Boundary Conditions for the Interaction Region Design

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Boundary Conditions

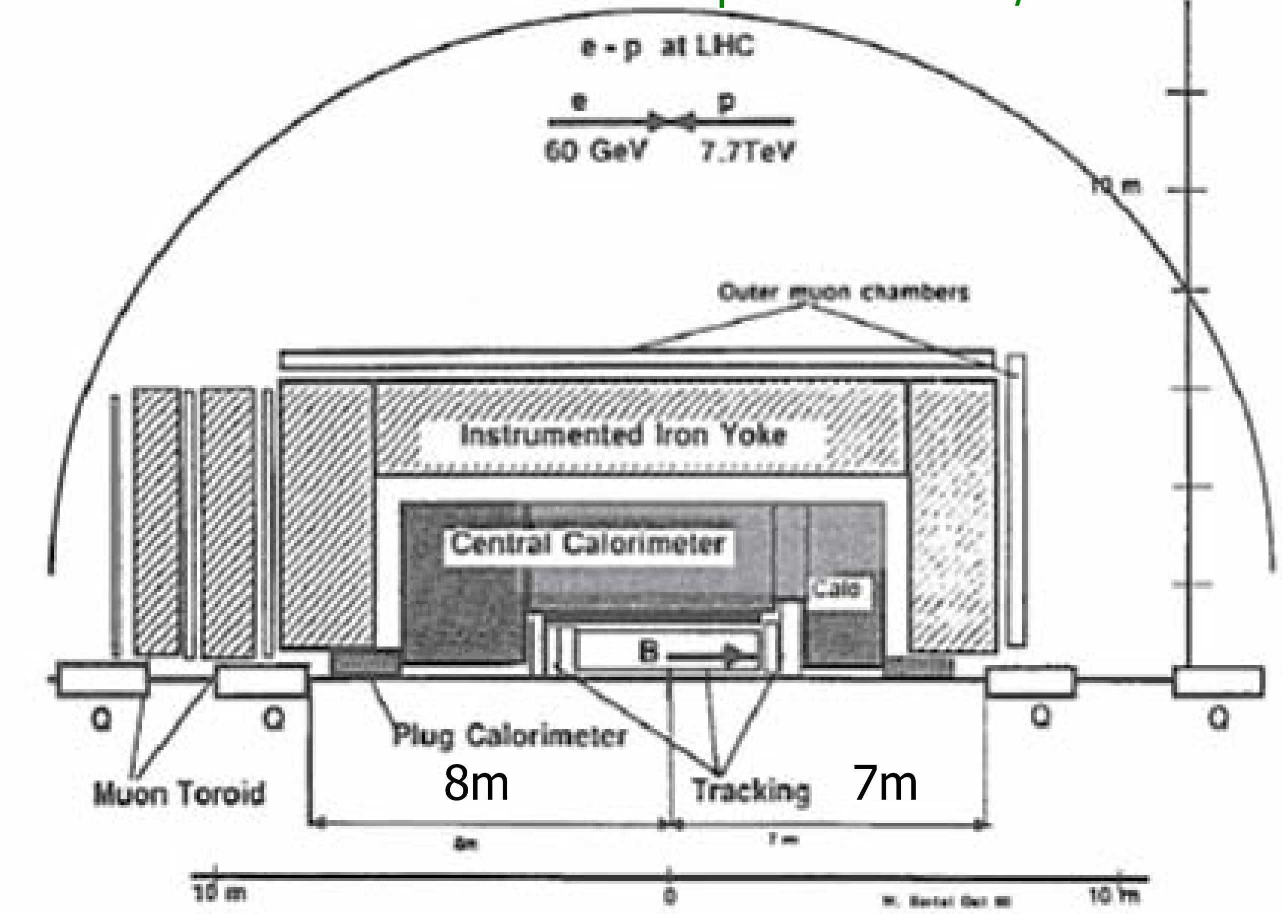
A few general remarks on boundary conditions from the detector side

- Ideally, high luminosity, full (4π) detector acceptance and low background conditions

- More realistic:
  - High luminosity, as required for the physics program
  - Good detector acceptance in forward and rear direction
  - Acceptable background conditions

