Very Forward Proton Spectrometer VFPS @H1
An Overview

- VFPS : purpose/location
- VFPS implementation
  - Cold bypass
  - Roman pot structure
  - Fiber Detector
- VFPS operation
  - Trigger & Readout
  - Roman pot controls / user interface
  - Roman pot movement
  - Some experiences …
- Collected data /data quality
- First look onto analyses
  - Inclusive diffraction
  - Diffractive jets
- Momentum reconstruction
- Conclusions

Purpose of VFPS

- Purpose VFPS

  ➪ tagging of diffractive proton with
  1. Large acceptance in x_p
  2. Full t coverage (down to t_{min})

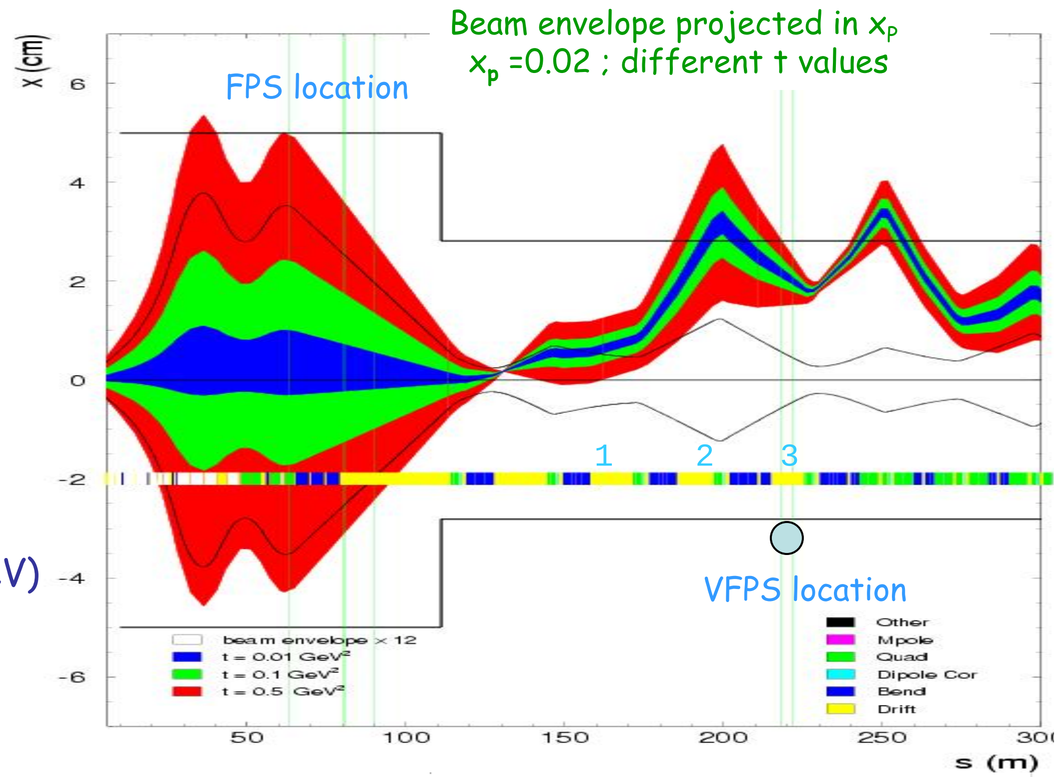
- Complementary to FPS (H,V)
  - Small acceptance in larger x_p range
  - limited t-acceptance (0.08 < t < -0.5 GeV)

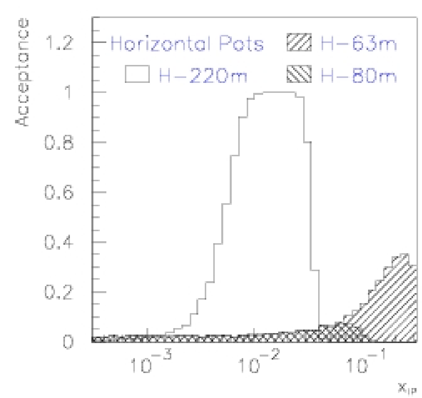
- Location
  - 3 possible locations
  - Best acceptance in (x_p,t) @ 220 m
  - Roman pots located

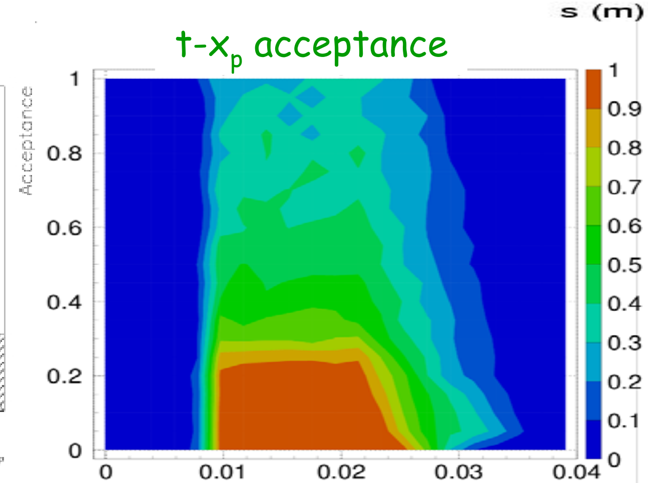
    @ 218 m ➪ VFPS1

    @ 222 m ➪ VFPS2

- VFPS location in cold HERA section







VFPS Cold Bypass

Bypass chronology

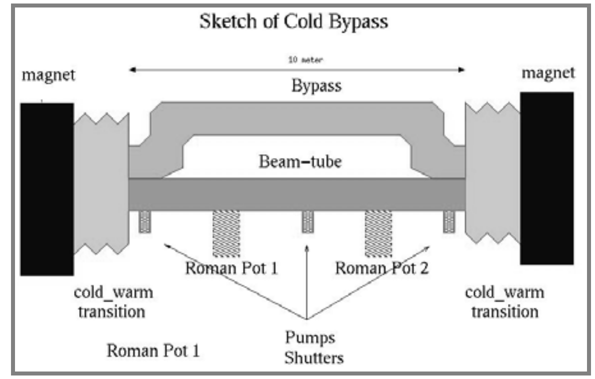
- 2000 first ideas to replace
-   Roman pots cold ?
-   Roman pots warm ?

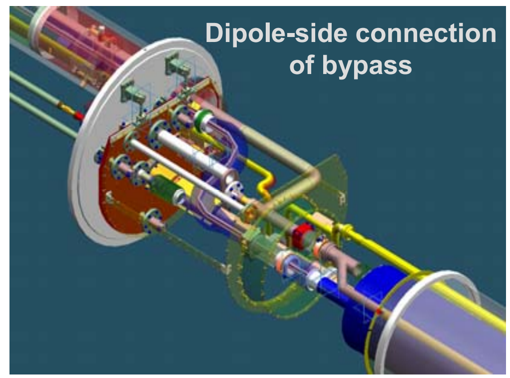
- 2000-Nov design start (ext. firm)
- 2001-June end design (350 drawings)

- 2002-Febr Tenders out
- 2002-April Offers received
- 2002-May Starting construction
-   (Dutch firm Demaco)

- 2002-Dec Shipping to DESY
- 2002-Dec Test bench DESY
-   He-Leak tests
-   Superconductors tests
-   ⇨ successful

