FLAIR Project ~~Proposal~~ at GSI

Carsten P. Welsch - MPI-K, Heidelberg
Present address: CERN

Outline

- Present situation: AD @ CERN
- FLAIR...a bit of history
- Facility layout (rings, areas)
- The ultra-low energy storage ring (USR)
- Electron cooling at ultra-low energies
- pbar numbers @ FLAIR

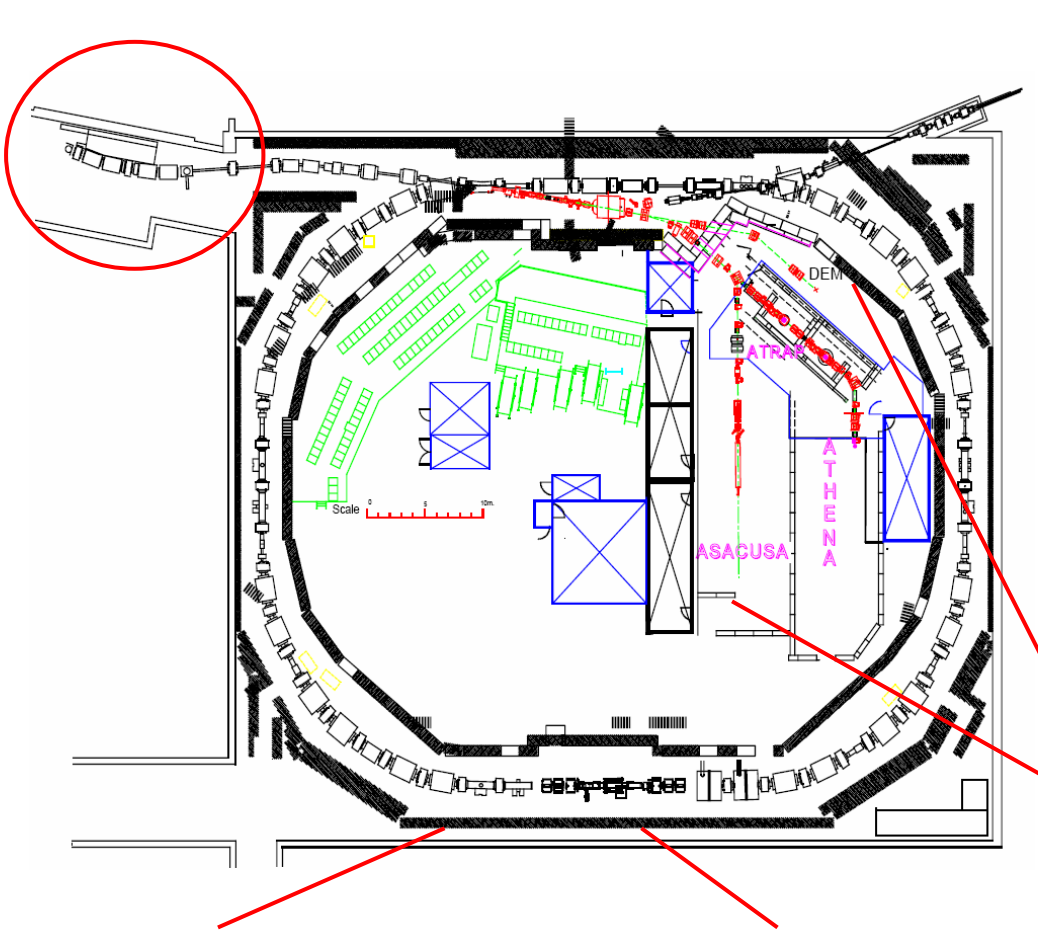
Present Situation: AD @ CERN

Target Area

26 GeV/c p

