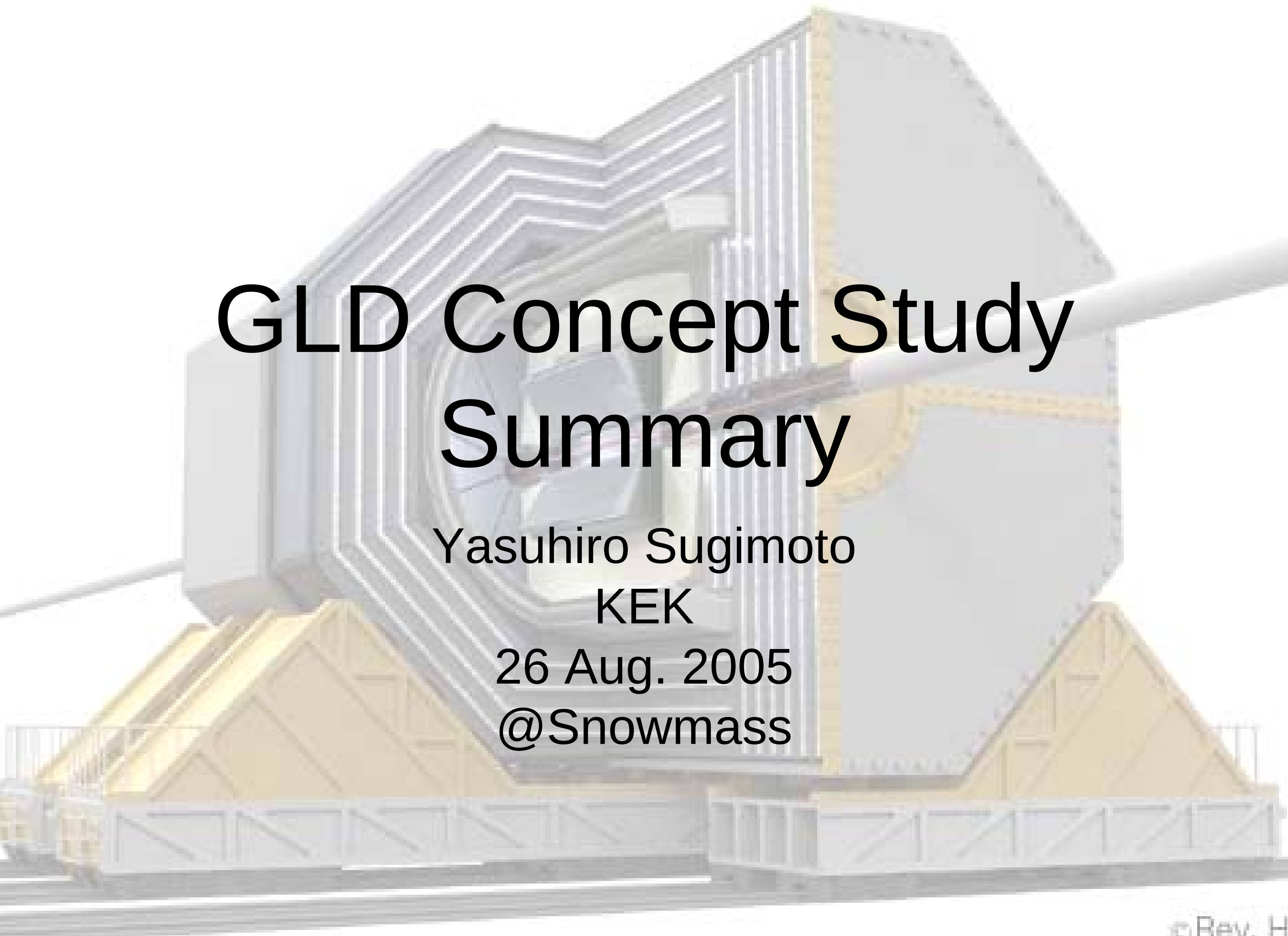

GLD Concept Study Summary

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KEK

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@Snowmass

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  - Study items to be attacked after Snowmass

GLD overview

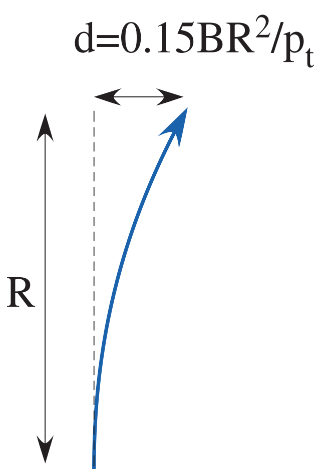
Basic design concept

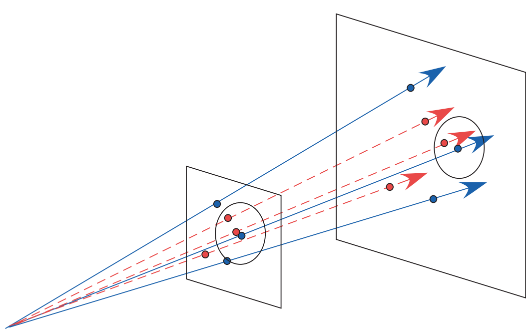
- GLD detector concept
  - Large inner radius of ECAL to optimize for PFA
  - Large gaseous tracker for excellent $\delta p_t/p_t^2$ and good pattern recognition (efficiency for K^0, Λ, and new long-lived particles)
  - Moderate B field of 3T
- PFA: The way to get the best jet E resolution
  - Measure γ, charged hadrons, neutral hadrons in a jet separately
    - γ : by EM CAL
    - Charged hadron : by tracker
    - Neutral hadron : by HCAL

Optimization for PFA is one of the hottest study issue in this workshop

Basic design concept: Optimization for PFA

- To avoid the "confusion" and get good jet energy resolution, separation of particles in CAL is important
- How?
  - Small effective Moliere length (R_M) of ECAL
  - Fine segmentation of CAL: ~R_M
  - High B field
  - Large distance from the IP → **Large Detector**





