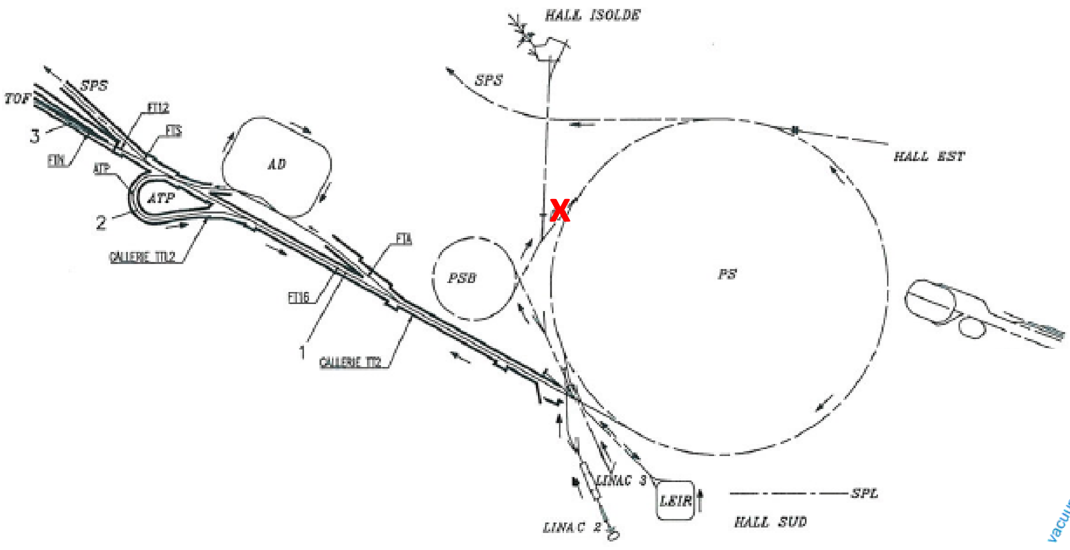
PSB dump replacement

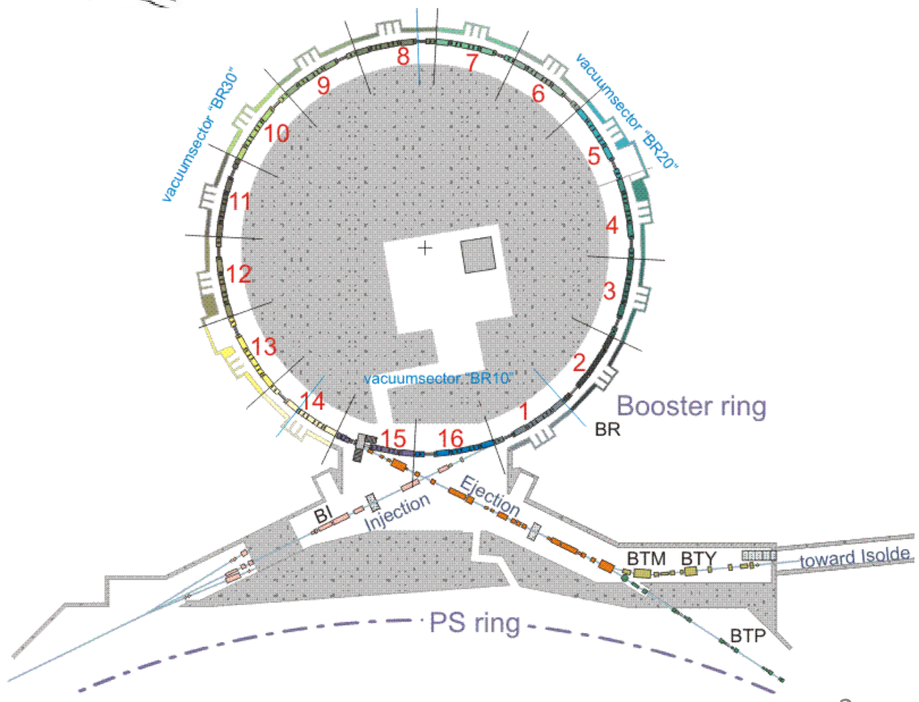
17th November 2011

LIU-PSB meeting

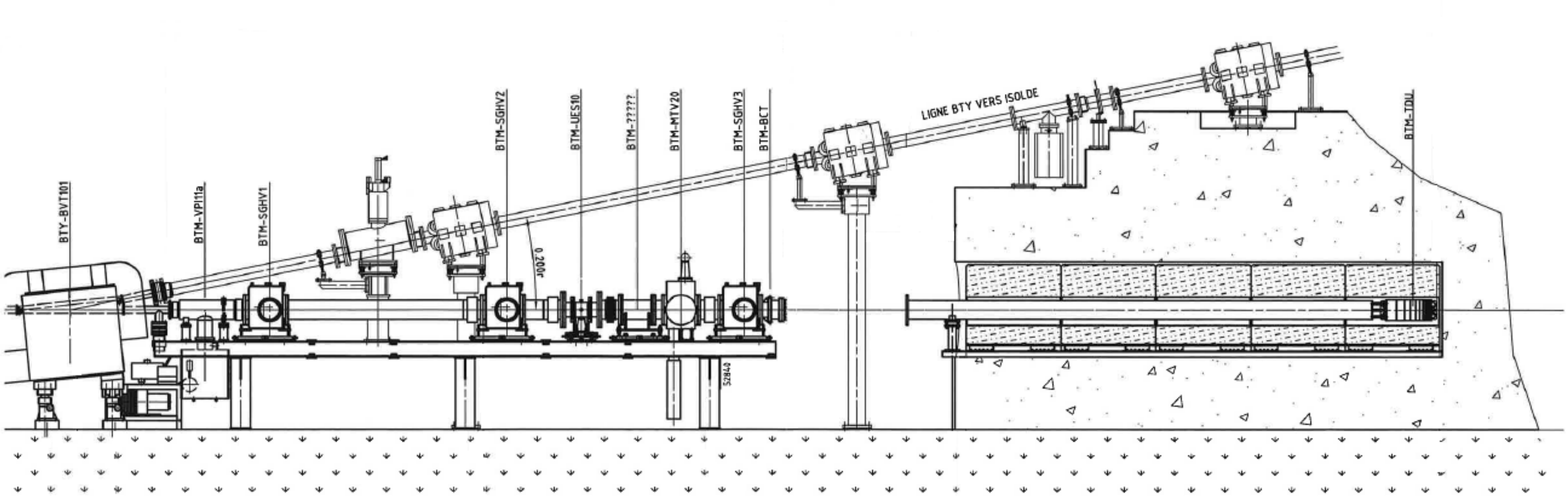
Alba Sarrió

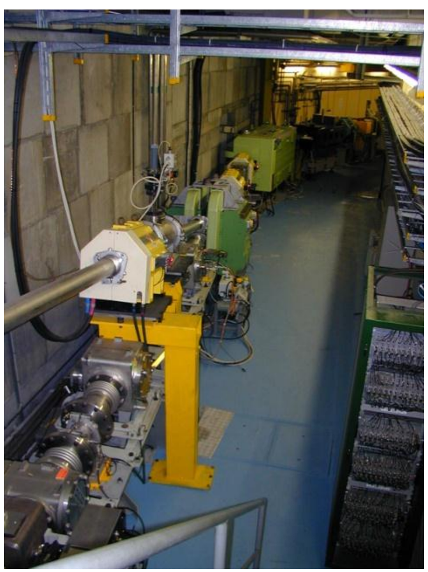
LOCATION


HALL ISOLDE
SPS
SPS
TOF
FT12
FTS
FTN
ATP
AD
ATP
GALLERIE TTL2
FTA
PSB
PS
HALL EST
FT16
GALLERIE TT2
LINAC 3
LEIR
SPL
LINAC 2
HALL SUD


