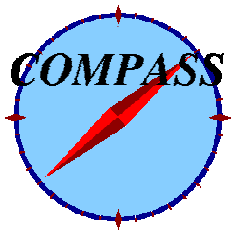
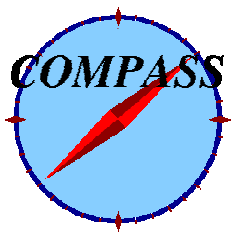


The COMPASS spectrometer: status and performance

Silvia Dalla Torre

INFN, Trieste

COMMON
MUON and
PROTON
APPARATUS for
STRUCTURE and
SPECTROSCOPY



THE COMPASS COLLABORATION

Bielefeld, Bochum, Bonn (ISKP), Bonn (PI), Burdwan and Calcutta, CERN, Dubna (LPP and LNP),Erlangen, Freiburg, Heidelberg, Helsinki, Mainz, Moscow (INR), Moscow (LPI), Moscow (State University), München (LMU), München (Technical University), Nagoya, Protvino, Saclay, Tel Aviv, Torino (University and INFN), Trieste (University and INFN), Warsaw (SINS), Warsaw (TU)

More than 200 physicists from 26 Institutes

PHYSICS OBJECTIVES

COMMON
MUON and
PROTON
APPARATUS for
STRUCTURE and
SPECTROSCOPY

Nucleon spin structure

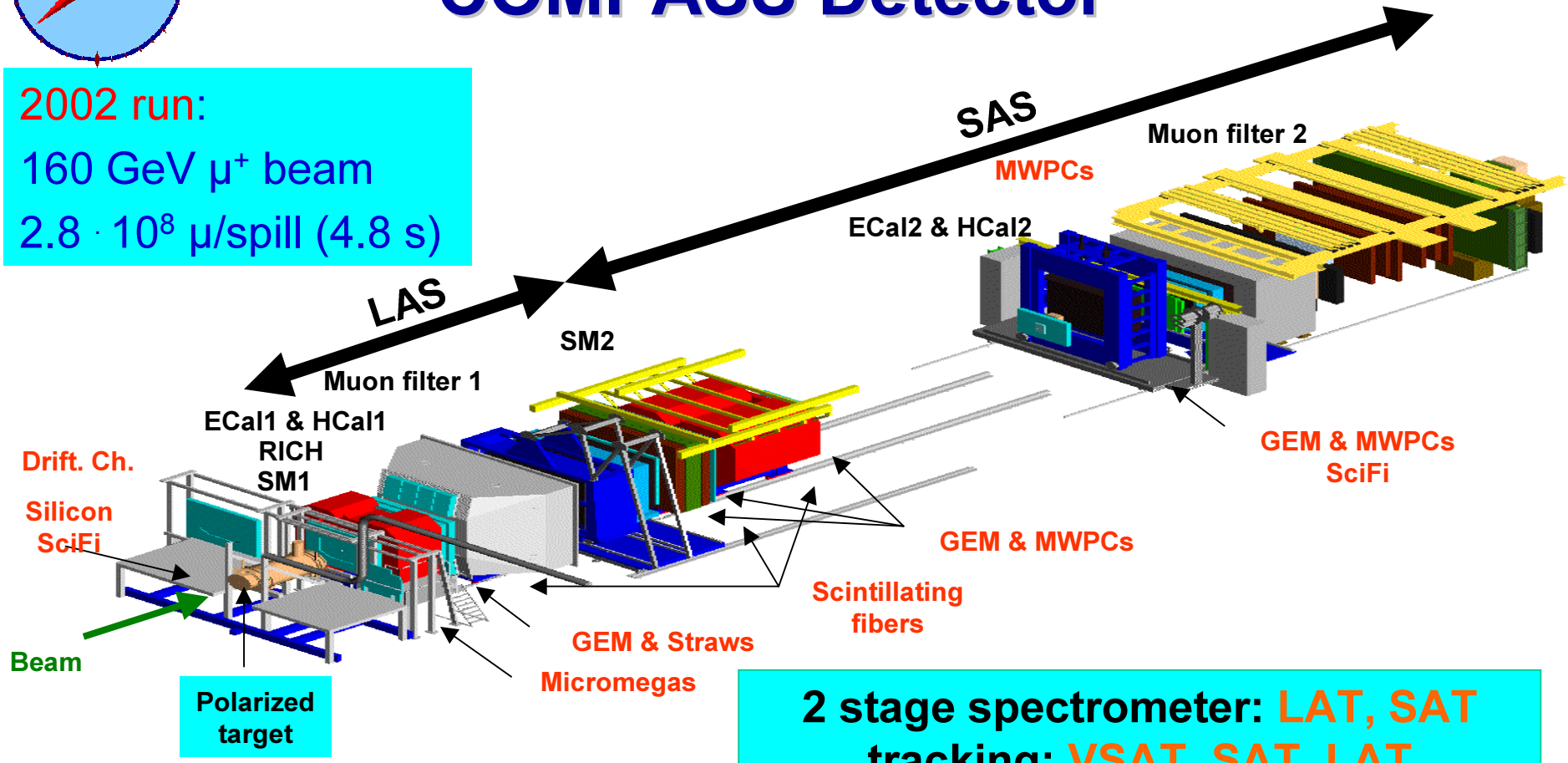
- Gluon polarization $\Delta G(x)$
- Flavour-dependent helicity functions $\Delta q(x)$
- Transverse-spin distribution functions $\Delta_T q(x)$
- Spin-dependent fragmentation (ΔD^{Λ}_{q})

Spectroscopy

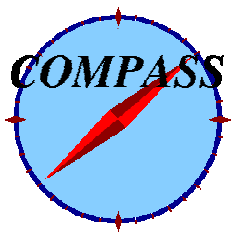
- Primakoff reactions
  - **Polarizability of π and K**
- Glueballs and hybrids
- Charmed mesons and baryons
  - **Semileptonic decays**
  - **Double-charmed baryons**

COMPASS Detector

2002 run:
160 GeV μ^+ beam
$2.8 \cdot 10^8$ μ/spill (4.8 s)



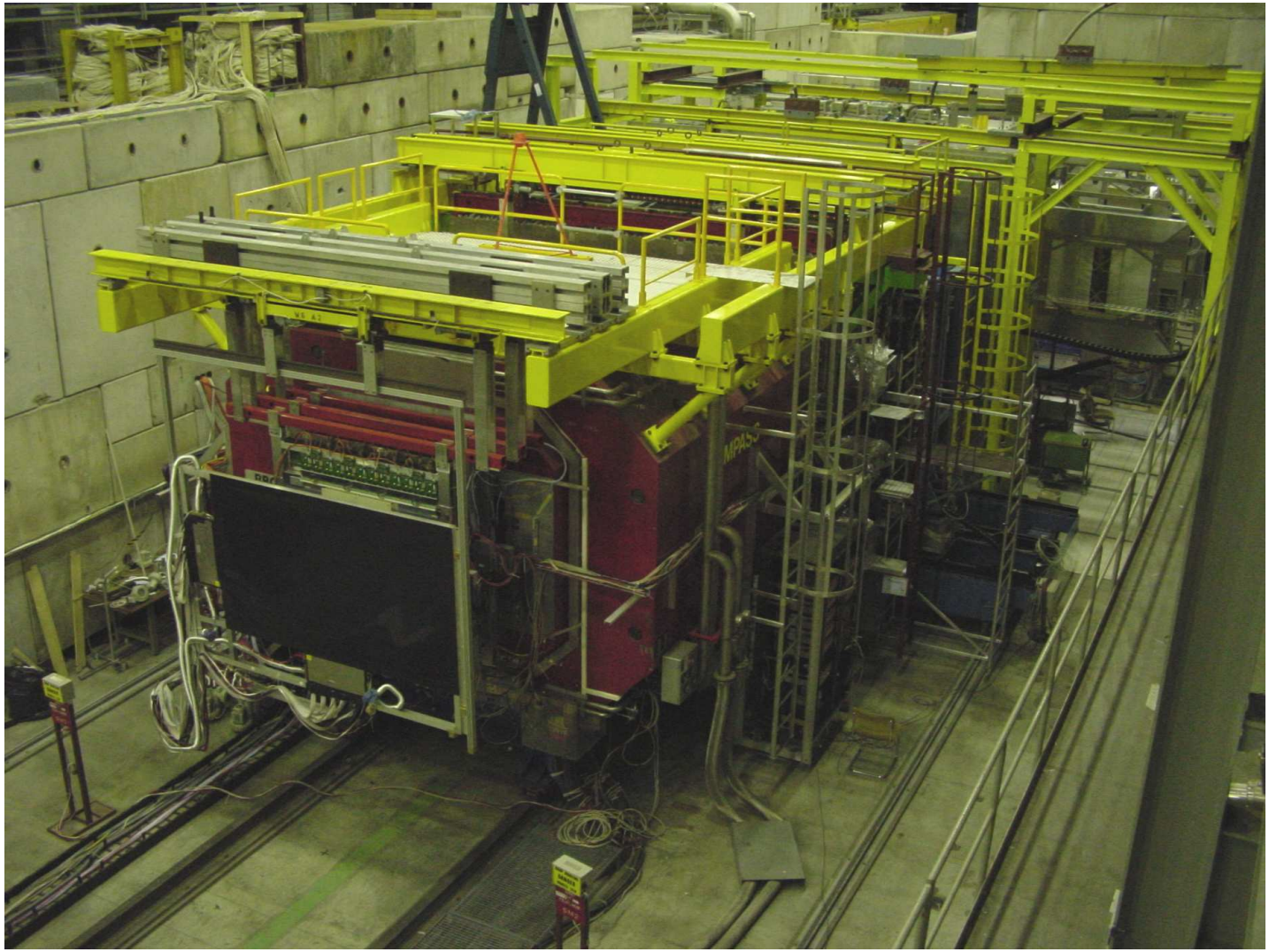
2 stage spectrometer: LAT, SAT
tracking: VSAT, SAT, LAT
calorimetry: Ecal1, Hcal1, Ecal2, Hcal2
PID: RICH-1, μ–wall1, μ–wall2
Polarised Target



