Gaseous Beam Position Detectors, with Low Cost and Low Material Budget

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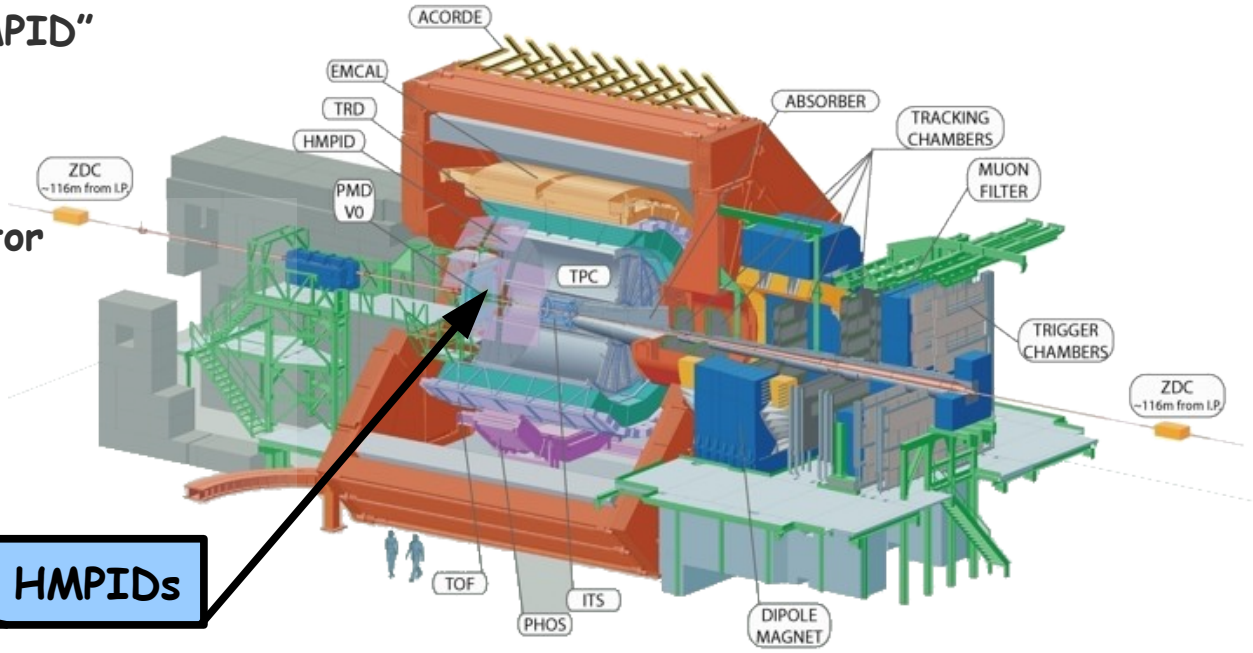
Outline

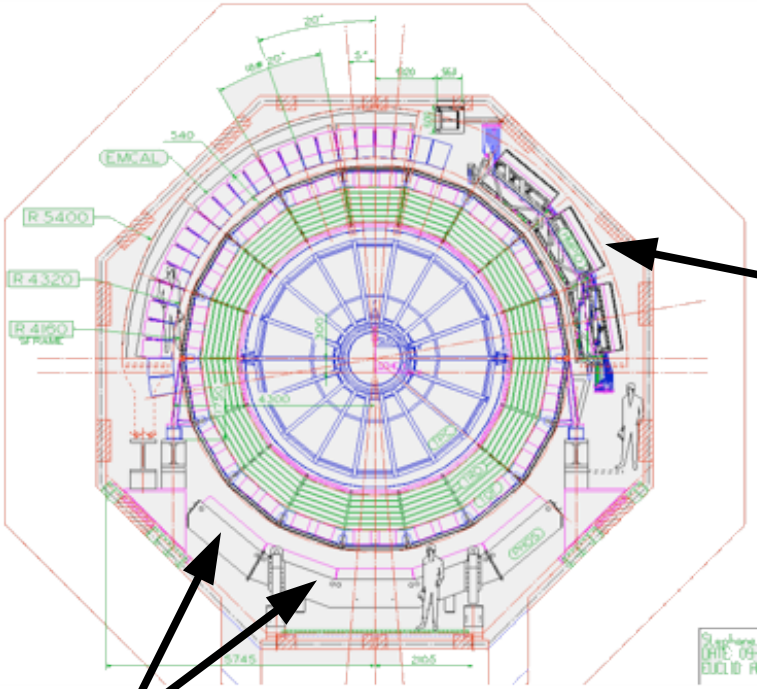
- Physics Motivation
- Newish MWPCs, the **C**lose **C**athode **C**hamber technology
- The **B**eam **P**osition **D**etector (with reduced material budget)
- Construction of a cost-efficient **BPD** Chamber
- Test measurements (in Lab and @ CERN PS)
- **BPD** upgrade and first tests (Oct-Nov 2011)
- Summary

Physics Motivation I.

- **ALICE upgrade**: HMPID → Very "HMPID"

  Very **H**igh **M**omentum **P**article **I**dentification **D**etector:
  High P_T (5-25 GeV/c) Trigger Detector
  (tracking and PID, $|\eta|<0.5$)



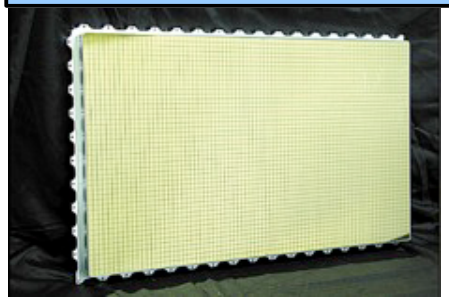


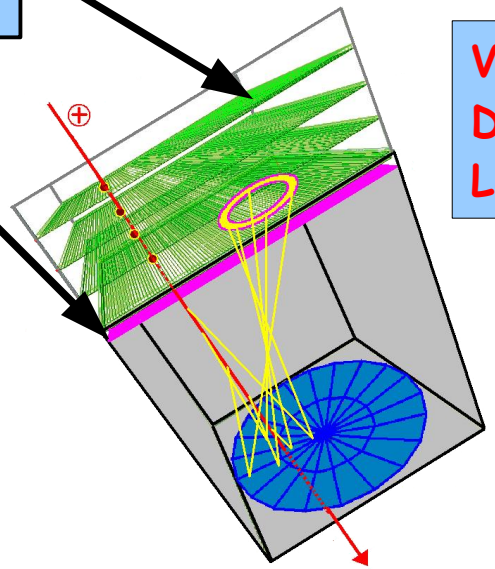
HMPIDs

VHMPIDs

MWPCs (GEMs, TGEMs)

CsI Photon Detector,
Padsize: 8x8.4mm^2





VHMPID Detector Layout

Physics Motivation II.

