SDA_1: Event generators and Higgs Physics at LHC

FY2007 R&D plan
(two photon production)

KURIHARA, Yoshimasa

10/May/2007,Workshop FJPPL'07

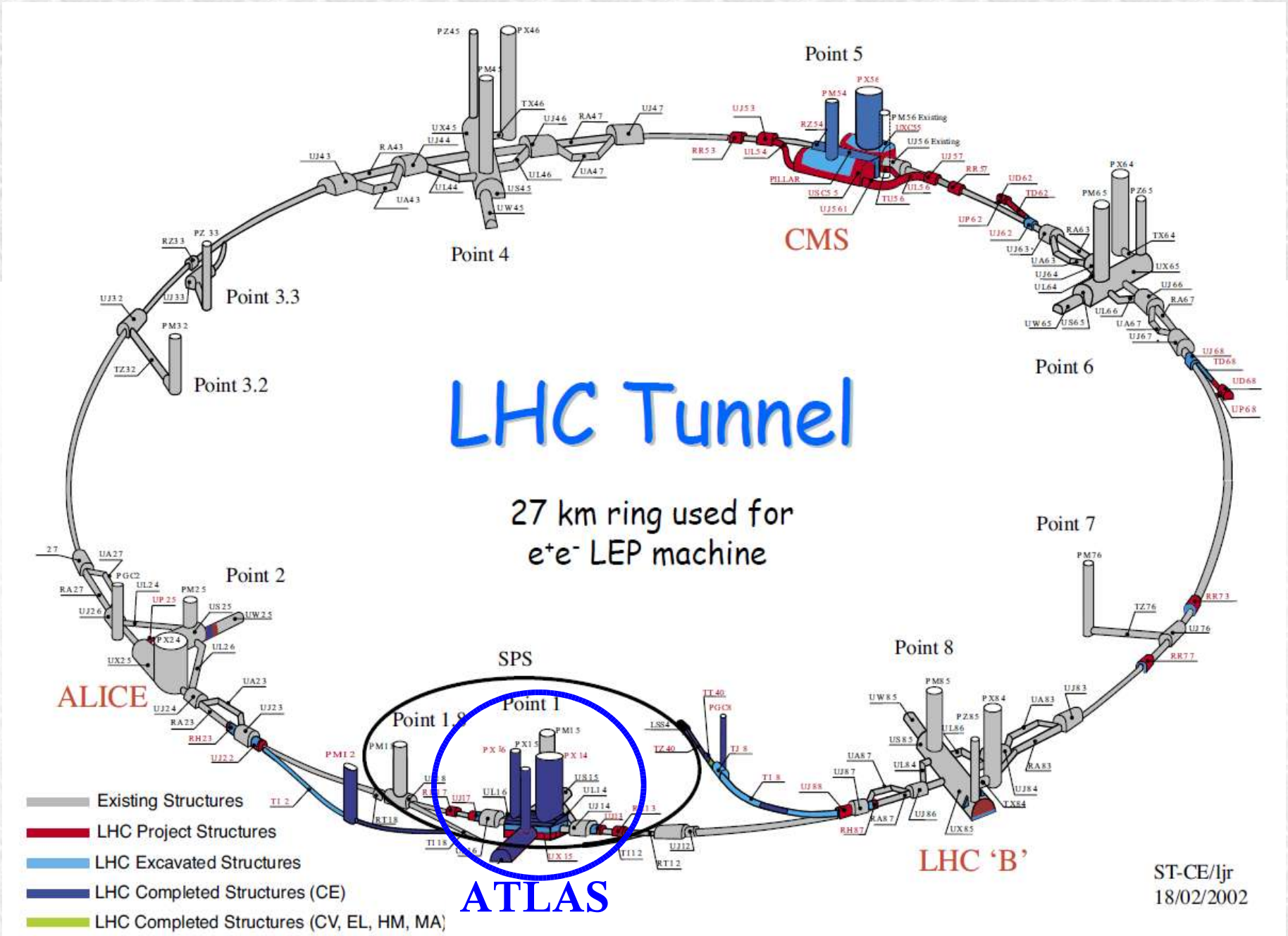
Members

French Group			Japanese Group		
Name	**Title**	**Affiliation**	**Name**	**Title**	**Affiliation**
Leader			Leader		
Jean-Philippe Guillet	Dr.	CNRS	Yoshimasa Kurihara	Dr.	KEK
Theory			Theory		
F. Arleo	Dr.	CNRS	H. Kawamura	Dr.	Riken
P. Aurenche,	Dr,	CNRS	J. Fujimoto	Dr.	KEK
E. Pilon	Dr.	CNRS	K. Kato	Pr.	Kogakuin Un.
G. Sanguinetti	PhD		H. Tanaka	Pr.	Rikkyo Univ.
M. Werlen	Dr.		T. Uematsu	Pr.	Kyoto Univ.
Experiment/Atlas			Experimental/Atlas		
S. Laplace	Dr.	CNRS	K. Kondo	Pr.	KEK
J.F. Marchand	Dr.	CNRS	S. Odaka	Dr.	KEK
I. Wingerter-Seez	Dr.	CNRS	J. Tojo	Dr.	KEK/LAPP
Denis Perret-Gallix	Dr.	CNRS			

Activity of SDA1 in 2006

- Subject: Developing NLO event-Generator in LHC physics
- Exchange in 2006:
  J→F:8 people, 45 days in total
  F→J:3 people, 25 days in total
- Publications(related):

1. "NLO-QCD calculation in GRACE ", Y. Kurihara et.al.Nucl.Phys.Proc.Suppl. 157(2006)157
2. "GR@PPA 2.7 event generator for pp / p anti-p collisions." S. Tsuno et.al., Comput.Phys.Commun.175:665-677,2006.
3. "Algebraic evaluation of rational polynomials in one-loop amplitudes." T. Binoth et.al, JHEP0702(2006)13.
4. "New one-loop techniques and first applications to LHC phenomenology." ,T. Binoth et.al, Nucl.Phys.Proc.Suppl.160:61-65,2006.



