Concluding remarks

S. Gammino

- **18th workshop: oldies but goodies**
- **30 years since Karlsruhe #1**

- The activity of our community does not show sign of decline
- Years ago, somebody asked “should we extend the period to three years instead of two?”
- Still today, we may answer ‘No’

- New challenges, new project, new techniques

- **Olympic year 2008**

Europe 25
America 32
Asia 8
Africa 1
Australia 1

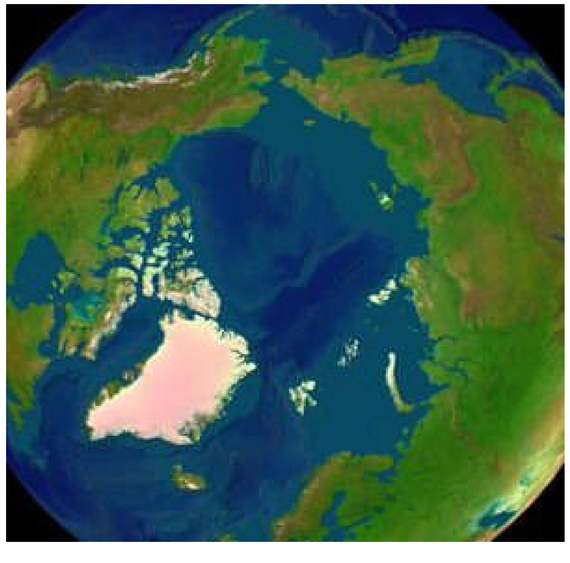
Citius, Altius, Fortius

Strength points

- Continuous generational changes (not always the same people).
- Well balanced mix of expert people and young'n'brilliant persons.
- Not to be neglected, many elder people feature young-like behavior (new ideas, new challenges, enthusiastic approach).
- IMPORTANT openings to non nuclear applications (biology, medical, material sciences, etc..) encouraging for the long-term future.
- IMPORTANT cooperation with the companies (not only exhibitors, but also coworkers).
- IMPORTANT use of up to date technologies.

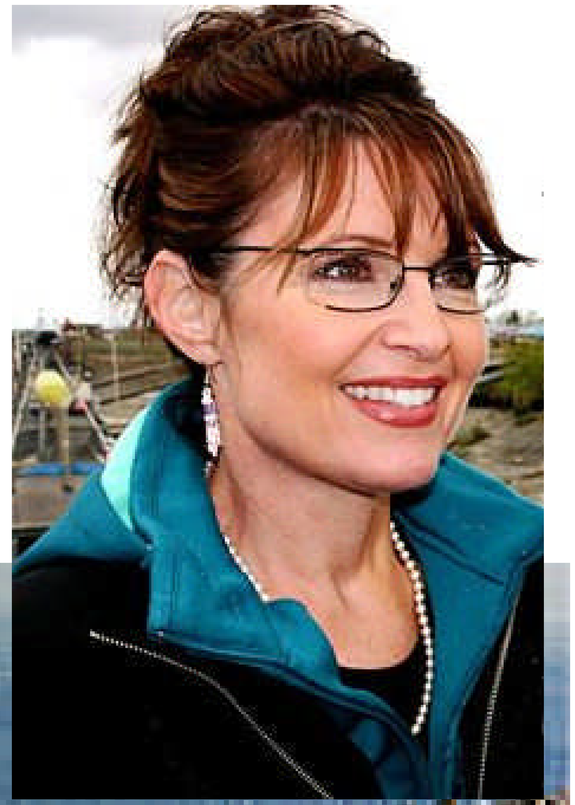
Weak points (few)

- Money is insufficient for the dream machines, but we are dreamers
- Few people use the word ‘bremsstrahlung’ with the correct spelling: considering the importance of this subject nowadays, our German-speaking colleagues are urged to start a course of language.
- Two continents are still absent: Arctic and Antarctica



- Contacts are under way

Concerning the Inuits, the competence of Mrs. Palin will be useful



Weak points (few)

- Gender policy (in the country of politically correct…): less than 10% of woman among chairs and IAC (to be improved in the next).

- The longest queue ever seen at immigration office of the airport (anyway I suppose it is not responsibility of Rick Vondrasek…)

About hospitality

- Aristocratic workshop venue
- Relaxing atmosphere, 4 days went away in a breathe…
- Well organized time schedule

- In one word, R. Geller would have said ‘IMPECCABLE’ !

About hospitality

- My personal comment: I wish to thank Rick Vondrasek not only for the exciting barbecue party at his home.

- I am really grateful to him and Richard Pardo for the organization of an excursion and of a 100 people party in a friendly Italian restaurant (including nice music), in occasion of my 45° birthday.

