New result from Θ^+ search experiment at LEPS

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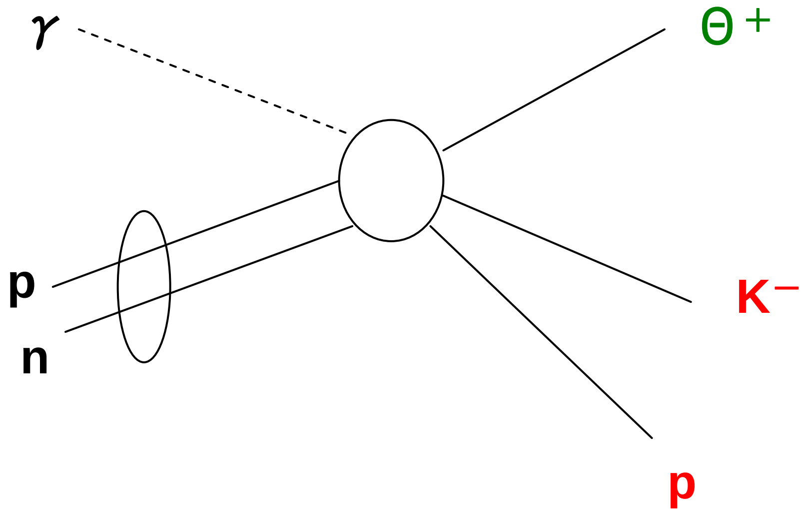
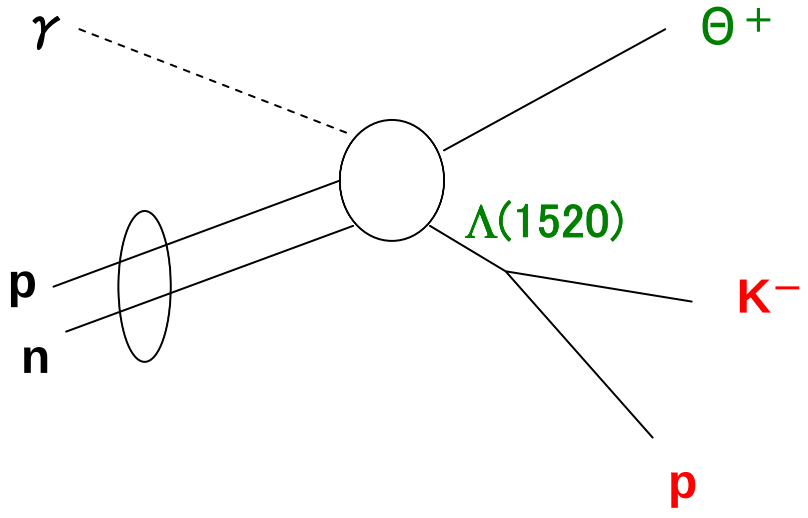
- **No introduction on the Θ^+**
- **New Analysis idea**
- **Analysis details**
- **Summary**

Chiral05 @ RIKEN., February 16, 2005

How to search for Θ^+?

Θ^+ is identified by K^-p missing mass from deuteron. $\Rightarrow$ No Fermi correction is needed.





LEPS New LD2 and LH2 runs

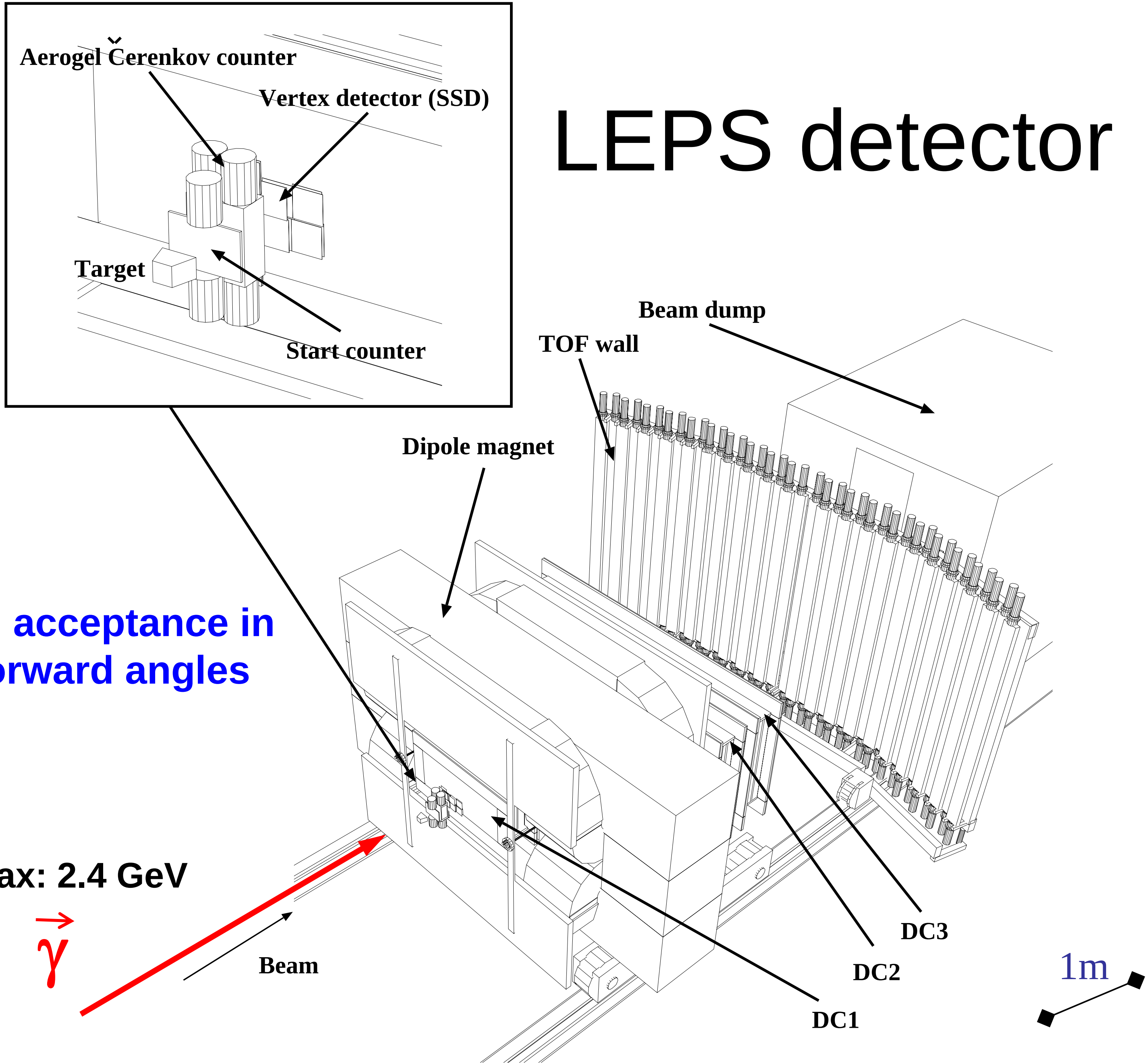
- **Data taken from Oct. 2002 to Jun. 2003.**
- **~$2 \cdot 10^{12}$ photons on a 15cm-long LD2 target.**
- **LH2 data were taken in the same period with ~ $1.4 \cdot 10^{12}$ photons on the target.**

# of photons: LH2:LD2 ≈ 2:3

# of events from a proton: LH2:LD2≈ 2:3
(e.g. KKp from ϕ production)

# of events from a nucleon: LH2:LD2≈ 1:3

LEPS detector



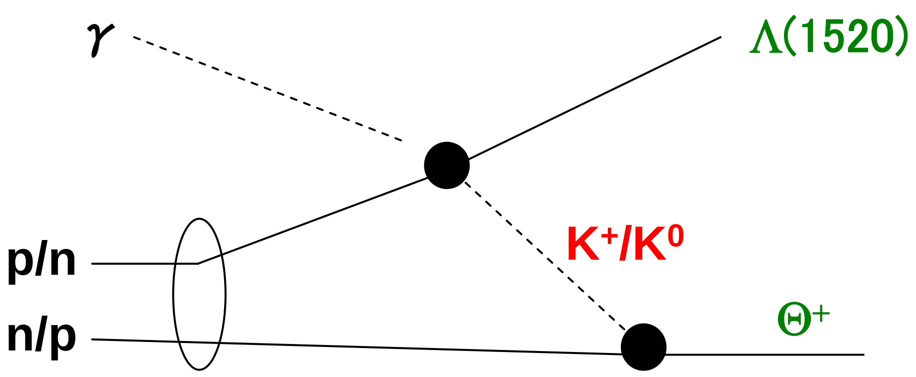
Good acceptance in the forward angles

Max: 2.4 GeV

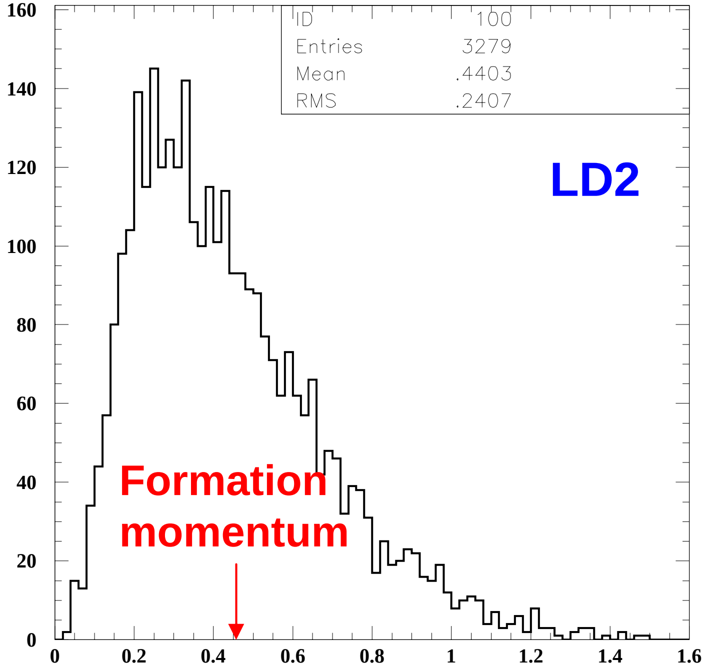
$\vec{\gamma}$

A possible reaction mechanism

- Θ^+ can be produced by re-scattering of K^+.
- K momentum spectrum is soft for forward going $\Lambda(1520)$.



