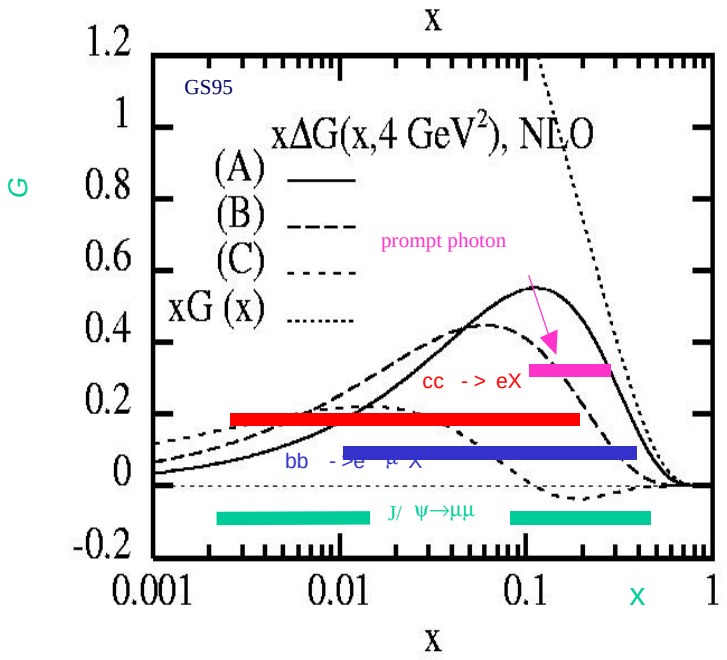
Overview of Vertex Detector Upgrade

- Physics recap
- Recent progress
  - Si strips/pads
  - B => displaced J/ψ
- Next tasks

Spin Goals

- extend x-range of ΔG gluon spin structure function
  - gg -> bb, or cc



prompt photon

cc -> eX

bb -> eμX

J/ψ -> μμ

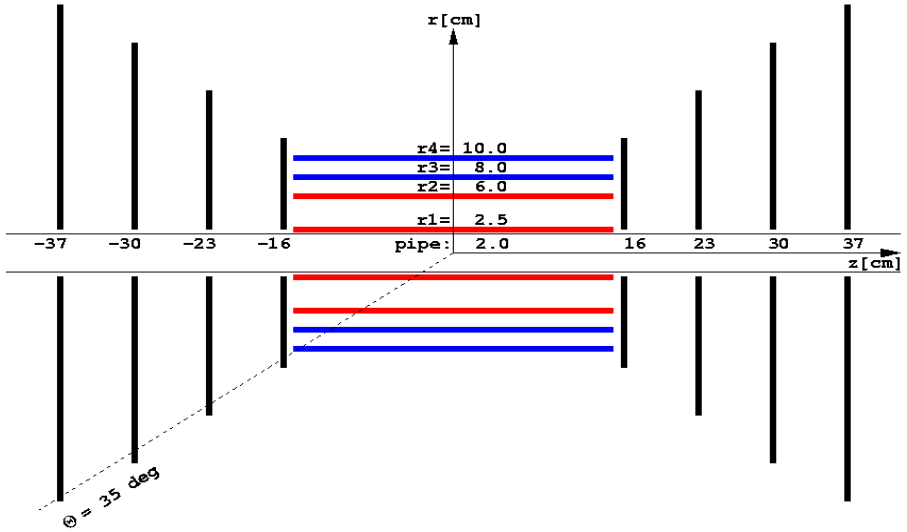
Hiroki Sato

“Heavy-Ion” goals

- Heavy-flavor production in pp, pA, AA over broad range y
  - unique measurement of b-mesons => displaced J/ψ
  - precision measurement of open charm spectra
- Physics case for open beauty, open charm
  - pp: detailed tests of initial hard-scattering processes
  - pA: gluon structure function in A, multi-step processes
  - AA: possible production in pre-equilibrium stage
    - probes earliest/hottest stage of reaction
    - energy-loss of heavy-quark different than light-quark
      - recoil less during gluon bremsstrahlung
    - open charm provides baseline for J/ψ