- In occasion of my 40°, we were only 50 people and I had to pay the bill!!

Scientific highlights

- **III generation ECRIS**
- **New projects**
- **Non-NP applications**
- **Charge breeders**
- **Theory and Simulations**
- **Diagnostics and beam management**

- **Increasing role of the beam management (we are already excellent in the production phase, less in the management).**

Third generation ECRIS

Before to comment today's achievements, let me recycle a slide prepared for HIAT'98 conference in ARGONNE Nat. Lab.

Richard I Geller

1st generation

SUPERMAFIOS (killed)

MINIMAFIOS

MICROMAFIOS

NEOMAFIOS

CAPRICE

RT-ECRIS

LBL 6.4 GHz ECR

ISIS

Julich

others good & bad

2nd generation

KVI ECRIS2&3

NANOGAN

CAPRICE ECR4M Hypernanogan

AECR

18 GHz RIKEN

SC-ECRIS

2 . 5 generation

Volume ECRIS

SERSE

3rd generation

Hybrid ECRIS

3rd gen. LBL ECRIS

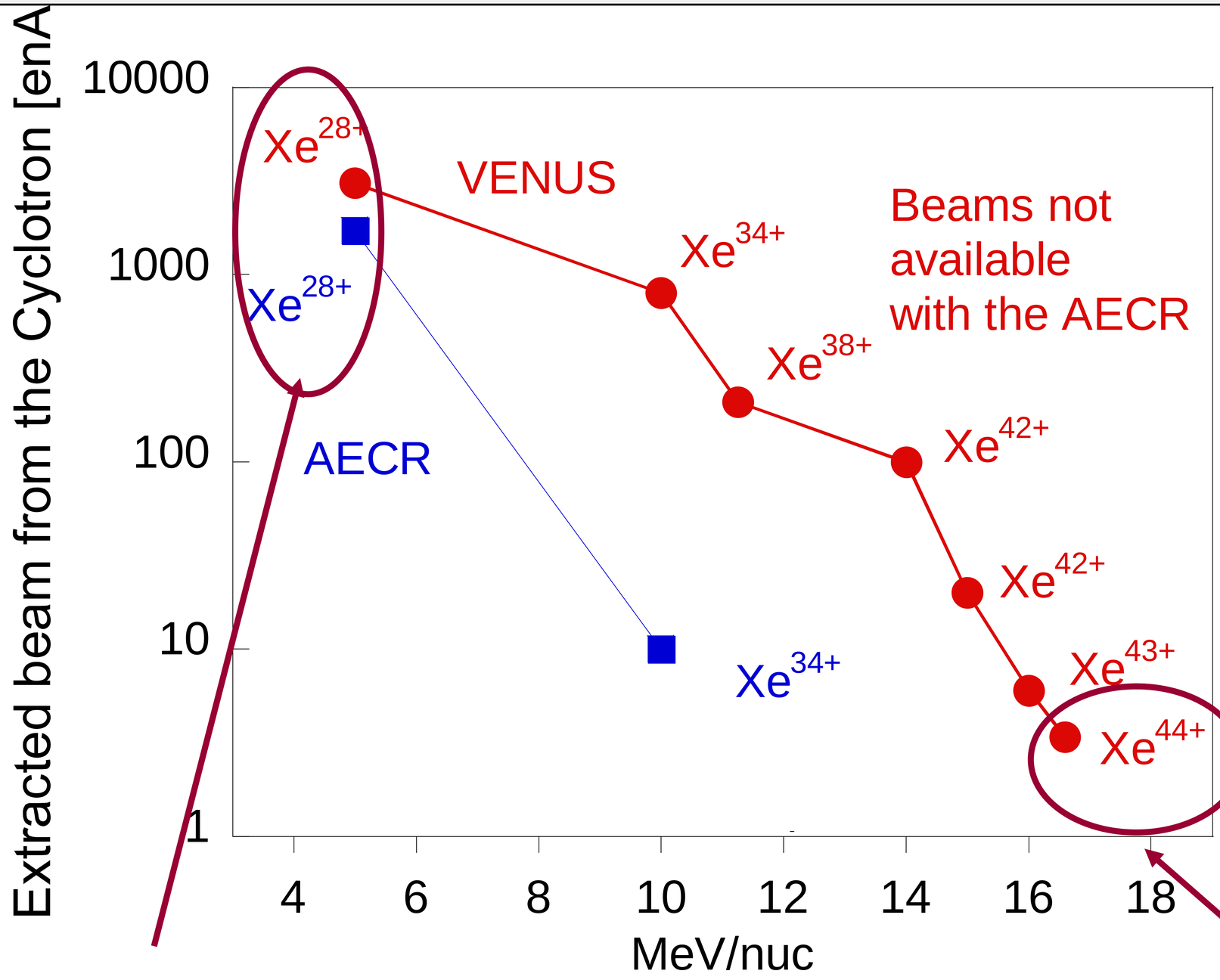
gyroSERSE

Limits coming from present technology

- **But the difficulties have been overcame by VENUS team (that is encouraging for SUSI, RIKEN, MS-ECRIS, etc…)**