LARGE MECHANICAL STRUCTURES

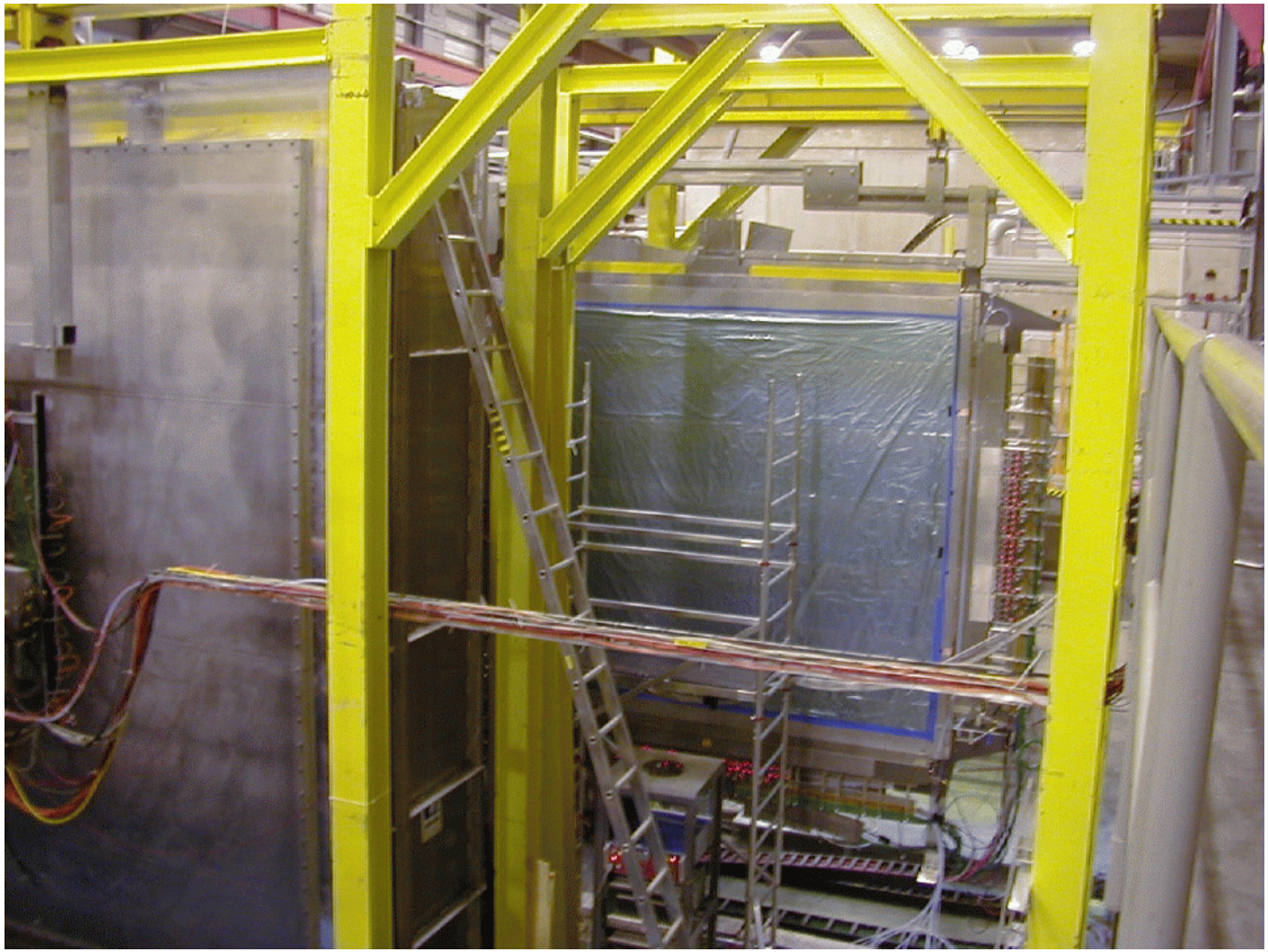
SOME EXAMPLES

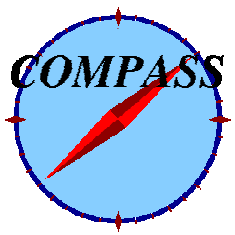
SAS + SM2 in the hall



ECAL1 frame

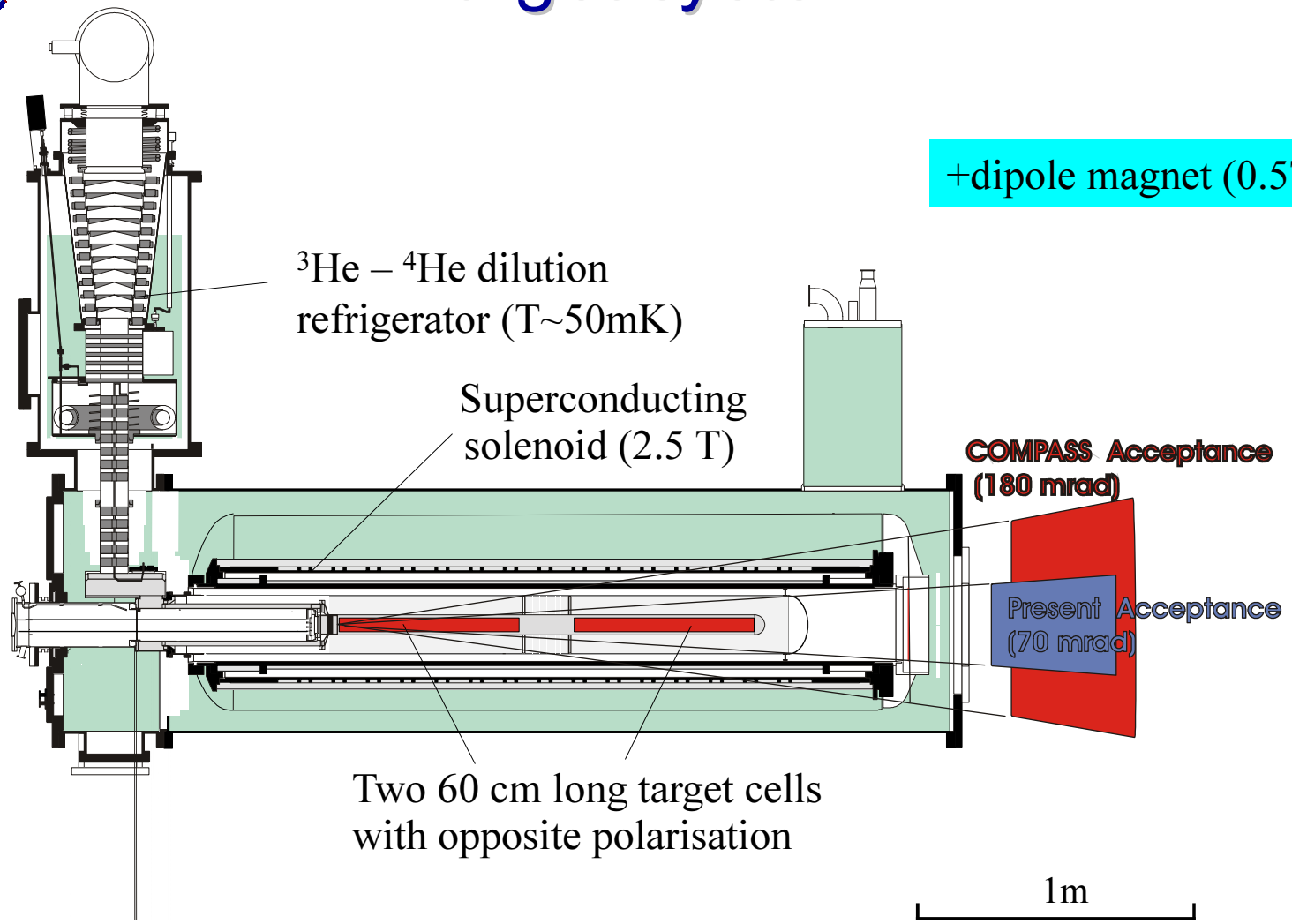
TRACKER SUPPORT IN RICH-1 REGION



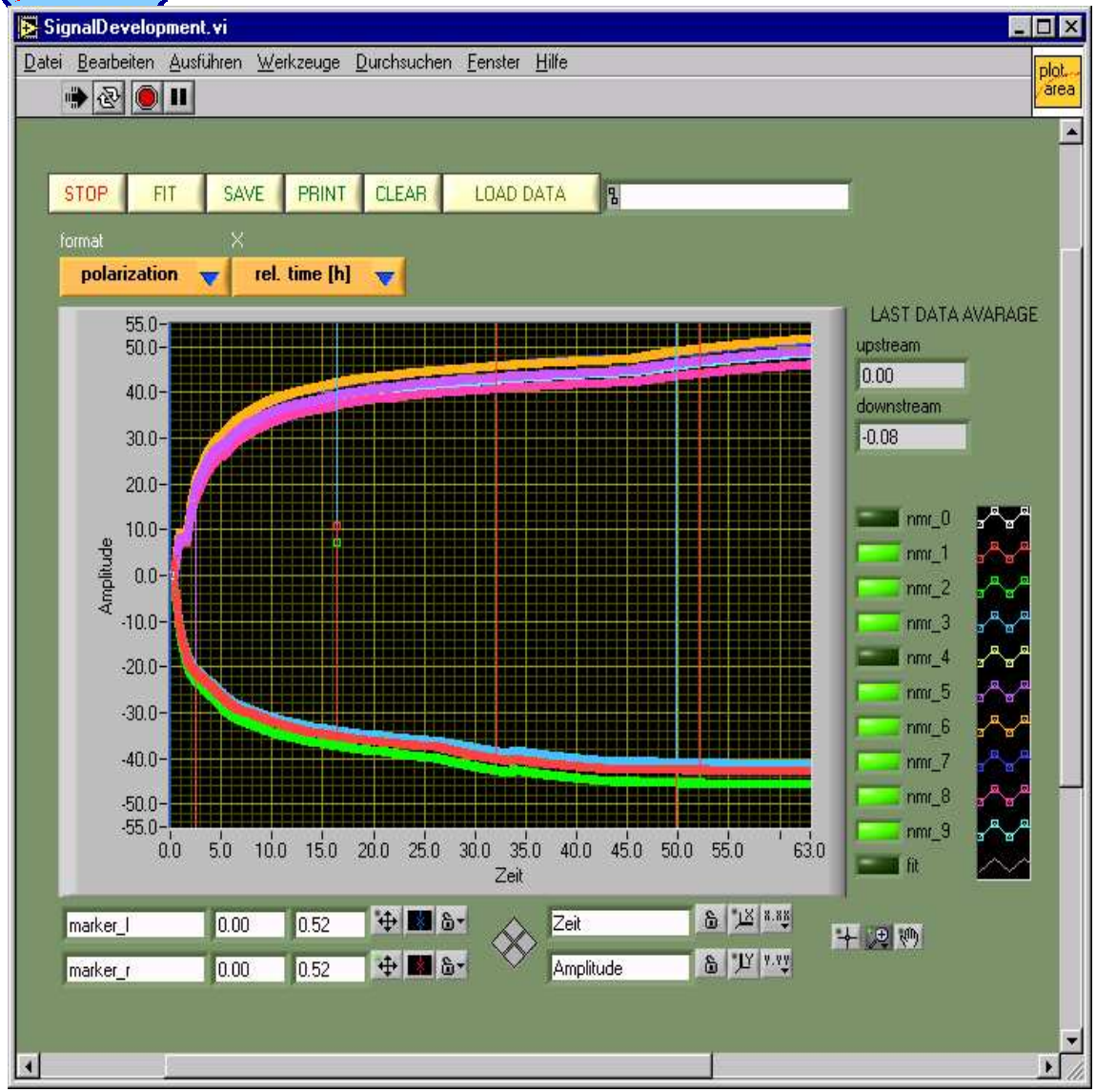


POLARIZED TARGET

Target system



^{6}LiD Target



Dynamic Nuclear Polarization

Dilution factor ~50%

Maximum P values

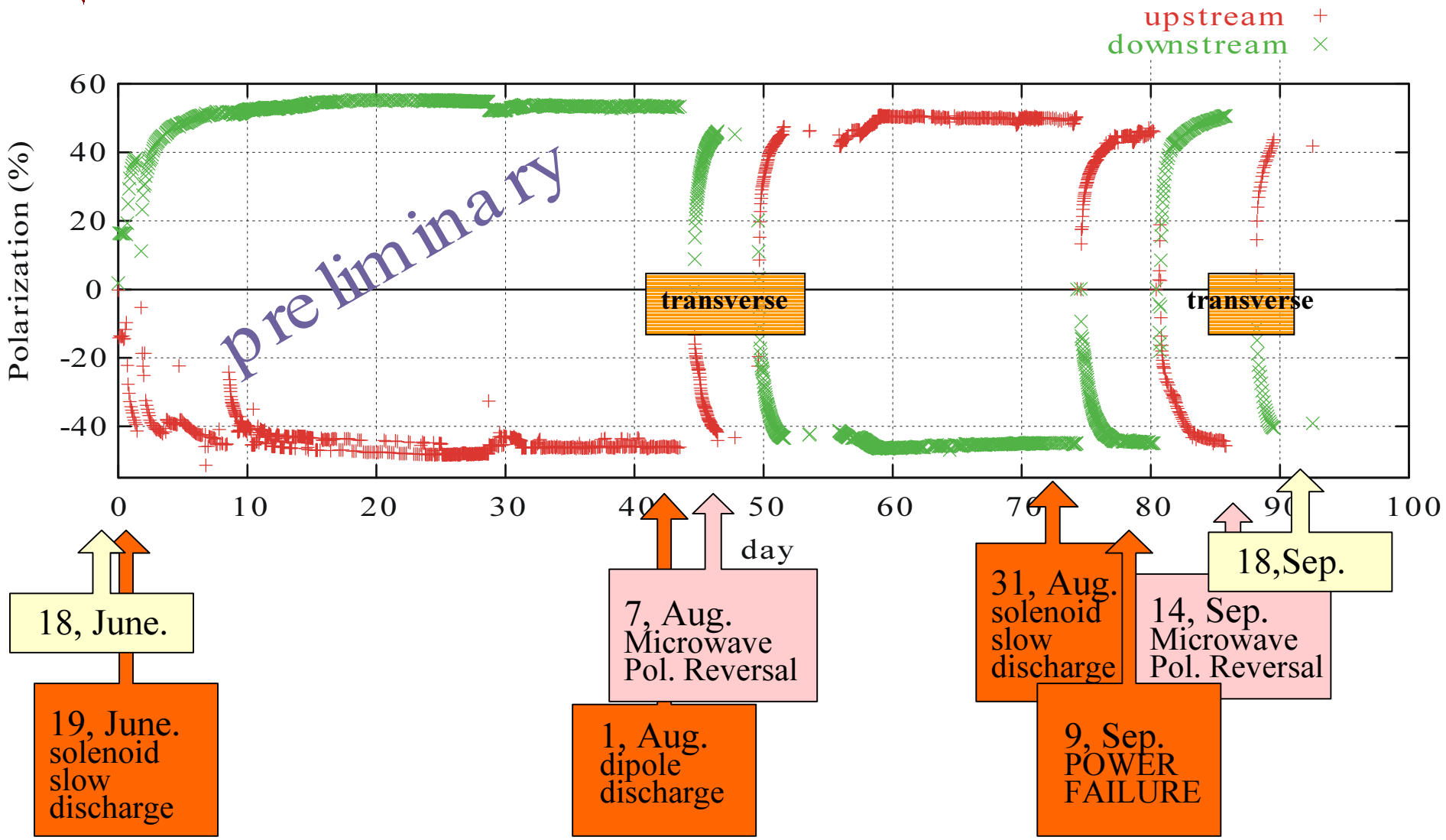
– 49% + 57%

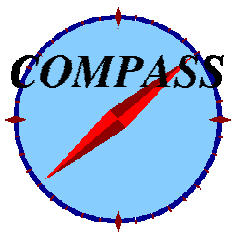
Spin relaxation time:

-Longitudinal spin (2.5 T): too long to be measured

-Transverse spin (0.5 T): >1000 hours

^{6}LiD Target Polarization 2002



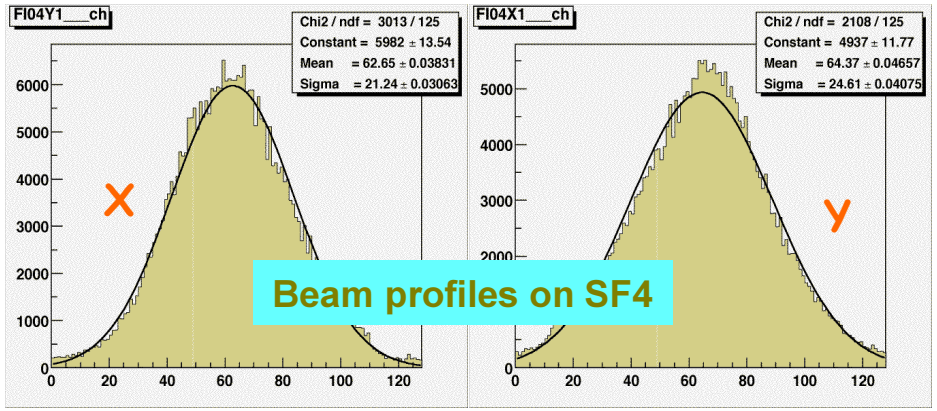


TRACKERS

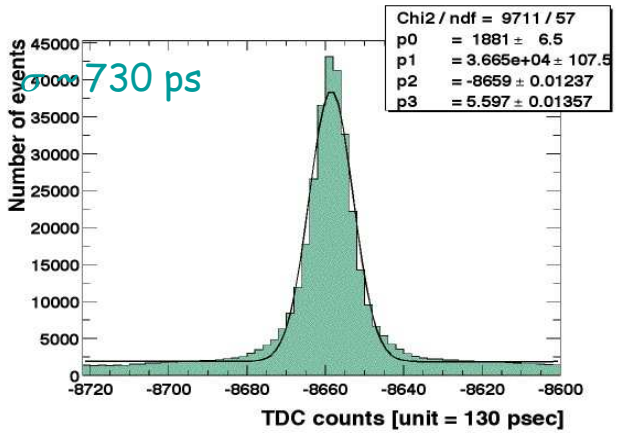
VERY SMALL ANGLE TRACKERS

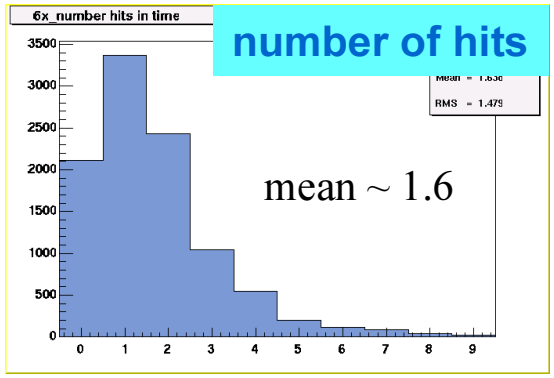
Scintillating Fiber Detectors

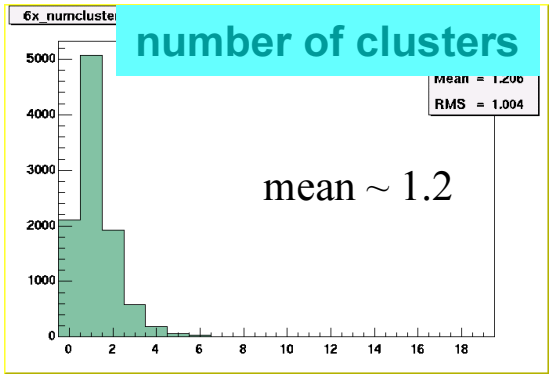
- 9 stations, 21 coordinates, 2668 fibre ch.s, 4008 discr. ch.s
- efficiency: typically 99%
- time resolution: 450 to 550 ps
- enormous rate capability: 5 MHz per fiber
- spatial resolution: 130 to 250 μm



time difference "SF1X -SF1Y"
(time resolution SF1: σ ~ 520 ps)

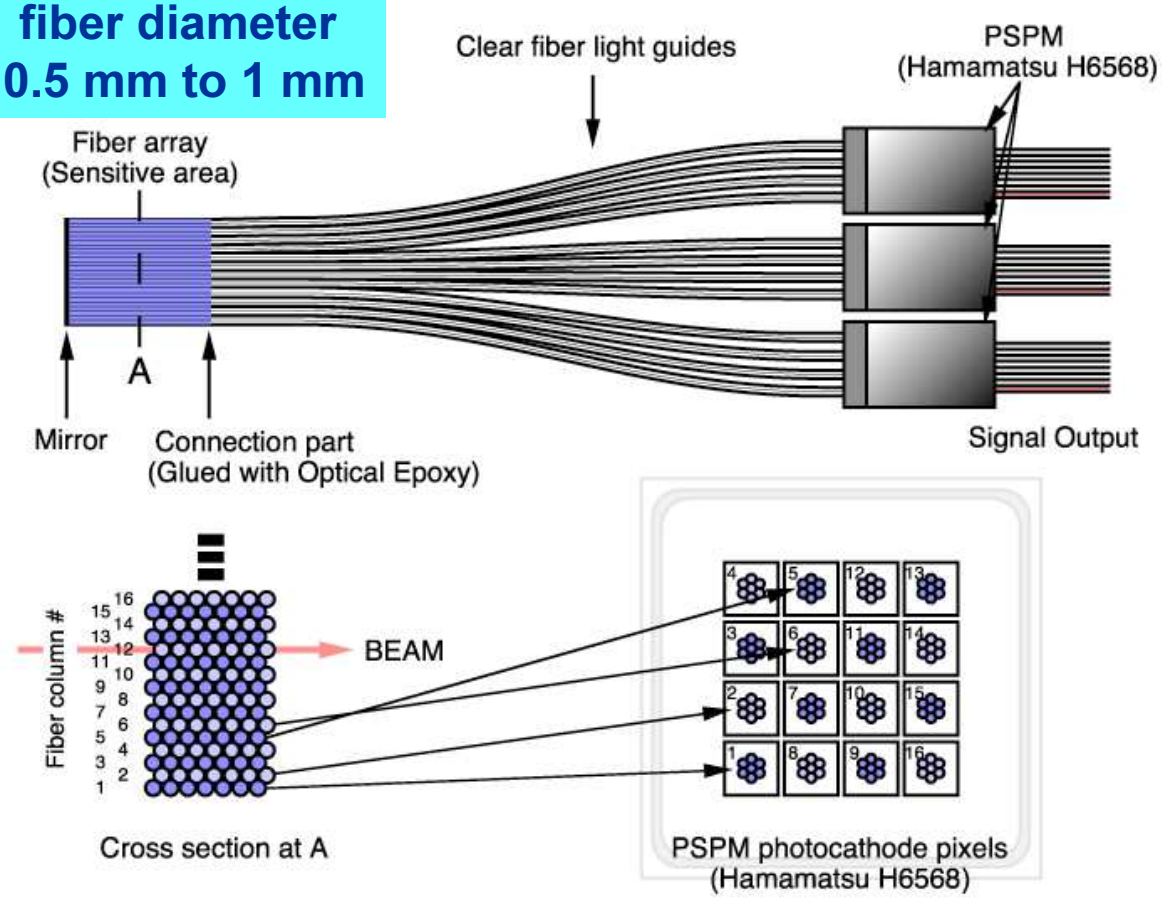






SciFi

fiber diameter
0.5 mm to 1 mm



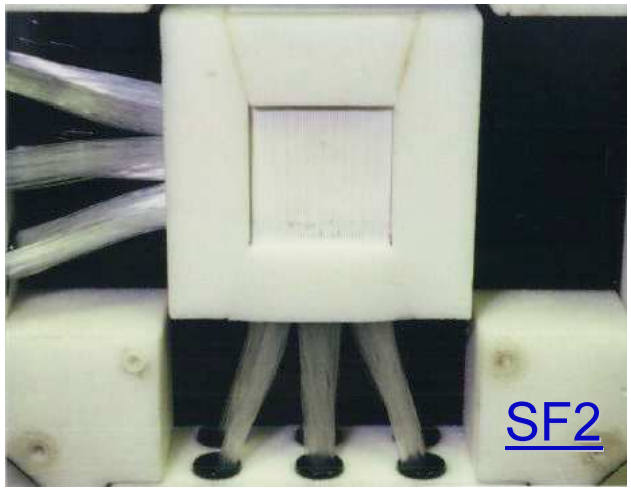
Position-Sensitive Photomultiplier (PSPM):