- Small Padsize → need good spatial resolution (~1mm, <1mm) MWPCs
  → track-by-track Particle Detection
- REGaRD group (from 2009, RMKI-ELTE Gaseous Research and Development)
  → develop gaseous particle detectors (MWPC, GEM, TGEM+CCC Photon Detector)
  → state-of-the-art MWPCs, with Close Cathode Chamber technology

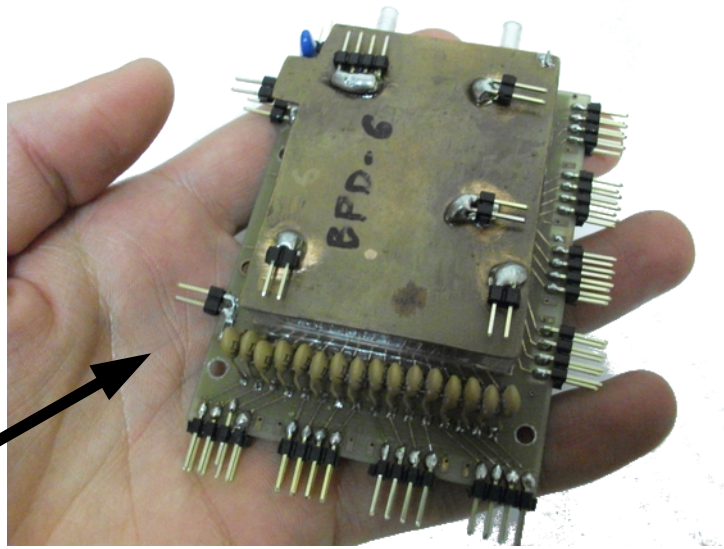
1.) Low cost, low material budget

+

2.) >1mm resolution so far...

1.) - 2.) improvable!

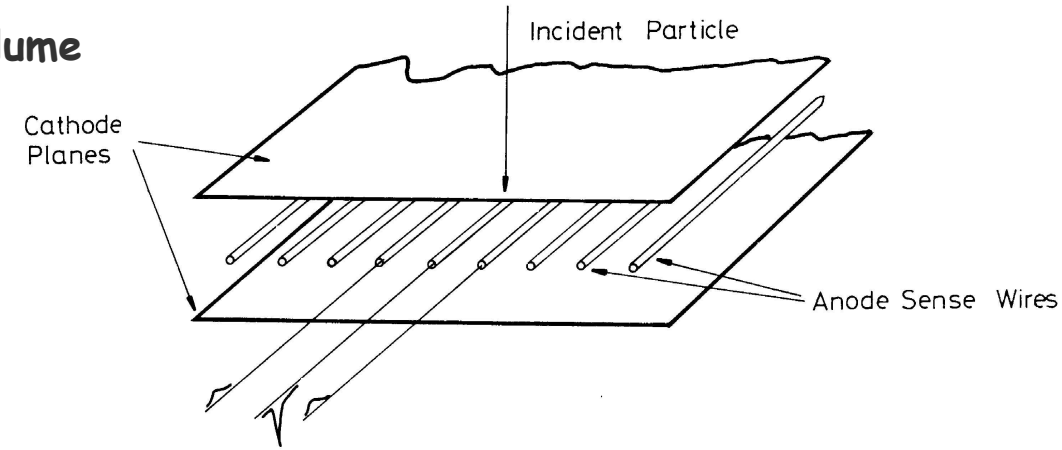
Possibility for Beam Position Detectors



Newish MWPCs, the Close Cathode Chamber technology I.

- **Multi Wire Proportional Chambers** (Charpak, 1968)

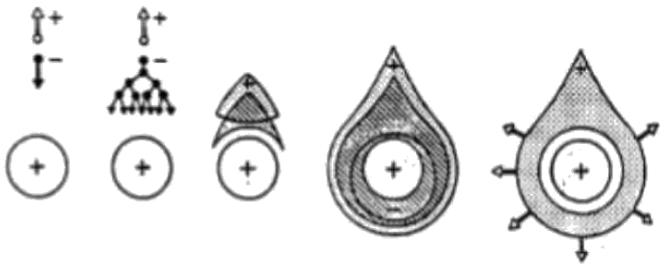
  → Thin anode wires (**Sense wires** (+), ~10-100 um)
  → **Cathode** plates
  → Closed, **noble-gas** (e.g. Ar) filled volume
  + few % quenching gas (e.g. CO2)



Construction's Drawback:

"bad" (~ 10um) mechanical tolerance
→ Need robust frame → increasing material budget
→ rising unwanted secondary interactions

Possible improvement:
asymmetric wire-pad distance → CCC technology



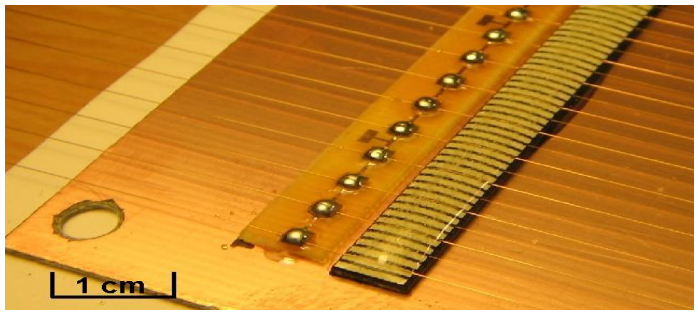
Amplification of ionization

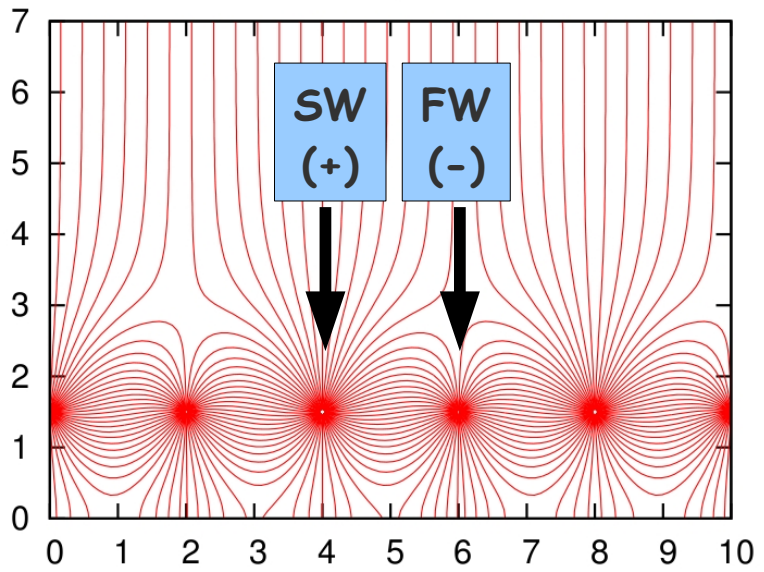
Newish MWPCs, the Close Cathode Chamber technology II.