- 2003-April Installation in HERA tunnel





VFPS Cold bypass installed - 2003 April

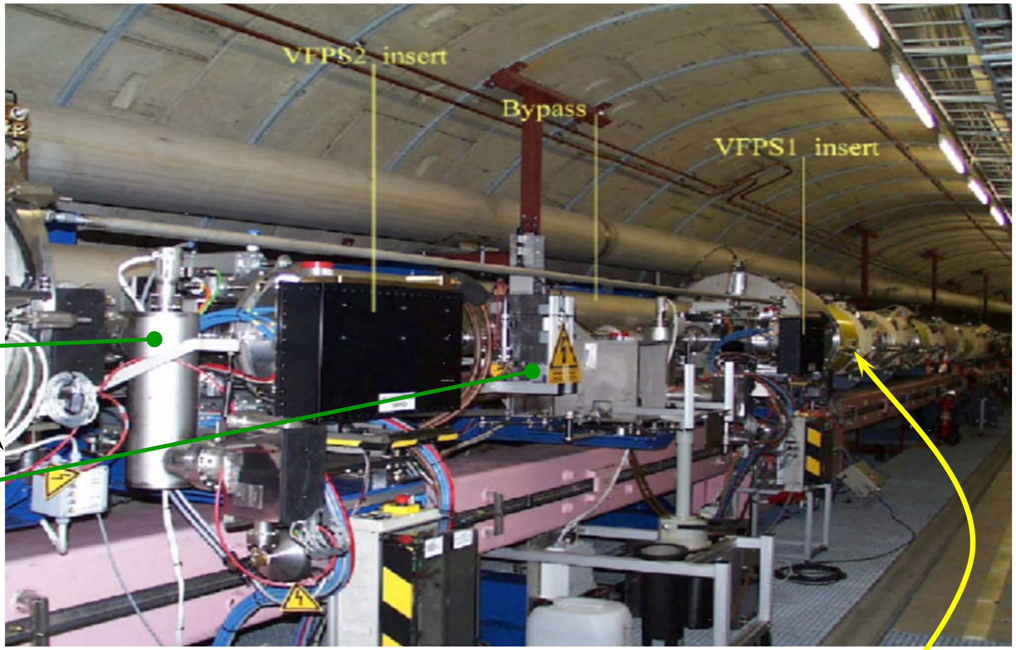
Bypass and associated elements

Ti-pump

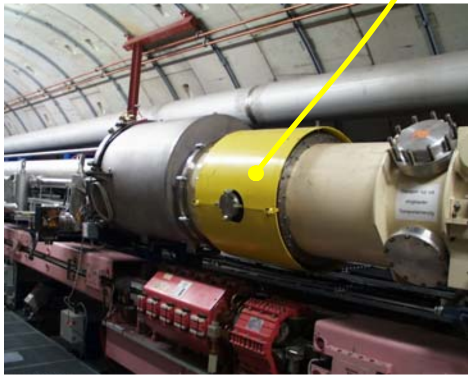
Beam position monitor

Bypass connections: quadrupole side

dipole side



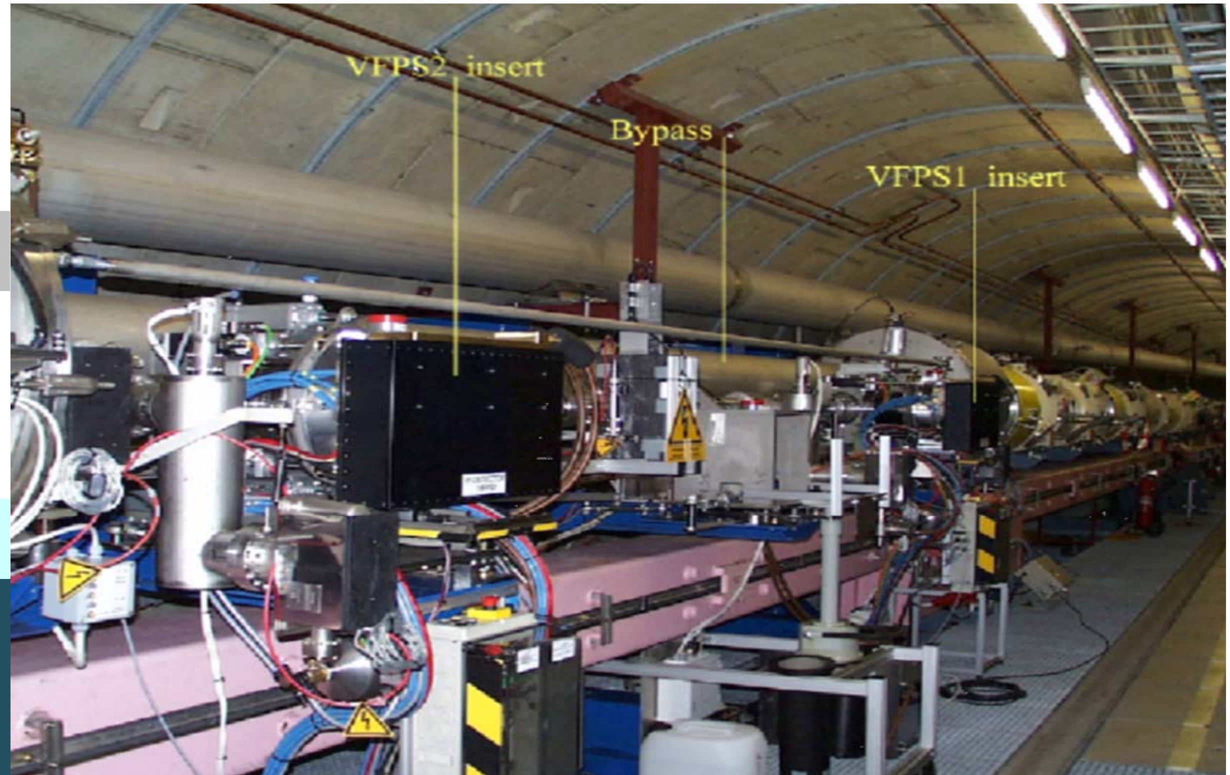
quadrupole connection



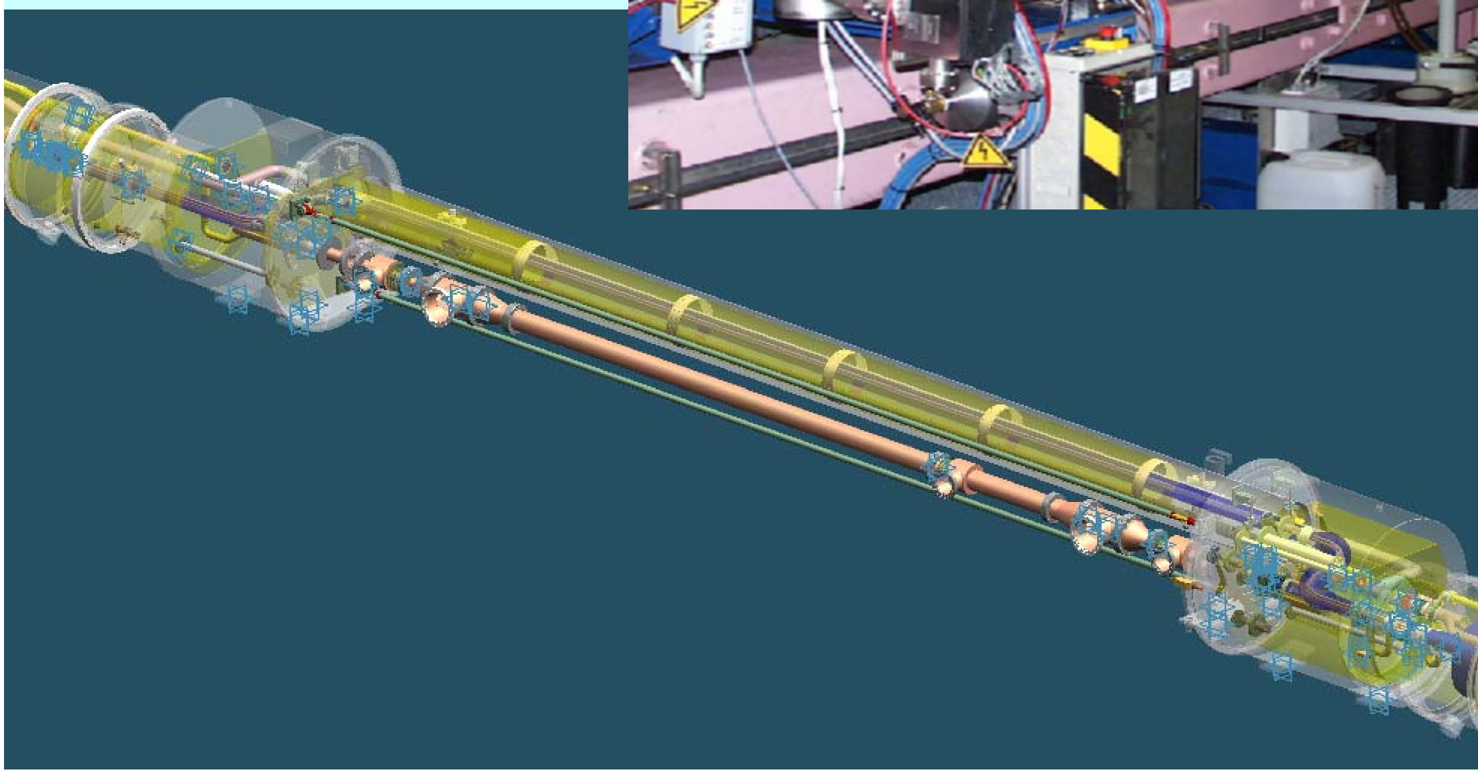
dipole connection

VFPS cold bypass

Hera tunnel:NL220m



Bypass design

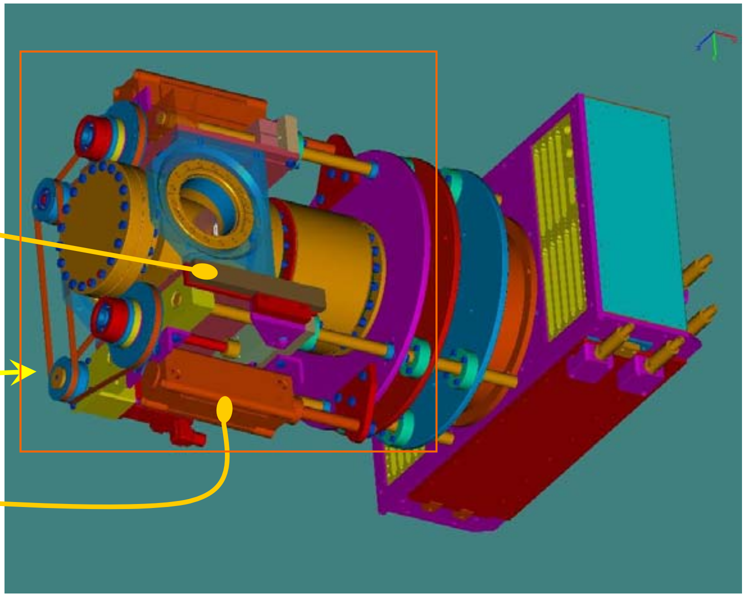


Roman pot structure

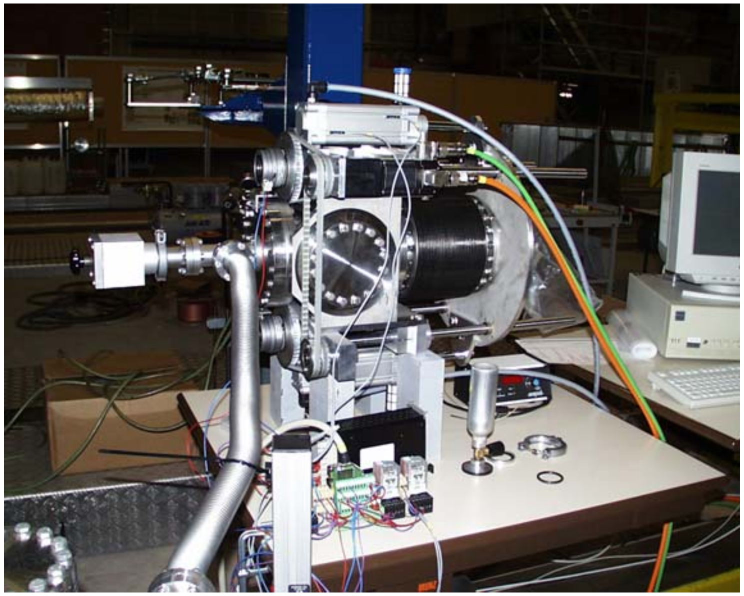
Roman pot main elements

- Heidenhain rulers
  - Ruler precision 5 μ
  - Range 120 mm
- Motor + movement transfer
  - Motor step 1/4 μ
- Pressure system for Roman pot ejection

Drag error 80 μ



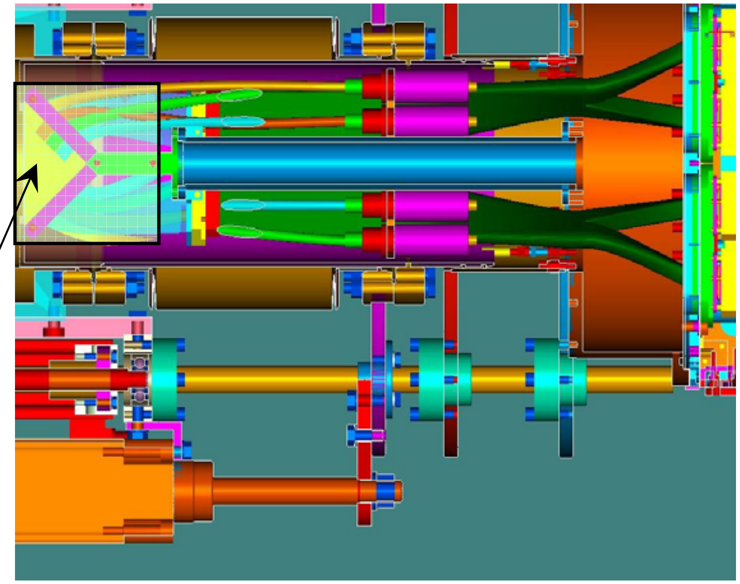
Roman pot mounting platform

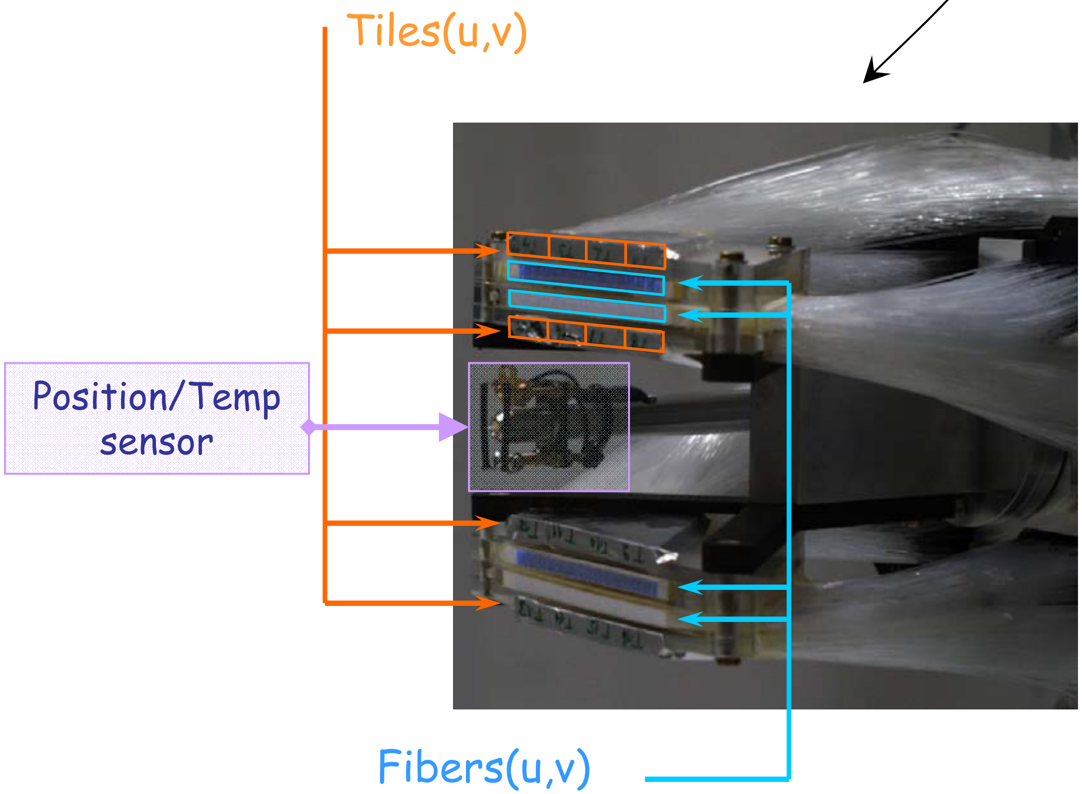


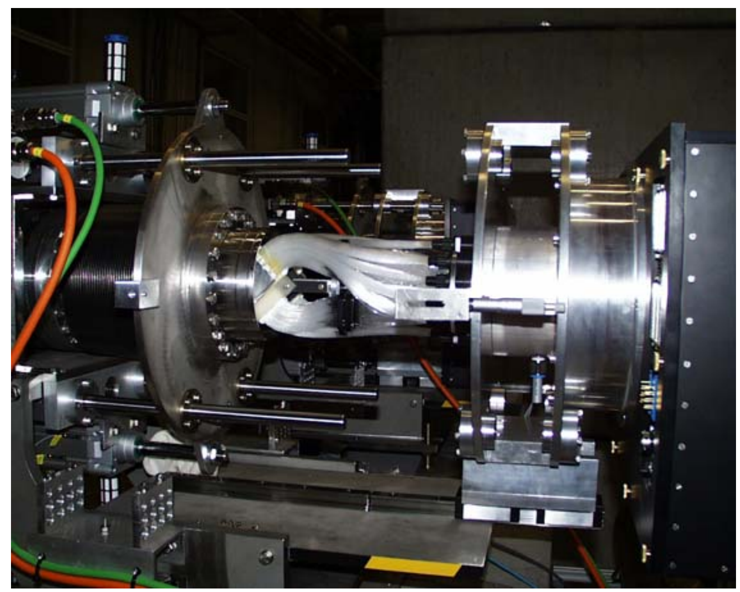
Roman pot + detector insert

Detector elements: scintillating fibers

- fibers (roads) 5 staggered fiber planes
  - 2 planes (u,v)/pot ⇨ tracking
  - Resolution 100 μ
- tiles (tiles) 4 tiles/plane
  - 2 planes (u,v)/pot ⇨ triggering