H6568MOD (HAMAMATSU)

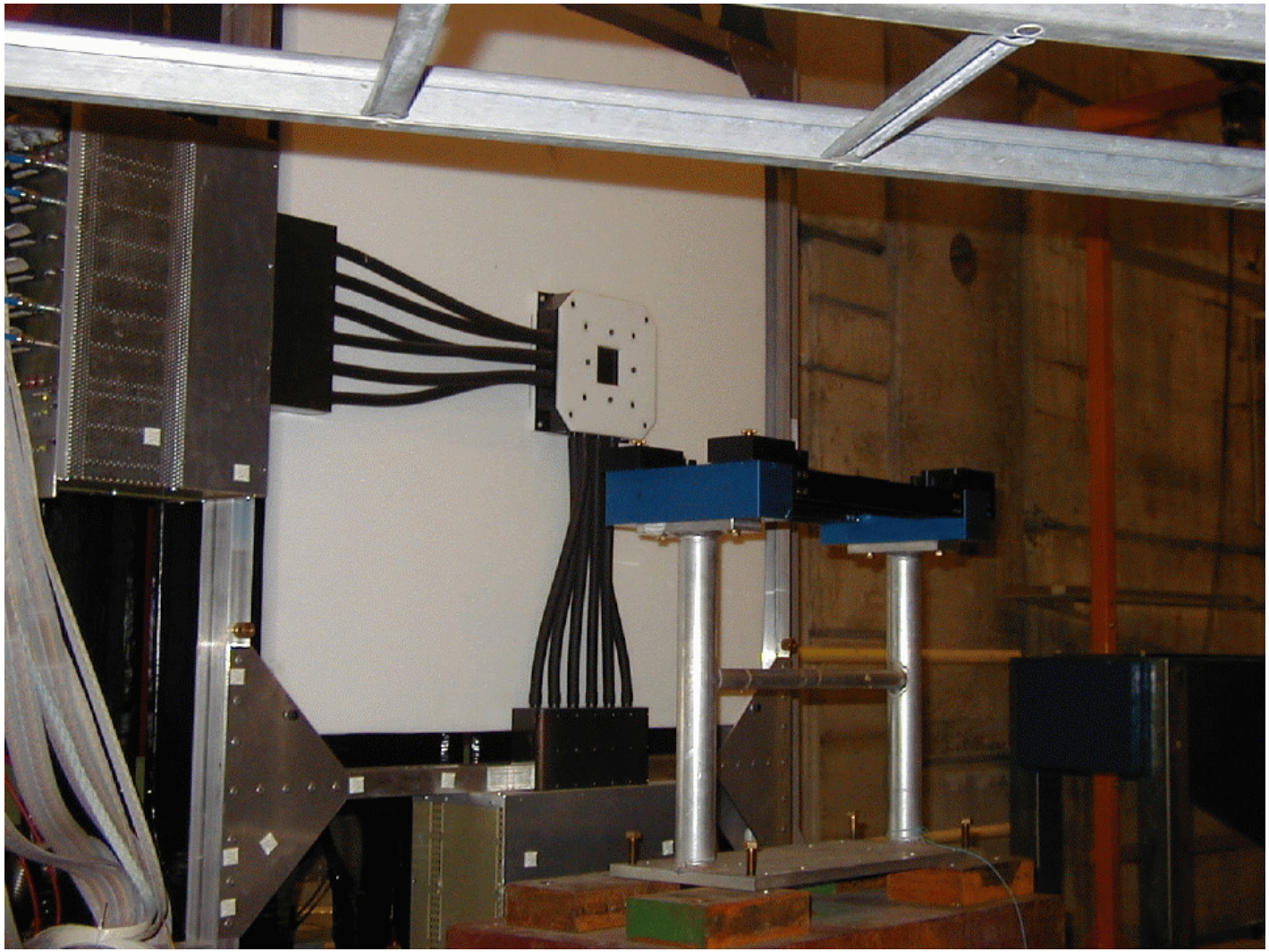
- 16 ch Multi-Anode
- Booster for the last 4 stages of dynodes

Sensitive area:

7-layers of Kuraray SCSF-78MJ 0.5 mm Ø

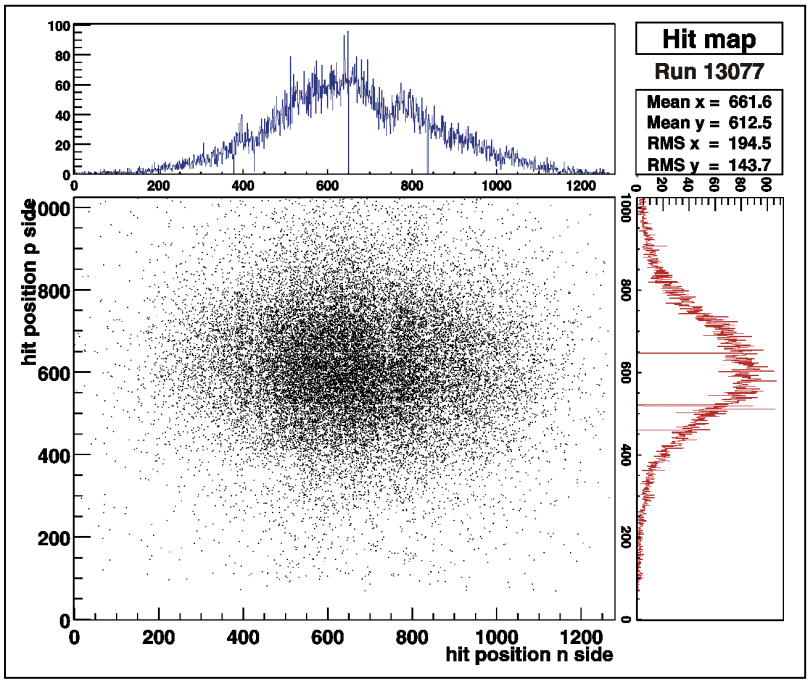


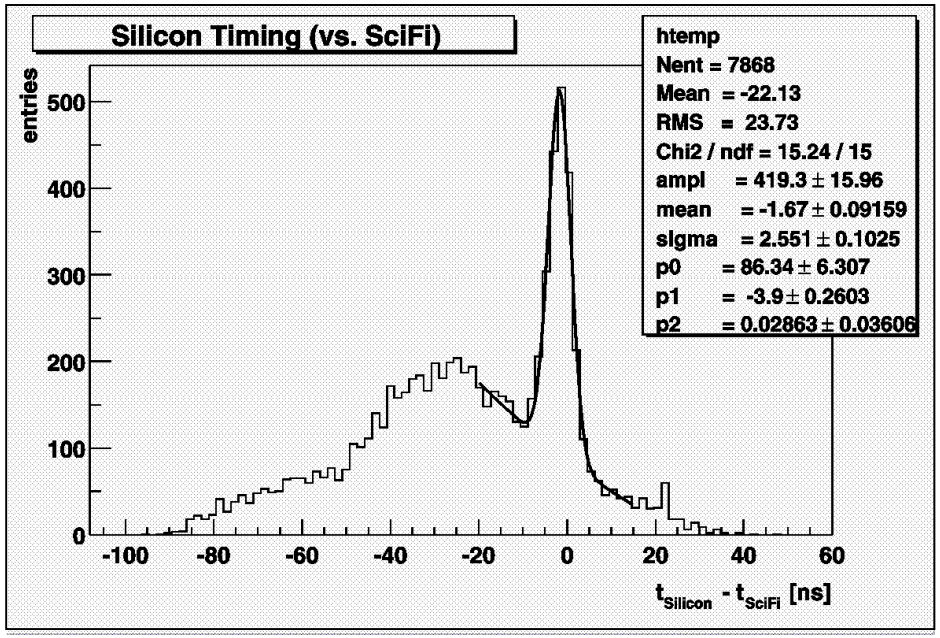
SciFi

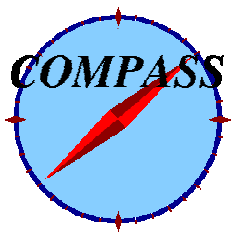


Silicon trackers

- 2 stations, i.e. 4 double sided silicon detector operated in 2002
- strip pitch 50 μm
- dimensions 50 x 70 mm^2
- time resolution 2.5 ns
- efficiency ~ 99%







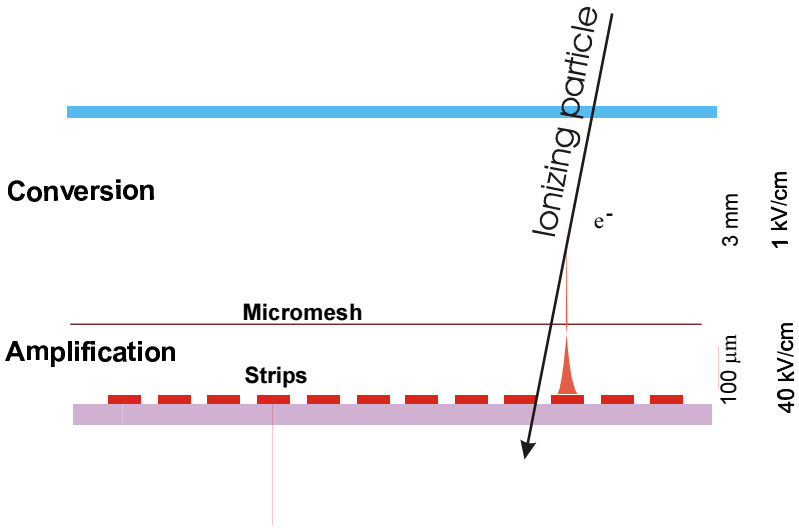
TRACKERS

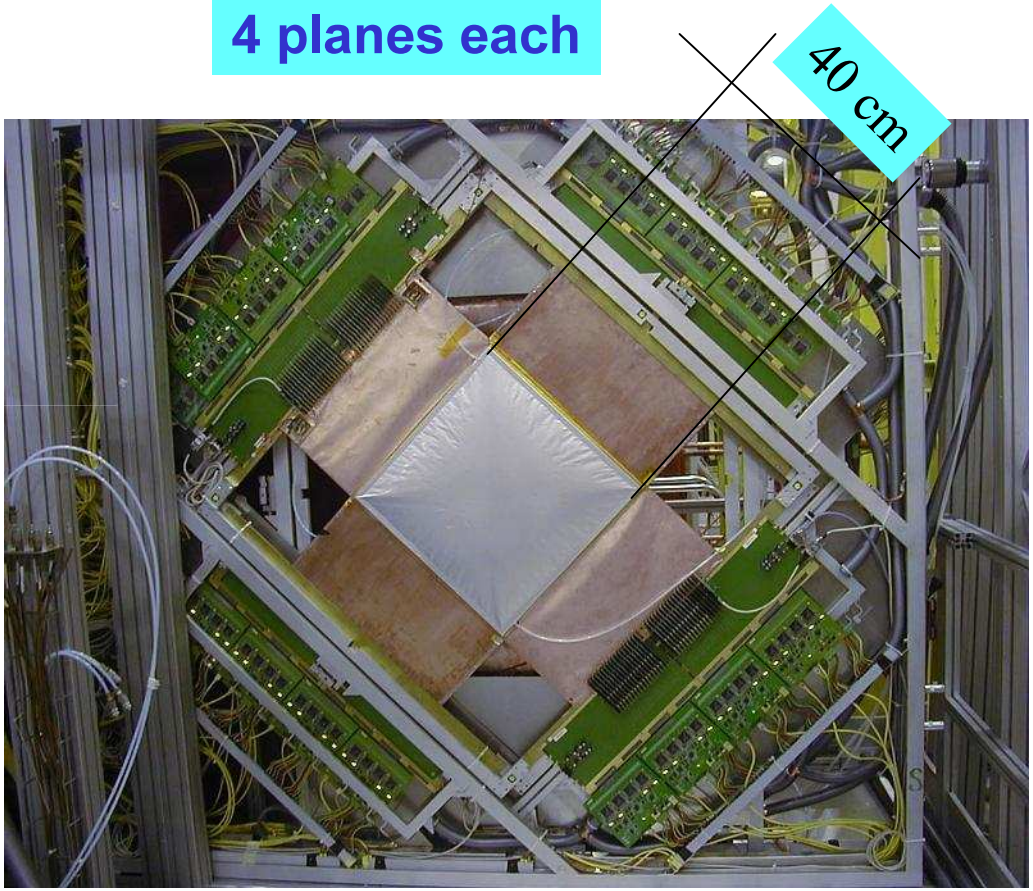
SMALL ANGLE TRACKERS

MicroMegas
(Micro Mesh Gas Detectors)

