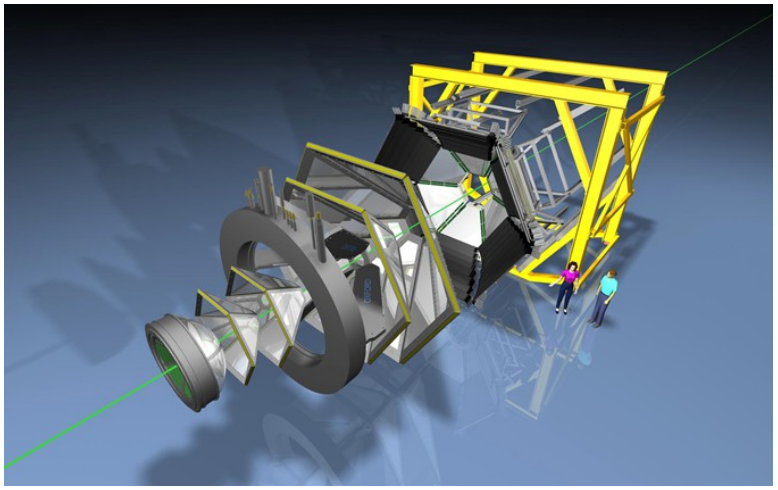
Preliminary results of pion induced reaction with carbon and polyethylene targets obtained by HADES-GSI in 2014

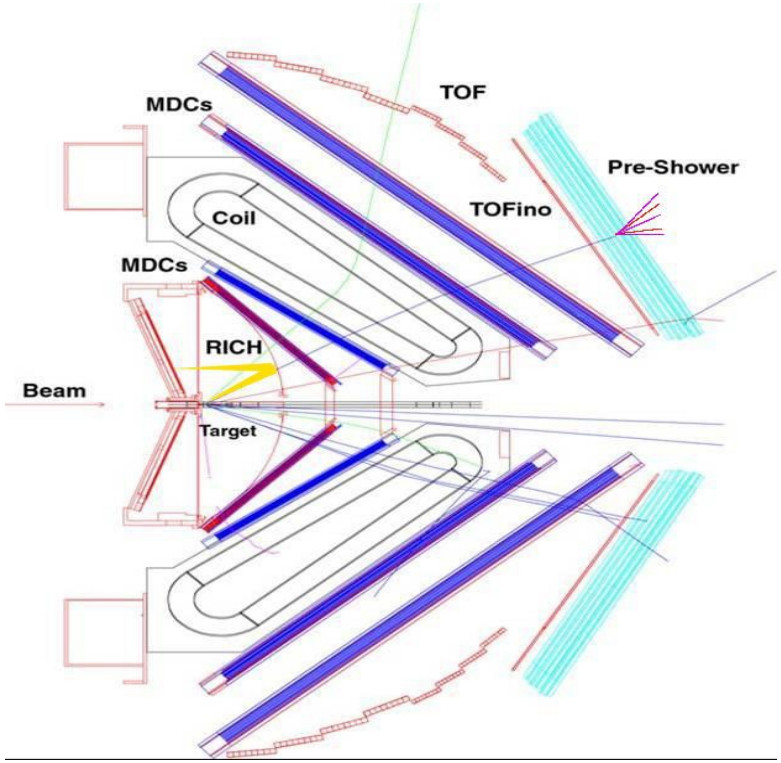
Pablo Rodríguez Ramos

Nuclear Physics Institute, Řež near Prague, Czech Republic.
Czech Technical University in Prague, Faculty of Nuclear Sciences and Physical Engineering, Prague, Czech Republic.

4th International Workshop for young scientists with research interests focused on physics at FAIR

HADES Spectrometer





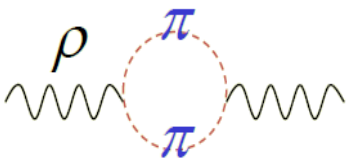
- The HADES spectrometer is installed at SIS18 synchrotron in GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany
- It is designed to measure systematically production of electron-positron pairs in elementary and heavy-ion collisions at SIS18 energy range.
- six identical sectors.
- almost full azimuthal angle.
- polar angle 18° - 85°
- high rate counting.

ρ in-medium: hadronic models

Vacuum

$\Sigma_\rho(M) = -i m_\rho \Gamma_{\pi\pi}(m)$

$M_\rho = 0{,}77\ GeV$

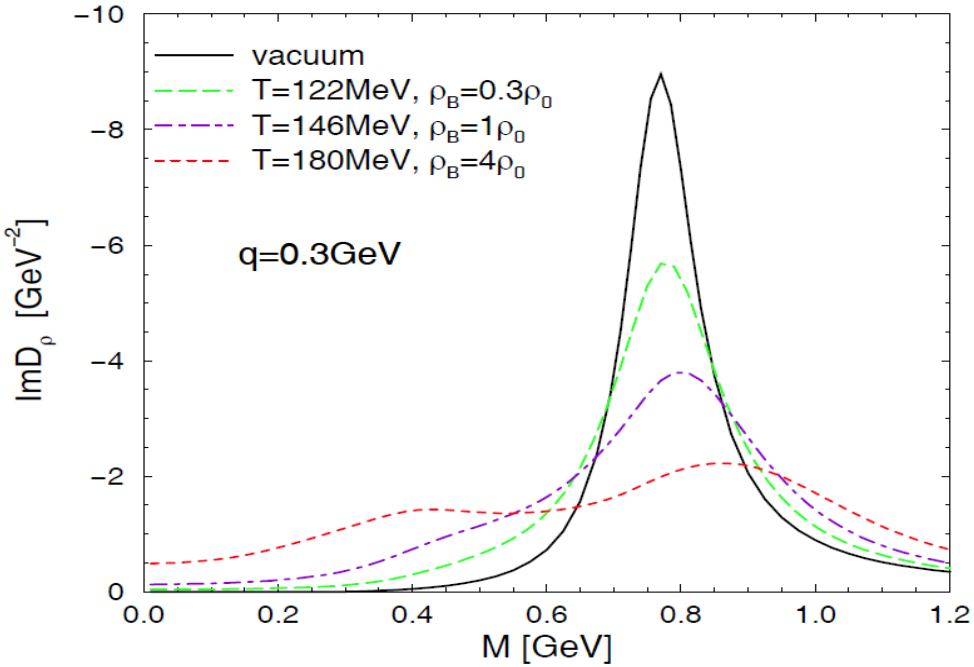


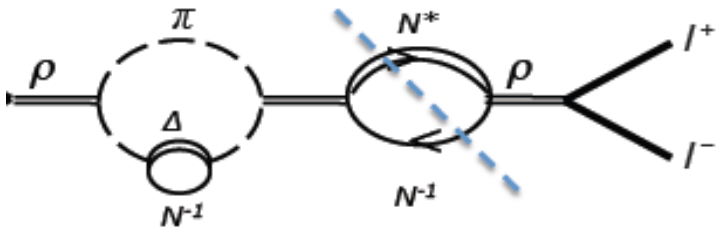
In-medium broadening

In-medium spectral function depends on ρNN* coupling.

Main players:

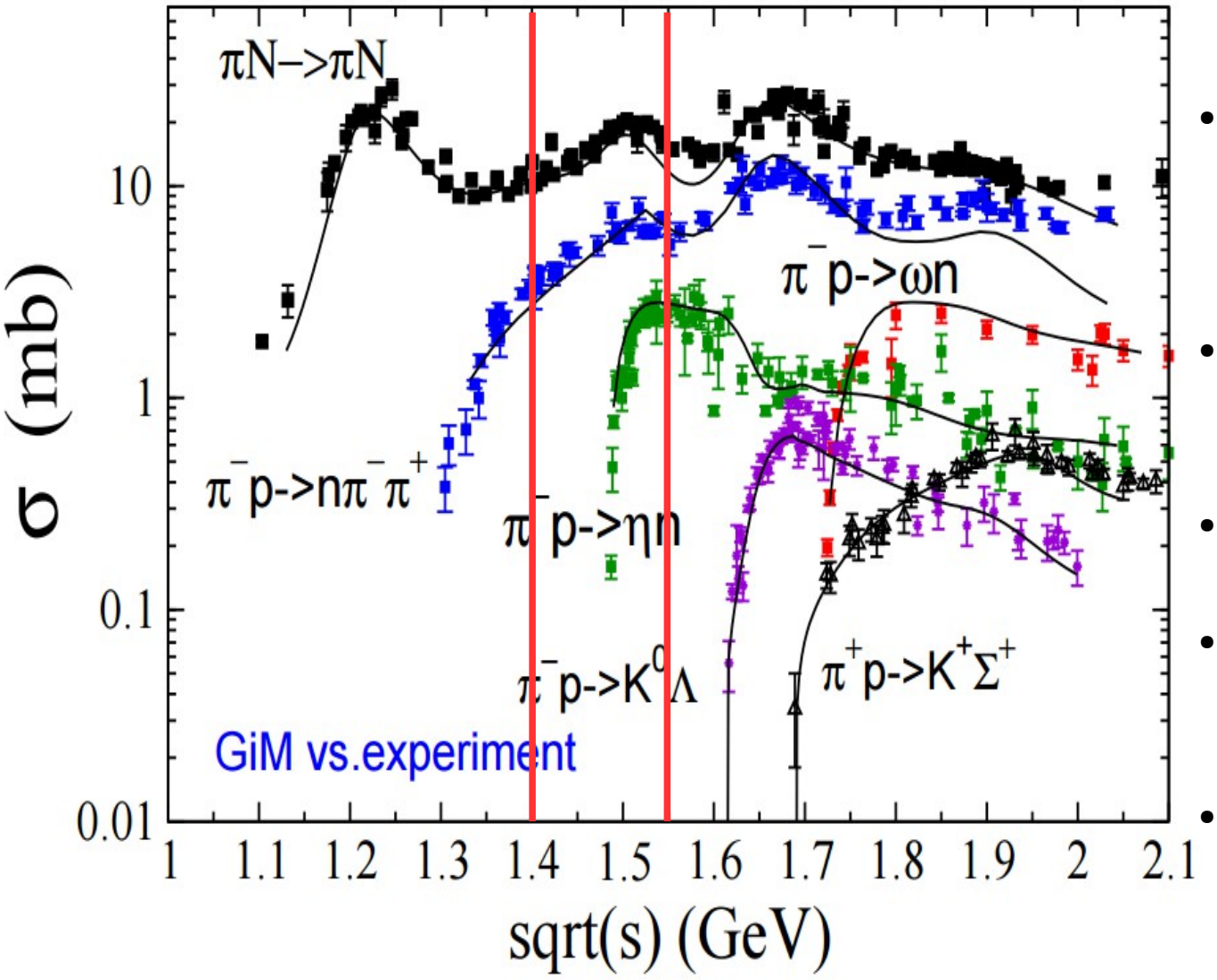
N(1520), Δ(1620), N(1720),...





