# VHMPID: ALICE Detector Upgrade in the High-$p_T$ Region

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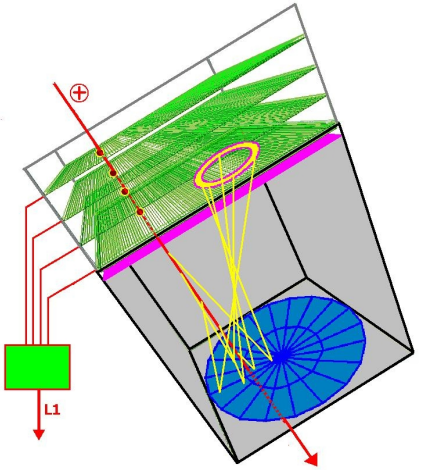
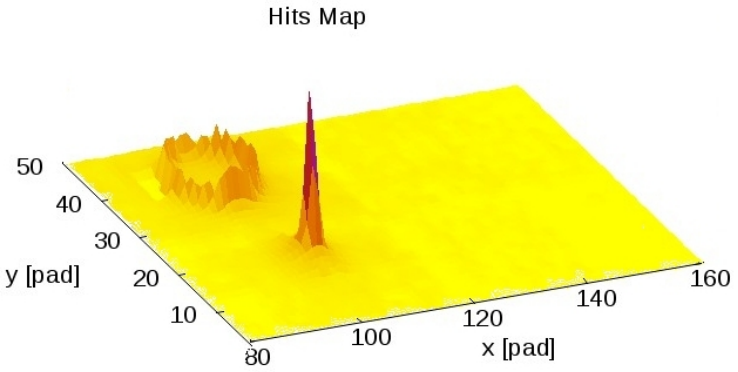
(MTA KFKI RMKI, Budapest)
on behalf of the:
**VHMPID** Collaboration
(and the **REGARD** Group)

6th International High-$p_T$ Physics Workshop, Utrecht
04-07. April 2011.

# Outline

- VHMPID
  - ALICE and PID
  - Physics motivation
  - Detector outline
- HPTD
  - Triggering and tracking
- Test Beam Measurements
  - TGEM study at PS
  - HPTD at PS
  - VHMPID at PS and SPS
- Summary



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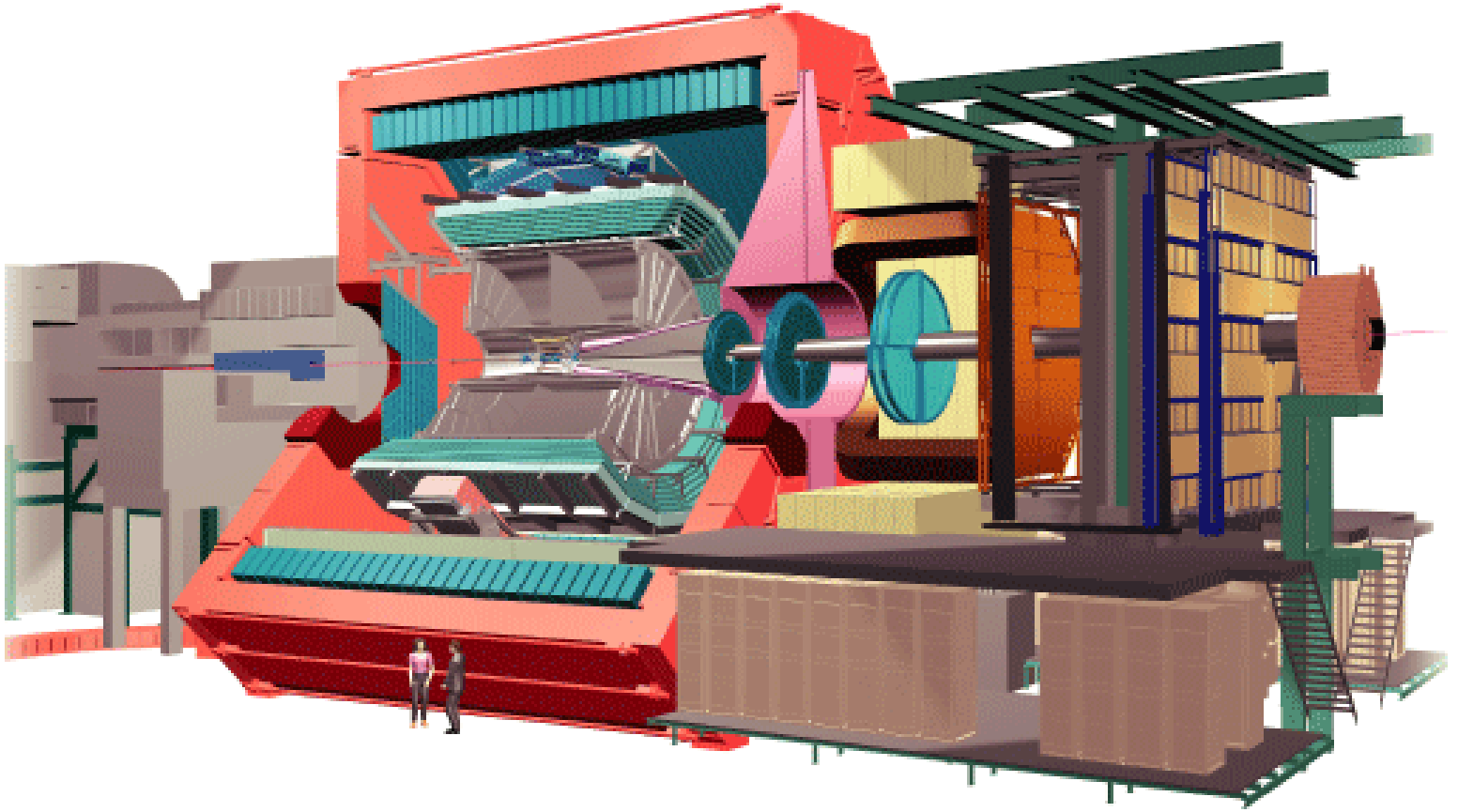
# Partice Identification at ALICE