- **Commissioning from this November**
- **Physics running at 14 TeV starts in 2008**

LHC Performance

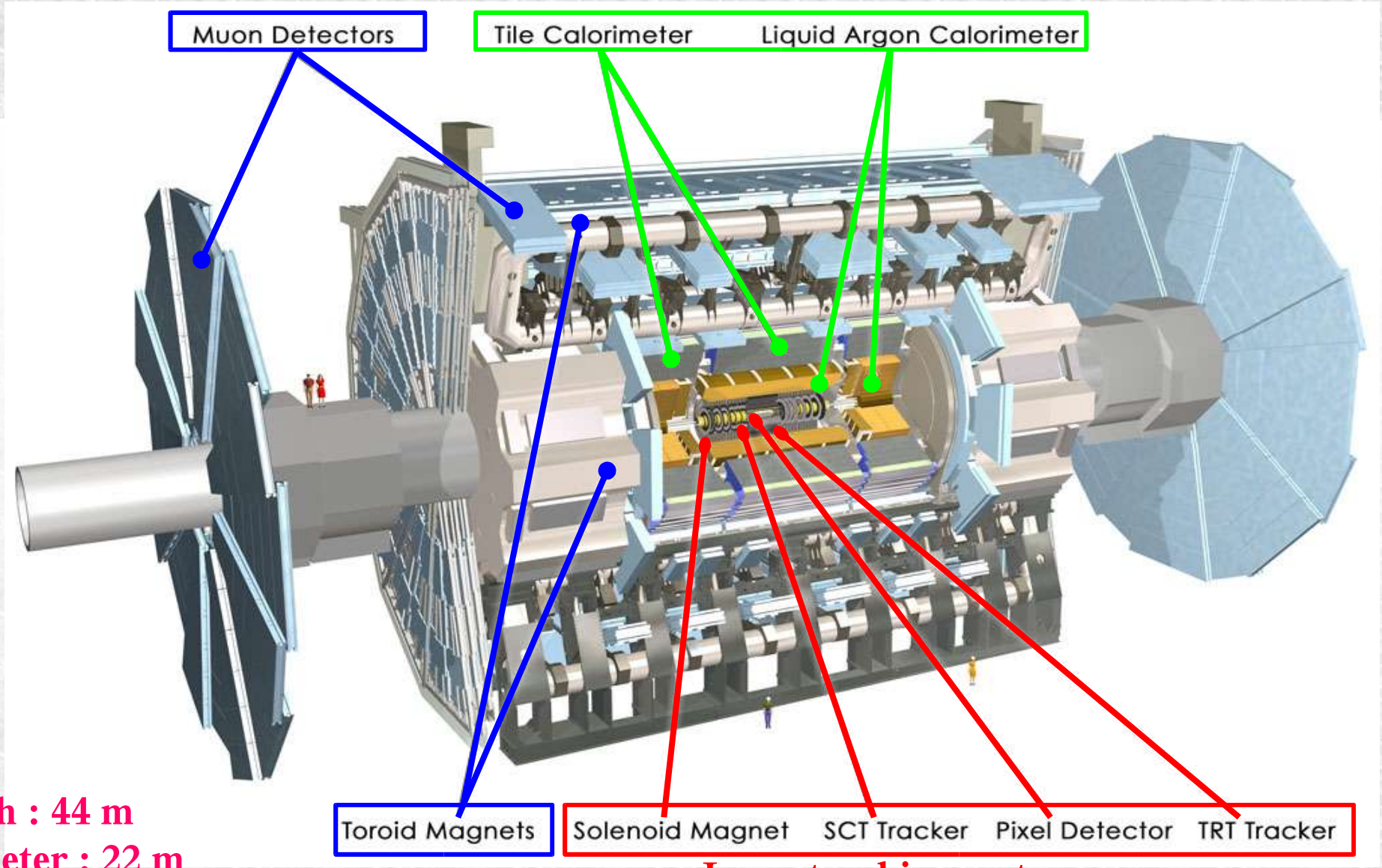
- The highest energy proton-proton collider
  - CM energy : $\sqrt{s}$ = 14 TeV (7 TeV + 7 TeV)

- Very high luminosity
  - 40 MHz (25ns) bunch crossing (!)
    - ~20 pp interactions per bunch crossing at design luminosity
  - Low luminosity runs for early 2-3 years (start in 2008)
    - $L_{peak} = 10^{33}\ cm^{-2}s^{-1}$, $\int L\,dt = 10\ fb^{-1}$ for 1 year
  - Design luminosity runs
    - $L_{peak} = 10^{34}\ cm^{-2}s^{-1}$, $\int L\,dt = 100\ fb^{-1}$ for 1 year

The ATLAS Detector

Muon spectometer
w/ toroidal magnetic field

Electromagnetic/hadronic Calorimeter



Width : 44 m
Diameter : 22 m
Weight : 7,000 t

Inner tracking system
w/ 2 T solenoid magnet

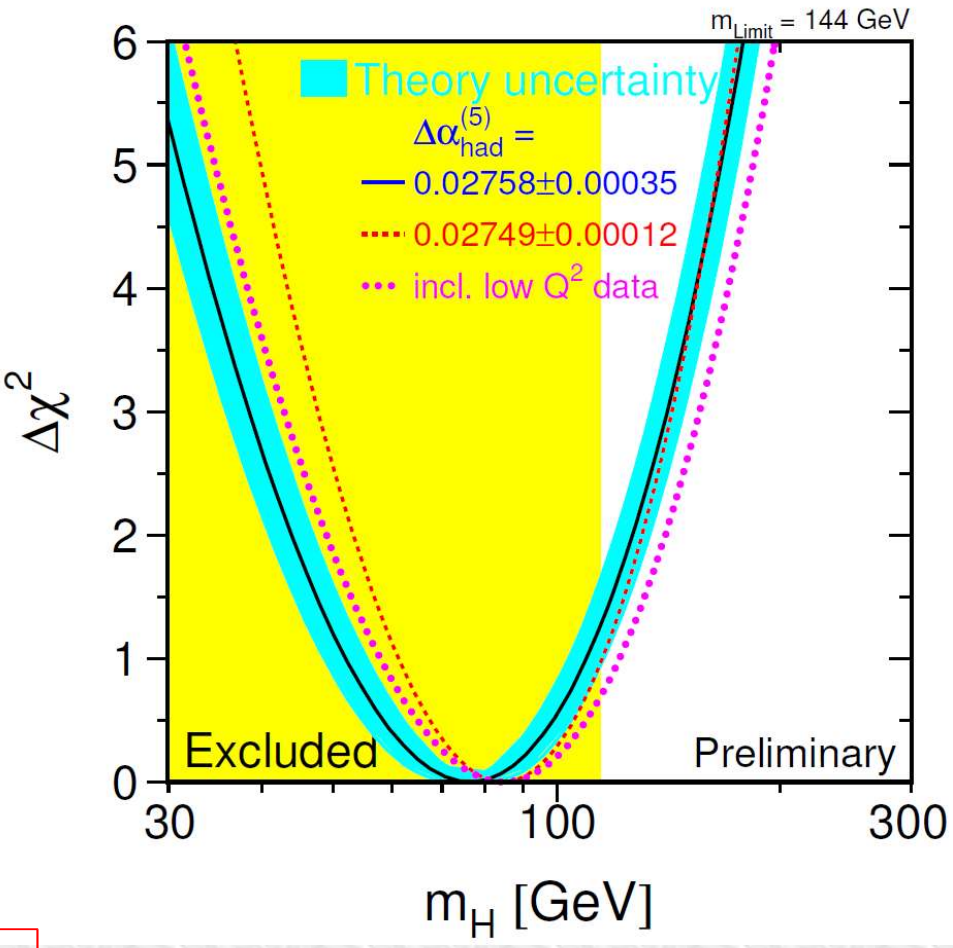
Recent Status of Constraint to SM Higgs Boson Mass