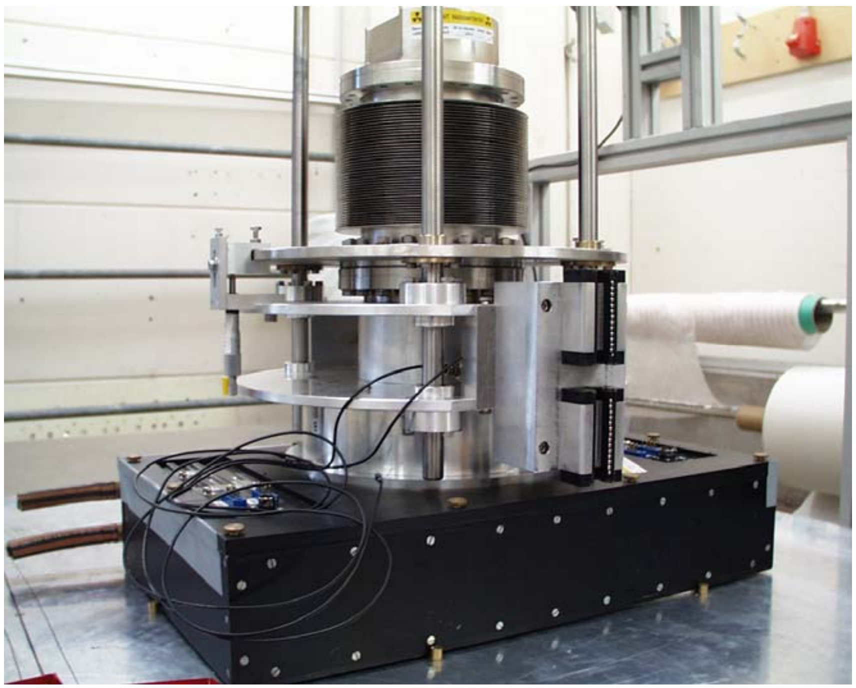


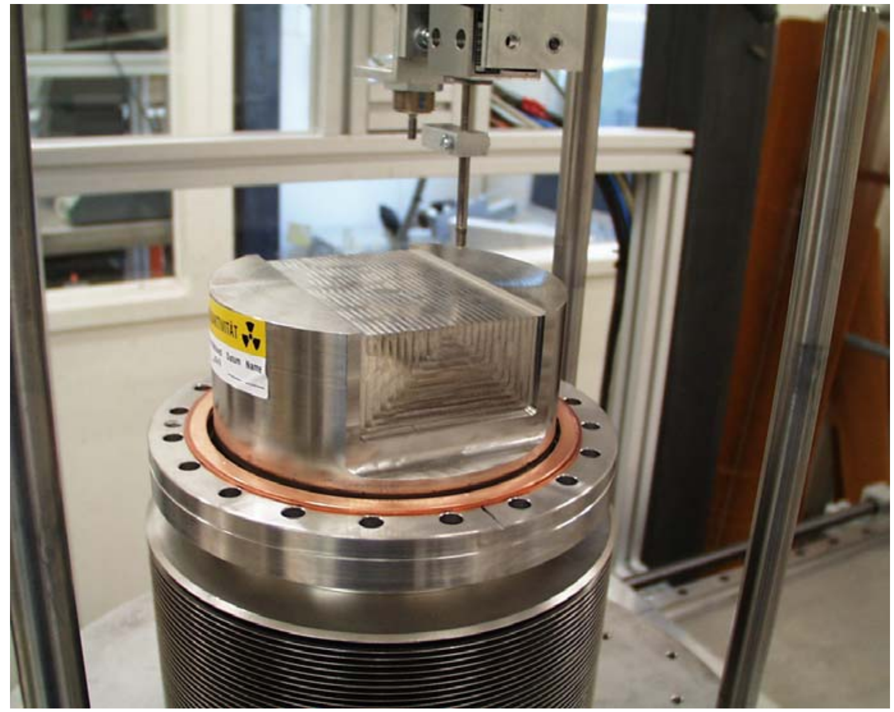


Roman pot window

Pot windows machined from one block
(standard machining method)

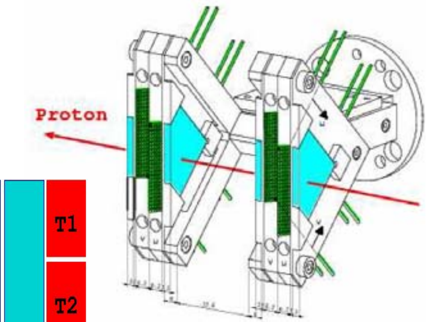
Thickness ≈ 300 μ ± 50 μ

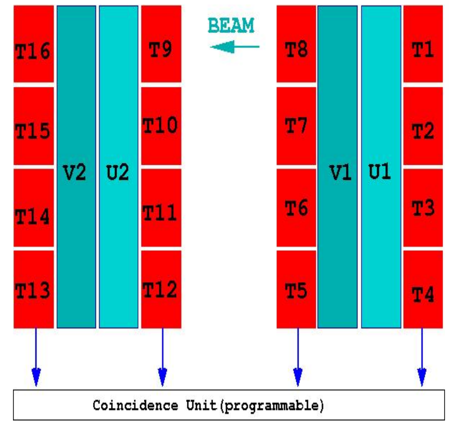




Trigger and Readout

- Trigger
  - Tile signals (T1-T16) to 16 PM's
  - Discriminated tile signals to programmable coincidence unit
  - Trigger requires 1 signal in 3 out of 4 planes
  - Trigger signal to H1 L1 trigger "air cable" (<2.3μs)

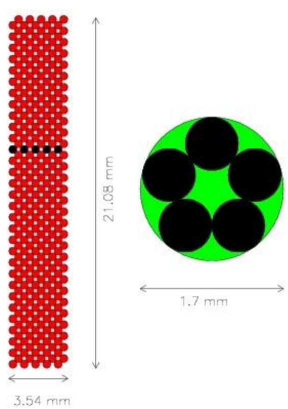


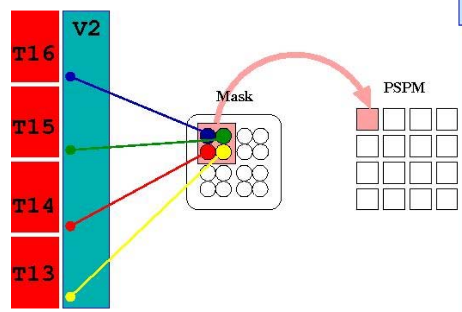


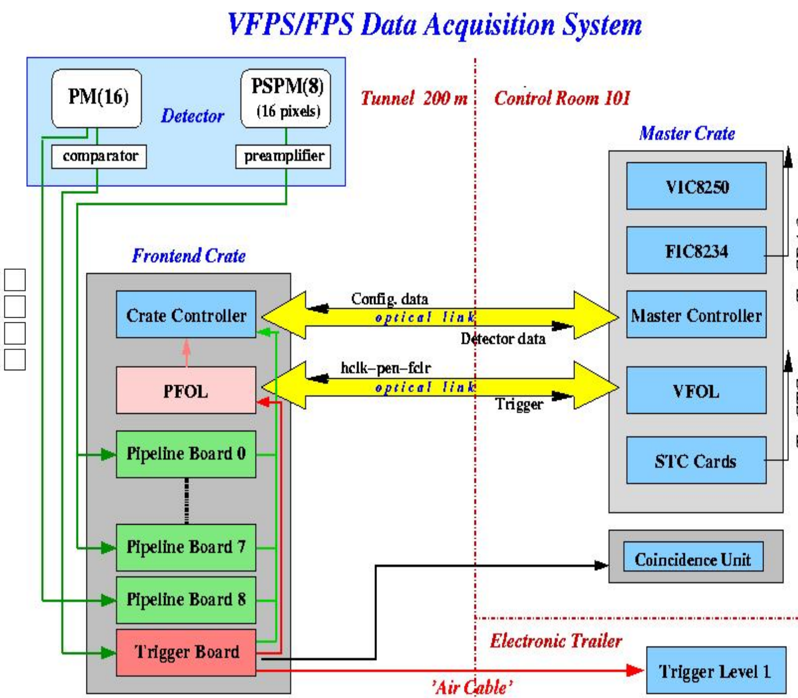
- Fiber signals

5 fibre layers 1 light guide 4 light guides to 1 PSPM pixel

Proton ---







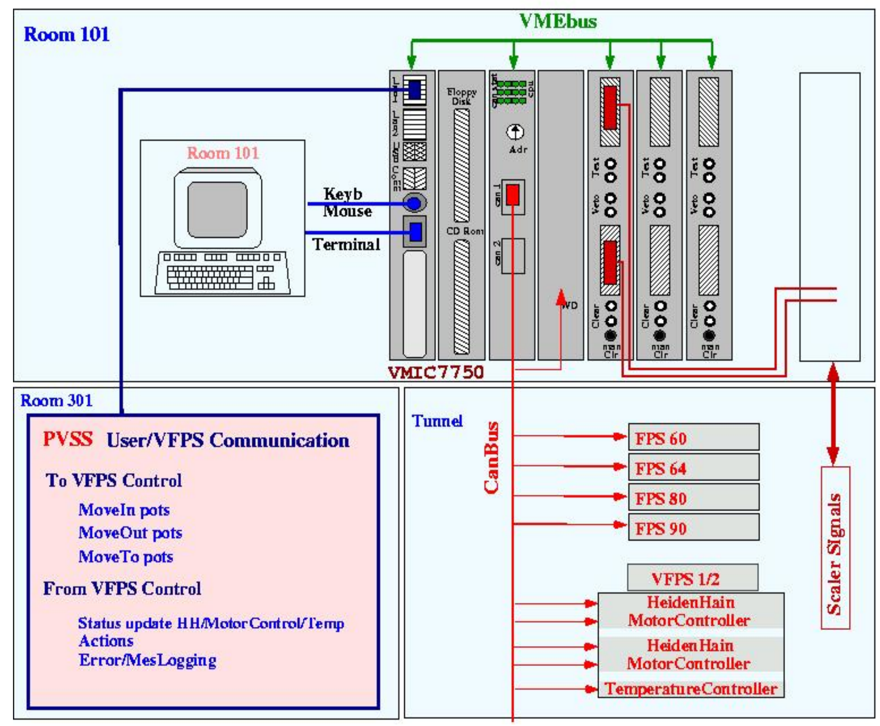
  - 480 fiber signals to 8 PSPM's (16 pixels)
  - Read by FPS/VFPS DAQ system over optical link

FPS/VFPS Roman pot controls

Roman pot control system is VME-based
(independent system)

- Control/readout VMIC7750-CPU (+disk)
  - Watch-Dog unit (control software running, temperature in limits) if not
    ⇨ motor power cut ⇨ Roman pot ejected
  - Scalers (detector rates, coincidences)
  - CAN bus controller: CAN bus connected to
    - Motor controllers (6) – control/readout
    - Heidenhain rulers(6) - readout
    - Temperature modules(2) – readout
- User communication VMIC7750-PVSS: TCP/IP
  1. PVSS ⇨ VMIC7750
     Action requests
     Updating of VMIC database
  2. VMIC7750 ⇨ PVSS
     Device status information
     Messages of actions
     Error messages

FPS/VFPS motor Control



Data Logging PVSS

- Values all devices / 1-3 sec
- Messages actions/errors
- Machine parameters
- Beam position monitor

Database(VMIC)

Contains all constants for devices and movements

PVSS: User displays

PVSS communicates with

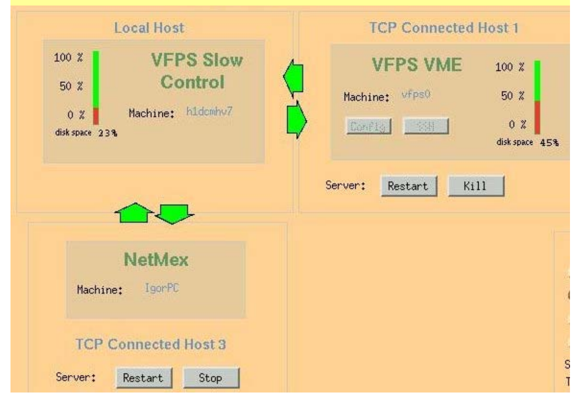
1. VMIC
2. NETMEX (HERA)
3. VFPS slow control (HV)

