HERA-III workshop, Zeuthen, March 10-14, 2003

Status of H1 projects

S. Levonian, H1

- Introduction: physics at HERA-3
- Possible schedule: H1 scenario
- eD case
- Detector requirements
- Some considerations beyond eD

Physics objectives for HERA-3

- Complete the measurements of structure of baryonic matter:
  - ▷ F_2^n
  - ▷ sea asymmetry and flavor decomposition
  - ▷ parton distributions inside nuclear matter

- Improve our understanding of QCD in high energy (low x) limit
  - ▷ new level of precision in ep-scattering:
    F_L, forward jets, etc.
  - ▷ novel phenomena in high density QCD:
    gluon saturation, BBL, colour transparency/opacity

- Contribute to the solution of the nucleon spin puzzle
  - ▷ helicity structure of DIS at low x in pQCD regime
  - ▷ access to completely new kinematic domain $\rightarrow$ high discovery potential
  - ▷ make use of the advantages of the collider geometry

Pre-requisits for HERA-3 programme

- Some injector for HERA
- Machine developments (D, heavy ions, polarized $p(D)$)
- Improved detector acceptances/resolutions optimized for this physics

⇒ Strong support inside HEP community

⇒ Optimal staged realization

H1 plan (supported by the majority of institutions)

Step 1: $e^{\pm}D$ program with present detector + p_{sp} tagger
Minimal shutdown to allow $p \to D$ change for HERA

Step 2: high precision ep at low x
Some detector upgrade + HERA IP modification

Step-3: eA physics with same detector configuration
HERA: ion beam source and (laser?) cooling

Step-4: Spin physics with polarized p or D
Both detector and machine upgrade are needed

Possible schedule for future HERA running

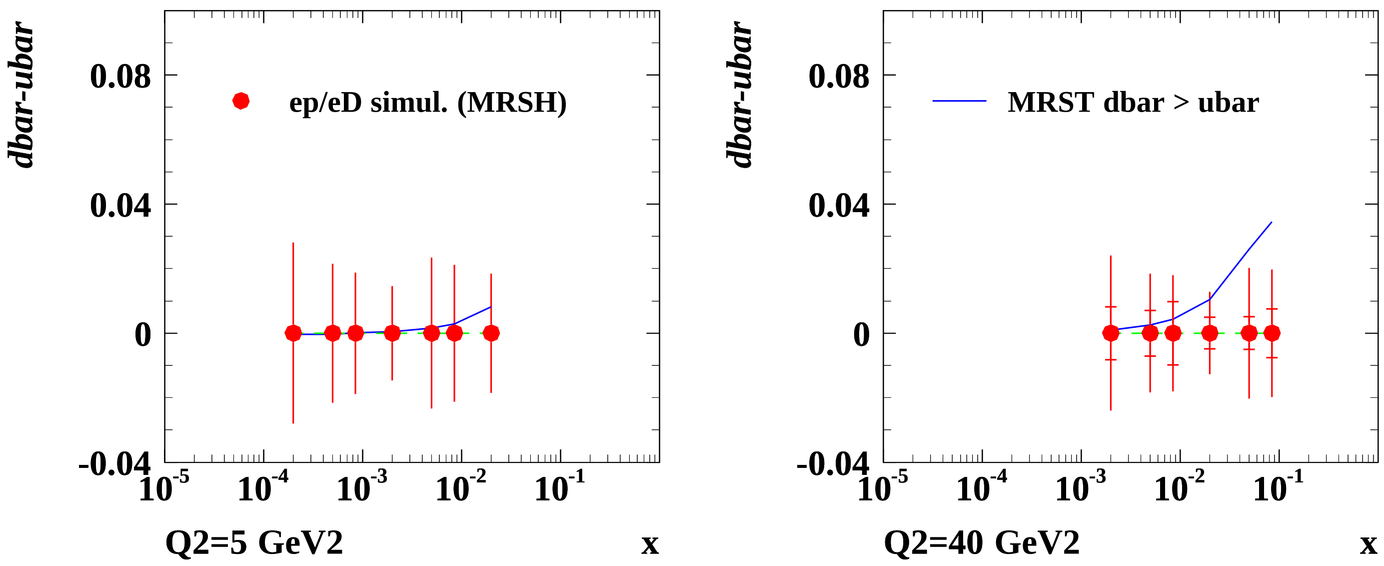
Year	H1	ZEUS	New Detector
2003	High Lumi	High Lumi	Design
2004	High Lumi	High Lumi	Prototype
2005	High Lumi	High Lumi	Construct in West Hall
2006	High Lumi	High Lumi	Construct in West Hall
2007	High Lumi/low E_p	High Lumi/low E_p	Construct in West Hall
2008	$e^{\pm}D$		Install in West Hall
2009	$e^{\pm}D$		Engineering run
2010	Upgrade		ep low x and Q^2
2011	ep low x and Q^2		ep low x and Q^2
2012	low E_p ep		low E_p ep
2013	eD		eD
2014	eA		eA
2015	eA		eA
2016	Spin		Spin

Table 1: Schematic schedule for future HERA eD running with H1, followed by a possible later programme involving H1 and a new HERA experiment. The H1 upgrade in 2010 would take place in conjunction with the reconstruction of the low Q^2 interaction region in the HERA North Hall. This schedule would be revised if major discoveries are made during the current HERA ep running. The ordering of the eA and spin programmes will depend on future developments.

eD programme

- SF and parton distributions
  - ▷ flavour asymmetry of the sea at low x
  - ▷ the ratio d_v/u_v at large x
  - ▷ parton distributions from NC and CC
- Non-linear effects: shadowing in the deuteron
  - ▷ from inclusive cross sections
  - ▷ from hadronic final states (via AGK cutting rules)
- Diffraction
  - ▷ coherent diffraction $eD \to eDX$
  - ▷ comparing ep and en diffractive dissociation
  - ▷ effective reduction of nucleon beam energy $\to F_L^D$

Testing flavour symmetry at low x



$$F_2^N - F_2^p = \frac{1}{2}(F_2^p + F_2^n) - F_2^p = \frac{x}{3}(\bar{d} - \bar{u})$$

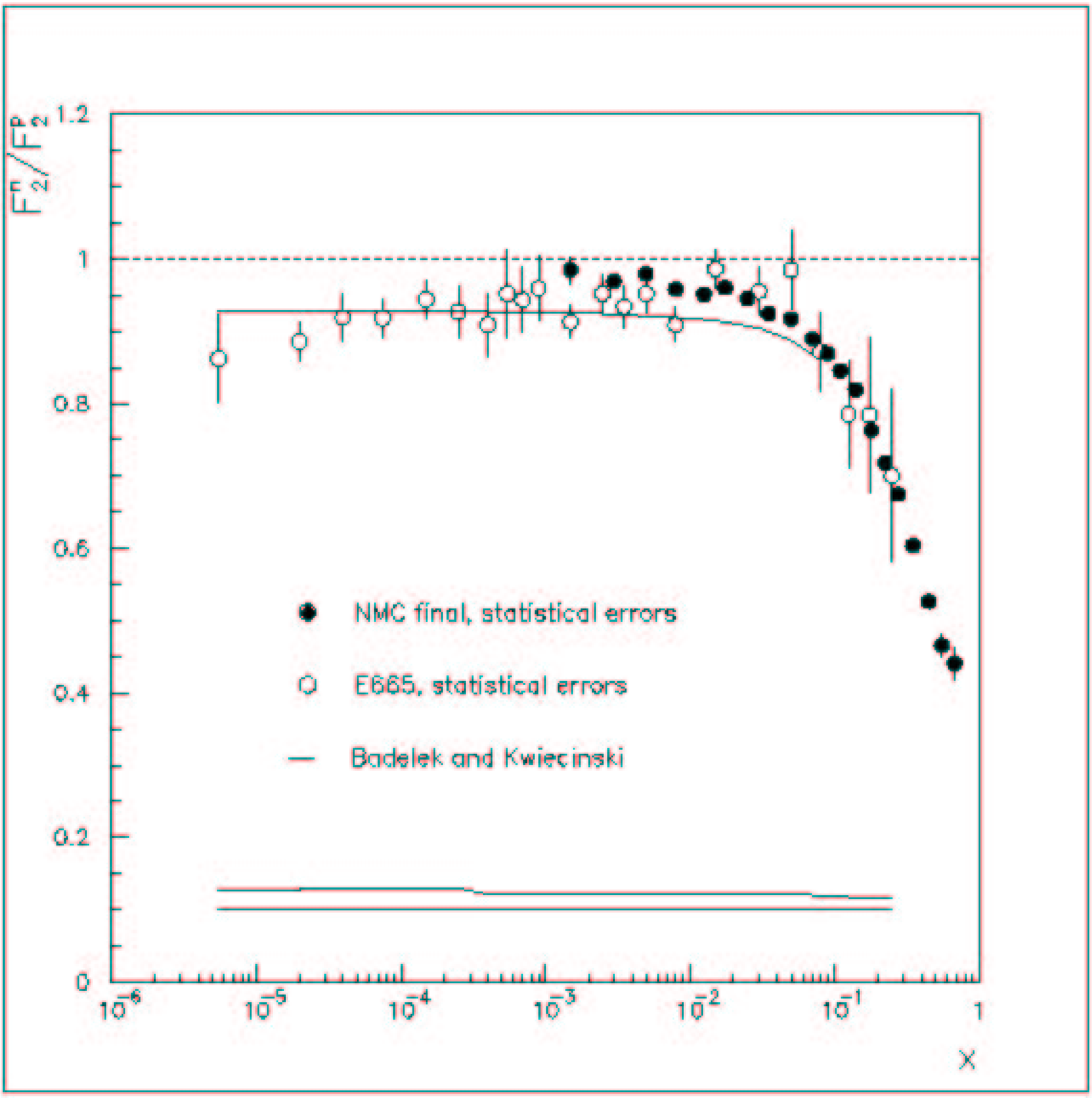
(using 40 pb^{-1} ep and 20 pb^{-1} eD)

