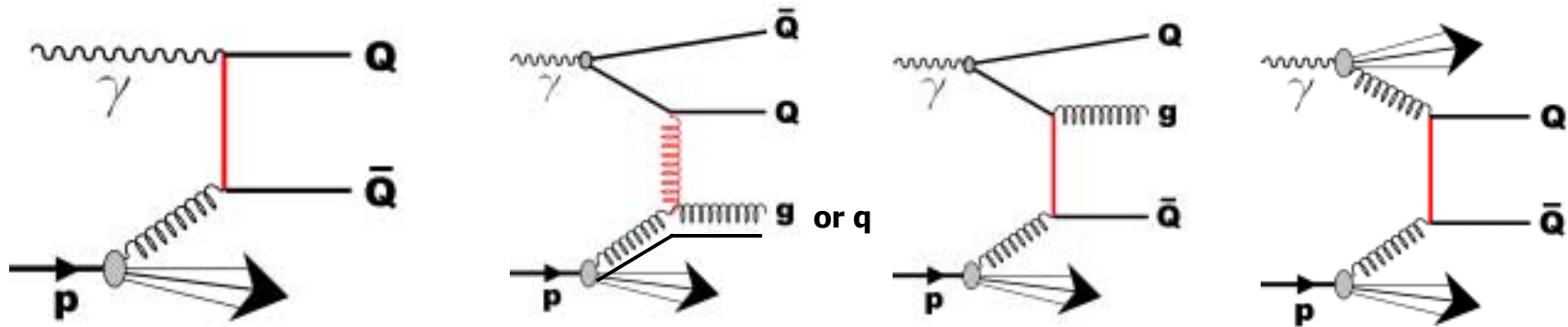
=> $O(10^3)$ beauty signal events / 100 pb^{-1} , + charm
separate b, c and light flavours through charge +
momentum correlations, pt_{rel} , MVD

=> high statistics high purity samples, measure double differential distributions



Why measure $Q\bar{Q}$ correlations?

- some NLO diagrams (massive scheme), $Q=b,c$



- 3rd jet not always detected (forward or low E_T)
- single tag measurement does not distinguish Q and g/q for 2nd jet
- double tag measurement does. combine!

=> test and understand NLO QCD
 use result to directly measure NLO gluon distribution in proton

Single Charm tag

- **Main channel so far: $D^* \rightarrow K \pi \pi$**

- ~30000 events (1995-00) for fragmentation studies and spectroscopy

- ~20000 events for cross section calculations

- smaller samples from other D meson decays

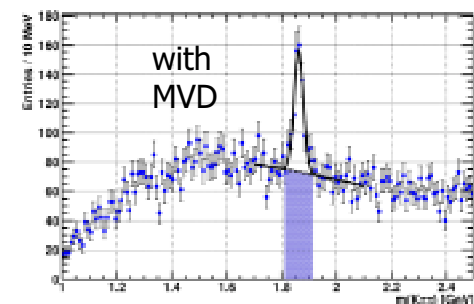
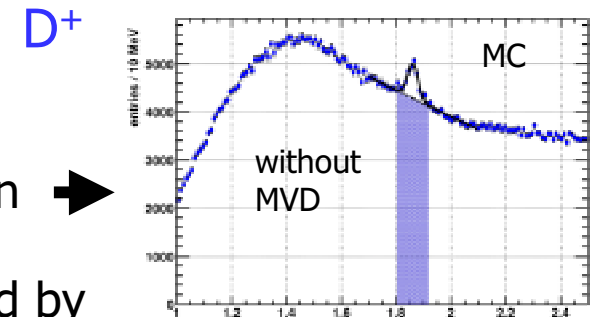
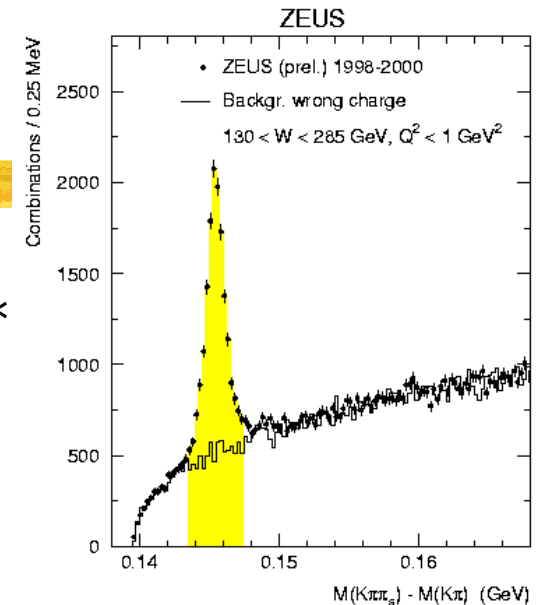
- **upgrade:**