- **VENUS allows to the old 88” cyclotron (maybe the oldest accelerator in the world today?) to remain in the business! All ions can be produced now above the Coulomb barrier (elsewhere expensive accelerator have been built).**

- **SECRAL increased by a factor 50 the current for HIRFL**



88-Inch Cyclotro
K=140

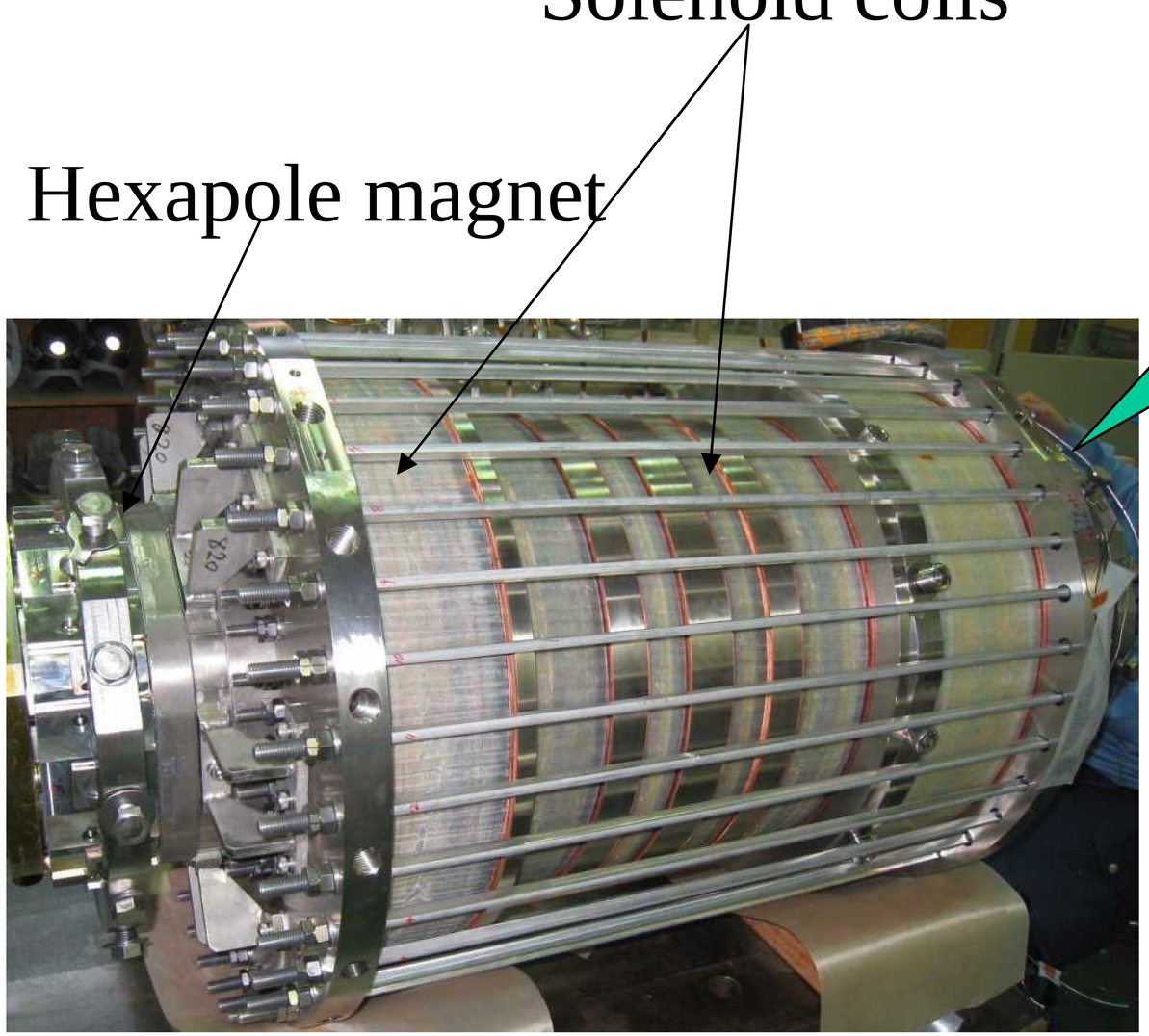
Beam intensity is space charge limited in the injection line, and by the buncher gradient