➡ 3.57 GeV/c $\bar{p}$

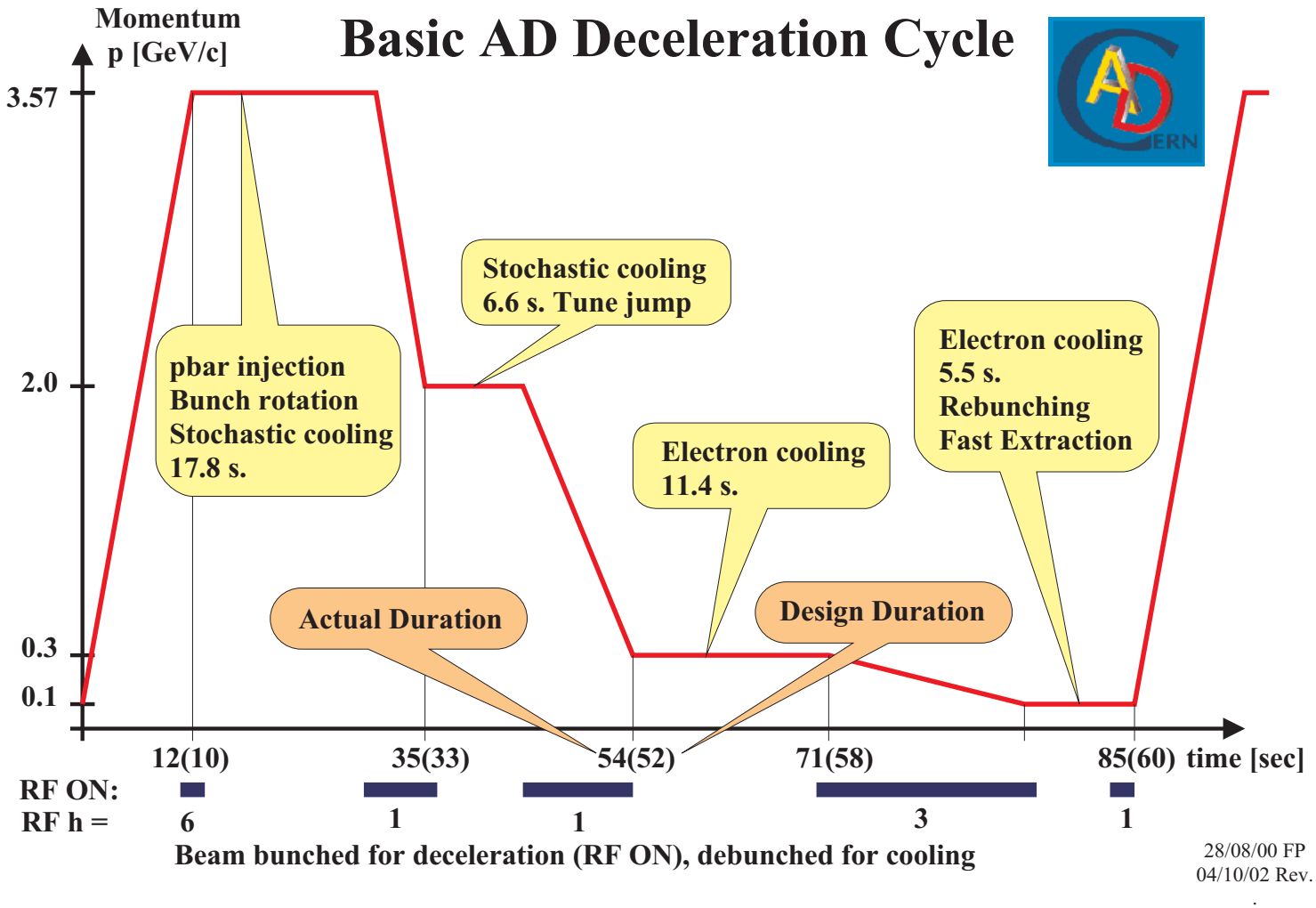
Yield: $4 \cdot 10^{-6}$



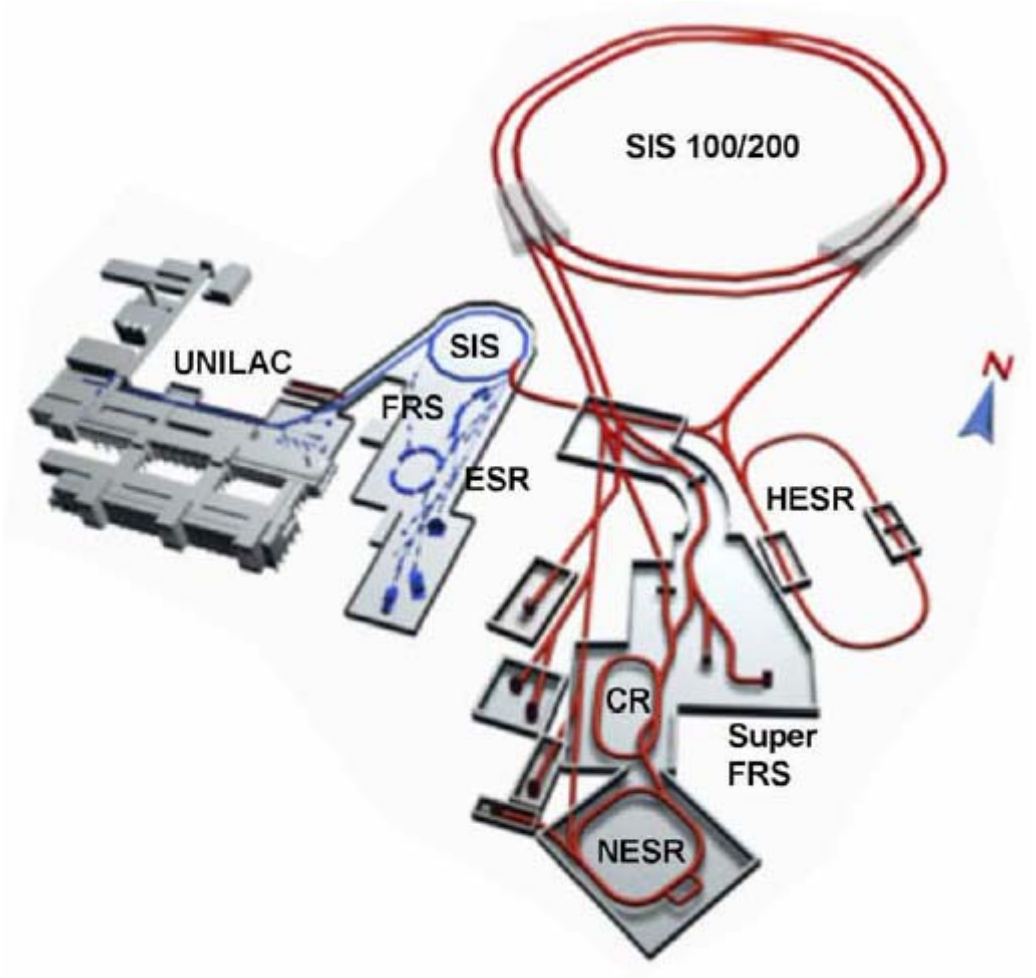
Parameters

- Started 2000
- Antiproton capture, deceleration and cooling
  - 100 MeV/c (5.3 MeV)
- Pulsed extraction
  - $4 \cdot 10^7$ pbars in 100 ns pulse
  - every 85 seconds
- Physics
  - Antiprotonic atoms
  - Spectroscopy of antihydrogen (traps)