LEP – LHC Detector

Aachen 1990 LHC Workshop CERN-90-10/ECFA 90-133



Looks like stretched out ZEUS detector

Luminosity vs. Acceptance

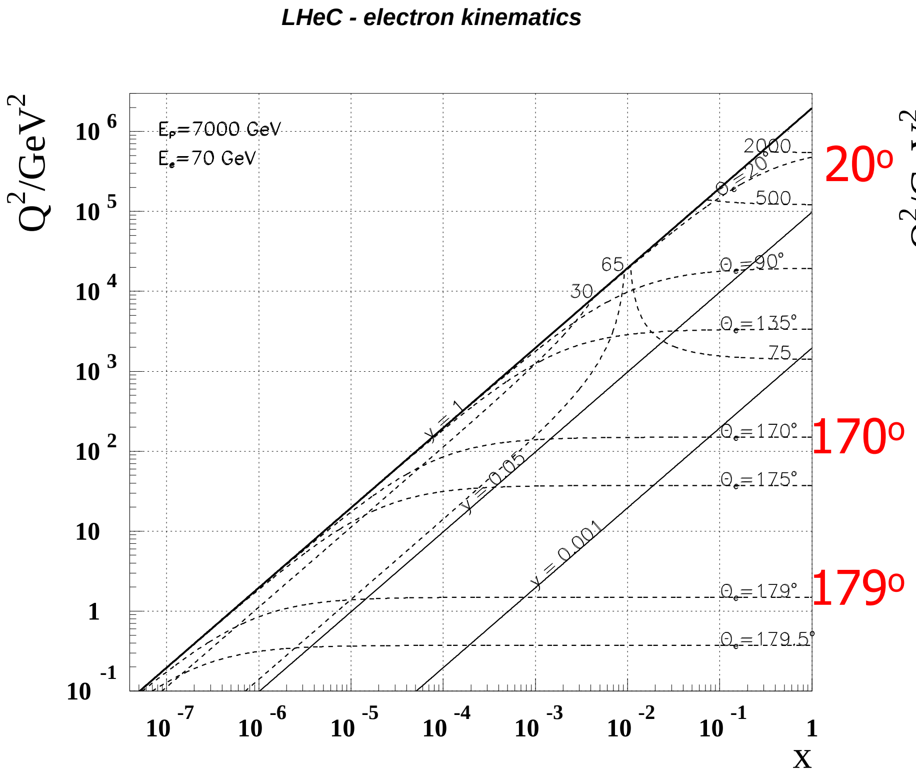
- Luminosity and acceptance very much depend on physics program (to be defined during this workshop)
- Agenda shows a broad range of topics from high Q^2 to low x and forward physics
- Deep inelastic cross section ~$1/Q^4$ (momentum transfer)
  - High Q^2 physics (search for new physics, electron-weak studies) require high luminosity. Can be done with reduced acceptance
  - Low Q^2 physics (high parton densities, diffraction,…) requires good forward and rear coverage 1 – 179°. Can be done with reduced luminosity.

