DIS 2006, Tsukuba, April 19-24 2006

MULTI-LEPTON EVENTS
and
DOUBLY CHARGED HIGGS at HERA

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for

Outstanding high-P_T multi-electron events observed at HERA I

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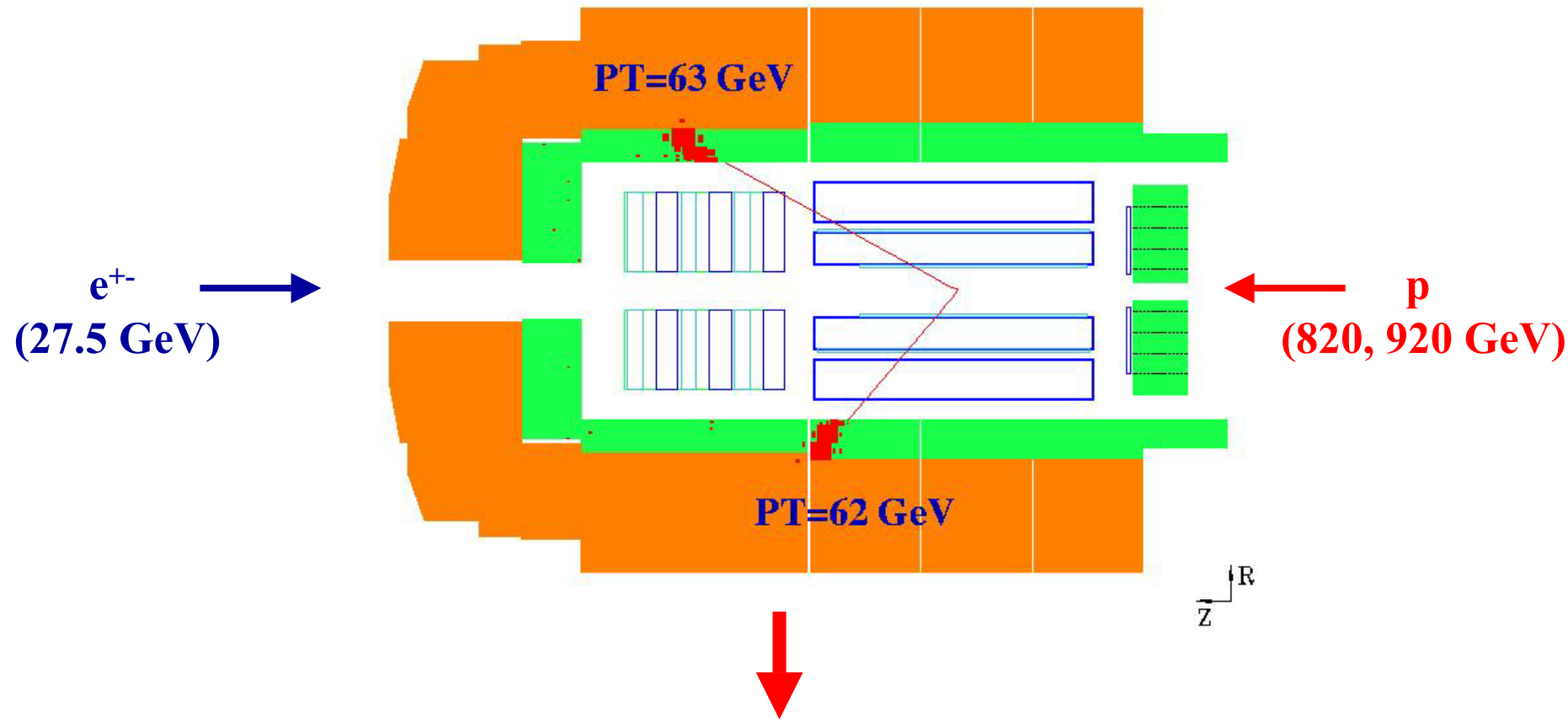
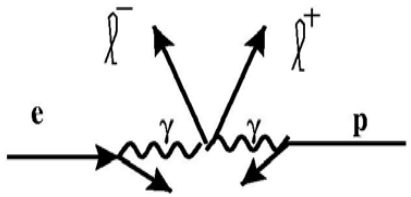
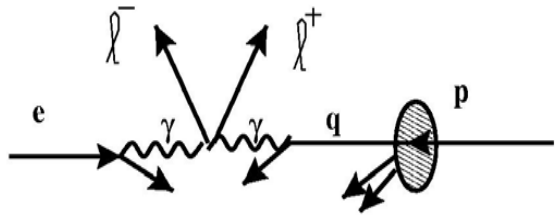


Extend search to muon channels and to latest HERA II data

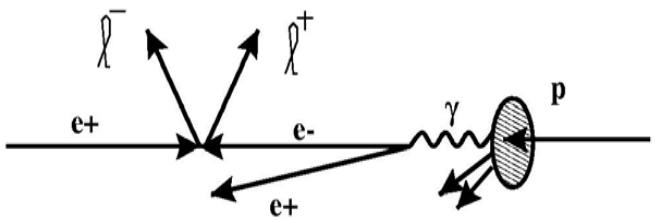
THE SM PROCESSES AND THEIR SIMULATION



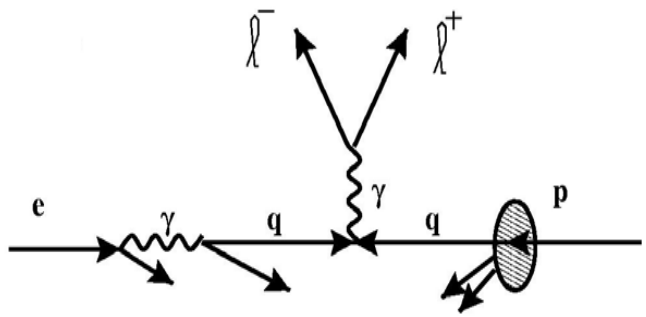
elastic γγ



inelastic γγ



Cabibbo-Parisi



Drell-Yan (negligible)

