High Precision Measurements of the Pion Proton Differential Cross Section.

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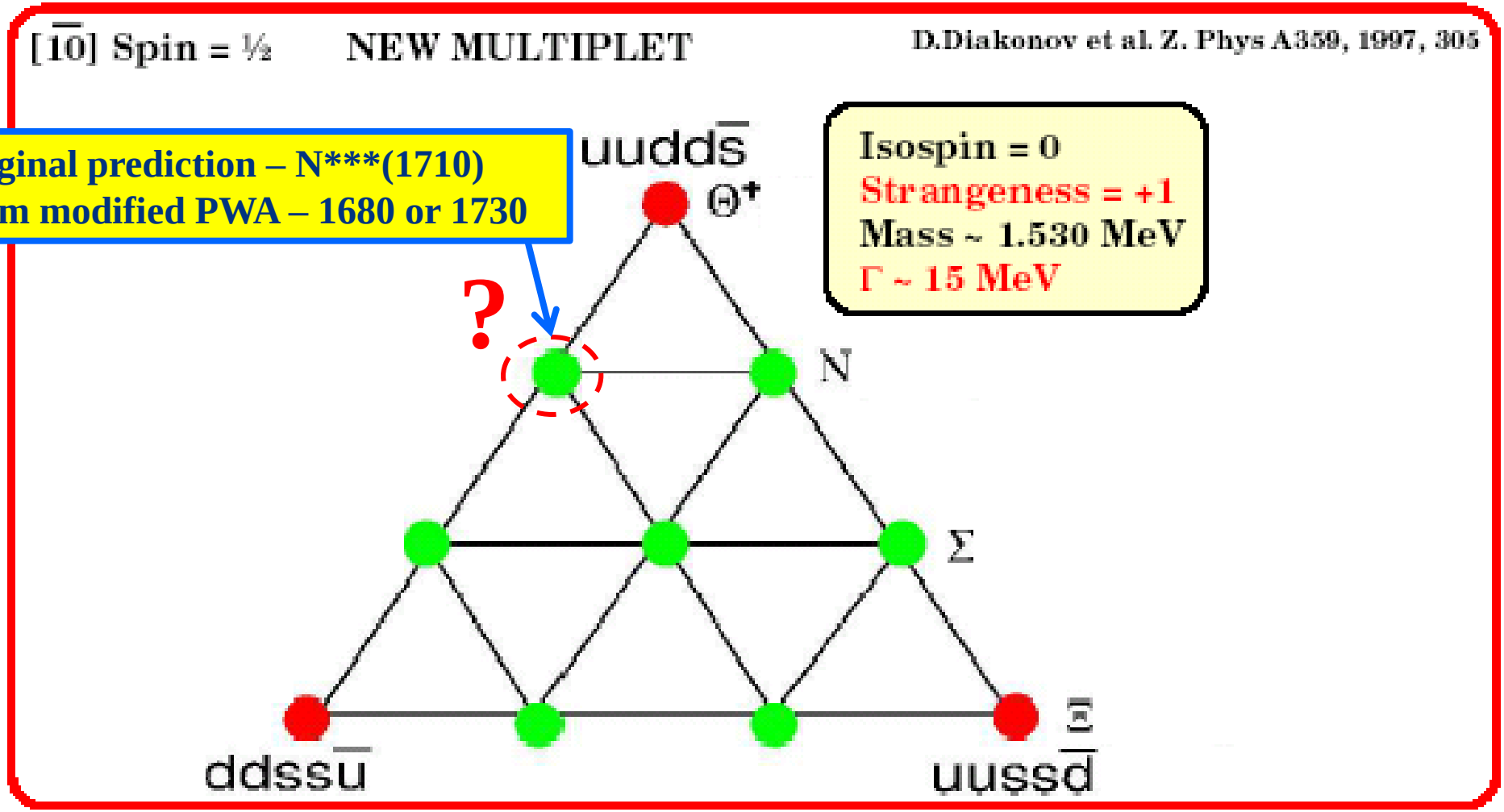
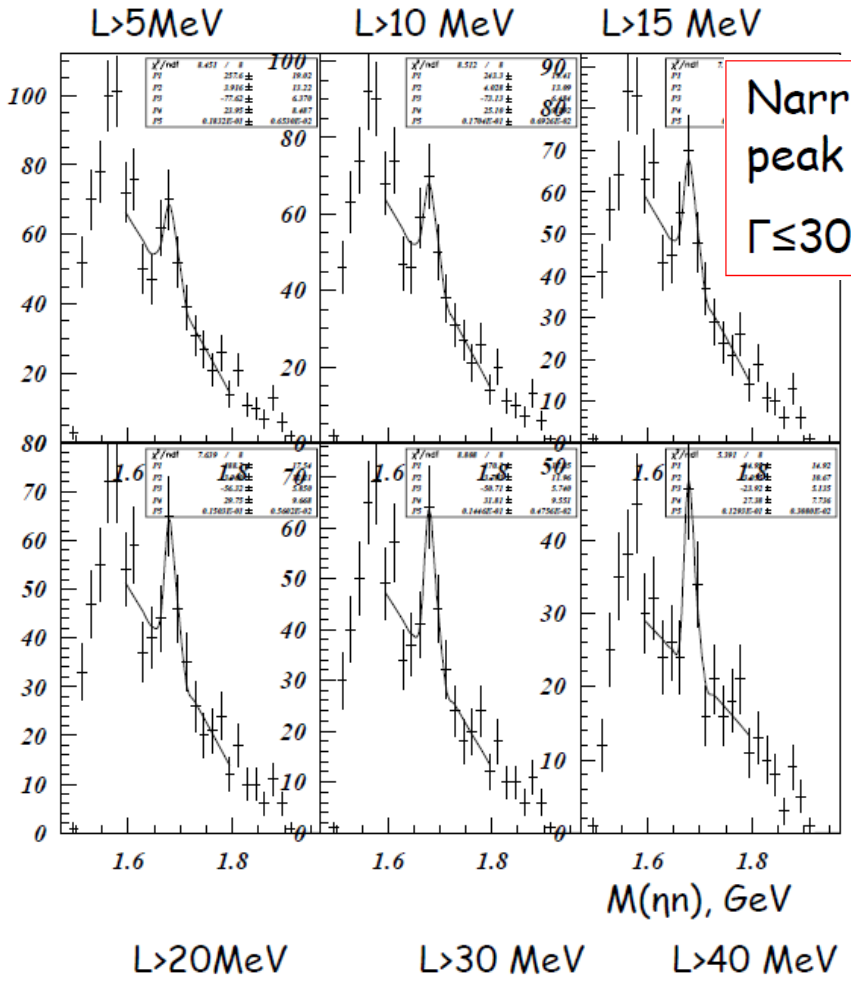
Pentaquark antidecuplet



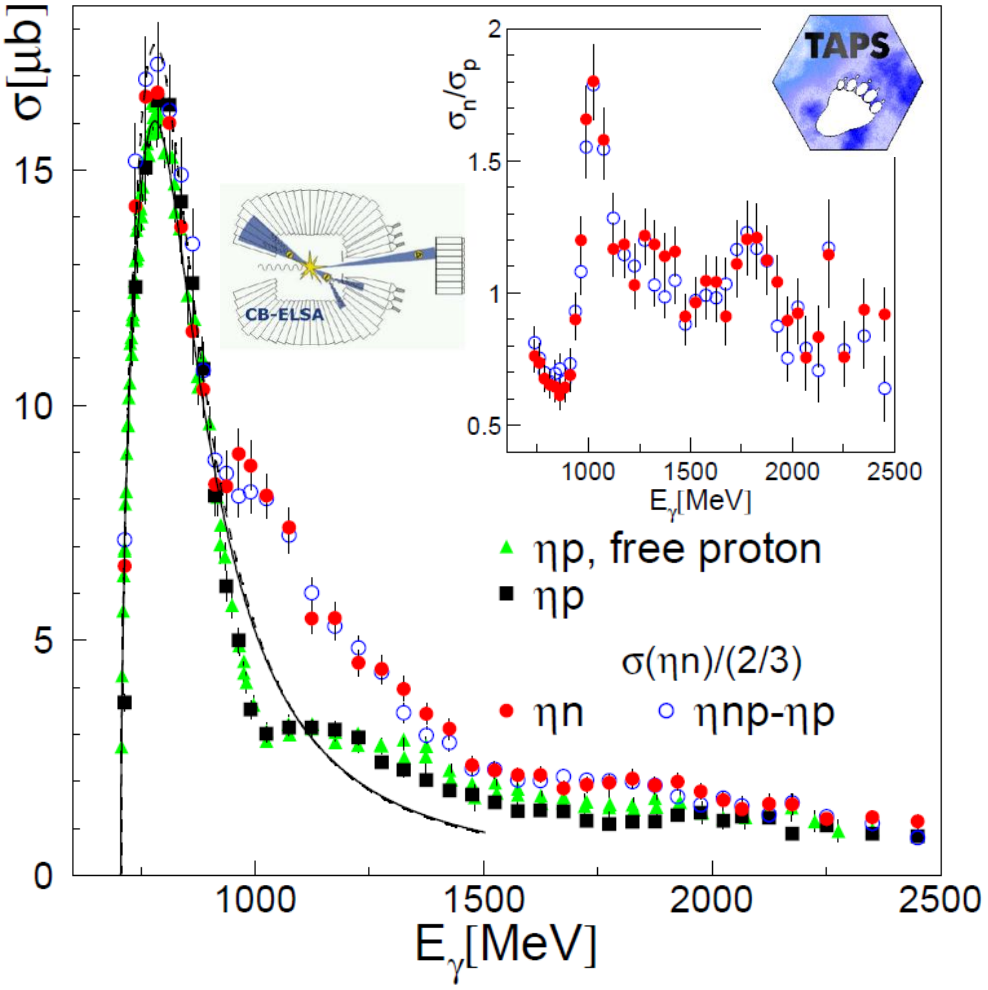
N(1685)

NNR'2009, Edinburg, June 8-10, 2009
http://2009physicsevents.org

η-photoproduction off **neutron**



GRAAL: V.Kuznetsov, NNR Workshop, June 8 - 10 2009, Edingburgh



B. Krusche, Narrow Nucleon Resonances, Edinburgh, June 2009

$\pi^- p \to \pi^- p$ and $\pi^- p \to K^0_S \Lambda$

What is special in our experiment:

- "Formation"–type experiment (s-channel).
- Extremely high invariant mass resolution (**~0.6 MeV**), provided by high momentum resolution of the magneto-optic channel **0.1%.**
- Magnetless spectrometer with drift chambers.
- Liquid hydrogen target.
- Very small amount of matter on the particle paths.
- High statistical precision: 0.5% for elastic scattering and 1% for KΛ-production.

Not only pentaquark…

- Precise cross section measurements:

$\pi^-p \to \pi^-p$: $d\sigma/d\Omega$ – **0.5%** statistical precision and **1 MeV** momentum step

$\pi^-p \to K^0\Lambda$: σ_{REAC} – **1%** statistical precision and the same step

$\Rightarrow$ Very important data for PWA

- Usual resonace P11 N(1710)***
- Λ-polarization in the reaction $\pi^-p \to K^0\Lambda$ - an order of magnitude better precision then the best data available now - NIMROD (78)

Setup for elastic scattering

⊙ Proportional chambers with 1mm pitch and 40 um aluminum foil potential electrode in the first focus (1FCH1-4) and in front of the target (2FCH1-4).

⊙ Liquid hydrogen target with beryllium outer shell and mylar hydrogen container. The target diameter is 40 mm and the length along the beam ~250 mm.

⊙ 8 modules of drift chambers with hexagonal structure to measure tracks of particles produced.

⊙ Trigger scintillation counters S1, S2, A1.

⊙ NMR system for measurement field in the magneto-optic channel dipoles with precision better 0.1%.

⊙ Triggers:

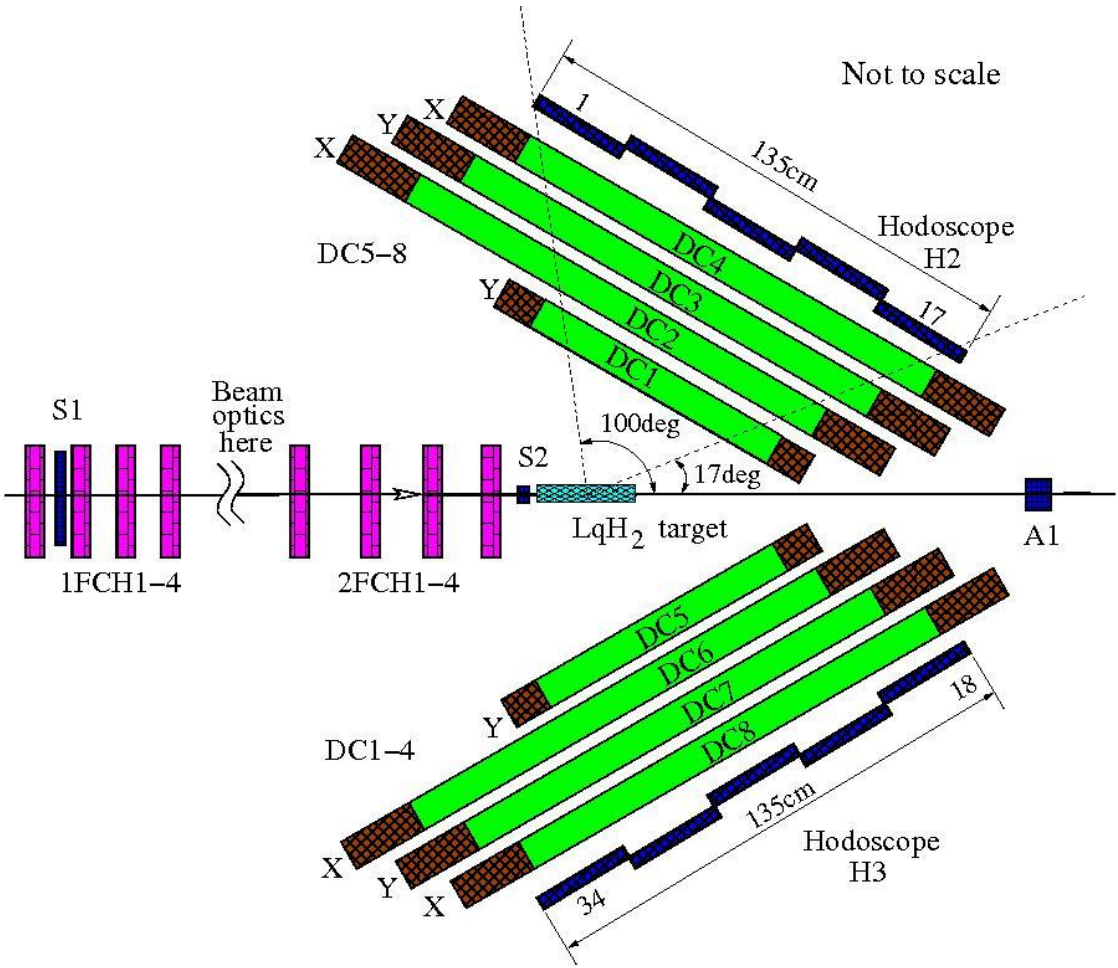
Main = S1·1FCH ·S2 ·2FCH ·(!A1)