- Theory
  - Unitarity limit of WW scatteri amplitude :

    $M_H < (8\sqrt{2}\pi / 3\ G_F)^{1/2} \approx 1$ TeV
- Experiment
  - High precision Electroweak measurements sensitive to SM Higgs boson mass through radiative correction (loop)

    $M_H = 76\ (+33\ -24)$ (68% CL)
  - Including direct search at LEP

    $114 < M_H < 182$ GeV (95% CL)



LEP EWWG, 2007 winter ver.
http://lepewwg.web.cern.ch/LEPEWWG/

Favor light SM Higgs boson mass :

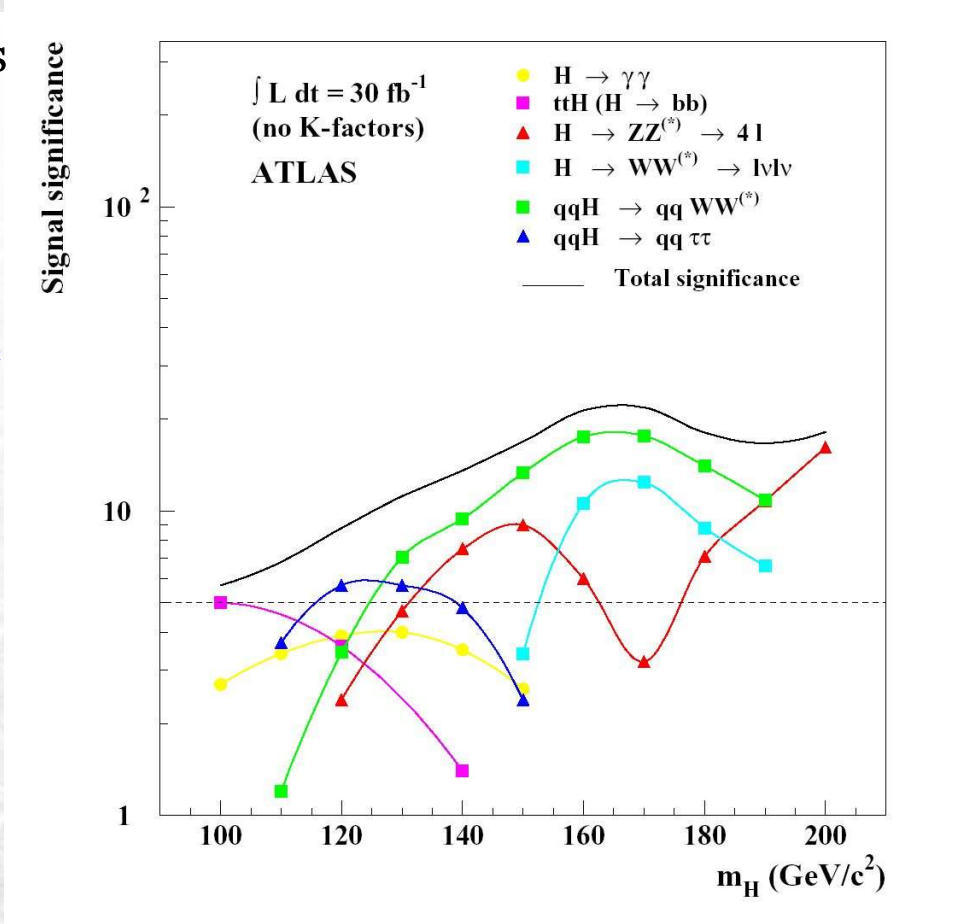
in a range of 100 – 200 GeV

Discovery Potential of SM Higgs Boson in ATLAS

- Discovery potential of SM Higgs boson has been studied in various production/decay channels for many years.

- The updates and improvements are actively under way in ATLAS to be ready for data-taking coming soon.

- One of the most promising discovery channels for light Higgs boson : $H \rightarrow \gamma\gamma$