GRAPE: elastic + inelastic γγ with interference terms + ISR + FSR
+ internal conv. ($\gamma \rightarrow e^+e^-$) + Cabibbo-Parisi + EW processes
interfaced with the H1 detector

LEPTON IDENTIFICATION

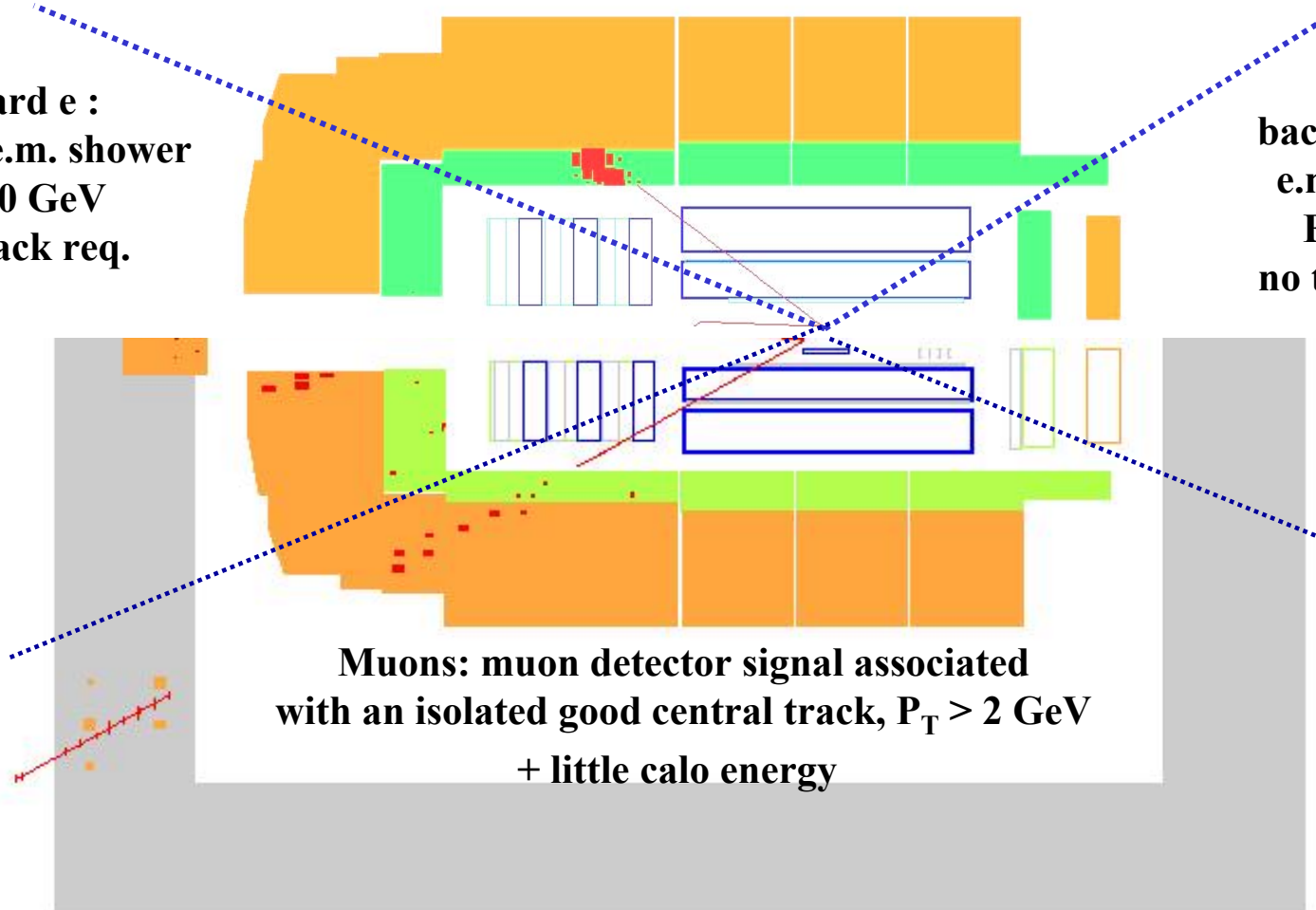
central e: isolated electromagnetic shower, E > 5 GeV
associated with an isolated good central track
+ shower-track momentum match

20°

150°

forward e :
isol. e.m. shower
E > 10 GeV
no track req.

backward e :
e.m. shower
E > 5 GeV
no track req.



160°

20°

Muons: muon detector signal associated
with an isolated good central track, P_T > 2 GeV
+ little calo energy

SELECTION STRATEGY and EVENT SAMPLES

DATA : HERA I (118 pb^{-1}) + HERA II e^+p (52 pb^{-1})
+ HERA II e^-p (105 pb^{-1}, extended by 65 pb^{-1} vs EPS05)