Coupling of ρ to baryonic resonances can be directly studied in NN and πN collisions at 1-2 GeV via $N^*(\Delta) \rightarrow e^+e^-$ decays

HADES physics for pion beams (2014)

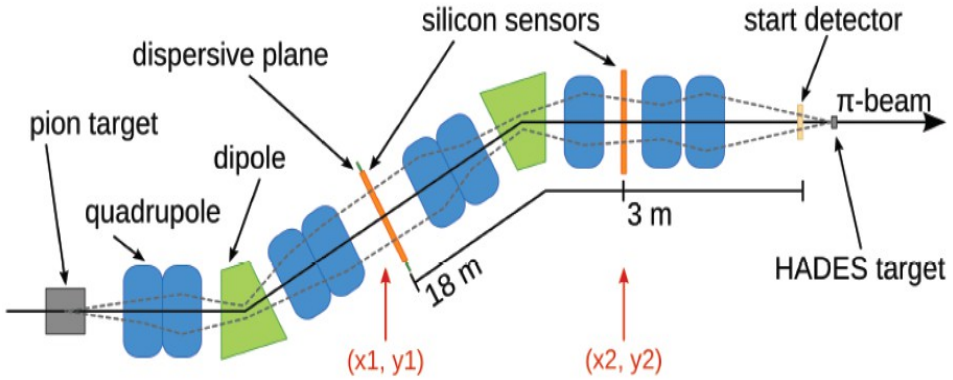


- Resonance excitation can be controlled by the variationof the projectile(pion) momentum
- HADES starts with p=0.656/0.69/0.748/0.8 GeV/c
- √s = 1.46-1.55 GeV: N(1520)
- π+π-production: couplingof ρ to resonance
- e+e- never measured from pion induced reactions

V. Shklyar *et al.* (GiBUU coupled-channel model)
arxiv: 1409.7920v1

Pion beam for HADES (2014)

Pion-beam

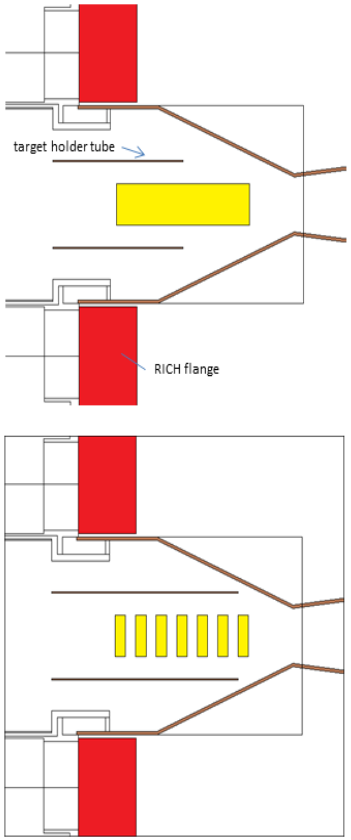


Carbon target

PE target allows to separate contribution from pion-proton from pion-carbon interactions by means of kinematical constraints.

Therefore it was possible to measure at the same time pi-p->e+e- n (exclusive channel) and inclusive e+e- production on carbon.

Targets



Targets for pion beam time AUG14

Polyethylen target

Diameter:	12 mm
Length:	46 mm
Lab position of center:	-32.7 mm

Carbon target

Number of segments:	7
Diameter of segments:	12 mm
Thickness of segments:	3.6 mm
Distance between segment centers:	7.1 mm
Total length:	46.2 mm
Lab position of center:	-32.6 mm

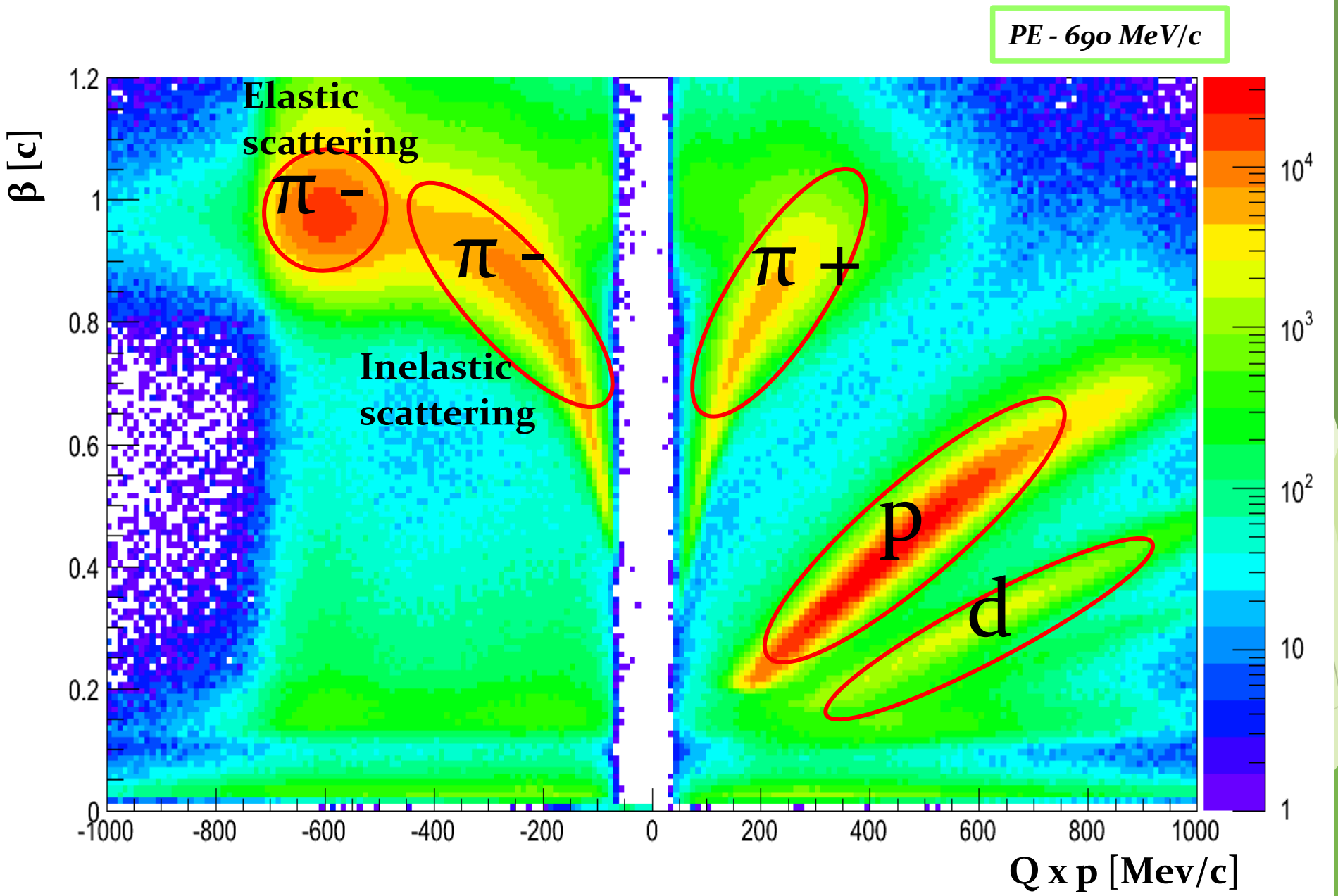
Target holder:
carbon-fibre tube with outer diameter of 26mm and wall thickness of 0.5 mm

Overview of Statistics

PE = 946 M C = 186 M

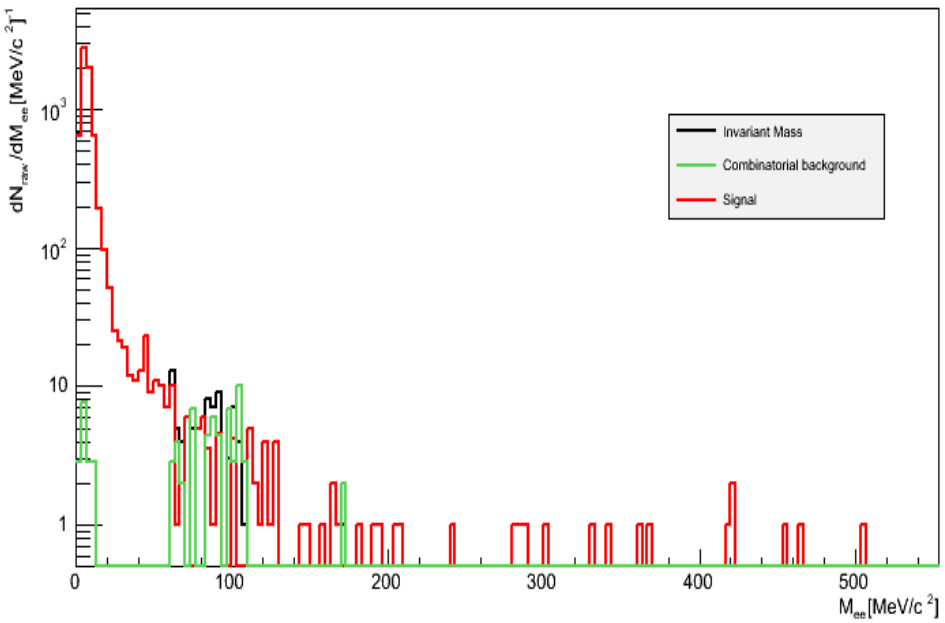
Collected statistics in beam time AUG14/SEP14					
Target	Momentum [MeV/c]	Data Begin	Data End	sum events	Data taking (h)
PE	690	20/08/2014 14:01	03/09/2014 12:47	774.7M	175.56
PE	748	03/09/2014 20:14	04/09/2014 9:14	76.5 M	11.61
PE	656	04/09/2014 21:38	06/09/2014 1:19	42.4 M	14.08
PE	800	06/09/2014 1:22	06/09/2014 9:01	52.4 M	7.48
C	612	06/09/2014 18:57	07/09/2014 13:09	47.8 M	16.26
C	690	07/09/2014 19:05	08/09/2014 8:25	60.7 M	13.06
C	800	08/09/2014 8:50	09/09/2014 2:51	41.2 M	6.27
C	748	09/09/2014 3:05	09/09/2014 11:37	42.2 M	6.8
C	656	09/09/2014 20:33	11/09/2014 6:21	41,9 M	14,75