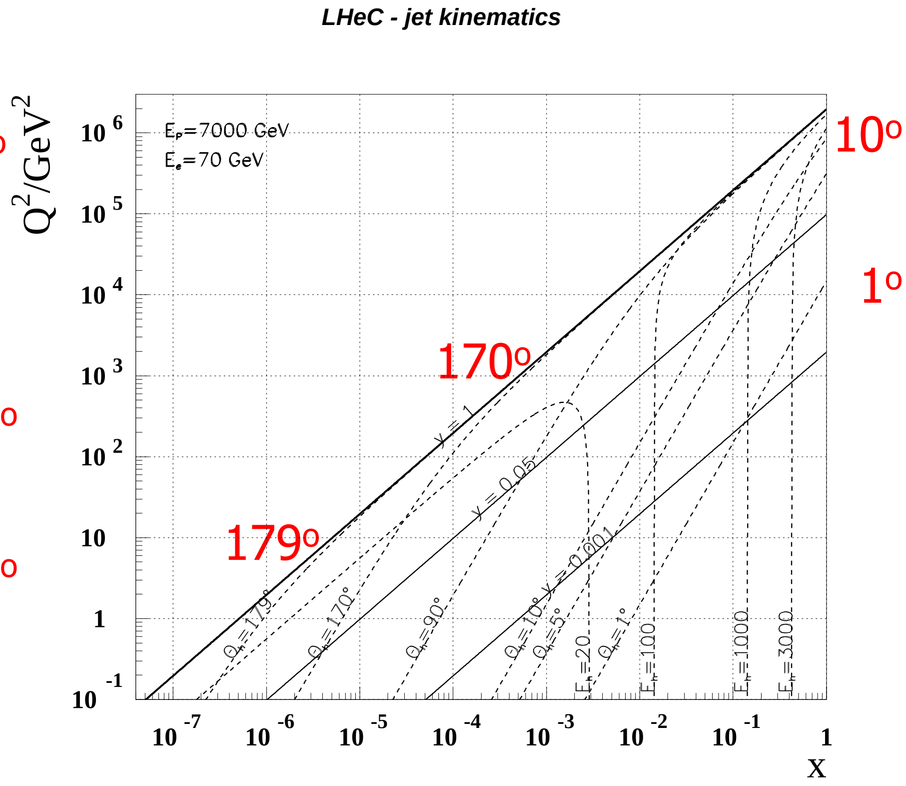
  => Possible scenario two different interaction region setups
    - $L = 10^{33}\ cm^{-2}\ s^{-1}$, $10^o < \theta < 170^o$ (prefer magnets not in front of calorimeter)
    - $L = 10^{31}\ cm^{-2}\ s^{-1}$, $1^o < \theta < 179^o$

