Tracking issues

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SuperB Workshop

LNF, 11-12 November, 2005

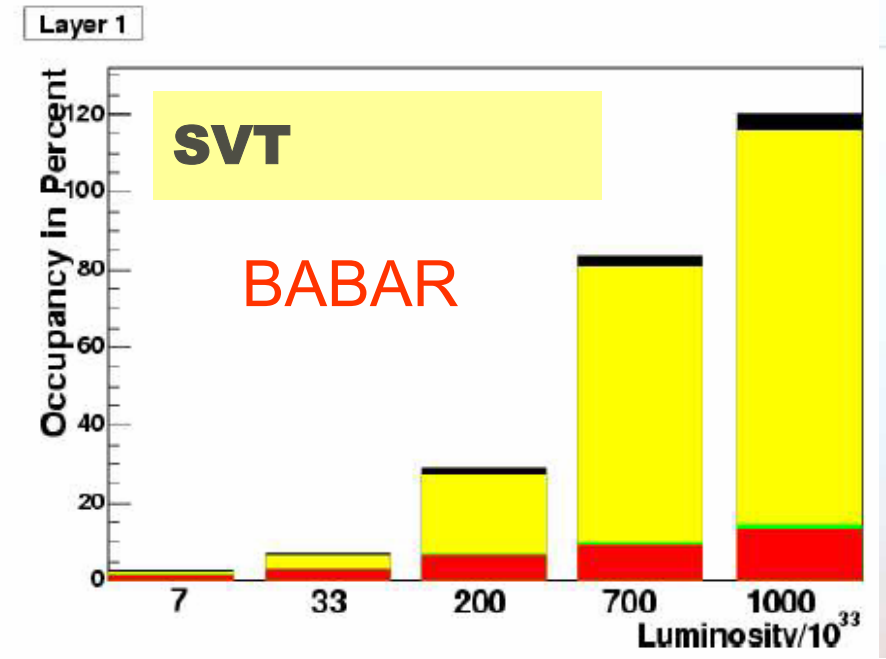
Tracking system

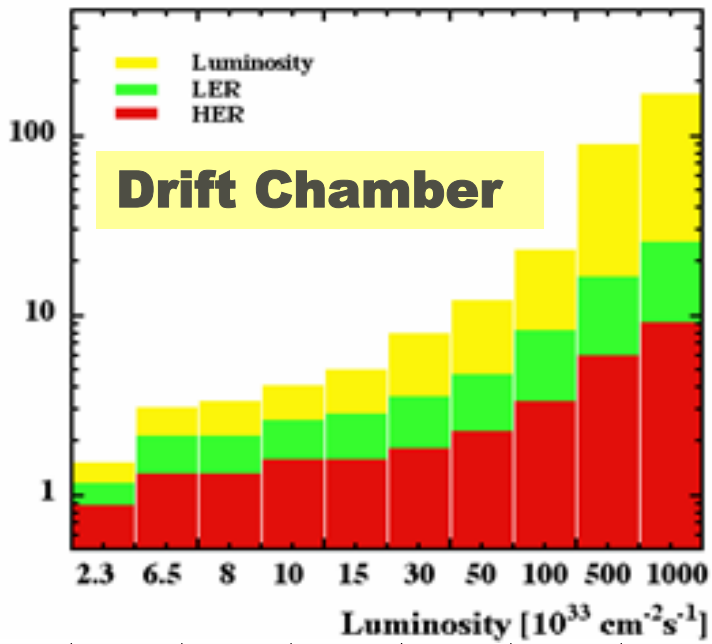
- Various stages/functions/devices
  - Vertex reconstruction
    - Dominated by first layers
  - Angle determination
    - SVT(more) + DCH(less)
  - Slow π finding
    - SVT multi layers
  - Momentum determination
    - DCH(mostly)
  - Track finding and recognition
    - DCH + (SVT for track hitting few layers)
  - dE/dx
    - DCH + (a bit of help from my friend SVT)
  - Trigger
    - DCH only

