Central production of Exotics

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1. Physical motivation

2. Experimental Layout

3. Simulation results

4. Conclusion

Central production of Exotics

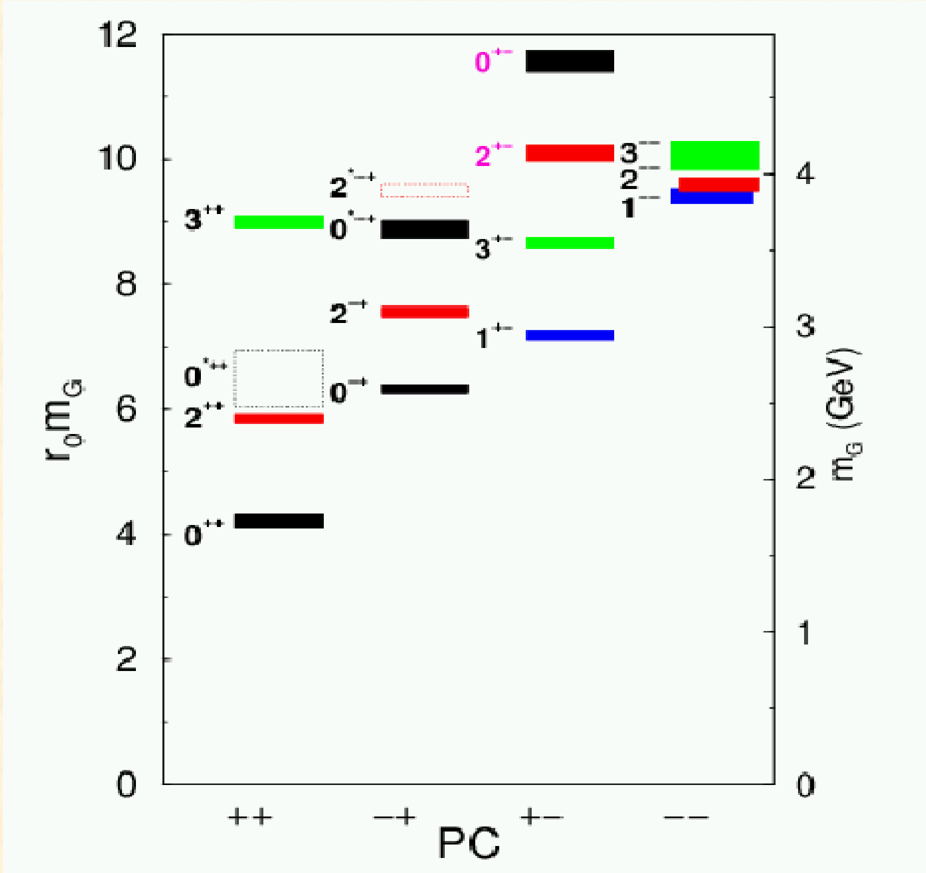
QCD predict existence of glueballs, bound states of mainly gluons. The best estimate for masses of glueballs comes from lattice gauge theory.

The lightest glueball has $J^{PC}=0^{++}$ and its mass should be in the range 1.45-1.75 GeV.

According to lattice inspired models glueballs will mix strongly with nearby $q\bar{q}$-states with the same J^{PC}. The three states in the glueball mass range are:

- f_0**(1370)**
- f_0**(1500)**
- f_0**(1710)**

Analysis of glueball-$q\bar{q}$ mixing is done by F.Close and A.Kirk.



The spectrum of glueballs in pure glue LGT (Morningstar, Peardon).

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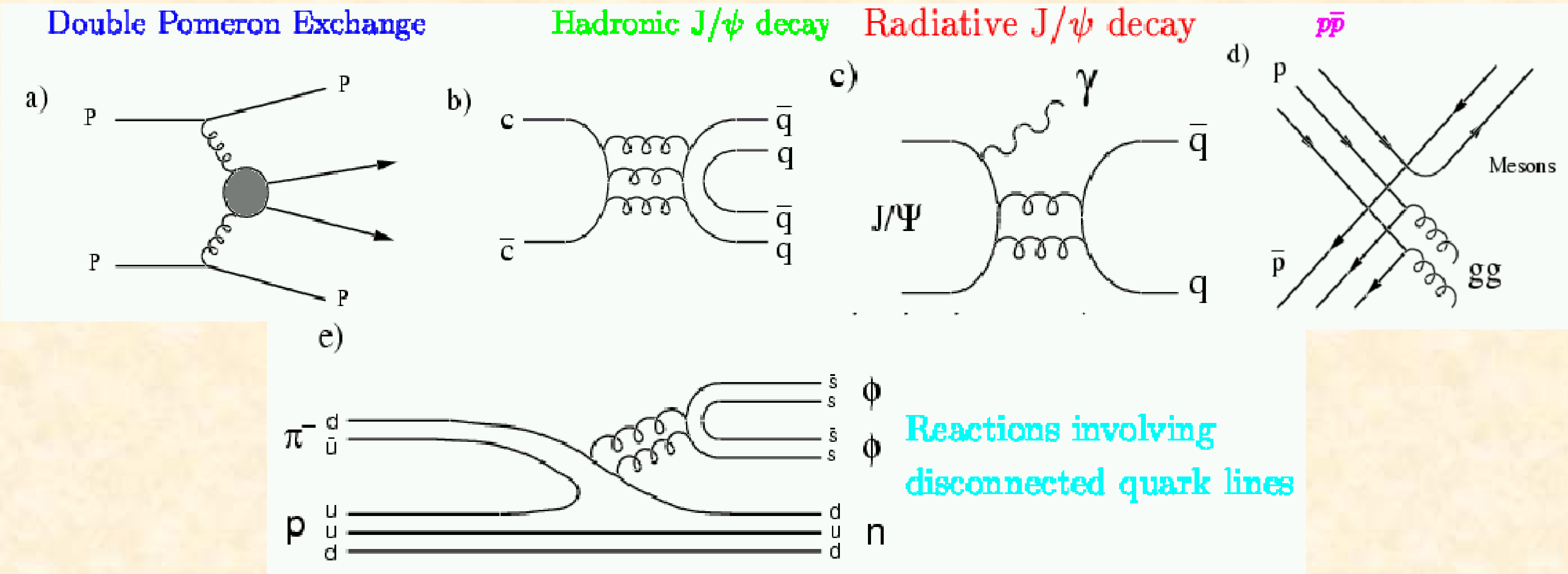
Search methods

- States with J^{PC} not allowed for normal $q\bar{q}$-states, for example 1^{-+}.
- Extra states, that is states that have the quantum numbers of already completed nonets, with low masses (exclude radially excited nonets members).
- Detailed study and look for states with unusual branching ratios.
- Search for states preferentially produced in gluon rich processes: Pomeron-Pomeron scattering, J/ψ decay, proton-antiproton annihilation, special hadronic reactions.



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Scalar Glueball-$q\bar{q}$ mixing above 1 GeV

The WA102 collaboration: $\Gamma_{\pi\pi}, \Gamma_{K\bar{K}}, \Gamma_{\eta\eta}, \Gamma_{\eta\eta'}, \Gamma_{4\pi}$

of the $f_0(1370)$, $f_0(1500)$ and $f_0(1710)$

In agreement with Crystal Barrel, BES, WA76, Mark III

Close and Kirk => glueball-$q\bar{q}$ mixing above 1 GeV.

$$\begin{pmatrix} |f_0(1710)\rangle \\ |f_0(1500)\rangle \\ |f_0(1370)\rangle \end{pmatrix} = \begin{pmatrix} x_1 & y_1 & z_1 \\ x_2 & y_2 & z_2 \\ x_3 & y_3 & z_3 \end{pmatrix} \begin{pmatrix} |G\rangle \\ |S\rangle \\ |N\rangle \end{pmatrix},$$

with $|G\rangle \equiv |gg\rangle, |S\rangle \equiv |s\bar{s}\rangle, |N\rangle \equiv |u\bar{u} + d\bar{d}\rangle/\sqrt{2}$

results for the flavour content of scalar mesons is:

	$f_{i1}^{(G)}$	$f_{i2}^{(S)}$	$f_{i3}^{(N)}$
$f_0(1710)$	0.39 ±0.03	0.91 ±0.02	0.15 ±0.02
$f_0(1500)$	-0.65 ±0.04	0.33 ±0.04	-0.70 ±0.07 ,
$f_0(1370)$	-0.69 ±0.07	0.15 ±0.01	0.70 ±0.07

m_G=1443±24 Mev, m_N =1377±20 MeV,
m_S =1674 ± 10 MeV.
solution compatible with pp central production, $p\bar{p}$ annihilations and J/ψ radiative decays.

