HERA Status

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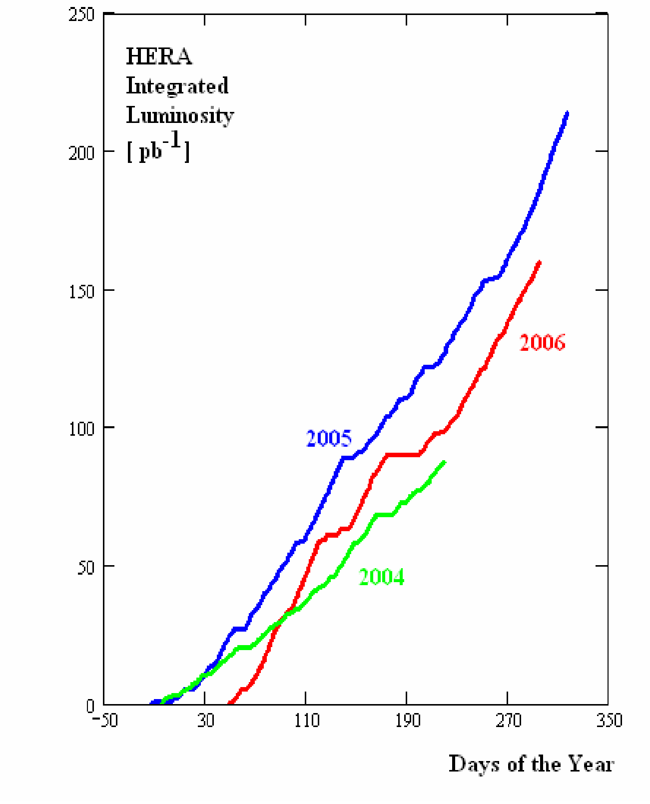
62th DESY PRC Meeting

October 23/24 2006

- 2006 Short Summary Electron Proton Run
- Switching from electron to positron
- Present HERA running
- Ongoing improvement program
- Preparation for low proton energy running



HERA 2006 Electron-Proton Running

Period: Mid February-end of June 2006 (124 days)

Integrated Luminosity 90 pb^{-1}

Run Characteristics

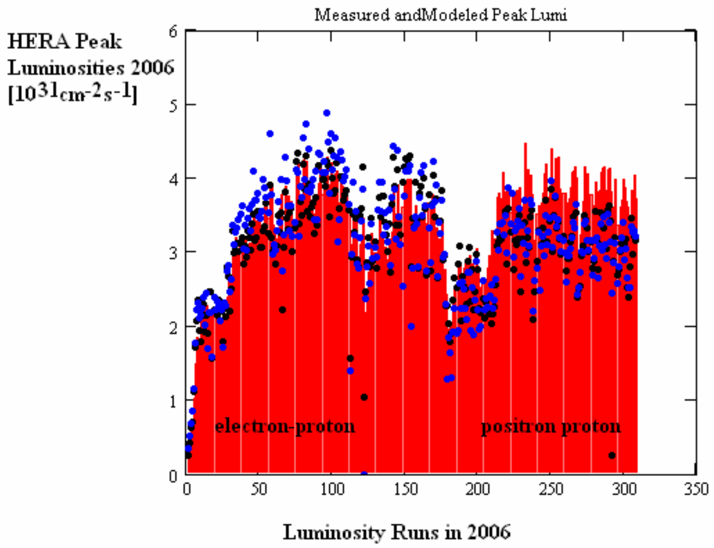
- High specific luminosity

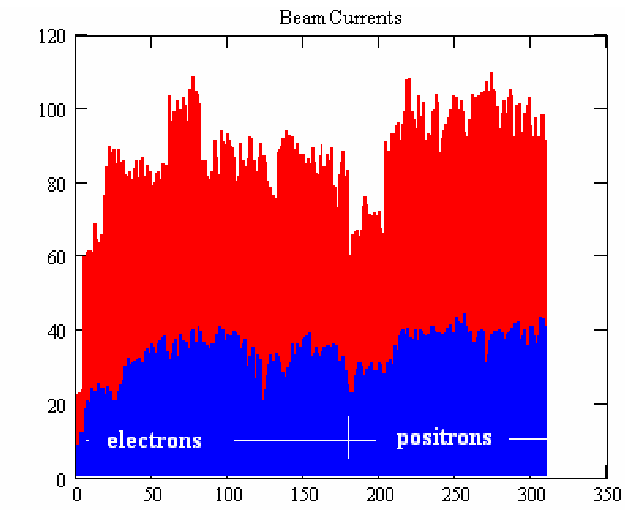
$L_{sp} > 2 \cdot 10^{30} mA^{-2} cm^{-2} s^{-1}$

- High peak Luminosity

$L_{sp} = 4.9 \cdot 10^{31} cm^{-2} s^{-1}$

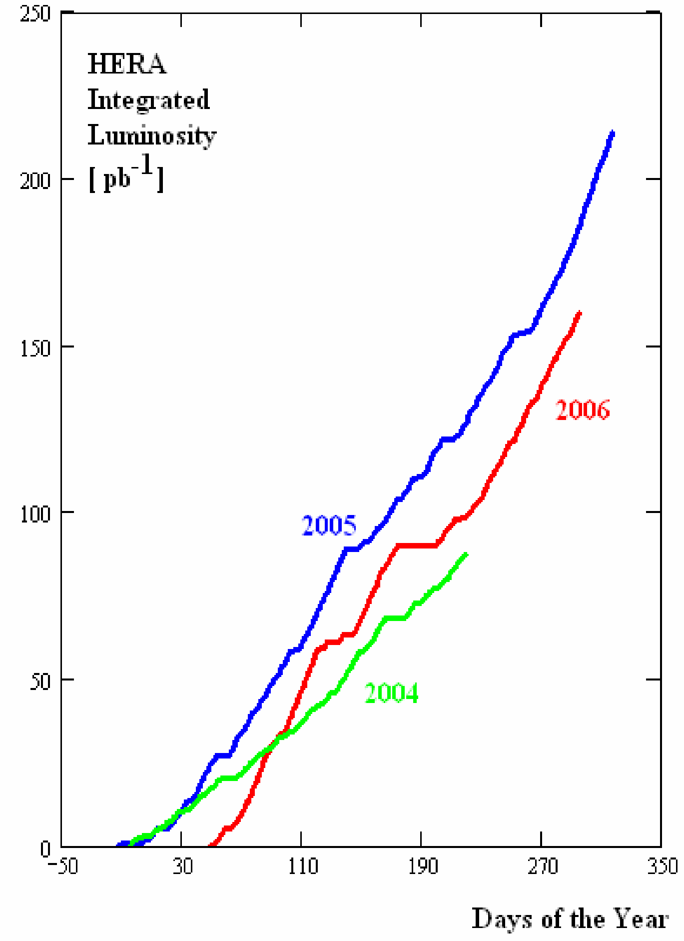
- Critical background conditions
- Electron beam current limited to about 40mA
- Second half of the run severely affected by HERMES target cell problems and a rotator leak
- Optics with smaller b not implemented due to unstable running conditions





