Cascades in COMPASS

Presented by G.Brona
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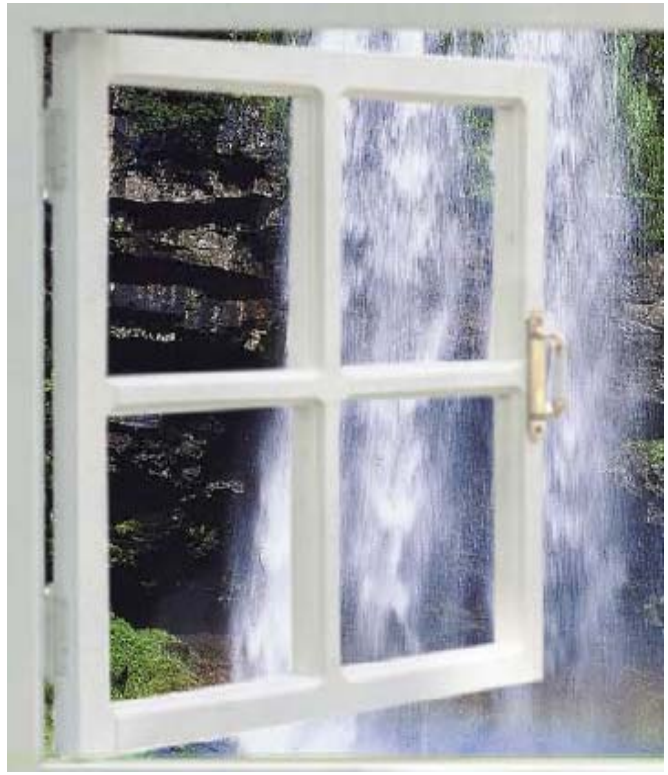
On behalf of the COMPASS collaboration

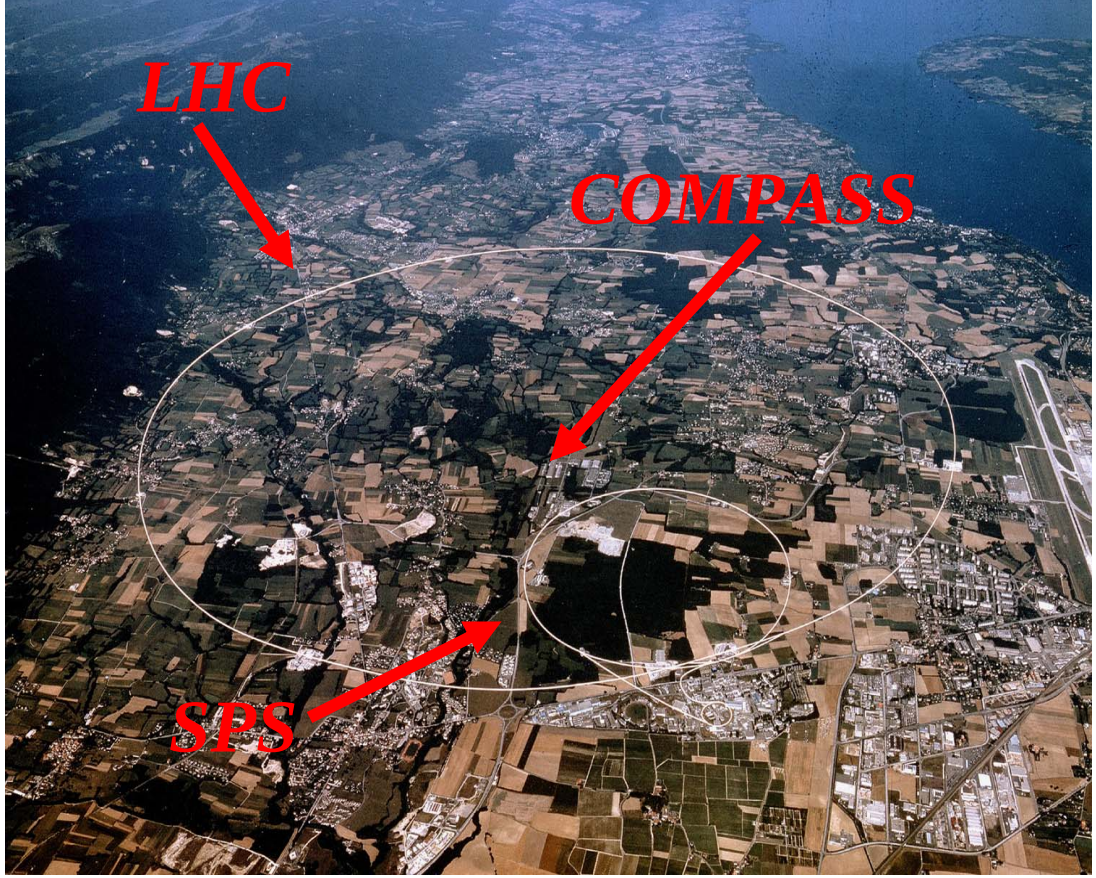


Outline:

1. **COMPASS experiment in a muon programme**
2. **Cascades spectroscopy in a muon programme**
3. **COMPASS experiment in a hadron programme**
4. **Plans and prospects for hadron spectroscopy**
5. **Summary**

Cascade Physics – A New Window On Baryon Spectroscopy
Jlab, Newport News, 1-3 December 2005

COmmon Muon and Proton Apparatus for Structure and Spectroscopy

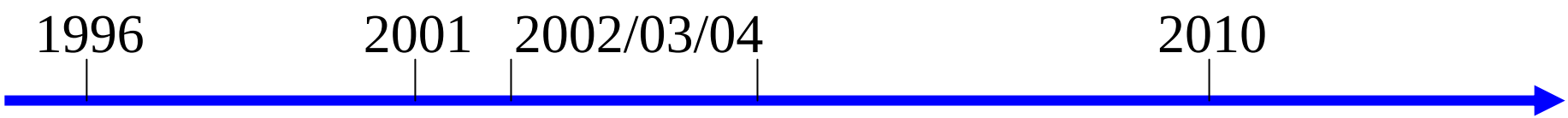


1996 COMPASS Proposal

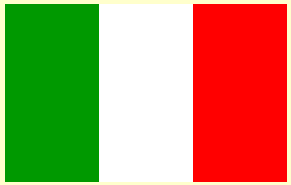
2001 Technical Run

2002, 2003, 2004 Data Taking (no data taking in 2005)

Data Taking Foreseen till 2010



The collaboration of ~250 physicists from 12 countries

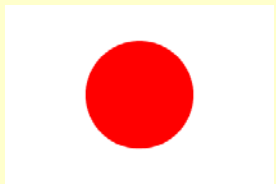


Torino(University,INFN),

Trieste(University,INFN)

Prague

Warsaw (WU, SINS, TU)



Nagoya

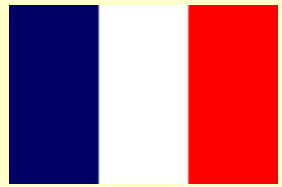
Tel Aviv

Dubna (LPP and LNP), Moscow (INR, LPI, State University), Protvino

Bielefeld, Bochum, Bonn (ISKP & PI), Erlangen, Freiburg, Heidelberg, Mainz, München (LMU & TU)

