

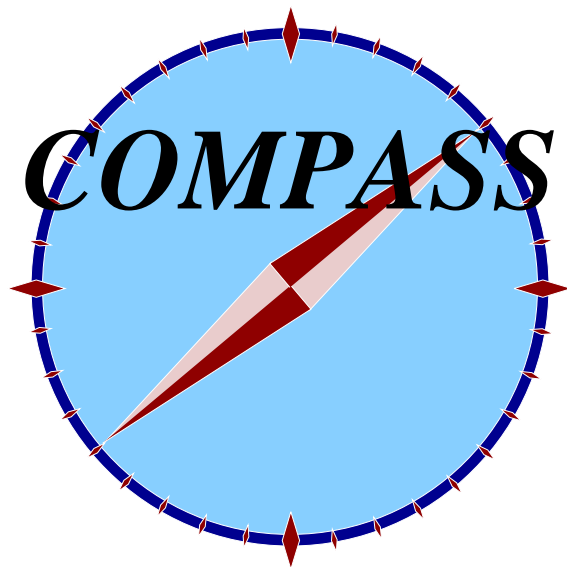
# *The DAQ of the COMPASS Experiment*

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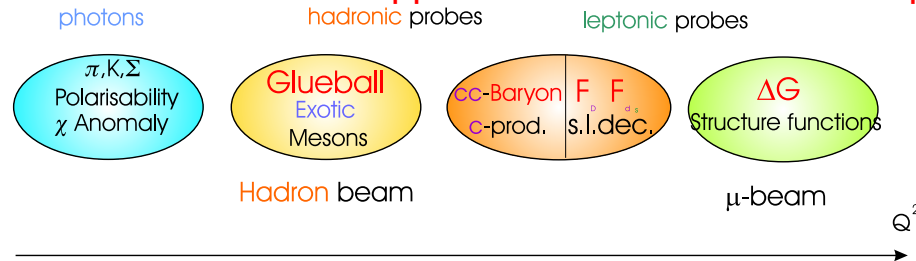
IEEE Realtime 2003 Conference, Montreal



- Introduction
- COMPASS Setup
- Architecture of the DAQ
- Performance 2002
- Outlook and Summary

# The Physics Program

## COmmon MUon and PProton Apparatus for Structure and Spectroscopy

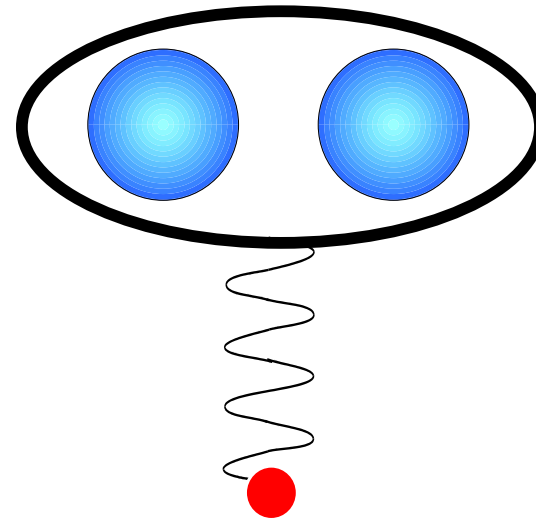
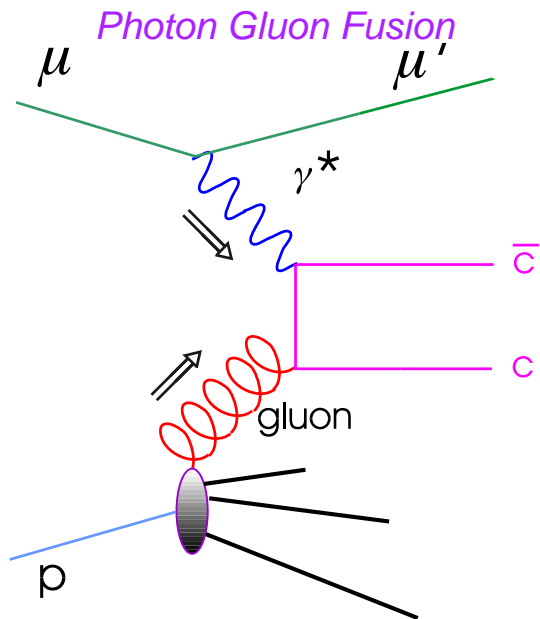


### Physics with the Muon Beam

- Gluon polarisation
- Polarisation of  $\Lambda$  and  $\bar{\Lambda}$
- Transversal spin distribution

