NA 48

SPSC presentation

Status report from NA48

G. Barr

24 March 1998

Cagliari
Cambridge
CERN
Dubna
Edinburgh
Ferrara
Florence
Mainz
Orsay
Perugia
Pisa
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Torino
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Epsilon Prime

Measure "direct" CP-violation in the neutral kaon system

$$Re\left(\frac{\varepsilon'}{\varepsilon}\right) \approx \frac{1}{6}\left\{1 - \left(\frac{\Gamma(K_L \to \pi^0\pi^0)}{\Gamma(K_S \to \pi^0\pi^0)} \cdot \frac{\Gamma(K_S \to \pi^+\pi^-)}{\Gamma(K_L \to \pi^+\pi^-)}\right)\right\}$$

with an error less than $2 \cdot 10^{-4}$ ($70\,\mathrm{GeV} \le E_K \le 170\,\mathrm{GeV}$).

BR of CP-violating decays:

$K_L \to \pi^0\pi^0$ $(0.936 \pm 0.020)‰$

$K_L \to \pi^+\pi^-$ $(2.067 \pm 0.035)‰$

BR of "dominant decays":

$K_L \to \pi^0\pi^0\pi^0$ ~226 x $K_L \to \pi^0\pi^0$

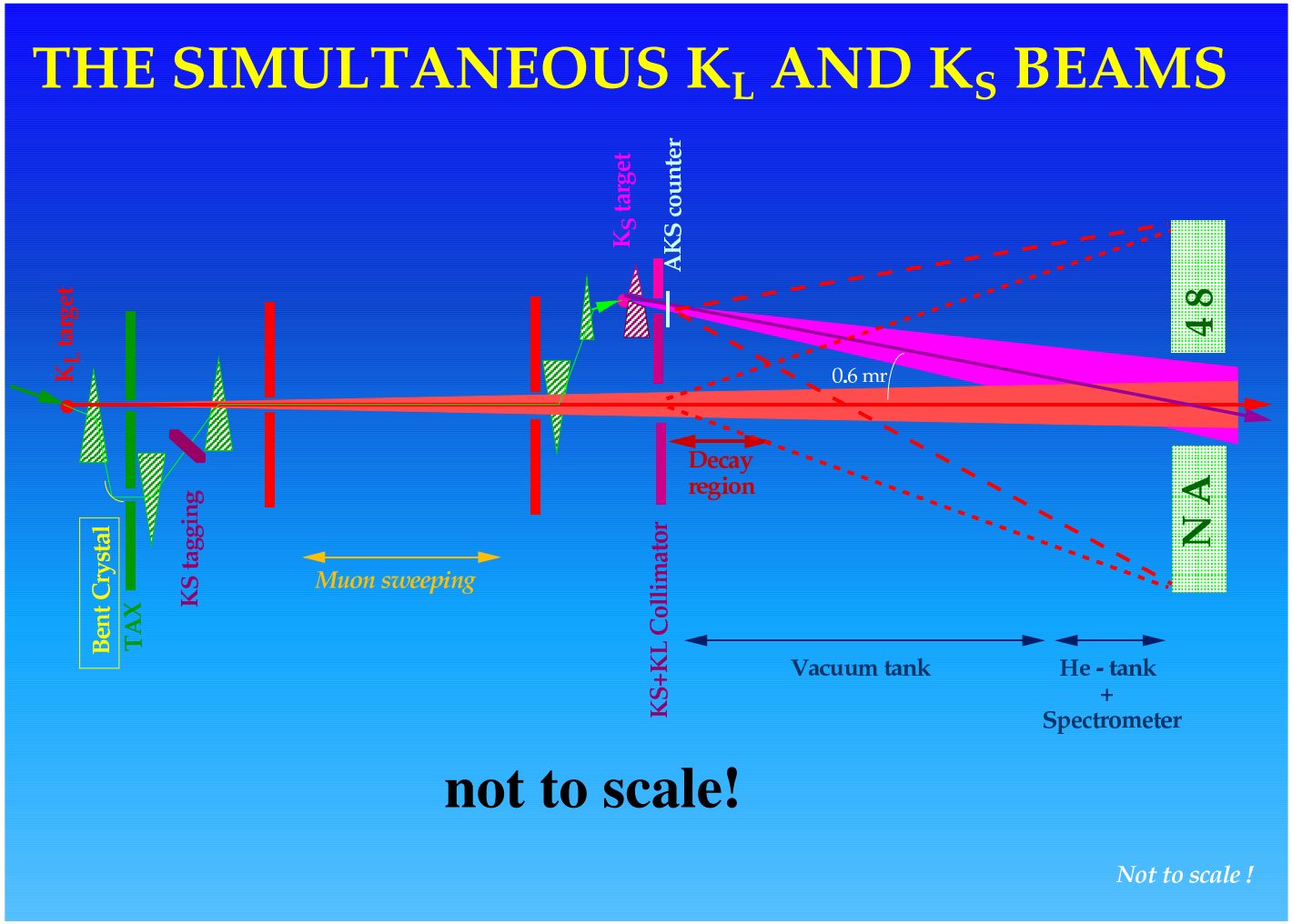
$K_L \to \pi e \nu$ ~188 x $K_L \to \pi^+\pi^-$

Need:

- ❒ **Measure all 4 relevant decay modes at the same time**
- ❒ **High statistics with high-intensity beams**
- ❒ **High-resolution spectrometer and EM-calorimeter**
- ❒ **Sophisticated trigger to reduce the amount of data**