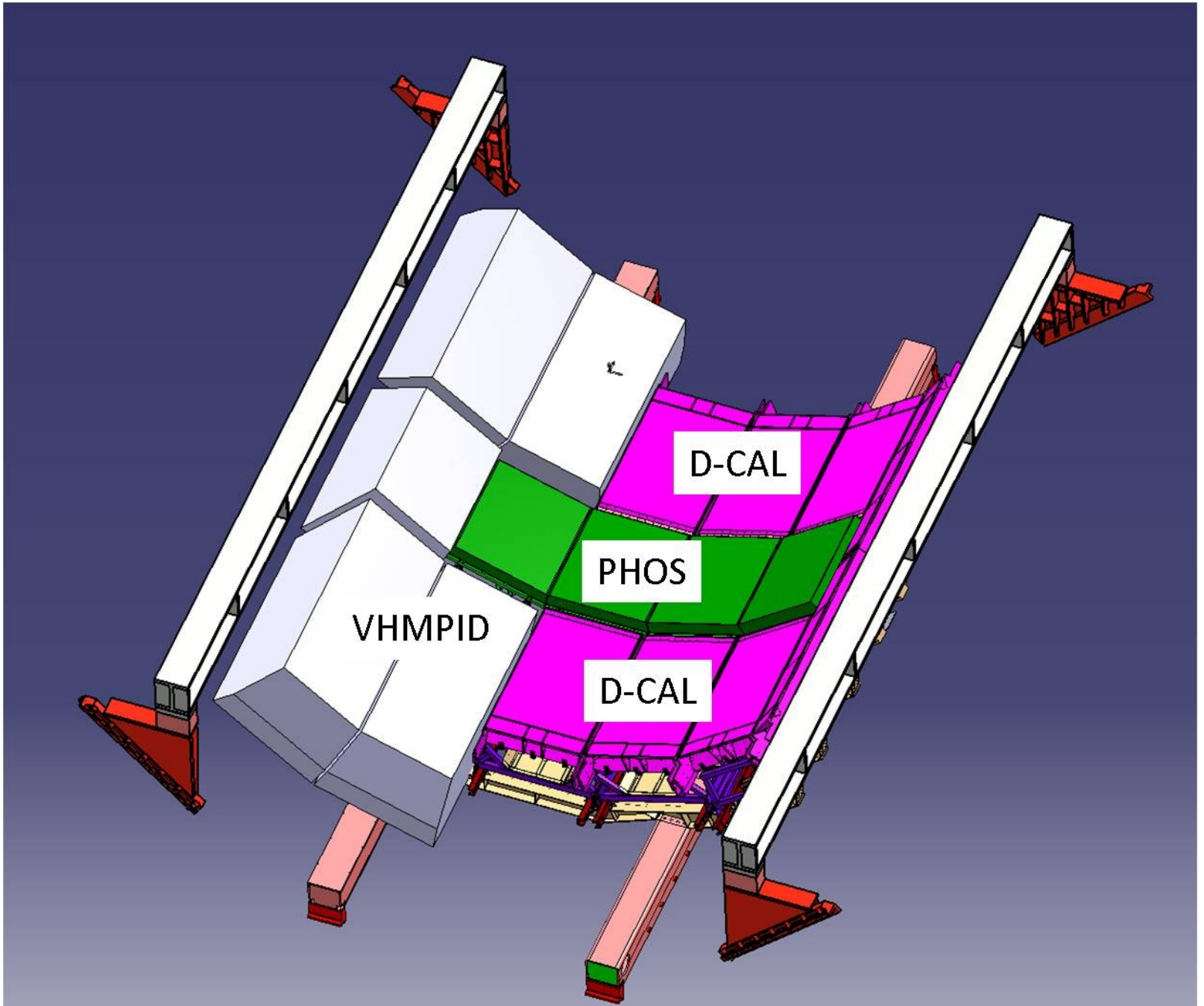


**ITS, TPC, TRD, TOF, Muon Arm,  ZDC, V0, T0,**

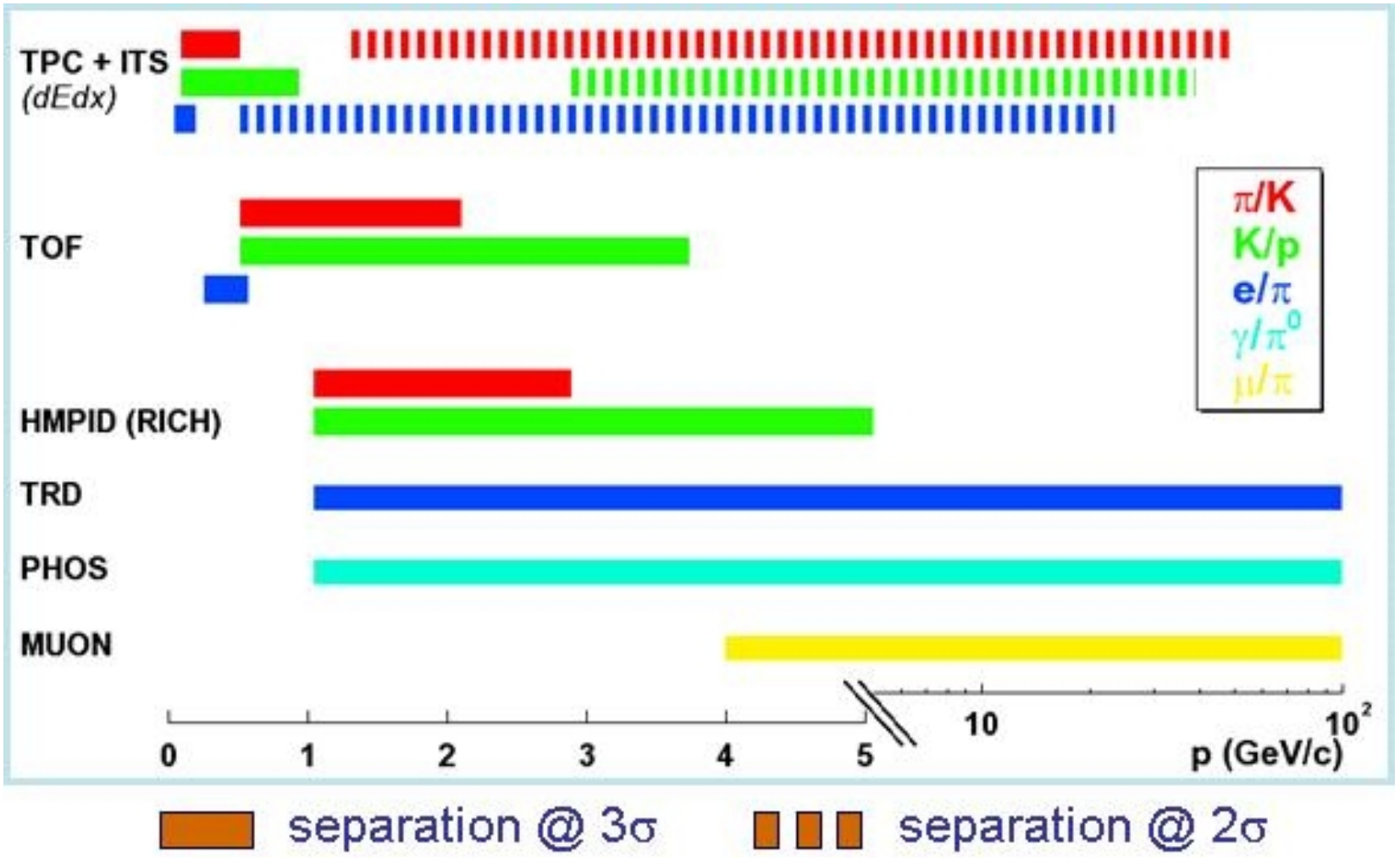
**HMPID, EMCal, PHOS,**

**Very High Momentum Particle Identification Detector**

# VHMPID inside ALICE



# PID at ALICE

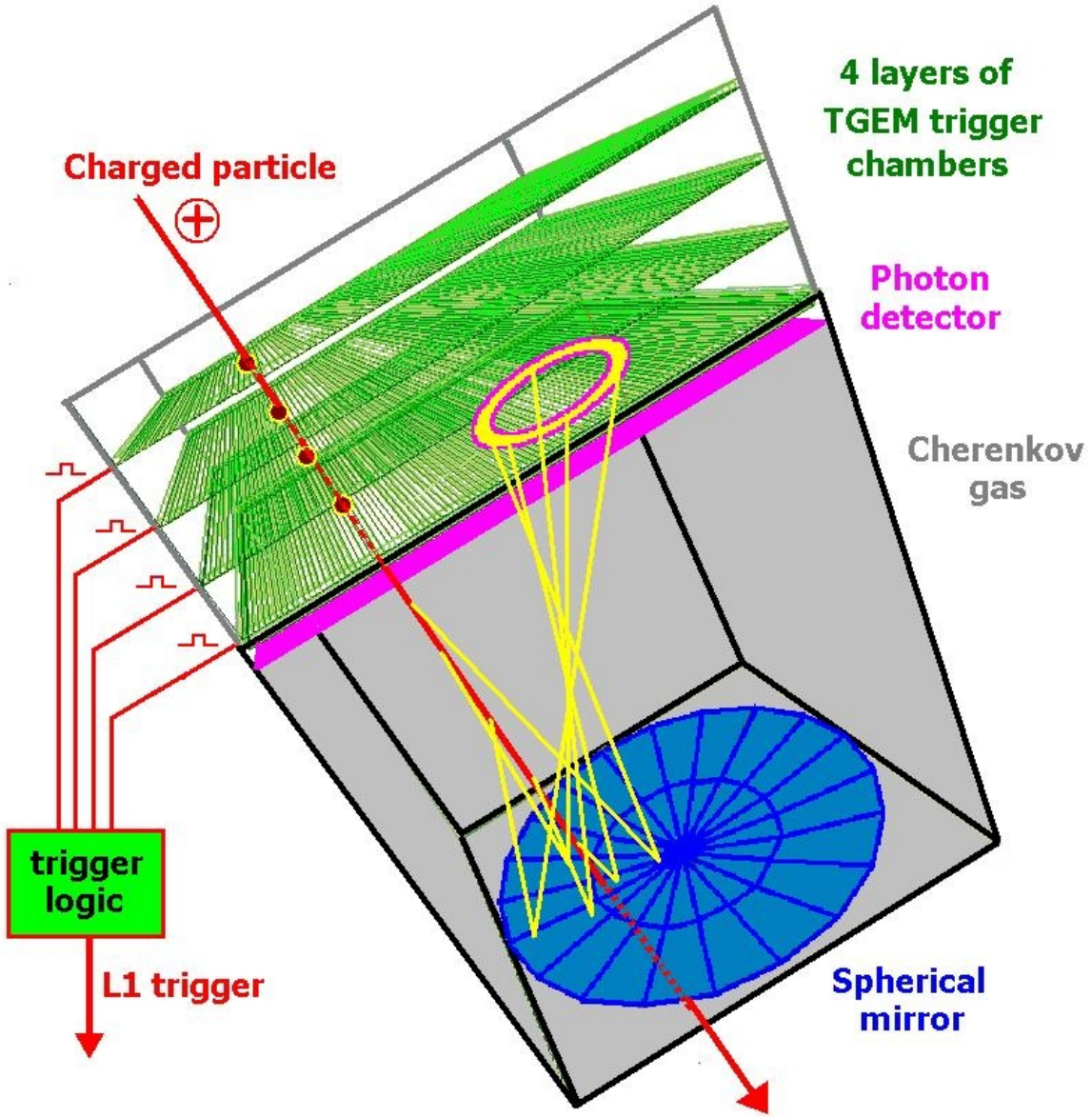



**VHMPID: $\pi$ ,K,p separation at 5 GeV/c < $p_T$ < 25 GeV/c**

# Physics Motivations for VHMPID

- **$\pi$, K, p yields at 5 GeV/c < $p_T$ < 25 GeV/c**
  - Proton/pion anomaly ( ~ RHIC)
  - Particle production mechanisms (thermal,coalescence,pQCD)
  - Modified fragmentation function in the QGP
  - Jet-energy loss, flavour dependence
  - High $p_T$ D- and B-meson and $\Lambda_c$, $\Lambda_b$-baryon reconstruction
- **Near-side hadron-hadron correlations**
  - B-M ($\pi$-p) and B-aB (p-p) correlation ( ~ RHIC)
  - Di- and Multihadron FF ( $D_{BM}$ =?= $D_B$*$D_M$ ; $D_B$*$D_{aB}$ ... )
- **Cooperation with other special detectors at ALICE**
  - Near-side $\gamma$-hadron correlations : PHOS
  - Away-side jet-photon correalations : EMCAL
  - Away-side jet-jet correalations : HMPID

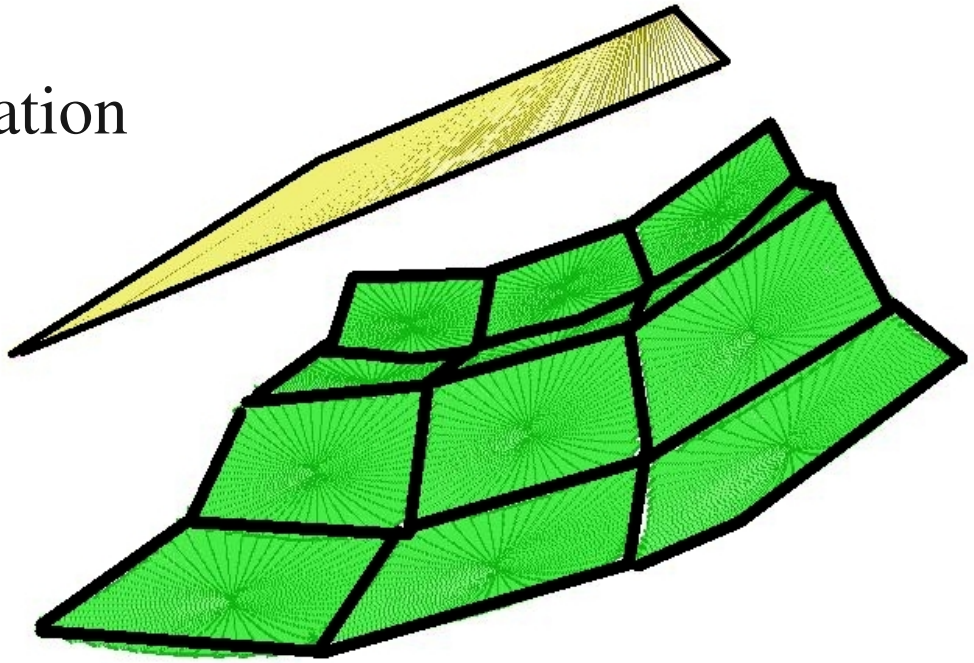
# Schematic View of the VHMPID




- Event by event PID in the region: $5\ \text{GeV/c} < p_T < 25\ \text{GeV/c}$
- Cherenkov radiation: only gas can be used: $C_4F_{10}$ Radiator length: ~ 80 cm
- Mirror generates circles
- Photon detection: CsI coated MWPC (+HMPID FEE)
- Need for triggering!
- Free space in ALICE: ~ 12% of TPC acceptance opposite side to HMPID

# R&D and Design

- **Photon detector:**
  - CsI-MWPC / CsI-TGEM / PTC options
  - Window material ($SiO_2$/$CaF_2$)
  - Window electrode implementation
  - Granularity (pixel size and associated FEE)
- **Mirror:**
  - Substrate technology (glass vs composite C-fiber)
  - Segmentation and orientation
  - Alignment procedure and monitoring
- **HPTD**
  - Geometry and number of layers (L0, L1, tracking)



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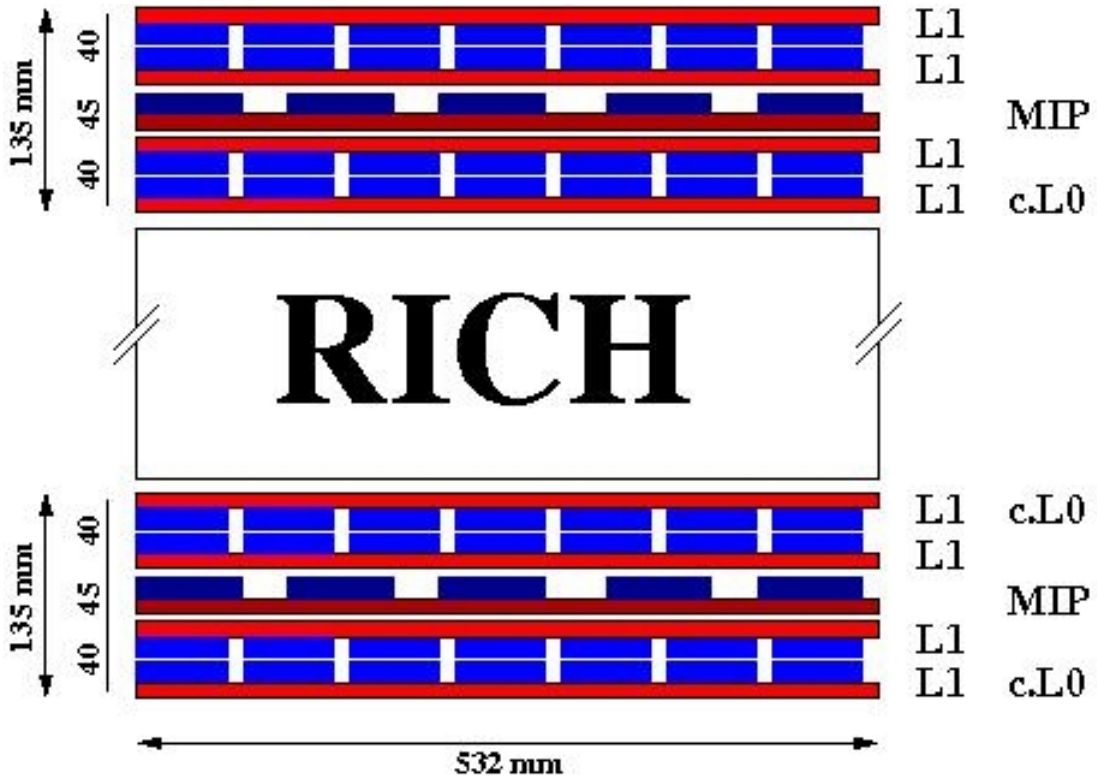
# High-$P_T$ Trigger Detector

- **L1 trigger** at PbPb collisions with $p_T$>10 GeV/c threshold
  (see: L.Boldizsár's talk)
  gains a factor **40** at high $p_T$ data!
- **L0 trigger** at pp collisions with $p_T$>5 GeV/c threshold
- **Tracking** before and after the RICH module
- **CCC technology**:
  low material budget,
  good resolution,
  digital readout,
  fast for triggering,
  cheap!
  (REGARD Bp group, submitted to NIMA)



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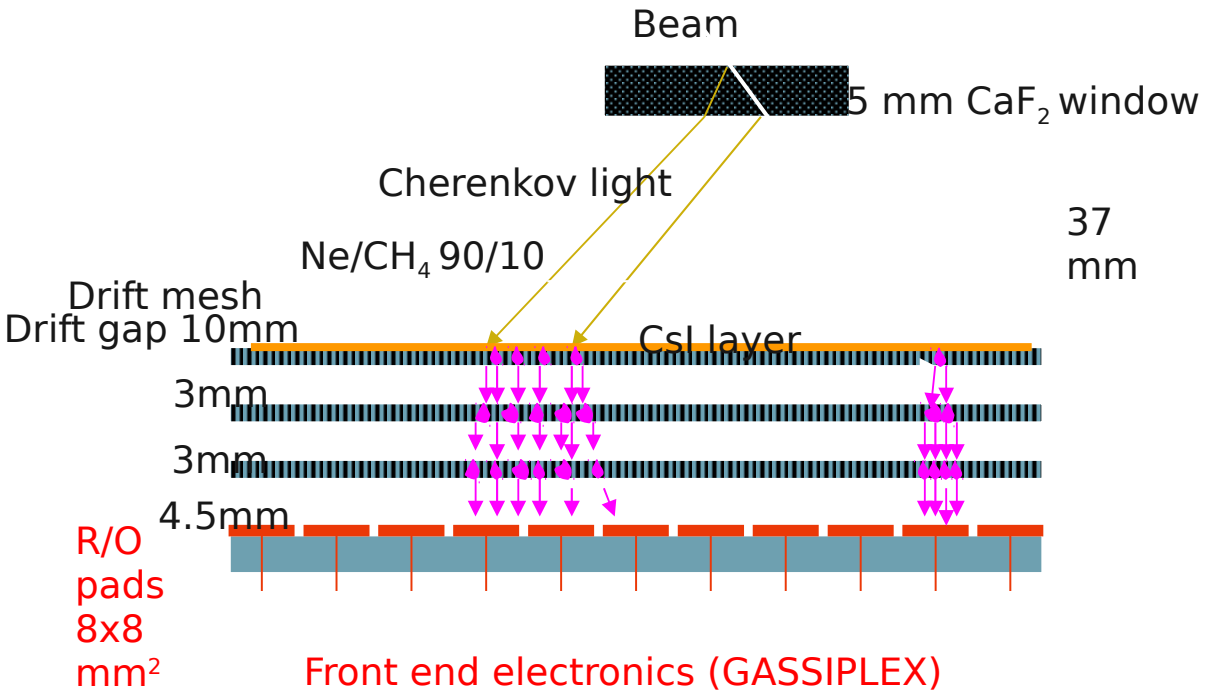
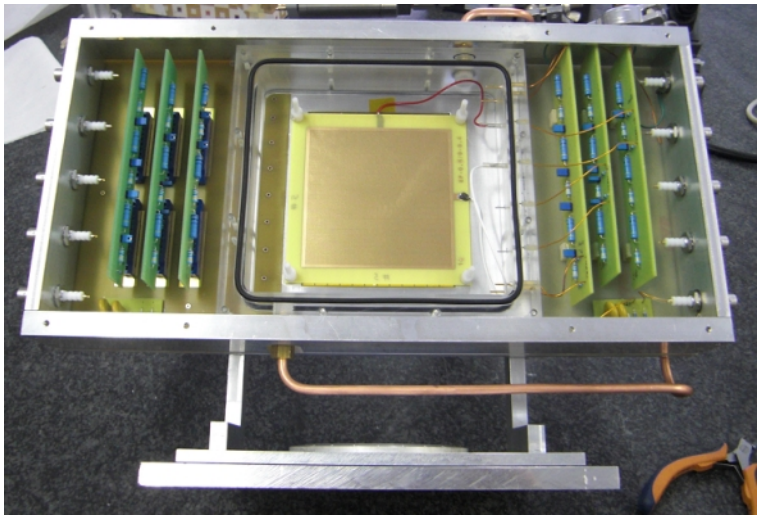
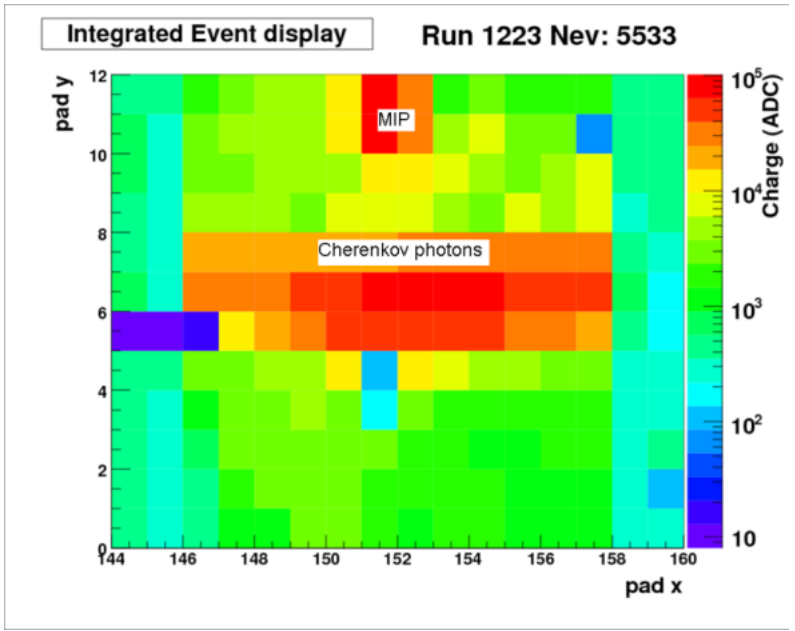
# TGEM Photo Detector Study






