HERA-g, a new experiment for Glueball, Hybrid and Odderon studies at DESY using the existing HERA-B detector

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My aim is to show that the HERA-B detector is uniquely suited to be the next-generation experiment in the field of Glueball, Hybrid and Odderon studies.

The (growing) HERA-g Collaboration

No. of Institutes = 16; No. of people = 86

Germany	3;	5	(DESY, MPI-Heidelberg, Humboldt)
Italy	3;	29	(INFN, Bologna, Brescia, Torino)
FSU	5;	42	(ITEP, JINR, KINR, Obninsk, IHEP)
Mexico	1;	2	(Guanajuato) (FNAL E-690 exp)
Slovenia	1;	3	(Ljubljana)
U.S.A.	1;	2	(UCLA)
Montenegro	1;	1	
Norway	1;	2	(Oslo) (WA-102)

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". The HERA-B spectrometer already exists and is still positioned in the beam area.

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 L-3).

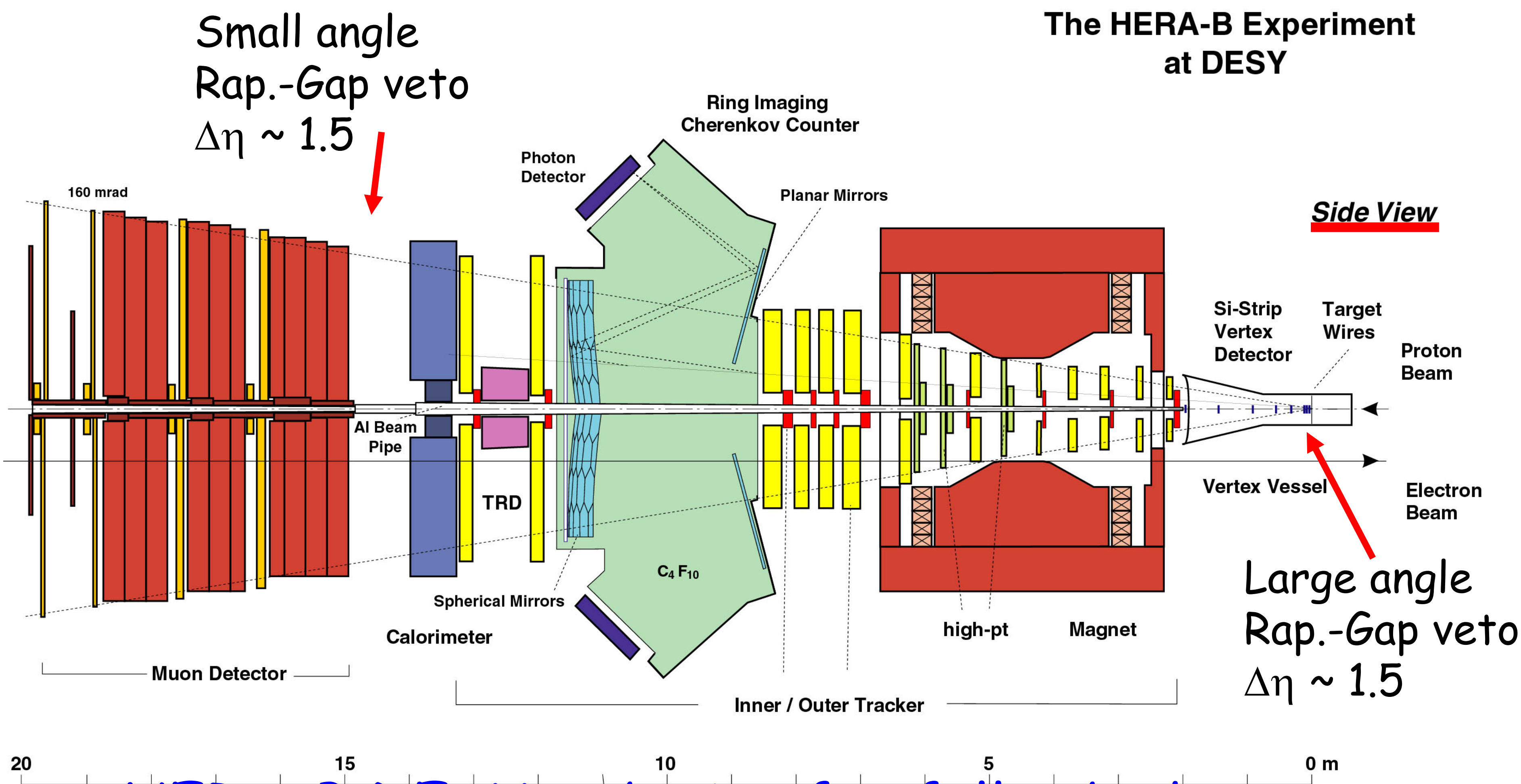
2. I will show you **real data** extracted from ~10^8 minimum-bias HERA-B interactions, which would correspond to ~5 minutes of running deadtime-free at 1 MHz with a Level-1 rapidity-gap trigger.

3. The yield from 100-hours of data-taking would be ~1000 times larger than the data shown here.

4. Example: 2100 $\pi^o\pi^o$ on hand → 2.1×10^6 events
where WA-102 had: 0.2×10^6 events

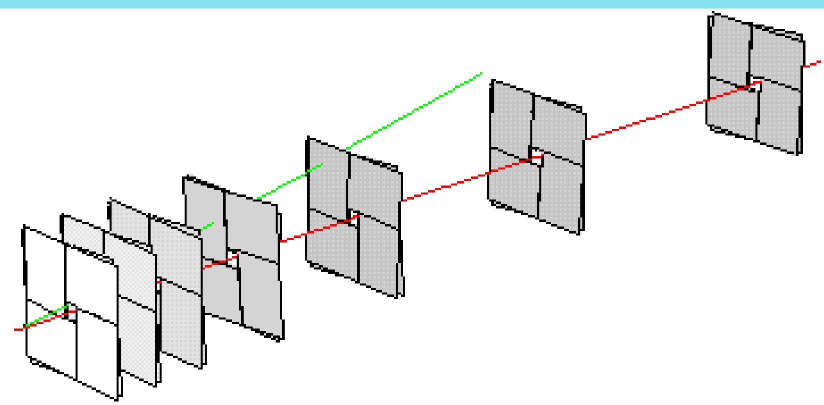
Example: 300 $\eta\pi^{\pm}$ → 3.0×10^5 events
Existing data in this channel (E852): 3.8×10^4 events

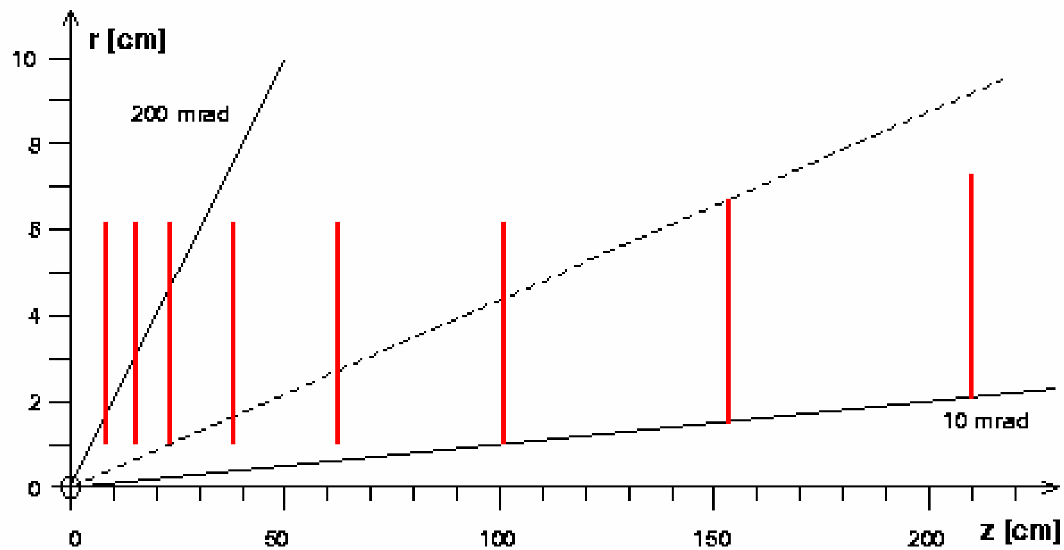
Existing HERA-B Detector



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 scintillation counters, e.g. 5mm-thick, inside Al RF-shielding pockets (SiPM readout).

ITEP, 1 month

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 $E = \gamma M = 22M$.

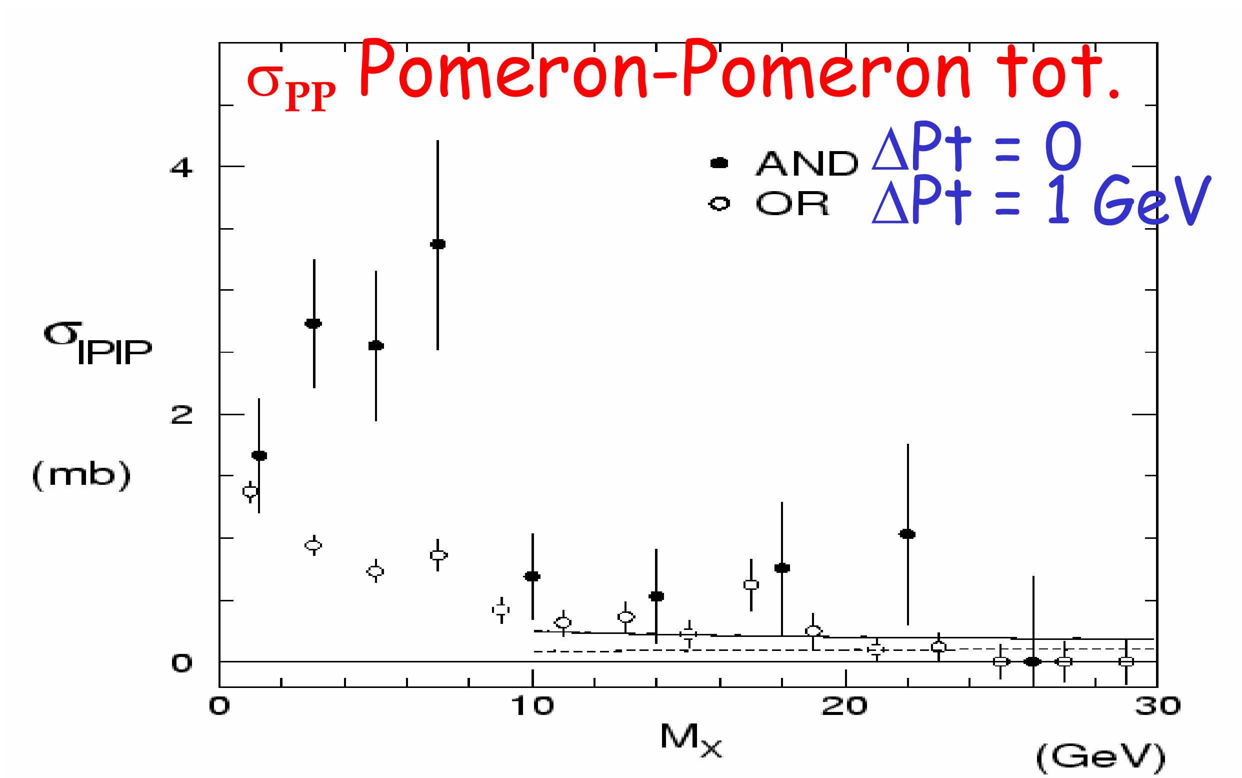
One class of such central systems are those that are produced by the collisions of "sea" partons in the beam & target particles, which continue on their way, relatively unperturbed. The UA8 and H1 experiments have shown us that there are dominantly digluon clusters in this sea, with a most likely momentum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