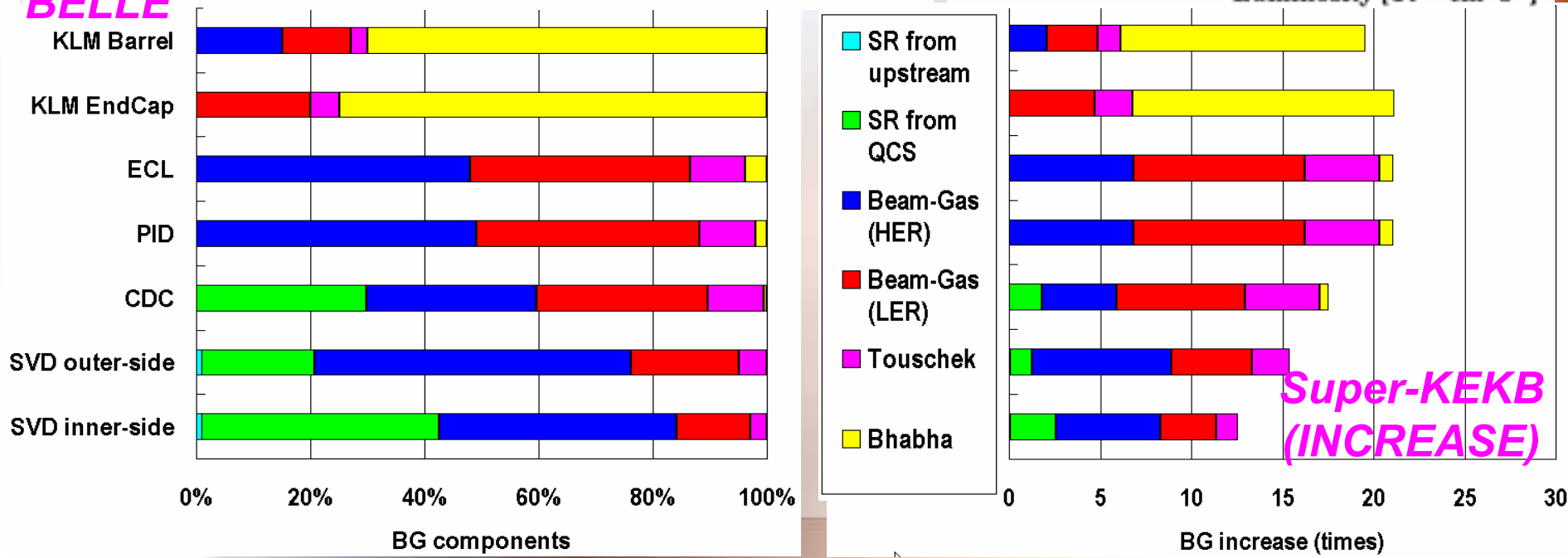
Types and level of backgrounds

- Beam gas
- Synchroton radiation
- → Both proportional to current
  - Should not be a problem at Superb
- Luminosity sources (eg radiative Bhabhas)
  - Careful IR design. Bhabhas into the detector are there.
- Beam-beam interactions
  - Potentially important
- Touschek background
  - $1/E^2$. Improves with smaller asymmetry. But, much higher beam density
- Thermal outgassing
  - Due to HOM losses. Not an issue with small currents
- Injection background
  - Not an issue because of damping rings scheme

Background composition







Background bottom line

- Single beam backgrounds reduced by large factor (1000?) thanks to small currents (See Steve's talk)
- Beam-beam interaction and beam blow-up is unknown
  - **Shielding of detector from interaction in collimators**
- Assume background is not larger than in present machines.
  - Babar-Belle task force has worked to understand and compare sources of backgrounds.
- But issue of Bhabhas vs acceptance vs boost needs to be addressed.

Comment on timing

- 1-10us beam crossing and small backgrounds will help relax some detector constraints
  - No need to be so fast
- But there are so many unknowns we should plan for a detector at least as robust as the present generation against backgrounds

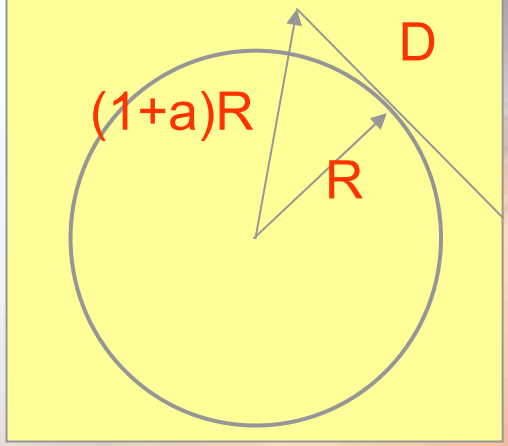
Vertexing

- Small radius beam pipe brings a lot of advantages
  - Need 5mm (or 10mm) radius detector
- Possibilities
  - Silicon strips
  - Silicon active pixels
    - Monolithic pixels are too thick
  - CCDs are too slow for 1us bx.
- Why strips won't work ?