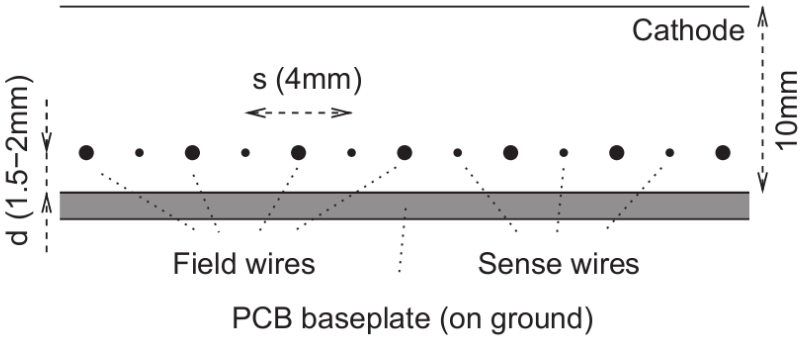
- **CCC option:**
  - + Thicker "Field wires"
  - + Asymmetric wire-padplane layout
  - + Optimal settings of high voltages (Sw/Fw)

Gain does not depend on Sense wire's charges

Better mechanical tolerance (~ 100um)
→ less material budget



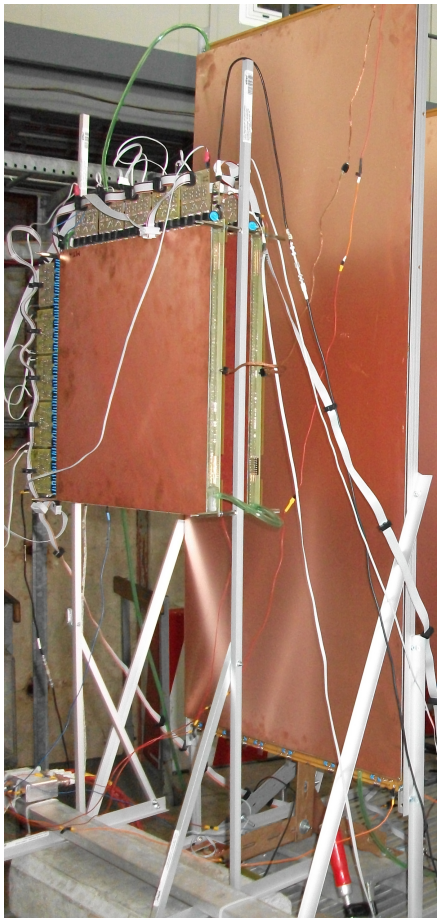




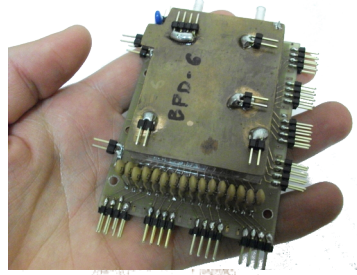
The Beam Position Detector (with reduced material budget)

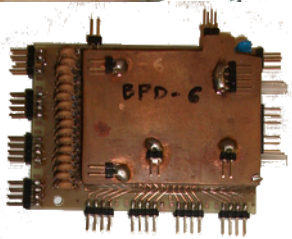
LO,MIP (~1m) CCC version, Aug. 2011

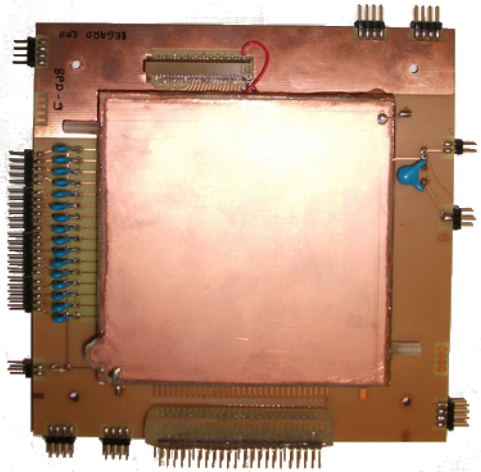
BPD (~5-15cm) CCC version, 2010 - 2011



Size	
LO ~ 1mx0.5m MIP ~ 0.5mx0.5m	Old ~ 5cmx4cm New ~ 15cmx15cm
Material thickness (PCB)	
~ 2-3mm	~ 0.8-1.5mm
Weights (total)	
~ 2-3kgs	< 0.05kgs
Support Structure	
Al bars	none

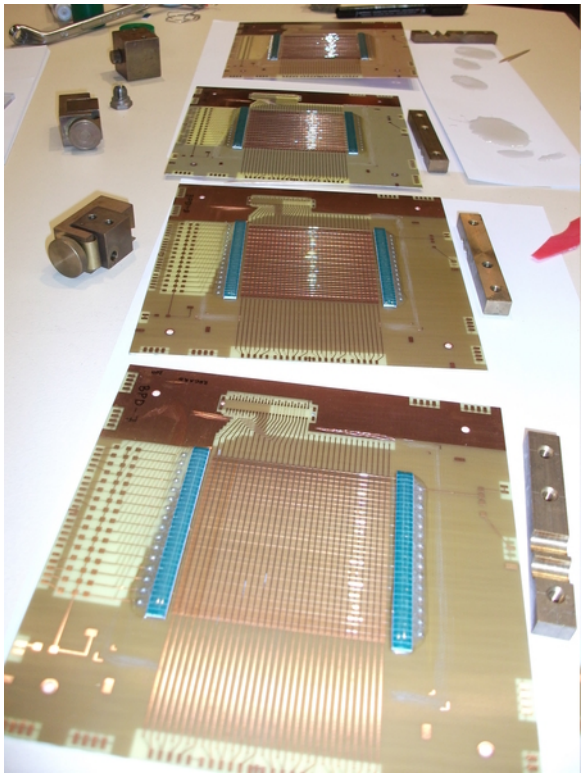


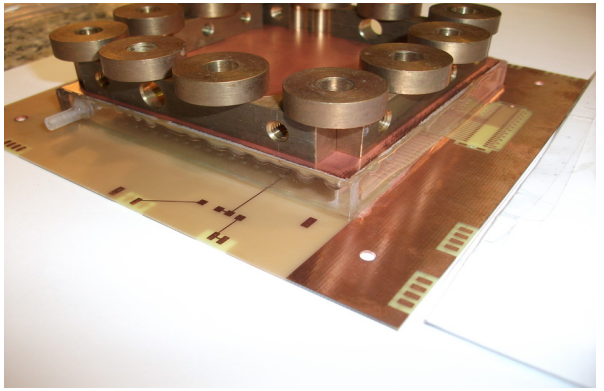


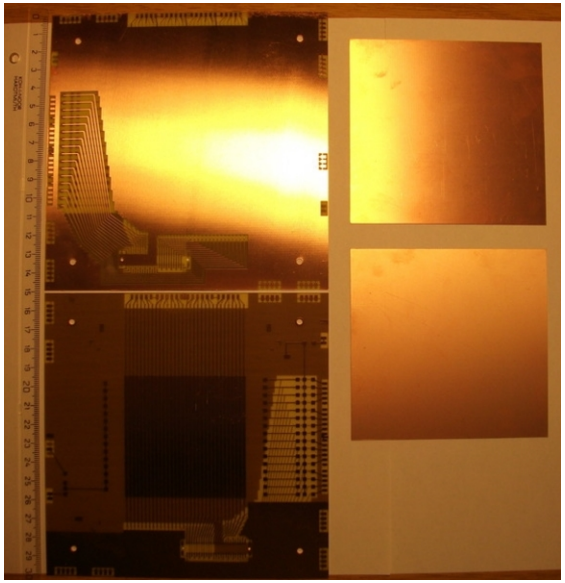


Construction of a cost-efficient **BPD** Chamber (Oct. 2011)

Wiring, gluing, soldering ...

