Quick estimation on ILD Calibration

Manqi Ruan

Outline

- Calibration:
  - DHCAL & SemiDHCAL: study the efficiency and multiplicity of a MIP ~ low threshold setting
  - ECAL & AHCAL: represent energy deposition in unit of MIP
- Estimation with different methods
  - Cosmic rays
  - Events with mip track
    - Muon events at Z threshold (Xsec(ZThr)>>Xsec(Nominal))
    - MIP tracks in hadronic shower
  - Beam halo: calibration in the forward region
  - Radiative gas
- Summary

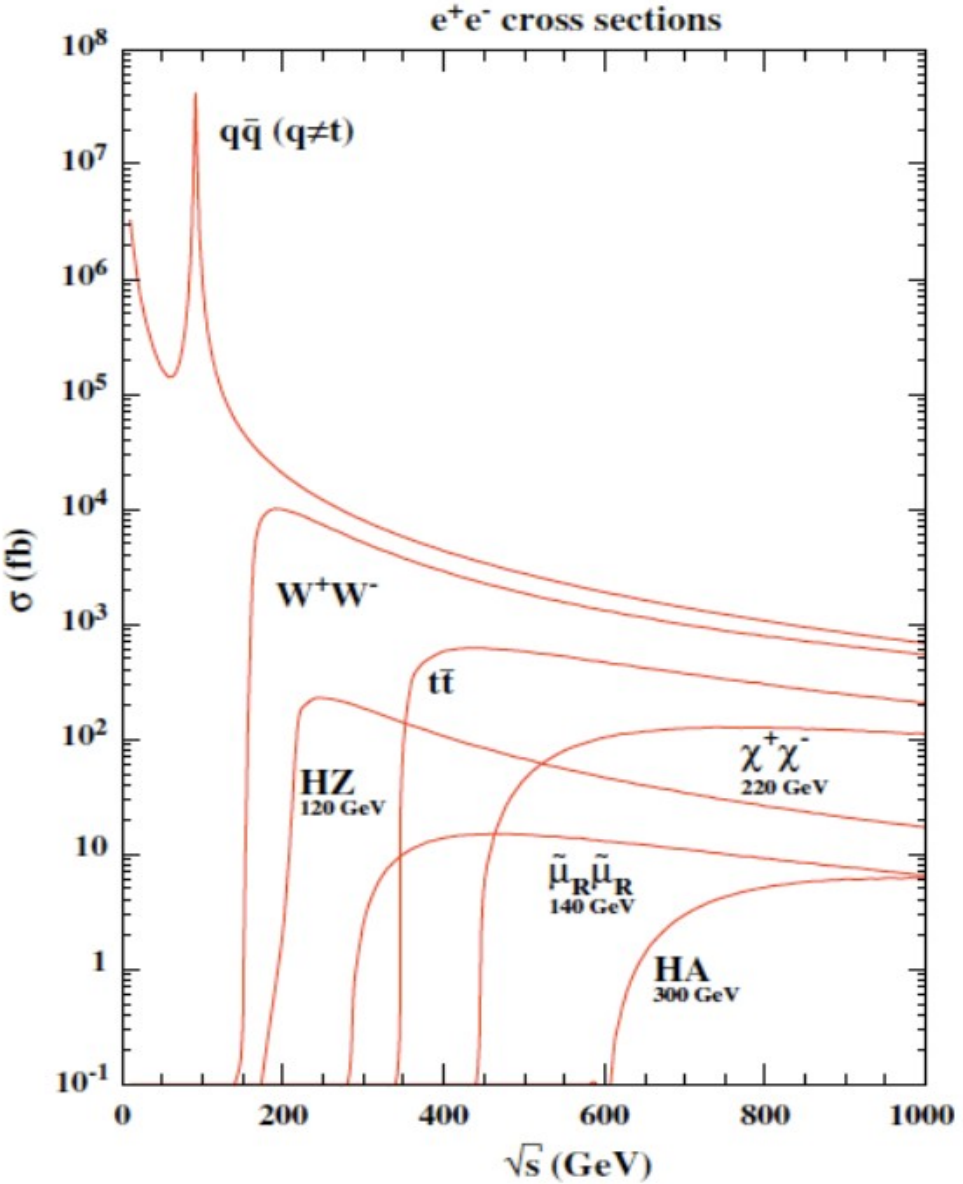
Cosmic rays

- Calibration after construction:
  - Muon with energy > 1GeV: 1Hits/(cm^2*min) ~ 16 hours to collect 1k hits for each cell at sea level (less time for AHCAL for large cell size)
- Calibration after installation: years of operation!
  - 0.5% electric duty circle ~ 200 times more time!
  - Majority of the cells are not horizontal
  - Detector under ground + tons of iron in the YOKE & Cole: Hit rate reduced by a factor of >2
- Calibration after construct each DHCAL module! ~ Other calibration scenario after installation

Cross section

Comparing to Nominal beam setting:

- GigaZ setting has 20 times less Luminosity ($10^{33}cm^{-2}s^{-1}$ to $2*10^{34}cm^{-2}s^{-1}$) but ~ 3 - 4 order of magnitudes large the cross section
- Run Calibration at GigaZ



Cross section

- Xsec for events with final states muon
  - ee -> mu mu

    Xsec(GigaZ): 2.1M fb ~ 4.2M muon tracks per inv(fb) ~ 200M hits (if each track has 48 hits) ~ 4.2 tracks per second

    Xsec(Nominal): 1194 fb, ISR effect actived
  - ee -> tau tau -> mu + (other particles)

    Xsec(GigaZ): 2.1M fb (tau tau) ~ 2.1M*0.35 = 0.7M muon tracks per inv(fb) ~ 0.7 trk/s