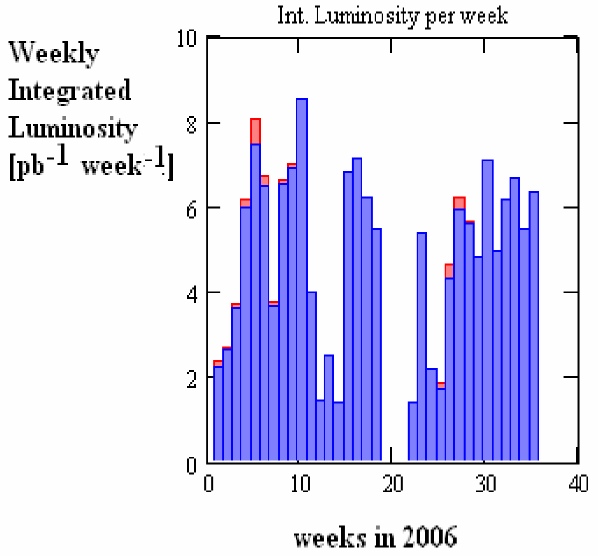
Switching from e^-p to e^+p running

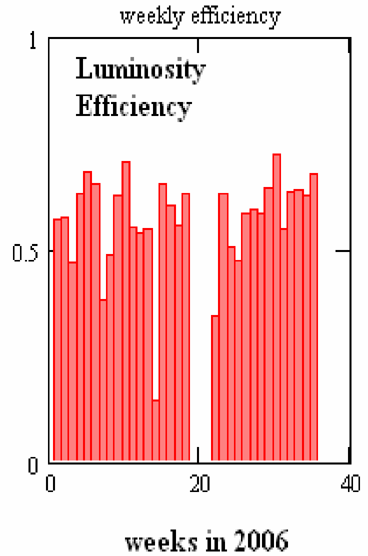
- Switching performed within 5 working days in the shadow of HERMES target cell and H1 calorimeter repair, quadrupole repair
- Accelerator tune-up within a few days
- Total:25 days
- Immediately after start-up efficient high luminosity running
- Luminosity smaller than in electron proton running but background conditions very good
- Running compared to 2004: less background, more luminosity, more efficient running

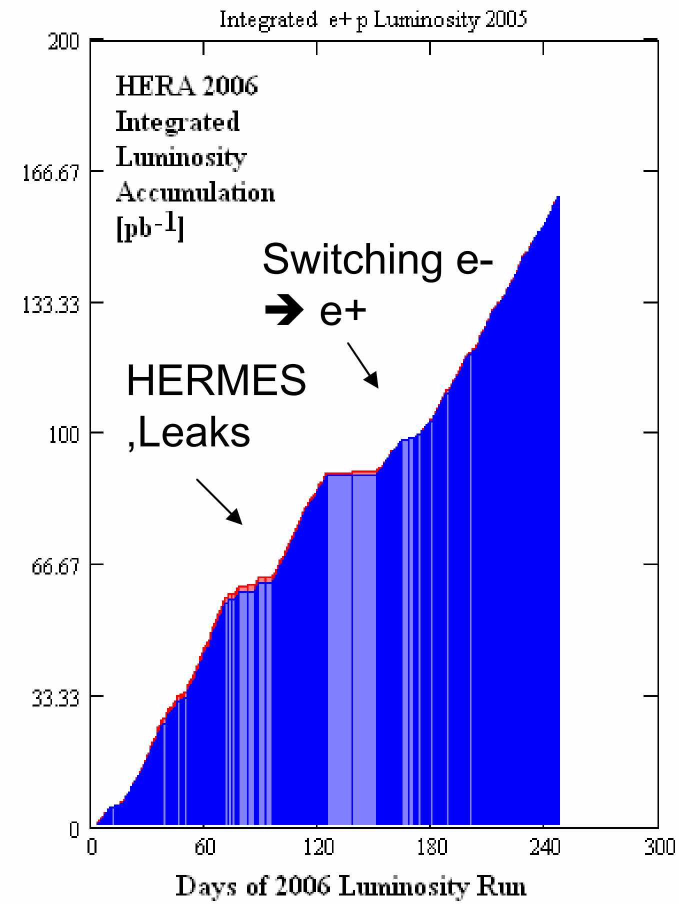


Luminosity Production & Running Efficiency

- Integrated 2006 e+p Luminosity: **70pb^{-1}**
- Positron proton running relatively smooth
- No large technical problems so far
- Increase of e+ current to 44mA relatively quickly but further increase of lepton intensity problematic (RF cavities, RF power)
- Operational efficiency very good: filling times of 3h and less frequent