Often quoted "Figure of Merit":

$$\frac{BR^2}{\sqrt{\sigma^2 + R_M{}^2}}$$

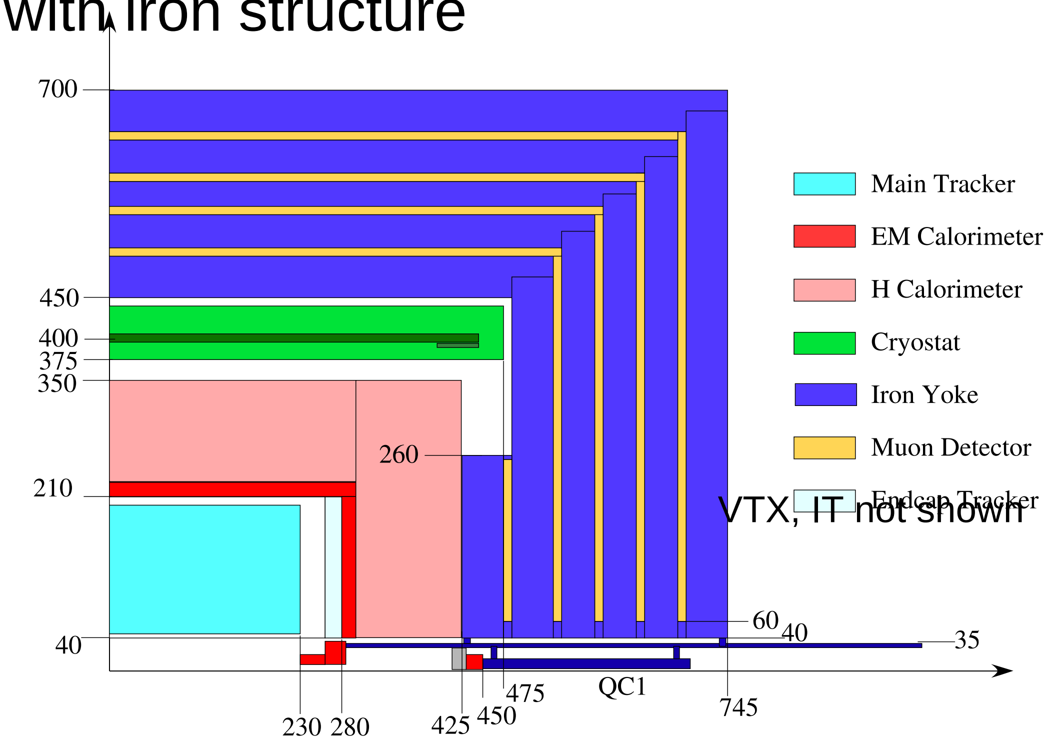
σ: CAL granularity

R_M: Effective Moliere length

GLD Baseline Design

- Large gaseous central tracker: TPC
- Large radius, medium/high granularity ECAL: W-Scint.
- Large radius, thick(~6λ), medium/high granularity HCAL: Pb-Scint.
- Forward ECAL down to 5mrad
- Precision Si micro-vertex detector
- Si inner/forward/endcap trackers
- Muon detector interleaved with iron structure
- Moderate B-field: 3T

The baseline design is just a working assumption. Detailed full simulation and results of R&D could modify the sub-detector technologies.

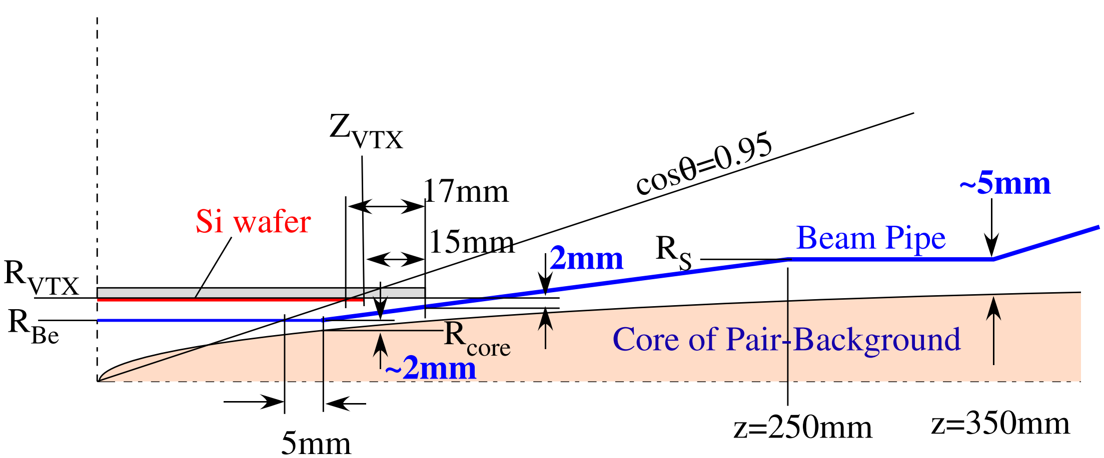


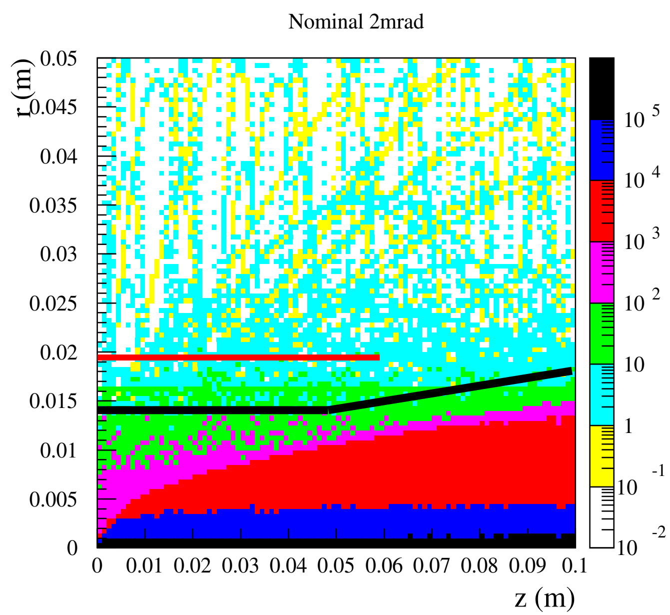
VTX, IT not shown

Machine parameter impact on GLD

Beam pipe/VTX radius

- Minimum radius of the vertex detector has been calculated based on a consideration of direct pair-background hits on beam pipe
- R_{VTX} has a strong dependence on machine parameter set: High Luminosity option requires larger R_{VTX} than Nominal option by 5 mm or more for all detector concepts
- Andrei's new parameters for High Luminosity option are very preferable from the viewpoint of background. His approach should also be applied to 500 GeV case if possible



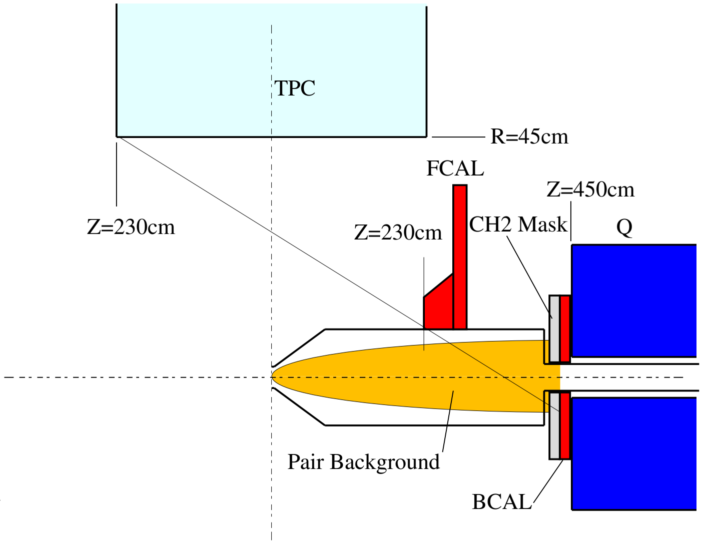


R_{VTX} v.s. Machine param.