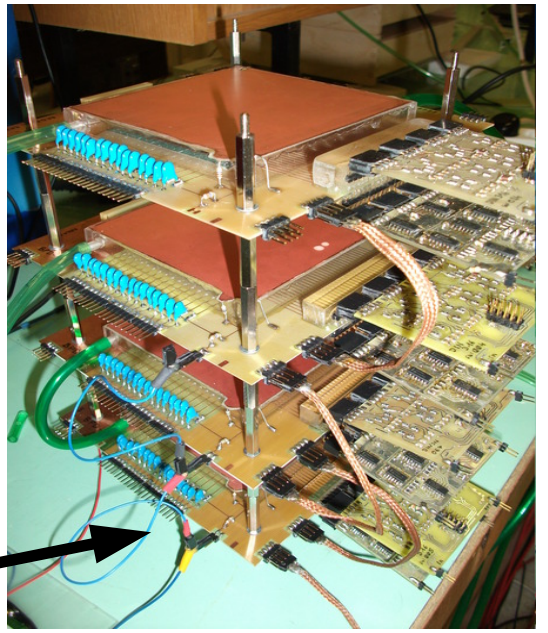






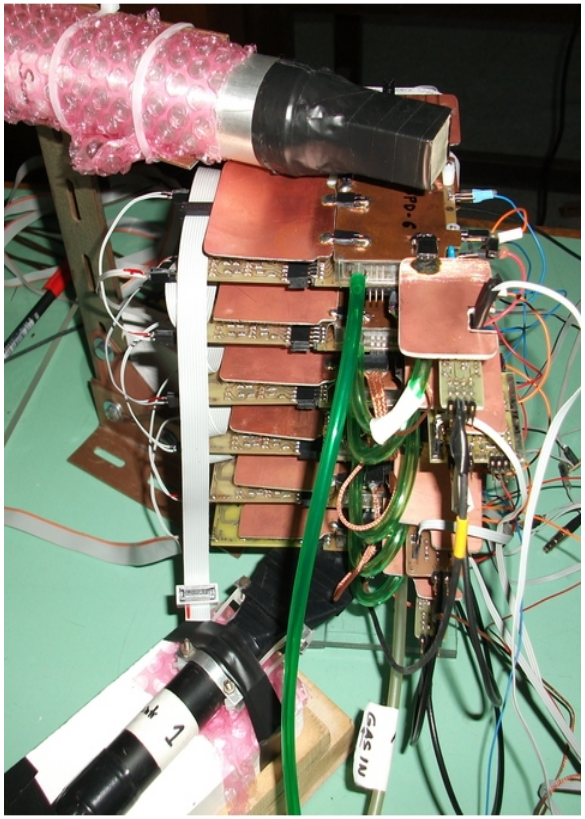
Raw, thin PCB plates

Ready for measurements



Test measurements in Lab I.

- Basic **cosmic-muon tests** with analog and digital 2D readout (on wires and pads)



Typical cosmic setup with
6 layers of BPDs (Feb. 2011)

Wire hits "x"

```
---x-----------
----x----------
------x--------
--------x------
----------x----
------------x---
```

Pad hits "x"

```
-------xxx-----
--------xxx----
---------xxx---
----------xxxx-
------------xx-
--------------xx
```

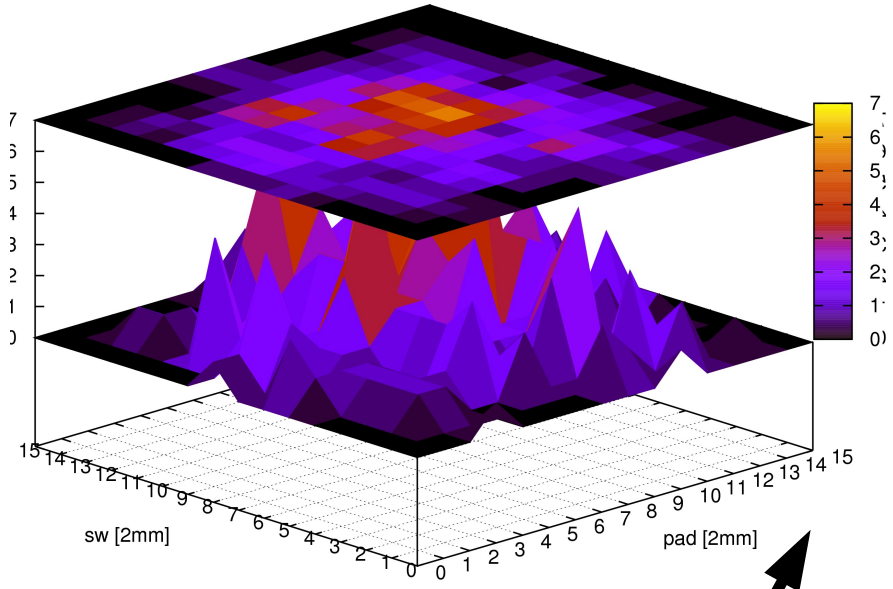
6 layers of BPDs
layer distance: 30mm

Some parameters right after the run

No. Collected events	17603
Collection time	158 hours 27 mins 57 secs
Nice / Good track events on sensewires	443 (2.5 %) / 3738 (21.2 %)
Nice / Good track events on pads	430 (2.4 %) / 3152 (17.9 %)
High Voltages	SenseWire: 880.0 V, FieldWire: -500.0 V, Cathode: -500.0 V
Gas	Ar/CO2 - 16.8/1.4, GasFlow = 10 l/h