Shadowing in the deuteron

- Measure directly (by tagging spectator $p(n)$):

$$\sigma^{\gamma^* D} = \sigma^{\gamma^* p} + \sigma^{\gamma^* n} - \Delta\sigma^{\gamma^* D}$$

- Cross check using relation shadowing $\Longleftrightarrow$ diffraction

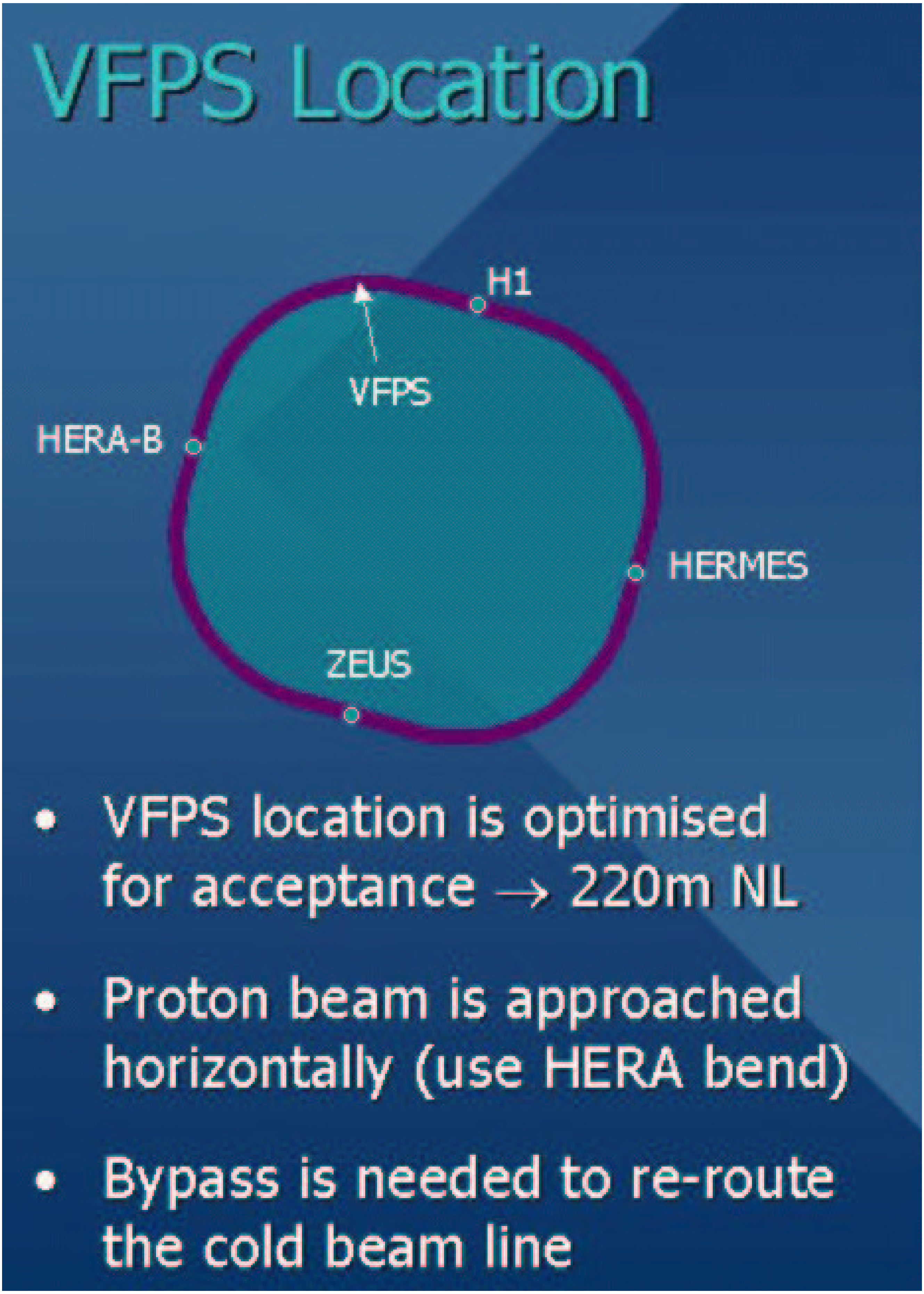


H1 detector components

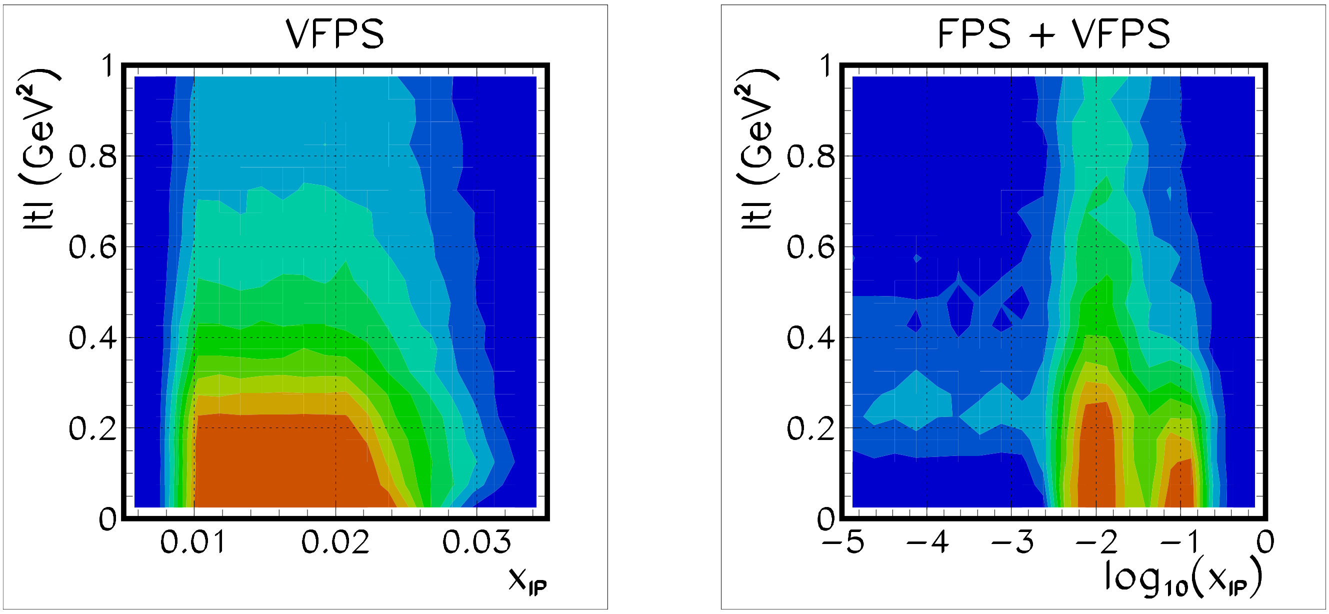
- Hadronic final states – present central H1
- Scattered electrons – main H1 ($Q^2 > 5$) and e-taggers ($Q^2 < 0.01$)
- Coherent Diffraction – present VFPS
- Nucleon spectators – present FNC, new P_{sp} detector

VFPS at HERA-2 and HERA-3:

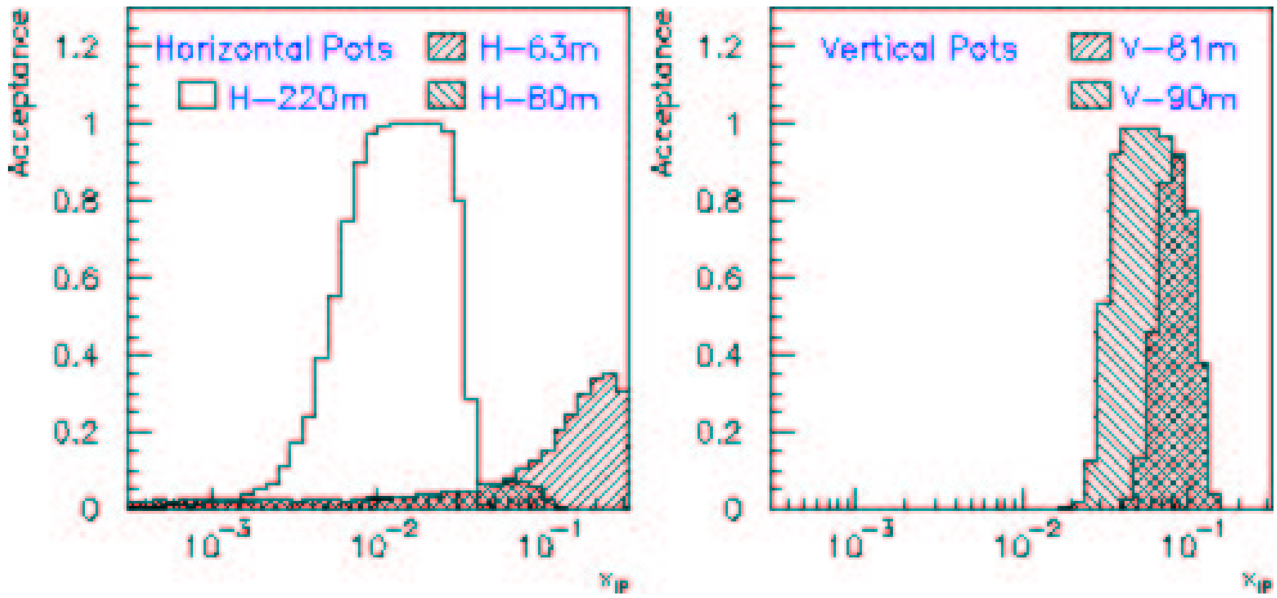
- Large acceptance for diffractive events $(x_{\mathbb{P}} = \mathcal{O}(0.01))$
- High efficiency and sufficient intrinsic resolution
- Triggering ability


VFPS Location
H1
VFPS
HERA-B
HERMES
ZEUS
• VFPS location is optimised for acceptance → 220m NL
• Proton beam is approached horizontally (use HERA bend)
• Bypass is needed to re-route the cold beam line

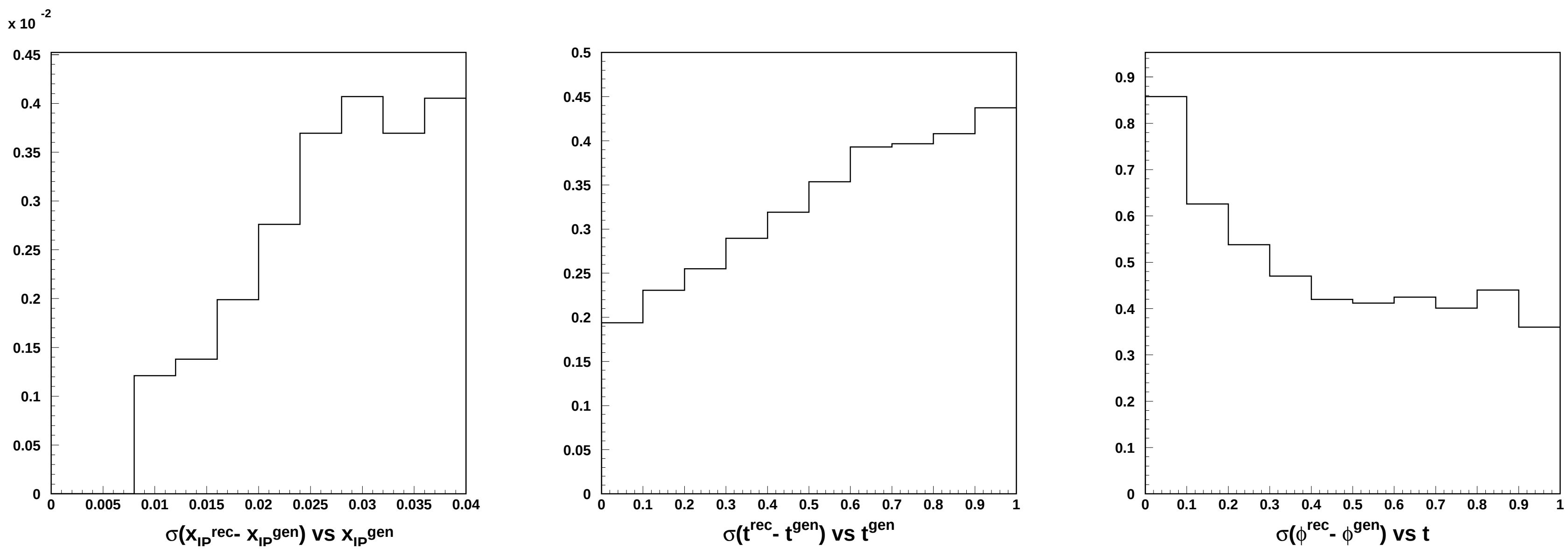
VFPS acceptance in $(x_{I\!P}, |t|)$ plane



