H1 for HERA II

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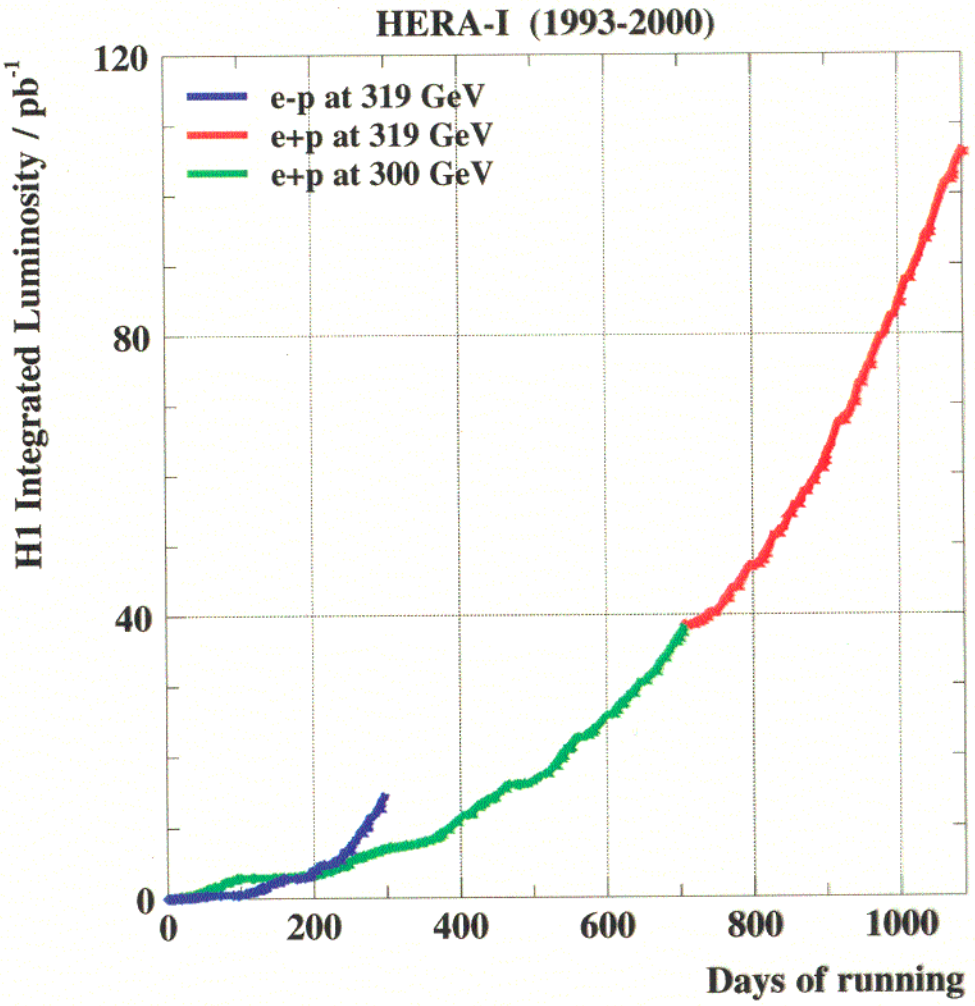
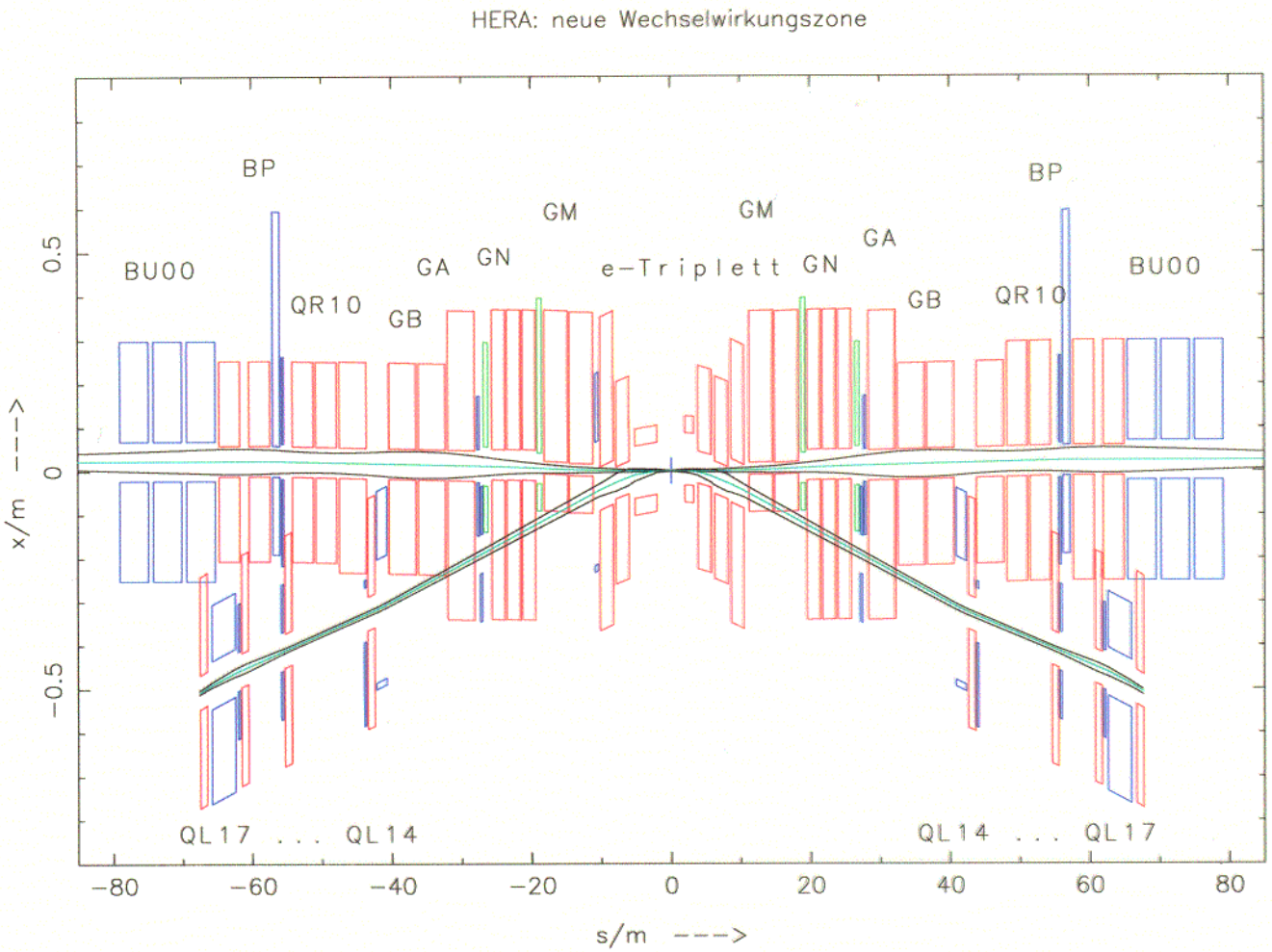
- HERA luminosity upgrade
- HERA startup
- H1 upgrades