### Physics with the Hadron Beam

- Primakoff scattering
- Study of exotic hadrons and glueballs
- Doubly Charmed Baryons

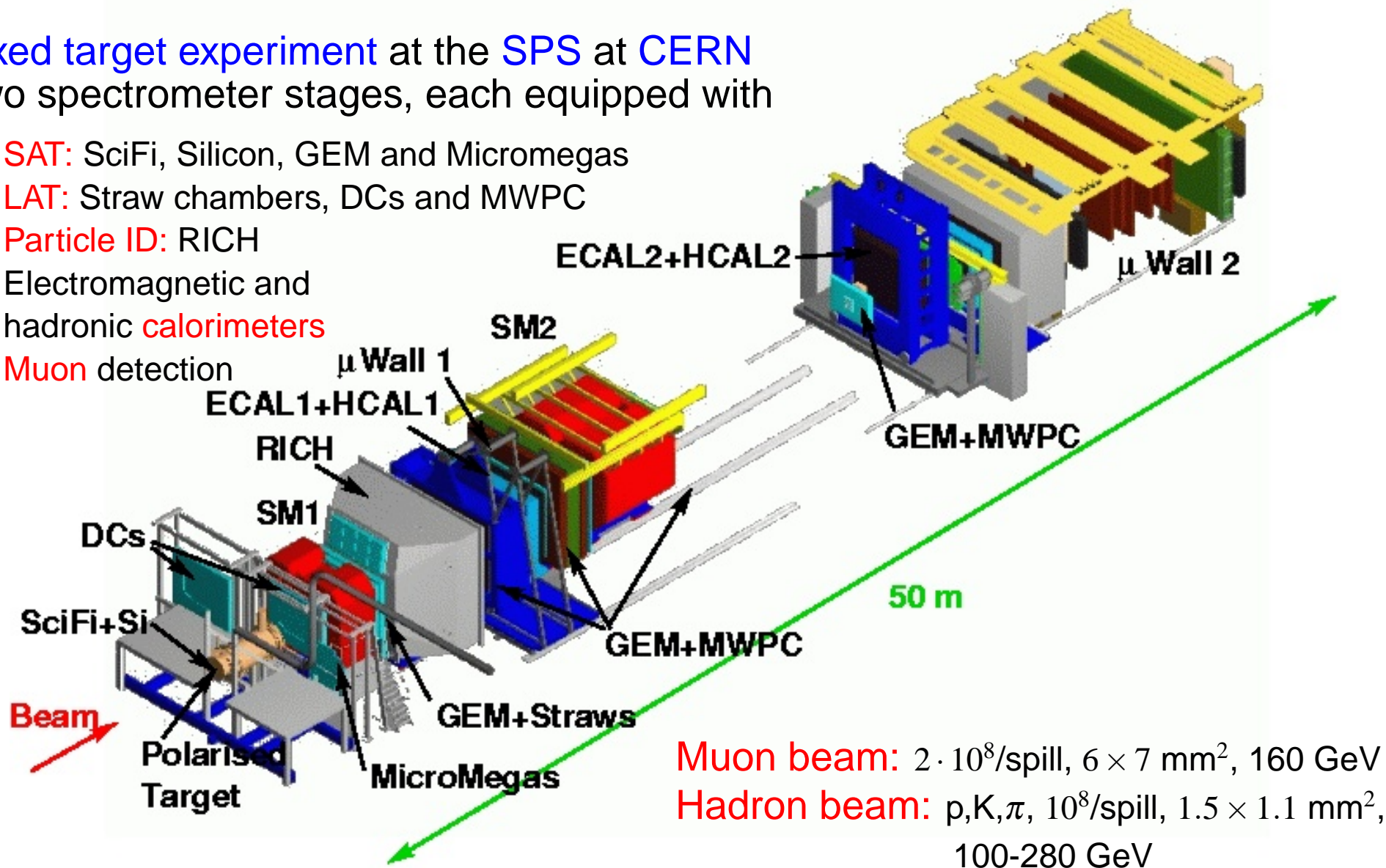


# The COMPASS Spectrometer

Fixed target experiment at the SPS at CERN

Two spectrometer stages, each equipped with

- **SAT:** SciFi, Silicon, GEM and Micromegas
- **LAT:** Straw chambers, DCs and MWPC
- **Particle ID:** RICH
- Electromagnetic and hadronic **calorimeters**
- **Muon** detection



