COMPASS Calorimetry in view of future plans

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on behalf of the COMPASS Collaboration

Outline:

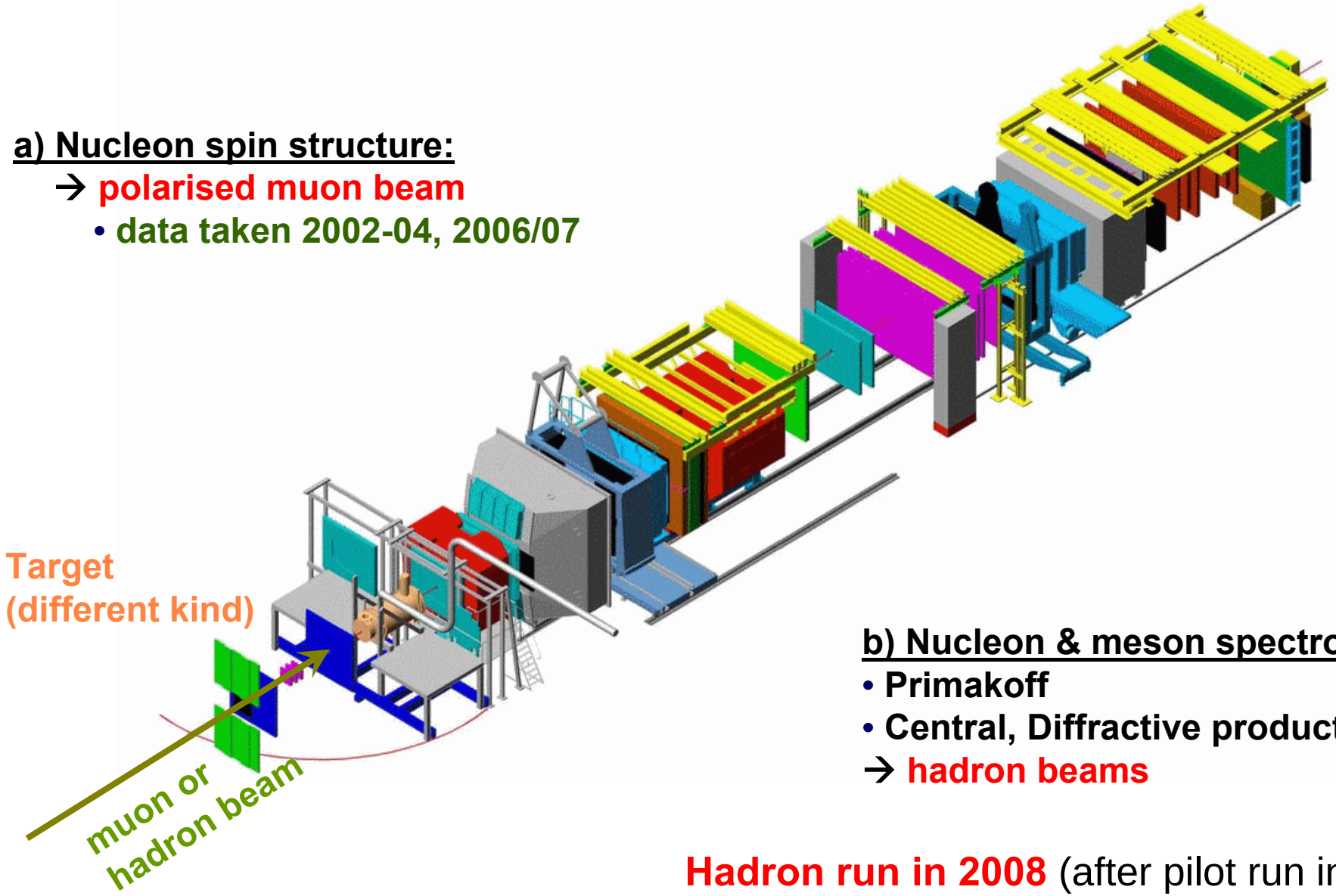
- COMPASS Hadron and DVCS programme
- Calorimetry:
  - Test beam measurements, first results
  - Calibration, monitorung using muons
- Outlook

bmb+f - Förderschwerpunkt COMPASS Großgeräte der physikalischen Grundlagenforschung

The COMPASS experiment

COmmon Muon Proton Apparatus for Structure and Spectroscopy
(~270 physicists, 25 institutes, 11 countries)

a) Nucleon spin structure:
→ **polarised muon beam**
• **data taken 2002-04, 2006/07**



b) Nucleon & meson spectroscopy:
• **Primakoff**
• **Central, Diffractive production**
→ **hadron beams**

Hadron run in 2008 (after pilot run in 2004)

Proposal: General Parton Distributions (GPD)

(EOI→ CERN-SPSC-05-007)

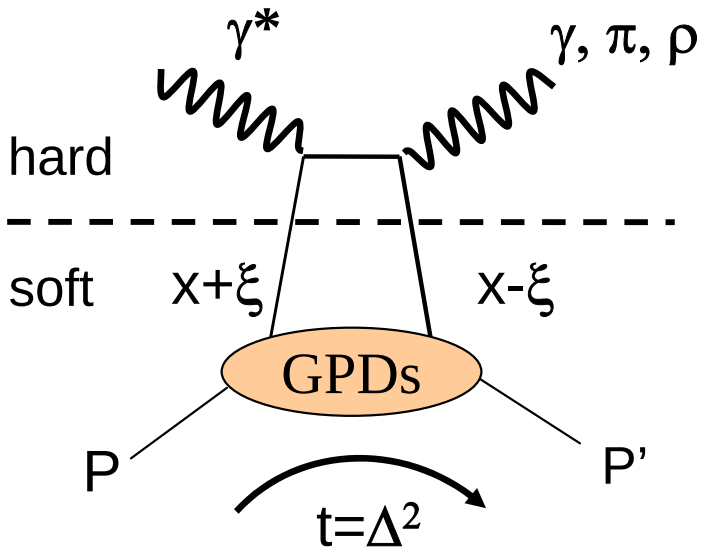
Why measure GPDs:

- GPD framework – Novel tool for investigating nucleon structure
- accessible through hard exclusive reactions:
  - → 3D picture of nucleon (quarks, gluons)
  - → possibilty to access still unknown quark & gluon orbital momentum

HEMP: $\mu p \rightarrow \mu p \pi,\rho,...$

&

DVCS: $\mu p \rightarrow \mu p \gamma$

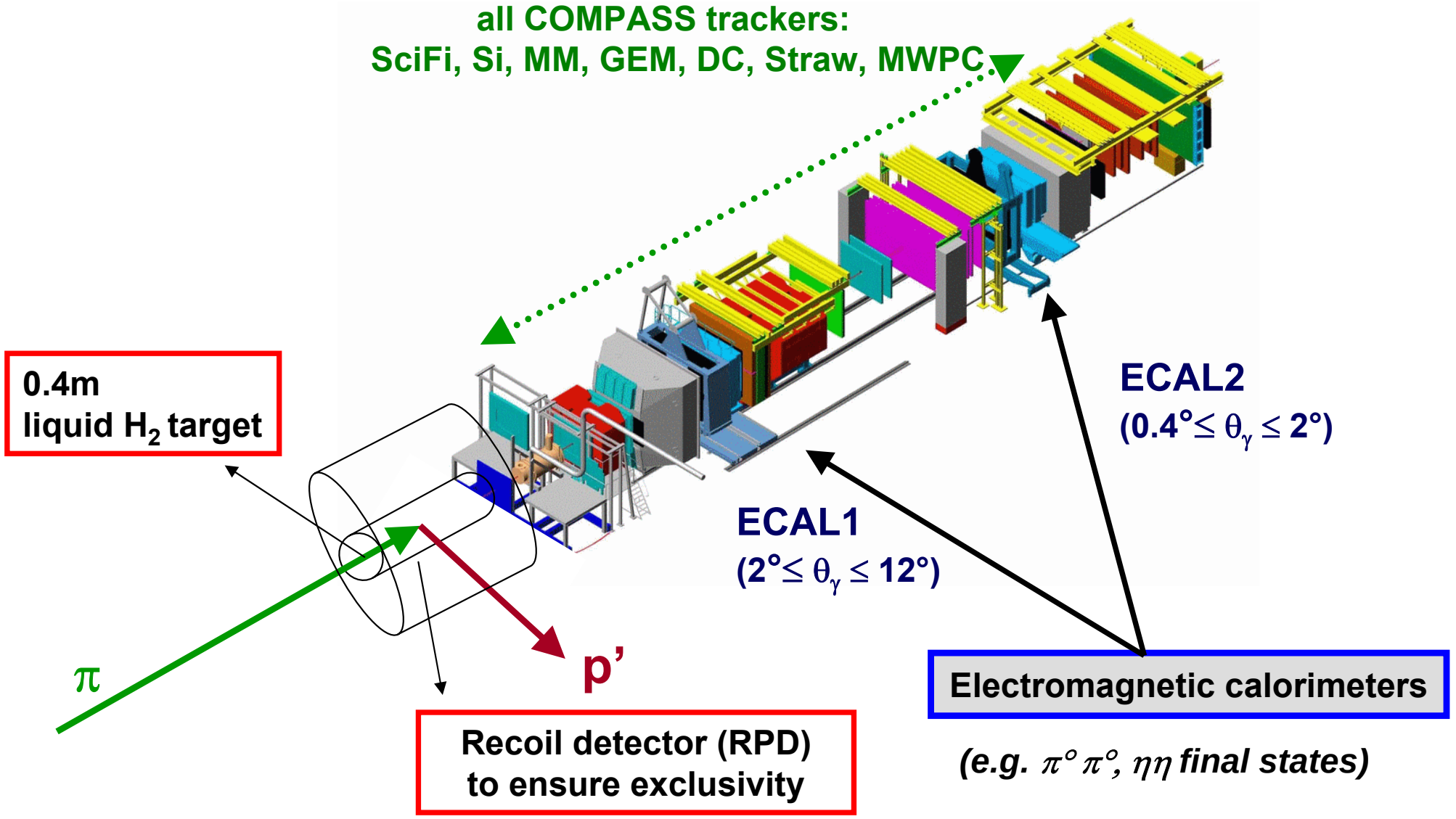


Why doing with COMPASS:

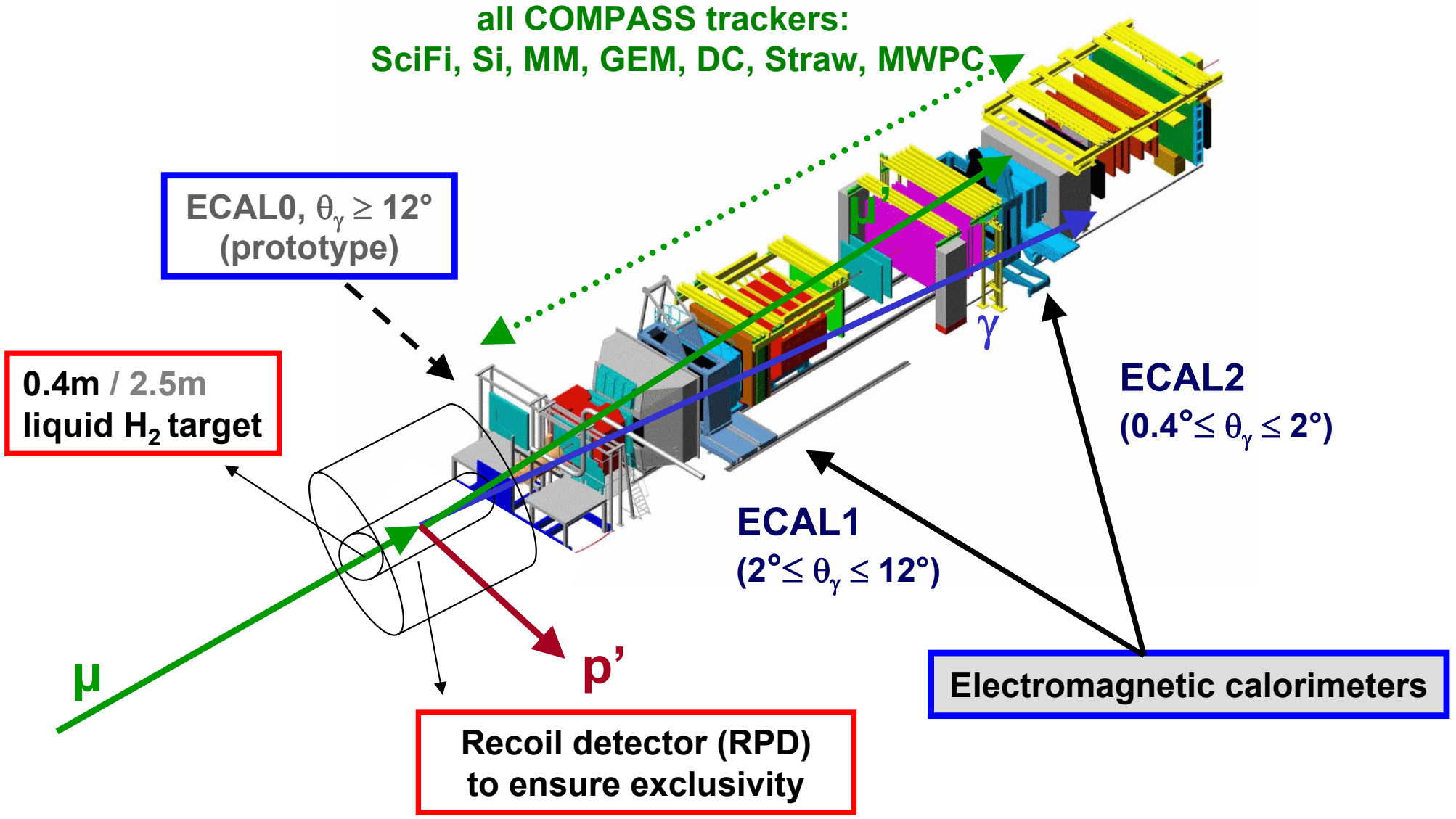
- high energies available at CERN
- possibility of using polarised, positive & negative muons
- → DVCS

→ **COMPASS** = **unique place** for studying **GPD via DVCS !**

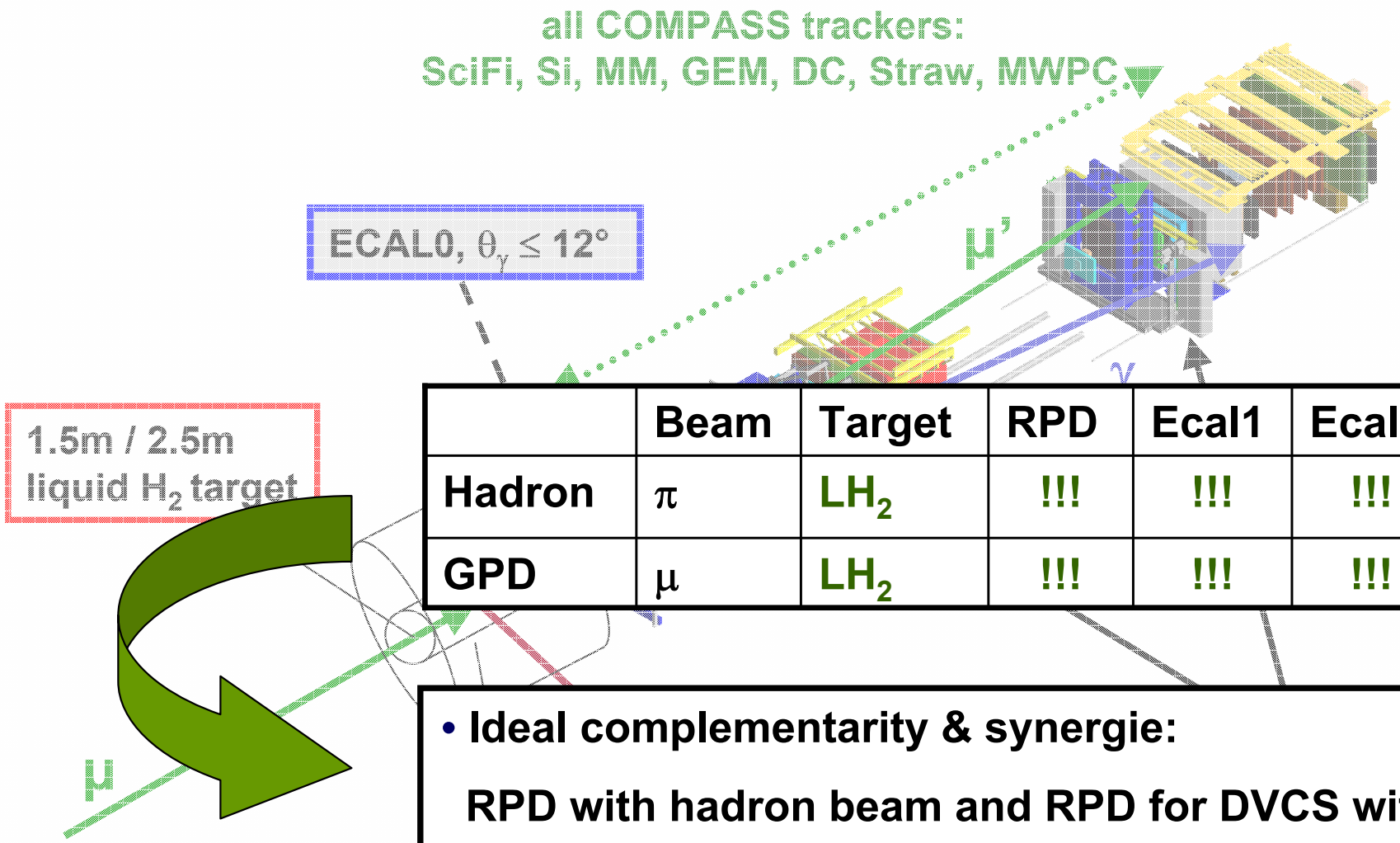
COMPASS spectrometer: Hadron setup 2008



COMPASS: Setup 2008 and beyond



COMPASS: Setup 2008 and beyond



	Beam	Target	RPD	Ecal1	Ecal2
Hadron	π	LH_2	!!!	!!!	!!!
GPD	μ	LH_2	!!!	!!!	!!!

- Ideal complementarity & synergie:

  RPD with hadron beam and RPD for DVCS with muon
- At COMPASS both hadron & muon beams available
- No big change over needed for GPD via DVCS!

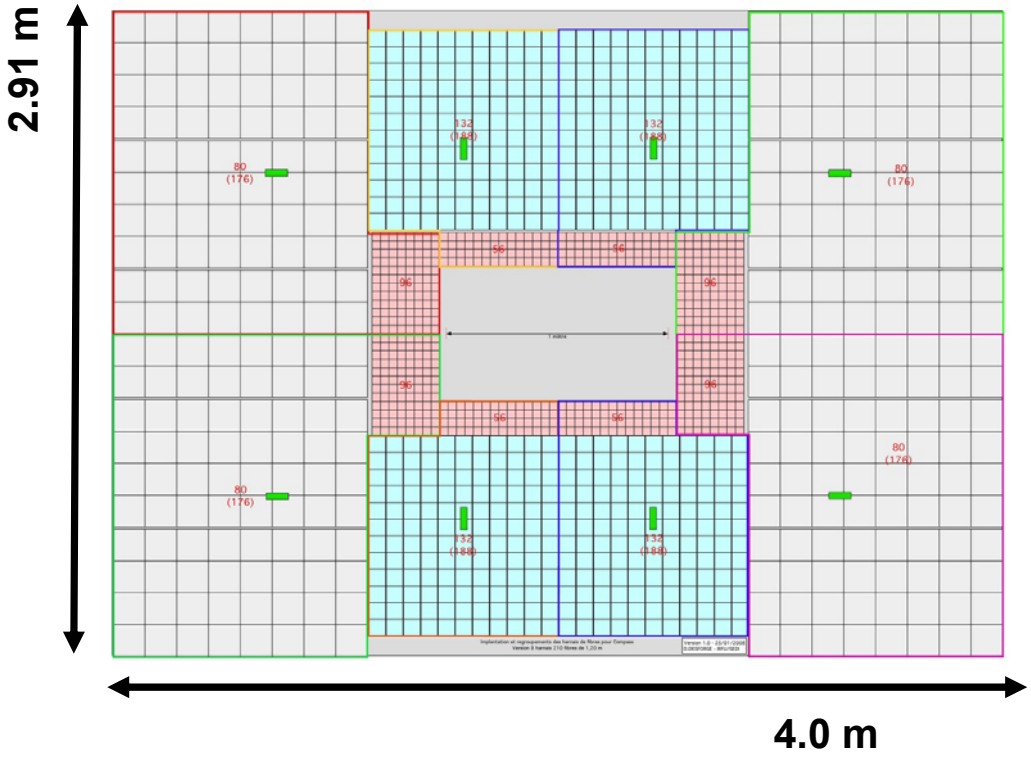
COMPASS ECAL1&2

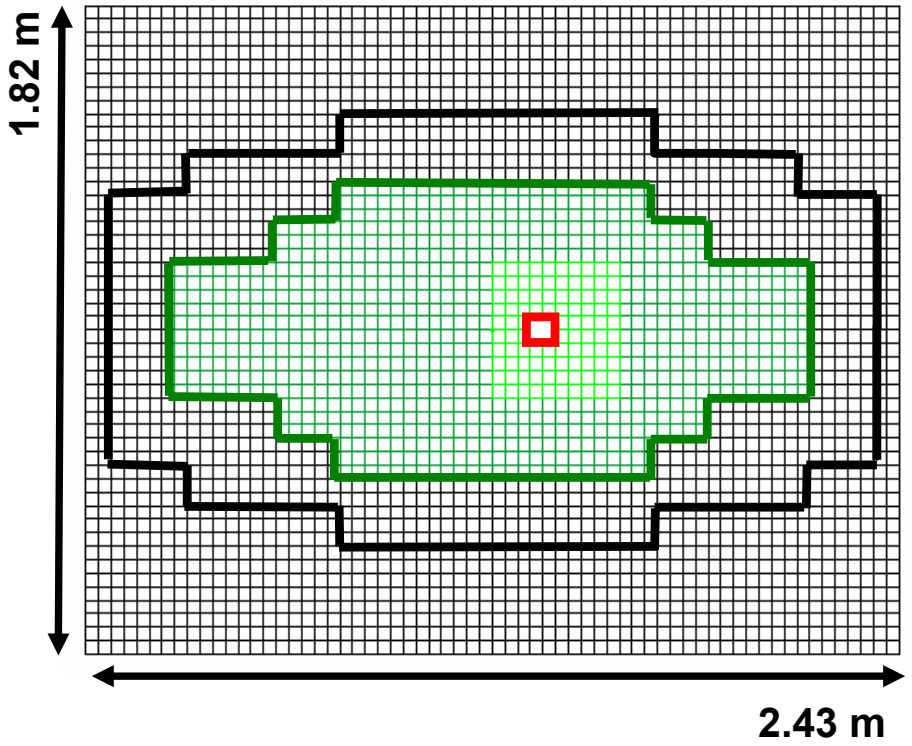
ECAL1, 1476 channels:

- Olga blocks (143 x 143mm^2): 320 chans
- Mainz blocks (75 x 75 mm^2): 580 chans
- GAMS blocks (38.2 x 38.2 mm^2): 576 chans

ECAL2, 3072 channels:

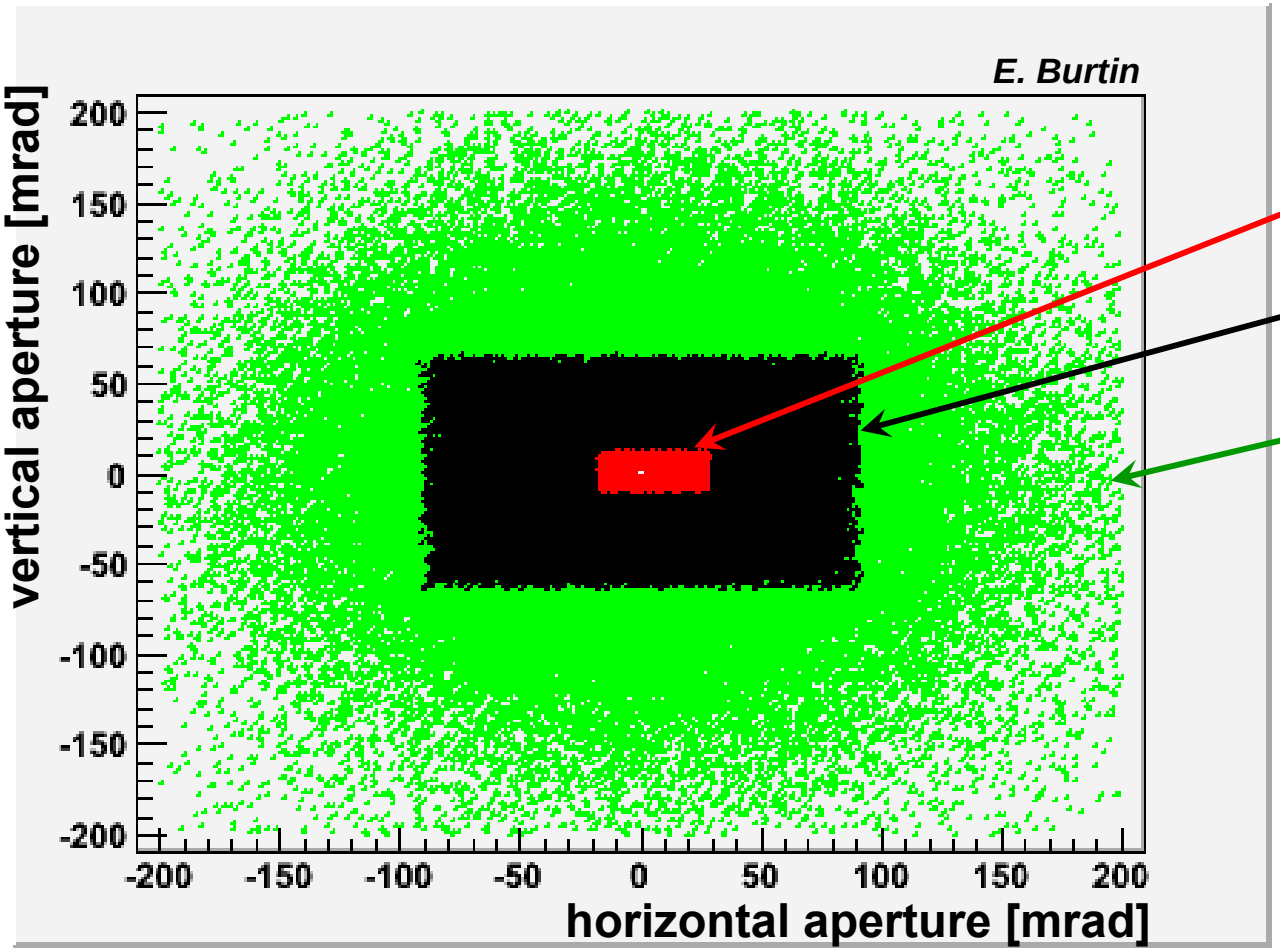
- GAMS blocks: 1440 chans
- radhard GAMS blocks : 768 chans
- Shashlik modules: 864 chans





Calorimeter coverage foreseen

Goals: Detect DVCS photons & π^0



ECAL2 (existing)

ECAL1 (existing)

ECAL0 (to be built*)

**prototype test in 2008*

DVCS photons:

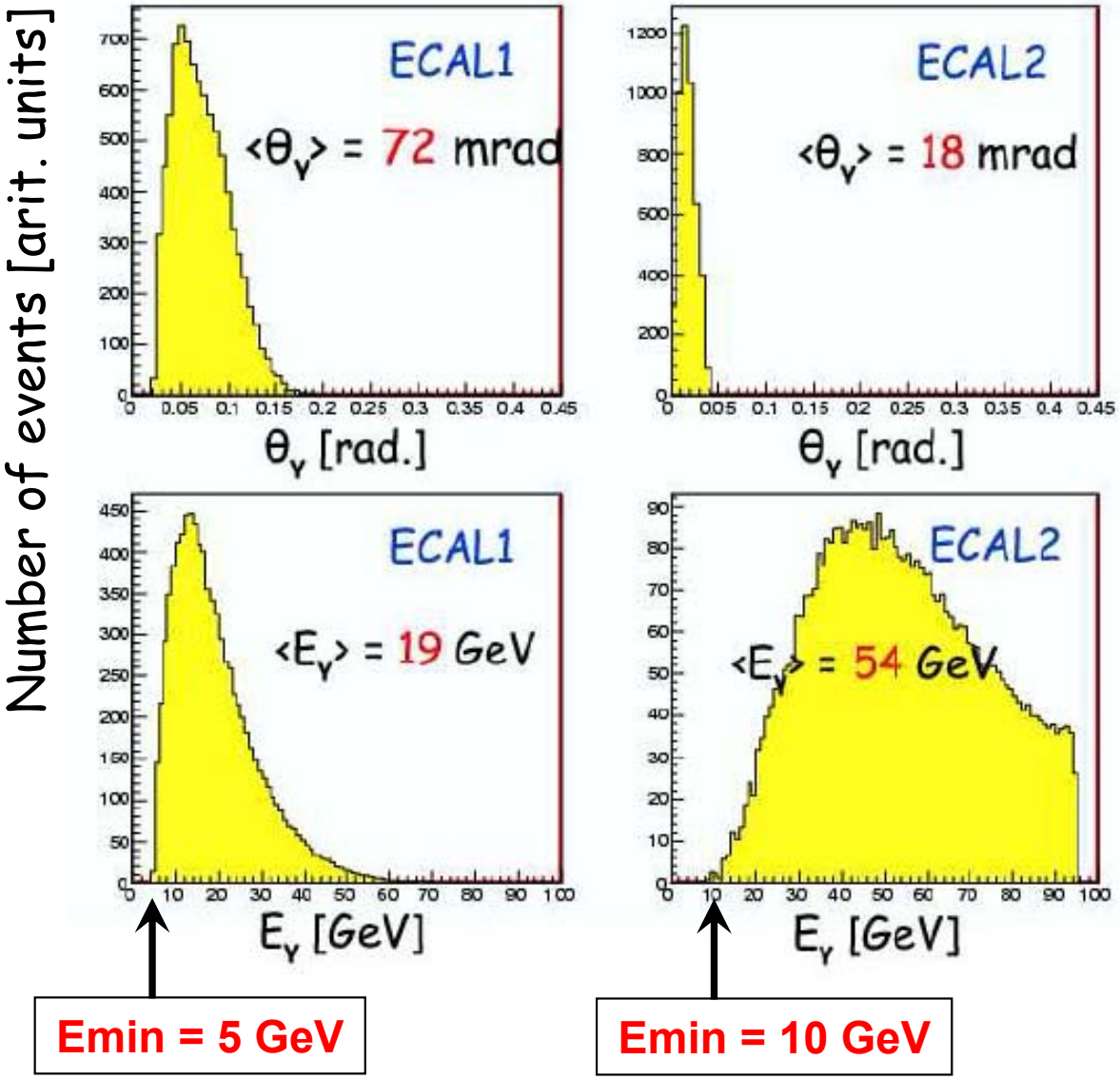
- 23% in Ecal2
- 43% in Ecal1 (!!!)
- 22% in Ecal0

~90% in total

DVCS γ impact point at ECAL 0 location

Kinematical ranges for photons in Ecals

A. Sandacz



Demands for Calorimetry
Goal: DVCS photon detection & bckg suppression

Goal: DVCS photon detection
- $E\gamma >=$ 5 GeV in ECAL1
- $E\gamma >=$ 10 GeV in ECAL2

Also needed : Bckg suppression, i.e. reconstruction of 2 photons from π° decay of
- $E\pi^\circ =$ 5 GeV in ECAL1
- $E\pi^\circ =$ 10 GeV in ECAL2

$\pi^\circ \rightarrow \gamma 1 + \gamma 2$

Probability to detect both bckgr photons from π°decay in lab syst.:

	Ecal1		Ecal2	
E_{thr} [GeV]	1.25	0.73	2.5	1.5
Prob. [%]	50	70	50	70

Needed for DVCS & good γ/π° separation:
- $Ecal1_{Ethr}$ ~ 1 GeV
- $Ecal2_{Ethr}$ ~ 2 GeV