Strawman Detector: 2001

Each Si layer, 1% radiation length {detector, cooling, support}



GEANT

* **pixel barrels**
* **strip barrels**
* **pixel disks**

endcap, pixels
4 circular disks
z=16, 23, 30, 37cm
1.2 < |η| < 2.4

- Barrel r = 2.5, 6, 8, 10 cm, -1.2 < η < 1.2

Served purpose, established feasibility (last DC meeting)

matching muon tracks to Si hits

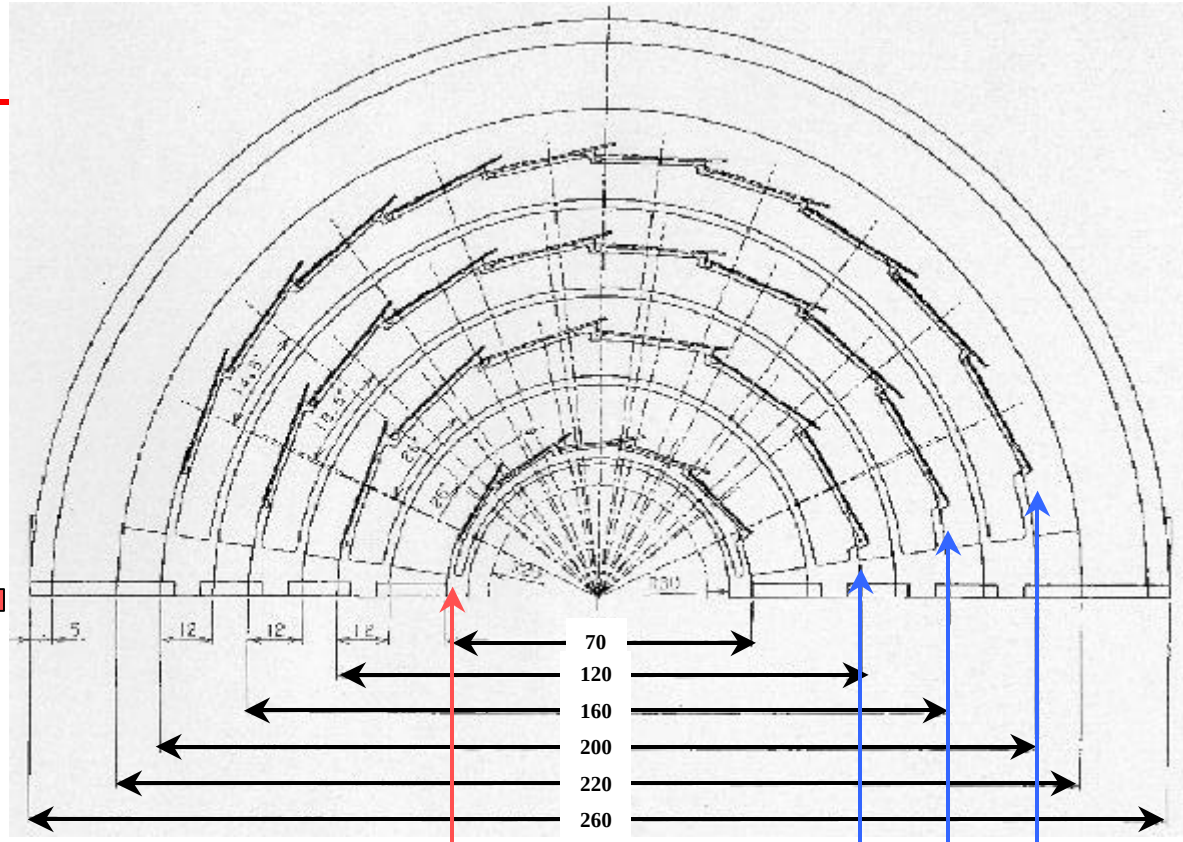
multiple-scattering reasonable for e, μ

D=> hadron decay, possible/borderline

Strawman 2002: In Progress

- Outer two/three layers: Si microstrips, Li from BNL
  - 80μm * (8mm-3cm)
  - test this Spring with analog readout
    - » possibly copy NA60 use of CERN SCTA128VG
  - open issue if final electronics have ADC or just a 0/1 bit
  - r_3 = 8 cm, r_4 = 10 cm
- Inner one/two layers
  - use Si pixels if ready, otherwise Si microstrips
- Endcaps, geometry being revisited
  - what pixel size is really needed for displaced vertices
  - what extent of disk (r) is needed to match with muon arms

Half shell of the silicon detector



pixel layer (r=2.5cm)

strip layers (r=6,8,10cm)

sensor chip: 3cm×6cm
sensor strip: 80μm(pitch)×3cm(length)
(1chip = 375×2strips×2direction)