- D^* : more multiple scattering (slow π) and tighter trigger => somewhat less efficiency

- D^+ : long lifetime + MVD => much better bg reduction →

- semileptonic charm decays can also be complemented by MVD information

=> should become fully competitive with D^* channel for cross section measurements and charm contribution to F_2 (DIS).

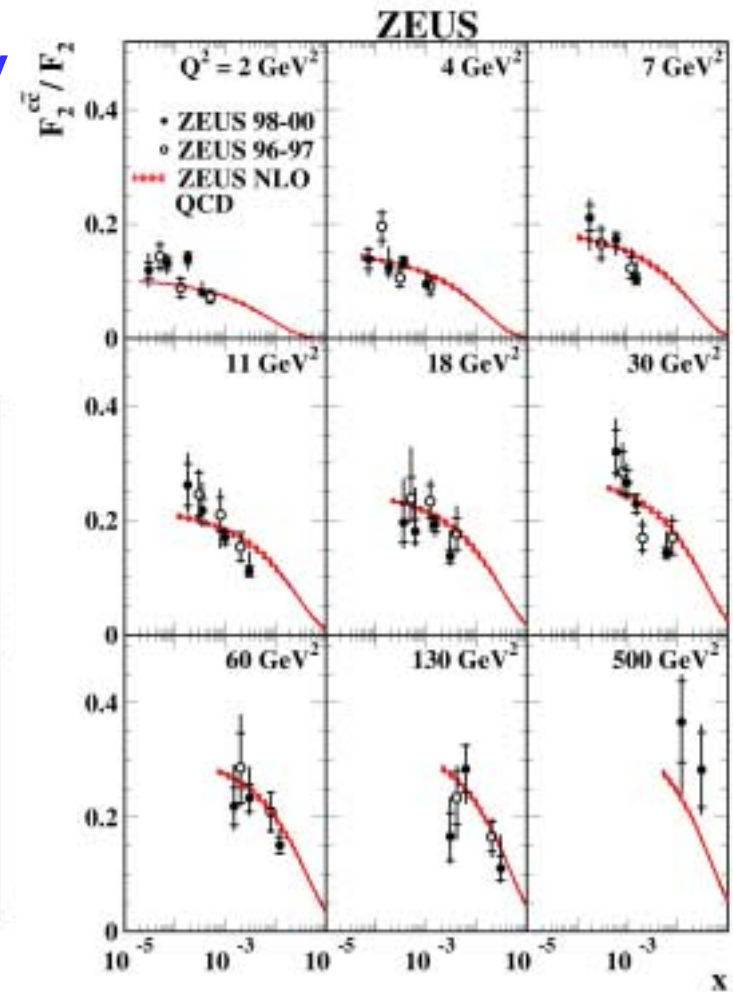
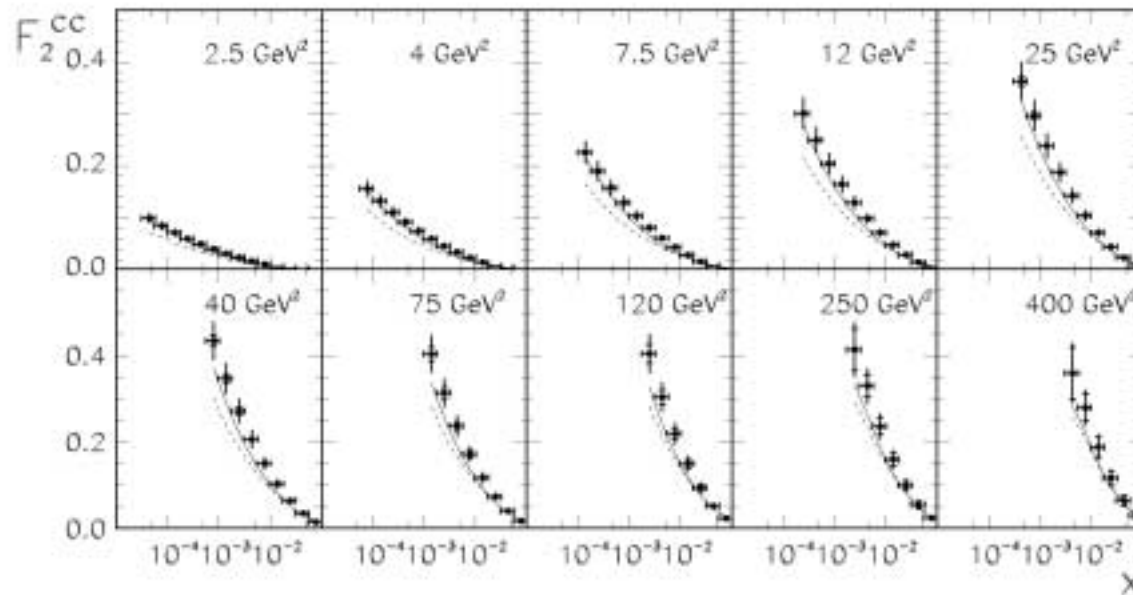