Deceleration Scheme



Future: FAIR



10^{11} cooled antiprotons at ~4 GeV

pbar production scheme

- 2.8 10^{13} p -> 1 10^{8} p @ ~4 GeV/c
- every 5 seconds
- precooled in CR
- accumulation in RESR up tp 10^{11} p

a) HESR

b) NESR -> 30 MeV

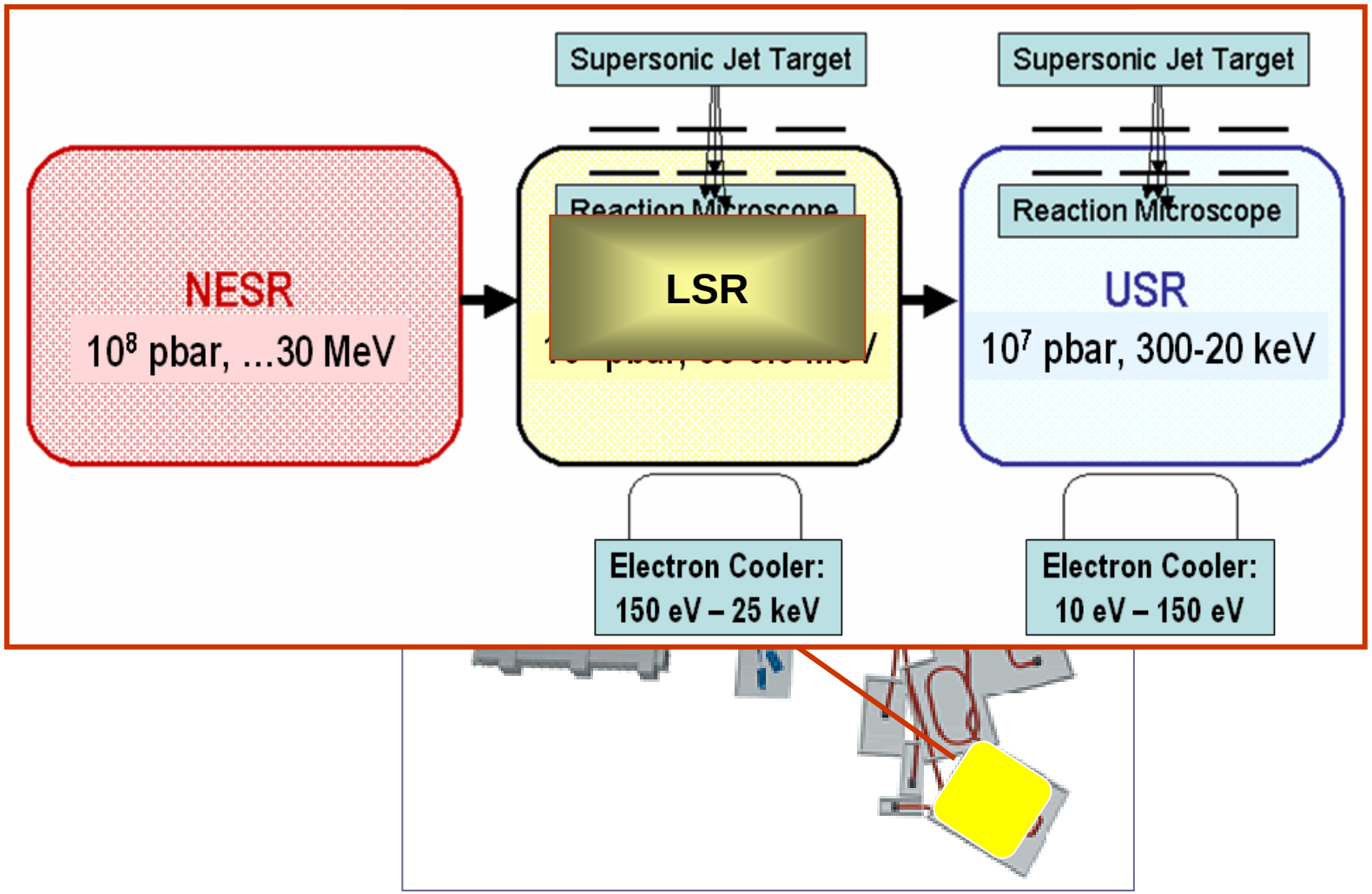
FLAIR Community

- Austria (SMI, Vienna TU)
- Canada (York, TRIUMF)
- Denmark (Aarhus U, ISA)
- France (Paris U)
- Germany (GSI, Dresden, Frankfurt, MPQ München, Giessen, MPI-K Heidelberg, FZ Jülich, Mainz, Tübingen, Berlin)
- Hungary (KFKI Budapest, ATOMKI, Debrecen U)
- India (VECC)
- Italy (Brescia, Firenze, Genova)
- Japan (RIKEN, Tokyo U)
- Netherlands (Amsterdam U, FOM)
- Poland (Warsaw U, Soltan Inst.)
- Russia (JINR, Moscow U, VNIIM, St. Petersburg U, Troitsk, Moskva)
- Sweden (MSL, Stockholm U)
- UK (Queens U, Wales U)
- USA (Harvard U, Pbar Labs, New Mexico U, Texas U, Indiana U)