# Requirements for the DAQ

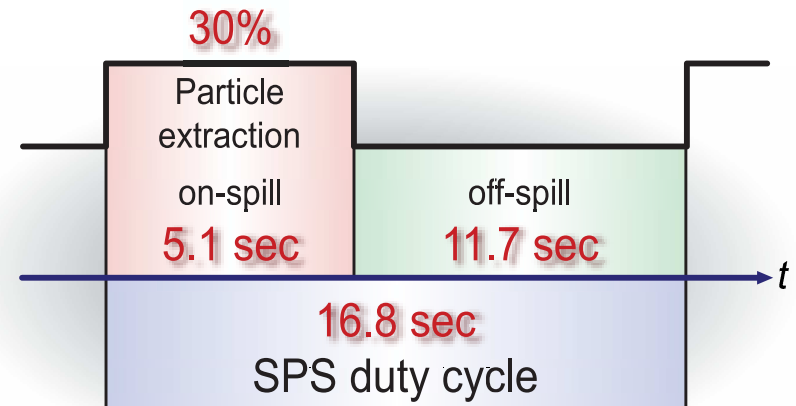
## Readout Requirements:

- Total number of channels: 207k
- Event size: 40–45 kB
- Deadtimes:
  - RICH: 5  $\mu$ s fixed (2002:  $\mu$ M: 13  $\mu$ s)
  - Silicon/GEM: 10 triggers in 250  $\mu$ s
  - Calorimeter: 3 triggers in 30  $\mu$ s

## Rate Requirements:

- SPS duty cycle: 5.1s beam in 16.8s
  - Trigger rates: 5-100 kHz
  - Data rates: 0.9-18 GB/SPS-spill
- Online filter

Detector	Channels	Occ. (%)	kB/evt.
BMS	256	12.2	0.35
SciFi	3936	6.5	2.71
Silicon	9168/13752	5.3	1.94/2.91
Micromegas	12288	5.8	4.39
GEM	30720	5.5	6.78
Small DC	4224	3.3	1.14
Straws	6912/11520	1.4	1.26/2.1
RICH	82944	3.5	13.13
MWPC	25592	0.8	3.00
Large DC	976/1952	15.1	0.72/1.44
Calorimeters	1024	1.9	0.21
Myon-Filters	9472	0.8	1.26
Hodoscopes	1536	5.2	0.80
Counters	576	94.5	2.42
<b>Total</b>	<b>190280/207360</b>	<b>3.9</b>	<b>40.1/42.5</b>