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

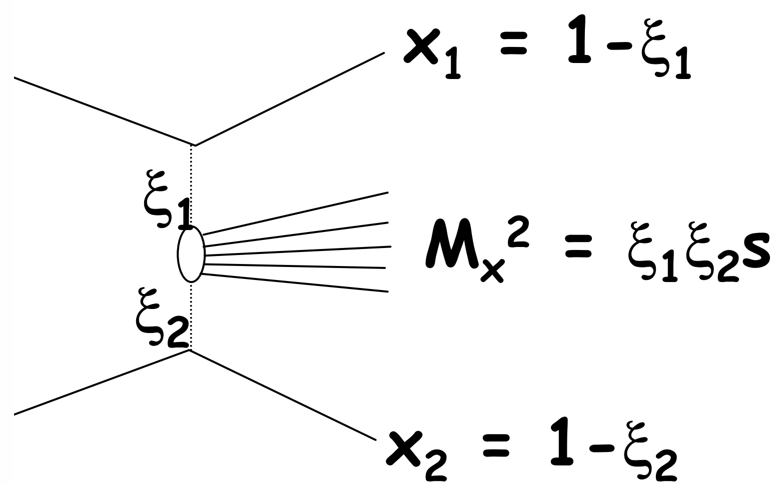
UA8 Double-Pomeron-Exchange

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

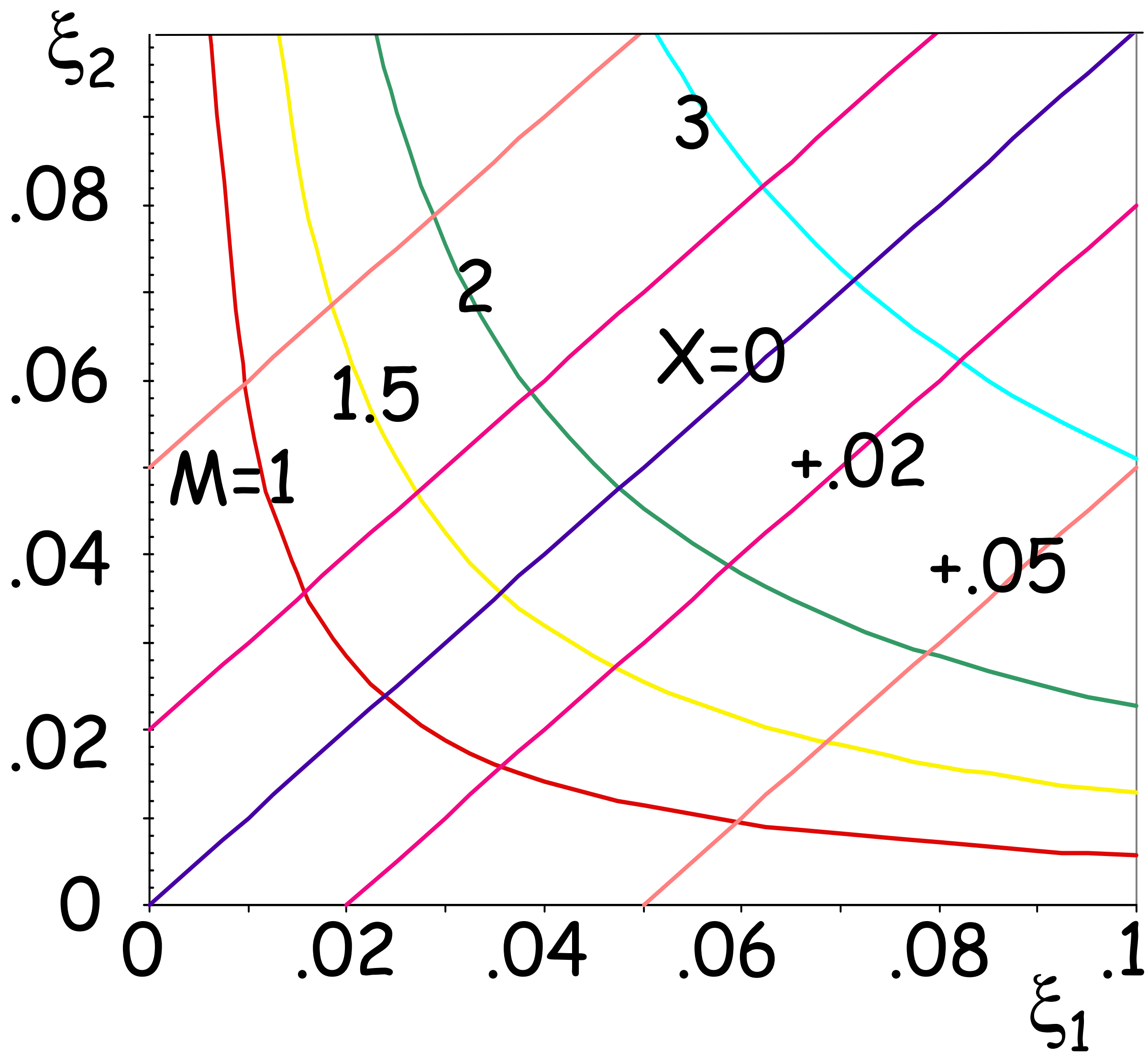
The data are described by: $\sigma \sim \xi_1^{-1.16} \; \xi_2^{-1.16} \; \sigma_{PP}(M_x)$

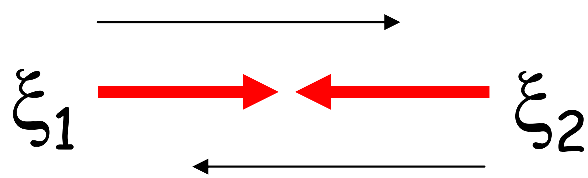


at low-|t|



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





Central mass sq.

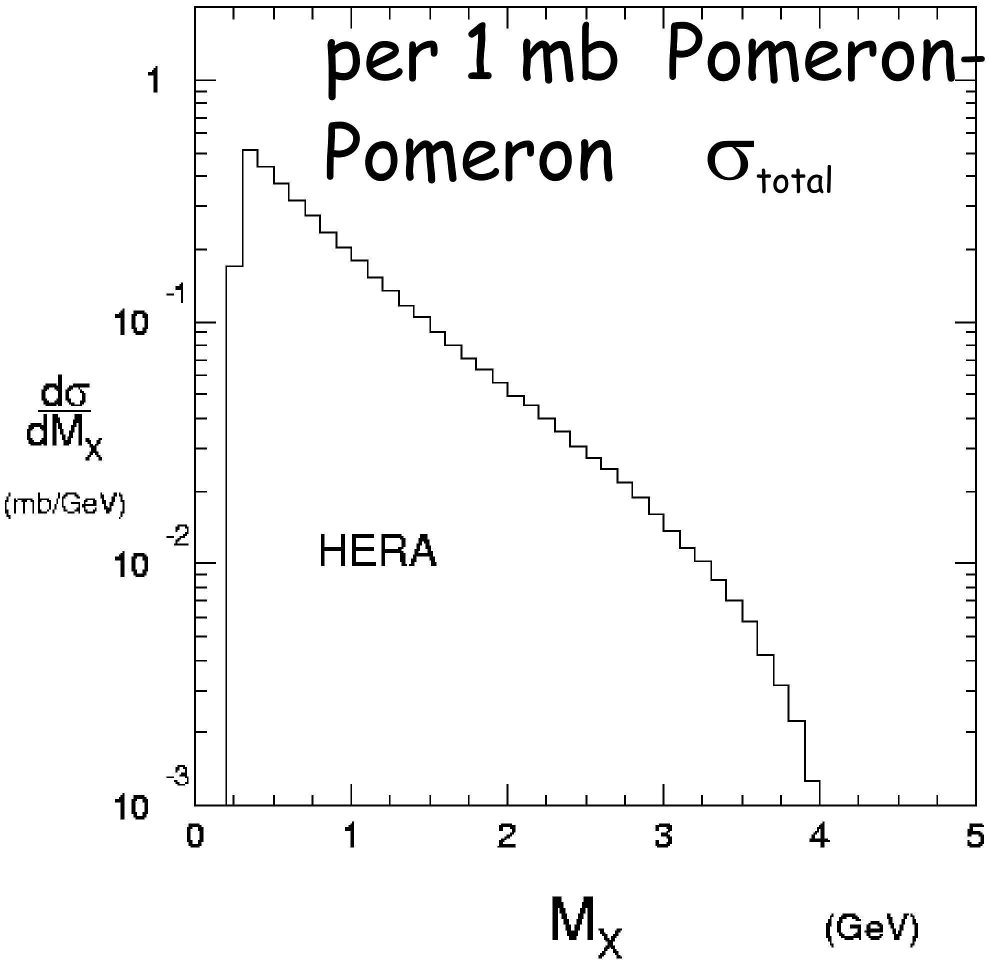
$M_x^2 = \xi_1 \xi_2 s$

$x = \xi_1 - \xi_2$

Measure M_x and x, we know ξ_1 and ξ_2.

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

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.