Ecal1&2: Hardware thresholds: ~ 150 MeV
→ a priori no limitation for Ethr < 1GeV

T9 Test beam at CERN organised by Protvino IHEP

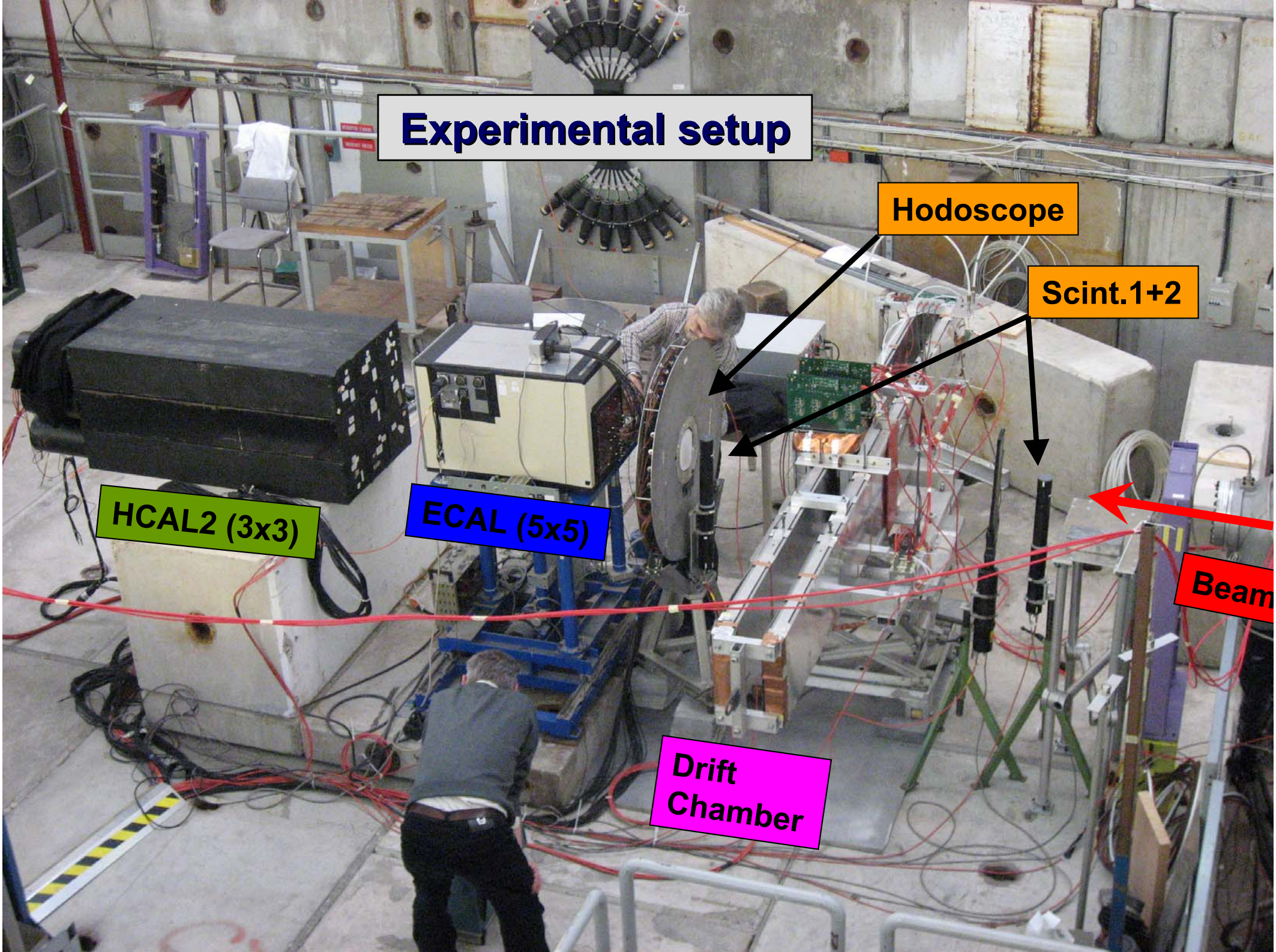
T9 Test beam data taken:

- **SPS East area, Oct. 2007** *(Dubna, IHEP, Mainz, Torino, TU Munich, Saclay & Freiburg)*
- **1-15 GeV positron, mu+, pion and proton beam**

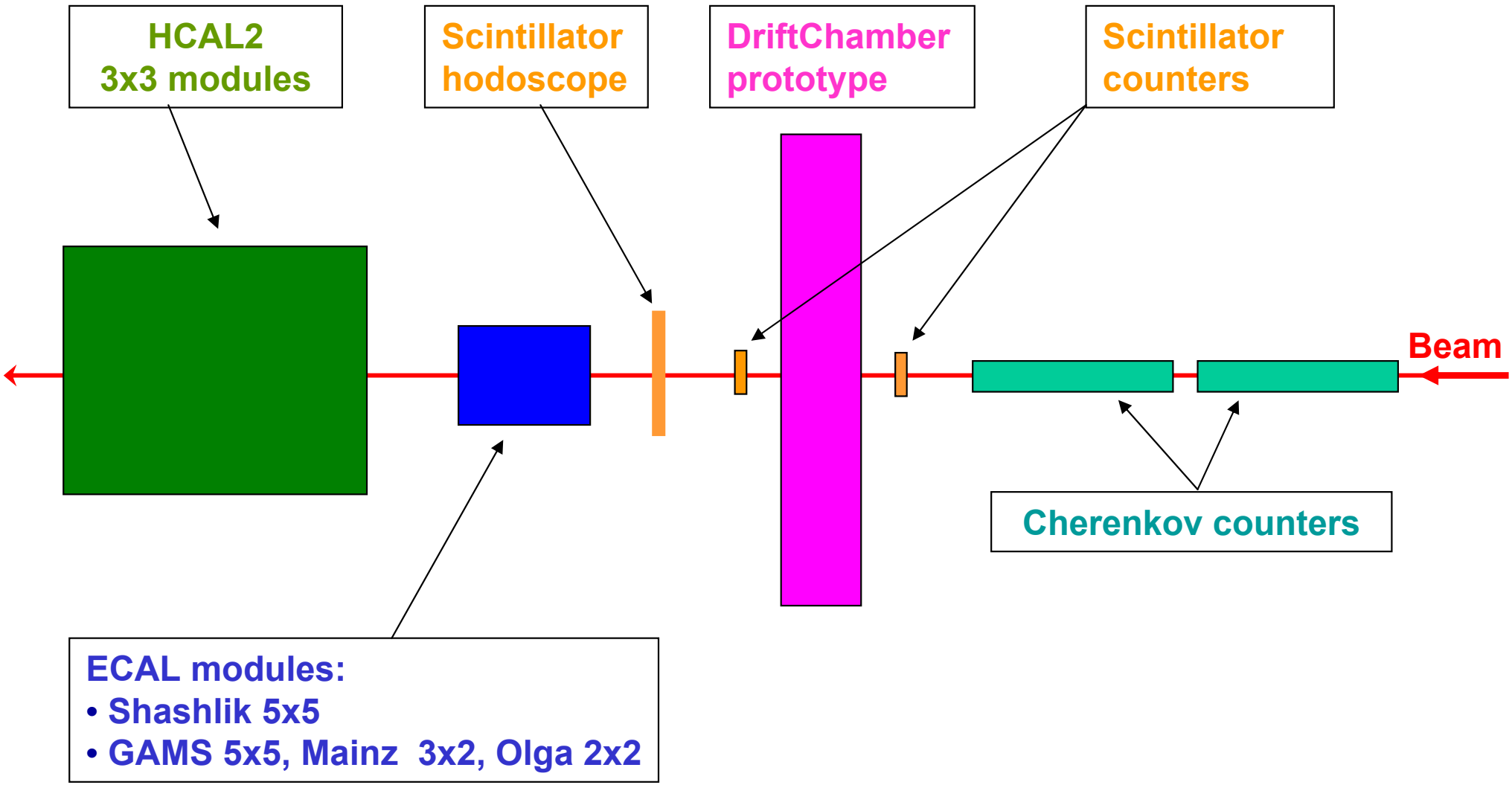
=> first, preliminary results shown here

Detector components involved: ECAL, DriftChamber, HCAL
→ *ECAL: Shashlik (ECAL2), GAMS (Ecal1+2), Mainz & Olga (Ecal1)*

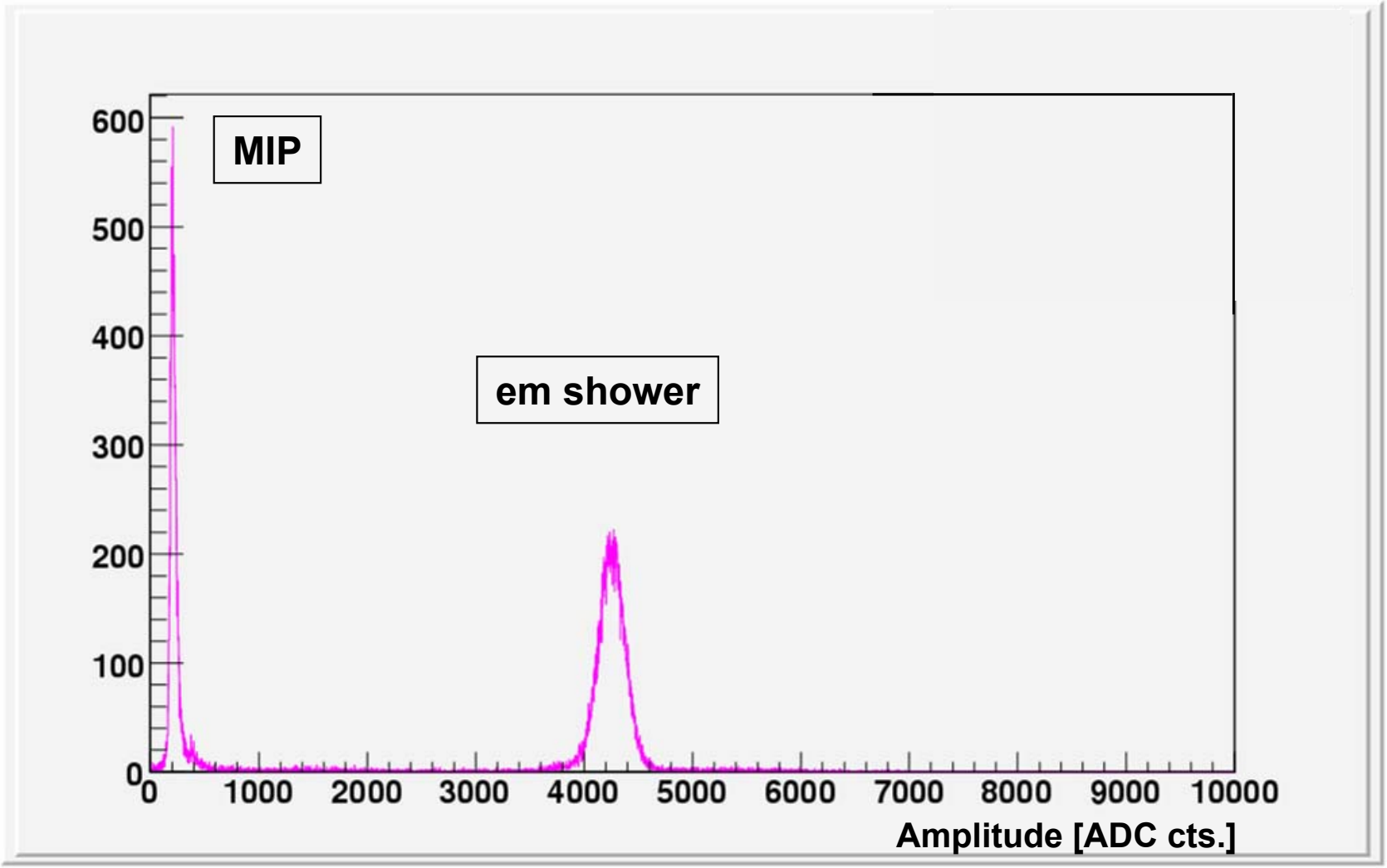
=> comissioning of new devices,
in view of improvements of existing calorimeters