Particle identification

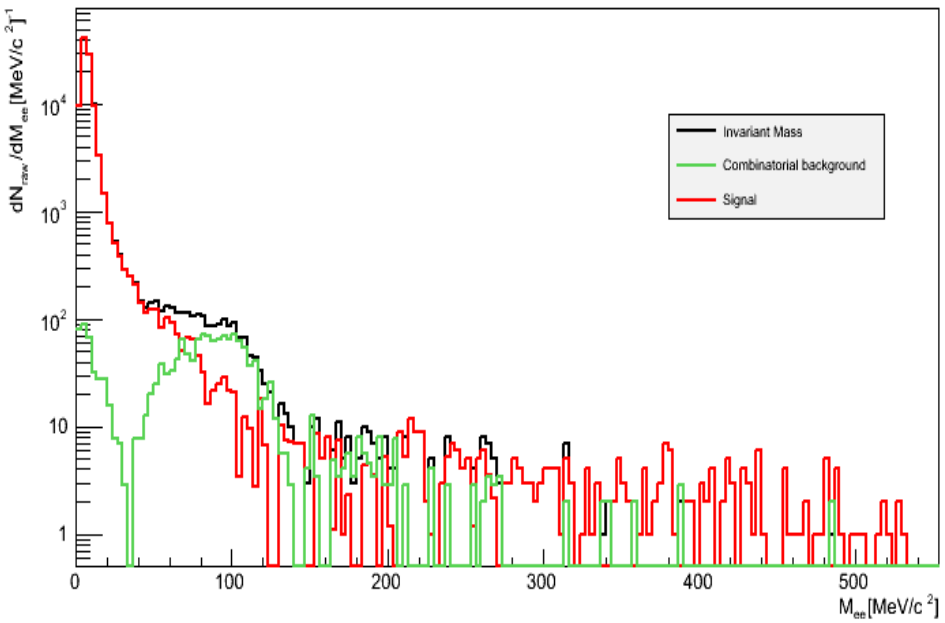


Signal=InvM-CB

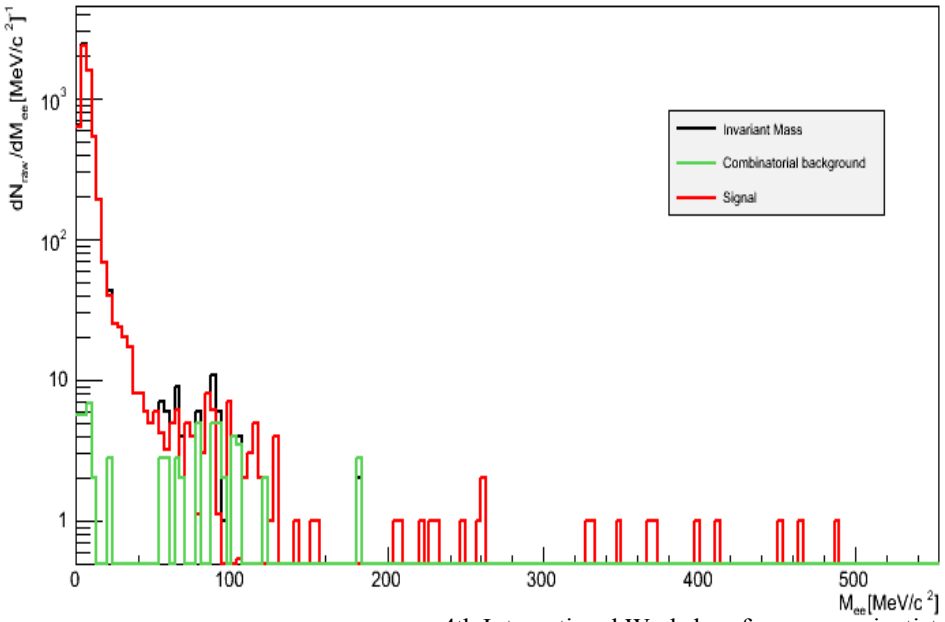
PE656



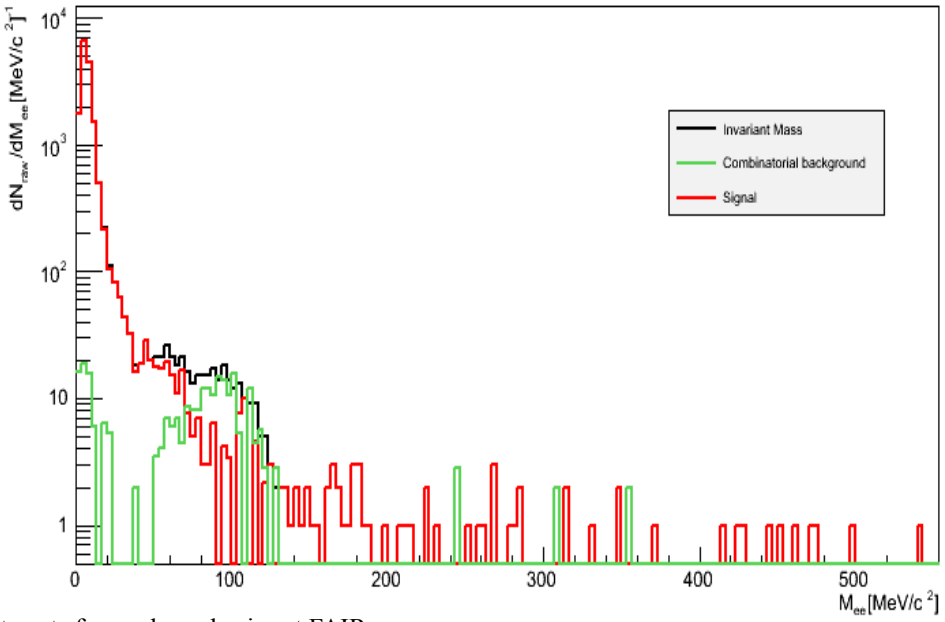
PE690



C656

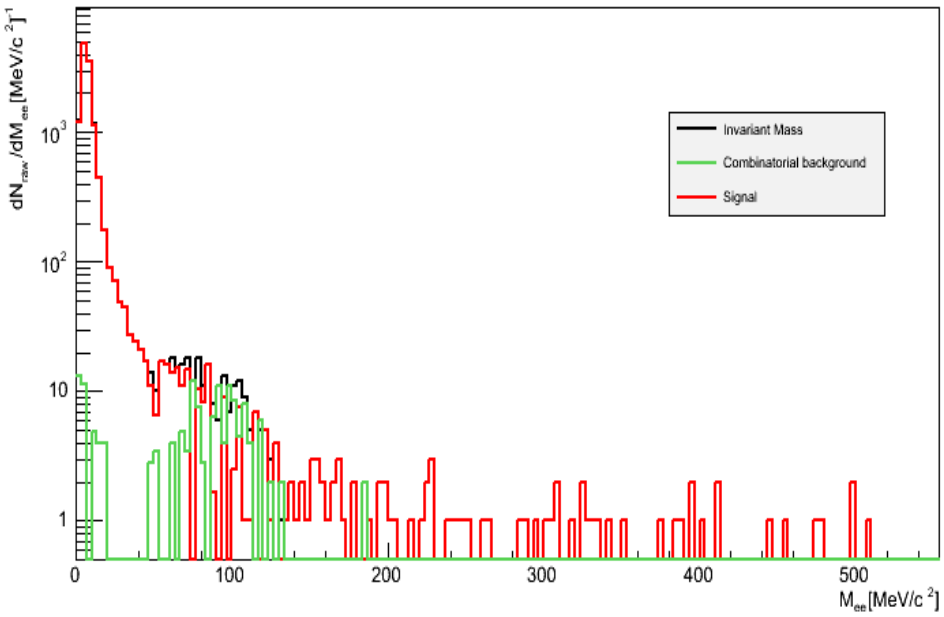


C690

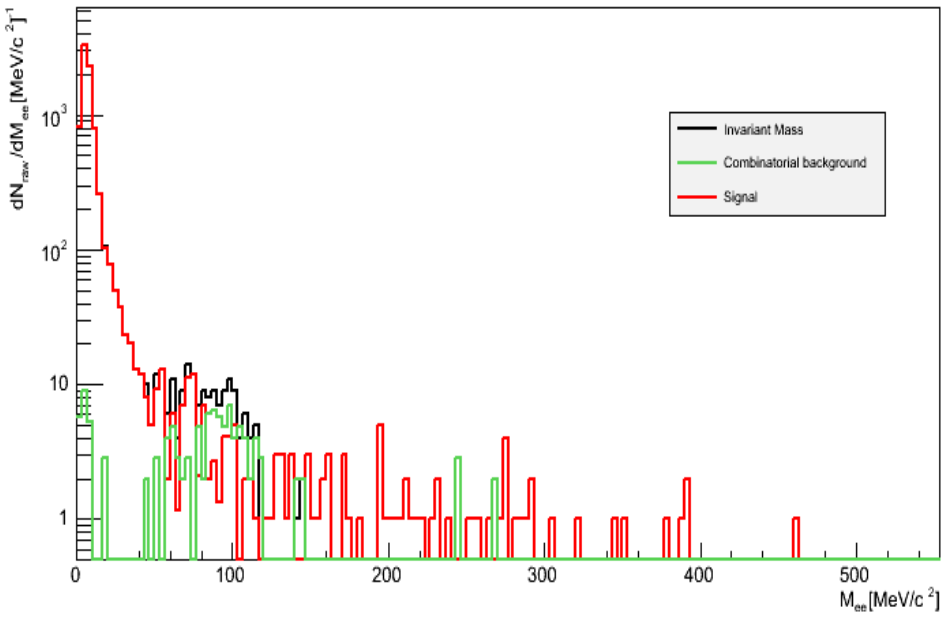


Signal=InvM-CB

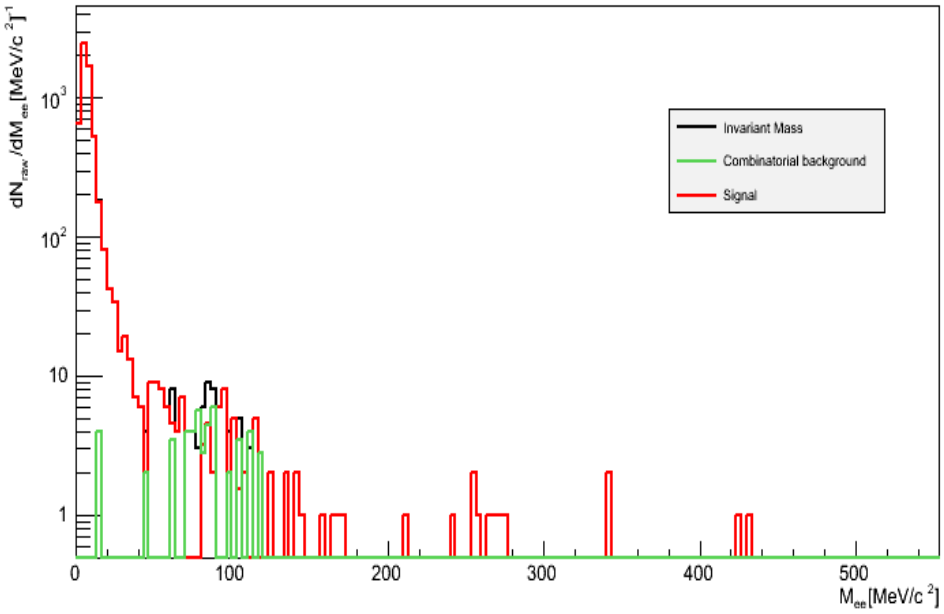
PE748



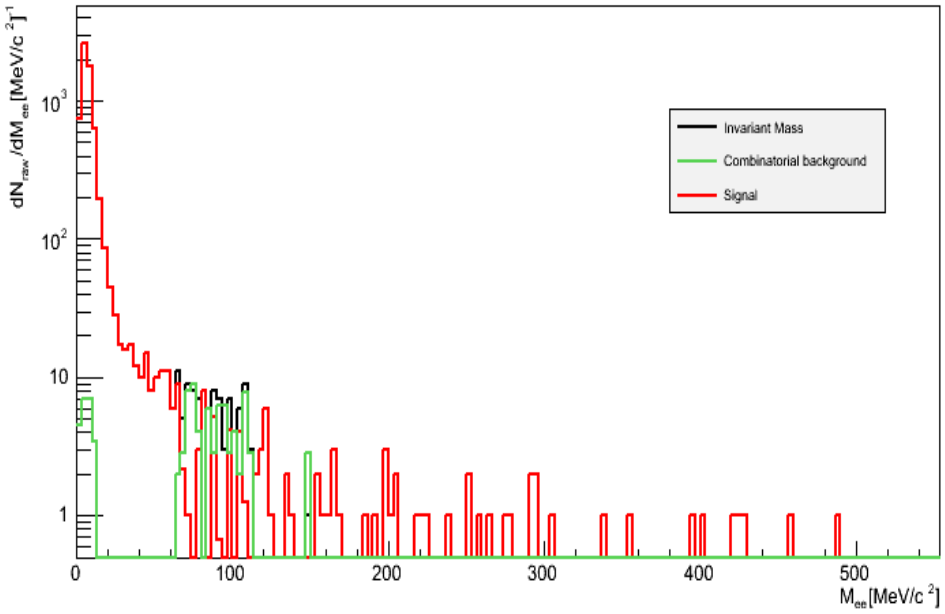
PE800



C748



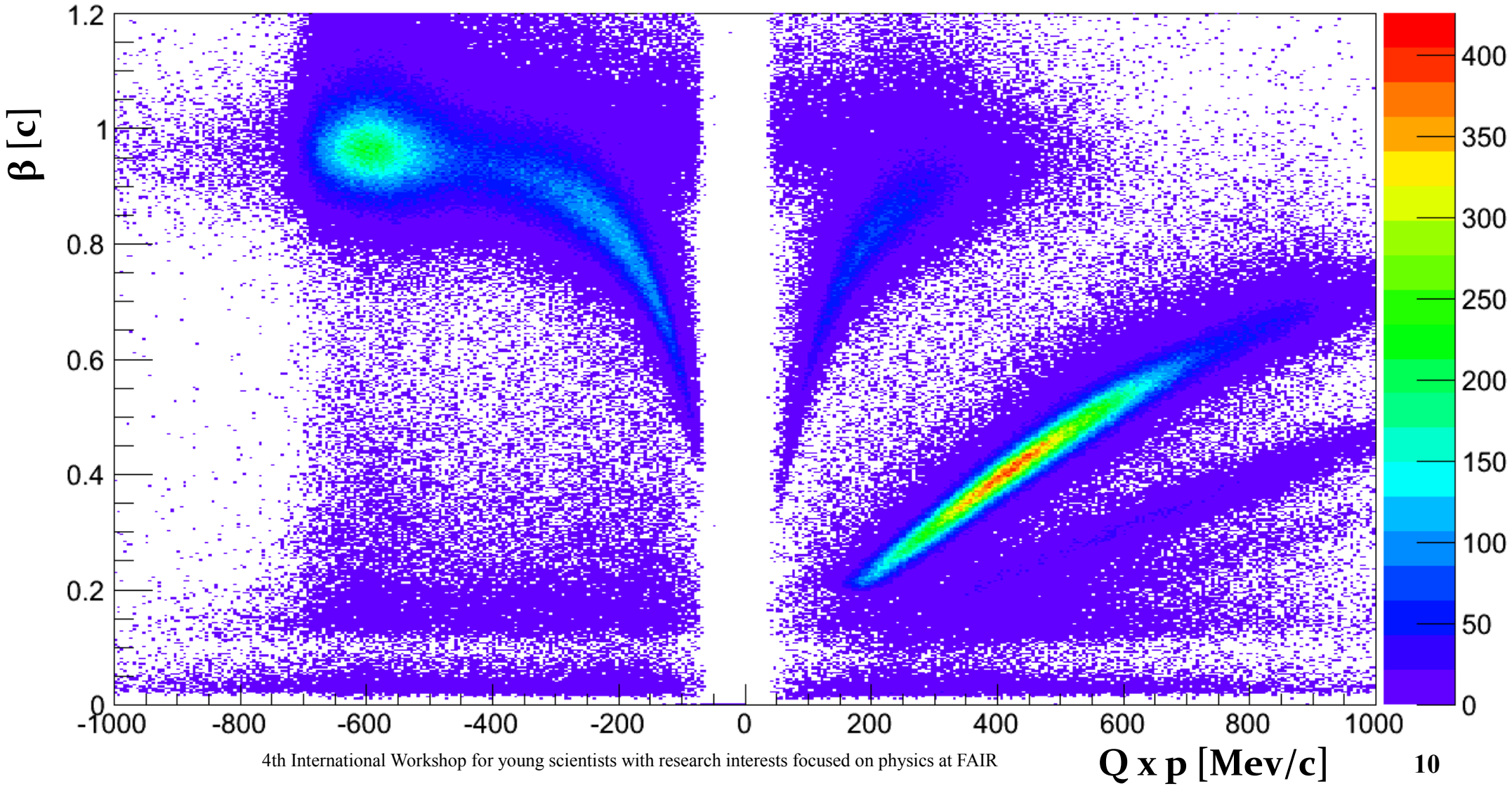
C800



Selection of events - Elastic Scattering

From BETA vs MOMENTUM·CHARGE

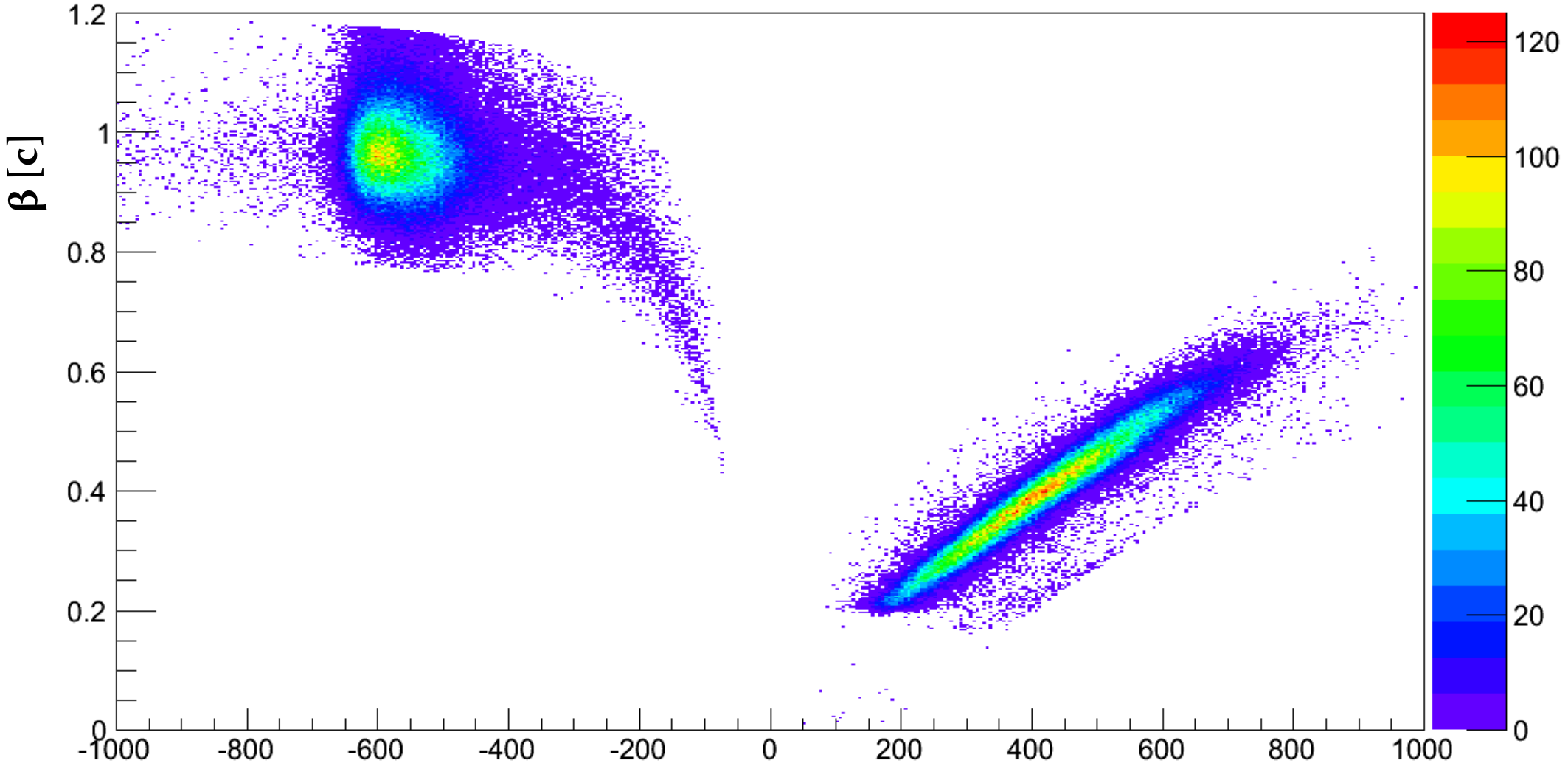
PE - 690 MeV/c



Selection of events - Elastic Scattering