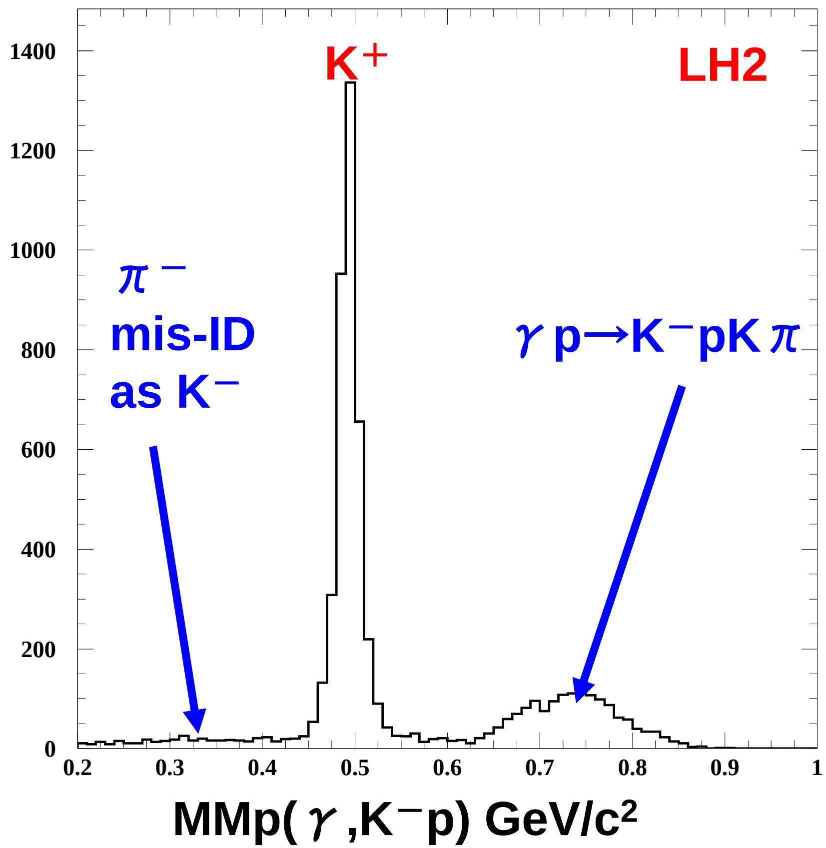
P_K obtained by missing momentum



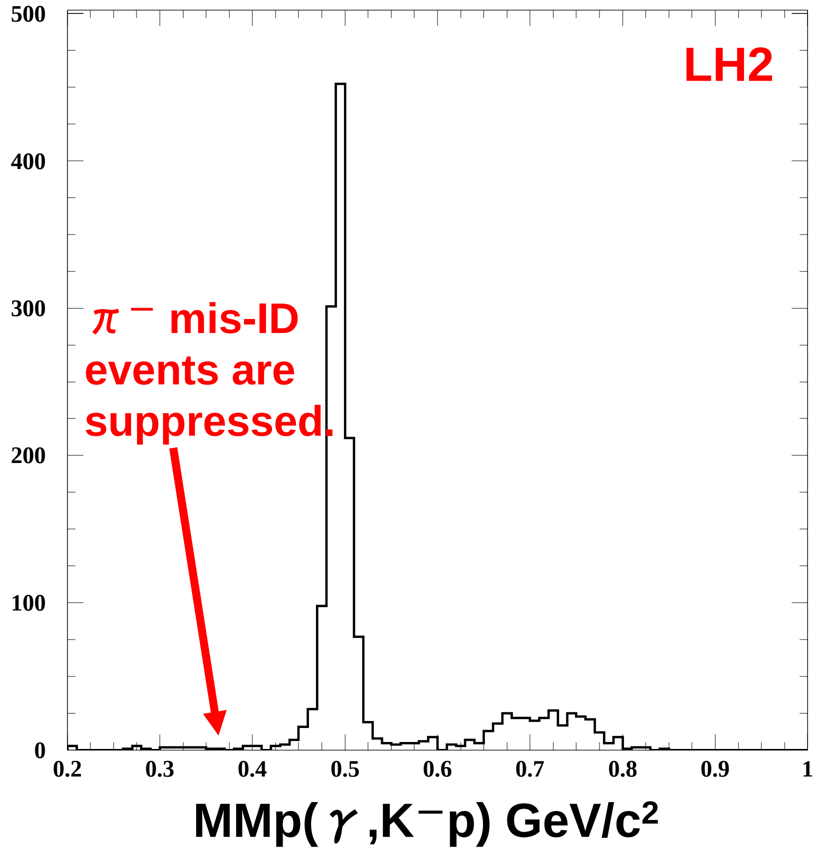
P_K GeV/c

Energy and momentum calibration

$\gamma\, p \rightarrow K^- p\, X$

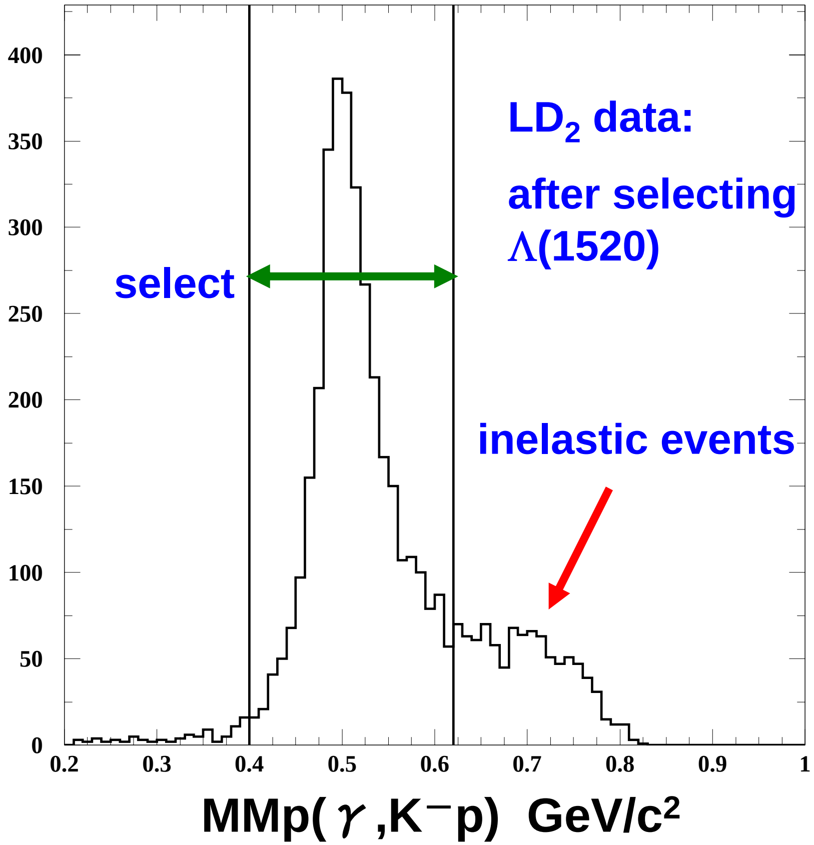


$\gamma\, p \rightarrow \Lambda(1520)\, X$
$\quad\hookrightarrow K^- p$



Event selection

K mass is smeared by Fermi motion.
(assumed proton at rest)



Select Λ(1520) in 1.50–1.54 GeV/c^2

⇒ calculate K$^-$ p missing mass
of γ d → K$^-$ p X reaction

K^-p missing mass in $1.50<M(K^-p)<1.54$ GeV/c^2

γ d $\rightarrow \Lambda(1520)$ X

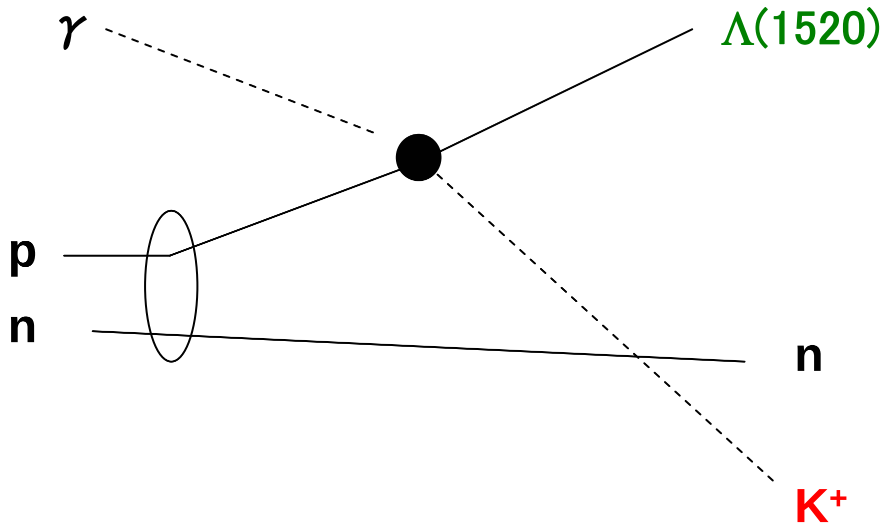
$\hookrightarrow K^-$ p

Good understanding of the background spectrum shape is crucial.

MMd(γ,K^-p) GeV/c^2

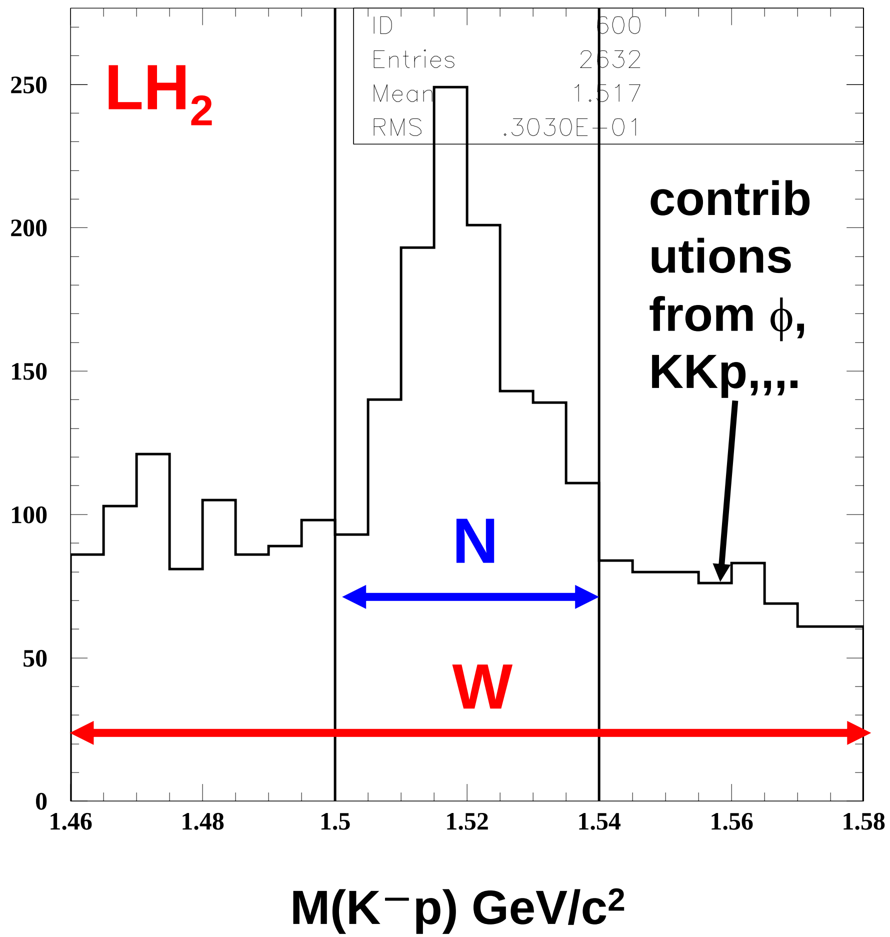
Major background process

- Quasi free Λ(1520) production must be the major background.
- The effect can be estimated from the LH2 data



Extracting Λ(1520) contribution

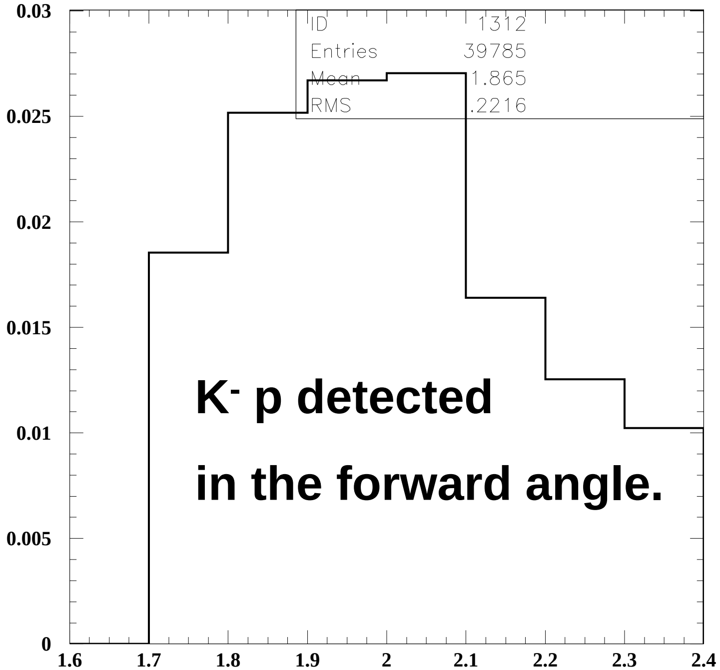
$$\Lambda(1520) = 1.5 \times N - 0.5 \times W$$



