# *30 GHz Power Production / Beam Line*

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- Beam optics
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- Beam phase switch for 30 GHz pulse compression
- Hardware improvements
- Brainware improvements

- **Motivation & requirements**

**- Get beam driven 30 GHz power source for CLIC structure R&D as early as possible in CTF3 → special PETS* in drive beam linac**

**- Easy switching from 30 GHz to production to linac / delay loop commisioning**

***Power source inline with linac, bypass around for normal operation***

Disadvantages:
- Gives artificial limitation of linac energy acceptance
- Complicates linac optics and energy/current ramping procedures

Advantage:
- Could be equipped as a bunch compressor

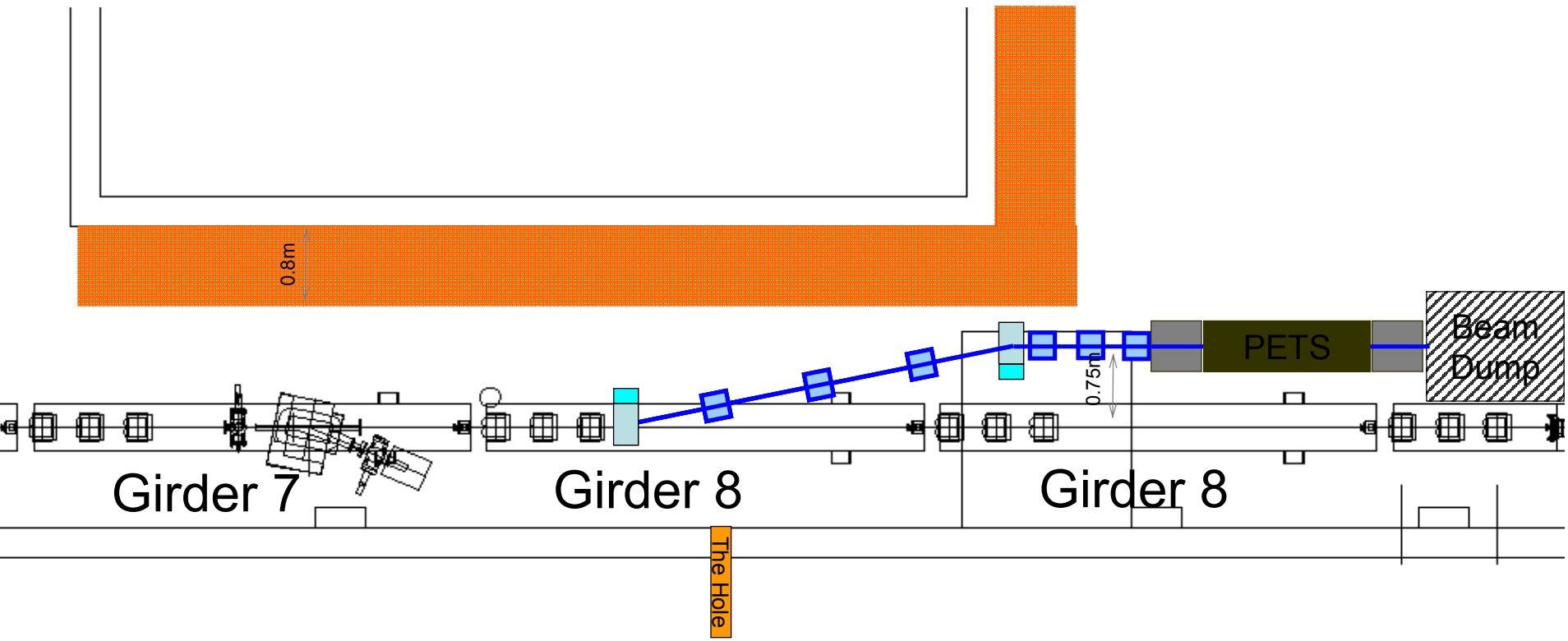
***Dogleg with off axis beamline for power source***

Disvantage:
- reduced energy acceptance for power source beam
- more difficult optics tuning for power source