vacuumsector "BR30"
vacuumsector "BR20"
vacuumsector "BR10"
Booster ring
BR
BI
Injection
Ejection
BTM
BTY
toward Isolde
BTP
PS ring

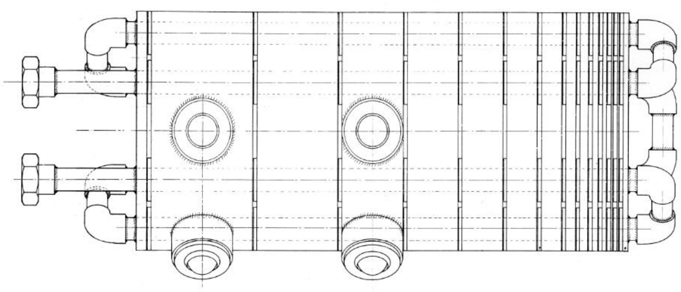
LOCATION

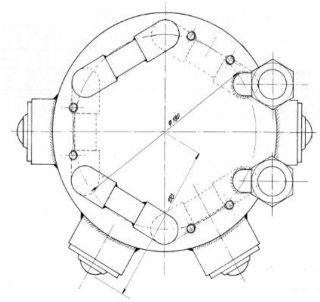

BTY-BVT101
BTM-VPI11a
BTM-SGHV1
BTM-SGHV2
BTM-UES10
BTM-MTV20
BTM-SGHV3
BTM-BCT
LIGNE BTY VERS ISOLDE
BTM-TDU



MAIN CHARACTERISTICS OF THE DESIGN

- EXISTING DUMP:

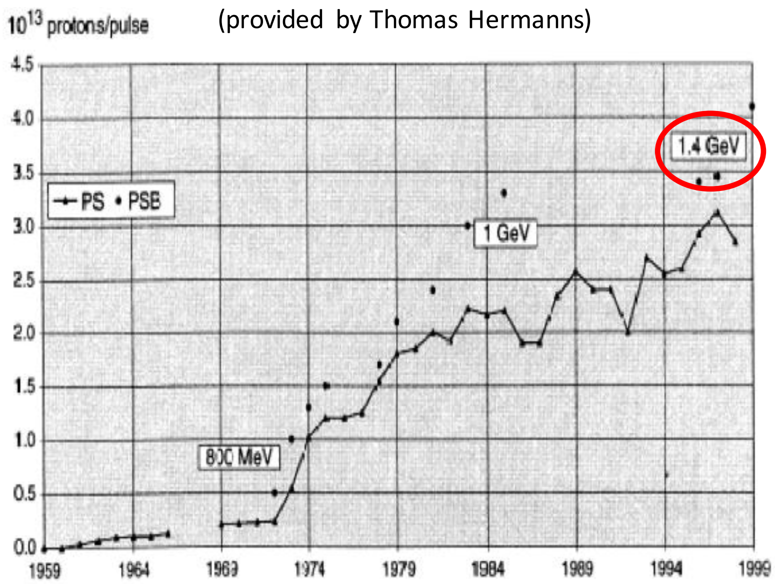




- Geometry:
  - Sliced design (15 disks)
- Material:
  - Structural Steel (disks)
  - Stainless steel 304/316 (pipes, joints, elbows...)
- Dimensions:
  - L = 483 mm
  - ∅ = 220 mm
- Beam parameters:
  - Designed in the 60's for an 800 MeV energy
  - Current energy: 1.4 GeV
  - Intensity: 8e+12 particles (p+)
  - Pulse period: 1.2 s
- Total Beam Power:
  - ~1.5 kW

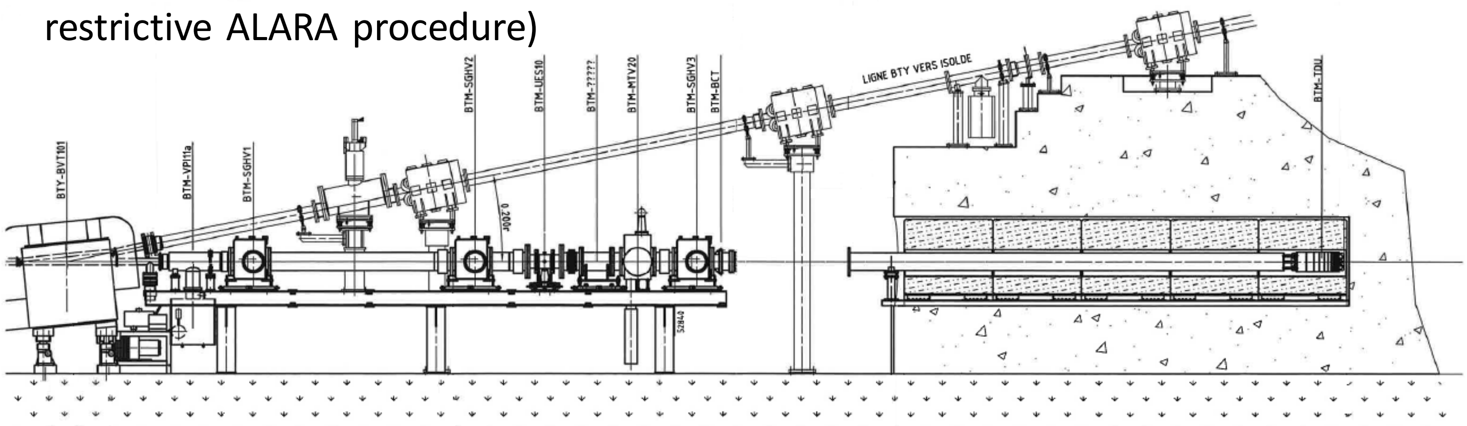
Historical diagram of peak beam intensities

(provided by Thomas Hermanns)