VFPS vs old FPS acceptances



VFPS resolutions



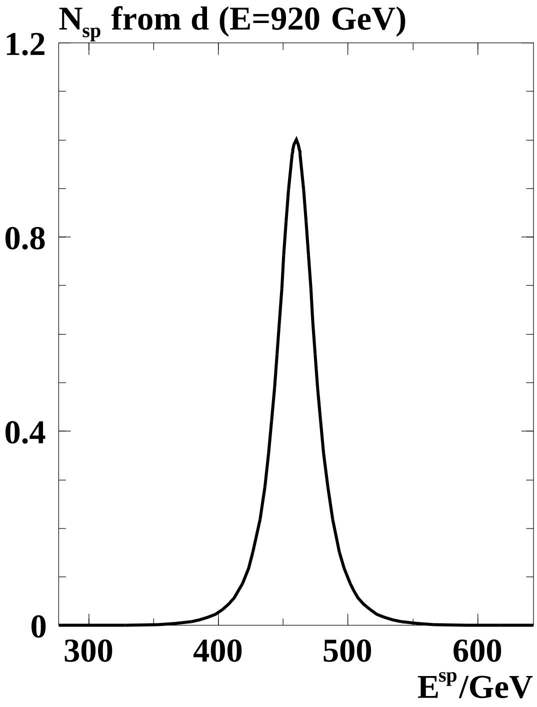
$x_{I\!P} : \mathcal{O}(10\%)$

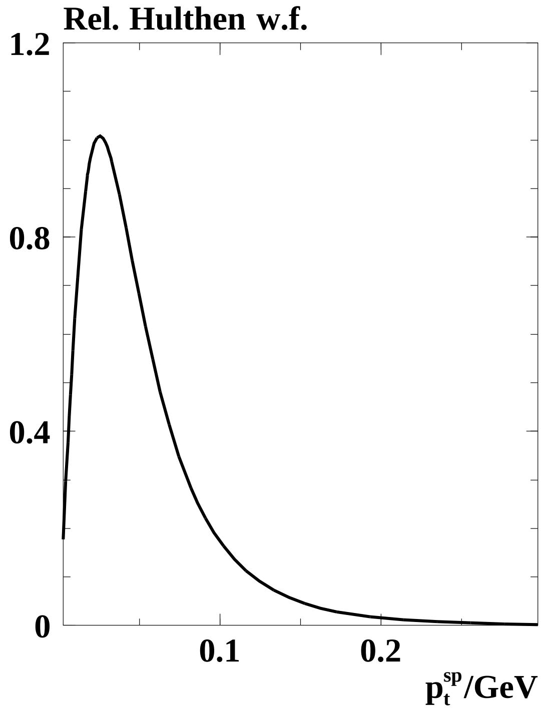
$|t| : 4$ bins in ep

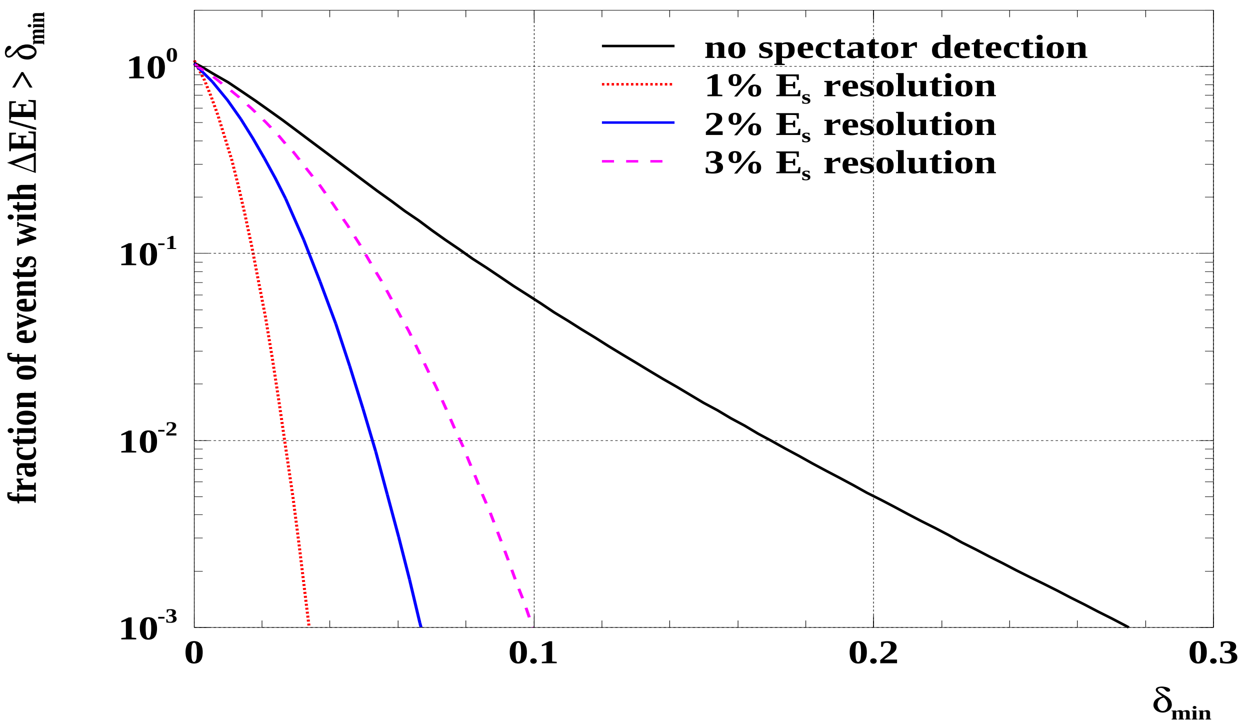
1 bin in eD

$\phi : 15$ bins

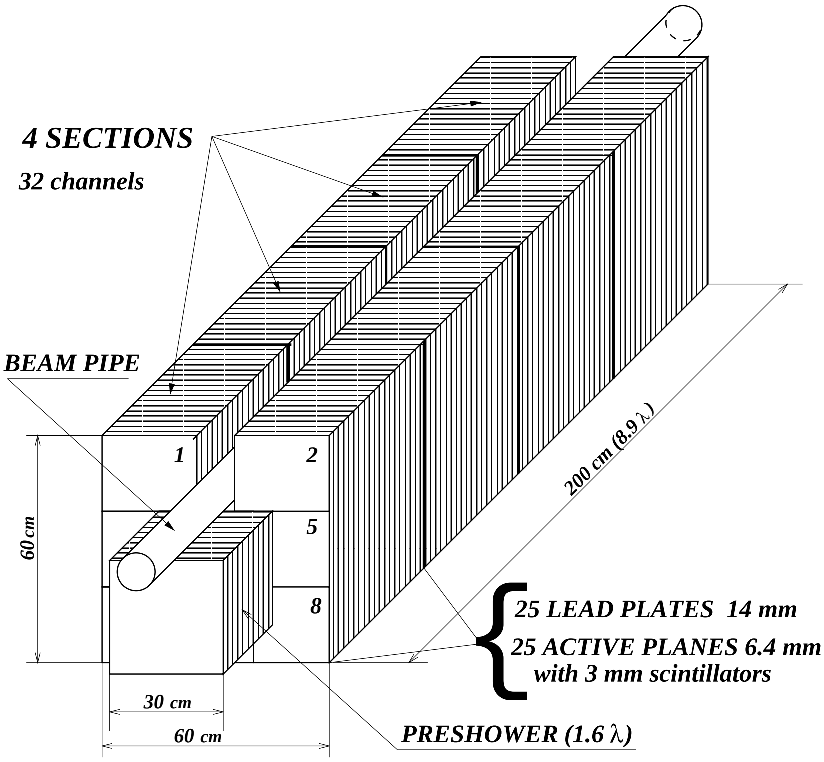
Spectator nucleon distributions from deuteron beam