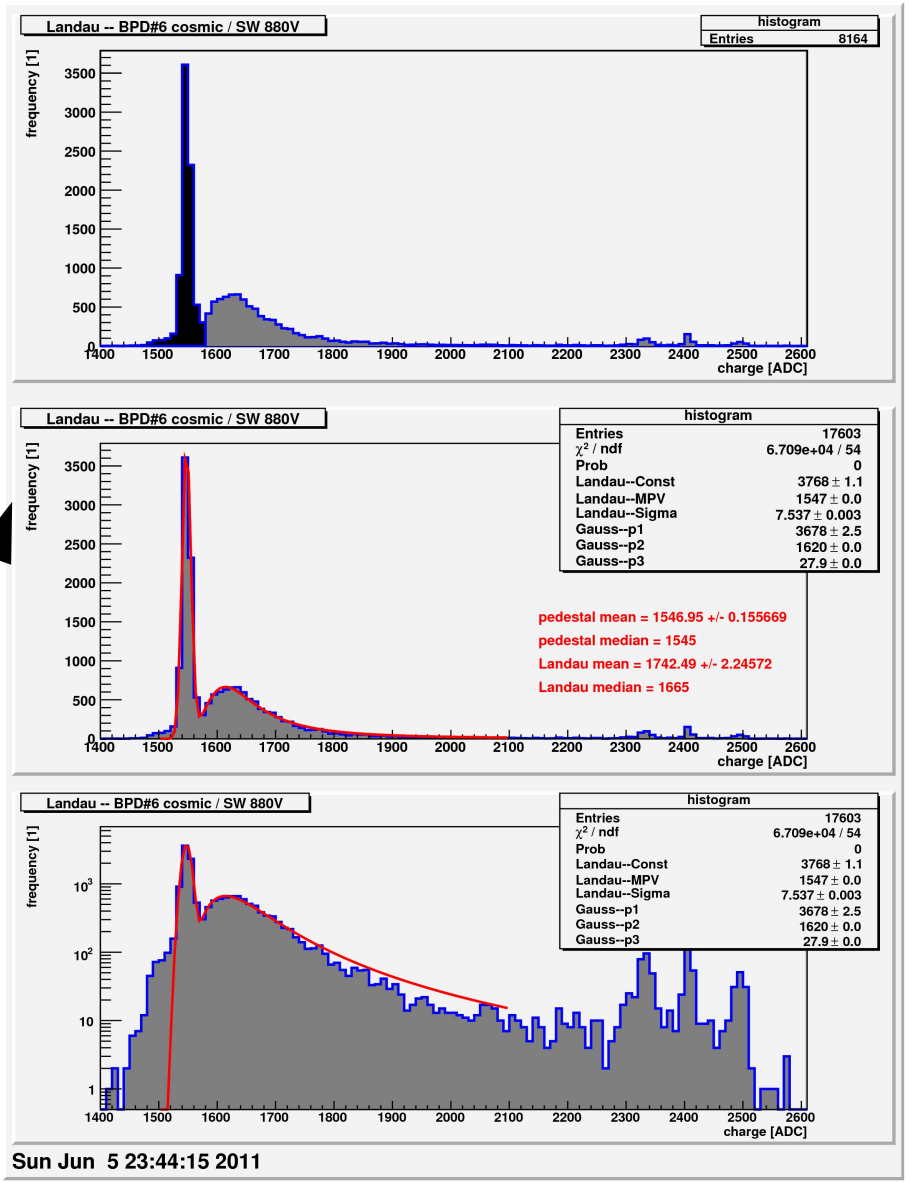
Trigger speed: ~1.85 event/min
→ too slow to study in detail
→ need beam tests @ CERN PS

Test measurements in Lab II.



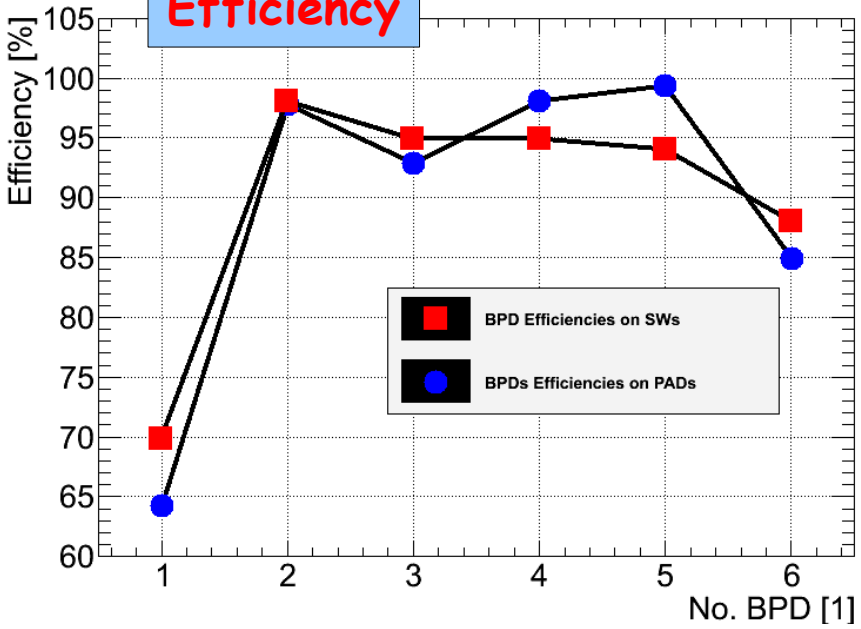
Hitmap of triggered cosmic muons

Reasonable Landau-distribution

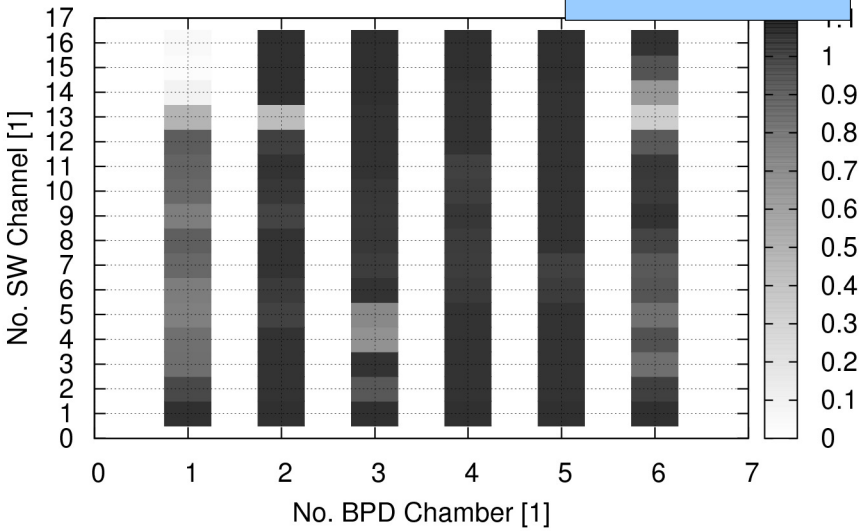


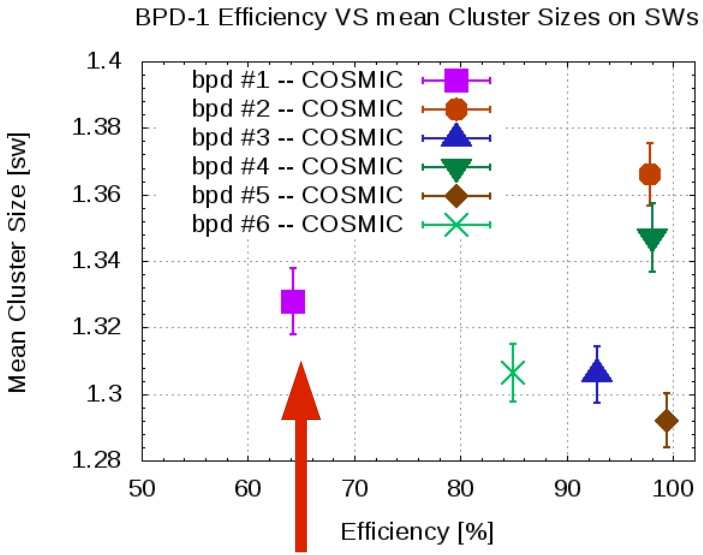
Test measurements in Lab III.