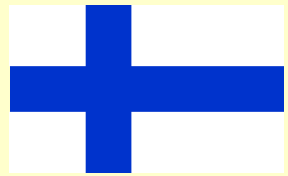
Lisboa

Saclay

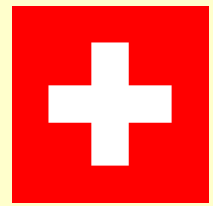


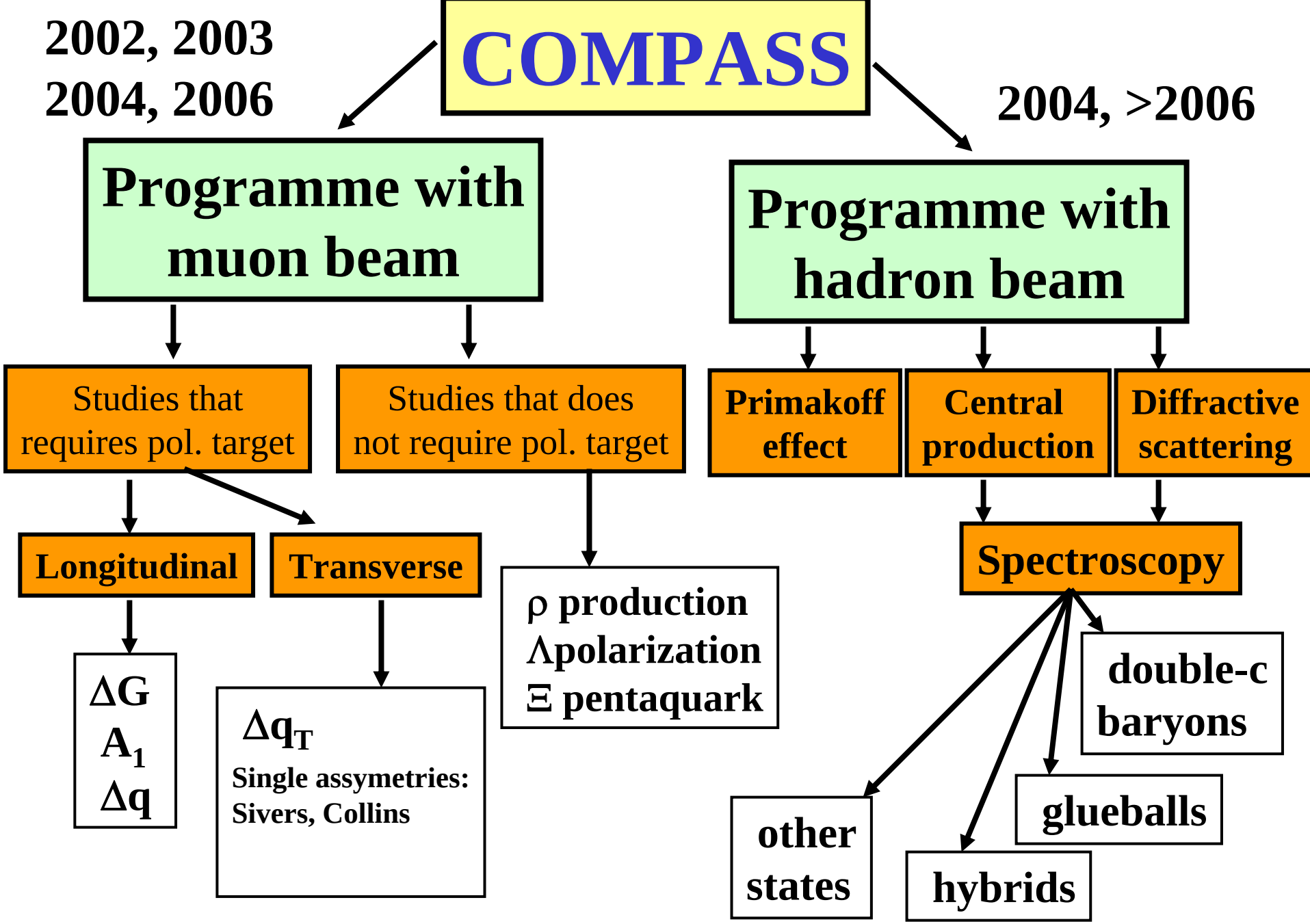
Burdwan, Calcutta

Helsinki

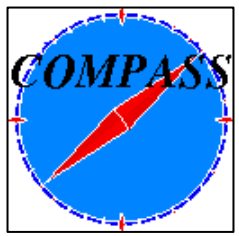


CERN



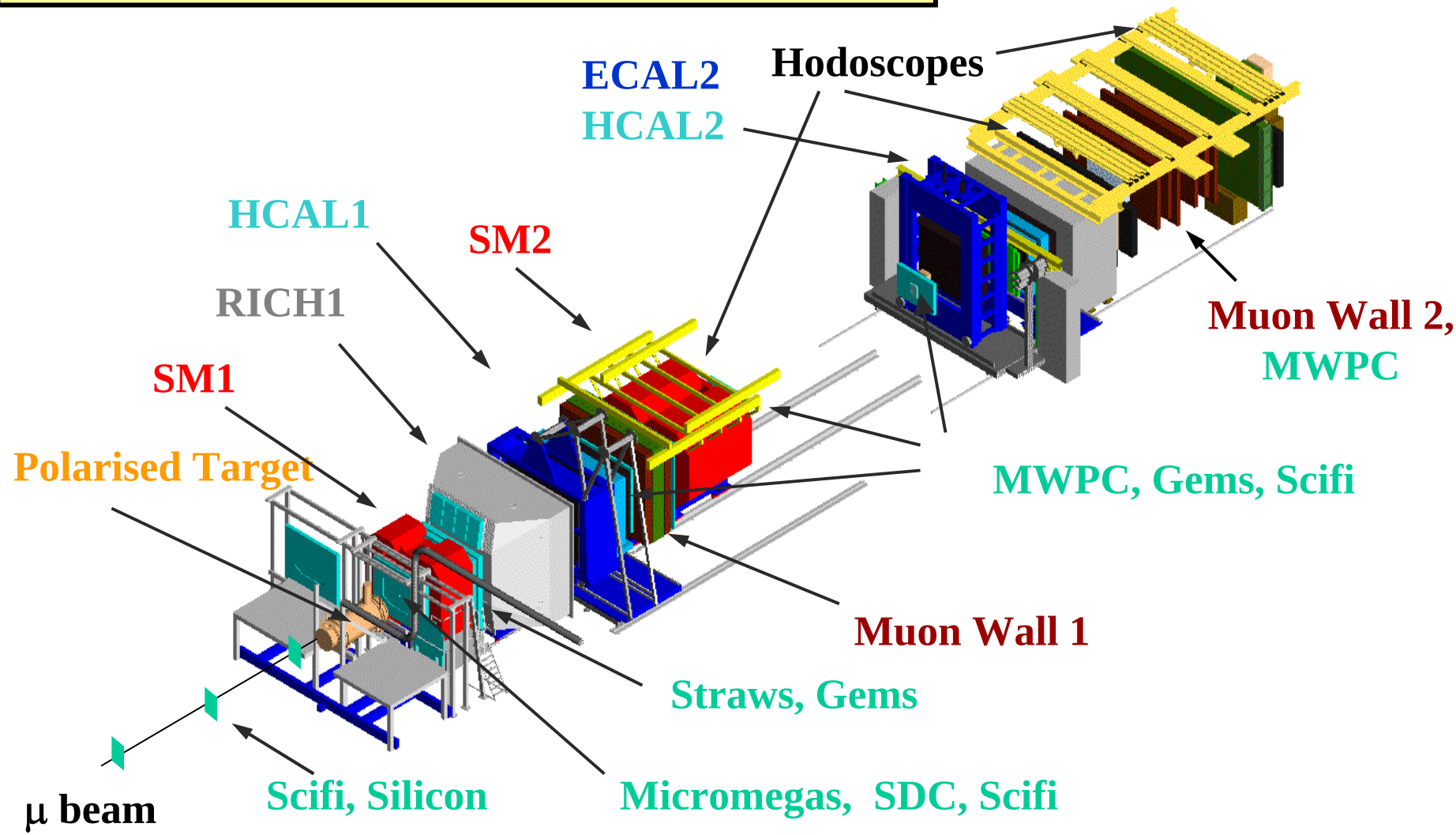

2002, 2003
2004, 2006
COMPASS
2004, >2006
Programme with muon beam
Programme with hadron beam
Studies that requires pol. target
Studies that does not require pol. target
Primakoff effect
Central production
Diffractive scattering
Longitudinal
Transverse
Spectroscopy
ρ production
Λpolarization
Ξ pentaquark
ΔG
A1
Δq
ΔqT
Single assymetries:
Sivers, Collins
double-c baryons
glueballs
other states
hybrids

Spectrometer setup and programme with the muon beam



Spectrometer for muon programme

2003 setup



Beam: $2 \cdot 10^8$ μ^+/ spill (4.8s / 12s)

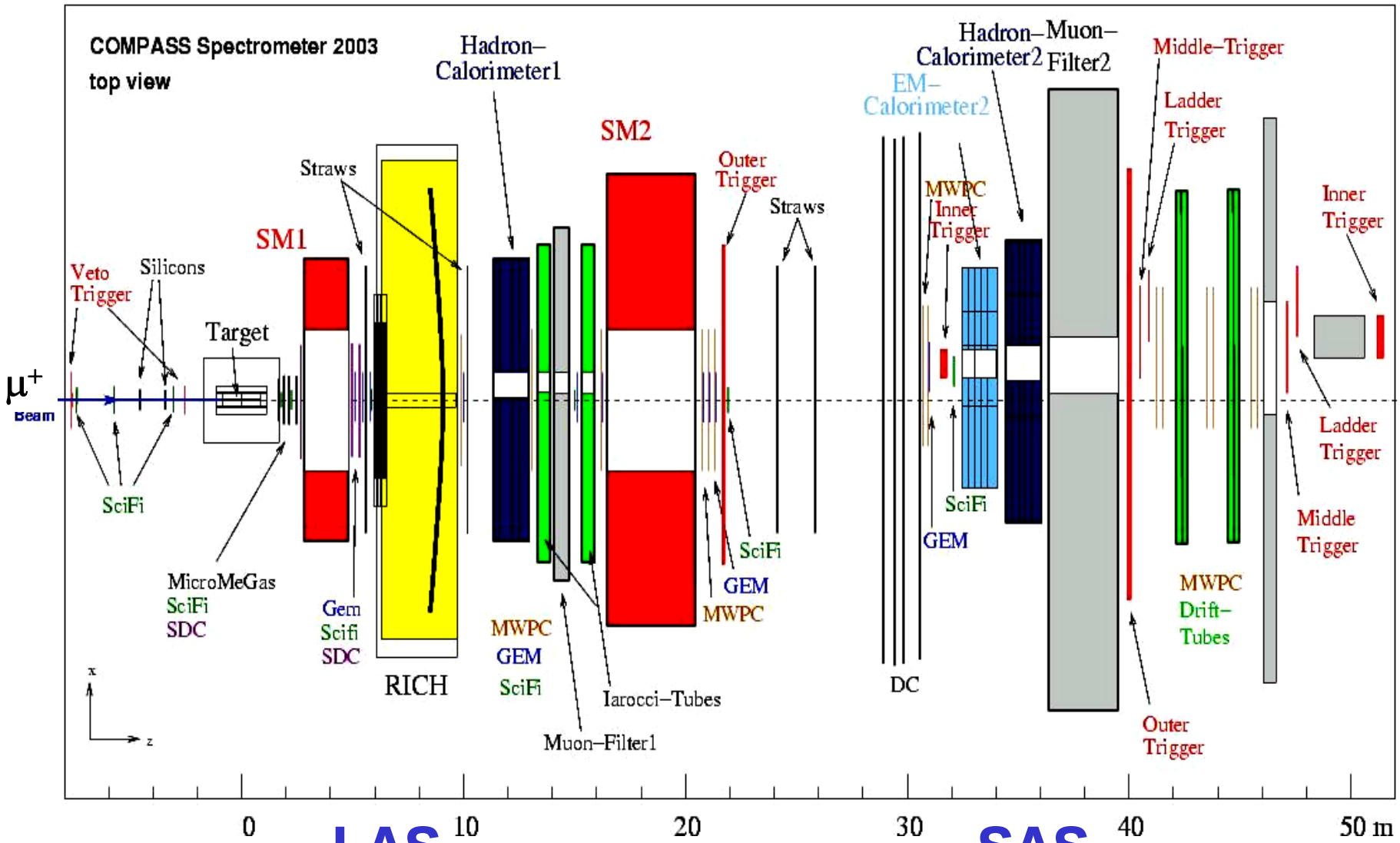
Beam momentum: 160 GeV/c

Luminosity: ~$5 \cdot 10^{32}$ cm^{-2} s^{-1}

Beam polarization: -76%

Spectrometer for muon programme

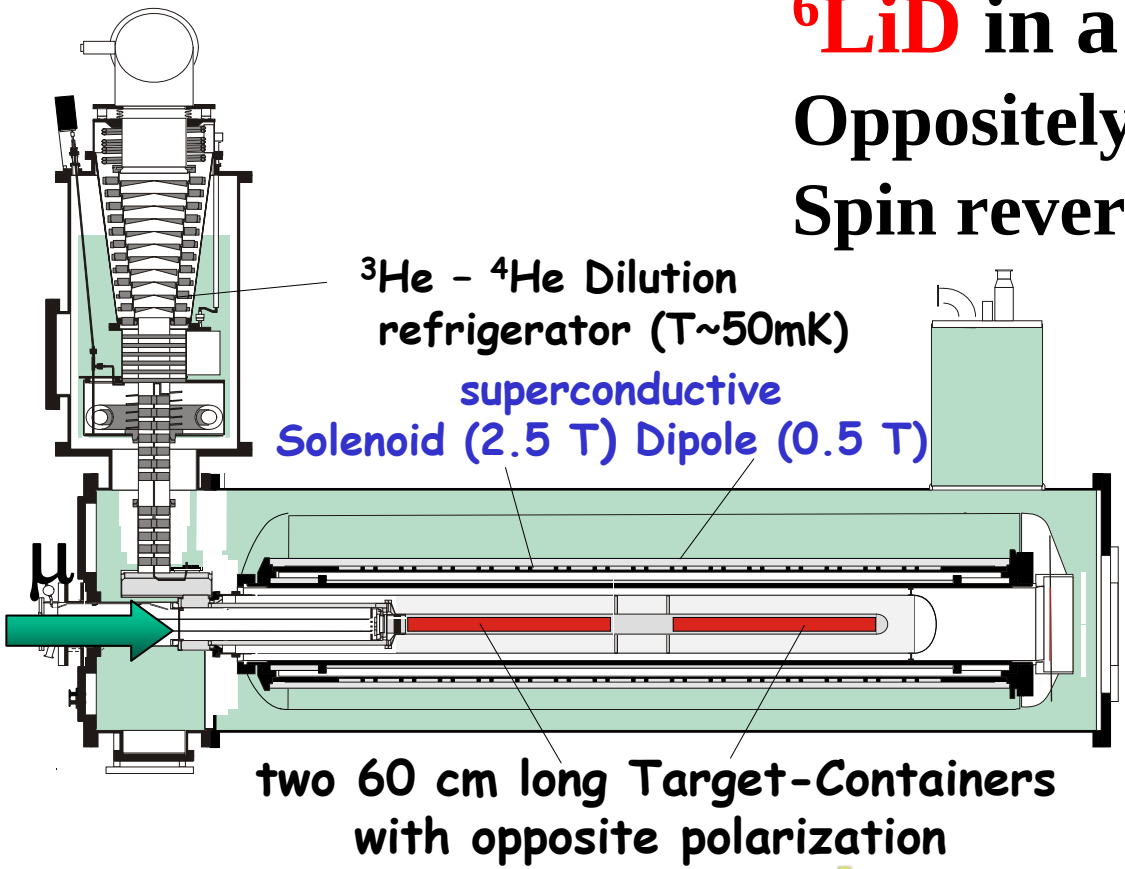
2003 setup



LAS (>30 mrad, >0.4GeV/c)