    Example HERA I and HERA II IRs and Detectors

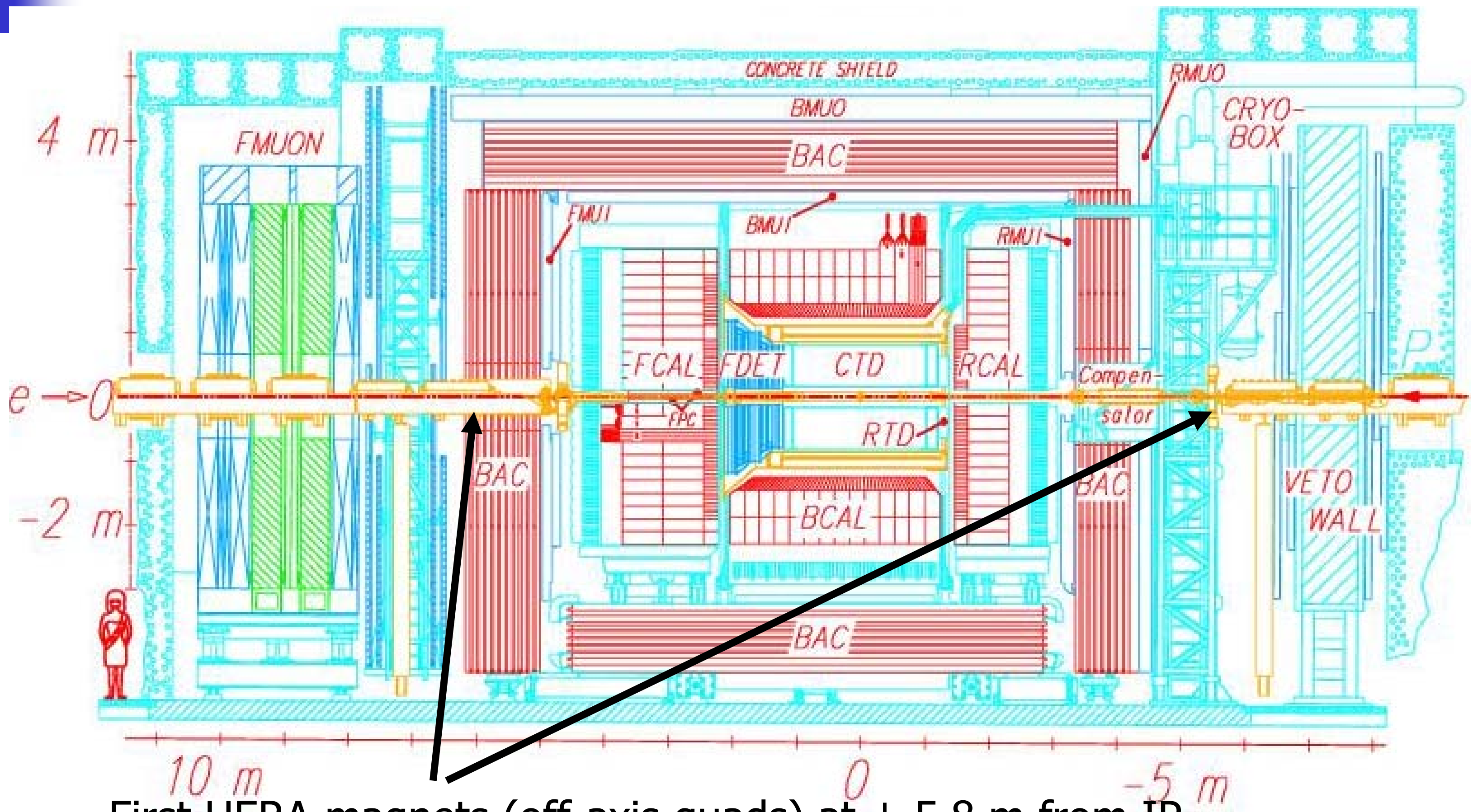
LHeC Kinematics

U. Klein



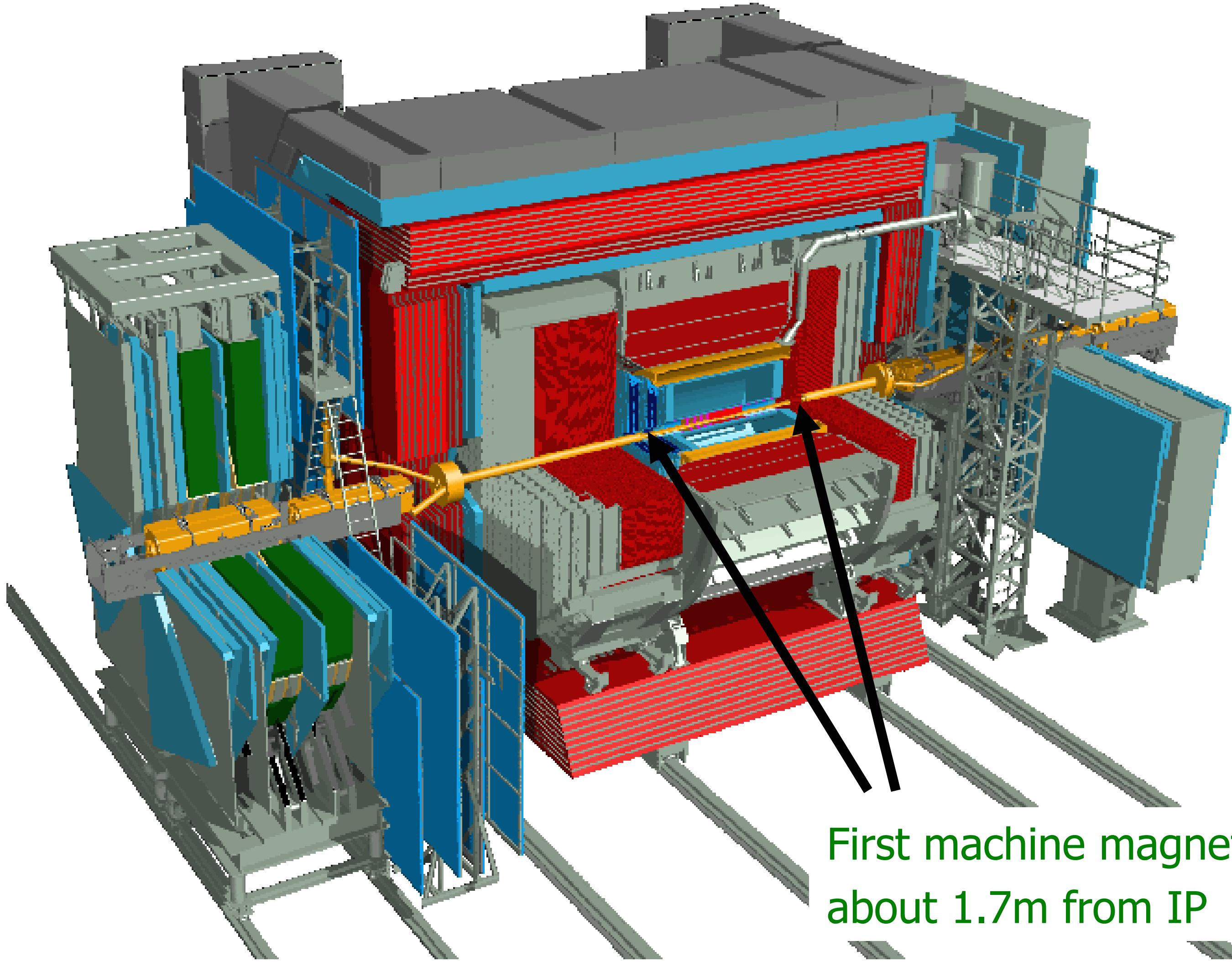


ZEUS Detector - HERA I



First HERA magnets (off-axis quads) at ± 5.8 m from IP
Calorimeter covers >99.8% of full solid angle
Very small hole in FCAL (6.3 cm diameter), small vertical opening of RCAL

