Humboldt University Berlin

The Backward Silicon Track Trigger for the HERA Experiment H1

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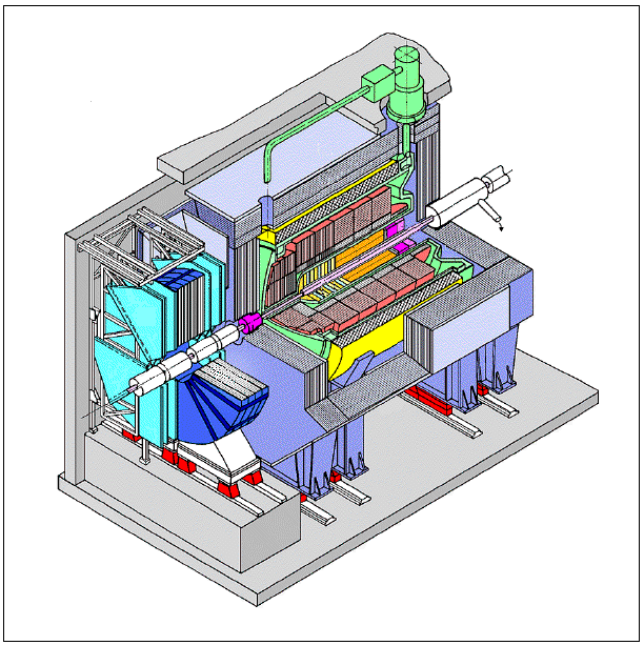
- Physics Motivation
- System Design and Test
- First Luminosity Data
- Radiation Monitor
- Summary

Berlin, October 21, 2003

eP collider HERA

H1 experiment



HERA-II

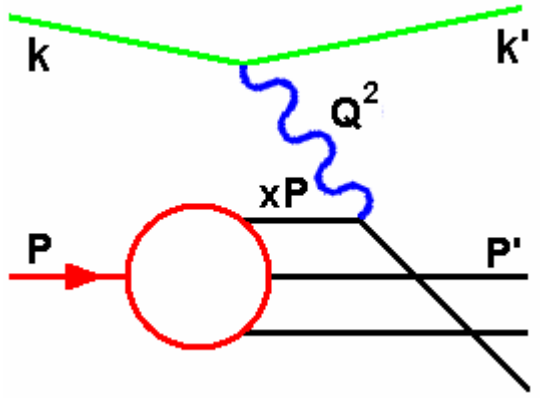
P-beam: 920 GeV
e-beam: 27.6 GeV

$$\sqrt{s} \approx 318\,GeV$$

P-beam: 130 mA
e-beam: 55 mA

$$L \approx 7 \cdot 10^{31}\ cm^{-2} s^{-1}$$

Deeply Inelastic Scattering



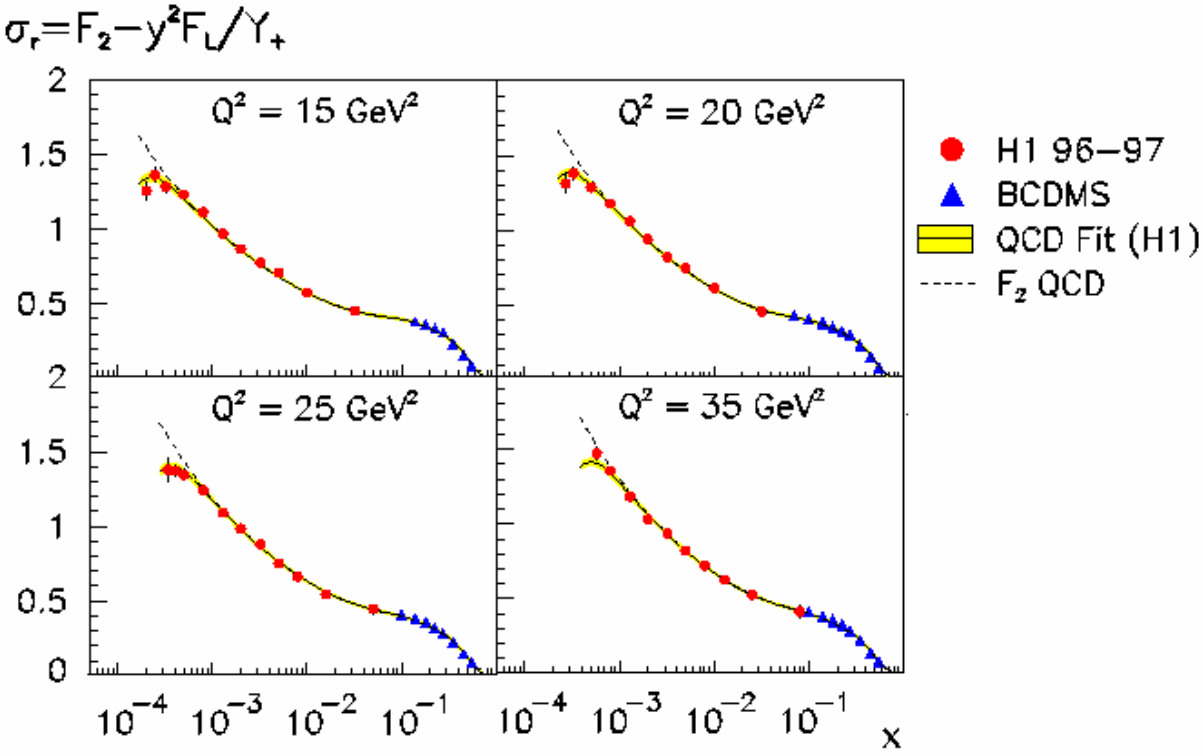
DIS kinematics

$$Q^2 = -q^2 = -(k - k')^2$$

$$x = -\frac{q^2}{2P \cdot q}; \qquad y = \frac{Q^2}{sx}$$

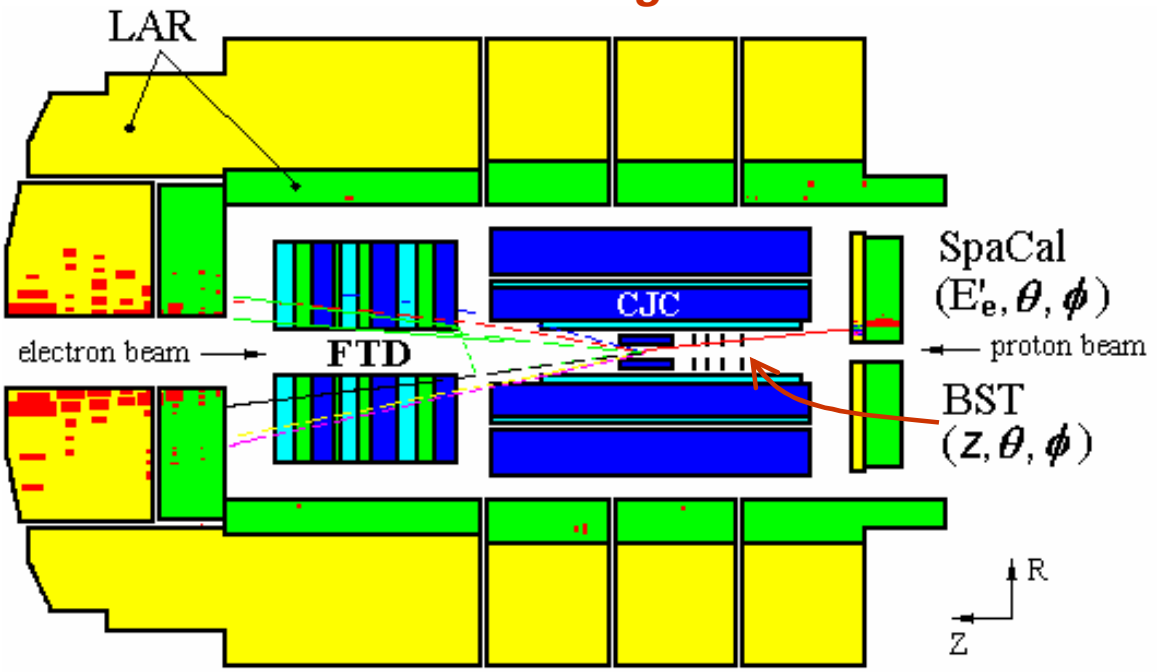
$$\frac{\partial^2 \sigma(x,Q^2)}{\partial x \partial Q^2} \propto \frac{1}{Q^4}\left(F_2(x,Q^2) - \frac{y^2}{1+(1-y)^2} F_L(x,Q^2) \right)$$