NEW DESIGN: constraints and decision-making

- Simplicity: use of classic materials and of simple design principles
- A system easy to access and to repair in case of need
- Low maintenance design
- Minimize any risk of failure (water, vacuum…)
- Constraints in layout, assuming that the current shielding is kept
  - Reasons to remove the concrete blocks: so that they do not constrain the diameter of the dump
  - Reasons to keep the concrete blocks: difficult work in a highly radiated area (more restrictive ALARA procedure)



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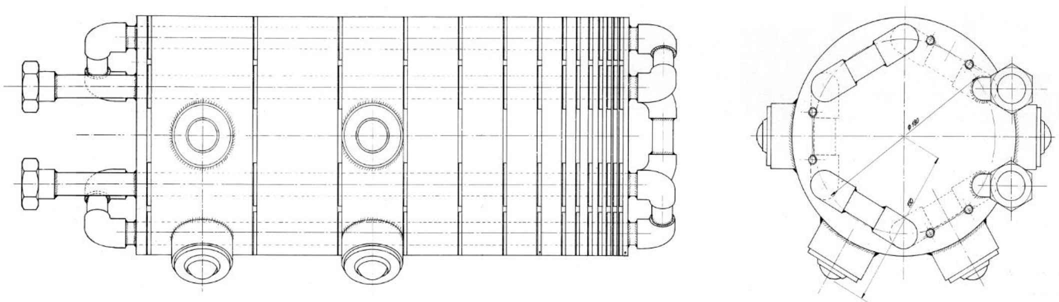

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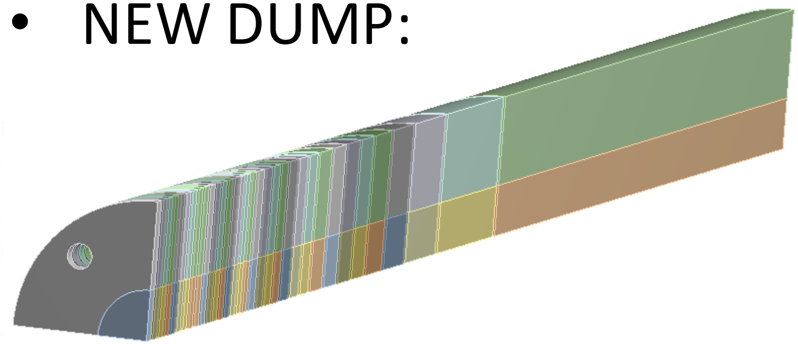
- NEW DUMP:



- Geometry:
  - Sliced design (33 disks)
- Material:
  - Copper alloy (disks)
- Dimensions:
  - L = 1435 mm
  - ∅ = 220 mm
- Beam parameters:
  - Energy: 2 GeV
  - Intensity: 1e+14 particles (p+)
  - Pulse period: 1.2 s
- Total Beam Power:
  - ~26.7 kW

BEAM SIZES

- Need to optimise beam sizes
- Minimum beam sizes:
  - Small values increase thermal load and mechanical stress
  - Need to increase the minimum as much as possible
- Maximum beam sizes:
  - High values increase spread to a point where a large part of the beam misses the target
  - Critical when defining the layout of the dump (position of cooling pipes, shielding...)
  - Need to reduce the maximum as much as possible

1 SIGMA-BEAM SIZES

(by Thomas Hermanns)

	Intensity	Horizontal Plane --- Beam Sizes [mm] Block 1	Block 2	Block 3	Block 4	Block 5	Core
NORMGPS	$8 \cdot 10^{12}$	6.77	8.07	9.45	10.89	12.35	12.99
	$4 \cdot 10^{12}$	5.07	6.11	7.19	8.32	9.47	9.97
	$1 \cdot 10^{12}$	3.07	3.80	4.57	5.37	6.18	6.53
CNGS	$7.5 \cdot 10^{12}$	6.17	7.50	8.93	10.40	11.90	12.55
	$3.75 \cdot 10^{12}$	4.71	5.78	6.92	8.09	9.29	9.81
	$1.5 \cdot 10^{12}$	3.30	4.09	4.92	5.79	6.68	7.06
LHC-25A	$1.6 \cdot 10^{12}$	3.28	4.01	4.78	5.57	6.39	6.74

Table 4: 1σ-beam sizes (horizontal plane) at the PS Booster dump. The contribution of the horizontal dispersion is added.