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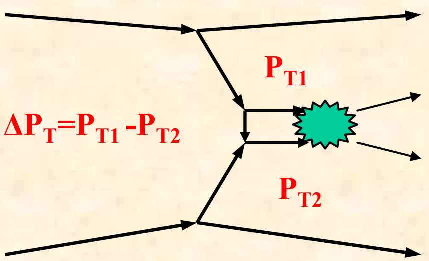
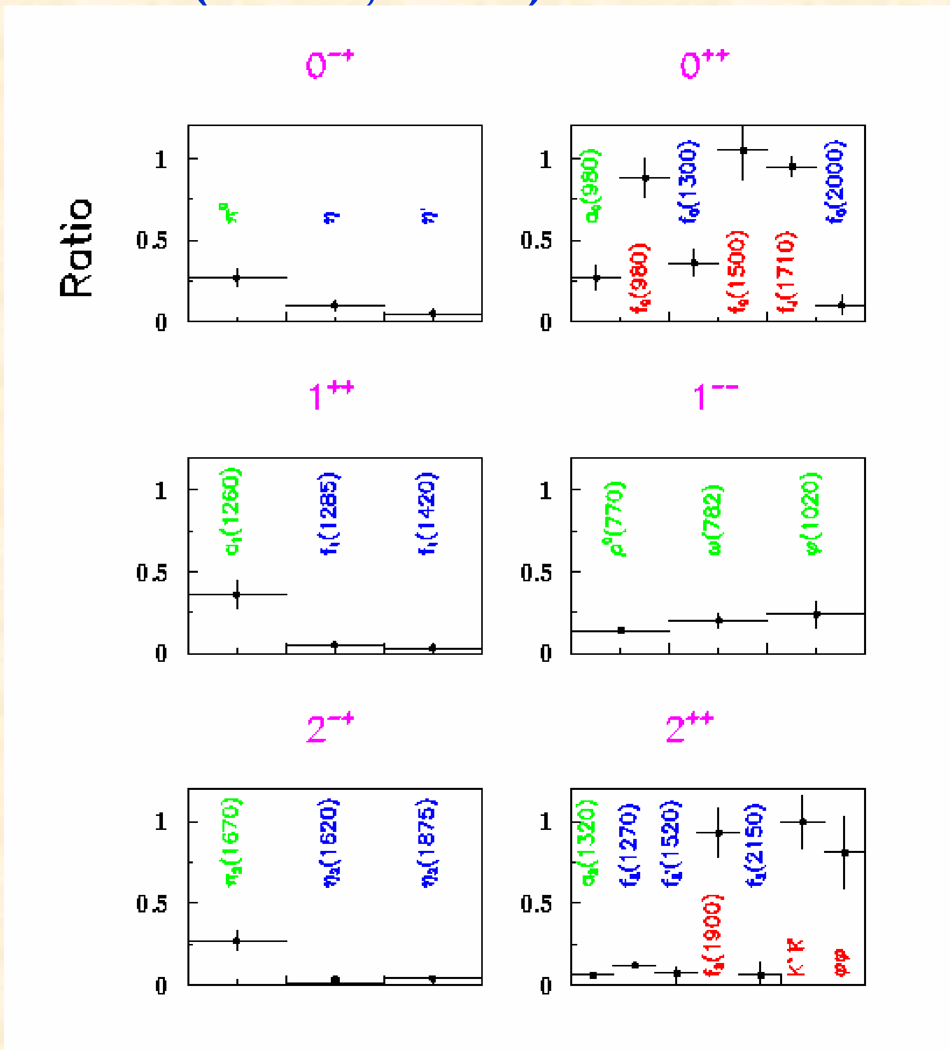
The glueball-$q\bar{q}$ kinematical filter (Close, Kirk)



$$R = \frac{N(\Delta P_T < 0.2 GeV)}{N(\Delta P_T > 0.5 GeV)}$$



sensitive to the resonance nature:

- R < 0.1 for undisputed $q\bar{q}$ states produced by DPE (G = + and I = 0);
- R ≈ 0.25 for the states which cannot be produced by DPE (I = 1 or G = –);
- R ≈ 1 for all glueball candidates.

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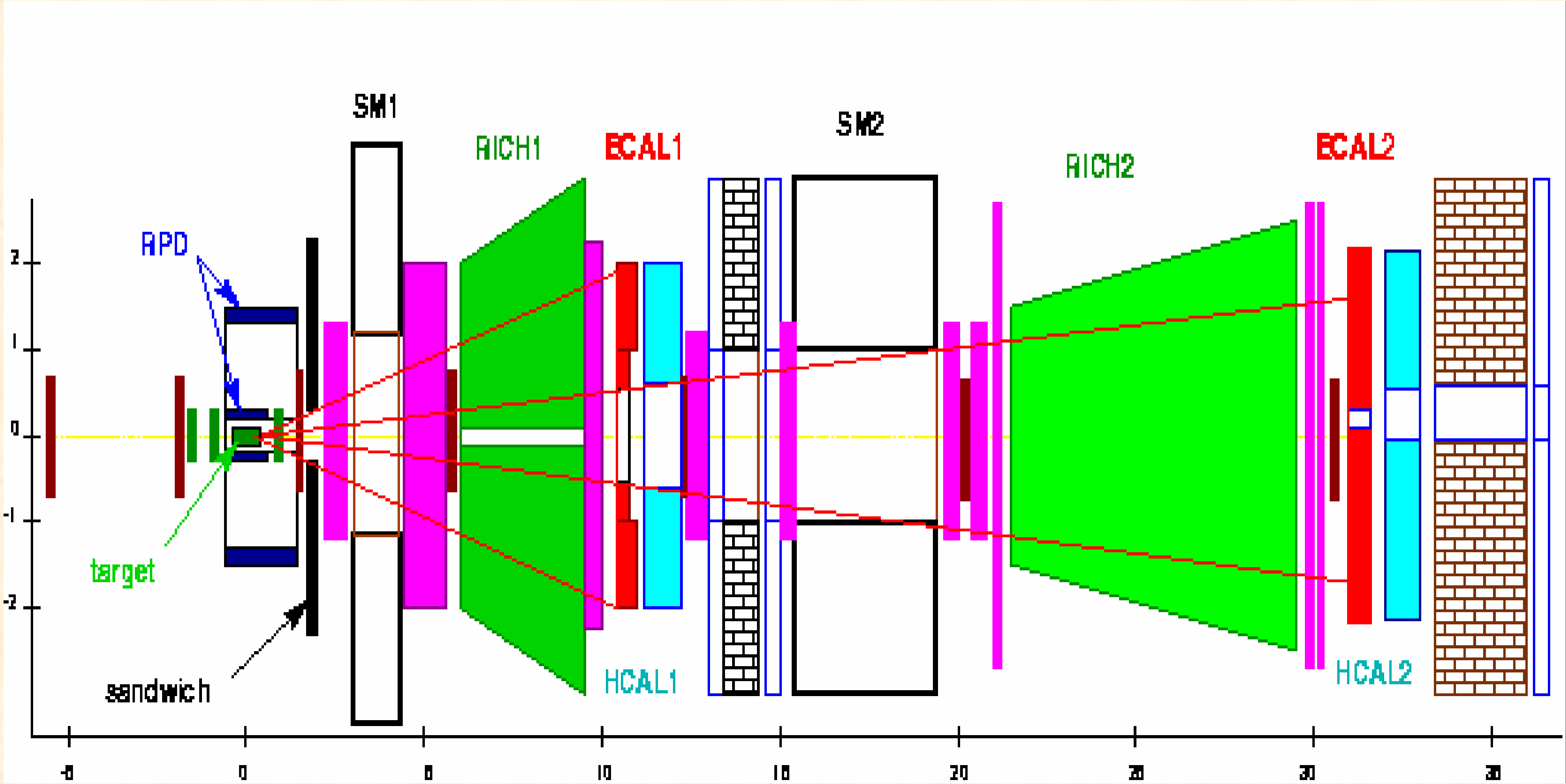

Central production of Exotics

- ECAL1
  - total number of channels – 3216
  - Size – 4 x 2.9 m^2
  - $\sigma(E)/E = 5\text{-}6\%/\sqrt{E} \otimes 2\%$
- ECAL2
  - total number of channels – 3436
  - Size – 4.4 x 2 m^2
  - $\sigma(E)/E = 5\text{-}6\%/\sqrt{E} \otimes 2\%$
- TARGET, liquid H_2, l = 40 cm, 2.83 g/cm^2, 0.046 X_0

- RPD
  - Total number of channels – 60
  - Time measurements
    - TOF resolution – 350 ps for MIP
    - Space resolution
      - A-layer – 1.8 cm
      - B-layer – 2.7 cm
  - Amplitude measurements:
    - Space measurements based on light att.
    - dE/dx
  - Measurements accuracy (P_{slow},positions) for time and amplitude are comparable.

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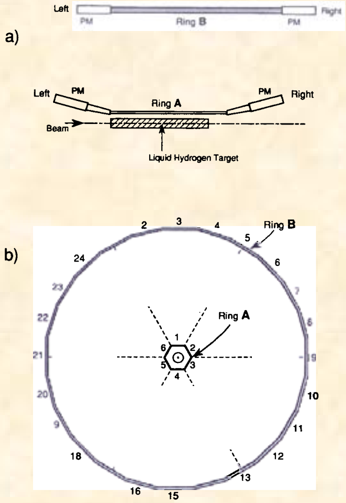
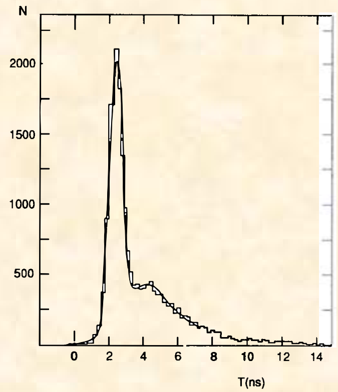
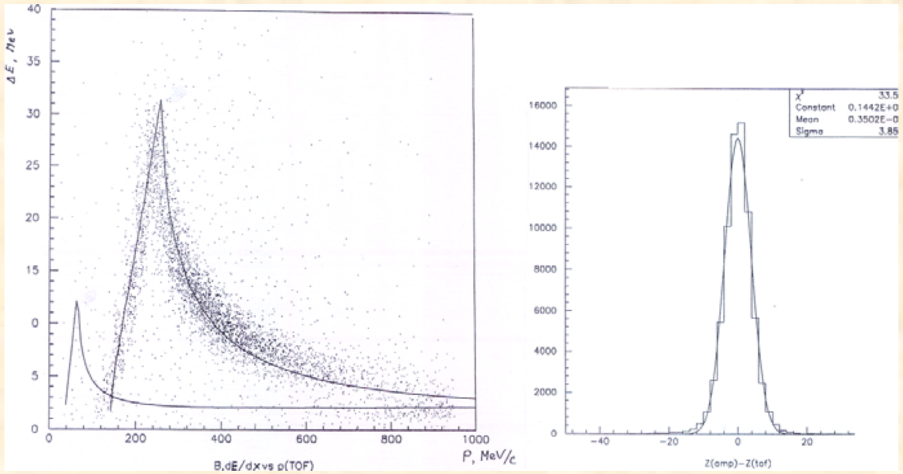
RPD



Sketch of the TOF detector. Longitudinal section (a), transverse section (b).