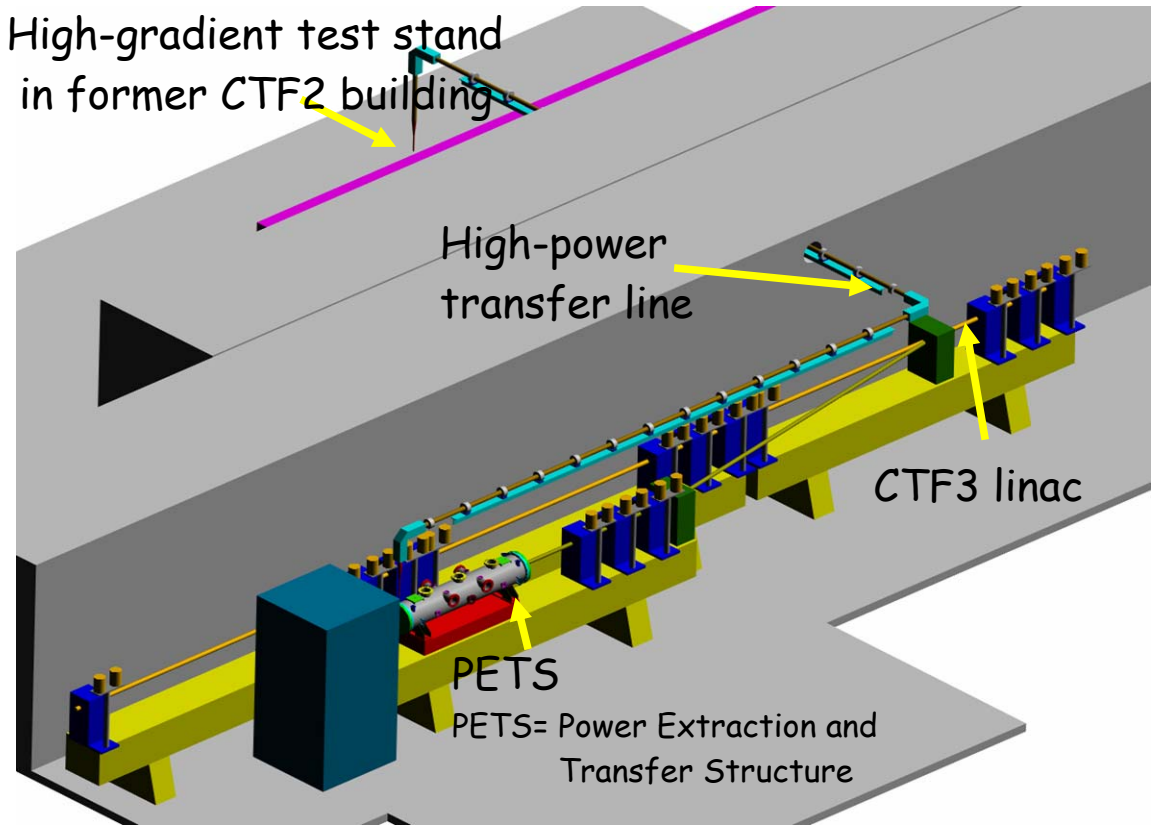
Advantages:
- relatively simple beamline
- DB linac optics properties unaffected

* PETS=power extraction and transfer structure discussed in next talk by Igor

## Layout



# Layout 30 GHz RF systems




**Overmoded 30 GHz transfer line to test stand in former CTF2 building**

***Advantages***

- Access for installation of 30 GHz structures while linac running
- Measurements not disturbed by presence of high power electron beam
- Delay between PETS and teststand decouples PETS from RF breakdowns in teststand for pulses < 80 ns

***Disadvantages***

- 27 % of power is lost in transport
- Line needs RF conditioning

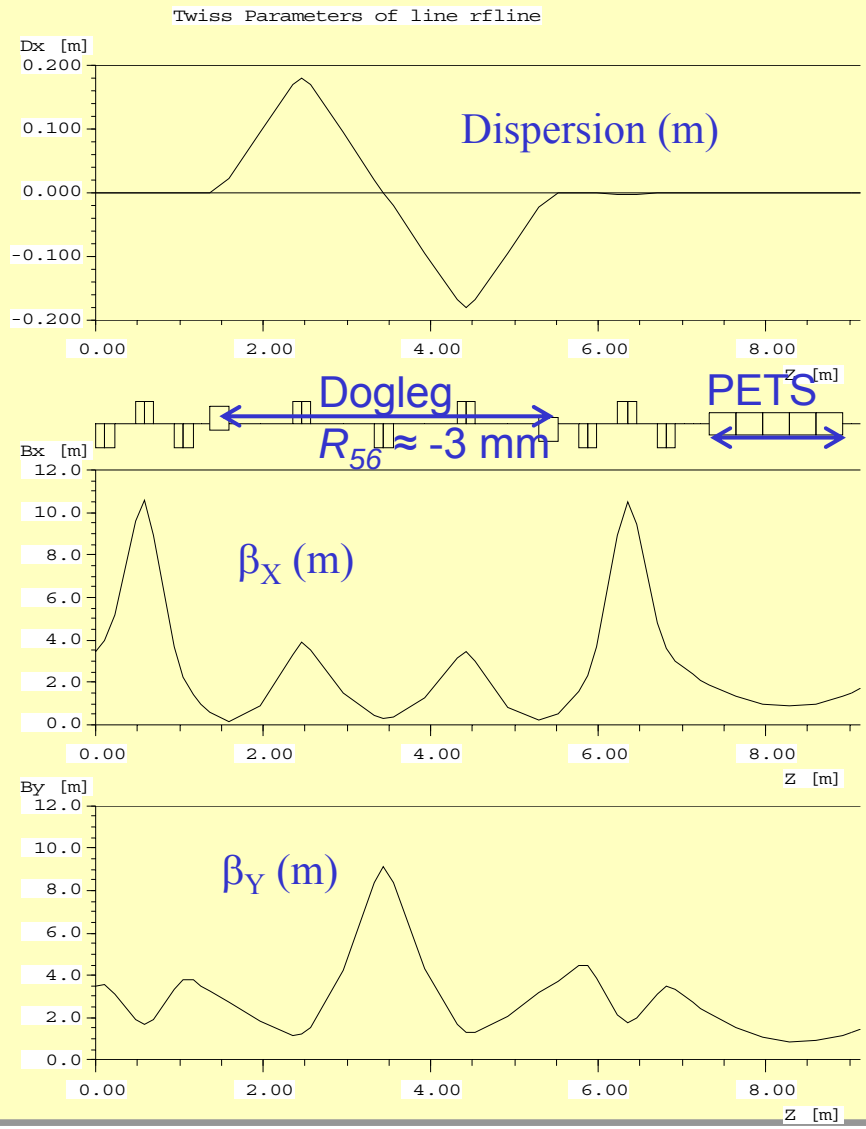
- **Power mode operation vs. CTF3 nominal parameters**