ECM (GeV)	Option	B (T)	R_{core} (mm)	R_{Be} (mm)	R_s (mm)	R_{VTX} (mm)	Z_{VTX} (mm)
500	Nominal	3	10.5	12.5	30	16.6	52.4
		4	9	11	28	14.9	47.4
		5	7.5	9.5	25	13.2	42.0
500	High L	3	16.5	18.5	42	24.1	75.4
		4	13.5	15.5	36	20.2	63.6
		5	12	14	33	18.4	57.9
1000	Nomonal	3	11	13	32	17.3	54.7
	High L	3	18.5	20.5	42	25.8	80.5
	High L’	**3**	**13**	**15**	**34**	**19.4**	**61.1**
	High L’’	**3**	**11.5**	**13.5**	**32**	**17.8**	**56.1**
500	**High L’’**	**3**	**11**	**13**	**30**	**17**	**53.7**

BCAL

- Locates just in front of final Q
- Coverage: down to ~5mrad
- Crucial role in SUSY study by tagging e+- from 2-γ background
- Exposed with pair B.G.



500 GeV

Option	θx (mrad)	Edep (TeV/BX)
Nominal	2	20.8
	20	44.3
High Lum	2	119
	20	184
Low Q	2	6.1
	20	15.7

1 TeV

Option	θx (mrad)	Edep (TeV/BX)
Nominal	2	53.9
	20	98.1
High Lum	2	303
	20	416
Low Q	2	16.3
	20	34.9
High Lum-I	2	141
High Lum-II	2	106

High Lum-I, II are Andrei's new param.

DID impact on GLD

- 20 mrad + DID option
  - Backscattering from BCAL hits Si Inner Tracker (R~9cm)
    → May be ok by changing R_{IT}
  - DID disturbs field uniformity in TPC volume
    → May be ok by field mapping and calibration run at Z-pole
    - ➔ Need more study

Map B-field to ~ 1 x 10-4 in the LC TPC (goal)
5 x 10-4 in the Aleph TPC (achieved)

$$\frac{\delta B_{r,\varphi}}{B_z} \simeq \frac{\delta h}{\ell_{TPC}} \simeq \frac{\sigma_0}{\ell_{drift}}.$$

~ 1.5 x 10-5 goal for the LC TPC
3.5 x 10-5 achieved for the Aleph TPC

Luminosity requirement on Z pole

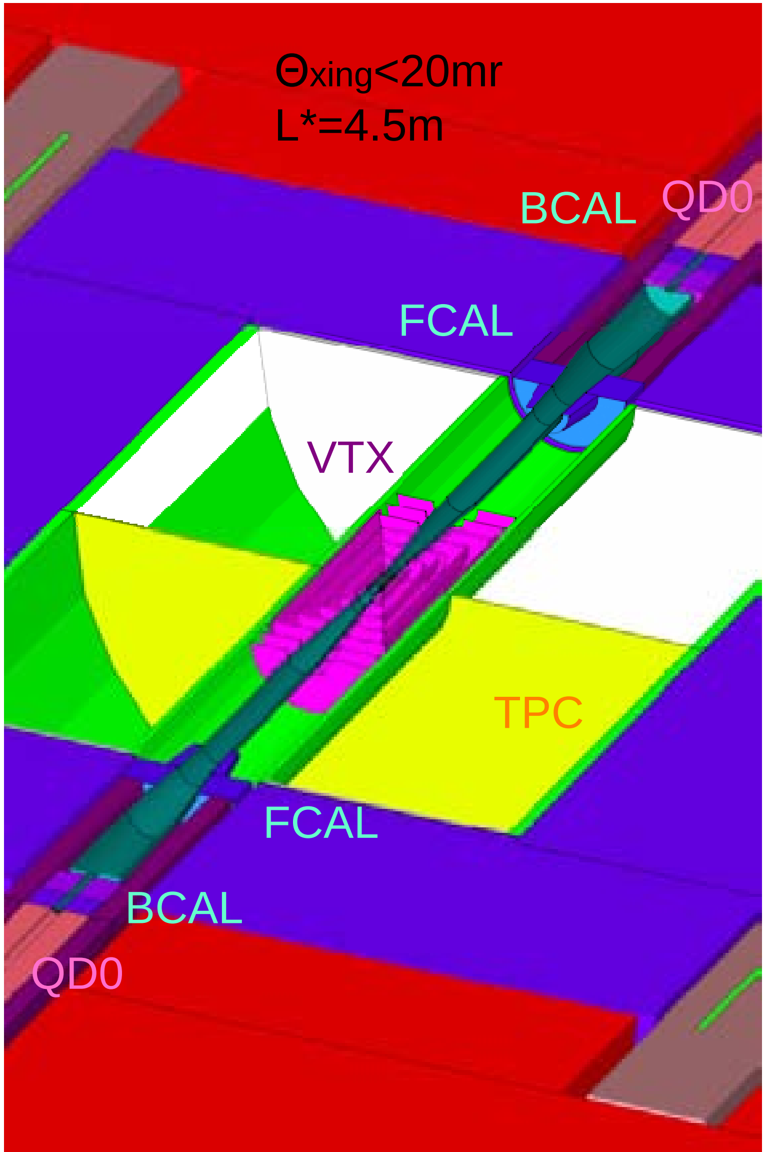
- TPC and CAL require >10pb^{-1} per run-period for calibration
  - TPC: From the experience at LEP-II
  - CAL: To get 100 muons per segment (scintillator strip)

  ➔ Machine should deliver >10pb^{-1} within few days

Progress at Snowmass towards baseline design

IR and background study

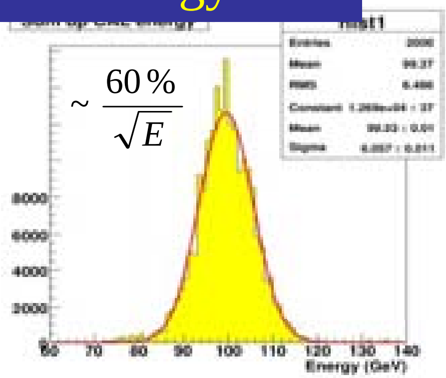
- Background simulation by JUPITER and LCBDS
  - Geometries installed at Snowmass
  - Detailed background study will be done for the detector optimization