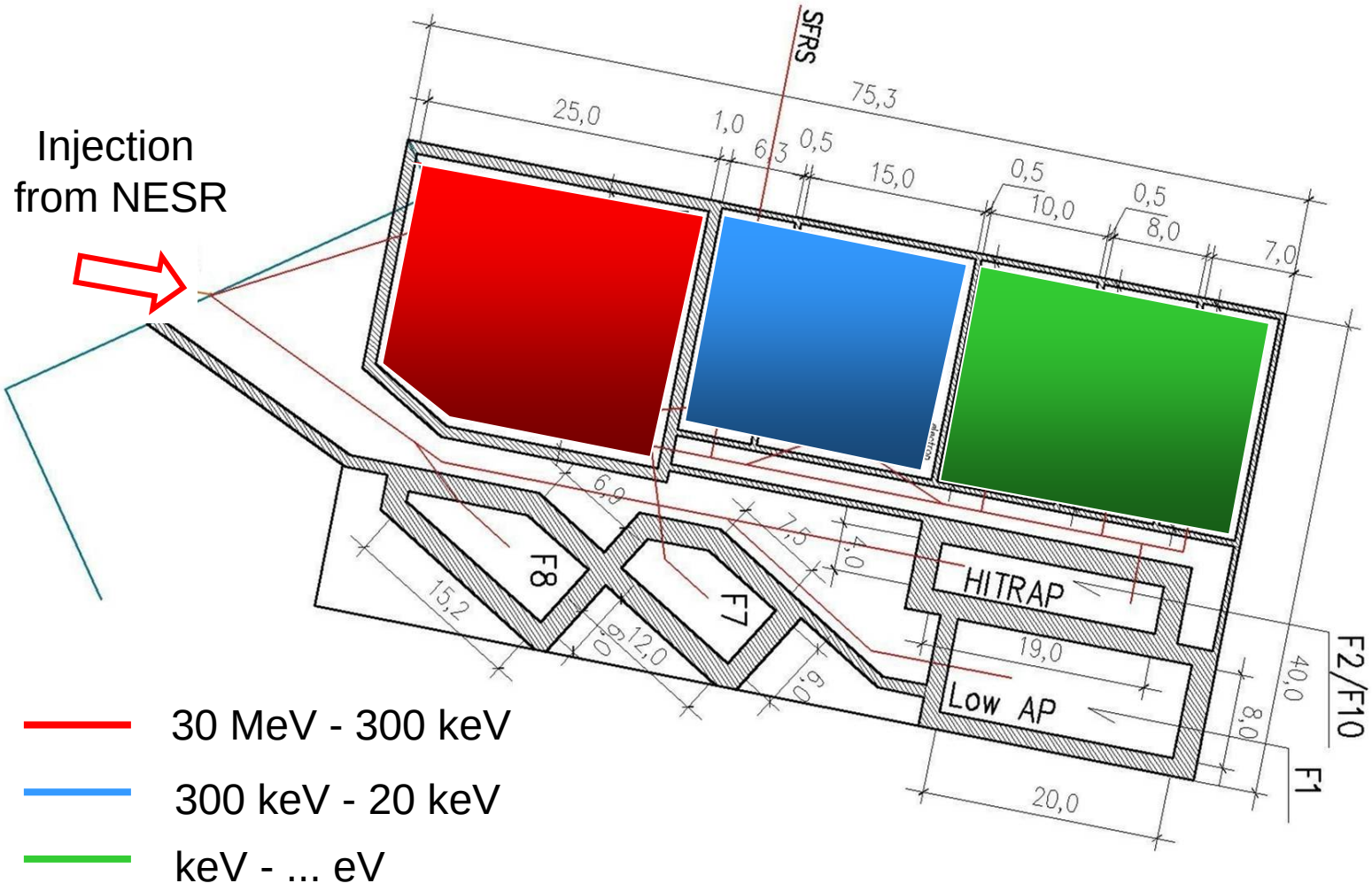
15 countries, 50 institutions

Spokesperson: E. Widmann

FLAIR Overview

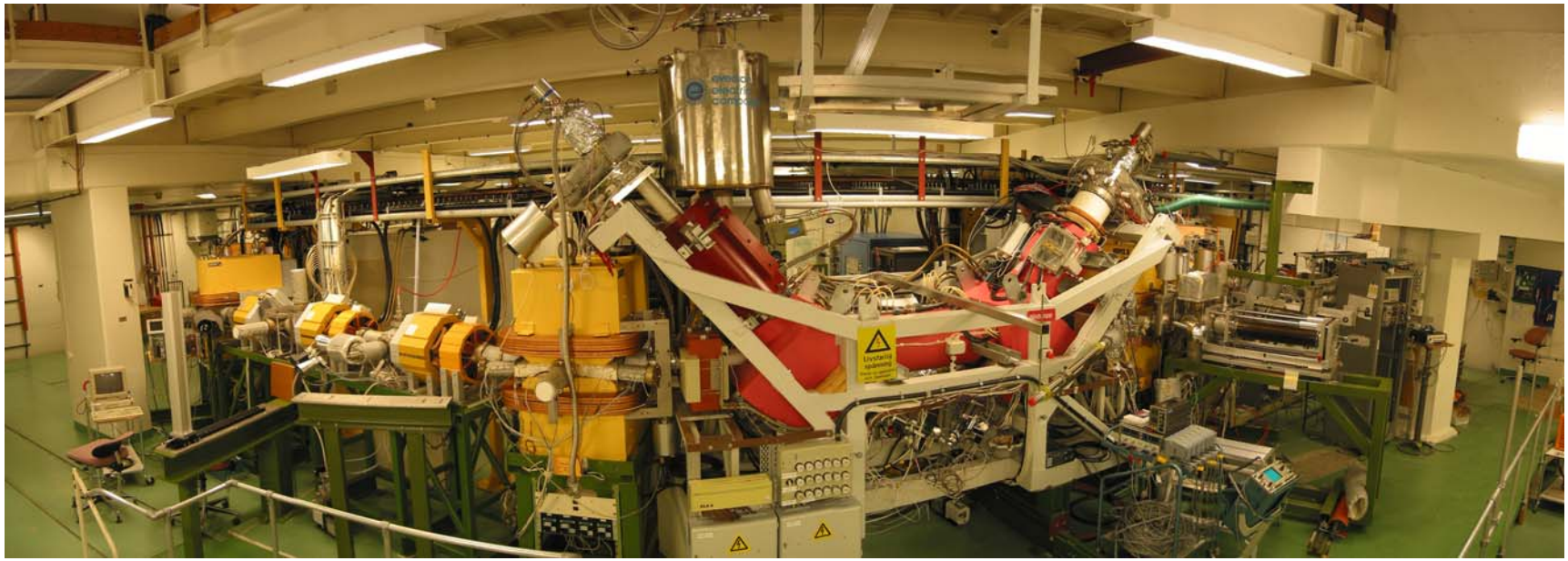


Facility Layout

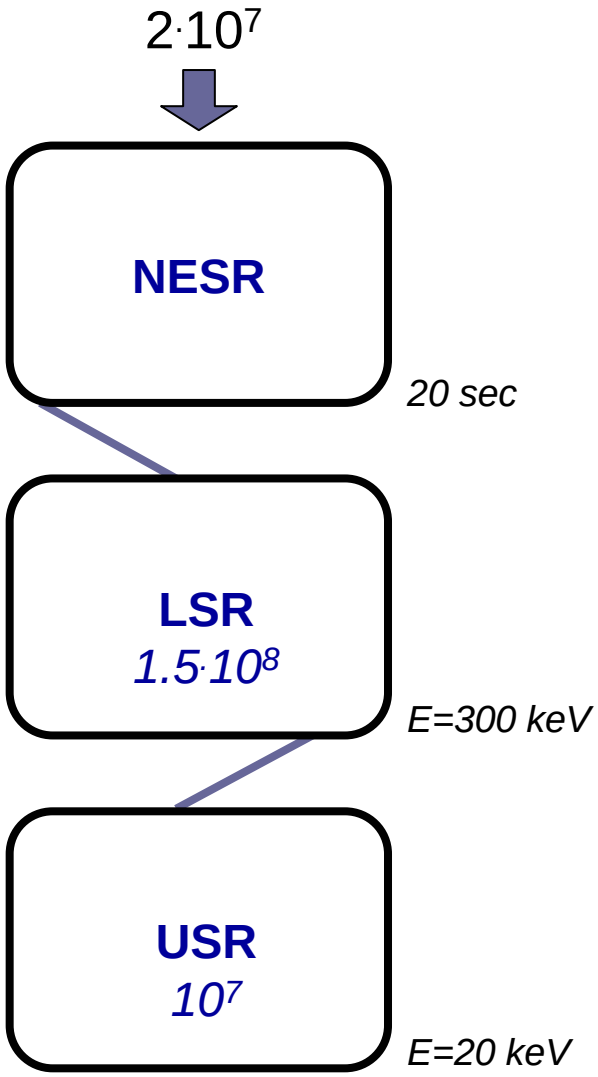


CRYRING: a perfect match for LSR

- LSR is central “working horse” of FLAIR
  - Internal target and extracted beams for experiments
  - Beam delivery for HITRAP and USR
- Advantages of CRYRING :