S. Asai *et al.*, EPJC32, 19 (2003)

Proposal

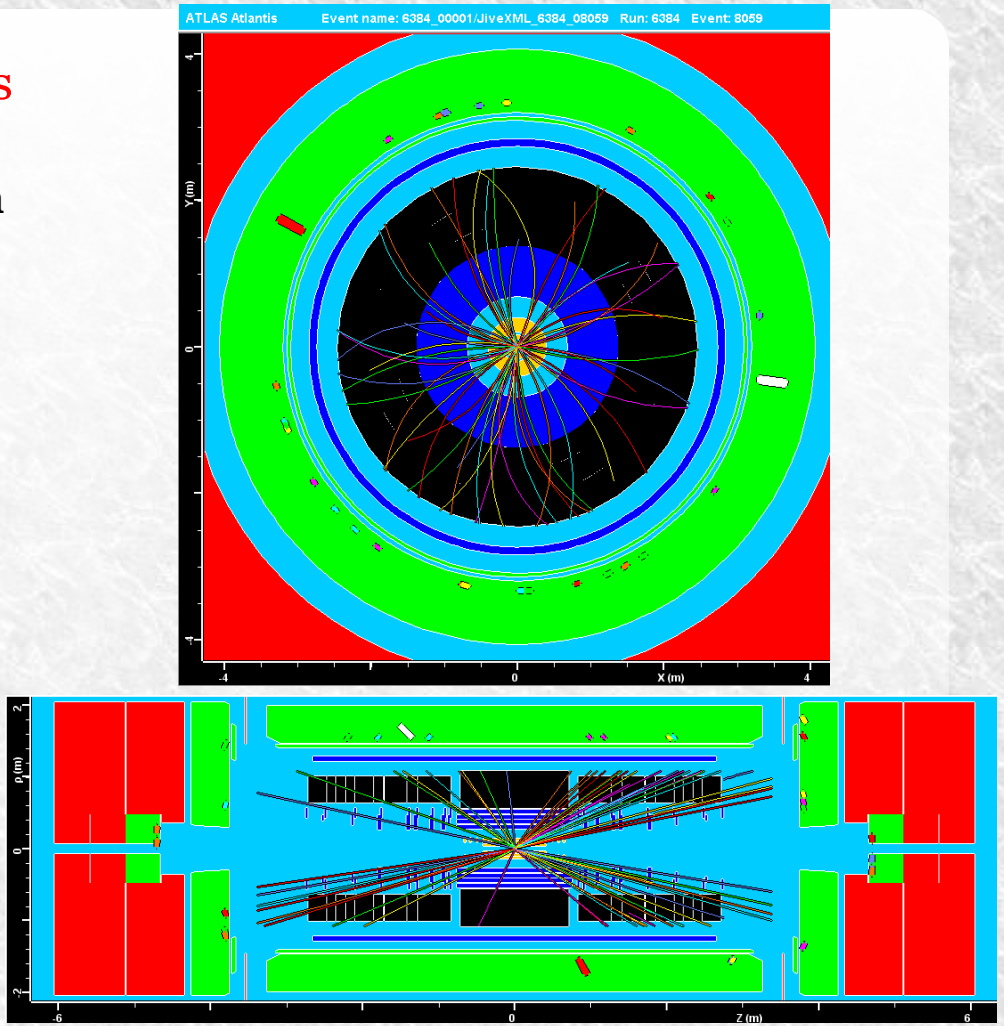
"Search for Higgs Boson via H→γγ and Study of Its Backgrounds"

- The most promising & important channel to discover a light Higgs boson
  - The simplest decay channel, which allows us to un-ambiguously determine Higgs boson mass.
  - Bench mark channel to establish the Higgs boson discovery in combination with other complicated channels.

- Experimental challenges

→ Key tasks in this proposal

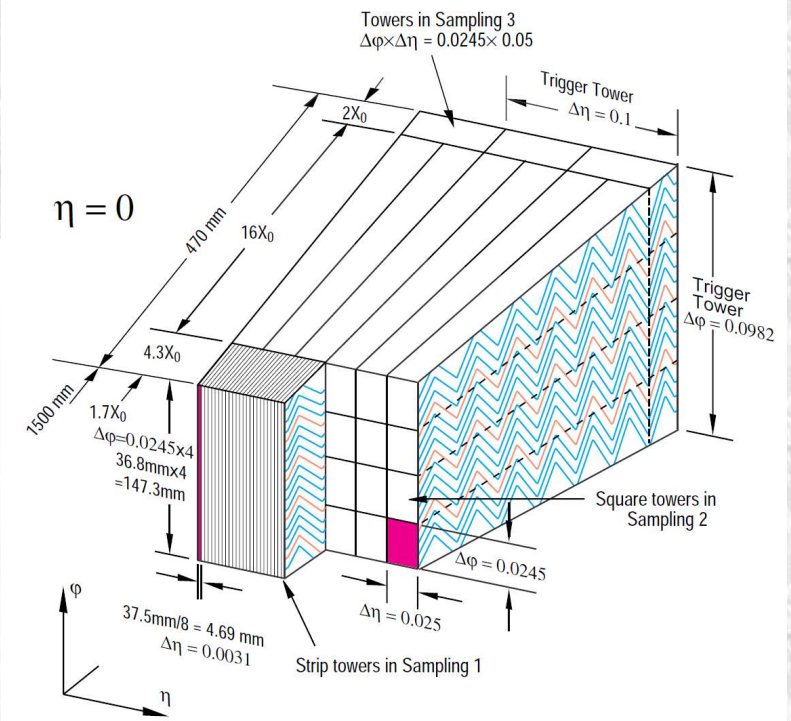
- Requirement for excellent detector performance for high-p_T photons in LHC/ATLAS environment
  - Understanding & estimation of SM backgrounds

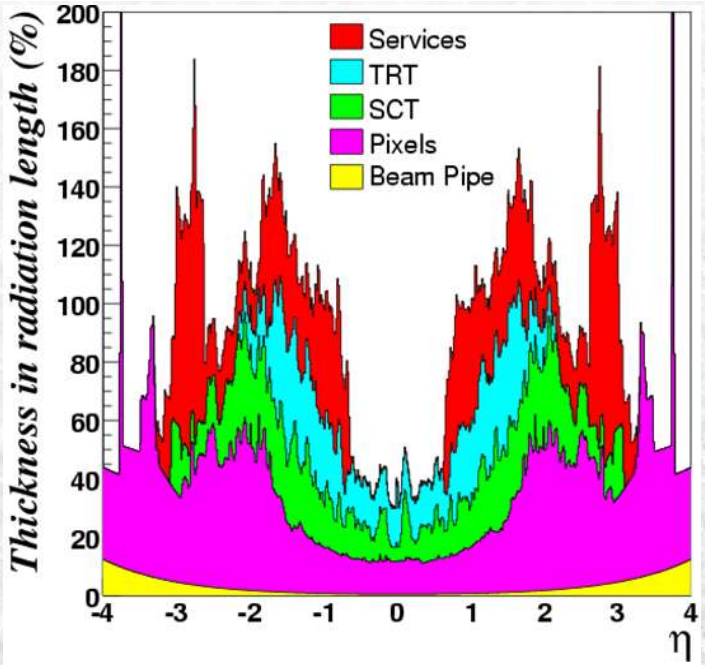


Full detector simulation for $H \rightarrow \gamma\gamma$ in ATLAS

Tasks in the Proposal (1/2)

- Performance studies of high-p_T photon identification
  - Jet rejection
    - Requirement of ~ 10^3 at efficiency of ~80%
    - Achieve with highly-granulated EM calorimeter
  - Photon conversion
    - ~30% of photons convert to e+e-, due to massive detector material
    - Pursuit a possibility to recover the conversion.
  - Primary vertex reconstruction
    - Degradation of the reconstruction efficiency caused by pile-up events especially in design luminosity
    - Improved reconstruction efficiency leads better invariant mass resolution and thus signal-to-background ratio.