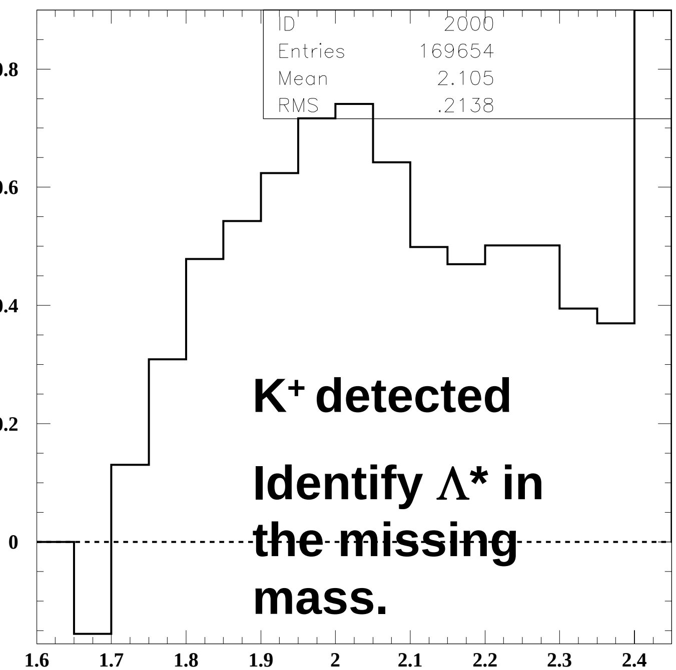
γ p → ϕ p reaction and non-resonant KKp production can contribute in the signal region. But they do not make a peak in K^-p invariant mass.

Λ(1520) contribution can extracted by sideband subtraction method.

Energy Dependence of $\Lambda(1520)$ production



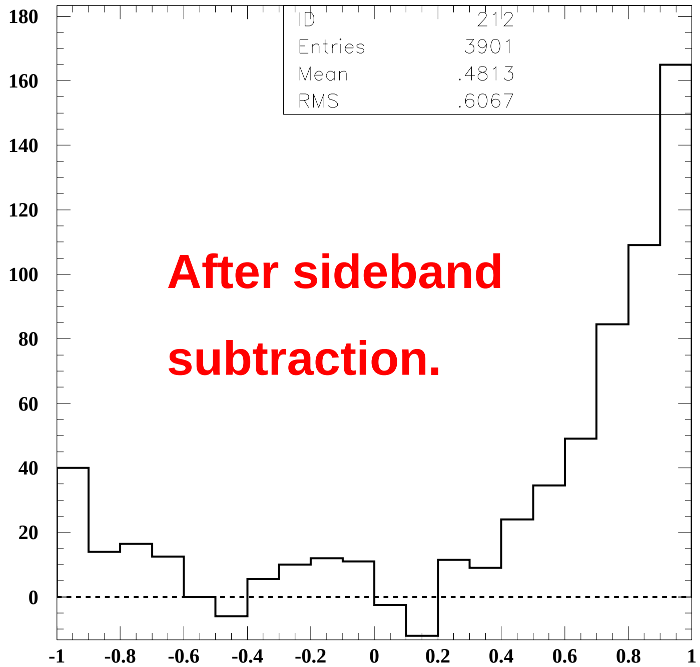
$E\gamma$ GeV

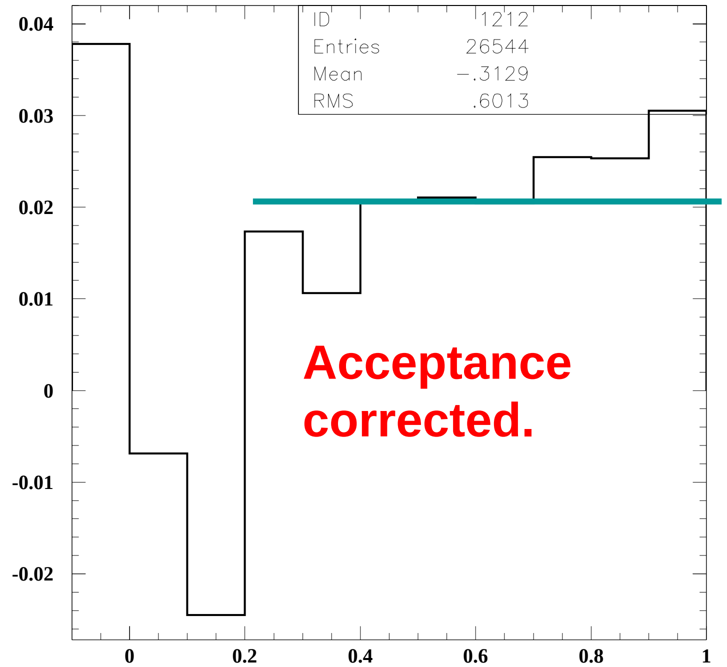


$E\gamma$ GeV

Energy dependences are similar in the both angle regions.
→ Energy dependence of the angular distributions must be small.

Λ(1520) angular distribution

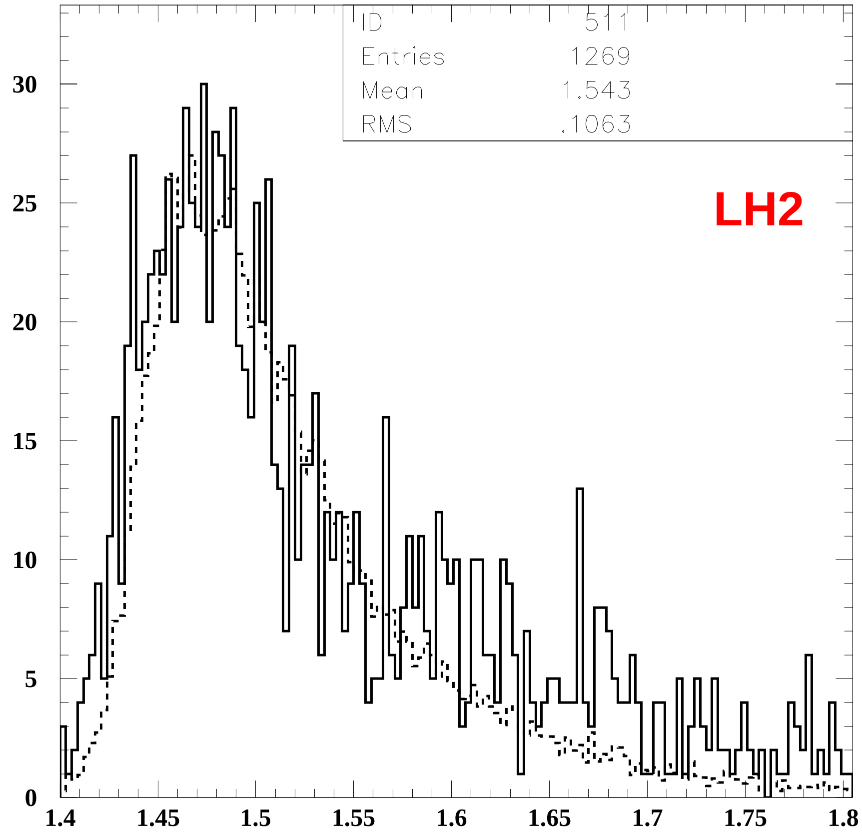




Cos Θ $_{Kp}$ in CMS   Cos Θ $_{Kp}$ in CMS

Angular distributions is flat.

LH_2 distribution: Comparison with MC



MMd(γ,K^-p) GeV/c^2

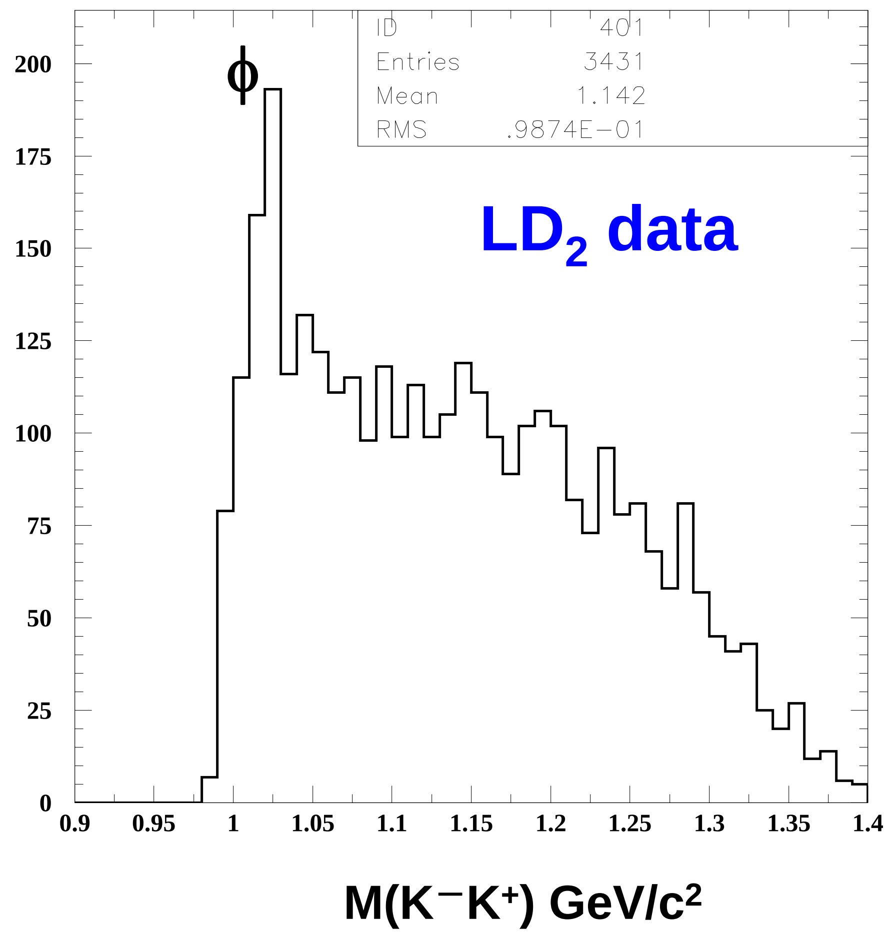
MC:

Energy dependence is obtained by fitting to data.

Angular distribution is assumed to be flat.