Experimental setup
Hodoscope
Scint.1+2
HCAL2 (3x3)
ECAL (5x5)
Beam
Drift Chamber

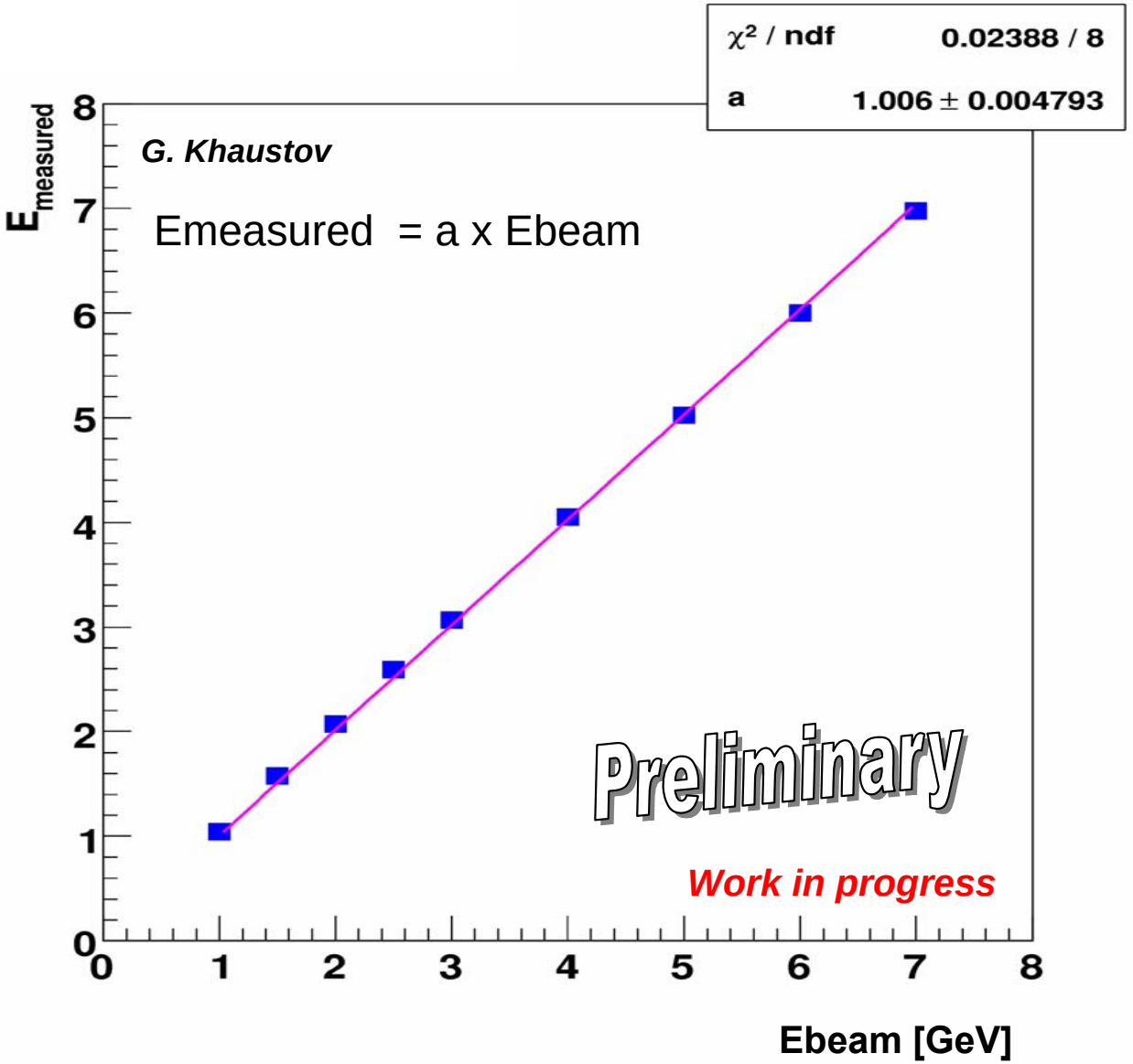
Experimental setup



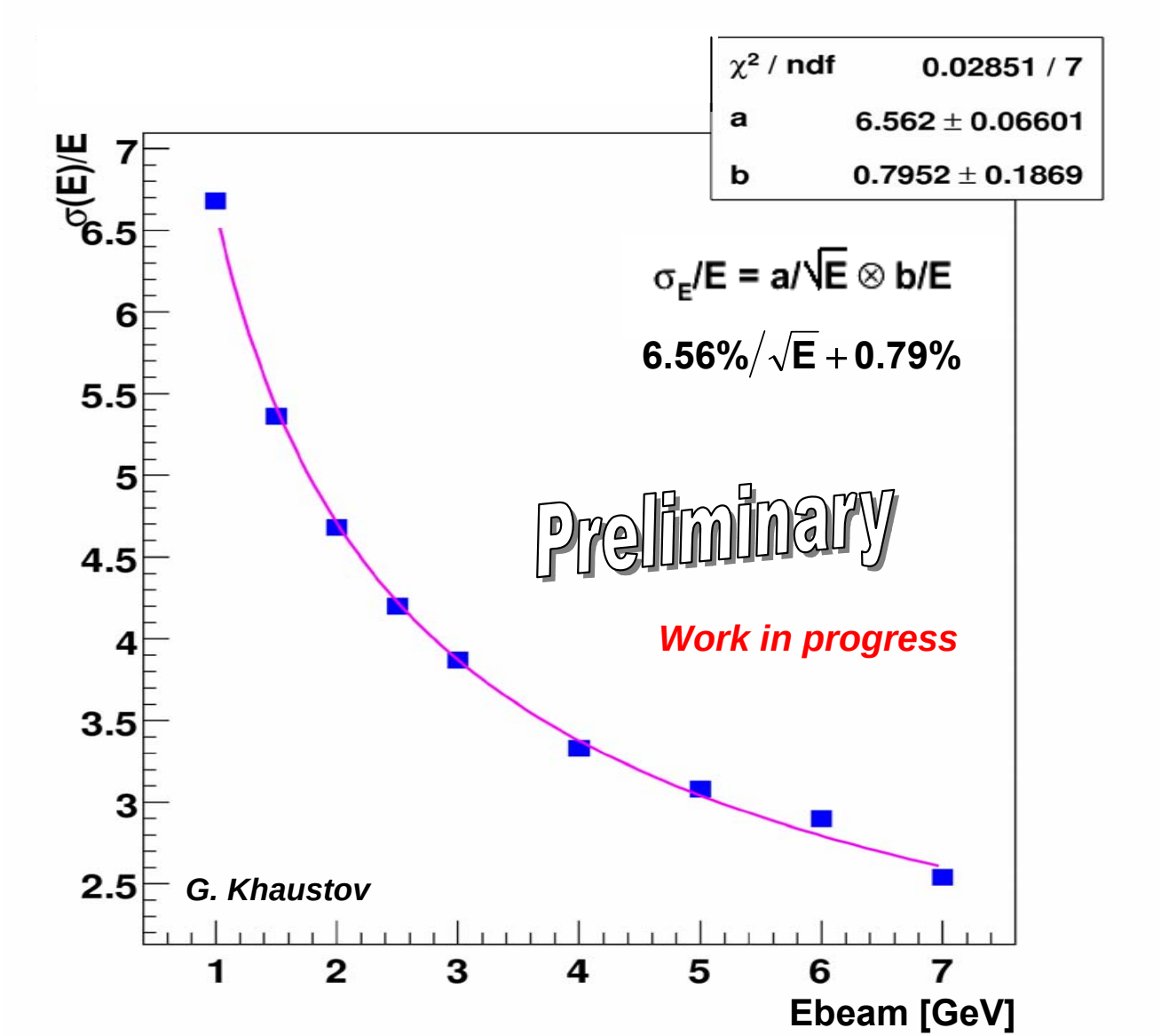
Shashlik: Muon & electron peak
4 GeV beam energy



