HERA-g, a new experiment for glueball & hybrid studies at DESY with the HERA-B detector

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The HERA-B Collaboration Board decided that any new physics program should be proposed by a new collaboration. That is why I am giving this talk. My aim is to show you that the HERA-B detector is perfectly suited to be the next-generation WA-102 experiment. But for this, we need new collaborators.

HERA-g !

1. Double-Pomeron-Exchange.
2. Pomeron-Reggeon-Exchange (for hybrids).
3. Search for Central Production of I=0, C=-1 states → Pomeron-Odderon-Exchange ?

We can take large data samples "immediately" (probably before end of 2003).

Trigger on events with the entire central system in the forward spectrometer and nothing elsewhere → Rapidity Gaps

The Essence of the argument

1. HERA-B Spectrometer in 920 GeV proton beam with high-speed pipelined DAQ (farms: L-2 and L3).

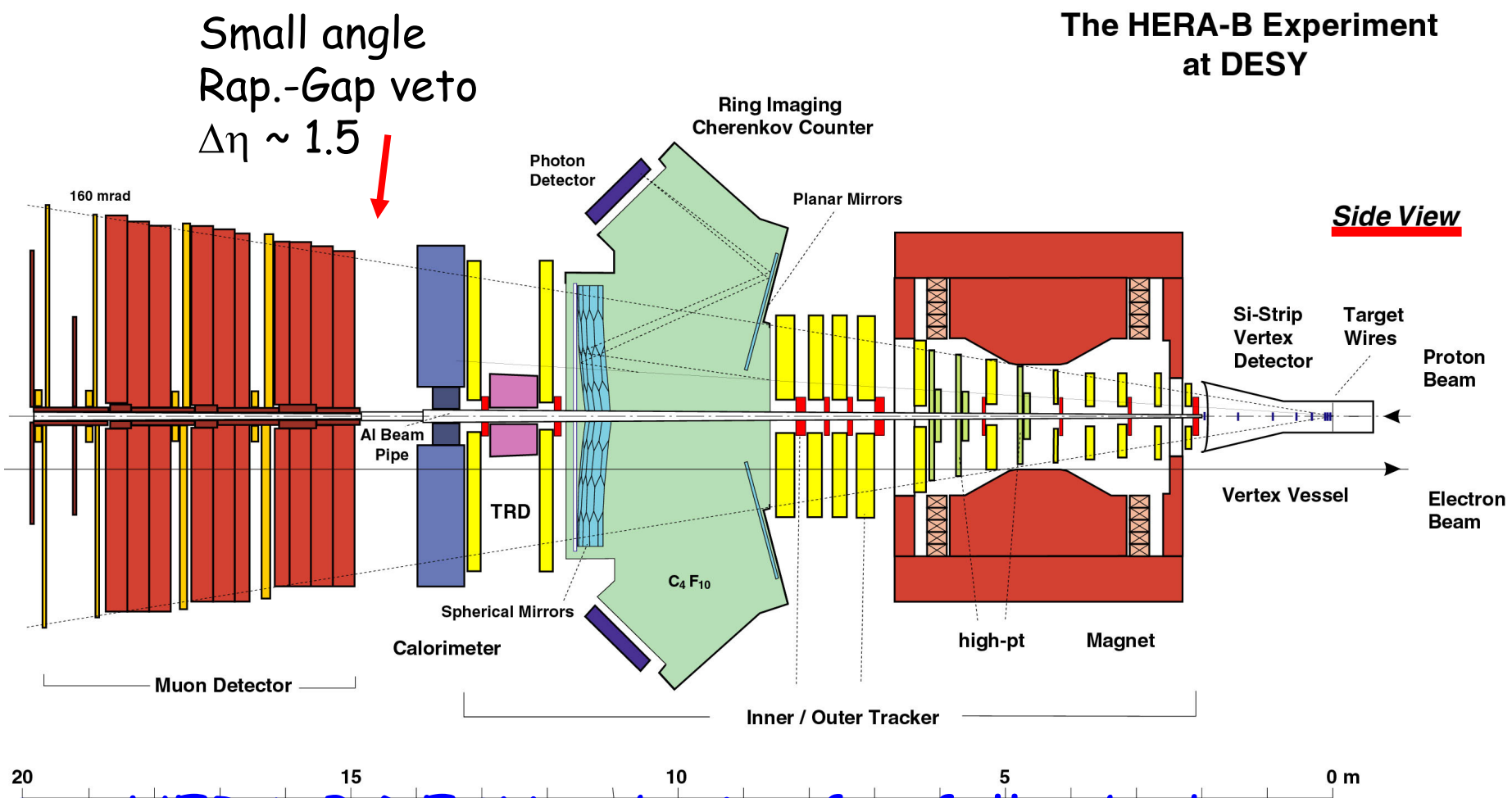
2. I will show you **real data** extracted from >10^8 minimum-bias HERA-B interactions, which would correspond to ~5 minutes of running deadtime-free at 1 MHz with a Level-1 rapidity-gap trigger.

3. The yield from a 10^7 sec experiment (~3 years) would be >10^4 times larger than our present data.

4. Example: 2930 $\pi^o\pi^o$ on hand → 80 x 10^6 events
where WA-102 had: 0.2 x 10^6 events

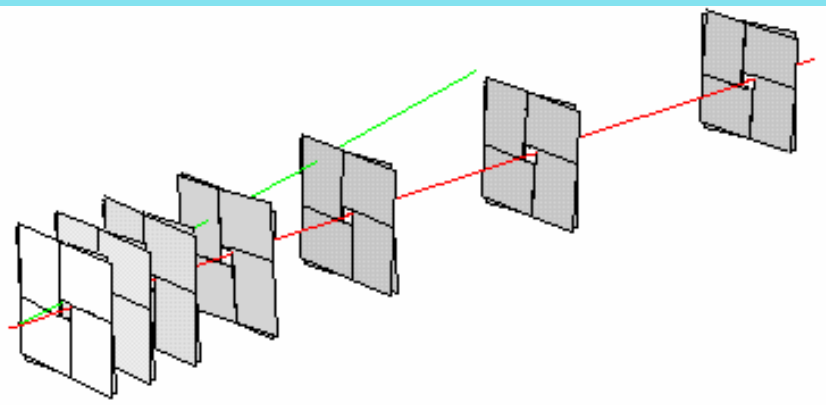
We could have ten times WA-102 statistics in 8 days

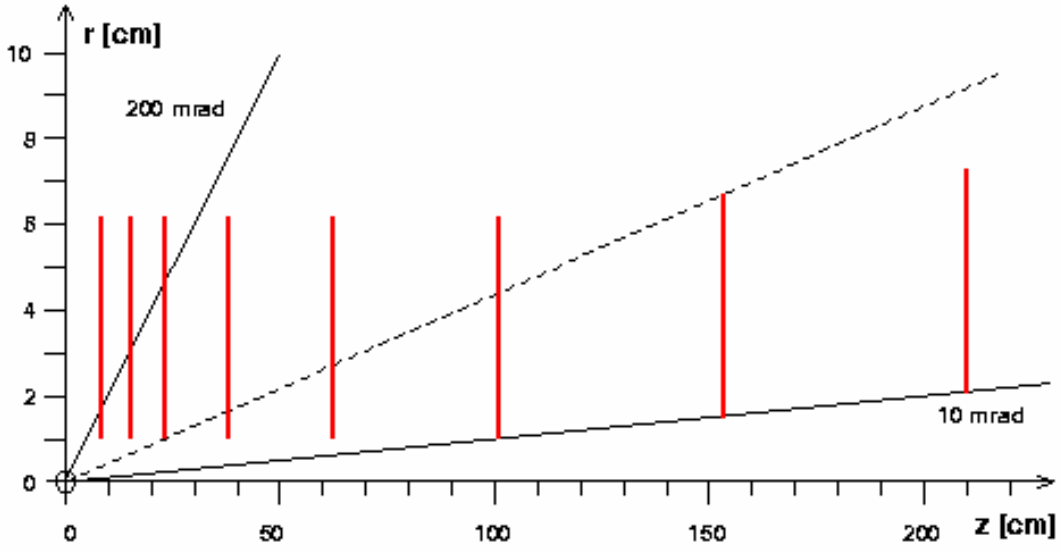
Existing HERA-B Detector



See HERA-B DESY web site for full sub-detector descriptions and HERA-g pages (www-hera-b.desy.de)

HERA-B Silicon Vertex Detector





Large-angle rapidity-gap veto for Level-1 trigger can be obtained by replacing 1st silicon station by position-independent detectors, e.g. 5mm-thick scintillators, inside Al RF shielding pockets.

HERA-g & Double-Pomeron-Exchange

HERA-B spectrometer was designed to optimally measure systems produced at $x = 0$ in the center-of-mass. With a proton beam energy of 920 GeV on a fixed target, a system with mass M travels forward in the laboratory with energy $E = \gamma M = 22M$.