PVSS logs all data

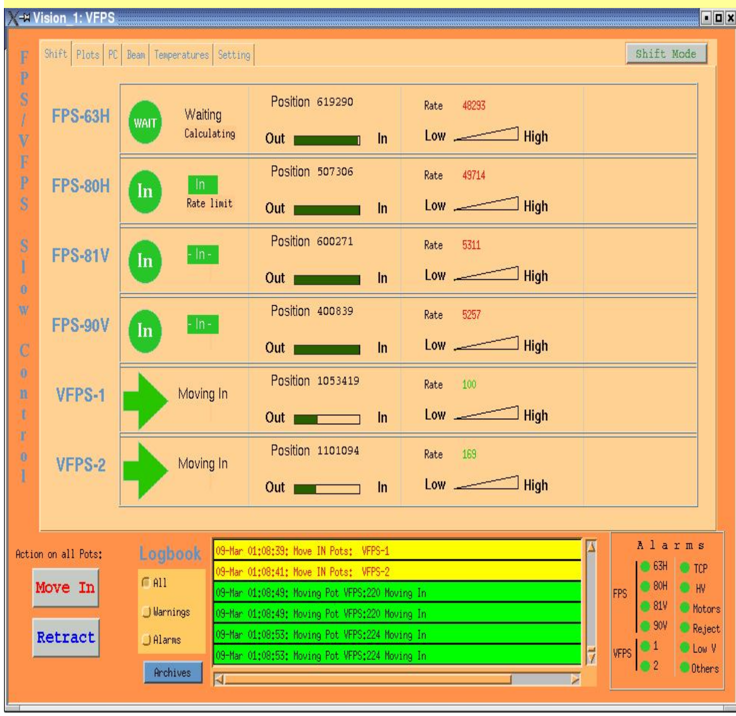
Roman pot (positions, temp,…), Hera (mag.,coll,…)

Stores logfiles

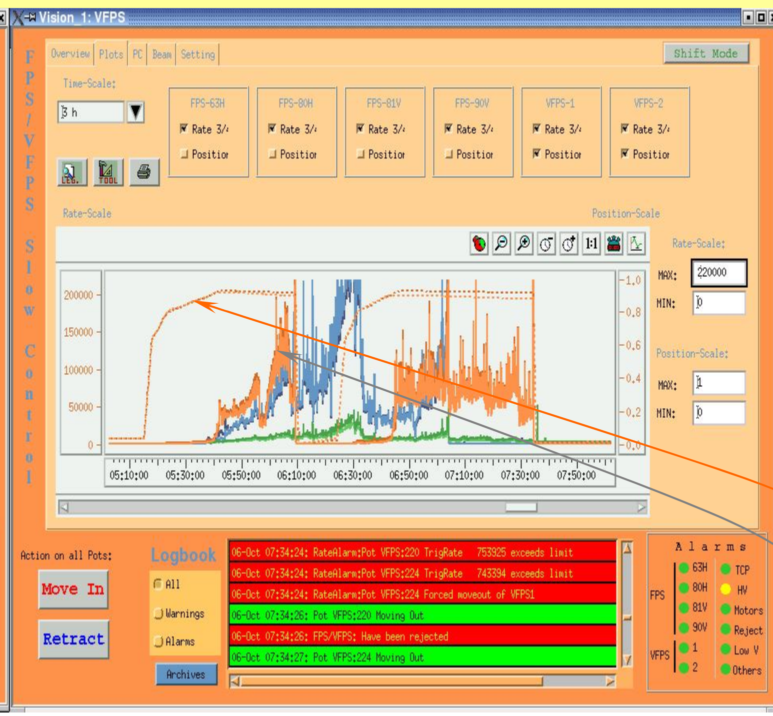
PVSS communication panel



PVSS main panel



PVSS rates/position panel



Detector position

Detector rate

VFPS operation: Roman pot movement

Move-in condition

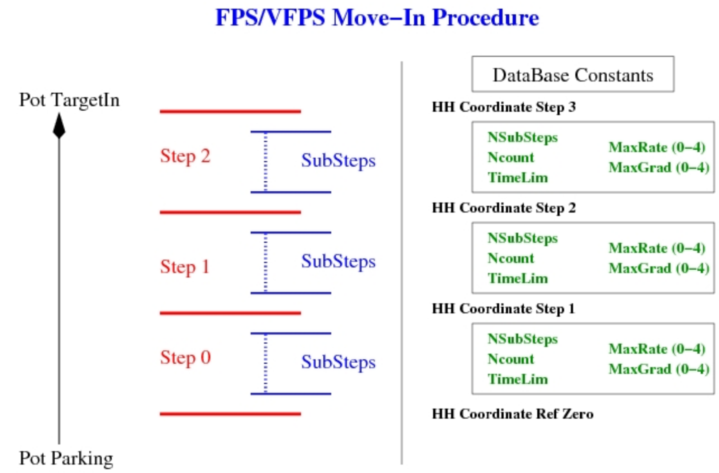
- Luminosity
- Scaler rates non zero

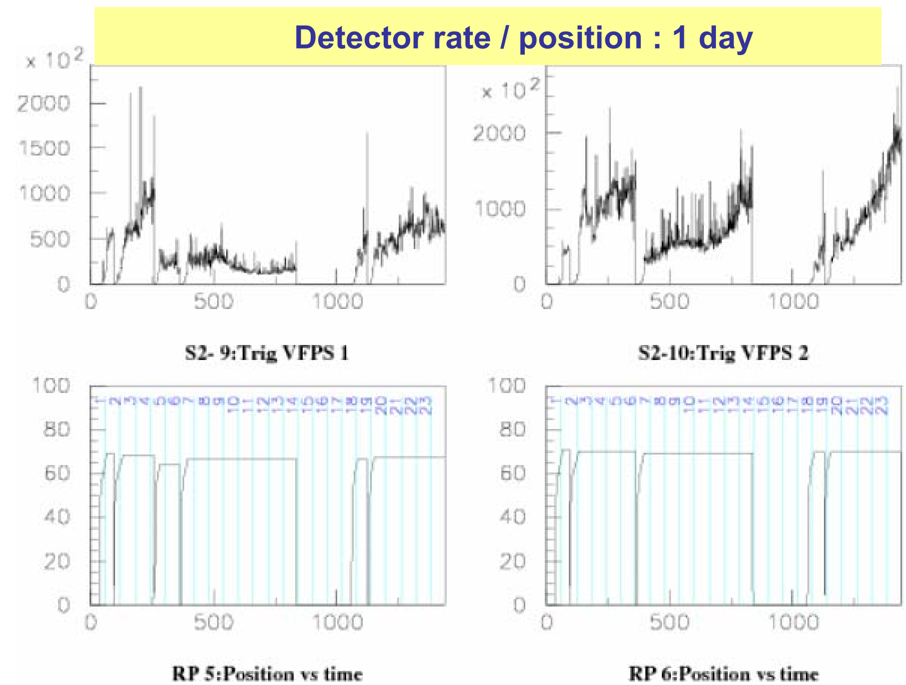
Checks during move-in

- Average coincidence rates (sampling ≈5 meas.)
- Gradient rate
- Movement is halted when rate over limit
- Peak rate exceeded → eject

Target-in position

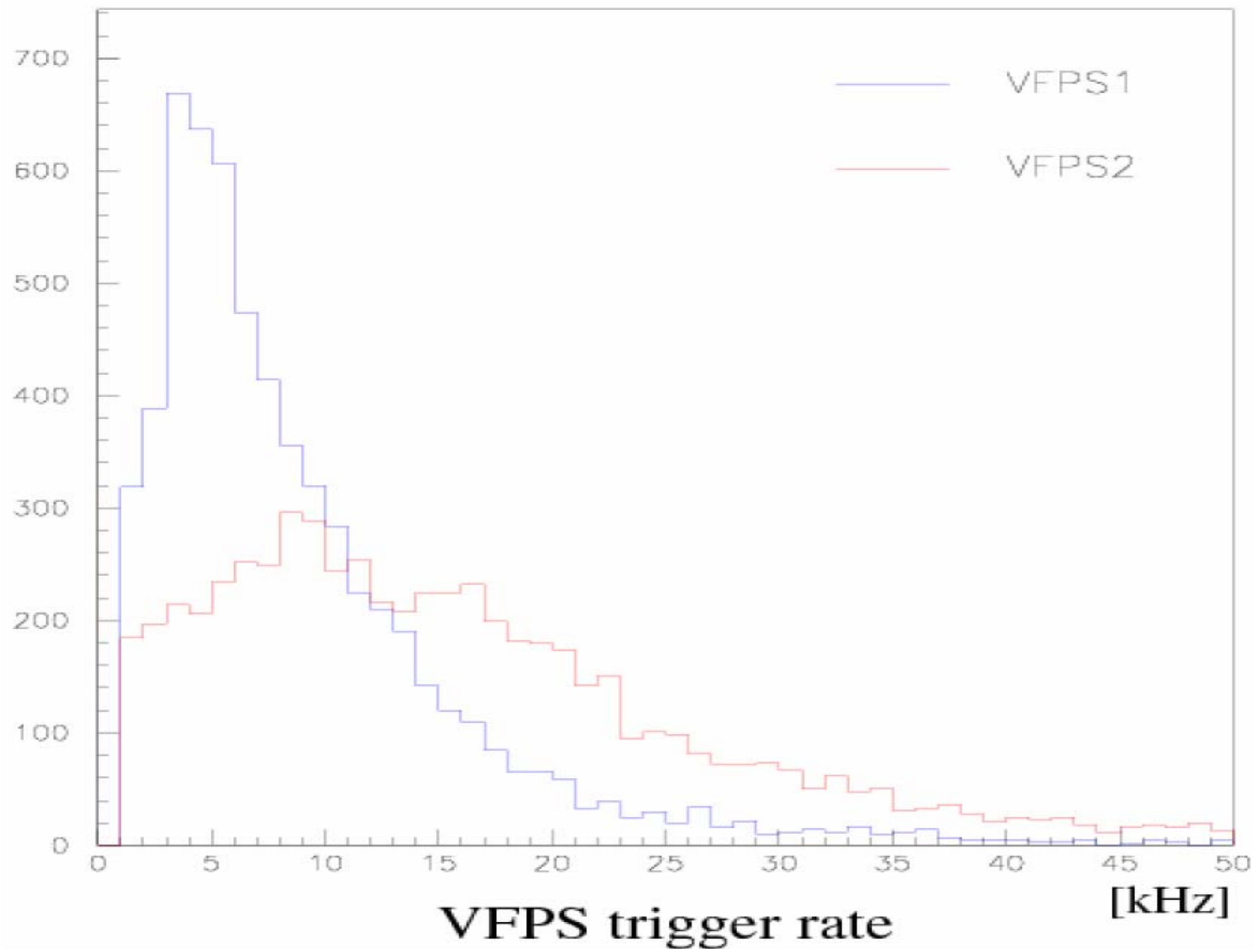
- Checking peak rate if exceeded → eject