With prescale:

Mom1F = S1·1FCH ·S2 ·2FCH

BeamPos = S1·1FCH·2FCH · A1

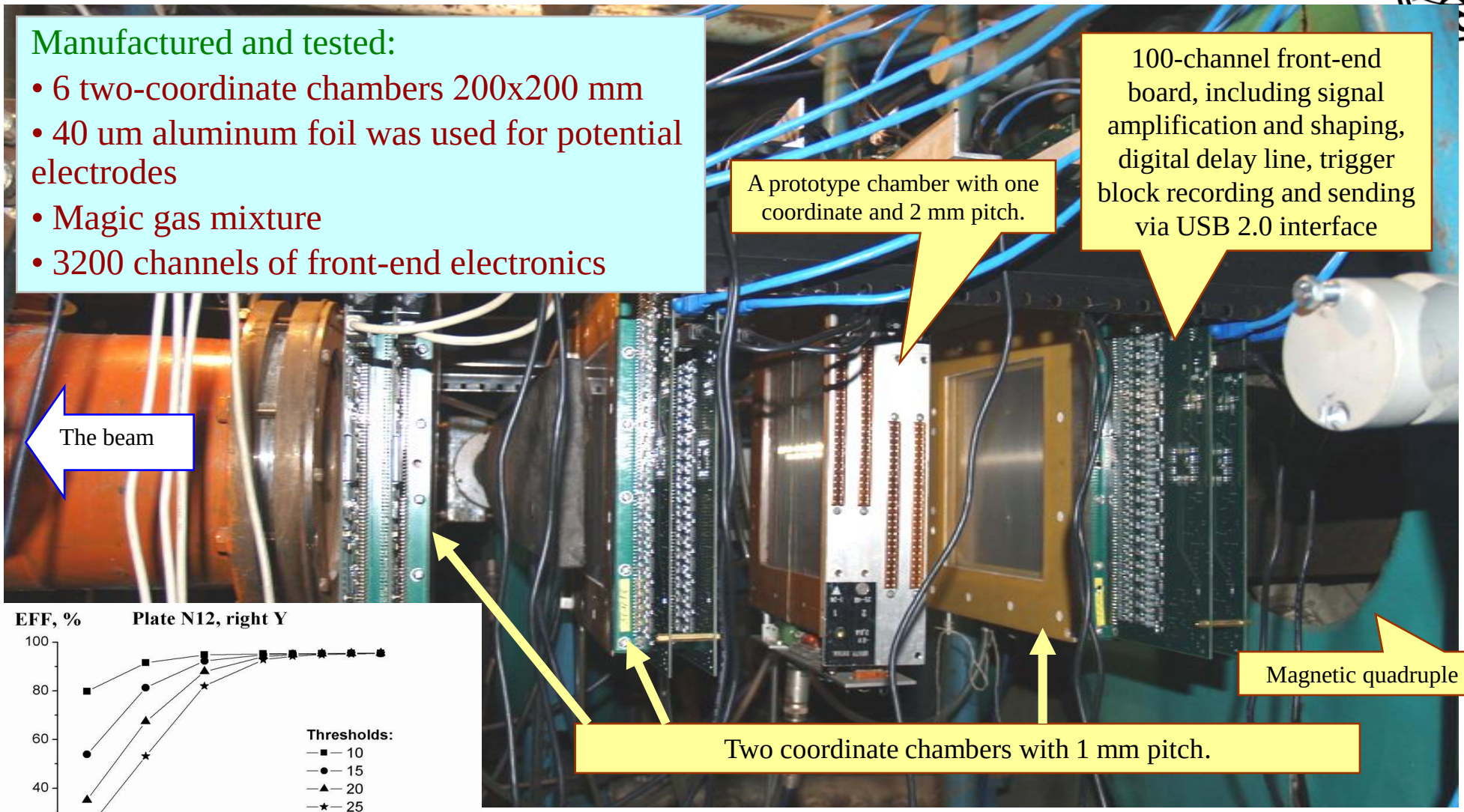
$\pi p \rightarrow \pi p$



Proportional chambers with 1 mm pitch

Manufactured and tested:

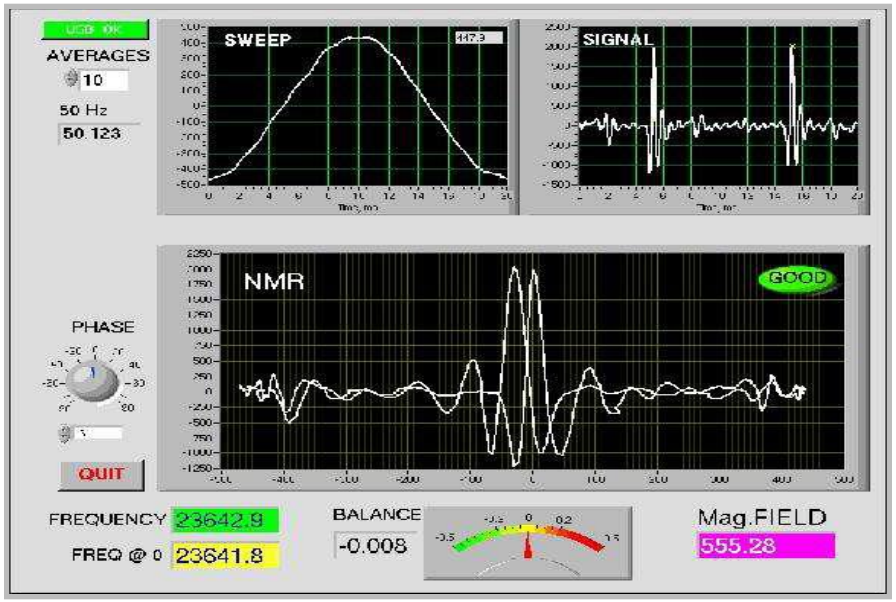
- 6 two-coordinate chambers 200x200 mm
- 40 um aluminum foil was used for potential electrodes
- Magic gas mixture
- 3200 channels of front-end electronics

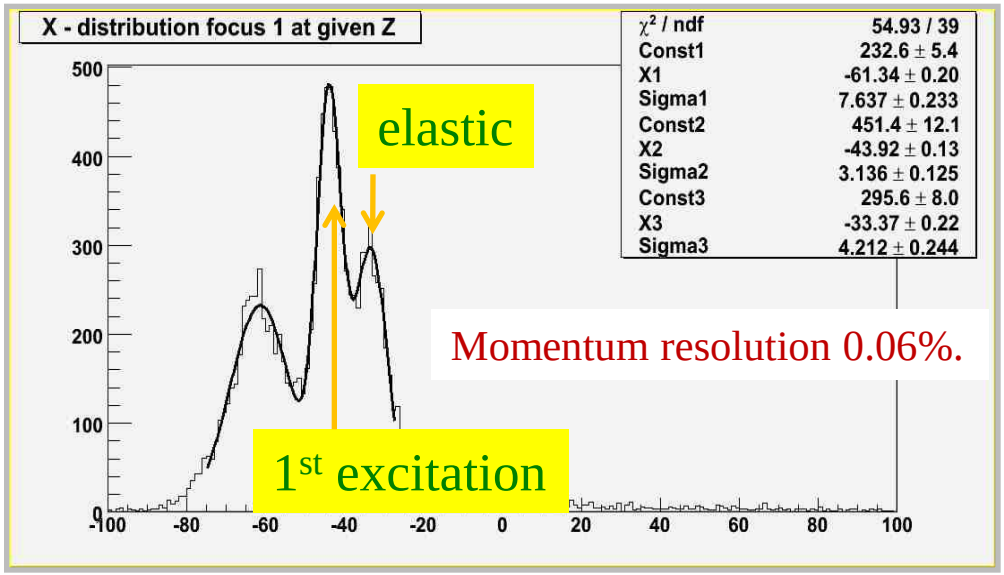


Test with β-source

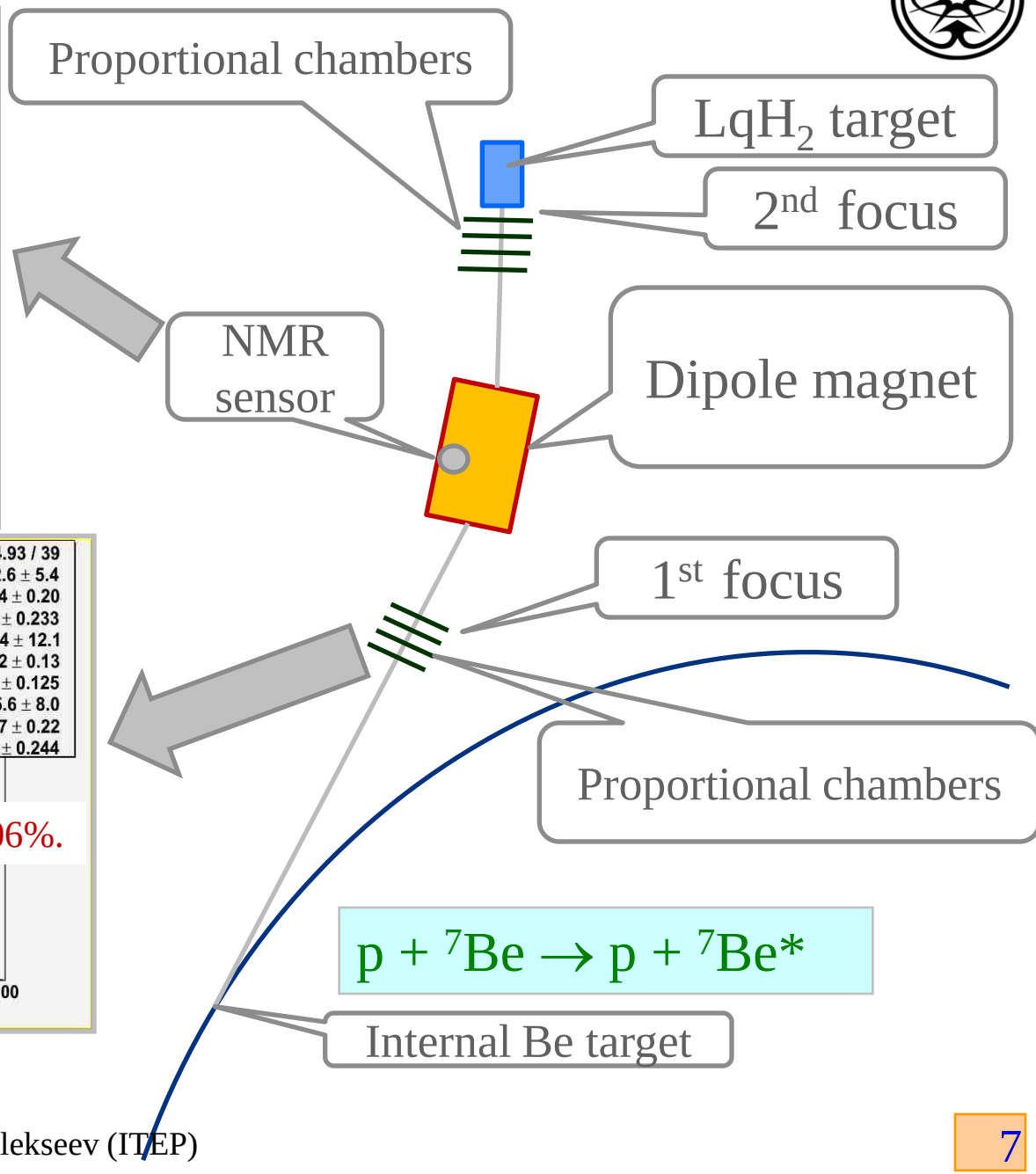
Proportional chambers in the first focus of the magneto-optic channel