- To see pure πp in PE target -> CUT Δφ = 180 ± 5

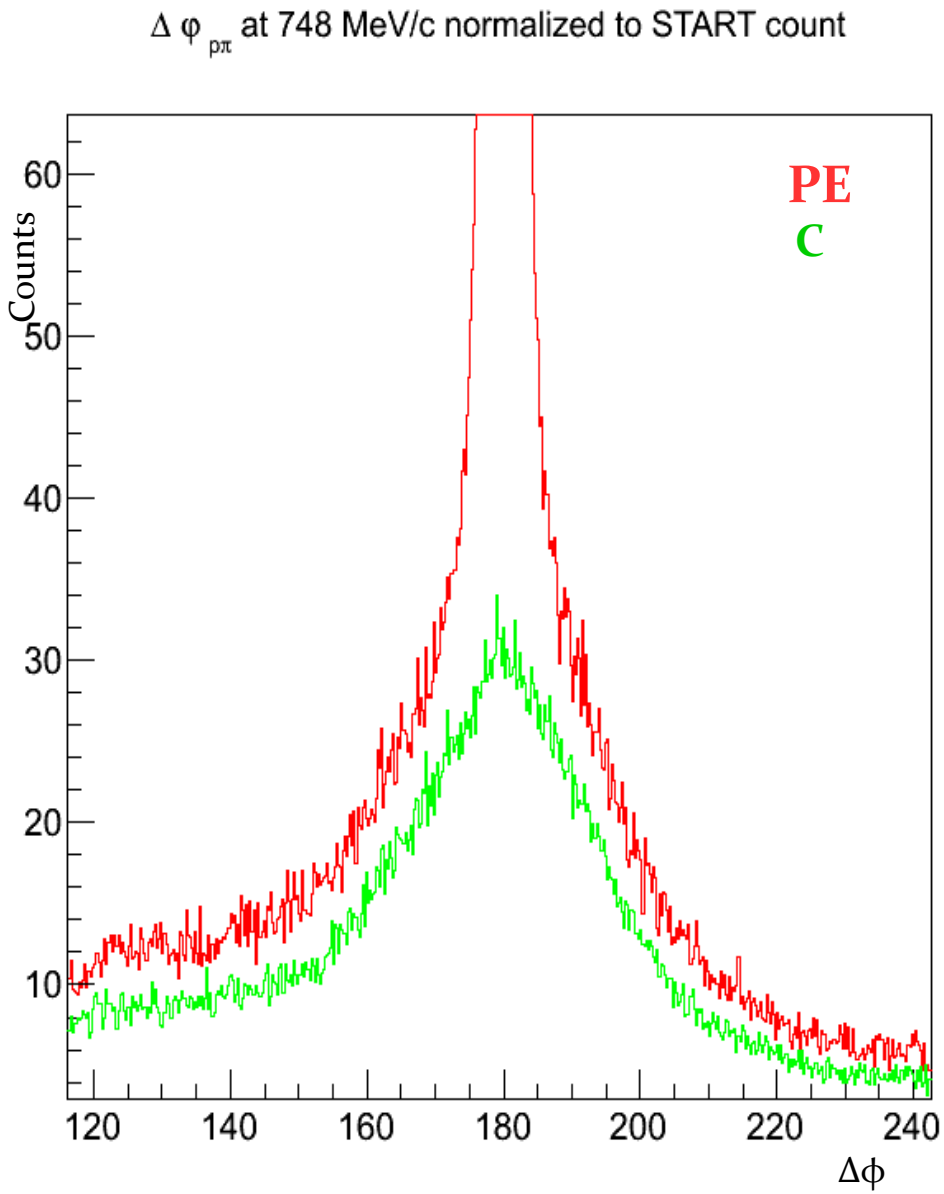
PE - 690 MeV/c

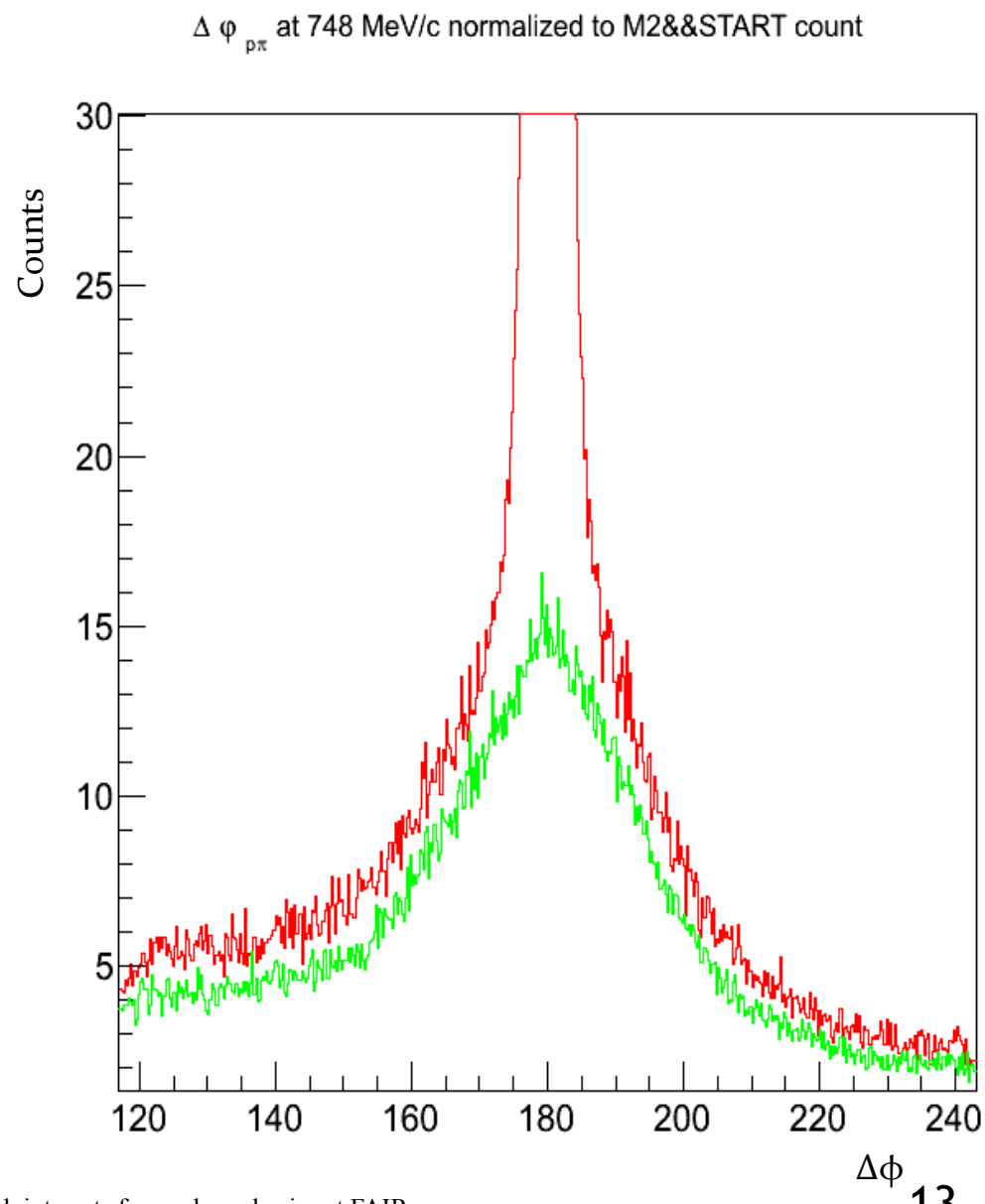


Contribution

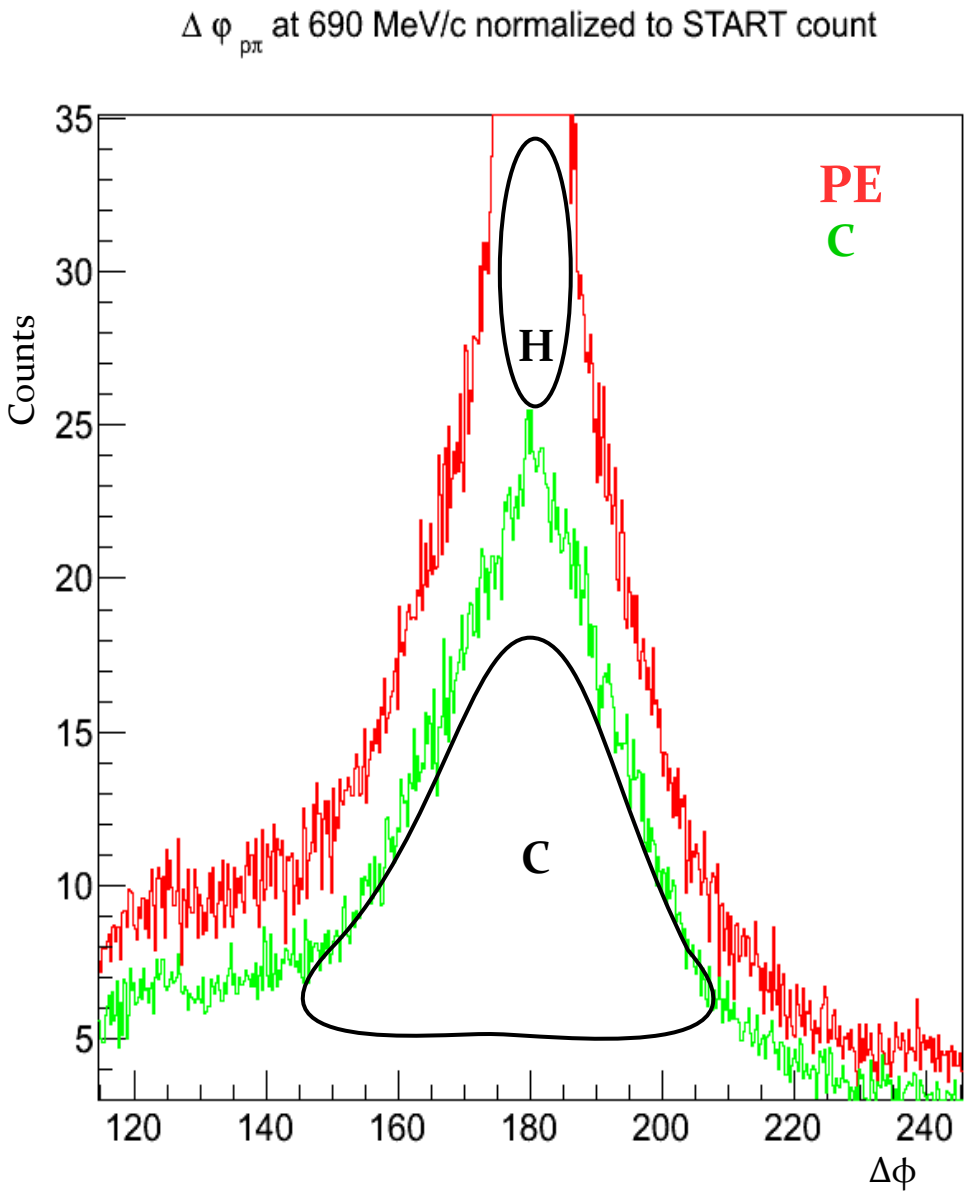
	n.Entries		START		M2&&START rate		M2&&START	
Beam Momenta (MeV/c)	PE	C	PE	C	PE	C	PE	C
800	52637463	42061978	3004436480	2504574464	69555720	56015344	52600968	42053336
748	76859353	41824953	4525079040	2608105984	99980168	53377880	76808144	41803456
690	778034316	116156584	47117643776	6430992896	1012665344	134040848	776825344	111829512
656	42589510	42054822	2914860032	3056054784	50607176	48930056	42544324	42095636
612		47927732		3632302080		54543588		47762352
M<120 Mev	Signal		Invariant_Mass		CB		error of Signal	
Beam Momenta (MeV/c)	PE	C	PE	C	PE	C	PE	C
800	7849	6219	7951	6307	102	88	89,738509	79,9687439
748	11770	5767,5	11911	5816	141	48,5	109,781601	76,5800235
690	96786	15455	98258	15698	1472	243	315,80057	126,257673
656	6625	5661	6694	5718	69	57	82,2374611	75,9934208
612		5530		5595		65		75,2329715
M>120 Mev	Signal		Invariant_Mass		CB		error of Signal	
Beam Momenta (MeV/c)	PE	C	PE	C	PE	C	PE	C
800	63	50	71	52	8	2	8,88819442	7,34846923
748	84	24	90	24	6	0	9,79795897	4,89897949
690	332	60	523	72	191	12	26,7207784	9,16515139
656	34	27	36	31	2	4	6,164414	5,91607978
612		22		22		0		4,69041576