The NA48 beamline

$1.5 \cdot 10^{12}$ ppp on K_L – target and $3 \cdot 10^{7}$ ppp on K_S – target



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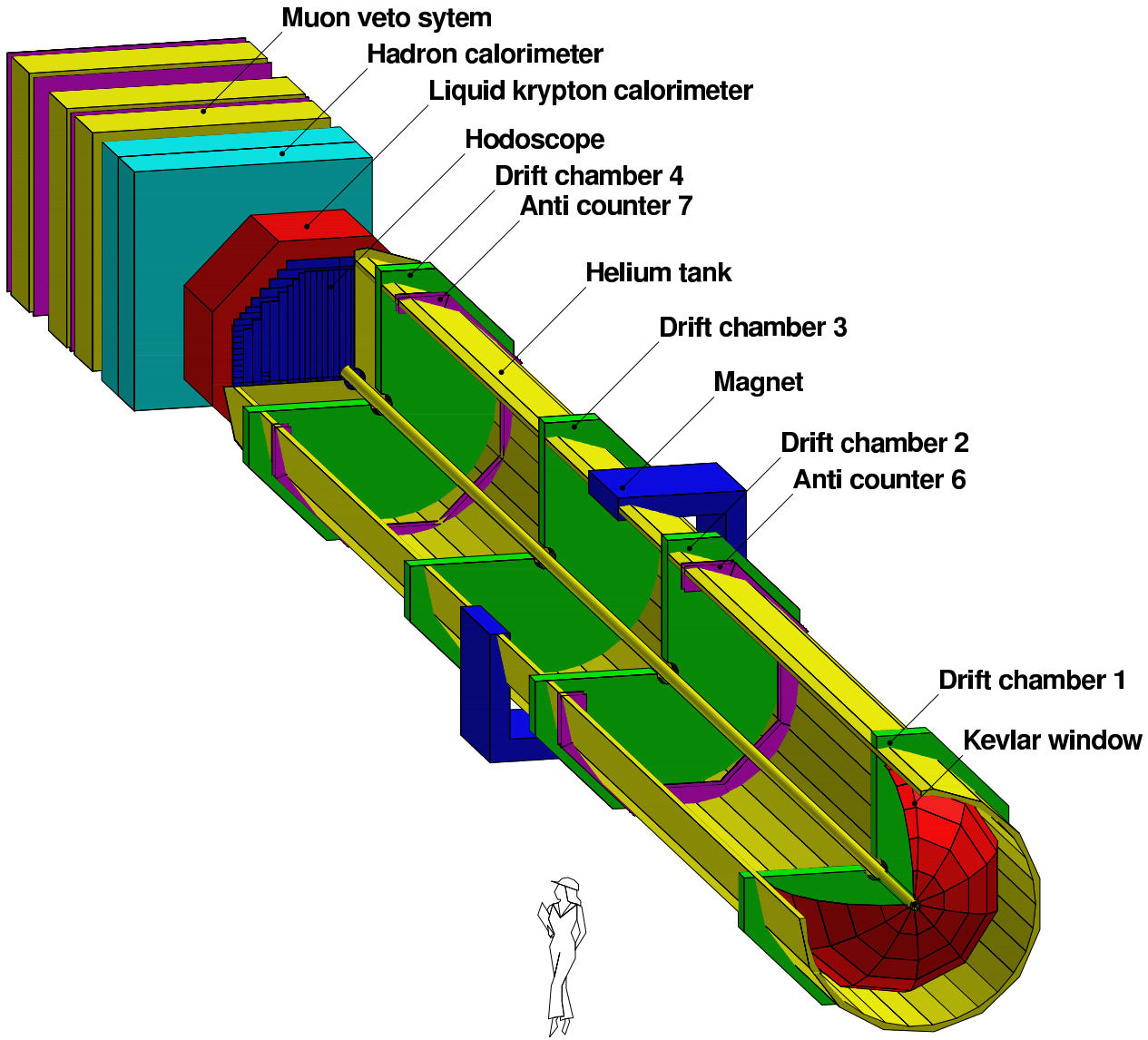
The NA48 detector



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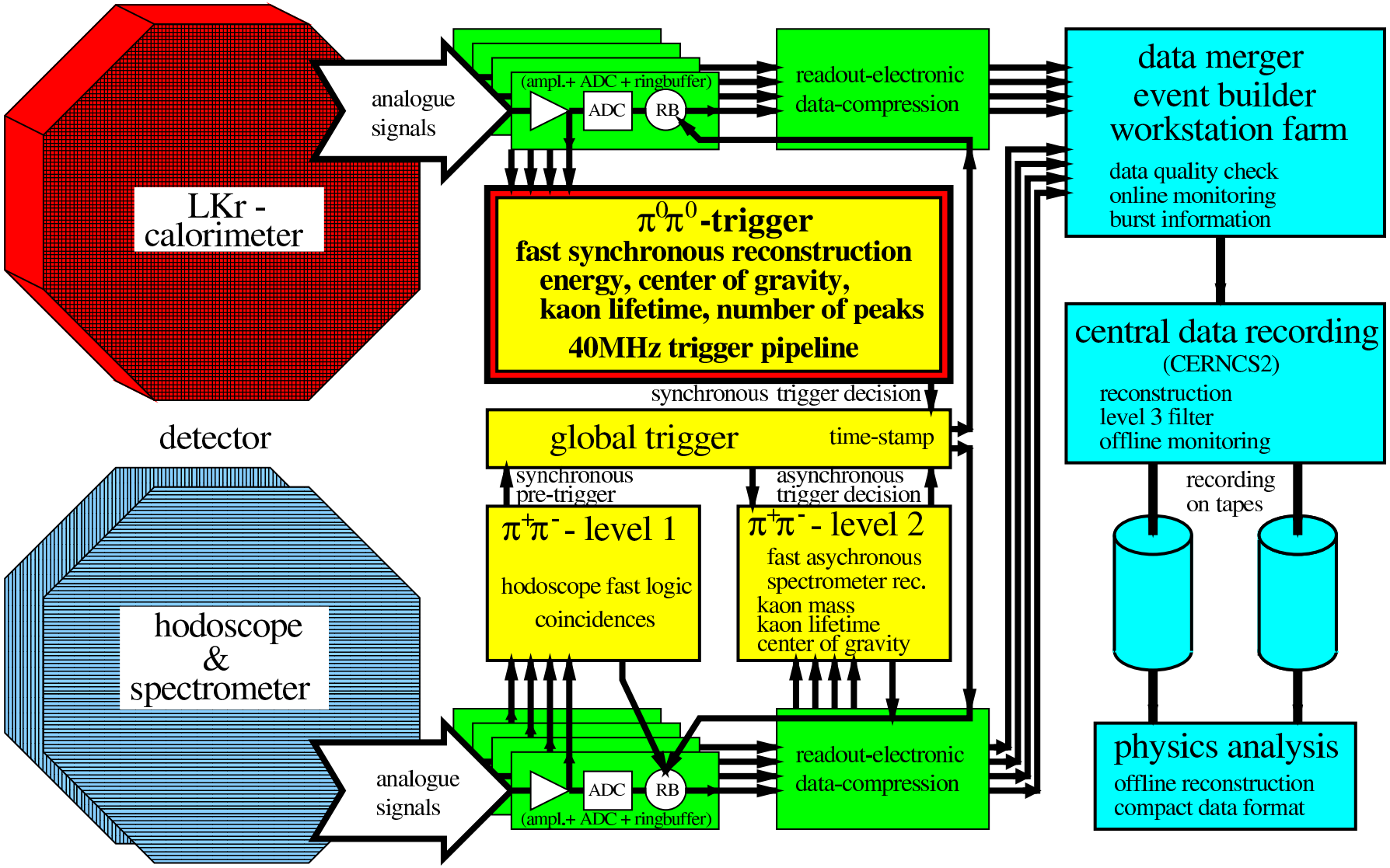
Trigger and DAQ