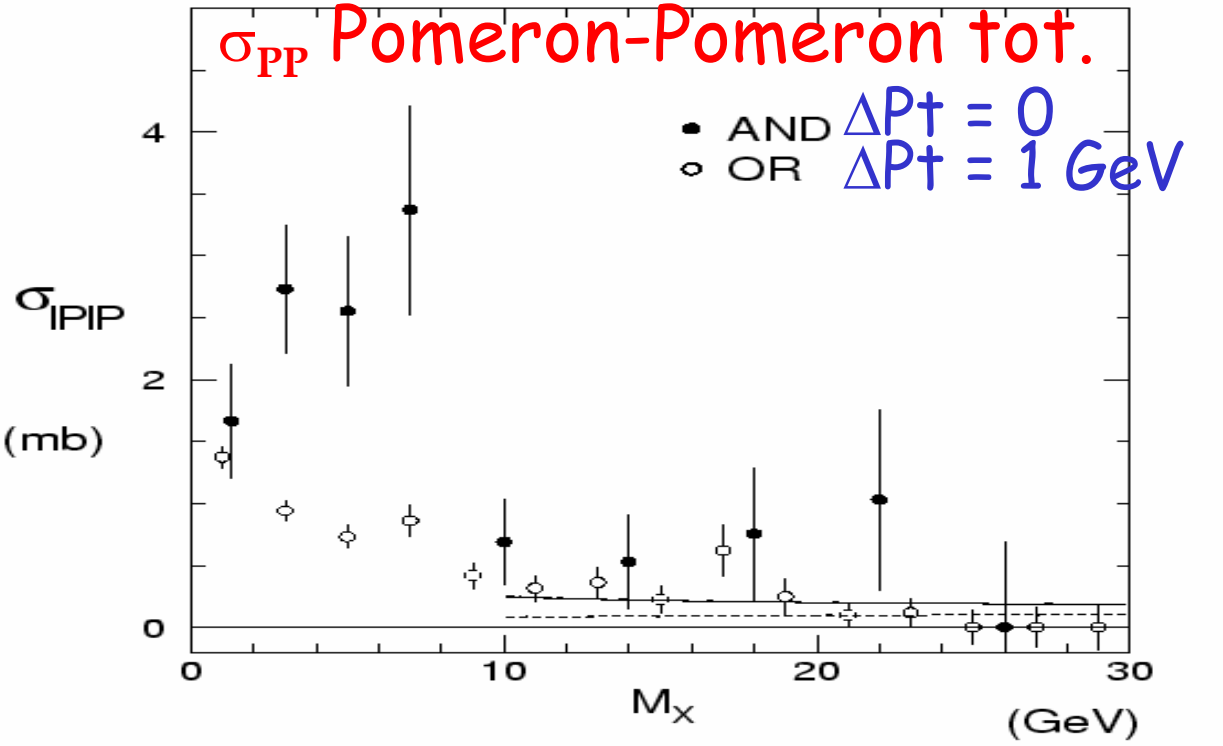
One class of such central systems are those that are produced by the collisions of "sea" partons in the beam & target particles, which continue on their way, relatively unperturbed. The UA8 and H1 experiments have shown us that there are dominantly digluon clusters in this sea, with a most likely momentum fraction near zero. These empirical objects are what we call Pomerons.

EPJ C 25 (2002) 361. hep-ex/ 0205037

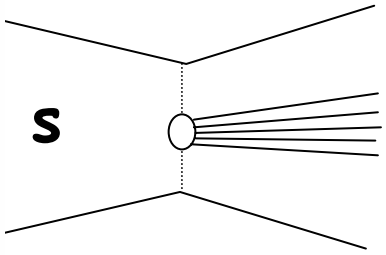
UA8 Double-Pomeron-Exchange

Observed enhancement in Pomeron-Pomeron σ_{tot} in few-GeV region: ---> Probable Glueball production.

The data are described by: $\sigma \sim \xi_1^{-1.16}\ \xi_2^{-1.16}\ \sigma_{PP}(M_x)$

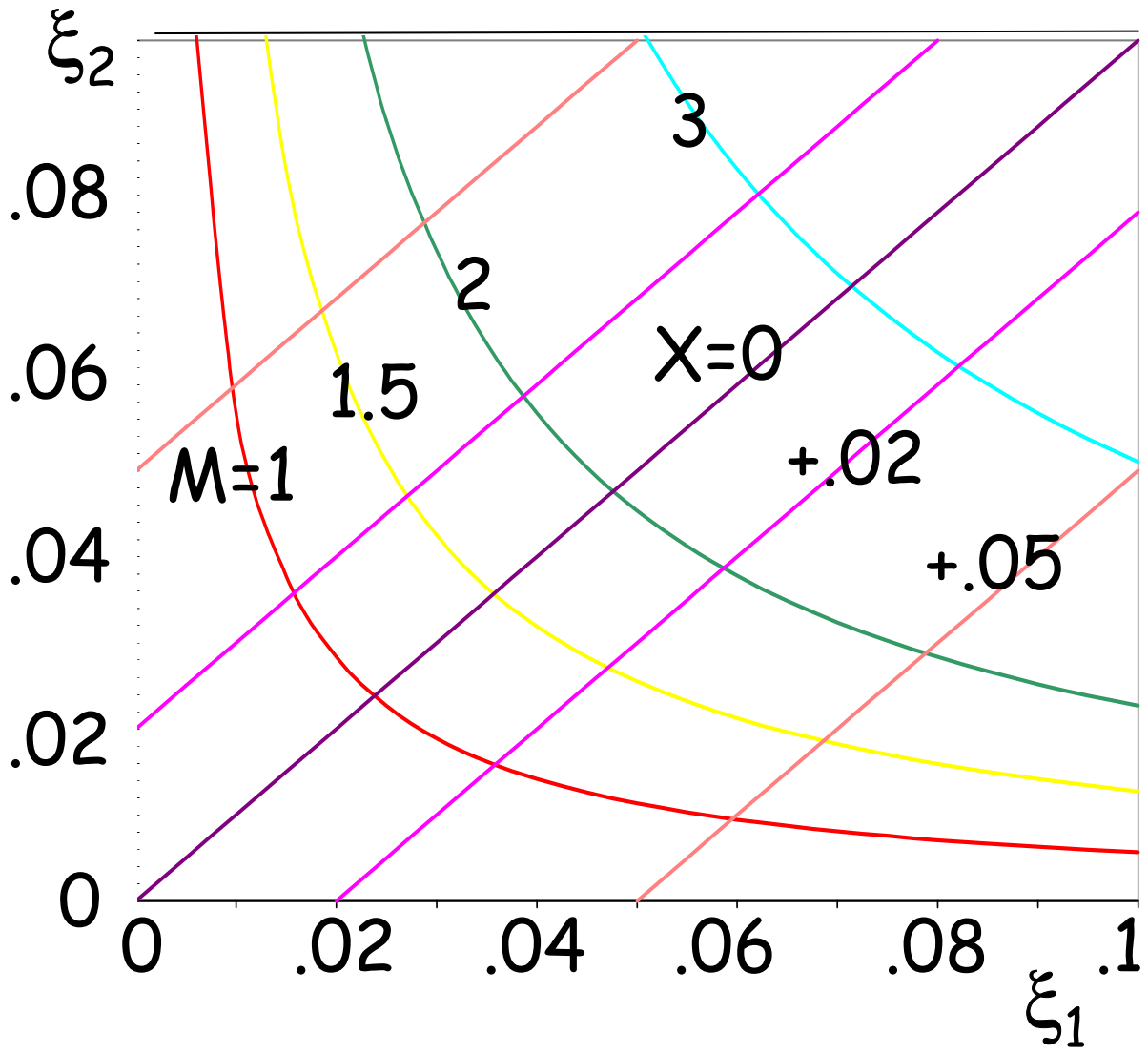


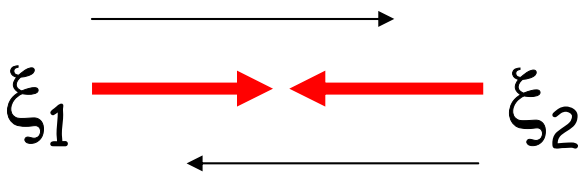
at low-|t|



$M_x^2 = \xi_1 \xi_2 s$

HERA-g kinematics at $\sqrt{s}$ = 42 GeV





Central mass sq.

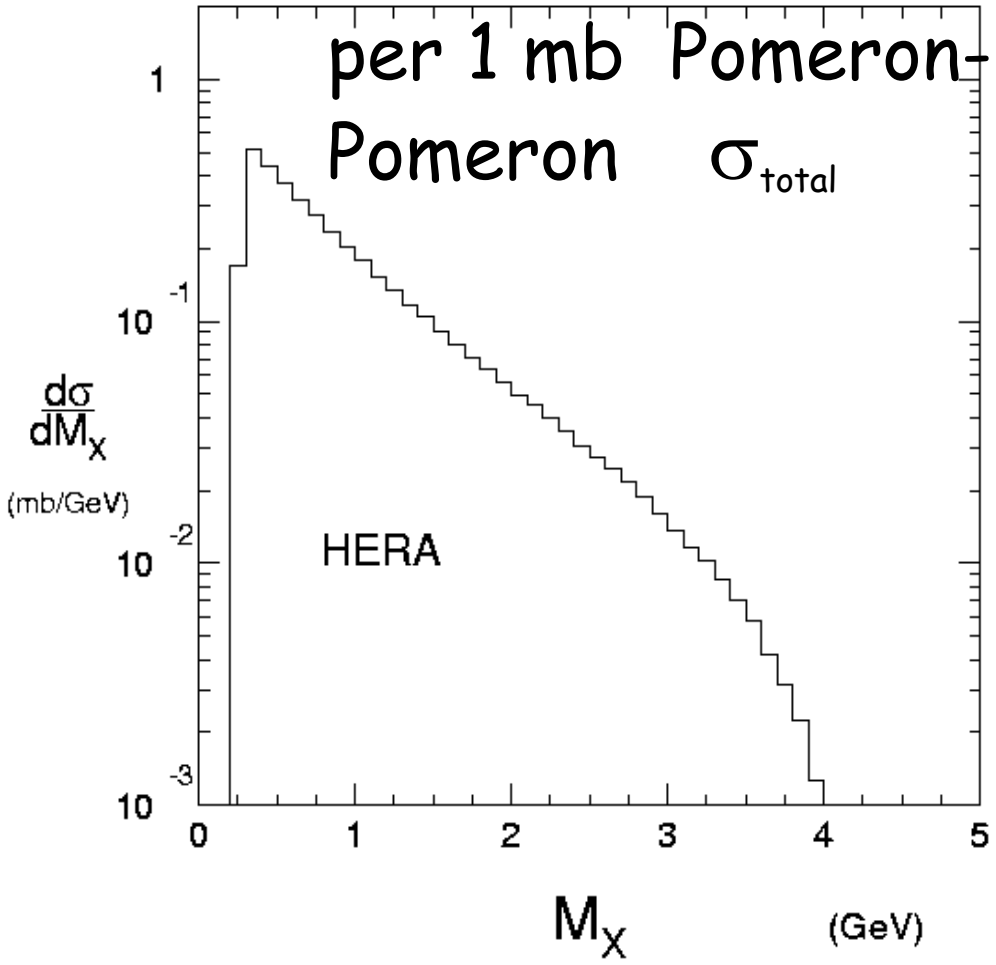
$M_x^2 = \xi_1 \xi_2 s$

$x = \xi_1 - \xi_2$

Measure M_x and x, we know ξ_1 and ξ_2.