Study of PFA

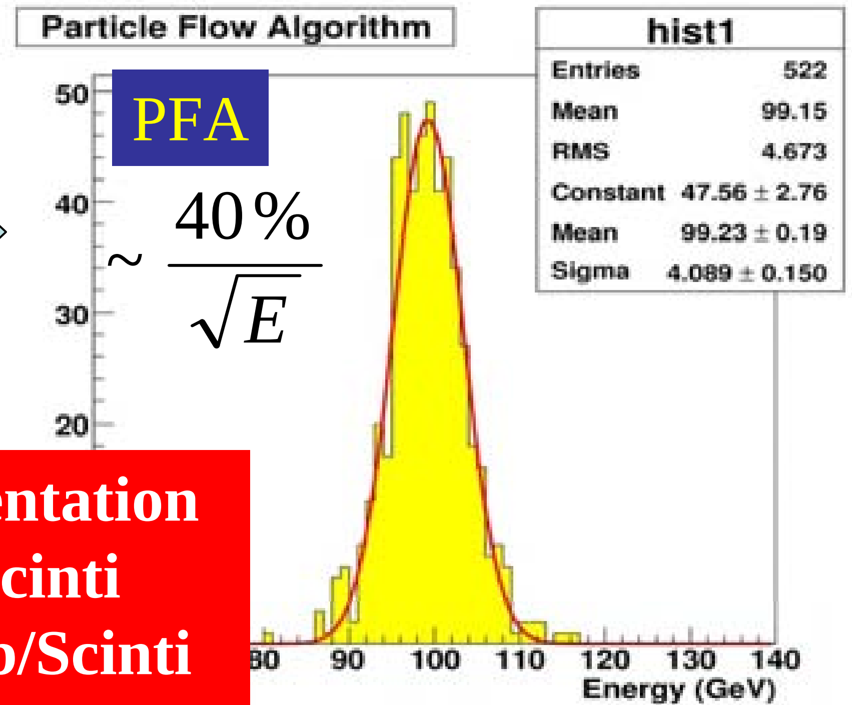
- E-resolution for Z

CAL Energy Sum



$\sim \frac{60\%}{\sqrt{E}}$

PFA

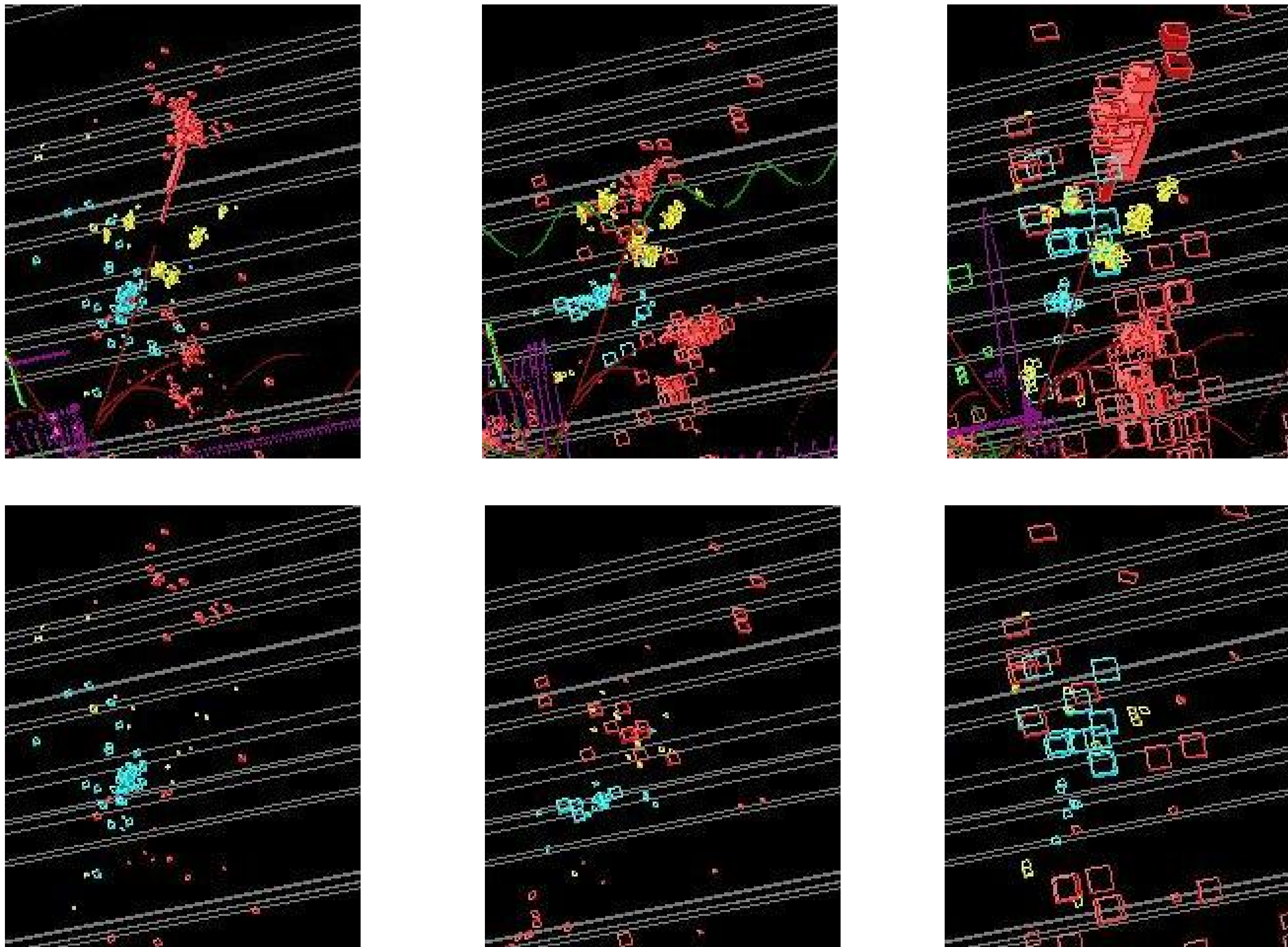


$\sim \frac{40\%}{\sqrt{E}}$

With reasonable segmentation
ECAL 4cm x 4cm Pb/Scinti
HCAL 12cm x 12cm Pb/Scinti
And simple/robust algorithm
→ ~40% resolution is achieved.

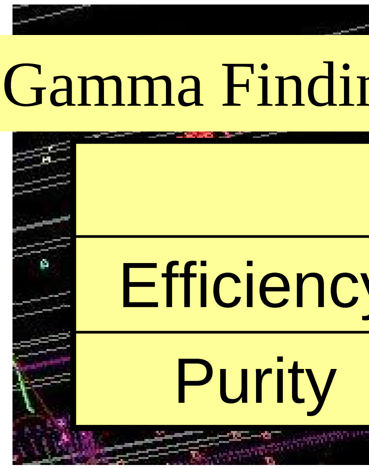
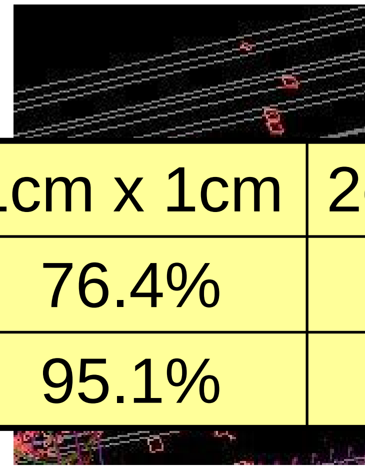
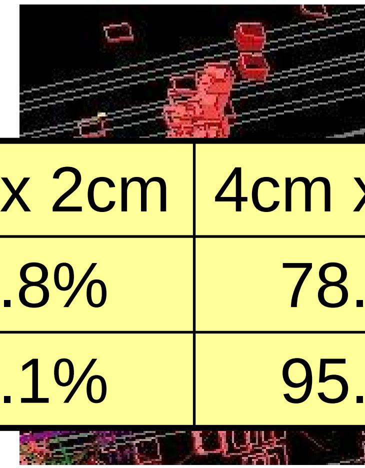
PFA: Granularity Study