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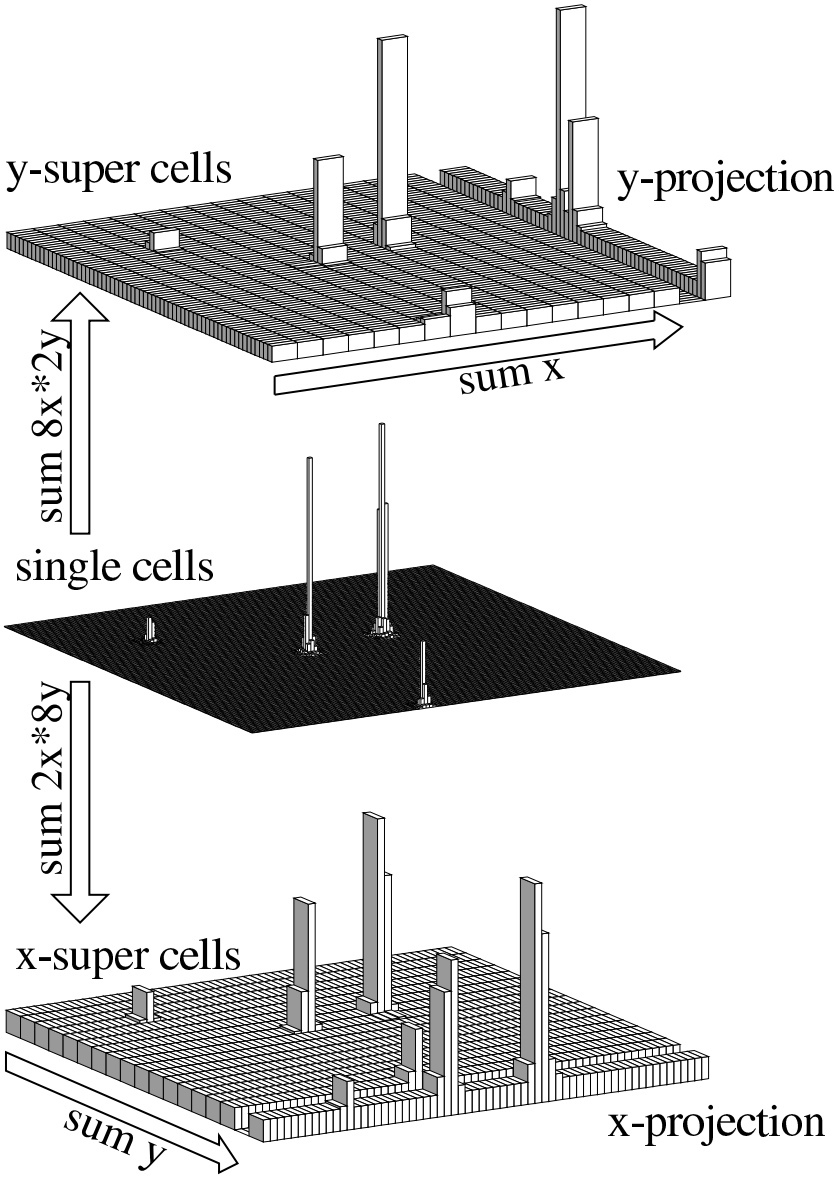
The $\pi^0\pi^0$-trigger



Energy sums in each view x,y:

$$m_0 = \sum_i E_i \qquad m_1 = \sum_i E_i \cdot s_i$$

$$m_2 = \sum_i E_i \cdot s_i^2$$

Event selection variables:

$$E_{\mathrm{TOT}} = (m_{0,x} + m_{0,y})/2$$

$$\mathrm{COG} = \sqrt{m_{1,x}^2 + m_{1,y}^2}/E_{\mathrm{TOT}}$$

$$d_{\mathrm{vertex}} = \frac{\sqrt{E_{tot} \cdot (m_{2,x} + m_{2,y}) - (m_{1,x}^2 + m_{1,y}^2)}}{m_K}$$

$$c\tau = (Z_{\mathrm{LKr}} - d_{\mathrm{vertex}}) \cdot m_K/E_{\mathrm{TOT}}$$

& peak finder

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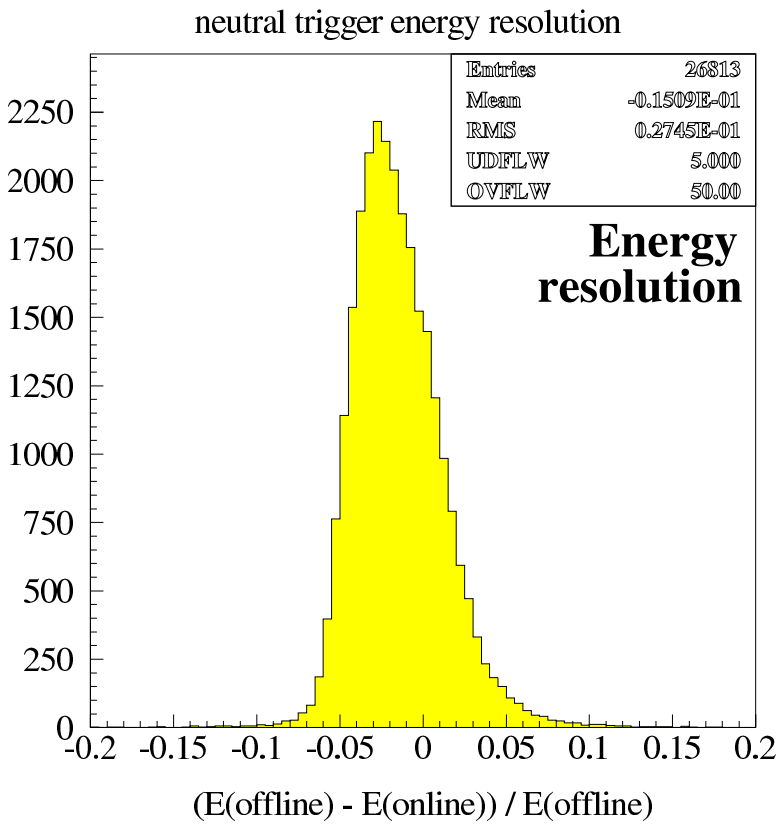
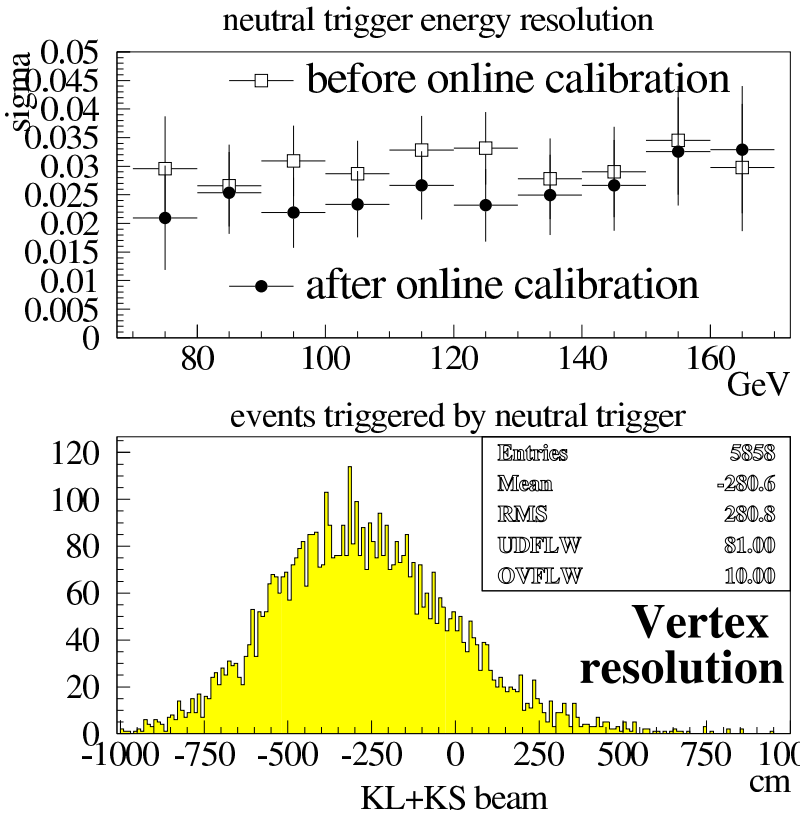
$\pi^0\pi^0$-trigger performance