| | Nominal | Power mode |
|---|---|---|
| Beam current | 3.5 A | 5 A |
| Bunch charge | 2.33 nC | 1.67 nC |
| Bunch frequency | 1.5 GHz | 3 GHz |
| Pulse length | 1540 ns | 50-400 ns |
| 3 GHz RF power / SICA structure | 30 MW | 60 MW |
| Beam energy girder #8 (PETS location) | 50 / 66* MeV | 69 / 92* MeV |
| Rep. rate | 5 Hz | 0.83-50 Hz |
| Av. beam power girder #8 | 1.4 / 1.8* kW | 6.9 / 9.2* kW |

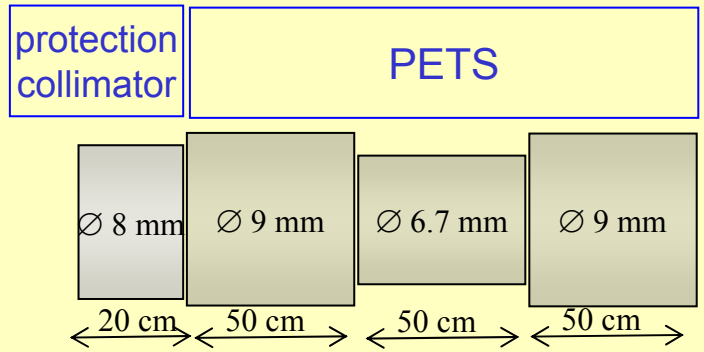
* with acceleration in girder #7,
installation during winter shutdown 2004/05

