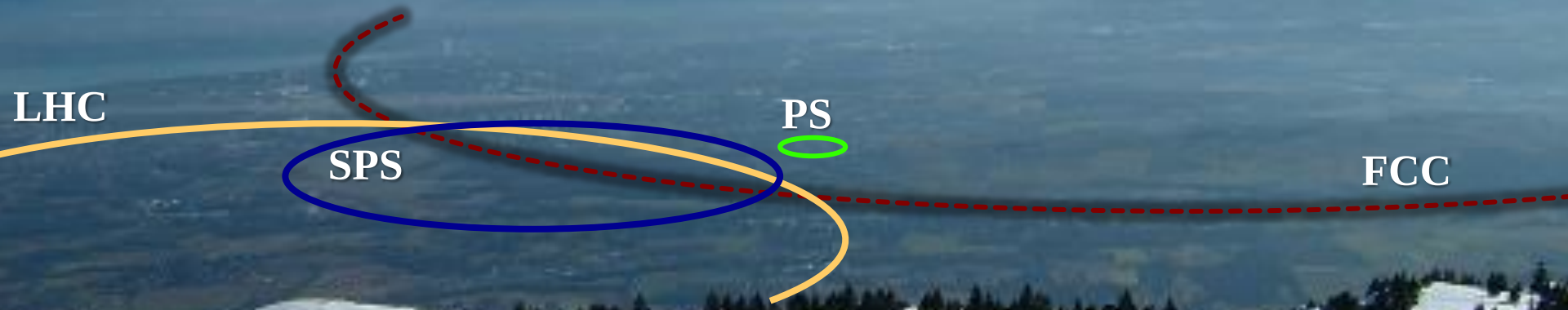
CEA/IRFU (Saclay) and FCC
Main areas of interest within FCC

IRFU: Institute of Research into the Fundamental laws of Universe at CEA

See also F. Millet presentation on proposed contributions for cryogenic system from CEA-Grenoble