Geometry and thickness

- For 5mm B.P., a=20% D=6.3mm
- Very very narrow strip detector
  - 0.5+0.5 mm dead area at the edges means about 20% overlap is needed to have full efficiency
- Very unfavorable aspect ratio
  - Very hard to readout
- Very hard to reduce thickness below 200um.

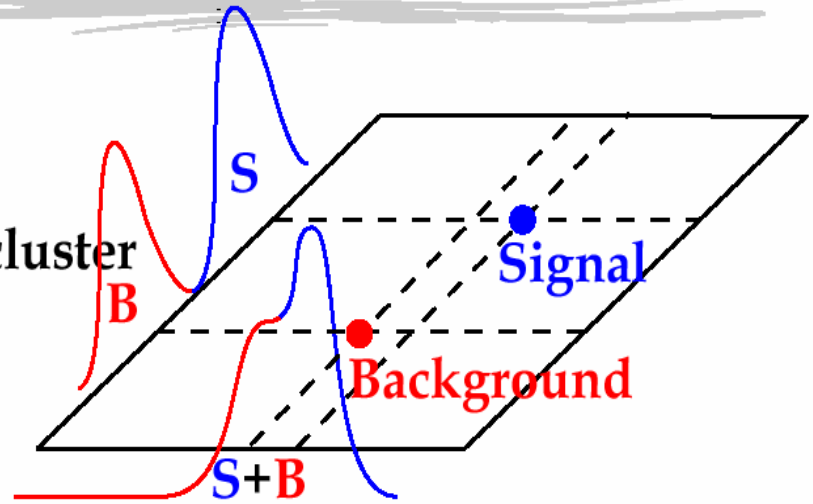
$$D = 2\sqrt{2aR}$$

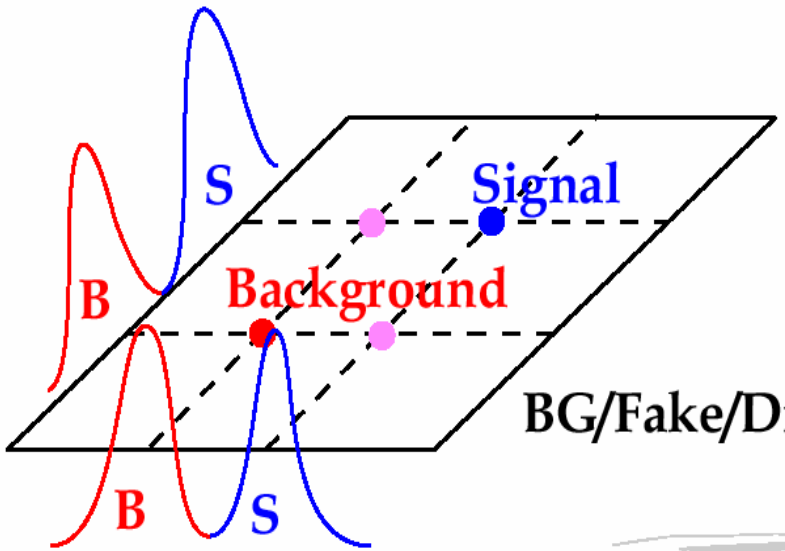


Distortion due to background

SVD Cluster Classification

- (S, S) True cluster
- (B, B) Background(BG) cluster
- (B,S), (S,B) Fake cluster



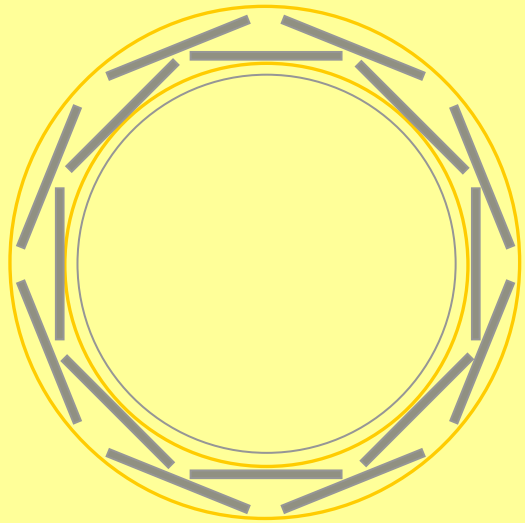


(S+B,S) Distorted cluster

BG/Fake/Distorted clusters smear hit position affect tracking/vertexing

Pixel concept

- Monolithic Active Pixels
- Thinned to 50um
  - **Possible because active region is only about 10um thick**
- With 5mm BP, 3mm^2 chip could be OK.
- Glue on kapton foil
- Support kapton off BP
- Reduce thickness of Au shield
  - **How much can we thin it ?**



x10 scale with 5mm radius BP, 3mm pixel chip

- Many issues to resolve
  - **Feasibility of a MAPS system**
  - **z overlap**
  - **Cables, cooling**
  - **Mechanical support**