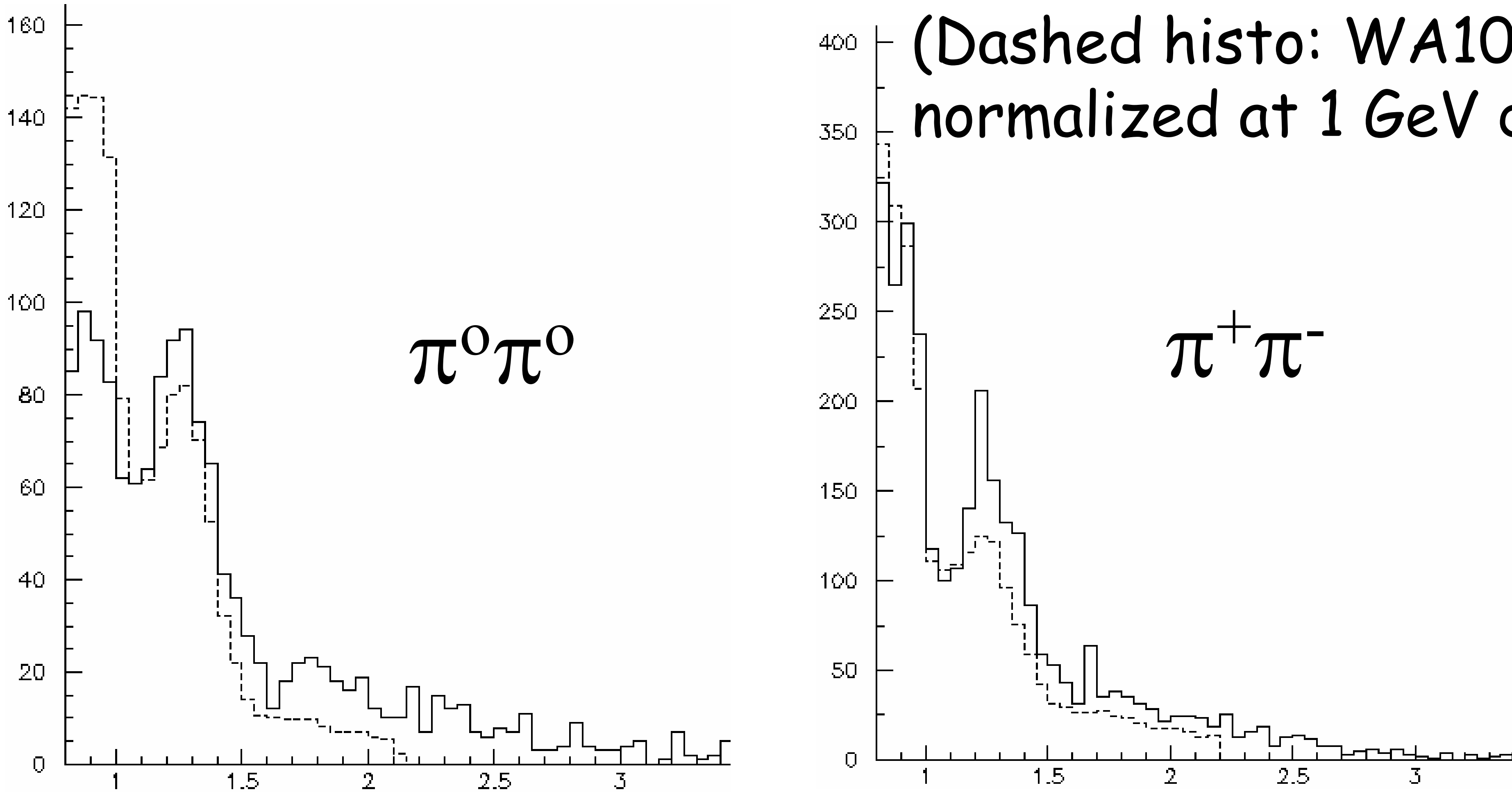
HERA-B

Events after rap-gap cuts & cleanup

No. charged tracks =	0	1	2	3	4	5
(Events in thousands)						
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

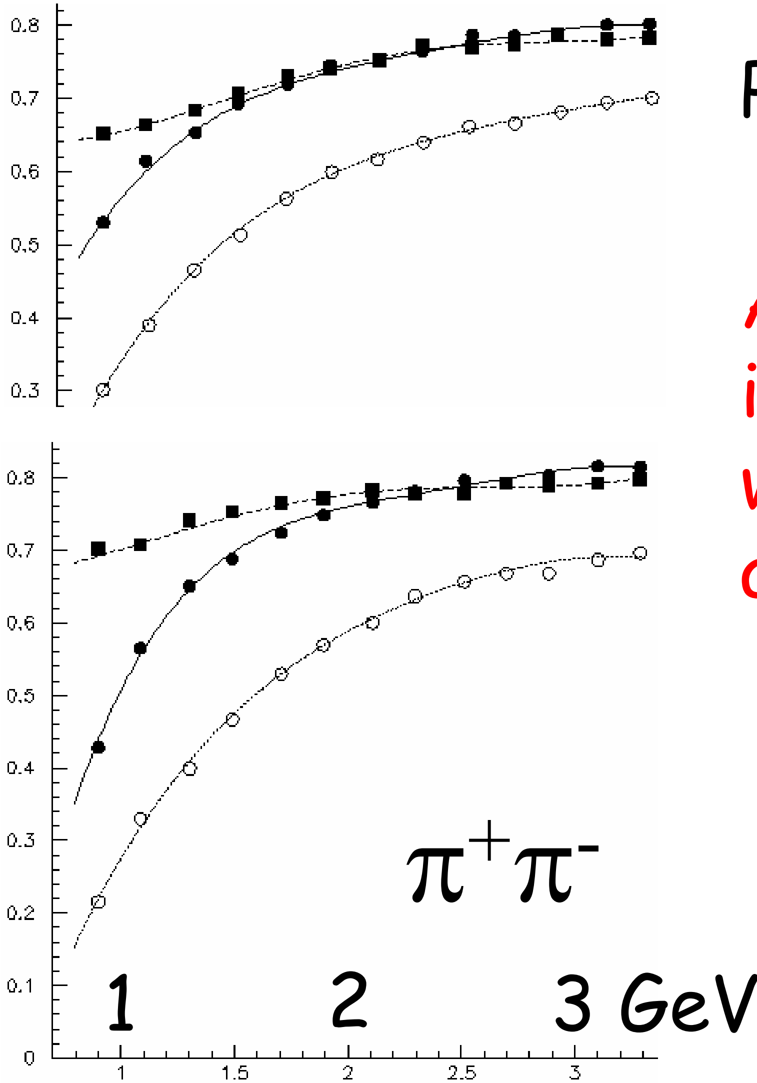
(Dashed histo: WA102 normalized at 1 GeV dip)



$\pi\pi$ Invariant Mass (GeV)

Fall-off at high mass is not due to acceptance

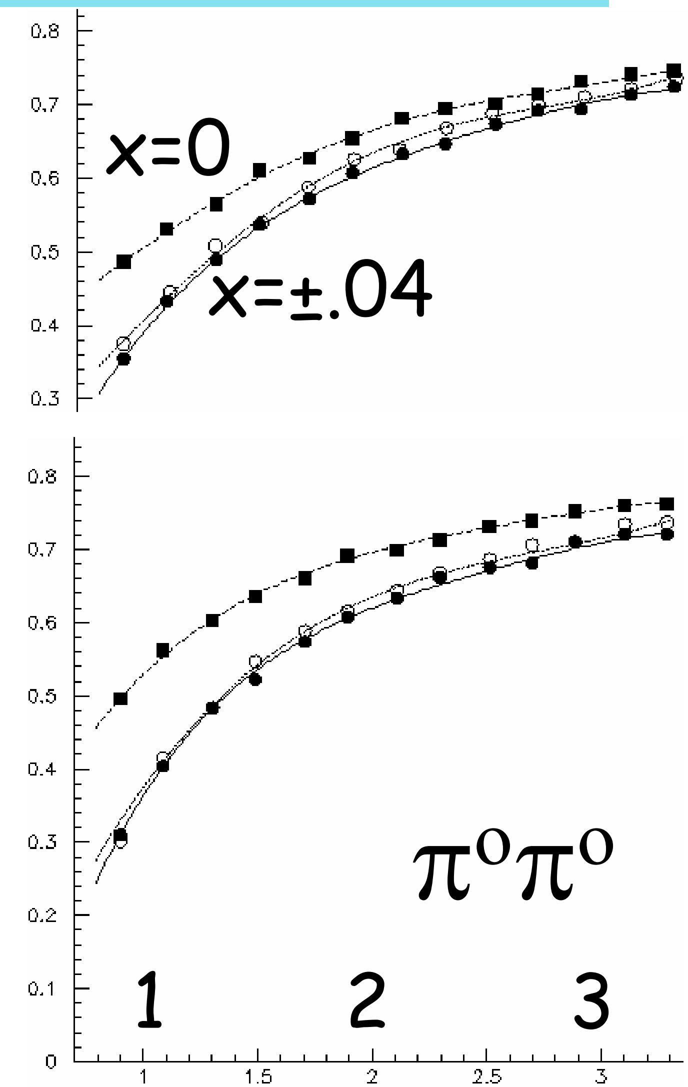
Dipion geometric acceptance vs. M



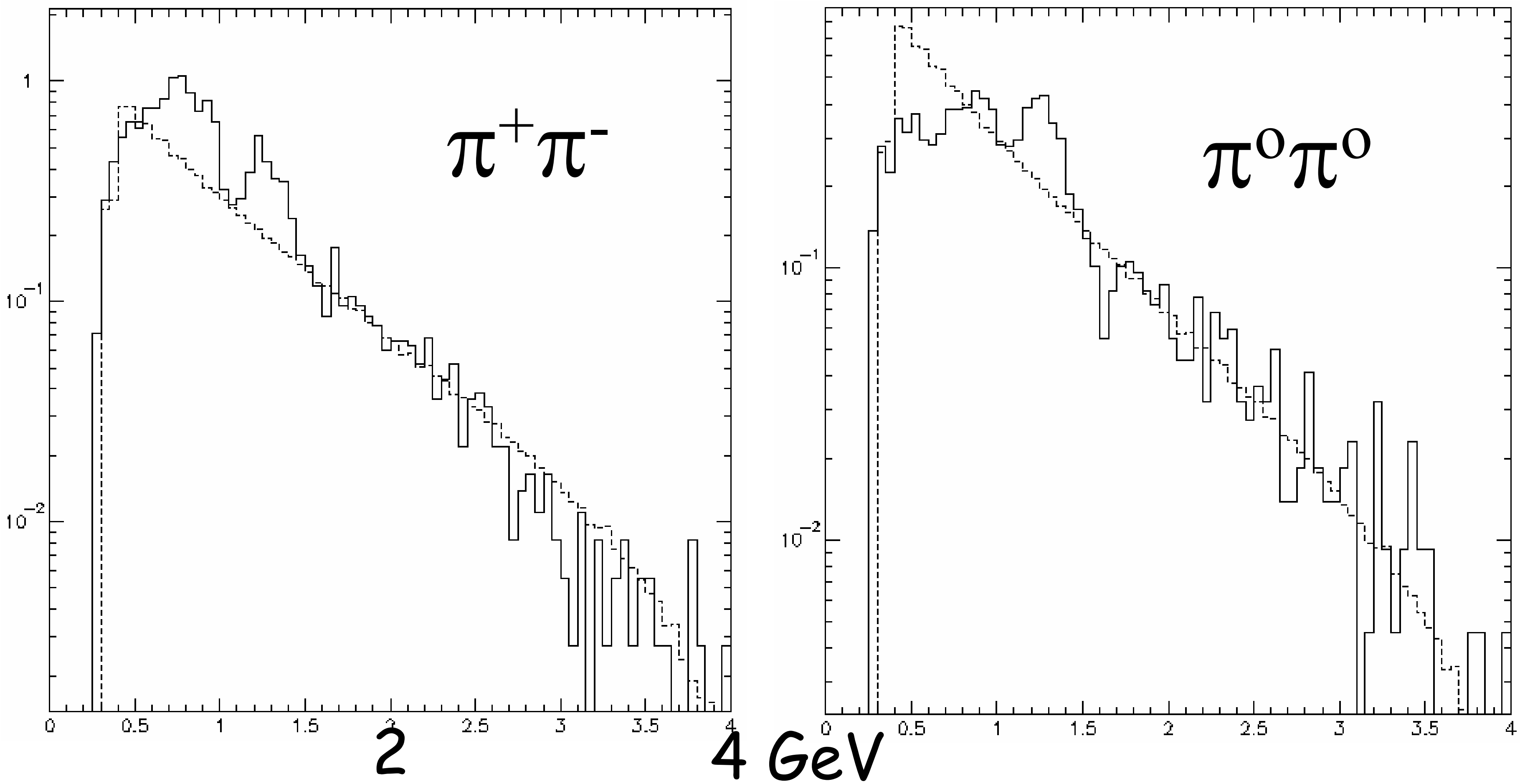
Pt = 0.5 GeV

Acceptance increases with mass and with Pt.