2002 run:
3 stations,
4 planes each

Novel gaseous detector

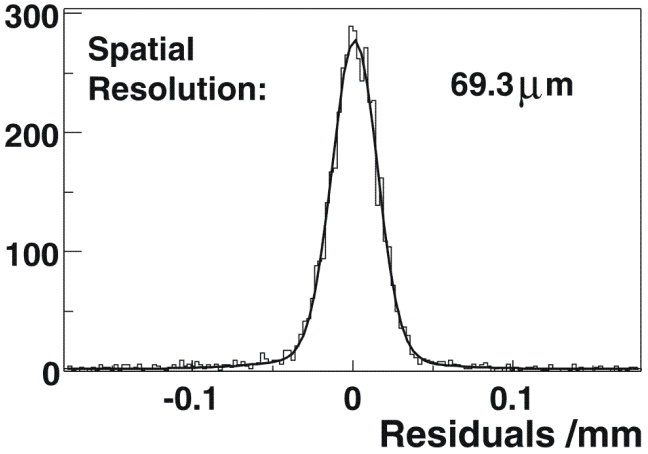




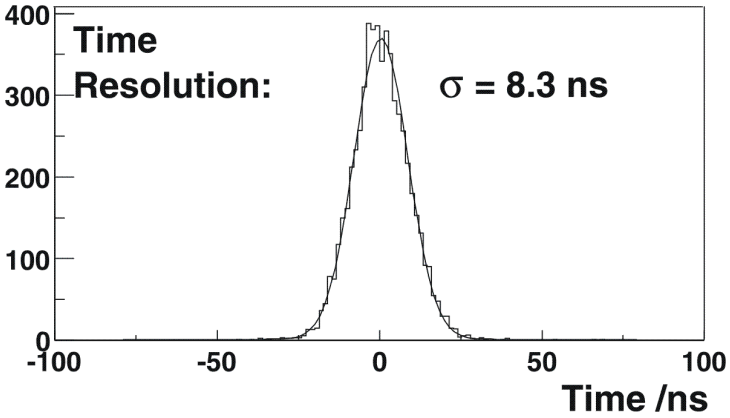
40x40 cm^2,
dead zone: 5 cm Ø

MicroMegas

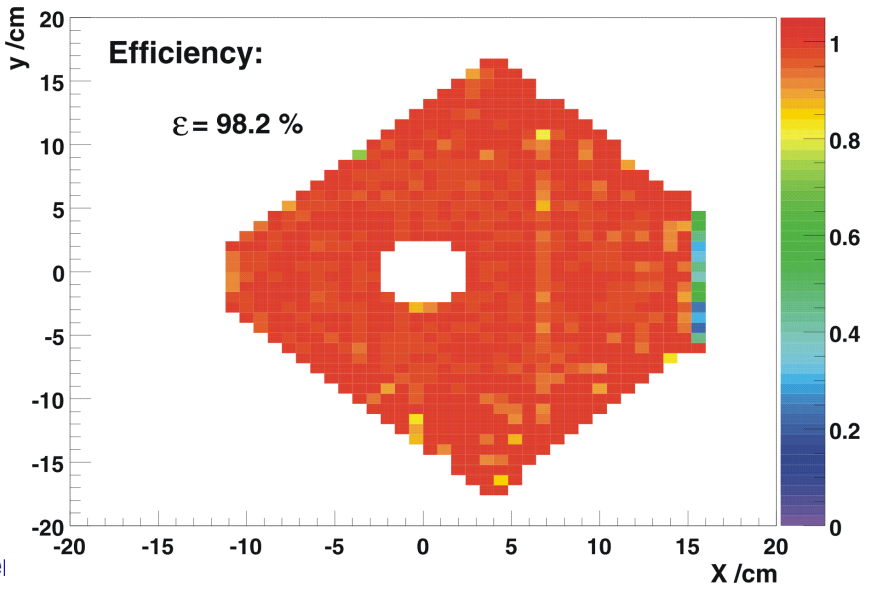
spatial resolution below 70 μm



time resolution below 10 ns



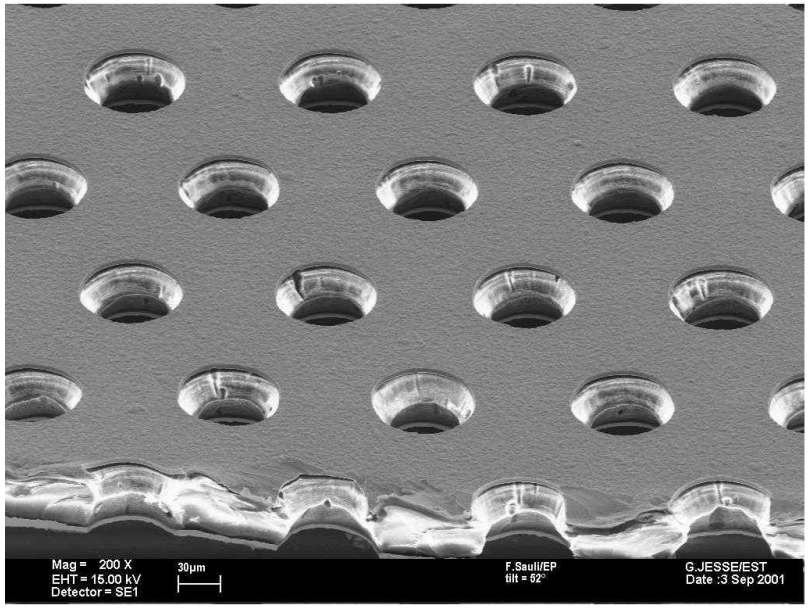
efficiency larger than 97%

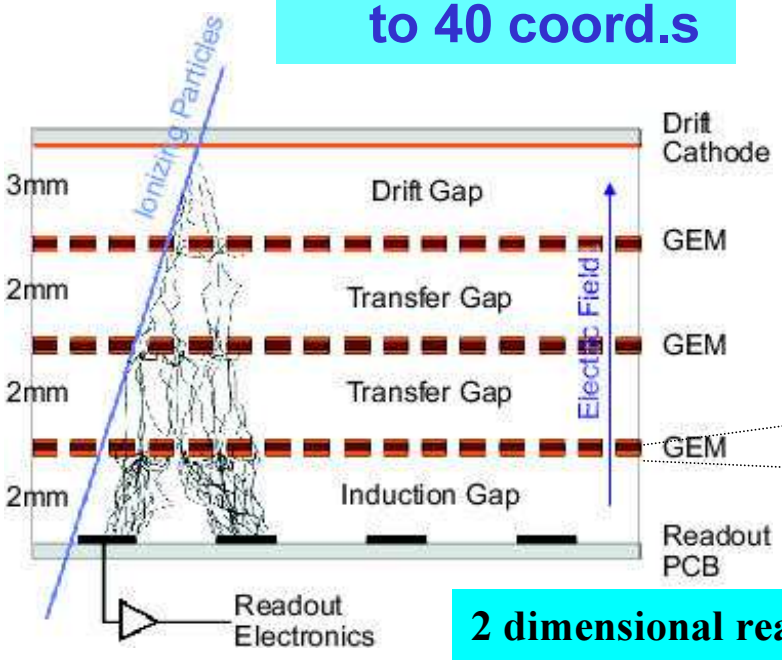


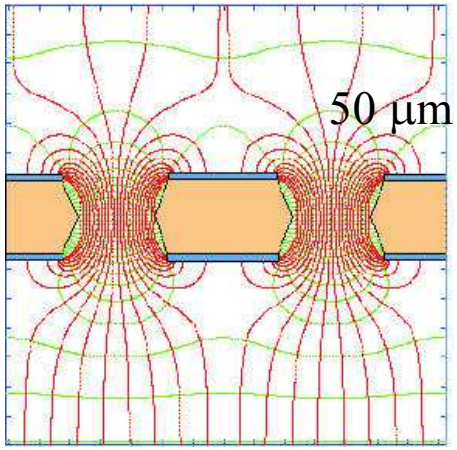
GEMs

- **novel gaseous detector**

2002 run:
10 stations,
2 detectors each corresponding to 40 coord.s





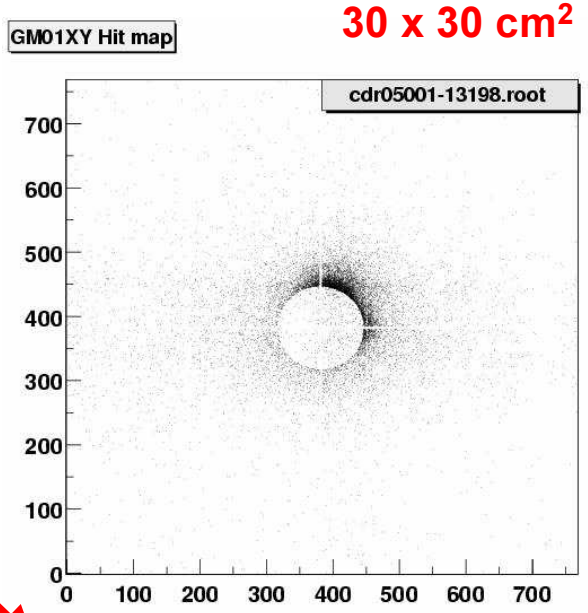


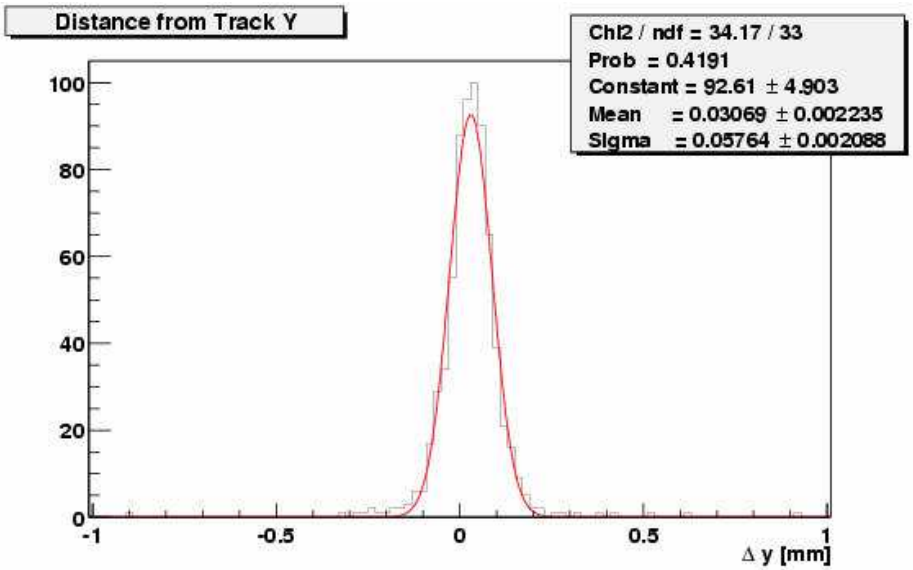
2 dimensional read-out

GEMs

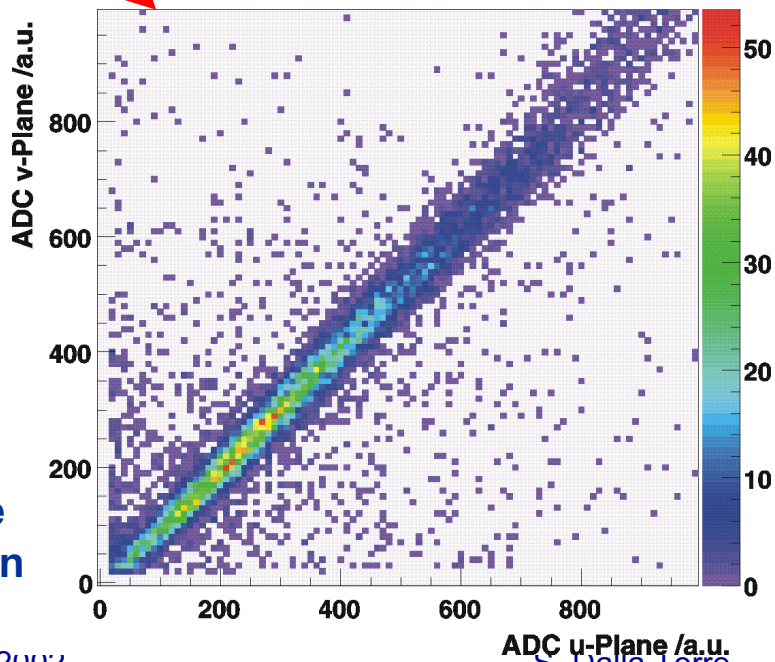
- two dimensional read-out
- spatial resolution ~50 μm
- time resolution ~ 12 ns
- efficiency ~ 96 – 97%

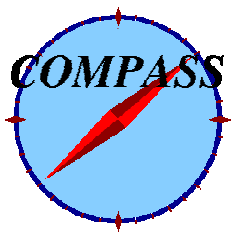
30 x 30 cm^2





amplitude correlation

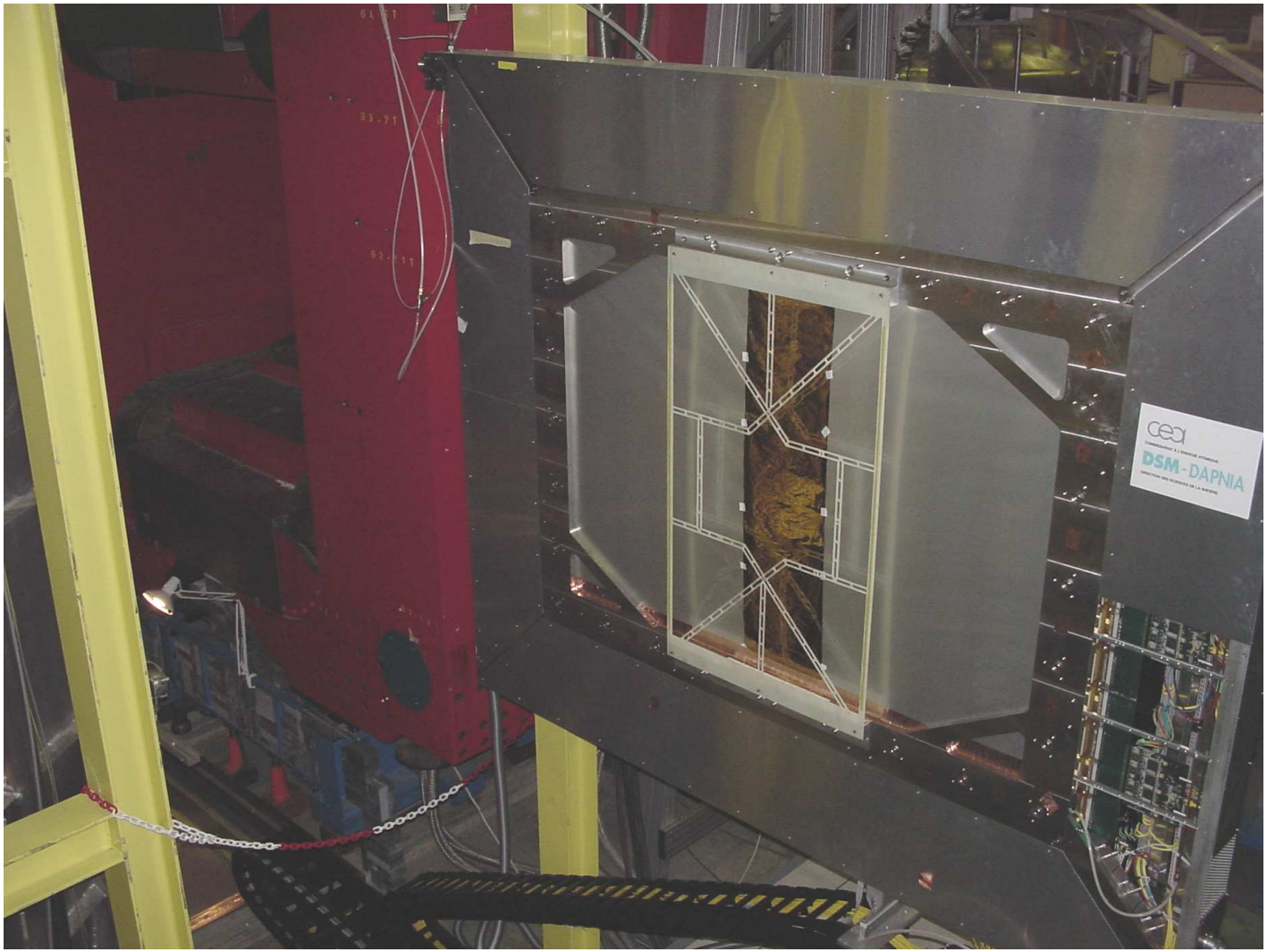




TRACKERS

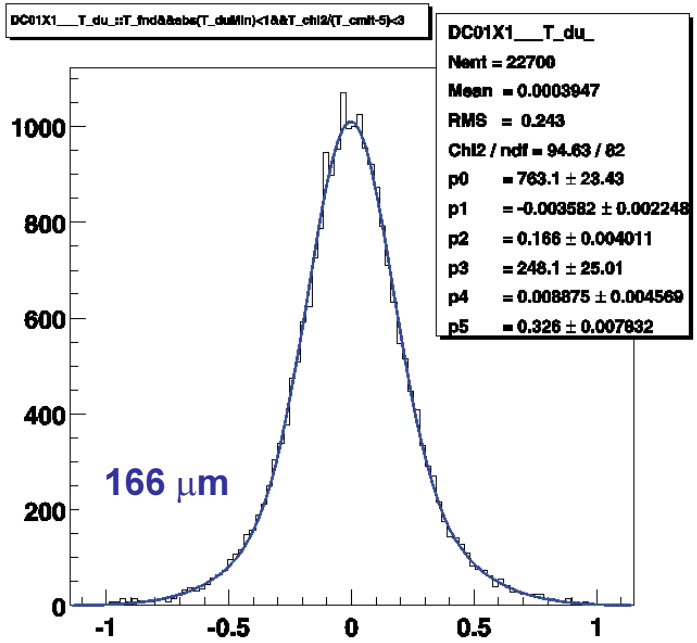
LARGE ANGLE TRACKERS

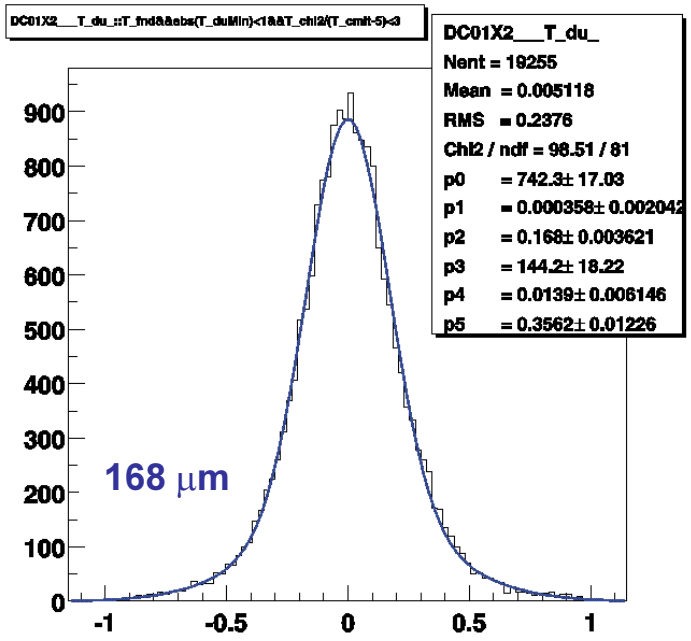
Drift Chamber (SDC)



Drift Chamber (SDC)

- Large Area Tracking in SAS
- 3 chamber in 2002
- Each chamber provides 8 coordinates with resolution ~170 μm
- Efficiency 95 – 99.8 %