Luminosity upgrade



- H1 collected $\int \mathcal{L}\,dt = 120\,\mathrm{pb}^{-1}$ in 1993 – 2000.
- Statistics limited for $Q^2 > 2000\,\mathrm{GeV}^2$, and for many exclusive measurements at lower Q^2.
- Next goal: $1\,\mathrm{fb}^{-1}$, with longitudinally polarized $e^{\pm}$ beams.
- History:
  - 1996 physics workshop
  - 1997 – 99 design and construction
  - Sep 2000 – Jun 2001 shutdown
  - Jul 2001 startup with 920 GeV p
  - Aug 2001 startup with 27.5 GeV e^+
  - Oct 2001 first ep collisions

New HERA interaction region



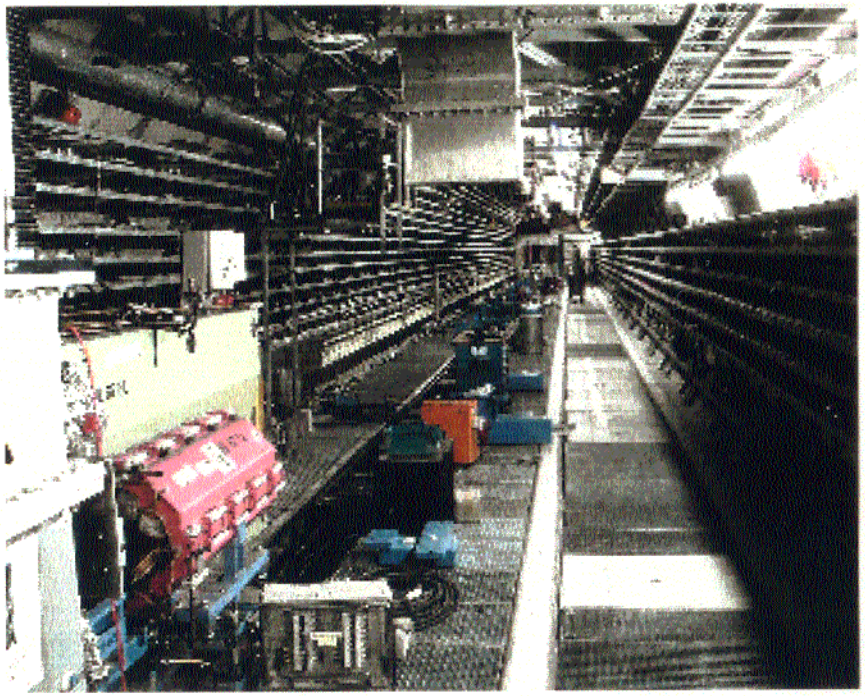
54 new warm magnets from St. Petersburg

4 new superconducting magnets from Brookhaven

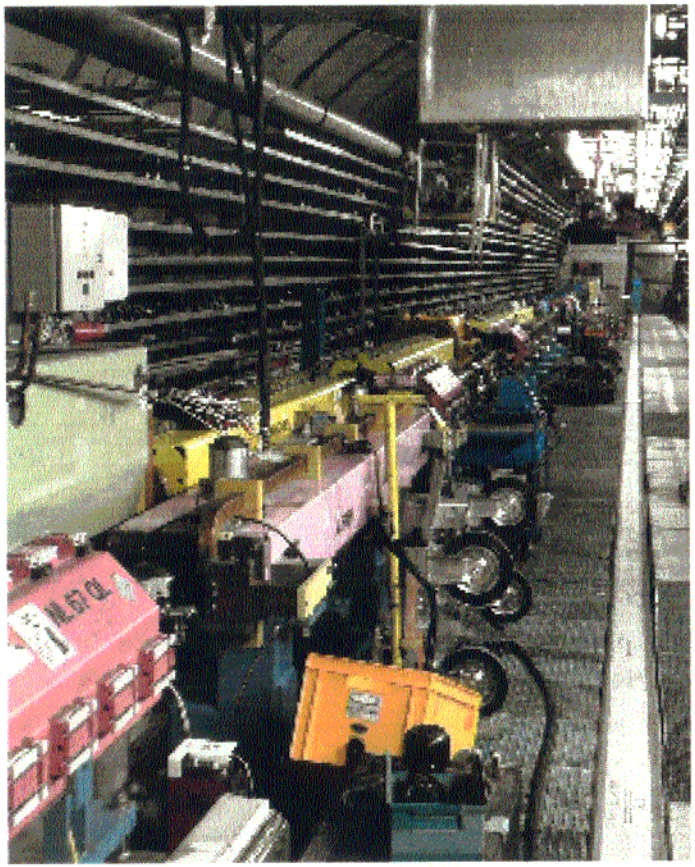
- e-bending magnets inside experiments
- earlier separation of e and p beams
- p focussing starts at 11 m instead 26 m
- $\beta^*_{y,p} = 0.18\,\mathrm{m} \approx \sigma_z$
- $\mathcal{L} = 7 \cdot 10^{31}/\mathrm{cm}^2\mathrm{s}$ for $I_p = 135\,\mathrm{mA}$ and $I_e = 55\,\mathrm{mA}$