ξ-dependence info. allows predictions of M_x and x dependences.

UA8 DPE Prediction for HERA-g



This prediction of $d\sigma/dM$ for DPE cross section at the HERAg energy has a mass-dependent shape that is determined by the ξ-dependence of the Pomeron flux factors and a magnitude that depends on the Pomeron-Pomeron total cross section. Thus, for Pomeron-Pomeron σ_{total} ~ 1.5 mb, we have

σ_{DPE} ~ 0.50 mb or 1.7% total inelastic pp.

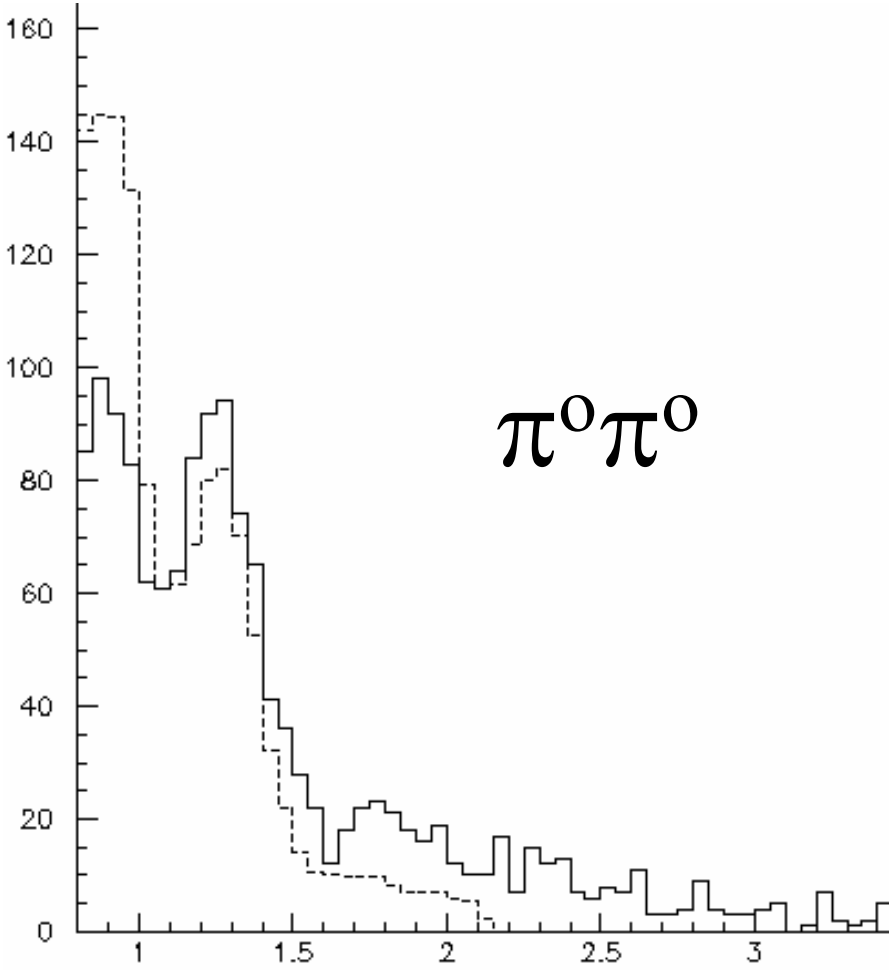
HERA-B

Events after rap-gap cuts & cleanup

(Events in thousands)

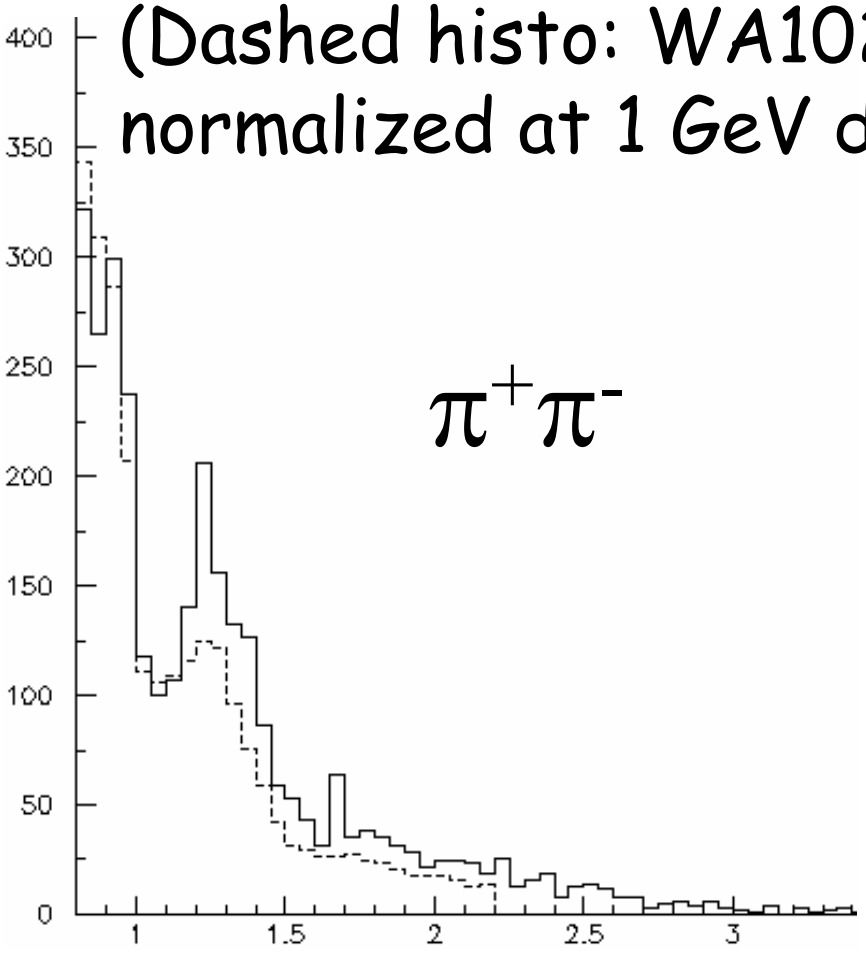
No. charged tracks =	0	1	2	3	4	5
No. e.m. clusters 8	11	0	0	0	0	0
7	18	0	0	0	0	0
6	28	1	1	1	0	0
5	42	1	2	1	0	0
4	70	3	3	1	1	0
3	115	5	4	2	1	0
2	234	9	6	2	1	0
1	578	10	6	2	1	0
0	--	10	6	1	0	0

Comparison with WA-102



$\pi^o\pi^o$

(Dashed histo: WA102 normalized at 1 GeV dip)

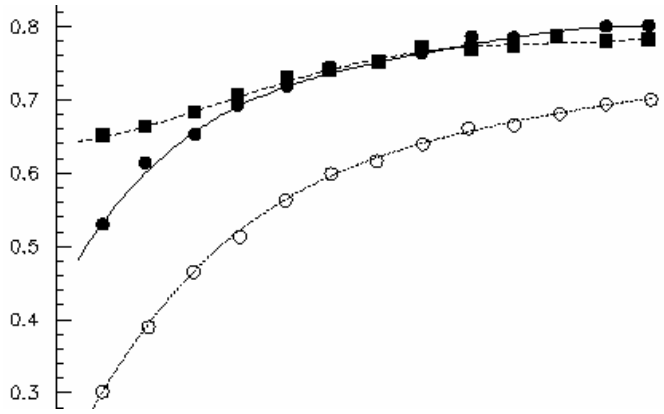


$\pi^+\pi^-$

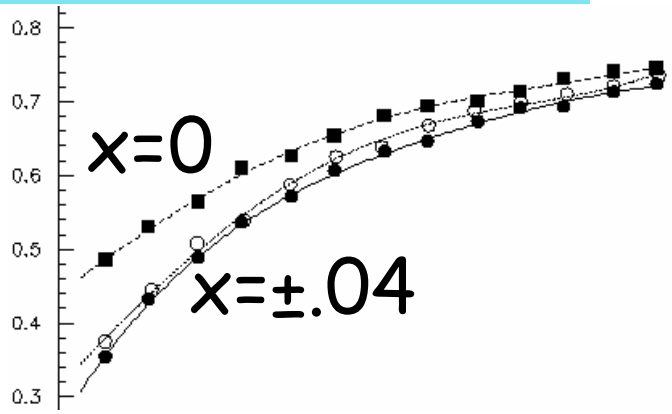
$\pi\pi$ Invariant Mass (GeV)