- **Beam optics**

## Twiss parameters




## Acceptance of PETS




$A=R^2/L=10.6\ \pi$ mm mrad

$\varepsilon_N < A\gamma / n_\sigma^2$

$n_\sigma \approx 2.5$, E=69 MeV

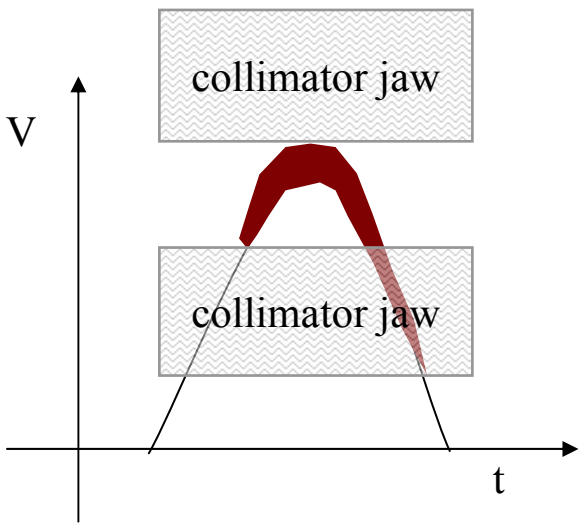
**$\varepsilon_N < 230\ \pi$ mm mrad**

***$\Delta P/P$ < ±7%***

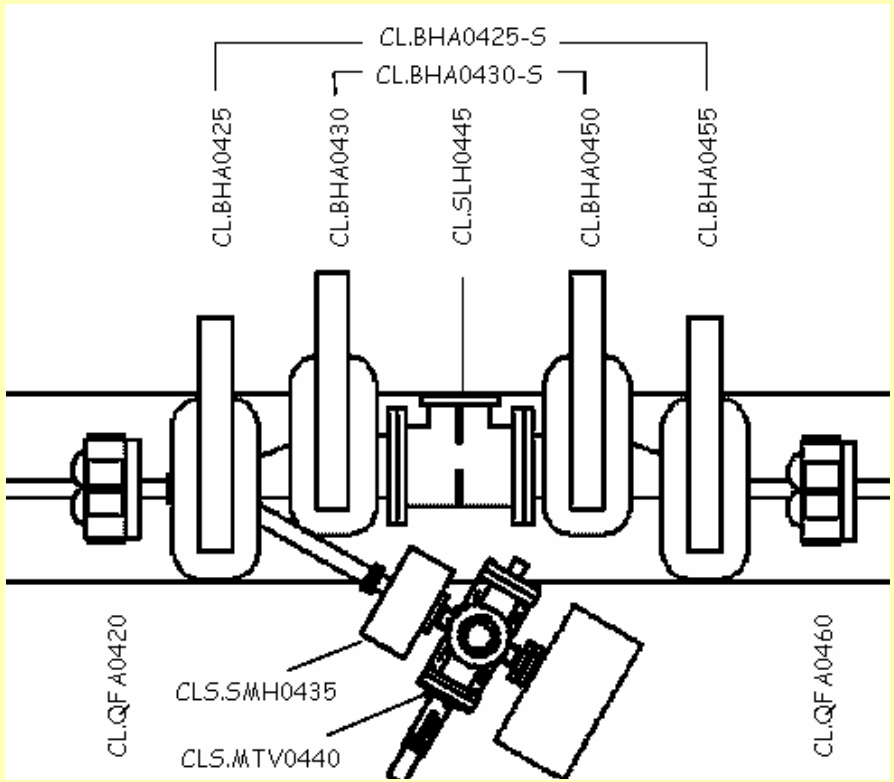
limited by chromatic errors for focusing into PETS and vacuum pipe of dogleg.