HERA tunnel

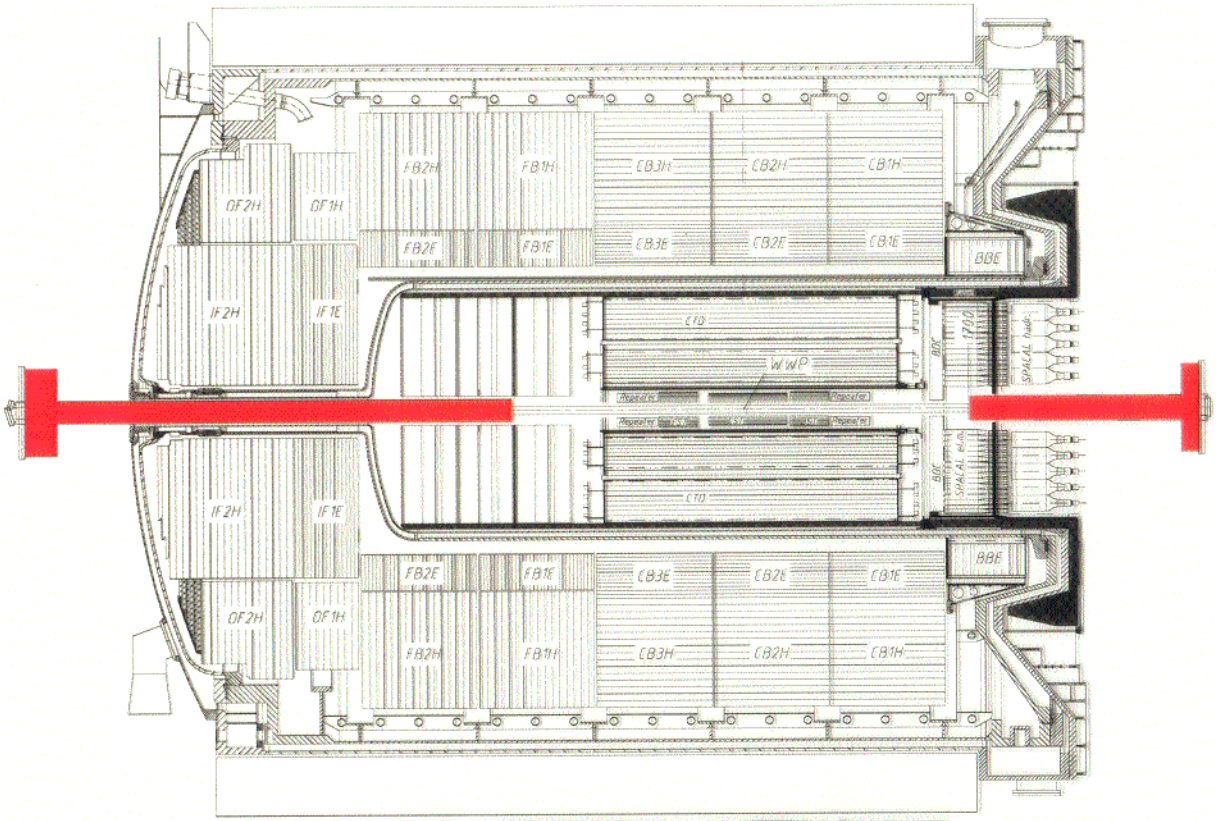
Dec 2000
Old magnets removed

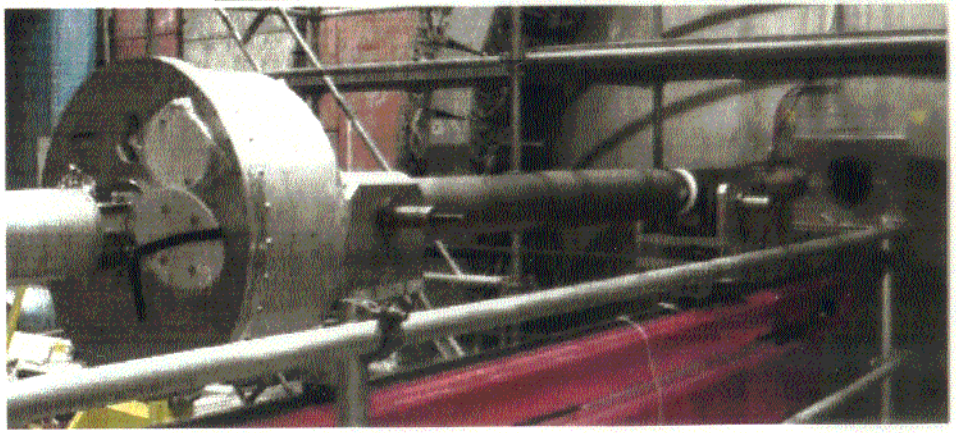


April 2001
New magnets installed



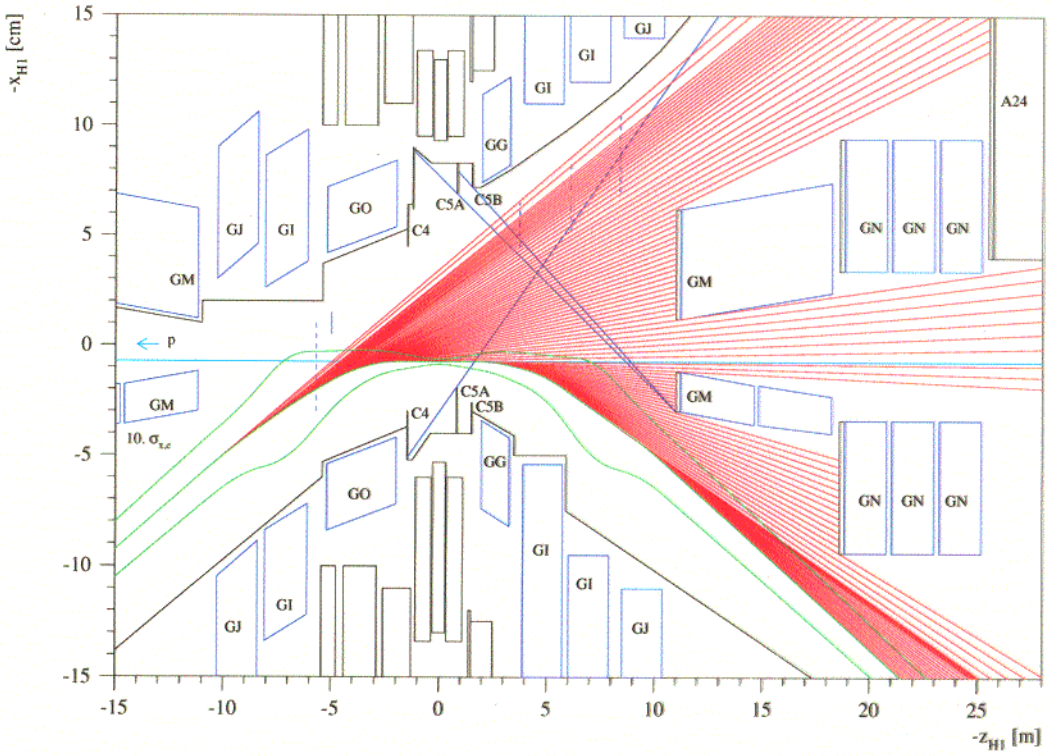
Superconducting beam magnets inside H1





- Tight space in LAr cryostat: $\emptyset < 18\,\text{cm}$.
- Superconducting magnets without iron.
- Combined function magnets: 5 coils.
- Movable supports inside H1.
- Stability requirement $< 0.1\,\text{mm}$ fulfilled.

