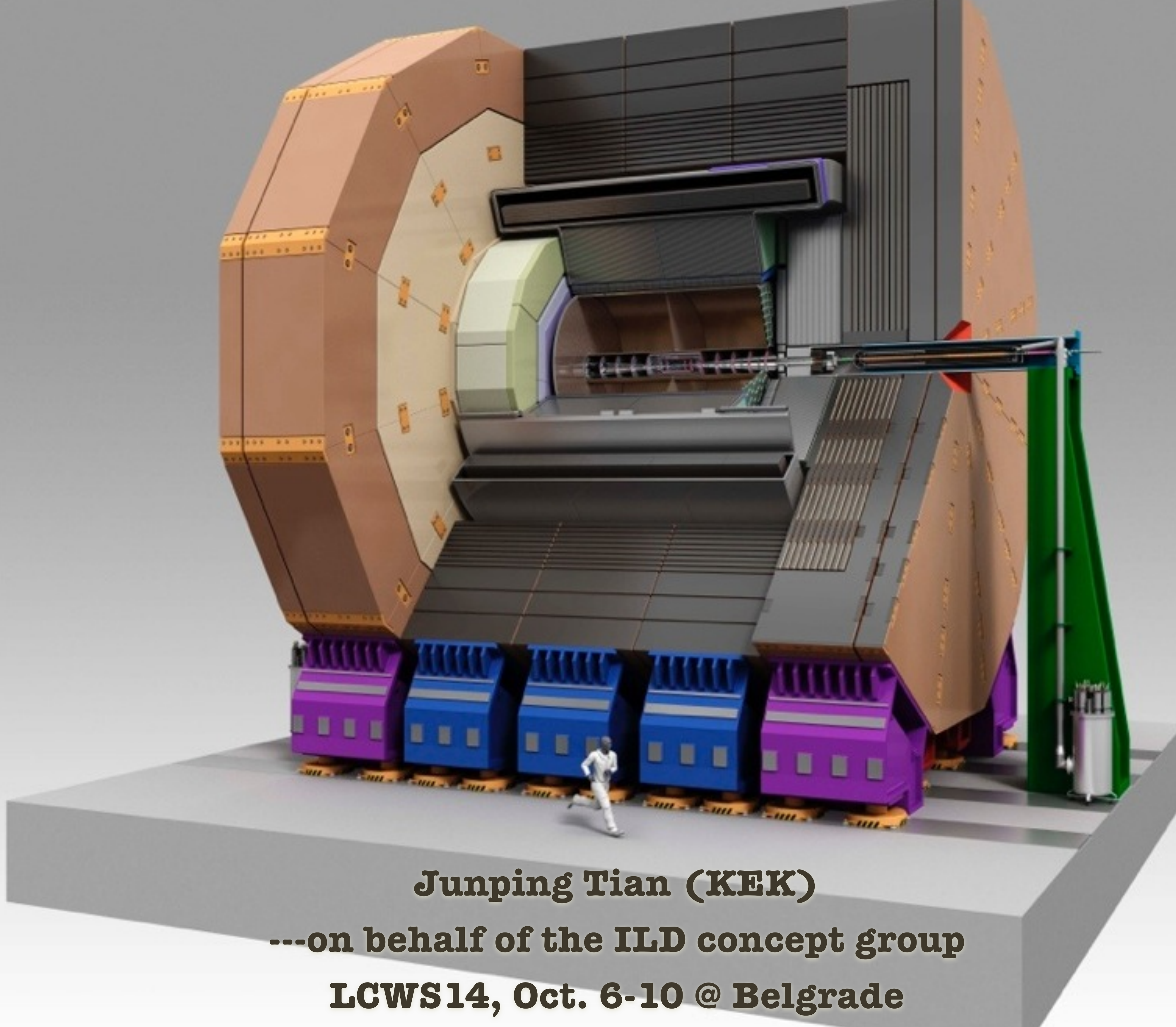
status of the ILD detector concept

— optimization & physics case



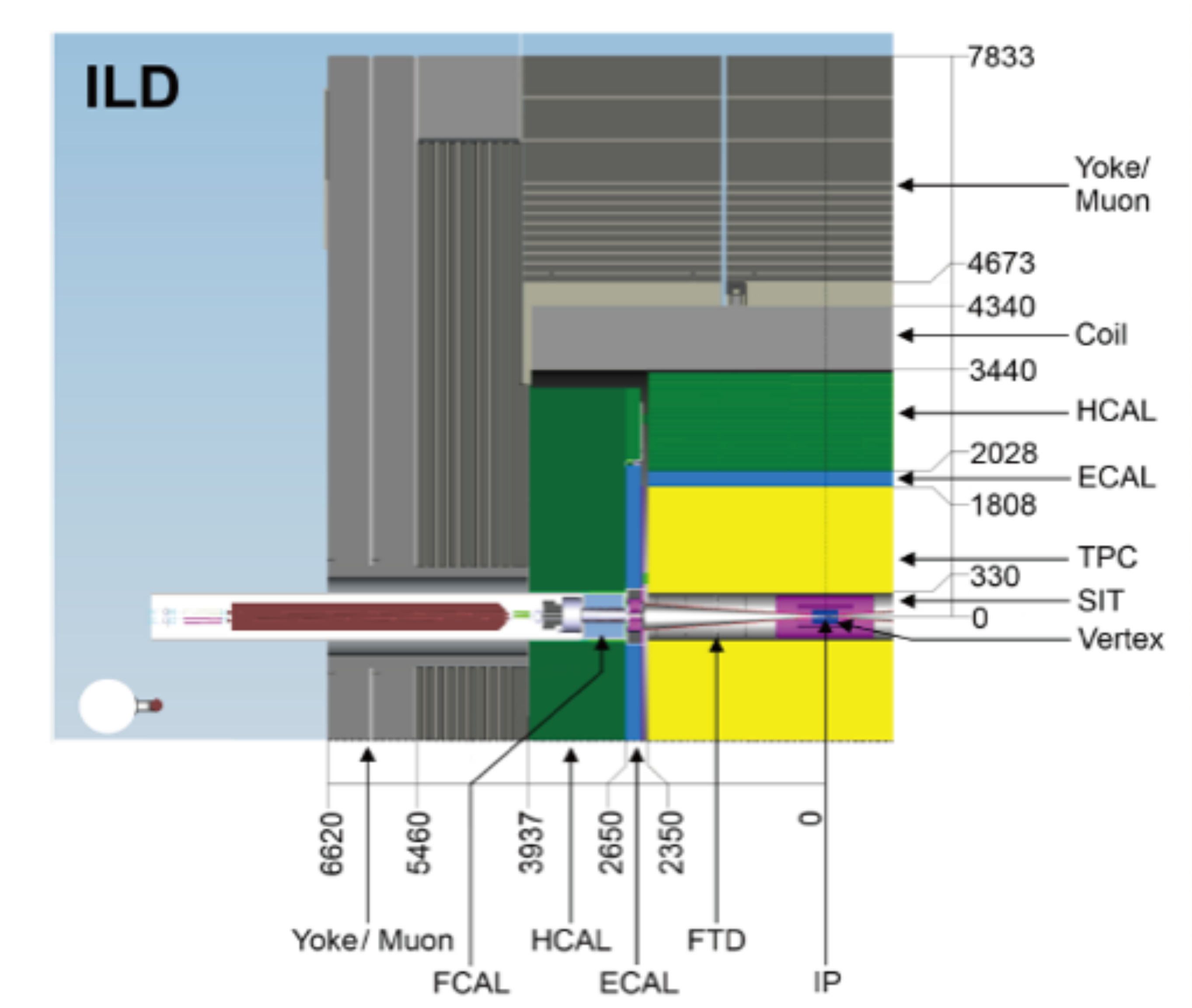
Junping Tian (KEK)

---on behalf of the ILD concept group

LCWS14, Oct. 6-10 @ Belgrade

philosophy and layout

view events as viewing Feynman diagrams ⟷ a detector driven by PFA



a quadrant view of ILD

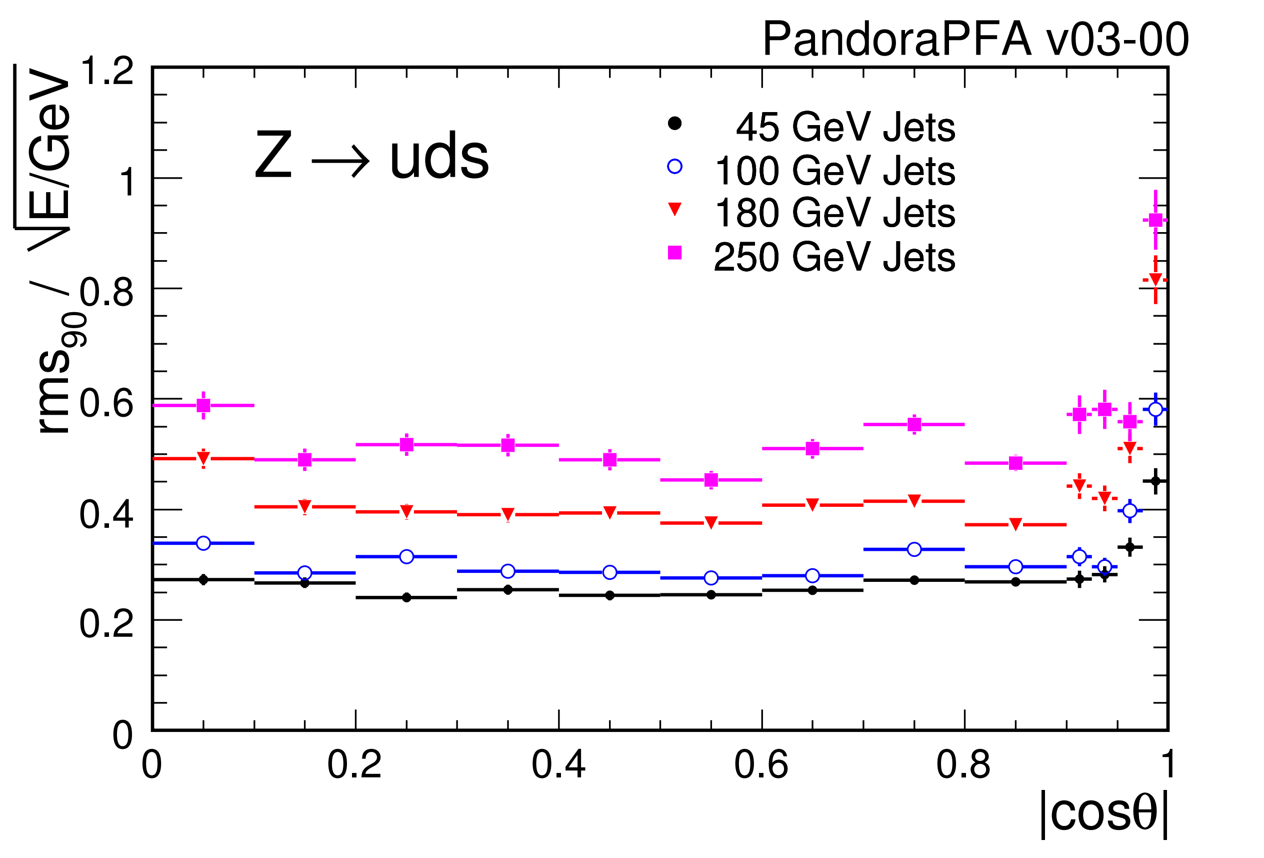
- separate charged & neutral particles
  - ☆ high granular ECAL & HCAL
  - ☆ large TPC & High B field
- identify b/c/q-jet
  - ☆ high performance VTX
- separate events by time stamping
  - ☆ high resolution SIT, SET…
- hermetic
  - ☆ endcaps, FTD…
- muon, BCAL, LCAL…

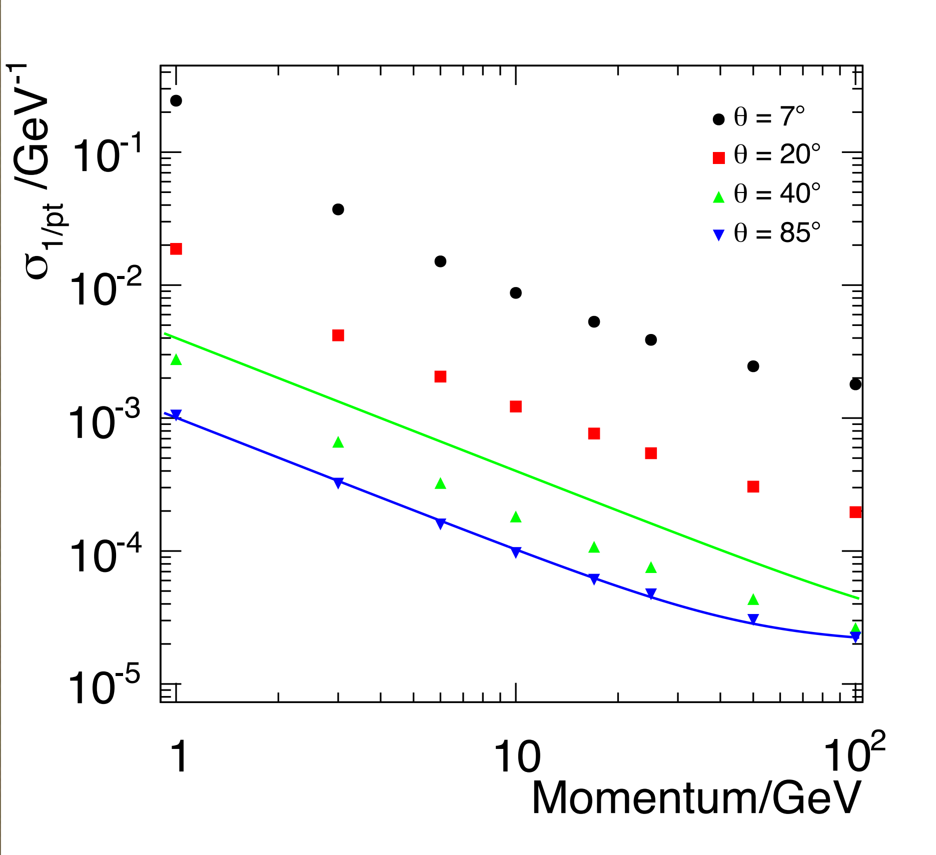
detector performance (DBD)