Pt = 0.

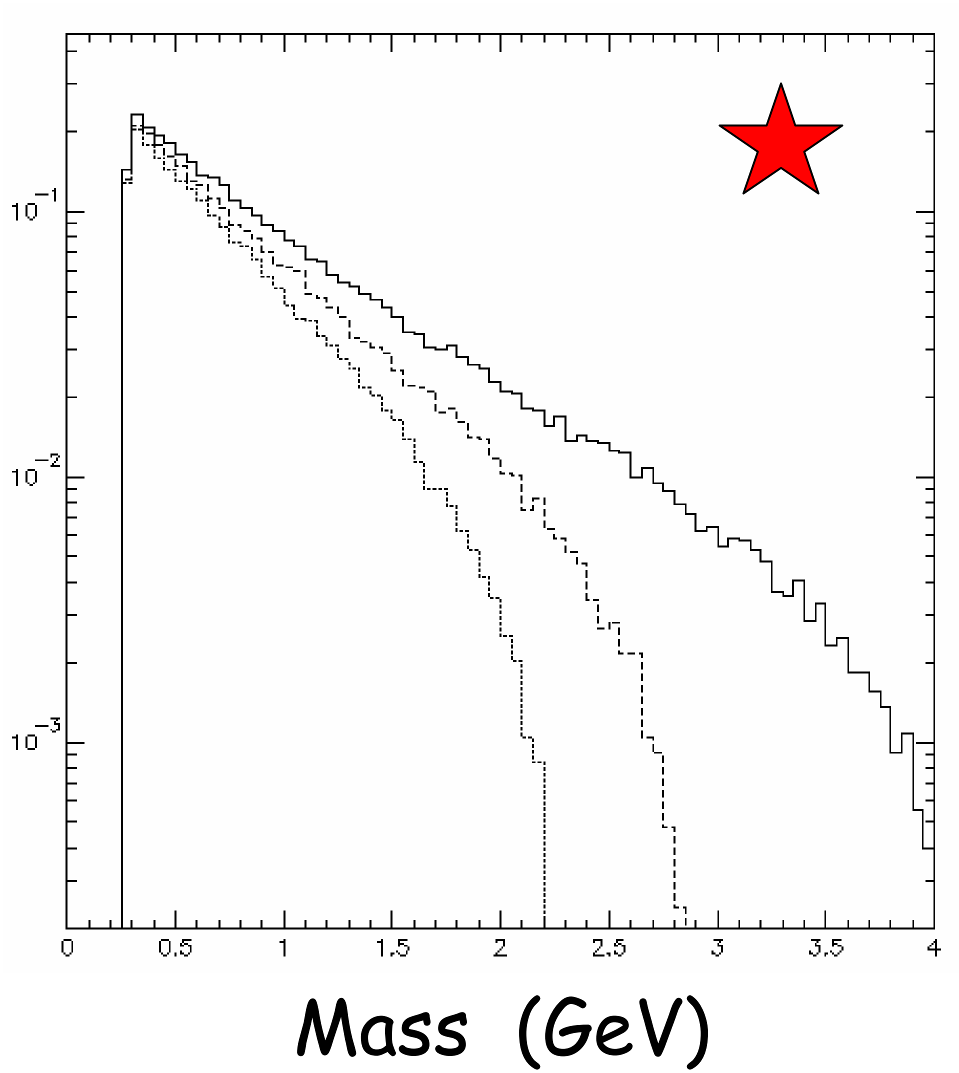


DPE prediction of mass spectrum



Fall off above 1.5 GeV is as expected in DPE.

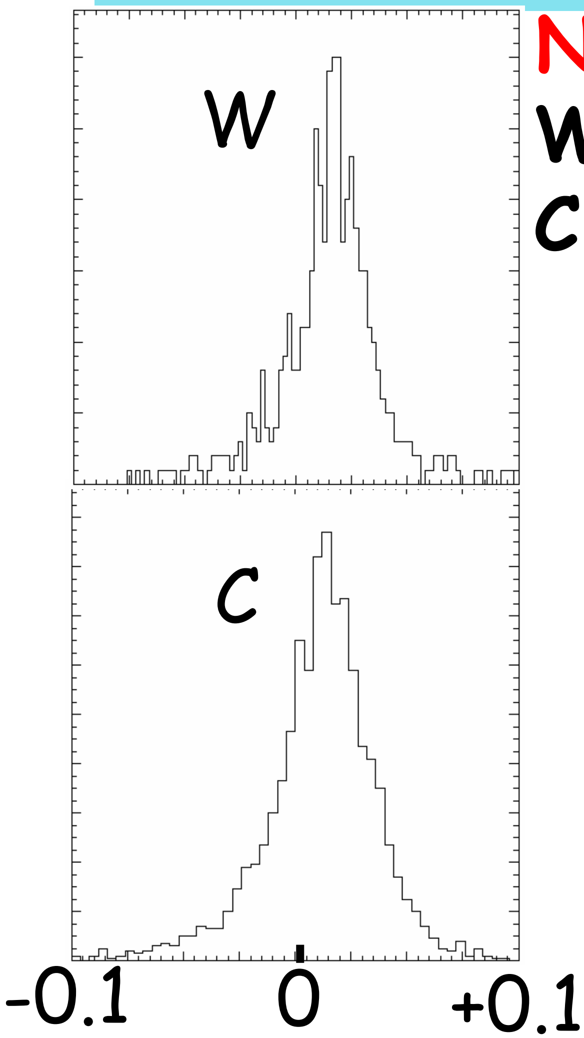
Predict mass spectrum 280-920 GeV



Beam mom.	280	450	920
			Cross section (mb)
All mass	0.311	0.384	0.504
> 1.5 GeV	4.5%	10.2%	18.5%
> 2.0 GeV	0.3%	2.7%	9.5%
> 2.5 GeV	---	0.4%	4.5%

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

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



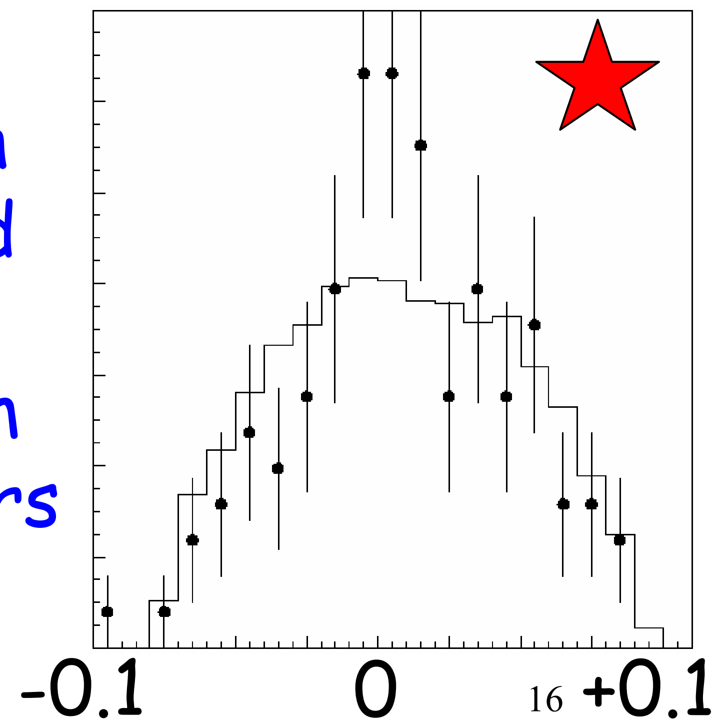
Nuclear Effect larger in W than in C.

W: x_F=**0.015**±0.001 (*MC*: -0.010±0.003)

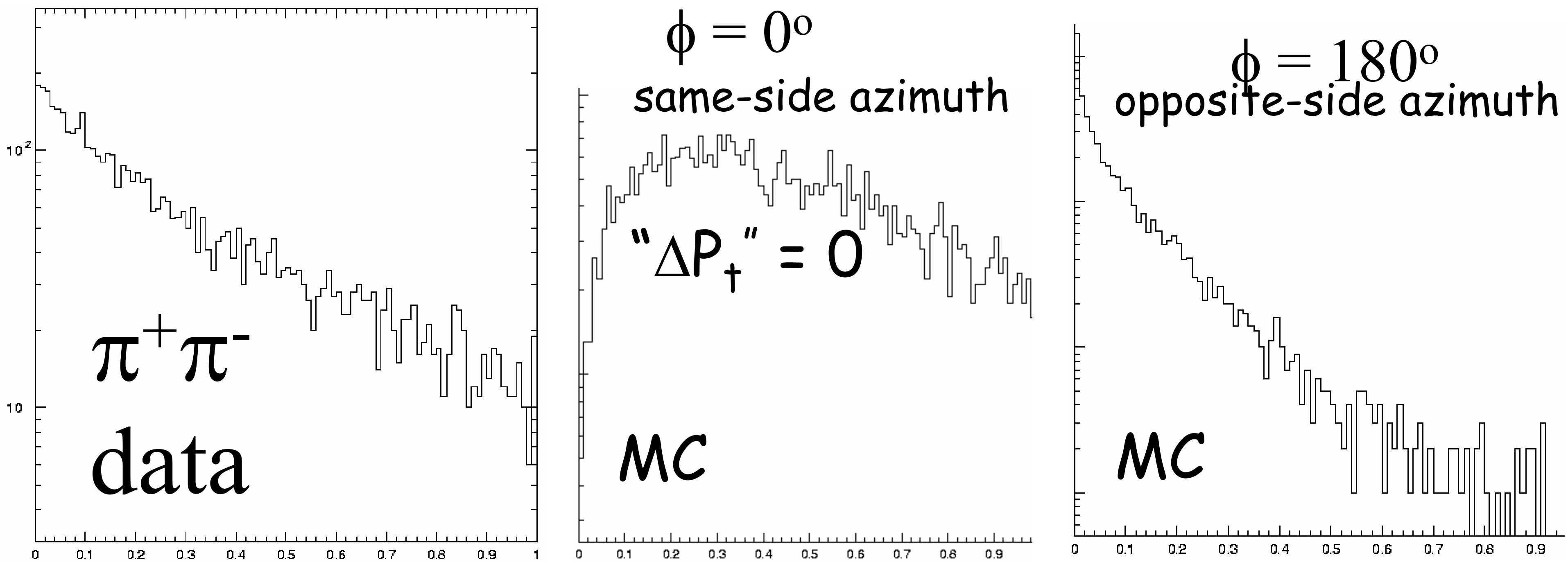
C: x_F=**0.011**±0.001 (*MC*: -0.016±0.007)

PRELIMINARY !