Calibrated TOF spectrum (T) obtained in an enriched $\beta \sim 1$ run (whole detector).



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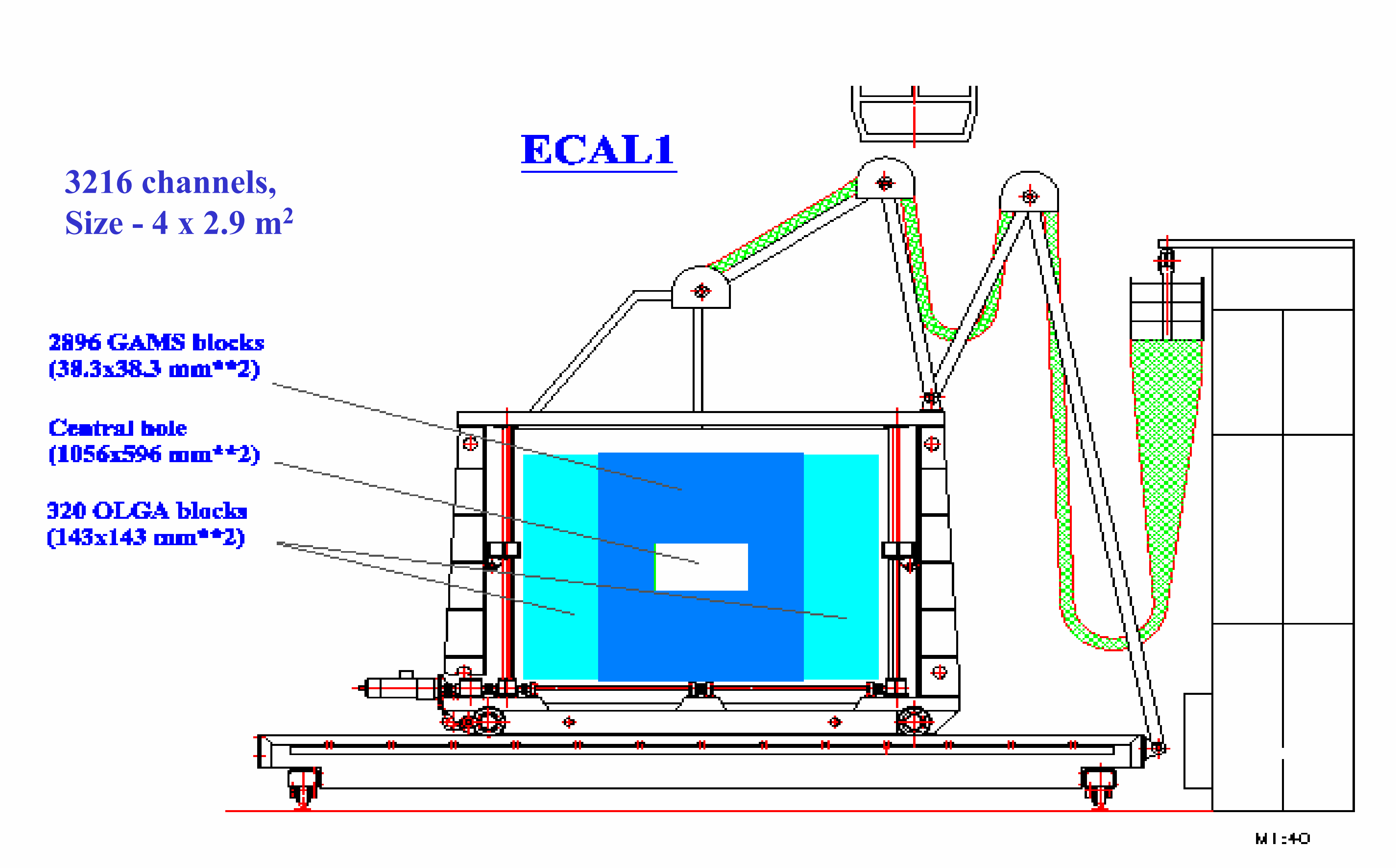

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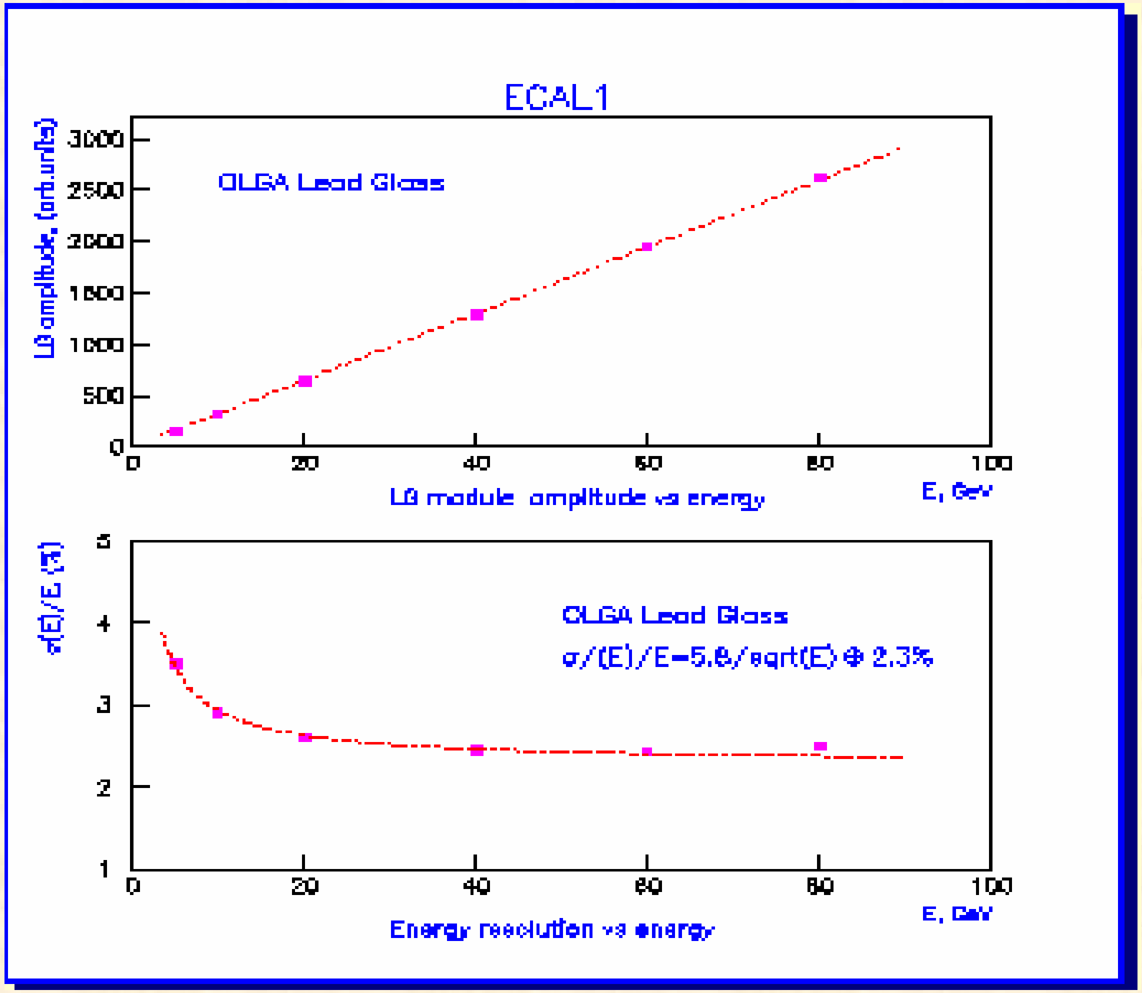