  - Energy range 0.3–96 MeV, electron cooling, fast ramping, internal target, low-energy injection from ion source for commissioning
  - Expertise: MSL staff has designed & built CRYRING



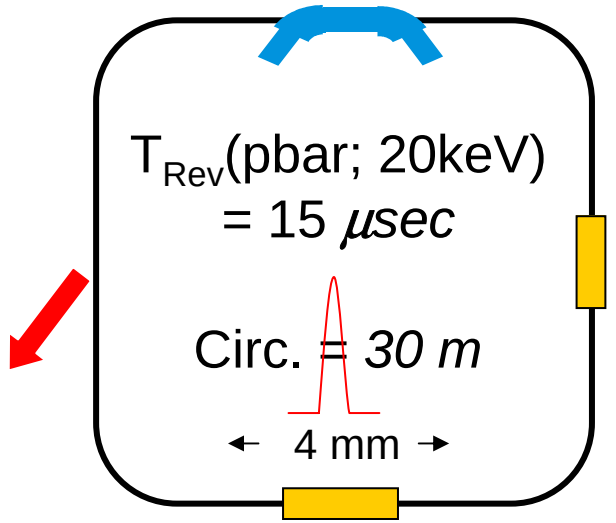
FLAIR rings (w/o accumulation)



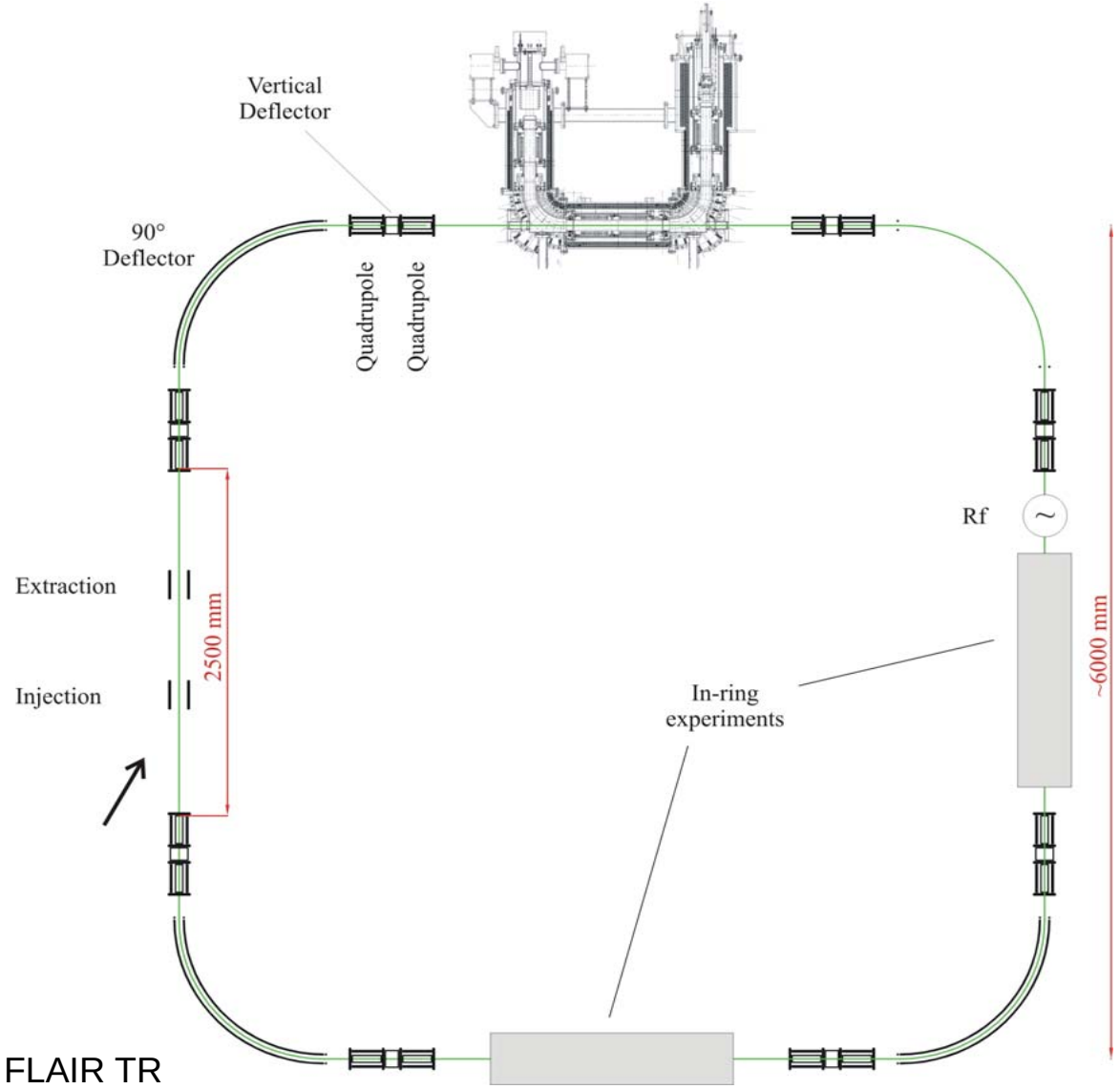
	Energy Range	# pbars
NESR	800 – 30 MeV	$4 \cdot 10^8$
LSR	30 – 0.3 MeV	$R_{eff} = 2 \cdot 10^{13}$ 1/s $R_{extr.} = 7 \cdot 10^6$ 1/s
USR	300 – 20 keV	$R_{eff} = 1 \cdot 10^{12}$ 1/s $R_{extr.} = 5 \cdot 10^5$ 1/s