eP cross-section measurements



DIS Measurements

Inelastic scattering eP -> e`X



BST acceptance in the x, Q^2 kinematic plane

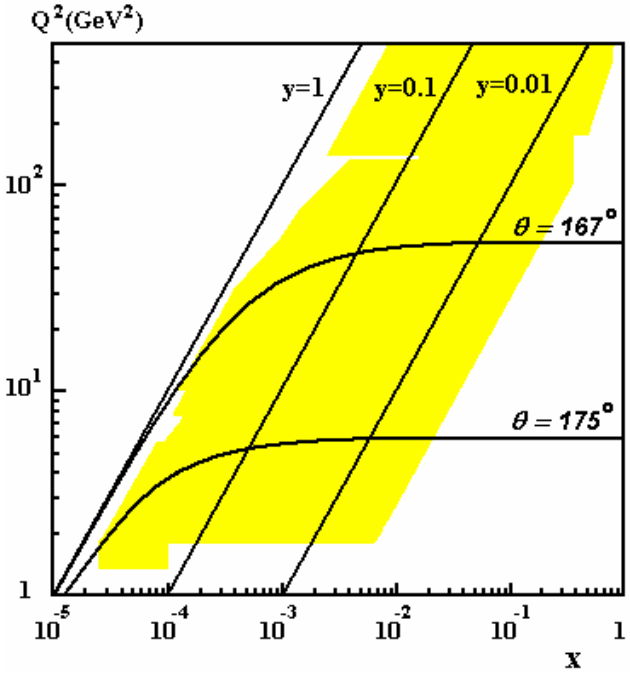
$$Q^2 \approx 2 E_e E'_e \cos^2 \frac{\theta_e}{2}$$

Low Q^2, extended x

F_2 measurements

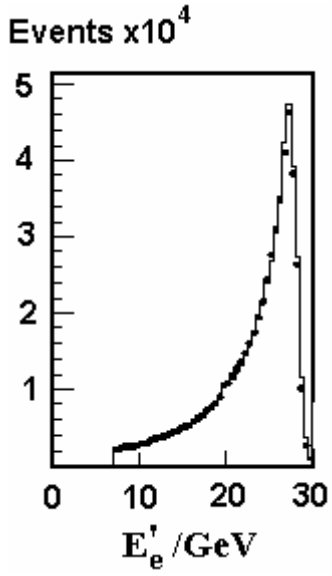
Low Q^2, high y

F_L measurements

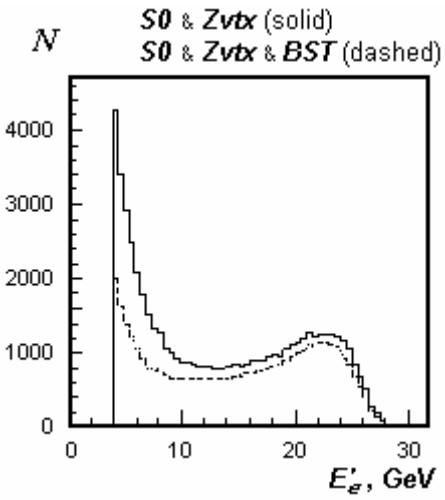


Trigger Purpose

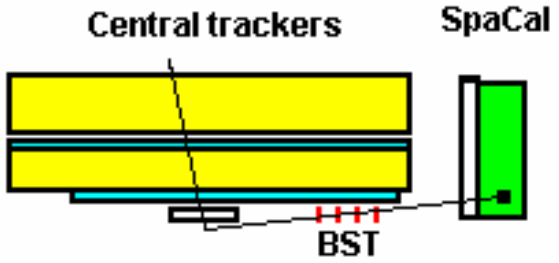
Energy spectrum in DIS ->



Photoproduction background



Track trigger



F_L trigger: low E'_e

$$y = 1 - \frac{E_e'}{E_e}$$

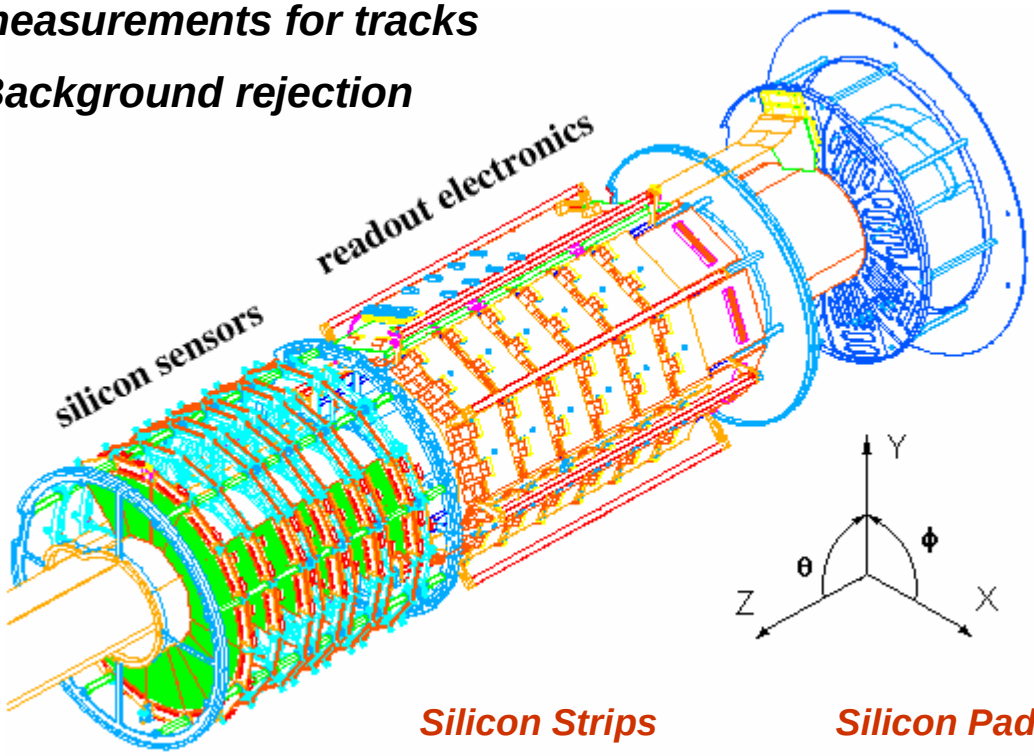
Data quality improvement

- ***DIS low Q^2 trigger with no rate scaling***
- ***Efficient electron trigger at low energies***
- ***Online reduction of the beam background***

Backward Silicon Tracker

Main tasks

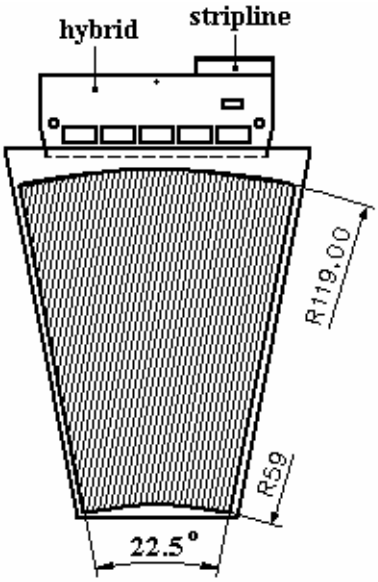
- *Z-Vertex and curvature measurements for tracks*
- *Background rejection*



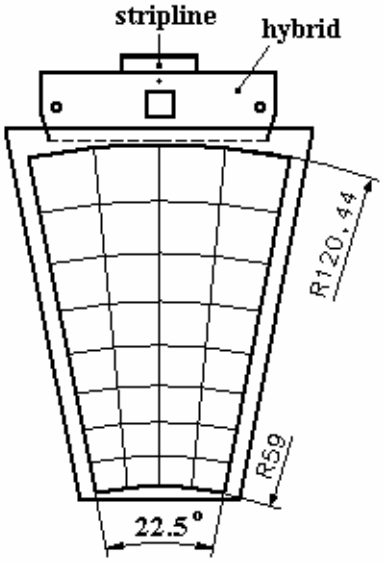
Detector system

- *U-V strip detectors (number of readout strips = 92.160)*
- *Pad detectors (number of trigger channels = 1536)*