readout chips on top of the sensor
(12 readout chips for 1 sensor)

Open Beauty Via Displaced J/ψ

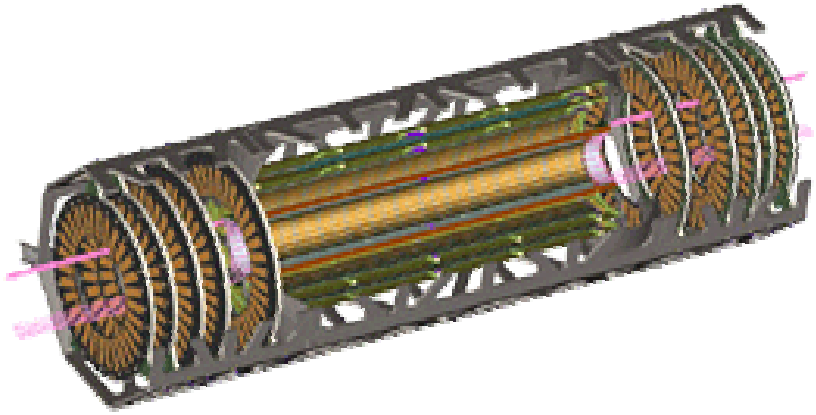
- B cτ ~ 388-449 μm larger than D cτ 120-317 μm
- b-tagging in HE experiments
  - pair of b, $\bar{b}$ each lead to a large displaced vertex
    - » small probability of both c, $\bar{c}$ decaying this far
  - not easily used in HI because of large c, $\bar{c}$ mult/event
- Use instead B -> J/ψ BR ~ 1.3%
  - displaced J/ψ
- Issues
  - rate
  - resolution of displaced J/ψ vertex

B–>J/ψ–> $\mu^+\mu^-$ (Strawman 2001)

- Displaced vertex resolution for reconstructed J/ψ~133μm
- Mean decay length for B ~1.1 mm, or 8 X our resolution!
- Fraction of events passing a 1 mm vertex cut is 39%.
- 2*10**-4 of prompt J/ψ background pass a 1 mm cut
- Mean Pt of J/ψ from B decay is 2.1 GeV/c.
  - further enhance our S/B by just making a Pt cut.
- Rates being looked at

Mechanical/Cooling Constraints

- Contact has been made with hytecinc.com
  - Los Alamos firm
  - experience with rigid, stable, low-mass support
    - » HEP (ATLAS pixel), space applications



Early conversations only,
benefits are experience and speed, save $ in long run ?