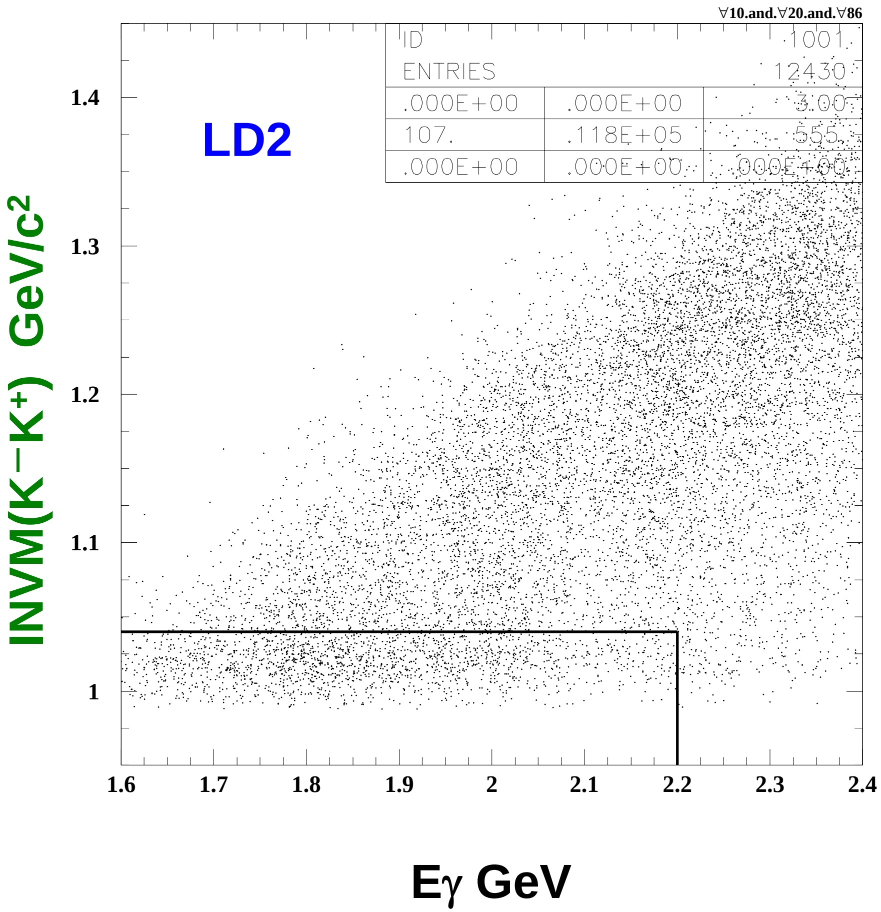
- **deuteron at rest was assumed in the missing mass calculaions.**
- **small missing mass events correspond to soft undetected kaons.**

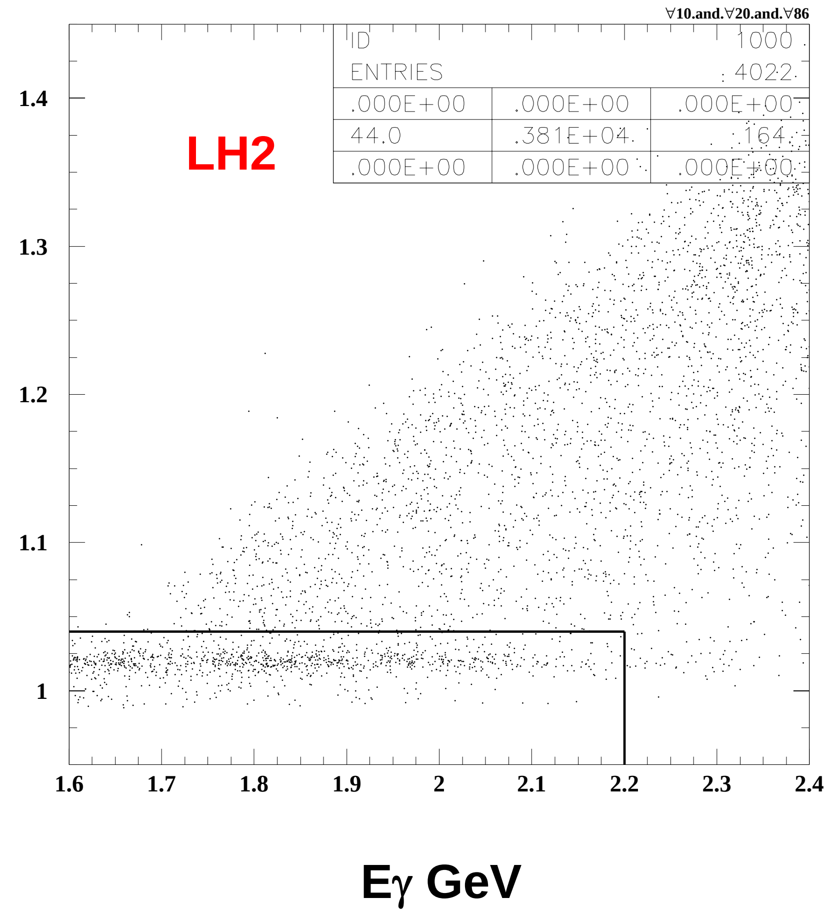
ϕ contribution



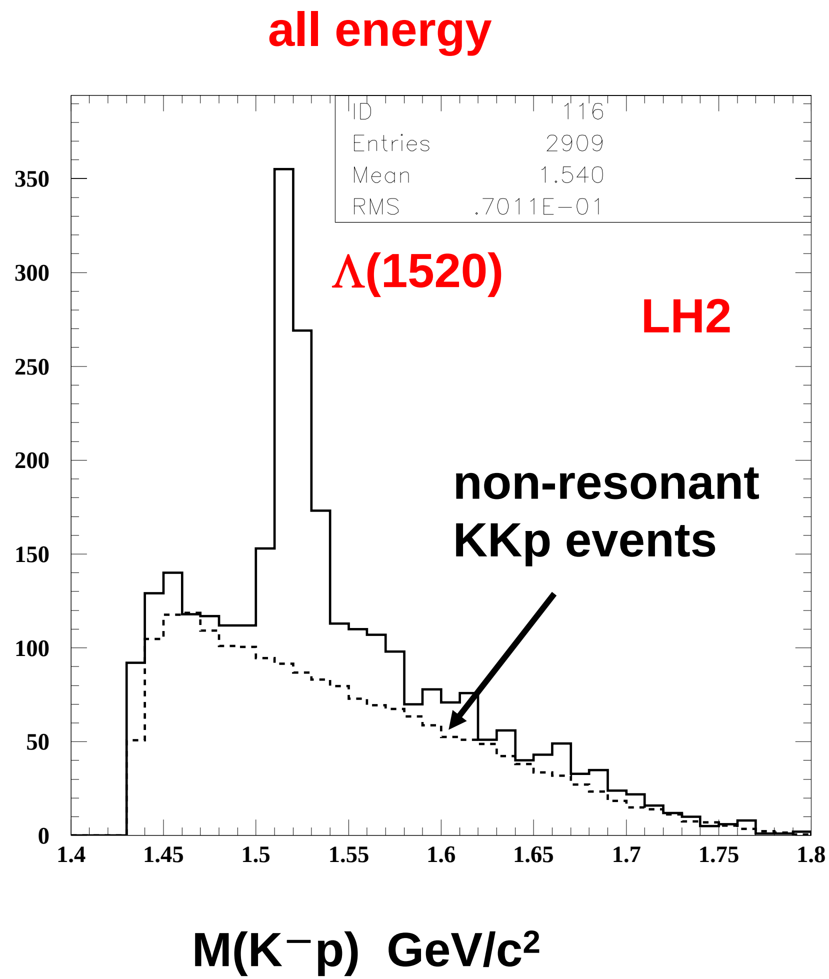
K+ momentum is estimated by missing momentum technique.
→ Smeared by Fermi motion.

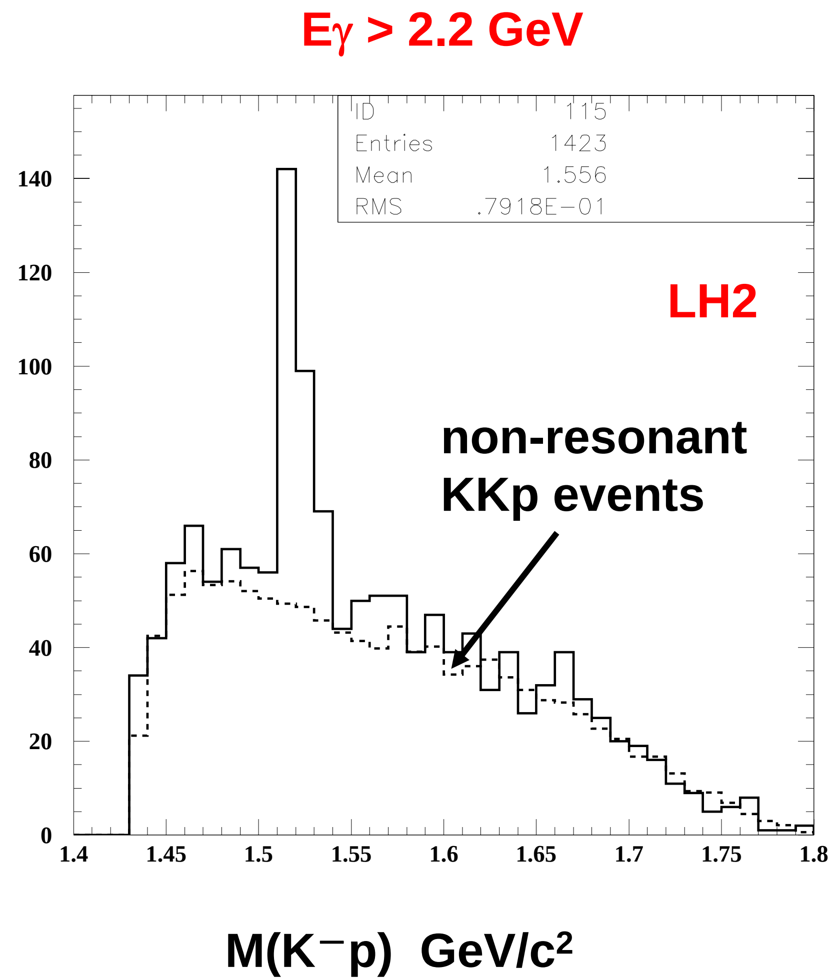
$K^{-}p$ invariant mass in the low energy region





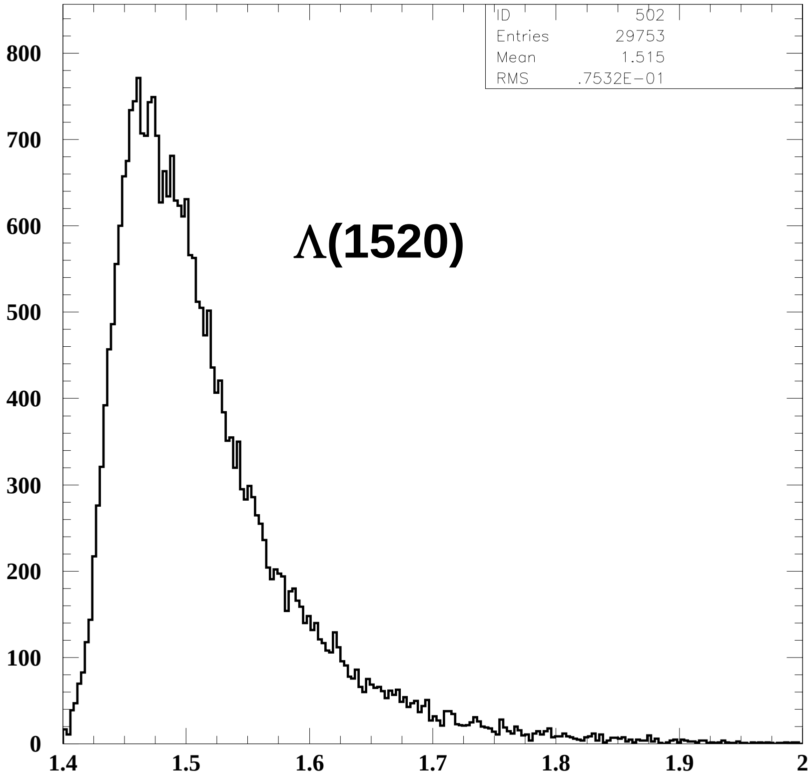
$K^{-}p$ invariant mass after ϕ exclusion





Non-resonant KKp (phase space) contribution
reproduces the spectrum shape under L(1520) well.