- CsI coated triple TGEM chamber
- Solid radiator ($CaF_2$ window)
- Standard HMPID FEE (Glassiplex)
- Beam test at CERN PS
- First time that Cherenkov light have been seen with TGEM based detector!

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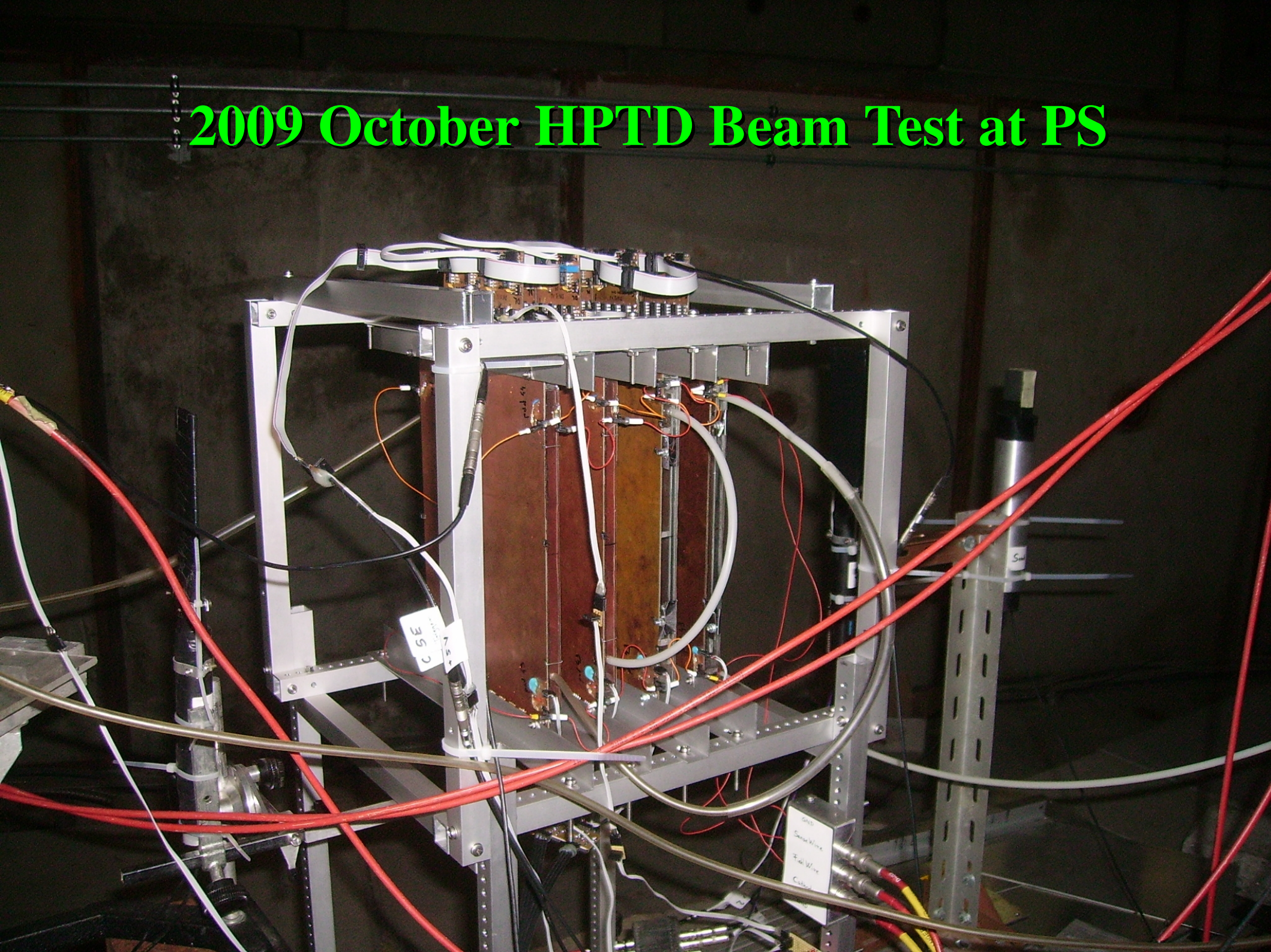
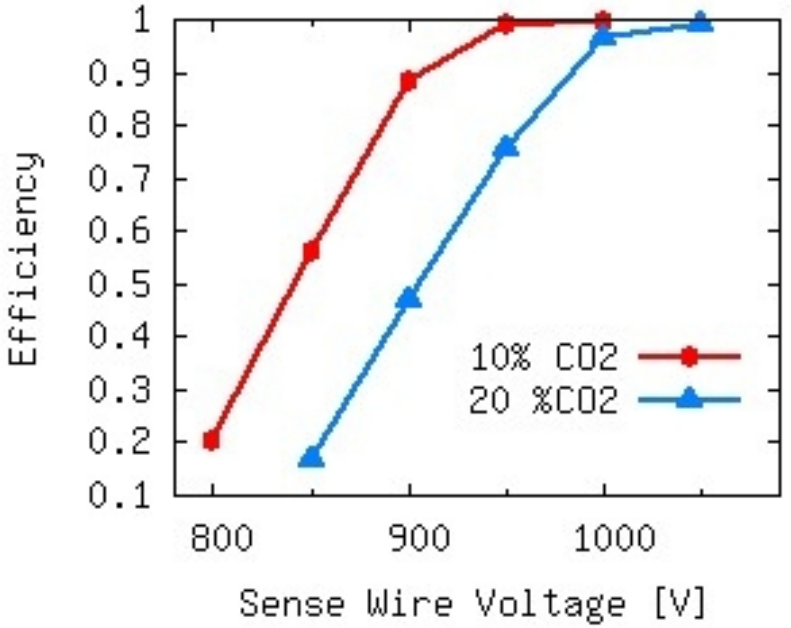
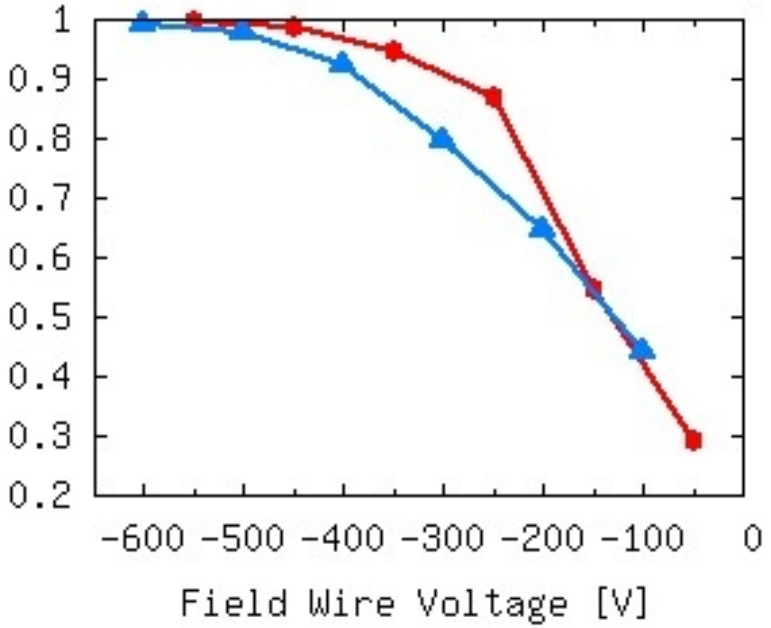
# 2009 October HPTD Beam Test at PS

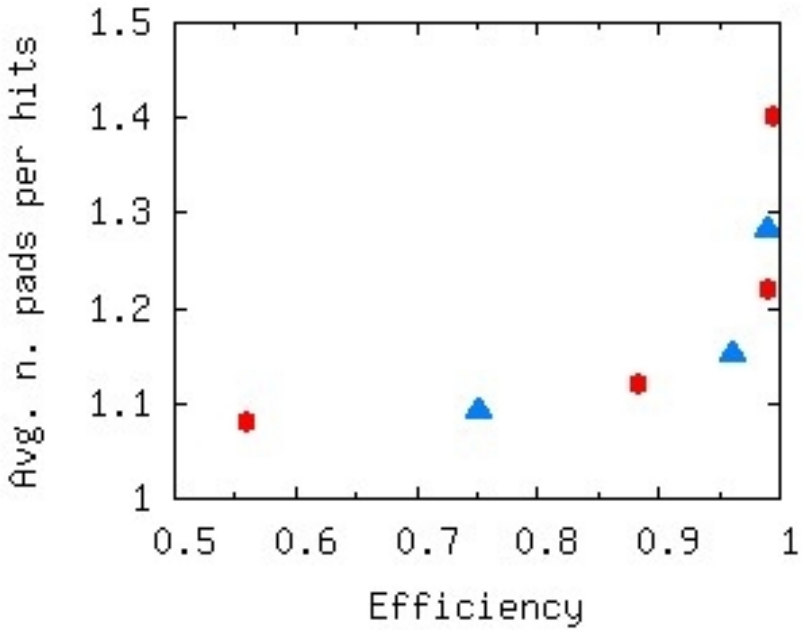


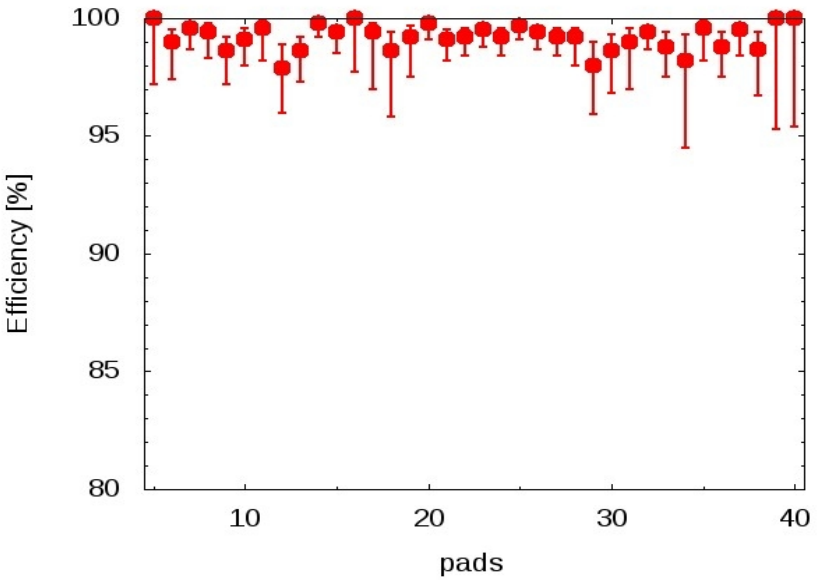
# 2010 August HPTD Beam Test at PS

# Efficiency

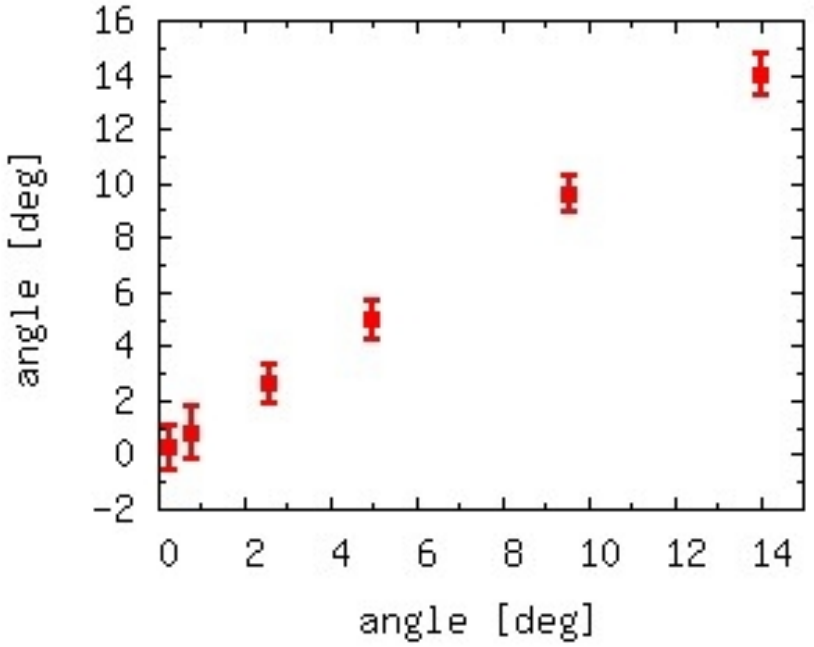

Efficiency
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
800
900
1000
Sense Wire Voltage [V]
10% CO2
20 %CO2