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



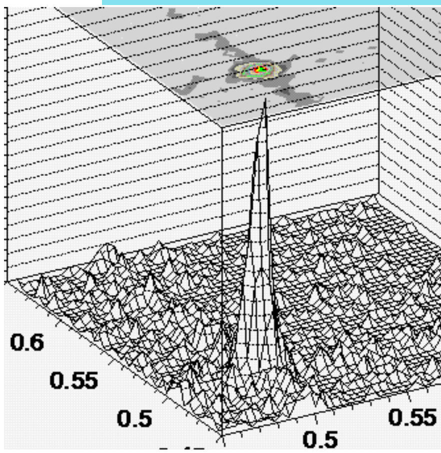
P_t^2 distributions and ϕ correlations

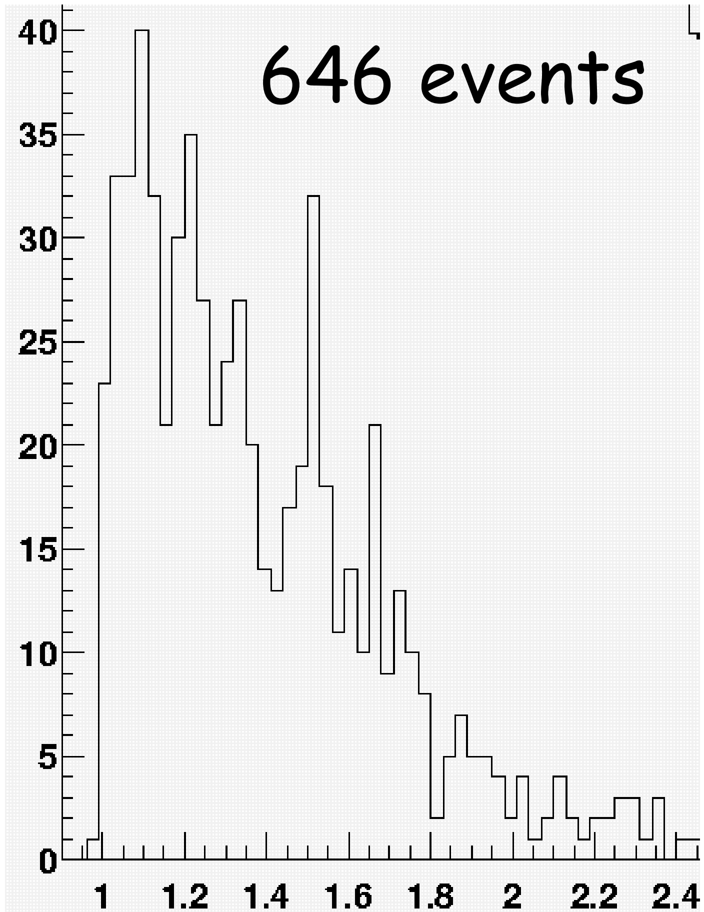


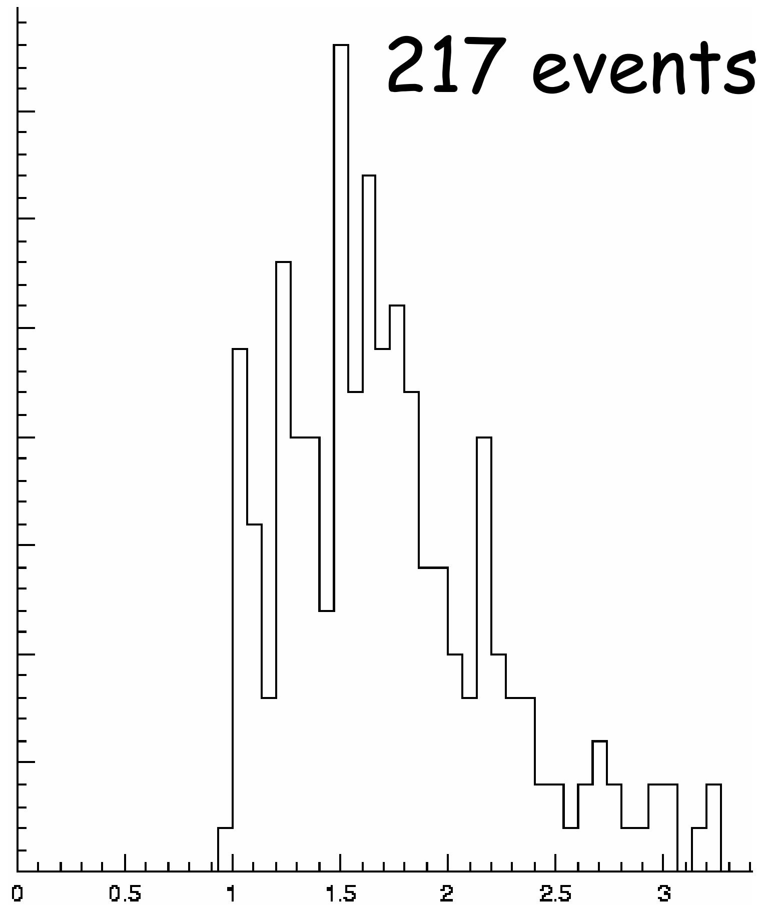
P_t^2

Selection of large P_t^2 data enhances "ΔP_t" = 0. According to WA-102, is optimal for glueballs.