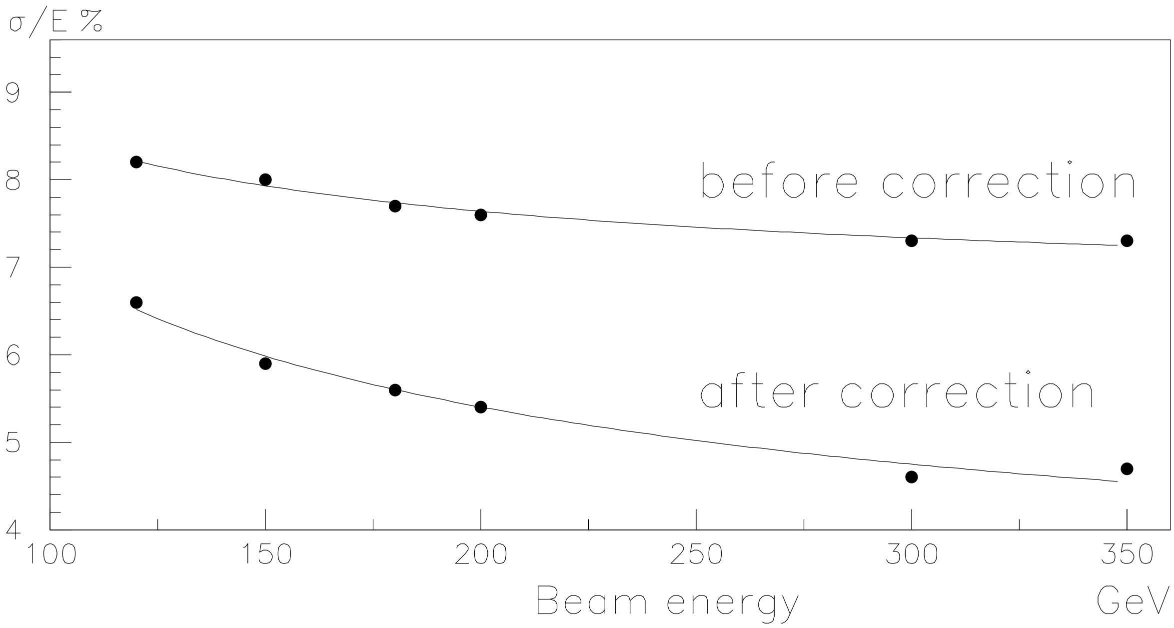




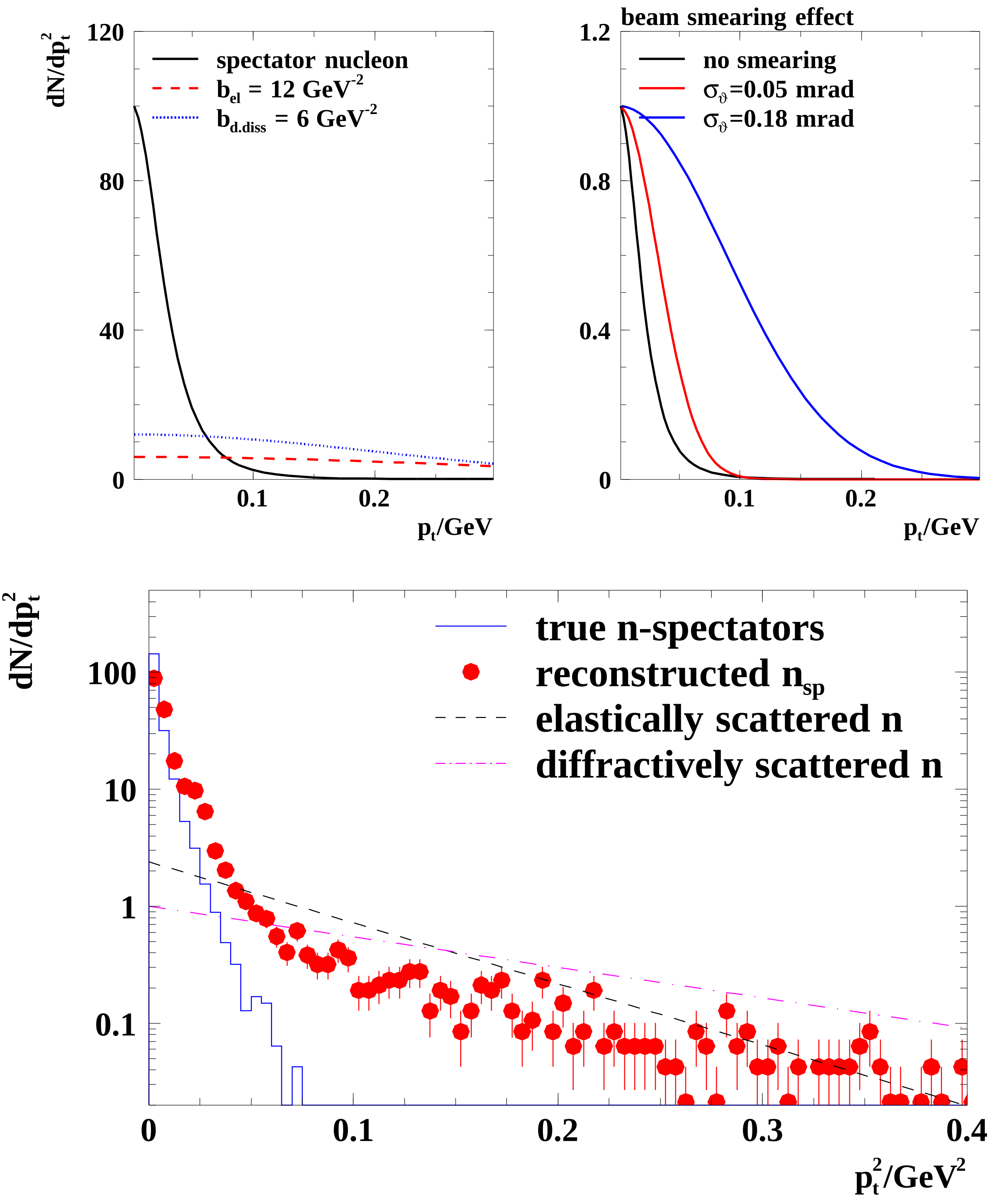
H1 FNC



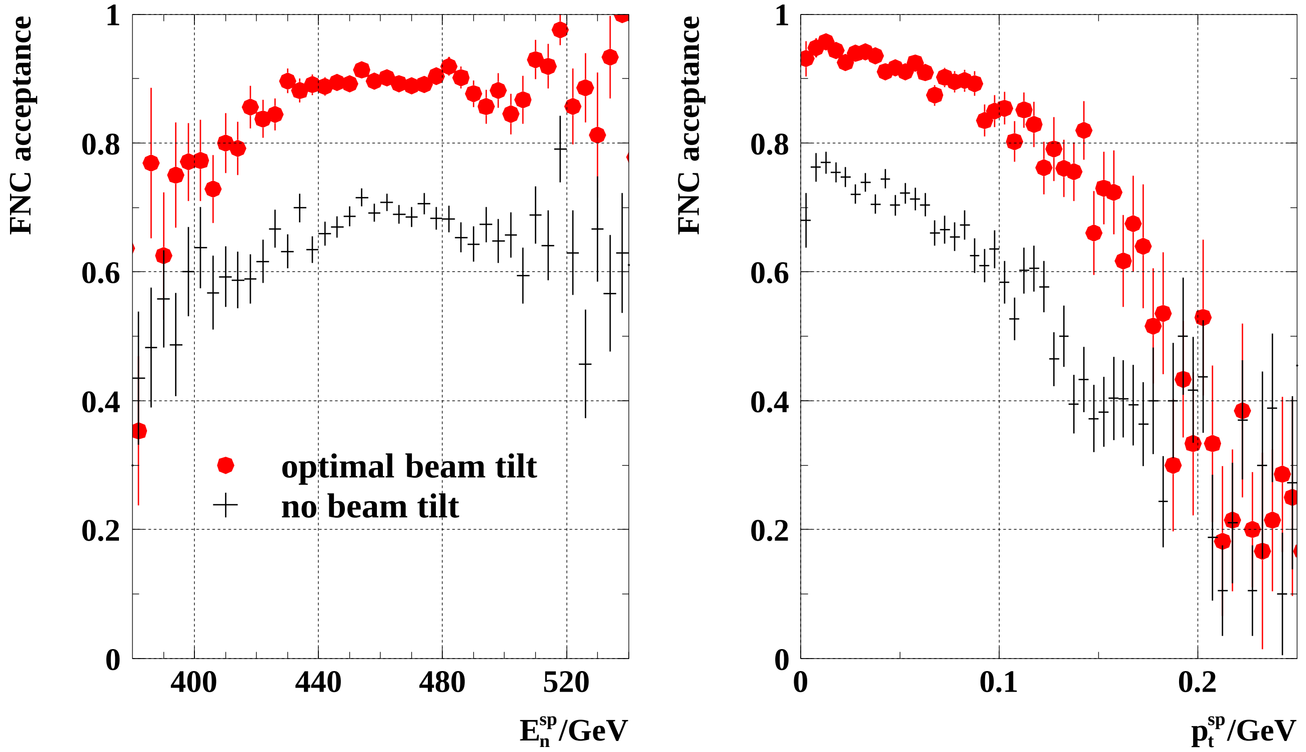
4 Main Modules (8 channels each)
Preshower (18 channels=9x+9y)
total 50 channels +Veto Counters (2 channels)