Momentum calibration and resolution



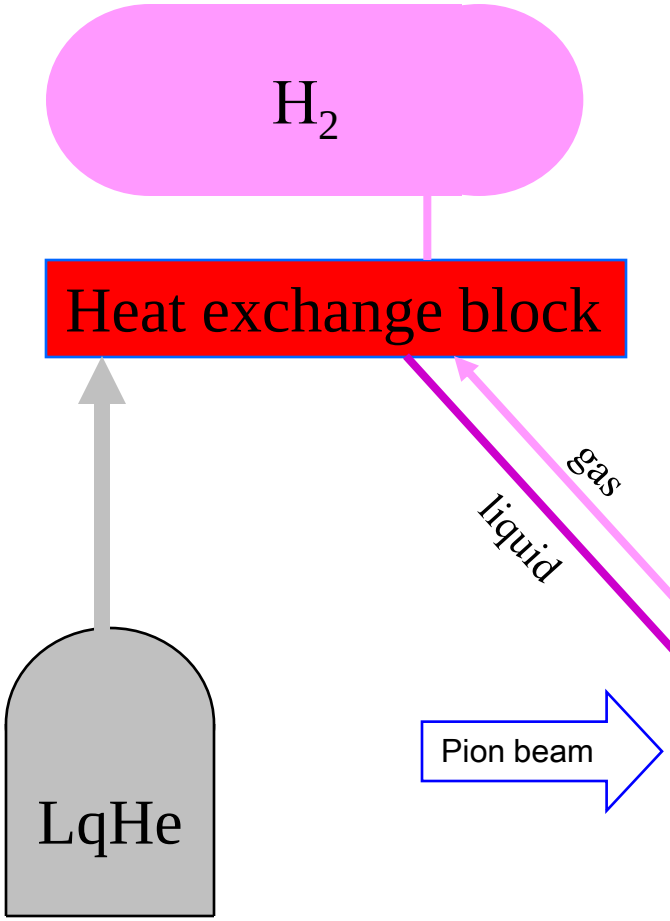


Calibration points 1.06, 1.20 and 1.30 GeV/c

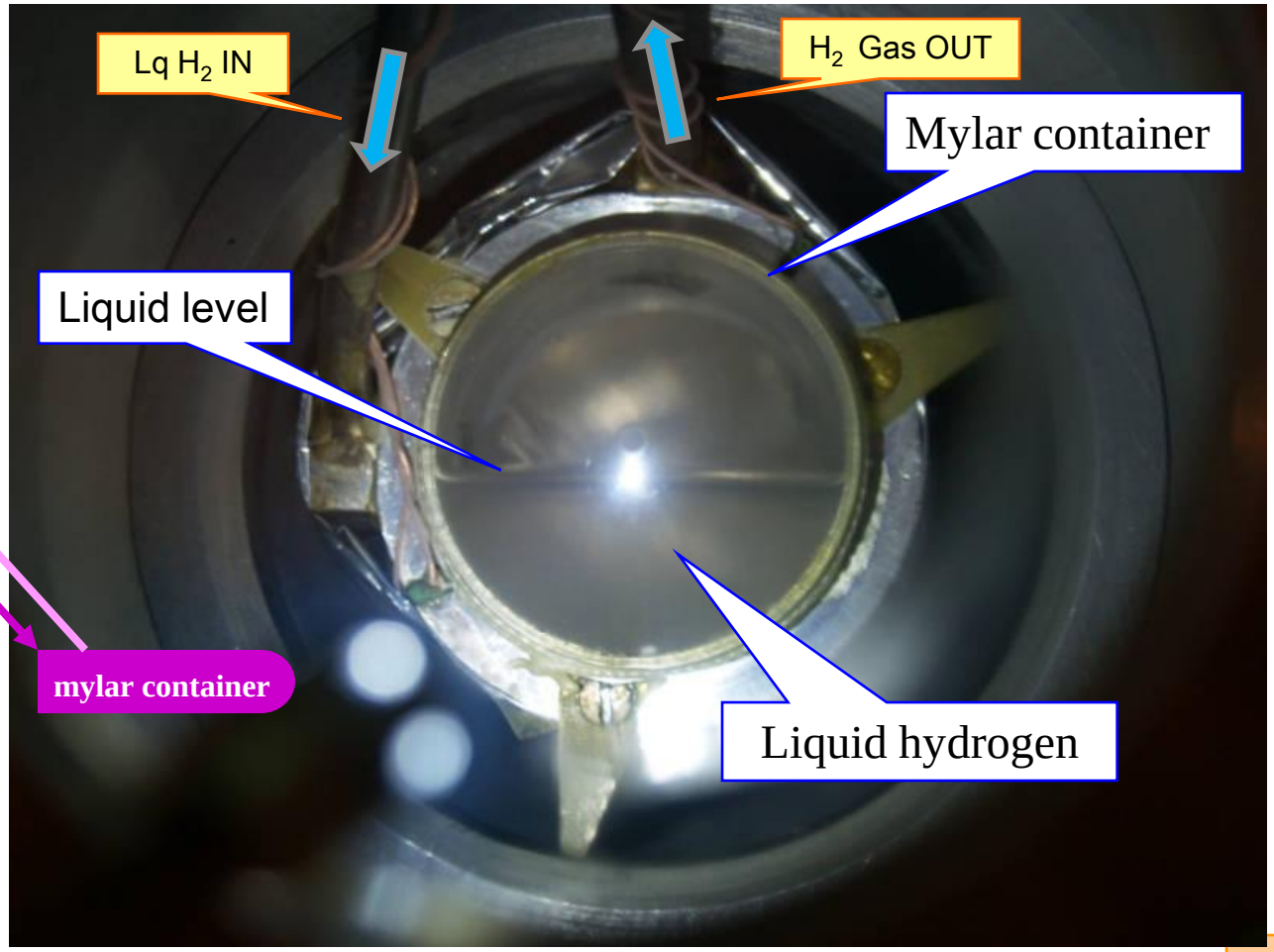


Liquid hydrogen target

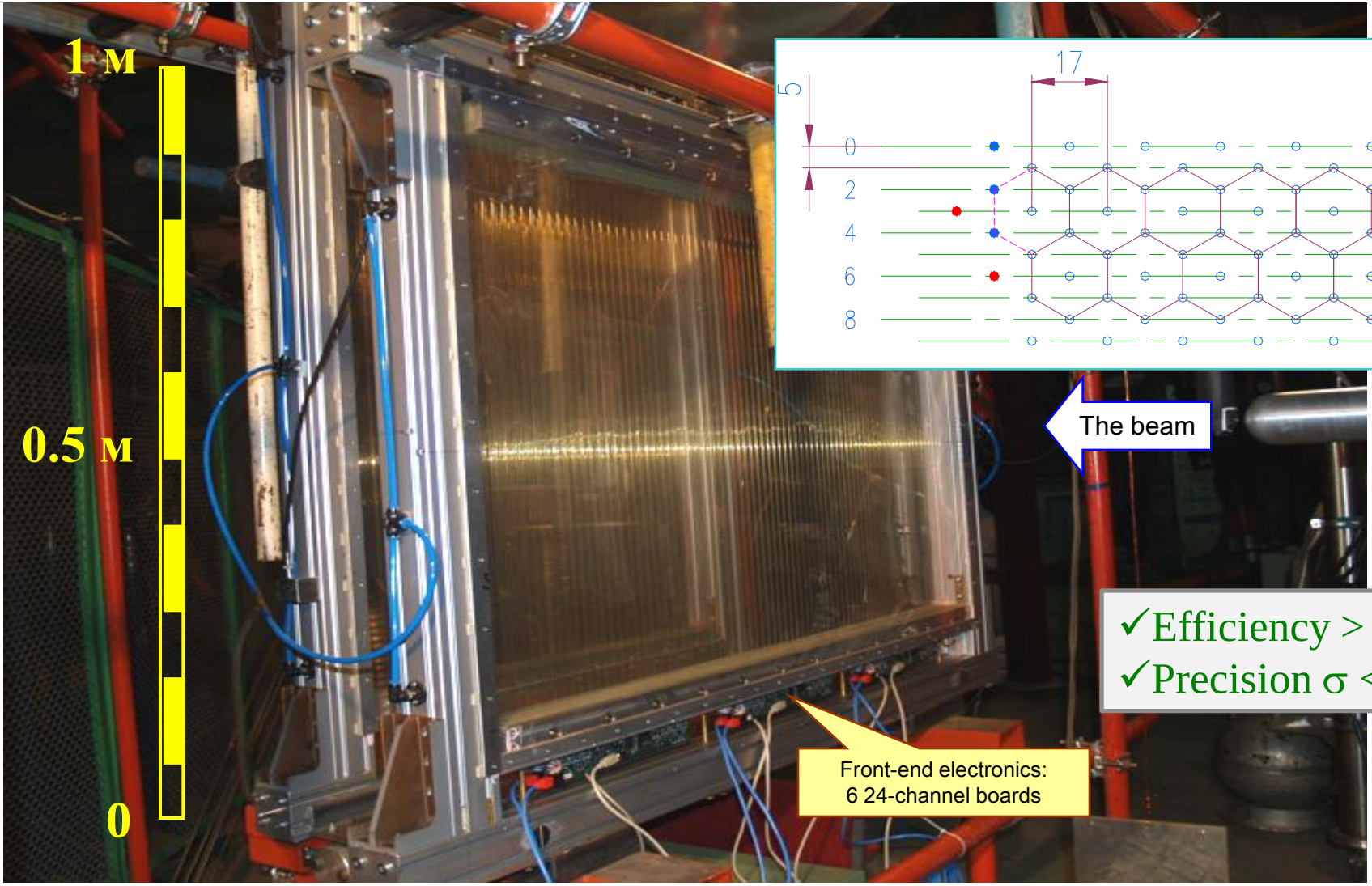
- The mylar container L=25 cm, ∅40 mm.
- Beryllium outer shell
- Tested with liquid neon and hydrogen.



While filling with hydrogen



Drift chambers with hexagonal structure

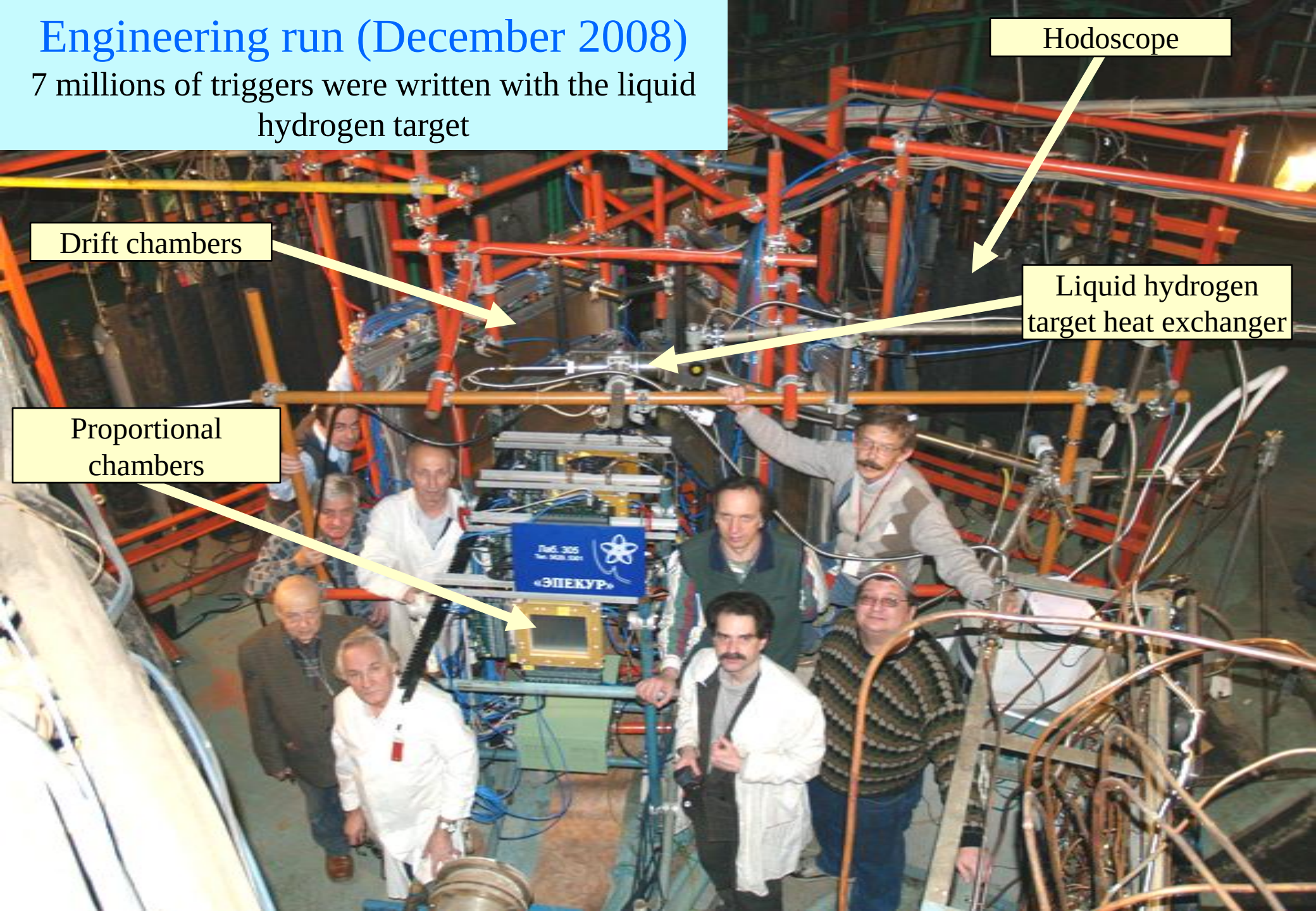


✓Efficiency > 99%
✓Precision σ < 0.2 mm

Drift chamber module “X” (wires along the short side) under test at ITEP accelerator. A “Y” module could be seen behind the “X” module.

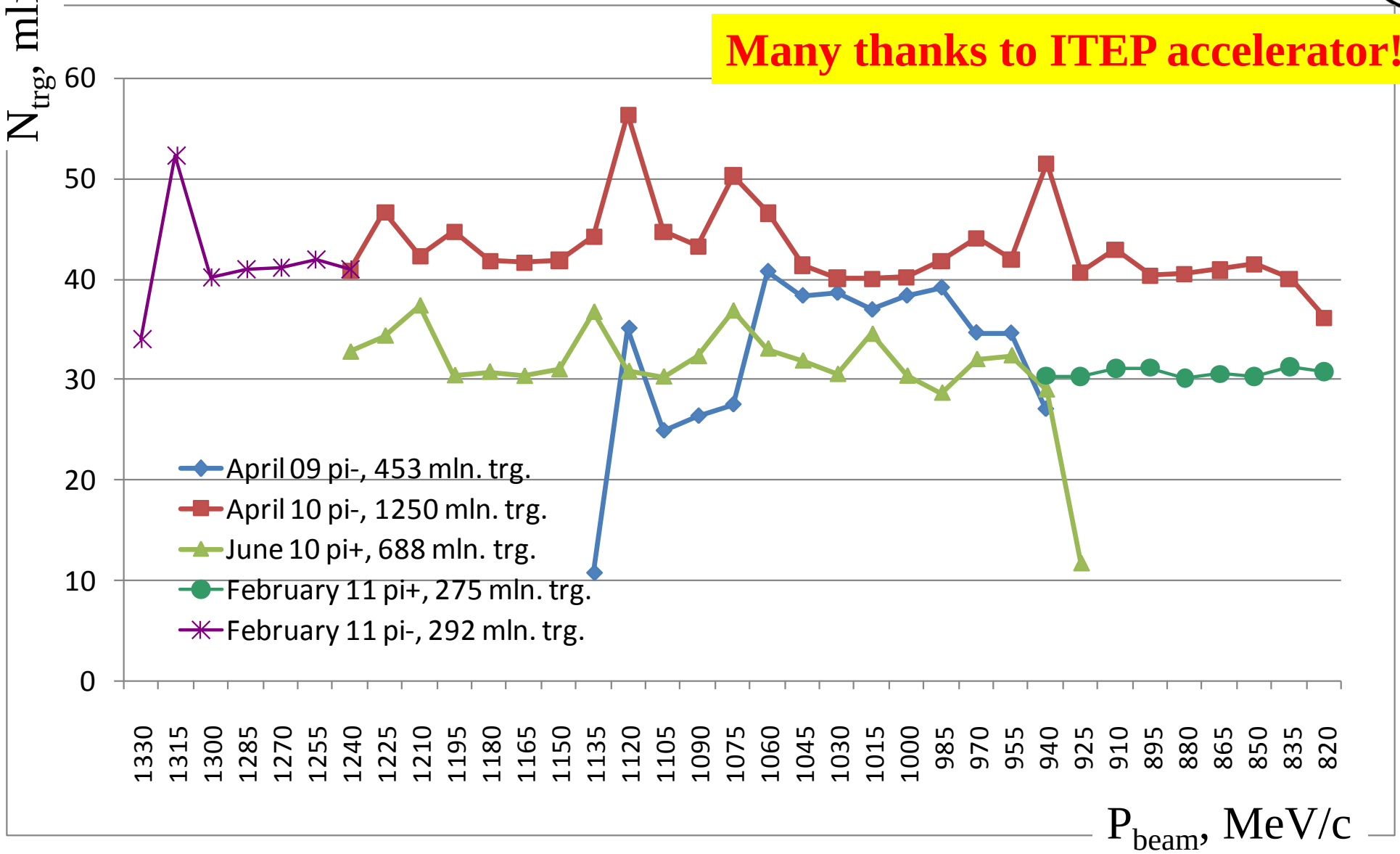
Engineering run (December 2008)