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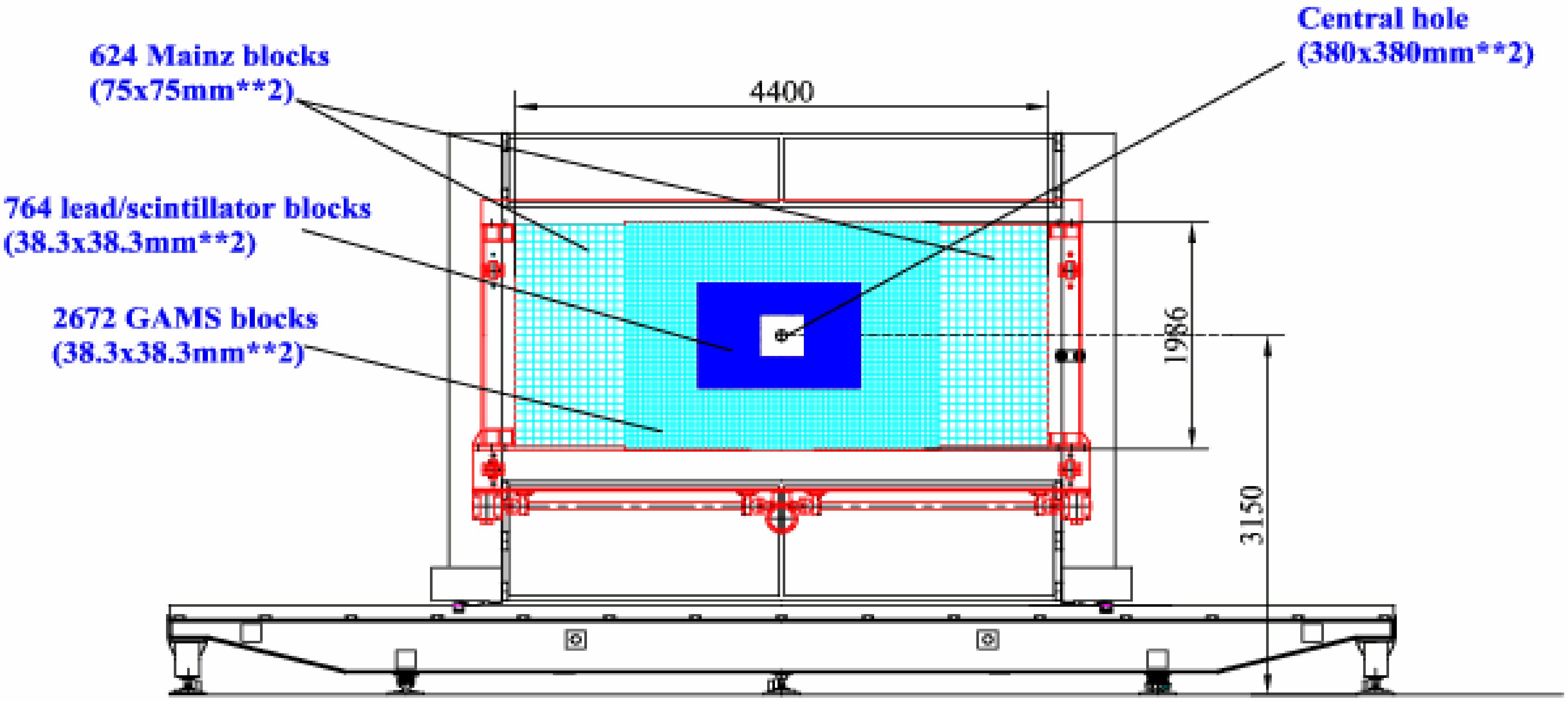
ECAL2

3436 channels,
Size – 4.4 x 2 m^2



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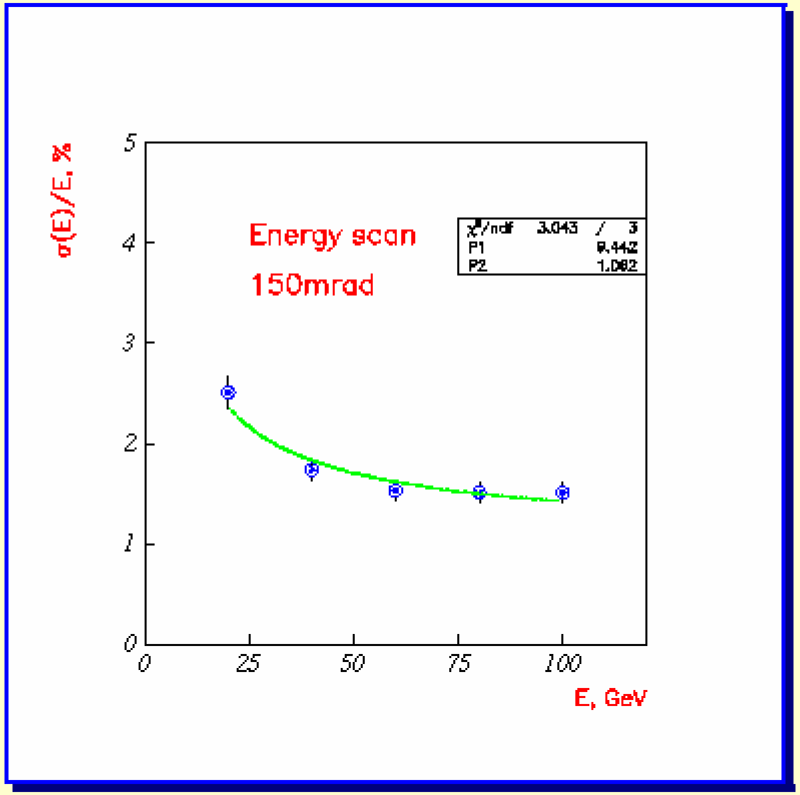
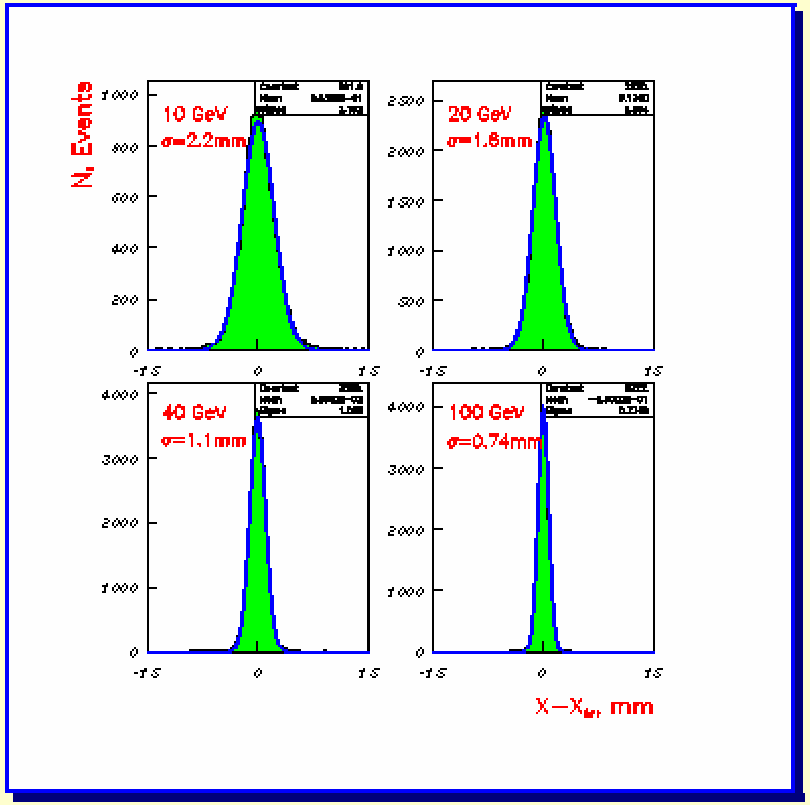
Pappardelle

- ✦ Energy resolution *vs* energy



- ✦ Coordinate resolution for different energy



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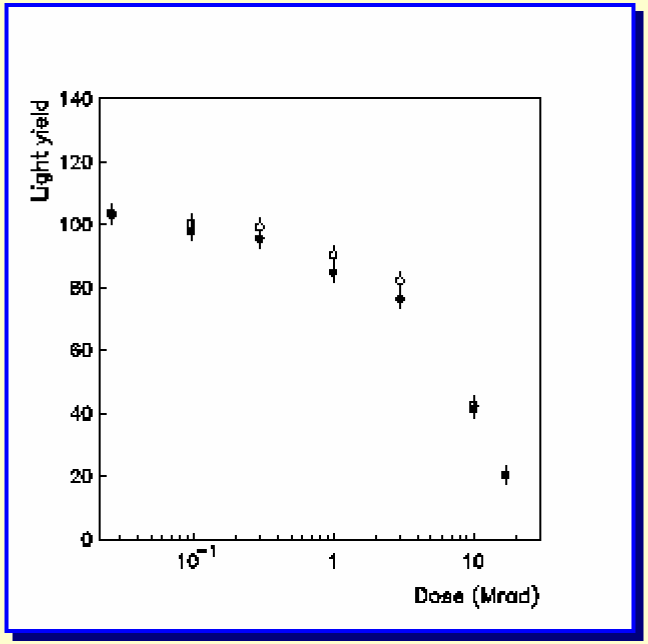
Radiation hardness of the sandwich type calorimeter

- Scintillator, 10% light loss
  SCSN-81 (Kuraray, Japan), 4 mm — 2.0 Mrad
  PSM-115(A) (IHEP, Protvino), 1 mm — 2.5 Mrad

- WLS fibers, 10% light loss
  Y-8 (Kuraray, Japan), 1 mm — 3.6 Mrad
  BCF-91a (Bicron, USA), 1 mm — 2.0 Mrad



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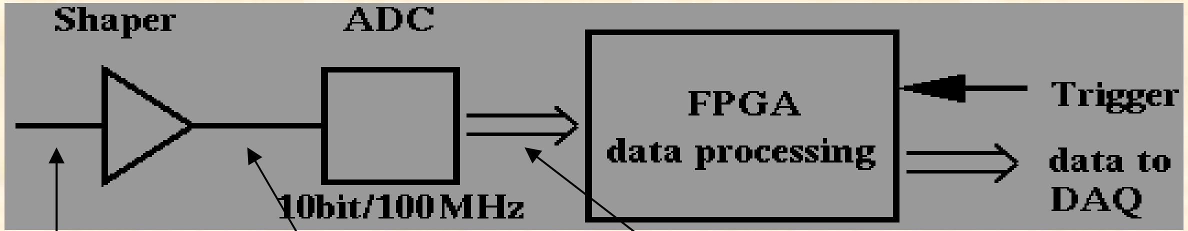
Front-end electronics for calorimetry