	1cm x 1cm	2cm x 2cm	4cm x 4cm
before			
after			



PFA: Granularity Study

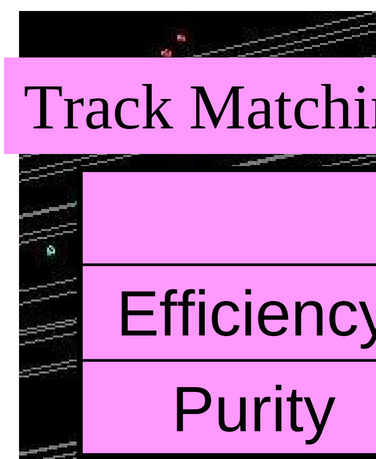
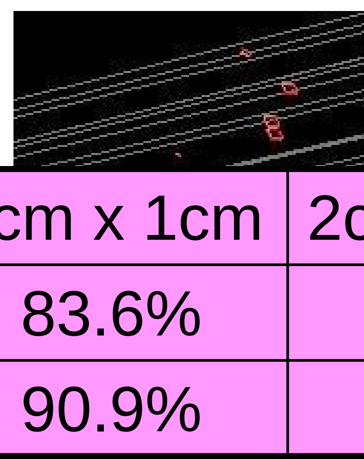
1cm x 1cm | 2cm x 2cm | 4cm x 4cm

Gamma Finding

before

	1cm x 1cm	2cm x 2cm	4cm x 4cm
Efficiency	76.4%	78.8%	78.4%
Purity	95.1%	95.1%	95.2%


Track Matching

after

	1cm x 1cm	2cm x 2cm	4cm x 4cm
Efficiency	83.6%	84.1%	84.2%
Purity	90.9%	91.7%	91.2%

PFA

Performance of Gamma finding and Track matching show almost no granularity dependence – a big puzzle

Next Step

-Obtain energy dependent calibration factor (first priority).

- Improve gamma finding method.
  - → Modify small clustering.
  - → Remove low momentum hadrons.
  - → Try H-Matrix method.
- Improve track matching method.
  - - MIP finder.
  - - Improve track matching purity for low momentum(< 1GeV). track.
- …

Optimization of sub-detectors

- VTX
  - Study of R_{VTX} from B.G. consideration
  - Input from physics requirement (R_{VTX} impact on vertex charge determination) → Importance of small R_{VTX} has been stressed
- Si trackers
  - Barrel Inner Tracker: Long or short strip? → Impact on bunch ID capability
  - Forward Inner Tracker: Geometry for the baseline design determined → to be put in the simulator