7 millions of triggers were written with the liquid hydrogen target



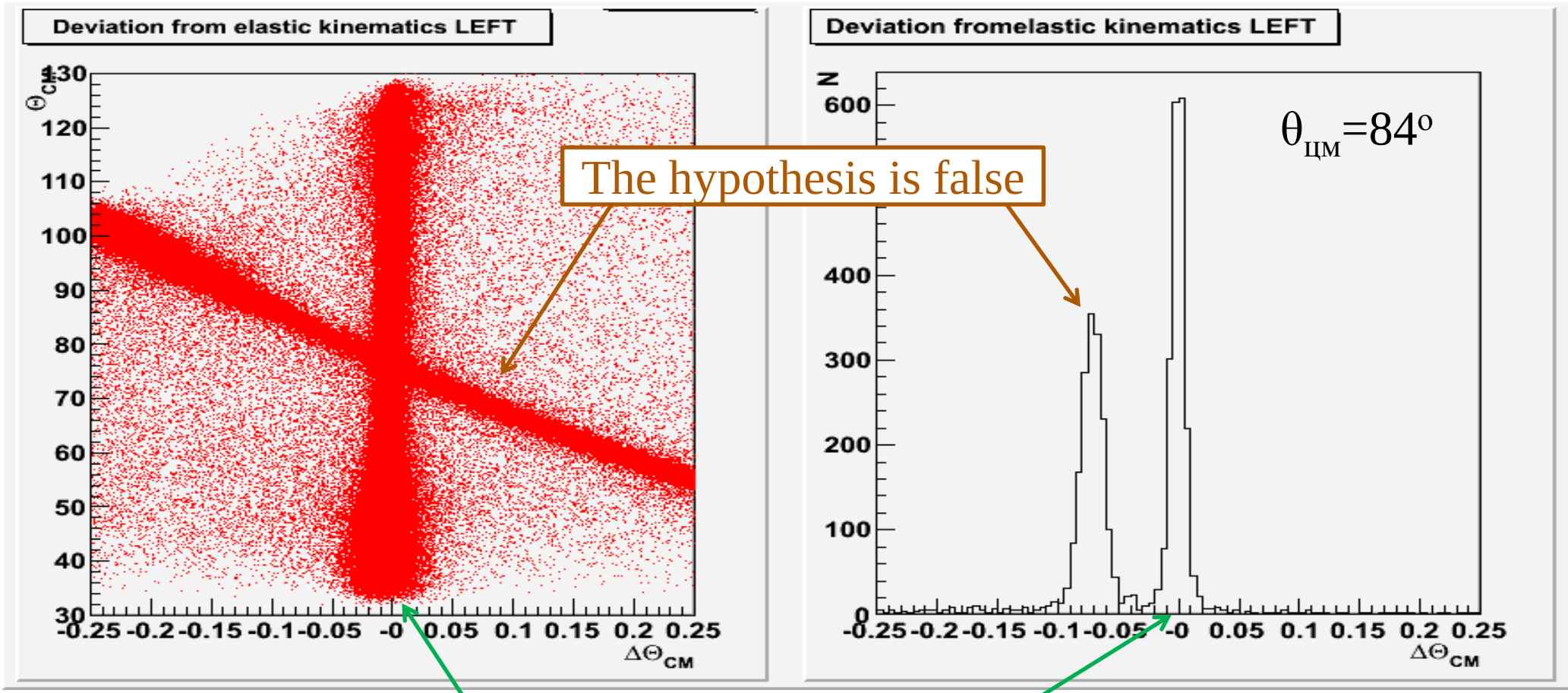
Statistics so far 2.97 billion triggers

Many thanks to ITEP accelerator!

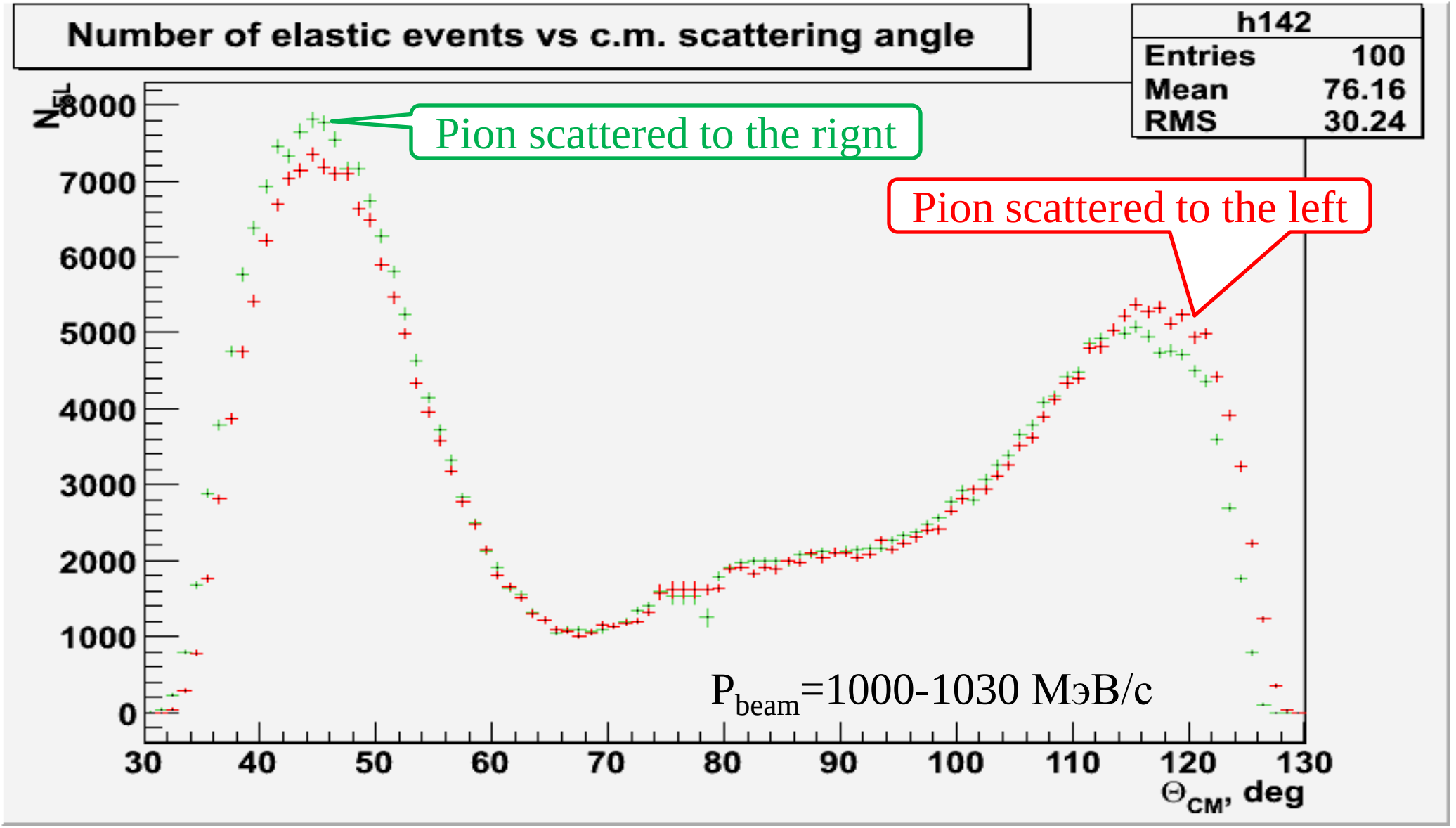


Elastic events selection

Hypothesis – pion scattered to the left arm

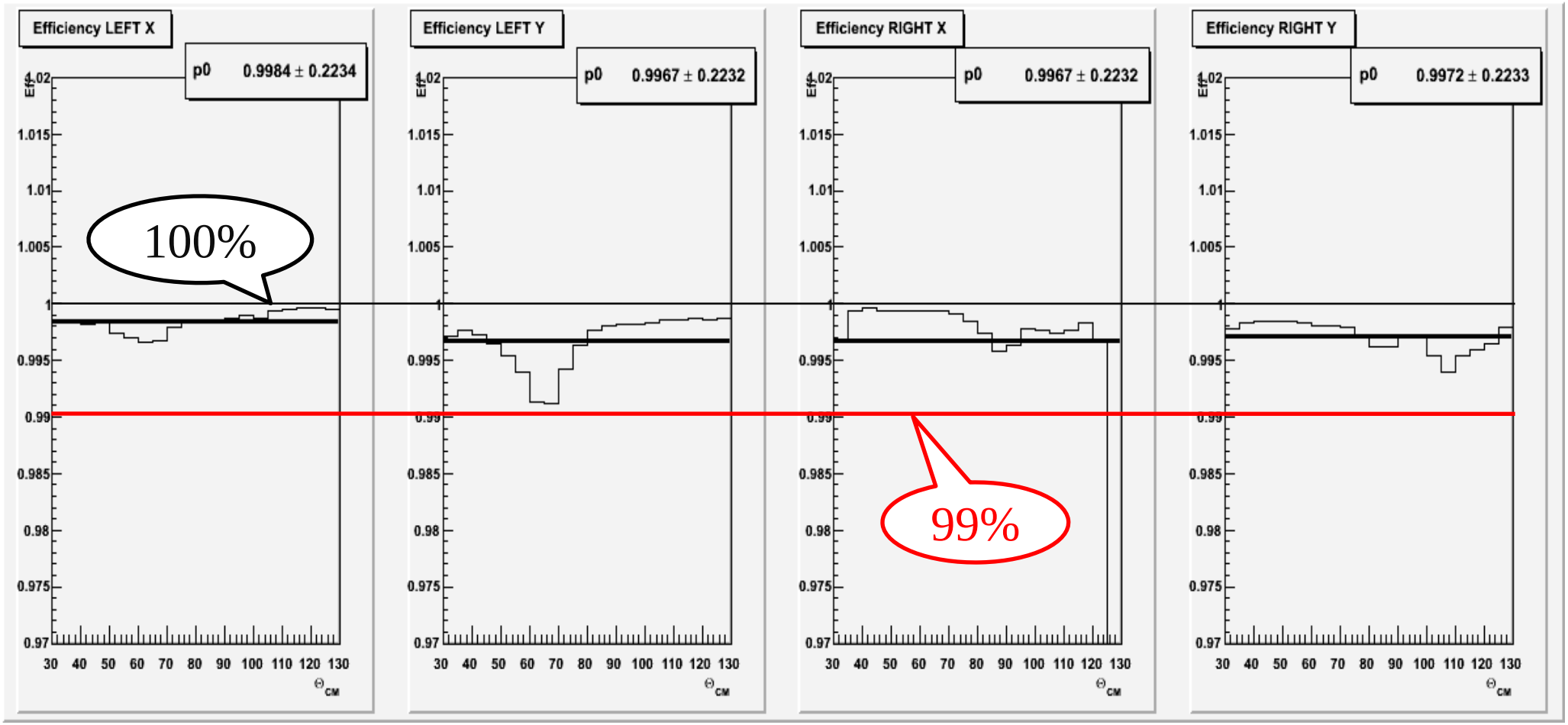


Raw angular distribution (unnormalized)



Track reconstruction efficiency

We require 3 hits on the track out of 4 possible in each projection



Acceptance, decays etc.
(very preliminary)

✓ We start with array of real tracks written with trigger Mom1F.

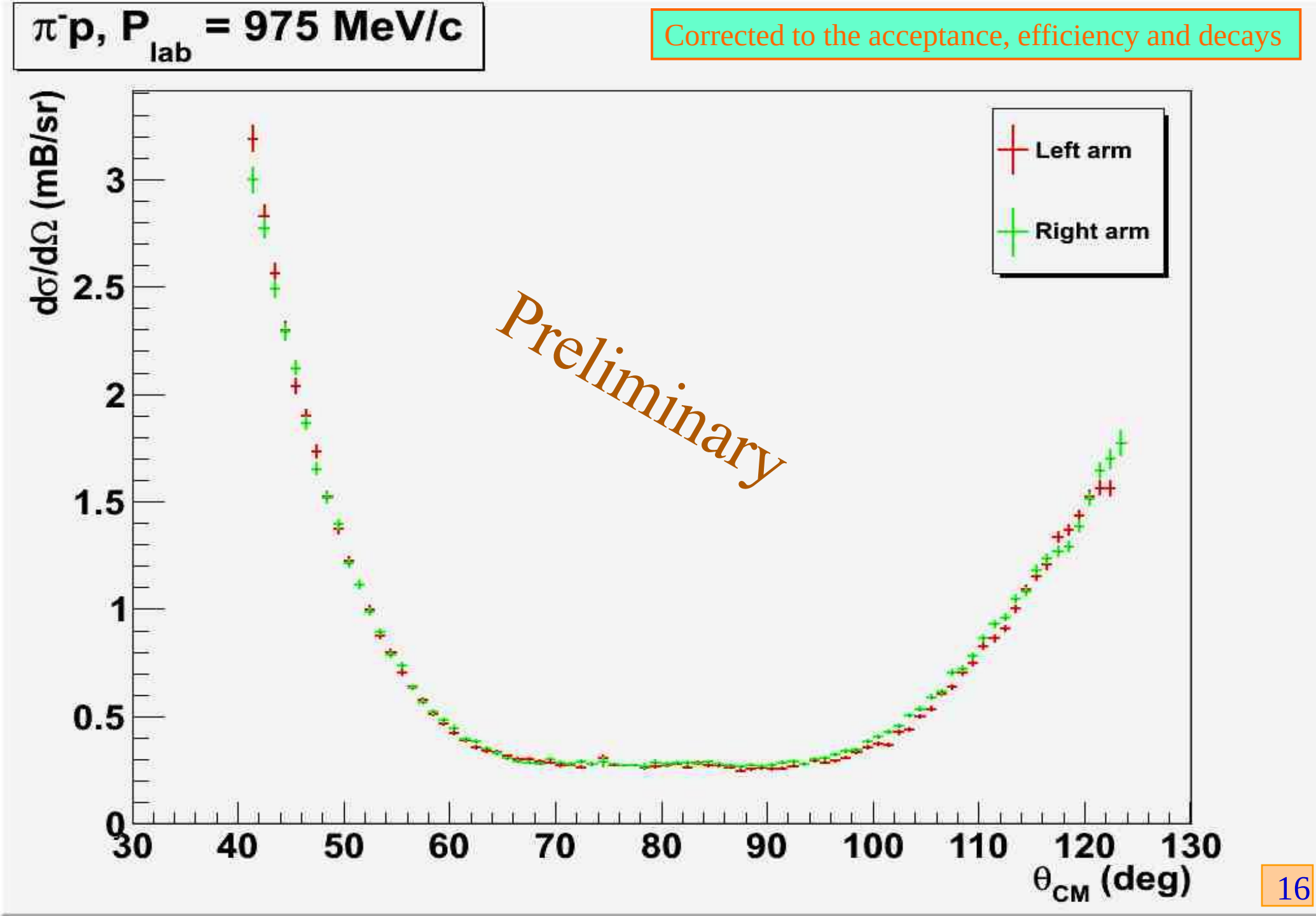
✓ With 1 mm step along the beam, 1° in the scattering angle in the CM-system and 10 MeV/c in momentum random azimuth angles are played and if the straight trajectories will hit the chambers is checked.