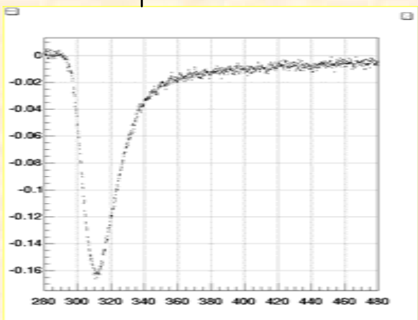
- FIADC (design IHEP-TUM)
  - dynamic range – 12 bit
  - linearity – 10 bit
  - sampling rate – 25 MHz
  - 64 channels/9U VME
  - dead time 150/450 ns
  - tested at trigger rate 50 KHz

ECAL Sampling ADC, design started at TUM

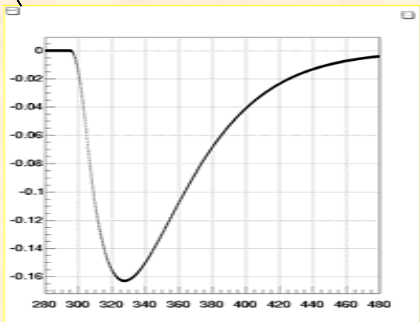
Simplified diagram of single channel ADC



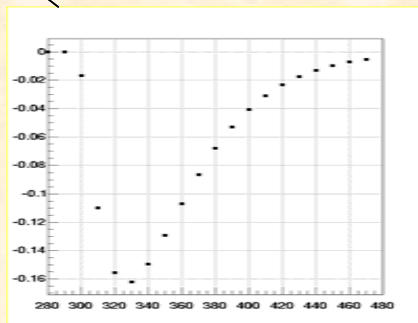
- SHAPER
  Stretching and smoothing input signal
  Being optimized for lead glass signal
- ADC
  100 MHz sampling rate
  10 bit resolution
- FPGA
  compressing data, fitting signal
  Fit -> Amplitude and Time



Input signal 10 GeV electron



Reshaped signal



Digitized signal

Advantages

- illumination of long signal cables
- very good time resolution 1-2 ns
- rejection or correction pileup events

- Full prototype test in summer 2003
- Production in 2003-2004

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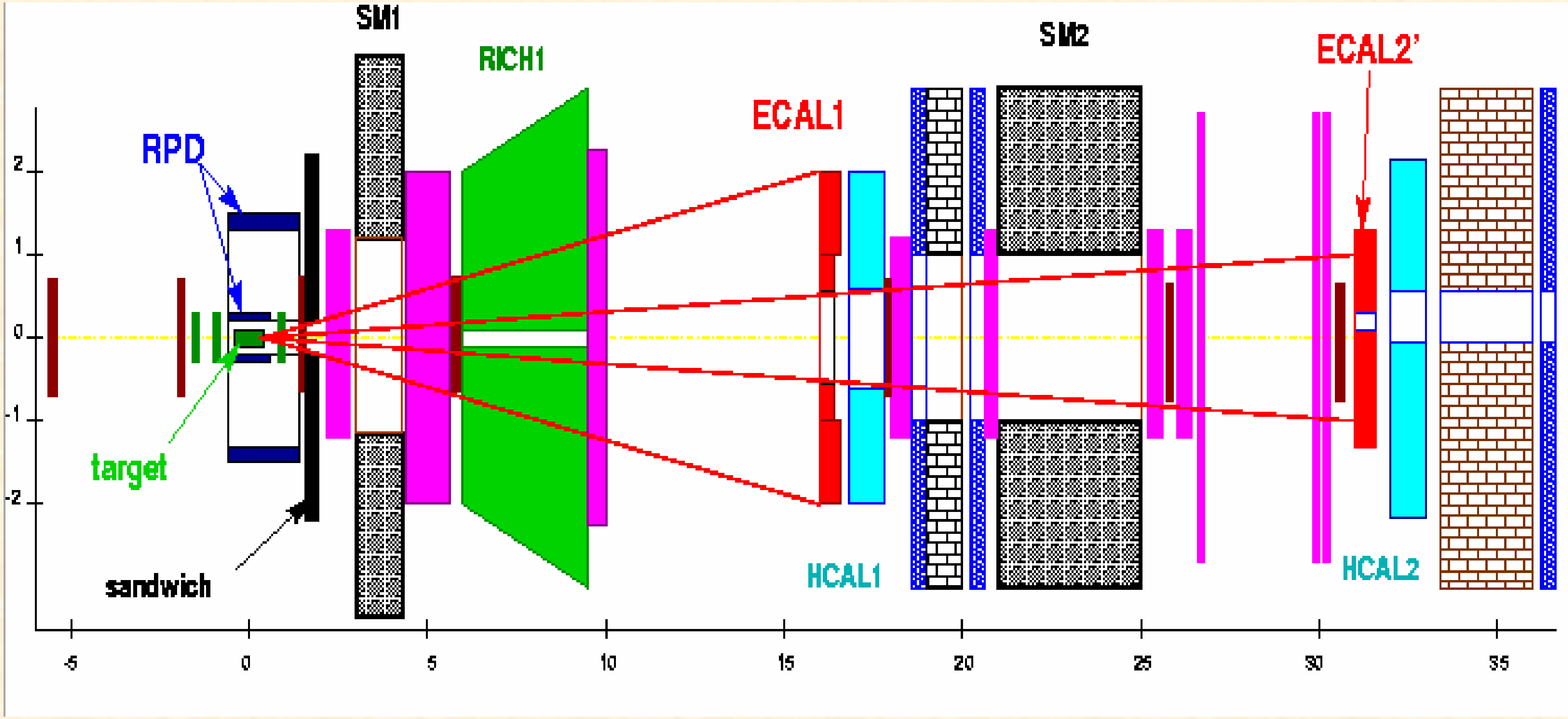

Central production of Exotics

SIMULATION: $hp \to h X^0 p$

$\hookrightarrow \eta\eta \ (\eta \to \gamma\gamma, \ \eta \to \pi^0 \pi^- \pi^+)$

$\hookrightarrow \gamma\gamma$

- **Event generator $\Rightarrow$ WA102, based on real data.**
- **Beam momentum – 280 GeV/c, RMS 1.5%.**
- **Trigger conditions:**
  - **one particle traverse two RPD layers;**
  - **no signals in sandwiches;**
  - **fast particle at the end of setup outside the beam spot.**

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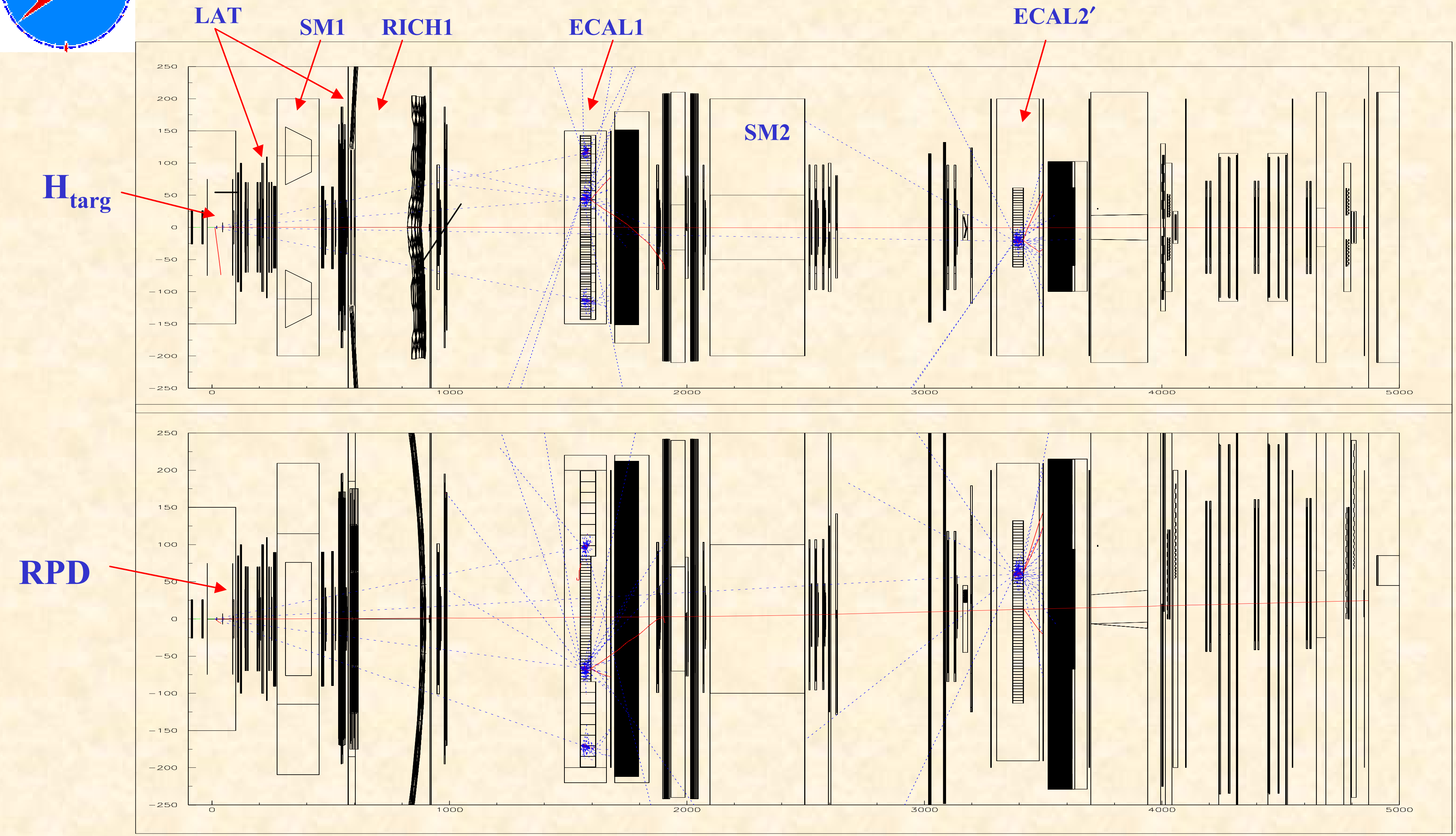