Next Steps

- Phenix technical note being prepared
  - summarize work done so far (Strawman 2001)
  - re-use parts for phenix letter-of-intent
- Strawman 2002 being developed for LOI
- Aim to rapidly move to project, funded by RIKEN
  - Si micro-strips, tests this spring
- Steps not really started
  - zero-suppression, have to do this but how and what will final event-size be
  - on-line triggering to get statistics
    - » algorithms from other expts start with outer-tracks match Si hits

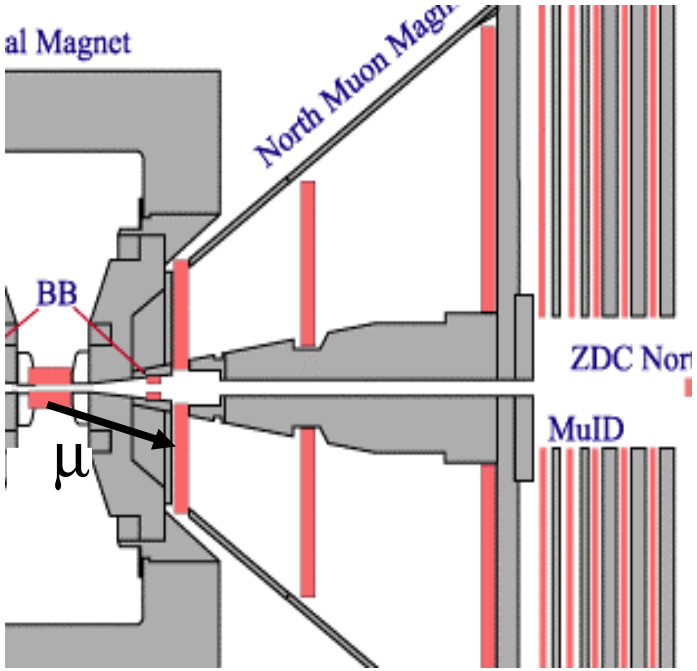
Backup Slides

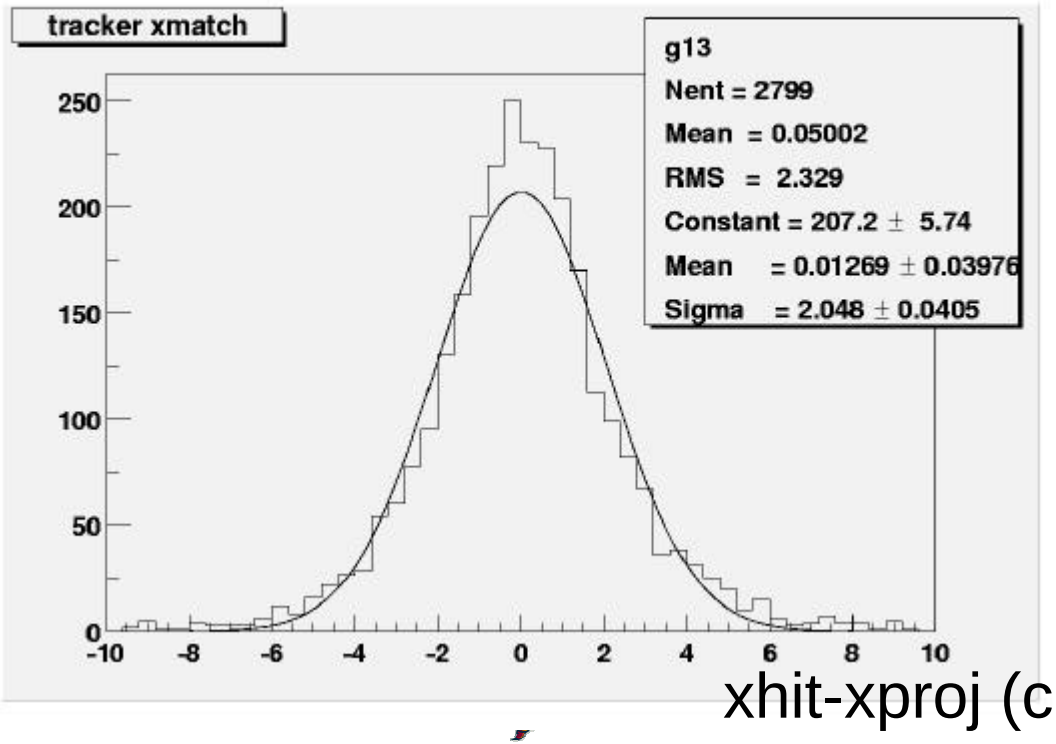
Pixel Hardware Options

- Si Pixel
  - hybrid: two sensor+readout chips bump-bonded
    - SUNY-SB and RIKEN
    - “piggy-back” on NA60/ALICE production
    - chip wafers now in production
    - bump-bonding vendors either booked or $$$$
    - now to be done at VTT, Finland
    - delivery to NA60 2/2002
  - monolithic: one chip sensor+readout
    - e- from epitaxial layer
    - Iowa State, LBNL (STAR)
    - feasibility studies, similar products in optical industry

Matching to Muon Arms

- Match tracklets in Si to muon spectrometer
  - cut on same charge
  - momentum similar to 50% before/after muon shielding
  - match hit within 3σ on first tracking layer