Preliminary results: Linearity – Shashlik modules

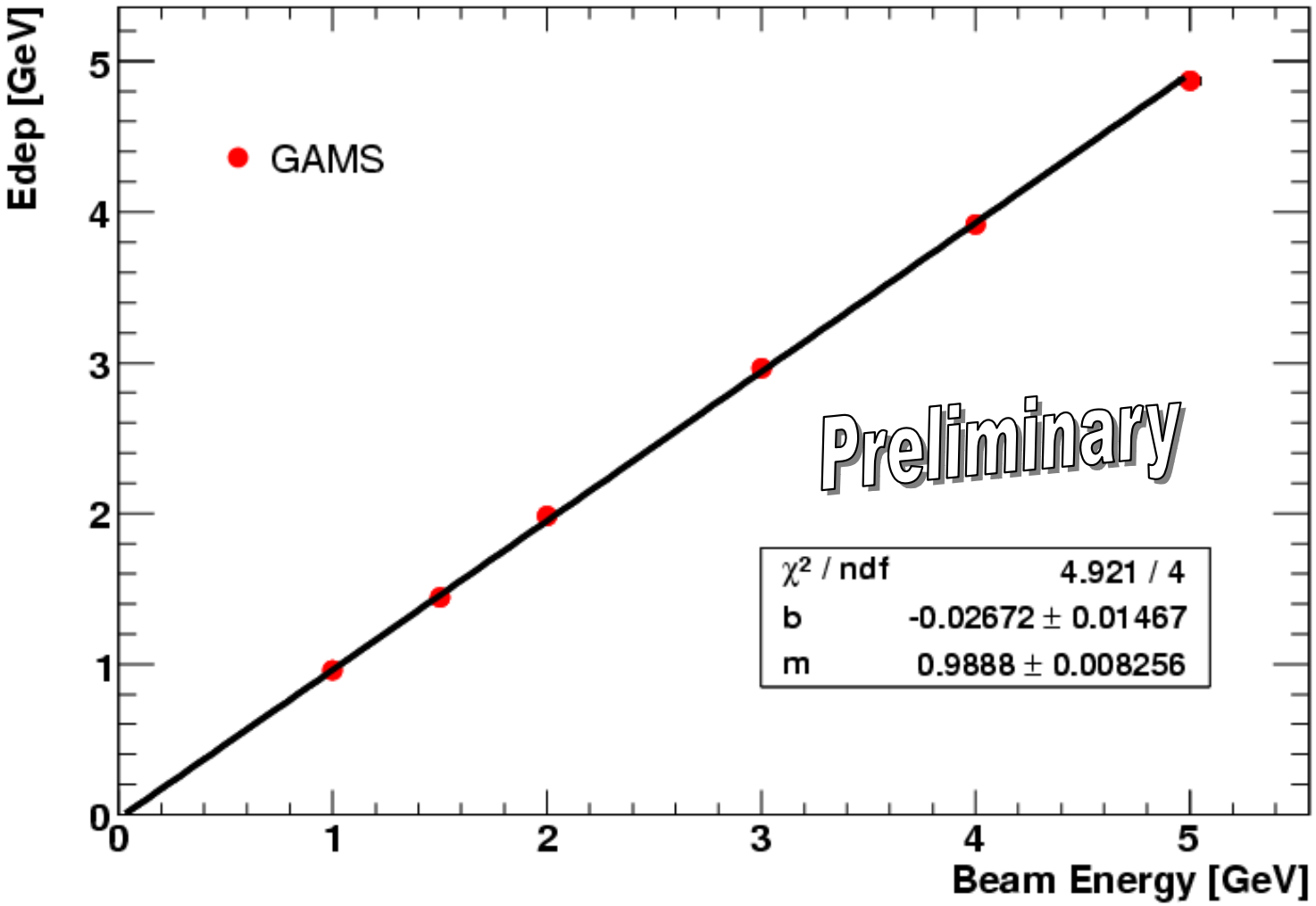


Preliminary results: Resolution - Shashlik modules

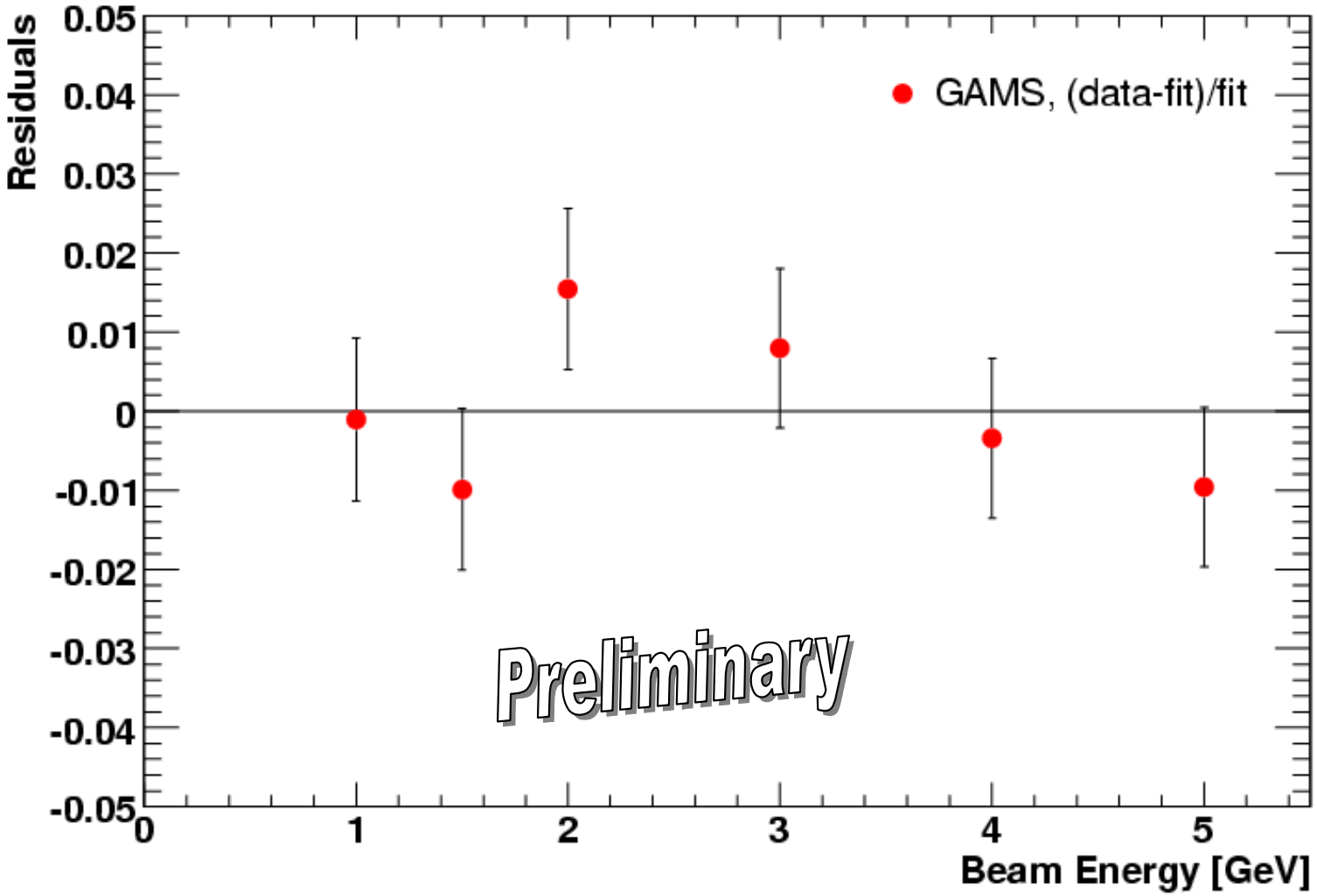


Preliminary: No correction for non-linearity

Linearity – GAMS

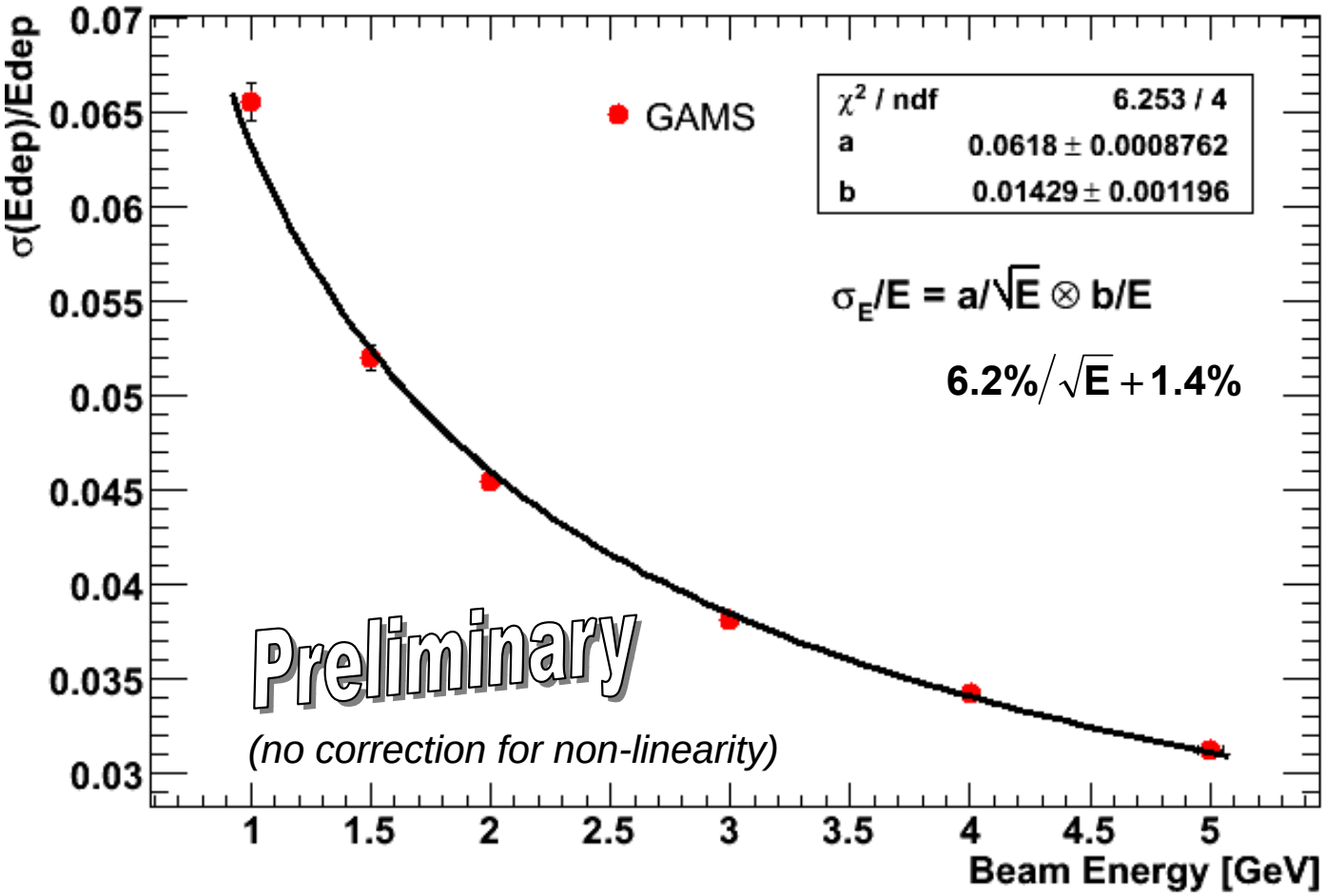


Linearity – GAMS



- **error bars: statistical (small) + beam momentum uncertainty (incoorporated)**
- **not all systematic effects yet taken into account**
  (e.g. beam position: yes, uniformity: no) → **work in progress**

Energy resolution – GAMS

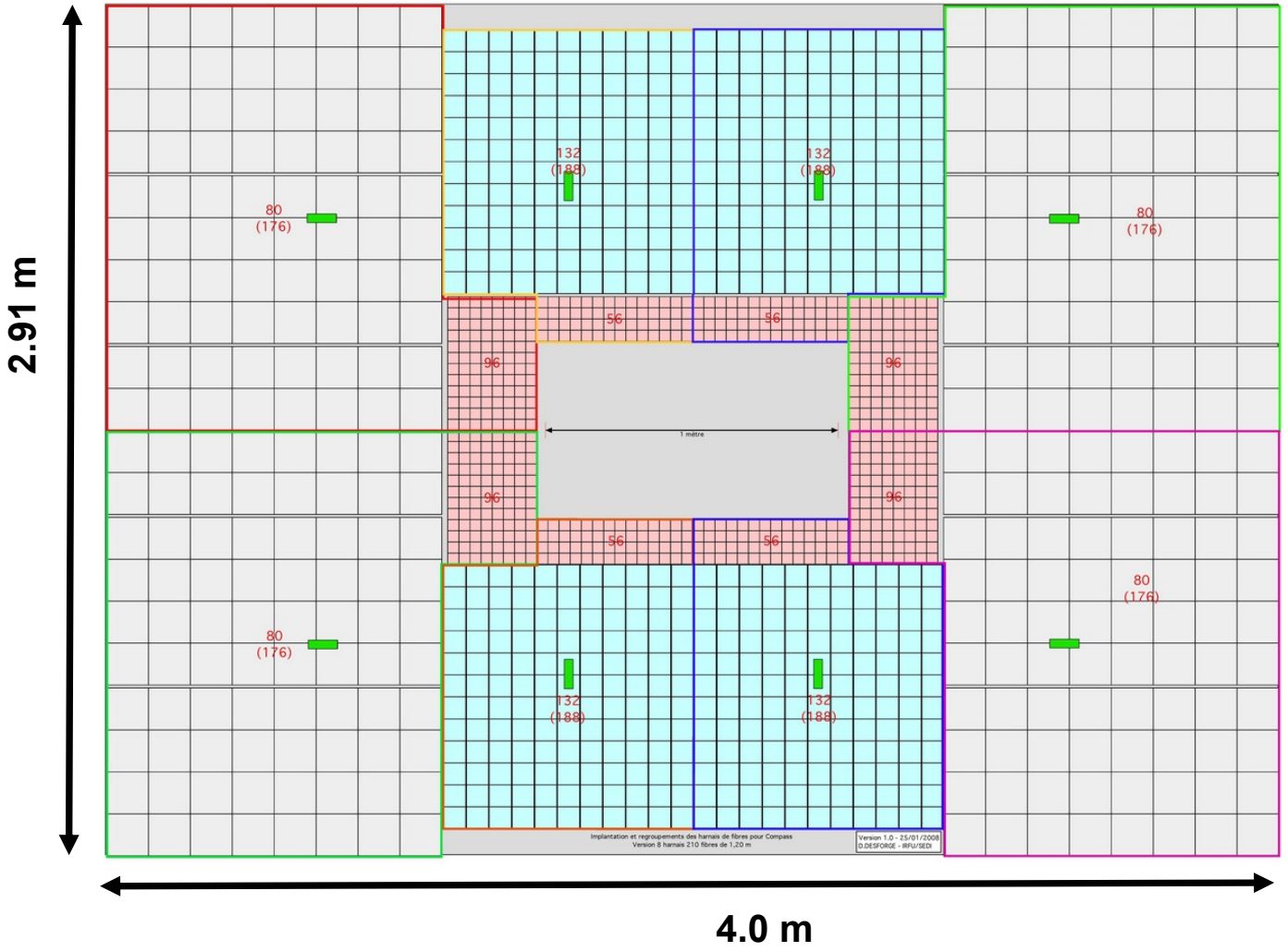


For comparison:

- **Phenix:** $6.2\%/\sqrt{E}+1.2\%$ **(at higher E:** $8.1\%/\sqrt{E}+2.1\%$**)**
- **Hermes:** $5.1\%/\sqrt{E}+1.1\%$

sampling calo's
homogene calo's

Calibration / monitoring of ECALs using muons?