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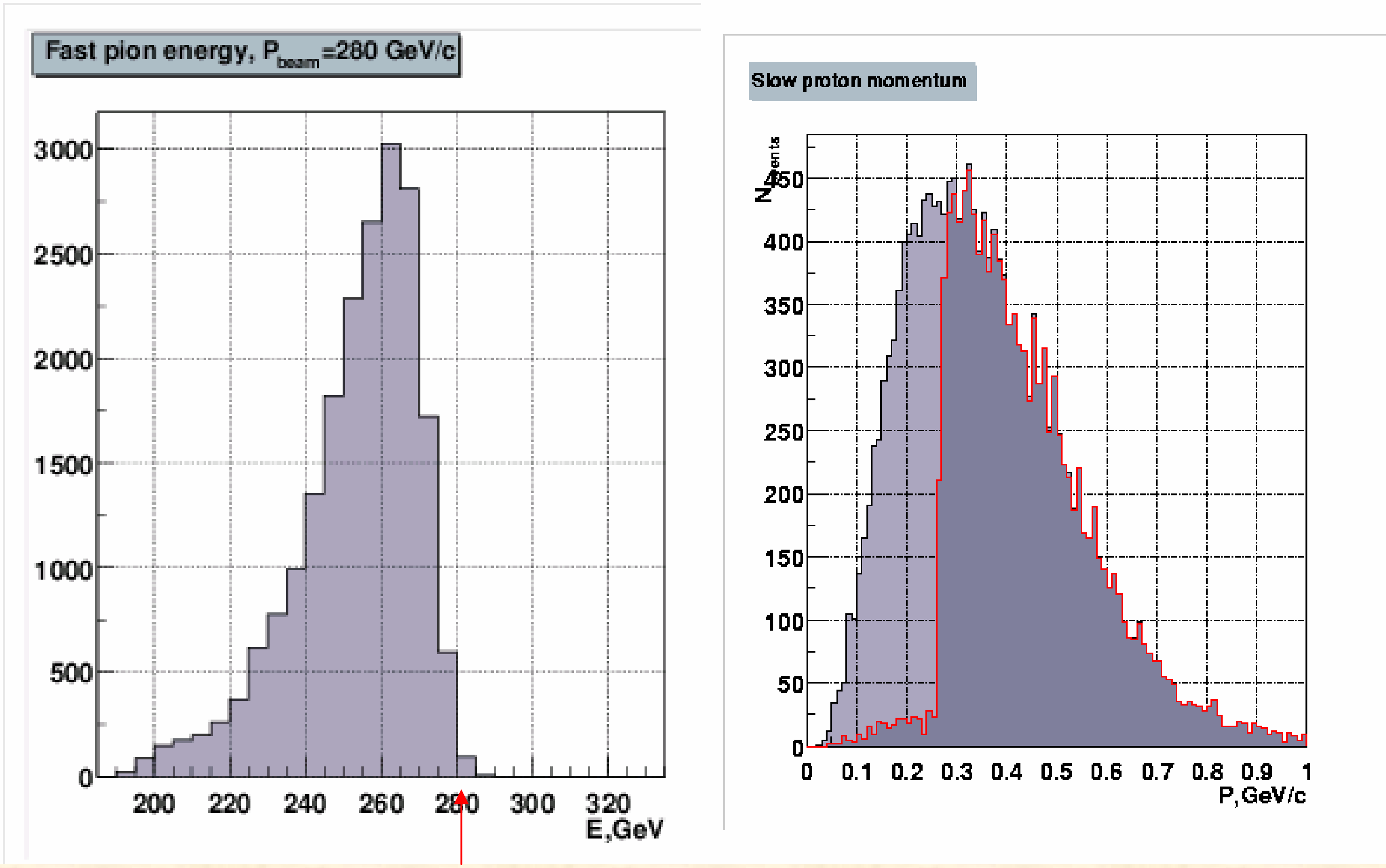
Fast and slow hadron distributions



beam

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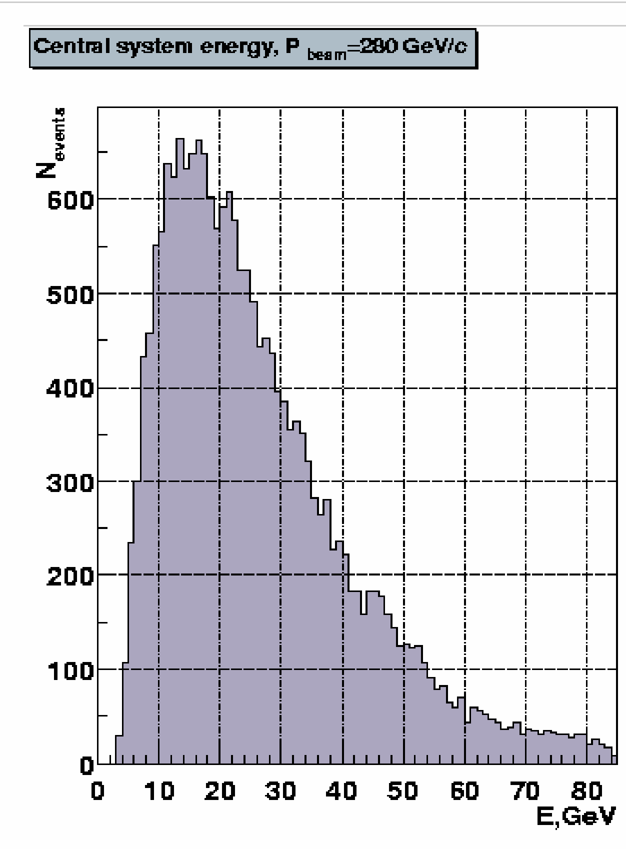
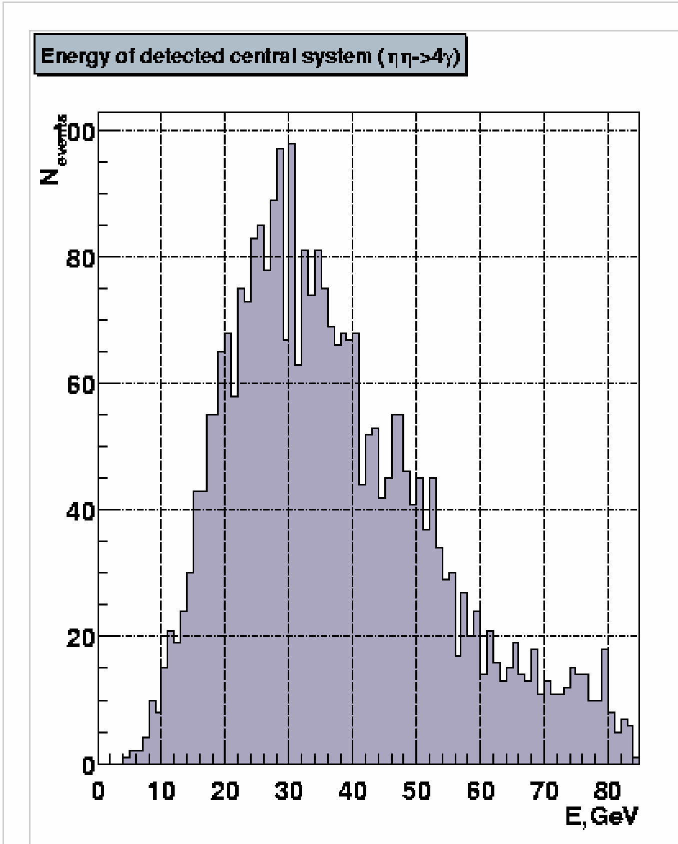
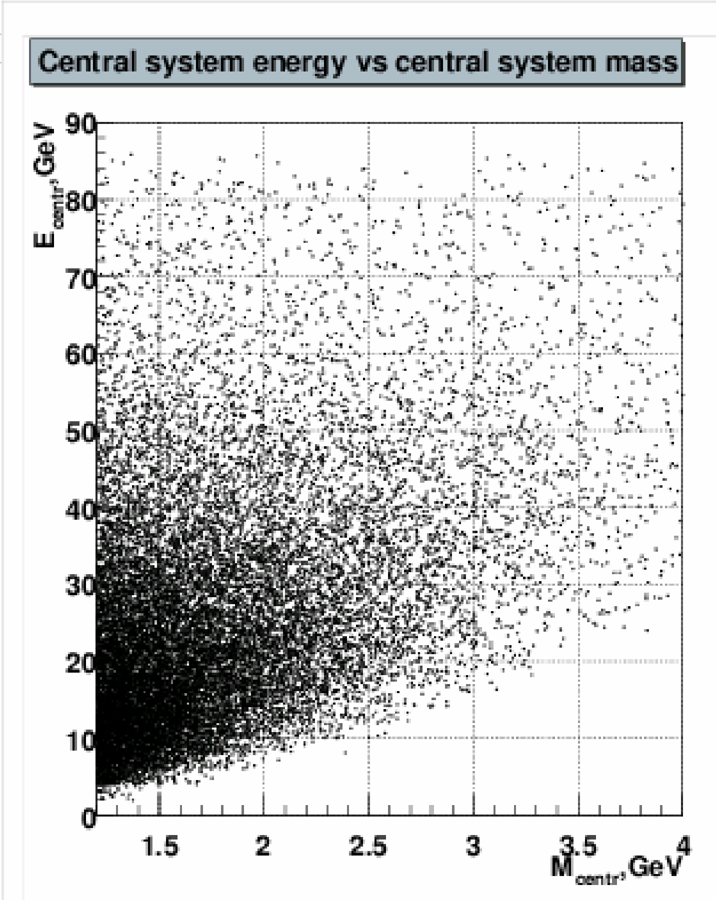
Central system energy