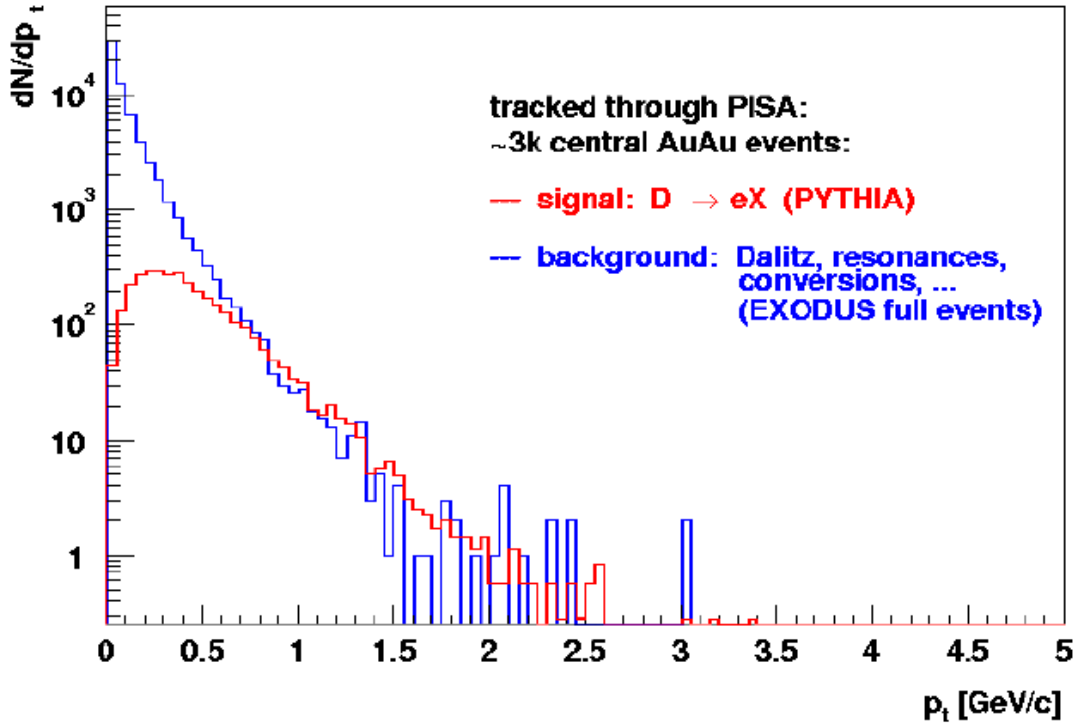




Signal/Background Muons from Charm

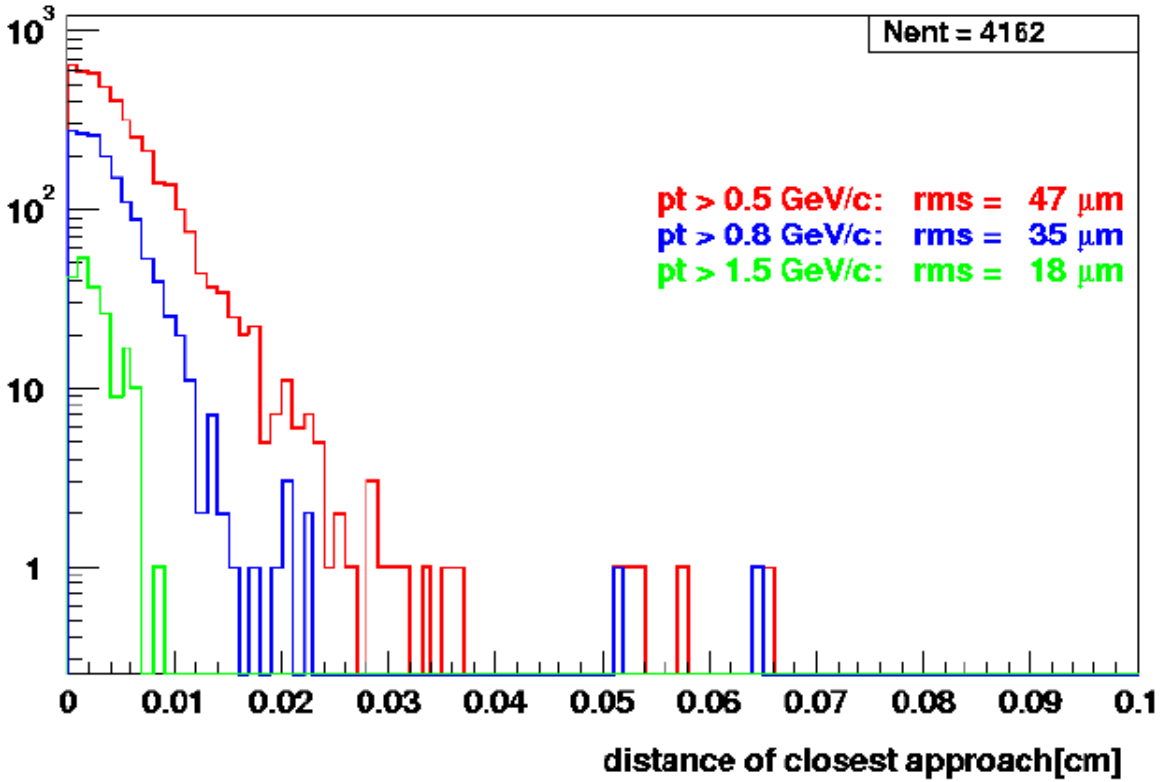
- p+p simulations (in progress)
  - tracklets matched to muon spectrometer
  - DCA resolution to collision vertex ~ 100μm
  - identify displaced decays, candidate μ from D, B
  - D =>μ+X
    - » confirm by having displaced track (X) in coincidence
  - upper cut on decay removes long-lived pion decays
  - (μ from D)/(μ from π)
    - » S/B > 1 for pt > 0.5 GeV/c
  - will enable measurement of spectra of open charm

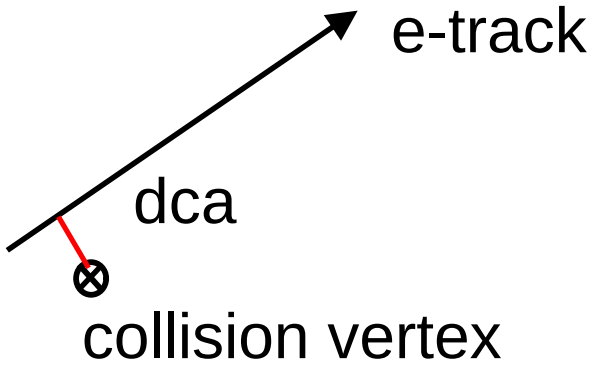
Central Arm:
Electrons from D decay (Au+Au Simulations)