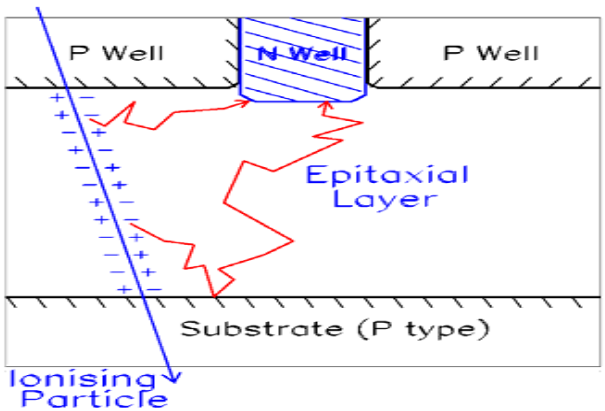
Lots of MAPS R&D in many places

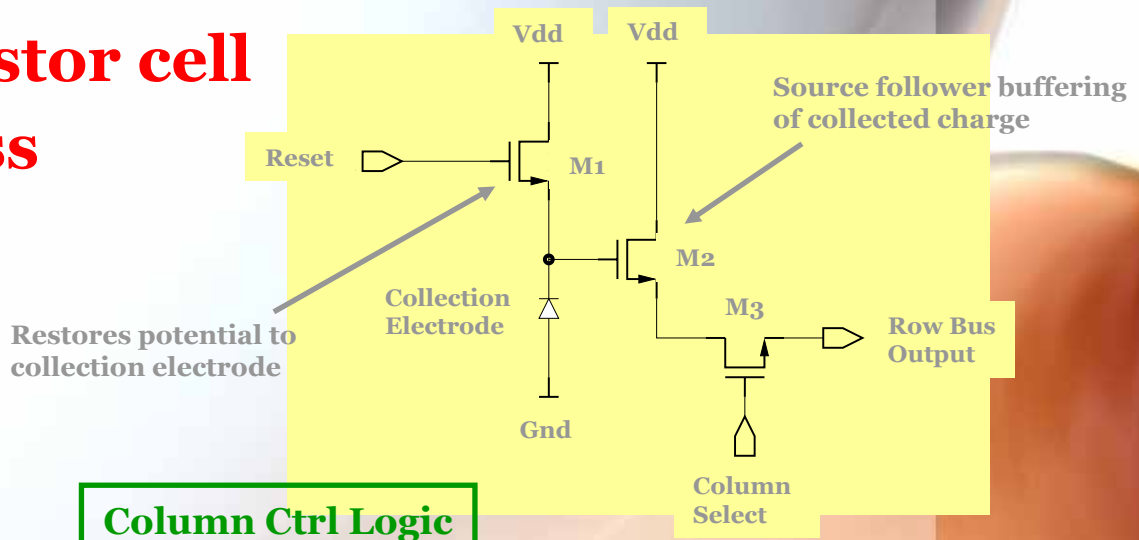
MAPS R&D

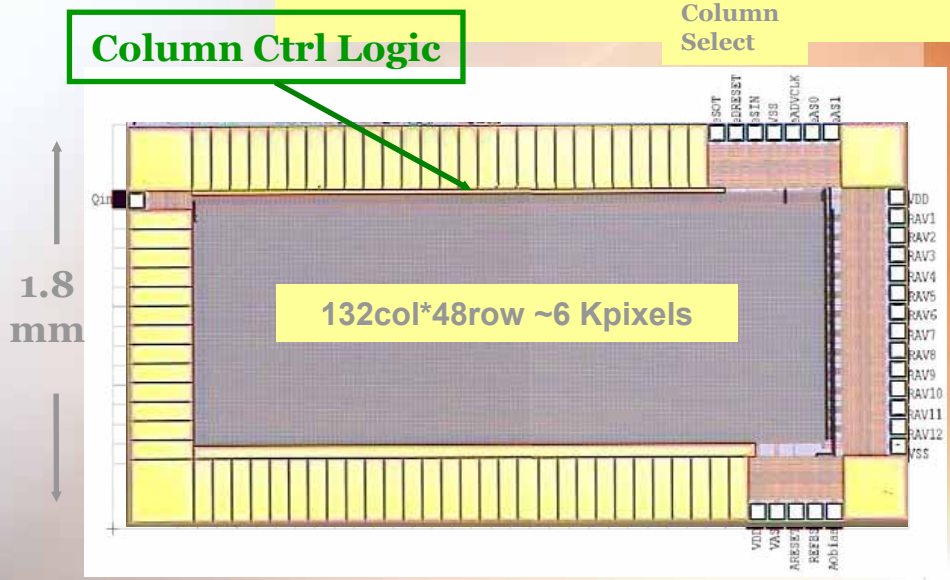
CAP chip (Belle collaborators)