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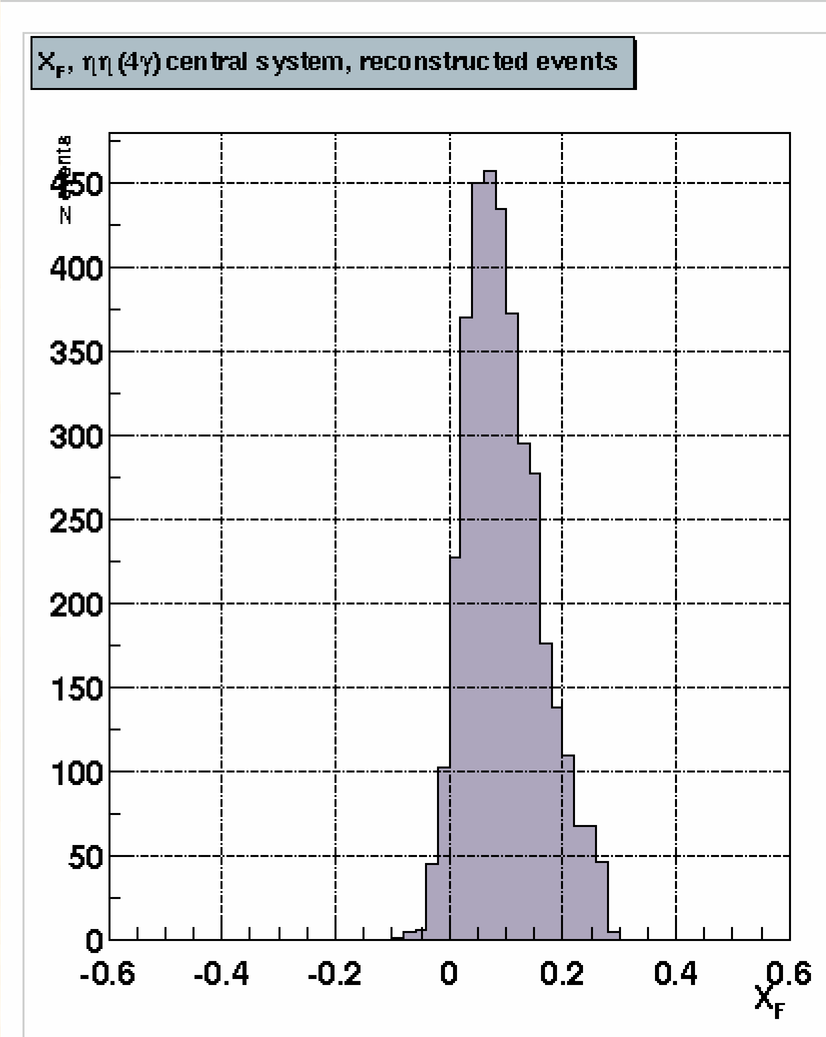

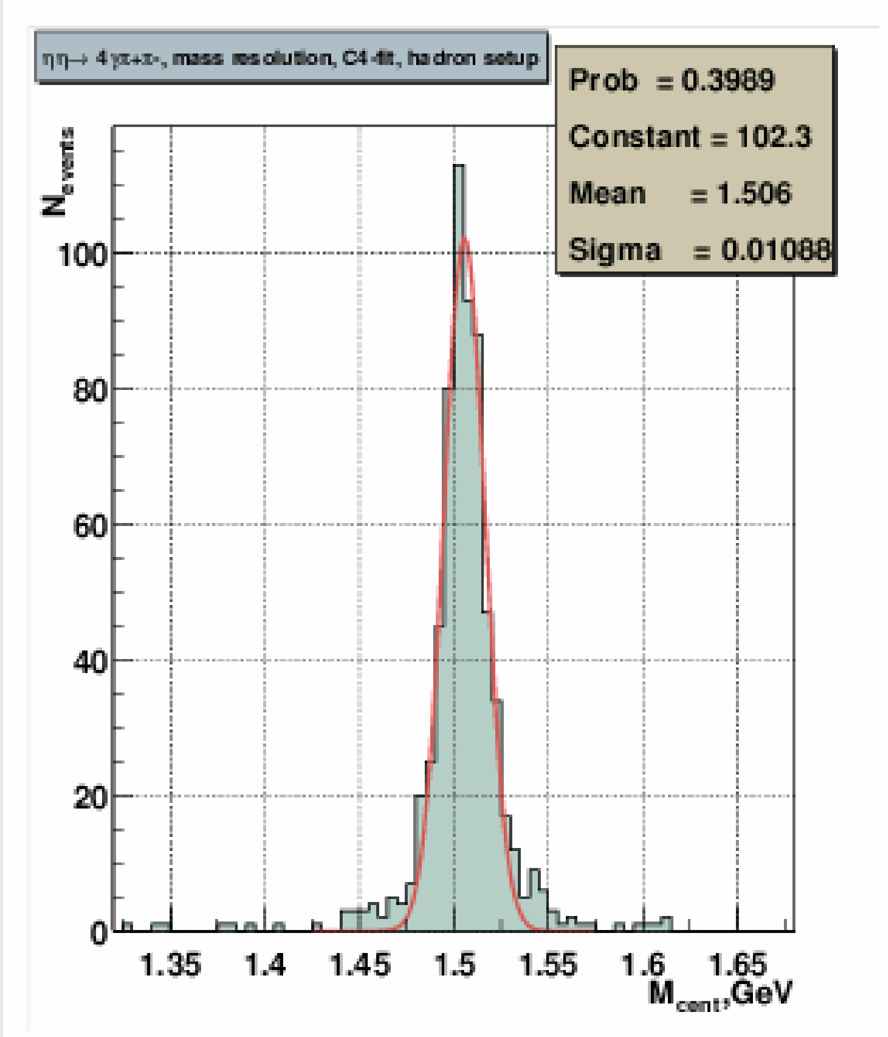

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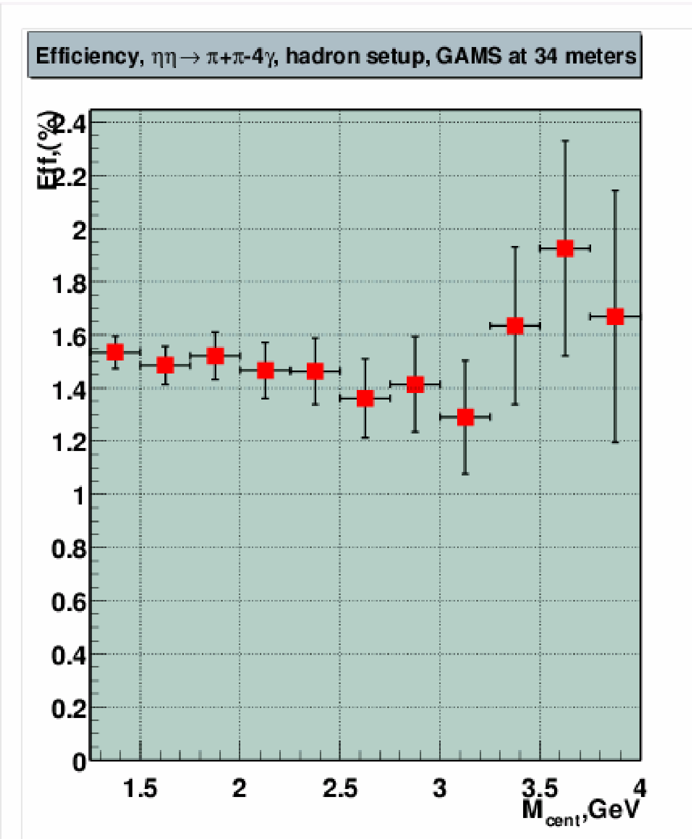
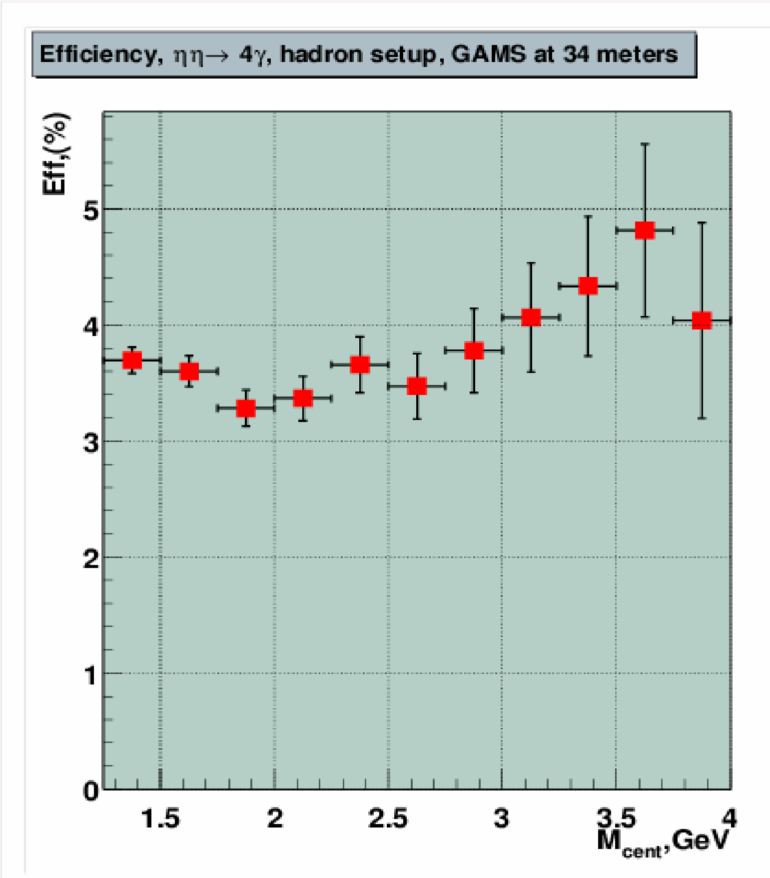
Mixed decay mode efficiency