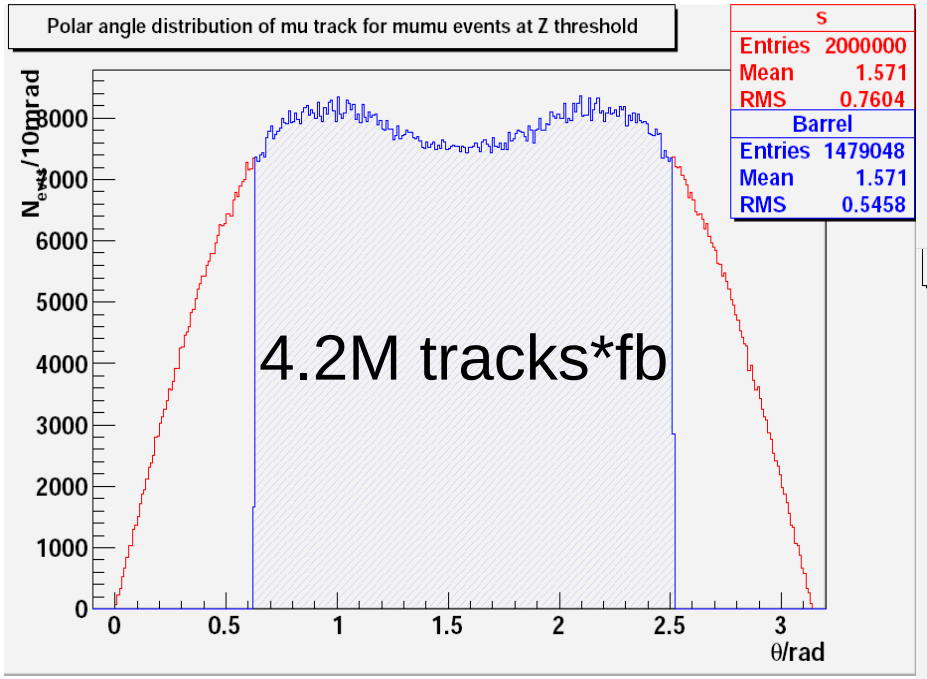
    Xsec(Nominal): 1172 fb, ISR effect actived
  - ee -> bb -> mu + (other particles)

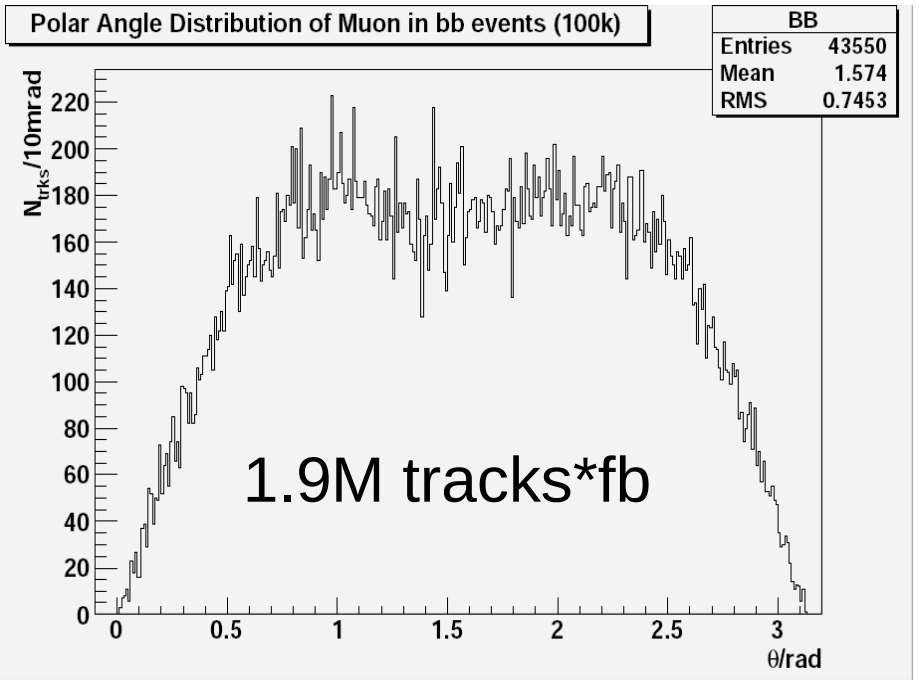
    Xsec(GigaZ): 9.2M ~ 1.9M muon tracks per inv(fb) ~ 1.9 trk/s

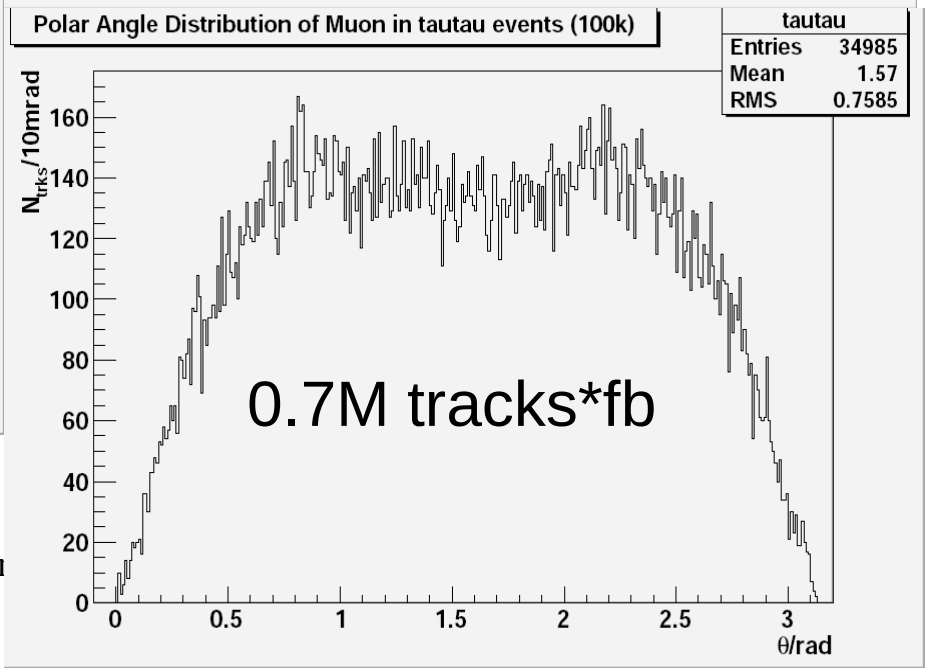
    Xsec(Nominal): 2201 fb. ISR effect actived