K_sK_s K^+K^-

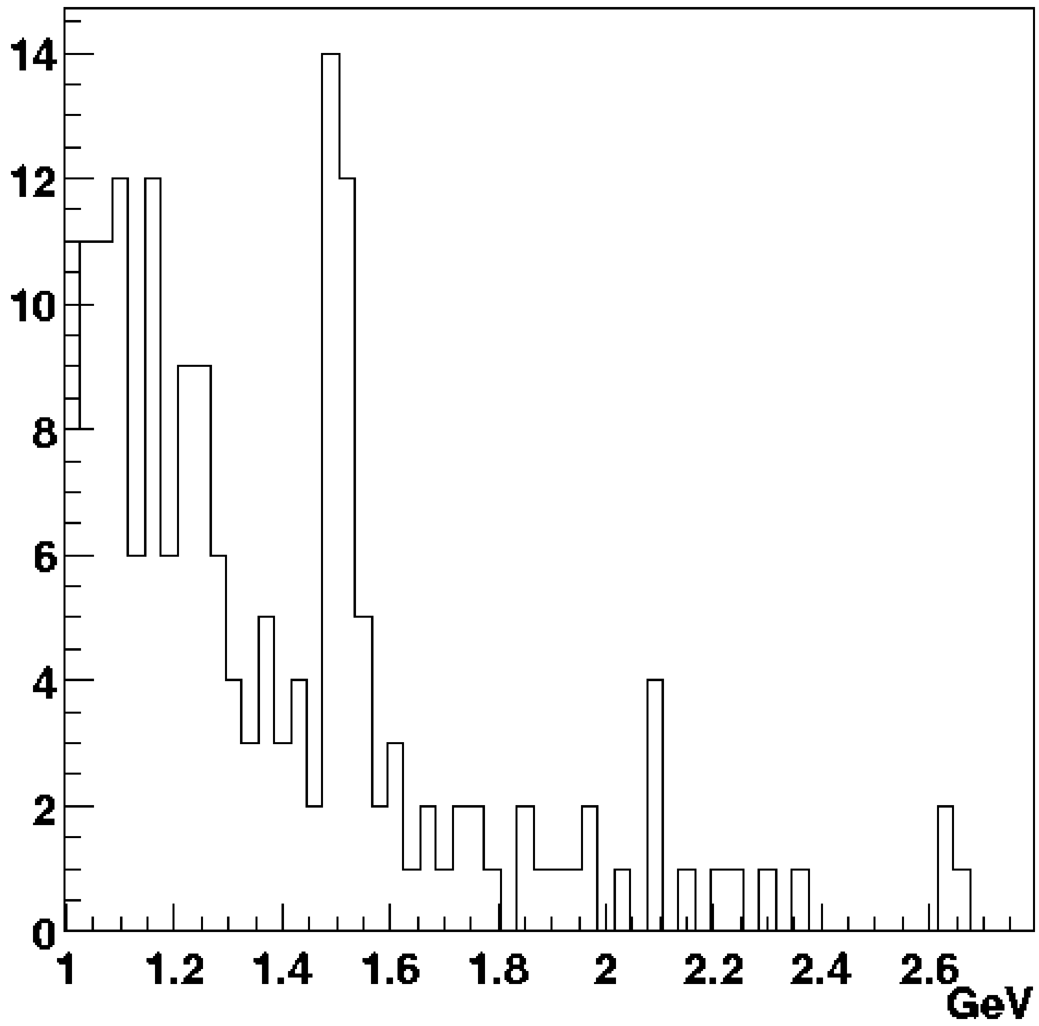






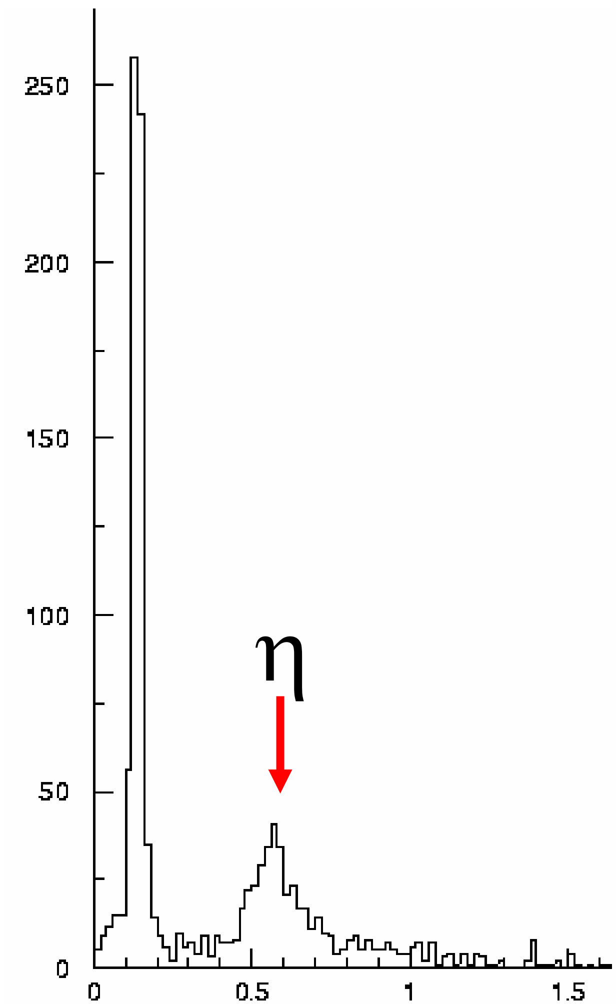
Invariant Mass

K_sK_s after ECAL veto

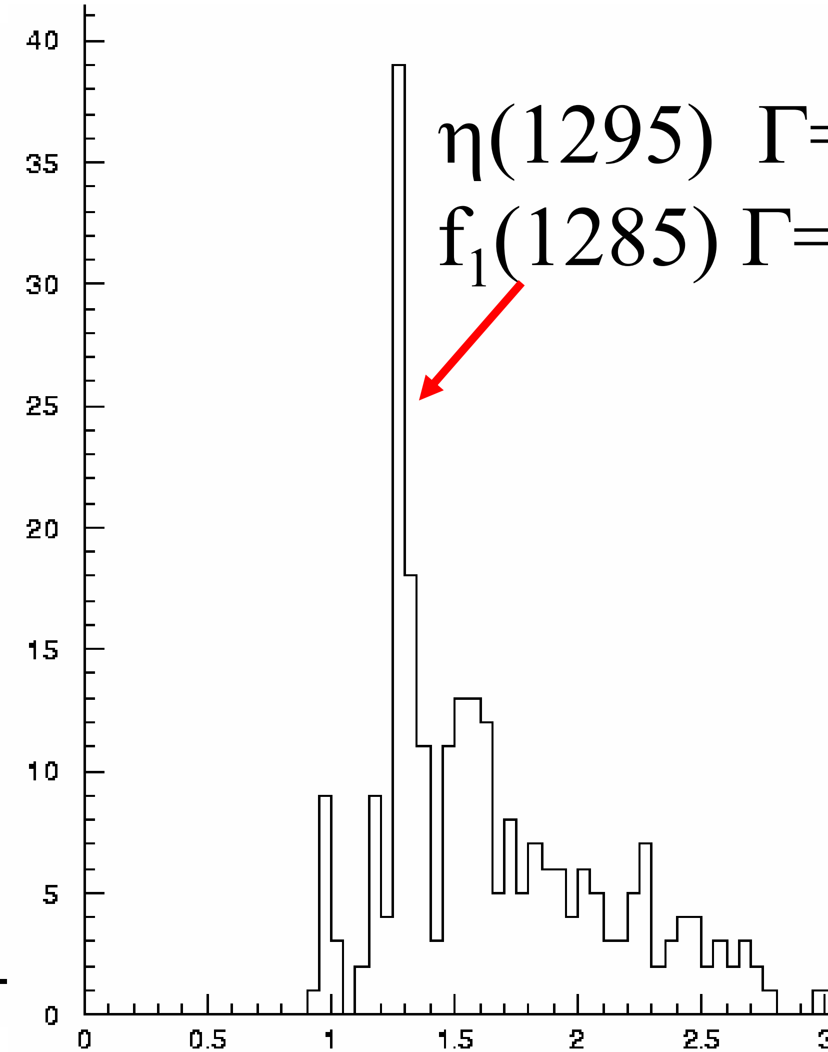


WA-102 sees no such effect

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

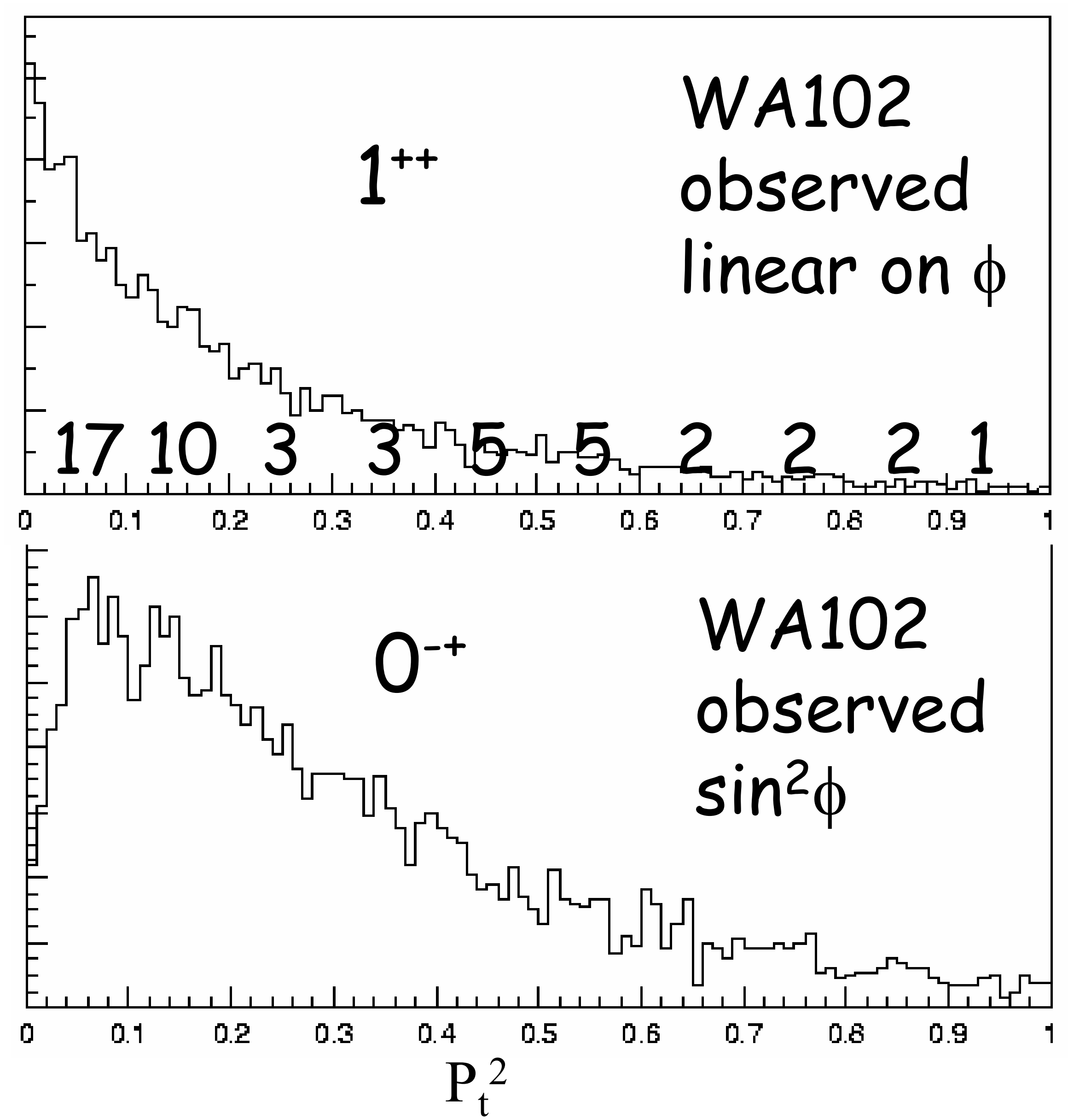


Mass $\gamma\gamma$



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

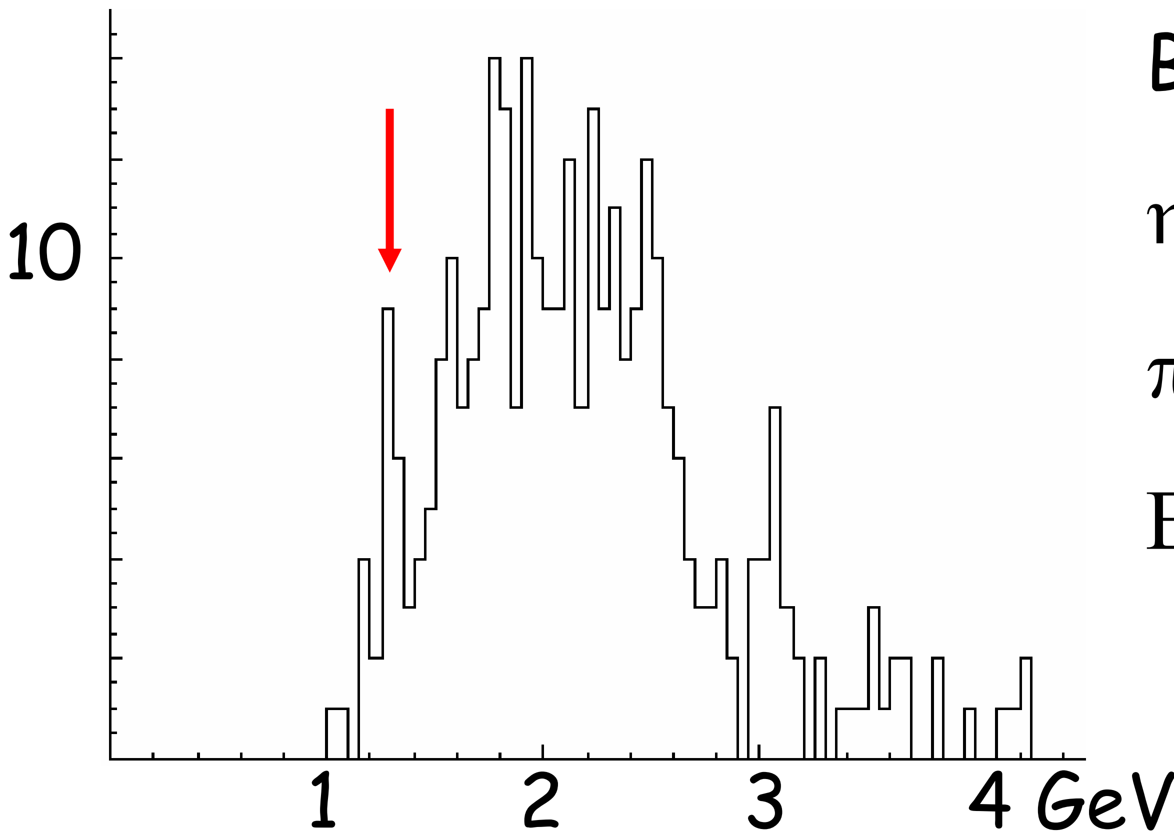
Use of P_t^2 to determine spin-parity



We can generate P_t^2 distribution given the ϕ distribution observed by WA102.

P_t^2 distribution of 1285 state is shown to left on 1^{++} plot in bins of 0.1 GeV^2 . So we likely have f(1285).

f(1285) --> $\pi^+\pi^-\pi^+\pi^-$?