Neutral decay mode efficiency



Expected statistic:
450 events/day of f_0(1500) in **ηη decay mode**

Beam 2.5 * 10^7/spill limited by ECAL2 radiation resistance.

$\sigma_{prod} \sim 3\ \mu b$

(WA102: 3351 ev.)

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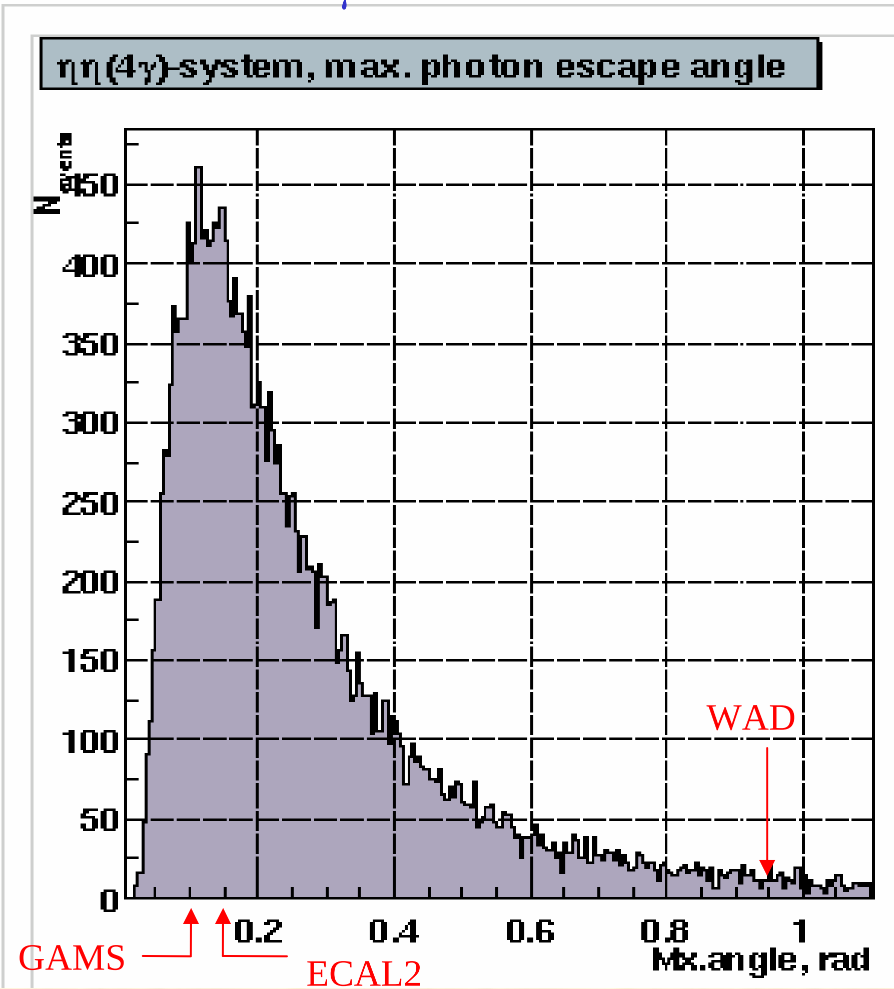
Max. θ_γ from η's decay



Acceptance cut

Distance	ECAL1	GAMS	ECAL2	Acc_γ
	16 m	34 m	-	0.18
	11 m	-	34 m	0.36

Wide Angular Electromagnetic Calorimeter before SM1 is desirable to increase significantly acceptance for gammas ($Acc_\gamma \sim 0.95$).

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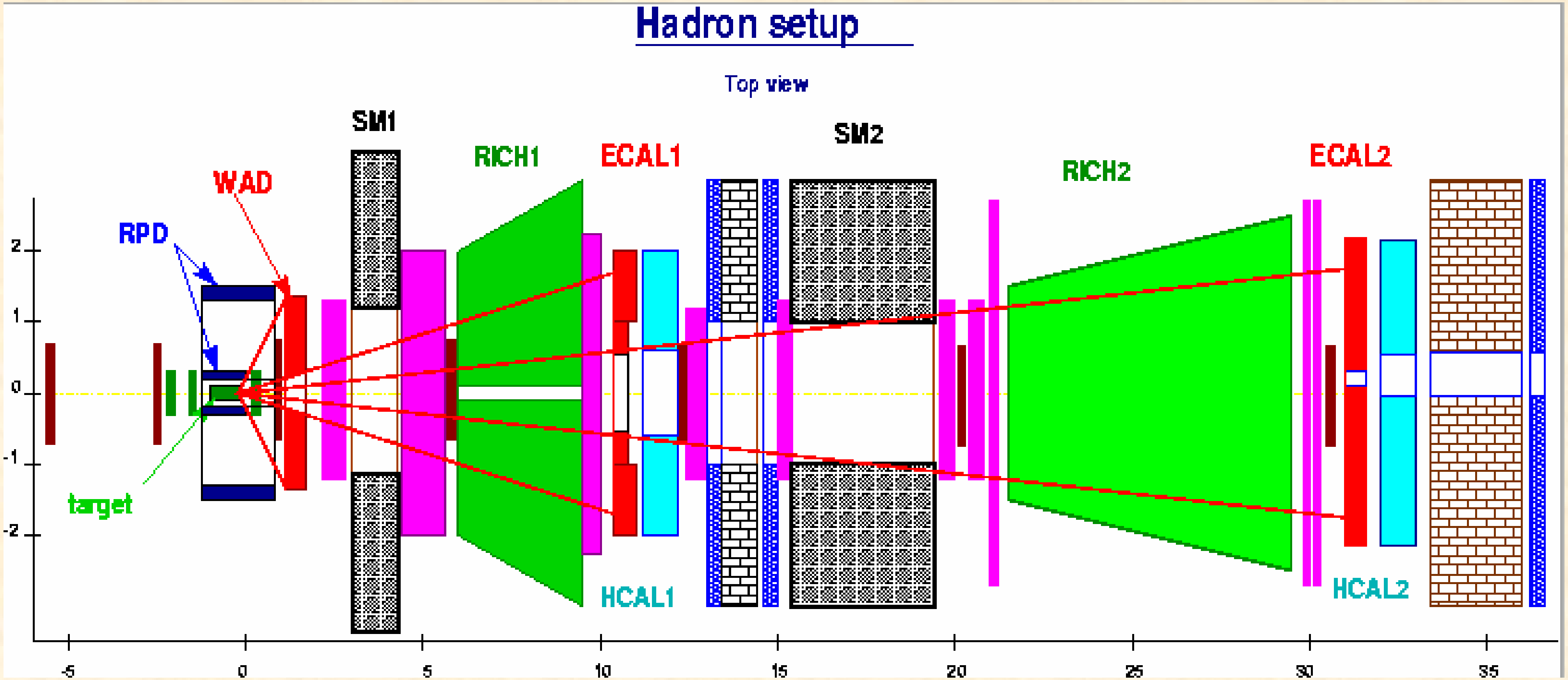

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Project status

- **Target, RPD ⇒ exist** ☺
  Electronic ⇒ should be produced 😐
- **ECAL1**
  Platform ⇒ exist ☺
  Cassette ⇒ in production 😐
  Front End :
  FIADC ⇒ 3000 ☺
  SADC ⇒ design in progress 😐
- **ECAL2**
  Design ⇒ ready ☺
  production ⇒ ☹
- **GAMS ⇒ exist** ☺
- **Trigger ⇒ should be produced** 😐

Central production of Exotics

Conclusions

- High intensity beam
- Precise Large & Small Area Tracking
- Electromagnetic & Hadron Calorimetry
- Particle identification
- Fast Read-out electronics
- High performance powerful DAQ

Improvement:

- WAD

COMPASS has a good perspective in meson spectroscopy