CAP1: simple 3-transistor cell

TSMC 0.35μm Process







Pixel size:

22.5 μm x 22.5 μm

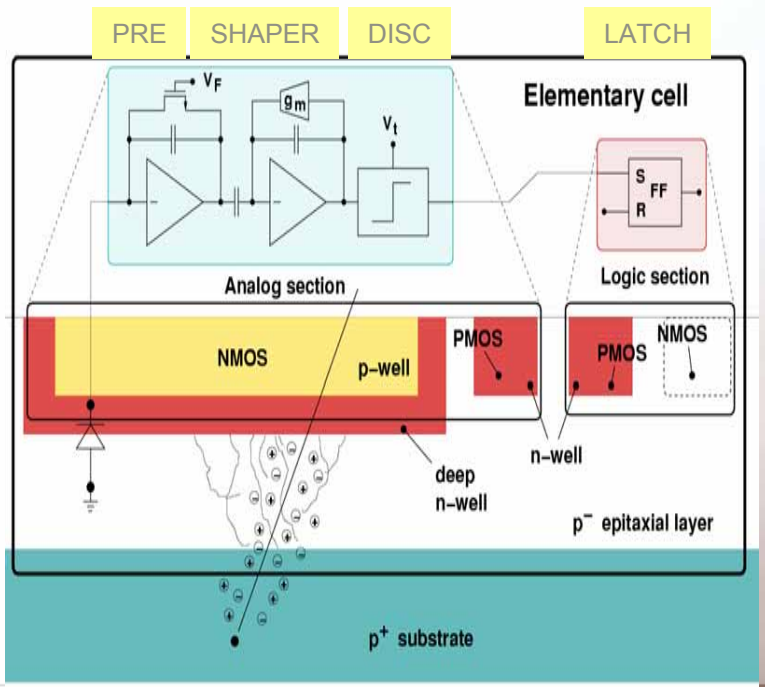
CAPs sample tested: **all detectors (>15) function.**

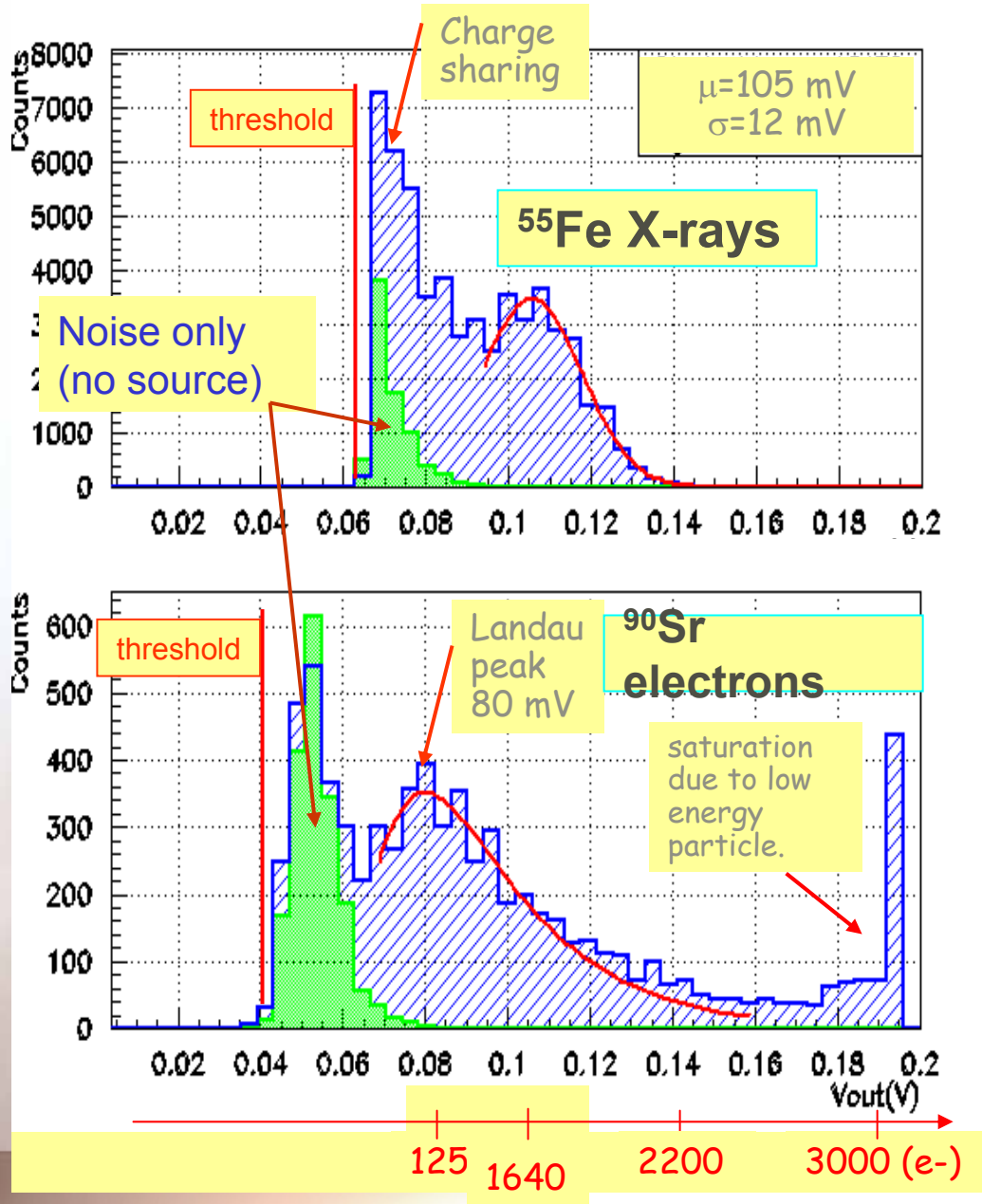
TESTED IN BEAM.