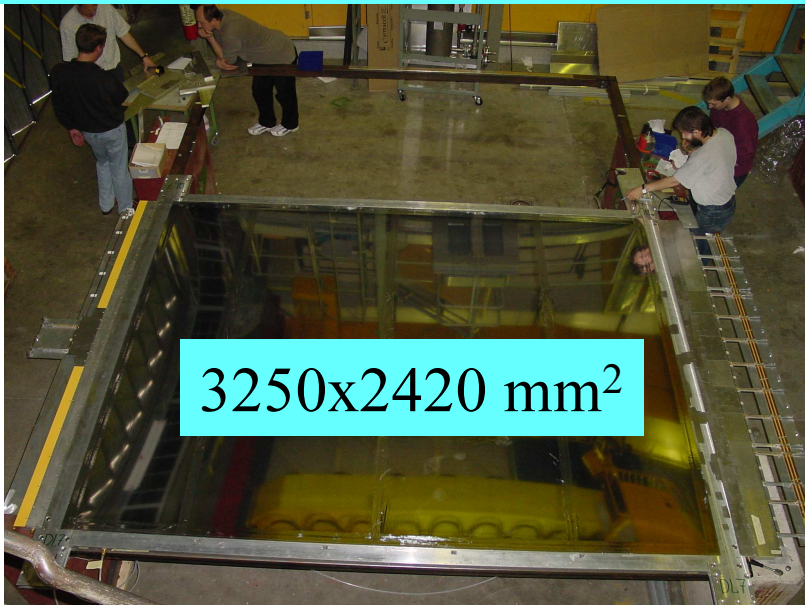




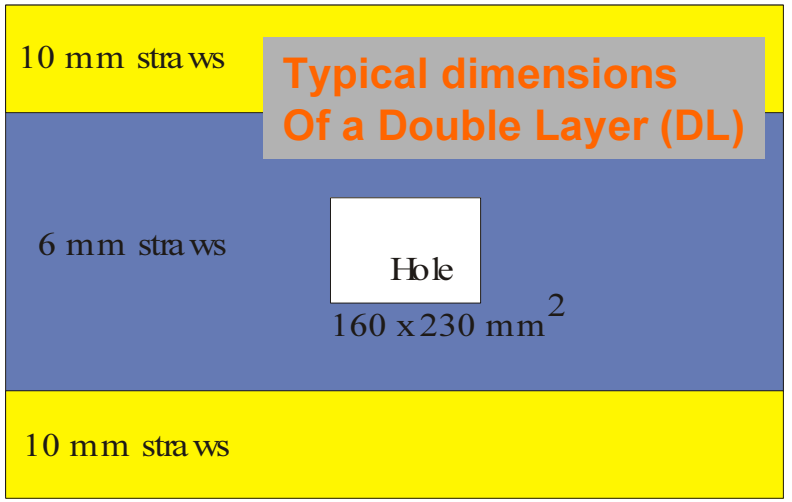
STRAWs

- 9 DLs operational in year 2002:
  1 full station (6 DLs) + 1 half station
  efficiency 85 – 98%
  spatial resolution ~ 270 μm
- construction in Dubna completed:
  all 15 DLs built

gluing of aluminized mylar foil

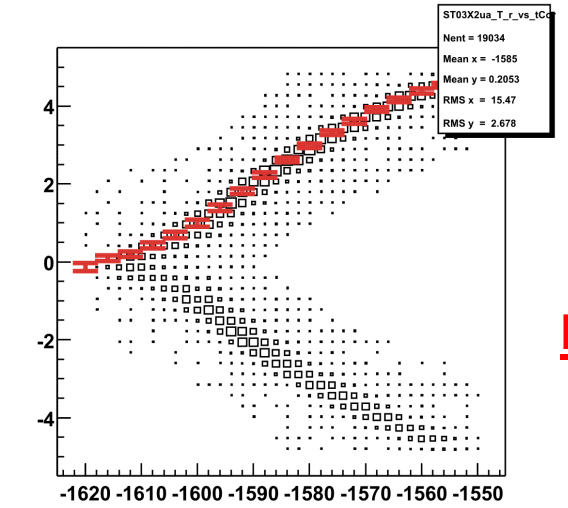


Assembly of first Straw Module (6 DL's)

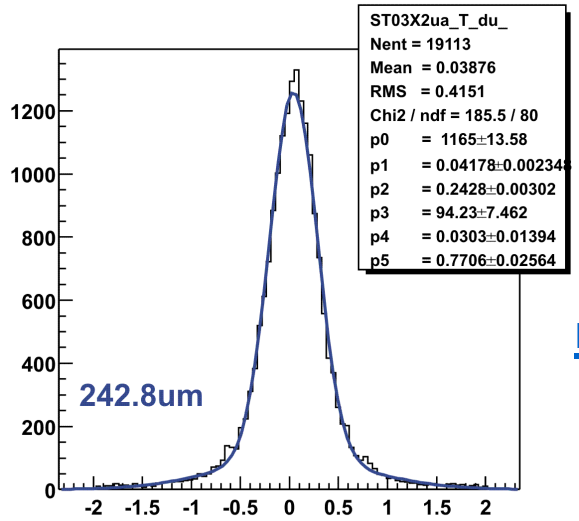


STRAWs tracking results

6 mm straw

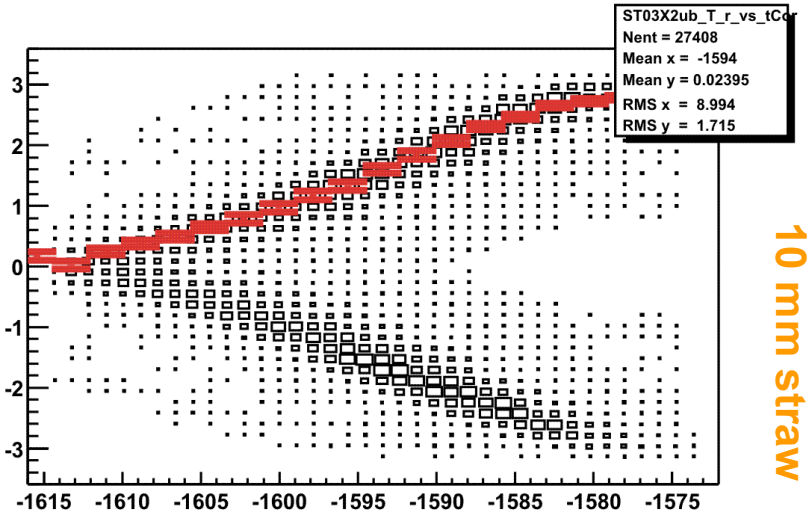


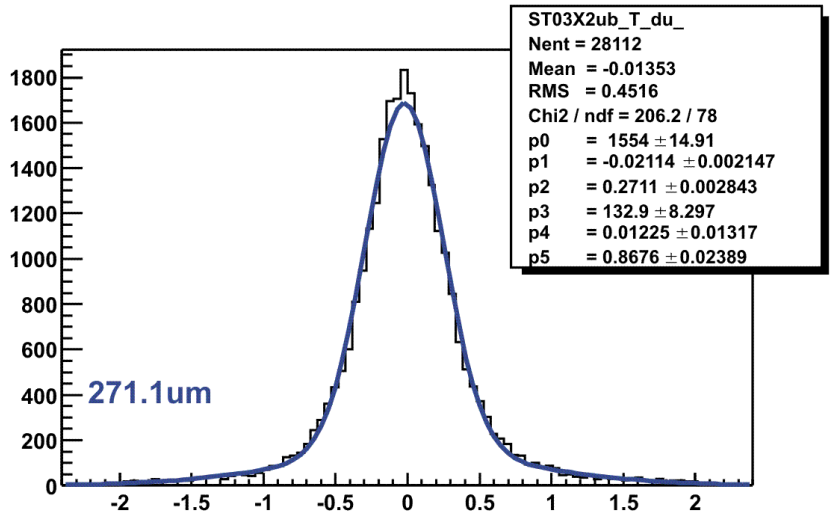
RT relations



residuals

10 mm straw

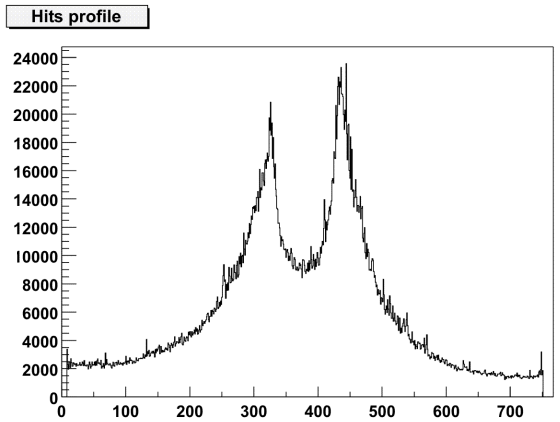


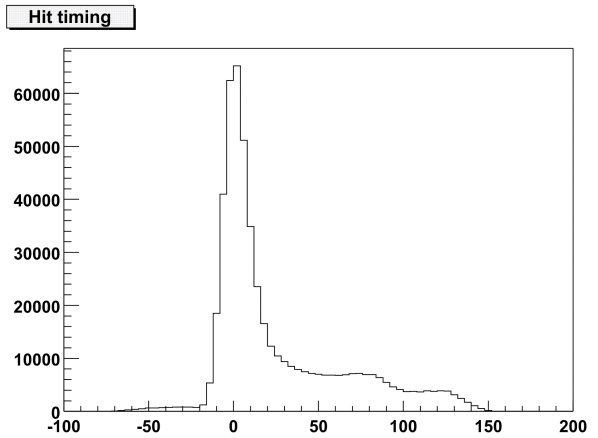


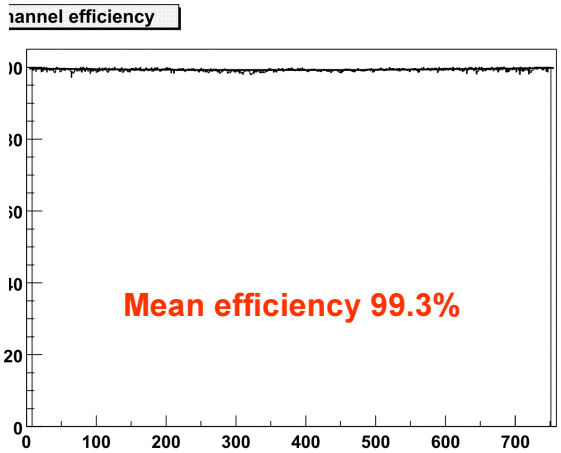
MWPCs

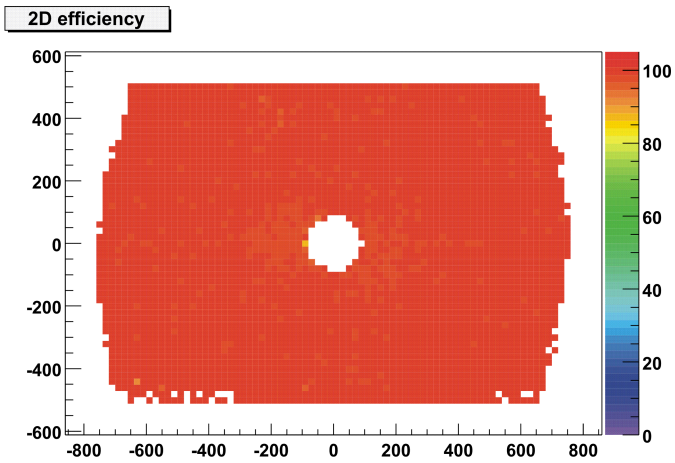
- **Backbone tracking system in SAS**
- **11 stations installed for a total of 34 planes**

- **Gas mixture:**
  70% Ar, 20% CF_4, 10% CO_2
- **High voltage:**
  4.25 kV
- **Discr. threshold:**
  4fC



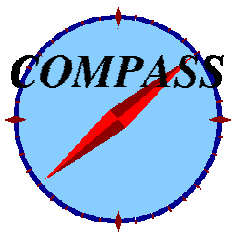






W45: Large Area Drift Chambers for SAS

2 detectors,
in total 8 planes



COMPASS CALORIMETRY

COMPASS CALORIMETRY

- **HCAL 1**

sandwich: Fe + scintillator + planar WLS for read-out

fully mounted and instrumented

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

$$e : \frac{\sigma}{E} = \frac{24.3\%}{\sqrt{E}} \oplus 0.6\%$$

- **HCAL 2**

sandwich: Fe + scintillator + WLS fibres for read-out

fully mounted and instrumented

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

- **ECAL 1**

lead glass (blocks from GAMS + OLGA)

not mounted (supports in production)

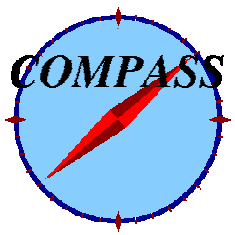
$$\frac{\sigma}{E} = \frac{5.8\%}{\sqrt{E}} \oplus 2.3\%$$ **(GAMS)**

- **ECAL 2**

lead glass (from GAMS, mounted) + sandwich (pappardelle or shashlik)