Energy resolution: $\sigma(E_{NUT})/E_{NUT} = 2.7\%$

Vertex resolution: $\sigma(z_{NUT}) \sim 2.8m$ *(over 100m)*

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$\pi^0\pi^0$-trigger performance

- **Overall latency: 128 pipeline steps (3.2μs)**
- **Trigger rates:**

$E_{NUT} > 30$GeV:	110 000 Hz
$2\pi^0$ triggers:	1 800 Hz
Neutral hodoscope:	37 000 Hz

- **Energy resolution:** $\sigma(E_{NUT})/E_{NUT} = 2.7\%$
- **Trigger efficency (preliminary):**

Measured using neutral hodoscope triggers

Pure K_S-beam: $\varepsilon_{2\pi^0} = (99.91 \pm 0.02)\%$

K_S+K_L-beam: $\varepsilon_{2\pi^0} = (99.79 \pm 0.06)\%$

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Charged trigger

Level 1:

Based on hodoscope counters and E_{TOT} from calorimeters.

Level 2:

- Hardware based coordinate builders on chambers 1 & 2 (before magnet) and 4 (after magnet) and extraction of data from drift chamber readout.
- Microprocessor based computation engine farm and hardware queueing system.

  XYUV spacepoint construction

  Analysis of 2 track combinations: Vertex reconstruction

  Magnet deflection analysis: Mass reconstruction

Input rate: 70 kHz — 32 x C40 microprocessors

Output rate: 2 kHz — Event processing time: 80 μs

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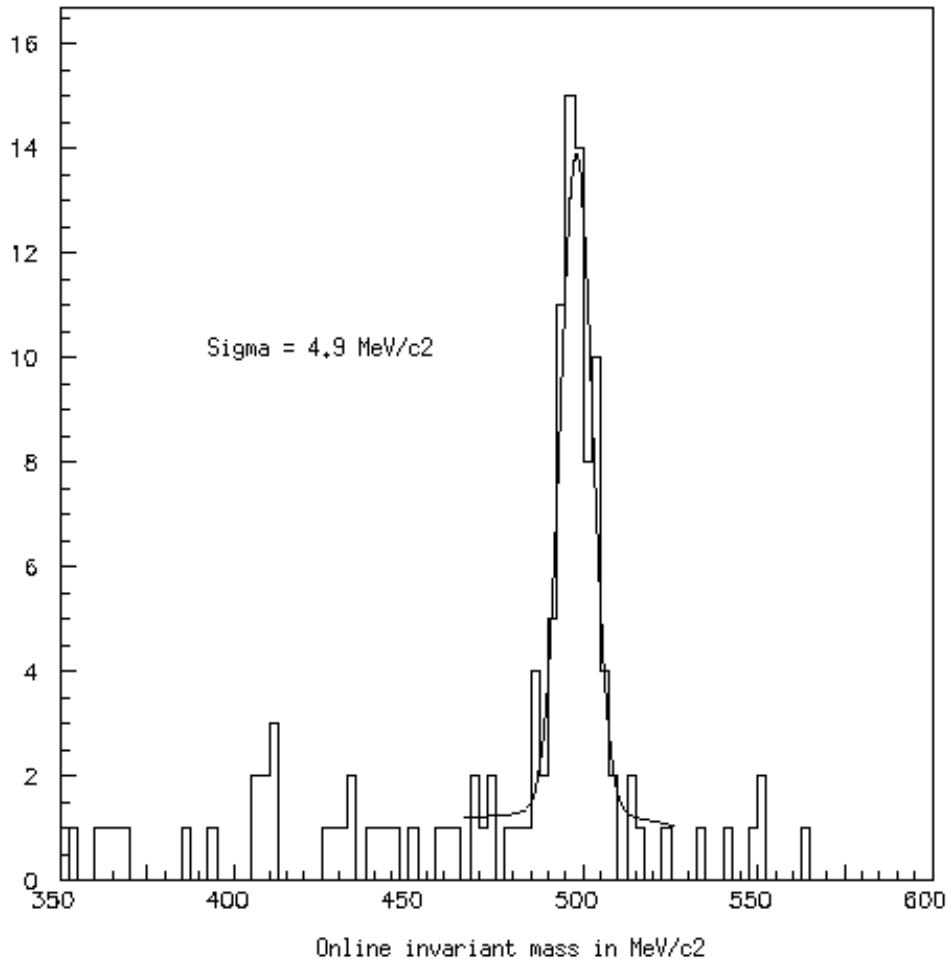
$\pi^+\pi^-$-trigger performance



❒ Efficiencies (working values)

Hodoscope: >99.9%
E_{TOT}: >99.5%
Mass box: ~91%
Error: few x 10^{-4}.

❒ Upgrade for 1998

Upgrade processors with PowerPCs. Higher rate can be handled, more complex events can be processed within trigger time.
Processing time: 32μs.

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Data rates

- **Overall trigger rate: 12000 events/burst**

  2.3s spill: 5 200 Hz

  With effective spill 1.7s: 7 000 Hz

- **Data volume: 200 MB/burst**

  Data were transferred to CS2 in the computer centre and processed through the L3/reconstruction program within minutes and then written to tape = (Central data recording).

- **Good ε'/ε running: Sept/Oct = 42 days**

  Recorded 1.09 x 10^9 triggers, 25,000 GBytes of data. Containing 650,000 CP-violating $K_L \rightarrow 2\pi^0$ events inside our cuts with $0 < \tau < 4\tau_S$. This leads to a statistical error on epsilon prime of ~ 4 to 5 x 10^{-4} (depending on cuts).

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Calorimeter operation

❒ Calorimeter operated well at 1.5kV.

From last year's status report, you know that we ran at reduced drift voltage due to a failure of a few of the 13000 blocking calpacitors. We are applying a small space charge correction in the data.
A separate HV feed through fault affected a 4cm x 256cm strip of cells.