✓ An acceptance as a function of θ_{CM}, P_{beam} and z is created.

✓ For each event we introduce its weight based on the acceptance interpolated to the particular event kinematic parameters, tracking efficiency and correction to the decays and interactions.

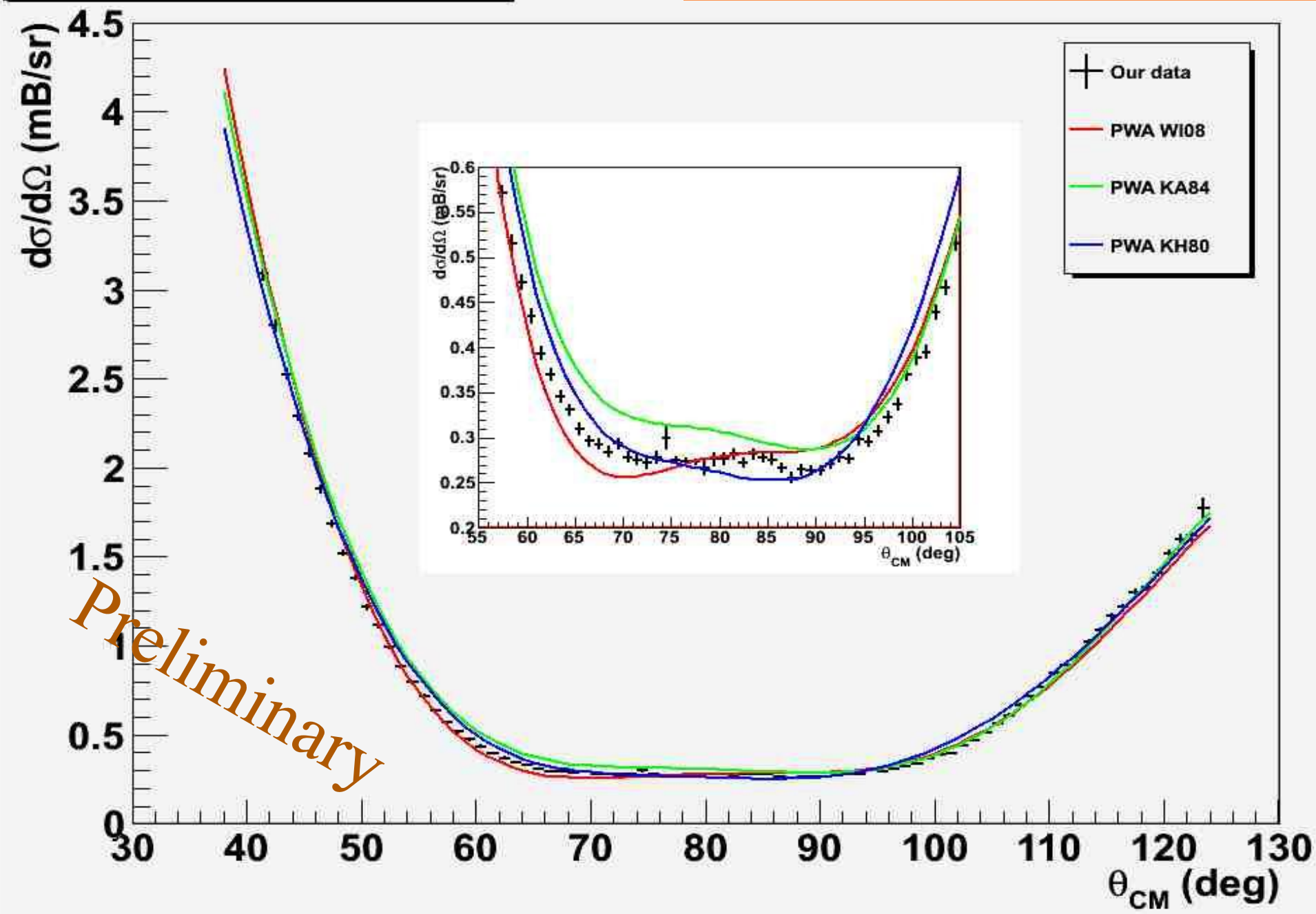
❖ Standard Monte-Carlo simulations are under way based on Geant.

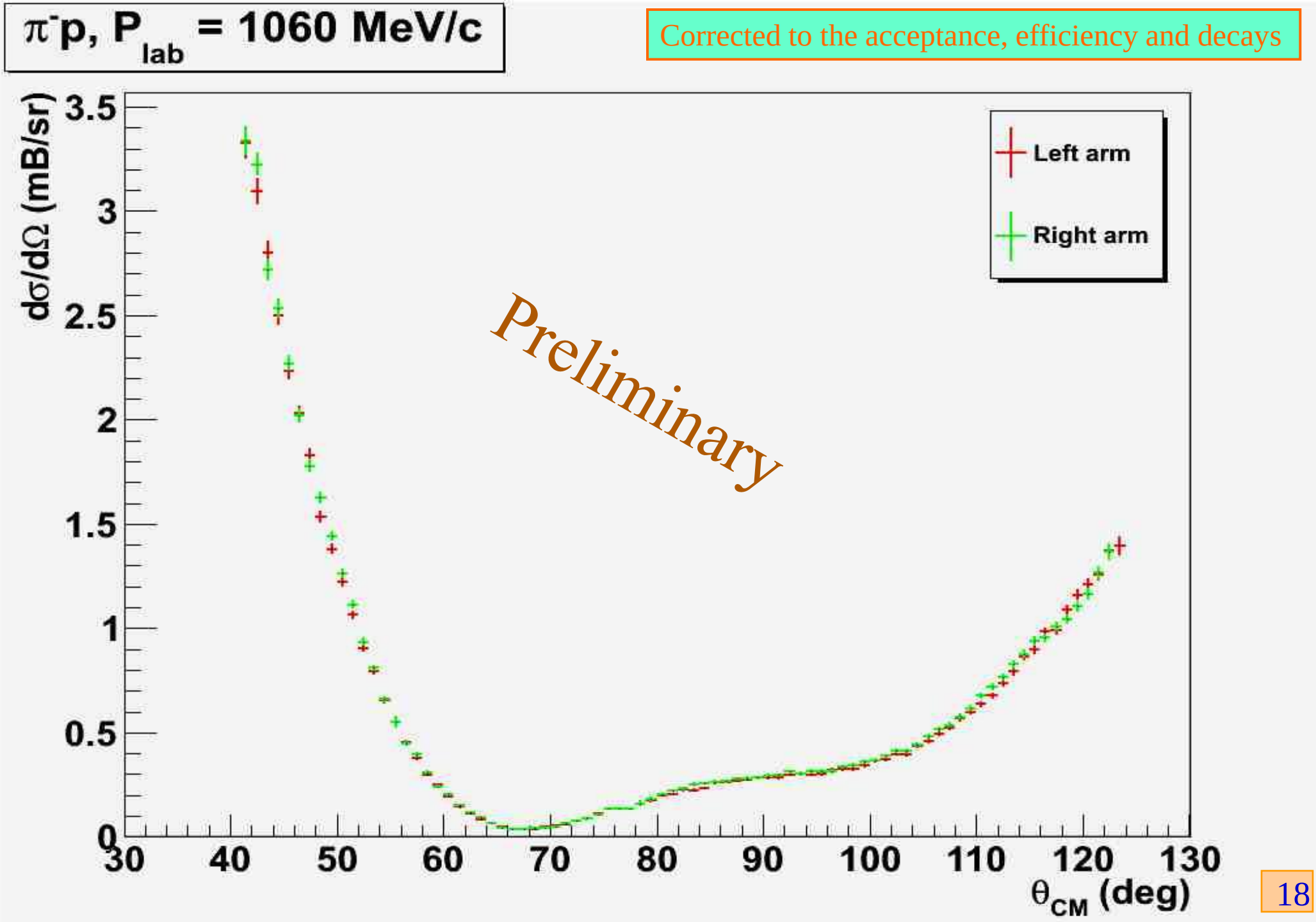
❖ We are in the preparation for measurement of the beam muon and electron contamination using gas Cherenkov counter. We are also going to perform Monte-Carlo simulation of the decays after the beam optics.


$\pi^- p$, P_{lab} = 975 MeV/c
Corrected to the acceptance, efficiency and decays
Left arm
Right arm
Preliminary
$d\sigma/d\Omega$ (mB/sr)
0
0.5
1
1.5
2
2.5
3
30
40
50
60
70
80
90
100
110
120
130
θ_{CM} (deg)

$\pi^- p$, P_{lab} = 975 MeV/c

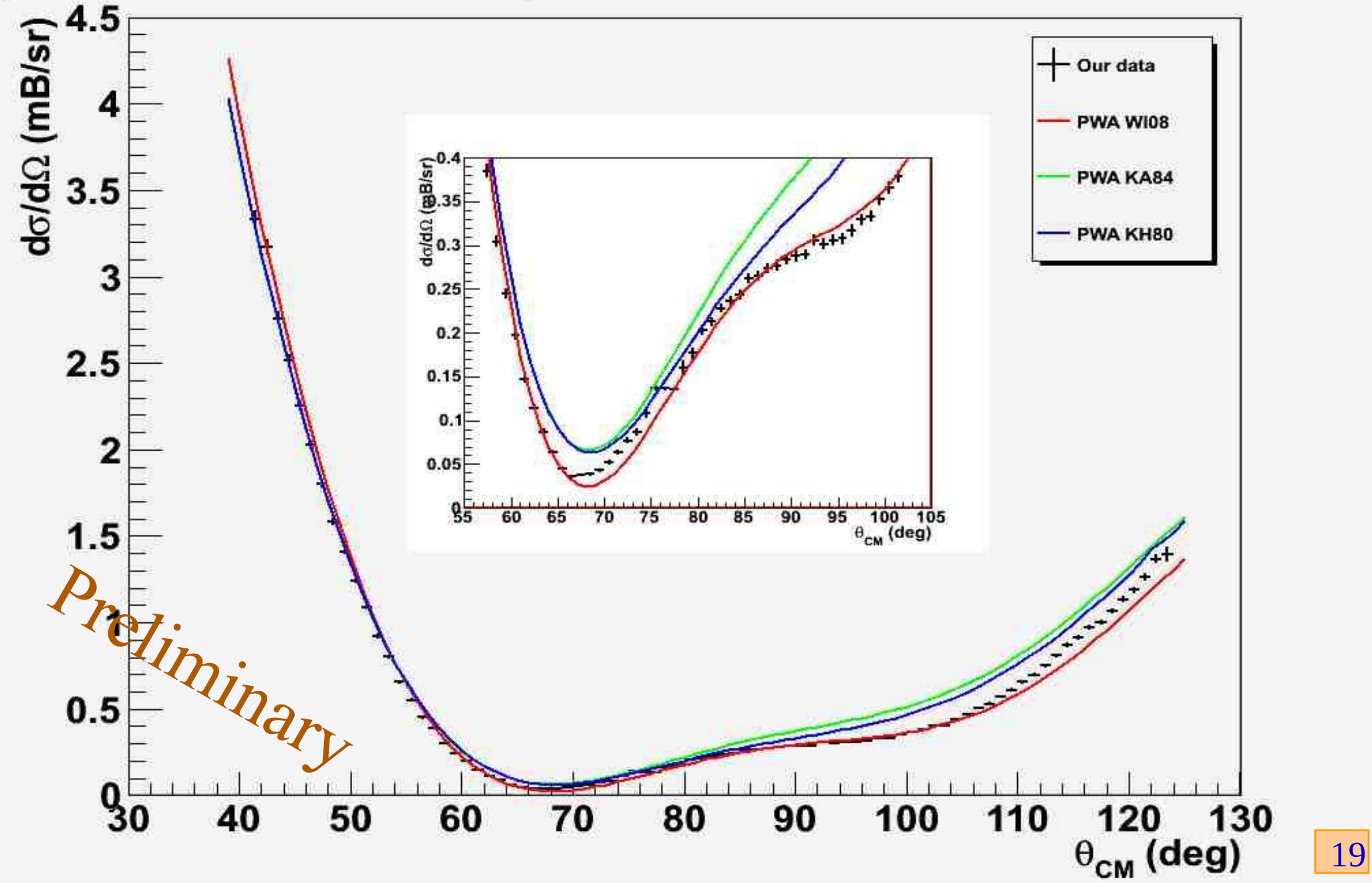
Corrected to the acceptance, efficiency and decays



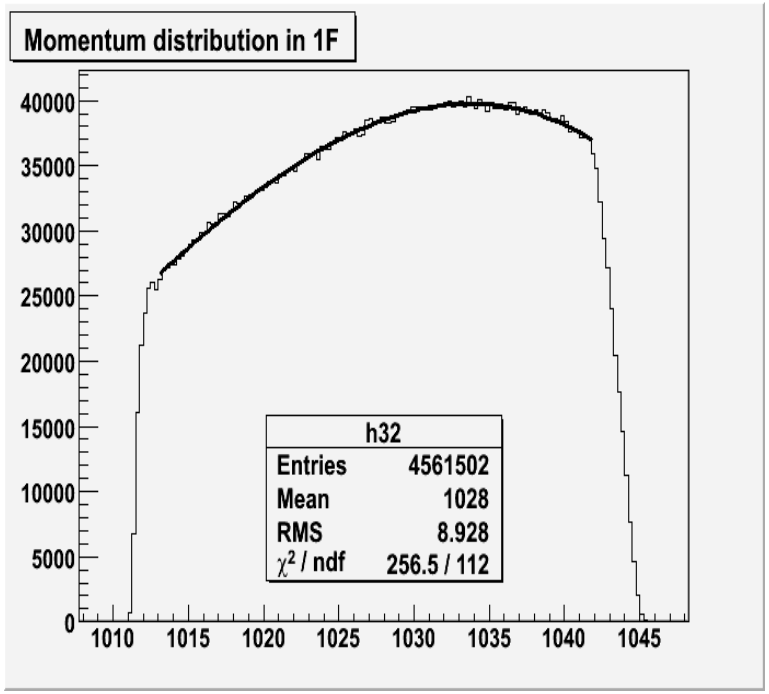

π^-p, P_{lab} = 1060 MeV/c
Corrected to the acceptance, efficiency and decays
dσ/dΩ (mB/sr)
3.5
3
2.5
2
1.5
1
0.5
0
30
40
50
60
70
80
90
100
110
120
130
θ_{CM} (deg)
Left arm
Right arm
Preliminary