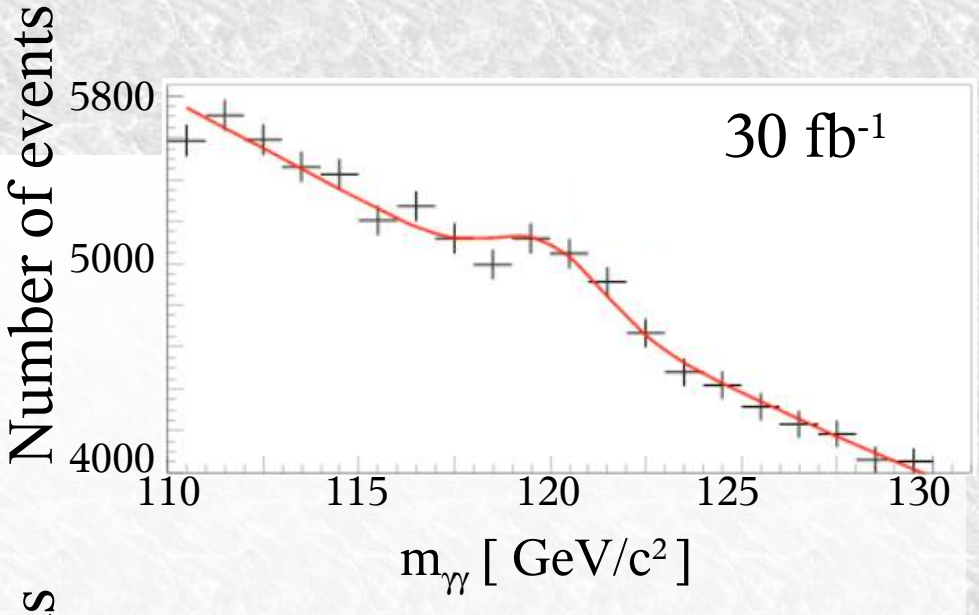


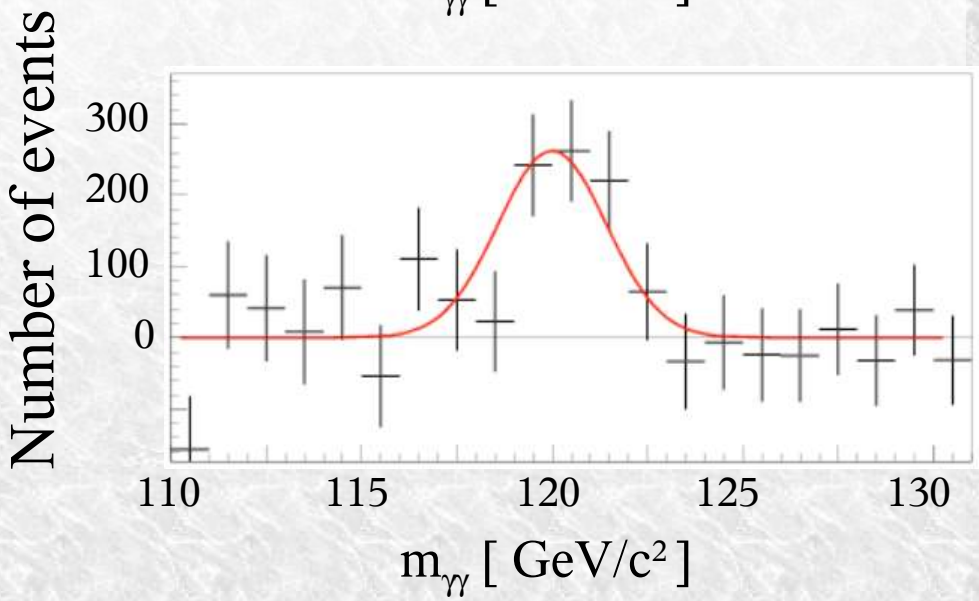


Tasks in the Proposal (2/2)

- Understanding of SM physics backgrounds
  - Reducible background
    - jet+jet & photon+jet production
    - Large cross-section
    - Reducible with jet rejection requirement (~10^3) fulfilled.
  - Irreducible background
    - 2 photon production
    - Dominant background irreducible in 2 photon system
    - Need better theoretical/experimental understanding to reduce systematics

    → Event generator will help this aspect.



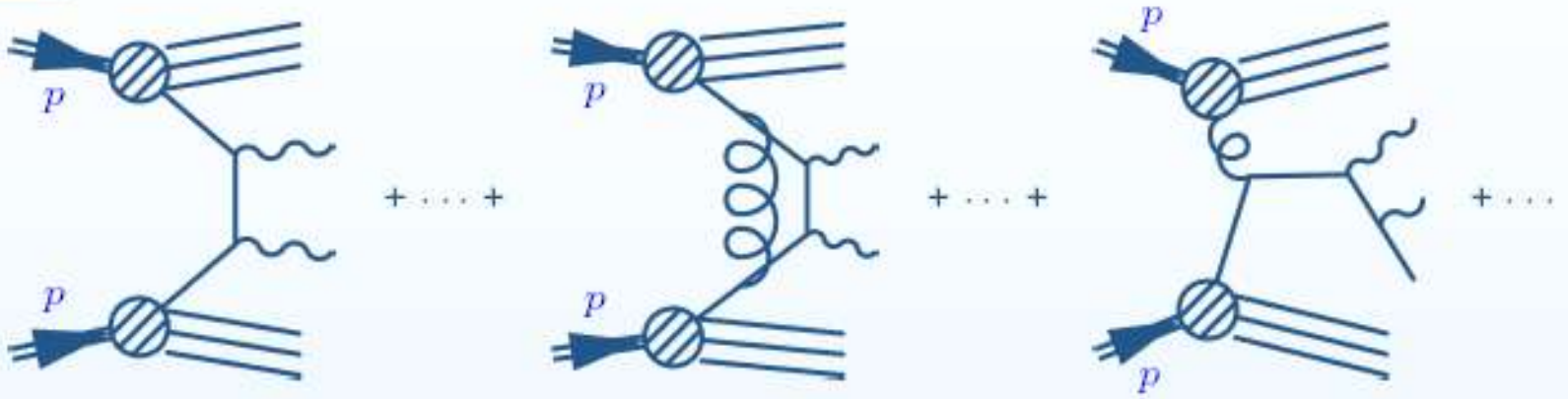


DIPHOX

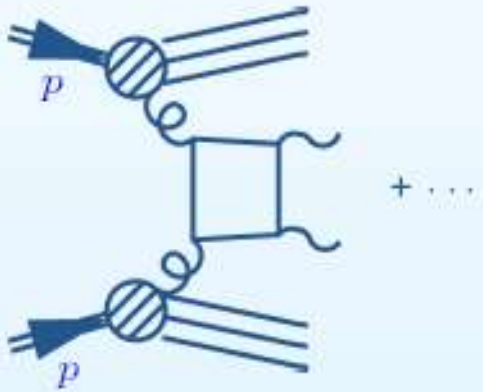
A program to calculate the hadroproduction of two photons (or one hadron plus one photon, or two hadrons) at NLO.