Optimization of sub-detectors

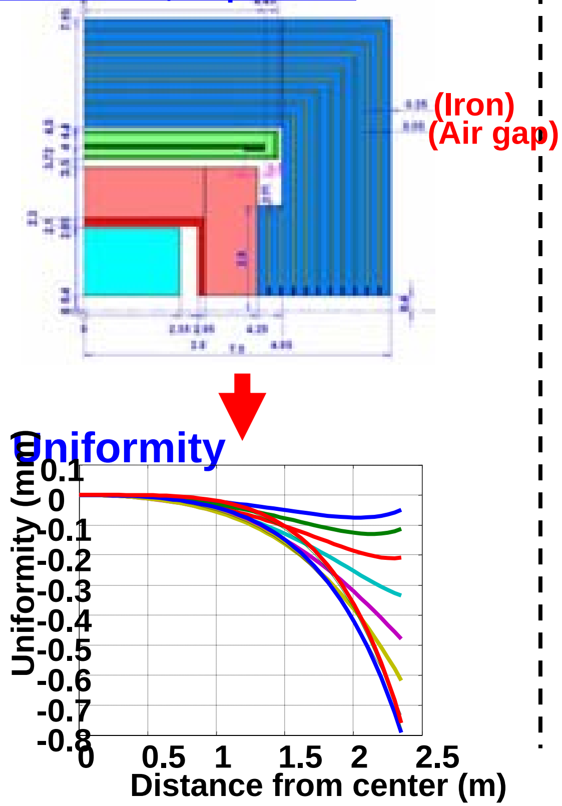
- Muon detector/
  Iron yoke

Study of x2 and x4 more layers configuration

➔ B uniformity still OK

Iron=25cm, Gap=5cm

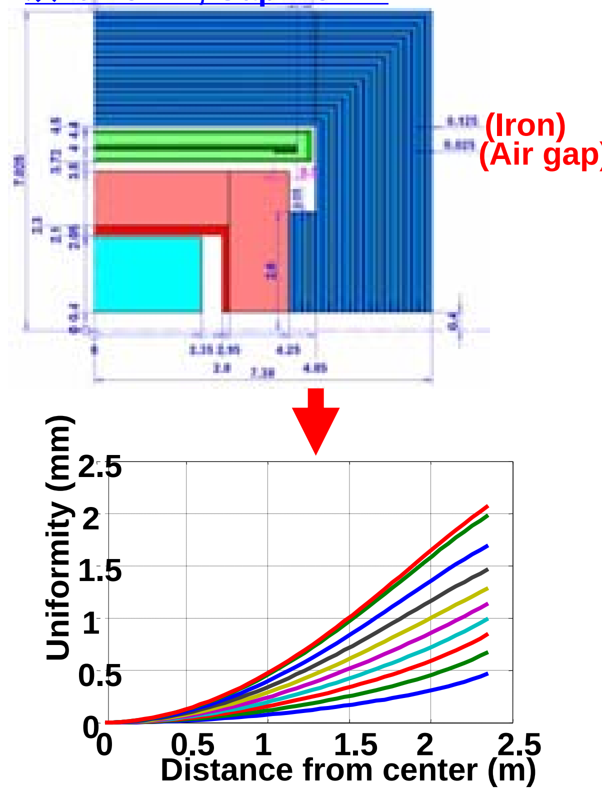
鉄: t250mm, Gap=50mm



Unif.= -0.8 ~ -0.05 < 2mm

Iron=12.5cm Gap=2.5cm

鉄: t125mm, Gap=25mm

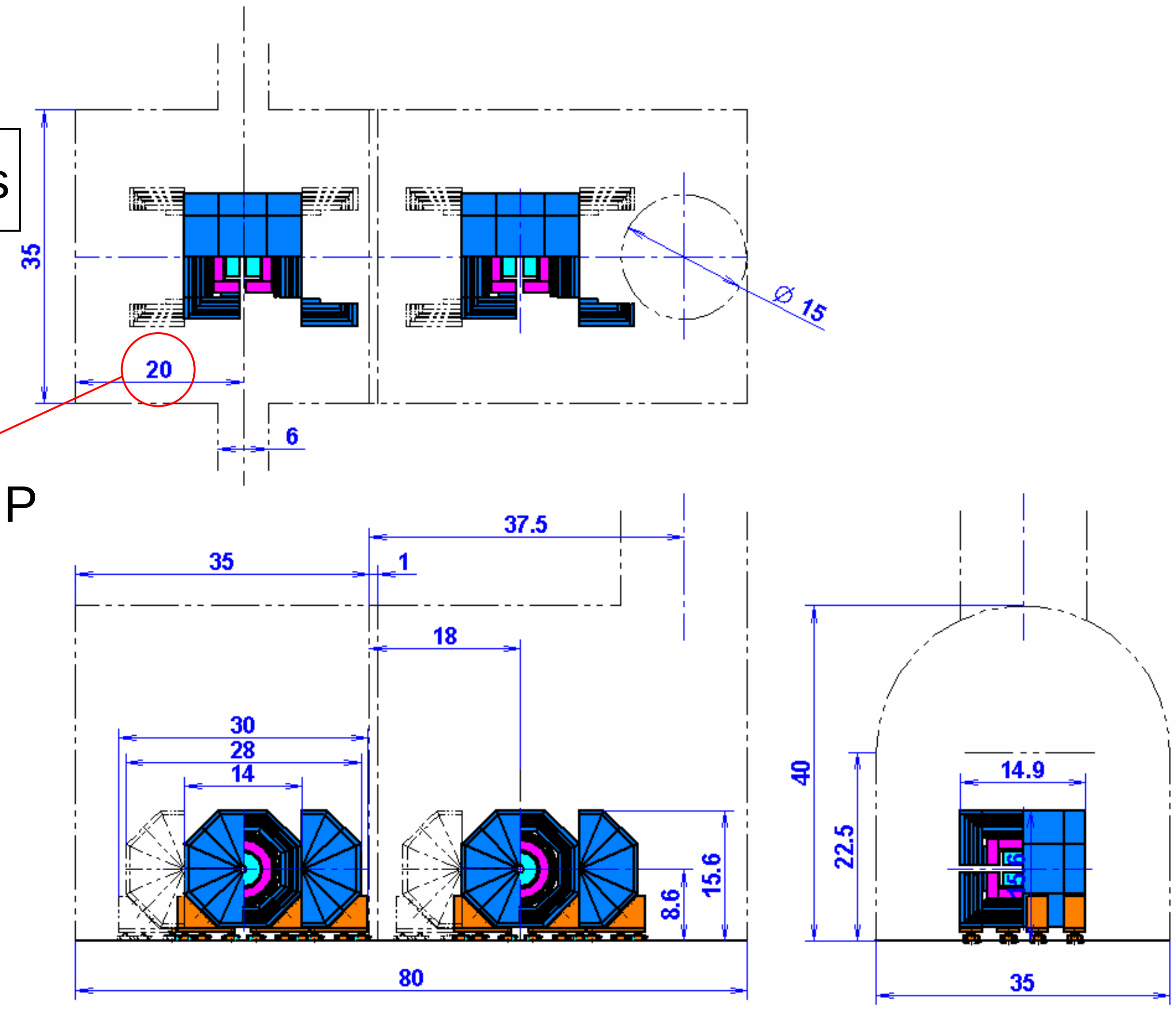


Unif.= +0.5 ~ +2.1

Optimization of sub-detectors

- Design of experimental hall

Before Snowmass

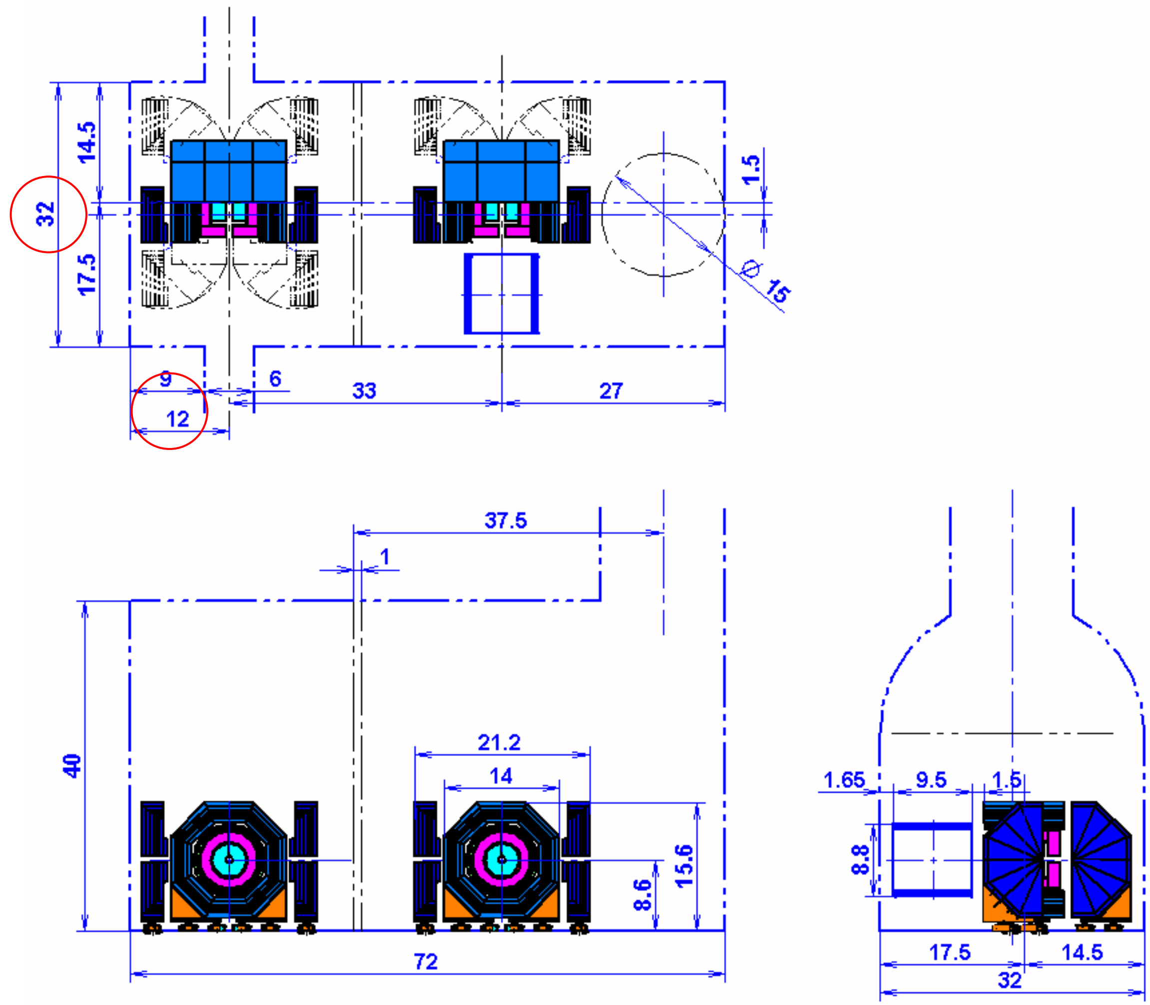


Too long for 2-IP design of acc.