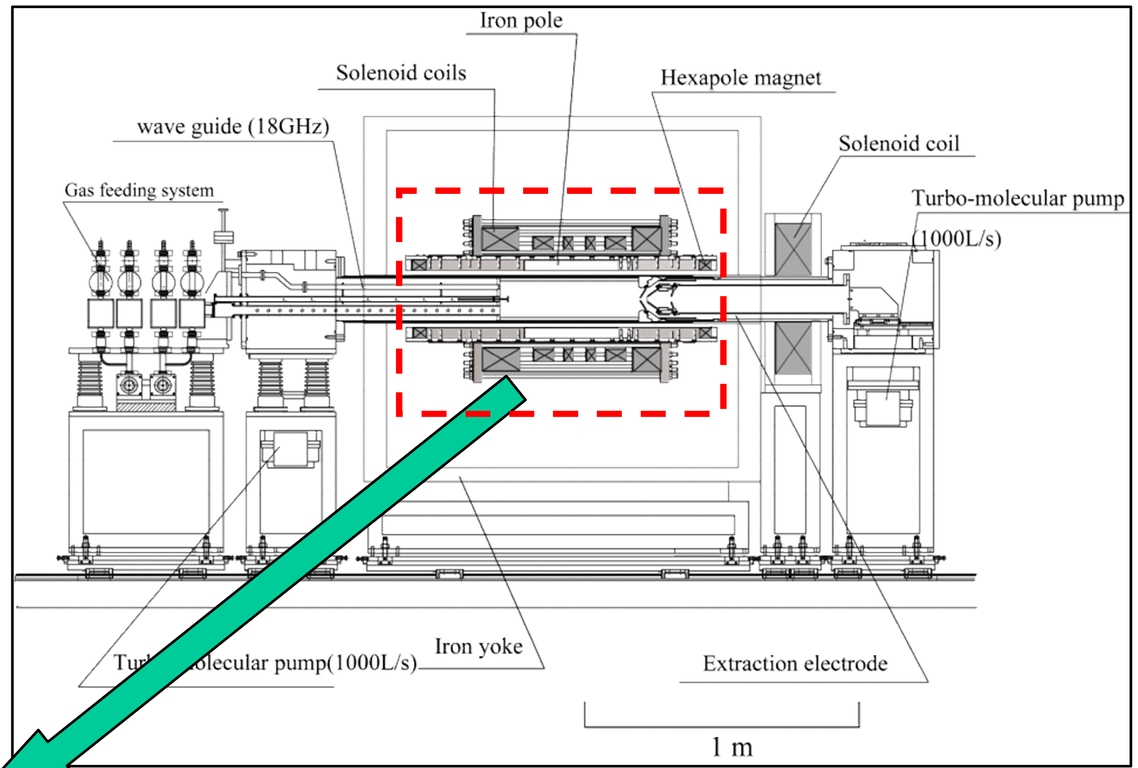
upgrade of the cyclotron center region and injection line will be necessary.

Neon like Xe has been extracted, pointing to plasma densities ~10^{12}/cm^3

($n_e \tau_i \sim 2 \cdot 10^{11}$ sec/cm^3)