SAS (<30 mrad, >4GeV/c)

Target for muon programme



^{6}LiD in a solid state

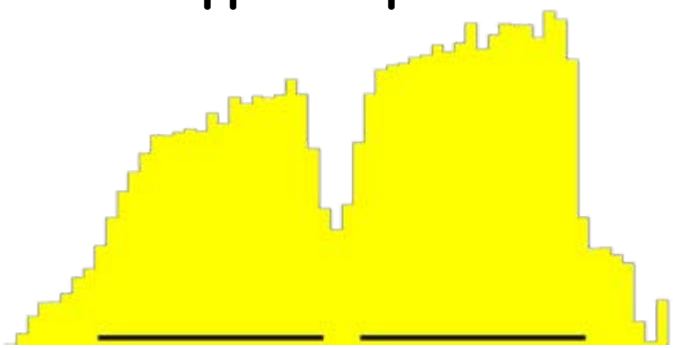
Oppositely polarized ~50%

Spin reversal every 8h

Acceptance:

2002-4 ±70 mrad

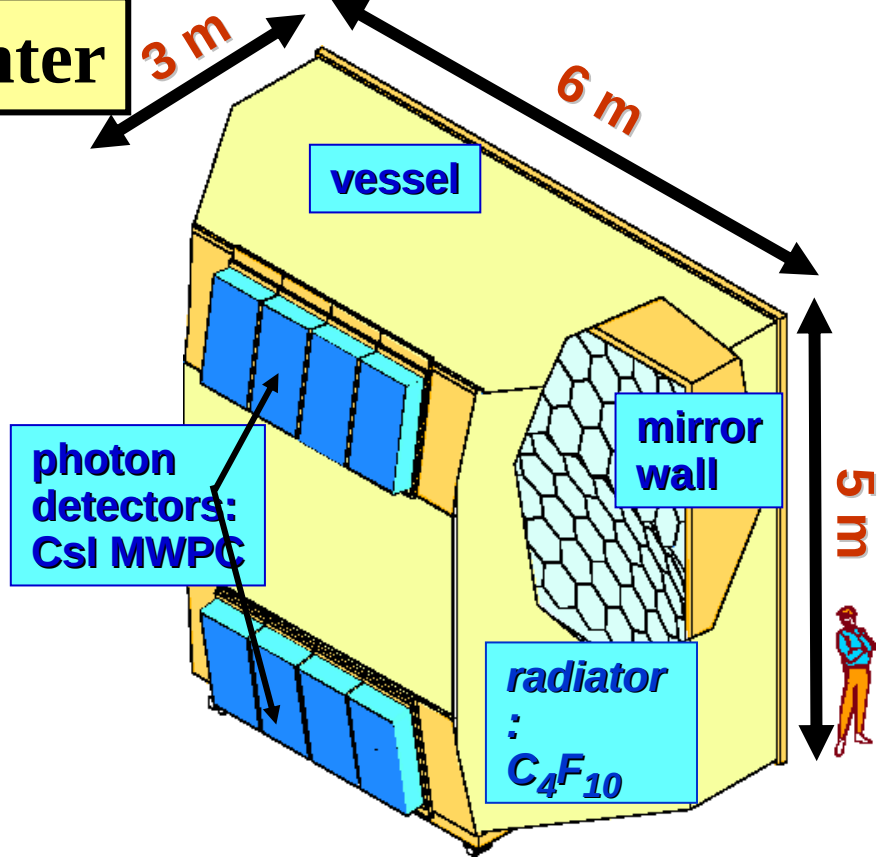
>2006 ±180 mrad

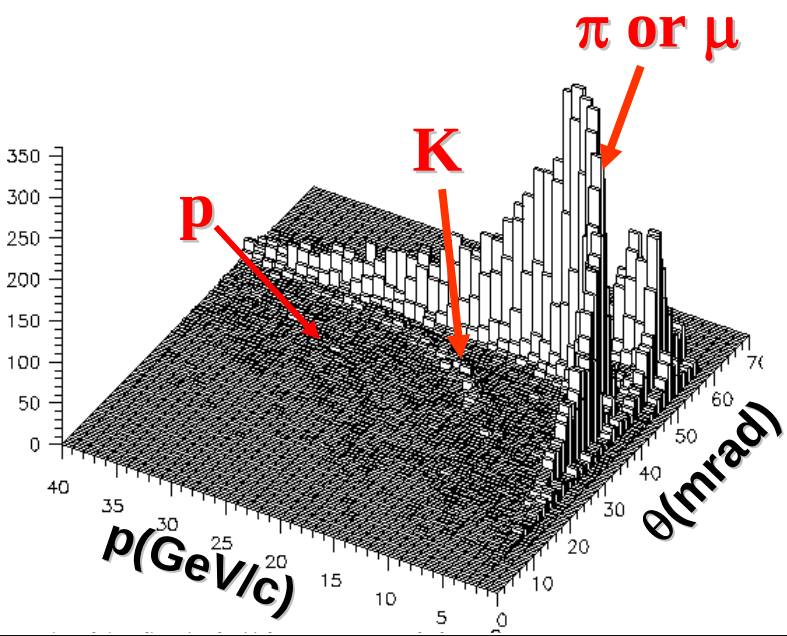


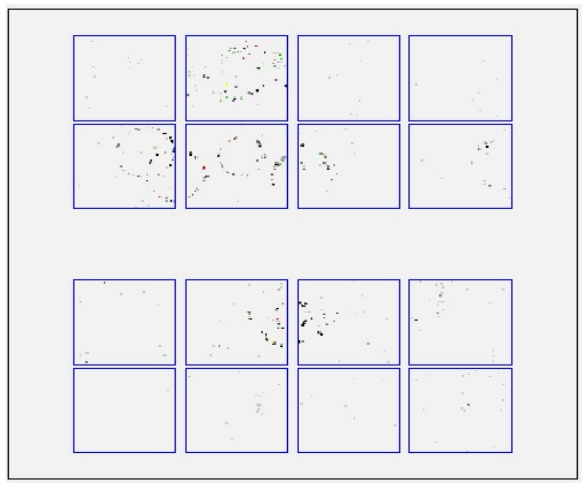
vertex reconstruction

Ring Imaging CHerenkov Counter

- >80 m^3 filled with C_4F_{10}
- 116 VUV mirrors
- 5.3 m^2 photodetectors
  82 944 pixels
- >80k channels
- π/K/p identification up to 50 GeV from 2.5/9/17 GeV







Calorimetry

HCAL1:

$$\frac{\sigma}{E} = \frac{59.4\%}{\sqrt{E}} \oplus 7.6\%$$

for π

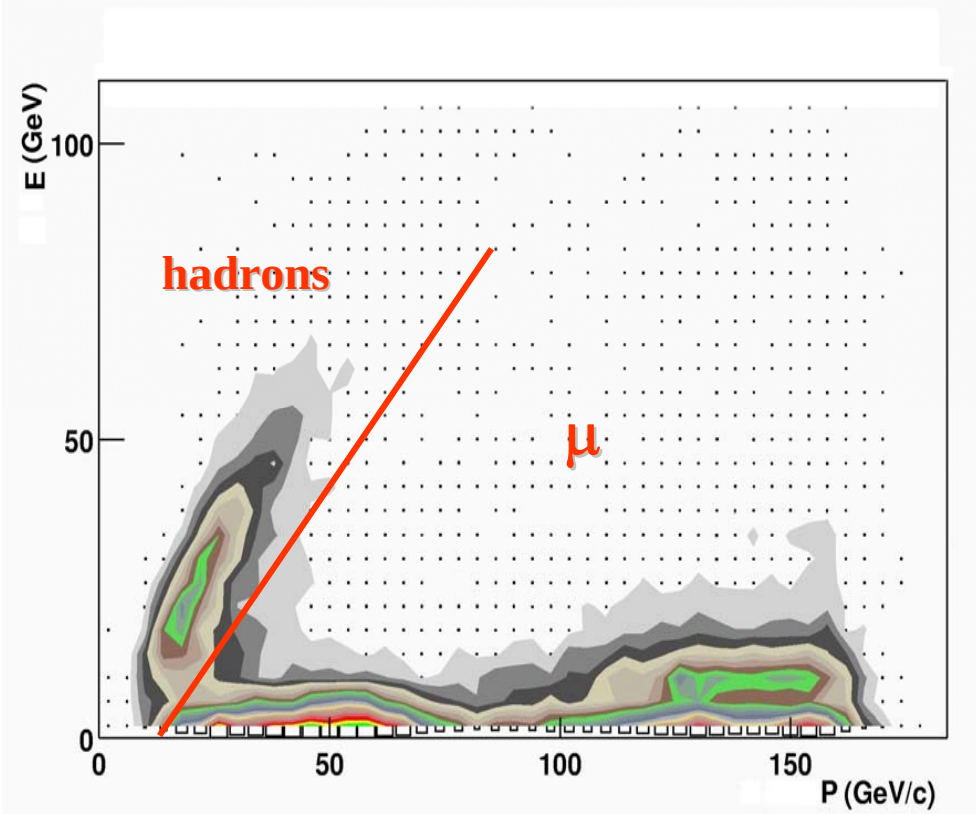
HCAL2:

$$\frac{\sigma}{E} = \frac{65\%}{\sqrt{E}} \oplus 4\%$$

for π

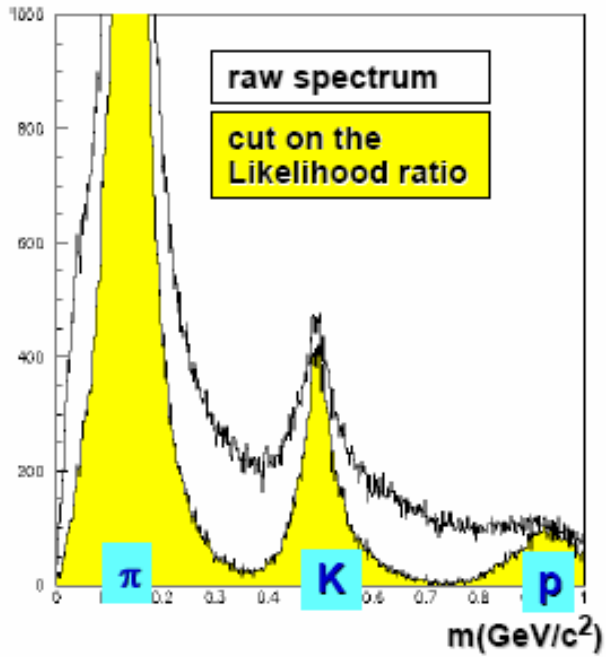
ECAL2:

$$\frac{\sigma}{E} = \frac{5.8\%}{\sqrt{E}} \oplus 2.3\%$$

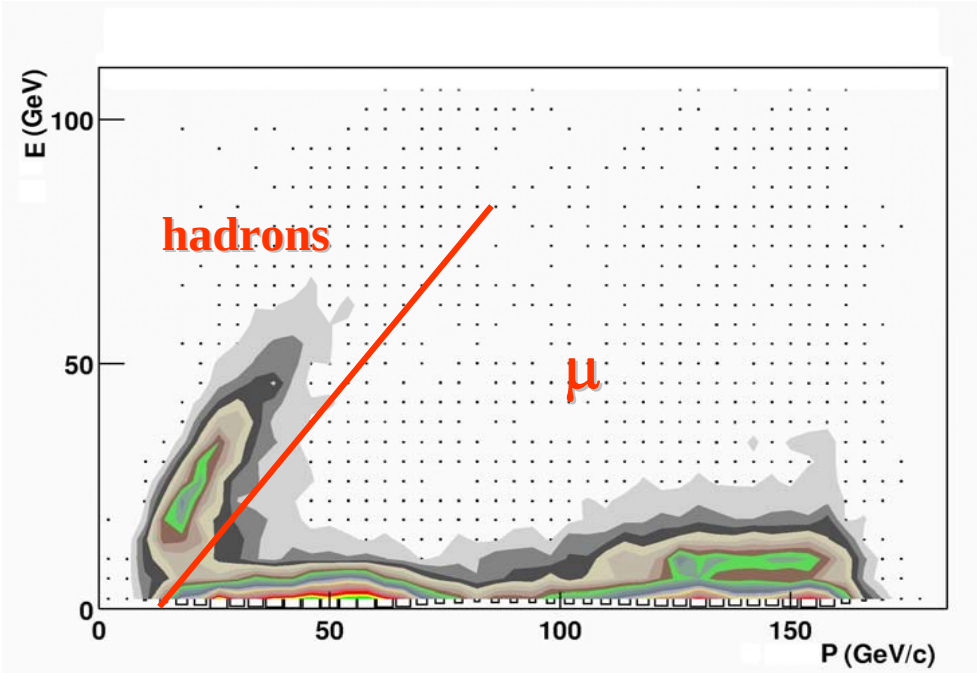


Particles identification

RICH (π/K/p)

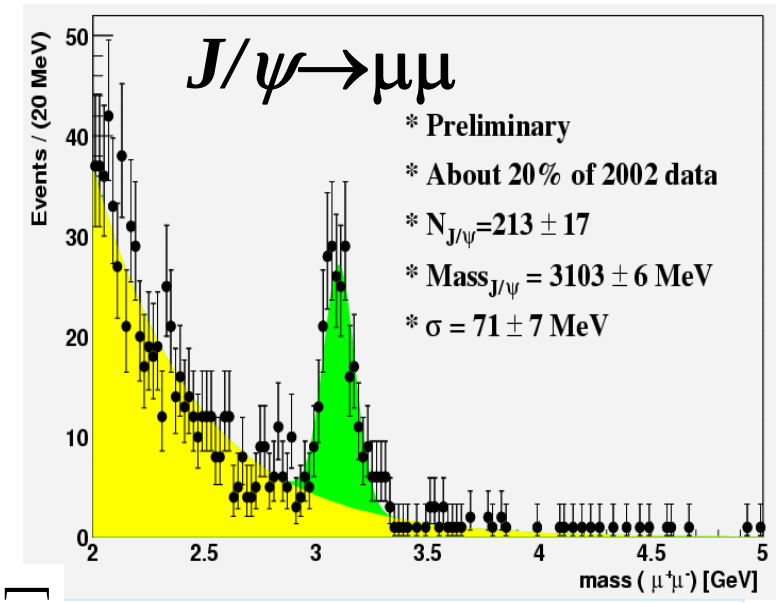


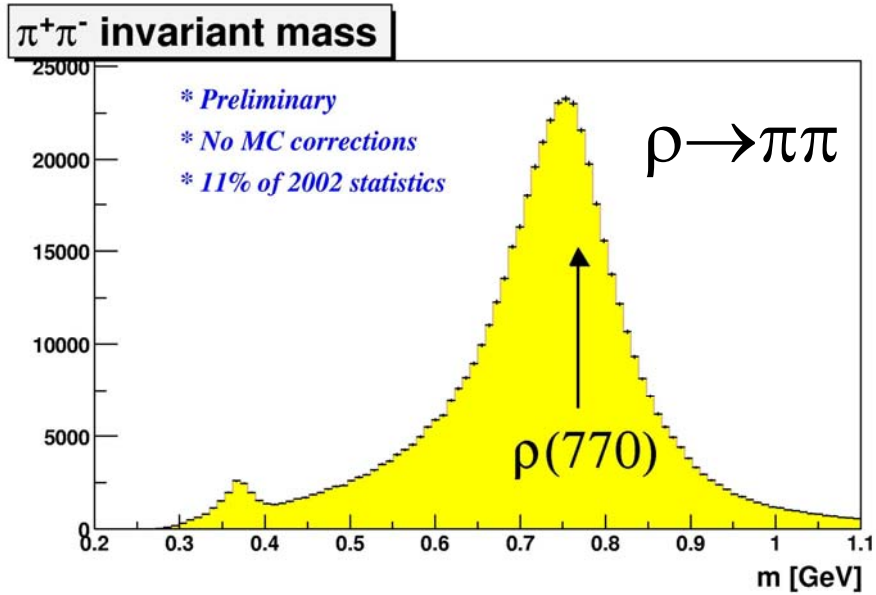
HCAL (hadrons/μ)

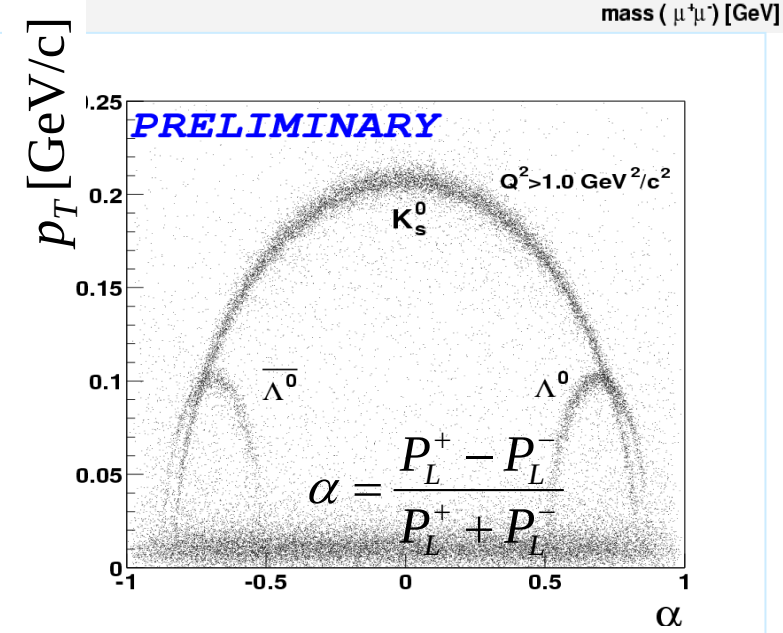


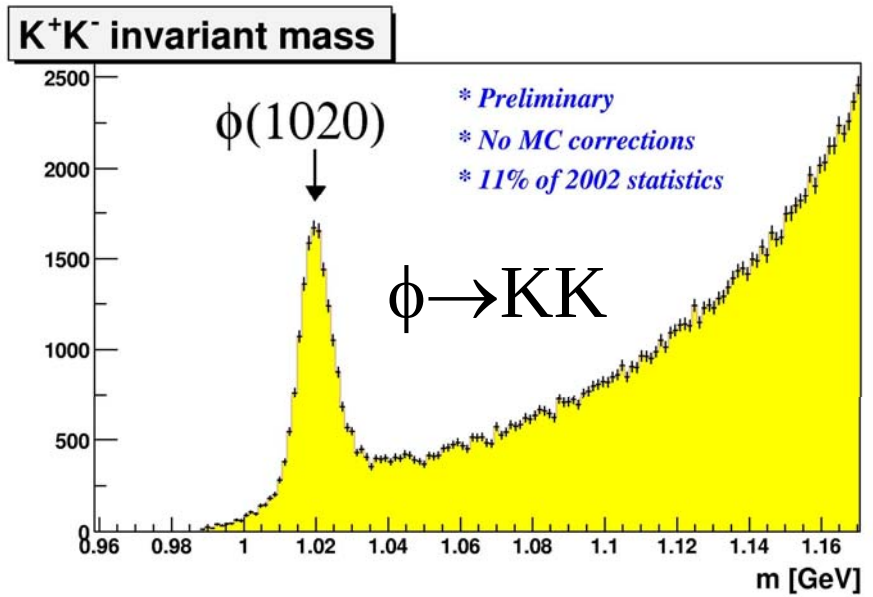
+ Muon filters and muon detectors at the end of SAS and LAS
+ Magnets 1Tm and 4.4Tm – momenta measurment
+ ECAL for neutral particles identification (e.g. $\pi^0 \rightarrow \gamma\gamma$)

Examples of the reconstructed states









Weak decays reconstruction

For weak decays happening outside the target:

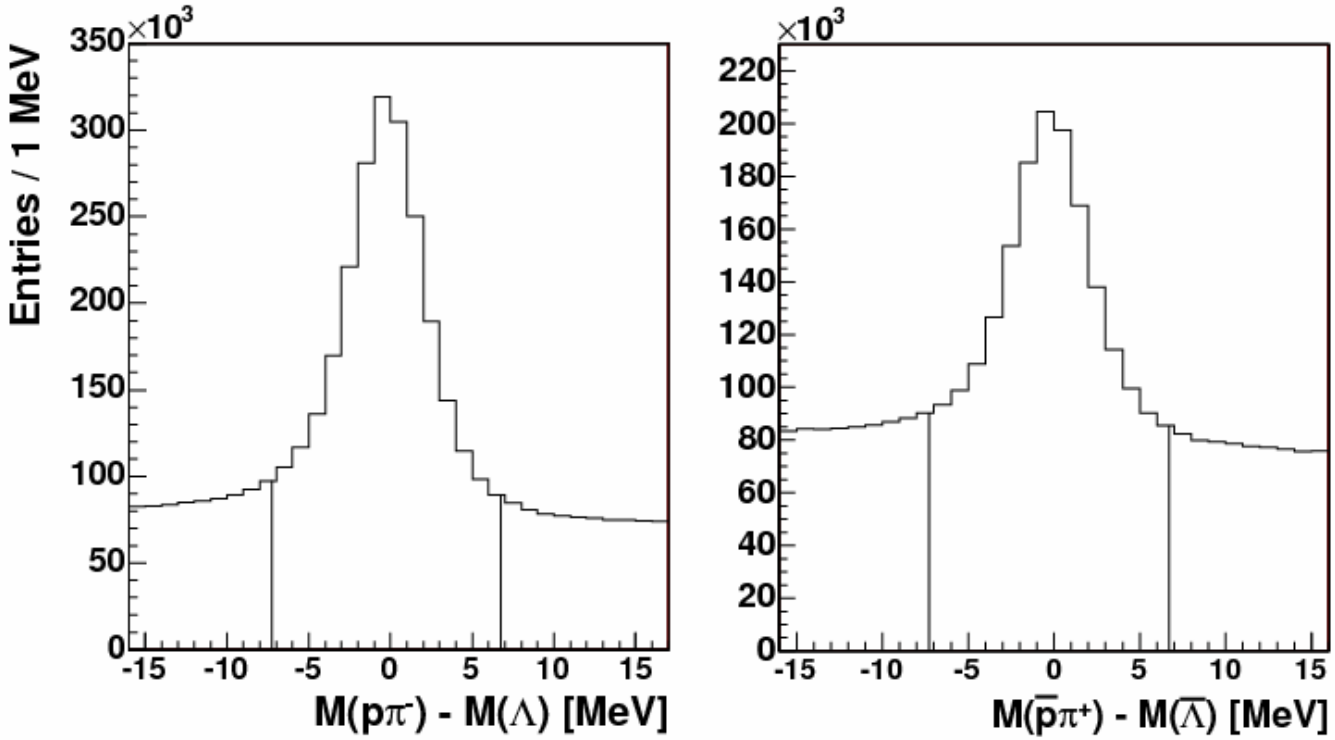
- No multiple scattering
- Less combinatorial background
- Decays into two charged particles: $K^0 \rightarrow \pi\pi$, $\Lambda \rightarrow p\pi$

Secondary vertices with 2-outgoing tracks + p/π mass assumption + $|\cos\theta_{\Lambda\pi}|<0.9$