Efficiency



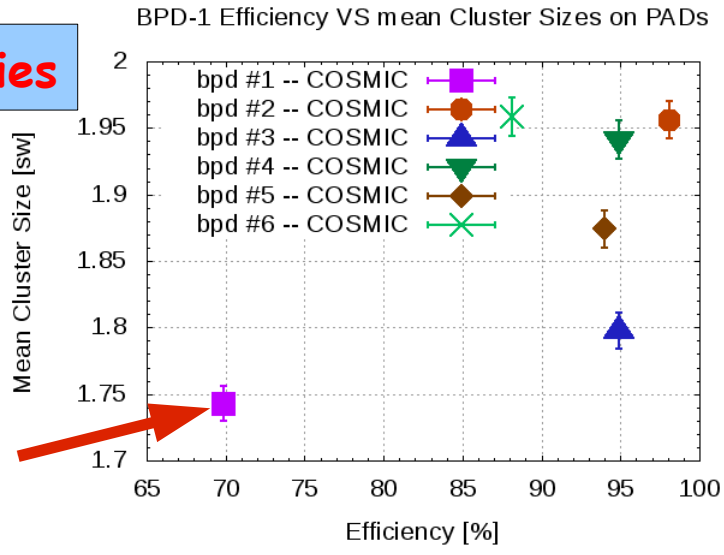
Uniformity



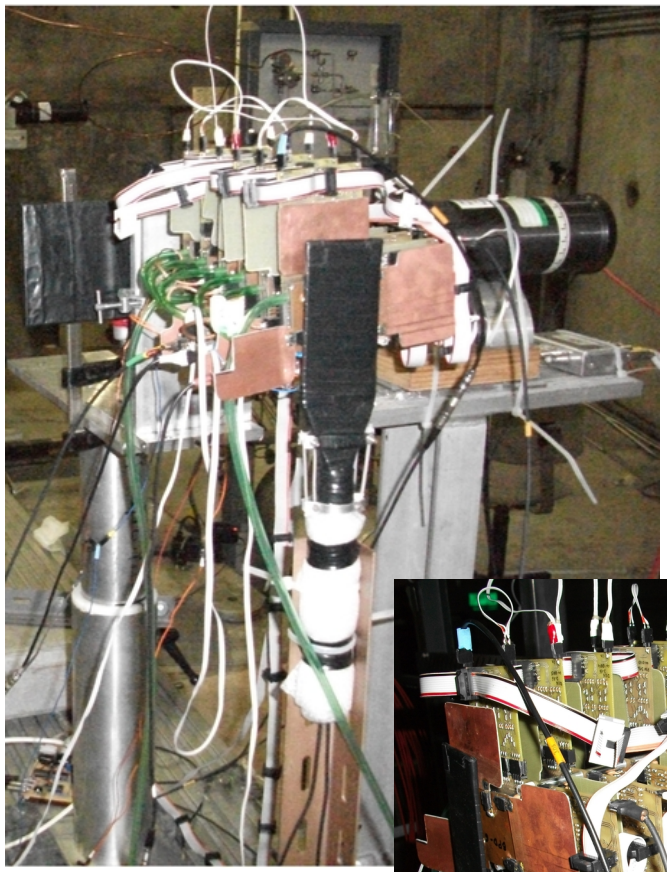


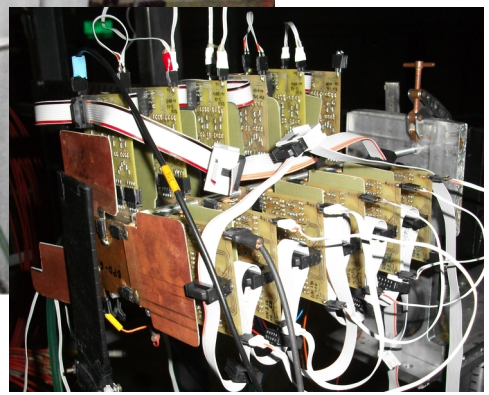
Cluster Sizes vs Efficiencies

Efficiencies : OK (> 90%)
Uniformities: OK (> 90%)
Cluster Sizes remain small

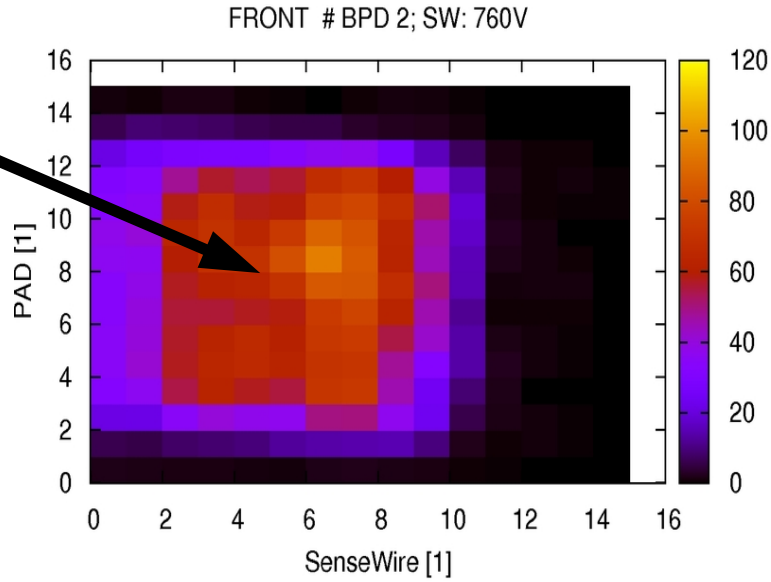


Test measurements @ CERN PS I.

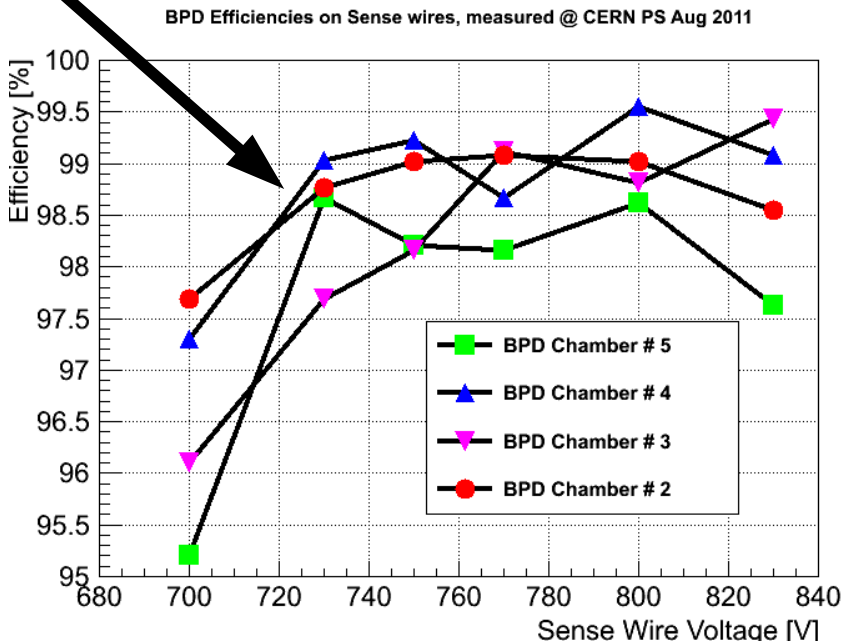




Shadow of a small scintillator (2x3cm), on front side → triggered effective surface