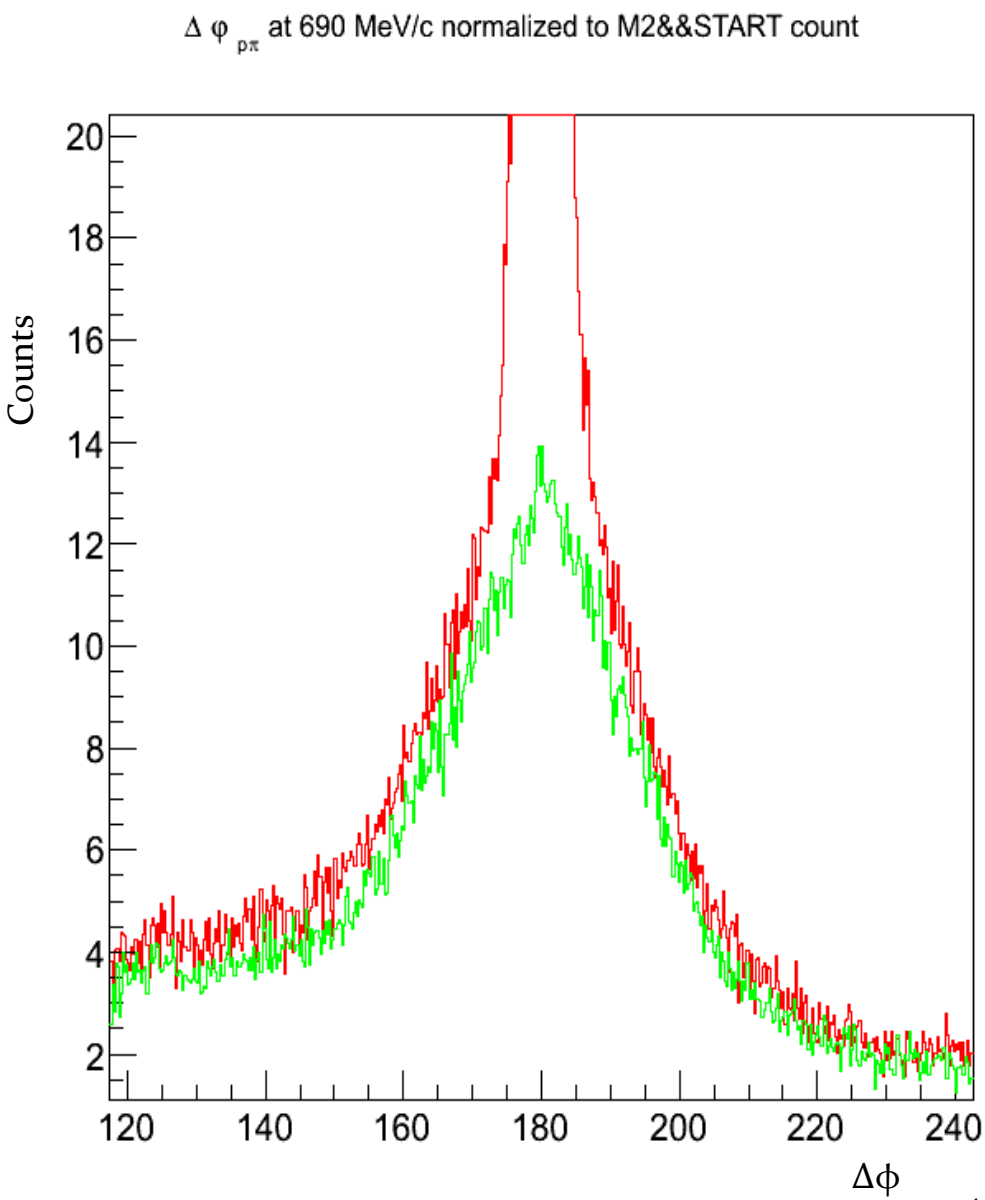
Δϕ spectra to compare normalization





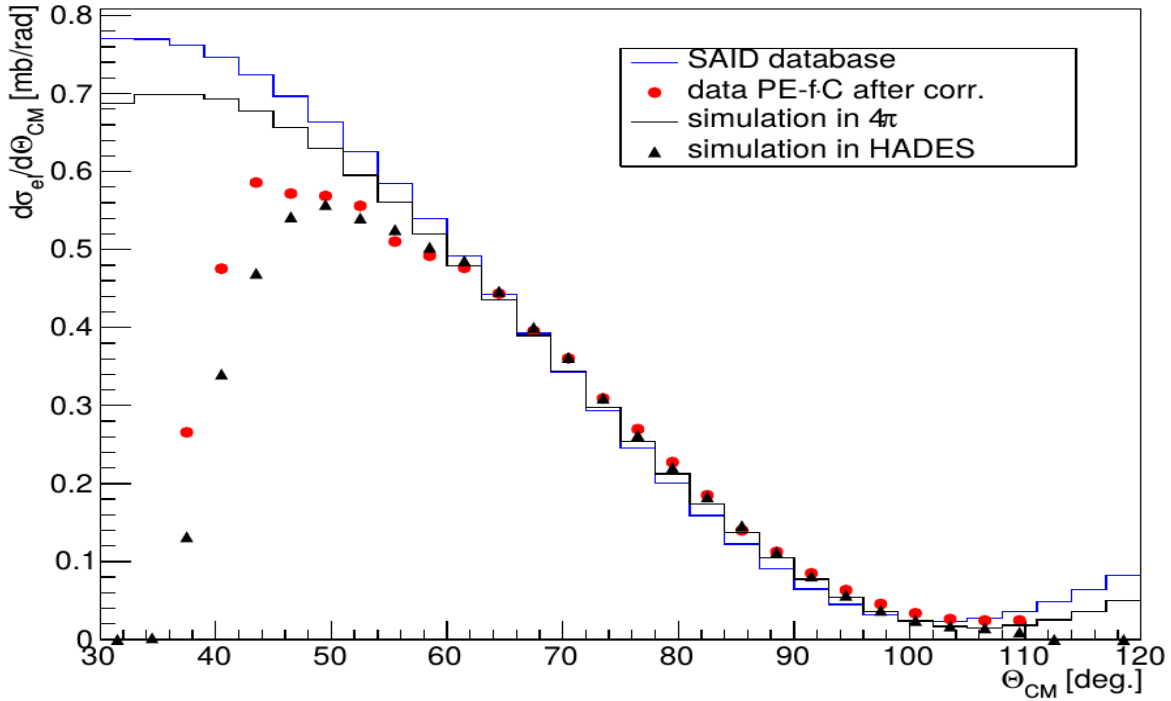
Δϕ spectra to compare normalization





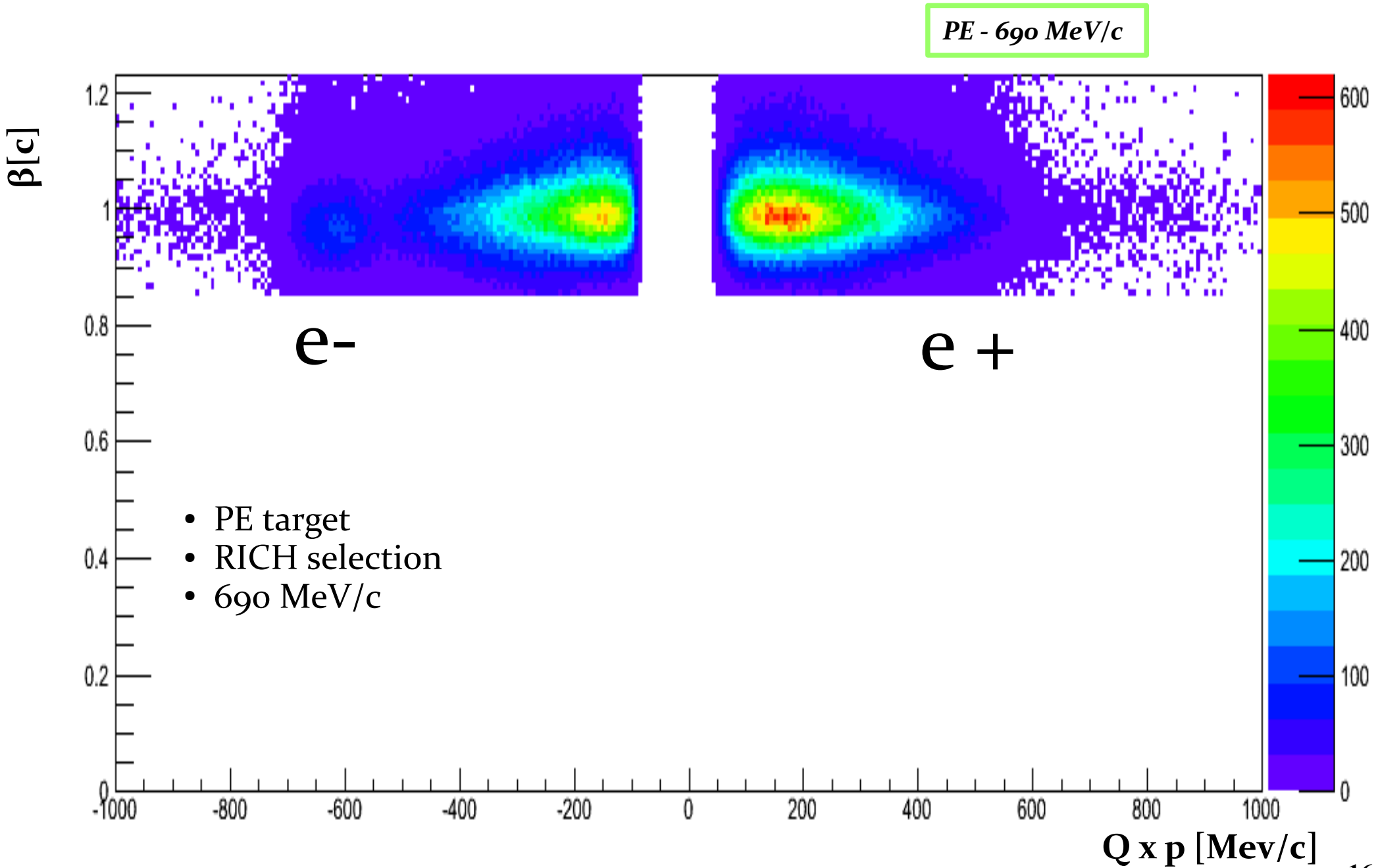
Normalization Factor

P [MeV/c]	N_{ev}(PE)·10^6	N_{beam}·10^9 corrected for dead time	N_{START}·10^9 scalers	Dead time [%]	N_{el}(61-109)^{corr}·106	σ(61-109) [mb]	$σ/N_{el}$ ·10^{-7}
656	42,64	2,13	2,95	16	2,15	2,99	13,97
690	776,82	36,59	47,11	23	34,86	3,077	0,88
748	76,90	3,67	4,52	23	3,45	3,055	8,85
800	52,66	2,46	3,04	24	1,92	2,57	13,38