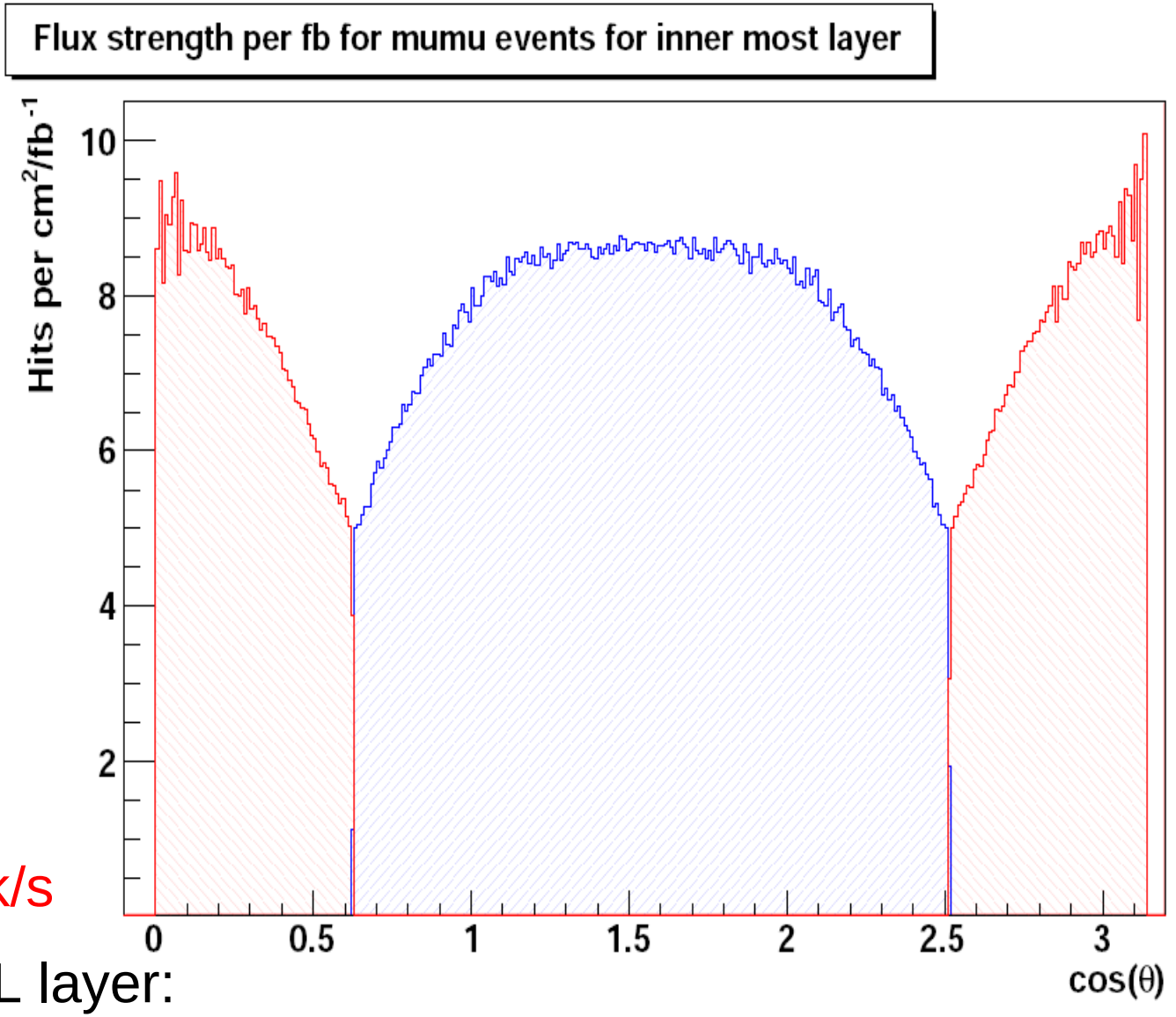
Muon events

Similar muon polar angle distribution





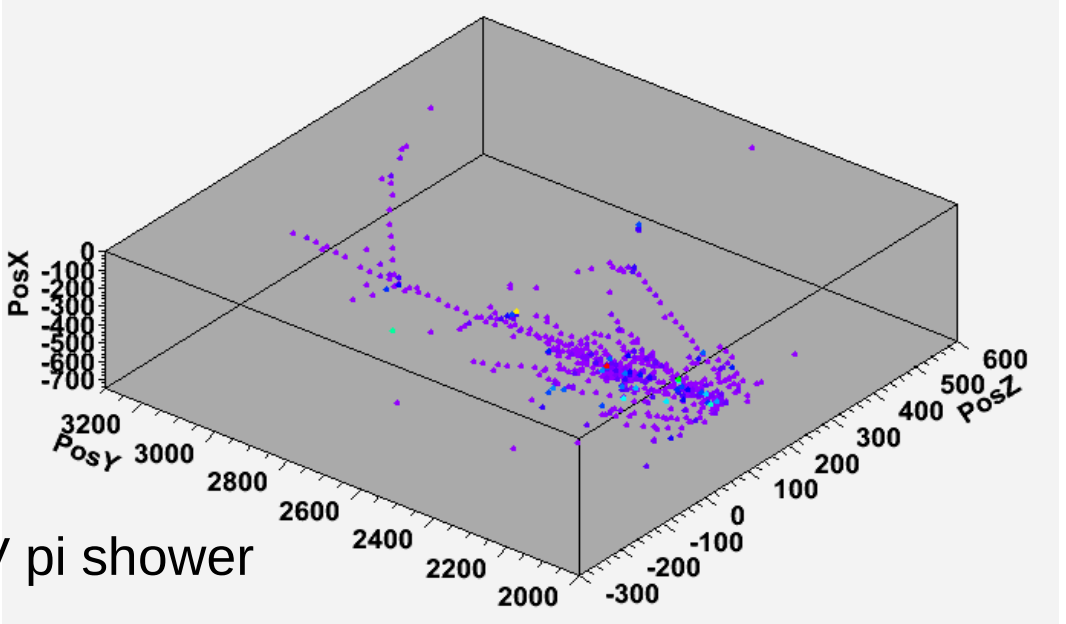




- Track frequency: 6.8 Trk/s
- For the inner most HCAL layer:
  - ee -> mu mu events only: 7 Hits/(cm^2*fb^(-1))
  - ee -> muon + (other particles): 11 Hits/(cm^2*fb^(-1))

MIP tracks in hadronic shower

- Each hadronic shower has at least 1-2 MIP tracks;



100 GeV pi shower

- At GigaZ point: Xsec(qqbar)~21*Xsec(mu-mu) ~ 2G Mip hits*fb (Suppose for each qqbar events we can reconstruct 50 Mip hits);
- Together with muon events: 9 months to collect 1k hits/cm^2
- Original idea: Frank Simon: ILD HCAL Calibration with Track Segments in Hadron Showers 20.02.2009