- Without cuts on displaced vertex
  - S/B ~ 1 for high-pt
  - S/B ~ 0.1 pt=0.5 GeV/c

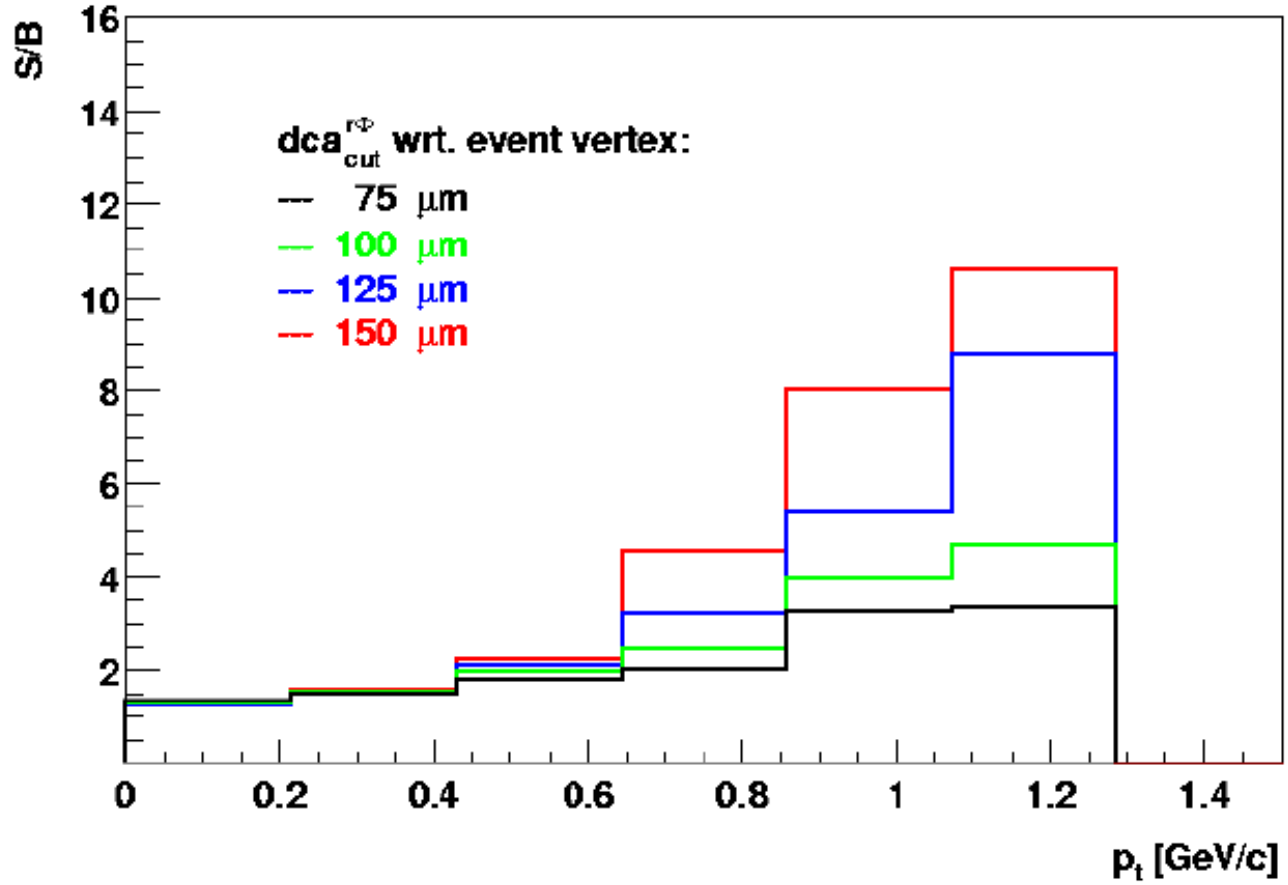
Distance of Closest Approach





50μm x 425μm pixels, full multiple scattering
dca resolution (electrons) < 50 μm
less than cτ, D^0: 125μm $D^{\pm}$: 317 μm