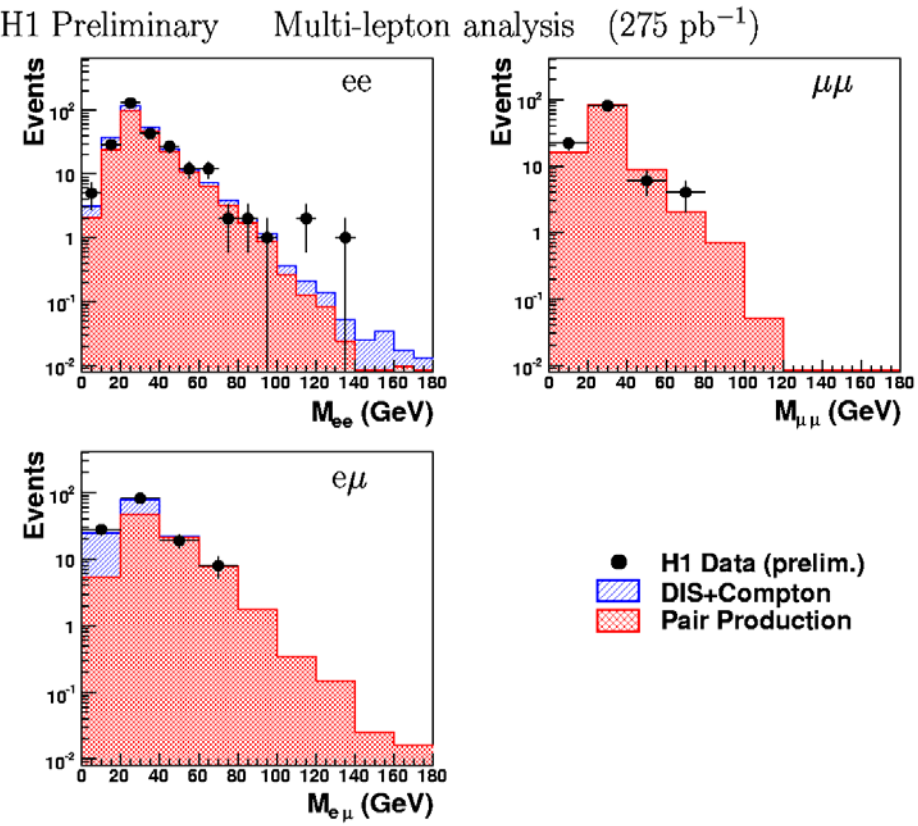
At least 2 central leptons with $P_T^{l1} > 10$ GeV, $P_T^{l2} > 5$ GeV, $20^o < \theta_{l1,2} < 150^o$
+ any additional e with $E_e > 5$ GeV, $5^o < \theta_e < 175^o$
+ any additional μ with $P_T^{\mu} > 2$ GeV, $20^o < \theta_{\mu} < 160^o$

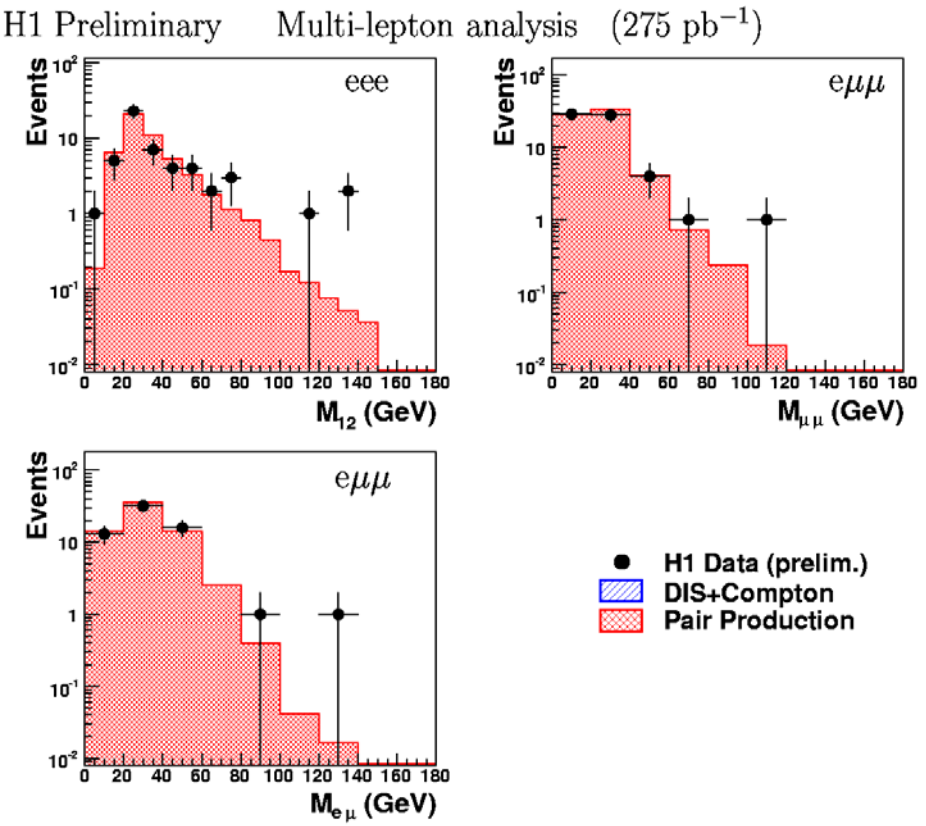
→ observed topologies : ee, μμ, eμ, eee, eμμ

H1 Preliminary 275 pb^{-1} (1994–2005)

Selection	Data	SM	Pair Production	NC-DIS + Compton
ee	266	261 ± 37	217 ± 23	44 ± 22
$\mu\mu$	113	112 ± 21	112 ± 21	—
$e\mu$	137	136 ± 21	83 ± 6.5	53 ± 16
eee	52	52 ± 6	52 ± 6	—
$e\mu\mu$	63	67 ± 10.5	67 ± 10.5	—

MASS DISTRIBUTIONS





3 *ee* events $M_{ee} > 100$ GeV (HERA I)

3 *eee* events $M_{ee} > 100$ GeV (HERA I)
1 *e*$\mu\mu$ event with $M_{e\mu} > 100$ GeV (HERA II)
1 *e*$\mu\mu$ event with $M_{\mu\mu} > 100$ GeV (HERA II)