Beam Halo Muons

- With different method of muon shielding, our friends in the BDS & Magnetic group is trying to reduce the Beam Halo muon density by orders of magnitude

- Their goal is to reach 10μ /200bunches ~ 660μ /s from the tunnel

- Ideal source for EndCap Calibration!

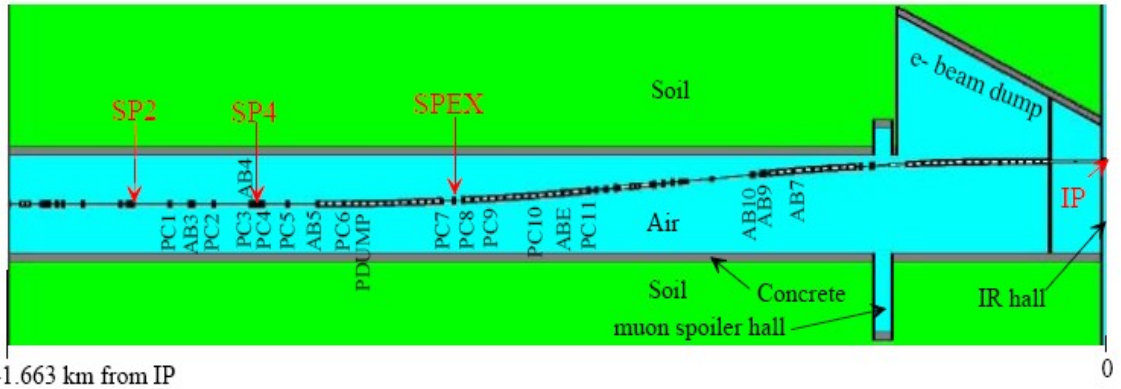
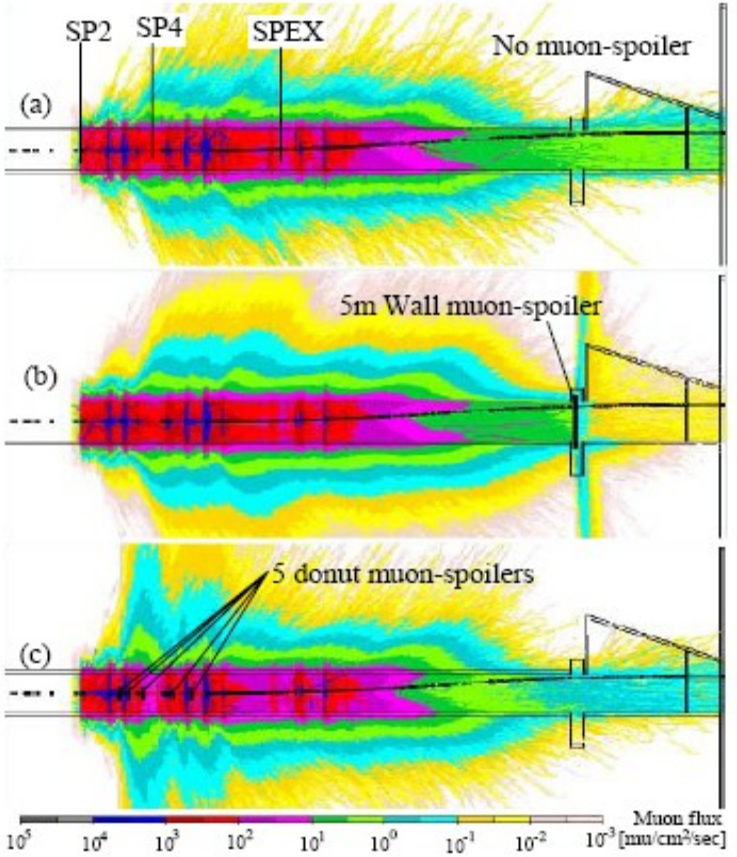


Figure 3: A top view of the BDS tunnel with the entire beam line described in MARS15 simulation. Three beam-loss locations at primary collimators(SP2, SP4, SPEX) are shown. The locations of protection collimators(PC) and absorbers(AB) are also shown.