- huge dimensions of ECAL1 → peripheral cells
- electr. calib time consuming, monitoring

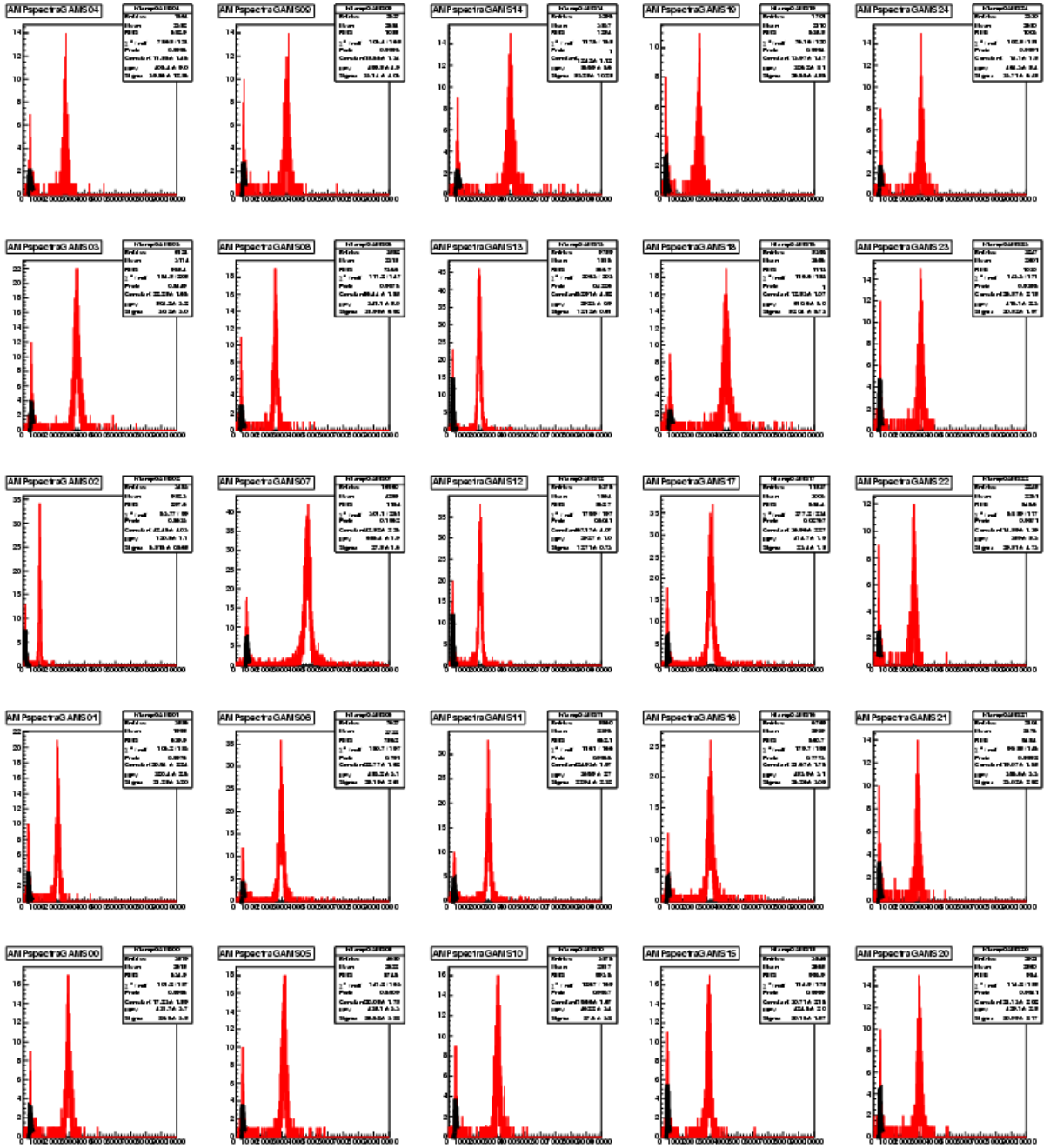
Calibration using muons – before inter-calibration

- 5 GeV, electr, μ
- beam centered in each cell

1.) intercalibration:

→ $c_i = E_{MIP} / A_i$

$E_{MIP} \approx 0.7\text{GeV}$ *(guess)*



5x5 GAMS matrix
Same ampl. range for all 25 cells

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- 5 GeV, electr, μ
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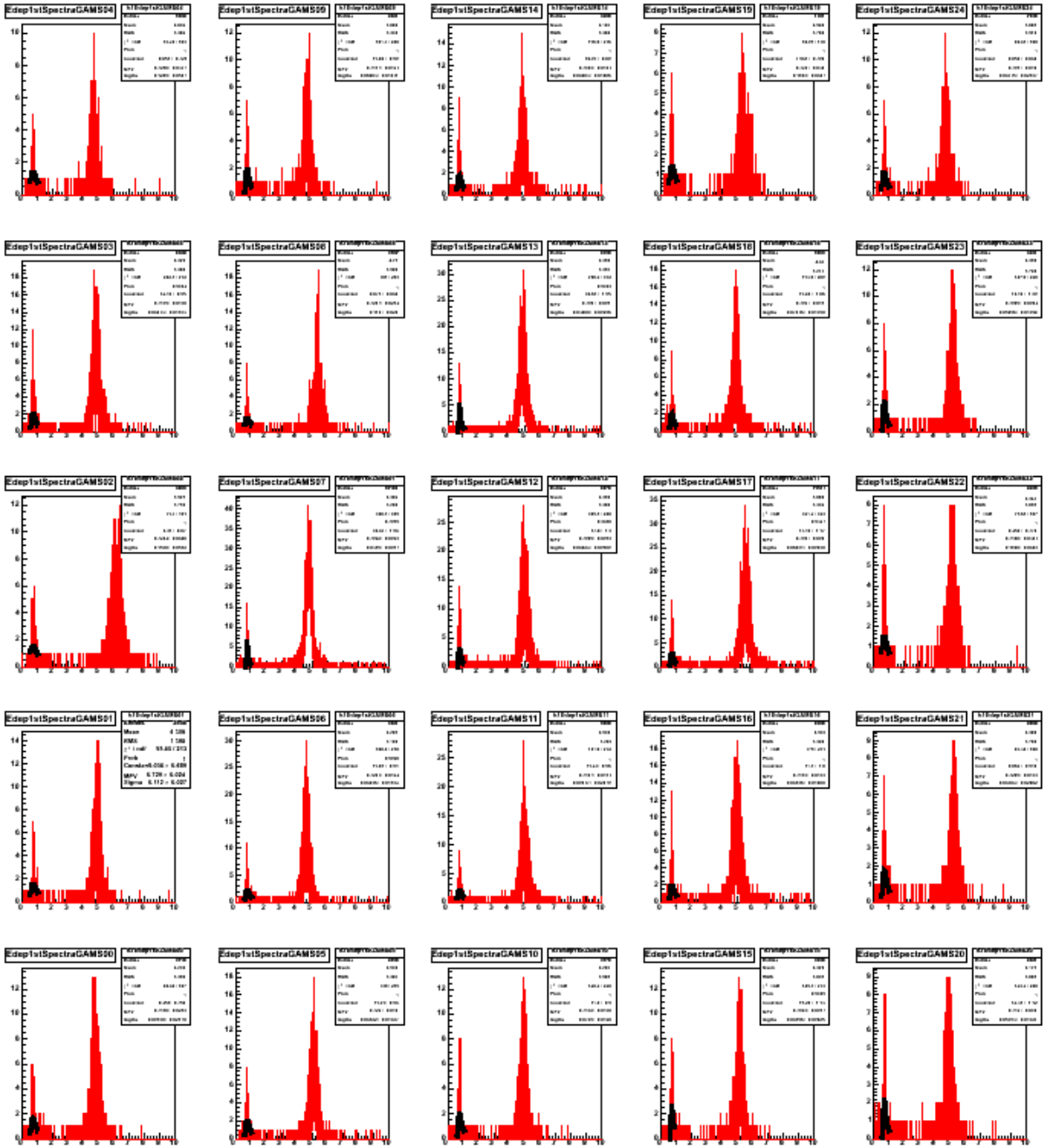
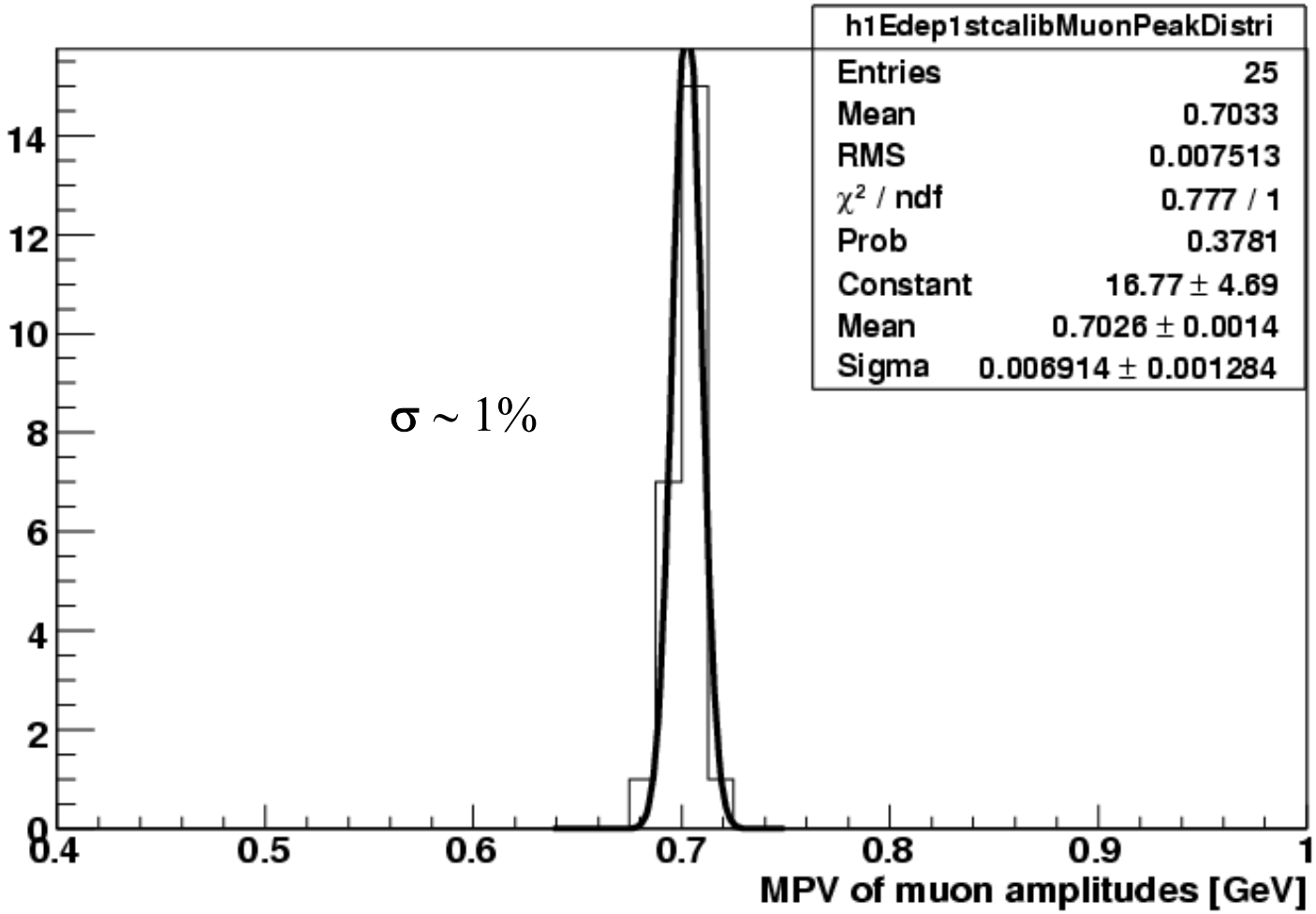