No new very high mass event in the recent e$^-$p data

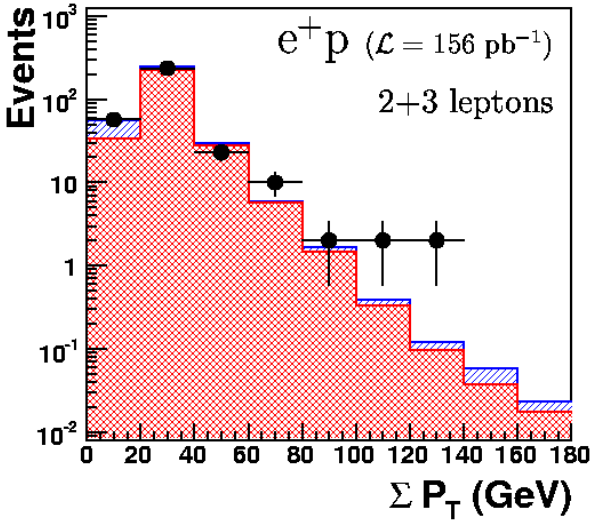
EVENT YIELDS AT HIGH MASS

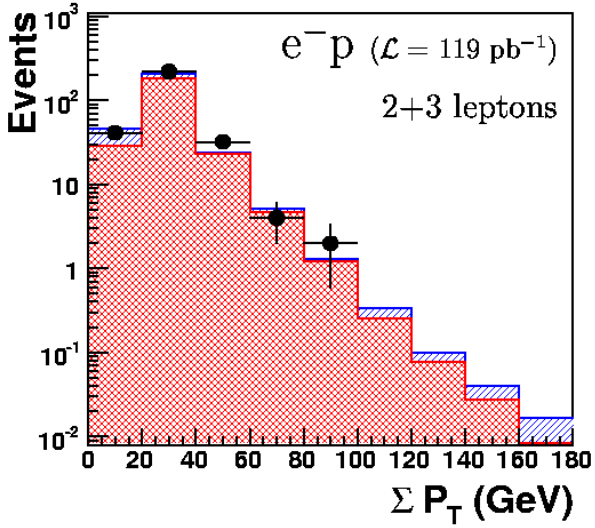
H1 Preliminary 275 pb^{-1} (1994–2005)

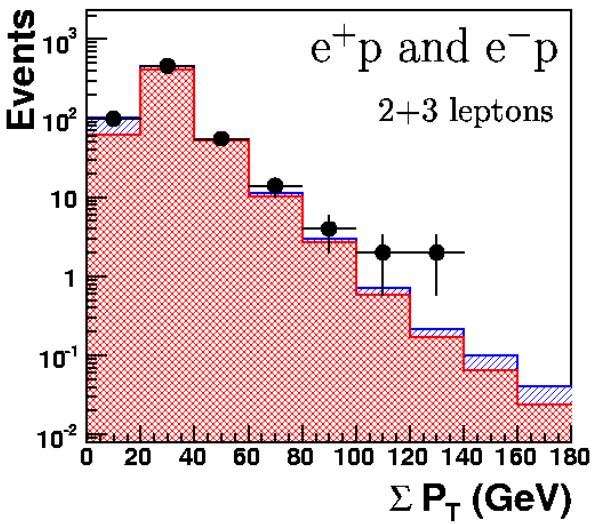
Selection	Data	SM	Pair Production	NC-DIS + Compton
e^+p collisions (156 pb^{-1})				
ee M_{12} >100 GeV	3	0.44 ± 0.10	0.29 ± 0.09	0.15 ± 0.04
$\mu\mu$ $M_{\mu\mu}$ >100 GeV	0	0.03 ± 0.02	0.03 ± 0.02	—
$e\mu$ $M_{e\mu}$ >100 GeV	0	0.29 ± 0.03	0.29 ± 0.03	—
eee M_{12} >100 GeV	3	0.29 ± 0.06	0.29 ± 0.06	—
$e\mu\mu$ $M_{e\mu}$ >100 GeV	1	0.04 ± 0.01	0.04 ± 0.01	—
$e\mu\mu$ $M_{\mu\mu}$ >100 GeV	1	0.015 ± 0.007	0.015 ± 0.007	—
e^-p collisions (119 pb^{-1})				
ee M_{12} >100 GeV	0	0.42 ± 0.11	0.23 ± 0.06	0.19 ± 0.06
$\mu\mu$ $M_{\mu\mu}$ >100 GeV	0	0.02 ± 0.02	0.02 ± 0.02	—
$e\mu$ $M_{e\mu}$ >100 GeV	0	0.24 ± 0.04	0.24 ± 0.04	—
eee M_{12} >100 GeV	0	0.18 ± 0.05	0.18 ± 0.05	—
$e\mu\mu$ $M_{e\mu}$ >100 GeV	0	0.03 ± 0.01	0.03 ± 0.01	—
$e\mu\mu$ $M_{\mu\mu}$ >100 GeV	0	0.004 ± 0.003	0.004 ± 0.003	—

$\sum P_T$ DISTRIBUTIONS

H1 Preliminary Multi-lepton analysis (275 pb^{-1})







H1 Data (prelim.)
DIS+Compton
Pair Production

H1 Preliminary 275 pb^{-1} (1994–2005)

Selection	Data	SM	Pair Production	NC-DIS + Compton
$e^+p \sum P_T > 100$ GeV	4	0.6 ± 0.1	0.49 ± 0.09	0.11 ± 0.04
$e^-p \sum P_T > 100$ GeV	0	0.5 ± 0.1	0.37 ± 0.10	0.13 ± 0.04
All $\sum P_T > 100$ GeV	4	1.1 ± 0.2	0.86 ± 0.18	0.24 ± 0.06

No new event at very high $\sum P_T$ in the recent e^-p data

SEARCH FOR DOUBLY CHARGED HIGGS

(DESY 06-038, hep-ex/0604027)

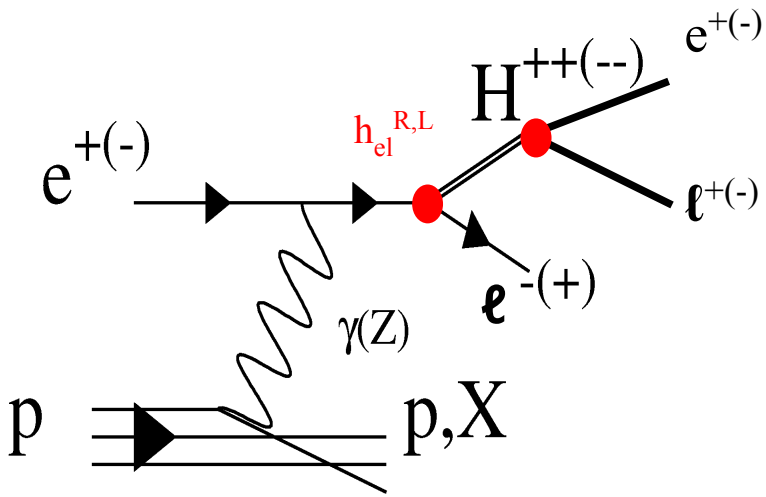
- $H^{\pm\pm}$ appear as Higgs triplets of non-zero hypercharge in some extensions of the SM (eg SUSY LRS models which can generate light neutrino masses)
- No coupling to quarks (charge conservation)
- Coupling to leptons not related to lepton masses