	Intensity	Vertical Plane --- Beam Sizes [mm] Block 1	Block 2	Block 3	Block 4	Block 5	Core
NORMGPS	$8 \cdot 10^{12}$	22.49	24.87	27.24	29.62	32.00	33.03
	$4 \cdot 10^{12}$	15.99	17.67	19.36	21.05	22.73	23.46
	$1 \cdot 10^{12}$	9.25	10.23	11.21	12.19	13.17	13.60
CNGS	$7.5 \cdot 10^{12}$	22.10	24.45	26.81	29.16	31.52	32.54
	$3.75 \cdot 10^{12}$	15.64	17.31	18.98	20.64	22.31	23.03
	$1.5 \cdot 10^{12}$	10.39	11.50	12.61	13.72	14.82	15.30
LHC-25A	$1.6 \cdot 10^{12}$	12.33	13.63	14.94	16.25	17.56	18.13

Table 5: 1σ-beam sizes (vertical plane) at the PS Booster dump.

Maximum beam size at the dump core:

- 1 sigma horizontal plane: **12.99 mm**
- 1 sigma vertical plane: **33.03 mm**

Minimum beam size at the dump core:

- 1 sigma horizontal plane: **6.53 mm**
- 1 sigma vertical plane: **13.60 mm**

PRELIMINARY ANALYSIS

(BASED ON THE NEW DESIGN)

- Parameters:
  - Sliced geometry
    - L = 1435 mm
    - ∅ = 220 mm
  - Copper alloy
  - Energy: 2 GeV
  - Intensity: 1e+14 particles (p+)
  - 1 sigma-beam size (old values from Thomas Hermanns):
    - Horizontal plane: 6.53 mm
    - Vertical plane: 13.60 mm
- Results (from ANSYS, thermal analysis):
  - ΔT after 1 pulse: 20 ^{o}C
  - ΔT steady state: 76 ^{o}C

$\Longrightarrow$ ΔTmax in steady state ~ 100 ^{o}C
MeltT(~1000 ^{o}C), Critical T (~300 ^{o}C)

- Results (from FLUKA):
  - 21% of the PRIMARY (BEAM) particles escape the system (radially)

OPTIONS TO COPE WITH THE ENERGY / PARTICLES LOST?