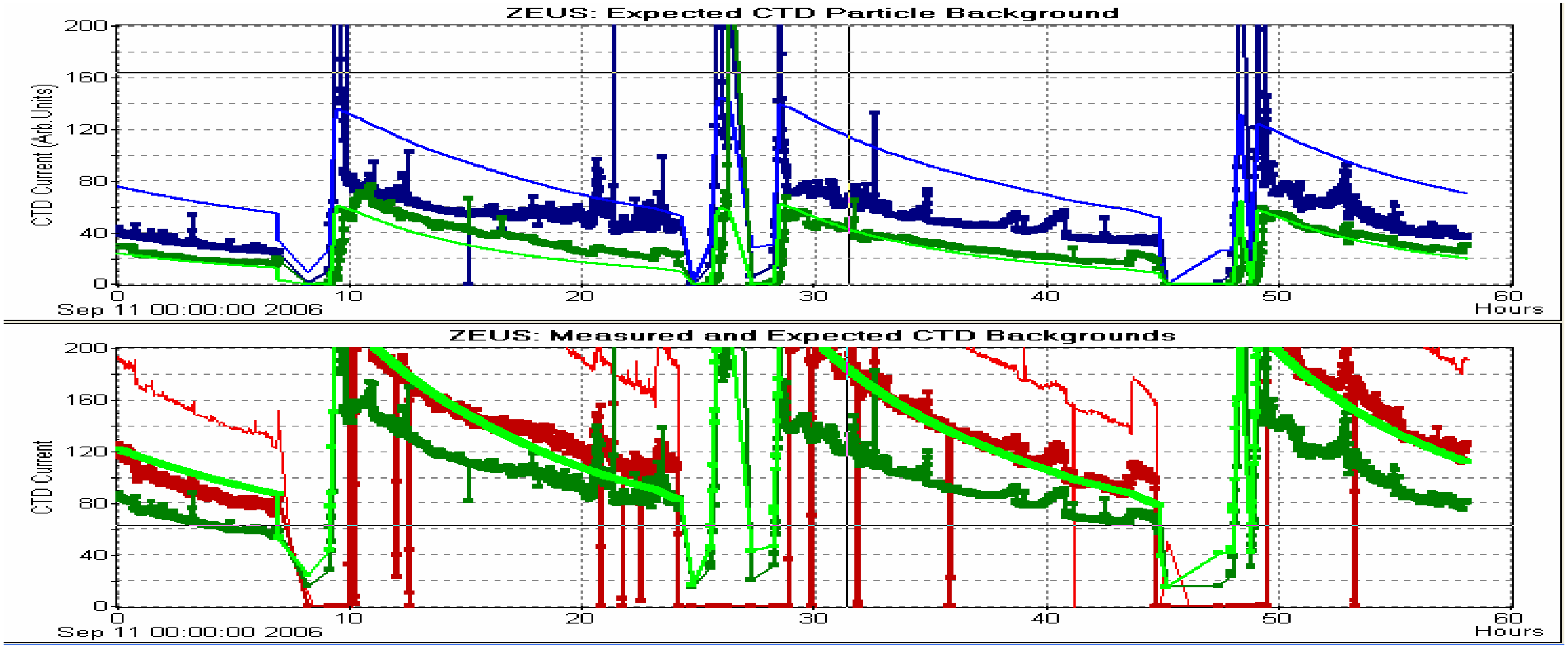




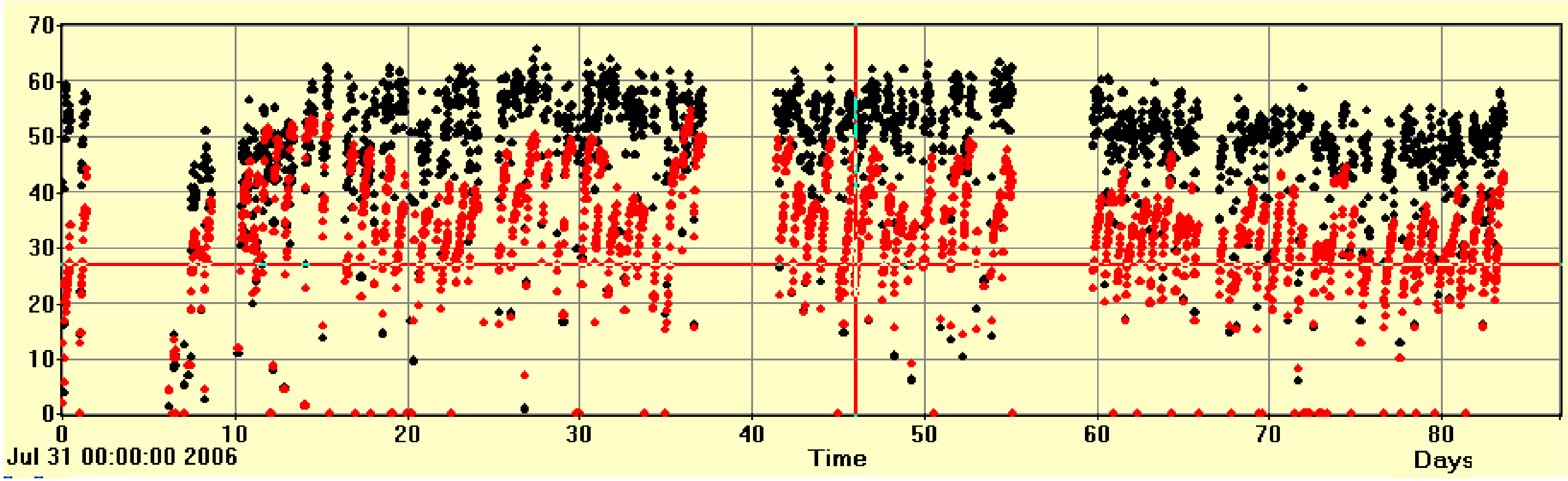
e^{+}-p Collision Operations

Backgrounds:

Positrons –Proton running more quite than electron proton running



Polarization



The polarization for the non-colliding bunches is 55%, quite stable

➔ Optimum polarization tuning

Polarization for colliding bunches is (35-50) %, continues to be anti-correlated with luminosity, profits from the somewhat reduced luminosity

lowering e+ tunes helpful

Accelerator Physics Issues of e^+p Running

Specific Luminosity in e^+p Running:
Dynamic β increases e^+ beam size for nominal tunes

- Implement positron optics with tunes below the integer (mirror tunes)

$L_{sp} \approx 2 \cdot 10^{30} mA^{-2} cm^{-2} s^{-1}$, but

Frequent blow-up of the proton beam when brought into collision presumably due to nonlinear beam-beam resonances

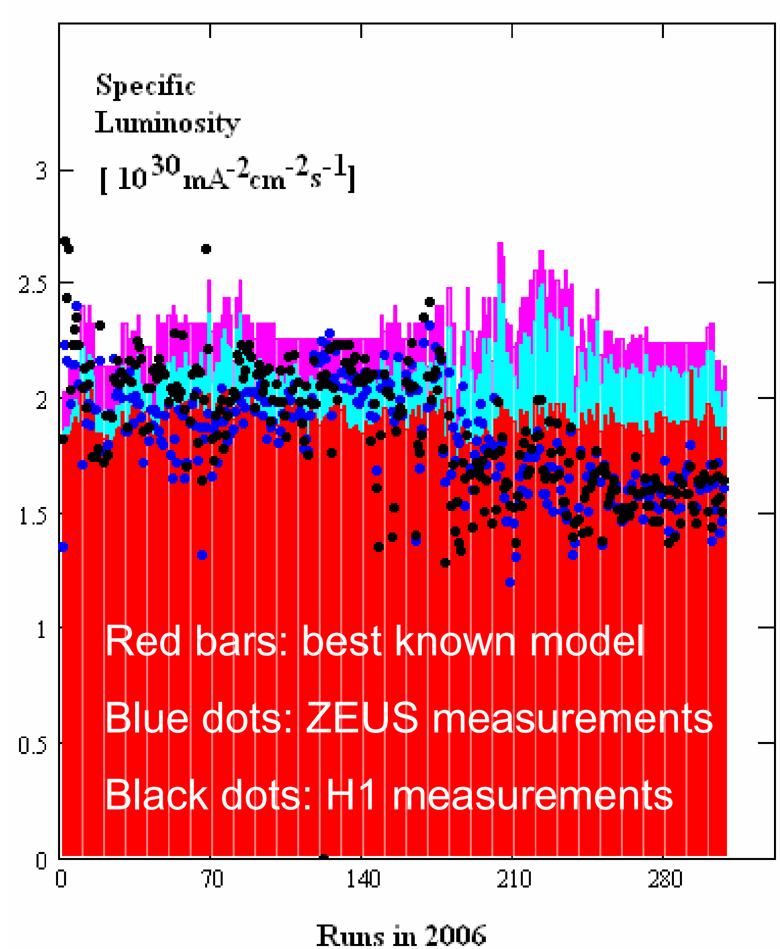
- Proton optics with mirror tunes implemented begin of August