MAPS R&D II

- **SLIM chip (Babar collabor.)**

ST 0.13um triple well technology
Single pixels tested with source
Full signal processing chain





Small radius tracking

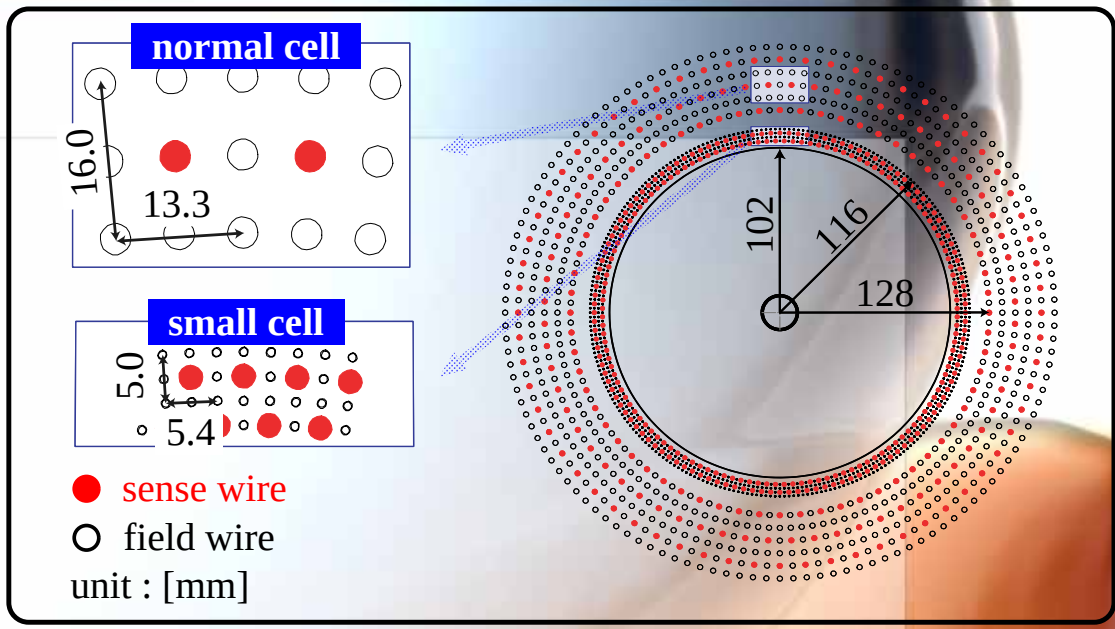
- Silicon strips work beautifully
  - Don’t fix it, it ain’t broken
- Time structure and small background might allow to lengthen the shaping time
  - 100ns → 500 or 1000 ns ?
  - Better S/N, or longer strips.
- Small angle region will be very crowded
  - Need to study that area
  - Disks ? Striplets ?
  - Actual angle will be larger due to reduced boost