Fall-off at high mass is not due to acceptance

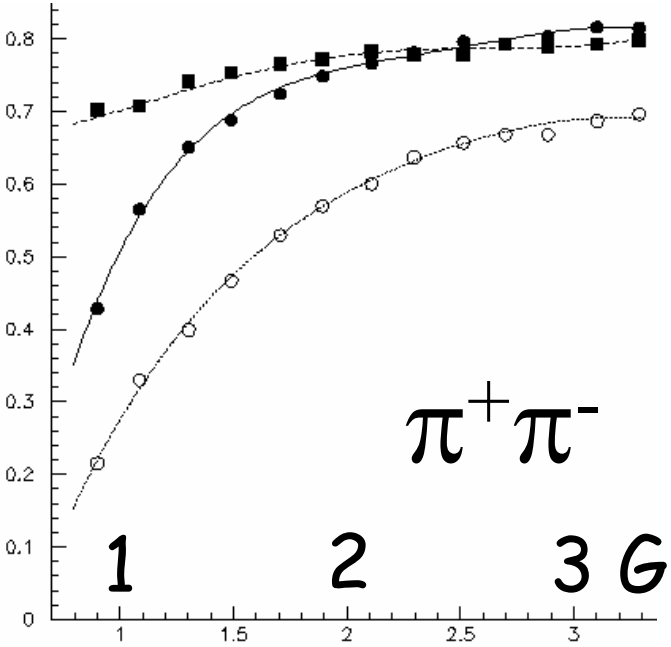
Dipion geometric acceptance vs. M



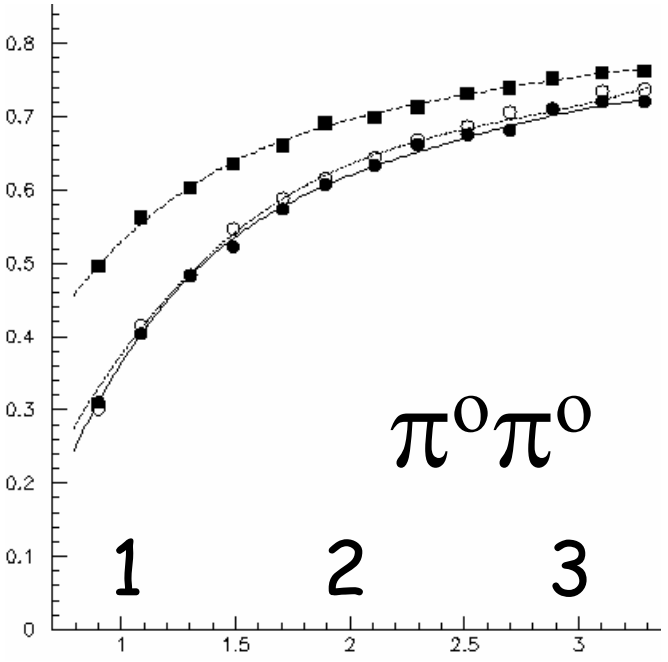
Pt = 0.5 GeV



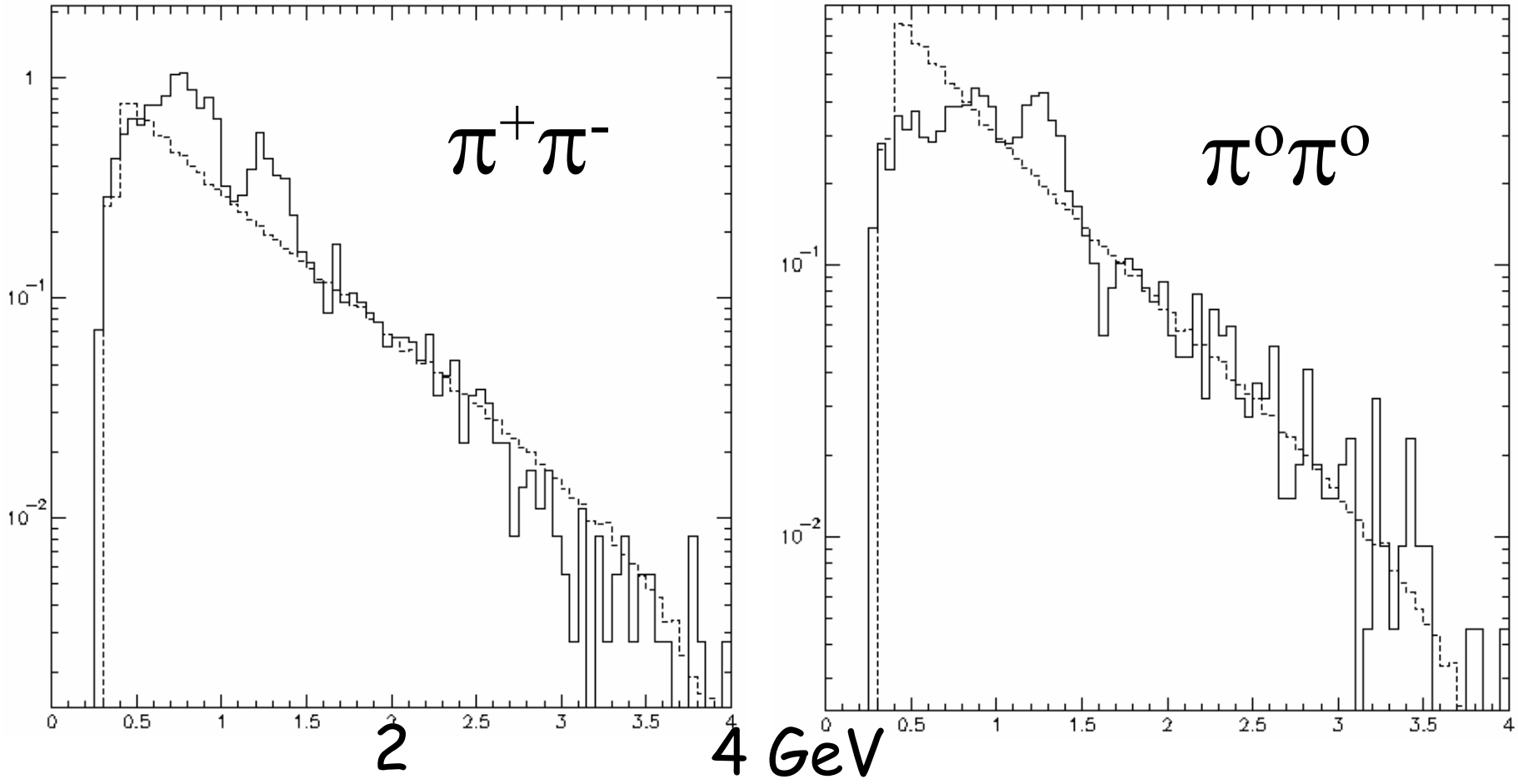
Acceptance increases with mass and with Pt.



Pt = 0.

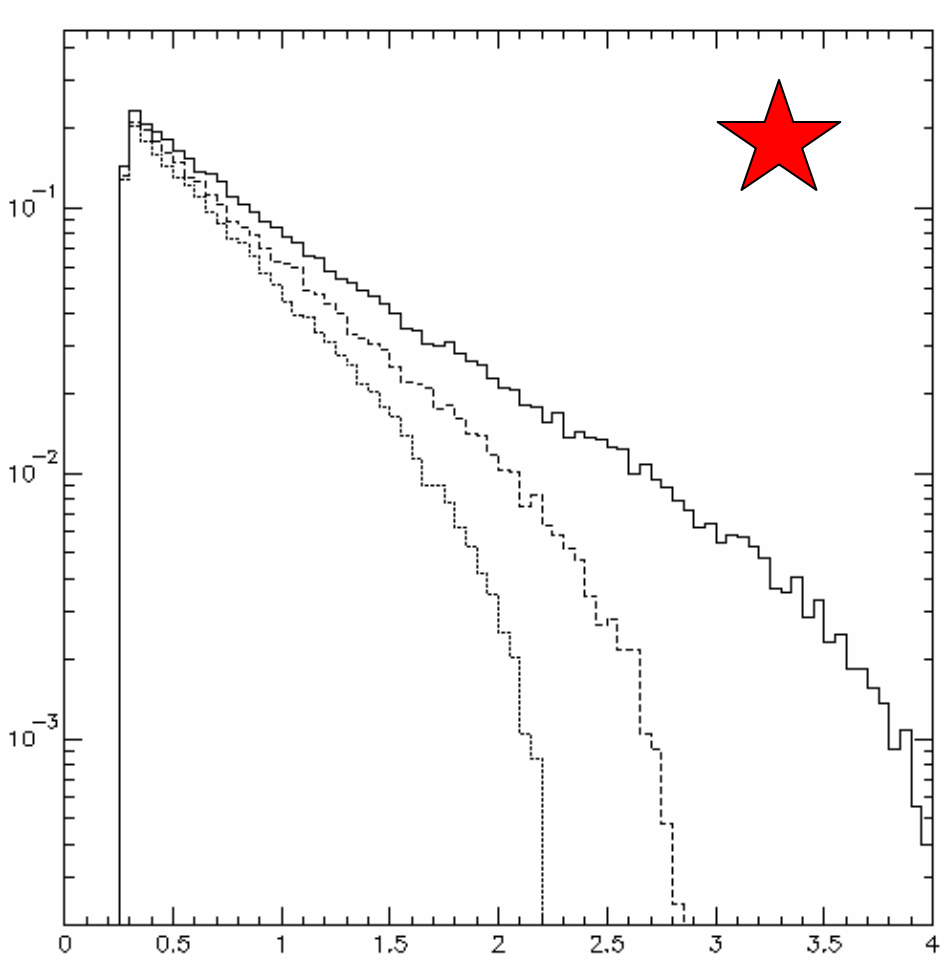


DPE prediction of mass spectrum



Fall off above 1.5 GeV is as expected in DPE.

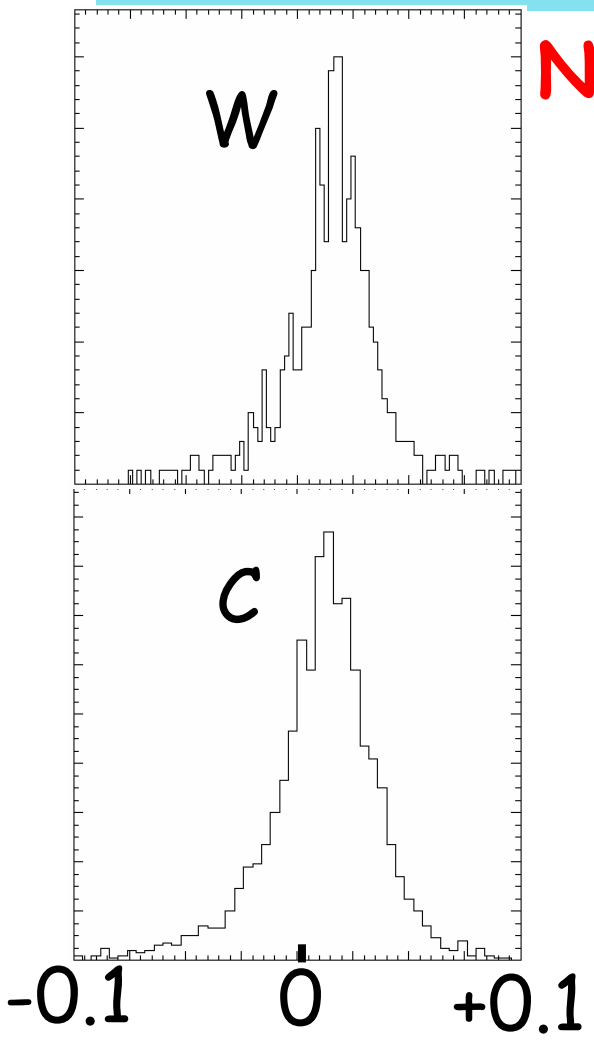
Predict mass spectrum 280-920 GeV



Beam mom.	920	450	280
	Cross section (mb)		
All mass	0.336	0.256	0.207
> 1.5 GeV	0.062	0.026	0.009
> 2.0 GeV	0.032	0.007	0.001
> 2.5 GeV	0.015	0.001	---

920 Gev beam energy is clearly better for high-mass studies.

$\pi^+\pi^-$ x_F asymmetric around 0.