$\pi^- p$, P_{lab} = 1060 MeV/c

Corrected to the acceptance, efficiency and decays

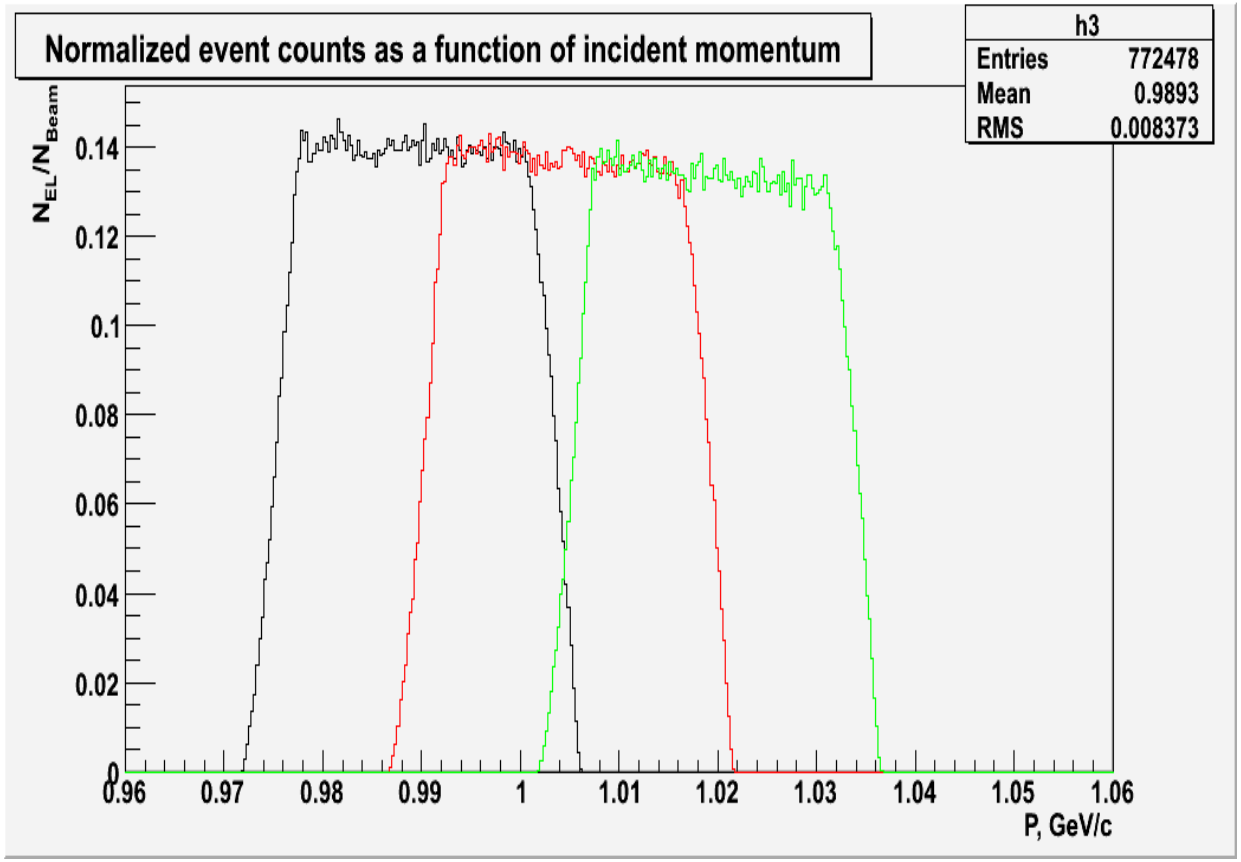


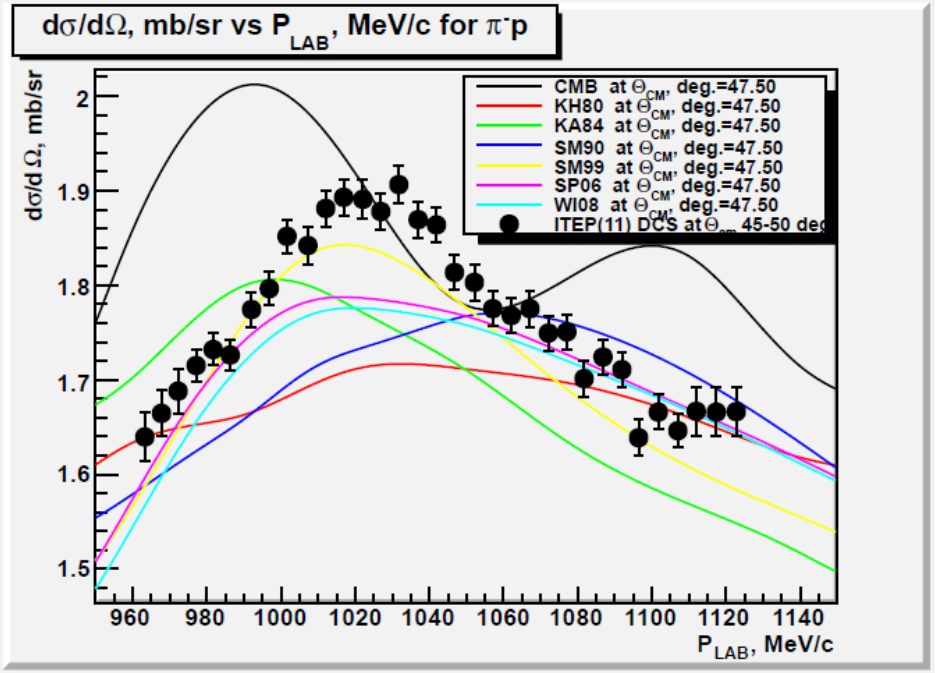
Neighbor momentum intervals match

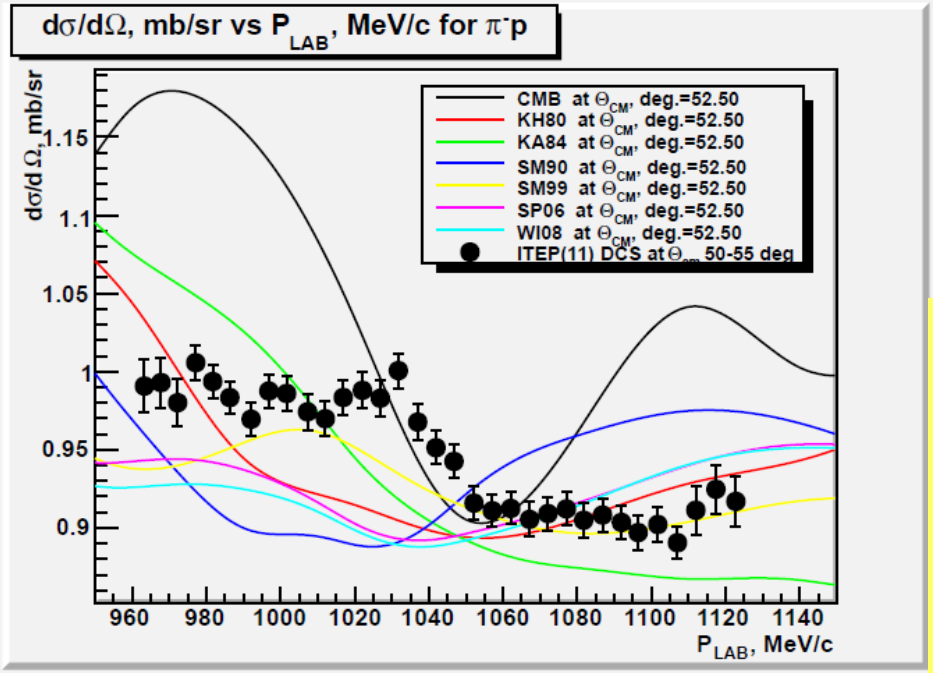


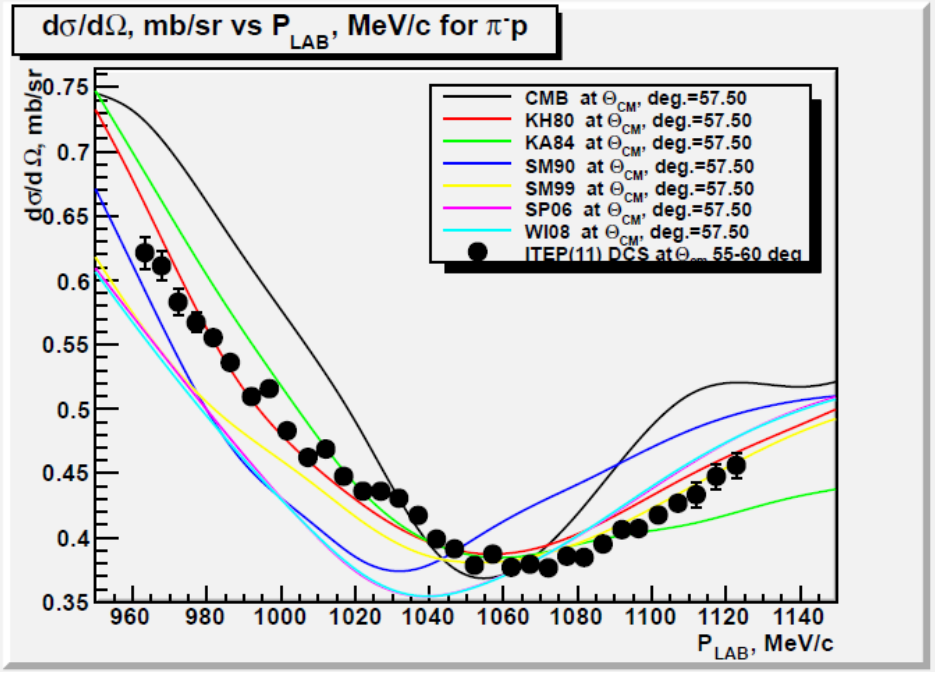
The momentum distribution with single beam optics setting from Mom1F-trigger.

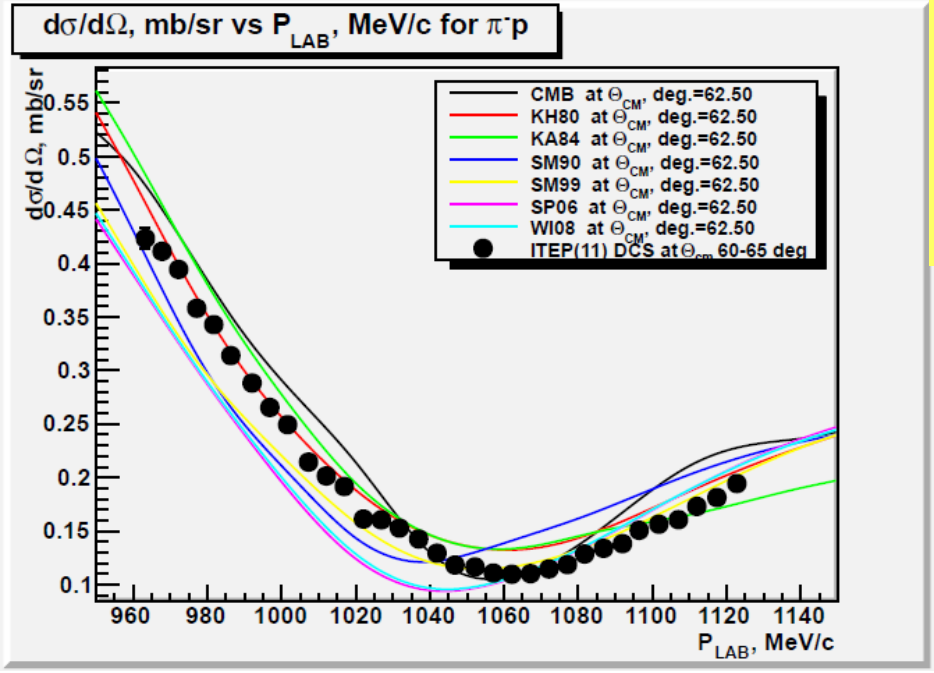
Normalized counts of the elastic events measured with 3 consecutive beam optics settings. The match in the overlapping regions is better than 0.7%.