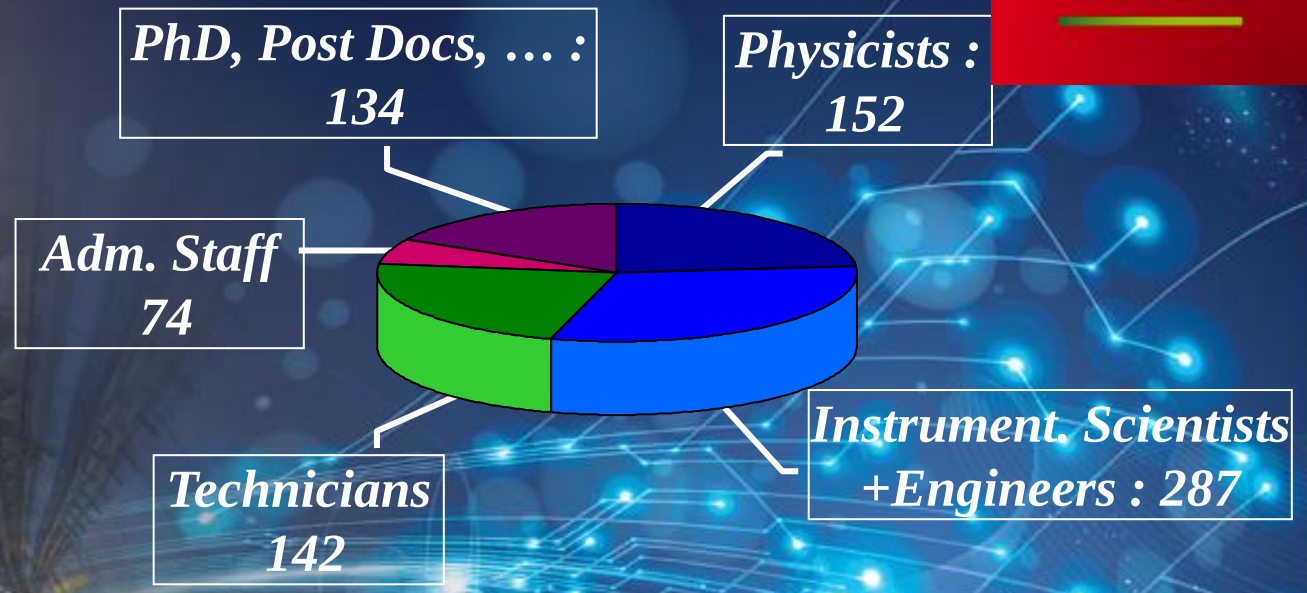
R. Aleksan
ICB
Sept. 10, 2014

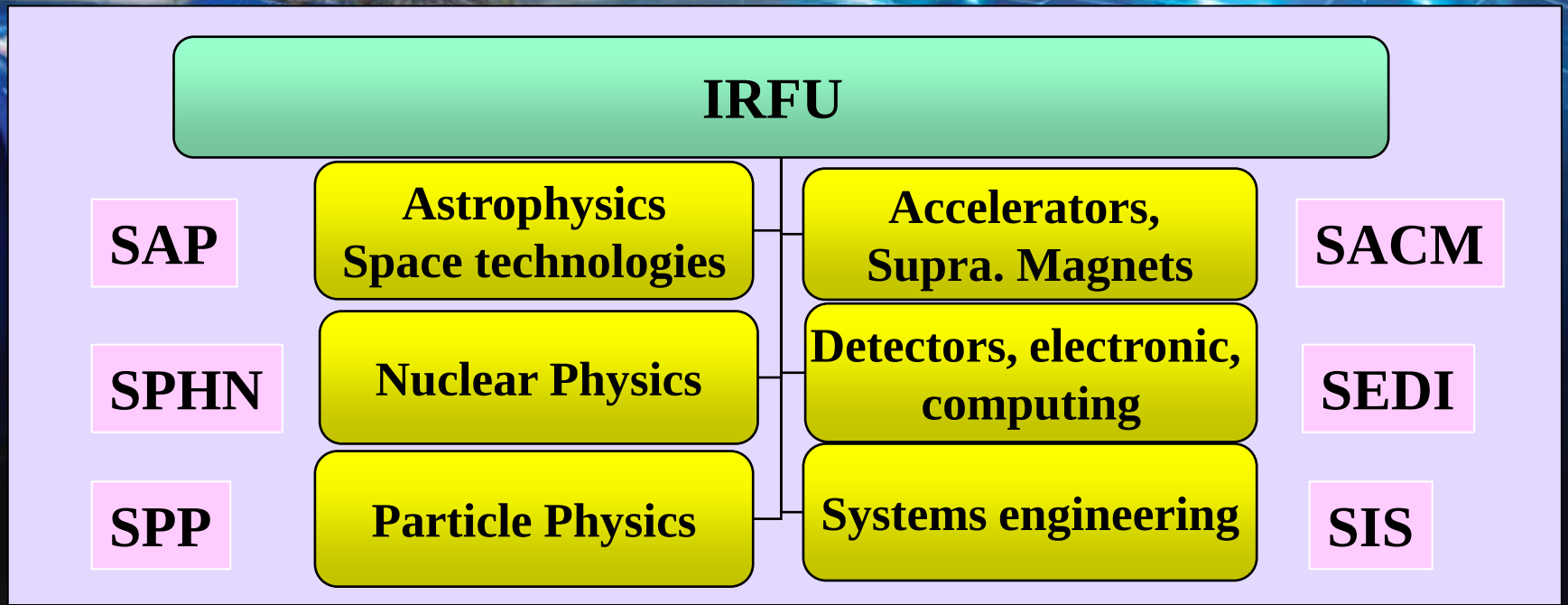


- **Organization**
- **IRFU's area of interest**

IRFU

IRFU personnel in 2013 : ~790





IRFU and FCC

Both for FCC-hh and FCC-ee , the areas of interest cover

- ***Physics Studies***
- ***Detector Studies***
- ***Accelerator Studies***

In the following, the proposed contributions with quantitative commitment efforts are indicated in green,
Interest without quantitative commitment efforts is indicated in magenta

Note: other topics (not mentioned here) are under discussion in the group

Involvement of IRFU in FCC Physics Studies

DE LA RECHERCHE À L'INDUSTRIE
cea

FCC-hh

Search of new physics

The physicists are mainly interested to study the mass reach at FCC-hh for BSM particles : SUSY and heavy resonances in di-lepton, $t\bar{t}$ or multi-boson final states.