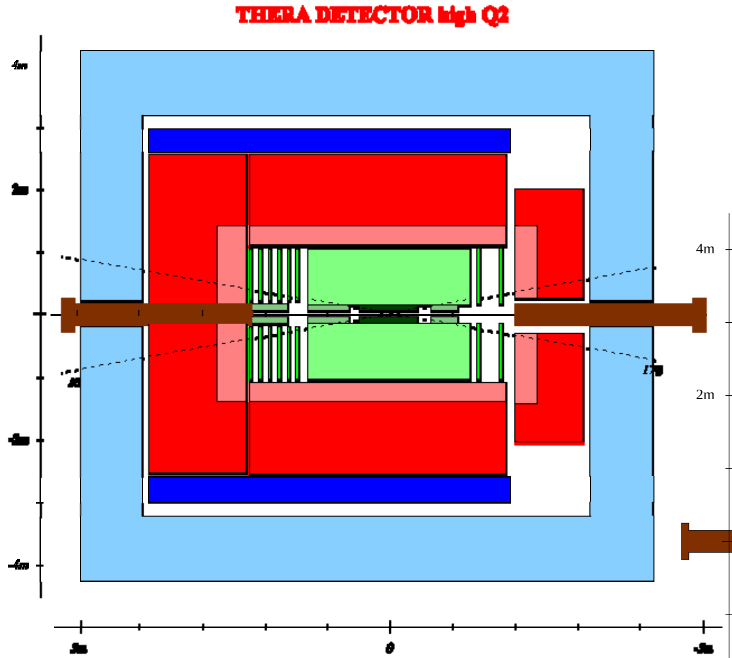
ZEUS Detector - HERA II

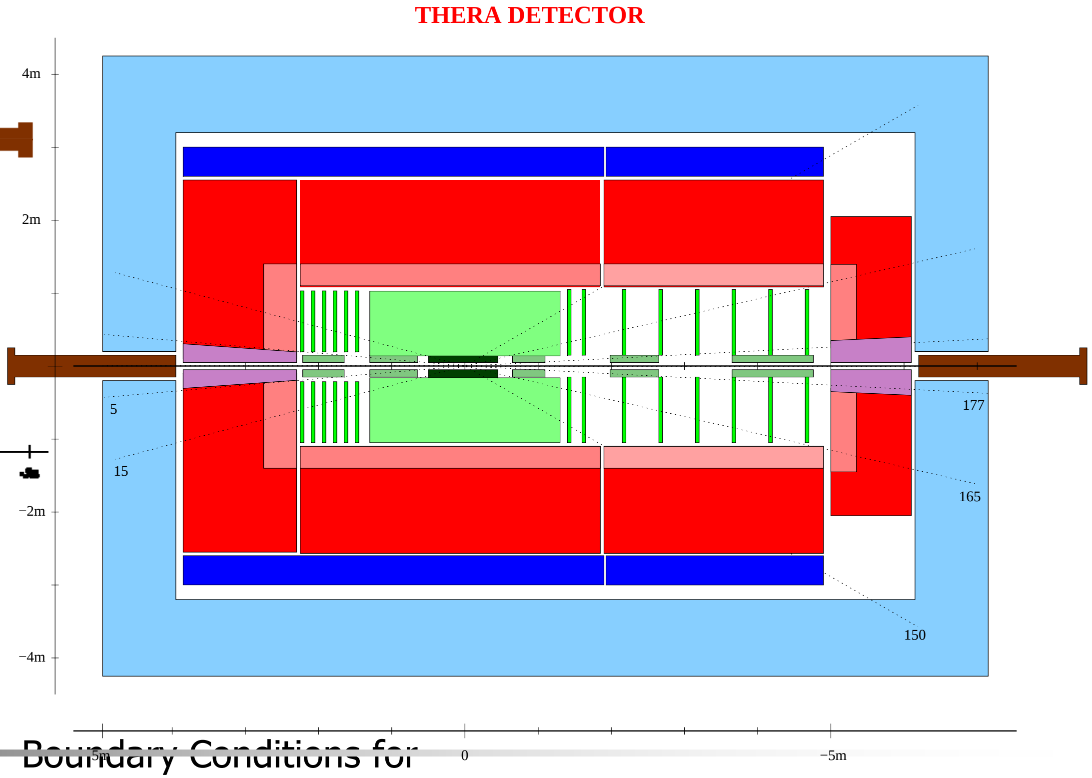


First machine magnets
about 1.7m from IP

THERA: TESLA on HERA Study

Sketches of high Q^2 and low x detector/IR setups





Detector Magnet

In general, collider detector have solenoidal fields.

LHeC Detector

Solenoid:

- Certainly for high Q^2 physics
- Probably also for low x physics
  - Dedicated low x experiment may prefer dipole magnet. Being considered for eRHIC/EIC.
  - Should look into solenoid with integrated dipole magnet
    - Proposed by B.Parker for eRHIC mainly for beam separation.
    - Recently, being studied for ILC IR in order to reduce backgrounds.
    - Question whether dipole field can be sufficiently large.

Background Sources at HERA/LHeC

Electron/positron beam

- Synchrotron radiation
  - Backscattering
  - Photo desorption

  -> degradation of vacuum
- Beam gas interactions
  - Off momentum electrons
- Higher order mode losses
  - Local heating at injection and ramp (short bunches)

  -> degradation of vacuum

Proton beam

- Low beam lifetime during injection and ramping
- Beam gas interactions, large hadronic cross section
  - Secondary interactions with aperture limitations, i.e. with magnets, beam pipe, masks

Need

- Careful design of interaction region and masks
- Excellent vacuum system

Background Conditions

HERA II

- Initially, very severe background conditions. Lost about two years of data taking.
- Mainly limited by current/trips in central drift chambers
  - Proton beam gas background highest rate
  - Electron beam gas and synchrotron radiation depending on beam conditions
- H1 some radiation damage of non-radiation hard silicon vertex detector electronics (~1 kGy)
  - No problem after radiation hard electronics installed
- Max. track trigger rate 100kHz (H1)

LHeC

- Detector will probably use Si tracker. Max. dose ~10 kGy ?
  - Should talk to ATLAS and CMS experts
  - Question: material budget in rear direction might be too large for electron detection.
- First ring-ring study
  - Synchrotron radiation background (talk by B.Nagorny) and degradation of vacuum pressure probably somewhat similar to HERA II

Conclusions

- Luminosity and acceptance requirements very much depend on physics program
- Possible scenario two different interaction region setups
  - $L = 10^{33}\ cm^{-2}\ s^{-1}$, $10^o < \theta < 170^o$
  - $L = 10^{31}\ cm^{-2}\ s^{-1}$, $1^o < \theta < 179^o$
- Need detailed design of IR setups
- Need detailed study of backgrounds
  - Detector sensitivity depends on chosen technologies