K^-p missing mass for $\Lambda(1520)$ and non-resonant events in the



MMd(γ,K^-p) GeV/c^2 **MMd(γ,K^-p) GeV/c^2**

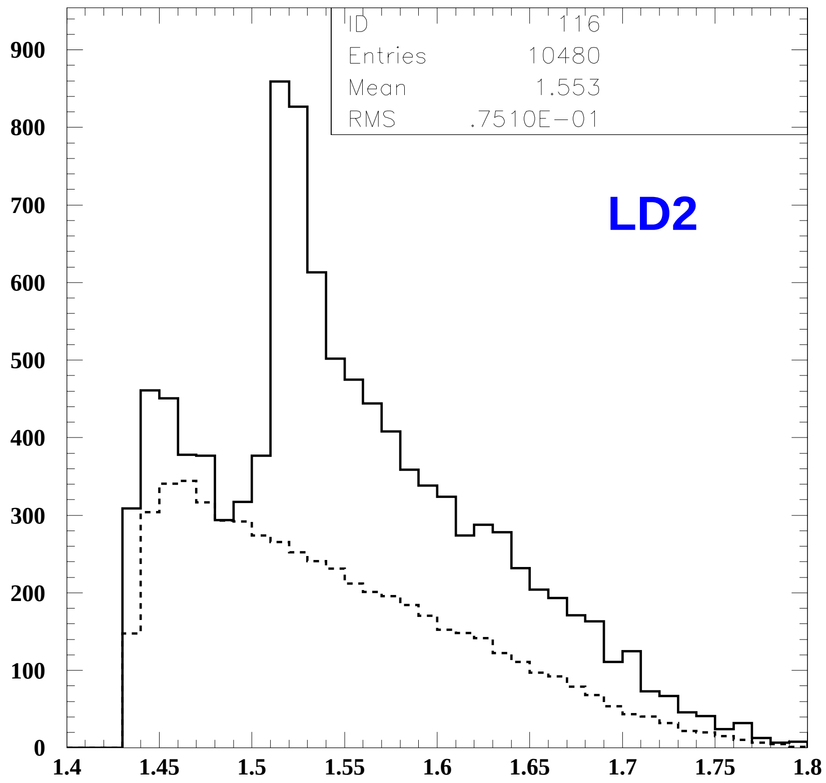
Energy dependences are set to be the same.

No angular dependence has been introduced in the both reactions.

$K^{-}p$ invariant mass after ϕ exclusion

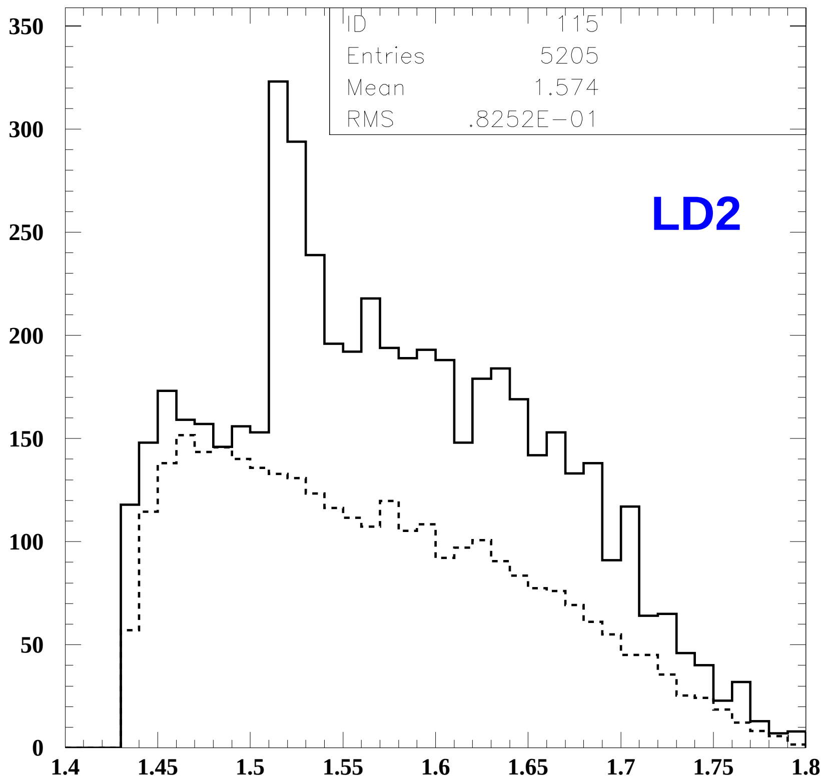
LD_2 data

all energy



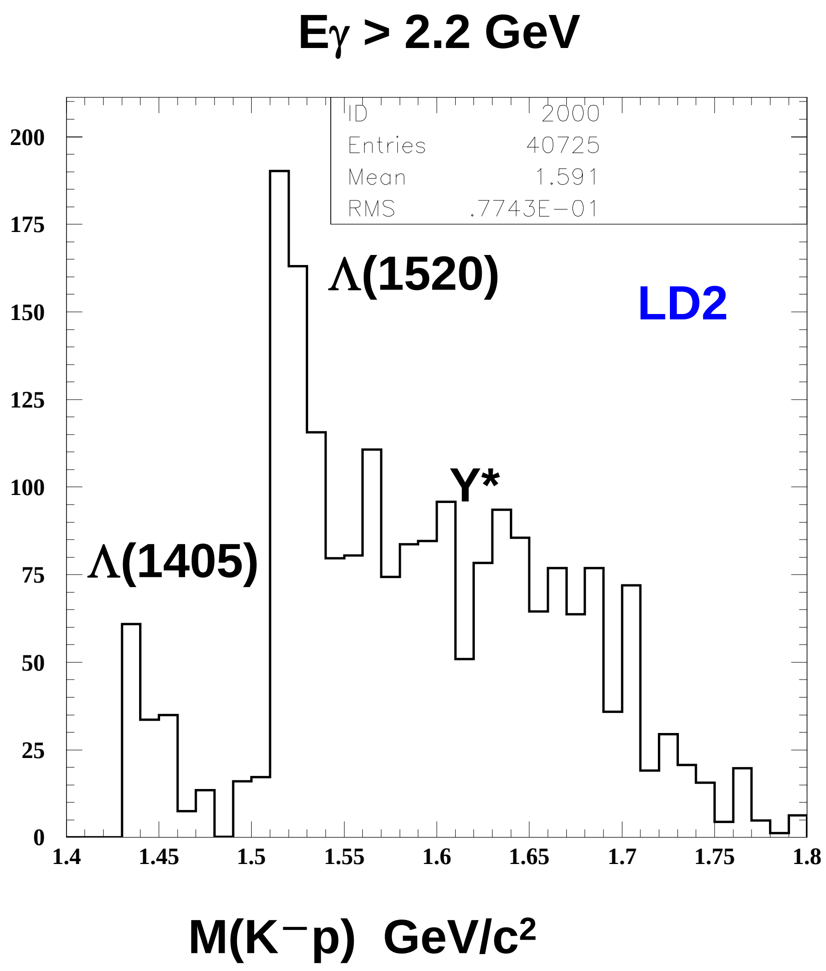
M(K⁻p) GeV/c²

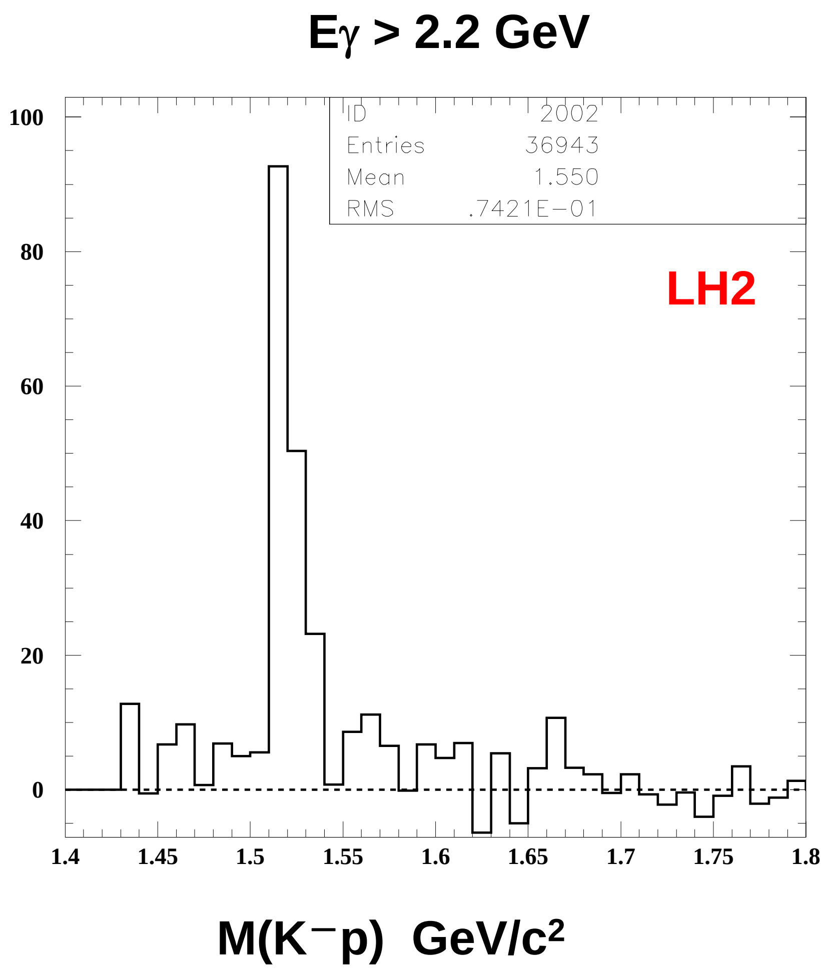
Eγ > 2.2 GeV



M(K⁻p) GeV/c²

K⁻p invariant mass after subtracting KKp



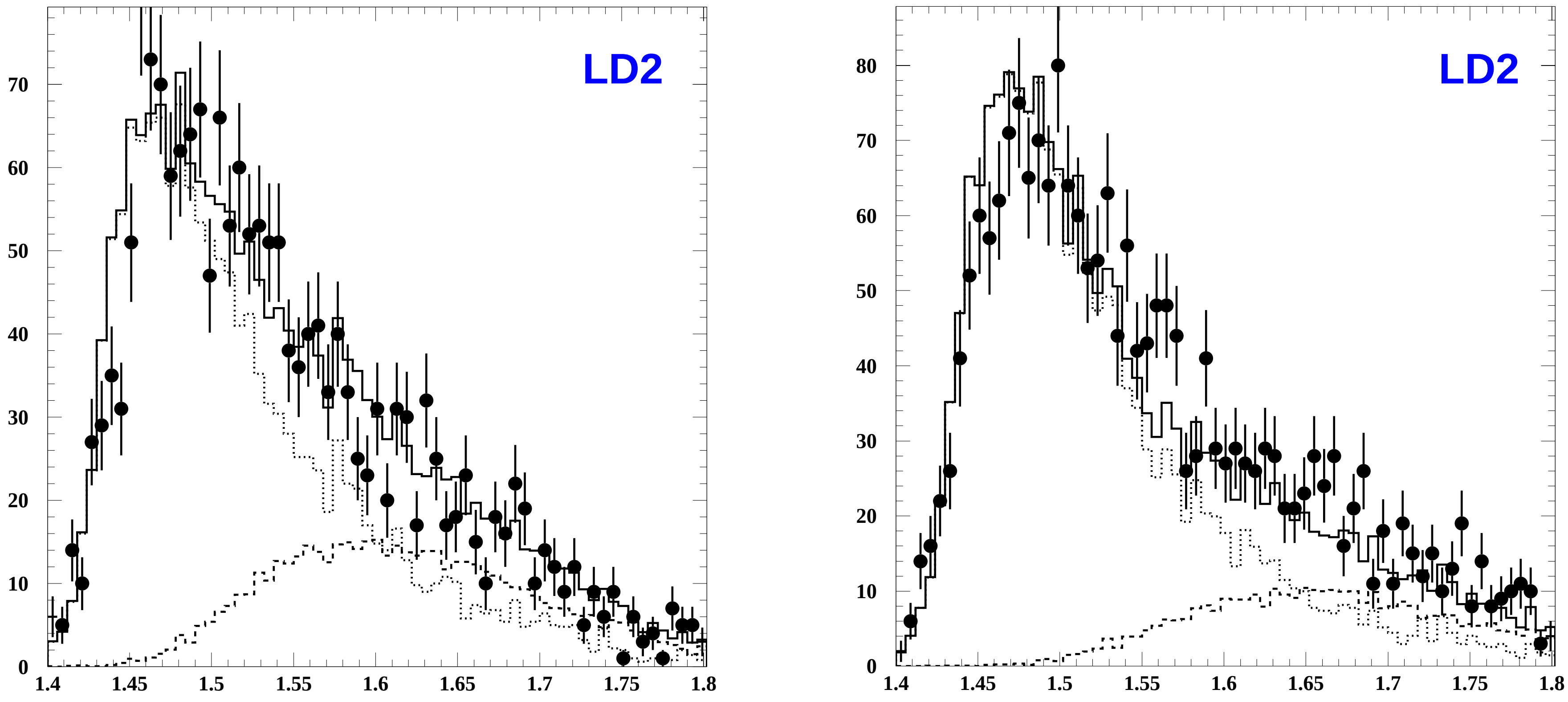


Enhancement of Λ(1405) and Y* productions from neutron?