T. Binoth, J.P. Guillet, E. Pilon, M. Werlen
(Annecy, LAPTH)
Eur.Phys.J.C16:311-330,2000

Direct

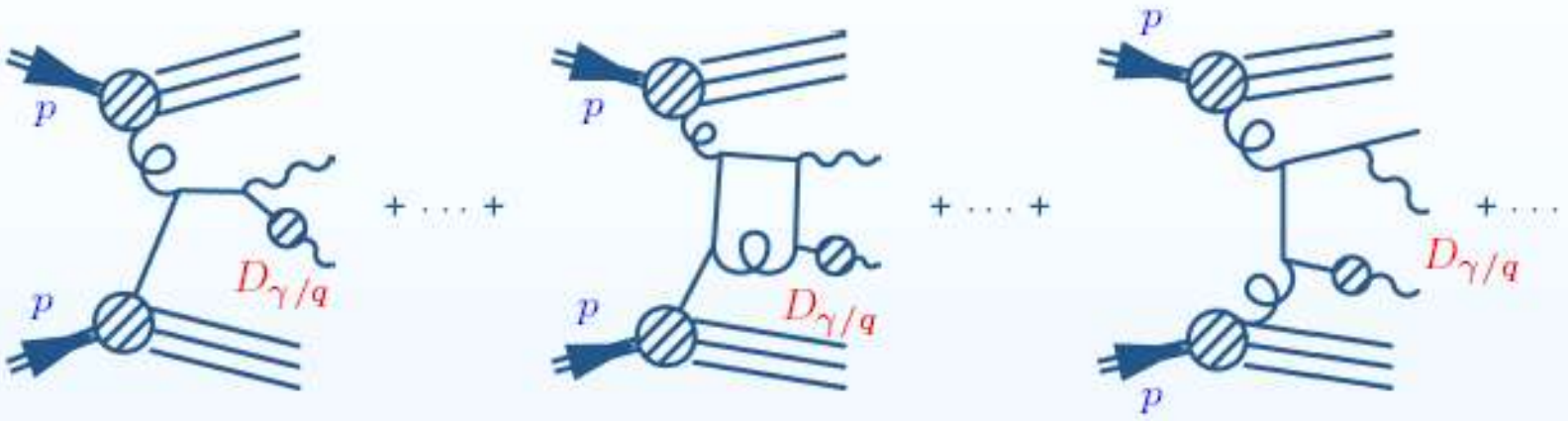


$O(\alpha^2)$ + $O(\alpha^2\ \alpha_s)$



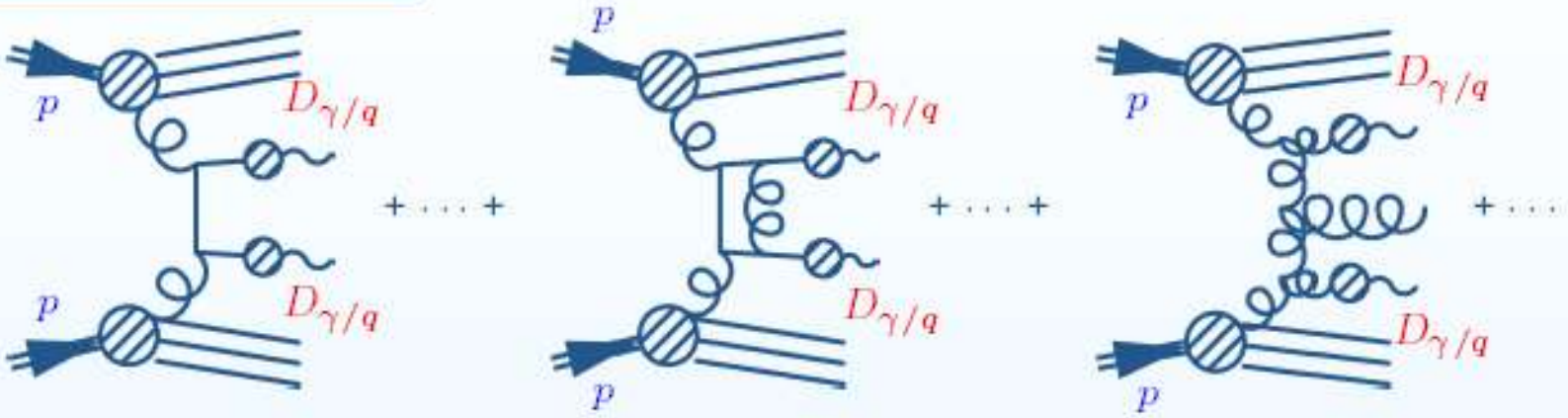
$O(\alpha^2\ \alpha_s^2)$

One Fragmentation



$O(\alpha^2\ \alpha_s)$ + $O(\alpha^2\ \alpha_s^2)$ but $D_{\gamma/q}(z, M_f^2) \simeq 1/\alpha_s(M_f^2)$

Two Fragmentation



$O(\alpha^2\ \alpha_s^2) + O(\alpha^2\ \alpha_s^3)$

NLO codes

	type of code	Direct	One Frag.	Two Frag.
Aurenche et al.	I/FO	NLO	LO	none
Owens et al.	G/FO	NLO	LO	none
DIPHOX (*)	G/FO	NLO	NLO	NLO
RESBOS	G/SGS	NLO	NLO	NLO