❒ Calorimeter read out with 208 CPDs

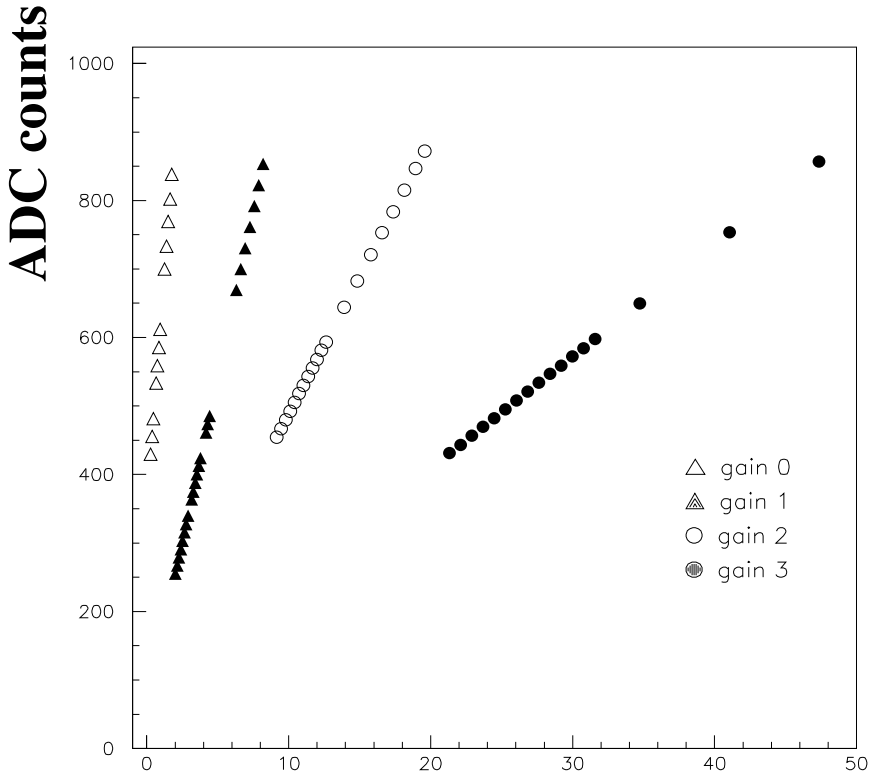
CPD delivery was a worry at last year's SPSC status report. Operated during the run with 208/216 CPDs (few missed channels at the edges).

Data Concentrator provided zero suppression with halos.

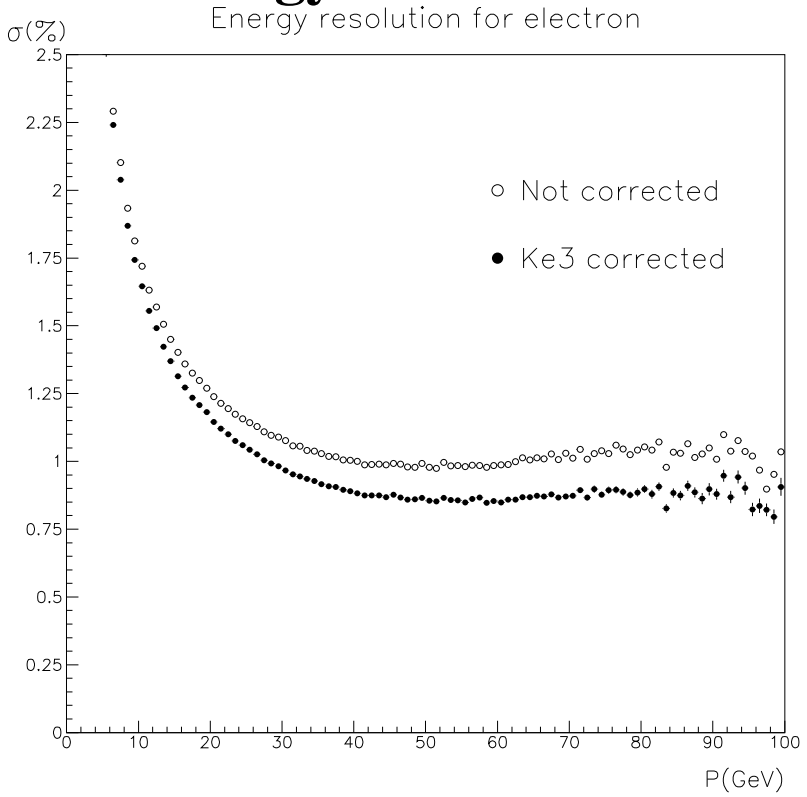
Calorimeter Calibration

Electronics noise: Incoherent: 2.8 ADC counts/channel (~11MeV).
Coherent 0.15 ADC counts/ch (0.075 for CPD alone).

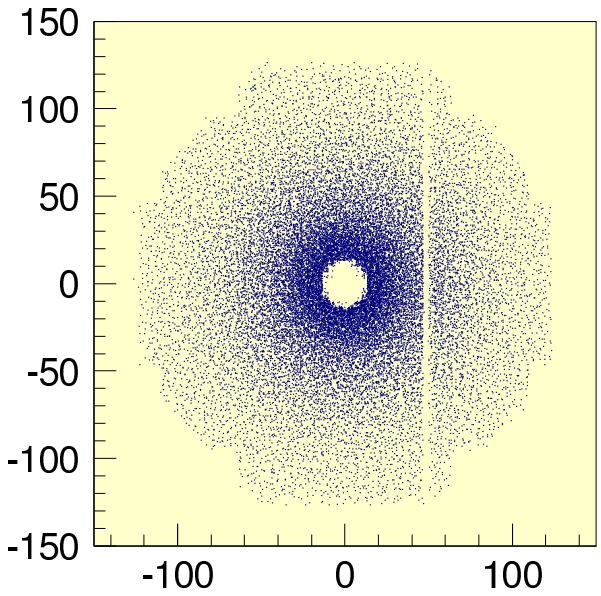
Calibration pulses (1 channel)