FCC-ee

Precision measurements

Measured parameter	Method	Energy (GeV)
Γ_H	σ_{HZ}	240
	$\sigma_{HZ} \times \mathrm{Br}(\mathrm{H} \to \mathrm{ZZ})$	
$\Gamma_{\mathrm{H}\to inv}$	$\sigma_{HZ} \times \mathrm{Br}(\mathrm{H} \to \mathrm{inv})$	240
g_{Hcc}	$\sigma_{HZ} \times \mathrm{Br}(\mathrm{H} \to c\bar{c})$	240
N_ν	$\sigma_{HZ} \times \mathrm{Br}(\mathrm{Z} \to \mathrm{inv})$	240
	$\sigma_{ZZ} \times \mathrm{Br}(\mathrm{Z} \to \mathrm{inv})$	
	$\sigma_{\gamma Z} \times \mathrm{Br}(\mathrm{Z} \to \mathrm{inv})$	
N_ν	$\sigma_{\gamma Z} \times \mathrm{Br}(\mathrm{Z} \to \mathrm{inv})$	126
$\mathrm{Br}(\mathrm{H} \to \mathrm{ee})$	$\sigma_{e^+e^-\to H}$	126
$\mathrm{m_t}, \Gamma_\mathrm{t}, g_{Htt}$	$\sigma_{e^+e^-\to \mathrm{t}\bar{\mathrm{t}}}$, $\frac{\mathrm{d}p_{peak}}{\mathrm{d}E_{cm}}$, A_{FB}	Scan 350
$\mathrm{m_W}$	$\sigma_{e^+e^-\to WW}$	Scan 160

Involvement of IRFU in FCC Detector study

FCC-hh

Study and optimization of the magnetic configuration and magnet layout of the FCC-hh detectors.

Capitalizing on IRFU's experience in LEP and LHC, we propose to study the magnetic configuration and magnet layout of the FCC-hh detectors.

- **Comparative studies of the solenoid options with passive and active shielding.**
- **Study of the a large toroid option.**

This may be extended for the FCC-ee detectors

FCC-ee

Study of the operability of a TPC for a FCC-ee detector

Two important issues have to be studied

1) Ions

- **Primary ions**
- **Back flow of ions**

2) Low power electronic

- **Minimization of material in the end plates**

Synergy with IRFU contribution to ILD detector for ILC

Involvement of IRFU in FCC

Accelerator study

FCC-hh

Fully involved in EuroCirCol

- **Design of the arc lattice , e.g.**
  - Dynamic aperture evaluation
  - Aperture and field quality specifications

⇨ 108 p-m

- **High-field Accelerator Magnet Design e.g.**
  - Dipole Magnet design
  - Field quality evaluation, comparison and optimization

⇨ 36 p-m

- Arc Quad Magnet design
- Field quality evaluation, comparison and optimization

FCC-ee

SRF system

- RF generation
- Cavities
- Cryomodule

IRFU is a major participant to XFEL (photo) and ESS SC-RF systems

Conclusions

Strong interest from IRFU in FCC Study

- ⇨ ***Physics Studies***
- ⇨ ***Detector Studies***
- ⇨ ***Accelerator Studies***

Potentially large group

- ⇨ ***18 physicists***
- ⇨ ***9 engineers***

have declared interest… but most people involved in operating experiments/projects

- ⇨ **144 p-m committed in EuroCIRCOL (pending its approval)**
- ⇨ **Yet difficult to quantify the available p-m on other topics**


Backup

With the discovery of the Higgs Boson

Self-consistent model (SM) accounting for all Particle Physics phenomena at presently accessible energy

but does not explain major issues

Mass of neutrino (in the most general way)
Baryon Asymmetry of Universe
Dark Matter, Dark Energy

Unification of all interactions

New Physics must exist … but at which energy scale?