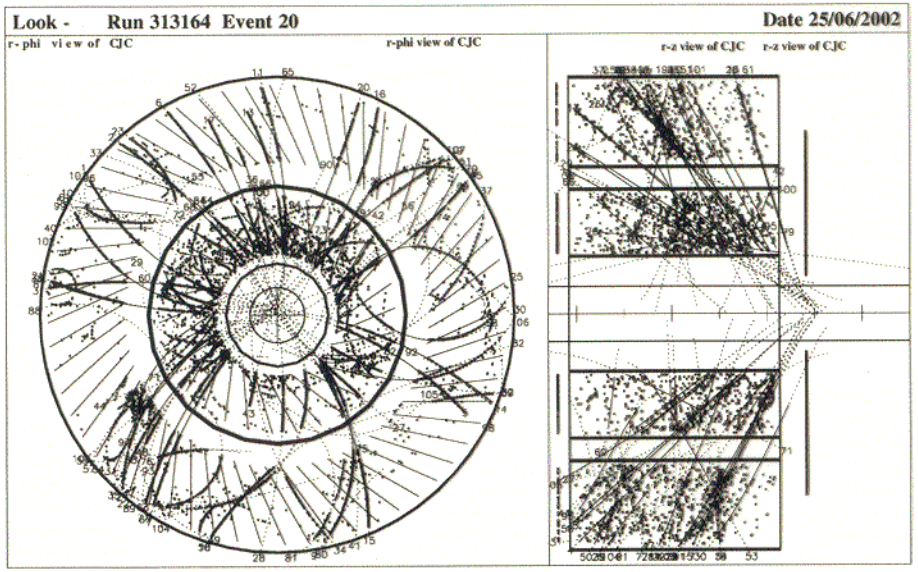
Synchrotron radiation

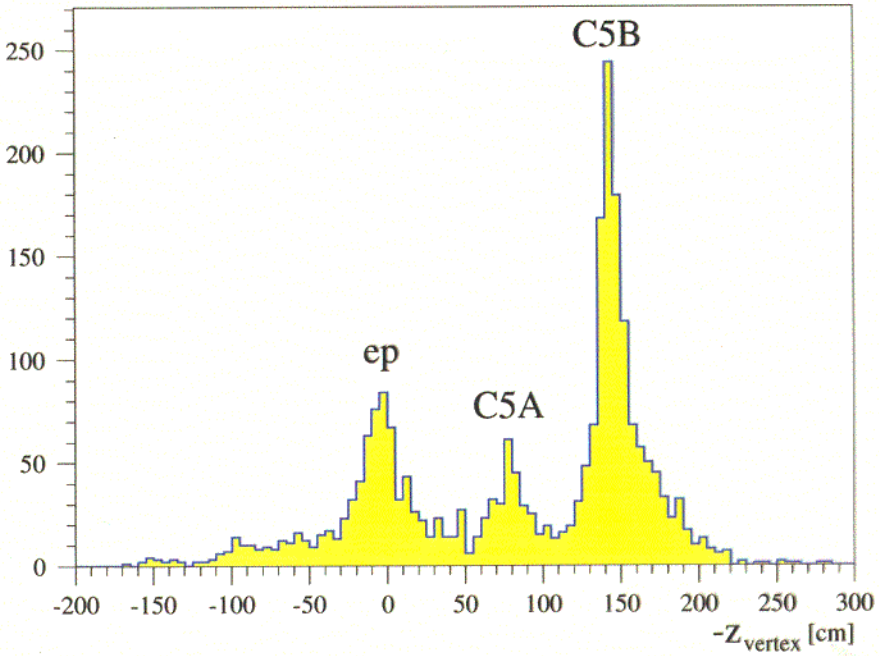


Top view, different scales in x and z.

- 10 mrad bend of e-beam $R = 400$ m, was 1280 m.
- Synchrotron radiation power 26 kW at 55 mA.
- Upstream collimation not possible anymore.
- Wide beam pipe for SynRad beam.
- First downstream absorber at 11 m.
- Collimators against backscattering.
- Tight tolerances.
- Had to increase vertical absorber opening in March shutdown.
- Found optimal beam orbit for H1.