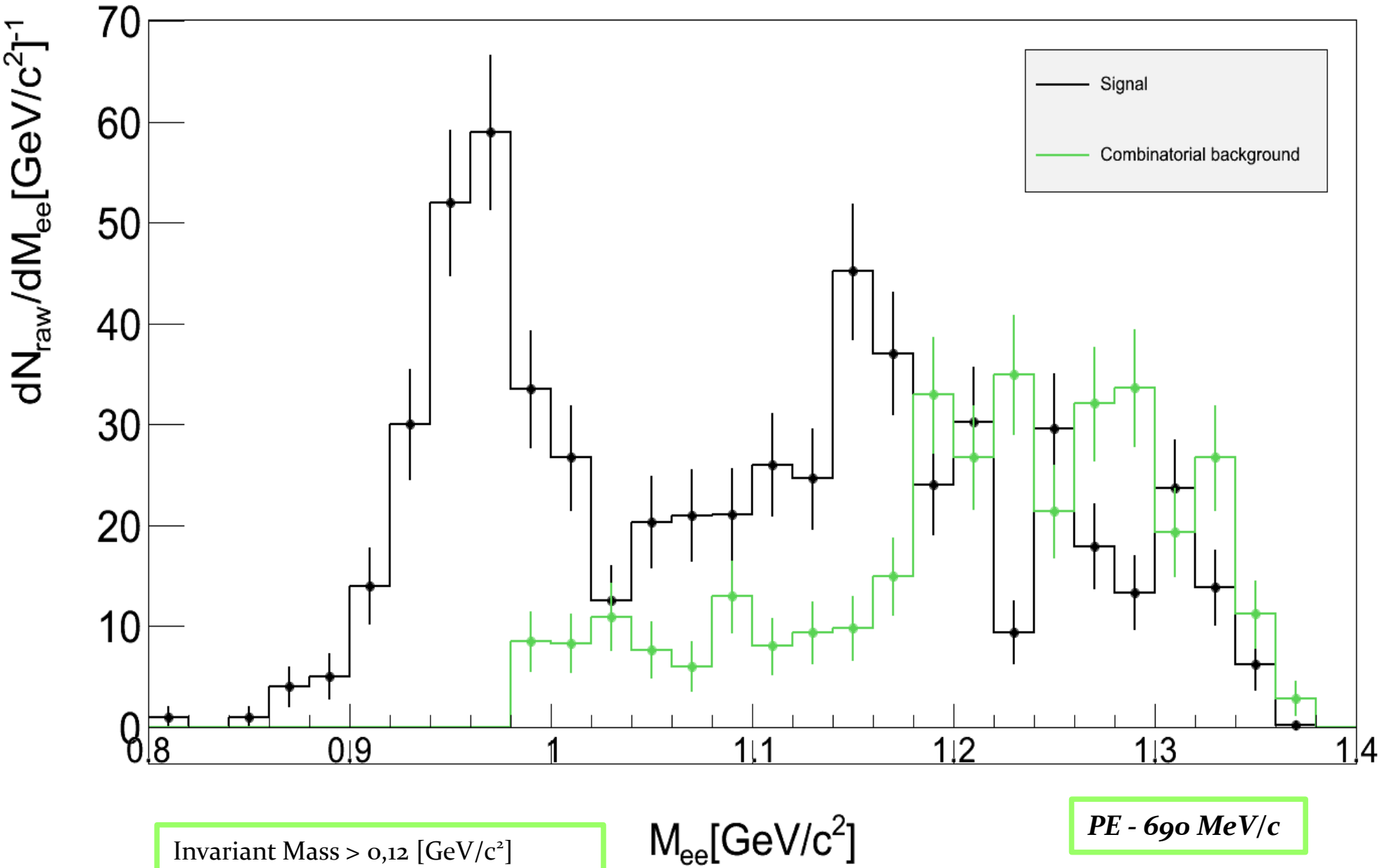


$$F=\sigma/N_{ES}$$

Particle identification



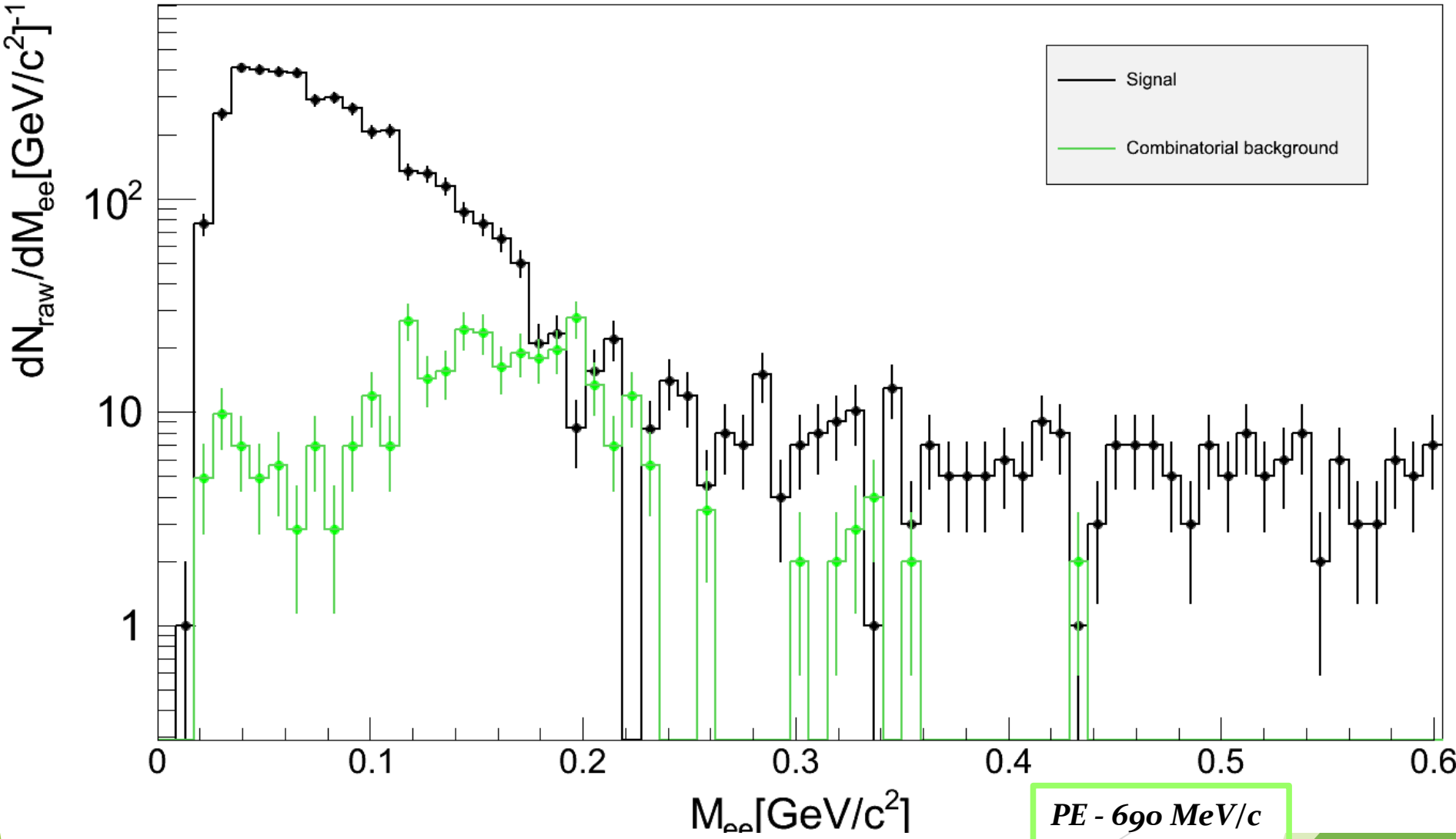
Exclusive missing mass e+e- Signal-CB



Invariant Mass > 0,12 [GeV/c²]
Neutron peak around 0,95 [GeV/c²]

PE - 690 MeV/c

Exclusive invariant mass e+e- Signal-CB

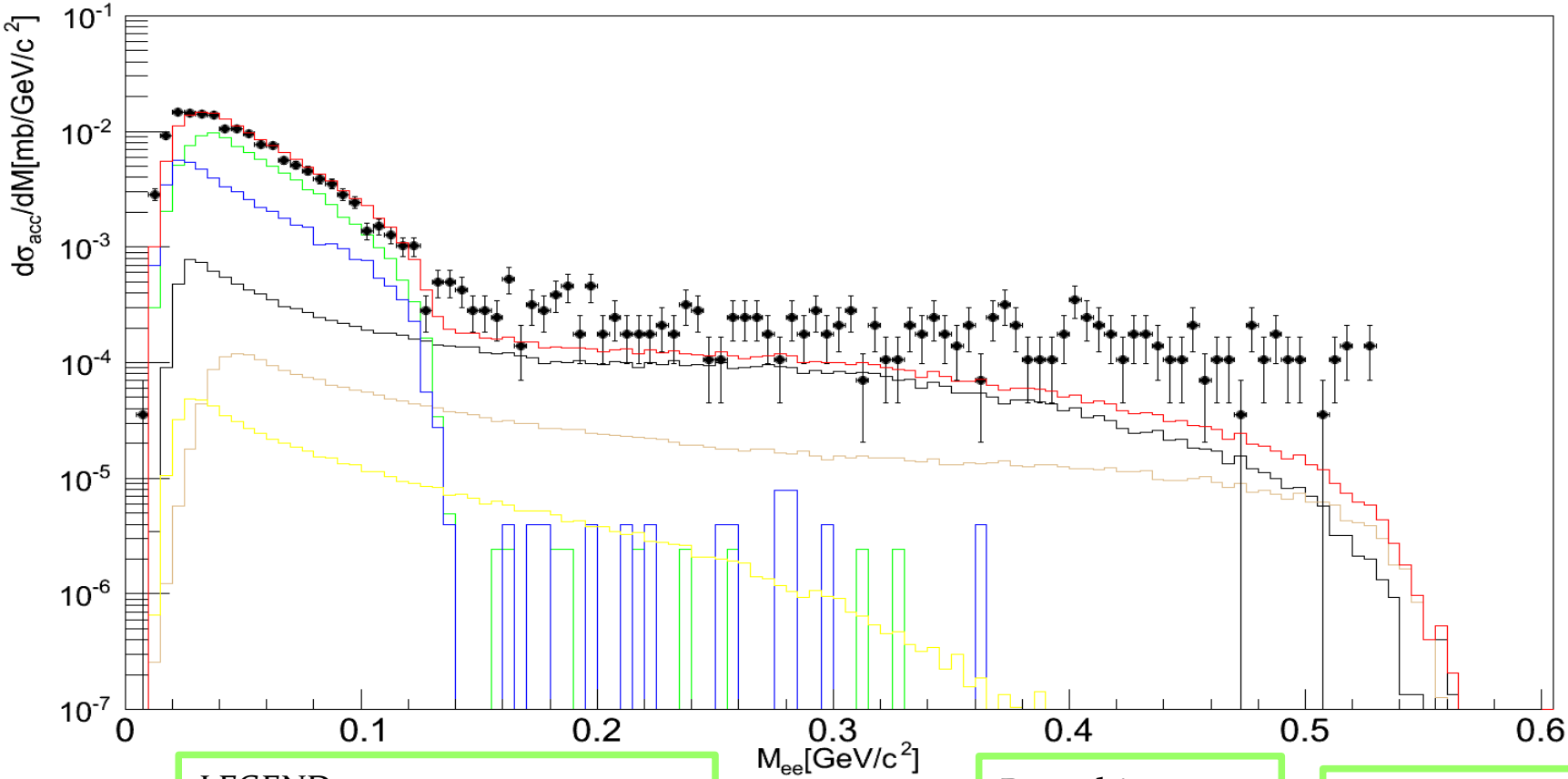


PE - 690 MeV/c

Cocktail sources

Channel	σ [mb]	Data source	model
$\pi^- + p \rightarrow n\pi^\circ$ (π°Dalitz)	9.2	Landolt-Bornstain (LB) constant (±1 mb) for p ∈ (0.6-0.72)	45% N(1520),45%N(1440),10 % N(1535)
$\pi^-+p \rightarrow n\ \pi^\circ\pi^\circ$ $\pi^-+p \rightarrow p\ \pi^-\pi^\circ$ (single π°Dalitz)	2 x 1.8 3.72 ~ 7.4 tot	Crystall Ball L-B (for √s=1.461 20% reduction)	$\Delta\pi \rightarrow (N\pi)\ \pi^\circ$ $\rightarrow (N\pi)e+e-\gamma$
$\pi^-+ p \rightarrow \Delta\pi$ $\rightarrow Ne+e-\pi$	8.4	From single and double pion -isospin relation	$\Delta^\circ\pi^\circ \rightarrow ne+e-\pi^\circ$
$\pi^-p \rightarrow N(1520)^\circ$ $\rightarrow ne+e-$ Dalitz decay	20.5	From single and double pion -isospin relation	Wolf/Zetenyi „QED" model With BR=4.0e-5
$\pi^-+ p \rightarrow n\ \eta$ (π° Dalitz)	0.3 (p) 0.7 (C)	Parametrizatio n from L-B	

Inclusive invariant mass distribution



LEGEND
- total
- [9,2 mb] $\pi^\circ \rightarrow e^+e^-\gamma$
- [7,4 mb] $2*\pi^\circ(\rightarrow e^+e^-\gamma)$
- [1,0 mb] $\eta \rightarrow e+e-\gamma$
- [20,5 mb] $N(1520) \rightarrow n\, e^+e^-$
- [8,4 mb] $\Delta(1232) \rightarrow ne^+e^-$