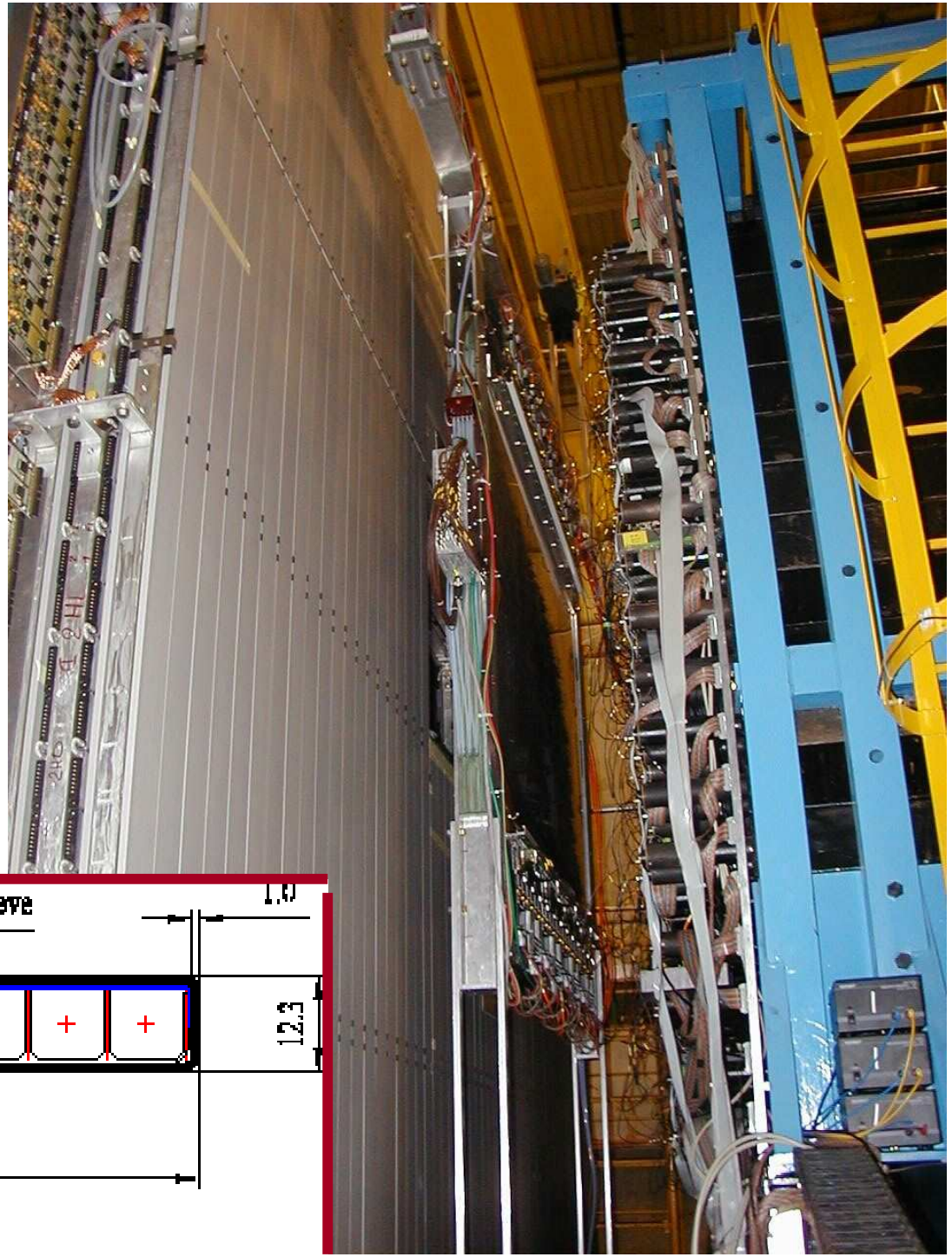
LG mounted and partially instrumented

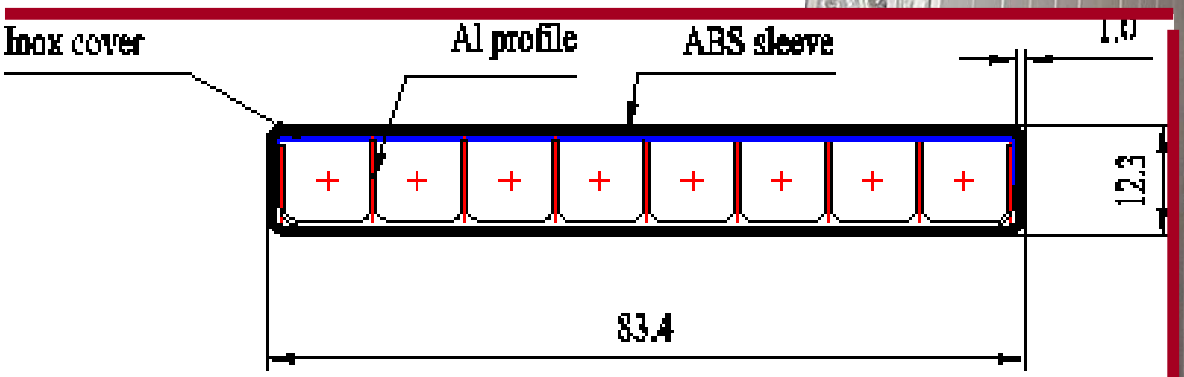
HCAL1



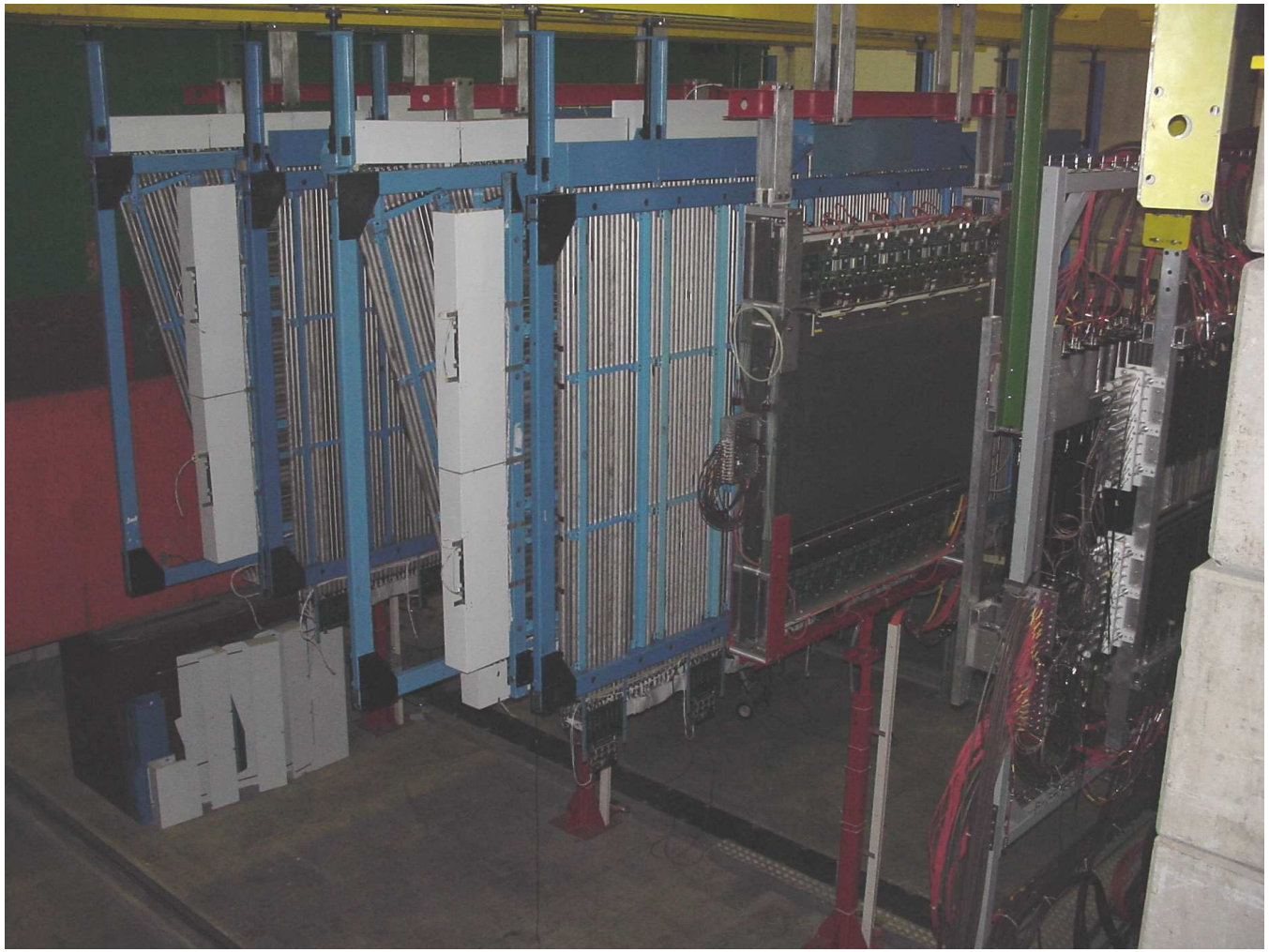
COMPASS PID

Muon Wall 1



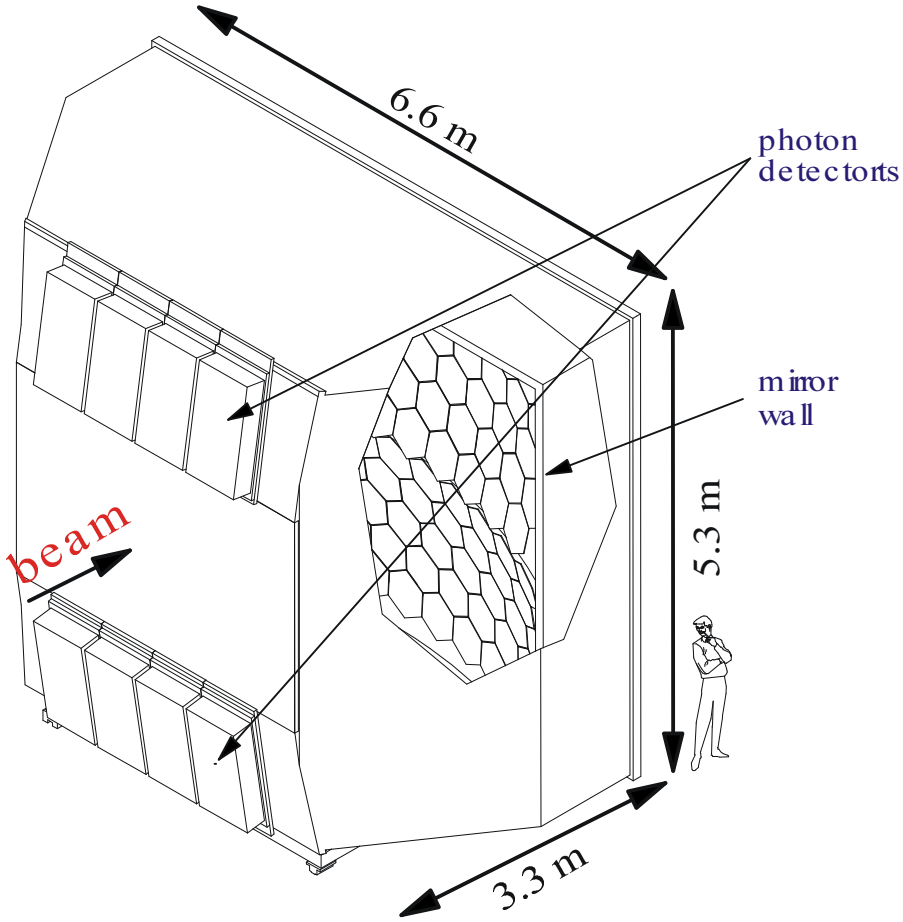


Muon Wall 2

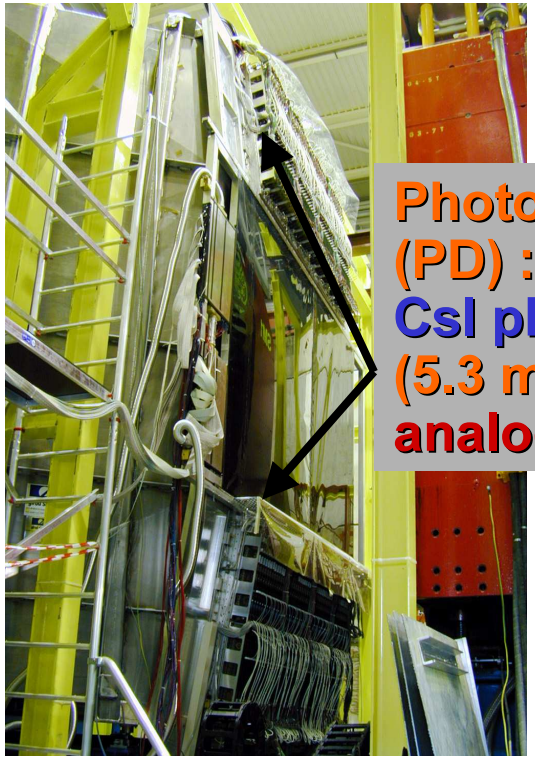


RICH1
Ring Imaging Cherenkov

- 80 m^3 (3 m C_4F_{10})
- 116 VUV mirrors (3.3 m focal length)
- 5.3 m^2 VUV detectors
  - MWPC CsI photon-sensitive cathodes
  - 8x8 mm^2 pads
- 84k channels of analog read-out

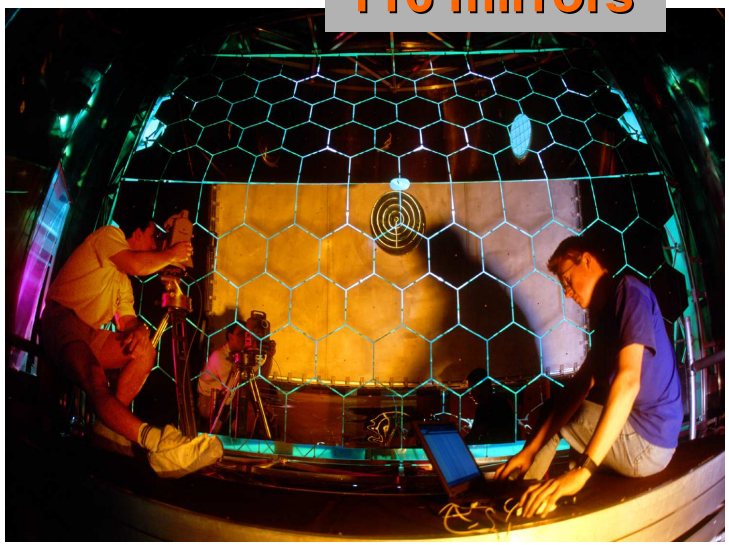


RICH-1

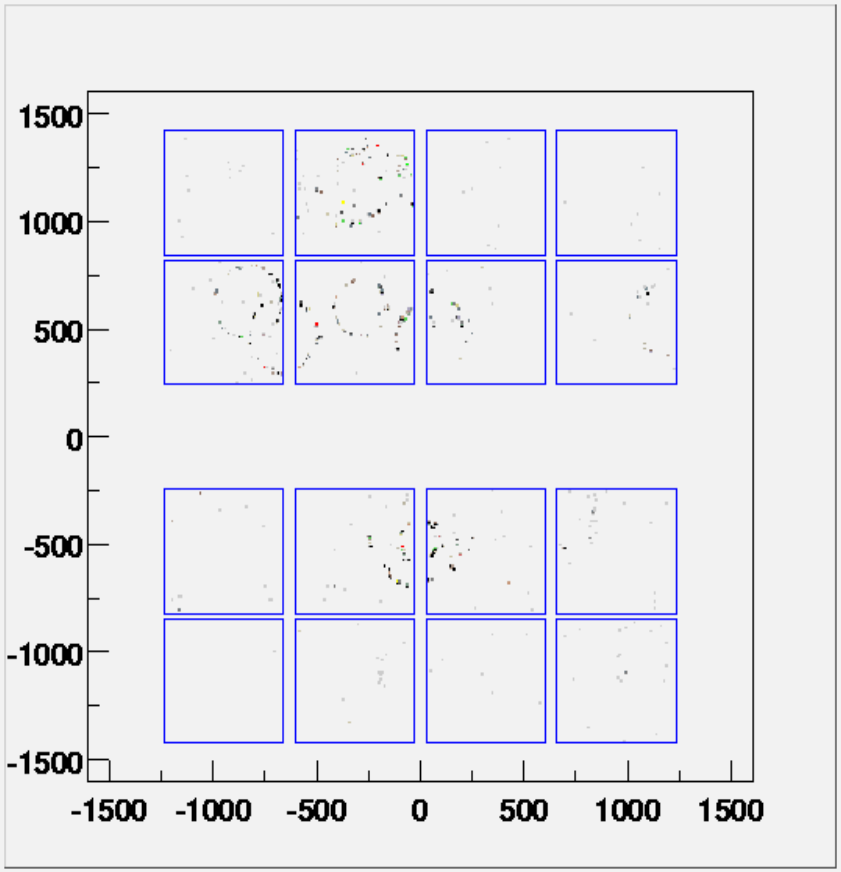


Photon detectors (PD) : MWPCs with CsI photocathodes (5.3 m^2), 84,000 analog read-out ch.s

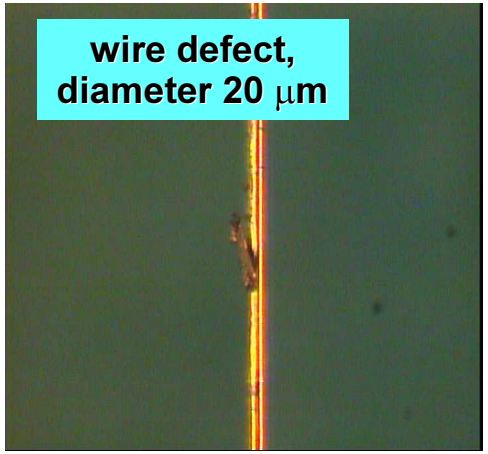
VUV mirror wall, 21 m^2, 116 mirrors



an event from on-line display



RICH-1, MORE WORK NEED FOR …



- **Photon Detectors electrical stability**

  Run 2001: 2 PDs (over 8) OK

  problem identified: local defects of anode wires

  replacement of wires

  Run 2002: 5 PDs (over 8) OK

- **stability of mirror angular alignment:**

  misalignment up to 1.5 mrad, position correlated

  repeated checks, RICH thermalisation,

  on-line monitoring of mirror alignment

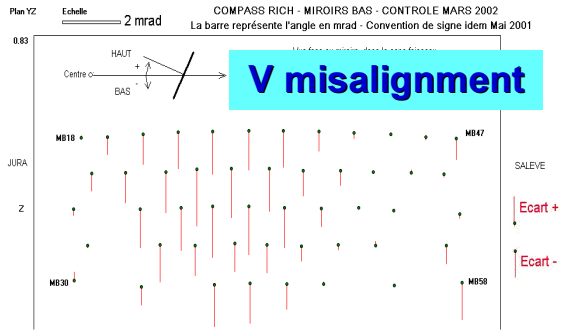
  being studied

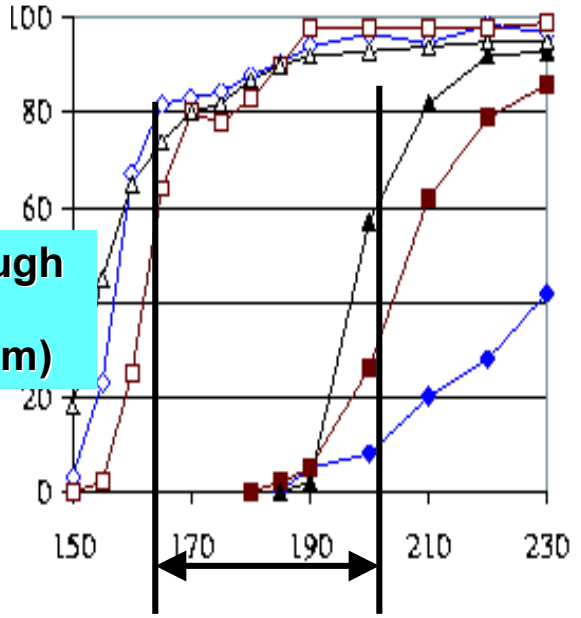
- **Radiator gas VUV trasparency:**

  raw gas cleaning

  on-line gas filtering

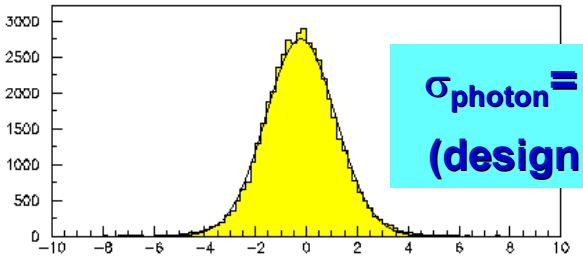
  gas consumption





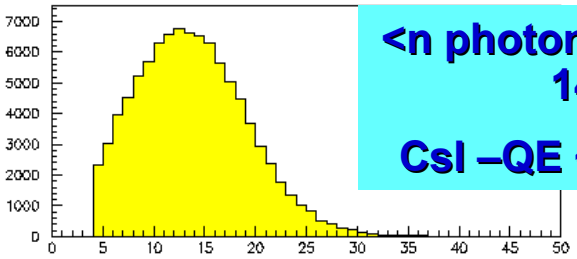
Transmission through 5 m of gas (1 bar) vs. λ(nm)

calibration runs (low beam intensity)



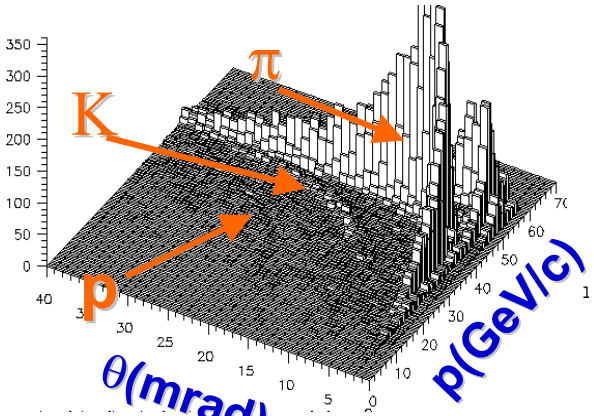
σ_{photon} = 1.4 mrad

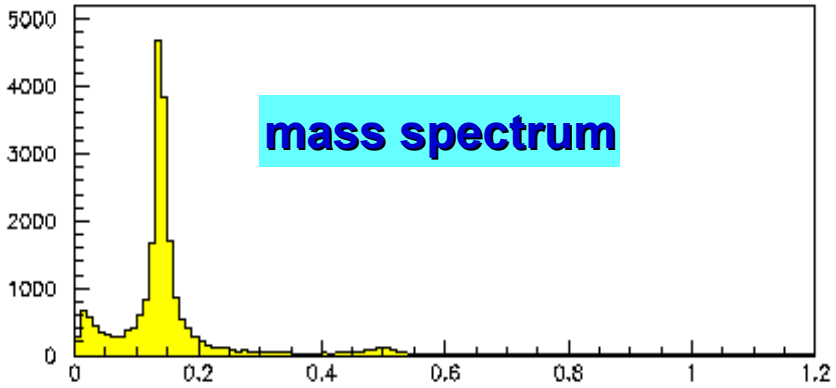
(design:0.8 mrad)