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

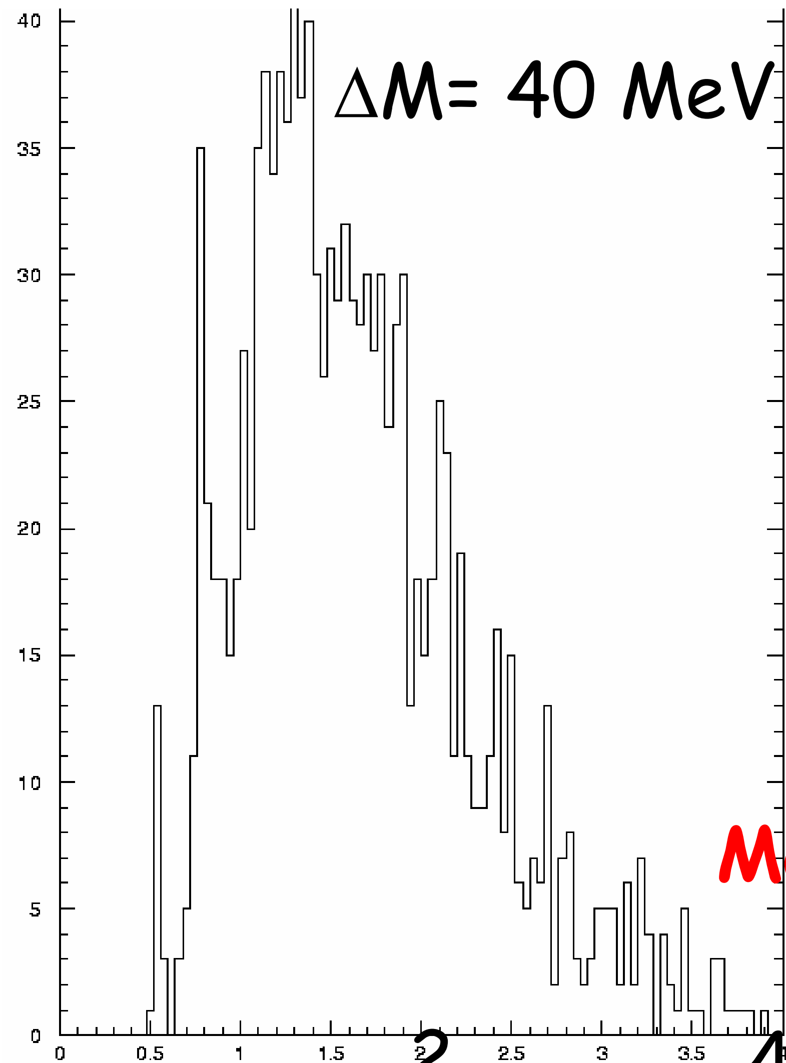
Branching ratios

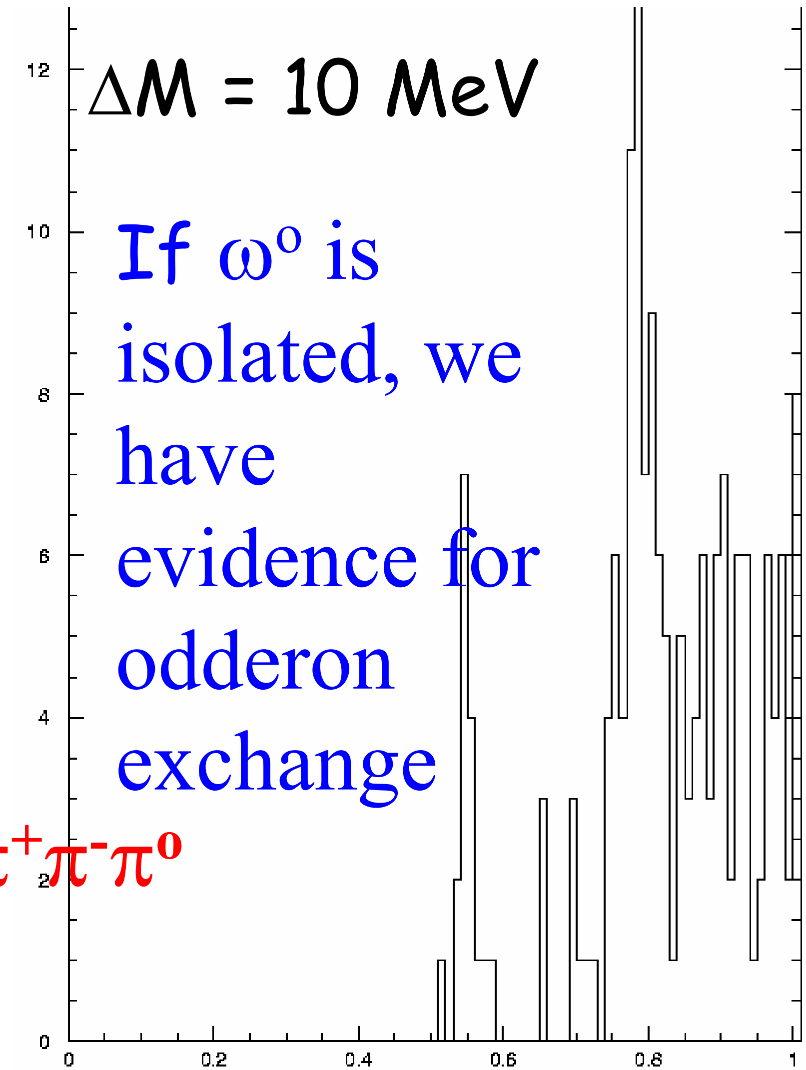
$\eta(\gamma\gamma)\pi^+\pi^-$ $(20 \pm 6)\%$

$\pi^+\pi^-\pi^+\pi^-$ 11%

Expect 27 ± 9 events

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

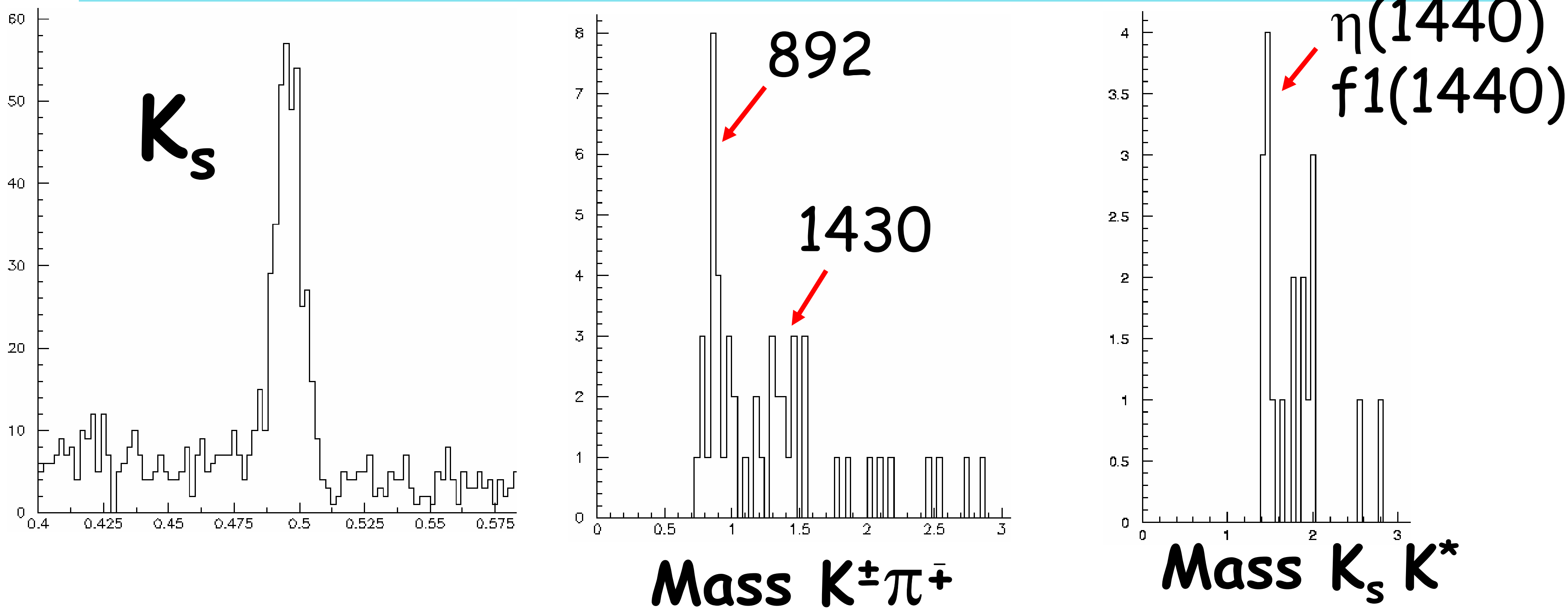




Mass $\pi^+\pi^-\pi^o$

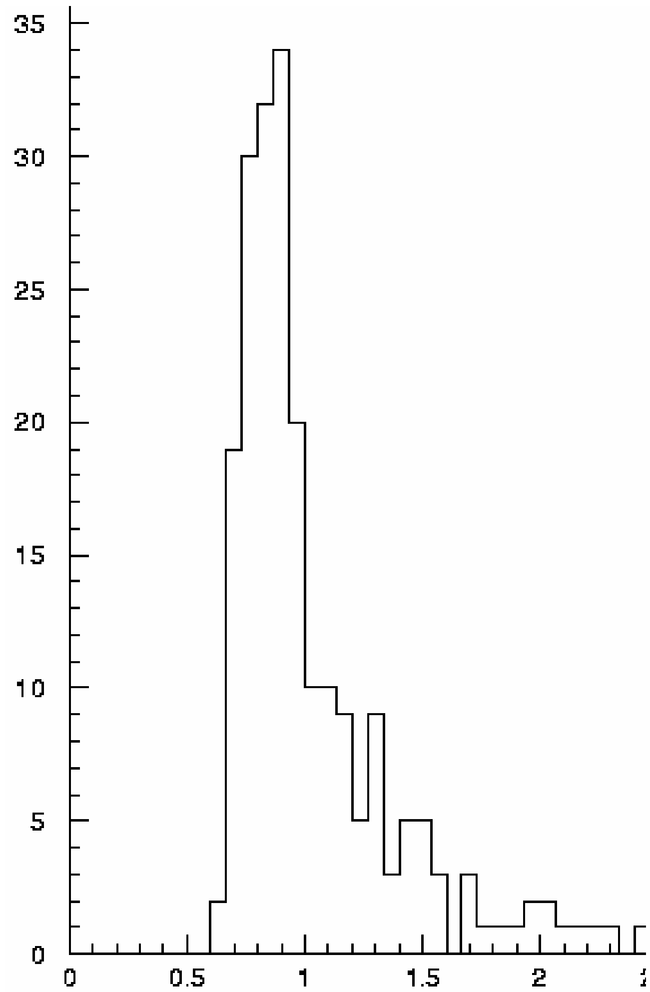
If ω^o is isolated, we have evidence for odderon exchange

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

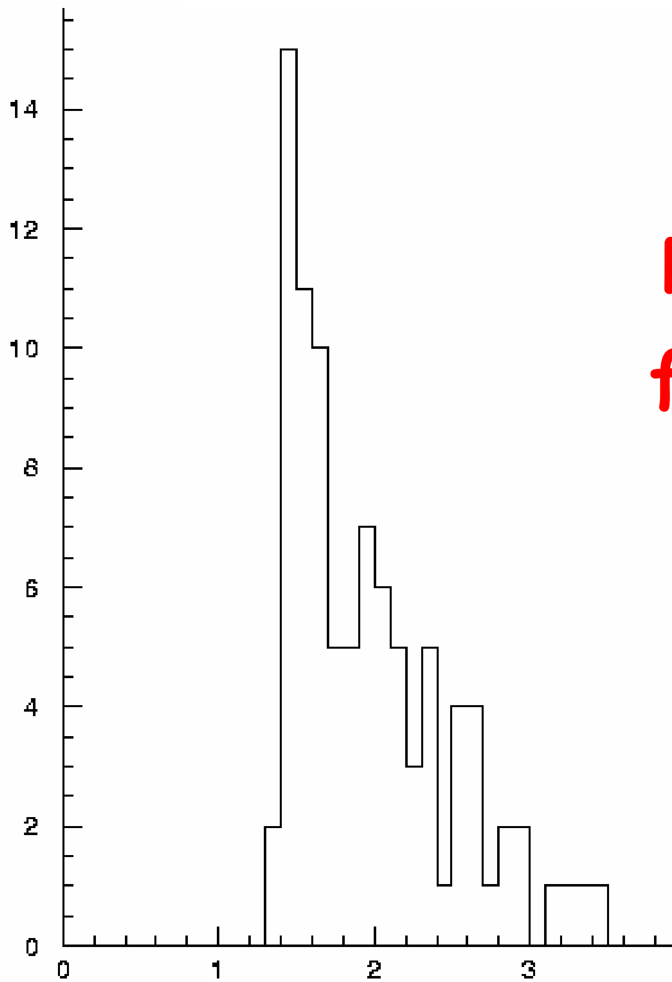


A good hint that we may be producing the $\eta(1440)$.
With events at 2 GeV mass, the future looks good.