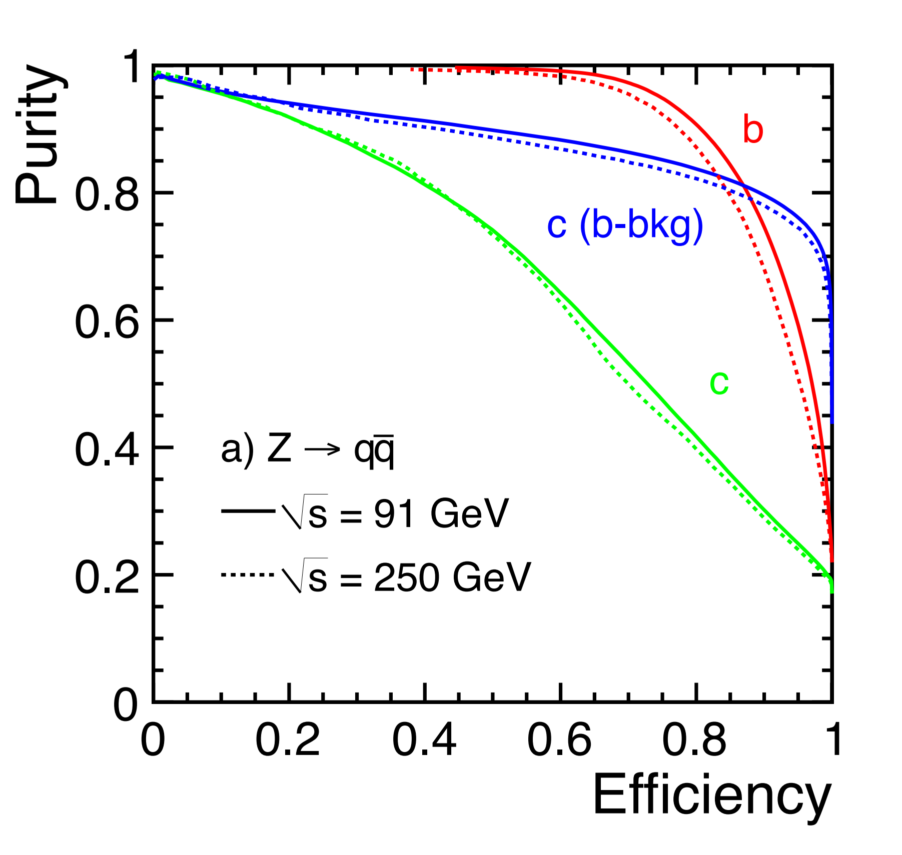
$$\sigma_E/E \sim 3-4\% \sim 30\%/\sqrt{E} \text{ @100GeV}$$

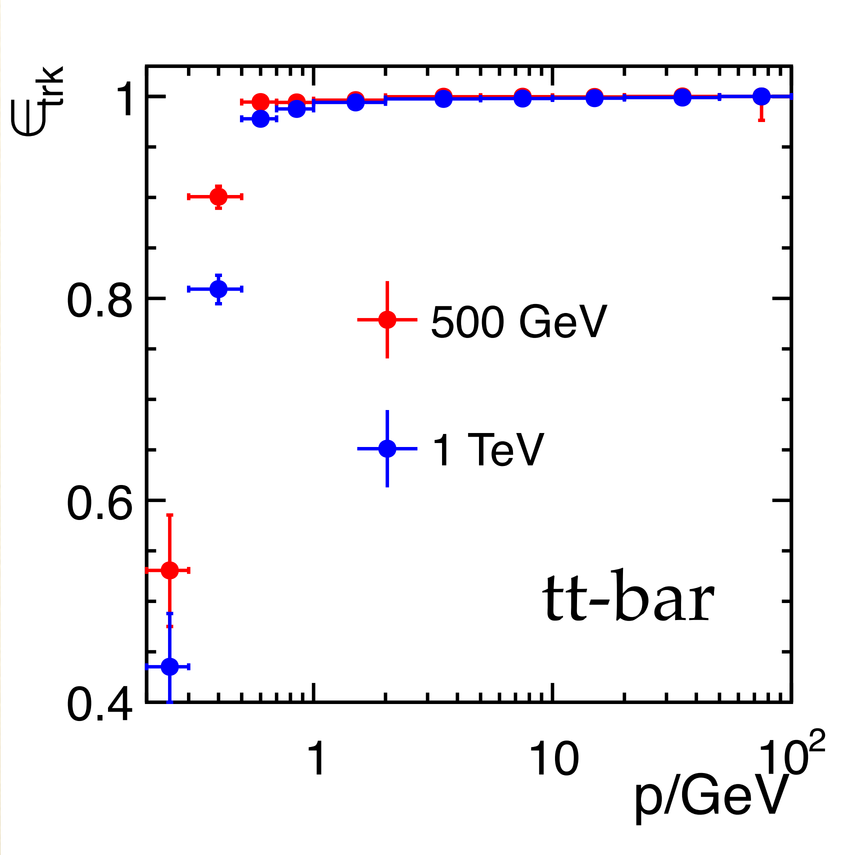
$$\sigma_{1/p_T} \sim 2\times10^{-5}\ \text{GeV}^{-1}$$

$$\sigma_{r\phi} = 5\ \mu\text{m} \oplus \frac{10}{p(\text{GeV}\sin^{3/2}\theta)}\ \mu\text{m}$$









physics performance (DBD)

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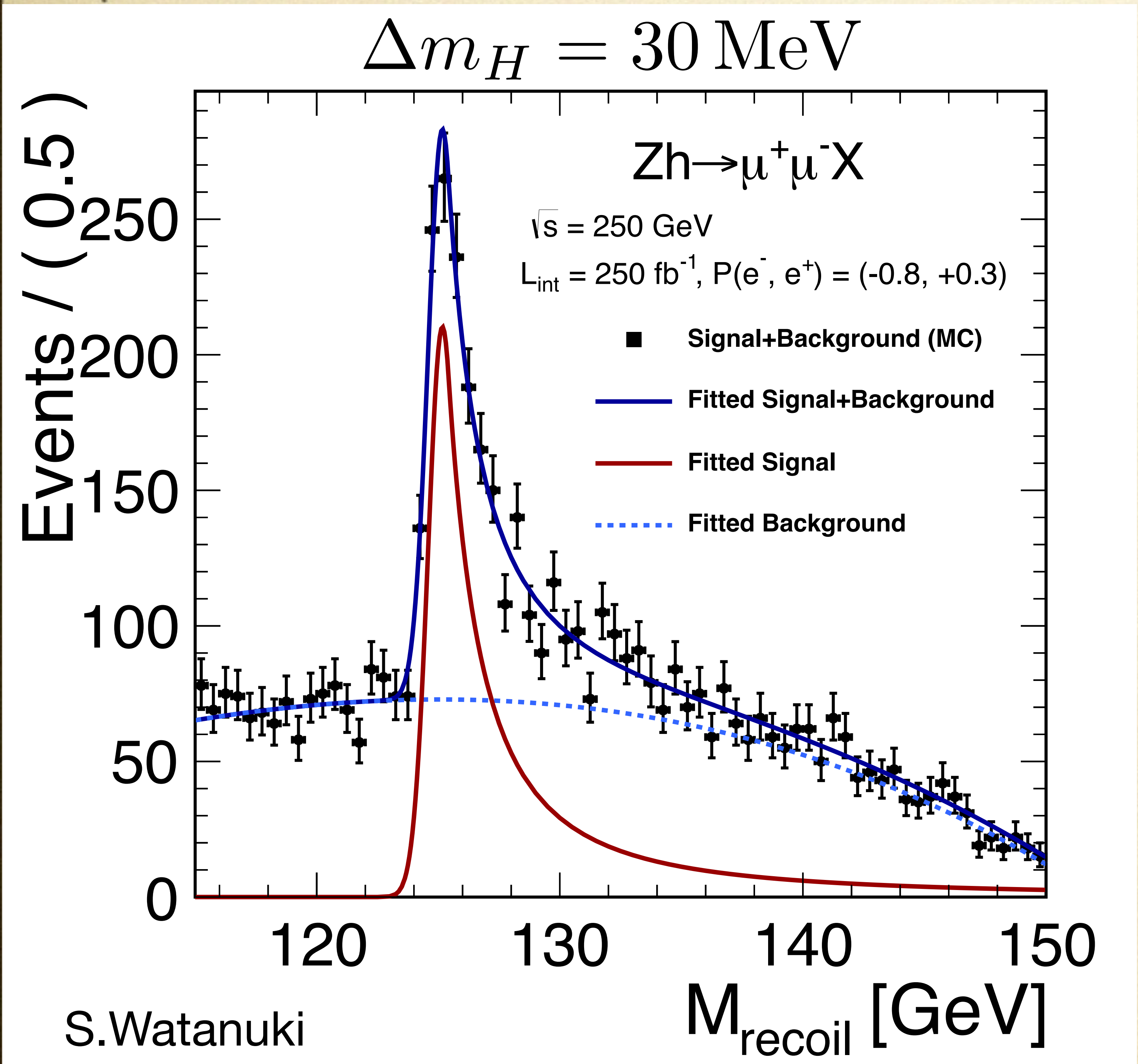
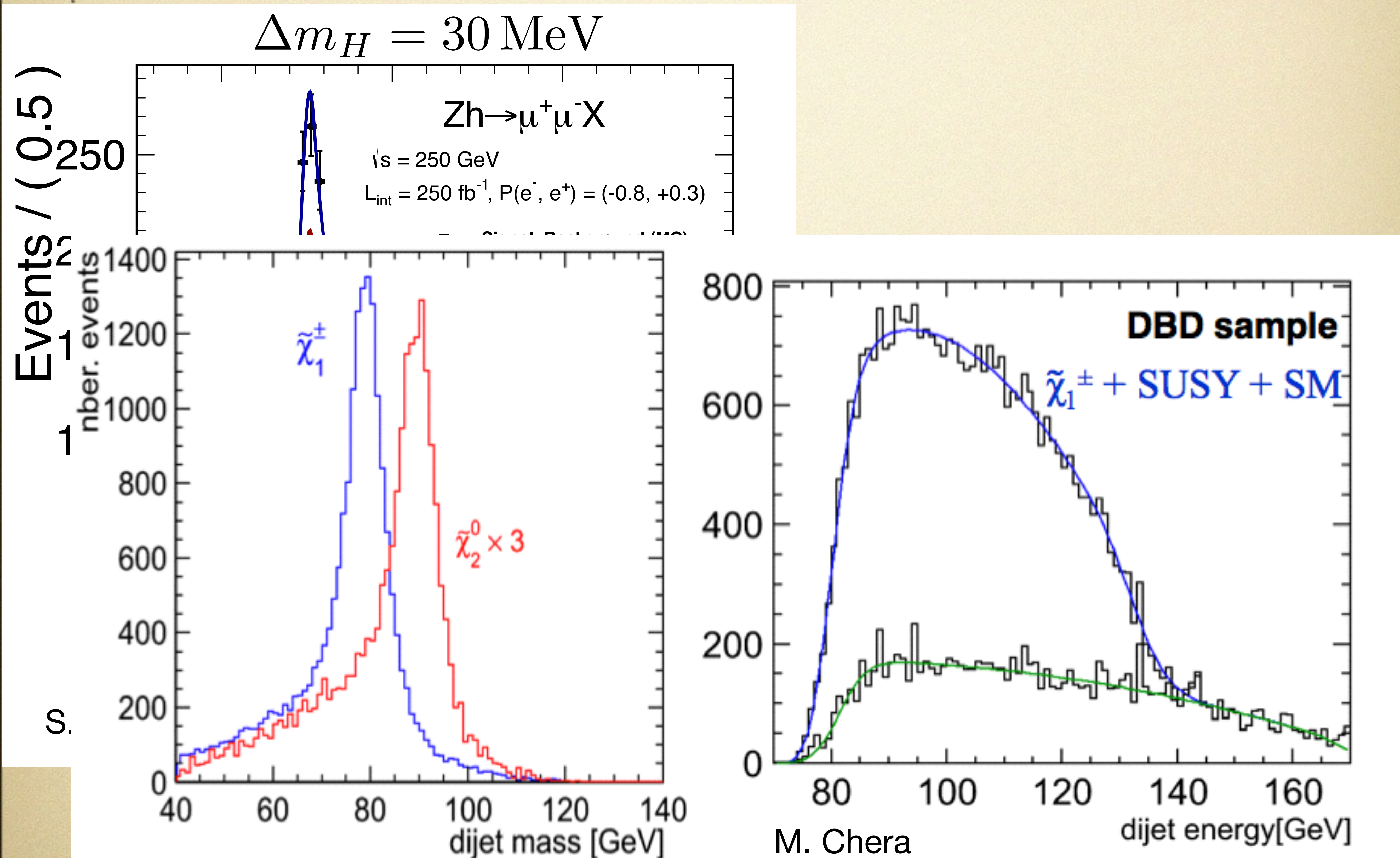


S.Watanuki

physics performance (DBD)



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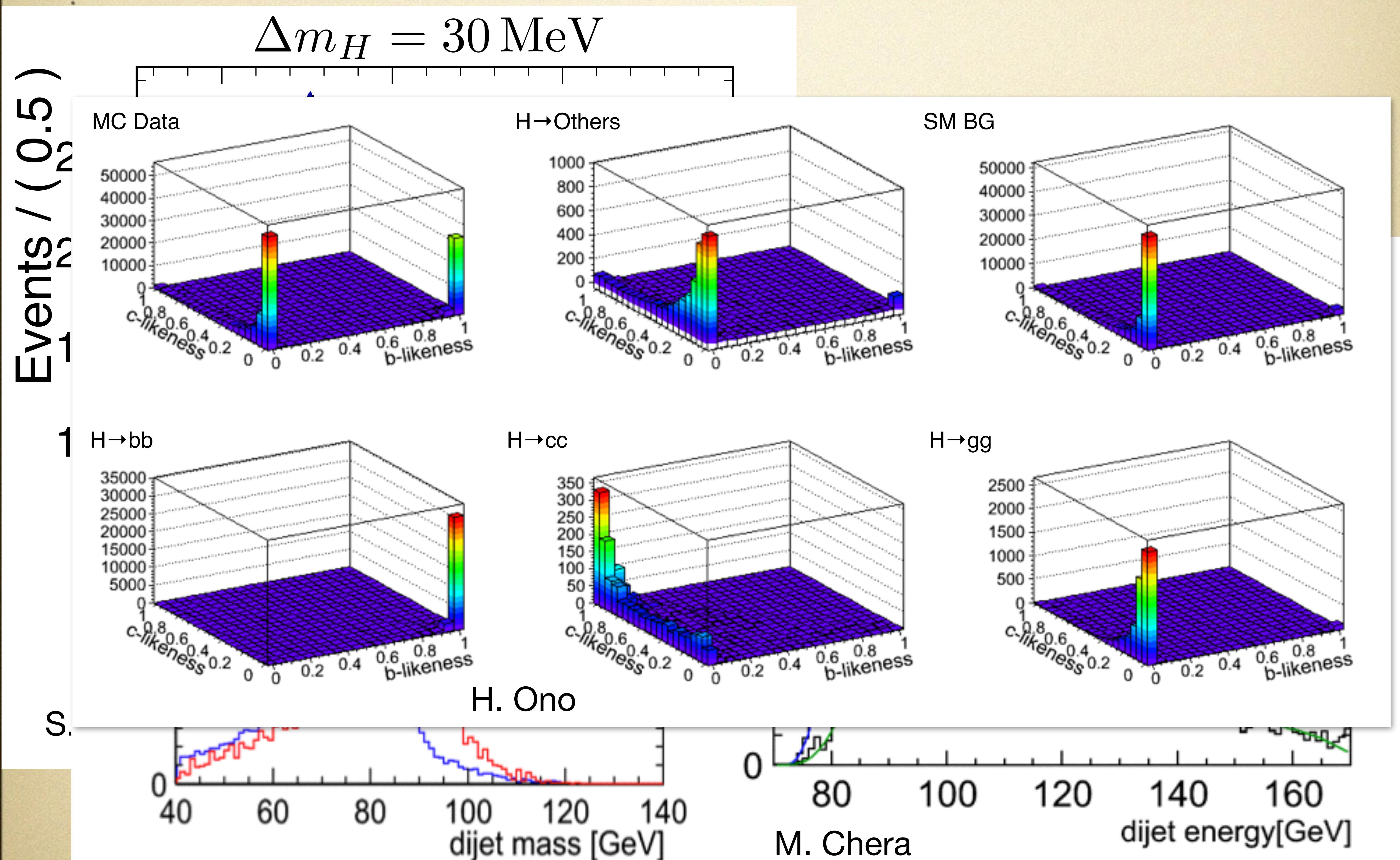