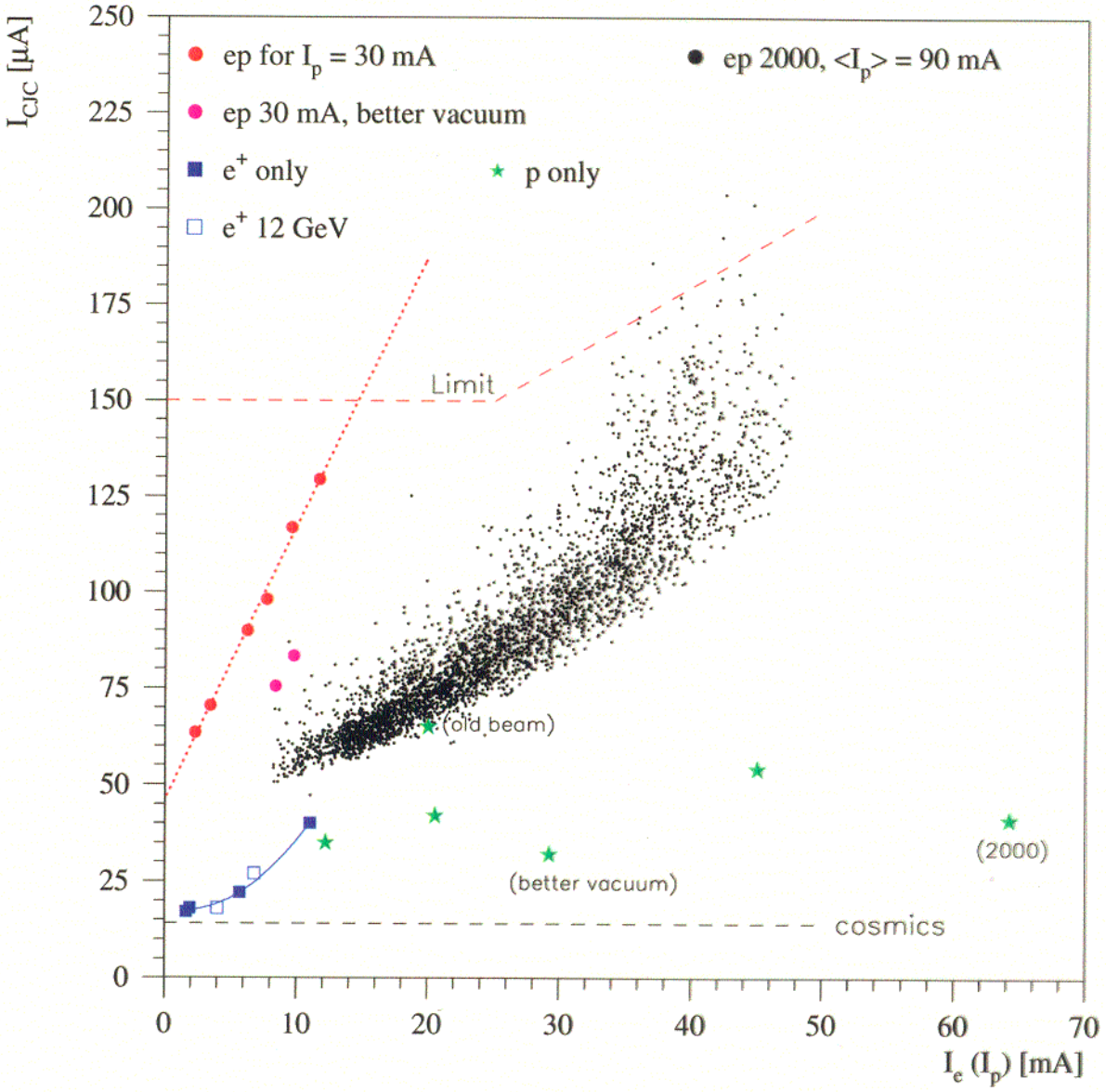
Proton background





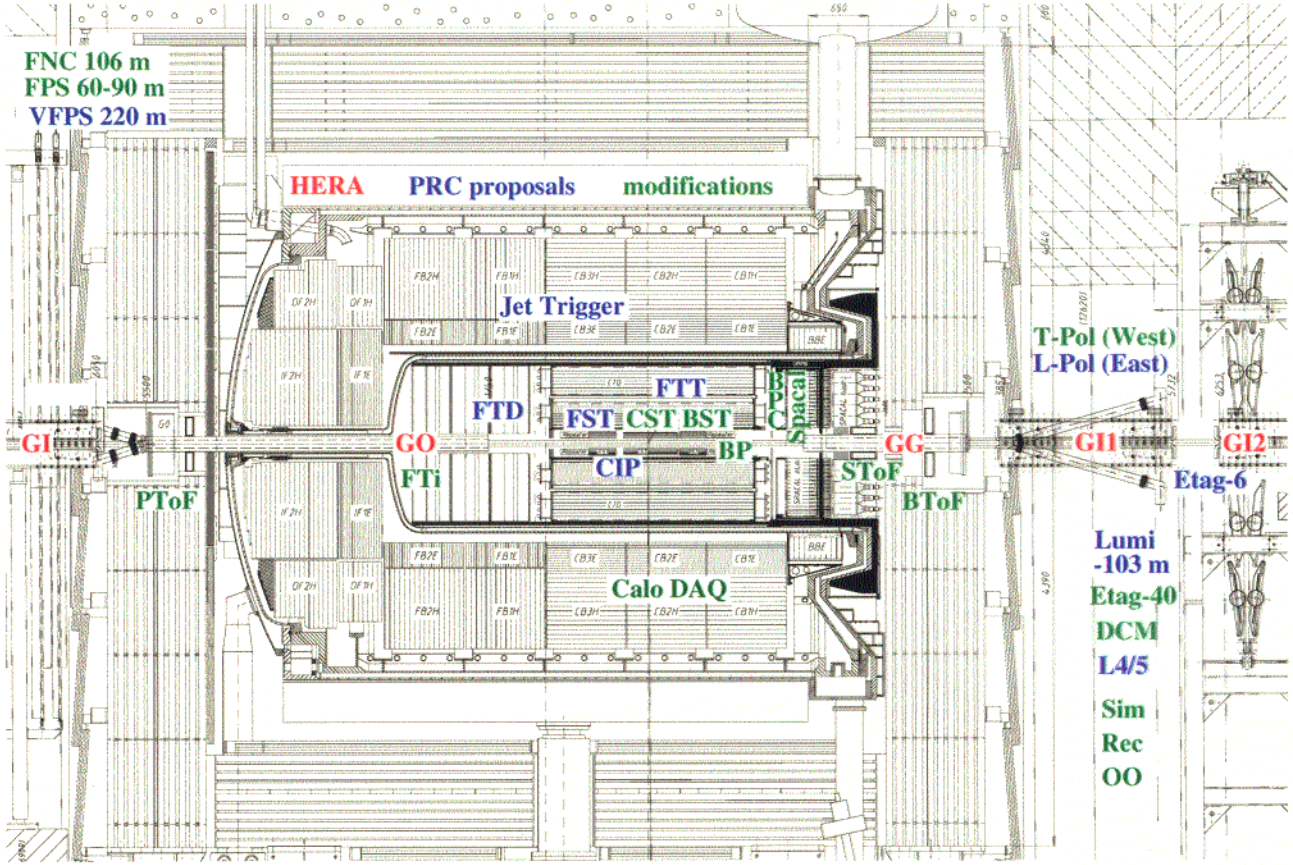
- Proton background dominates chamber current and trigger rate.
- Off-momentum hadrons interact with synchrotron radiation absorbers.
- Trigger background can be suppressed.
- Beam pipe vacuum has to improve for chamber currents.

Chamber current vs beam current



- Limit 150–200 μA to prevent ageing.
- p only: slightly worse than in 2000, improves with vacuum.
- e^+ only: equal at 27.5 and 12 GeV: all beam-gas.
- ep: increases with I_e: beam-gas with increasing pressure. Cold beam pipe stores impurities.
- ep: improvement after vacuum conditioning.
- Need $\times 10$ improvement.

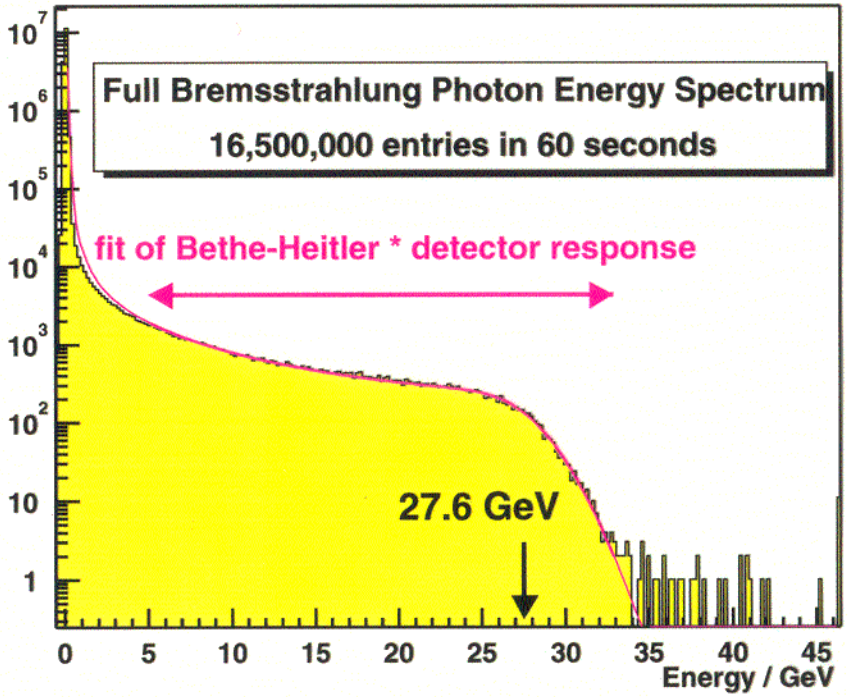
H1 Upgrade



- 19 upgrade projects
- emphasis on
  - Forward tracking: Si and DC
  - Triggering: tracks, low E_t jets
  - Luminosity measurement
  - Leading baryons

Unchanged: Liquid Argon calorimeter, central drift chambers, muon detectors, superconducting solenoid.