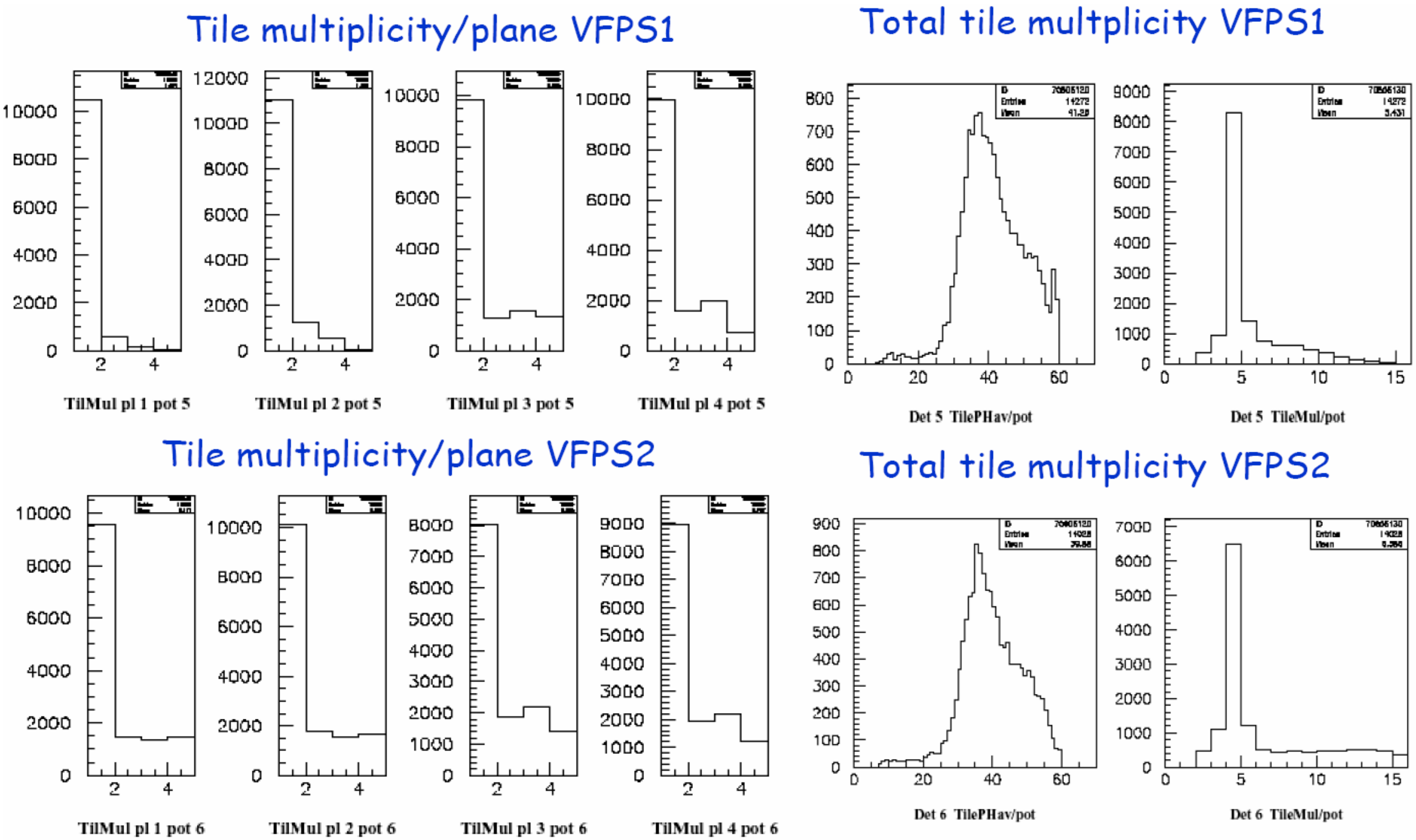
VFPS operation: influence VFPS1 on VFPS2

- During move-in procedure
- Normal running



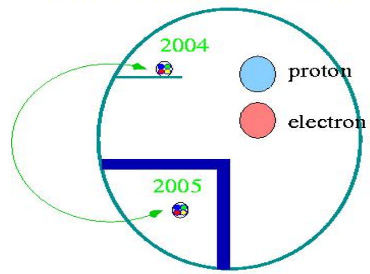
VFPS operation: Effect of VFPS1 on VFPS2

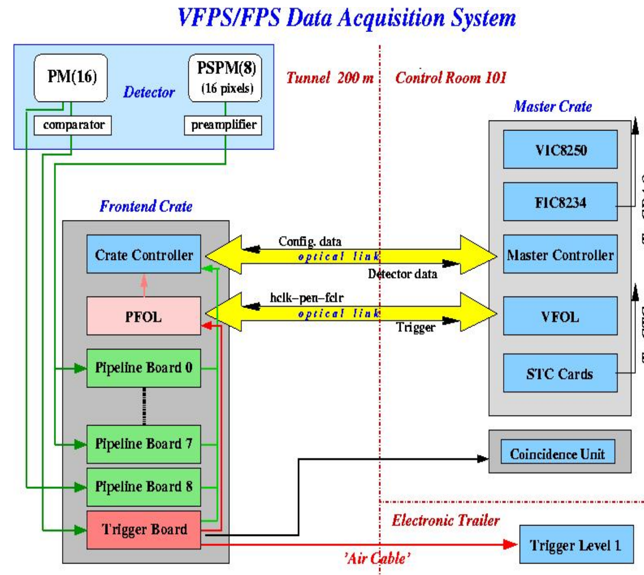
- Effect on the hit multiplicity



VFPS Running experience 2004-2007

Fibres Location in Tunnel





2004

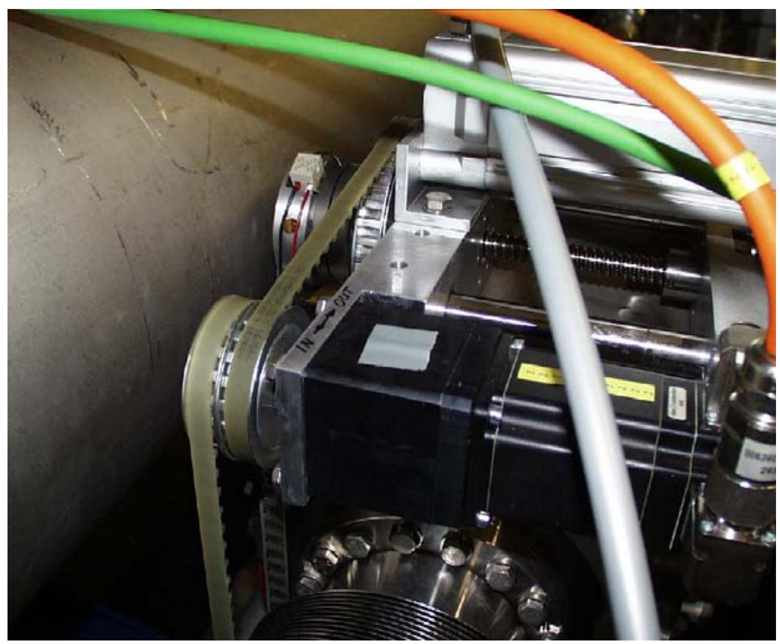
Irradiated fibers (trigger rate ↘)

2005

Detector shift in pot (access !!)

Good data after June

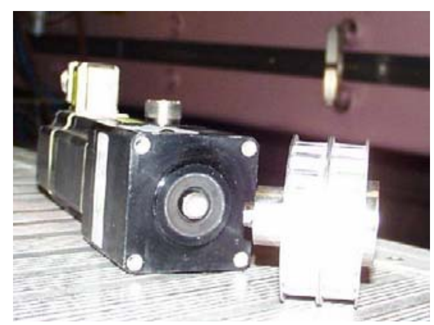
2006



Broken motor axis

Standard running

Various beam kicks

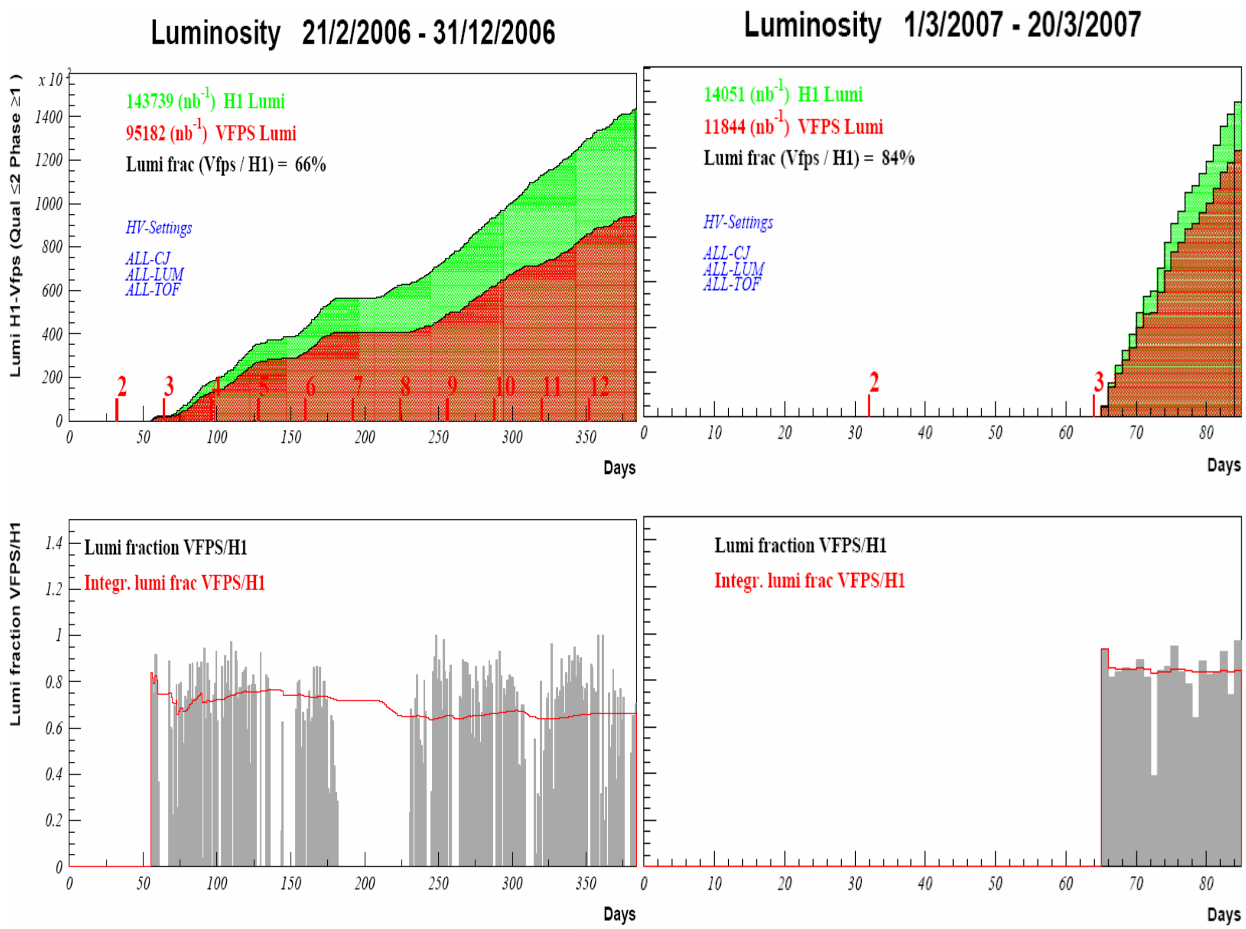


2007

Standard running

Collected VFPS data

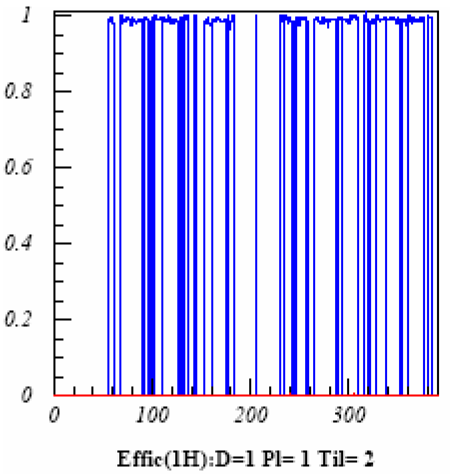
- 2004 startup period (fiber problem)
- 2005 detector fixing problem
  - 20 pb^{-1}
- 2006
  - 95 pb^{-1} 66%
- 2007 E=920 GeV
  - 12 pb^{-1} 84%
- 2007 Low E
  - 3.9 pb^{-1} 82%

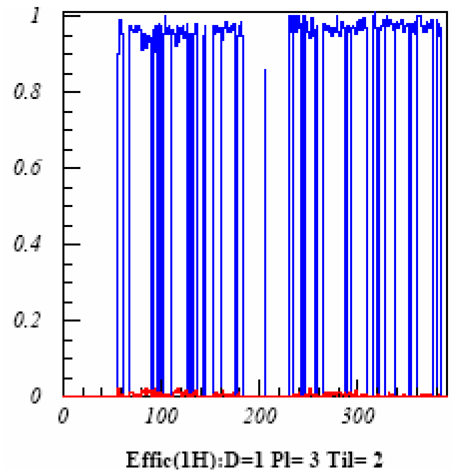


Data Quality: Tiles

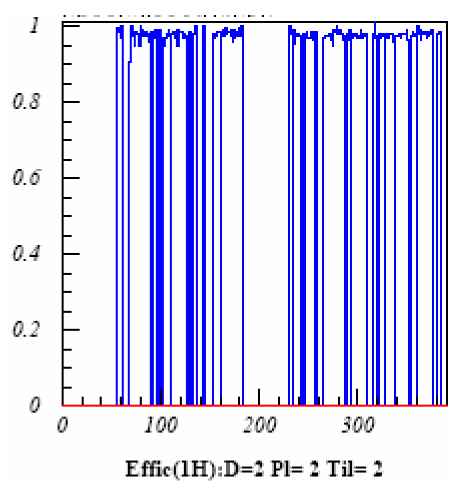
Tile 2 : Efficiency / DayOfYear

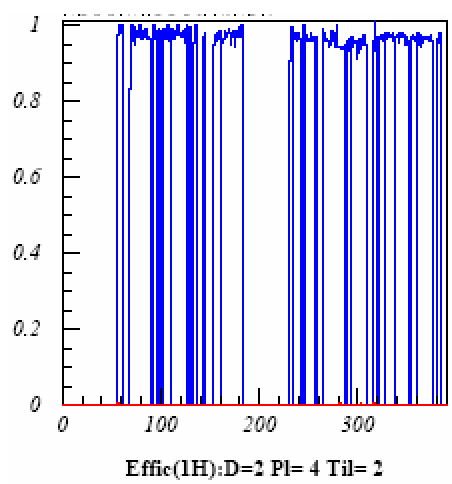
-----------------------VFPS1-----------------------