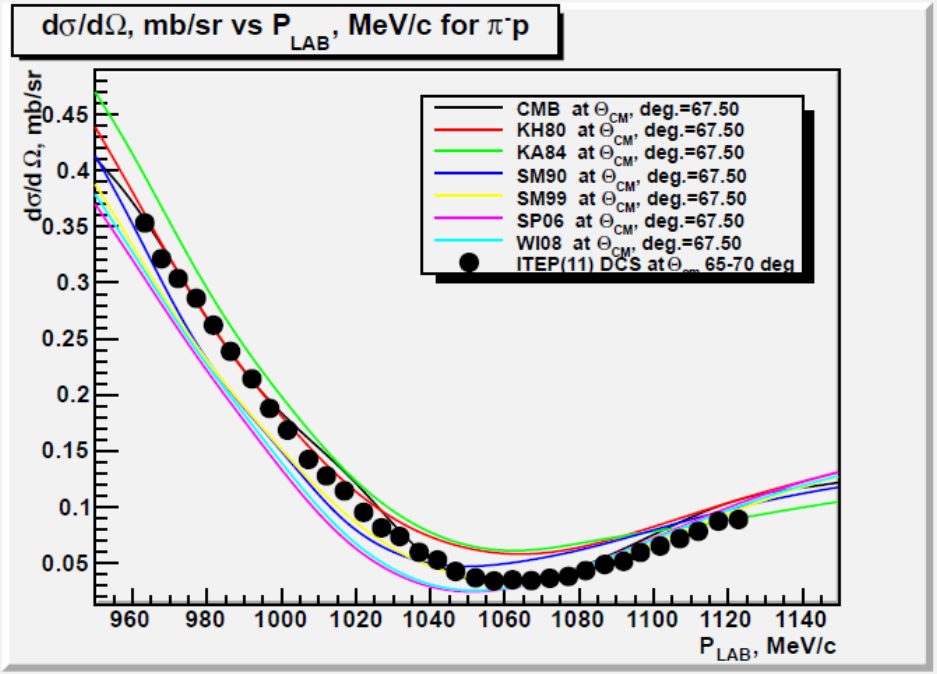


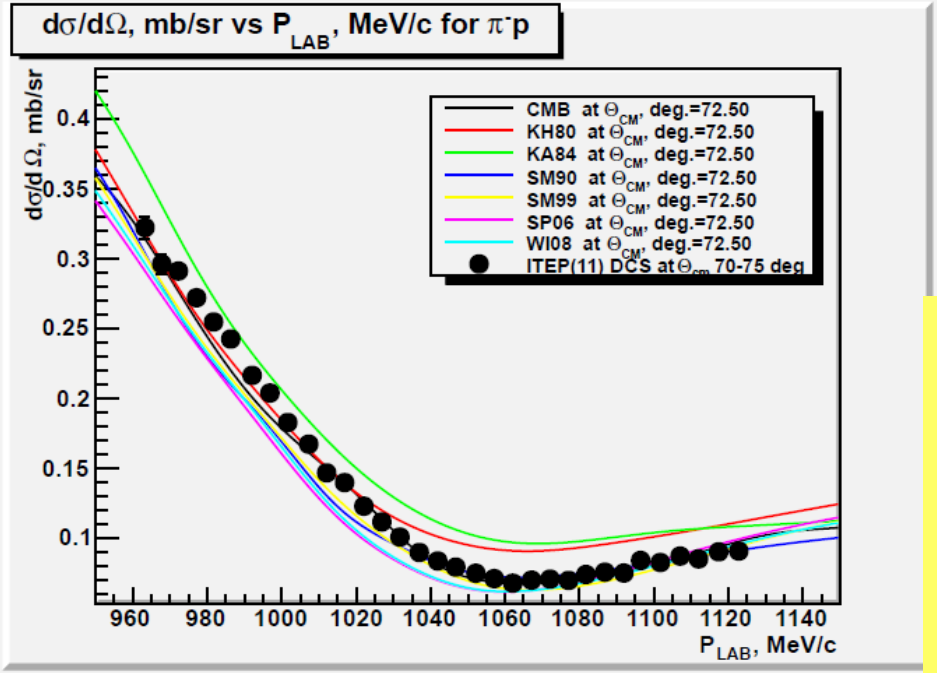


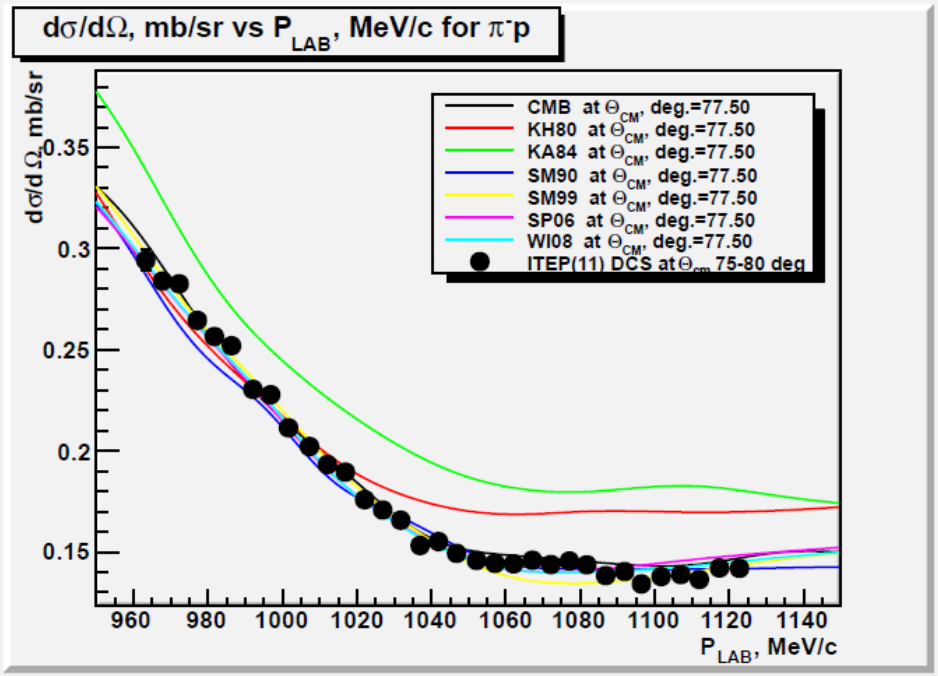


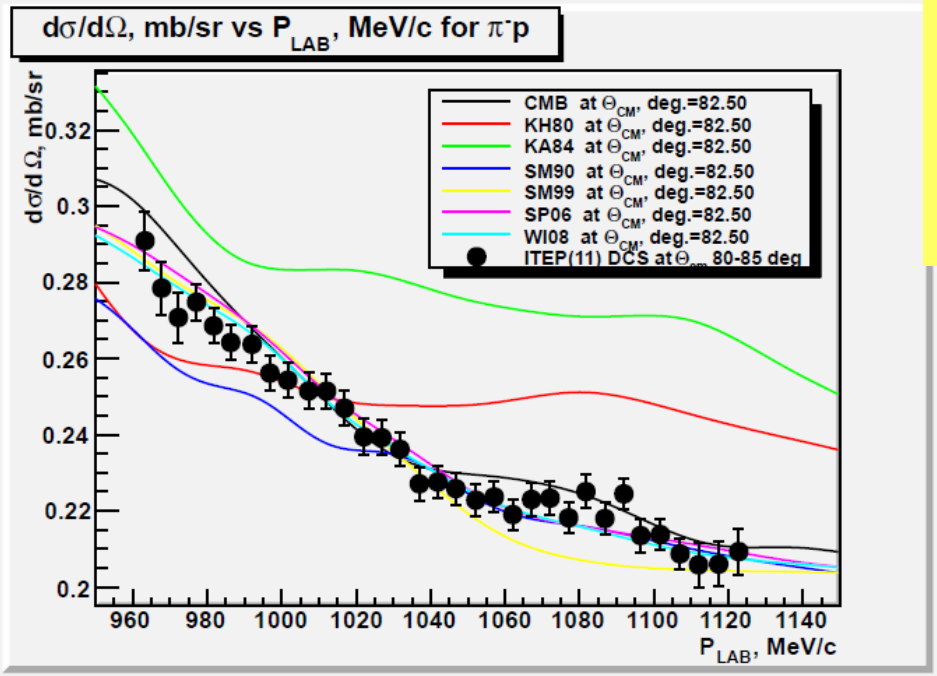


Statistical errors only

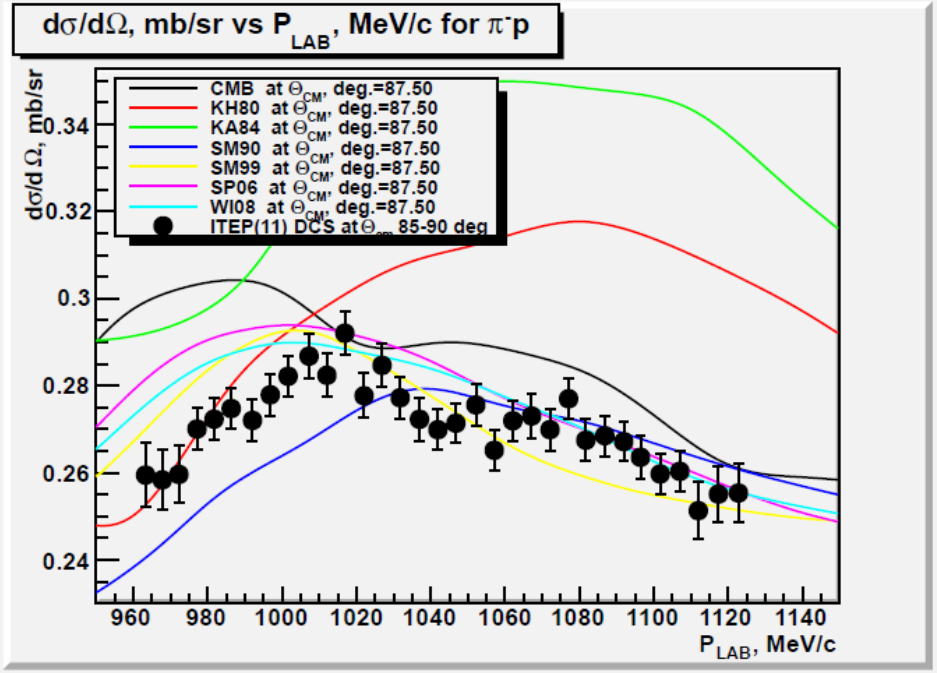


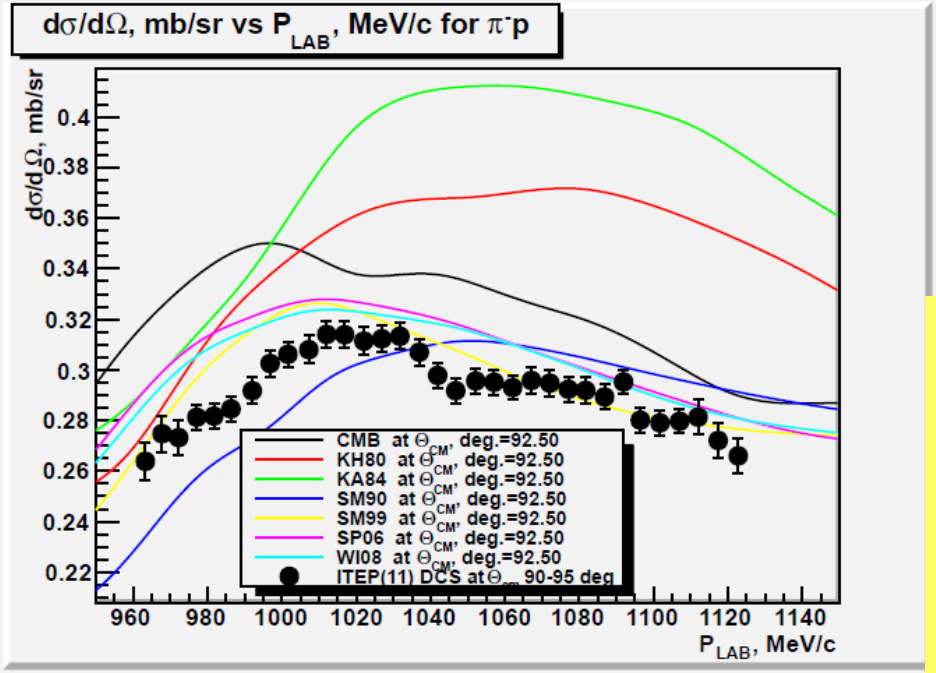


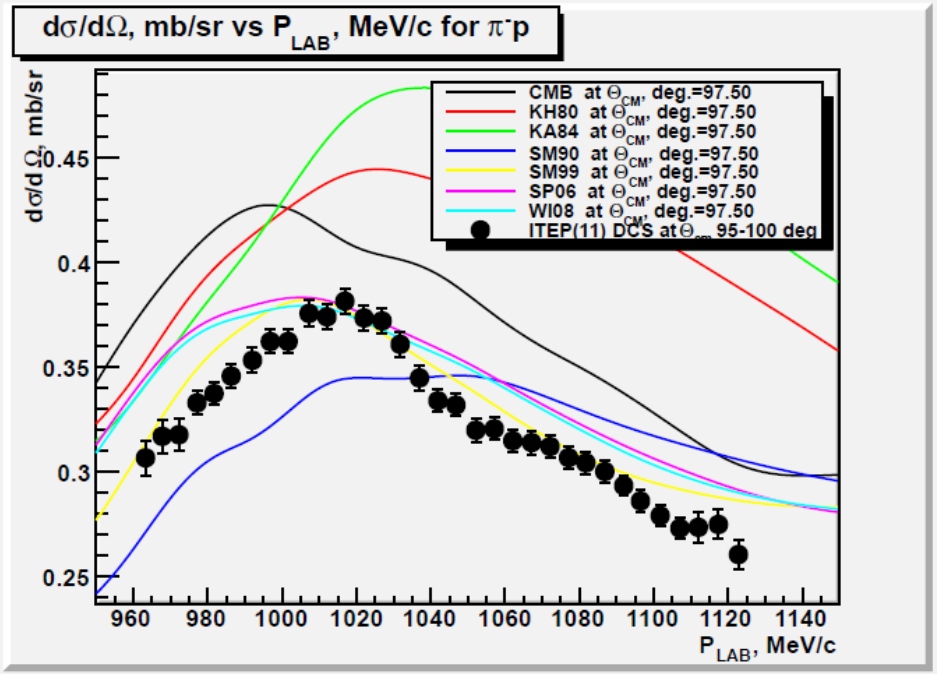


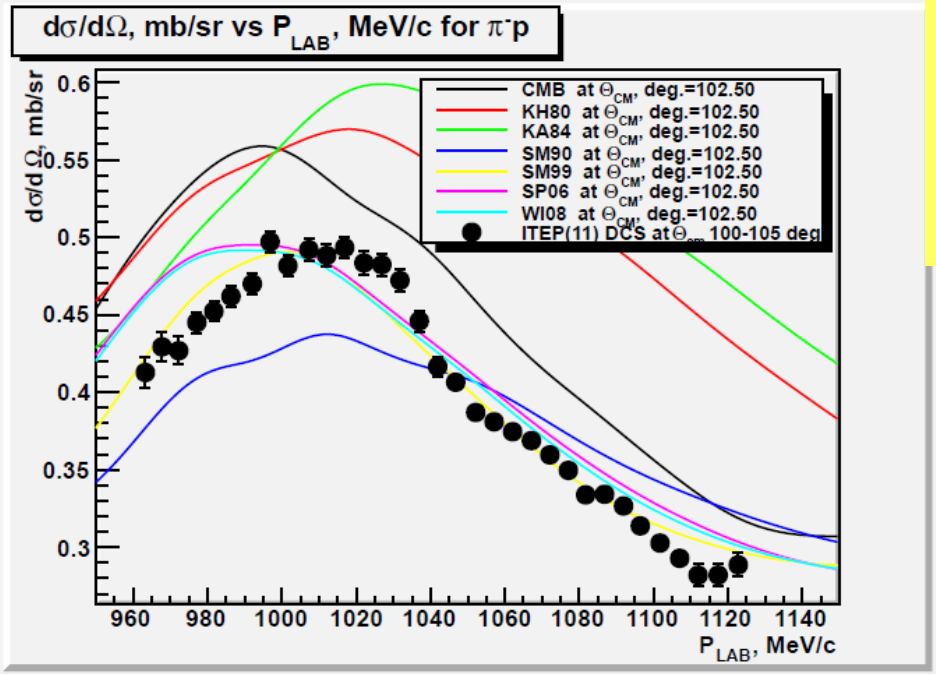


Statistical errors only









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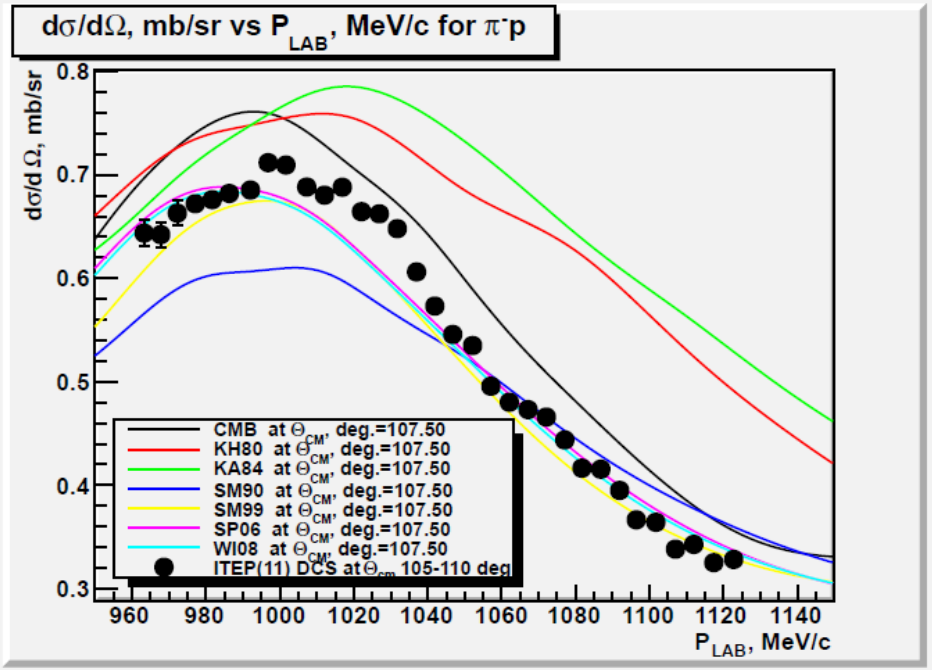
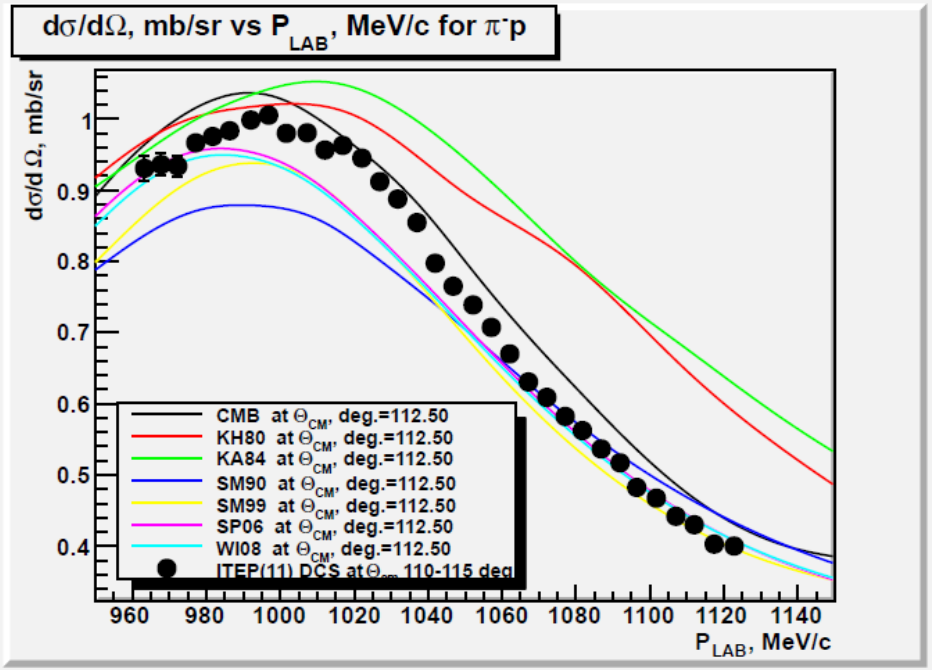
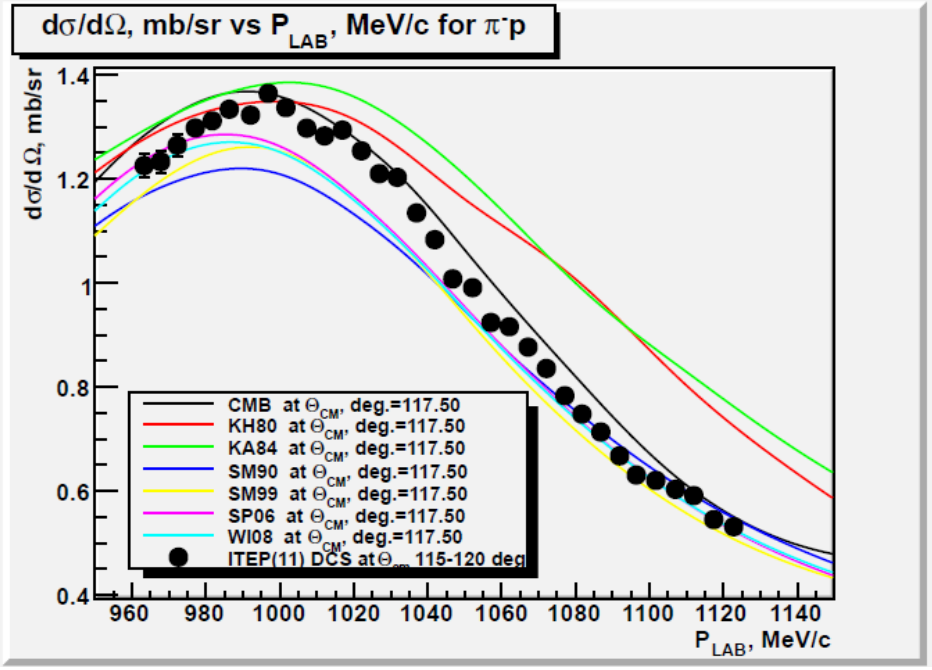






Statistical errors only

✓ We already collected nearly 3 billion triggers

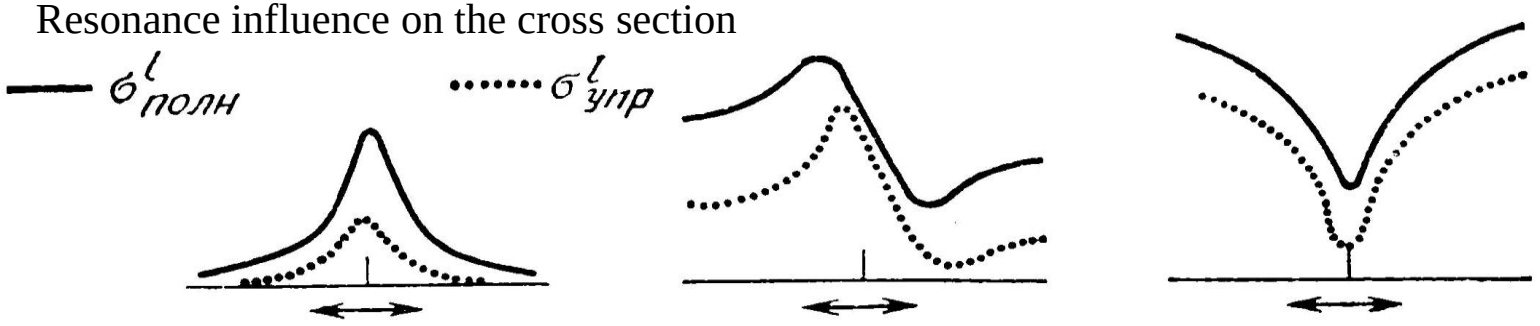
✓ We see some narrow effect

We need to:

- Process the whole statistics
- Do Monte-Carlo simulations
- Find muon and electron contamination to the pion beam
- Get more statistics