Superconducting coils





New projects

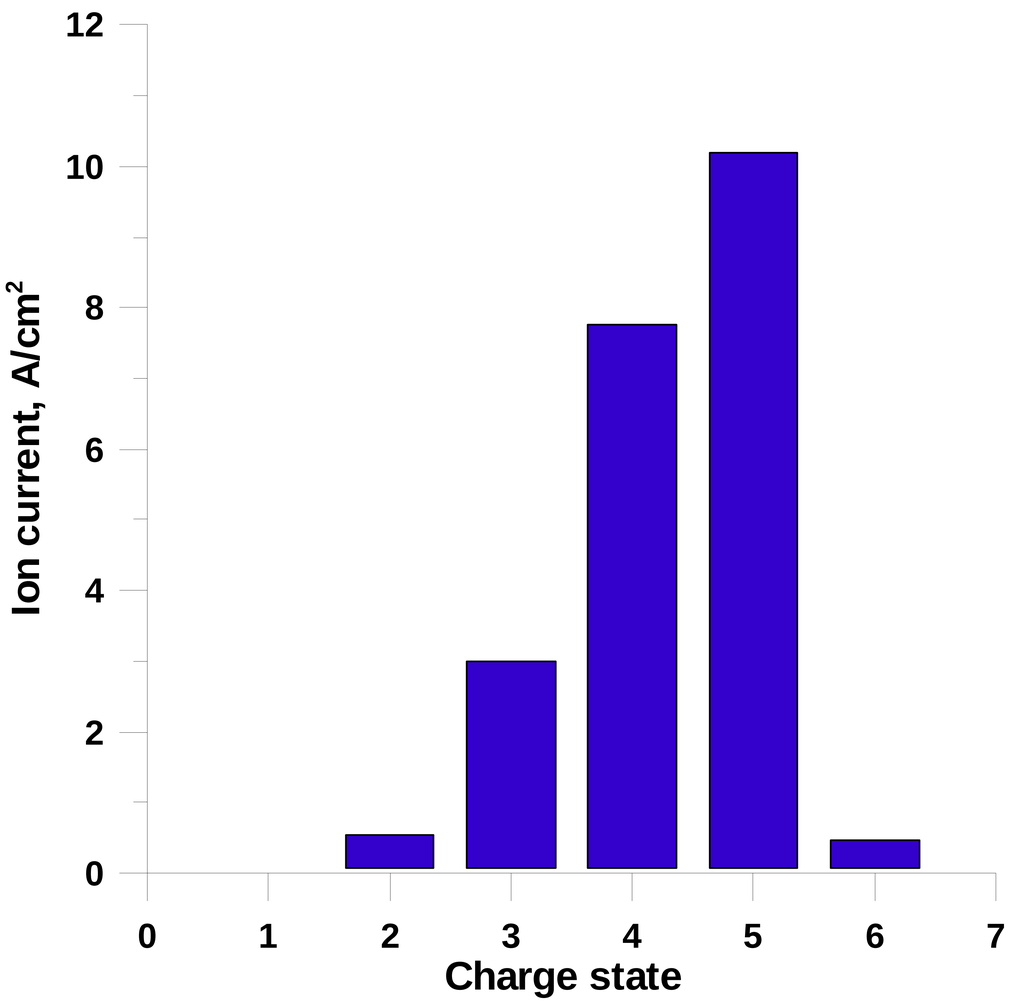
- **56 GHz for LBNL (similar dreams at INFN, Catania)**
- **60 GHz for beta-beams**
- **100 GHz REGIS**
- **What else?**

ReGIS 100 GHz

Calculations 100 GHz, 500 kW, L_{eff}=100 cm :

Operating gas	*Charge state*	*Ion current density (in plug) A/cm²*
Carbon	*+4*	*10*
Nitrogen	*+5*	*10*
Oxygen	*+6*	*10*
Argon	*+10*	*6*
Xenon	*+15*	*1*

Nitrogen



New approaches

- **Standing waves study**
- **Broadband excitation**
- **Better comprehension of the microwave-plasma interaction**

New technological supports

- **Jory and Bikov proposed new appealing microwave generators that may be adapted to our needs.**

- **Simulations are becoming reliable and you do not need to wait for weeks the results.**

- **Better plasma diagnostics.**

Relevance of bremsstrahlung studies

- **Not so many papers in ‘90s.**

- **Broad interest now (many people asked me for information about the rough X-ray measurements with SERSE in 2000) and many papers at this workshop contains valuable results of precise measurements.**

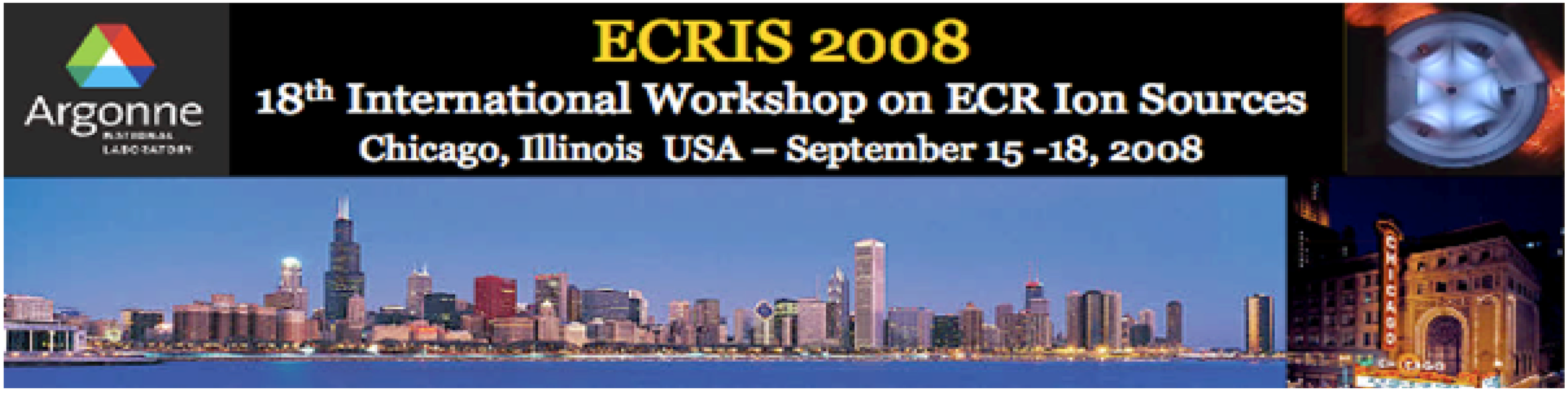
- **A role in the increase of ECRIS performances will be played by the relation between plasma and beam diagnostics.**