350m from IP

Figure 6: Two dimensional distributions of total muon flux for (a)no, (b)wall and (c)donut muon-spoiler cases.

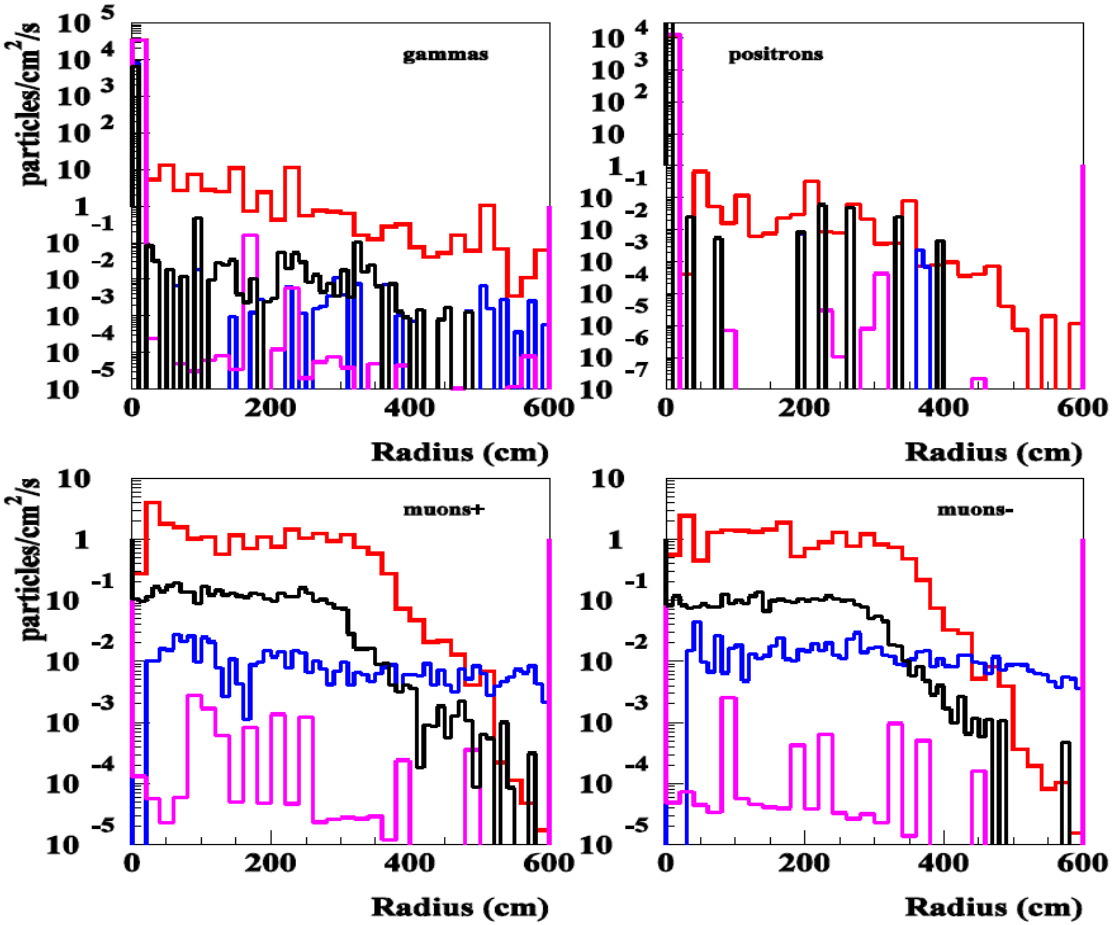
Beam Halo Muons

Particle Fluxes ($cm^{-2}s^{-1}$) at SiD from e^+ BDS

- DHCAL EndCap Outer Radius: 338.2cm ~ Area: 36 m^2 ~ 300 Trks/s for Nominal beam with best shielding

Red lines: no shielding
Magenta: 9m + 18m walls
Blue: 5m wall
Black: Five 4-m doughnuts

OK with a safety margin



Radiative Gas

- Characteristic energy spectrum
- Check the Geometry Uniformity
  - Small fraction of radiative gas during run time allow us to check uniformity on time
- High Hit Rate: (f, radiative gas fraction; τ, half life time)

$$Rate = ln2\frac{V_{chamber}N_A f}{V_0 \tau} = 2.24 * 10^{18}\frac{f}{\tau(s)} Hz/cm^2$$

Radiative Gas

- Considering the electric duty circle, only 1/200 of hits could be detected ~ we still could have large hit rate!
- Gas candidates:
  - Xe133: ~100 keV β decay; τ = 4.5*10^5 sec
    - Event Rate: $2.4*10^{10}*f$ Hz/cell
  - Rd222: 5.5 MeV α decay; τ = 3.3*10^5 sec
    - Event Rate: $3.3*10^{10}*f$ Hz/cell
  - ...
- Problem: a radiative hit is not a MIP hit! Energy deposition property of radiative hits need to be studied;

Summary

- Cosmic ray: Calibration right after construct each module ~ 16 hours for 1k hits per cell (cm^2)