Silicon Strips



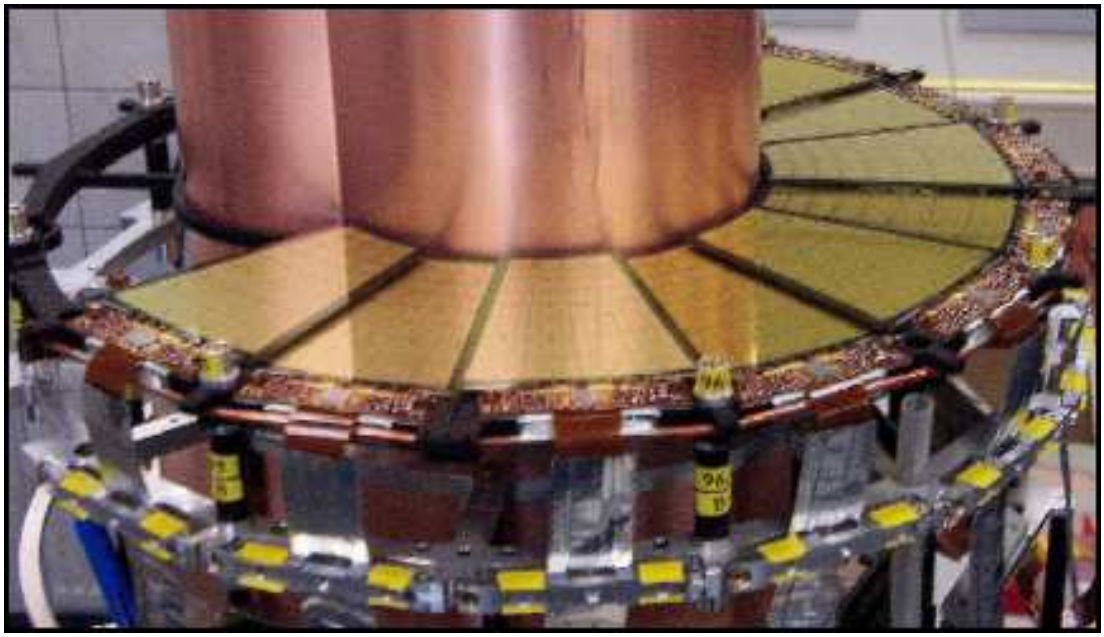
Silicon Pads



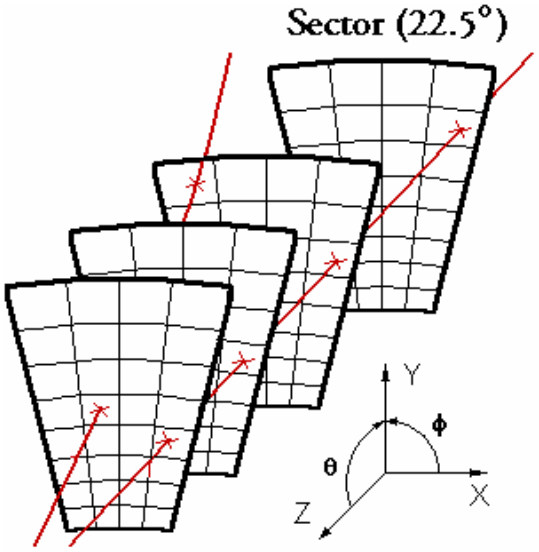
Detector Layers

Strip detectors

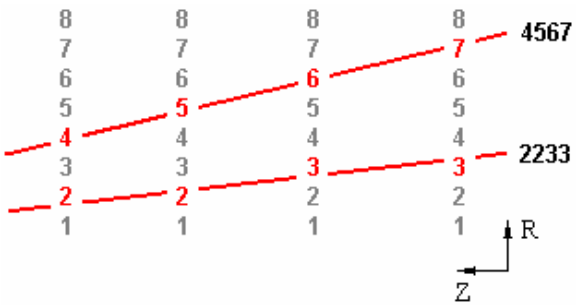
Pad detectors



Trigger Mask Concept



Trigger patterns



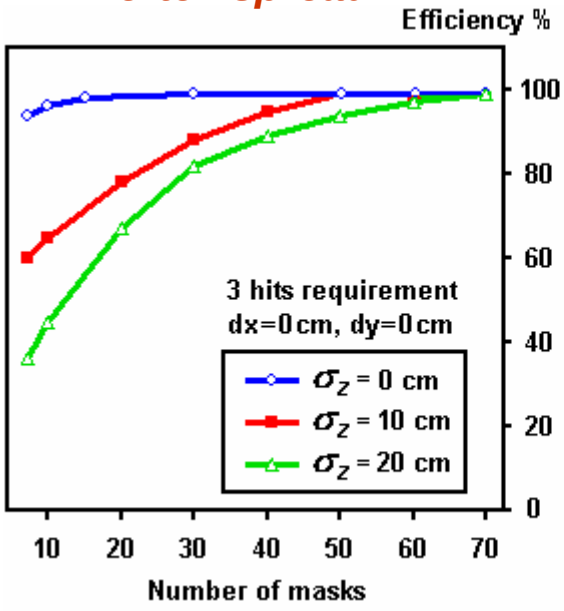
Longitudinal positions

$$Z_{n+1} = Z_n \sqrt[8]{\frac{r_{max}}{r_{min}}}$$

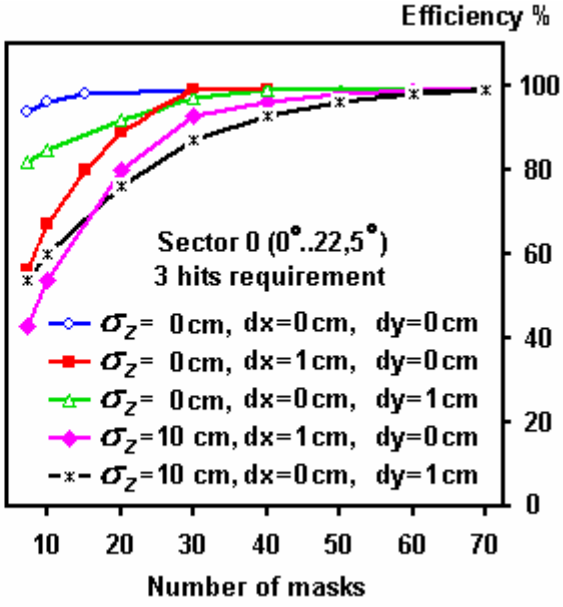
Radial division

$$r_k = \left(\frac{Z_2}{Z_1}\right)^k \cdot r_{min}$$

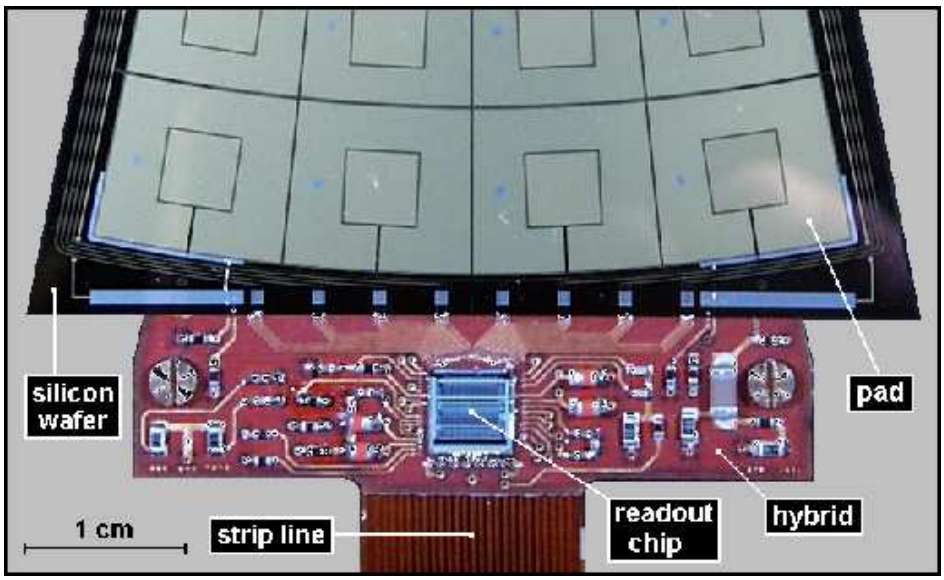