Beam diagnostics and beam management

- **In the past ECRIS experts did not take care to following beam management (all the attention was absorbed by the beam production).**

- **Now it is clear that for a proper beam transport to the accelerator one should know the ion sources very well.**

- **I do not remember an ECRIS workshop with 8 papers on the subject, each one with specific innovations (different movies have been presented, including Lord of the Rings).**



Theory and simulations

- **20 years ago, the simulations were used to understand what was experimentally observed.**

- **Now the simulations are really able to predict the phenomena and this is a major asset for the next years developments.**

- **Ion dynamics is probably deemed to become more important as it gives important hints for a beam brightness increase.**

- **EEDF may be adapted to the needs (courageous efforts…)**

RIB/Charge breeders

- **After the continuous development of previous 10 years, following the pioneers in ‘90s, now this subject is living a sort of ‘quiet chaos’ and the refinement of techniques is a priority (including less noble activities, as the cleaning techniques for the plasma chamber walls, needed to limit contamination)**

- **Continuing demands from NP will excite new ideas soon.**

- **It must be remarked that this is the most difficult field (let’s say a MINEFIELD!)**

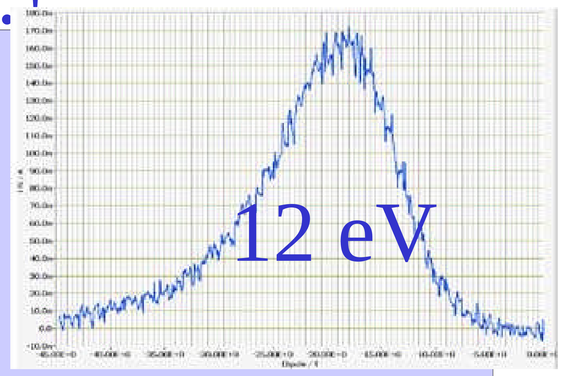
New Configuration and Results with the LPSC Charge Breeder