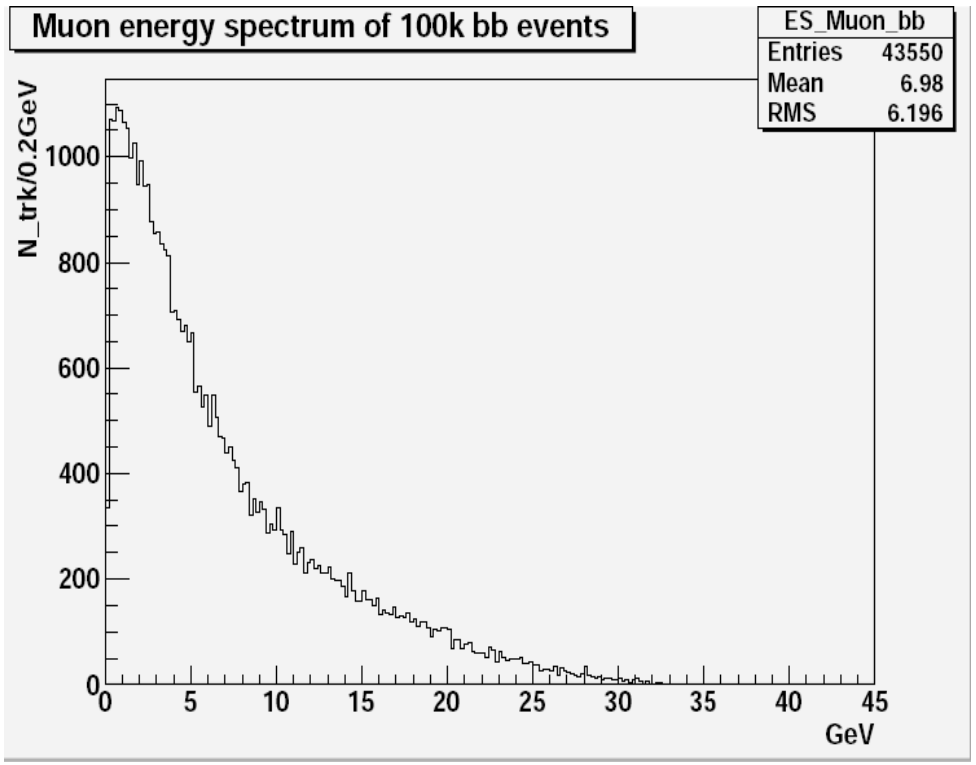
- Machine-based events
  - mu events: ~ 6.8 Trk/s at GigaZ (much lower than the Cosmic ray frequency!);
  - Hadronic shower: ~ 2k Mip hits/s; together with mu events, we need 9 months for 1k hits/cell
  - **Beam hole events:** ~ 300 Trk/s with Nominal Beam & best shielding (10μ /200bunches from 4.5 diameter beam tunnel ~ 660μ /s), only 1 month is needed for 1k hits/cell in the forward region. could be increased by orders of magnitude if turn off muon spoiler ;

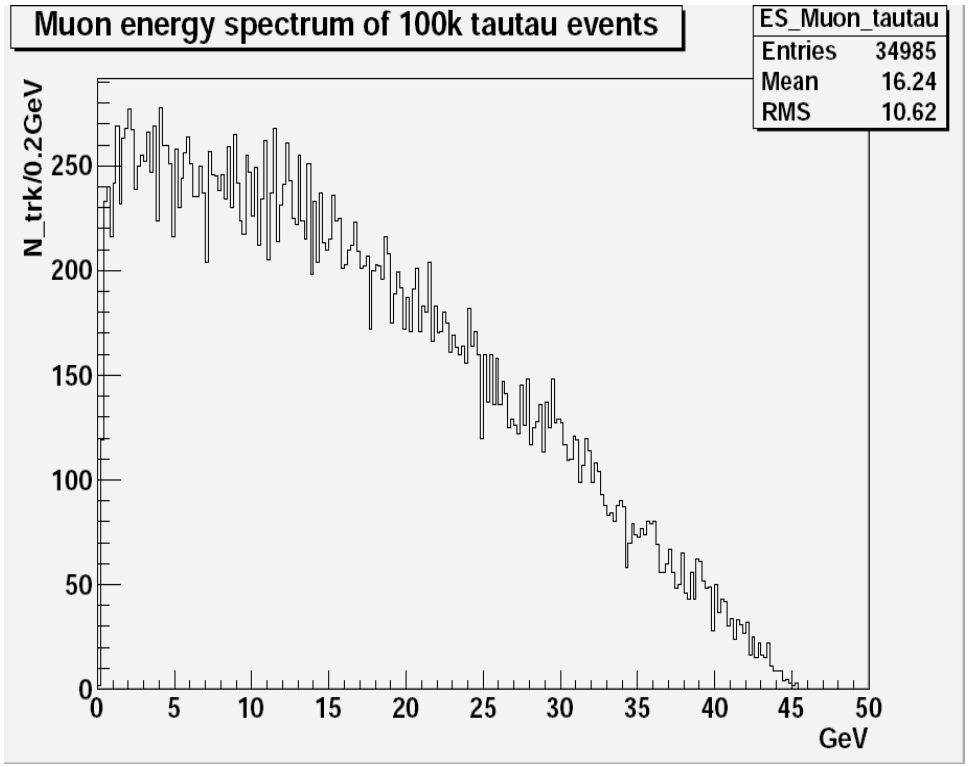
Summary

- Radiative gas method:
  - Could be used during run time for on-time uniformity check
  - Promising & need further study.
- Majority of the hits are MIP hits: thus for ECAL and AHCAL by reading the ADC spectrum per cell, iteration to upgrade the Calibration constant with time is possible

Muon events

B Field: not all the muon tracks could be used for DHCAL Barrel Calibration





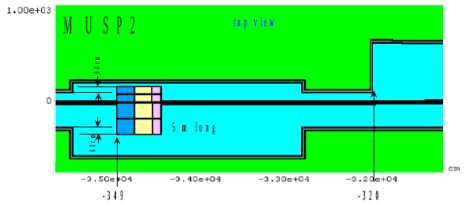
Beam Halo Muons

- With different method of muon shielding, our friends in the BDS & Magnetic group is trying to reduce the Beam Halo muon density by orders of magnitude

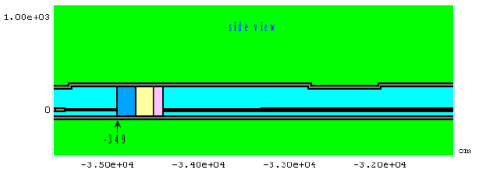
- Their goal is to reach 10μ /200bunches ~ 660μ /s from the tunnel

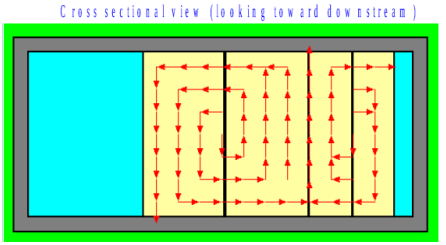
- Ideal source for EndCap Calibration!