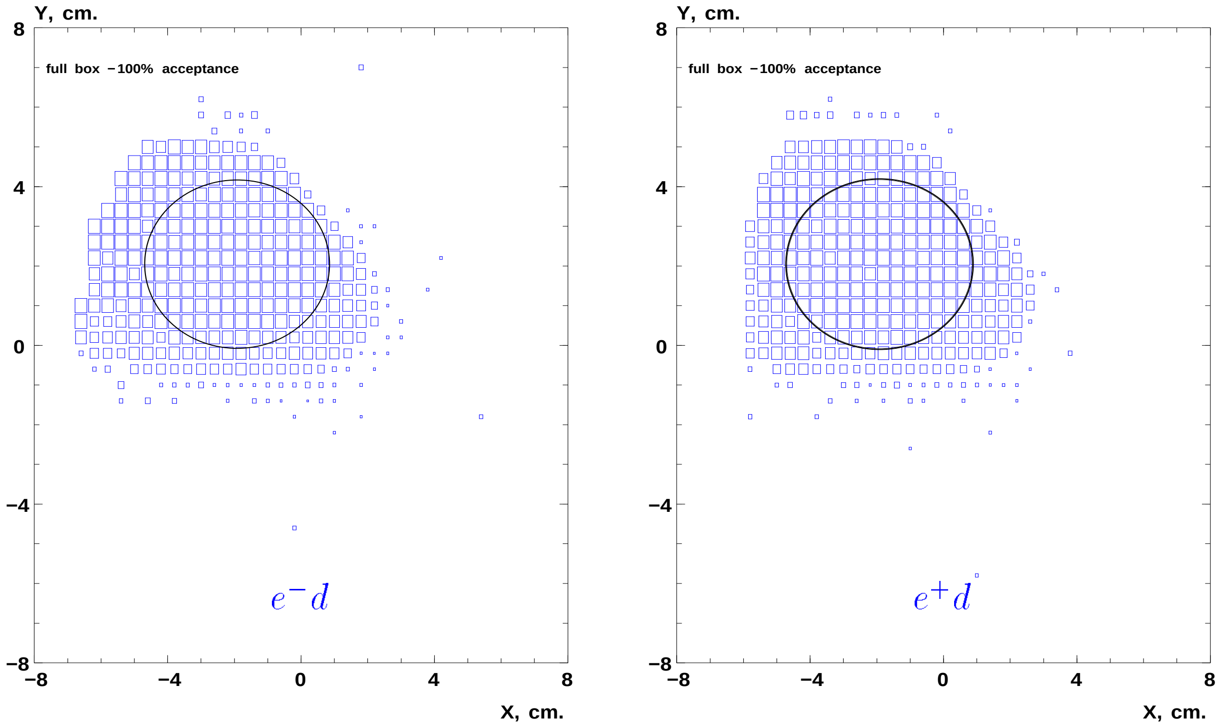


Spectator nucleons vs diffractively scattered ones



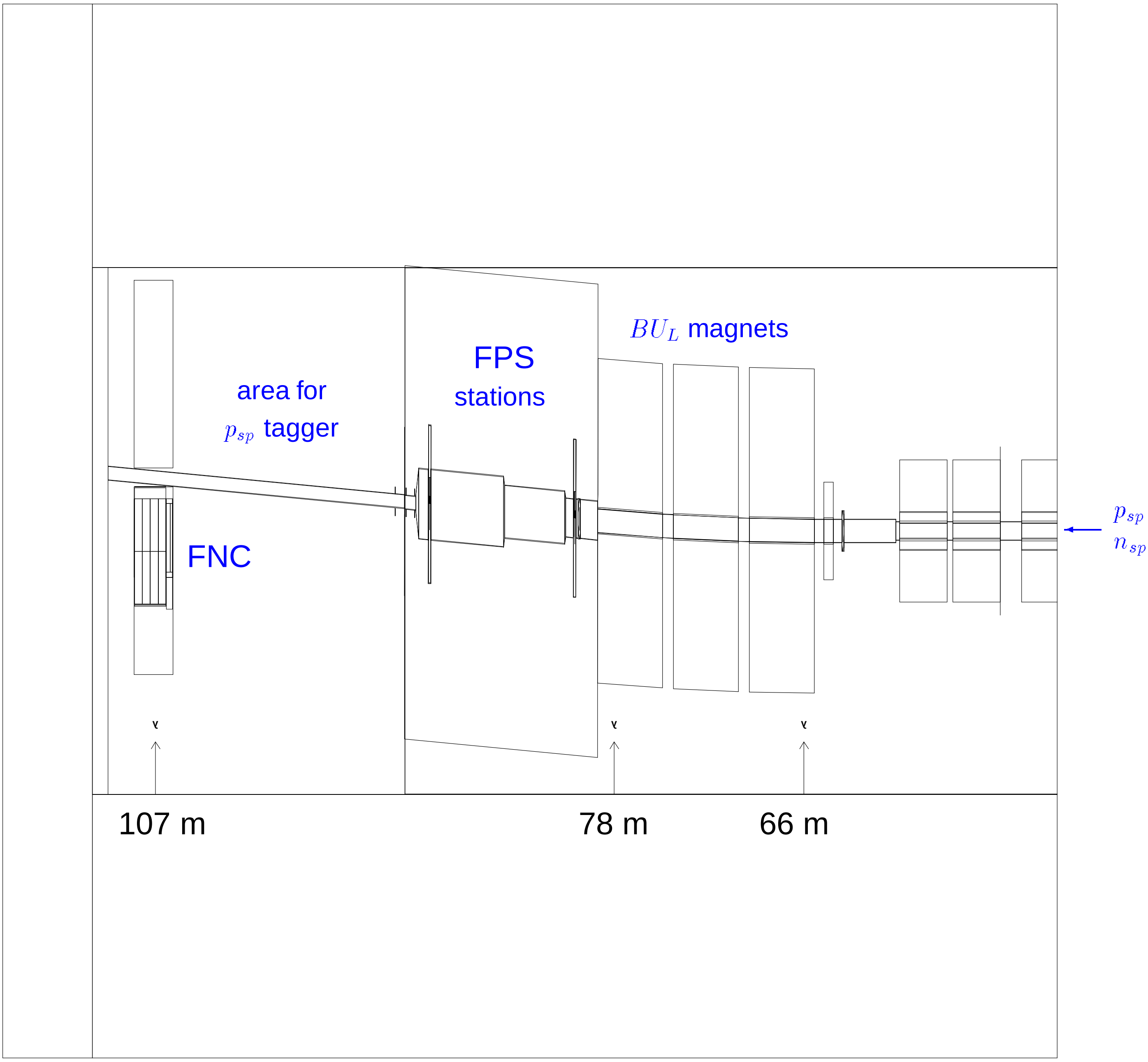
FNC acceptance for n_{sp} for HERA-2 optics