Luminosity measurement



- Bethe-Heitler process $ep \Rightarrow ep\gamma$.
- Up to 10 MHz rate at peak luminosity.
- Frequent multiple interactions: pile up in calorimeter.
- Determine rate from fit to energy spectrum, bunch-wise.
- Need fast local DAQ: dual processor PowerPC board.
- So far, HERA delivered $1.0\,\mathrm{pb}^{-1}$
- Highest specific luminosity so far: $\mathcal{L}_{\mathrm{spec}}^{\mathrm{max}} = 1.7 \cdot 10^{30}/\mathrm{cm}^2\mathrm{s}\,\mathrm{mA}^2$
- Design $\mathcal{L}_{\mathrm{spec}} = 1.9 \cdot 10^{30}/\mathrm{cm}^2\mathrm{s}\,\mathrm{mA}^2$

Silicon Tracking

New elliptical excentric beam pipe: BeAl, 1% X_0

FST:

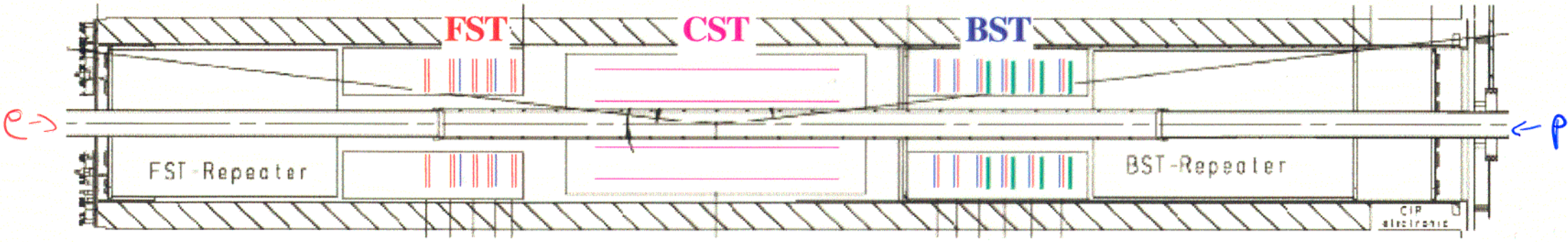
- New forward silicon tracker covering $7^o - 17^o$.
- 12 planes with strips in 3 projections.
- S/N = 32 for single-metal planes.

CST:

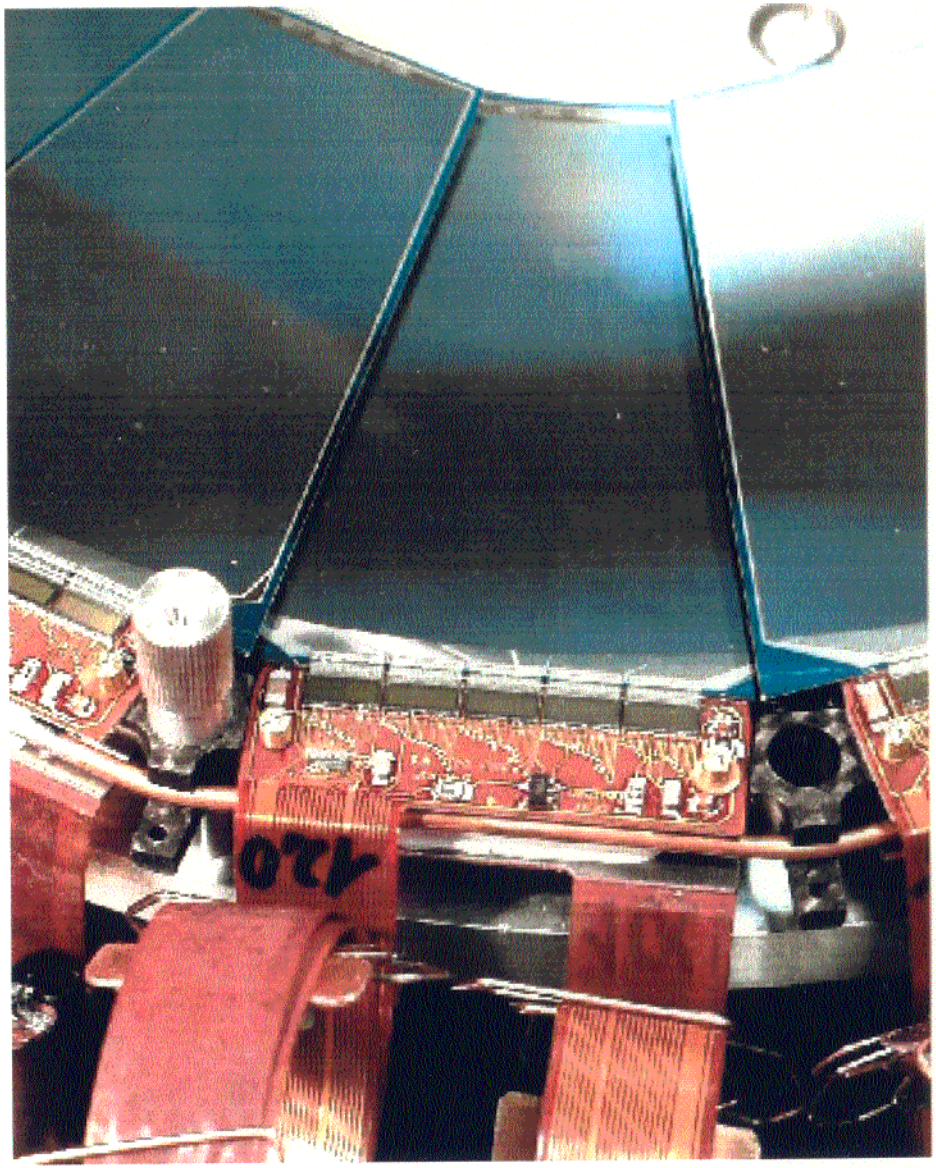
- 2-layer Si vertex detector for c and b-tagging operational since 1997.
- Adapted to elliptical beam pipe shape.
- Use radiation hard readout chips (DMILL).