## Bunch shortening for effective 30 GHz power production

$\sigma_B \leq 2$ ps desirable




Cleaning chicane of injector



## Achieved Performance

***Power***

$P_{TESTSTAND}$ = 54 MW

$P_{PETS}$= 74 MW (*design goal 100 MW)*

***Pulselength***

$T_{PULS}$ for 54 MW =80ns

$T_{PULS}$ for 40 MW =140ns

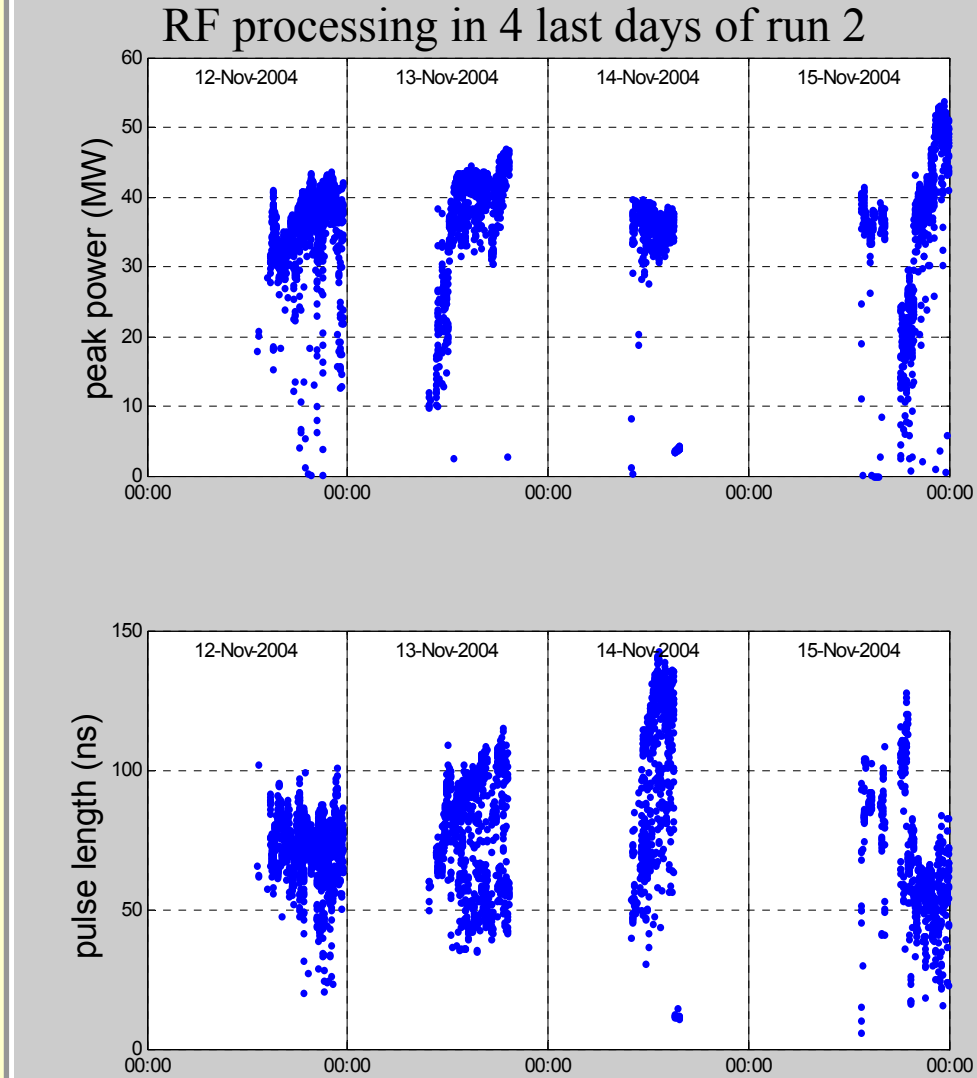
***Beam***

$I_{BEAM}$=5 A, 80% Transm., @ 40 MW

$I_{BEAM}$=6 A, 58% Transm. @ 54 MW

peak power is limited by beam transmission through PETS