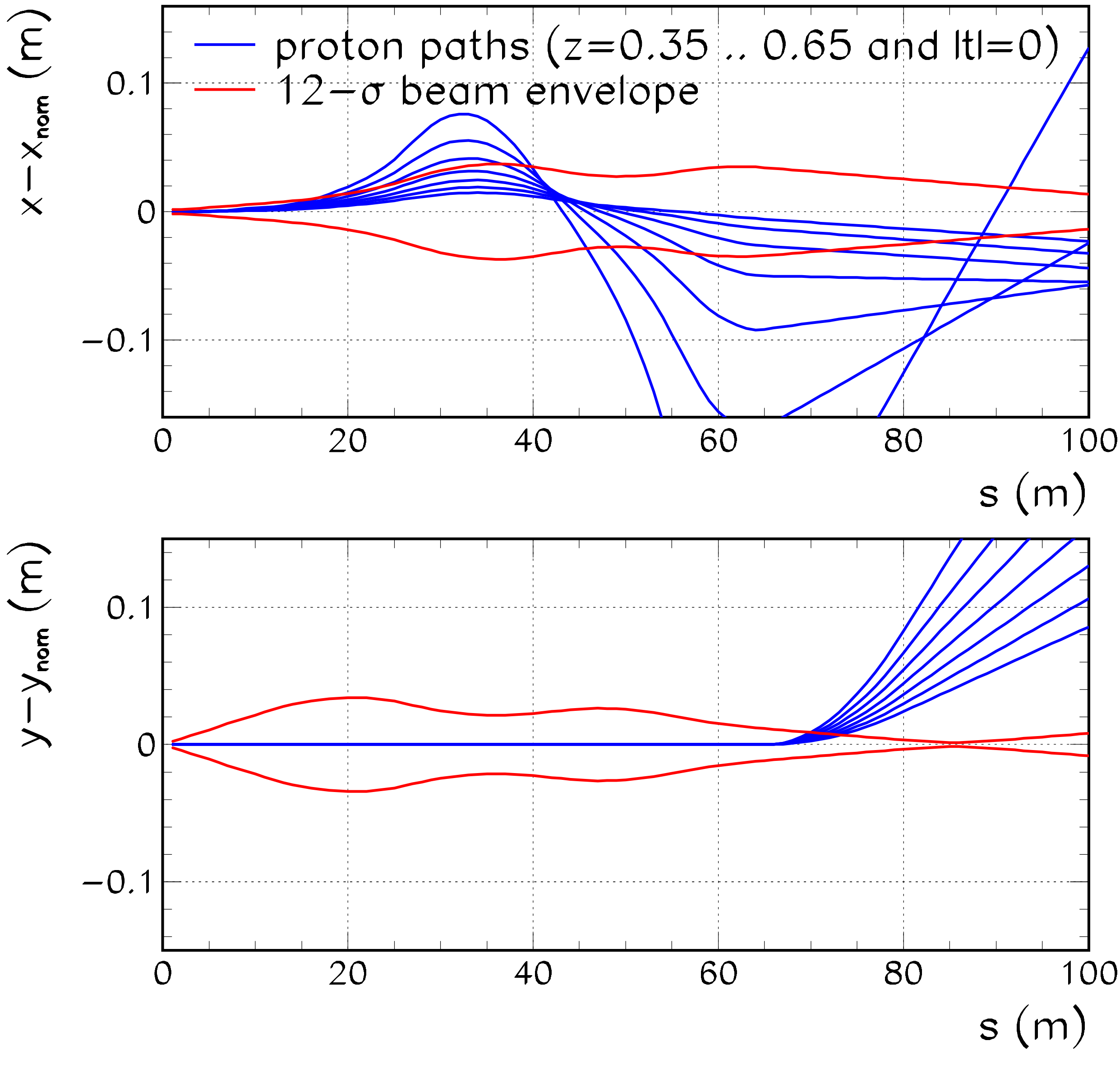


Circles show $p_t = 100$ MeV line for spectator neutrons with $E_n = 460$ GeV

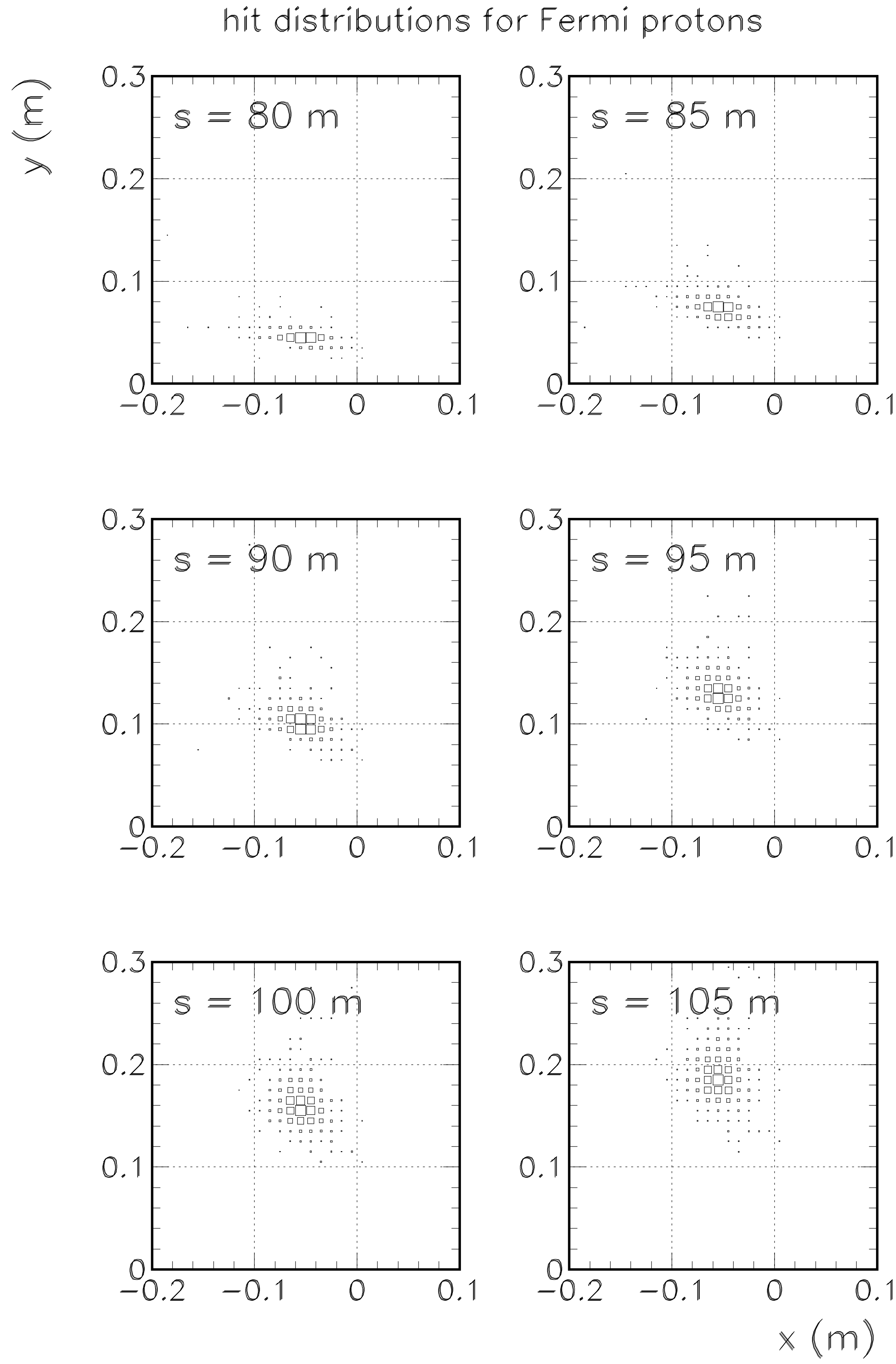
Beamline geometry in the forward direction (NL area)

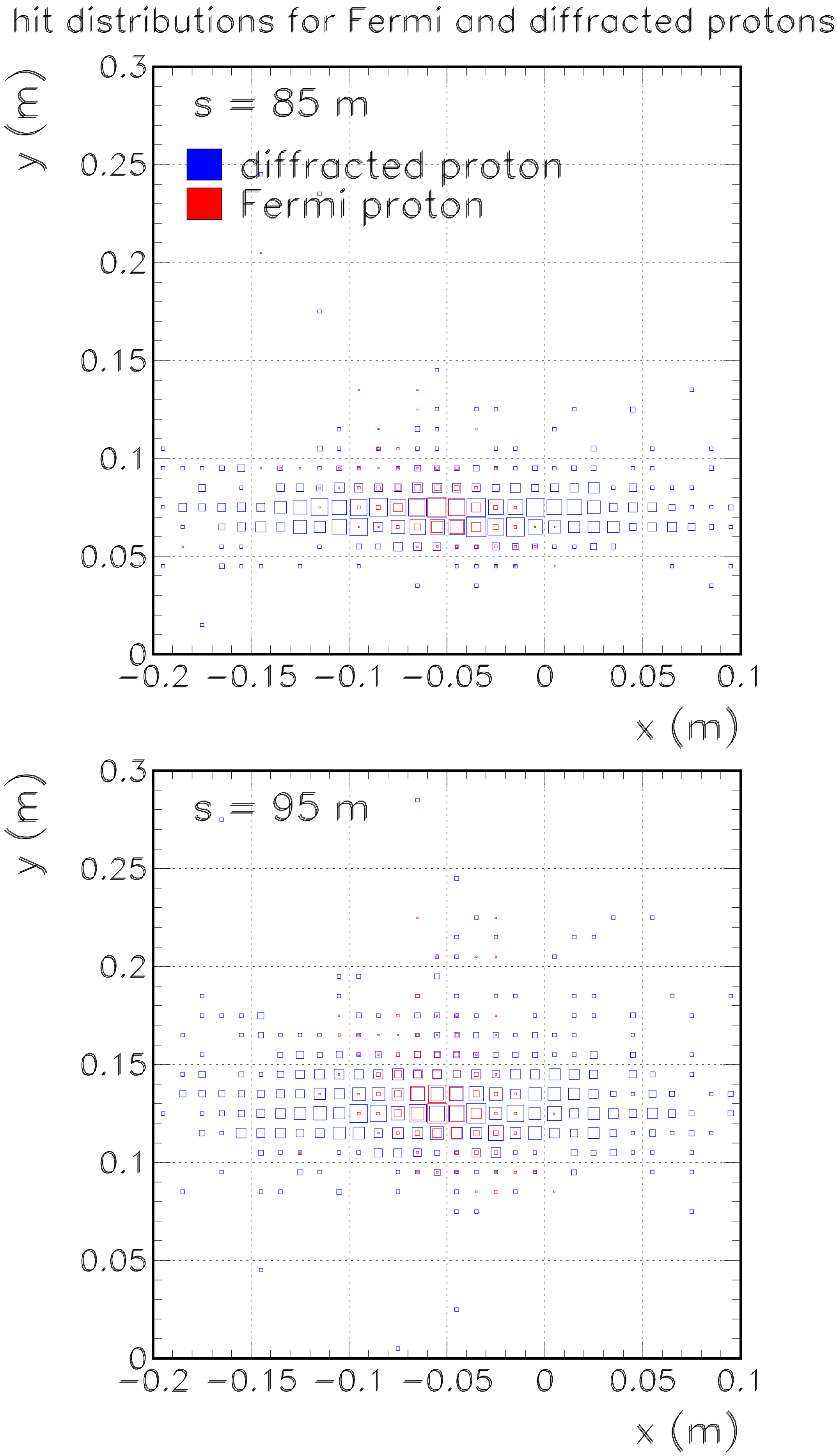


Trajectories of the spectator protons with different $z = P_{sp}/P_{beam}$ in horizontal and vertical planes for HERA-2 optics