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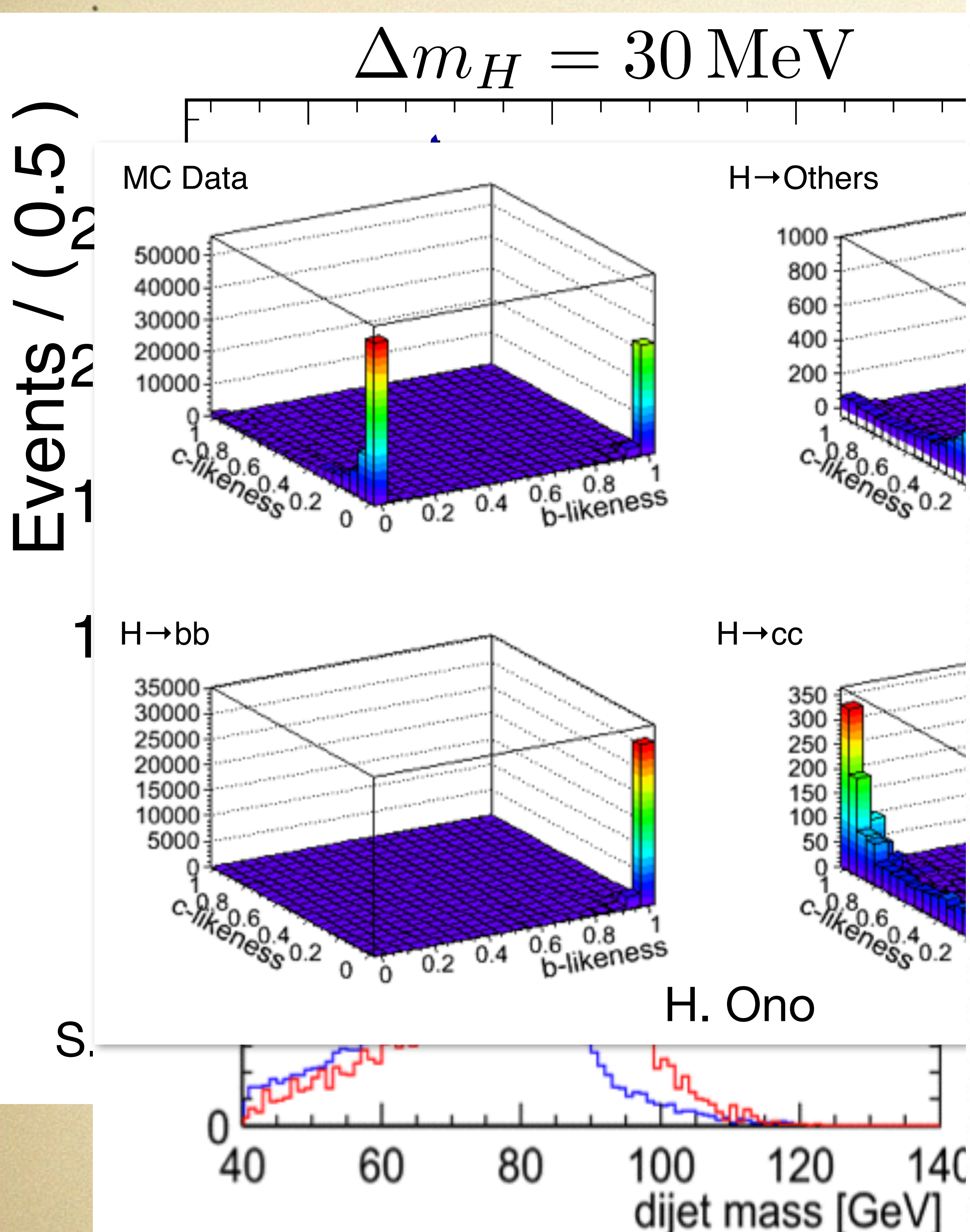
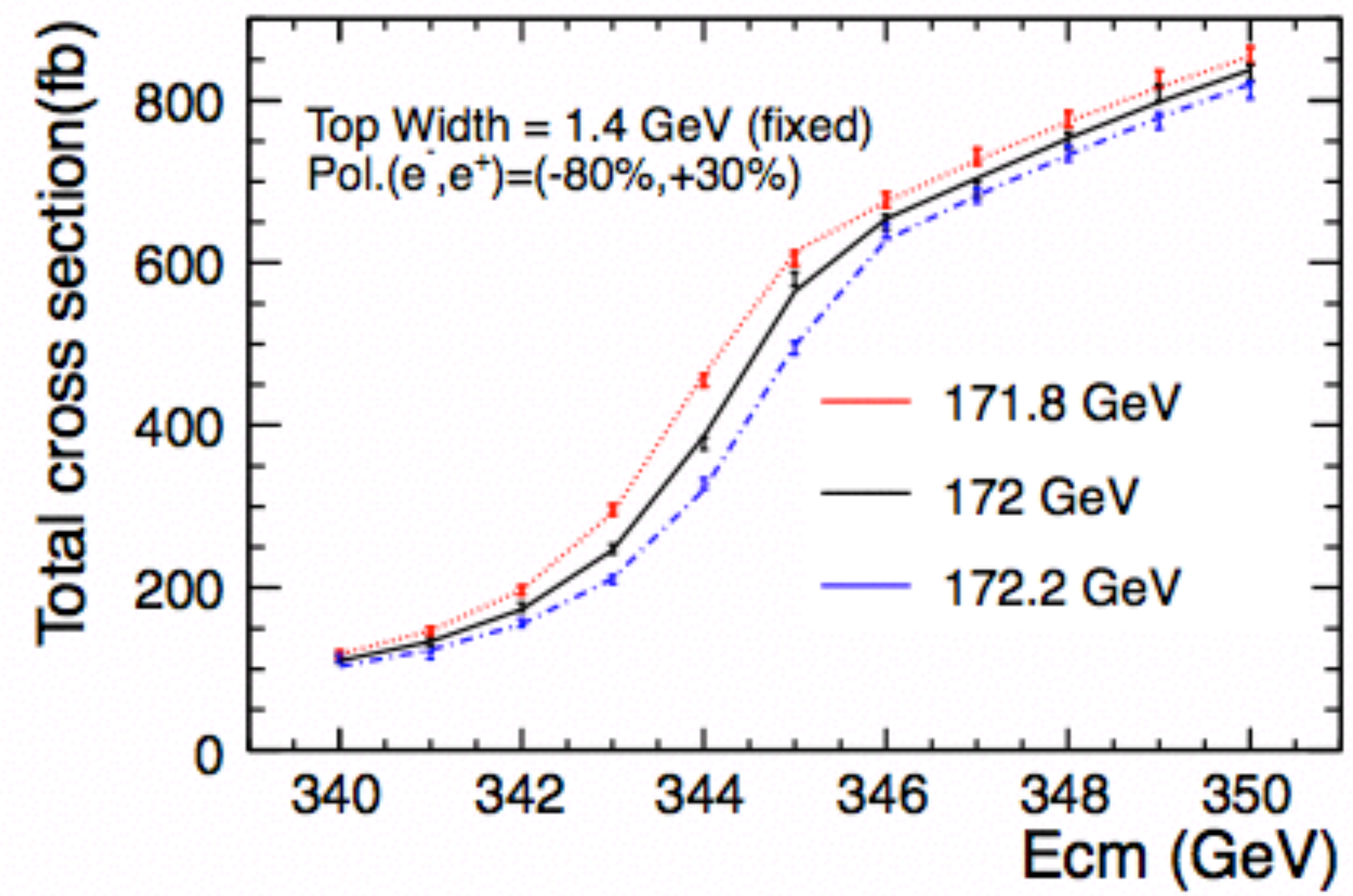
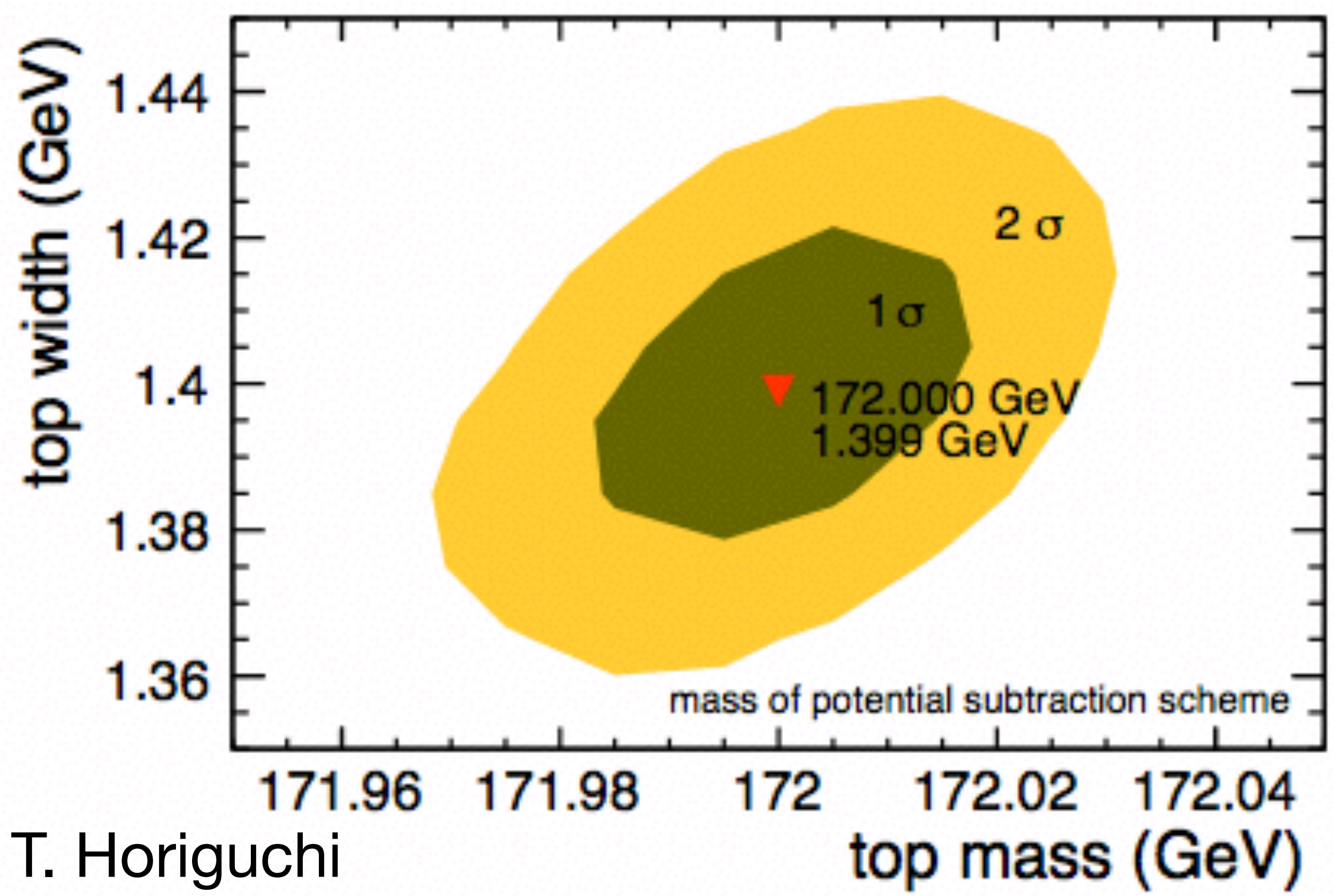
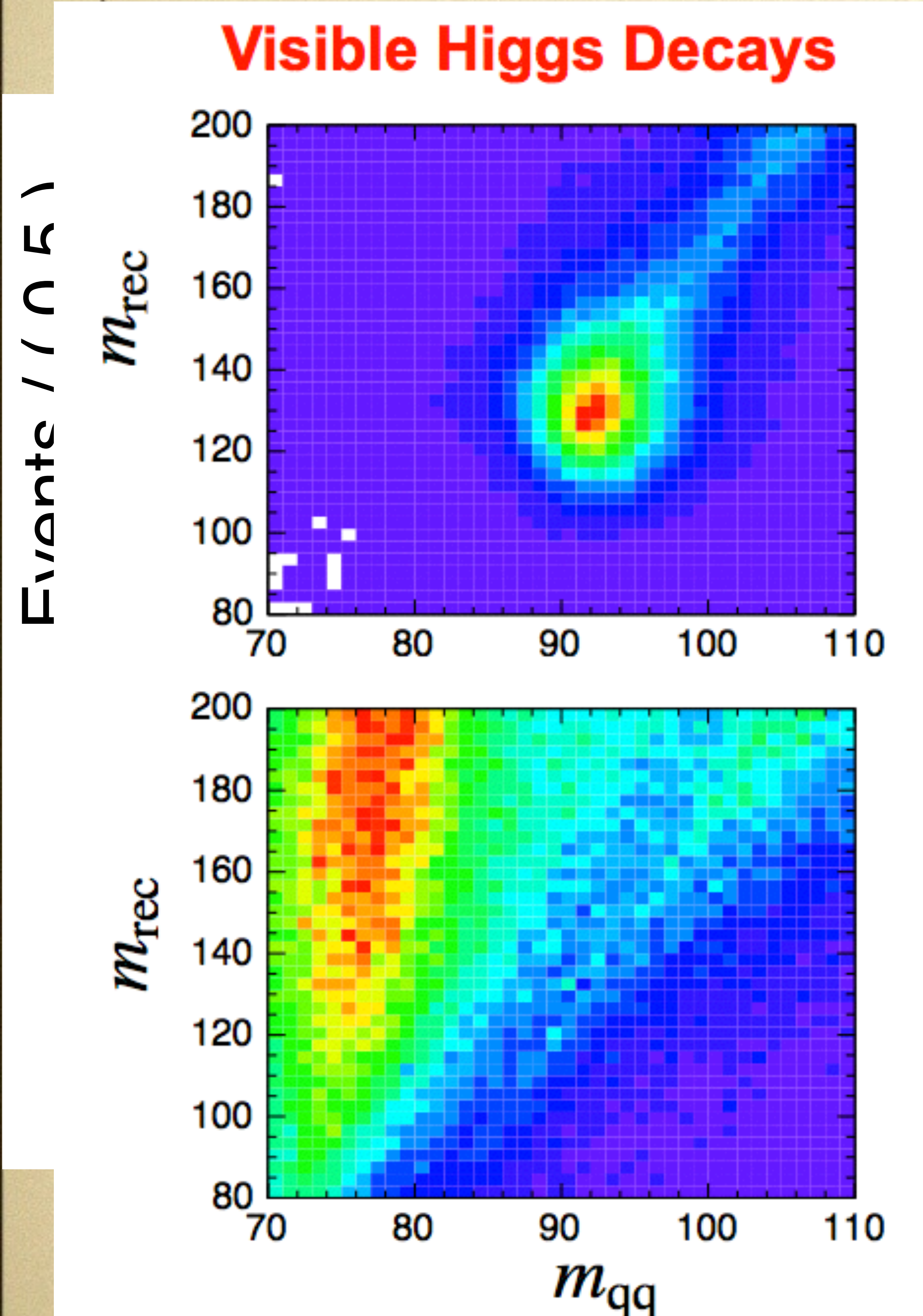