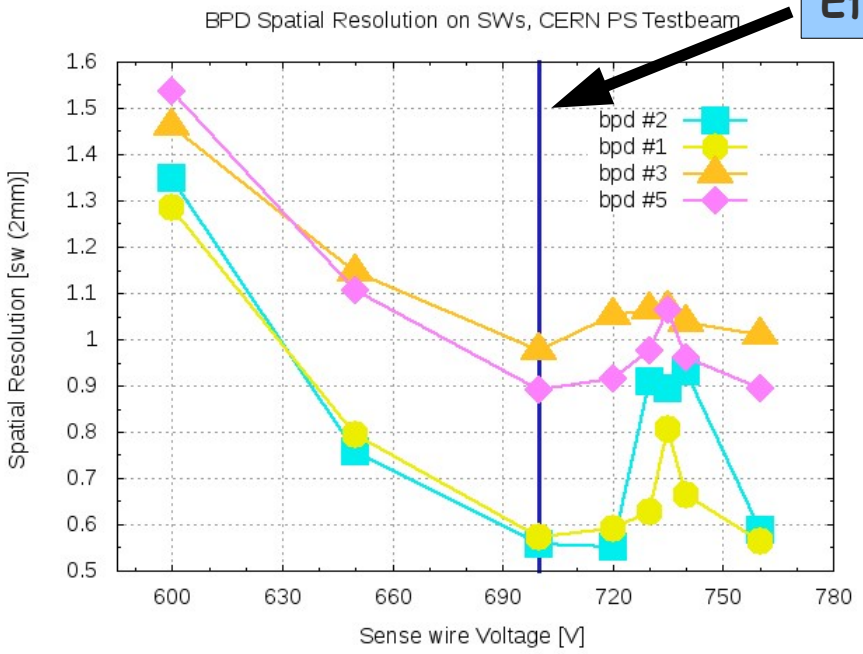
Efficiency > 98%



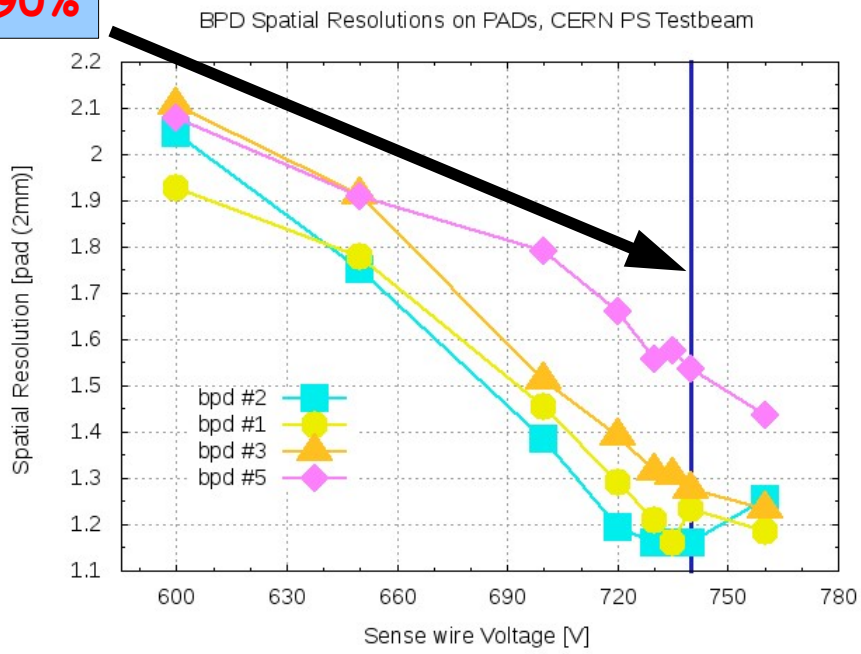
Beam test of the 6 layers of BPDs @ CERN, Aug. 2011

Test measurements @ CERN PS II.

Efficiency cut > 90%



Spatial resolution ~1mm can be reached, with digital readout

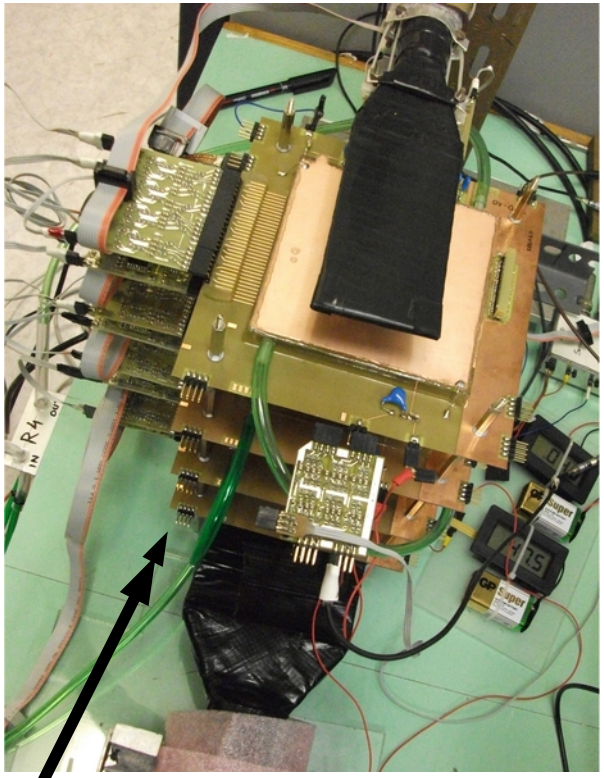


→ **Efficiencies, Uniformities: OK**

→ **Spatial resolutions are such as we expected (generally 1-2mm, best case ~1mm)**

To increase the resolutions more: BPDs need to be upgraded → new construction → capable to readout with HMPID electronics

BPD upgrade and first tests (Oct-Nov 2011)



First cosmic test, 22nd Oct 2011

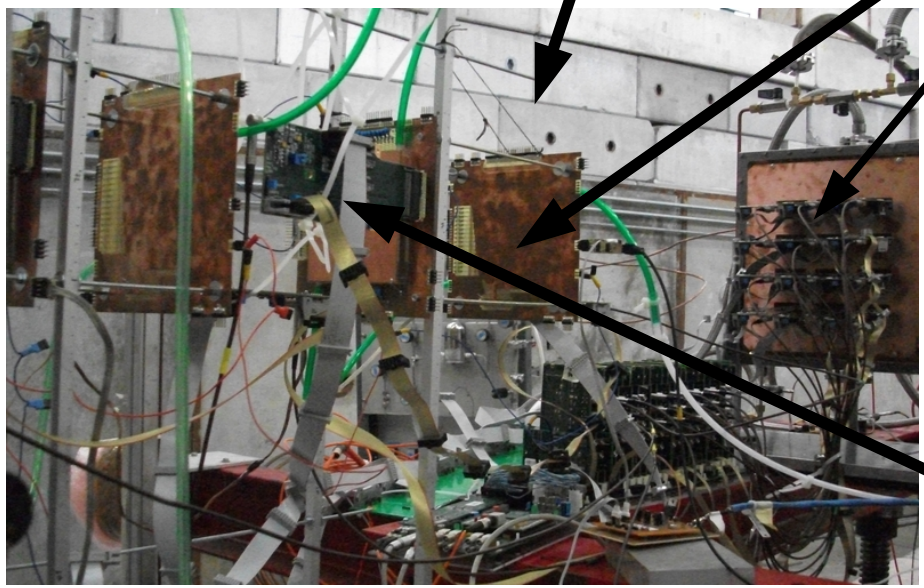
16 Chs of FWs **32 Chs of PADs**

```
event    54 - 12199371 us
      .......XX.......                        .........................XXX.....
      .........XX.....                        .......................XX.......
      ...........XX...                        .......................XX.......
      .............XX.                        ....................XXX.........

event    55 - 12265503 us
      .....X..........                        .....XXX.........................
      ....XX..........                        .......XXX.......................
      ...XX...........                        .........XXX.....................
      ...X............                        ............XXX..................
```