HERA sensitive only to $h_{el}^{R,L}$

same cross section for

h_{el}^{R} and h_{el}^{L} at HERA I

(unpolarized beams)



Assumed here: one dominant coupling: $h_{el} >> 0$, others ~ 0

SEARCH STRATEGY AND EVENT SAMPLES

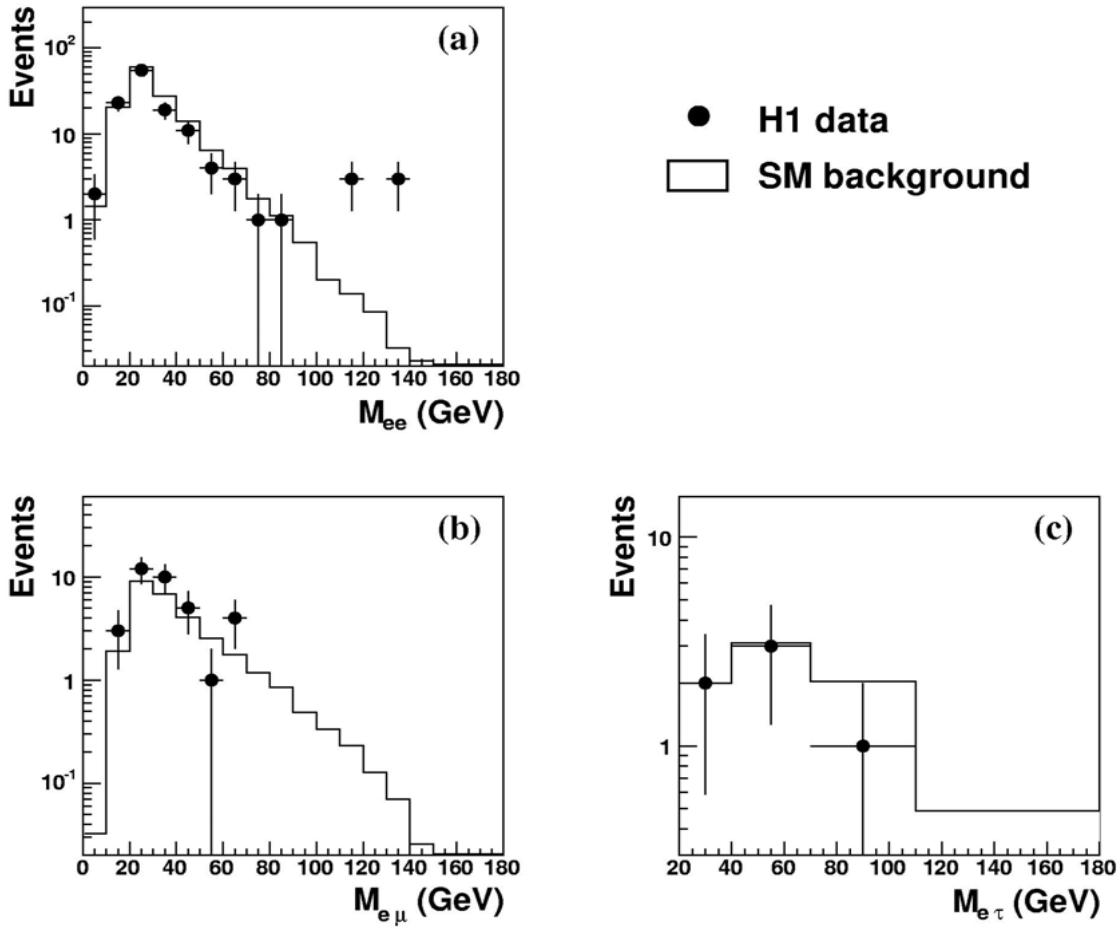
Look for *ee*, *eμ* or *eτ* pairs of high-P_T equally charged leptons (lepton charges = beam charge)

- ***ee* and *eμ* channels :** based on high-P_T multi-lepton analysis (HERA I)
- ***eτ* channel :** dedicated analysis (HERA I, 88 pb^{-1})

  all τ decays considered : e, μ and hadronic decays

  $P_T^{e,\tau} > 10, 5$ GeV, $20^o < \theta^{e,\tau} < 140^o$

MASS DISTRIBUTIONS
(preselected samples)