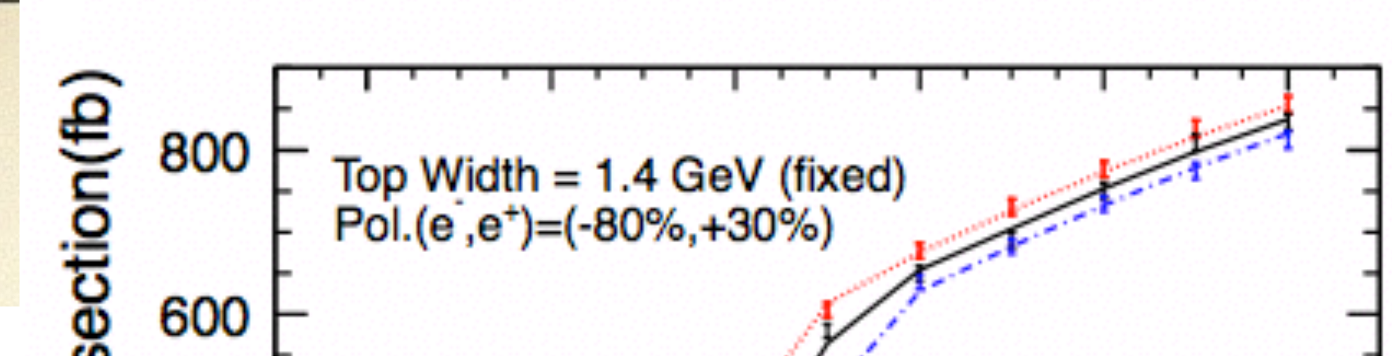




T. Horiguchi

physics performance (DBD)





★ **Leptonic recoil at 250 GeV:**

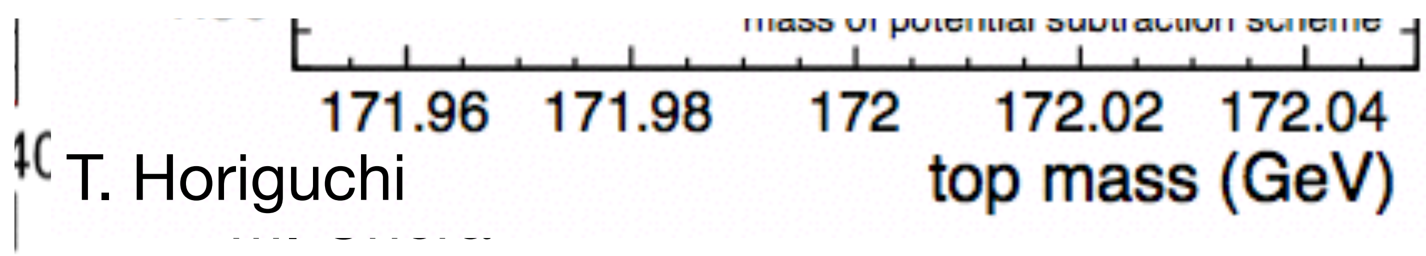
$$\frac{\Delta\sigma}{\sigma} = 2.6\,\%$$

★ **Hadronic recoil at 350 GeV:**

M. Thomson

$$\frac{\Delta\sigma}{\sigma} = 1.7\,\%$$

new study after DBD, and a full set of physics @ 350 GeV need be studied (running scenario)



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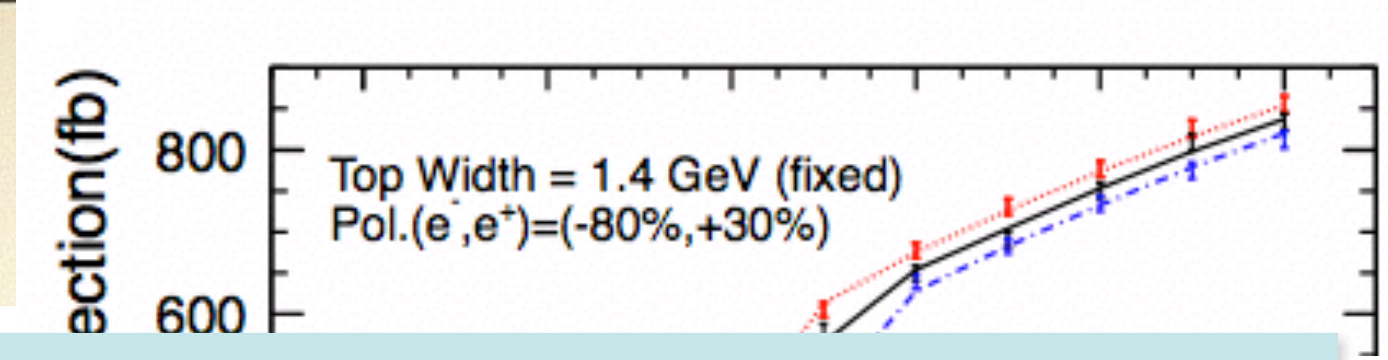


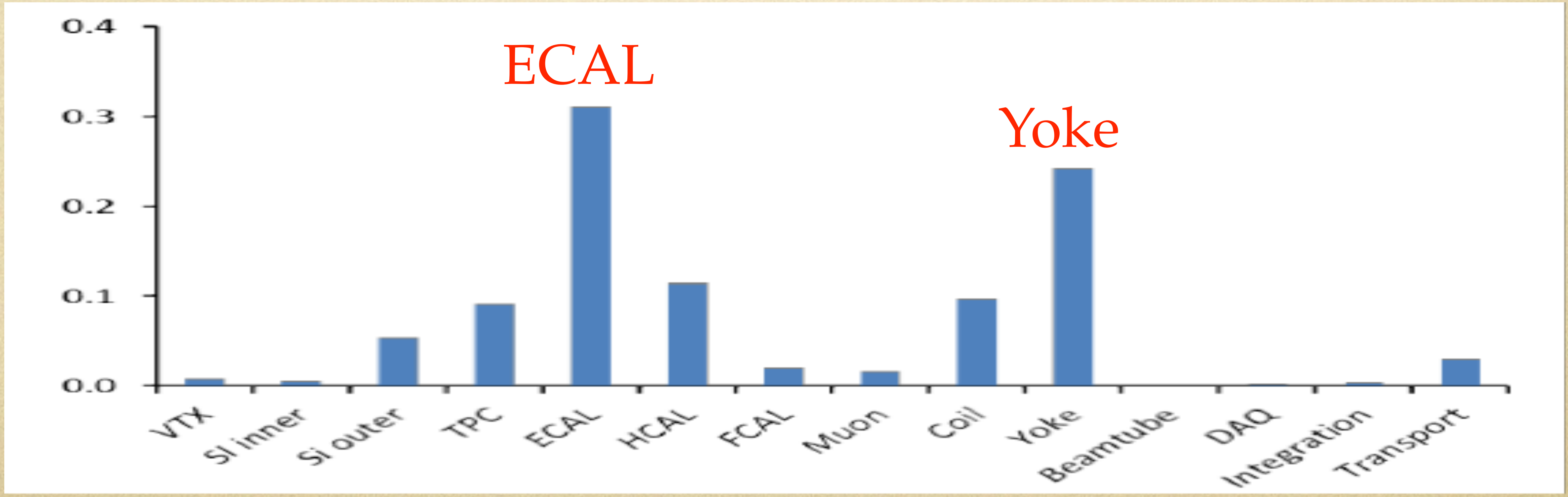
Visible Higgs Decays

coupling Δg/g	Baseline			LumiUP		
	250 GeV	+ 500 GeV	+ 1 TeV	250 GeV	+ 500 GeV	+ 1 TeV
HZZ	1.3%	1%	1%	0.61%	0.51%	0.51%
HWW	4.8%	1.2%	1.1%	2.3%	0.58%	0.56%
Hbb	5.3%	1.6%	1.3%	2.5%	0.83%	0.66%
Hcc	6.8%	2.8%	1.8%	3.2%	1.5%	1%
Hgg	6.4%	2.3%	1.6%	3%	1.2%	0.87%
Hττ	5.7%	2.3%	1.7%	2.7%	1.2%	0.93%
Hγγ	18%	8.4%	4%	8.2%	4.5%	2.4%
Hμμ	-	-	16%	-	-	10%
Htt	-	14%	3.1%	-	7.8%	1.9%
Γ	11%	5%	4.6%	5.4%	2.5%	2.3%
Br(Inv)	<0.95%	<0.95%	<0.95%	0.44%	0.44%	0.44%
HHH	-	83%	21%	-	46%	13%

m_{rec} m_{rec} m_{qq}

post DBD, before approval of ILC

- collaboration meeting at Cracow 2013 and Oshu 2014
- general ILD optimization meeting (monthly, this year~)
- site specific studies (Kitakami)
- engineering/integration
- are our detectors optimized?
- is cost-performance justified?
- is ILC physics case fully justified?



(I) detector (re)-optimization

started since meeting at Cracow 2013 —> re-invent ILD the "detector"

LoI studied fairly in detail

- B field (for vertex, PFA, $\delta_{1/pt}$)
- TPC radius, aspect ratio
- ECAL segmentation
- HCAL segmentation/depth
- VTX layers
- SiW versus ScW ECAL
- AHCAL versus DHCAL

what've been changed?

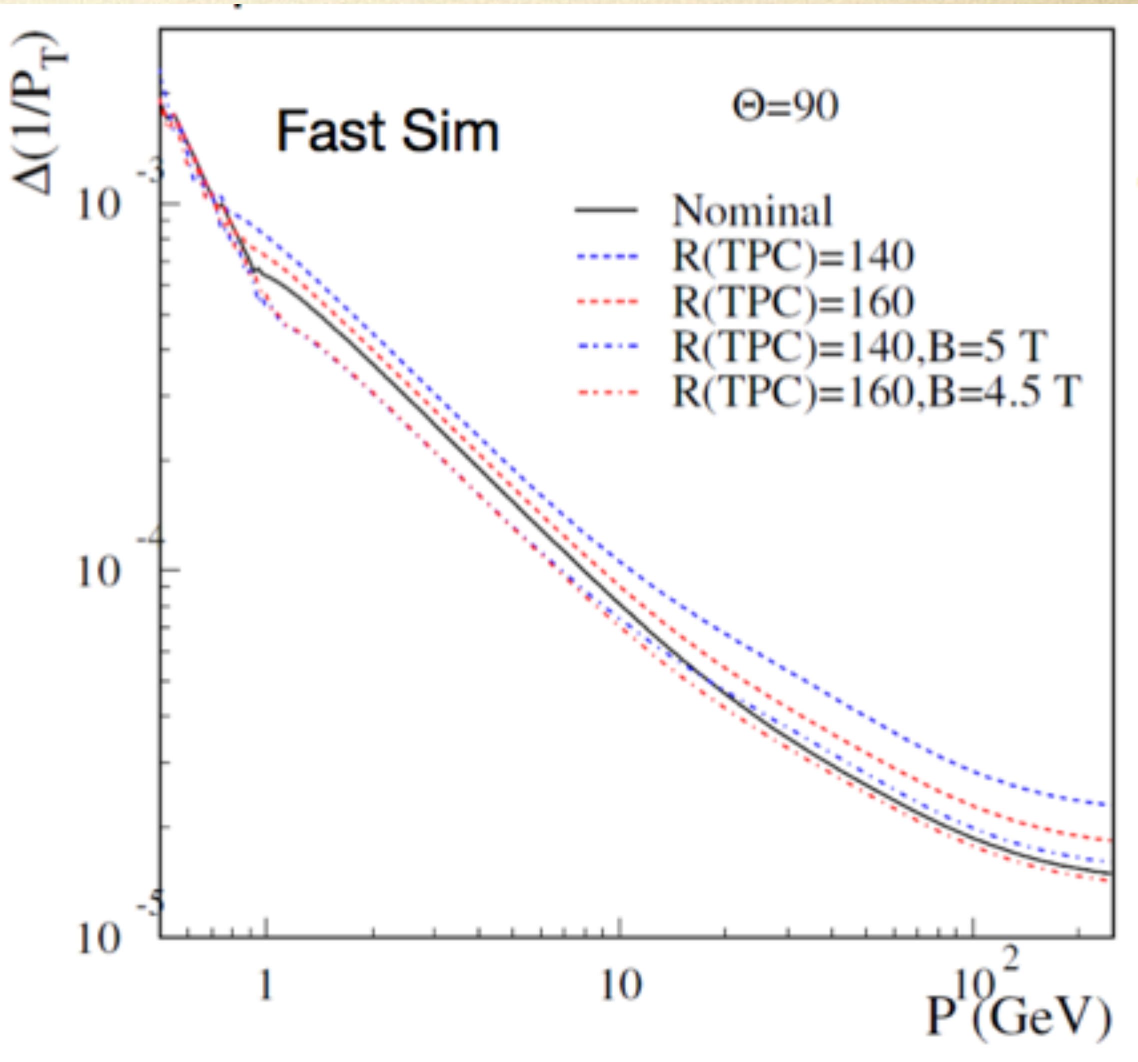
- physics case more shaped, after discovery of Higgs
- sub-detector performance more realistic, learned from R&D, beam test, etc.
- simulation more detailed, material budget, dead area, beam background, etc.
- reconstruction tools improved, tracking, PandoraPFA, LCFIPlus, etc.