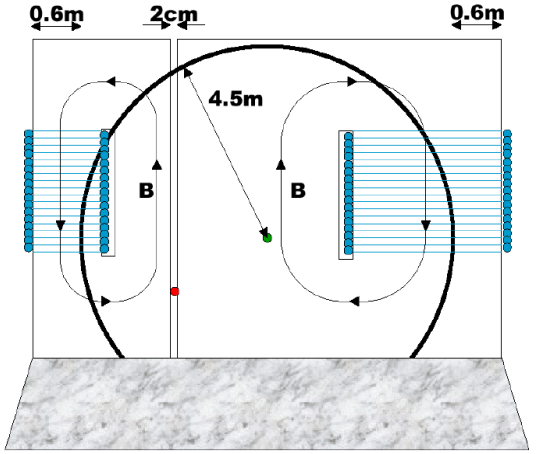
TUNNEL MUON SPOILERS: 9+18 m or 5 m Walls



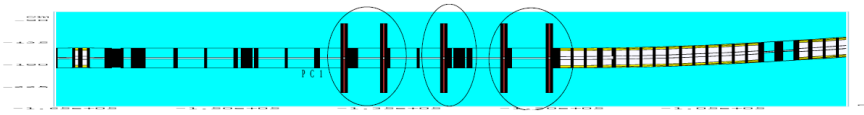
Thick steel 1.5-T magnetic wall sealing tunnel x-section, to spray the muons out of the tunnel