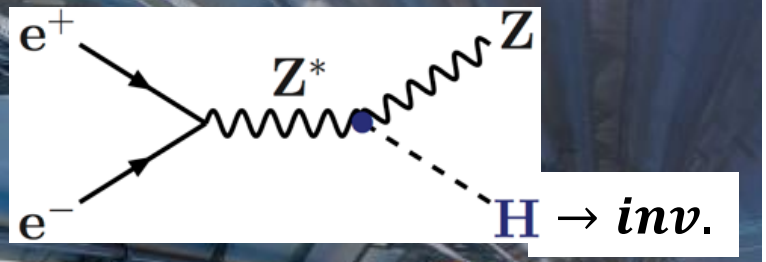
Direct Exploration of Higher Energy Scales

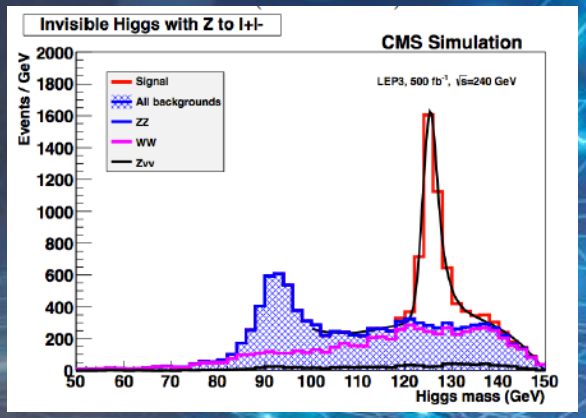
Precision measurements rare process studies

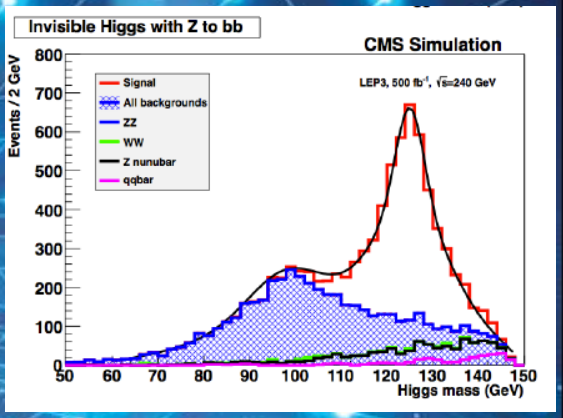
Involvement of IRFU in FCC

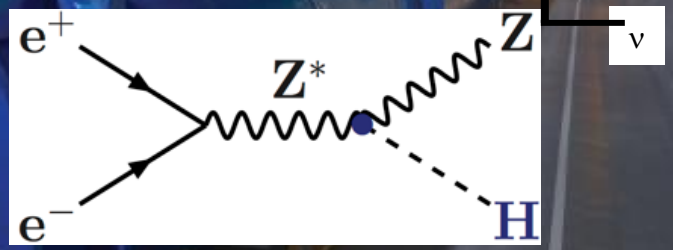
N_ν at FCC-ee (240 GeV)

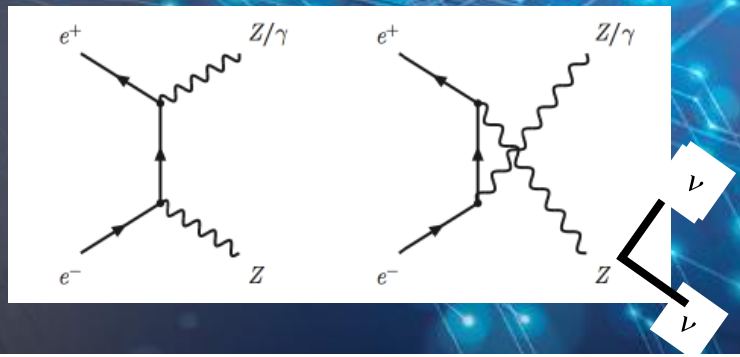
LEP measurement : $N_\nu = 2.984 \pm 0.008$