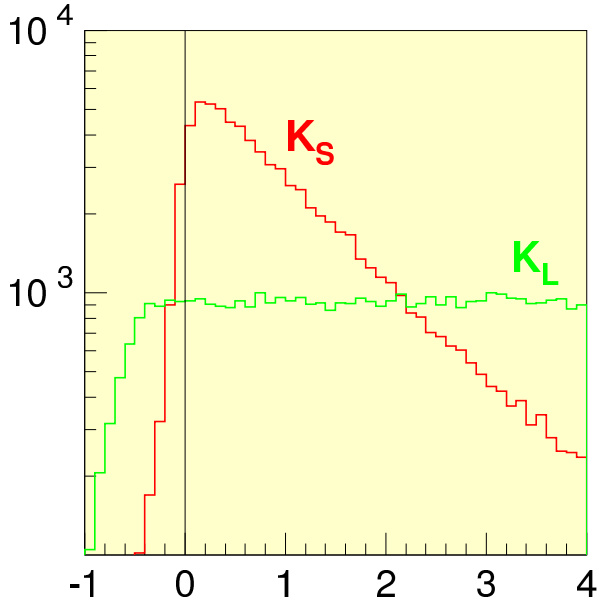
Energy resolution



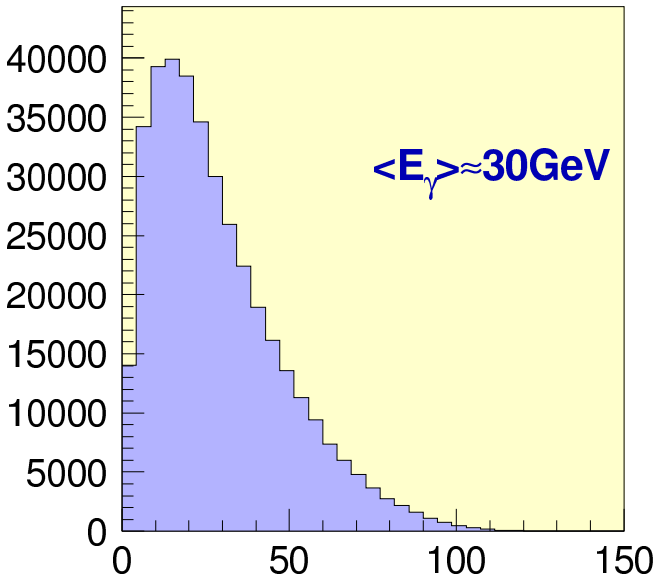
Neutral distributions



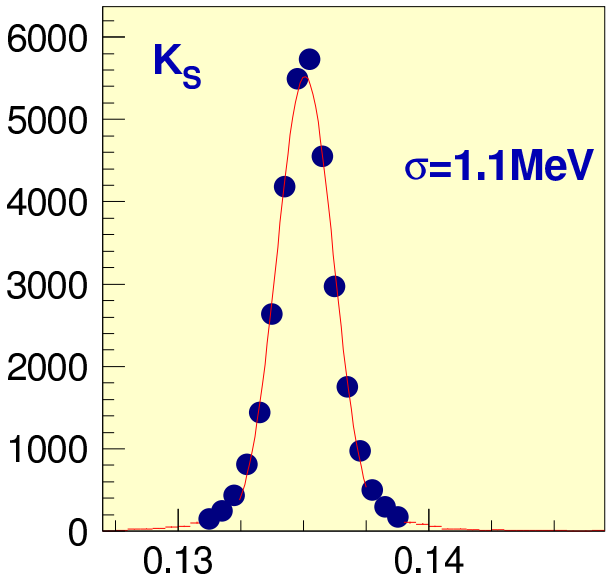
x/y LKR clusters for neutrals



$c\tau$ [$<c\tau_{KS}>$]



Photon energy (4cluster events)



$m_{\gamma\gamma}$[GeV/c^2]

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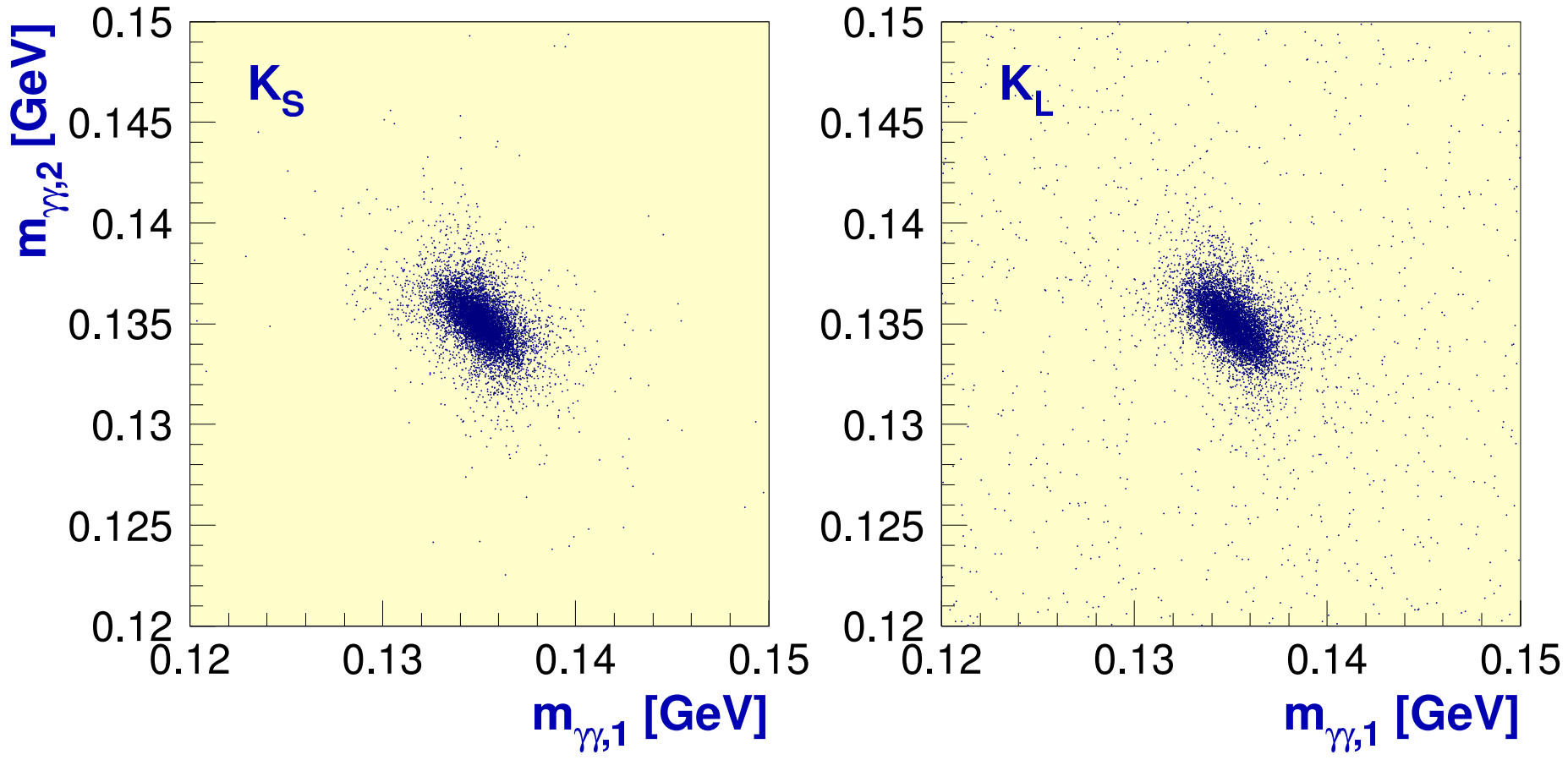
Neutral distributions