K⁻p missing mass in the sideband regions

1.46< M(K⁻p) < 1.50 GeV/c²

1.54< M(K⁻p) < 1.58 GeV/c²



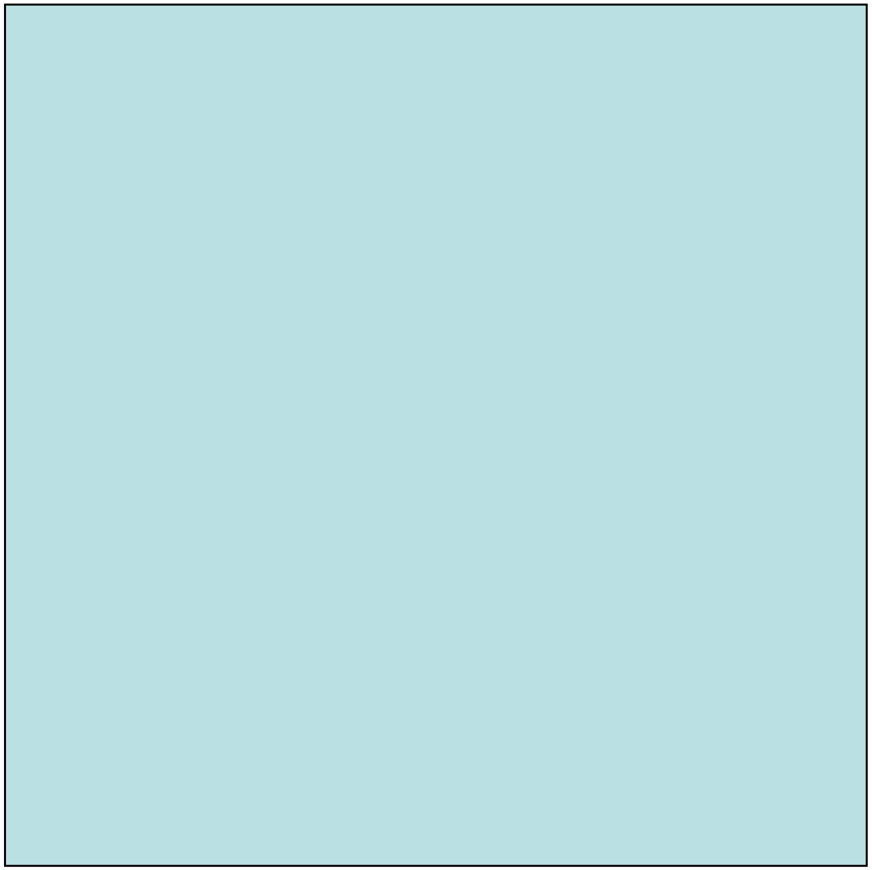
MMd(γ ,K⁻p) GeV/c²

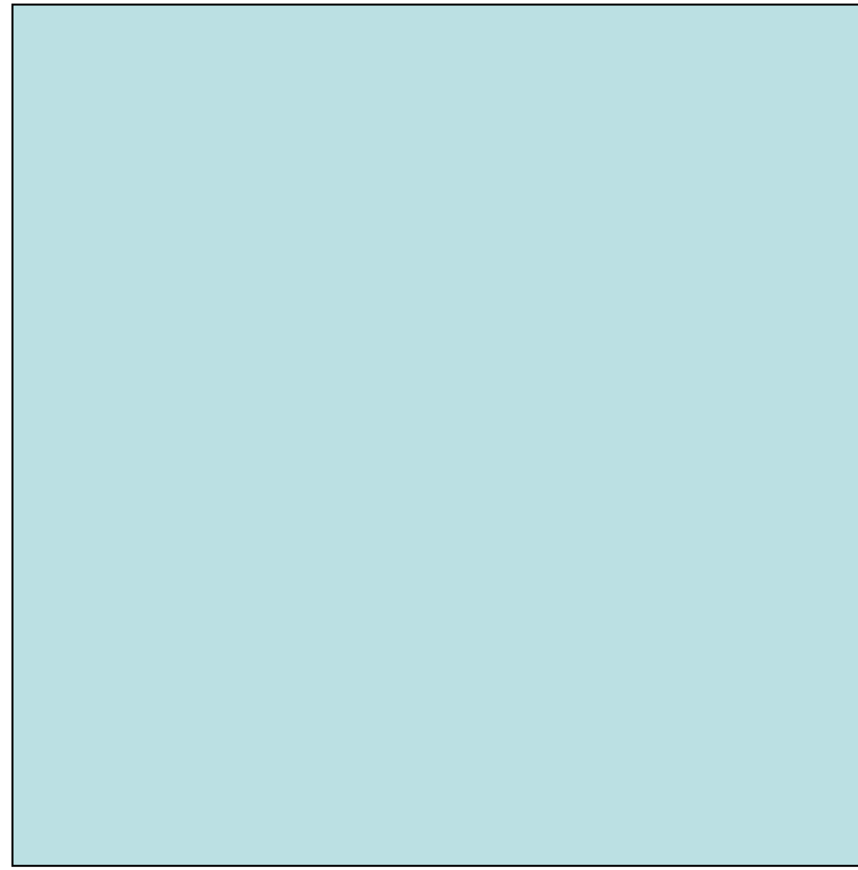
MMd(γ ,K⁻p) GeV/c²

ϕ: Energy and angular dependences were obtained by fitting to the data.

KKp: Enegy dependence → fit to the data. Angulardependence → flat.

K^-p missing mass for $\Lambda(1520)$





Test by side-band subtraction

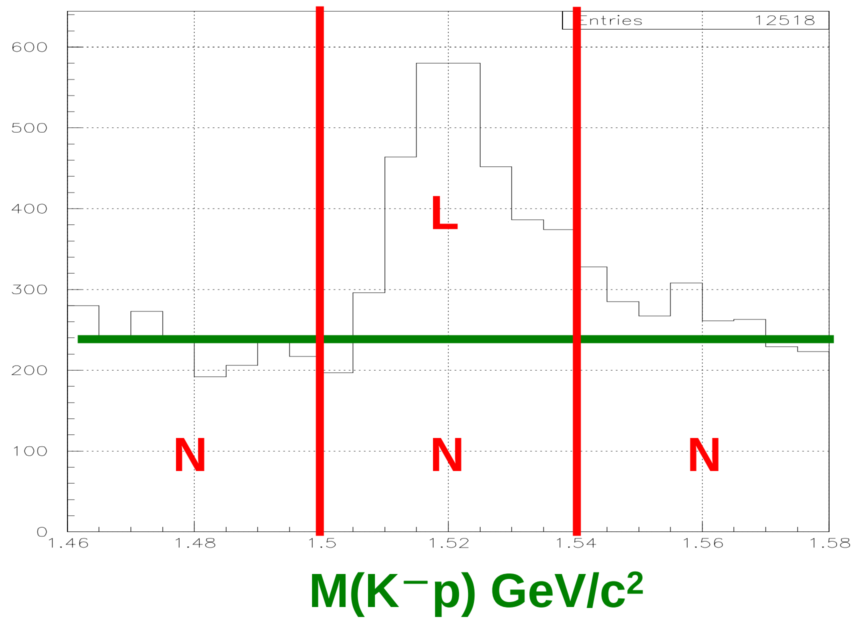
Narrow gate ($1.52 < M(K^-p) < 1.54$ GeV/c^2) = L + N

$\Lambda(1520)$ is enhanced.

Wide gate ($1.46 < M(K^-p) < 1.58$ GeV/c^2) = L + 3N

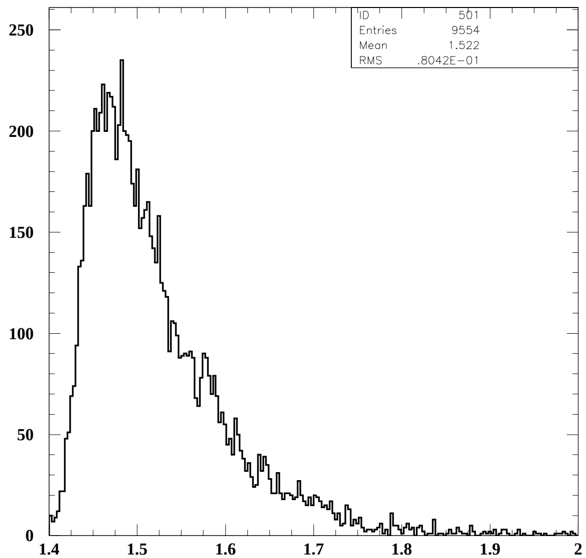
Non-resonant KKp is enhanced.

$$\Rightarrow \quad L = 1.5\,\underbrace{(L+N)}_{\text{narrow gate}} - 0.5\,\underbrace{(L+3N)}_{\text{wide gate}}$$



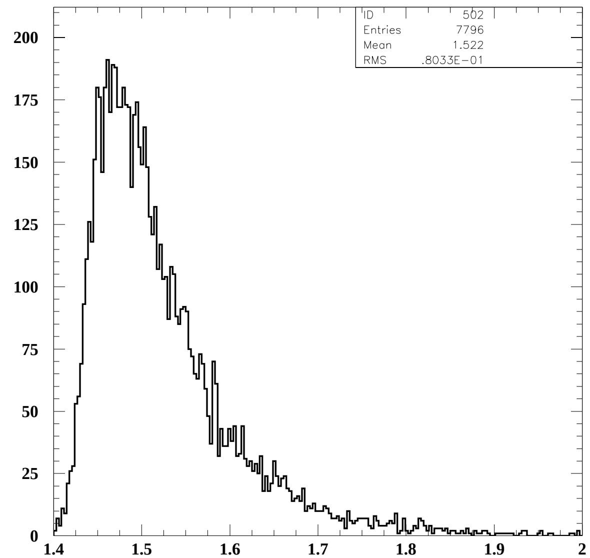
K⁻p missing mass for non-resonant KKp events