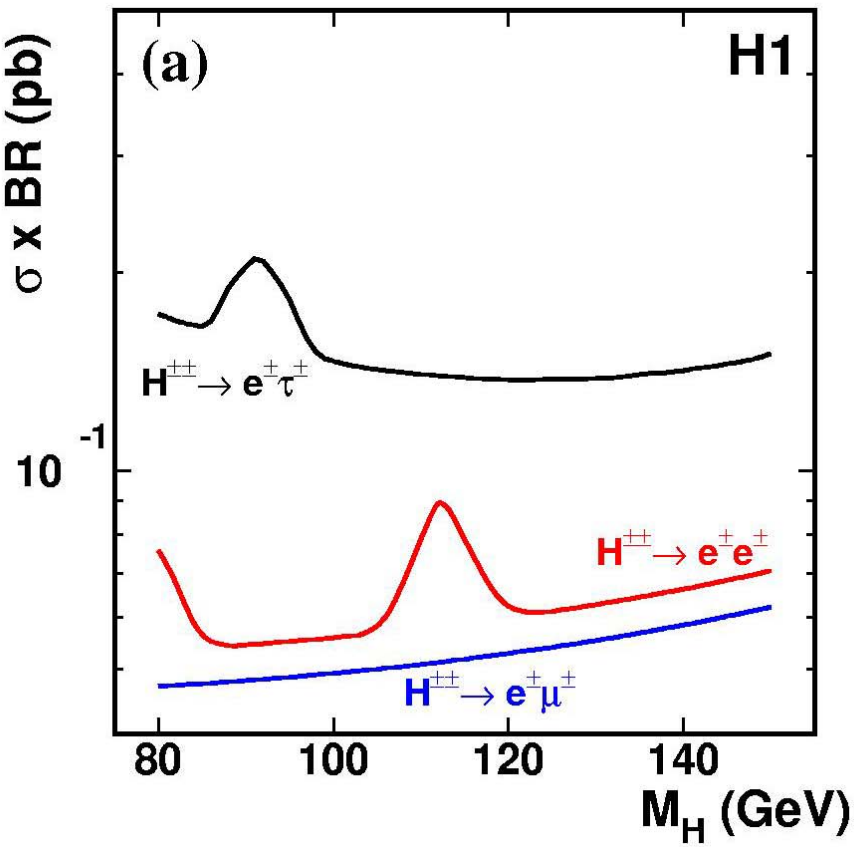


Final candidates
$M_{el} > 65$ GeV
+ charge condition

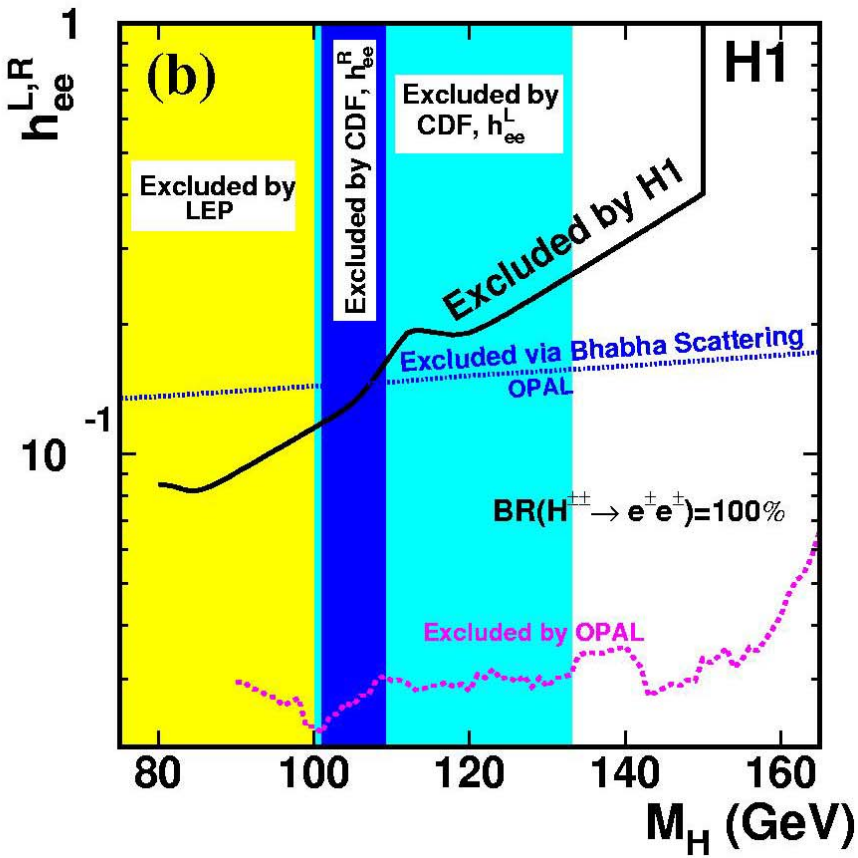
3 *ee* candidates for 2.45 + 0.11 expected from SM
1 *eμ* " " 4.17 + 0.44 " " "
1 *eτ* " " 2.07 + 0.54 " " "