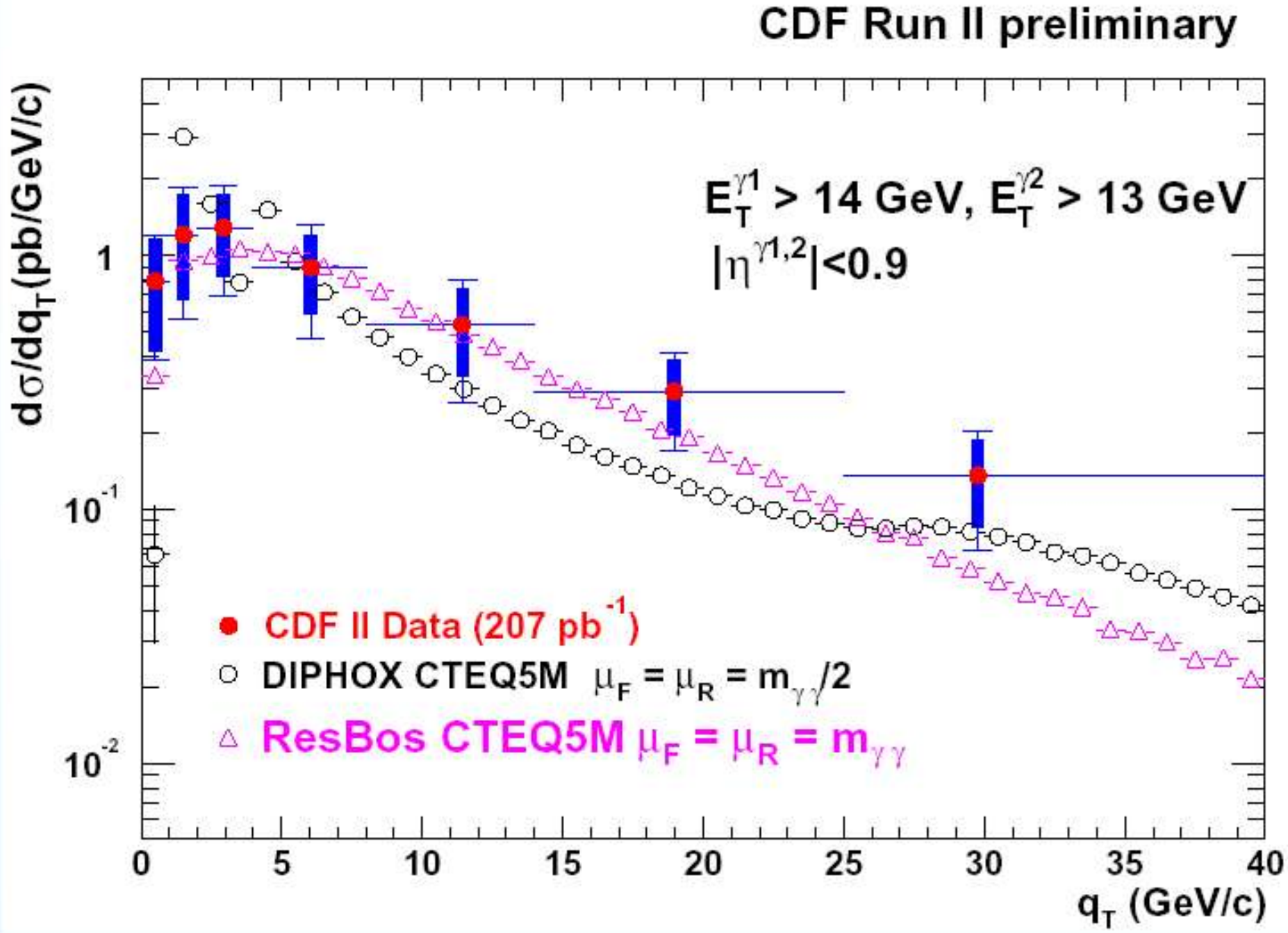
I : Inclusive
G : Generator
FO : Fixed Order
SGS: Soft Gluon Summation