1.46< M(K⁻p) < 1.50 GeV/c²



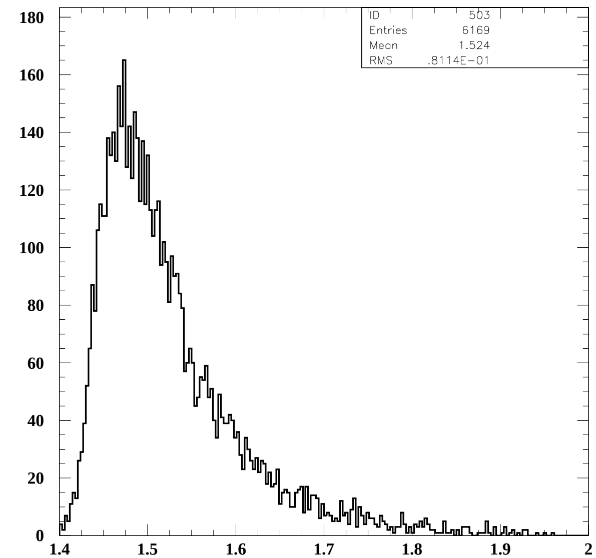
MMd(γ,K⁻p) GeV/c²

1.50< M(K⁻p) < 1.54 GeV/c²



MMd(γ,K⁻p) Ge V/c²

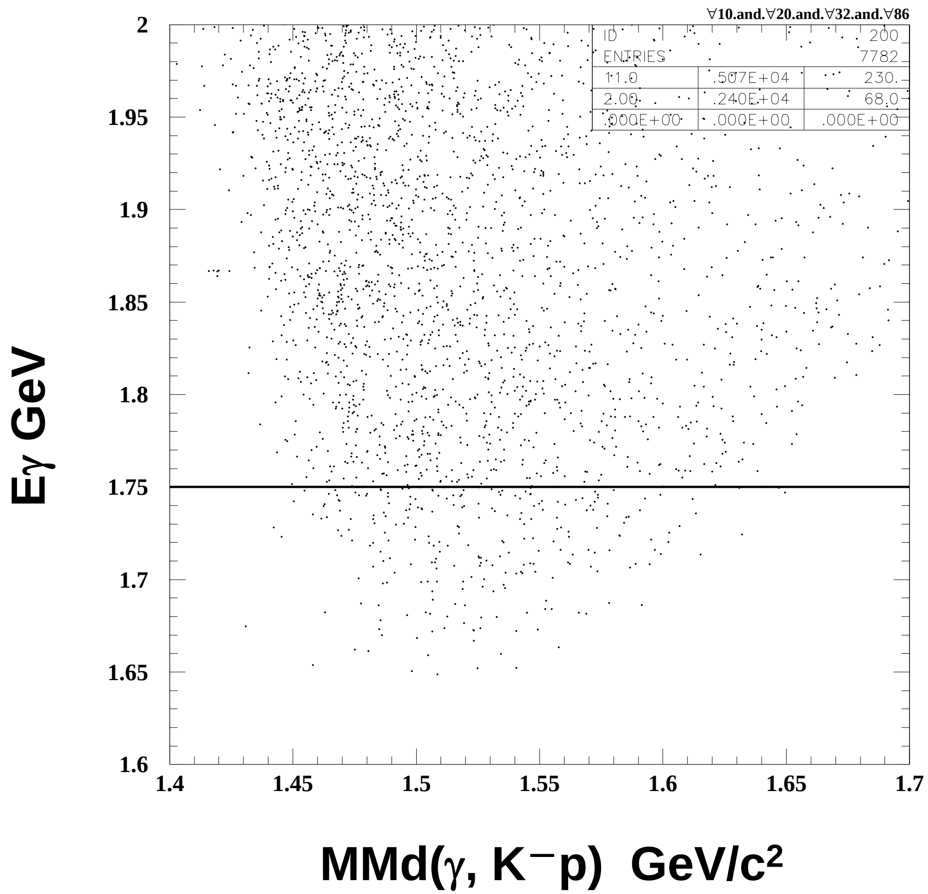
1.54< M(K⁻p) < 1.58 GeV/c²



MMd(γ,K⁻p) GeV/c²

Missing mass spectrum shapes are almost identical. → Sideband subtraction works well.

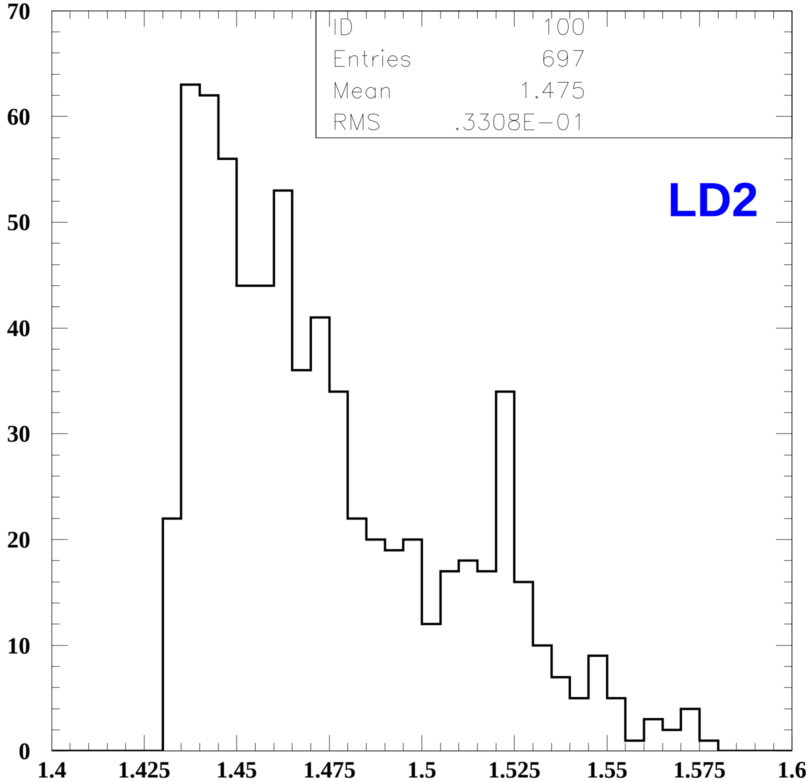
K⁻p missing mass vs. Eγ for KKp events



Events in low Eγ concentrated in the signal region.
→ Sideband subtraction will not work well in this energy region.

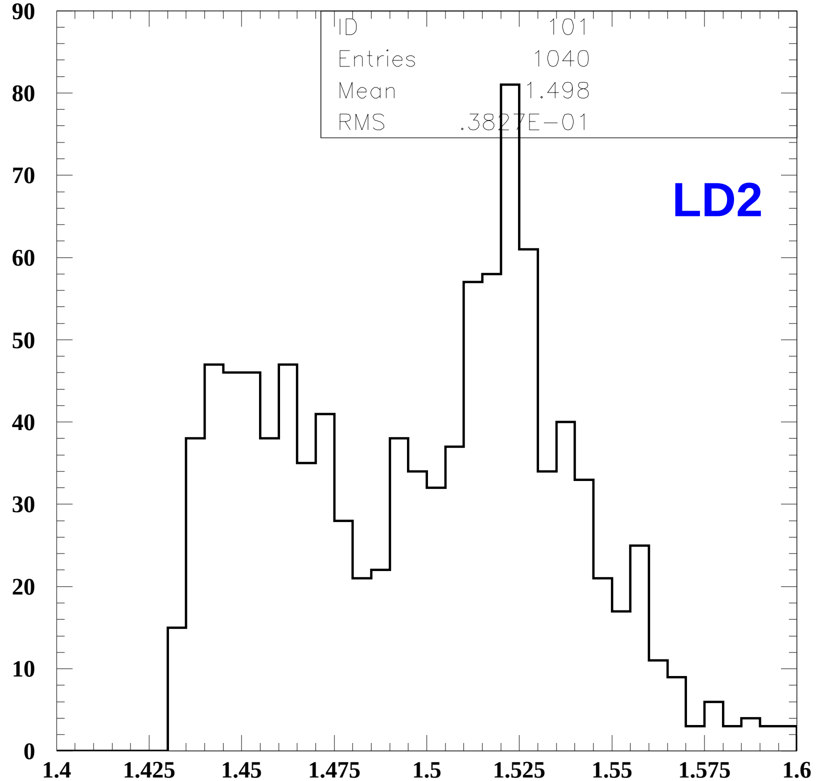
K^-p invariant mass in the low photon energy regions

$E\gamma$ < 1.75 GeV



M(K^-p) GeV/c^2

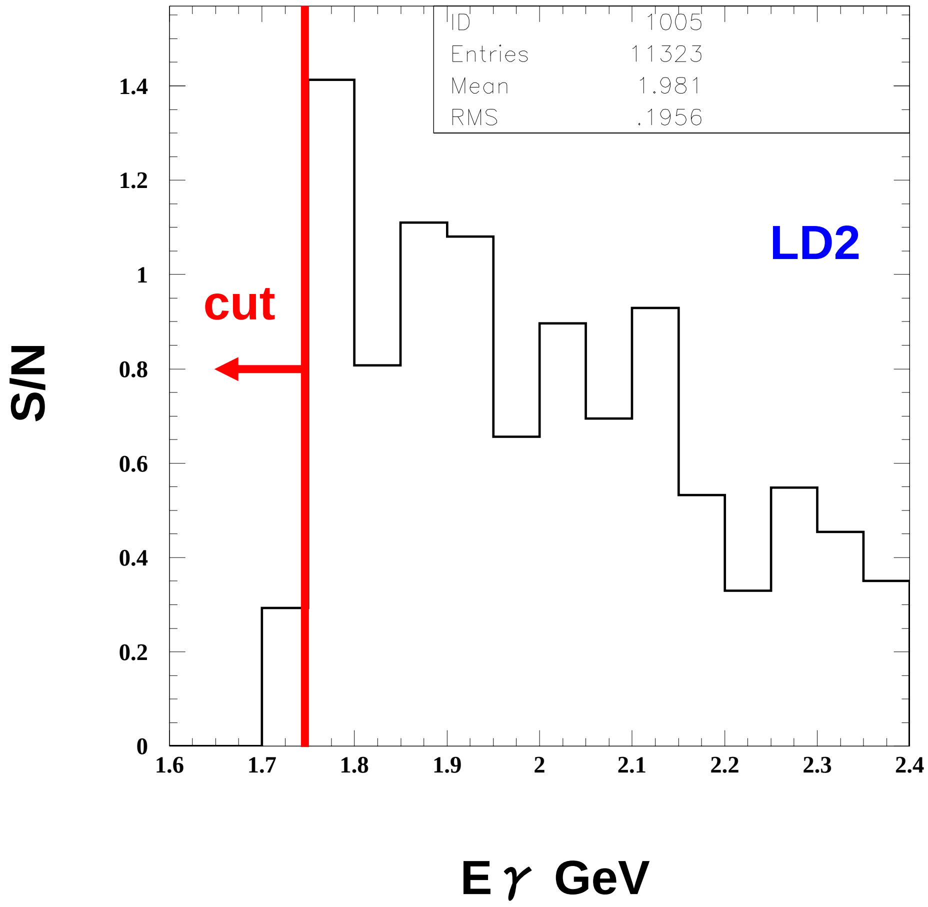
1.75 < $E\gamma$ < 1.85 GeV



M(K^-p) GeV/c^2

Contribution from Λ(1520) is small below 1.75 GeV.