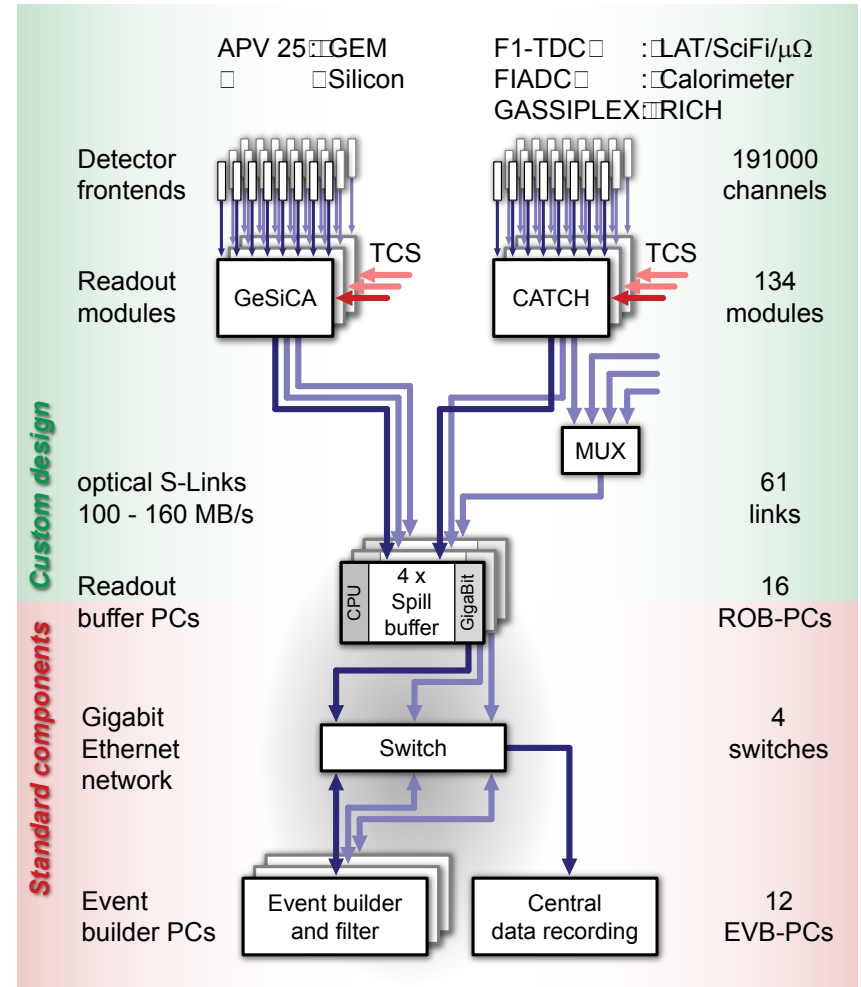
# DAQ Architecture

## Features:

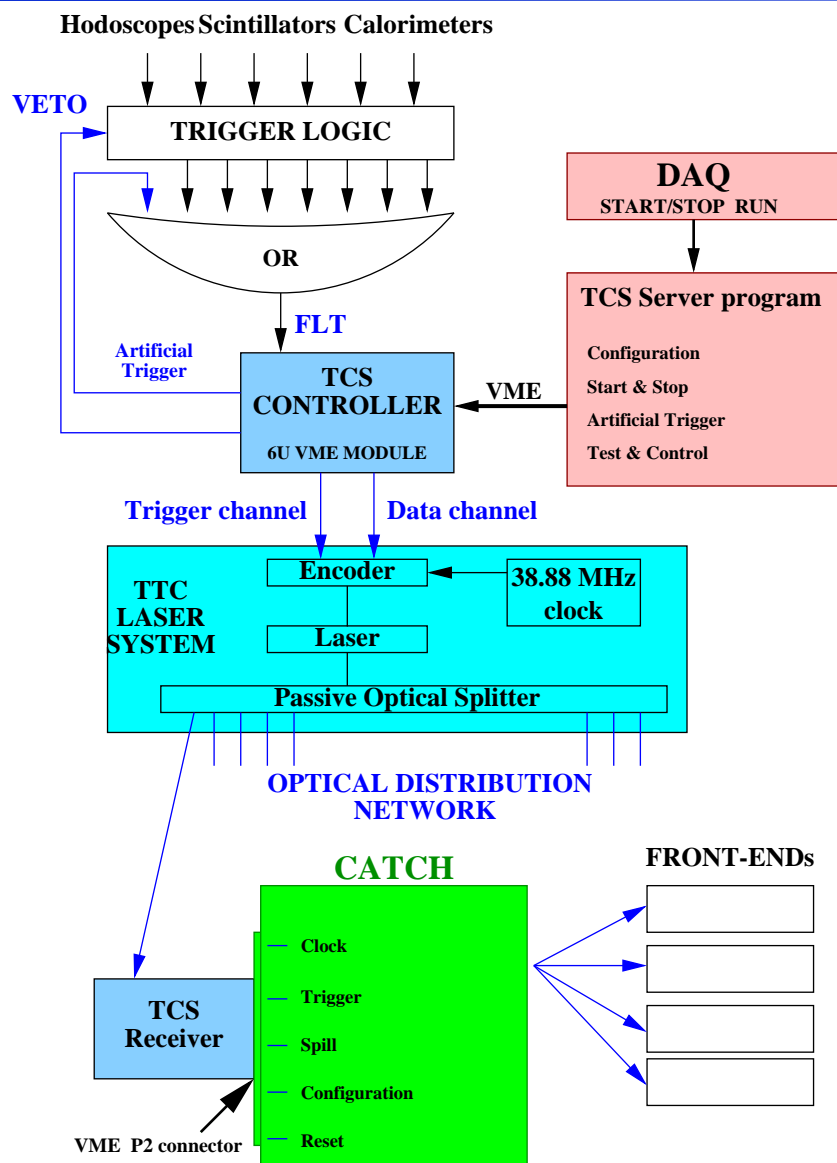
- Pipelined readout architecture
- Data transfer via S-Link
- Buffering of bursts (SPS duty cycle  $\sim 30\%$ )
- Network eventbuilding
  - Gigabit Ethernet
  - Dual processor server PCs
- Central data recording
  - Storage in CASTOR HSM
  - 2002: Formatting to Objectivity
  - 2003: Metadata in Oracle, raw data to CASTOR

## Software:

- ALICE DATE for eventbuilding, run control, event sampling, info logging
- PCI DMA driver
- Monitoring DATE + ROOT
- Run Logbook (TCL, PHP, MySQL)
- Frontend DB (MySQL)