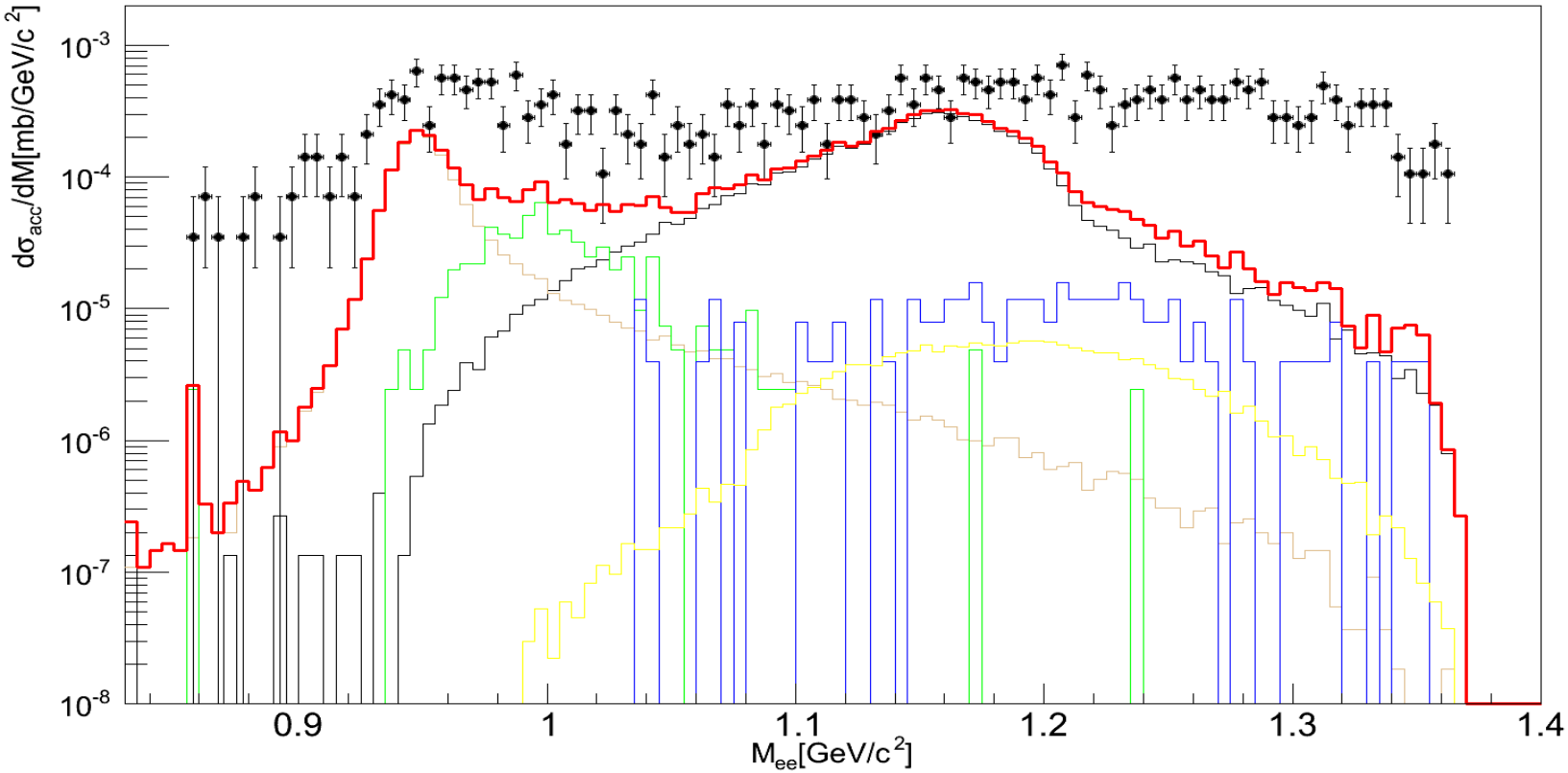
Branching Ratios
π°: 0,012
η: 0,006
N(1520): $4\cdot10^{-5}$
$\Delta(1232)$: $4\cdot10^{-5}$

PE - 690 MeV/c

Dilepton cocktail

***PLUTO** event generator + (acc*eff) filters, include realistic momentum distribution of nucleons in carbon*

Inclusive missing mass distribution

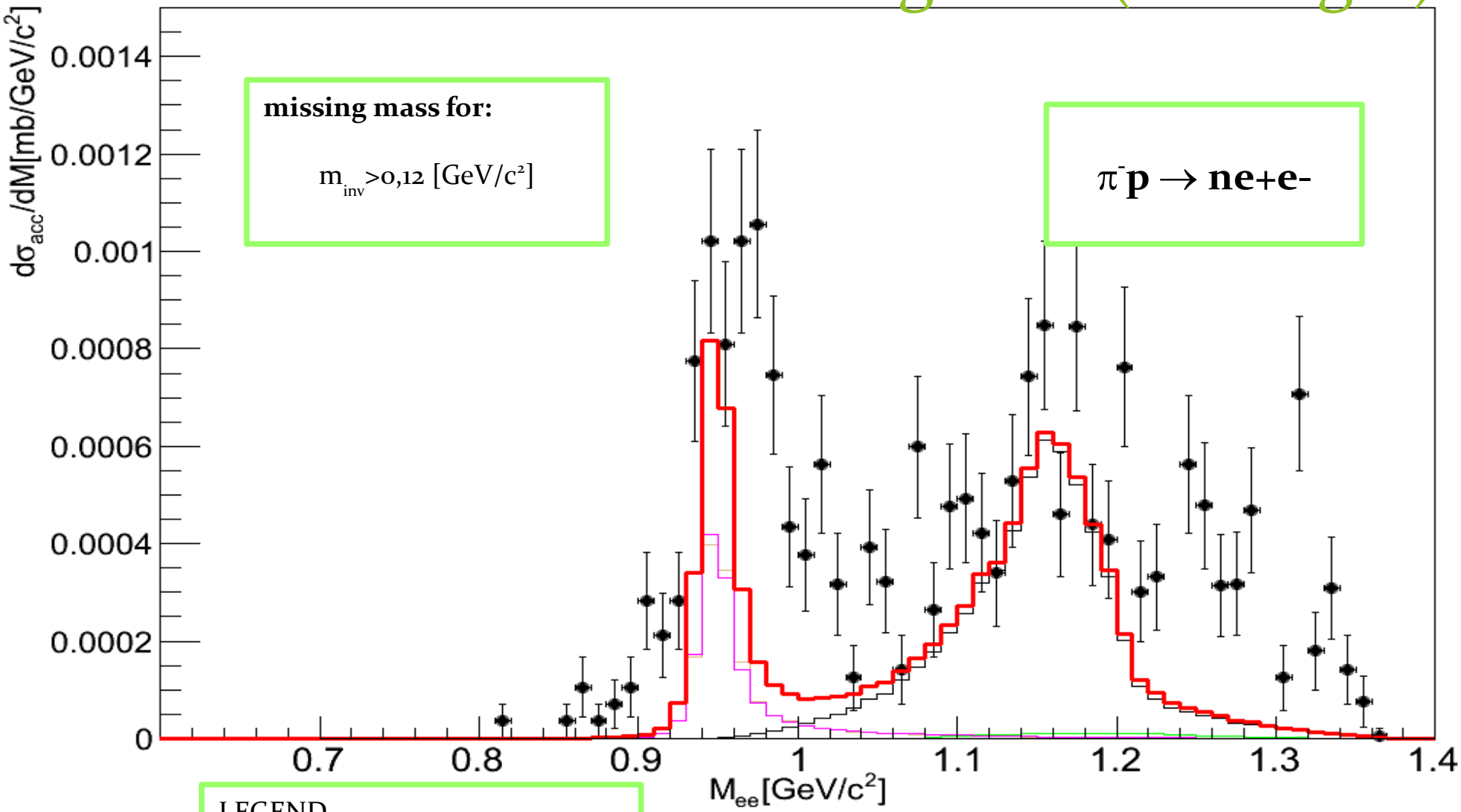


LEGEND
- total
- [9,2 mb] $\pi^\circ \rightarrow e^+e^-\gamma$
- [7,4 mb] $2*\pi^\circ(\rightarrow e^+e^-\gamma)$
- [1,0 mb] $\eta \rightarrow e+e-\gamma$
- [20,5 mb] $N(1520) \rightarrow n\, e^+e^-$
- [8,4 mb] $\Delta(1232) \rightarrow ne^+e^-$

Branching Ratios
π°: 0,012
η: 0,006
$N(1520)$: $4 \cdot 10^{-5}$
$\Delta(1232)$: $4 \cdot 10^{-5}$

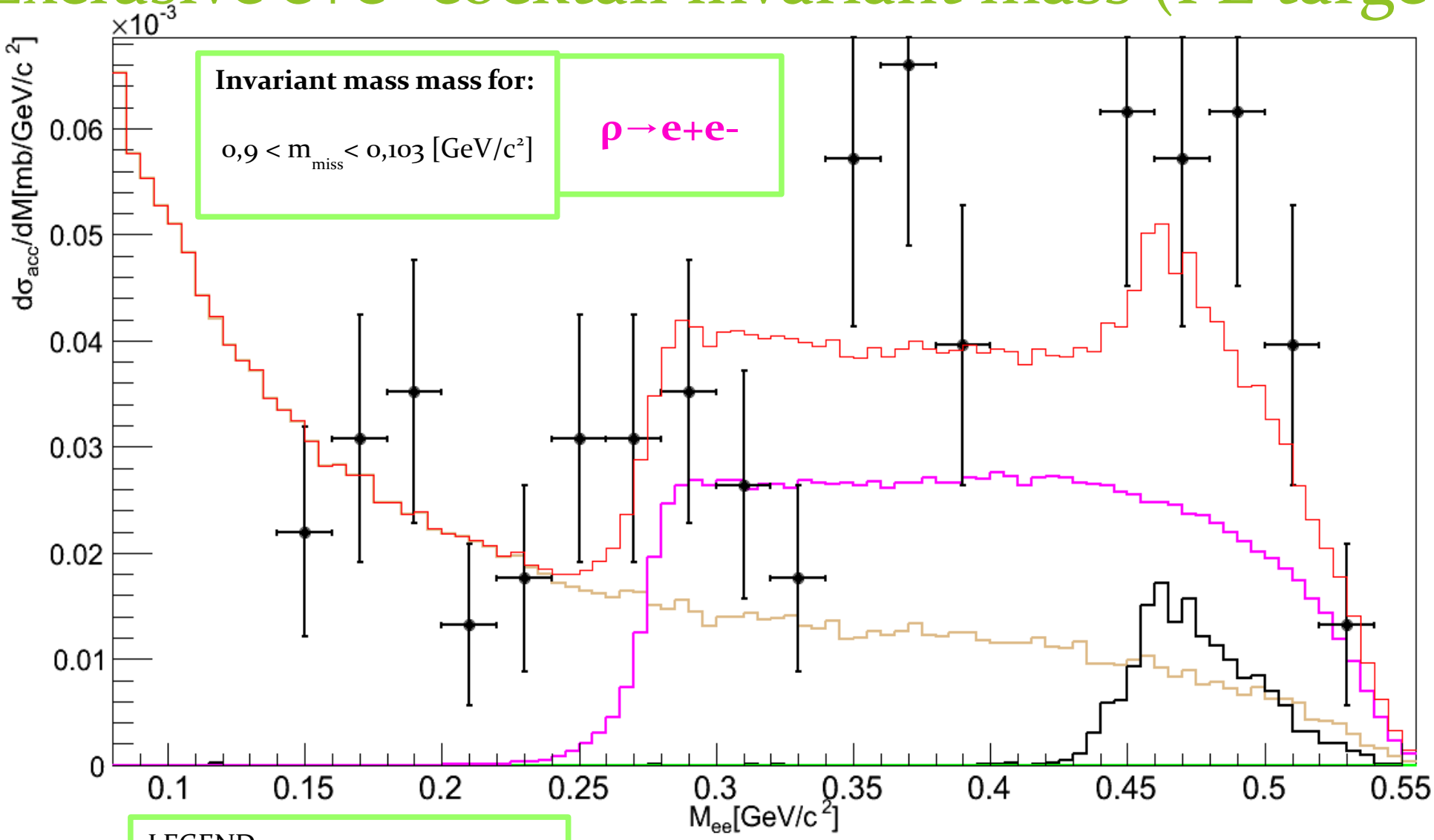
PE - 690 MeV/c

Exclusive e+e- cocktail missing mass(PE target)



PE - 690 MeV/c

Exclusive e+e- cocktail invariant mass (PE target)



PE - 690 MeV/c

Summary

- Discrepancy between data and simulation to be understood.
- Further investigations are necessary.
- Improvements with “backtracking” and “to reconstruction” methods upcoming

Thanks for your attention


backup

How to obtain pure hydrogen

- **Scaling data by number of pions**

$$\text{Signal\_scaled} = \frac{(InvM - CB)}{Livetime}$$

$$\frac{Signal\_scale}{START} \qquad Livetime = \frac{M2\&\&START}{M2\&\&START\_rate}$$

- **Subtracting hydrogen from PE**

Properties of targets	diameter [cm]	length [cm]	M [g/mol]	density [g/cm3]	Number of carbon atoms
PE = (C2H4)	1,2	4,6	28	0,93	18,4·1022
C	1,2	2,52	12	1,85	23,4·1022

$$\boldsymbol{H = PE - f \cdot C}$$

$$\boldsymbol{f = \frac{PE}{C} = 0,78}$$

Witold Przygoda (HADES Collaboration)
Jagiellonian University in Kraków, Poland