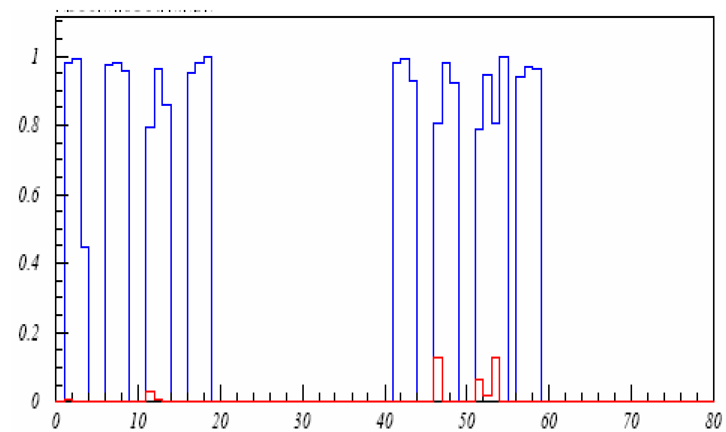
-----------------------VFPS2-----------------------



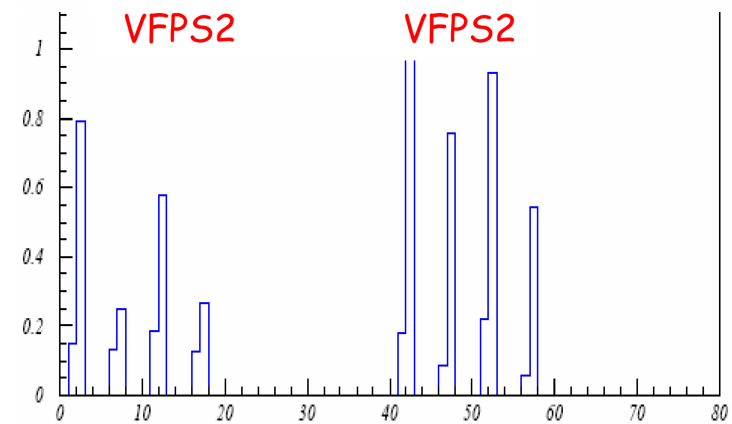


Summary tile efficiencies

Efficiency



Hit frequency

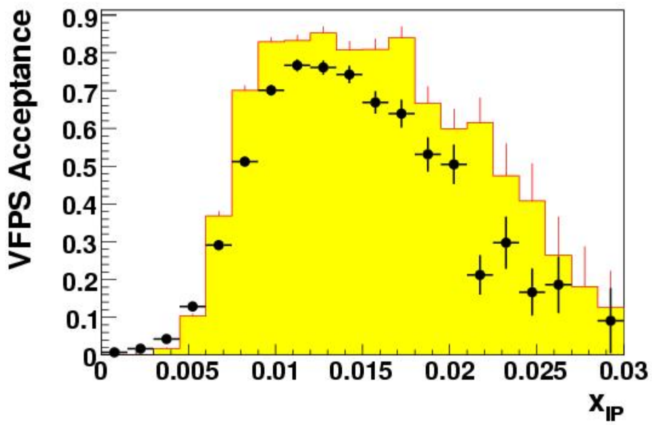


P1-2-3-4 D1

P1-2-3-4 D2

Inclusive diffraction (T.Hreus)

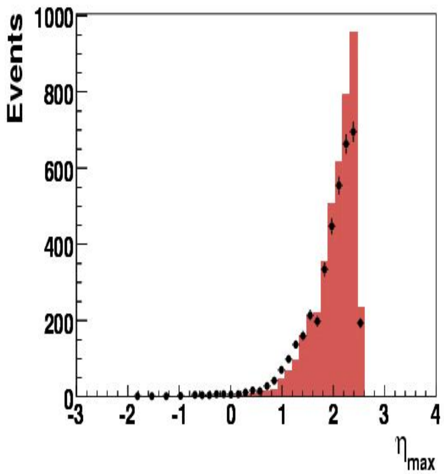
- VFPS acceptance
  - X_p as measured is H1
    ⇨ Good acceptance in expected x_p region
    (Tile efficiency to be added)

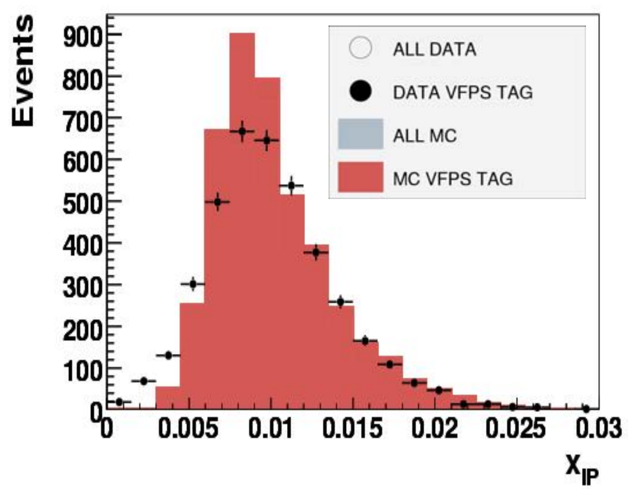


- Statistics used 24 pb^{-1} = 80K (130 pb^{-1})
  - Proton beam bump @ 6mm
  - 3900 VFPS tagged events (η_{max},R_{spac} cut)

- Analysis F_2D_3

- In conjunction with t-measurement
  ⇨ F_2D_4

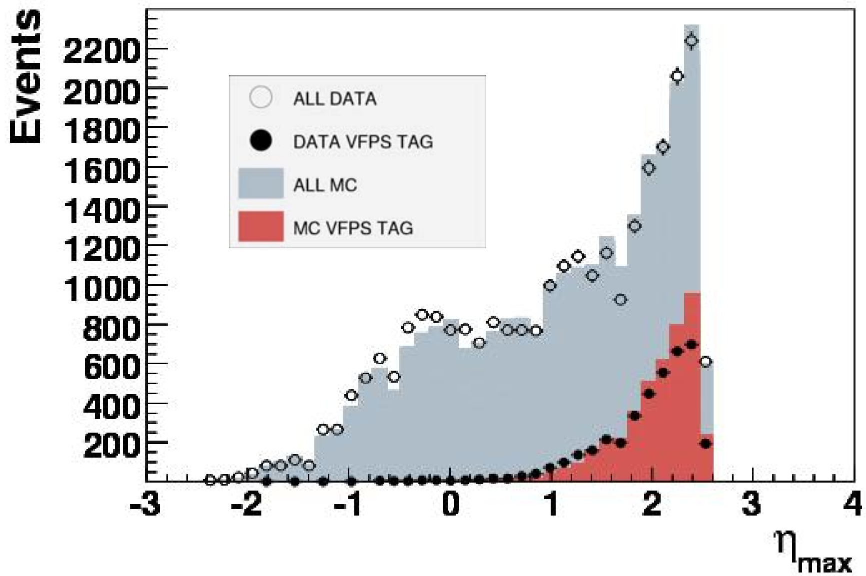


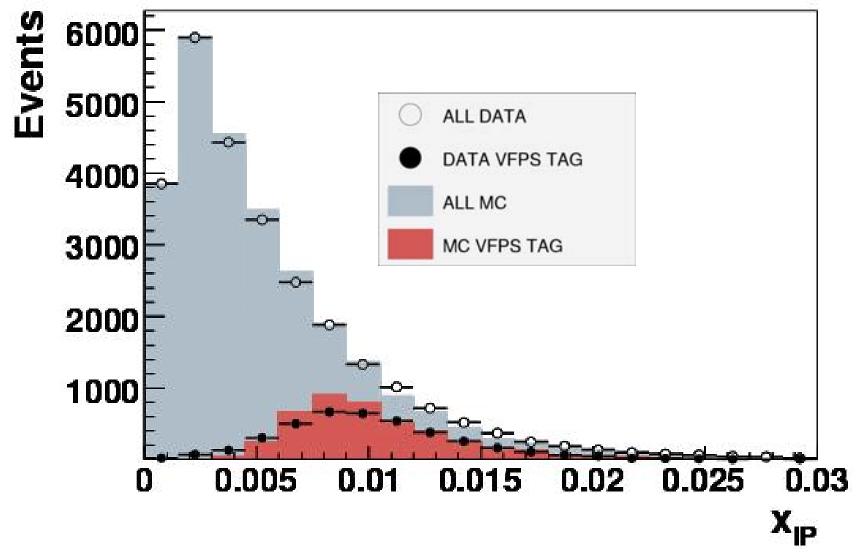


Inclusive diffraction (T.Hreus)

- Event selection - H1 detector

  1. $|Z_{vertex}|$ < 40 cm
  2. $E_{electron}$ > 10 GeV
  3. $Q^2_{electron}$ > 10 GeV
  4. E_x > 3 GeV
  5. M_X > 3.5 GeV
  6. Rapidity gap
     - Forward Muons
       $\#F_\mu(P_1+P_2) < 2$ && $\#F_\mu(p_1+p_2+p_3) < 3$
     - $\eta_{MAX} < 2.5$



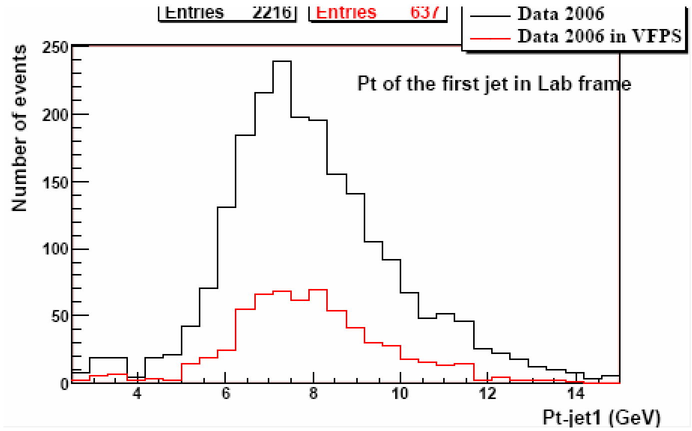


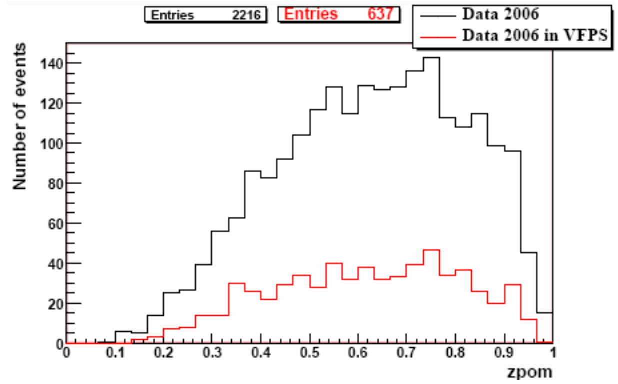
- Event selection – VFPS tag

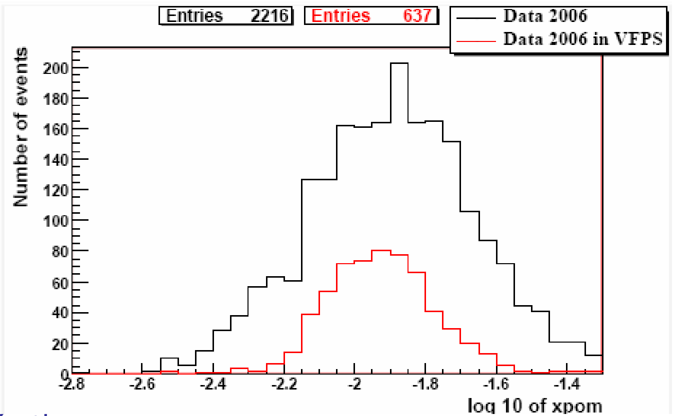
  Trigger
  vfps1te && vfps2te
  (vfps1te = 3 planes of 4 have >=1 hit)

Di-jet analysis - DIS (J.Delvax)

- Event selection - H1 (K_t-algorithm)
  - DIS cuts
  - ($P^*_{T,1} > 5$ GeV) & ($P^*_{T,2} > 4$ GeV)
  - $\eta_{J1,J2} \in [-1,+2]$
- Event selection VFPS
  - vfps1te && vfps2te
- Statistics:
  - $97 pb^{-1}$ (75% of total event sample)
  - ⇨ 637 events
- VFPS tag selects di-jets with good acceptance