USR - Main Goals

- Variable down to very low energies
  - 300 keV ~ 20 keV
- High luminosity for in-ring experiments
- Well defined extracted beams:
  - small emittance
  - small momentum spread
- Multi-User operation:
  - 2 straight lines for in-ring experiments
  - 1 extraction port
  - additional beam lines possible
- Central requirements
  - Δt ~ 500 nsec for injection into trap
  - Δt ~ 2 nsec / 10^4 ions for collision experiments

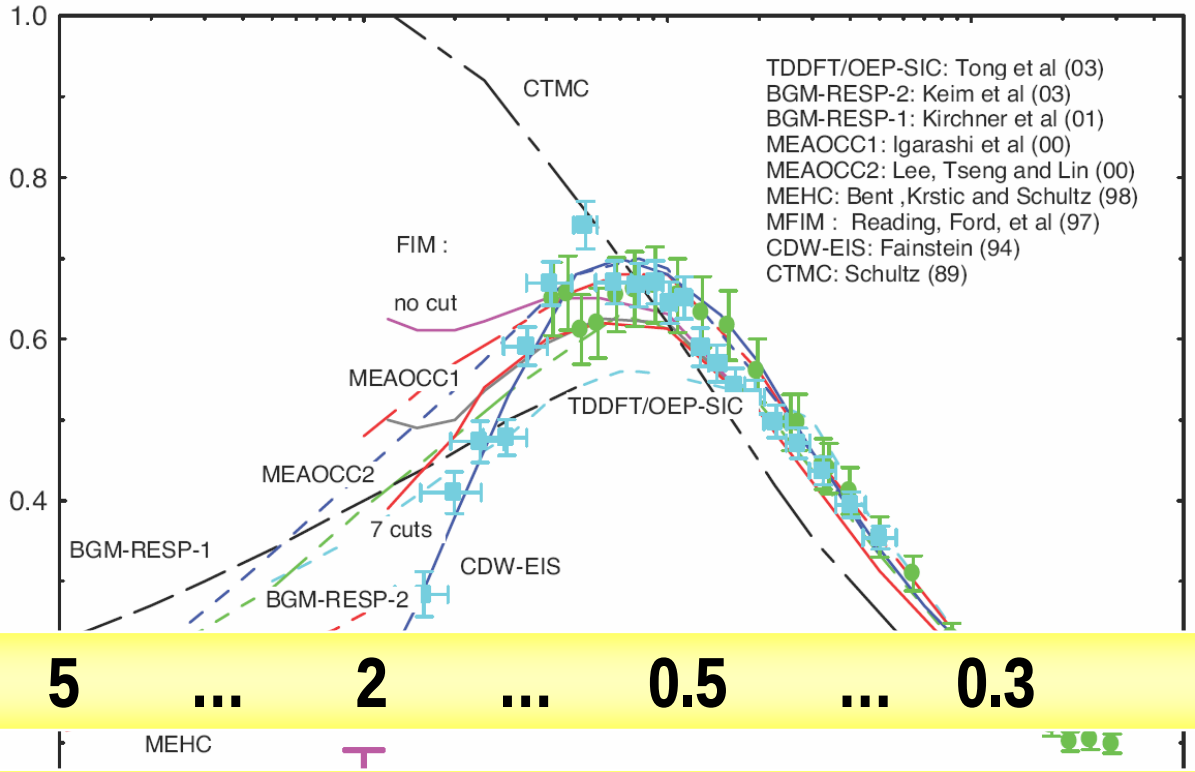


At a Glance



FLAIR TR

Antiprotons: Kinematically complete



Z/v **5 ... 2 ... 0.5 ... 0.3**

Interaction time **1 fs ... 0.3 fs ... 0.1 fs ... 30 as**

ASACUSA results

⇨ Ultimate test of strong-field theories

⇨ Benchmark: dynamical two-electron correlation

Challenges

- Electron cooling at lowest energies
- Energy variability
- Ultra-short bunches
- In-ring Reaction Microscope

.....never realized in electrostatic ring !

! Cryogenic system required for HCI !

➡ **CSR**

(see talk A. Wolf & poster today)

Electron cooling @ lowest energies

- Max. pbar number in machine ?
- Life time of beam ?

Design parameter

Length	0.8 m
Magnetic field	0.1 kG
Beta function (h/v)	7.5 m / 2 m
Horizontal dispersion	0.77 m
Electron beam radius	0.5 cm
Electron beam current	0.05 mA
T_e (transv./long.)	4 meV / 0.5 meV
Perveance	2 µP
Cathode diameter	2 mm
$\tau_{20\ keV}$	< 100 ms

GaAs Photocathode ??