pulse length is limited by sparking in PETS and 30 GHz high power network

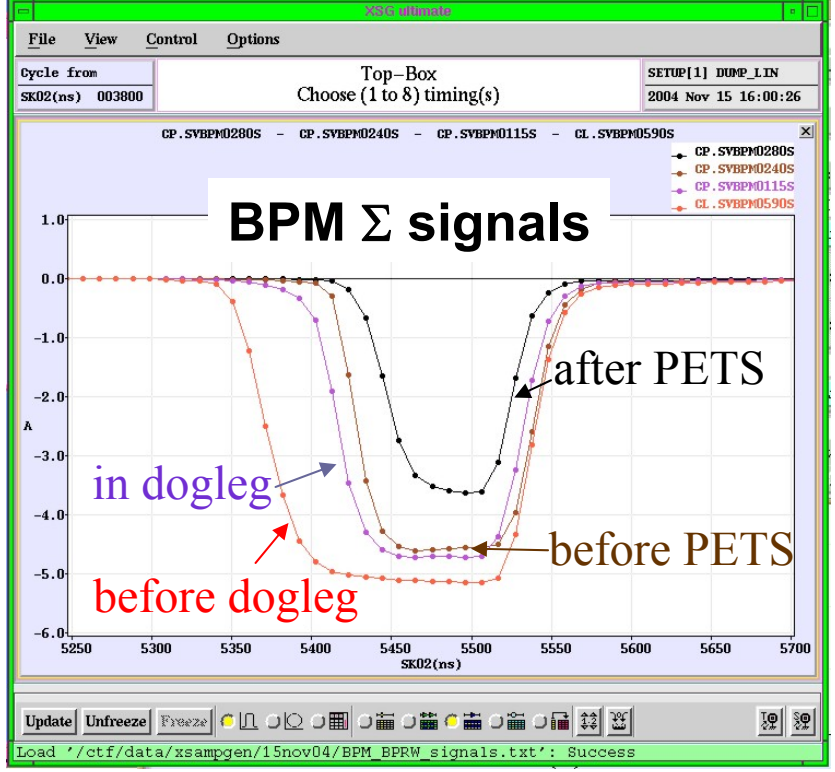


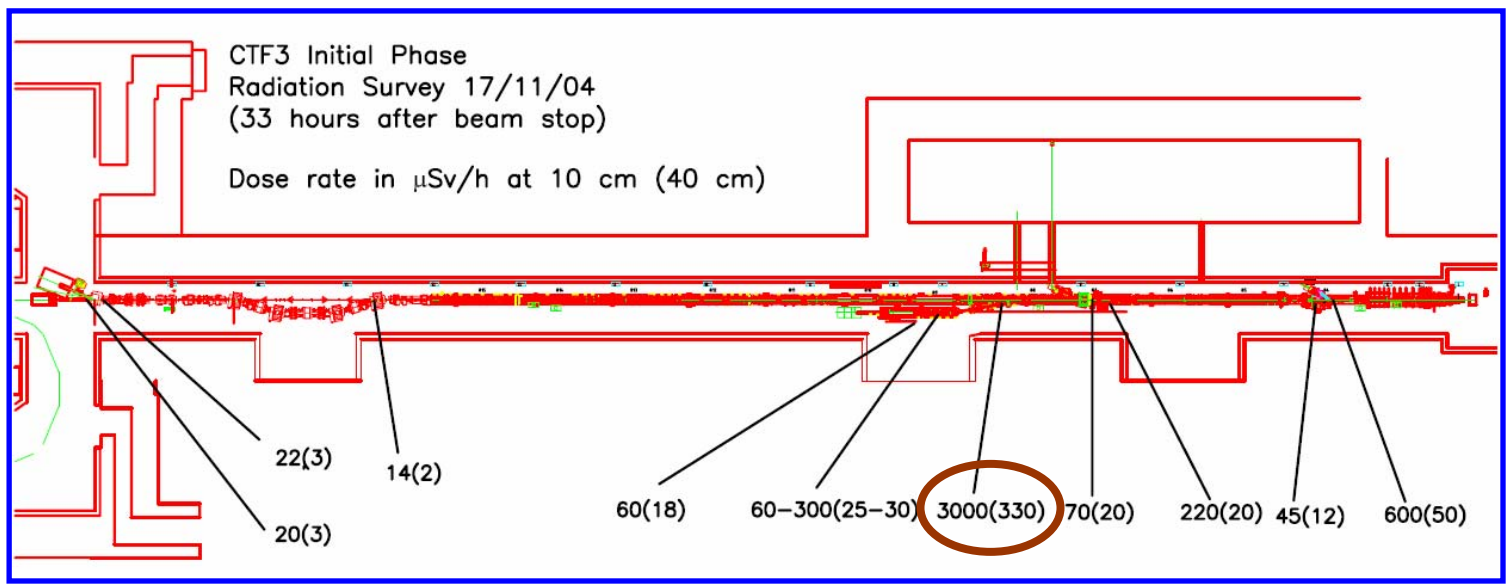
## Problems

Beam losses and reasons

1. Energy transient from beam loading is lost on Y vacuum chamber at the beginning of PETS line (300 W of average beampower at 16 Hz rep rate)
2. In power mode $\varepsilon_X \approx$ **400** $\pi$ mm mrad,
   $\varepsilon_Y \approx 150\ \pi$ mm mrad