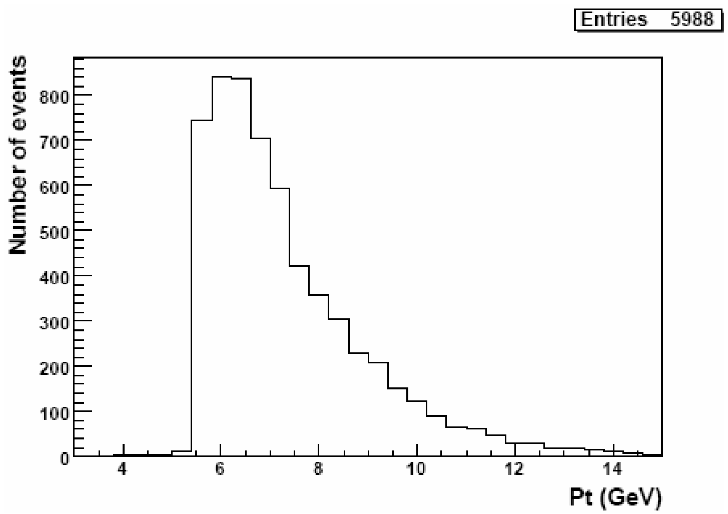


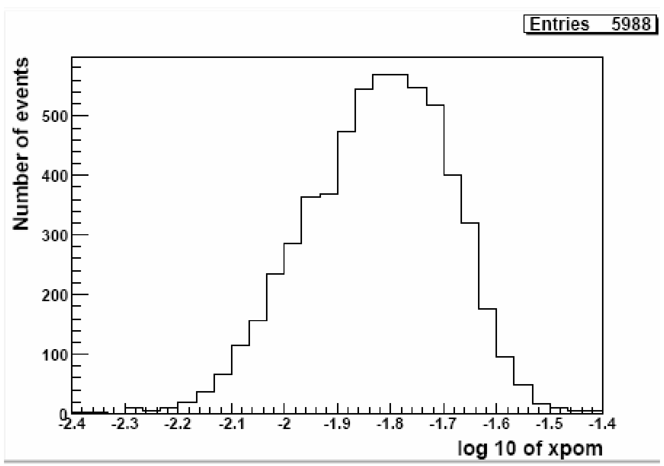




Jet analysis – Photoproduction (J.Delvax)

- Event selection H1: 2 Jets (Kt-algorithm)
  - $\eta_{MAX}<2.5$
  - $(P^{*}_{T,1} > 5$ GeV$)$ & $(P^{*}_{T,2} > 4$ GeV$)$
  - $\eta_{J1,J2} \in [-1,+2]$
- Event selection VFPS
  - vfps1te && vfps2te
- Statistics 23.7 pb^{-1}
  - Collected with dedicated trigger
  - total statistics 2006+2007
    6000 events
- Goal
  Compare t-dependence in
  DIS & Photo production jets
  (factorization breaking)

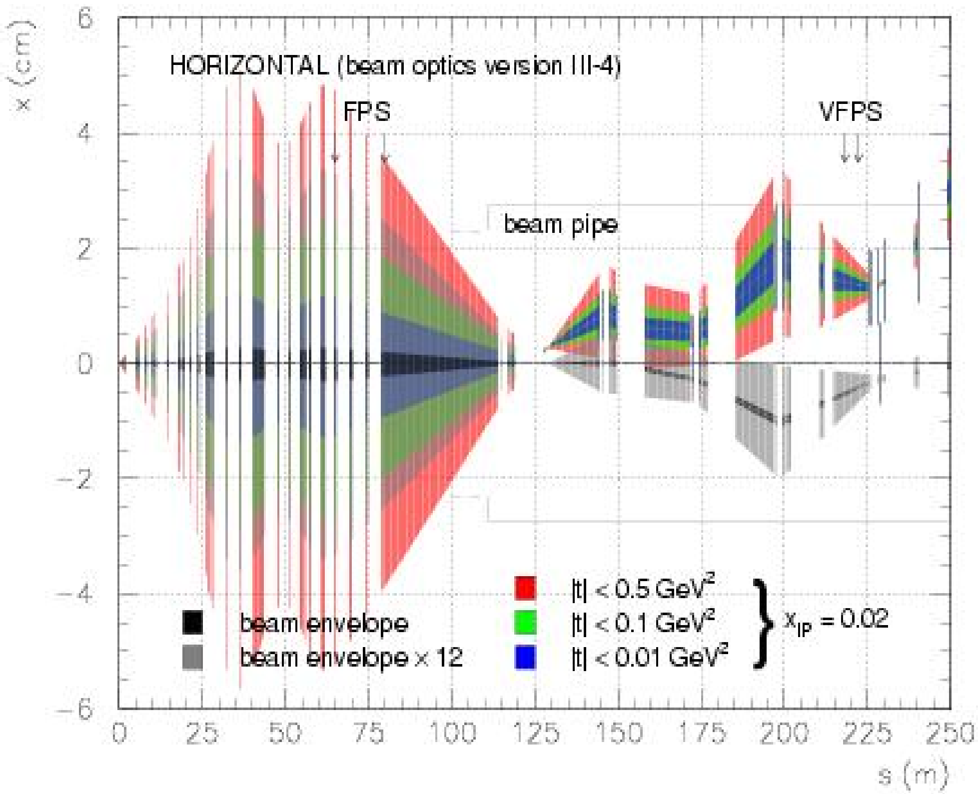




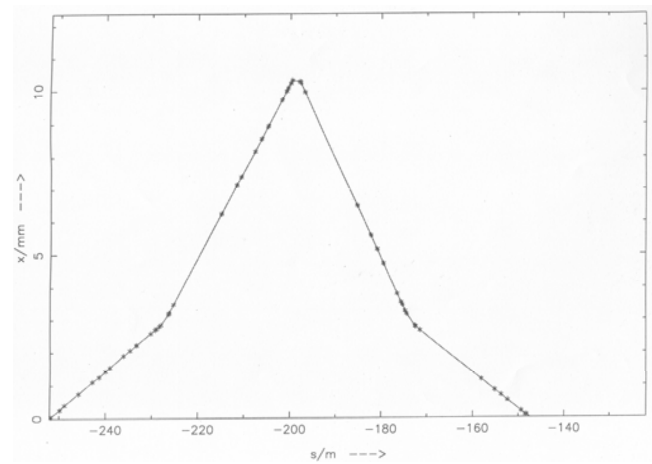
Proton beam bumps for VFPS

Beampipe aperture limitation at 200 m ⇨ high x_p scattered protons are lost

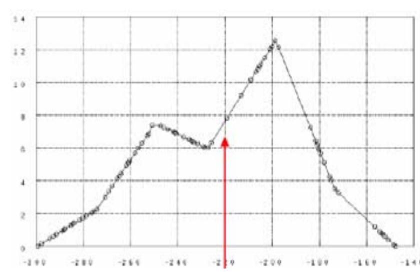
Solution ⇨ Introduce beam kick

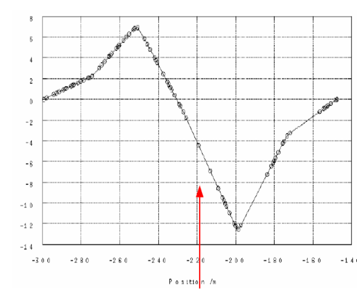


Principle



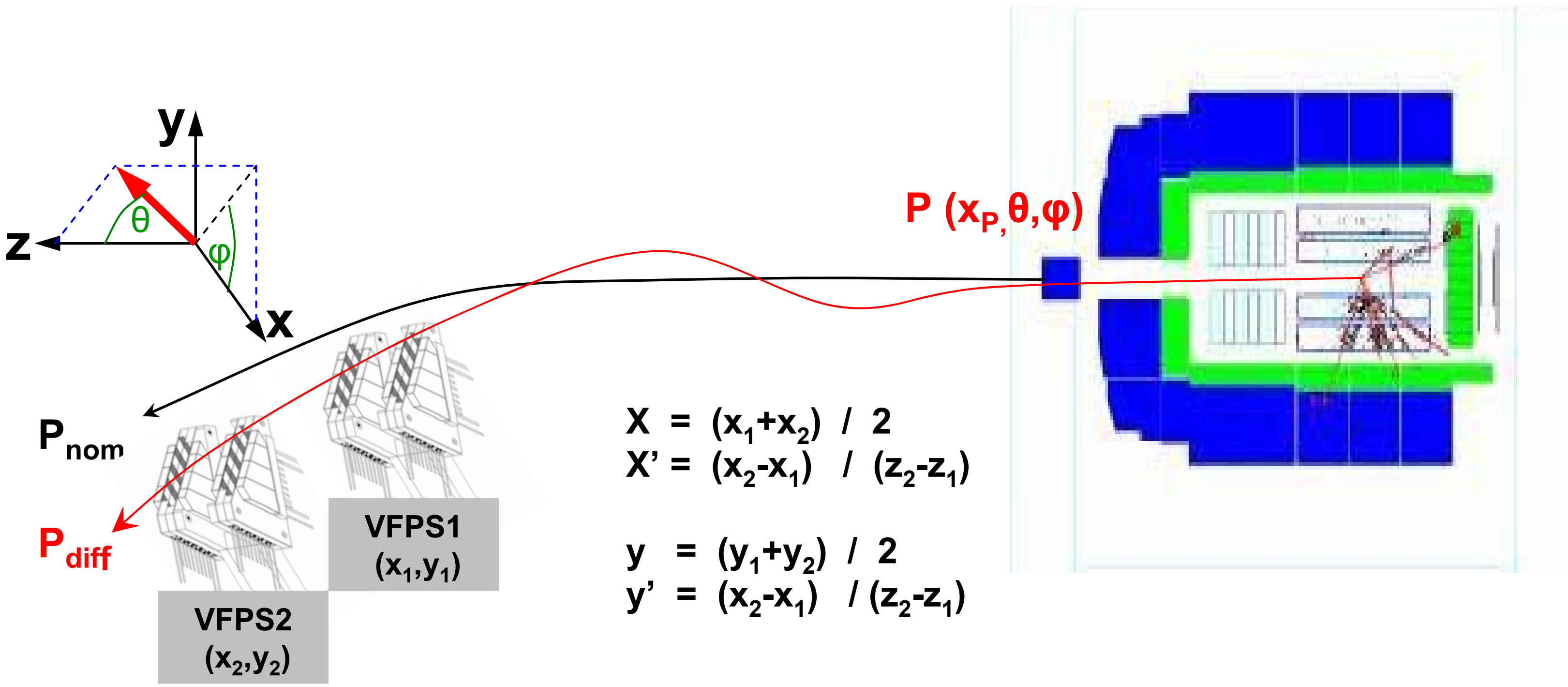
Practice: different bumps used 2006





Closed bumps for nominal protons
for diffractive protons ?