At first run:
~95% efficiency

First run in VHMPID beam test, Nov 2011



New BPDs , new TCPD

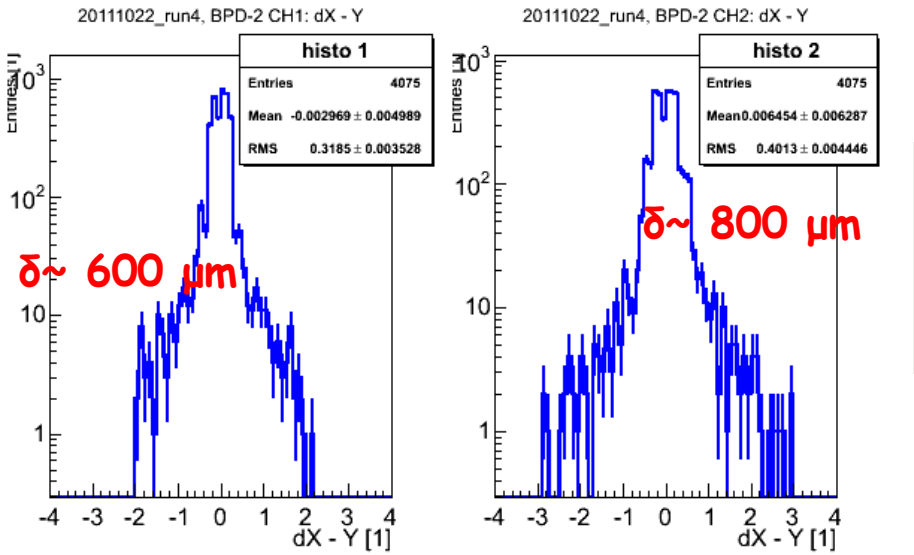
Included in Alice DAQ

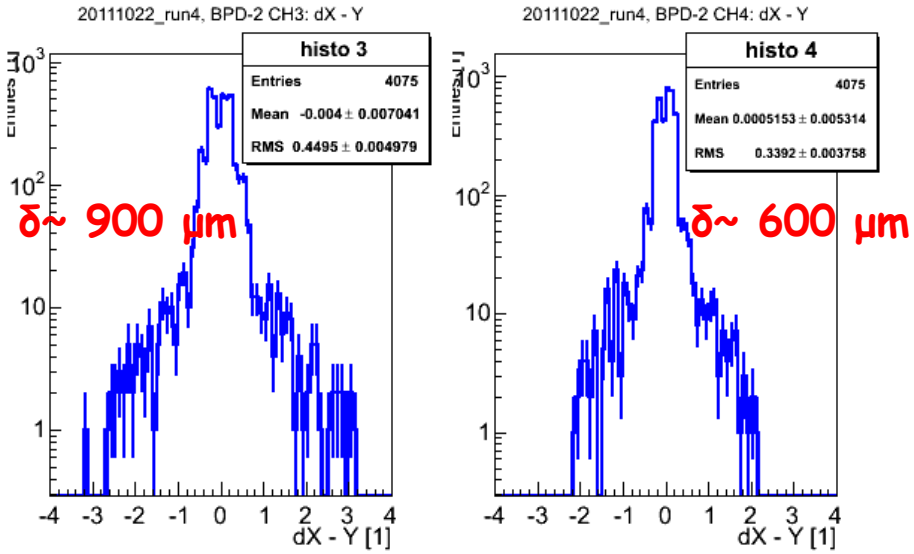
Simultaneously readout with TCPD

Gassiplex card

Upgrade: 16 → 32 channel PAD, thiner PCBs (0.5mm !), included HMPID Gassiplex connectors

Ongoing analysis from the latest data, preliminary...



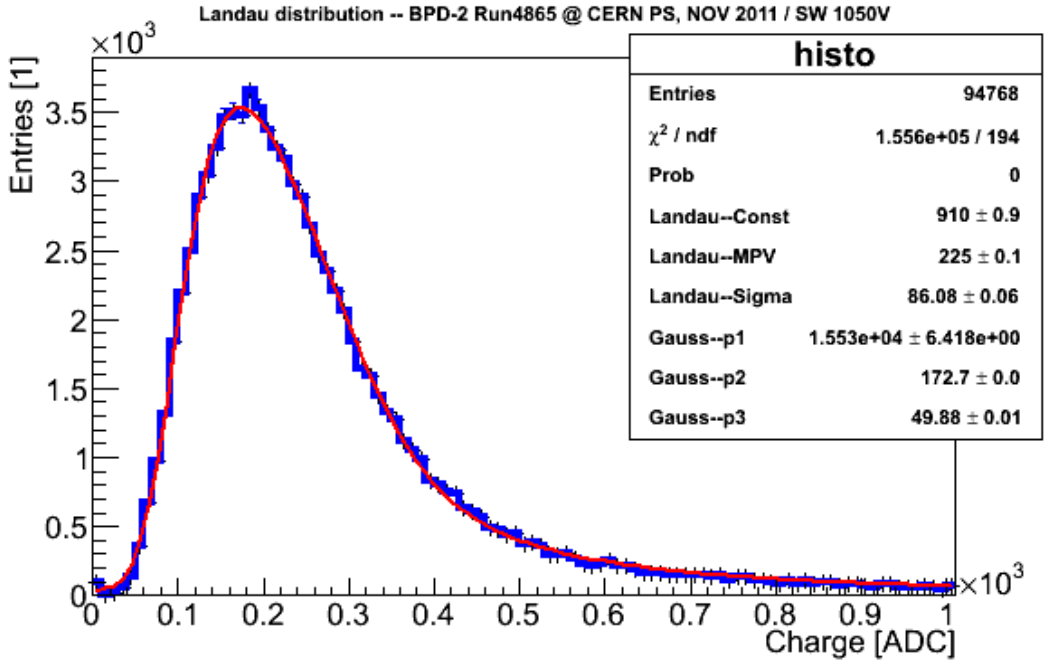


Pad 1 - - - - - - - - - - - - - - - - - - 12 59 26 45 103 26 - - - - - - - - - -

Fw 2 - 23 62 39 - - - - -

Pad 3 - - - - - - - - - 6 32 46 23 106 82 9 - - - - - - - - - - - -

Fw 4 - 18 73 48 - - - - - -



Summary

- BPDs are potentially good candidates to measure charged particle track positions with high efficiency (The Close Cathode Chamber technology works fine)
- Spatial resolution is good, it can be even better in the upgraded version (expected to be under 500 microns due to the newly developed version)
- Manifestly easy to construct relatively cheap BPDs, containing low amount/cost material budget
- Hopefully they will serve reasonable resolutions in VHMPID beam tests, and in other applications as well