1. Remove the concrete blocks: change all of the new design, change the ALARA, etc.

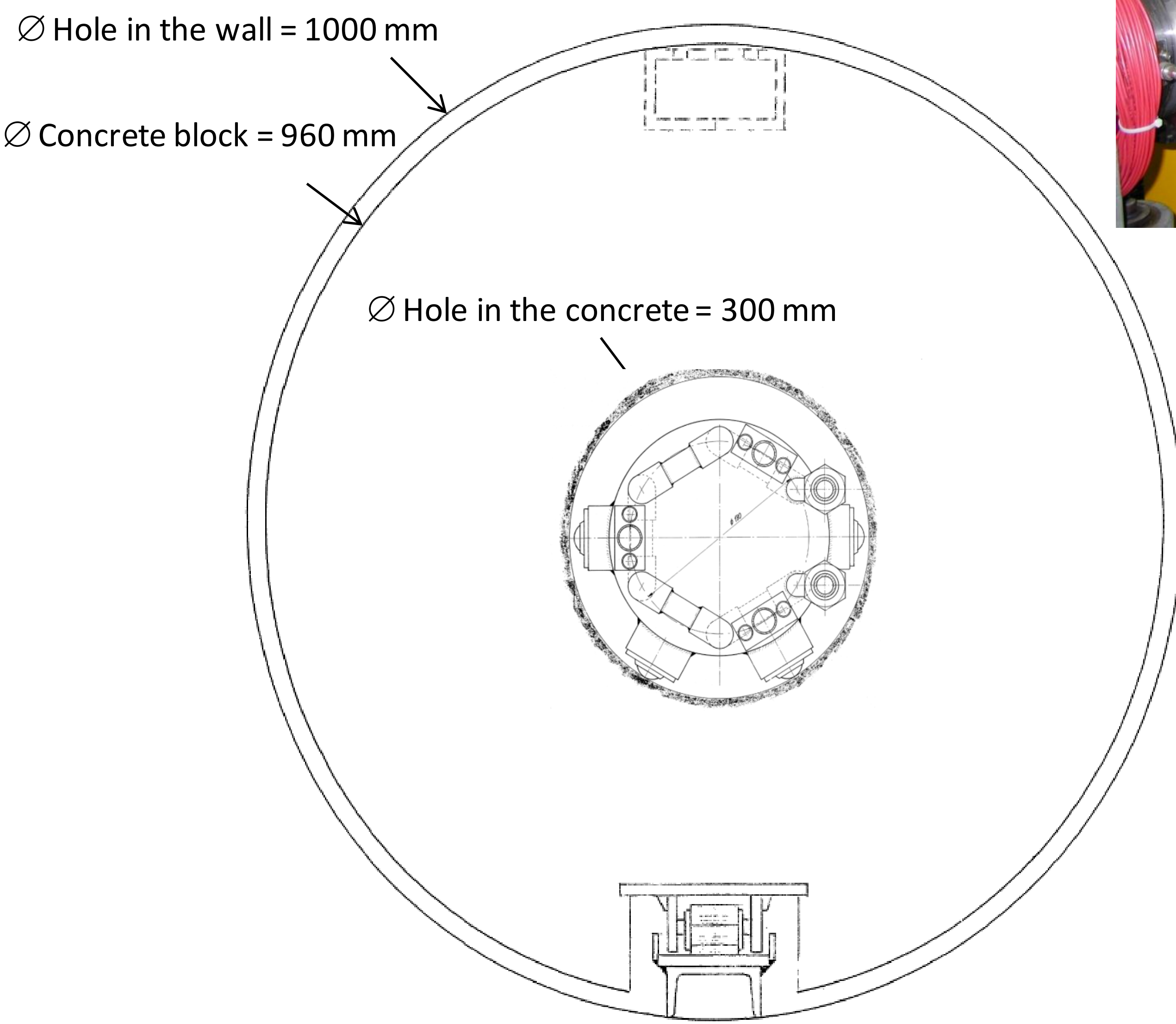
   ⟶ **'COMPLETE CHANGE'**

2. Impose a certain beam size (**optical focusing**), optimal in terms of layout/ALARA, which has to be checked for thermal stress.

   Keep the concrete blocks and adapt the geometry of the new dump to the existing layout