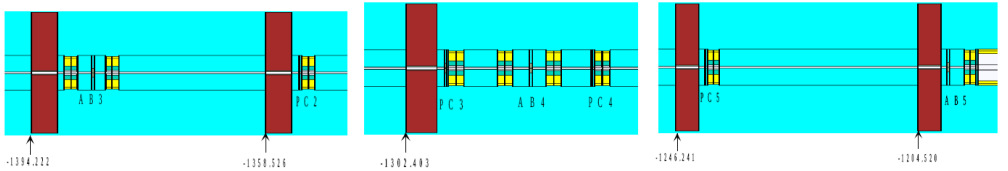


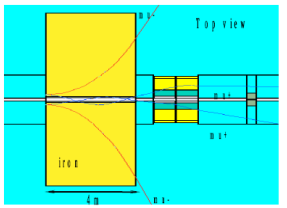


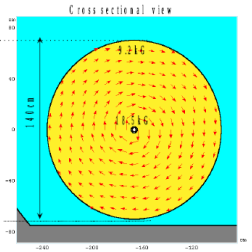


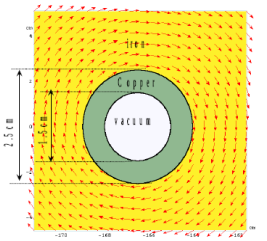
Five 4-m Thick Doughnut Scheme





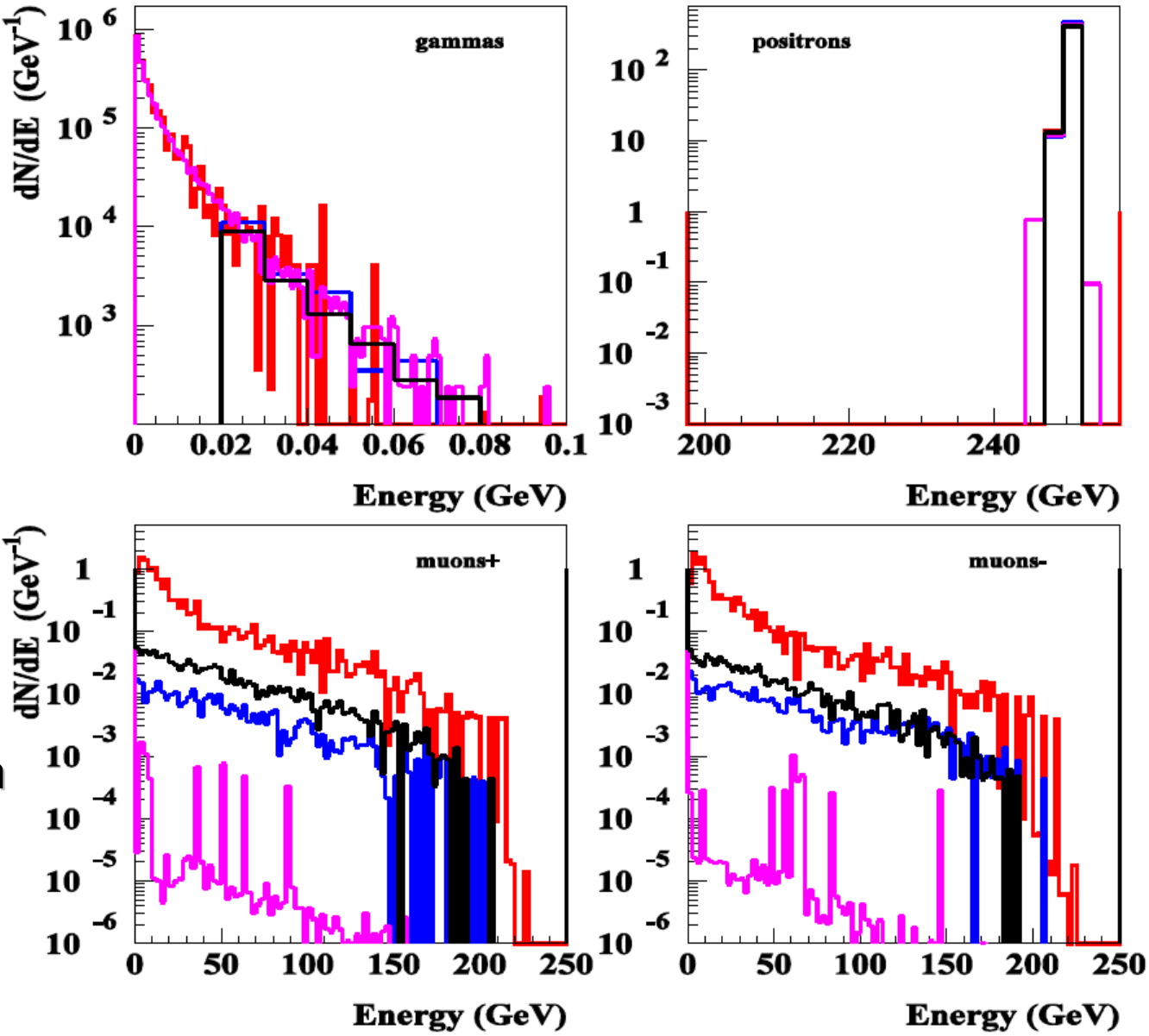




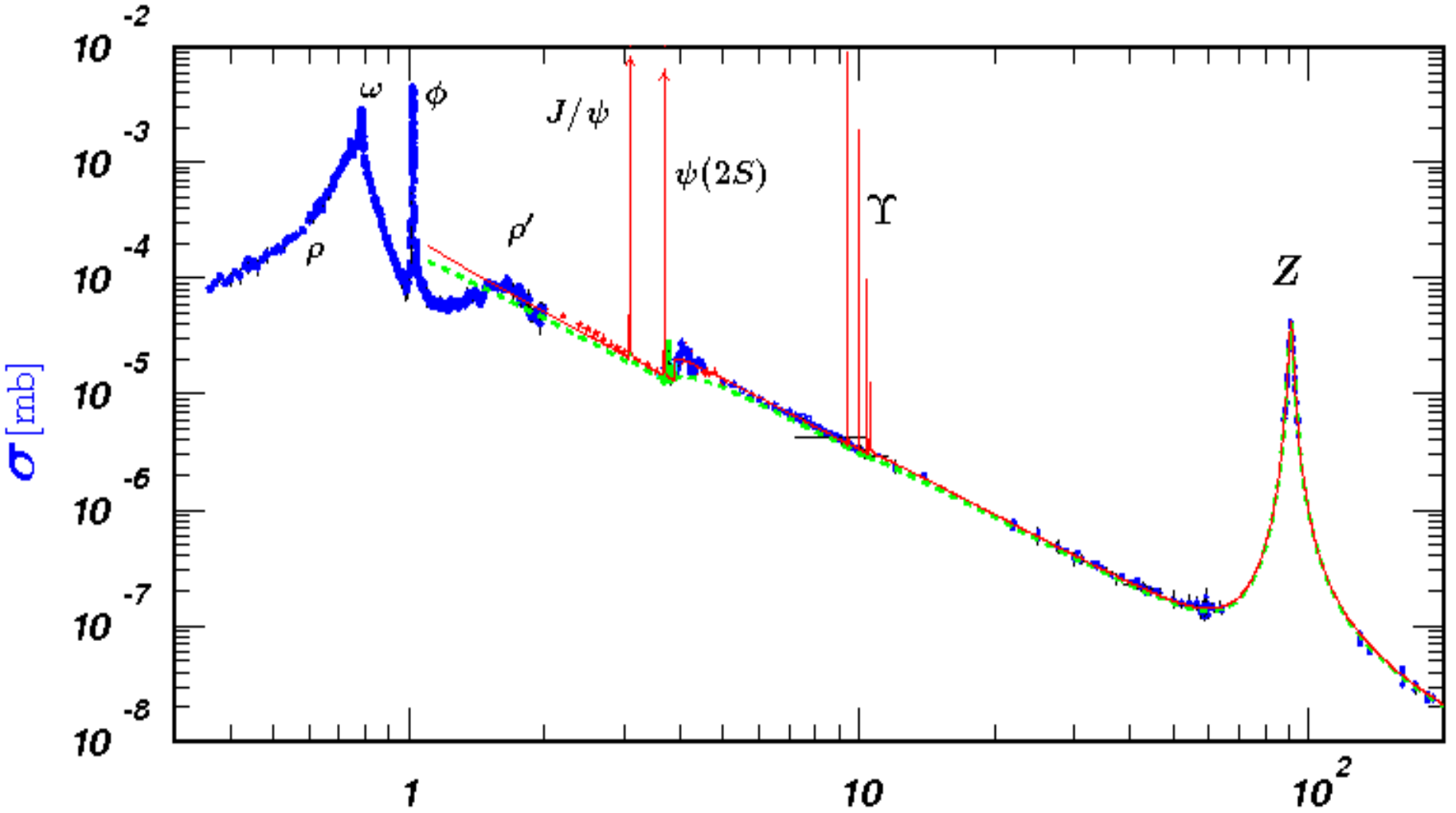


Particle Energy Spectra (per bunch) at SiD from e+ BDS

Red lines: no shielding
Magenta: 9m + 18m walls
Blue: 5m wall
Black: Five 4-m doughnuts



10μ /200bunches
HCAL EC inner radius: 350 mm
Barrel inner radius: 1705,
half Z: 2350


σ [mb]
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
1
10
10^2
ω
φ
J/ψ
ψ(2S)
ρ
ρ′
ϒ
Z