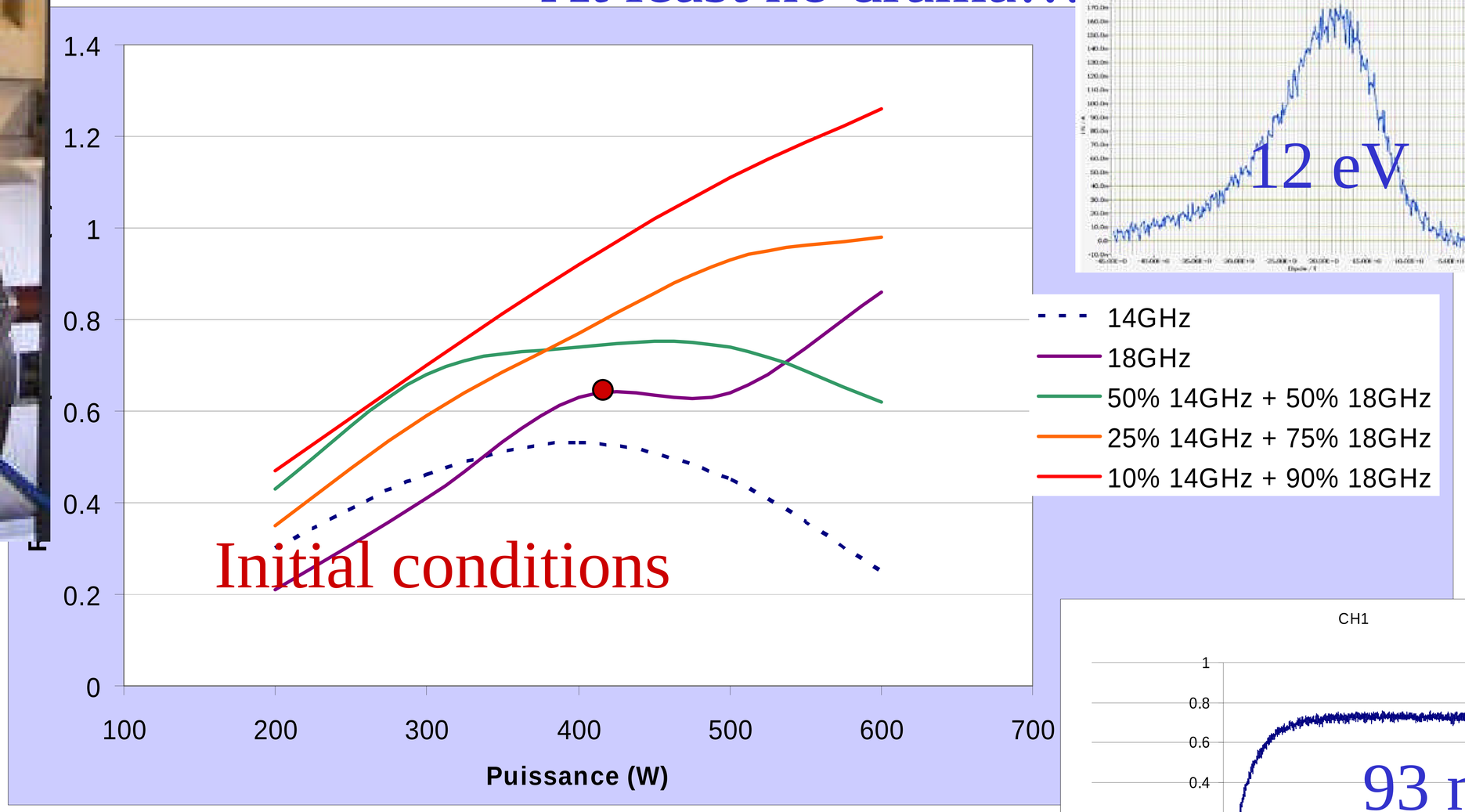
Preliminary results

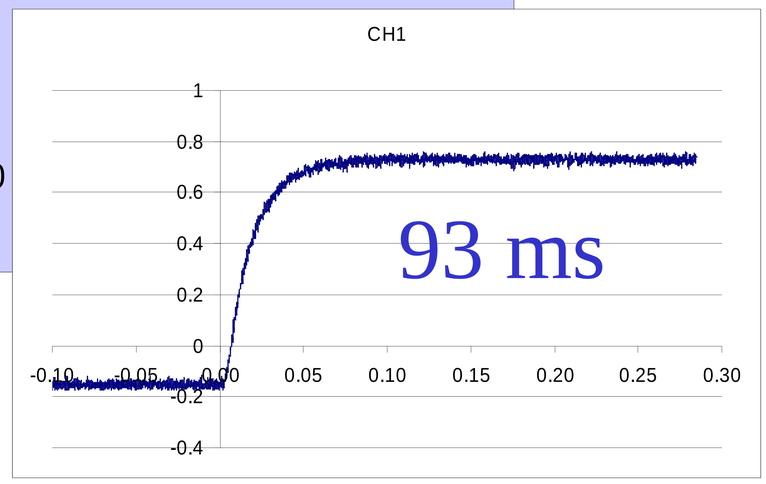
1.3 % at best after 3 hours experiment

‘slight’ effect of frequency mixing

At least no drama…!