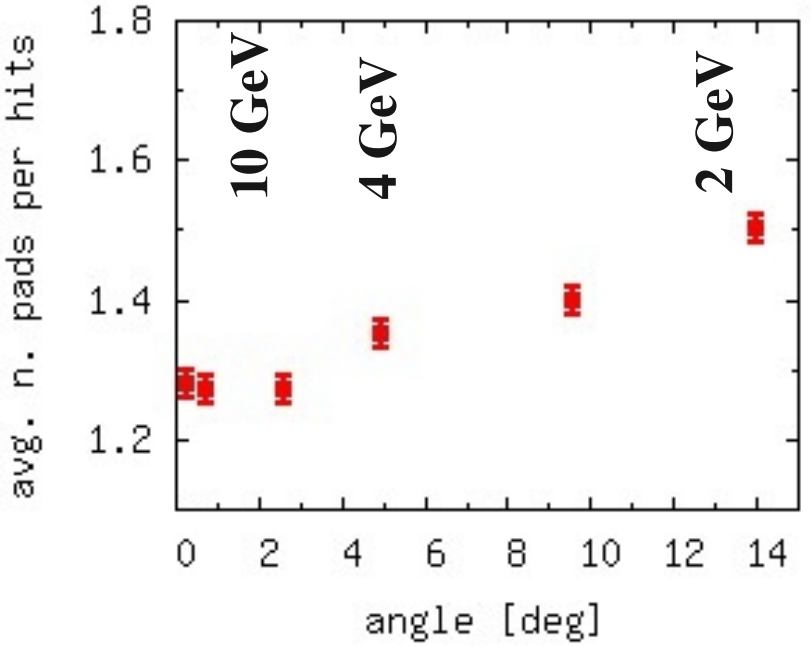

1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
-600 -500 -400 -300 -200 -100 0
Field Wire Voltage [V]

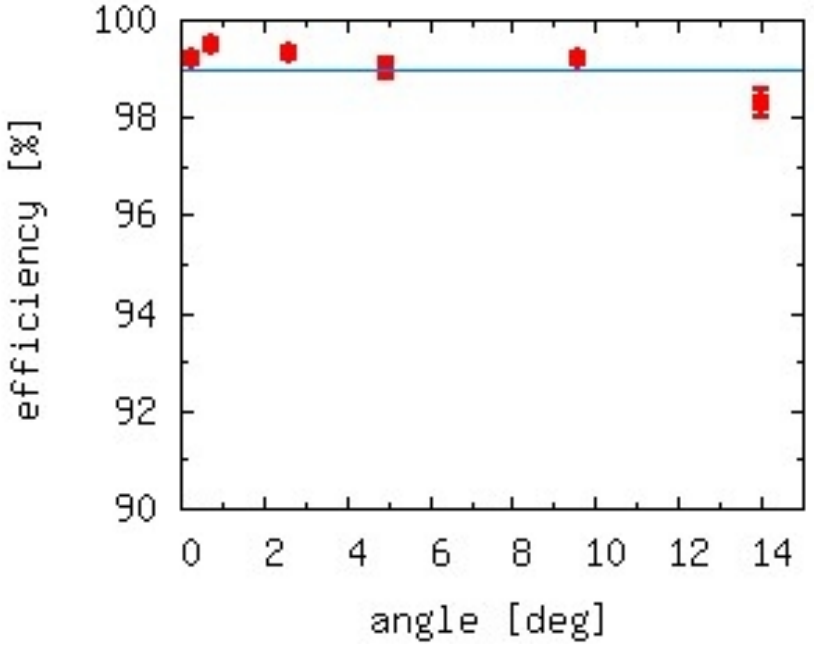

Avg. n. pads per hits
1.5
1.4
1.3
1.2
1.1
1
0.5 0.6 0.7 0.8 0.9 1
Efficiency


Efficiency [%]
100
95
90
85
80
10 20 30 40
pads

# Dependencies on Angle of Incidence



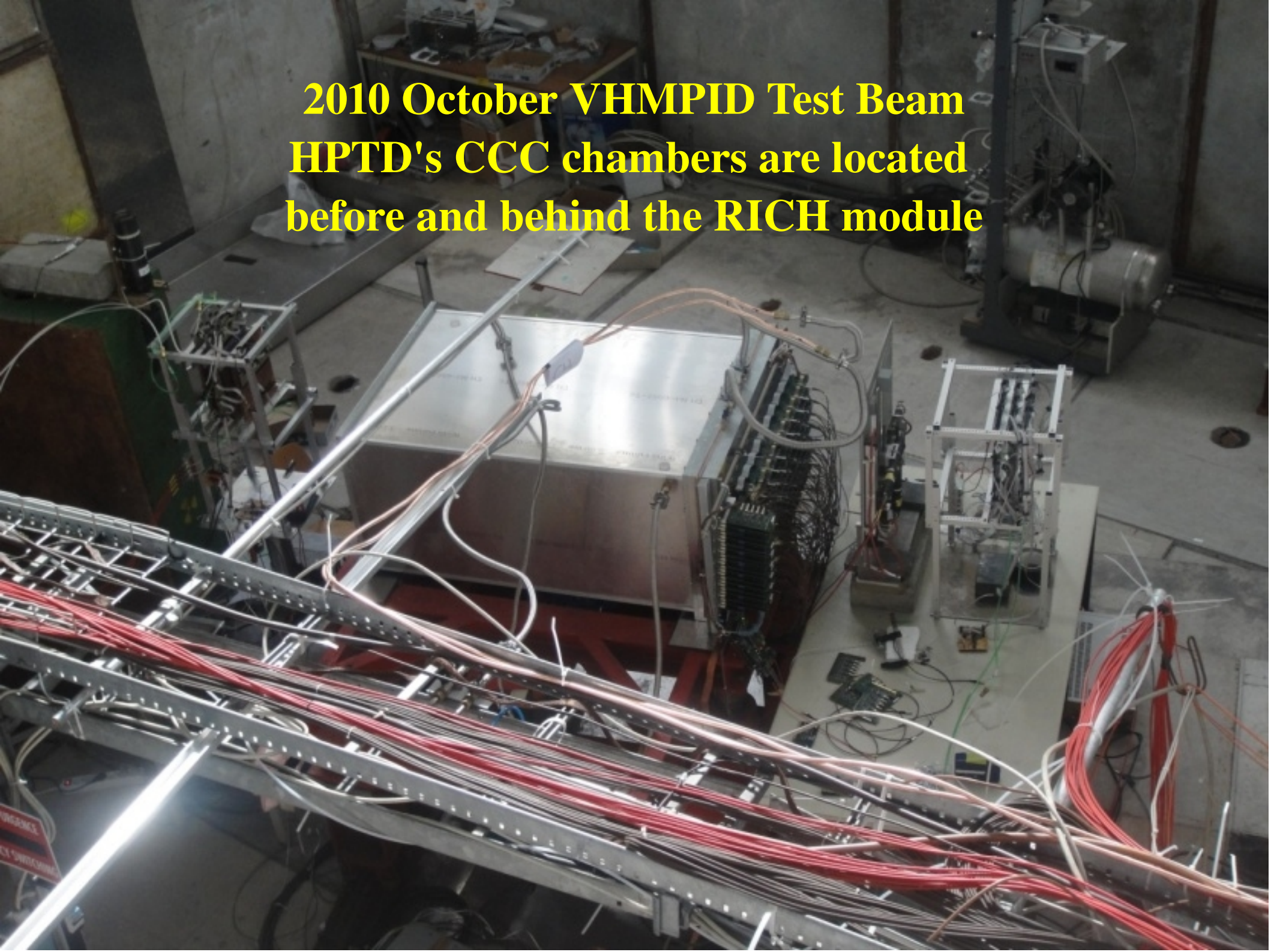




- Angular resolution: ~1.4 deg
  remains the same up to 15 deg
- Efficiency is still above 99%
  (up to 10 deg)
- Average number of hits :
  slightly increases 1.1 -> 1.5
  (feature of the CCC design)

# HPTD Test: Main Results

- 7 layers of CCC:
  - Efficiency above 98-99%
  - Spatial and angular resolution are as desired
  - Two dimensional CCC's are good candidates for MIP detection for VHMPID
- New readout electronics : ok
- 50 cm x 50 cm CCC
  - Works reliably
  - Dead zone of spacers : ~ 4 mm (~ 2 % loss)
  - Technology is expandable to large surfaces
- FPGA:
  - Readout : ok
  - Trigger pattern recognition : ok
  - Operation speed still to be increased


2010 October VHMPID Test Beam
HPTD's CCC chambers are located
before and behind the RICH module

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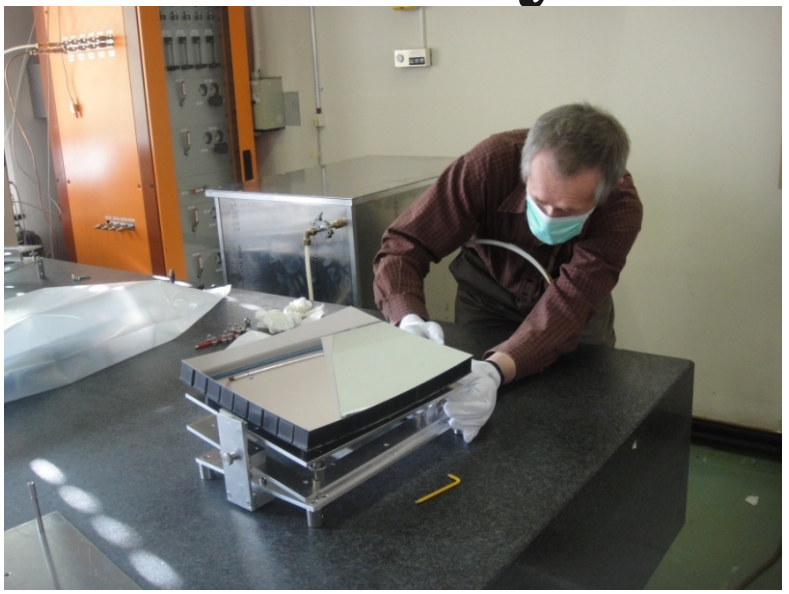
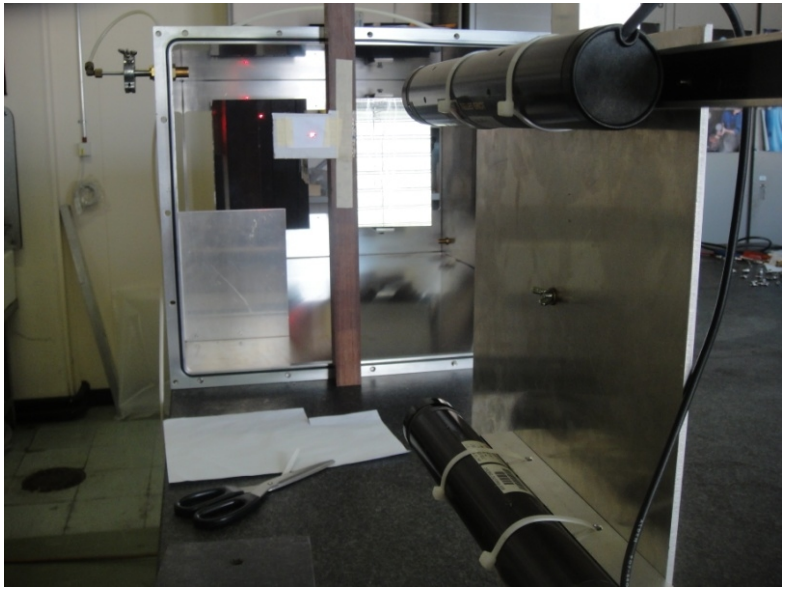
# VHMPID Prototype

- Two spherical mirrors
- Radiator length:
  100 cm / 80 cm
- Mirror orientation:
  straight / tilted
- Cathode: on windows:
  Strip / Mesh
- HMPID FEE
- Detector: CsI + MWPC