   → Transmission only 80 %
3. Last horizontal corrector before PETS at 10 mrad
   → something wrong with alignment or a magnet

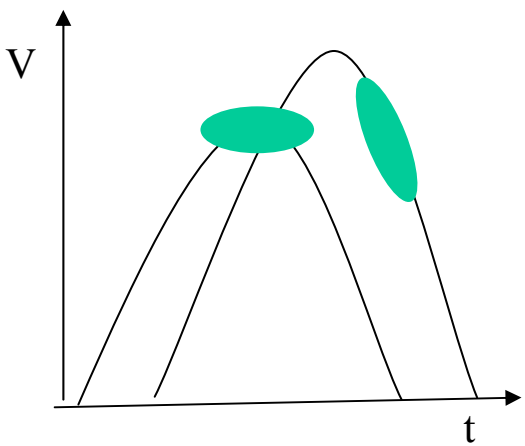


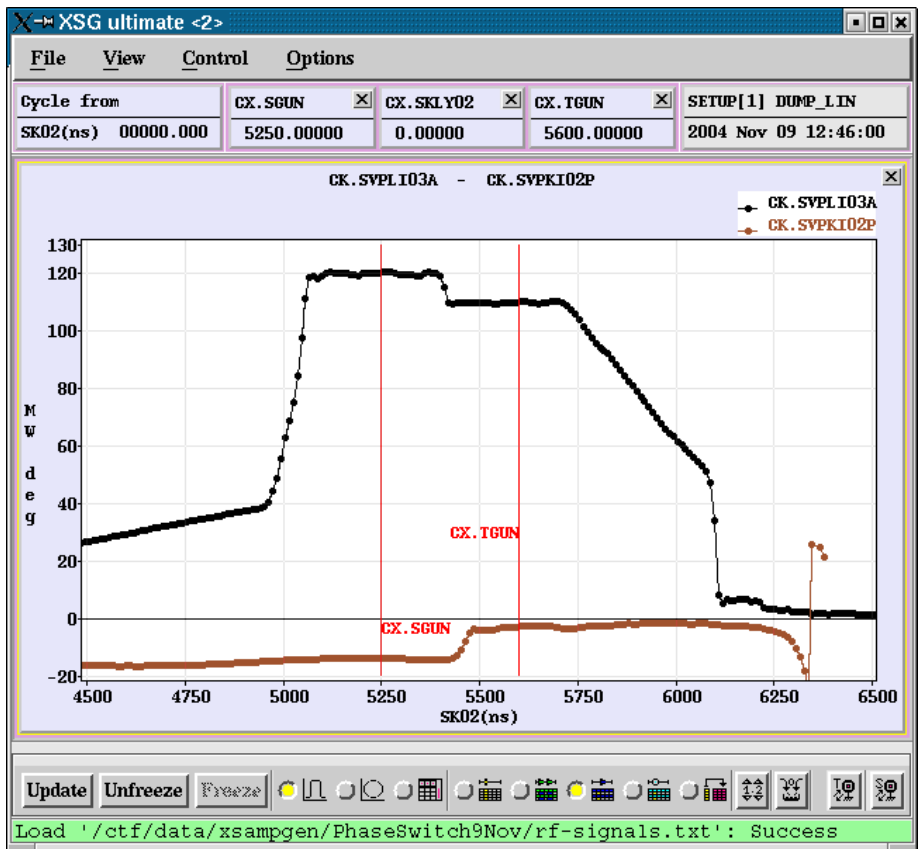



## Beam phase switch for 30 GHz pulse compression

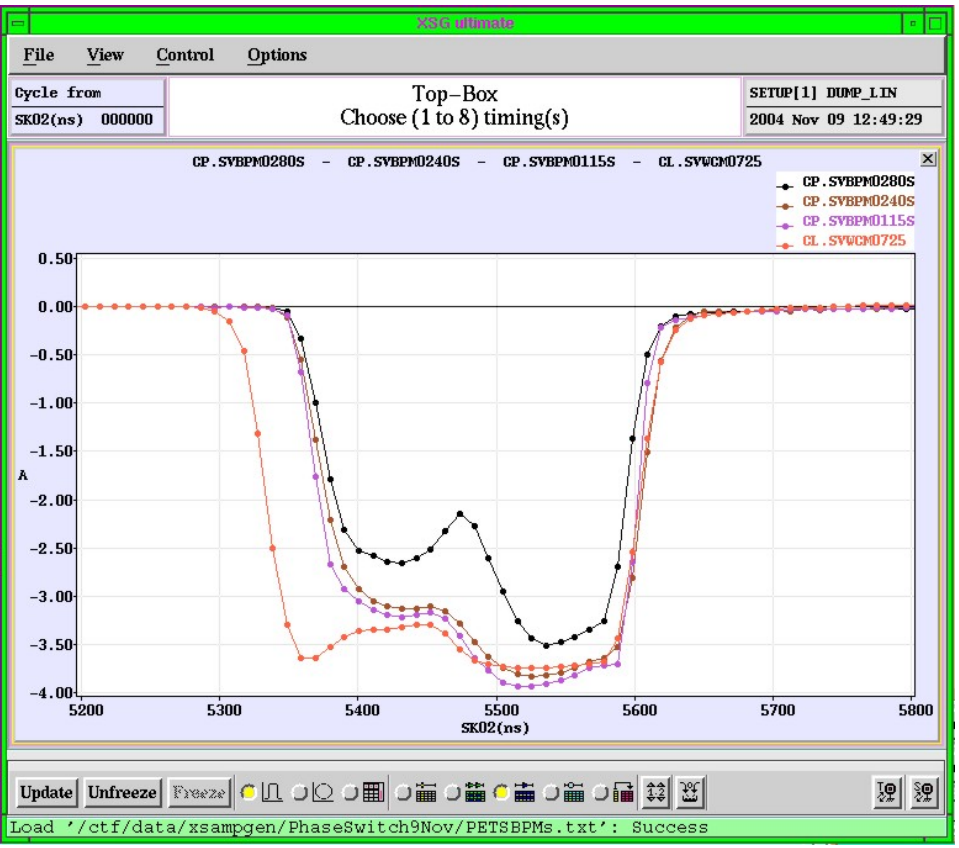
To increase available peak power from PETS a 30 GHz pulse compression à la SLED II is desirable. This requires rapid phase switching of PETS output by $180^0$, i.e. a rapid phase switch of the beam by $18^0$ *(because power is produced on 10th of bunch frequency !)* .

This can be done relatively easy by applying a phase jump to the klystron feeding pre-buncher and –buncher, but the 3 GHz accelerating structures cannot follow rapidly in phase, because of filling time and 3 GHz pulse compression. But a power step can be applied with the phase program for pulse compression.