Charm contribution to F_2

DIS

today

2007 ? 500 pb⁻¹



An experimental and theoretical challenge: Search for QCD instantons through multi-flavour tag ??

■ Flavour democracy => instanton „couples“ to all kinematically allowed flavours

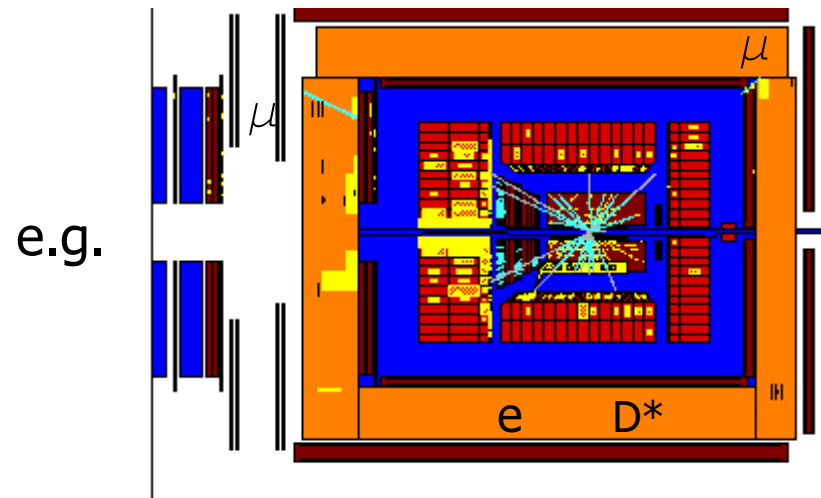
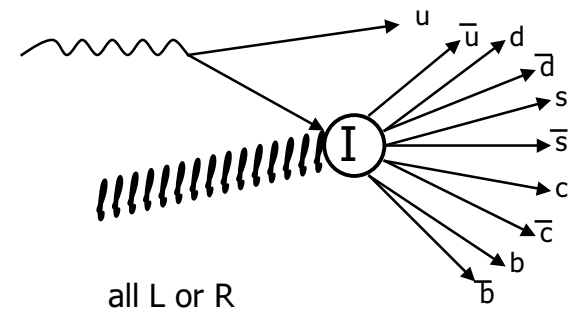
- $b\bar{b} c\bar{c} s\bar{s} u\bar{u} d\bar{d}$ (+ gluons) , $b \rightarrow c \rightarrow s$, $c \rightarrow s$
- => 6 chances to get lepton (μ or e)
- 4 chances to get $D^{(*)}$ meson
- 6 chances to get V^0 (K^0, Δ) directly from s quark
- >=10 chances to get V^0 from fragmentation

=> look for „isotropic“ events with several (at least 3) flavour tags,

but: cross section currently not calculable (could it be „large“?)

QCD background (e.g. $b\bar{b} c\bar{c}$ final state) needs NNLO calculation

=> not for tomorrow ...



Conclusions



- MVD, STT, and trigger upgrades ready for data taking and performing well
- First competitive results from beauty production with MVD can already be obtained from few months running
 - hope for first preliminary results by next summer conferences
- Very good prospects also for charm, but no reliable quantitative estimates yet
- extensive studies of multi-differential distributions in single and double tagged charm and beauty events will become possible => QCD tests, gluon distribution
- Many other interesting physics topics! (see other talks)