Combined (ZZ, ZH) precision potentially lead to $\delta N_\nu = 0.006$

γZ events potentially lead to $\delta N_\nu = 0.001$

Involvement of IRFU in FCC

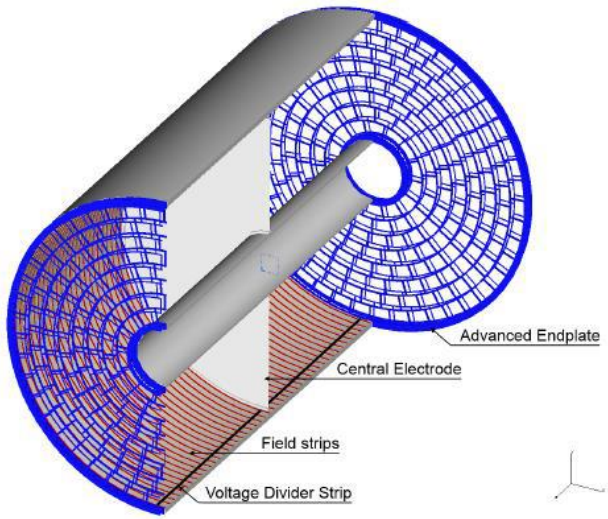
TPC for FCC-ee

There is a believe that TPC is the ideal detector for e^+e^-. Certainly TPC have been used with success at LEP and LHC (ALICE)

- **Minimum of material**
- **For excellent tracking capability (large number of measured points)**
- **Some PID with de/dx (5% resolution)**
- **Capitalization of studies done at IRFU (T2K/ILC) using micromegas**
- **Possible synergies with linear collider studies (ILD)**

But cannot be used in all environments!

- **R_{in} : 229 mm**
- **R_{out} : 1808 mm**
- **L_z : 2×2350 mm**
- **B=4 T**
- **$\sigma_{R\text{-}\phi}$ ~100 μm**
- **$\sigma_{R\text{-}Z}$ ~500 μm**
- **$dp/p^2 = 8 \times 10^{-5}$ (full tracking : 2×10^{-5})**



Most demanding conditions @ Z-pole

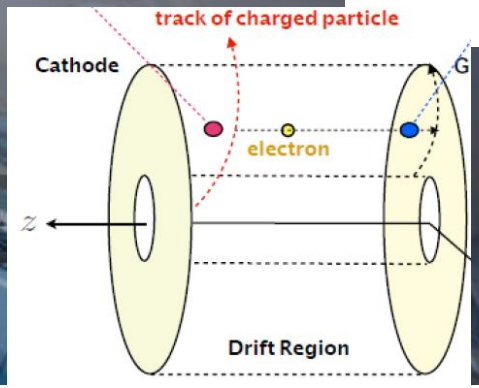
- **~33 kHz Bhabhas**
- **~17 kHz of hadronic events with <mult.> ~20 (~1 evt / 60 μs avg)**
- **Total drift time ~50μs**
- **On average < 1 evt drifting in TPC**
- **2-hit r-z resolution is 8 mm (160 ns drift time) ⇨ evt mixing is negligible**