# Trigger Control System



## Functions:

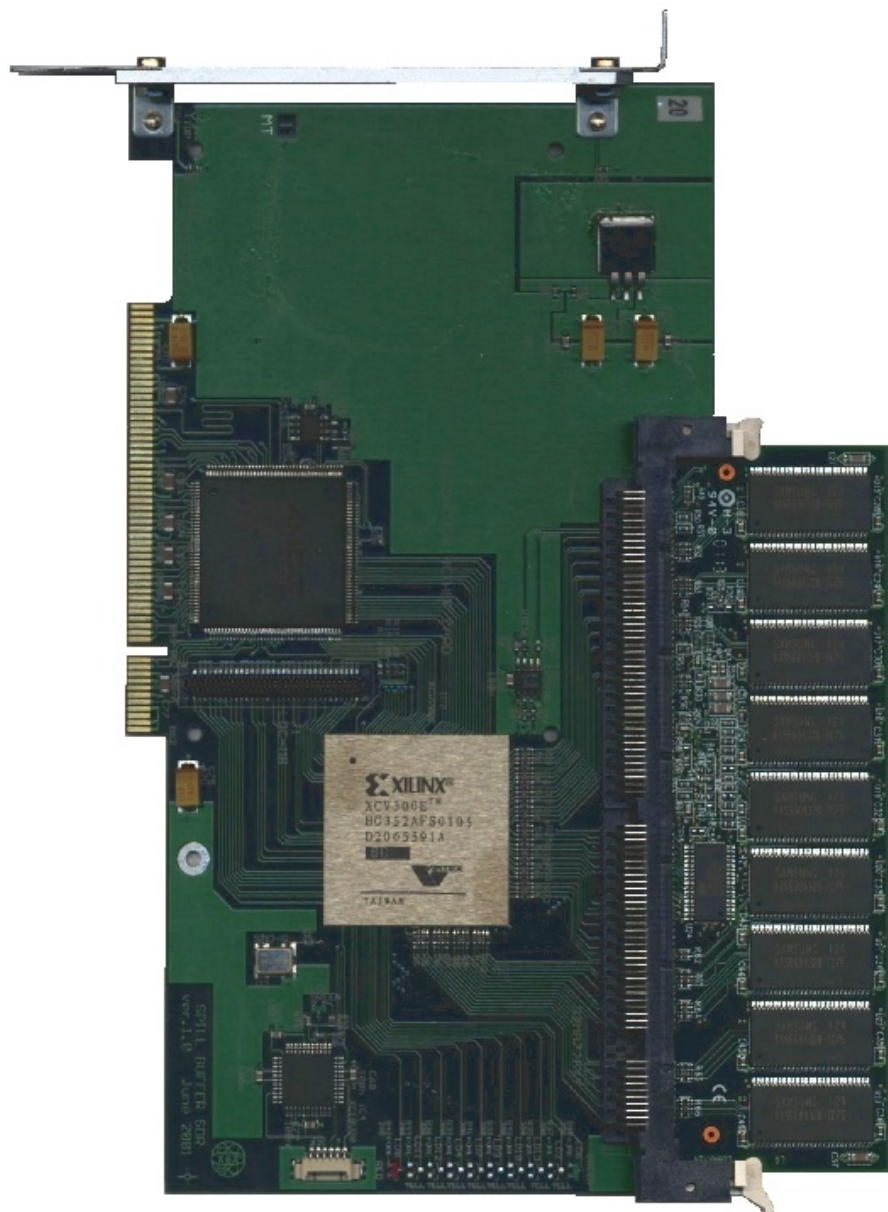
- Provides precise **clock** of 38.88 MHz, measured jitter  $\approx 44$  ps RMS (between FEs)
- Generates unique **event number**
- Distributes **trigger**
- Keeps experiment **deadtimes**:
  - Fixed:  $F \mu s$
  - Variable:  $N$  triggers per  $T$  clocks
- Generates **artificial triggers** for test
- DAQ sectioning: 8 indep. **sub-DAQs**
- **Control**: resets, setup, masks

## Components:

- TCS Controller: FPGA based VME module
- TCS Receiver: P2 transition board
- LHC TTC optical distribution