No blow up, but reduced specific luminosity

$L_{sp} \approx 1.6 \cdot 10^{30} mA^{-2} cm^{-2} s^{-1}$

- Recent correction of dipole calibration error,

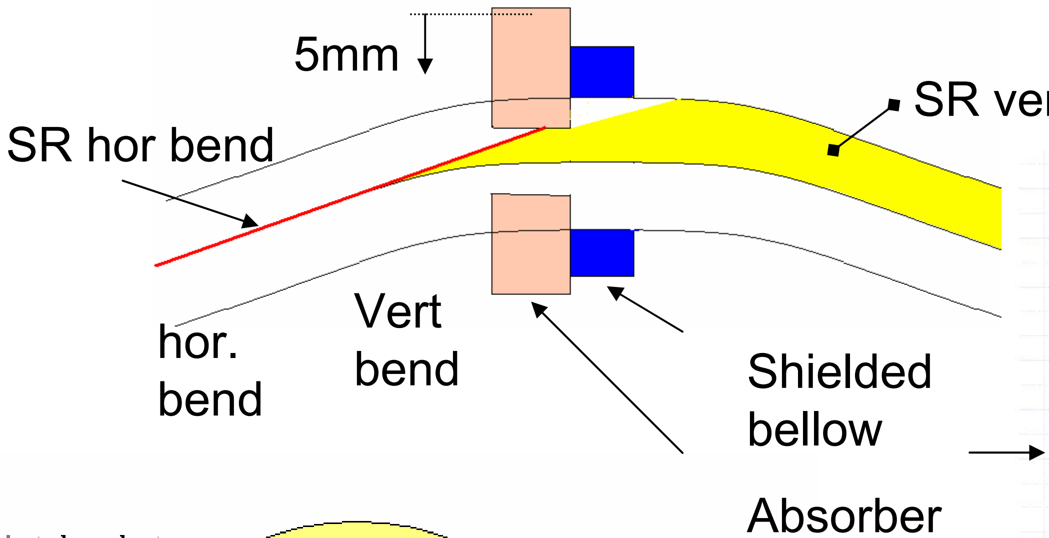
Small recovery of L_{sp} by 5%

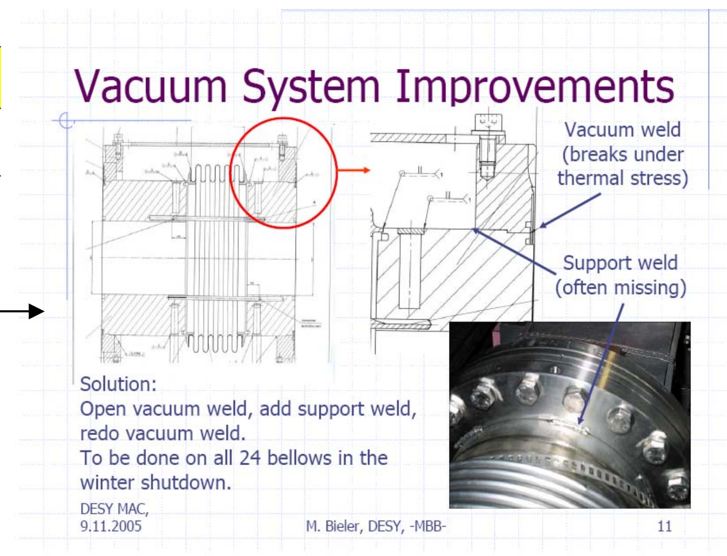


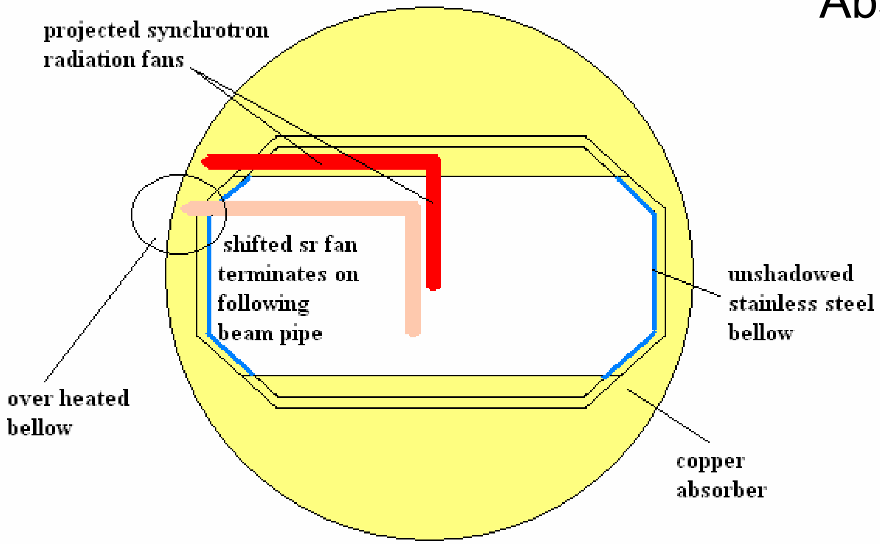
Improvements

- Technical improvements
- Beam optics improvements
- Fast orbit stabilizations
- Preparations for low energy running

Spin-Rotator Vacuum Leaks





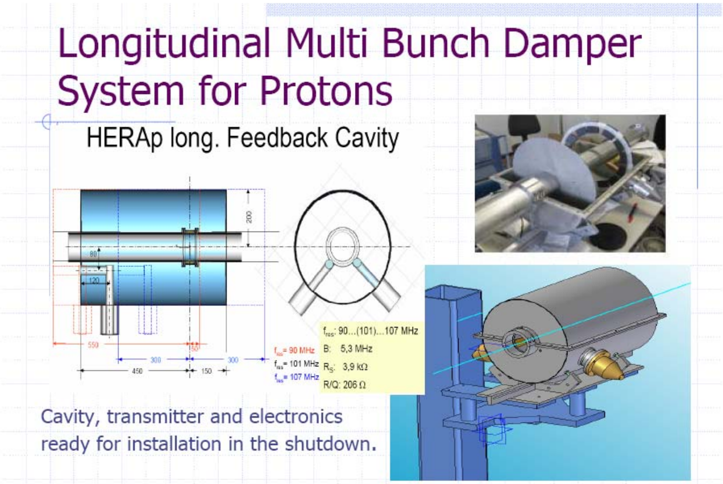


Found that spin rotator vacuum system has severe design errors

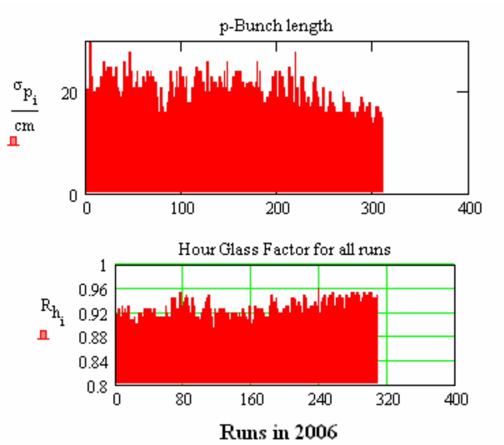
➔mitigated by 5mm Vertical shift of absorber position

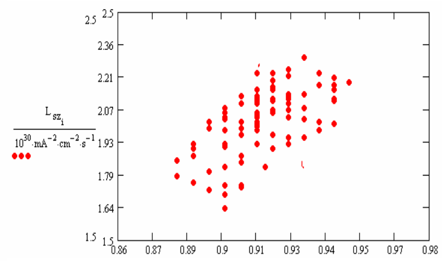
Control of Proton Bunch Length

- Longitudinal broadband damper system for the proton beam is running routinely and provides initial proton bunch lengths corresponding to the design value