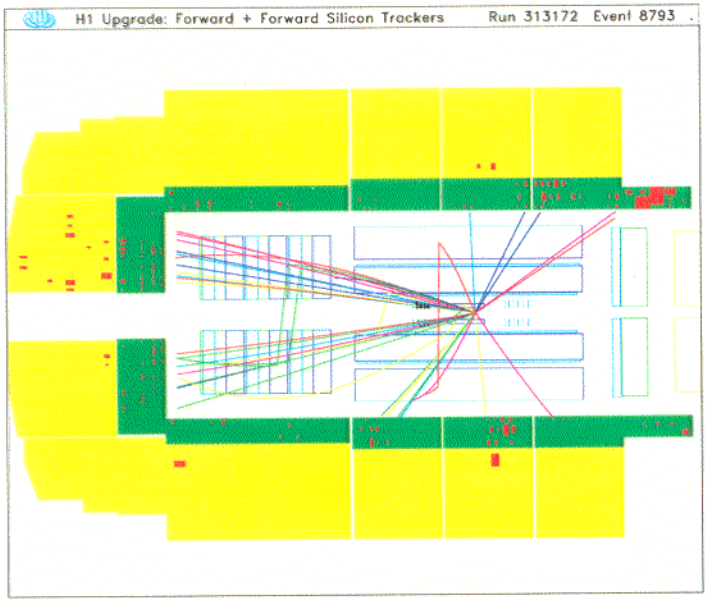
BST:

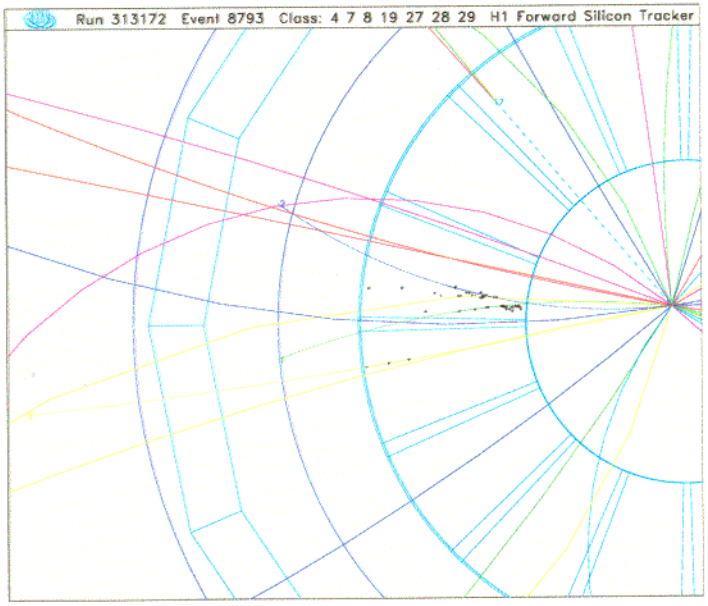
- 12-plane backward silicon for low-angle tracking operational since 1997.
- Adapted to new geometry.
- 4 Si pad planes for triggering.