2002-3 data

Λ^0: 1 250 000

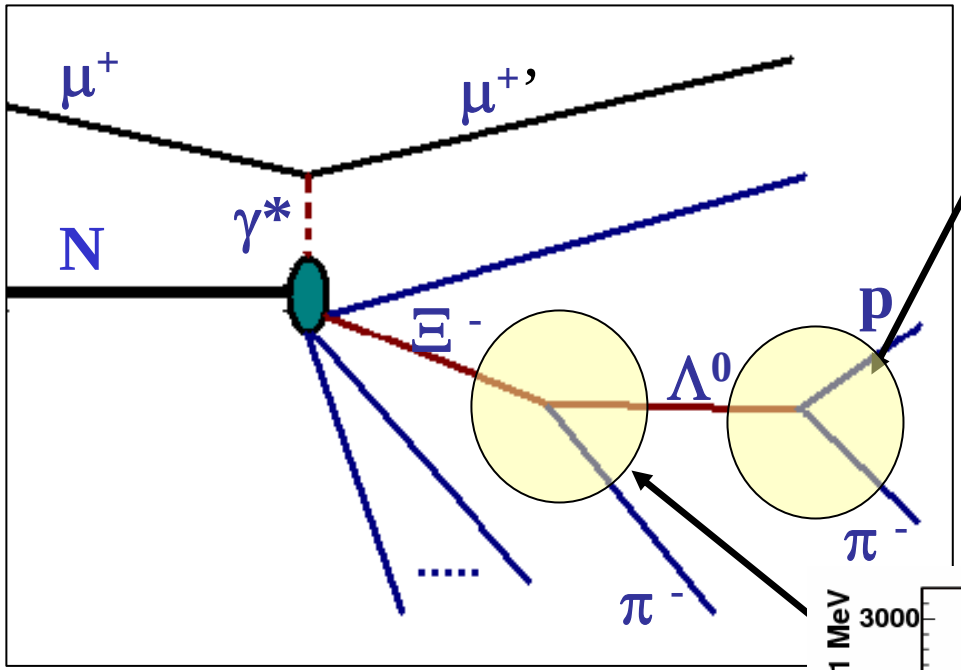
$\overline{\Lambda}^0$: 640 000

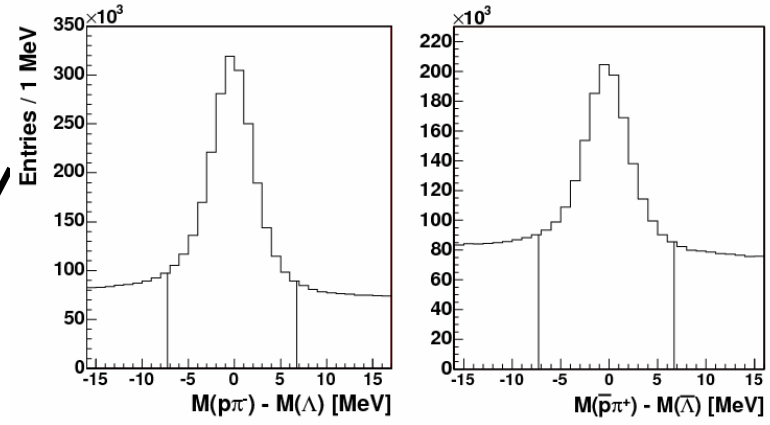


Λ sample can be used as an input for Ξ reconstruction

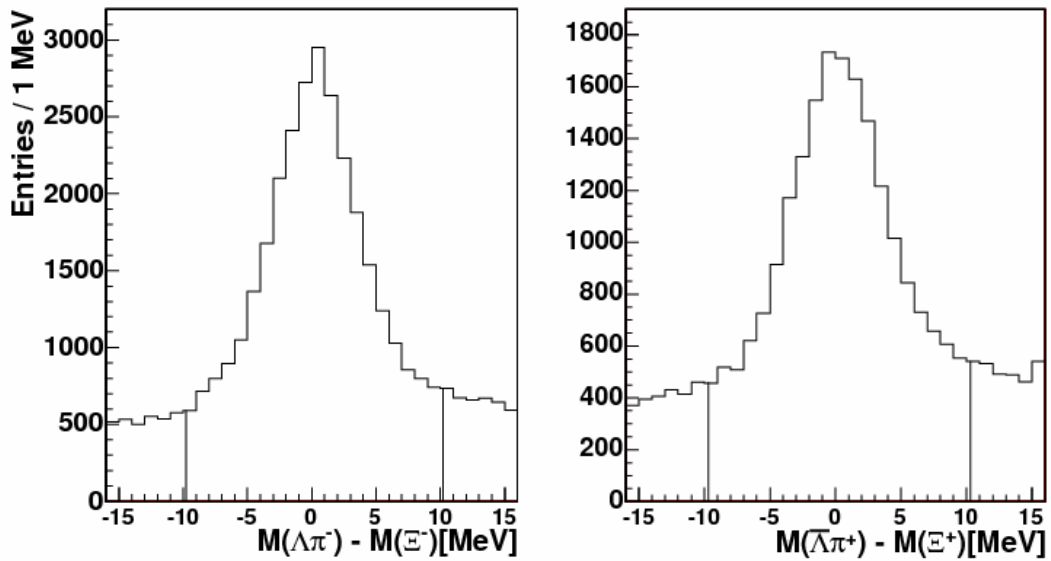
Ξ(1321) reconstruction

$$\mu N \rightarrow \gamma^{*} N \rightarrow \Xi^{-}(1321) X$$





CDA<0.8 cm
vertices hierarchy
p.v. , Ξ- , Λ0



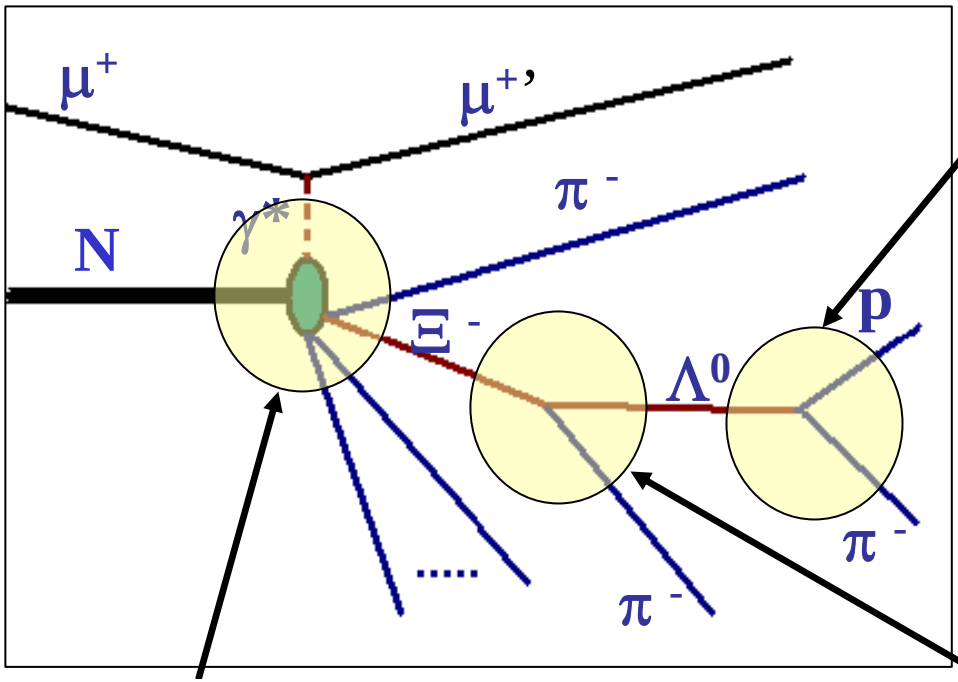
2002-3 data

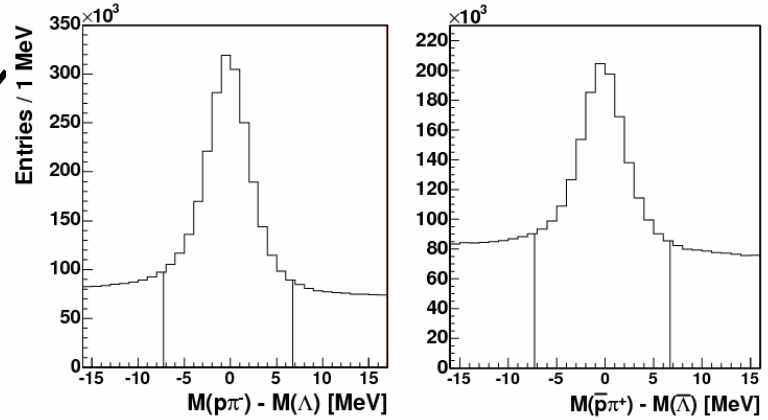
Ξ -: 17 900 events

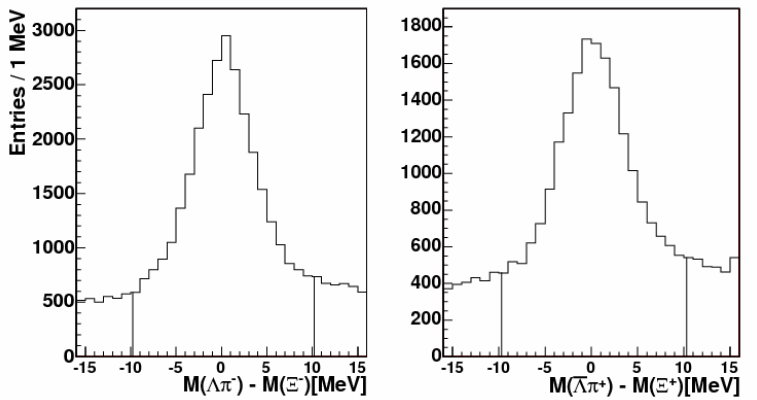
Ξ̄ +: 10 600 events

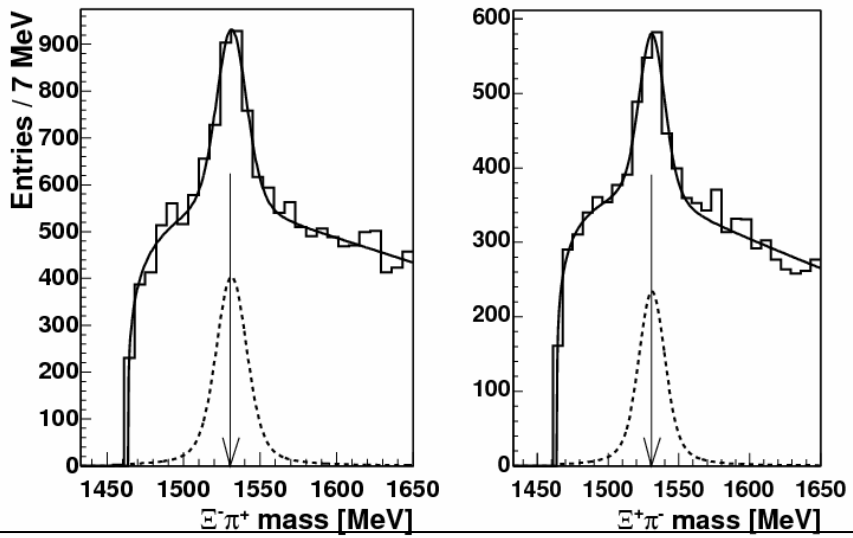
(background substracted)

Reconstruction of the first excited state









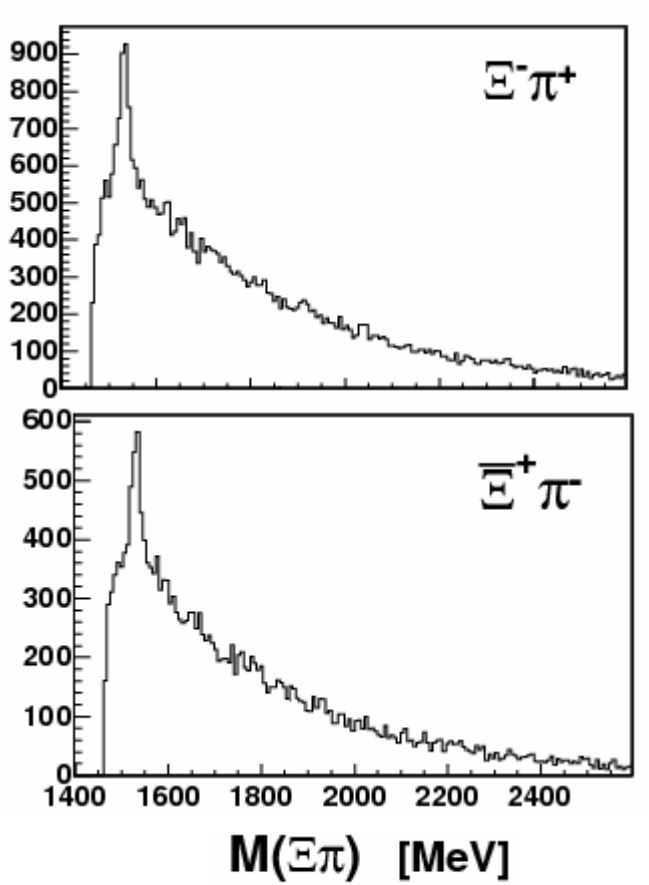
2002-3 data

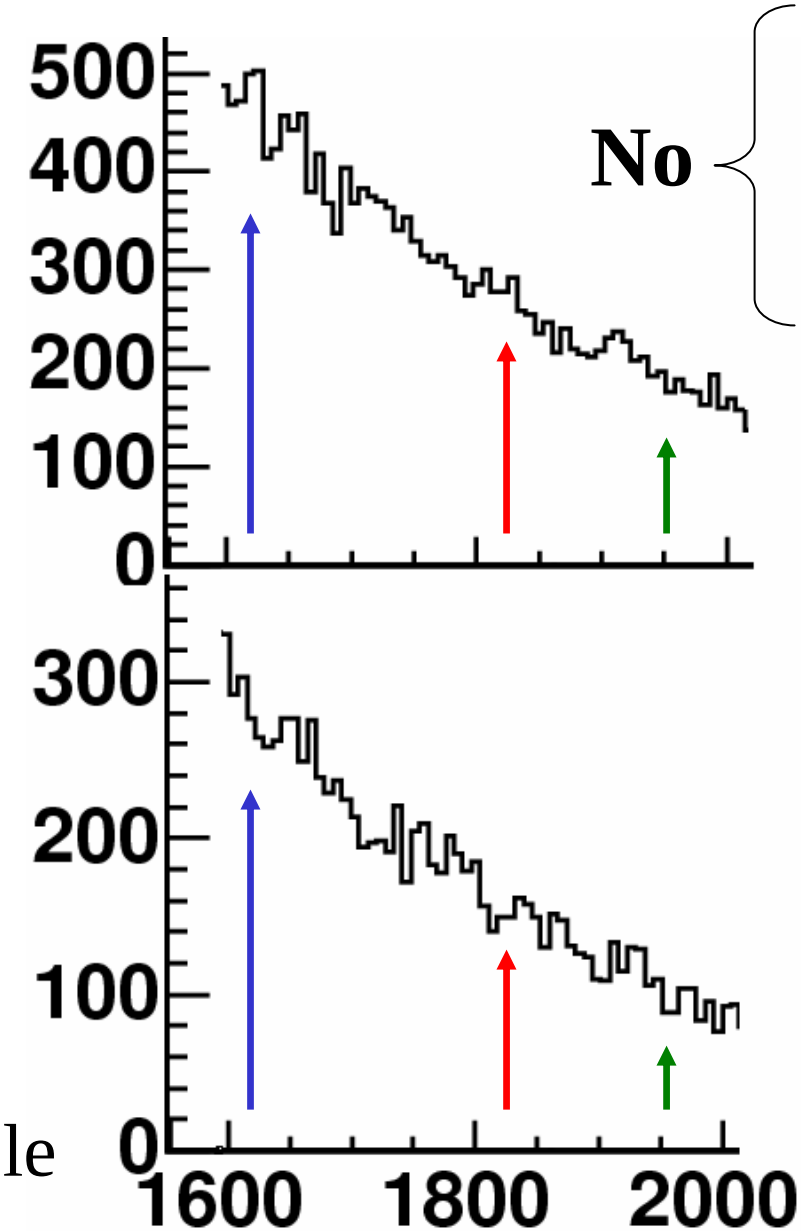
$\Xi(1530)^0$: 1080 ± 90 events

$\bar{\Xi}(1530)^0$: 780 ± 80 events

Other possible resonances in Ξ(1321)π

2002-3 data



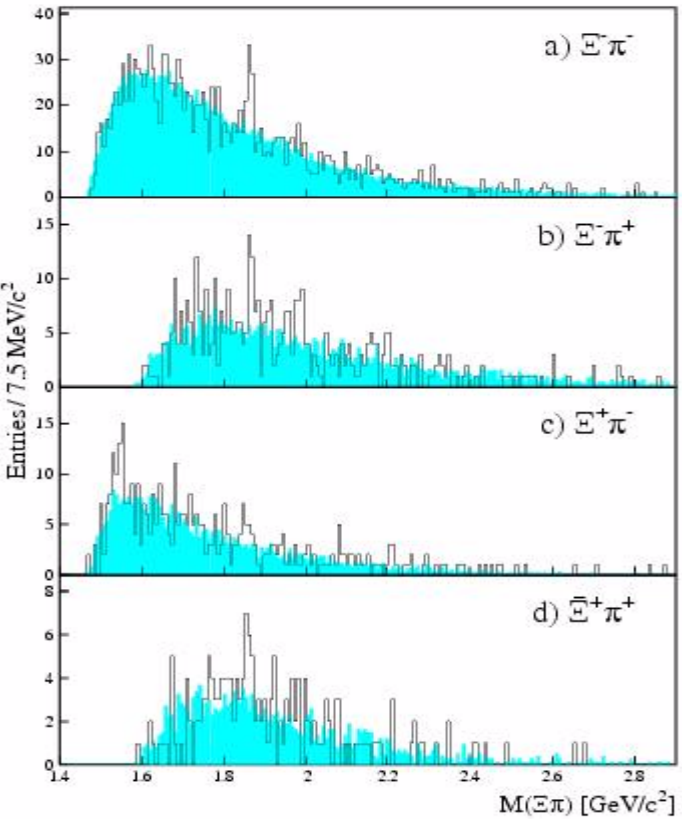


No other resonances visible

Ξ_5 search

NA49(CERN):

- $\Xi^-\pi^- \to \Lambda^0\pi^-\pi^- \to p\pi^-\pi^-\pi^-$
- $\Xi^-\pi^+ \to \Lambda^0\pi^-\pi^+ \to p\pi^-\pi^-\pi^+$
- $\bar{\Xi}^+\pi^+ \to \bar{\Lambda}^0\pi^+\pi^+ \to \bar{p}\pi^+\pi^+\pi^+$
- $\bar{\Xi}^+\pi^- \to \bar{\Lambda}^0\pi^+\pi^- \to \bar{p}\pi^+\pi^+\pi^-$