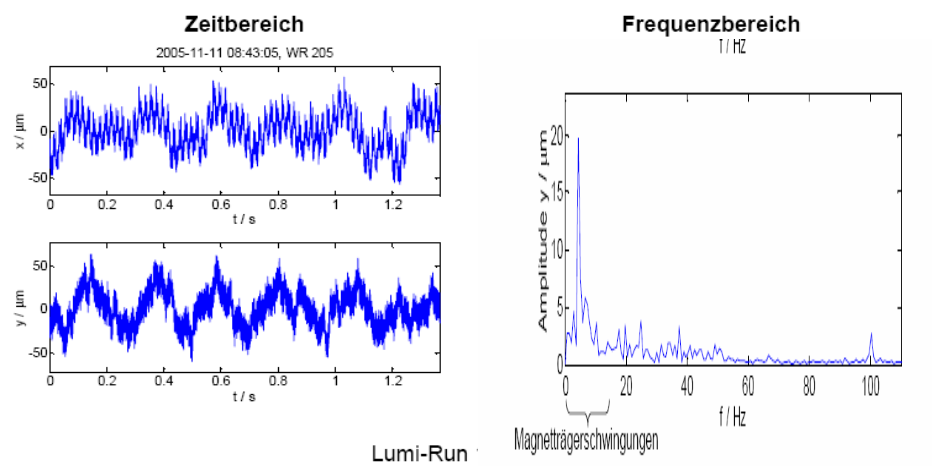
- The increase of the 208MHz RF amplitude was not quite so successful, but the voltage could be raised by 30%



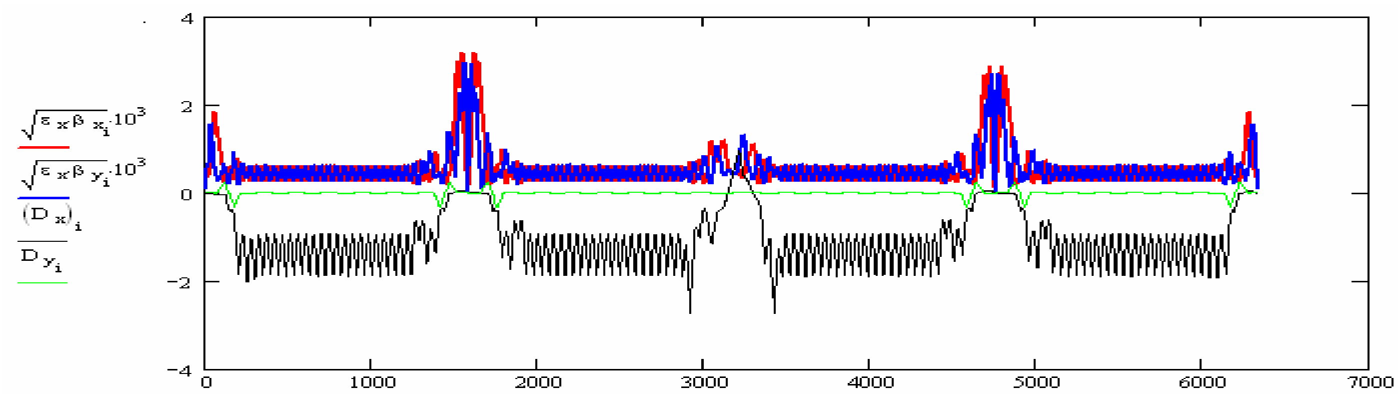


Fast Orbit feedback to reduce proton emittance growths and backgrounds

- Vertical& horizontal air coil correctors installed
- Fast BPM read-out working
- Drivers for air coil correctors implemented and tested
- System test planned October 26



Beam Optics with smaller β



- Did not get implemented for electron-proton running because of the difficulties with HERMES target cell and corresponding unstable running
- New oprics for positron proton optics with beta functions reduced by 20% have been implemented.
- Positron optics needs improvement (instable during optics transfer)
- Further improvements to be tested on October 26

Low Energy Optics

- Concepts and beam optics conceptual design completed, no news since the last PRC
- Present assumption: 27.5GeV Positrons on 460GeV protons, no hardware changes required
- Regular meetings between machine and experiments to prepare low energy running
- Beam optics preparation for tests in December 2006 underway
- Intermediate energy step at 690 GeV possible, no work done so far

Prospects of Low Energy Proton Running

Scaling of the Luminosity with Proton Energy

Luminosity $\propto \dfrac{I_p \cdot I_e}{\sigma_{xp} \cdot \sigma_{yp}}$

Adiabatic damping:
Proton beam emittance ~ $1/\gamma$

Aperture requirements:
$\beta_{IP} \sim 1/\gamma$

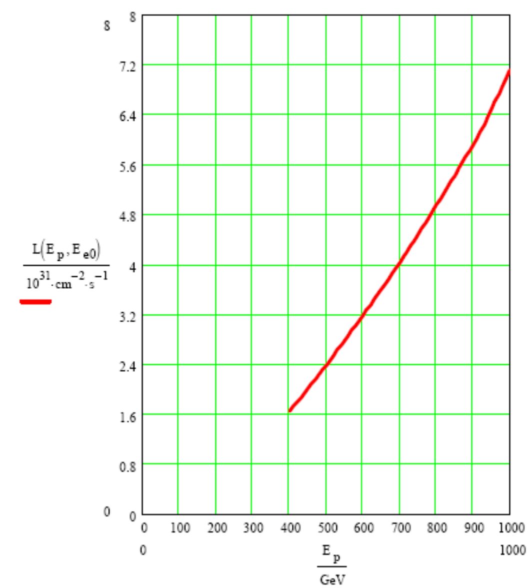
$\sigma_{xp}\sigma_{yp} \sim 1/\gamma^2$

No need to reduce I_e

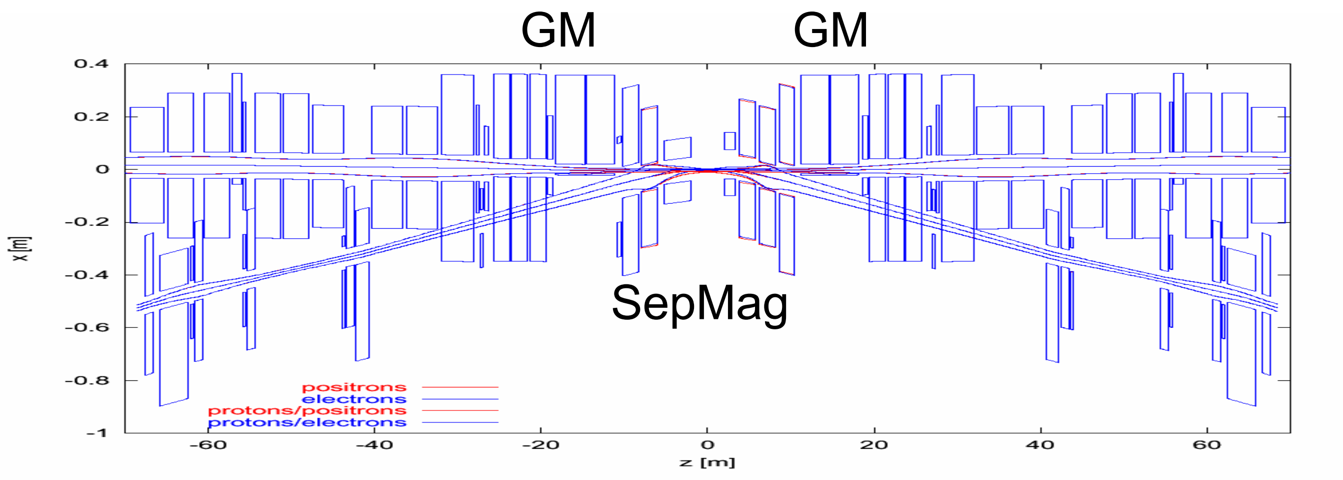
No possibility to increase I_p

$I_p I_e \sim$ const.