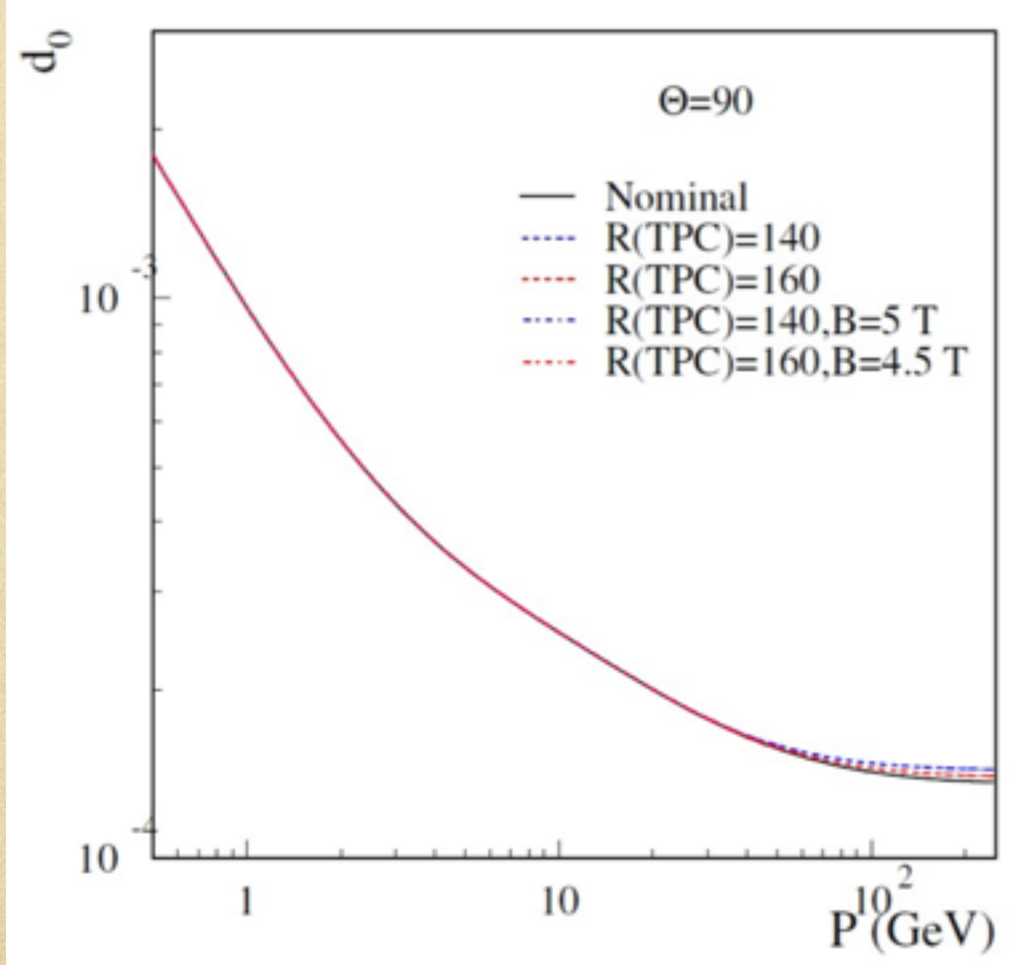
detailed studies can be found in past six general ILD optimisation meetings

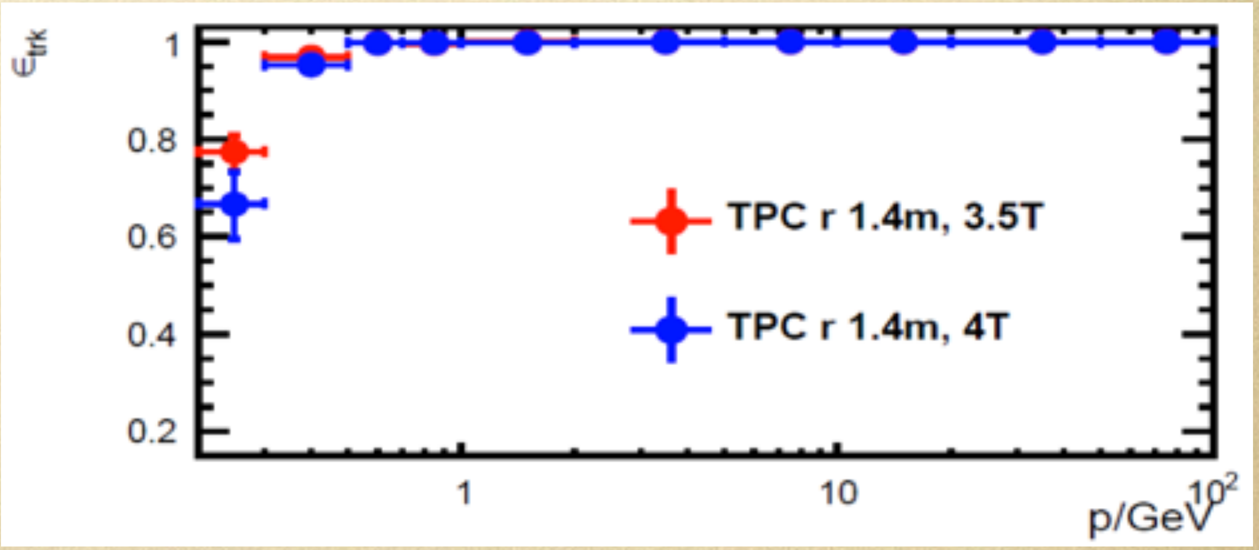
momentum resolution: TPC radius & B-Field

Y. Voutsinas/M. Berggen/F.Gaede

- momentum resolution not scale as $1/(BL^{2.5})$, 10-20% level at low-pt
- resolution with smaller R can be restored with a higher B-Field (with a cost of lower efficiency for low-pt)
- negligible effect on IP resolution







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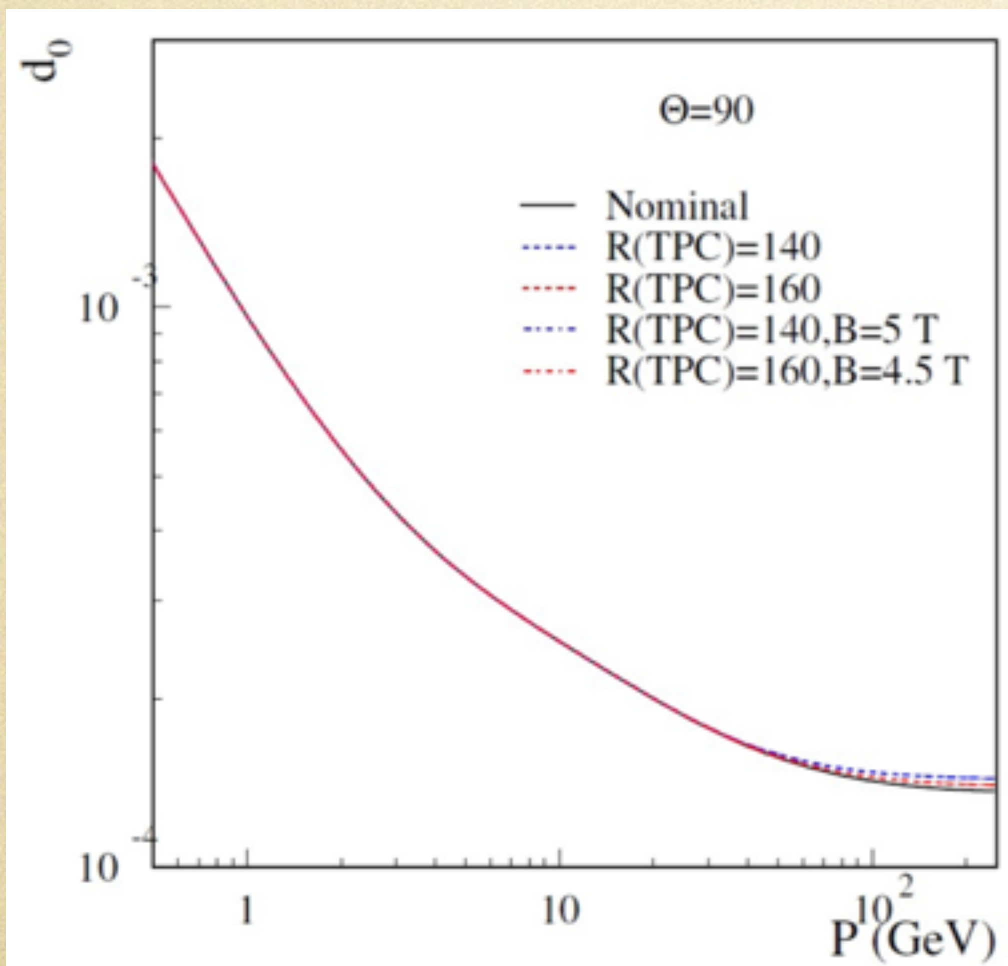
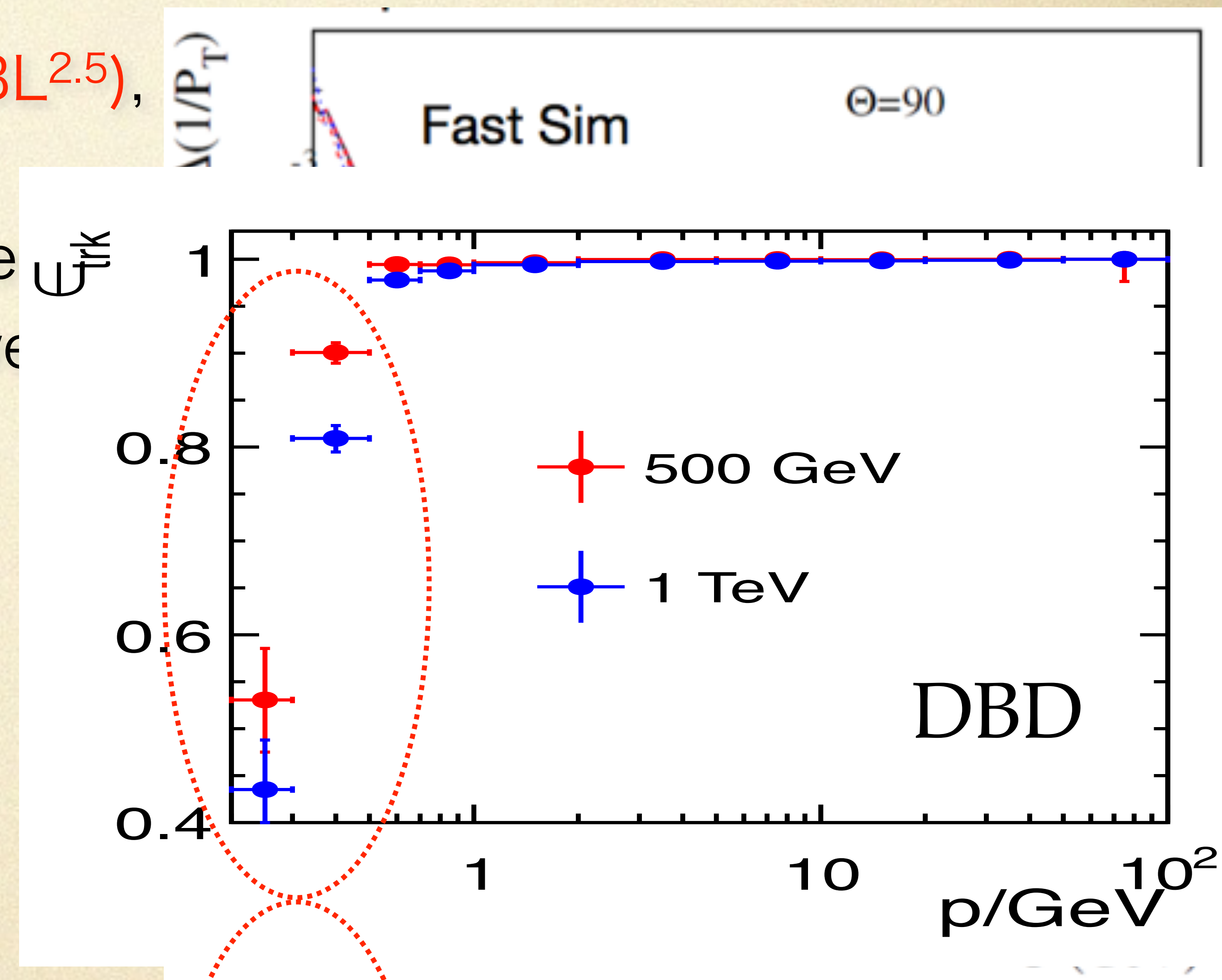
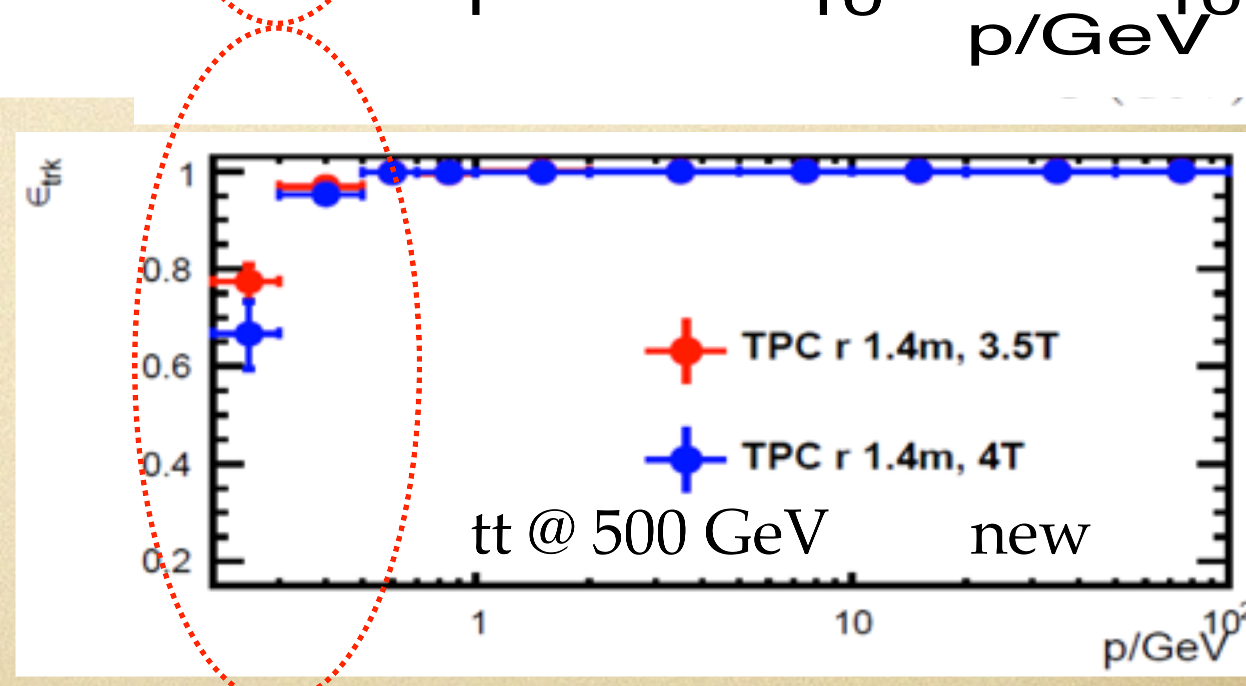