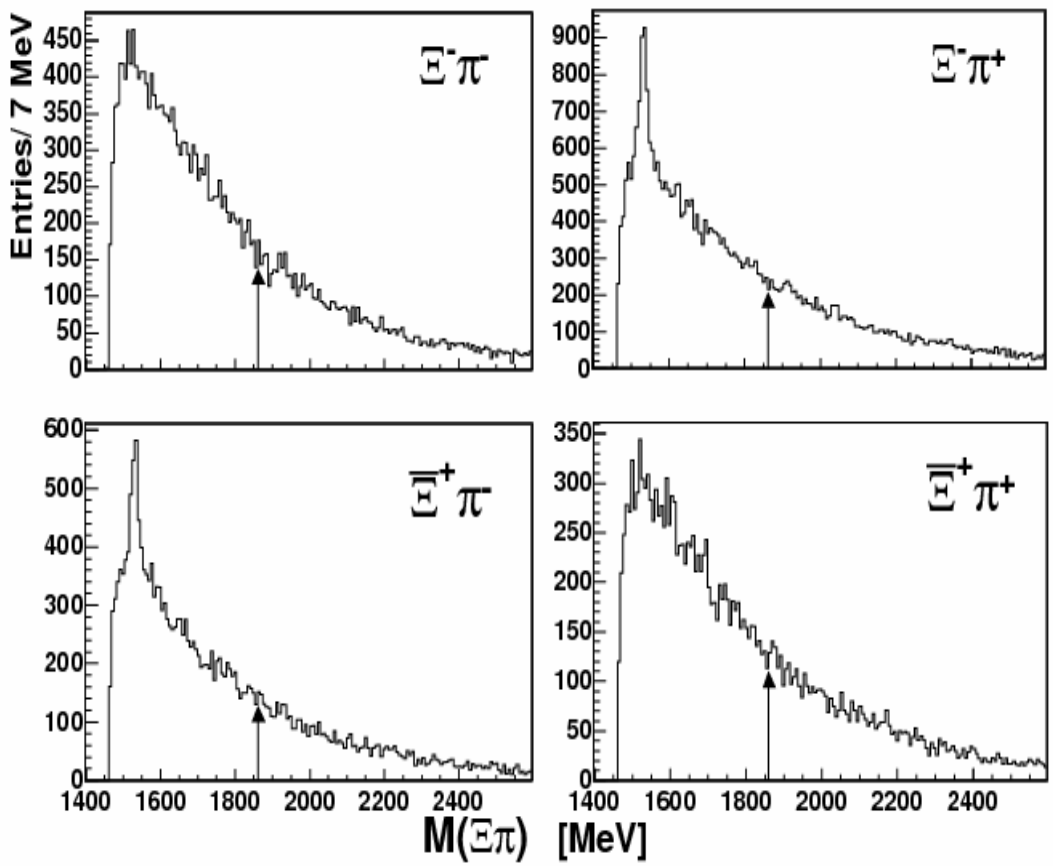
C. Alt *et al.*, Phys. Rev. Lett. 92, 042003 (2004)

COMPASS:

2002-3 data

Basing on the reconstructed Ξ(1321) search for $\Xi_5(1860)$ pentaquark

No signal found



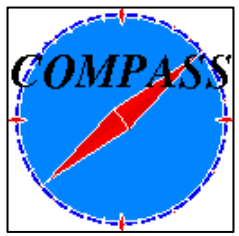
E.S. Ageev *et al.*, EPJ C41, 469-474 (2005)

Other possibilities for Ξ spectroscopy in COMPASS

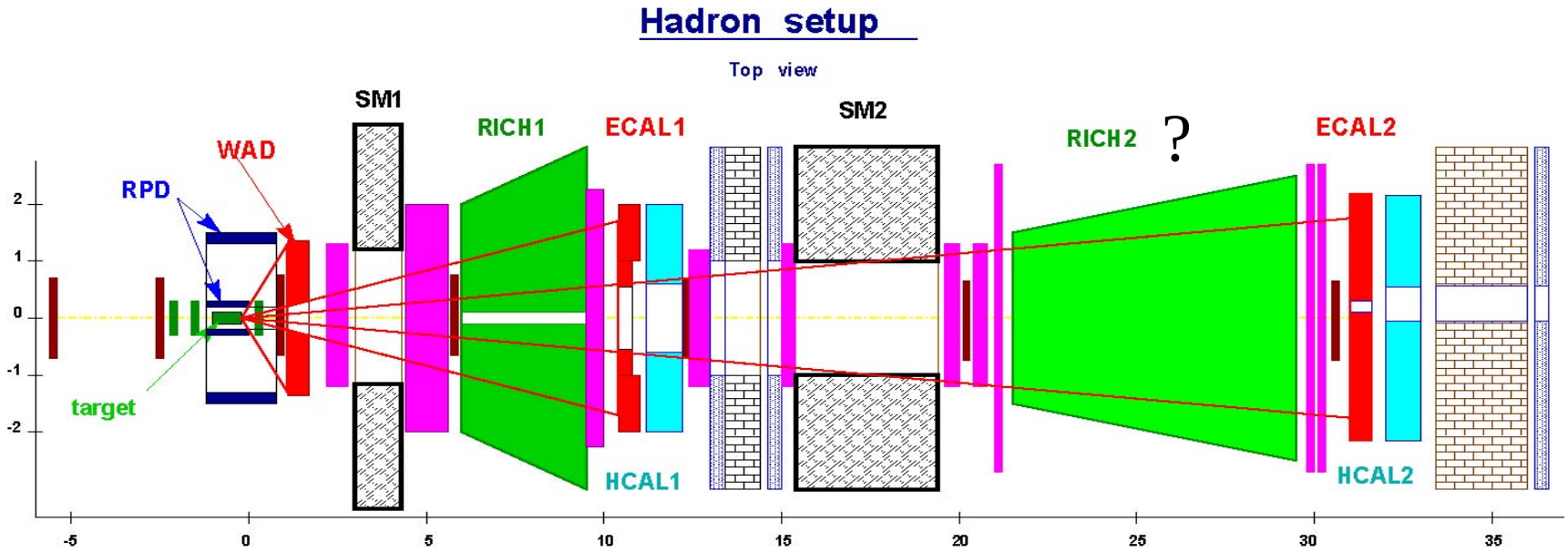
- **2004 data will double 2002-3 statistics**
- **further data will come in 2006**

  with larger hadron acceptance in the target
- **other channels can be studied:**
  - $\Xi^0(1530)\pi$
  - ΛK

Spectrometer setup and programme with the hadron beam



Spectrometer for hadron programme



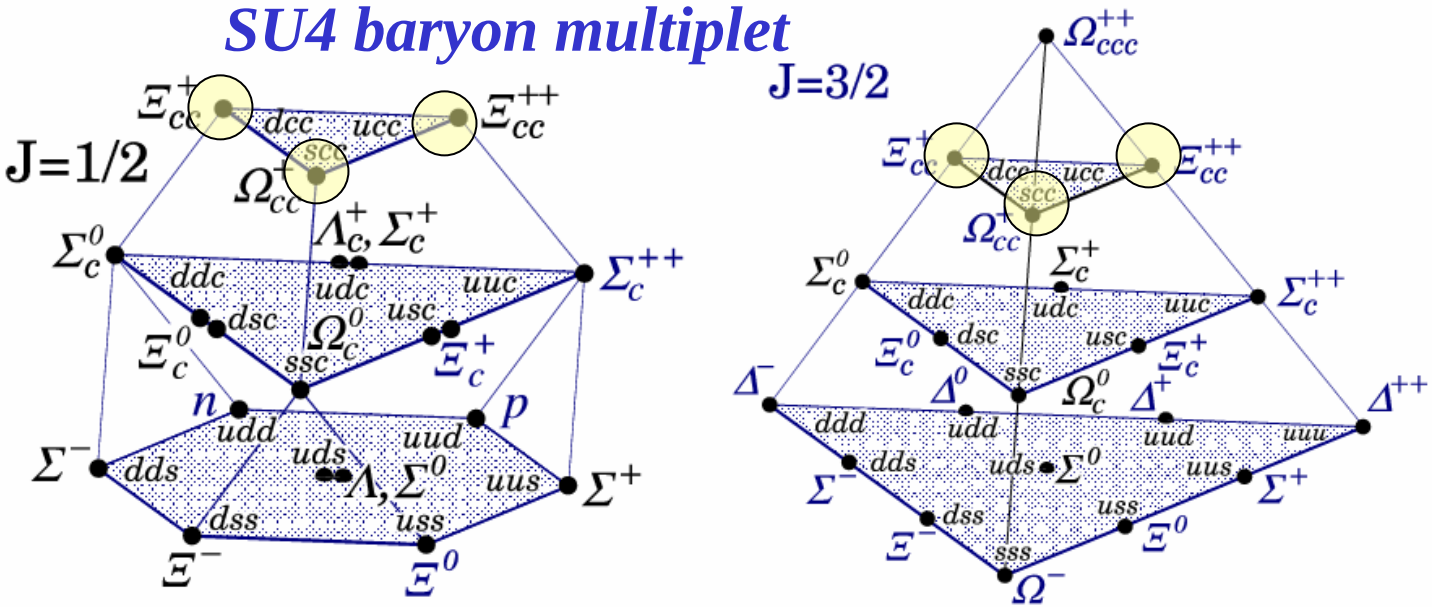
target: liquid hydrogen
thin foils with different A

beam: π/K/p

New detectors planned:
CEDARs, ECAL1, RPD,
vertex detector
new tracking detectors

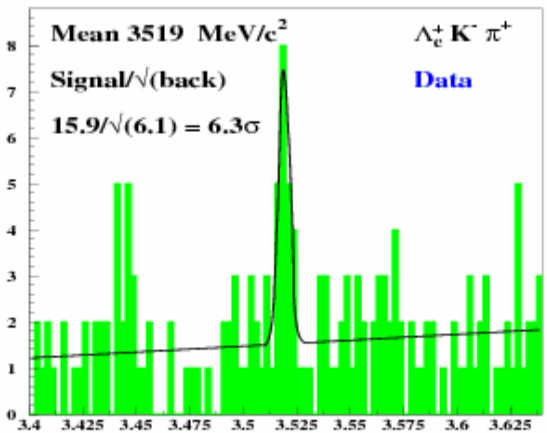
Double charmed baryons

SU4 baryon multiplet

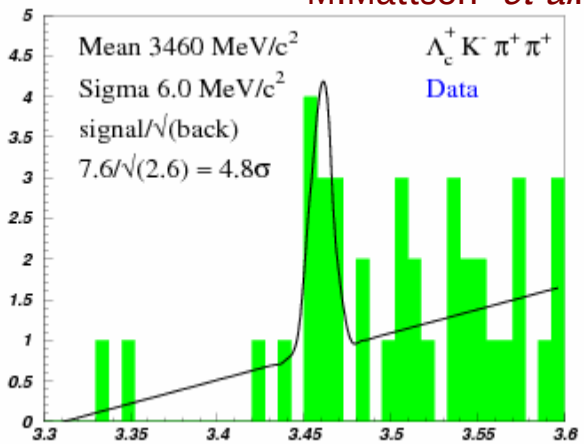


First evidence for Ξ_{CC}^{+} state **SELEX (hadro-production):**

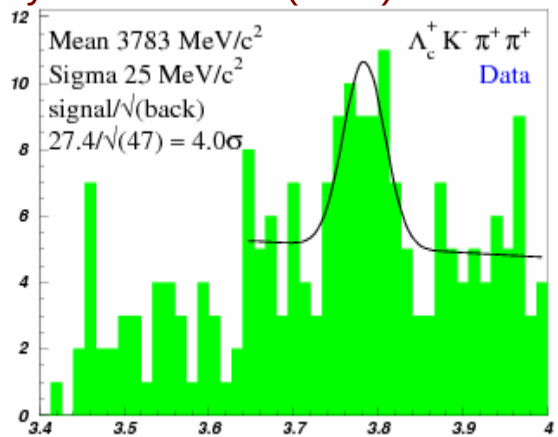
M.Mattson *et al.*, Phys.Rev.Lett. 89 (2002) 112001