Luminosity scales as γ^2



Concept



Reduce GM Halfquad in strength to provide local compensation of the increased dipole kicks from separator magnets

leave all p-magnets in the nominal proton-positron/electron positions, quadrupole wiring unchanged

positron Lattice unchanged,

positron IR quads unchanged

Positron optics in the arc: 60 degree, no frequency offset ➔ 40nm

nominal positron/proton IP (-1mm?) (-7.5mm radially displace from detector axis)

➔ Optical Parameters:

β_{xp}=4.9m	β_{xe} = 1.20m
β_{yp}=0.36m	β_{ye} = 0.52m
ε_{Np}=16 mm	ε_{xe} = 40nm ε_{ye} = 6 nm

Transverse Beam Parameters

Normalized p Emittance $\varepsilon_{Np} := 4\cdot10^{-6}\cdot m$ $\varepsilon_{xp} := \frac{\varepsilon_{Np}}{\gamma_p}$ $\varepsilon_{xp} = 8.159\,nm$

e-Emittance $\varepsilon_{xe} := 40\cdot nm$ $\varepsilon_{ye} := 6\cdot nm$

p hor beta function, $\beta_{xp} := 4.90\cdot m$ $\sigma_s := 20\cdot cm$

p-hor rms beamsize $\sigma_{xp} := \sqrt{\frac{\varepsilon_{Np}\cdot\beta_{xp}}{\gamma_p}}$ $\sigma_{xp} = 1.999\times10^{-4}\,m$

p vert beta function, $\beta_{yp} := 0.36\cdot m$

p-vert rms beamsize $\sigma_{yp} := \sqrt{\frac{\varepsilon_{Np}\cdot\beta_{yp}}{\gamma_p}}$ $\sigma_{yp} = 5.42\times10^{-5}\,m$

e hor beta function, $\beta_{xe} := 1.20\cdot m$

e-hor rms beamsize $\sigma_{xe} := \sqrt{\varepsilon_{xe}\cdot\beta_{xe}}$ $\sigma_{xe} = 2.191\times10^{-4}\,m$

e vert beta function, $\beta_{ye} := 0.52\cdot m$

p-vert rms beamsize $\sigma_{ye} := \sqrt{\varepsilon_{ye}\cdot\beta_{ye}}$ $\sigma_{ye} = 5.586\times10^{-5}\,m$

Hourglass factor $u(\sigma_s) := \frac{\beta_{yp}\cdot\beta_{ye}}{\sigma_s\cdot\sqrt{\beta_{ye}^2+\beta_{yp}^2}}$

$$R(\sigma_s) := \frac{2\cdot u(\sigma_s)}{\sqrt{\pi}}\cdot\exp\left(2\cdot u(\sigma_s)^2\right)\cdot Kn\left(0, 2\cdot u(\sigma_s)^2\right) \qquad R(\sigma_s) = 0.974$$

effective Beam size $\sigma_x := \sqrt{\sigma_{xp}^2+\sigma_{xe}^2}$ $\sigma_y := \sqrt{\sigma_{yp}^2+\sigma_{ye}^2}$

$\sigma_x = 296.612\,\mu m$ $\sigma_y = 77.828\,\mu m$

Peak Luminosity

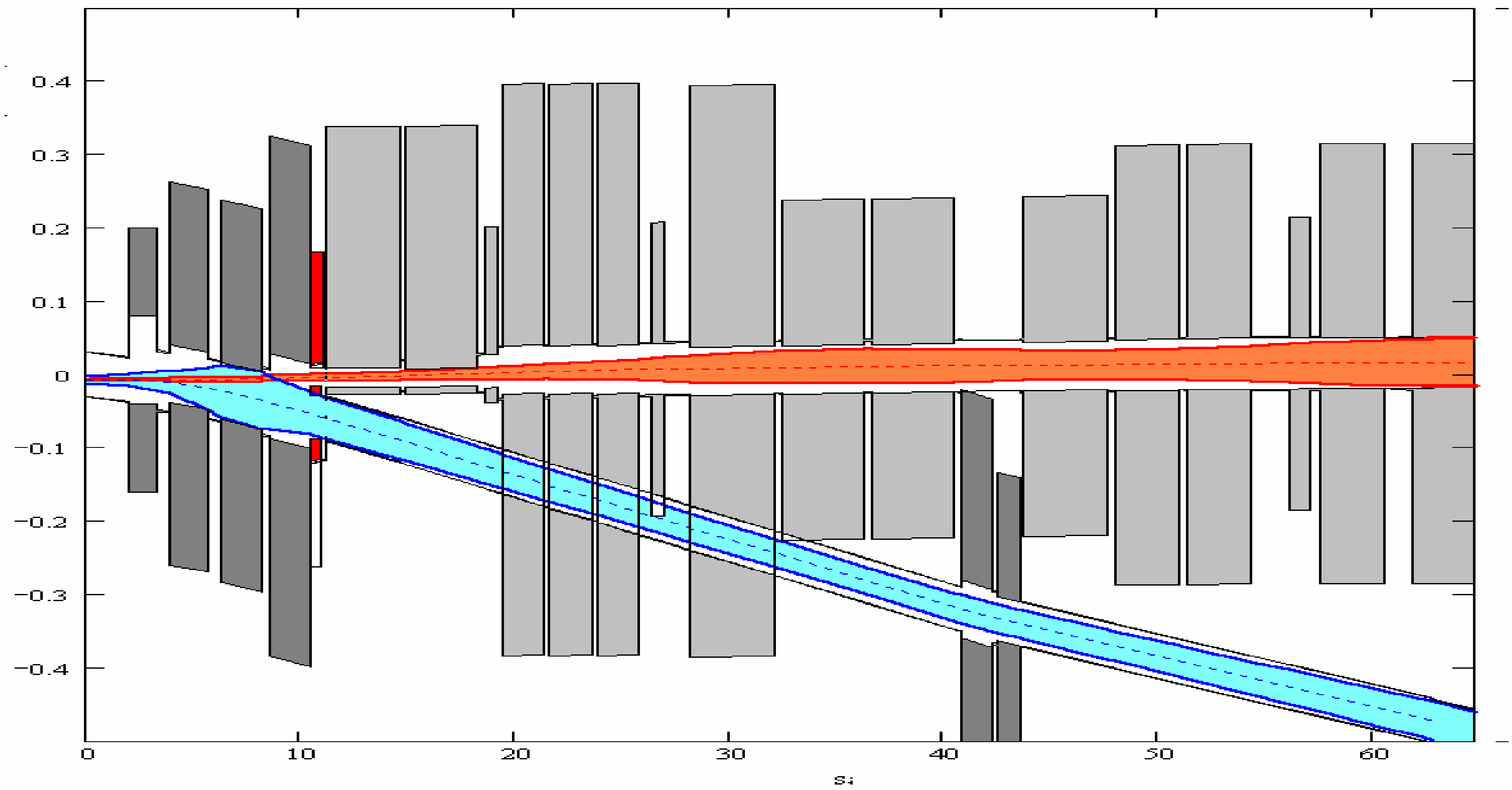
$$L_{peak} := \frac{N_p\cdot I_e\cdot R(\sigma_s)}{2\cdot\pi\cdot e\cdot\sigma_x\cdot\sigma_y}$$