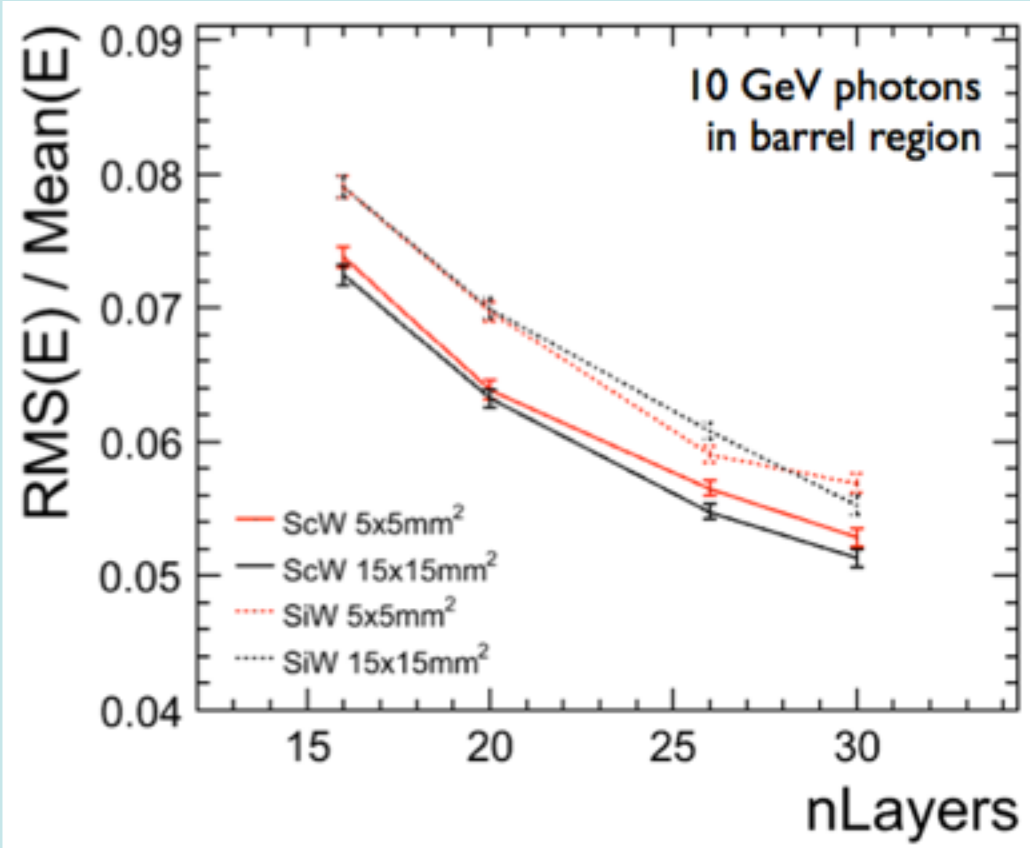


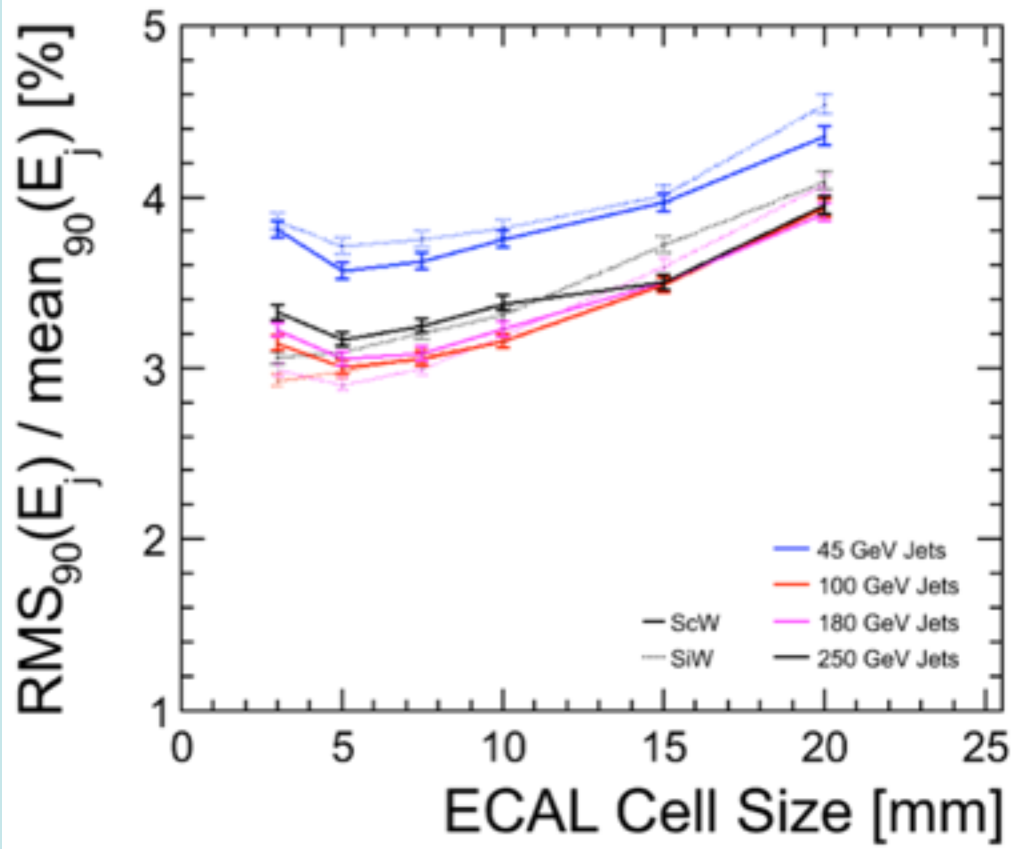


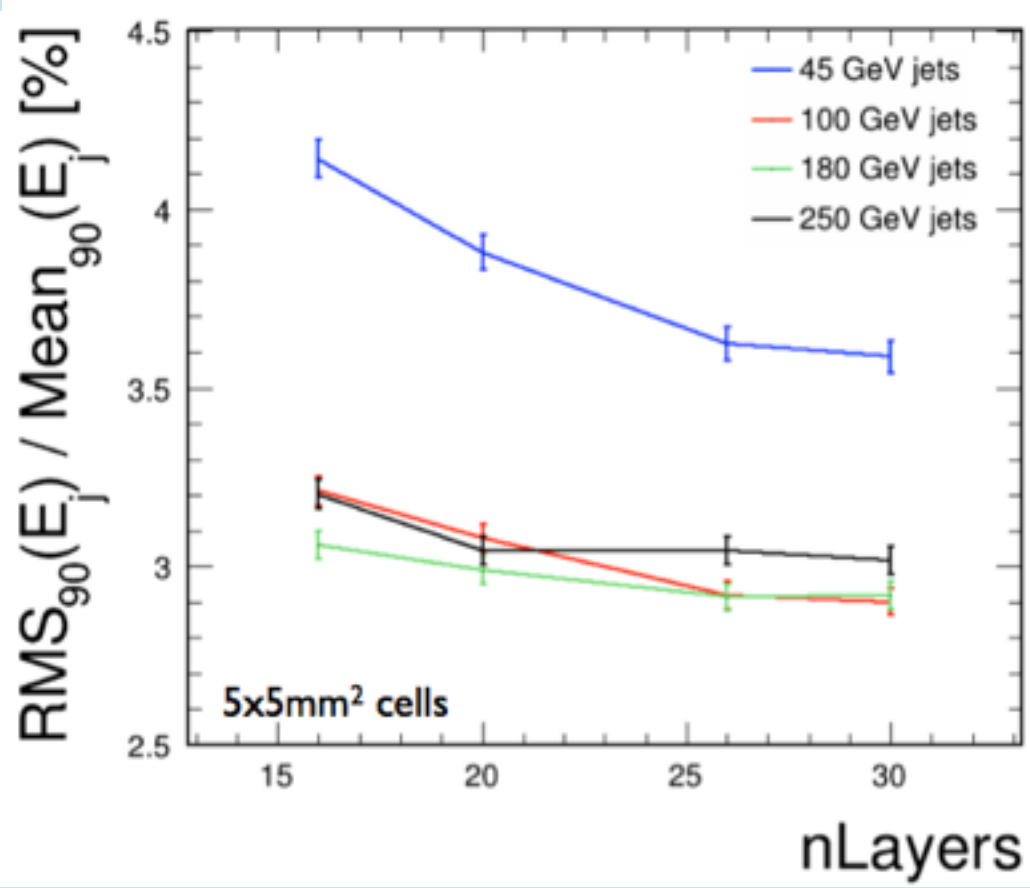
note the improvement of tracking efficiency by new algorithm

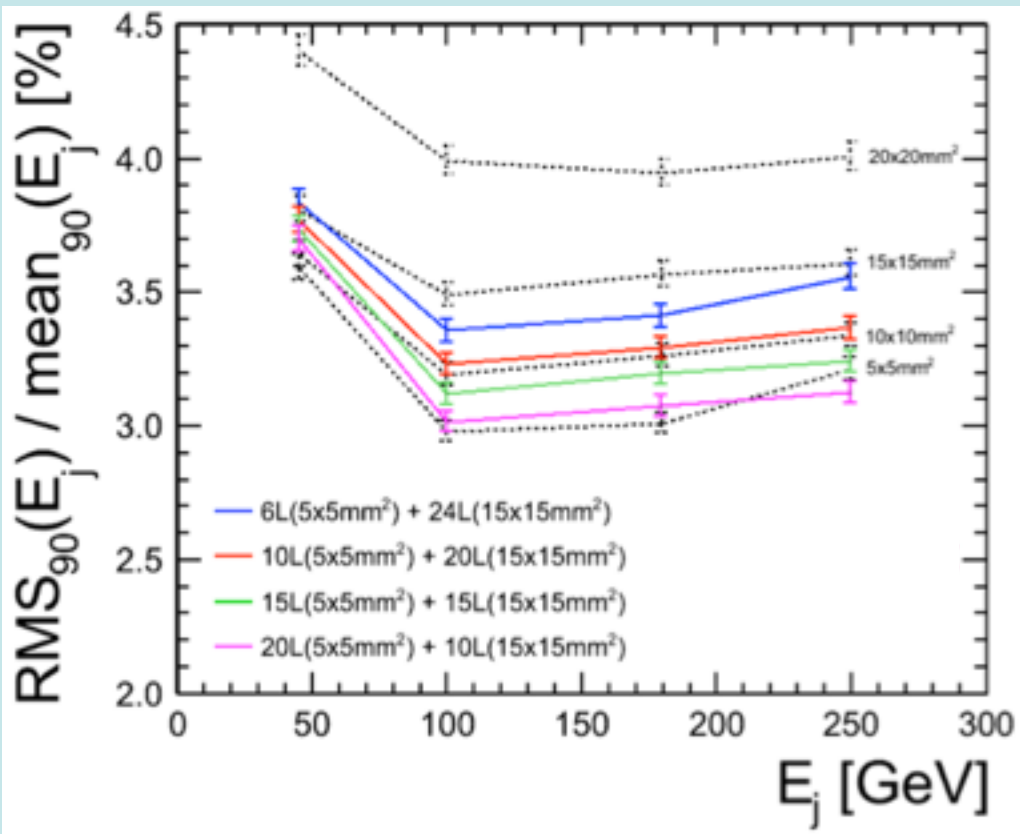
jet energy resolution: ECAL layers & granularity