DOUBLY CHARGED HIGGS : RESULTS

σ * branching ratio



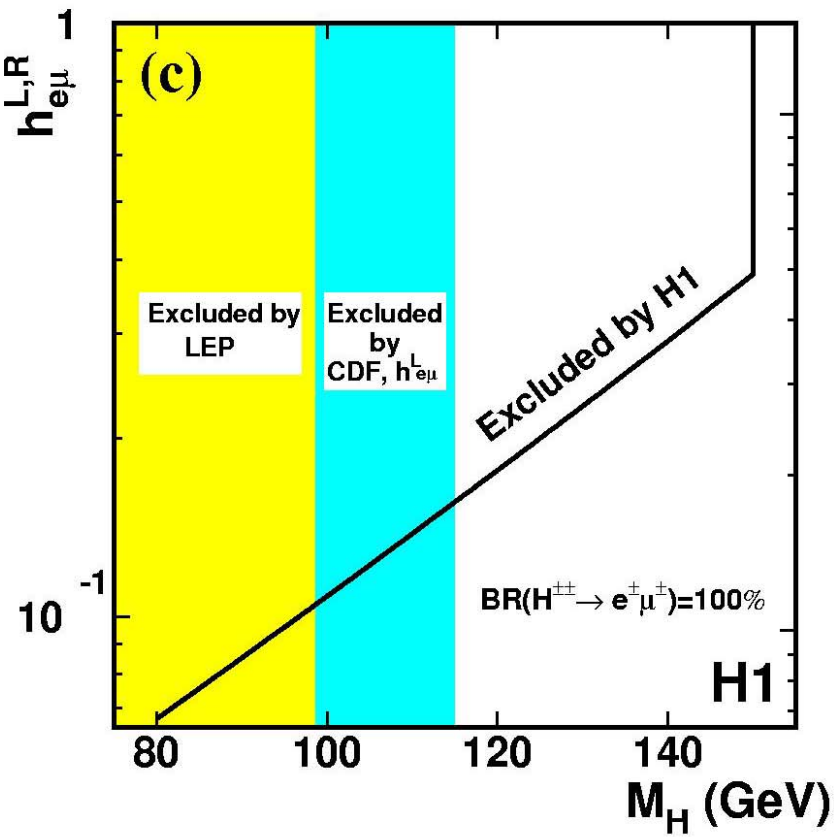
Limit on h_{ee}



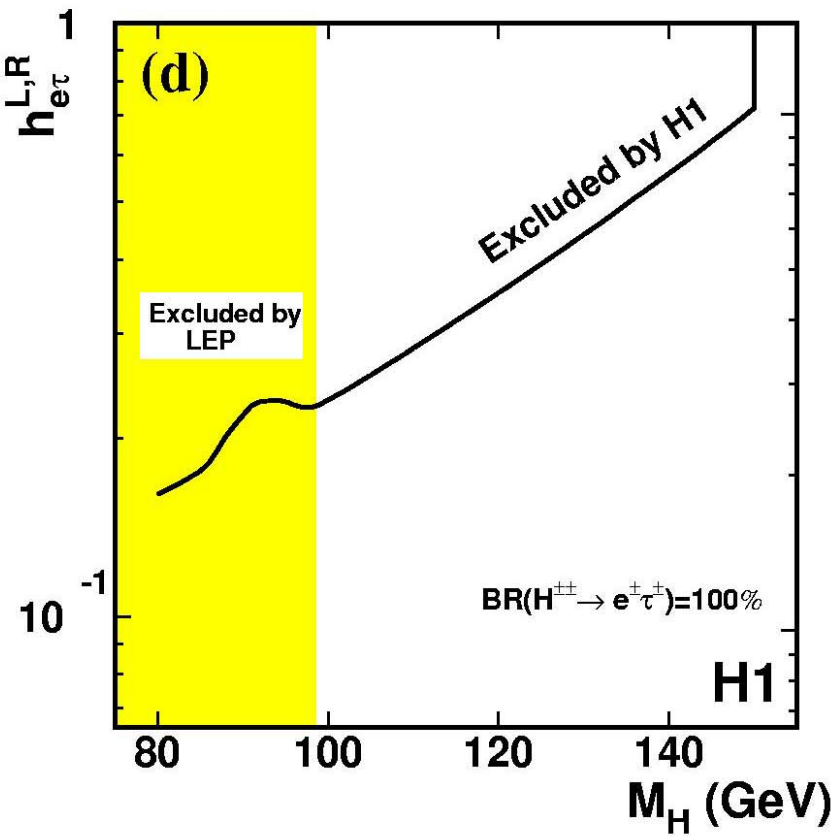
Confirms that high-P_T multi-electron events are unlikely to be due to $H^{\pm\pm}$ decay

$H^{\pm\pm}$: LIMITS on $h_{e\mu}$ and $h_{e\tau}$

$h_{e\mu}$



$h_{e\tau}$



H1 limits extend the excluded regions

SUMMARY

High-P_T multi-lepton analysis extended to the full e^-p data taken in 2005 (full H1 1994-2005 data sample now amounts to 275 pb^{-1}).

- ee, $\mu\mu$, $e\mu$, eee and $e\mu\mu$ topologies studied
- At $\sum P_T > 100$ GeV, 4 events are observed for 1.1 + 0.2 expected
- All outstanding events were taken in e^+p collisions

Exotic production of H^{++} studied with HERA I data

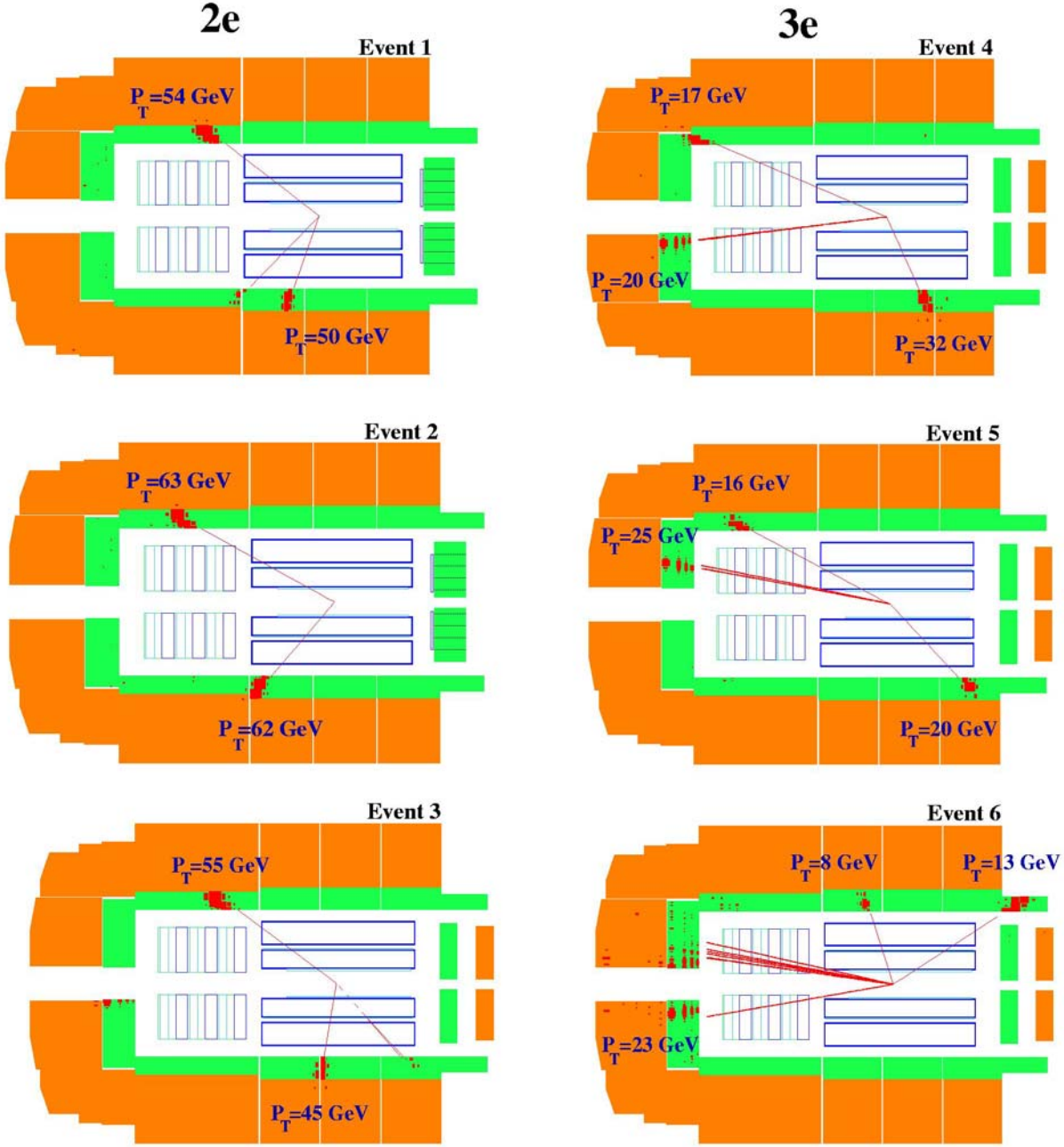
- ee, $e\mu$ and $e\tau$ topologies analysed
- ee and eee high mass events unlikely to be H^{++}
- Improved limits set on non-diagonal couplings $h_{e\mu}$ and $h_{e\tau}$