$$L_{peak} = 0.147\,10^{32}\cdot cm^{-2}\cdot s^{-1}$$

Factor of ~4 reduction

6

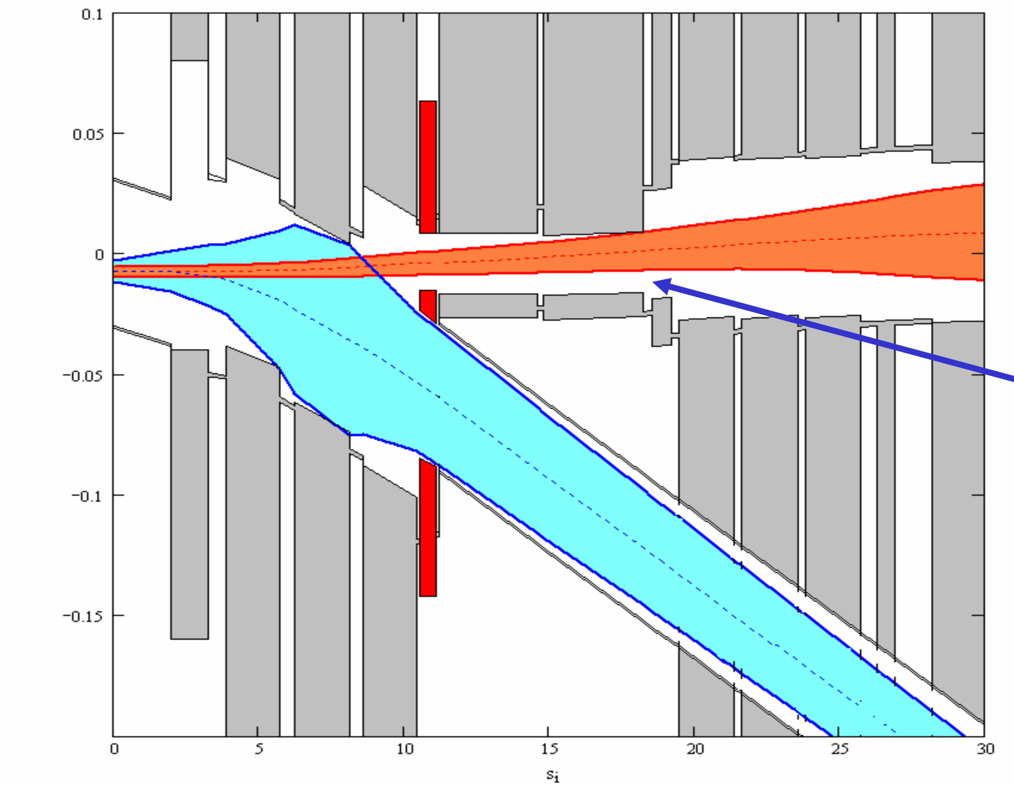
IR Top View

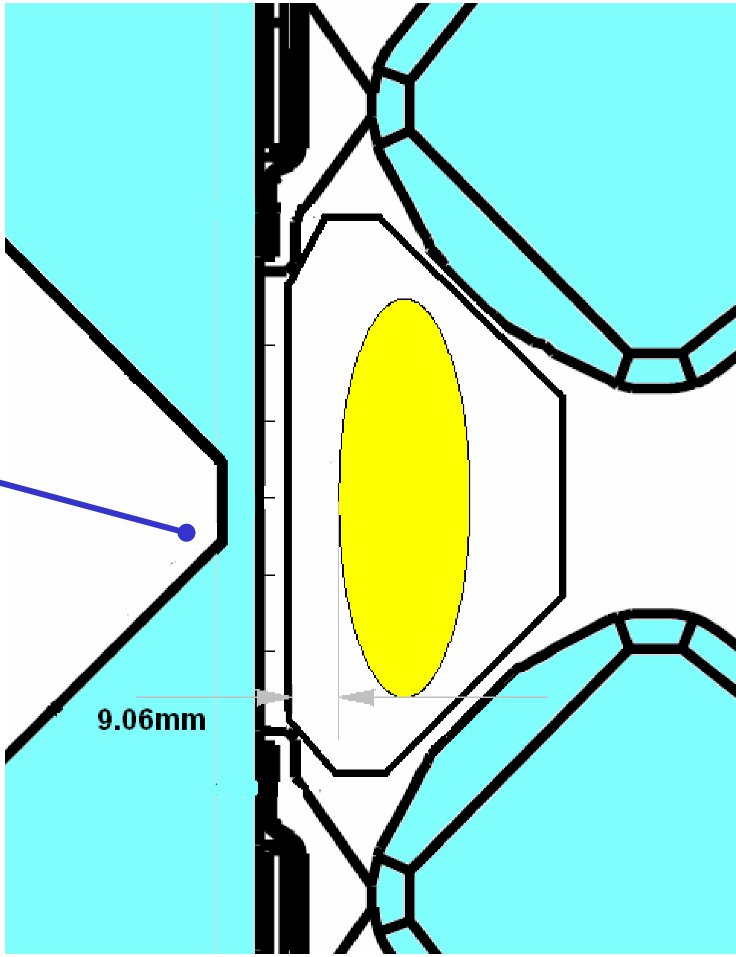


P-Magnets: Nominal positron/electron positions

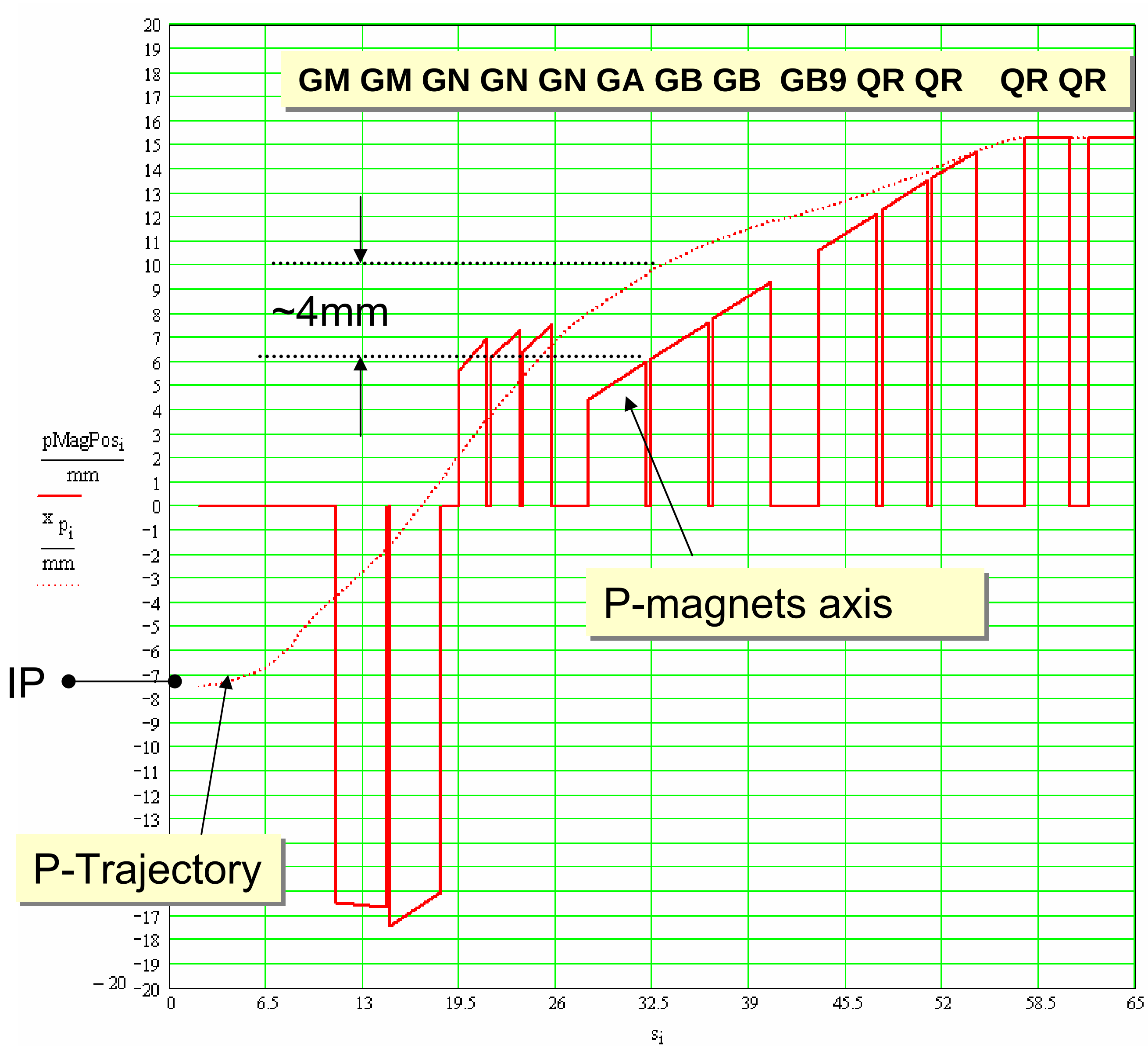
E-Magnets: Nominal positron positions

IR Top View Close-up

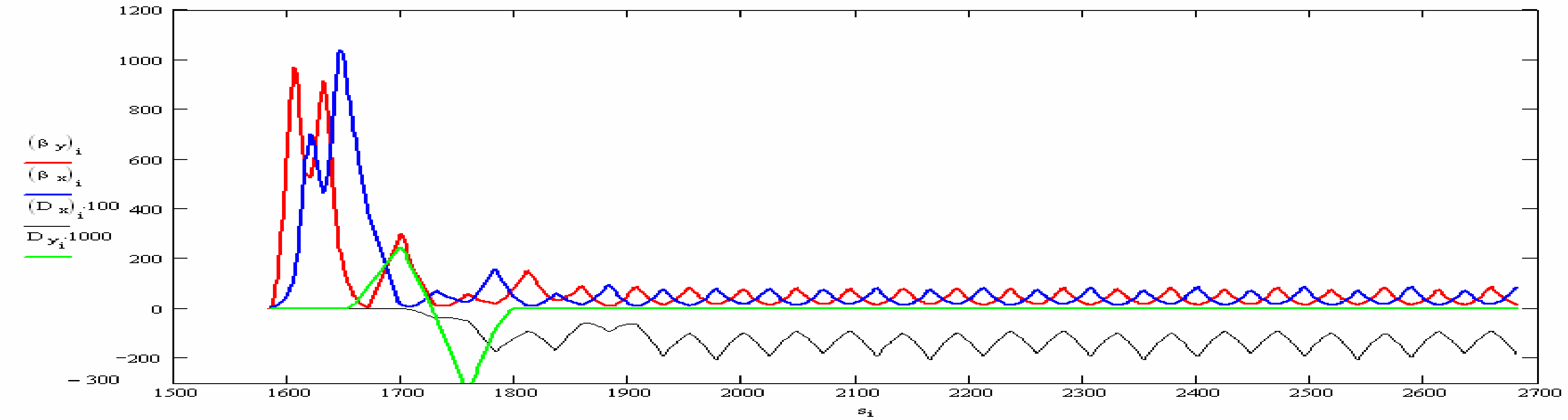




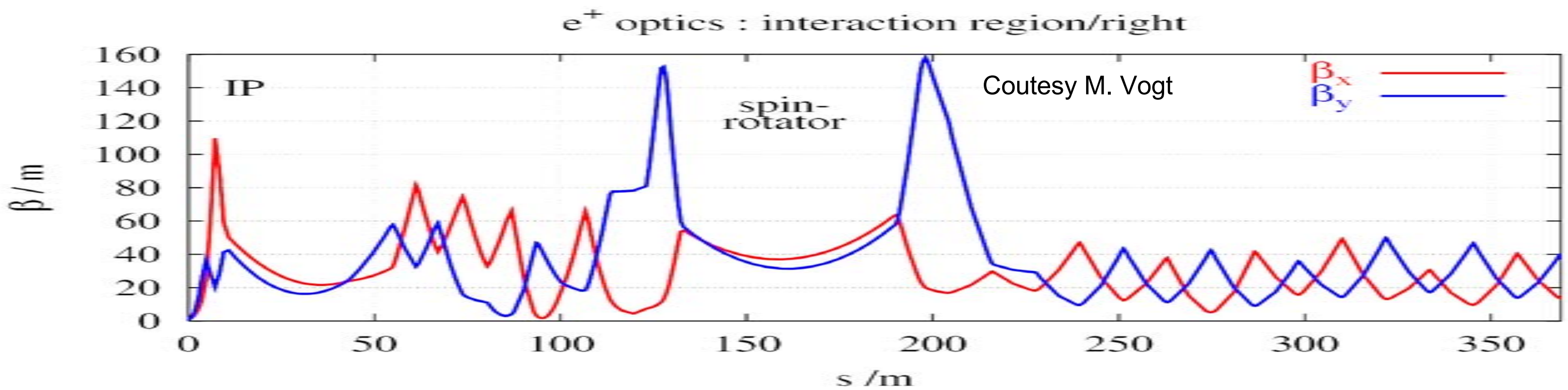
All p-magnets are now at nominal positions



P-Optics



Positron Optics



Required Preparation and Running Time

$$\int_{\text{one day}} Ldt = 200\ \text{nb-1} \quad @\ \ 460\text{GeV}$$

Assuming a data taking efficiency of **70%**
luminosity of **14.4 pb^{-1}** needs to be delivered to get **10pb^{-1}** on tape

In order to deliver an integrated Luminosity of **14.4 pb^{-1}**, with 200nb^{-1}d^{-1} need **72** days plus a two-week set up time

The accumulation of 10 pb^{-1} by the experiments will require a running time of **86** days.

Some of the preparation (preparation of machine files) can be performed at MD after maintenance days

In order to assess the major expected difficulties, a dedicated study time will be necessary.

Early studies will require additional time to be taken away from high energy running

HERA Running Until 2007

- Luminosity Running until short Christmas break 2006/2007)
- Further small improvements underway
- Run 2007 from Dec.26-June 30
- ~289 Days of running left
- switching to lower energy running if requested in March or April 2006

Conclusion

- HERA switched successfully from electron-proton running to positron proton running
- Positron proton running provides better background conditions but 20% less luminosity per unit time
- The polarization continues to be sensitive to the beam-beam parameters but profits from the somewhat smaller peak luminosity
- HERA pursues its improvement program, but some items are delayed and the benefit with regard to the overall HERA luminosity will be small
- The preparation of the low proton energy running have progressed. First tests of the new beam optics are planned for the end of 2006.