(*) http://wwwlapp.in2p3.fr/lapth/PHOX_FAMILY/main.html

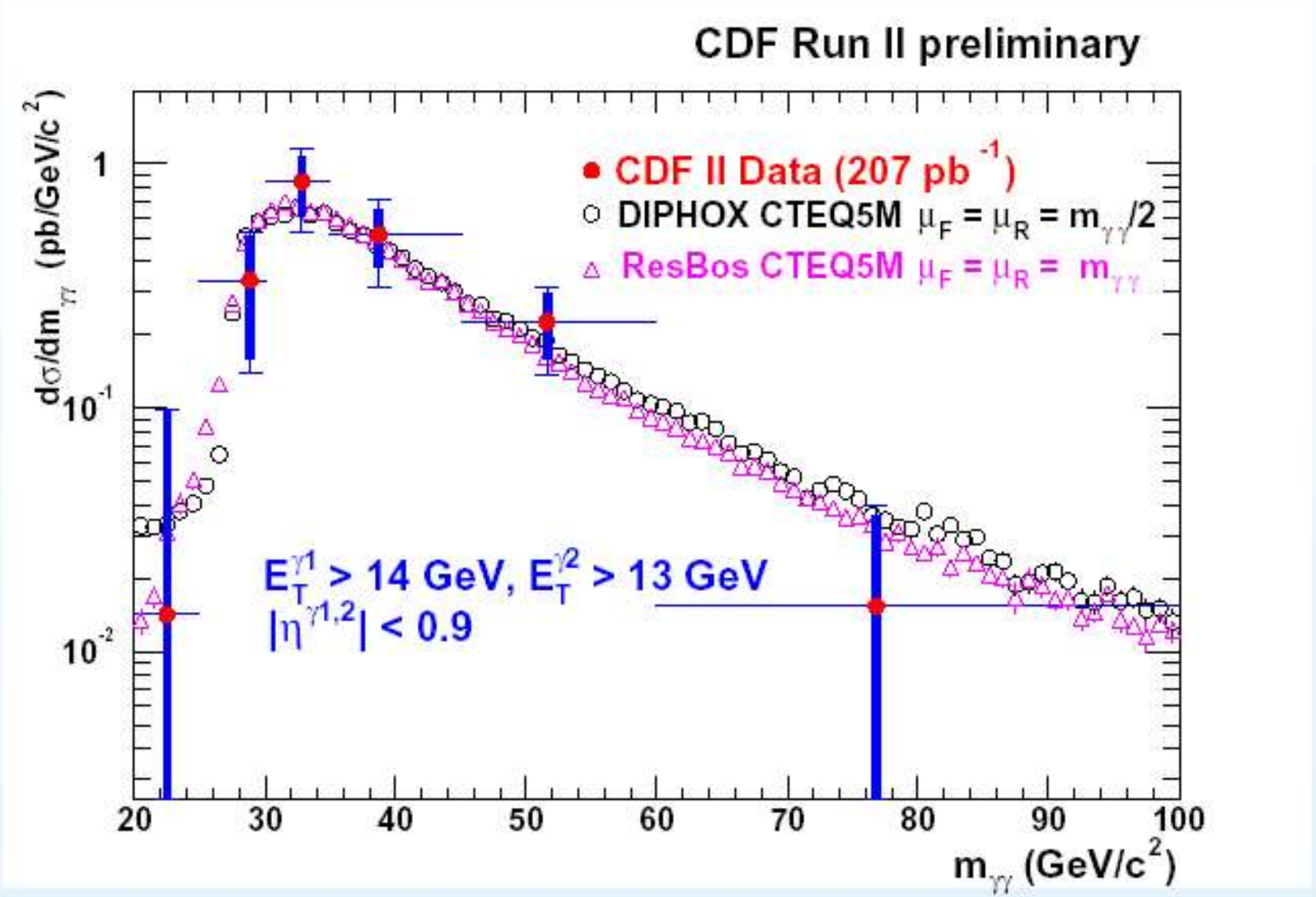
Fully exclusive Generator

Inclusive Generator

q_T of the pair distribution



Invariant mass distribution



Points will be improved

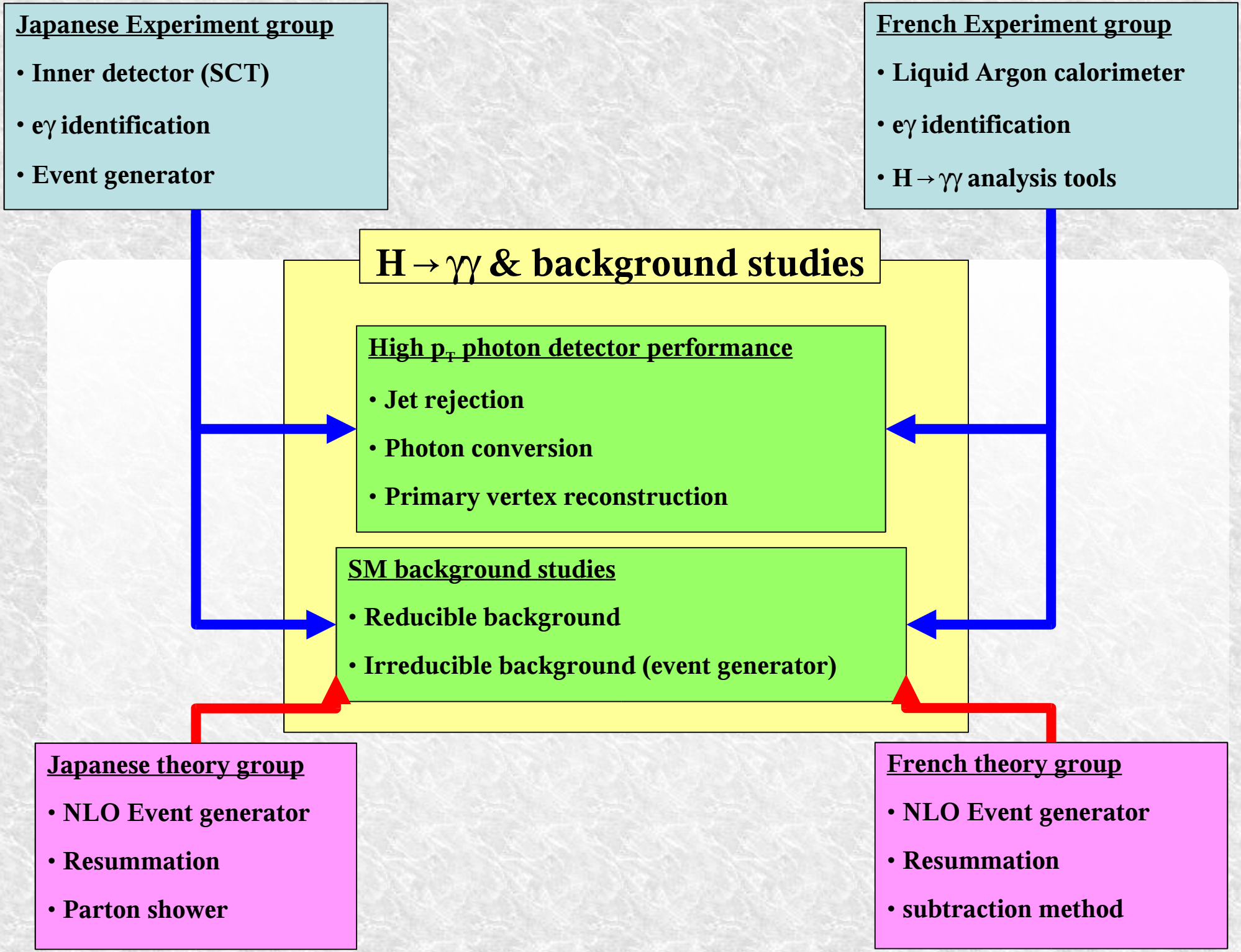
A phase-space slicing is used for the NLO regularization.

-Non smooth behavior at small p_Ts

-Large negative cross sections

- In the default setting, more than 40% of the generated events have a negative weight(=-1)

It has to be replaced with a subtraction method.
Soft parton resummetion (PS) must be included.


Japanese Experiment group
• Inner detector (SCT)
• eγ identification
• Event generator
French Experiment group
• Liquid Argon calorimeter
• eγ identification
• H→γγ analysis tools
H→γγ & background studies
High p_T photon detector performance
• Jet rejection
• Photon conversion
• Primary vertex reconstruction
SM background studies
• Reducible background
• Irreducible background (event generator)
Japanese theory group
• NLO Event generator
• Resummation
• Parton shower
French theory group
• NLO Event generator
• Resummation
• subtraction method

Application for LIA Project (2007)

Budget Plan

French Teams				Japanese Teams			
Item		**Euro**	**Supported by**	**Item**		**kYen**	**Supported by**
Travel cost	1000€			Travel+per-diem	200K¥		
Theory	3	8000	CNRS/Bilateral	Theory		2500	JSPS/Bilateral
Experimental	2	5000	IN2P3	Experimental		2400	KEK
Total		13000				4900	