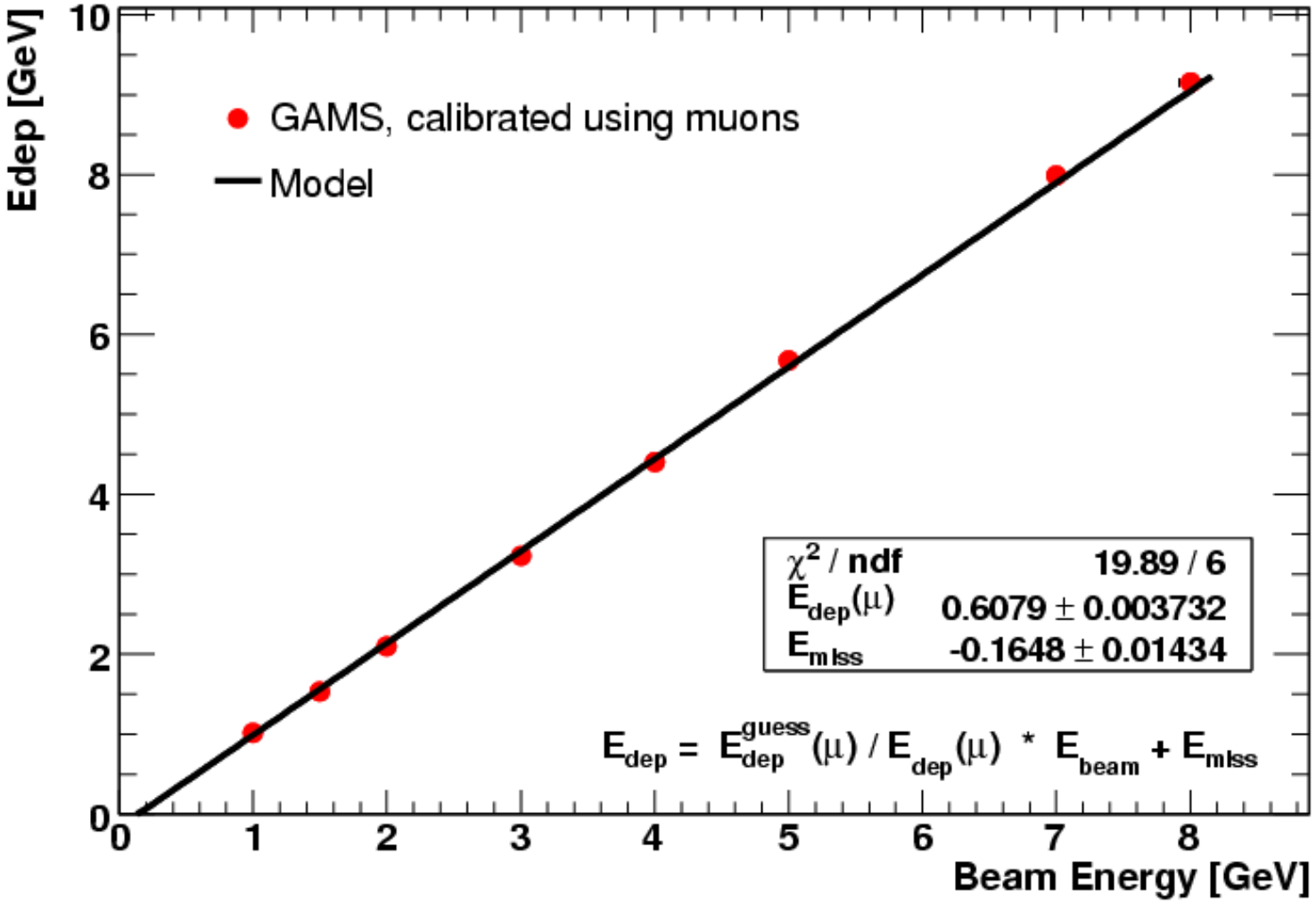
5x5 GAMS matrix
Same ampl. range for all 25 cells

Distribution of muon amplitudes A_μ

(*fitted* Edep(μ) in 25 GAMS cells, *after intercalibration)*



Description of electr. signals at different energy?
- fit of Edep(μ) & Emiss

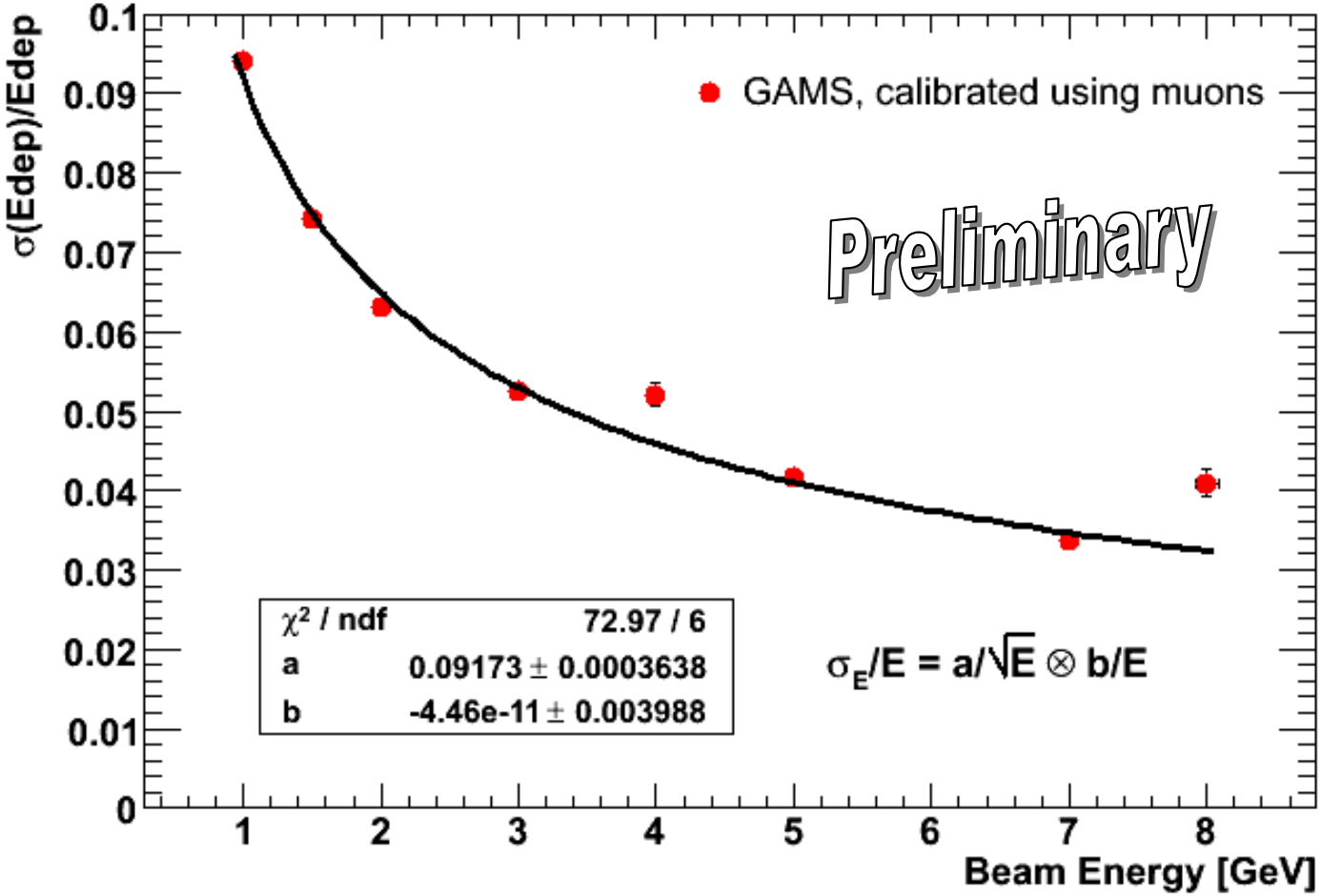


Simple fit model:

- **assumed (and shown before) → *Linearity***
- **allow for correction of guessed Edep(μ) => *indirect measurement of Edep(μ)***

=> **Edep(μ) = 0.61 GeV** (cf. indirectly measured value: 0.62 GeV, PDG: MIP=300MeV)

Resultant resolution on electr. signals (after inter-calibration using μ)



Resultant resolution:

- **inter-calibration using muons**
- **cross-calibration w electron signals**

=> ***resolution obtained by this method: ~2-3 % worse***

Work in progress

Conclusions & outlook

- **Calorimetry crucial for Hadron run 2008/09 and GPD via DVCS**

- **Test beam measurements at CERN T9** ***initiated & organised by Protvino IHEP***

- **First, preliminary T9 analysis results** (work in progress)**:**
  - **o linearity & energy resolution** (Shashlik modules, GAMS modules)
    → *performances as expected, details to be studied*
    => ***realistic input for preparation of DVCS proposal***

  - **o Calibration using muons**
    => ***inter-calibration using muons possible (~ 1%)***
    → ***cross-calibration with electron needed for proper final calibration (independence of muon and electron signals)***

Outlook:

- **Combined Ecal+Hcal reconstr.**
- **New laser monitoring system (before LEDs)**
- **Further beam tests foreseen this year** (higher energies, H2 North area, ECal0 R&D, T9)

→ **Going for excellent calorimetry as needed for COMPASS future program**