Central tracking

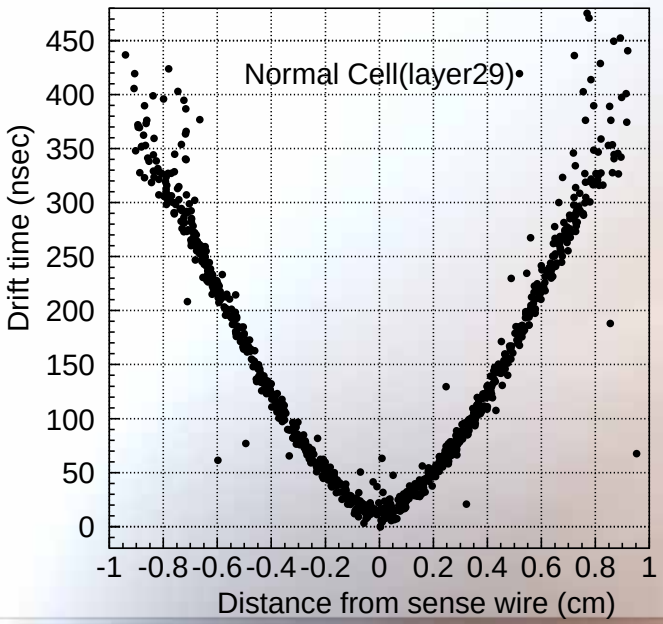
- Silicon or gas ?
  - Solid state only interesting to cope with high backgrounds, otherwise a loser.
- Gas drift chamber in high background
  - Extensively studied by Belle
  - Smaller cell drift chamber (in the inner layers) constructed and installed in 2003
    - (See Uno talk at 2005 Hawaij workshop and Senyo talk 2004 Belle workshop)
- Other options
  - Jet chamber ?
  - TPC ?