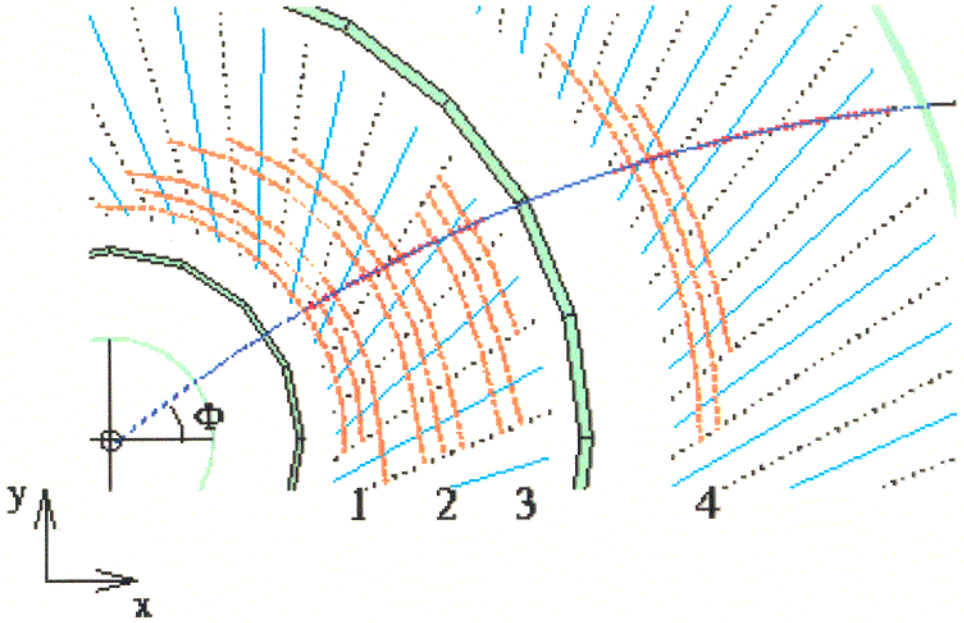
Forward Tracking



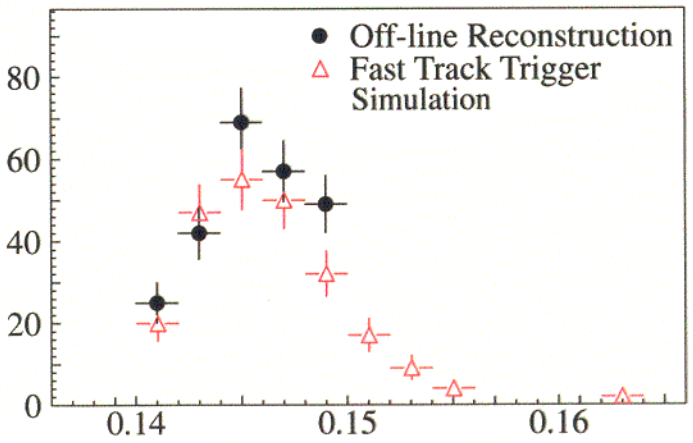




Fast Track Trigger

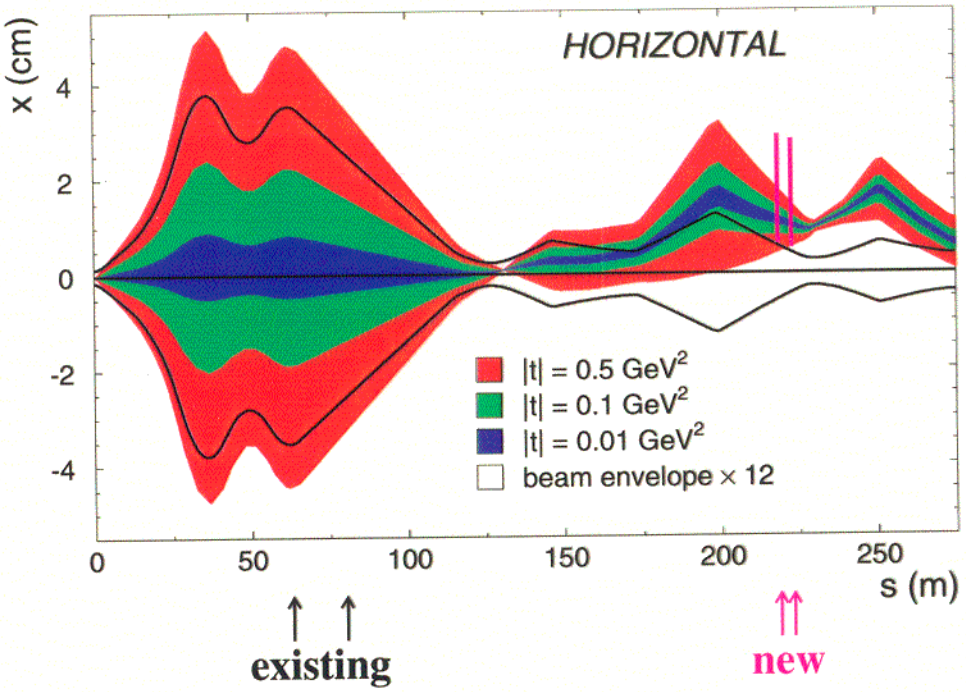


$D^\star$ finder ΔM:



- Use 12 of 56 wire layers in the Central Jet Chamber.
- Independent FADC, pipeline, hit finding.
- Coarse track finding in $r-\phi$: 2.2 μs with content addressable memory in large FPGAs.
- Refined track finding and eam-spot constrained 3-D track fit: 22 μs with DSPs.
- Invariant mass calculation: 100 μs with PowerPC CPUs.
- To be commissioned in autumn.

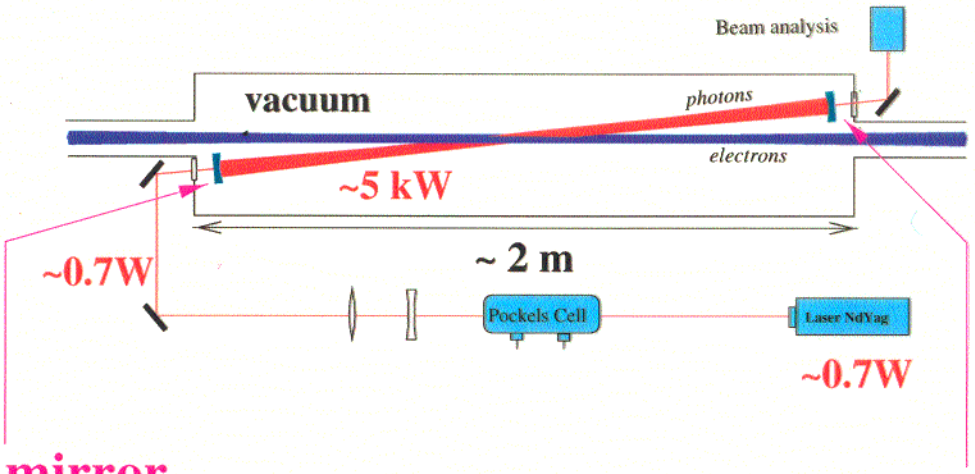
Very Forward Proton Spectrometer

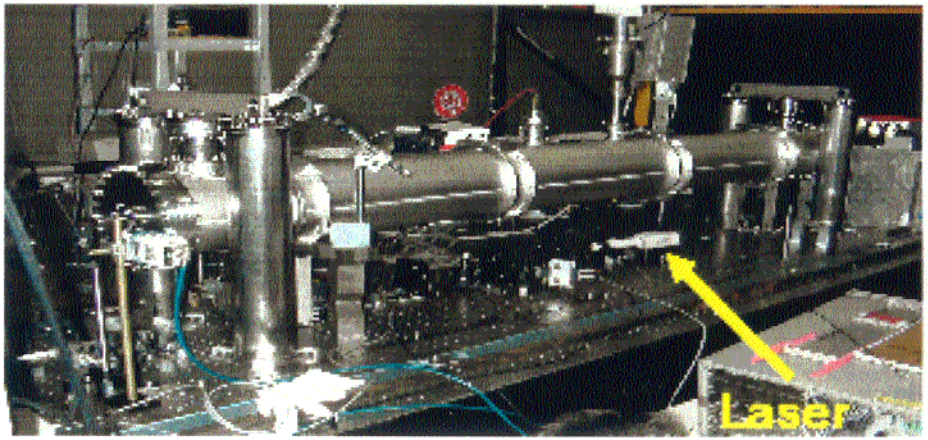


Proton envelopes for $E_p/E_{\rm beam} = 0.98$ ($x_{I\!P} = 0.02$).

- Measure diffractively scattered protons
- Use first proton bending magnets as spectrometer.
- 2 Roman pots with fiber tracking at 220 m from IP.
- Optimized for acceptance in $x_{I\!P} = 0.005$ to 0.03 and in $|t|$ from 0.5 GeV^2 down 0.
- Requires bypass for cryogenic lines and new warm beam pipe.
- Ready for installation in 10 week shutdown early 2003.

Polarimeter





- Expect $e^{\pm}$ polarization of 40–50%
- New spin rotators for long. pol. in H1 and ZEUS
- Existing transverse polarimeter upgraded: DAQ, Si
- Longitudinal polarimeter upgrade: Fabry-Perot lasrer cavity
- Goal: $\sigma_P/P = 1\%/\text{bunch}/\text{min}$ statistical
- $\sigma_P/P < 0.5\%$ systematic
- Search for right-handed couplings at 1% level
- Ready for installation early next year

Summary

- Challenging upgrade of machine and experiments completed.
- Rough startup period:
  - Synchrotron radiation background tolerable in H1.
  - Proton background requires better vacuum.
  - Gradual increase of beam currents until the end of the year.
- H1 is ready to take high Q^2 data.
- Dedicated projects for selected final states underway:
  - Drift chamber Fast Track Trigger: commission in autumn
  - LAr calorimeter Jet Trigger: early next year.
  - Very Forward Proton Spectrometer: install early next year.

- Goal: collect $1\,\mathrm{fb}^{-1}$, equally shared between e^+p and e^-p and with both lepton polarisations, until the end of 2006.