# S-Link and Spillbuffer



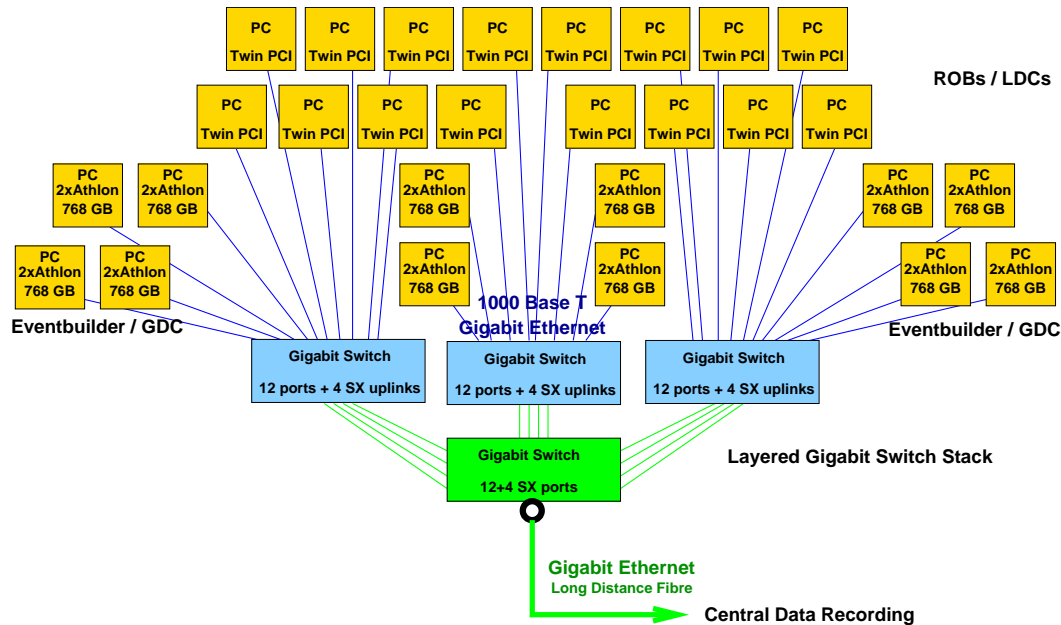
## S-Link

- CERN Standard Interface
  - IEEE 1386 CMC connector
  - In COMPASS 3 types:
    - FCS 100 MB/s
    - Single G-Link 128 MB/s
    - Double G-Link 160 MB/s
- adapt to detector rate

## Spillbuffer PCI-card

- PCI interface AMCC 5935 with 32-bit
  - 512 SDRAM operating as FIFO
  - Xilinx Virtex 300 control FPGA
  - S-link interface for data input
  - Linux module for readout
    - DMA readout to main memory
    - Interrupt controlled event blocks
    - Dynamic event directory
- throughput 72 MB/s at 4 kB/evt

# Computers and Network



## ROB Computers: 17 units

- Dual PIII 1266 MHz, 1 GB RAM
- ServerWorks Chipset
- 32-bit PCI bus for S-Link inputs
- 64-bit PCI bus for network output

## Eventbuilder PCs: 12 units

- Dual Athlon MP 1900+, 1 GB RAM
- 640 GB net IDE-RAID (3Ware)
- Online filtering at 4ms/evt (10 kHz)

## Run 2002/2003 figures

- **2002:** 5 kHz rate (20-25k / spill)
- **2003:** 10 kHz rate (~50k / spill) with online filter
- event size 40–50 kB

## Gigabit Network

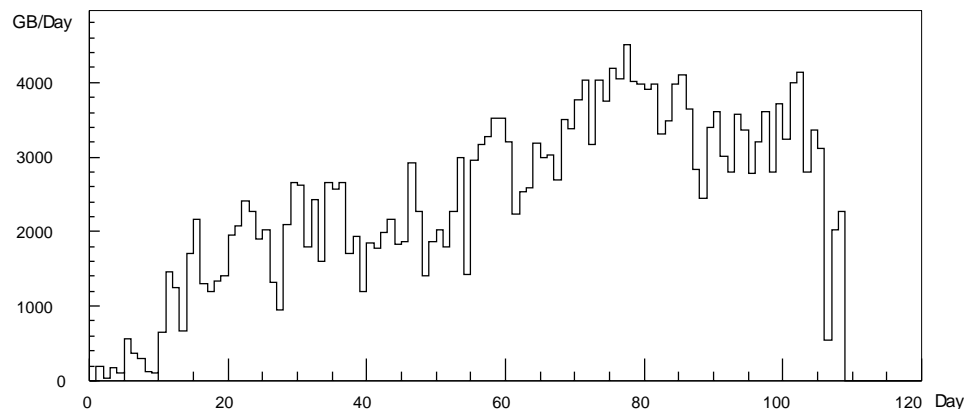
- 1 3COM 4900 SX(12 + 4 SX ports) as backbone
- 3 3COM 4900 (12 TX + 4 SX ports) as frontend switches, each with 4 uplinks to backbone
- up to 36 x 1000 BaseT ports
- Balancing: 4 EVBs/FE switch