# Assemby of VHMPID Proto-3



Mirror fixation

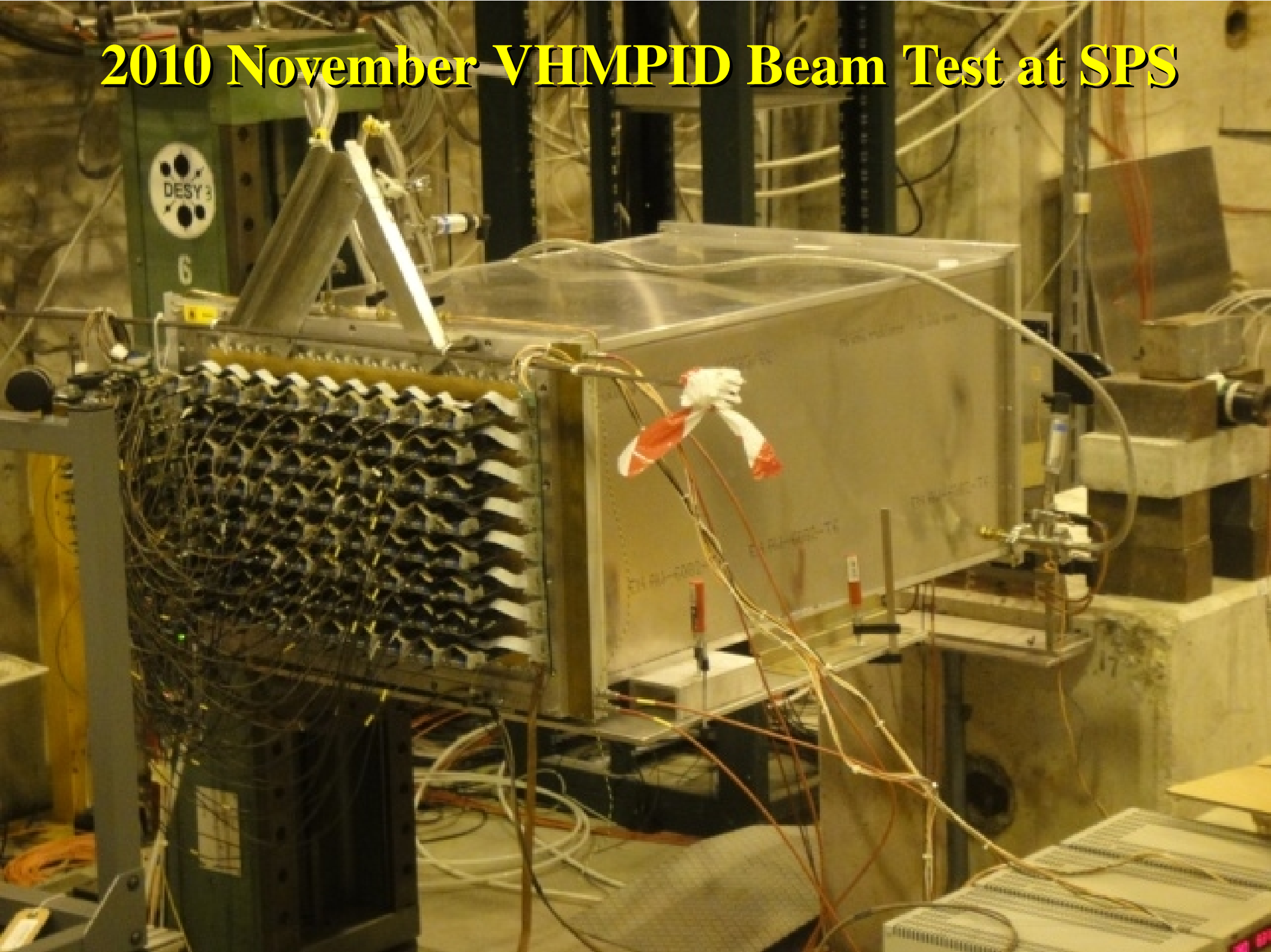


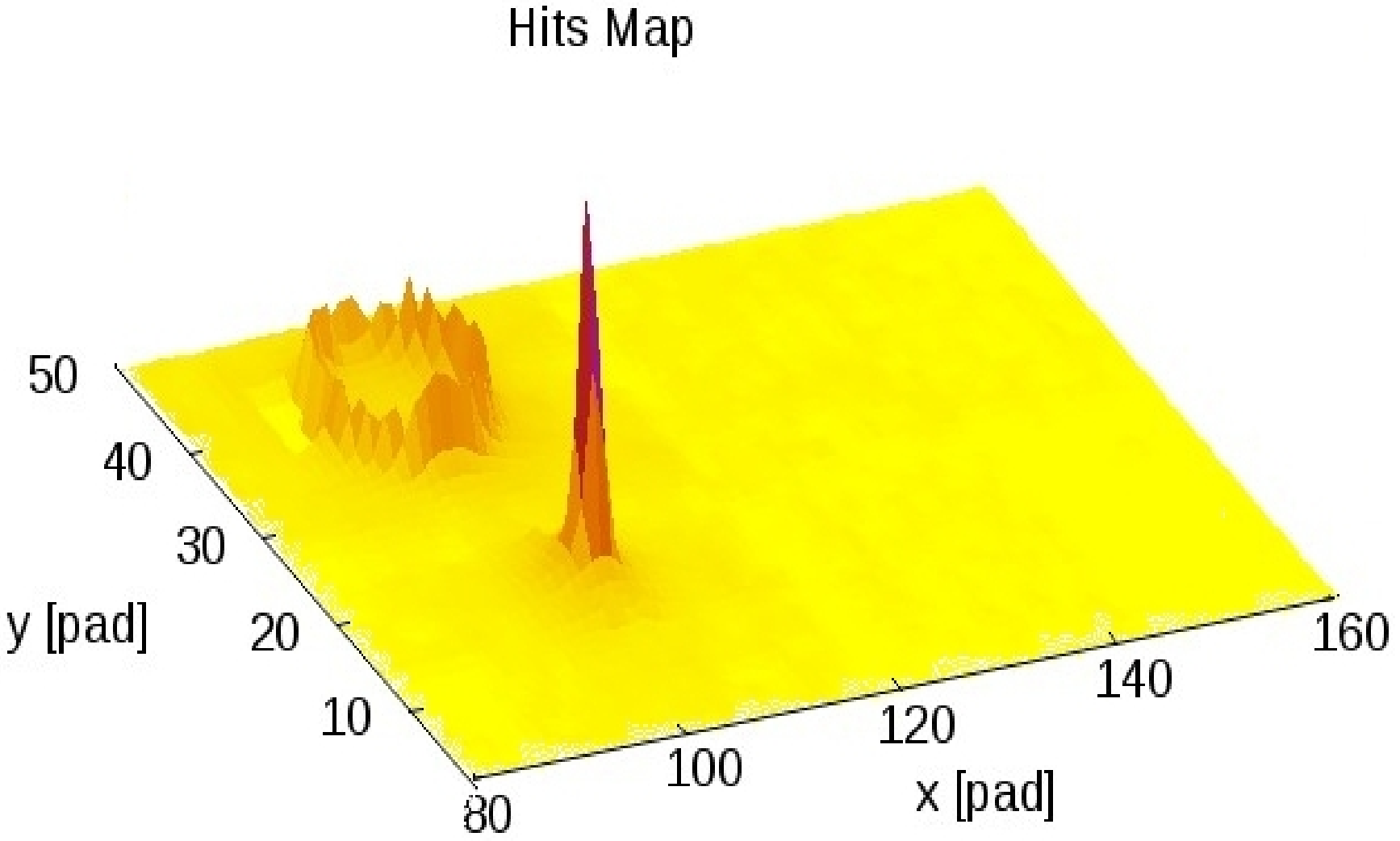
Mirror adjustment

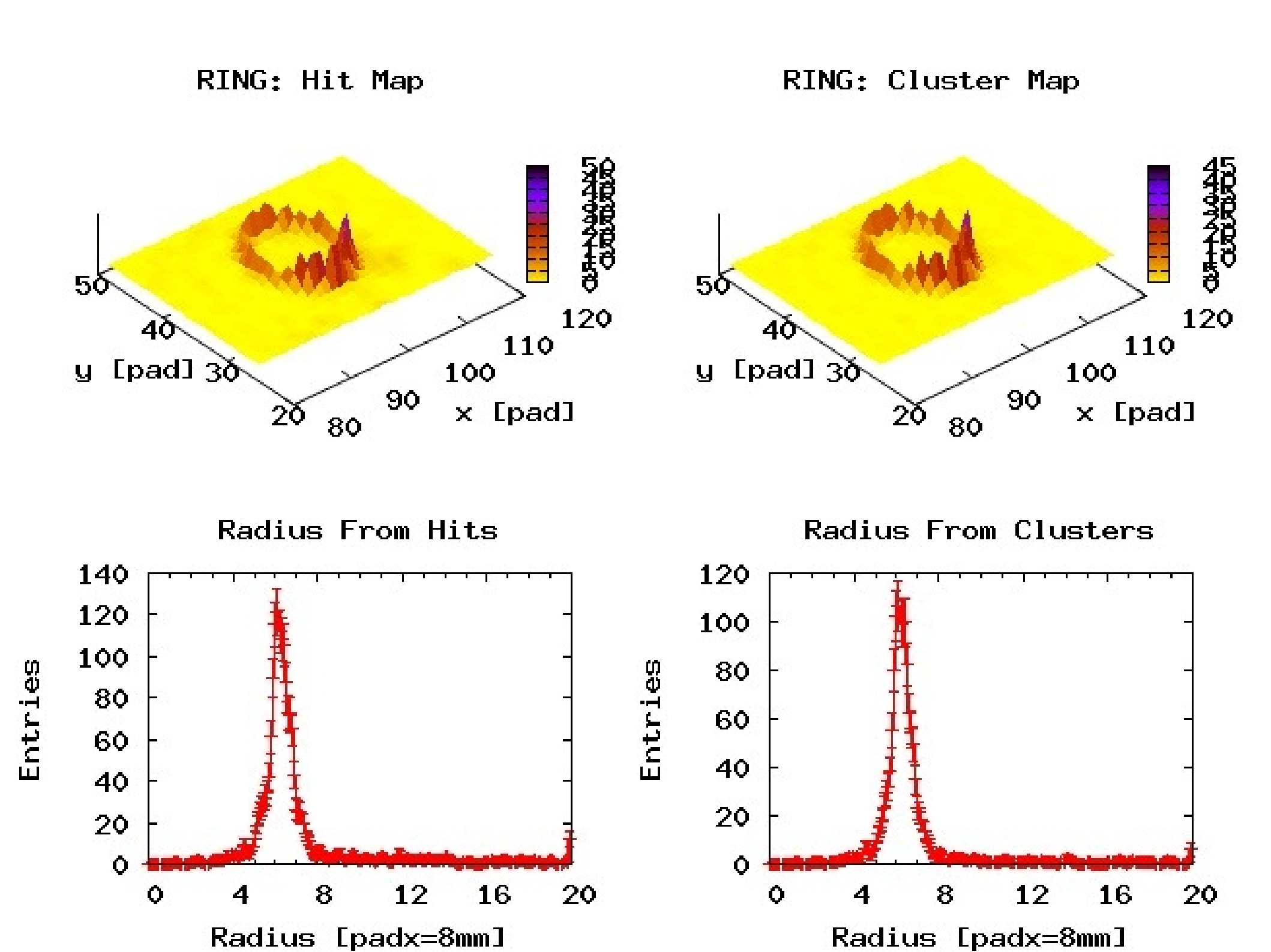
Radiator vessel ready

Fixation of Proto-3

# 2010 November VHMPID Beam Test at SPS

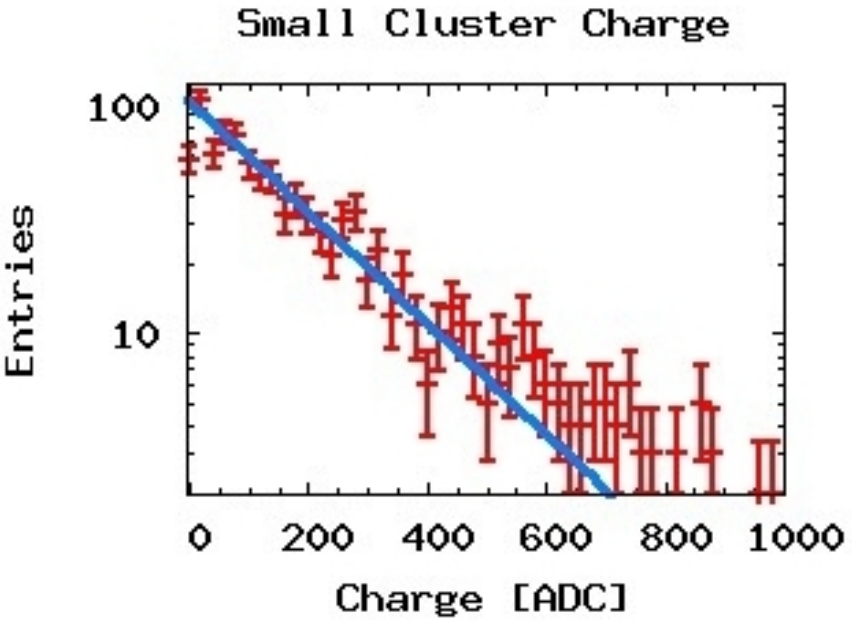


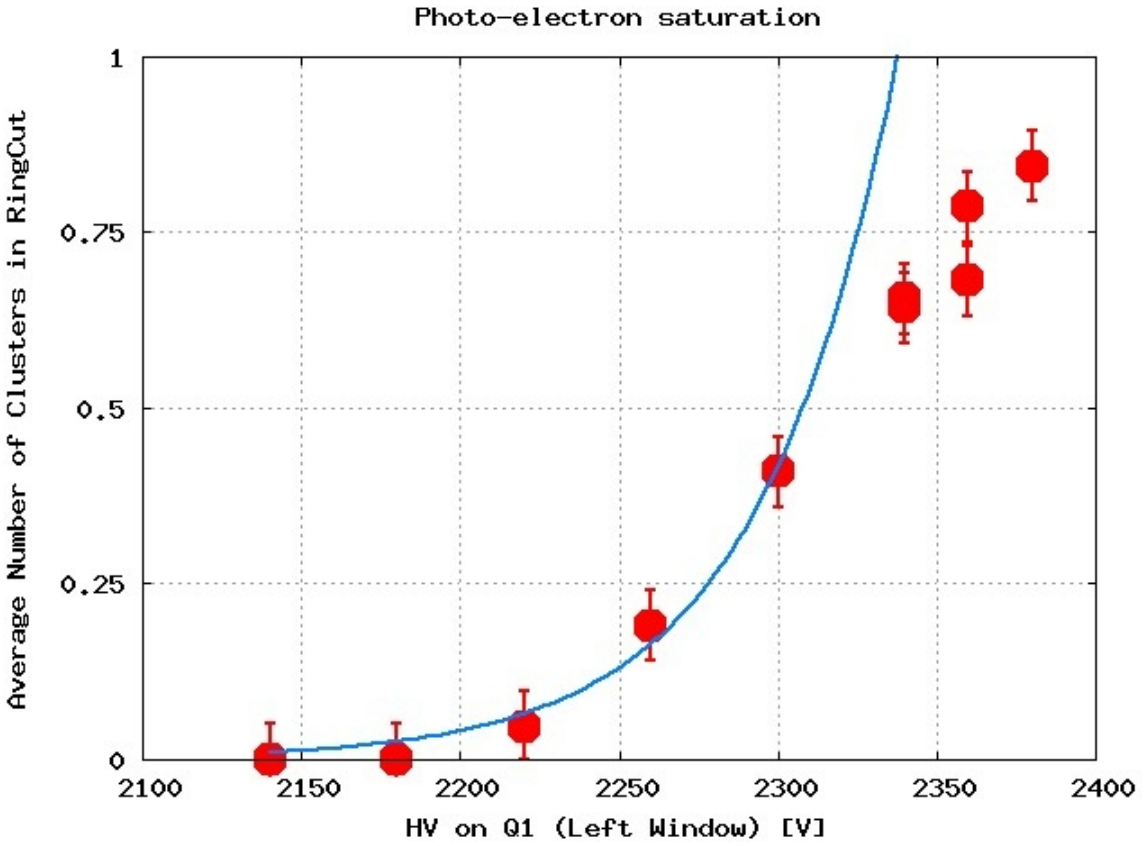

Hits Map
50
40
30
20
10
y [pad]
80
100
120
140
160
x [pad]