<n photons/ring> = 14

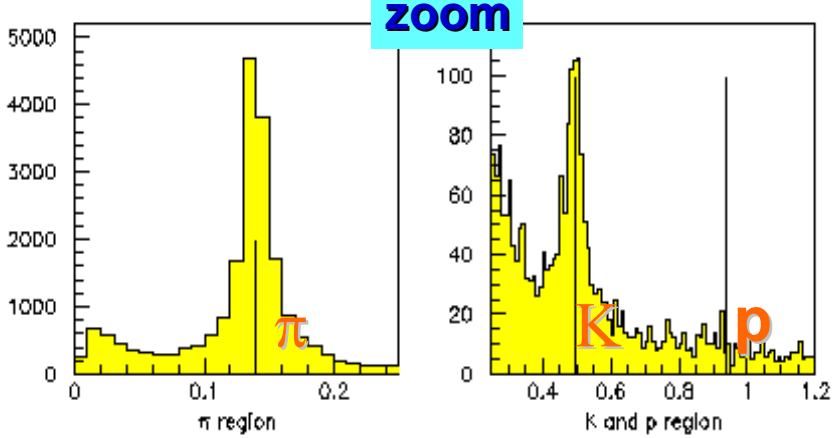
CsI –QE ~ design



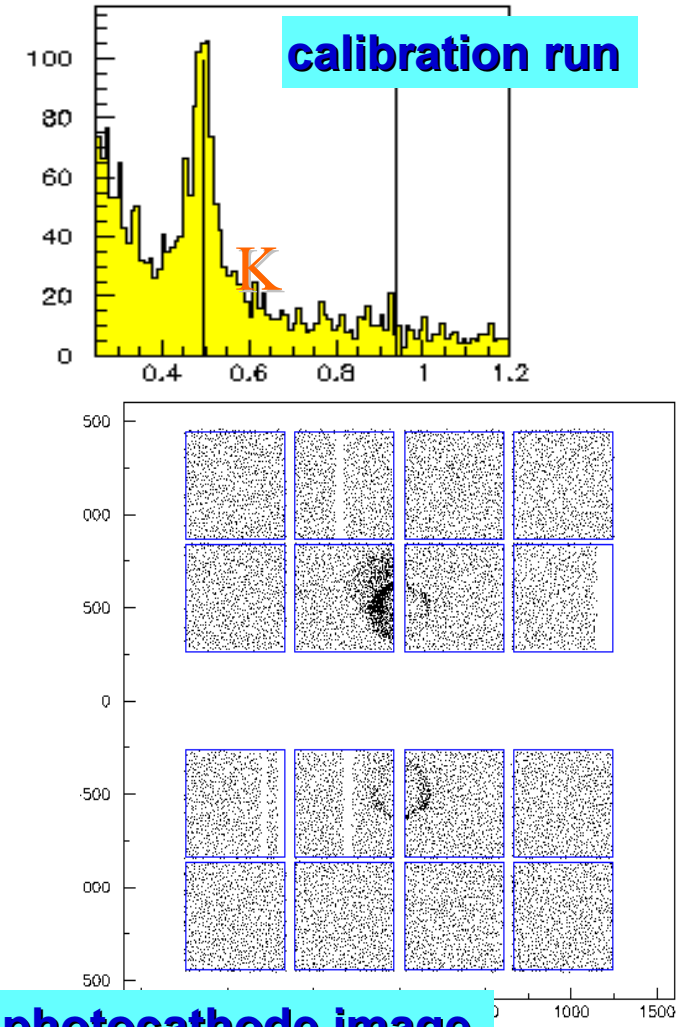


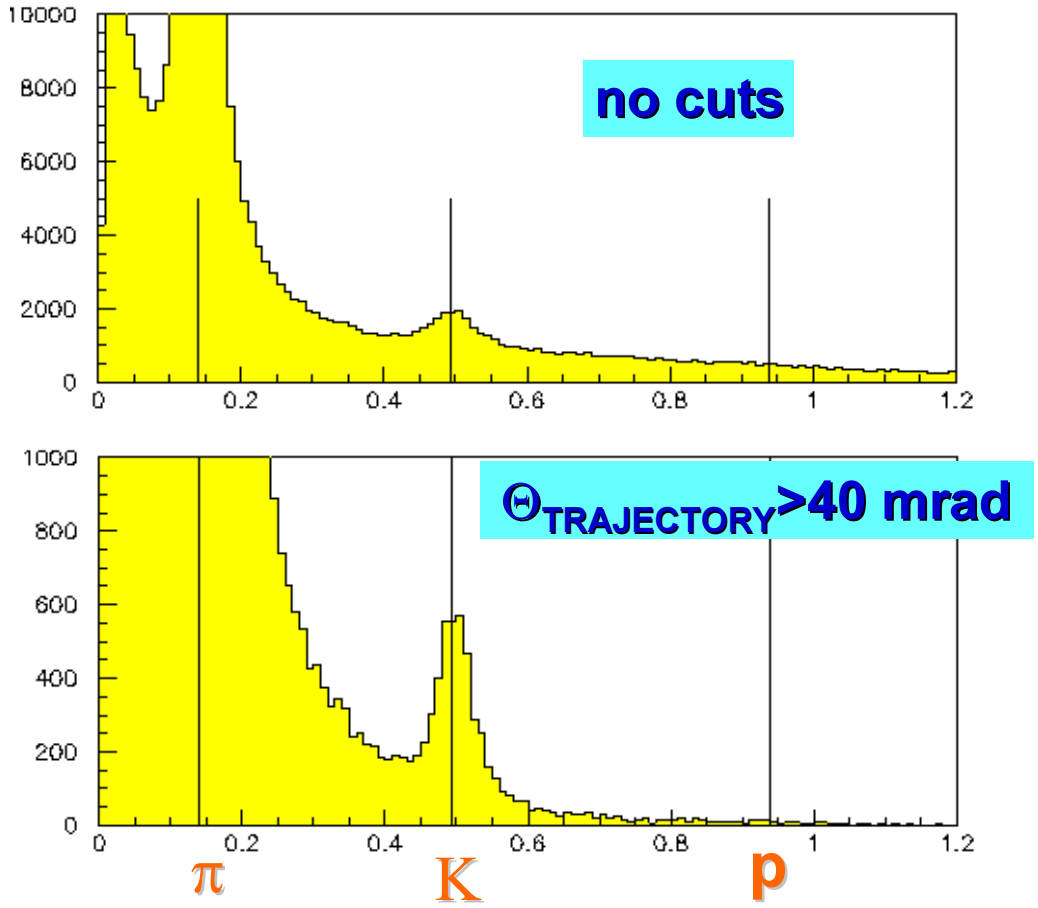
mass spectrum

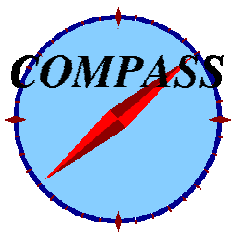
zoom



PHYSICS RUNS





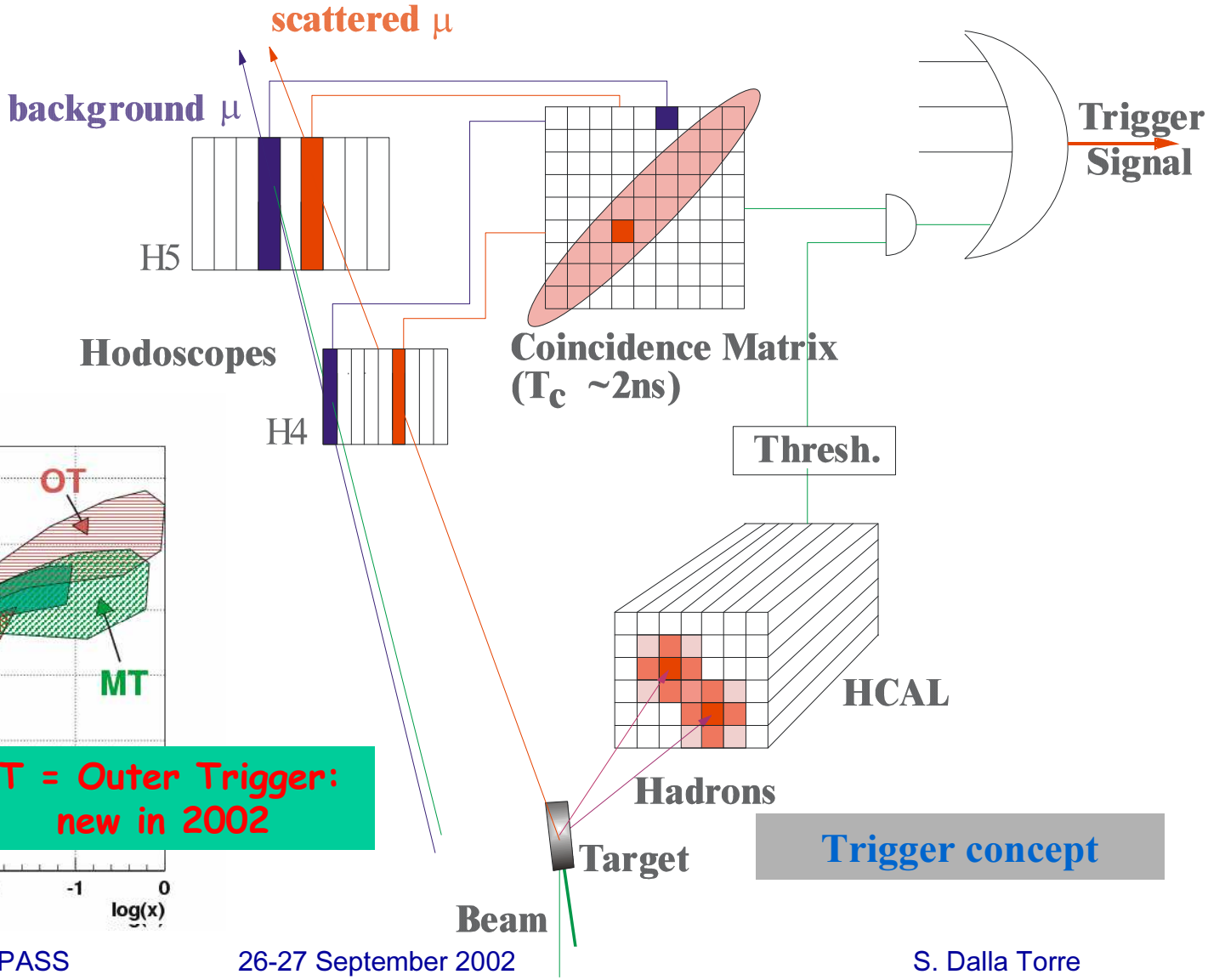


COMPASS TRIGGER

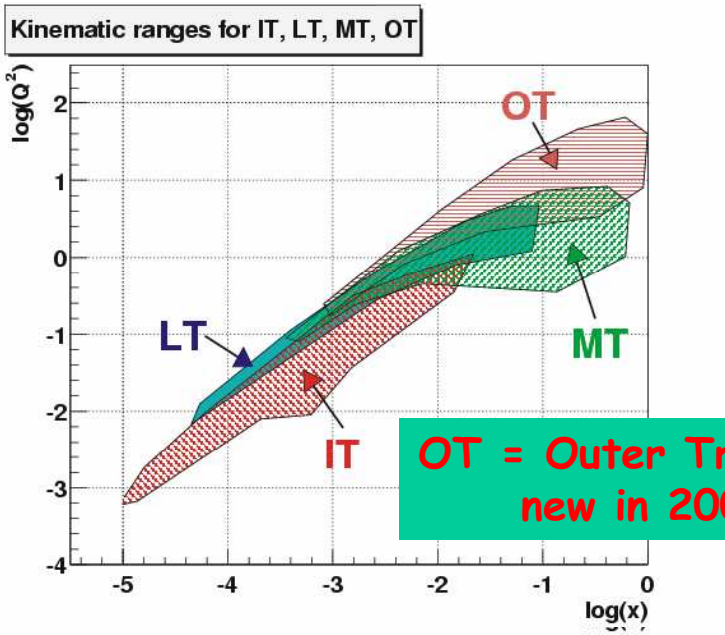
TRIGGER

Trigger: (H4 * H5) * (HCAL1 ∨ HCAL2)

Trigger hardware:
- ~ 500 channels
- discriminator boards with mean-timer
- matrix boards



Trigger concept



OT = Outer Trigger: new in 2002

DETECTOR SUMMARY:
Comparison with Initial lay-out

Detector	In. Lay-out	2001 run	2002 run	
Target	^{6}LiD	^{6}LiD	^{6}LiD	
Solenoid	COMPASS	SMC	SMC	☹
BMS	4	4	4	
Scint. Fibers	18	18	21	☺
Silicon	4	2	4	
GEM	20	14	20	
Micromegas	12	6	12	
Drift Chambers	16	8	24	☺
Straws	15	4	9	☹
MWPC	30	30	34	☺
W45	0	0	8	☺
Muon Walls	100%	10%	100%	
HCAL	100%	10%	100%	
RICH mirrors	116	116	116	
RICH PDs	8	8	8	
RICH radiator	100%	50%	100%	
DAQ	100%	50%	100%	

FE & DAQ

FEATURES

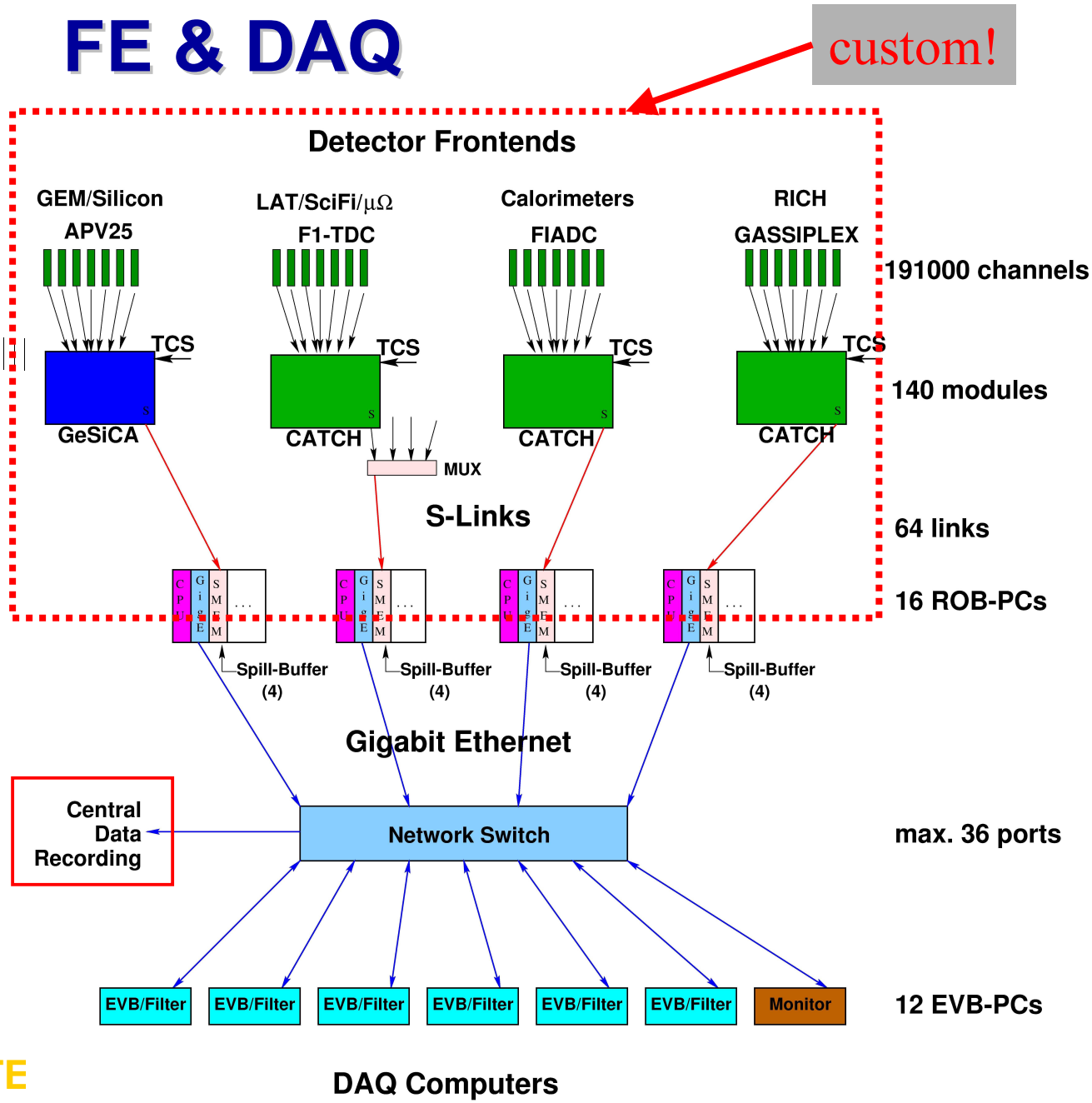
- Pipelined readout architecture
- Fully extendable
- Data transfer via S-Link
- Buffering of burst (SPS duty cycle ~30%)
- Network event-builders