Optimization of sub-detectors

- Design of experimental hole (cont.)

At Snowmass



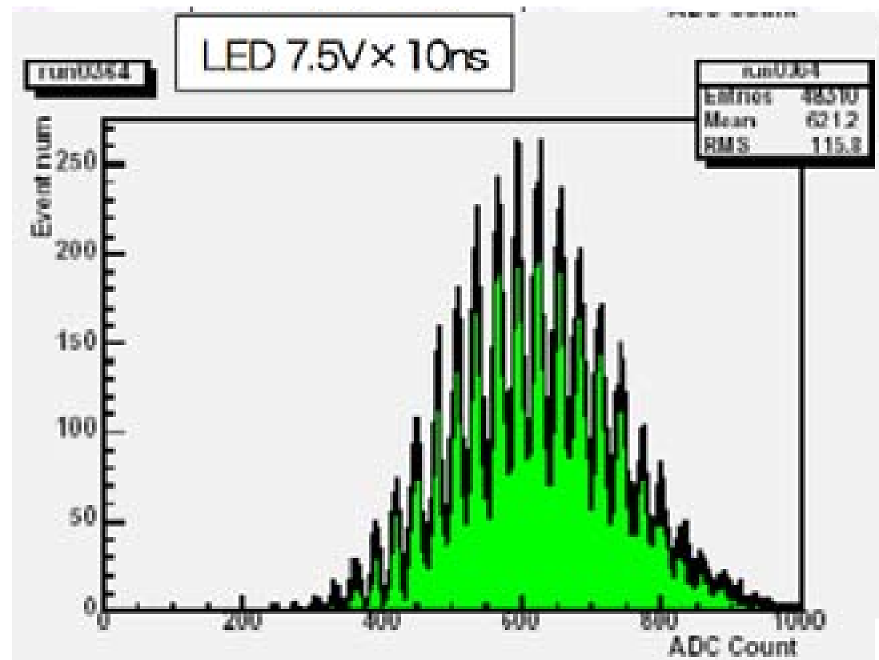
Homework

Critical R&D for GLD

- VTX
  - Sensor development
  - Wafer thinning and the support system
    →Demonstration within 2-3 years
- IT
  - DSSD and SSSD with large wafer
  - FEE for fast shaping (Bunch ID)
- TPC
  - Prove feasibility of MPGD TPC (~1 year)
  - Large prototype (ϕ>75cm, drift>1m) (+3-4 years)

Critical R&D for GLD

- CAL/MU
  - MPC: Large area, Photon-counting with many (>1000) pixels
  - Readout electronics



Spectrum of MPC with 100 pixels

Sub-detectors still to be designed

- Endcap Tracker (ET)
  – Presumably, several Si layers
- FCAL/BCAL
  – Layout is considered
  – But detailed design not exists

New Ideas

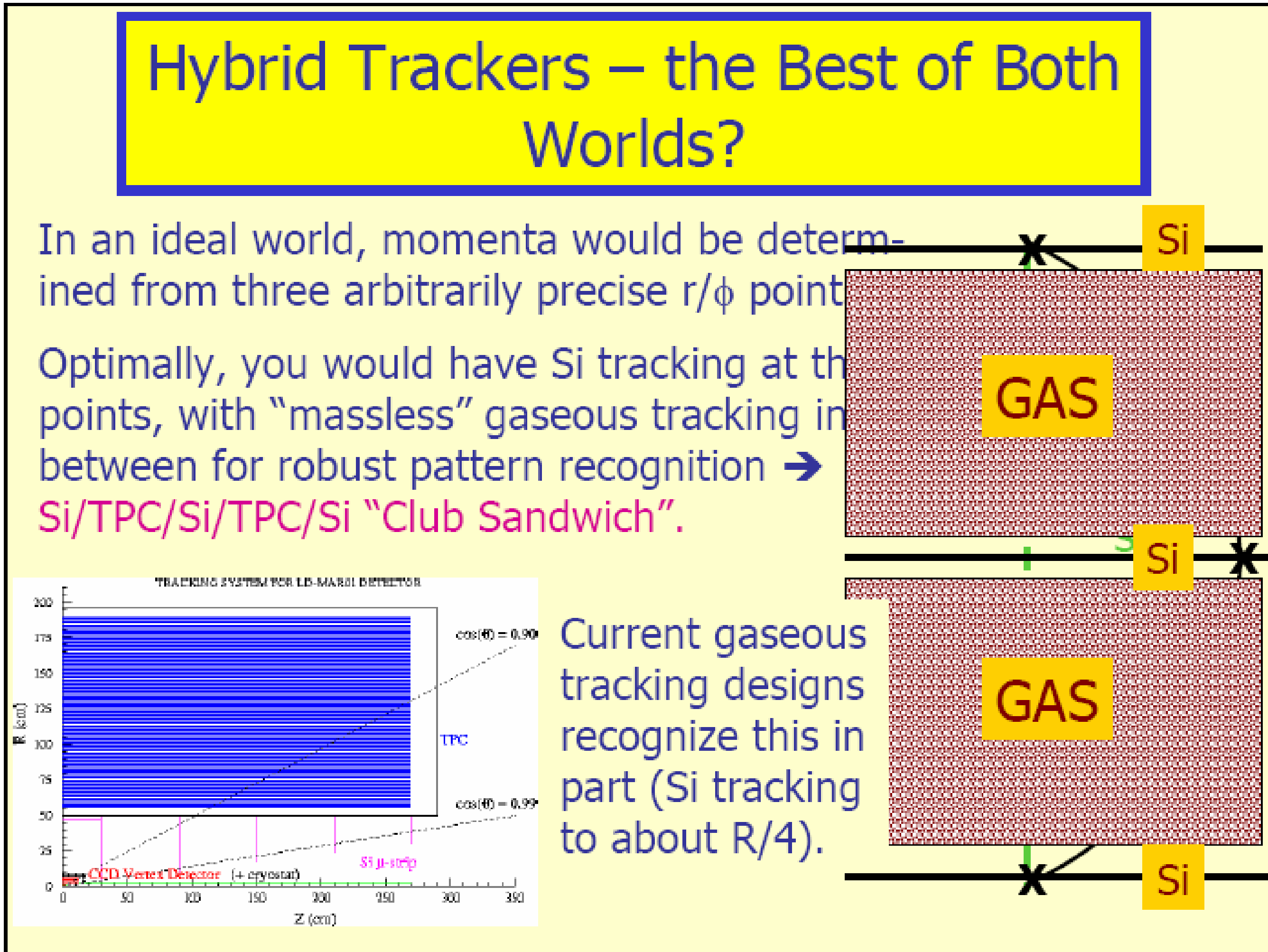
- Proposal of new tracking system at Snowmass
  - Performance goal of tracking system: $\delta p_t/p_t^2=5\times10^{-5}$ ← δM_H in e+e- → ZH, Z→μμ should be dominated by beam E spread and beamstrahlung in old beam parameters
  - With new beam parameters, better momentum resolution can do better physics (Tim Barklow's study)