(see talk A. Wolf)

(see Betacool poster today)

Space Charge Limitations

Protons / Antiprotons:

$$N = const. \cdot \gamma^3 \cdot \beta^2 \cdot \varepsilon$$

Non-relativistic: $\gamma = 1$

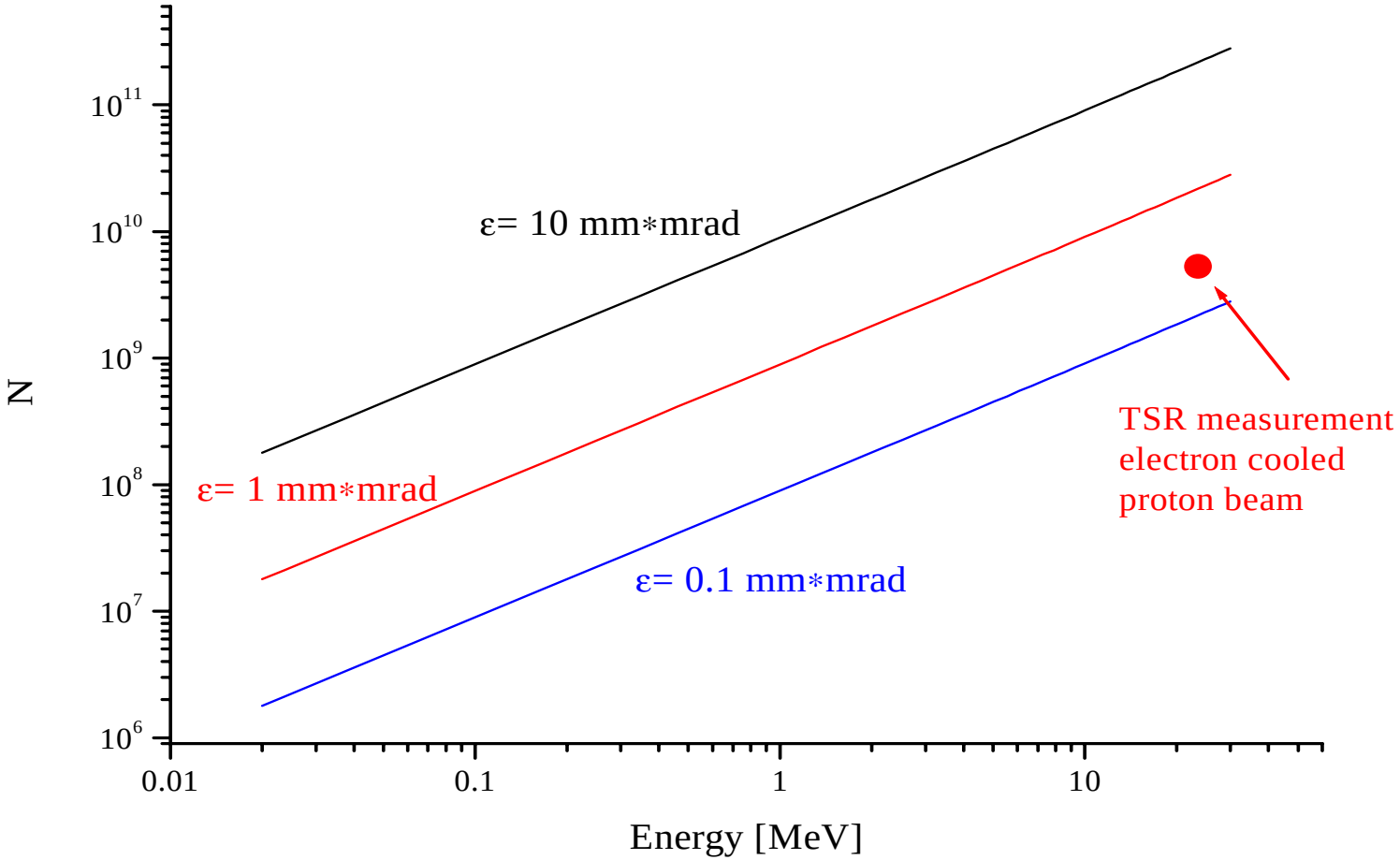
$$\frac{N}{N_0} = \frac{\varepsilon}{\varepsilon_0}\frac{E}{E_0}$$

TSR measurements (e^--cooled beam)