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



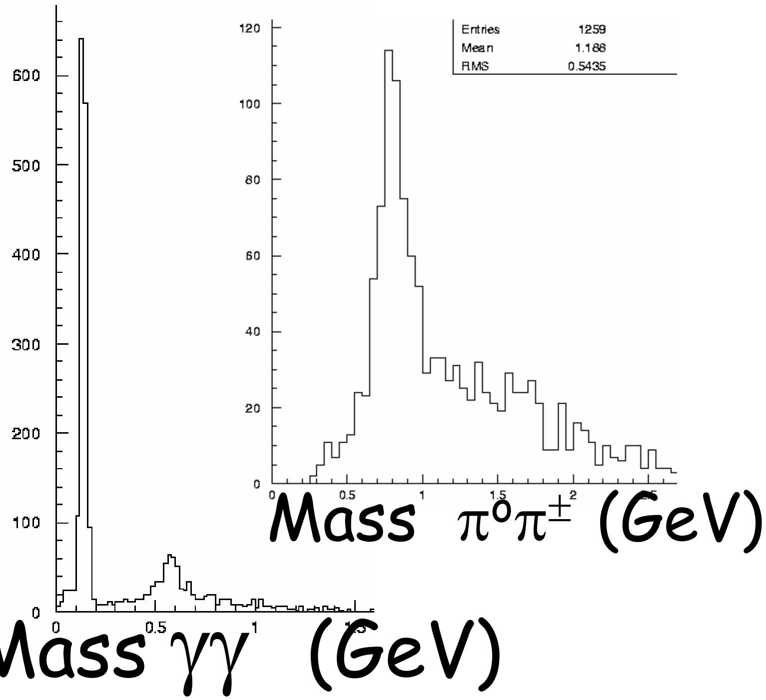
Mass $K^{\pm}\pi^{\mp}$

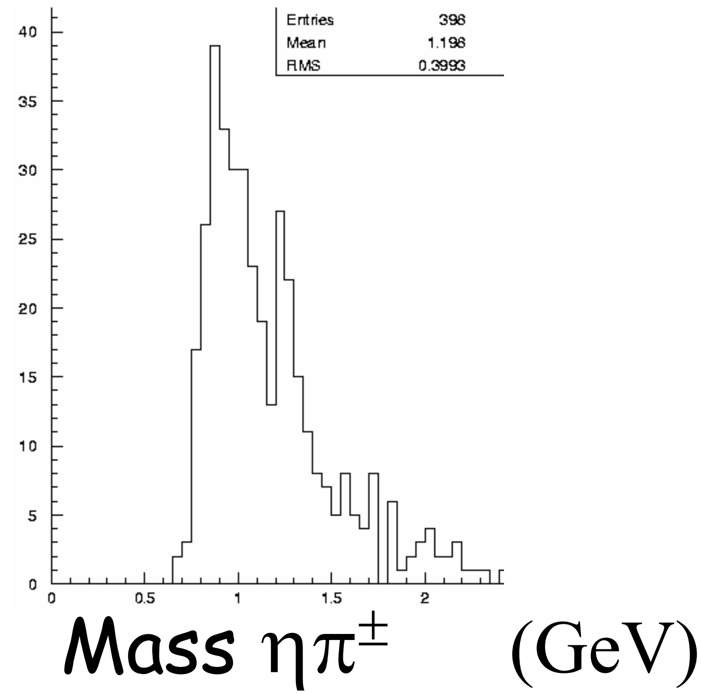


Mass K_s K^*

Reinforces $f_1/\eta(1440)$

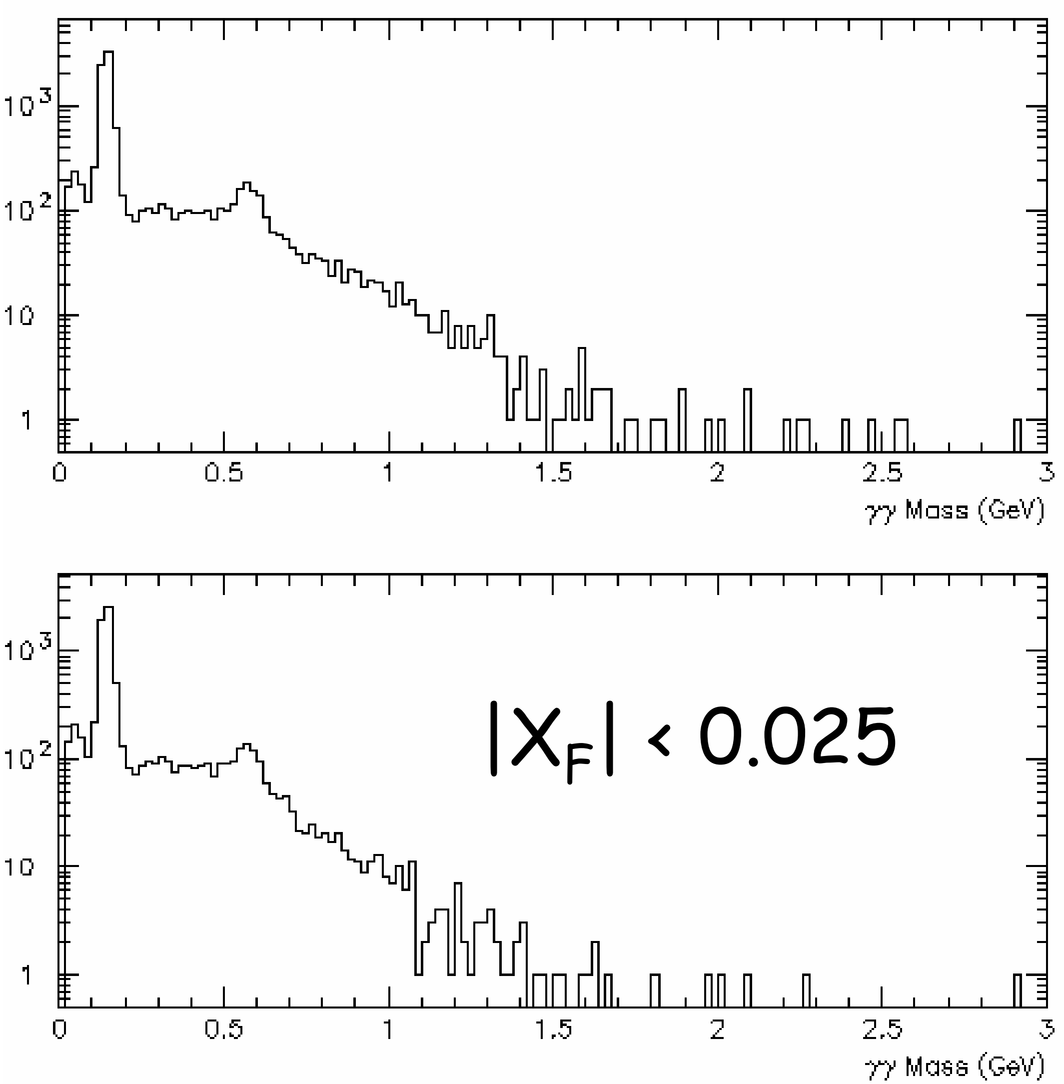
$\eta\pi^{\pm}$ Hybrid search in PomR collisions





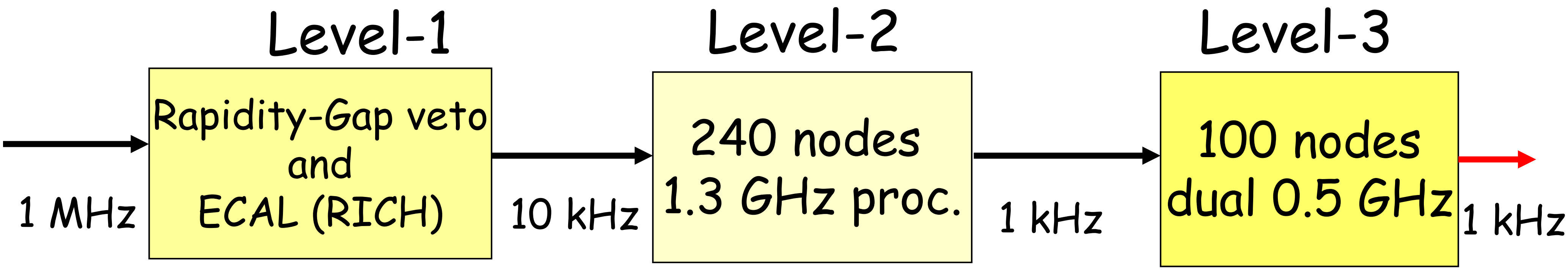
Pomeron-Reggeon collisions may be an excellent production source of hybrids. Since hybrid candidates (1^{-+}) were obtained from phase-shift analyses of $\eta\pi^{\pm}$, HERA-g could be major contributor to hybrid physics

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. With higher statistics, HERA-g may 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 1/2 is already available, before study of silicon and other tracking algorithms.

Conclusions

The HERA-B detector is available. The yield from a 100-hour experiment is one order-of-magnitude larger than presently existing data (e.g. WA102) in many channels and a larger fraction of the data is in the interesting higher mass region.

We believe that HERA-g has the unique opportunity to make major contributions to exotic spectroscopy and to the physics of color-singlet exchange in high-energy collisions. It is clear that, without anybody realizing it, the HERA-B spectrometer was designed for this exp.
New idea: Pomeron-Reggeon exchange → hybrids.
Probable changes in effective Pomeron momenta due to nuclear effects.