Vertex spread



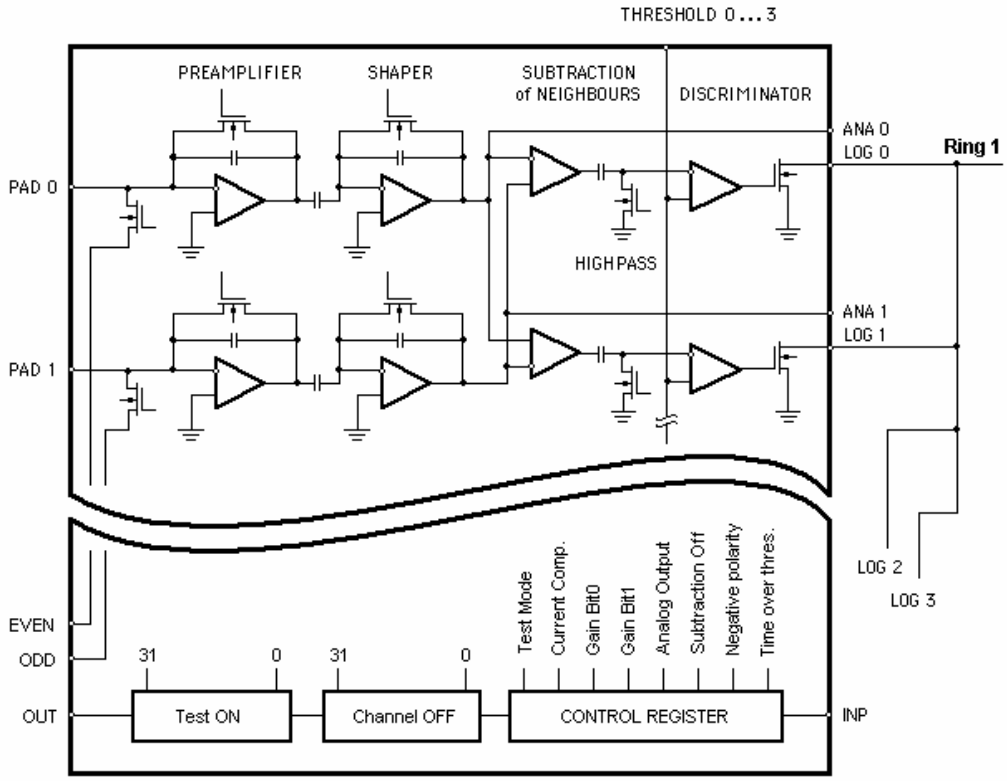
Beam offset



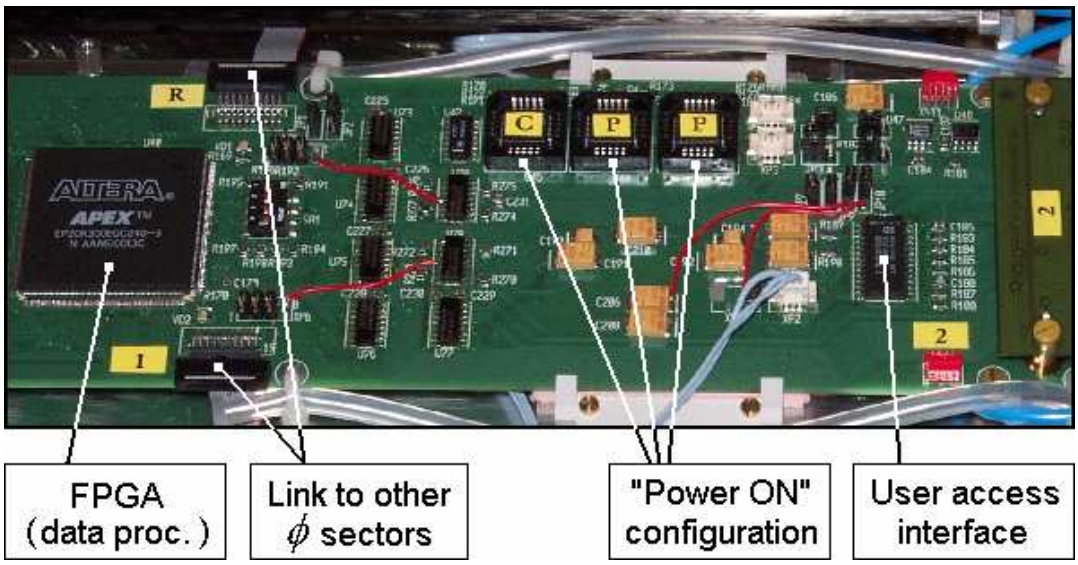
Detector Module



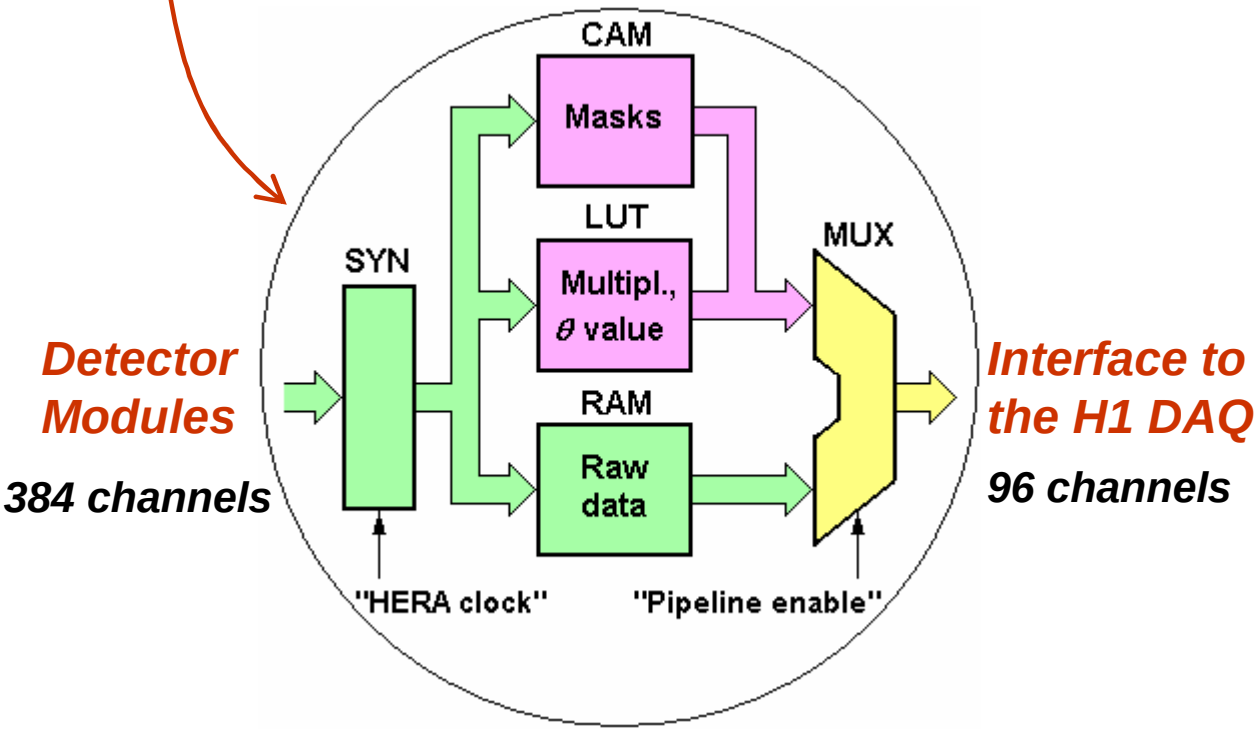
PRO/A readout chip



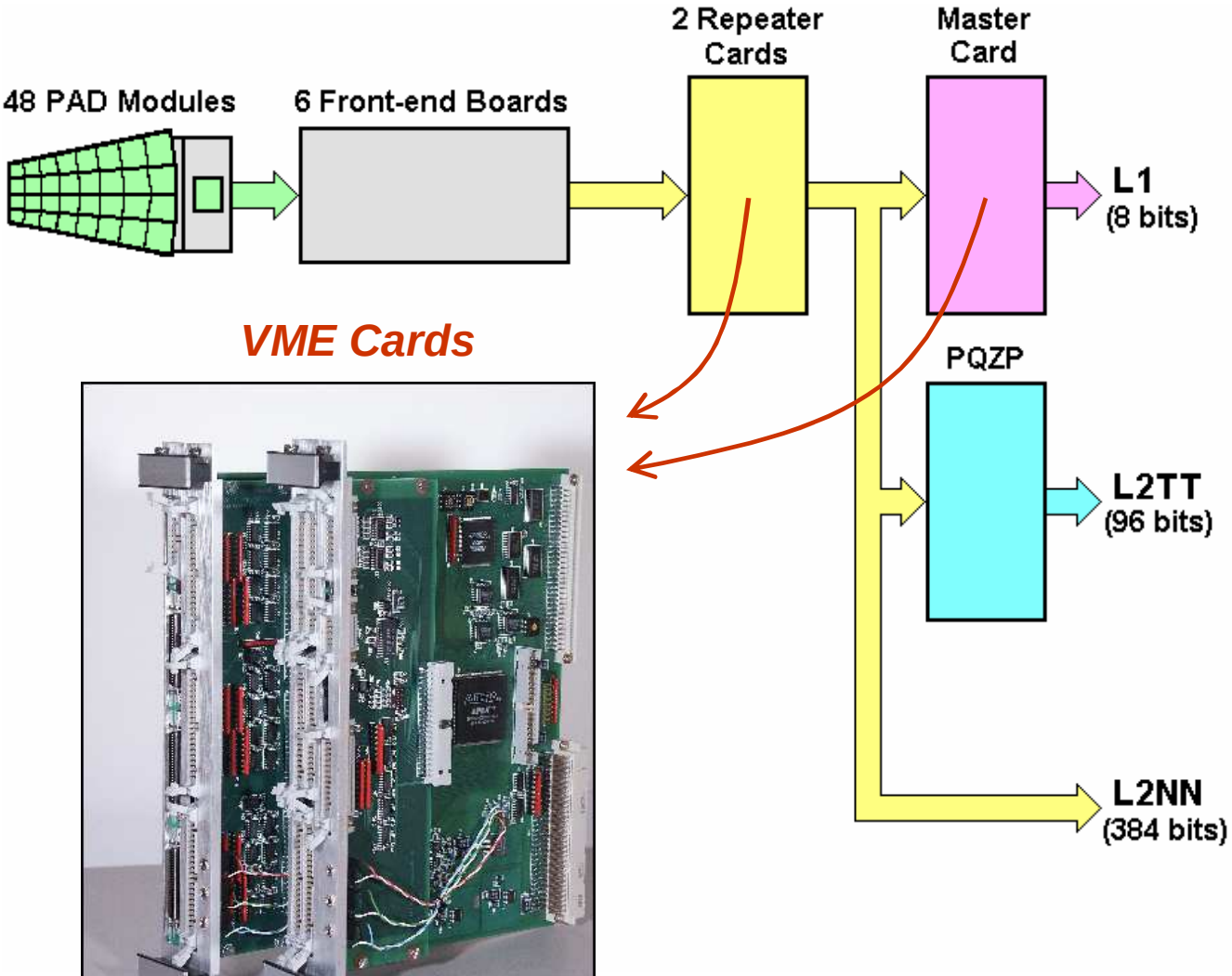
Front-end Electronics



- ***Individual mask set for each φ-sector;***
- ***Exchange of sets for different trigger phases;***
- ***Each event contains the mask set identifier.***



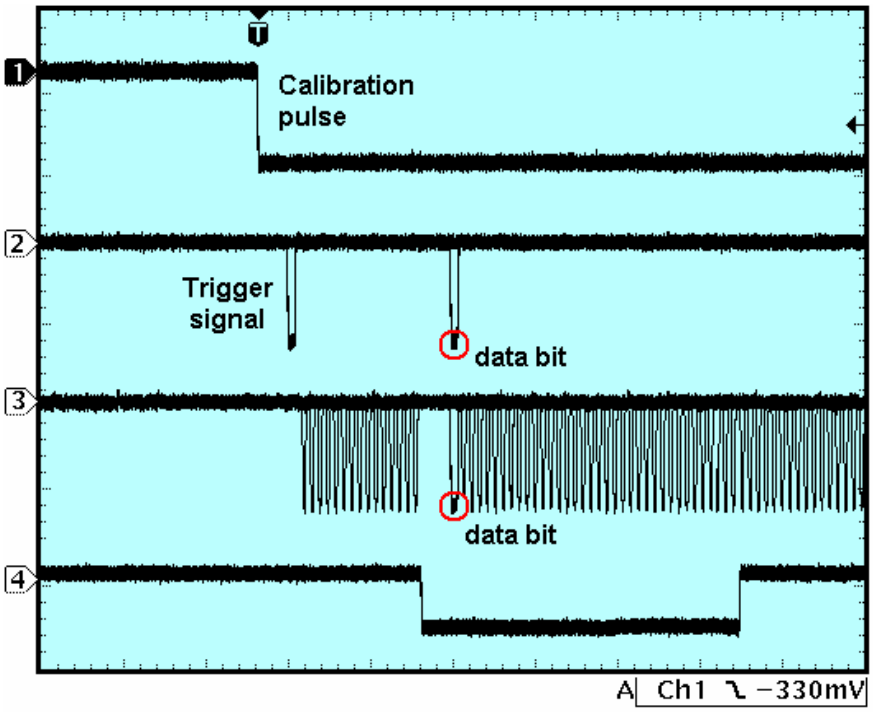
Pad Readout System



VME Cards

Low noise power supply system