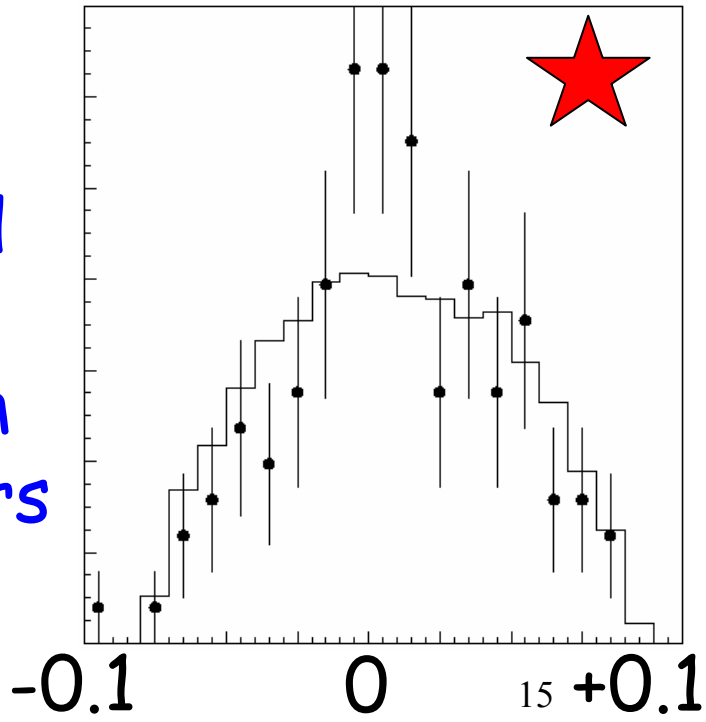


Nuclear Effect larger in W than in C.

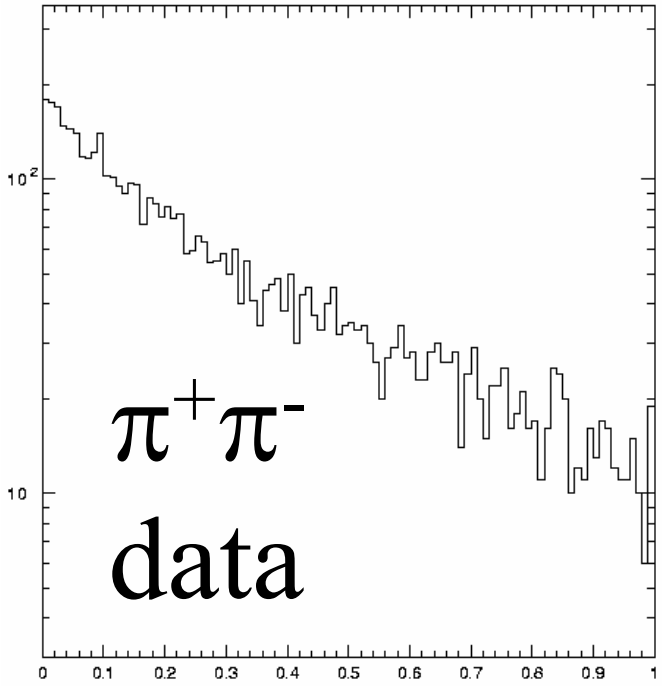
Mean x_F in W = 0.0147 ± 0.0011

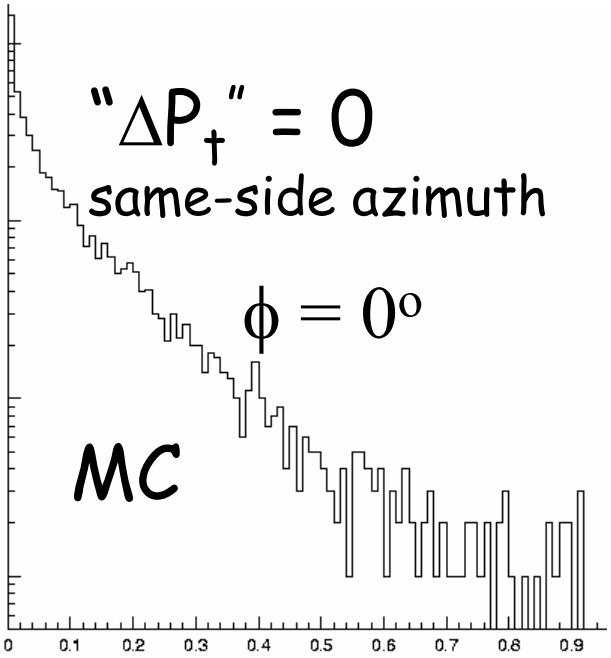
Mean x_F in C = 0.0111 ± 0.0006

x_F distribution for events with $M > 1.5$ GeV and $P_t^2 < 0.3$ GeV^2. Prediction from DPE flux factors



P_t^2 distributions and ϕ correlations

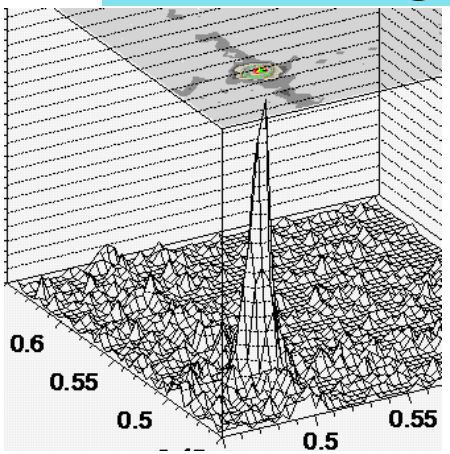


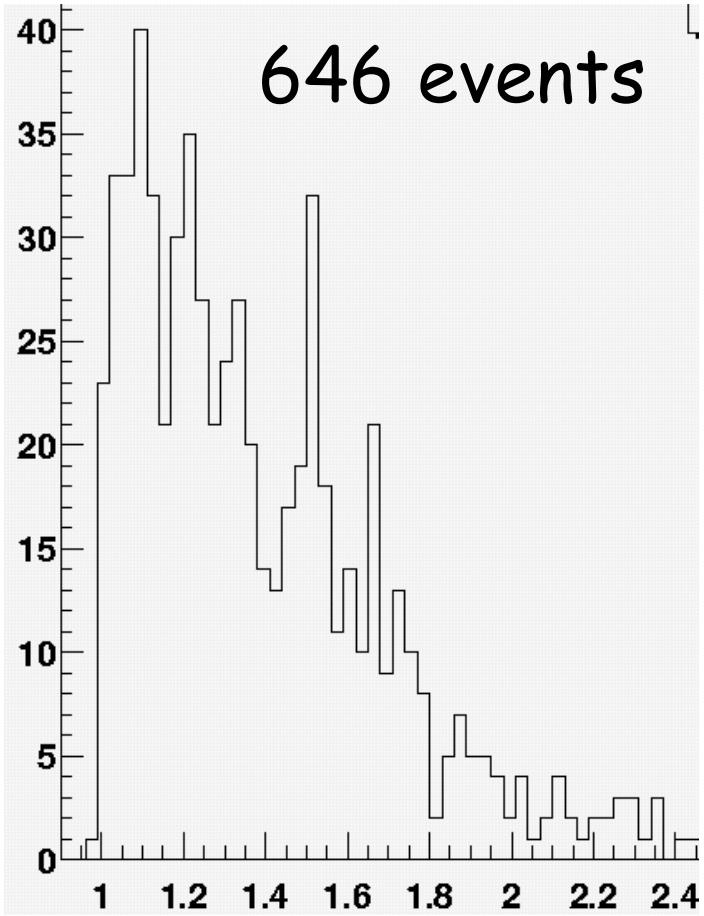


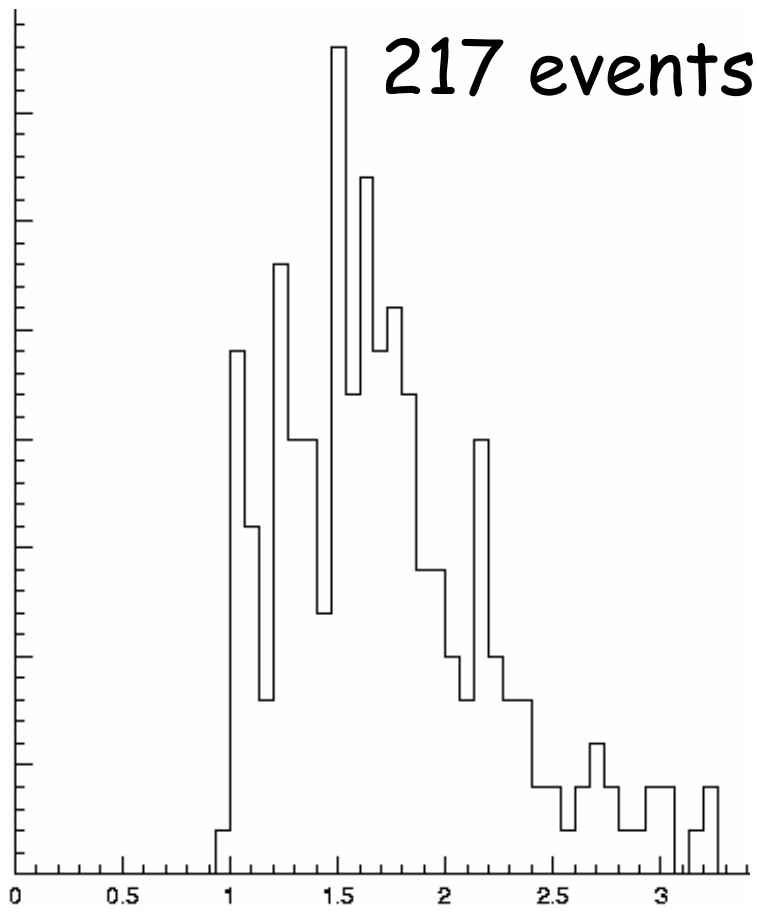
P_t^2

Selection of small P_t^2 data enhances "ΔP_t" = 0.