$K_{S,L} \rightarrow \pi^0\pi^0$



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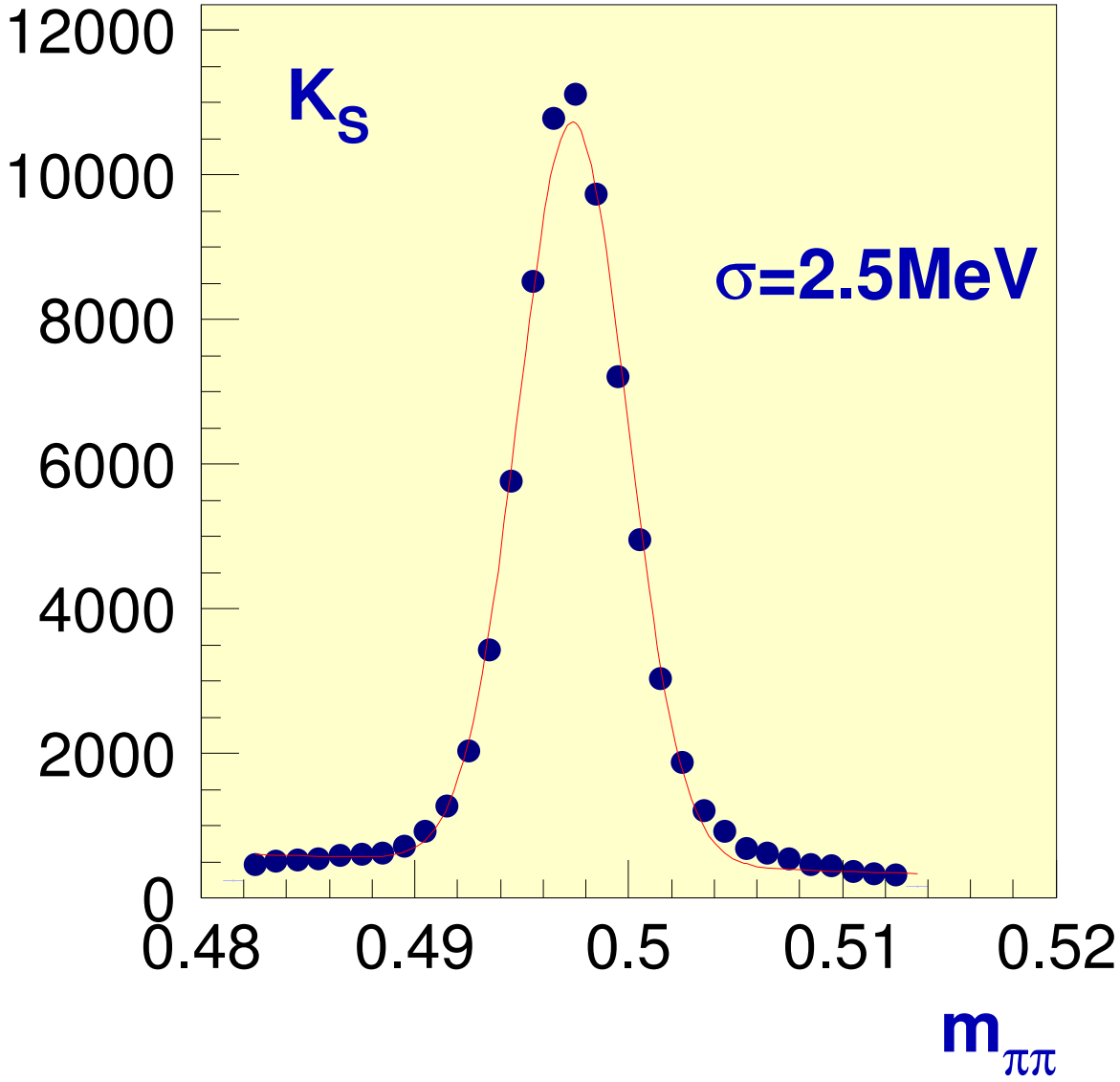
Charged mode



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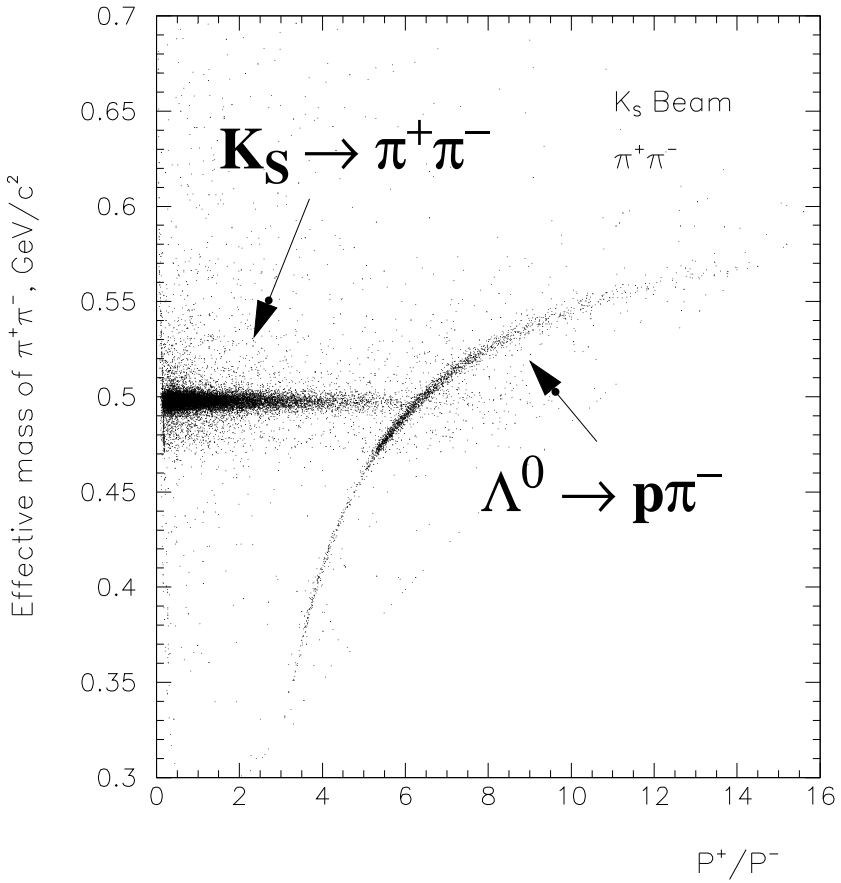
Charged mode

Reconstruction assuming two pion tracks



p_t^2

A plot was shown here for the SPSC, but it is too early to show shuch a plot at conference talks.