L1/L2 Data Processing



Sampling phase

L1 Trigger Elements:
- ***Track trigger;***
- ***Back-to-back cand.;***
- ***Background veto.***

L2TT information:
- ***θ and φ of the track;***
- ***Hit multiplicity.***

Radiation monitor

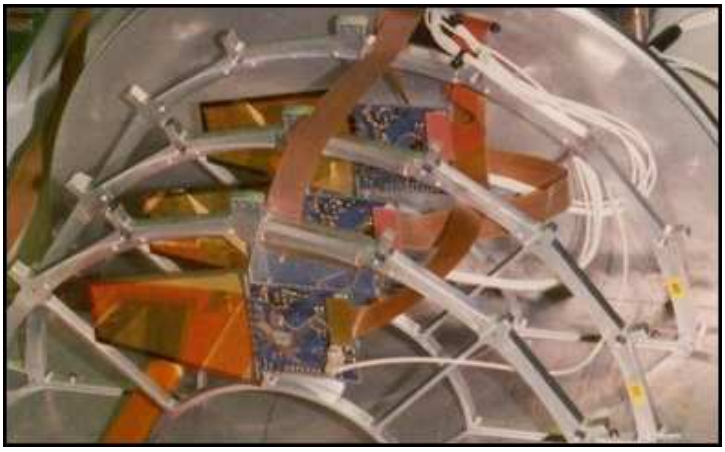
Readout phase

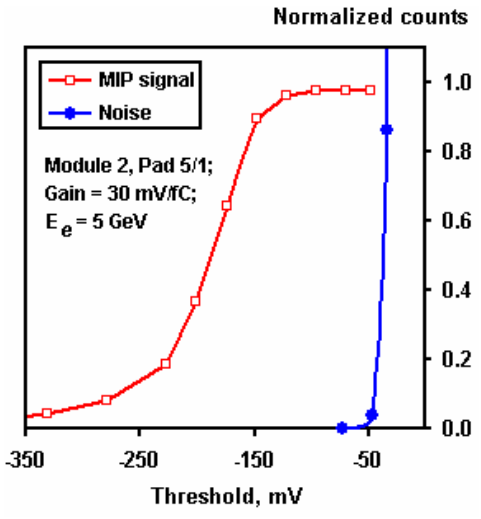
L2TT information:
- ***θ and φ of the track;***
- ***Hit multiplicity.***

Raw data output for L2TT and (or) L2NN

Radiation monitor (interrupted during the raw data transmission and corrected afterwards)