K_sK_s K^+K^-

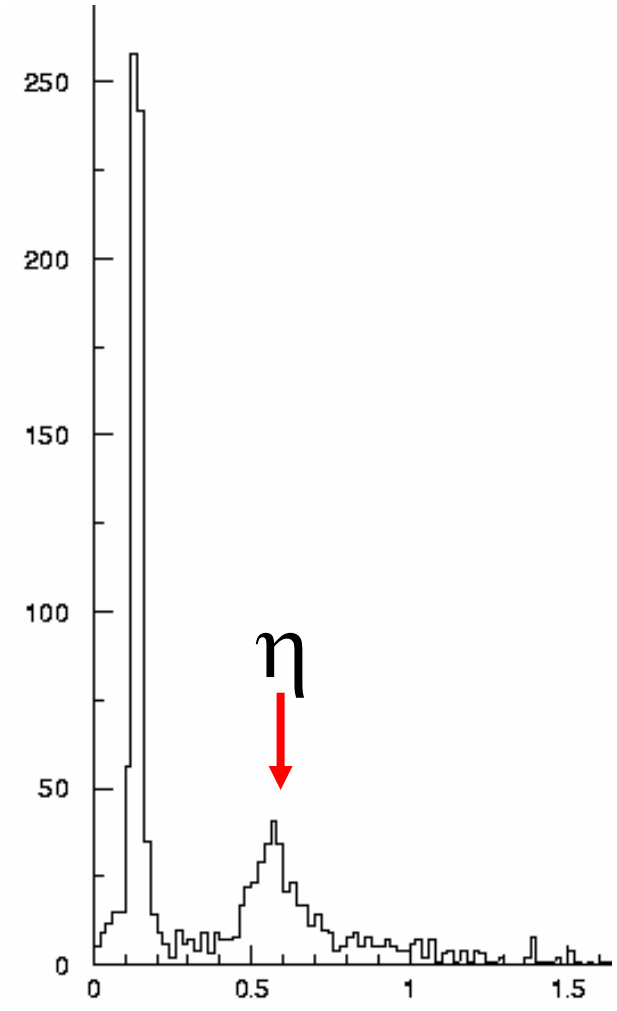




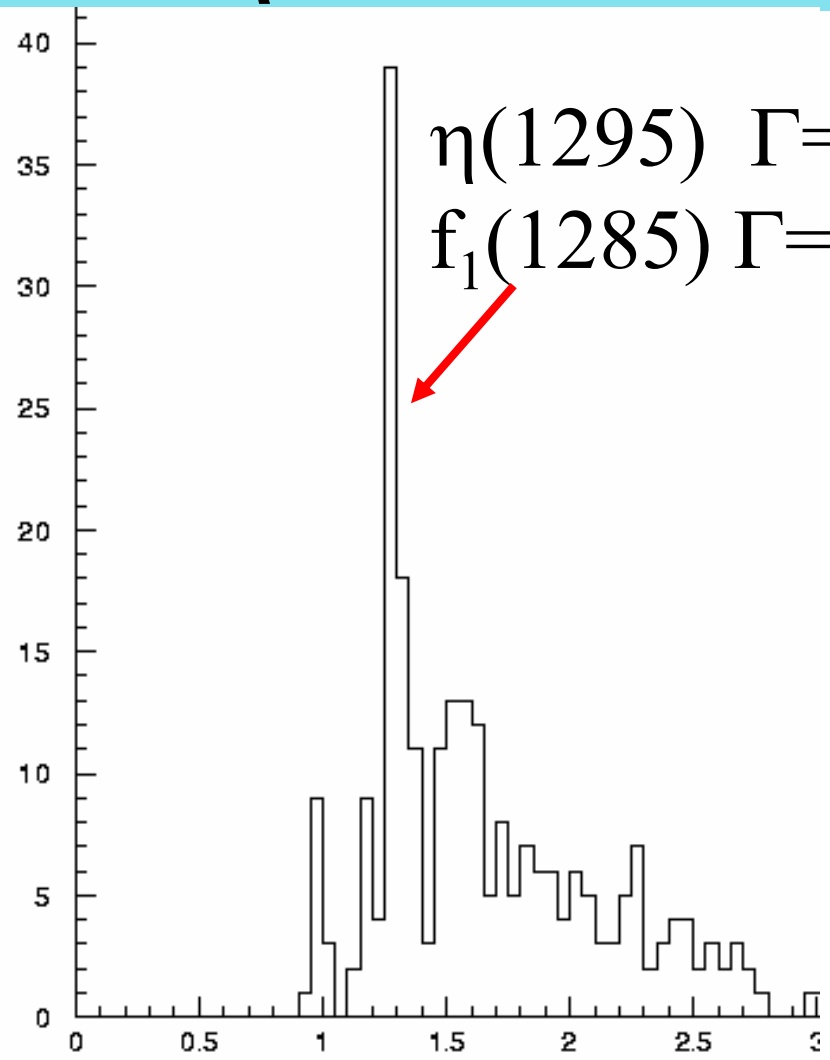


Invariant Mass

$\eta\pi^+\pi^-$



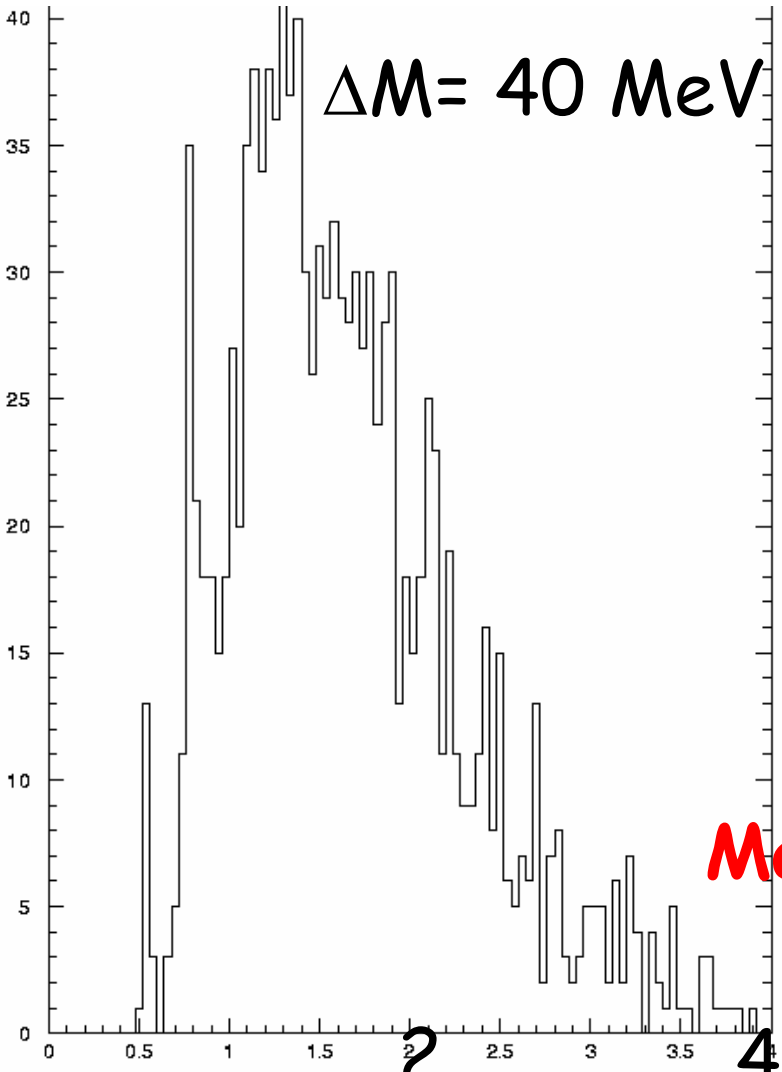
Mass $\gamma\gamma$

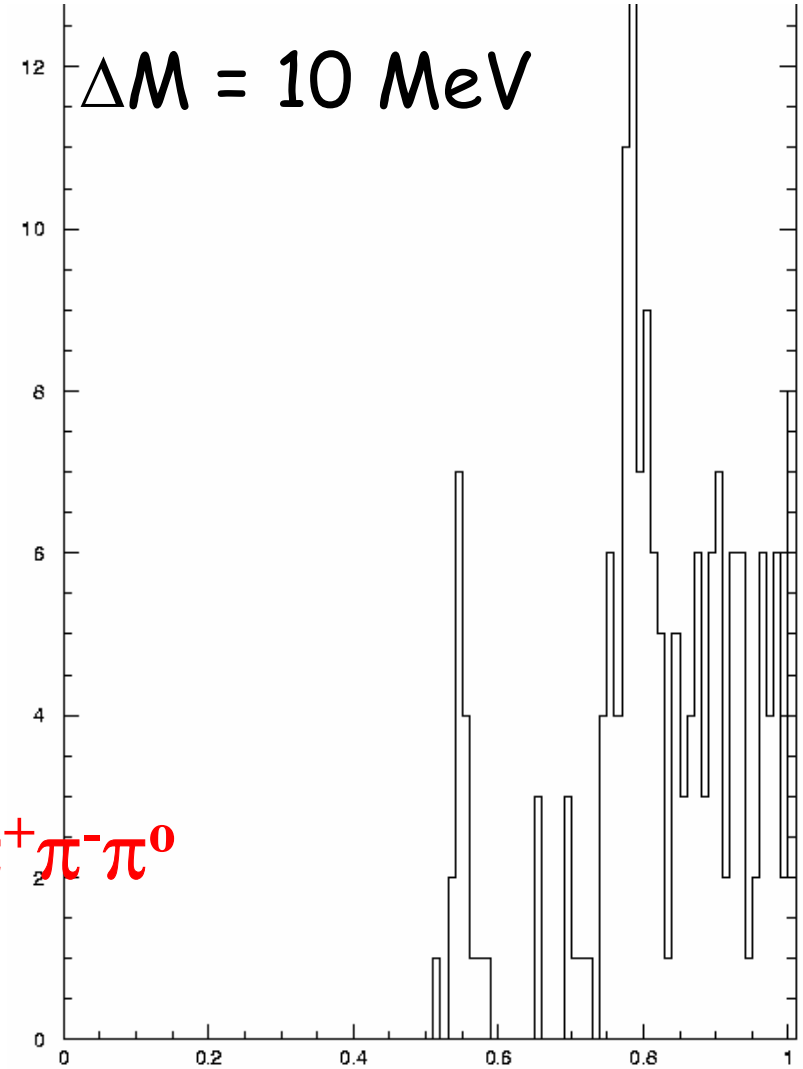


$\eta(1295)$ Γ=55 MeV or
$f_1(1285)$ Γ=25 MeV

Mass $\eta\pi^+\pi^-$

Observation of η and ω^o in $\pi^+\pi^-\pi^o$

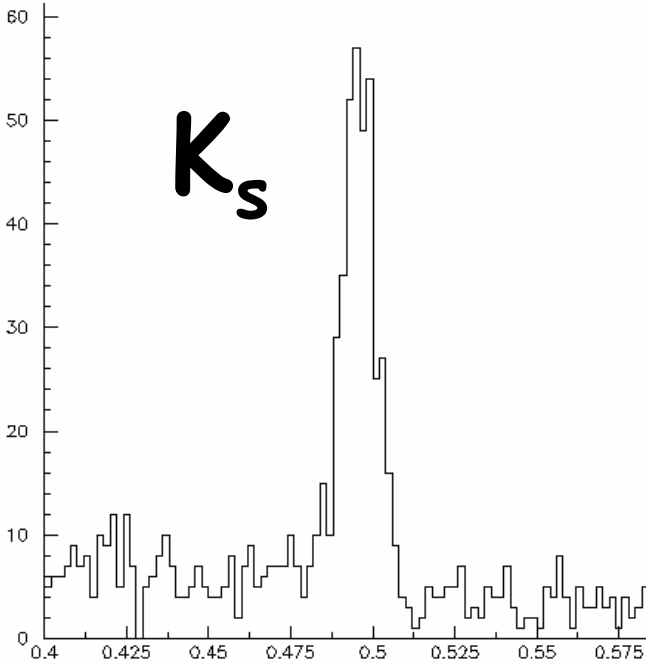