Involvement of IRFU in FCC

TPC for FCC-ee : ions are the main issue

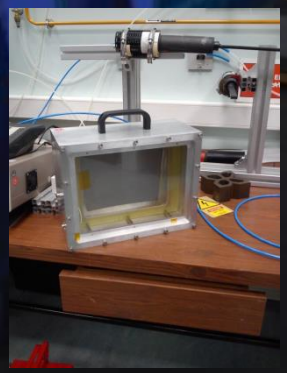
Primary ions

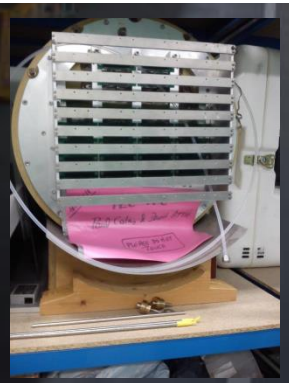
Secondary ions



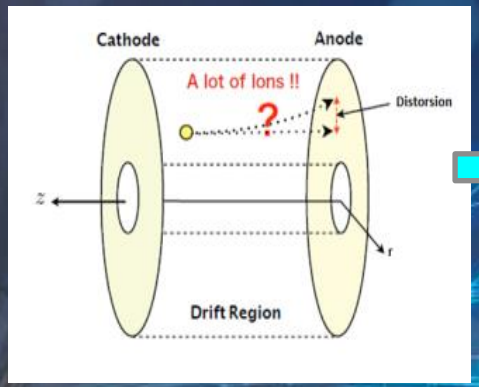
Secondary ions are a serious issue. May in principle be reduced but one needs

- **Study optimized end-plate chamber configuration for ion suppression**
- **Calculate the impact on resol.**
- **Verify with test**



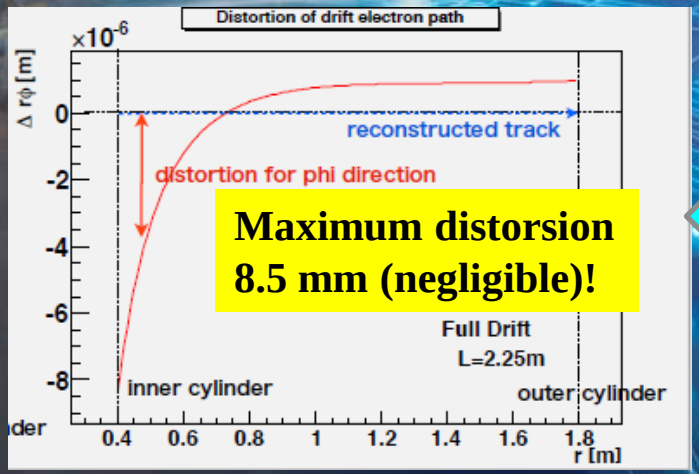


With high evt rate TPC is filled with primary ions

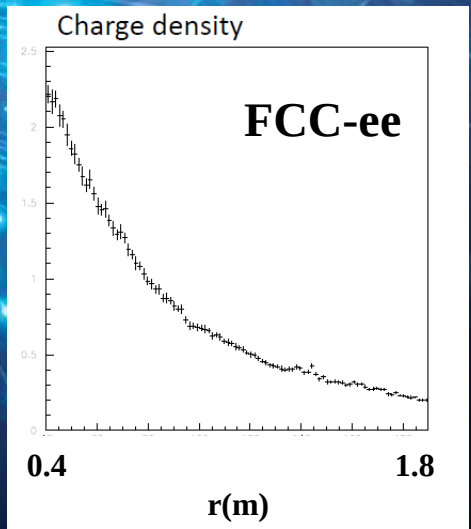


Preliminary calculations for Z-pole operation

$0.70*10^9$ Ions (B=3.5 T)
($0.66*10^9$ @ ILC dominated by beamstrahlung γ–γ events; non-issue @ FCC-ee)



Maximum distorsion 8.5 mm (negligible)!



We need

- **To improve simulations for FCC-ee environment**
- **To carry out an R&D programme for measuring these effects**

Involvement of IRFU in FCC

TPC: Electronic power consumption

Typically, the present power per channel for high rate operation is 30-40mW. With 1 x 4mm^2 pads one gets 7-10kW/m^2

This is manageable but requires but significant (excessive?) material will be needed to evacuate such a heat load. ILC solves the issue with power pulsing, not possible @ FCC-ee.

Conceptual architecture study to reduce consumption by factor 10

Other possible studies

- **Comparative study of options for calorimetry and optimization for FCC-ee requirements of resolution/operability/cost**
- **Investigation of wireless powering and data transmission**