   ⟶ **'PARTIAL CHANGE'**

LAYOUT: CROSS SECTION



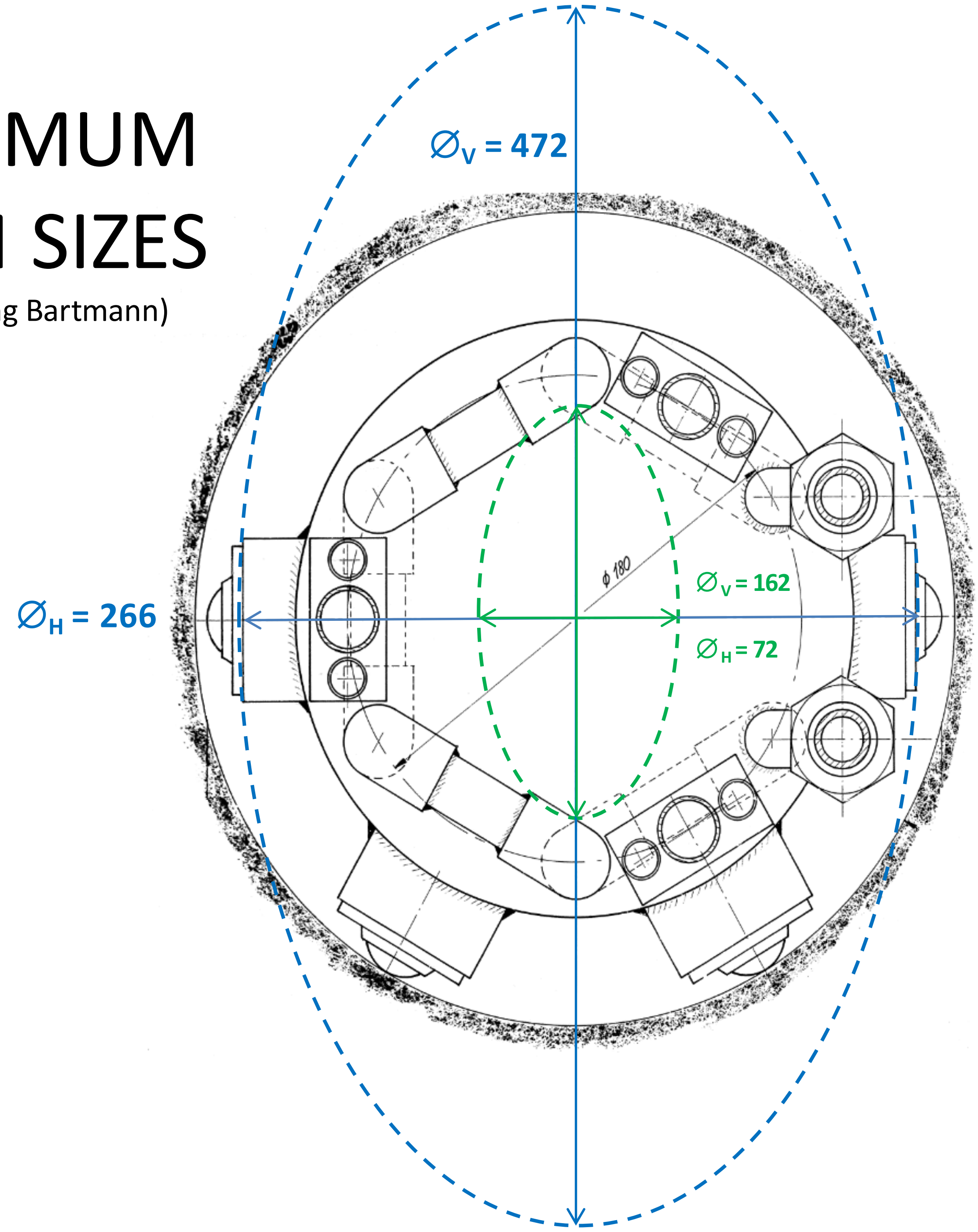
MAXIMUM BEAM SIZES

(by Wolfgang Bartmann)

Energy = 2 GeV

5 sigma-beam size (max)

½ FWHM (1.17 sigma-beam size) (max)

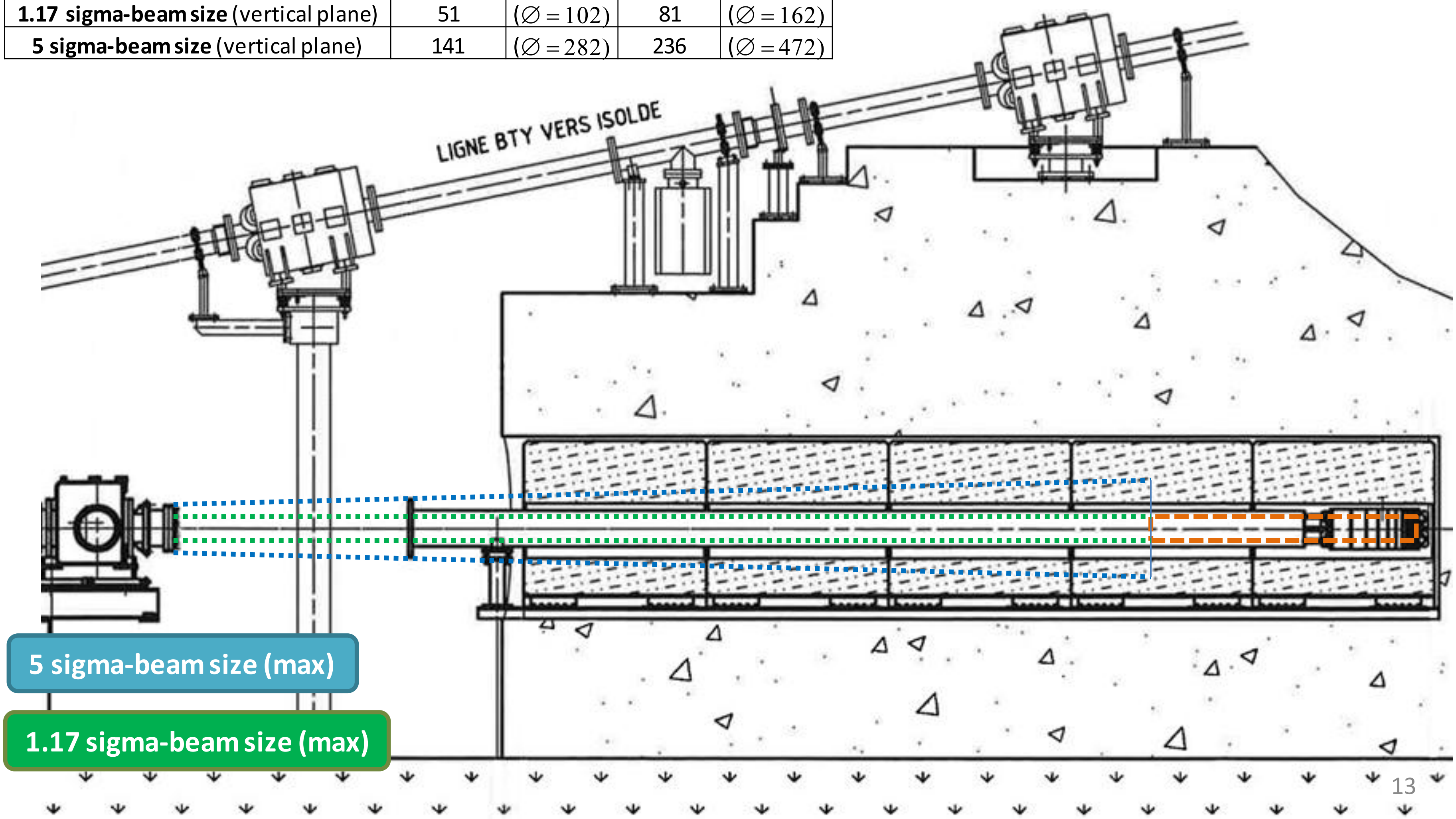


MAXIMUM BEAM SIZES

(by Wolfgang Bartmann)