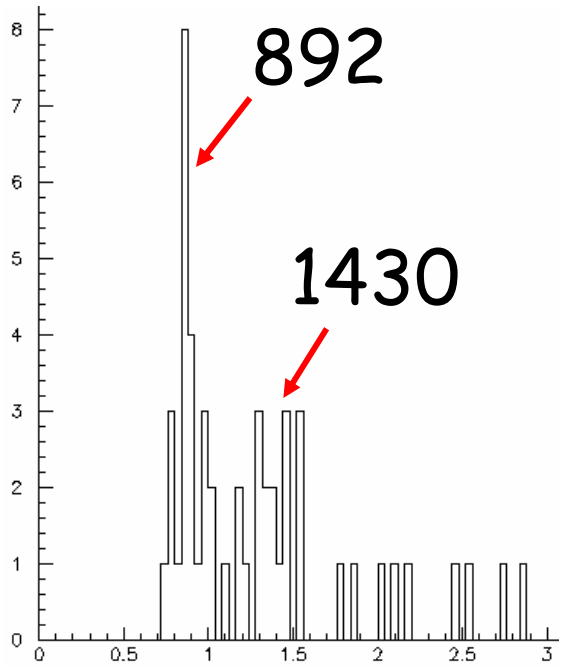


Mass $\pi^+\pi^-\pi^o$

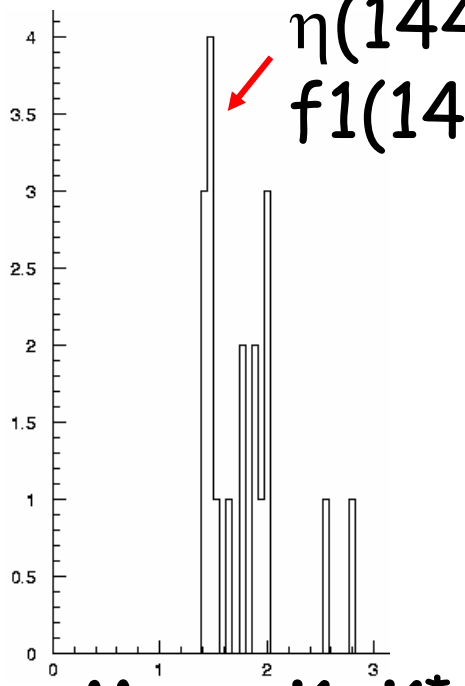
2 4 GeV

$K_s\ K^{\pm}\ \pi^{\mp}$ in 4-track events





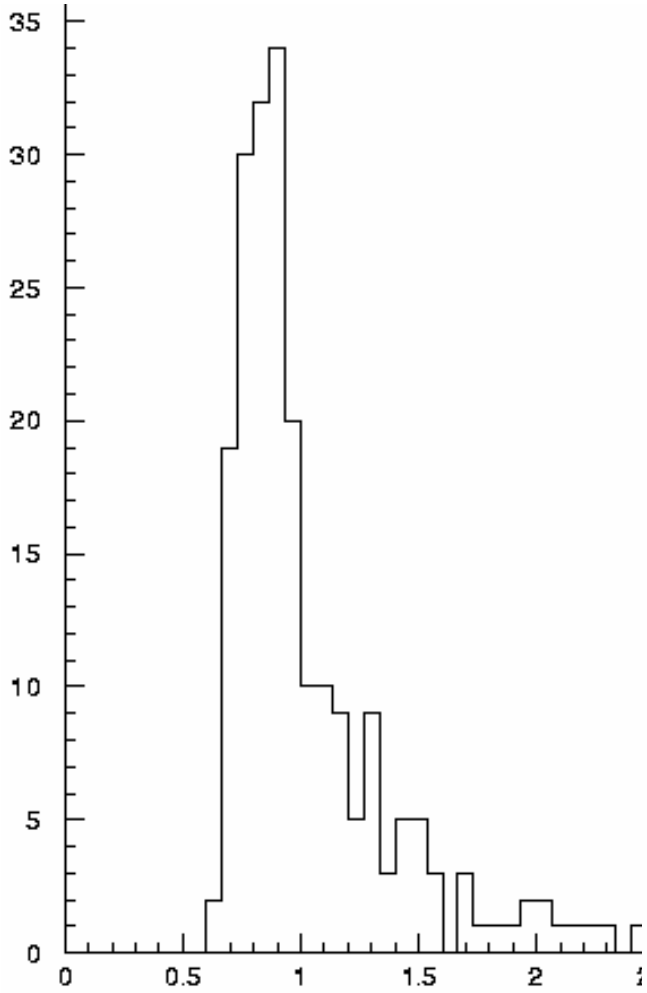
Mass $K^{\pm}\pi^{\mp}$



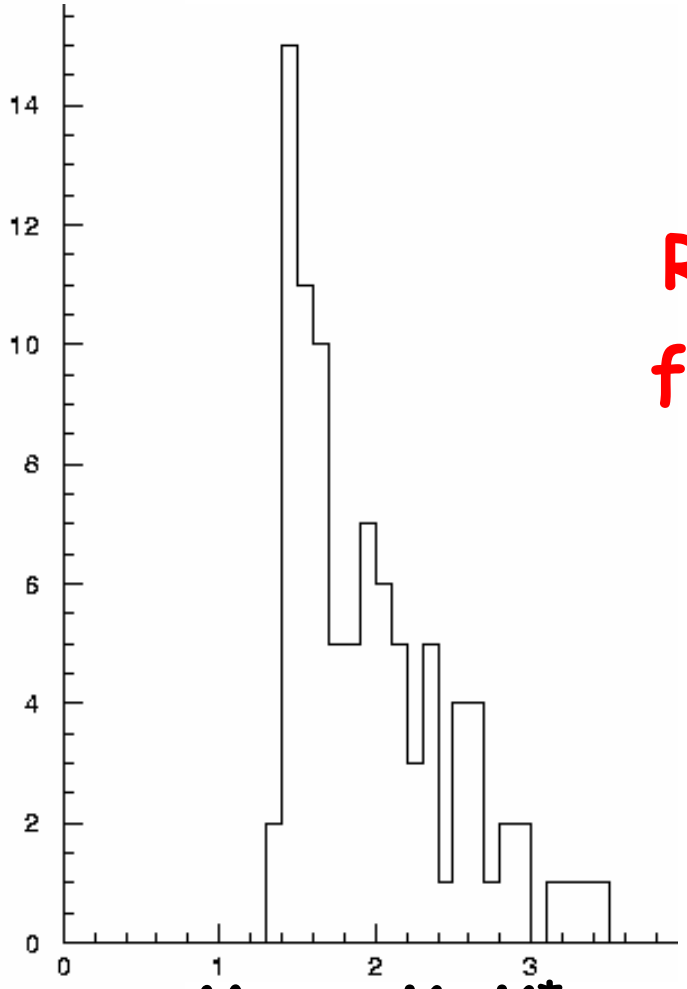
Mass $K_s\ K^*$

A good hint that we may be producing the η(1440). With events at 2 GeV mass, the future looks good.