Beam Test + Calibration

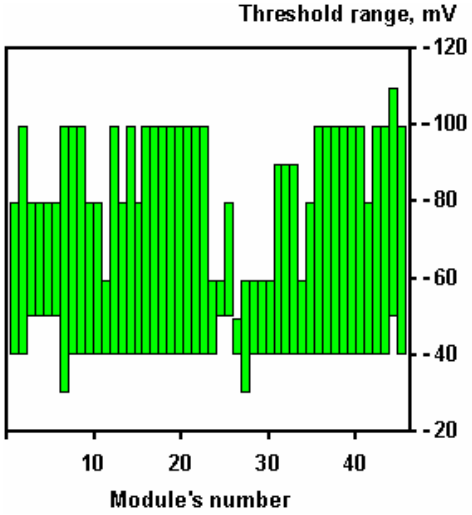


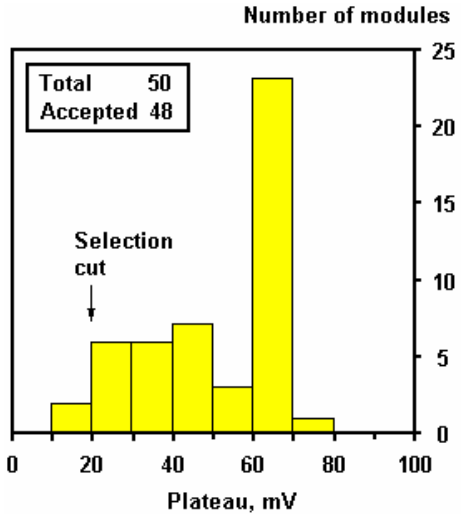


Threshold scan

$$N_{trigger}(V) = \int_0^V N_{tracks} \cdot P(V-\varepsilon)\, d\varepsilon$$

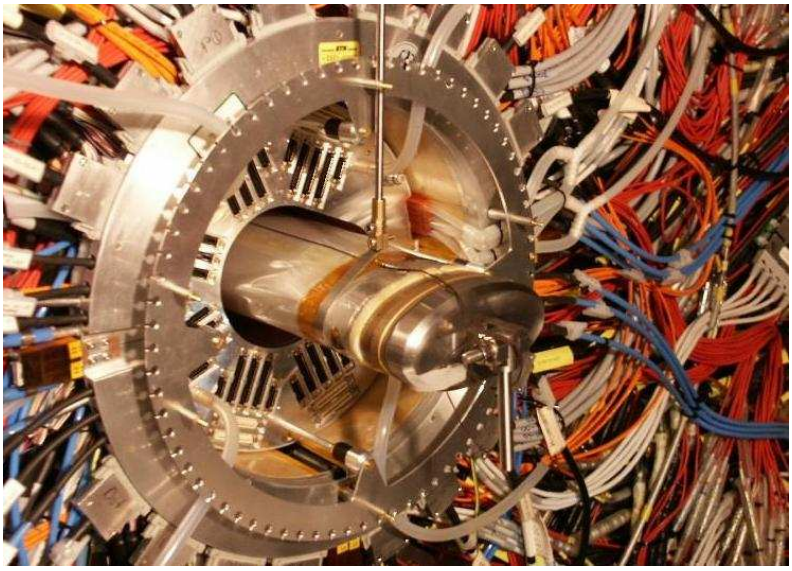
Plateau width





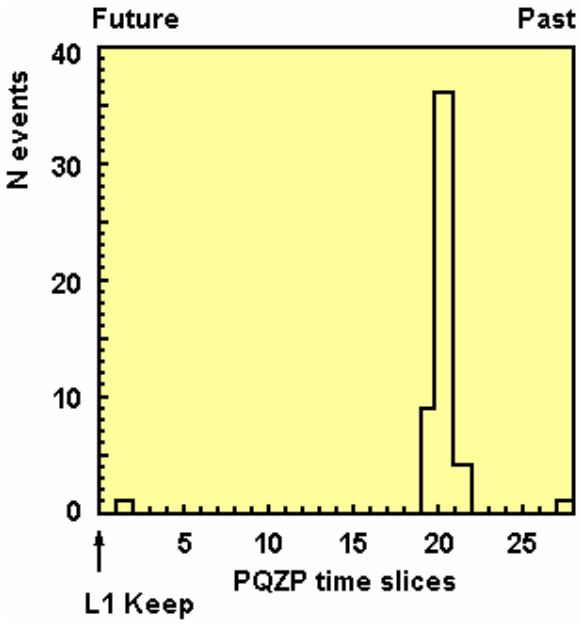
Detector evaluation

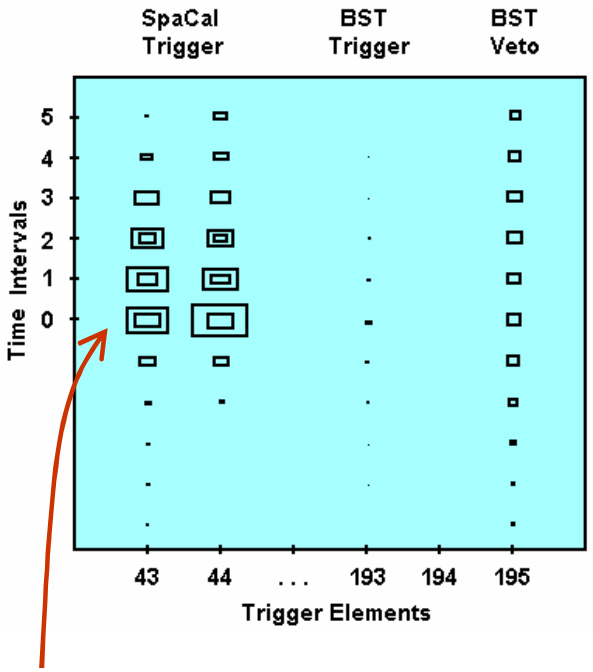
BST installation



Timing scheme:

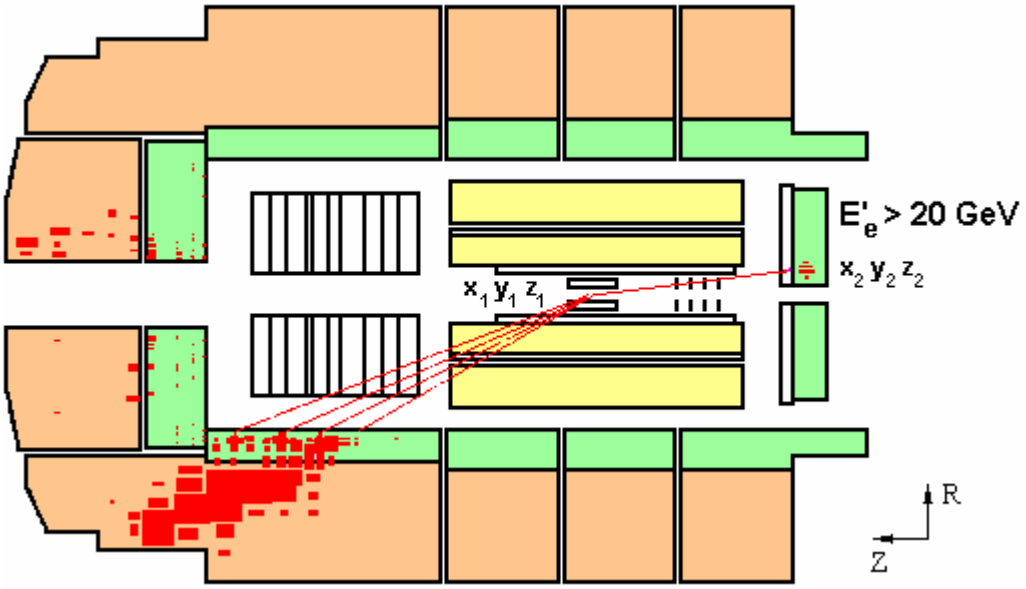
- ***Delay with respect to the HERA bunches***
- ***Offset with respect to the unique T0 of H1***





T0 (L1 decision time)