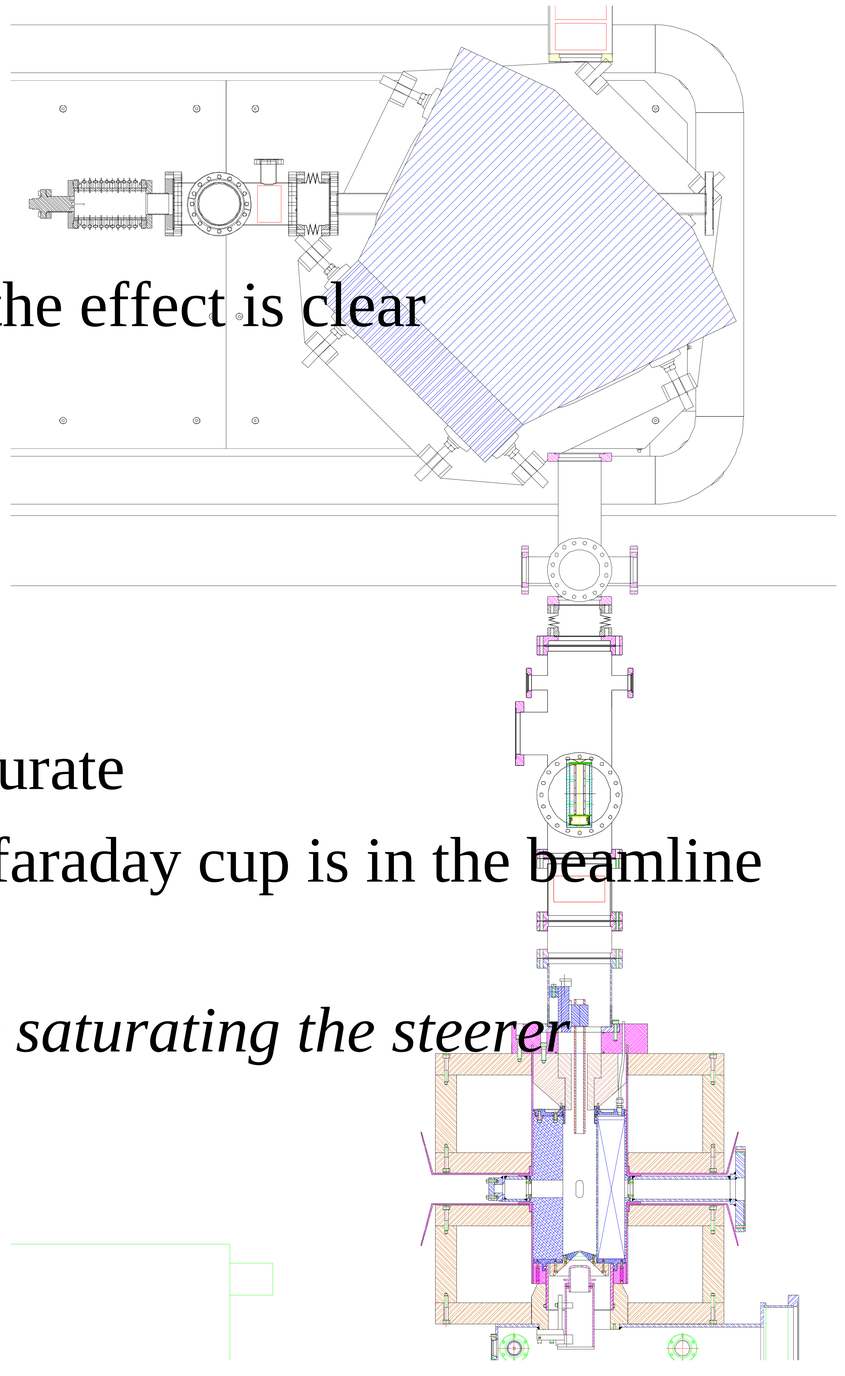






Background measurement

- The difference in the background level is due to outgassing in the 1+ analyzing magnet and low energy line which is generated by the beam coming out of the injection side of the ECRCB
  - $^{133}Cs^{20+}$ very similar m/q as $^{40}Ar^{6+}$
  - $^{133}Cs^{23+}$ very similar m/q as $^{40}Ar^{7+}$
- For $^{133}Cs^{20+}$, with the same incoming Cs^{+} intensity, the effect is clear
  - Saturating the steerer
    - *2.6% efficiency*
  - Putting the faraday cup in
    - *6.5% efficiency*
- Problem two: background measurement was not accurate
  - Due to gas loading that is not present when the faraday cup is in the beamline and intercepts the outgoing ECR beam
    - *Background measurement has to be taken by saturating the steerer*



Non NP applications

- **Mass spectrometry**
- **Fullerenes**
- **Chemistry**
- **Material sciences**
- **Medical applications**
- **Neutron generations**
- **Atomic physics**
- **Oceanography!**
- **Dark matter studies !!!!**

Nobody could imagine such a large scope of applications in ’80s

Final remarks

- **Recession of the markets will affect our activity, because of narrower budgets of our institutions**

- **We may still be optimist ‘cause our community demonstrated in the past to be able to cross the fire….**

- **I wish to repeat what I said at ECPM 2002 in Warsaw**

Advertisement

- **"If your Director evaluates each €/$ spent in the Lab, he/she will see that the most convenient investment has been by far the one for ECR ion sources**
- **Relatively cheap, with respect to accelerators' upgrade**
- **High performances**
- **Low maintanance and minimum manpower is needed**
- **Multi-year guaranteed**

Final remarks

- **The circle may be closed: Richard Geller complained for headache due to the sources maintanance**

- **ECRIS are able to limit the headache**

I think that there in the Paradise of scientist,
Richard Geller may be happy….

See you in 2010