J. Marshall





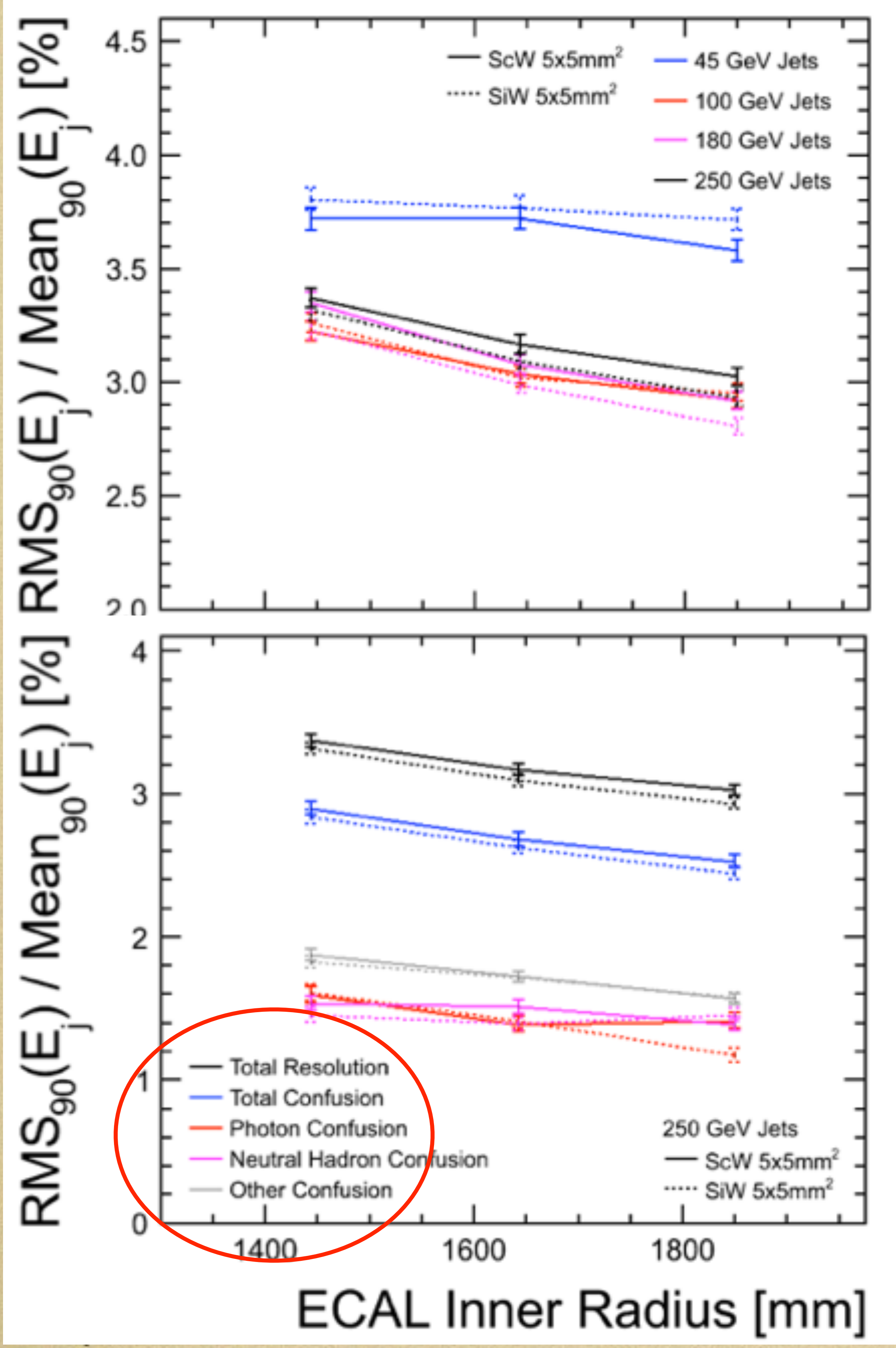


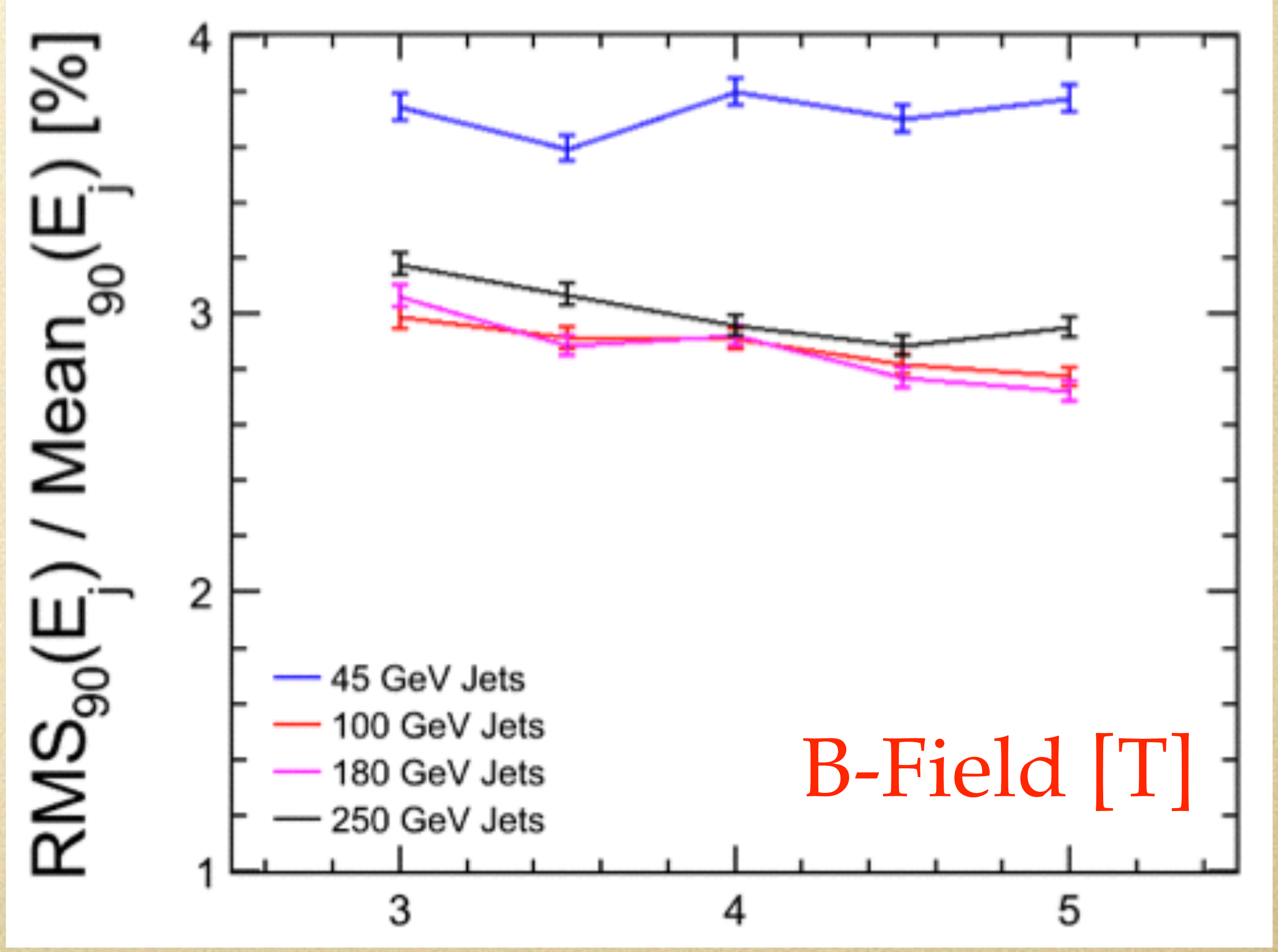


jet energy resolution: ECAL inner radius & B-Field

J. Marshall

- single photon .vs. jet
- multi granularity ECAL
- smaller cell size, larger radius, high B-Field can help separate particles
- to understand PFA performance is most crucial here





detector optimization —> impact on physics

- detector difference needs be translated to physics performance
- however, not trivial at all
- modelling and full simulation for each detector configuration
- careful tune of reconstruction software, PFA, flavor tagging
- but it has to be done in next round, possibly start full comparison when there are only few agreed detector models (similar to what we did in DBD)

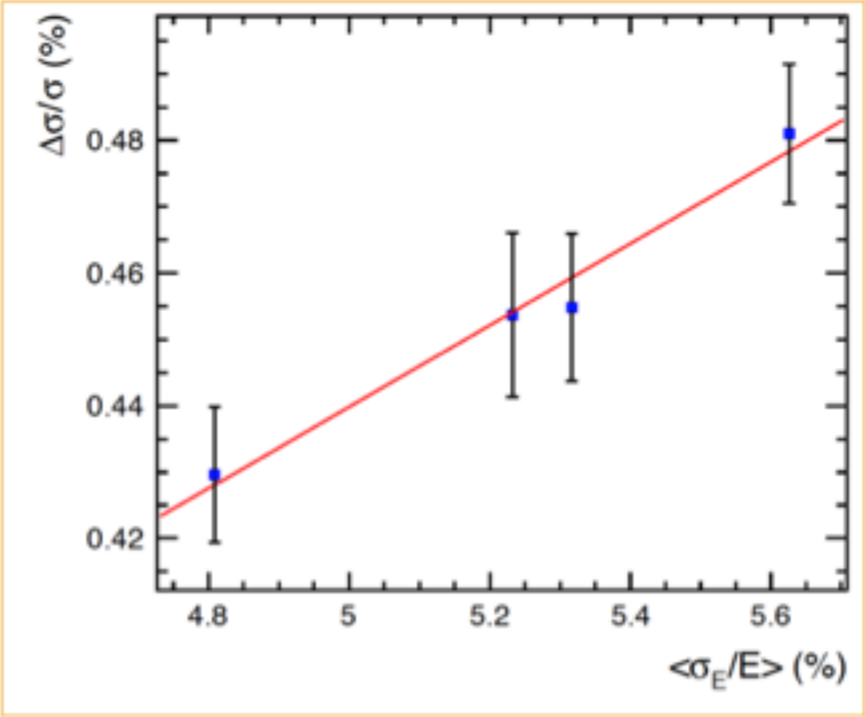
several analyses are already ongoing to check impact on physics, here I only show one of them

impact of JER on measurement of Higgs invisible width

M. Thomson @ Oshu

ZH —> qq + invisible, expected to be sensitive to JER

Model	$\Delta\sigma_{inv} / \sigma_{SM}$	σ_m /m	< σ_E /E >
30 layers: 5 x 5	0.43 %	4.8 %	3.4 %
30 layers: 15 x 15	0.45 %	5.3 %	3.8 %
15 layers: 5 x 5	0.45 %	5.2 %	3.7 %
15 layers: 15 x 15	0.48 %	5.6 %	4.0 %



17 % increase in jet E resolution

⇨ **12 ± 3 % decrease in sensitivity**

⇨ **17 ± 4 % decrease in integrated luminosity**

K. Mei, J. Marshall

(II) physics case fully justified by our detector?

The Next Two Years

M. Demarteau @ Oshu

- In my humble opinion, for the next two years the emphasis for the whole ILC community should be placed on sharpening as much as possible the physics case for the ILC along the three P5 science drivers in a coherent way:
  - Higgs as a new tool for discovery
  - Identify the new physics of dark matter
  - Explore the unknown

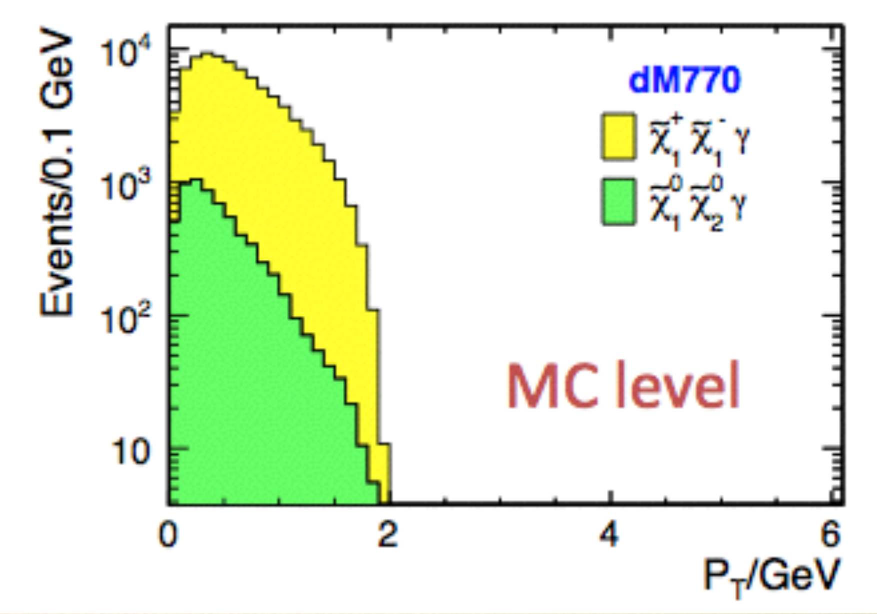
many physics measurements have been justified as showed; however there are still a lot more to be done; some of them are rather sensitive to detector performance

not fully demonstrated physics case: some examples

J. List @ Oshu

- natural SUSY —> light, de-generate Higgsinos

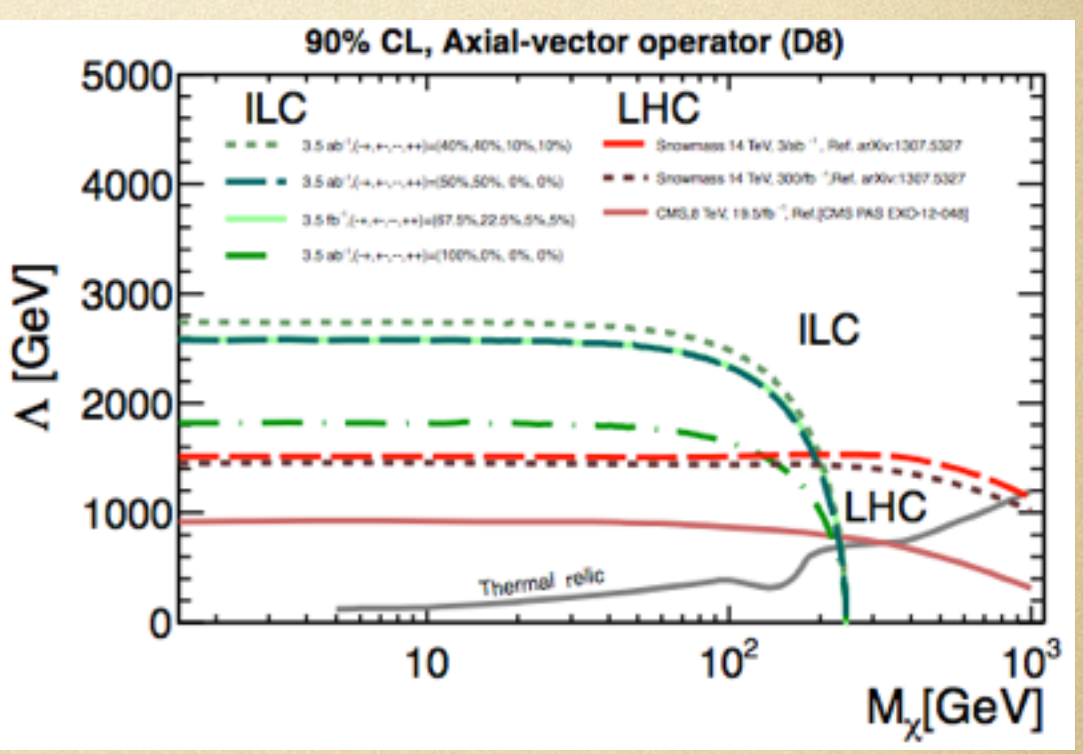
arxiv: 1307.3566



Requires:
- stand-alone Si tracking with low number of fakes
- PID for < 2 GeV , vertexing / impact parameter, π^0 reconstruction
- Excellent hermeticity and γ energy resolution

- DM search —> mono-photon WIMPS

arxiv: 1206.6639 / 1211.4008



Systematic uncertainties:
- very important
- dP, dE_{CM}, dL/dE_{CM}
- Fake tracks
- Photon efficiciency, energy scale

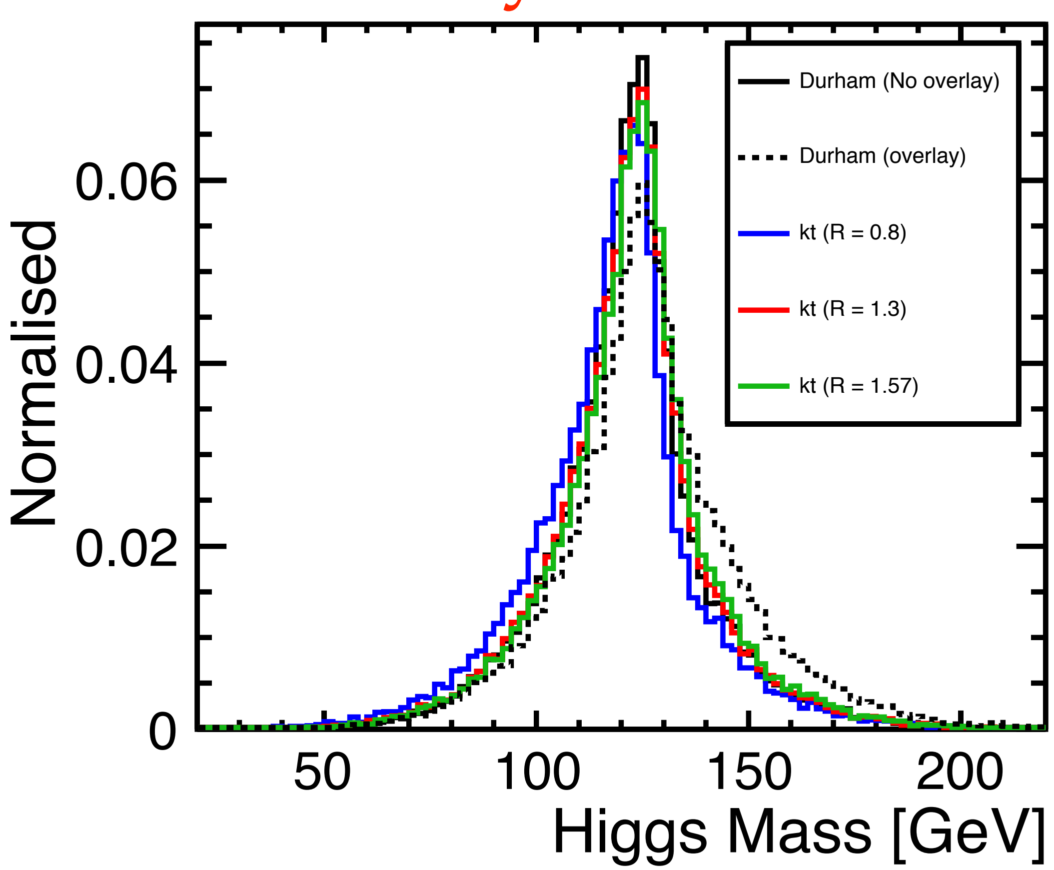
performance to be improved case: Higgs self-coupling