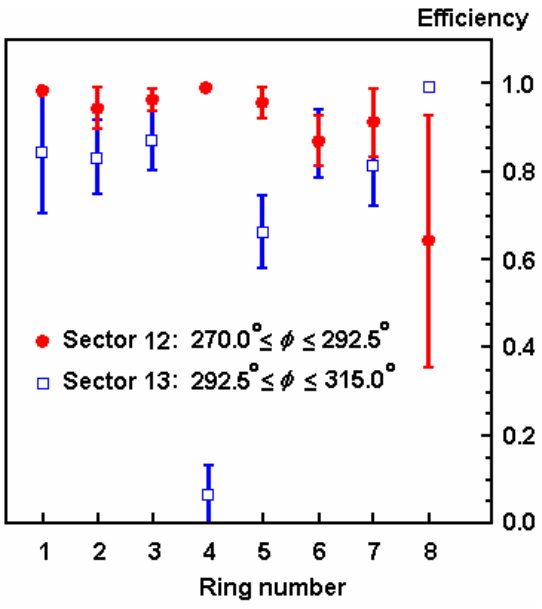
BST Trigger Signal

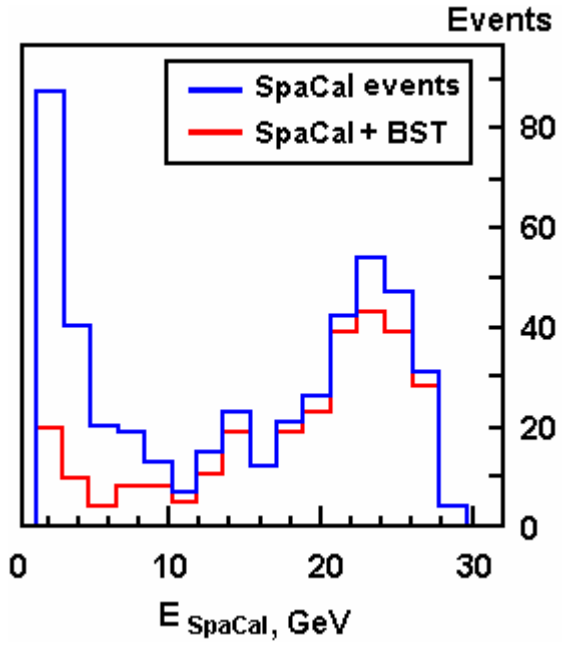


Single plane efficiency $\varepsilon_s = (90 \pm 2)\%$

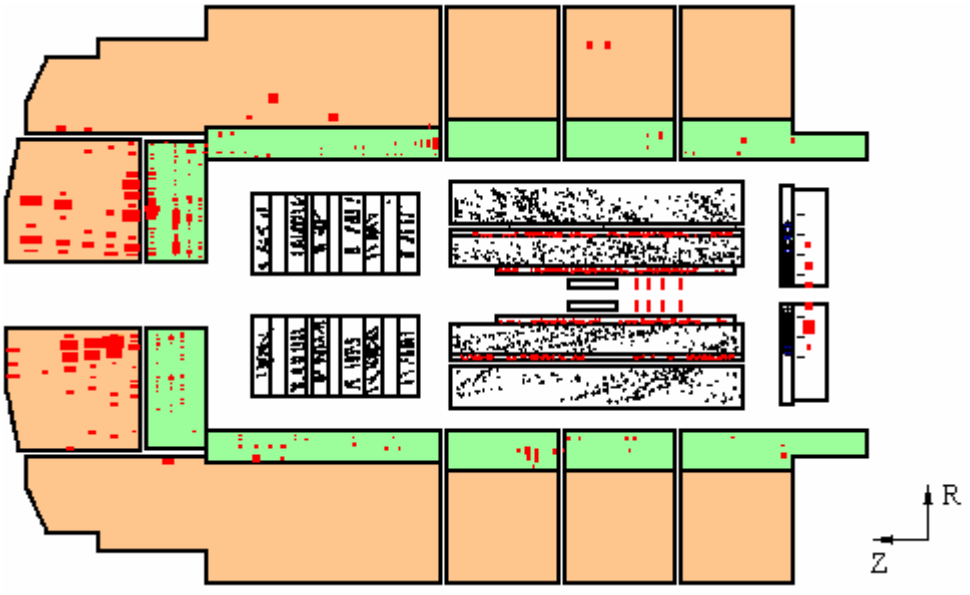
Estimate $\varepsilon_{tot} = \varepsilon_s^4 + 4\,\varepsilon_s^3 (1 - \varepsilon_s) = (95 \pm 2)\%$

First luminosity data taken prior 2003 shutdown



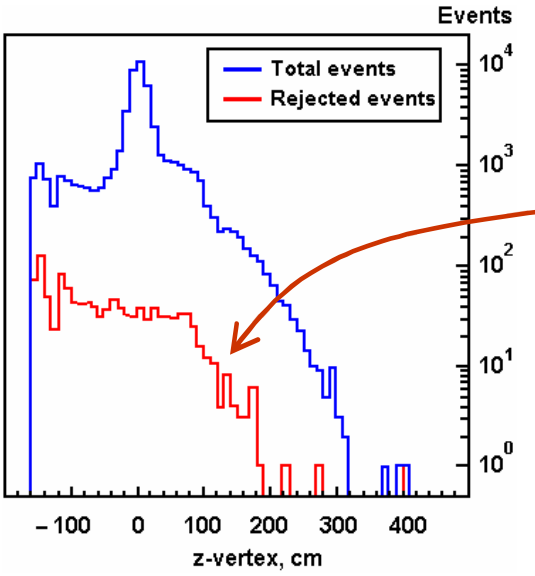


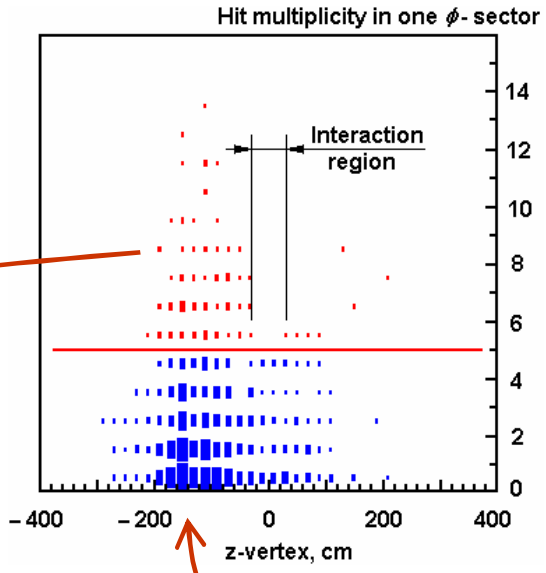
BST Veto Signal



Raw data taking

Online veto





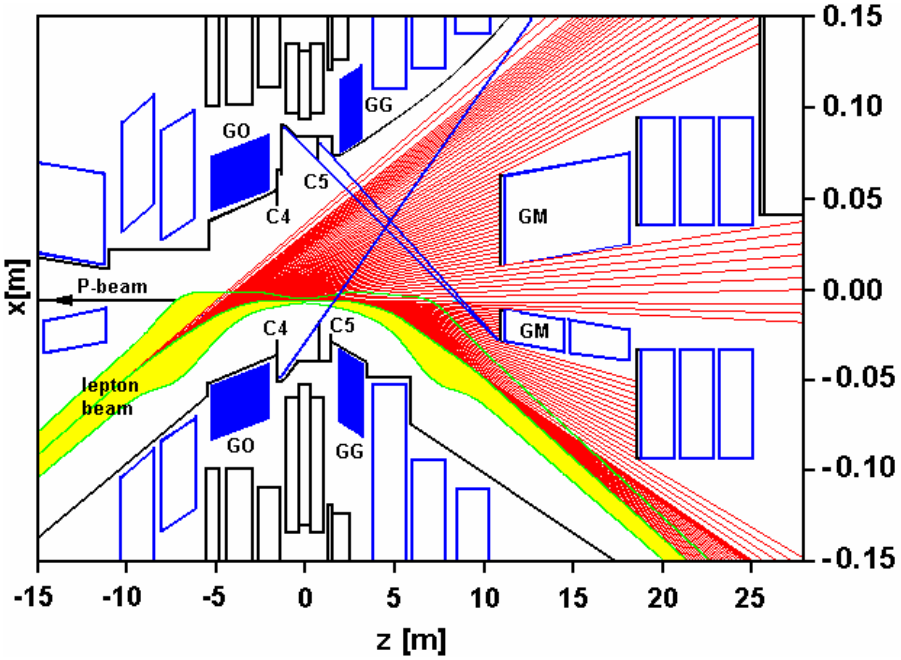
HERA collimator

Needs full detector and more data to estimate the rejection efficiency

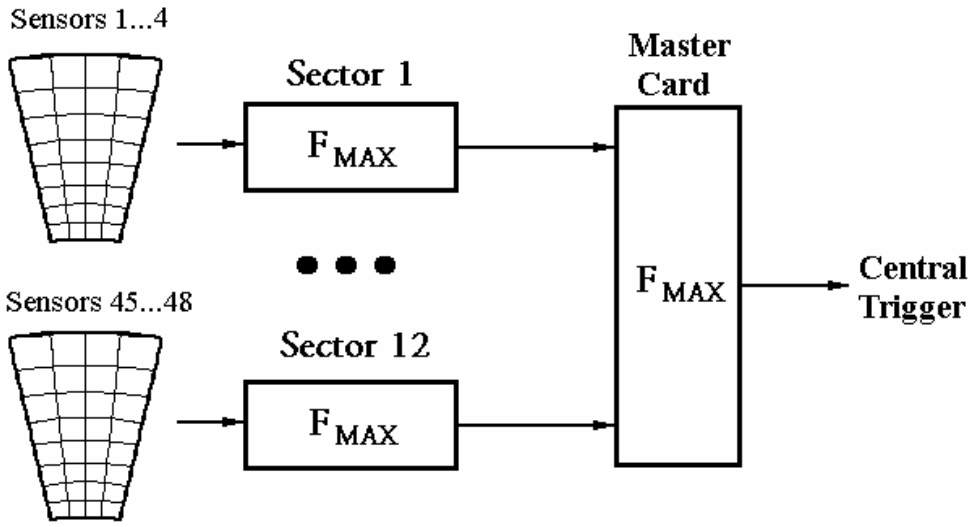
HERA Background

Intense components

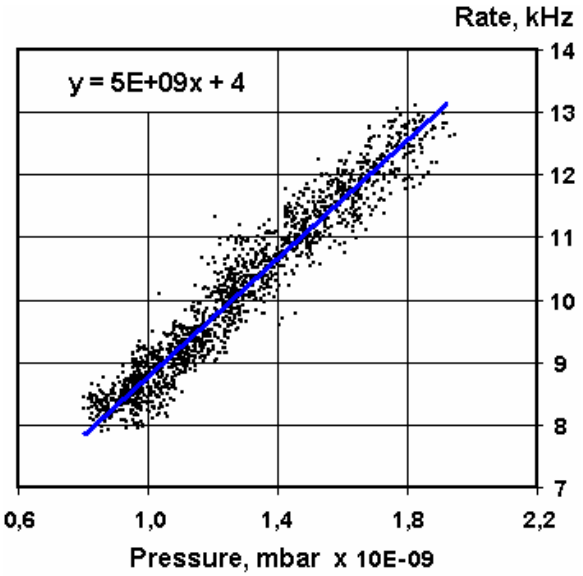
- ***Synchrotron radiation***
- ***p-gas, e-gas scattering***