Resonances and channel thresholds in the differential cross section

Resonance influence on the cross section

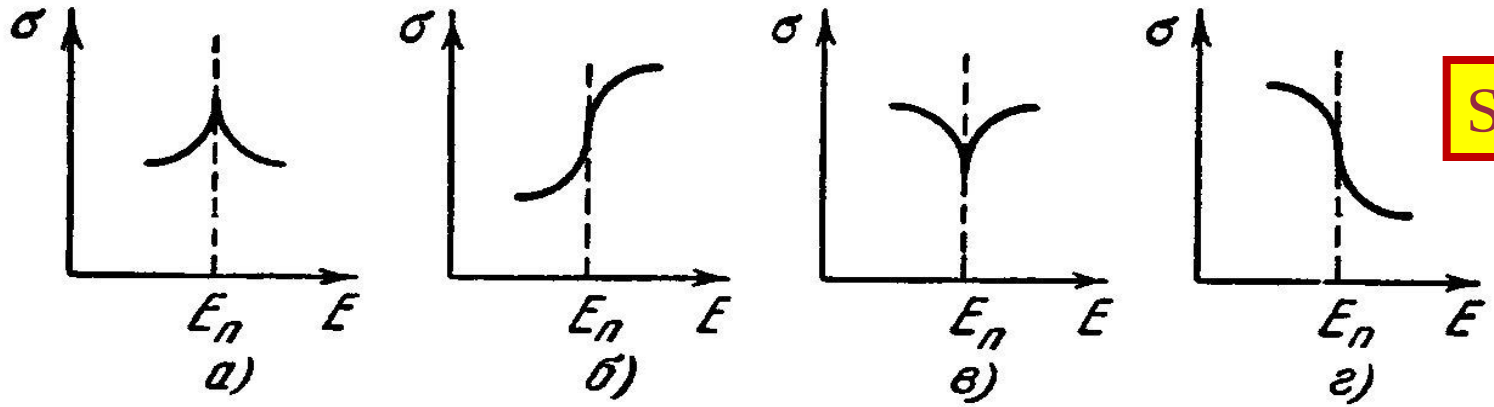


Any wave

Energy →

N(1685) – M_{inv}=1685 МэВ → P_{beam} = 1024 MeV/c

Other channel threshold influence on the cross section



S-wave only

$\pi^- p \to K^0 \Sigma^0$ – M_{inv}=1690.2 MeV P_{beam} = 1033 MeV/c

$\pi^- p \to K^+ \Sigma^-$ – M_{inv}=1691.1 MeV P_{beam} = 1035 MeV/c

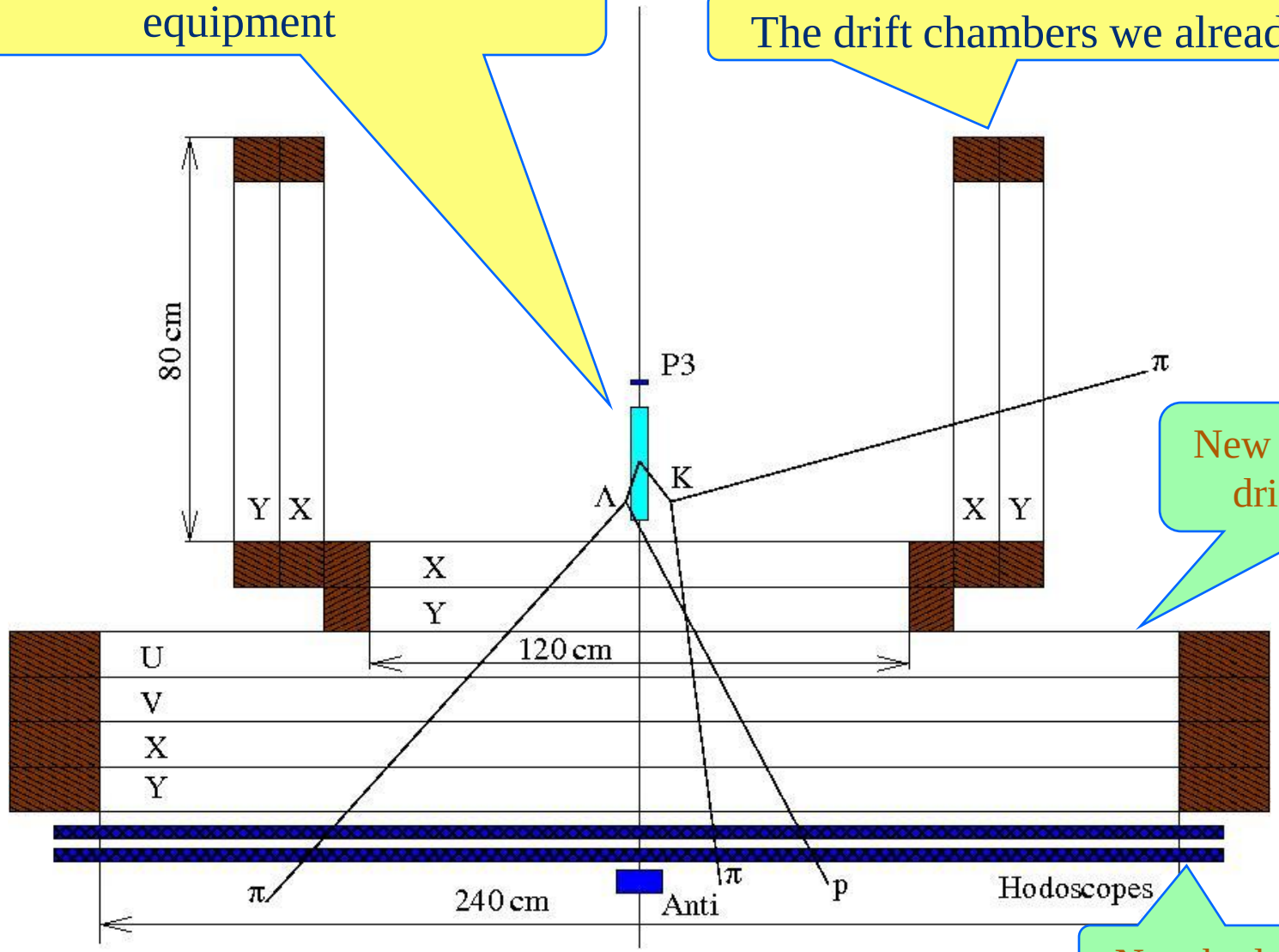
$\pi^- p \to \omega n$ – M_{inv}=1722.3 MeV P_{beam} = 1092 MeV/c

$\pi^- p \rightarrow K^0_S \Lambda \rightarrow \pi^+ \pi^- \pi^- p$

Most of the events have either all 4 particles going forward or 3 particles including the proton going forward and one pion going in some other direction

We keep the target and the beam equipment

The drift chambers we already have



New wide-aperture drift chambers

New hodoscopes