Ξ_{CC}^{+}



Ξ_{CC}^{++}

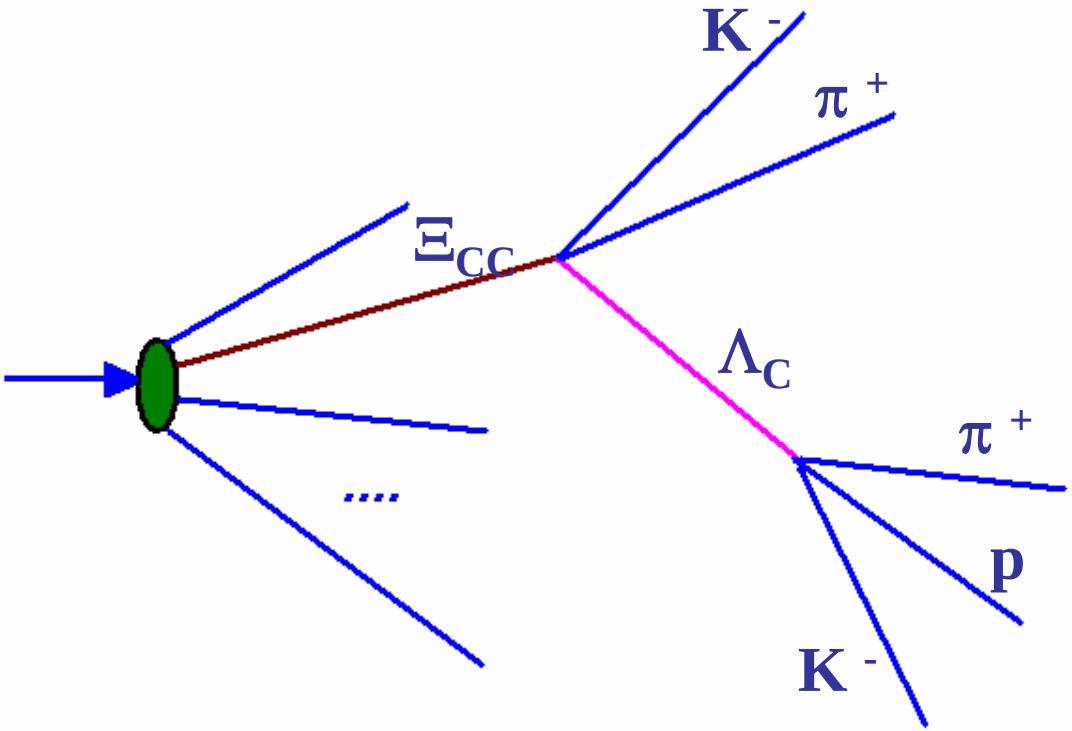


Ξ_{CC}^{*++}

FOCUS does not confirm (photo-production) S.Ratti Nucl.Phys.Proc.Suppl.115:33-36,2003

Ξ_{CC} reconstruction scheme

280 GeV proton beam 10^8/spill
Thin targets of different ***A***



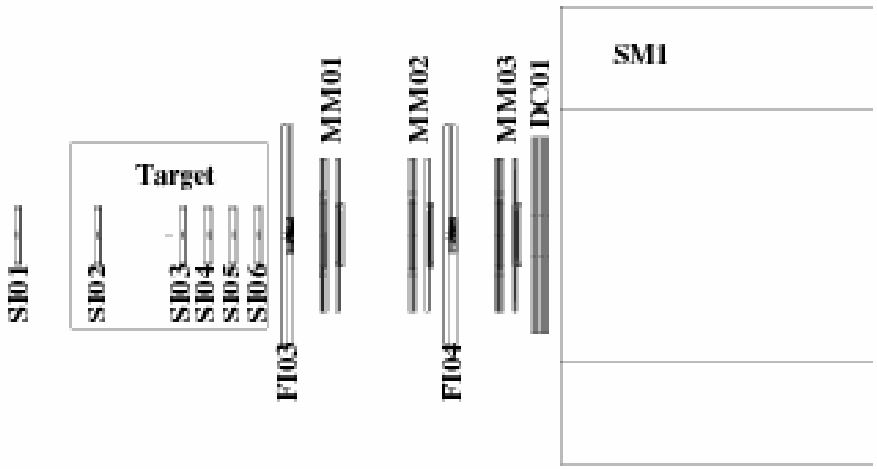
$$pp \rightarrow \Xi_{CC}^{+} X$$
$$\downarrow$$
$$\Lambda_{C}^{+} K^{-} \pi^{+}$$
$$\downarrow$$
$$pK^{-}\pi^{+}$$

Optimistic (based on SELEX) estimation: >1000 Ξ_{CC} reconstructed
possible CCq spectroscopy

More conservative estimations: 100-170 Ξ_{CC} reconstructed
100 effective days

Tracks reconstruction

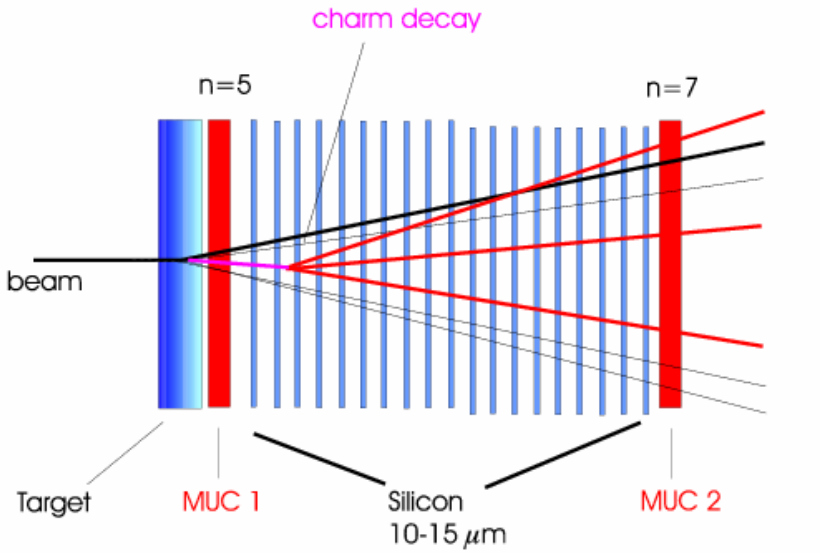
Vertex detector:



- SI telescope
- SCIFI, MicroMega detectors

- Vertex reconstruction

Decay detector:



- 16 (or more) SI plates
- Spaced by 2 mm
- 10-15μm pitch

- Allows to reconstruct the charm decay cascade

Exotics

Glueballs - **States with valence g, without valence q**

Hybrids - **States with non-trivial gluonic component**

4 quark states - **$q\bar{q}q\bar{q}$ states**

Pentaquarks - **$qqqq\bar{q}$ states**

Signature to look for:

- exotic quantum numbers, eg. B=1,S=-2,Q=+1 for $\Xi_5(1860)$
- J^{PC} not allowed for normal qq mesons e.q. 1^{-+}
- Unusual branching ratios
- Large production cross sections in gluon-rich processes

Exotics 2

Experimental status:

Possible candidates: **glueballs** ($f_0(1370)$,$f_0(1500)$, $f_0(1710)$)

hybrids ($\pi_1(1600)$)

4-quarks ($f_1(1430)$)

pentaquarks (Θ^+,Ξ_5)

High statistics needed to measure partial widths,

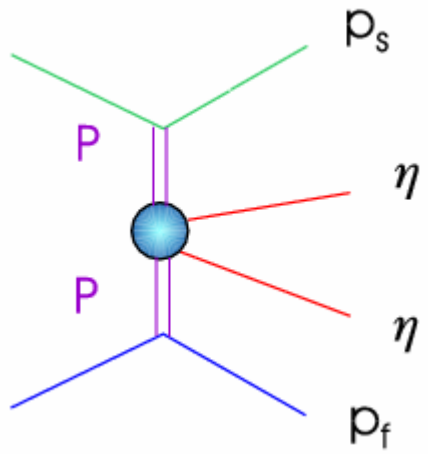
production mechanisms,

PWA,

glueball mixing etc.

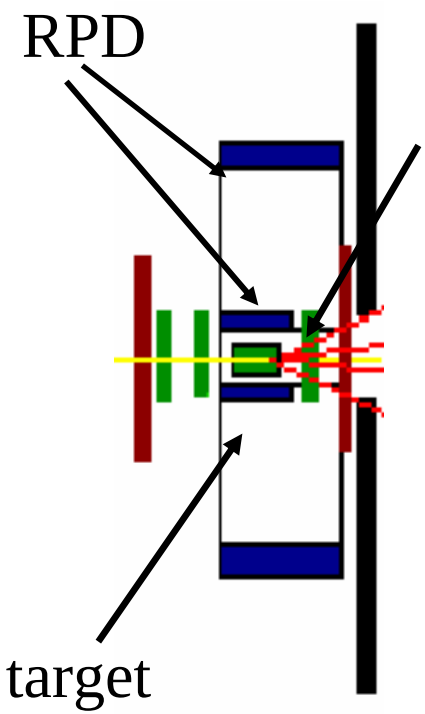
Such high statistics feasible to obtain with COMPASS setup.

Study of exotics in COMPASS



- 40 cm liquid hydrogen target
- π/K or p beam will be used
  - Central production of exotics:

The Recoil Particle Detector used for reconstruction and TOF measurement of large-angle tracks with low momenta:



The scintillator detector installed at the end of the setup register fast hadrons

- Very good acceptance
- High statistics
- Access to higher mass states
- Varying beam energy and particles type

COMPASS features during hadron run

- Different kinds of beam: π/K/p
- Different targets
- Vertex detector which allows to reconstruct short living states decaying in a secondary vertex
- Decay detector which allows to study in details the decay patterns
- Many additional tracking detectors improving global tracking efficiency

Many features useful for *Cascade physics*

Summary

- COMPASS is running since 2002 in a muon mode
- After 2006 hadron mode is foreseen
- Present setup gives a possibility to study cascade hyperons
  ($\Xi(1320)$, $\Xi(1530)$, other excited states, $\Xi_5(1860)$)
- More data to come from 2004, 2006 years
- Future setup will allow to perform accurate spectroscopy at COMPASS
  - vertex and decay detectors
  - various hadron targets
  - various hadron beams
  - new trackers
- our most exciting spectroscopy aims are double charm and exotics, but there are also excellent opportunities for studies of cascade hyperons