Dose rate measurement with Pads

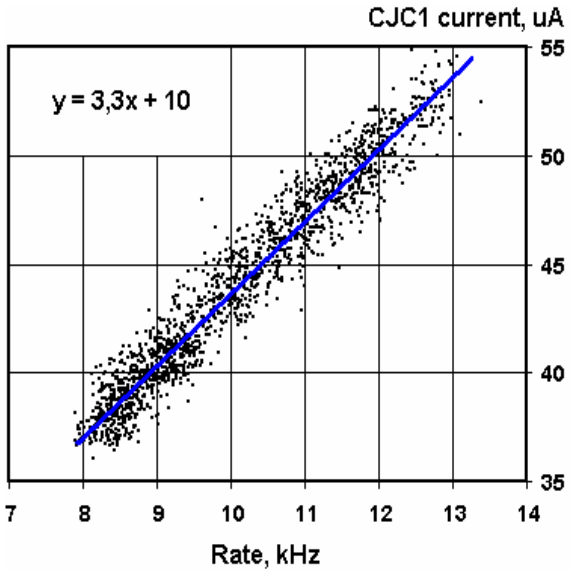


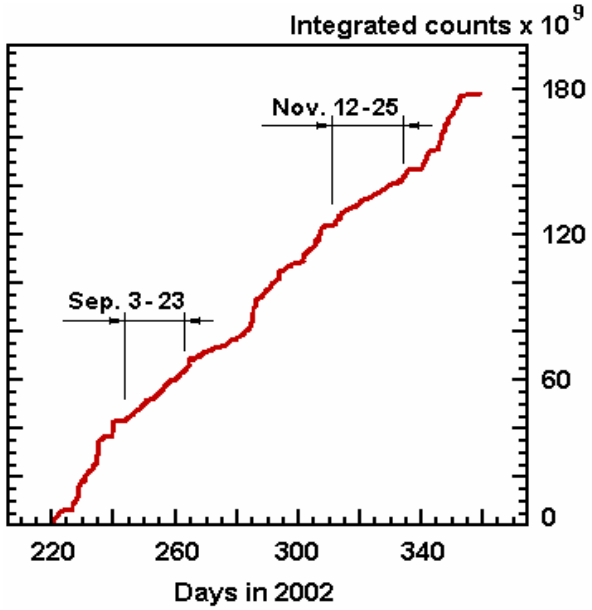
Radiation Monitor for H1



Monitoring beam-gas scattering

Indicating "turn on" conditions for the trackers





Cumulative dose

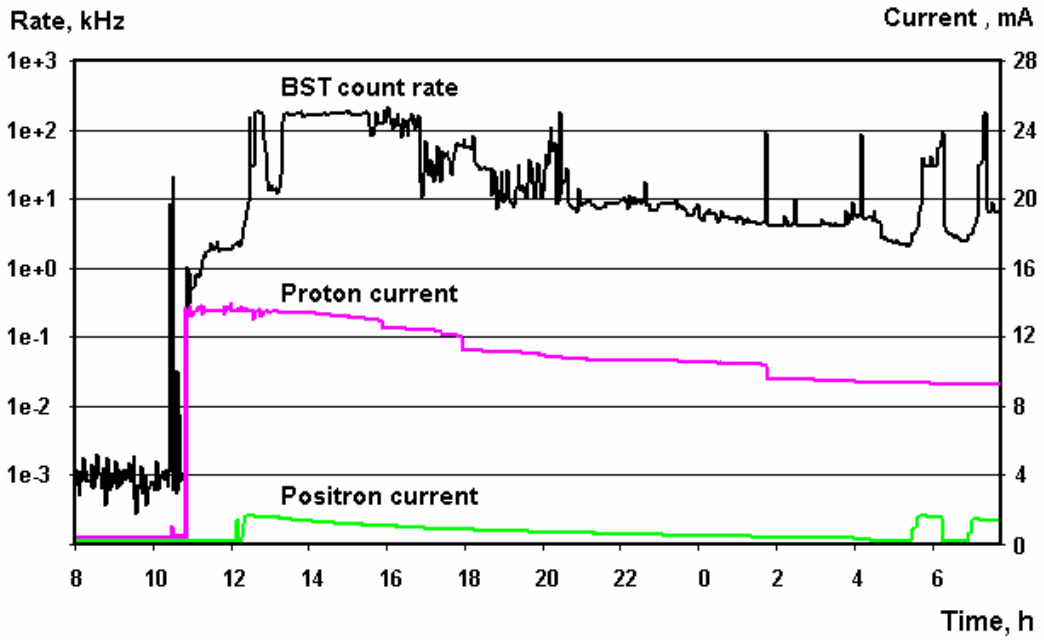
$$\dot{D} = \frac{N}{t[s]} \cdot \frac{\varepsilon}{S[cm^2]}$$

$$\varepsilon \approx 2\,MeV \cdot cm^2 / g$$

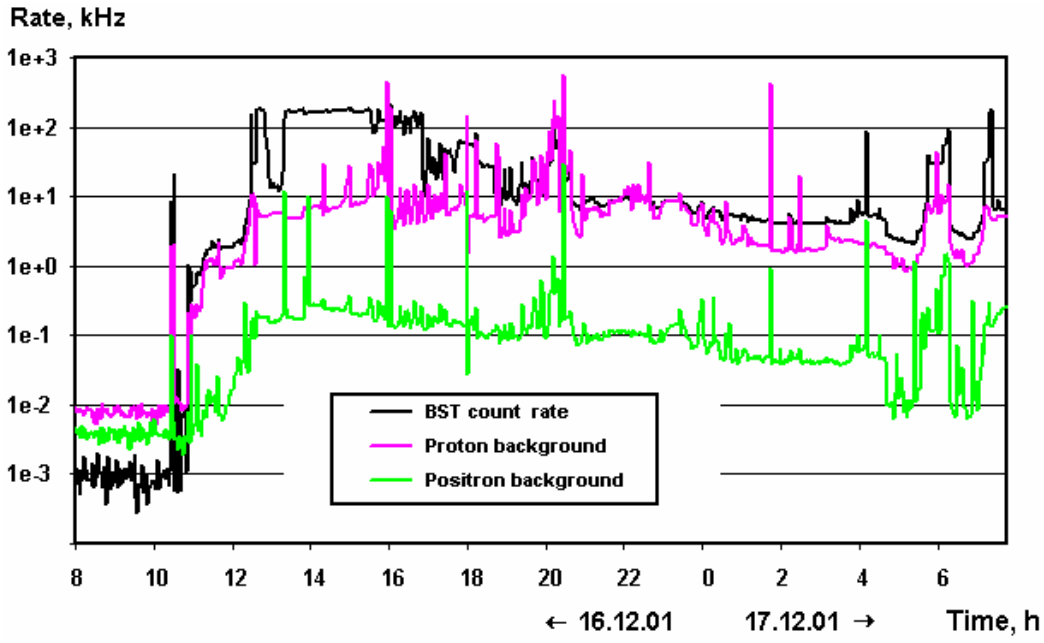
$$\dot{D} \approx 7{,}5\,Gy / year$$

Radiation Monitor for HERA

Reaction to the beam currents



Correlation with scintillation counter rates



Summary

- *The BST pad is a new level-one trigger of H1 with the fast timing response (50ns) and the online coherent noise suppression;*

- *Reprogrammable logic devices allow for the combined track trigger + veto functionality of this detector;*

- *The BST trigger system is being integrated into higher trigger levels of H1 to imply the granularity of the trigger hardware;*

- *In addition to the original plan, the BST pad detector is used as the main radiation monitor of H1 for understanding HERA backgrounds;*

- *With the repaired trigger electronics and improved background conditions the pad detector is becoming an essential device for low Q^2 physics.*

Acknowledgments

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Maxim Lukyanov ☺ Mikhail Kalmykov


HOCHSPANNUNG
HIGH VOLTAGE