C. Dürig / JT

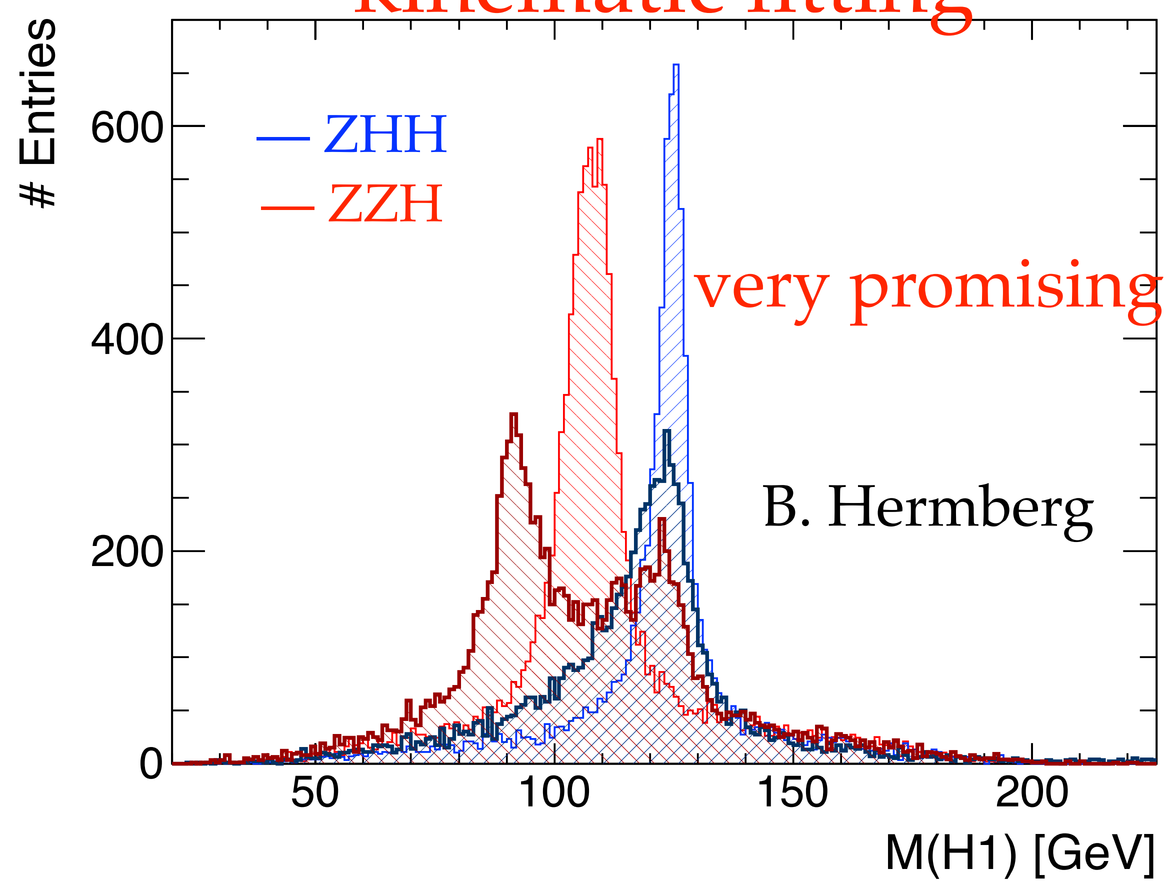
- DBD analyses have been updated with mH = 125 GeV
- impact of beam background & P(e-,e+)
- lots of activities ongoing to improve analysis technique

$\Delta\lambda_{HHH}/\lambda_{HHH}$	500 GeV	+ 1 TeV
Baseline	83%	21%
LumiUP	46%	13%

overlay removal



kinematic fitting



see my talk tomorrow in Higgs session

Optimisation benchmarks Physics Level – a suggestion

J. List @ Oshu

m_H from ee->ννH->ννbb

- JER
- π^0 reconstruction
- b-tag, l in jet, excl. B decays
- JES, b-tag, had., frag, neutral hadrons fraction uncertainties

Similar, but for "light jets":
m_W from ee->eνW->eνqq

Higgs CP properties H->ττ

- τ reconstruction
- PID, Exclusive decay modes
- momentum & impact parameter

Near-degenerate Higgsinos

- Reco of low momentum particles
- Fake tracks
- PID, Exclusive decay modes
- Hermeticity
- Low and high-energy photon energy & angle resolution

A_{FB} (top)

- JER, lepton ID, b-tag
- *Jet charge*, excl. B-decays,

Mono-photon WIMPs

- Photon energy resolution & scale, hermeticity, *suppression of Bhabhas, dL/dE_{CM}*

towards a more formal ILD organisation

Yasuhiro / Ties @ Oshu

Step 1: Define ILD membership

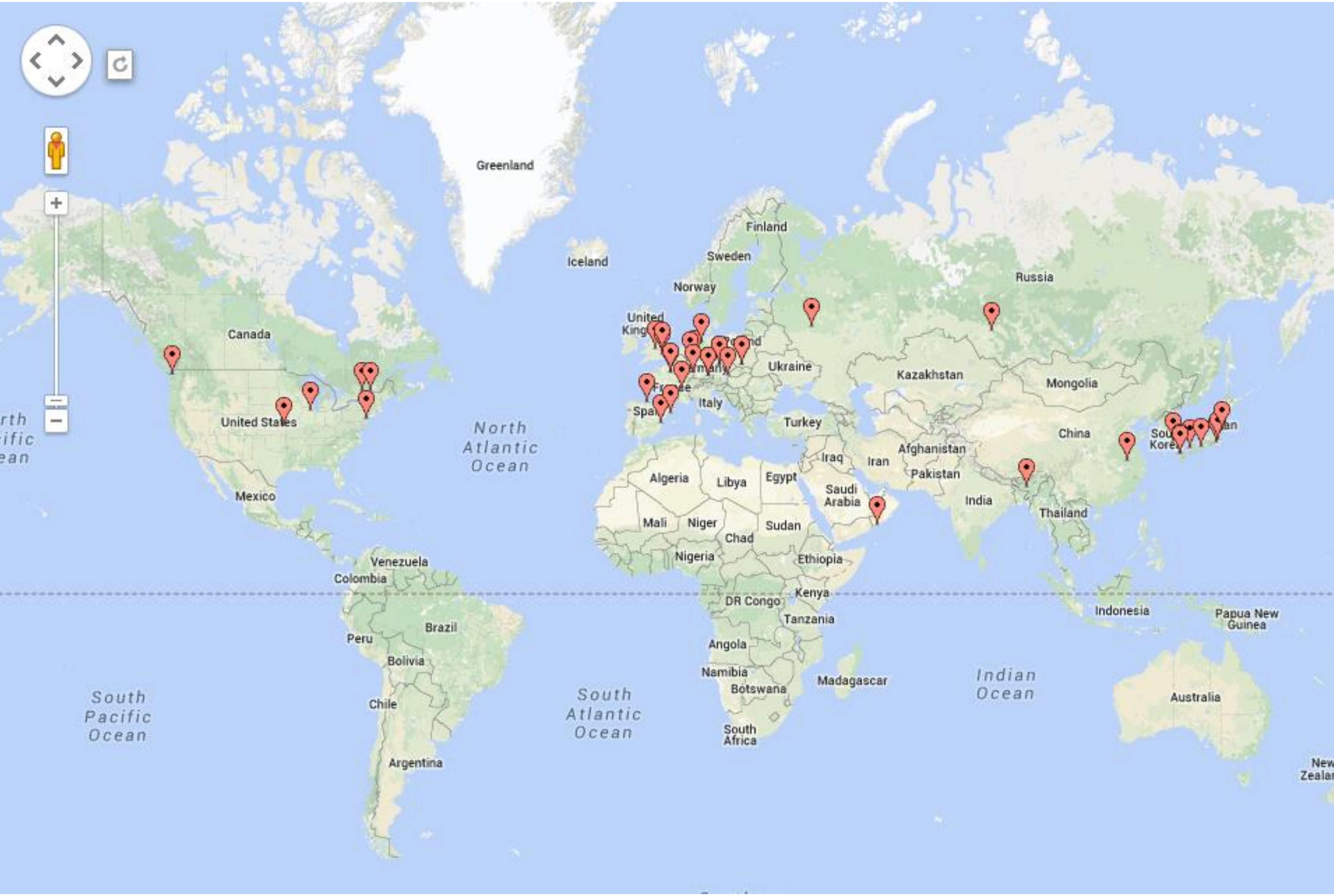
Call for groups to sign "Statement of participation" in ILD

No financial etc commitment,
but "formal" expression of the intent to participate in ILD.

So far 57 Institutes have signed up: great success in my view

Step 2: ILD institute assembly elects a chair ongoing

Defines the next step of the ILD structure
Setup a procedure to move towards election of ILD leadership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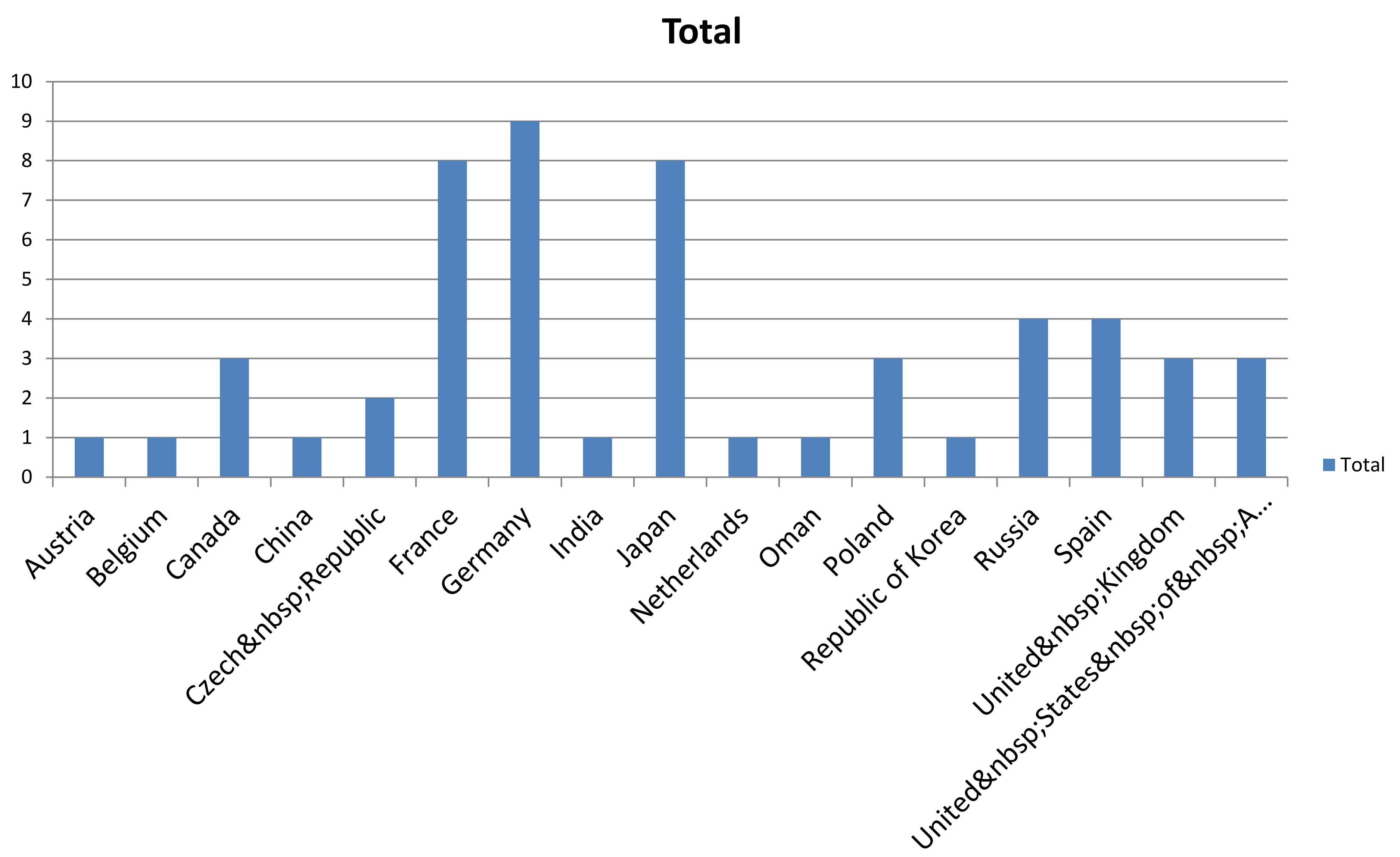
Iceland
Finland
Sweden
Norway
Russia
Canada
United States
Ukraine
Kazakhstan
Mongolia
Italy
Turkey
China
North Atlantic Ocean
Mexico
Algeria
Libya
Egypt
Iraq
Iran
Afghanistan
Pakistan
Saudi Arabia
India
Thailand
Mali
Niger
Chad
Sudan
Nigeria
Ethiopia
Venezuela
Colombia
Kenya
DR Congo
Tanzania
Indonesia
Papua New Guinea
Brazil
Peru
Angola
Bolivia
Namibia
Botswana
Madagascar
Indian Ocean
Australia
South Pacific Ocean
Chile
South Atlantic Ocean
South Africa
Argentina

IA: Country Distribution



summary

- ILD concept is very mature, performance based on DBD is very impressive.
- significant and very active effort continuing to develop the technologies and to show the maturity of the proposed system.
- performance might not be optimized, particularly cost-performance; lots of efforts have been put on optimization of ECAL in terms of JER; to understand PFA is crucial.
- significant efforts are needed to translate to impact on physics.
- making the ILC physics case is currently one of the most important tasks in ILD group; working group is now looking into systematics/calibration/PID/low-p tracking, etc.
- more formal organisation, everyone is welcome to join!

apologies to many sub-detector efforts that I couldn't cover