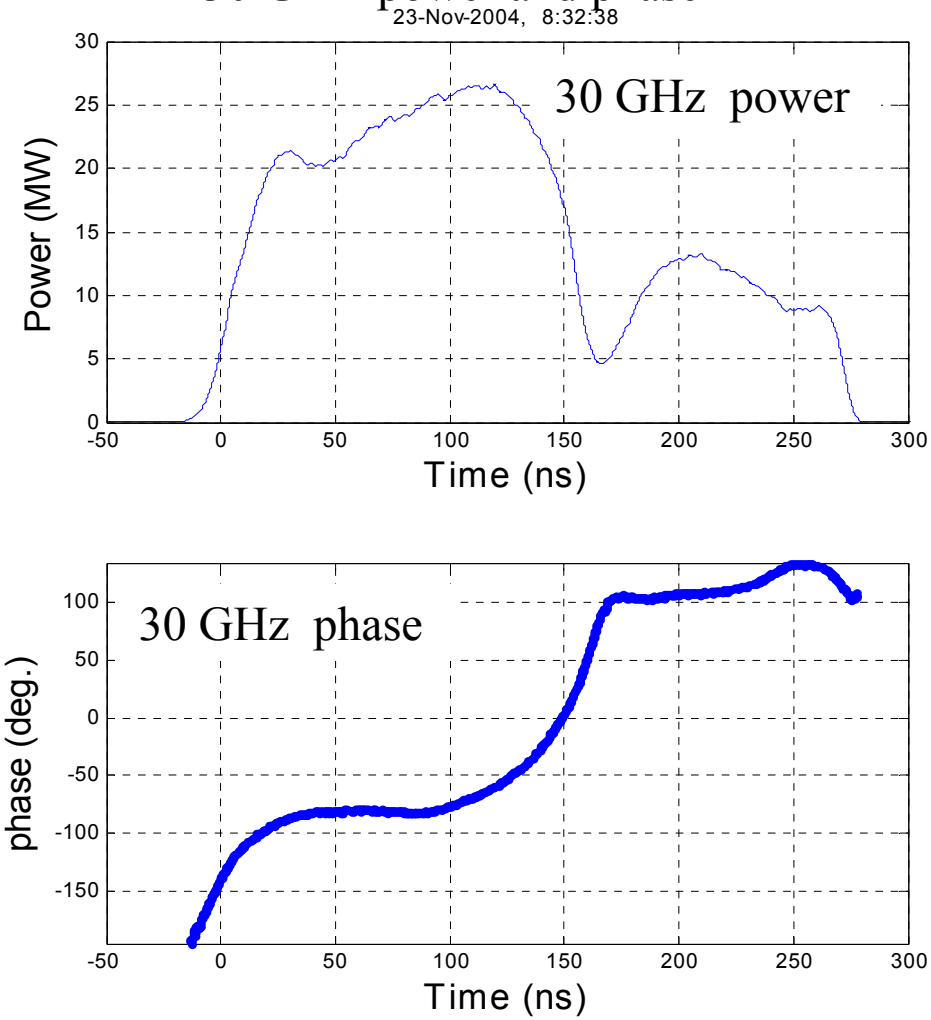


# Beam transmission with phase switch

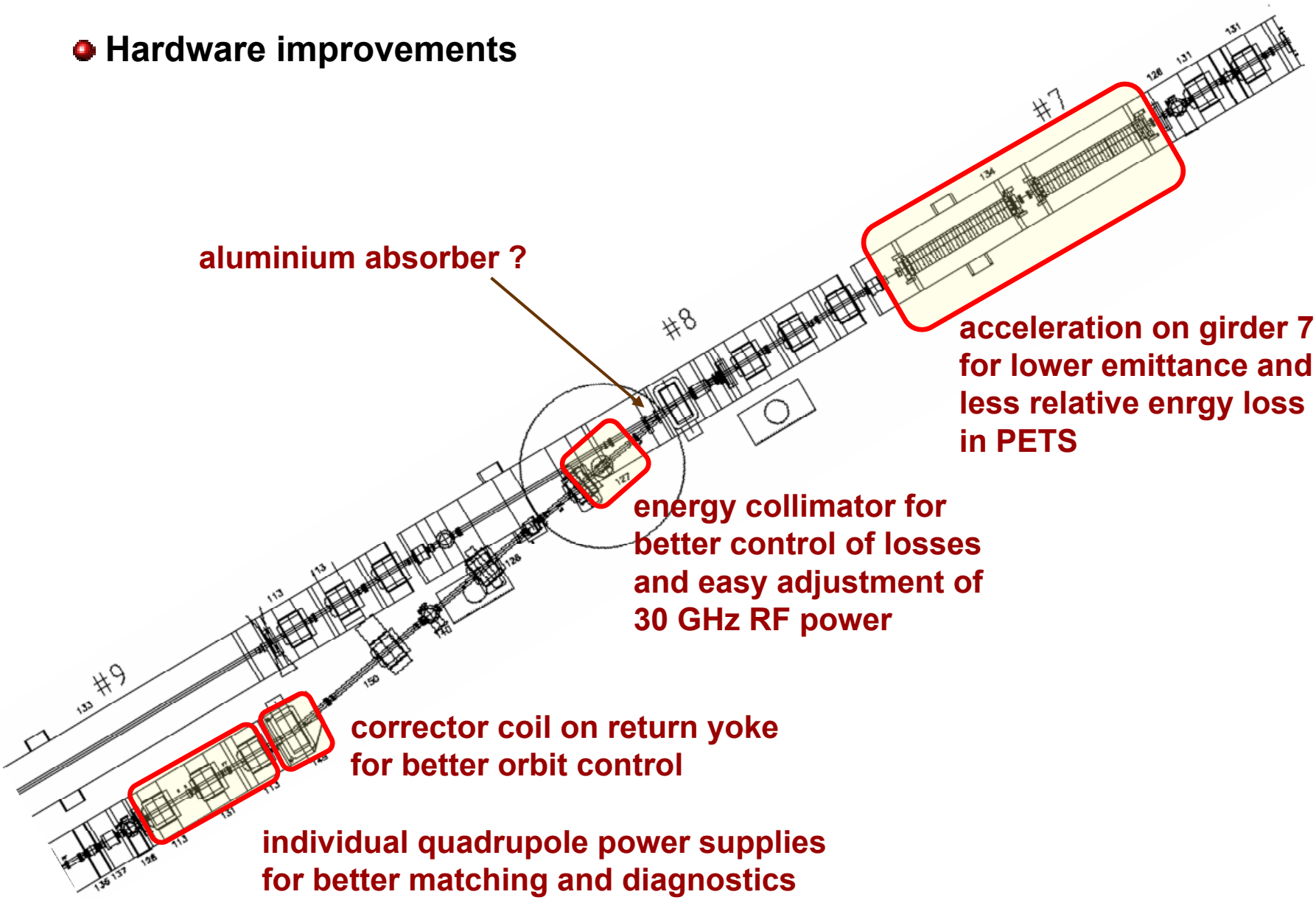



# 30 GHz power and phase




Works in principle. If this can be further improved, the PETS line together with a 30 GHz pulse compressor could provide 30 GHz power of ≈300 MW, covering all the needs for the 30 GHz accelerating structure development programme !

## Hardware improvements



## Brainware improvements

- Staggered klystron timing to reduce charge in transient
- Injector studies to reduce emittance in power mode
- Understand and solve beam orbit problems in PETS line
- Studies on beam collimation to avoid uncontrolled losses
- Optimised set-up's for 30 GHz phase switching
- Improve 30 GHz power measurement calibration
  *(and please change the time derivative of the calibration factor !)*