REQUIREMENTS AND PERFORMANCES

- Channels : 191 k
- Trigger rates: 5 kHz, dead time: 7%
- Event size ~ 40kB
- Data rates: 220 MB/s in spill, 60 MB/s DC

DAQ SOFTWARE:

based on ALICE DATE



DAQ & FRONTEND DURING 2002 RUN

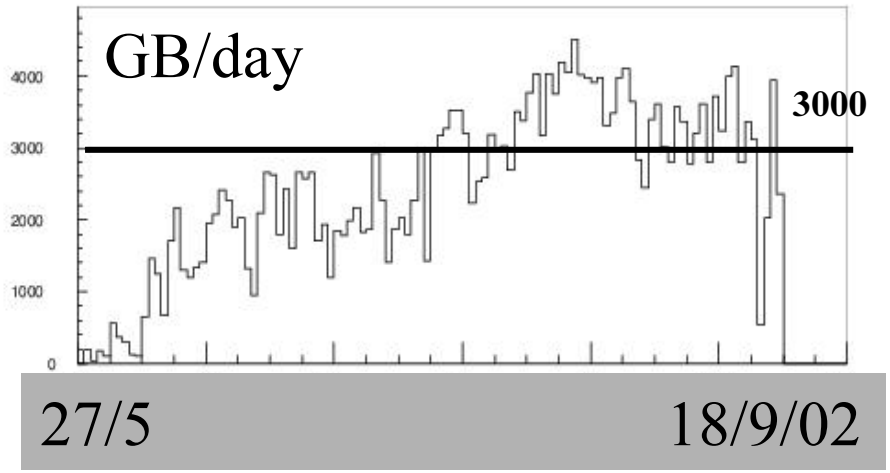
FRONTEND & DAQ stability improved during the run:

Uptime of FE& DAQ:

- 6-8 July: 57%
- 26-27.Aug.: 85%

in particular:

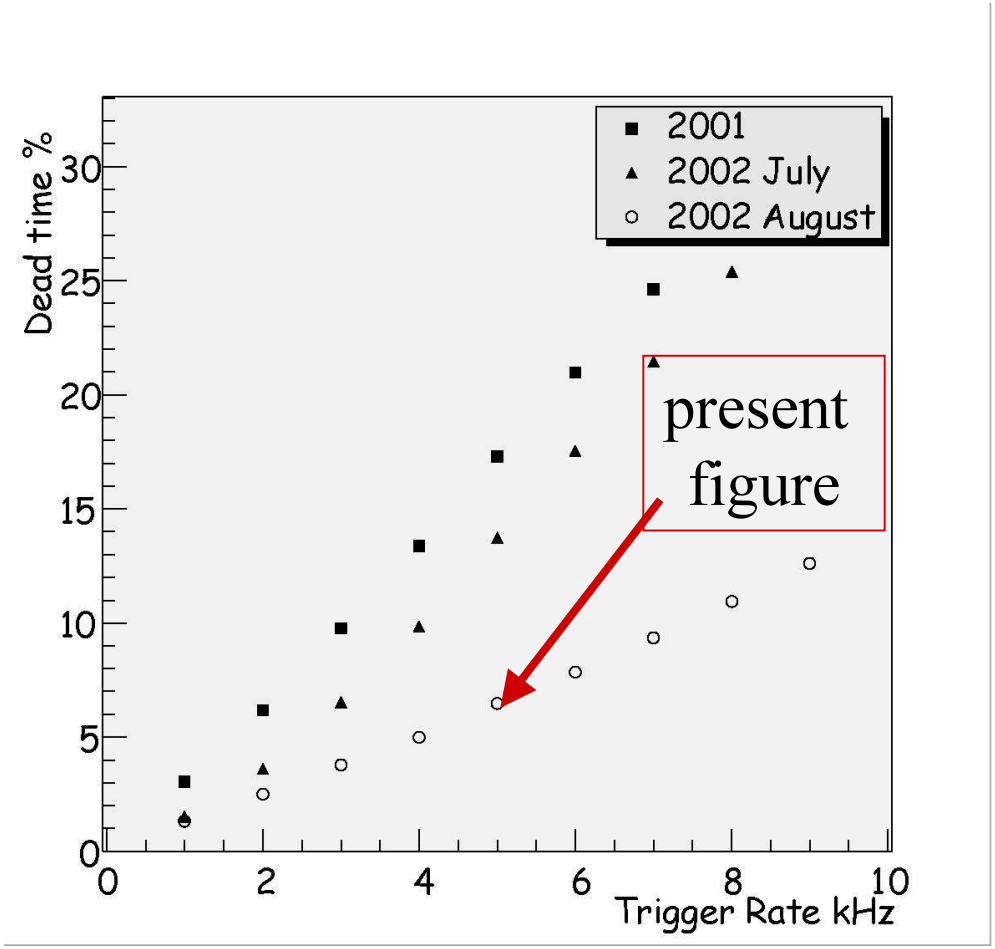
- **Limitations in Central Data Recording**
  - **Total data rate >/= maximum originally planned**
  - **at EOR, ~ 2 x foreseen rate**

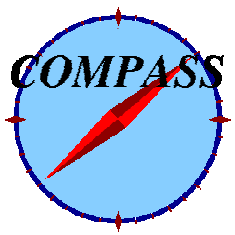


total: 260TB, i.e. 5 G events

Frontend and DAQ Performance

- **5 kHz** trigger rate
- Dead time: 13μs,
  5 triggers in 300 μs
  → 7% dead time
- **improved performances coming**





NECESSARY COMPLEMENTS OF A MODERN EXPERIMENT

DETECTOR CONTROL SYSTEM (DCS)

aims:

- **operator control** of HV, LV, …
- **monitoring and long-term periods archiving** of parameters (HV, LV, crates, gas system, P and T sensors, data taking, cooling systems, data from SPS)
- **alarm** handling and information **visualisation**

COMPASS DCS uses **Framework**, based on **PVSS**, CERN **designed for LHC experiments**

COMPASS DCS has 3 layers:

- **supervision layer** (**PVSS II SCADA** system running on Linux PC)
- **process management layer** (PCs work stations with Linux and NT systems, VME CPUs)
- **device level** using fieldbuses (like **VME, CAN bus, Profibus, serial RS232 lines**)

DETECTOR CONTROL SYSTEM (DCS)

Status

- **system started** with large support from CERN/IT division
- **sub-systems included**
- **only basic functionality** implemented
- **optimisation required** to make it more stable and fast

Detectors / Systems	CAEN HV	CAEN LV	ISEC HV	WIENER LV	Gas Monit	AMS	DAQ Crates	DCS connect
Hodoscopes	368 ch						+	
BMS	256 ch					20 V	+	
SciFi J	30 ch						+	
SciFi G	188 ch						+	
GEM	20 ch	100 ch			PLC2		+	
Silicon		16 ch				16 T	+	
MM/DC	40 ch			6 crates			+	
STRAW			160 ch	1 crate	PLC2	33 T/H	+	
RICH	16 ch			8 crates	PLC1,2	16 T	+	
MWPC	28 ch				PLC2	144 V	+	
mW1	16 ch				+	3 V	+	
mW2	20 ch				+	23 V	+	
DC W4/5	16 ch						+	
HCAL1						20 V	+	
HCAL2							+	
ECAL1								
ECAL2								
SM1,SM2						3 MF		
DAQ								Data File
PT								Data File
SPS								Data File
NMR								Data File
Monochromator					+			OPC server
888 Exp Hall						15 T/H		
Total	958 ch	116 ch	160 ch	15 crates	2 PLC	294 ch	16 crates	

ON-LINE DATA MONITORING

COOOL

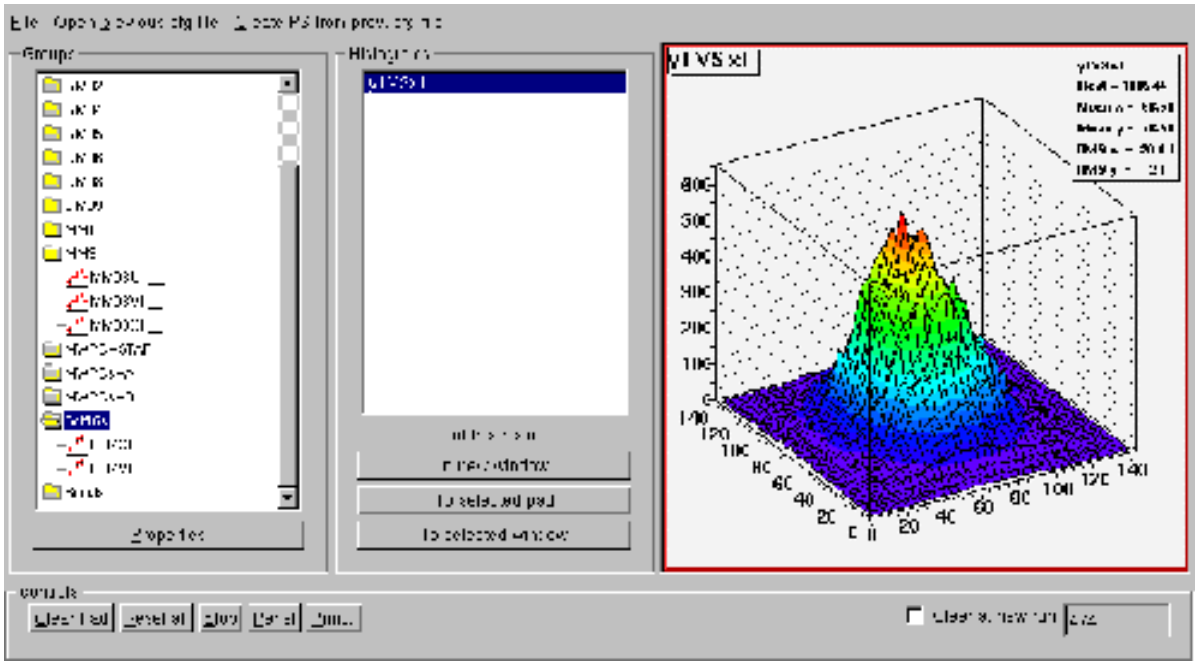
up-to-date on-line monitoring code in **C++**

built on **ROOT** libraries

sharing **decoding** with off-line software

data from DAQ farm (event builder PCs)

~ 80 events/burst (over~25000) analyzed



ELECTRONIC LOG-BOOK

- information access via www
- edited by shift crew
- paste in histograms, tables
- data taking information automatically transferred, including monitoring hist.s
- data from SPS and PT also transferred

Begin of the shift: **Saturday 07 September**

Crew members: E.-H. Heinsius
R. Jahn
D. Peshekonov

Target shift: S. Reicherz

tob7:
tob8:
tob9:
tob10
tob11
tob13
tob14

Summary of the shift:

0:25 reboot of pccotb06
Trigger HV was off, therefore too high trigger rate
1:00-6:00 DAQ-Frontend Rate Tests
6:00-7:00 Test of physics run
7:10-7:55 Silicon timing scan

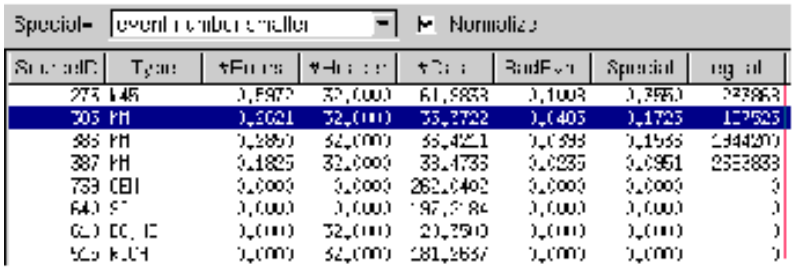
RICH PD4 tripped and brought back up after 2 hour wait.
Recording most of the time disabled to speed DST production.

General comments submited during this shift:

Comment nb	Time	Author	Domain	
3112	01:11	E.-H.Heinsius	*Trigger*	All HV for Hodoscop

Switched on on PVSS
rates where before switching off

3115 02:08 E.-H.Heinsius *DAQ* run23182 30kHz



3116 02:36 E.-H.Heinsius *RICH* PD4 tripped

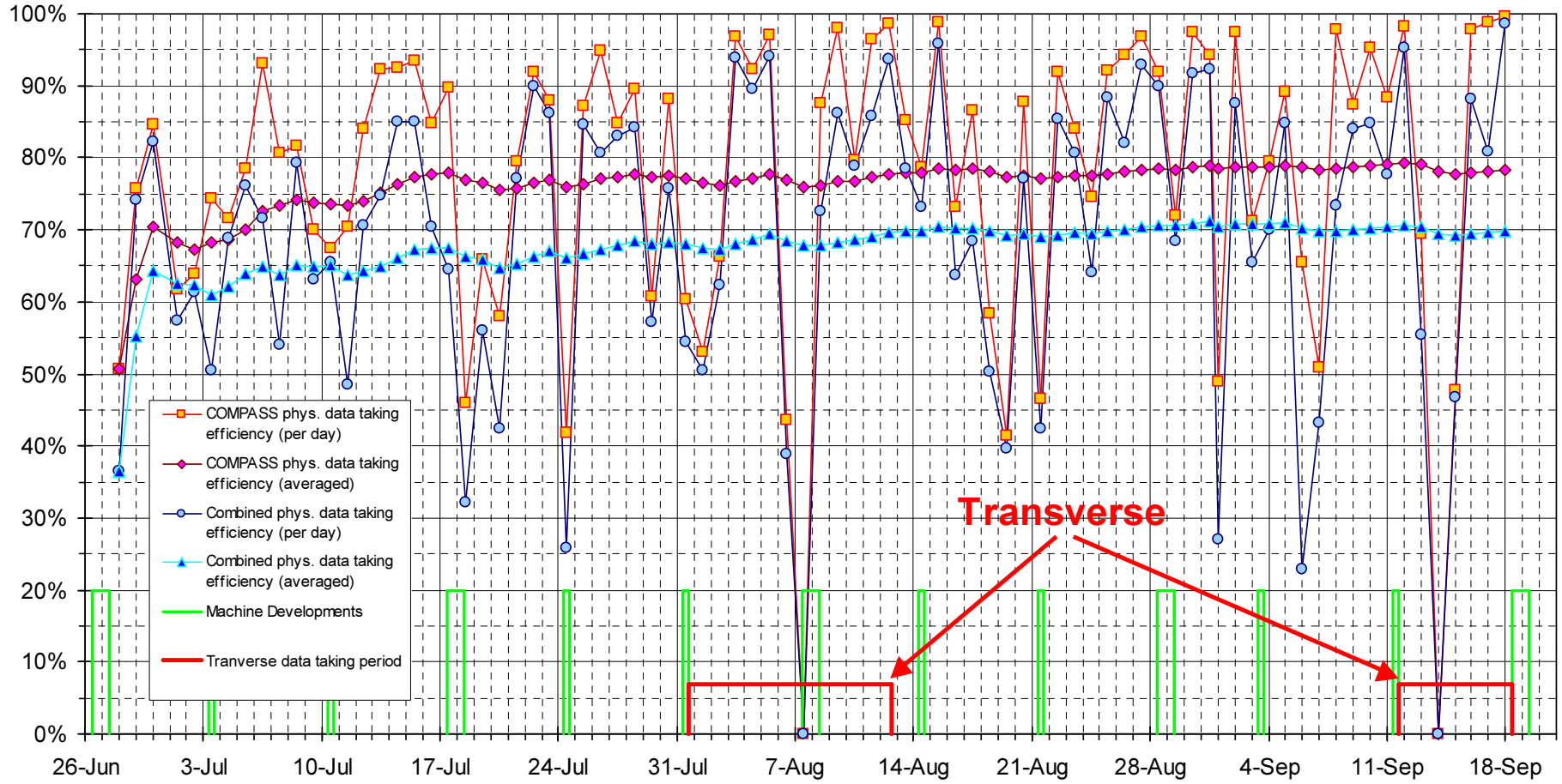
3117 03:57 E.-H.Heinsius *RICH* PD4 back at 190

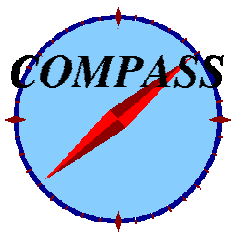
3118 05:36 E.-H.Heinsius *DAQ* test phase 2: test

This time DC,MM,W45,Si excluded from tests.

Start with 40kHz run 23192
GEM errors:

CONCLUSION: COMPASS DATA TAKING EFFICIENCY





THANK YOU