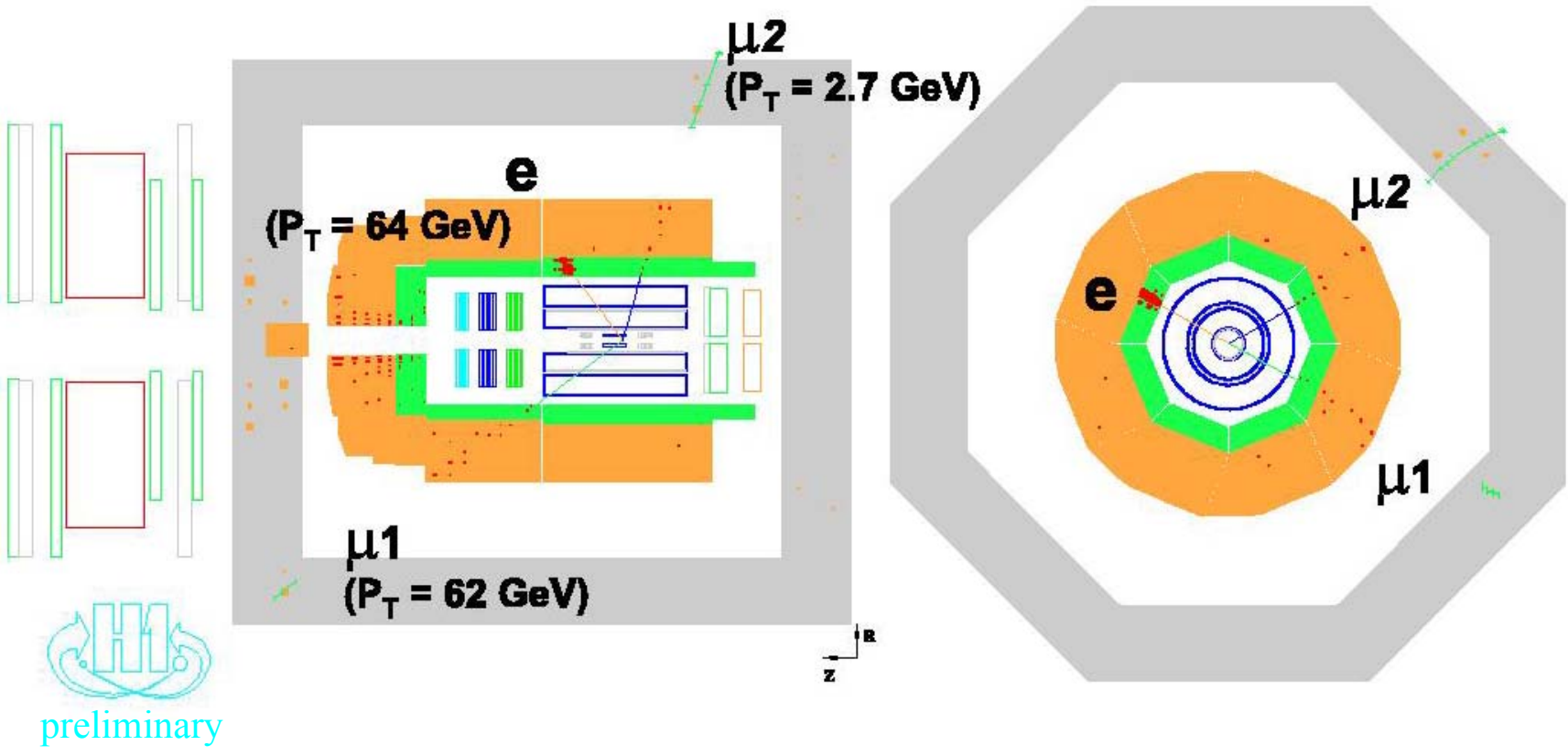
OUTLOOK

HERA data samples expected to be doubled until mid-2007: expect a significant e^+p sample to clarify the excess observed in this mode.

ADDITIONAL SLIDES

Event Displays of high-P_T multi-lepton events


2e
Event 1
P_T=54 GeV
P_T=50 GeV
Event 2
P_T=63 GeV
P_T=62 GeV
Event 3
P_T=55 GeV
P_T=45 GeV
3e
Event 4
P_T=17 GeV
P_T=20 GeV
P_T=32 GeV
Event 5
P_T=16 GeV
P_T=25 GeV
P_T=20 GeV
Event 6
P_T=8 GeV
P_T=13 GeV
P_T=23 GeV



preliminary