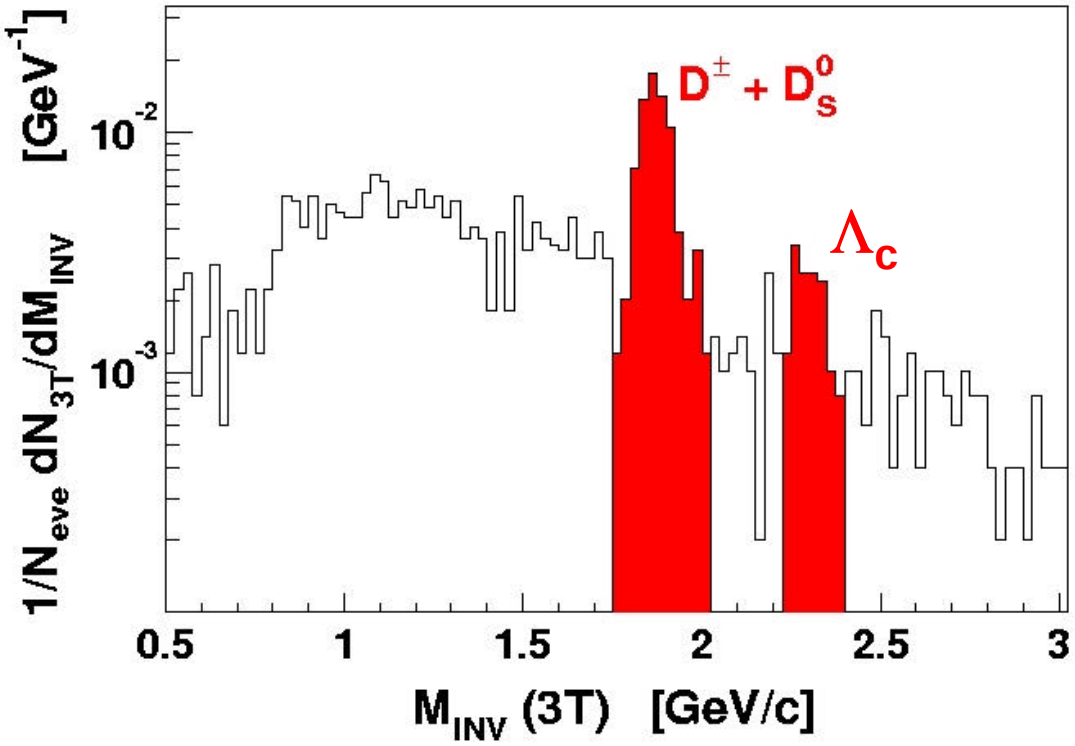
Signal/Background With DCA Cut



- S/B from 2 to 10 => sample largely e from D-decay
  - large momentum range => spectra and yields of D

Hadronic Decays of D

- Construct invariant mass => extract counts => spectra
  - multiple scattering, slow hadrons, makes this very tough



$D^+ \Rightarrow K^- \pi^+ \pi^+$ (BR 9%)
full multiple-scattering
three displaced tracks,
parent points to collision

- Provides 2nd measure of D spectra, consistency with D=>e+X

Vital Statistics

- Total silicon surface area = 1.4 m^2
- Barrel pixels 5M
- Barrel strips 50K
- Endcap pixels ~ 12M
- Requires zero suppression
- Two estimates of data volume per central event
  - hit channels (real+background) => 80K channels
  - 97% zero suppression => 500K channels
- No discussion yet on trigger possibilities