New tracking systems:

Sandwich (Si-TPC-Si)

Club-sandwich (Si-TPC-Si-TPC-Si)

New ideas: Hybrid tracker



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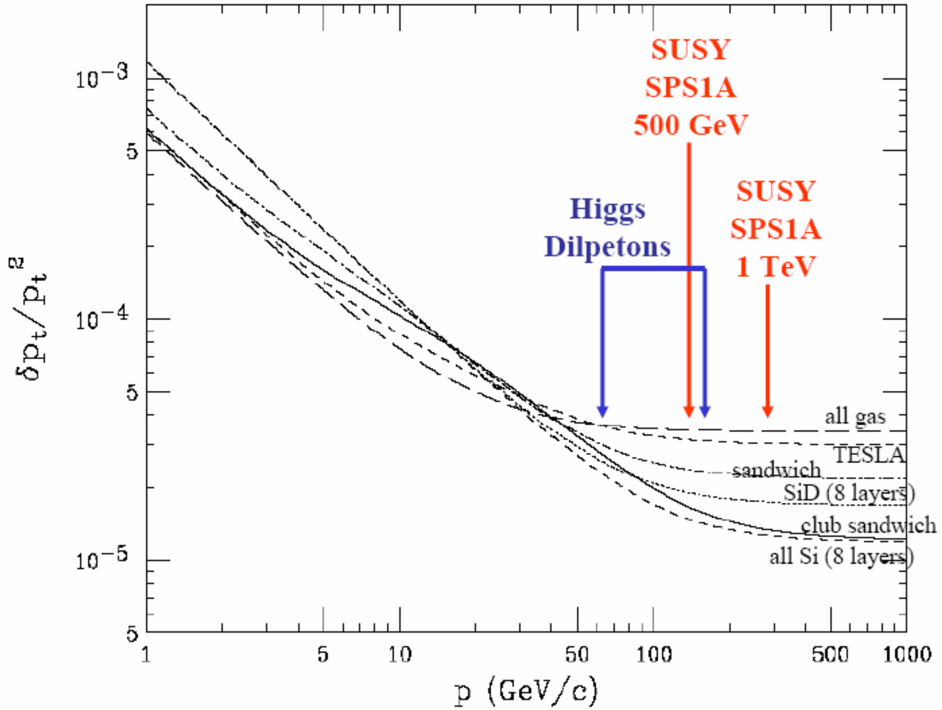
Momentum resolution needed…

"Club sandwich" possible in GLD because of large size. We will study performance & feasibility of this option in case the momentum precision is required.



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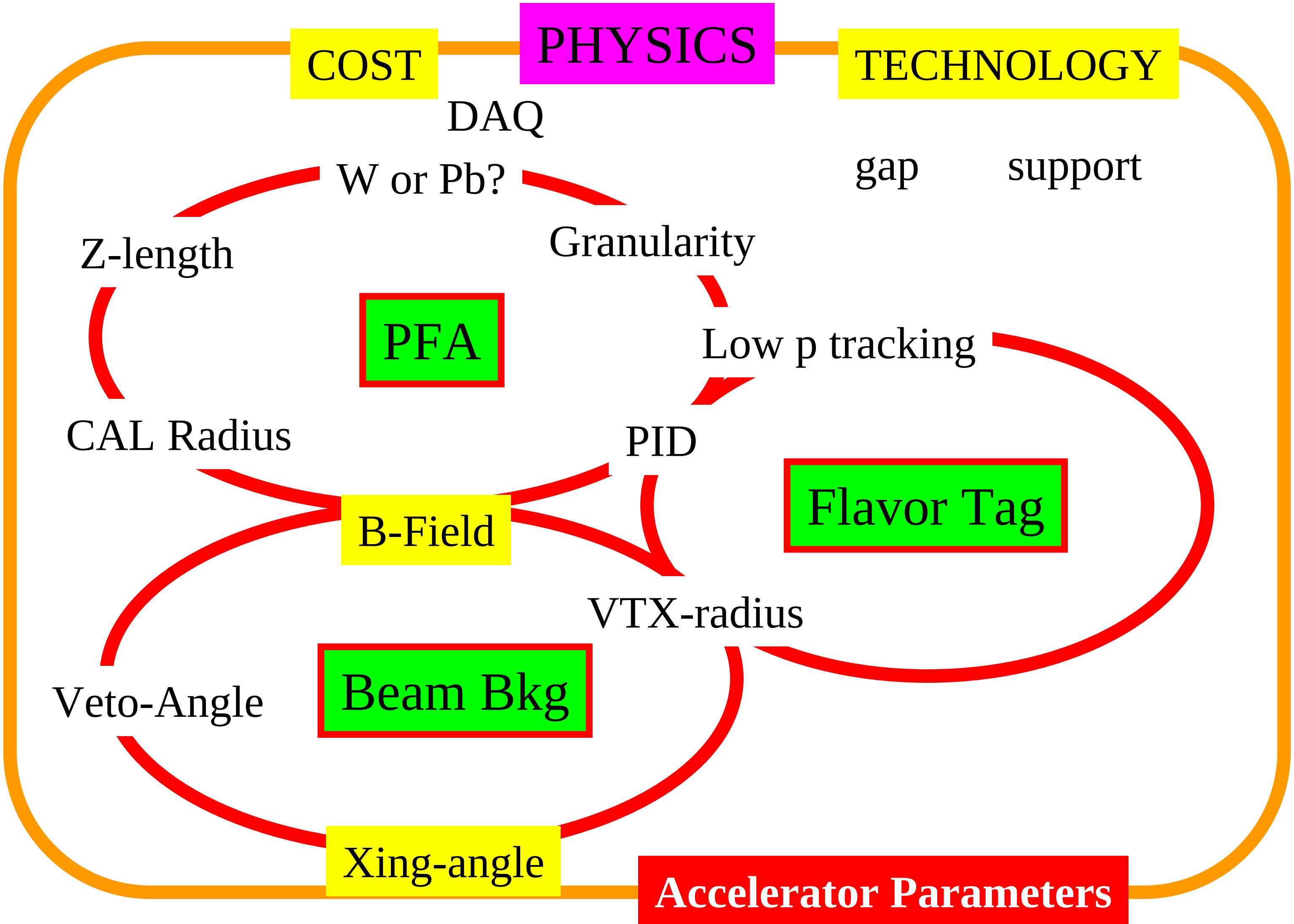
Study items to be attacked after Snowmass



Summary and outlook

- GLD detector optimization study has been successfully launched, particularly in PFA study and background study
- Towards the detector optimization, there are still many issues to be attacked.
- Inter-concept study is being strengthened at this workshop in the fields of PFA, MDI, Simulation, etc. and it will continue

➔ a great success of the Snowmass Workshop