RING: Hit Map
y [pad]
x [pad]
RING: Cluster Map
y [pad]
x [pad]
Radius From Hits
Entries
Radius [padx=8mm]
Radius From Clusters
Entries
Radius [padx=8mm]

# Photon Studies

HV defaults set with MIPs
Photo-electron detection
capability have been studied
Nice photo-electron charge distribution




The saturation has been reached (at 2360 V)
Not enough detected photo-electrons! :(

# Gas Purity

Really sensitive to gas purity:

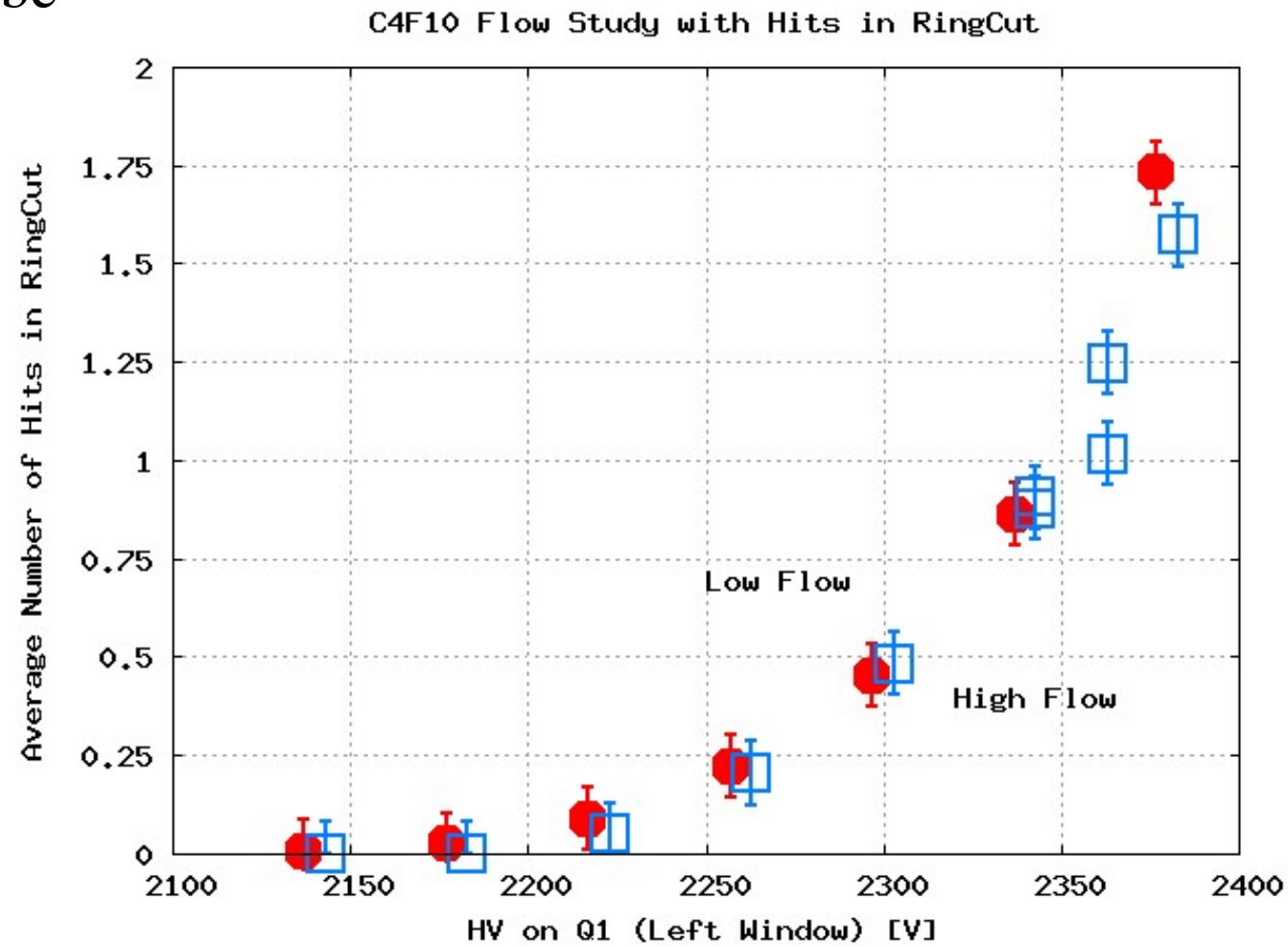
$O_2$ and $H_2O$ level should be around 5-10 ppm!

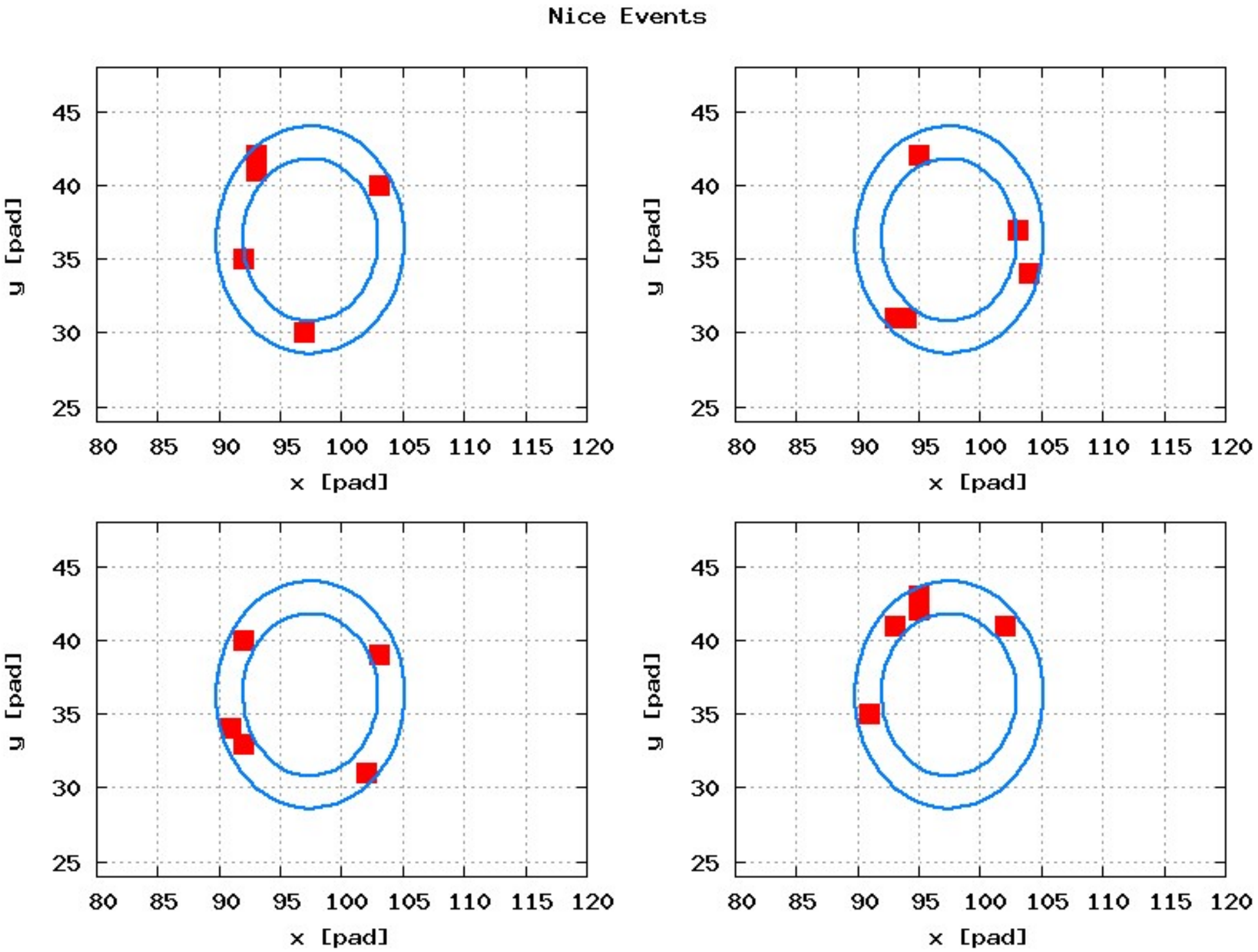
Gas precleaning is necessery

Outgasing became important

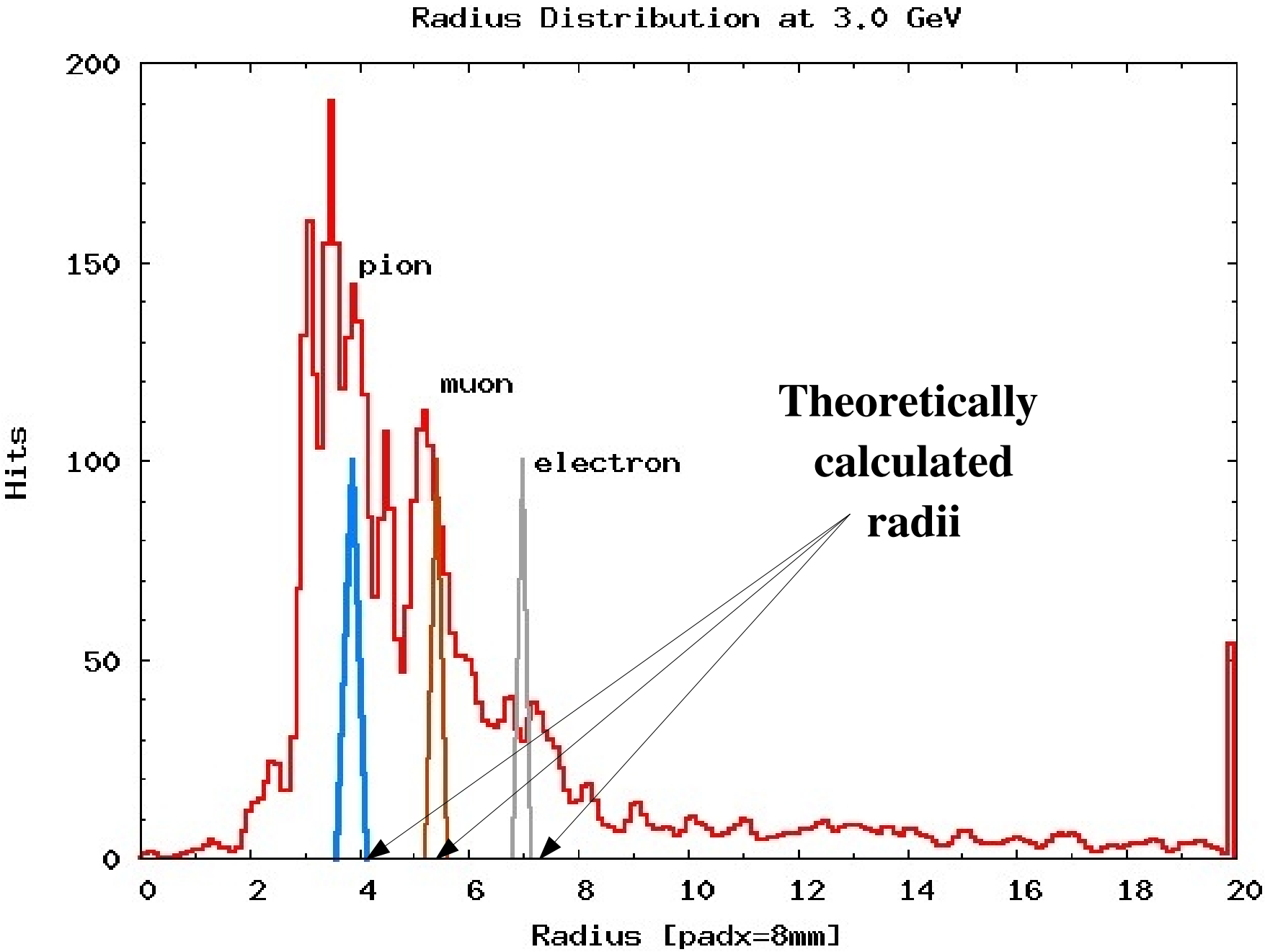
Transparency meter is under construction

Flow dependence could be measured



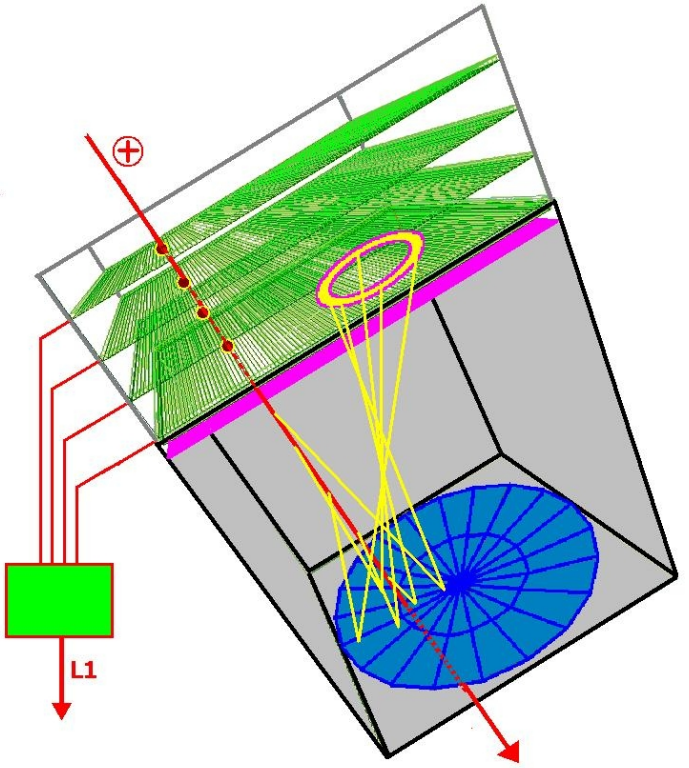

Nice Events
y [pad]
x [pad]
25
30
35
40
45
80
85
90
95
100
105
110
115
120

# Multi-ring at 3.0 GeV



# Summary

- **PID extension of ALICE in the high pT region:**
- **VHMPID: track by track PID in the 5-25 GeV/c region**
- **Gaseous Cherenkov detector**
- **State-of-the-art technology**
- **Still uder R&D**
- **Test beam sresults are promising**
- **HPTD : Triggering and tracking for VHMPID**
  **pp:L0, PbPb: L1, Tracking**