Momentum reconstruction diffractive proton (T.Sykora)



$X = (x_1+x_2) / 2$
$X' = (x_2-x_1) / (z_2-z_1)$

$y = (y_1+y_2) / 2$
$y' = (x_2-x_1) / (z_2-z_1)$

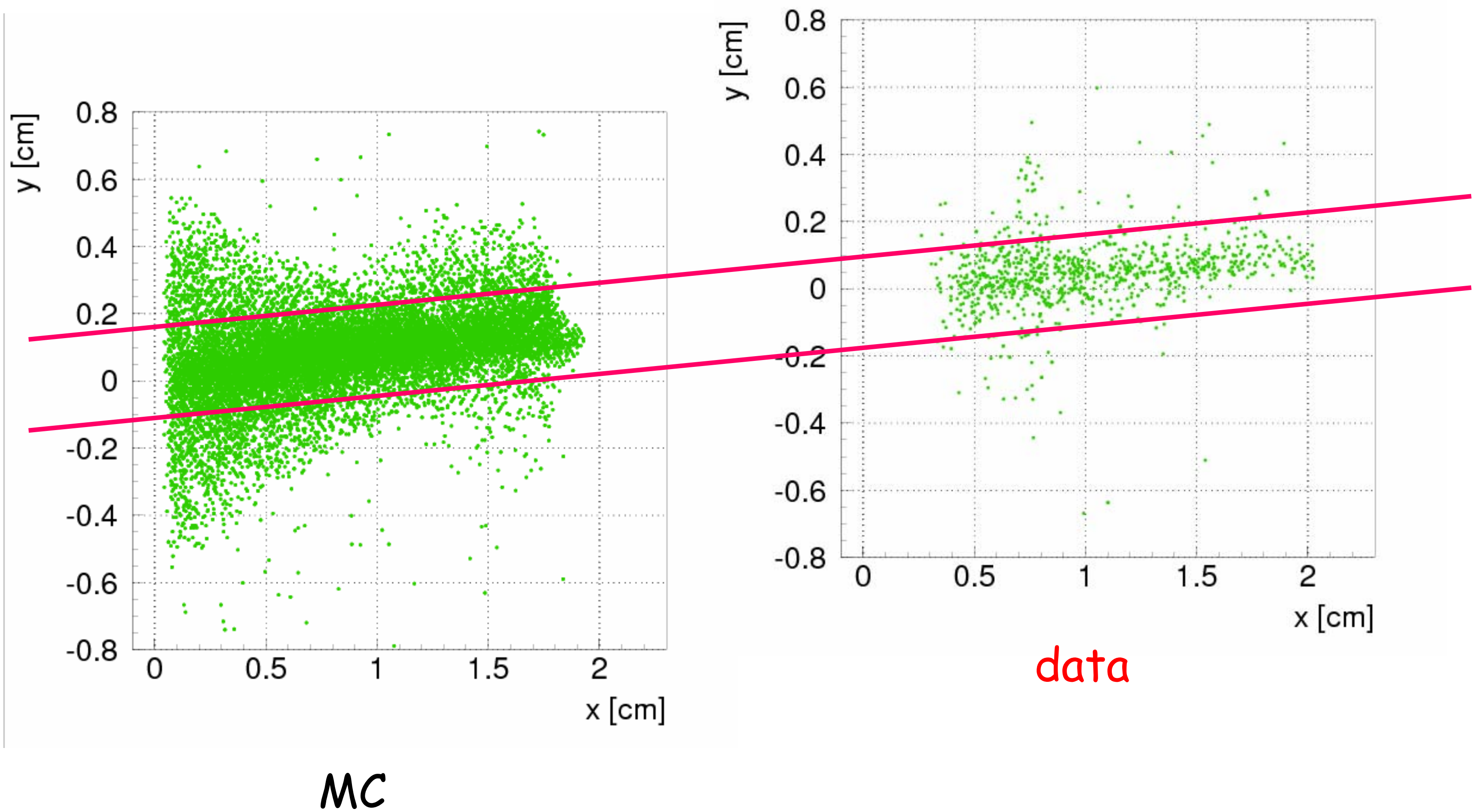
Beam Optics: find map: M^{-1}: (x_P,θ,φ) ⇨ (x,y,y',y')
- standalone
- H1SIM

Reconstruction: find map: M :(x,y,y',y') ⇨ (x_P,θ,φ)
- N(eural) N(et)

Calibration: Detector - beam distance

MC versus data

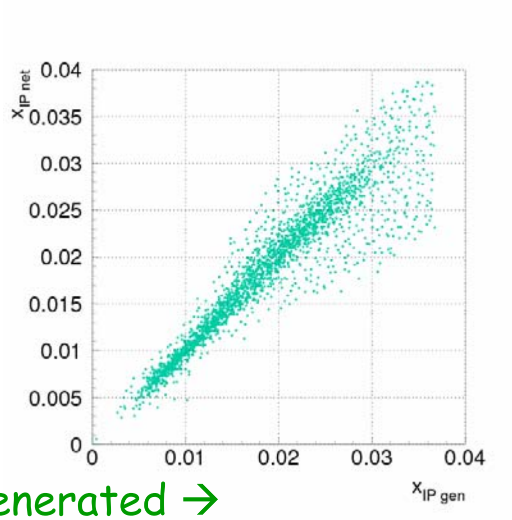
Detector x-y hit maps

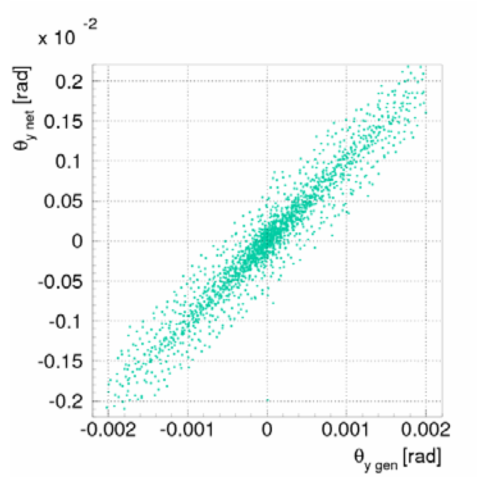


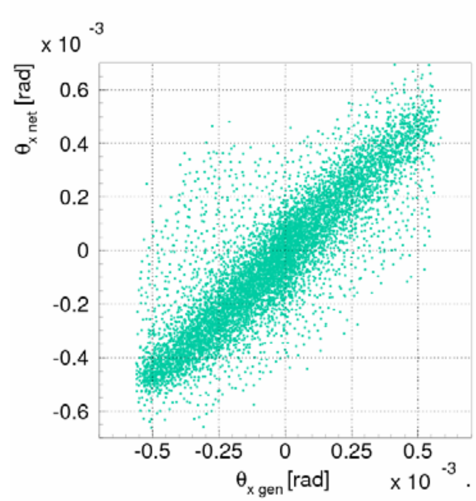
Neural Net Reconstruction

$$Minimize \longrightarrow \sigma = \frac{1}{2}\sum\left(y^{gen}_{\alpha,i}(\vec{x}) - y^{data}_{\alpha,i}(\vec{x})\right)$$

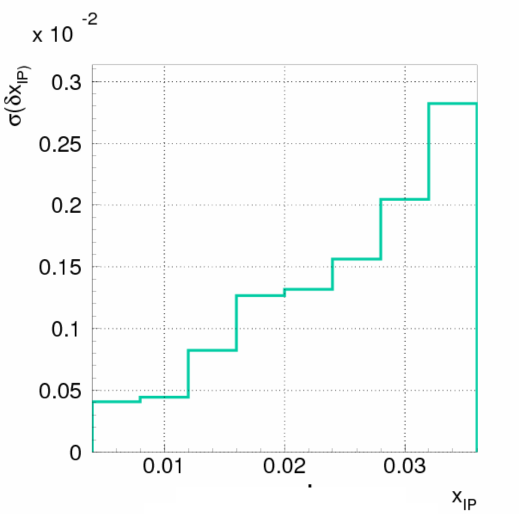
Net Reconstruction

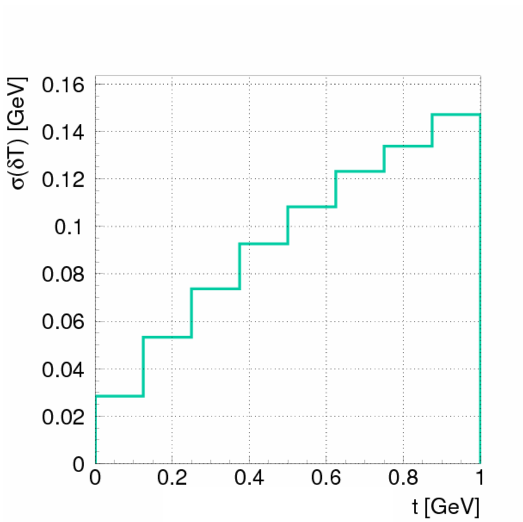


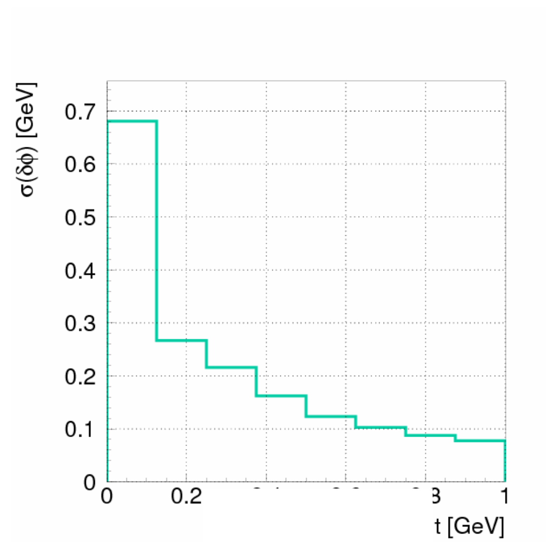




Generated →

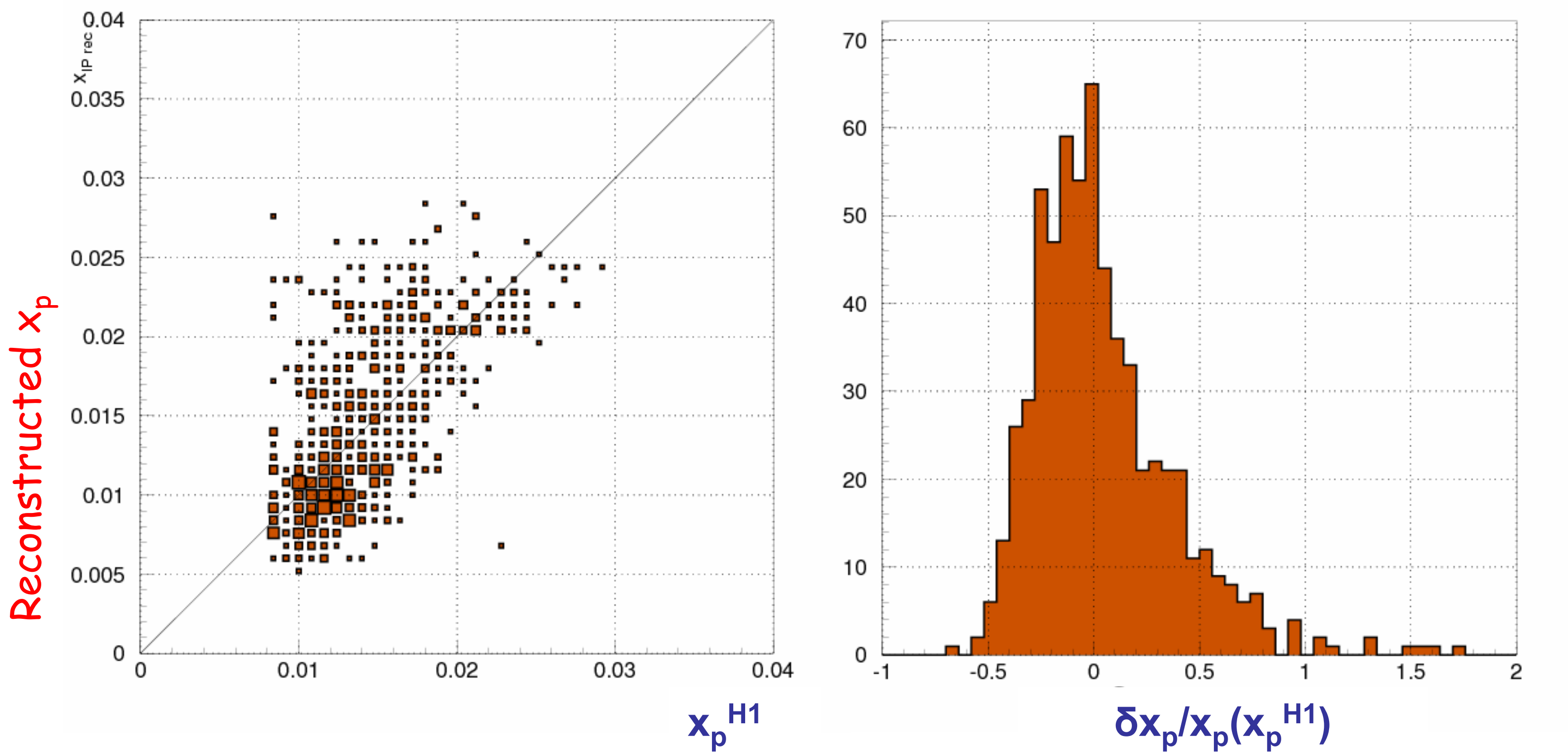






x_p _ Reconstruction

1. Kinematic peak method: t-spectrum unbiased ÿ $<\Theta_x>=0$ $<\Theta_y>=0$



2. ρ events kinematically fully defined ; e + p ⇨ e' + ρ + p' p' is known from H1
(in progress) acceptance in t 100 %

Conclusions

- VFPS hardware experience: (very) good except
  - irradiated fibers (unforeseeable)
  - Even small problems can turn out to be big because of limited tunnel access !
- VFPS software experience: (very) good
  - No major problems
  - Once properly adjusted to beam environment: fine
- VFPS ↔ HERA machine
  - Many parameters to survey: needs permanent attention
- Proton momentum Reconstruction: difficult because of many details to be taken into account (beam bumps)
- Analyses in progress and planned
  - F_2D_3 analysis based on VFPS trigger only
  - F_2D_4 analysis : follow-up of F_2D_3 with t-measurement
  - Analysis of DIS/photo-produced jets with t-slope measurements

END