XT Curve & Max. Drift Time

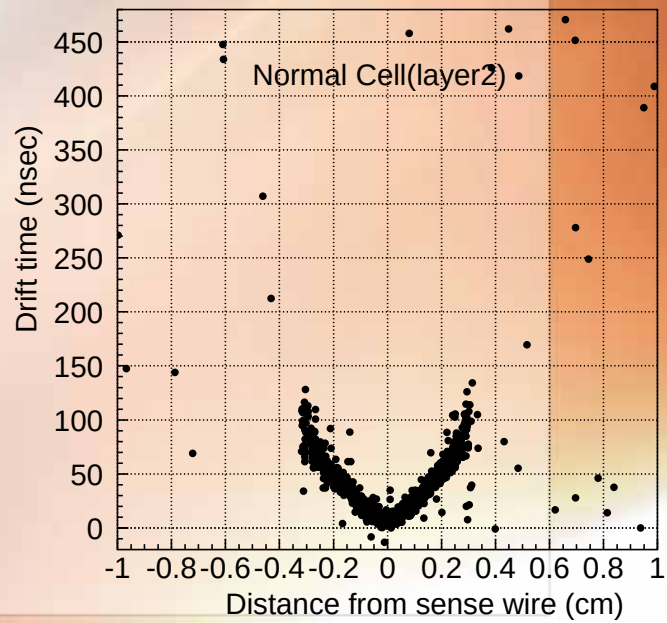
Position resolution 150um



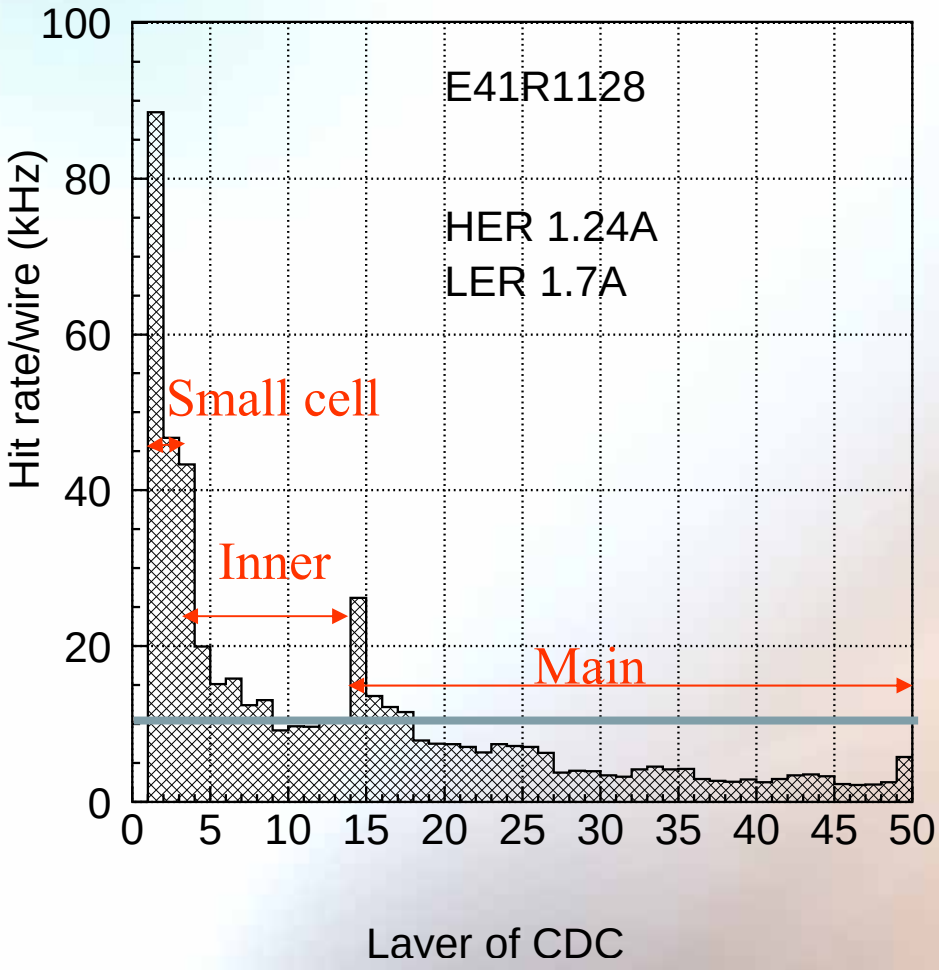
Normal cell(17.3mm)



Small cell(5.4mm)



Hit rate in the present Belle CDC



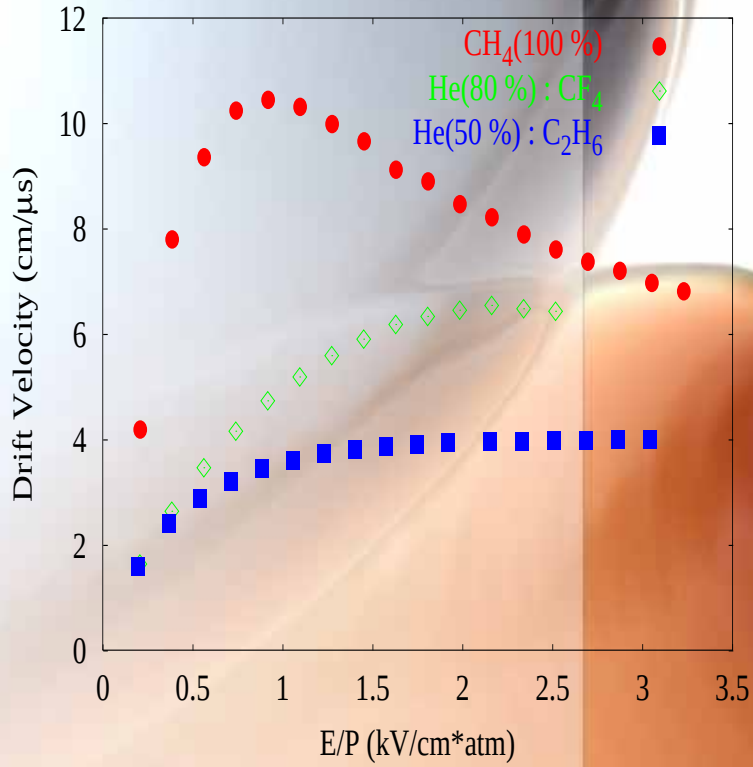
Apr.-5th ,2005
I_{HER} = 1.24A
I_{LER} = 1.7A
$L_{peak} = 1.5 \times 10^{34} cm^{-2} sec^{-1}$
I_{CDC} = 1mA

10KHz

Small cell drift chamber

Drift chamber optimization

- Fast gas is another option
  - but higher Lorentz angle degrades resolution
- Need to optimize the transition radius
  - SuperBelle plans on 160mm
- How small ?
  - small cell has also implications for other issues:
    - number of wires increase material and force on endplate
    - number of holes in endplate decrease stiffness
  - Clearly doable.



Conclusion and summary

- Low backgrounds are key
- Optimization of present tracking systems seems fine and doable
  - **Keep system robust**
- Very small radius vertexing device requires R&D
  - **MAPS are very promising**
  - **strip solution looks hard, but could probably worked out with some compromise**
- Bhabha rate and charateristics need to be studied.