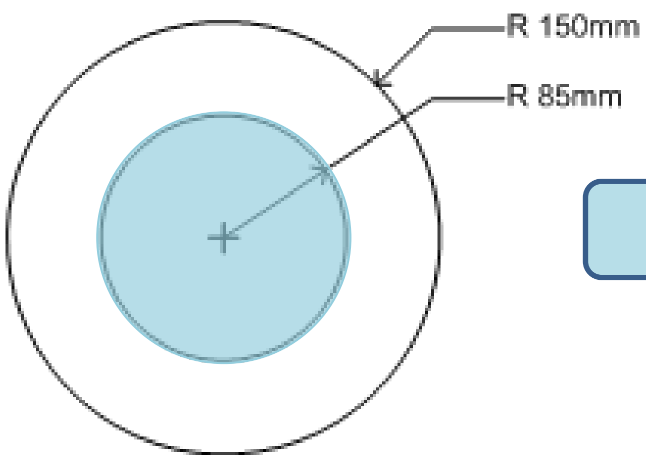
∅ window [mm]	220
∅ dump core [mm]	220
∅ hole in concrete [mm]	300

	at window [mm]		at dump core [mm]	
1.17 sigma-beam size (vertical plane)	51	$(\varnothing = 102)$	81	$(\varnothing = 162)$
5 sigma-beam size (vertical plane)	141	$(\varnothing = 282)$	236	$(\varnothing = 472)$



WHAT IS ACCEPTABLE AS A MAXIMUM BEAM SIZE?

- Cross section (imperfection of the surface, new shielding, cooling pipes...)



$r_{required}$ **= 85 mm**

- Recommended 5 sigma-beam size:
  - Horizontal plane = 85 mm
  - Vertical plane = 85 mm

REQUIRED BEAM SIZES

REQUIRED <u>MAXIMUM</u> BEAM SIZE:

Acceptable max. beam size [mm]	
Horizontal plane	Vertical plane
85	85

Present values of 5 sigma-beam size (max):

- at dump core
- 1.4 GeV

5 sigma-max.beam size [mm]	
Horizontal plane	Vertical plane
151	265

It needs to be shrunk by a **factor of 5.5**

REQUIRED <u>MINIMUM</u> BEAM SIZE:

Maximum service temperature of Copper ~ 300 – 350 ˚C

Assuming ΔTmax in steady state ~ 300 ^{o}C

→ The minimum beam size can shrink up to a **factor of 2.3**:

1 sigma-min.beam size [mm]	
Horizontal plane	Vertical plane
2.82	2.82

OPTIONS

SOLUTION	PROS	CONS
1. FULL CHANGE (remove the dump and the existing concrete blocks)	- More **freedom** in elaborating the new design - No constraints regarding the **diameter** of the dump - If the dump can be bigger in diameter, **beam sizes** would not be such a constraint - The concrete blocks can be replaced by any other material, one that can act as a **more efficient shielding**. Reduction in **dose rates** in the area. Fulfilling **RP**'s requirements	- Much bigger **work load** in a **highly radiated** area - The works would take much **longer** - More restrictive **ALARA** procedure - Due to the objects' age and their degraded state, there's **no guarantee** that the concrete blocks would come out of the wall easily (or at all). - **Special tools** would be required to **dismantle** the concrete blocks - Special machines would be required for the **transport** and **disposal of the radioactive waste** - A big part of the **line** (BTM, BTY and ejection) would need to be **dismantled temporarily** in order to allow the machines to access the area
2. PARTIAL CHANGE (keep the concrete blocks and adapt the geometry of the new dump to the existing layout)	- **Faster** and **easier** dismantling of the old object and assembly of the new one - Less restrictive **ALARA** procedure - **Safer** for workers (who would be exposed to much lower dose rates for a shorter time)	- **Beam sizes** constrain the design, making it more complicated

3. NEW LOCATION
(find a different site for the dump)

CONCLUSIONS

- Preliminary simulations have been performed
- Some issues have been identified: layout, space, access restrictions, beam sizes...
- A comparative study on the replacement of the PSB dump has been done

WHAT’S NEXT?

- A decision has to be made before March 2012 by the LIU-PSB Working Group
- An opinion from RP is required by the same time

THANK YOU