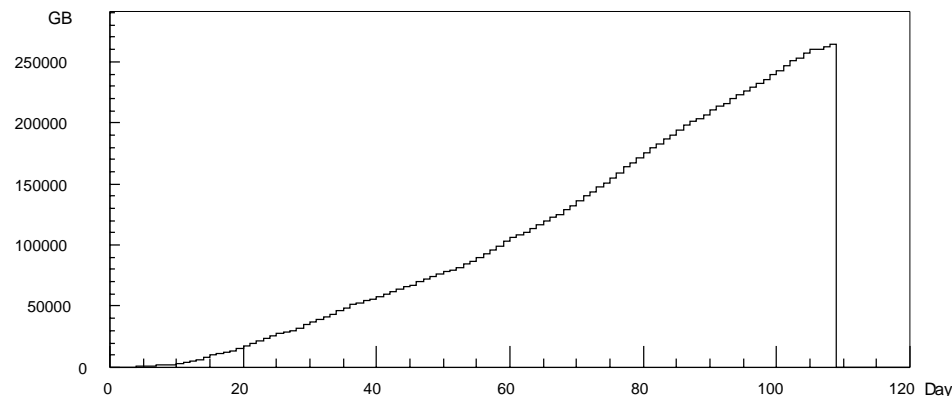
# View of the COMPASS DAQ



# Data Taking Performance 2002



*Daily Datarate: max. 4.4 TB/day*



*Accumulated Data: 260 TB, 5 G ev*

## DAQ Performance in 2002

- Design 35 MB/s exceeded by 50%
  - Recording: <60 MB/s sustained, < 4.4 TB/day
  - Limits: <120 MB/s sustained from disk I/O
  - Reconstruction:  $\sim 400\text{--}700$  ms/evt
- 100–150 days on 200 CPUs
- Storage: 260000 files

- Trans. Pol.: 19 days, 52k spills
- Long. Pol.: 57 days, 173k spills

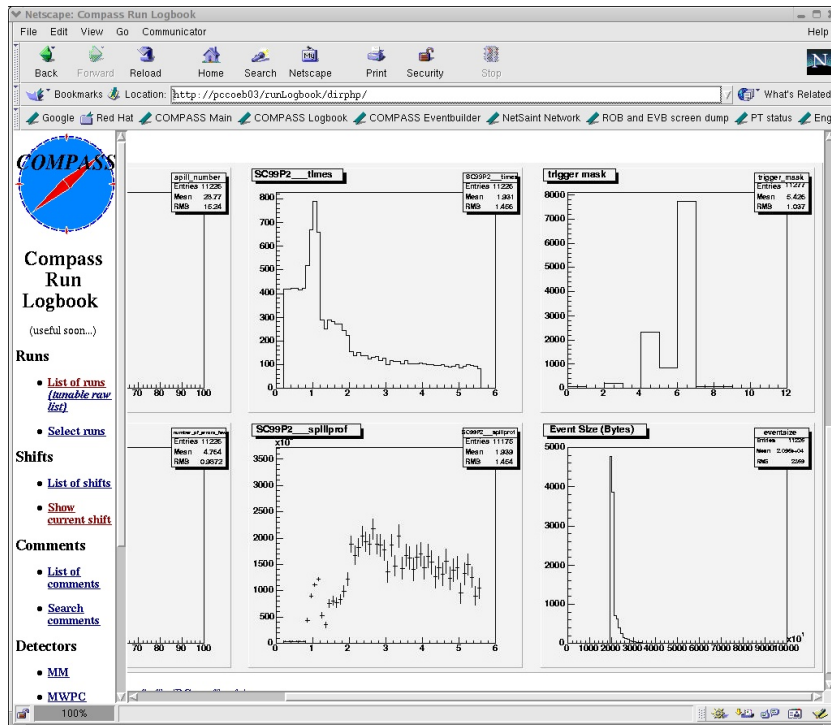
## Comparison 2002/2003

Item	2002	2003
Channels	191k	207k
CATCH/GeSiCA	134	144
S-Links	61	66
Deadtime	7% @ 5 kHz	2% @ 5 kHz, 4.5% @ 10 kHz