$K_s\ K^{\pm}\ \pi^+$ with no RICH ID on $K^{\pm}$



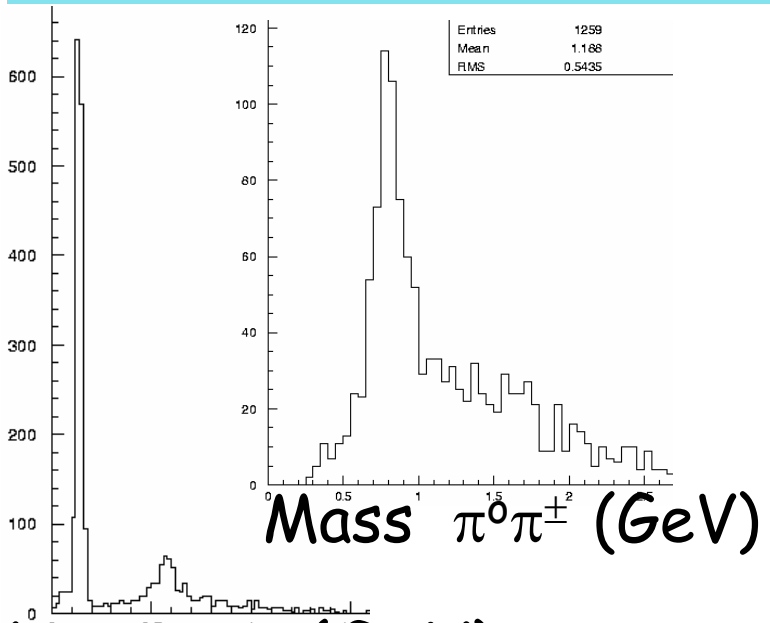
Mass $K^{\pm}\pi^{\mp}$



Mass $K_s\ K^*$

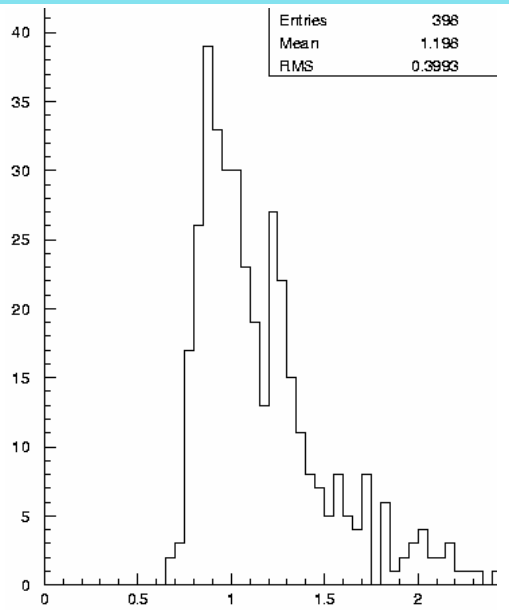
Reinforces $f_1/\eta(1440)$

$\eta\pi^{\pm}$ Hybrid search in PomR collisions



Mass $\pi^0\pi^{\pm}$ (GeV)

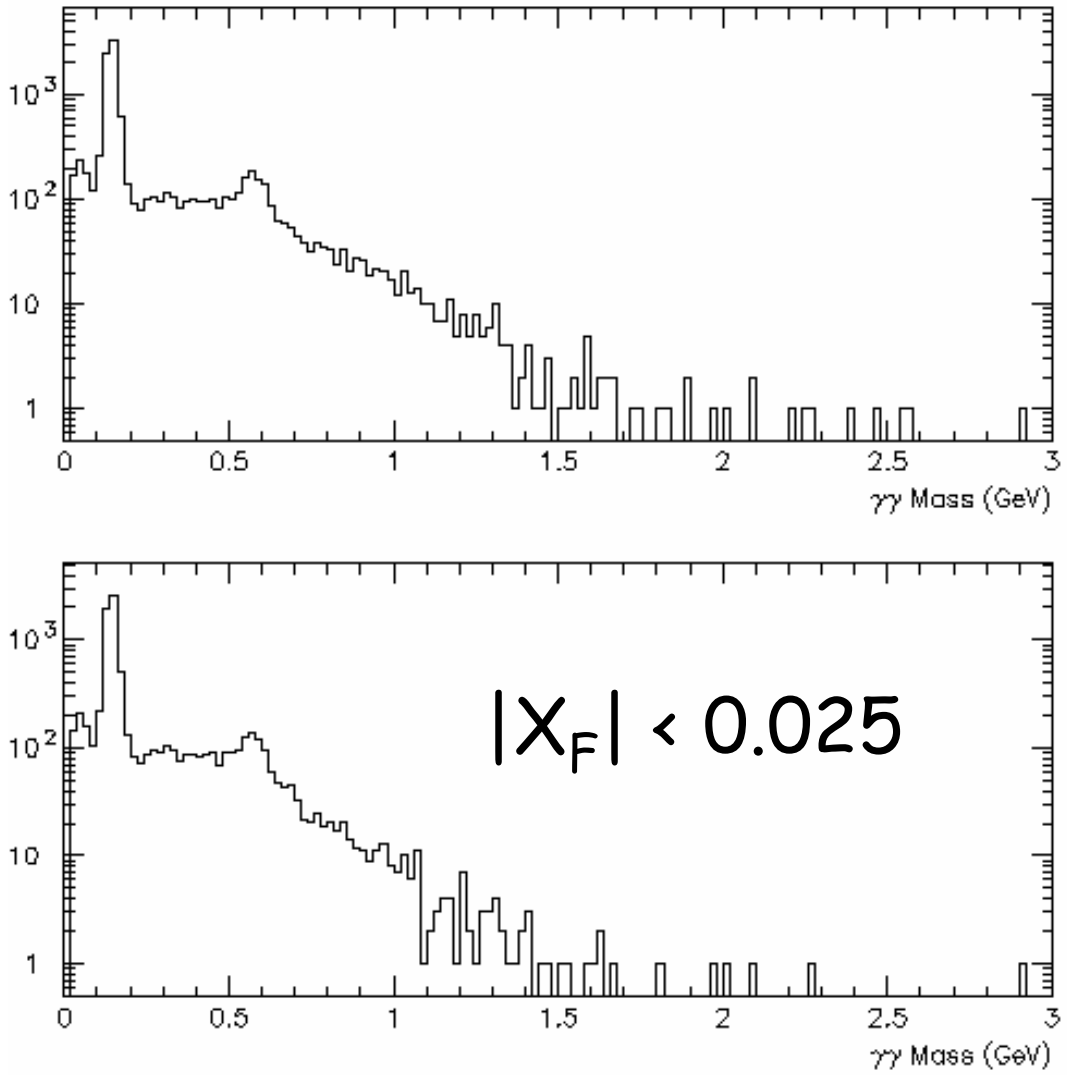
Mass $\gamma\gamma$ (GeV)



Mass $\eta\pi^{\pm}$ (GeV)

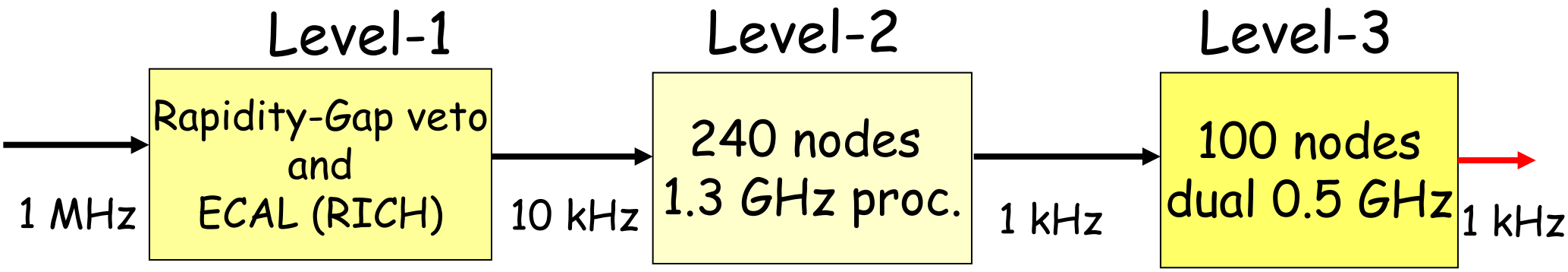
Pomeron-Reggeon collisions may be an excellent production source of hybrids. Since hybrid candidates (1^{-+}) were obtained from phase-shift analyses of $\eta\pi^{\pm}$, HERA-g should be major contributor to hybrid physics

γγ



The relative absence of events above 1.5 GeV mass and the lack of vertex knowledge of events reinforces the cleanliness of the data sample. Perhaps, with higher statistics, HERA-g will be able to directly see γγ decays.

Triggering



Rates show what each Level must accomplish to achieve deadtime-free operation.

Existing small-angle Rapidity-Gap veto in Level-1 already gives 1/10 reduction. Large angle veto will give at least an additional 1/10 reduction. Level-2 reduction of 1/5 already available, before study of silicon and other tracking algorithms.

Conclusions

The HERA-B detector is ready and available.

The yield in a 10^7 sec experiment is orders-of-magnitude larger than presently existing data and a larger fraction of the data is in the interesting higher mass region. 8-day run already 10x(WA102).

DPE phenomenology in agreement with UA8 at SPS. Pomeron-Reggeon exchange → hybrids.

Proposal must be submitted to DESY by 30 Sept. for PRC 30 Oct. Interested people, please contact me or Marco Bruschi at bruschi@mail.desy.de

HERA access day: Monday, 29 Sept. Come and see the spectrometer, touch it and discuss with experts.