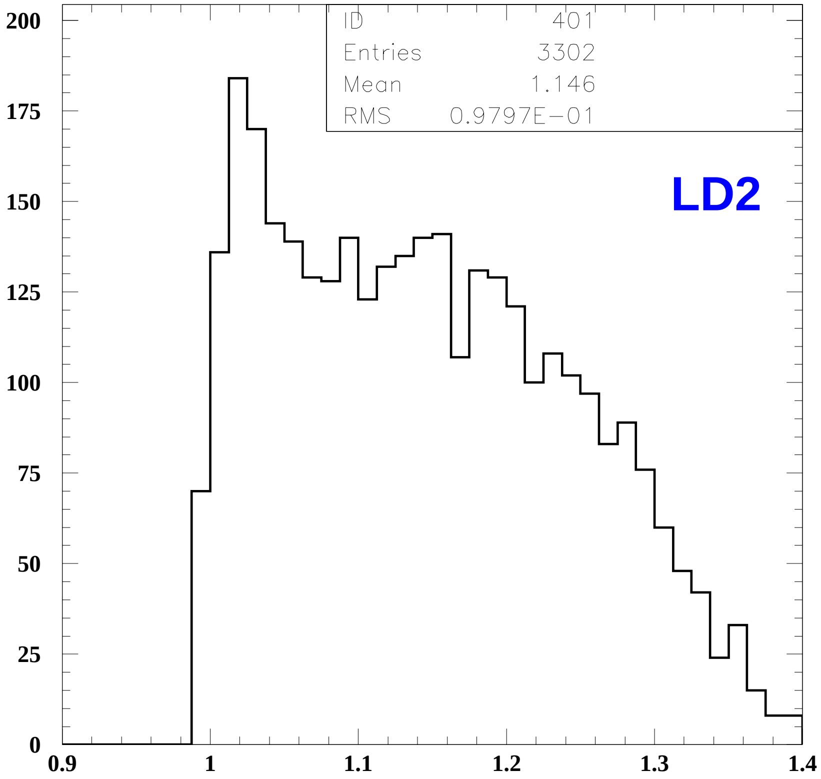
S/N (Λ(1520)/Others)



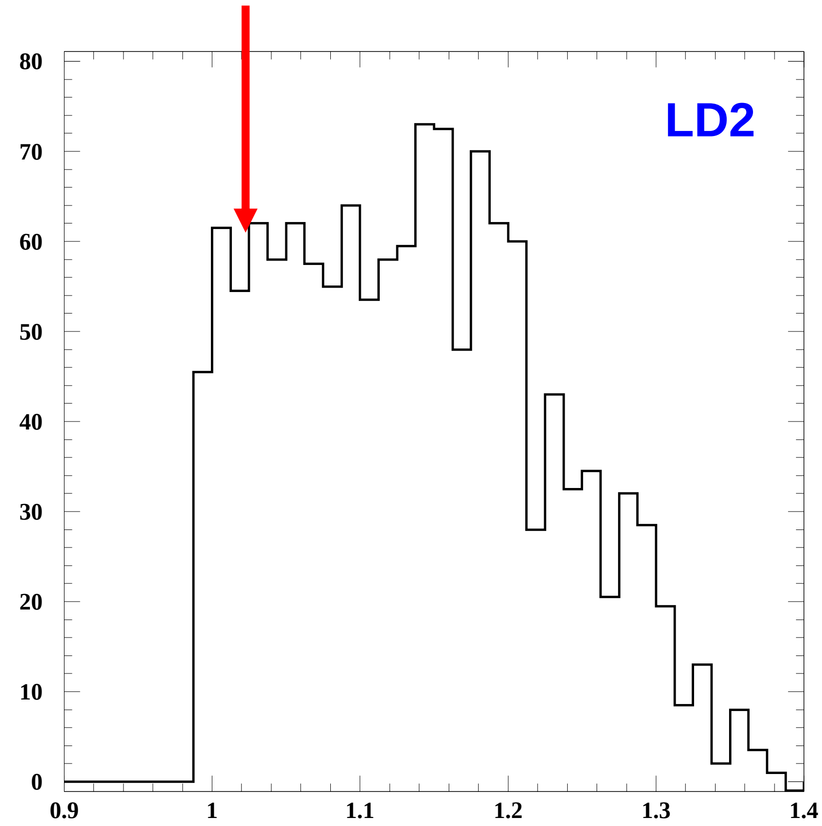
S/N is bad near threshold and in the high energies.

Side-band subtraction in KK invariant mass

Since ϕ is not related with $\Lambda(1520)$, ϕ peak disappears.



M(K$^+$,K$^-$) GeV/c^2



M(K$^+$,K$^-$) GeV/c^2

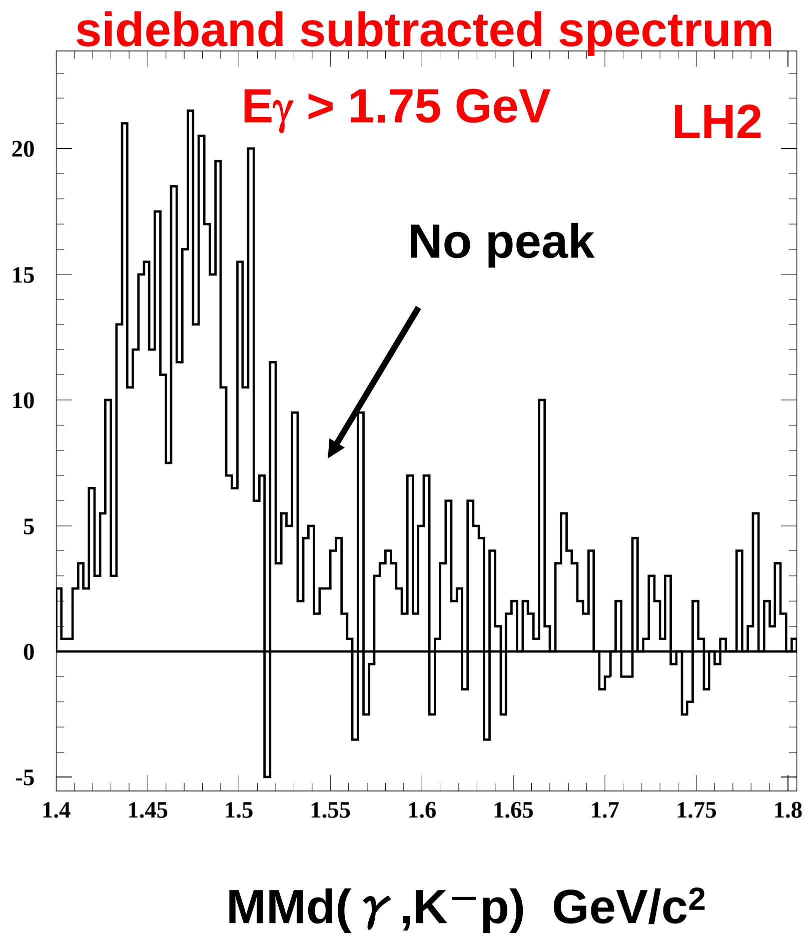
after side-band subtraction

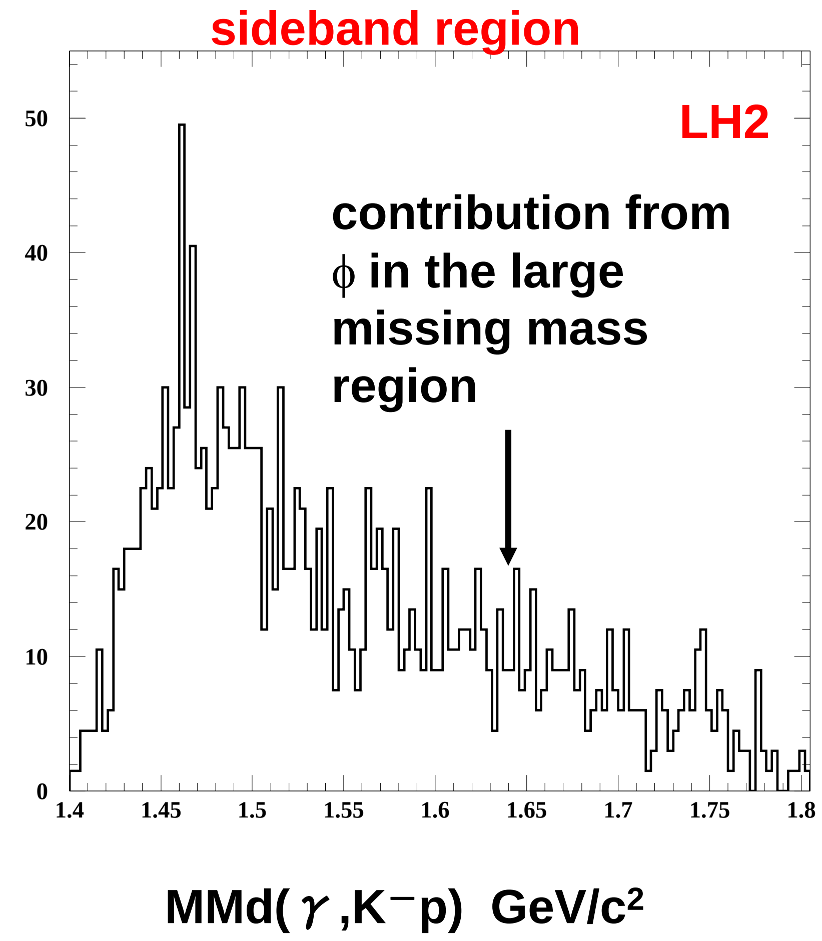
Side-band subtraction in $K^{-}p$ missing mass

MMd(γ,$K^{-}p$) GeV/c^2

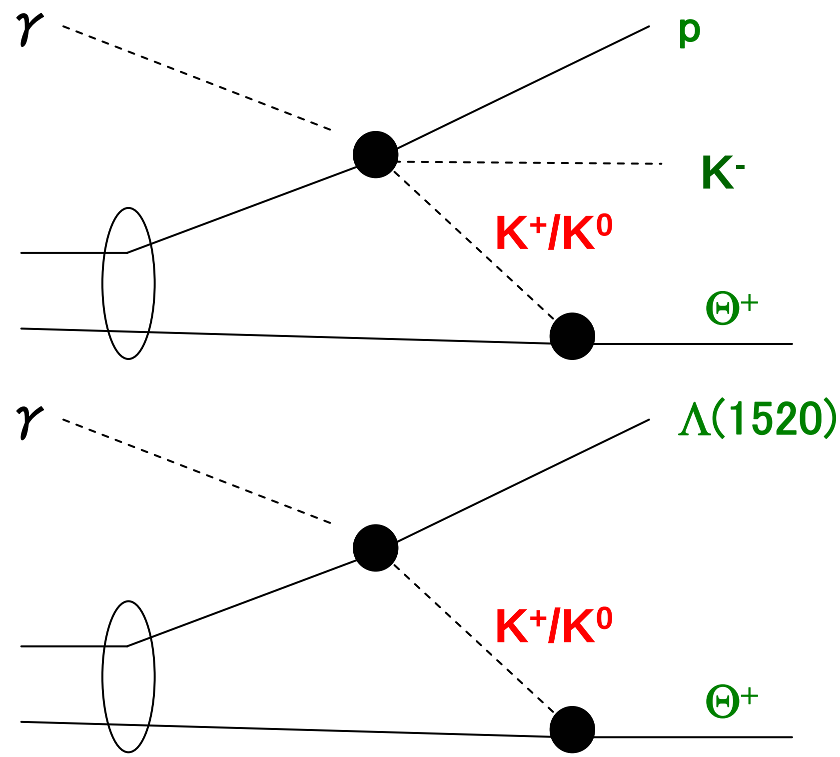
MMd(γ,$K^{-}p$) GeV/c^2
after side-band subtraction

K^-p missing mass (assuming deuteron at rest) from LH2 (proton) data





K⁻p missing mass in sideband regions



Θ^+ formation cross-section by simple kaon re-scattering should be small.

A. Titov estimated it is small.

Width

The resolution study is underway.

The resolution depends on both photon energy and momenta of charged particles.
→need to know energy and angular distributions of the signal.

The estimation of the width depends on the BG shape and level.

Width: Comparison with a MC spectrum

MMd(γ,K^{-}p) GeV/c^2

Conclusion