# Data Quality Control

## Automatic detector monitoring

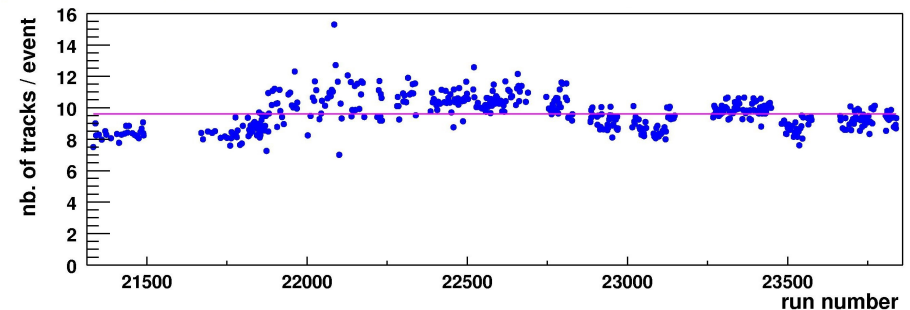
- Based on ROOT, CARROT, MySQL
- Automated batch job for each run
- Viewing via browser or run logbook



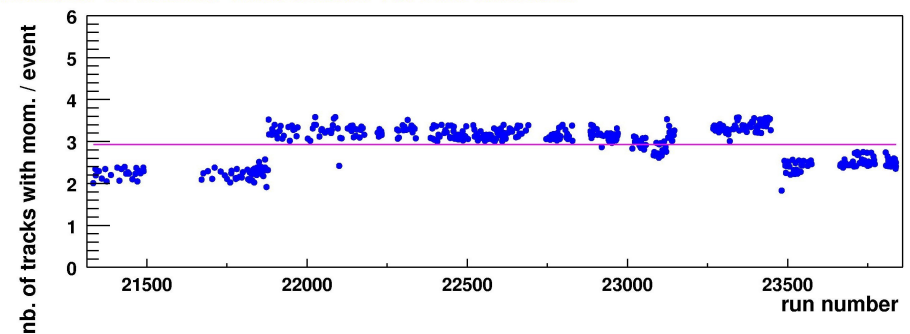
## Data quality parameters

- Regular data quality checks
- Full event reconstruction
- Number of tracks, vertizes, etc.

Number of tracks vs. run number



Number of tracks with mom. vs. run number



# Outlook: Online Filtering

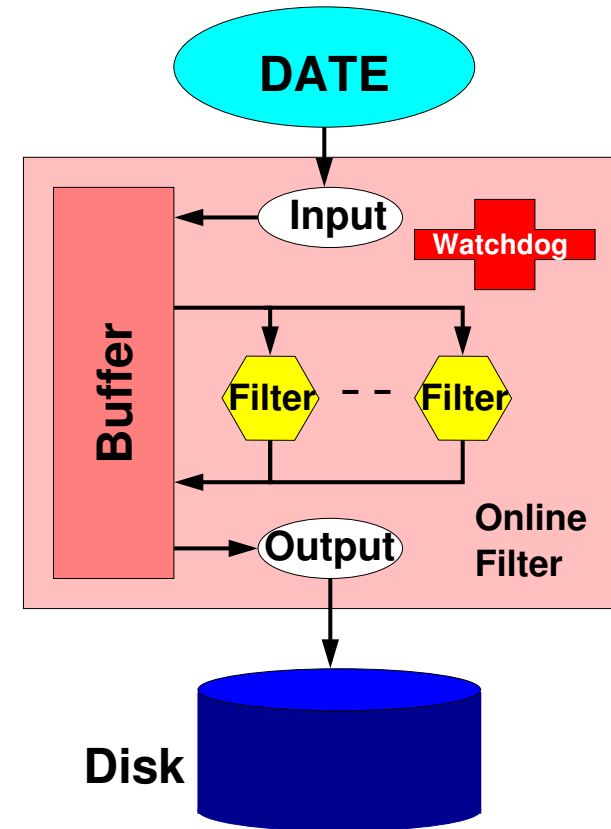
COMPASS will examine more and more demanding physics topics.

## Necessity for Filter:

- Higher interaction rates
  - Too low selectivity of FLT
  - Too high data rate (max. 40-60 MB/s)
  - Difficult event topologies
- Filter after event building

## Stages and scenarios:

- Simple filter on EVB computers
- 4-8 ms per event
- reduction factor 2-4
- Later: dedicated filter farm
- ~ 100 ms per event
- reduction factor 10-20



## Requirements:

- Filter before writing
- rejected events lost
- Close connection to DAQ

# Summary

- COMPASS has a very broad Physics Spectrum
- COMPASS Apparatus completed
- COMPASS has started Data Taking
- COMPASS DAQ takes 45 MB/s, 4.4 TB/day, 300 TB/year
- Two more Years in this Setup
- Online Filter for higher Selectivity
- Upgrade for a Second Phase after 2005 in Preparation
- Filter Farm to reach 100 kHz FLT rate
- COMPASS will run well into the LHC Era