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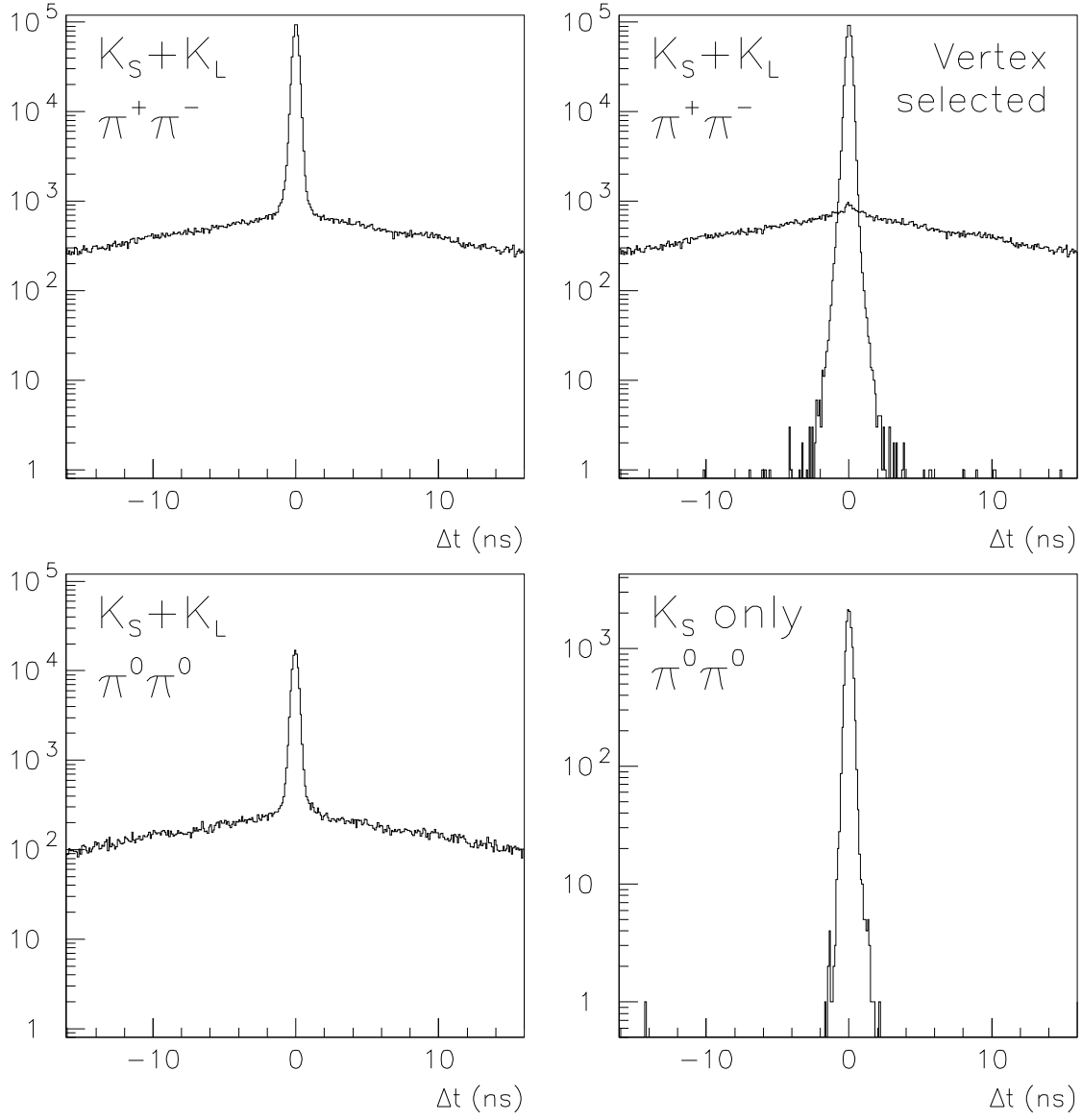
Tagging



Measure event time, if a proton is seen in the tagger within 2ns, it is assigned to be K-short.

α=Fraction of K_L events wrongly assigned to be K_S (~11.5%).

α^{+-} ,α^{00} measured with out of time tagger hits

$\delta(\varepsilon'/\varepsilon) < 10^{-4}$

β=Fraction of K_S events with no tag.

β^{+-}=Measure easily (vtx).

β^{00}=Measure with Dalitz or in K_S only where 4 out of 30000 events are seen.

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Other analysis topics

- **Check of energy scale:** η run plots
- **Accidentals**
  - **Overlay 'random' events on good events to evaluate effect of accidental activity.**
  - **(Losses - Gains) is <2% in each mode which is good and low**
    [Except for tagger and DCH overflows which are handled separately].
- **Monte-Carlo and detector studies**
  - **Continuing ...**
- **1997 statistics:** 650,000 $K_L \rightarrow \pi^0\pi^0$ in $4\tau_S$
  - **Leads to a statistical error of 4 to 5 x 10^{-4} on Re(ε'/ε).**
  - **NA31 total error from three years of data taking was 7 x 10^{-4} .**

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Other physics

Publications:

$K_L \rightarrow \mu\mu\gamma$

$K_L \rightarrow \pi\mu\nu\gamma$

Thesis topics:

$\Gamma(\pi^+\pi^-)/\Gamma(\pi e\nu)$, $\Gamma(\pi^+\pi^-)/\Gamma(\pi\mu\nu)$

Transverse Λ polarization.

Ongoing work:

$\Gamma(\pi^0\pi^0)/\Gamma(\pi^0\pi^0\pi^0)$

Cascade hyperon decays

$ee\gamma$ -> 10900 event sample shown at Morriond.

$ee\gamma\gamma$ -> 124 events shown at Morriond.

SUSY particle searches.

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Preparation for 1998 run

- **Calorimeter repair:**

  Proceeded well, practically completely reinstalled. Will cool down and fill during NA50 run. New design of capacitors will allow us to run at full voltage. Dead strip HV repaired.

- **Tagger scintillator** **replaced after 3 years irradiation.**
- **Hodoscope scintillator:**

  Original scintillator was from bad batch. First plane rebuilt 1996/7, Second plane was rebuilt during this winter shutdown.

- **HAC PMs replaced.**
- **New beam pipe** **see earlier.**
- **New event builder farm:**

  Major DAQ upgrade to allow data rates above 200MB/burst and to upgrade the sub-detector data feeds. New system uses 100 individual ethernet connections to build the events.

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Preparation/Expectations

Active level 3 trigger in 1998.

Filtering will be active on CS2 using E/p cut for charged events. Some filtering will be done on the event building farm to reduce the data entering the CS2.

Expectations:

- **Increase to nominal intensity: 1.5 x 10^{12} ppp on T10. Factor 1.5**
- **Longer run, 130 days rather than 42 days.**

Overall we expect to get 4.5 times more data than in 1997.

(Note that if the rate is pushed too high, we get hit by accidentals in the tagger. We like continuous stable running.)

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Conclusions

- **Overall, the last 12 months have been extremely pleasing.**
- **The prospects also look very good.**

Goals are to have a preliminary ε'/ε result from the 1997 data ....

and to collect the full statistics to measure ε'/ε to 2×10^{-4} (proposal).

and to do some rare decays.