$$E_0 = 23\,MeV \quad N = 5 \cdot 10^9$$

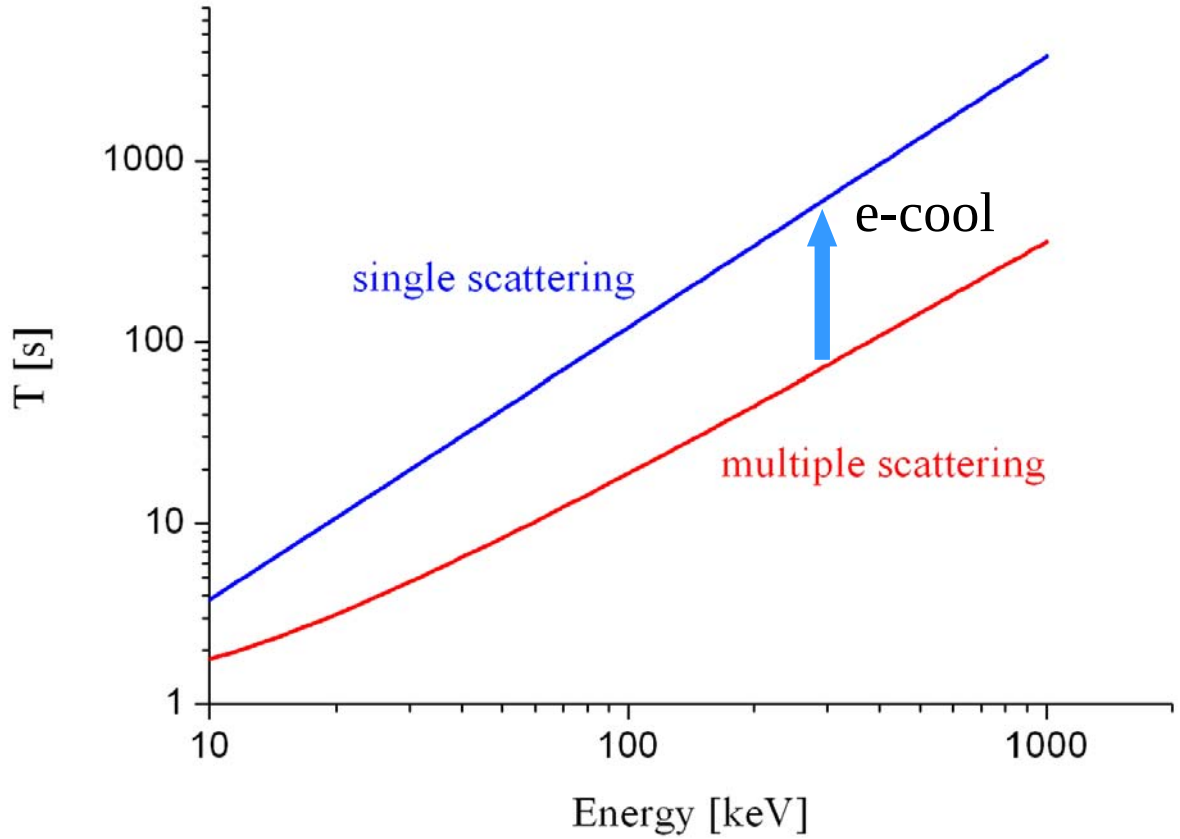
$$\boxed{N_{20\,keV} = 10^7}$$

Space Charge Limitations II



Calculated for $\Delta Q = -0.1$

pbar Lifetime

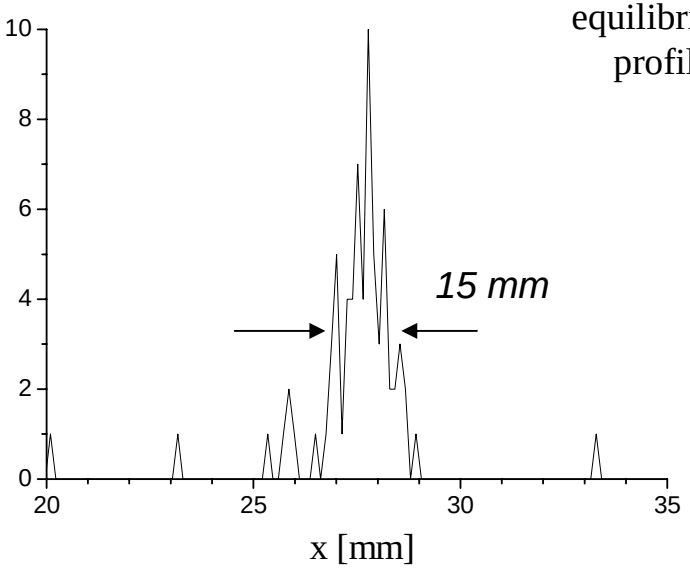


Electron cooling: p @ 480 keV

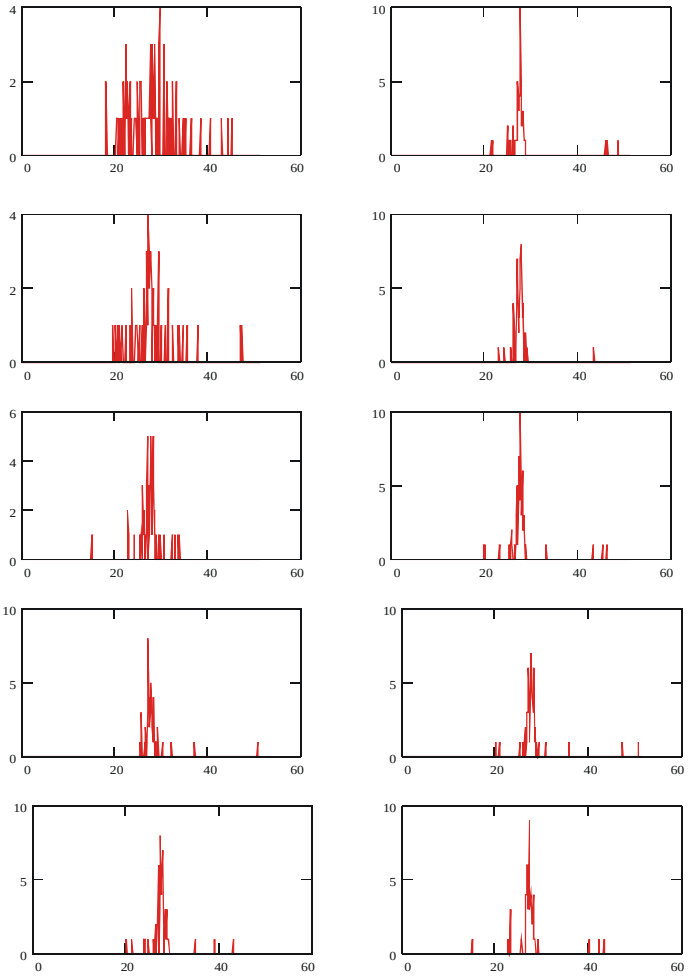
p beam parameter
E= 480 keV
rigidity = 0.1 Tm
ß =0.032

e^- beam parameter
I_e = 5.7 mA
n_e= 5.4 10^6 1/cm^3
α_{ex}= 9.6
U_{cath}= 284 V
B_{cool}= 100 Gauss

horiz. cooling time: $T_{cool} \approx 1s$



equilibrium profile



M. Grieser

Summary & status of FLAIR

- Cooled antiprotons at 20 keV will revolutionize low-energy antiproton physics
- DC beams enable nuclear and particle physics type experiments (not possible at AD)
- Availability of radioactive ion beams (RIB) offers new synergies
- Status of FLAIR
  - LoI approved March 2004,
  - PAC & STI approved TP with very good results
  - Work towards TDR