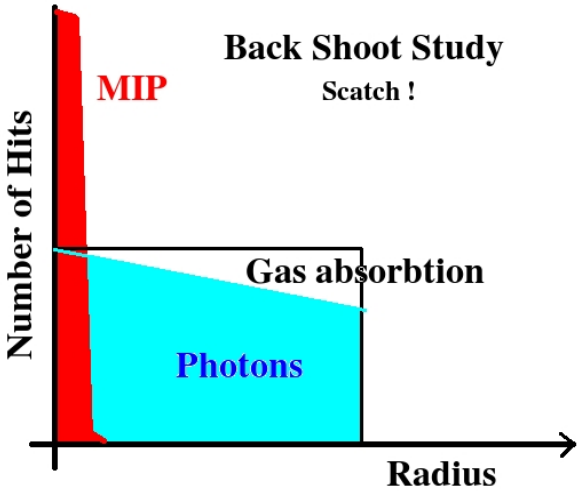


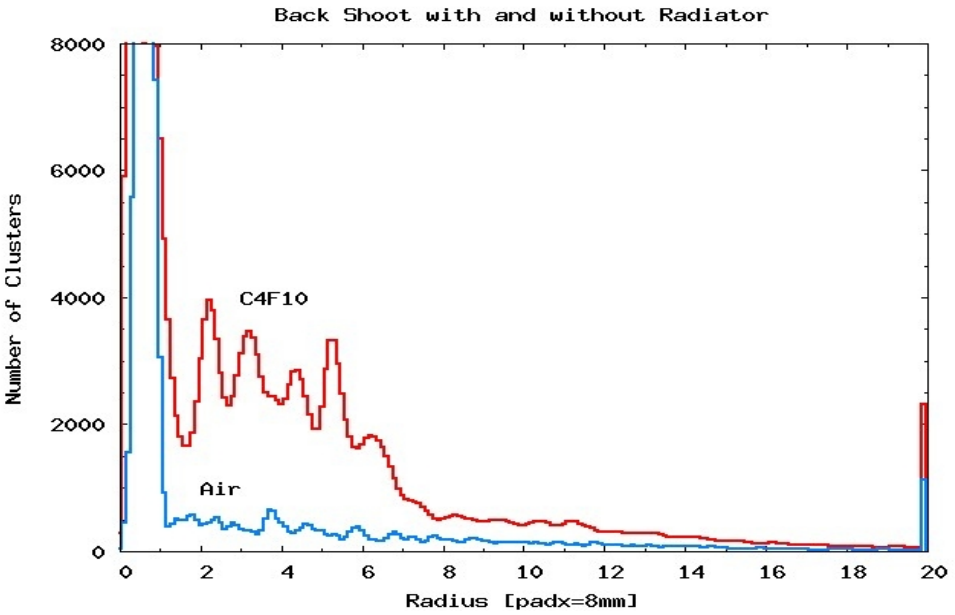
# Backup slides

- Mirror study – VHMPID test 2010SPS
- CCC – schematic and analog signals
- HPTD digital readout – example
- VHMPID signal simulation
- HPTD – idea: angle of incidence vs pT

# Mirror studies

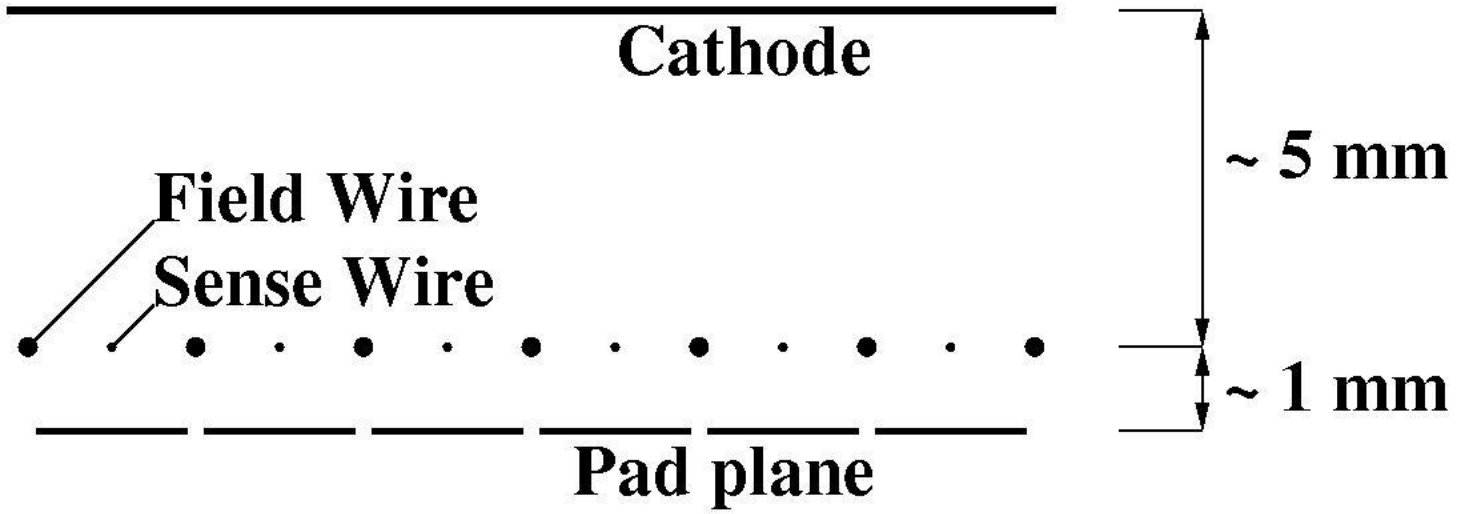
- Reflectivity measured
  before tests
- Focusing: ok
- Tilted vs straight mirror
  both were ok
- Track position vs ring position:
  movement < 1mm
- “Back shoot study”:
  still 1-2 detected
  photons / event



# Close Cathode Chamber

**Development of the REGARD Collaboration**
**(Rmki-Elte Gaseous detector R&D Collab.)**
**(proposed by D.Varga)**



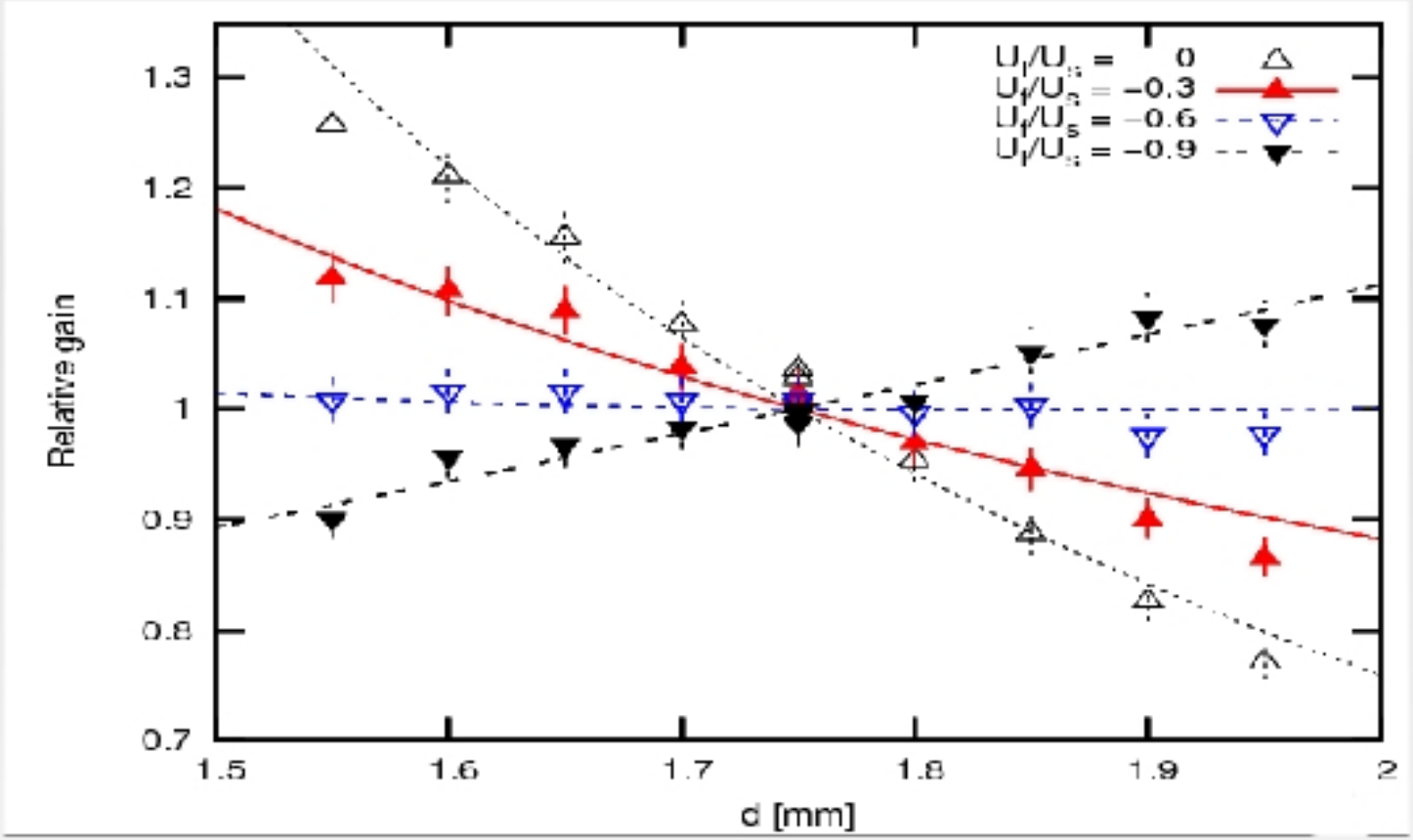

- Main parameters:
  Sense Wire ~ +1000 V
  Field Wire ~ -600 V
  Cathode ~ -600 V
  Pad plane ~ 0 V

Gas mixture : Ar/$CO_2$

Pad size typically 2-4 mm

Wire distance typically 1-2 mm

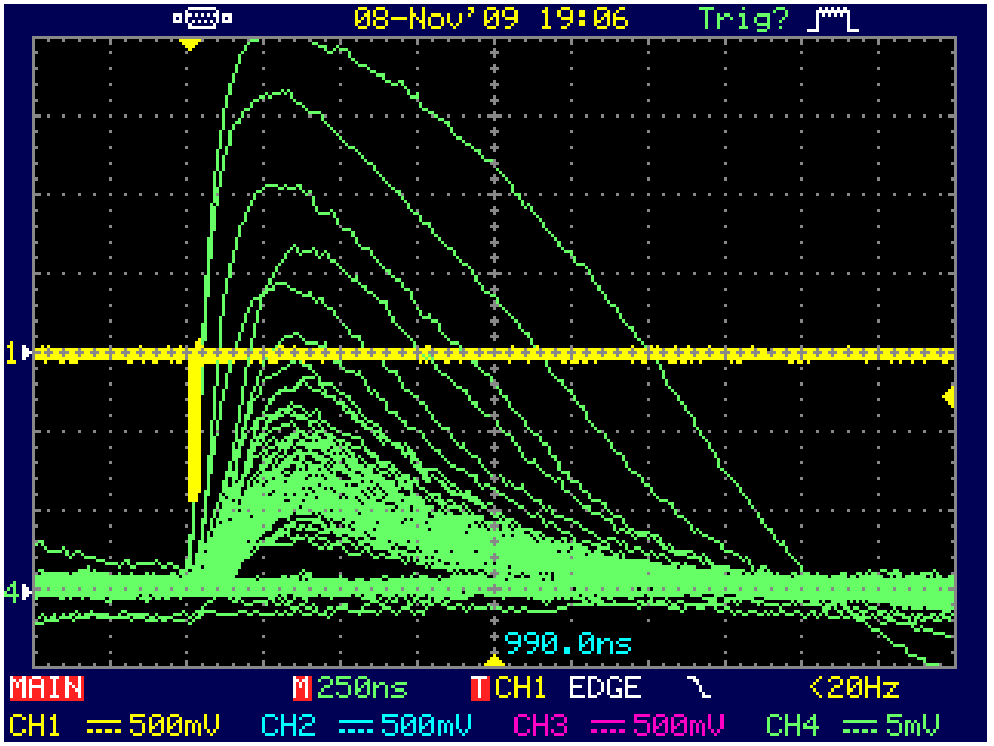
# CCC - measurements II.