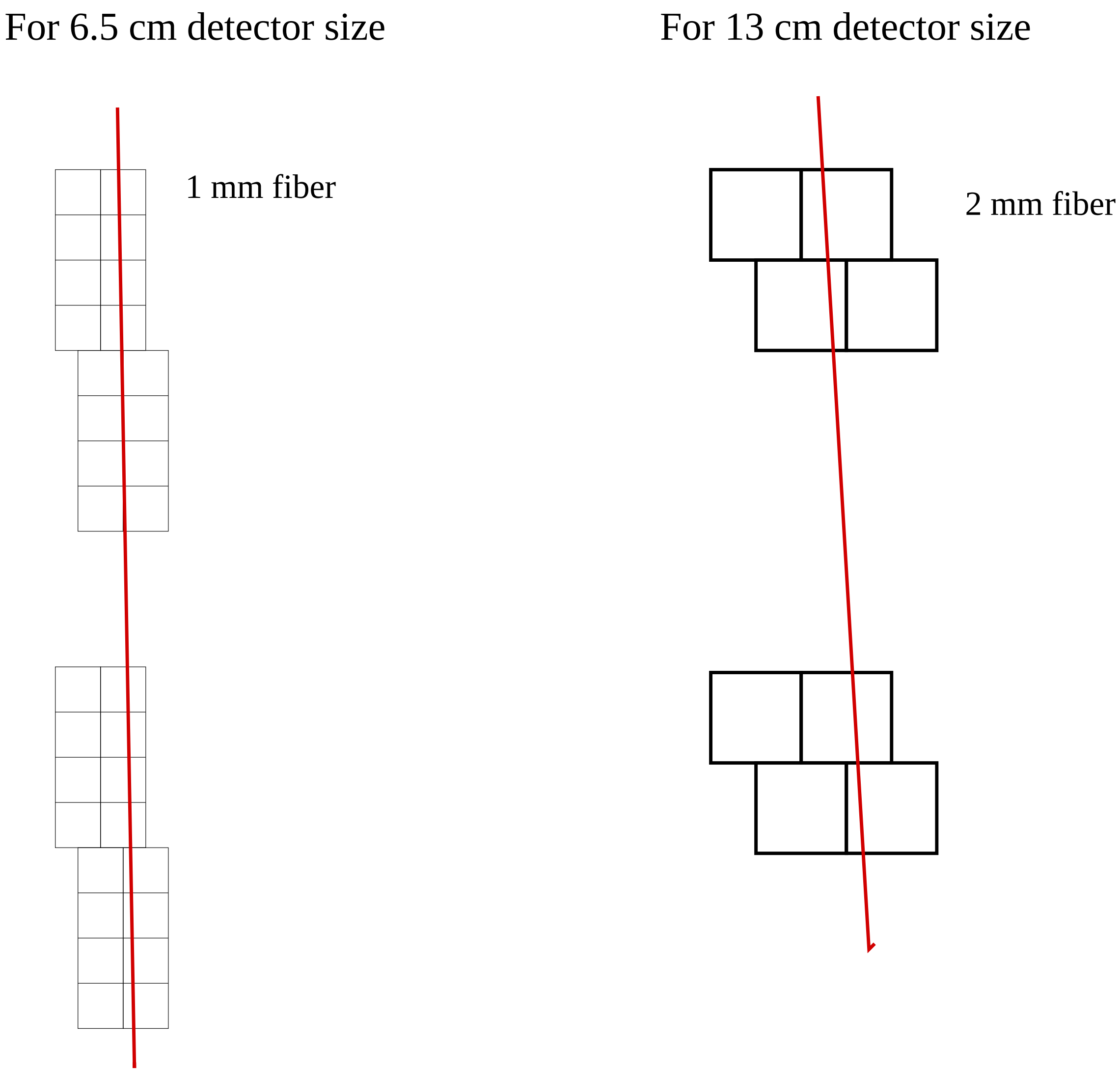
⇒ Aperture limitations between 50 and 80 m need to be reduced


hit distributions for Fermi protons
y (m)
x (m)
s = 80 m
s = 85 m
s = 90 m
s = 95 m
s = 100 m
s = 105 m
0.3
0.2
0.1
0
−0.2
−0.1
0
0.1



hit distributions for Fermi and diffracted protons
s = 85 m
diffracted proton
Fermi proton
y (m)
x (m)
0
0.05
0.1
0.15
0.2
0.25
0.3
−0.2
−0.15
−0.1
−0.05
0.05
0.1
s = 95 m

Possible Spectator Proton Detector
(2 stations between 85m and 105m from IP)



−> 1% energy resolution for HERA−2 optics

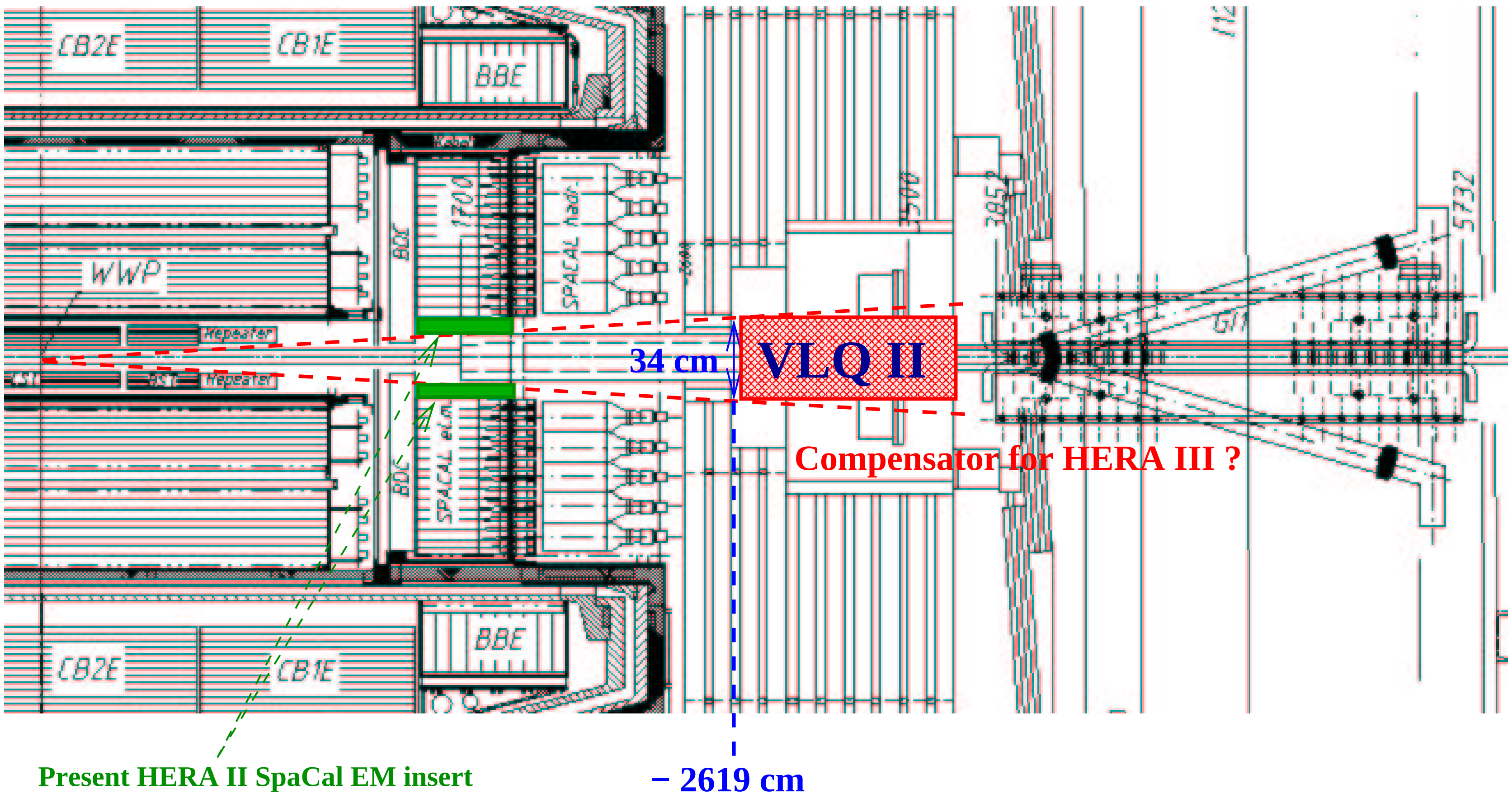
efficiency $\geq 90\%$/track
Number of channels: 16 PSPM $\times$ 64 channels
cost estimate: $\mathcal{O}(100k\$)$

Running HERA beyond eD

- Step 2: low x and Q^2 ep programme
  - ▷ Rebuild IP region (remove GG/GO magnets)
  - ▷ Improve low Q2 acceptance for scattered electrons $\rightarrow$ NVLQ
  - ▷ Improve acceptance in forward direction $\rightarrow$ new PLUG, active beampipe (?), ...

- Step 3: eA collisions ($A = 2, 201, ...$?)
  - ▷ H1 detector configuration same as for step-2
  - ▷ Q1: Laser cooling using existing FEL (?)
  - ▷ Q2: Ion source(s) ?

Possible revival of VLQ spectrometer for HERA III



Summary

- H1 is srongly in favour of extending HERA program beyond 2007. An optimal strategy is seen as staged running, starting with eD mode

- Spectator proton detector is the only missing component for step-1. Technical solution to be detailed during this workshop

- Running beyond eD requires more significant detector modification which should also be specified during this week

- Both eA and spin programmes require essential machine development. At present accelerating $A = 201$ ions with adequate beam parameters seems to be the easiest extention.