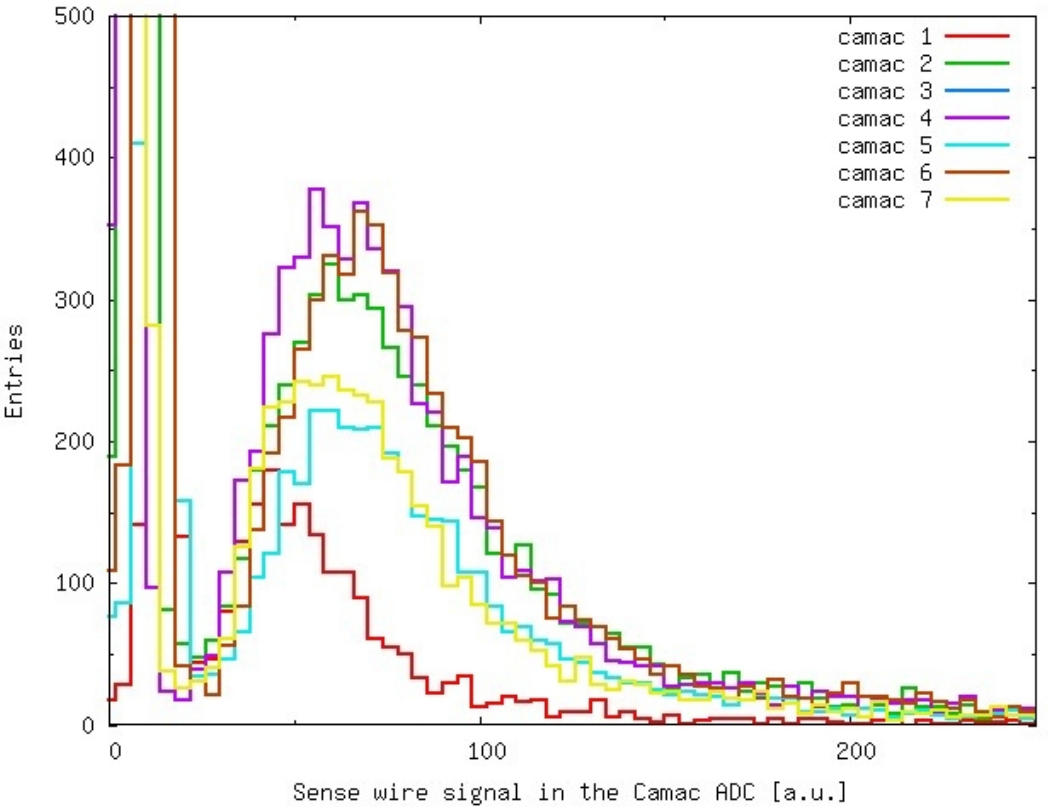



- The relative gain as a function of lower cathode and wire plane distance (d). The calculations are consistent with the measurements.
- Measurements with a chamber where the wires were fixed at different heights on the two side

# **Analog signals** of the MIPs

## from the sense wires

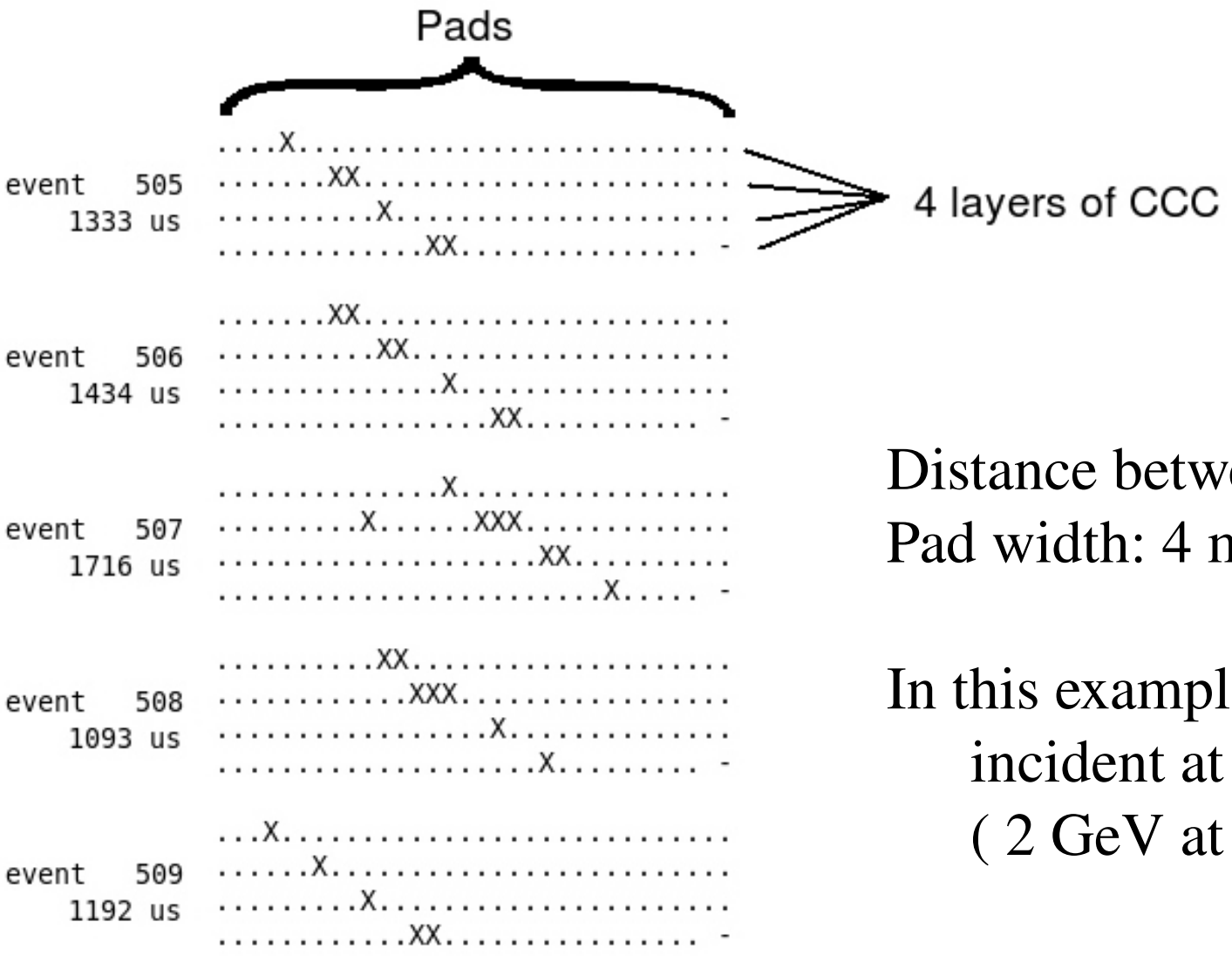



- **Oscilloscope screenshot**

- **Charge distribution**
  **(2 channels in all the 4 chambers)**

# Screenshot example of digital hit patterns

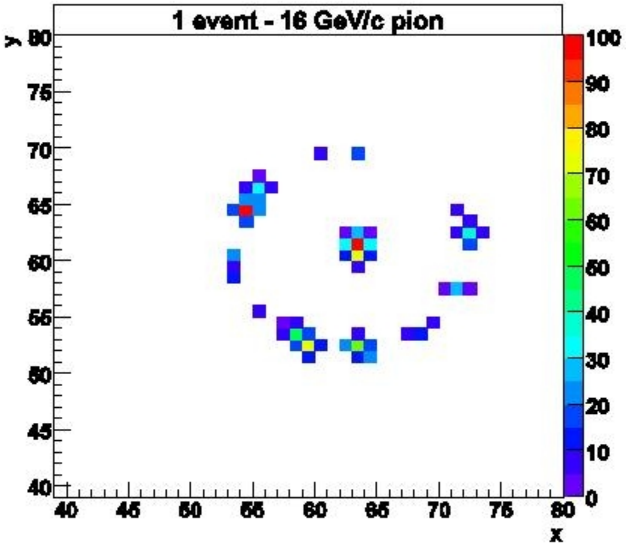



Distance between layers: 50 mm
Pad width: 4 mm

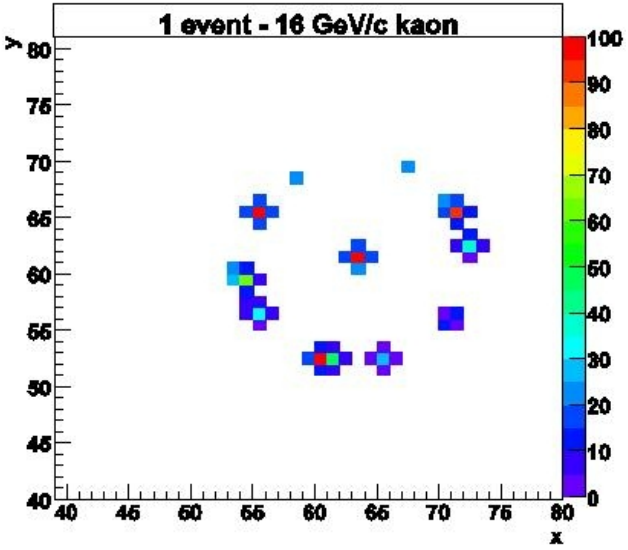
In this example the particles
incident at 15 degrees
( 2 GeV at ALICE )

# Signals in the VHMPID

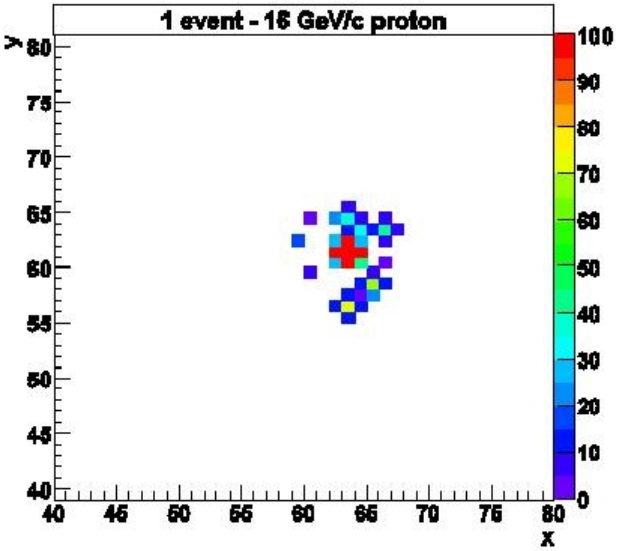
pion

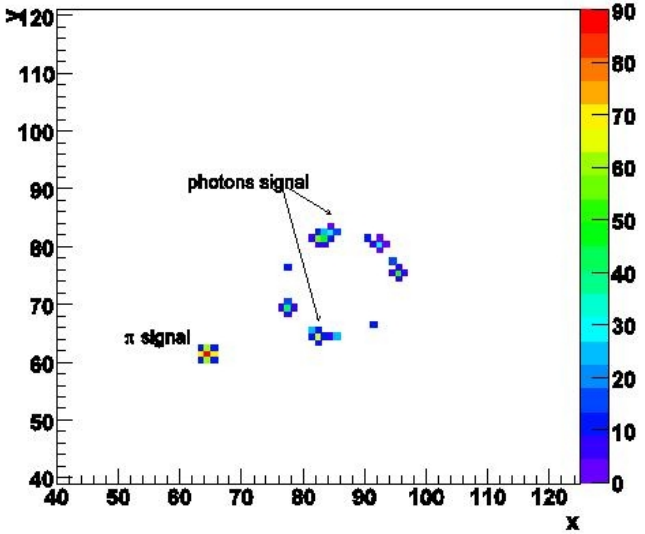



kaon




proton




Usage of a spherical mirror ->

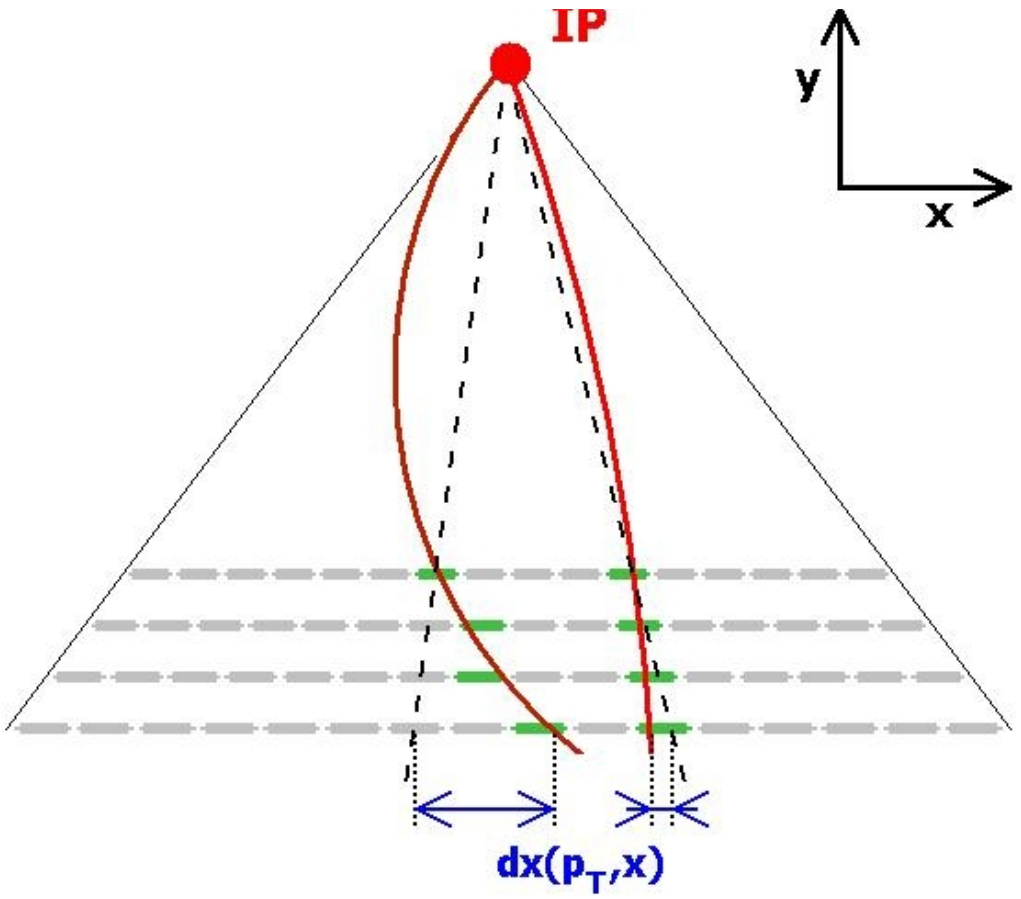
Circle shape signals ->

- Easier to measure diameter
- Which gives better resolution
- HMPID reconstruction method could be used

simulation and picture by G. Volpe

# HPTD in ALICE

## High $P_T$ Trigger Detector




- Measure particle inclination
- Good resolution along the direction of bending
- Pad size optimization through simulations (2-5 mm wide)
- Detector requirement
  - high granularity (pads<2cm$^2$)
  - high multitrack resolution
  - no amplitude meas. needed
  - narrow response function ( 1 pad/hit )

- Simple pattern recognition with FPGAs